

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 $\Delta[Pt, N], \Sigma[Pt, N]$
 - 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:

$\pi^{+/-}$, $p^{+/-}$, $K^{+/-}$ $|\eta| < 0.8$, $0.15 < p_t < 2$

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

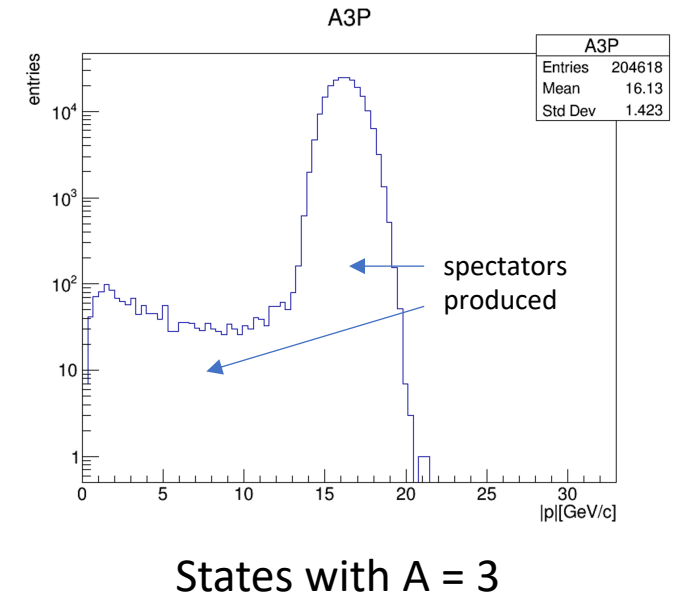
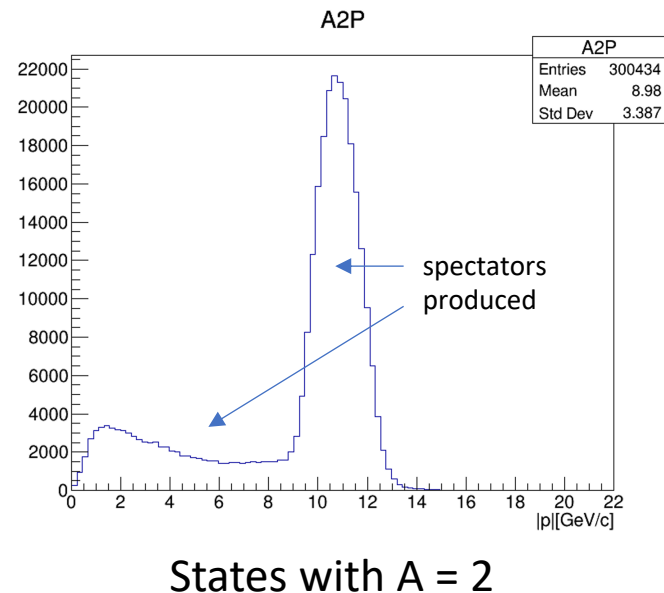
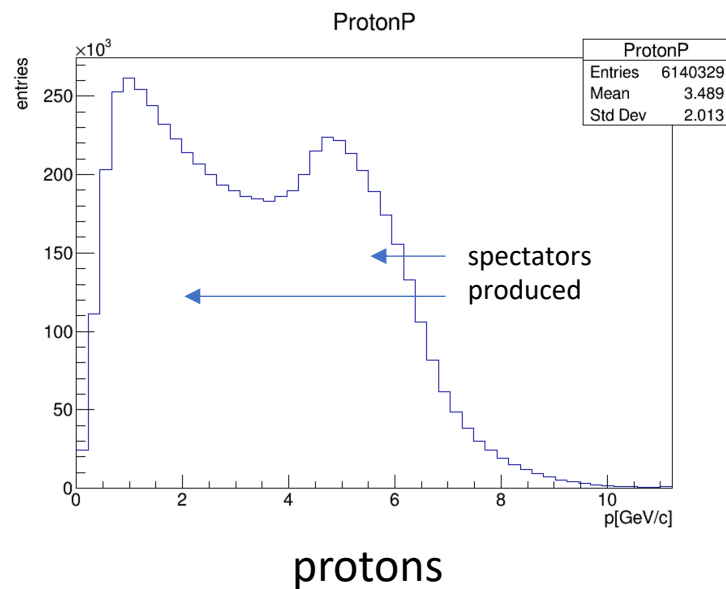
- b is taken from the generator
- Nc is a sum of all charged particles (π^{\pm} , p^{\pm} , K^{\pm} , e^{\pm} , μ^{\pm}) in $0.8 < |\eta| < 1.2$ with $p_t > 0.15$. A particle detection efficiency = 75% was introduced too.
- I consider two types of centrality intervals: 0-X% and X \pm 2.5% (5% width).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



