Determination of centrality in nucleus-nucleus collisions on the MPD/NICA installation

A.Kurepin, A.Litvinenko, E.Litvinenko
Institute for Nuclear Research RAS, Moscow
Joint Institute for Nuclear Research, Dubna

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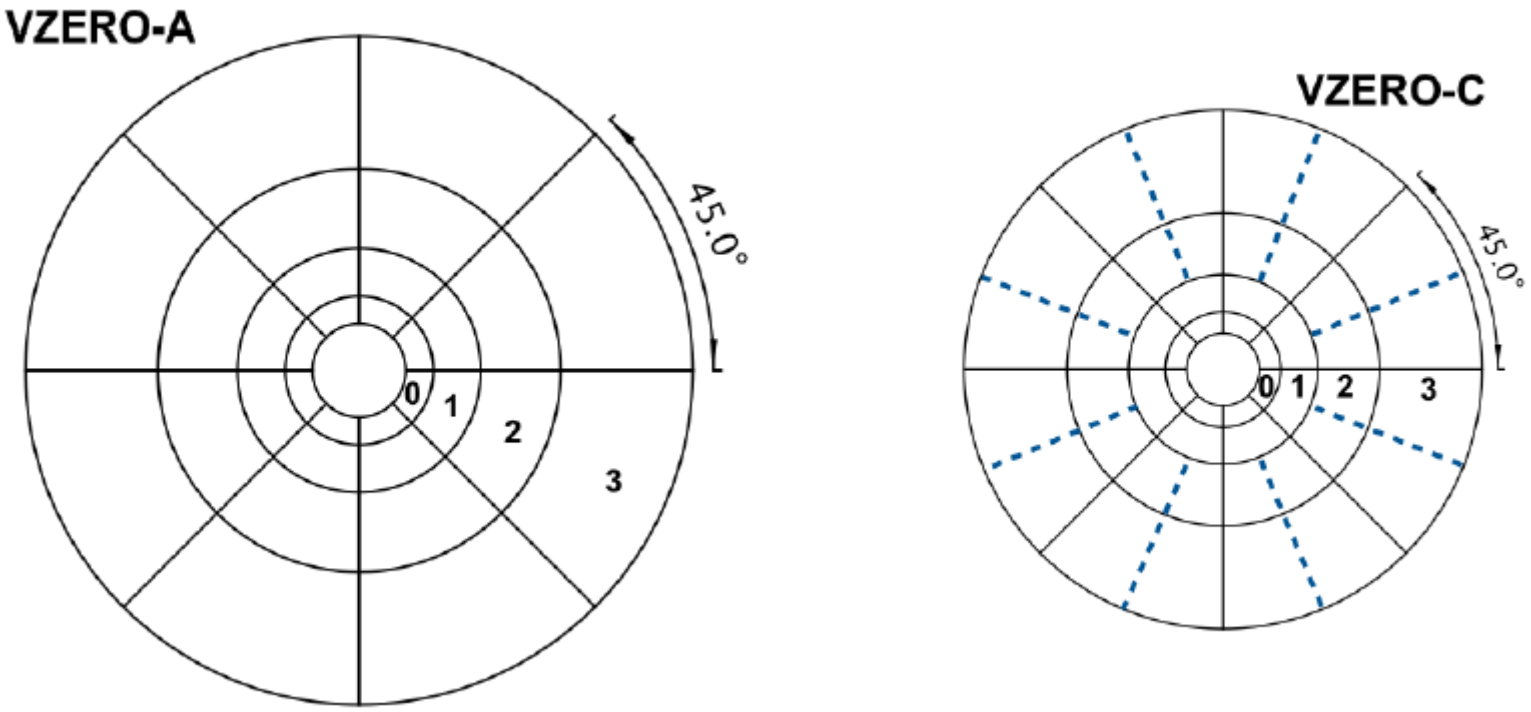
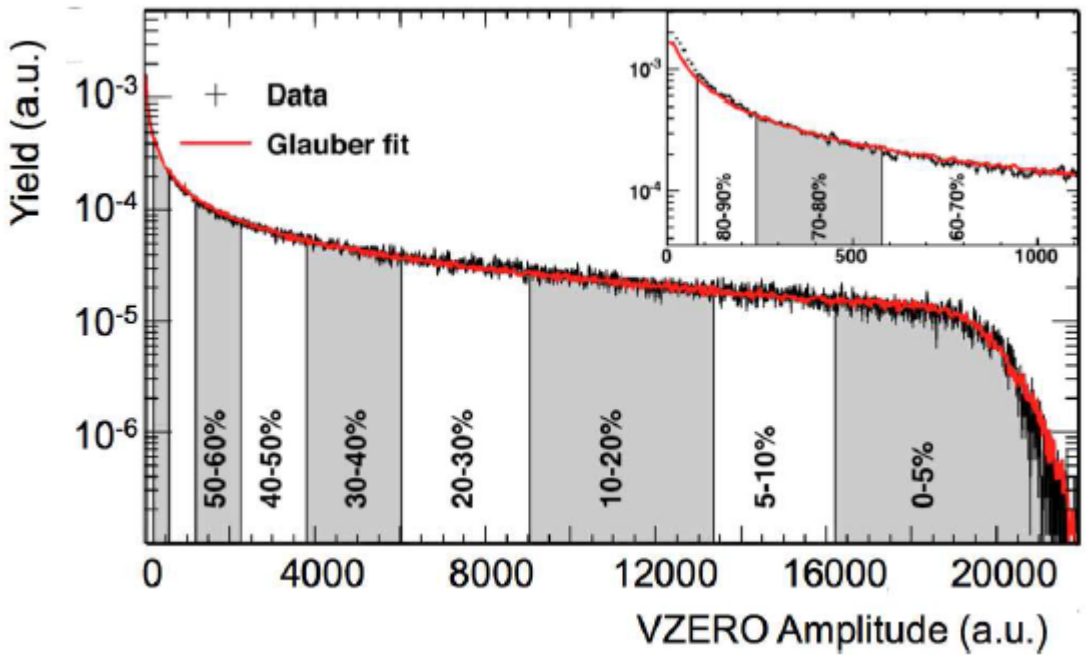
- Centrality determination in collider and fixed target experiments
- Forward calorimeter FHCal for MPD/NICA
- Simulation of possible multiplicity detector for MPD/NICA
- Conclusions

The XXIV International Baldin Seminar on High Energy Physics Problems "Relativistic Nuclear Physics and Quantum Chromodynamics“, September 17 - 22, 2018 , JINR, Dubna, Russia.



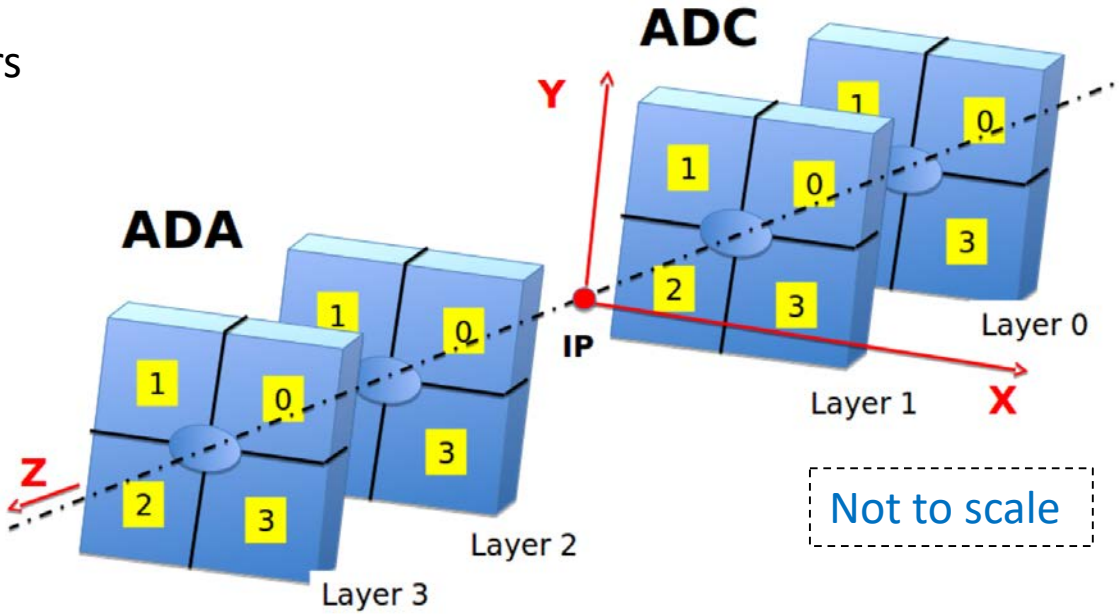
Sketches of VZERO-A and VZERO-C arrays showing their segmentation. Scintillator thicknesses are 2.5 and 2 cm respectively.

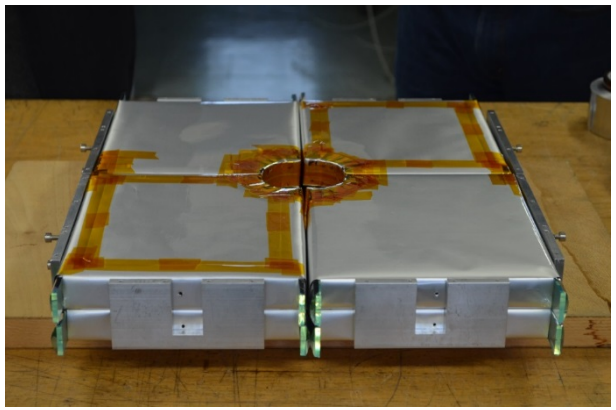


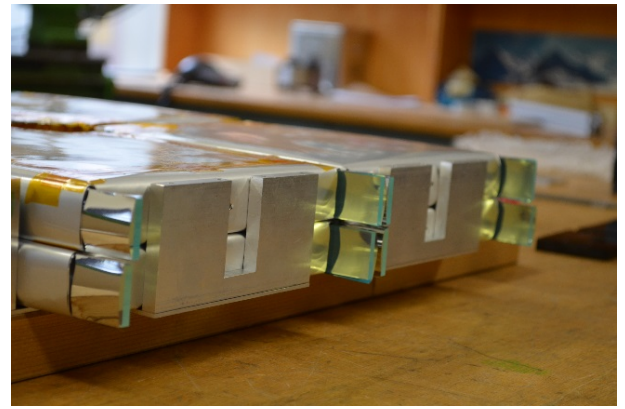
Distribution of the sum of amplitudes in the two VZERO arrays (black histogram) in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. The red line shows the fit with a Glauber model. The shaded areas define the different centrality classes of hadronic collisions. The inset shows the low amplitude part of the distribution.

The ALICE Diffractive detector

- AD is formed by two main stations, each station consists of 2 layers with 4 plastic scintillator pads each (8 pads per side).
- Each scintillator measures roughly 18cm x 21cm.
- Each scintillator plastic is coupled to a PMT through a wave length shifting bar and an array of clear optic fibers.
- For trigger generation, a coincidence between adjacent pads is required.







