Constraining HIJING code of Geant4

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HIJING code

HIJING: Heavy Ion Jet Interaction Generator

Xin-Nian Wang and Miklos Gyulassy, Physical Rev. D 44, 3501(1991)

- A microscopic transport model

- Build to work at LHC energy

-A two component model for beam parton interactions

- In each collision

➢ Jet Production ($p_T > p_0$) (Main source of hadrons at LHC energies

Jet cross section (σ_{jet})

➢ String interactions ($p_T < p_0$) (FTF/DPM)

soft parton cross section (σ_{soft})

HIJING uses

- Eikonal formalism to determine the number of wounded nucleons
- PYTHIA 5.3 to generate kinetic variables for each hard scattering (high p_T).
- JETSET 7.2 for jet fragmentation.

Parameters of HIJING code for A+A collisions

- The jet cross section σ_{jet}.

  -Cut off parameter p_0.

  -Parton Distribution function (**PDF**) ★ new

  -QCD running coupling ★ new

- The soft parton cross section σ_{soft}.
- Parton ($\alpha_{g(q)}$)Shadowing. ★ new

➢ σ_{soft}, p_0 are determined once for all

- Tune $p + p$ inelastic and total cross sections.

➢ For $A + A$ collisions, one needs

- Exact QCD running coupling α_s.
- Adjust Parton shadowing $\alpha_{g(q)}$

The main improvements

HIJING 1.383

- The Duke-Owen (1984) parameterizations of parton distribution functions are used.

- QCD Coupling

$$\alpha_s = \frac{1}{\beta_0 \, L_\Lambda}$$

$$L_\Lambda = ln(Q^2/\Lambda), \beta_0 = 11 - 2/3n_f$$

- Parton shadowing

$$\alpha_a(r_i) = s_{q(g)} \frac{4}{3} \sqrt{1 - {r_i}^2/R_A^2}$$

$$r_i = \sqrt{x_i^2 + y_i^2}$$

$$s_{q(g)} = 0.17 - 0.23$$

Improved HIJING

- Martin-Stirling-Throne-Watt (2009) of parton distribution functions are used.

- QCD coupling (A. Vogt, Comp. Phys. Comm.170, 65 (2005))

$$\frac{d\alpha_s(Q^2)}{d\, ln(Q^2)} = -\beta_0 \alpha_s(Q^2) - \beta_1 \alpha_s(Q^2)$$

- Parton shadowing

$$\alpha_A(r_{ij}) = s_{q(g)} \left(A^{\frac{1}{3}} - 1\right) \frac{5}{3} \left(1 - \frac{r_{ij}^2}{R_A^2}\right)$$

$$r_{ij} = \sqrt{\left(b_x + x_i - x_j\right)^2 + \left(b_y + y_i - y_j\right)^2}$$

$$s_{q(g)} = 0.068 - 0.0328c + 0.0109\, c^2$$

$$s_{q(g)} = 0.068 - 0.048c + 0.063\, c^2 - 0.014\, c^3$$

Nucleon shadowing in ImHIJING

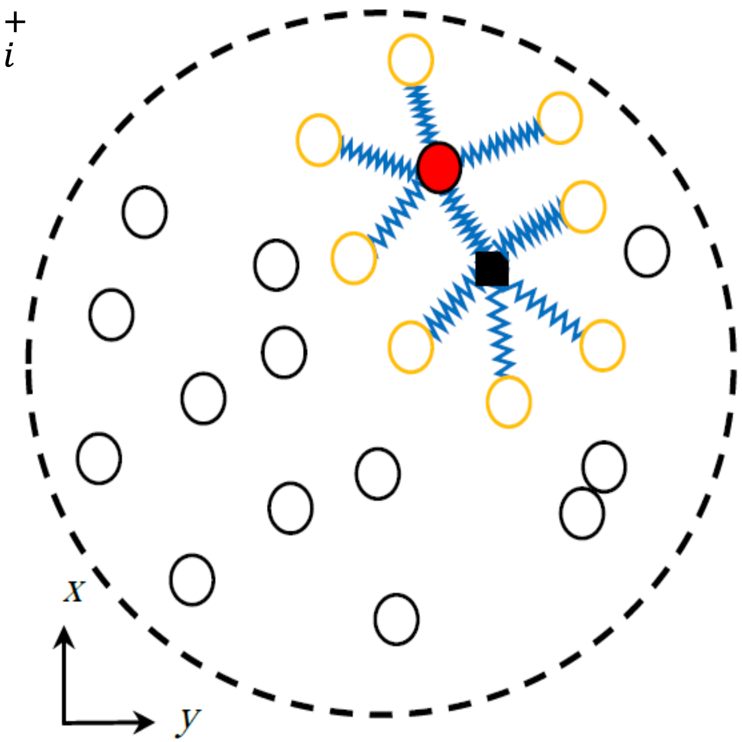
$$P(x'^{+}_{i}) \propto \prod_{i=1}^{N_A} \exp\left(-\frac{\left(x'^{+}_{i} - \frac{1}{N_A}\right)^2}{d^2}\right) \delta\left(1 - \sum_{i=1}^{N_A} x'^{+}_{i}\right) dx'^{+}_{i}$$

