NCN

Z boson production in p-Pb collisions at the LHC accounting for transverse momenta of initial partons

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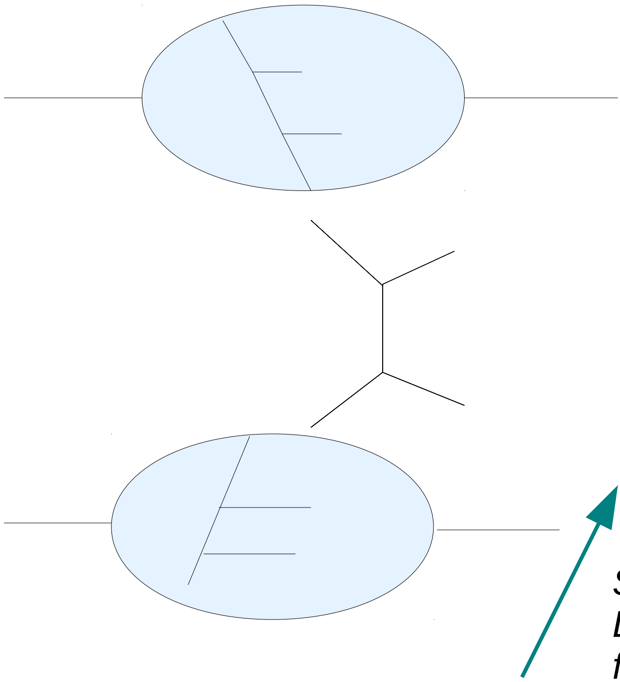
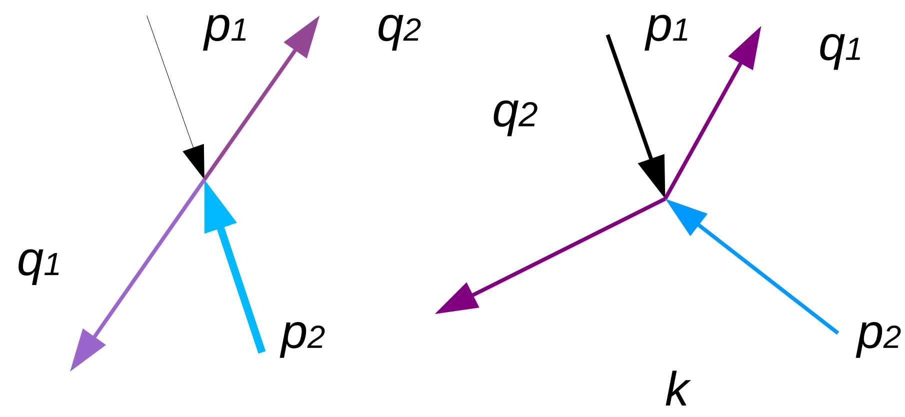
Based on ongoing project with:
E. Blanco, A. van Hameren, H. Jung, A. Kusina

High Energy Factorization



Strongly decreasing
Longitudinal momentum
fractions of off-shell partons



$p_1+p_2=q_1+q_2$

$p_1+p_2=q_1+q_2+k$

$$\frac{d\sigma}{dPS} \propto \mathcal{F}_{a^*}(x_1, k_{\perp\,1}) \otimes \hat{\sigma}_{ab\to cd}(x_1, x_2) \otimes \mathcal{F}_{b^*}(x_2, k_{\perp\,2})$$

Ciafaloni, Catani, Hautman '93
Collins, Ellis '93

New helicity based methods for ME
Kotko, K.K, van Hameren, '12

Although there is transversal momentum dependence
no gauge links at present → difficult for two off-shell partons

Transversal momentum for Pb pdfs

At low x one derives the Balitsky-Kovchegov equation. Nonlinear equation where the nonlinear term suppresses the growth of gluon density

→ uninterated parton density but only for for gluon

→ used for forward processes in ITMD factorization

Some progress made toward obtaining splitting functions covering low "z" and large "z" domain (see talk by Aleksander Kusina) .
We have real splitting kernels unifying DGLAP and BFKL. Virtual pieces are still missing.