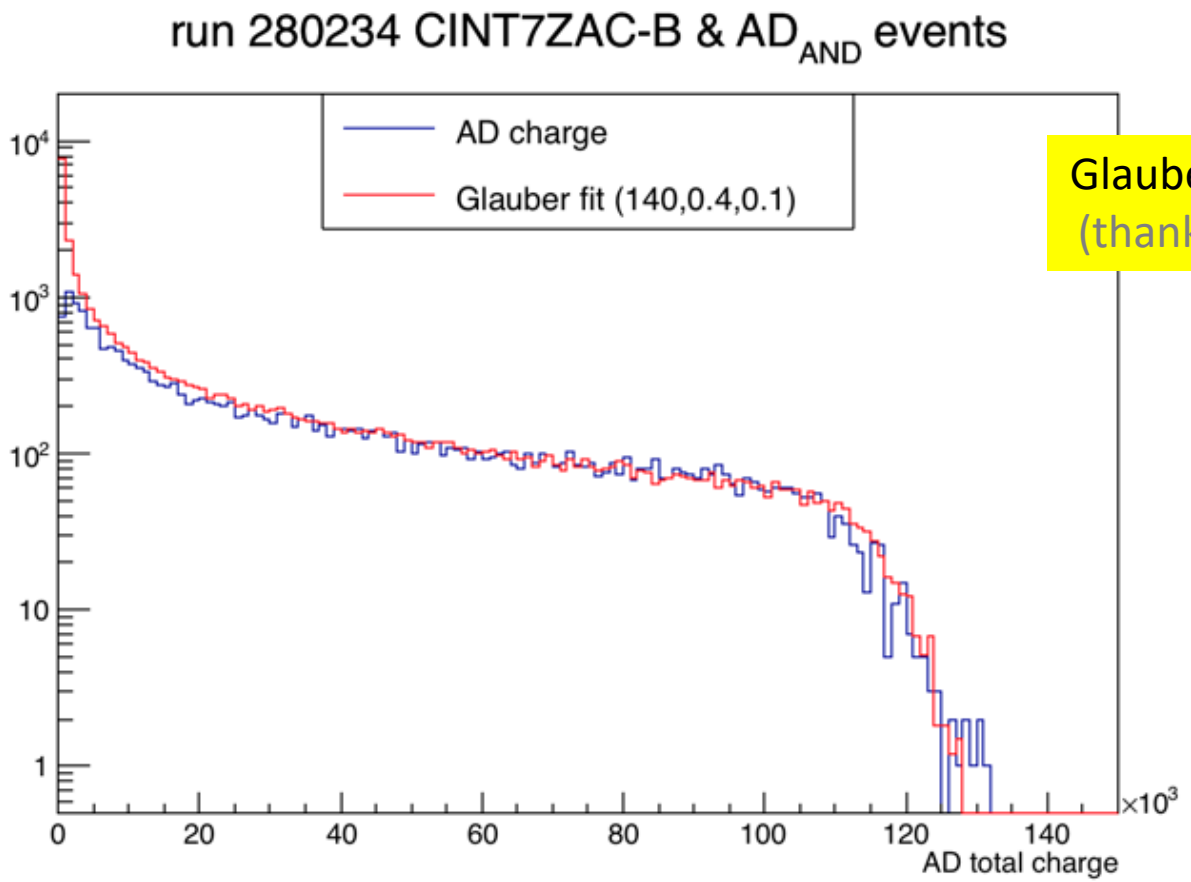
XeXe run

Used data:

- pass1 AOD data
- ADC saturation was corrected in CPass1
- charges were normalized to have the same 90% quantile

Event selection:

- CINT7ZAC (CINT7 + ZDC)
- AD_{AND} (online+offline BB)



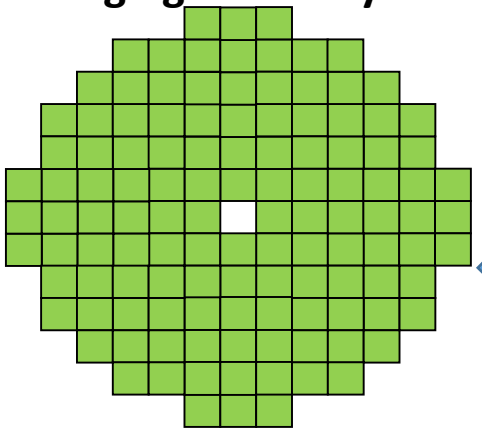
Glauber ntuples for XeXe
(thanks to Alberica Toia)

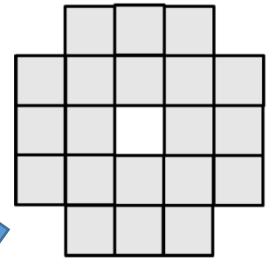
Evolution of FHCAL

Extended HCAL of 120 modules with high granularity

transverse sizes 10x10 cm²

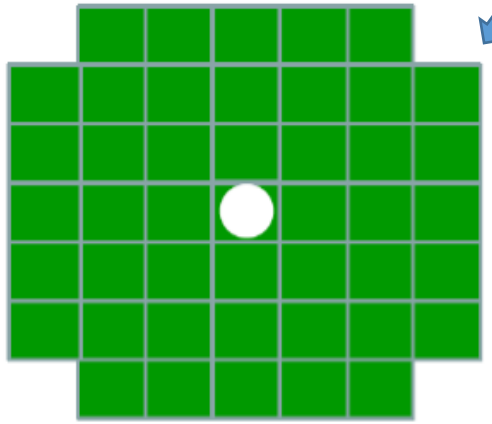
Compact ZDC of 20 modules with high granularity.





High acceptance, perfect event plane resolution.
Very expensive, complicated .

Simplicity, cheap.
Low acceptance.
Poor event plane angular resolution.



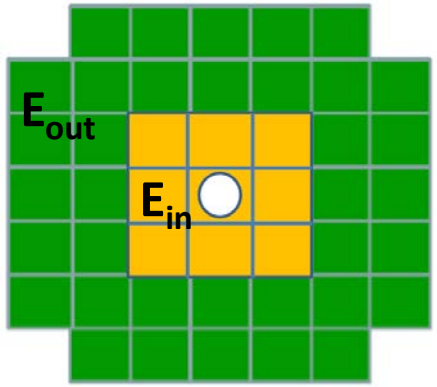
FHCAL of 45 modules: transverse sizes 15x15 cm²

Moderate segmentation,
High acceptance,
Nice event plane resolution,
Reasonably simple and cheap.

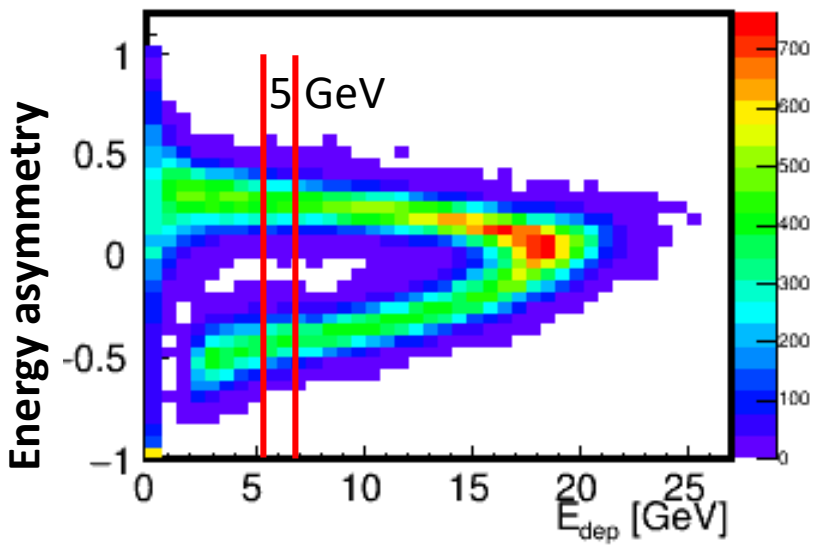
FHCAL alone can measure the centrality (without any other detectors).

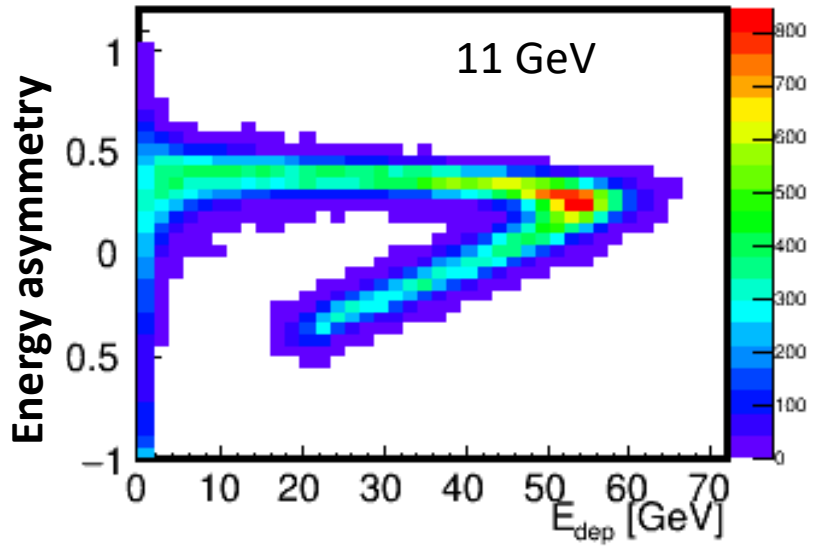
Together with energy deposition E_{dep} in FHCAL another observable " energy asymmetry" is introduced:

$$As=(E_{in}-E_{out})/(E_{in}+E_{out}).$$

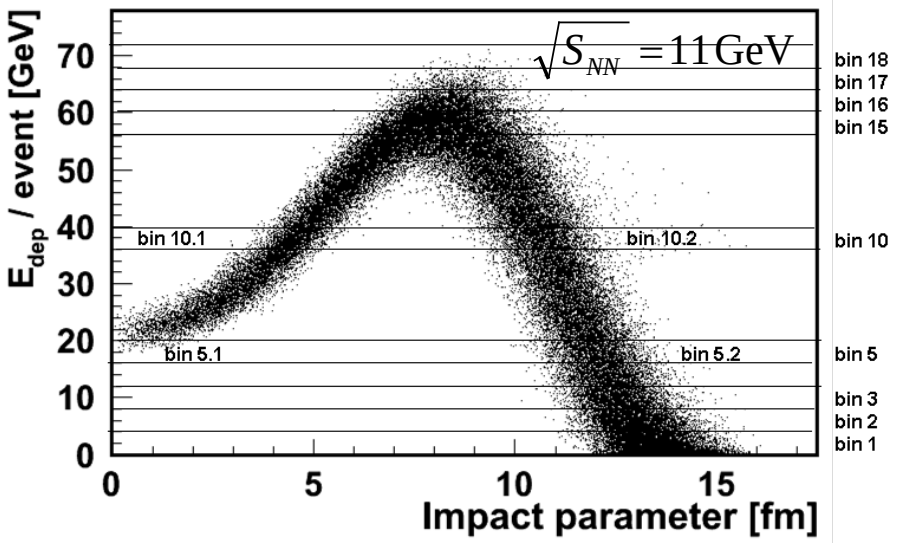


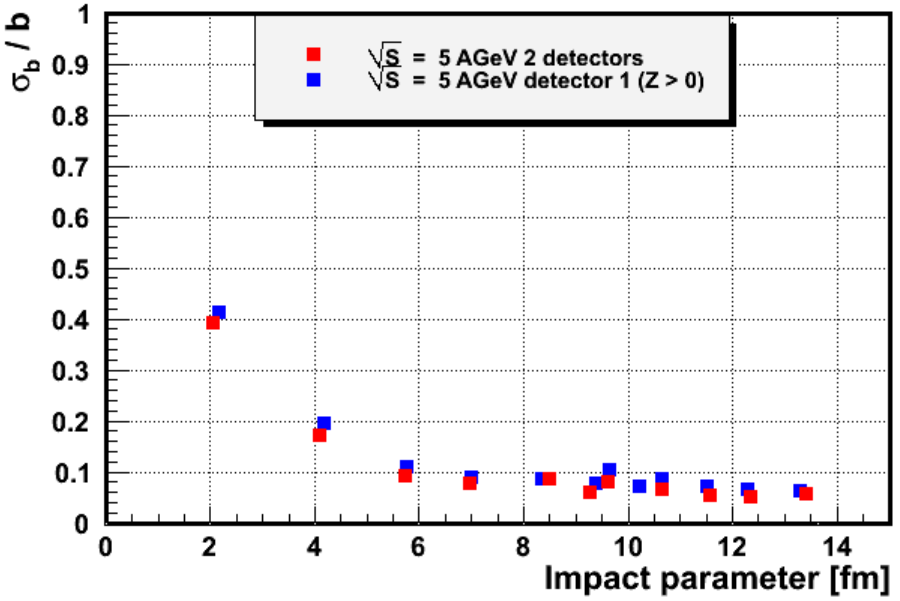
By taking the horizontal cut at asymmetry and the vertical bins at energy deposition one can resolve the ambiguity in centrality determination.

