

Lab

$$p + p \rightarrow p + p + p + \bar{p}$$

$$S = \left(\sum_i E_i \right)^2 - \left(\sum_i \vec{p}_i c \right)^2$$

$$S_{\text{Lab, prod}} = S_{\text{CMS, po}}$$

tylko en. spontaniczna,
to niemożliwe
wynika
prógowego

$$(E_p + m_p c^2)^2 - (p_p c)^2 = (4 m_p c^2)^2$$

energia całkowita
protonu w LAB

$$E_p^2 = (m_p c^2)^2 + (p_p c)^2$$

proton w LAB

$$\cancel{E_p^2} + 2 E_p m_p c^2 + \cancel{(m_p c^2)^2} - \cancel{E_p^2} + \cancel{(m_p c^2)^2} = (4 m_p c^2)^2$$

$$E_p = \frac{14 (m_p c^2)^2}{2 m_p c^2} = 7 m_p c^2$$

$$E_p^{\text{kin}} = E_p - m_p c^2 = 6 m_p c^2$$

minimalna energia
kinetyczna protonu w LAB