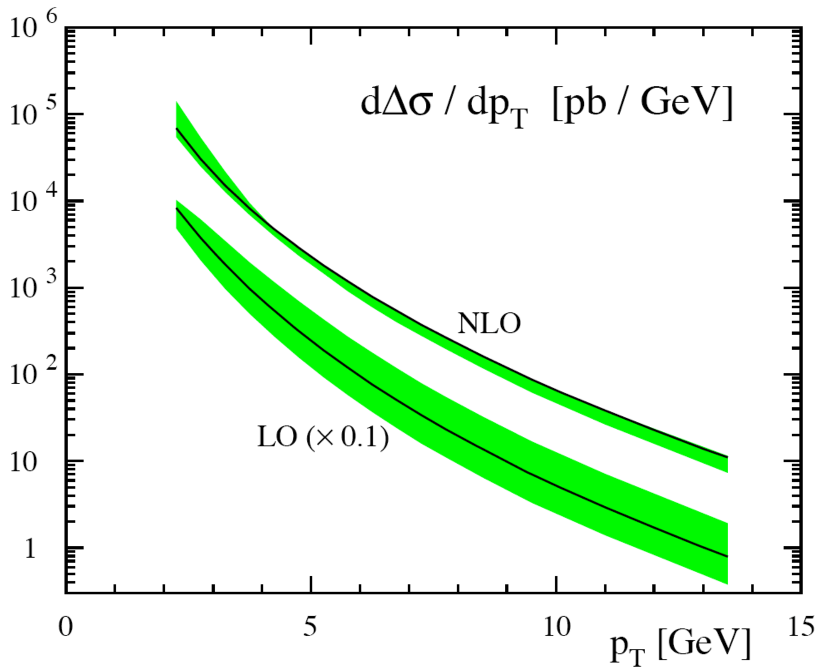
Some remarks about theory uncertainties in extractions of polarized pdfs

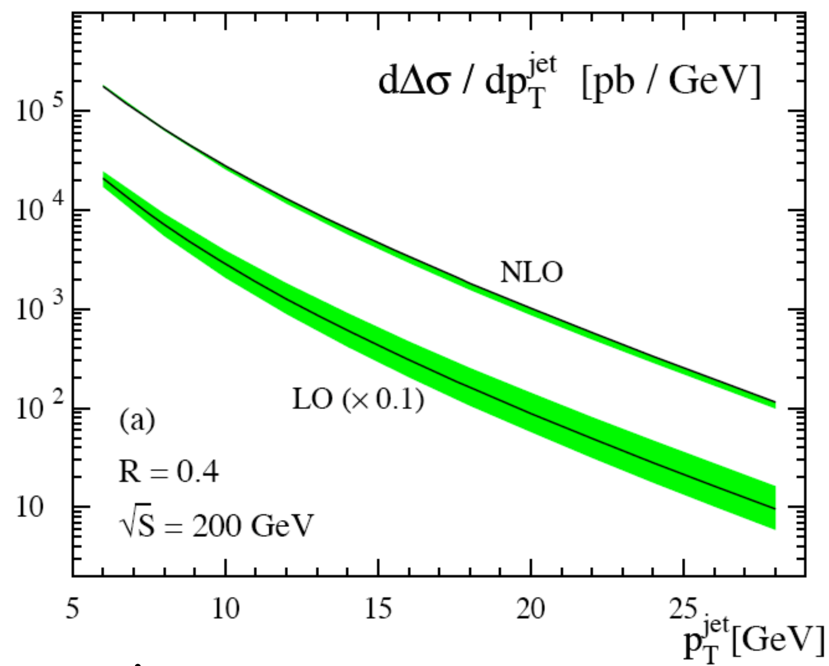
Werner Vogelsang
Nuclear Theory, BNL

Scale dependence:

- typically significant in hadronic collisions
- (some) decrease from LO to NLO
- often better in in polarized case:

