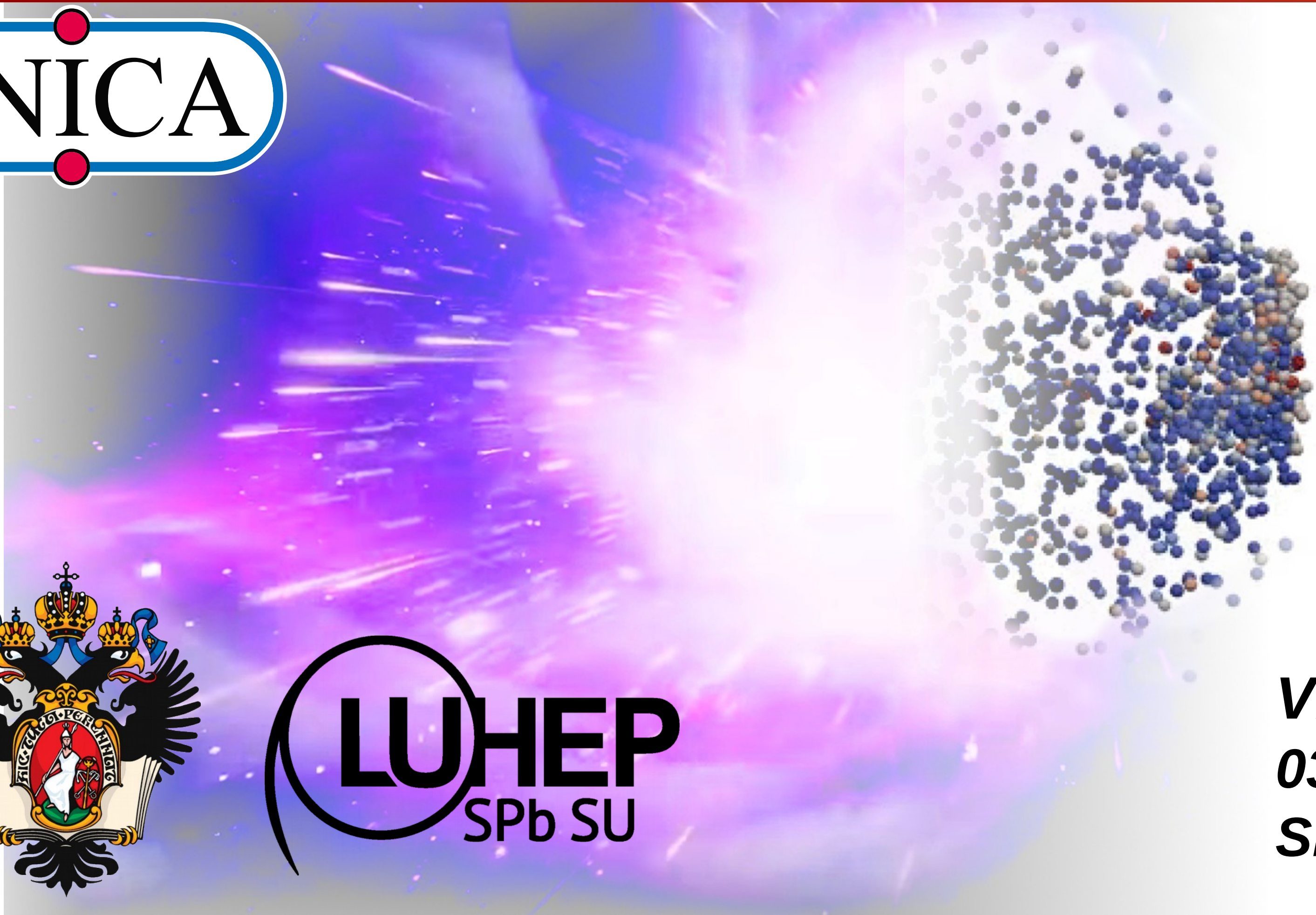
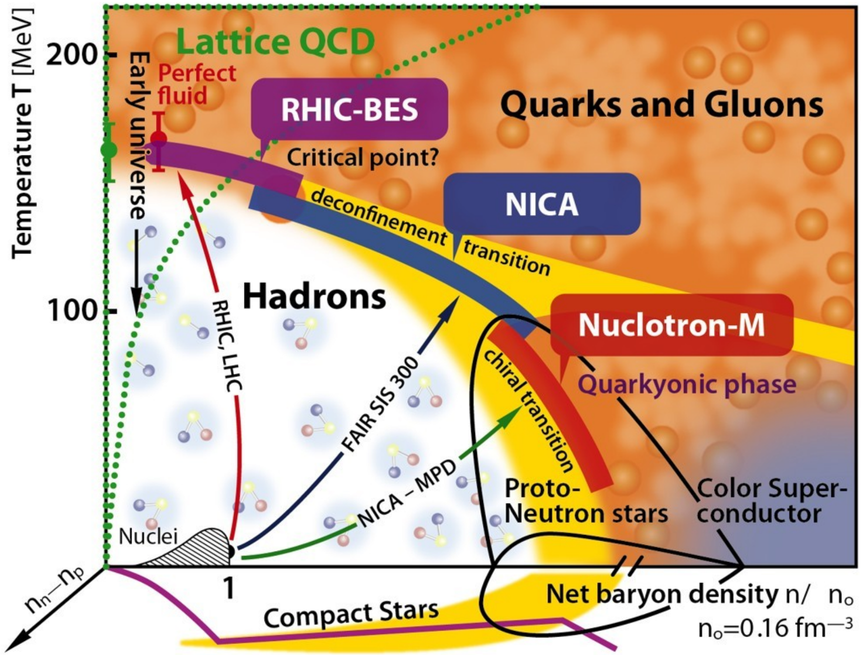
Impact parameter and multiplicity at NICA energies: SMASH modeling



Vladislav Sandul
03.09.2019
SPbSU, LUHEP

NICA: experimental conditions and restrictions



The “NICA complex” is aimed in the study in the laboratory of *the properties of nuclear matter in the region of the maximum baryonic density.*

Such conditions can be obtained in *relativistic nuclear collisions.*

The NICA experiments provide us next conditions/restrictions for colliding systems:

- the range of collision energies **from 4 to 11 AGeV**
- colliding systems: **from p+p up to Au+Au**

Our present goals are preparation of the data analysis instrument and algorithms and attempt to predict some physical results using MC event generators

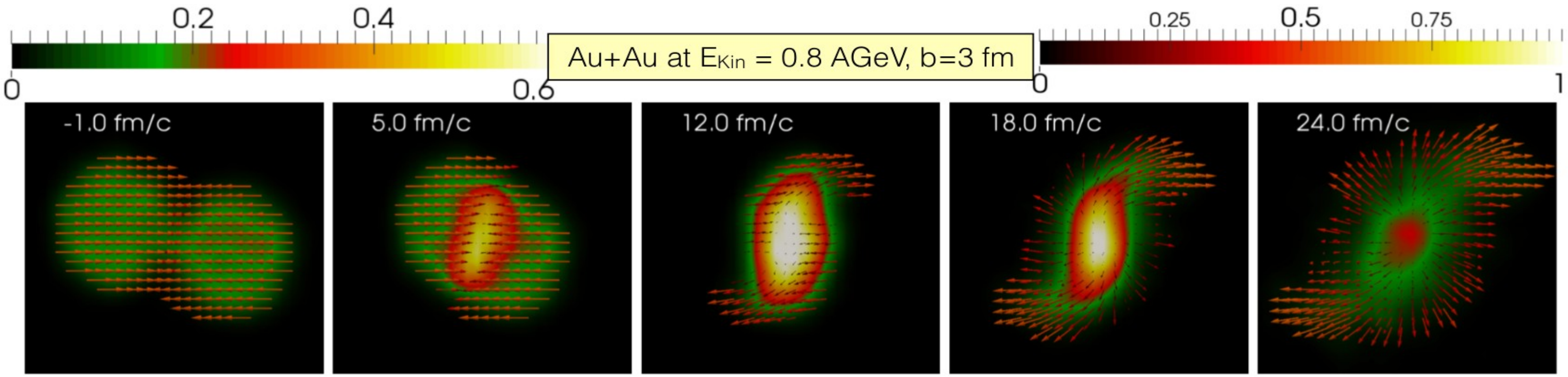
SMASH event generator

SMASH - **S**imulating **M**any **A**ccelerated **S**trongly-Interacting **H**adrons

https://smash-transport.github.io/

- SMASH is based on a hadronic transport approach
- Particles dynamics described by relativistic Bolzman equation:

$$p^\mu \partial_\mu f_i(x,p) + m_i F^\alpha \partial^p_\alpha f_i(x,p) = C^i_{\text{coll}}$$



