St. Petersburg State University
Laboratory of Ultra-High Energy Physics

A new look on signals of collective effects in AA and pA at LHC based on Modified Glauber Model.

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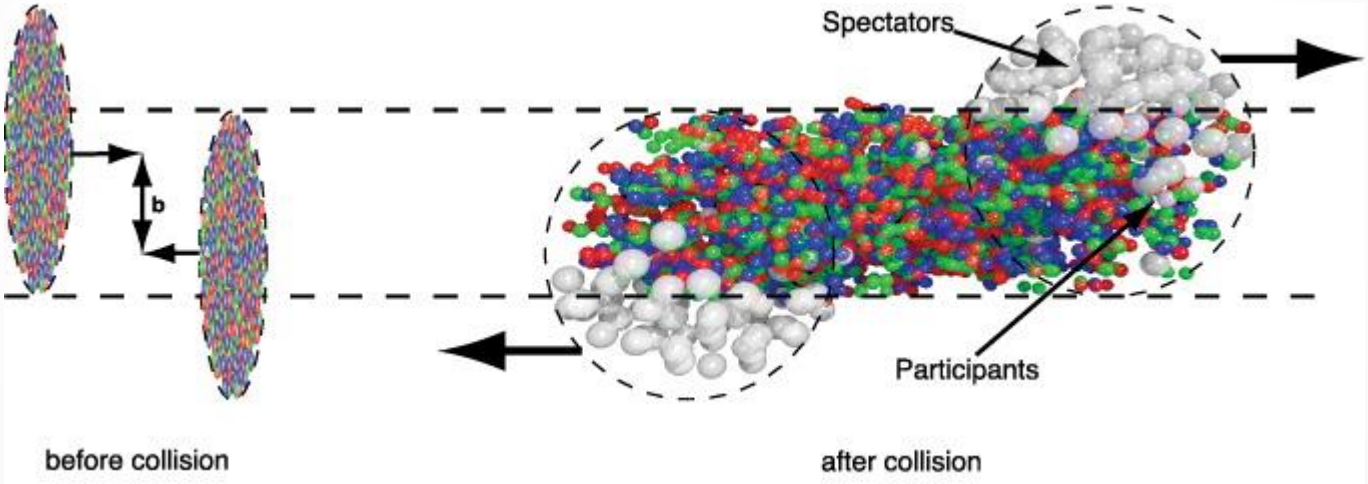
Terminology

N_{part} - number of nucleons in both nucleus with were interacted
N_{coll} - number of binary nucleon-nucleon collisions in AA
b - impact parameter

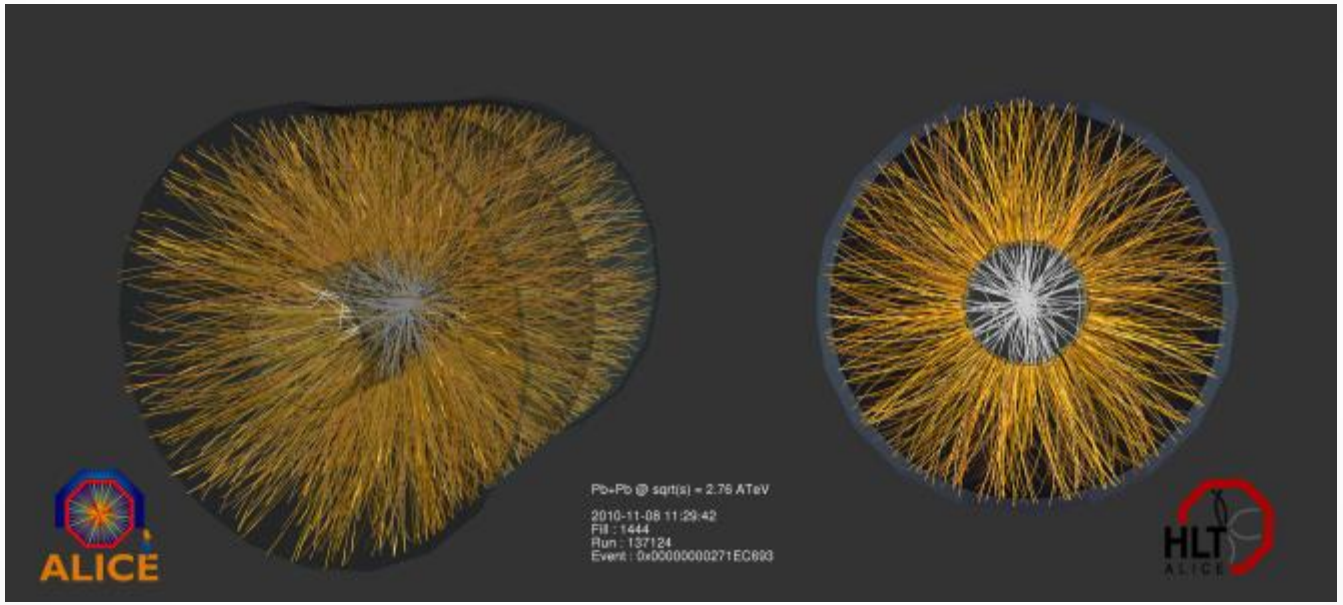


Collider experiment possibilities

N_{part} - number of nucleons in both nucleus with were interacted

N_{coll} - number of binary nucleon-nucleon collisions in AA can not be measured

b - impact parameter can not be measured



N_{ch} - multiplicity of charged particles (number of charged tracks)

$\overrightarrow{p_i}$ - momentum of each charged particle

$\eta_i(\theta_i)$ - pseudorapidity of each charged particle

Signals of collectivity

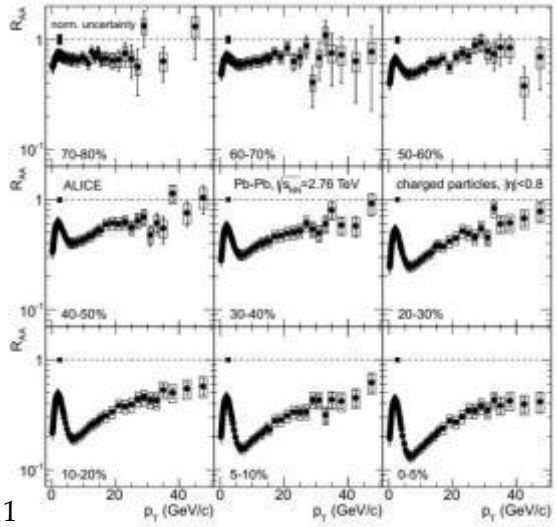
Nuclear modification factor

Multiplicity in AA

$$R_{AA} = \frac{d^2N_{ch}^{AA}/dp_t d\eta}{\langle N_{coll}^{AA}\rangle\, d^2N_{ch}^{pp}/dp_t d\eta}$$

Multiplicity in pp

Number of nucleon collisions



ALICE arXiv:1208.2711

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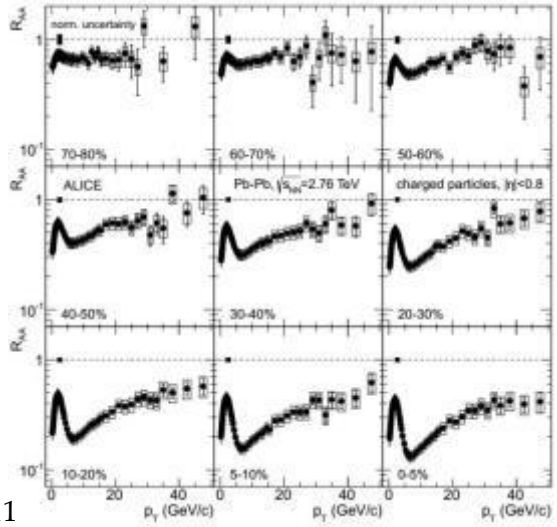
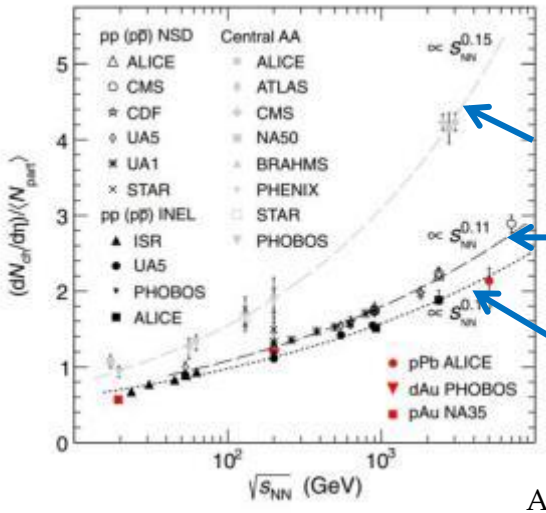


ALICE arXiv:1208.2711

Pseudorapidity density of charged particles



The most central AA

pp

pA

ALICE arXiv:1210.3615

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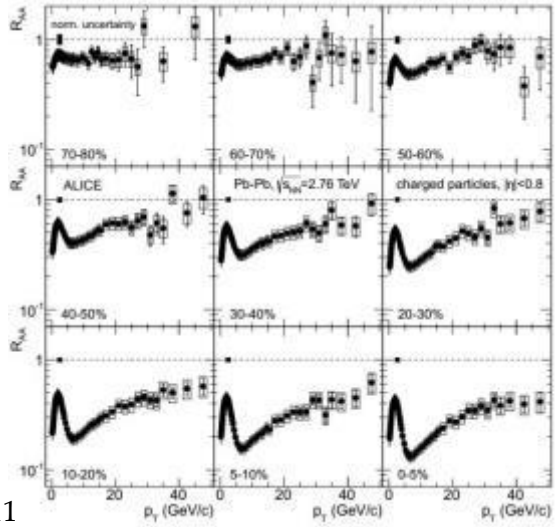

ALICE arXiv:1208.2711

Is it the experimental data?