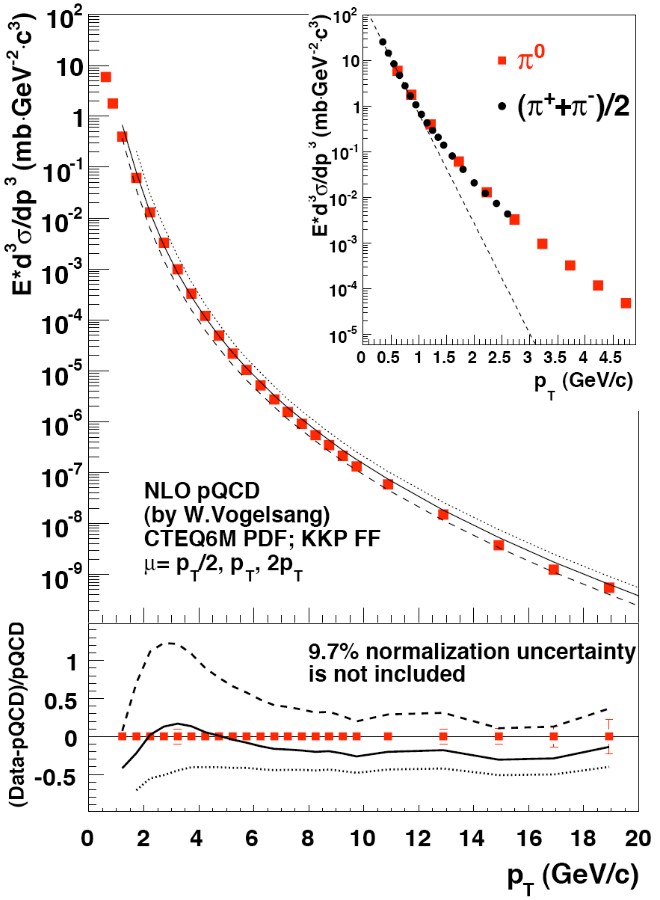


pions



jets

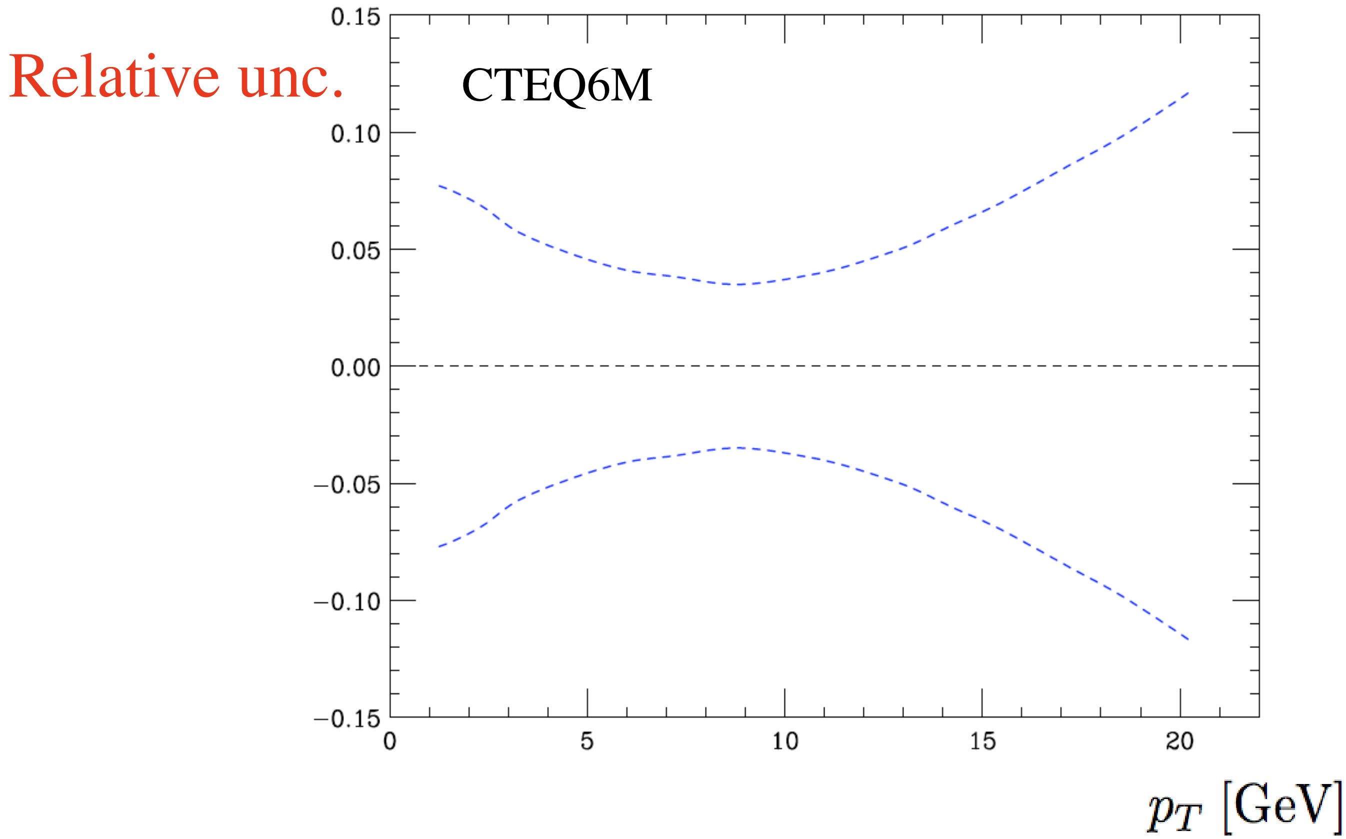
- Use unpolarized cross section for guidance on scale choice



