HIJING: a MC model for particle and jet production in pp, pA and AA collisions

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In collaboration with

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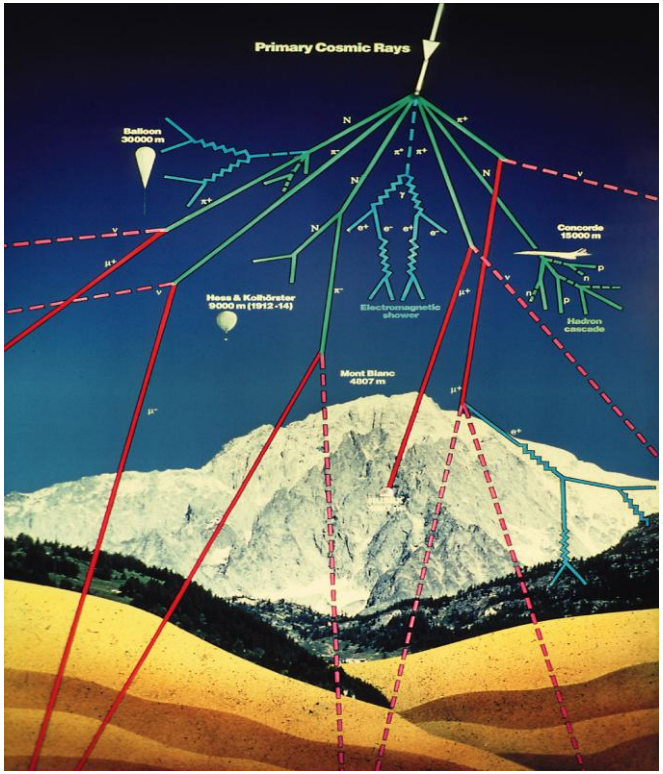
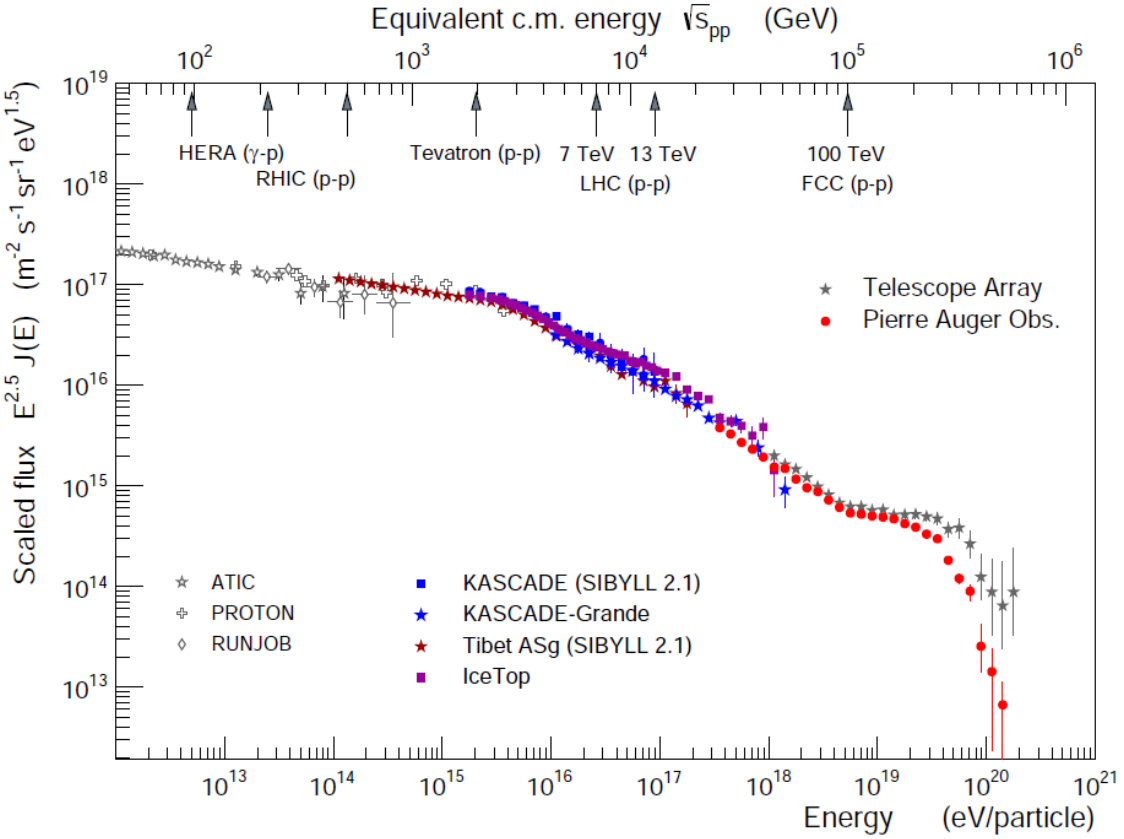
Outline

- HIJING (Heavy Ion Jet INteraction Generator) Model
  - Binary collisions for p+A and A+A.
  - Two component model for p+p/N+N collision.
  - Shadowing effect in nuclear PDFs.
  - Multiple scattering in p+A and A+A.

- Hadron production in p+A
  - as function of Pseudorapidity.
  - as function of Feynman x_F .

Cosmic Ray





Primary Cosmic Ray:

- Mostly H / He.
- $\sqrt{s}$=10^1 ~10^6 GeV.

→ High energy p+p, p+A and A+A collisions → HIJING

HIJING Model

Binary Collision Approximation

Phy. Rev. D 44, 3501 (1991)
X.-N. Wang & M. Gyulassy

Phys.Rev.C83 (2011) 014915,
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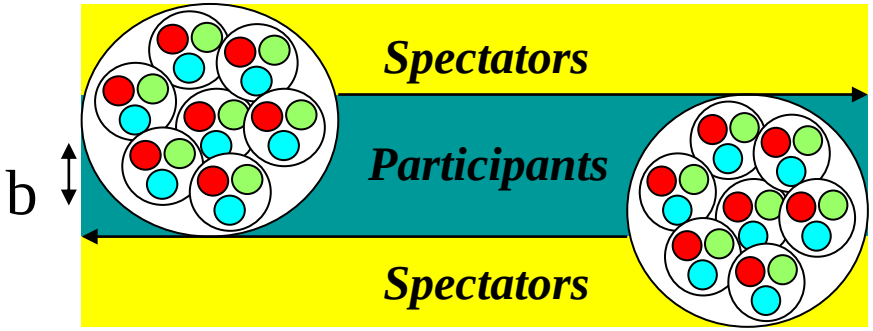
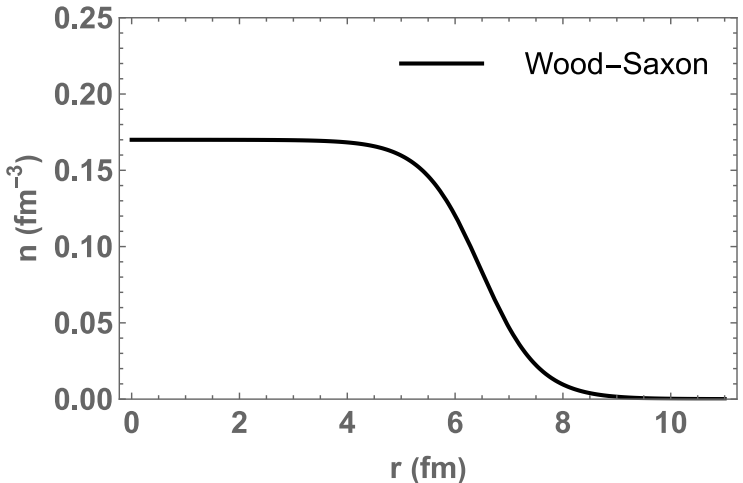
A+A collision

