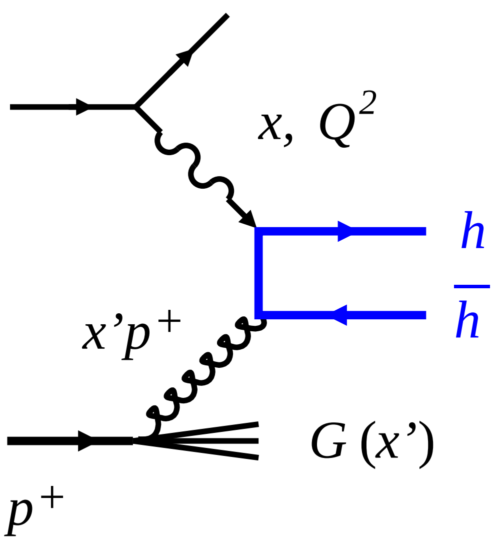
F_2^c and rate estimates using analytic methods

C. Weiss, LDRD Project "Nuclear gluons with charm at EIC," Meeting 16-Dec-15

- Heavy–quark structure function F_2^h in LO QCD



$$F_2^h(x, Q^2) = \int_{ax}^{1} \frac{dx'}{x'}\, x' G(x')\, \hat{F}_g^h(x/x',\, Q^2,\, m_h^2,\, \mu^2)$$

$$\hat{F}_g^h(\ldots) = \frac{\alpha_s(\mu^2)}{m_h^2} \frac{Q^2}{4\pi^2}\, e_h^2 \times \text{function}(x/x', Q^2)$$

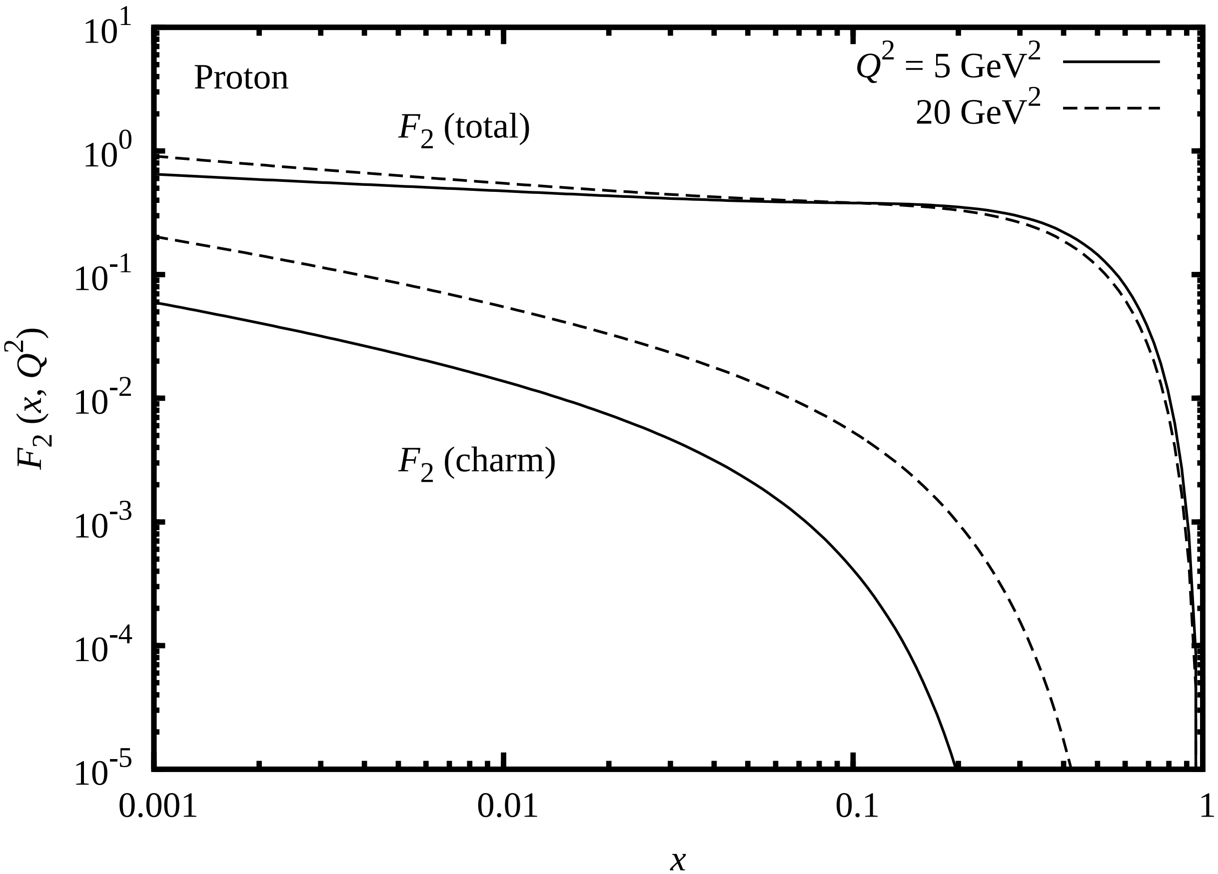
$$a = 1 + \frac{4m_h^2}{Q^2}$$ sets limit of x' integral

