Centrality with ZDC in argon-nucleus data

4th Collaboration Meeting of the BM@N Experiment at the NICA Facility

15.10.2019

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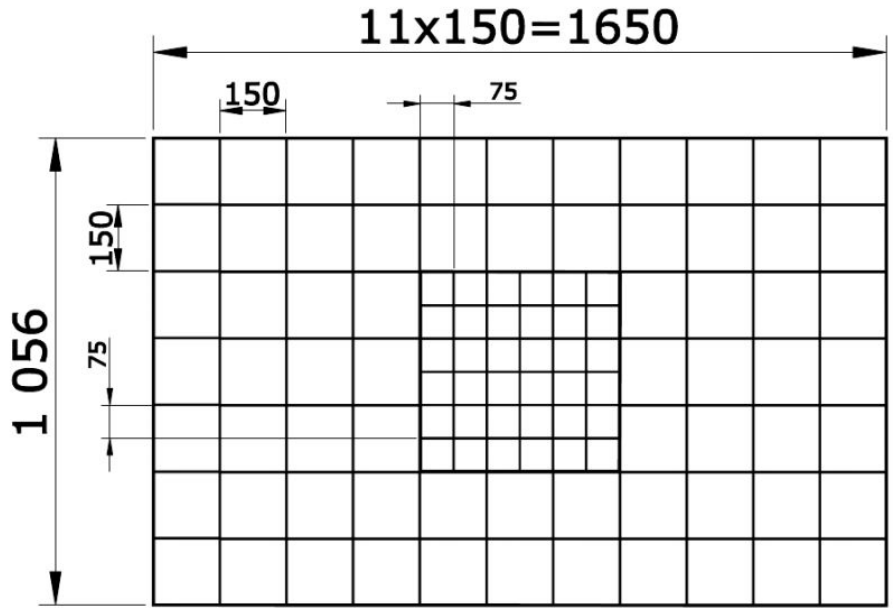
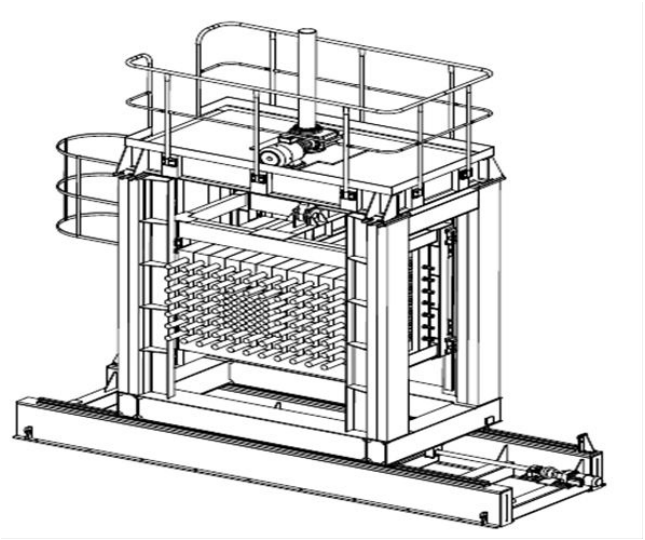
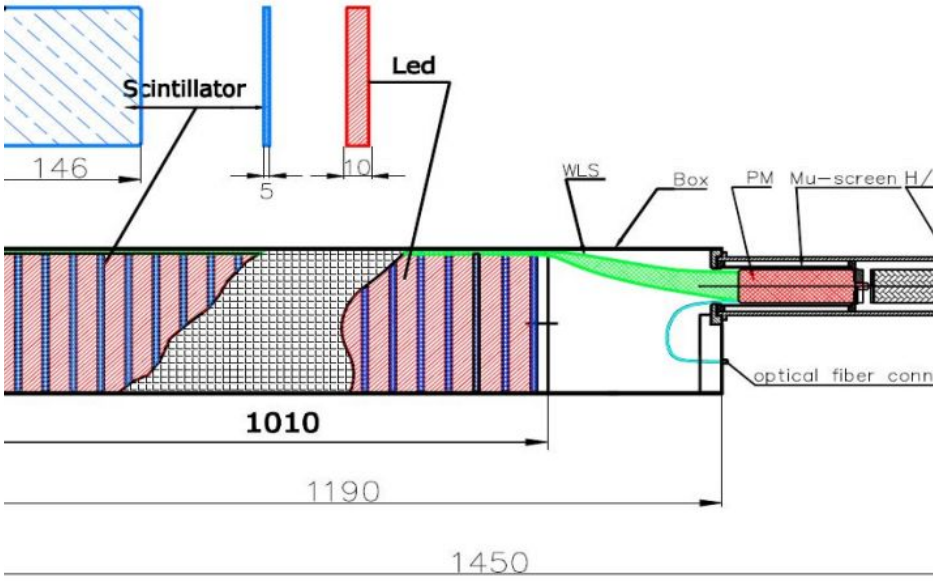
ZDC setup





- Central part consist of 36 modules with sizes 7.5×7.5 cm^2
- Peripheral part contains 68 modules of 15×15 cm^2

ZDC module design



- 64 layers: 5mm scintillator + 10mm lead absorber
- Wave length shifter
- PMT with voltage divider

Objective

- Analyze ZDC experimental data of 7-th BM@N period
- Obtain Monte-Carlo data for ZDC in the same setup
- Compare the results
- Provide the method of impact parameter estimation for experimental data

Problem

Experimental data

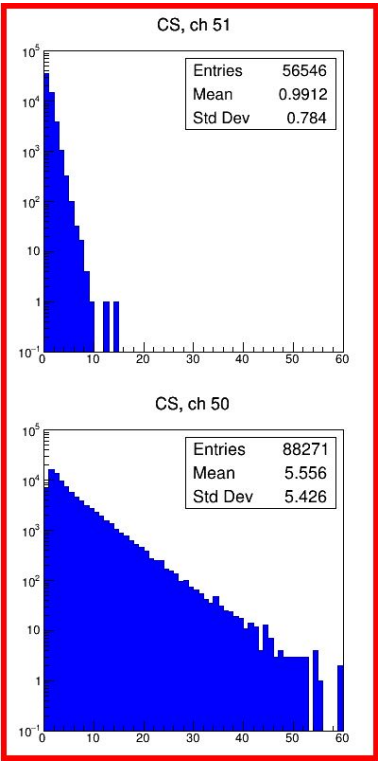
- Calibration
- Data quality
- Pileup
- Saturation?