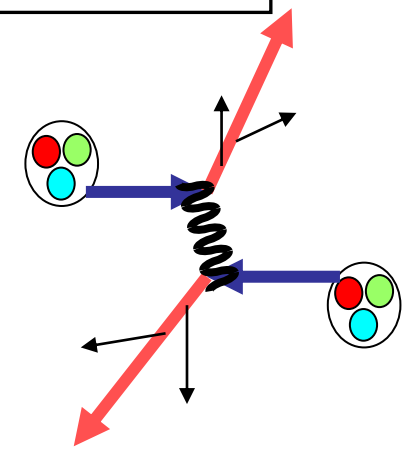


Wood-Saxon nuclear density



Number of Binary collisions

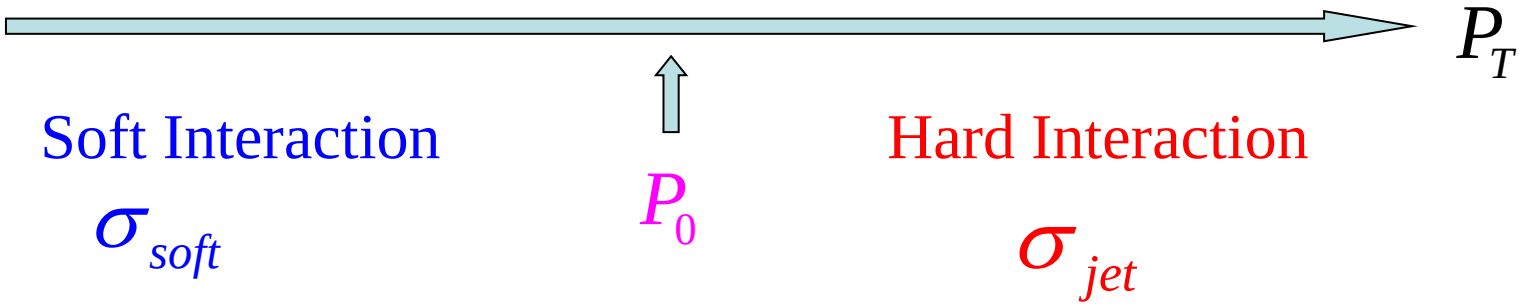
independent



N+N collisions

HIJING Model

Two-Component Model in Nucleon+Nucleon Collisions



σ_{soft} is a parameter.

$$\sigma_{jet} = \int_{p_0^2}^{s/4} dp_T^2 dy_1 dy_2 \frac{1}{2} \frac{d\sigma_{jet}}{dp_p^2 dy_1 dy_2}$$

$$\frac{d\sigma_{jet}}{dp_p^2 dy_1 dy_2} = K \sum_{a,b,c,d} x_1 f_a(x_1) x_2 f_b(x_2) \frac{d\sigma_{a,b\to c,d}}{d\hat{t}}$$

PDF

HIJING Model

Two-Component Model in N+N Collisions

Jet Independent Approximation

$$\sigma_{in} = \int d^2b \sum_{j=0}^{\infty} g_j(b)$$

$$= \int d^2b [1 - e^{-(\sigma_{soft} + \sigma_{jet}) T_{NN}(b)}]$$

Eikonal Formalism

$$\sigma_{el} = \pi \int_0^{\infty} db^2 (1 - e^{-\chi(b,s)})^2$$

$$\sigma_{in} = \pi \int_0^{\infty} db^2 (1 - e^{-2\chi(b,s)})$$

$$\sigma_{tot} = 2\pi \int_0^{\infty} db^2 (1 - e^{-\chi(b,s)})$$

The Eikonal Function:

$$\chi(b,s) = \chi_s(b,s) + \chi_h(b,s)$$

$$= \frac{1}{2} \sigma_{soft} T_{NN}(b,s) + \frac{1}{2} \sigma_{jet} T_{NN}(b,s)$$

HIJING Model

Two-Component Model in N+N Collisions

Probability for event with j≥1 number of jets

$$G_j = \frac{\pi}{\sigma_{in}} \int_0^\infty db^2 \frac{[2\chi_h(b,s)]^j}{j!} e^{-2\chi_h(b,s)}$$

Probability for event without jet:

$$G_0 = \frac{\pi}{\sigma_{in}} \int_0^\infty db^2 [1 - e^{-2\chi_s(b,s)}] e^{-2\chi_h(b,s)}$$

