The GLUON PDF at low x

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Summary

Parton Distribution Functions (PDFs)

PDFs :

- encode information on the partonic structure of nucleons
- are fundamental to explore hadron collisons & enter in any calculation involving hadrons in the initial state (LHC, EIC, ...)
- are non-perturbative object $\longrightarrow$ x-dependence non-calculable by pQCD

but they are UNIVERSAL $\longrightarrow$ predictive power !

PDFs are determined in Global Analyses

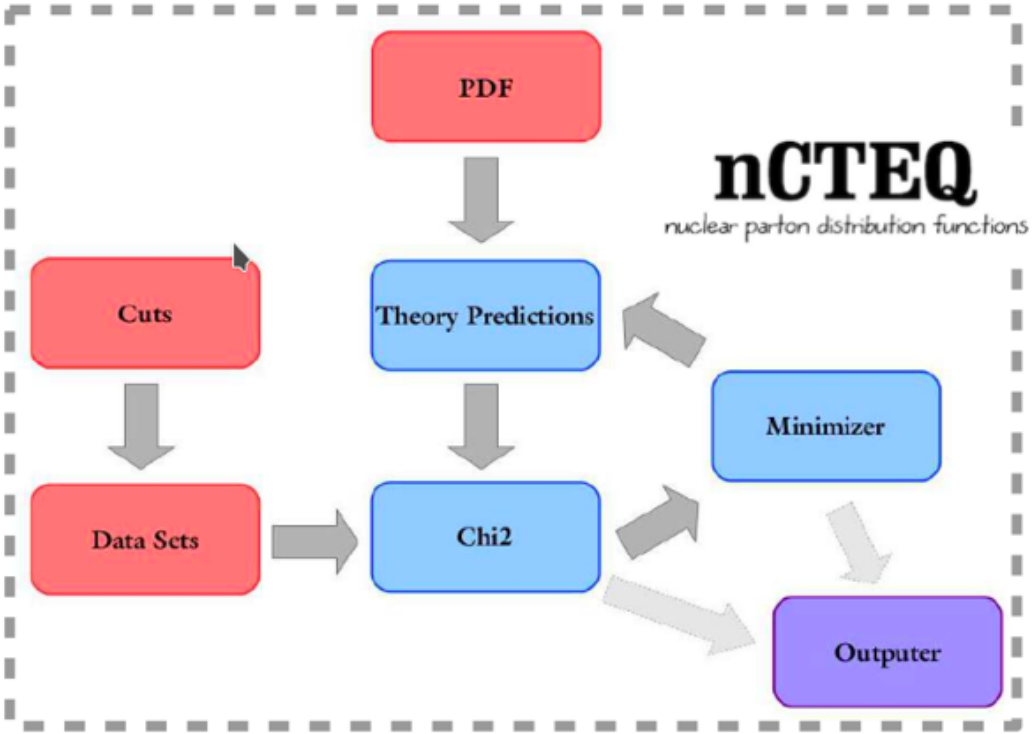
$$f_i^{p/A}(x, Q_0) = c_0 x^{c_1} (1_x)^{c_2} e^{c_3 x} (1 + e^{c_4} x)^{c_5}$$

$Q_0 \longrightarrow Q_i$ by DGLAP evolution

$$\mu^2 \frac{d}{d\mu^2} f_i(x, \mu^2) = \frac{\alpha_S}{2\pi} (P_{ij} \otimes f_j)(x, \mu^2)$$

(13 coupled integro-differential equations)

Wide variety of data at scale Q_i



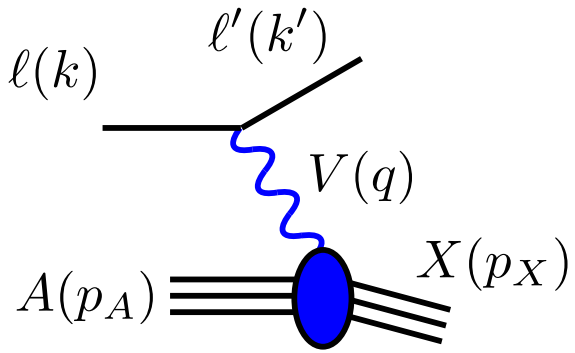
Multiple processes

Need lots of processes to constrain PDFs
We have many processes in the nCTEQ global analysis :

- DIS -> (Work on TMC)
- Drell-Yan
- W^+, W^-, Z production
- Heavy quark production
- Inclusive hadron production
- Jets
- $\gamma + X$ -> The process I will add to the nCTEQ global analysis

