Prediction for 4.4 ATeV *pPb* Collisions at the LHC

(PR C85, 024903, 2012)

Gergely Gábor Barnaföldi

Wigner RCP RMI of the HAS

in collaboration

J. Barrette, M. Gyulassy, P. Lévai, G. Papp, V. Topor Pop

High-p_T Physics for the LHC 2012, Hanau am Main 4-8 April 2012

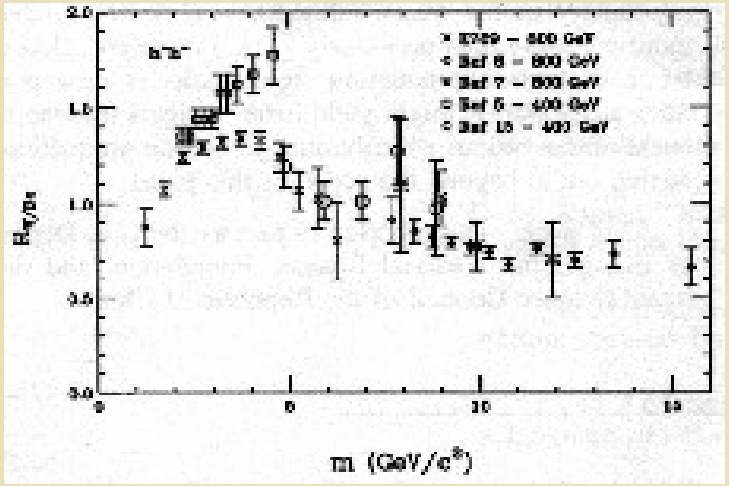
O U T L I N E

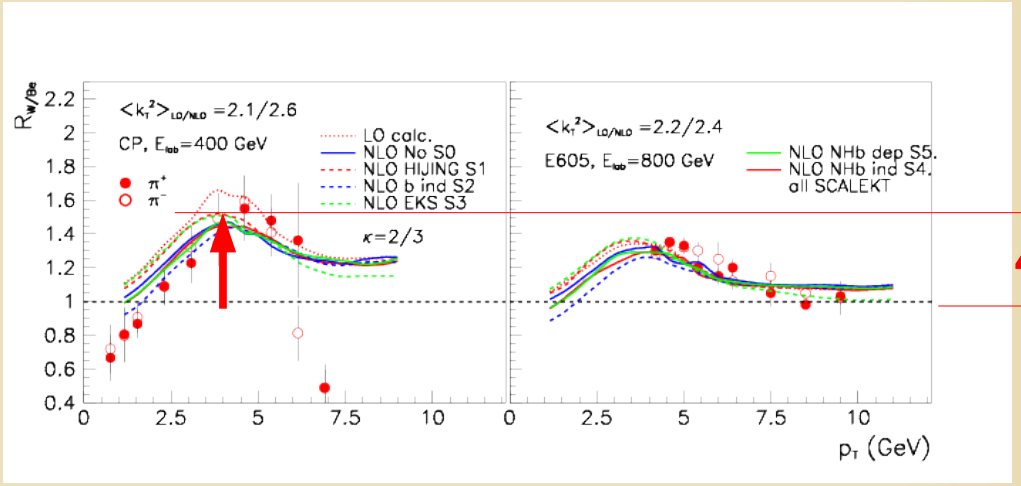
- Motivation for *pA* collisions
  - Will have pA in 2012 (in 2011 it was cancelled)
  - High & low-p_T hadron spectra incl. nuclear effect
  - Separation of initial/final state effects
- Nuclear Modification, $R_{pA}(p_T)$
  - High-p_T nuclear effects @ midrapidity & large y
  - Low-x and high-x tests?
  - From SPS, RHIC, to LHC: finding proper scaling
- Rapidity dependence, asymmetry, $Y(\eta)$
  - Puzzle: interpaly of nuclear effects

M O T I V A T I O N

- Cronin effect at SPS energies

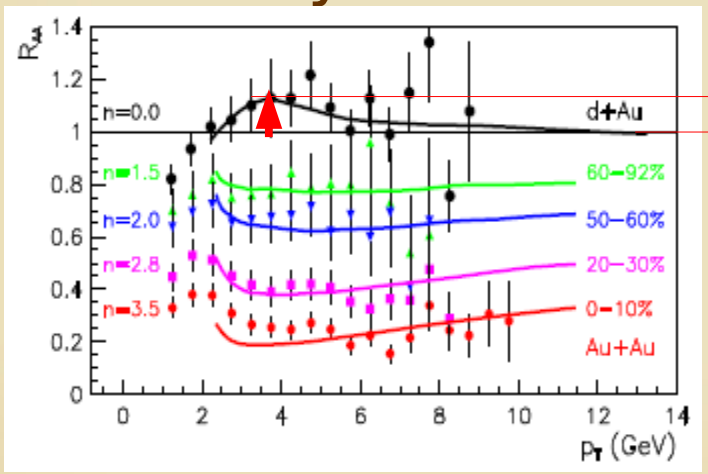
Brown et al: PRD11 (1975) 3105, Ric.Sci.Edu.Perm Suppl. 122 (2003) 541





40%

- RHIC analysis on dAu and AuAu



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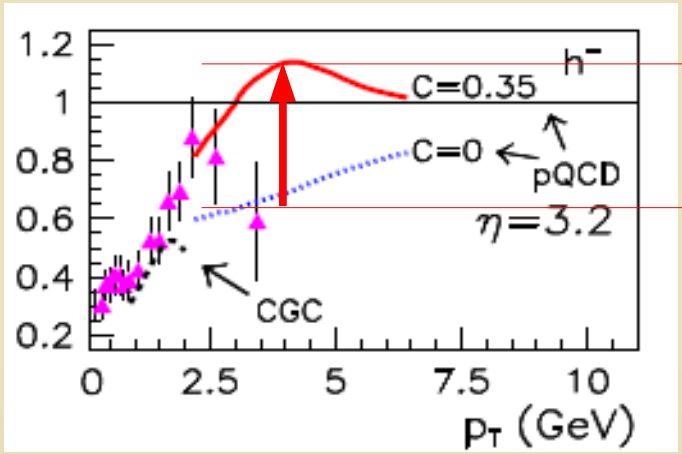

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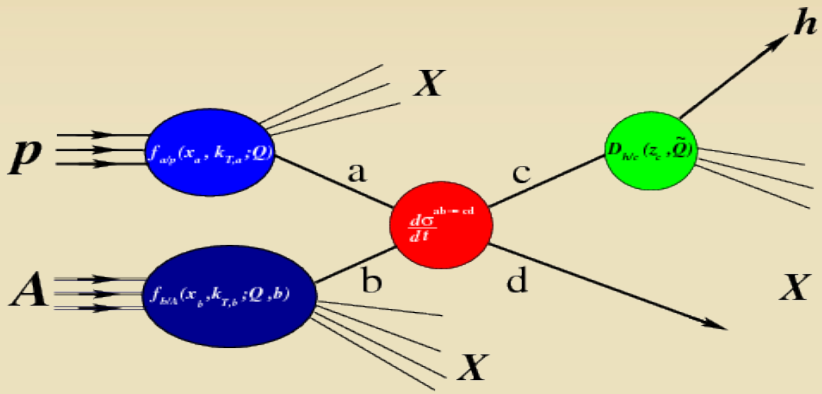
G.G. Barnaföldi: Prediction for 4.4 ATeV pPb Collisions at the LHC

Models & Parameters



HIJING B/B2.0

PRC83 024902, PRC84 022002 (2010)

Modified version of HIJING 2.0

Minijet cutoff: p_0=3.1 GeV/c

$$p_0(s,A) = 0.416\ \sqrt{s}^{0.191}\ A^{0.128}\ \mathrm{GeV}/c$$

String tension: κ_0=2.9 GeV/fm

$$\kappa(s,A) = \kappa_0\ (s/s0)^{0.06}\ A^{0.167}\ \mathrm{GeV/fm}.$$

PDF: GRV+ HIJING shadowing

FF: PYTHIA + minijet

kTpQCD

PRC65 (2002)034903

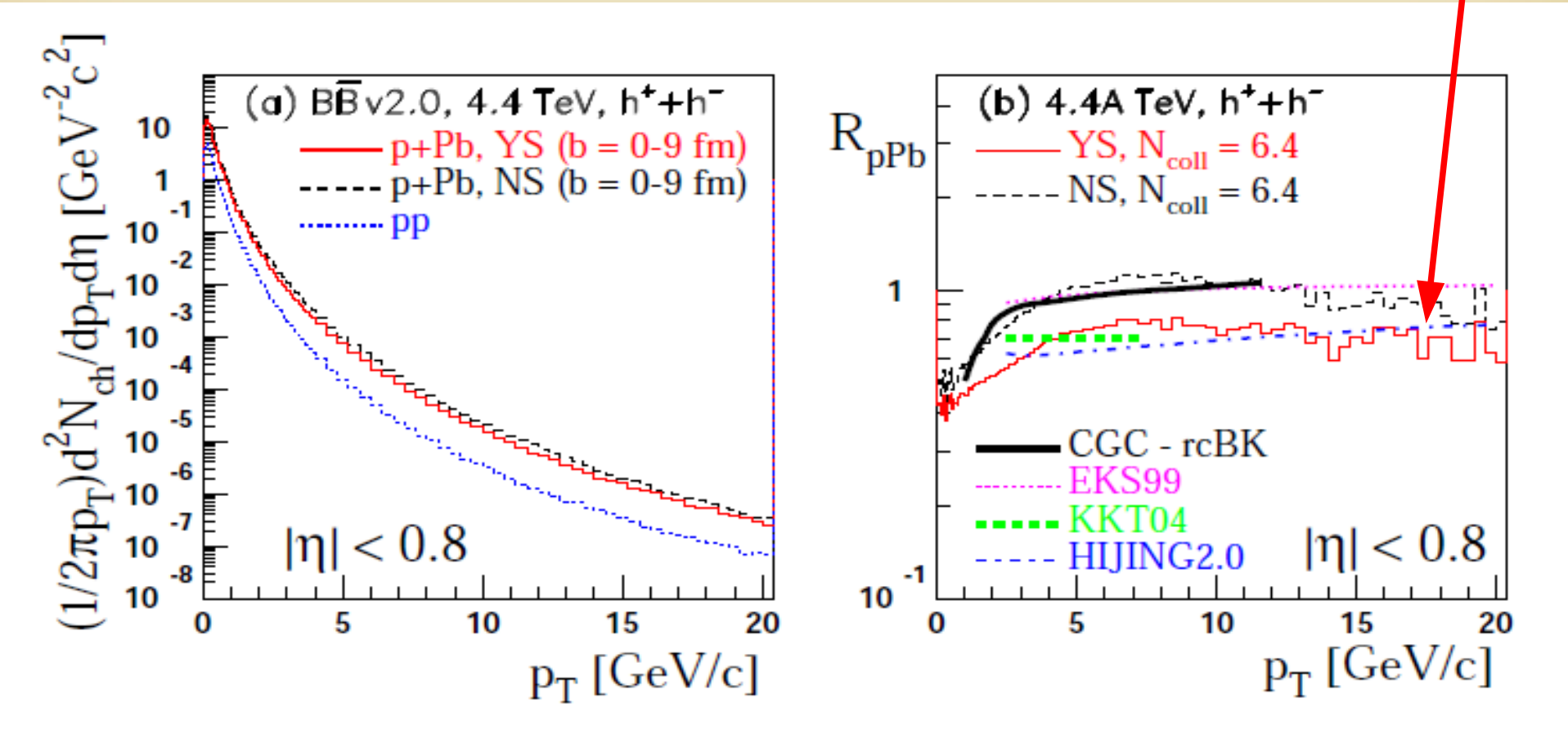
NLO pQCD based parton model with intrinsic-k_T, k_T-broadening, and various shadowing parametrization.

