Prompt photon production in p–A collisions at the LHC and the extraction of gluon shadowing

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Definition

Leading twist modification of per-nucleon parton densities

$$\begin{aligned} u_p(x,Q^2) &\quad\longrightarrow\quad u_A(x,Q^2), \\ G_p(x,Q^2) &\quad\longrightarrow\quad G_A(x,Q^2), \ldots \end{aligned}$$

also described by ratios, e.g.

$$R_G^{(A)}(x,Q^2) = G_A(x,Q^2)/G_p(x,Q^2)$$

worth knowing in the shadowing region, i.e. $x < 10^{-1}$

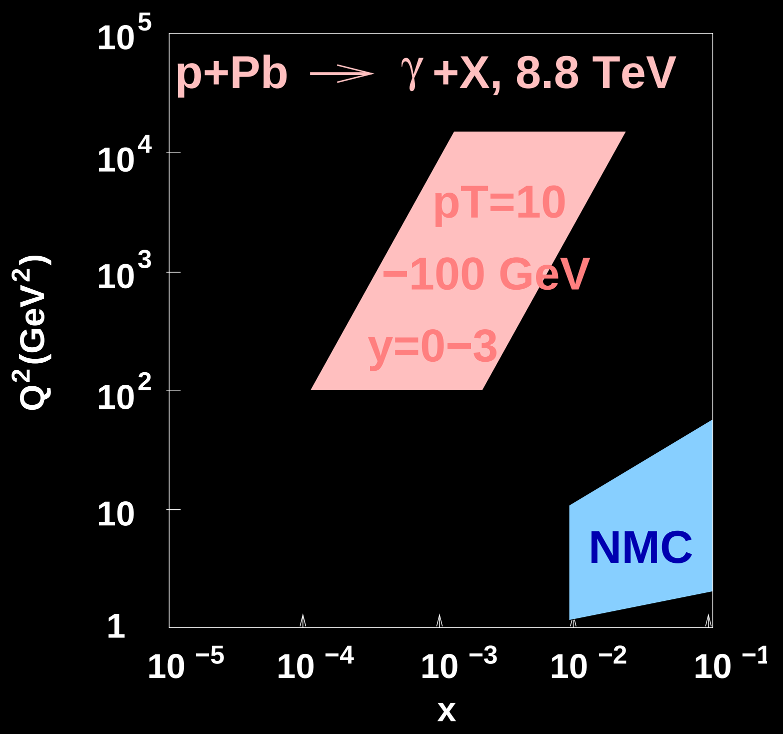
Current knowledge

Reviews: Arneodo, M, Phys Rep 240, 301 (1994) ; Armesto, N, J Phys G 32, R367 (2006)

Extracted from deep inelastic scattering and Drell-Yan data

Several global fits (with DGLAP evolution): Eskola *et al* (EKS),...

We use recent **NLO** analysis from de Florian and Sassot (nDS)



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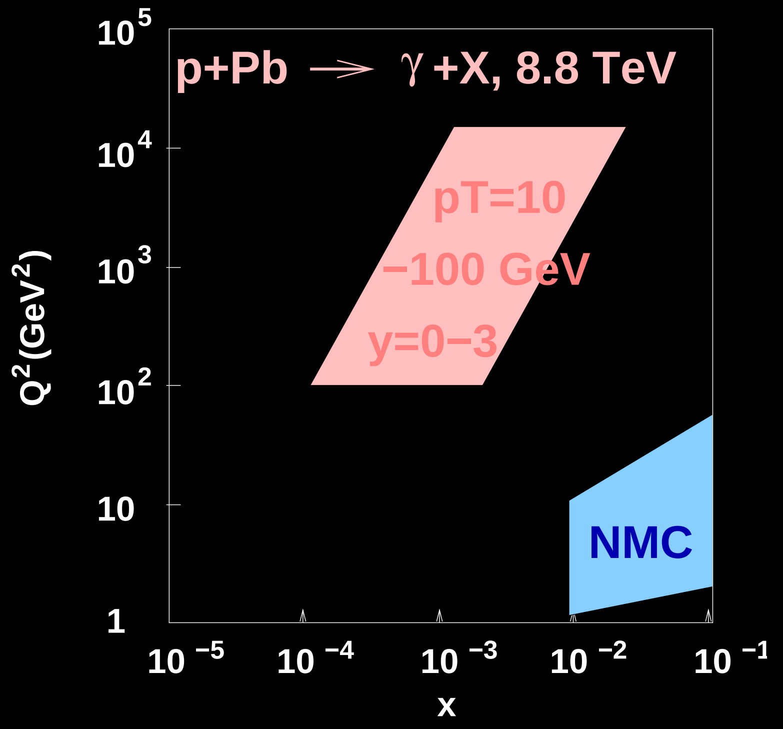