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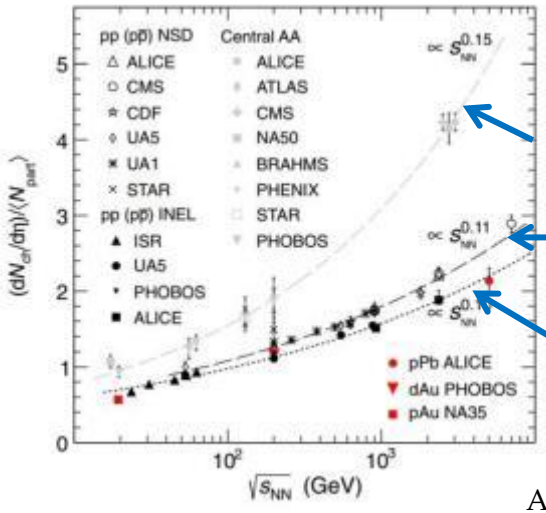

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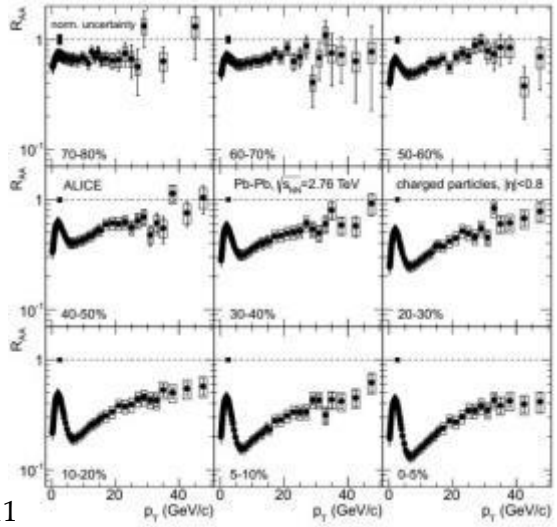


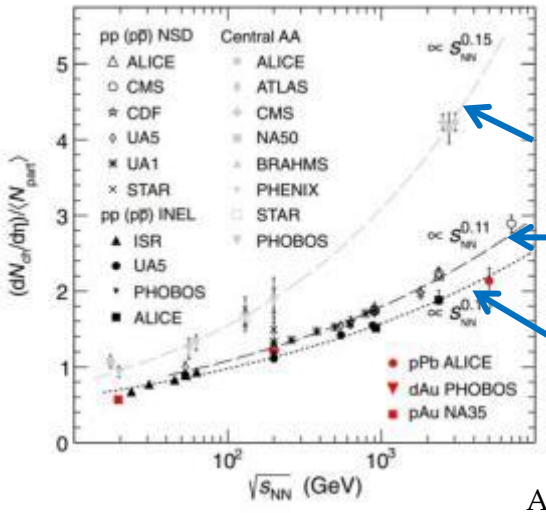
ALICE arXiv:1208.2711

Is it the experimental data?

Not exactly!

N_{part}, N_{coll} - were not measured in the experiment

Pseudorapidity density of charged particles



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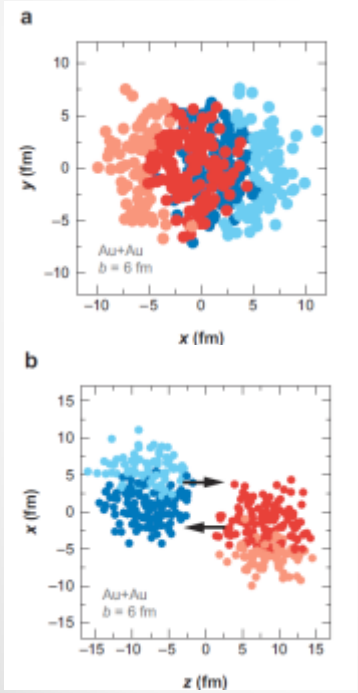
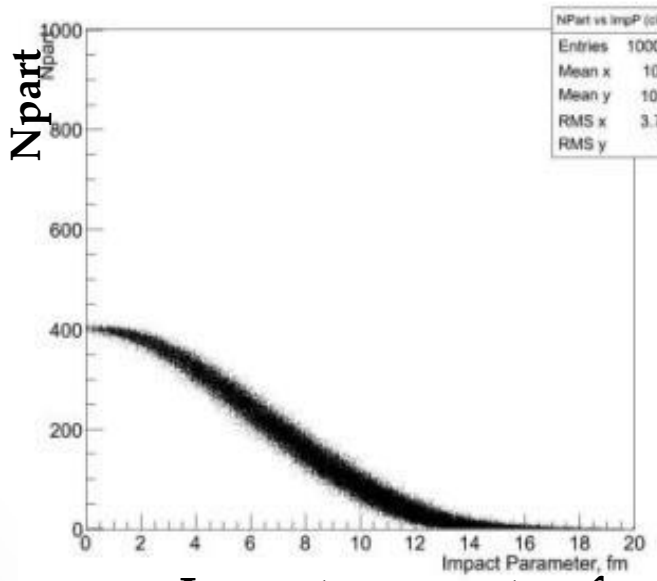
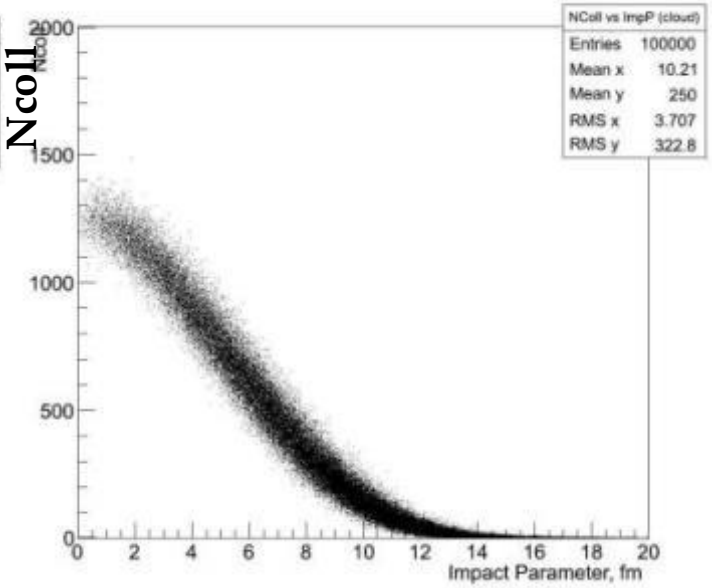
Standard Glauber Model

- AA collision is a superposition of independent nucleon-nucleon collisions.
- Nucleon density and σ_{inel}^{NN} are taken from experimental data
- Optical limit: all nucleon trajectories are linear
  $\sigma_{inel}^{NN} = const$ rot each nucleon-nucleon collision





Impact parameter, fm



Impact parameter, fm

M.Miller, arXiv:nucl-ex/0701025v1, 2007.

PbPb 200GeV

Standard Glauber Model

Problem:
how to make a connection between Glauber model and experimental multiplicity?

Native solution:
use multiplicity from experimental pp data as we take σ_{inel}^{NN} for given $\sqrt{s}$

$$N_{ch}^{AA} = N_{coll} N_{ch}^{pp}$$

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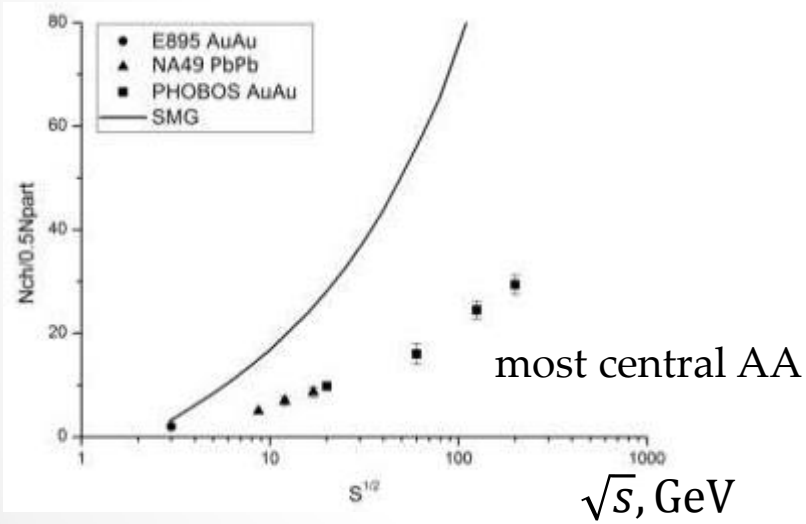

$N_{ch}/0.5N_{part}$

most central AA

$\sqrt{s}$, GeV

PHOBOS Collaboration, arXiv:nucl-ex/0301017.

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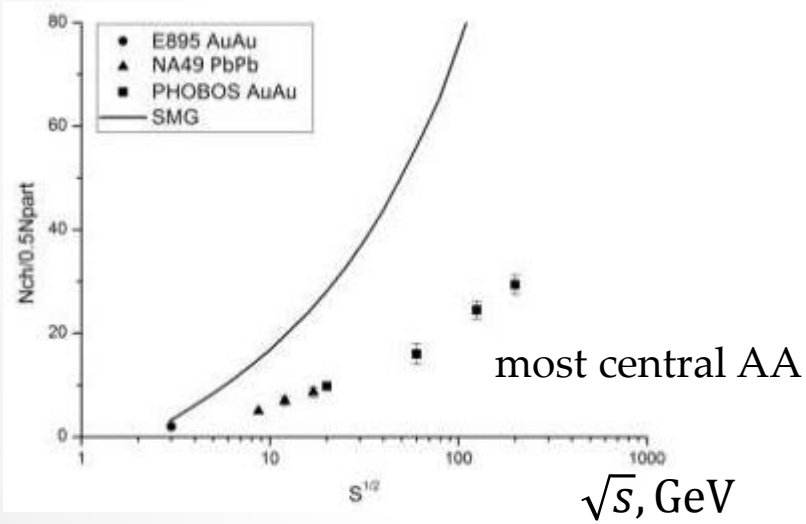

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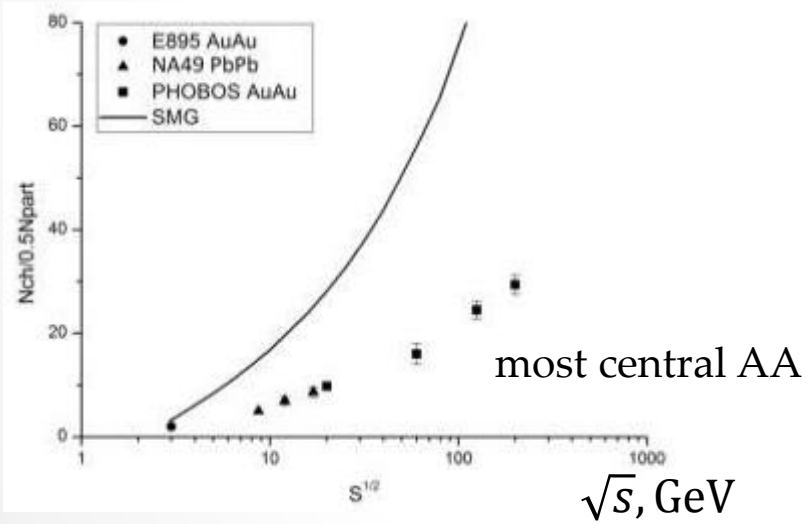

PHOBOS Collaboration, arXiv:nucl-ex/0301017.