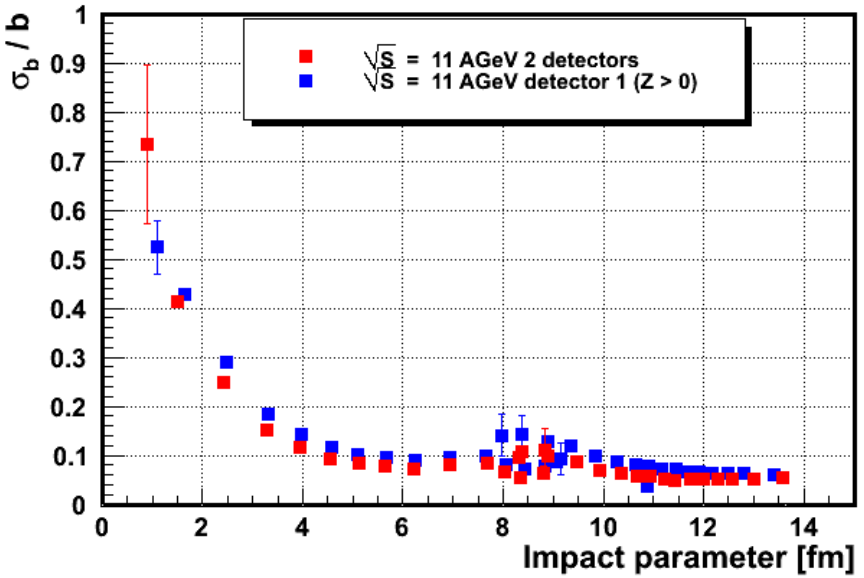




Centrality determination from the energy depositions in calorimeter.

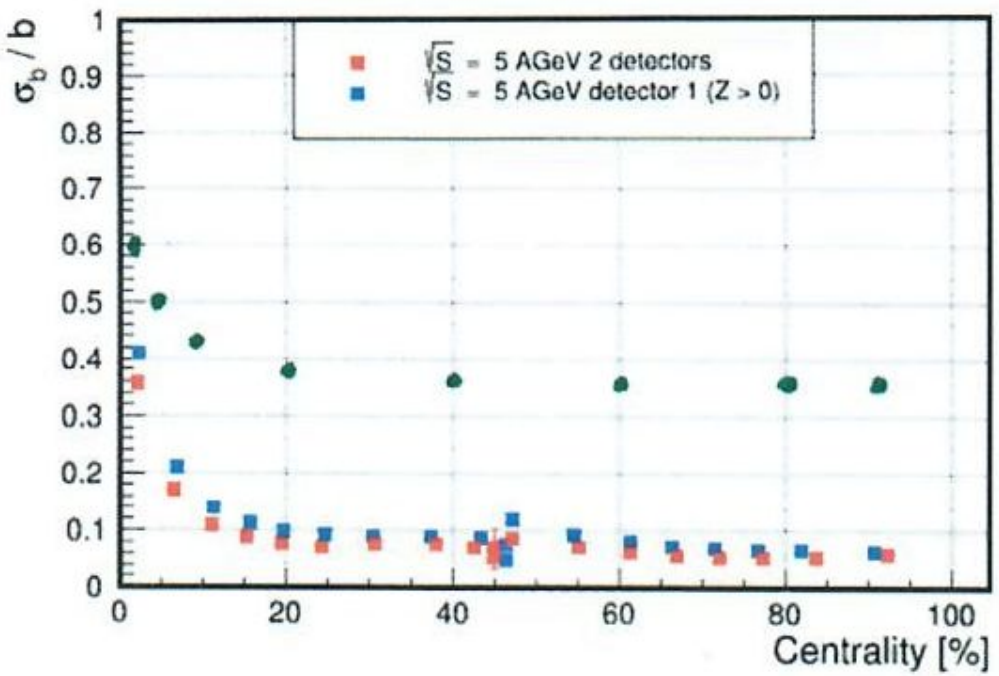


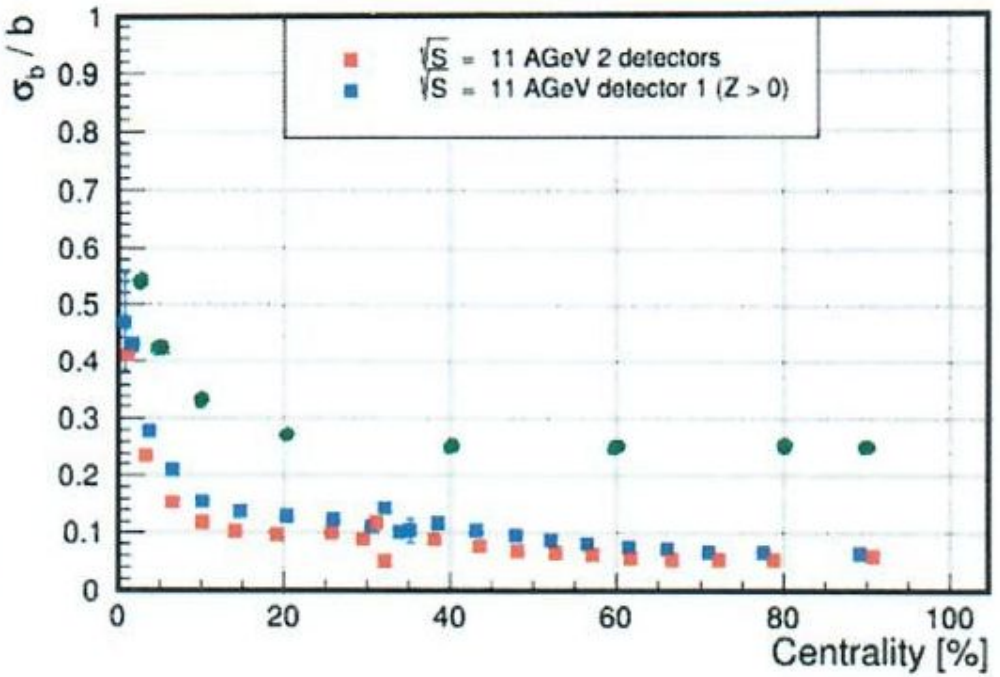




M.Golubeva et al. " Nuclear-Nuclear Collision Centrality Determination by the Spectators Calorimeter for the MPD Setup at the NICA Facility "
Yad.Fiz. 76 (2013) 2-17

The ambiguity in centrality determination can be resolved by taking track multiplicity in TPC.

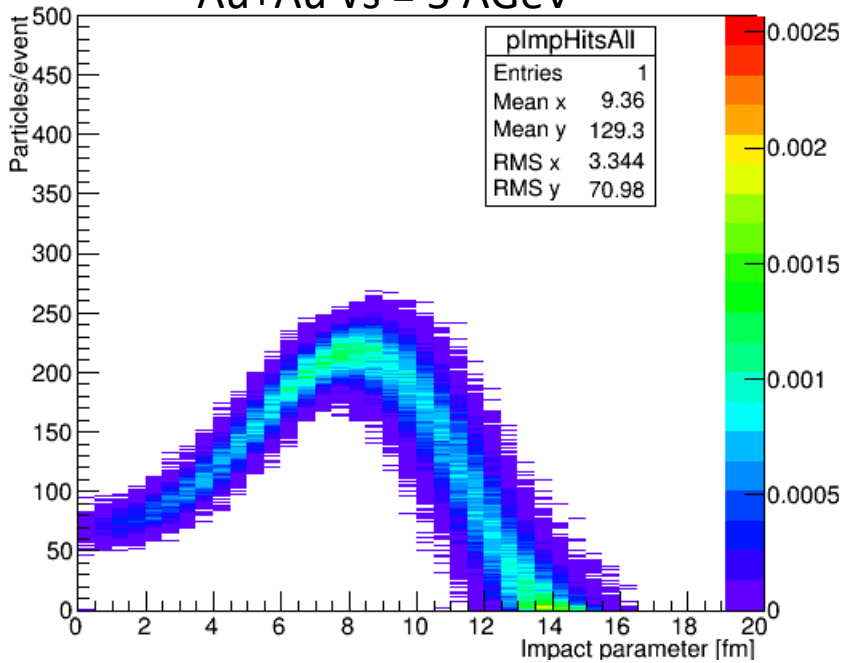




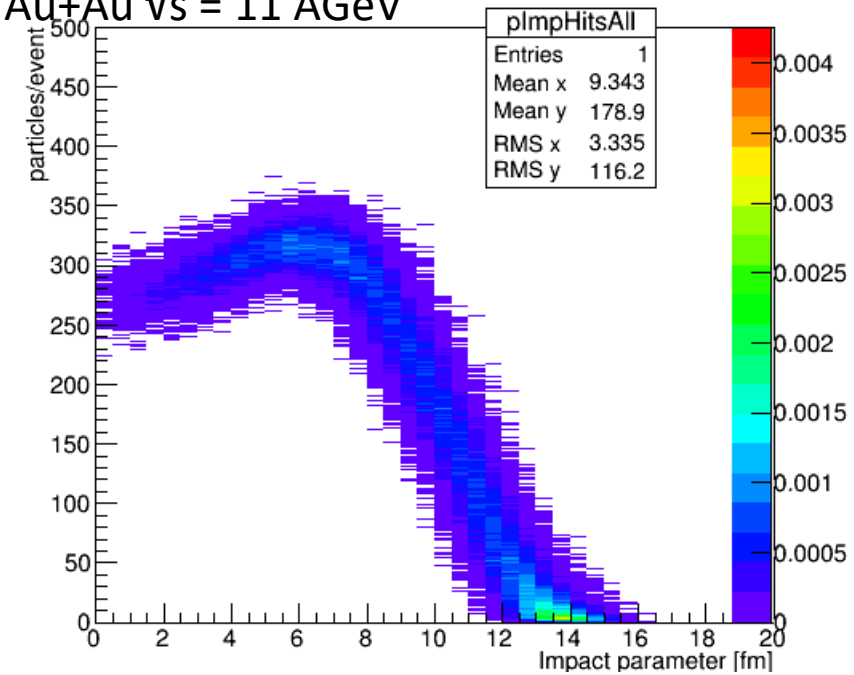
The resolution of impact parameter obtained in separate bins of the energy depositions in FHCal for beam energy √ s = 5 GeV (left) and √ s= 11 GeV (right). Blue and red points correspond to the one and two parts of FHCal, respectively. Green points - estimation with allowance for spectator number fluctuations.

