Geometric properties and charged particles yields behind Glauber model in high energy pA and AA collisions

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Saint-Petersburg
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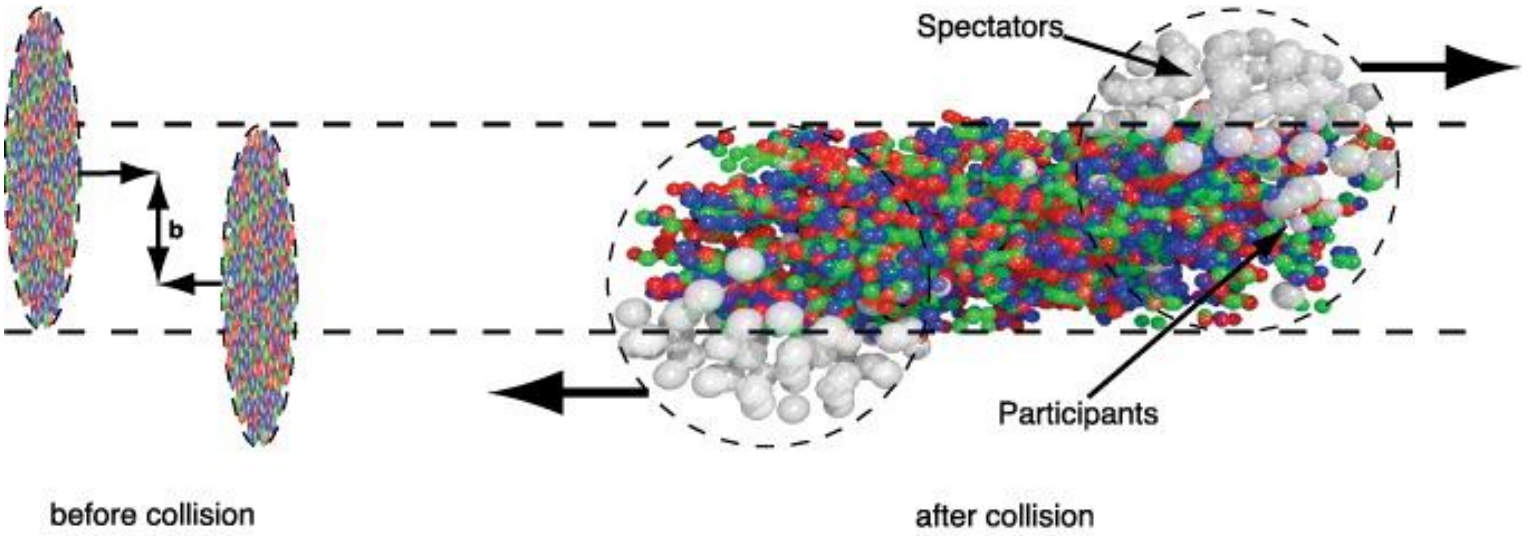
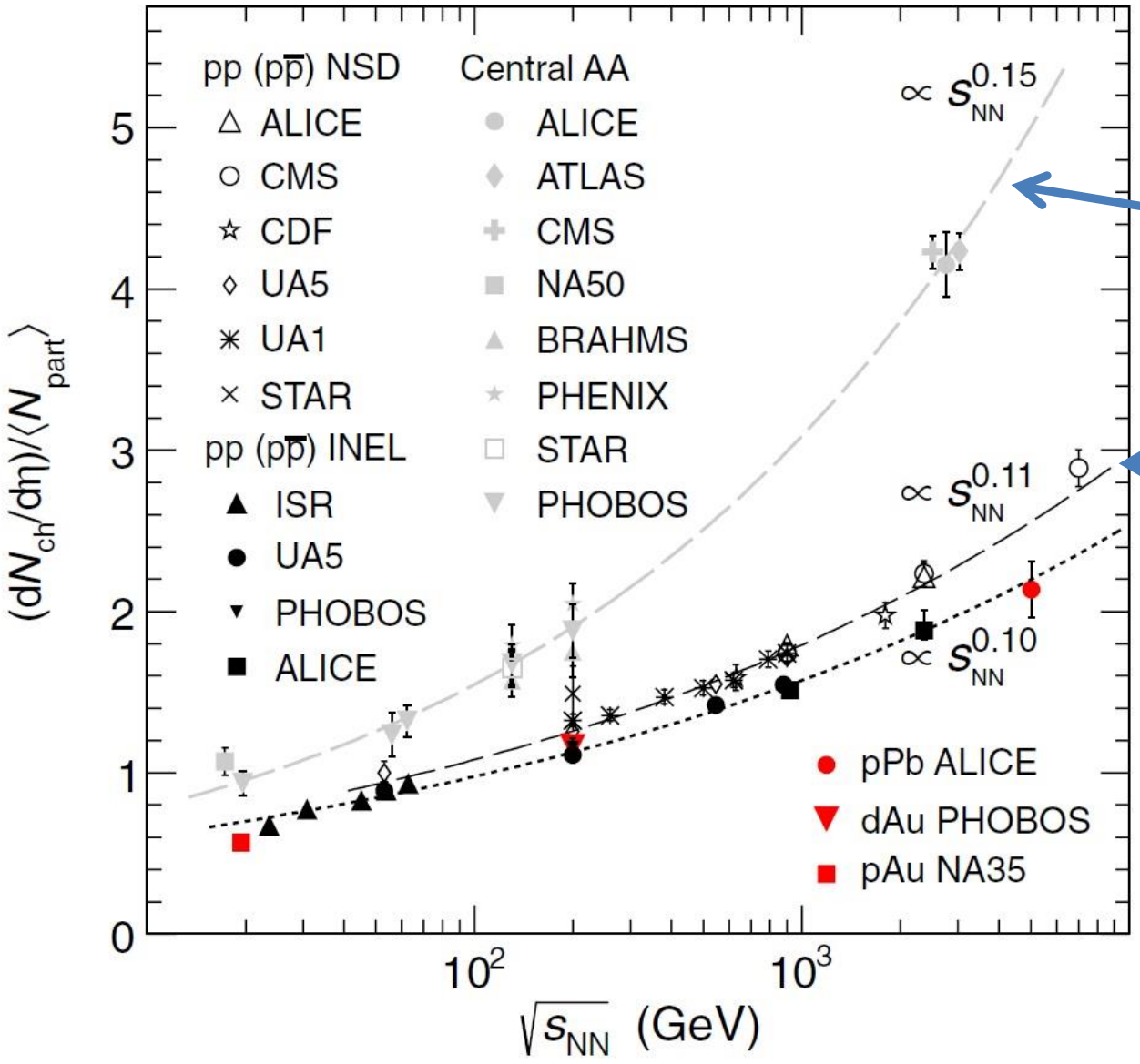
Terminology



- Nucleon-participants (N_{part}) – nucleons collided at least once
- Nucleon-spectators ($N_{spec} = 2A - N_{part}$=216 $- N_{part}$) – nucleons which didn't interact
- Number of nucleon-nucleon collisions (N_{coll})
- Multiplicity of charged particles (N_{ch})

Charged-particle pseudorapidity density at midrapidity normalized to Npart



most central AA collisions

pp collisions

AA collisions are not simple a superposition of nucleon collisions!