Two another possibilities:

1. Traditional way
Glauber model is correct, but
$N_{ch}^{AA} \sim f N_{part} + (1-f) N_{coll}$
~ Soft | Hard processes

ALICE: arXiv:1301.4361
ATLAS: arXiv:1108.6027
PHOBOS: arXiv:nucl-ex/0403033

2. Another way
Glauber model is not correct

Modified Glauber Model

«Energy conservation law»

The momentum of each nucleon after each nucleon-nucleon collision in the center of mass system:

$$\boldsymbol{p' = kp}$$

A Ivanov, G Feofilov, Journal of Physics Conference Series, 5, 2005

k – is a fraction of momentum loss

as a result every next collision of each nucleon will pass with less energy and correspondingly with less σ_{inel}^{NN} and multiplicity.

$$N_{ch}^{AA} = \sum_{i=1}^{N_{coll}} N_{ch}^{pp}(\sqrt{s_i})$$

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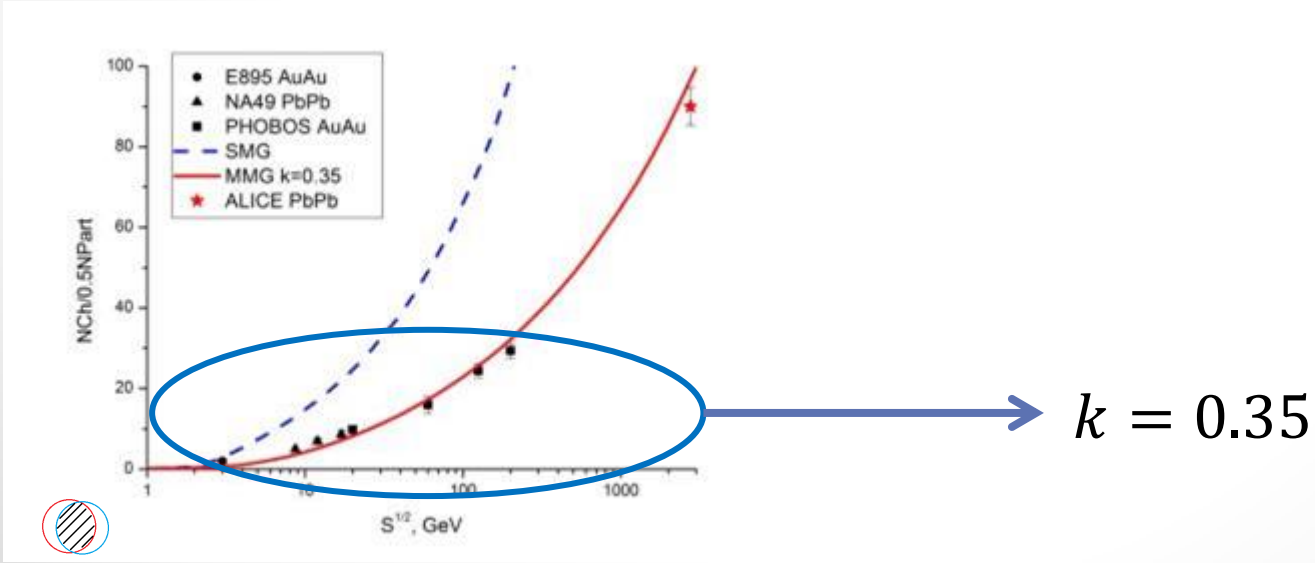

$k = 0.35$

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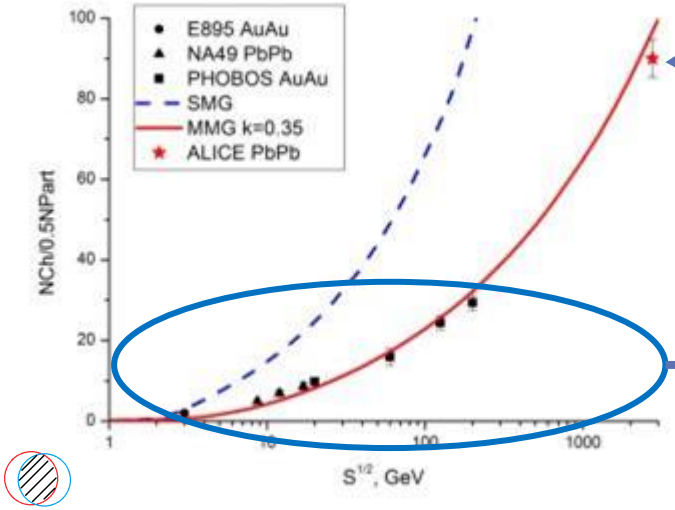

This point was obtained by integration of ALICE pseudorapidity distributions

T.Drozhzhova, G.Feofilov, V.Kovalenko, A.Seryakov, PoS(QFTHEP 2013)053, 2013.

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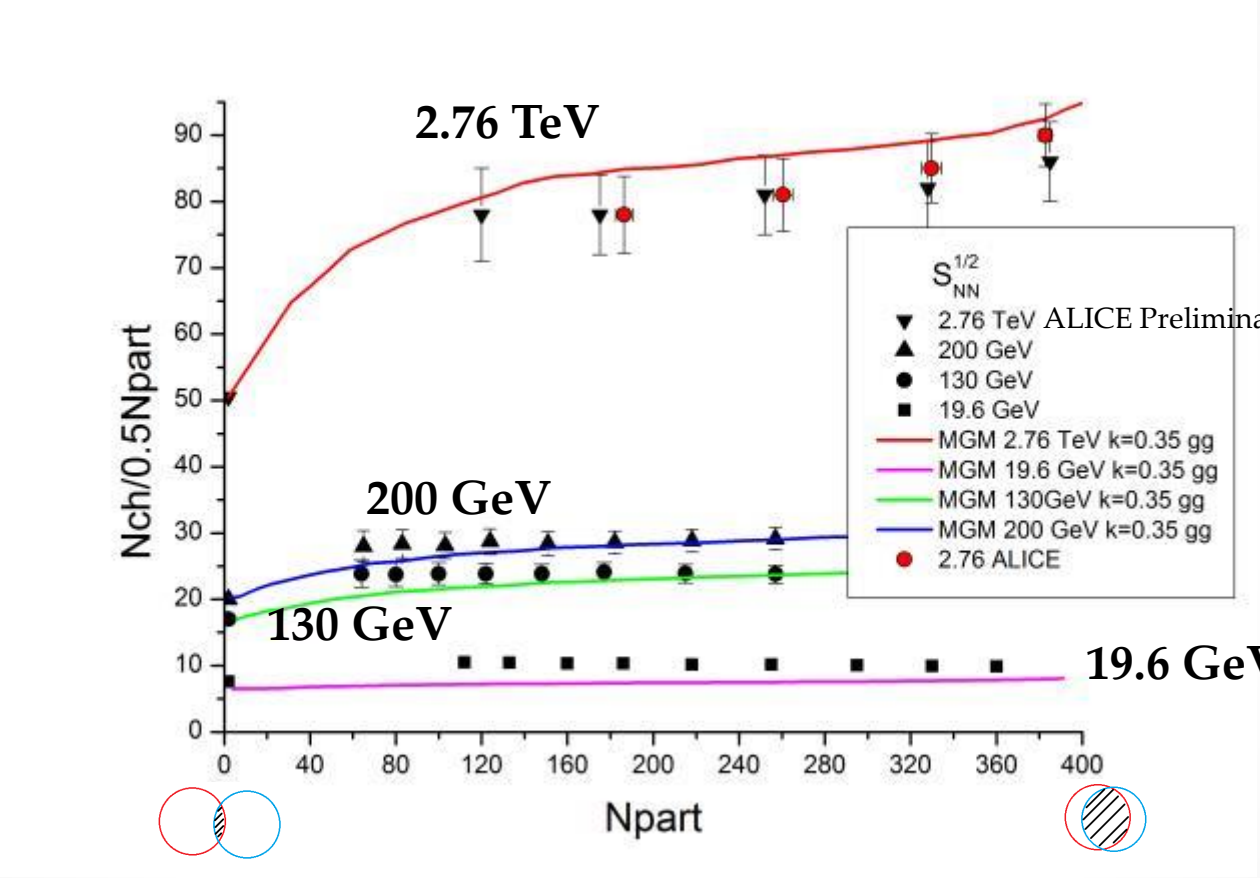

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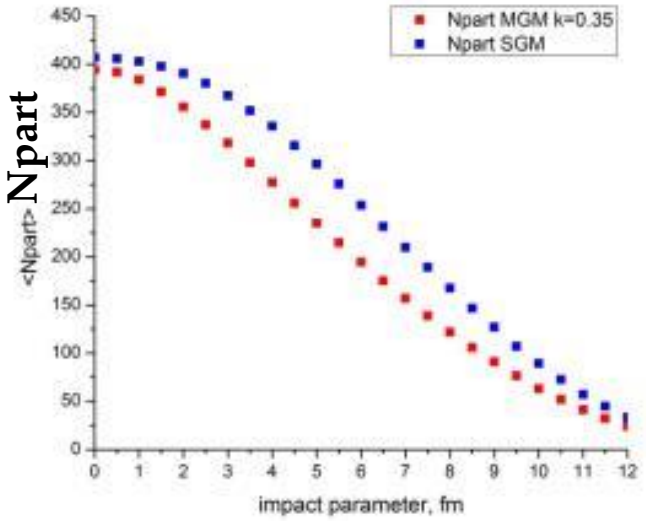
k is const for all energy and types of system

Comparison of the models: AA case.