•DIS

The Deep Ineslatic Scattering (DIS) is a key process for studying PDFs. There are many data to constrain PDFs.



$$d\sigma \propto W^A_{\mu\nu} L^{\mu\nu} \tag{1}$$

$\longrightarrow$ access to Structure Functions (SF)
The link between PDFs and Structure Functions can be expressed by :

$$F(x,Q) = (q \otimes C_q)(x,Q) + (g \otimes C_g)(x,Q) \tag{2}$$

Target Mass Corrections (TMC)

Here the master formula :

$$\mathrm{F}_1^{A,}(x_N,Q^2) = \frac{x_N}{\xi_N r_N} F_1^{A,(0)}(\xi_N,Q^2) + \frac{M_N^2 x_N^2}{Q^2 r_N^2}\, h_2^A(\xi_N,Q^2) + \frac{2M_N^4 x_N^3}{Q^4 r_N^3}\, g_2^A(\xi_N,Q^2)\,,$$

$$F_2^{A,}(x_N,Q^2) = \frac{x_N^2}{\xi_N^2 r_N^3} F_2^{A,(0)}(\xi_N,Q^2) + \frac{6M_N^2 x_N^3}{Q^2 r_N^4}\, h_2^A(\xi_N,Q^2) + \frac{12M_N^4 x_N^4}{Q^4 r_N^5}\, g_2^A(\xi_N,Q^2)\,,$$

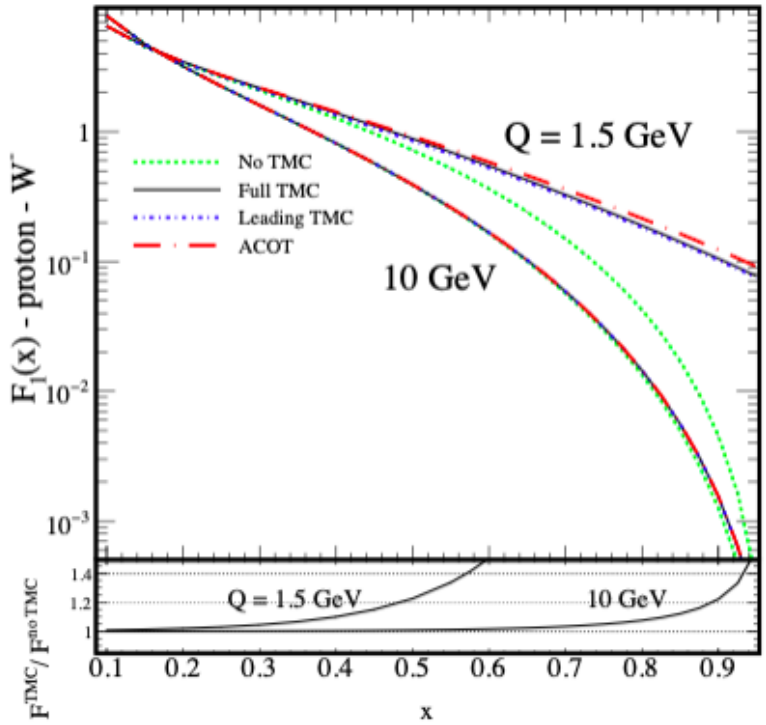
$$F_3^{A,}(x_N,Q^2) = \frac{x_N}{\xi_N r_N^2} F_3^{A,(0)}(\xi_N,Q^2) + \frac{2M_N^2 x_N^2}{Q^2 r_N^3}\, h_3^A(\xi_N,Q^2) + \quad 0\,.$$

