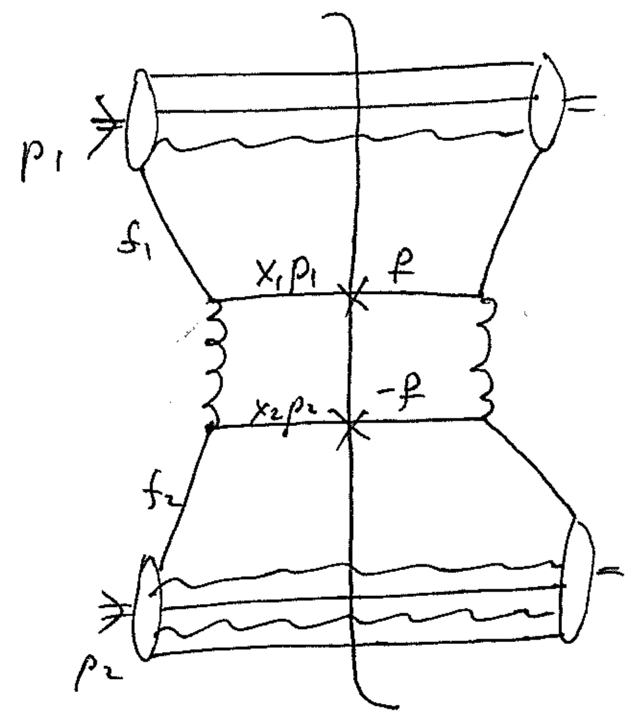
Last time | **Particle Production in High Energy Hadronic Collisions**



$$\left.\right\} \; p^{f_i}(x_1, \mu^2)$$

$$\left.\right\} \; E_p \frac{d\hat{\sigma}^{f_1 f_2 \to f_1' f_2'}}{d^3 p}$$

$$\left.\right\} \; p^{f_2}(x_2, \mu^2)$$

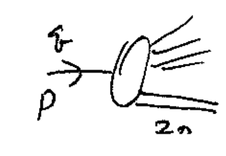
$\Rightarrow$ Jet production cross section at leading twist is

$$E_p \frac{d\sigma}{d^3 p} = \sum_{i,j} \int_0^1 dx_1 \int_0^1 dx_2 \; p^{f_i}(x_1, \mu^2) \, E_p \frac{d\hat{\sigma}_{f_i f_j \to f_i' f_j'}}{d^3 p} \, p^{f_j}(x_2, \mu^2) + O\left(\frac{m^2}{p_T^2}\right)$$

$\nwarrow$ corrections

$\mu^2 = \# \, p_T^2$ ~ standard choice

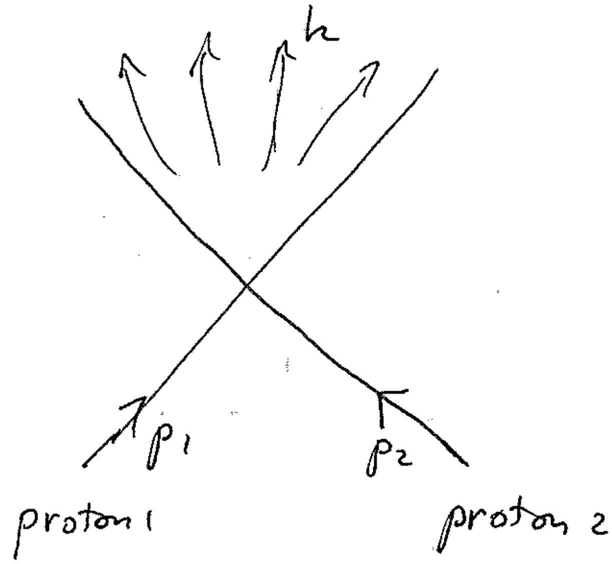
If interested in a particular hadron production, one defines <u>fragmentation functions</u>: $D(z, \mu^2) =$ $= \#$ of hadrons of a particular kind (e.g. pions) carrying fraction z of the parton's momentum.