- Provide polarized cross section from experiment Bunce

- Resummation of higher orders

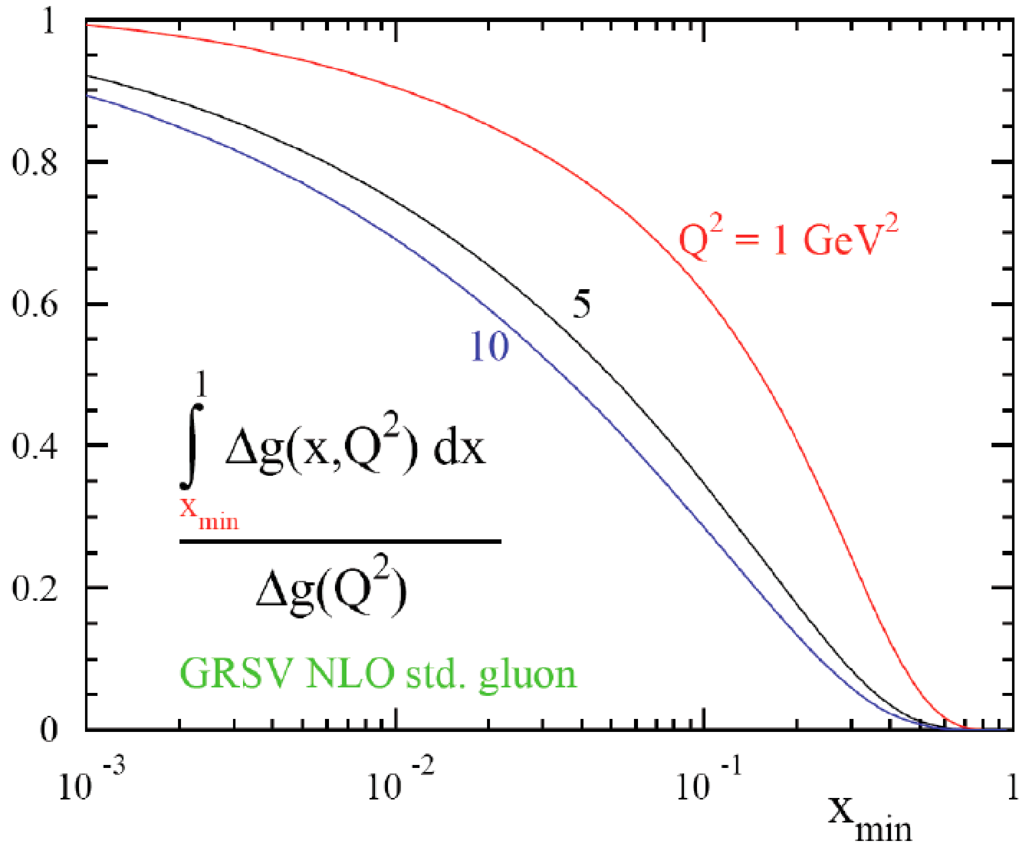
- Unpolarized pdfs: $pp \to \gamma X$ RHIC