Standard Glauber model (SGM)

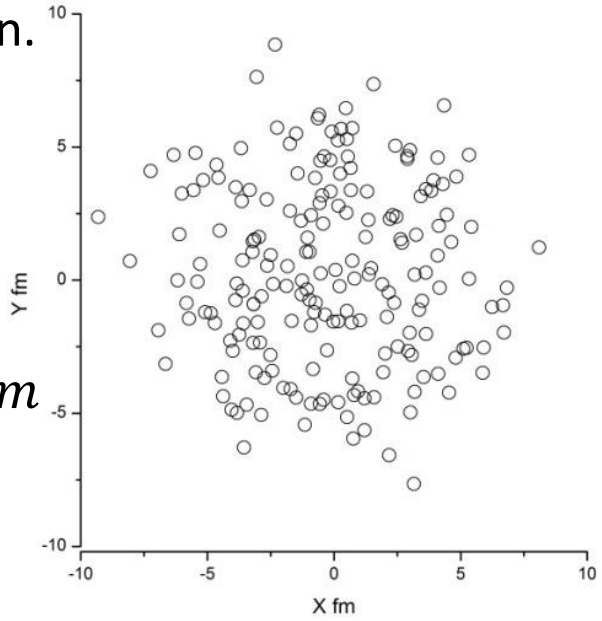
- AA-collision – sequence of nucleon-nucleon collisions.
- Nuclear density – distribution of the Woods-Saxon.
- Trajectories of nucleons are linear
- σ_{inel}^{nn}=const ← from experiments

$$\rho(r) = \rho_0 \frac{1}{1 + exp\left(\frac{r - R}{\alpha}\right)}$$

$$\alpha = 0.545$$

$$R = 1.07A^{1/3}\ fm$$

ρ_0 – nucleon density in the center of nucleus
R – radius of the nucleus
A – atomic number
α – diffusivity



- **Energy loss in nucleon collisions due to particle production are not considered**

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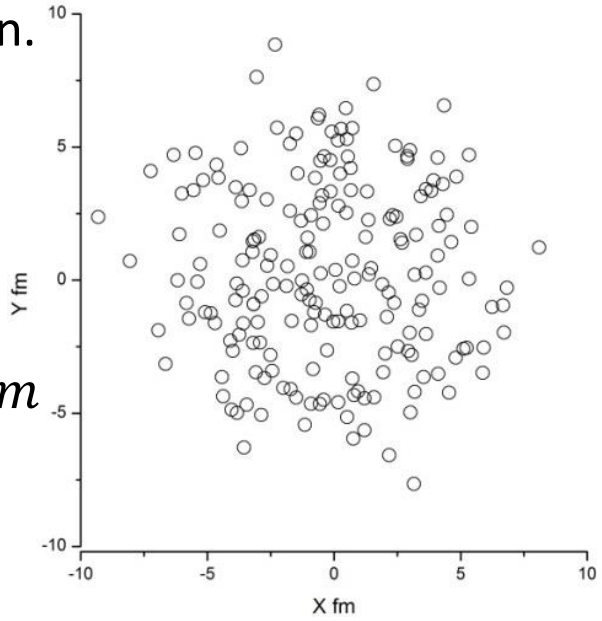

Number of nucleon-participants (Npart) and nucleon-nucleon collisions (Ncoll)

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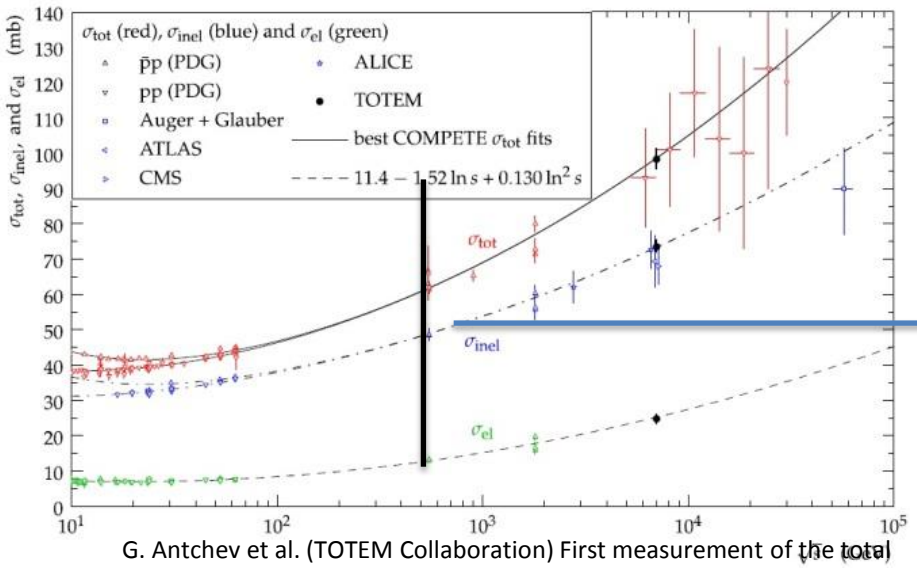
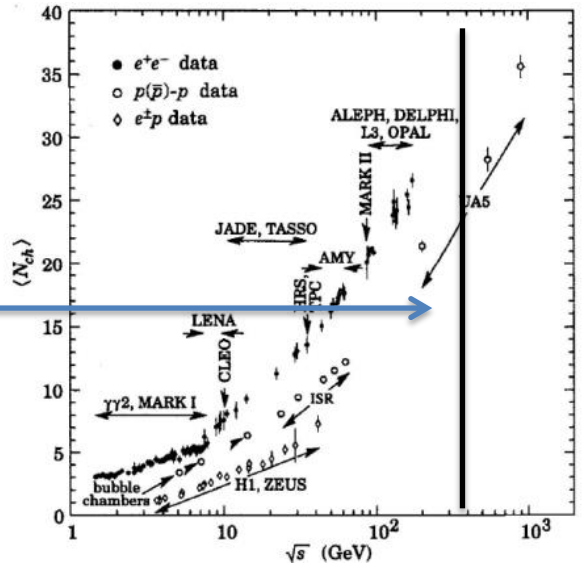


G. Antchev et al. (TOTEM Collaboration) First measurement of the total proton-proton cross-section at the LHC energy of $\sqrt{S}$ = 7 TeV, EPL, 96 (2011) 21002

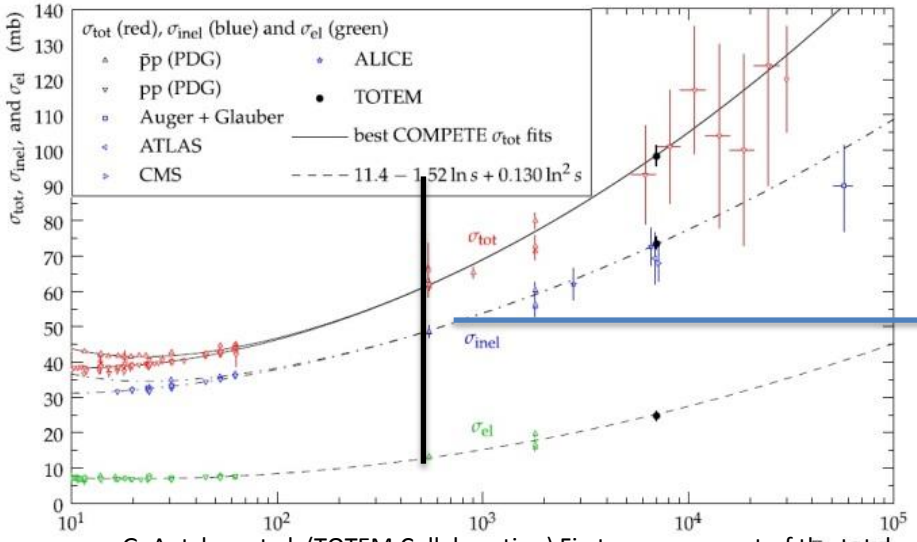


A. Ivanov: Long-range correlations and collectivity in pp and AA collisions, SPSU 2010, 42

Calculated for each nucleon-nucleon collision

$$N_{ch}^{AA}(\sqrt{s}) = N_{ch}^{pp}(\sqrt{s}) * N_{coll}$$

Standard Glauber model (SGM)



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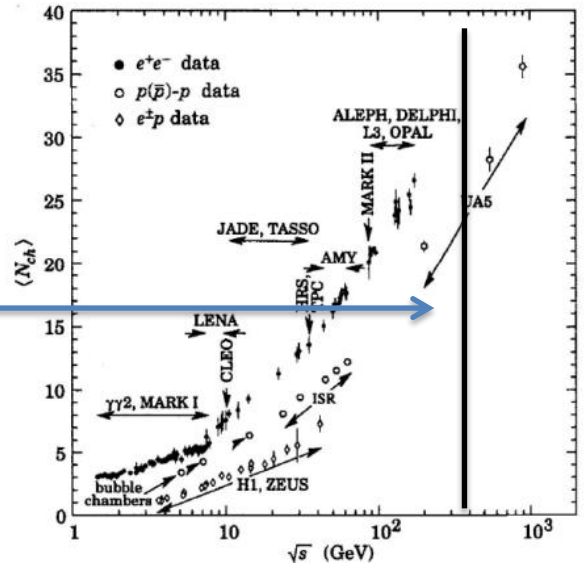