LO scale set at $\mu^2 = 4m_h^2$, perturbative stability
Gluck, Reya, Stratmann, NPB 422, 37 (1994)

Charm mass $m_c \sim 1.5\,\mathrm{GeV}$

Can be generalized to photoproduction

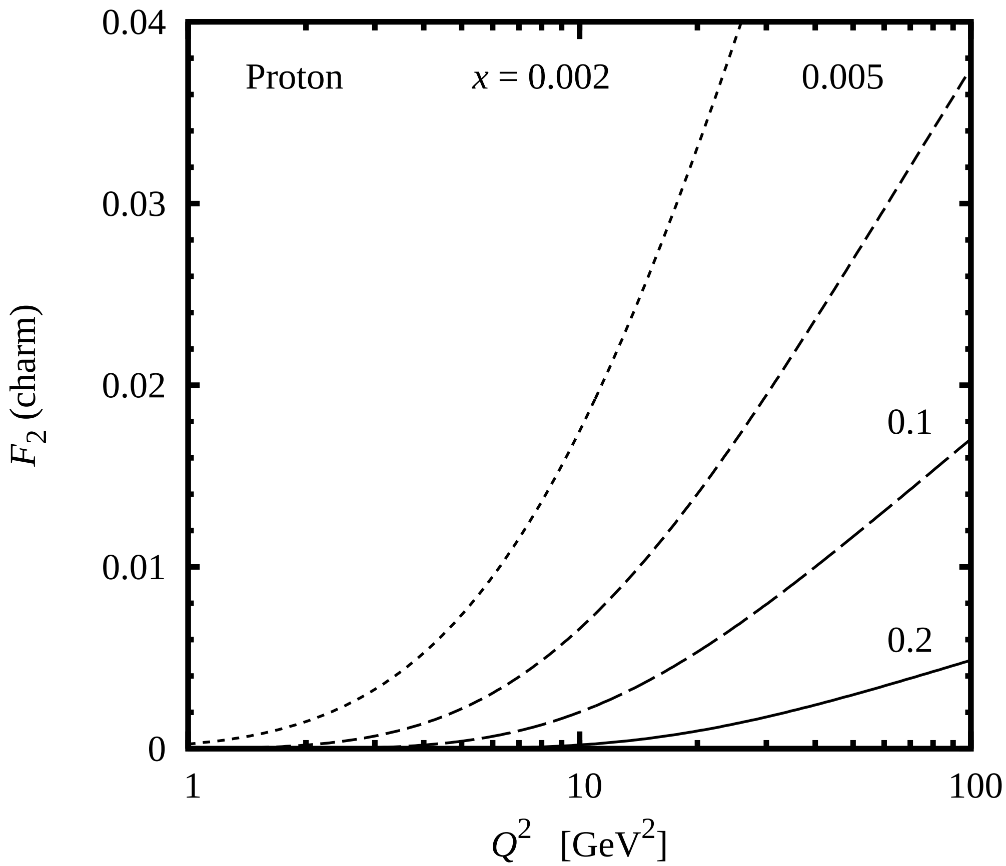
Charm structure function F_2^c: x–dependence



F_2^c and ratio F_2^c/F_2 decrease rapidly with x

Strong Q^2 variation of F_2^c at fixed x: Kinematic effect

Charm structure function F_2^c: Q^2–dependence



F_2^c increases rapidly with Q^2 at fixed x: Kinematic effect

Charm cross section and rate

$d\sigma(eN \to e' + c\bar{c} + X) \; = \; \mathcal{F}(x, Q^2) \; dx \; dQ^2$ diff cross section, $\int d\phi(e')$

$$\mathcal{F}(x, Q^2) \; = \; \frac{2\pi\alpha_{\text{em}}^2 y^2}{Q^4(1-\epsilon)} \left[\frac{F_2^c}{x} \; - \; (1-\epsilon)\frac{F_L^c}{x} \right]$$

