Update of a Multi-Phase Transport Model with Modern Parton Distribution Functions and Nuclear Shadowing

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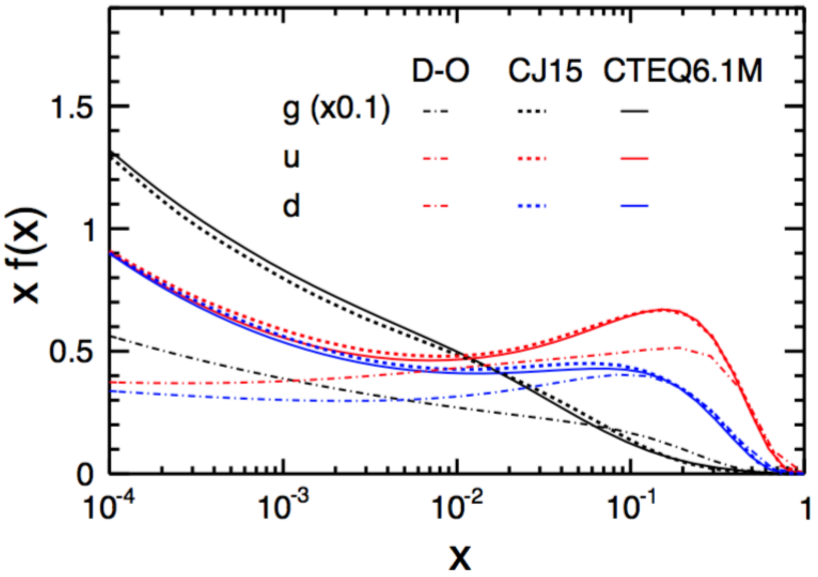
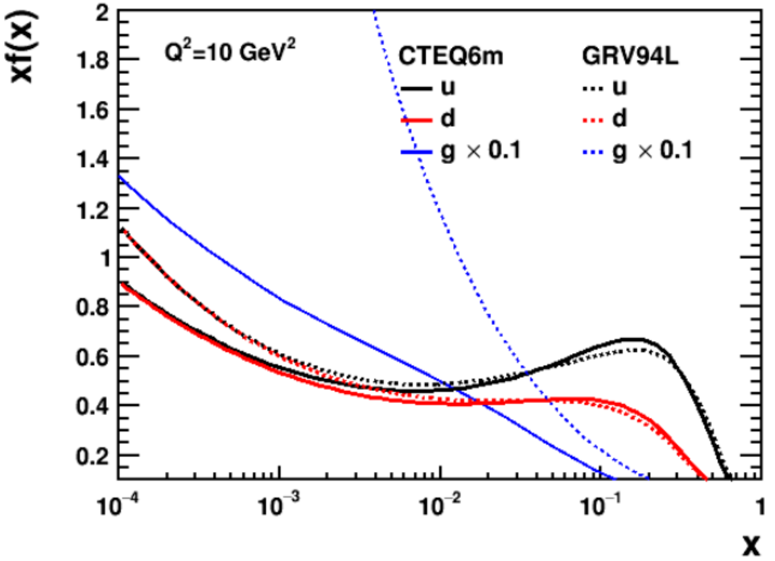
Outline

1. CTEQ6 PDF and eps09s nPDFs
2. Total and inelastic cross section in AMPT
3. Particle production in pp&AA collisions
4. Summary

PDF: Parton Distribution Function



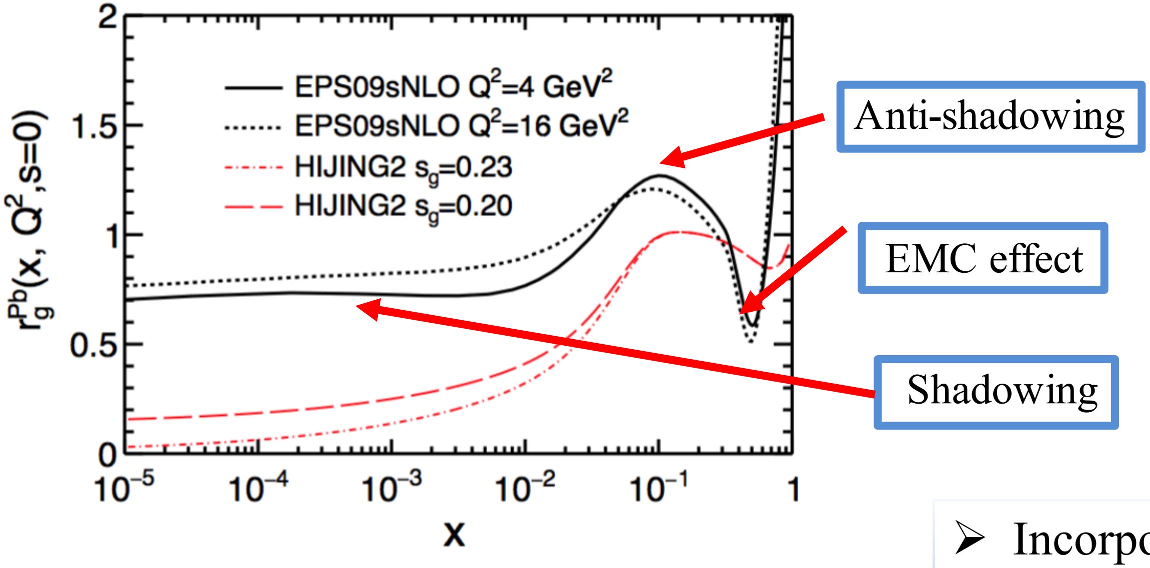


- ➢ *Duke-Owens*: used in the current published AMPT model. ***Outdated*;** *CJ15*: experiments data at LHC utilized, ***modern PDF***. *GRV94L*: HIJING 2.0 work.
- ➢ AMPT model: valid for wide energy range, especially LHC energies when minijet production reaches to a very small-x region, where gluon distribution is much ***higher*** than Duke-Owens parameterization. ***Update of the PDF*** is important.