$$d = \frac{\delta}{N_A}$$

$$\delta(c) = 0.1 + 2c(1 - \frac{3}{4}\sqrt{c})$$

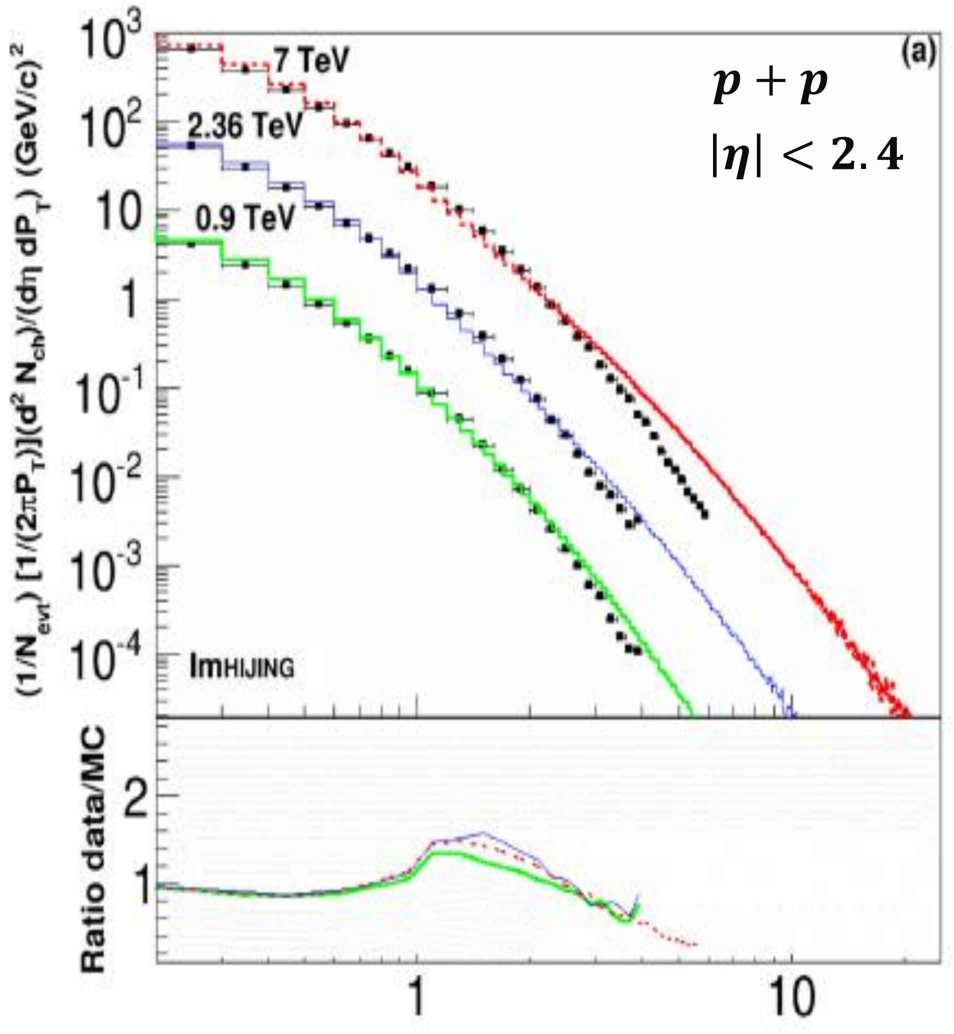
new

$$r_{ij} = \sqrt{\left(b_x + x_i - x_j\right)^2 + \left(b_y + y_i - y_j\right)^2}$$