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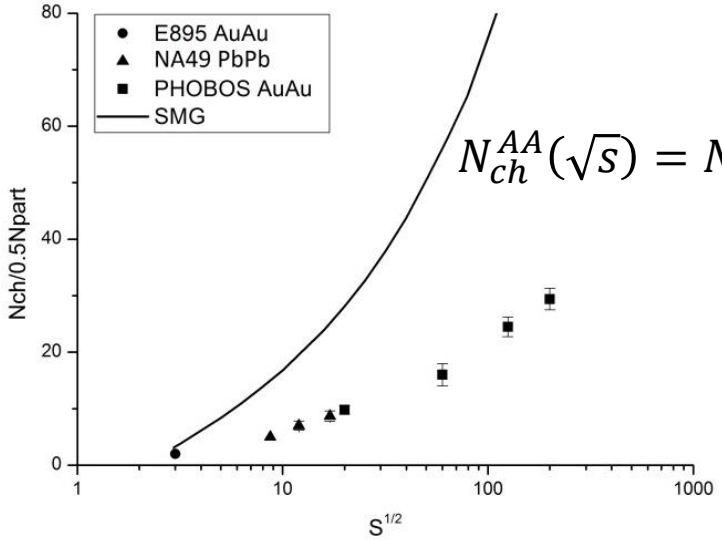

$$N_{ch}^{AA}(\sqrt{s}) = N_{ch}^{pp}(\sqrt{s}) * N_{coll}$$

Models with energy-momentum conservation

- Modified Glauber model
- Non-Glauber MC model (V. Kovalenko)
- HIJING

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Modified Glauber model (MGM)

- Each nucleon in collisions loses in the inelastic collision the fixed portion (1-k) of momentum in the center of mass system[1]:

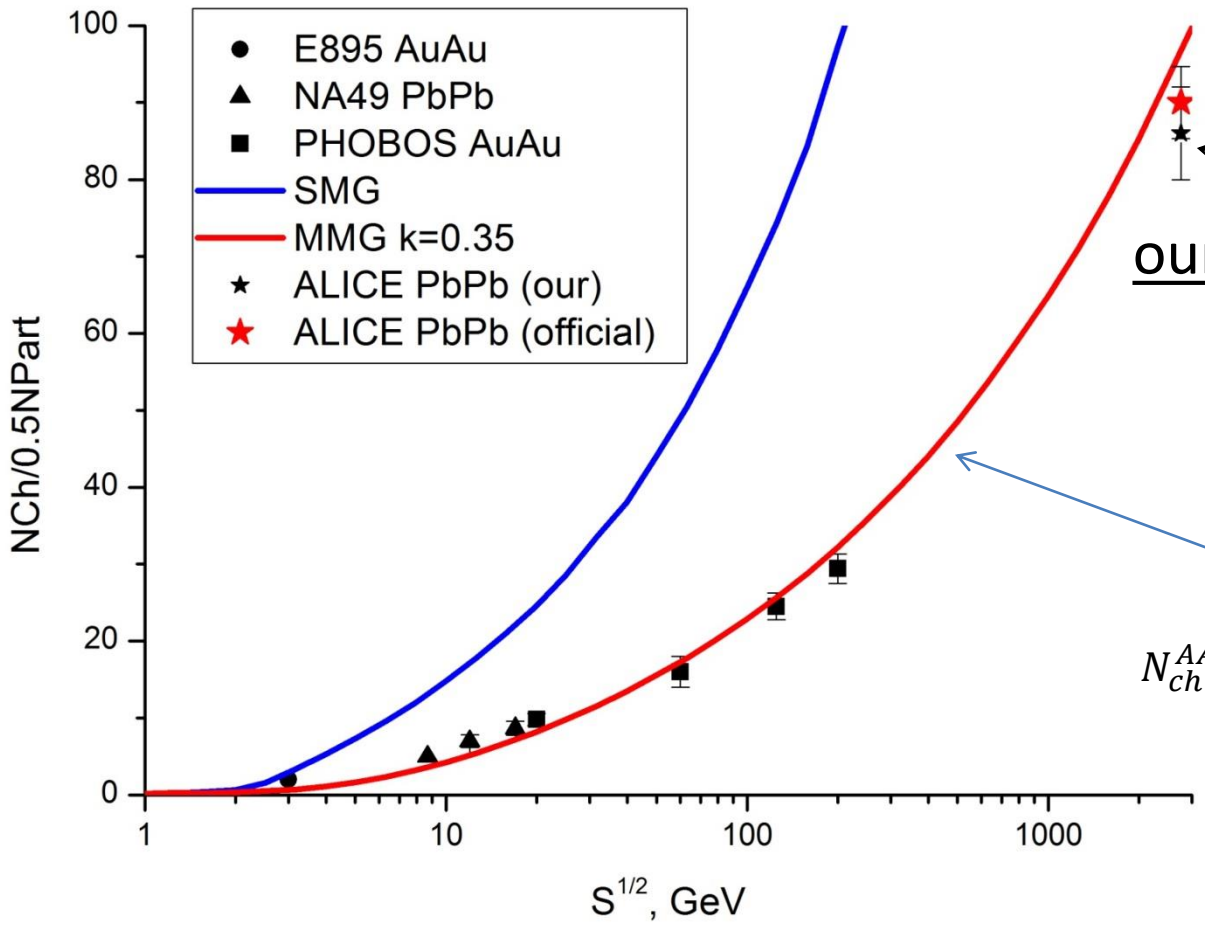
$$p' = kp$$

- This loss of momentum goes to the production of charged and neutral particles
- One can define parameter *k* by fitting the available experimental data on charged-particle multiplicity yields in AA collisions

- New: Nucleon core
- New: Secondary collisions – collisions between nucleons of one nucleus

[1]. G.Feofilov, A.Ivanov, Number of nucleon-nucleon collisions vs energy in modified Glauber calculations // Journal of Physics G CS, 5, (2005) 230-237

Total multiplicity of charged particles for the most central AA collisions



our estimates from [2]