$$E_\pi \frac{\mathrm{d}\sigma_\pi^{dAu}}{\mathrm{d}^3 p_\pi} = f_{a/d}(x_a, Q^2; \mathbf{k}_{Ta}) \otimes f_{b/Au}(x_b, Q^2; \mathbf{k}_{Tb}) \otimes \otimes \frac{\mathrm{d}\sigma^{ab\to cd}}{\mathrm{d}\hat{t}} \otimes \frac{D_{\pi/c}(z_c, \hat{Q}^2)}{\pi z_c^2}, \quad (1)$$

PDF:GRV/MRST+Shad, FF:KKP

The Spectra and $R_{pPb}(p_T)$ for $|\eta|<0.8$

Charged hadron production with HIJING 2.0 @ 4.4 ATeV $R_{pA} \sim 0.7$



GGB, J. Barrette, M. Gyulassy, P. Lévai, V. Topor Pop PRC85 024903 (2012)

The Spectra and $R_{pPb}(p_T)$ for $|\eta|<0.35$ & 0.8

Hadron production with HIJING2.0 @ 0.2 AGeV & 4.4 AteV

Shadowing:

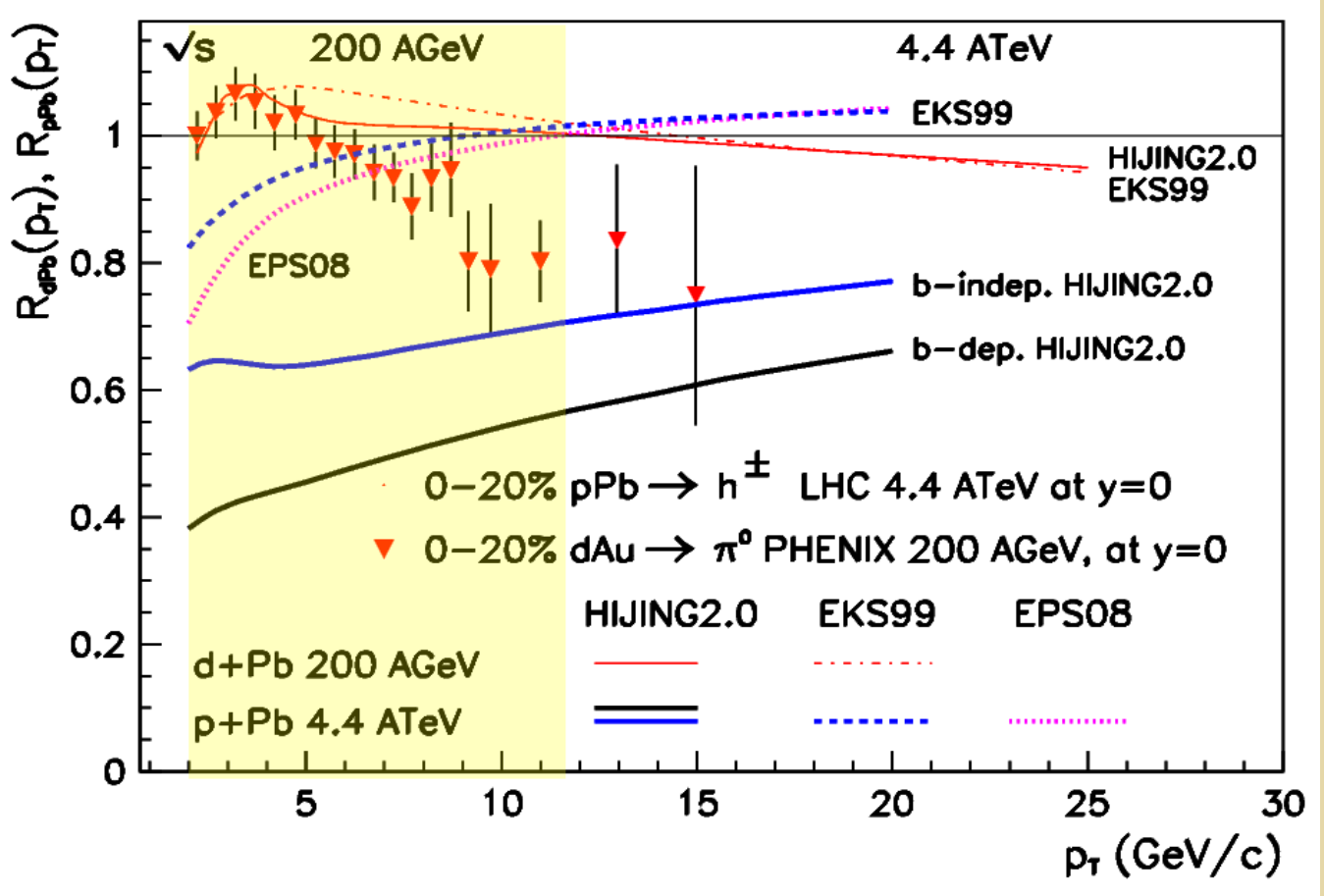
$$f_{a/A}(x,Q^2) = S_{a/A}(x,Q^2) f_{a/N}(x,Q^2)$$

b-dependent part

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

with

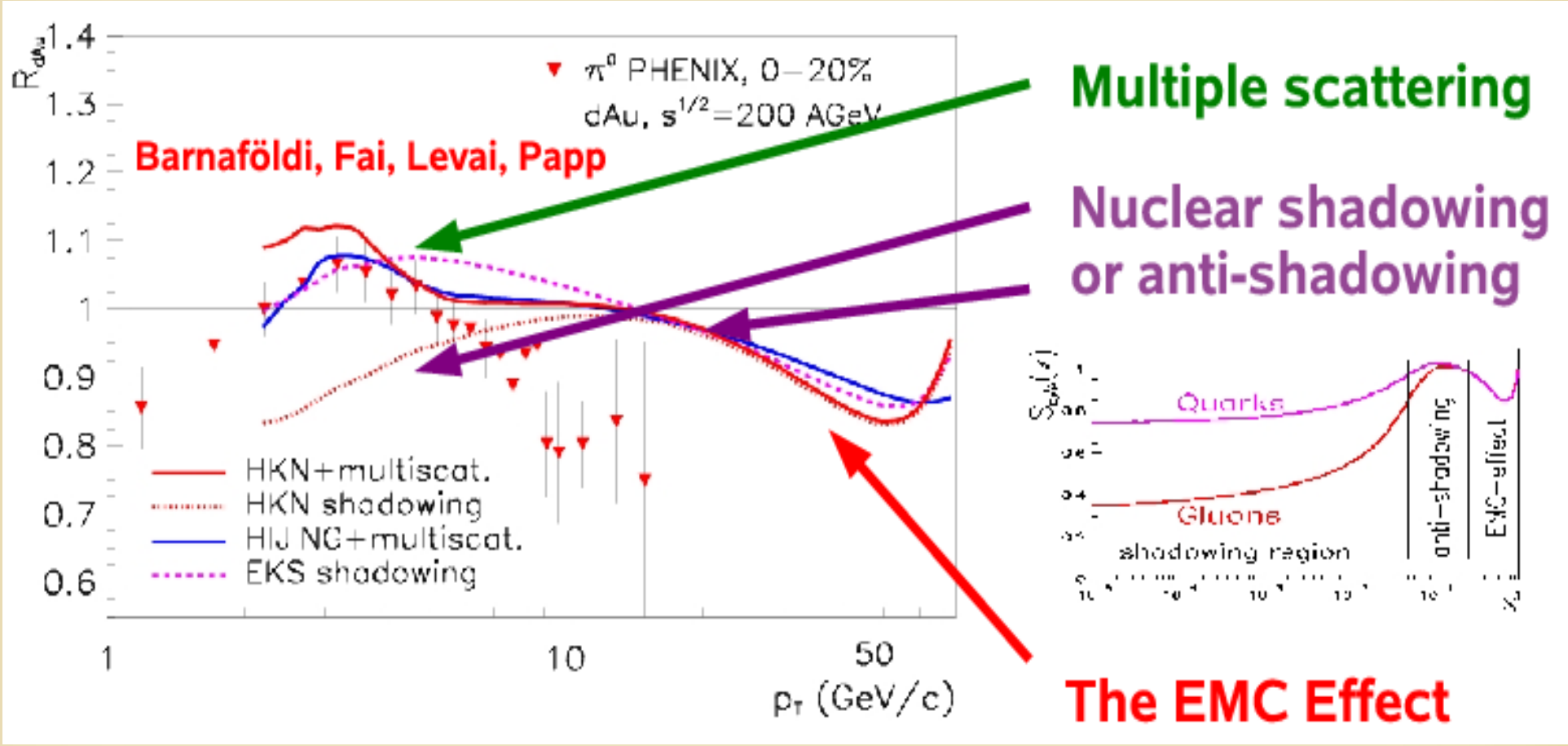
$$R_A = 1.12 A^{1/3}$$



GGB, J. Barrette, M. Gyulassy, P. Lévai, V. Topor Pop PRC85 024903 (2012)

Shadowing effects on $R_{dAu}(p_T)$ for $|\eta| < 0.35$

Extreme high-p_T Pion production with kTpQCD @ 200 AGeV



BA Cole, GGB, G. Fai, P. Lévai, G. Papp, arXiv:08073384 (2007)