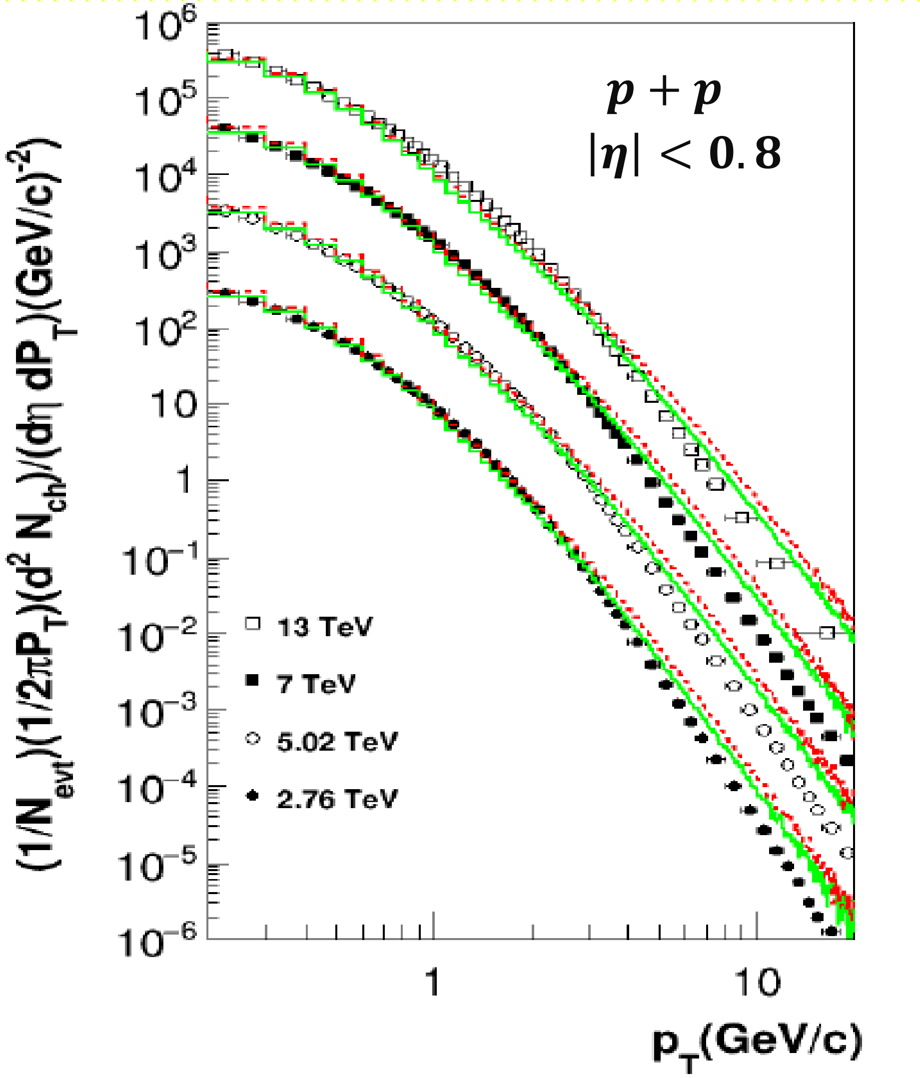


The results of the improved HIJING codes at LHC energies

Exact QCD running coupling calculations

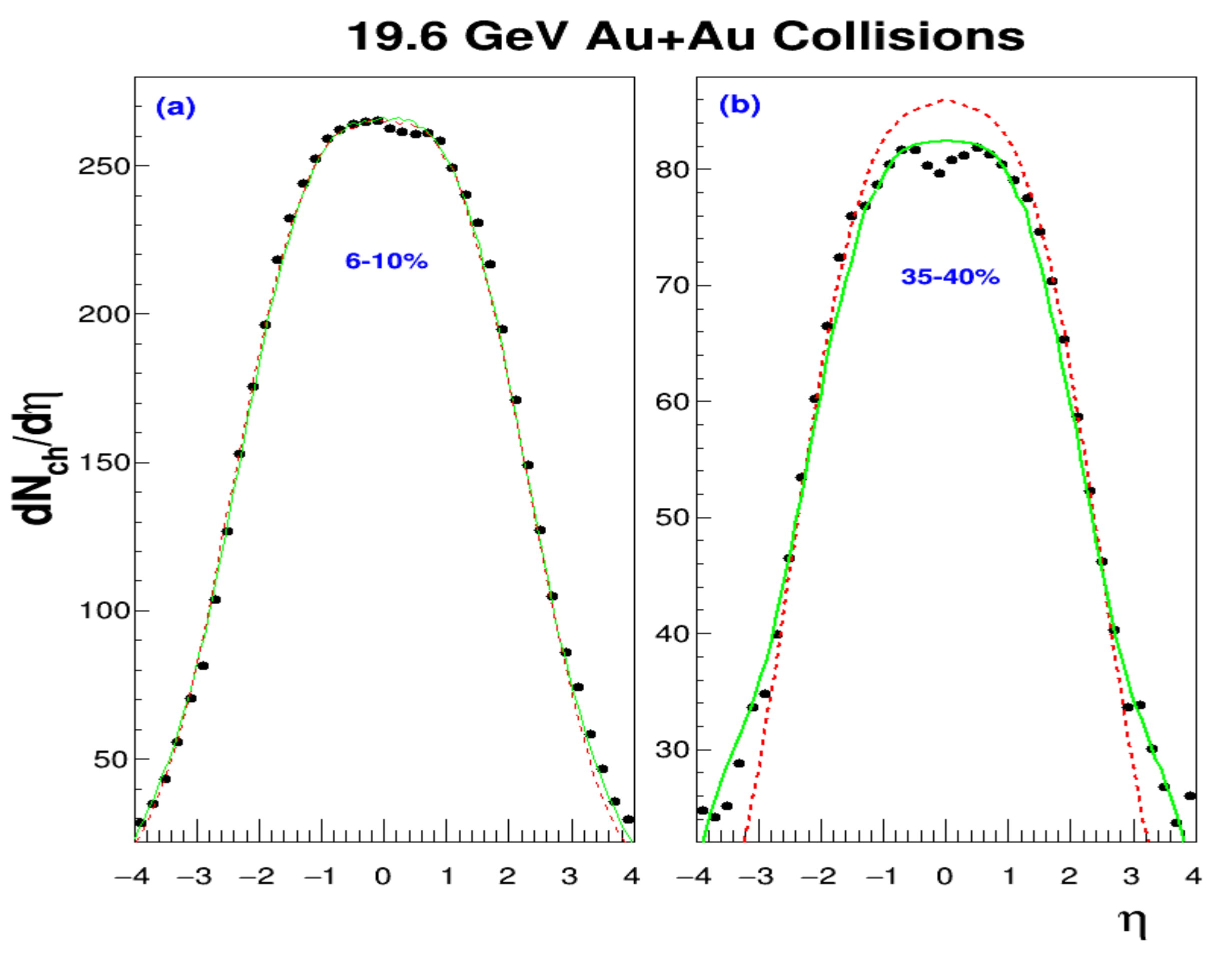


Khaled,
Phys. Rev. C 91, 034908(2015)