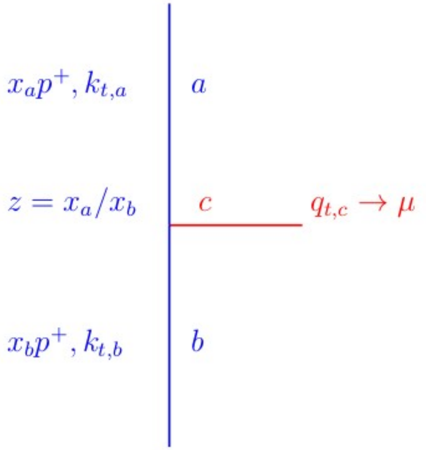
Already available method to get the nTMD is the PB method (see talks by A. Lelek, S. Taheri M. Schmitz)

→ apply it to construct Parton Branching nTMDS!

Parton branching method for nTMD's

The basic equation:

$$x\mathcal{A}_a^{Pb}(x,k_t^2,\mu^2) = \int dx' \mathcal{A}_{0,b}^{Pb}(x',k_{t,0}^2,\mu_0^2)\frac{x}{x'}\,\mathcal{K}_{ba}\left(\frac{x}{x'},k_{t,0}^2,k_t^2,\mu_0^2,\mu^2\right)$$



The initial condition is given by:

$$\mathcal{A}_{0,b}^{Pb}(x,k_{t,0}^2,\mu_0^2) = f_{0,b}^{Pb}(x,\mu_0^2)\cdot\exp(-|k_{t,0}^2|/\sigma^2)$$

The kernel is given by NLO DGLAP (LO DGLAP) splitting function.
The kinematics in the emission vertex accounts for traversal momentum