Midrapidity $R_{dA}(x_T)$ for $|\eta|< 0.35$

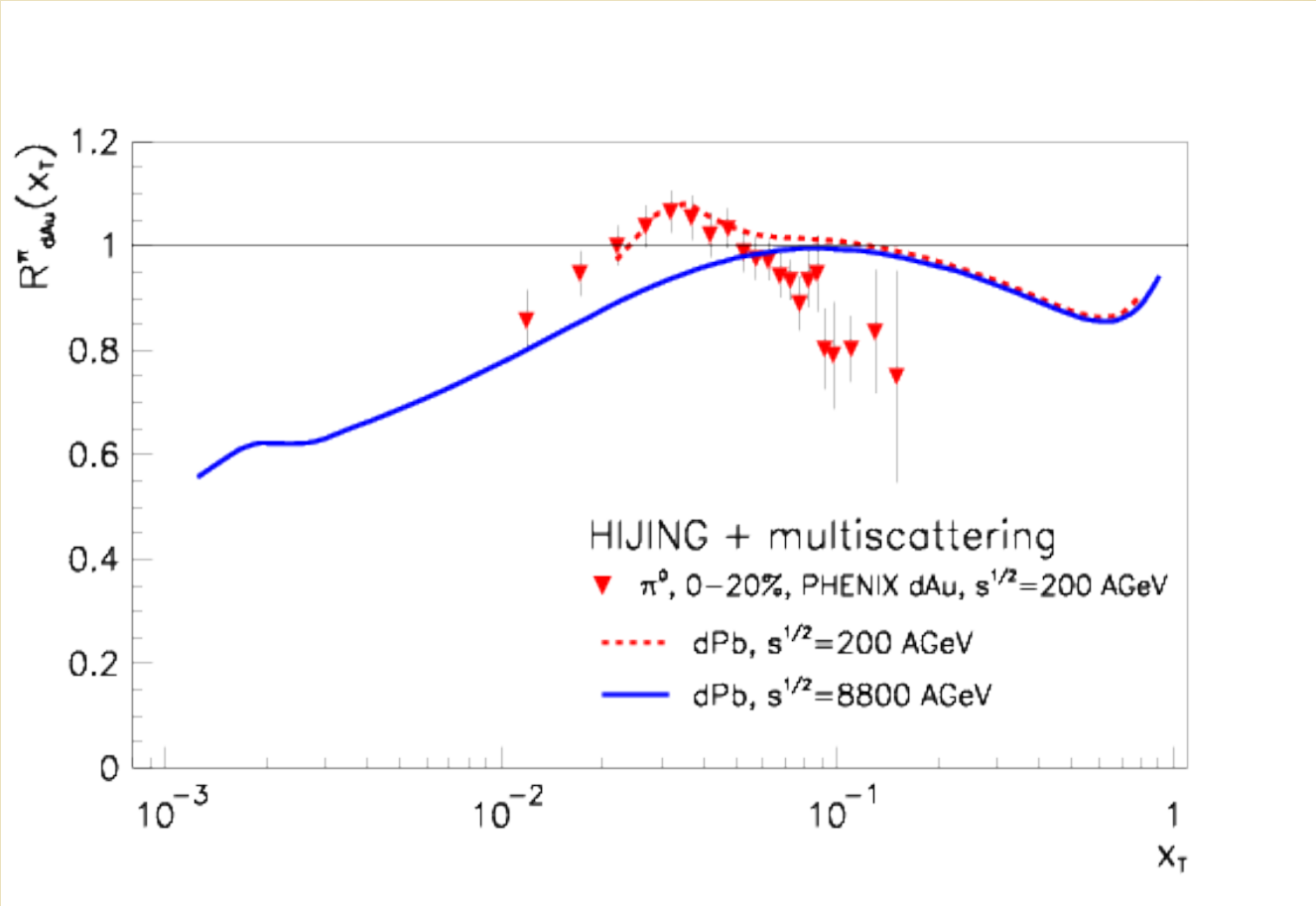
Pion production with HIJING shadowing kTpQCD @ 0.2 & 8.8 ATeV

HIJING Shadowing

x-scaling

DGLAP evolution

Need for additional multiple scattering



GGB, G. Fai, P. Lévai, BA Cole, G. Papp, Indian J.Phys. 84 (2010) 1721-1725

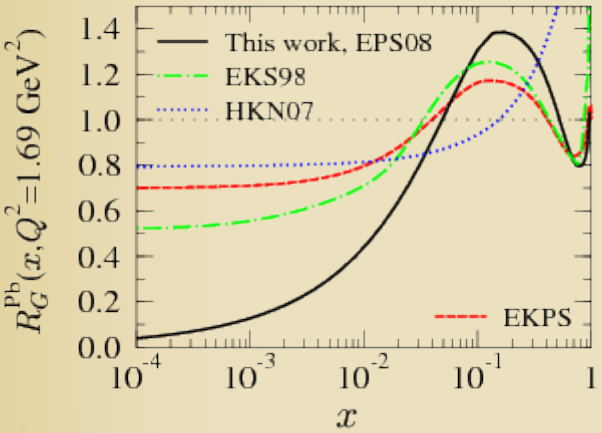
Midrapidity $R_{dA}(x_T)$ for $|\eta| < 0.35$

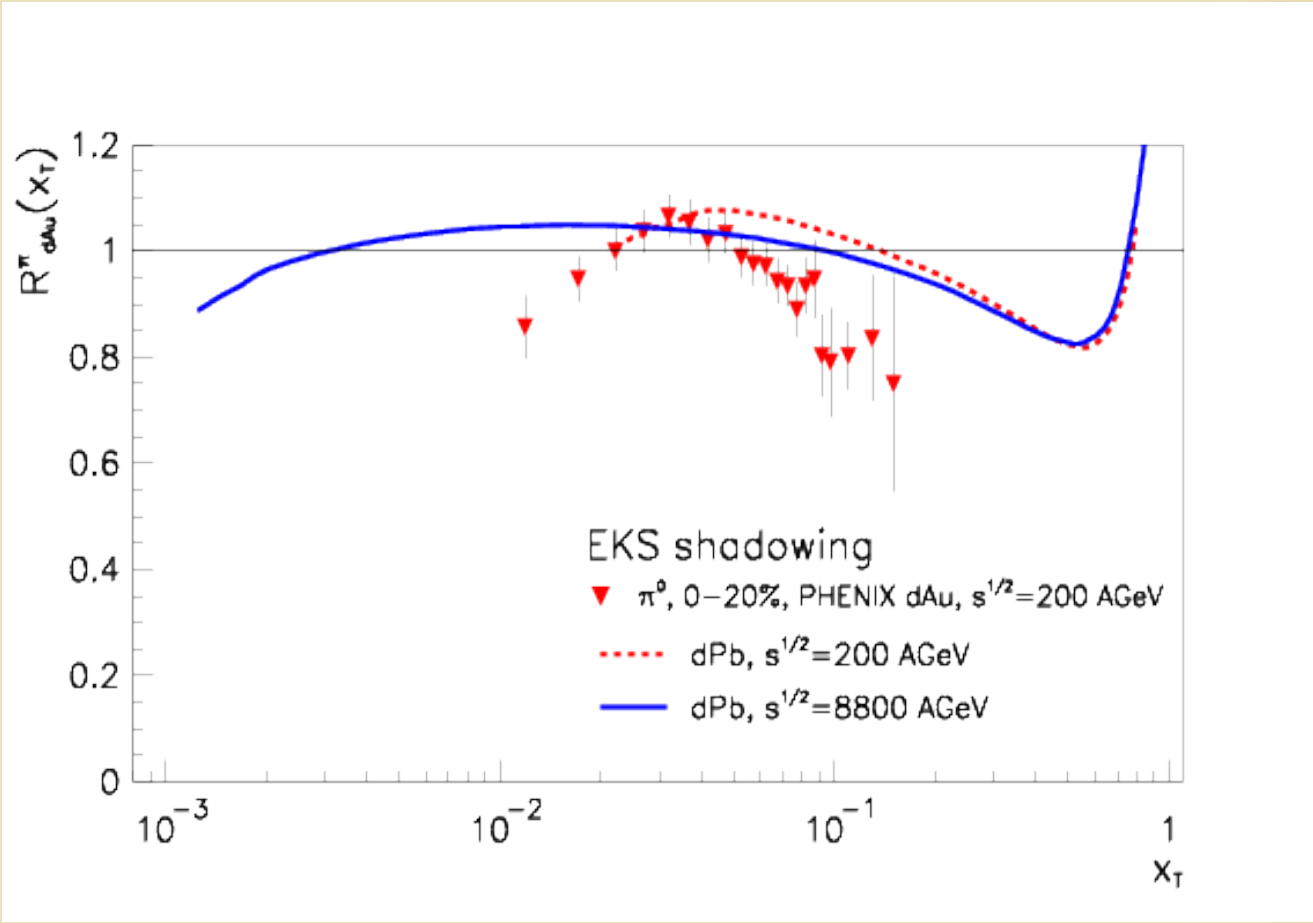
Pion production with EKS shadowing kTpQCD @ 0.2 & 8.8 ATeV

EKS Shadowing

x-scaling

DGLAP evolution





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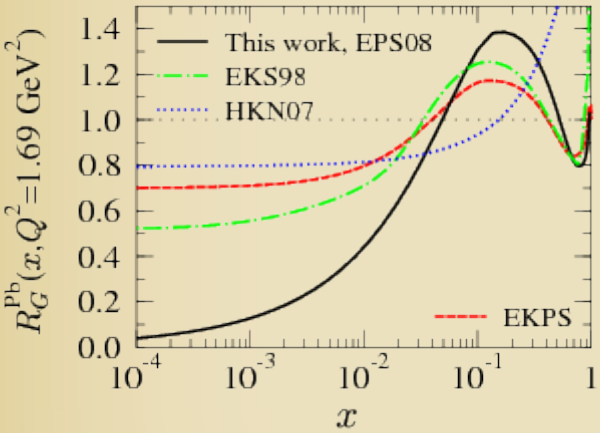

