

Current Status

Kentaro Inoue

December 5, 2025

Current Status

- Chapter.1 Introduction check is finished.
 - Introduce some theoritical calculation.
- Chapter.4 Discussion is being written.
 - Comparison with theoritical calculation.
Calculation by K. Miyagawa et. el.
Dynamical Coupled Channel(DCC), H. Kamano et. el.
 - Fit assuming the 2-step reaction.
I have not written document yet.
Response function will be updated by Kawasaki.
⇒ Fitting will be revised.
- Chapter.2 Experimental setup and Chapter.3 Analysis have not arranged.

Table of Content

- Introduction

- Discovery of $\Lambda(1405)$
- $\bar{K}N$ interaction
- Two pole structure of the $\Lambda(1405)$
- Recent experimental status of the $\Lambda(1405)$
- Recent theoretical status of the $\Lambda(1405)$
- $d(K^-, n)$ reaction
- The J-PARC E31 experiment

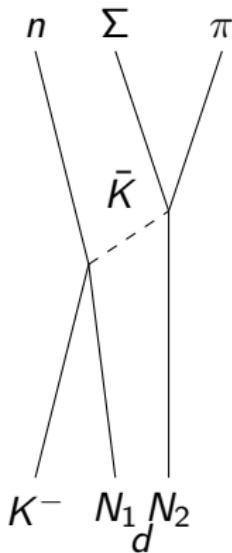
- Discussion

- Spectra

- Qualitative properties of obtained spectra
 - Comparison with theoretical calculation
 - Fit assuming the 2-step reaction

Fitting assuming the 2-step reaction

This reaction was explained by K. Miyagawa [3].



$$\frac{d\sigma}{dM d\Omega} = \int T_{K^- p \rightarrow \bar{K} N} \Phi_d(q_N 2) G_0 T_{\bar{K} N \rightarrow \pi \Sigma} dq$$
$$f_{res}(M_{\pi \Sigma}) = \left| \int T_{\bar{K} N \rightarrow \bar{K} N} G_0 \Phi_d(q_N 2) \right|$$
$$G_0(q_1, q_2) = \frac{1}{q_0^q - \mathbf{q}^2 + i\epsilon}$$

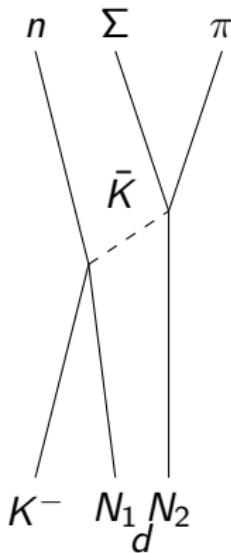
: Green Function of the \bar{K}

$$T_{K^- p \rightarrow \bar{K} N} : \text{Data from Gopal et. el. [1]}$$
$$\Phi(q_N 2) : \text{Wave-function of deuteron [2]}$$

- [1] G. P. Gopal et al., Nucl. Phys. B **119**, 362 (1977).
- [2] R. Machleidt, Phys. Rev. C **63**, 024001 (2001).
- [3] K. Miyagawa and J. Haidenbauer, Phys. Rev. C **85**, 065201 (2012).

Fitting assuming the 2-step reaction

This reaction was explained by K. Miyagawa [3].

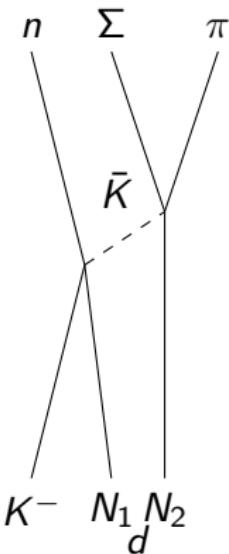


$$\frac{d\sigma}{dM d\Omega} = \int T_{K^- p \rightarrow \bar{K}N} \Phi_d(q_N 2) G_0 T_{\bar{K}N \rightarrow \pi \Sigma} dq$$
$$f_{res}(M_{\pi\Sigma}) = \left| \int T_{\bar{K}N \rightarrow \bar{K}N} G_0 \Phi_d(q_N 2) \right|$$

- ▶ I use Noumi's f_{res} .
- ▶ f_{res} will be updated by Kawasaki.
⇒ The fitting will be updated.