⇒ gluon practically unconstrained

Prompt photon production at large p_T

$$d\sigma(p+p\to\gamma+X) \stackrel{\text{LO}}{=} u_1 * \bar{u}_2 * d\hat{\sigma}(u+\bar{u}\to\gamma+g) + \\ u_1 * G_2 * d\hat{\sigma}(u+g\to\gamma+u) + \cdots + \\ u_1 * G_2 * D_u^\gamma * d\hat{\sigma}(u+g\to u+g) + \cdots$$

Prompt photon production at large p_T

$$d\sigma(p + p \longrightarrow \gamma + X) \stackrel{\text{LO}}{=} \underbrace{u_1 * \bar{u}_2 * d\hat{\sigma}(u + \bar{u} \longrightarrow \gamma + g) + u_1 * G_2 * d\hat{\sigma}(u + g \longrightarrow \gamma + u) + \cdots +}_{\text{direct}} \underbrace{u_1 * G_2 * D_u^\gamma * d\hat{\sigma}(u + g \longrightarrow u + g) + \cdots}_{\text{fragmentation}}$$

direct

fragmentation

Prompt photon production at large p_T

$$d\sigma(p + p \to \gamma + X) \stackrel{\text{LO}}{=} u_1 * \bar{u}_2 * d\hat{\sigma}(u + \bar{u} \to \gamma + g) + \\ u_1 * G_2 * d\hat{\sigma}(u + g \to \gamma + u) + \cdots + \\ u_1 * G_2 * D_u^\gamma * d\hat{\sigma}(u + g \to u + g) + \cdots$$

$$\frac{d^3\sigma}{dy d^2 p_T}(p + p \to \gamma + X) \text{ vs } s,\ p_T,\ y$$

- measured at several energies
- with various projectiles
- collider data well described by pQCD at NLO

Nuclear ratios

$$R_{pA} = \frac{d\sigma(p + A \to \gamma + X)}{d\sigma(p + p \to \gamma + X} \text{ vs } x_T,\ y,\ s$$