Number of primary particles/event hitting FWALL surface (hole d=10 cm) Including neutrons

Au+Au √s = 5 AGeV



Au+Au √s = 11 AGeV



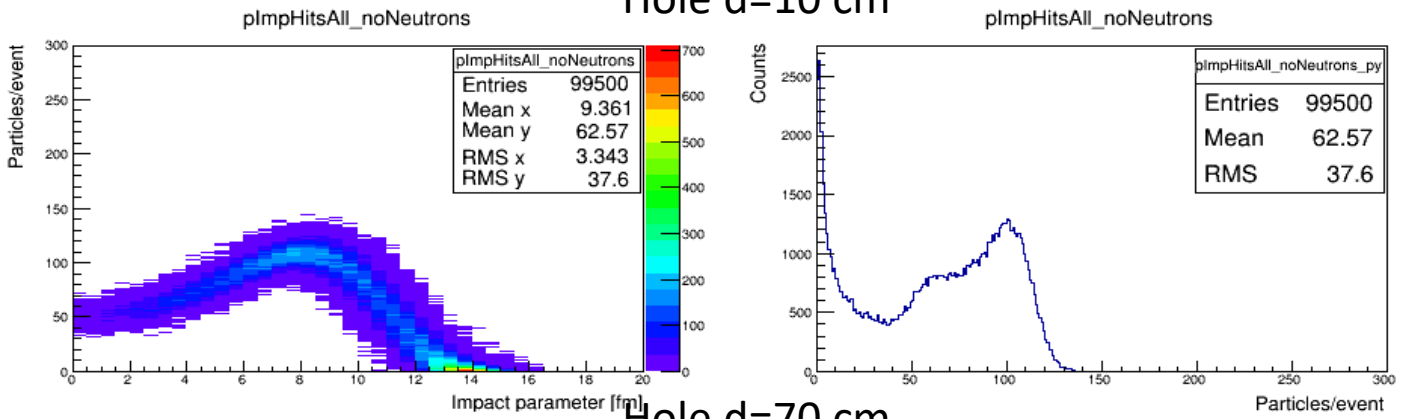
M.Golubeva, A.Ivashkin, A.Kurepin
“Study of nuclear fragmentation at MPD/NICA “
EPJ Web of Conferences 138, 11001 (2017)
Baldin ISHEPP XXIII

Au+Au √s = 5 AGeV
Without neutrons

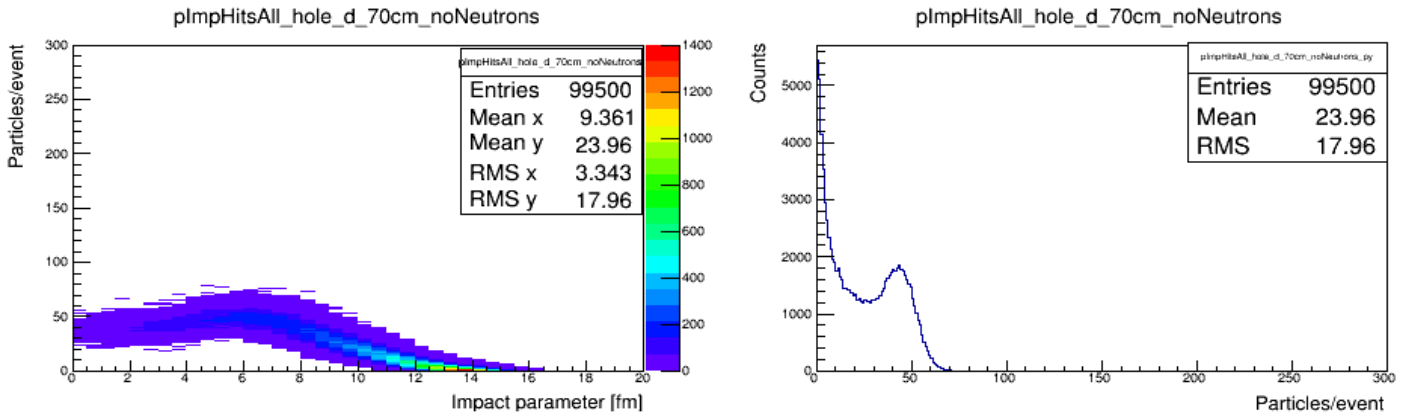
Number of primary particles/event hitting FWALL surface

(from generator)

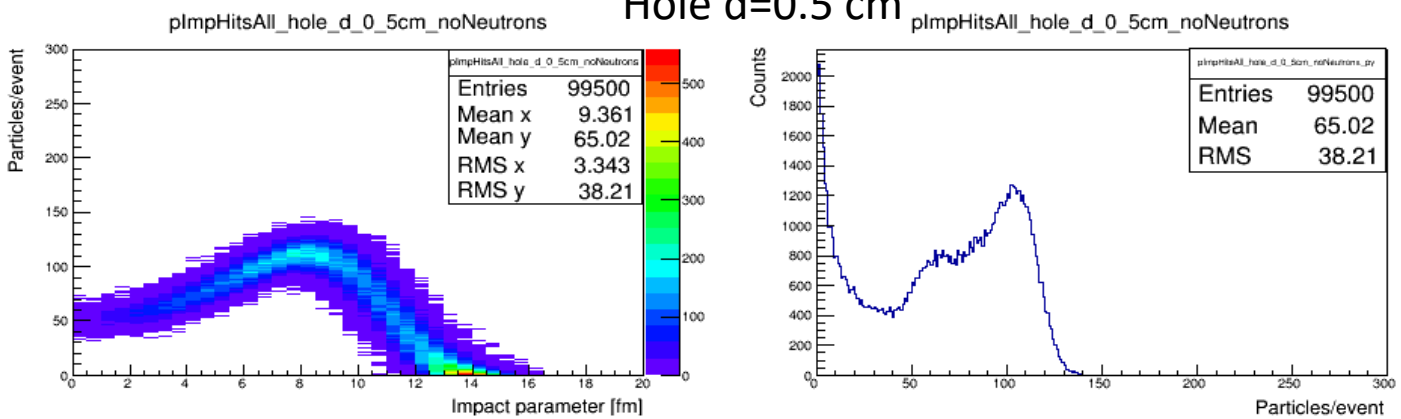
Hole d=10 cm



Hole d=70 cm



Hole d=0.5 cm

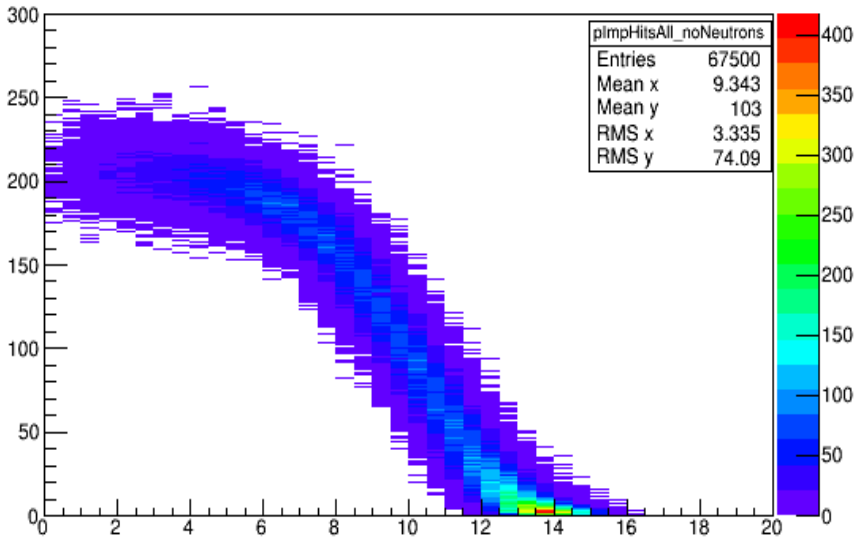


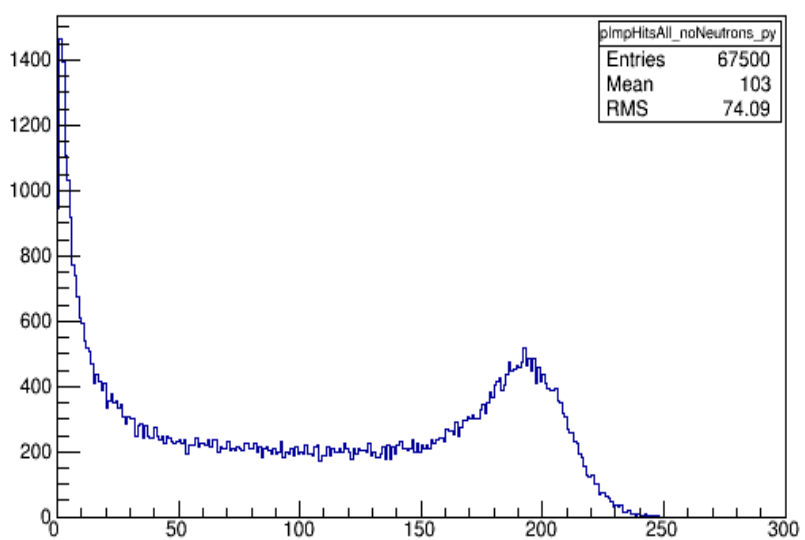
Au+Au √s = 11 AGeV
Without neutrons

Number of primary particles/event hitting FWALL surface

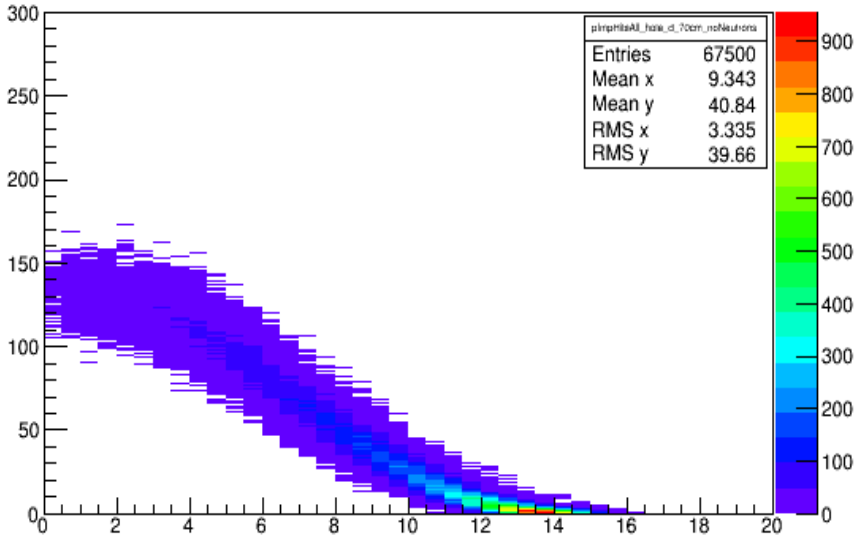
(Using info from MC tracks category)

