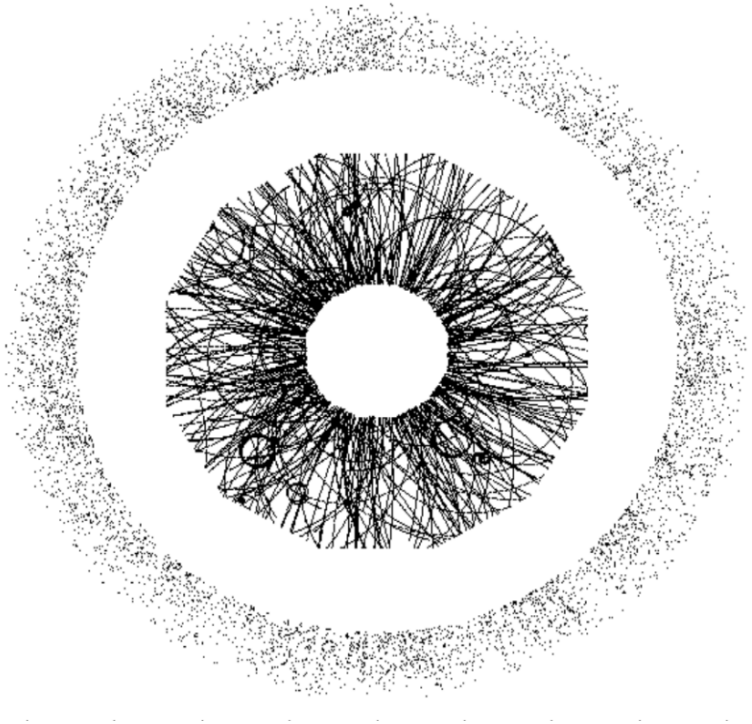

Influence of different centrality methods on multiplicity fluctuations MPD case

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Problem

I want to estimate how different ways of defining centrality influence multiplicity fluctuations, which are, probably, the most sensitive observables.

I consider:

- 4 centrality methods (more information is on the next slides):
  - Impact parameter – ideal, unrealistic case
  - Number of nucleon participants – realistic, but currently unreachable
  - FHCall pyramid algorithm
  - Multiplicity in a separate rapidity window
- a bunch of fluctuations quantities:
  - First 4 moments of multiplicity distributions
  - Strongly intensive $\Delta[\mathrm{Pt}, \mathrm{N}], \Sigma[\mathrm{Pt}, \mathrm{N}]$
  - First 4 factorial moments of net charge distributions

Data set

90k events DCM-CMM min.bias Au+Au 11A GeV produced by INR

Only FHCal was simulated (GEANT 4)

No reconstruction was done not to interfere with centrality effects.

Therefore measured multiplicity is a pure one from MC:
pi+/-, p+/-, K+/- $|\eta|<0.8$, $0.15<pt<2$

Impact parameter (b) and multiplicity (Nc) based centrality

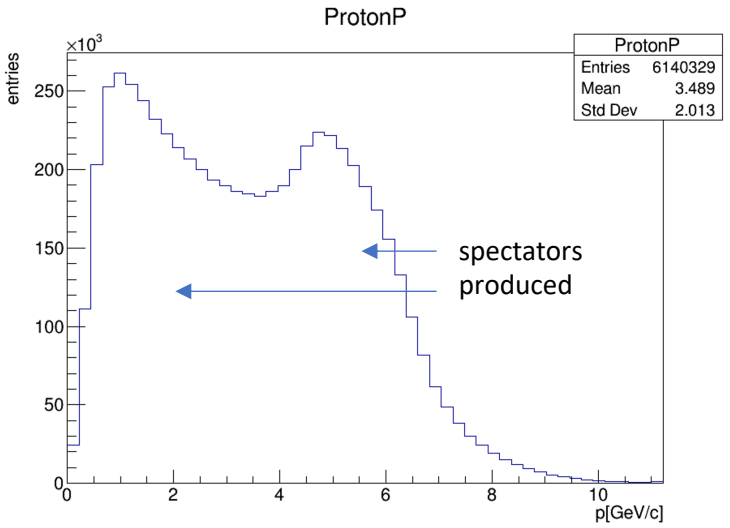
- b is taken from the generator
- Nc is a sum of all charged particles (pi+/-, p+/-, K+/-, e+/-, mu+/-) in $0.8<|\boldsymbol{\eta}|<1.2$ with $\mathbf{pt}>0.15$. A particle detection efficiency = 75% was introduced too.
- I consider two types of centrality intervals: 0-X% and X+/-2.5% (5% width). 0-X% means that these are X% of events with lower b (higher Nc)
  X+/-2.5%: take 0-(X+2.5%) and exclude 0-(X-2.5%)

Number of nucleon participants (Npart)

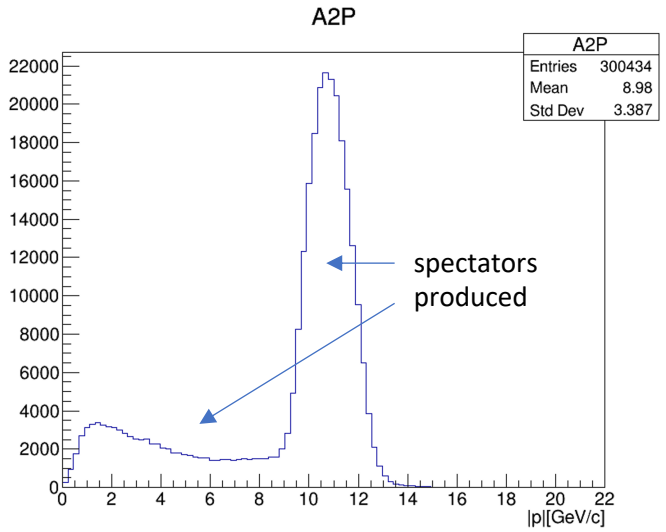
N.B. Npart is an unmeasurable quantity! *contrary to a common believe*

The reason is that in HI collisions a lot of nucleons are produced which are undistinguishable from spectators.