transversal momentum ordering

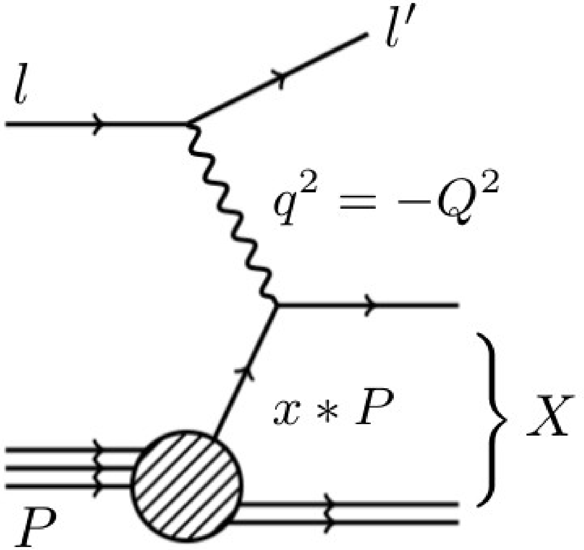
$$\mu = |\mathbf{q}_c|$$

angular ordering

$$\mu = |\mathbf{q}_c|/(1-z)$$

Collinear factorization

Factorization in case of DIS



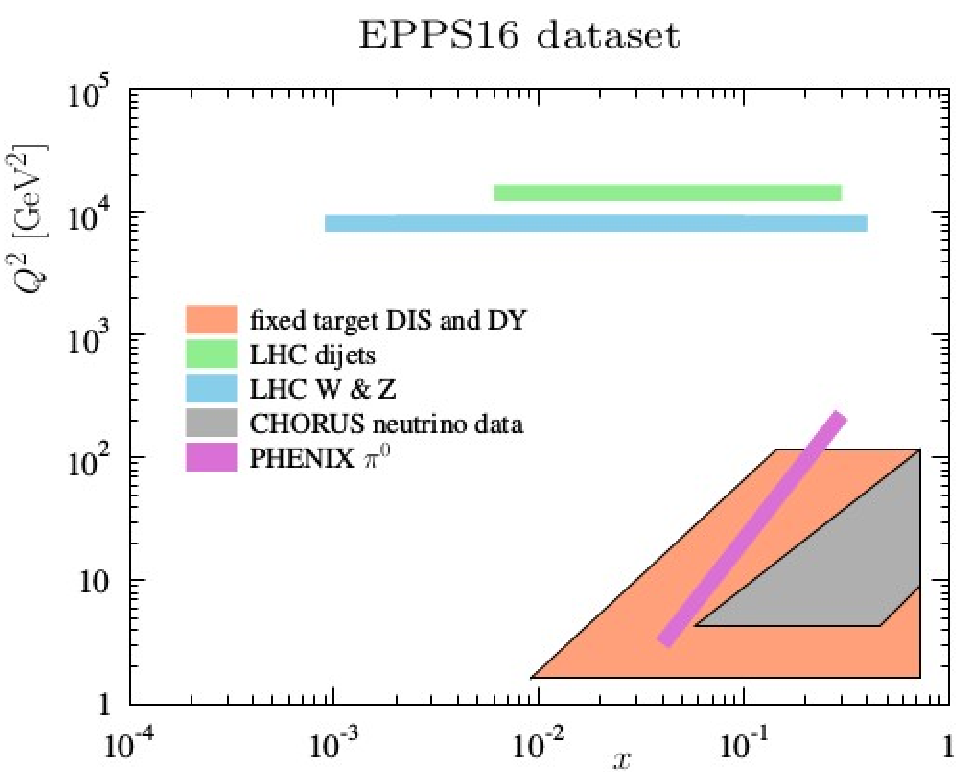
$$\frac{d^2\sigma}{dx dQ^2} = \sum_i f_i(x, Q^2) \otimes d\hat{\sigma}_{il \to l' X}$$

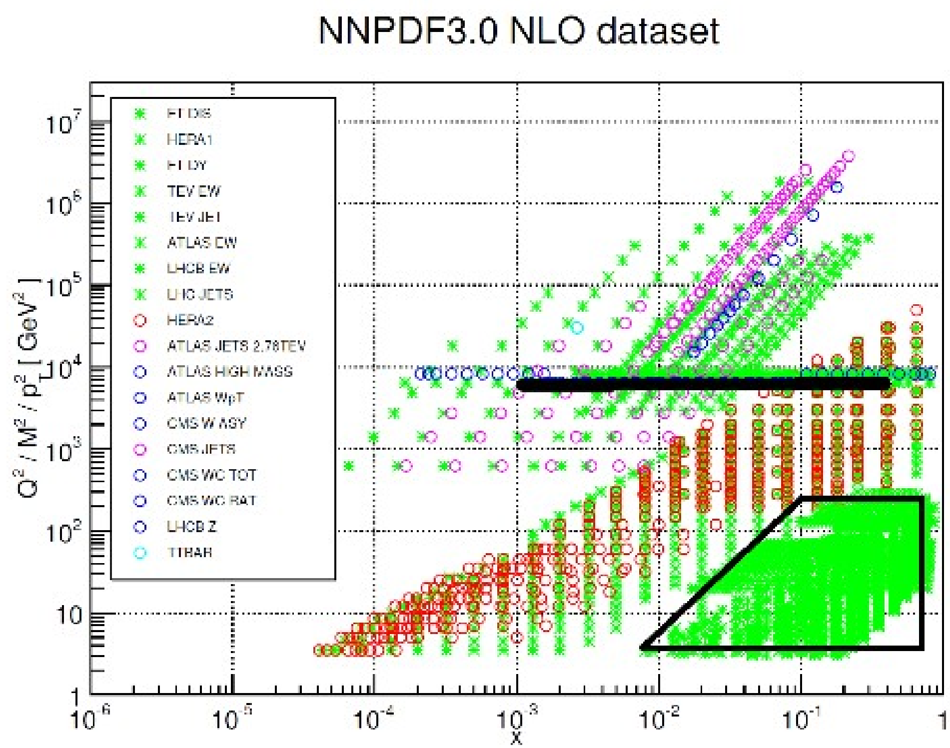
For DIS on nuclear target one assumes that nuclear effects can be absorbed into the universal nPDFs.