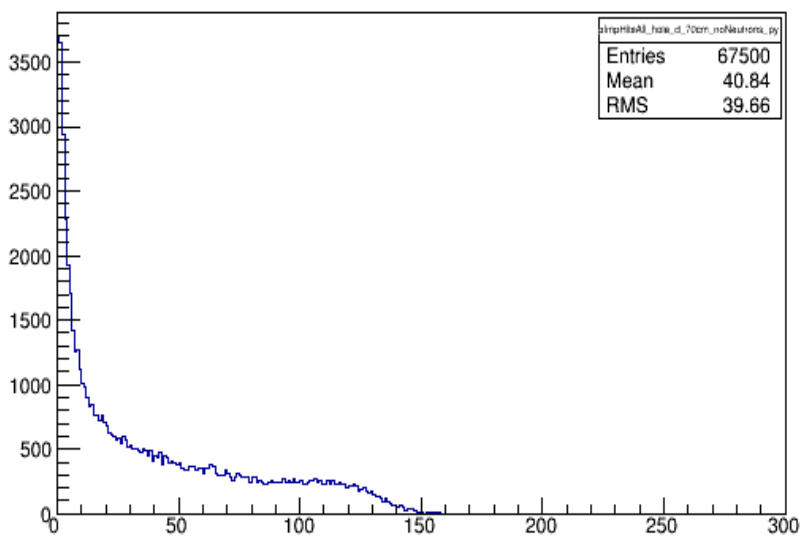
Hole d=10 cm

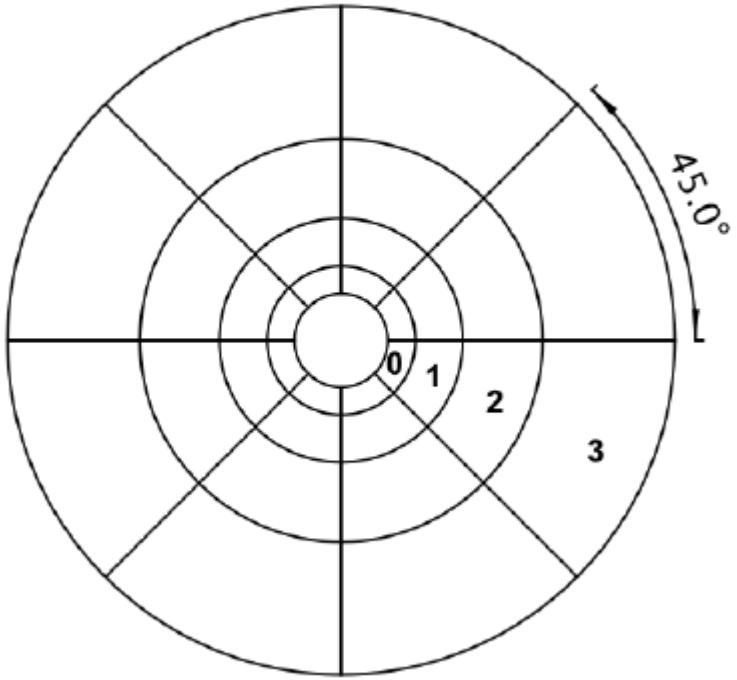


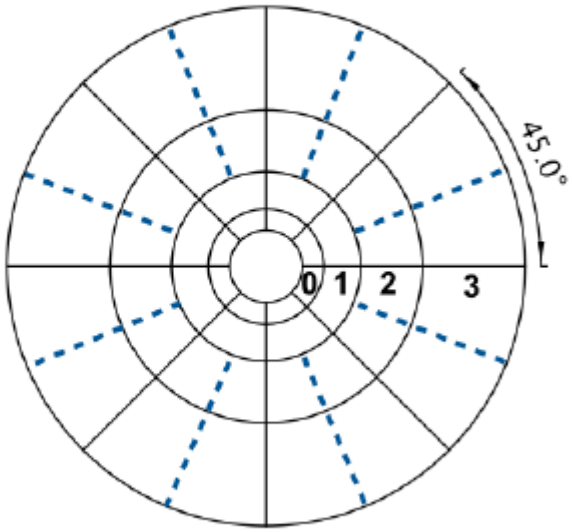


Hole d=70 cm

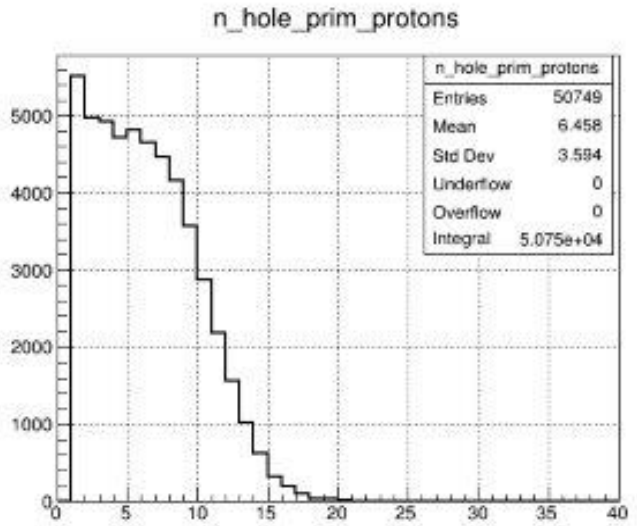


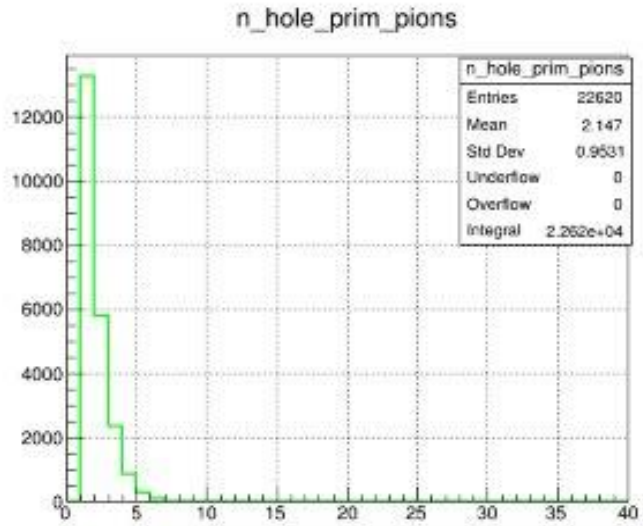


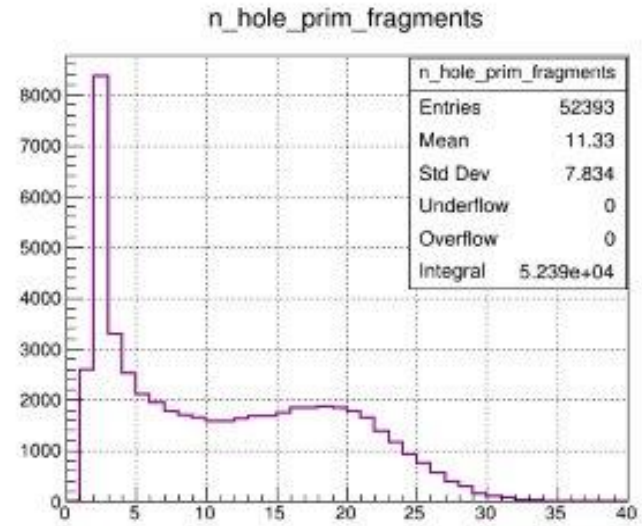




Sketch of FMD array showing their segmentation. Scintillator thicknesses are 2.5 cm. Radius of the hole is 6 cm. Outer radius is 70 cm.







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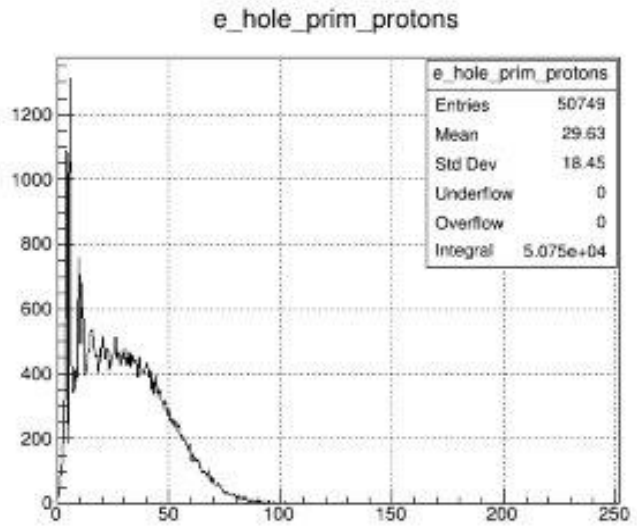
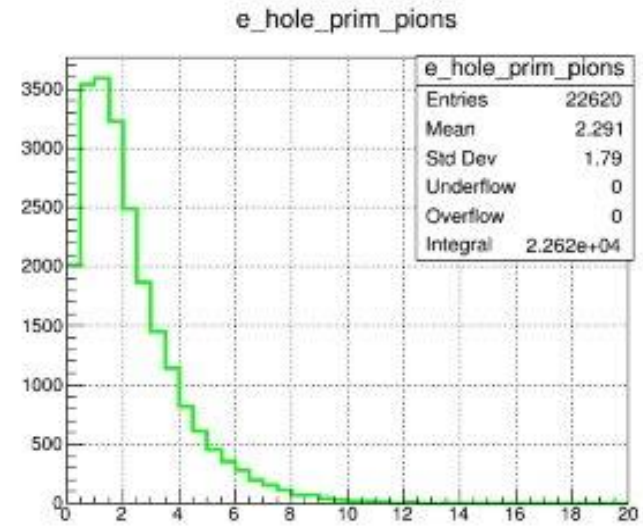
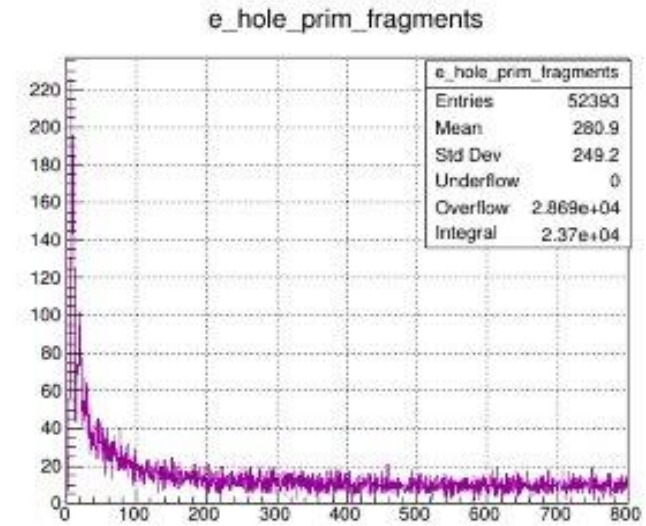
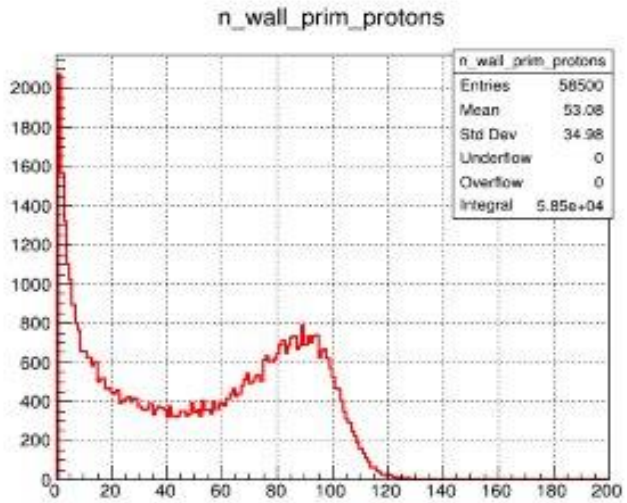
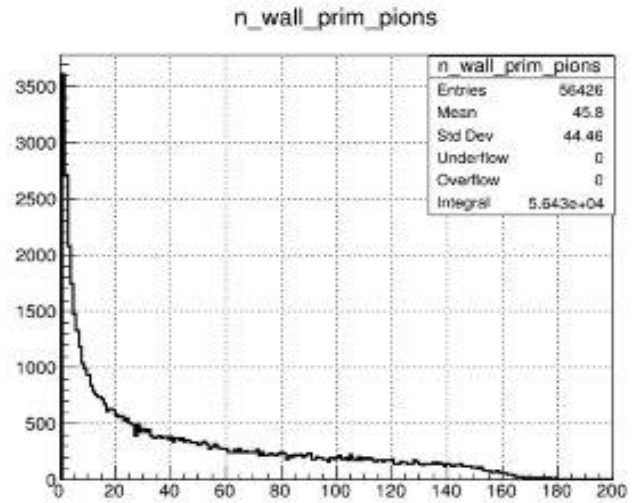


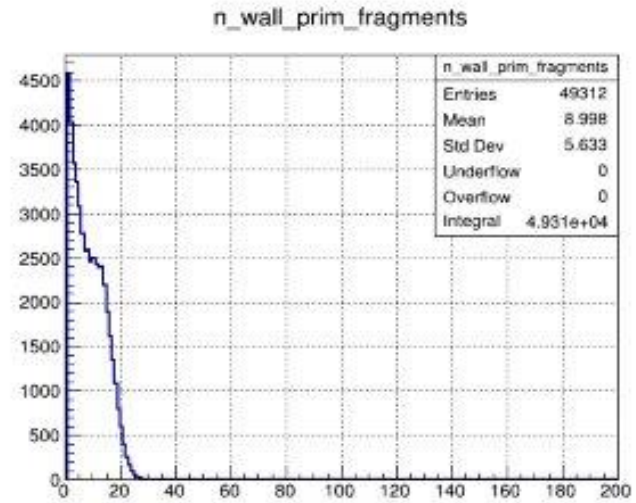




Multiplicity and energy distributions of protons, pions and fragments passing through the hole the FMD detector.