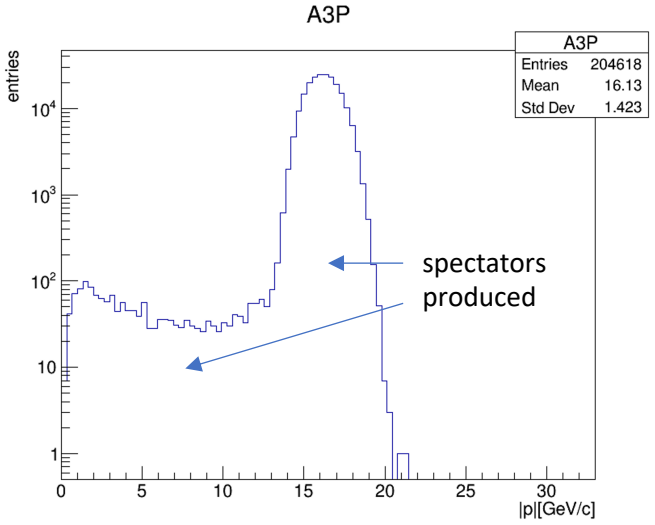
DCM-CMM min.bias Au+Au 11A GeV



protons



States with A = 2



States with A = 3

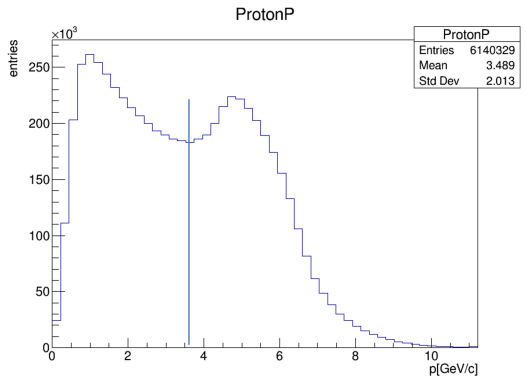
Number of nucleon participants (Npart)

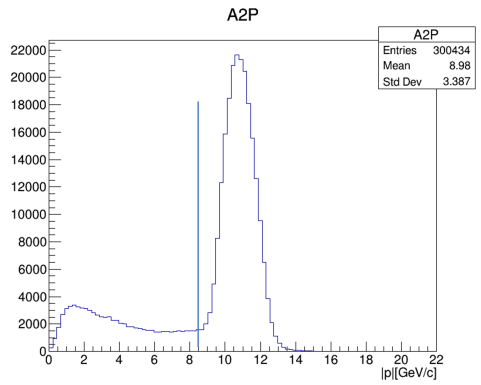
To measure something similar to Npart a set of momentum cuts has to be introduced.

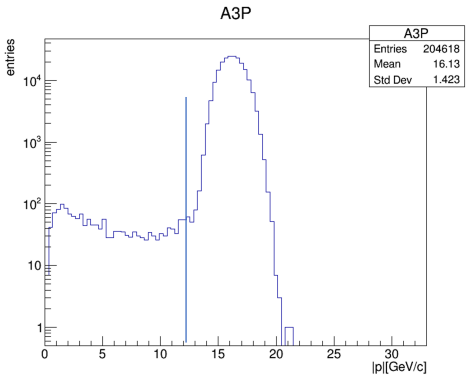
Henceforth I will call a particle a spectator if it is:

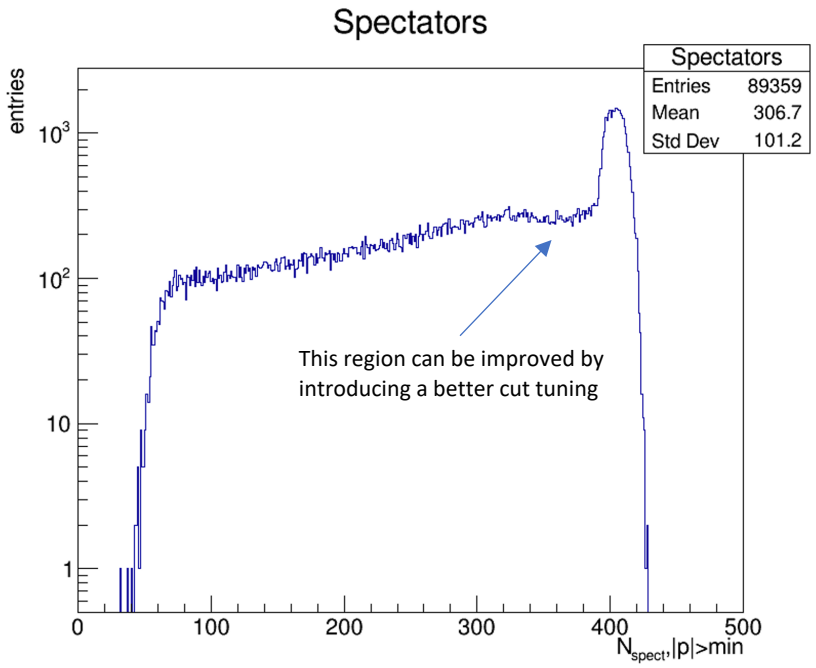
- A nucleon with p > 3.6 GeV/c
- A=2 states with p > 8.5 GeV/c
- A=3 states with p > 12.6 GeV/c
- A > 3 states

I didn't really tune it, as I don't think it's important for my current goal.