- [1] G. P. Gopal et al., Nucl. Phys. B **119**, 362 (1977).
- [2] R. Machleidt, Phys. Rev. C **63**, 024001 (2001).
- [3] K. Miyagawa and J. Haidenbauer, Phys. Rev. C **85**, 065201 (2012).

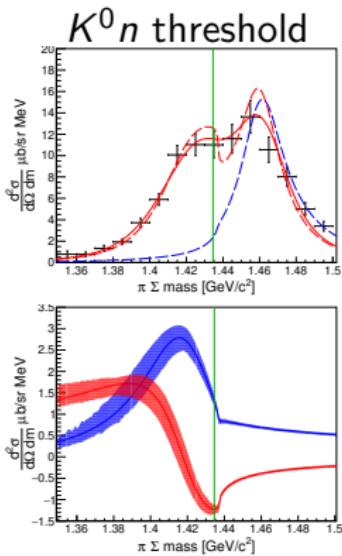
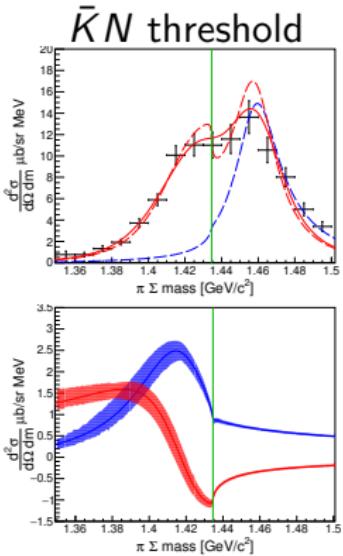
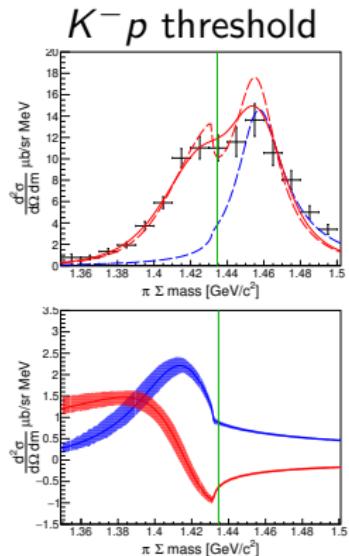
Fitting assuming the 2-step reaction



$$\frac{d\sigma}{dM d\Omega} = \int T_{K^- p \rightarrow \bar{K} N} \Phi_d(q_N 2) G_0 T_{\bar{K} N \rightarrow \pi \Sigma} dq$$
$$T_{\bar{K} N \rightarrow \pi \Sigma} = \frac{e^{i\delta}}{\sqrt{k_1}} \frac{\sqrt{\mathbf{Im} A - \frac{1}{2}|A|^2 \mathbf{Im} R k^2}}{1 - iAk_2 + \frac{1}{2}ARk_2^2}$$
$$T_{\bar{K} N \rightarrow \bar{K} N} = \frac{A}{1 - iAk_2 + \frac{1}{2}ARk_2^2}$$
$$\Rightarrow (\text{Poleposition}) : 1 - iAk_2 + \frac{1}{2}ARk_2^2 = 0$$

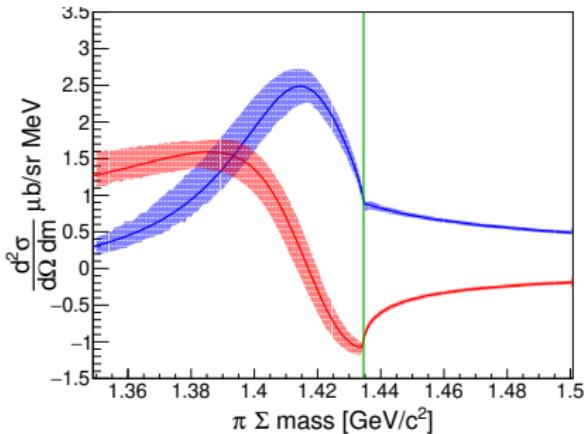
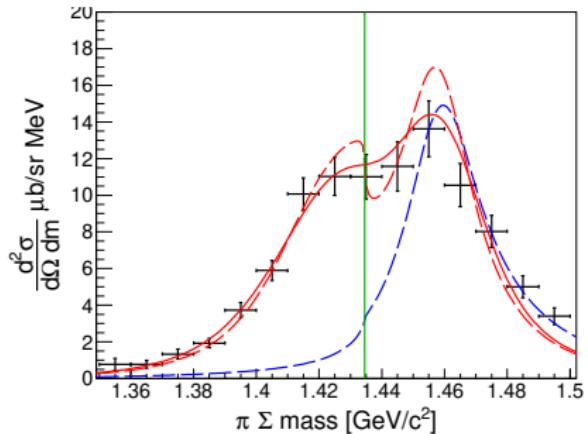
This fitting 2-complex, A & R param and scaling factor.
⇒ 5 parameters