Wei-Tian Deng PHYSICAL REVIEW C **83**, 014915 ; A. Accardi, Phys. Rev. D 93, no. 11, 114017 (2016).

Spatial-Dependent nPDFs

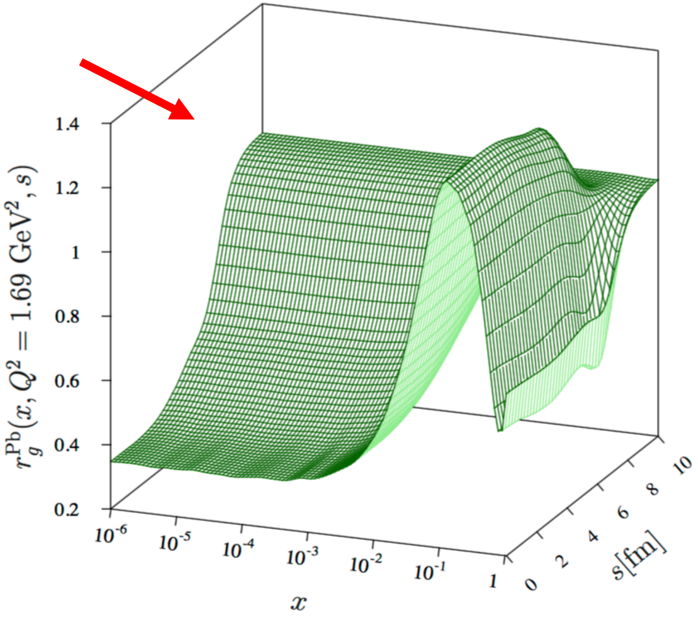
$$f_i^A(x,Q^2) \equiv R_i^A(x,Q^2)\, f_i^{\mathrm{CTEQ6.1M}}(x,Q^2)$$



Anti-shadowing

EMC effect

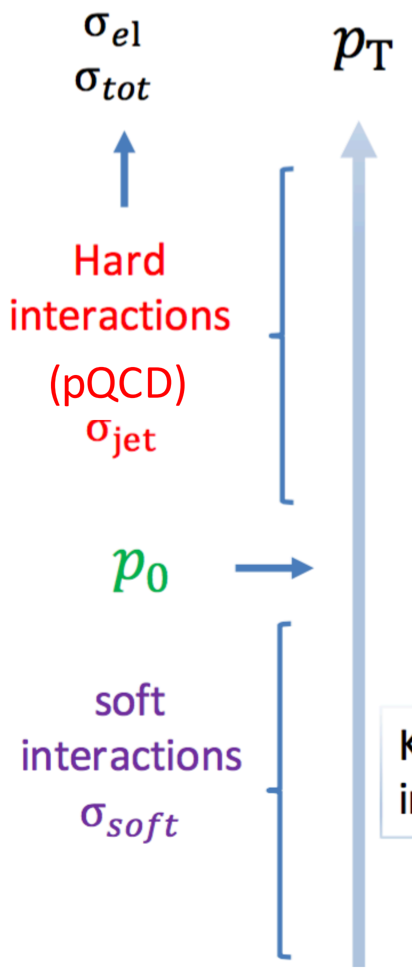
Shadowing



Ilkka helenius. JHEP 1207 (2012) 073

- Incorporate modern PDF and nPDFs improve the AMPT model for heavy flavor and high p_T observables.

The HIJING Two-Component Model



$$\sigma_{jet} = \int_{p_0^2}^{s/4} \mathrm{d}p_T^2 \mathrm{d}y_1 \mathrm{d}y_2 \frac{1}{2} \frac{\mathrm{d}\sigma_{jet}}{\mathrm{d}p_T^2 \mathrm{d}y_1 \mathrm{d}y_2},$$

$$\frac{\mathrm{d}\sigma_{jet}}{\mathrm{d}p_T^2 \mathrm{d}y_1 \mathrm{d}y_2} = K \sum_{a,b} x_1 f_a(x_1, p_T^2) x_2 f_b(x_2, p_T^2) \frac{\mathrm{d}\sigma^{ab}(\hat{s}, \hat{t}, \hat{u})}{\mathrm{d}\hat{t}}$$

$$\begin{aligned}\chi(b,s) &\equiv \chi_s(b,s) + \chi_h(b,s) \\ &= \frac{1}{2}\left[\sigma_{soft} T_{NN}(b) + \sigma_{jet} T_{NN}(b)\right],\end{aligned}$$