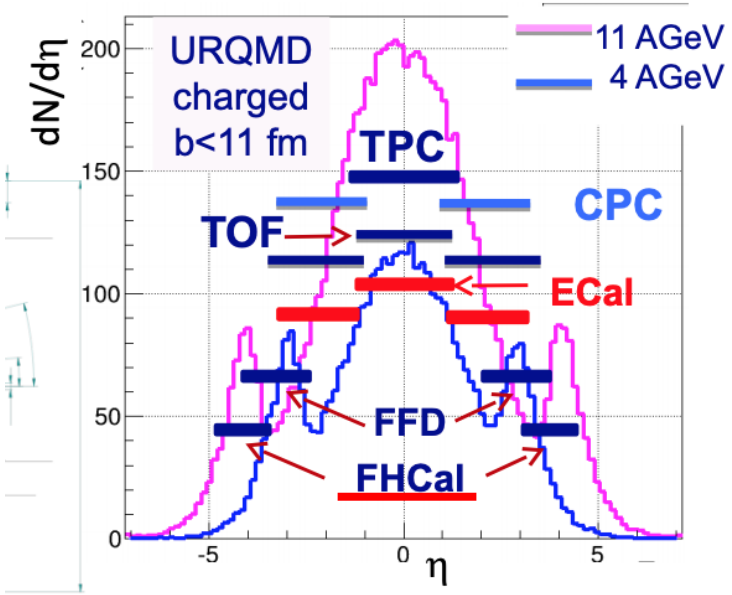


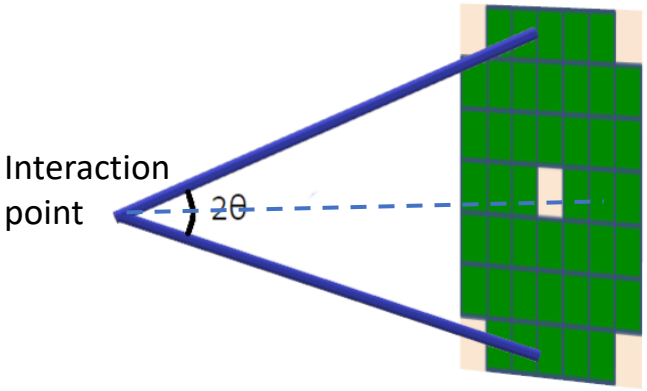


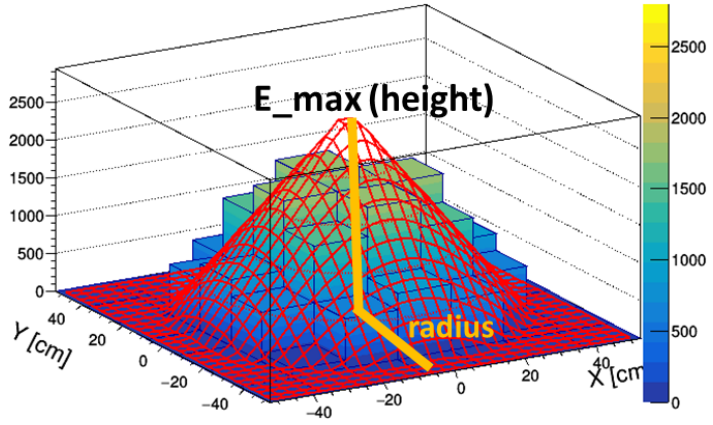


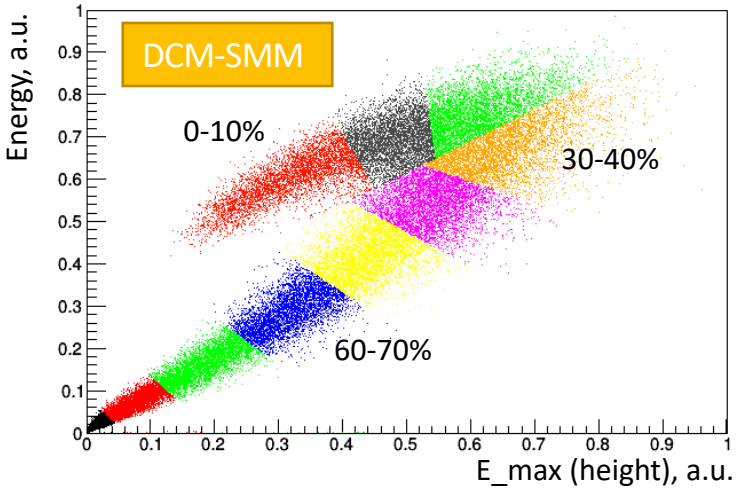
MPD FHCal

FHCal measures only a fraction of nucleon spectators, peripheral and central events may deposit the same energy in the calorimeter. Therefore an algorithm to determine centrality based on a FHCal signal shape was introduced by INR group. More information can be found here: https://indico.jinr.ru/event/1570/