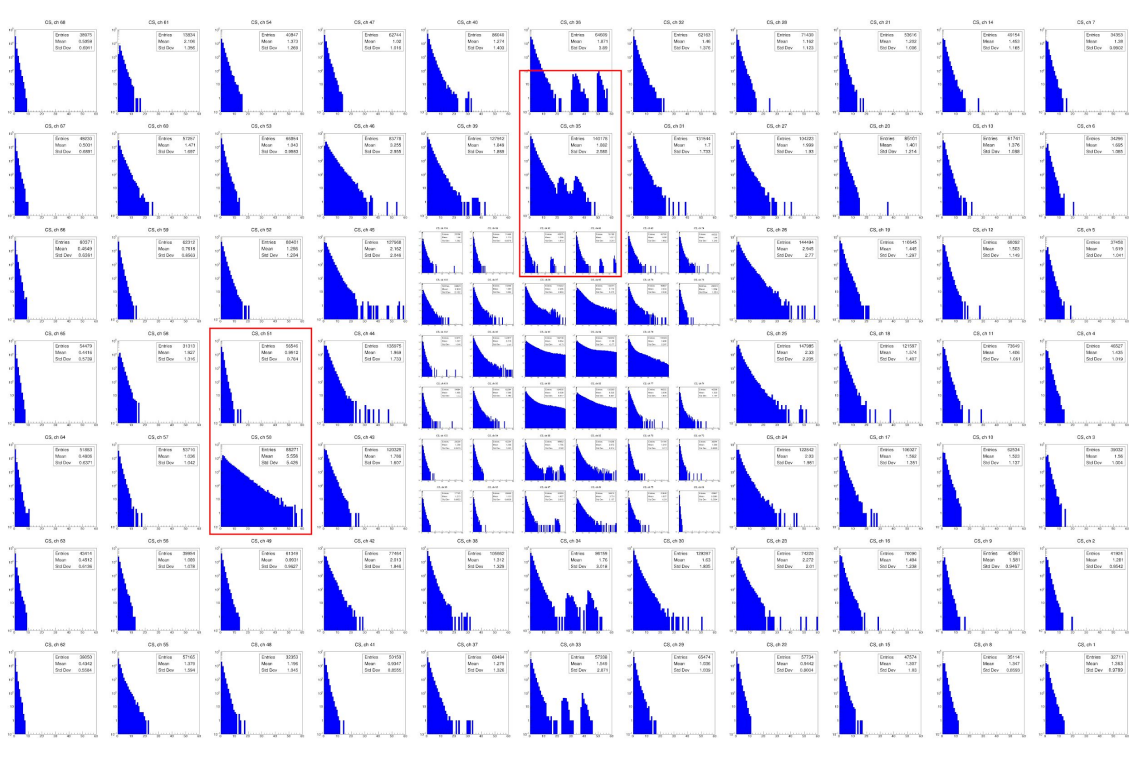
Compliance with simulation

- Multiplicity of hits
- Energy spectra
- Cluster shape
- Particle species set

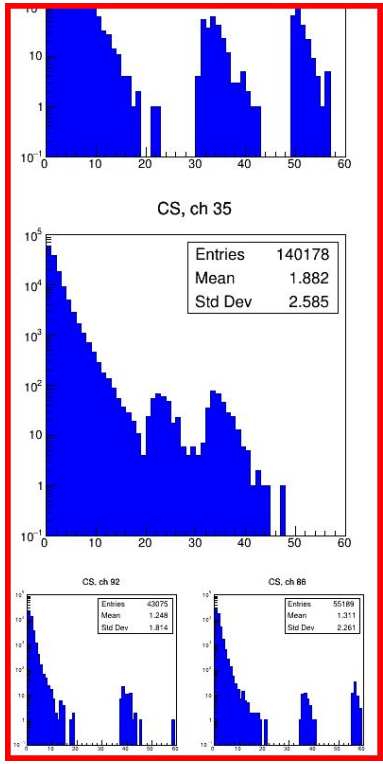
Run 3978

Calibration

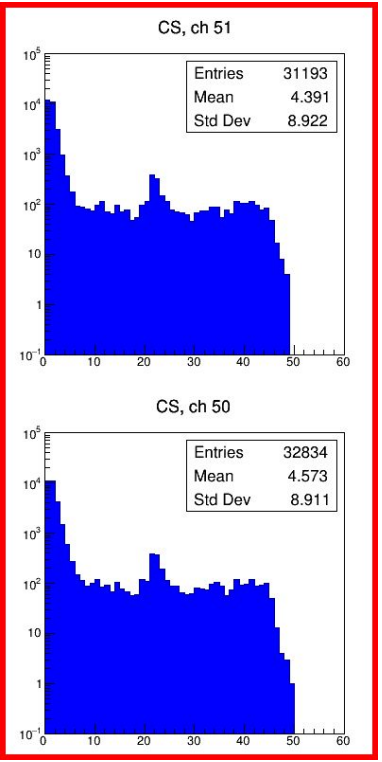


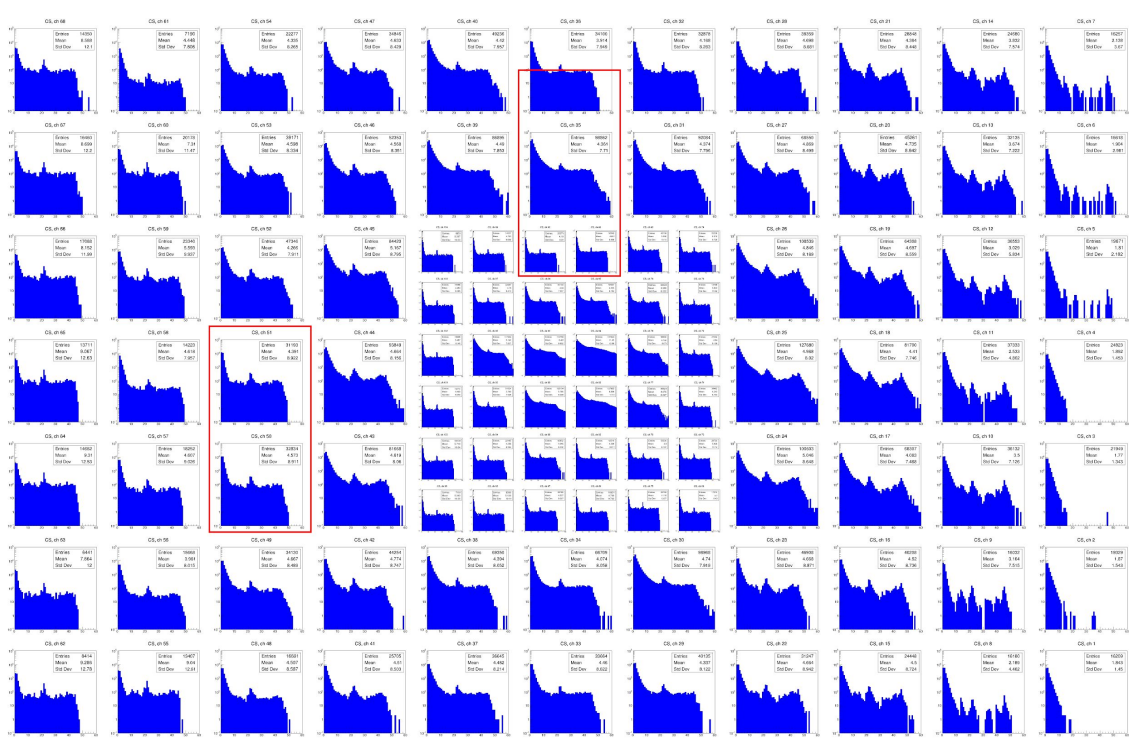


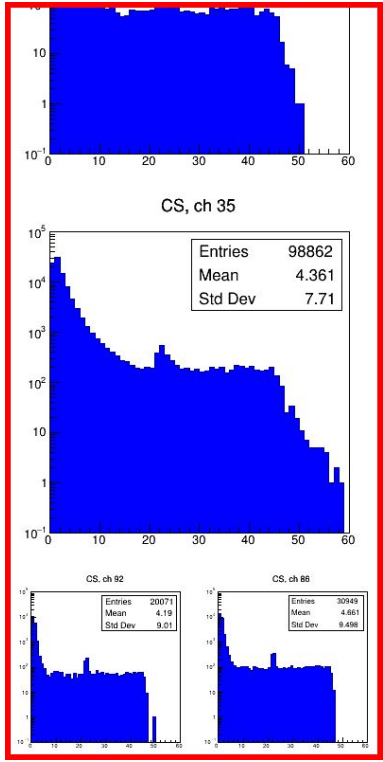
Distortion



Run 4435

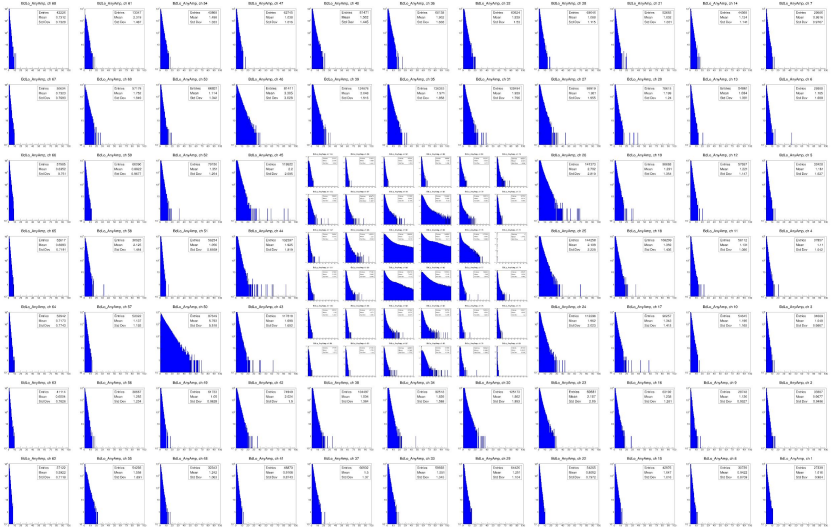

CS, ch 51
Entries 31193
Mean 4.391
Std Dev 8.922
CS, ch 50
Entries 32834
Mean 4.573
Std Dev 8.911




CS, ch 35
Entries 98862
Mean 4.361
Std Dev 7.71
CS, ch 92
Entries 20071
Mean 4.19
Std Dev 9.01
CS, ch 86
Entries 30949
Mean 4.661
Std Dev 9.498

Data selection criteria

- Not less than 200k events
- No peaks or pedestals on energy spectra of the channels
- Mean value of the weighted average event center is near by ZDC center (not greater than 5mm)
- Identified tracks (The runs should be in the list provided by Vasiliy Plotnikov)
- Runs processed together should have identical parameters (field, trigger...)