Key input parameters in the model

$$\sigma_{tot} = 2\pi \int_0^\infty \mathrm{d}b^2 \left[1 - e^{\chi(b,s)}\right]$$

$$\sigma_{el} = \pi \int_0^\infty \mathrm{d}b^2 \left[1 - e^{\chi(b,s)}\right]^2$$

$$\sigma_{in} = \pi \int_0^\infty \mathrm{d}b^2 \left[1 - e^{2\chi(b,s)}\right]$$

$$\sigma_{tot} = 2\pi \int_0^\infty \mathrm{d}b^2 \left[1 - e^{\chi(b,s)}\right]$$

Tuning Method

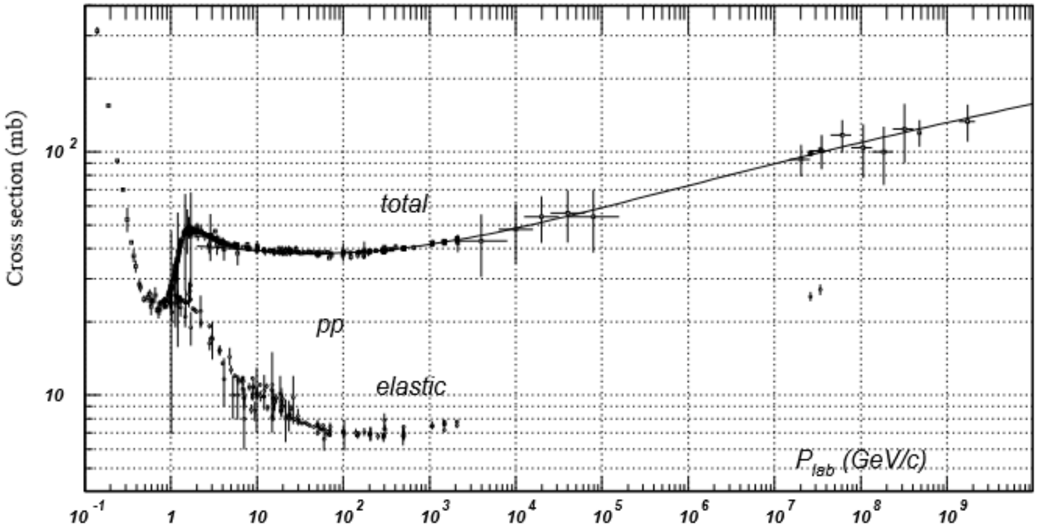
$p_0 \quad \sigma_{soft}$

↓

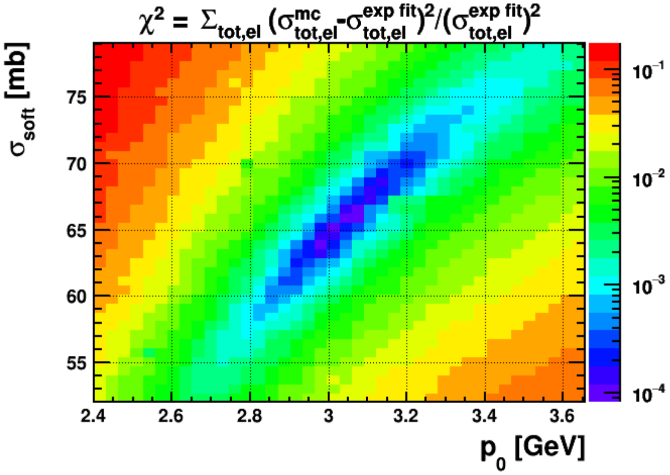
$\sigma_{el\_ampt} \quad \sigma_{tot\_ampt}$

↓ compare

$\sigma_{el\_fit} \quad \sigma_{tot\_fit}$



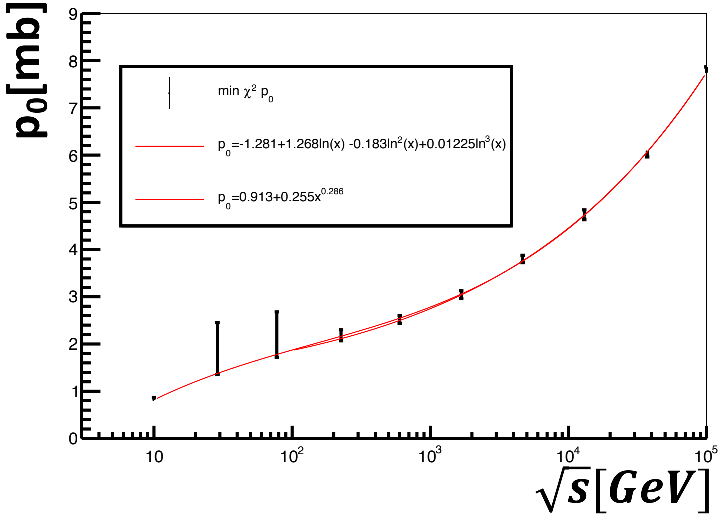
A relative residual sum of squared is defined as the target function to be minimized allowed p_0 and σ_{soft} parameters

