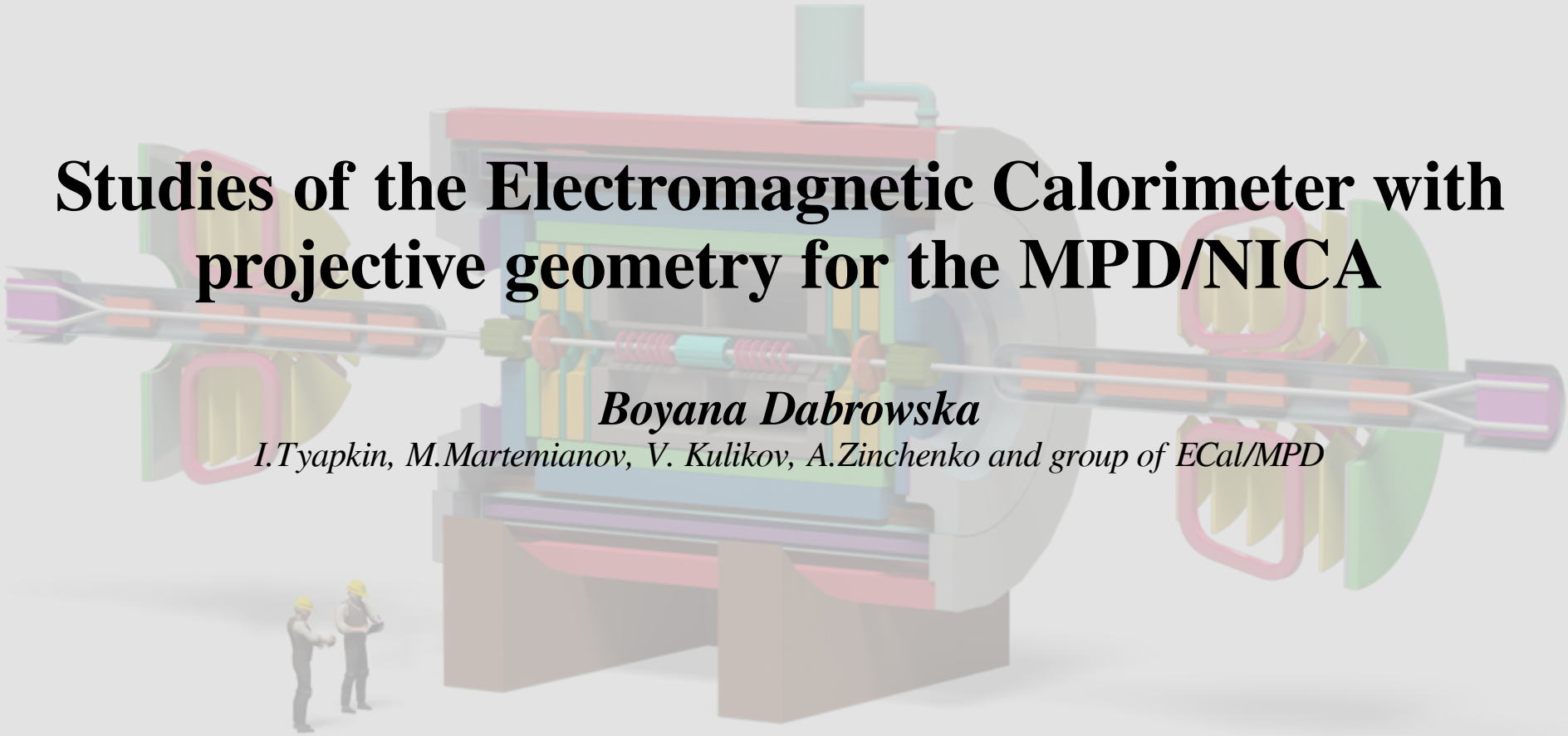
Studies of the Electromagnetic Calorimeter with projective geometry for the MPD/NICA

Boyana Dabrowska

I.Tyapkin, M.Martemianov, V. Kulikov, A.Zinchenko and group of ECal/MPD



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Electromagnetic calorimeter

The main goals of the ECal:

- ✓ Participation in particles identification;
- ✓ Measurements of the photons flux;
- ✓ Reconstruction of some decays with participation of the photons;

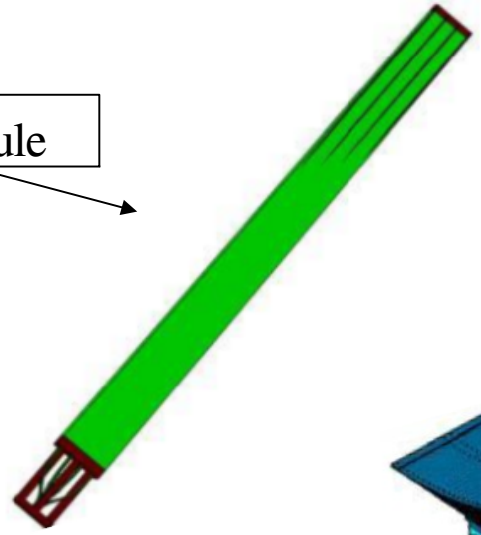
Basic requirements:

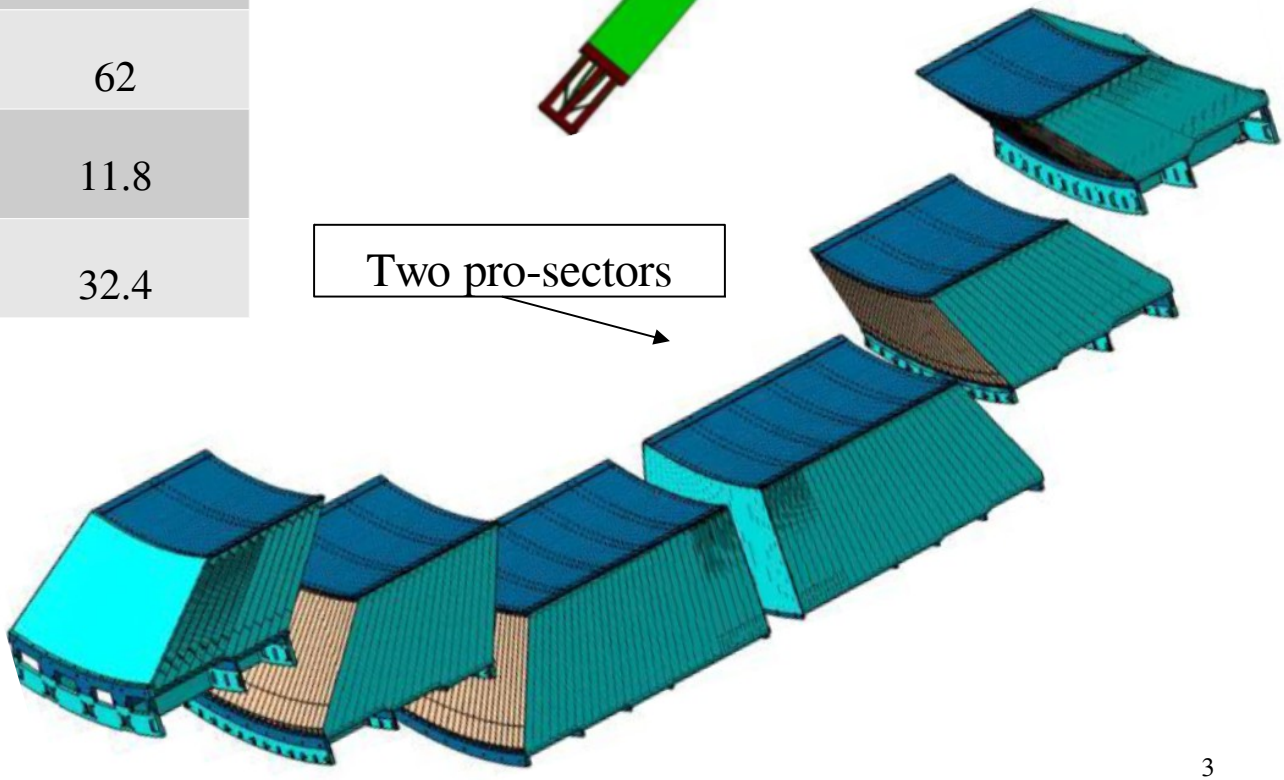
- ✓ high segmentation;
- ✓ large enough distance to the vertex;
- ✓ dense active medium with the small Moli'ere radius;
- ✓ adequate space resolution;
- ✓ small shower overlaps;
- ✓ the particle occupancy should not exceed 5%;
- ✓ calorimeter must be able to operate in the magnetic field up to 0.5T;
- ✓ time resolution should be at least below 1ns;