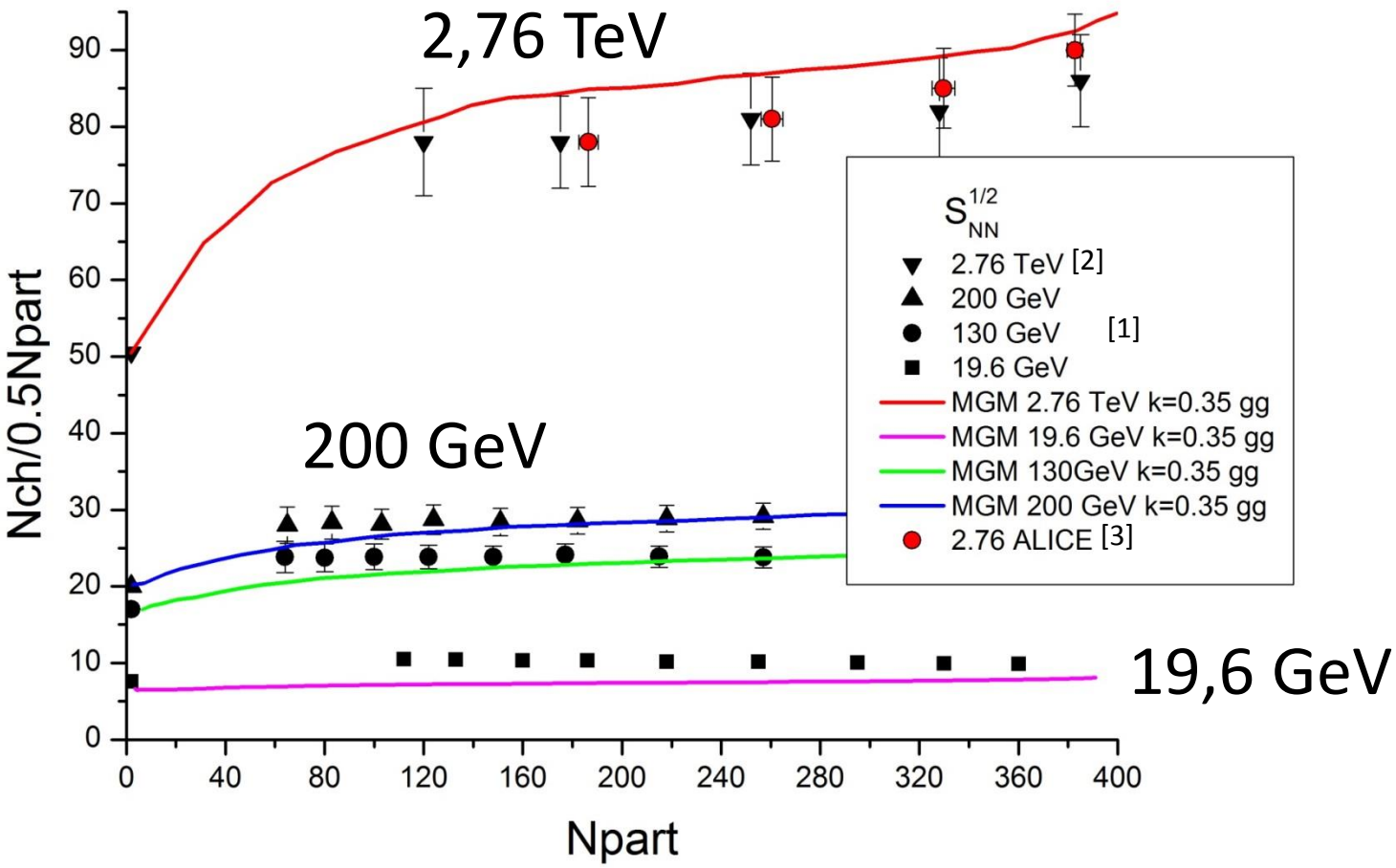
$$N_{ch}^{AA}(\sqrt{s}) = \sum_{j=1}^{N_{coll}} N_{ch}^{pp}\left(\sqrt{s_j}\right)$$

[1] B. Back et al. (PHOBOS Collaboration) Comparison of the Total Charged-Particle Multiplicity in High-Energy Heavy Ion Collisions with e+e− and pp/p(anti)p Data // arXiv:nucl-ex/0301017v1 28 Jan 2003

[2] ALICE experimental pseudo-rapidity distribution 2011 APW Guilbaud Maxime & Hans Dalsgaard 16.04.2012

[3] K. Aamodt et al. (ALICE Collaboration) Centrality dependence of the pseudorapidity density distribution for charged particles in Pb-Pb collisions at √SNN = 2.76 TeV, arXiv:1304.0347 [nucl-ex], 2013

AA - scaling



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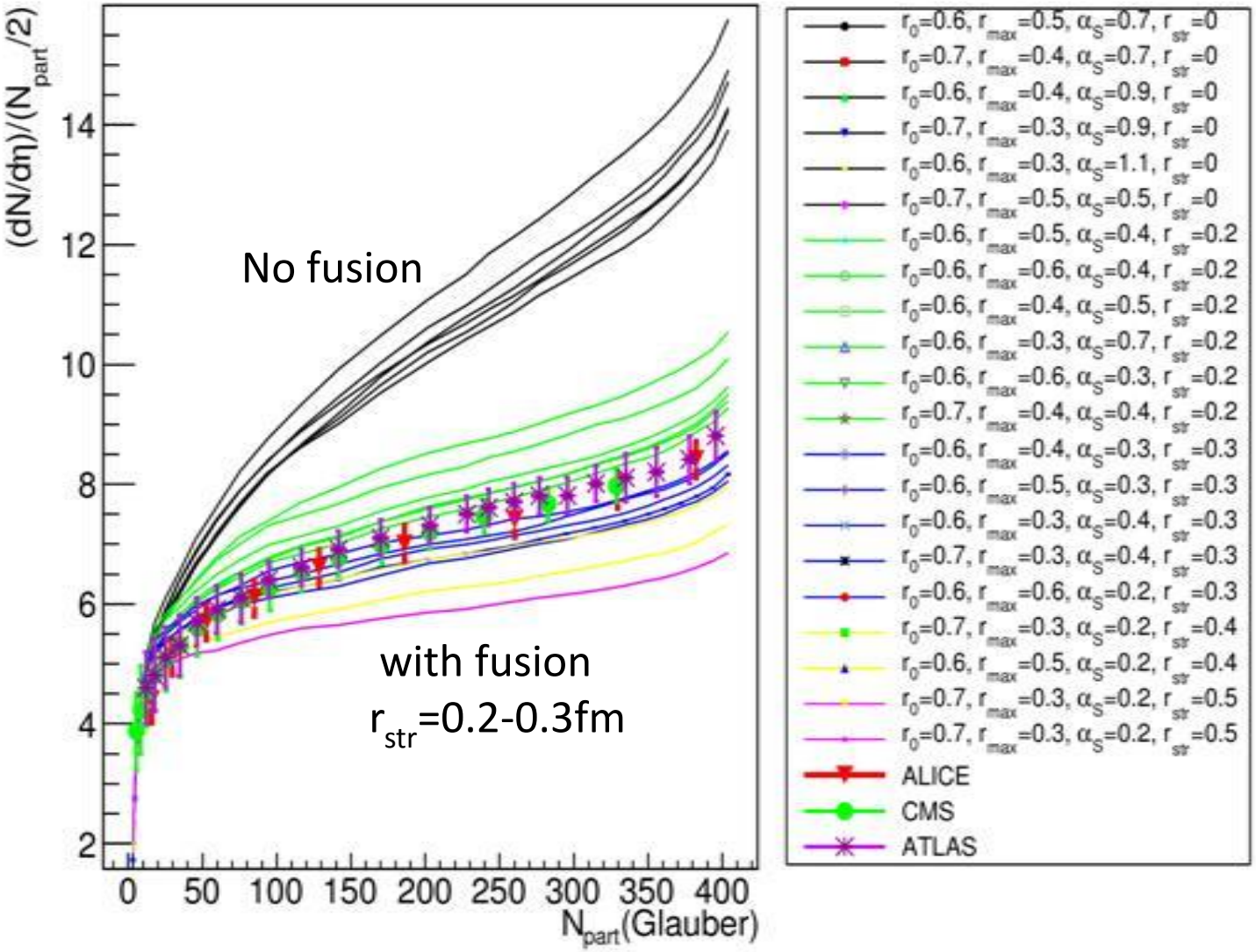
  see report at the present workshop
- HIJING