Fitting result



	A_{re}	A_{im}	R_{re}	R_{im}	M	Γ
$K^- p$	-0.95 ± 0.11	0.94 ± 0.16	-0.27 ± 0.40	0.52 ± 0.18	1417.6	30.3
$\bar{K}N$	-1.05 ± 0.12	0.86 ± 0.15	-0.22 ± 0.40	0.42 ± 0.16	1418.3	27.8
$K^0 n$	-1.13 ± 0.13	0.79 ± 0.15	-0.16 ± 0.40	0.33 ± 0.16	1419.3	25.9

Fitting result with $\bar{K}N = \frac{1}{2}(K^- p + K^0 n)$ threshold



$$Scale = 0.0372 \pm 0.0047$$

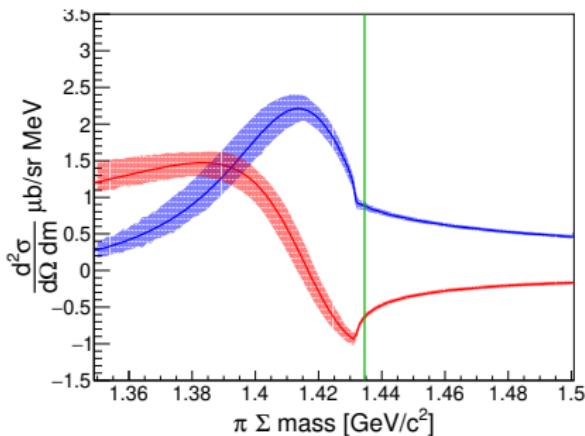
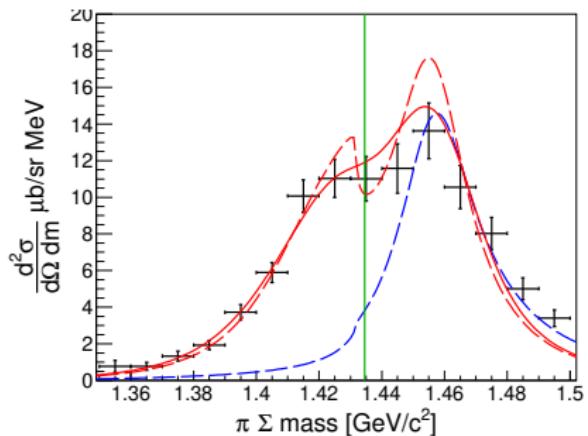
$$A = -1.05 \pm 0.12 + (0.86 \pm 0.15)i$$