- Fragmentation functions
- Strong coupling α_s
- Ideally, use all in one global fit ...

Small-x behavior of pdfs :

- Intersting by its own right
- May be crucial for first moments



Approaches:

- Perturbative: evolution, resummation
- Non-perturbative: models

• what does DGLAP evolution tell us ?

$$\mu \frac{\mathrm{d}}{\mathrm{d}\mu} \begin{pmatrix} \Delta\Sigma(x,\mu^2) \\ \Delta g(x,\mu^2) \end{pmatrix} = \int_x^1 \frac{dz}{z} \begin{pmatrix} \Delta\mathcal{P}_{qq} & \Delta\mathcal{P}_{qg} \\ \Delta\mathcal{P}_{gq} & \Delta\mathcal{P}_{gg} \end{pmatrix}_{(z,\alpha_s(\mu))} \cdot \begin{pmatrix} \Delta\Sigma \\ \Delta g \end{pmatrix} \left(\frac{x}{z},\mu^2\right)$$

• at $x \longrightarrow 0$ (and to lowest order):

$$\begin{pmatrix} \Delta\mathcal{P}_{qq} & \Delta\mathcal{P}_{qg} \\ \Delta\mathcal{P}_{gq} & \Delta\mathcal{P}_{gg} \end{pmatrix}(x,\alpha_s) \approx \frac{\alpha_s}{2\pi} \begin{pmatrix} C_F & -n_f \\ 2C_F & 4C_A \end{pmatrix} + \mathcal{O}(x)$$

• compare unpolarized case:

$$\begin{pmatrix} \mathcal{P}_{qq} & \mathcal{P}_{qg} \\ \mathcal{P}_{gq} & \mathcal{P}_{gg} \end{pmatrix} \approx \frac{\alpha_s}{2\pi} \frac{1}{x} \begin{pmatrix} 0 & 0 \\ 2C_F & 2C_A \end{pmatrix} + \mathcal{O}(1)$$

- solution (double-log approx. DLA)

Berera
Ball, Forte, Ridolfi
Gehrmann, Stirling

- interplay between input and pert. evolution:

  * "flat" input : small-x behavior driven by evolution

$$\Delta g(x,Q^2) \;\propto\; \frac{1}{\sqrt{4\pi\gamma_+\sqrt{\ln\frac{x_0}{x}\ln\frac{t}{t_0}}}}\;\exp\left[2\gamma_+\sqrt{\ln\frac{x_0}{x}\ln\frac{t}{t_0}}-\delta\ln\frac{t}{t_0}\right]$$

$$\gamma_+ \approx 2.5$$

  * power-like input $\Delta\Sigma\,,\,\Delta g \;\sim\; x^{-\alpha}$

    preserved under evolution -- rise indep. of Q^2

- for first case:

$$\frac{\Delta g(x,Q^2)}{xg(x,Q^2)} \;\propto\; \exp\left[2(\gamma_+-\gamma_u)\sqrt{\ln\frac{x_0}{x}\ln\frac{t}{t_0}}+\ldots\right]$$