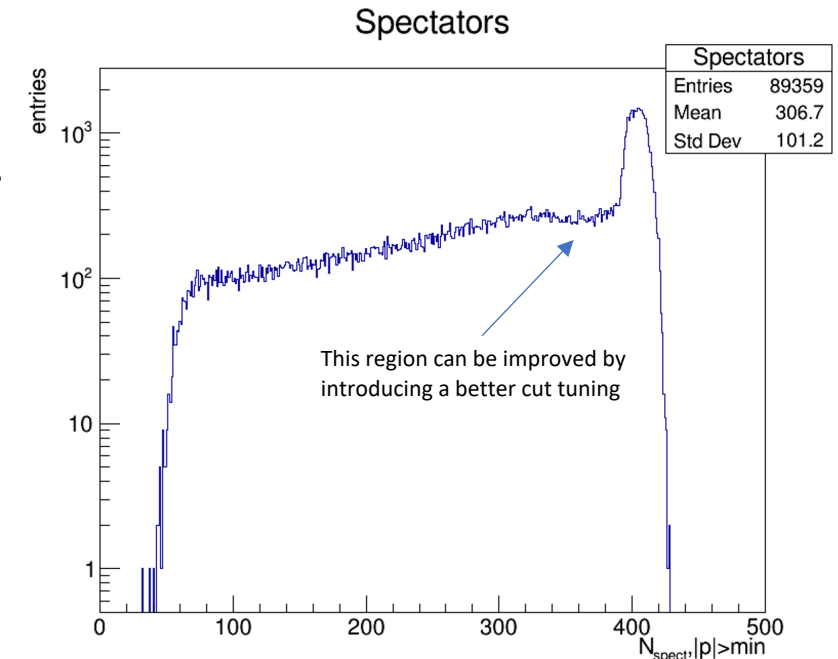
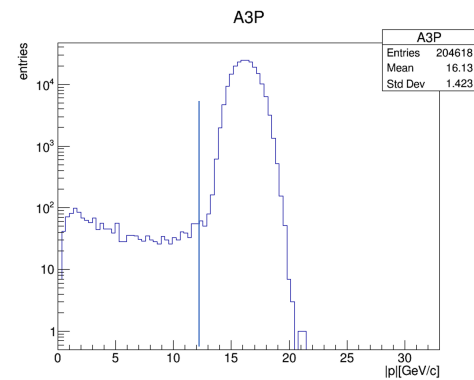
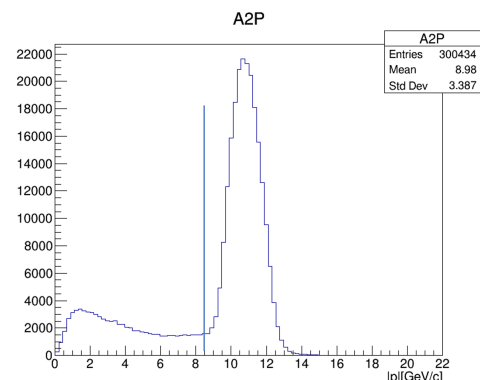
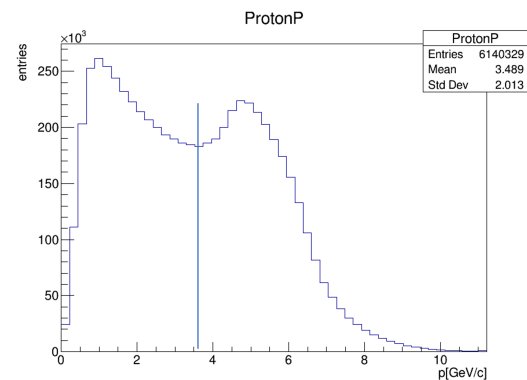
Number of nucleon participants (Npart)

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:

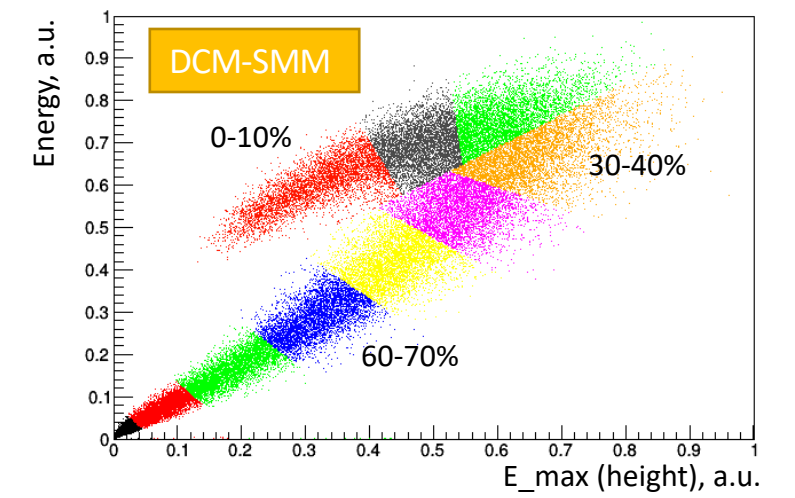
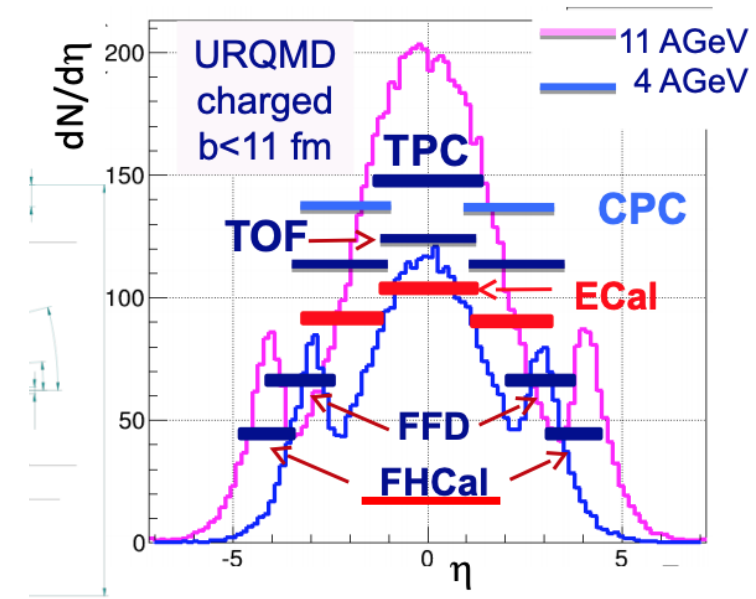
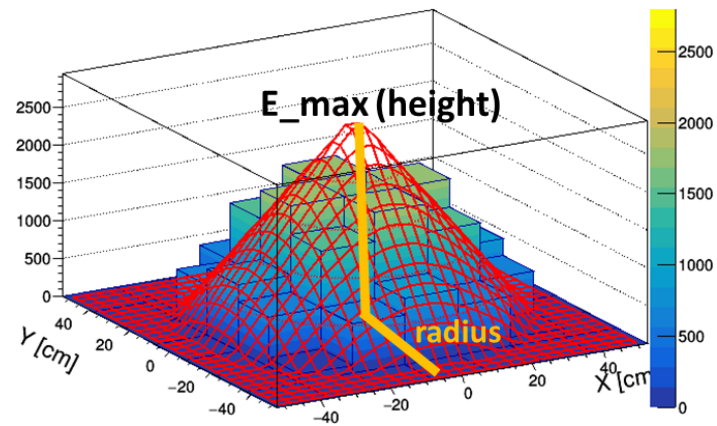
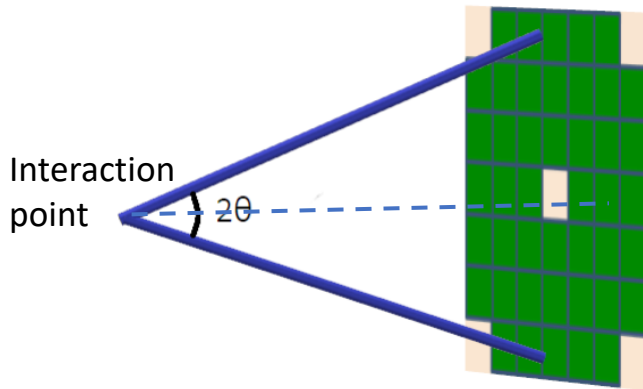
- A nucleon with $p > 3.6$ GeV/c
- A=2 states with $p > 8.5$ GeV/c
- A=3 states with $p > 12.6$ GeV/c
- A > 3 states