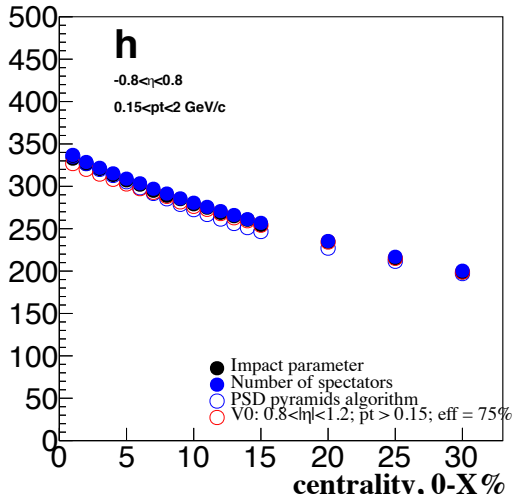


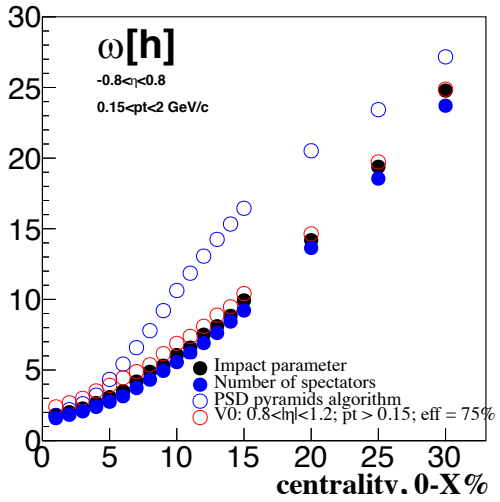


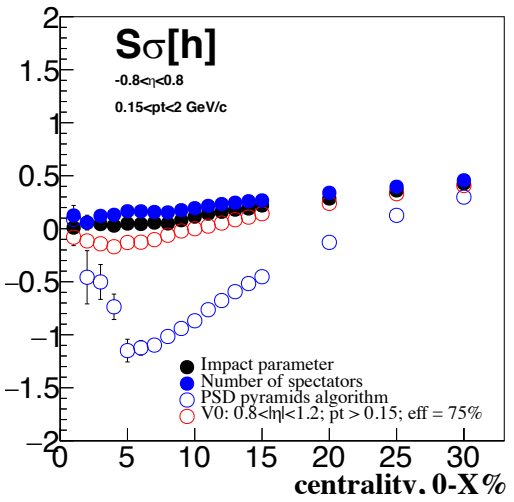


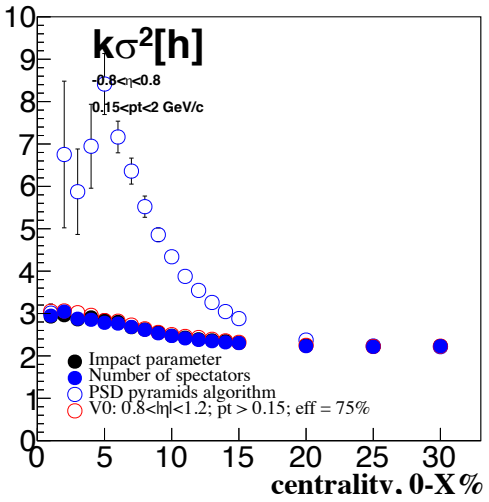


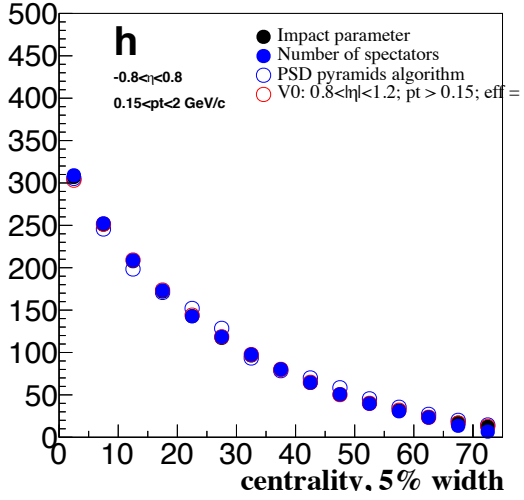
Multiplicity moments

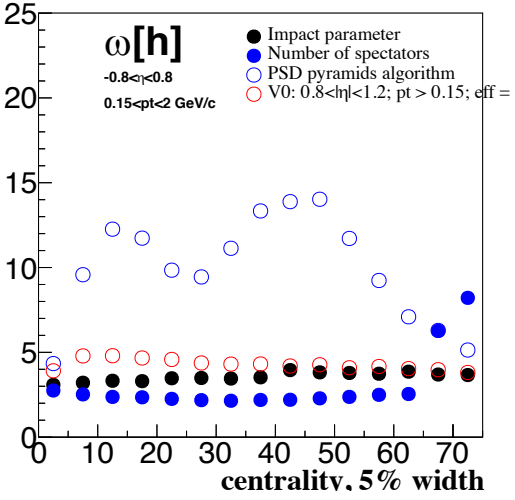


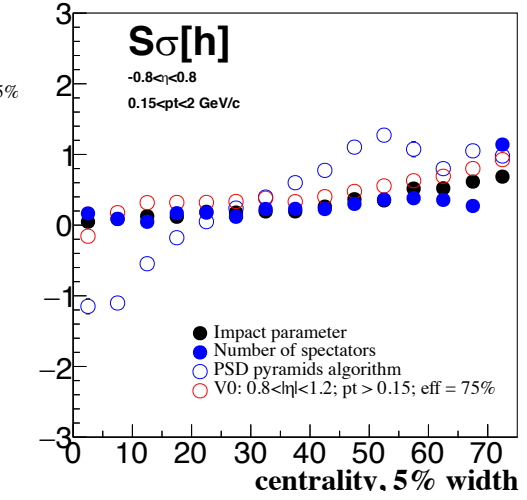


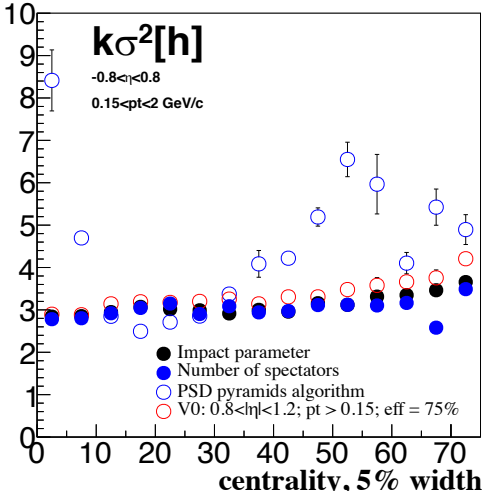




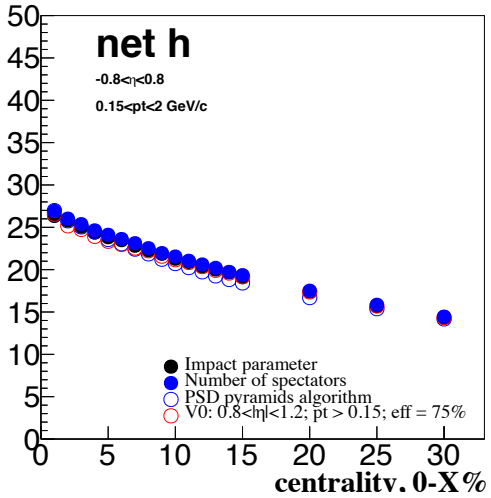


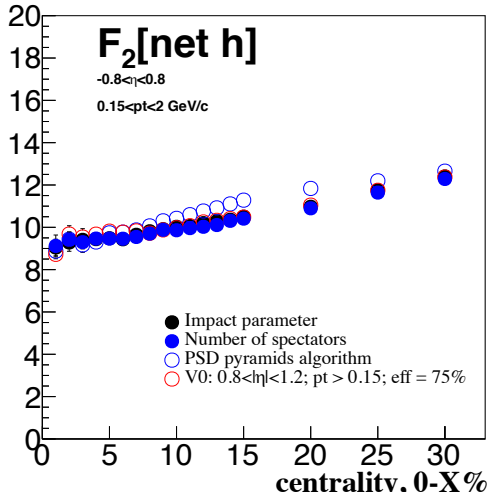


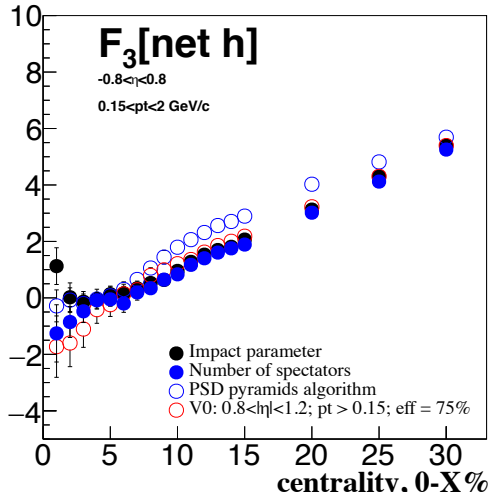


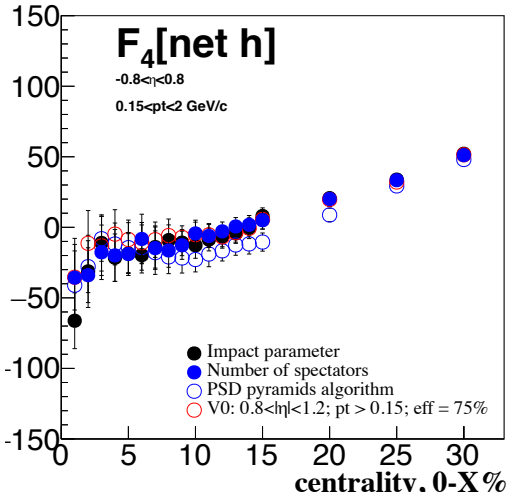


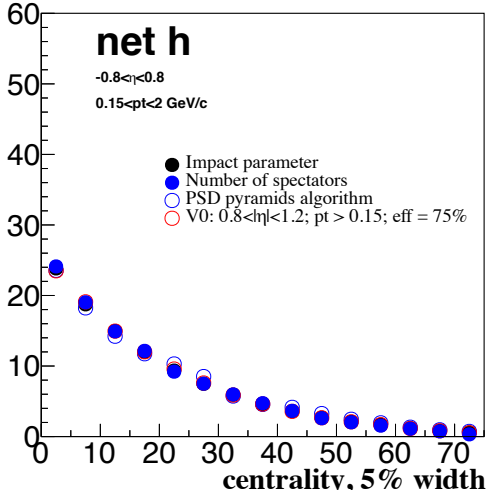