- higher orders in the splitting functions at small x:

$$\Delta P(x) = \frac{\alpha_s}{2\pi} c_0 + \left(\frac{\alpha_s}{2\pi}\right)^2 c_1 \ln^2 x + \ldots + \left(\frac{\alpha_s}{2\pi}\right)^{k+1} c_k \ln^{2k} x + \ldots$$

- compare unpolarized case: (gq, gg spl. fcts.)

$$P(x) = \frac{\alpha_s}{2\pi} \frac{c_0'}{x} + \left(\frac{\alpha_s}{2\pi}\right)^2 c_1' \frac{\ln x}{x} + \ldots + \left(\frac{\alpha_s}{2\pi}\right)^{k+1} c_k' \frac{\ln^k x}{x} + \ldots$$

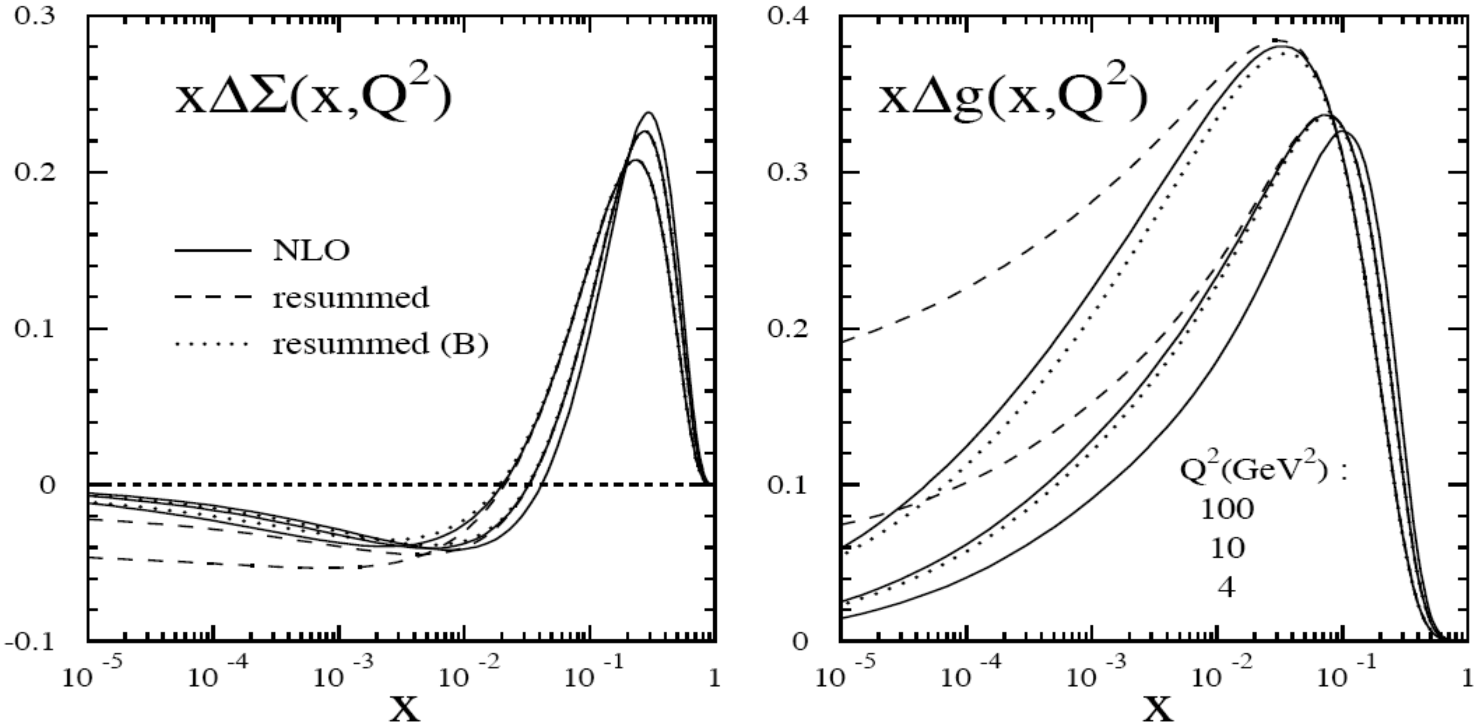
- all-order resummation in polarized case:

Kirschner,Lipatov; Bartels,Ermolaev,Ryskin; Kwiecinski,Ziaja; Ermolaev,Greco,Troyan; Maul

- typically predict steep power-like rise

- however, subleading terms probably remain crucial

Blümlein,Riemersma,Vogt

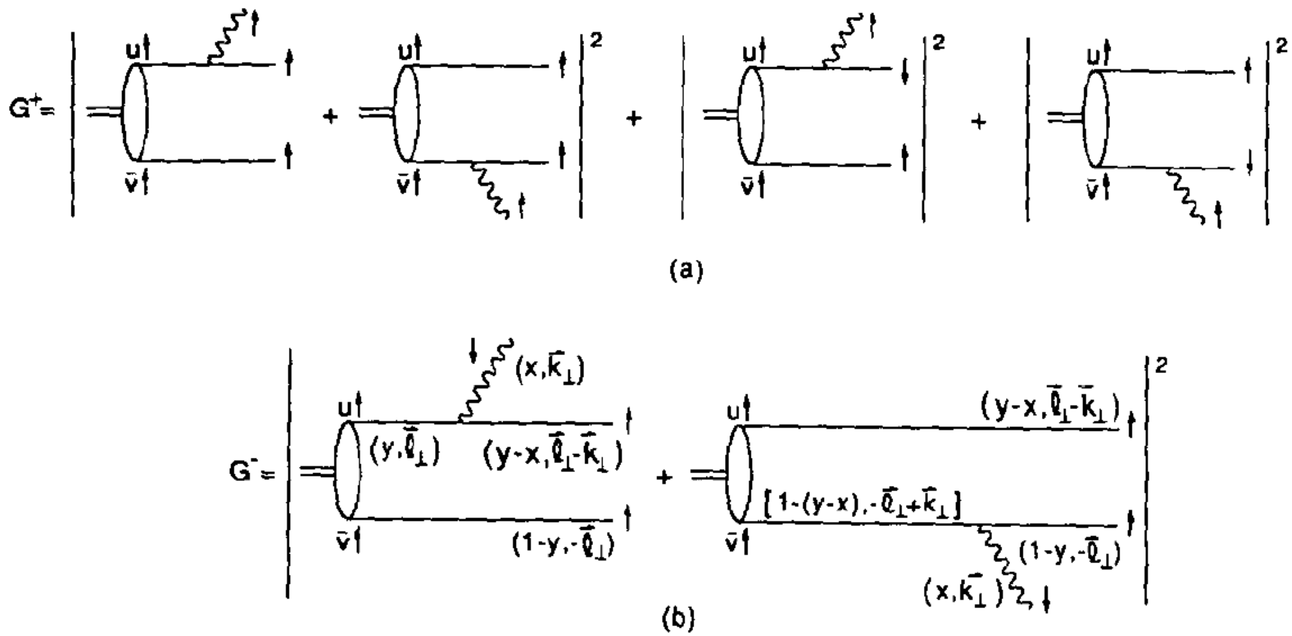


Blümlein,Riemersma,Vogt

• model approach:

Brodsky, Schmidt

Positronium



• argue that $\Delta g(x) \;\approx\; x g(x) \qquad x \to 0$

• CTEQ6M:

$$\int_0^{0.01} dx\, x\, g(x, Q^2 = 10) \;=\; 0.065$$

$$\int_{0.3}^{1} dx\, g(x, Q^2 = 10) \;=\; 0.096$$

$\int \Delta g$ [DSSV]

-0.1

0.017