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

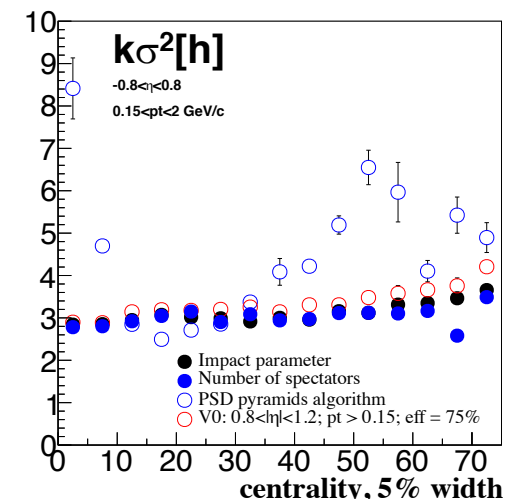
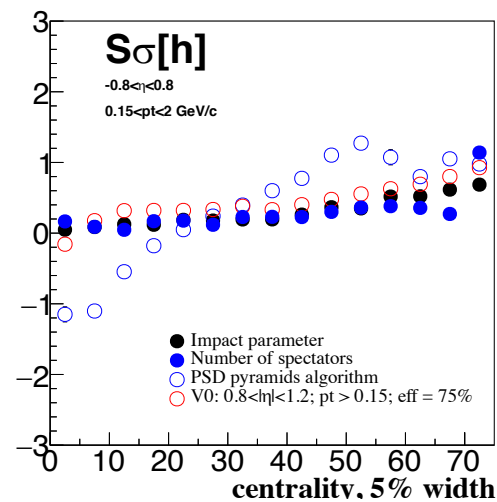
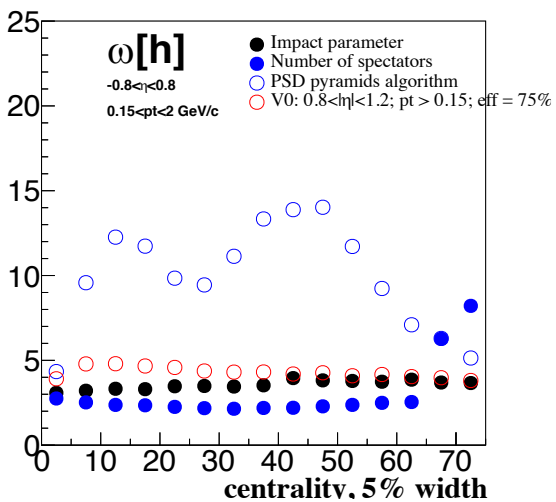
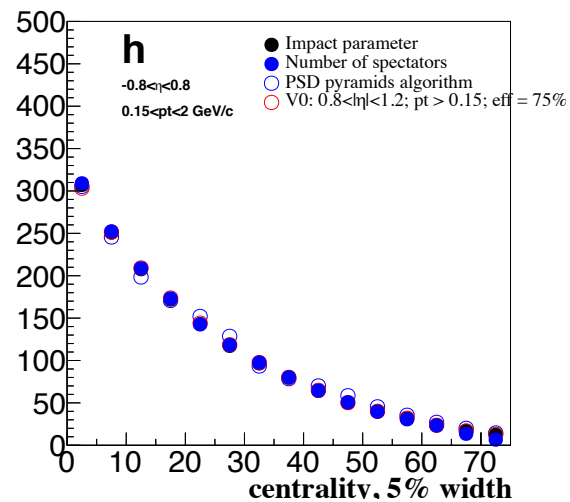
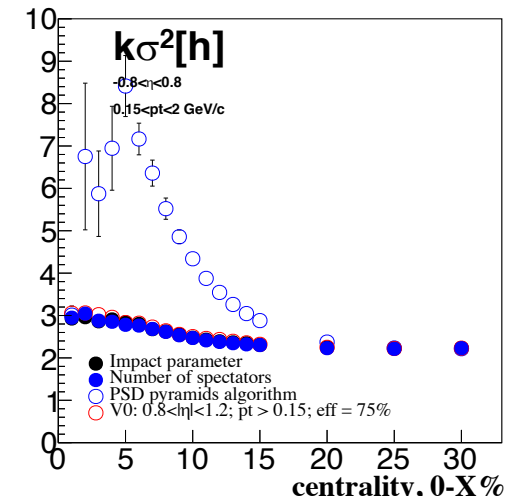
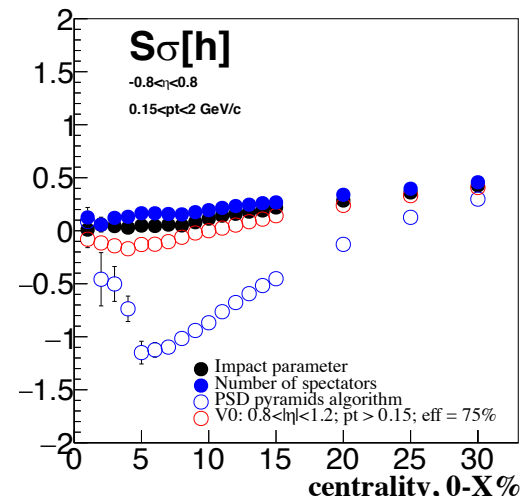
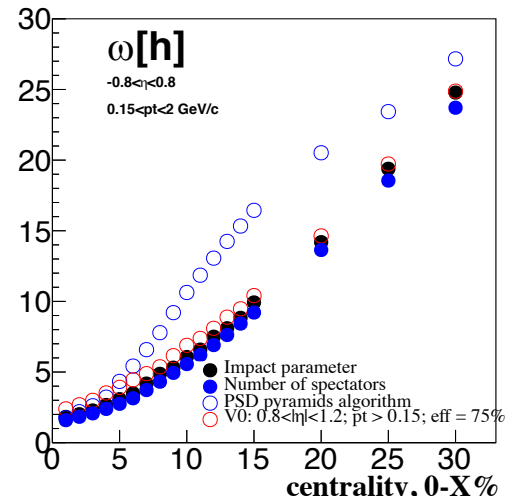
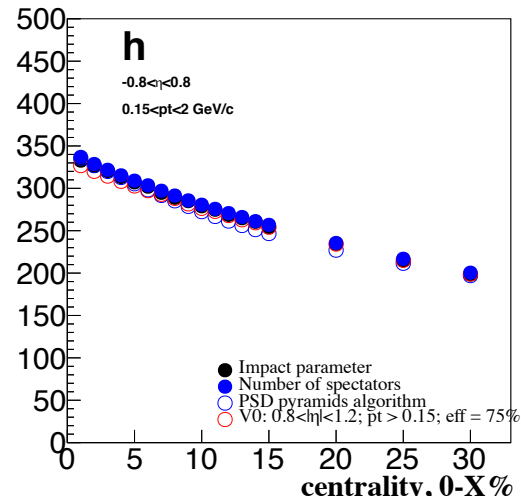