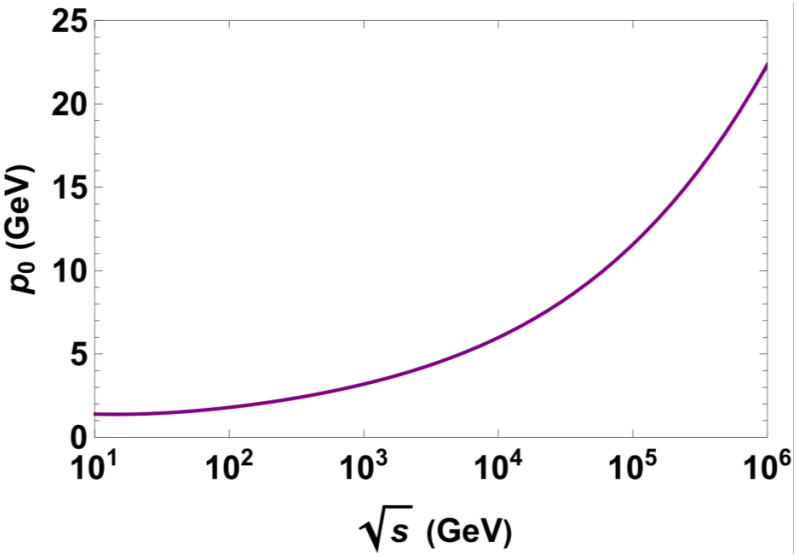
$$\sum_{j=0}^{\infty} G_j = 1$$

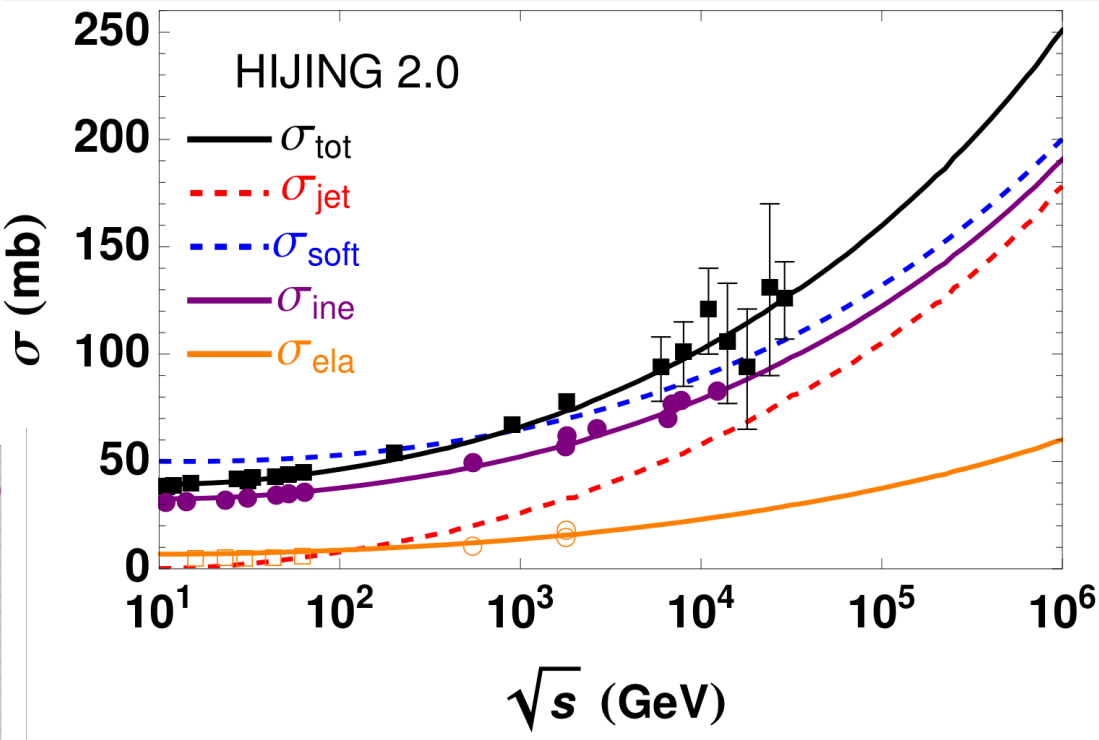
HIJING Model

Parameters:

PDF — GRV 98 parameterization

σ_{soft}, p_0 — Energy dependent





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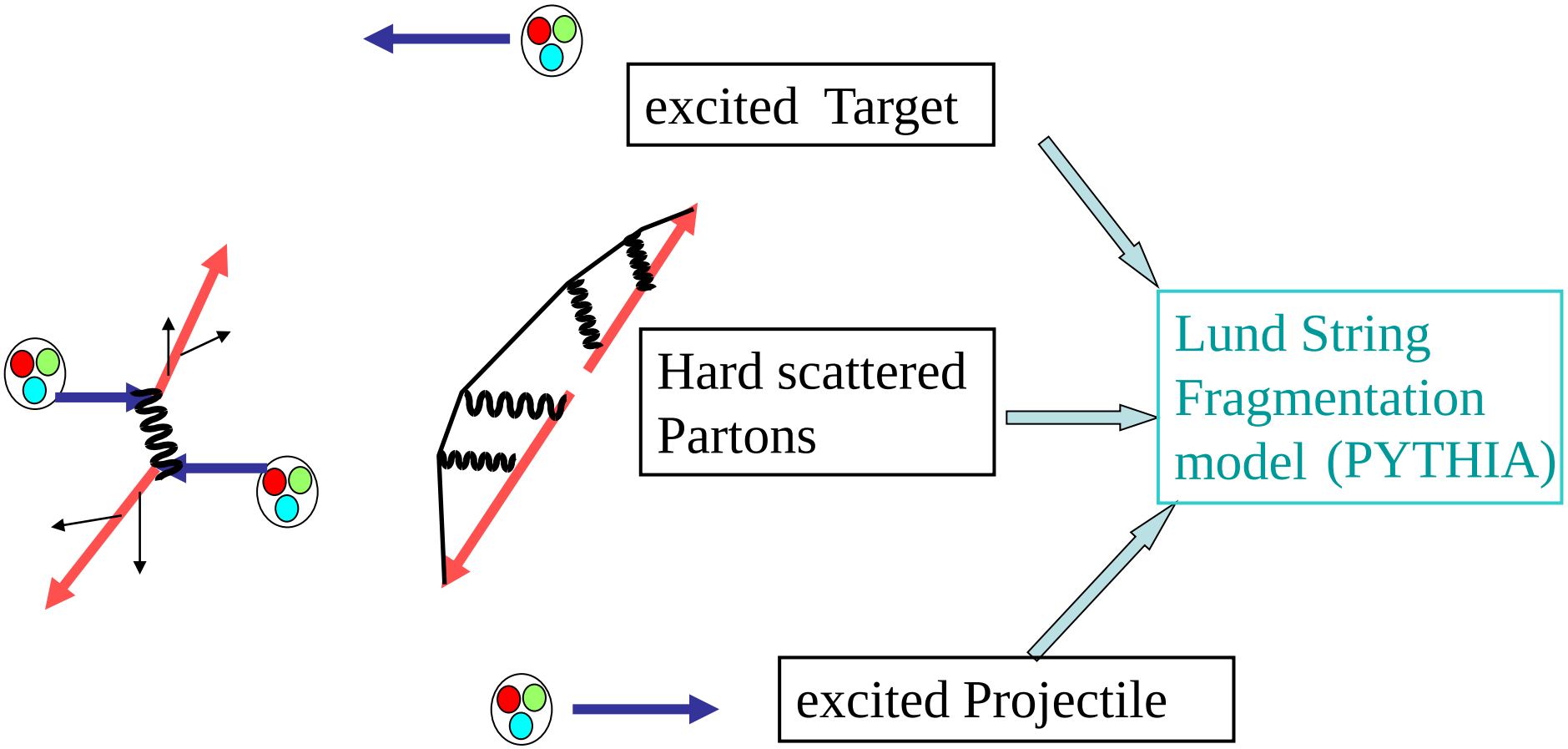
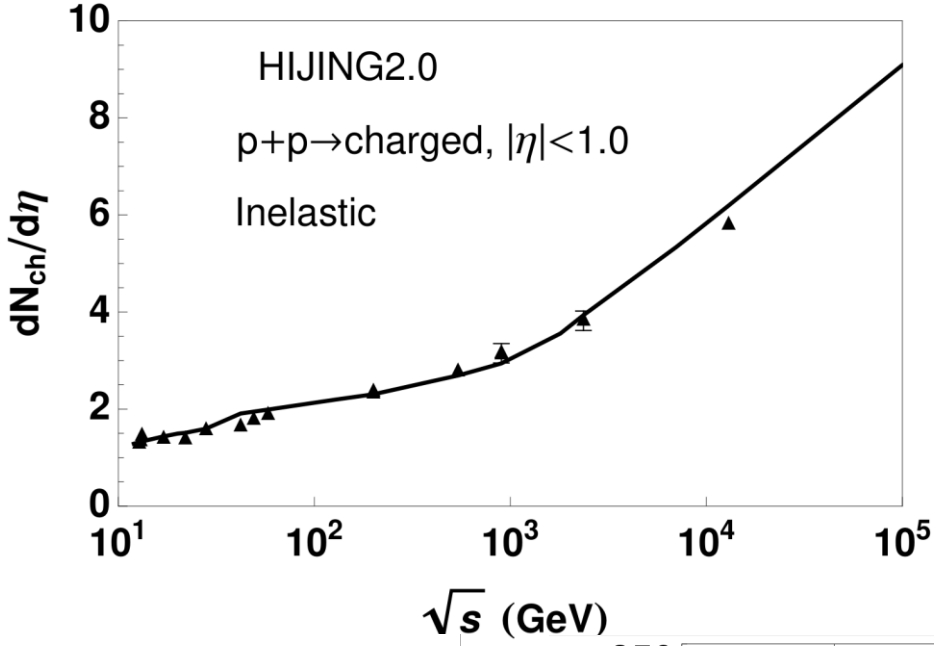
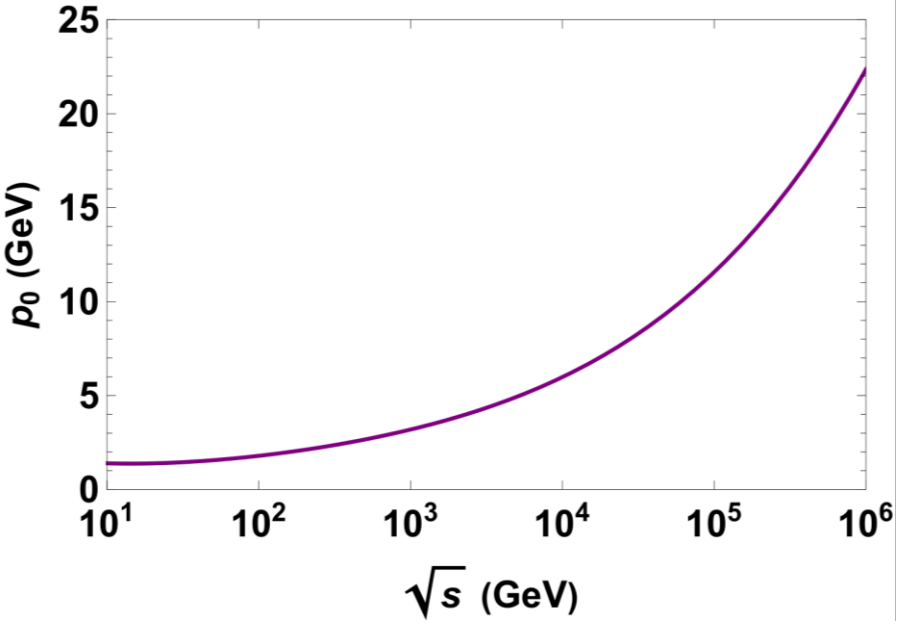
HIJING Model