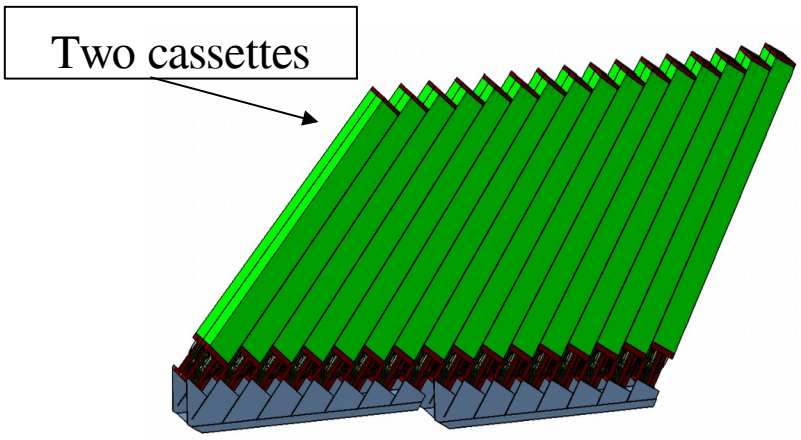
Projective geometry of ECal type “Shashlik”

Parameters of main module	
Transvere size, mm^2	40x40
WLS fibers	16
Number of layers	220
Lead absorber thickness, mm	0.3
Polystyrene scintillator thickness, mm	1.5
Moll'ere radius, mm	62
Radiation length, X_0	11.8
Effective radiation length, mm	32.4

Every module will be cutted out from the both side - in Phi and Theta plane.





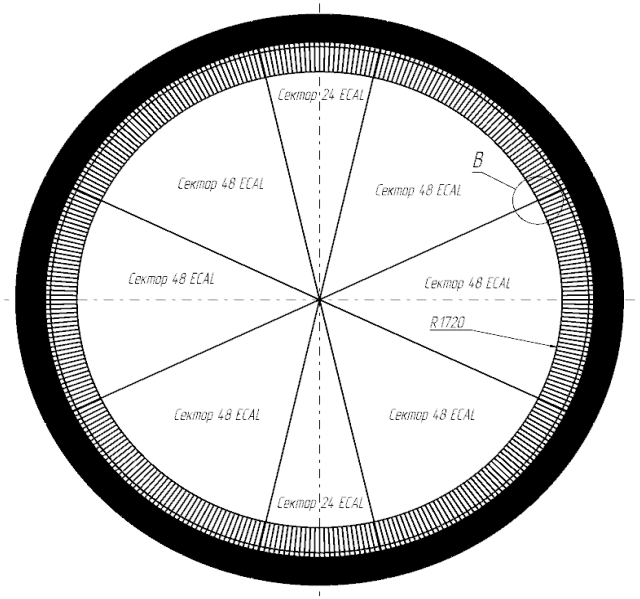


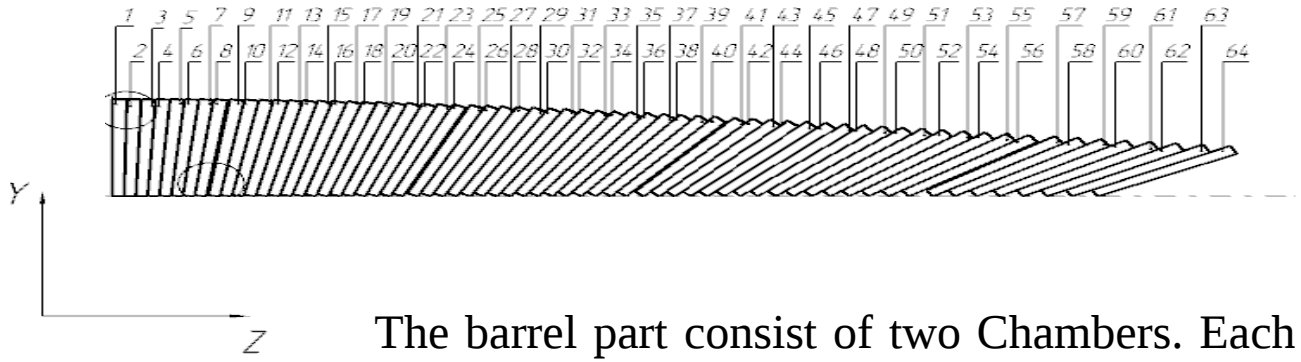
Monte Carlo simulations

Geometry in MpdRoot

EMC module

- ✓ Total number of modules : 43008
- ✓ Each module has 221 Pb (h = 0.3 mm) plates and 221 FscScint (h = 1.5 mm)
- ✓ Module is fixed by two plates on top and bottom (Kapton, h = 8 mm)
- ✓ EMC geometry is stored in ROOT – file (emc_v2.root)





The barrel part consist of two Chambers. Each of them consist eight sectors:
- two of them - 24 modules in Phi plane;
- six of them - 48 modules in Phi plane;

Every row in sector composed with 64 modules in Theta plane.

Two types of digitizers and cluster methods in MpdRoot:

I type *- Classes made by Maxim Martemianov (from group of ITEP);*
II type *- Classes made by Alexander Zinchenko (JINR);*

Digitizer

I type: Use special function which relates point to the corresponding module by minimal angle between module axis and direction to the point and merges all points in active element to hit.

II type: Use GeoManager class.