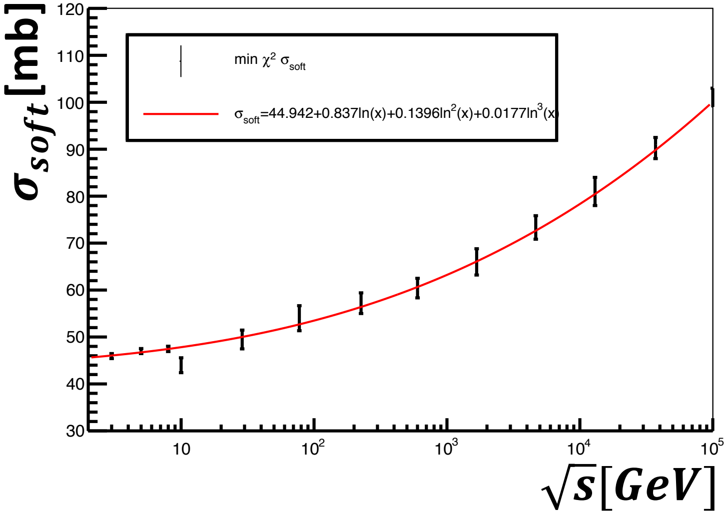


$$\text{Minimize } \chi^2 = \frac{(\sigma_{tot\_ampt}-\sigma_{tot\_fit})^2}{(\sigma_{tot\_fit})^2} + \frac{(\sigma_{el\_ampt}-\sigma_{el\_fit})^2}{(\sigma_{el\_fit})^2}$$

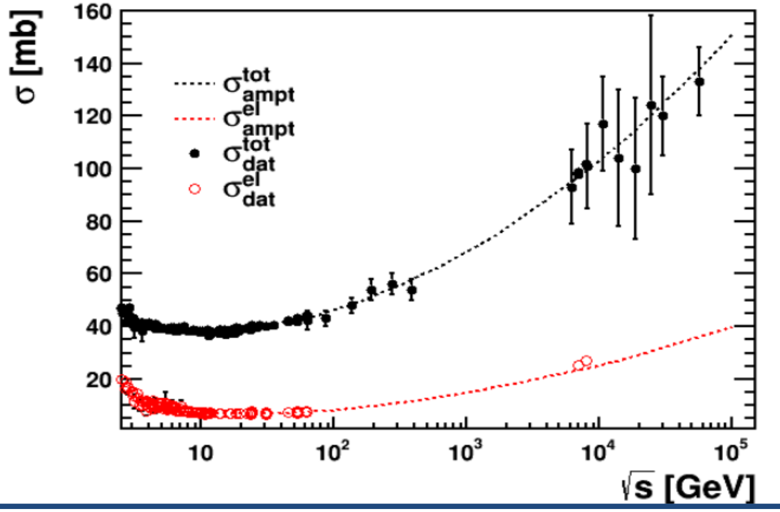
C. Patrignani et al. (Particle Data Group), Chin. Phys. C, 40, 100001 (2016).

Tuning of p_0^{pp} and σ_{soft}

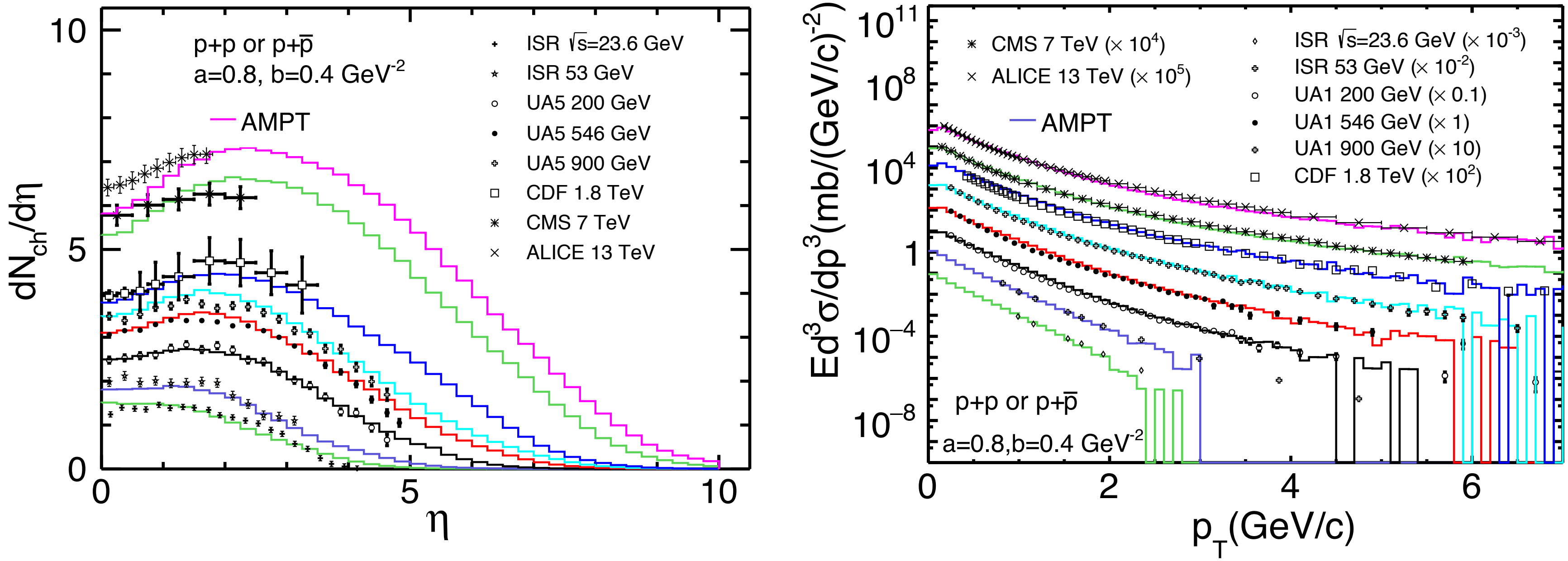




- Tuning the p_0^{pp} and σ_{soft} by fitting the experimental data of total and inelastic cross section.