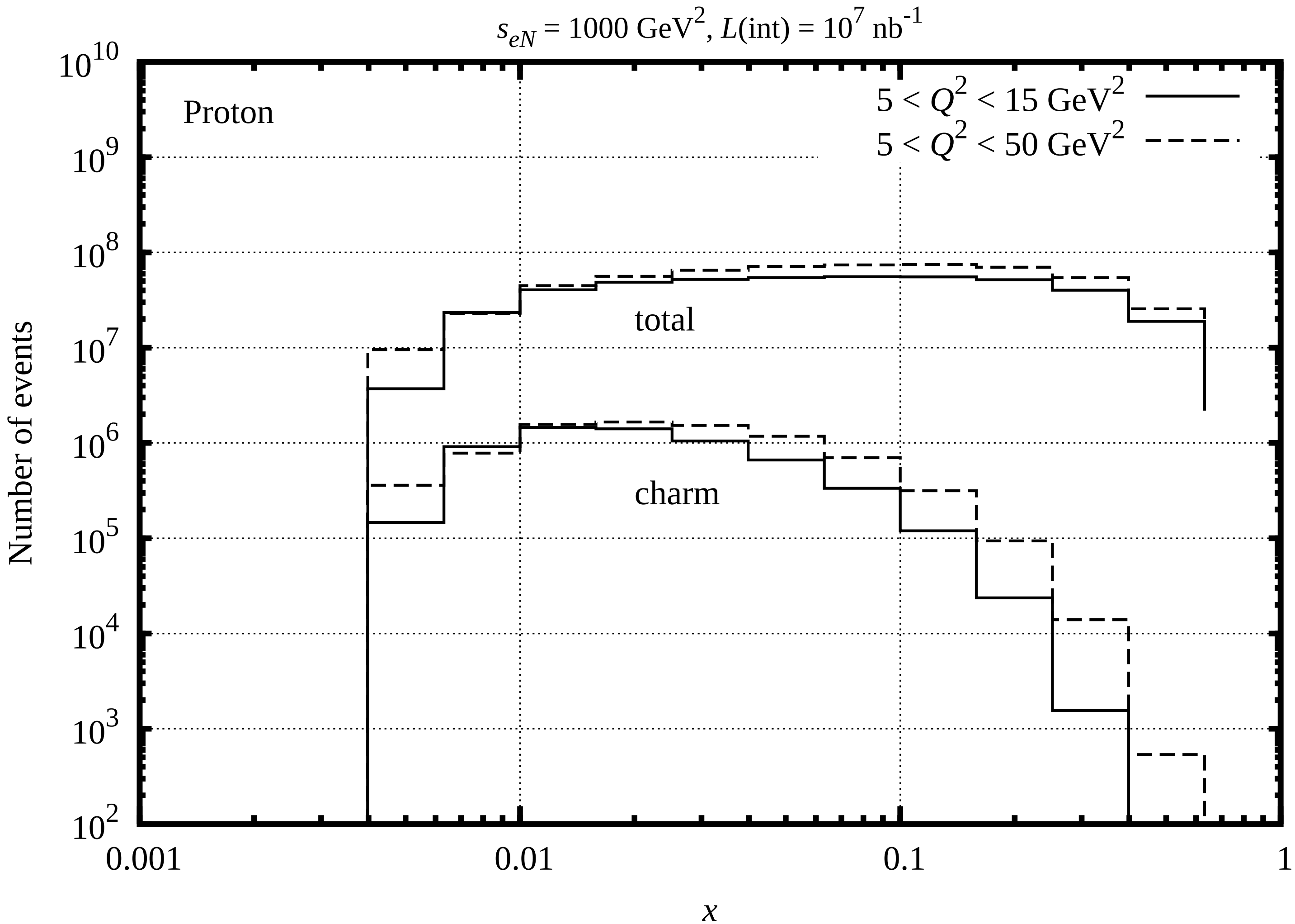
$\Delta N \; = \; L_{\text{int}} \int\limits_{x_1, x_2} dx \int\limits_{Q_1^2, Q_2^2} dQ^2 \; \mathcal{F}(x, Q^2)$ event nr in bin $[x_1, x_2] \times [Q_1^2, Q_2^2]$

$L_{\text{int}} \; = \; LT$ integrated luminosity

$L_{\text{int}} = 10^7 \, \text{nb}^{-1}$ for $L = 10^{34} \text{cm}^{-2} \text{s}^{-1}$, $T = 2 \, \text{weeks} \approx 10^6 \, \text{s}$ ref value