- studied with INCNLO

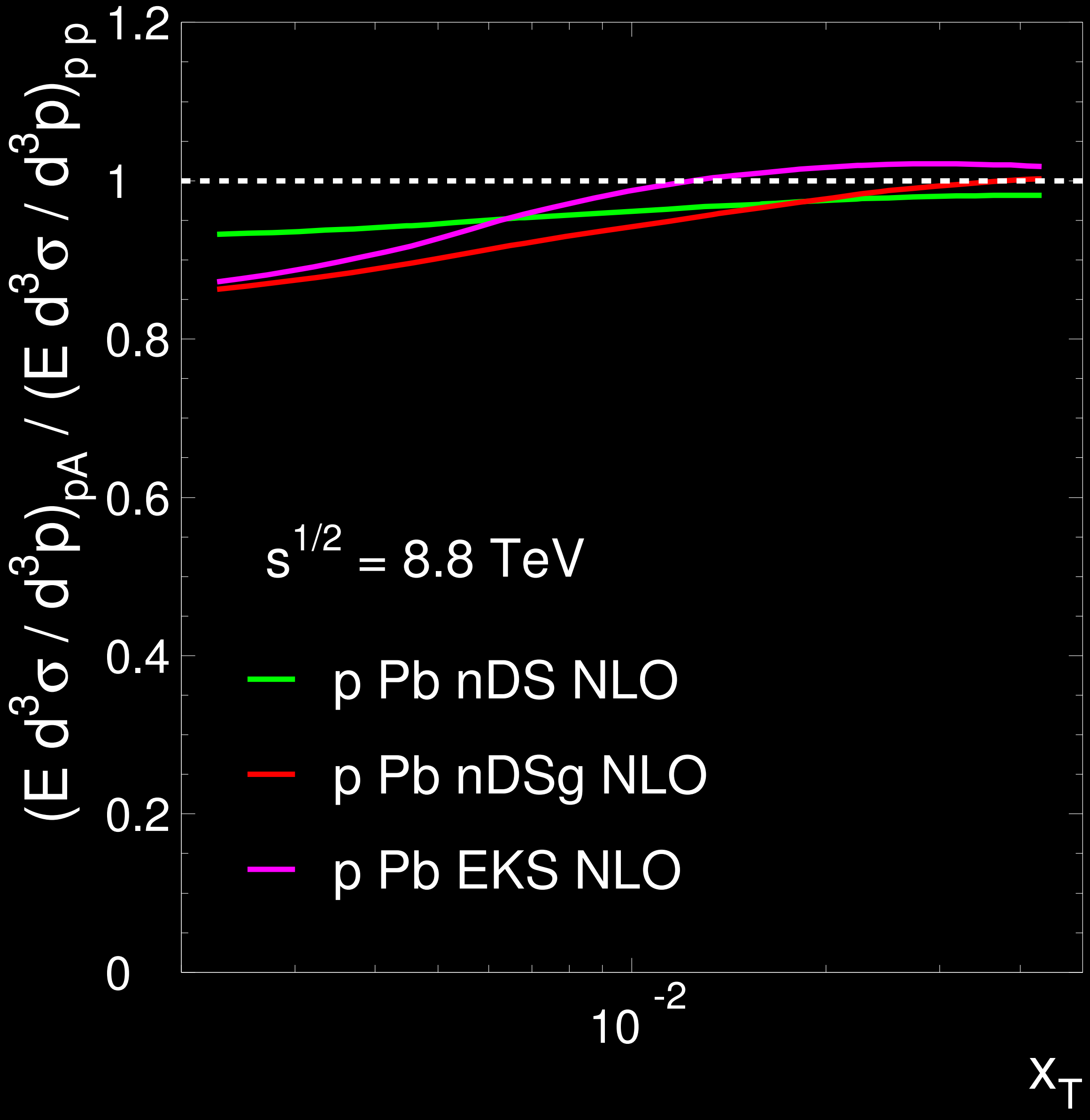
  [Aurenche *et al*, Eur Phys J 9, 107 (1999)]

- putting either f_p or f_A
- $\sqrt{s} = 8.8$ TeV, $x_T = p_T/(\sqrt{s}/2)$
- plotted versus $x_T e^{-y}$, $\sim x_2$ region probed

$\longrightarrow$ sensitive to modification of parton densities. . .