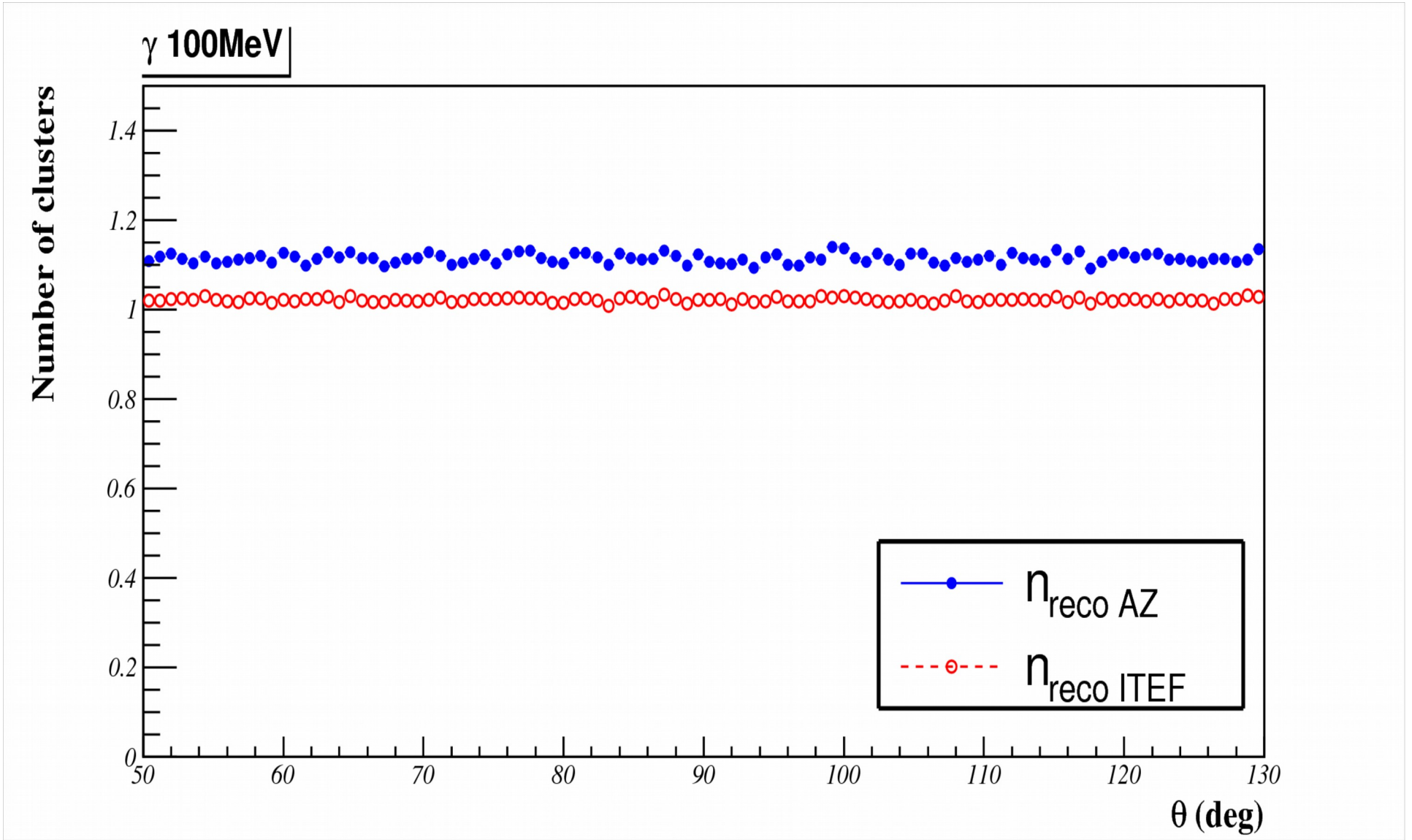
Cluster method

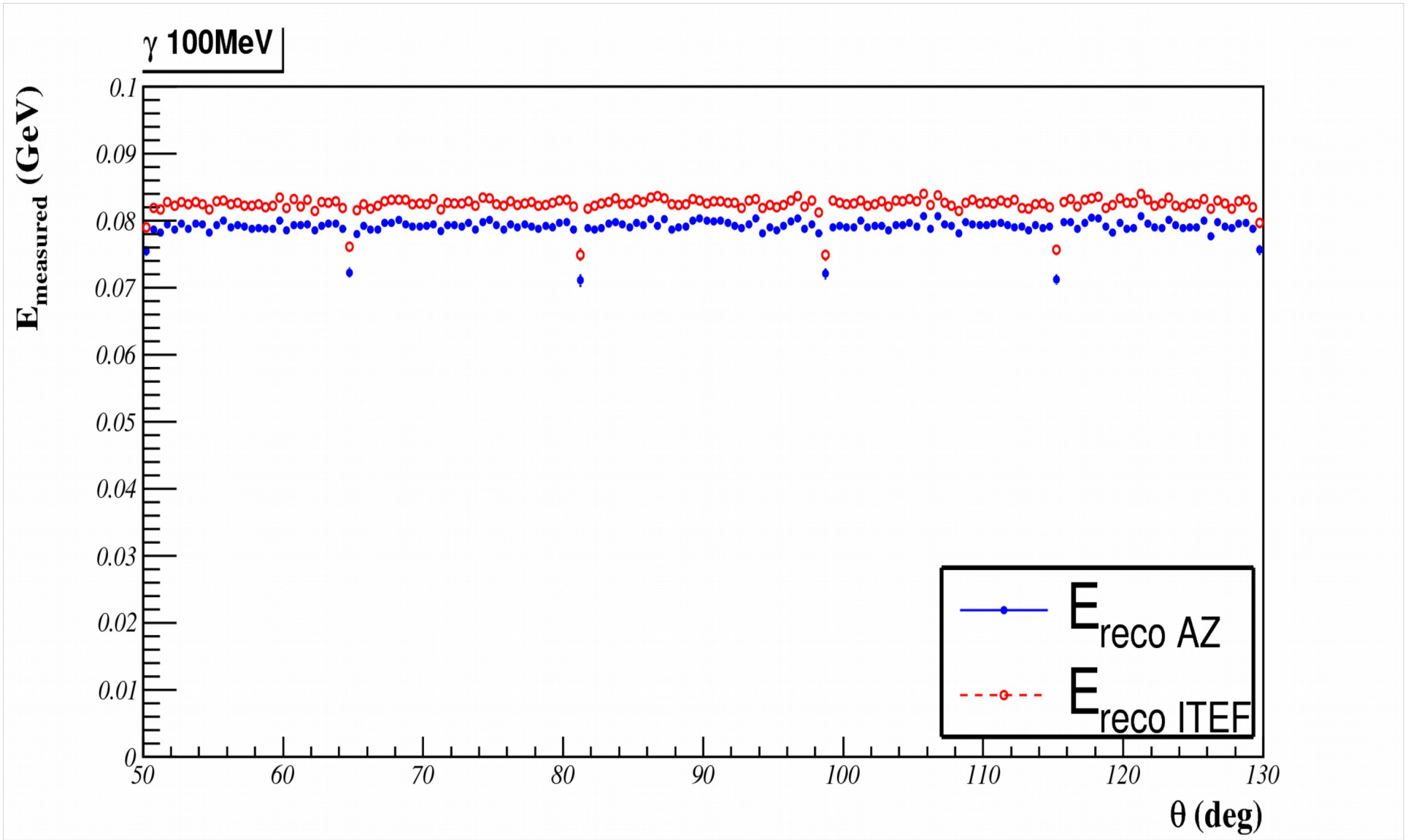
I type: Algorithm is merging hits into cluster around hit with maximal energy. It's based on a module frame and it used nRow and nLine;

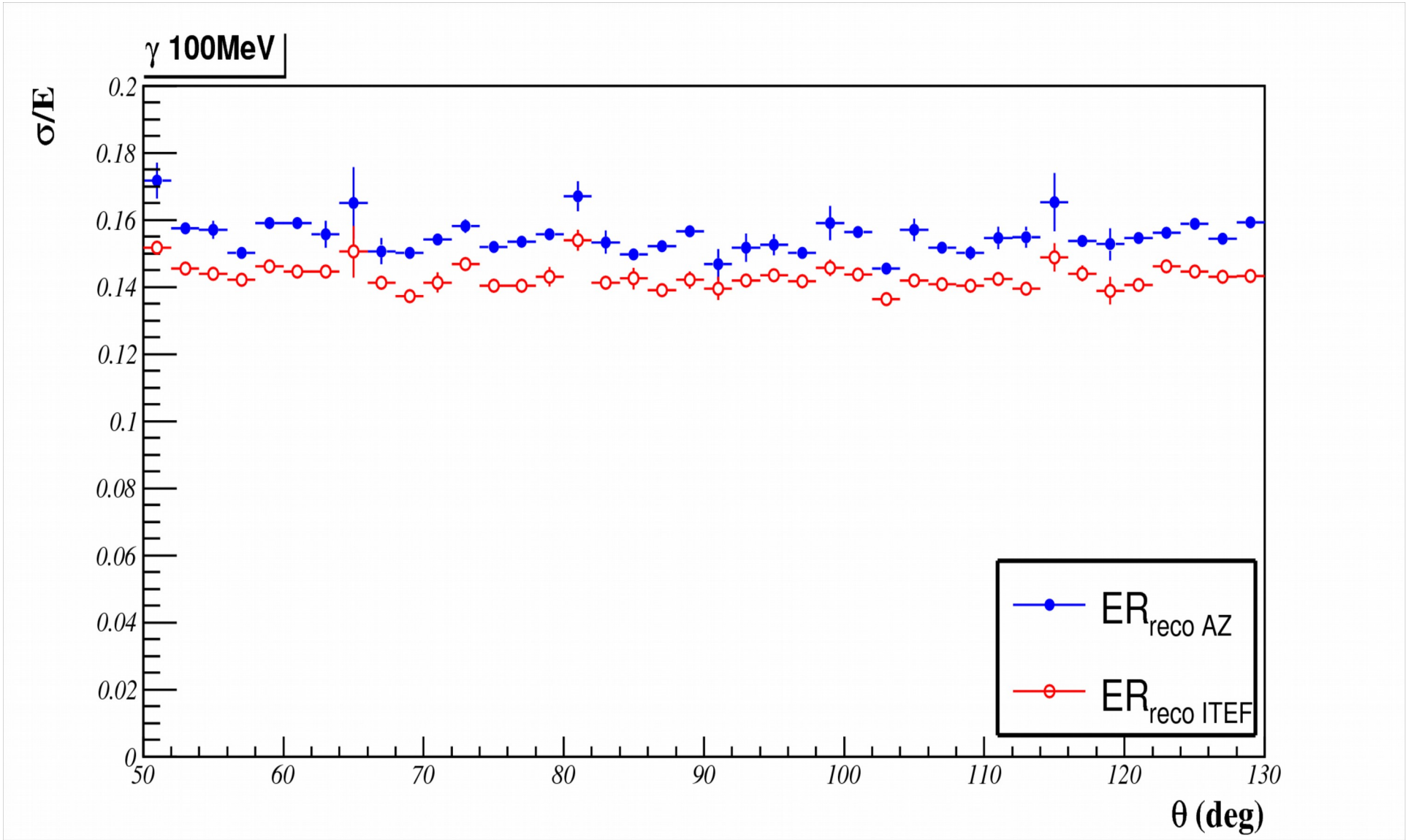
II type: Also algorithm merges hits into cluster around hit with maximal energy, but we have digits alongside each other.

