Lepton Flavor Violation at CEPC

Introduction

- In Standard Model(SM): lepton flavor numbers are strictly conserved.
- Neutrino oscillation: $\mathscr{B}_{\tau\to\mu\gamma} \leq 10^{-50}$.

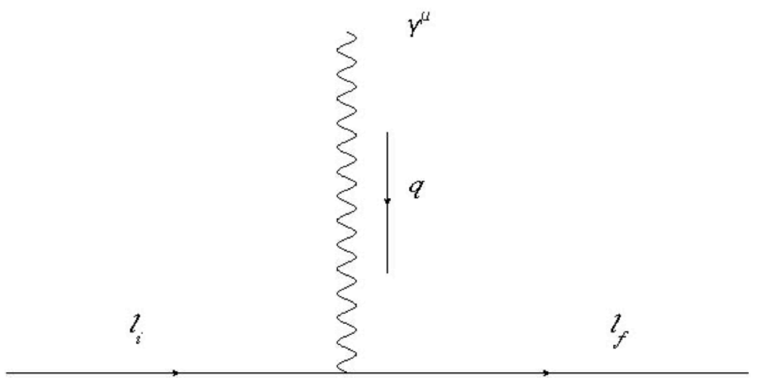
LFV In The BSM

The effective Lagragian for lepton-flavor-violating(LFV) processes

$$\mathscr{L}_{l_i \to l_f \gamma} = \frac{-4G_f}{\sqrt{2}}(m_i A_R \bar{l}_{iR} \sigma^{\mu\nu} l_{fL} F_{\mu\nu} + m_i A_L \bar{l}_{iL} \sigma^{\mu\nu} l_{fR} F_{\mu\nu}) + H.C.$$

The Feynman rule of the $l_i l_f \gamma$ vertex

$$-i[e\gamma^\mu \delta_{fi} + \frac{4G_f}{\sqrt{2}} m_i \sigma^{\mu\nu}(A_R P_L + A_L P_R) q_\nu]$$



The total branch ratio is given by

$$Br(l_i \to l_f \gamma) = \frac{G_f^2 m_i^5}{2\pi \Gamma_{l_i}}(|A_R|^2 + |A_L|^2)$$

The up limit of the branch ratio

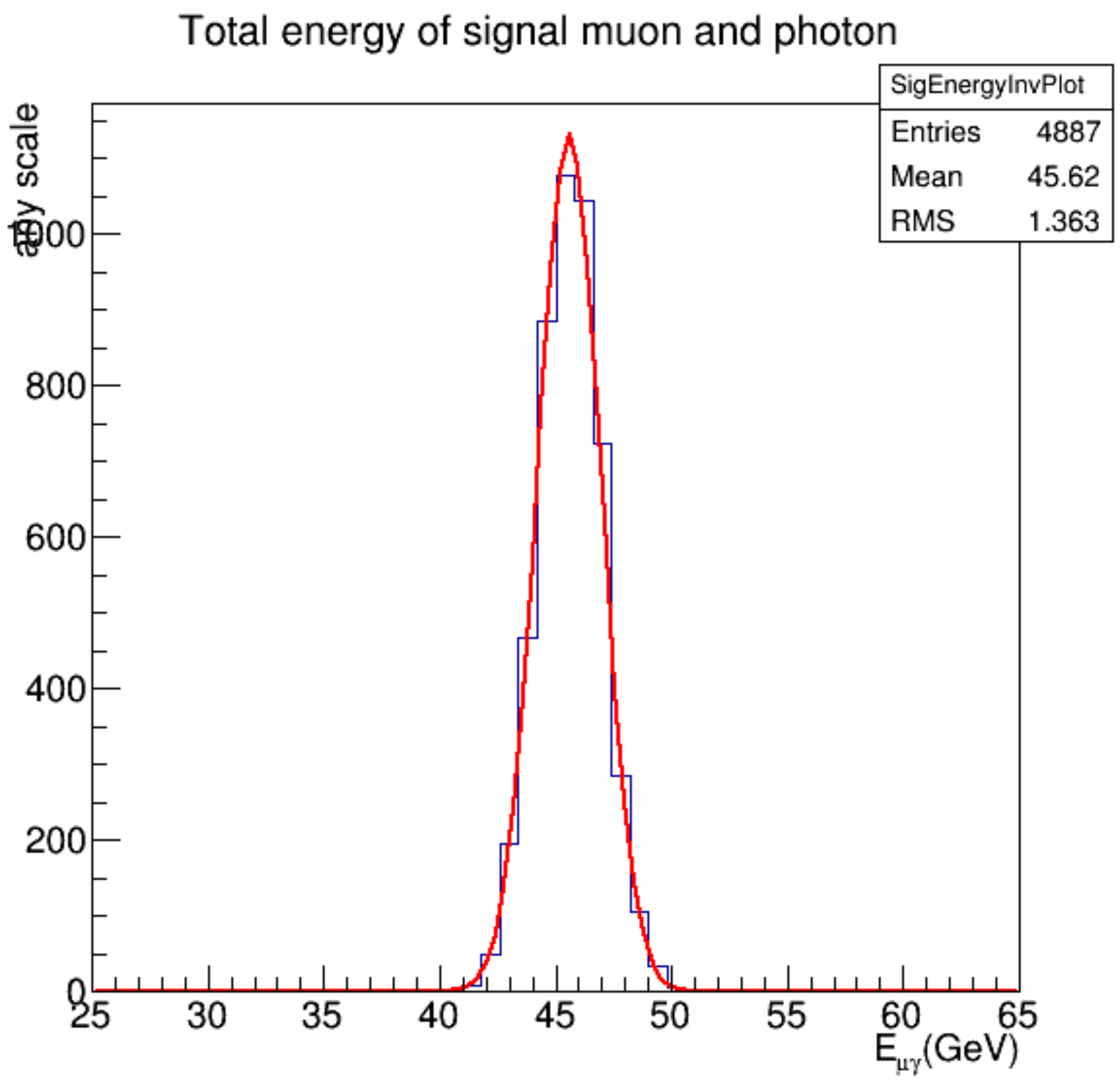
- $Br(\tau \to \mu\gamma) \leq 4.4 \times 10^{-8}$
- $Br(\tau \to e\gamma) \leq 3.3 \times 10^{-8}$
- $Br(\mu \to e\gamma) \leq 5.7 \times 10^{-13}$