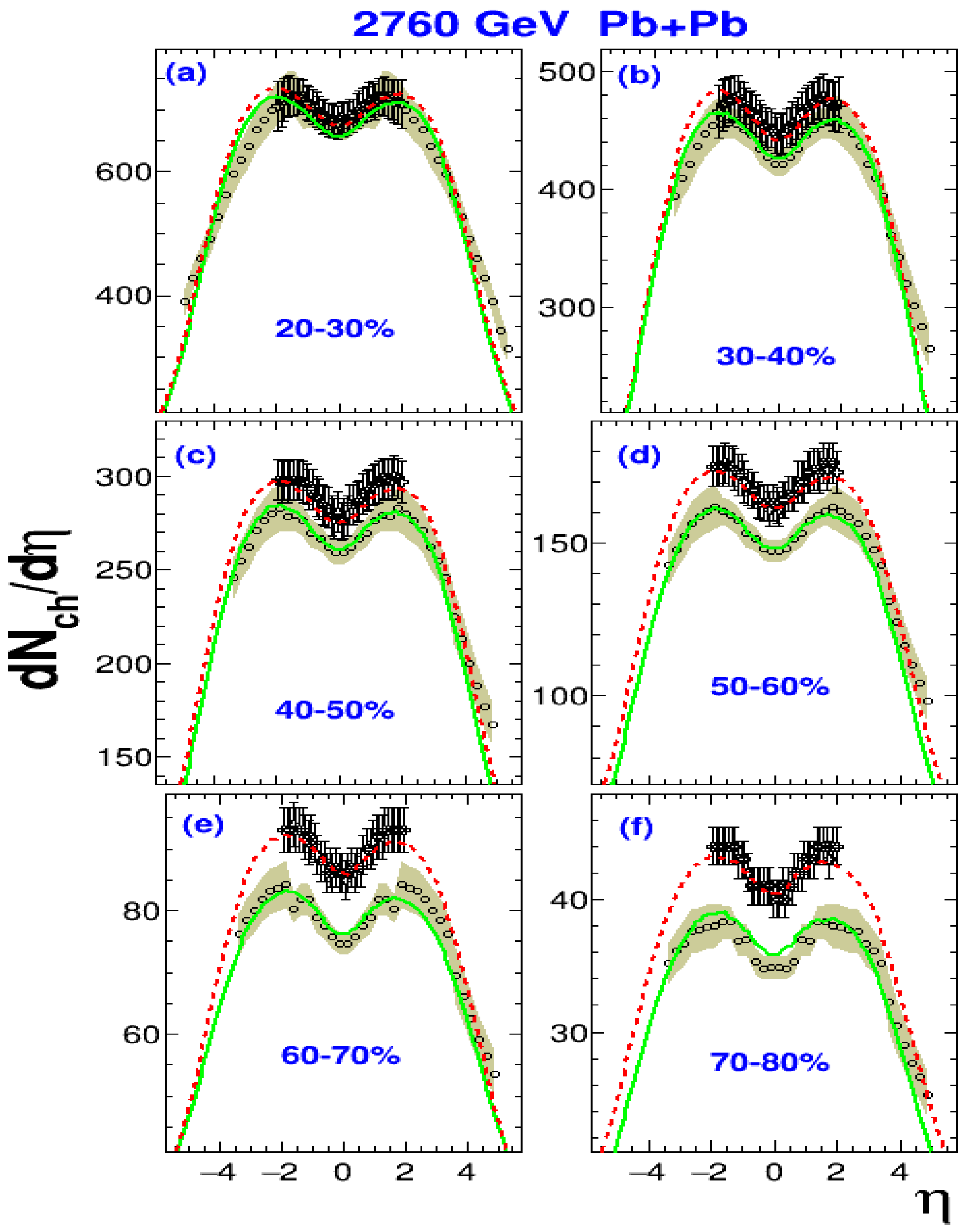
Khaled,
........................(2017)

Constraining nucleon shadowing parameters



PHOBOS data,
Phys. Rev. C 83, 024913(2011)

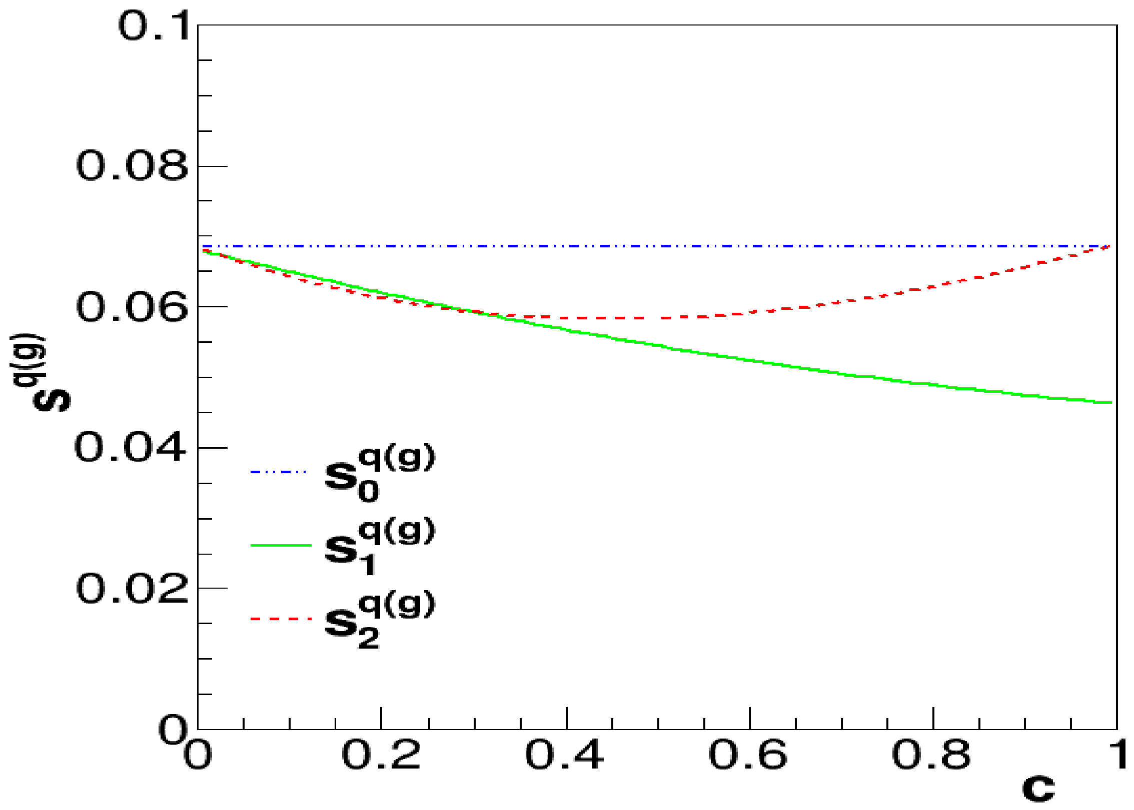
Constraining parton shadowing parameters