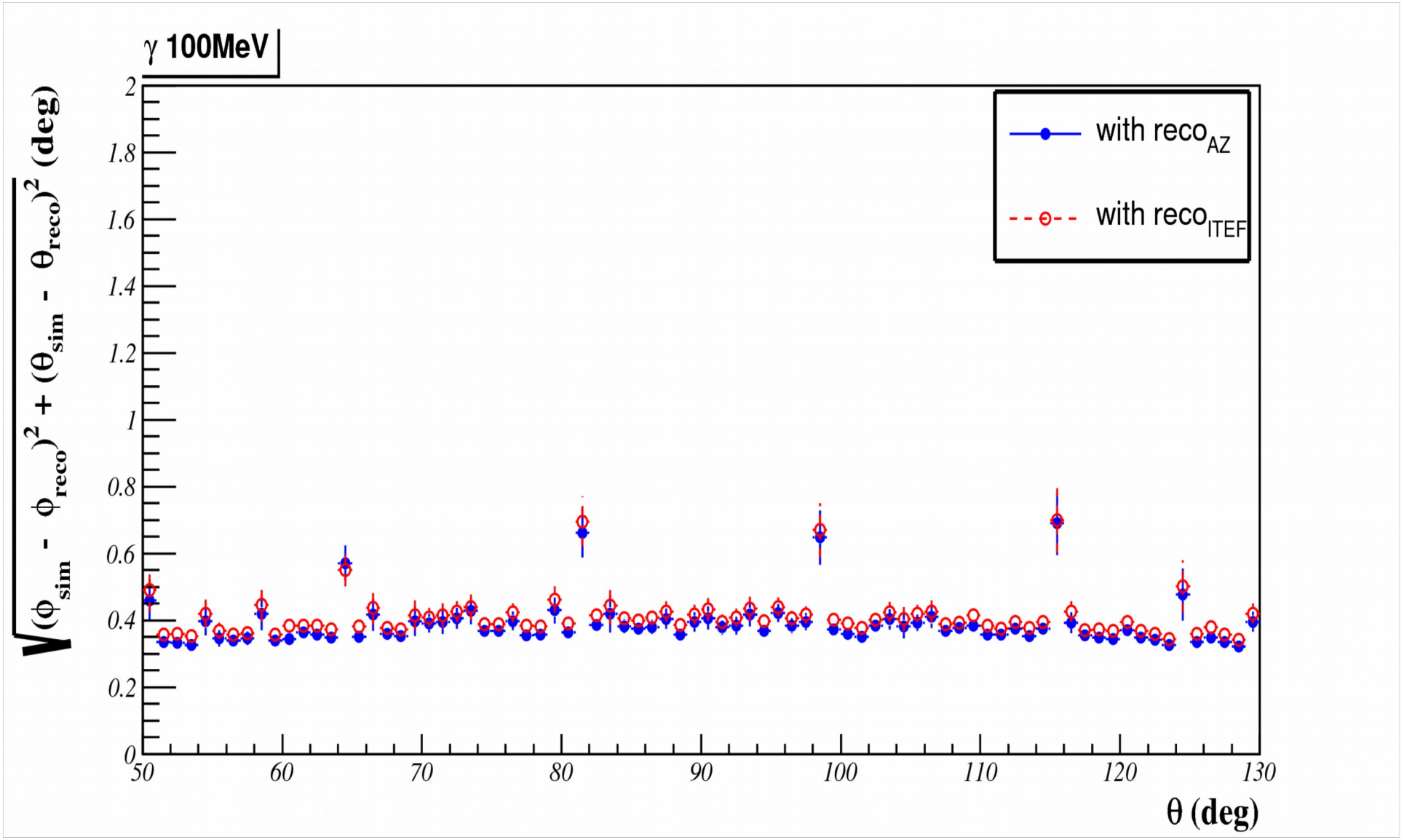
ECal parameters cheked with these two methods:

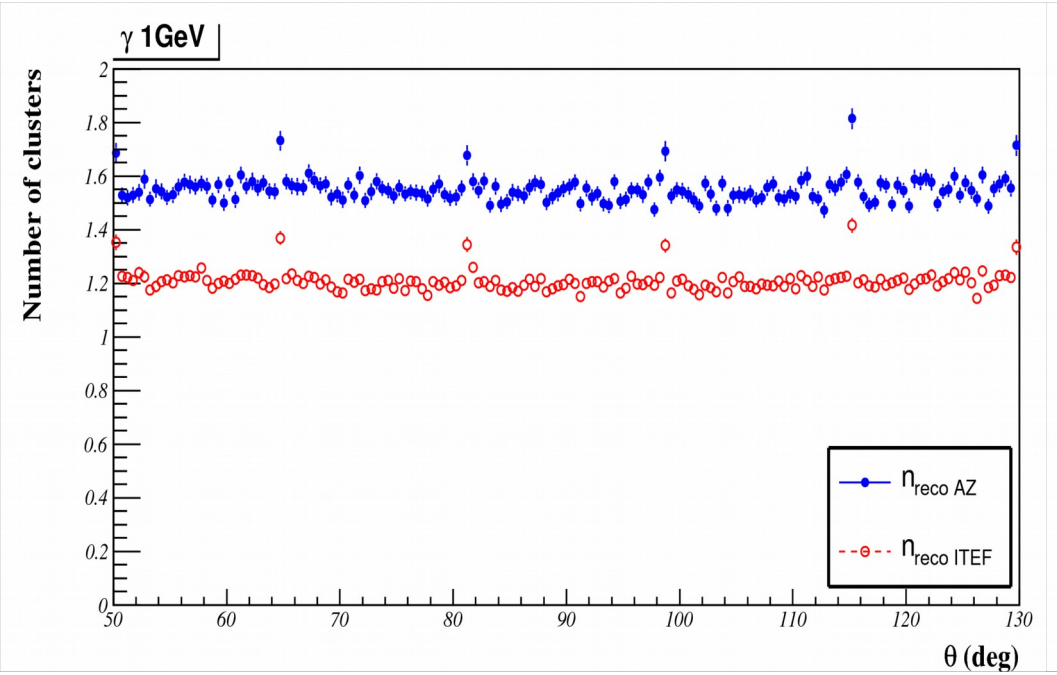
1. BOX Generator, only ECal;
2. Photons with different energy;
3. Events 100 000, with magnetic field 0.5T, Threshould > 10MeV;
4. Hit fall in azimuth angle 89.2 degree and in polar angle range 50 ÷ 130 degrees.

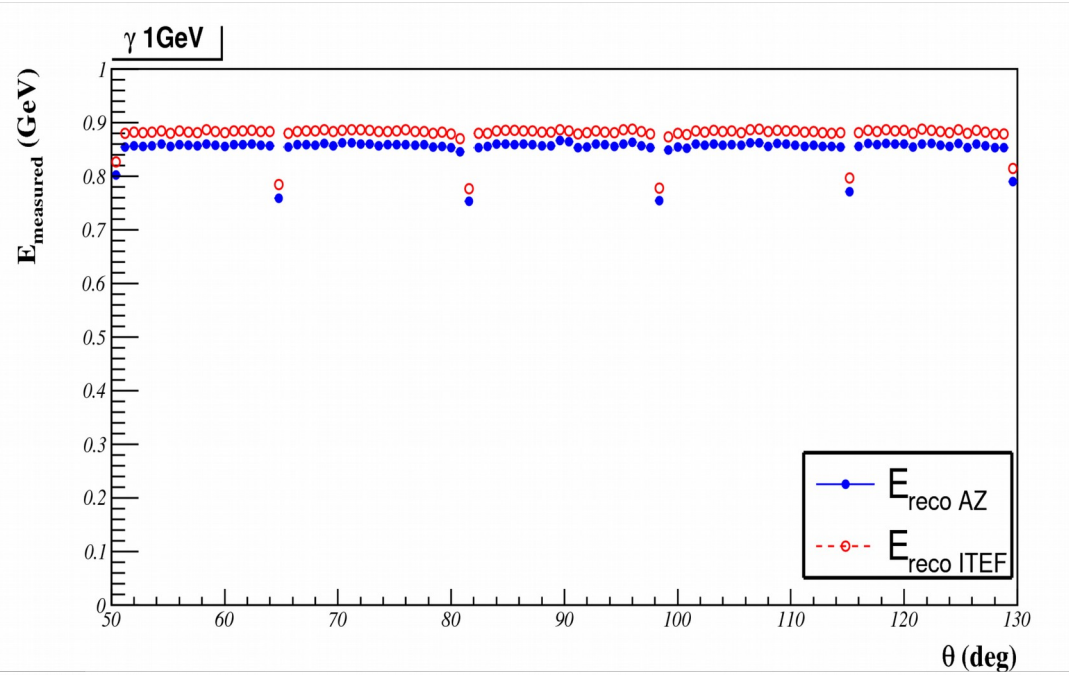

γ 100MeV
Number of clusters
1.4
1.2
1
0.8
0.6
0.4
0.2
0
50
60
70
80
90
100
110
120
130
θ (deg)
n reco AZ
n reco ITEF