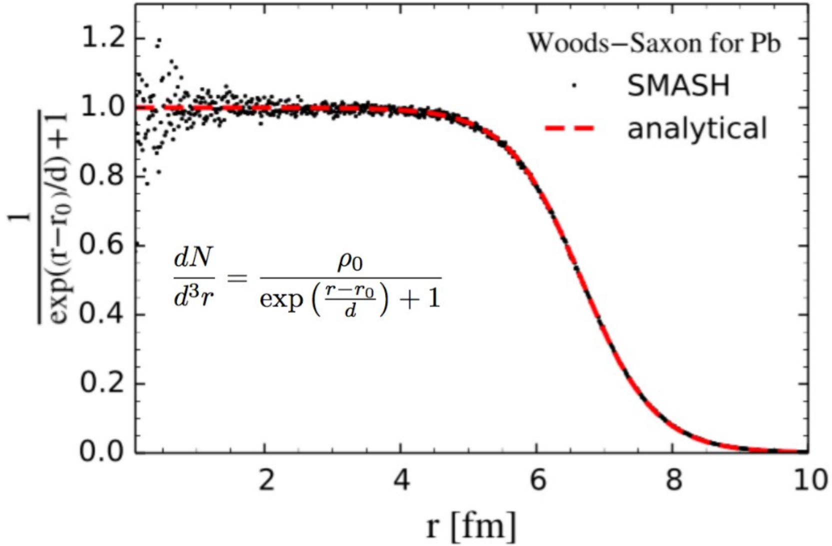
J. Weil et al, PRC 94 (2016)

SMASH event generator

- Particles represented by Gaussian wave packets for density calculations
- Geometric collision criterion:

If $d_{\text{trans}} < d_{\text{int}} = \sqrt{\frac{\sigma_{\text{tot}}}{\pi}}$ => we have a collision; $d^2_{\text{trans}} = (\vec{r_a} - \vec{r_b})^2 - \frac{((\vec{r_a} - \vec{r_b}) \cdot (\vec{p_a} - \vec{p_b}))^2}{(\vec{p_a} - \vec{p_b})^2}$

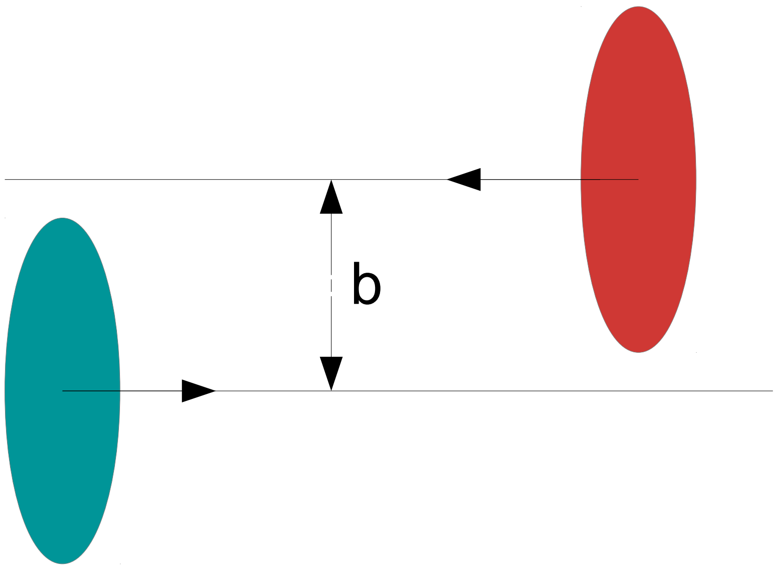
- Collisions are binary interactions: Inelastic collisions through resonance / string excitation and decay
- Initial conditions: nucleons distributed by Woods-Saxon distr. in coordinate space

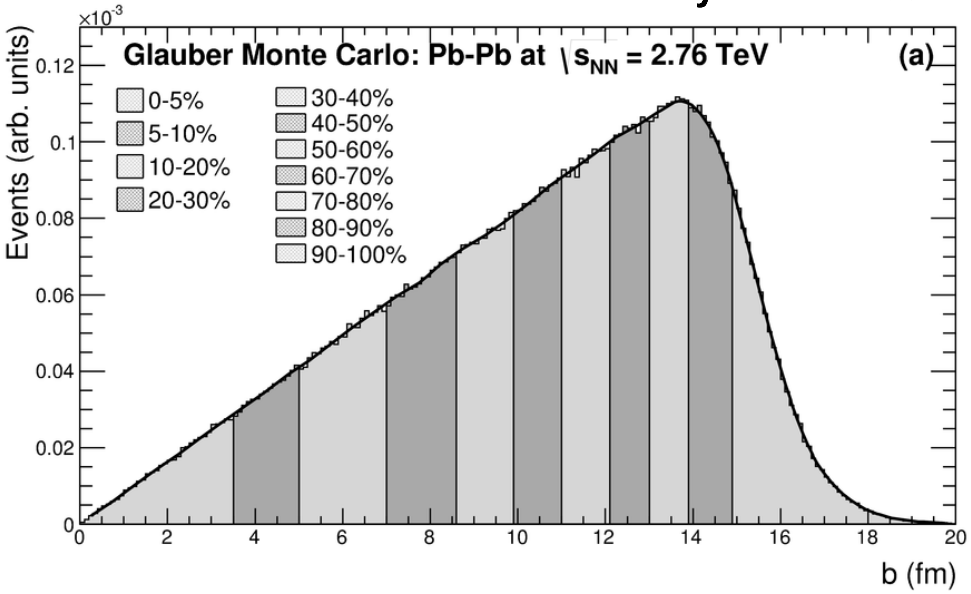


Hannah Elfner. SMASH and Baryon Stopping

Impact parameter and centrality

B. Abelev et al. Phys. Rev. C 88 2013



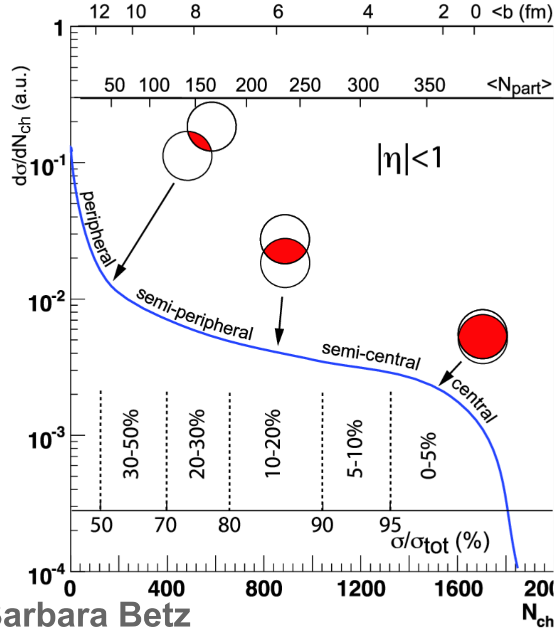


Impact parameter ***b*** is the perpendicular distance between the pathes of a centers of a “projectile” and “target” particles.