ATLAS data,
Phys. Lett. B 710, 363(2012)

ALICE data,
Phys. Lett. B 754, 373(2016)

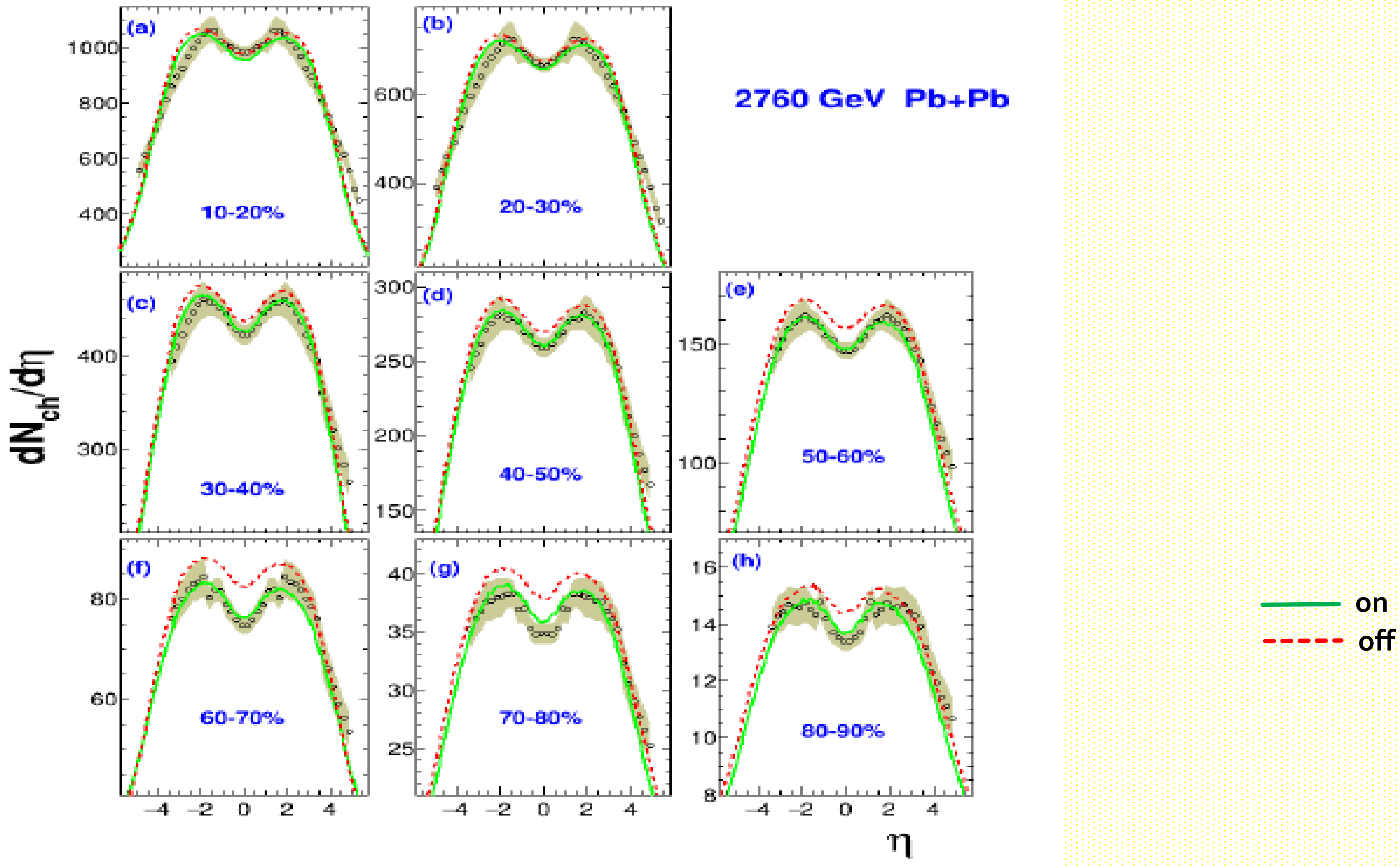
Deduced parton shadowing parameterizations



