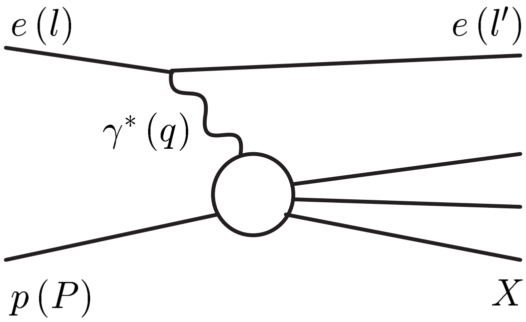
# Kinematics at HERA

$$s = (l + P)^2 \approx 10^5\, GeV^2 \qquad \Rightarrow \sqrt{s_{ep}} \simeq 300 \text{ GeV}$$

$$Q^2 = -q^2 = 4E_e E'_e \cos\frac{\theta}{2}$$




$$y = \frac{q \cdot P}{l \cdot P} \left[ = \frac{E_\gamma}{E_e} \right]_{Q^2=0} \qquad x = \frac{Q^2}{2P \cdot l}$$

$$s_{\gamma p} = W^2_{\gamma p} = (q+P)^2 \cong sy - Q^2$$

$$\hat{y} = \frac{1}{2}\ln(\frac{E+p_z}{E-p_z}) \quad \eta = -\ln(\tan\frac{\theta}{2})$$

- $Q^2 \approx 0$ — Photoproduction ($\gamma$p)

  ▷ Weizsäcker - Williams Approximation :
  electrons act as source of quasi-real photons with flux $f_{\gamma/e}$;
  relation between $\sigma_{\gamma p}$ and $\sigma_{ep}$ (given range in $y$ and $Q^2$)

$$\sigma_{ep}(\bar{y}) = \int_{y_{min}}^{y_{max}} \int_{Q^2_{min}}^{Q^2_{max}} f_{\gamma/e}(y, Q^2) \cdot \sigma_{\gamma p}(y, Q^2) \cdot dQ^2 dy$$

  ▷ $\gamma p$ CM energy : $40\, GeV \leq W_{\gamma p} = \sqrt{sy} \leq 250\, GeV$

- $Q^2 \geq 4\, GeV^2$ — Deep Inelastic Scattering (DIS)

  ▷ Includes longitudinal $\gamma$ and full $Q^2$-dependence

  ▷ $\gamma^\star p$ CM energy : $10\, GeV \leq W_{\gamma^\star p} \leq 300\, GeV$

  ▷ $Q^2$ and $x$ ranges: $1 \leq Q^2 \leq 5 \cdot 10^4$ GeV$^2$ and $3 \cdot 10^{-4} \leq x \leq 0.5$