Impact parameter determines centrality of collision: more impact parameter – less centrality.

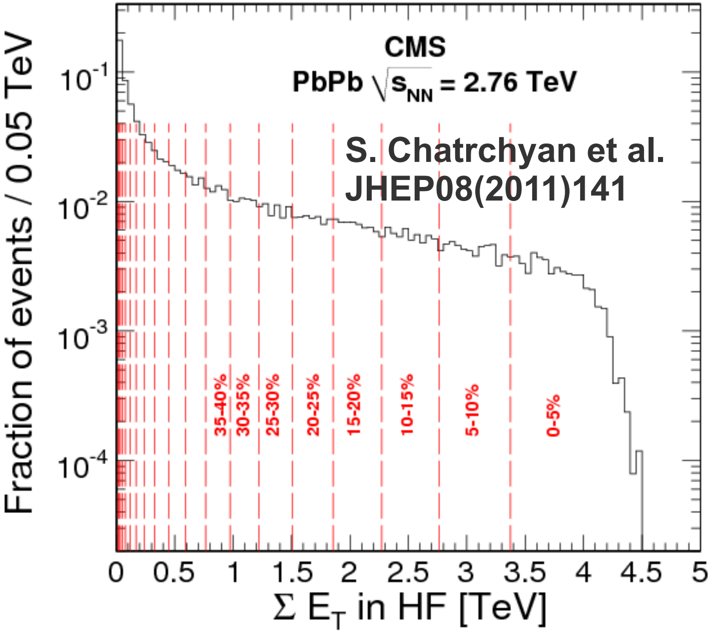
Since we can not measure impact parameter experimentally, we try to connect centrality with others observables, such as:

Number of participants or created particles;

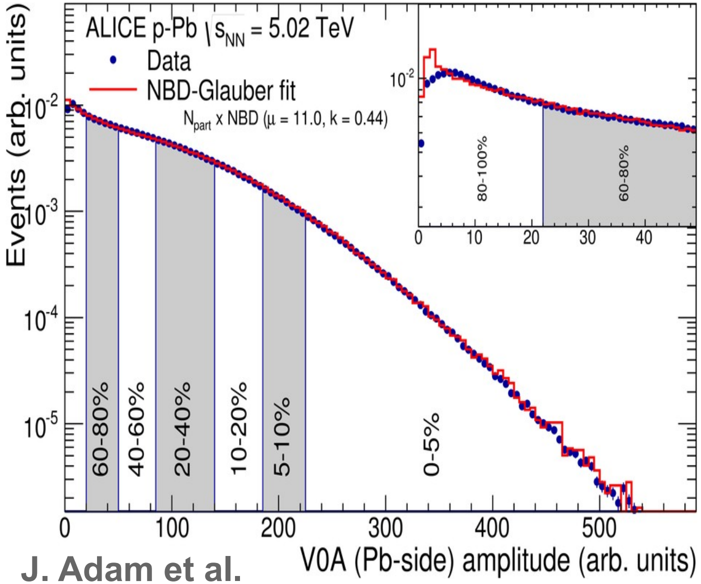


Barbara Betz
arXiv:0910.4114

Total transverse energy;



Amplitude of signal in detectors, etc.

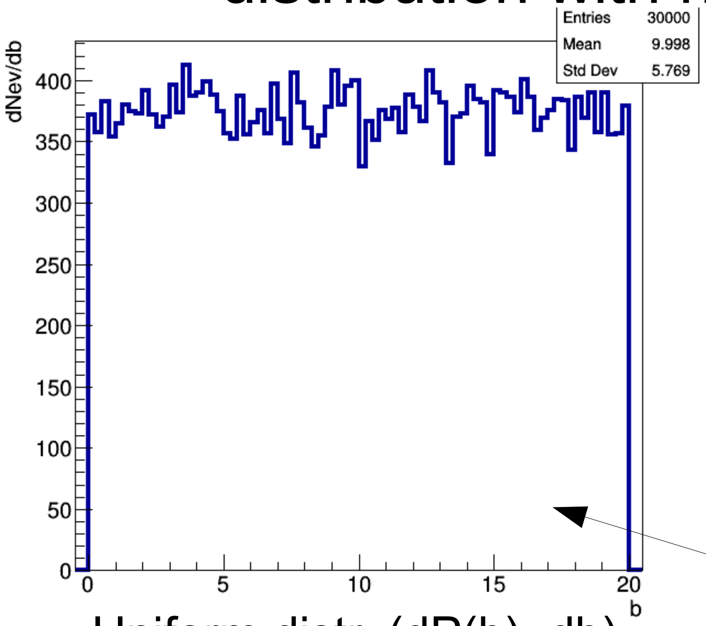


J. Adam et al.
Phys. Rev. C 91, 064905

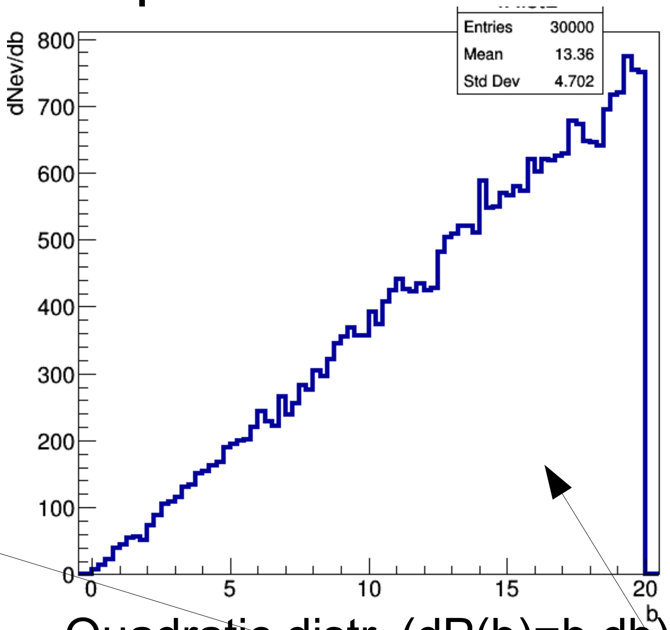
One of our goals is the development of centrality event selection methods and search for others observables for centrality determination.

Impact parameter in SMASH

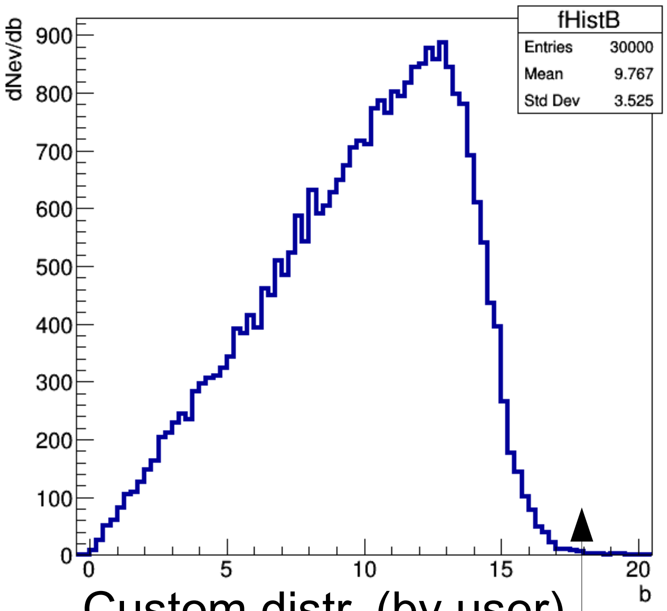
SMASH provide us an ability to set up impact parameter distribution with next options:



Uniform distr. (dP(b)=db)



Quadratic distr. (dP(b)=b db)



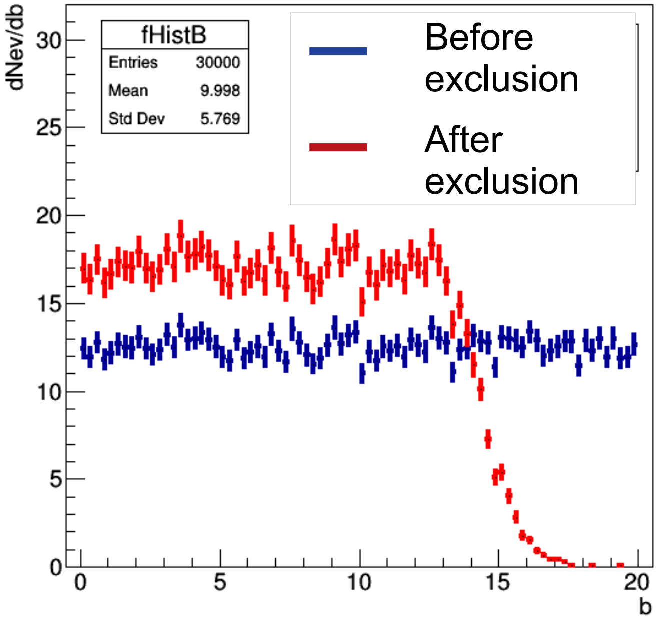
Custom distr. (by user)

Which one we should choose?

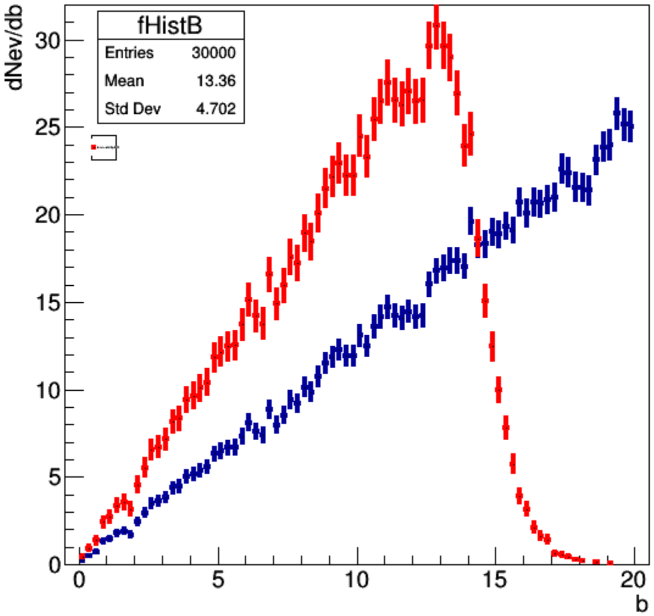
Au+Au collisions; √s = 4 AGeV

Let's exclude events with Number of final particles = 197+197=394. In the first approximation it is exclusion of events without inelastic interactions.
How impact parameter distribution will change?

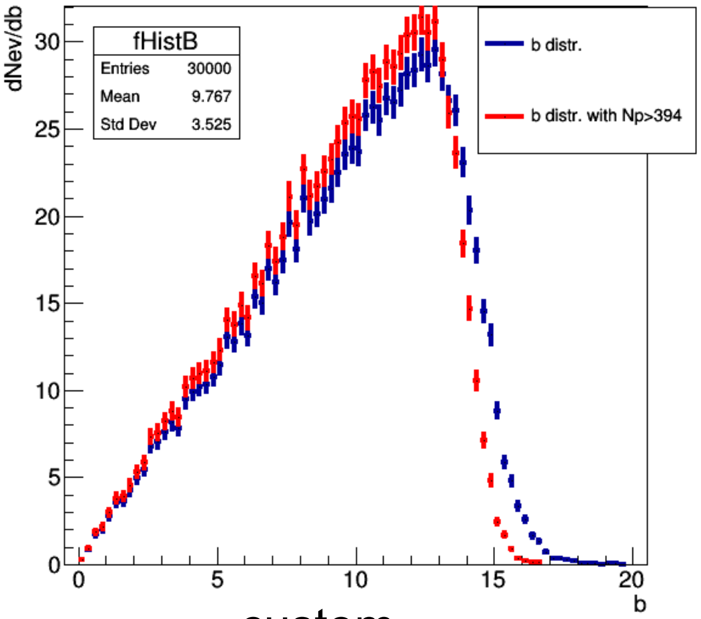
Histograms are normalized to 100



uniform



quadratic

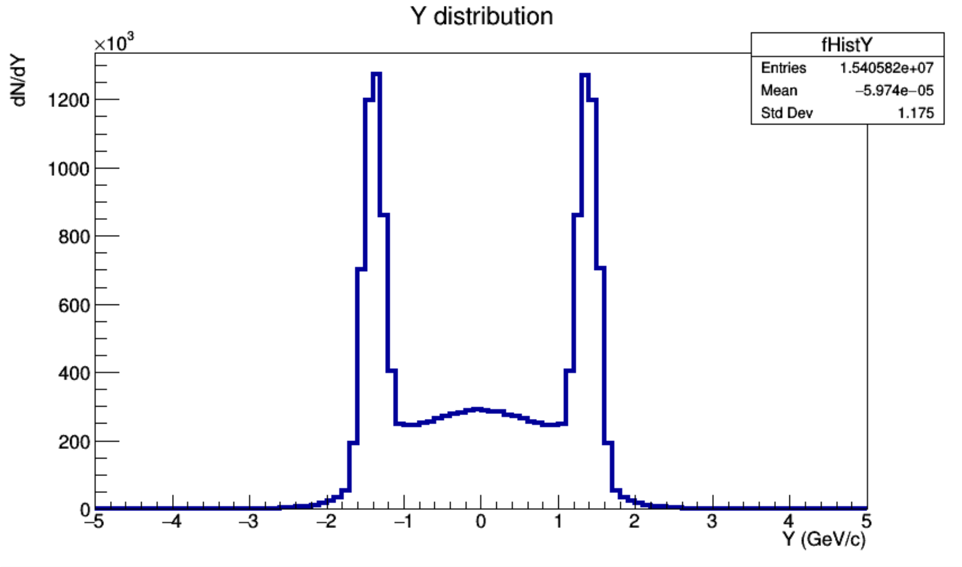


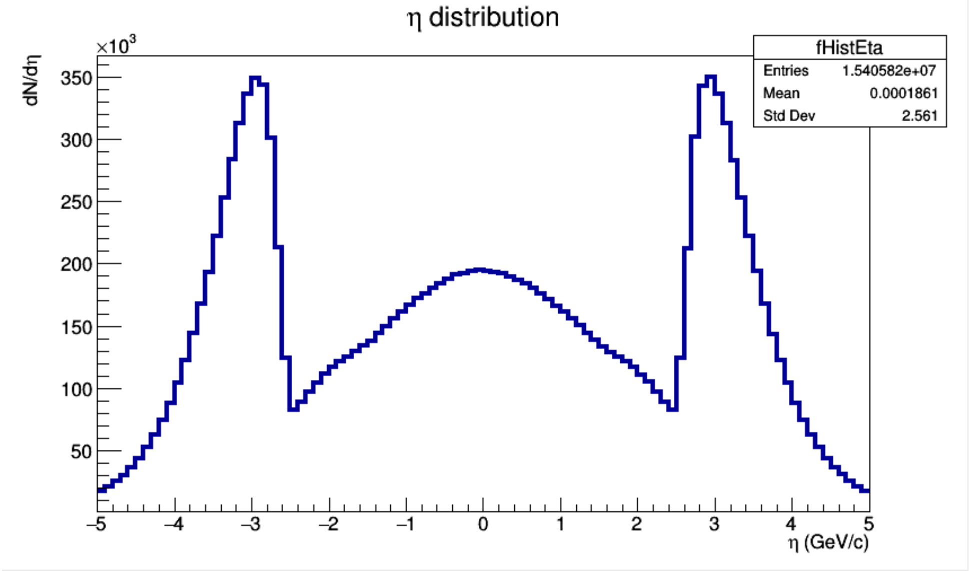
custom (pseudorealistic)

<u>Quadratic distribution seems the most natural and realistic one.</u>

But after such event filtering **approximately a half of event will be excluded** => we have poor statistic in this case.