$\longrightarrow$ . . . and to change of isospin composition

Inclusive photons at $y = 0$



Inclusive photons at $y = 3$

Motivations

Inclusive photons

Prompt photon

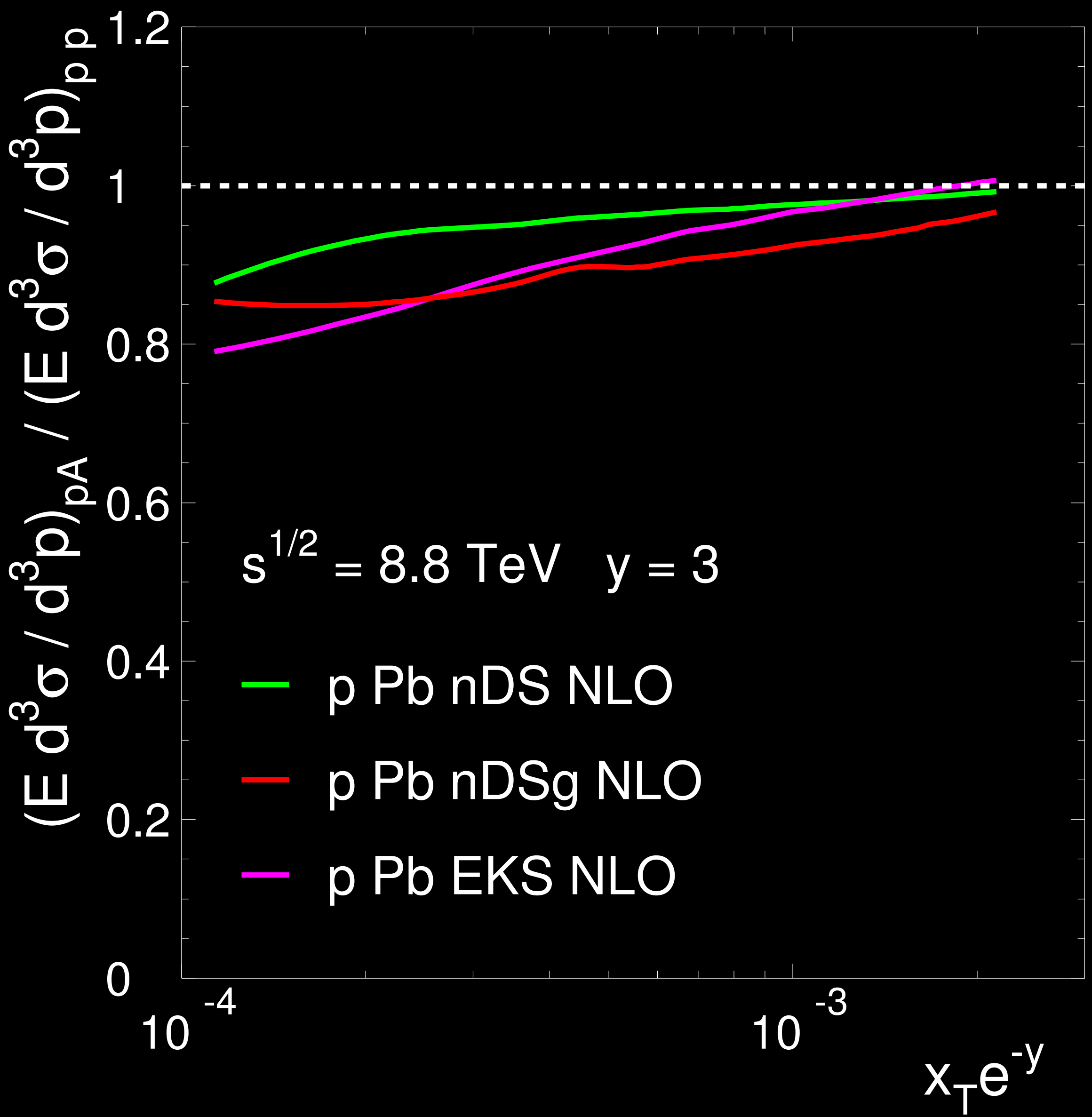
Nuclear ratios

$y = 0$

$y = 3$

Isolated photons

Outlook



Isolated photons

- Cut out the π^0 background...
- ...and the fragmentation component
- Nuclear ratio computed with JETPHOX

  [Aurenche *et al*, Phys Rev D 73, 094007 (2006)]
- isolation criterion: $E_T^{\rm had}/p_T^\gamma \leq 0.1$ in a cone of radius $R = 0.4$ around the photon

$\longrightarrow$ direct extraction of shadowing ratios

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$\longrightarrow$ direct extraction of shadowing ratios

- in $d\sigma = f_1 * f_2 * d\hat{\sigma}$ the x region is selected by the behavior of the parton densities
- ratios such as $R_G = G_A/G_p$ show much less variation

$\longrightarrow$ factorize them out of the convolution

Direct extraction of f_A/f_p

Which x? At LO, the Compton cross section is

$$\frac{d^3\sigma}{dyd^2p_T} \propto \int dv \; F^{(1)}\left(\frac{x_T e^y}{2v}\right) G^{(2)}\left(\frac{x_T e^{-y}}{2(1-v)}\right)\left(1 - v + \frac{1}{1-v}\right)$$
$$+ G^{(1)}\left(\frac{x_T e^y}{2v}\right) F^{(2)}\left(\frac{x_T e^{-y}}{2(1-v)}\right)\left(v + \frac{1}{v}\right),$$