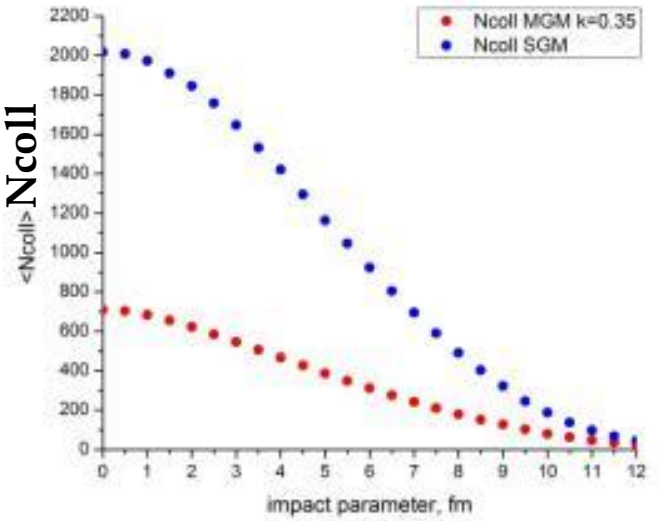
PbPb 2.76TeV



Impact parameter, fm

SGM

MGM



Impact parameter, fm

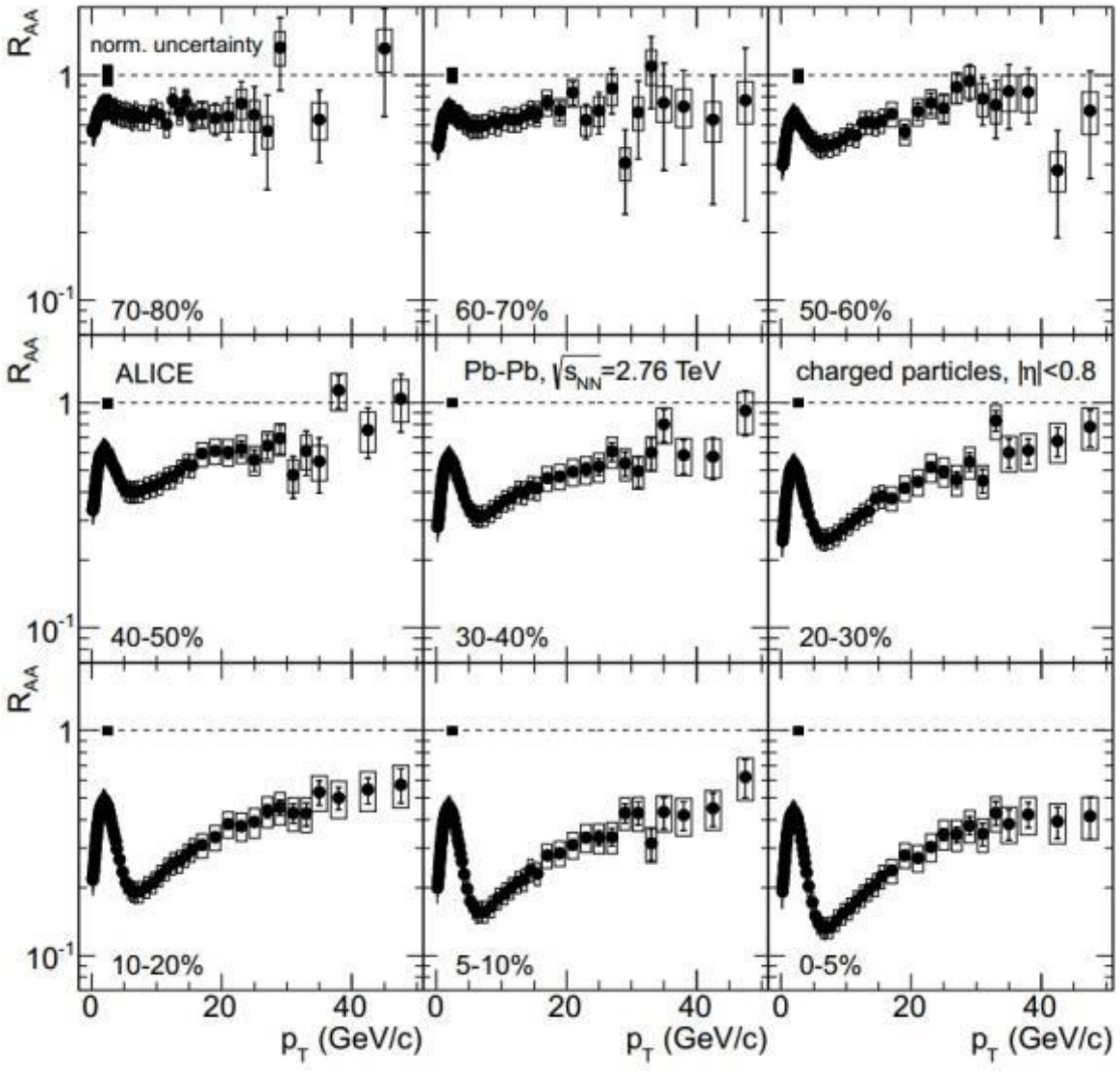
$$N_{part}^{MGM} \approx N_{part}^{SGM}$$

$$N_{coll}^{MGM} \approx {}^{1}/_{3}\, N_{coll}^{SGM}$$

Nuclear modification factor and Ncoll

$$R_{AA} = \frac{d^2N_{ch}^{AA}/dp_t d\eta}{\langle N_{coll}^{AA}\rangle\, d^2N_{ch}^{pp}/dp_t d\eta}$$

Can we just multiply each point by $\langle N_{coll}^{SGM}\rangle/\langle N_{coll}^{MGM}\rangle$?



arXiv:1208.2711

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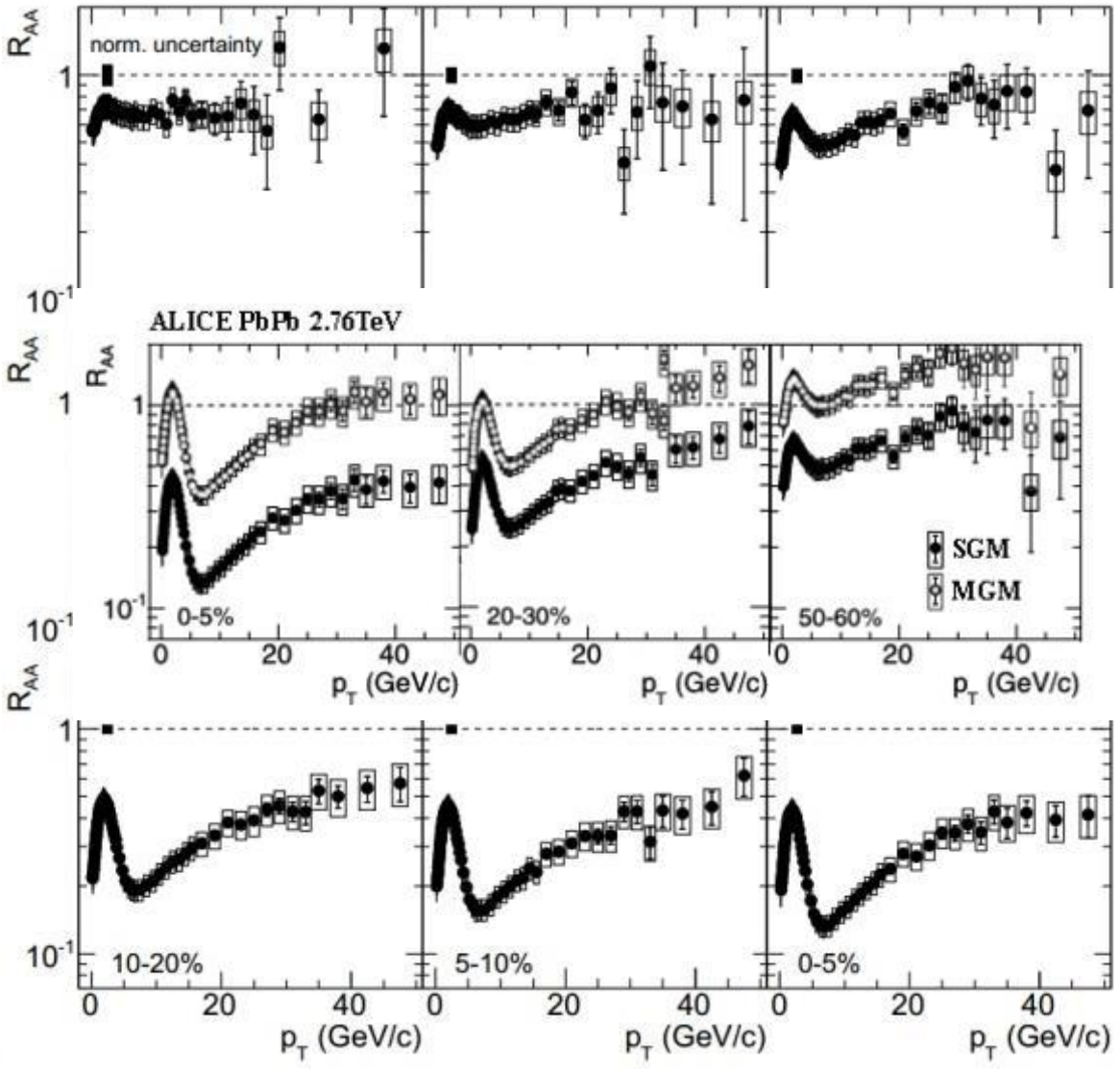