$$R = -0.22 \pm 0.40 - (0.42 \pm 0.16)i$$

$$M = 1418.3 \text{ MeV}$$

$$\Gamma = 27.8 \text{ MeV}$$

Fitting result with $K^- p$ threshold



$$Scale = 0.0377 \pm 0.0042$$

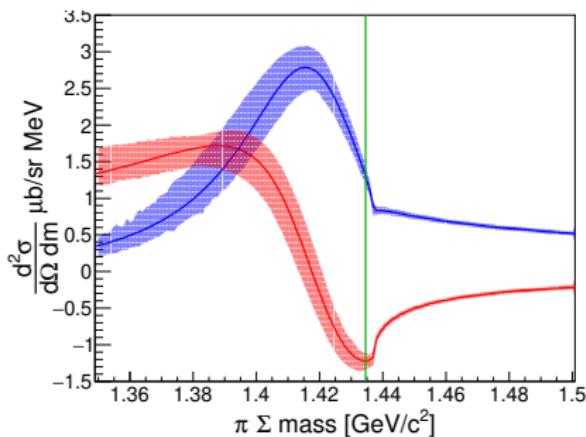
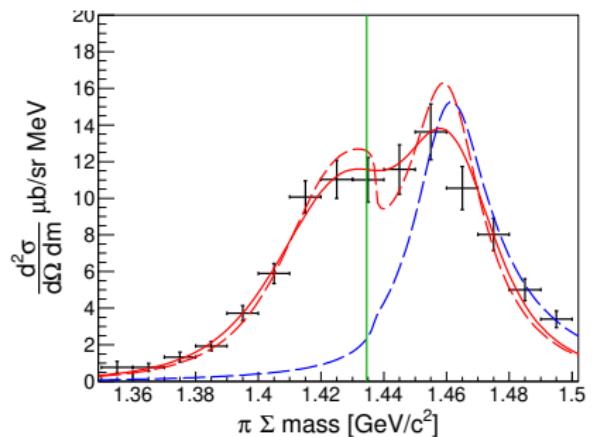
$$A = -0.95 \pm 0.11 + (0.94 \pm 0.16)i$$

$$R = -0.27 \pm 0.40 - (0.52 \pm 0.18)i$$

$$M = 1417.6 \text{ MeV}$$

$$\Gamma = 30.3 \text{ MeV}$$

Fitting result with $K^0 n$ threshold



$$Scale = 0.0367 \pm 0.0053$$

$$A = -1.13 \pm 0.13 + (0.79 \pm 0.15)i$$

$$R = -0.16 \pm 0.40 - (0.33 \pm 0.16)i$$

$$M = 1419.3 \text{ MeV}$$

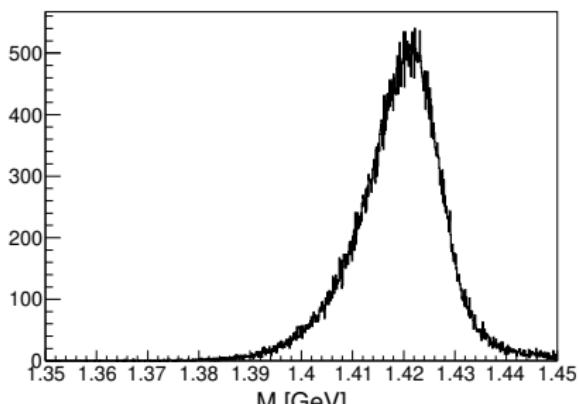
$$\Gamma = 25.9 \text{ MeV}$$

Pole parameter of $\Lambda(1405)$ ($\bar{K}N$ threshold)

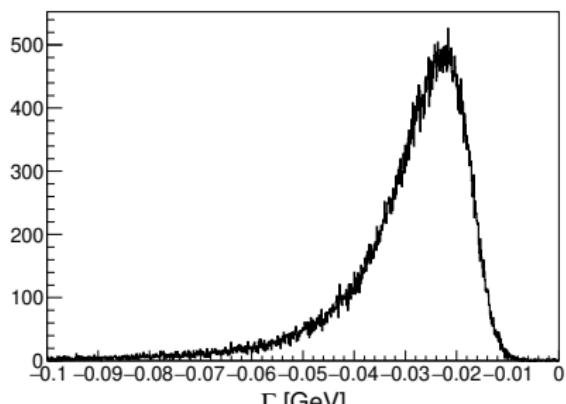
Distribution is distorted due to threshold effect.

⇒ Distribution is produced by Gaussian random ($N = 100,000$).

Mass



Width



Errors of mass and width are estimated using these distributions.

⇒ Tail component should be not included.

⇒ Fit range should be determined w/o arbitrariness.

Summary

- I should write Doctor thesis.
Check of Chapter.1 Introduction is finished.
I'm writing Chapter.4 Discussion.
- I discuss comparison w/ theoritiacl calc. and
fit assuming the 2-step reaction.
 $\Rightarrow f_{res}(M_{\pi\Sigma})$ will be modified and fit is reavaied.