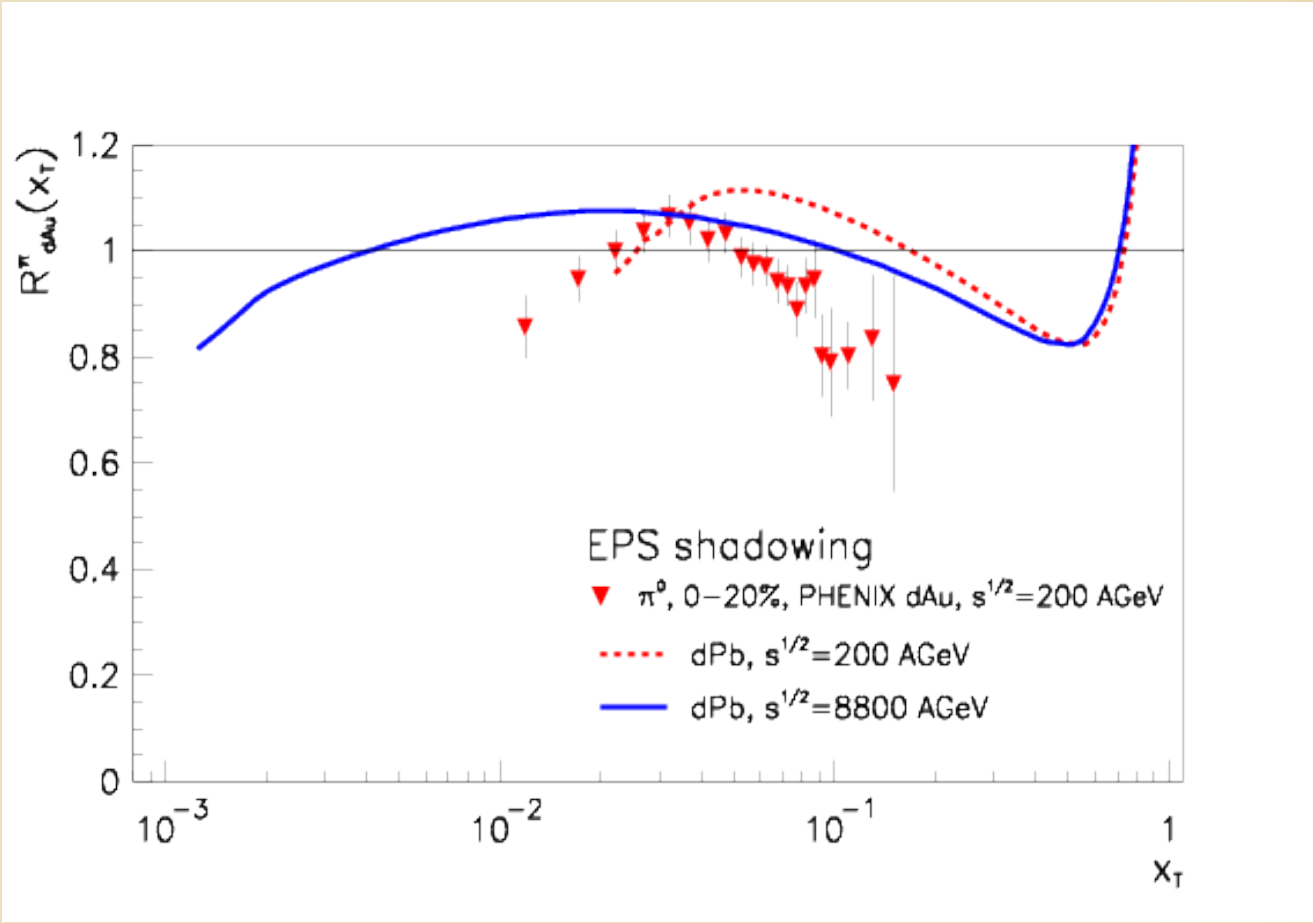

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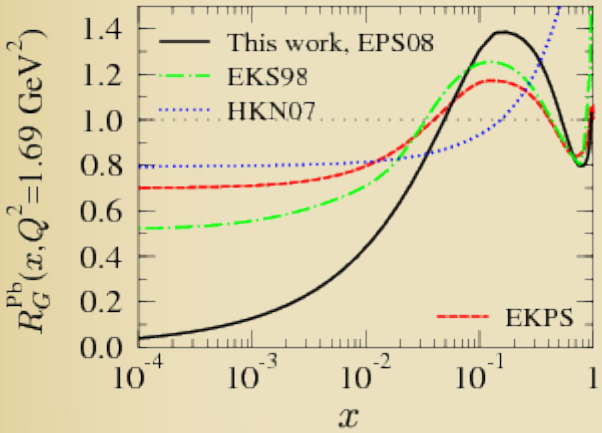
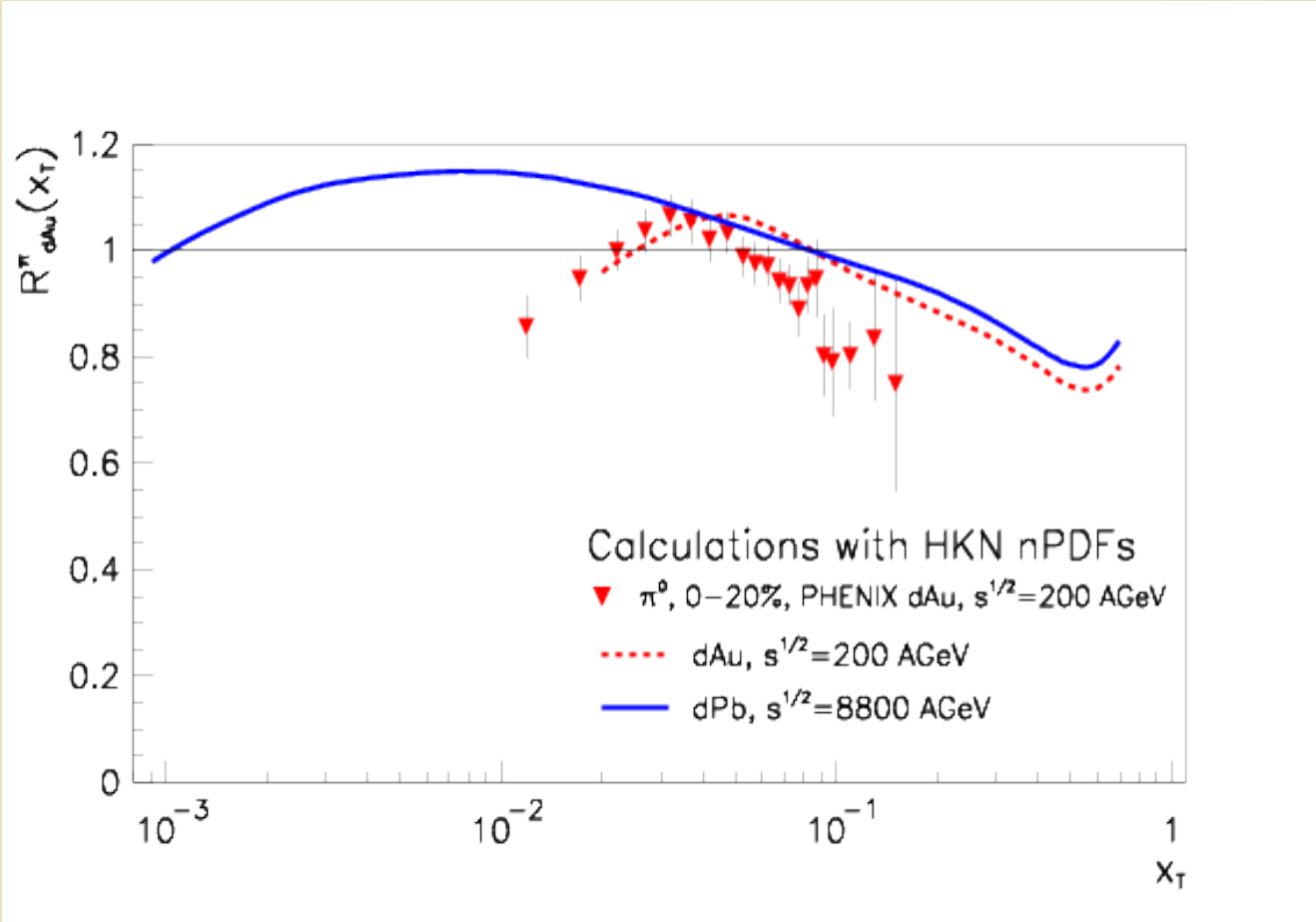
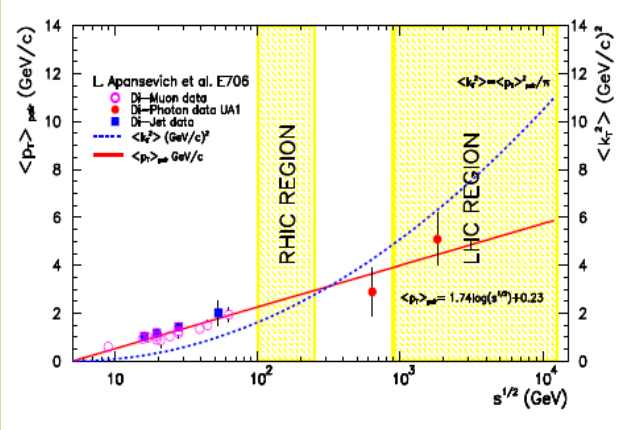