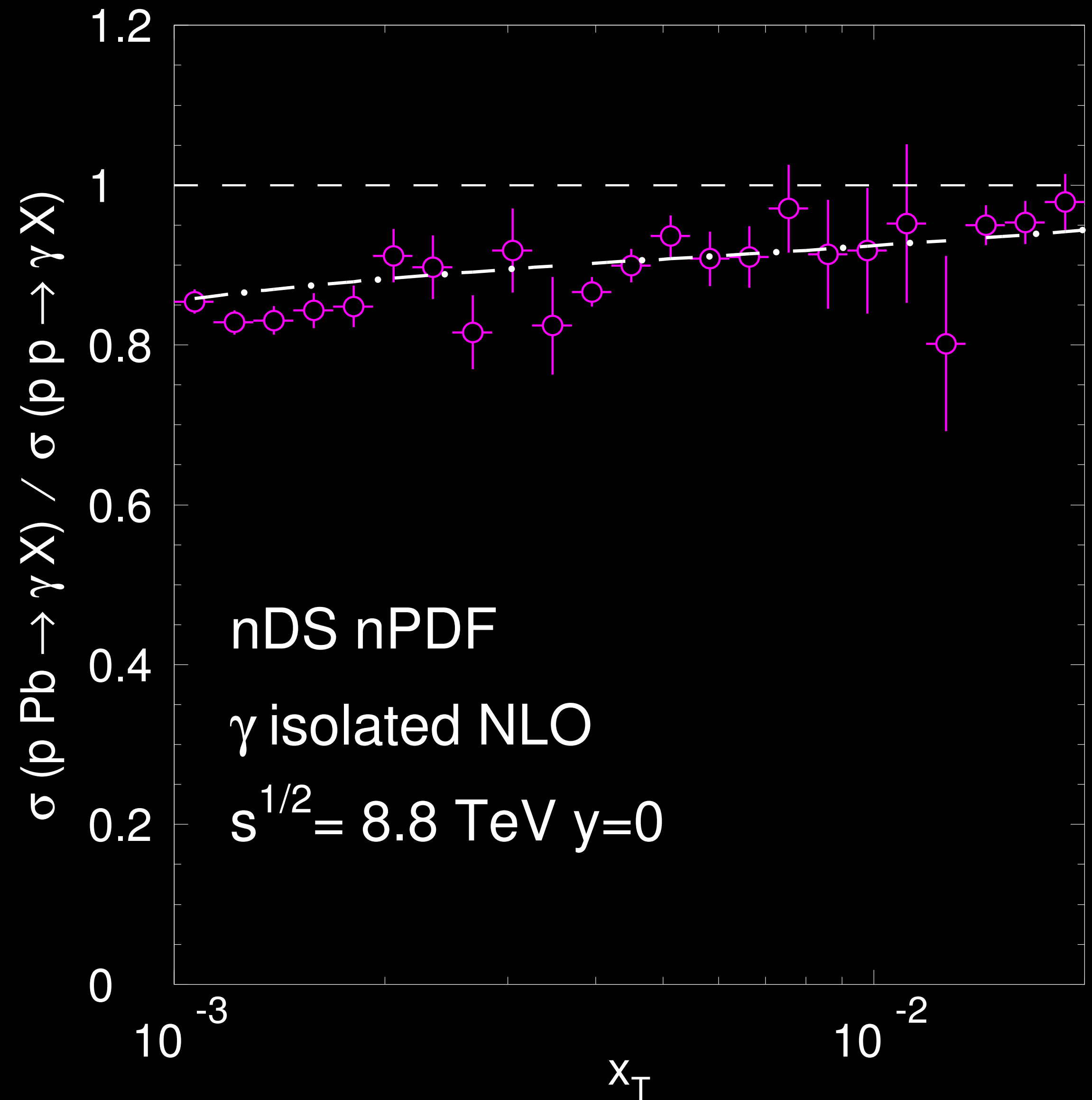
At small x_T (and not-too-large $|y|$)

- $F(x) \sim Ax^{-a}$ and $G(x) \sim Bx^{-b} \rightarrow F \times G \propto v^a(1-v)^b$

