Modal Logic K+T+4+5

July 6, 2022

Abstract

This system does not have cut-elimination.

Contents

1 Height preserving admissibility of weakening on the left

- Case(s) rule $\rightarrow_R$

$$\frac{\mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5}\ {\rightarrow_R} \quad \rightsquigarrow \quad \frac{\dfrac{\overline{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_3, \mathtt{F}_5}^{\ \mathtt{ax}}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4, \mathtt{F}_W \vdash \Delta_3, \mathtt{F}_5}\ {\mathtt{IH}}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5}\ {\rightarrow_R}$$

- Case(s) rule $\wedge_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_4, \Delta_3 \quad \mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5}\ {\wedge_R} \quad \rightsquigarrow \quad \frac{\dfrac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4}^{\ \mathtt{ax}}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \Delta_3, \mathtt{F}_4}\ {\mathtt{IH}} \quad \dfrac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_5}^{\ \mathtt{ax}}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \Delta_3, \mathtt{F}_5}\ {\mathtt{IH}}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5}\ {\wedge_R}$$

- Case(s) rule $\vee_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_4, \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5}\ {\vee_R} \quad \rightsquigarrow \quad \frac{\dfrac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_5}^{\ \mathtt{ax}}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_5}\ {\mathtt{IH}}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5}\ {\vee_R}$$

- Case(s) rule $\bot_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \bot, \Delta_3}\ {\bot_R} \quad \rightsquigarrow \quad \frac{\dfrac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}^{\ \mathtt{ax}}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \Delta_3}\ {\mathtt{IH}}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \bot, \Delta_3}\ {\bot_R}$$

- Case(s) rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \top, \Delta_3}\ {\top_R} \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \top, \Delta_3}\ {\top_R}$$

- Case(s) rule K

$$\frac{\mathtt{h}_1 : unbox(\Box\Gamma_2) \vdash \mathtt{F}_5}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \Delta_3 \vdash \Delta_4, []\mathtt{F}_5}\ {K} \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : unbox(\Box\Gamma_2) \vdash \mathtt{F}_5}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_3, \mathtt{F}_W, \Box\Gamma_2 \vdash \Delta_4, []\mathtt{F}_5}\ {K}$$

- Case(s) rule $A45$

$$\frac{\mathtt{h}_1 : \Box\Gamma_2 \vdash \Box\Gamma_4, \mathtt{F}_6}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \Delta_3 \vdash \Box\Gamma_4, \Delta_5, []\mathtt{F}_6}\ {A45} \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Box\Gamma_2 \vdash \mathtt{F}_6, \Box\Gamma_4}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_3, \mathtt{F}_W, \Box\Gamma_2 \vdash \Delta_5, \Box\Gamma_4, []\mathtt{F}_6}\ {A45}$$

- Case(s) rule $\rightarrow_L$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_3, \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \rightarrow \mathtt{F}_4 \vdash \Delta_5}\ {\rightarrow_L} \quad \rightsquigarrow \quad \frac{\dfrac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3}^{\ \mathtt{ax}}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \Delta_5, \mathtt{F}_3}\ {\mathtt{IH}} \quad \dfrac{\overline{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}^{\ \mathtt{ax}}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4, \mathtt{F}_W \vdash \Delta_5}\ {\mathtt{IH}}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W, \mathtt{F}_3 \rightarrow \mathtt{F}_4 \vdash \Delta_5}\ {\rightarrow_L}$$

- Case(s) rule $\wedge_L$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \wedge \mathtt{F}_4 \vdash \Delta_5}\ \wedge_L \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_4 \vdash \Delta_5}\ \mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_4, \mathtt{F}_W \vdash \Delta_5}\ \mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W, \mathtt{F}_3 \wedge \mathtt{F}_4 \vdash \Delta_5}\ \wedge_L$$

- Case(s) rule $\vee_L$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2 \vdash \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5}\ \vee_L \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vdash \Delta_5}\ \mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_W \vdash \Delta_5}\ \mathtt{IH} \quad \dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\ \mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4, \mathtt{F}_W \vdash \Delta_5}\ \mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W, \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5}\ \vee_L$$

- Case(s) rule AT

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2, []\mathtt{F}_3 \vdash \Delta_4}{\bullet \mathtt{h}_1 : \Delta_2, []\mathtt{F}_3 \vdash \Delta_4}\ AT \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, []\mathtt{F}_3 \vdash \Delta_4}\ \mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_W, []\mathtt{F}_3 \vdash \Delta_4}\ \mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W, []\mathtt{F}_3 \vdash \Delta_4}\ AT$$

- Case(s) rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_1 : \bot, \Delta_2 \vdash \Delta_3}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : \bot, \Delta_2, \mathtt{F}_W \vdash \Delta_3}\ \bot_L$$

- Case(s) rule I

$$\frac{}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{p}_3 \vdash \Delta_4, \mathtt{p}_3}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_W, \mathtt{p}_3 \vdash \Delta_4, \mathtt{p}_3}\ I$$

- Case(s) rule $\top_L$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}{\bullet \mathtt{h}_1 : \top, \Delta_2 \vdash \Delta_3}\ \top_L \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\ \mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_W \vdash \Delta_3}\ \mathtt{IH}}{\bullet \mathtt{h}_1 : \top, \Delta_2, \mathtt{F}_W \vdash \Delta_3}\ \top_L$$

2 Height preserving admissibility of weakening on the right

- Case(s) rule $\rightarrow_R$

$$\frac{\mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5} \rightarrow_R \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_3, \mathtt{F}_5}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_3, \mathtt{F}_5, \mathtt{F}_W}\,\mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_W, \mathtt{F}_4 \rightarrow \mathtt{F}_5} \rightarrow_R$$

- Case(s) rule $\wedge_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_4, \Delta_3 \quad \mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5} \wedge_R \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_W}\,\mathtt{IH} \quad \dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_5}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_5, \mathtt{F}_W}\,\mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_W, \mathtt{F}_4 \wedge \mathtt{F}_5} \wedge_R$$

- Case(s) rule $\vee_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_4, \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5} \vee_R \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_5}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_5, \mathtt{F}_W}\,\mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_W, \mathtt{F}_4 \vee \mathtt{F}_5} \vee_R$$

- Case(s) rule $\bot_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \bot, \Delta_3} \bot_R \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_W}\,\mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \bot, \Delta_3, \mathtt{F}_W} \bot_R$$

- Case(s) rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \top, \Delta_3} \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \top, \Delta_3, \mathtt{F}_W} \top_R$$

- Case(s) rule K

$$\frac{\mathtt{h}_1 : unbox(\Box\Gamma_2) \vdash \mathtt{F}_5}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \Delta_3 \vdash \Delta_4, []\mathtt{F}_5} K \quad \rightsquigarrow \quad \dfrac{\dfrac{}{\mathtt{h}_1 : unbox(\Box\Gamma_2) \vdash \mathtt{F}_5}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_3, \Box\Gamma_2 \vdash \Delta_4, \mathtt{F}_W, []\mathtt{F}_5} K$$

- Case(s) rule $A45$

$$\frac{\mathtt{h}_1 : \Box\Gamma_2 \vdash \Box\Gamma_4, \mathtt{F}_6}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \Delta_3 \vdash \Box\Gamma_4, \Delta_5, []\mathtt{F}_6} A45 \quad \rightsquigarrow \quad \dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_2 \vdash \mathtt{F}_6, \Box\Gamma_4}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_3, \Box\Gamma_2 \vdash \Delta_5, \mathtt{F}_W, \Box\Gamma_4, []\mathtt{F}_6} A45$$

- Case(s) rule $\rightarrow_L$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_3, \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \rightarrow \mathtt{F}_4 \vdash \Delta_5} \rightarrow_L \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3, \mathtt{F}_W}\,\mathtt{IH} \quad \dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5, \mathtt{F}_W}\,\mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \rightarrow \mathtt{F}_4 \vdash \Delta_5, \mathtt{F}_W} \rightarrow_L$$

- Case(s) rule $\wedge_L$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \wedge \mathtt{F}_4 \vdash \Delta_5} \wedge_L \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_4 \vdash \Delta_5}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_4 \vdash \Delta_5, \mathtt{F}_W}\,\mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \wedge \mathtt{F}_4 \vdash \Delta_5, \mathtt{F}_W} \wedge_L$$

- Case(s) rule $\vee_L$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2 \vdash \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5} \vee_L \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vdash \Delta_5}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_W}\,\mathtt{IH} \quad \dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\,\mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5, \mathtt{F}_W}\,\mathtt{IH}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5, \mathtt{F}_W} \vee_L$$

- Case(s) rule AT

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2, []\mathtt{F}_3 \vdash \Delta_4}{\bullet\mathtt{h}_1 : \Delta_2, []\mathtt{F}_3 \vdash \Delta_4}\ AT \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, []\mathtt{F}_3 \vdash \Delta_4}\ \mathtt{ax}}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, []\mathtt{F}_3 \vdash \Delta_4, \mathtt{F}_W}\ \mathtt{IH}}{\bullet\mathtt{h}_1 : \Delta_2, []\mathtt{F}_3 \vdash \Delta_4, \mathtt{F}_W}\ AT$$

- Case(s) rule $\bot_L$

$$\frac{}{\bullet\mathtt{h}_1 : \bot, \Delta_2 \vdash \Delta_3}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_1 : \bot, \Delta_2 \vdash \Delta_3, \mathtt{F}_W}\ \bot_L$$

- Case(s) rule I

$$\frac{}{\bullet\mathtt{h}_1 : \Delta_2, \mathtt{p}_3 \vdash \Delta_4, \mathtt{p}_3}\ I \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_1 : \Delta_2, \mathtt{p}_3 \vdash \Delta_4, \mathtt{F}_W, \mathtt{p}_3}\ I$$

- Case(s) rule $\top_L$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}{\bullet\mathtt{h}_1 : \top, \Delta_2 \vdash \Delta_3}\ \top_L \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\ \mathtt{ax}}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_W}\ \mathtt{IH}}{\bullet\mathtt{h}_1 : \top, \Delta_2 \vdash \Delta_3, \mathtt{F}_W}\ \top_L$$

3 Measure of derivations

- Case(s) rule $\rightarrow_R$

$$\frac{\mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5} \rightarrow_R \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_3, \mathtt{F}_5}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_3, \mathtt{F}_5}\,\mathtt{IH}}{\bullet\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5} \rightarrow_R$$

- Case(s) rule $\wedge_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_4, \Delta_3 \quad \mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5} \wedge_R \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4}\,\mathtt{IH} \quad \dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_5}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_5}\,\mathtt{IH}}{\bullet\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5} \wedge_R$$

- Case(s) rule $\vee_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_4, \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5} \vee_R \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_5}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_5}\,\mathtt{IH}}{\bullet\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5} \vee_R$$

- Case(s) rule $\bot_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \bot, \Delta_3} \bot_R \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\,\mathtt{IH}}{\bullet\bullet \mathtt{h}_1 : \Delta_2 \vdash \bot, \Delta_3} \bot_R$$

- Case(s) rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \top, \Delta_3} \top_R \quad \rightsquigarrow \quad \frac{}{\bullet\bullet \mathtt{h}_1 : \Delta_2 \vdash \top, \Delta_3} \top_R$$

- Case(s) rule K

$$\frac{\mathtt{h}_1 : \mathit{unbox}(\Box\Gamma_2) \vdash \mathtt{F}_5}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \Delta_3 \vdash \Delta_4, []\mathtt{F}_5} K \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \mathit{unbox}(\Box\Gamma_2) \vdash \mathtt{F}_5}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \mathit{unbox}(\Box\Gamma_2) \vdash \mathtt{F}_5}\,\mathtt{IH}}{\bullet\bullet \mathtt{h}_1 : \Delta_3, \Box\Gamma_2 \vdash \Delta_4, []\mathtt{F}_5} K$$

- Case(s) rule $A45$

$$\frac{\mathtt{h}_1 : \Box\Gamma_2 \vdash \Box\Gamma_4, \mathtt{F}_6}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \Delta_3 \vdash \Box\Gamma_4, \Delta_5, []\mathtt{F}_6} A45 \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_2 \vdash \mathtt{F}_6, \Box\Gamma_4}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Box\Gamma_2 \vdash \mathtt{F}_6, \Box\Gamma_4}\,\mathtt{IH}}{\bullet\bullet \mathtt{h}_1 : \Delta_3, \Box\Gamma_2 \vdash \Delta_5, \Box\Gamma_4, []\mathtt{F}_6} A45$$

- Case(s) rule $\rightarrow_L$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_3, \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \rightarrow \mathtt{F}_4 \vdash \Delta_5} \rightarrow_L \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3}\,\mathtt{IH} \quad \dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\,\mathtt{IH}}{\bullet\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \rightarrow \mathtt{F}_4 \vdash \Delta_5} \rightarrow_L$$

- Case(s) rule $\wedge_L$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \wedge \mathtt{F}_4 \vdash \Delta_5} \wedge_L \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_4 \vdash \Delta_5}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_4 \vdash \Delta_5}\,\mathtt{IH}}{\bullet\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \wedge \mathtt{F}_4 \vdash \Delta_5} \wedge_L$$

- Case(s) rule $\vee_L$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2 \vdash \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5} \vee_L \quad \rightsquigarrow \quad \frac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vdash \Delta_5}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vdash \Delta_5}\,\mathtt{IH} \quad \dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\,\mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\,\mathtt{IH}}{\bullet\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5} \vee_L$$

- Case(s) rule AT

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2, []\mathtt{F}_3 \vdash \Delta_4}{\bullet\mathtt{h}_1 : \Delta_2, []\mathtt{F}_3 \vdash \Delta_4}\ AT \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, []\mathtt{F}_3 \vdash \Delta_4}\ \mathtt{ax}}{\bullet\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, []\mathtt{F}_3 \vdash \Delta_4}\ \mathtt{IH}}{\bullet\bullet\mathtt{h}_1 : \Delta_2, []\mathtt{F}_3 \vdash \Delta_4}\ AT$$

- Case(s) rule $\bot_L$

$$\frac{}{\bullet\mathtt{h}_1 : \bot, \Delta_2 \vdash \Delta_3}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet\bullet\mathtt{h}_1 : \bot, \Delta_2 \vdash \Delta_3}\ \bot_L$$

- Case(s) rule I

$$\frac{}{\bullet\mathtt{h}_1 : \Delta_2, \mathtt{p}_3 \vdash \Delta_4, \mathtt{p}_3}\ I \quad \rightsquigarrow \quad \frac{}{\bullet\bullet\mathtt{h}_1 : \Delta_2, \mathtt{p}_3 \vdash \Delta_4, \mathtt{p}_3}\ I$$

- Case(s) rule $\top_L$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}{\bullet\mathtt{h}_1 : \top, \Delta_2 \vdash \Delta_3}\ \top_L \quad \rightsquigarrow \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\ \mathtt{ax}}{\bullet\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\ \mathtt{IH}}{\bullet\bullet\mathtt{h}_1 : \top, \Delta_2 \vdash \Delta_3}\ \top_L$$

4 Invertibility of Rules

4.1 Status of $\rightarrow_R$: : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_3 : \mathtt{F}_5, \Delta_4 \vdash \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2), \mathtt{F}_5 \rightarrow \mathtt{F}_6}\ {\scriptstyle \rightarrow_R} \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_4, \mathtt{F}_1, \mathtt{F}_5 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_6}\ {\scriptstyle \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4, \mathtt{F}_1 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \rightarrow \mathtt{F}_6}\ {\scriptstyle \rightarrow_R}$$

$$\frac{\mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5}\ {\scriptstyle \rightarrow_R} \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_3, \mathtt{F}_5}\ {\scriptstyle \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_3, \mathtt{F}_5}\ {\scriptstyle \mathtt{H}}$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \quad \mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2), \mathtt{F}_5 \wedge \mathtt{F}_6}\ {\scriptstyle \wedge_R} \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_4, \mathtt{F}_1 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5}\ {\scriptstyle \mathtt{ax/ind}} \quad \dfrac{}{\mathtt{h}_3 : \Delta_4, \mathtt{F}_1 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_6}\ {\scriptstyle \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4, \mathtt{F}_1 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \wedge \mathtt{F}_6}\ {\scriptstyle \wedge_R}$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_5, \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2), \mathtt{F}_5 \vee \mathtt{F}_6}\ {\scriptstyle \vee_R} \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_4, \mathtt{F}_1 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5, \mathtt{F}_6}\ {\scriptstyle \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4, \mathtt{F}_1 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \vee \mathtt{F}_6}\ {\scriptstyle \vee_R}$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \Delta_5, \mathtt{F}_1 \rightarrow \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \bot, \Delta_5, \mathtt{F}_1 \rightarrow \mathtt{F}_2}\ {\scriptstyle \bot_R} \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_4, \mathtt{F}_1 \vdash \Delta_5, \mathtt{F}_2}\ {\scriptstyle \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4, \mathtt{F}_1 \vdash \bot, \Delta_5, \mathtt{F}_2}\ {\scriptstyle \bot_R}$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \top, \Delta_5, \mathtt{F}_1 \rightarrow \mathtt{F}_2}\ {\scriptstyle \top_R} \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_4, \mathtt{F}_1 \vdash \top, \Delta_5, \mathtt{F}_2}\ {\scriptstyle \top_R}$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_5 \vdash (\Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2), []\mathtt{F}_6}\ {\scriptstyle K} \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}\ {\scriptstyle \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_5, \mathtt{F}_1, \Box\Gamma_4 \vdash \Delta_7, \mathtt{F}_2, []\mathtt{F}_6}\ {\scriptstyle K}$$

- Case rule $A45$

$$\frac{\mathtt{h}_3 : \Box\Gamma_4 \vdash \Box\Gamma_6, \mathtt{F}_7}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_5 \vdash \Box\Gamma_6, (\Delta_8, \mathtt{F}_1 \rightarrow \mathtt{F}_2), []\mathtt{F}_7}\ {\scriptstyle A45} \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Box\Gamma_4 \vdash \mathtt{F}_7, \Box\Gamma_6}\ {\scriptstyle \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_5, \mathtt{F}_1, \Box\Gamma_4 \vdash \Delta_8, \mathtt{F}_2, \Box\Gamma_6, []\mathtt{F}_7}\ {\scriptstyle A45}$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_4 : \Delta_5 \vdash \mathtt{F}_6, \Delta_1, \mathtt{F}_2 \rightarrow \mathtt{F}_3 \quad \mathtt{h}_4 : \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \rightarrow \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \rightarrow \mathtt{F}_3}\ {\scriptstyle \rightarrow_L} \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : \Delta_5, \mathtt{F}_2 \vdash \Delta_1, \mathtt{F}_3, \mathtt{F}_6}\ {\scriptstyle \mathtt{ax/ind}} \quad \dfrac{}{\mathtt{h}_4 : \Delta_5, \mathtt{F}_2, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}\ {\scriptstyle \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_2, \mathtt{F}_6 \rightarrow \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}\ {\scriptstyle \rightarrow_L}$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3}\ \wedge_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_2, \mathtt{F}_6, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_2, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}\ \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \quad \mathtt{h}_4 : \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3}\ \vee_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_2, \mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_2, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_2, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}\ \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3}\ AT \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_2, \mathtt{F}_6, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_2, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_3}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_4 : \bot, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : \bot, \Delta_5, \mathtt{F}_2 \vdash \Delta_1, \mathtt{F}_3}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_3 : \mathtt{p}_5, \Delta_4 \vdash \mathtt{p}_5, \Delta_6, \mathtt{F}_1 \to \mathtt{F}_2}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_4, \mathtt{F}_1, \mathtt{p}_5 \vdash \Delta_6, \mathtt{F}_2, \mathtt{p}_5}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3}{\bullet \mathtt{h}_4 : \top, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3}\ \top_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_2 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \top, \Delta_5, \mathtt{F}_2 \vdash \Delta_1, \mathtt{F}_3}\ \top_L$$

4.2 Status of $\wedge_R$: (Left Premise): `Invertible`

- Case rule $\to_R$

$$\frac{\mathtt{h}_3 : \mathtt{F}_5, \Delta_4 \vdash \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), \mathtt{F}_5 \to \mathtt{F}_6}\ \to_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4, \mathtt{F}_5 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_5 \to \mathtt{F}_6}\ \to_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2 \quad \mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), \mathtt{F}_5 \wedge \mathtt{F}_6}\ \wedge_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_5}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_5 \wedge \mathtt{F}_6}\ \wedge_R$$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_4, \Delta_3 \quad \mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5}\ \wedge_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4}\ \mathtt{H}$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_5, \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), \mathtt{F}_5 \vee \mathtt{F}_6}\ \vee_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_5, \mathtt{F}_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_5 \vee \mathtt{F}_6}\ \vee_R$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \Delta_5, \mathtt{F}_1 \wedge \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \bot, \Delta_5, \mathtt{F}_1 \wedge \mathtt{F}_2}\ \bot_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_5, \mathtt{F}_1}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \bot, \Delta_5, \mathtt{F}_1}\ \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \top, \Delta_5, \mathtt{F}_1 \wedge \mathtt{F}_2}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \top, \Delta_5, \mathtt{F}_1}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_5 \vdash (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), []\mathtt{F}_6}\ K \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_5, \Box\Gamma_4 \vdash \Delta_7, \mathtt{F}_1, []\mathtt{F}_6}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_3 : \Box\Gamma_4 \vdash \Box\Gamma_6, \mathtt{F}_7}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_5 \vdash \Box\Gamma_6, (\Delta_8, \mathtt{F}_1 \wedge \mathtt{F}_2), []\mathtt{F}_7}\ A45 \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Box\Gamma_4 \vdash \mathtt{F}_7, \Box\Gamma_6}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_5, \Box\Gamma_4 \vdash \Delta_8, \mathtt{F}_1, \Box\Gamma_6, []\mathtt{F}_7}\ A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_4 : \Delta_5 \vdash \mathtt{F}_6, \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \quad \mathtt{h}_4 : \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \rightarrow_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_6}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2}\ \rightarrow_L$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \wedge_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_6, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2}\ \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \quad \mathtt{h}_4 : \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \vee_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2}\ \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ AT \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_6, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_4 : \bot, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : \bot, \Delta_5 \vdash \Delta_1, \mathtt{F}_2}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_3 : \mathtt{p}_5, \Delta_4 \vdash \mathtt{p}_5, \Delta_6, \mathtt{F}_1 \wedge \mathtt{F}_2}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_4, \mathtt{p}_5 \vdash \Delta_6, \mathtt{F}_1, \mathtt{p}_5}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \top, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \top_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_2}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \top, \Delta_5 \vdash \Delta_1, \mathtt{F}_2}\ \top_L$$

4.3 Status of $\wedge_R$ (Right Premise): : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_3 : \mathtt{F}_5, \Delta_4 \vdash \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), \mathtt{F}_5 \rightarrow \mathtt{F}_6}\ \rightarrow_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4, \mathtt{F}_5 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \rightarrow \mathtt{F}_6}\ \rightarrow_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2 \quad \mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), \mathtt{F}_5 \wedge \mathtt{F}_6}\ \wedge_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \wedge \mathtt{F}_6}\ \wedge_R$$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_4, \Delta_3 \quad \mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5}\ \wedge_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_5}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_5}\ \mathtt{H}$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_5, \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), \mathtt{F}_5 \vee \mathtt{F}_6}\ \vee_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5, \mathtt{F}_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \vee \mathtt{F}_6}\ \vee_R$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \Delta_5, \mathtt{F}_1 \wedge \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \bot, \Delta_5, \mathtt{F}_1 \wedge \mathtt{F}_2}\ \bot_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_5, \mathtt{F}_2}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \bot, \Delta_5, \mathtt{F}_2}\ \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \top, \Delta_5, \mathtt{F}_1 \wedge \mathtt{F}_2}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \top, \Delta_5, \mathtt{F}_2}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_5 \vdash (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), []\mathtt{F}_6}\ K \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_5, \Box\Gamma_4 \vdash \Delta_7, \mathtt{F}_2, []\mathtt{F}_6}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_3 : \Box\Gamma_4 \vdash \Box\Gamma_6, \mathtt{F}_7}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_5 \vdash \Box\Gamma_6, (\Delta_8, \mathtt{F}_1 \wedge \mathtt{F}_2), []\mathtt{F}_7}\ A45 \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Box\Gamma_4 \vdash \mathtt{F}_7, \Box\Gamma_6}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_5, \Box\Gamma_4 \vdash \Delta_8, \mathtt{F}_2, \Box\Gamma_6, []\mathtt{F}_7}\ A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_4 : \Delta_5 \vdash \mathtt{F}_6, \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \quad \mathtt{h}_4 : \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \rightarrow_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_3, \mathtt{F}_6}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}\ \rightarrow_L$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \wedge_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_6, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}\ \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \quad \mathtt{h}_4 : \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \vee_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_3}\ \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ AT \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_6, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_3}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_4 : \bot, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : \bot, \Delta_5 \vdash \Delta_1, \mathtt{F}_3}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_3 : \mathtt{p}_5, \Delta_4 \vdash \mathtt{p}_5, \Delta_6, \mathtt{F}_1 \wedge \mathtt{F}_2}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_4, \mathtt{p}_5 \vdash \Delta_6, \mathtt{F}_2, \mathtt{p}_5}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}{\bullet \mathtt{h}_4 : \top, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3}\ \top_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \top, \Delta_5 \vdash \Delta_1, \mathtt{F}_3}\ \top_L$$

4.4 Status of $\vee_R$: : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_3 : \mathtt{F}_5, \Delta_4 \vdash \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), \mathtt{F}_5 \rightarrow \mathtt{F}_6}\ \rightarrow_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4, \mathtt{F}_5 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_5 \rightarrow \mathtt{F}_6}\ \rightarrow_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \quad \mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), \mathtt{F}_5 \wedge \mathtt{F}_6}\ \wedge_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_5}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_5 \wedge \mathtt{F}_6}\ \wedge_R$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \mathtt{F}_5, \mathtt{F}_6, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), \mathtt{F}_5 \vee \mathtt{F}_6}\ \vee_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_5, \mathtt{F}_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_5 \vee \mathtt{F}_6}\ \vee_R$$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_4, \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5}\ \vee_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_5}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_5}\ \mathtt{H}$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_3 : \Delta_4 \vdash \Delta_5, \mathtt{F}_1 \vee \mathtt{F}_2}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \bot, \Delta_5, \mathtt{F}_1 \vee \mathtt{F}_2}\ \bot_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_4 \vdash \Delta_5, \mathtt{F}_1, \mathtt{F}_2}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \bot, \Delta_5, \mathtt{F}_1, \mathtt{F}_2}\ \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \top, \Delta_5, \mathtt{F}_1 \vee \mathtt{F}_2}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_4 \vdash \top, \Delta_5, \mathtt{F}_1, \mathtt{F}_2}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_5 \vdash (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), []\mathtt{F}_6}\ K \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_5, \Box\Gamma_4 \vdash \Delta_7, \mathtt{F}_1, \mathtt{F}_2, []\mathtt{F}_6}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_3 : \Box\Gamma_4 \vdash \Box\Gamma_6, \mathtt{F}_7}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_5 \vdash \Box\Gamma_6, (\Delta_8, \mathtt{F}_1 \vee \mathtt{F}_2), []\mathtt{F}_7}\ A45 \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Box\Gamma_4 \vdash \mathtt{F}_7, \Box\Gamma_6}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_5, \Box\Gamma_4 \vdash \Delta_8, \mathtt{F}_1, \mathtt{F}_2, \Box\Gamma_6, []\mathtt{F}_7}\ A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_4 : \Delta_5 \vdash \mathtt{F}_6, \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \quad \mathtt{h}_4 : \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}\ \rightarrow_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3, \mathtt{F}_6}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}\ \rightarrow_L$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}\ \wedge_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_6, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}\ \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \quad \mathtt{h}_4 : \mathtt{F}_7, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}\ \vee_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}\ \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}{\bullet \mathtt{h}_4 : \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}\ AT \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5, \mathtt{F}_6, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_5, []\mathtt{F}_6 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_4 : \bot, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : \bot, \Delta_5 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_3 : \mathtt{p}_5, \Delta_4 \vdash \mathtt{p}_5, \Delta_6, \mathtt{F}_1 \vee \mathtt{F}_2}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_4, \mathtt{p}_5 \vdash \Delta_6, \mathtt{F}_1, \mathtt{F}_2, \mathtt{p}_5}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}{\bullet \mathtt{h}_4 : \top, \Delta_5 \vdash \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3}\ \top_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_5 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \top, \Delta_5 \vdash \Delta_1, \mathtt{F}_2, \mathtt{F}_3}\ \top_L$$

4.5 Status of $\bot_R$: : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2 \vdash \bot, \mathtt{F}_4, \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2 \vdash (\bot, \Delta_5), \mathtt{F}_3 \rightarrow \mathtt{F}_4}\ \rightarrow_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_4}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3 \rightarrow \mathtt{F}_4}\ \rightarrow_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \bot, \mathtt{F}_3, \Delta_5 \quad \mathtt{h}_1 : \Delta_2 \vdash \bot, \mathtt{F}_4, \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2 \vdash (\bot, \Delta_5), \mathtt{F}_3 \wedge \mathtt{F}_4}\ \wedge_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_4}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3 \wedge \mathtt{F}_4}\ \wedge_R$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \bot, \mathtt{F}_3, \mathtt{F}_4, \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2 \vdash (\bot, \Delta_5), \mathtt{F}_3 \vee \mathtt{F}_4}\ \vee_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3, \mathtt{F}_4}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3 \vee \mathtt{F}_4}\ \vee_R$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \bot, \Delta_3}\ \bot_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\ \mathtt{H}$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \top, \bot, \Delta_3}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \top, \Delta_3}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_1 : unbox(\Box\Gamma_2) \vdash \mathtt{F}_4}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \Delta_3 \vdash (\bot, \Delta_5), []\mathtt{F}_4}\ K \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : unbox(\Box\Gamma_2) \vdash \mathtt{F}_4}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_3, \Box\Gamma_2 \vdash \Delta_5, []\mathtt{F}_4}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_1 : \Box\Gamma_2 \vdash \Box\Gamma_4, \mathtt{F}_5}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \Delta_3 \vdash \Box\Gamma_4, (\bot, \Delta_6), []\mathtt{F}_5}\ A45 \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Box\Gamma_2 \vdash \mathtt{F}_5, \Box\Gamma_4}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_3, \Box\Gamma_2 \vdash \Delta_6, \Box\Gamma_4, []\mathtt{F}_5}\ A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_2 : \Delta_3 \vdash \bot, \mathtt{F}_4, \Delta_1 \quad \mathtt{h}_2 : \mathtt{F}_5, \Delta_3 \vdash \bot, \Delta_1}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \bot, \Delta_1}\ \rightarrow_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_2 : \Delta_3 \vdash \Delta_1, \mathtt{F}_4}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_2 : \Delta_3, \mathtt{F}_5 \vdash \Delta_1}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_1}\ \rightarrow_L$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_2 : \mathtt{F}_4, \mathtt{F}_5, \Delta_3 \vdash \bot, \Delta_1}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \bot, \Delta_1}\ \wedge_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Delta_3, \mathtt{F}_4, \mathtt{F}_5 \vdash \Delta_1}\ \text{ax/ind}}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_1}\ \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_2 : \mathtt{F}_4, \Delta_3 \vdash \bot, \Delta_1 \quad \mathtt{h}_2 : \mathtt{F}_5, \Delta_3 \vdash \bot, \Delta_1}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \bot, \Delta_1}\ \vee_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \vdash \Delta_1}\ \text{ax/ind} \quad \dfrac{}{\mathtt{h}_2 : \Delta_3, \mathtt{F}_5 \vdash \Delta_1}\ \text{ax/ind}}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_1}\ \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_2 : \mathtt{F}_4, \Delta_3, []\mathtt{F}_4 \vdash \bot, \Delta_1}{\bullet \mathtt{h}_2 : \Delta_3, []\mathtt{F}_4 \vdash \bot, \Delta_1}\ AT \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Delta_3, \mathtt{F}_4, []\mathtt{F}_4 \vdash \Delta_1}\ \text{ax/ind}}{\bullet \mathtt{h}_2 : \Delta_3, []\mathtt{F}_4 \vdash \Delta_1}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_2 : \bot, \Delta_3 \vdash \bot, \Delta_1}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_2 : \bot, \Delta_3 \vdash \Delta_1}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_1 : \mathtt{p}_3, \Delta_2 \vdash \mathtt{p}_3, \bot, \Delta_4}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{p}_3 \vdash \Delta_4, \mathtt{p}_3}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_2 : \Delta_3 \vdash \bot, \Delta_1}{\bullet \mathtt{h}_2 : \top, \Delta_3 \vdash \bot, \Delta_1}\ \top_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Delta_3 \vdash \Delta_1}\ \text{ax/ind}}{\bullet \mathtt{h}_2 : \top, \Delta_3 \vdash \Delta_1}\ \top_L$$

4.6 Status of $\top_R$: : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2 \vdash \top, \mathtt{F}_4, \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2 \vdash (\top, \Delta_5), \mathtt{F}_3 \rightarrow \mathtt{F}_4}\ \rightarrow_R \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \top, \mathtt{F}_3, \Delta_5 \quad \mathtt{h}_1 : \Delta_2 \vdash \top, \mathtt{F}_4, \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2 \vdash (\top, \Delta_5), \mathtt{F}_3 \wedge \mathtt{F}_4}\ \wedge_R \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \top, \mathtt{F}_3, \mathtt{F}_4, \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2 \vdash (\top, \Delta_5), \mathtt{F}_3 \vee \mathtt{F}_4}\ \vee_R \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \top, \Delta_3}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \bot, \top, \Delta_3}\ \bot_R \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \top, \Delta_3}\ \top_R \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule K

$$\frac{\mathtt{h}_1 : unbox(\Box \Gamma_2) \vdash \mathtt{F}_4}{\bullet \mathtt{h}_1 : \Box \Gamma_2, \Delta_3 \vdash (\top, \Delta_5), [] \mathtt{F}_4}\ K \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $A45$

$$\frac{\mathtt{h}_1 : \Box \Gamma_2 \vdash \Box \Gamma_4, \mathtt{F}_5}{\bullet \mathtt{h}_1 : \Box \Gamma_2, \Delta_3 \vdash \Box \Gamma_4, (\top, \Delta_6), [] \mathtt{F}_5}\ A45 \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_2 : \Delta_3 \vdash \top, \mathtt{F}_4, \Delta_1 \quad \mathtt{h}_2 : \mathtt{F}_5, \Delta_3 \vdash \top, \Delta_1}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \top, \Delta_1}\ \rightarrow_L \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_2 : \mathtt{F}_4, \mathtt{F}_5, \Delta_3 \vdash \top, \Delta_1}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \top, \Delta_1}\ \wedge_L \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_2 : \mathtt{F}_4, \Delta_3 \vdash \top, \Delta_1 \quad \mathtt{h}_2 : \mathtt{F}_5, \Delta_3 \vdash \top, \Delta_1}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \top, \Delta_1}\ \vee_L \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule AT

$$\frac{\mathtt{h}_2 : \mathtt{F}_4, \Delta_3, [] \mathtt{F}_4 \vdash \top, \Delta_1}{\bullet \mathtt{h}_2 : \Delta_3, [] \mathtt{F}_4 \vdash \top, \Delta_1}\ AT \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_2 : \bot, \Delta_3 \vdash \top, \Delta_1}\ \bot_L \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_1 : \mathtt{p}_3, \Delta_2 \vdash \mathtt{p}_3, \top, \Delta_4}\ I \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_2 : \Delta_3 \vdash \top, \Delta_1}{\bullet \mathtt{h}_2 : \top, \Delta_3 \vdash \top, \Delta_1}\ \top_L \quad \rightsquigarrow \quad \texttt{trivial}$$

4.7 Status of K: : `Non invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_4 : \Box\Gamma_1, \mathtt{F}_5, \Delta_2 \vdash \mathtt{F}_6, \Delta_7, []\mathtt{F}_3}{\bullet \mathtt{h}_4 : \Box\Gamma_1, \Delta_2 \vdash (\Delta_7, []\mathtt{F}_3), \mathtt{F}_5 \rightarrow \mathtt{F}_6}\ \rightarrow_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : unbox(\Box\Gamma_1) \vdash \mathtt{F}_3}\ \texttt{ax/ind}}{\bullet \mathtt{h}_4 : unbox(\Box\Gamma_1) \vdash \mathtt{F}_3}\ \texttt{H}$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_4 : \Box\Gamma_1, \Delta_2 \vdash \mathtt{F}_5, \Delta_7, []\mathtt{F}_3 \quad \mathtt{h}_4 : \Box\Gamma_1, \Delta_2 \vdash \mathtt{F}_6, \Delta_7, []\mathtt{F}_3}{\bullet \mathtt{h}_4 : \Box\Gamma_1, \Delta_2 \vdash (\Delta_7, []\mathtt{F}_3), \mathtt{F}_5 \wedge \mathtt{F}_6}\ \wedge_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : unbox(\Box\Gamma_1) \vdash \mathtt{F}_3}\ \texttt{ax/ind}}{\bullet \mathtt{h}_4 : unbox(\Box\Gamma_1) \vdash \mathtt{F}_3}\ \texttt{H}$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_4 : \Box\Gamma_1, \Delta_2 \vdash \mathtt{F}_5, \mathtt{F}_6, \Delta_7, []\mathtt{F}_3}{\bullet \mathtt{h}_4 : \Box\Gamma_1, \Delta_2 \vdash (\Delta_7, []\mathtt{F}_3), \mathtt{F}_5 \vee \mathtt{F}_6}\ \vee_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : unbox(\Box\Gamma_1) \vdash \mathtt{F}_3}\ \texttt{ax/ind}}{\bullet \mathtt{h}_4 : unbox(\Box\Gamma_1) \vdash \mathtt{F}_3}\ \texttt{H}$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_4 : \Box\Gamma_1, \Delta_2 \vdash \Delta_5, []\mathtt{F}_3}{\bullet \mathtt{h}_4 : \Box\Gamma_1, \Delta_2 \vdash \bot, \Delta_5, []\mathtt{F}_3}\ \bot_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : unbox(\Box\Gamma_1) \vdash \mathtt{F}_3}\ \texttt{ax/ind}}{\bullet \mathtt{h}_4 : unbox(\Box\Gamma_1) \vdash \mathtt{F}_3}\ \texttt{H}$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_4 : \Box\Gamma_1, \Delta_2 \vdash \top, \Delta_5, []\mathtt{F}_3}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : unbox(\Box\Gamma_1) \vdash \mathtt{F}_3}\ \texttt{fail}$$

- Case rule K

$$\frac{\mathtt{h}_2 : unbox(\Box\Gamma_5), unbox(\Box\Gamma_6) \vdash \mathtt{F}_3}{\bullet \mathtt{h}_2 : (\Box\Gamma_5, \Box\Gamma_6), \Box\Gamma_7, \Delta_8 \vdash (\Delta_4, []\mathtt{F}_1), []\mathtt{F}_3}\ K \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_2 : unbox(\Box\Gamma_5), unbox(\Box\Gamma_7) \vdash \mathtt{F}_1}\ \texttt{fail}$$

$$\frac{\mathtt{h}_1 : unbox(\Box\Gamma_4), unbox(\Box\Gamma_5) \vdash \mathtt{F}_3}{\bullet \mathtt{h}_1 : (\Box\Gamma_4, \Box\Gamma_5), \Box\Gamma_6, \Delta_7 \vdash \Delta_2, []\mathtt{F}_3}\ K \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : unbox(\Box\Gamma_4), unbox(\Box\Gamma_6) \vdash \mathtt{F}_3}\ \texttt{fail}$$

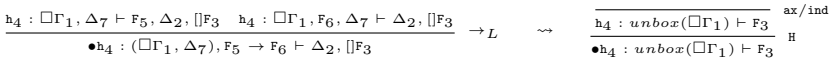
- Case rule $A45$

$$\frac{\mathtt{h}_2 : \Box\Gamma_6, \Box\Gamma_7 \vdash \Box\Gamma_5, \mathtt{F}_4, []\mathtt{F}_1}{\bullet \mathtt{h}_2 : (\Box\Gamma_6, \Box\Gamma_7), \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_5, []\mathtt{F}_1), \Delta_3, []\mathtt{F}_4}\ A45 \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_2 : unbox(\Box\Gamma_6), unbox(\Box\Gamma_8) \vdash \mathtt{F}_1}\ \texttt{fail}$$

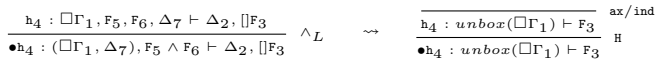
$$\frac{\mathtt{h}_2 : \Box\Gamma_6, \Box\Gamma_7 \vdash \Box\Gamma_3, \mathtt{F}_4}{\bullet \mathtt{h}_2 : (\Box\Gamma_6, \Box\Gamma_7), \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_3, (\Delta_5, []\mathtt{F}_1), []\mathtt{F}_4}\ A45 \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_2 : unbox(\Box\Gamma_6), unbox(\Box\Gamma_8) \vdash \mathtt{F}_1}\ \texttt{fail}$$

$$\frac{\mathtt{h}_1 : \Box\Gamma_5, \Box\Gamma_6 \vdash \Box\Gamma_2, \mathtt{F}_4}{\bullet \mathtt{h}_1 : (\Box\Gamma_5, \Box\Gamma_6), \Box\Gamma_7, \Delta_8 \vdash \Box\Gamma_2, \Delta_3, []\mathtt{F}_4}\ A45 \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : unbox(\Box\Gamma_5), unbox(\Box\Gamma_7) \vdash \mathtt{F}_4}\ \texttt{fail}$$

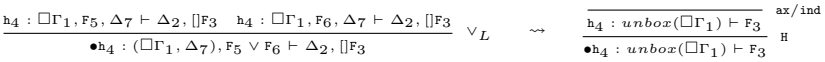
- Case rule $\rightarrow_L$



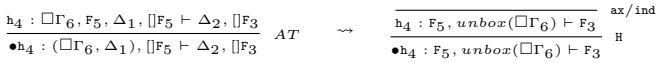
- Case rule $\wedge_L$

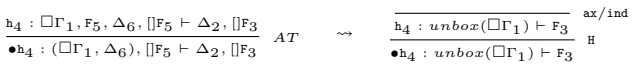


- Case rule $\vee_L$



- Case rule AT

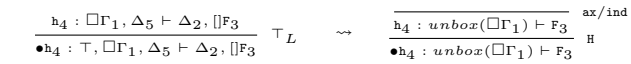




- Case rule $\bot_L$

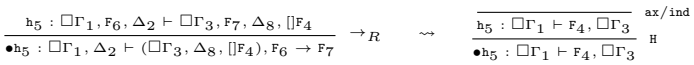
- Case rule I

- Case rule $\top_L$

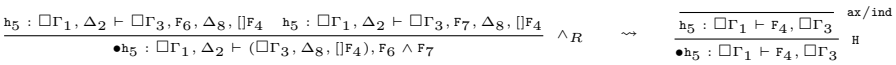


4.8 Status of $A45$: : `Non invertible`

- Case rule $\rightarrow_R$



- Case rule $\wedge_R$



- Case rule $\vee_R$

$$\frac{\mathtt{h}_5 : \Box\Gamma_1, \Delta_2 \vdash \Box\Gamma_3, \mathtt{F}_6, \mathtt{F}_7, \Delta_8, []\mathtt{F}_4}{\bullet\mathtt{h}_5 : \Box\Gamma_1, \Delta_2 \vdash (\Box\Gamma_3, \Delta_8, []\mathtt{F}_4), \mathtt{F}_6 \vee \mathtt{F}_7}\ \vee_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_5 : \Box\Gamma_1 \vdash \mathtt{F}_4, \Box\Gamma_3}\ \text{ax/ind}}{\bullet\mathtt{h}_5 : \Box\Gamma_1 \vdash \mathtt{F}_4, \Box\Gamma_3}\ \text{H}$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_5 : \Box\Gamma_1, \Delta_2 \vdash \Box\Gamma_3, \Delta_6, []\mathtt{F}_4}{\bullet\mathtt{h}_5 : \Box\Gamma_1, \Delta_2 \vdash \bot, \Box\Gamma_3, \Delta_6, []\mathtt{F}_4}\ \bot_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_5 : \Box\Gamma_1 \vdash \mathtt{F}_4, \Box\Gamma_3}\ \text{ax/ind}}{\bullet\mathtt{h}_5 : \Box\Gamma_1 \vdash \mathtt{F}_4, \Box\Gamma_3}\ \text{H}$$

- Case rule $\top_R$

$$\frac{}{\bullet\mathtt{h}_5 : \Box\Gamma_1, \Delta_2 \vdash \top, \Box\Gamma_3, \Delta_6, []\mathtt{F}_4}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_5 : \Box\Gamma_1 \vdash \Box\Gamma_3, \mathtt{F}_4}\ \text{fail}$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_6), unbox(\Box\Gamma_7) \vdash \mathtt{F}_4}{\bullet\mathtt{h}_3 : (\Box\Gamma_6, \Box\Gamma_7), \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_5, \Delta_1, []\mathtt{F}_2), []\mathtt{F}_4}\ K \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_3 : \Box\Gamma_6, \Box\Gamma_8 \vdash \Box\Gamma_5, \mathtt{F}_2, []\mathtt{F}_4}\ \text{fail}$$

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_6), unbox(\Box\Gamma_7) \vdash \mathtt{F}_4}{\bullet\mathtt{h}_3 : (\Box\Gamma_6, \Box\Gamma_7), \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_1, \Delta_5, []\mathtt{F}_2), []\mathtt{F}_4}\ K \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_3 : \Box\Gamma_6, \Box\Gamma_8 \vdash \Box\Gamma_1, \mathtt{F}_2}\ \text{fail}$$

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_5), unbox(\Box\Gamma_6) \vdash \mathtt{F}_4}{\bullet\mathtt{h}_3 : (\Box\Gamma_5, \Box\Gamma_6), \Box\Gamma_7, \Delta_8 \vdash (\Box\Gamma_1, \Delta_2), []\mathtt{F}_4}\ K \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_3 : \Box\Gamma_5, \Box\Gamma_7 \vdash \Box\Gamma_1, \mathtt{F}_4}\ \text{fail}$$

- Case rule $A45$

$$\frac{\mathtt{h}_2 : \Box\Gamma_8, \Box\Gamma_9 \vdash \Box\Gamma_4, \Box\Gamma_5, \mathtt{F}_3, []\mathtt{F}_1}{\bullet\mathtt{h}_2 : (\Box\Gamma_8, \Box\Gamma_9), \Box\Gamma_{10}, \Delta_{11} \vdash (\Box\Gamma_4, \Box\Gamma_5, []\mathtt{F}_1), (\Box\Gamma_6, \Delta_7), []\mathtt{F}_3}\ A45 \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Box\Gamma_{10} \vdash \Box\Gamma_4, \Box\Gamma_6, \mathtt{F}_1, []\mathtt{F}_3}\ \text{fail}$$

$$\frac{\mathtt{h}_2 : \Box\Gamma_8, \Box\Gamma_9 \vdash \Box\Gamma_4, \Box\Gamma_5, \mathtt{F}_3}{\bullet\mathtt{h}_2 : (\Box\Gamma_8, \Box\Gamma_9), \Box\Gamma_{10}, \Delta_{11} \vdash (\Box\Gamma_4, \Box\Gamma_5), (\Box\Gamma_6, \Delta_7, []\mathtt{F}_1), []\mathtt{F}_3}\ A45 \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Box\Gamma_{10} \vdash \Box\Gamma_4, \Box\Gamma_6, \mathtt{F}_1, []\mathtt{F}_3}\ \text{fail}$$

$$\frac{\mathtt{h}_2 : \Box\Gamma_8, \Box\Gamma_9 \vdash \Box\Gamma_4, \Box\Gamma_5, \mathtt{F}_3, []\mathtt{F}_1}{\bullet\mathtt{h}_2 : (\Box\Gamma_8, \Box\Gamma_9), \Box\Gamma_{10}, \Delta_{11} \vdash (\Box\Gamma_4, \Box\Gamma_5, []\mathtt{F}_1), (\Box\Gamma_6, \Delta_7), []\mathtt{F}_3}\ A45 \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Box\Gamma_{10} \vdash \Box\Gamma_4, \Box\Gamma_6, \mathtt{F}_1}\ \text{fail}$$

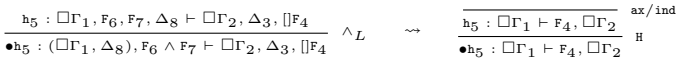
$$\frac{\mathtt{h}_2 : \Box\Gamma_8, \Box\Gamma_9 \vdash \Box\Gamma_4, \Box\Gamma_5, \mathtt{F}_3}{\bullet\mathtt{h}_2 : (\Box\Gamma_8, \Box\Gamma_9), \Box\Gamma_{10}, \Delta_{11} \vdash (\Box\Gamma_4, \Box\Gamma_5), (\Box\Gamma_6, \Delta_7, []\mathtt{F}_1), []\mathtt{F}_3}\ A45 \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Box\Gamma_{10} \vdash \Box\Gamma_4, \Box\Gamma_6, \mathtt{F}_1}\ \text{fail}$$

$$\frac{\mathtt{h}_1 : \Box\Gamma_7, \Box\Gamma_8 \vdash \Box\Gamma_3, \Box\Gamma_4, \mathtt{F}_2}{\bullet\mathtt{h}_1 : (\Box\Gamma_7, \Box\Gamma_8), \Box\Gamma_9, \Delta_{10} \vdash (\Box\Gamma_3, \Box\Gamma_4), (\Box\Gamma_5, \Delta_6), []\mathtt{F}_2}\ A45 \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Box\Gamma_9 \vdash \Box\Gamma_3, \Box\Gamma_5, \mathtt{F}_2}\ \text{fail}$$

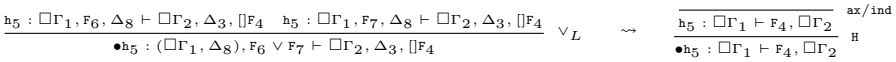
- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_5 : \Box\Gamma_1, \Delta_8 \vdash \Box\Gamma_2, \mathtt{F}_6, \Delta_3, []\mathtt{F}_4 \quad \mathtt{h}_5 : \Box\Gamma_1, \mathtt{F}_7, \Delta_8 \vdash \Box\Gamma_2, \Delta_3, []\mathtt{F}_4}{\bullet\mathtt{h}_5 : (\Box\Gamma_1, \Delta_8), \mathtt{F}_6 \rightarrow \mathtt{F}_7 \vdash \Box\Gamma_2, \Delta_3, []\mathtt{F}_4}\ \rightarrow_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_5 : \Box\Gamma_1 \vdash \mathtt{F}_4, \Box\Gamma_2}\ \text{ax/ind}}{\bullet\mathtt{h}_5 : \Box\Gamma_1 \vdash \mathtt{F}_4, \Box\Gamma_2}\ \text{H}$$

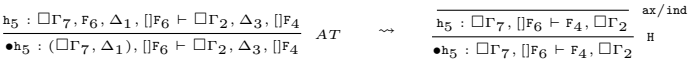
- Case rule $\wedge_L$

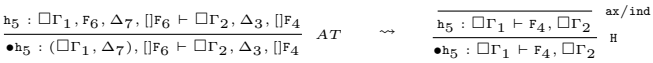


- Case rule $\vee_L$

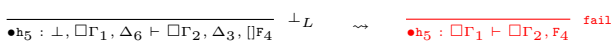


- Case rule AT

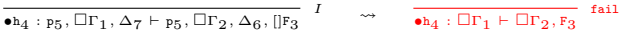




- Case rule $\bot_L$



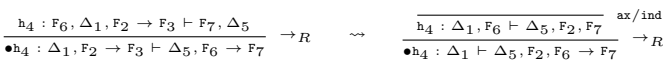
- Case rule I



- Case rule $\top_L$

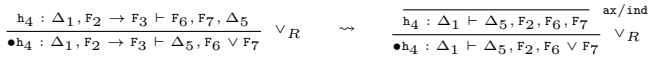
4.9 Status of $\rightarrow_L$: (Left Premise): `Invertible`

- Case rule $\rightarrow_R$



- Case rule $\wedge_R$

- Case rule $\vee_R$



- Case rule $\bot_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \bot, \Delta_5}\ \bot_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1 \vdash \Delta_5, \mathtt{F}_2}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_1 \vdash \bot, \Delta_5, \mathtt{F}_2}\ \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \top, \Delta_5}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : \Delta_1 \vdash \top, \Delta_5, \mathtt{F}_2}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_7, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_5, []\mathtt{F}_6}\ K \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_7, \Box\Gamma_4 \vdash \Delta_5, \mathtt{F}_1, []\mathtt{F}_6}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_3 : \Box\Gamma_4 \vdash \Box\Gamma_5, \mathtt{F}_7}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_8, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Box\Gamma_5, \Delta_6, []\mathtt{F}_7}\ A45 \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Box\Gamma_4 \vdash \mathtt{F}_7, \Box\Gamma_5}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_8, \Box\Gamma_4 \vdash \Delta_6, \mathtt{F}_1, \Box\Gamma_5, []\mathtt{F}_7}\ A45$$