Non-Glauber MC model

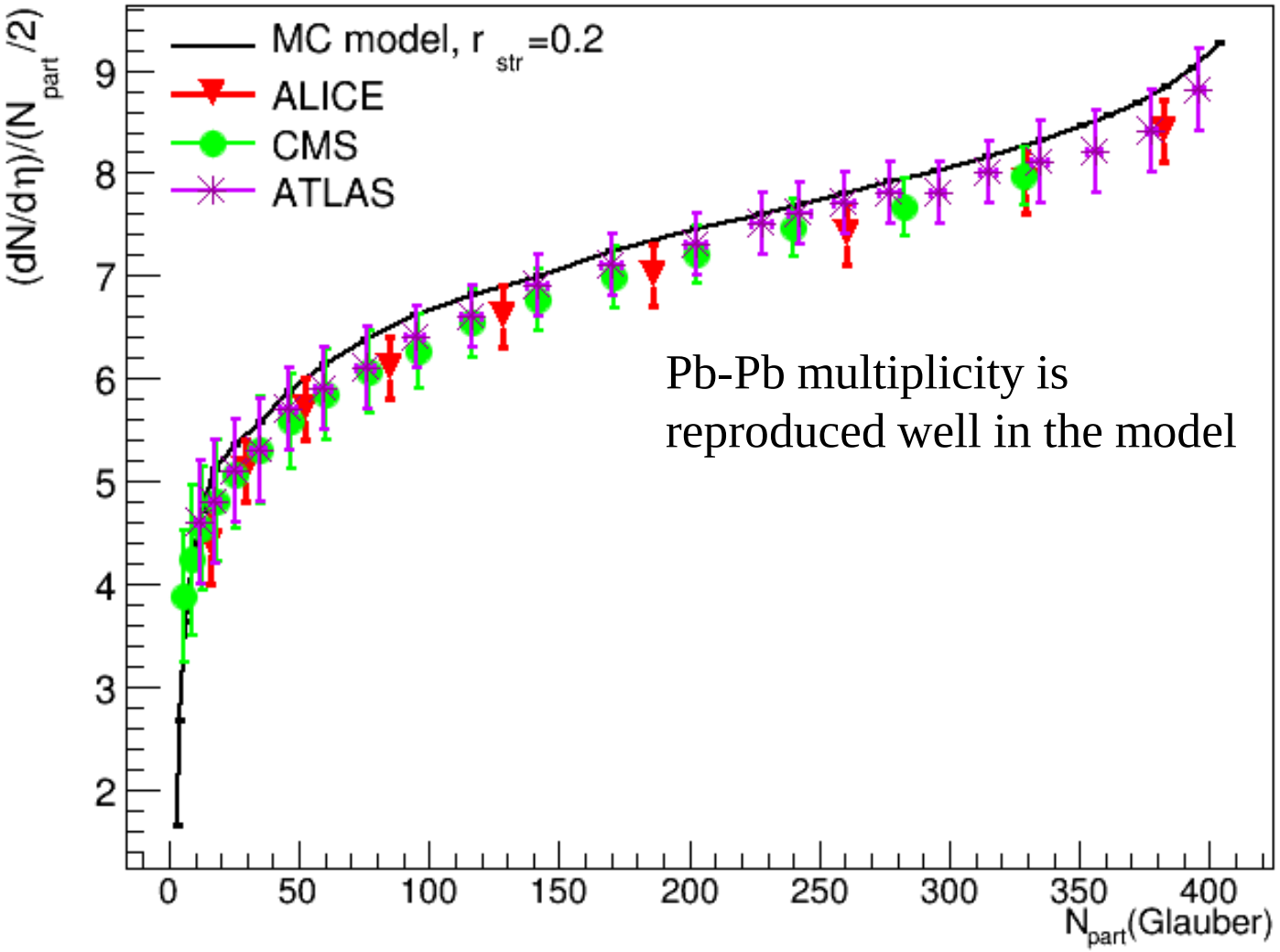
- Partonic picture of nucleons interaction.
- Every parton can interact with other one only once (contrary to Glauber supposition of constant nucleon cross section)
- Nucleon is participating in the collision if at least one of it's partons collides with parton from another nucleus.
- Parameters of the model are constrained from the p-p data on total inelastic cross section and multiplicity
- Additional requirement is consistent description of the multiplicity in min. bias p-Pb collisions

V. Kovalenko, Phys. Atom Nucl 76 (accepted), arXiv:1211.6209 [hep-ph];
V. Kovalenko, V. Vechernin. PoS (Baldin ISHEPP XXI) 077, 2012, arXiv:1212.2590 [nucl-th]

Systematic uncertainties of the model



Charged multiplicity over Npart



Models with energy-momentum conservation

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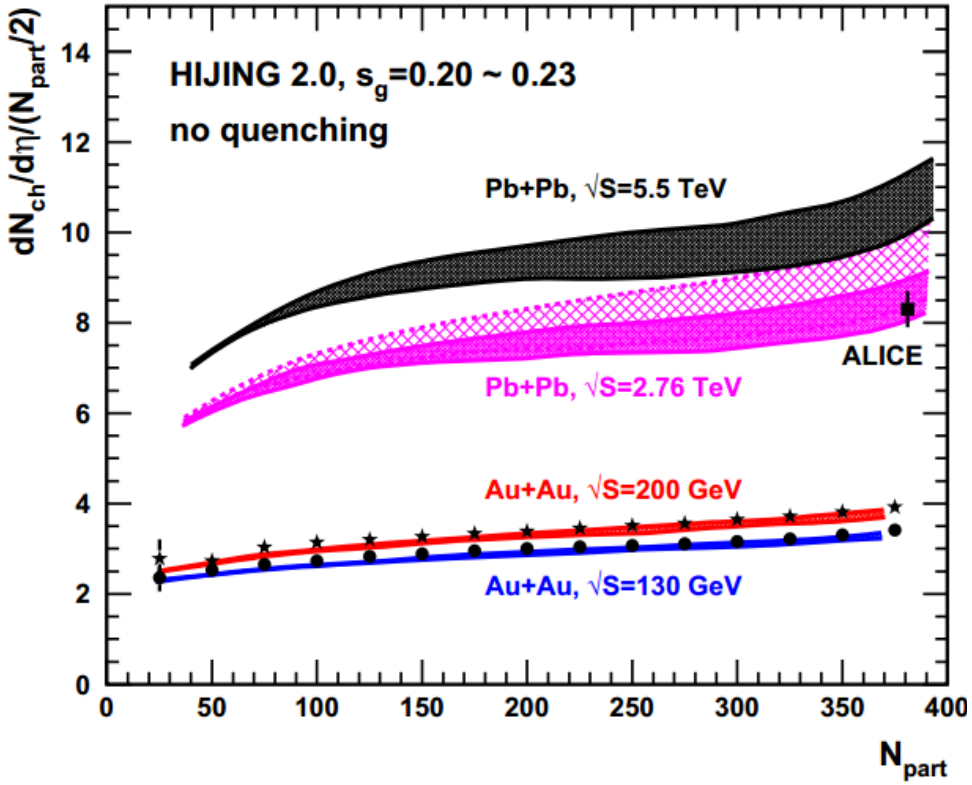
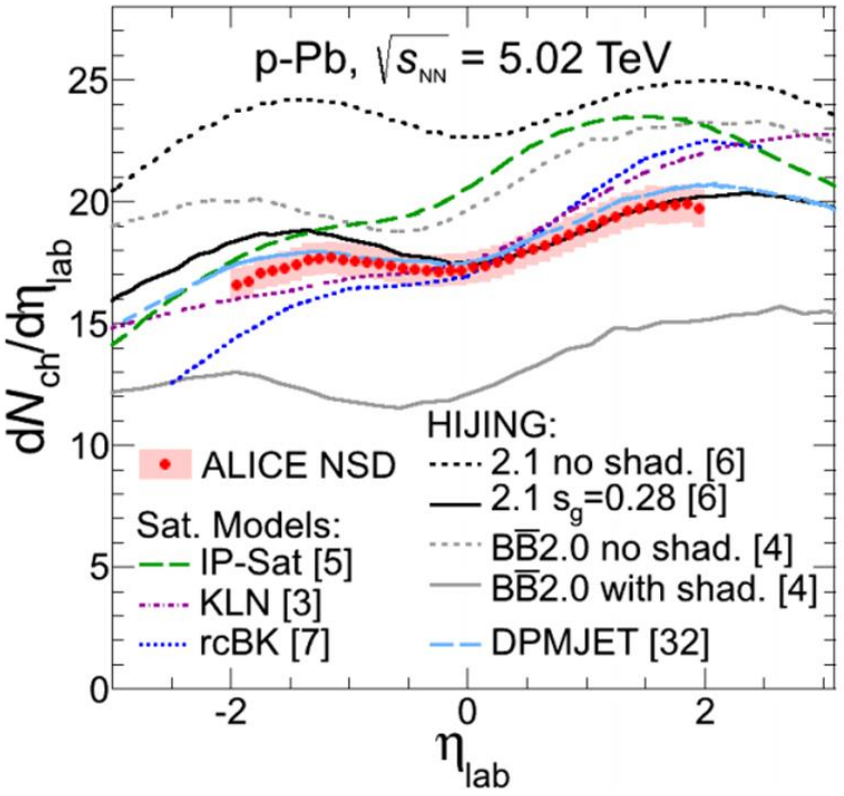
HIJING

- HIJING is the MC event generator for hadron production in high energy pp, pA, AA collisions.
- Gives reasonable description of multiplicity yields.