MPD FHCaI

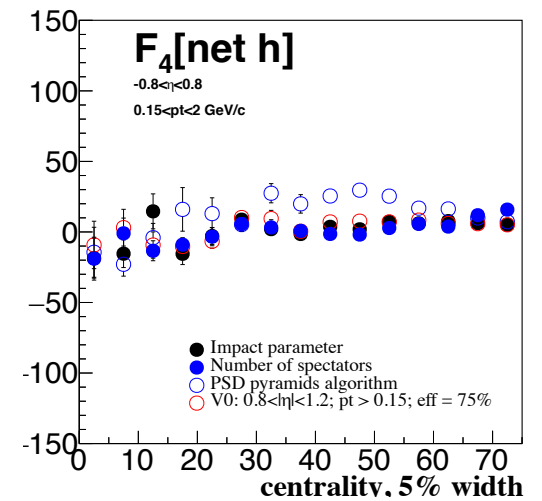
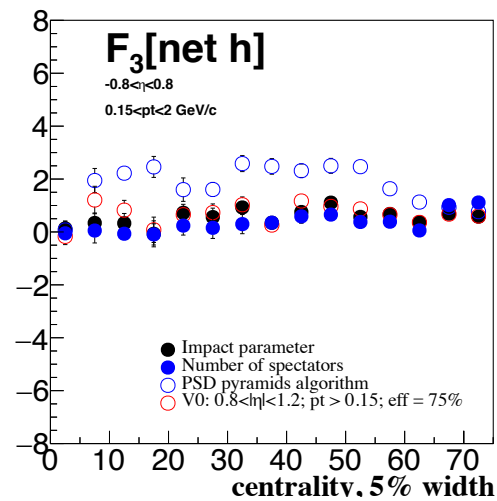
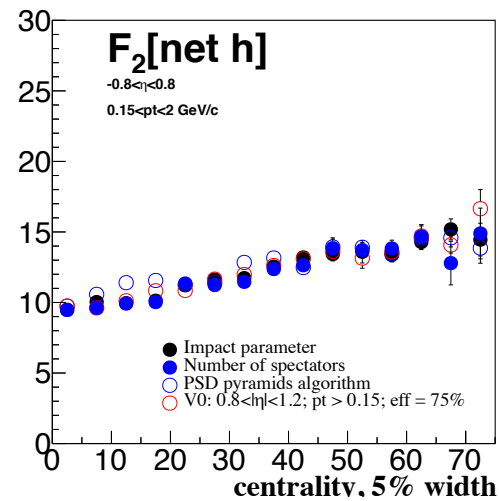
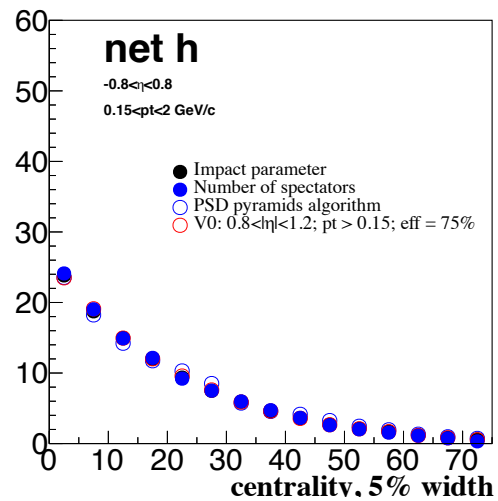
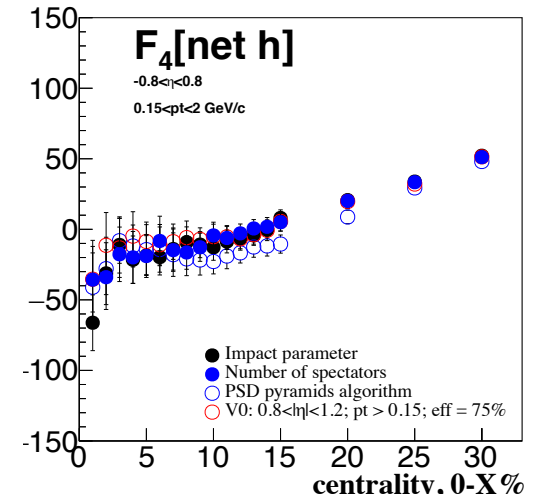
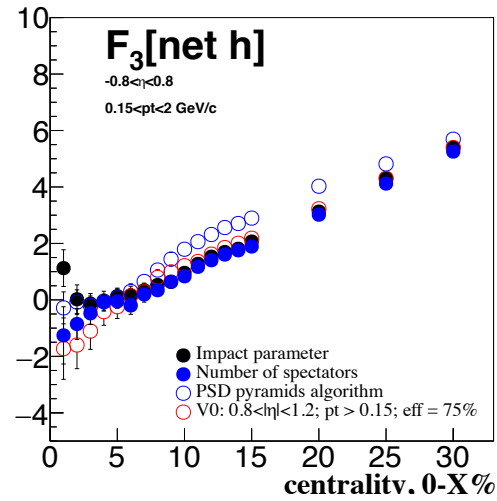
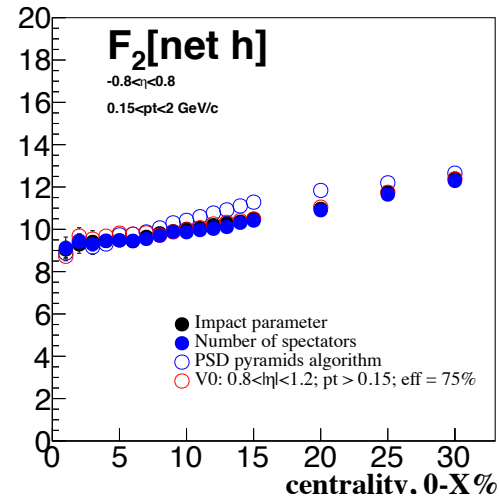
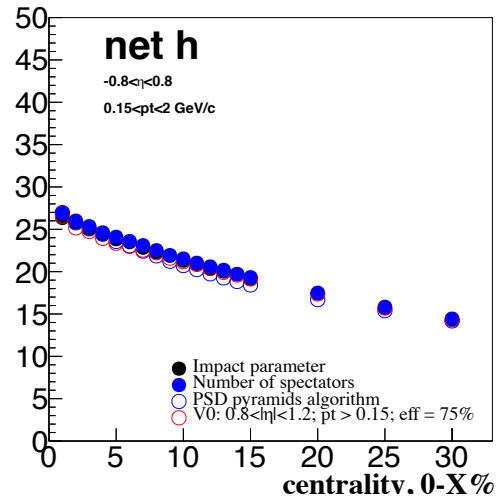
FHCaI measures only a fraction of nucleon spectators, peripheral and central events may deposit the same energy in the calorimeter. Therefore an algorithm to determine centrality based on a FHCaI signal shape was introduced by INR group. More information can be found here: <https://indico.jinr.ru/event/1570/>