- Case rule $\to_L$

$$\frac{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \mathtt{F}_4, \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \to \mathtt{F}_2), \mathtt{F}_4 \to \mathtt{F}_5 \vdash \Delta_6}\ \to_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_7 \vdash \Delta_6, \mathtt{F}_1, \mathtt{F}_4}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_5 \vdash \Delta_6, \mathtt{F}_1}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_4 \to \mathtt{F}_5 \vdash \Delta_6, \mathtt{F}_1}\ \to_L$$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_3, \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \to \mathtt{F}_4 \vdash \Delta_5}\ \to_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_5, \mathtt{F}_3}\ \mathtt{H}$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \to \mathtt{F}_2), \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6}\ \wedge_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_4, \mathtt{F}_5 \vdash \Delta_6, \mathtt{F}_1}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6, \mathtt{F}_1}\ \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_7, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \to \mathtt{F}_2), \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6}\ \vee_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_4 \vdash \Delta_6, \mathtt{F}_1}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_5 \vdash \Delta_6, \mathtt{F}_1}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6, \mathtt{F}_1}\ \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_6, []\mathtt{F}_4, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_5}{\bullet \mathtt{h}_3 : (\Delta_6, \mathtt{F}_1 \to \mathtt{F}_2), []\mathtt{F}_4 \vdash \Delta_5}\ AT \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_6, \mathtt{F}_4, []\mathtt{F}_4 \vdash \Delta_5, \mathtt{F}_1}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_6, []\mathtt{F}_4 \vdash \Delta_5, \mathtt{F}_1}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_4}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5 \vdash \Delta_4, \mathtt{F}_1}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_3 : \mathtt{p}_4, \Delta_6, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \mathtt{p}_4, \Delta_5}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_6, \mathtt{p}_4 \vdash \Delta_5, \mathtt{F}_1, \mathtt{p}_4}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_3 : \Delta_5, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_4}{\bullet \mathtt{h}_3 : \top, \Delta_5, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_4}\ \top_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_5 \vdash \Delta_4, \mathtt{F}_1}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_4, \mathtt{F}_1}\ \top_L$$

4.10 Status of $\to_L$ (Right Premise): : `Invertible`

- Case rule $\to_R$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \to \mathtt{F}_7}\ \to_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3, \mathtt{F}_6 \vdash \Delta_5, \mathtt{F}_7}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \to \mathtt{F}_7}\ \to_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \mathtt{F}_6, \Delta_5 \quad \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7}\ \wedge_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_7}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7}\ \wedge_R$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7}\ \vee_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6, \mathtt{F}_7}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7}\ \vee_R$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \bot, \Delta_5}\ \bot_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \bot, \Delta_5}\ \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \to \mathtt{F}_3 \vdash \top, \Delta_5}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \top, \Delta_5}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_7, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Delta_5, []\mathtt{F}_6}\ K \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \Box\Gamma_4 \vdash \Delta_5, []\mathtt{F}_6}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_3 : \Box\Gamma_4 \vdash \Box\Gamma_5, \mathtt{F}_7}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_8, \mathtt{F}_1 \to \mathtt{F}_2 \vdash \Box\Gamma_5, \Delta_6, []\mathtt{F}_7}\ A45 \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Box\Gamma_4 \vdash \mathtt{F}_7, \Box\Gamma_5}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_2, \Box\Gamma_4 \vdash \Delta_6, \Box\Gamma_5, []\mathtt{F}_7}\ A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \mathtt{F}_4, \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2), \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_6} \rightarrow_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2 \vdash \Delta_6, \mathtt{F}_4}\ \mathtt{ax/ind} \quad \dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \vdash \Delta_6}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_6} \rightarrow_L$$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \mathtt{F}_3, \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \rightarrow \mathtt{F}_4 \vdash \Delta_5} \rightarrow_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\ \mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\ \mathtt{H}$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2), \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6} \wedge_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4, \mathtt{F}_5 \vdash \Delta_6}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6} \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \rightarrow \mathtt{F}_2), \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6} \vee_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4 \vdash \Delta_6}\ \mathtt{ax/ind} \quad \dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \vdash \Delta_6}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6} \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_6, []\mathtt{F}_4, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \Delta_5}{\bullet \mathtt{h}_3 : (\Delta_6, \mathtt{F}_1 \rightarrow \mathtt{F}_2), []\mathtt{F}_4 \vdash \Delta_5}\ AT \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_6, \mathtt{F}_2, \mathtt{F}_4, []\mathtt{F}_4 \vdash \Delta_5}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_3 : \Delta_6, \mathtt{F}_2, []\mathtt{F}_4 \vdash \Delta_5}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \Delta_4}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5, \mathtt{F}_2 \vdash \Delta_4}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_3 : \mathtt{p}_4, \Delta_6, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \mathtt{p}_4, \Delta_5}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_6, \mathtt{F}_2, \mathtt{p}_4 \vdash \Delta_5, \mathtt{p}_4}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_3 : \Delta_5, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \Delta_4}{\bullet \mathtt{h}_3 : \top, \Delta_5, \mathtt{F}_1 \rightarrow \mathtt{F}_2 \vdash \Delta_4} \top_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_5, \mathtt{F}_2 \vdash \Delta_4}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_3 : \top, \Delta_5, \mathtt{F}_2 \vdash \Delta_4} \top_L$$

4.11 Status of $\wedge_L$: : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7} \rightarrow_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3, \mathtt{F}_6 \vdash \Delta_5, \mathtt{F}_7}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7} \rightarrow_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \mathtt{F}_6, \Delta_5 \quad \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7} \wedge_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6}\ \mathtt{ax/ind} \quad \dfrac{}{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_7}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7} \wedge_R$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7}\ \vee_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6, \mathtt{F}_7}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7}\ \vee_R$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \bot, \Delta_5}\ \bot_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3 \vdash \Delta_5}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3 \vdash \bot, \Delta_5}\ \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \top, \Delta_5}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_3 \vdash \top, \Delta_5}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Delta_5, []\mathtt{F}_6}\ K \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \Box\Gamma_4 \vdash \Delta_5, []\mathtt{F}_6}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_3 : \Box\Gamma_4 \vdash \Box\Gamma_5, \mathtt{F}_7}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_8, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Box\Gamma_5, \Delta_6, []\mathtt{F}_7}\ A45 \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Box\Gamma_4 \vdash \mathtt{F}_7, \Box\Gamma_5}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_1, \mathtt{F}_2, \Box\Gamma_4 \vdash \Delta_6, \Box\Gamma_5, []\mathtt{F}_7}\ A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \mathtt{F}_4, \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_6}\ \rightarrow_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_2 \vdash \Delta_6, \mathtt{F}_4}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_5 \vdash \Delta_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_6}\ \rightarrow_L$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6}\ \wedge_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_4, \mathtt{F}_5 \vdash \Delta_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6}\ \wedge_L$$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \wedge \mathtt{F}_4 \vdash \Delta_5}\ \wedge_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_4 \vdash \Delta_5}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_4 \vdash \Delta_5}\ \mathtt{H}$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \wedge \mathtt{F}_2), \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6}\ \vee_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_4 \vdash \Delta_6}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_5 \vdash \Delta_6}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6}\ \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_6, []\mathtt{F}_4, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Delta_5}{\bullet \mathtt{h}_3 : (\Delta_6, \mathtt{F}_1 \wedge \mathtt{F}_2), []\mathtt{F}_4 \vdash \Delta_5}\ AT \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_6, \mathtt{F}_1, \mathtt{F}_2, \mathtt{F}_4, []\mathtt{F}_4 \vdash \Delta_5}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_3 : \Delta_6, \mathtt{F}_1, \mathtt{F}_2, []\mathtt{F}_4 \vdash \Delta_5}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Delta_4}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5, \mathtt{F}_1, \mathtt{F}_2 \vdash \Delta_4}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_3 : \mathtt{p}_4, \Delta_6, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \mathtt{p}_4, \Delta_5}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_6, \mathtt{F}_1, \mathtt{F}_2, \mathtt{p}_4 \vdash \Delta_5, \mathtt{p}_4}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_3 : \Delta_5, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Delta_4}{\bullet \mathtt{h}_3 : \top, \Delta_5, \mathtt{F}_1 \wedge \mathtt{F}_2 \vdash \Delta_4}\ \top_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_5, \mathtt{F}_1, \mathtt{F}_2 \vdash \Delta_4}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_3 : \top, \Delta_5, \mathtt{F}_1, \mathtt{F}_2 \vdash \Delta_4}\ \top_L$$

4.12 Status of $\vee_L$: (Left Premise): `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7}\ \rightarrow_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2, \mathtt{F}_6 \vdash \Delta_5, \mathtt{F}_7}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vdash \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7}\ \rightarrow_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \mathtt{F}_6, \Delta_5 \quad \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7}\ \wedge_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vdash \Delta_5, \mathtt{F}_6}\ \mathtt{ax/ind} \quad \dfrac{}{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vdash \Delta_5, \mathtt{F}_7}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vdash \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7}\ \wedge_R$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7}\ \vee_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vdash \Delta_5, \mathtt{F}_6, \mathtt{F}_7}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vdash \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7}\ \vee_R$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \bot, \Delta_5}\ \bot_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vdash \Delta_5}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vdash \bot, \Delta_5}\ \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \top, \Delta_5}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vdash \top, \Delta_5}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_5, []\mathtt{F}_6}\ K \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}\ \mathtt{ax}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \Box\Gamma_4 \vdash \Delta_5, []\mathtt{F}_6}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_3 : \Box\Gamma_4 \vdash \Box\Gamma_5, \mathtt{F}_7}{\bullet\mathtt{h}_3 : \Box\Gamma_4, \Delta_8, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Box\Gamma_5, \Delta_6, []\mathtt{F}_7}\ A45 \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Box\Gamma_4 \vdash \mathtt{F}_7, \Box\Gamma_5}\ \mathtt{ax}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_1, \Box\Gamma_4 \vdash \Delta_6, \Box\Gamma_5, []\mathtt{F}_7}\ A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \mathtt{F}_4, \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_6}{\bullet\mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_6}\ \rightarrow_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1 \vdash \Delta_6, \mathtt{F}_4}\ \mathtt{ax/ind} \quad \dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_5 \vdash \Delta_6}\ \mathtt{ax/ind}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_6}\ \rightarrow_L$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_6}{\bullet\mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6}\ \wedge_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_4, \mathtt{F}_5 \vdash \Delta_6}\ \mathtt{ax/ind}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6}\ \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_6}{\bullet\mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6}\ \vee_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_4 \vdash \Delta_6}\ \mathtt{ax/ind} \quad \dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_5 \vdash \Delta_6}\ \mathtt{ax/ind}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_1, \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6}\ \vee_L$$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2 \vdash \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet\mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5}\ \vee_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vdash \Delta_5}\ \mathtt{ax}}{\bullet\mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vdash \Delta_5}\ \mathtt{H}$$

- Case rule AT

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_6, []\mathtt{F}_4, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_5}{\bullet\mathtt{h}_3 : (\Delta_6, \mathtt{F}_1 \vee \mathtt{F}_2), []\mathtt{F}_4 \vdash \Delta_5}\ AT \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_6, \mathtt{F}_1, \mathtt{F}_4, []\mathtt{F}_4 \vdash \Delta_5}\ \mathtt{ax/ind}}{\bullet\mathtt{h}_3 : \Delta_6, \mathtt{F}_1, []\mathtt{F}_4 \vdash \Delta_5}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet\mathtt{h}_3 : \bot, \Delta_5, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_4}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_3 : \bot, \Delta_5, \mathtt{F}_1 \vdash \Delta_4}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet\mathtt{h}_3 : \mathtt{p}_4, \Delta_6, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \mathtt{p}_4, \Delta_5}\ I \quad \rightsquigarrow \quad \frac{}{\bullet\mathtt{h}_3 : \Delta_6, \mathtt{F}_1, \mathtt{p}_4 \vdash \Delta_5, \mathtt{p}_4}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_3 : \Delta_5, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_4}{\bullet\mathtt{h}_3 : \top, \Delta_5, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_4}\ \top_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_5, \mathtt{F}_1 \vdash \Delta_4}\ \mathtt{ax/ind}}{\bullet\mathtt{h}_3 : \top, \Delta_5, \mathtt{F}_1 \vdash \Delta_4}\ \top_L$$

4.13 Status of $\vee_L$ (Right Premise): : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_4 : \mathtt{F}_6, \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7} \rightarrow_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3, \mathtt{F}_6 \vdash \Delta_5, \mathtt{F}_7}^{\ ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \rightarrow \mathtt{F}_7} \rightarrow_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \mathtt{F}_6, \Delta_5 \quad \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7} \wedge_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6}^{\ ax/ind} \quad \overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_7}^{\ ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \wedge \mathtt{F}_7} \wedge_R$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7} \vee_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6, \mathtt{F}_7}^{\ ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5, \mathtt{F}_6 \vee \mathtt{F}_7} \vee_R$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_5}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \bot, \Delta_5} \bot_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \Delta_5}^{\ ax/ind}}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \bot, \Delta_5} \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \top, \Delta_5} \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_4 : \Delta_1, \mathtt{F}_3 \vdash \top, \Delta_5} \top_R$$

- Case rule K

$$\frac{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_5, []\mathtt{F}_6} K \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : unbox(\Box\Gamma_4) \vdash \mathtt{F}_6}^{\ ax}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \Box\Gamma_4 \vdash \Delta_5, []\mathtt{F}_6} K$$

- Case rule $A45$

$$\frac{\mathtt{h}_3 : \Box\Gamma_4 \vdash \Box\Gamma_5, \mathtt{F}_7}{\bullet \mathtt{h}_3 : \Box\Gamma_4, \Delta_8, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Box\Gamma_5, \Delta_6, []\mathtt{F}_7} A45 \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Box\Gamma_4 \vdash \mathtt{F}_7, \Box\Gamma_5}^{\ ax}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_2, \Box\Gamma_4 \vdash \Delta_6, \Box\Gamma_5, []\mathtt{F}_7} A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_3 : \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \mathtt{F}_4, \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_6} \rightarrow_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2 \vdash \Delta_6, \mathtt{F}_4}^{\ ax/ind} \quad \overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \vdash \Delta_6}^{\ ax/ind}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_6} \rightarrow_L$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6} \wedge_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4, \mathtt{F}_5 \vdash \Delta_6}^{\ ax/ind}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_6} \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_6 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_6}{\bullet \mathtt{h}_3 : (\Delta_7, \mathtt{F}_1 \vee \mathtt{F}_2), \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6} \vee_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4 \vdash \Delta_6}\,{\scriptstyle ax/ind} \quad \dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_5 \vdash \Delta_6}\,{\scriptstyle ax/ind}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_2, \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_6} \vee_L$$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2 \vdash \Delta_5 \quad \mathtt{h}_1 : \mathtt{F}_4, \Delta_2 \vdash \Delta_5}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5} \vee_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\,{\scriptstyle ax}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_4 \vdash \Delta_5}\,{\scriptstyle H}$$

- Case rule AT

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_6, []\mathtt{F}_4, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_5}{\bullet \mathtt{h}_3 : (\Delta_6, \mathtt{F}_1 \vee \mathtt{F}_2), []\mathtt{F}_4 \vdash \Delta_5} AT \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_6, \mathtt{F}_2, \mathtt{F}_4, []\mathtt{F}_4 \vdash \Delta_5}\,{\scriptstyle ax/ind}}{\bullet \mathtt{h}_3 : \Delta_6, \mathtt{F}_2, []\mathtt{F}_4 \vdash \Delta_5} AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_4} \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5, \mathtt{F}_2 \vdash \Delta_4} \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_3 : \mathtt{p}_4, \Delta_6, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \mathtt{p}_4, \Delta_5} I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_6, \mathtt{F}_2, \mathtt{p}_4 \vdash \Delta_5, \mathtt{p}_4} I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_3 : \Delta_5, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_4}{\bullet \mathtt{h}_3 : \top, \Delta_5, \mathtt{F}_1 \vee \mathtt{F}_2 \vdash \Delta_4} \top_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_5, \mathtt{F}_2 \vdash \Delta_4}\,{\scriptstyle ax/ind}}{\bullet \mathtt{h}_3 : \top, \Delta_5, \mathtt{F}_2 \vdash \Delta_4} \top_L$$

4.14 Status of AT: : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_3 : \mathtt{F}_5, \Delta_1, []\mathtt{F}_2 \vdash \mathtt{F}_6, \Delta_4}{\bullet \mathtt{h}_3 : \Delta_1, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_5 \rightarrow \mathtt{F}_6} \rightarrow_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_1, \mathtt{F}_2, \mathtt{F}_5, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_6}\,{\scriptstyle ax/ind}}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{F}_2, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_5 \rightarrow \mathtt{F}_6} \rightarrow_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_3 : \Delta_1, []\mathtt{F}_2 \vdash \mathtt{F}_5, \Delta_4 \quad \mathtt{h}_3 : \Delta_1, []\mathtt{F}_2 \vdash \mathtt{F}_6, \Delta_4}{\bullet \mathtt{h}_3 : \Delta_1, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_5 \wedge \mathtt{F}_6} \wedge_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_1, \mathtt{F}_2, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_5}\,{\scriptstyle ax/ind} \quad \dfrac{}{\mathtt{h}_3 : \Delta_1, \mathtt{F}_2, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_6}\,{\scriptstyle ax/ind}}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{F}_2, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_5 \wedge \mathtt{F}_6} \wedge_R$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_3 : \Delta_1, []\mathtt{F}_2 \vdash \mathtt{F}_5, \mathtt{F}_6, \Delta_4}{\bullet \mathtt{h}_3 : \Delta_1, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_5 \vee \mathtt{F}_6} \vee_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_1, \mathtt{F}_2, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_5, \mathtt{F}_6}\,{\scriptstyle ax/ind}}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{F}_2, []\mathtt{F}_2 \vdash \Delta_4, \mathtt{F}_5 \vee \mathtt{F}_6} \vee_R$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_3 : \Delta_1, []\mathtt{F}_2 \vdash \Delta_4}{\bullet \mathtt{h}_3 : \Delta_1, []\mathtt{F}_2 \vdash \bot, \Delta_4} \bot_R \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_3 : \Delta_1, \mathtt{F}_2, []\mathtt{F}_2 \vdash \Delta_4}\,{\scriptstyle ax/ind}}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{F}_2, []\mathtt{F}_2 \vdash \bot, \Delta_4} \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_3 : \Delta_1, []\mathtt{F}_2 \vdash \top, \Delta_4}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{F}_2, []\mathtt{F}_2 \vdash \top, \Delta_4}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_2 : \mathtt{F}_1, unbox(\Box\Gamma_6) \vdash \mathtt{F}_5}{\bullet \mathtt{h}_2 : (\Box\Gamma_6, []\mathtt{F}_1), \Delta_3 \vdash \Delta_4, []\mathtt{F}_5}\ K \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \mathtt{F}_1, unbox(\Box\Gamma_6) \vdash \mathtt{F}_5}\ \mathtt{ax}}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_1, \Box\Gamma_6, []\mathtt{F}_1 \vdash \Delta_4, []\mathtt{F}_5}\ K$$

$$\frac{\mathtt{h}_2 : unbox(\Box\Gamma_3) \vdash \mathtt{F}_5}{\bullet \mathtt{h}_2 : \Box\Gamma_3, \Delta_6, []\mathtt{F}_1 \vdash \Delta_4, []\mathtt{F}_5}\ K \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : unbox(\Box\Gamma_3) \vdash \mathtt{F}_5}\ \mathtt{ax}}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{F}_1, \Box\Gamma_3, []\mathtt{F}_1 \vdash \Delta_4, []\mathtt{F}_5}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_2 : \Box\Gamma_7, []\mathtt{F}_1 \vdash \Box\Gamma_4, \mathtt{F}_6}{\bullet \mathtt{h}_2 : (\Box\Gamma_7, []\mathtt{F}_1), \Delta_3 \vdash \Box\Gamma_4, \Delta_5, []\mathtt{F}_6}\ A45 \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_7, []\mathtt{F}_1 \vdash \mathtt{F}_6, \Box\Gamma_4}\ \mathtt{ax}}{\bullet \mathtt{h}_2 : \Delta_3, \mathtt{F}_1, \Box\Gamma_7, []\mathtt{F}_1 \vdash \Delta_5, \Box\Gamma_4, []\mathtt{F}_6}\ A45$$

$$\frac{\mathtt{h}_2 : \Box\Gamma_3 \vdash \Box\Gamma_4, \mathtt{F}_6}{\bullet \mathtt{h}_2 : \Box\Gamma_3, \Delta_7, []\mathtt{F}_1 \vdash \Box\Gamma_4, \Delta_5, []\mathtt{F}_6}\ A45 \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_3 \vdash \mathtt{F}_6, \Box\Gamma_4}\ \mathtt{ax}}{\bullet \mathtt{h}_2 : \Delta_7, \mathtt{F}_1, \Box\Gamma_3, []\mathtt{F}_1 \vdash \Delta_5, \Box\Gamma_4, []\mathtt{F}_6}\ A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_2 : \Delta_6, []\mathtt{F}_1 \vdash \mathtt{F}_3, \Delta_5 \quad \mathtt{h}_2 : \mathtt{F}_4, \Delta_6, []\mathtt{F}_1 \vdash \Delta_5}{\bullet \mathtt{h}_2 : (\Delta_6, []\mathtt{F}_1), \mathtt{F}_3 \rightarrow \mathtt{F}_4 \vdash \Delta_5}\ \rightarrow_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Delta_6, \mathtt{F}_1, []\mathtt{F}_1 \vdash \Delta_5, \mathtt{F}_3}\ \mathtt{ax/ind} \quad \dfrac{}{\mathtt{h}_2 : \Delta_6, \mathtt{F}_1, \mathtt{F}_4, []\mathtt{F}_1 \vdash \Delta_5}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{F}_1, []\mathtt{F}_1, \mathtt{F}_3 \rightarrow \mathtt{F}_4 \vdash \Delta_5}\ \rightarrow_L$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_2 : \mathtt{F}_3, \mathtt{F}_4, \Delta_6, []\mathtt{F}_1 \vdash \Delta_5}{\bullet \mathtt{h}_2 : (\Delta_6, []\mathtt{F}_1), \mathtt{F}_3 \wedge \mathtt{F}_4 \vdash \Delta_5}\ \wedge_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Delta_6, \mathtt{F}_1, \mathtt{F}_3, \mathtt{F}_4, []\mathtt{F}_1 \vdash \Delta_5}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{F}_1, []\mathtt{F}_1, \mathtt{F}_3 \wedge \mathtt{F}_4 \vdash \Delta_5}\ \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_2 : \mathtt{F}_3, \Delta_6, []\mathtt{F}_1 \vdash \Delta_5 \quad \mathtt{h}_2 : \mathtt{F}_4, \Delta_6, []\mathtt{F}_1 \vdash \Delta_5}{\bullet \mathtt{h}_2 : (\Delta_6, []\mathtt{F}_1), \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5}\ \vee_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Delta_6, \mathtt{F}_1, \mathtt{F}_3, []\mathtt{F}_1 \vdash \Delta_5}\ \mathtt{ax/ind} \quad \dfrac{}{\mathtt{h}_2 : \Delta_6, \mathtt{F}_1, \mathtt{F}_4, []\mathtt{F}_1 \vdash \Delta_5}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{F}_1, []\mathtt{F}_1, \mathtt{F}_3 \vee \mathtt{F}_4 \vdash \Delta_5}\ \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_2 : \mathtt{F}_3, \Delta_5, []\mathtt{F}_1, []\mathtt{F}_3 \vdash \Delta_4}{\bullet \mathtt{h}_2 : (\Delta_5, []\mathtt{F}_1), []\mathtt{F}_3 \vdash \Delta_4}\ AT \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Delta_5, \mathtt{F}_1, \mathtt{F}_3, []\mathtt{F}_1, []\mathtt{F}_3 \vdash \Delta_4}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_2 : \Delta_5, \mathtt{F}_1, []\mathtt{F}_1, []\mathtt{F}_3 \vdash \Delta_4}\ AT$$

$$\frac{\mathtt{h}_1 : \mathtt{F}_3, \Delta_2, []\mathtt{F}_3 \vdash \Delta_4}{\bullet \mathtt{h}_1 : \Delta_2, []\mathtt{F}_3 \vdash \Delta_4}\ AT \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_1 : \Delta_2, \mathtt{F}_3, \mathtt{F}_3, []\mathtt{F}_3 \vdash \Delta_4}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_1 : \Delta_2, \mathtt{F}_3, []\mathtt{F}_3 \vdash \Delta_4}\ AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_2 : \bot, \Delta_4, []\mathtt{F}_1 \vdash \Delta_3}\ \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_2 : \bot, \Delta_4, \mathtt{F}_1, []\mathtt{F}_1 \vdash \Delta_3}\ \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_2 : \mathtt{p}_3, \Delta_5, []\mathtt{F}_1 \vdash \mathtt{p}_3, \Delta_4}\ I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_2 : \Delta_5, \mathtt{F}_1, \mathtt{p}_3, []\mathtt{F}_1 \vdash \Delta_4, \mathtt{p}_3}\ I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_2 : \Delta_4, []\mathtt{F}_1 \vdash \Delta_3}{\bullet \mathtt{h}_2 : \top, \Delta_4, []\mathtt{F}_1 \vdash \Delta_3}\ \top_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_2 : \Delta_4, \mathtt{F}_1, []\mathtt{F}_1 \vdash \Delta_3}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_2 : \top, \Delta_4, \mathtt{F}_1, []\mathtt{F}_1 \vdash \Delta_3}\ \top_L$$

4.15 Status of $\bot_L$: : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_2 : \bot, \mathtt{F}_4, \Delta_1 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_2 : \bot, \Delta_1 \vdash \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5}\ \rightarrow_R \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_2 : \bot, \Delta_1 \vdash \mathtt{F}_4, \Delta_3 \quad \mathtt{h}_2 : \bot, \Delta_1 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_2 : \bot, \Delta_1 \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5}\ \wedge_R \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_2 : \bot, \Delta_1 \vdash \mathtt{F}_4, \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_2 : \bot, \Delta_1 \vdash \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5}\ \vee_R \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_2 : \bot, \Delta_1 \vdash \Delta_3}{\bullet \mathtt{h}_2 : \bot, \Delta_1 \vdash \bot, \Delta_3}\ \bot_R \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_2 : \bot, \Delta_1 \vdash \top, \Delta_3}\ \top_R \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule K

$$\frac{\mathtt{h}_1 : unbox(\Box\Gamma_2) \vdash \mathtt{F}_4}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \bot, \Delta_5 \vdash \Delta_3, []\mathtt{F}_4}\ K \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $A45$

$$\frac{\mathtt{h}_1 : \Box\Gamma_2 \vdash \Box\Gamma_3, \mathtt{F}_5}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \bot, \Delta_6 \vdash \Box\Gamma_3, \Delta_4, []\mathtt{F}_5}\ A45 \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_1 : \bot, \Delta_5 \vdash \mathtt{F}_2, \Delta_4 \quad \mathtt{h}_1 : \bot, \mathtt{F}_3, \Delta_5 \vdash \Delta_4}{\bullet \mathtt{h}_1 : (\bot, \Delta_5), \mathtt{F}_2 \rightarrow \mathtt{F}_3 \vdash \Delta_4} \rightarrow_L \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_1 : \bot, \mathtt{F}_2, \mathtt{F}_3, \Delta_5 \vdash \Delta_4}{\bullet \mathtt{h}_1 : (\bot, \Delta_5), \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \Delta_4} \wedge_L \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_1 : \bot, \mathtt{F}_2, \Delta_5 \vdash \Delta_4 \quad \mathtt{h}_1 : \bot, \mathtt{F}_3, \Delta_5 \vdash \Delta_4}{\bullet \mathtt{h}_1 : (\bot, \Delta_5), \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_4} \vee_L \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule AT

$$\frac{\mathtt{h}_1 : \bot, \mathtt{F}_2, \Delta_4, []\mathtt{F}_2 \vdash \Delta_3}{\bullet \mathtt{h}_1 : (\bot, \Delta_4), []\mathtt{F}_2 \vdash \Delta_3} AT \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_1 : \bot, \Delta_2 \vdash \Delta_3} \bot_L \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_1 : \mathtt{p}_2, \bot, \Delta_4 \vdash \mathtt{p}_2, \Delta_3} I \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_1 : \bot, \Delta_3 \vdash \Delta_2}{\bullet \mathtt{h}_1 : \top, \bot, \Delta_3 \vdash \Delta_2} \top_L \quad \rightsquigarrow \quad \texttt{trivial}$$

4.16 Status of I: : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_1, \mathtt{p}_2 \vdash \mathtt{F}_5, \Delta_6, \mathtt{p}_2}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{p}_2 \vdash (\Delta_6, \mathtt{p}_2), \mathtt{F}_4 \rightarrow \mathtt{F}_5} \rightarrow_R \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_3 : \Delta_1, \mathtt{p}_2 \vdash \mathtt{F}_4, \Delta_6, \mathtt{p}_2 \quad \mathtt{h}_3 : \Delta_1, \mathtt{p}_2 \vdash \mathtt{F}_5, \Delta_6, \mathtt{p}_2}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{p}_2 \vdash (\Delta_6, \mathtt{p}_2), \mathtt{F}_4 \wedge \mathtt{F}_5} \wedge_R \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_3 : \Delta_1, \mathtt{p}_2 \vdash \mathtt{F}_4, \mathtt{F}_5, \Delta_6, \mathtt{p}_2}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{p}_2 \vdash (\Delta_6, \mathtt{p}_2), \mathtt{F}_4 \vee \mathtt{F}_5} \vee_R \quad \rightsquigarrow \quad \texttt{trivial}$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_3 : \Delta_1, \mathtt{p}_2 \vdash \Delta_4, \mathtt{p}_2}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{p}_2 \vdash \bot, \Delta_4, \mathtt{p}_2}\ \bot_R \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_3 : \Delta_1, \mathtt{p}_2 \vdash \top, \Delta_4, \mathtt{p}_2}\ \top_R \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule K

$$\frac{\mathtt{h}_2 : unbox(\Box\Gamma_3) \vdash \mathtt{F}_4}{\bullet \mathtt{h}_2 : \Box\Gamma_3, \Delta_6, \mathtt{p}_1 \vdash (\Delta_5, \mathtt{p}_1), []\mathtt{F}_4}\ K \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $A45$

$$\frac{\mathtt{h}_2 : \Box\Gamma_3 \vdash \Box\Gamma_4, \mathtt{F}_5}{\bullet \mathtt{h}_2 : \Box\Gamma_3, \Delta_7, \mathtt{p}_1 \vdash \Box\Gamma_4, (\Delta_6, \mathtt{p}_1), []\mathtt{F}_5}\ A45 \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_3 : \Delta_6, \mathtt{p}_1 \vdash \mathtt{F}_4, \Delta_2, \mathtt{p}_1 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_6, \mathtt{p}_1 \vdash \Delta_2, \mathtt{p}_1}{\bullet \mathtt{h}_3 : (\Delta_6, \mathtt{p}_1), \mathtt{F}_4 \rightarrow \mathtt{F}_5 \vdash \Delta_2, \mathtt{p}_1}\ \rightarrow_L \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \mathtt{F}_5, \Delta_6, \mathtt{p}_1 \vdash \Delta_2, \mathtt{p}_1}{\bullet \mathtt{h}_3 : (\Delta_6, \mathtt{p}_1), \mathtt{F}_4 \wedge \mathtt{F}_5 \vdash \Delta_2, \mathtt{p}_1}\ \wedge_L \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_6, \mathtt{p}_1 \vdash \Delta_2, \mathtt{p}_1 \quad \mathtt{h}_3 : \mathtt{F}_5, \Delta_6, \mathtt{p}_1 \vdash \Delta_2, \mathtt{p}_1}{\bullet \mathtt{h}_3 : (\Delta_6, \mathtt{p}_1), \mathtt{F}_4 \vee \mathtt{F}_5 \vdash \Delta_2, \mathtt{p}_1}\ \vee_L \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule AT

$$\frac{\mathtt{h}_3 : \mathtt{F}_4, \Delta_5, \mathtt{p}_1, []\mathtt{F}_4 \vdash \Delta_2, \mathtt{p}_1}{\bullet \mathtt{h}_3 : (\Delta_5, \mathtt{p}_1), []\mathtt{F}_4 \vdash \Delta_2, \mathtt{p}_1}\ AT \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_3 : \bot, \Delta_4, \mathtt{p}_1 \vdash \Delta_2, \mathtt{p}_1}\ \bot_L \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_2 : \mathtt{p}_3, \Delta_5, \mathtt{p}_1 \vdash \mathtt{p}_3, \Delta_4, \mathtt{p}_1}\ I \quad \rightsquigarrow \quad \mathtt{trivial}$$

$$\frac{}{\bullet \mathtt{h}_1 : \mathtt{p}_3, \Delta_2 \vdash \mathtt{p}_3, \Delta_4}\ I \quad \rightsquigarrow \quad \mathtt{trivial}$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_3 : \Delta_4, \mathtt{p}_1 \vdash \Delta_2, \mathtt{p}_1}{\bullet \mathtt{h}_3 : \top, \Delta_4, \mathtt{p}_1 \vdash \Delta_2, \mathtt{p}_1}\ \top_L \quad \rightsquigarrow \quad \texttt{trivial}$$

4.17 Status of $\top_L$: : `Invertible`

- Case rule $\rightarrow_R$

$$\frac{\mathtt{h}_2 : \top, \mathtt{F}_4, \Delta_1 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_2 : \top, \Delta_1 \vdash \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5}\ \rightarrow_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_2 : \Delta_1, \mathtt{F}_4 \vdash \Delta_3, \mathtt{F}_5}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_2 : \Delta_1 \vdash \Delta_3, \mathtt{F}_4 \rightarrow \mathtt{F}_5}\ \rightarrow_R$$

- Case rule $\wedge_R$

$$\frac{\mathtt{h}_2 : \top, \Delta_1 \vdash \mathtt{F}_4, \Delta_3 \quad \mathtt{h}_2 : \top, \Delta_1 \vdash \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_2 : \top, \Delta_1 \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5}\ \wedge_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_2 : \Delta_1 \vdash \Delta_3, \mathtt{F}_4}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_2 : \Delta_1 \vdash \Delta_3, \mathtt{F}_5}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_2 : \Delta_1 \vdash \Delta_3, \mathtt{F}_4 \wedge \mathtt{F}_5}\ \wedge_R$$

- Case rule $\vee_R$

$$\frac{\mathtt{h}_2 : \top, \Delta_1 \vdash \mathtt{F}_4, \mathtt{F}_5, \Delta_3}{\bullet \mathtt{h}_2 : \top, \Delta_1 \vdash \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5}\ \vee_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_2 : \Delta_1 \vdash \Delta_3, \mathtt{F}_4, \mathtt{F}_5}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_2 : \Delta_1 \vdash \Delta_3, \mathtt{F}_4 \vee \mathtt{F}_5}\ \vee_R$$

- Case rule $\bot_R$

$$\frac{\mathtt{h}_2 : \top, \Delta_1 \vdash \Delta_3}{\bullet \mathtt{h}_2 : \top, \Delta_1 \vdash \bot, \Delta_3}\ \bot_R \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_2 : \Delta_1 \vdash \Delta_3}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_2 : \Delta_1 \vdash \bot, \Delta_3}\ \bot_R$$

- Case rule $\top_R$

$$\frac{}{\bullet \mathtt{h}_2 : \top, \Delta_1 \vdash \top, \Delta_3}\ \top_R \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_2 : \Delta_1 \vdash \top, \Delta_3}\ \top_R$$

- Case rule K

$$\frac{\mathtt{h}_1 : unbox(\Box\Gamma_2) \vdash \mathtt{F}_4}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \top, \Delta_5 \vdash \Delta_3, []\mathtt{F}_4}\ K \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : unbox(\Box\Gamma_2) \vdash \mathtt{F}_4}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_5, \Box\Gamma_2 \vdash \Delta_3, []\mathtt{F}_4}\ K$$

- Case rule $A45$

$$\frac{\mathtt{h}_1 : \Box\Gamma_2 \vdash \Box\Gamma_3, \mathtt{F}_5}{\bullet \mathtt{h}_1 : \Box\Gamma_2, \top, \Delta_6 \vdash \Box\Gamma_3, \Delta_4, []\mathtt{F}_5}\ A45 \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Box\Gamma_2 \vdash \mathtt{F}_5, \Box\Gamma_3}^{\ \mathtt{ax}}}{\bullet \mathtt{h}_1 : \Delta_6, \Box\Gamma_2 \vdash \Delta_4, \Box\Gamma_3, []\mathtt{F}_5}\ A45$$

- Case rule $\rightarrow_L$

$$\frac{\mathtt{h}_1 : \top, \Delta_5 \vdash \mathtt{F}_2, \Delta_4 \quad \mathtt{h}_1 : \top, \mathtt{F}_3, \Delta_5 \vdash \Delta_4}{\bullet \mathtt{h}_1 : (\top, \Delta_5), \mathtt{F}_2 \rightarrow \mathtt{F}_3 \vdash \Delta_4}\ \rightarrow_L \quad \rightsquigarrow \quad \frac{\overline{\mathtt{h}_1 : \Delta_5 \vdash \Delta_4, \mathtt{F}_2}^{\ \mathtt{ax/ind}} \quad \overline{\mathtt{h}_1 : \Delta_5, \mathtt{F}_3 \vdash \Delta_4}^{\ \mathtt{ax/ind}}}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{F}_2 \rightarrow \mathtt{F}_3 \vdash \Delta_4}\ \rightarrow_L$$

- Case rule $\wedge_L$

$$\frac{\mathtt{h}_1 : \top, \mathtt{F}_2, \mathtt{F}_3, \Delta_5 \vdash \Delta_4}{\bullet \mathtt{h}_1 : (\top, \Delta_5), \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \Delta_4} \wedge_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_1 : \Delta_5, \mathtt{F}_2, \mathtt{F}_3 \vdash \Delta_4}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{F}_2 \wedge \mathtt{F}_3 \vdash \Delta_4} \wedge_L$$

- Case rule $\vee_L$

$$\frac{\mathtt{h}_1 : \top, \mathtt{F}_2, \Delta_5 \vdash \Delta_4 \quad \mathtt{h}_1 : \top, \mathtt{F}_3, \Delta_5 \vdash \Delta_4}{\bullet \mathtt{h}_1 : (\top, \Delta_5), \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_4} \vee_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_1 : \Delta_5, \mathtt{F}_2 \vdash \Delta_4}\ \mathtt{ax/ind} \quad \dfrac{}{\mathtt{h}_1 : \Delta_5, \mathtt{F}_3 \vdash \Delta_4}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{F}_2 \vee \mathtt{F}_3 \vdash \Delta_4} \vee_L$$

- Case rule AT

$$\frac{\mathtt{h}_1 : \top, \mathtt{F}_2, \Delta_4, []\mathtt{F}_2 \vdash \Delta_3}{\bullet \mathtt{h}_1 : (\top, \Delta_4), []\mathtt{F}_2 \vdash \Delta_3} AT \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_1 : \Delta_4, \mathtt{F}_2, []\mathtt{F}_2 \vdash \Delta_3}\ \mathtt{ax/ind}}{\bullet \mathtt{h}_1 : \Delta_4, []\mathtt{F}_2 \vdash \Delta_3} AT$$

- Case rule $\bot_L$

$$\frac{}{\bullet \mathtt{h}_1 : \bot, \top, \Delta_3 \vdash \Delta_2} \bot_L \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : \bot, \Delta_3 \vdash \Delta_2} \bot_L$$

- Case rule I

$$\frac{}{\bullet \mathtt{h}_1 : \mathtt{p}_2, \top, \Delta_4 \vdash \mathtt{p}_2, \Delta_3} I \quad \rightsquigarrow \quad \frac{}{\bullet \mathtt{h}_1 : \Delta_4, \mathtt{p}_2 \vdash \Delta_3, \mathtt{p}_2} I$$

- Case rule $\top_L$

$$\frac{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}{\bullet \mathtt{h}_1 : \top, \Delta_2 \vdash \Delta_3} \top_L \quad \rightsquigarrow \quad \frac{\dfrac{}{\mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\ \mathtt{ax}}{\bullet \mathtt{h}_1 : \Delta_2 \vdash \Delta_3}\ \mathtt{H}$$

5 Identity-Expansion

$$\dfrac{\dfrac{}{- : \mathtt{F}_0 \vdash \mathtt{F}_0}\,\mathtt{IH}}{- : \Box\mathtt{F}_0 \vdash \Box\mathtt{F}_0}\,K$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{- : \mathtt{F}_0 \vdash \mathtt{F}_0}\,\mathtt{IH}}{- : \mathtt{F}_0 \vdash \mathtt{F}_0, \mathtt{F}_1}\,W \qquad \dfrac{\dfrac{}{- : \mathtt{F}_1 \vdash \mathtt{F}_1}\,\mathtt{IH}}{- : \mathtt{F}_1 \vdash \mathtt{F}_0, \mathtt{F}_1}\,W}{- : \mathtt{F}_0 \vee \mathtt{F}_1 \vdash \mathtt{F}_0, \mathtt{F}_1}\,\vee_L}{- : \mathtt{F}_0 \vee \mathtt{F}_1 \vdash \mathtt{F}_0 \vee \mathtt{F}_1}\,\vee_R$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{- : \mathtt{F}_0 \vdash \mathtt{F}_0}\,\mathtt{IH}}{- : \mathtt{F}_0, \mathtt{F}_1 \vdash \mathtt{F}_0}\,W \qquad \dfrac{\dfrac{}{- : \mathtt{F}_1 \vdash \mathtt{F}_1}\,\mathtt{IH}}{- : \mathtt{F}_0, \mathtt{F}_1 \vdash \mathtt{F}_1}\,W}{- : \mathtt{F}_0, \mathtt{F}_1 \vdash \mathtt{F}_0 \wedge \mathtt{F}_1}\,\wedge_R}{- : \mathtt{F}_0 \wedge \mathtt{F}_1 \vdash \mathtt{F}_0 \wedge \mathtt{F}_1}\,\wedge_L$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{- : \mathtt{F}_0 \vdash \mathtt{F}_0}\,\mathtt{IH}}{- : \mathtt{F}_0 \vdash \mathtt{F}_0, \mathtt{F}_1}\,W \qquad \dfrac{\dfrac{}{- : \mathtt{F}_1 \vdash \mathtt{F}_1}\,\mathtt{IH}}{- : \mathtt{F}_0, \mathtt{F}_1 \vdash \mathtt{F}_1}\,W}{- : \mathtt{F}_0, \mathtt{F}_0 \to \mathtt{F}_1 \vdash \mathtt{F}_1}\,\to_L}{- : \mathtt{F}_0 \to \mathtt{F}_1 \vdash \mathtt{F}_0 \to \mathtt{F}_1}\,\to_R$$

$$\dfrac{}{- : \top \vdash \top}\,\top_R$$

$$\dfrac{}{- : \bot \vdash \bot}\,\bot_L$$

6 Cut-Elimination

6.1 Status of $\to_R$: OK

- Case rule $\to_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_7, \Delta_6 \vdash \mathtt{F}_8, \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}{\bullet \mathtt{h}_1 : \Delta_6 \vdash (\Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}), \mathtt{F}_7 \to \mathtt{F}_8}\to_R \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_{11}, \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet \mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\to_R}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6, \mathtt{F}_{11}, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_8}\,\mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_1 : \Delta_6, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7 \to \mathtt{F}_8}\to_R \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_{11}, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_6, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\to_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}}{\bullet \mathtt{h}_2 : \Delta_8 \vdash ((\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7}\to_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{12}, \Delta_8 \vdash \mathtt{F}_{13}, \Delta_{14}, \mathtt{F}_9 \to \mathtt{F}_{10}}{\bullet \mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_9 \to \mathtt{F}_{10}}\to_R}{- : \Delta_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8, \mathtt{F}_{12}, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{13}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_2 : \Delta_8, \mathtt{F}_{12} \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10}}\to_R \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{12}, \mathtt{F}_7 \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_{12} \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{hCut}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}, \mathtt{F}_9 \to \mathtt{F}_{10}}\to_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_{11}, \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{12}, \Delta_{10}}{\bullet \mathtt{h}_2 : \Delta_8 \vdash (\Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}), \mathtt{F}_7}\to_R \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_7, \mathtt{F}_{11}, \Delta_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet \mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\to_R}{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_9 : \Delta_8, \mathtt{F}_{11}, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{ax/W}}{\bullet \mathtt{h}_9 : \Delta_8, \mathtt{F}_{11}, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{H}}{- : \Delta_8, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\to_R$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_7, \Delta_6 \vdash \mathtt{F}_8, \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}{\bullet \mathtt{h}_1 : \Delta_6 \vdash (\Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_7 \to \mathtt{F}_8}\to_R \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \mathtt{F}_{11}, \Delta_{10} \quad \mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet \mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\wedge_R}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_8}\,\mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_7 \to \mathtt{F}_8}\to_R \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11}}\,\mathtt{ax/W}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}}\,\mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_8}\,\mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7 \to \mathtt{F}_8}\to_R \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{ax/}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{hCu}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\wedge_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}{\bullet \mathtt{h}_2 : \Delta_8 \vdash ((\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7}\to_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{12}, \Delta_{14}, \mathtt{F}_9 \to \mathtt{F}_{10} \quad \mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{13}, \Delta_{14}, \mathtt{F}_9 \to \mathtt{F}_{10}}{\bullet \mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_9 \to \mathtt{F}_{10}}\wedge_R}{- : \Delta_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_7, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12}}\,\mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\,\mathtt{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{13}}\,\mathtt{inv\text{-}th/ax}}{\wedge_R}}{- : \Delta_8, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\to_R}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_9 \to \mathtt{F}_{10}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_7, \Delta_6 \vdash \mathtt{F}_8, \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}), \mathtt{F}_7 \to \mathtt{F}_8}\,{\to_R} \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,{\vee_R}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_7 \to \mathtt{F}_8}\,{\to_R} \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,{\vee_R}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_{14}, \mathtt{F}_9 \to \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_9 \to \mathtt{F}_{10}}\,{\vee_R}}{- : \Delta_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_7, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12}, \mathtt{F}_{13}}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\,{\vee_R}}{- : \Delta_8, \mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\,\mathtt{hCut}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_9 \to \mathtt{F}_{10}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\,{\to_R}$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_7, \Delta_6 \vdash \mathtt{F}_8, \bot, \Delta_{10}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\bot, \Delta_{10}), \mathtt{F}_7 \to \mathtt{F}_8}\,{\to_R} \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \bot, \Delta_{10}}\,{\bot_R}}{- : \Delta_6 \vdash \bot, \Delta_{10}}\,\mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \bot, \Delta_{10}}\,\mathtt{ax/W}}{- : \Delta_6 \vdash \bot, \Delta_{10}}\,\mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \bot, \Delta_{12}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\bot, \Delta_{12}), \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\bot, \Delta_{12}), \mathtt{F}_9 \to \mathtt{F}_{10}}\,{\bot_R}}{- : \Delta_8 \vdash (\bot, \Delta_{12}), \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_2 : \Delta_8 \vdash \bot, \Delta_{12}, \mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash \bot, \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8 \vdash \bot, \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{hCut}$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_7, \Delta_6 \vdash \mathtt{F}_8, \top, \Delta_{10}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\top, \Delta_{10}), \mathtt{F}_7 \to \mathtt{F}_8}\,{\to_R} \quad \dfrac{}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \top, \Delta_{10}}\,{\top_R}}{- : \Delta_6 \vdash \top, \Delta_{10}}\,\mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_6 \vdash \top, \Delta_{10}}\,{\top_R}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \top, \Delta_{12}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\top, \Delta_{12}), \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7}\,{\to_R} \quad \dfrac{}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\top, \Delta_{12}), \mathtt{F}_9 \to \mathtt{F}_{10}}\,{\top_R}}{- : \Delta_8 \vdash (\top, \Delta_{12}), \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_8 \vdash \top, \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}}\,{\top_R}$$

- Case rule K

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_6, \Box\Gamma_9, \Delta_{12} \vdash \mathtt{F}_7, \Delta_{10}, []\mathtt{F}_{11}}{\bullet\mathtt{h}_1 : \Box\Gamma_9, \Delta_{12} \vdash (\Delta_{10}, []\mathtt{F}_{11}), \mathtt{F}_6 \to \mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_8 : \mathit{unbox}(\Box\Gamma_9) \vdash \mathtt{F}_{11}}{\bullet\mathtt{h}_8 : (\Box\Gamma_9, \Delta_{12}), \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_{11}}\,K}{- : \Box\Gamma_9, \Delta_{12} \vdash \Delta_{10}, []\mathtt{F}_{11}}\,\mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \mathit{unbox}(\Box\Gamma_9) \vdash \mathtt{F}_{11}}\,\mathtt{ax/W}}{- : \Delta_{12}, \Box\Gamma_9 \vdash \Delta_{10}, []\mathtt{F}_{11}}\,K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Box\Gamma_{14}, \Delta_{11} \vdash \Box\mathtt{F}_7, \mathtt{F}_9, \Delta_{13}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_{14}, \Delta_{11} \vdash ((\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9), \Box\mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{14}), unbox(\Box\mathtt{F}_7) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{14}, \Delta_{11}), \Box\mathtt{F}_7 \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9}\,K}{- : \Box\Gamma_{14}, \Delta_{11} \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \mathtt{F}_8, \Box\Gamma_{14} \vdash \Box\mathtt{F}_7, \Delta_{13}, \mathtt{F}_9, []\mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : unbox(\Box\mathtt{F}_7), unbox(\Box\Gamma_{14}) \vdash \mathtt{F}_{12}}\,\mathtt{ax/W}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{11}, \mathtt{F}_8, \Box\Gamma_{14} \vdash \Delta_{13}, \mathtt{F}_9, []\mathtt{F}_{12}}\,K}{- : \Delta_{11}, \mathtt{F}_8, \Box\Gamma_{14} \vdash \Delta_{13}, \mathtt{F}_9, []\mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_{11}, \Box\Gamma_{14} \vdash \Delta_{13}, []\mathtt{F}_{12}, \mathtt{F}_8 \to \mathtt{F}_9}\,{\to_R}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Box\Gamma_{11}, \Delta_{14} \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{13}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_{14} \vdash ((\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_7 \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9}\,K}{- : \Box\Gamma_{11}, \Delta_{14} \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{11} \vdash \Delta_{13}, []\mathtt{F}_{12}, \mathtt{F}_8 \to \mathtt{F}_9}\,K$$

- Case rule $A45$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_6, \Box\Gamma_9, \Delta_{13} \vdash \mathtt{F}_7, \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_1 : \Box\Gamma_9, \Delta_{13} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_6 \to \mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_8 : (\Box\Gamma_9, \Delta_{13}), \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\,A45}{- : \Box\Gamma_9, \Delta_{13} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_9 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\,\mathtt{ax/W}}{- : \Delta_{13}, \Box\Gamma_9 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\,A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Box\Gamma_{15}, \Delta_{11} \vdash \Box\mathtt{F}_7, \mathtt{F}_9, \Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Box\Gamma_{15}, \Delta_{11} \vdash ((\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \to \mathtt{F}_9), \Box\mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{15}, \Box\mathtt{F}_7 \vdash \Box\Gamma_{12}, \mathtt{F}_{13}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{15}, \Delta_{11}), \Box\mathtt{F}_7 \vdash (\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \to \mathtt{F}_9}\,A45}{- : \Box\Gamma_{15}, \Delta_{11} \vdash (\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \mathtt{F}_8, \Box\Gamma_{15} \vdash \Box\mathtt{F}_7, \Delta_{14}, \mathtt{F}_9, \Box\Gamma_{12}, []\mathtt{F}_{13}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Box\mathtt{F}_7, \Box\Gamma_{15} \vdash \mathtt{F}_{13}, \Box\Gamma_{12}}\,\mathtt{ax/W}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{11}, \mathtt{F}_8, \Box\Gamma_{15} \vdash \Delta_{14}, \mathtt{F}_9, \Box\Gamma_{12}, []\mathtt{F}_{13}}\,A45}{- : \Delta_{11}, \mathtt{F}_8, \Box\Gamma_{15} \vdash \Delta_{14}, \mathtt{F}_9, \Box\Gamma_{12}, []\mathtt{F}_{13}}\,\mathtt{hCut}}{- : \Delta_{11}, \Box\Gamma_{15} \vdash \Delta_{14}, \Box\Gamma_{12}, []\mathtt{F}_{13}, \mathtt{F}_8 \to \mathtt{F}_9}\,{\to_R}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Box\Gamma_{11}, \Delta_{15} \vdash \mathtt{F}_7, \mathtt{F}_9, \Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_{15} \vdash ((\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{11} \vdash \Box\Gamma_{12}, \mathtt{F}_{13}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_7 \vdash (\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \to \mathtt{F}_9}\,A45}{- : \Box\Gamma_{11}, \Delta_{15} \vdash (\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{11} \vdash \mathtt{F}_{13}, \Box\Gamma_{12}}\,\mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{11} \vdash \Delta_{14}, \Box\Gamma_{12}, []\mathtt{F}_{13}, \mathtt{F}_8 \to \mathtt{F}_9}\,A45$$