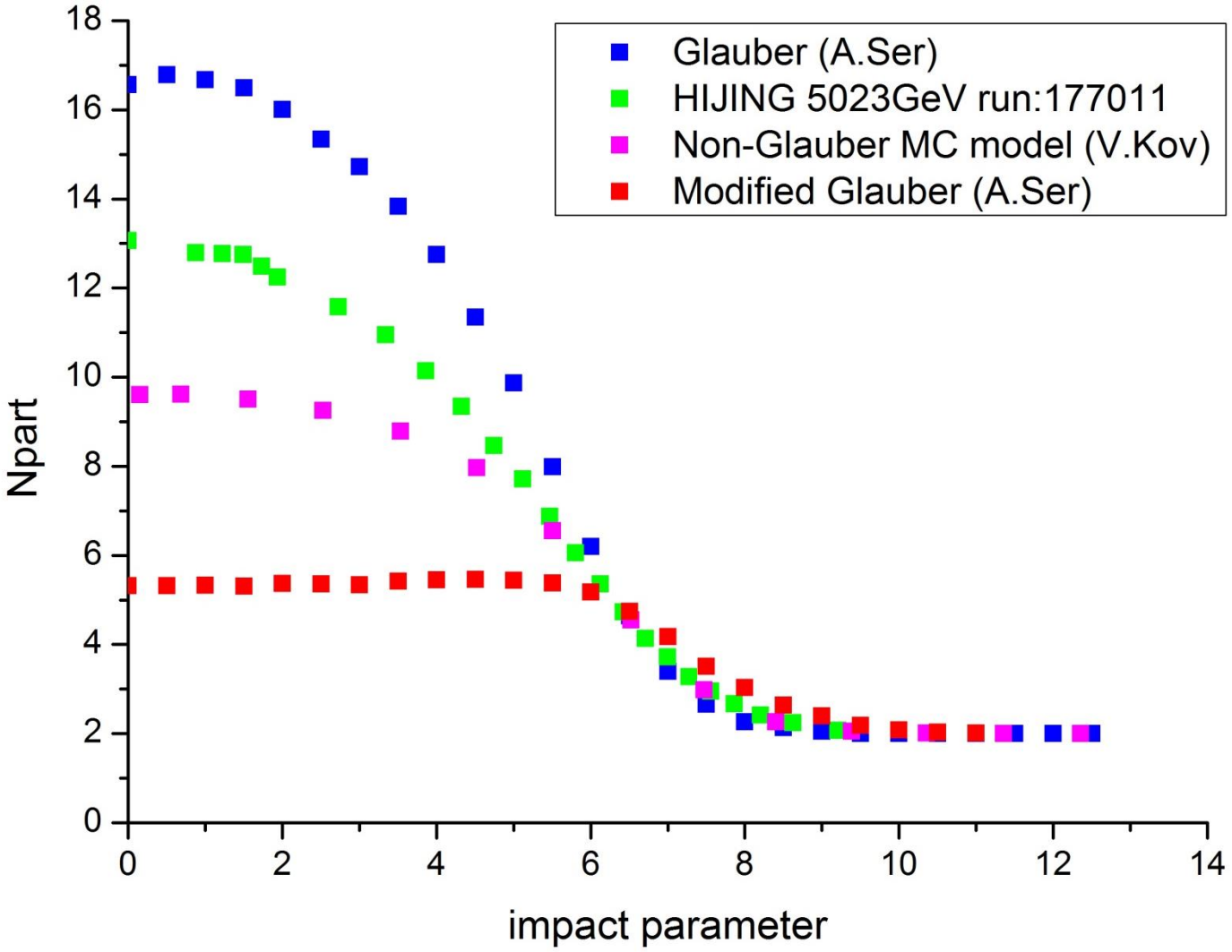


HIJING, R. Xu, W.-T. Deng, and X.-N. Wang, arXiv:1204.1998
Wei-tian Deng, Xin-Nian Wang, Rong Xu Phys.Lett.B701:133-136,2011
B. Abelev et al. (ALICE Collaboration) Phys. Rev. Lett. 110, 032301 (2013)

pA collisions

- Glauber model
- Modified Glauber model
- Non-Glauber MC model
- HIJING

pPb collisions 5.02 TeV



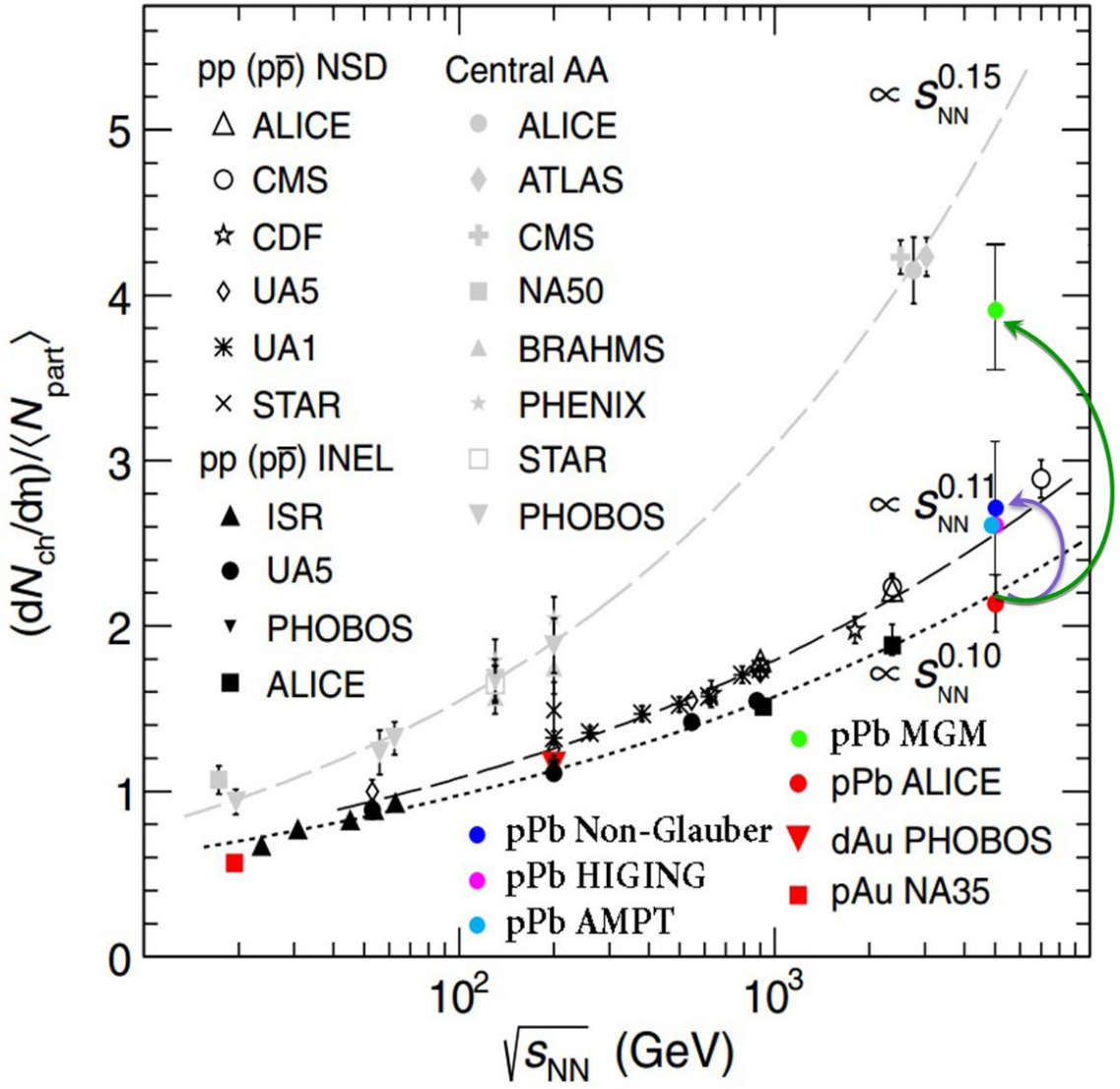
pA collisions

	<Npart> at 5.02 TeV ALICE p-Pb MinBias	<Npart> at 200GeV PHOBOS d-Au MinBias	<Npart> at 2.76 TeV ALICE Pb-Pb 0-5% centrality
Glauber	7.87 (A.Ser) 7.9±0.6 (ALICE[1])	8.4 (A.Ser)	408 (A.Ser)
MGM	4.3±0.3	5.0±0.3	397
Non-Glauber	6.2±0.6		
HIJING	6.5	8.1±0.7 [2]	