A few words about (pseudo)rapidity distributions



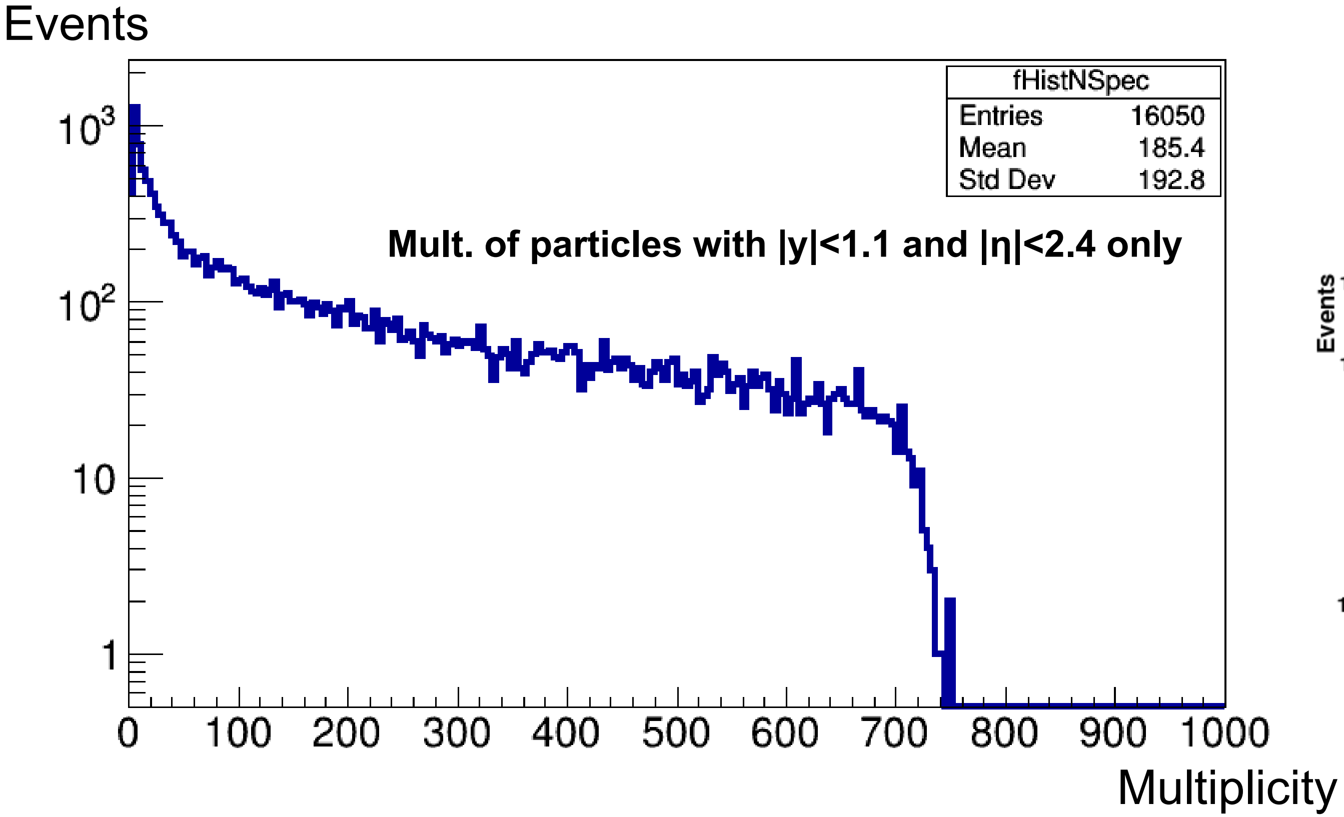


Since we can not separate participants and spectators in SMASH, we have such abnormal pseudorapidity and rapidity distributions.

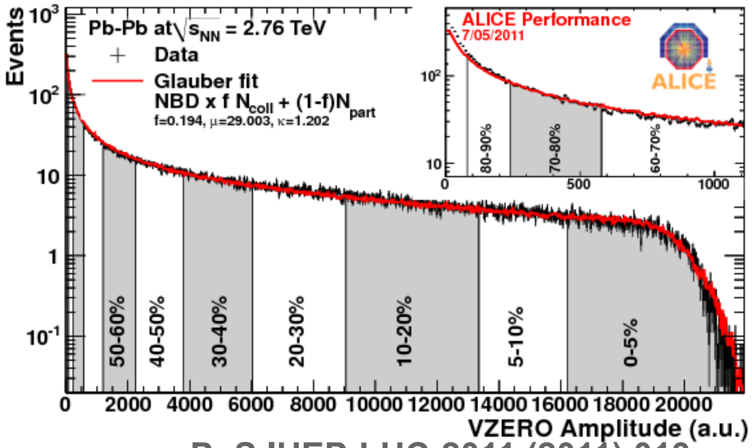
The rough solution of this problem – work in central pseudo- and rapidity intervals only