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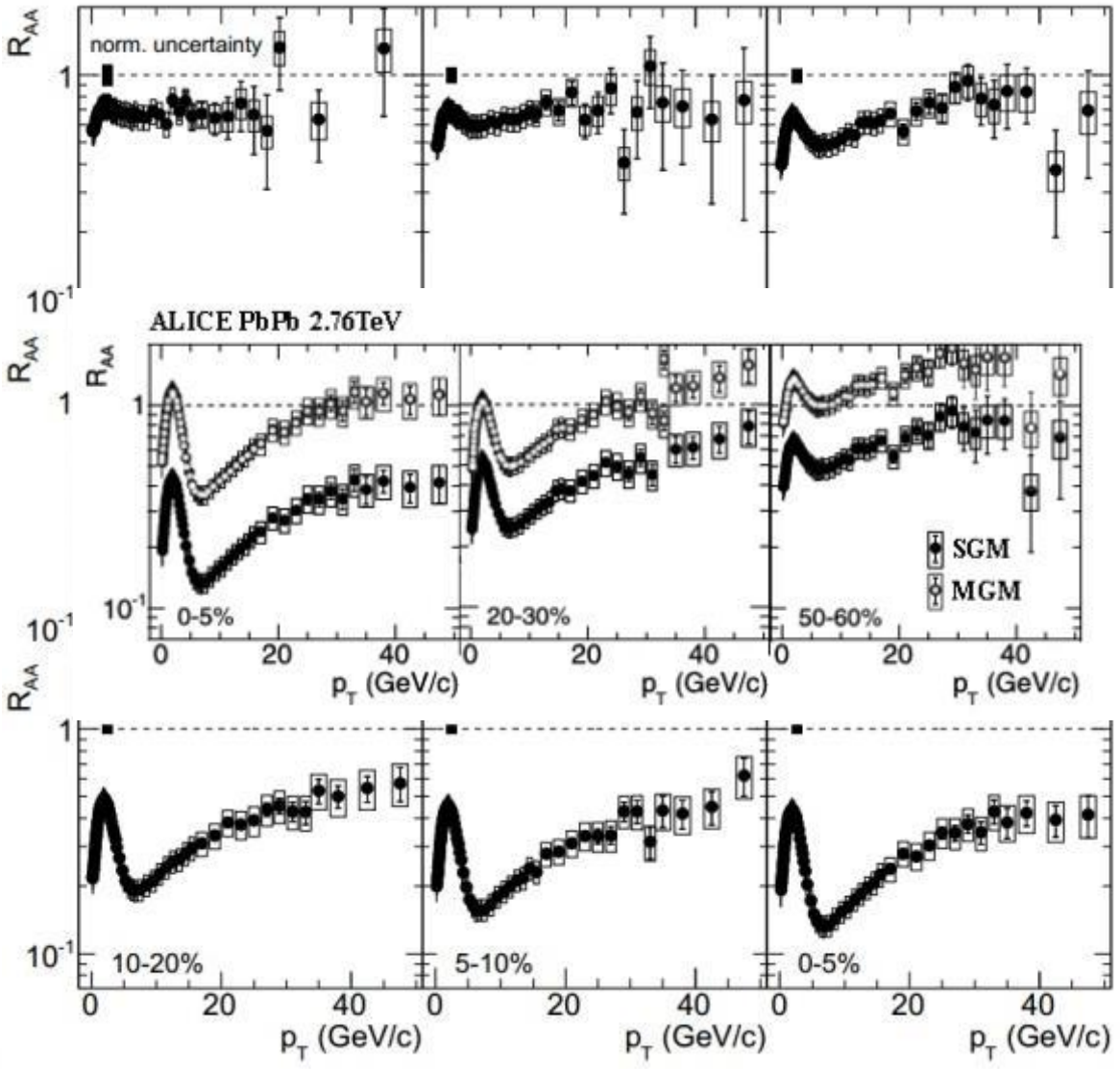
99% of particles has $p_t < 2GeV/c$



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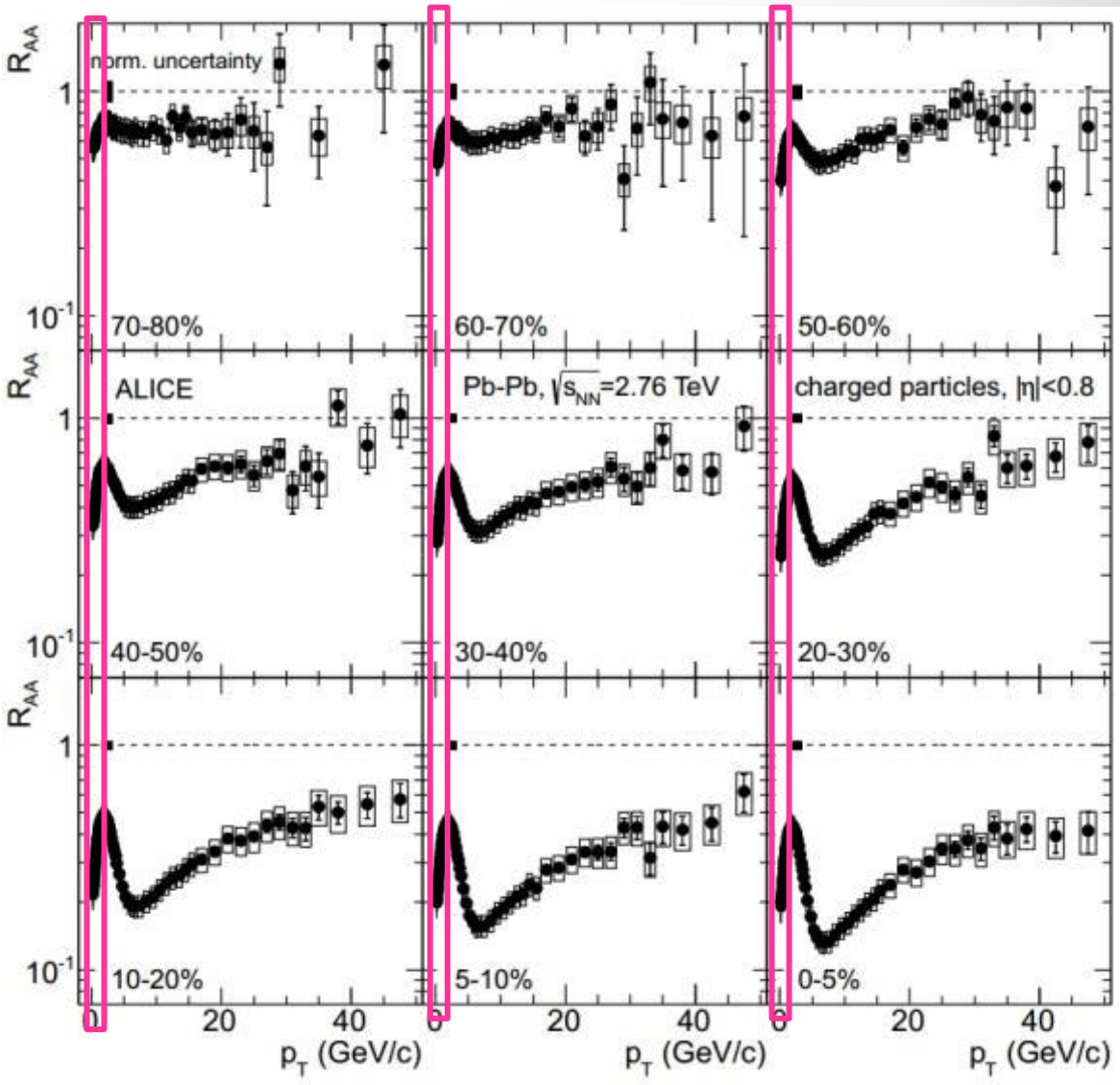
we can move up only soft part of pt spectra.

The problem is still open …



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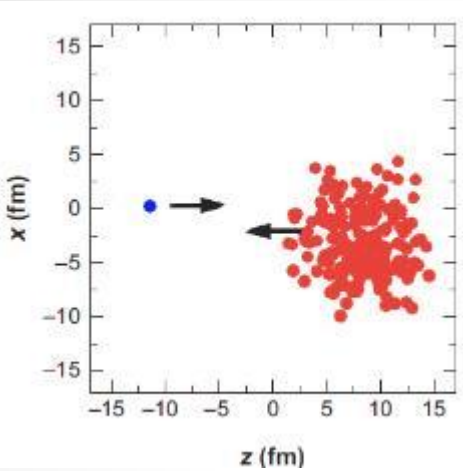
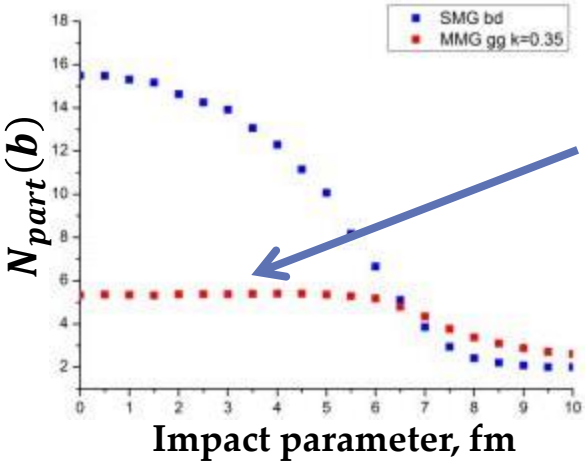
Comparison of the models : pA case





Proton totally losses his momentum

$$\langle N_{part} \rangle = \langle N_{coll} \rangle + 1$$

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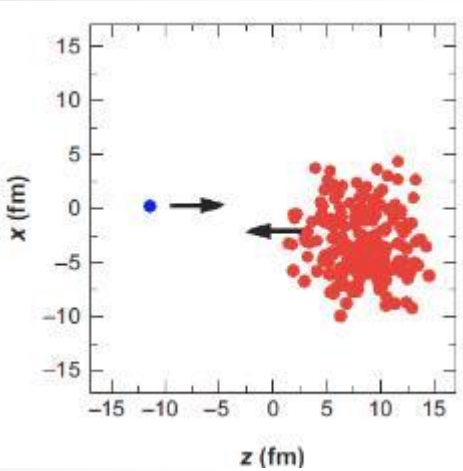