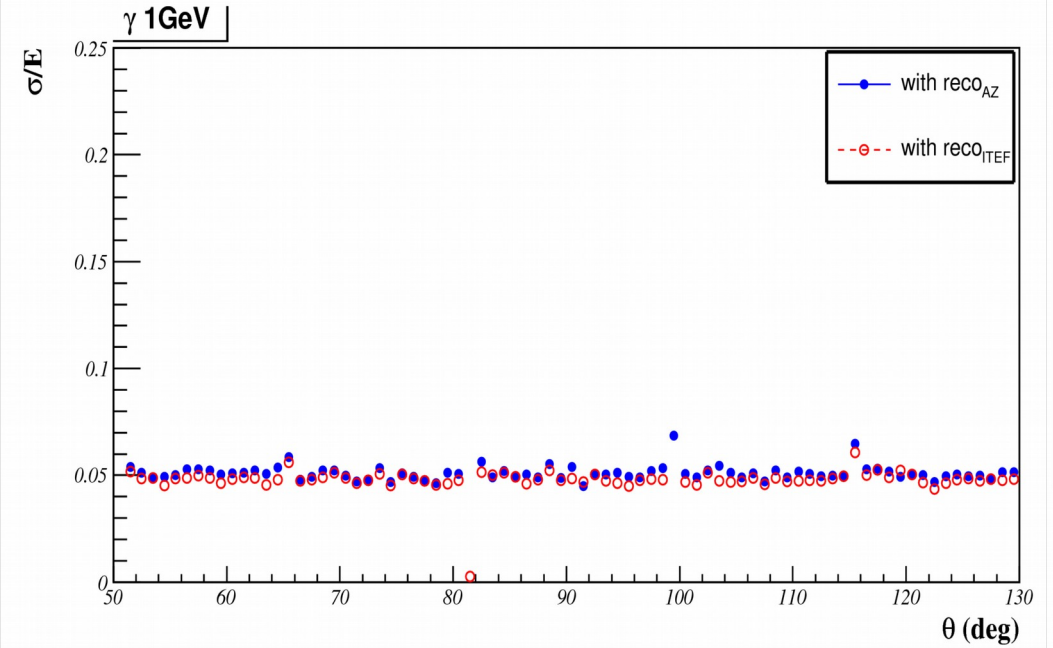

γ 100MeV
E measured (GeV)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
50
60
70
80
90
100
110
120
130
θ (deg)
E reco AZ
E reco ITEF

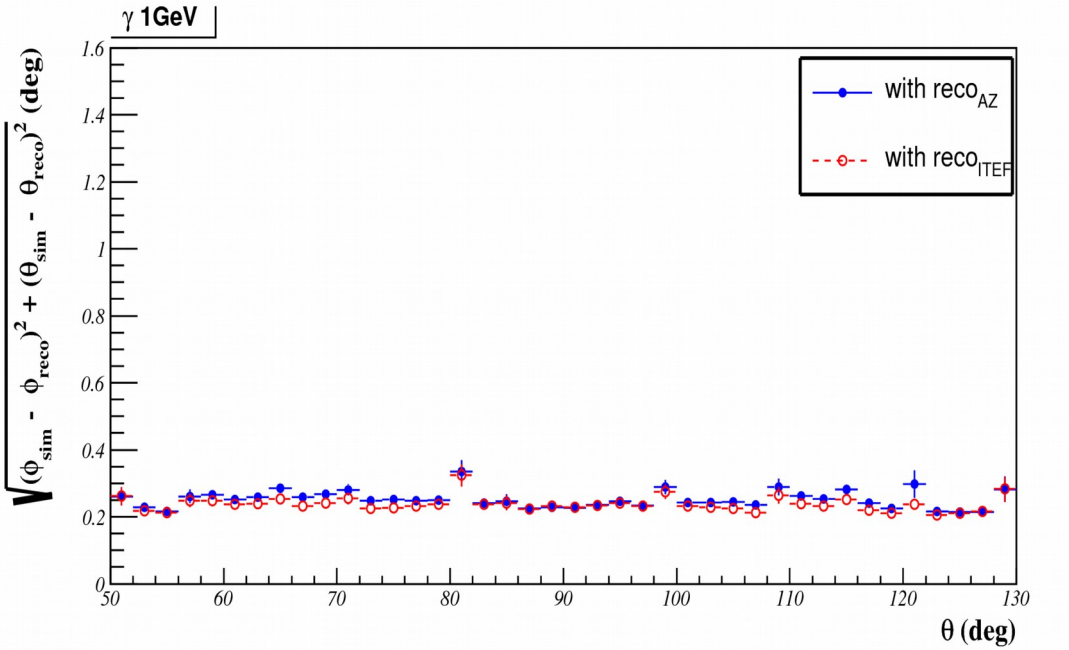

γ 100MeV
σ/E
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
50
60
70
80
90
100
110
120
130
θ (deg)
ER reco AZ
ER reco ITEF


γ 100MeV
with reco_AZ
with reco_ITEF
√(φ_sim - φ_reco)^2 + (θ_sim - θ_reco)^2 (deg)
θ (deg)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
50
60
70
80
90
100
110
120
130


γ 1GeV
Number of clusters
θ (deg)
n reco AZ
n reco ITEF


γ 1GeV
E measured (GeV)
θ (deg)
E reco AZ
E reco ITEF


γ 1GeV
σ/E
θ (deg)
with reco AZ
with reco ITEF


γ 1GeV
θ (deg)
with reco AZ
with reco ITEF

Conclusions and future steps:

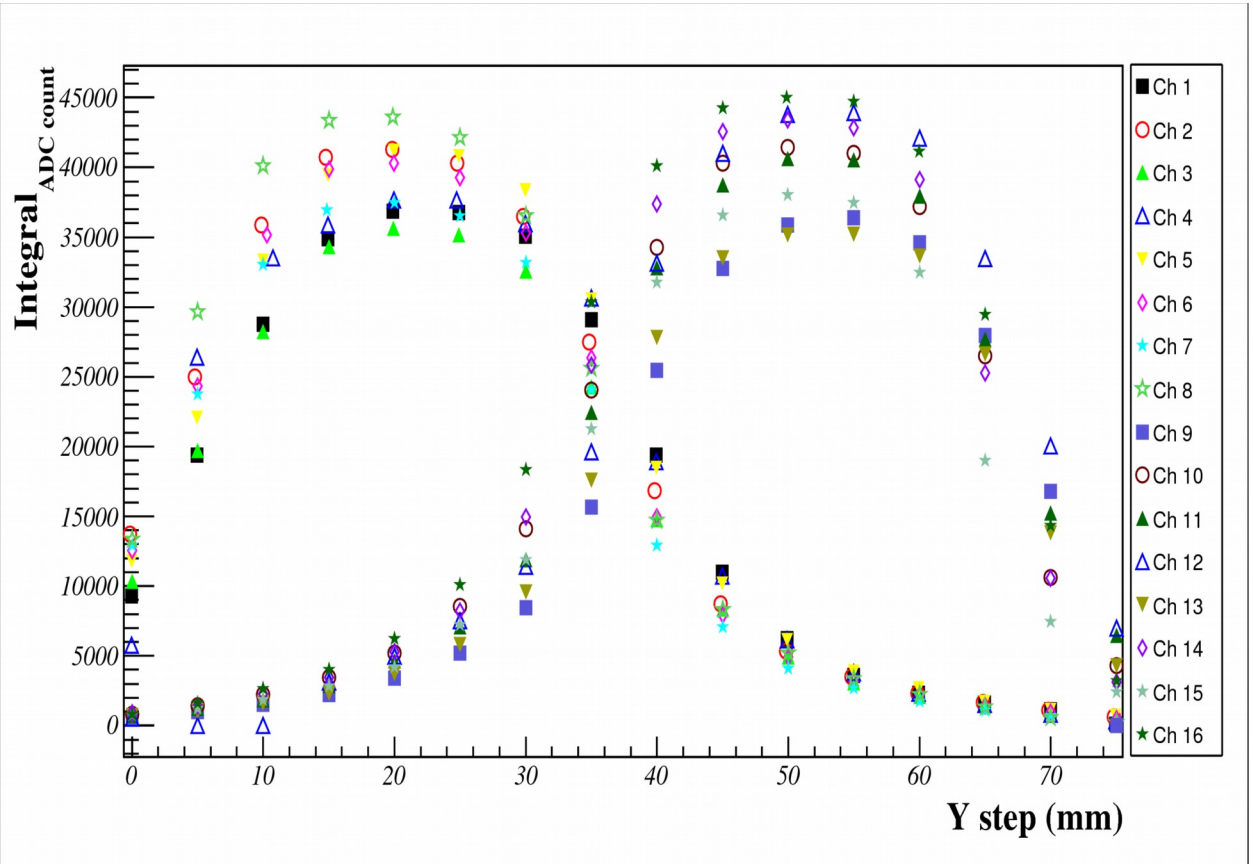
1. Both of types work correctly.
2. For low energy it's better to use type I.
3. For high energy, type II is more precise.
4. Next step is to make and use *Matching class*.
5. II type already have *Matching* class.