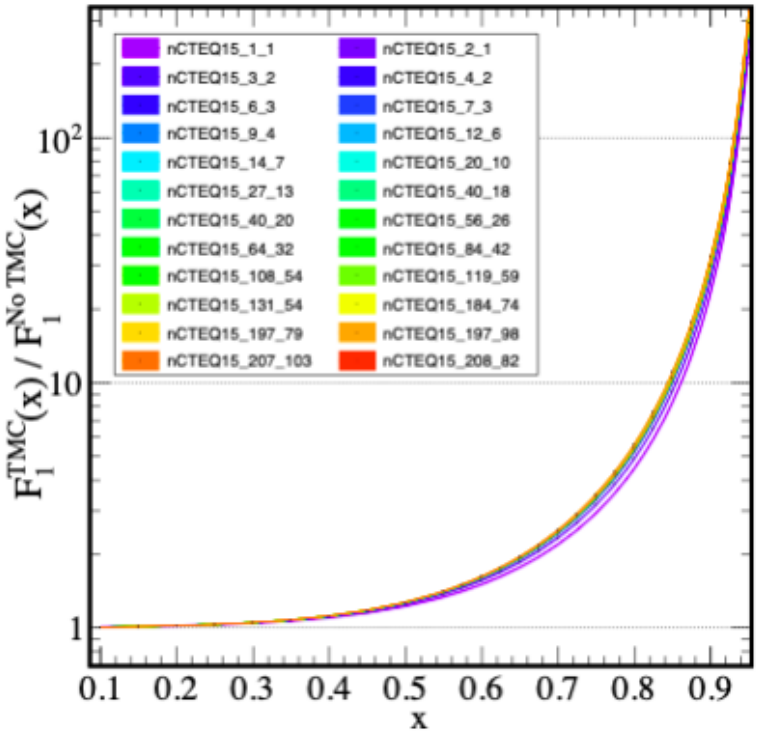
Figure – from arXiv : 0709.1775

We formulate this correction for nuclei and not for a collection of nucleons like it was done before.
We compare two methods ; OPE (Operator Product Expension) and parton model including mass effects (ACOT formalism).

Numerical results of TMCs

- significant at low Q and high x.

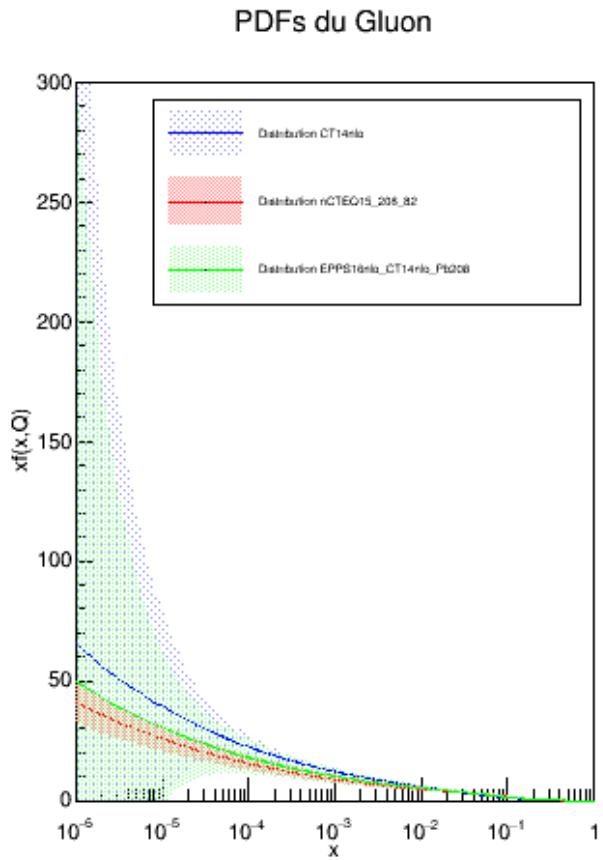


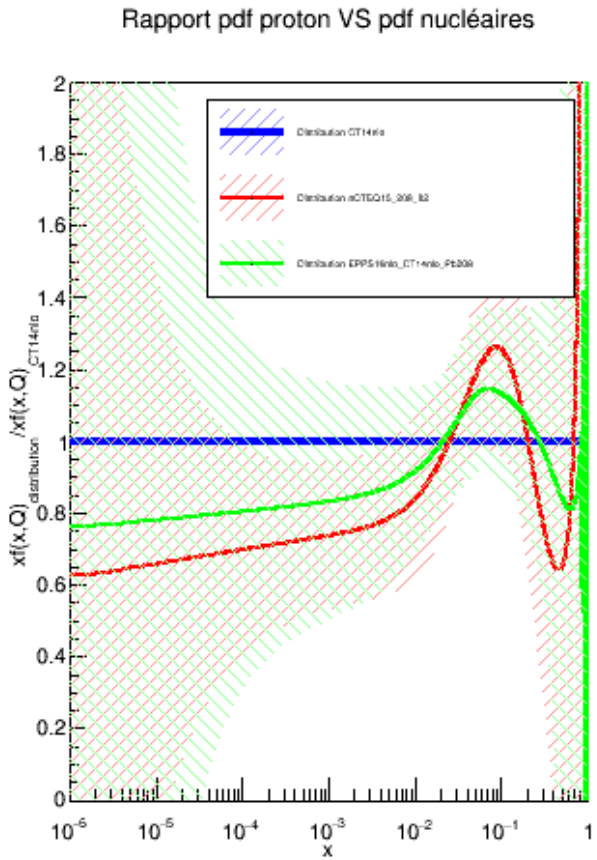


$\longrightarrow$ provide a parametrization usable by everyone

Gluon PDF at small x

The GLUON PDF has very large uncertainties at low x and we need to understand the effects involved in the suppression of the gluon in the nuclei compared to the gluon in the proton alone.