Differences with free proton PDFs

Parametrization – more parameters to model A-dependence

Different data sets – much less data:





Less data → less constraining power → more assumptions (fixing) about fitting parameters

Available nuclear PDFs

Multiplicative correction factor

$$f_i^{p/A}(x_N, \mu_0) = R_i(x_N, \mu_0, A)\; f_i^{\text{free proton}}(x_N, \mu_0)$$

HKN: Hirai, Kumano, Nagai [PRC 76, 065207 (2007)]
DSSZ: de Florian, Sassot, Stratmann, Zurita [PRD 85, 074028 (2012)]
EPS09: Eskola, Paukkunen, Salgado [JHEP 04 (2009) 065]
EPPS16: Eskola, Paakkinen, Paukkunen, Salgado [EPJC 77 (2017) 163]
KT16: Khanpour, Tehrani [PRD 93, 014026 (2016)]

Native nuclear PDFs

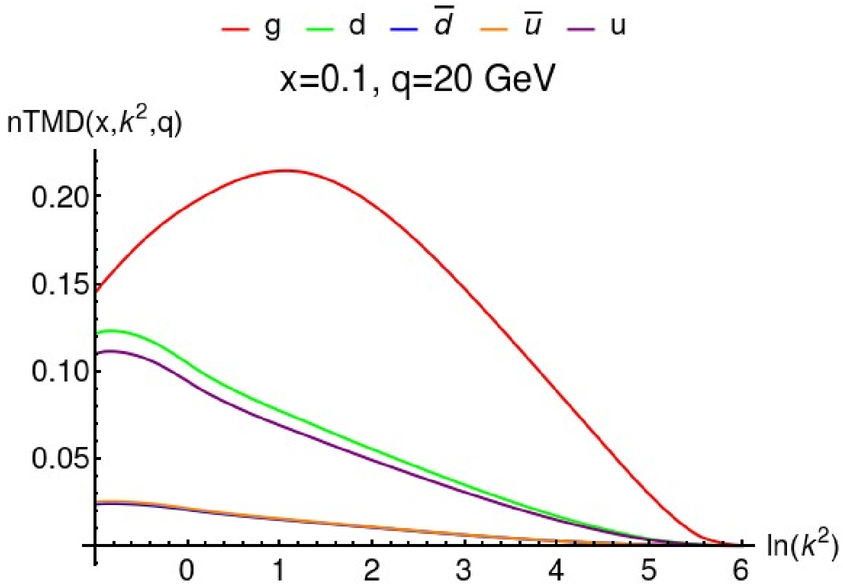
$$f_i^{p/A}(x_N, \mu_0) = f_i(x_N, A, \mu_0)$$

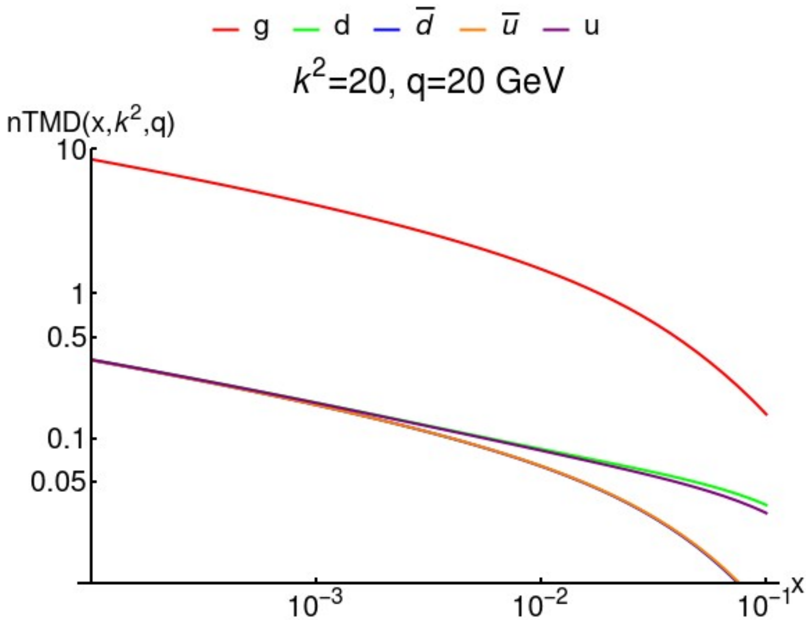
$$f_i(x_N, A = 1, \mu_0) \equiv f_i^{\text{free proton}}(x_N, \mu_0)$$

nCTEQ15: Kovarik, Kusina, Jezo, Clark, Keppel, Lyonnet, Morfin, Olness, Owens, Schienbein, Yu [PRD 93, 085037 (2016), arXiv:1509.00792]