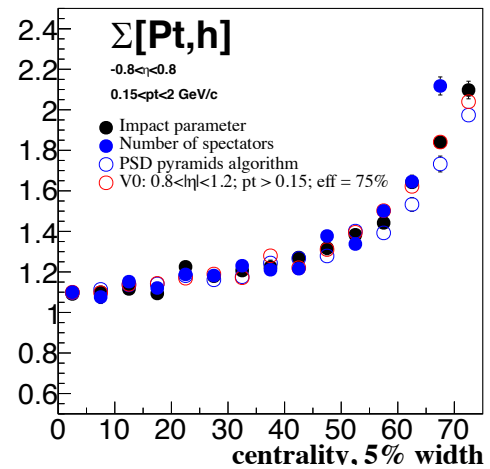
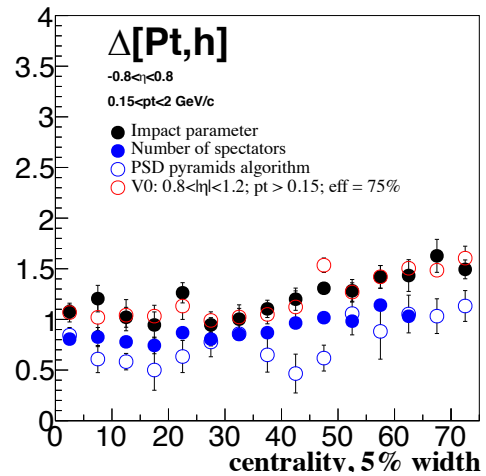
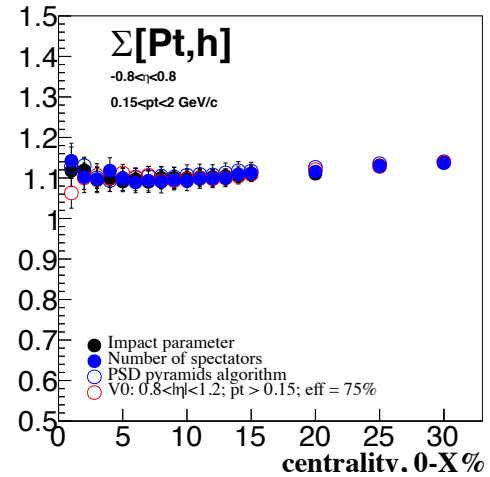
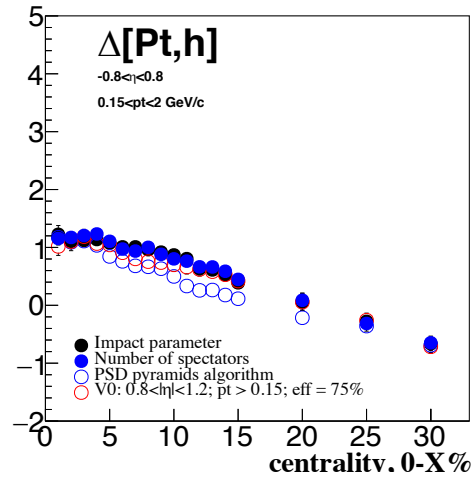
Multiplicity moments