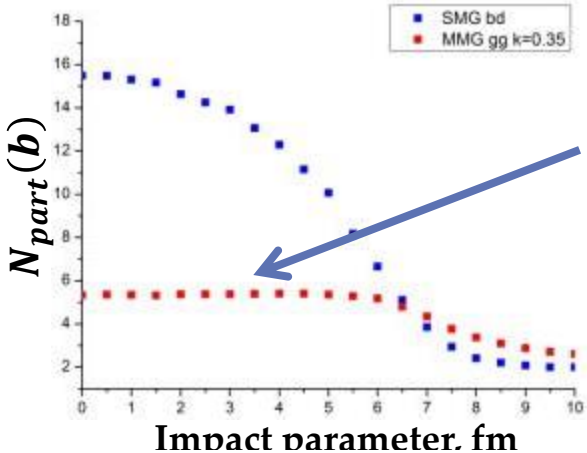

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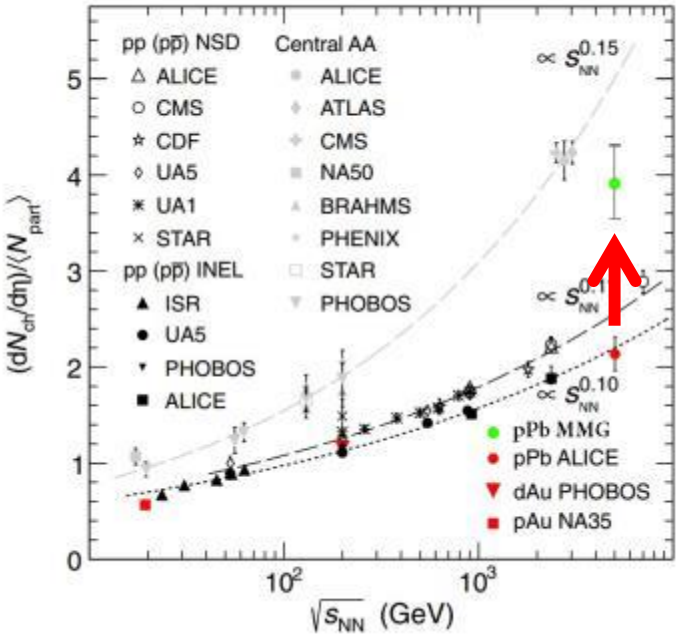
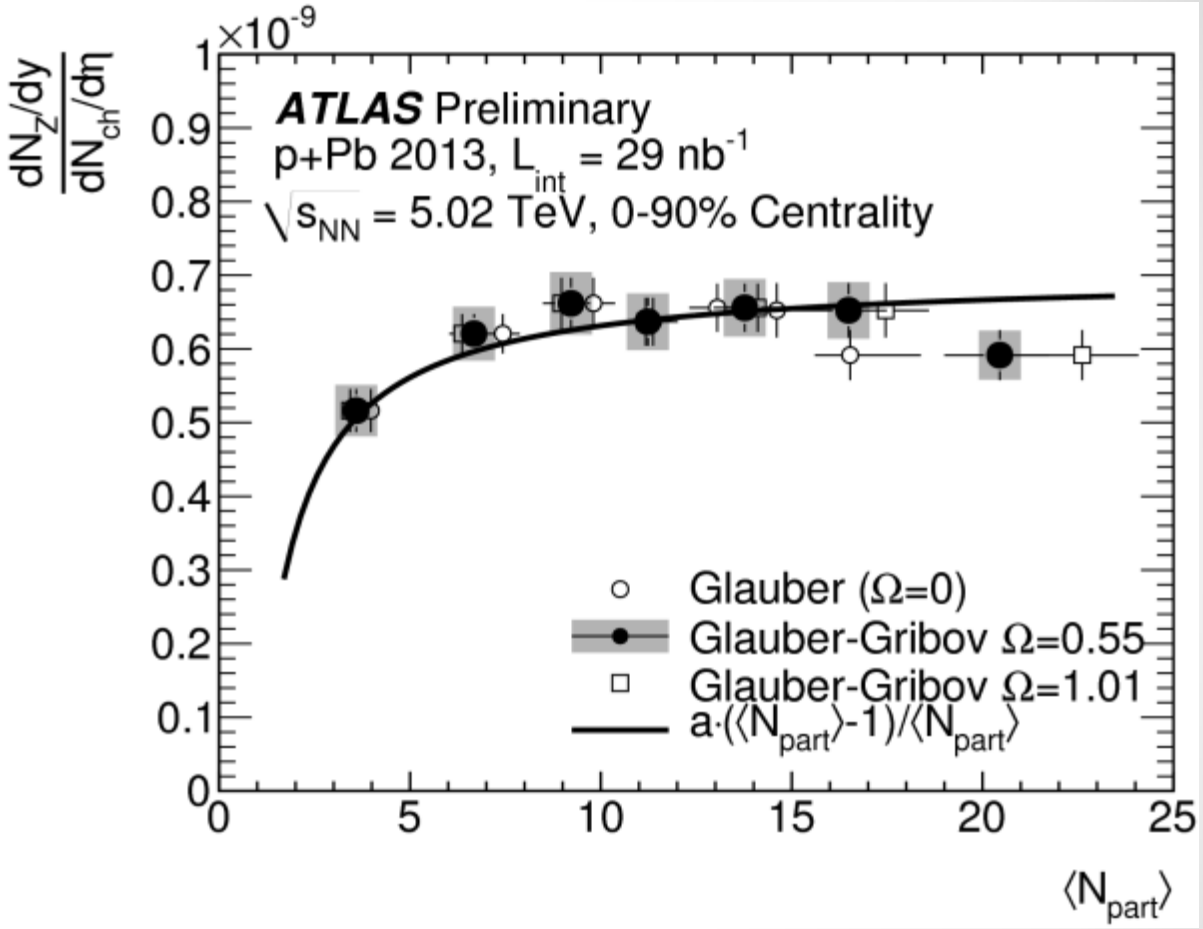
Pseudorapidity density of charged particles



Model comparison: pA case

ATLAS-CONF-2014-020
The ratio of Z-bosons and full multiplicity is independent of <Npart>



https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2014-020/

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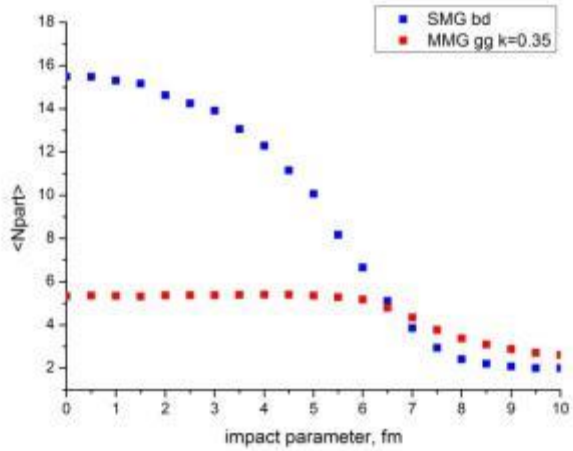

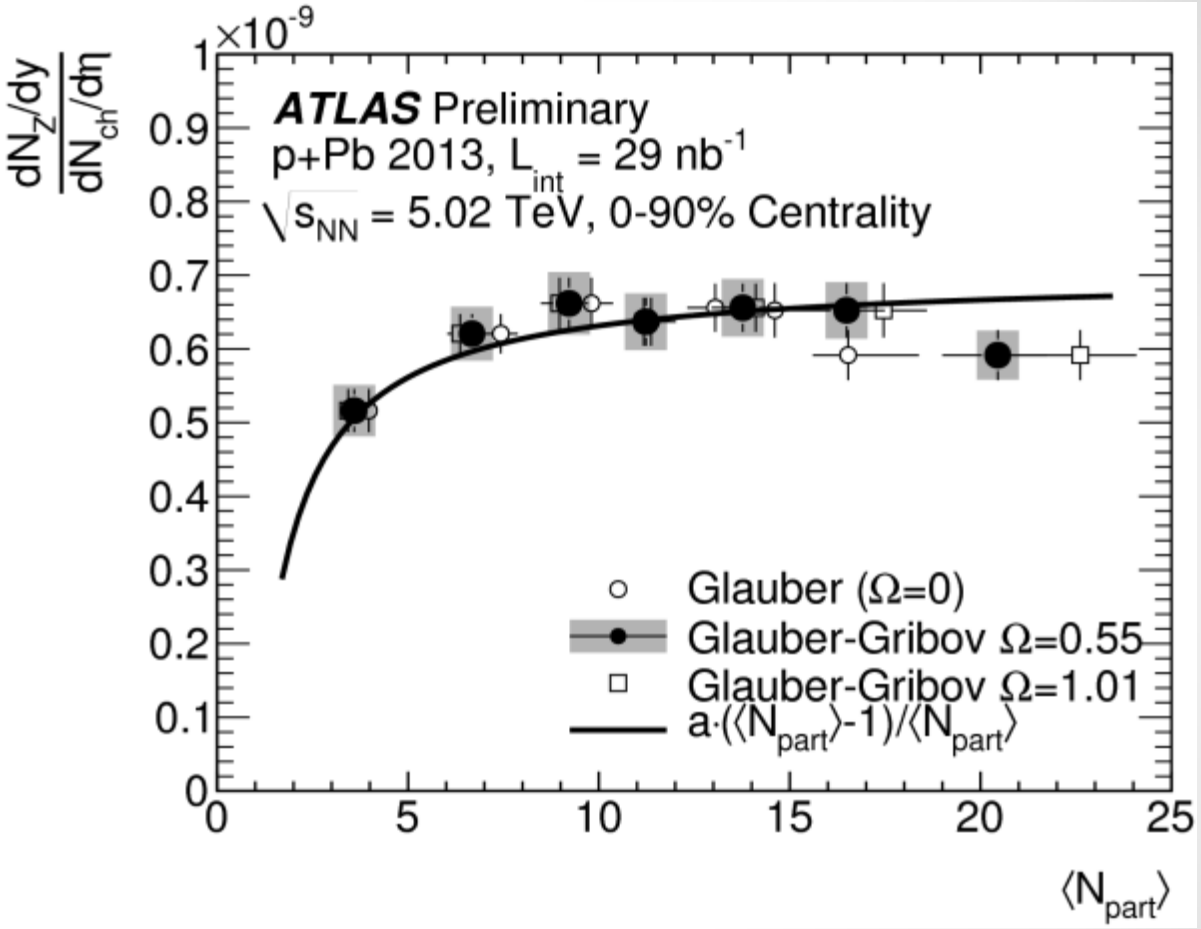

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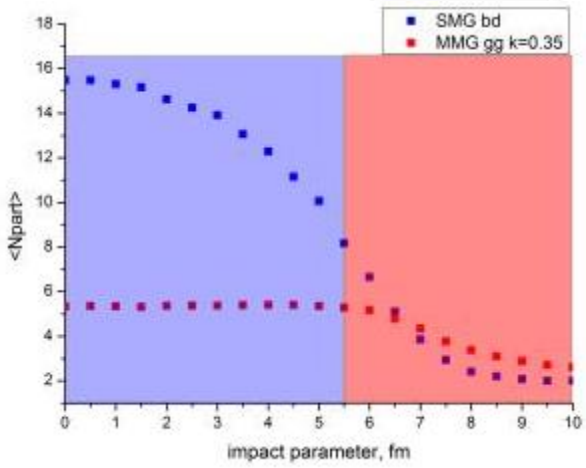