Factorial moments

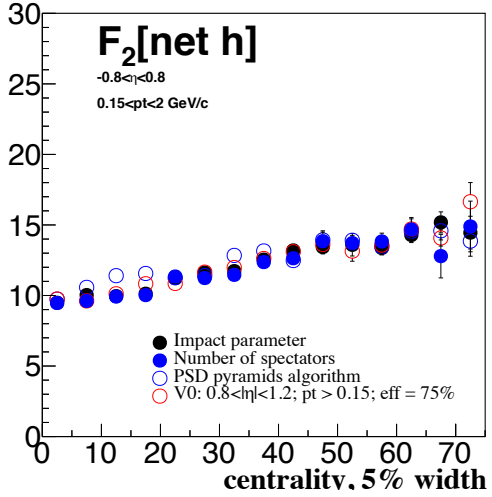


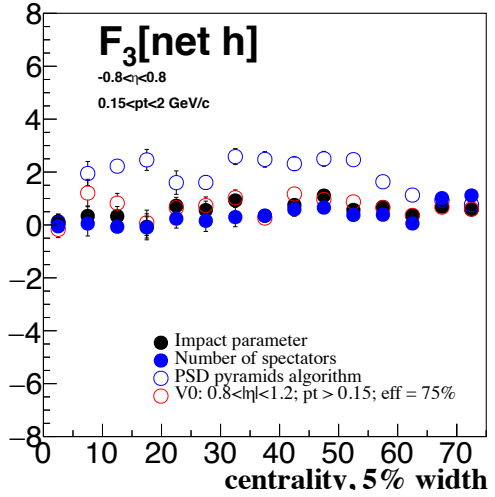


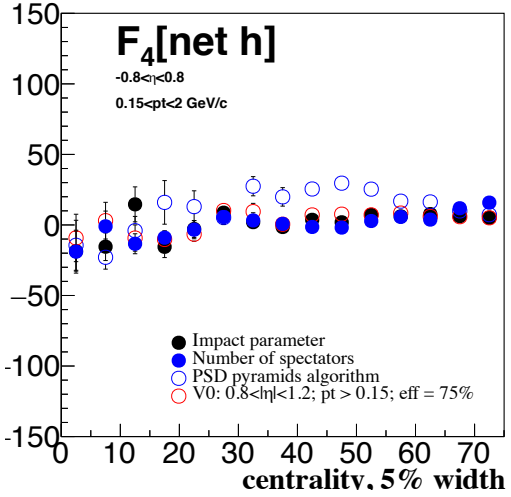




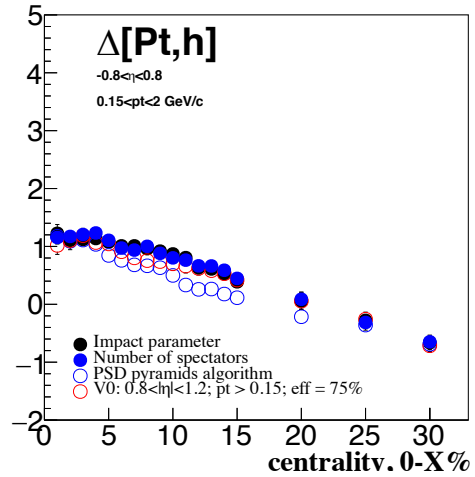


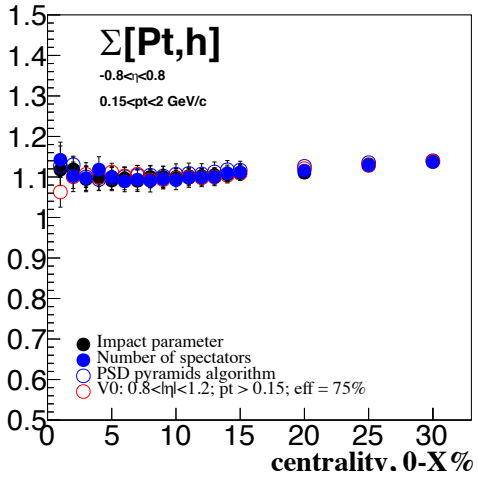


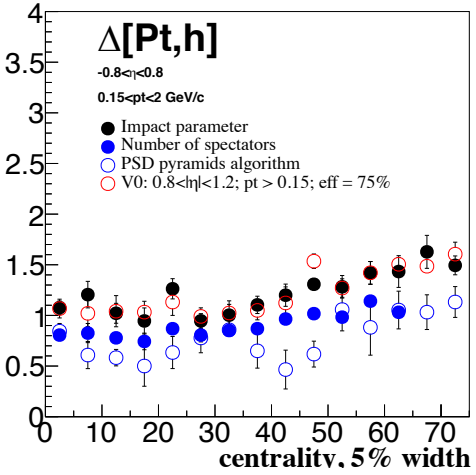


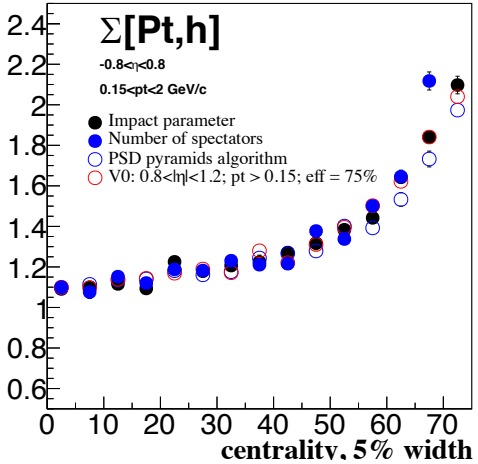


Strongly intensive



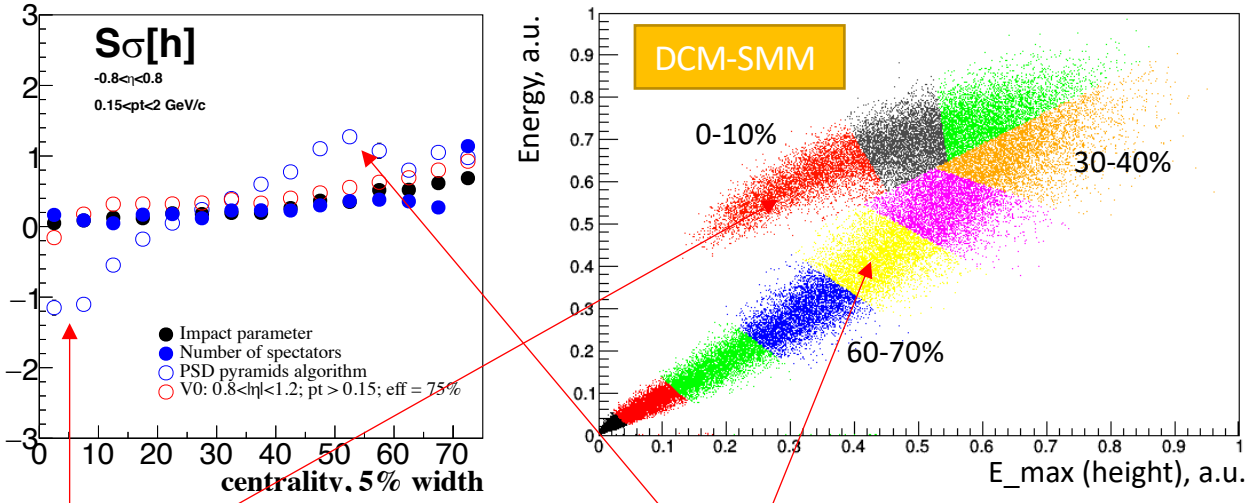


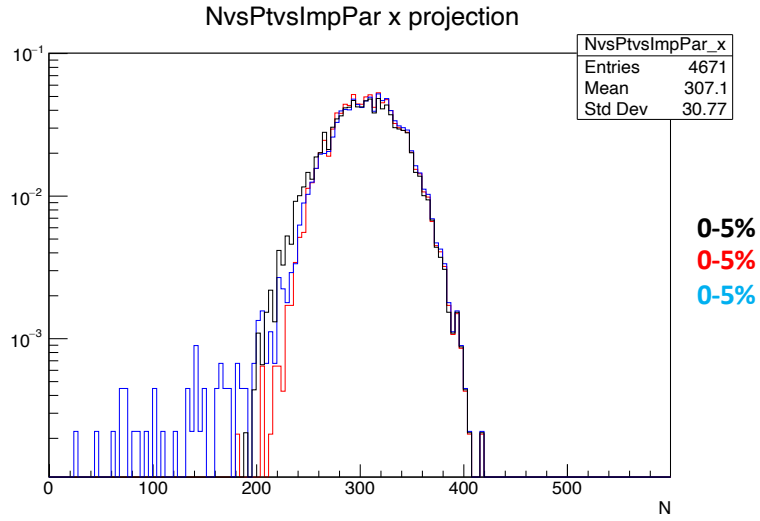




Discussion

- Why FHCal pyramids are so far away from other methods



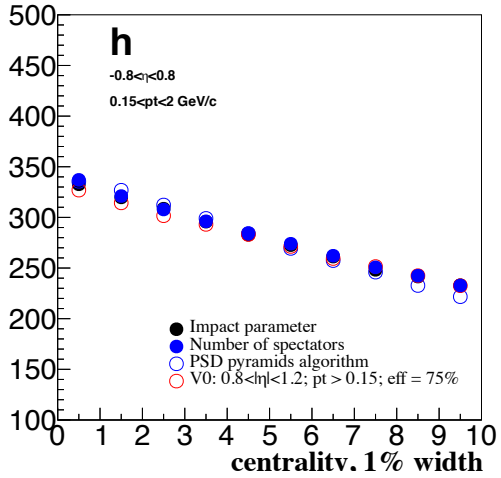


