Exphy 6 Blatt 3 Julian Bergmann

Aufg. 1

a) $s+u+t = (p_a+p_b)^2 + (p_a-p_c)^2 + (p_a-p_d)^2$

$= 3p_a^2 + p_b^2 + p_c^2 + p_d^2 + 2p_a p_b - 2p_a p_c - 2p_a p_d$

$= p_a^2 + p_b^2 + p_c^2 + p_d^2 + 2(p_a(p_a+p_b-p_c-p_d))$

$p_a^2 = m_a^2$

$p_a + p_b = p_c + p_d$

$\Rightarrow s+u+t = m_a^2 + m_b^2 + m_c^2 + m_d^2 + 2p_a(p_a+p_b-p_a-p_b)$

$= 3E_a^2 - 3\vec{p}_a^2 + E_b^2 - \vec{p}_b^2 + E_c^2 - \vec{p}_c^2 + E_d^2 - \vec{p}_d^2 + 2E_aE_b - 2\vec{p}_a\vec{p}_b - 2E_aE_c + 2\vec{p}_a\vec{p}_c - 2E_aE_d + 2\vec{p}_a\vec{p}_d$

$= 3E_a^2 - 3E_a^2 + 3m_a^2 - 6E_b^2 + 3m_b^2 - 6E_c^2 + 3m_c^2 - 6E_d^2 + 3m_d^2$

$+ 2E_aE_b - 2\sqrt{E_a^2-m_a^2}\sqrt{E_b^2-m_b^2} - 2E_aE_c + 2\sqrt{E_a^2-m_a^2}\sqrt{E_c^2-m_c^2}$

$- 2E_aE_d + 2\sqrt{E_a^2-m_a^2}\sqrt{E_d^2-m_d^2}$

$= 3(m_a^2+m_b^2+m_c^2+m_d^2) + 2E_a(E_b+E_c+E_d)$

$- 2\sqrt{E_a^2-m_a^2}\left(\sqrt{E_b^2-m_b^2} + \sqrt{E_c^2-m_c^2} + \sqrt{E_d^2-m_d^2}\right)$

b) Hera:

$s = (p_a+p_b)^2 = \left(\frac{E_a}{c}+\frac{E_b}{c}\right)^2 + \left(\sqrt{\frac{E_a^2}{c^2}-m_a^2} + \sqrt{\frac{E_b^2}{c^2}-m_b^2}\right)^2$

$E_a = 920\,\text{GeV}$, $m_a = 938{,}272\,\frac{\text{MeV}}{c^2}$

$E_b = 27\,\text{GeV}$, $m_b = 511\,\frac{\text{keV}}{c^2}$

$s = \left(920\frac{\text{GeV}}{c} + 27\frac{\text{GeV}}{c}\right)^2 + \left(\sqrt{\left(920\frac{\text{GeV}}{c}\right)^2 - \left(938{,}272\frac{\text{MeV}}{c}\right)^2}\right.$

$\left. + \sqrt{\left(27\frac{\text{GeV}}{c}\right)^2 - \left(511\frac{\text{keV}}{c}\right)^2}\right)^2 \cdot 1{,}012 \cdot 10^{23}\left(\frac{\text{eV}}{c}\right)^2$

Hermes:

$s = \left(938{,}272\frac{\text{MeV}}{c} + 27\frac{\text{GeV}}{c}\right)^2 - \sqrt{\left(938{,}272\frac{\text{MeV}}{c}\right)^2 - \left(938{,}272\frac{\text{MeV}}{c}\right)^2} + \left(27\frac{\text{GeV}}{c}\right)^2 - \left(511\frac{\text{keV}}{c}\right)^2$

$= 5{,}249 \cdot 10^{19}\left(\frac{\text{eV}}{c}\right)^2$

c) $s = \left(938{,}272\frac{\text{MeV}}{c} + 15\frac{\text{GeV}}{c}\right)^2 + \sqrt{\left(15\frac{\text{GeV}}{c}\right)^2 - \left(938{,}272\frac{\text{MeV}}{c}\right)^2}$

$= 2{,}99 \cdot 10^{19}\left(\frac{\text{eV}}{c}\right)^2$

Aufg. 2

$d = \frac{1}{2}gt_d^2 \Rightarrow t_d = \sqrt{\frac{2d}{g}}$,

$v_r = \sqrt{\frac{mc^2}{mc^2+T}}\,c$, $s = vt_y \Rightarrow n = \frac{v_r \cdot t_{ay}}{27\,\text{km}}$

$\Rightarrow n = \sqrt{\frac{mc^2}{mc^2+T}} \cdot \sqrt{\frac{2d}{g}} \cdot \frac{1}{\sqrt{1-\left(\sqrt{\frac{mc^2}{mc^2+T}}\right)^2}} \cdot \frac{1}{27\,\text{km}}$, $mc^2 = 938{,}272\,\text{MeV}$, $T = 4\,\text{TeV}$, $d = 9\,\text{mm}$, $g = 9{,}81\,\frac{\text{m}}{\text{s}^2}$

$= 2{,}61 \cdot 10^{10}$

$n_{10} = \frac{v_r \cdot 10\,\text{h} \cdot g}{27\,\text{km}}$