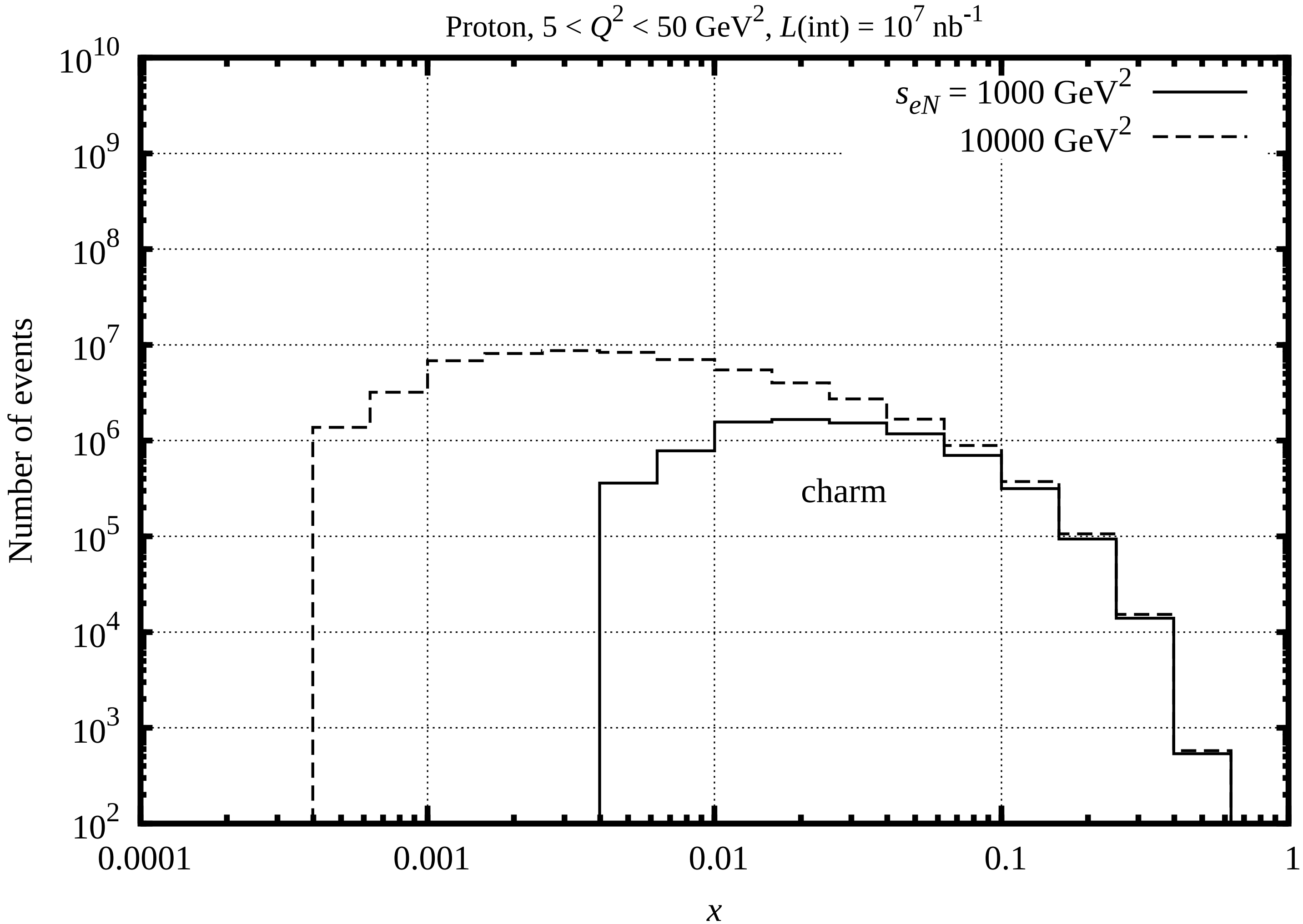
Rates estimated by numerical integration of LO cross section

Charm rate: x–dependence



- Here 5 bins per decade in x, single wide bin in Q^2
- Rates drop rapidly at large x
- Nuclear rates comparable: Structure function $F^c_{2A} \sim AF^c_{2N}$, but luminosity $L_A \approx L_N/A$

Charm rate: CM energy dependence



- Little dependence on s_{eN} at large x, because flux $y^2/(1-\epsilon)$ independent of s_{eN} for $y \ll 1$
- Lower limit in x depends on s_{eN}
- Angular distributions at given x will change with s_{eN}

Questions and tasks

- Analytic estimates should be confirmed by MC integration
- Sensitivity to gluon PDF can be studied using analytic estimates
- What does ratio charm/total imply for charm identification/reconstruction?