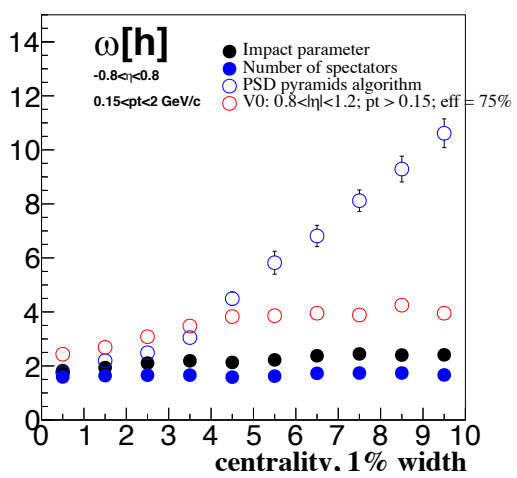
0-5% Impact parameter
0-5% multiplicity
0-5% FHCal

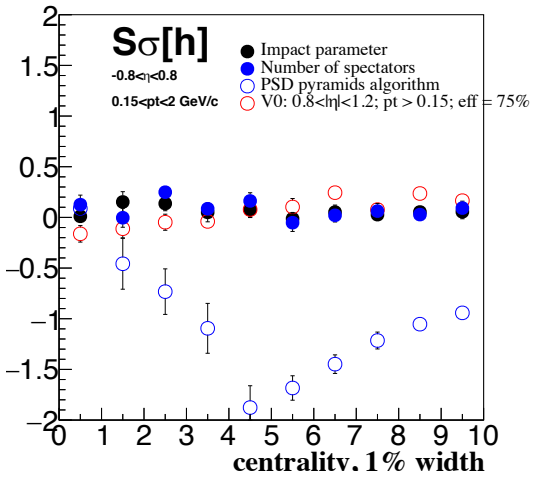
Central event with a small fraction of very peripheral

Peripheral events with a small fraction of very central

1% width


h
-0.8<η<0.8
0.15<pt<2 GeV/c
Impact parameter
Number of spectators
PSD pyramids algorithm
V0: 0.8<|η|<1.2; pt > 0.15; eff = 75%
centrality, 1% width


ω[h]
-0.8<η<0.8
0.15<pt<2 GeV/c
Impact parameter
Number of spectators
PSD pyramids algorithm
V0: 0.8<|η|<1.2; pt > 0.15; eff = 75%
centrality, 1% width