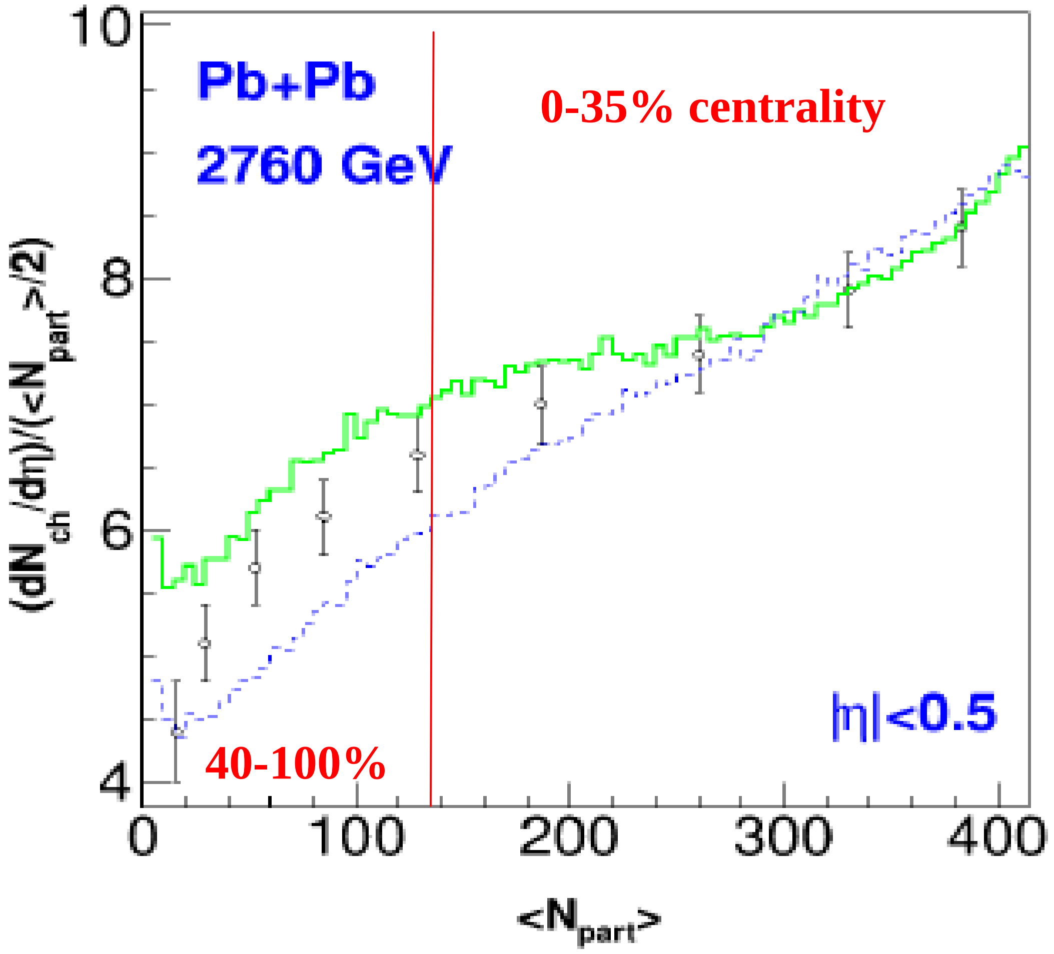
ALICE data

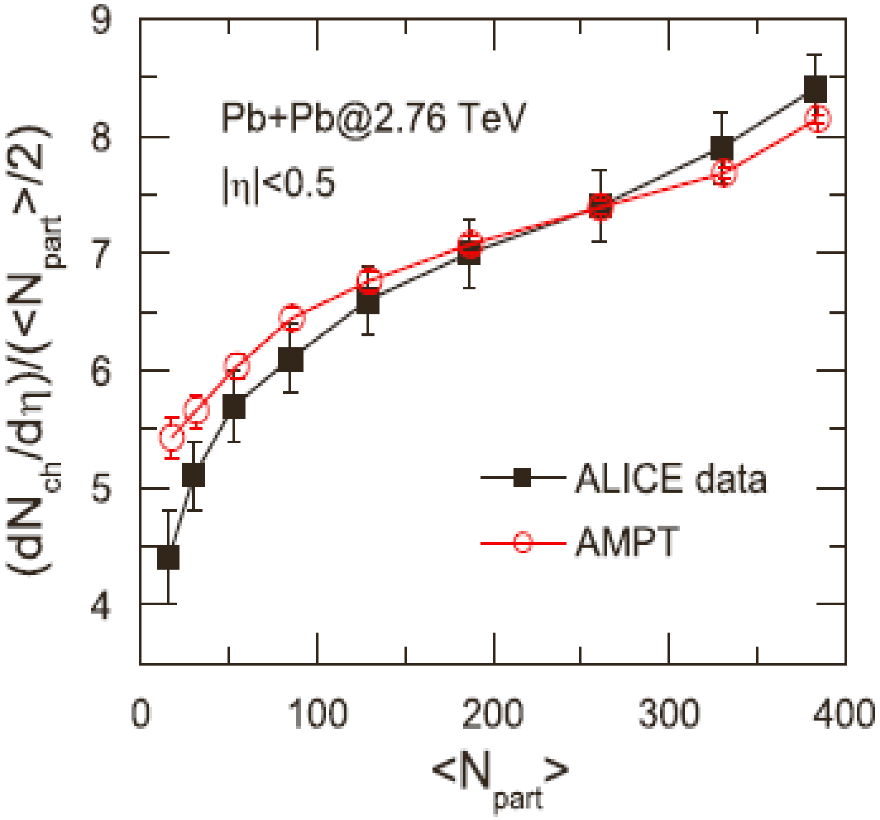
ATLAS data