- Inclusive hadron production
- Heavy quark production

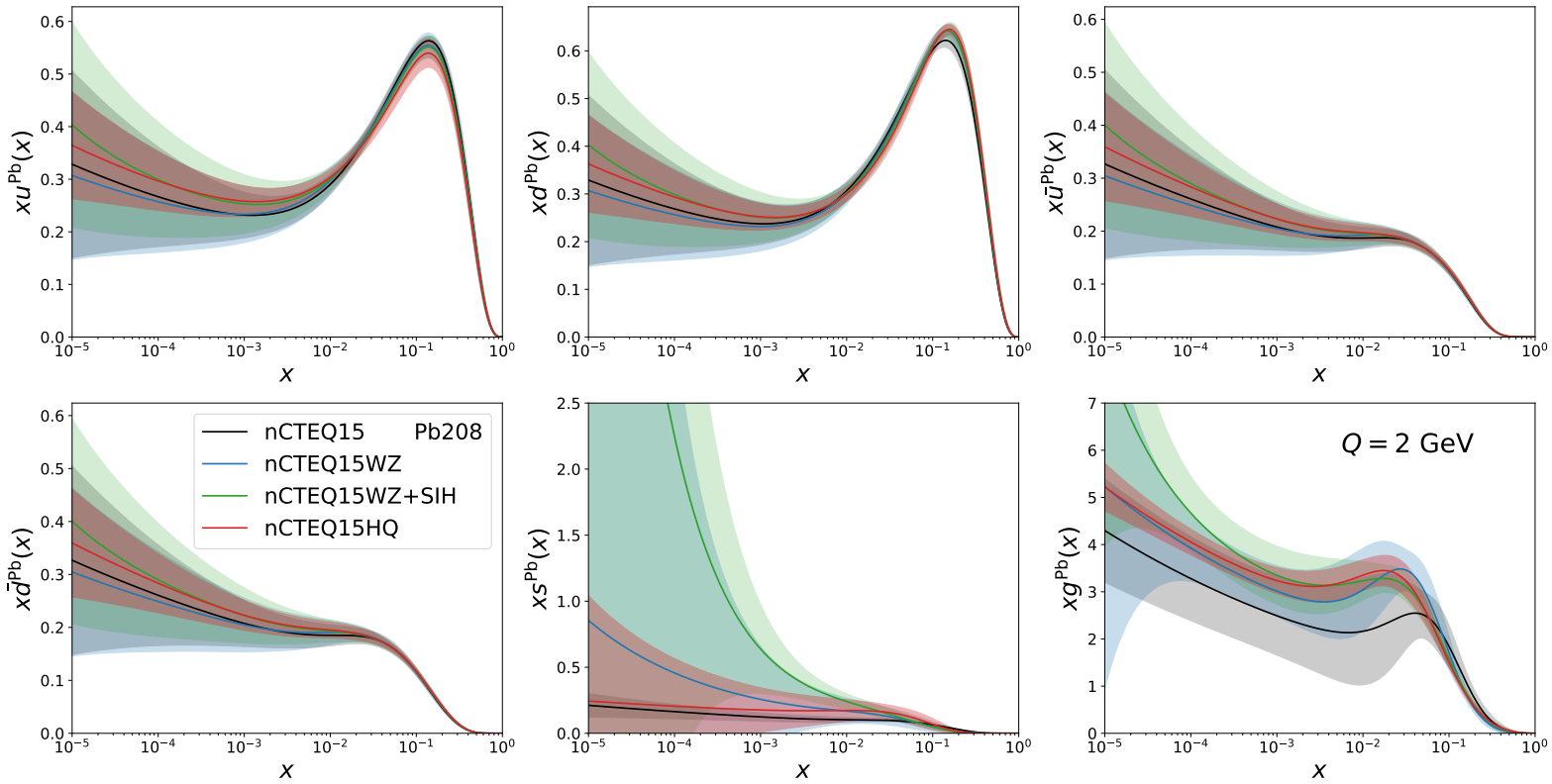
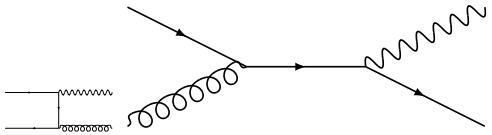
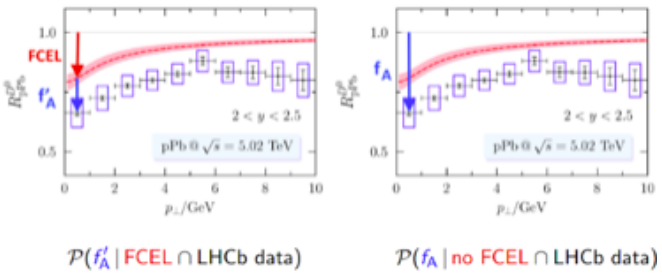
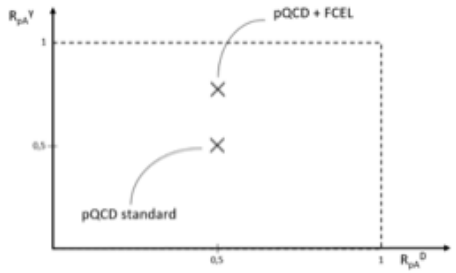


