definitions:

$$s = (q + k_1)^2 \qquad \Rightarrow \qquad 2qk_1 = s - q^2 \tag{1}$$

$$s_3 = (k_2 + p_2)^2 - m^2 \qquad \Rightarrow \qquad 2k_2p_2 = s_3 \tag{2}$$

$$s_4 = (k_2 + p_1)^2 - m^2 \qquad \Rightarrow \qquad 2k_2p_1 = s_4 \tag{3}$$

$$s_5 = (p_1 + p_2)^2 = -u_5 \qquad \Rightarrow \qquad 2p_1p_2 = s_5 - 2m^2 \tag{4}$$

$$t_1 = (k_1 - p_2)^2 - m^2 = t - m^2 \qquad \Rightarrow \qquad 2k_1p_2 = -t_1 \tag{5}$$

$$t' = (k_1 - k_2)^2 \qquad \Rightarrow \qquad 2k_1k_2 = -t' \tag{6}$$

$$u_1 = (q - p_2)^2 - m^2 = u - m^2 \qquad \Rightarrow \qquad 2qp_2 = -u_1 + q^2 \tag{7}$$

$$u_6 = (k_1 - p_1)^2 - m^2 \qquad \Rightarrow \qquad 2k_1p_1 = -u_6 \tag{8}$$

$$u_7 = (q - p_1)^2 - m^2 \qquad \Rightarrow \qquad 2qp_1 = -u_7 + q^2 \tag{9}$$

$$u' = (q - k_2)^2 \qquad \Rightarrow \qquad 2qk_2 = -u' + q^2 \tag{10}$$

momentum conservation:

$$q + k_1 = p_1 + p_2 + k_2 \tag{11}$$

contract with 2 times momentum:

I: $\quad 2q^2 \quad +s - q^2 = -u_7 + q^2 \quad -u_1 + q^2 \quad -u' + q^2 \quad \Leftrightarrow \quad 0 = s + u_1 + u_7 + u' - 2q^2$ (12)

II: $\quad s - q^2 \quad +0 = -u_6 \quad -t_1 \quad -t' \quad \Leftrightarrow \quad 0 = s + t_1 + t' + u_6 - q^2$ (13)

III: $\quad -u_7 + q^2 \quad -u_6 = 2m^2 \quad +s_5 - 2m^2 \quad +s_4 \quad \Leftrightarrow \quad 0 = s_4 + s_5 + u_6 + u_7 - q^2$ (14)

IV: $\quad -u_1 + q^2 \quad -t_1 = s_5 - 2m^2 \quad +2m^2 \quad +s_3 \quad \Leftrightarrow \quad 0 = s_3 + s_5 + t_1 + u_1 - q^2$ (15)

V: $\quad -u' + q^2 \quad -t' = s_4 \quad +s_3 \quad +0 \quad \Leftrightarrow \quad 0 = s_3 + s_4 + t' + u' - q^2$ (16)

$$\frac{1}{2}\left(\text{I} + \text{II} + \text{IV} - \text{III} - \text{V}\right): \qquad\qquad 0 = s - q^2 + t_1 + u_1 - s_4 \tag{17}$$