[1] B. Abelev et al. (ALICE Collaboration) Phys. Rev. Lett. 110, 032301 (2013)
[2] B. Back et al. (PHOBOS Collaboration), Phys. Rev. Lett.93, 082301 (2004)
[3] AMPTJ. Albaete, N. Armesto, R. Baier, et al., Int. J. Mod. Phys. E 22, 1330007 (2013), arXiv:1301.3395

Corrections

Charged-particle pseudorapidity density at midrapidity normalized to Npart



MinBias	*<Npart> at 5.02 TeV* *ALICE p-Pb*
Glauber	7.87 (A.Ser) 7.9±0.6 (ALICE)
MGM	4.3±0.3
Non-Glauber	6.2±0.6
HIJING	6.5

Conclusions

- MGM, non-Glauber, HIJING and AMPT – all these models gives smaller values of <Npart> compared to Glauber
- This indicates considerable stopping of nucleons in AA and pA interactions at the LHC energies.

MinBias	*<Npart> at 5.02 TeV* *ALICE p-Pb*
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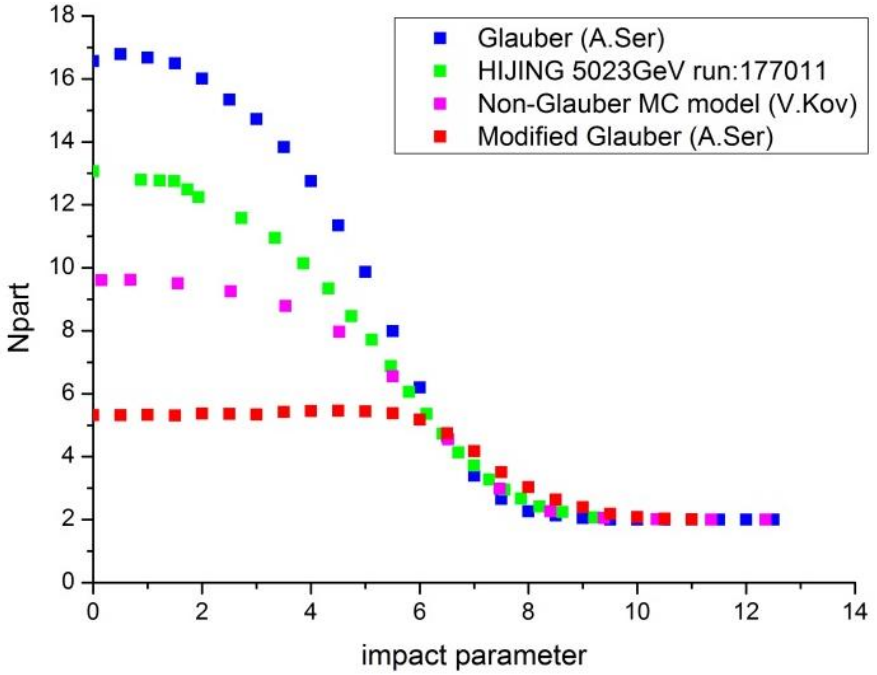
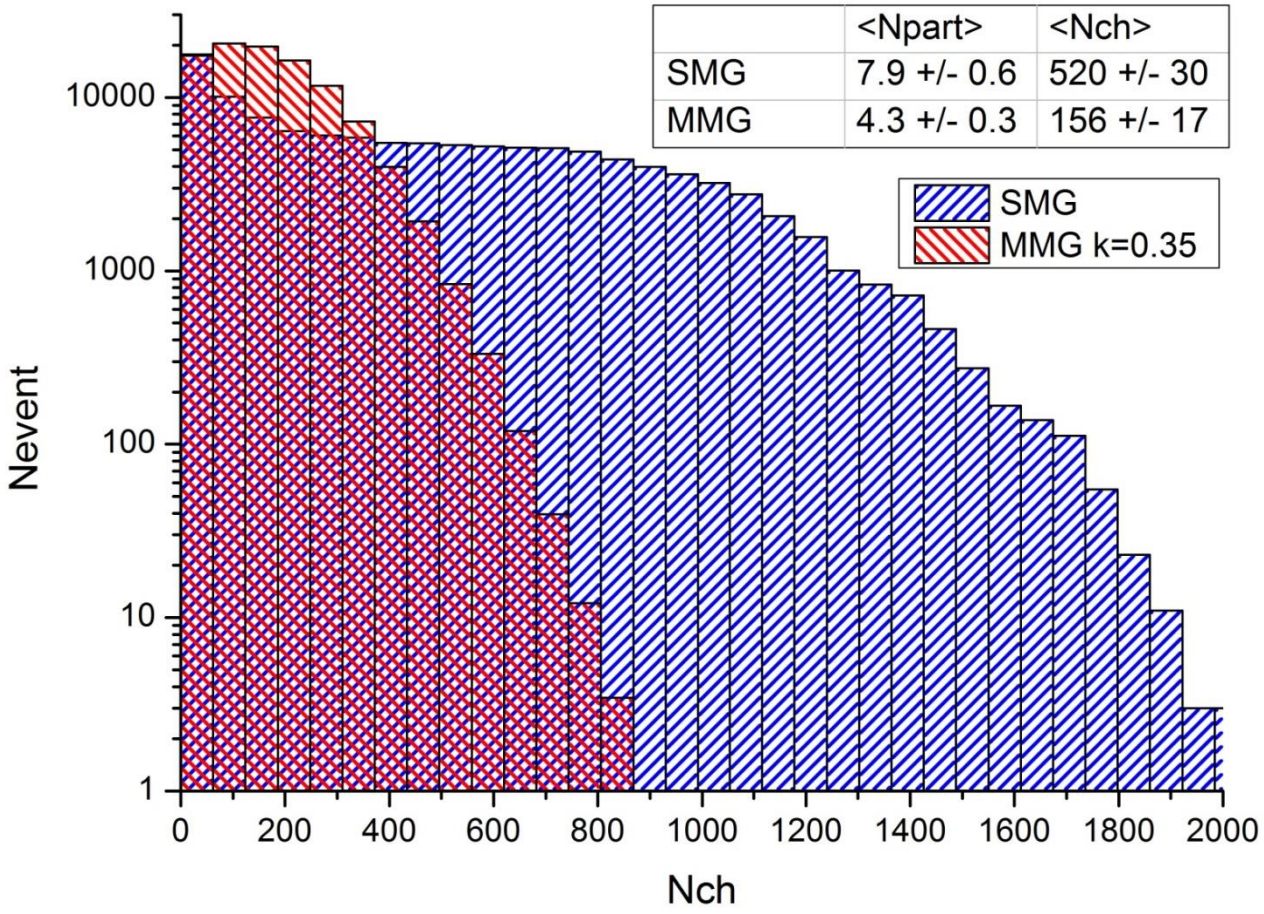