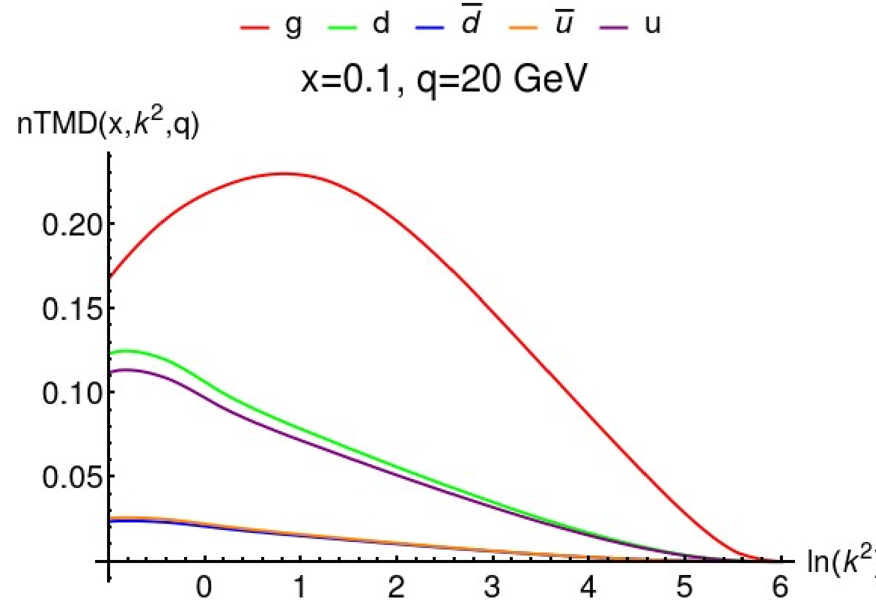
Plots of obtained densities

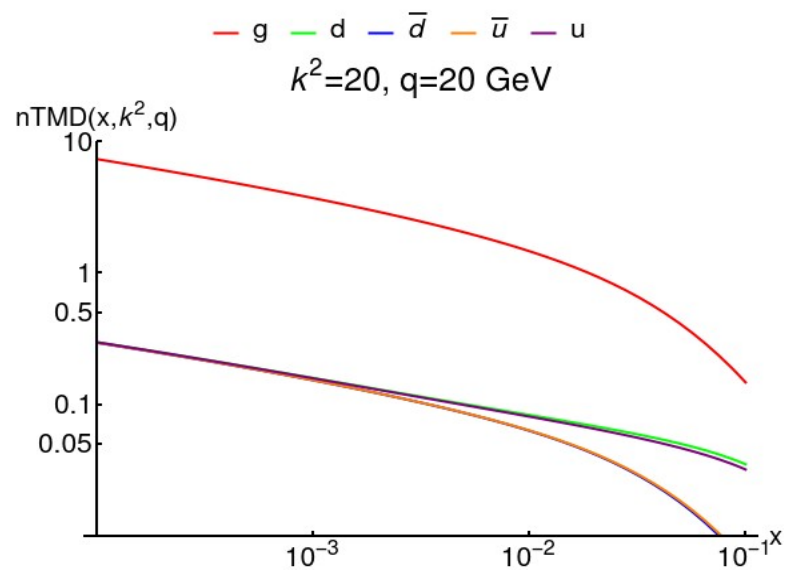
Underlying pdf is EPS16nlo_Pb208





Underlying pdf is nCTEQ15FullNuc_Pb208

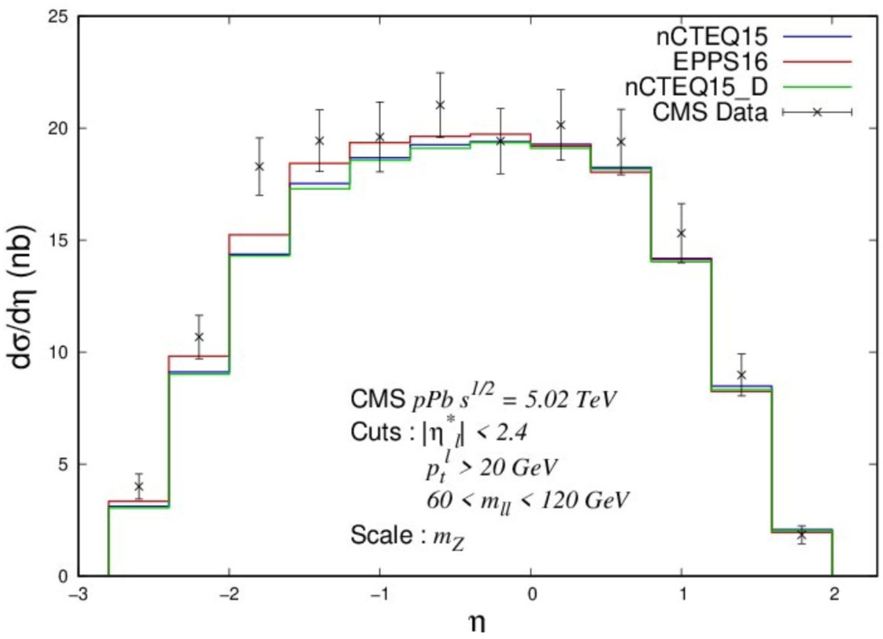