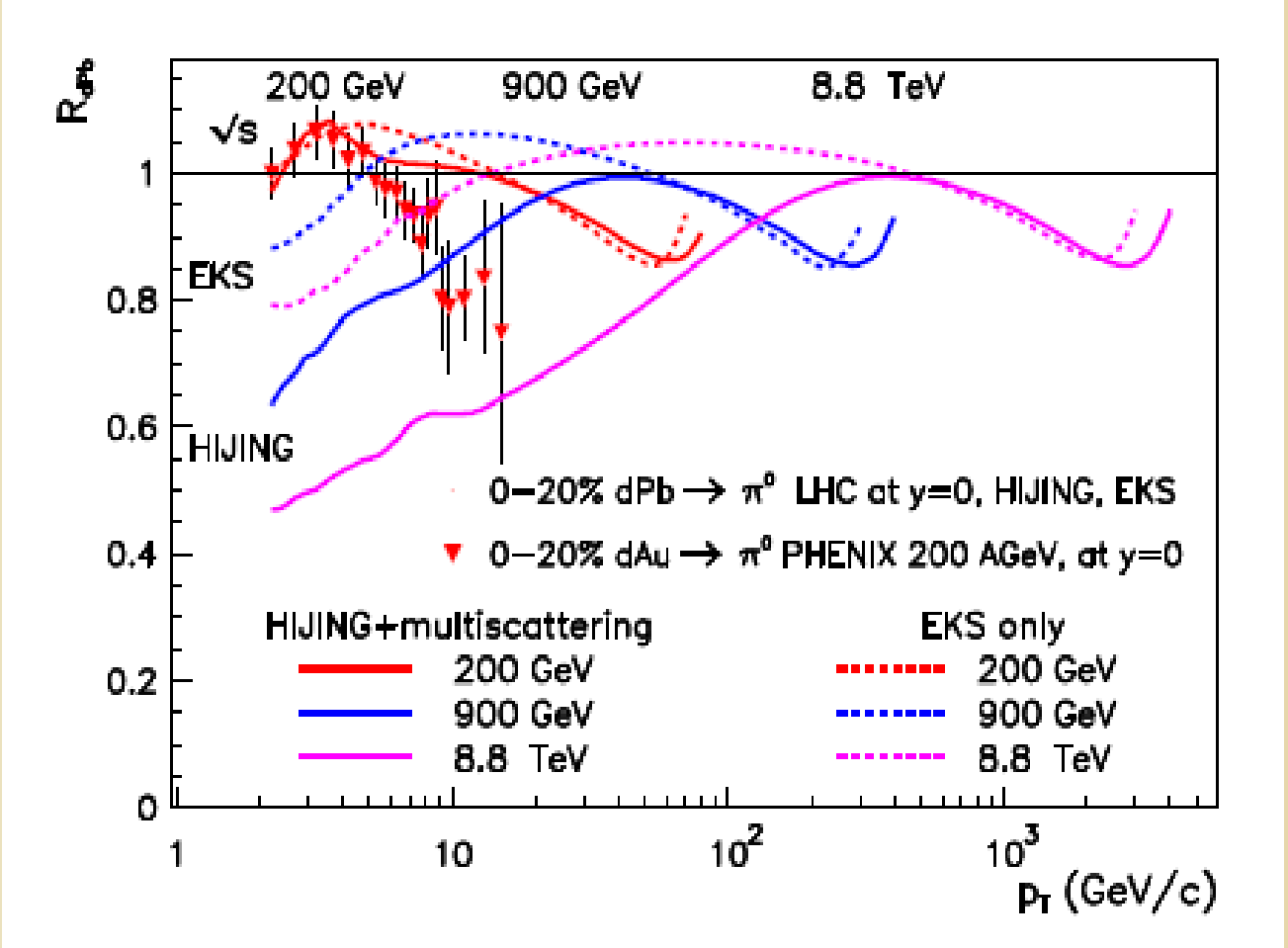


BA Cole, GGB, G. Fai, P. Lévai, G. Papp, arXiv:08073384 (2007)

Midrapidity $R_{dA}(p_T)$ fot LHC – Summary

Extreme high-p_T Pion production kTpQCD @ 0.2, 0.9, & 8.8 ATeV





k_T-broadening:

$$f_{a/p}(x_a, \mathrm{k}_{Ta}, Q^2) = f_{a/p}(x_a, Q^2) \cdot g_{a/p}(\mathrm{k}_{Ta})$$

$$\langle k_T^2 \rangle_{pA} = \langle k_T^2 \rangle_{pp} + C \cdot h_{pA}(b)$$

$$\langle k_T^2 \rangle_{pp} = \langle p_T \rangle_{pair}^2 / \pi$$

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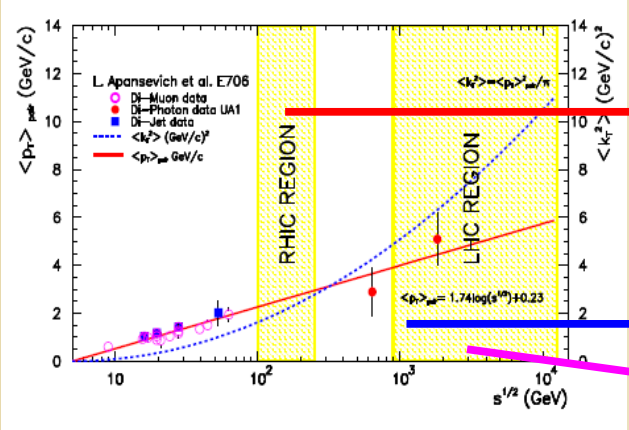

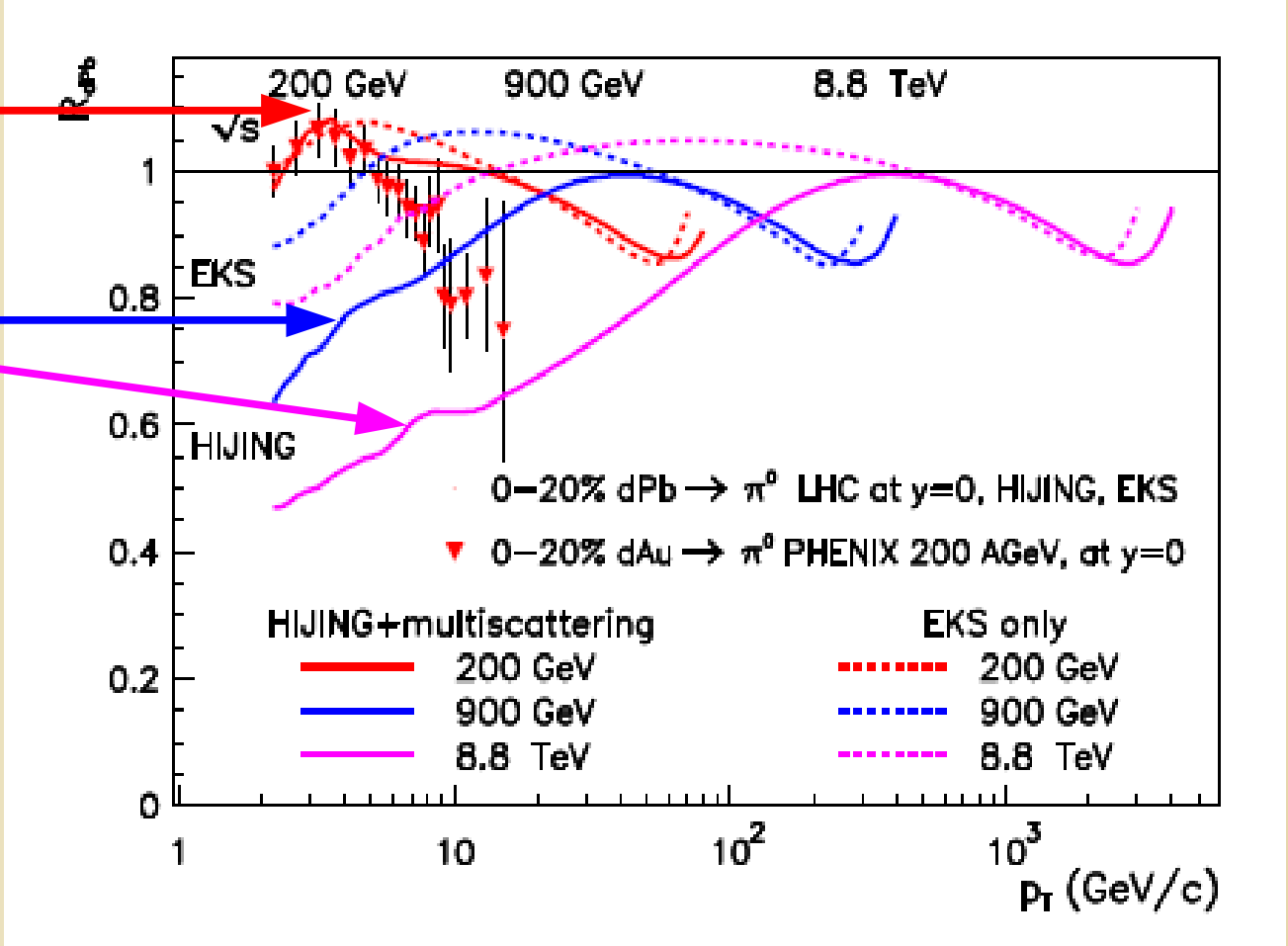

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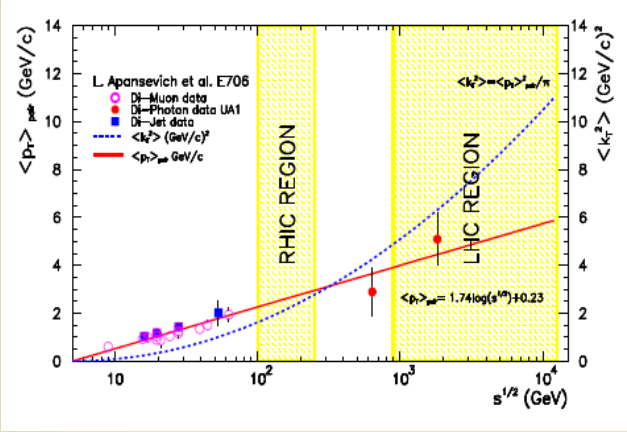
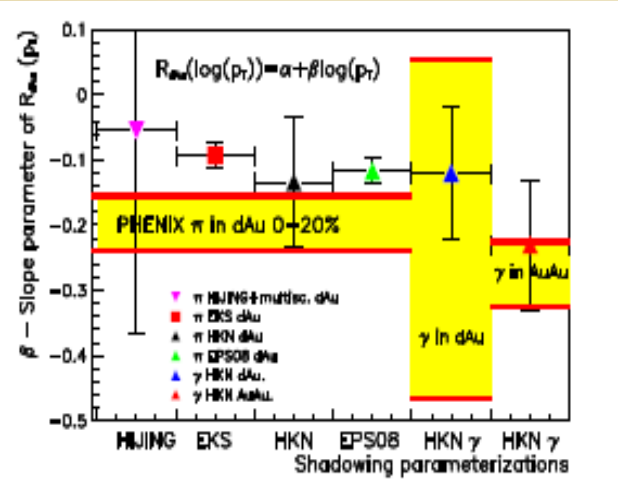
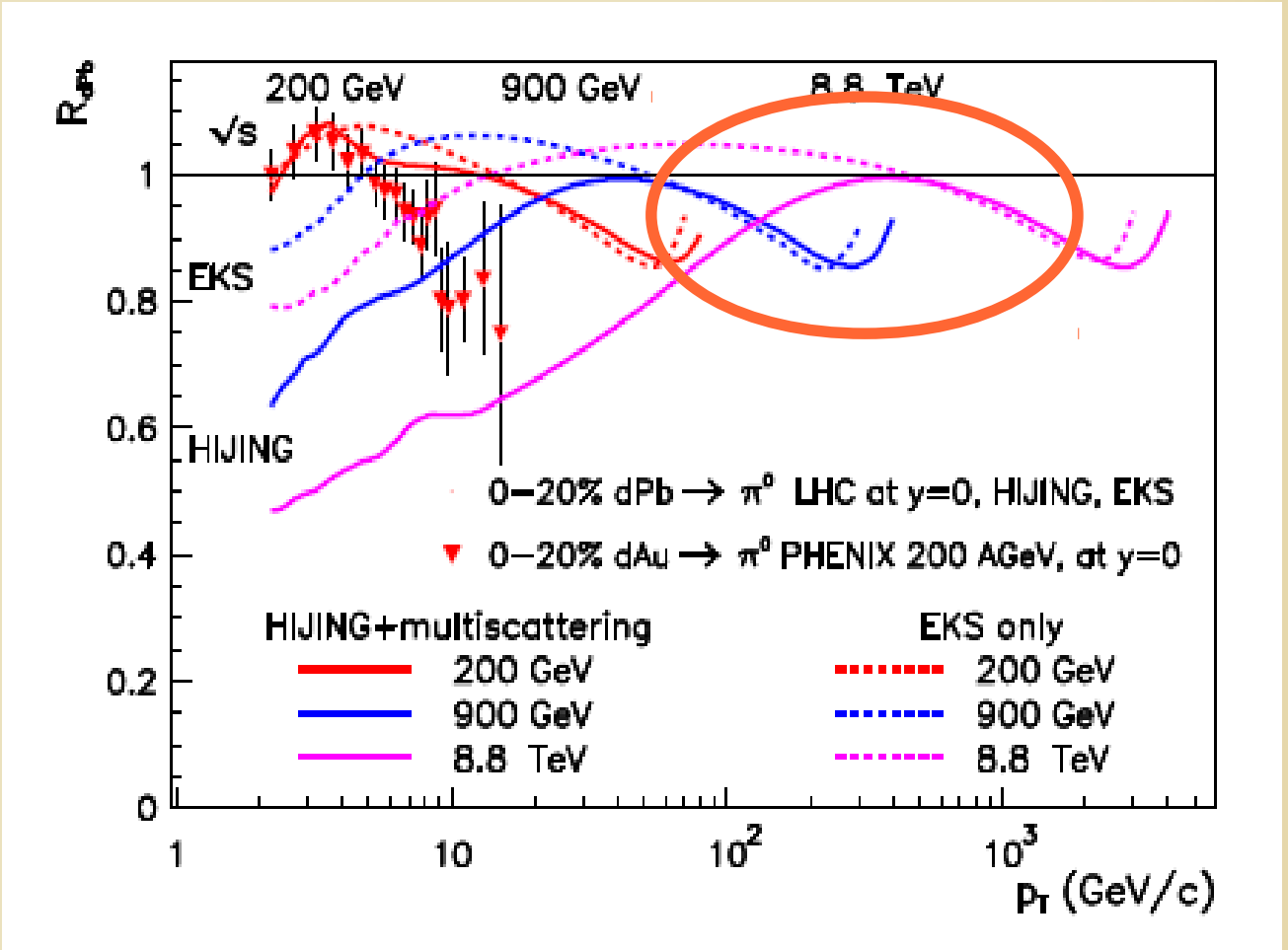