- Case rule $\to_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_6, \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \mathtt{F}_7, \Delta_{11}}{\bullet\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6 \to \mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \mathtt{F}_9, \Delta_{11} \quad \mathtt{h}_8 : \mathtt{F}_{10}, \Delta_{12}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : (\Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}}\,{\to_L}}{- : \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_6 \vdash \Delta_{11}, \mathtt{F}_7, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_{12} \vdash \Delta_{11}, \mathtt{F}_9, \mathtt{F}_6 \to \mathtt{F}_7}\,{\to_R} \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_9}\,\mathtt{ax/W}}{- : \Delta_{12} \vdash \Delta_{11}, \mathtt{F}_9}\,\mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_6 \vdash \Delta_{11}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6 \to \mathtt{F}_7}\,{\to_R} \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}}\,\mathtt{h}}{- : \Delta_{12}, \mathtt{F}_{10} \vdash \Delta_{11}}\,{\to_L}}{- : \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}}$$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_8, \Delta_7 \vdash \mathtt{F}_9, \Delta_{10}}{\bullet\mathtt{h}_1 : \Delta_7 \vdash \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9}\,{\to_R} \quad \dfrac{\mathtt{h}_6 : \Delta_7 \vdash \mathtt{F}_8, \Delta_{10} \quad \mathtt{h}_6 : \mathtt{F}_9, \Delta_7 \vdash \Delta_{10}}{\bullet\mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{10}}\,{\to_L}}{- : \Delta_7 \vdash \Delta_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Delta_7 \vdash \Delta_{10}, \mathtt{F}_8}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{- : \Delta_7, \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_9}\,\mathtt{ax/W} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_8 \vdash \Delta_{10}}\,\mathtt{sCut}}{- : \Delta_7 \vdash \Delta_{10}}\,\mathtt{sCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Delta_{11} \vdash \mathtt{F}_{12} \to \mathtt{F}_{13}, \mathtt{F}_9, \Delta_7}{\bullet \mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_{12} \to \mathtt{F}_{13}} \to_R \quad \dfrac{\mathtt{h}_{10} : \Delta_{11} \vdash \mathtt{F}_{12}, \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \quad \mathtt{h}_{10} : \mathtt{F}_{13}, \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}{\bullet \mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9} \to_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9, \mathtt{F}_{12} \to \mathtt{F}_{13}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_{12}, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{13}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_8, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_7, \mathtt{F}_9} \to_L}\ \mathtt{hCut}}{- : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9} \to_R}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_2 : \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7} \to_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_{14} \vdash \mathtt{F}_{12}, \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \quad \mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{13}, \Delta_{14} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}{\bullet \mathtt{h}_{11} : (\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}} \to_L}{- : \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{14}, \mathtt{F}_9, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_{12}}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_8, \mathtt{F}_{10}}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}} \to_L}\ \mathtt{hCut}}{- : \Delta_{14}, \mathtt{F}_9, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}} \to_R}{- : \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_6, \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \mathtt{F}_7, \Delta_{11}}{\bullet \mathtt{h}_1 : \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6 \to \mathtt{F}_7} \to_R \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_9, \mathtt{F}_{10}, \Delta_{12}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}}{\bullet \mathtt{h}_8 : (\Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}} \wedge_L}{- : \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_6, \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_6 \to \mathtt{F}_7} \to_R \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_9, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}}\ \mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_9 \vdash \Delta_{11}}\ \mathtt{hCut}}{- : \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}} \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Delta_{11} \vdash \mathtt{F}_{12} \wedge \mathtt{F}_{13}, \mathtt{F}_9, \Delta_7}{\bullet \mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_{12} \wedge \mathtt{F}_{13}} \to_R \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}{\bullet \mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9} \wedge_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_8, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_7, \mathtt{F}_9} \wedge_L}\ \mathtt{hCut}}{- : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9} \to_R}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_2 : \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7} \to_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_{14} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}{\bullet \mathtt{h}_{11} : (\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}} \wedge_L}{- : \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{14}, \mathtt{F}_9, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_8, \mathtt{F}_{10}}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}} \wedge_L}\ \mathtt{hCut}}{- : \Delta_{14}, \mathtt{F}_9, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}} \to_R}{- : \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_6, \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \mathtt{F}_7, \Delta_{11}}{\bullet \mathtt{h}_1 : \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6 \to \mathtt{F}_7} \to_R \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_9, \Delta_{12}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11} \quad \mathtt{h}_8 : \mathtt{F}_{10}, \Delta_{12}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}}{\bullet \mathtt{h}_8 : (\Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}} \vee_L}{- : \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_6, \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_1 : \Delta_{12}, \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_6 \to \mathtt{F}_7} \to_R \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_9, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}}\ \mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_9 \vdash \Delta_{11}}\ \mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_6 \vdash \Delta_{11}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6 \to \mathtt{F}_7} \to_R \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{11}}\ \mathtt{a}}{- : \Delta_{12}, \mathtt{F}_{10} \vdash \Delta_{11}}\ \mathtt{h}}{- : \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}} \vee_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Delta_{11} \vdash \mathtt{F}_{12} \vee \mathtt{F}_{13}, \mathtt{F}_9, \Delta_7}{\bullet \mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_{12} \vee \mathtt{F}_{13}} \to_R \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{12}, \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \quad \mathtt{h}_{10} : \mathtt{F}_{13}, \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}{\bullet \mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9} \vee_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{13}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax}\ \vee_L}{\bullet \mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_8, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_7, \mathtt{F}_9}\,\mathtt{hCut}}{- : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9} \to_R}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_2 : \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7} \to_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{12}, \Delta_{14} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \quad \mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{13}, \Delta_{14} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}{\bullet \mathtt{h}_{11} : (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}} \vee_L}{- : \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{14}, \mathtt{F}_9, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_8, \mathtt{F}_{10}}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_8, \mathtt{F}_{10}}\,\mathtt{inv\text{-}th/ax}\ \vee_L}{\bullet \mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}}\,\mathtt{hCut}}{- : \Delta_{14}, \mathtt{F}_9, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}} \to_R}{- : \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}$$

- Case rule AT

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_6, \Delta_{11}, []\mathtt{F}_9 \vdash \mathtt{F}_7, \Delta_{10}}{\bullet \mathtt{h}_1 : \Delta_{11}, []\mathtt{F}_9 \vdash \Delta_{10}, \mathtt{F}_6 \to \mathtt{F}_7} \to_R \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_9, \Delta_{11}, []\mathtt{F}_9, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{10}}{\bullet \mathtt{h}_8 : (\Delta_{11}, []\mathtt{F}_9), \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{10}}\,AT}{- : \Delta_{11}, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_{11}, \mathtt{F}_9, []\mathtt{F}_9 \vdash \Delta_{10}, \mathtt{F}_6 \to \mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \Delta_{11}, \mathtt{F}_9, []\mathtt{F}_9, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{10}}\,\mathtt{ax/W}}{- : \Delta_{11}, \mathtt{F}_9, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{hCut}}{- : \Delta_{11}, []\mathtt{F}_9 \vdash \Delta_{10}}\,ATG$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Delta_{11} \vdash []\mathtt{F}_{12}, \mathtt{F}_9, \Delta_7}{\bullet \mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), []\mathtt{F}_{12}} \to_R \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{12}, \Delta_{11}, []\mathtt{F}_{12} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}{\bullet \mathtt{h}_{10} : \Delta_{11}, []\mathtt{F}_{12} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\,AT}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9, []\mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12}, \mathtt{F}_8, []\mathtt{F}_{12} \vdash \Delta_7, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_8, []\mathtt{F}_{12} \vdash \Delta_7, \mathtt{F}_9}\,AT\,\mathtt{hCut}}{- : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9} \to_R}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \Delta_{13}, []\mathtt{F}_{12} \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_2 : \Delta_{13}, []\mathtt{F}_{12} \vdash (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7} \to_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{12}, \Delta_{13}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}{\bullet \mathtt{h}_{11} : (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,AT}{- : \Delta_{13}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_{13}, \mathtt{F}_{12}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{13}, \mathtt{F}_{12}, \mathtt{F}_7, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_{13}, \mathtt{F}_{12}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{hCut}}{- : \Delta_{13}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,ATG$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_6, \bot, \Delta_{10} \vdash \mathtt{F}_7, \Delta_9}{\bullet \mathtt{h}_1 : \bot, \Delta_{10} \vdash \Delta_9, \mathtt{F}_6 \to \mathtt{F}_7} \to_R \quad \dfrac{}{\bullet \mathtt{h}_8 : (\bot, \Delta_{10}), \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_9}\,\bot_L}{- : \bot, \Delta_{10} \vdash \Delta_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_{10} \vdash \Delta_9}\,\bot_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Delta_{11} \vdash \bot, \mathtt{F}_9, \Delta_7}{\bullet \mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), \bot} \to_R \quad \dfrac{}{\bullet \mathtt{h}_{10} : \Delta_{11}, \bot \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\,\bot_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \mathtt{F}_8 \vdash \bot, \Delta_7, \mathtt{F}_9}\,\mathtt{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_{10} : \bot, \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9}\,\bot_L\,\mathtt{hCut}}{- : \Delta_{11}, \mathtt{F}_8 \vdash \Delta_7, \mathtt{F}_9} \to_R}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \bot, \Delta_{12} \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_2 : \bot, \Delta_{12} \vdash (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7}\,{\to_R} \quad \dfrac{}{\bullet \mathtt{h}_{11} : (\bot, \Delta_{12}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,{\bot_L}}{- : \bot, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,{\bot_L}$$

- Case rule I

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_6, \Delta_{11}, \mathtt{p}_9 \vdash \mathtt{F}_7, \Delta_{10}, \mathtt{p}_9}{\bullet \mathtt{h}_1 : \Delta_{11}, \mathtt{p}_9 \vdash (\Delta_{10}, \mathtt{p}_9), \mathtt{F}_6 \to \mathtt{F}_7}\,{\to_R} \quad \dfrac{}{\bullet \mathtt{h}_8 : (\Delta_{11}, \mathtt{p}_9), \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9}\,I}{- : \Delta_{11}, \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{11}, \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_9}\,I$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_7, \Delta_{10} \vdash \mathtt{p}_{11}, \mathtt{F}_8, \Delta_{12}, \mathtt{p}_{11}}{\bullet \mathtt{h}_2 : \Delta_{10} \vdash ((\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_7 \to \mathtt{F}_8), \mathtt{p}_{11}}\,{\to_R} \quad \dfrac{}{\bullet \mathtt{h}_9 : \Delta_{10}, \mathtt{p}_{11} \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_7 \to \mathtt{F}_8}\,I}{- : \Delta_{10} \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_7 \to \mathtt{F}_8}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{10}, \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_8, \mathtt{p}_{11}, \mathtt{p}_{11}}\,\mathtt{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_9 : \Delta_{10}, \mathtt{F}_7, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{F}_8, \mathtt{p}_{11}}\,I}{- : \Delta_{10}, \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_8, \mathtt{p}_{11}}\,\mathtt{hCut}}{- : \Delta_{10} \vdash \Delta_{12}, \mathtt{p}_{11}, \mathtt{F}_7 \to \mathtt{F}_8}\,{\to_R}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Delta_{13}, \mathtt{p}_{11} \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{12}, \mathtt{p}_{11}}{\bullet \mathtt{h}_2 : \Delta_{13}, \mathtt{p}_{11} \vdash ((\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_7}\,{\to_R} \quad \dfrac{}{\bullet \mathtt{h}_{10} : (\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_7 \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_8 \to \mathtt{F}_9}\,I}{- : \Delta_{13}, \mathtt{p}_{11} \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{13}, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}, \mathtt{F}_8 \to \mathtt{F}_9}\,I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathtt{F}_6, \top, \Delta_{10} \vdash \mathtt{F}_7, \Delta_9}{\bullet \mathtt{h}_1 : \top, \Delta_{10} \vdash \Delta_9, \mathtt{F}_6 \to \mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_8 : \Delta_{10}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_9}{\bullet \mathtt{h}_8 : (\top, \Delta_{10}), \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_9}\,{\top_L}}{- : \top, \Delta_{10} \vdash \Delta_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \top, \Delta_{10} \vdash \Delta_9, \mathtt{F}_6 \to \mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \top, \Delta_{10}, \mathtt{F}_6 \to \mathtt{F}_7 \vdash \Delta_9}\,\mathtt{ax/W}}{- : \top, \Delta_{10} \vdash \Delta_9}\,\mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_8, \Delta_{11} \vdash \top, \mathtt{F}_9, \Delta_7}{\bullet \mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), \top}\,{\to_R} \quad \dfrac{\mathtt{h}_{10} : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}{\bullet \mathtt{h}_{10} : \Delta_{11}, \top \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\,{\top_L}}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9}\,\mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathtt{F}_9, \top, \Delta_{12} \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_2 : \top, \Delta_{12} \vdash (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7}\,{\to_R} \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}{\bullet \mathtt{h}_{11} : (\top, \Delta_{12}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,{\top_L}}{- : \top, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \top, \Delta_{12} \vdash \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \top, \Delta_{12}, \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \top, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\,\mathtt{hCut}$$

6.2 Status of $\wedge_R$: OK

- Case rule $\to_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12} \quad \mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_8, \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}{\bullet \mathtt{h}_1 : \Delta_6 \vdash (\Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}), \mathtt{F}_7 \wedge \mathtt{F}_8}\,{\wedge_R} \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_{11}, \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet \mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,{\to_R}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_1 : \Delta_6, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_8}\,\mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_1 : \Delta_6, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7 \wedge \mathtt{F}_8}\,{\wedge_R} \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_{11}, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_6, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,{\to_R}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13} \quad \mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7}\,\wedge_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{12}, \Delta_8 \vdash \mathtt{F}_{13}, \Delta_{14}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\to_R}{- : \Delta_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8, \mathtt{F}_{12} \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_2 : \Delta_8, \mathtt{F}_{12} \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{13}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_2 : \Delta_8, \mathtt{F}_{12} \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\wedge_R \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{12}, \mathtt{F}_7 \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_{12} \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{hCut}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\to_R$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \quad \mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_8, \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_7 \wedge \mathtt{F}_8}\,\wedge_R \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \mathtt{F}_{11}, \Delta_{10} \quad \mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\wedge_R}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_7, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{- : \Delta_6, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_8, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_6, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{sCut}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{sCut} \quad \dfrac{\dfrac{}{- : \Delta_6, \mathtt{F}_7, \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11}}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{- : \Delta_6, \mathtt{F}_7, \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{inv\text{-}th/ax}}{- : \Delta_6, \mathtt{F}_7, \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\wedge_R}{- : \Delta_6, \mathtt{F}_7, \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{sCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \quad \mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7}\,\wedge_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{12}, \Delta_{14}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\Delta}}{- : \Delta_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_9 \wedge \mathtt{F}_{10}}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\wedge_R \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{hCut} \quad \dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9}\,\mathtt{inv\text{-}}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{11}, \Delta_{10} \quad \mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash (\Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_7}\,\wedge_R \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{11}, \Delta_{10} \quad \mathtt{h}_9 : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\wedge_R}{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11}}\,\mathtt{ax/W}}{\bullet\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11}}\,\mathtt{H}}{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11}}\,\mathtt{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{ax/W}}{\bullet\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{H}}{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\wedge_R$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12} \quad \mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_8, \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}), \mathtt{F}_7 \wedge \mathtt{F}_8}\,\wedge_R \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\vee_R}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_7 \wedge \mathtt{F}_8}\,\wedge_R \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\vee_R$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \quad \mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7}\,\wedge_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_{14}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\vee_R}{- : \Delta_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\wedge_R \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{hCut}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_9 \wedge \mathtt{F}_{10}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\,\vee_R$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \bot, \Delta_{10} \quad \mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_8, \bot, \Delta_{10}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\bot, \Delta_{10}), \mathtt{F}_7 \wedge \mathtt{F}_8}\wedge_R \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \bot, \Delta_{10}}\bot_R}{- : \Delta_6 \vdash \bot, \Delta_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \bot, \Delta_{10}}\,\mathtt{ax/W}}{- : \Delta_6 \vdash \bot, \Delta_{10}}\,\mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \bot, \Delta_{12} \quad \mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \bot, \Delta_{12}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\bot, \Delta_{12}), \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7}\wedge_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\bot, \Delta_{12}), \mathtt{F}_9 \wedge \mathtt{F}_{10}}\bot_R}{- : \Delta_8 \vdash (\bot, \Delta_{12}), \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_2 : \Delta_8 \vdash \bot, \Delta_{12}, \mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash \bot, \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8 \vdash \bot, \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{hCut}$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \top, \Delta_{10} \quad \mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_8, \top, \Delta_{10}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\top, \Delta_{10}), \mathtt{F}_7 \wedge \mathtt{F}_8}\wedge_R \quad \dfrac{}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \top, \Delta_{10}}\top_R}{- : \Delta_6 \vdash \top, \Delta_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_6 \vdash \top, \Delta_{10}}\top_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \top, \Delta_{12} \quad \mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \top, \Delta_{12}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\top, \Delta_{12}), \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7}\wedge_R \quad \dfrac{}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\top, \Delta_{12}), \mathtt{F}_9 \wedge \mathtt{F}_{10}}\top_R}{- : \Delta_8 \vdash (\top, \Delta_{12}), \mathtt{F}_9 \wedge \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_8 \vdash \top, \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\top_R$$

- Case rule K

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_9, \Delta_{12} \vdash \mathtt{F}_6, \Delta_{10}, []\mathtt{F}_{11} \quad \mathtt{h}_1 : \Box\Gamma_9, \Delta_{12} \vdash \mathtt{F}_7, \Delta_{10}, []\mathtt{F}_{11}}{\bullet\mathtt{h}_1 : \Box\Gamma_9, \Delta_{12} \vdash (\Delta_{10}, []\mathtt{F}_{11}), \mathtt{F}_6 \wedge \mathtt{F}_7}\wedge_R \quad \dfrac{\mathtt{h}_8 : unbox(\Box\Gamma_9) \vdash \mathtt{F}_{11}}{\bullet\mathtt{h}_8 : (\Box\Gamma_9, \Delta_{12}), \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_{11}}K}{- : \Box\Gamma_9, \Delta_{12} \vdash \Delta_{10}, []\mathtt{F}_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_9) \vdash \mathtt{F}_{11}}\,\mathtt{ax/W}}{- : \Delta_{12}, \Box\Gamma_9 \vdash \Delta_{10}, []\mathtt{F}_{11}}K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Delta_{11} \vdash \Box\mathtt{F}_7, \mathtt{F}_8, \Delta_{13}, []\mathtt{F}_{12} \quad \mathtt{h}_2 : \Box\Gamma_{14}, \Delta_{11} \vdash \Box\mathtt{F}_7, \mathtt{F}_9, \Delta_{13}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_{14}, \Delta_{11} \vdash ((\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9), \Box\mathtt{F}_7}\wedge_R \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{14}), unbox(\Box\mathtt{F}_7) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{14}, \Delta_{11}), \Box\mathtt{F}_7 \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}}}{- : \Box\Gamma_{14}, \Delta_{11} \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \Box\Gamma_{14} \vdash \Box\mathtt{F}_7, \Delta_{13}, \mathtt{F}_8, []\mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : unbox(\Box\mathtt{F}_7), unbox(\Box\Gamma_{14}) \vdash \mathtt{F}_{12}}\,\mathtt{ax/W}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{11}, \Box\Gamma_{14} \vdash \Delta_{13}, \mathtt{F}_8, []\mathtt{F}_{12}}K}{- : \Delta_{11}, \Box\Gamma_{14} \vdash \Delta_{13}, \mathtt{F}_8, []\mathtt{F}_{12}}\,\mathtt{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \Box\Gamma_{14} \vdash \Box\mathtt{F}_7, \Delta_{13}, \mathtt{F}_9, []\mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : unbox(\Box\mathtt{F}}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{11}}}{- : \Delta_{11}, \Box\Gamma_{14} \vdash \Delta_{13}, \mathtt{F}_9, []\mathtt{F}_{12}}\wedge$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_{14} \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{13}, []\mathtt{F}_{12} \quad \mathtt{h}_2 : \Box\Gamma_{11}, \Delta_{14} \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{13}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_{14} \vdash ((\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7}\wedge_R \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_7 \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9}K}{- : \Box\Gamma_{11}, \Delta_{14} \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

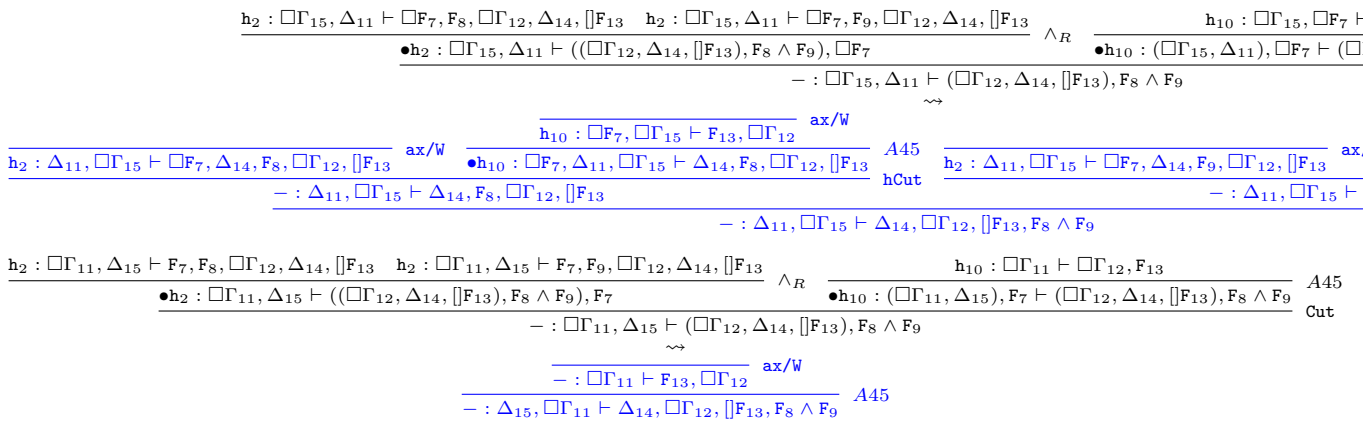
$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{11} \vdash \Delta_{13}, []\mathtt{F}_{12}, \mathtt{F}_8 \wedge \mathtt{F}_9}K$$

- Case rule $A45$

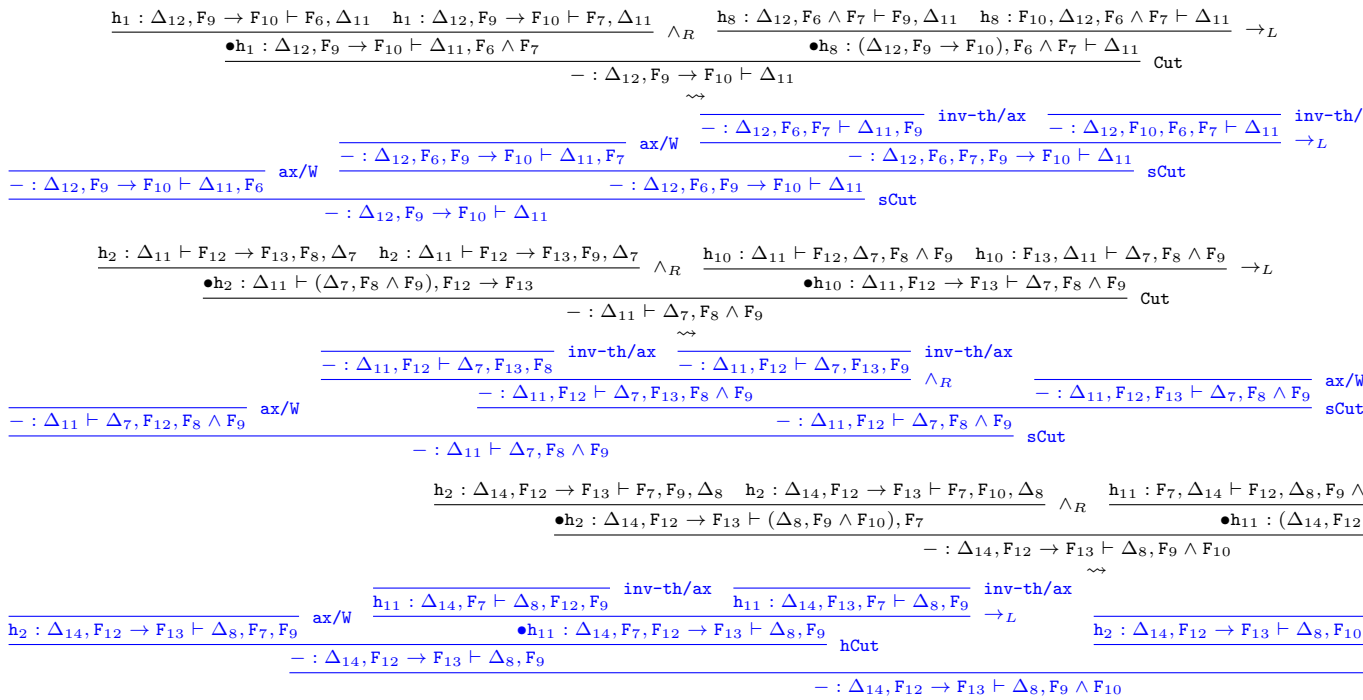
$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_9, \Delta_{13} \vdash \mathtt{F}_6, \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12} \quad \mathtt{h}_1 : \Box\Gamma_9, \Delta_{13} \vdash \mathtt{F}_7, \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_1 : \Box\Gamma_9, \Delta_{13} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_6 \wedge \mathtt{F}_7}\wedge_R \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_8 : (\Box\Gamma_9, \Delta_{13}), \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}A45}{- : \Box\Gamma_9, \Delta_{13} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

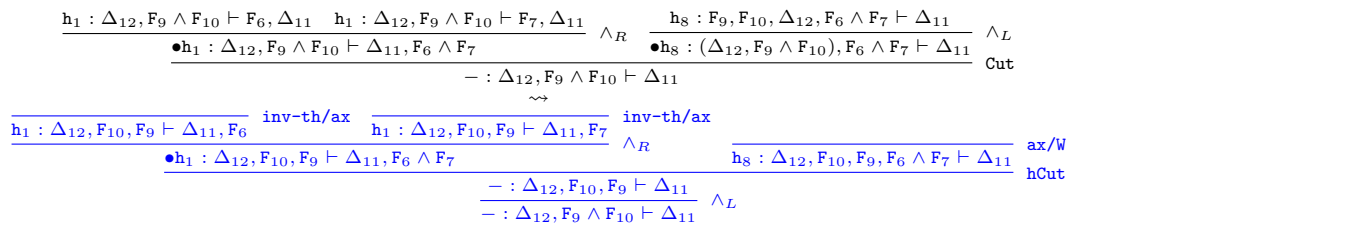
$$\dfrac{\dfrac{}{- : \Box\Gamma_9 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\,\mathtt{ax/W}}{- : \Delta_{13}, \Box\Gamma_9 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}A45$$

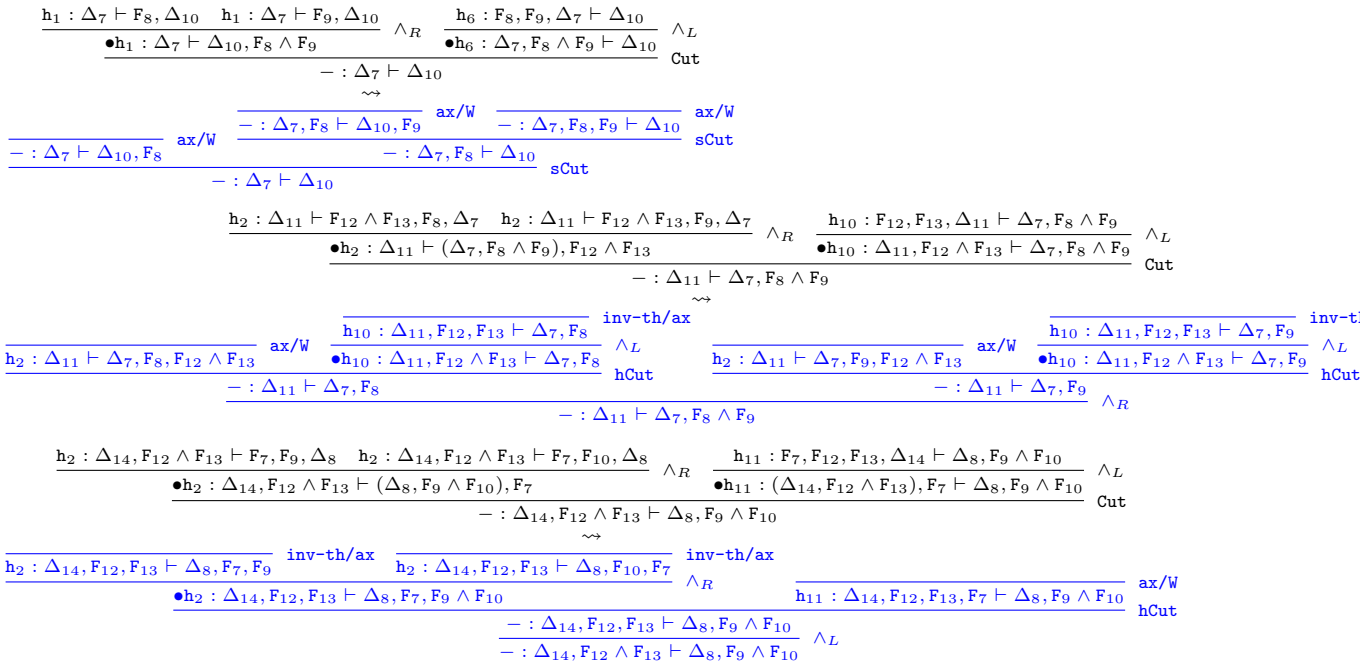


- Case rule $\rightarrow_L$

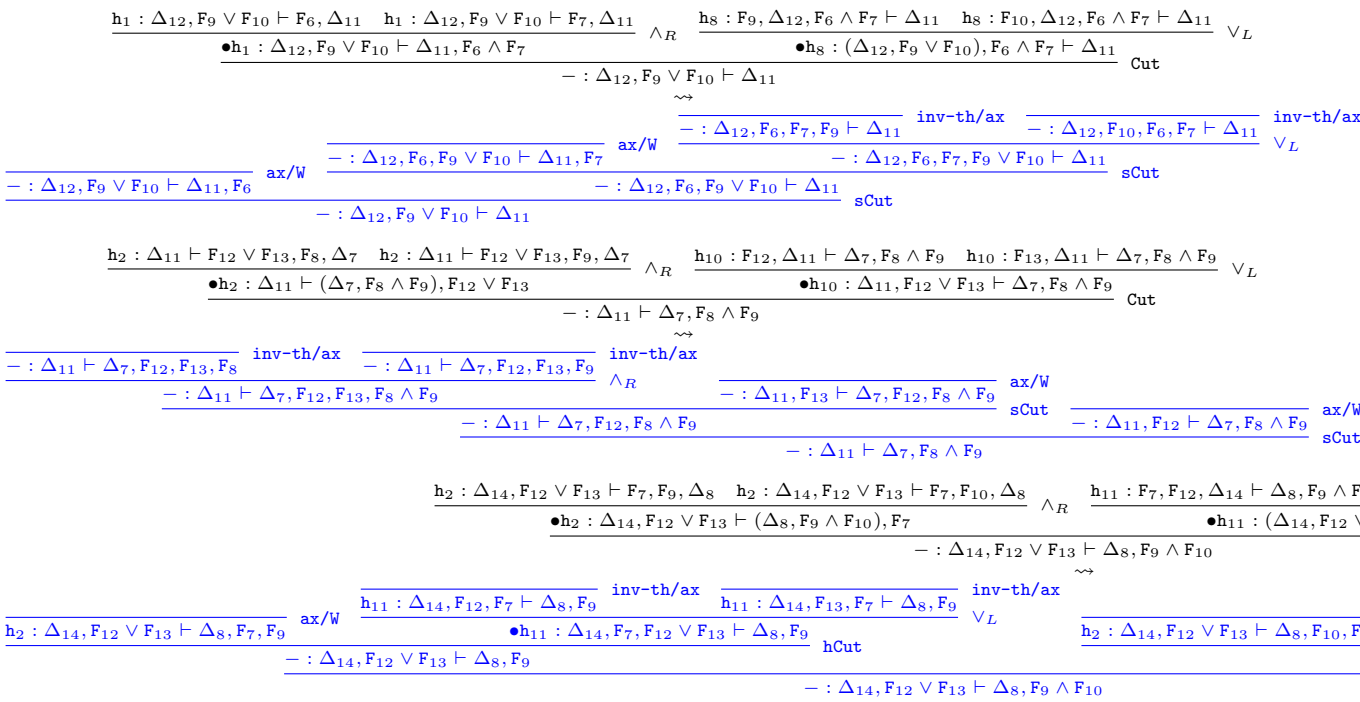


- Case rule $\wedge_L$

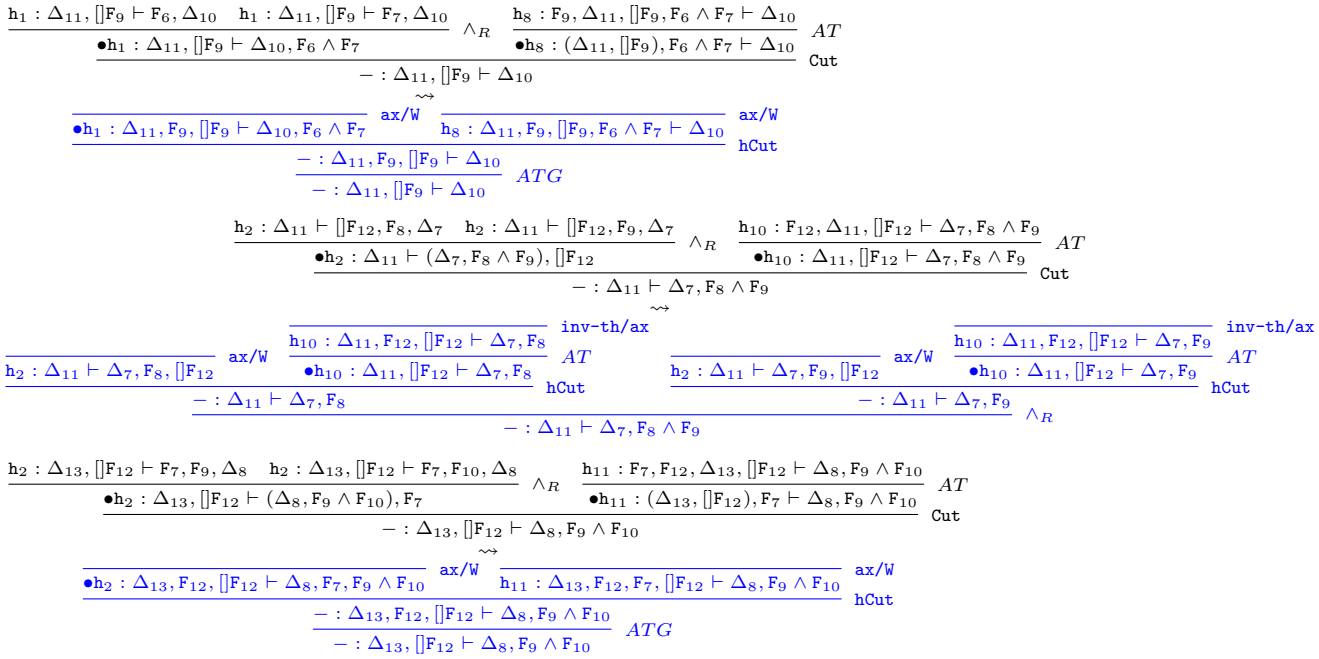




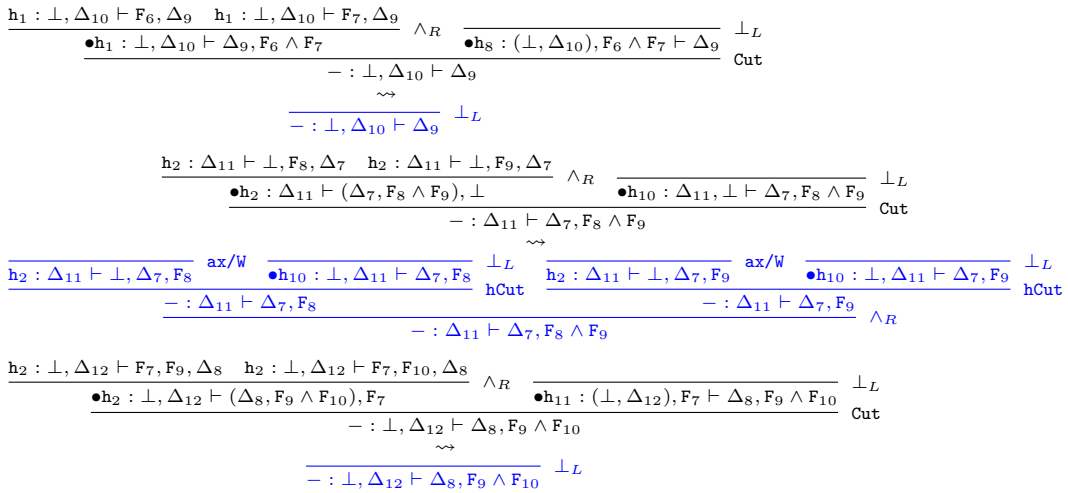
- Case rule $\vee_L$



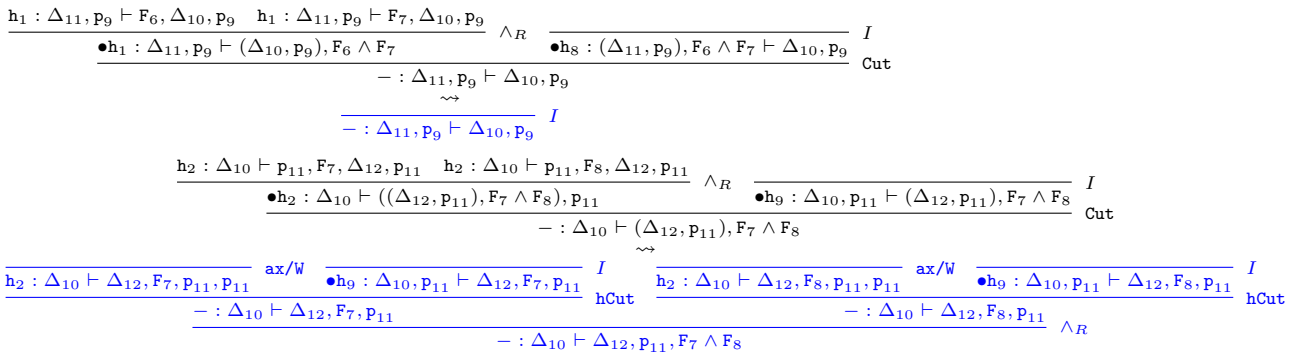
- Case rule AT



- Case rule $\bot_L$



- Case rule I



$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{13}, \mathtt{p}_{11} \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{12}, \mathtt{p}_{11} \quad \mathtt{h}_2 : \Delta_{13}, \mathtt{p}_{11} \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{12}, \mathtt{p}_{11}}{\bullet\mathtt{h}_2 : \Delta_{13}, \mathtt{p}_{11} \vdash ((\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7}\ \wedge_R \quad \dfrac{}{\bullet\mathtt{h}_{10} : (\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_7 \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_8 \wedge \mathtt{F}_9}\ I}{- : \Delta_{13}, \mathtt{p}_{11} \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_8 \wedge \mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{13}, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9}\ I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \top, \Delta_{10} \vdash \mathtt{F}_6, \Delta_9 \quad \mathtt{h}_1 : \top, \Delta_{10} \vdash \mathtt{F}_7, \Delta_9}{\bullet\mathtt{h}_1 : \top, \Delta_{10} \vdash \Delta_9, \mathtt{F}_6 \wedge \mathtt{F}_7}\ \wedge_R \quad \dfrac{\mathtt{h}_8 : \Delta_{10}, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_9}{\bullet\mathtt{h}_8 : (\top, \Delta_{10}), \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_9}\ \top_L}{- : \top, \Delta_{10} \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \top, \Delta_{10} \vdash \Delta_9, \mathtt{F}_6 \wedge \mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \top, \Delta_{10}, \mathtt{F}_6 \wedge \mathtt{F}_7 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \top, \Delta_{10} \vdash \Delta_9}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{11} \vdash \top, \mathtt{F}_8, \mathtt{F}_7 \quad \mathtt{h}_2 : \Delta_{11} \vdash \top, \mathtt{F}_9, \mathtt{F}_7}{\bullet\mathtt{h}_2 : \Delta_{11} \vdash (\mathtt{F}_7, \mathtt{F}_8 \wedge \mathtt{F}_9), \top}\ \wedge_R \quad \dfrac{\mathtt{h}_{10} : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9}{\bullet\mathtt{h}_{10} : \Delta_{11}, \top \vdash \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \top_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \top, \Delta_{12} \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_8 \quad \mathtt{h}_2 : \top, \Delta_{12} \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_8}{\bullet\mathtt{h}_2 : \top, \Delta_{12} \vdash (\Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7}\ \wedge_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\top, \Delta_{12}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ \top_L}{- : \top, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_2 : \top, \Delta_{12} \vdash \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \top, \Delta_{12}, \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \top, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ \mathtt{hCut}$$

6.3 Status of $\vee_R$: OK

- Case rule $\to_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}), \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_{11}, \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\ \to_R}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_8}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_6, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_{11}, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_6, \mathtt{F}_{11} \vdash \Delta_{10}, \mathtt{F}_{12}}\ \mathtt{hCut}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\ \to_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{10}, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7}\ \vee_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{12}, \Delta_8 \vdash \mathtt{F}_{13}, \Delta_{14}, \mathtt{F}_9 \vee \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \to_R}{- : \Delta_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8, \mathtt{F}_{12} \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_2 : \Delta_8, \mathtt{F}_{12} \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \vee_R \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{12}, \mathtt{F}_7 \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_{12} \vdash \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{hCut}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \to_R$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \mathtt{F}_{11}, \Delta_{10} \quad \mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\ \wedge_R}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_7, \mathtt{F}_8}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11}}\ \mathtt{ax/W}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}}\ \mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_8}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{12}, \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{12}}\ \mathtt{hCut}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\ \wedge_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{10}, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7}\ \vee_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{12}, \Delta_{14}, \mathtt{F}_9 \vee \mathtt{F}_{10} \quad \mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{13}, \Delta_{14}, \mathtt{F}_9 \vee \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \wedge_R}{- : \Delta_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12}, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{13}, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_9, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\ \wedge_R}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_9, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\ \mathtt{hCut}$$

$$\dfrac{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_9, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \vee_R$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}), \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\ \vee_R}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_8}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\ \mathtt{hCut}$$

$$\dfrac{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}{- : \Delta_6 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\ \vee_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{10}, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7}\ \vee_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_{14}, \mathtt{F}_9 \vee \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \vee_R}{- : \Delta_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{10}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \vee_R \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{hCut}$$

$$\dfrac{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10}}{- : \Delta_8 \vdash \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \vee_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash (\Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}), \mathtt{F}_7}\ \vee_R \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\ \vee_R}{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\ \mathtt{H}}{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\ \mathtt{hCut}$$

$$\dfrac{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}{- : \Delta_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\ \vee_R$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \mathtt{F}_8, \bot, \Delta_{10}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\bot, \Delta_{10}), \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_{10}}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \bot, \Delta_{10}}\ \bot_R}{- : \Delta_6 \vdash \bot, \Delta_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \bot, \Delta_{10}}\ \mathtt{ax/W}}{- : \Delta_6 \vdash \bot, \Delta_{10}}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{10}, \bot, \Delta_{12}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\bot, \Delta_{12}), \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7}\ \vee_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8 \vdash \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\bot, \Delta_{12}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \bot_R}{- : \Delta_8 \vdash (\bot, \Delta_{12}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_2 : \Delta_8 \vdash \bot, \Delta_{12}, \mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash \bot, \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_8 \vdash \bot, \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{hCut}$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_6 \vdash \mathtt{F}_7, \mathtt{F}_8, \top, \Delta_{10}}{\bullet\mathtt{h}_1 : \Delta_6 \vdash (\top, \Delta_{10}), \mathtt{F}_7 \vee \mathtt{F}_8}\vee_R \quad \dfrac{}{\bullet\mathtt{h}_9 : \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \top, \Delta_{10}}\top_R}{- : \Delta_6 \vdash \top, \Delta_{10}}\,\mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6 \vdash \top, \Delta_{10}}\top_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{10}, \top, \Delta_{12}}{\bullet\mathtt{h}_2 : \Delta_8 \vdash ((\top, \Delta_{12}), \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7}\vee_R \quad \dfrac{}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7 \vdash (\top, \Delta_{12}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\top_R}{- : \Delta_8 \vdash (\top, \Delta_{12}), \mathtt{F}_9 \vee \mathtt{F}_{10}}\,\mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_8 \vdash \top, \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\top_R$$

- Case rule K

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_9, \Delta_{12} \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_{10}, []\mathtt{F}_{11}}{\bullet\mathtt{h}_1 : \Box\Gamma_9, \Delta_{12} \vdash (\Delta_{10}, []\mathtt{F}_{11}), \mathtt{F}_6 \vee \mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_8 : unbox(\Box\Gamma_9) \vdash \mathtt{F}_{11}}{\bullet\mathtt{h}_8 : (\Box\Gamma_9, \Delta_{12}), \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_{11}}K}{- : \Box\Gamma_9, \Delta_{12} \vdash \Delta_{10}, []\mathtt{F}_{11}}\,\mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_9) \vdash \mathtt{F}_{11}}\,\mathtt{ax/W}}{- : \Delta_{12}, \Box\Gamma_9 \vdash \Delta_{10}, []\mathtt{F}_{11}}K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Delta_{11} \vdash \Box\mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9, \Delta_{13}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_{14}, \Delta_{11} \vdash ((\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9), \Box\mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{14}), unbox(\Box\mathtt{F}_7) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{14}, \Delta_{11}), \Box\mathtt{F}_7 \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9}K}{- : \Box\Gamma_{14}, \Delta_{11} \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9}\,\mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \Box\Gamma_{14} \vdash \Box\mathtt{F}_7, \Delta_{13}, \mathtt{F}_8, \mathtt{F}_9, []\mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : unbox(\Box\mathtt{F}_7), unbox(\Box\Gamma_{14}) \vdash \mathtt{F}_{12}}\,\mathtt{ax/W}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{11}, \Box\Gamma_{14} \vdash \Delta_{13}, \mathtt{F}_8, \mathtt{F}_9, []\mathtt{F}_{12}}K}{- : \Delta_{11}, \Box\Gamma_{14} \vdash \Delta_{13}, \mathtt{F}_8, \mathtt{F}_9, []\mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_{11}, \Box\Gamma_{14} \vdash \Delta_{13}, []\mathtt{F}_{12}, \mathtt{F}_8 \vee \mathtt{F}_9}\vee_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_{14} \vdash \mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9, \Delta_{13}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_{14} \vdash ((\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_7 \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9}K}{- : \Box\Gamma_{11}, \Delta_{14} \vdash (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9}\,\mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{11} \vdash \Delta_{13}, []\mathtt{F}_{12}, \mathtt{F}_8 \vee \mathtt{F}_9}K$$

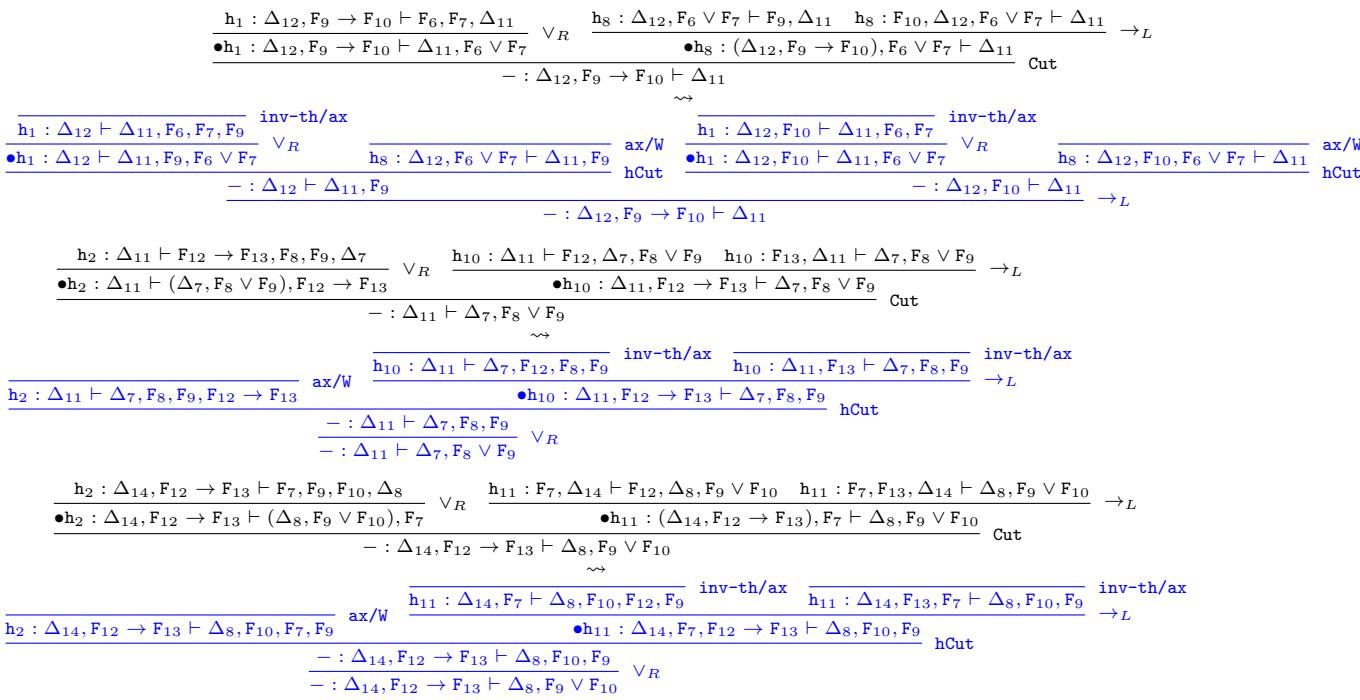
- Case rule $A45$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_9, \Delta_{13} \vdash \mathtt{F}_6, \mathtt{F}_7, \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_1 : \Box\Gamma_9, \Delta_{13} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_6 \vee \mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_8 : (\Box\Gamma_9, \Delta_{13}), \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}A45}{- : \Box\Gamma_9, \Delta_{13} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\,\mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_9 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\,\mathtt{ax/W}}{- : \Delta_{13}, \Box\Gamma_9 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}A45$$

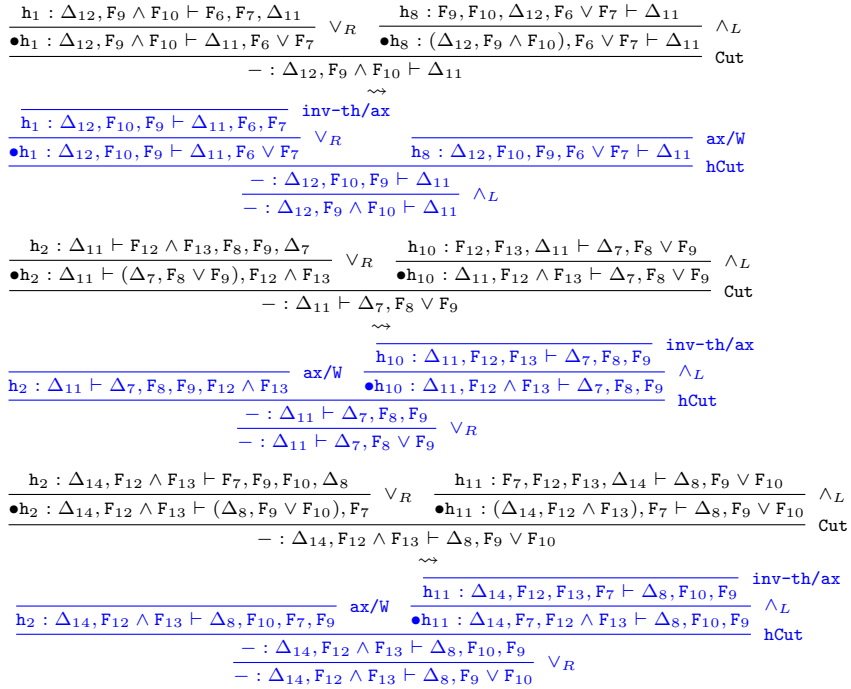
$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{15}, \Delta_{11} \vdash \Box\mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Box\Gamma_{15}, \Delta_{11} \vdash ((\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \vee \mathtt{F}_9), \Box\mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{15}, \Box\mathtt{F}_7 \vdash \Box\Gamma_{12}, \mathtt{F}_{13}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{15}, \Delta_{11}), \Box\mathtt{F}_7 \vdash (\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \vee \mathtt{F}_9}A45}{- : \Box\Gamma_{15}, \Delta_{11} \vdash (\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \vee \mathtt{F}_9}\,\mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11}, \Box\Gamma_{15} \vdash \Box\mathtt{F}_7, \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{12}, []\mathtt{F}_{13}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Box\mathtt{F}_7, \Box\Gamma_{15} \vdash \mathtt{F}_{13}, \Box\Gamma_{12}}\,\mathtt{ax/W}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{11}, \Box\Gamma_{15} \vdash \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{12}, []\mathtt{F}_{13}}A45}{- : \Delta_{11}, \Box\Gamma_{15} \vdash \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{12}, []\mathtt{F}_{13}}\,\mathtt{hCut}}{- : \Delta_{11}, \Box\Gamma_{15} \vdash \Delta_{14}, \Box\Gamma_{12}, []\mathtt{F}_{13}, \mathtt{F}_8 \vee \mathtt{F}_9}\vee_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_{15} \vdash \mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}}{\bullet\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_{15} \vdash ((\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{11} \vdash \Box\Gamma_{12}, \mathtt{F}_{13}}{\bullet\mathtt{h}_{10} : (\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_7 \vdash (\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \vee \mathtt{F}_9}A45}{- : \Box\Gamma_{11}, \Delta_{15} \vdash (\Box\Gamma_{12}, \Delta_{14}, []\mathtt{F}_{13}), \mathtt{F}_8 \vee \mathtt{F}_9}\,\mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{11} \vdash \mathtt{F}_{13}, \Box\Gamma_{12}}\,\mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{11} \vdash \Delta_{14}, \Box\Gamma_{12}, []\mathtt{F}_{13}, \mathtt{F}_8 \vee \mathtt{F}_9}A45$$