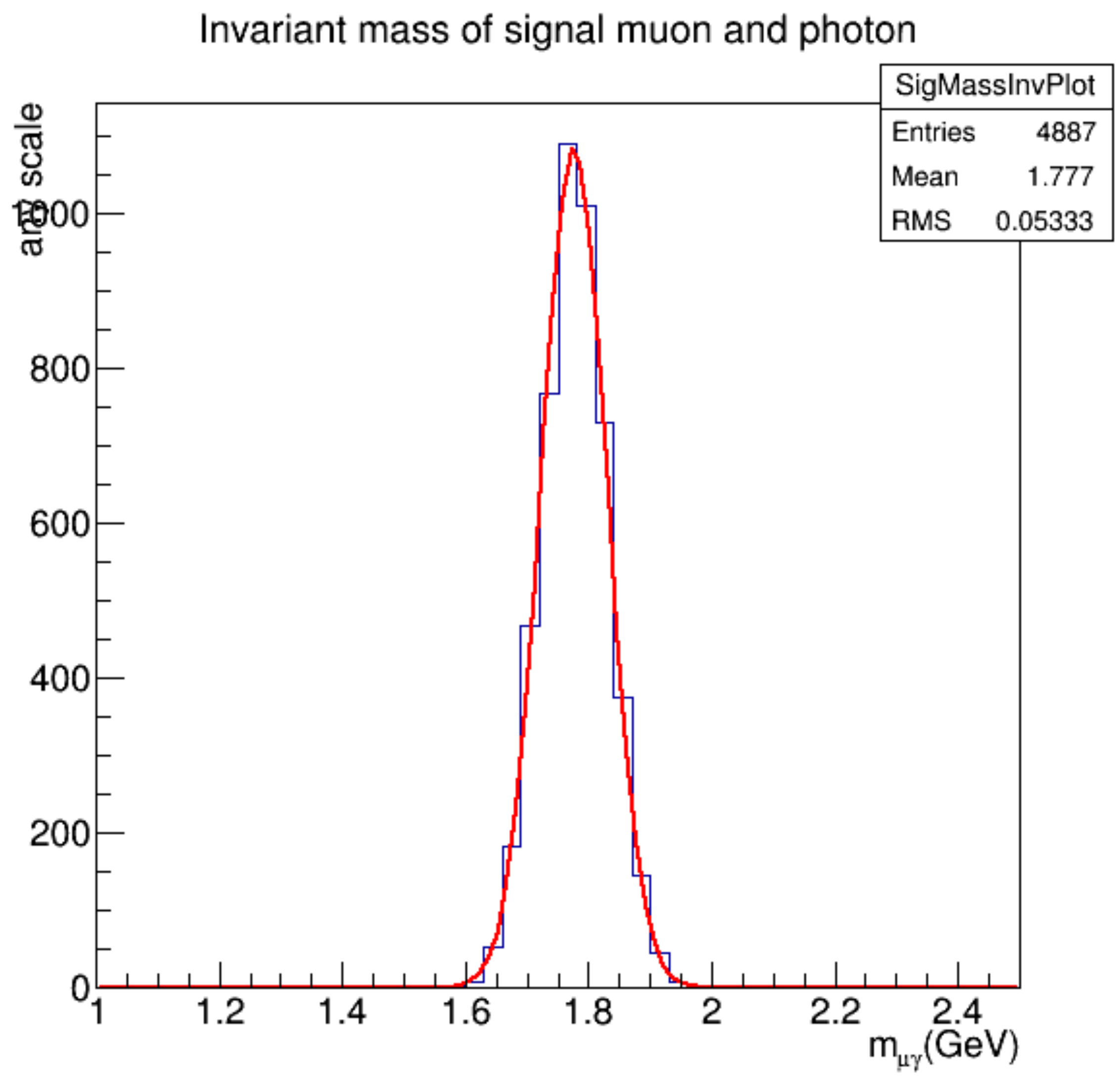
The differential angular distribution

$$\frac{dBr(l_i \to l_f\gamma)}{dcos\theta_f} = \frac{G_f^2 m_i^5}{2\pi}[\,|A_R|^2(1 + P_i \cos\theta_f) + |A_L|^2(1 - P_i \cos\theta_f)]$$