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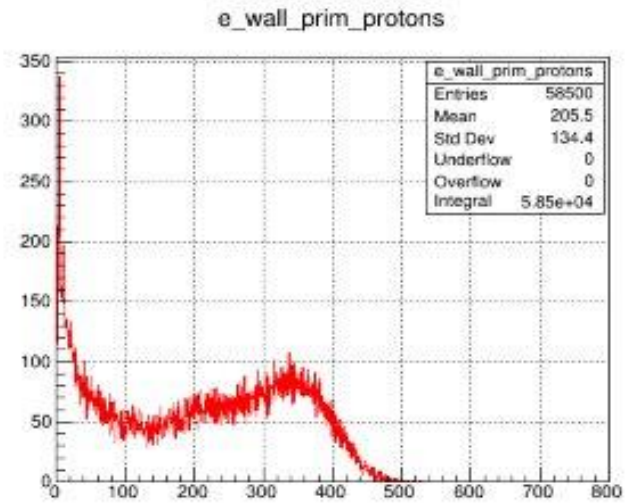
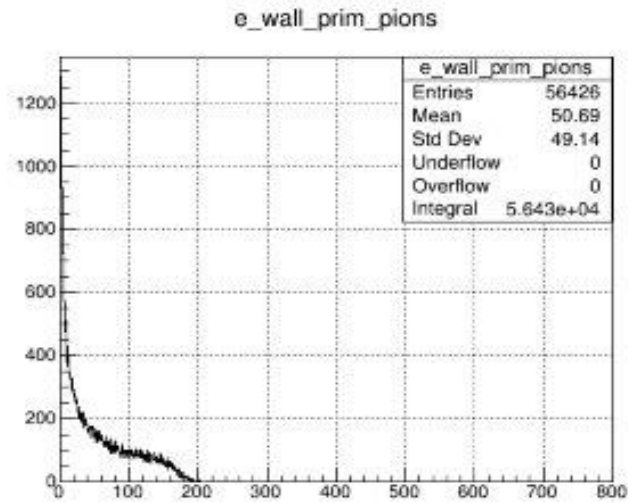
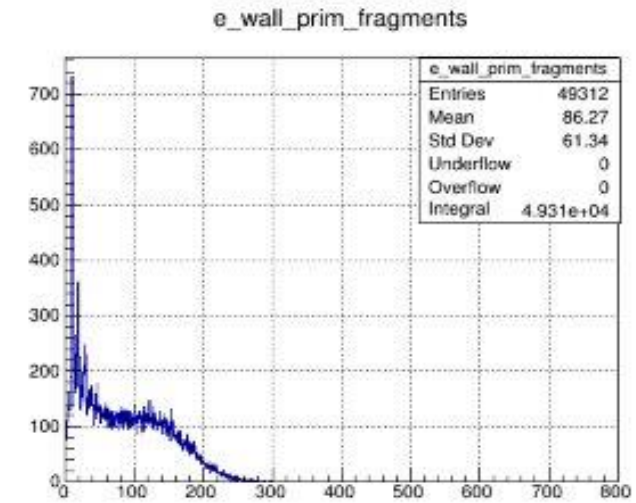
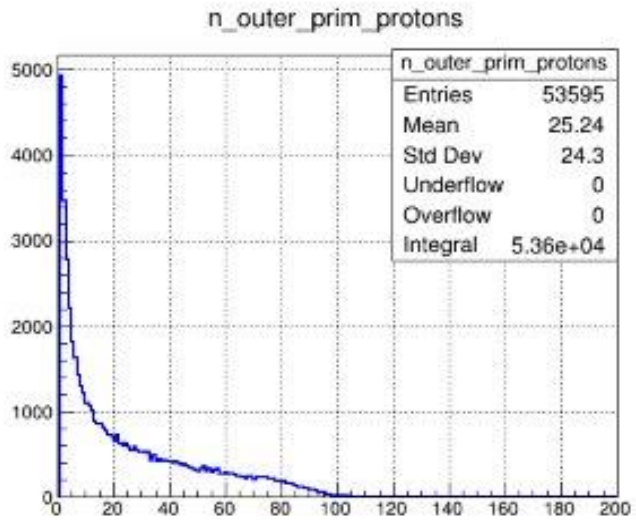
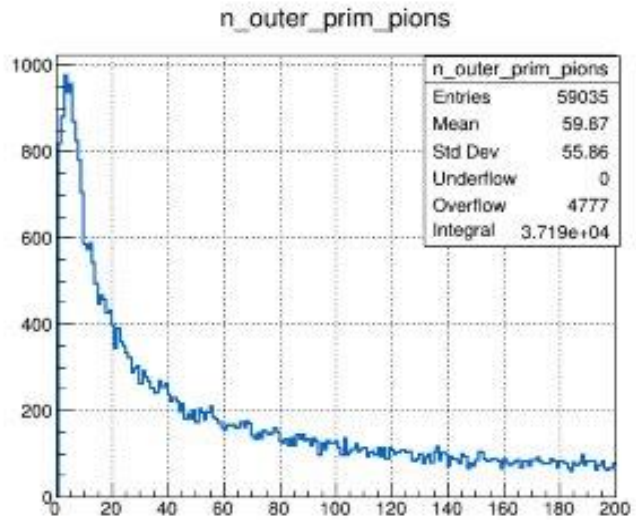


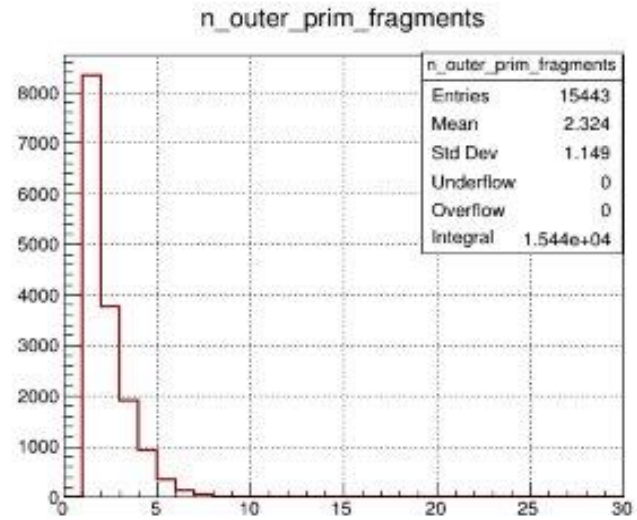




Multiplicity and energy distributions of protons, pions and fragments hitting the FMD detector