Subsequent presented results relate to particles with |y|<1.1 and |η|<2.4

Multiplicity distribution

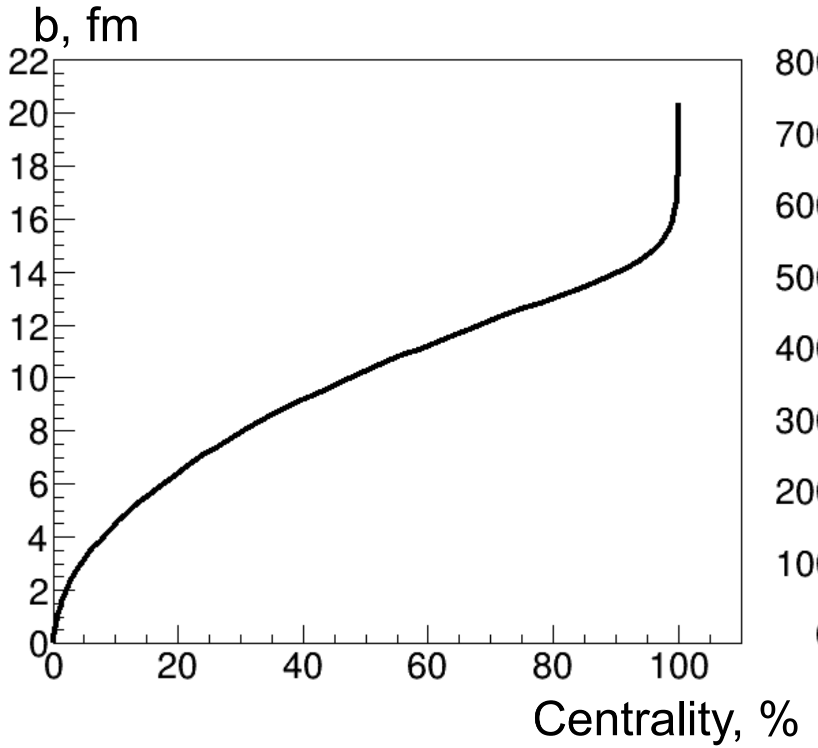


We can see well-known picture for event multiplicity distribution



PoS IHEP-LHC-2011 (2011) 013

Impact parameter, multiplicity and centrality



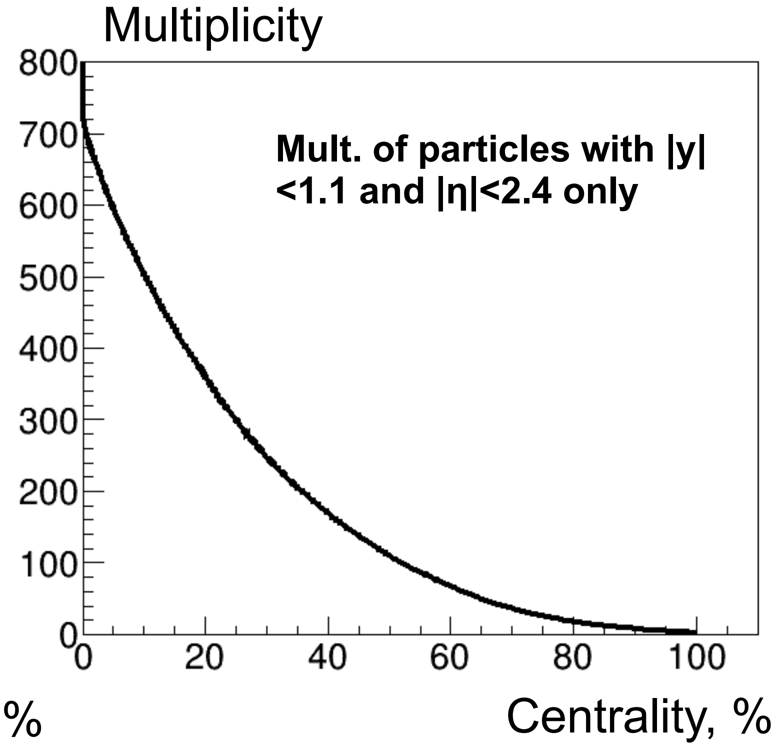


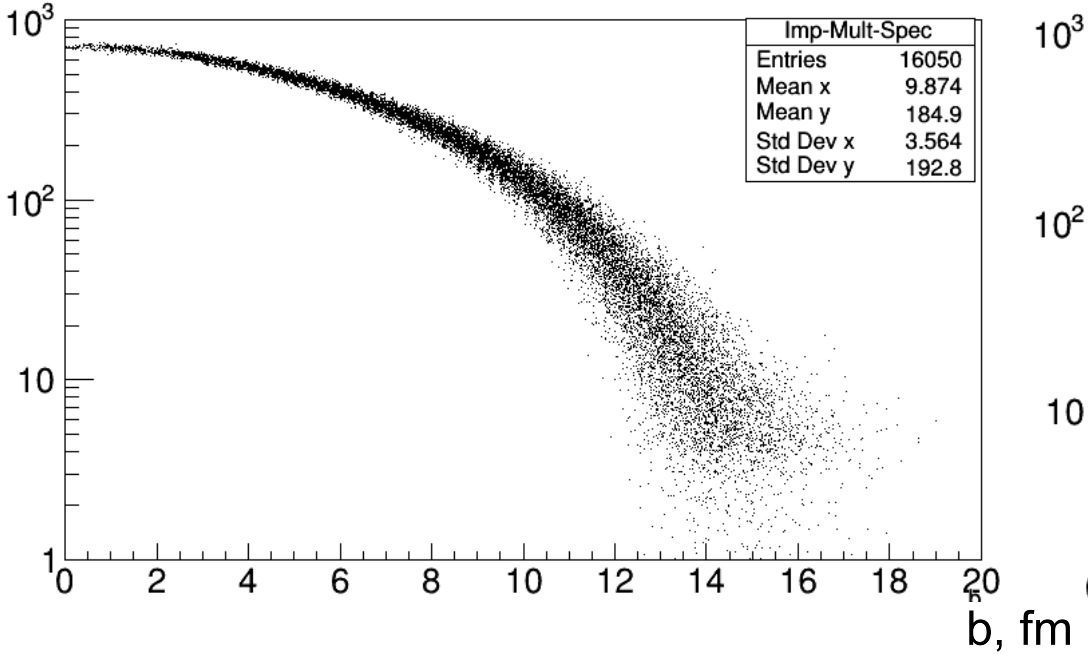
Table 1

Centrality, %	b	Multiplicity
0-5	0-3	596-752
5-10	3-4.5	504-595
10-20	4.5-6.4	361-503
20-30	6.4-8	247-360
30-40	8-9.2	170-246
40-50	9.2-10.2	110-169
50-60	10.2-11.2	67-109
60-70	11.2-12.1	38-66
70-80	12.1-13	18-37
80-90	13-14	8-17

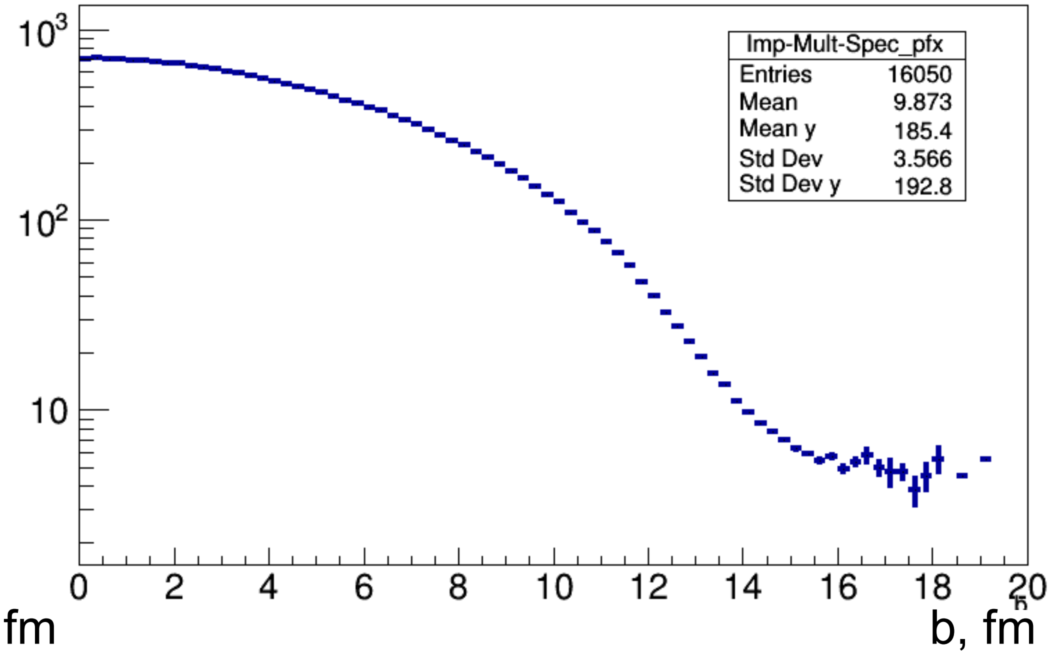
Here are dependencies of ***b*** and multiplicity on centrality. Knowing them we can determine centrality classes match them with multiplicity and ***b*** values