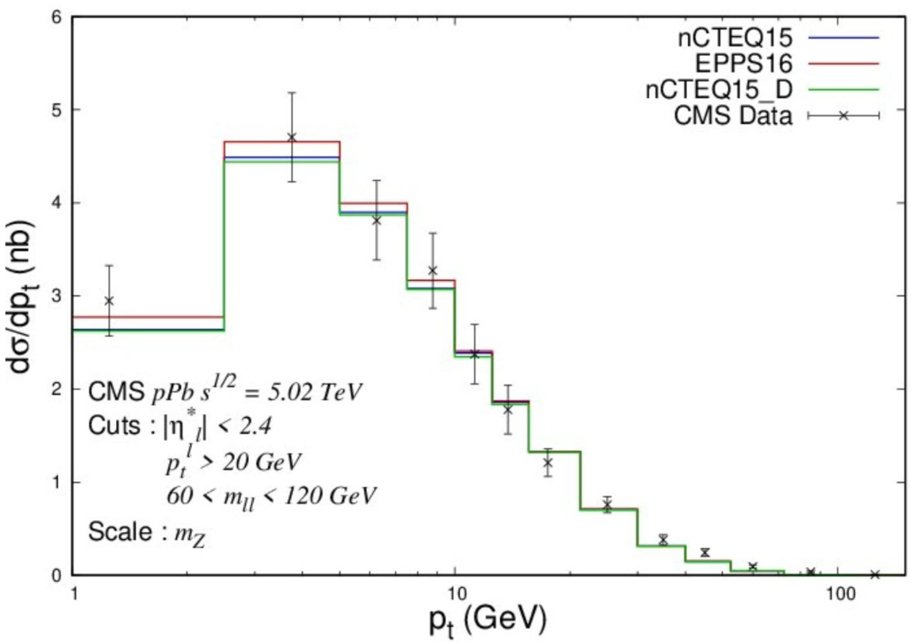


Results for Drell-Yan

$$p + Pb \to Z^* \to \mu^+ + \mu^-$$

preliminary results

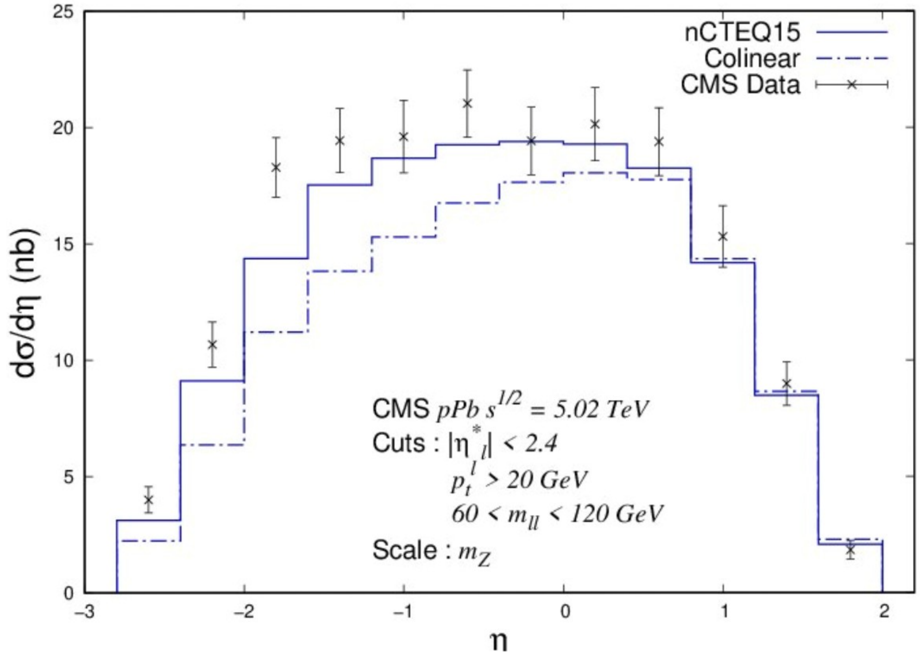


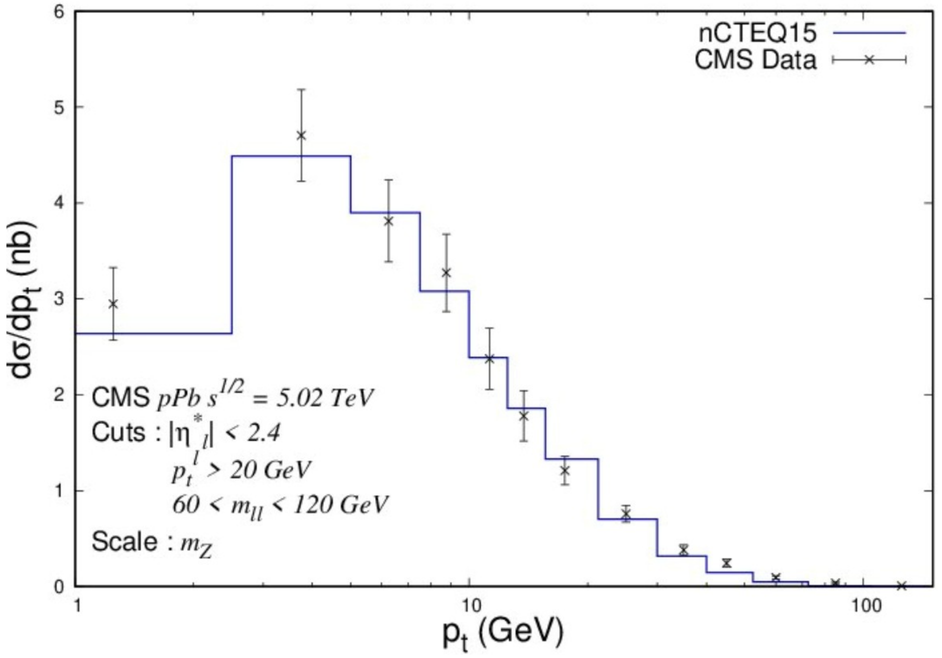