Factorial moments

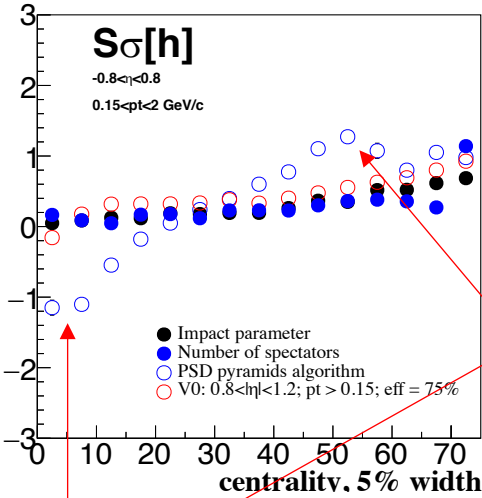


Strongly intensive

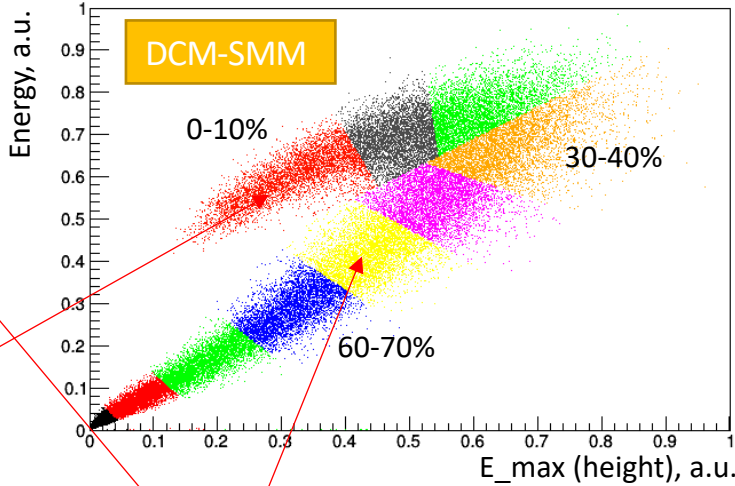


Discussion

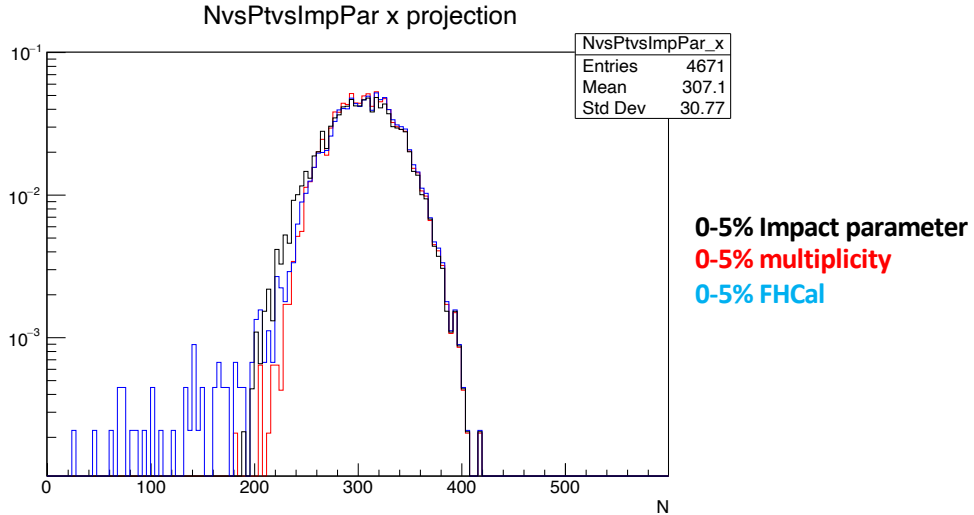
- Why FHCAL pyramids are so far away from other methods