$\Rightarrow D_{\pi/q}(z, \mu^2)$

Rapidity in p+p Collisions

Rapidity: $y = \frac{1}{2} \ln \frac{k^+}{k^-}$



$$p_1^\mu = \left(p_1^+, \frac{m^2}{2p_1^+}, \underline{0}\right)$$

$$p_2^\mu = \left(\frac{m^2}{2p_2^-}, p_2^-, \underline{0}\right)$$

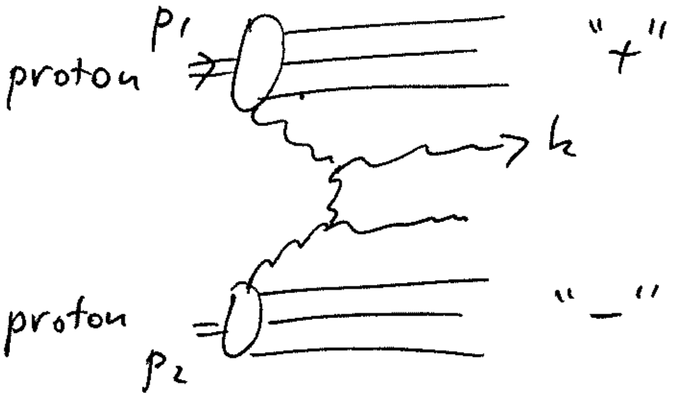
$$y_1 = \ln \frac{p_1^+ \sqrt{2}}{m} \quad , \quad y_2 = -\ln \frac{p_2^- \sqrt{2}}{m}$$

$y_1 \sim$ large & positive, $y_2 \sim$ large & negative

CMS energy squared $s = (p_1 + p_2)^2 \approx 2 p_1^+ p_2^-$.

Rapidity in p+p collisions

Def. Rapidity variable $\boxed{y \equiv \frac{1}{2} \ln \frac{k^+}{k^-}}$ for an outgoing particle with momentum 4-vector k^μ.



at a collider, one proton comes in with

$$p_1^\mu = \left(p_1^+ , \frac{m^2}{2p_1^+} , \underline{0} \right) ,$$

another one has

$$p_2^\mu = \left(\frac{m^2}{2p_2^-} , p_2^- , \underline{0} \right) .$$

p_1^+ , p_2^- are very large, m = proton mass

$$s = (p_1 + p_2)^2 \simeq 2 p_1 \cdot p_2 = 2 p_1^+ p_2^- .$$

Proton rapidities: $y_1 = \frac{1}{2} \ln \frac{p_1^+}{m^2/2p_1^+} = \ln \frac{p_1^+ \sqrt{2}}{m}$.

$$y_2 = \frac{1}{2} \ln \frac{m^2/2p_2^-}{p_2^-} = - \ln \frac{p_2^- \sqrt{2}}{m} .$$

y_1 is large and positive, y_2 is large and <0.

The net rapidity interval between the protons

is $y_1 - y_2 = \ln \frac{2p_1^+ p_2^-}{m^2} = \ln \frac{s}{m^2}$ $\Rightarrow$ the higher is the energy, the wider is the interval.

$$\boxed{y_1 - y_2 = \ln \frac{s}{m^2}}$$

Rapidity interval between our particle k and the proton p_1 is $y_1 - y_K = \ln \frac{p_1^+ \sqrt{2}}{m} - \frac{1}{2} \ln \frac{k^+}{k^-} =$

$= \Big|$ as $k^- = \frac{k_\perp^2}{2k^+}$ for massless particle $= \ln \frac{p_1^+ \sqrt{2}}{m} - \ln \frac{k^+ \sqrt{2}}{k_\perp} = \ln \frac{p_1^+}{k^+} + \ln \frac{k_\perp}{m}$

for $k_\perp \simeq m$ get $y_1 - y_K = \ln \frac{p_1^+}{k^+} = \ln \frac{1}{x_1}$, where $x_1 = \frac{k^+}{p_1^+}$ is the Bjorken-x in proton #1: $\boxed{y_1 - y_K \approx \ln \frac{1}{x_1}}$

Similarly, $\boxed{y_K - y_2 \simeq \ln \frac{1}{x_2}}$ with $x_2 = \frac{k^-}{p_2^-}$ ~ Bjorken-x in proton #2

We thus have