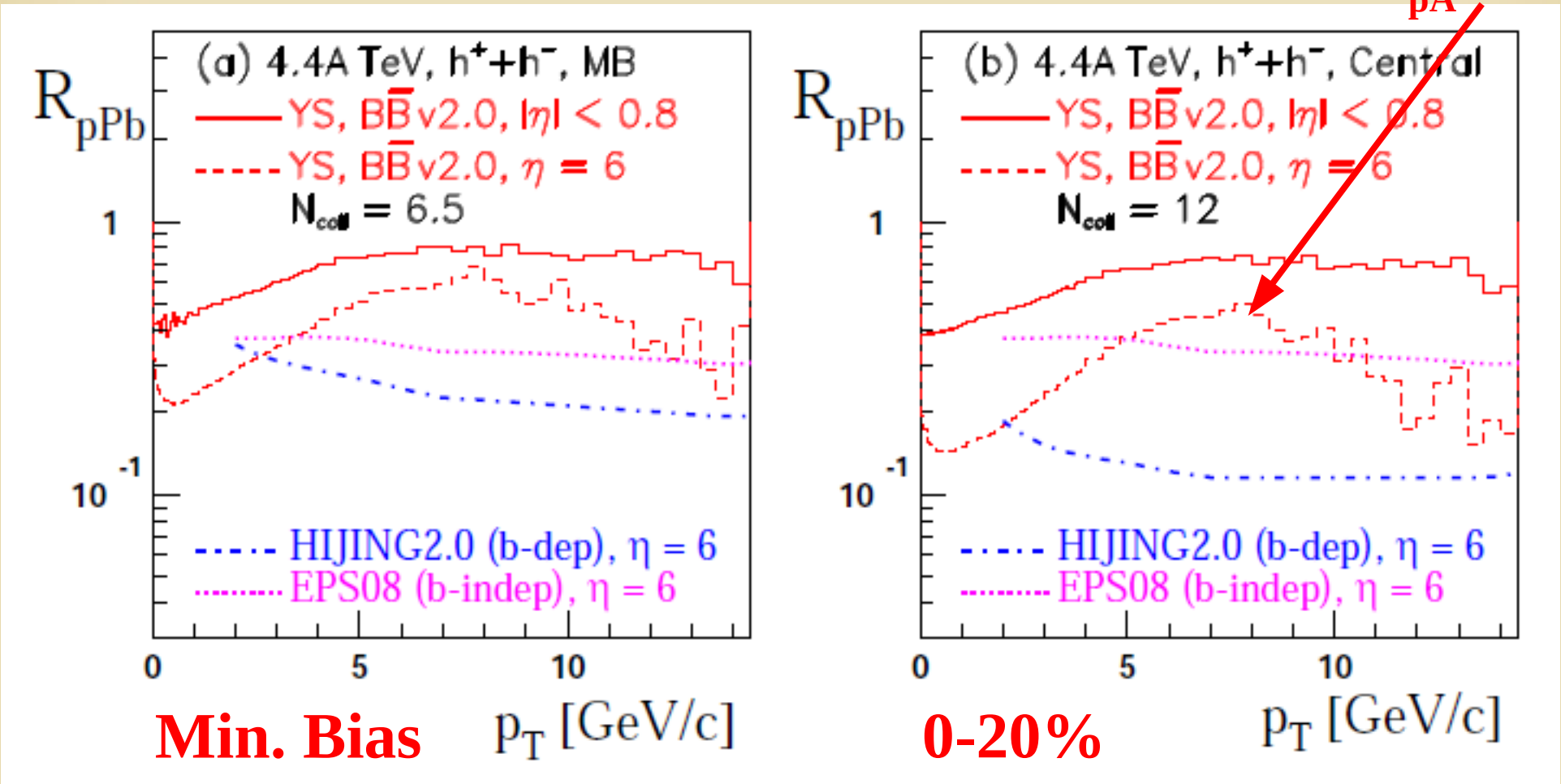




BA Cole, GGB, G. Fai, P. Lévai, G. Papp, arXiv:08073384 (2007)

Forward $R_{pPb}(p_T)$ at $|\eta|< 0.8$ & $\eta=6.0$

Charged hadron production with HIJING 2.0 @ 4.4 ATeV $R_{pA} \sim 0.35$



GGB, J. Barrette, M. Gyulassy, P. Lévai, V. Topor Pop PRC85 024903 (2012)

Rapidity asymmetry for *dAu* at RHIC

Pion production with kTpQCD @ 200 AGeV

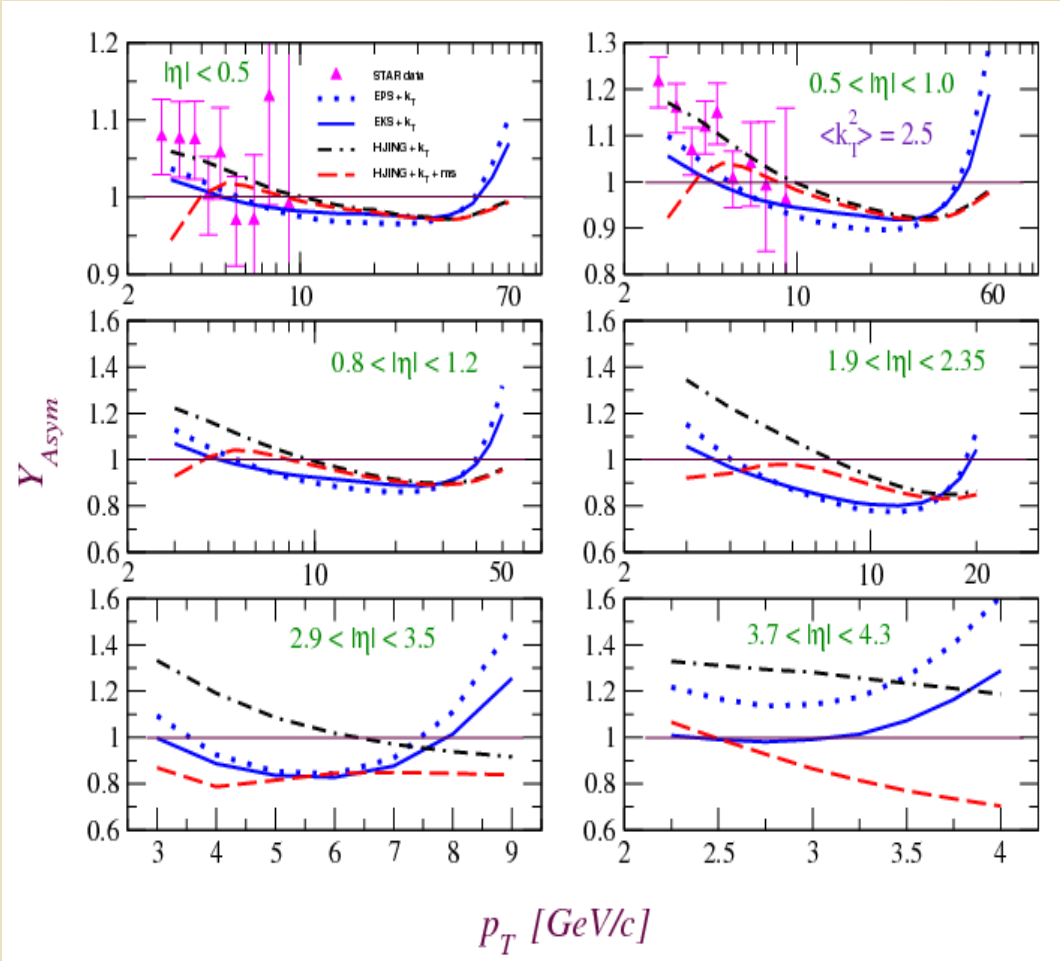
Rapidity asymmatry

$$Y^h_{Asym}(p_T) = E_h \frac{\mathrm{d}^3\sigma^h_{AB}}{\mathrm{d}^3 p_T}\bigg|_{\eta<0} \Big/ E_h \frac{\mathrm{d}^3\sigma^h_{AB}}{\mathrm{d}^3 p_T}\bigg|_{\eta>0}$$