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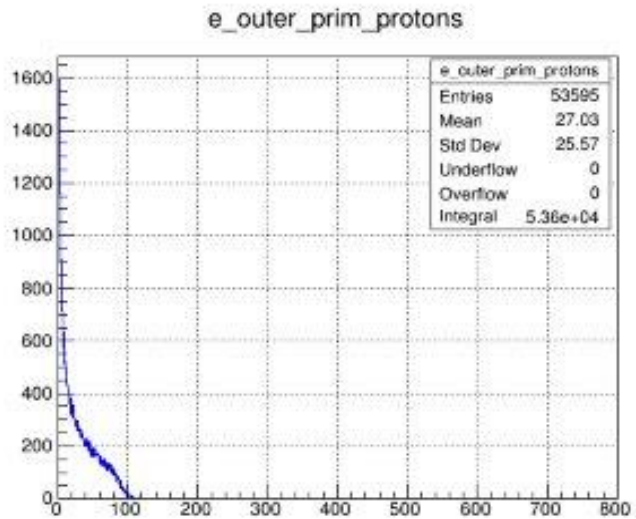
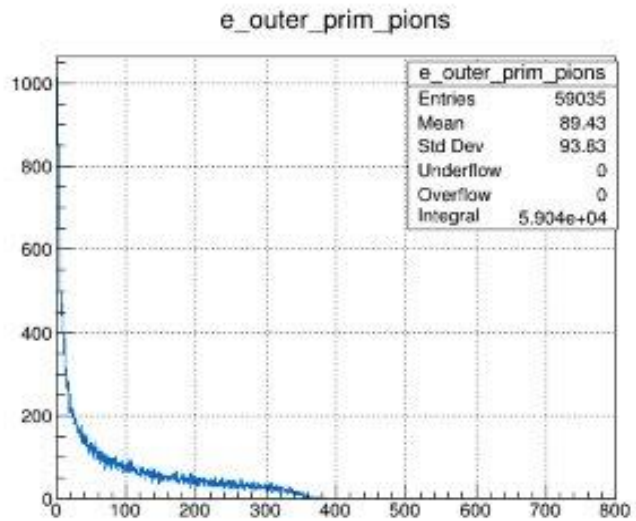
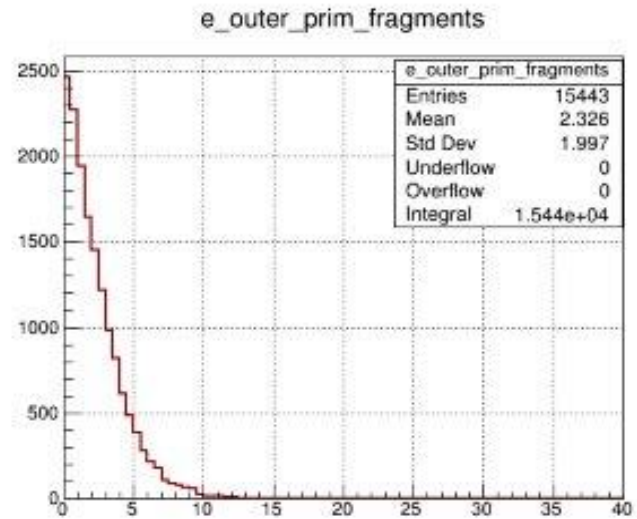
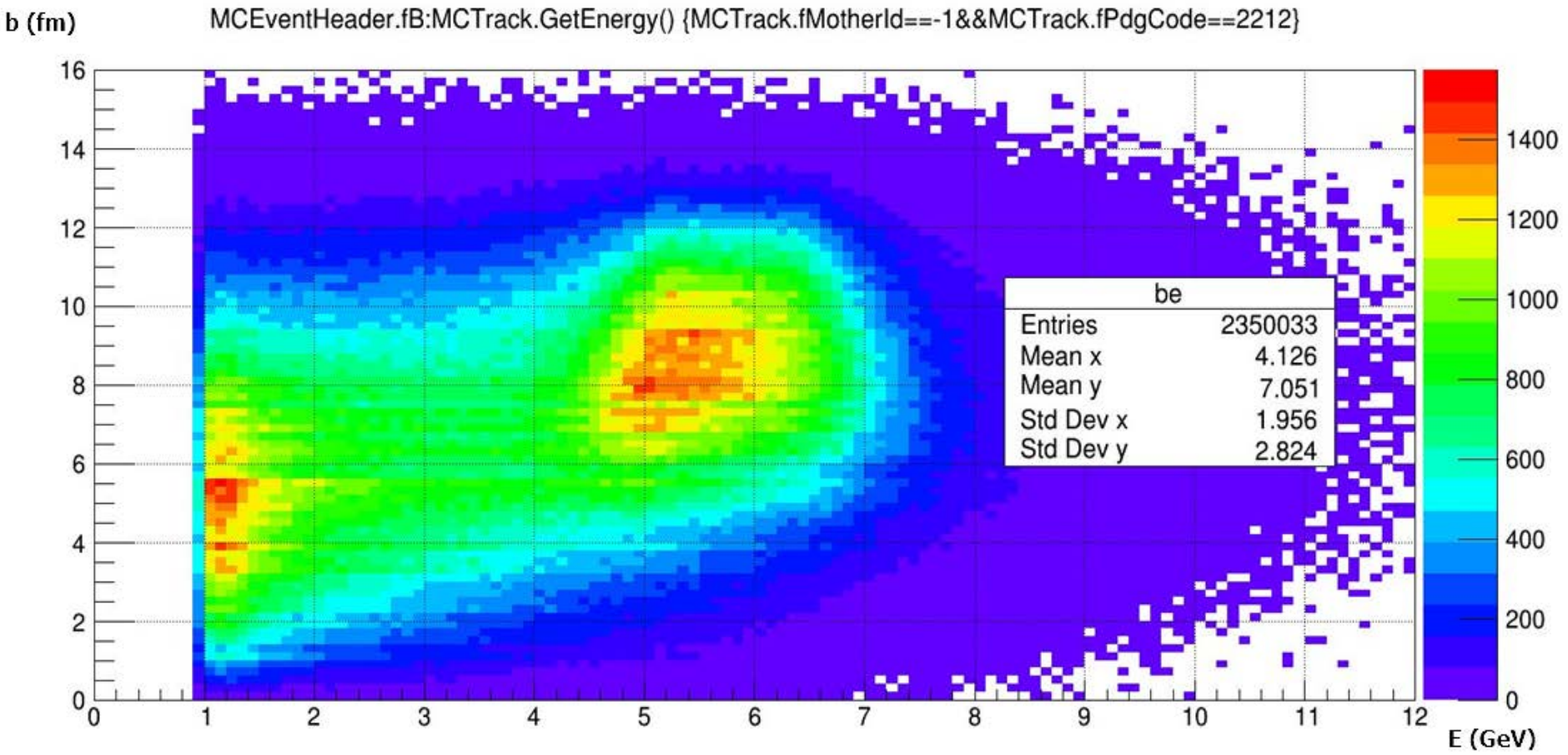


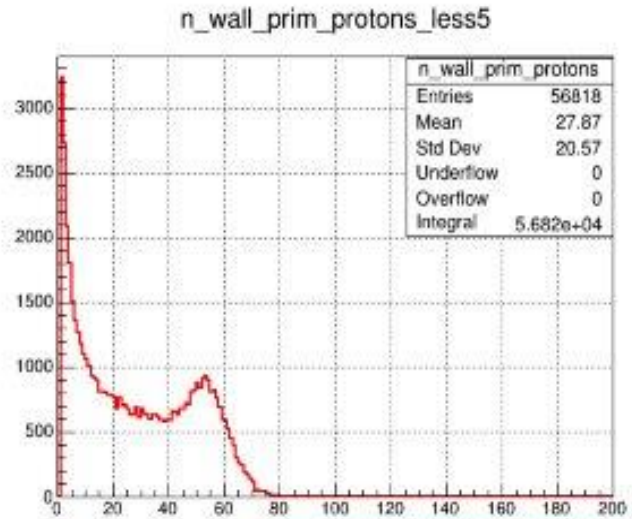


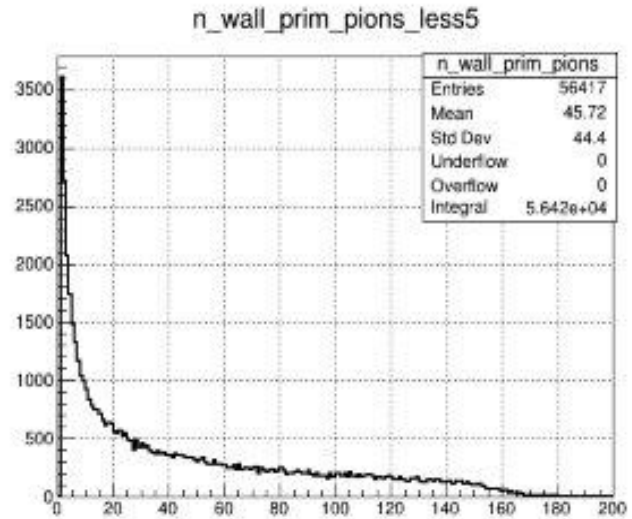


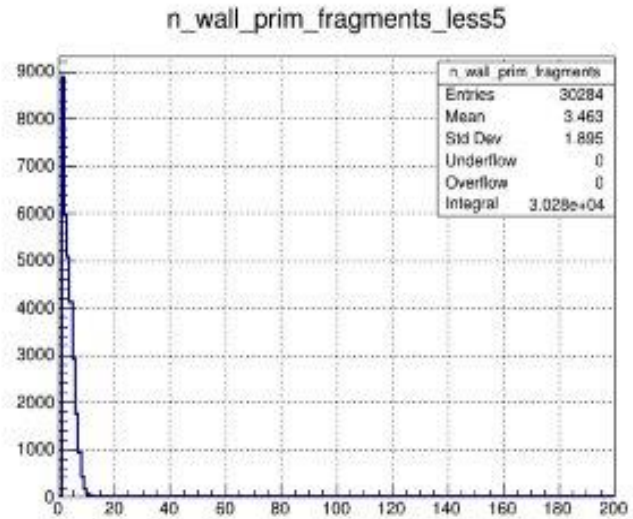
Multiplicity and energy distributions of protons, pions and fragments passing outside of the FMD detector



Dependence of the total energy in GeV of protons hitting the FMD detector on the impact parameter b in fm







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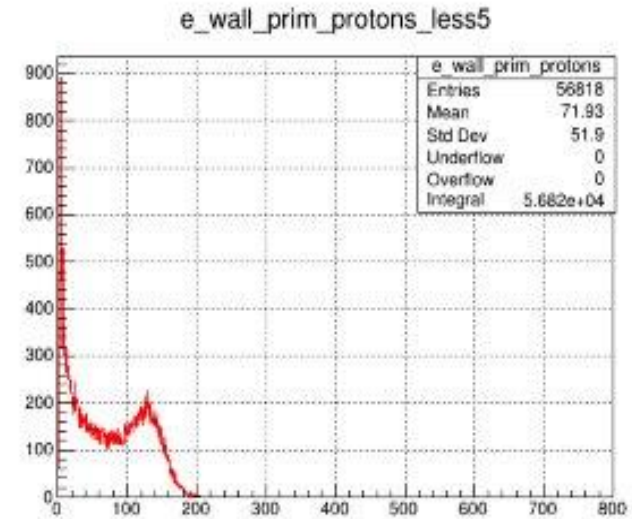
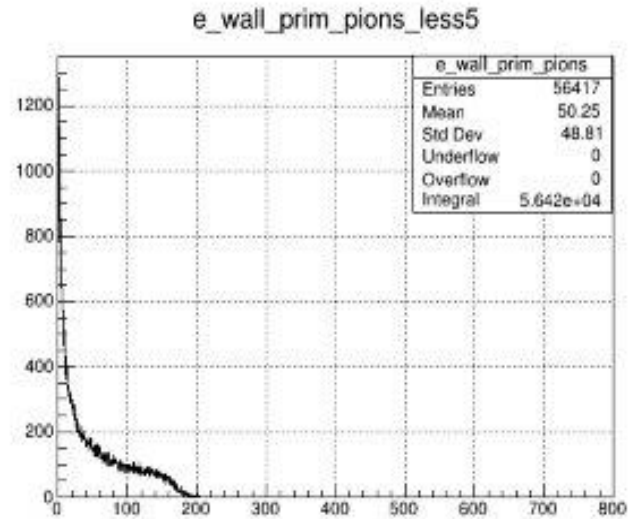
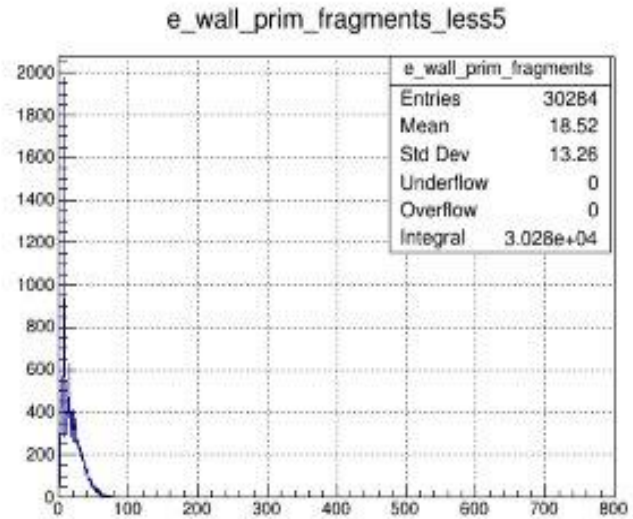
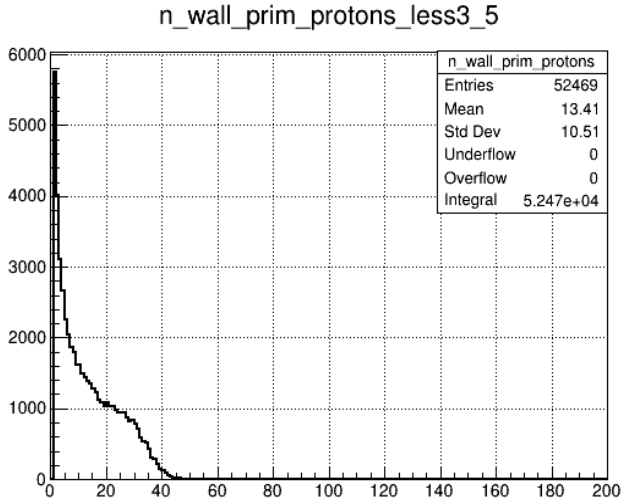
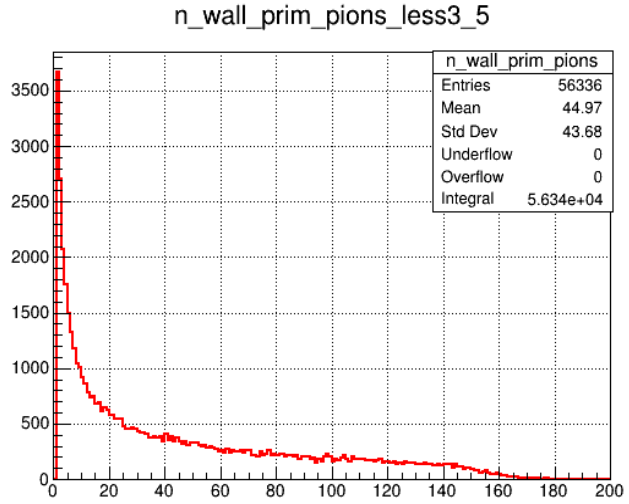