Multiplicity - impact parameter correlations

Muliplicity



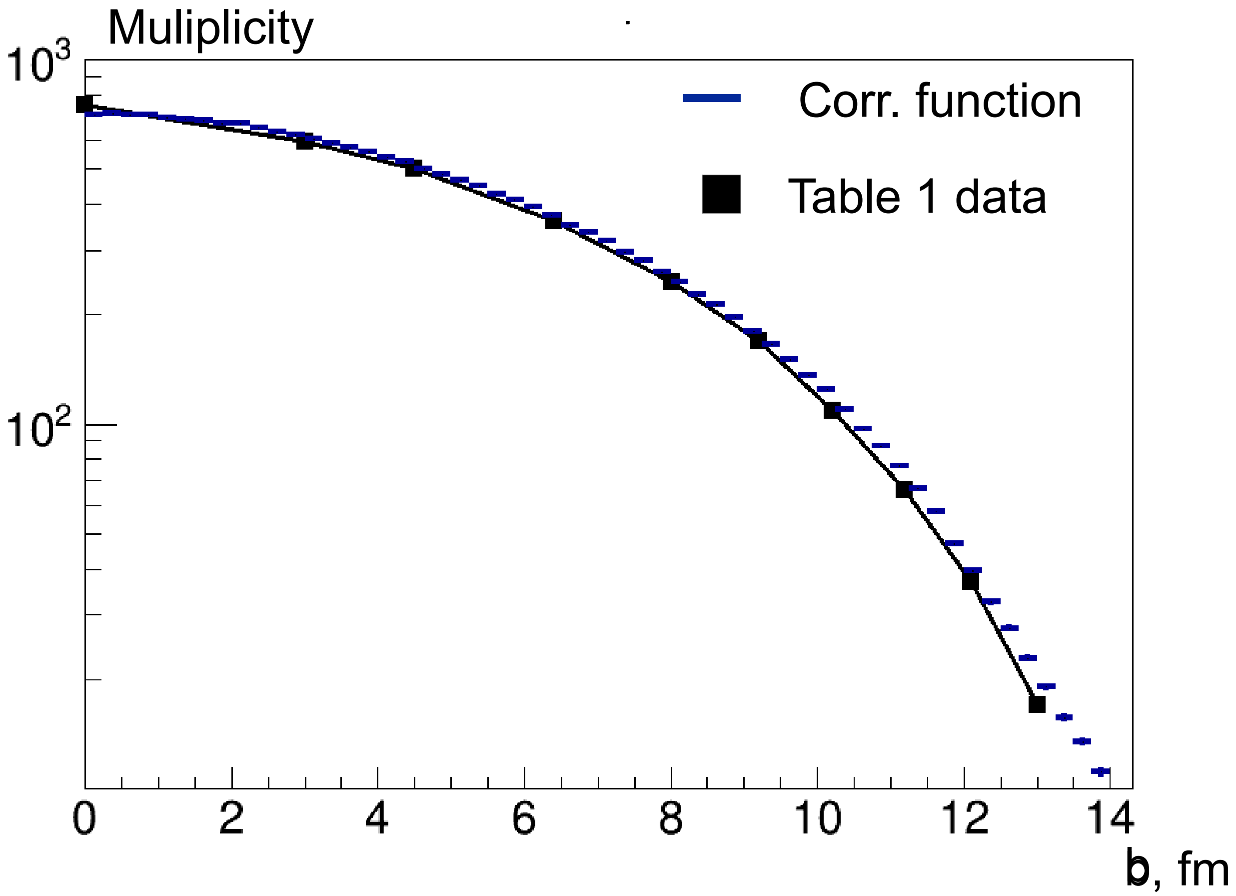
Muliplicity trend



Here is the bulk of events. Every event have a certain values of multiplicity and impact parameter, presented on this 2d-histogram

Obviously, the greatest multiplicity corresponds to the smallest impact parameter, and vice versa

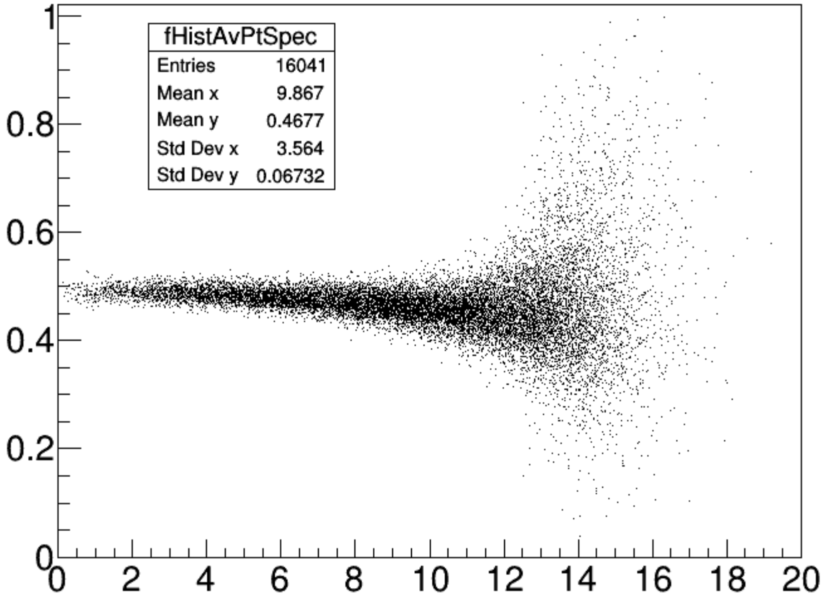
Relation of impact parameter and multiplicity



As we can see, relations of impact parameter and multiplicity from correlation function and from centrality classes comparing (Table 1) are in a good agreement.

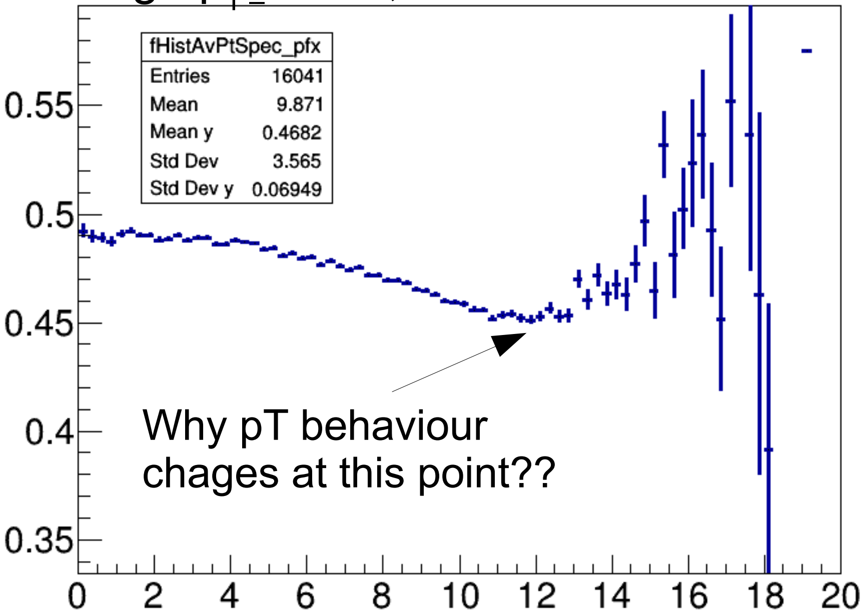
Dependence of average p_T on impact parameter