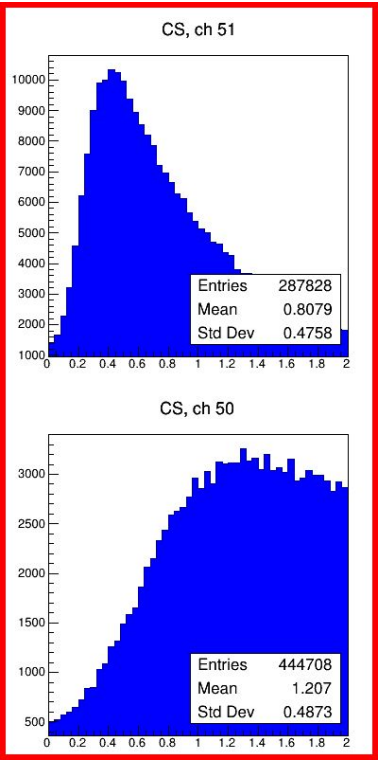


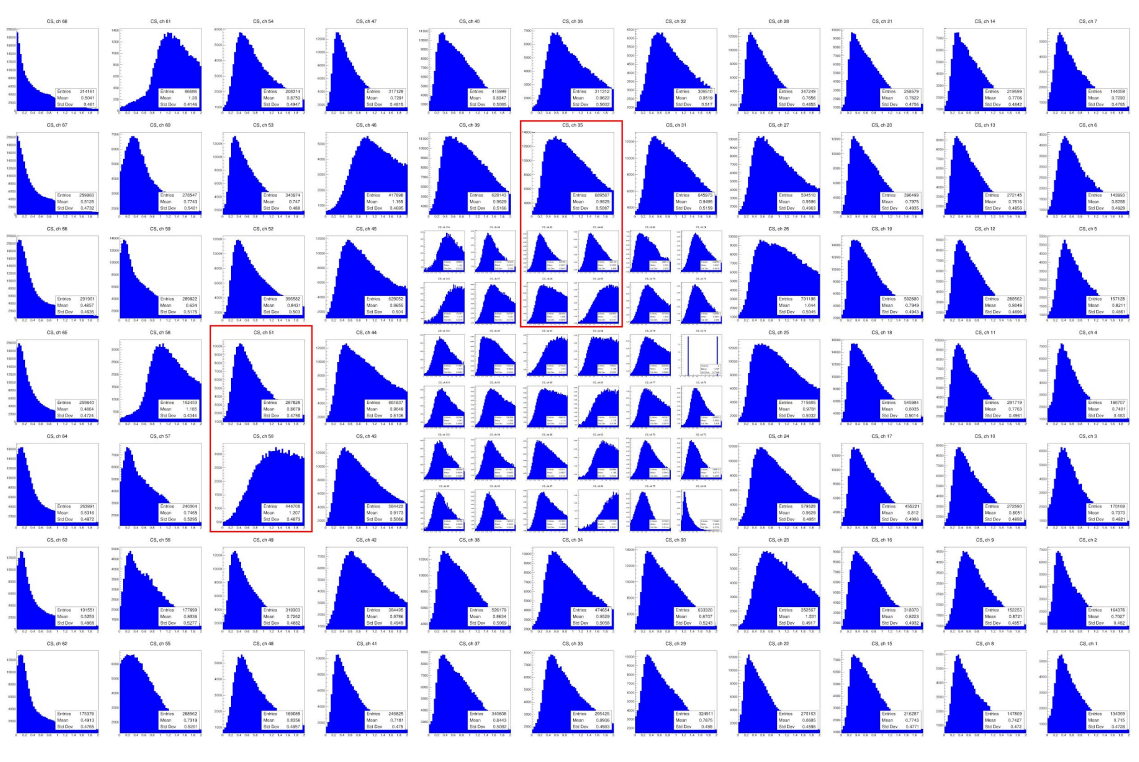
Ar (3.2 AGeV) →Al (3.33 mm), Beam Trigger + BD(>=2) and FD(>=3)

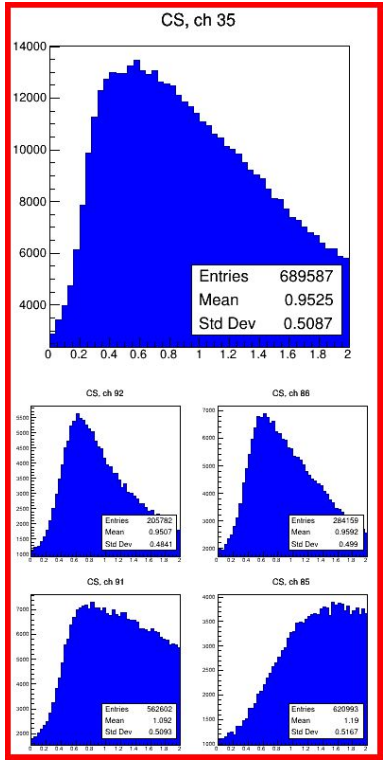
Run numbers that has been used in the presentation:

3977, 3979, 3980, 4046, 4048

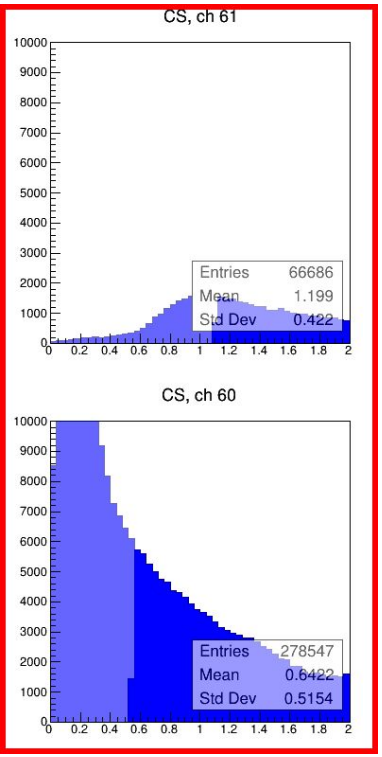
Thresholds

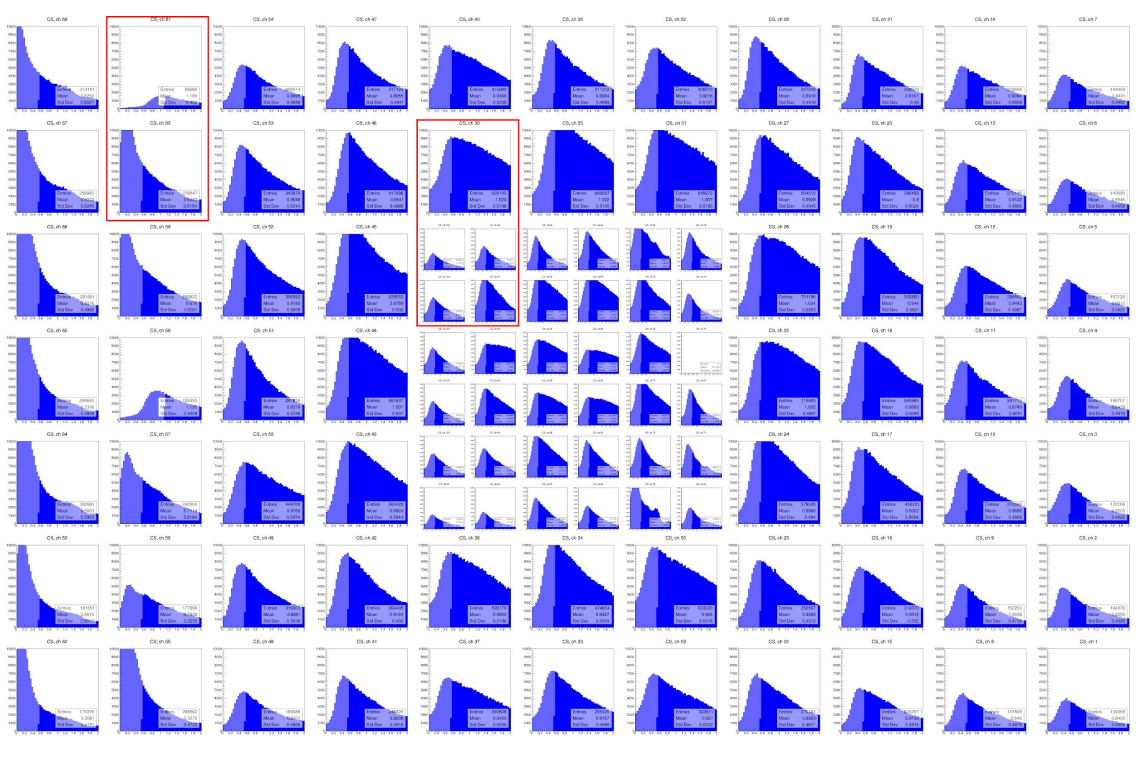

CS, ch 51
Entries 287828
Mean 0.8079
Std Dev 0.4758
CS, ch 50
Entries 444708
Mean 1.207
Std Dev 0.4873

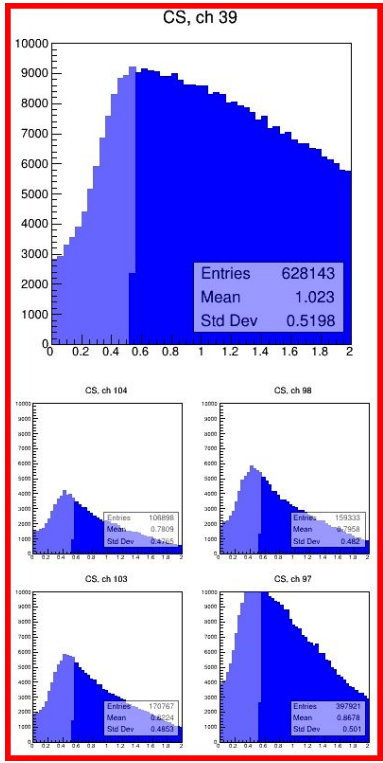



CS, ch 35
Entries 689587
Mean 0.9525
Std Dev 0.5087
CS, ch 92
Entries 205762
Mean 0.9507
Std Dev 0.4841
CS, ch 86
Entries 284158
Mean 0.9592
Std Dev 0.499
CS, ch 91
Entries 562602
Mean 1.052
Std Dev 0.5093
CS, ch 85
Entries 629993
Mean 1.19
Std Dev 0.5167

Thresholds (calibration canceled)