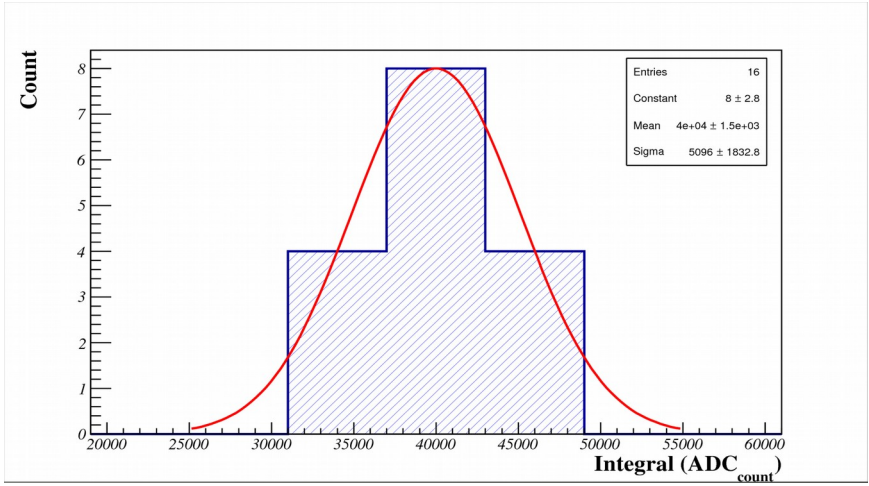
Beam test DESY 2018

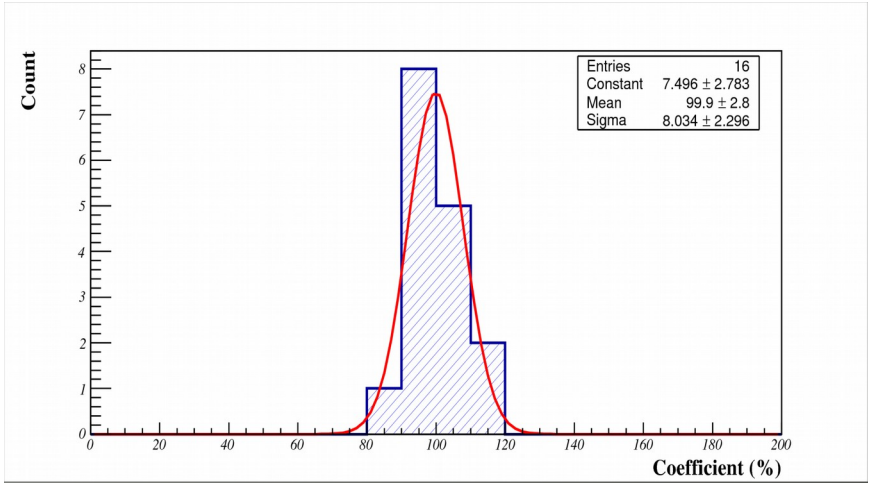
One cassette (2x8 modules, Dubna 8001) was produced, which will be located on the large pseudorapidity region (far in the ZY plane from the interaction point). We tested it on the electron beam with energy range from 1 GeV to 2 GeV.

Calibrations:

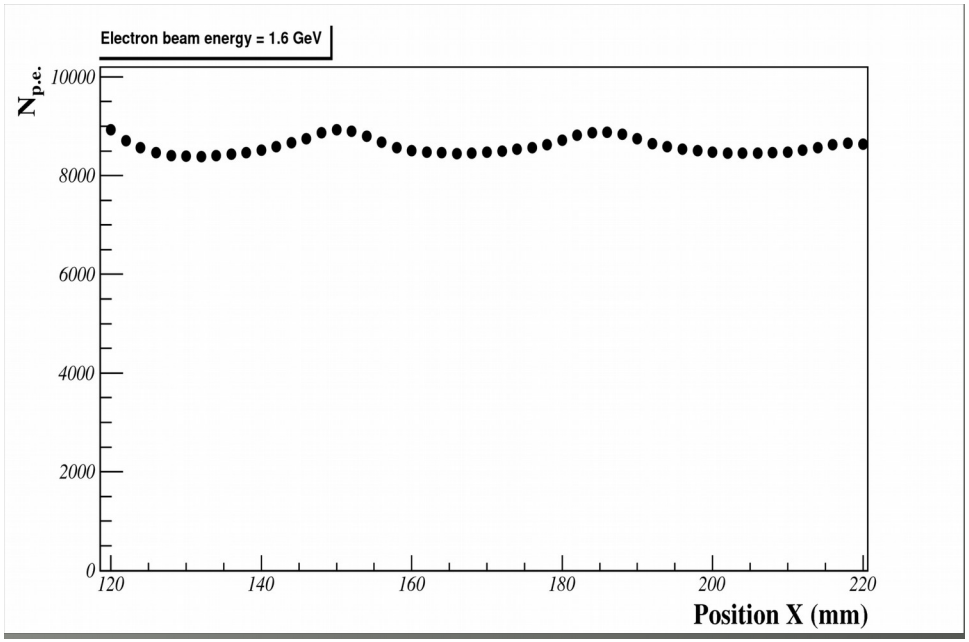
1. By voltage - find work point;
2. By signal value (calibration coefficient) – scan per Y (C5, ADC connector 1);
3. By muons - C5, ADC connector 2;