- Case rule $\to_L$



- Case rule $\wedge_L$



- Case rule $\vee_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_{11}}{\bullet\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6 \vee \mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_9, \Delta_{12}, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{11} \quad \mathtt{h}_8 : \mathtt{F}_{10}, \Delta_{12}, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : (\Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{11}}\vee_L}{- : \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_6, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_6 \vee \mathtt{F}_7}\vee_R \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_9, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{11}}\,\mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6 \vee \mathtt{F}_7}\vee_R \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{11}}\,\mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_{10} \vdash \Delta_{11}}\,\mathtt{hCut}}{- : \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\vee_L$$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_7 \vdash \mathtt{F}_8, \mathtt{F}_9, \Delta_{10}}{\bullet\mathtt{h}_1 : \Delta_7 \vdash \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9}\vee_R \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_8, \Delta_7 \vdash \Delta_{10} \quad \mathtt{h}_6 : \mathtt{F}_9, \Delta_7 \vdash \Delta_{10}}{\bullet\mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{10}}\vee_L}{- : \Delta_7 \vdash \Delta_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{- : \Delta_7 \vdash \Delta_{10}, \mathtt{F}_8, \mathtt{F}_9}\,\mathtt{ax/W} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_9 \vdash \Delta_{10}, \mathtt{F}_8}\,\mathtt{ax/W}}{- : \Delta_7 \vdash \Delta_{10}, \mathtt{F}_8}\,\mathtt{sCut} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_8 \vdash \Delta_{10}}\,\mathtt{ax/W}}{- : \Delta_7 \vdash \Delta_{10}}\,\mathtt{sCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{11} \vdash \mathtt{F}_{12} \vee \mathtt{F}_{13}, \mathtt{F}_8, \mathtt{F}_9, \Delta_7}{\bullet\mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_{12} \vee \mathtt{F}_{13}}\vee_R \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{12}, \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \quad \mathtt{h}_{10} : \mathtt{F}_{13}, \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}{\bullet\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\vee_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{13} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\vee_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\,\mathtt{hCut}}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\vee_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8}{\bullet\mathtt{h}_2 : \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{12}, \Delta_{14} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \quad \mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{13}, \Delta_{14} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\vee_L}{- : \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_7, \mathtt{F}_9}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{13}, \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9}\vee_L}{- : \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9}\,\mathtt{hCut}}{- : \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\vee_R$$

- Case rule AT

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_{11}, []\mathtt{F}_9 \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_{10}}{\bullet\mathtt{h}_1 : \Delta_{11}, []\mathtt{F}_9 \vdash \Delta_{10}, \mathtt{F}_6 \vee \mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_9, \Delta_{11}, []\mathtt{F}_9, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{10}}{\bullet\mathtt{h}_8 : (\Delta_{11}, []\mathtt{F}_9), \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{10}}\,AT}{- : \Delta_{11}, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_{11}, \mathtt{F}_9, []\mathtt{F}_9 \vdash \Delta_{10}, \mathtt{F}_6 \vee \mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \Delta_{11}, \mathtt{F}_9, []\mathtt{F}_9, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{10}}\,\mathtt{ax/W}}{- : \Delta_{11}, \mathtt{F}_9, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{hCut}}{- : \Delta_{11}, []\mathtt{F}_9 \vdash \Delta_{10}}\,ATG$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{11} \vdash []\mathtt{F}_{12}, \mathtt{F}_8, \mathtt{F}_9, \Delta_7}{\bullet\mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9), []\mathtt{F}_{12}}\vee_R \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{12}, \Delta_{11}, []\mathtt{F}_{12} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}{\bullet\mathtt{h}_{10} : \Delta_{11}, []\mathtt{F}_{12} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\,AT}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9, []\mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_{11}, \mathtt{F}_{12}, []\mathtt{F}_{12} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{10} : \Delta_{11}, []\mathtt{F}_{12} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\,AT}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\,\mathtt{hCut}}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\vee_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{13}, []\mathtt{F}_{12} \vdash \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8}{\bullet\mathtt{h}_2 : \Delta_{13}, []\mathtt{F}_{12} \vdash (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{12}, \Delta_{13}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\,AT}{- : \Delta_{13}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\bullet\mathtt{h}_2 : \Delta_{13}, \mathtt{F}_{12}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10}}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{13}, \mathtt{F}_{12}, \mathtt{F}_7, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_{13}, \mathtt{F}_{12}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\,\mathtt{hCut}}{- : \Delta_{13}, []\mathtt{F}_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\,AT$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \bot, \Delta_{10} \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_9}{\bullet\mathtt{h}_1 : \bot, \Delta_{10} \vdash \Delta_9, \mathtt{F}_6 \vee \mathtt{F}_7}\vee_R \quad \dfrac{}{\bullet\mathtt{h}_8 : (\bot, \Delta_{10}), \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_9}\bot_L}{- : \bot, \Delta_{10} \vdash \Delta_9}\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \bot, \Delta_{10} \vdash \Delta_9}\bot_L$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{11} \vdash \bot, \mathtt{F}_8, \mathtt{F}_9, \Delta_7}{\bullet\mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9), \bot}\vee_R \quad \dfrac{}{\bullet\mathtt{h}_{10} : \Delta_{11}, \bot \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\bot_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{11} \vdash \bot, \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_{10} : \bot, \Delta_{11} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\bot_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8, \mathtt{F}_9}\mathtt{hCut}}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\vee_R$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \bot, \Delta_{12} \vdash \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8}{\bullet\mathtt{h}_2 : \bot, \Delta_{12} \vdash (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7}\vee_R \quad \dfrac{}{\bullet\mathtt{h}_{11} : (\bot, \Delta_{12}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\bot_L}{- : \bot, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \bot, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\bot_L$$

- Case rule I

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Delta_{11}, \mathtt{p}_9 \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_{10}, \mathtt{p}_9}{\bullet\mathtt{h}_1 : \Delta_{11}, \mathtt{p}_9 \vdash (\Delta_{10}, \mathtt{p}_9), \mathtt{F}_6 \vee \mathtt{F}_7}\vee_R \quad \dfrac{}{\bullet\mathtt{h}_8 : (\Delta_{11}, \mathtt{p}_9), \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9}I}{- : \Delta_{11}, \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_9}\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_{11}, \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_9}I$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{10} \vdash \mathtt{p}_{11}, \mathtt{F}_7, \mathtt{F}_8, \Delta_{12}, \mathtt{p}_{11}}{\bullet\mathtt{h}_2 : \Delta_{10} \vdash ((\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_7 \vee \mathtt{F}_8), \mathtt{p}_{11}}\vee_R \quad \dfrac{}{\bullet\mathtt{h}_9 : \Delta_{10}, \mathtt{p}_{11} \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_7 \vee \mathtt{F}_8}I}{- : \Delta_{10} \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_7 \vee \mathtt{F}_8}\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{10} \vdash \Delta_{12}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{p}_{11}, \mathtt{p}_{11}}\mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_9 : \Delta_{10}, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{p}_{11}}I}{- : \Delta_{10} \vdash \Delta_{12}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{p}_{11}}\mathtt{hCut}}{- : \Delta_{10} \vdash \Delta_{12}, \mathtt{p}_{11}, \mathtt{F}_7 \vee \mathtt{F}_8}\vee_R$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{13}, \mathtt{p}_{11} \vdash \mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9, \Delta_{12}, \mathtt{p}_{11}}{\bullet\mathtt{h}_2 : \Delta_{13}, \mathtt{p}_{11} \vdash ((\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_7}\vee_R \quad \dfrac{}{\bullet\mathtt{h}_{10} : (\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_7 \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_8 \vee \mathtt{F}_9}I}{- : \Delta_{13}, \mathtt{p}_{11} \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_8 \vee \mathtt{F}_9}\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_{13}, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}, \mathtt{F}_8 \vee \mathtt{F}_9}I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \top, \Delta_{10} \vdash \mathtt{F}_6, \mathtt{F}_7, \Delta_9}{\bullet\mathtt{h}_1 : \top, \Delta_{10} \vdash \Delta_9, \mathtt{F}_6 \vee \mathtt{F}_7}\vee_R \quad \dfrac{\mathtt{h}_8 : \Delta_{10}, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_9}{\bullet\mathtt{h}_8 : (\top, \Delta_{10}), \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_9}\top_L}{- : \top, \Delta_{10} \vdash \Delta_9}\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \top, \Delta_{10} \vdash \Delta_9, \mathtt{F}_6 \vee \mathtt{F}_7}\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \top, \Delta_{10}, \mathtt{F}_6 \vee \mathtt{F}_7 \vdash \Delta_9}\mathtt{ax/W}}{- : \top, \Delta_{10} \vdash \Delta_9}\mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{11} \vdash \top, \mathtt{F}_8, \mathtt{F}_9, \Delta_7}{\bullet\mathtt{h}_2 : \Delta_{11} \vdash (\Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9), \top}\vee_R \quad \dfrac{\mathtt{h}_{10} : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}{\bullet\mathtt{h}_{10} : \Delta_{11}, \top \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\top_L}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_{11} \vdash \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9}\mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \top, \Delta_{12} \vdash \mathtt{F}_7, \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8}{\bullet\mathtt{h}_2 : \top, \Delta_{12} \vdash (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7}\ \vee_R \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\top, \Delta_{12}), \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \top_L}{- : \top, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_2 : \top, \Delta_{12} \vdash \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \top, \Delta_{12}, \mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \top, \Delta_{12} \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{hCut}$$

6.4 Status of $\bot_R$: OK

- Case rule $\rightarrow_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Delta_4 \vdash (\Delta_6, \mathtt{F}_7 \to \mathtt{F}_8), \bot}\ \bot_R \quad \dfrac{\mathtt{h}_5 : \bot, \mathtt{F}_7, \Delta_4 \vdash \mathtt{F}_8, \Delta_6}{\bullet\mathtt{h}_5 : \Delta_4, \bot \vdash \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8}\ \to_R}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_6 \vdash \mathtt{F}_5, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9}{\bullet\mathtt{h}_2 : \Delta_6 \vdash (\bot, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_8, \Delta_6 \vdash \bot, \mathtt{F}_9, \Delta_{10}}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9}\ \to_R}{- : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_5, \mathtt{F}_8 \to \mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9}\ \mathtt{hCut}$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Delta_4 \vdash (\Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8), \bot}\ \bot_R \quad \dfrac{\mathtt{h}_5 : \bot, \Delta_4 \vdash \mathtt{F}_7, \Delta_6 \quad \mathtt{h}_5 : \bot, \Delta_4 \vdash \mathtt{F}_8, \Delta_6}{\bullet\mathtt{h}_5 : \Delta_4, \bot \vdash \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8}\ \wedge_R}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_6 \vdash \mathtt{F}_5, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9}{\bullet\mathtt{h}_2 : \Delta_6 \vdash (\bot, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_6 \vdash \bot, \mathtt{F}_8, \Delta_{10} \quad \mathtt{h}_7 : \mathtt{F}_5, \Delta_6 \vdash \bot, \mathtt{F}_9, \Delta_{10}}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \wedge_R}{- : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_5, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \mathtt{hCut}$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Delta_4 \vdash (\Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8), \bot}\ \bot_R \quad \dfrac{\mathtt{h}_5 : \bot, \Delta_4 \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_6}{\bullet\mathtt{h}_5 : \Delta_4, \bot \vdash \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_6 \vdash \mathtt{F}_5, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9}{\bullet\mathtt{h}_2 : \Delta_6 \vdash (\bot, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_6 \vdash \bot, \mathtt{F}_8, \mathtt{F}_9, \Delta_{10}}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9}\ \vee_R}{- : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_5, \mathtt{F}_8 \vee \mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_6 \vdash \bot, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9}\ \mathtt{hCut}$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_4 \vdash \bot, \Delta_6}{\bullet\mathtt{h}_1 : \Delta_4 \vdash (\bot, \Delta_6), \bot}\ \bot_R \quad \dfrac{\mathtt{h}_5 : \bot, \Delta_4 \vdash \Delta_6}{\bullet\mathtt{h}_5 : \Delta_4, \bot \vdash \bot, \Delta_6}\ \bot_R}{- : \Delta_4 \vdash \bot, \Delta_6}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_4 \vdash \bot, \Delta_6}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_6 \vdash \mathtt{F}_5, \Delta_8}{\bullet\mathtt{h}_2 : \Delta_6 \vdash (\bot, \Delta_8), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_6 \vdash \Delta_8}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \bot, \Delta_8}\ \bot_R}{- : \Delta_6 \vdash \bot, \Delta_8}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_6 \vdash \bot, \Delta_8, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \bot, \Delta_8}\ \mathtt{ax/W}}{- : \Delta_6 \vdash \bot, \Delta_8}\ \mathtt{hCut}$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Delta_4 \vdash \top, \Delta_6}{\bullet\mathtt{h}_1 : \Delta_4 \vdash (\top, \Delta_6), \bot}\ \bot_R \quad \dfrac{}{\bullet\mathtt{h}_5 : \Delta_4, \bot \vdash \top, \Delta_6}\ \top_R}{- : \Delta_4 \vdash \top, \Delta_6}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_4 \vdash \top, \Delta_6}\ \top_R$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_6 \vdash \mathtt{F}_5, \top, \Delta_8}{\bullet\mathtt{h}_2 : \Delta_6 \vdash (\bot, \top, \Delta_8), \mathtt{F}_5}\ \bot_R \quad \dfrac{}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \bot, \top, \Delta_8}\ \top_R}{- : \Delta_6 \vdash \bot, \top, \Delta_8}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_6 \vdash \bot, \top, \Delta_8}\ \top_R$$

- Case rule K

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_5, \Delta_8 \vdash \Delta_6, []\mathtt{F}_7}{\bullet\mathtt{h}_1 : \Box\Gamma_5, \Delta_8 \vdash (\Delta_6, []\mathtt{F}_7), \bot}\ \bot_R \quad \dfrac{\mathtt{h}_4 : unbox(\Box\Gamma_5) \vdash \mathtt{F}_7}{\bullet\mathtt{h}_4 : (\Box\Gamma_5, \Delta_8), \bot \vdash \Delta_6, []\mathtt{F}_7}\ K}{- : \Box\Gamma_5, \Delta_8 \vdash \Delta_6, []\mathtt{F}_7}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_8, \Box\Gamma_5 \vdash \Delta_6, []\mathtt{F}_7}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{10}, \Delta_7 \vdash \Box\mathtt{F}_5, \Delta_9, []\mathtt{F}_8}{\bullet\mathtt{h}_2 : \Box\Gamma_{10}, \Delta_7 \vdash (\bot, \Delta_9, []\mathtt{F}_8), \Box\mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_6 : unbox(\Box\Gamma_{10}), unbox(\Box\mathtt{F}_5) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_6 : (\Box\Gamma_{10}, \Delta_7), \Box\mathtt{F}_5 \vdash \bot, \Delta_9, []\mathtt{F}_8}\ K}{- : \Box\Gamma_{10}, \Delta_7 \vdash \bot, \Delta_9, []\mathtt{F}_8}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_7, \Box\Gamma_{10} \vdash \bot, \Box\mathtt{F}_5, \Delta_9, []\mathtt{F}_8}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \Box\mathtt{F}_5, \Delta_7, \Box\Gamma_{10} \vdash \bot, \Delta_9, []\mathtt{F}_8}\ \mathtt{ax/W}}{- : \Delta_7, \Box\Gamma_{10} \vdash \bot, \Delta_9, []\mathtt{F}_8}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_7, \Delta_{10} \vdash \mathtt{F}_5, \Delta_9, []\mathtt{F}_8}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_{10} \vdash (\bot, \Delta_9, []\mathtt{F}_8), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_6 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_6 : (\Box\Gamma_7, \Delta_{10}), \mathtt{F}_5 \vdash \bot, \Delta_9, []\mathtt{F}_8}\ K}{- : \Box\Gamma_7, \Delta_{10} \vdash \bot, \Delta_9, []\mathtt{F}_8}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_8}\ \mathtt{ax/W}}{- : \Delta_{10}, \Box\Gamma_7 \vdash \bot, \Delta_9, []\mathtt{F}_8}\ K$$

- Case rule $A45$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_5, \Delta_9 \vdash \Box\Gamma_6, \Delta_7, []\mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_5, \Delta_9 \vdash (\Box\Gamma_6, \Delta_7, []\mathtt{F}_8), \bot}\ \bot_R \quad \dfrac{\mathtt{h}_4 : \Box\Gamma_5 \vdash \Box\Gamma_6, \mathtt{F}_8}{\bullet\mathtt{h}_4 : (\Box\Gamma_5, \Delta_9), \bot \vdash \Box\Gamma_6, \Delta_7, []\mathtt{F}_8}\ A45}{- : \Box\Gamma_5, \Delta_9 \vdash \Box\Gamma_6, \Delta_7, []\mathtt{F}_8}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_9, \Box\Gamma_5 \vdash \Delta_7, \Box\Gamma_6, []\mathtt{F}_8}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_7 \vdash \Box\mathtt{F}_5, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_{11}, \Delta_7 \vdash (\bot, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9), \Box\mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_6 : \Box\Gamma_{11}, \Box\mathtt{F}_5 \vdash \Box\Gamma_8, \mathtt{F}_9}{\bullet\mathtt{h}_6 : (\Box\Gamma_{11}, \Delta_7), \Box\mathtt{F}_5 \vdash \bot, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}\ A45}{- : \Box\Gamma_{11}, \Delta_7 \vdash \bot, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_7, \Box\Gamma_{11} \vdash \bot, \Box\mathtt{F}_5, \Delta_{10}, \Box\Gamma_8, []\mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \Box\mathtt{F}_5, \Delta_7, \Box\Gamma_{11} \vdash \bot, \Delta_{10}, \Box\Gamma_8, []\mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_7, \Box\Gamma_{11} \vdash \bot, \Delta_{10}, \Box\Gamma_8, []\mathtt{F}_9}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_7, \Delta_{11} \vdash \mathtt{F}_5, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_{11} \vdash (\bot, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_6 : \Box\Gamma_7 \vdash \Box\Gamma_8, \mathtt{F}_9}{\bullet\mathtt{h}_6 : (\Box\Gamma_7, \Delta_{11}), \mathtt{F}_5 \vdash \bot, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}\ A45}{- : \Box\Gamma_7, \Delta_{11} \vdash \bot, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_7 \vdash \mathtt{F}_9, \Box\Gamma_8}\ \mathtt{ax/W}}{- : \Delta_{11}, \Box\Gamma_7 \vdash \bot, \Delta_{10}, \Box\Gamma_8, []\mathtt{F}_9}\ A45$$

- Case rule $\to_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \to \mathtt{F}_6 \vdash \Delta_7}{\bullet\mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \to \mathtt{F}_6 \vdash \Delta_7, \bot}\ \bot_R \quad \dfrac{\mathtt{h}_4 : \bot, \Delta_8 \vdash \mathtt{F}_5, \Delta_7 \quad \mathtt{h}_4 : \bot, \mathtt{F}_6, \Delta_8 \vdash \Delta_7}{\bullet\mathtt{h}_4 : (\Delta_8, \mathtt{F}_5 \to \mathtt{F}_6), \bot \vdash \Delta_7}\ \to_L}{- : \Delta_8, \mathtt{F}_5 \to \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_8, \mathtt{F}_5 \to \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_7 \vdash \mathtt{F}_8 \to \mathtt{F}_9, \Delta_5}{\bullet\mathtt{h}_2 : \Delta_7 \vdash (\bot, \Delta_5), \mathtt{F}_8 \to \mathtt{F}_9}\ \bot_R \quad \dfrac{\mathtt{h}_6 : \Delta_7 \vdash \bot, \mathtt{F}_8, \Delta_5 \quad \mathtt{h}_6 : \mathtt{F}_9, \Delta_7 \vdash \bot, \Delta_5}{\bullet\mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \bot, \Delta_5}\ \to_L}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_7 \vdash \bot, \Delta_5, \mathtt{F}_8 \to \mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \bot, \Delta_5}\ \mathtt{ax/W}}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \mathtt{F}_5, \Delta_6}{\bullet\mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash (\bot, \Delta_6), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_{10} \vdash \bot, \mathtt{F}_8, \Delta_6 \quad \mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_9, \Delta_{10} \vdash \bot, \Delta_6}{\bullet\mathtt{h}_7 : (\Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_5 \vdash \bot, \Delta_6}\ \to_L}{- : \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \bot, \Delta_6}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \bot, \Delta_6, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \Delta_{10}, \mathtt{F}_5, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \bot, \Delta_6}\ \mathtt{ax/W}}{- : \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \bot, \Delta_6}\ \mathtt{hCut}$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \wedge \mathtt{F}_6 \vdash \Delta_7}{\bullet\mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \wedge \mathtt{F}_6 \vdash \Delta_7, \bot}\ \bot_R \quad \dfrac{\mathtt{h}_4 : \bot, \mathtt{F}_5, \mathtt{F}_6, \Delta_8 \vdash \Delta_7}{\bullet\mathtt{h}_4 : (\Delta_8, \mathtt{F}_5 \wedge \mathtt{F}_6), \bot \vdash \Delta_7}\ \wedge_L}{- : \Delta_8, \mathtt{F}_5 \wedge \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_8, \mathtt{F}_5 \wedge \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_7 \vdash \mathtt{F}_8 \wedge \mathtt{F}_9, \Delta_5}{\bullet\mathtt{h}_2 : \Delta_7 \vdash (\bot, \Delta_5), \mathtt{F}_8 \wedge \mathtt{F}_9}\ \bot_R \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_8, \mathtt{F}_9, \Delta_7 \vdash \bot, \Delta_5}{\bullet\mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \bot, \Delta_5}\ \wedge_L}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_7 \vdash \bot, \Delta_5, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \bot, \Delta_5}\ \mathtt{ax/W}}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \mathtt{F}_5, \Delta_6}{\bullet\mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash (\bot, \Delta_6), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_8, \mathtt{F}_9, \Delta_{10} \vdash \bot, \Delta_6}{\bullet\mathtt{h}_7 : (\Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_5 \vdash \bot, \Delta_6}\ \wedge_L}{- : \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \bot, \Delta_6}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \bot, \Delta_6, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \Delta_{10}, \mathtt{F}_5, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \bot, \Delta_6}\ \mathtt{ax/W}}{- : \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \bot, \Delta_6}\ \mathtt{hCut}$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \vee \mathtt{F}_6 \vdash \Delta_7}{\bullet\mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \vee \mathtt{F}_6 \vdash \Delta_7, \bot}\ \bot_R \quad \dfrac{\mathtt{h}_4 : \bot, \mathtt{F}_5, \Delta_8 \vdash \Delta_7 \quad \mathtt{h}_4 : \bot, \mathtt{F}_6, \Delta_8 \vdash \Delta_7}{\bullet\mathtt{h}_4 : (\Delta_8, \mathtt{F}_5 \vee \mathtt{F}_6), \bot \vdash \Delta_7}\ \vee_L}{- : \Delta_8, \mathtt{F}_5 \vee \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_8, \mathtt{F}_5 \vee \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_7 \vdash \mathtt{F}_8 \vee \mathtt{F}_9, \Delta_5}{\bullet \mathtt{h}_2 : \Delta_7 \vdash (\bot, \Delta_5), \mathtt{F}_8 \vee \mathtt{F}_9}\ \bot_R \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_8, \Delta_7 \vdash \bot, \Delta_5 \quad \mathtt{h}_6 : \mathtt{F}_9, \Delta_7 \vdash \bot, \Delta_5}{\bullet \mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \bot, \Delta_5}\ \vee_L}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{Cut}}{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_7 \vdash \bot, \Delta_5, \mathtt{F}_8 \vee \mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \bot, \Delta_5}\ \mathtt{ax/W}}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{hCut}}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \mathtt{F}_5, \Delta_6}{\bullet \mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash (\bot, \Delta_6), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_8, \Delta_{10} \vdash \bot, \Delta_6 \quad \mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_9, \Delta_{10} \vdash \bot, \Delta_6}{\bullet \mathtt{h}_7 : (\Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_5 \vdash \bot, \Delta_6}\ \vee_L}{- : \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \bot, \Delta_6}\ \mathtt{Cut}}{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \bot, \Delta_6, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_7 : \Delta_{10}, \mathtt{F}_5, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \bot, \Delta_6}\ \mathtt{ax/W}}{- : \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \bot, \Delta_6}\ \mathtt{hCut}}$$

- Case rule AT

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Delta_7, []\mathtt{F}_5 \vdash \Delta_6}{\bullet \mathtt{h}_1 : \Delta_7, []\mathtt{F}_5 \vdash \Delta_6, \bot}\ \bot_R \quad \dfrac{\mathtt{h}_4 : \bot, \mathtt{F}_5, \Delta_7, []\mathtt{F}_5 \vdash \Delta_6}{\bullet \mathtt{h}_4 : (\Delta_7, []\mathtt{F}_5), \bot \vdash \Delta_6}\ AT}{- : \Delta_7, []\mathtt{F}_5 \vdash \Delta_6}\ \mathtt{Cut}}{\dfrac{}{- : \Delta_7, []\mathtt{F}_5 \vdash \Delta_6}\ \mathtt{ax/W}}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_7 \vdash []\mathtt{F}_8, \Delta_5}{\bullet \mathtt{h}_2 : \Delta_7 \vdash (\bot, \Delta_5), []\mathtt{F}_8}\ \bot_R \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_8, \Delta_7, []\mathtt{F}_8 \vdash \bot, \Delta_5}{\bullet \mathtt{h}_6 : \Delta_7, []\mathtt{F}_8 \vdash \bot, \Delta_5}\ AT}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{Cut}}{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_7 \vdash \bot, \Delta_5, []\mathtt{F}_8}\ \mathtt{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_6 : \Delta_7, []\mathtt{F}_8 \vdash \bot, \Delta_5}\ \mathtt{ax/W}}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{hCut}}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_9, []\mathtt{F}_8 \vdash \mathtt{F}_5, \Delta_6}{\bullet \mathtt{h}_2 : \Delta_9, []\mathtt{F}_8 \vdash (\bot, \Delta_6), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_8, \Delta_9, []\mathtt{F}_8 \vdash \bot, \Delta_6}{\bullet \mathtt{h}_7 : (\Delta_9, []\mathtt{F}_8), \mathtt{F}_5 \vdash \bot, \Delta_6}\ AT}{- : \Delta_9, []\mathtt{F}_8 \vdash \bot, \Delta_6}\ \mathtt{Cut}}{\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_9, []\mathtt{F}_8 \vdash \bot, \Delta_6, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_7 : \Delta_9, \mathtt{F}_5, []\mathtt{F}_8 \vdash \bot, \Delta_6}\ \mathtt{ax/W}}{- : \Delta_9, []\mathtt{F}_8 \vdash \bot, \Delta_6}\ \mathtt{hCut}}$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Delta_5 \vdash \Delta_6}{\bullet \mathtt{h}_1 : \Delta_5 \vdash \Delta_6, \bot}\ \bot_R \quad \dfrac{}{\bullet \mathtt{h}_4 : \Delta_5, \bot \vdash \Delta_6}\ \bot_L}{- : \Delta_5 \vdash \Delta_6}\ \mathtt{Cut}}{\dfrac{}{- : \Delta_5 \vdash \Delta_6}\ \mathtt{ax/W}}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Delta_7 \vdash \bot, \Delta_5}{\bullet \mathtt{h}_2 : \Delta_7 \vdash (\bot, \Delta_5), \bot}\ \bot_R \quad \dfrac{}{\bullet \mathtt{h}_6 : \Delta_7, \bot \vdash \bot, \Delta_5}\ \bot_L}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{Cut}}{\dfrac{}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{ax/W}}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \bot, \Delta_8 \vdash \mathtt{F}_5, \Delta_6}{\bullet \mathtt{h}_2 : \bot, \Delta_8 \vdash (\bot, \Delta_6), \mathtt{F}_5}\ \bot_R \quad \dfrac{}{\bullet \mathtt{h}_7 : (\bot, \Delta_8), \mathtt{F}_5 \vdash \bot, \Delta_6}\ \bot_L}{- : \bot, \Delta_8 \vdash \bot, \Delta_6}\ \mathtt{Cut}}{\dfrac{}{- : \bot, \Delta_8 \vdash \bot, \Delta_6}\ \bot_L}$$

- Case rule I

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Delta_7, \mathtt{p}_5 \vdash \Delta_6, \mathtt{p}_5}{\bullet \mathtt{h}_1 : \Delta_7, \mathtt{p}_5 \vdash (\Delta_6, \mathtt{p}_5), \bot}\ \bot_R \quad \dfrac{}{\bullet \mathtt{h}_4 : (\Delta_7, \mathtt{p}_5), \bot \vdash \Delta_6, \mathtt{p}_5}\ I}{- : \Delta_7, \mathtt{p}_5 \vdash \Delta_6, \mathtt{p}_5}\ \mathtt{Cut}}{\dfrac{}{- : \Delta_7, \mathtt{p}_5 \vdash \Delta_6, \mathtt{p}_5}\ I}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_6 \vdash \mathtt{p}_7, \Delta_8, \mathtt{p}_7}{\bullet\mathtt{h}_2 : \Delta_6 \vdash (\bot, \Delta_8, \mathtt{p}_7), \mathtt{p}_7}\ \bot_R \quad \dfrac{}{\bullet\mathtt{h}_5 : \Delta_6, \mathtt{p}_7 \vdash \bot, \Delta_8, \mathtt{p}_7}\ I}{- : \Delta_6 \vdash \bot, \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Delta_6 \vdash \bot, \Delta_8, \mathtt{p}_7, \mathtt{p}_7}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_5 : \Delta_6, \mathtt{p}_7 \vdash \bot, \Delta_8, \mathtt{p}_7}\ I}{- : \Delta_6 \vdash \bot, \Delta_8, \mathtt{p}_7}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_9, \mathtt{p}_7 \vdash \mathtt{F}_5, \Delta_8, \mathtt{p}_7}{\bullet\mathtt{h}_2 : \Delta_9, \mathtt{p}_7 \vdash (\bot, \Delta_8, \mathtt{p}_7), \mathtt{F}_5}\ \bot_R \quad \dfrac{}{\bullet\mathtt{h}_6 : (\Delta_9, \mathtt{p}_7), \mathtt{F}_5 \vdash \bot, \Delta_8, \mathtt{p}_7}\ I}{- : \Delta_9, \mathtt{p}_7 \vdash \bot, \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_9, \mathtt{p}_7 \vdash \bot, \Delta_8, \mathtt{p}_7}\ I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \top, \Delta_6 \vdash \Delta_5}{\bullet\mathtt{h}_1 : \top, \Delta_6 \vdash \Delta_5, \bot}\ \bot_R \quad \dfrac{\mathtt{h}_4 : \bot, \Delta_6 \vdash \Delta_5}{\bullet\mathtt{h}_4 : (\top, \Delta_6), \bot \vdash \Delta_5}\ \top_L}{- : \top, \Delta_6 \vdash \Delta_5}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \top, \Delta_6 \vdash \Delta_5}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Delta_7 \vdash \top, \Delta_5}{\bullet\mathtt{h}_2 : \Delta_7 \vdash (\bot, \Delta_5), \top}\ \bot_R \quad \dfrac{\mathtt{h}_6 : \Delta_7 \vdash \bot, \Delta_5}{\bullet\mathtt{h}_6 : \Delta_7, \top \vdash \bot, \Delta_5}\ \top_L}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7 \vdash \bot, \Delta_5}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \top, \Delta_8 \vdash \mathtt{F}_5, \Delta_6}{\bullet\mathtt{h}_2 : \top, \Delta_8 \vdash (\bot, \Delta_6), \mathtt{F}_5}\ \bot_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_8 \vdash \bot, \Delta_6}{\bullet\mathtt{h}_7 : (\top, \Delta_8), \mathtt{F}_5 \vdash \bot, \Delta_6}\ \top_L}{- : \top, \Delta_8 \vdash \bot, \Delta_6}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \top, \Delta_8 \vdash \bot, \Delta_6, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \top, \Delta_8, \mathtt{F}_5 \vdash \bot, \Delta_6}\ \mathtt{ax/W}}{- : \top, \Delta_8 \vdash \bot, \Delta_6}\ \mathtt{hCut}$$

6.5 Status of $\top_R$: OK

- Case rule $\to_R$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_4 \vdash (\Delta_6, \mathtt{F}_7 \to \mathtt{F}_8), \top}\ \top_R \quad \dfrac{\mathtt{h}_5 : \top, \mathtt{F}_7, \Delta_4 \vdash \mathtt{F}_8, \Delta_6}{\bullet\mathtt{h}_5 : \Delta_4, \top \vdash \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8}\ \to_R}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_4, \mathtt{F}_7 \vdash \top, \Delta_6, \mathtt{F}_8}\ \top_R \quad \dfrac{}{\mathtt{h}_5 : \top, \Delta_4, \mathtt{F}_7 \vdash \Delta_6, \mathtt{F}_8}\ \mathtt{ax/W}}{- : \Delta_4, \mathtt{F}_7 \vdash \Delta_6, \mathtt{F}_8}\ \mathtt{hCut}$$

$$\dfrac{}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \to \mathtt{F}_8}\ \to_R$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_2 : \Delta_6 \vdash (\top, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_8, \Delta_6 \vdash \top, \mathtt{F}_9, \Delta_{10}}{\bullet\mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \top, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9}\ \to_R}{- : \Delta_6 \vdash \top, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_6 \vdash \top, \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9}\ \top_R$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_4 \vdash (\Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8), \top}\ \top_R \quad \dfrac{\mathtt{h}_5 : \top, \Delta_4 \vdash \mathtt{F}_7, \Delta_6 \quad \mathtt{h}_5 : \top, \Delta_4 \vdash \mathtt{F}_8, \Delta_6}{\bullet\mathtt{h}_5 : \Delta_4, \top \vdash \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8}\ \wedge_R}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_4 \vdash \top, \Delta_6, \mathtt{F}_7}\ \top_R \quad \dfrac{}{\mathtt{h}_5 : \top, \Delta_4 \vdash \Delta_6, \mathtt{F}_7}\ \mathtt{ax/W}}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7}\ \mathtt{hCut} \quad \dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_4 \vdash \top, \Delta_6, \mathtt{F}_8}\ \top_R \quad \dfrac{}{\mathtt{h}_5 : \top, \Delta_4 \vdash \Delta_6, \mathtt{F}_8}\ \mathtt{ax/W}}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_8}\ \mathtt{hCut}}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \wedge \mathtt{F}_8}\ \wedge_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6 \vdash (\top, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_6 \vdash \top, \mathtt{F}_8, \Delta_{10} \quad \mathtt{h}_7 : \mathtt{F}_5, \Delta_6 \vdash \top, \mathtt{F}_9, \Delta_{10}}{\bullet \mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \top, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \wedge_R}{- : \Delta_6 \vdash \top, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6 \vdash \top, \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9}\ \top_R$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_4 \vdash (\Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8), \top}\ \top_R \quad \dfrac{\mathtt{h}_5 : \top, \Delta_4 \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_6}{\bullet \mathtt{h}_5 : \Delta_4, \top \vdash \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_4 \vdash \top, \Delta_6, \mathtt{F}_7, \mathtt{F}_8}\ \top_R \quad \dfrac{}{\mathtt{h}_5 : \top, \Delta_4 \vdash \Delta_6, \mathtt{F}_7, \mathtt{F}_8}\ \mathtt{ax/W}}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7, \mathtt{F}_8}\ \mathtt{hCut}}{- : \Delta_4 \vdash \Delta_6, \mathtt{F}_7 \vee \mathtt{F}_8}\ \vee_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6 \vdash (\top, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_6 \vdash \top, \mathtt{F}_8, \mathtt{F}_9, \Delta_{10}}{\bullet \mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \top, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9}\ \vee_R}{- : \Delta_6 \vdash \top, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6 \vdash \top, \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9}\ \top_R$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_4 \vdash (\bot, \Delta_6), \top}\ \top_R \quad \dfrac{\mathtt{h}_5 : \top, \Delta_4 \vdash \Delta_6}{\bullet \mathtt{h}_5 : \Delta_4, \top \vdash \bot, \Delta_6}\ \bot_R}{- : \Delta_4 \vdash \bot, \Delta_6}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_4 \vdash \bot, \top, \Delta_6}\ \top_R \quad \dfrac{}{\mathtt{h}_5 : \top, \Delta_4 \vdash \bot, \Delta_6}\ \mathtt{ax/W}}{- : \Delta_4 \vdash \bot, \Delta_6}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6 \vdash (\top, \bot, \Delta_8), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_6 \vdash \top, \Delta_8}{\bullet \mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \top, \bot, \Delta_8}\ \bot_R}{- : \Delta_6 \vdash \top, \bot, \Delta_8}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6 \vdash \bot, \top, \Delta_8}\ \top_R$$

- Case rule $\top_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_4 \vdash (\top, \Delta_6), \top}\ \top_R \quad \dfrac{}{\bullet \mathtt{h}_5 : \Delta_4, \top \vdash \top, \Delta_6}\ \top_R}{- : \Delta_4 \vdash \top, \Delta_6}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_4 \vdash \top, \Delta_6}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6 \vdash (\top, \Delta_8), \mathtt{F}_5}\ \top_R \quad \dfrac{}{\bullet \mathtt{h}_7 : \Delta_6, \mathtt{F}_5 \vdash \top, \Delta_8}\ \top_R}{- : \Delta_6 \vdash \top, \Delta_8}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6 \vdash \top, \Delta_8}\ \top_R$$

- Case rule K

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Box\Gamma_5, \Delta_8 \vdash (\Delta_6, []\mathtt{F}_7), \top}\ \top_R \quad \dfrac{\mathtt{h}_4 : unbox(\Box\Gamma_5) \vdash \mathtt{F}_7}{\bullet \mathtt{h}_4 : (\Box\Gamma_5, \Delta_8), \top \vdash \Delta_6, []\mathtt{F}_7}\ K}{- : \Box\Gamma_5, \Delta_8 \vdash \Delta_6, []\mathtt{F}_7}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_5) \vdash \mathtt{F}_7}\ \mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_5 \vdash \Delta_6, []\mathtt{F}_7}\ K$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Box\Gamma_{10}, \Delta_7 \vdash (\top, \Delta_9, []\mathtt{F}_8), \Box\mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_6 : unbox(\Box\Gamma_{10}), unbox(\Box\mathtt{F}_5) \vdash \mathtt{F}_8}{\bullet \mathtt{h}_6 : (\Box\Gamma_{10}, \Delta_7), \Box\mathtt{F}_5 \vdash \top, \Delta_9, []\mathtt{F}_8}\ K}{- : \Box\Gamma_{10}, \Delta_7 \vdash \top, \Delta_9, []\mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7, \Box\Gamma_{10} \vdash \top, \Delta_9, []\mathtt{F}_8}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Box\Gamma_7, \Delta_{10} \vdash (\top, \Delta_9, []\mathtt{F}_8), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_6 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_8}{\bullet \mathtt{h}_6 : (\Box\Gamma_7, \Delta_{10}), \mathtt{F}_5 \vdash \top, \Delta_9, []\mathtt{F}_8}\ K}{- : \Box\Gamma_7, \Delta_{10} \vdash \top, \Delta_9, []\mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{10}, \Box\Gamma_7 \vdash \top, \Delta_9, []\mathtt{F}_8}\ \top_R$$

- Case rule $A45$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Box\Gamma_5, \Delta_9 \vdash (\Box\Gamma_6, \Delta_7, []\mathtt{F}_8), \top}\ \top_R \quad \dfrac{\mathtt{h}_4 : \Box\Gamma_5 \vdash \Box\Gamma_6, \mathtt{F}_8}{\bullet \mathtt{h}_4 : (\Box\Gamma_5, \Delta_9), \top \vdash \Box\Gamma_6, \Delta_7, []\mathtt{F}_8}\ A45}{- : \Box\Gamma_5, \Delta_9 \vdash \Box\Gamma_6, \Delta_7, []\mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_5 \vdash \mathtt{F}_8, \Box\Gamma_6}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_5 \vdash \Delta_7, \Box\Gamma_6, []\mathtt{F}_8}\ A45$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Box\Gamma_{11}, \Delta_7 \vdash (\top, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9), \Box\mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_6 : \Box\Gamma_{11}, \Box\mathtt{F}_5 \vdash \Box\Gamma_8, \mathtt{F}_9}{\bullet \mathtt{h}_6 : (\Box\Gamma_{11}, \Delta_7), \Box\mathtt{F}_5 \vdash \top, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}\ A45}{- : \Box\Gamma_{11}, \Delta_7 \vdash \top, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7, \Box\Gamma_{11} \vdash \top, \Delta_{10}, \Box\Gamma_8, []\mathtt{F}_9}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Box\Gamma_7, \Delta_{11} \vdash (\top, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_6 : \Box\Gamma_7 \vdash \Box\Gamma_8, \mathtt{F}_9}{\bullet \mathtt{h}_6 : (\Box\Gamma_7, \Delta_{11}), \mathtt{F}_5 \vdash \top, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}\ A45}{- : \Box\Gamma_7, \Delta_{11} \vdash \top, \Box\Gamma_8, \Delta_{10}, []\mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{11}, \Box\Gamma_7 \vdash \top, \Delta_{10}, \Box\Gamma_8, []\mathtt{F}_9}\ \top_R$$

- Case rule $\rightarrow_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \to \mathtt{F}_6 \vdash \Delta_7, \top}\ \top_R \quad \dfrac{\mathtt{h}_4 : \top, \Delta_8 \vdash \mathtt{F}_5, \Delta_7 \quad \mathtt{h}_4 : \top, \mathtt{F}_6, \Delta_8 \vdash \Delta_7}{\bullet \mathtt{h}_4 : (\Delta_8, \mathtt{F}_5 \to \mathtt{F}_6), \top \vdash \Delta_7}\ \to_L}{- : \Delta_8, \mathtt{F}_5 \to \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_8 \vdash \top, \Delta_7, \mathtt{F}_5}\ \top_R \quad \dfrac{}{\mathtt{h}_4 : \top, \Delta_8 \vdash \Delta_7, \mathtt{F}_5}\ \mathtt{ax/W}}{- : \Delta_8 \vdash \Delta_7, \mathtt{F}_5}\ \mathtt{hCut} \quad \dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_8, \mathtt{F}_6 \vdash \top, \Delta_7}\ \top_R \quad \dfrac{}{\mathtt{h}_4 : \top, \Delta_8, \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{hCut}}{- : \Delta_8, \mathtt{F}_5 \to \mathtt{F}_6 \vdash \Delta_7}\ \to_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7 \vdash (\top, \Delta_5), \mathtt{F}_8 \to \mathtt{F}_9}\ \top_R \quad \dfrac{\mathtt{h}_6 : \Delta_7 \vdash \top, \mathtt{F}_8, \Delta_5 \quad \mathtt{h}_6 : \mathtt{F}_9, \Delta_7 \vdash \top, \Delta_5}{\bullet \mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \top, \Delta_5}\ \to_L}{- : \Delta_7 \vdash \top, \Delta_5}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7 \vdash \top, \Delta_5}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash (\top, \Delta_6), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_{10} \vdash \top, \mathtt{F}_8, \Delta_6 \quad \mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_9, \Delta_{10} \vdash \top, \Delta_6}{\bullet \mathtt{h}_7 : (\Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_5 \vdash \top, \Delta_6}\ \to_L}{- : \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \top, \Delta_6}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{10}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \top, \Delta_6}\ \top_R$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \wedge \mathtt{F}_6 \vdash \Delta_7, \top}\ \top_R \quad \dfrac{\mathtt{h}_4 : \top, \mathtt{F}_5, \mathtt{F}_6, \Delta_8 \vdash \Delta_7}{\bullet \mathtt{h}_4 : (\Delta_8, \mathtt{F}_5 \wedge \mathtt{F}_6), \top \vdash \Delta_7}\ \wedge_L}{- : \Delta_8, \mathtt{F}_5 \wedge \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_8, \mathtt{F}_5, \mathtt{F}_6 \vdash \top, \Delta_7}\ \top_R \quad \dfrac{}{\mathtt{h}_4 : \top, \Delta_8, \mathtt{F}_5, \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_5, \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{hCut}}{- : \Delta_8, \mathtt{F}_5 \wedge \mathtt{F}_6 \vdash \Delta_7}\ \wedge_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7 \vdash (\top, \Delta_5), \mathtt{F}_8 \wedge \mathtt{F}_9}\ \top_R \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_8, \mathtt{F}_9, \Delta_7 \vdash \top, \Delta_5}{\bullet \mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \top, \Delta_5}\ \wedge_L}{- : \Delta_7 \vdash \top, \Delta_5}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7 \vdash \top, \Delta_5}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash (\top, \Delta_6), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_8, \mathtt{F}_9, \Delta_{10} \vdash \top, \Delta_6}{\bullet \mathtt{h}_7 : (\Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_5 \vdash \top, \Delta_6}\ \wedge_L}{- : \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \top, \Delta_6}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{10}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \top, \Delta_6}\ \top_R$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \vee \mathtt{F}_6 \vdash \Delta_7, \top}\ \top_R \quad \dfrac{\mathtt{h}_4 : \top, \mathtt{F}_5, \Delta_8 \vdash \Delta_7 \quad \mathtt{h}_4 : \top, \mathtt{F}_6, \Delta_8 \vdash \Delta_7}{\bullet \mathtt{h}_4 : (\Delta_8, \mathtt{F}_5 \vee \mathtt{F}_6), \top \vdash \Delta_7}\ \vee_L}{- : \Delta_8, \mathtt{F}_5 \vee \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_8, \mathtt{F}_5 \vdash \top, \Delta_7}\ \top_R \quad \dfrac{}{\mathtt{h}_4 : \top, \Delta_8, \mathtt{F}_5 \vdash \Delta_7}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_5 \vdash \Delta_7}\ \mathtt{hCut} \quad \dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_8, \mathtt{F}_6 \vdash \top, \Delta_7}\ \top_R \quad \dfrac{}{\mathtt{h}_4 : \top, \Delta_8, \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_6 \vdash \Delta_7}\ \mathtt{hCut}}{- : \Delta_8, \mathtt{F}_5 \vee \mathtt{F}_6 \vdash \Delta_7}\ \vee_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7 \vdash (\top, \Delta_5), \mathtt{F}_8 \vee \mathtt{F}_9}\ \top_R \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_8, \Delta_7 \vdash \top, \Delta_5 \quad \mathtt{h}_6 : \mathtt{F}_9, \Delta_7 \vdash \top, \Delta_5}{\bullet \mathtt{h}_6 : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \top, \Delta_5}\ \vee_L}{- : \Delta_7 \vdash \top, \Delta_5}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7 \vdash \top, \Delta_5}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash (\top, \Delta_6), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_8, \Delta_{10} \vdash \top, \Delta_6 \quad \mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_9, \Delta_{10} \vdash \top, \Delta_6}{\bullet \mathtt{h}_7 : (\Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_5 \vdash \top, \Delta_6}\ \vee_L}{- : \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \top, \Delta_6}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{10}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \top, \Delta_6}\ \top_R$$

- Case rule AT

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_7, []\mathtt{F}_5 \vdash \Delta_6, \top}\ \top_R \quad \dfrac{\mathtt{h}_4 : \top, \mathtt{F}_5, \Delta_7, []\mathtt{F}_5 \vdash \Delta_6}{\bullet \mathtt{h}_4 : (\Delta_7, []\mathtt{F}_5), \top \vdash \Delta_6}\ AT}{- : \Delta_7, []\mathtt{F}_5 \vdash \Delta_6}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_7, \mathtt{F}_5, []\mathtt{F}_5 \vdash \top, \Delta_6}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_4 : \top, \Delta_7, \mathtt{F}_5, []\mathtt{F}_5 \vdash \Delta_6}\ \mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_5, []\mathtt{F}_5 \vdash \Delta_6}\ \mathtt{hCut}}{- : \Delta_7, []\mathtt{F}_5 \vdash \Delta_6}\ AT$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7 \vdash (\top, \Delta_5), []\mathtt{F}_8}\ \top_R \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_8, \Delta_7, []\mathtt{F}_8 \vdash \top, \Delta_5}{\bullet \mathtt{h}_6 : \Delta_7, []\mathtt{F}_8 \vdash \top, \Delta_5}\ AT}{- : \Delta_7 \vdash \top, \Delta_5}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7 \vdash \top, \Delta_5}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_9, []\mathtt{F}_8 \vdash (\top, \Delta_6), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \mathtt{F}_8, \Delta_9, []\mathtt{F}_8 \vdash \top, \Delta_6}{\bullet \mathtt{h}_7 : (\Delta_9, []\mathtt{F}_8), \mathtt{F}_5 \vdash \top, \Delta_6}\ AT}{- : \Delta_9, []\mathtt{F}_8 \vdash \top, \Delta_6}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_9, []\mathtt{F}_8 \vdash \top, \Delta_6}\ \top_R$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \bot, \Delta_6 \vdash \Delta_5, \top}\ \top_R \quad \dfrac{}{\bullet \mathtt{h}_4 : (\bot, \Delta_6), \top \vdash \Delta_5}\ \bot_L}{- : \bot, \Delta_6 \vdash \Delta_5}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_6 \vdash \Delta_5}\ \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7 \vdash (\top, \Delta_5), \bot}\ \top_R \quad \dfrac{}{\bullet \mathtt{h}_6 : \Delta_7, \bot \vdash \top, \Delta_5}\ \bot_L}{- : \Delta_7 \vdash \top, \Delta_5}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_7 \vdash \top, \Delta_5}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \bot, \Delta_8 \vdash (\top, \Delta_6), \mathtt{F}_5}\ \top_R \quad \dfrac{}{\bullet \mathtt{h}_7 : (\bot, \Delta_8), \mathtt{F}_5 \vdash \top, \Delta_6}\ \bot_L}{- : \bot, \Delta_8 \vdash \top, \Delta_6}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_8 \vdash \top, \Delta_6}\ \top_R$$

- Case rule I

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_7, \mathtt{p}_5 \vdash (\Delta_6, \mathtt{p}_5), \top}\ \top_R \quad \dfrac{}{\bullet \mathtt{h}_4 : (\Delta_7, \mathtt{p}_5), \top \vdash \Delta_6, \mathtt{p}_5}\ I}{- : \Delta_7, \mathtt{p}_5 \vdash \Delta_6, \mathtt{p}_5}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_7, \mathtt{p}_5 \vdash \Delta_6, \mathtt{p}_5}\ I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6 \vdash (\top, \Delta_8, \mathtt{p}_7), \mathtt{p}_7}\ \top_R \quad \dfrac{}{\bullet \mathtt{h}_5 : \Delta_6, \mathtt{p}_7 \vdash \top, \Delta_8, \mathtt{p}_7}\ I}{- : \Delta_6 \vdash \top, \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6 \vdash \top, \Delta_8, \mathtt{p}_7}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_9, \mathtt{p}_7 \vdash (\top, \Delta_8, \mathtt{p}_7), \mathtt{F}_5}\ \top_R \quad \dfrac{}{\bullet \mathtt{h}_6 : (\Delta_9, \mathtt{p}_7), \mathtt{F}_5 \vdash \top, \Delta_8, \mathtt{p}_7}\ I}{- : \Delta_9, \mathtt{p}_7 \vdash \top, \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_9, \mathtt{p}_7 \vdash \top, \Delta_8, \mathtt{p}_7}\ \top_R$$