$\rightarrow$ $R \rightarrow R(x_T e^{-y})$

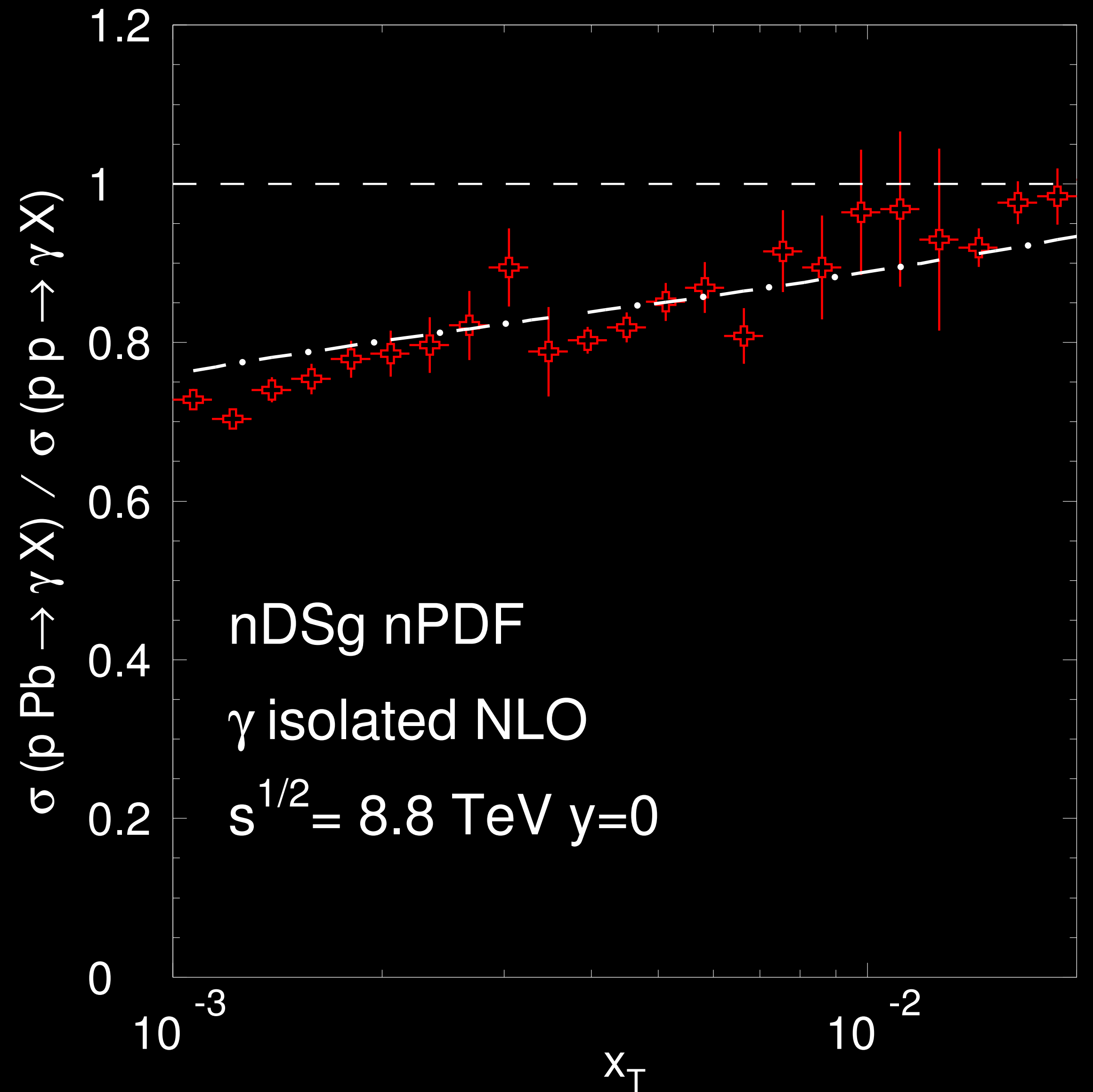
- at $y = 0$, the nuclear ratio is $\approx 0.5(R_G + R_{F_2})$
- at $y = 3$, it is $\approx R_G$

Isolated photons at $y = 0$



Isolated photons at $y = 0$

- Motivations
- Inclusive photons
- Isolated photons
  - Isolated photons
  - Direct extraction
  - $y = 0$
- Outlook



- Nuclear modifications up to 30%

$\Rightarrow$ **challenging measurements**

- same energy for pp and pA or effect of extrapolation
- photon channel to be compared with
  - ◇ jet production
  - ◇ low-mass dilepton
  - ◇ open charm and beauty