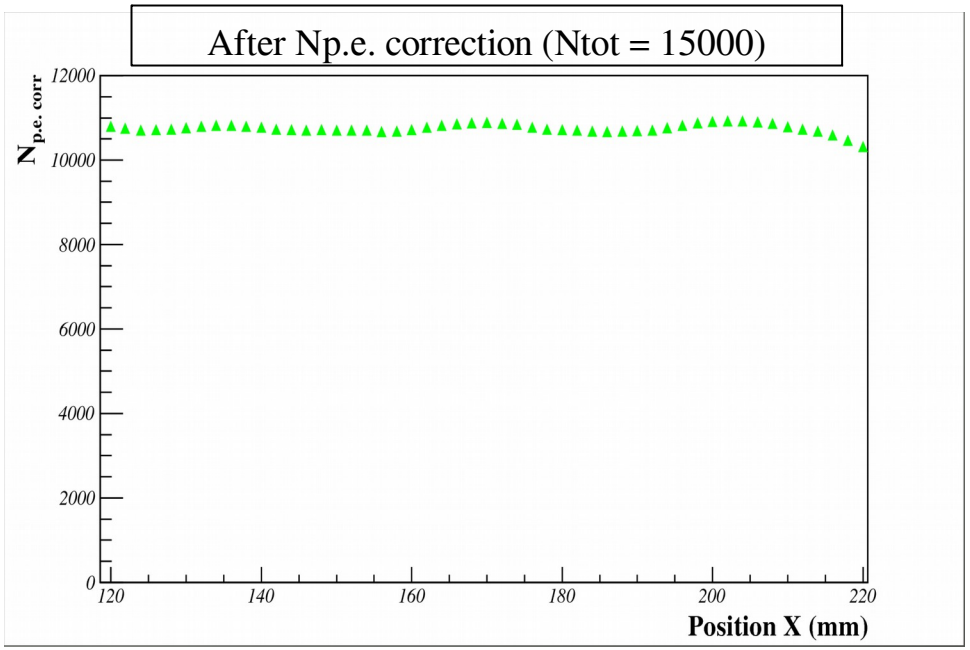


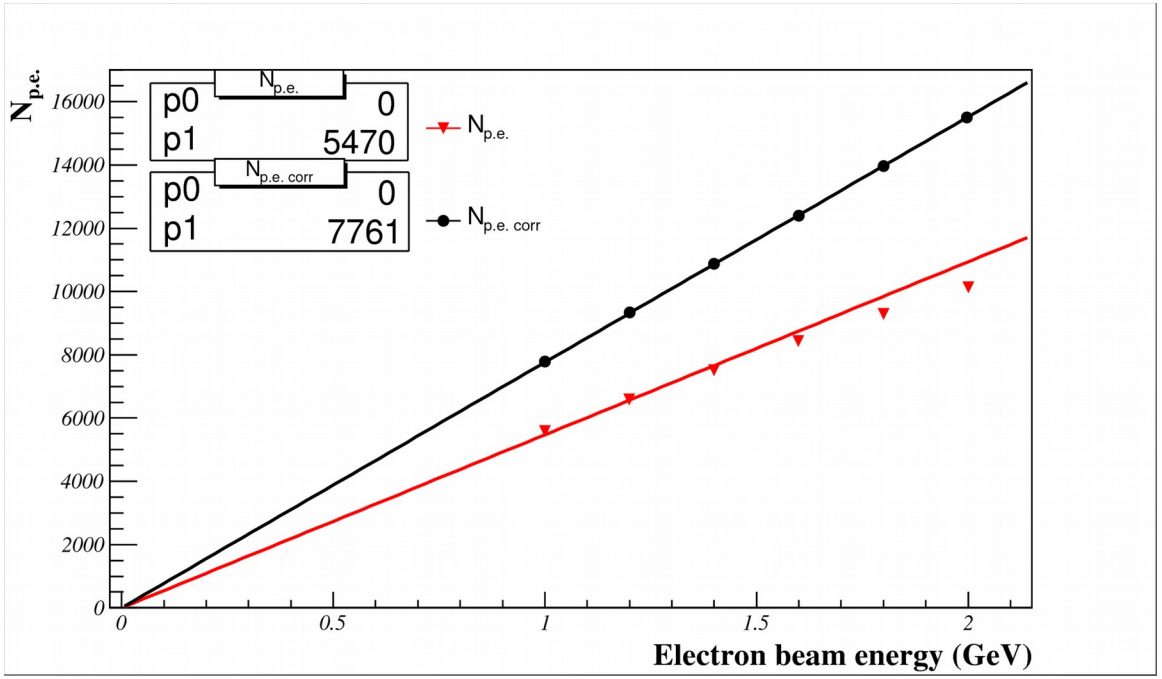




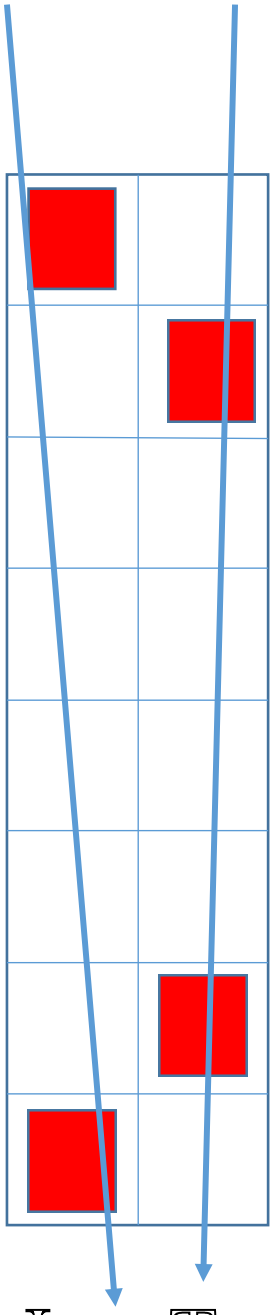
Scan X after correction

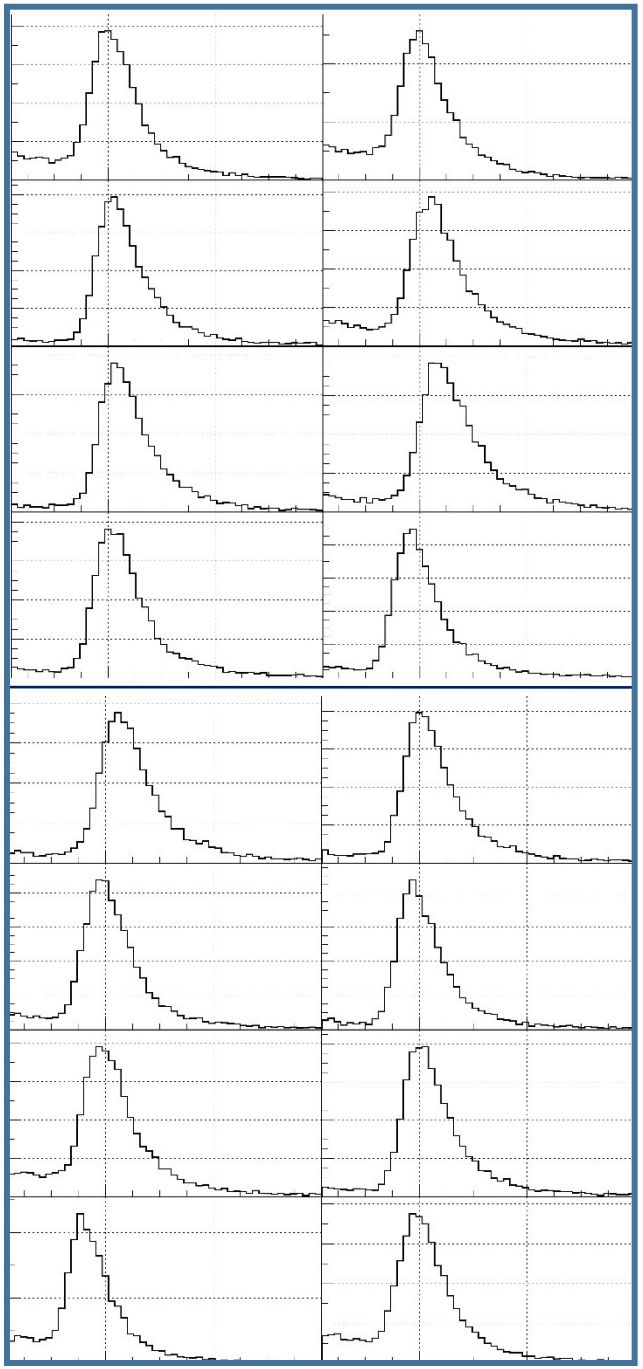


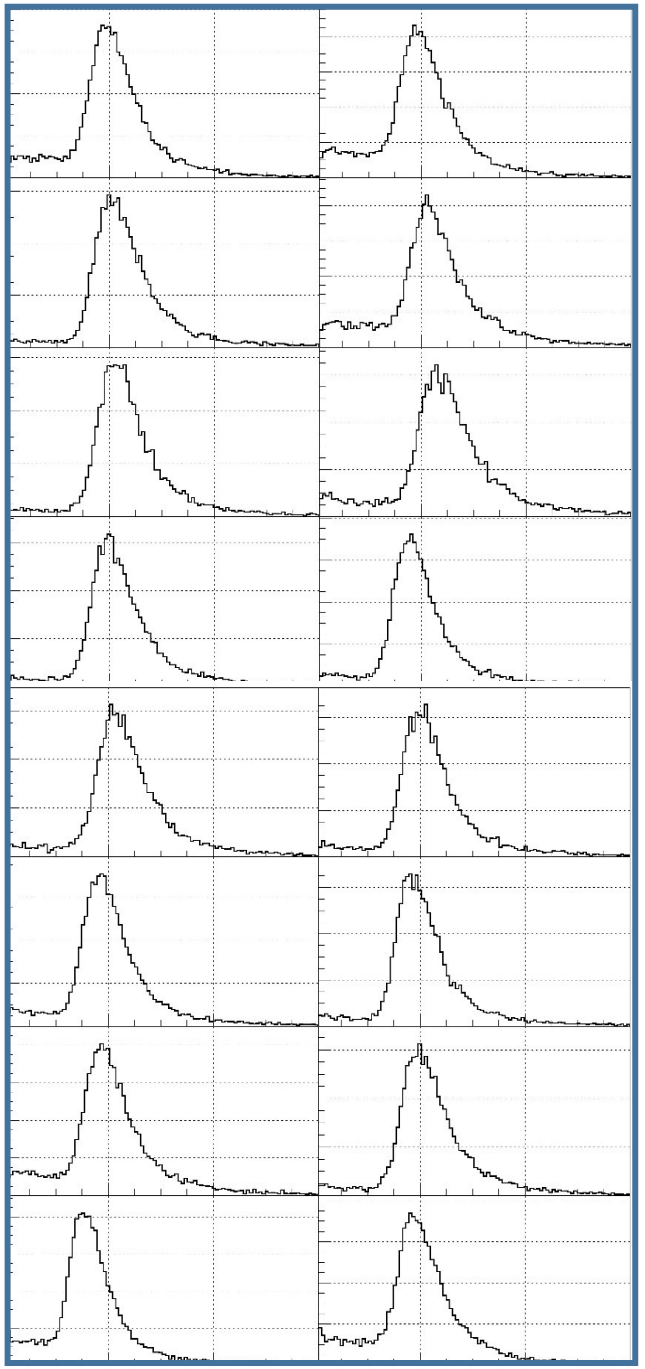




Scan muons







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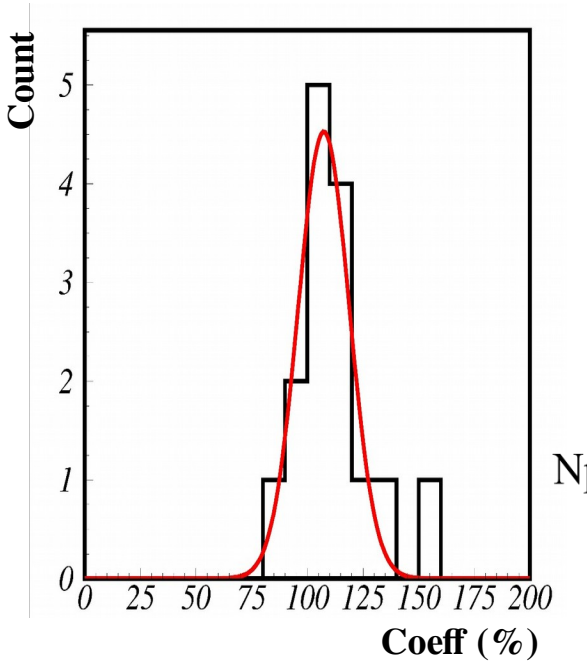
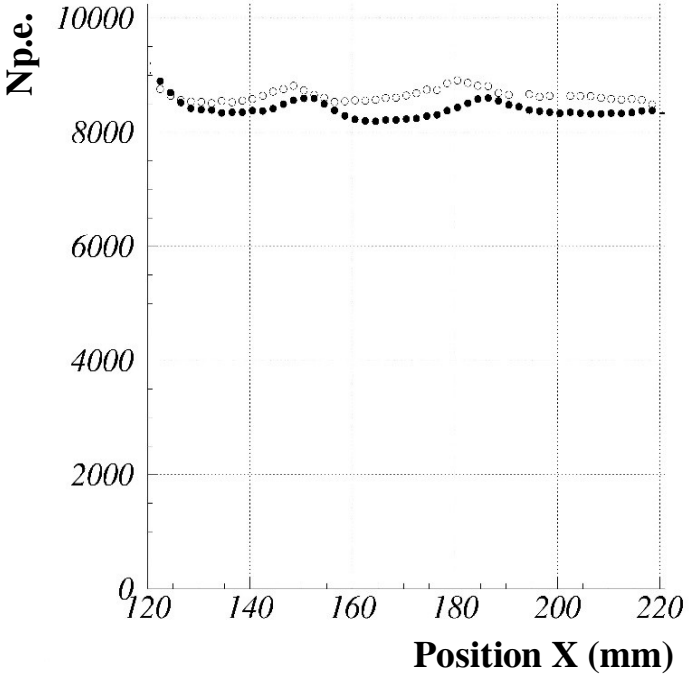
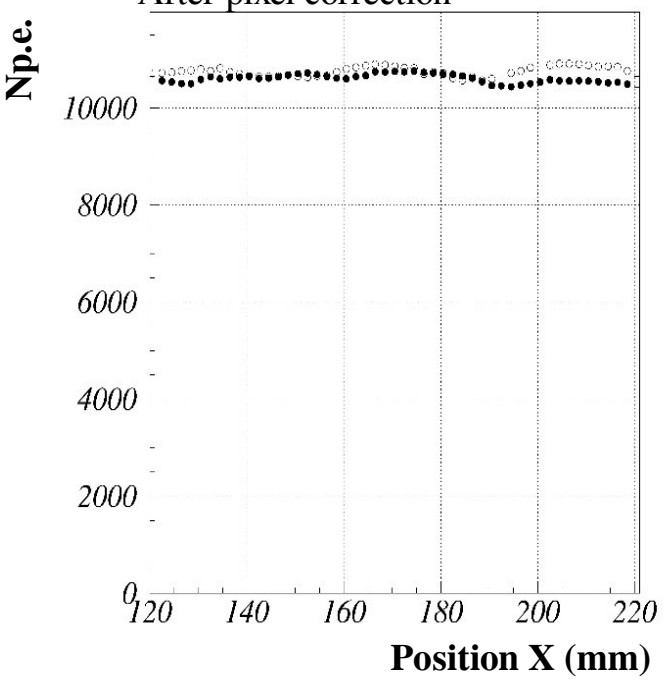
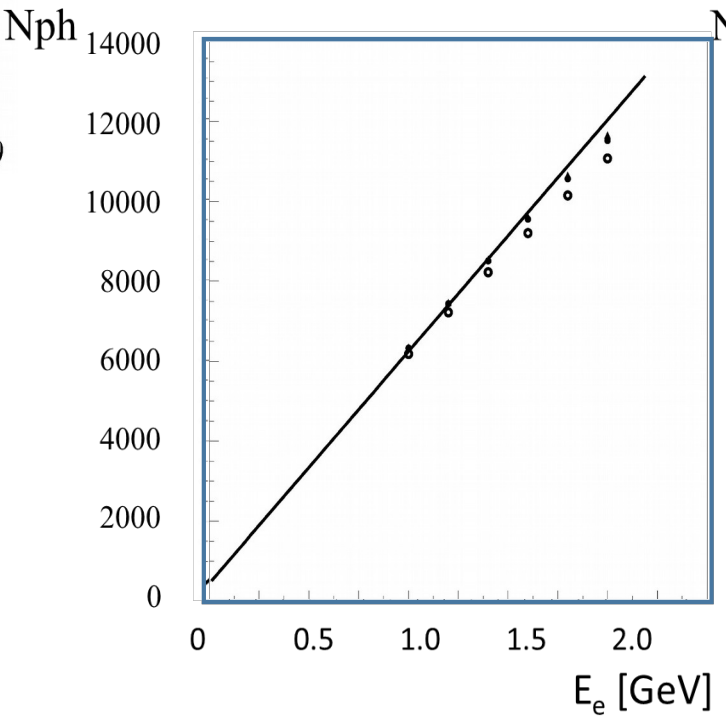