N_{ch} in pp Collisions

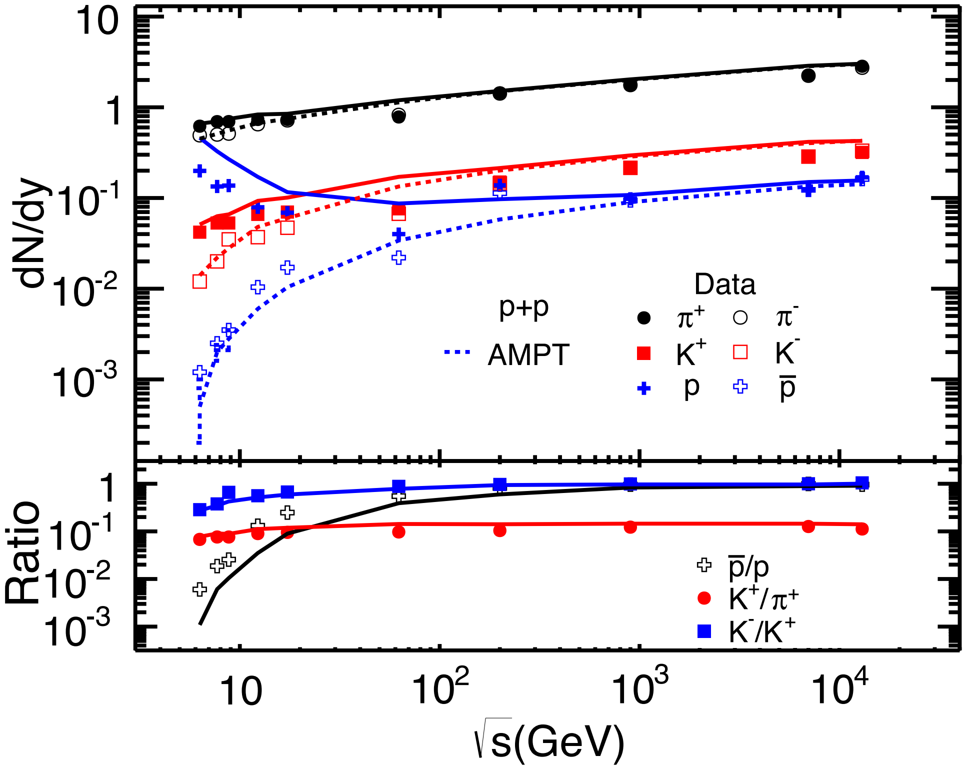


- Larger lund ***a*** typically gives larger pseudo-rapidity distributions, smaller ***b*** leads to a more flat p_T spectrum.
- Lund ***a***=0.8 , ***b***=0.4 agrees with data in general.

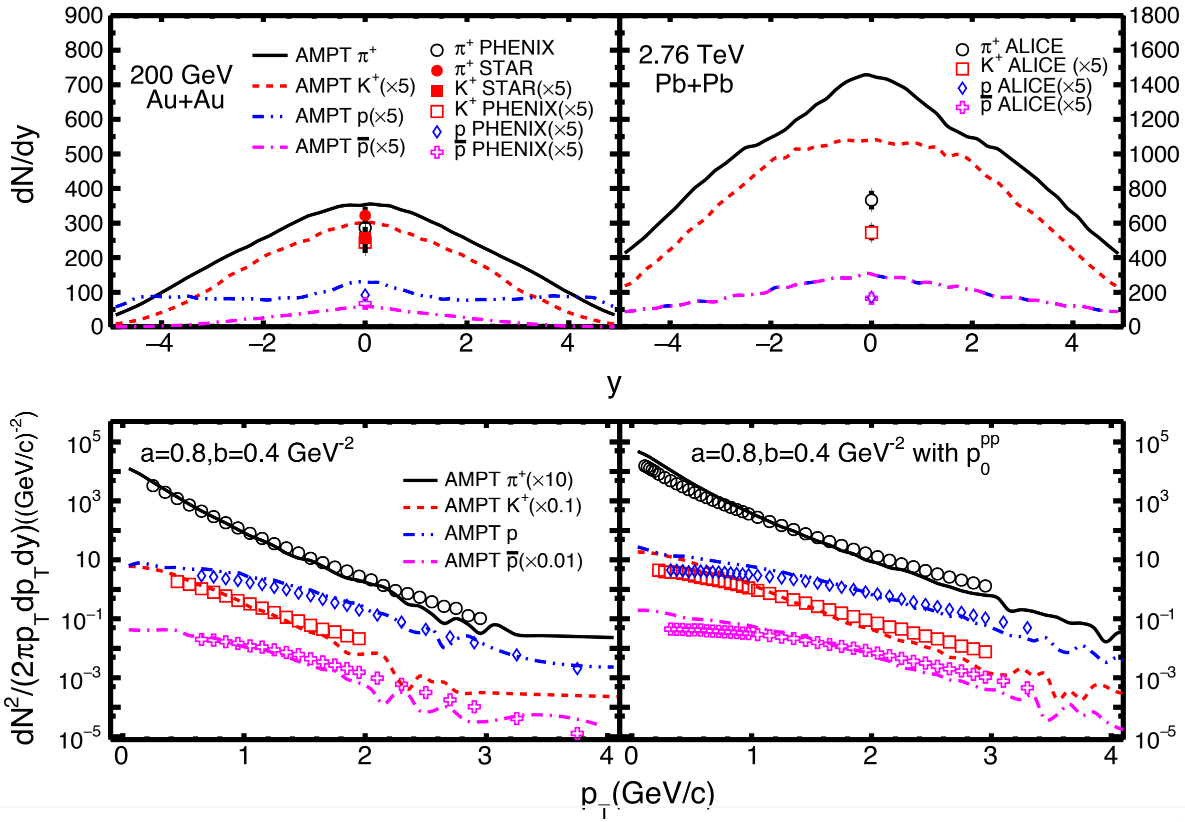
UA5 Collaboration, Z. Phys. C – Particles and Fields 33, 1-6(1986). CDF Collaboration, Phys. Rev. D 41, 2330 (1990).
CMS Collaboration, PRL 105, 022002 (2010). ALICE Collaboration, Physics Letters B 751 (2015) 143–163 .
UA1 Collaboration, C. Nuclear Physics B335 (1990) 261-287. CDF *Collaboration,* Phys. Rev. Lett. **61**, 1819 (1988).