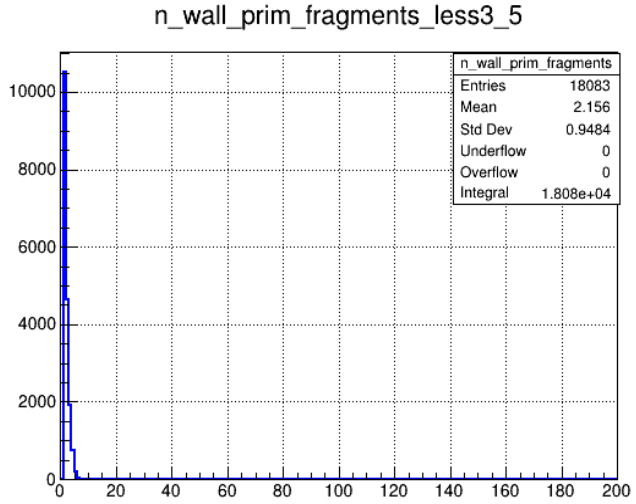




Multiplicity and energy distributions of protons, pions and fragments with energy less 5 GeV hitting the FMD detector







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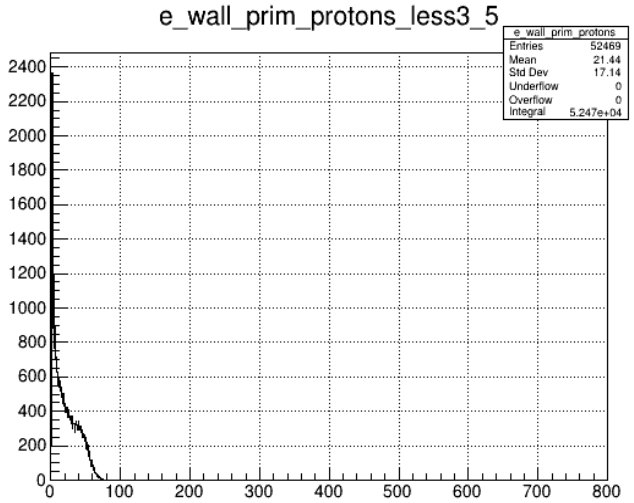
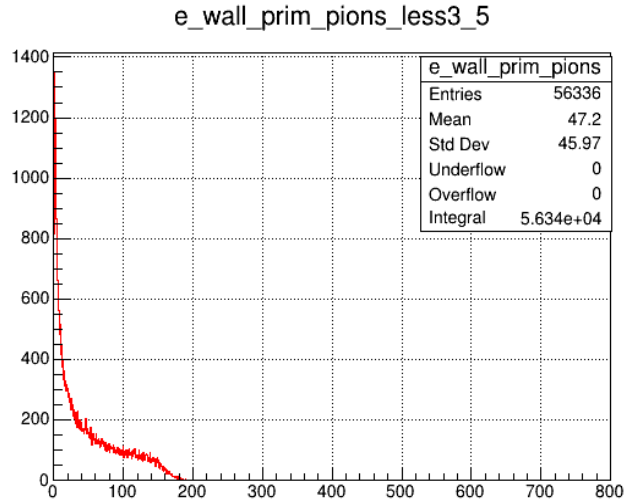
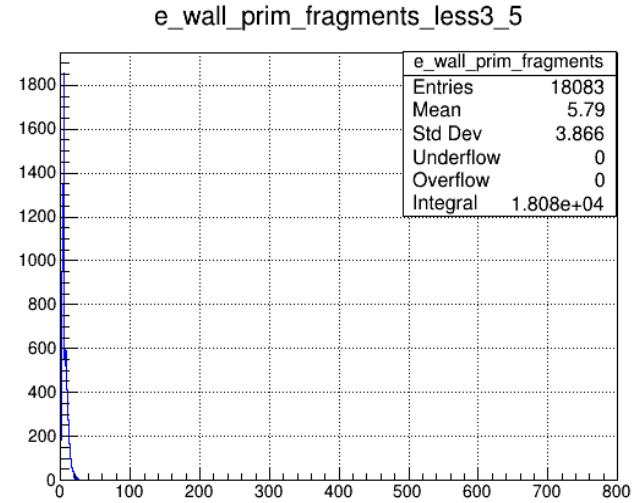
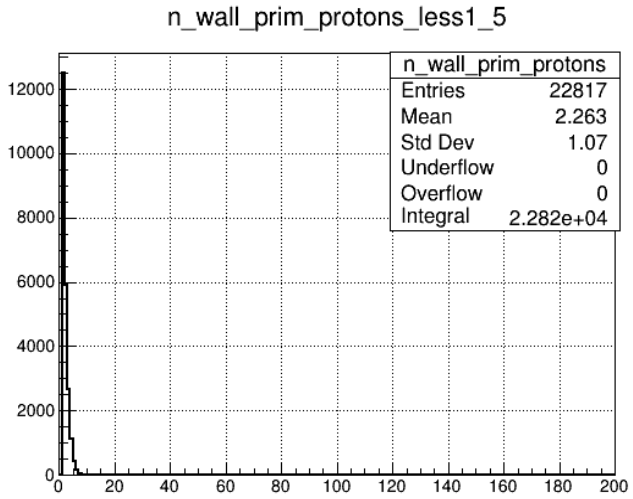
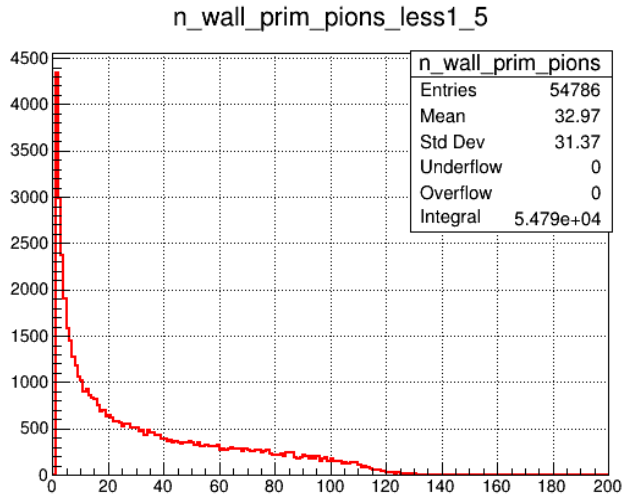


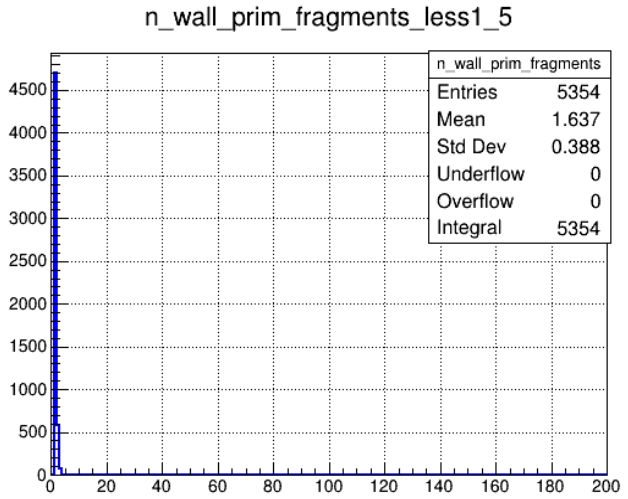




Multiplicity and energy distributions of protons, pions and fragments with energy less 3.5 GeV hitting the FMD detector







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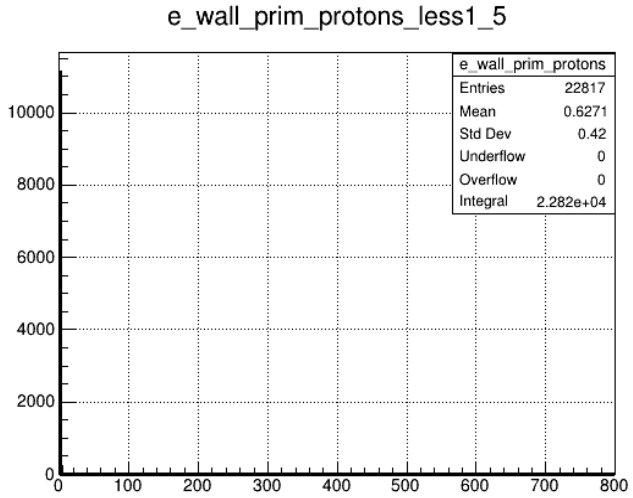

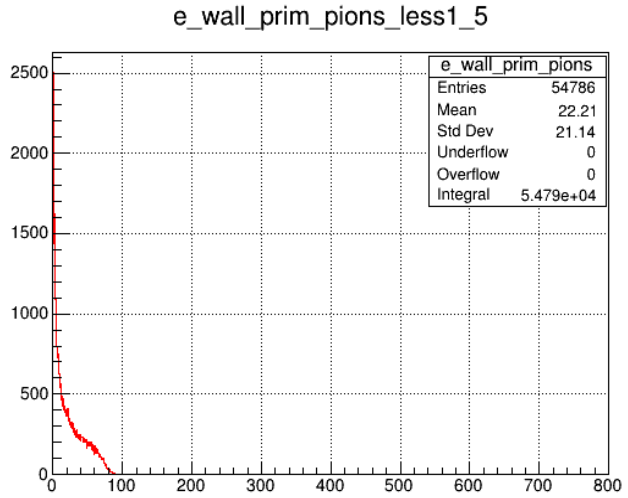

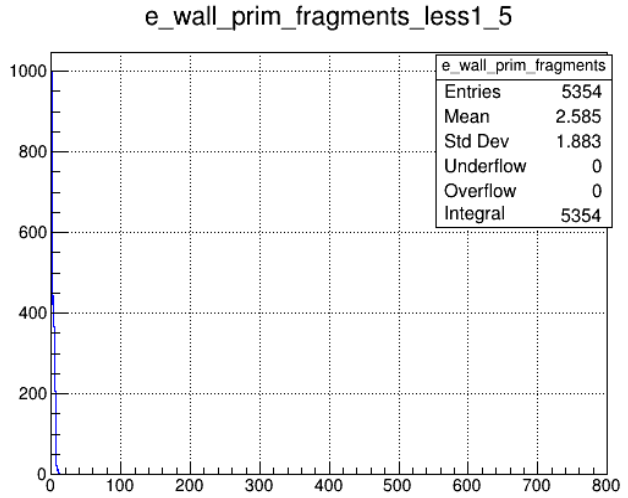

Multiplicity and energy distributions of protons, pions and fragments with energy less 1.5 GeV hitting the FMD detector

Conclusions

1. Centrality in nucleus-nucleus collisions could be measured at MPD/NICA by using the Forward Multiplicity Detector with accuracy better than FHCal of the order of 5 – 10 % for the central and semi-central collisions
2. The contribution of spectators could be removed from the multiplicity distribution by anticoincidence with FHCal with the threshold of 3.5 GeV