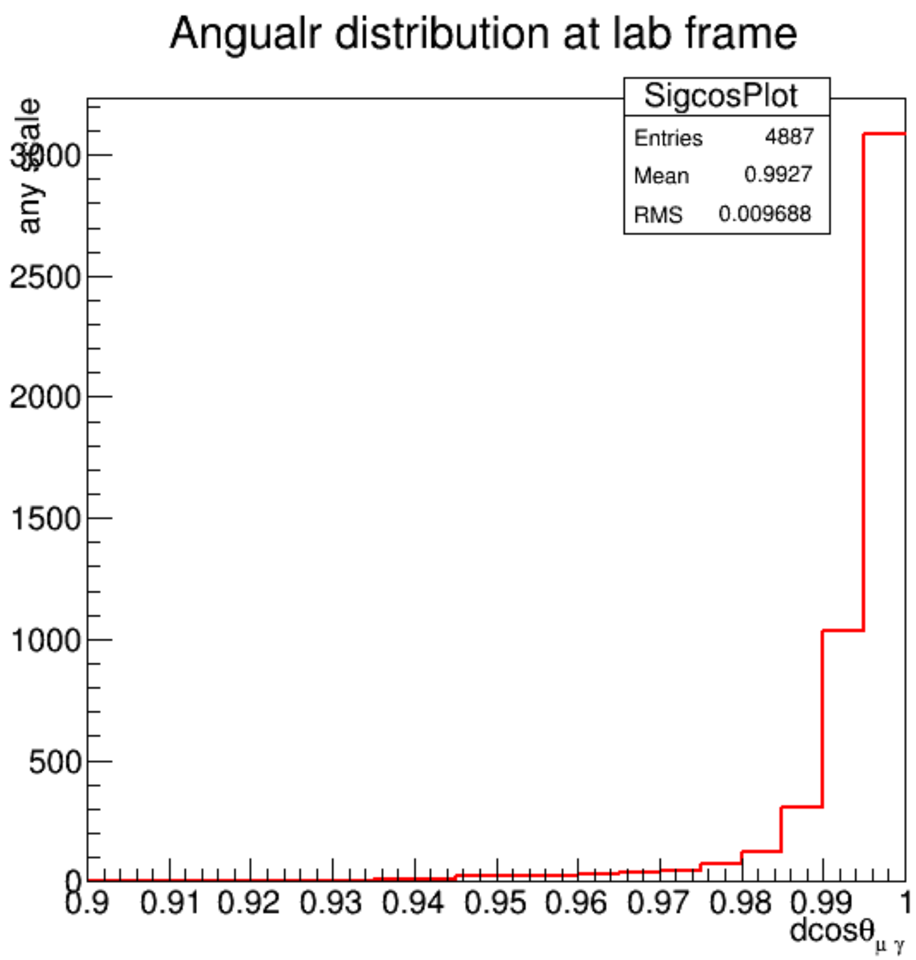
Where P_i is the magnitude of the muon spin polarization, θ_f is the angle between the lepton i polarization and lepton f momentum vectors.