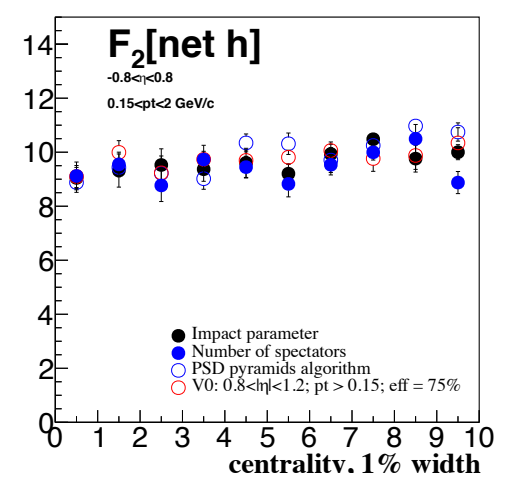
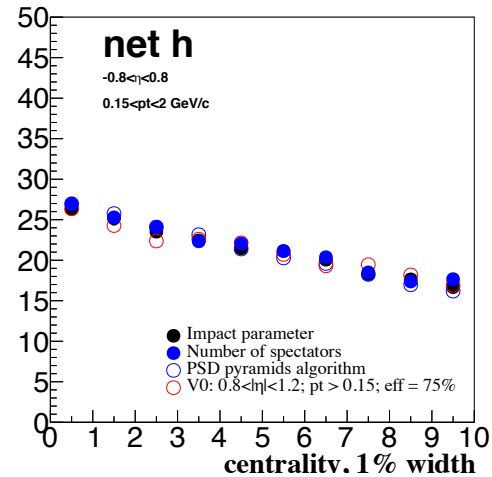
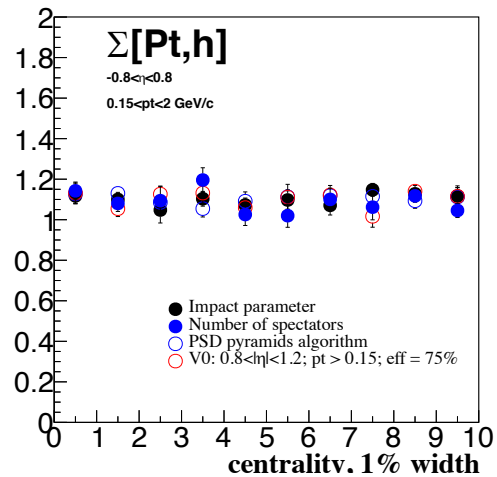
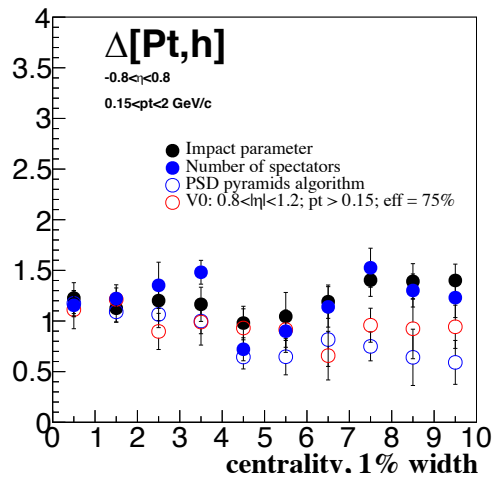
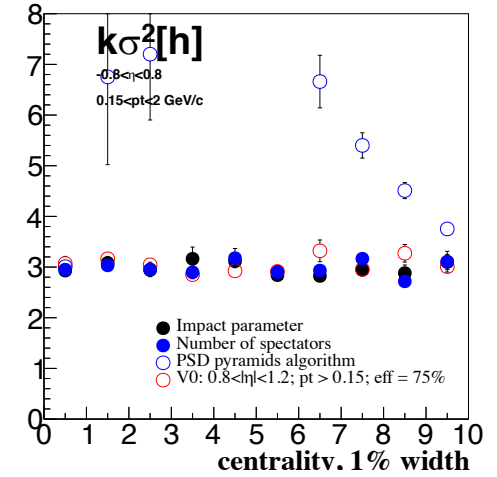
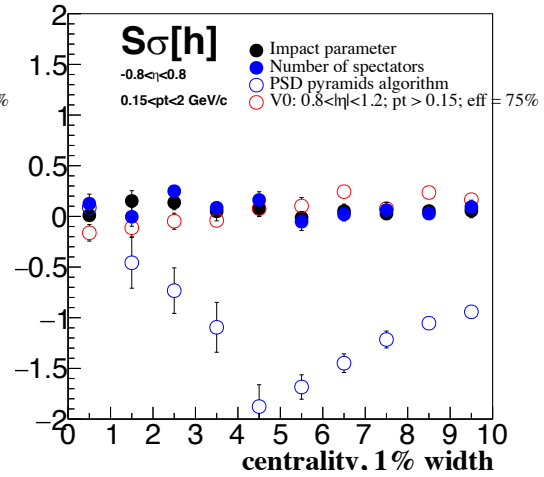
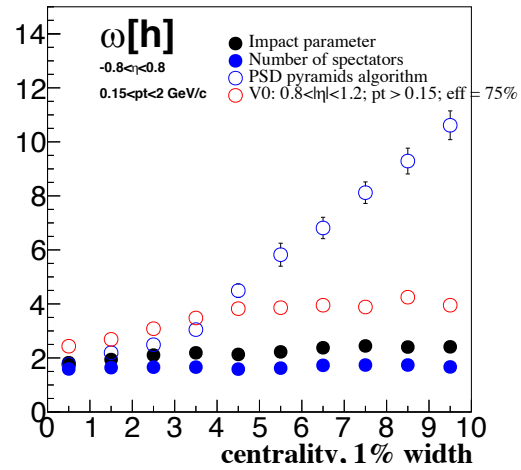
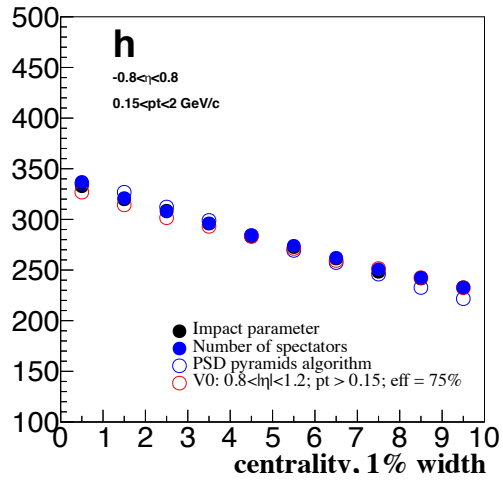
Central event with a small fraction of very peripheral