- Case rule $\top_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5 \vdash \Delta_6, \top}\ \top_R \quad \dfrac{\mathtt{h}_4 : \Delta_5 \vdash \Delta_6}{\bullet \mathtt{h}_4 : \Delta_5, \top \vdash \Delta_6}\ \top_L}{- : \Delta_5 \vdash \Delta_6}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_5 \vdash \Delta_6}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7 \vdash (\top, \Delta_5), \top}\ \top_R \quad \dfrac{\mathtt{h}_6 : \Delta_7 \vdash \top, \Delta_5}{\bullet \mathtt{h}_6 : \Delta_7, \top \vdash \top, \Delta_5}\ \top_L}{- : \Delta_7 \vdash \top, \Delta_5}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_7 \vdash \top, \Delta_5}\ \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \top, \Delta_8 \vdash (\top, \Delta_6), \mathtt{F}_5}\ \top_R \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_8 \vdash \top, \Delta_6}{\bullet \mathtt{h}_7 : (\top, \Delta_8), \mathtt{F}_5 \vdash \top, \Delta_6}\ \top_L}{- : \top, \Delta_8 \vdash \top, \Delta_6}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \top, \Delta_8 \vdash \top, \Delta_6}\ \top_R$$

6.6 Status of K: OK

- Case rule $\to_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_7 \vdash (\Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}), []\mathtt{F}_8}\, K \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_6, \mathtt{F}_{11}, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : (\Box\Gamma_6, \Delta_7), []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\, {\to_R}}{- : \Box\Gamma_6, \Delta_7 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_8}\, \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_7, \mathtt{F}_{11}, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{12}, []\mathtt{F}_8}\, K \quad \dfrac{}{\mathtt{h}_9 : \Delta_7, \mathtt{F}_{11}, \Box\Gamma_6, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{12}}\, \mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_{11}, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{12}}\, \mathtt{hCut}$$

$$\dfrac{- : \Delta_7, \mathtt{F}_{11}, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{12}}{- : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\, {\to_R}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_9 \vdash ((\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), []\mathtt{F}_{10}), \mathtt{F}_8}\, K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \mathtt{F}_{12}, \Delta_9 \vdash \mathtt{F}_{13}, \Delta_{14}, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_9), \mathtt{F}_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), []\mathtt{F}_{10}}\, {\to_R}}{- : \Box\Gamma_7, \Delta_9 \vdash (\Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), []\mathtt{F}_{10}}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\, \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_7 \vdash \Delta_{14}, []\mathtt{F}_{10}, \mathtt{F}_{12} \to \mathtt{F}_{13}}\, K$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_7 \vdash (\Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), []\mathtt{F}_8}\, K \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_6, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_{11}, \Delta_{10} \quad \mathtt{h}_9 : \Box\Gamma_6, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : (\Box\Gamma_6, \Delta_7), []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\, {\wedge_R}}{- : \Box\Gamma_6, \Delta_7 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_8}\, \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{11}, []\mathtt{F}_8}\, K \quad \dfrac{}{\mathtt{h}_9 : \Delta_7, \Box\Gamma_6, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11}}\, \mathtt{ax/W}}{- : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{11}}\, \mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_8}\, \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{12}, []\mathtt{F}_8}\, K \quad \dfrac{}{\mathtt{h}_9 : \Delta_7, \Box\Gamma_6, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{12}}\, \mathtt{ax/W}}{- : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{12}}\, \mathtt{hCut}}{- : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\, {\wedge_R}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_9 \vdash ((\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), []\mathtt{F}_{10}), \mathtt{F}_8}\, K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \Delta_9 \vdash \mathtt{F}_{12}, \Delta_{14}, []\mathtt{F}_{10} \quad \mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \Delta_9 \vdash \mathtt{F}_{13}, \Delta_{14}, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_9), \mathtt{F}_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), []\mathtt{F}_{10}}\, {\wedge_R}}{- : \Box\Gamma_7, \Delta_9 \vdash (\Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), []\mathtt{F}_{10}}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\, \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_7 \vdash \Delta_{14}, []\mathtt{F}_{10}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\, K$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_7 \vdash (\Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}), []\mathtt{F}_8}\, K \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_6, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : (\Box\Gamma_6, \Delta_7), []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\, {\vee_R}}{- : \Box\Gamma_6, \Delta_7 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_8}\, \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}, []\mathtt{F}_8}\, K \quad \dfrac{}{\mathtt{h}_9 : \Delta_7, \Box\Gamma_6, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\, \mathtt{ax/W}}{- : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}\, \mathtt{hCut}$$

$$\dfrac{- : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{11}, \mathtt{F}_{12}}{- : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\, {\vee_R}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_9 \vdash ((\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), []\mathtt{F}_{10}), \mathtt{F}_8}\, K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \Delta_9 \vdash \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_{14}, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_9), \mathtt{F}_8 \vdash (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), []\mathtt{F}_{10}}\, {\vee_R}}{- : \Box\Gamma_7, \Delta_9 \vdash (\Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), []\mathtt{F}_{10}}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\, \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_7 \vdash \Delta_{14}, []\mathtt{F}_{10}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\, K$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_7 \vdash (\bot, \Delta_{10}), []\mathtt{F}_8}\, K \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_6, \Delta_7, []\mathtt{F}_8 \vdash \Delta_{10}}{\bullet\mathtt{h}_9 : (\Box\Gamma_6, \Delta_7), []\mathtt{F}_8 \vdash \bot, \Delta_{10}}\, {\bot_R}}{- : \Box\Gamma_6, \Delta_7 \vdash \bot, \Delta_{10}}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_7, \Box\Gamma_6 \vdash \bot, \Delta_{10}, []\mathtt{F}_8}\, \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_9 : \Delta_7, \Box\Gamma_6, []\mathtt{F}_8 \vdash \bot, \Delta_{10}}\, \mathtt{ax/W}}{- : \Delta_7, \Box\Gamma_6 \vdash \bot, \Delta_{10}}\, \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_9 \vdash ((\bot, \Delta_{12}), []\mathtt{F}_{10}), \mathtt{F}_8}\ K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \Delta_9 \vdash \Delta_{12}, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_9), \mathtt{F}_8 \vdash (\bot, \Delta_{12}), []\mathtt{F}_{10}}\ \bot_R}{- : \Box\Gamma_7, \Delta_9 \vdash (\bot, \Delta_{12}), []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_7 \vdash \bot, \Delta_{12}, []\mathtt{F}_{10}}\ K$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_7 \vdash (\top, \Delta_{10}), []\mathtt{F}_8}\ K \quad \dfrac{}{\bullet\mathtt{h}_9 : (\Box\Gamma_6, \Delta_7), []\mathtt{F}_8 \vdash \top, \Delta_{10}}\ \top_R}{- : \Box\Gamma_6, \Delta_7 \vdash \top, \Delta_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7, \Box\Gamma_6 \vdash \top, \Delta_{10}}\ \top_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_9 \vdash ((\top, \Delta_{12}), []\mathtt{F}_{10}), \mathtt{F}_8}\ K \quad \dfrac{}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_9), \mathtt{F}_8 \vdash (\top, \Delta_{12}), []\mathtt{F}_{10}}\ \top_R}{- : \Box\Gamma_7, \Delta_9 \vdash (\top, \Delta_{12}), []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_9, \Box\Gamma_7 \vdash \top, \Delta_{12}, []\mathtt{F}_{10}}\ \top_R$$

- Case rule K

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_{10}, \Box\Gamma_{12}) \vdash \mathtt{F}_6}{\bullet\mathtt{h}_1 : (\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13} \vdash (\Delta_8, []\mathtt{F}_9), []\mathtt{F}_6}\ K \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_6, unbox(\Box\Gamma_{10}), unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_9}{\bullet\mathtt{h}_7 : ((\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13}), []\mathtt{F}_6 \vdash \Delta_8, []\mathtt{F}_9}\ K}{- : (\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13} \vdash \Delta_8, []\mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{10}), unbox(\Box\Gamma_{11}), unbox(\Box\Gamma_{12}) \vdash \mathtt{F}_6, \mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{- : \mathtt{F}_6, unbox(\Box\Gamma_{10}), unbox(\Box\Gamma_{11}), unbox(\Box\Gamma_{12}) \vdash \mathtt{F}_9}\ \mathtt{ax/W}}{- : unbox(\Box\Gamma_{10}), unbox(\Box\Gamma_{11}), unbox(\Box\Gamma_{12}) \vdash \mathtt{F}_9}\ \mathtt{sCut}$$

$$\dfrac{}{- : \Delta_{13}, \Box\Gamma_{10}, \Box\Gamma_{11}, \Box\Gamma_{12} \vdash \Delta_8, []\mathtt{F}_9}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_{10}, \Box\Gamma_{12}) \vdash \mathtt{F}_6}{\bullet\mathtt{h}_1 : (\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13} \vdash (\Delta_8, []\mathtt{F}_9), []\mathtt{F}_6}\ K \quad \dfrac{\mathtt{h}_7 : unbox(\Box\Gamma_{10}), unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_9}{\bullet\mathtt{h}_7 : ((\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13}), []\mathtt{F}_6 \vdash \Delta_8, []\mathtt{F}_9}\ K}{- : (\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13} \vdash \Delta_8, []\mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{10}), unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_{13}, \Box\Gamma_{10}, \Box\Gamma_{11}, \Box\Gamma_{12} \vdash \Delta_8, []\mathtt{F}_9}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{12}, \Box\Gamma_{14}) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash ((\Delta_{11}, []\mathtt{F}_{10}), []\mathtt{F}_8), \Box\mathtt{F}_7}\ K \quad \dfrac{\mathtt{h}_9 : unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}), unbox(\Box\mathtt{F}_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15}), \Box\mathtt{F}_7 \vdash (\Delta_{11}, []\mathtt{F}_{10}), []\mathtt{F}_8}\ K}{- : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash (\Delta_{11}, []\mathtt{F}_{10}), []\mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{14}) \vdash \mathtt{F}_8}\ \mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \Delta_{11}, []\mathtt{F}_{10}, []\mathtt{F}_8}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{11}, \Box\Gamma_{13}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14} \vdash (\Delta_9, []\mathtt{F}_{10}), \Box\mathtt{F}_7}\ K \quad \dfrac{\mathtt{h}_8 : unbox(\Box\Gamma_{11}), unbox(\Box\Gamma_{12}), unbox(\Box\mathtt{F}_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14}), \Box\mathtt{F}_7 \vdash \Delta_9, []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14} \vdash \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{11}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{12}, \Box\Gamma_{14}) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash ((\Delta_{11}, []\mathtt{F}_{10}), []\mathtt{F}_8), \mathtt{F}_7}\ K \quad \dfrac{\mathtt{h}_9 : unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15}), \mathtt{F}_7 \vdash (\Delta_{11}, []\mathtt{F}_{10}), []\mathtt{F}_8}\ K}{- : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash (\Delta_{11}, []\mathtt{F}_{10}), []\mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \Delta_{11}, []\mathtt{F}_{10}, []\mathtt{F}_8}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{11}, \Box\Gamma_{13}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14} \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_7}\, K \quad \dfrac{\mathtt{h}_8 : unbox(\Box\Gamma_{11}), unbox(\Box\Gamma_{12}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14}), \mathtt{F}_7 \vdash \Delta_9, []\mathtt{F}_{10}}\, K}{- : (\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14} \vdash \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{11}), unbox(\Box\Gamma_{12}) \vdash \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\, K$$

- Case rule $A45$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_{11}, \Box\Gamma_{13}) \vdash \mathtt{F}_6}{\bullet\mathtt{h}_1 : (\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14} \vdash (\Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}), []\mathtt{F}_6}\, K \quad \dfrac{\mathtt{h}_7 : \Box\Gamma_{11}, \Box\Gamma_{12}, []\mathtt{F}_6 \vdash \Box\Gamma_8, \mathtt{F}_{10}}{\bullet\mathtt{h}_7 : ((\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_6 \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\, A45}{- : (\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14} \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : unbox(\Box\Gamma_{11}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_6}\,\mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13} \vdash \mathtt{F}_{10}, \Box\Gamma_8, []\mathtt{F}_6}\, K \quad \dfrac{}{\mathtt{h}_7 : \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_6 \vdash \mathtt{F}_{10}, \Box\Gamma_8}\,\mathtt{ax/W}}{- : \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13} \vdash \mathtt{F}_{10}, \Box\Gamma_8}\,\mathtt{hCut}}{- : \Delta_{14}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13} \vdash \Delta_9, \Box\Gamma_8, []\mathtt{F}_{10}}\, A45$$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_{11}, \Box\Gamma_{13}) \vdash \mathtt{F}_6}{\bullet\mathtt{h}_1 : (\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14} \vdash (\Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}), []\mathtt{F}_6}\, K \quad \dfrac{\mathtt{h}_7 : \Box\Gamma_{11}, \Box\Gamma_{12} \vdash \Box\Gamma_8, \mathtt{F}_{10}}{\bullet\mathtt{h}_7 : ((\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_6 \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\, A45}{- : (\Box\Gamma_{11}, \Box\Gamma_{13}), \Box\Gamma_{12}, \Delta_{14} \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{11}, \Box\Gamma_{12} \vdash \mathtt{F}_{10}, \Box\Gamma_8}\,\mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13} \vdash \Delta_9, \Box\Gamma_8, []\mathtt{F}_{10}}\, A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{13}, \Box\Gamma_{15}) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash ((\Box\Gamma_{12}, \Delta_{10}, []\mathtt{F}_{11}), []\mathtt{F}_8), \Box\mathtt{F}_7}\, K \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_{13}, \Box\Gamma_{14}, \Box\mathtt{F}_7 \vdash \Box\Gamma_{12}, \mathtt{F}_{11}, []\mathtt{F}_8}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16}), \Box\mathtt{F}_7 \vdash (\Box\Gamma_{12}, \Delta_{10}, []\mathtt{F}_{11}), []\mathtt{F}_8}\, A45}{- : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash (\Box\Gamma_{12}, \Delta_{10}, []\mathtt{F}_{11}), []\mathtt{F}_8}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_8}\,\mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_{13}, \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \Delta_{10}, \Box\Gamma_{12}, []\mathtt{F}_{11}, []\mathtt{F}_8}\, K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{13}, \Box\Gamma_{15}) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash ((\Box\Gamma_{10}, \Delta_{12}, []\mathtt{F}_{11}), []\mathtt{F}_8), \Box\mathtt{F}_7}\, K \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_{13}, \Box\Gamma_{14}, \Box\mathtt{F}_7 \vdash \Box\Gamma_{10}, \mathtt{F}_{11}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16}), \Box\mathtt{F}_7 \vdash (\Box\Gamma_{10}, \Delta_{12}, []\mathtt{F}_{11}), []\mathtt{F}_8}\, A45}{- : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash (\Box\Gamma_{10}, \Delta_{12}, []\mathtt{F}_{11}), []\mathtt{F}_8}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_8}\,\mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_{13}, \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \Delta_{12}, \Box\Gamma_{10}, []\mathtt{F}_{11}, []\mathtt{F}_8}\, K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{12}, \Box\Gamma_{14}) \vdash \mathtt{F}_{11}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash ((\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_{11}), \Box\mathtt{F}_7}\, K \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\mathtt{F}_7 \vdash \Box\Gamma_9, \mathtt{F}_{11}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15}), \Box\mathtt{F}_7 \vdash (\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_{11}}\, A45}{- : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash (\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{14}) \vdash \mathtt{F}_{11}}\,\mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{11}}\, K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{13}, \Box\Gamma_{15}) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash ((\Box\Gamma_{12}, \Delta_{10}, []\mathtt{F}_{11}), []\mathtt{F}_8), \mathtt{F}_7}\, K \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \Box\Gamma_{12}, \mathtt{F}_{11}, []\mathtt{F}_8}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16}), \mathtt{F}_7 \vdash (\Box\Gamma_{12}, \Delta_{10}, []\mathtt{F}_{11}), []\mathtt{F}_8}\, A45}{- : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash (\Box\Gamma_{12}, \Delta_{10}, []\mathtt{F}_{11}), []\mathtt{F}_8}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_8}\,\mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_{13}, \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \Delta_{10}, \Box\Gamma_{12}, []\mathtt{F}_{11}, []\mathtt{F}_8}\, K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{13}, \Box\Gamma_{15}) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash ((\Box\Gamma_{10}, \Delta_{12}, []\mathtt{F}_{11}), []\mathtt{F}_8), \mathtt{F}_7}\, K \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \Box\Gamma_{10}, \mathtt{F}_{11}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16}), \mathtt{F}_7 \vdash (\Box\Gamma_{10}, \Delta_{12}, []\mathtt{F}_{11}), []\mathtt{F}_8}\, A45}{- : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash (\Box\Gamma_{10}, \Delta_{12}, []\mathtt{F}_{11}), []\mathtt{F}_8}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_8}\,\mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_{13}, \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \Delta_{12}, \Box\Gamma_{10}, []\mathtt{F}_{11}, []\mathtt{F}_8}\, K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathit{unbox}(\Box\Gamma_{12}, \Box\Gamma_{14}) \vdash \mathtt{F}_{11}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash ((\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_{11}), \mathtt{F}_7}\, K \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{12}, \Box\Gamma_{13} \vdash \Box\Gamma_9, \mathtt{F}_{11}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15}), \mathtt{F}_7 \vdash (\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_{11}}\, A45}{- : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash (\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \mathit{unbox}(\Box\Gamma_{12}), \mathit{unbox}(\Box\Gamma_{14}) \vdash \mathtt{F}_{11}}\,\mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{11}}\, K$$

- Case rule $\to_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathit{unbox}(\Box\Gamma_6) \vdash \mathtt{F}_7}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}, []\mathtt{F}_7}\, K \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_6, \Delta_{12}, []\mathtt{F}_7 \vdash \mathtt{F}_9, \Delta_{11} \quad \mathtt{h}_8 : \Box\Gamma_6, \mathtt{F}_{10}, \Delta_{12}, []\mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : (\Box\Gamma_6, \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \Delta_{11}}\,\to_L}{- : \Box\Gamma_6, \Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \mathit{unbox}(\Box\Gamma_6) \vdash \mathtt{F}_7}\,\mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{12}, \Box\Gamma_6 \vdash \Delta_{11}, \mathtt{F}_9, []\mathtt{F}_7}\, K \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \Box\Gamma_6, []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_9}\,\mathtt{ax/W}}{- : \Delta_{12}, \Box\Gamma_6 \vdash \Delta_{11}, \mathtt{F}_9}\,\mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \mathit{unbox}(\Box\Gamma_6) \vdash \mathtt{F}_7}\,\mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10}, \Box\Gamma_6 \vdash \Delta_{11}, []\mathtt{F}_7}\, K \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_{10}, \Box\Gamma_6, []\mathtt{F}_7 \vdash \Delta_{11}}\,\mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_{10}, \Box\Gamma_6 \vdash \Delta_{11}}\,\mathtt{hCut}}{- : \Delta_{12}, \Box\Gamma_6, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}}\,\to_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_8 \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_{12} \to \mathtt{F}_{13}}\, K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \Delta_8 \vdash \mathtt{F}_{12}, \Delta_9, []\mathtt{F}_{10} \quad \mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{13}, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\,\to_L}{- : \Box\Gamma_7, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_9, []\mathtt{F}_{10}}\, K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_8}\, K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \Delta_{14} \vdash \mathtt{F}_{12}, \Delta_9, []\mathtt{F}_{10} \quad \mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \mathtt{F}_{13}, \Delta_{14} \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), \mathtt{F}_8 \vdash \Delta_9, []\mathtt{F}_{10}}\,\to_L}{- : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_7, \mathtt{F}_{12} \to \mathtt{F}_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\, K$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \mathit{unbox}(\Box\Gamma_6) \vdash \mathtt{F}_7}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}, []\mathtt{F}_7}\, K \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_6, \mathtt{F}_9, \mathtt{F}_{10}, \Delta_{12}, []\mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : (\Box\Gamma_6, \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \Delta_{11}}\,\wedge_L}{- : \Box\Gamma_6, \Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \mathit{unbox}(\Box\Gamma_6) \vdash \mathtt{F}_7}\,\mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_9, \Box\Gamma_6 \vdash \Delta_{11}, []\mathtt{F}_7}\, K \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_9, \Box\Gamma_6, []\mathtt{F}_7 \vdash \Delta_{11}}\,\mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_9, \Box\Gamma_6 \vdash \Delta_{11}}\,\mathtt{hCut}}{- : \Delta_{12}, \Box\Gamma_6, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}}\,\wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_8 \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\, K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\,\wedge_L}{- : \Box\Gamma_7, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_9, []\mathtt{F}_{10}}\, K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_8}\, K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_{14} \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), \mathtt{F}_8 \vdash \Delta_9, []\mathtt{F}_{10}}\,\wedge_L}{- : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_7, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\, K$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_7}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}, []\mathtt{F}_7}\,K \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_6, \mathtt{F}_9, \Delta_{12}, []\mathtt{F}_7 \vdash \Delta_{11} \quad \mathtt{h}_8 : \Box\Gamma_6, \mathtt{F}_{10}, \Delta_{12}, []\mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : (\Box\Gamma_6, \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \Delta_{11}}\vee_L}{- : \Box\Gamma_6, \Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_7}\,\mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_9, \Box\Gamma_6 \vdash \Delta_{11}, []\mathtt{F}_7}\,K \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_9, \Box\Gamma_6, []\mathtt{F}_7 \vdash \Delta_{11}}\,\mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_9, \Box\Gamma_6 \vdash \Delta_{11}}\,\mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_7}\,\mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{12}, \mathtt{F}_{10}, \Box\Gamma_6 \vdash \Delta_{11}, []\mathtt{F}_7}\,K \quad \dfrac{}{\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_{10}, \Box\Gamma_6, []\mathtt{F}_7 \vdash \Delta_{11}}\,\mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_{10}, \Box\Gamma_6 \vdash \Delta_{11}}\,\mathtt{hCut}}{- : \Delta_{12}, \Box\Gamma_6, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\vee_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_8 \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_{12} \vee \mathtt{F}_{13}}\,K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{12}, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10} \quad \mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{13}, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\vee_L}{- : \Box\Gamma_7, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_9, []\mathtt{F}_{10}}\,K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_8}\,K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \mathtt{F}_{12}, \Delta_{14} \vdash \Delta_9, []\mathtt{F}_{10} \quad \mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \mathtt{F}_{13}, \Delta_{14} \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), \mathtt{F}_8 \vdash \Delta_9, []\mathtt{F}_{10}}\vee_L}{- : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_7, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_9, []\mathtt{F}_{10}}\,K$$

- Case rule AT

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_{11}, []\mathtt{F}_9) \vdash \mathtt{F}_7}{\bullet\mathtt{h}_1 : (\Box\Gamma_{11}, []\mathtt{F}_9), \Delta_6 \vdash \Delta_{10}, []\mathtt{F}_7}\,K \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{11}, \mathtt{F}_9, \Delta_6, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{11}, []\mathtt{F}_9), \Delta_6), []\mathtt{F}_7 \vdash \Delta_{10}}\,AT}{- : (\Box\Gamma_{11}, []\mathtt{F}_9), \Delta_6 \vdash \Delta_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_6, \mathtt{F}_9, \Box\Gamma_{11}, []\mathtt{F}_9 \vdash \Delta_{10}, []\mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \Delta_6, \mathtt{F}_9, \Box\Gamma_{11}, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{ax/W}}{- : \Delta_6, \mathtt{F}_9, \Box\Gamma_{11}, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{hCut}$$

$$\dfrac{}{- : \Delta_6, \Box\Gamma_{11}, []\mathtt{F}_9 \vdash \Delta_{10}}\,AT$$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_7}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_{11}, []\mathtt{F}_9 \vdash \Delta_{10}, []\mathtt{F}_7}\,K \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_6, \mathtt{F}_9, \Delta_{11}, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}{\bullet\mathtt{h}_8 : (\Box\Gamma_6, \Delta_{11}, []\mathtt{F}_9), []\mathtt{F}_7 \vdash \Delta_{10}}\,AT}{- : \Box\Gamma_6, \Delta_{11}, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_{11}, \mathtt{F}_9, \Box\Gamma_6, []\mathtt{F}_9 \vdash \Delta_{10}, []\mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \Delta_{11}, \mathtt{F}_9, \Box\Gamma_6, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{ax/W}}{- : \Delta_{11}, \mathtt{F}_9, \Box\Gamma_6, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{hCut}$$

$$\dfrac{}{- : \Delta_{11}, \Box\Gamma_6, []\mathtt{F}_9 \vdash \Delta_{10}}\,AT$$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_9}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_7 \vdash \Delta_{10}, []\mathtt{F}_9}\,K \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_6, \mathtt{F}_9, \Delta_7, []\mathtt{F}_9 \vdash \Delta_{10}}{\bullet\mathtt{h}_8 : (\Box\Gamma_6, \Delta_7), []\mathtt{F}_9 \vdash \Delta_{10}}\,AT}{- : \Box\Gamma_6, \Delta_7 \vdash \Delta_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{- : \Delta_7, \Box\Gamma_6, unbox(\Box\Gamma_6) \vdash \Delta_{10}, \mathtt{F}_9}\,\mathtt{ax/W}}{- : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}, \mathtt{F}_9}\,ATG \quad \dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_7, \mathtt{F}_9, \Box\Gamma_6 \vdash \Delta_{10}, []\mathtt{F}_9}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \Delta_7, \mathtt{F}_9, \Box\Gamma_6, []\mathtt{F}_9 \vdash \Delta_{10}}\,\mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_9, \Box\Gamma_6 \vdash \Delta_{10}}\,\mathtt{hCut}}{- : \Delta_7, \Box\Gamma_6 \vdash \Delta_{10}}\,\mathtt{sCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_{13}, []\mathtt{F}_{12}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_8 \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_7}\,K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_{13}, \mathtt{F}_7, \mathtt{F}_{12}, \Delta_8, []\mathtt{F}_{12} \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_8), \mathtt{F}_7 \vdash \Delta_9, []\mathtt{F}_{10}}\,AT}{- : (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \mathtt{F}_{12}, unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_{13}, []\mathtt{F}_{12} \vdash \Delta_9, []\mathtt{F}_{10}}\,K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_8 \vdash (\Delta_9, []\mathtt{F}_{10}), []\mathtt{F}_{12}}\,K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{12}, \Delta_8, []\mathtt{F}_{12} \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), []\mathtt{F}_{12} \vdash \Delta_9, []\mathtt{F}_{10}}\,AT}{- : \Box\Gamma_7, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\,\mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_9, []\mathtt{F}_{10}}\,K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_{13}, []\mathtt{F}_{12} \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_8}\ K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \mathtt{F}_{12}, \Delta_{13}, []\mathtt{F}_{12} \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_{13}, []\mathtt{F}_{12}), \mathtt{F}_8 \vdash \Delta_9, []\mathtt{F}_{10}}\ AT}{- : \Box\Gamma_7, \Delta_{13}, []\mathtt{F}_{12} \vdash \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_{13}, \Box\Gamma_7, []\mathtt{F}_{12} \vdash \Delta_9, []\mathtt{F}_{10}}\ K$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_7}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \bot, \Delta_{10} \vdash \Delta_9, []\mathtt{F}_7}\ K \quad \dfrac{}{\bullet\mathtt{h}_8 : (\Box\Gamma_6, \bot, \Delta_{10}), []\mathtt{F}_7 \vdash \Delta_9}\ \bot_L}{- : \Box\Gamma_6, \bot, \Delta_{10} \vdash \Delta_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_{10}, \Box\Gamma_6 \vdash \Delta_9}\ \bot_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_8 \vdash (\Delta_9, []\mathtt{F}_{10}), \bot}\ K \quad \dfrac{}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), \bot \vdash \Delta_9, []\mathtt{F}_{10}}\ \bot_L}{- : \Box\Gamma_7, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_9, []\mathtt{F}_{10}}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \bot, \Delta_{12} \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_8}\ K \quad \dfrac{}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \bot, \Delta_{12}), \mathtt{F}_8 \vdash \Delta_9, []\mathtt{F}_{10}}\ \bot_L}{- : \Box\Gamma_7, \bot, \Delta_{12} \vdash \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_{12}, \Box\Gamma_7 \vdash \Delta_9, []\mathtt{F}_{10}}\ \bot_L$$

- Case rule I

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_7}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \Delta_{11}, \mathtt{p}_9 \vdash (\Delta_{10}, \mathtt{p}_9), []\mathtt{F}_7}\ K \quad \dfrac{}{\bullet\mathtt{h}_8 : (\Box\Gamma_6, \Delta_{11}, \mathtt{p}_9), []\mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9}\ I}{- : \Box\Gamma_6, \Delta_{11}, \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_{11}, \Box\Gamma_6, \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_9}\ I$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_8 \vdash ((\Delta_{12}, \mathtt{p}_{11}), []\mathtt{F}_9), \mathtt{p}_{11}}\ K \quad \dfrac{}{\bullet\mathtt{h}_{10} : (\Box\Gamma_7, \Delta_8), \mathtt{p}_{11} \vdash (\Delta_{12}, \mathtt{p}_{11}), []\mathtt{F}_9}\ I}{- : \Box\Gamma_7, \Delta_8 \vdash (\Delta_{12}, \mathtt{p}_{11}), []\mathtt{F}_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_7) \vdash \mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_{12}, \mathtt{p}_{11}, []\mathtt{F}_9}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_{13}, \mathtt{p}_{11} \vdash ((\Delta_{12}, \mathtt{p}_{11}), []\mathtt{F}_9), \mathtt{F}_8}\ K \quad \dfrac{}{\bullet\mathtt{h}_{10} : (\Box\Gamma_7, \Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \vdash (\Delta_{12}, \mathtt{p}_{11}), []\mathtt{F}_9}\ I}{- : \Box\Gamma_7, \Delta_{13}, \mathtt{p}_{11} \vdash (\Delta_{12}, \mathtt{p}_{11}), []\mathtt{F}_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_{13}, \Box\Gamma_7, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}, []\mathtt{F}_9}\ I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : unbox(\Box\Gamma_6) \vdash \mathtt{F}_7}{\bullet\mathtt{h}_1 : \Box\Gamma_6, \top, \Delta_{10} \vdash \Delta_9, []\mathtt{F}_7}\ K \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_6, \Delta_{10}, []\mathtt{F}_7 \vdash \Delta_9}{\bullet\mathtt{h}_8 : (\Box\Gamma_6, \top, \Delta_{10}), []\mathtt{F}_7 \vdash \Delta_9}\ \top_L}{- : \Box\Gamma_6, \top, \Delta_{10} \vdash \Delta_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \top, \Delta_{10}, \Box\Gamma_6 \vdash \Delta_9, []\mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \top, \Delta_{10}, \Box\Gamma_6, []\mathtt{F}_7 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \top, \Delta_{10}, \Box\Gamma_6 \vdash \Delta_9}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \Delta_8 \vdash (\Delta_9, []\mathtt{F}_{10}), \top}\ K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), \top \vdash \Delta_9, []\mathtt{F}_{10}}\ \top_L}{- : \Box\Gamma_7, \Delta_8 \vdash \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_9, []\mathtt{F}_{10}}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_7, \top, \Delta_{12} \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_8}\ K \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_8, \Delta_{12} \vdash \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \top, \Delta_{12}), \mathtt{F}_8 \vdash \Delta_9, []\mathtt{F}_{10}}\ \top_L}{- : \Box\Gamma_7, \top, \Delta_{12} \vdash \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}}{- : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \top, \Delta_{12}, \Box\Gamma_7 \vdash \Delta_9, []\mathtt{F}_{10}}\ K$$

6.7 Status of $A45$: `fail`

- Case rule $\to_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_{10}, \mathtt{F}_9}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Delta_8 \vdash (\Box\Gamma_{10}, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}), []\mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{12}, \Delta_8, []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{13}, \Delta_{14}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}}\ \to_R}{- : \Box\Gamma_7, \Delta_8 \vdash \Box\Gamma_{10}, \Delta_{14}, \mathtt{F}_{12} \to \mathtt{F}_{13}}\ \mathtt{Cut}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_{14}, \Box\Gamma_{10}, \mathtt{F}_{12} \to \mathtt{F}_{13}}\ \to_R$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_7 \vdash \mathtt{F}_9, \Box\Gamma_{10}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_8, \mathtt{F}_{12}, \Box\Gamma_7 \vdash \Delta_{14}, \mathtt{F}_{13}, \Box\Gamma_{10}, []\mathtt{F}_9}\ A45 \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{12}, \Box\Gamma_7, []\mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{13}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_{12}, \Box\Gamma_7 \vdash \Delta_{14}, \mathtt{F}_{13}, \Box\Gamma_{10}}\ \mathtt{hCut}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_{14}, \Box\Gamma_{10}, \mathtt{F}_{12} \to \mathtt{F}_{13}}\ \to_R$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}, \Box\mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \to \mathtt{F}_{15}), []\mathtt{F}_{12}), \Box\mathtt{F}_{10}}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{14}, \Delta_9, \Box\mathtt{F}_{10} \vdash \Box\Gamma_{11}, \mathtt{F}_{15}, \Delta_{16}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \Box\mathtt{F}_{10} \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \to \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \to_R}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \to \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \mathtt{Cut}}{- : \Delta_9, \mathtt{F}_{14}, \Box\Gamma_8 \vdash \Delta_{16}, \mathtt{F}_{15}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \to_R$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\mathtt{F}_{10}, \mathtt{F}_{12}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Delta_9, \mathtt{F}_{14}, \Box\Gamma_8 \vdash \Box\mathtt{F}_{10}, \Delta_{16}, \mathtt{F}_{15}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ A45 \quad \dfrac{}{\mathtt{h}_{13} : \Box\mathtt{F}_{10}, \Delta_9, \mathtt{F}_{14}, \Box\Gamma_8 \vdash \Delta_{16}, \mathtt{F}_{15}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_9, \mathtt{F}_{14}, \Box\Gamma_8 \vdash \Delta_{16}, \mathtt{F}_{15}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \mathtt{hCut}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{16}, \Box\Gamma_{11}, []\mathtt{F}_{12}, \mathtt{F}_{14} \to \mathtt{F}_{15}}\ \to_R$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{10} \vdash (\Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \to \mathtt{F}_{15}), []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \mathtt{F}_{14}, \Delta_{10} \vdash \Box\Gamma_{11}, \mathtt{F}_{15}, \Delta_{16}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{10}), \mathtt{F}_9 \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \to \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \to_R}{- : \Box\Gamma_8, \Delta_{10} \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \to \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \mathtt{Cut}}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{- : \Delta_{10}, \Box\Gamma_8 \vdash \Delta_{16}, \Box\Gamma_{11}, []\mathtt{F}_{12}, \mathtt{F}_{14} \to \mathtt{F}_{15}}\ A45$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_{10}, \mathtt{F}_9}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Delta_8 \vdash (\Box\Gamma_{10}, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), []\mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \Delta_8, []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}, \Delta_{14} \quad \mathtt{h}_{11} : \Box\Gamma_7, \Delta_8, []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{13}, \Delta_{14}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}}{- : \Box\Gamma_7, \Delta_8 \vdash \Box\Gamma_{10}, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}}\ \mathtt{Cut}$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_7 \vdash \mathtt{F}_9, \Box\Gamma_{10}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_8, \Box\Gamma_7 \vdash \Delta_{14}, \mathtt{F}_{12}, \Box\Gamma_{10}, []\mathtt{F}_9}\ A45 \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \Box\Gamma_7, []\mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_{14}, \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_7 \vdash \mathtt{F}_9, \Box\Gamma_{10}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_8, \Box\Gamma_7 \vdash \Delta_{14}, \mathtt{F}_{13}, \Box\Gamma_{10}, []\mathtt{F}_9}\ A45 \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \Box\Gamma_7, []$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}, \Box\mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15}), []\mathtt{F}_{12}), \Box\mathtt{F}_{10}}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \Delta_9, \Box\mathtt{F}_{10} \vdash \Box\Gamma_{11}, \mathtt{F}_{14}, \Delta_{16}, []\mathtt{F}_{12} \quad \mathtt{h}_{13} : \Box\Gamma_8, \Delta_9, \Box\mathtt{F}_{1}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \Box\mathtt{F}_{10} \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{1}}}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15}), []\mathtt{F}_{12}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\mathtt{F}_{10}, \mathtt{F}_{12}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Delta_9, \Box\Gamma_8 \vdash \Box\mathtt{F}_{10}, \Delta_{16}, \mathtt{F}_{14}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ A45 \quad \dfrac{}{\mathtt{h}_{13} : \Box\mathtt{F}_{10}, \Delta_9, \Box\Gamma_8 \vdash \Delta_{16}, \mathtt{F}_{14}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{16}, \mathtt{F}_{14}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \mathtt{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\mathtt{F}_{10}, \mathtt{F}_{12}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Delta_9, \Box\Gamma_8 \vdash \Box\mathtt{F}_{10}, \Delta_{16}, \mathtt{F}_{15}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ A}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta}$$

$$- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{16}, \Box\Gamma_{11}, []\mathtt{F}_{12}, \mathtt{F}_{14} \wedge \mathtt{F}_{15}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{10} \vdash (\Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15}), []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \Delta_{10} \vdash \Box\Gamma_{11}, \mathtt{F}_{14}, \Delta_{16}, []\mathtt{F}_{12} \quad \mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \Delta_{10} \vdash \Box\Gamma_{11}, \mathtt{F}_{15}, \Delta_{16}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{10}), \mathtt{F}_9 \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \wedge_R}{- : \Box\Gamma_8, \Delta_{10} \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{- : \Delta_{10}, \Box\Gamma_8 \vdash \Delta_{16}, \Box\Gamma_{11}, []\mathtt{F}_{12}, \mathtt{F}_{14} \wedge \mathtt{F}_{15}}\ A45$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_{10}, \mathtt{F}_9}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Delta_8 \vdash (\Box\Gamma_{10}, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), []\mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \Delta_8, []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_{14}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\ \vee_R}{- : \Box\Gamma_7, \Delta_8 \vdash \Box\Gamma_{10}, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_7 \vdash \mathtt{F}_9, \Box\Gamma_{10}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_8, \Box\Gamma_7 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \Box\Gamma_{10}, []\mathtt{F}_9}\ A45 \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \Box\Gamma_7, []\mathtt{F}_9 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \Box\Gamma_{10}}\ \mathtt{hCut}}{- : \Delta_8, \Box\Gamma_7 \vdash \Delta_{14}, \Box\Gamma_{10}, \mathtt{F}_{12} \vee \mathtt{F}_{13}}\ \vee_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}, \Box\mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15}), []\mathtt{F}_{12}), \Box\mathtt{F}_{10}}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \Delta_9, \Box\mathtt{F}_{10} \vdash \Box\Gamma_{11}, \mathtt{F}_{14}, \mathtt{F}_{15}, \Delta_{16}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \Box\mathtt{F}_{10} \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \vee_R}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\mathtt{F}_{10}, \mathtt{F}_{12}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Delta_9, \Box\Gamma_8 \vdash \Box\mathtt{F}_{10}, \Delta_{16}, \mathtt{F}_{14}, \mathtt{F}_{15}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ A45 \quad \dfrac{}{\mathtt{h}_{13} : \Box\mathtt{F}_{10}, \Delta_9, \Box\Gamma_8 \vdash \Delta_{16}, \mathtt{F}_{14}, \mathtt{F}_{15}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{16}, \mathtt{F}_{14}, \mathtt{F}_{15}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \mathtt{hCut}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{16}, \Box\Gamma_{11}, []\mathtt{F}_{12}, \mathtt{F}_{14} \vee \mathtt{F}_{15}}\ \vee_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{10} \vdash (\Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15}), []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \Delta_{10} \vdash \Box\Gamma_{11}, \mathtt{F}_{14}, \mathtt{F}_{15}, \Delta_{16}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{10}), \mathtt{F}_9 \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \vee_R}{- : \Box\Gamma_8, \Delta_{10} \vdash \Box\Gamma_{11}, (\Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15}), []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{- : \Delta_{10}, \Box\Gamma_8 \vdash \Delta_{16}, \Box\Gamma_{11}, []\mathtt{F}_{12}, \mathtt{F}_{14} \vee \mathtt{F}_{15}}\ A45$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_{10}, \mathtt{F}_9}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Delta_8 \vdash (\Box\Gamma_{10}, \bot, \Delta_{12}), []\mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \Delta_8, []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{12}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \bot, \Delta_{12}}\ \bot_R}{- : \Box\Gamma_7, \Delta_8 \vdash \Box\Gamma_{10}, \bot, \Delta_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \Delta_8, \Box\Gamma_7 \vdash \bot, \Delta_{12}, \Box\Gamma_{10}, []\mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \Box\Gamma_7, []\mathtt{F}_9 \vdash \bot, \Delta_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_8, \Box\Gamma_7 \vdash \bot, \Delta_{12}, \Box\Gamma_{10}}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}, \Box\mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{11}, (\bot, \Delta_{14}), []\mathtt{F}_{12}), \Box\mathtt{F}_{10}}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \Delta_9, \Box\mathtt{F}_{10} \vdash \Box\Gamma_{11}, \Delta_{14}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \Box\mathtt{F}_{10} \vdash \Box\Gamma_{11}, (\bot, \Delta_{14}), []\mathtt{F}_{12}}\ \bot_R}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{11}, (\bot, \Delta_{14}), []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_2 : \Delta_9, \Box\Gamma_8 \vdash \bot, \Box\mathtt{F}_{10}, \Delta_{14}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{13} : \Box\mathtt{F}_{10}, \Delta_9, \Box\Gamma_8 \vdash \bot, \Delta_{14}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_8 \vdash \bot, \Delta_{14}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{10} \vdash (\Box\Gamma_{11}, (\bot, \Delta_{14}), []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \Delta_{10} \vdash \Box\Gamma_{11}, \Delta_{14}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{10}), \mathtt{F}_9 \vdash \Box\Gamma_{11}, (\bot, \Delta_{14}), []\mathtt{F}_{12}}\ \bot_R}{- : \Box\Gamma_8, \Delta_{10} \vdash \Box\Gamma_{11}, (\bot, \Delta_{14}), []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{- : \Delta_{10}, \Box\Gamma_8 \vdash \bot, \Delta_{14}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ A45$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_{10}, \mathtt{F}_9}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Delta_8 \vdash (\Box\Gamma_{10}, \top, \Delta_{12}), []\mathtt{F}_9}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_8), []\mathtt{F}_9 \vdash \Box\Gamma_{10}, \top, \Delta_{12}}\ \top_R}{- : \Box\Gamma_7, \Delta_8 \vdash \Box\Gamma_{10}, \top, \Delta_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_8, \Box\Gamma_7 \vdash \top, \Delta_{12}, \Box\Gamma_{10}}\ \top_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}, \Box\mathtt{F}_{10}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{11}, (\top, \Delta_{14}), []\mathtt{F}_{12}), \Box\mathtt{F}_{10}}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \Box\mathtt{F}_{10} \vdash \Box\Gamma_{11}, (\top, \Delta_{14}), []\mathtt{F}_{12}}\ \top_R}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{11}, (\top, \Delta_{14}), []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_9, \Box\Gamma_8 \vdash \top, \Delta_{14}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \top_R$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{11}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{10} \vdash (\Box\Gamma_{11}, (\top, \Delta_{14}), []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{10}), \mathtt{F}_9 \vdash \Box\Gamma_{11}, (\top, \Delta_{14}), []\mathtt{F}_{12}}\ \top_R}{- : \Box\Gamma_8, \Delta_{10} \vdash \Box\Gamma_{11}, (\top, \Delta_{14}), []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{10}, \Box\Gamma_8 \vdash \top, \Delta_{14}, \Box\Gamma_{11}, []\mathtt{F}_{12}}\ \top_R$$

- Case rule K

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_{12}, \Box\Gamma_{14} \vdash (\Box\Gamma_{11}, []\mathtt{F}_{10}), \mathtt{F}_7}{\bullet\mathtt{h}_1 : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash ((\Box\Gamma_{11}, []\mathtt{F}_{10}), \Delta_8), []\mathtt{F}_7}\ A45 \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_7, unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_7 \vdash (\Box\Gamma_{11}, []\mathtt{F}_{10}), \Delta_8}\ K}{- : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash (\Box\Gamma_{11}, []\mathtt{F}_{10}), \Delta_8}\ \mathtt{Cut} \quad \rightsquigarrow \quad \dfrac{}{- : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15}}$$

```
Axioms assumed:

inf : C:MSFormula |-- True ; C':MSFormula
inf : False ; C:MSFormula |-- C':MSFormula
inf : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
suc(hx:FNat) : C:MSFormula |-- True ; C':MSFormula
suc(hx:FNat) : False ; C:MSFormula |-- C':MSFormula
suc(hx:FNat) : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
```

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_{12}, \Box\Gamma_{14} \vdash \Box\Gamma_8, \mathtt{F}_7}{\bullet\mathtt{h}_1 : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash (\Box\Gamma_8, \Delta_{11}, []\mathtt{F}_{10}), []\mathtt{F}_7}\ A45 \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_7, unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_7 \vdash \Box\Gamma_8, \Delta_{11}, []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash \Box\Gamma_8, \Delta_{11}, []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \mathtt{F}_{10}, \mathtt{F}_7, \Box\Gamma_8}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{- : \mathtt{F}_7, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}, \Box\Gamma_8}\ \mathtt{ax/W}}{- : \mathtt{F}_7, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \mathtt{F}_{10}, \Box\Gamma_8}\ ATG}{- : \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \mathtt{F}_{10}, \Box\Gamma_8}\ \mathtt{sCut}}{- : \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \Delta_{11}, \Box\Gamma_8, []\mathtt{F}_{10}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_{12}, \Box\Gamma_{14} \vdash (\Box\Gamma_{11}, []\mathtt{F}_{10}), \mathtt{F}_7}{\bullet\mathtt{h}_1 : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash ((\Box\Gamma_{11}, []\mathtt{F}_{10}), \Delta_8), []\mathtt{F}_7}\ A45 \quad \dfrac{\mathtt{h}_9 : unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_7 \vdash (\Box\Gamma_{11}, []\mathtt{F}_{10}), \Delta_8}\ K}{- : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash (\Box\Gamma_{11}, []\mathtt{F}_{10}), \Delta_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \Delta_8, \Box\Gamma_{11}, []\mathtt{F}_{10}}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_{12}, \Box\Gamma_{14} \vdash \Box\Gamma_8, \mathtt{F}_7}{\bullet\mathtt{h}_1 : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash (\Box\Gamma_8, \Delta_{11}, []\mathtt{F}_{10}), []\mathtt{F}_7}\ A45 \quad \dfrac{\mathtt{h}_9 : unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_7 \vdash \Box\Gamma_8, \Delta_{11}, []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{12}, \Box\Gamma_{14}), \Box\Gamma_{13}, \Delta_{15} \vdash \Box\Gamma_8, \Delta_{11}, []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{12}), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14} \vdash \Delta_{11}, \Box\Gamma_8, []\mathtt{F}_{10}}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \mathtt{F}_{10}, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash ((\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}), unbox(\Box\mathtt{F}_8) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Box\mathtt{F}_8, \mathtt{F}_{10}, \Box\Gamma_{13}, []\mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : unbox(\Box\mathtt{F}_8), unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_{11} : \Box\mathtt{F}_8, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \mathtt{F}_{10}, \Box\Gamma_{13}, []\mathtt{F}_{12}}\ K}{- : \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \mathtt{F}_{10}, \Box\Gamma_{13}, []\mathtt{F}_{12}}\ \mathtt{hCut}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_9, \Box\Gamma_{13}, []\mathtt{F}_{10}, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash \Box\Gamma_9, \mathtt{F}_{10}, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}), unbox(\Box\mathtt{F}_8) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), \Box\mathtt{F}_8 \vdash \Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash \Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Box\mathtt{F}_8, \mathtt{F}_{10}, \Box\Gamma_9, []\mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : unbox(\Box\mathtt{F}_8), unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_{11} : \Box\mathtt{F}_8, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \mathtt{F}_{10}, \Box\Gamma_9, []\mathtt{F}_{12}}\ K}{- : \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \mathtt{F}_{10}, \Box\Gamma_9, []\mathtt{F}_{12}}\ \mathtt{hCut}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_{13}, \Box\Gamma_9, []\mathtt{F}_{10}, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{13}, \Box\Gamma_{15} \vdash \Box\Gamma_9, \mathtt{F}_{12}, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash (\Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{14}), unbox(\Box\mathtt{F}_8) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16}), \Box\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}}\ K}{- : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow \quad \dfrac{}{- : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash}$$

```
Axioms assumed:

inf : C:MSFormula |-- True ; C':MSFormula
inf : False ; C:MSFormula |-- C':MSFormula
inf : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
suc(hx:FNat) : C:MSFormula |-- True ; C':MSFormula
suc(hx:FNat) : False ; C:MSFormula |-- C':MSFormula
suc(hx:FNat) : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
```

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \mathtt{F}_{10}, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash ((\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_9, \Box\Gamma_{13}, []\mathtt{F}_{10}, []\mathtt{F}_{12}}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash \Box\Gamma_9, \mathtt{F}_{10}, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), \Box\mathtt{F}_8 \vdash \Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash \Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_{13}, \Box\Gamma_9, []\mathtt{F}_{10}, []\mathtt{F}_{12}}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{13}, \Box\Gamma_{15} \vdash \Box\Gamma_9, \mathtt{F}_{12}, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash (\Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{14}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16}), \Box\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}}\ K}{- : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{14}) \vdash \mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_{13}, \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{12}}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash ((\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}), unbox(\Box\mathtt{F}_8) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash \mathtt{F}_{10}, \Box\Gamma_{13}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_9, \Box\Gamma_{13}, []\mathtt{F}_{10}, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash \Box\Gamma_9, \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}), unbox(\Box\mathtt{F}_8) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), \Box\mathtt{F}_8 \vdash \Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash \Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash \mathtt{F}_{10}, \Box\Gamma_9}\ \mathtt{ax/W}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_{13}, \Box\Gamma_9, []\mathtt{F}_{10}, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{13}, \Box\Gamma_{15} \vdash \Box\Gamma_9, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash (\Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{14}), unbox(\Box\mathtt{F}_8) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16}), \Box\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}}\ K}{- : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{13}, \Box\Gamma_{15} \vdash \mathtt{F}_{12}, \Box\Gamma_9}\ \mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_{13}, \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash ((\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}), \mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), \mathtt{F}_8 \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_{13}, []\mathtt{F}_{12}), \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_9, \Box\Gamma_{13}, []\mathtt{F}_{10}, []\mathtt{F}_{12}}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash \Box\Gamma_9, \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}), \mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), \mathtt{F}_8 \vdash \Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}}\ K}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash \Box\Gamma_9, (\Delta_{13}, []\mathtt{F}_{12}), []\mathtt{F}_{10}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{14}), unbox(\Box\Gamma_{15}) \vdash \mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_{13}, \Box\Gamma_9, []\mathtt{F}_{10}, []\mathtt{F}_{12}}\ K$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{13}, \Box\Gamma_{15} \vdash \Box\Gamma_9, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash (\Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}), \mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{14}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{11} : ((\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16}), \mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}}\ K}{- : (\Box\Gamma_{13}, \Box\Gamma_{15}), \Box\Gamma_{14}, \Delta_{16} \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{12}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{13}), unbox(\Box\Gamma_{14}) \vdash \mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_{13}, \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{12}}\ K$$

- Case rule $A45$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}, []\mathtt{F}_9), \mathtt{F}_7}{\bullet\mathtt{h}_1 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash ((\Box\Gamma_{10}, \Box\Gamma_{12}, []\mathtt{F}_9), \Box\Gamma_{11}, \Delta_{13}), []\mathtt{F}_7}\ A45 \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{14}, \Box\Gamma_{15}, []\mathtt{F}_7 \vdash \Box\Gamma_{10}, \Box\Gamma_{11}, \mathtt{F}_9}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), []\mathtt{F}_7 \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}, []\mathtt{F}_9), \Box\Gamma_{11}, \Delta_{13}}\ A45}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}, []\mathtt{F}_9), \Box\Gamma_{11}, \Delta_{13}}\ \mathtt{Cut}} \quad \rightsquigarrow \quad \_$$

Axioms assumed:

```
inf : C:MSFormula |-- True ; C':MSFormula
inf : False ; C:MSFormula |-- C':MSFormula
inf : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
suc(hx:FNat) : C:MSFormula |-- True ; C':MSFormula
suc(hx:FNat) : False ; C:MSFormula |-- C':MSFormula
suc(hx:FNat) : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
```