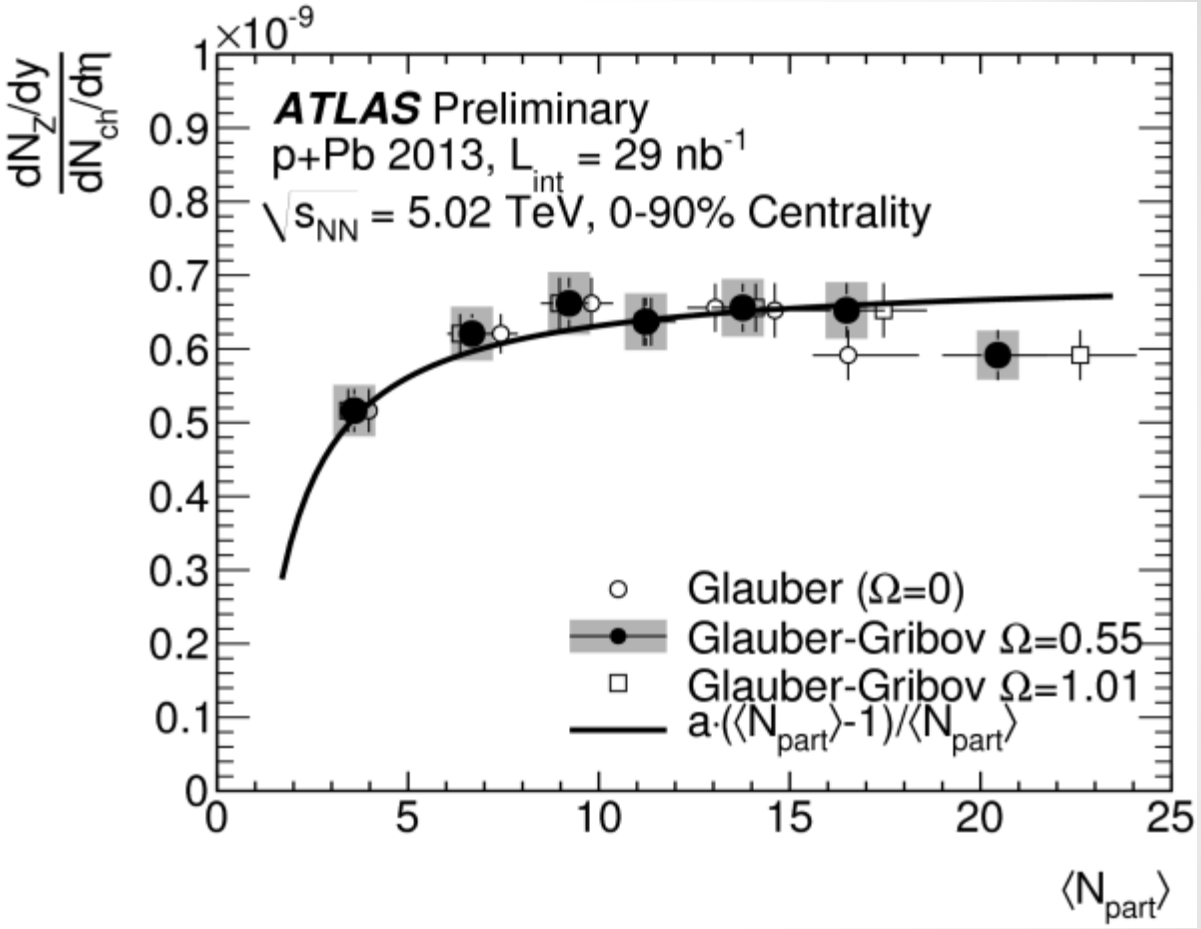

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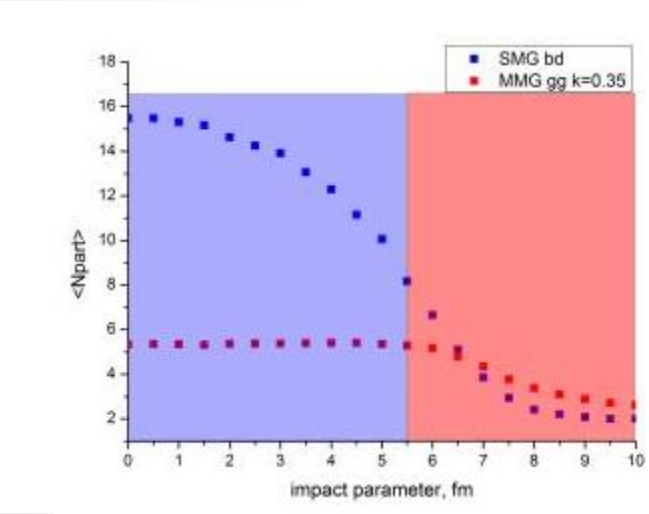
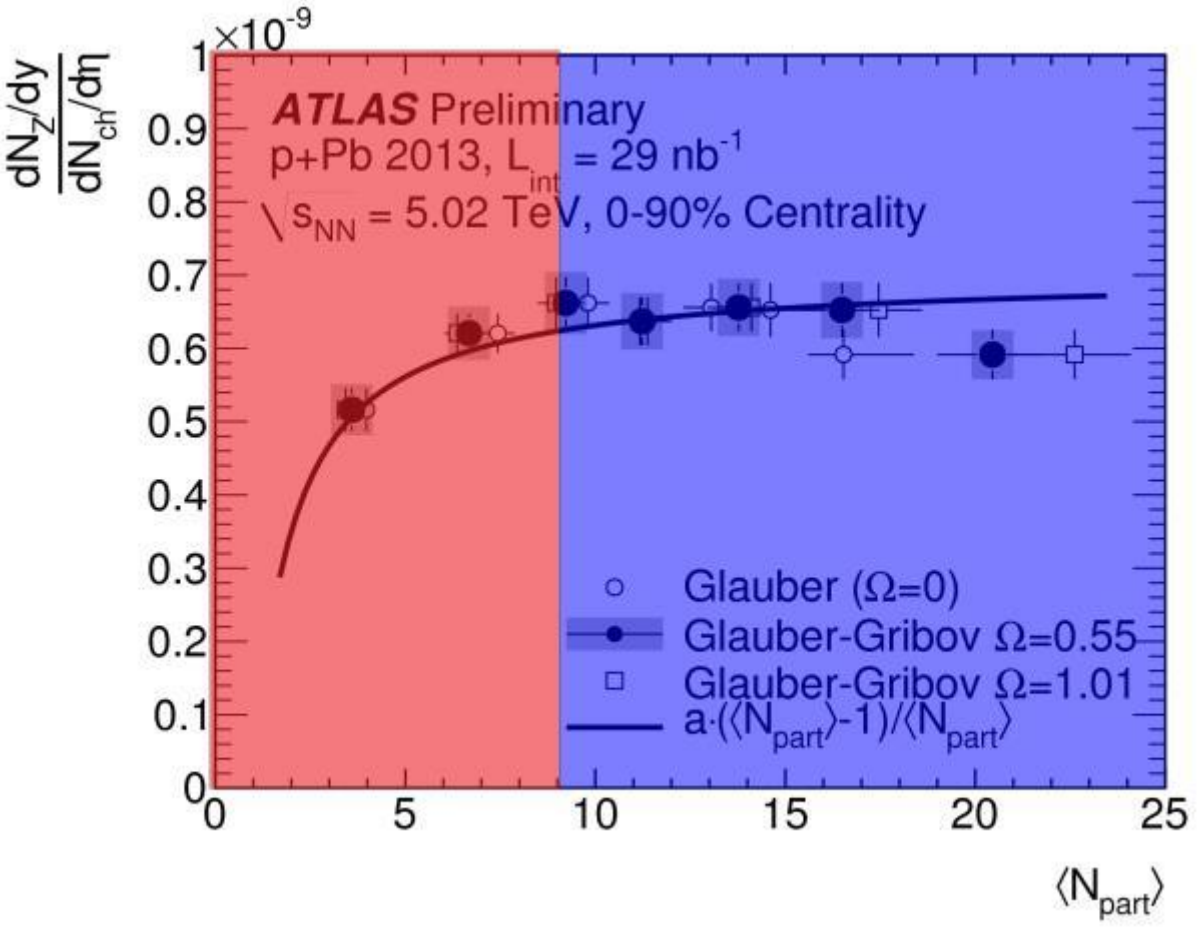
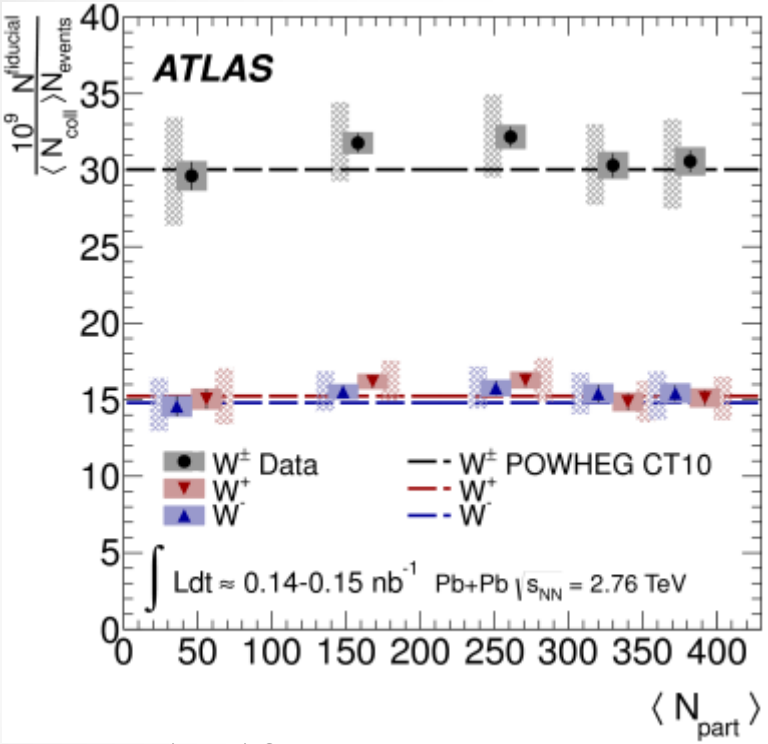