Backup

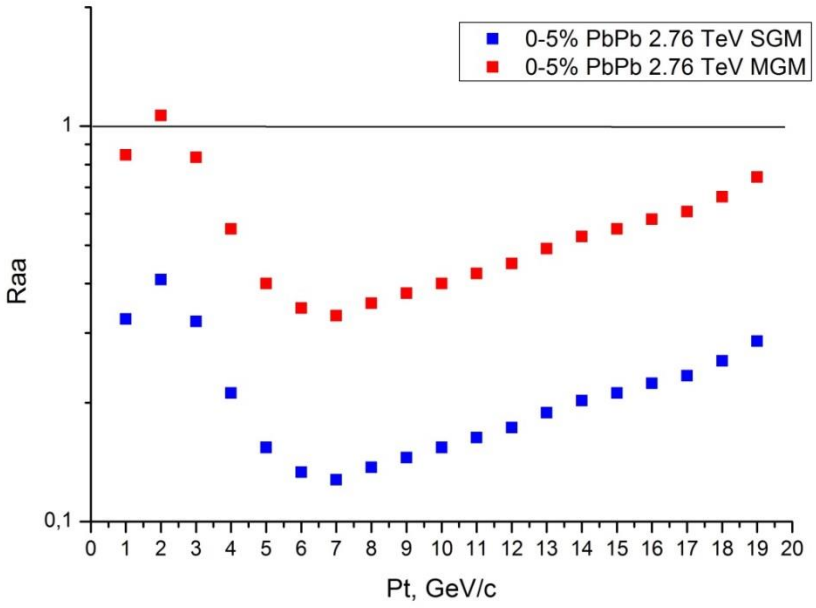
pPb 5.02 TeV

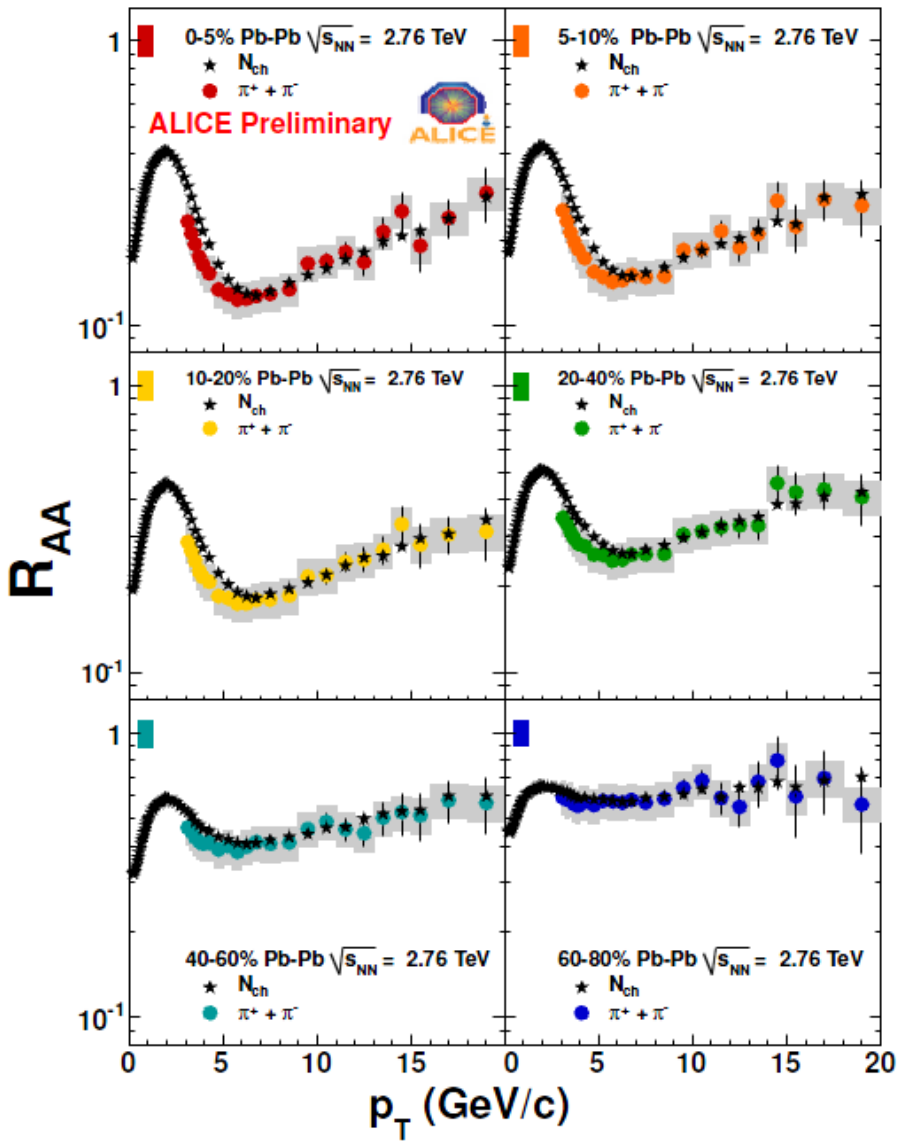


	<Npart>	<Nch>
SMG	7.9 +/- 0.6	520 +/- 30
MMG	4.3 +/- 0.3	156 +/- 17

Backup

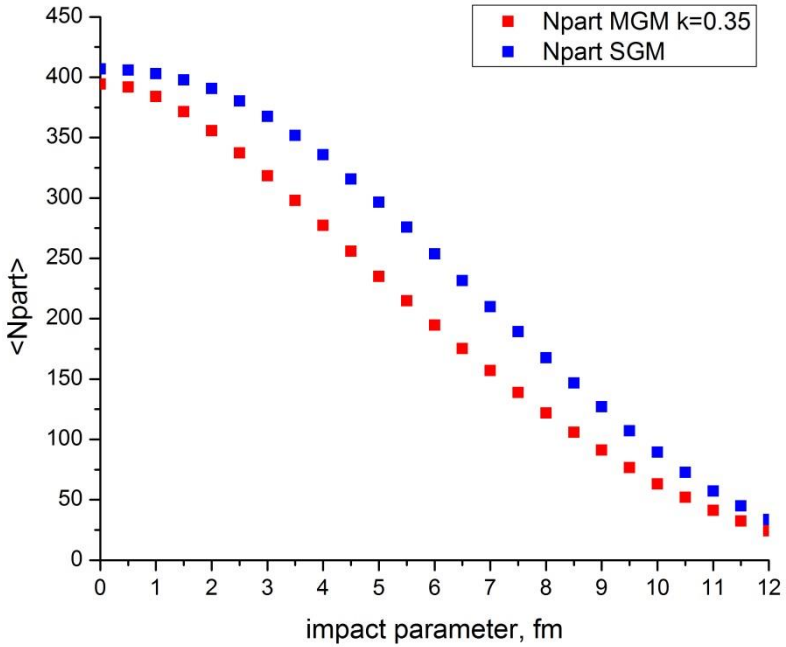
$$R_{AA} = \frac{1}{< N_{coll} >} \frac{d^2 N_{AA}/d\eta dp_t}{d^2 N_{pp}/d\eta dp_t}$$

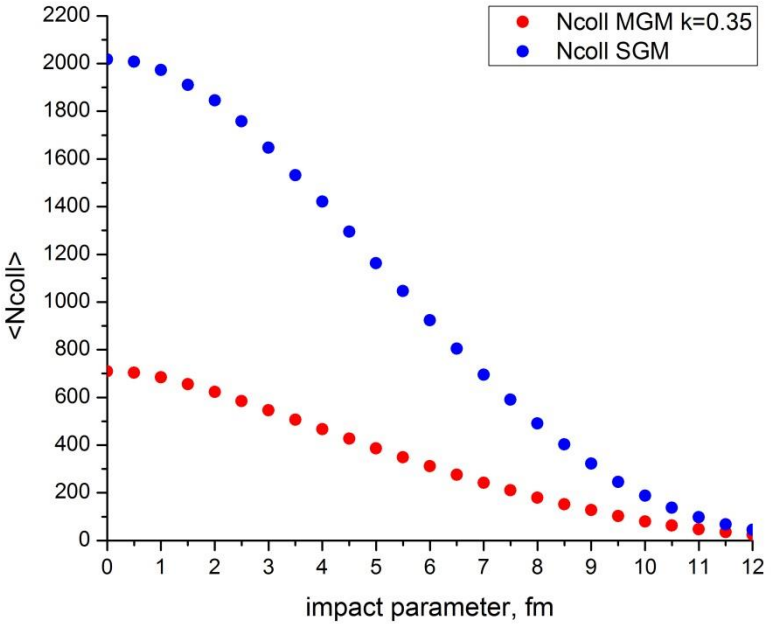




Backup

PbPb 2.76 TeV





For the most central collisions:

$$N_{part}{}^{MMG} \cong N_{part}{}^{SMG}$$

$$N_{coll}{}^{MMG} = 0.35\, N_{coll}{}^{SMG}$$