Relation to NMF

$$Y^h_{Asym}(p_T) = R^h_\eta(p_T) = \frac{R^h_{dAu}(p_T, \eta<0)}{R^h_{dAu}(p_T, \eta>0)}$$

X-scaling is OK,
Multiscattering changes *Y(η)*

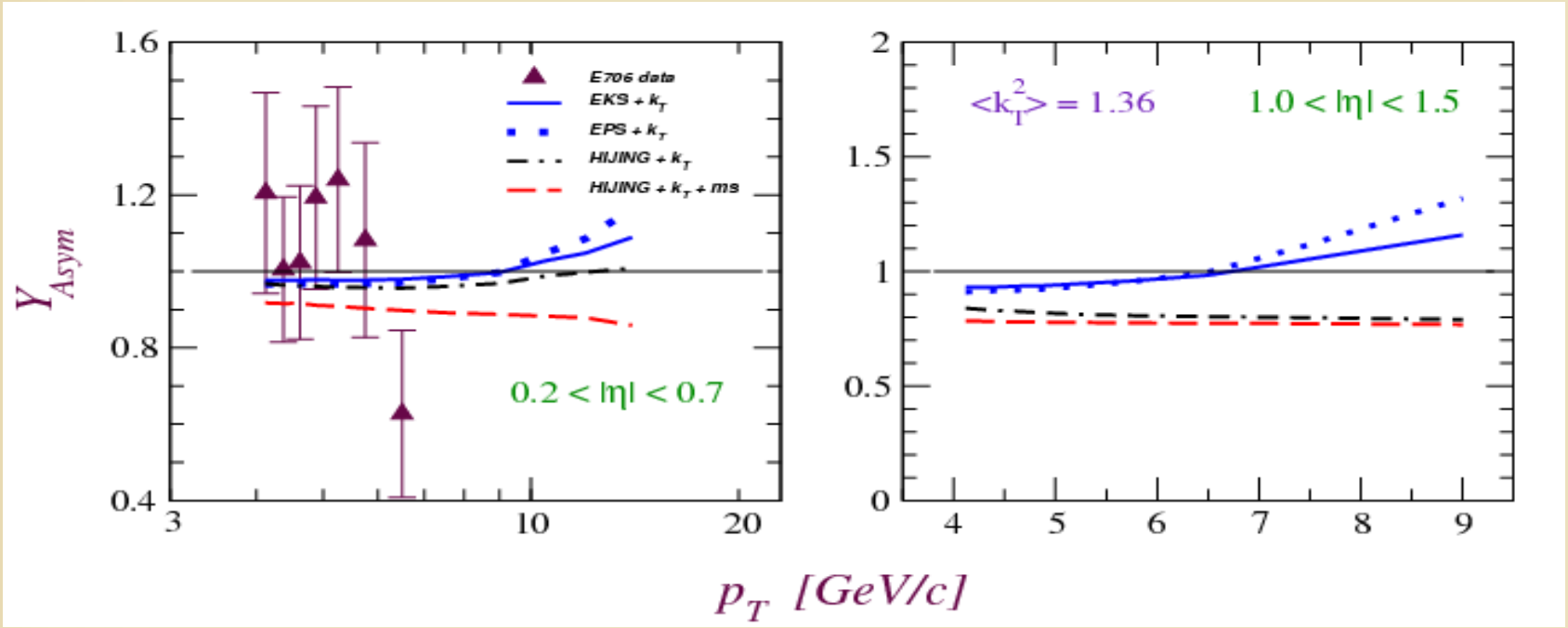


A. Adeluy, GGB, G. Fai, P. Lévai, PRC80 (2009) 014903

Rapidity asymmetry for *pBe* at FNAL

Pion production with kTpQCD @ 30.7 GeV

$$Y^h_{Asym}(p_T) = E_h \frac{d^3\sigma^h_{AB}}{d^3p_T}\bigg|_{\eta<0} \Big/ E_h \frac{d^3\sigma^h_{AB}}{d^3p_T}\bigg|_{\eta>0}$$

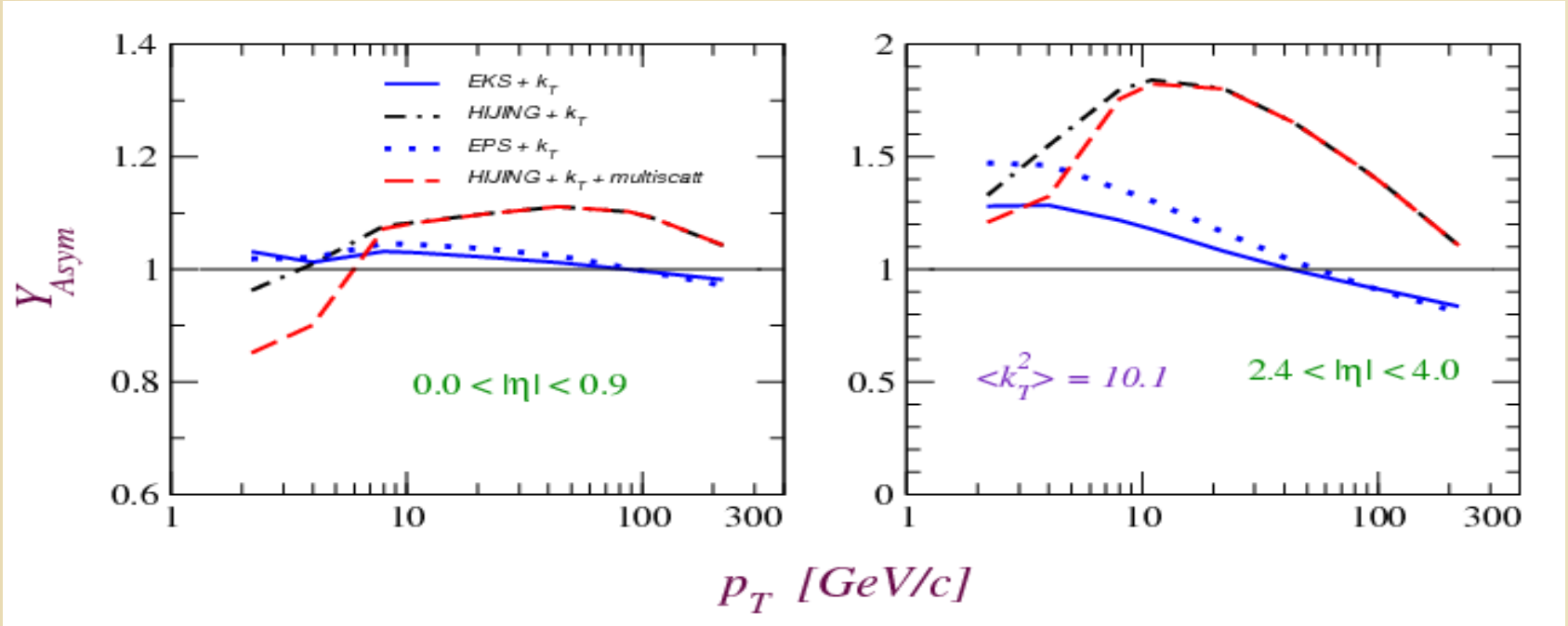


A. Adeluy, GGB, G. Fai, P. Lévai, PRC80 (2009) 014903

Rapidity asymmetry for *dPb* at LHC

Pion production with kTpQCD @ 8.8 ATeV

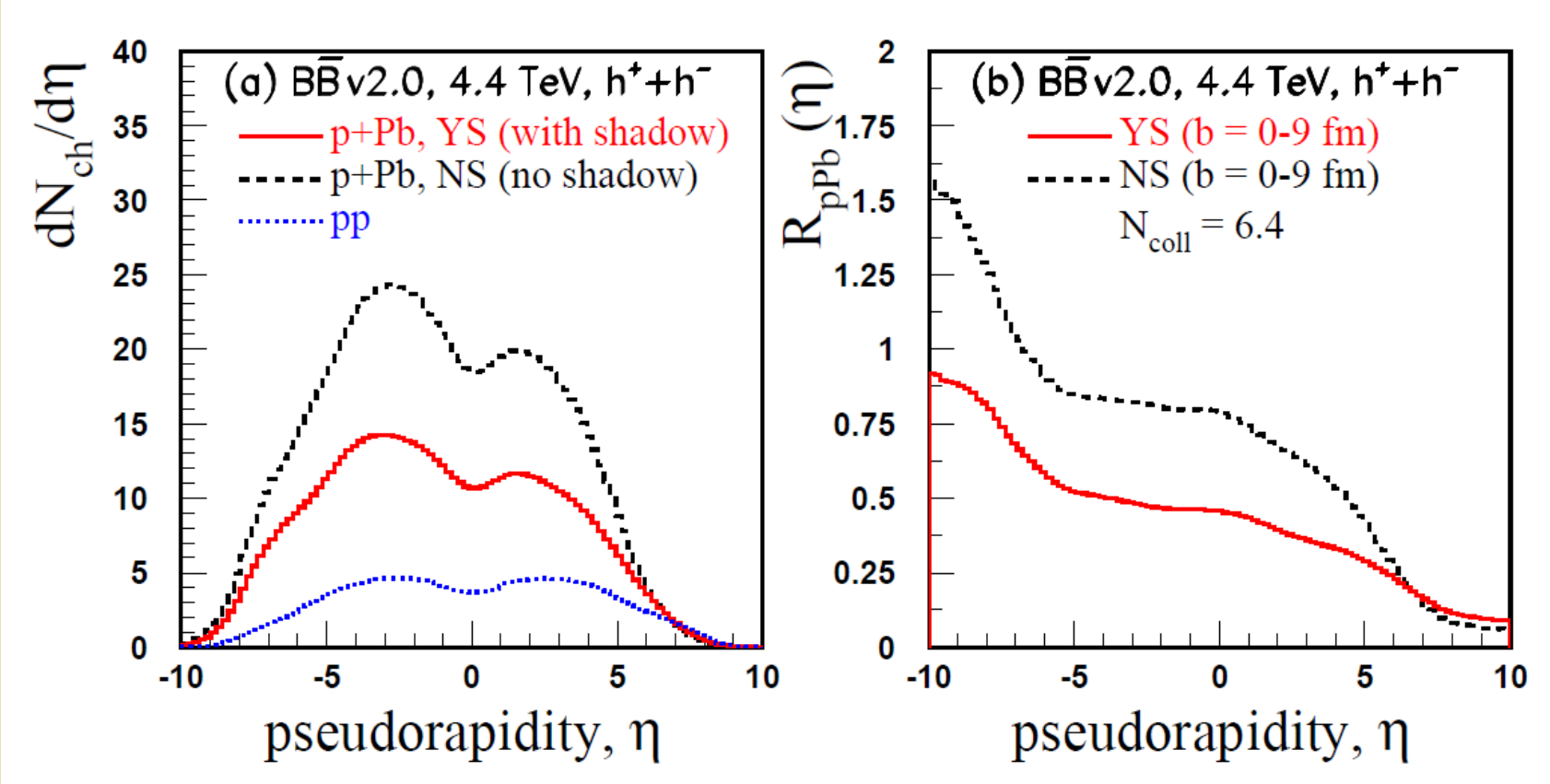
$$Y^h_{Asym}(p_T) = E_h \frac{d^3\sigma^h_{AB}}{d^3p_T}\bigg|_{\eta<0} \Big/ E_h \frac{d^3\sigma^h_{AB}}{d^3p_T}\bigg|_{\eta>0}$$



A. Adeluy, GGB, G. Fai, P. Lévai, PRC80 (2009) 014903

HIJINGB/B 2.0: Rapidity distribution for pp & pPb

Charged hadron production with HIJING 2.0 @ 4.4 ATeV



GGB, J. Barret, M. Gyulassy, P. Lévai, V. Topor Pop PRC85 024903 (2012)

S U M M A R Y

Our choice from the menu...