Figure – Lead PDFs from different nCTEQ15 versions. The baseline nCTEQ15 fit is shown in black, nCTEQ15WZ in blue, nCTEQ15WZSIH in green and the new fit in red.

Why $\gamma + X$?







The prompt photon production is an interesting process ; it is :

- Sensitive to the gluon distribution (about 90% of entering process includes gluon) -> may constraint the PDF ?
- no color charge at final state for the γ -> mesurement of energy loss in PQG *

Jetphox vs MCFM

$$\sigma(p_\gamma) = \sum_a \int_0^1 \frac{dz}{z} \hat{\sigma}^a(p_{\gamma/z}, \mu, M, M_F) D_a^\gamma(z, M_F) + \hat{\sigma}^\gamma(p_\gamma, \mu, M, M_F) \tag{3}$$

	Direct	**Fragmentation**	**Grid**	**Speed**
Jetphox	NLO	NLO	not yet	low
MCFM	NLO	LO	yes	faster

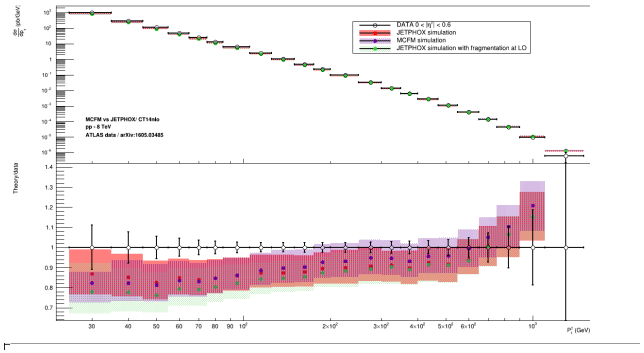
Not a problem to use MCFM because the fragmentation is not so big at this P_t-range, but at lower P_t, it could be important (like in future ALICE data).
Data available for $p + Pb \to \gamma + X$:

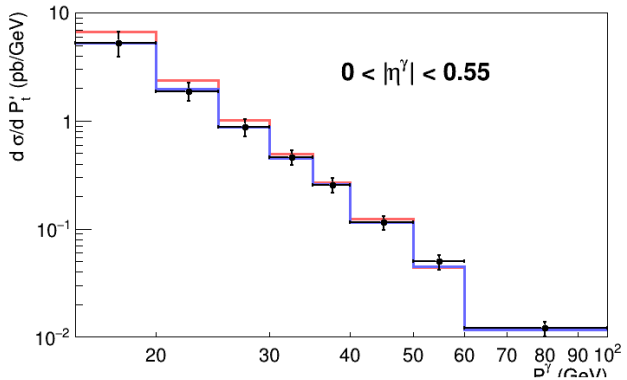
- ATLAS 8.16 TeV
- ALICE soon

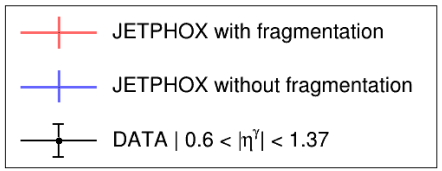
Data available for $p + p \to \gamma + X$: ATLAS (7, 8, 13 TeV), ALICE (2.76, 7, 8 TeV), CMS, LHCb...

Jetphox vs MCFM

Some tests







Gridding in progress (validation)
$\longrightarrow$ Next step : Global analysis !

Summary & Conclusion

- TMC in lA DIS
- $p + Pb \longrightarrow \gamma + X$ in nCTEQ global analysis at NLO
  - Gluon
  - comparison with FCEL
- Jetphox VS MCFM
- work in progress with J-P Guillet : QJetphox $(\gamma + j_Q + X)$

Thank you