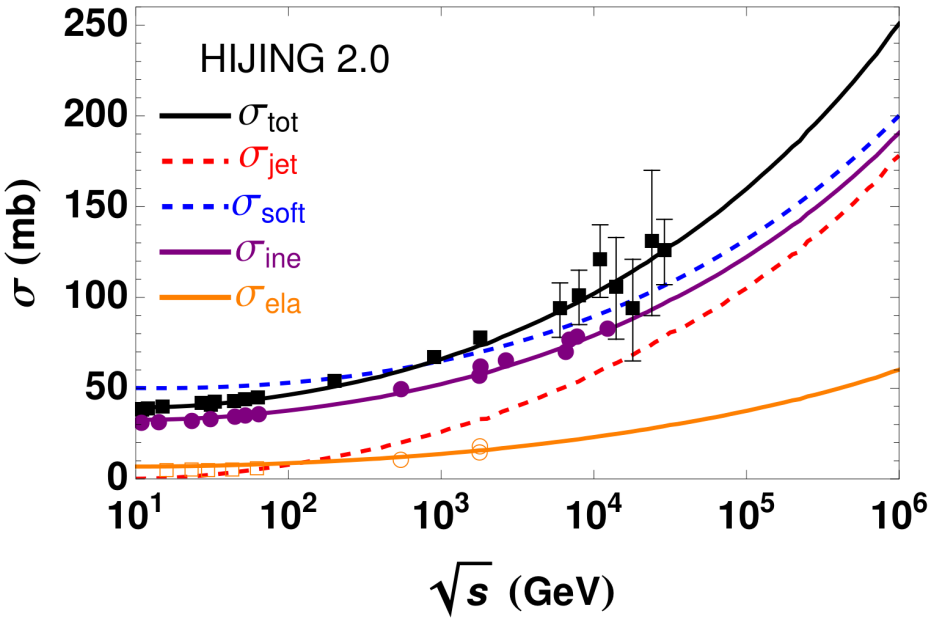
Fragmentation:



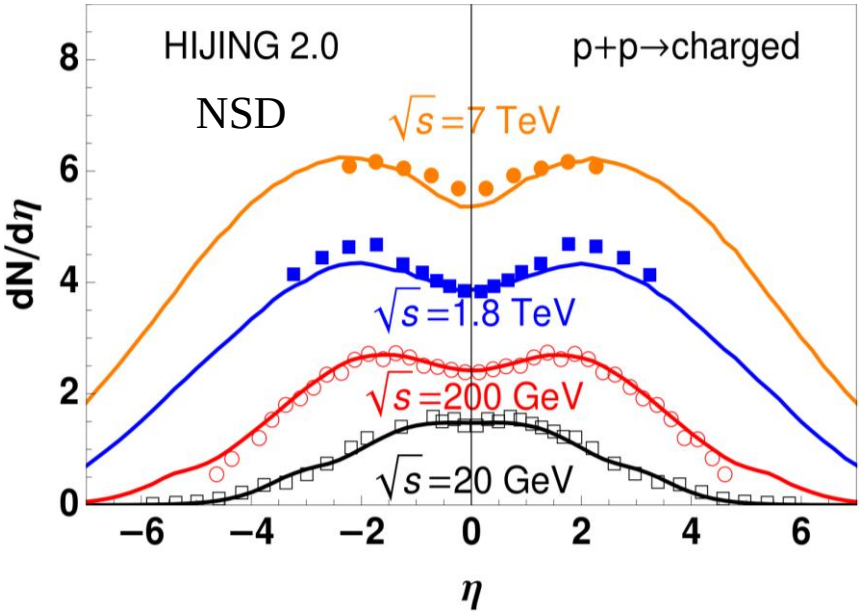
Multiplicity in p+p







Multiplicity in p+p



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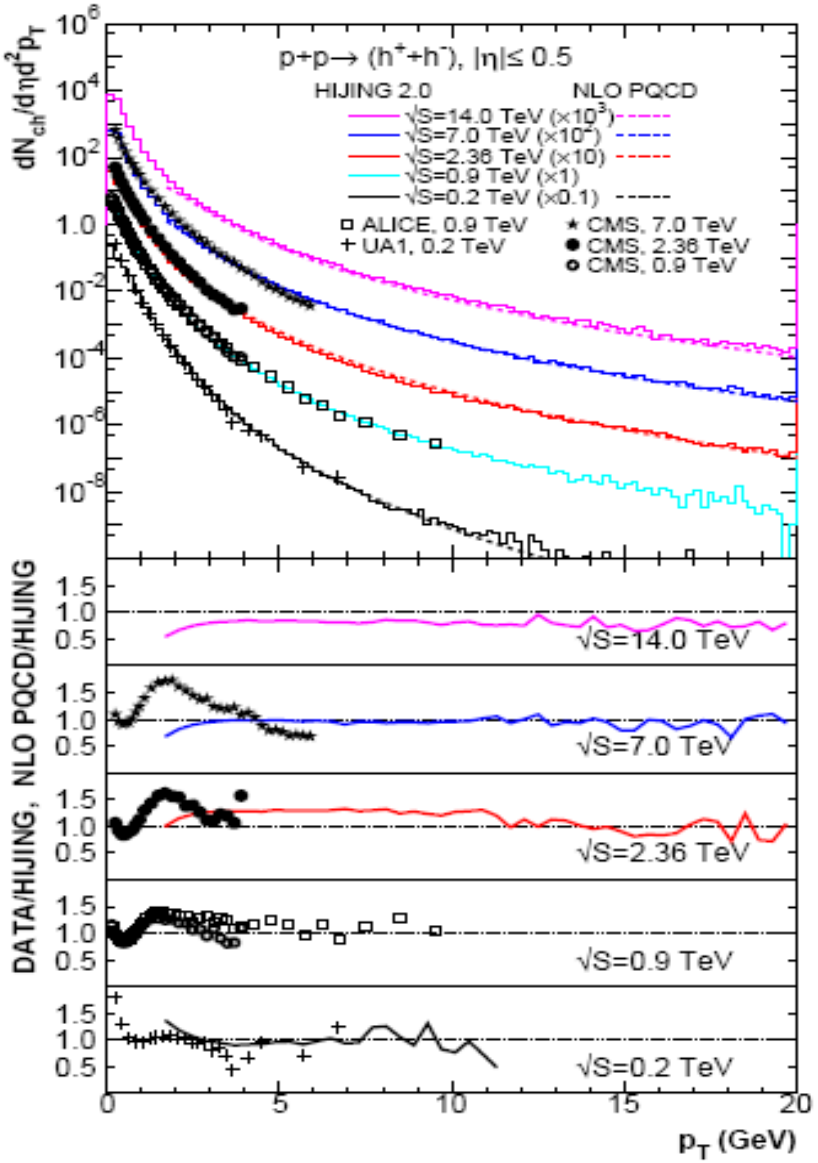
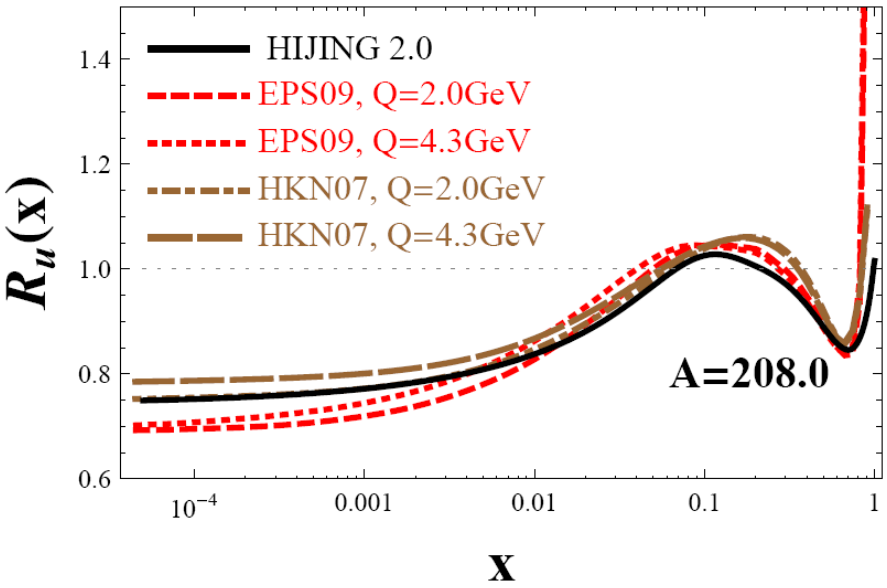


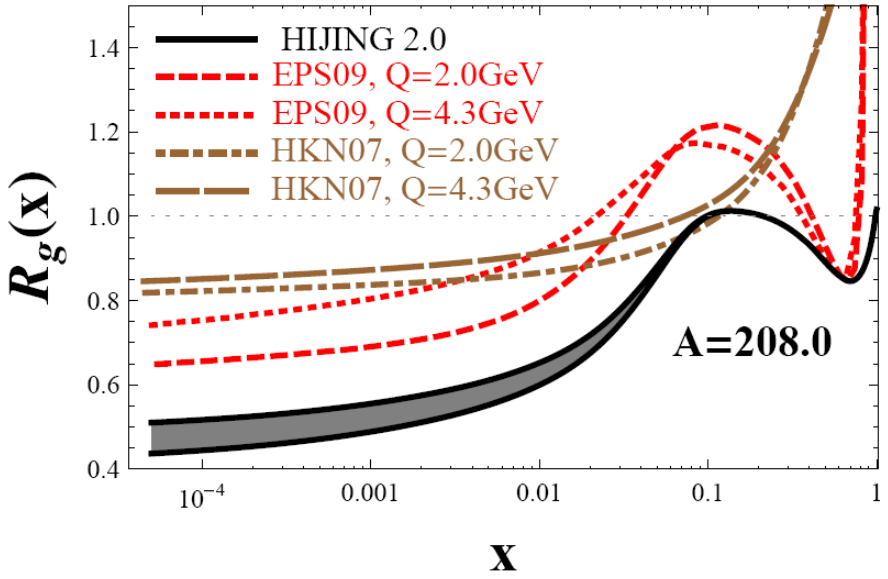
HIJING Model

Shadowing Effect in Nuclear PDF:

$$R_a^A(x,Q^2) = \frac{f_a^A(x,Q^2)}{A f_a^N(x,Q^2)}$$



Quark, fixed on DIS



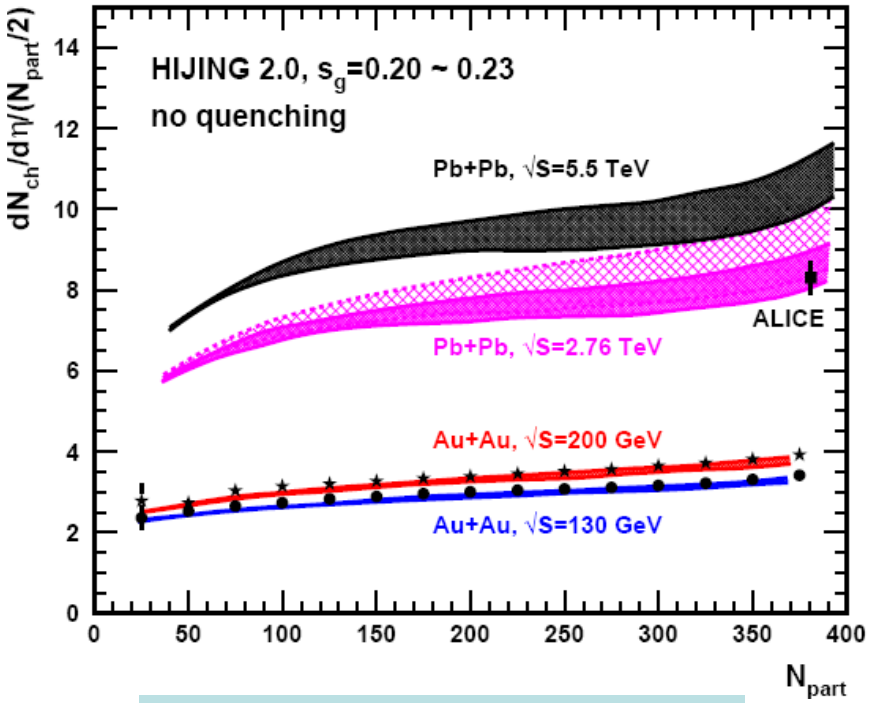
Gluon, fit to the RHIC

$$s_a(b) = s_a \frac{5}{3}(1 - b^2 / R_A^2)$$

Phys.Lett.B 527, 85 (2002), S.-Y. Li & X.-N. Wang

A+A collisions

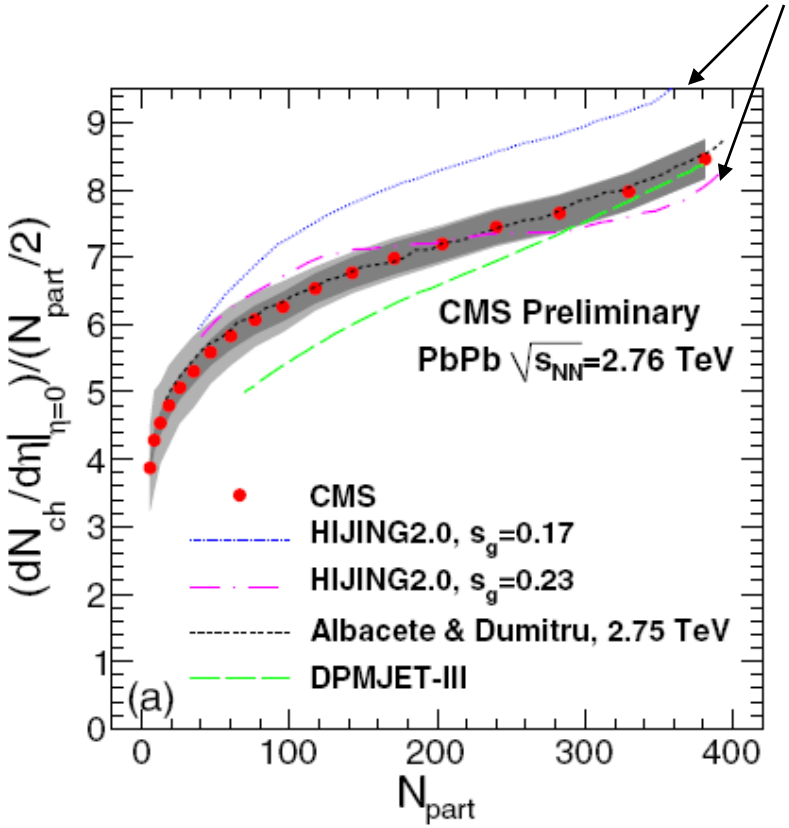
b-dependence of dN/dη :



Phys.Rev.C83 (2011) 014915, WTD, X.-N. Wang & R. Xu

Phys.Lett. B701 (2011) 133-136, WTD, X.-N. Wang & R. Xu

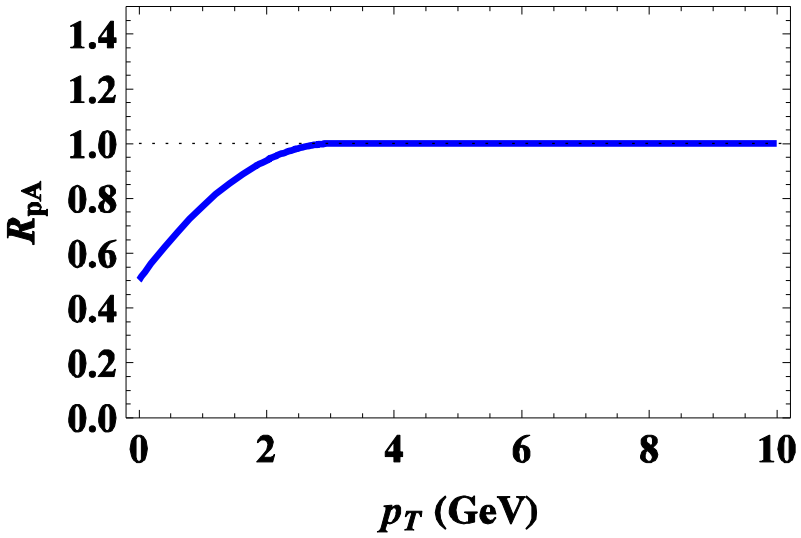
HIJING2.0 first prediction

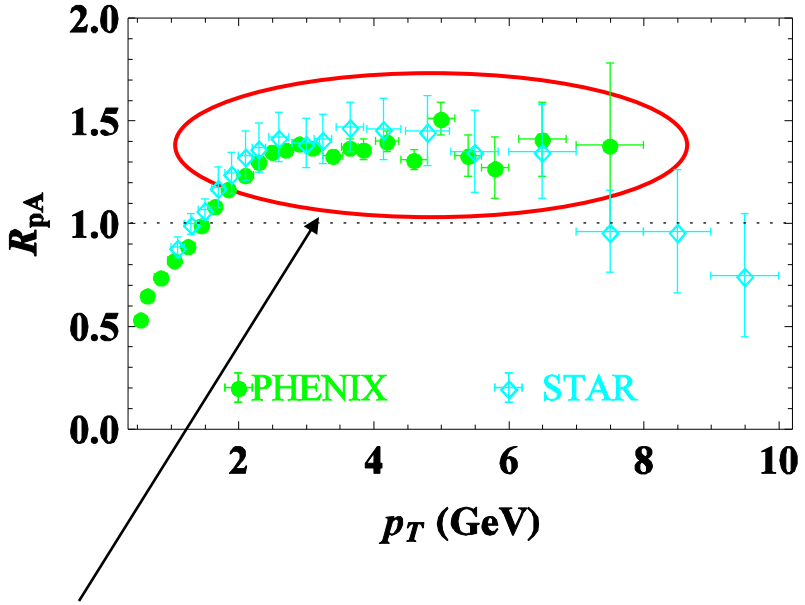


JHEP 1108 (2011) 141, CMS

Cronin effect

Nuclear modification: $R_{pA}(p_T) = \dfrac{dN_{pA}/dyd^2p_T}{\langle N_{bin}\rangle dN_{pp}/dyd^2p_T}$