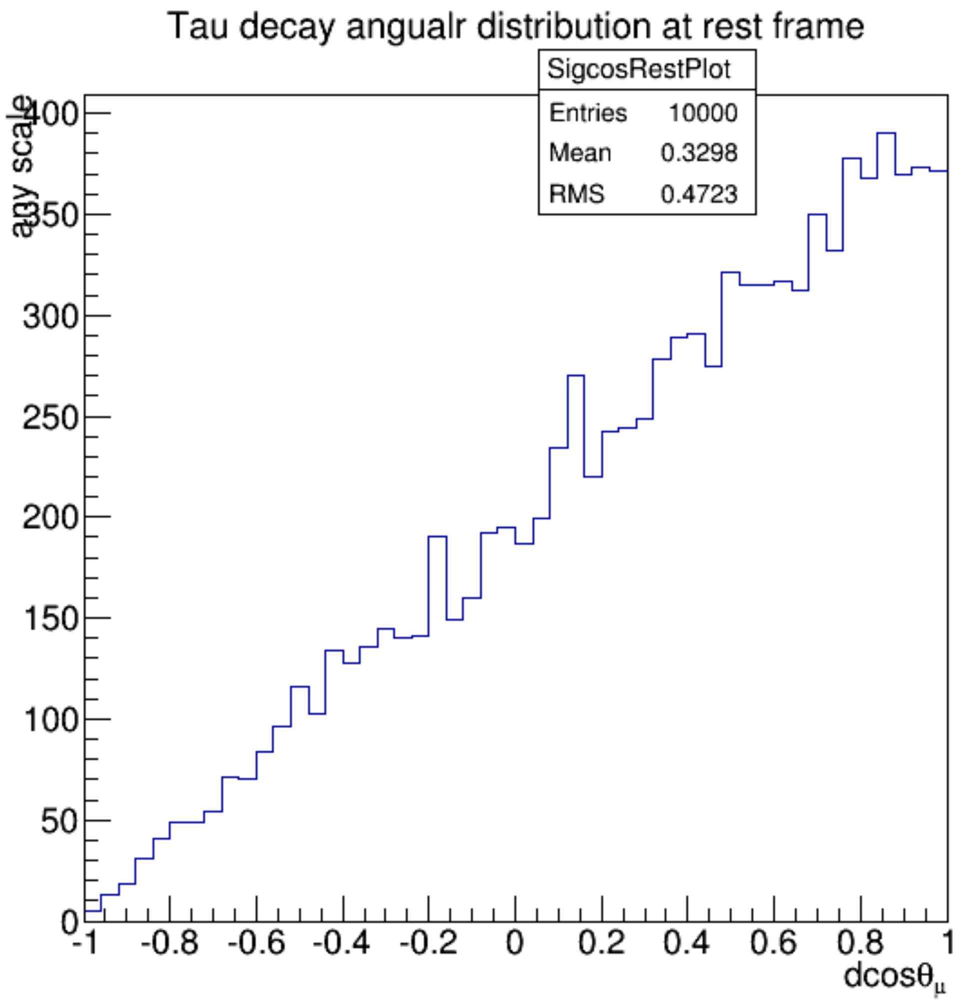
The energy and invariant mass of signal





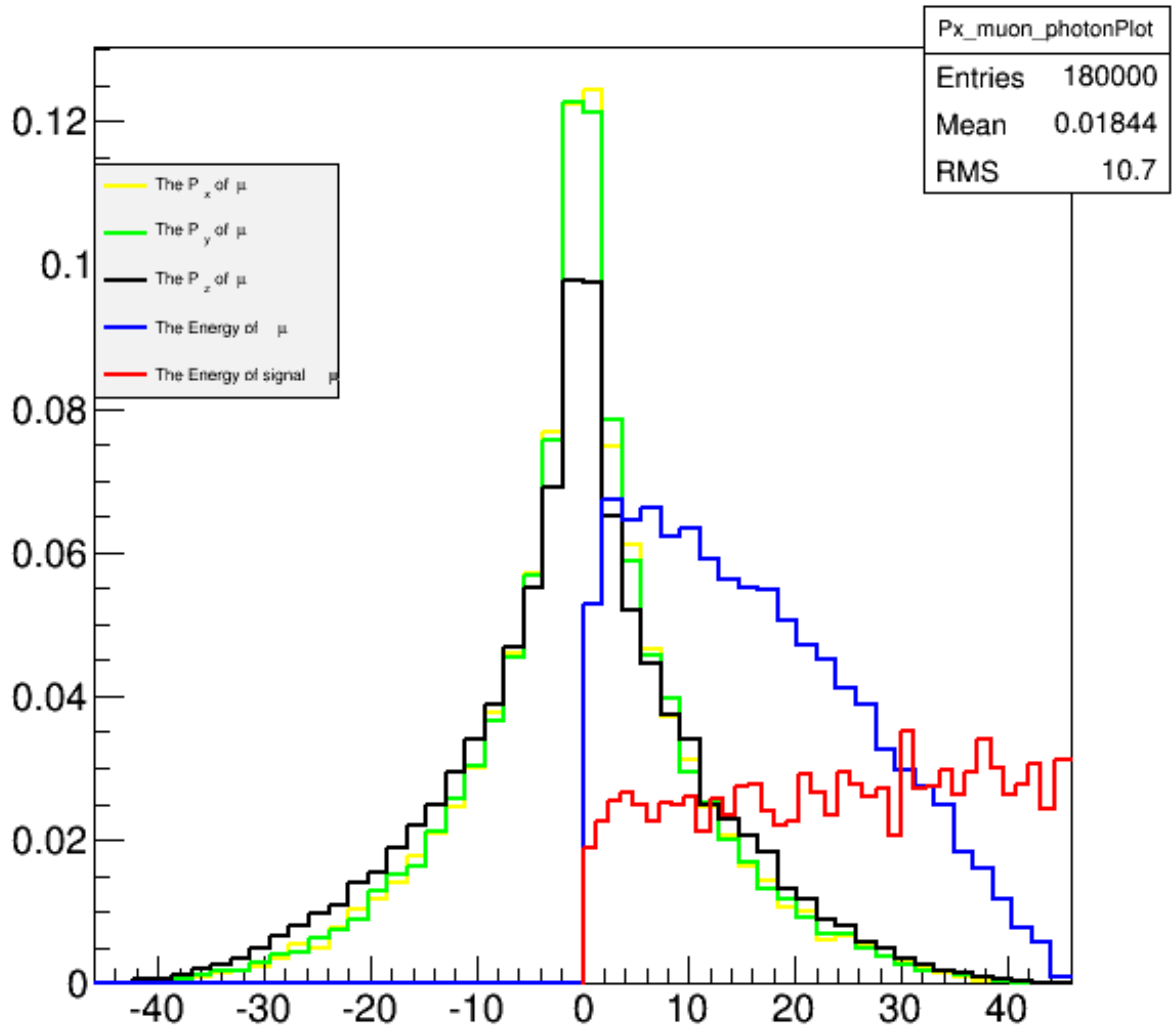
The angular distribution of the signal muon and photon





The cut flow of muon and photon

	Bkg
total generated	180000000
$N_{\mu^+} \geq 1$	31314000
40.6 GeV $< E_{\mu\gamma} <$50.6 GeV	157000
1.6 GeV $< M_{\mu\gamma} <$2 GeV	7000
$E_\gamma >$10 GeV	1000
$E_\mu >$10 GeV	600



The energy limit for two body decay

Generally one particle($p_0 = (E_0, \vec{P}_0)$) decay to two particles($p_1 = (E_1, \vec{P}_1)$, $p_1 = (E_1, \vec{P}_1)$), we could express E_1 as

$$\begin{aligned} E_1 &= E_0 - E_2 \\ &= E_0 - \sqrt{P_2^2 + M_2^2} \\ &= E_0 - \sqrt{(\vec{P}_0 - \vec{P}_1)^2 + M_2^2} \\ &= E_0 - \sqrt{P_0^2 - 2P_0P_1\cos\theta + P_1^2 + M_2^2} \end{aligned} \tag{1}$$

then we have

$$\begin{aligned} (E_0 - E_1)^2 &= P_0^2 - 2P_0P_1\cos\theta + P_1^2 + M_2^2 \\ 2E_0E_1 - 2P_0P_1\cos\theta &= M_0^2 + M_1^2 - M_2^2 \end{aligned} \tag{2}$$

This is a quadratic equation of one variable.

Next the apprioximation is made that $E_1 \gg M_1 (E_1 \simeq P_1)$ and the result is get by

$$E_1 = \frac{M_0^2 + M_1^2 - M_2^2}{2(E_0 - P_0\cos\theta)} \tag{3}$$

The maximal value of E_1 is get as $\cos\theta = 1$ and the minimal value ofE_1 as $\cos\theta = -1$.

$$\begin{aligned} E_{1max} &= \frac{M_0^2 + M_1^2 - M_2^2}{2(E_0 - P_0)} \\ &= \frac{(M_0^2 + M_1^2 - M_2^2)(E_0 + P_0)}{2M_0^2} \\ E_{1min} &= \frac{M_0^2 + M_1^2 - M_2^2}{2(E_0 + P_0)} \end{aligned} \tag{4}$$