Sσ[h]
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0.15<pt<2 GeV/c
Impact parameter
Number of spectators
PSD pyramids algorithm
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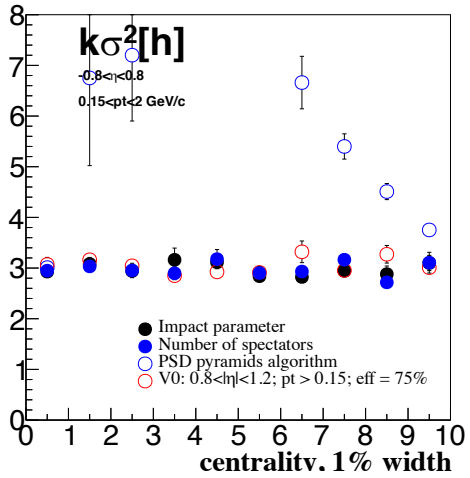
centrality, 1% width


kσ²[h]
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0.15<pt<2 GeV/c
Impact parameter
Number of spectators
PSD pyramids algorithm
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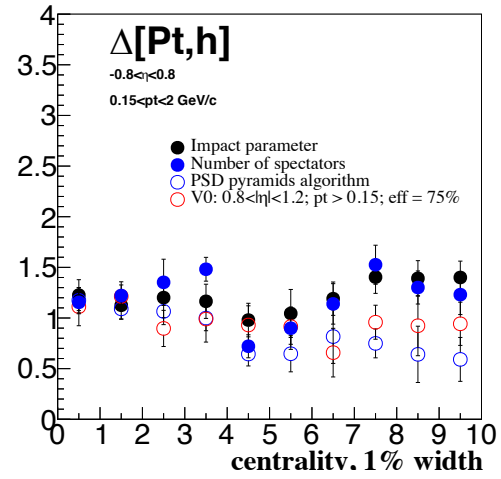
centrality, 1% width


Δ[Pt,h]
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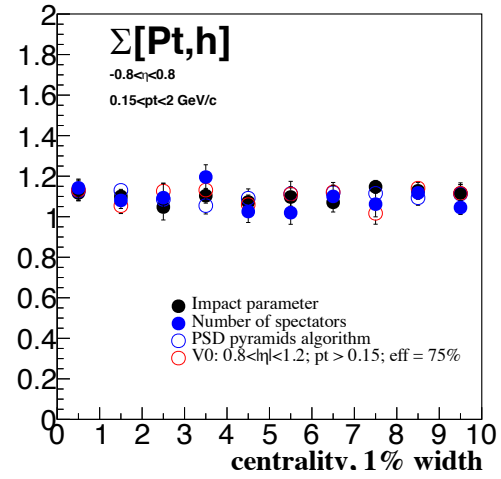
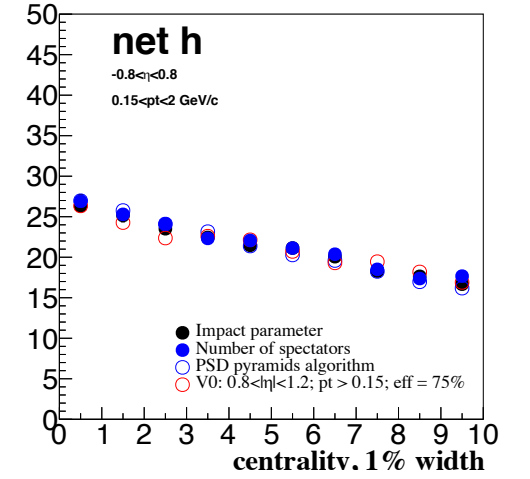
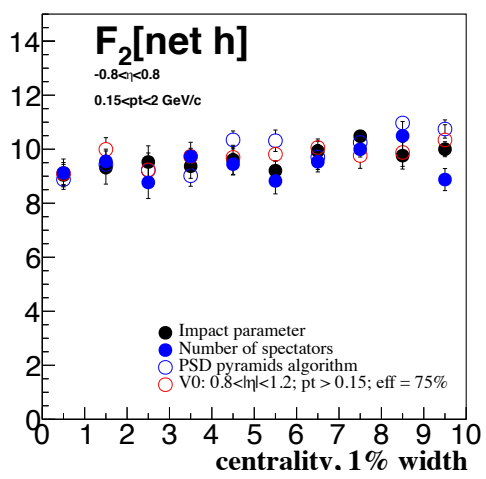
0.15<pt<2 GeV/c
Impact parameter
Number of spectators
PSD pyramids algorithm
V0: 0.8<|η|<1.2; pt > 0.15; eff = 75%
centrality, 1% width


Σ[Pt,h]
-0.8<η<0.8
0.15<pt<2 GeV/c
Impact parameter
Number of spectators
PSD pyramids algorithm
V0: 0.8<|η|<1.2; pt > 0.15; eff = 75%
centrality, 1% width


net h
-0.8<η<0.8
0.15<pt<2 GeV/c
Impact parameter
Number of spectators
PSD pyramids algorithm
V0: 0.8<|η|<1.2; pt > 0.15; eff = 75%
centrality, 1% width


F2[net h]
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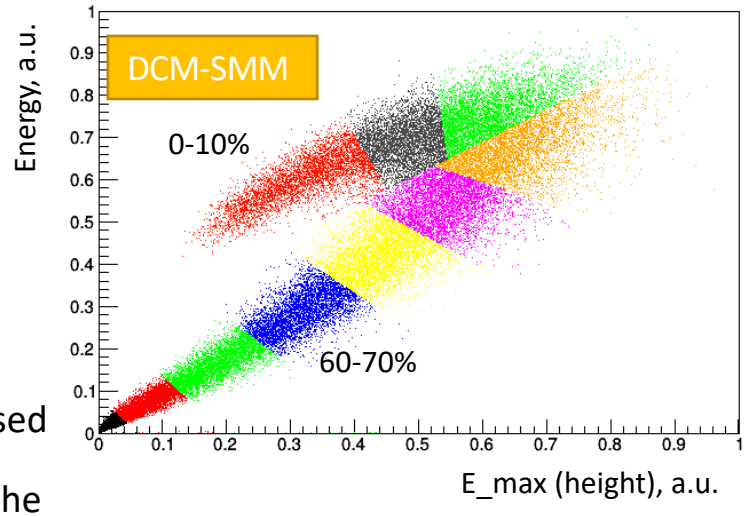
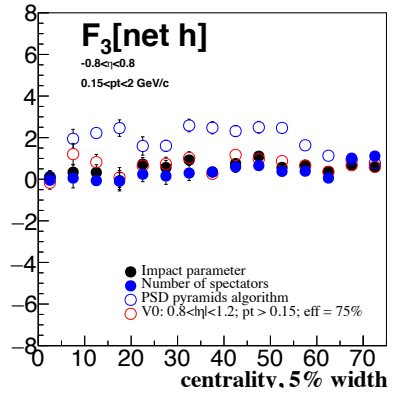
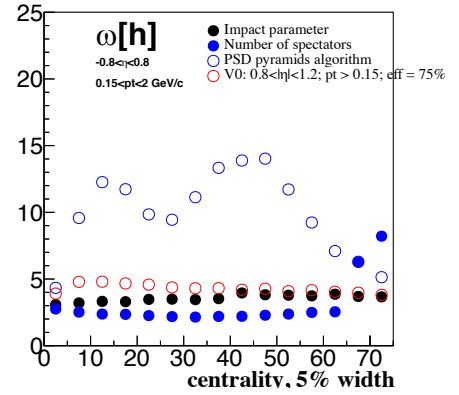
0.15<pt<2 GeV/c
Impact parameter
Number of spectators
PSD pyramids algorithm
V0: 0.8<|η|<1.2; pt > 0.15; eff = 75%
centrality, 1% width