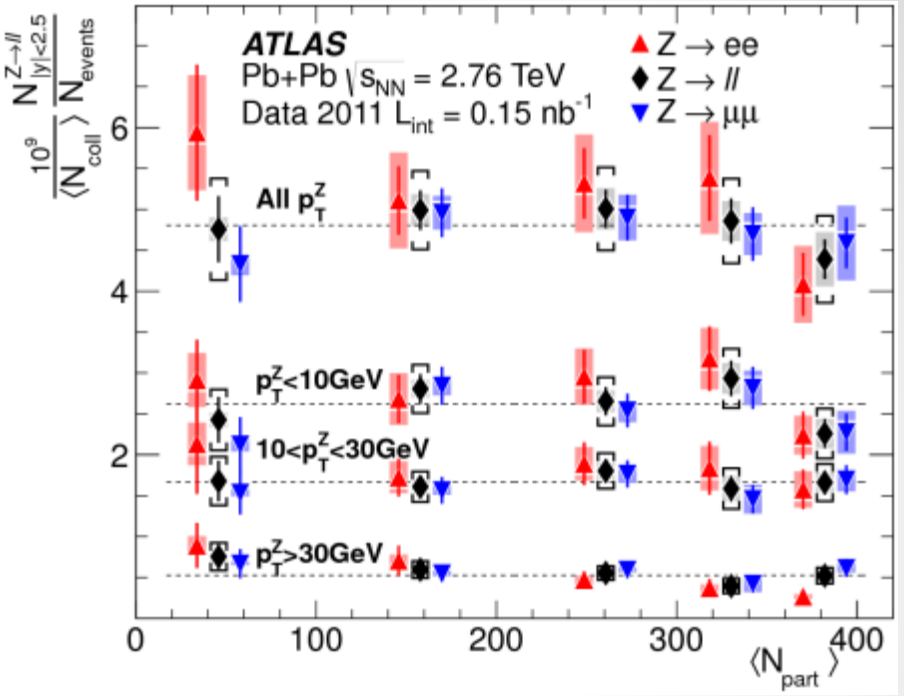
In MGM we do not have Npart > 6

In terms of MGM the points with Npart (SGM) > 9 are just a one stretched point.

Rare processes



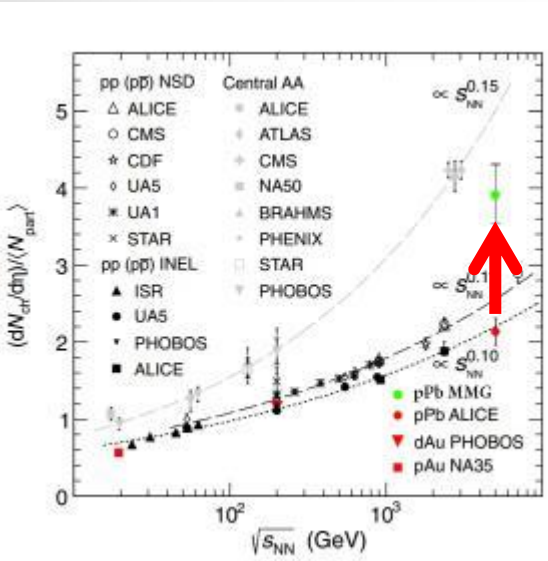
ATLAS arXiv:1408.4674

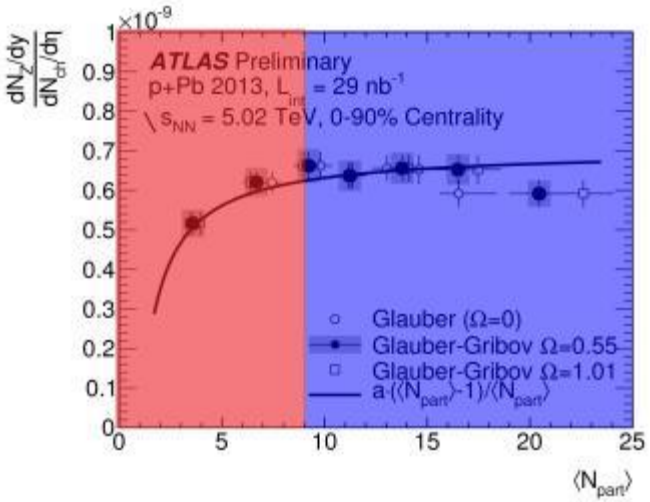


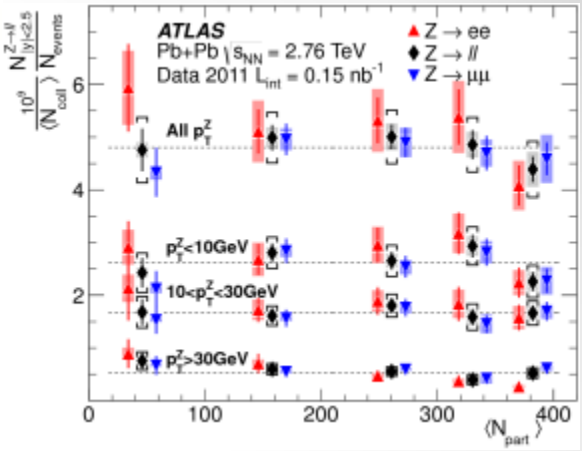
ATLAS arXiv:1210.6486

Standard Glauber model is correct for rare processes

Conclusions



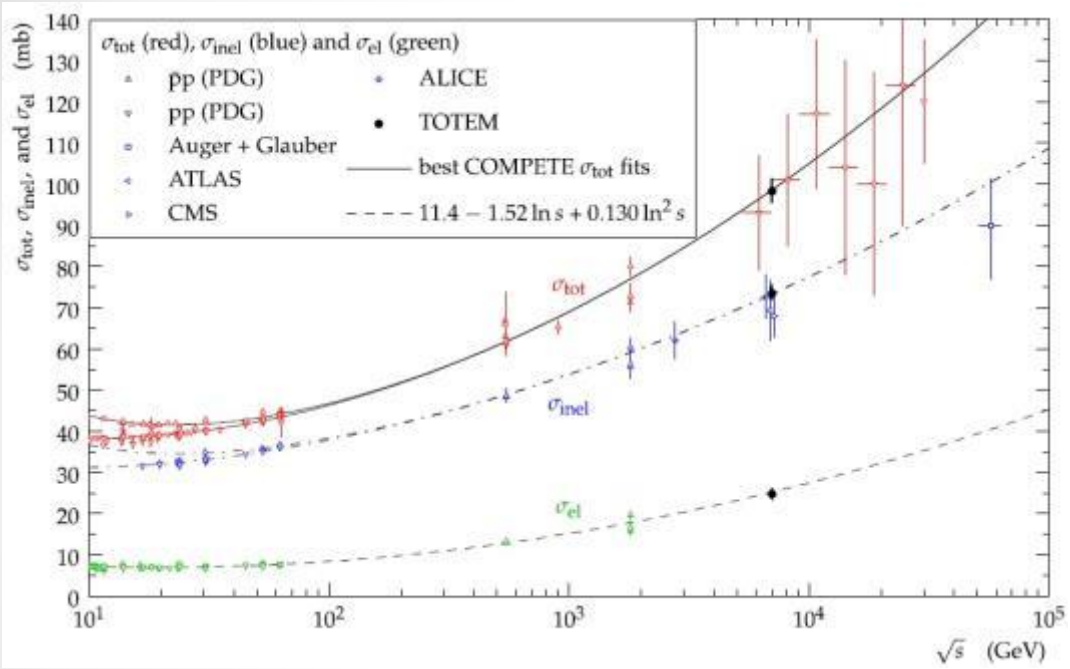




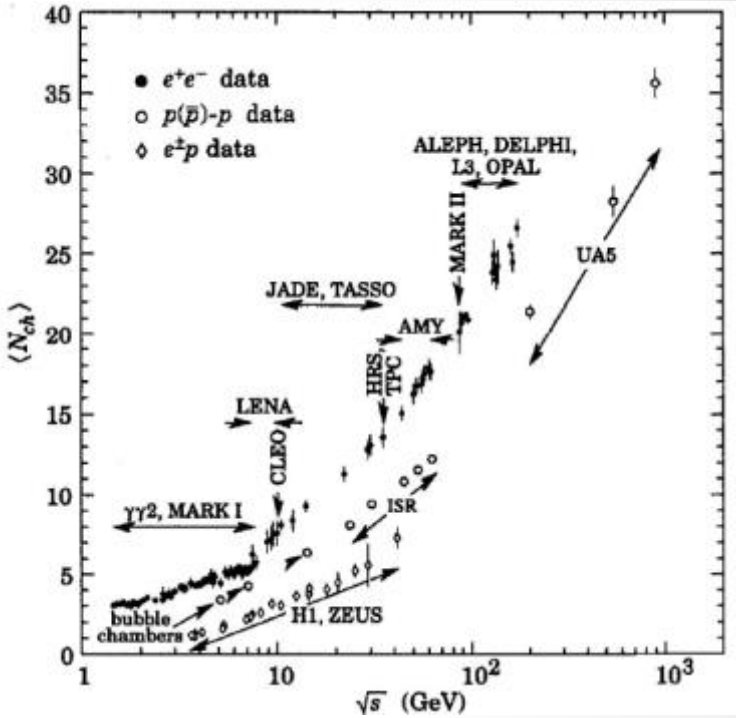
- Number of nucleon-nucleon collision (and N_{part} for pA) is not the same for soft and hard processes
- We have to be very careful with dividing experimental data by values which were obtained from theoretical models, because this results may be misleading

Backup

Proton-proton data



cross-section



multiplicity

Introduction