If no any nuclear modification

Cronin Effect

P.R.L. 91, 072303
PHENIX

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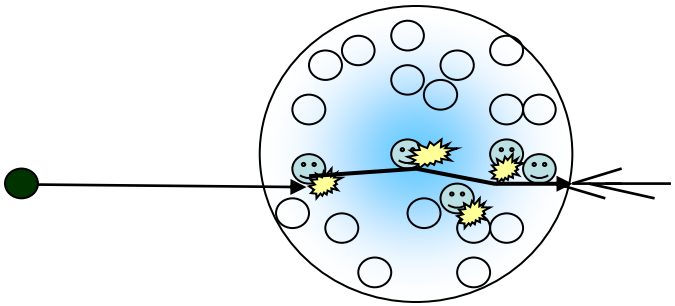
STAR

K_T Broadening in HIJING

k_T kick in p+A collisions:

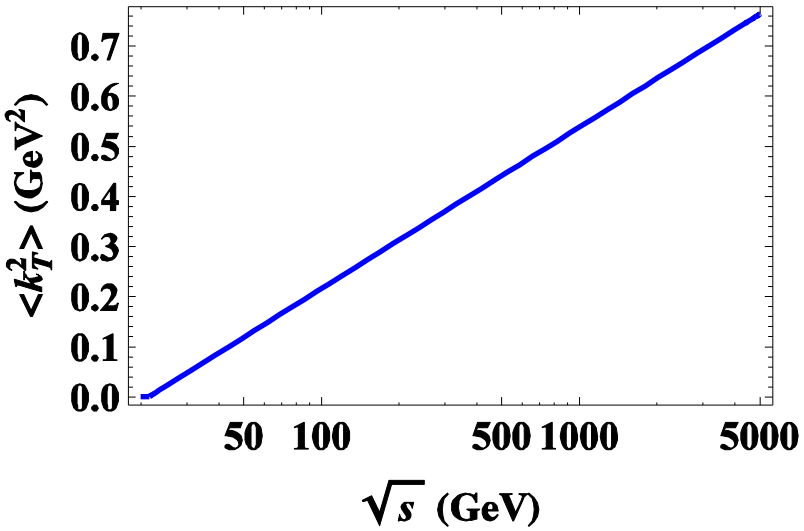


Multiple inelastic scattering

K_T broadening of initial and final partons, with Gaussian distribution

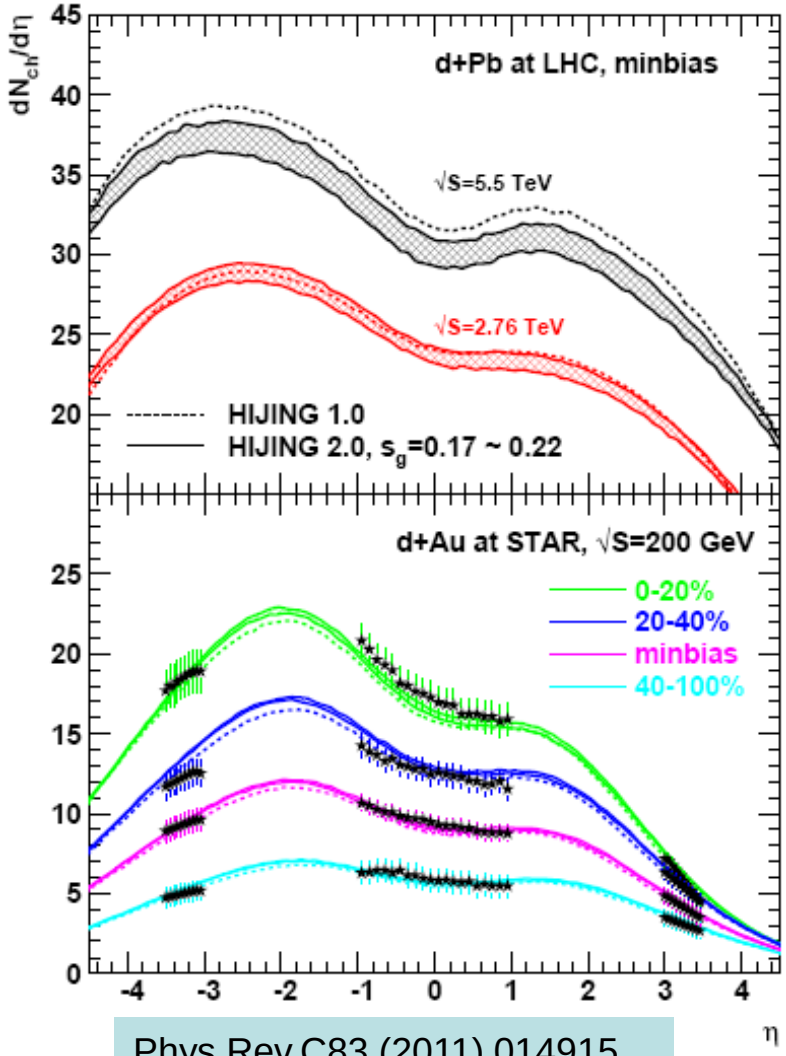
Energy dependence of the width in Gaussian distribution

$$\left\langle k_T^2 \right\rangle = 0.14 \mathrm{Log}\left(\sqrt{s}\right) - 0.43 \ \mathrm{GeV}^2$$



p+A collisions

Multiplicity as function of rapidity:



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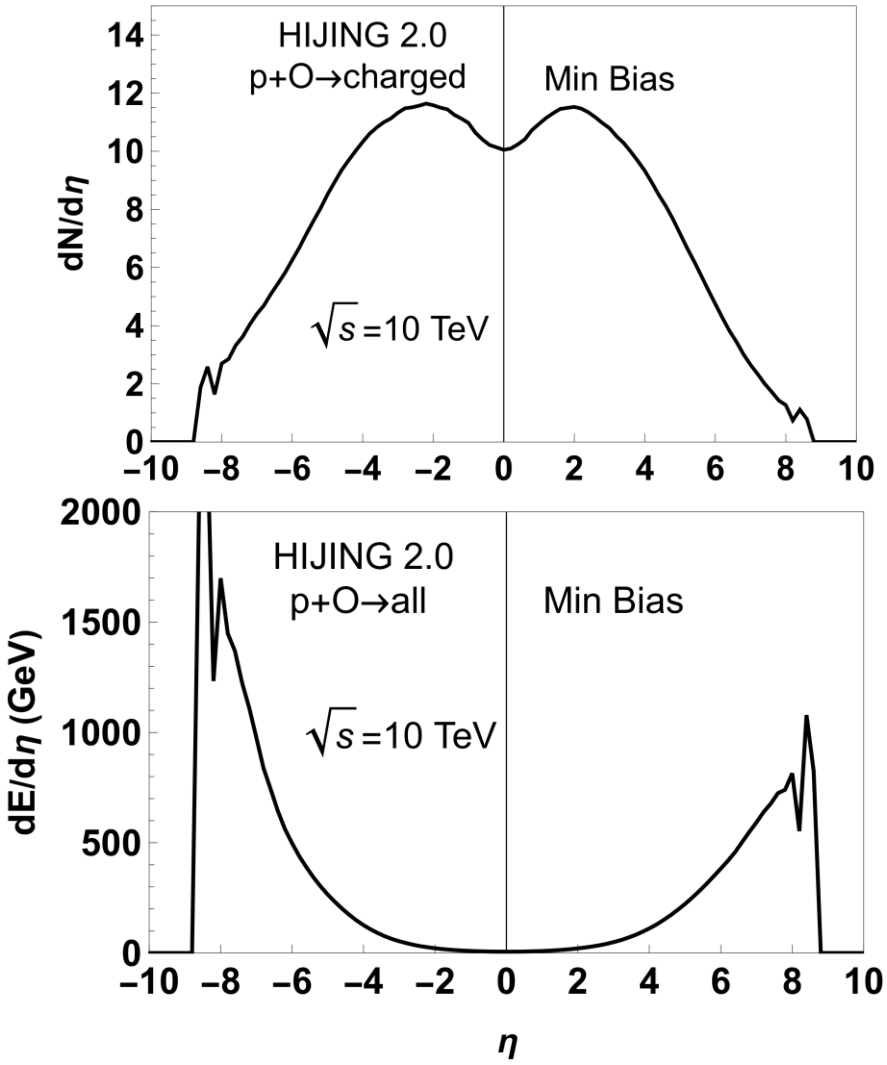
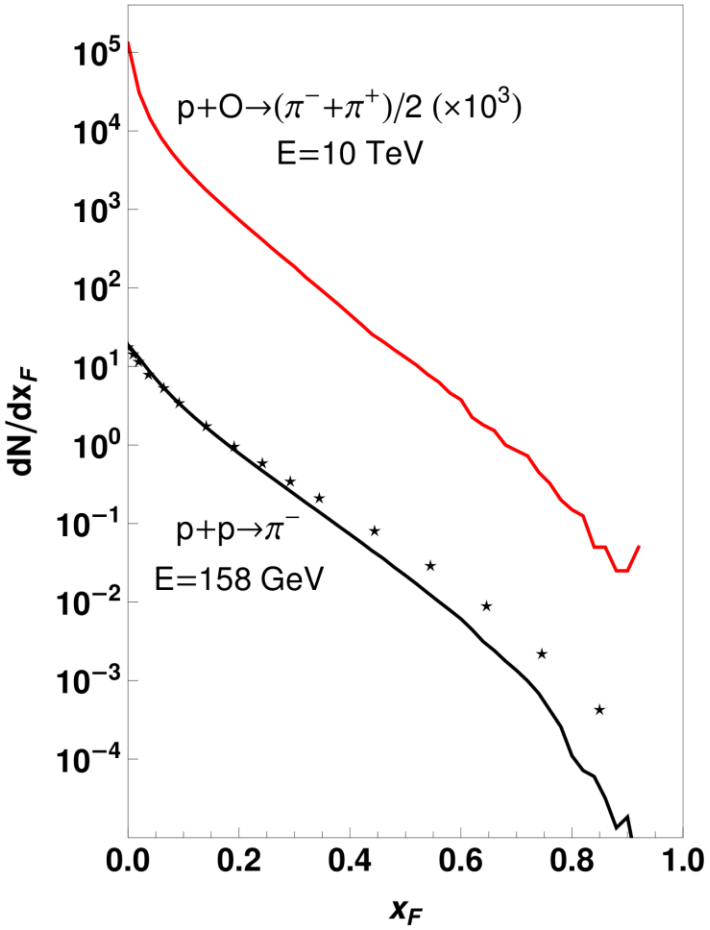
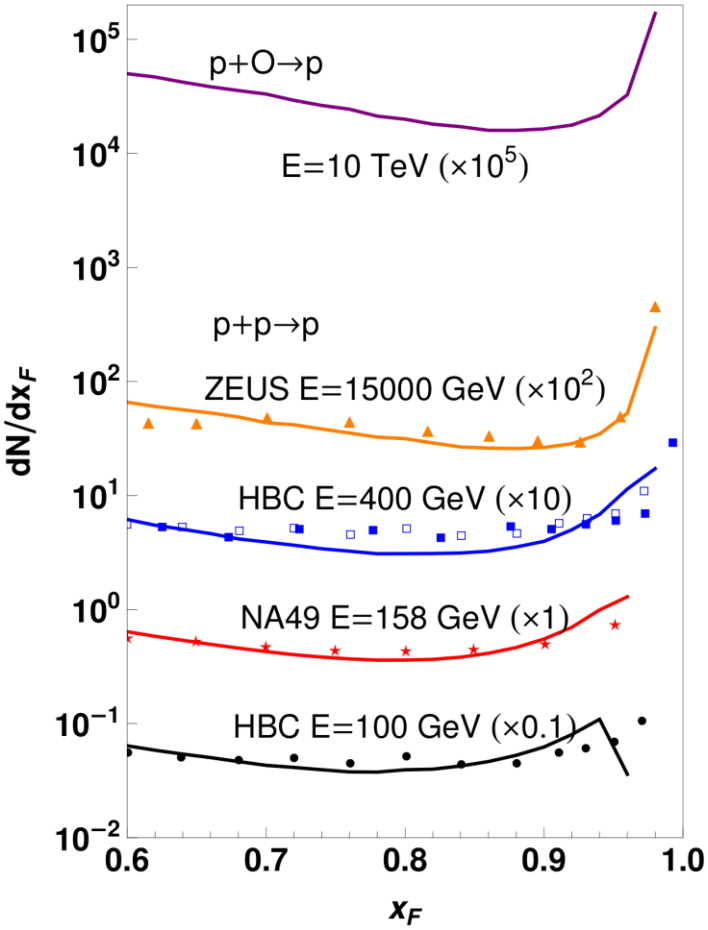


p+A collisions

Longitudinal momentum distribution:



Hadrons from string frag. have very small momentum fractions



$$x_F = \frac{p_{\parallel}}{\sqrt{s}/2}$$

Hadrons inherited valence quark have a flat distribution.

Summary

- HIJING model
- HIJING describes the hadron production well up to LHC energy in p+p, p+A and A+A collisions.
- HIJING can be used to study the hadron interaction in Cosmic Rays.