π/k/p Production

- Energy dependence of the identified particles dN/dy at mid-rapidity.
- Charged π and k productions from the AMPT model show good consistency with data.
- AMPT underestimates the anti-proton yields and overestimates the proton yields at low colliding energies.

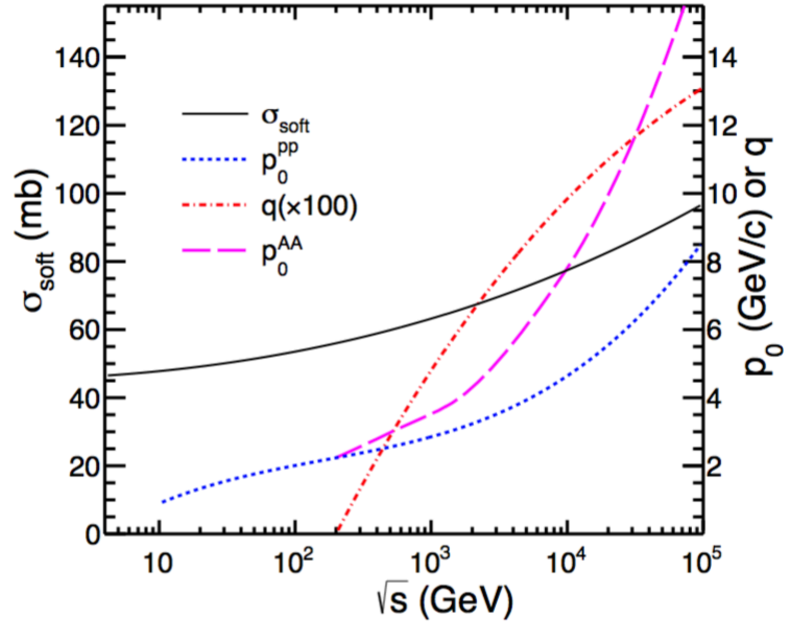


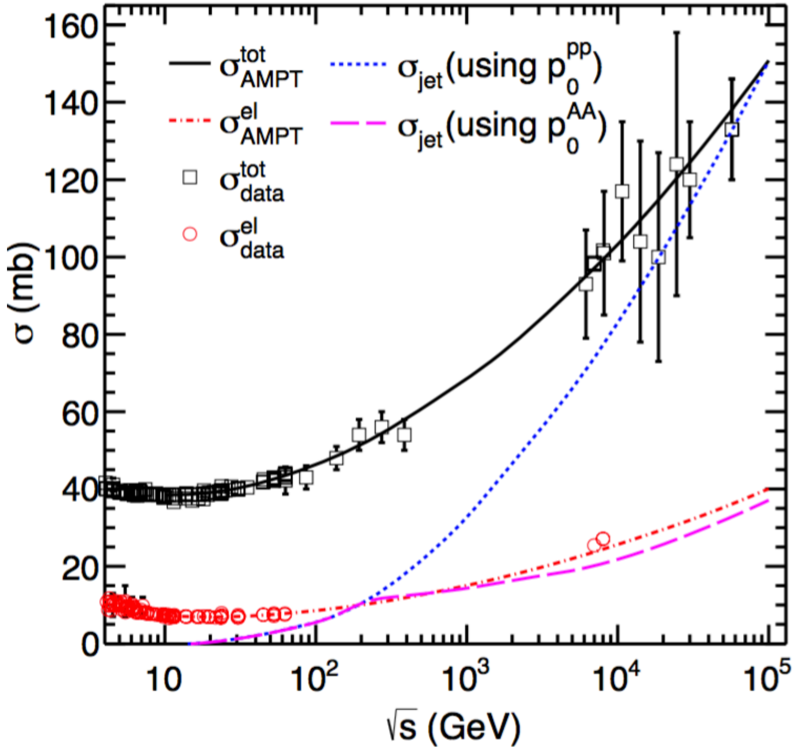
Particle Production in AA Collision



- ➢ AMPT string-melting version with lund a=0.8 & b=0.4 and p_0^{pp} minijet cutoff.
- ➢ Overestimates the yields of most of these particles, the p_T spectra from the AMPT model are mostly softer than data.