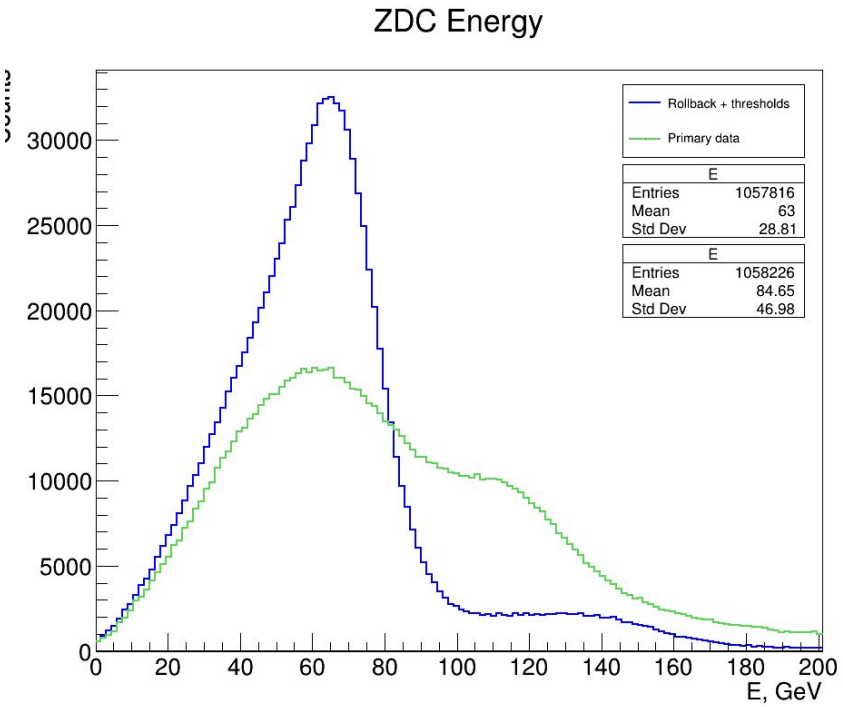


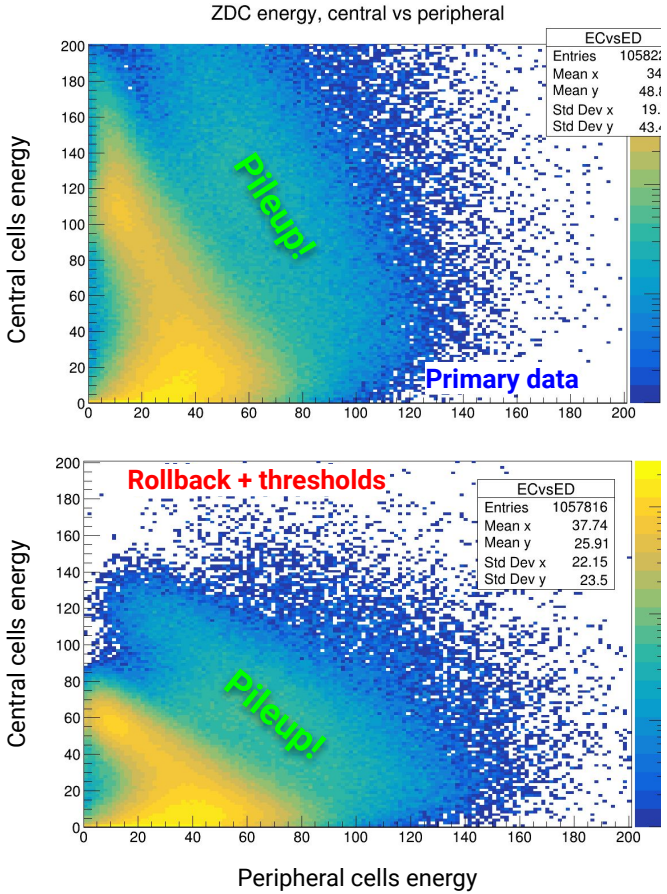




Most of the channels has thresholds less than 0.55 except of two channels with greater value

ZDC Energy spectra before and after the rollback of calibration coefficients and applying the thresholds





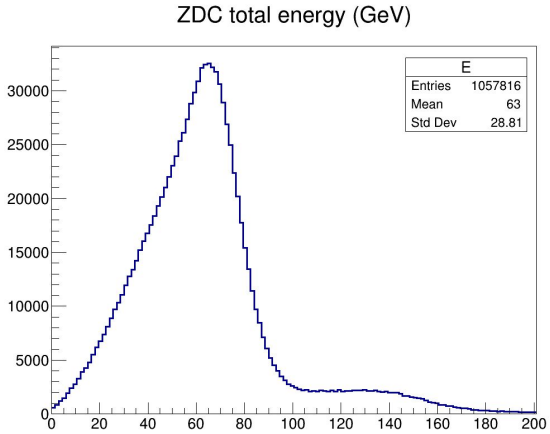
MC Simulation

- The beam center was obtained from experimental data
- ZDC geometry for simulation was adjusted
- GEANT4 simulation completed for Ar-Al 3.2AGeV interaction. It has about 200k events
- The pileup was simulated by randomly mixing some pairs of the events
- The same thresholds as for experimental data was applied to MC
- Channels amplitudes before thresholds was adjusted to obtain similar multiplicity and energy spectra

ZDC total energy in the experimental data and in the simulation results

Experimental data

```
Period:  7
SP-41:   1250 A
Beam:    Ar, 3.2 AGeV
Target:  Al, 3.3 mm
Trigger: Beam + BD≥2 & FD≥3
Run:     3977, 3979, 3980,
         4046, 4048
```

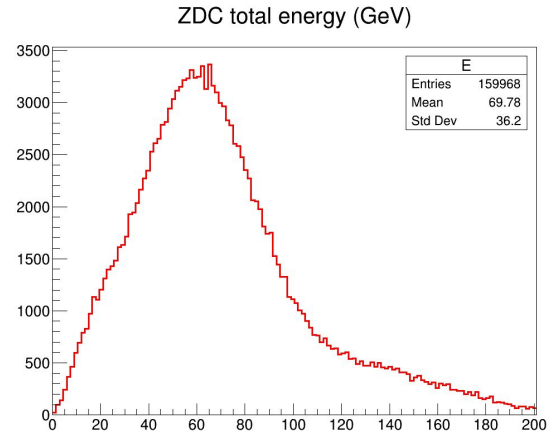


Simulation data

Generator:
LAQGSM ArAl_3.2AGeV_mb

ZDC position:
x=50 cm, y=-6.3 cm,
z=1000 cm

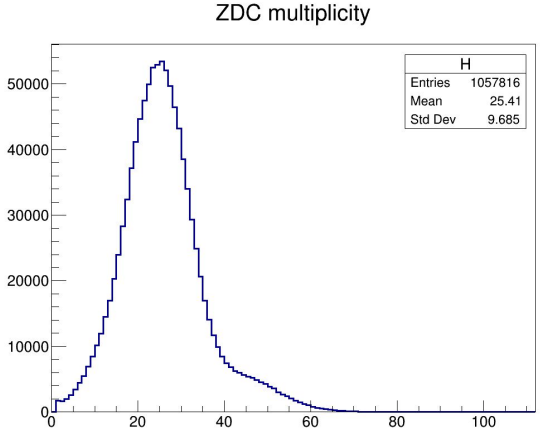
160k events
Pileup 20%

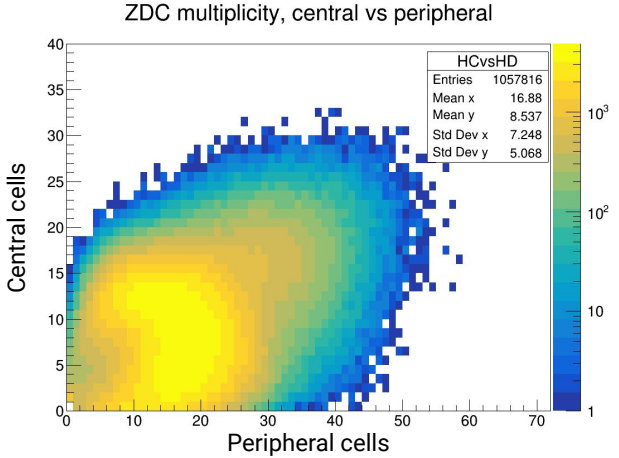


ZDC multiplicity in the experimental data and in the simulation results

Experimental data

```
Period:  7
SP-41:   1250 A
Beam:    Ar, 3.2 AGeV
Target:  Al, 3.3 mm
Trigger: Beam + BD≥2 & FD≥3
Run:     3977, 3979, 3980,
         4046, 4048
```