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}), \mathtt{F}_7}{\bullet\mathtt{h}_1 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash ((\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13}, []\mathtt{F}_9), []\mathtt{F}_7}\ A45 \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{14}, \Box\Gamma_{15}, []\mathtt{F}_7 \vdash \Box\Gamma_{10}, \Box\Gamma_{11}, \mathtt{F}_9}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), []\mathtt{F}_7 \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13}, []\mathtt{F}_9}}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13}, []\mathtt{F}_9}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash \mathtt{F}_7, \Box\Gamma_{10}, \Box\Gamma_{12}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \mathtt{F}_9, \Box\Gamma_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}, []\mathtt{F}_7}\ A45 \quad \dfrac{}{\mathtt{h}_8 : \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16}, []\mathtt{F}_7 \vdash \mathtt{F}_9, \Box\Gamma_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}}\ \mathtt{ax/W}}{- : \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \mathtt{F}_9, \Box\Gamma_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}}\ \mathtt{hCut}$$

$$\dfrac{}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_{13}, \Box\Gamma_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}, []\mathtt{F}_9), \mathtt{F}_7}{\bullet\mathtt{h}_1 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash ((\Box\Gamma_{10}, \Box\Gamma_{12}, []\mathtt{F}_9), \Box\Gamma_{11}, \Delta_{13}), []\mathtt{F}_7}\ A45 \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \Box\Gamma_{10}, \Box\Gamma_{11}, \mathtt{F}_9}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), []\mathtt{F}_7 \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}, []\mathtt{F}_9), \Box\Gamma_{11}, \Delta_{13}}}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}, []\mathtt{F}_9), \Box\Gamma_{11}, \Delta_{13}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \mathtt{F}_9, \Box\Gamma_{10}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_{13}, \Box\Gamma_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_{14}, \Box\Gamma_{16} \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}), \mathtt{F}_7}{\bullet\mathtt{h}_1 : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash ((\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13}, []\mathtt{F}_9), []\mathtt{F}_7}\ A45 \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \Box\Gamma_{10}, \Box\Gamma_{11}, \mathtt{F}_9}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17}), []\mathtt{F}_7 \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13}, []\mathtt{F}_9}}{- : (\Box\Gamma_{14}, \Box\Gamma_{16}), \Box\Gamma_{15}, \Delta_{17} \vdash (\Box\Gamma_{10}, \Box\Gamma_{12}), \Box\Gamma_{11}, \Delta_{13}, []\mathtt{F}_9}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{14}, \Box\Gamma_{15} \vdash \mathtt{F}_9, \Box\Gamma_{10}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{- : \Delta_{17}, \Box\Gamma_{14}, \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Delta_{13}, \Box\Gamma_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), \mathtt{F}_9, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}, []\mathtt{F}_9}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9}$$

$$- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9$$

Axioms assumed:

```
inf : C:MSFormula |-- True ; C':MSFormula
inf : False ; C:MSFormula |-- C':MSFormula
inf : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
suc(hx:FNat) : C:MSFormula |-- True ; C':MSFormula
suc(hx:FNat) : False ; C:MSFormula |-- C':MSFormula
suc(hx:FNat) : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
```

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), \mathtt{F}_9, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Box\mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Box\mathtt{F}_8, \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_8, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \mathtt{F}_9, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}}\ A}{- : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \mathtt{F}_9, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}}\ \mathtt{hC}$$

$$\dfrac{}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), \mathtt{F}_9, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}, []\mathtt{F}_9}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13},}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9}$$

$\rightsquigarrow$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash \Box\mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{12}, \Box\Gamma_{14}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Box\mathtt{F}_8, \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_9}\ A45 \quad \dfrac{}{\mathtt{h}_{10} : \Box\mathtt{F}_8, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_9}\ \mathtt{ax}}{- : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_9}\ \mathtt{hC}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), \mathtt{F}_9, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13},}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9}$$

$\rightsquigarrow$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash \Box\mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{12}, \Box\Gamma_{14}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Box\mathtt{F}_8, \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_9}\ A45 \quad \dfrac{}{\mathtt{h}_{10} : \Box\mathtt{F}_8, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_9}\ \mathtt{ax}}{- : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_9}\ \mathtt{hC}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{15}, \Box\Gamma_{17} \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), \mathtt{F}_{10}, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18} \vdash ((\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_{10}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{11}, \Box\Gamma_{12}, \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14})}}{- : (\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18} \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_{10}}$$

$\rightsquigarrow$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Box\mathtt{F}_8, \mathtt{F}_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_9 : \Box\mathtt{F}_8, \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_9 : \Box\mathtt{F}_8, \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}}\ \mathtt{H}}{- : \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}}\ \mathtt{hCut}}{- : \Delta_{18}, \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Delta_{14}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_{10}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), \mathtt{F}_9, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}, []\mathtt{F}_9}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9}$$

$\rightsquigarrow$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), \mathtt{F}_9, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9}$$

$\rightsquigarrow$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), \mathtt{F}_9, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}, []\mathtt{F}_9}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13},}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9}$$

$\rightsquigarrow$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), \mathtt{F}_9, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13},}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9}$$

$\rightsquigarrow$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{15}, \Box\Gamma_{17} \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), \mathtt{F}_{10}, \Box\mathtt{F}_8}{\bullet\mathtt{h}_2 : (\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18} \vdash ((\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_{10}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Box\Gamma_{11}, \Box\Gamma_{12}, \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14})}}{- : (\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18} \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_{10}}$$

$\rightsquigarrow$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \mathtt{F}_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}}\ \mathtt{ax/W}}{- : \Delta_{18}, \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Delta_{14}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_{10}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), \mathtt{F}_9}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}, []\mathtt{F}_9}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash \mathtt{F}_9, \Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), \mathtt{F}_9}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash \mathtt{F}_9, \Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), \mathtt{F}_9}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}, []\mathtt{F}_9}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13},}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash \mathtt{F}_9, \Box\Gamma_{12}, \Box\Gamma_{14}}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), \mathtt{F}_9}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13},}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash \mathtt{F}_9, \Box\Gamma_{12}, \Box\Gamma_{14}}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{15}, \Box\Gamma_{17} \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18} \vdash ((\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_{10}), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\mathtt{F}_8 \vdash \Box\Gamma_{11}, \Box\Gamma_{12}, \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18}), \Box\mathtt{F}_8 \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14})}}{- : (\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18} \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_{10}}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{15}, \Box\Gamma_{17} \vdash \mathtt{F}_{10}, \Box\Gamma_{11}, \Box\Gamma_{13}}\ \mathtt{ax/W}}{- : \Delta_{18}, \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Delta_{14}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_{10}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), \mathtt{F}_9}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9), \Box\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}, []\mathtt{F}_9}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{1}}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), \mathtt{F}_9}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9), \mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{1}}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}, []\mathtt{F}_{11}), (\Box\Gamma_{13}, \Delta_{15}), []\mathtt{F}_9}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), \mathtt{F}_9}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9), \mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}, []\mathtt{F}_9}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{1}}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{16}, \Box\Gamma_{18} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), \mathtt{F}_9}{\bullet\mathtt{h}_2 : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash ((\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9), \mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Box\Gamma_{12}, \Box\Gamma_{13}, \mathtt{F}_{11}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19}), \mathtt{F}_8 \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{1}}}{- : (\Box\Gamma_{16}, \Box\Gamma_{18}), \Box\Gamma_{17}, \Delta_{19} \vdash (\Box\Gamma_{12}, \Box\Gamma_{14}), (\Box\Gamma_{13}, \Delta_{15}, []\mathtt{F}_{11}), []\mathtt{F}_9}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \mathtt{F}_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}}\ \mathtt{ax/W}}{- : \Delta_{19}, \Box\Gamma_{16}, \Box\Gamma_{17}, \Box\Gamma_{18} \vdash \Delta_{15}, \Box\Gamma_{12}, \Box\Gamma_{13}, \Box\Gamma_{14}, []\mathtt{F}_{11}, []\mathtt{F}_9}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_{15}, \Box\Gamma_{17} \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), \mathtt{F}_{10}}{\bullet\mathtt{h}_2 : (\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18} \vdash ((\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_{10}), \mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_9 : \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \Box\Gamma_{11}, \Box\Gamma_{12}, \mathtt{F}_{10}}{\bullet\mathtt{h}_9 : ((\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18}), \mathtt{F}_8 \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}}}{- : (\Box\Gamma_{15}, \Box\Gamma_{17}), \Box\Gamma_{16}, \Delta_{18} \vdash (\Box\Gamma_{11}, \Box\Gamma_{13}), (\Box\Gamma_{12}, \Delta_{14}), []\mathtt{F}_{10}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{15}, \Box\Gamma_{16} \vdash \mathtt{F}_{10}, \Box\Gamma_{11}, \Box\Gamma_{12}}\ \mathtt{ax/W}}{- : \Delta_{18}, \Box\Gamma_{15}, \Box\Gamma_{16}, \Box\Gamma_{17} \vdash \Delta_{14}, \Box\Gamma_{11}, \Box\Gamma_{12}, \Box\Gamma_{13}, []\mathtt{F}_{10}}\ A45$$

- Case rule $\rightarrow_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_9, \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \rightarrow \mathtt{F}_{13} \vdash (\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \Delta_{14}, []\mathtt{F}_8 \vdash \Box\Gamma_9, \mathtt{F}_{12}, \Delta_{10} \quad \mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{13}, \Delta_{14}, []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \rightarrow \mathtt{F}_{13}), []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}}\ \rightarrow_L}{- : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \rightarrow \mathtt{F}_{13} \vdash \Box\Gamma_9, \Delta_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_7 \vdash \mathtt{F}_8, \Box\Gamma_9}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{14}, \Box\Gamma_7 \vdash \Delta_{10}, \mathtt{F}_{12}, \Box\Gamma_9, []\mathtt{F}_8}\ A45 \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \Box\Gamma_7, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{12}, \Box\Gamma_9}\ \mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_7 \vdash \Delta_{10}, \mathtt{F}_{12}, \Box\Gamma_9}\ \mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_7 \vdash \mathtt{F}_8, \Box\Gamma_9}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{14}, \mathtt{F}_{13}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_8}\ A45 \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{13}, \Box}}{- : \Delta_{14}, \mathtt{F}_{13}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9}\ \rightarrow_L}{- : \Delta_{14}, \Box\Gamma_7, \mathtt{F}_{12} \rightarrow \mathtt{F}_{13} \vdash \Delta_{10}, \Box\Gamma_9}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}, \Box\mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \rightarrow \mathtt{F}_{15} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \Box\mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \Delta_{16}, \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{14}, \Delta_{11}, []\mathtt{F}_{12} \quad \mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{15}, \Delta_{16}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \rightarrow \mathtt{F}_{15}), \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}}}{- : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \rightarrow \mathtt{F}_{15} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Delta_{16}, \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \Delta_{11}, \mathtt{F}_{14}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45 \quad \dfrac{}{\mathtt{h}_{13} : \Box\mathtt{F}_9, \Delta_{16}, \Box\Gamma_8 \vdash \Delta_{11}, \mathtt{F}_{14}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_8 \vdash \Delta_{11}, \mathtt{F}_{14}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Delta_{16}, \mathtt{F}_{15}, \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A}{- : \Delta_{16}, \mathtt{F}_{15}, \Box\Gamma_8}}{- : \Delta_{16}, \Box\Gamma_8, \mathtt{F}_{14} \rightarrow \mathtt{F}_{15} \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_{14} \rightarrow \mathtt{F}_{15}}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{14}, \Delta_{11}, []\mathtt{F}_{12} \quad \mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{15}, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \mathtt{F}_{14} \rightarrow \mathtt{F}_{15} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \rightarrow_L}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \rightarrow \mathtt{F}_{15} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \Delta_{16} \vdash \Box\Gamma_{10}, \mathtt{F}_{14}, \Delta_{11}, []\mathtt{F}_{12} \quad \mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \mathtt{F}_{15}, \Delta_{16} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \rightarrow \mathtt{F}_{15}), \mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \rightarrow_L}{- : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \rightarrow \mathtt{F}_{15} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_8, \mathtt{F}_{14} \rightarrow \mathtt{F}_{15} \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_9, \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash (\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{12}, \mathtt{F}_{13}, \Delta_{14}, []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13}), []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}}\ \wedge_L}{- : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Box\Gamma_9, \Delta_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_7 \vdash \mathtt{F}_8, \Box\Gamma_9}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_8}\ A45 \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \Box\Gamma_7, []\mathtt{F}_8 \vdash \Delta_{10}, \Box\Gamma_9}\ \mathtt{ax/W}}{- : \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_{13}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9}\ \mathtt{hCut}}{- : \Delta_{14}, \Box\Gamma_7, \mathtt{F}_{12} \wedge \mathtt{F}_{13} \vdash \Delta_{10}, \Box\Gamma_9}\ \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}, \Box\mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \Box\mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{14}, \mathtt{F}_{15}, \Delta_{16}, \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15}), \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \wedge_L}{- : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Delta_{16}, \mathtt{F}_{14}, \mathtt{F}_{15}, \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45 \quad \dfrac{}{\mathtt{h}_{13} : \Box\mathtt{F}_9, \Delta_{16}, \mathtt{F}_{14}, \mathtt{F}_{15}, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{16}, \mathtt{F}_{14}, \mathtt{F}_{15}, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{hCut}}{- : \Delta_{16}, \Box\Gamma_8, \mathtt{F}_{14} \wedge \mathtt{F}_{15} \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_{14} \wedge \mathtt{F}_{15}}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{14}, \mathtt{F}_{15}, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \mathtt{F}_{14} \wedge \mathtt{F}_{15} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \wedge_L}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \mathtt{F}_{14}, \mathtt{F}_{15}, \Delta_{16} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15}), \mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \wedge_L}{- : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \wedge \mathtt{F}_{15} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_8, \mathtt{F}_{14} \wedge \mathtt{F}_{15} \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_9, \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash (\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{12}, \Delta_{14}, []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10} \quad \mathtt{h}_{11} : \Box\Gamma_7, \mathtt{F}_{13}, \Delta_{14}, []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13}), []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}}\ \vee_L}{- : \Box\Gamma_7, \Delta_{14}, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Box\Gamma_9, \Delta_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_7 \vdash \mathtt{F}_8, \Box\Gamma_9}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{14}, \mathtt{F}_{12}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_8}\ A45 \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{12}, \Box\Gamma_7, []\mathtt{F}_8 \vdash \Delta_{10}, \Box\Gamma_9}\ \mathtt{ax/W}}{- : \Delta_{14}, \mathtt{F}_{12}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9}\ \mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_1 : \Box\Gamma_7 \vdash \mathtt{F}_8, \Box\Gamma_9}\ \mathtt{ax/W}}{\bullet\mathtt{h}_1 : \Delta_{14}, \mathtt{F}_{13}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_8}\ A45 \quad \dfrac{}{\mathtt{h}_{11} : \Delta_{14}, \mathtt{F}_{13}, \Box}}{- : \Delta_{14}, \mathtt{F}_{13}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9}$$

$$- : \Delta_{14}, \Box\Gamma_7, \mathtt{F}_{12} \vee \mathtt{F}_{13} \vdash \Delta_{10}, \Box\Gamma_9\ \vee_L$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}, \Box\mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \Box\mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{14}, \Delta_{16}, \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12} \quad \mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{15}, \Delta_{16}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15}), \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}}}{- : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Delta_{16}, \mathtt{F}_{14}, \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45 \quad \dfrac{}{\mathtt{h}_{13} : \Box\mathtt{F}_9, \Delta_{16}, \mathtt{F}_{14}, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{16}, \mathtt{F}_{14}, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{hCut} \quad \dfrac{\dfrac{\dfrac{}{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_2 : \Delta_{16}, \mathtt{F}_{15}, \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A}{- : \Delta_{16}, \mathtt{F}_{15}, \Box\Gamma_8}$$

$$- : \Delta_{16}, \Box\Gamma_8, \mathtt{F}_{14} \vee \mathtt{F}_{15} \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_{14} \vee \mathtt{F}_{15}}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{14}, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12} \quad \mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{15}, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \mathtt{F}_{14} \vee \mathtt{F}_{15} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \vee_L}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

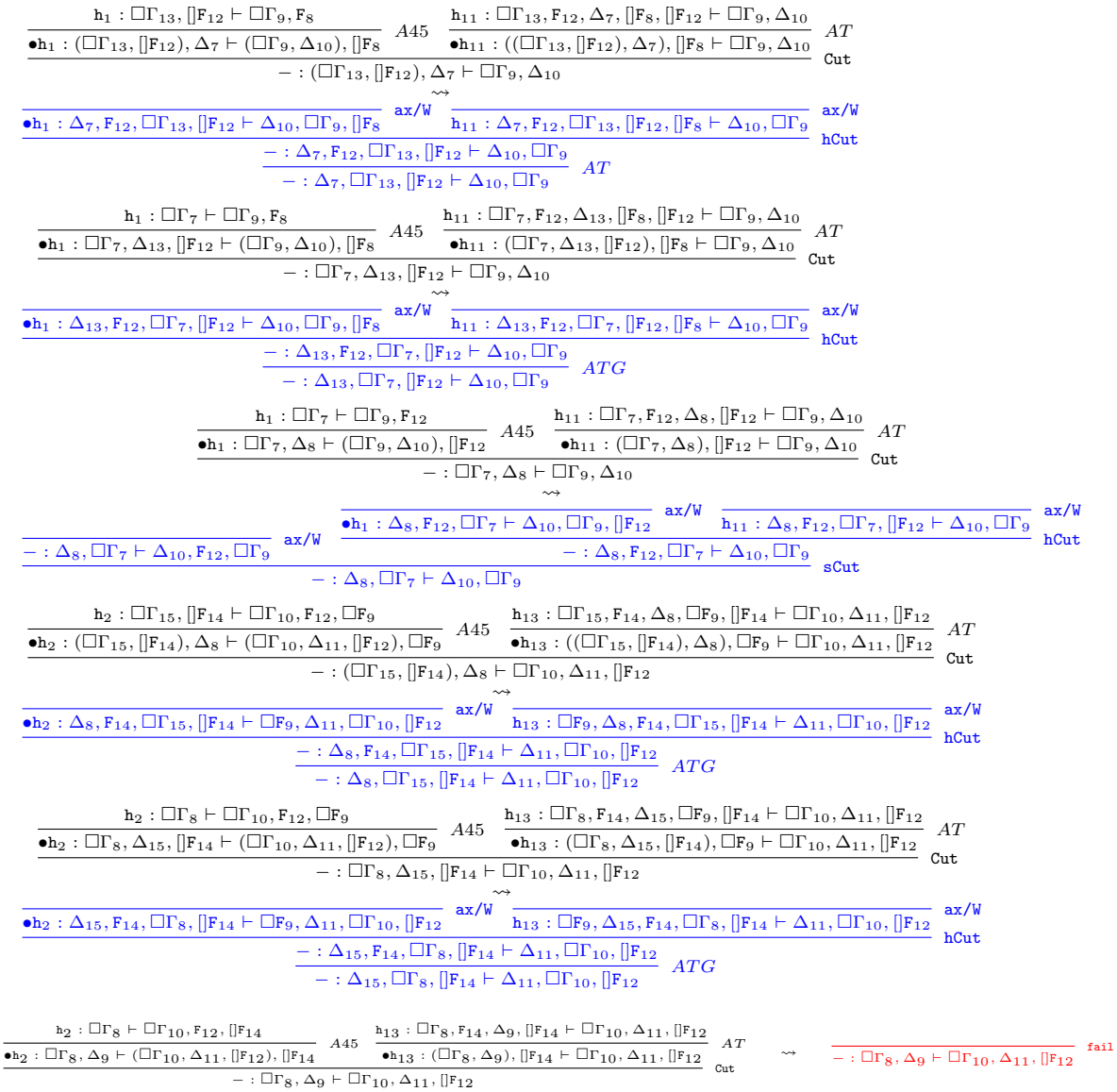
$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \mathtt{F}_{14}, \Delta_{16} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12} \quad \mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \mathtt{F}_{15}, \Delta_{16} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15}), \mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \vee_L}{- : \Box\Gamma_8, \Delta_{16}, \mathtt{F}_{14} \vee \mathtt{F}_{15} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

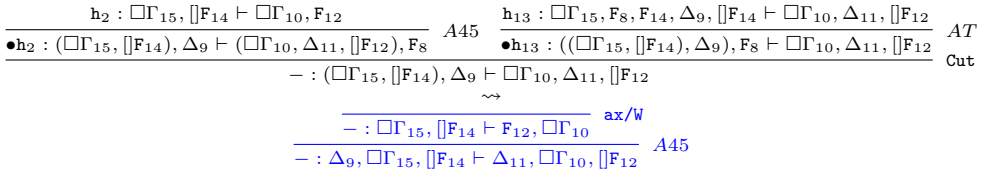
$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_{16}, \Box\Gamma_8, \mathtt{F}_{14} \vee \mathtt{F}_{15} \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

- Case rule AT



```
Axioms assumed:

inf : C:MSFormula |-- True ; C':MSFormula
inf : False ; C:MSFormula |-- C':MSFormula
inf : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
suc(hx:FNat) : C:MSFormula |-- True ; C':MSFormula
suc(hx:FNat) : False ; C:MSFormula |-- C':MSFormula
suc(hx:FNat) : P:Prop ; C:MSFormula |-- P:Prop ; C':MSFormula
```



$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), []\mathtt{F}_{14}}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_{14}, \Delta_9, []\mathtt{F}_{14} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), []\mathtt{F}_{14} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ AT}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{15}, []\mathtt{F}_{14} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \mathtt{F}_{14}, \Delta_{15}, []\mathtt{F}_{14} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_{15}, []\mathtt{F}_{14}), \mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ AT}{- : \Box\Gamma_8, \Delta_{15}, []\mathtt{F}_{14} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_8, []\mathtt{F}_{14} \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_9, \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \bot, \Delta_{12} \vdash (\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_8}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \bot, \Delta_{12}), []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}}\ \bot_L}{- : \Box\Gamma_7, \bot, \Delta_{12} \vdash \Box\Gamma_9, \Delta_{10}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{}{- : \bot, \Delta_{12}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9}\ \bot_L$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}, \Box\mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \bot, \Delta_{14} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \Box\mathtt{F}_9}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \bot, \Delta_{14}), \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \bot_L}{- : \Box\Gamma_8, \bot, \Delta_{14} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{}{- : \bot, \Delta_{14}, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \bot_L$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \bot}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \bot \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \bot_L}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \bot, \Delta_{14} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \bot, \Delta_{14}), \mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \bot_L}{- : \Box\Gamma_8, \bot, \Delta_{14} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{}{- : \bot, \Delta_{14}, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \bot_L$$

- Case rule I

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_9, \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \Delta_{13}, \mathtt{p}_{11} \vdash (\Box\Gamma_9, \Delta_{12}, \mathtt{p}_{11}), []\mathtt{F}_8}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{10} : (\Box\Gamma_7, \Delta_{13}, \mathtt{p}_{11}), []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{12}, \mathtt{p}_{11}}\ I}{- : \Box\Gamma_7, \Delta_{13}, \mathtt{p}_{11} \vdash \Box\Gamma_9, \Delta_{12}, \mathtt{p}_{11}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{}{- : \Delta_{13}, \Box\Gamma_7, \mathtt{p}_{11} \vdash \Delta_{12}, \Box\Gamma_9, \mathtt{p}_{11}}\ I$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{11}, \Box\mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{15}, \mathtt{p}_{13} \vdash (\Box\Gamma_{10}, (\Delta_{14}, \mathtt{p}_{13}), []\mathtt{F}_{11}), \Box\mathtt{F}_9}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{12} : (\Box\Gamma_8, \Delta_{15}, \mathtt{p}_{13}), \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, (\Delta_{14}, \mathtt{p}_{13}), []\mathtt{F}_{11}}\ I}{- : \Box\Gamma_8, \Delta_{15}, \mathtt{p}_{13} \vdash \Box\Gamma_{10}, (\Delta_{14}, \mathtt{p}_{13}), []\mathtt{F}_{11}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{}{- : \Delta_{15}, \Box\Gamma_8, \mathtt{p}_{13} \vdash \Delta_{14}, \Box\Gamma_{10}, \mathtt{p}_{13}, []\mathtt{F}_{11}}\ I$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{11}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{10}, (\Delta_{14}, \mathtt{p}_{13}), []\mathtt{F}_{11}), \mathtt{p}_{13}}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{12} : (\Box\Gamma_8, \Delta_9), \mathtt{p}_{13} \vdash \Box\Gamma_{10}, (\Delta_{14}, \mathtt{p}_{13}), []\mathtt{F}_{11}}\ I}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{10}, (\Delta_{14}, \mathtt{p}_{13}), []\mathtt{F}_{11}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{11}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{14}, \Box\Gamma_{10}, \mathtt{p}_{13}, []\mathtt{F}_{11}}\ A45$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{11}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_{15}, \mathtt{p}_{13} \vdash (\Box\Gamma_{10}, (\Delta_{14}, \mathtt{p}_{13}), []\mathtt{F}_{11}), \mathtt{F}_9}\ A45 \quad \dfrac{}{\bullet\mathtt{h}_{12} : (\Box\Gamma_8, \Delta_{15}, \mathtt{p}_{13}), \mathtt{F}_9 \vdash \Box\Gamma_{10}, (\Delta_{14}, \mathtt{p}_{13}), []\mathtt{F}_{11}}\ I}{- : \Box\Gamma_8, \Delta_{15}, \mathtt{p}_{13} \vdash \Box\Gamma_{10}, (\Delta_{14}, \mathtt{p}_{13}), []\mathtt{F}_{11}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{}{- : \Delta_{15}, \Box\Gamma_8, \mathtt{p}_{13} \vdash \Delta_{14}, \Box\Gamma_{10}, \mathtt{p}_{13}, []\mathtt{F}_{11}}\ I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_1 : \Box\Gamma_7 \vdash \Box\Gamma_9, \mathtt{F}_8}{\bullet\mathtt{h}_1 : \Box\Gamma_7, \top, \Delta_{12} \vdash (\Box\Gamma_9, \Delta_{10}), []\mathtt{F}_8}\ A45 \quad \dfrac{\mathtt{h}_{11} : \Box\Gamma_7, \Delta_{12}, []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}}{\bullet\mathtt{h}_{11} : (\Box\Gamma_7, \top, \Delta_{12}), []\mathtt{F}_8 \vdash \Box\Gamma_9, \Delta_{10}}\ \top_L}{- : \Box\Gamma_7, \top, \Delta_{12} \vdash \Box\Gamma_9, \Delta_{10}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{\dfrac{}{\bullet\mathtt{h}_1 : \top, \Delta_{12}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_8}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \top, \Delta_{12}, \Box\Gamma_7, []\mathtt{F}_8 \vdash \Delta_{10}, \Box\Gamma_9}\ \mathtt{ax/W}}{- : \top, \Delta_{12}, \Box\Gamma_7 \vdash \Delta_{10}, \Box\Gamma_9}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}, \Box\mathtt{F}_9}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \top, \Delta_{14} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \Box\mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \Delta_{14}, \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \top, \Delta_{14}), \Box\mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \top_L}{- : \Box\Gamma_8, \top, \Delta_{14} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{\dfrac{}{\bullet\mathtt{h}_2 : \top, \Delta_{14}, \Box\Gamma_8 \vdash \Box\mathtt{F}_9, \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{13} : \top, \Box\mathtt{F}_9, \Delta_{14}, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \top, \Delta_{14}, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \Delta_9 \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \top}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \Delta_9), \top \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \top_L}{- : \Box\Gamma_8, \Delta_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{}{- : \Delta_9, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_2 : \Box\Gamma_8 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_2 : \Box\Gamma_8, \top, \Delta_{14} \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_9}\ A45 \quad \dfrac{\mathtt{h}_{13} : \Box\Gamma_8, \mathtt{F}_9, \Delta_{14} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_{13} : (\Box\Gamma_8, \top, \Delta_{14}), \mathtt{F}_9 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \top_L}{- : \Box\Gamma_8, \top, \Delta_{14} \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{\dfrac{}{- : \Box\Gamma_8 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \top, \Delta_{14}, \Box\Gamma_8 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

6.8 Status of $\rightarrow_L$: OK

- Case rule $\rightarrow_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash (\Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}), \mathtt{F}_7}\ \rightarrow_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{13}, \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \mathtt{F}_{14}, \Delta_{12}}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10}), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}}\ \rightarrow_R}{- : \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}}\ \mathtt{Cut}}{\rightsquigarrow}$$
$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{13} \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_{13} \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7}\ \rightarrow_L \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{14}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{14}}\ \mathtt{hCut}}{- : \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}}\ \rightarrow_R$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash (\Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}), \mathtt{F}_7}\ \rightarrow_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \mathtt{F}_{13}, \Delta}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \rightarrow}}{- : \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}}}{\rightsquigarrow}$$
$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8 \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_7}\ \rightarrow_L \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}}\ \mathtt{hCut} \quad \dfrac{\mathtt{h}_3 : \Delta_8 \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7, \mathtt{F}_9}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 -}\ \mathtt{inv}}{- : \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}}$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash (\Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}), \mathtt{F}_7}\ \to_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \mathtt{F}_{13}, \mathtt{F}_{14}, \Delta_{12}}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}\ \vee_R}{- : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8 \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7, \mathtt{F}_9}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7}\ \to_L \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}}\ \mathtt{hCut}}{- : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}\ \vee_R$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \bot, \Delta_{12} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \bot, \Delta_{12}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash (\bot, \Delta_{12}), \mathtt{F}_7}\ \to_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{12}}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7 \vdash \bot, \Delta_{12}}\ \bot_R}{- : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \bot, \Delta_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \bot, \Delta_{12}, \mathtt{F}_7}{}\ \mathtt{ax/W} \quad \dfrac{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \bot, \Delta_{12}}{}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \bot, \Delta_{12}}\ \mathtt{hCut}$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_9, \top, \Delta_{12} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \top, \Delta_{12}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash (\top, \Delta_{12}), \mathtt{F}_7}\ \to_L \quad \dfrac{}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_7 \vdash \top, \Delta_{12}}\ \top_R}{- : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \top, \Delta_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \top, \Delta_{12}}\ \top_R$$

- Case rule K

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Box\Gamma_{13}, \Delta_{14} \vdash \Box\mathtt{F}_7, \mathtt{F}_8, \Delta_{11}, []\mathtt{F}_{12} \quad \mathtt{h}_3 : \mathtt{F}_9, \Box\Gamma_{13}, \Delta_{14} \vdash \Box\mathtt{F}_7, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{13}, \Delta_{14}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash (\Delta_{11}, []\mathtt{F}_{12}), \Box\mathtt{F}_7}\ \to_L \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{13}), unbox(\Box\mathtt{F}_7) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{13}, \Delta_{14}), \mathtt{F}_8 \to \mathtt{F}_9), \Box\mathtt{F}_7 \vdash \Delta_{11}, []\mathtt{F}}}{- : (\Box\Gamma_{13}, \Delta_{14}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}, []\mathtt{F}_{12}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \Box\Gamma_{13} \vdash \Box\mathtt{F}_7, \Delta_{11}, \mathtt{F}_8, []\mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{\mathtt{h}_{10} : unbox(\Box\mathtt{F}_7), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{14}, \Box\Gamma_{13} \vdash \Delta_{11}, \mathtt{F}_8, []\mathtt{F}_{12}}\ K}{- : \Delta_{14}, \Box\Gamma_{13} \vdash \Delta_{11}, \mathtt{F}_8, []\mathtt{F}_{12}}\ \mathtt{hCut} \quad \dfrac{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_9, \Box\Gamma_{13} \vdash \Box\mathtt{F}_7, \Delta_{11}, []\mathtt{F}_{12}}{- : \Delta_{14}, \mathtt{F}_9, \Box\Gamma_{13} \vdash \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{13}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Box\Gamma_{11}, \Delta_{14} \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{12}, []\mathtt{F}_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Box\Gamma_{11}, \Delta_{14} \vdash \mathtt{F}_7, \Delta_{12}, []\mathtt{F}_{13}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash (\Delta_{12}, []\mathtt{F}_{13}), \mathtt{F}_7}\ \to_L \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{13}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{12}, []\mathtt{F}_{13}}\ K}{- : (\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{12}, []\mathtt{F}_{13}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{13}}\ \mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{11}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{12}, []\mathtt{F}_{13}}\ K$$

- Case rule $A45$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Box\Gamma_{14}, \Delta_{15} \vdash \Box\mathtt{F}_7, \mathtt{F}_8, \Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Box\Gamma_{14}, \Delta_{15} \vdash \Box\mathtt{F}_7, \Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{14}, \Delta_{15}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash (\Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}), \Box\mathtt{F}_7}\ \to_L \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{14}, \Box\mathtt{F}_7 \vdash}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{14}, \Delta_{15}), \mathtt{F}_8 \to \mathtt{F}_9)}}{- : (\Box\Gamma_{14}, \Delta_{15}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{15}, \Box\Gamma_{14} \vdash \Box\mathtt{F}_7, \Delta_{12}, \mathtt{F}_8, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{\mathtt{h}_{10} : \Box\mathtt{F}_7, \Box\Gamma_{14} \vdash \mathtt{F}_{13}, \Box\Gamma_{11}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{15}, \Box\Gamma_{14} \vdash \Delta_{12}, \mathtt{F}_8, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ A45}{- : \Delta_{15}, \Box\Gamma_{14} \vdash \Delta_{12}, \mathtt{F}_8, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ \mathtt{hCut} \quad \dfrac{\mathtt{h}_3 : \Delta_{15}, \mathtt{F}_9, \Box\Gamma_{14} \vdash \Box\mathtt{F}_7, \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}{- : \Delta_{15}, \mathtt{F}_9, \Box\Gamma_{14}}\ \mathtt{ax/}$$

$$- : \Delta_{15}, \Box\Gamma_{14}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Box\Gamma_{11}, \Delta_{15} \vdash \mathtt{F}_7, \mathtt{F}_8, \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14} \quad \mathtt{h}_3 : \mathtt{F}_9, \Box\Gamma_{11}, \Delta_{15} \vdash \mathtt{F}_7, \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash (\Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}), \mathtt{F}_7}\,{\to_L} \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{11} \vdash \Box\Gamma_{12}, \mathtt{F}_{14}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_7 \vdash \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}}\,A45}{- : (\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}}\,\mathrm{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{11} \vdash \mathtt{F}_{14}, \Box\Gamma_{12}}\,\text{ax/W}}{- : \Delta_{15}, \Box\Gamma_{11}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \Box\Gamma_{12}, []\mathtt{F}_{14}}\,A45$$

- Case rule $\to_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_7 \vdash \mathtt{F}_{11} \to \mathtt{F}_{12}, \mathtt{F}_8, \Delta_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_7 \vdash \mathtt{F}_{11} \to \mathtt{F}_{12}, \Delta_{13}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,{\to_L} \quad \dfrac{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \mathtt{F}_{11}, \Delta_{13} \quad \mathtt{h}_{10} : \mathtt{F}_{12}, \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_{11} \to \mathtt{F}_{12} \vdash \Delta_{13}}\,{\to_L}}{- : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}\,\mathrm{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{- : \Delta_7, \mathtt{F}_{11} \vdash \Delta_{13}, \mathtt{F}_{12}, \mathtt{F}_8}\,\text{inv-th/ax} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{12}}\,\text{inv-th/ax}}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{12}}\,{\to_L} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}\,\text{ax}}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}\,\text{sC} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\,\text{ax/W}}{- : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}\,\text{sCut}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12} \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12} \vdash \mathtt{F}_7, \Delta_{13}}{\bullet\mathtt{h}_3 : (\Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\,{\to_L} \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \Delta_{14}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \mathtt{F}_{11},}{\bullet\mathtt{h}_{10} : ((\Delta_{14}, \mathtt{F}_{11}}}{- : (\Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14} \vdash \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_7, \mathtt{F}_8}\,\text{inv-th/ax} \quad \dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_7}\,\text{inv-th/ax}}{\bullet\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_7}\,{\to_L} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\,\text{ax/W}}{- : \Delta_{14}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\,\text{hCut} \quad \dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{12} \vdash \Delta_{13}, \mathtt{F}_7, \mathtt{F}_8}\,\text{i}}{\bullet\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_1}$$

$$- : \Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_8 \vdash \mathtt{F}_7, \mathtt{F}_{10}, \Delta_{12} \quad \mathtt{h}_3 : \mathtt{F}_{11}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10} \to \mathtt{F}_{11} \vdash \Delta_{12}, \mathtt{F}_7}\,{\to_L} \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_7, \Delta_8 \vdash \mathtt{F}_{10}, \Delta_{12} \quad \mathtt{h}_9 : \mathtt{F}_7, \mathtt{F}_{11}, \Delta_8 \vdash \Delta_{12}}{\bullet\mathtt{h}_9 : (\Delta_8, \mathtt{F}_{10} \to \mathtt{F}_{11}), \mathtt{F}_7 \vdash \Delta_{12}}\,{\to_L}}{- : \Delta_8, \mathtt{F}_{10} \to \mathtt{F}_{11} \vdash \Delta_{12}}\,\mathrm{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8 \vdash \Delta_{12}, \mathtt{F}_{10}, \mathtt{F}_7}\,\text{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_{10}}\,\text{ax/W}}{\bullet\mathtt{h}_9 : \Delta_8, \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_{10}}\,\text{H}}{- : \Delta_8 \vdash \Delta_{12}, \mathtt{F}_{10}}\,\text{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{11} \vdash \Delta_{12}, \mathtt{F}_7}\,\text{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_9 : \Delta_8, \mathtt{F}_{11}, \mathtt{F}_7 \vdash \Delta_{12}}\,\text{ax/W}}{\bullet\mathtt{h}_9 : \Delta_8, \mathtt{F}_{11}, \mathtt{F}_7 \vdash \Delta_{12}}\,\text{H}}{- : \Delta_8, \mathtt{F}_{11} \vdash \Delta_{12}}\,\text{hCut}}{- : \Delta_8, \mathtt{F}_{10} \to \mathtt{F}_{11} \vdash \Delta_{12}}\,{\to_L}$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_7 \vdash \mathtt{F}_{11} \wedge \mathtt{F}_{12}, \mathtt{F}_8, \Delta_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_7 \vdash \mathtt{F}_{11} \wedge \mathtt{F}_{12}, \Delta_{13}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,{\to_L} \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \Delta_{13}}\,{\wedge_L}}{- : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}\,\mathrm{Cut}$$

$$\rightsquigarrow$$

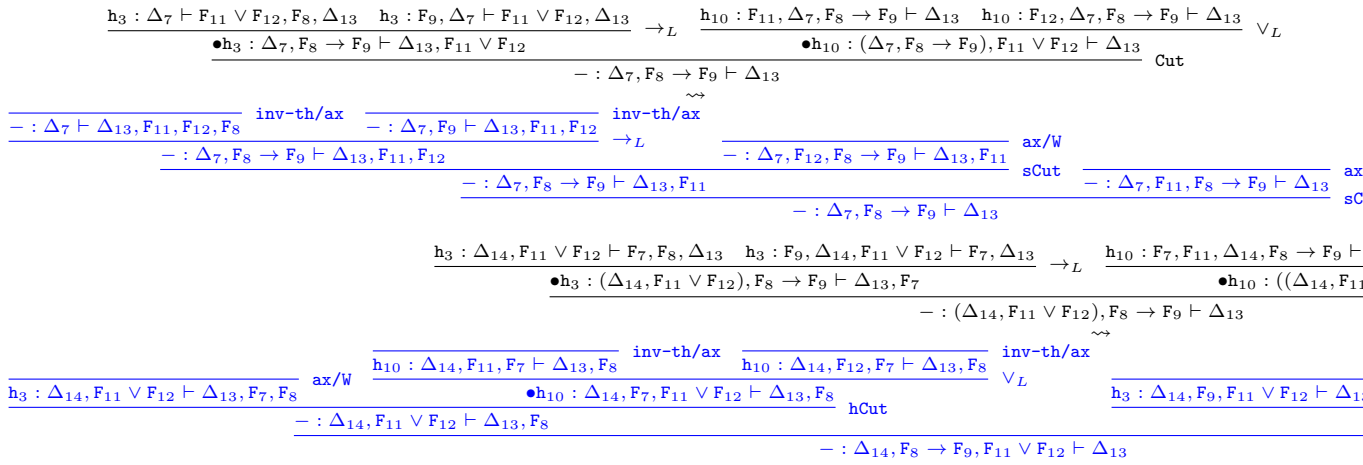
$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7 \vdash \Delta_{13}, \mathtt{F}_8, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\text{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_{12} \vdash \Delta_{13}, \mathtt{F}_8}\,\text{inv-th/ax}}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \Delta_{13}, \mathtt{F}_8}\,{\wedge_L}}{- : \Delta_7 \vdash \Delta_{13}, \mathtt{F}_8}\,\text{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\text{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_9 \vdash \Delta_{13}}\,\text{inv-t}}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{F}_9, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \Delta_{13}}\,{\wedge_L}}{- : \Delta_7, \mathtt{F}_9 \vdash \Delta_{13}}\,\text{hCut}}{- : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}\,{\to_L}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \mathtt{F}_7, \Delta_{13}}{\bullet\mathtt{h}_3 : (\Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\,{\to_L} \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{14}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : ((\Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{13}}\,{\wedge_L}}{- : (\Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}\,\mathrm{Cut}$$

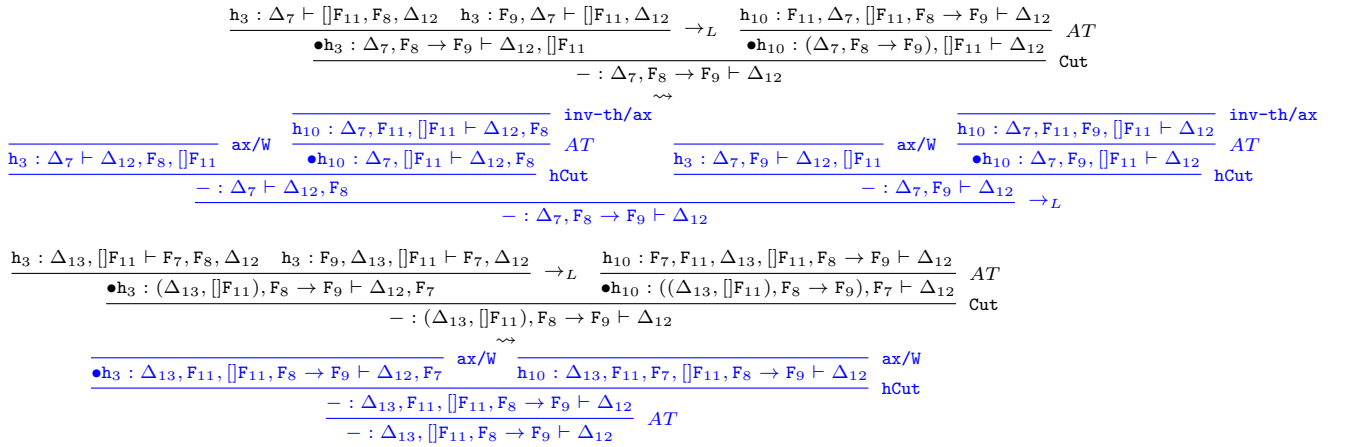
$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12} \vdash \Delta_{13}, \mathtt{F}_7, \mathtt{F}_8}\,\text{inv-th/ax} \quad \dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\,\text{inv-th/ax}}{\bullet\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\,{\to_L} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}\,\text{ax/W}}{- : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{13}}\,\text{hCut}}{- : \Delta_{14}, \mathtt{F}_8 \to \mathtt{F}_9, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \Delta_{13}}\,{\wedge_L}$$

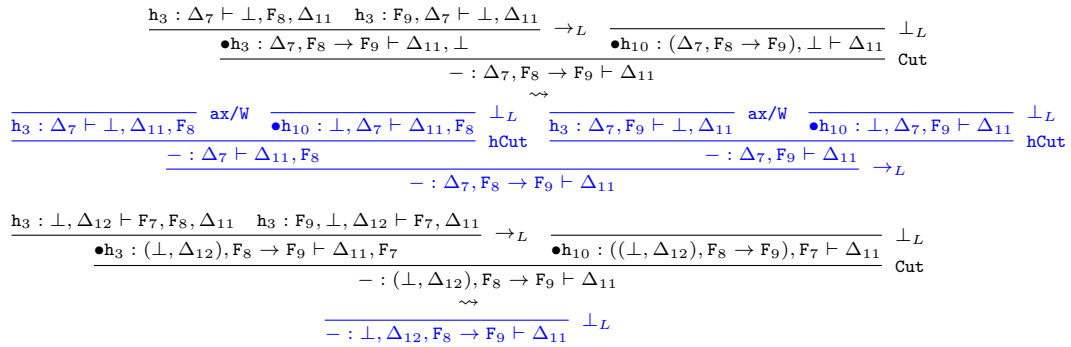
- Case rule $\vee_L$



- Case rule AT



- Case rule $\bot_L$



- Case rule I

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_7 \vdash \mathtt{p}_{11}, \mathtt{F}_8, \Delta_{12}, \mathtt{p}_{11} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_7 \vdash \mathtt{p}_{11}, \Delta_{12}, \mathtt{p}_{11}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{p}_{11}} \to_L \quad \dfrac{}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}}\, I}{- : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7 \vdash \Delta_{12}, \mathtt{F}_8, \mathtt{p}_{11}, \mathtt{p}_{11}}\,\mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{F}_8, \mathtt{p}_{11}}\, I}{- : \Delta_7 \vdash \Delta_{12}, \mathtt{F}_8, \mathtt{p}_{11}}\,\mathtt{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}, \mathtt{p}_{11}}\,\mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{F}_9, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}}\, I}{- : \Delta_7, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\,\mathtt{hCut}}{- : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}} \to_L$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_{13}, \mathtt{p}_{11} \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{12}, \mathtt{p}_{11} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_{13}, \mathtt{p}_{11} \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{p}_{11}}{\bullet\mathtt{h}_3 : (\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_7} \to_L \quad \dfrac{}{\bullet\mathtt{h}_{10} : ((\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{p}_{11}}\, I}{- : (\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_{13}, \mathtt{p}_{11}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\, I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_7 \vdash \top, \mathtt{F}_8, \Delta_{11} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_7 \vdash \top, \Delta_{11}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}, \top} \to_L \quad \dfrac{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \to \mathtt{F}_9), \top \vdash \Delta_{11}}\, \top_L}{- : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \top, \Delta_{12} \vdash \mathtt{F}_7, \mathtt{F}_8, \Delta_{11} \quad \mathtt{h}_3 : \mathtt{F}_9, \top, \Delta_{12} \vdash \mathtt{F}_7, \Delta_{11}}{\bullet\mathtt{h}_3 : (\top, \Delta_{12}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_7} \to_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \Delta_{12}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}}{\bullet\mathtt{h}_{10} : ((\top, \Delta_{12}), \mathtt{F}_8 \to \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{11}}\, \top_L}{- : (\top, \Delta_{12}), \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_3 : \top, \Delta_{12}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{10} : \top, \Delta_{12}, \mathtt{F}_7, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{ax/W}}{- : \top, \Delta_{12}, \mathtt{F}_8 \to \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{hCut}$$

6.9 Status of $\wedge_L$: OK

- Case rule $\to_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \to \mathtt{F}_{14}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash (\Delta_{12}, \mathtt{F}_{13} \to \mathtt{F}_{14}), \mathtt{F}_7} \wedge_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{13}, \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \mathtt{F}_{14}, \Delta_{12}}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_{13} \to \mathtt{F}_{14}} \to_R}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \to \mathtt{F}_{14}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_{13}, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7} \wedge_L \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{14}}\,\mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{14}}\,\mathtt{hCut}}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \to \mathtt{F}_{14}} \to_R$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash (\Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}), \mathtt{F}_7} \wedge_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \mathtt{F}_{13}, \Delta_{12} \quad \mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \mathtt{F}_{14}, \Delta_{12}}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}} \wedge_R}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}}\,\mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_7, \mathtt{F}_{13} \wedge \mathtt{F}_{14}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{13}}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{14}}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_7, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}} \wedge_R}{- : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}}\,\mathtt{hCut}}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}} \wedge_L$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash (\Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}), \mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \mathtt{F}_{13}, \mathtt{F}_{14}, \Delta_{12}}{\bullet \mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}\ \vee_R}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7}\ \wedge_L \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}}\ \mathtt{hCut}$$

$$\dfrac{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}\ \vee_R$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \bot, \Delta_{12}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash (\bot, \Delta_{12}), \mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{12}}{\bullet \mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7 \vdash \bot, \Delta_{12}}\ \bot_R}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \bot, \Delta_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \bot, \Delta_{12}, \mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \bot, \Delta_{12}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \bot, \Delta_{12}}\ \mathtt{hCut}$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \top, \Delta_{12}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash (\top, \Delta_{12}), \mathtt{F}_7}\ \wedge_L \quad \dfrac{}{\bullet \mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_7 \vdash \top, \Delta_{12}}\ \top_R}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \top, \Delta_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \top, \Delta_{12}}\ \top_R$$

- Case rule K

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{13}, \Delta_{14} \vdash \Box\mathtt{F}_7, \Delta_{11}, []\mathtt{F}_{12}}{\bullet \mathtt{h}_3 : (\Box\Gamma_{13}, \Delta_{14}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash (\Delta_{11}, []\mathtt{F}_{12}), \Box\mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{13}), unbox(\Box\mathtt{F}_7) \vdash \mathtt{F}_{12}}{\bullet \mathtt{h}_{10} : ((\Box\Gamma_{13}, \Delta_{14}), \mathtt{F}_8 \wedge \mathtt{F}_9), \Box\mathtt{F}_7 \vdash \Delta_{11}, []\mathtt{F}_{12}}\ K}{- : (\Box\Gamma_{13}, \Delta_{14}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{13} \vdash \Box\mathtt{F}_7, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : unbox(\Box\mathtt{F}_7), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{12}}\ \mathtt{ax/W}}{\bullet \mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{13} \vdash \Delta_{11}, []\mathtt{F}_{12}}\ K}{- : \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{13} \vdash \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{hCut}}{- : \Delta_{14}, \Box\Gamma_{13}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}, []\mathtt{F}_{12}}\ \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{11}, \Delta_{14} \vdash \mathtt{F}_7, \Delta_{12}, []\mathtt{F}_{13}}{\bullet \mathtt{h}_3 : (\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash (\Delta_{12}, []\mathtt{F}_{13}), \mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{13}}{\bullet \mathtt{h}_{10} : ((\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{12}, []\mathtt{F}_{13}}\ K}{- : (\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, []\mathtt{F}_{13}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{13}}\ \mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, []\mathtt{F}_{13}}\ K$$

- Case rule $A45$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{14}, \Delta_{15} \vdash \Box\mathtt{F}_7, \Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}}{\bullet \mathtt{h}_3 : (\Box\Gamma_{14}, \Delta_{15}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash (\Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}), \Box\mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{14}, \Box\mathtt{F}_7 \vdash \Box\Gamma_{11}, \mathtt{F}_{13}}{\bullet \mathtt{h}_{10} : ((\Box\Gamma_{14}, \Delta_{15}), \mathtt{F}_8 \wedge \mathtt{F}_9), \Box\mathtt{F}_7 \vdash \Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}}\ A45}{- : (\Box\Gamma_{14}, \Delta_{15}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{15}, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{14} \vdash \Box\mathtt{F}_7, \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Box\mathtt{F}_7, \Box\Gamma_{14} \vdash \mathtt{F}_{13}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{\bullet \mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{15}, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{14} \vdash \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ A45}{- : \Delta_{15}, \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{14} \vdash \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ \mathtt{hCut}}{- : \Delta_{15}, \Box\Gamma_{14}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Box\Gamma_{11}, \Delta_{15} \vdash \mathtt{F}_7, \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash (\Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}), \mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{11} \vdash \Box\Gamma_{12}, \mathtt{F}_{14}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7 \vdash \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}}\ A45}{- : (\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{11} \vdash \mathtt{F}_{14}, \Box\Gamma_{12}}\ \mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}, \Box\Gamma_{12}, []\mathtt{F}_{14}}\ A45$$