A-scaling of p_0 (p_0^{AA})



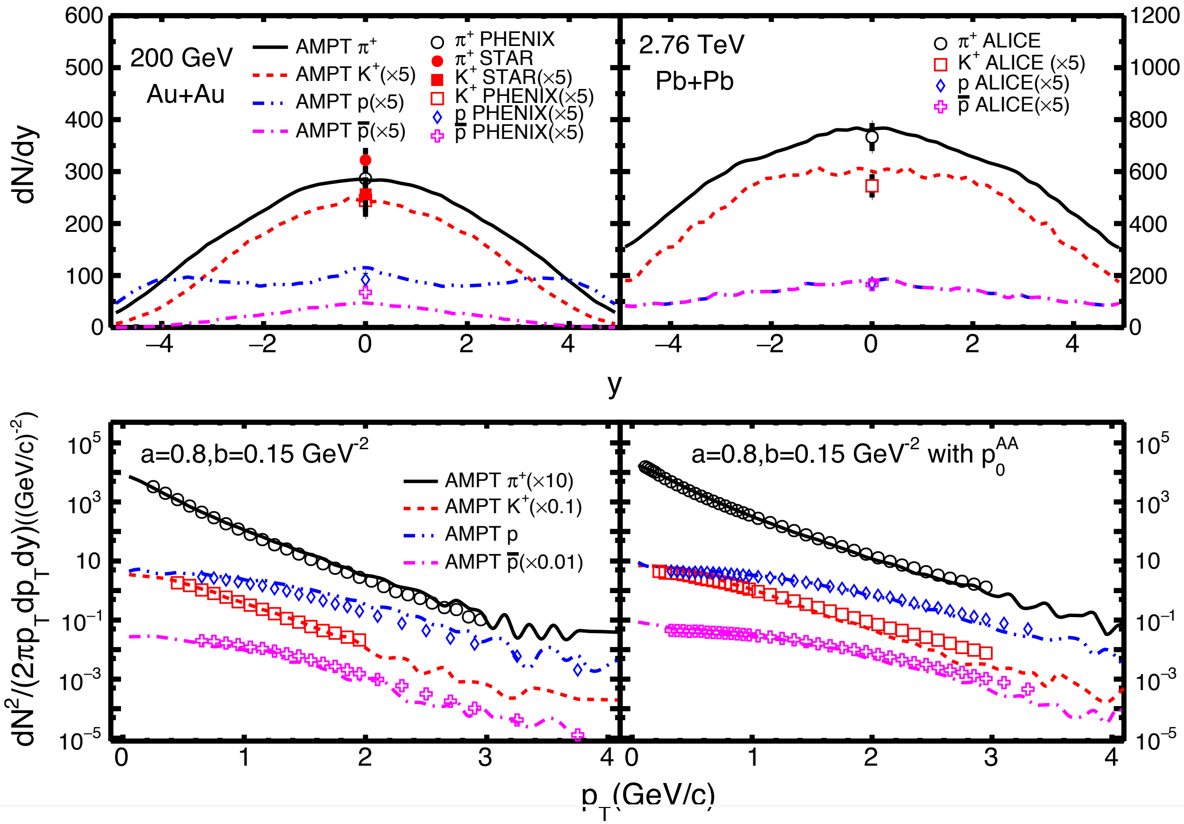


$$p_0^{AA} = p_0^{pp} A^{q(s)},$$

$$q(s) = 0.0334\ ln\left(\frac{\sqrt{s}}{200}\right) - 0.00232\ ln^2\left(\frac{\sqrt{s}}{200}\right) + 0.0000541\ ln^3\left(\frac{\sqrt{s}}{200}\right),\ \text{for}\ \sqrt{s} \geq 200\ \text{GeV}$$