Calculated using KaTie i.e. TMD by Monte Carlo by A. van Hameren

TMD vs. collinear

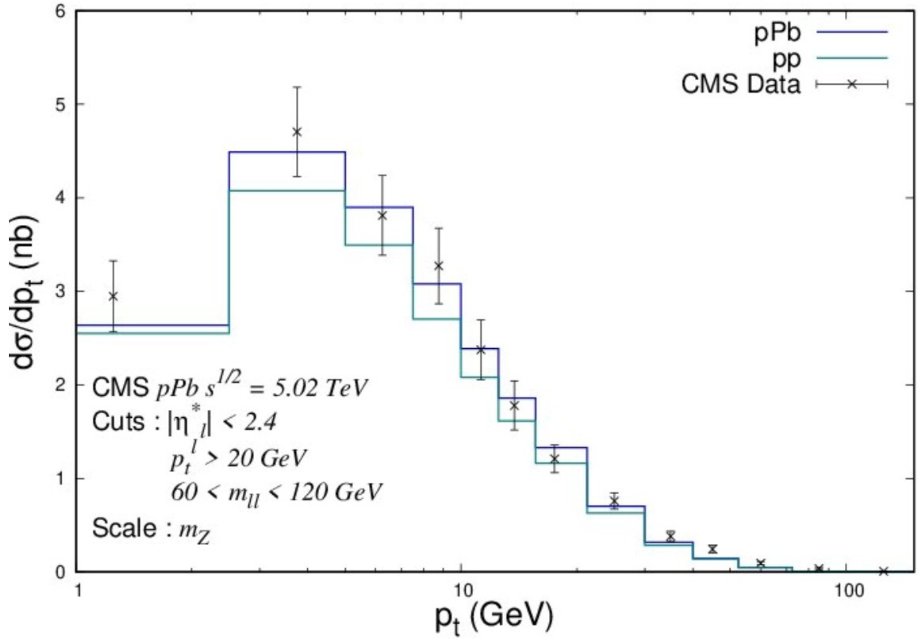
preliminary results

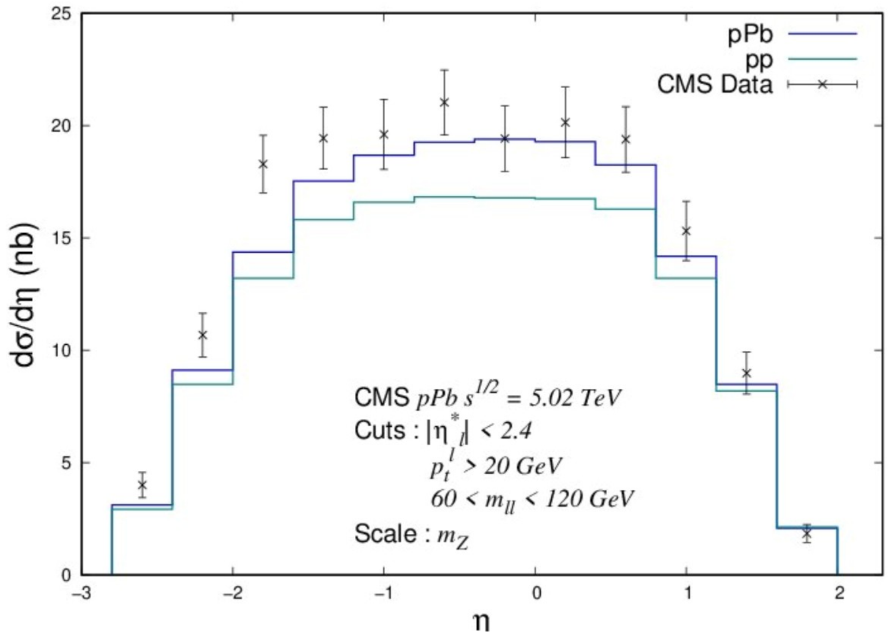




Nuclear effects p-Pb vs. p-p

preliminary results





nTMD = nCTEQ 15 + PB method

TMD = HERAP pdf + PB

Conclusions and outlook

New TMD introduced: i.e. nTMD's using PB method

The set does well describing Drell-Yan data

More checks on the way

Perhaps one needs to refit the nTMDS