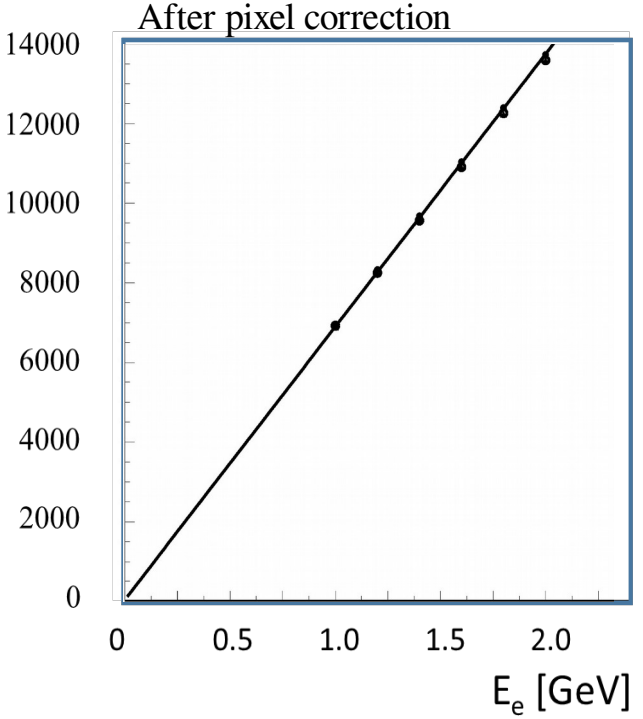


After pixel correction





After pixel correction



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Conclusions

1. One cassette of ECal (produced in Dubna) was tested;

2. Front-end electronic for this type of module was tested also;

3. After correction of the photomultiplier's pixel we saw the linearity of the detector response;

4. New projective module has good characteristic (results in line with expectations);

THANK YOU FOR ATTENTION!