- Case rule $\rightarrow_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_7 \vdash \mathtt{F}_{11} \rightarrow \mathtt{F}_{12}, \Delta_{13}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12}}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \mathtt{F}_{11}, \Delta_{13} \quad \mathtt{h}_{10} : \mathtt{F}_{12}, \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_{11} \rightarrow \mathtt{F}_{12} \vdash \Delta_{13}}\ \rightarrow_L}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{12}, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12} \vdash \Delta_{13}}\ \rightarrow_L\ \mathtt{hCut}}{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}}\ \wedge_L}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12} \vdash \mathtt{F}_7, \Delta_{13}}{\bullet\mathtt{h}_3 : (\Delta_{14}, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \Delta_{14}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \mathtt{F}_{11}, \Delta_{13} \quad \mathtt{h}_{10} : \mathtt{F}_7, \mathtt{F}_{12}, \Delta_{14}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : ((\Delta_{14}, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{13}}\ \rightarrow_L}{- : (\Delta_{14}, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12} \vdash \Delta_{13}, \mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12} \vdash \Delta_{13}}\ \rightarrow_L\ \mathtt{hCut}}{- : \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12} \vdash \Delta_{13}}\ \wedge_L}{- : \Delta_{14}, \mathtt{F}_{11} \rightarrow \mathtt{F}_{12}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \wedge_L$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_7 \vdash \mathtt{F}_{11} \wedge \mathtt{F}_{12}, \Delta_{13}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \Delta_{13}}\ \wedge_L}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \Delta_{13}}\ \wedge_L\ \mathtt{hCut}}{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}}\ \wedge_L}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \mathtt{F}_7, \Delta_{13}}{\bullet\mathtt{h}_3 : (\Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{14}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : ((\Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{13}}\ \wedge_L}{- : (\Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\ \wedge_L \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \mathtt{ax/W}\ \mathtt{hCut}}{- : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \wedge_L}{- : \Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}\ \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_{10}, \mathtt{F}_{11}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10} \wedge \mathtt{F}_{11} \vdash \Delta_{12}, \mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_7, \mathtt{F}_{10}, \mathtt{F}_{11}, \Delta_8 \vdash \Delta_{12}}{\bullet\mathtt{h}_9 : (\Delta_8, \mathtt{F}_{10} \wedge \mathtt{F}_{11}), \mathtt{F}_7 \vdash \Delta_{12}}\ \wedge_L}{- : \Delta_8, \mathtt{F}_{10} \wedge \mathtt{F}_{11} \vdash \Delta_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_{11} \vdash \Delta_{12}, \mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_9 : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_{11}, \mathtt{F}_7 \vdash \Delta_{12}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_9 : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_{11}, \mathtt{F}_7 \vdash \Delta_{12}}\ \mathtt{H}\ \mathtt{hCut}}{- : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_{11} \vdash \Delta_{12}}\ \wedge_L}{- : \Delta_8, \mathtt{F}_{10} \wedge \mathtt{F}_{11} \vdash \Delta_{12}}\ \wedge_L$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_7 \vdash \mathtt{F}_{11} \vee \mathtt{F}_{12}, \Delta_{13}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \vee \mathtt{F}_{12}} \wedge_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{11}, \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13} \quad \mathtt{h}_{10} : \mathtt{F}_{12}, \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}{\bullet \mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_{11} \vee \mathtt{F}_{12} \vdash \Delta_{13}} \vee_L}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}} \text{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \vee \mathtt{F}_{12}} \text{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}} \text{inv-th/ax} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{12}, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}} \text{inv-th/ax}}{\bullet \mathtt{h}_{10} : \Delta_7, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \vee \mathtt{F}_{12} \vdash \Delta_{13}} \vee_L}{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}} \text{hCut}$$

$$\dfrac{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}} \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{11} \vee \mathtt{F}_{12} \vdash \mathtt{F}_7, \Delta_{13}}{\bullet \mathtt{h}_3 : (\Delta_{14}, \mathtt{F}_{11} \vee \mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7} \wedge_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \mathtt{F}_{11}, \Delta_{14}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13} \quad \mathtt{h}_{10} : \mathtt{F}_7, \mathtt{F}_{12}, \Delta_{14}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}}{\bullet \mathtt{h}_{10} : ((\Delta_{14}, \mathtt{F}_{11} \vee \mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{13}} \vee_L}{- : (\Delta_{14}, \mathtt{F}_{11} \vee \mathtt{F}_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{13}} \text{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \vee \mathtt{F}_{12} \vdash \Delta_{13}, \mathtt{F}_7} \text{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}} \text{inv-th/ax} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{13}} \text{inv-th/ax}}{\bullet \mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \vee \mathtt{F}_{12} \vdash \Delta_{13}} \vee_L}{- : \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \vee \mathtt{F}_{12} \vdash \Delta_{13}} \text{hCut}$$

$$\dfrac{- : \Delta_{14}, \mathtt{F}_8, \mathtt{F}_9, \mathtt{F}_{11} \vee \mathtt{F}_{12} \vdash \Delta_{13}}{- : \Delta_{14}, \mathtt{F}_8 \wedge \mathtt{F}_9, \mathtt{F}_{11} \vee \mathtt{F}_{12} \vdash \Delta_{13}} \wedge_L$$

- Case rule AT

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_7 \vdash []\mathtt{F}_{11}, \Delta_{12}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, []\mathtt{F}_{11}} \wedge_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{11}, \Delta_7, []\mathtt{F}_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}}{\bullet \mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9), []\mathtt{F}_{11} \vdash \Delta_{12}} AT}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}} \text{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{12}, []\mathtt{F}_{11}} \text{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_8, \mathtt{F}_9, []\mathtt{F}_{11} \vdash \Delta_{12}} \text{inv-th/ax}}{\bullet \mathtt{h}_{10} : \Delta_7, \mathtt{F}_8, \mathtt{F}_9, []\mathtt{F}_{11} \vdash \Delta_{12}} AT}{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{12}} \text{hCut}$$

$$\dfrac{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{12}}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}} \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_{13}, []\mathtt{F}_{11} \vdash \mathtt{F}_7, \Delta_{12}}{\bullet \mathtt{h}_3 : (\Delta_{13}, []\mathtt{F}_{11}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_7} \wedge_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \mathtt{F}_{11}, \Delta_{13}, []\mathtt{F}_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}}{\bullet \mathtt{h}_{10} : ((\Delta_{13}, []\mathtt{F}_{11}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{12}} AT}{- : (\Delta_{13}, []\mathtt{F}_{11}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}} \text{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \Delta_{13}, \mathtt{F}_{11}, []\mathtt{F}_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_7} \text{ax/W} \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_7, []\mathtt{F}_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}} \text{ax/W}}{- : \Delta_{13}, \mathtt{F}_{11}, []\mathtt{F}_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}} \text{hCut}$$

$$\dfrac{- : \Delta_{13}, \mathtt{F}_{11}, []\mathtt{F}_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}}{- : \Delta_{13}, []\mathtt{F}_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}} ATG$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_7 \vdash \bot, \Delta_{11}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}, \bot} \wedge_L \quad \dfrac{}{\bullet \mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9), \bot \vdash \Delta_{11}} \bot_L}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}} \text{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \bot, \Delta_{11}} \text{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_{10} : \bot, \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{11}} \bot_L}{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{11}} \text{hCut}$$

$$\dfrac{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{11}}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}} \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \bot, \Delta_{12} \vdash \mathtt{F}_7, \Delta_{11}}{\bullet \mathtt{h}_3 : (\bot, \Delta_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_7} \wedge_L \quad \dfrac{}{\bullet \mathtt{h}_{10} : ((\bot, \Delta_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{11}} \bot_L}{- : (\bot, \Delta_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}} \text{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_{12}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}} \bot_L$$

- Case rule I

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_7 \vdash \mathtt{p}_{11}, \Delta_{12}, \mathtt{p}_{11}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{p}_{11}}\ \wedge_L \quad \dfrac{}{\bullet \mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}}\ I}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}, \mathtt{p}_{11}}\ \mathtt{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_{10} : \Delta_7, \mathtt{F}_8, \mathtt{F}_9, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}}\ I}{- : \Delta_7, \mathtt{F}_8, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\ \mathtt{hCut}}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\ \wedge_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_{13}, \mathtt{p}_{11} \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{p}_{11}}{\bullet \mathtt{h}_3 : (\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_7}\ \wedge_L \quad \dfrac{}{\bullet \mathtt{h}_{10} : ((\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{p}_{11}}\ I}{- : (\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{13}, \mathtt{p}_{11}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\ I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \Delta_7 \vdash \top, \Delta_{11}}{\bullet \mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}, \top}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}}{\bullet \mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9), \top \vdash \Delta_{11}}\ \top_L}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}}\ \mathtt{ax/W}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \mathtt{F}_9, \top, \Delta_{12} \vdash \mathtt{F}_7, \Delta_{11}}{\bullet \mathtt{h}_3 : (\top, \Delta_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_7}\ \wedge_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \Delta_{12}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}}{\bullet \mathtt{h}_{10} : ((\top, \Delta_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{11}}\ \top_L}{- : (\top, \Delta_{12}), \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \top, \Delta_{12}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{10} : \top, \Delta_{12}, \mathtt{F}_7, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}}\ \mathtt{ax/W}}{- : \top, \Delta_{12}, \mathtt{F}_8 \wedge \mathtt{F}_9 \vdash \Delta_{11}}\ \mathtt{hCut}$$

6.10 Status of $\vee_L$: OK

- Case rule $\rightarrow_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash (\Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}), \mathtt{F}_7}\ \vee_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \mathtt{F}_{13}, \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \mathtt{F}_{14}, \Delta_{12}}{\bullet \mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}}\ \rightarrow_R}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10}, \mathtt{F}_{13} \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7}\ \vee_L \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{14}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_{13}, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{14}}\ \mathtt{hCut}}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \rightarrow \mathtt{F}_{14}}\ \rightarrow_R$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash (\Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}), \mathtt{F}_7}\ \vee_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \mathtt{F}_{13}, \Delta_{12}}{\bullet \mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_1}}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_7}\ \vee_L \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}}\ \mathtt{hCut} \quad \dfrac{}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{14}, \mathtt{F}_7}\ \mathtt{inv\text{-}}$$

$$\bullet \mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee$$

$$- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \wedge \mathtt{F}_{14}$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash (\Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}), \mathtt{F}_7}\ \vee_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \mathtt{F}_{13}, \mathtt{F}_{14}, \Delta_{12}}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}\ \vee_R}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax} \quad \dfrac{\mathtt{h}_3 : \Delta_8, \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7}{\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7}\ \mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}, \mathtt{F}_7}\ \vee_L \quad \dfrac{}{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13}, \mathtt{F}_{14}}\ \mathtt{hCut}}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}, \mathtt{F}_{13} \vee \mathtt{F}_{14}}\ \vee_R$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \bot, \Delta_{12} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \bot, \Delta_{12}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash (\bot, \Delta_{12}), \mathtt{F}_7}\ \vee_L \quad \dfrac{\mathtt{h}_{11} : \mathtt{F}_7, \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{12}}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7 \vdash \bot, \Delta_{12}}\ \bot_R}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \bot, \Delta_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \bot, \Delta_{12}, \mathtt{F}_7}{}\ \mathtt{ax/W} \quad \dfrac{\mathtt{h}_{11} : \Delta_8, \mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \bot, \Delta_{12}}{}\ \mathtt{ax/W}}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \bot, \Delta_{12}}\ \mathtt{hCut}$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \Delta_8 \vdash \mathtt{F}_7, \top, \Delta_{12} \quad \mathtt{h}_3 : \mathtt{F}_{10}, \Delta_8 \vdash \mathtt{F}_7, \top, \Delta_{12}}{\bullet\mathtt{h}_3 : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash (\top, \Delta_{12}), \mathtt{F}_7}\ \vee_L \quad \dfrac{}{\bullet\mathtt{h}_{11} : (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_7 \vdash \top, \Delta_{12}}\ \top_R}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \top, \Delta_{12}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \top, \Delta_{12}}\ \top_R$$

- Case rule K

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Box\Gamma_{13}, \Delta_{14} \vdash \Box\mathtt{F}_7, \Delta_{11}, []\mathtt{F}_{12} \quad \mathtt{h}_3 : \mathtt{F}_9, \Box\Gamma_{13}, \Delta_{14} \vdash \Box\mathtt{F}_7, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{13}, \Delta_{14}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash (\Delta_{11}, []\mathtt{F}_{12}), \Box\mathtt{F}_7}\ \vee_L \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{13}), unbox(\Box\mathtt{F}_7) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{13}, \Delta_{14}), \mathtt{F}_8 \vee \mathtt{F}_9), \Box\mathtt{F}_7 \vdash \Delta_{11}, []\mathtt{F}_1}}{- : (\Box\Gamma_{13}, \Delta_{14}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}, []\mathtt{F}_{12}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_8, \Box\Gamma_{13} \vdash \Box\mathtt{F}_7, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{\mathtt{h}_{10} : unbox(\Box\mathtt{F}_7), unbox(\Box\Gamma_{13}) \vdash \mathtt{F}_{12}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{14}, \mathtt{F}_8, \Box\Gamma_{13} \vdash \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W}}{}\ K}{- : \Delta_{14}, \mathtt{F}_8, \Box\Gamma_{13} \vdash \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_9, \Box\Gamma_{13} \vdash \Box\mathtt{F}_7, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{ax/W} \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\mathtt{F}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{14}}}{- : \Delta_{14}, \mathtt{F}_9, \Box\Gamma_{13} \vdash \Delta_{11}, []\mathtt{F}_{12}}$$

$$- : \Delta_{14}, \Box\Gamma_{13}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}, []\mathtt{F}_{12}\ \vee$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Box\Gamma_{11}, \Delta_{14} \vdash \mathtt{F}_7, \Delta_{12}, []\mathtt{F}_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Box\Gamma_{11}, \Delta_{14} \vdash \mathtt{F}_7, \Delta_{12}, []\mathtt{F}_{13}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash (\Delta_{12}, []\mathtt{F}_{13}), \mathtt{F}_7}\ \vee_L \quad \dfrac{\mathtt{h}_{10} : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{13}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{12}, []\mathtt{F}_{13}}\ K}{- : (\Box\Gamma_{11}, \Delta_{14}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{12}, []\mathtt{F}_{13}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : unbox(\Box\Gamma_{11}) \vdash \mathtt{F}_{13}}\ \mathtt{ax/W}}{- : \Delta_{14}, \Box\Gamma_{11}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{12}, []\mathtt{F}_{13}}\ K$$

- Case rule $A45$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Box\Gamma_{14}, \Delta_{15} \vdash \Box\mathtt{F}_7, \Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Box\Gamma_{14}, \Delta_{15} \vdash \Box\mathtt{F}_7, \Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{14}, \Delta_{15}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash (\Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}), \Box\mathtt{F}_7}\ \vee_L \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{14}, \Box\mathtt{F}_7 \vdash}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{14}, \Delta_{15}), \mathtt{F}_8 \vee \mathtt{F}_9),}}{- : (\Box\Gamma_{14}, \Delta_{15}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Box\Gamma_{11}, \Delta_{12}, []\mathtt{F}_{13}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{15}, \mathtt{F}_8, \Box\Gamma_{14} \vdash \Box\mathtt{F}_7, \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ \mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Box\mathtt{F}_7, \Box\Gamma_{14} \vdash \mathtt{F}_{13}, \Box\Gamma_{11}}\ \mathtt{ax/W}}{\bullet\mathtt{h}_{10} : \Box\mathtt{F}_7, \Delta_{15}, \mathtt{F}_8, \Box\Gamma_{14} \vdash \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ A45}{- : \Delta_{15}, \mathtt{F}_8, \Box\Gamma_{14} \vdash \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ \mathtt{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{15}, \mathtt{F}_9, \Box\Gamma_{14} \vdash \Box\mathtt{F}_7, \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}\ \mathtt{ax}}{- : \Delta_{15}, \mathtt{F}_9, \Box\Gamma_{1}}}{- : \Delta_{15}, \Box\Gamma_{14}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_{13}}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Box\Gamma_{11}, \Delta_{15} \vdash \mathtt{F}_7, \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14} \quad \mathtt{h}_3 : \mathtt{F}_9, \Box\Gamma_{11}, \Delta_{15} \vdash \mathtt{F}_7, \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash (\Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}), \mathtt{F}_7}\,\vee_L \quad \dfrac{\mathtt{h}_{10} : \Box\Gamma_{11} \vdash \Box\Gamma_{12}, \mathtt{F}_{14}}{\bullet\mathtt{h}_{10} : ((\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_7 \vdash \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}}\,A45}{- : (\Box\Gamma_{11}, \Delta_{15}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Box\Gamma_{12}, \Delta_{13}, []\mathtt{F}_{14}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{11} \vdash \mathtt{F}_{14}, \Box\Gamma_{12}}\,\mathtt{ax/W}}{- : \Delta_{15}, \Box\Gamma_{11}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \Box\Gamma_{12}, []\mathtt{F}_{14}}\,A45$$

- Case rule $\rightarrow_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7 \vdash \mathtt{F}_{11} \to \mathtt{F}_{12}, \Delta_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_7 \vdash \mathtt{F}_{11} \to \mathtt{F}_{12}, \Delta_{13}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,\vee_L \quad \dfrac{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \mathtt{F}_{11}, \Delta_{13} \quad \mathtt{h}_{10} : \mathtt{F}_{12}, \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_{11} \to \mathtt{F}_{12} \vdash \Delta_{13}}\,\to_L}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_8 \vdash \Delta_{13}, \mathtt{F}_{12}}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{12}}\,\mathtt{inv\text{-}th/ax}}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{12}}\,\vee_L \quad \dfrac{}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{sCut} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\,\mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{sCut}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12} \vdash \mathtt{F}_7, \Delta_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12} \vdash \mathtt{F}_7, \Delta_{13}}{\bullet\mathtt{h}_3 : (\Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\,\vee_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \Delta_{14}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \mathtt{F}_{11}, \Delta}{\bullet\mathtt{h}_{10} : ((\Delta_{14}, \mathtt{F}_{11}}}{- : (\Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_8 \vdash \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_7}\,\vee_L \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\,\mathtt{ax/W}}{- : \Delta_{14}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\,\mathtt{hCut} \quad \dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{12}, \mathtt{F}_8 \vdash \Delta_{13}, \mathtt{F}_7}\,\mathtt{in}}{- : \Delta_{14}, \mathtt{F}_{11} \to \mathtt{F}_{12}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7 \vdash \mathtt{F}_{11} \wedge \mathtt{F}_{12}, \Delta_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_7 \vdash \mathtt{F}_{11} \wedge \mathtt{F}_{12}, \Delta_{13}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\vee_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \Delta_{13}}\,\wedge_L}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \vdash \Delta_{13}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \vdash \Delta_{13}}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \Delta_{13}}\,\wedge_L}{- : \Delta_7, \mathtt{F}_8 \vdash \Delta_{13}}\,\mathtt{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{\dfrac{}{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{inv\text{-}t}}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{F}_9, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \Delta_{13}}\,\wedge_L}{- : \Delta_7, \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{hCut}}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\vee_L$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \mathtt{F}_7, \Delta_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12} \vdash \mathtt{F}_7, \Delta_{13}}{\bullet\mathtt{h}_3 : (\Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\,\vee_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{14}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : ((\Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{13}}\,\wedge_L}{- : (\Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

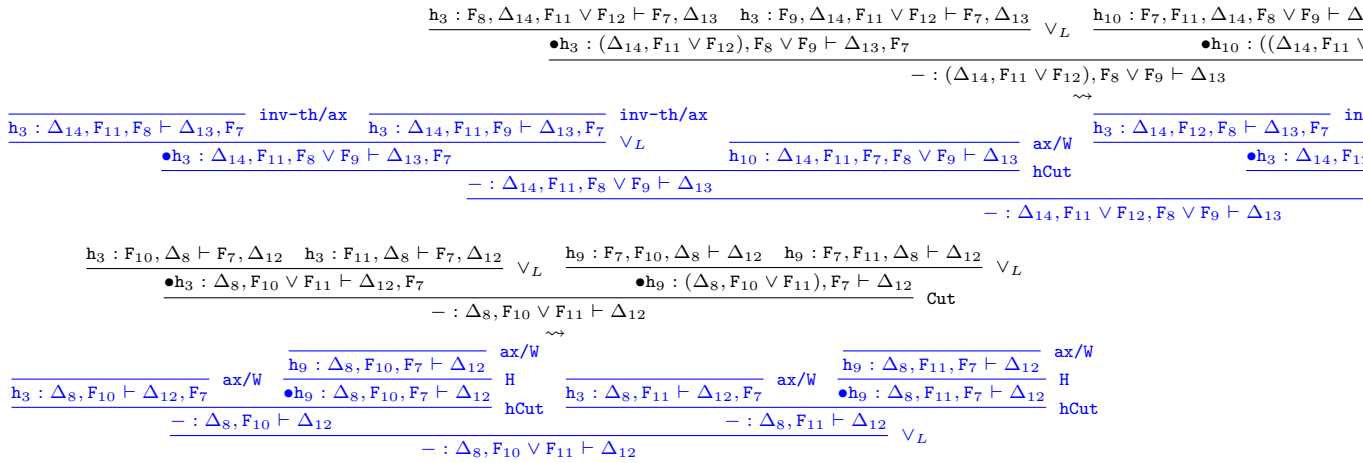
$$\dfrac{\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \vdash \Delta_{13}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\,\mathtt{inv\text{-}th/ax}}{\bullet\mathtt{h}_3 : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_7}\,\vee_L \quad \dfrac{}{\mathtt{h}_{10} : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{ax/W}}{- : \Delta_{14}, \mathtt{F}_{11}, \mathtt{F}_{12}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{hCut}}{- : \Delta_{14}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\wedge_L$$

- Case rule $\vee_L$

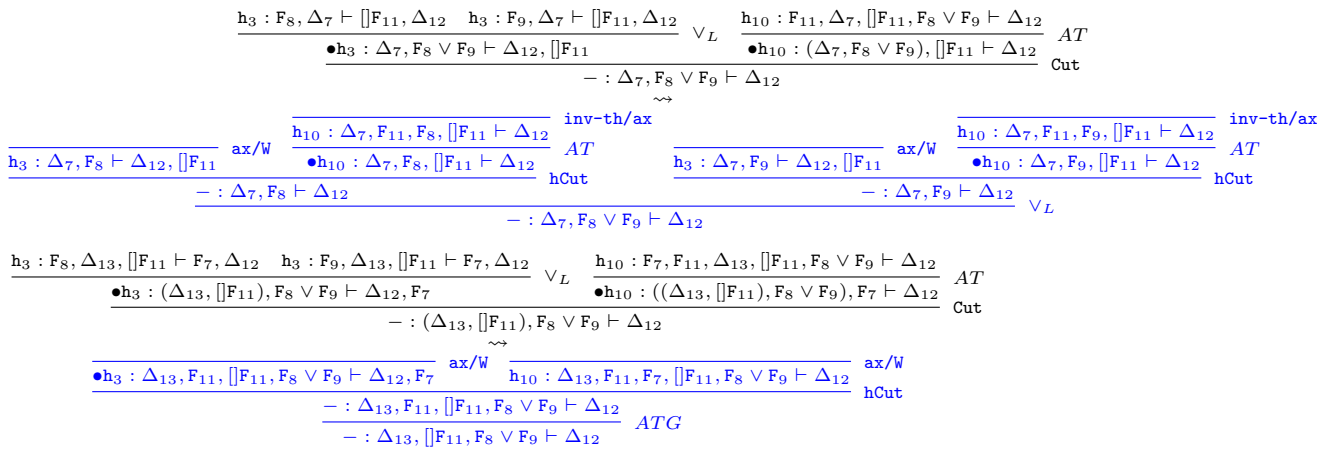
$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7 \vdash \mathtt{F}_{11} \vee \mathtt{F}_{12}, \Delta_{13} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_7 \vdash \mathtt{F}_{11} \vee \mathtt{F}_{12}, \Delta_{13}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\vee_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_{11}, \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13} \quad \mathtt{h}_{10} : \mathtt{F}_{12}, \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_{11} \vee \mathtt{F}_{12} \vdash \Delta_{13}}\,\vee_L}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

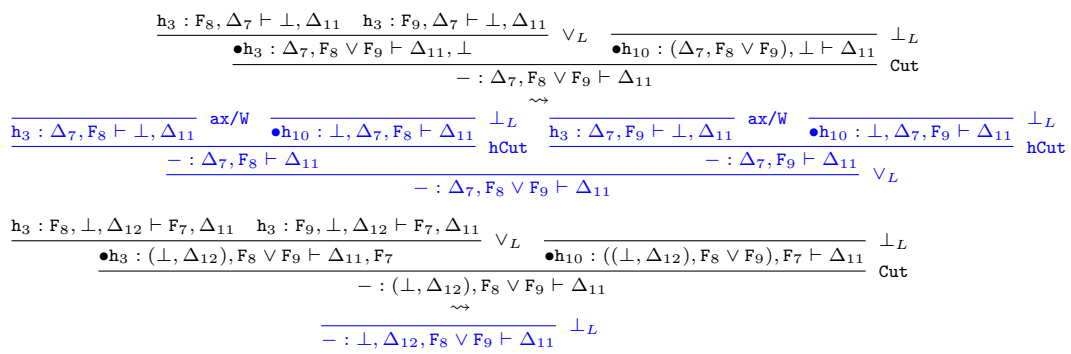
$$\dfrac{\dfrac{\dfrac{\dfrac{}{- : \Delta_7, \mathtt{F}_8 \vdash \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_{12}}\,\mathtt{inv\text{-}th/ax} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_{12}}\,\mathtt{inv\text{-}th/ax}}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}, \mathtt{F}_{12}}\,\vee_L \quad \dfrac{}{- : \Delta_7, \mathtt{F}_{12}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\,\mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}, \mathtt{F}_{11}}\,\mathtt{sCut} \quad \dfrac{}{- : \Delta_7, \mathtt{F}_{11}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{13}}\,\mathtt{sCut}$$



- Case rule AT



- Case rule $\bot_L$



- Case rule I

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7 \vdash \mathtt{p}_{11}, \Delta_{12}, \mathtt{p}_{11} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_7 \vdash \mathtt{p}_{11}, \Delta_{12}, \mathtt{p}_{11}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{p}_{11}} \vee_L \quad \dfrac{}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}}\, I}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\,\mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \vdash \Delta_{12}, \mathtt{p}_{11}, \mathtt{p}_{11}}\,\mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}}\, I}{- : \Delta_7, \mathtt{F}_8 \vdash \Delta_{12}, \mathtt{p}_{11}}\,\mathtt{hCut} \quad \dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}, \mathtt{p}_{11}}\,\mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_{10} : \Delta_7, \mathtt{F}_9, \mathtt{p}_{11} \vdash \Delta_{12}, \mathtt{p}_{11}}\, I}{- : \Delta_7, \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\,\mathtt{hCut}}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\,\vee_L$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_{13}, \mathtt{p}_{11} \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{p}_{11} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_{13}, \mathtt{p}_{11} \vdash \mathtt{F}_7, \Delta_{12}, \mathtt{p}_{11}}{\bullet\mathtt{h}_3 : (\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash (\Delta_{12}, \mathtt{p}_{11}), \mathtt{F}_7} \vee_L \quad \dfrac{}{\bullet\mathtt{h}_{10} : ((\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{12}, \mathtt{p}_{11}}\, I}{- : (\Delta_{13}, \mathtt{p}_{11}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\,\mathtt{Cut}}{- : \Delta_{13}, \mathtt{p}_{11}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{12}, \mathtt{p}_{11}}\, I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7 \vdash \top, \Delta_{11} \quad \mathtt{h}_3 : \mathtt{F}_9, \Delta_7 \vdash \top, \Delta_{11}}{\bullet\mathtt{h}_3 : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}, \top} \vee_L \quad \dfrac{\mathtt{h}_{10} : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}}{\bullet\mathtt{h}_{10} : (\Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9), \top \vdash \Delta_{11}}\,\top_L}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \top, \Delta_{12} \vdash \mathtt{F}_7, \Delta_{11} \quad \mathtt{h}_3 : \mathtt{F}_9, \top, \Delta_{12} \vdash \mathtt{F}_7, \Delta_{11}}{\bullet\mathtt{h}_3 : (\top, \Delta_{12}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_7} \vee_L \quad \dfrac{\mathtt{h}_{10} : \mathtt{F}_7, \Delta_{12}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}}{\bullet\mathtt{h}_{10} : ((\top, \Delta_{12}), \mathtt{F}_8 \vee \mathtt{F}_9), \mathtt{F}_7 \vdash \Delta_{11}}\,\top_L}{- : (\top, \Delta_{12}), \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_3 : \top, \Delta_{12}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}, \mathtt{F}_7}\,\mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_{10} : \top, \Delta_{12}, \mathtt{F}_7, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{ax/W}}{- : \top, \Delta_{12}, \mathtt{F}_8 \vee \mathtt{F}_9 \vdash \Delta_{11}}\,\mathtt{hCut}$$

6.11 Status of AT: OK

- Case rule $\to_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_6, \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}{\bullet\mathtt{h}_3 : \Delta_7, []\mathtt{F}_8 \vdash (\Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}), \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \mathtt{F}_{11}, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : (\Delta_7, []\mathtt{F}_8), \mathtt{F}_6 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,\to_R}{- : \Delta_7, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_6, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_9 : \Delta_7, \mathtt{F}_6, \mathtt{F}_8, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_8, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_7, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \to \mathtt{F}_{12}}\, AT$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_6, \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}{\bullet\mathtt{h}_3 : \Delta_7, []\mathtt{F}_8 \vdash (\Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}), \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_{11}, \Delta_{10} \quad \mathtt{h}_9 : \mathtt{F}_6, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : (\Delta_7, []\mathtt{F}_8), \mathtt{F}_6 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\wedge_R}{- : \Delta_7, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_6, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_9 : \Delta_7, \mathtt{F}_6, \mathtt{F}_8, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_8, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_7, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \wedge \mathtt{F}_{12}}\, ATG$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_6, \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}{\bullet\mathtt{h}_3 : \Delta_7, []\mathtt{F}_8 \vdash (\Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}), \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_{11}, \mathtt{F}_{12}, \Delta_{10}}{\bullet\mathtt{h}_9 : (\Delta_7, []\mathtt{F}_8), \mathtt{F}_6 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\vee_R}{- : \Delta_7, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_7, \mathtt{F}_8, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_6, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_9 : \Delta_7, \mathtt{F}_6, \mathtt{F}_8, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_8, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\,\mathtt{hCut}}{- : \Delta_7, []\mathtt{F}_8 \vdash \Delta_{10}, \mathtt{F}_{11} \vee \mathtt{F}_{12}}\, AT$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_6, \bot, \Delta_{10}}{\bullet\mathtt{h}_3 : \Delta_7, []\mathtt{F}_8 \vdash (\bot, \Delta_{10}), \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \Delta_7, []\mathtt{F}_8 \vdash \Delta_{10}}{\bullet\mathtt{h}_9 : (\Delta_7, []\mathtt{F}_8), \mathtt{F}_6 \vdash \bot, \Delta_{10}}\, \bot_R}{- : \Delta_7, []\mathtt{F}_8 \vdash \bot, \Delta_{10}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_3 : \Delta_7, []\mathtt{F}_8 \vdash \bot, \Delta_{10}, \mathtt{F}_6}\, \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_9 : \Delta_7, \mathtt{F}_6, []\mathtt{F}_8 \vdash \bot, \Delta_{10}}\, \mathtt{ax/W}}{- : \Delta_7, []\mathtt{F}_8 \vdash \bot, \Delta_{10}}\, \mathtt{hCut}$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_8, \Delta_7, []\mathtt{F}_8 \vdash \mathtt{F}_6, \top, \Delta_{10}}{\bullet\mathtt{h}_3 : \Delta_7, []\mathtt{F}_8 \vdash (\top, \Delta_{10}), \mathtt{F}_6}\, AT \quad \dfrac{}{\bullet\mathtt{h}_9 : (\Delta_7, []\mathtt{F}_8), \mathtt{F}_6 \vdash \top, \Delta_{10}}\, \top_R}{- : \Delta_7, []\mathtt{F}_8 \vdash \top, \Delta_{10}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_7, []\mathtt{F}_8 \vdash \top, \Delta_{10}}\, \top_R$$

- Case rule K

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Box\Gamma_{12}, \Delta_9), []\mathtt{F}_7 \vdash \Box\mathtt{F}_6, \Delta_{10}, []\mathtt{F}_{11}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{12}, \Delta_9), []\mathtt{F}_7 \vdash (\Delta_{10}, []\mathtt{F}_{11}), \Box\mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_7, \mathit{unbox}(\Box\Gamma_{12}), \mathit{unbox}(\Box\mathtt{F}_6) \vdash \mathtt{F}_{11}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{12}, \Delta_9), []\mathtt{F}_7), \Box\mathtt{F}_6 \vdash \Delta_{10}, []\mathtt{F}_{11}}\, K}{- : (\Box\Gamma_{12}, \Delta_9), []\mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_{11}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_9, \mathtt{F}_7, \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Box\mathtt{F}_6, \Delta_{10}, []\mathtt{F}_{11}}\, \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_8 : \Box\mathtt{F}_6, \Delta_9, \mathtt{F}_7, \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_{11}}\, \mathtt{ax/W}}{- : \Delta_9, \mathtt{F}_7, \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_{11}}\, \mathtt{hCut}}{- : \Delta_9, \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_{11}}\, ATG$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Box\Gamma_{11}, \Delta_{12}), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{11}, \Delta_{12}), []\mathtt{F}_7 \vdash (\Delta_9, []\mathtt{F}_{10}), \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_7, \mathit{unbox}(\Box\Gamma_{11}) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{11}, \Delta_{12}), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Delta_9, []\mathtt{F}_{10}}\, K}{- : (\Box\Gamma_{11}, \Delta_{12}), []\mathtt{F}_7 \vdash \Delta_9, []\mathtt{F}_{10}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{- : \mathtt{F}_7, \mathit{unbox}(\Box\Gamma_{11}) \vdash \mathtt{F}_{10}}\, \mathtt{ax/W}}{- : \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_7 \vdash \Delta_9, []\mathtt{F}_{10}}\, K$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Box\Gamma_{11}, \Delta_{12}), []\mathtt{F}_7 \vdash \Box\mathtt{F}_6, \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{11}, \Delta_{12}), []\mathtt{F}_7 \vdash (\Delta_9, []\mathtt{F}_{10}), \Box\mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_8 : \mathit{unbox}(\Box\Gamma_{11}), \mathit{unbox}(\Box\mathtt{F}_6) \vdash \mathtt{F}_{10}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{11}, \Delta_{12}), []\mathtt{F}_7), \Box\mathtt{F}_6 \vdash \Delta_9, []\mathtt{F}_{10}}\, K}{- : (\Box\Gamma_{11}, \Delta_{12}), []\mathtt{F}_7 \vdash \Delta_9, []\mathtt{F}_{10}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{12}, \mathtt{F}_7, \Box\Gamma_{11}, []\mathtt{F}_7 \vdash \Box\mathtt{F}_6, \Delta_9, []\mathtt{F}_{10}}\, \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_8 : \Box\mathtt{F}_6, \Delta_{12}, \mathtt{F}_7, \Box\Gamma_{11}, []\mathtt{F}_7 \vdash \Delta_9, []\mathtt{F}_{10}}\, \mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_7, \Box\Gamma_{11}, []\mathtt{F}_7 \vdash \Delta_9, []\mathtt{F}_{10}}\, \mathtt{hCut}}{- : \Delta_{12}, \Box\Gamma_{11}, []\mathtt{F}_7 \vdash \Delta_9, []\mathtt{F}_{10}}\, ATG$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Box\Gamma_9, \Delta_{12}), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Delta_{10}, []\mathtt{F}_{11}}{\bullet\mathtt{h}_3 : (\Box\Gamma_9, \Delta_{12}), []\mathtt{F}_7 \vdash (\Delta_{10}, []\mathtt{F}_{11}), \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_8 : \mathit{unbox}(\Box\Gamma_9) \vdash \mathtt{F}_{11}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_9, \Delta_{12}), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Delta_{10}, []\mathtt{F}_{11}}\, K}{- : (\Box\Gamma_9, \Delta_{12}), []\mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_{11}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{- : \mathit{unbox}(\Box\Gamma_9) \vdash \mathtt{F}_{11}}\, \mathtt{ax/W}}{- : \Delta_{12}, \Box\Gamma_9, []\mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_{11}}\, K$$

- Case rule $A45$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Box\Gamma_{13}, \Delta_9), []\mathtt{F}_7 \vdash \Box\mathtt{F}_6, \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{13}, \Delta_9), []\mathtt{F}_7 \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \Box\mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{13}, \Box\mathtt{F}_6, []\mathtt{F}_7 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{13}, \Delta_9), []\mathtt{F}_7), \Box\mathtt{F}_6 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\, A45}{- : (\Box\Gamma_{13}, \Delta_9), []\mathtt{F}_7 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_9, \mathtt{F}_7, \Box\Gamma_{13}, []\mathtt{F}_7 \vdash \Box\mathtt{F}_6, \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\, \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_8 : \Box\mathtt{F}_6, \Delta_9, \mathtt{F}_7, \Box\Gamma_{13}, []\mathtt{F}_7 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\, \mathtt{ax/W}}{- : \Delta_9, \mathtt{F}_7, \Box\Gamma_{13}, []\mathtt{F}_7 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\, \mathtt{hCut}}{- : \Delta_9, \Box\Gamma_{13}, []\mathtt{F}_7 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\, ATG$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Box\Gamma_{12}, \Delta_{13}), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{11}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{12}, \Delta_{13}), []\mathtt{F}_7 \vdash (\Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{11}), \mathtt{F}_6}\ AT \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Box\Gamma_9, \mathtt{F}_{11}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{12}, \Delta_{13}), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{11}}\ A45}{- : (\Box\Gamma_{12}, \Delta_{13}), []\mathtt{F}_7 \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{11}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \mathtt{F}_{11}, \Box\Gamma_9}\ \mathtt{ax/W}}{- : \Delta_{13}, \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{11}}\ A45$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Box\Gamma_{12}, \Delta_{13}), []\mathtt{F}_7 \vdash \Box\mathtt{F}_6, \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{11}}{\bullet\mathtt{h}_3 : (\Box\Gamma_{12}, \Delta_{13}), []\mathtt{F}_7 \vdash (\Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{11}), \Box\mathtt{F}_6}\ AT \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{12}, \Box\mathtt{F}_6 \vdash \Box\Gamma_9, \mathtt{F}_{11}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_{12}, \Delta_{13}), []\mathtt{F}_7), \Box\mathtt{F}_6 \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{11}}\ A45}{- : (\Box\Gamma_{12}, \Delta_{13}), []\mathtt{F}_7 \vdash \Box\Gamma_9, \Delta_{10}, []\mathtt{F}_{11}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{13}, \mathtt{F}_7, \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Box\mathtt{F}_6, \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{11}}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_8 : \Box\mathtt{F}_6, \Delta_{13}, \mathtt{F}_7, \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{11}}\ \mathtt{ax/W}}{- : \Delta_{13}, \mathtt{F}_7, \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{11}}\ \mathtt{hCut}}{- : \Delta_{13}, \Box\Gamma_{12}, []\mathtt{F}_7 \vdash \Delta_{10}, \Box\Gamma_9, []\mathtt{F}_{11}}\ AT$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Box\Gamma_9, \Delta_{13}), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}{\bullet\mathtt{h}_3 : (\Box\Gamma_9, \Delta_{13}), []\mathtt{F}_7 \vdash (\Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}), \mathtt{F}_6}\ AT \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{12}}{\bullet\mathtt{h}_8 : ((\Box\Gamma_9, \Delta_{13}), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ A45}{- : (\Box\Gamma_9, \Delta_{13}), []\mathtt{F}_7 \vdash \Box\Gamma_{10}, \Delta_{11}, []\mathtt{F}_{12}}\ \mathtt{Cut}}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_9 \vdash \mathtt{F}_{12}, \Box\Gamma_{10}}\ \mathtt{ax/W}}{- : \Delta_{13}, \Box\Gamma_9, []\mathtt{F}_7 \vdash \Delta_{11}, \Box\Gamma_{10}, []\mathtt{F}_{12}}\ A45$$

- Case rule $\rightarrow_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, \Delta_6, []\mathtt{F}_7 \vdash \mathtt{F}_9 \to \mathtt{F}_{10}, \Delta_{11}}{\bullet\mathtt{h}_3 : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_9 \to \mathtt{F}_{10}}\ AT \quad \dfrac{\mathtt{h}_8 : \Delta_6, []\mathtt{F}_7 \vdash \mathtt{F}_9, \Delta_{11} \quad \mathtt{h}_8 : \mathtt{F}_{10}, \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : (\Delta_6, []\mathtt{F}_7), \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}}\ \to_L}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_9 \to \mathtt{F}_{10}}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_8 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}}\ \mathtt{ax/W}}{- : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{11}}\ \mathtt{hCut}}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}}\ AT$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Delta_{11}}{\bullet\mathtt{h}_3 : (\Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_6}\ AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_6, \Delta_{12}, []\mathtt{F}_7 \vdash \mathtt{F}_9, \Delta_{11} \quad \mathtt{h}_8 : \mathtt{F}_6, \mathtt{F}_{10}, \Delta_{12}, []\mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : ((\Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Delta_{11}}\ \to_L}{- : (\Delta_{12}, \mathtt{F}_9 \to \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \Delta_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{12}, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_6, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}}\ \mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}}\ \mathtt{hCut}}{- : \Delta_{12}, []\mathtt{F}_7, \mathtt{F}_9 \to \mathtt{F}_{10} \vdash \Delta_{11}}\ ATG$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, \Delta_6, []\mathtt{F}_7 \vdash \mathtt{F}_9 \wedge \mathtt{F}_{10}, \Delta_{11}}{\bullet\mathtt{h}_3 : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_9, \mathtt{F}_{10}, \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : (\Delta_6, []\mathtt{F}_7), \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}}\ \wedge_L}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_8 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}}\ \mathtt{ax/W}}{- : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{11}}\ \mathtt{hCut}}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}}\ ATG$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Delta_{11}}{\bullet\mathtt{h}_3 : (\Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_6}\ AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_6, \mathtt{F}_9, \mathtt{F}_{10}, \Delta_{12}, []\mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : ((\Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Delta_{11}}\ \wedge_L}{- : (\Delta_{12}, \mathtt{F}_9 \wedge \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \Delta_{11}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_{12}, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_6, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}}\ \mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}}\ \mathtt{hCut}}{- : \Delta_{12}, []\mathtt{F}_7, \mathtt{F}_9 \wedge \mathtt{F}_{10} \vdash \Delta_{11}}\ ATG$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, \Delta_6, []\mathtt{F}_7 \vdash \mathtt{F}_9 \vee \mathtt{F}_{10}, \Delta_{11}}{\bullet\mathtt{h}_3 : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_9 \vee \mathtt{F}_{10}}\, AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_9, \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11} \quad \mathtt{h}_8 : \mathtt{F}_{10}, \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : (\Delta_6, []\mathtt{F}_7), \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\, \vee_L}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}}\, \mathtt{Cut}}{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_9 \vee \mathtt{F}_{10}}{}\, \mathtt{ax/W} \rightsquigarrow \dfrac{}{\bullet\mathtt{h}_8 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\, \mathtt{ax/W}}{- : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{11}}\, \mathtt{hCut}}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{11}}\, AT$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Delta_{11}}{\bullet\mathtt{h}_3 : (\Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \Delta_{11}, \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_6, \mathtt{F}_9, \Delta_{12}, []\mathtt{F}_7 \vdash \Delta_{11} \quad \mathtt{h}_8 : \mathtt{F}_6, \mathtt{F}_{10}, \Delta_{12}, []\mathtt{F}_7 \vdash \Delta_{11}}{\bullet\mathtt{h}_8 : ((\Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Delta_{11}}\, \vee_L}{- : (\Delta_{12}, \mathtt{F}_9 \vee \mathtt{F}_{10}), []\mathtt{F}_7 \vdash \Delta_{11}}\, \mathtt{Cut}}{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_{12}, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}, \mathtt{F}_6}{}\, \mathtt{ax/W} \rightsquigarrow \dfrac{}{\bullet\mathtt{h}_8 : \Delta_{12}, \mathtt{F}_6, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\, \mathtt{ax/W}}{- : \Delta_{12}, \mathtt{F}_7, []\mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\, \mathtt{hCut}}{- : \Delta_{12}, []\mathtt{F}_7, \mathtt{F}_9 \vee \mathtt{F}_{10} \vdash \Delta_{11}}\, ATG$$

- Case rule AT

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, \Delta_6, []\mathtt{F}_7 \vdash []\mathtt{F}_9, \Delta_{10}}{\bullet\mathtt{h}_3 : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_9}\, AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_9, \Delta_6, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}{\bullet\mathtt{h}_8 : (\Delta_6, []\mathtt{F}_7), []\mathtt{F}_9 \vdash \Delta_{10}}\, AT}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{10}}\, \mathtt{Cut}}{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{10}, []\mathtt{F}_9}{}\, \mathtt{ax/W} \rightsquigarrow \dfrac{}{\bullet\mathtt{h}_8 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}\, \mathtt{ax/W}}{- : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{10}}\, \mathtt{hCut}}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{10}}\, AT$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Delta_{11}, []\mathtt{F}_9), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Delta_{10}}{\bullet\mathtt{h}_3 : (\Delta_{11}, []\mathtt{F}_9), []\mathtt{F}_7 \vdash \Delta_{10}, \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_6, \mathtt{F}_9, \Delta_{11}, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}{\bullet\mathtt{h}_8 : ((\Delta_{11}, []\mathtt{F}_9), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Delta_{10}}\, AT}{- : (\Delta_{11}, []\mathtt{F}_9), []\mathtt{F}_7 \vdash \Delta_{10}}\, \mathtt{Cut}}{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_{11}, \mathtt{F}_7, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}, \mathtt{F}_6}{}\, \mathtt{ax/W} \rightsquigarrow \dfrac{}{\bullet\mathtt{h}_8 : \Delta_{11}, \mathtt{F}_6, \mathtt{F}_7, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}\, \mathtt{ax/W}}{- : \Delta_{11}, \mathtt{F}_7, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}\, \mathtt{hCut}}{- : \Delta_{11}, []\mathtt{F}_7, []\mathtt{F}_9 \vdash \Delta_{10}}\, ATG$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_9, \Delta_7, []\mathtt{F}_9 \vdash \mathtt{F}_6, \Delta_{10}}{\bullet\mathtt{h}_3 : \Delta_7, []\mathtt{F}_9 \vdash \Delta_{10}, \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_6, \mathtt{F}_9, \Delta_7, []\mathtt{F}_9 \vdash \Delta_{10}}{\bullet\mathtt{h}_8 : (\Delta_7, []\mathtt{F}_9), \mathtt{F}_6 \vdash \Delta_{10}}\, AT}{- : \Delta_7, []\mathtt{F}_9 \vdash \Delta_{10}}\, \mathtt{Cut}}{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_7, \mathtt{F}_9, []\mathtt{F}_9 \vdash \Delta_{10}, \mathtt{F}_6}{}\, \mathtt{ax/W} \rightsquigarrow \dfrac{}{\bullet\mathtt{h}_8 : \Delta_7, \mathtt{F}_6, \mathtt{F}_9, []\mathtt{F}_9 \vdash \Delta_{10}}\, \mathtt{ax/W}}{- : \Delta_7, \mathtt{F}_9, []\mathtt{F}_9 \vdash \Delta_{10}}\, \mathtt{hCut}}{- : \Delta_7, []\mathtt{F}_9 \vdash \Delta_{10}}\, AT$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, \Delta_6, []\mathtt{F}_7 \vdash \bot, \Delta_9}{\bullet\mathtt{h}_3 : \Delta_6, []\mathtt{F}_7 \vdash \Delta_9, \bot}\, AT \quad \dfrac{}{\bullet\mathtt{h}_8 : (\Delta_6, []\mathtt{F}_7), \bot \vdash \Delta_9}\, \bot_L}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_9}\, \mathtt{Cut}}{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \bot, \Delta_9}{}\, \mathtt{ax/W} \rightsquigarrow \dfrac{}{\bullet\mathtt{h}_8 : \bot, \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_9}\, \bot_L}{- : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_9}\, \mathtt{hCut}}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_9}\, AT$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\bot, \Delta_{10}), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Delta_9}{\bullet\mathtt{h}_3 : (\bot, \Delta_{10}), []\mathtt{F}_7 \vdash \Delta_9, \mathtt{F}_6}\, AT \quad \dfrac{}{\bullet\mathtt{h}_8 : ((\bot, \Delta_{10}), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Delta_9}\, \bot_L}{- : (\bot, \Delta_{10}), []\mathtt{F}_7 \vdash \Delta_9}\, \mathtt{Cut}}{\dfrac{}{- : \bot, \Delta_{10}, []\mathtt{F}_7 \vdash \Delta_9}\, \bot_L} \rightsquigarrow$$

- Case rule I

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, \Delta_6, []\mathtt{F}_7 \vdash \mathtt{p}_9, \Delta_{10}, \mathtt{p}_9}{\bullet\mathtt{h}_3 : \Delta_6, []\mathtt{F}_7 \vdash (\Delta_{10}, \mathtt{p}_9), \mathtt{p}_9}\, AT \quad \dfrac{}{\bullet\mathtt{h}_8 : (\Delta_6, []\mathtt{F}_7), \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_9}\, I}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9, \mathtt{p}_9}\, \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_8 : \Delta_6, \mathtt{F}_7, \mathtt{p}_9, []\mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9}\, I}{- : \Delta_6, \mathtt{F}_7, []\mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9}\, \mathtt{hCut}}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9}\, ATG$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\Delta_{11}, \mathtt{p}_9), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Delta_{10}, \mathtt{p}_9}{\bullet\mathtt{h}_3 : (\Delta_{11}, \mathtt{p}_9), []\mathtt{F}_7 \vdash (\Delta_{10}, \mathtt{p}_9), \mathtt{F}_6}\, AT \quad \dfrac{}{\bullet\mathtt{h}_8 : ((\Delta_{11}, \mathtt{p}_9), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Delta_{10}, \mathtt{p}_9}\, I}{- : (\Delta_{11}, \mathtt{p}_9), []\mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_{11}, \mathtt{p}_9, []\mathtt{F}_7 \vdash \Delta_{10}, \mathtt{p}_9}\, I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, \Delta_6, []\mathtt{F}_7 \vdash \top, \Delta_9}{\bullet\mathtt{h}_3 : \Delta_6, []\mathtt{F}_7 \vdash \Delta_9, \top}\, AT \quad \dfrac{\mathtt{h}_8 : \Delta_6, []\mathtt{F}_7 \vdash \Delta_9}{\bullet\mathtt{h}_8 : (\Delta_6, []\mathtt{F}_7), \top \vdash \Delta_9}\, \top_L}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_9}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \Delta_6, []\mathtt{F}_7 \vdash \Delta_9}\, \mathtt{ax/W}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \mathtt{F}_7, (\top, \Delta_{10}), []\mathtt{F}_7 \vdash \mathtt{F}_6, \Delta_9}{\bullet\mathtt{h}_3 : (\top, \Delta_{10}), []\mathtt{F}_7 \vdash \Delta_9, \mathtt{F}_6}\, AT \quad \dfrac{\mathtt{h}_8 : \mathtt{F}_6, \Delta_{10}, []\mathtt{F}_7 \vdash \Delta_9}{\bullet\mathtt{h}_8 : ((\top, \Delta_{10}), []\mathtt{F}_7), \mathtt{F}_6 \vdash \Delta_9}\, \top_L}{- : (\top, \Delta_{10}), []\mathtt{F}_7 \vdash \Delta_9}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\bullet\mathtt{h}_3 : \top, \Delta_{10}, []\mathtt{F}_7 \vdash \Delta_9, \mathtt{F}_6}\, \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_8 : \top, \Delta_{10}, \mathtt{F}_6, []\mathtt{F}_7 \vdash \Delta_9}\, \mathtt{ax/W}}{- : \top, \Delta_{10}, []\mathtt{F}_7 \vdash \Delta_9}\, \mathtt{hCut}$$

6.12 Status of $\bot_L$: OK

- Case rule $\to_R$

$$\dfrac{\dfrac{\dfrac{}{\bullet\mathtt{h}_3 : \bot, \Delta_6 \vdash (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{F}_5}\, \bot_L \quad \dfrac{\mathtt{h}_7 : \bot, \mathtt{F}_5, \mathtt{F}_9, \Delta_6 \vdash \mathtt{F}_{10}, \Delta_8}{\bullet\mathtt{h}_7 : (\bot, \Delta_6), \mathtt{F}_5 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\, \to_R}{- : \bot, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \bot, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\, \bot_L$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\dfrac{}{\bullet\mathtt{h}_3 : \bot, \Delta_6 \vdash (\Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_5}\, \bot_L \quad \dfrac{\mathtt{h}_7 : \bot, \mathtt{F}_5, \Delta_6 \vdash \mathtt{F}_9, \Delta_8 \quad \mathtt{h}_7 : \bot, \mathtt{F}_5, \Delta_6 \vdash \mathtt{F}_{10}, \Delta_8}{\bullet\mathtt{h}_7 : (\bot, \Delta_6), \mathtt{F}_5 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\, \wedge_R}{- : \bot, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \bot, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\, \bot_L$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\dfrac{}{\bullet\mathtt{h}_3 : \bot, \Delta_6 \vdash (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_5}\, \bot_L \quad \dfrac{\mathtt{h}_7 : \bot, \mathtt{F}_5, \Delta_6 \vdash \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8}{\bullet\mathtt{h}_7 : (\bot, \Delta_6), \mathtt{F}_5 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\, \vee_R}{- : \bot, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\, \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \bot, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\, \bot_L$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_6 \vdash (\bot, \Delta_8), \mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_7 : \bot, \mathtt{F}_5, \Delta_6 \vdash \Delta_8}{\bullet \mathtt{h}_7 : (\bot, \Delta_6), \mathtt{F}_5 \vdash \bot, \Delta_8}\ \bot_R}{- : \bot, \Delta_6 \vdash \bot, \Delta_8}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_6 \vdash \bot, \Delta_8}\ \bot_L$$