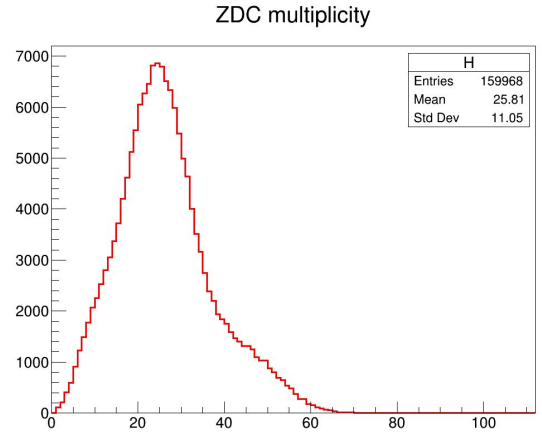


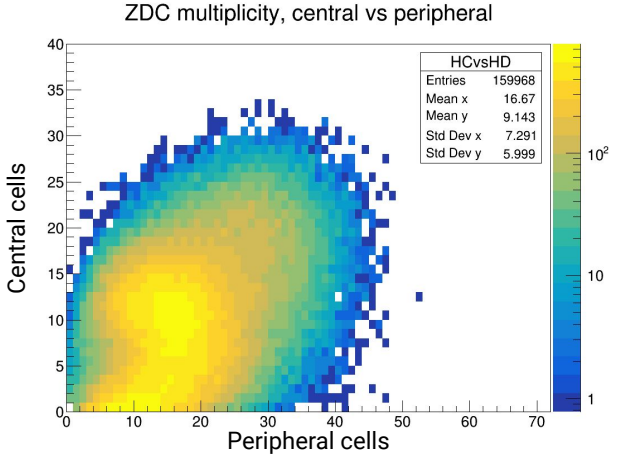
Simulation data

Generator:
LAQGSM ArAl_3.2AGeV_mb

ZDC position:
x=50 cm, y=-6.3 cm,
z=1000 cm

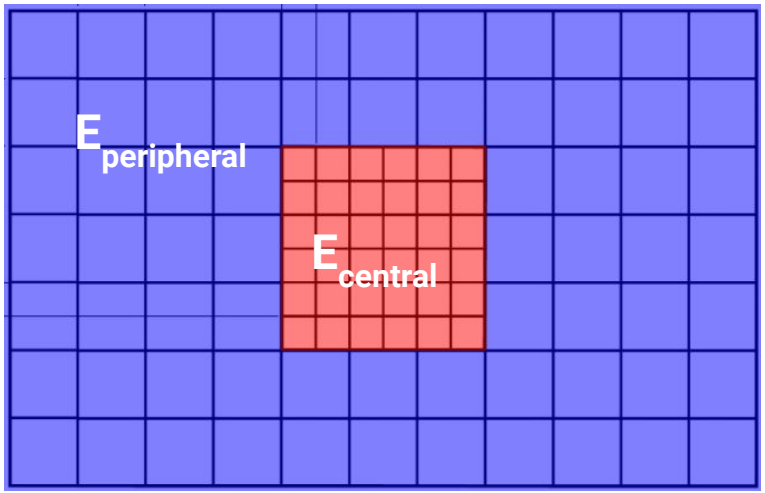
160k events
Pileup 20%





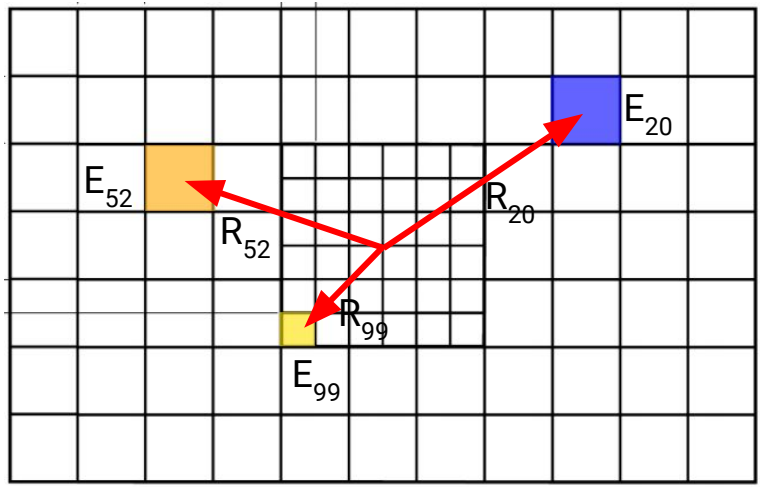
Cluster shape

Asymmetry



$$A = \frac{E_{central} - E_{peripheral}}{E_{central} + E_{peripheral}}$$

Normalized moment

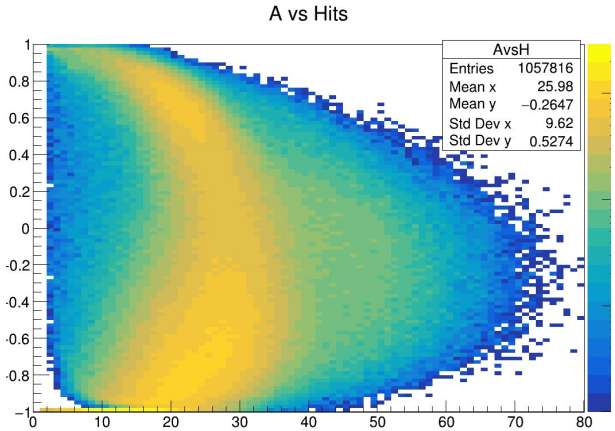


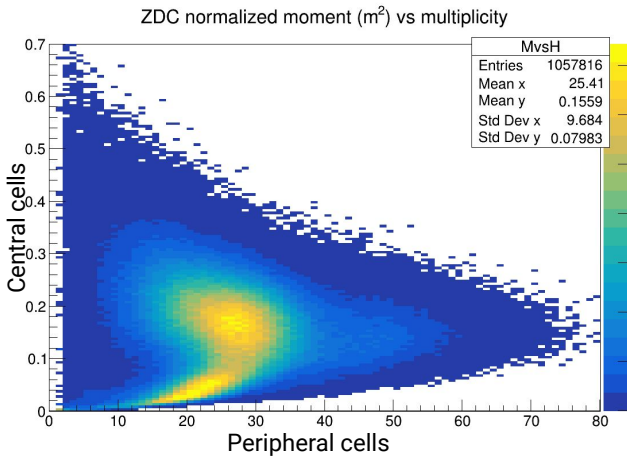
$$M_{norm} = \frac{\Sigma(E_i \times R_i^2)}{\Sigma E_i}$$

ZDC asymmetry and moment in the experimental data and in the simulation results

Experimental data

```
Period:  7
SP-41:   1250 A
Beam:    Ar, 3.2 AGeV
Target:  Al, 3.3 mm
Trigger: Beam + BD≥2 & FD≥3
Run:     3977, 3979, 3980,
         4046, 4048
```



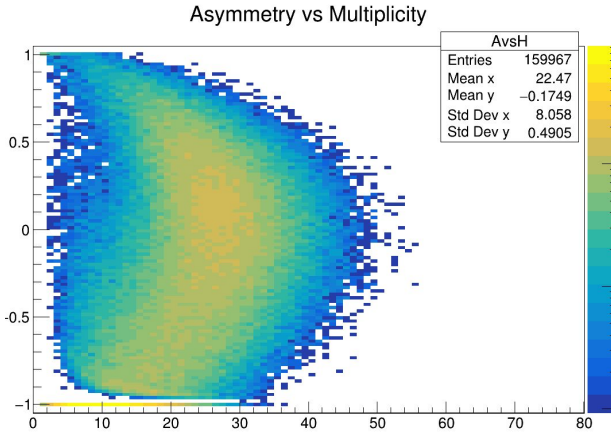


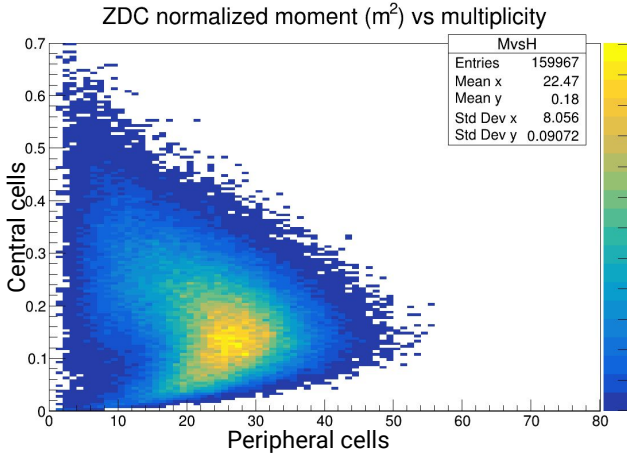
Simulation data

Generator:
LAQGSM ArAl_3.2AGeV_mb

ZDC position:
x=50 cm, y=-6.3 cm,
z=1000 cm

100k events

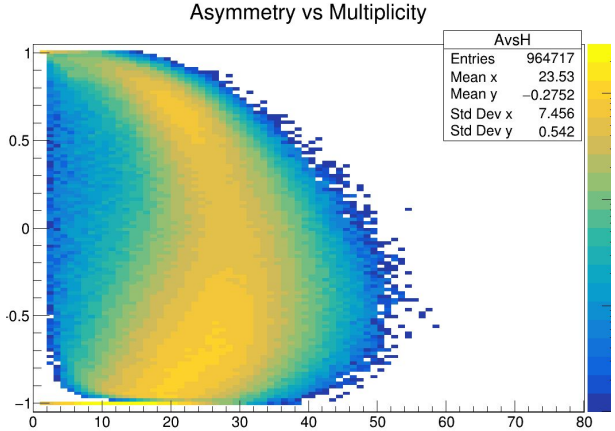


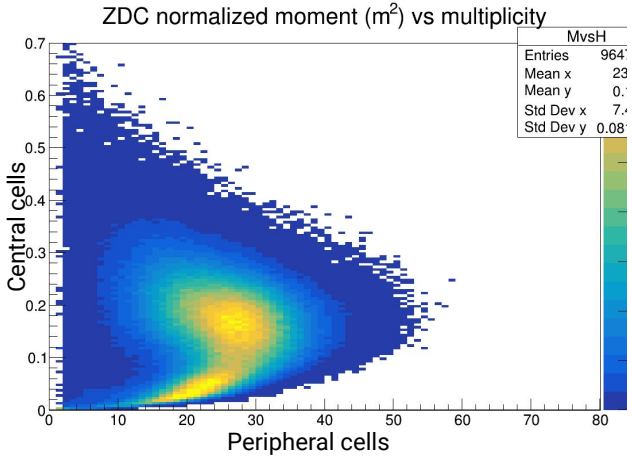


ZDC asymmetry and moment in the experimental data and in the simulation results (pileup removed, 100GeV cut)