Nucleon shadowing effects



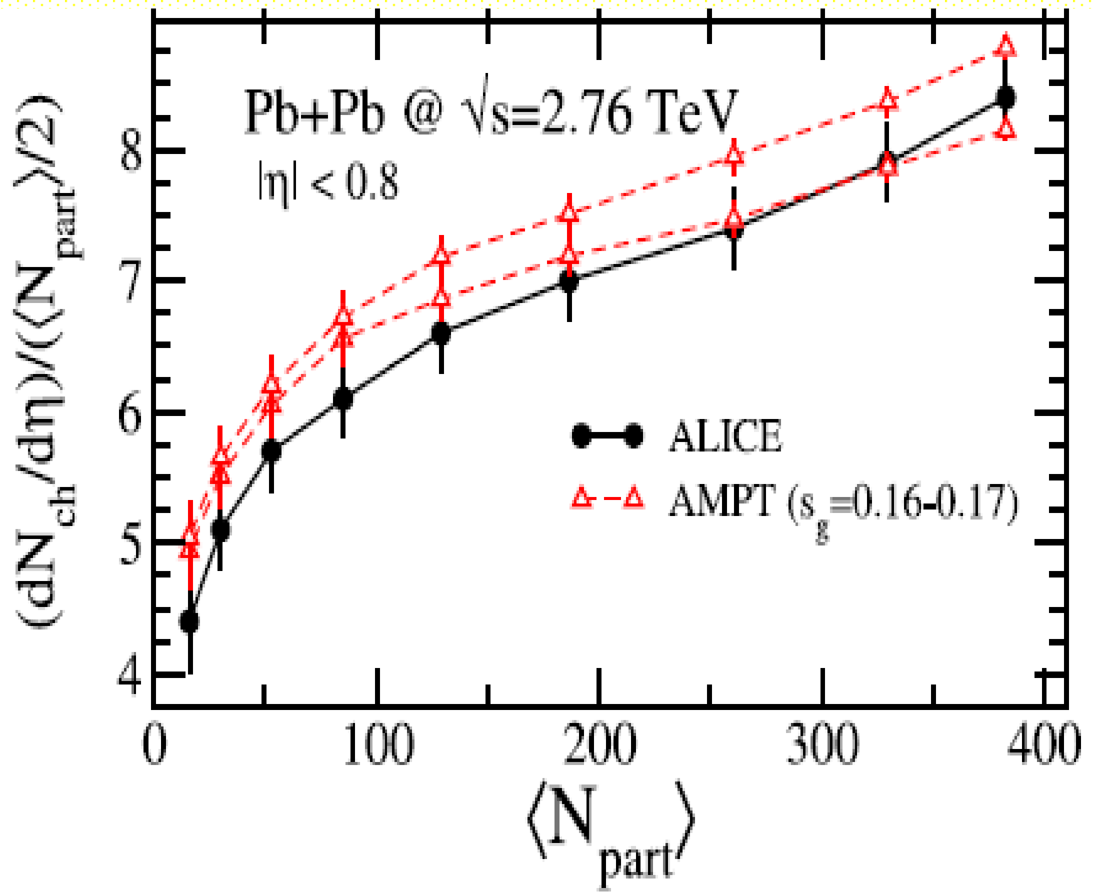
Impact parameter independent Parton shadowing