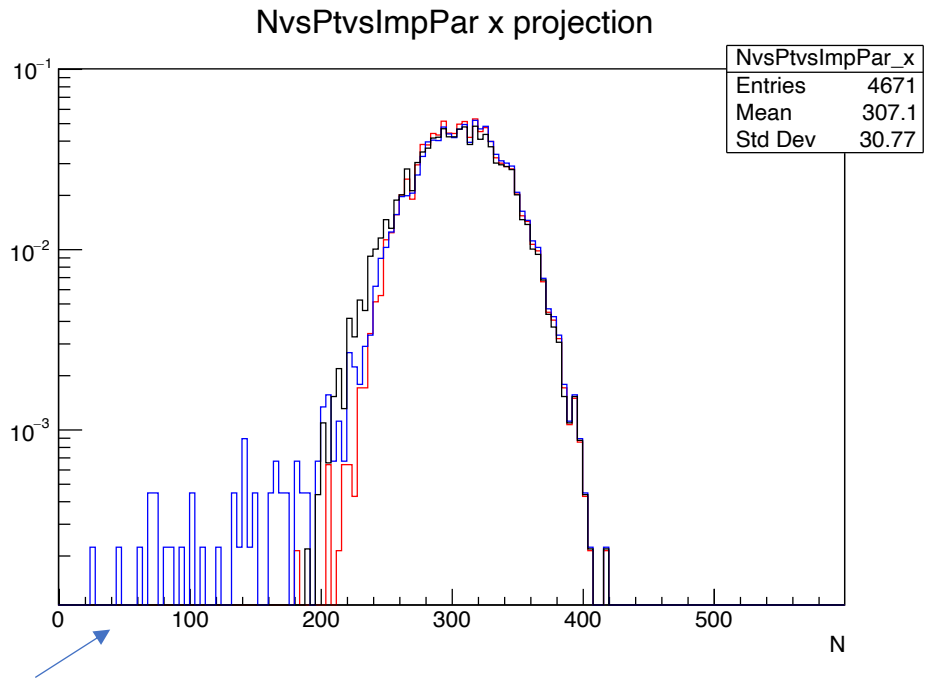
Conclusions

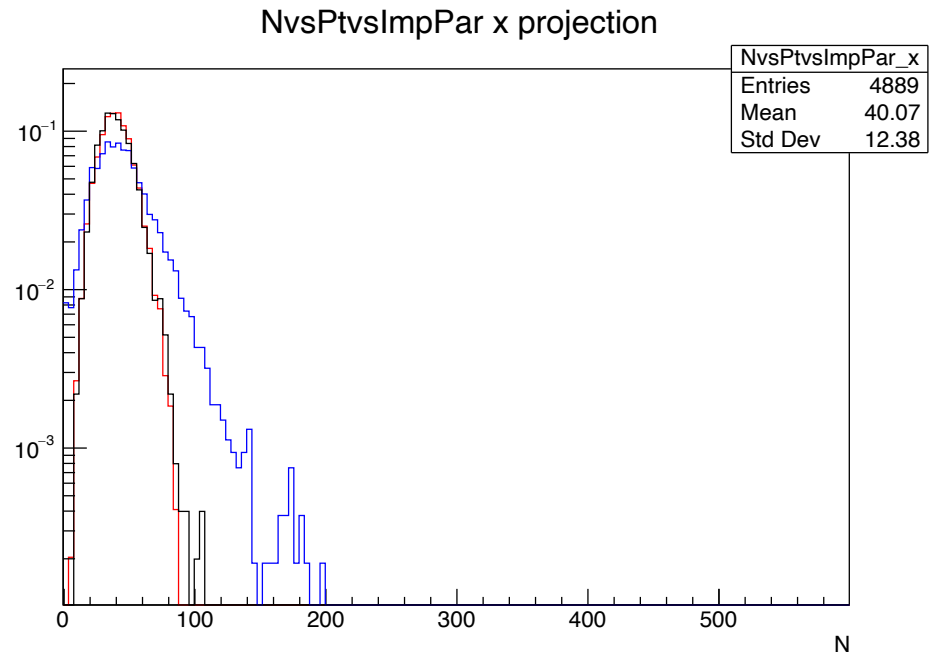
- The current state of the pyramid procedure:
  - Can't be reproduced in pure MC by people from outside the collaboration, so it may be used only as a proxy to Npart or b.
  - Doesn't restrict volume fluctuations enough to measure multiplicity fluctuations, except the most central point (0-1%). Although I would expect this region to become narrower with statistic and better calorimeter description (effects of electronics).
  - A further development is needed
    - Maybe a 3rd axis (multiplicity) has to be introduced to increase resolution capability between very central and very peripheral events.
    - A different fit instead of the pyramid?
  - We have to be very careful with this procedure as:
    - MC generators are usually having a much worse description of the forward region compare to the central rapidity
    - GEANT 4 description of FHCal doesn't not include effects of electronic, which can be very significant (based on my experience of analyzing data from PSD at NA61/SHINE)
- Contrary to FHCal, the multiplicity based procedure shows very close results to Npart and b and can be easily reproduced by people from outside MPD.
- Considering all of the above, I would not recommend using FHCal for fluctuation measures till it shows significantly better results than the multiplicity based approach.











Причина взрыва
3 и 4 моментов

5%	**Impact parameter**	**45-50%**
5%	**multiplicity**	**45-50%**
5%	**FHCAL**	**45-50%**