- Case rule $\top_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_6 \vdash (\top, \Delta_8), \mathtt{F}_5}\ \bot_L \quad \dfrac{}{\bullet \mathtt{h}_7 : (\bot, \Delta_6), \mathtt{F}_5 \vdash \top, \Delta_8}\ \top_R}{- : \bot, \Delta_6 \vdash \top, \Delta_8}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_6 \vdash \top, \Delta_8}\ \top_R$$

- Case rule K

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Box\Gamma_9, \Delta_{10} \vdash (\Delta_7, []\mathtt{F}_8), \Box\mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_6 : unbox(\Box\Gamma_9), unbox(\Box\mathtt{F}_5) \vdash \mathtt{F}_8}{\bullet \mathtt{h}_6 : (\bot, \Box\Gamma_9, \Delta_{10}), \Box\mathtt{F}_5 \vdash \Delta_7, []\mathtt{F}_8}\ K}{- : \bot, \Box\Gamma_9, \Delta_{10} \vdash \Delta_7, []\mathtt{F}_8}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_{10}, \Box\Gamma_9 \vdash \Delta_7, []\mathtt{F}_8}\ \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Box\Gamma_7, \Delta_{10} \vdash (\Delta_8, []\mathtt{F}_9), \mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_6 : unbox(\Box\Gamma_7) \vdash \mathtt{F}_9}{\bullet \mathtt{h}_6 : (\bot, \Box\Gamma_7, \Delta_{10}), \mathtt{F}_5 \vdash \Delta_8, []\mathtt{F}_9}\ K}{- : \bot, \Box\Gamma_7, \Delta_{10} \vdash \Delta_8, []\mathtt{F}_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_{10}, \Box\Gamma_7 \vdash \Delta_8, []\mathtt{F}_9}\ \bot_L$$

- Case rule $A45$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Box\Gamma_{10}, \Delta_{11} \vdash (\Box\Gamma_7, \Delta_8, []\mathtt{F}_9), \Box\mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \Box\Gamma_{10}, \Box\mathtt{F}_5 \vdash \Box\Gamma_7, \mathtt{F}_9}{\bullet \mathtt{h}_6 : (\bot, \Box\Gamma_{10}, \Delta_{11}), \Box\mathtt{F}_5 \vdash \Box\Gamma_7, \Delta_8, []\mathtt{F}_9}\ A45}{- : \bot, \Box\Gamma_{10}, \Delta_{11} \vdash \Box\Gamma_7, \Delta_8, []\mathtt{F}_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_{11}, \Box\Gamma_{10} \vdash \Delta_8, \Box\Gamma_7, []\mathtt{F}_9}\ \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Box\Gamma_7, \Delta_{11} \vdash (\Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}), \mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \Box\Gamma_7 \vdash \Box\Gamma_8, \mathtt{F}_{10}}{\bullet \mathtt{h}_6 : (\bot, \Box\Gamma_7, \Delta_{11}), \mathtt{F}_5 \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\ A45}{- : \bot, \Box\Gamma_7, \Delta_{11} \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_{11}, \Box\Gamma_7 \vdash \Delta_9, \Box\Gamma_8, []\mathtt{F}_{10}}\ \bot_L$$

- Case rule $\rightarrow_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5 \vdash \Delta_9, \mathtt{F}_7 \to \mathtt{F}_8}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \Delta_5 \vdash \mathtt{F}_7, \Delta_9 \quad \mathtt{h}_6 : \bot, \mathtt{F}_8, \Delta_5 \vdash \Delta_9}{\bullet \mathtt{h}_6 : (\bot, \Delta_5), \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9}\ \to_L}{- : \bot, \Delta_5 \vdash \Delta_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_5 \vdash \Delta_9}\ \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9, \mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \mathtt{F}_5, \Delta_{10} \vdash \mathtt{F}_7, \Delta_9 \quad \mathtt{h}_6 : \bot, \mathtt{F}_5, \mathtt{F}_8, \Delta_{10} \vdash \Delta_9}{\bullet \mathtt{h}_6 : (\bot, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8), \mathtt{F}_5 \vdash \Delta_9}\ \to_L}{- : \bot, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9}\ \bot_L$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5 \vdash \Delta_9, \mathtt{F}_7 \wedge \mathtt{F}_8}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \mathtt{F}_7, \mathtt{F}_8, \Delta_5 \vdash \Delta_9}{\bullet \mathtt{h}_6 : (\bot, \Delta_5), \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9}\ \wedge_L}{- : \bot, \Delta_5 \vdash \Delta_9}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_5 \vdash \Delta_9}\ \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9, \mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \mathtt{F}_5, \mathtt{F}_7, \mathtt{F}_8, \Delta_{10} \vdash \Delta_9}{\bullet \mathtt{h}_6 : (\bot, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8), \mathtt{F}_5 \vdash \Delta_9}\ \wedge_L}{- : \bot, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9}\ \bot_L$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5 \vdash \Delta_9, \mathtt{F}_7 \vee \mathtt{F}_8}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \mathtt{F}_7, \Delta_5 \vdash \Delta_9 \quad \mathtt{h}_6 : \bot, \mathtt{F}_8, \Delta_5 \vdash \Delta_9}{\bullet \mathtt{h}_6 : (\bot, \Delta_5), \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9}\ \vee_L}{- : \bot, \Delta_5 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_5 \vdash \Delta_9}\ \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9, \mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \mathtt{F}_5, \mathtt{F}_7, \Delta_{10} \vdash \Delta_9 \quad \mathtt{h}_6 : \bot, \mathtt{F}_5, \mathtt{F}_8, \Delta_{10} \vdash \Delta_9}{\bullet \mathtt{h}_6 : (\bot, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8), \mathtt{F}_5 \vdash \Delta_9}\ \vee_L}{- : \bot, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9}\ \bot_L$$

- Case rule AT

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5 \vdash \Delta_8, []\mathtt{F}_7}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \mathtt{F}_7, \Delta_5, []\mathtt{F}_7 \vdash \Delta_8}{\bullet \mathtt{h}_6 : (\bot, \Delta_5), []\mathtt{F}_7 \vdash \Delta_8}\ AT}{- : \bot, \Delta_5 \vdash \Delta_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_5 \vdash \Delta_8}\ \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_9, []\mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \mathtt{F}_5, \mathtt{F}_7, \Delta_9, []\mathtt{F}_7 \vdash \Delta_8}{\bullet \mathtt{h}_6 : (\bot, \Delta_9, []\mathtt{F}_7), \mathtt{F}_5 \vdash \Delta_8}\ AT}{- : \bot, \Delta_9, []\mathtt{F}_7 \vdash \Delta_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_9, []\mathtt{F}_7 \vdash \Delta_8}\ \bot_L$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_6 \vdash \Delta_8, \mathtt{F}_5}\ \bot_L \quad \dfrac{}{\bullet \mathtt{h}_7 : (\bot, \Delta_6), \mathtt{F}_5 \vdash \Delta_8}\ \bot_L}{- : \bot, \Delta_6 \vdash \Delta_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_6 \vdash \Delta_8}\ \bot_L$$

- Case rule I

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{p}_7}\ \bot_L \quad \dfrac{}{\bullet \mathtt{h}_6 : (\bot, \Delta_5), \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ I}{- : \bot, \Delta_5 \vdash \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_5 \vdash \Delta_8, \mathtt{p}_7}\ \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_9, \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_5}\ \bot_L \quad \dfrac{}{\bullet \mathtt{h}_6 : (\bot, \Delta_9, \mathtt{p}_7), \mathtt{F}_5 \vdash \Delta_8, \mathtt{p}_7}\ I}{- : \bot, \Delta_9, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_9, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ \bot_L$$

- Case rule $\top_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \Delta_5 \vdash \Delta_7, \top}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \Delta_5 \vdash \Delta_7}{\bullet \mathtt{h}_6 : (\bot, \Delta_5), \top \vdash \Delta_7}\ \top_L}{- : \bot, \Delta_5 \vdash \Delta_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \bot, \Delta_5 \vdash \Delta_7}\ \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_3 : \bot, \top, \Delta_8 \vdash \Delta_7, \mathtt{F}_5}\ \bot_L \quad \dfrac{\mathtt{h}_6 : \bot, \mathtt{F}_5, \Delta_8 \vdash \Delta_7}{\bullet \mathtt{h}_6 : (\bot, \top, \Delta_8), \mathtt{F}_5 \vdash \Delta_7}\ \top_L}{- : \bot, \top, \Delta_8 \vdash \Delta_7}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \top, \Delta_8 \vdash \Delta_7}\ \bot_L$$

6.13 Status of I: OK

- Case rule $\to_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_6 \vdash (\Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}), \mathtt{p}_6}\ I \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_9, \Delta_5, \mathtt{p}_6, \mathtt{p}_6 \vdash \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_7 : (\Delta_5, \mathtt{p}_6), \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\ \to_R}{- : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{F}_9, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{p}_6}\ I \quad \dfrac{}{\mathtt{h}_7 : \Delta_5, \mathtt{F}_9, \mathtt{p}_6, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_5, \mathtt{F}_9, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_{10}}\ \mathtt{hCut}}{- : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9 \to \mathtt{F}_{10}}\ \to_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7, \mathtt{p}_8 \vdash ((\Delta_{12}, \mathtt{F}_{10} \to \mathtt{F}_{11}), \mathtt{p}_8), \mathtt{F}_6}\ I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \mathtt{F}_{10}, \Delta_7, \mathtt{p}_8 \vdash \mathtt{F}_{11}, \Delta_{12}, \mathtt{p}_8}{\bullet \mathtt{h}_9 : (\Delta_7, \mathtt{p}_8), \mathtt{F}_6 \vdash (\Delta_{12}, \mathtt{F}_{10} \to \mathtt{F}_{11}), \mathtt{p}_8}\ \to_R}{- : \Delta_7, \mathtt{p}_8 \vdash (\Delta_{12}, \mathtt{F}_{10} \to \mathtt{F}_{11}), \mathtt{p}_8}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_7, \mathtt{p}_8 \vdash \Delta_{12}, \mathtt{p}_8, \mathtt{F}_{10} \to \mathtt{F}_{11}}\ I$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_6 \vdash (\Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{p}_6}\ I \quad \dfrac{\mathtt{h}_7 : \Delta_5, \mathtt{p}_6, \mathtt{p}_6 \vdash \mathtt{F}_9, \Delta_8 \quad \mathtt{h}_7 : \Delta_5, \mathtt{p}_6, \mathtt{p}_6 \vdash \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_7 : (\Delta_5, \mathtt{p}_6), \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ \wedge_R}{- : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9, \mathtt{p}_6}\ I \quad \dfrac{}{\mathtt{h}_7 : \Delta_5, \mathtt{p}_6, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9}\ \mathtt{hCut} \quad \dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{p}_6}\ I \quad \dfrac{}{\mathtt{h}_7 : \Delta_5, \mathtt{p}_6, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_{10}}\ \mathtt{hCut}}{- : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\ \wedge_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7, \mathtt{p}_8 \vdash ((\Delta_{12}, \mathtt{F}_{10} \wedge \mathtt{F}_{11}), \mathtt{p}_8), \mathtt{F}_6}\ I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \Delta_7, \mathtt{p}_8 \vdash \mathtt{F}_{10}, \Delta_{12}, \mathtt{p}_8 \quad \mathtt{h}_9 : \mathtt{F}_6, \Delta_7, \mathtt{p}_8 \vdash \mathtt{F}_{11}, \Delta_{12}, \mathtt{p}_8}{\bullet \mathtt{h}_9 : (\Delta_7, \mathtt{p}_8), \mathtt{F}_6 \vdash (\Delta_{12}, \mathtt{F}_{10} \wedge \mathtt{F}_{11}), \mathtt{p}_8}\ \wedge_R}{- : \Delta_7, \mathtt{p}_8 \vdash (\Delta_{12}, \mathtt{F}_{10} \wedge \mathtt{F}_{11}), \mathtt{p}_8}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_7, \mathtt{p}_8 \vdash \Delta_{12}, \mathtt{p}_8, \mathtt{F}_{10} \wedge \mathtt{F}_{11}}\ I$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_6 \vdash (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{p}_6}\ I \quad \dfrac{\mathtt{h}_7 : \Delta_5, \mathtt{p}_6, \mathtt{p}_6 \vdash \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_7 : (\Delta_5, \mathtt{p}_6), \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \vee_R}{- : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9, \mathtt{p}_6}\ I \quad \dfrac{}{\mathtt{h}_7 : \Delta_5, \mathtt{p}_6, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9}\ \mathtt{ax/W}}{- : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_{10}, \mathtt{F}_9}\ \mathtt{hCut}}{- : \Delta_5, \mathtt{p}_6 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \vee_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7, \mathtt{p}_8 \vdash ((\Delta_{12}, \mathtt{F}_{10} \vee \mathtt{F}_{11}), \mathtt{p}_8), \mathtt{F}_6}\ I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \Delta_7, \mathtt{p}_8 \vdash \mathtt{F}_{10}, \mathtt{F}_{11}, \Delta_{12}, \mathtt{p}_8}{\bullet \mathtt{h}_9 : (\Delta_7, \mathtt{p}_8), \mathtt{F}_6 \vdash (\Delta_{12}, \mathtt{F}_{10} \vee \mathtt{F}_{11}), \mathtt{p}_8}\ \vee_R}{- : \Delta_7, \mathtt{p}_8 \vdash (\Delta_{12}, \mathtt{F}_{10} \vee \mathtt{F}_{11}), \mathtt{p}_8}\ \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_7, \mathtt{p}_8 \vdash \Delta_{12}, \mathtt{p}_8, \mathtt{F}_{10} \vee \mathtt{F}_{11}}\ I$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_6 \vdash (\bot, \Delta_8), \mathtt{p}_6}\, I \quad \dfrac{\mathtt{h}_7 : \Delta_5, \mathtt{p}_6, \mathtt{p}_6 \vdash \Delta_8}{\bullet \mathtt{h}_7 : (\Delta_5, \mathtt{p}_6), \mathtt{p}_6 \vdash \bot, \Delta_8}\, \bot_R}{- : \Delta_5, \mathtt{p}_6 \vdash \bot, \Delta_8}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_6 \vdash \bot, \Delta_8, \mathtt{p}_6}\, I \quad \dfrac{\mathtt{h}_7 : \Delta_5, \mathtt{p}_6, \mathtt{p}_6 \vdash \bot, \Delta_8}{}\, \mathtt{ax/W}}{- : \Delta_5, \mathtt{p}_6 \vdash \bot, \Delta_8}\, \mathtt{hCut}$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7, \mathtt{p}_8 \vdash ((\bot, \Delta_{10}), \mathtt{p}_8), \mathtt{F}_6}\, I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \Delta_7, \mathtt{p}_8 \vdash \Delta_{10}, \mathtt{p}_8}{\bullet \mathtt{h}_9 : (\Delta_7, \mathtt{p}_8), \mathtt{F}_6 \vdash (\bot, \Delta_{10}), \mathtt{p}_8}\, \bot_R}{- : \Delta_7, \mathtt{p}_8 \vdash (\bot, \Delta_{10}), \mathtt{p}_8}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7, \mathtt{p}_8 \vdash \bot, \Delta_{10}, \mathtt{p}_8}\, I$$

- Case rule $\top_R$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_6 \vdash (\top, \Delta_8), \mathtt{p}_6}\, I \quad \dfrac{}{\bullet \mathtt{h}_7 : (\Delta_5, \mathtt{p}_6), \mathtt{p}_6 \vdash \top, \Delta_8}\, \top_R}{- : \Delta_5, \mathtt{p}_6 \vdash \top, \Delta_8}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_5, \mathtt{p}_6 \vdash \top, \Delta_8}\, \top_R$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7, \mathtt{p}_8 \vdash ((\top, \Delta_{10}), \mathtt{p}_8), \mathtt{F}_6}\, I \quad \dfrac{}{\bullet \mathtt{h}_9 : (\Delta_7, \mathtt{p}_8), \mathtt{F}_6 \vdash (\top, \Delta_{10}), \mathtt{p}_8}\, \top_R}{- : \Delta_7, \mathtt{p}_8 \vdash (\top, \Delta_{10}), \mathtt{p}_8}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_7, \mathtt{p}_8 \vdash \top, \Delta_{10}, \mathtt{p}_8}\, \top_R$$

- Case rule K

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : (\Box\Gamma_7, \Delta_{10}), \mathtt{p}_5 \vdash (\Delta_8, []\mathtt{F}_9), \mathtt{p}_5}\, I \quad \dfrac{\mathtt{h}_6 : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_9}{\bullet \mathtt{h}_6 : ((\Box\Gamma_7, \Delta_{10}), \mathtt{p}_5), \mathtt{p}_5 \vdash \Delta_8, []\mathtt{F}_9}\, K}{- : (\Box\Gamma_7, \Delta_{10}), \mathtt{p}_5 \vdash \Delta_8, []\mathtt{F}_9}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_9}\, \mathtt{ax/W}}{- : \Delta_{10}, \Box\Gamma_7, \mathtt{p}_5 \vdash \Delta_8, []\mathtt{F}_9}\, K$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\Box\Gamma_{11}, \Delta_{12}), \mathtt{p}_7 \vdash ((\Delta_{10}, []\mathtt{F}_9), \mathtt{p}_7), \Box\mathtt{F}_6}\, I \quad \dfrac{\mathtt{h}_8 : \mathit{unbox}(\Box\Gamma_{11}), \mathit{unbox}(\Box\mathtt{F}_6) \vdash \mathtt{F}_9}{\bullet \mathtt{h}_8 : ((\Box\Gamma_{11}, \Delta_{12}), \mathtt{p}_7), \Box\mathtt{F}_6 \vdash (\Delta_{10}, []\mathtt{F}_9), \mathtt{p}_7}\, K}{- : (\Box\Gamma_{11}, \Delta_{12}), \mathtt{p}_7 \vdash (\Delta_{10}, []\mathtt{F}_9), \mathtt{p}_7}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{12}, \Box\Gamma_{11}, \mathtt{p}_7 \vdash \Delta_{10}, \mathtt{p}_7, []\mathtt{F}_9}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\Box\Gamma_9, \Delta_{12}), \mathtt{p}_7 \vdash ((\Delta_{11}, []\mathtt{F}_{10}), \mathtt{p}_7), \mathtt{F}_6}\, I \quad \dfrac{\mathtt{h}_8 : \mathit{unbox}(\Box\Gamma_9) \vdash \mathtt{F}_{10}}{\bullet \mathtt{h}_8 : ((\Box\Gamma_9, \Delta_{12}), \mathtt{p}_7), \mathtt{F}_6 \vdash (\Delta_{11}, []\mathtt{F}_{10}), \mathtt{p}_7}\, K}{- : (\Box\Gamma_9, \Delta_{12}), \mathtt{p}_7 \vdash (\Delta_{11}, []\mathtt{F}_{10}), \mathtt{p}_7}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{12}, \Box\Gamma_9, \mathtt{p}_7 \vdash \Delta_{11}, \mathtt{p}_7, []\mathtt{F}_{10}}\, I$$

- Case rule $A45$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : (\Box\Gamma_7, \Delta_{11}), \mathtt{p}_5 \vdash (\Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}), \mathtt{p}_5}\, I \quad \dfrac{\mathtt{h}_6 : \Box\Gamma_7 \vdash \Box\Gamma_8, \mathtt{F}_{10}}{\bullet \mathtt{h}_6 : ((\Box\Gamma_7, \Delta_{11}), \mathtt{p}_5), \mathtt{p}_5 \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\, A45}{- : (\Box\Gamma_7, \Delta_{11}), \mathtt{p}_5 \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_7 \vdash \mathtt{F}_{10}, \Box\Gamma_8}\, \mathtt{ax/W}}{- : \Delta_{11}, \Box\Gamma_7, \mathtt{p}_5 \vdash \Delta_9, \Box\Gamma_8, []\mathtt{F}_{10}}\, A45$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\Box\Gamma_{12}, \Delta_{13}), \mathtt{p}_7 \vdash ((\Box\Gamma_9, \Delta_{11}, []\mathtt{F}_{10}), \mathtt{p}_7), \Box\mathtt{F}_6}\, I \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_{12}, \Box\mathtt{F}_6 \vdash \Box\Gamma_9, \mathtt{F}_{10}}{\bullet \mathtt{h}_8 : ((\Box\Gamma_{12}, \Delta_{13}), \mathtt{p}_7), \Box\mathtt{F}_6 \vdash (\Box\Gamma_9, \Delta_{11}, []\mathtt{F}_{10}), \mathtt{p}_7}\, A45}{- : (\Box\Gamma_{12}, \Delta_{13}), \mathtt{p}_7 \vdash (\Box\Gamma_9, \Delta_{11}, []\mathtt{F}_{10}), \mathtt{p}_7}\, \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{13}, \Box\Gamma_{12}, \mathtt{p}_7 \vdash \Delta_{11}, \Box\Gamma_9, \mathtt{p}_7, []\mathtt{F}_{10}}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\Box\Gamma_9, \Delta_{13}), \mathtt{p}_7 \vdash ((\Box\Gamma_{10}, \Delta_{12}, []\mathtt{F}_{11}), \mathtt{p}_7), \mathtt{F}_6}\ I \quad \dfrac{\mathtt{h}_8 : \Box\Gamma_9 \vdash \Box\Gamma_{10}, \mathtt{F}_{11}}{\bullet \mathtt{h}_8 : ((\Box\Gamma_9, \Delta_{13}), \mathtt{p}_7), \mathtt{F}_6 \vdash (\Box\Gamma_{10}, \Delta_{12}, []\mathtt{F}_{11}), \mathtt{p}_7}\ A45}{- : (\Box\Gamma_9, \Delta_{13}), \mathtt{p}_7 \vdash (\Box\Gamma_{10}, \Delta_{12}, []\mathtt{F}_{11}), \mathtt{p}_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{13}, \Box\Gamma_9, \mathtt{p}_7 \vdash \Delta_{12}, \Box\Gamma_{10}, \mathtt{p}_7, []\mathtt{F}_{11}}\ I$$

- Case rule $\rightarrow_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : (\Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8), \mathtt{p}_5 \vdash \Delta_9, \mathtt{p}_5}\ I \quad \dfrac{\mathtt{h}_6 : \Delta_{10}, \mathtt{p}_5, \mathtt{p}_5 \vdash \mathtt{F}_7, \Delta_9 \quad \mathtt{h}_6 : \mathtt{F}_8, \Delta_{10}, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_9}{\bullet \mathtt{h}_6 : ((\Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8), \mathtt{p}_5), \mathtt{p}_5 \vdash \Delta_9}\ \to_L}{- : (\Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8), \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_{10}, \mathtt{p}_5 \vdash \Delta_9, \mathtt{F}_7, \mathtt{p}_5}\ I \quad \dfrac{}{\mathtt{h}_6 : \Delta_{10}, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_9, \mathtt{F}_7}\ \mathtt{ax/W}}{- : \Delta_{10}, \mathtt{p}_5 \vdash \Delta_9, \mathtt{F}_7}\ \mathtt{hCut} \quad \dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_{10}, \mathtt{F}_8, \mathtt{p}_5 \vdash \Delta_9, \mathtt{p}_5}\ I \quad \dfrac{}{\mathtt{h}_6 : \Delta_{10}, \mathtt{F}_8, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \Delta_{10}, \mathtt{F}_8, \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{hCut}}{- : \Delta_{10}, \mathtt{p}_5, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9}\ \to_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_{10} \to \mathtt{F}_{11}}\ I \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{p}_7 \vdash \mathtt{F}_{10}, \Delta_8, \mathtt{p}_7 \quad \mathtt{h}_9 : \mathtt{F}_{11}, \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : (\Delta_6, \mathtt{p}_7), \mathtt{F}_{10} \to \mathtt{F}_{11} \vdash \Delta_8, \mathtt{p}_7}\ \to_L}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\Delta_{12}, \mathtt{F}_{10} \to \mathtt{F}_{11}), \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_6}\ I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \Delta_{12}, \mathtt{p}_7 \vdash \mathtt{F}_{10}, \Delta_8, \mathtt{p}_7 \quad \mathtt{h}_9 : \mathtt{F}_6, \mathtt{F}_{11}, \Delta_{12}, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : ((\Delta_{12}, \mathtt{F}_{10} \to \mathtt{F}_{11}), \mathtt{p}_7), \mathtt{F}_6 \vdash \Delta_8, \mathtt{p}_7}\ \to_L}{- : (\Delta_{12}, \mathtt{F}_{10} \to \mathtt{F}_{11}), \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{12}, \mathtt{p}_7, \mathtt{F}_{10} \to \mathtt{F}_{11} \vdash \Delta_8, \mathtt{p}_7}\ I$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : (\Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8), \mathtt{p}_5 \vdash \Delta_9, \mathtt{p}_5}\ I \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_7, \mathtt{F}_8, \Delta_{10}, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_9}{\bullet \mathtt{h}_6 : ((\Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8), \mathtt{p}_5), \mathtt{p}_5 \vdash \Delta_9}\ \wedge_L}{- : (\Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8), \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_{10}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{p}_5 \vdash \Delta_9, \mathtt{p}_5}\ I \quad \dfrac{}{\mathtt{h}_6 : \Delta_{10}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \Delta_{10}, \mathtt{F}_7, \mathtt{F}_8, \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{hCut}}{- : \Delta_{10}, \mathtt{p}_5, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9}\ \wedge_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_{10} \wedge \mathtt{F}_{11}}\ I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_{10}, \mathtt{F}_{11}, \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : (\Delta_6, \mathtt{p}_7), \mathtt{F}_{10} \wedge \mathtt{F}_{11} \vdash \Delta_8, \mathtt{p}_7}\ \wedge_L}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\Delta_{12}, \mathtt{F}_{10} \wedge \mathtt{F}_{11}), \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_6}\ I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \mathtt{F}_{10}, \mathtt{F}_{11}, \Delta_{12}, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : ((\Delta_{12}, \mathtt{F}_{10} \wedge \mathtt{F}_{11}), \mathtt{p}_7), \mathtt{F}_6 \vdash \Delta_8, \mathtt{p}_7}\ \wedge_L}{- : (\Delta_{12}, \mathtt{F}_{10} \wedge \mathtt{F}_{11}), \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \Delta_{12}, \mathtt{p}_7, \mathtt{F}_{10} \wedge \mathtt{F}_{11} \vdash \Delta_8, \mathtt{p}_7}\ I$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : (\Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8), \mathtt{p}_5 \vdash \Delta_9, \mathtt{p}_5}\ I \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_7, \Delta_{10}, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_9 \quad \mathtt{h}_6 : \mathtt{F}_8, \Delta_{10}, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_9}{\bullet \mathtt{h}_6 : ((\Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8), \mathtt{p}_5), \mathtt{p}_5 \vdash \Delta_9}\ \vee_L}{- : (\Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8), \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_{10}, \mathtt{F}_7, \mathtt{p}_5 \vdash \Delta_9, \mathtt{p}_5}\ I \quad \dfrac{}{\mathtt{h}_6 : \Delta_{10}, \mathtt{F}_7, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \Delta_{10}, \mathtt{F}_7, \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{hCut} \quad \dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_{10}, \mathtt{F}_8, \mathtt{p}_5 \vdash \Delta_9, \mathtt{p}_5}\ I \quad \dfrac{}{\mathtt{h}_6 : \Delta_{10}, \mathtt{F}_8, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \Delta_{10}, \mathtt{F}_8, \mathtt{p}_5 \vdash \Delta_9}\ \mathtt{hCut}}{- : \Delta_{10}, \mathtt{p}_5, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9}\ \vee_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_{10} \vee \mathtt{F}_{11}}\, I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_{10}, \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7 \quad \mathtt{h}_9 : \mathtt{F}_{11}, \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : (\Delta_6, \mathtt{p}_7), \mathtt{F}_{10} \vee \mathtt{F}_{11} \vdash \Delta_8, \mathtt{p}_7}\, \vee_L}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\Delta_{12}, \mathtt{F}_{10} \vee \mathtt{F}_{11}), \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_6}\, I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \mathtt{F}_{10}, \Delta_{12}, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7 \quad \mathtt{h}_9 : \mathtt{F}_6, \mathtt{F}_{11}, \Delta_{12}, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : ((\Delta_{12}, \mathtt{F}_{10} \vee \mathtt{F}_{11}), \mathtt{p}_7), \mathtt{F}_6 \vdash \Delta_8, \mathtt{p}_7}\, \vee_L}{- : (\Delta_{12}, \mathtt{F}_{10} \vee \mathtt{F}_{11}), \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_{12}, \mathtt{p}_7, \mathtt{F}_{10} \vee \mathtt{F}_{11} \vdash \Delta_8, \mathtt{p}_7}\, I$$

- Case rule AT

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : (\Delta_9, []\mathtt{F}_7), \mathtt{p}_5 \vdash \Delta_8, \mathtt{p}_5}\, I \quad \dfrac{\mathtt{h}_6 : \mathtt{F}_7, \Delta_9, \mathtt{p}_5, \mathtt{p}_5, []\mathtt{F}_7 \vdash \Delta_8}{\bullet \mathtt{h}_6 : ((\Delta_9, []\mathtt{F}_7), \mathtt{p}_5), \mathtt{p}_5 \vdash \Delta_8}\, AT}{- : (\Delta_9, []\mathtt{F}_7), \mathtt{p}_5 \vdash \Delta_8}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_9, \mathtt{F}_7, \mathtt{p}_5, []\mathtt{F}_7 \vdash \Delta_8, \mathtt{p}_5}\, \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_6 : \Delta_9, \mathtt{F}_7, \mathtt{p}_5, \mathtt{p}_5, []\mathtt{F}_7 \vdash \Delta_8}\, \mathtt{ax/W}}{- : \Delta_9, \mathtt{F}_7, \mathtt{p}_5, []\mathtt{F}_7 \vdash \Delta_8}\, \mathtt{hCut}}{- : \Delta_9, \mathtt{p}_5, []\mathtt{F}_7 \vdash \Delta_8}\, ATG$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), []\mathtt{F}_{10}}\, I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_{10}, \Delta_6, \mathtt{p}_7, []\mathtt{F}_{10} \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : (\Delta_6, \mathtt{p}_7), []\mathtt{F}_{10} \vdash \Delta_8, \mathtt{p}_7}\, AT}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\Delta_{11}, []\mathtt{F}_{10}), \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_6}\, I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \mathtt{F}_{10}, \Delta_{11}, \mathtt{p}_7, []\mathtt{F}_{10} \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : ((\Delta_{11}, []\mathtt{F}_{10}), \mathtt{p}_7), \mathtt{F}_6 \vdash \Delta_8, \mathtt{p}_7}\, AT}{- : (\Delta_{11}, []\mathtt{F}_{10}), \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_{11}, \mathtt{p}_7, []\mathtt{F}_{10} \vdash \Delta_8, \mathtt{p}_7}\, I$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : (\bot, \Delta_8), \mathtt{p}_5 \vdash \Delta_7, \mathtt{p}_5}\, I \quad \dfrac{}{\bullet \mathtt{h}_6 : ((\bot, \Delta_8), \mathtt{p}_5), \mathtt{p}_5 \vdash \Delta_7}\, \bot_L}{- : (\bot, \Delta_8), \mathtt{p}_5 \vdash \Delta_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_8, \mathtt{p}_5 \vdash \Delta_7}\, \bot_L$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \bot}\, I \quad \dfrac{}{\bullet \mathtt{h}_9 : (\Delta_6, \mathtt{p}_7), \bot \vdash \Delta_8, \mathtt{p}_7}\, \bot_L}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\bot, \Delta_{10}), \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_6}\, I \quad \dfrac{}{\bullet \mathtt{h}_9 : ((\bot, \Delta_{10}), \mathtt{p}_7), \mathtt{F}_6 \vdash \Delta_8, \mathtt{p}_7}\, \bot_L}{- : (\bot, \Delta_{10}), \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \bot, \Delta_{10}, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \bot_L$$

- Case rule I

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \Delta_5, \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{p}_7}\, I \quad \dfrac{}{\bullet \mathtt{h}_6 : (\Delta_5, \mathtt{p}_7), \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, I}{- : \Delta_5, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_5, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : (\Delta_9, \mathtt{p}_7), \mathtt{p}_5 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{p}_5}\, I \quad \dfrac{}{\bullet \mathtt{h}_6 : ((\Delta_9, \mathtt{p}_7), \mathtt{p}_5) \vdash \Delta_8, \mathtt{p}_7}\, I}{- : (\Delta_9, \mathtt{p}_7), \mathtt{p}_5 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_9, \mathtt{p}_5, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{p}_7 \vdash ((\Delta_{10}, \mathtt{p}_9), \mathtt{p}_7), \mathtt{p}_9}\, I \quad \dfrac{}{\bullet \mathtt{h}_8 : (\Delta_6, \mathtt{p}_7), \mathtt{p}_9 \vdash (\Delta_{10}, \mathtt{p}_9), \mathtt{p}_7}\, I}{- : \Delta_6, \mathtt{p}_7 \vdash (\Delta_{10}, \mathtt{p}_9), \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_{10}, \mathtt{p}_7, \mathtt{p}_9}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\Delta_{11}, \mathtt{p}_9), \mathtt{p}_7 \vdash ((\Delta_{10}, \mathtt{p}_9), \mathtt{p}_7), \mathtt{F}_6}\, I \quad \dfrac{}{\bullet \mathtt{h}_8 : ((\Delta_{11}, \mathtt{p}_9), \mathtt{p}_7), \mathtt{F}_6 \vdash (\Delta_{10}, \mathtt{p}_9), \mathtt{p}_7}\, I}{- : (\Delta_{11}, \mathtt{p}_9), \mathtt{p}_7 \vdash (\Delta_{10}, \mathtt{p}_9), \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_{11}, \mathtt{p}_7, \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_7, \mathtt{p}_9}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_7, \mathtt{p}_9 \vdash (\Delta_{10}, \mathtt{p}_9), \mathtt{F}_6}\, I \quad \dfrac{}{\bullet \mathtt{h}_8 : (\Delta_7, \mathtt{p}_9), \mathtt{F}_6 \vdash \Delta_{10}, \mathtt{p}_9}\, I}{- : \Delta_7, \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_9}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_7, \mathtt{p}_9 \vdash \Delta_{10}, \mathtt{p}_9}\, I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : (\top, \Delta_8), \mathtt{p}_5 \vdash \Delta_7, \mathtt{p}_5}\, I \quad \dfrac{\mathtt{h}_6 : \Delta_8, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_7}{\bullet \mathtt{h}_6 : ((\top, \Delta_8), \mathtt{p}_5), \mathtt{p}_5 \vdash \Delta_7}\, \top_L}{- : (\top, \Delta_8), \mathtt{p}_5 \vdash \Delta_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{\bullet \mathtt{h}_1 : \top, \Delta_8, \mathtt{p}_5 \vdash \Delta_7, \mathtt{p}_5}\, \mathtt{ax/W} \quad \dfrac{}{\mathtt{h}_6 : \top, \Delta_8, \mathtt{p}_5, \mathtt{p}_5 \vdash \Delta_7}\, \mathtt{ax/W}}{- : \top, \Delta_8, \mathtt{p}_5 \vdash \Delta_7}\, \mathtt{hCut}$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : \Delta_6, \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \top}\, I \quad \dfrac{\mathtt{h}_9 : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : (\Delta_6, \mathtt{p}_7), \top \vdash \Delta_8, \mathtt{p}_7}\, \top_L}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \Delta_6, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, I$$

$$\dfrac{\dfrac{}{\bullet \mathtt{h}_2 : (\top, \Delta_{10}), \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_6}\, I \quad \dfrac{\mathtt{h}_9 : \mathtt{F}_6, \Delta_{10}, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}{\bullet \mathtt{h}_9 : ((\top, \Delta_{10}), \mathtt{p}_7), \mathtt{F}_6 \vdash \Delta_8, \mathtt{p}_7}\, \top_L}{- : (\top, \Delta_{10}), \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{}{- : \top, \Delta_{10}, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\, I$$

6.14 Status of $\top_L$: OK

- Case rule $\rightarrow_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_6 \vdash \mathtt{F}_5, \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10}}{\bullet \mathtt{h}_3 : \top, \Delta_6 \vdash (\Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10}), \mathtt{F}_5}\, \top_L \quad \dfrac{\mathtt{h}_7 : \top, \mathtt{F}_5, \mathtt{F}_9, \Delta_6 \vdash \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_7 : (\top, \Delta_6), \mathtt{F}_5 \vdash \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10}}\, \rightarrow_R}{- : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10}}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_5, \mathtt{F}_9 \rightarrow \mathtt{F}_{10}}\, \mathtt{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_7 : \top, \Delta_6, \mathtt{F}_5 \vdash \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10}}\, \mathtt{ax/W}}{- : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \rightarrow \mathtt{F}_{10}}\, \mathtt{hCut}$$

- Case rule $\wedge_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_6 \vdash \mathtt{F}_5, \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}{\bullet \mathtt{h}_3 : \top, \Delta_6 \vdash (\Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}), \mathtt{F}_5}\, \top_L \quad \dfrac{\mathtt{h}_7 : \top, \mathtt{F}_5, \Delta_6 \vdash \mathtt{F}_9, \Delta_8 \quad \mathtt{h}_7 : \top, \mathtt{F}_5, \Delta_6 \vdash \mathtt{F}_{10}, \Delta_8}{\bullet \mathtt{h}_7 : (\top, \Delta_6), \mathtt{F}_5 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\, \wedge_R}{- : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\, \mathtt{Cut}$$
$$\rightsquigarrow$$
$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_5, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\, \mathtt{ax/W} \quad \dfrac{}{\bullet \mathtt{h}_7 : \top, \Delta_6, \mathtt{F}_5 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\, \mathtt{ax/W}}{- : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \wedge \mathtt{F}_{10}}\, \mathtt{hCut}$$

- Case rule $\vee_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_6 \vdash \mathtt{F}_5, \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}{\bullet\mathtt{h}_3 : \top, \Delta_6 \vdash (\Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}), \mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_7 : \top, \mathtt{F}_5, \Delta_6 \vdash \mathtt{F}_9, \mathtt{F}_{10}, \Delta_8}{\bullet\mathtt{h}_7 : (\top, \Delta_6), \mathtt{F}_5 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \vee_R}{- : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_5, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \top, \Delta_6, \mathtt{F}_5 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{ax/W}}{- : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_9 \vee \mathtt{F}_{10}}\ \mathtt{hCut}$$

- Case rule $\bot_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_6 \vdash \mathtt{F}_5, \bot, \Delta_8}{\bullet\mathtt{h}_3 : \top, \Delta_6 \vdash (\bot, \Delta_8), \mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_7 : \top, \mathtt{F}_5, \Delta_6 \vdash \Delta_8}{\bullet\mathtt{h}_7 : (\top, \Delta_6), \mathtt{F}_5 \vdash \bot, \Delta_8}\ \bot_R}{- : \top, \Delta_6 \vdash \bot, \Delta_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_6 \vdash \bot, \Delta_8, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \top, \Delta_6, \mathtt{F}_5 \vdash \bot, \Delta_8}\ \mathtt{ax/W}}{- : \top, \Delta_6 \vdash \bot, \Delta_8}\ \mathtt{hCut}$$

- Case rule $\top_R$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_6 \vdash \mathtt{F}_5, \top, \Delta_8}{\bullet\mathtt{h}_3 : \top, \Delta_6 \vdash (\top, \Delta_8), \mathtt{F}_5}\ \top_L \quad \dfrac{}{\bullet\mathtt{h}_7 : (\top, \Delta_6), \mathtt{F}_5 \vdash \top, \Delta_8}\ \top_R}{- : \top, \Delta_6 \vdash \top, \Delta_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{}{- : \top, \Delta_6 \vdash \top, \Delta_8}\ \top_R$$

- Case rule K

$$\dfrac{\dfrac{\mathtt{h}_3 : \Box\Gamma_9, \Delta_{10} \vdash \Box\mathtt{F}_5, \Delta_7, []\mathtt{F}_8}{\bullet\mathtt{h}_3 : \top, \Box\Gamma_9, \Delta_{10} \vdash (\Delta_7, []\mathtt{F}_8), \Box\mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_6 : \mathit{unbox}(\Box\Gamma_9), \mathit{unbox}(\Box\mathtt{F}_5) \vdash \mathtt{F}_8}{\bullet\mathtt{h}_6 : (\top, \Box\Gamma_9, \Delta_{10}), \Box\mathtt{F}_5 \vdash \Delta_7, []\mathtt{F}_8}\ K}{- : \top, \Box\Gamma_9, \Delta_{10} \vdash \Delta_7, []\mathtt{F}_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_{10}, \Box\Gamma_9 \vdash \Box\mathtt{F}_5, \Delta_7, []\mathtt{F}_8}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Box\mathtt{F}_5, \Delta_{10}, \Box\Gamma_9 \vdash \Delta_7, []\mathtt{F}_8}\ \mathtt{ax/W}}{- : \top, \Delta_{10}, \Box\Gamma_9 \vdash \Delta_7, []\mathtt{F}_8}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Box\Gamma_7, \Delta_{10} \vdash \mathtt{F}_5, \Delta_8, []\mathtt{F}_9}{\bullet\mathtt{h}_3 : \top, \Box\Gamma_7, \Delta_{10} \vdash (\Delta_8, []\mathtt{F}_9), \mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_6 : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_9}{\bullet\mathtt{h}_6 : (\top, \Box\Gamma_7, \Delta_{10}), \mathtt{F}_5 \vdash \Delta_8, []\mathtt{F}_9}\ K}{- : \top, \Box\Gamma_7, \Delta_{10} \vdash \Delta_8, []\mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \mathit{unbox}(\Box\Gamma_7) \vdash \mathtt{F}_9}\ \mathtt{ax/W}}{- : \top, \Delta_{10}, \Box\Gamma_7 \vdash \Delta_8, []\mathtt{F}_9}\ K$$

- Case rule $A45$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Box\Gamma_{10}, \Delta_{11} \vdash \Box\mathtt{F}_5, \Box\Gamma_7, \Delta_8, []\mathtt{F}_9}{\bullet\mathtt{h}_3 : \top, \Box\Gamma_{10}, \Delta_{11} \vdash (\Box\Gamma_7, \Delta_8, []\mathtt{F}_9), \Box\mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_6 : \Box\Gamma_{10}, \Box\mathtt{F}_5 \vdash \Box\Gamma_7, \mathtt{F}_9}{\bullet\mathtt{h}_6 : (\top, \Box\Gamma_{10}, \Delta_{11}), \Box\mathtt{F}_5 \vdash \Box\Gamma_7, \Delta_8, []\mathtt{F}_9}\ A45}{- : \top, \Box\Gamma_{10}, \Delta_{11} \vdash \Box\Gamma_7, \Delta_8, []\mathtt{F}_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_{11}, \Box\Gamma_{10} \vdash \Box\mathtt{F}_5, \Delta_8, \Box\Gamma_7, []\mathtt{F}_9}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Box\mathtt{F}_5, \Delta_{11}, \Box\Gamma_{10} \vdash \Delta_8, \Box\Gamma_7, []\mathtt{F}_9}\ \mathtt{ax/W}}{- : \top, \Delta_{11}, \Box\Gamma_{10} \vdash \Delta_8, \Box\Gamma_7, []\mathtt{F}_9}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Box\Gamma_7, \Delta_{11} \vdash \mathtt{F}_5, \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}{\bullet\mathtt{h}_3 : \top, \Box\Gamma_7, \Delta_{11} \vdash (\Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}), \mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_6 : \Box\Gamma_7 \vdash \Box\Gamma_8, \mathtt{F}_{10}}{\bullet\mathtt{h}_6 : (\top, \Box\Gamma_7, \Delta_{11}), \mathtt{F}_5 \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\ A45}{- : \top, \Box\Gamma_7, \Delta_{11} \vdash \Box\Gamma_8, \Delta_9, []\mathtt{F}_{10}}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{- : \Box\Gamma_7 \vdash \mathtt{F}_{10}, \Box\Gamma_8}\ \mathtt{ax/W}}{- : \top, \Delta_{11}, \Box\Gamma_7 \vdash \Delta_9, \Box\Gamma_8, []\mathtt{F}_{10}}\ A45$$

- Case rule $\to_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_5 \vdash \mathtt{F}_7 \to \mathtt{F}_8, \Delta_9}{\bullet\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_9, \mathtt{F}_7 \to \mathtt{F}_8}\ \top_L \quad \dfrac{\mathtt{h}_6 : \top, \Delta_5 \vdash \mathtt{F}_7, \Delta_9 \quad \mathtt{h}_6 : \top, \mathtt{F}_8, \Delta_5 \vdash \Delta_9}{\bullet\mathtt{h}_6 : (\top, \Delta_5), \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9}\ \to_L}{- : \top, \Delta_5 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_9, \mathtt{F}_7 \to \mathtt{F}_8}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Delta_5, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \top, \Delta_5 \vdash \Delta_9}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \mathtt{F}_5, \Delta_9}{\bullet\mathtt{h}_3 : \top, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9, \mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_6 : \top, \mathtt{F}_5, \Delta_{10} \vdash \mathtt{F}_7, \Delta_9 \quad \mathtt{h}_6 : \top, \mathtt{F}_5, \mathtt{F}_8, \Delta_{10} \vdash \Delta_9}{\bullet\mathtt{h}_6 : (\top, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8), \mathtt{F}_5 \vdash \Delta_9}\ \to_L}{- : \top, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Delta_{10}, \mathtt{F}_5, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \top, \Delta_{10}, \mathtt{F}_7 \to \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{hCut}$$

- Case rule $\wedge_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_5 \vdash \mathtt{F}_7 \wedge \mathtt{F}_8, \Delta_9}{\bullet\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_9, \mathtt{F}_7 \wedge \mathtt{F}_8}\ \top_L \quad \dfrac{\mathtt{h}_6 : \top, \mathtt{F}_7, \mathtt{F}_8, \Delta_5 \vdash \Delta_9}{\bullet\mathtt{h}_6 : (\top, \Delta_5), \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9}\ \wedge_L}{- : \top, \Delta_5 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_9, \mathtt{F}_7 \wedge \mathtt{F}_8}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Delta_5, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \top, \Delta_5 \vdash \Delta_9}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \mathtt{F}_5, \Delta_9}{\bullet\mathtt{h}_3 : \top, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9, \mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_6 : \top, \mathtt{F}_5, \mathtt{F}_7, \mathtt{F}_8, \Delta_{10} \vdash \Delta_9}{\bullet\mathtt{h}_6 : (\top, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8), \mathtt{F}_5 \vdash \Delta_9}\ \wedge_L}{- : \top, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Delta_{10}, \mathtt{F}_5, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \top, \Delta_{10}, \mathtt{F}_7 \wedge \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{hCut}$$

- Case rule $\vee_L$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_5 \vdash \mathtt{F}_7 \vee \mathtt{F}_8, \Delta_9}{\bullet\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_9, \mathtt{F}_7 \vee \mathtt{F}_8}\ \top_L \quad \dfrac{\mathtt{h}_6 : \top, \mathtt{F}_7, \Delta_5 \vdash \Delta_9 \quad \mathtt{h}_6 : \top, \mathtt{F}_8, \Delta_5 \vdash \Delta_9}{\bullet\mathtt{h}_6 : (\top, \Delta_5), \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9}\ \vee_L}{- : \top, \Delta_5 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_9, \mathtt{F}_7 \vee \mathtt{F}_8}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Delta_5, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \top, \Delta_5 \vdash \Delta_9}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \mathtt{F}_5, \Delta_9}{\bullet\mathtt{h}_3 : \top, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9, \mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_6 : \top, \mathtt{F}_5, \mathtt{F}_7, \Delta_{10} \vdash \Delta_9 \quad \mathtt{h}_6 : \top, \mathtt{F}_5, \mathtt{F}_8, \Delta_{10} \vdash \Delta_9}{\bullet\mathtt{h}_6 : (\top, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8), \mathtt{F}_5 \vdash \Delta_9}\ \vee_L}{- : \top, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Delta_{10}, \mathtt{F}_5, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{ax/W}}{- : \top, \Delta_{10}, \mathtt{F}_7 \vee \mathtt{F}_8 \vdash \Delta_9}\ \mathtt{hCut}$$

- Case rule AT

$$\dfrac{\dfrac{\mathtt{h}_3 : \Delta_5 \vdash []\mathtt{F}_7, \Delta_8}{\bullet\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_8, []\mathtt{F}_7}\ \top_L \quad \dfrac{\mathtt{h}_6 : \top, \mathtt{F}_7, \Delta_5, []\mathtt{F}_7 \vdash \Delta_8}{\bullet\mathtt{h}_6 : (\top, \Delta_5), []\mathtt{F}_7 \vdash \Delta_8}\ AT}{- : \top, \Delta_5 \vdash \Delta_8}\ \mathtt{Cut}$$

$$\rightsquigarrow$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_8, []\mathtt{F}_7}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Delta_5, []\mathtt{F}_7 \vdash \Delta_8}\ \mathtt{ax/W}}{- : \top, \Delta_5 \vdash \Delta_8}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_9, []\mathtt{F}_7 \vdash \mathtt{F}_5, \Delta_8}{\bullet\mathtt{h}_3 : \top, \Delta_9, []\mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_6 : \top, \mathtt{F}_5, \mathtt{F}_7, \Delta_9, []\mathtt{F}_7 \vdash \Delta_8}{\bullet\mathtt{h}_6 : (\top, \Delta_9, []\mathtt{F}_7), \mathtt{F}_5 \vdash \Delta_8}\ AT}{- : \top, \Delta_9, []\mathtt{F}_7 \vdash \Delta_8}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_9, []\mathtt{F}_7 \vdash \Delta_8, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Delta_9, \mathtt{F}_5, []\mathtt{F}_7 \vdash \Delta_8}\ \mathtt{ax/W}}{- : \top, \Delta_9, []\mathtt{F}_7 \vdash \Delta_8}\ \mathtt{hCut}$$

- Case rule $\bot_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_5 \vdash \bot, \Delta_7}{\bullet\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_7, \bot}\ \top_L \quad \dfrac{}{\bullet\mathtt{h}_6 : (\top, \Delta_5), \bot \vdash \Delta_7}\ \bot_L}{- : \top, \Delta_5 \vdash \Delta_7}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_5 \vdash \bot, \Delta_7}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \bot, \top, \Delta_5 \vdash \Delta_7}\ \bot_L}{- : \top, \Delta_5 \vdash \Delta_7}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \bot, \Delta_8 \vdash \mathtt{F}_5, \Delta_7}{\bullet\mathtt{h}_3 : \top, \bot, \Delta_8 \vdash \Delta_7, \mathtt{F}_5}\ \top_L \quad \dfrac{}{\bullet\mathtt{h}_6 : (\top, \bot, \Delta_8), \mathtt{F}_5 \vdash \Delta_7}\ \bot_L}{- : \top, \bot, \Delta_8 \vdash \Delta_7}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \bot, \top, \Delta_8 \vdash \Delta_7}\ \bot_L$$

- Case rule I

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_5 \vdash \mathtt{p}_7, \Delta_8, \mathtt{p}_7}{\bullet\mathtt{h}_3 : \top, \Delta_5 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{p}_7}\ \top_L \quad \dfrac{}{\bullet\mathtt{h}_6 : (\top, \Delta_5), \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ I}{- : \top, \Delta_5 \vdash \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_5 \vdash \Delta_8, \mathtt{p}_7, \mathtt{p}_7}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_6 : \top, \Delta_5, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ I}{- : \top, \Delta_5 \vdash \Delta_8, \mathtt{p}_7}\ \mathtt{hCut}$$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_9, \mathtt{p}_7 \vdash \mathtt{F}_5, \Delta_8, \mathtt{p}_7}{\bullet\mathtt{h}_3 : \top, \Delta_9, \mathtt{p}_7 \vdash (\Delta_8, \mathtt{p}_7), \mathtt{F}_5}\ \top_L \quad \dfrac{}{\bullet\mathtt{h}_6 : (\top, \Delta_9, \mathtt{p}_7), \mathtt{F}_5 \vdash \Delta_8, \mathtt{p}_7}\ I}{- : \top, \Delta_9, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{}{- : \top, \Delta_9, \mathtt{p}_7 \vdash \Delta_8, \mathtt{p}_7}\ I$$

- Case rule $\top_L$

$$\dfrac{\dfrac{\dfrac{\mathtt{h}_3 : \Delta_6 \vdash \mathtt{F}_5, \Delta_8}{\bullet\mathtt{h}_3 : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_5}\ \top_L \quad \dfrac{\mathtt{h}_7 : \mathtt{F}_5, \Delta_6 \vdash \Delta_8}{\bullet\mathtt{h}_7 : (\top, \Delta_6), \mathtt{F}_5 \vdash \Delta_8}\ \top_L}{- : \top, \Delta_6 \vdash \Delta_8}\ \mathtt{Cut}}{\rightsquigarrow}$$

$$\dfrac{\dfrac{}{\mathtt{h}_3 : \top, \Delta_6 \vdash \Delta_8, \mathtt{F}_5}\ \mathtt{ax/W} \quad \dfrac{}{\bullet\mathtt{h}_7 : \top, \Delta_6, \mathtt{F}_5 \vdash \Delta_8}\ \mathtt{ax/W}}{- : \top, \Delta_6 \vdash \Delta_8}\ \mathtt{hCut}$$