Peripheral events with a small fraction of very central

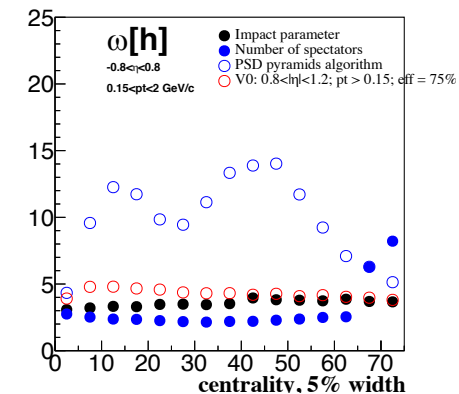
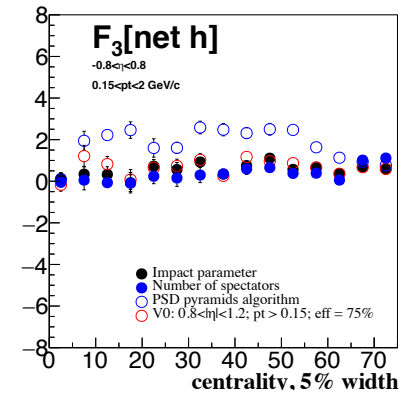
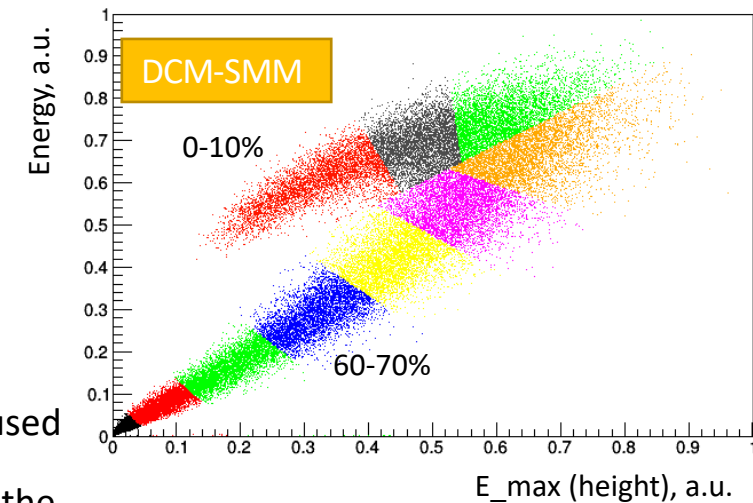


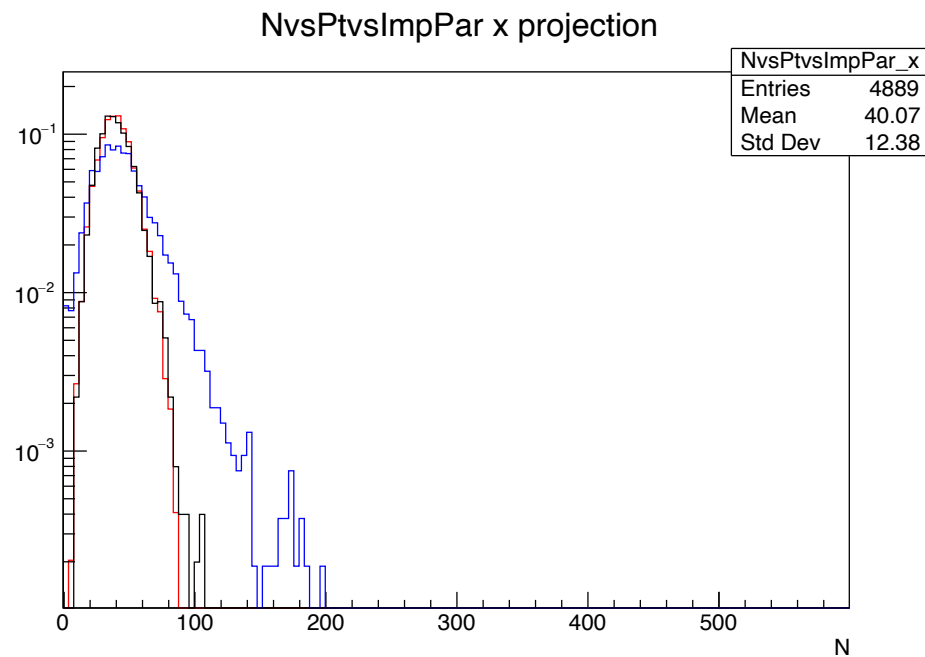
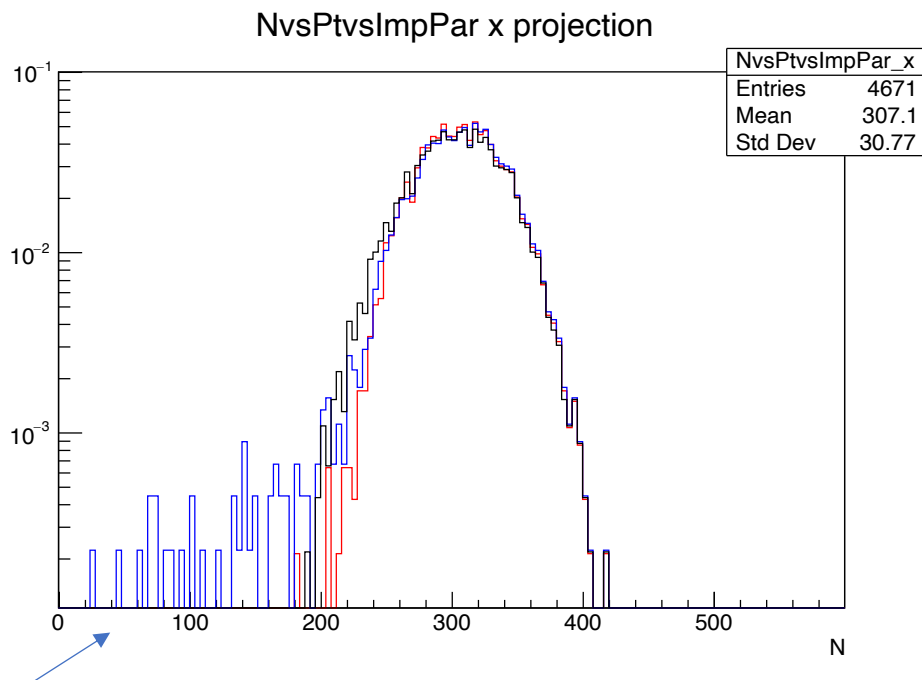
1% width



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 close results to Npart and b and can be easily reproduced by people from outside MPD.
- Considering all of the above, I would recommend using FHCAL for fluctuation measures only for the most central events and to study a possibility of using simultaneously both centrality proxies – multiplicity and FHCAL.





Причина взрыва
3 и 4 моментов

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