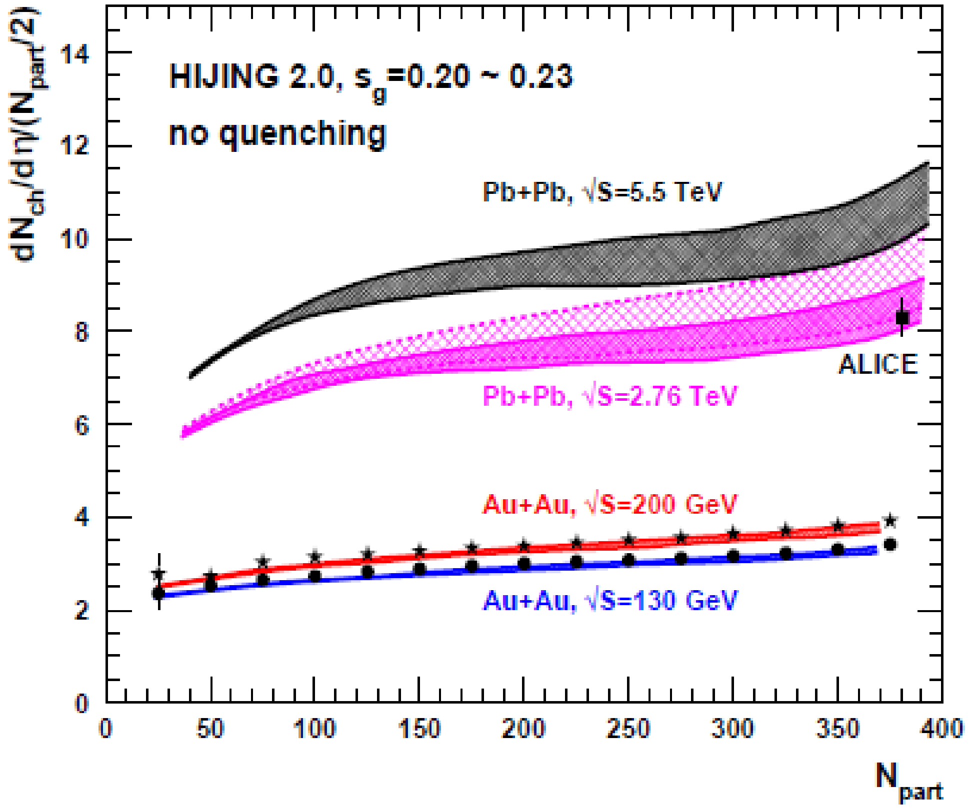


Phys. Rev. C 83, 034904(2011)

HIJING2 and AMPT calculations

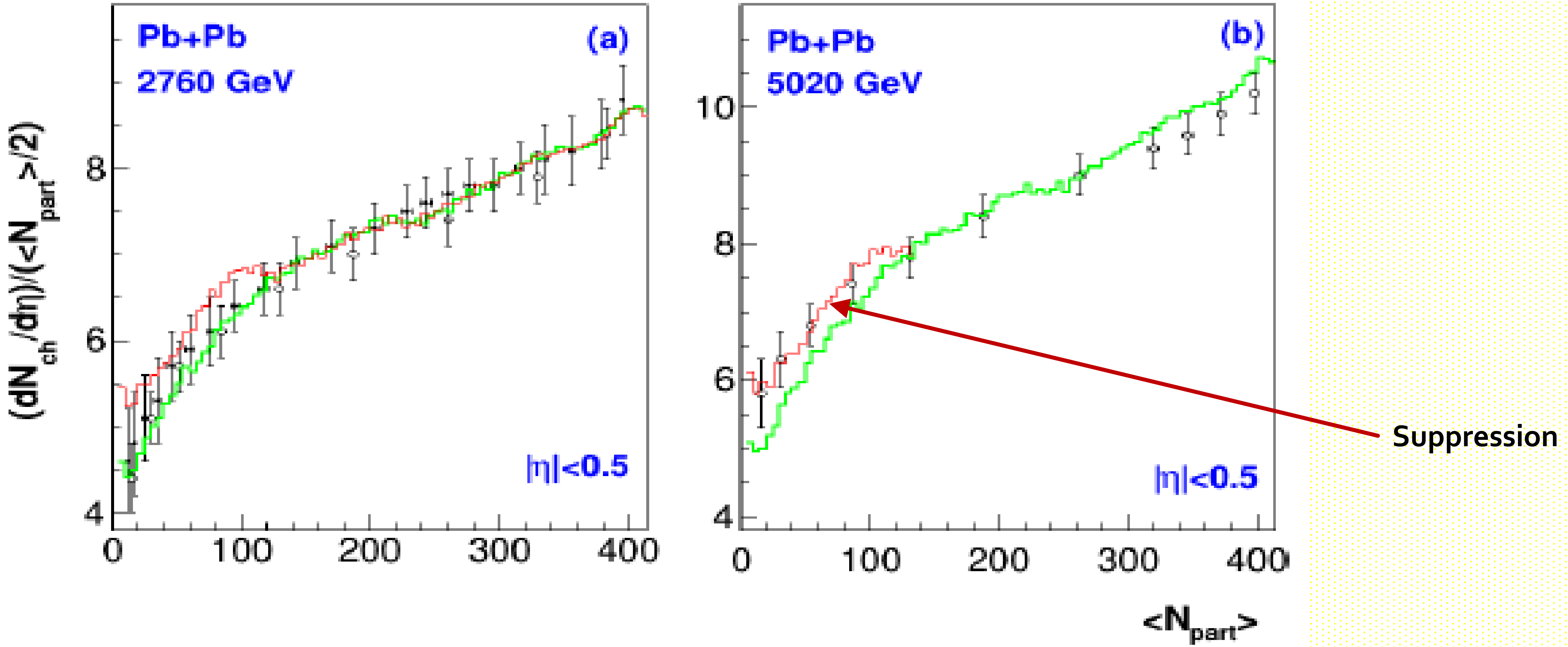


Phys. Lett. B 709, 82(2012)



Phys. Lett. B 701, 133(2011)

Results of improved HIJING



ALICE fit

ATLAS fit

NO FIT

Conclusions

- ✓ Improvements of HIJING code are
  - **Tabulated Martin-Stirling-Throne-Watt (2009) parton distribution functions are implemented.**
  - **Exact QCD running coupling is used.**
  - **Nucleon shadowing becomes impact-parameter dependent.**
  - **Parton shadowing becomes impact-parameter dependent.**

- ✓ Transverse momentum spectra are reproduced for
  - ✓ $p+p$ collisions at $\sqrt{s_{NN}} = 2.76, 5.02, 7$ and 13 TeV

- ✓ Centrality dependence of charged particle yield are well accounted for
  - ✓ Pb+Pb collisions data at $\sqrt{s_{NN}} = 2.76$ TeV.
  - ✓ Pb+Pb collisions data at $\sqrt{s_{NN}} = 5.02$ TeV

- ✓ HIJING parameters are constrained.

Thanks

Thanks