Experimental data - pileup

```
Period:  7
SP-41:   1250 A
Beam:    Ar, 3.2 AGeV
Target:  Al, 3.3 mm
Trigger: Beam + BD≥2 & FD≥3
Run:     3977, 3979, 3980,
         4046, 4048
```



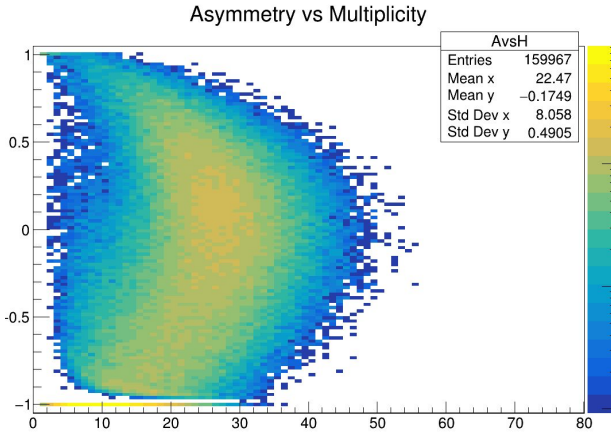


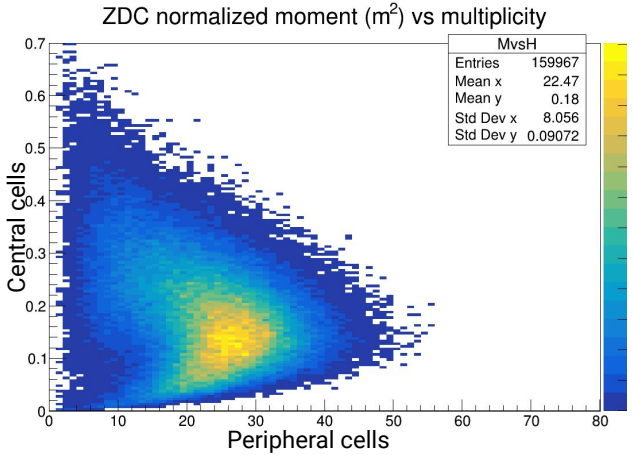
Simulation data

Generator:
LAQGSM ArAl_3.2AGeV_mb

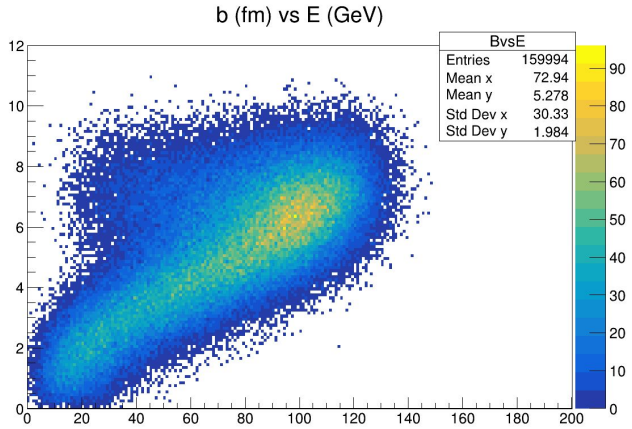
ZDC position:
x=50 cm, y=-6.3 cm,
z=1000 cm

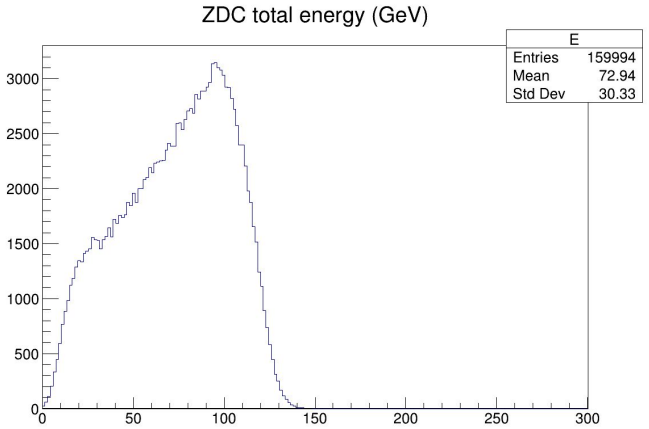
160k events



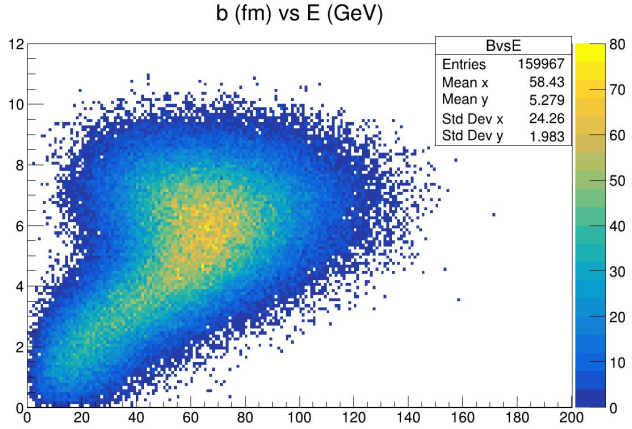


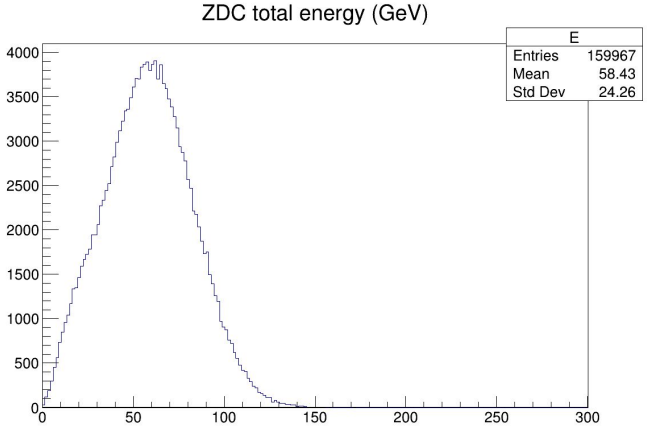
Digitalization time of MC points in the cell





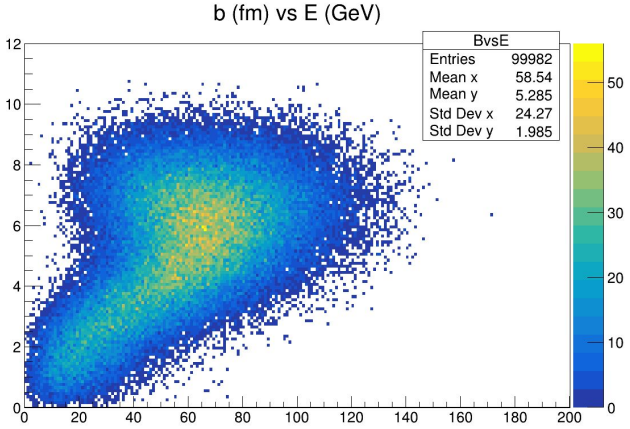
10 mks
Nearly all the energy is collected

