\[ E_y = P_y \cdot C \]

\( P + P_y = P_{A^*} \): momentum conservation

\[ m_{A^*}c^2 + E_y = \sqrt{(m_{A^*}c^2)^2 + P_{A^*}^2/c^2} \]: energy conservation

\[ V_{A^*} = \frac{P_{A^*}}{E_{A^*}/c^2} \]

\[ \frac{V_{A^*}}{c} = \frac{E_y/c^2}{m_A + E_y/c^2} \]

\[ = \frac{1}{1 + m_{A^*}c^2/E_y} \]

\[ \frac{V_{A^*}}{c} = \frac{(m_{A^*}c^2)^2 - (m_Ac^2)^2}{(m_{A^*}c^2)^2 + (m_Ac^2)^2} \leq 1 \]

\[ \text{for photon on H}: \]

\[ \Delta E = \frac{1/2 m_{A^*}}{2(m_Ac^2)^2} \]

\[ = \frac{3}{4} \cdot 12.6 \text{ eV} = 1.09 \times 10^8 \text{ eV} \]

\[ V_{\text{therm H}} \approx 0.8 \text{ m/s} \]
USE of KINEMATICS, INVARIANTS

Q1: Is it possible for a photon to decay into two massive particles? And what about \( m \rightarrow 0 \)?

Q2: Is it possible for a massive particle to decay into two photons? and reverse, two photons \( \rightarrow m^2 \).

Q3: (Quiz) What are thresholds for particle production reactions e.g. \( p \rightarrow p \Rightarrow pp + p\bar{p} \) but many others!