...to make consistent picture from 10 AGeV to 10 ATeV

- Test of the Cronin Effect in pA
  - How strong is the effect at LHC
  - Scaling x_T, p_T, etc?
- Test of shadowing parameterizations
  - Test of existing parameterizations at low-x
- Test of the rapidity asymmetry

EPJA: Topical issue on "Relativistic Hydro- and Thermodynamics"

One of the most striking and still unsolved puzzles in the physics of high energy elementary and complex reactions, like e+e-, pp, ppbar and heavy ion collisions at several GeV to several TeV energies, is represented by the unexpected and microscopically not reasoned success of the statistical equilibrium description. This description consists of two main aspects: the relativistic thermodynamic and hydrodynamic approach, including kinematic models based on particle concept. A comprehensive review of the multiple achievements and numerous assumptions embodied in the successful hydrodynamic approaches to high energy collisions in recent decades should serve as a basis for finding an explanation to the above puzzle. Detailed presentations of recent applications of contemporary developments towards a generalized equilibrium and non-equilibrium statistical physics description will be given as support. The planned issue may offer a wealthy source of information for future research aiming at microscopical or quantum physical understanding of the emergence of apparently thermal radiation and particle spectra in a number of high energy experiments.

The European Physics Journal A (Hadrons and Nuclei) therefore solicits submission of papers for a Topical Issue on *Relativistic Hydro- and Thermodynamics in Nuclear Physics*. Authors willing to contribute to this issue are expected to send an indication of their intention of submitting either a review or an original research article by e-mail to one of the Topical Issue guest editors

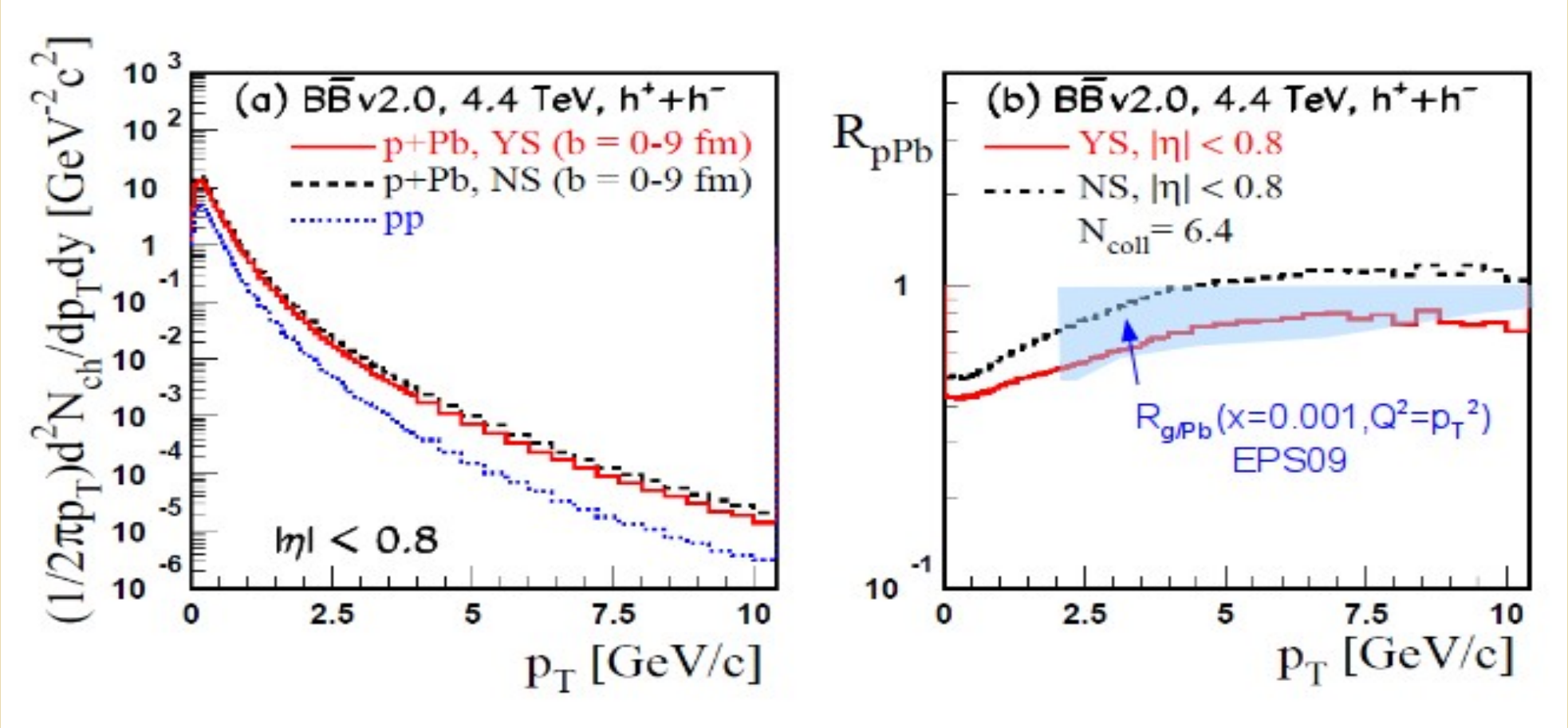
Deadline: 31st May 2012

Web: http://www.epj.org/special_issues_2.html

B A C K U P

The Spectra and RpPb(pT) for |eta|<0.8

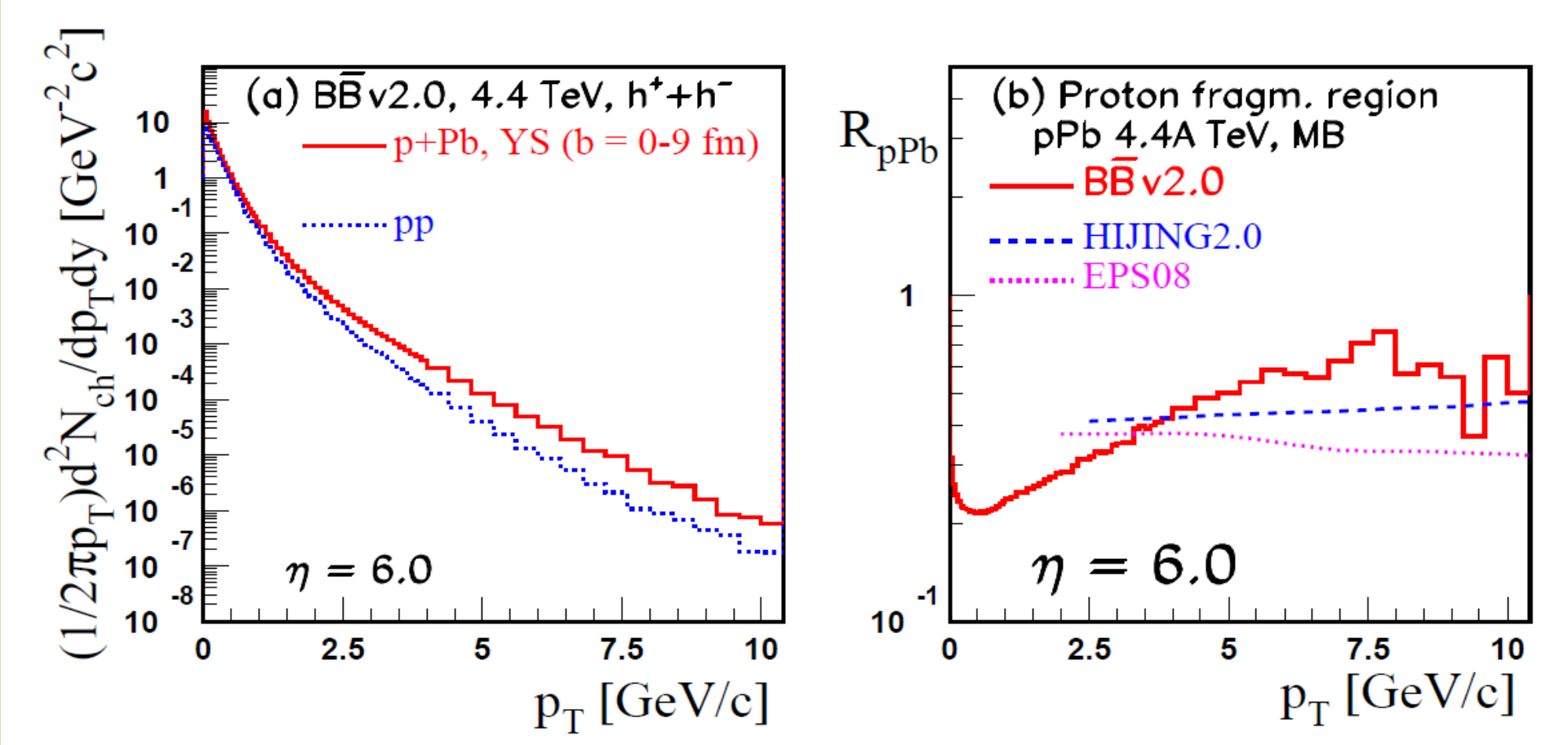
Charged hadron production with HIJING 2.0 @ 4.4 ATeV



GGB, J. Barrette, M. Gyulassy, P. Lévai, V. Topor Pop PRC85 024903 (2012)

Forward Spectra & $R_{pPb}(p_T)$ at η=6.0

Charged hadron production with HIJING 2.0 @ 4.4 ATeV



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