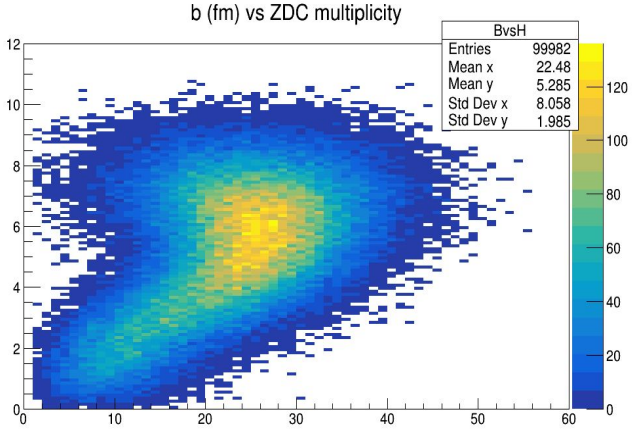


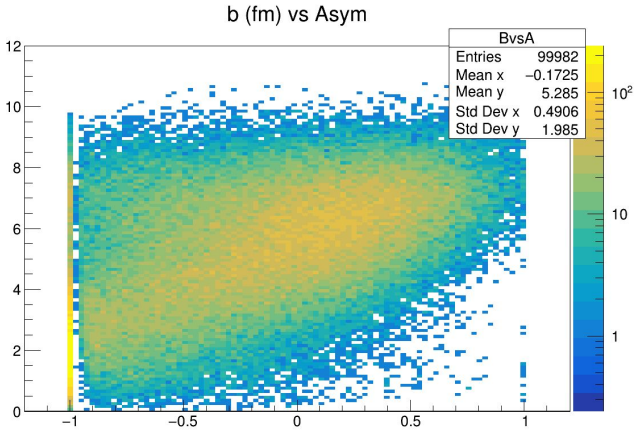


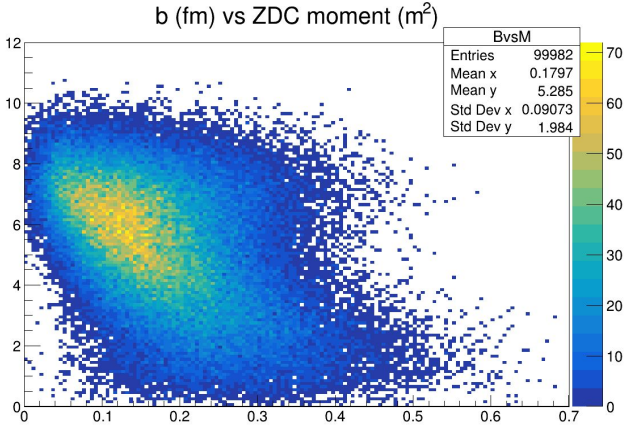
500 ns
Part of the energy is missed, especially in the high range

Impact parameter

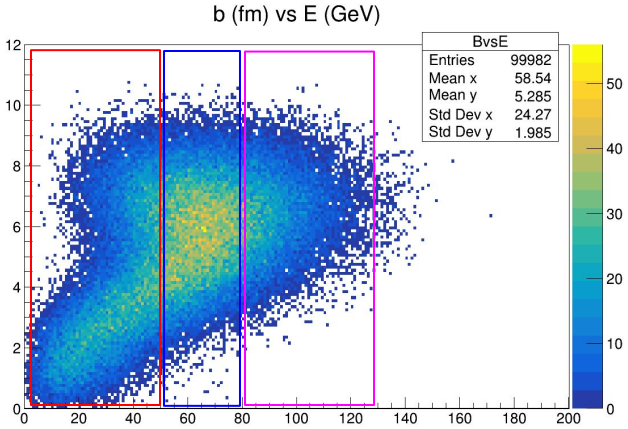


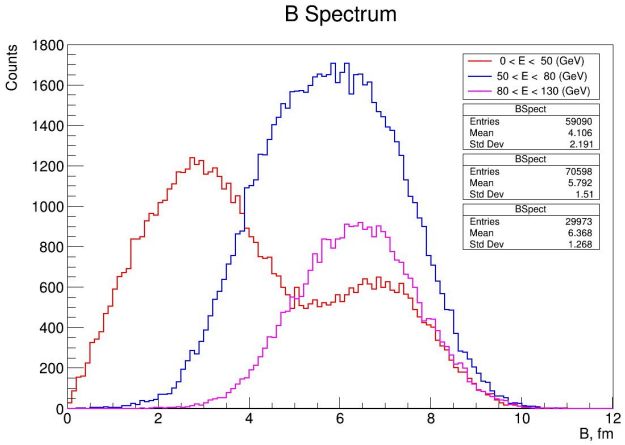


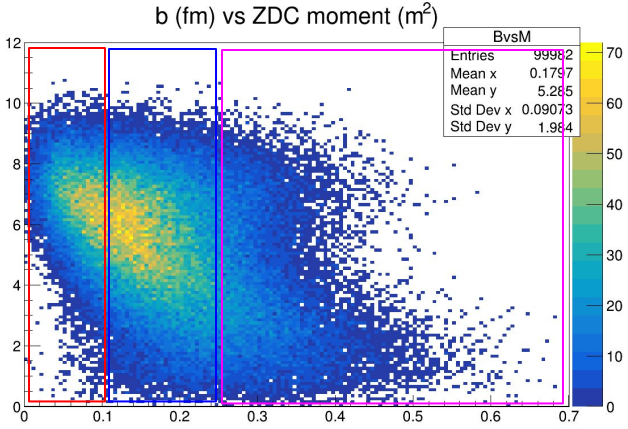


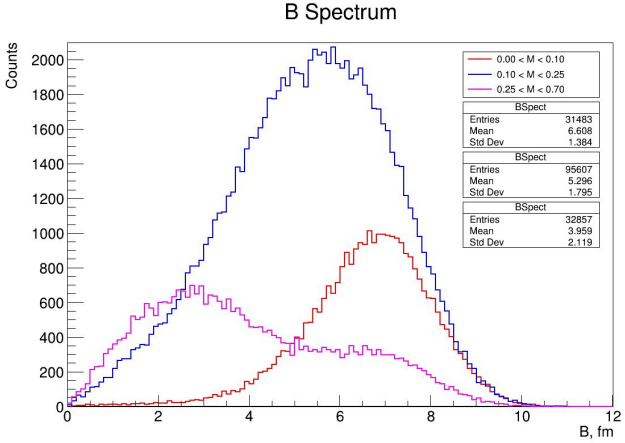


b-spectra (varying the parameters)



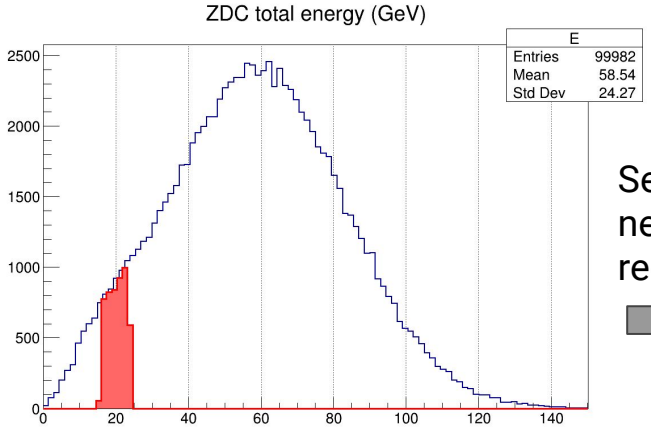




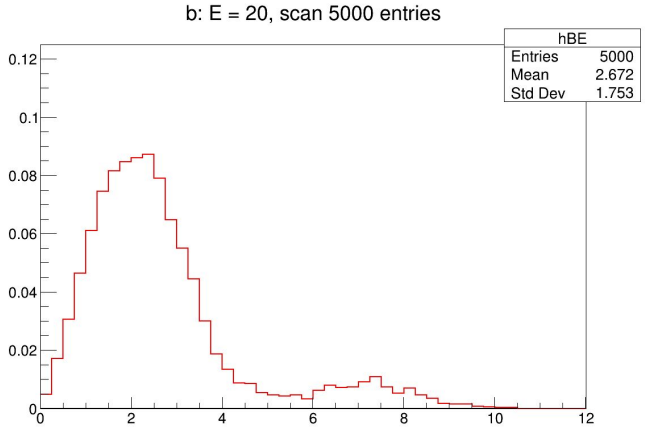


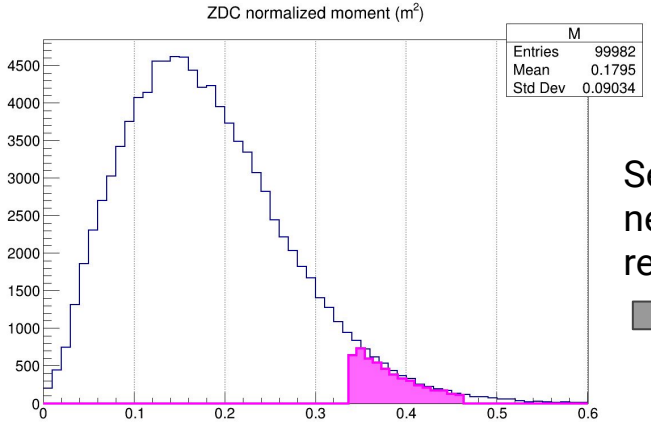
The spectra for varying any of the parameters are overlaps.

b-spectra for selected param. values

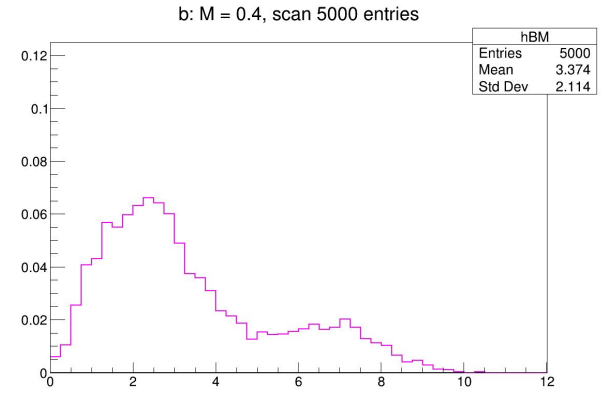


Selection of 5k events nearest to the energy requested (20 GeV for ex.)