Average p_T ,GeV/c



b, fm

Average p_T_ trend, GeV/c

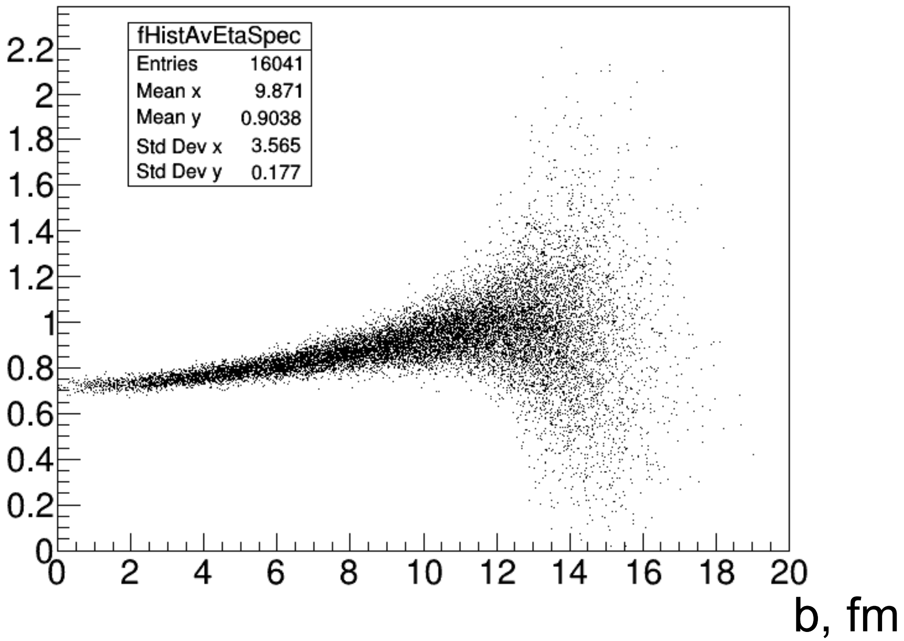


b, fm

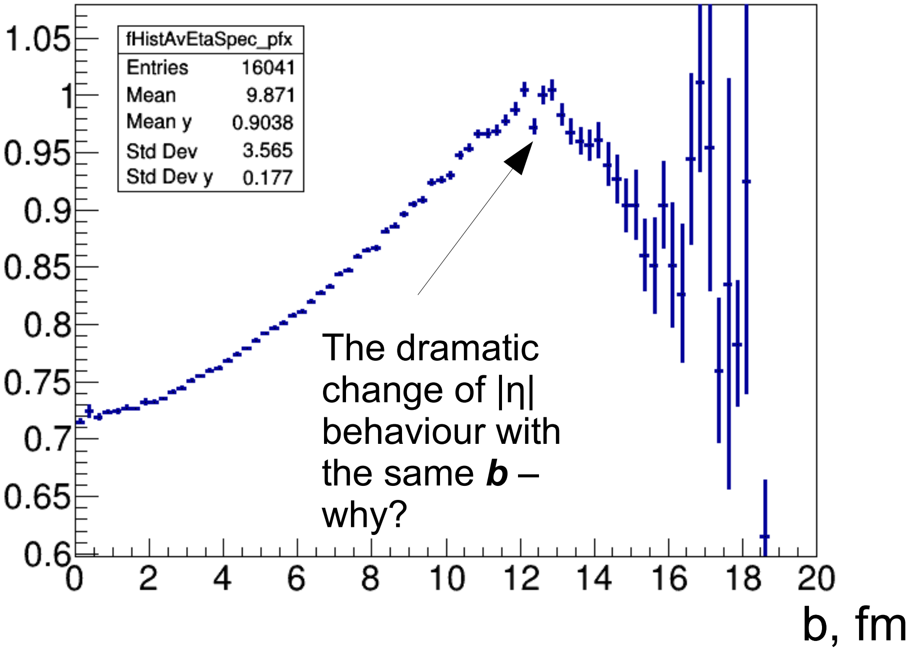
Average p_T changes noticably with centrality, so we may expect p_T spectra change upon transition from one centrality class to another

Dependence of average |η| on impact parameter

Average |η|



Average |η| - trend



Average |η| also changes noticably with centrality, so we may expect η distr. change upon transition from one centrality class to another .

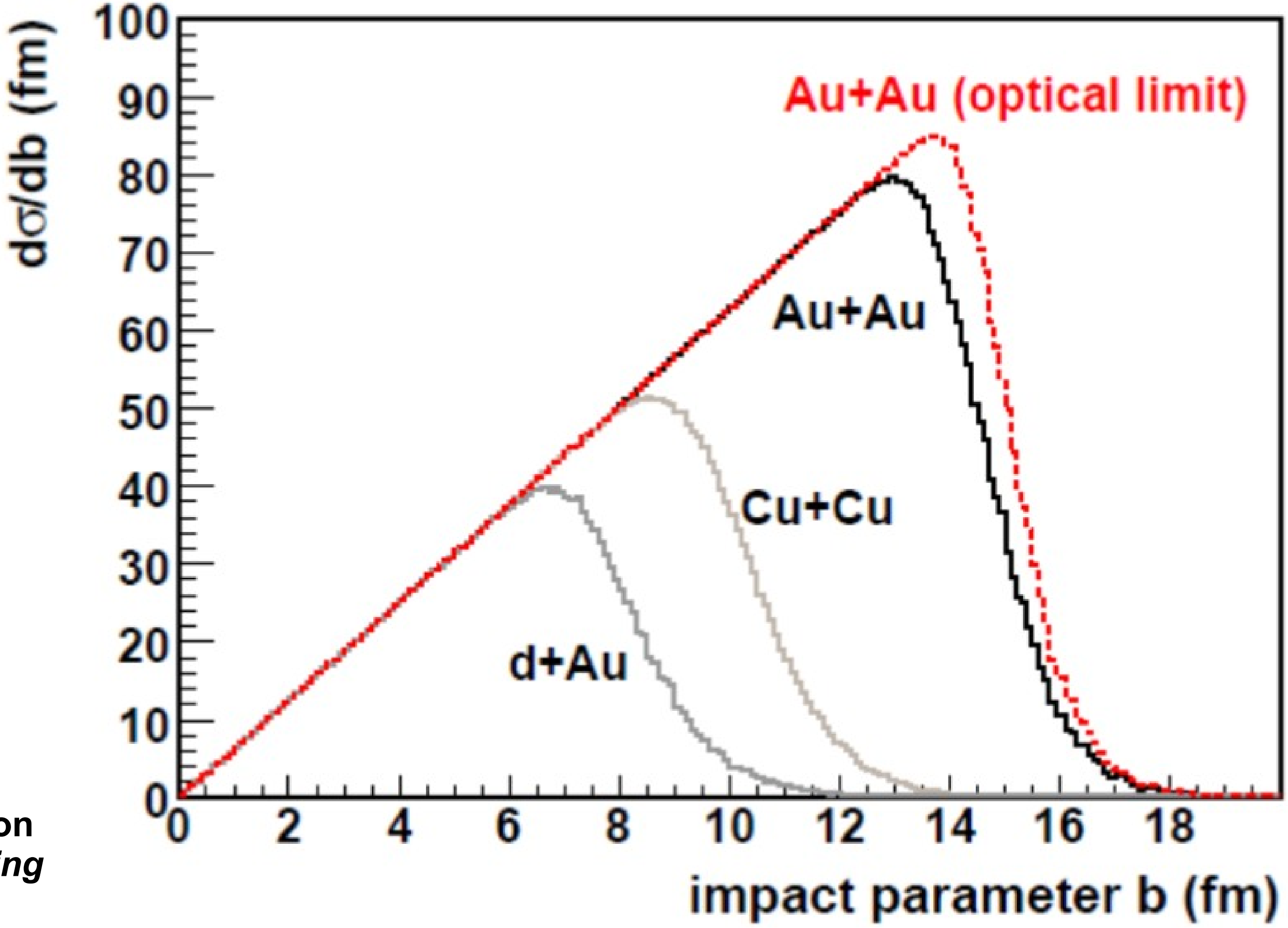
Summary

- We explore the possibilities of SMASH event generator to simulate particle collisions at NICA energies and try to tune it
- Using SMASH data we try to find relations between impact parameter, centrality and others observables
- Relations between impact parameter, centrality and multiplicity in central (pseudo)rapidity interval are received
- Also the dependencies of pT and $|\eta|$ on b are considered. The general point of significant change of behaviour for both dependencies at b=12-13 fm was found

Thank you for attention!

Back up

Sample for “custom” distribution



Jeremy Wilkinson
Glauber modelling in high-energy nuclear collisions