$p_\gamma = p_e' + p_A' \longrightarrow \dfrac{(h\nu)_{min}}{c} = p_e' + p_A'$

$h\nu + m_A c^2 = E_e' + E_A' = m_0 c^2 + T_e + m_A^* c^2 + T_A$

$h\nu = (m_0 + m_A^* - m_A)c^2 + T_e + T_A = E_B + T_e + T_A$

$\hookrightarrow (h\nu)_{min} + m_A c^2 = m_0 c^2 + m_A^* c^2 + (T_e + T_A)_{min}$

En (CM): $0 = p_e' + p_A'$

CM → v_{cm} con respecto al sist. de lab.

En (LAB): $p_\gamma = p_e' + p_A'$; si e y A se mueven en CM ⇒ ambos con v_{cm} en LAB

$$\left.\begin{aligned} p_e' &= m_0 v_{cm} \\ p_A' &= m_A^* v_{cm} \end{aligned}\right\} \quad p_A' = \frac{m_A^*}{m_0} p_e' = \frac{m_A^*}{m_0}(p_\gamma - p_A')$$

$$p_A' = \frac{m_A^*}{m_0 + m_A^*} p_\gamma \; ; \; p_e' = \frac{m_0}{m_0 + m_A^*} p_\gamma$$

$$(h\nu)_{min} + m_A c^2 = \sqrt{(p_e')^2 c^2 + m_e^2 c^4} + \sqrt{(p_A')^2 c^2 + m_A^{*2} c^4} =$$

$$= \sqrt{\frac{m_0^2 (h\nu)_{min}^2}{(m_0 + m_A^*)^2} + m_0^2 c^4} + \sqrt{\frac{m_A^{*2} (h\nu)_{min}^2}{(m_0 + m_A^*)^2} + m_A^{*2} c^4} =$$

$$= \frac{m_0}{(m_0 + m_A^*)} \sqrt{(h\nu)_{min}^2 + (m_0 + m_A^*)^2 c^4} + \frac{m_A^*}{(m_0 + m_A^*)} \sqrt{(h\nu)_{min}^2 + (m_0 + m_A^*)^2 c^4}$$

$$= \sqrt{(h\nu)_{min}^2 + (m_0 + m_A^*)^2 c^4}$$

$$(h\nu)_{min}^2 + m_A^2 c^4 + 2 m_A c^2 (h\nu)_{min} = (h\nu)_{min}^2 + (m_0 + m_A^*)^2 c^2$$

$$(h\nu)_{min} = \frac{(m_0 + m_A^*)^2 c^4 - m_A^2 c^4}{2 m_A c^2} =$$

$$= \frac{(m_0^2 + m_A^{*2} + 2 m_0 m_A^*) c^4 - m_A^2 c^4 + (2 m_0 m_A - 2 m_0 m_A + 2 m_A^* m_A - 2 m_A^* m_A) c^4 - m_A^2 c^4 + m_A^2 c^4}{2 m_A c^2}$$

$$= \frac{(m_0 + m_A^* - m_A)^2 c^4 - 2 m_A^2 c^4 + m_A^2 + (2 m_0 m_A + 2 m_A^* m_A) c^4}{2 m_A c^2}$$

$$= \frac{(m_0 + m_A^* - m_A)^2 c^4 + 2 m_A c^4 (m_0 + m_A^* - m_A)}{2 m_A c^2} =$$

$$= \frac{(m_0 + m_A^* - m_A) c^4}{E_B} \left[1 + \frac{(m_0 + m_A^* - m_A) c^4}{2 m_A c^2} \right] = E_B \left(1 + \frac{E_B}{2 m_A c^2} \right)$$