- A significant increasing of p_0^{pp} thus lead to suppressing of σ_{jet}

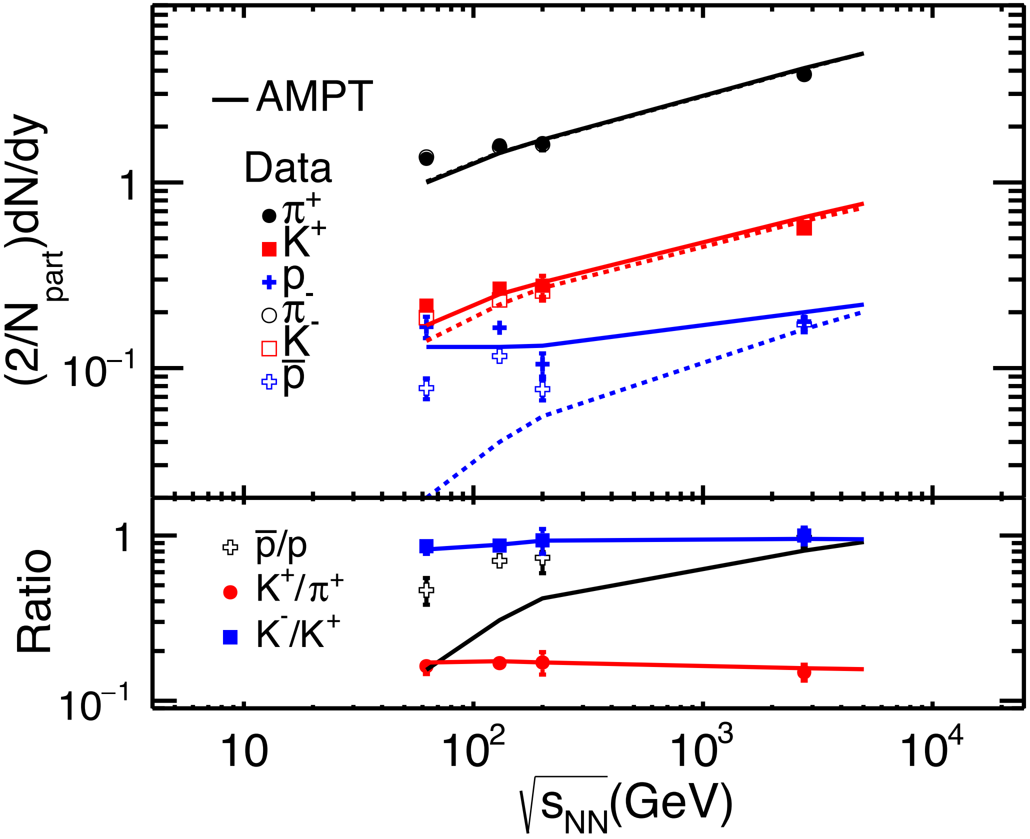
Particle Production with p_0^{AA}



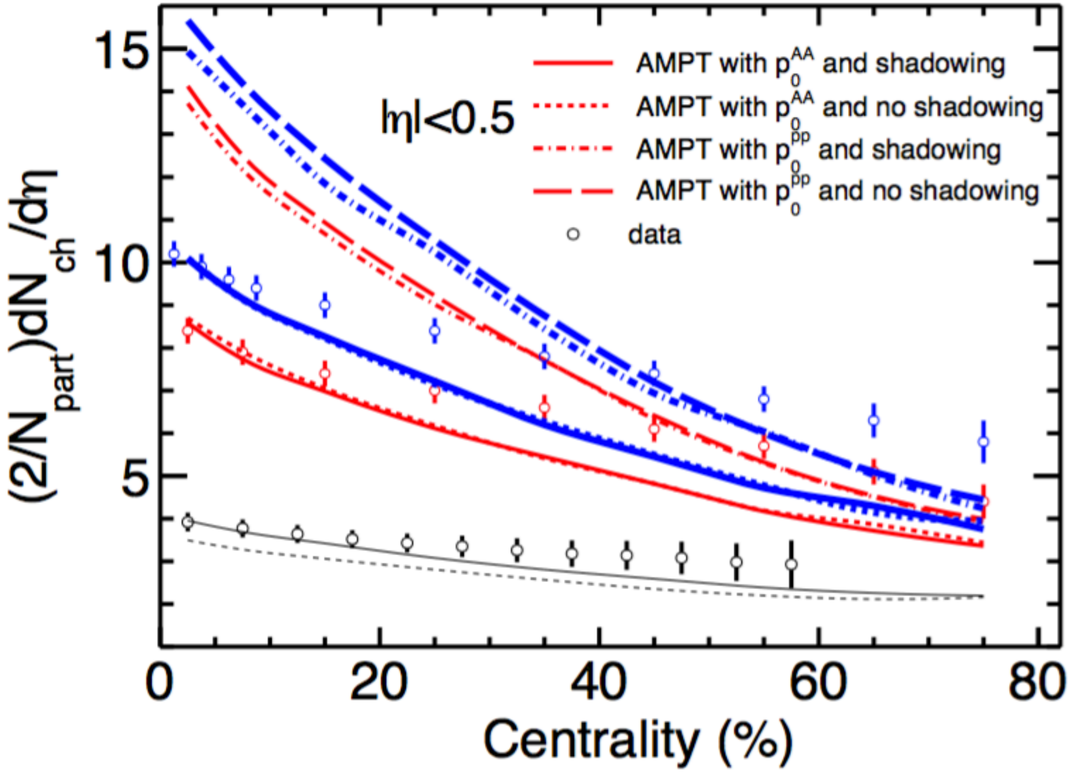
- ➢ AMPT string-melting version with lund ***a***=0.8 & ***b***=0.15 and p_0^{AA} minijet cutoff.
- ➢ The update AMPT model can reasonably reproduce the data at RHIC and LHC energies.

π/k/p Production with p_0^{AA}

- Energy dependence of identified particles $\frac{2}{\text{Npart}} * \frac{\text{dN}}{\text{dy}}$ at mid-rapidity for AA collision.
- The AMPT model can reproduce charged π and k productions, however, underestimates the anti-proton yields.



Centrality Dependence of N_{ch}



- The nuclear shadowing has a small effect on charged particle yields at all centralities due to large p_0 cutoff.
- p_0^{AA} suppress the particle production especially at central collisions.

Summary

1. We update the AMPT model with modern PDF and nPDFs.

2. We use a systematic strategy to determine the p_0^{pp} and σ_{soft} for pp collisions, introduced A-scaling of p_0 for AA collisions.

3. We show for both charged and identified particles production in pp and AA collisions using this update AMPT model.

Outlook

1. We will incorporate centrality dependence of A-scaling of p_0 and lund b value in the update AMPT for further study.

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THANKS for listening