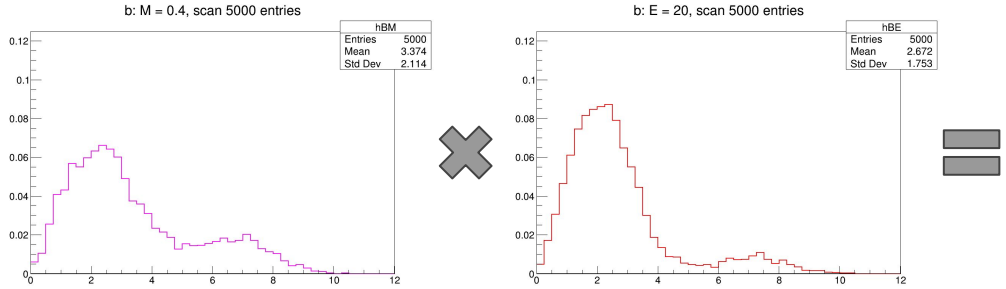


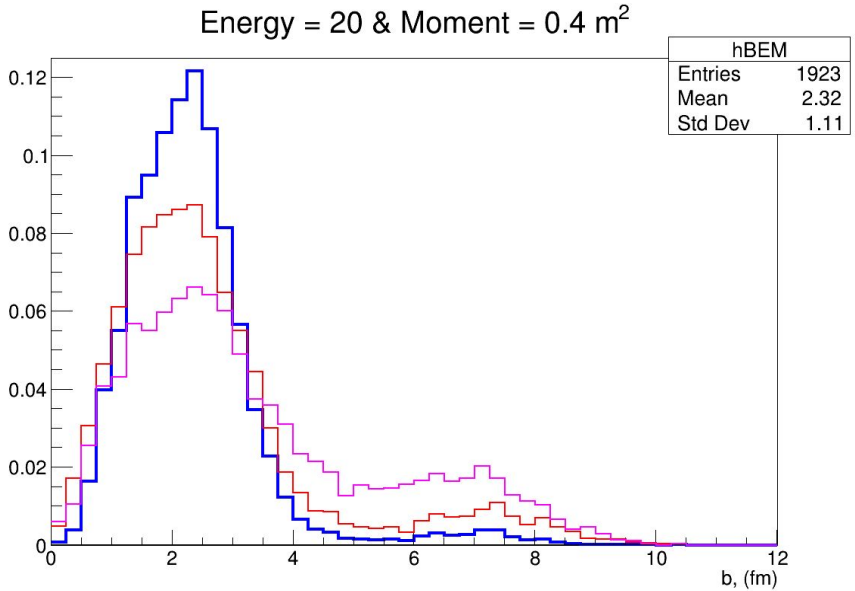


Selection of 5k events nearest to the moment requested (0.4 m^2 for ex.)



b-spectra for selected param. values





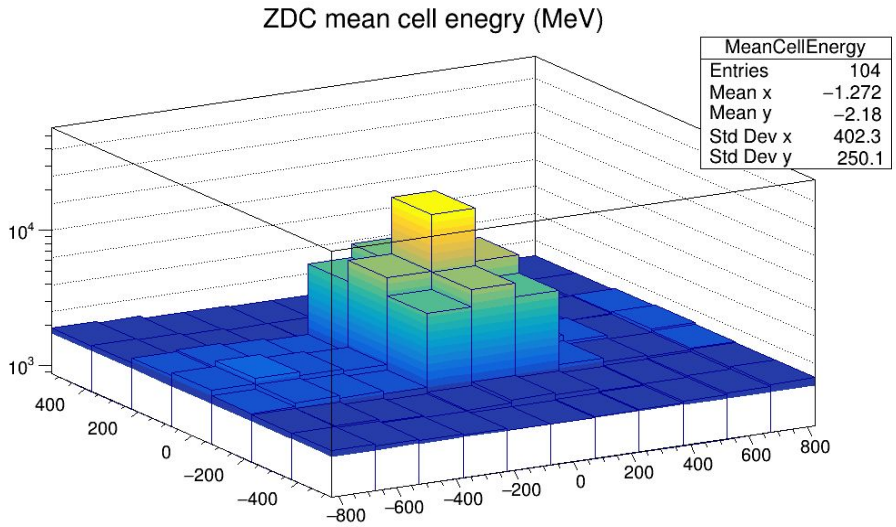
TODO

- Apply multiplicity data from other BM@N detectors
- Realize the time issue in the experimental data and in the MC
- Include other types of ions and target materials

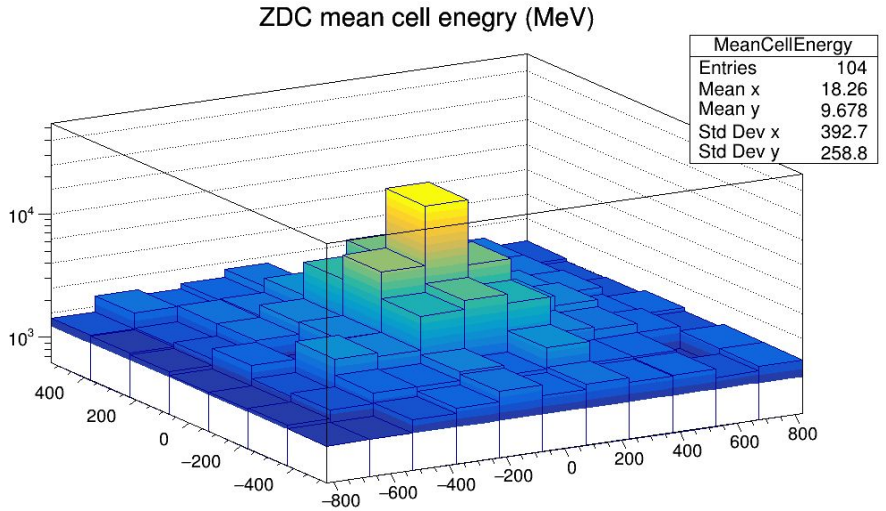
Thanks for your attention

Mean ZDC cell energy

MC

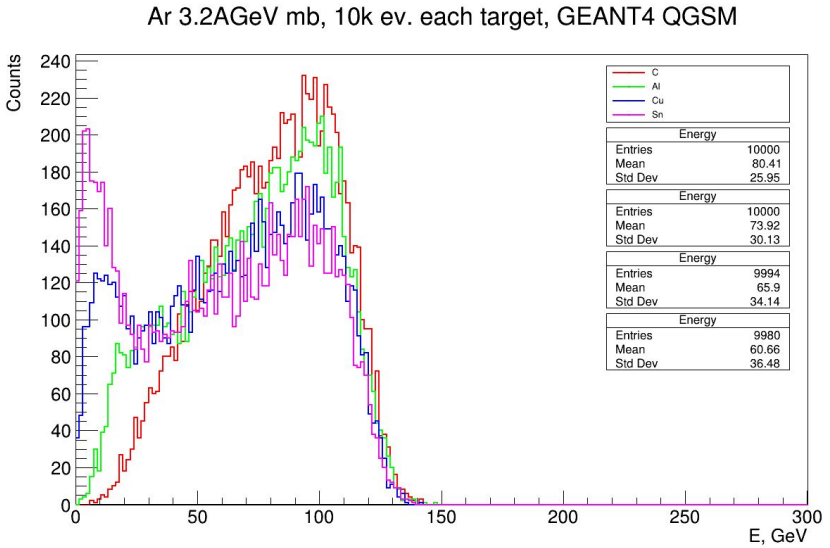


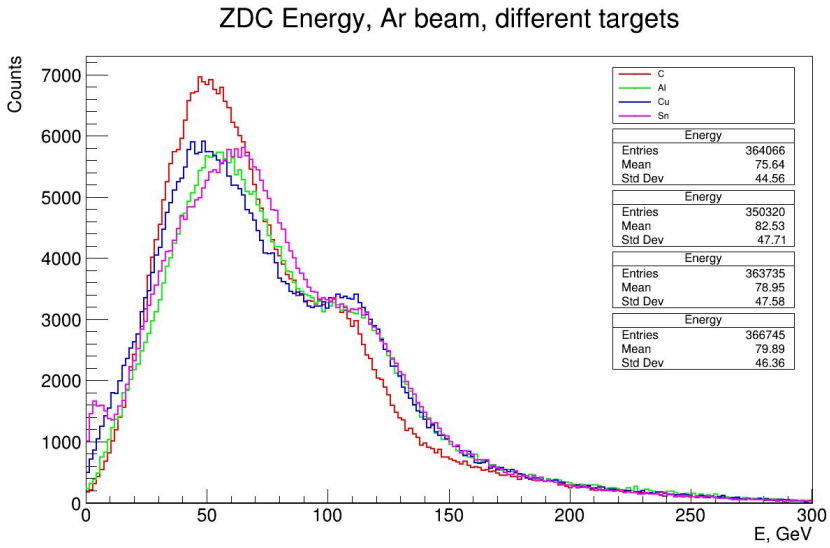
Data



Threshold 0.44GeV. No pileup in MC. No filters

Total ZDC energy, Ar 3.2AGeV, diff. targets





ZDC energy vs. B