# Quark-Gluon Plasma Physics (SS 2017)

Prof. Dr. K. Reygers problem sheet 1

**Problem 1: Spectrometer Acceptance**

The CERES/NA45 spectrometer was a fixed-target experiment at the CERN SPS. It subtended an acceptance of $\theta = 8^\circ - 14^\circ$.

a) What pseudorapidity coverage does this correspond to?

b) Indicate in a transverse momentrum $p_T$ vs rapidity $y$ diagram the acceptance for protons and pions. (hint: $p_L = m_T \sinh y = p_T \sinh \eta$).

**Problem 2: Center-of-mass energy for heavy-ions at the LHC**

Show that the center-of-mass energy $\sqrt{s_{NN}}$ for collisions of two nuclei with charges $Z_1$, $Z_2$ and mass numbers $A_1$, $A_2$ in a magnetic field set for protons of momentum $p_p$ is given by

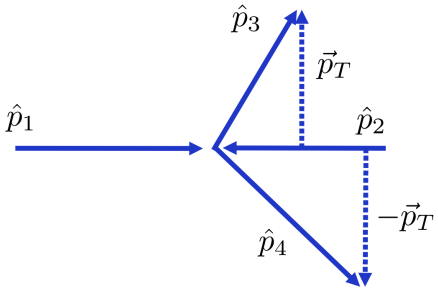
$$\sqrt{s_{NN}} = 2cp_p\sqrt{\frac{Z_1 Z_2}{A_1 A_2}}$$

and that the rapidity shift of the center-of-mass frame in th lab frame is given by

$$y_{NN} = \frac{1}{2}\log\left(\frac{Z_1 A_2}{Z_2 A_1}\right) .$$

**Problem 3: Parton scattering**

In a collision of two protons, the interaction of two (approximately massless) partons with momentum fractions $x_1$ and $x_2$ results in two outgoing partons 3 and 4:




The proton four-momenta can be written as $P_1 = (E_\mathrm{b}, 0, 0, E_\mathrm{b})$ and $P_2 = (E_\mathrm{b}, 0, 0, -E_\mathrm{b})$ where $E_\mathrm{b}$ is the beam energy. The parton four-momenta are given by

$$\begin{aligned}
\hat{p}_1 &= x_1 P_1, \\
\hat{p}_2 &= x_2 P_2, \\
\hat{p}_3 &= (p_T \cosh y_3, \vec{p}_T, p_T \sinh y_3), \\
\hat{p}_4 &= (p_T \cosh y_4, -\vec{p}_T, p_T \sinh y_4).
\end{aligned}$$

a) Show that $x_1 = \frac{p_T}{\sqrt{s}}(e^{y_3} + e^{y_4})$ and $x_2 = \frac{p_T}{\sqrt{s}}(e^{-y_3} + e^{-y_4})$.
(hint: $\hat{p}_1 + \hat{p}_2 = \hat{p}_3 + \hat{p}_4$)

b) Show that the center-of-mass rapidity of the parton system is given by $\frac{1}{2}\ln\frac{x_1}{x_2}$.