



JOINT INSTITUTE
FOR NUCLEAR RESEARCH

Electromagnetic Calorimeter at NICA/MPD

MPD Collaboration
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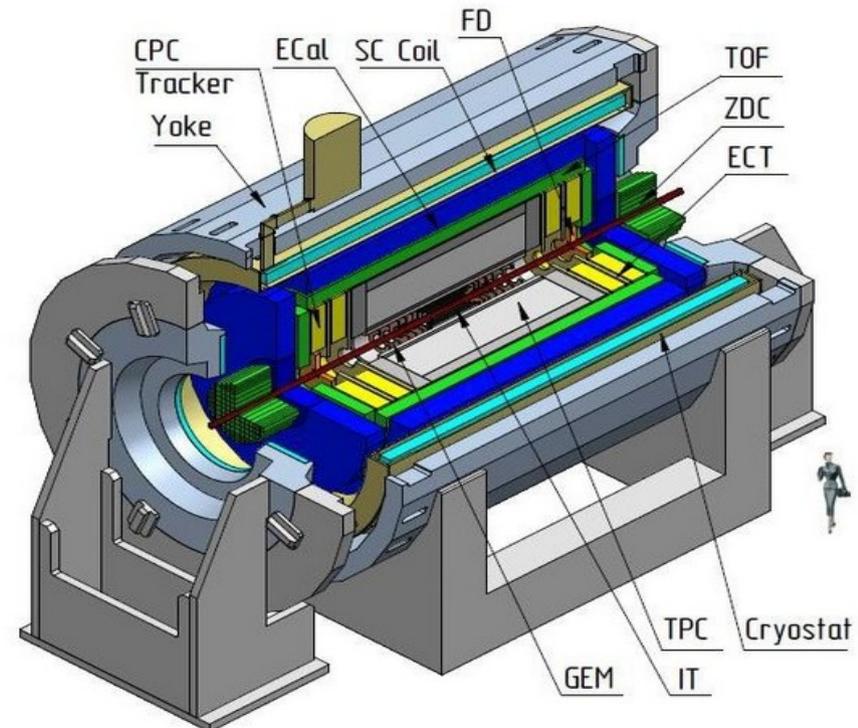
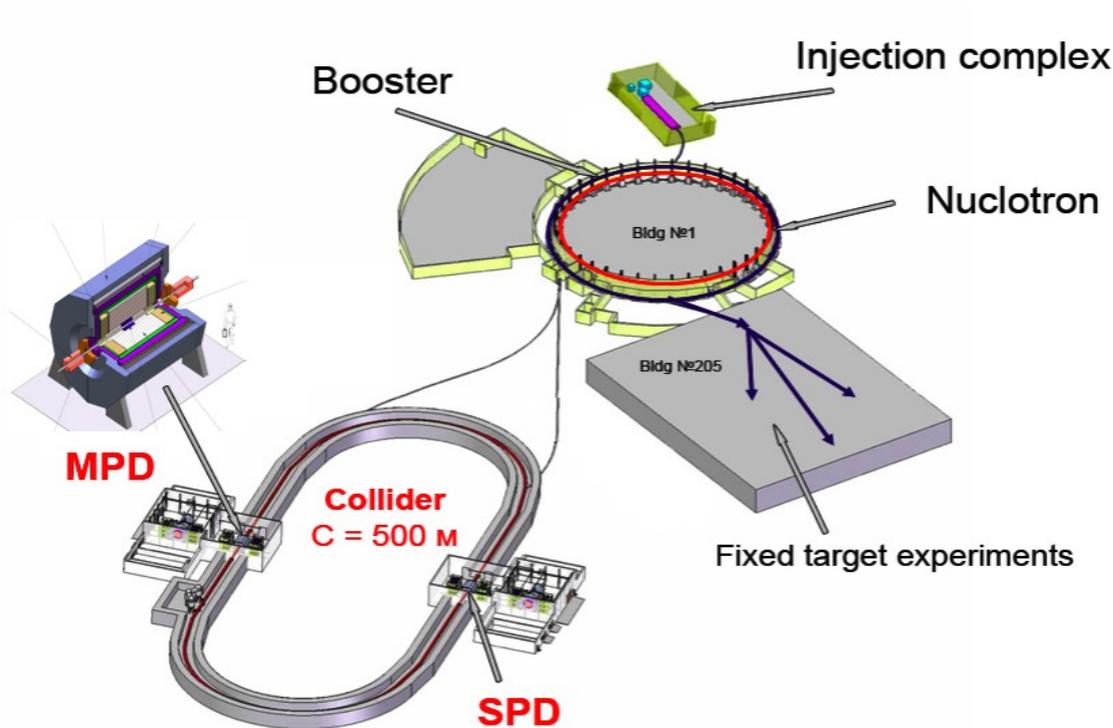
Nuclotron-based Ion Collider Facility



• NICA/MPD

The main goal of the NICA/MPD project is to start in the coming years experimental study of hot and dense strongly interacting QCD matter and search for a possible manifestation of the mixed phase formation and critical endpoint in heavy ion collisions.

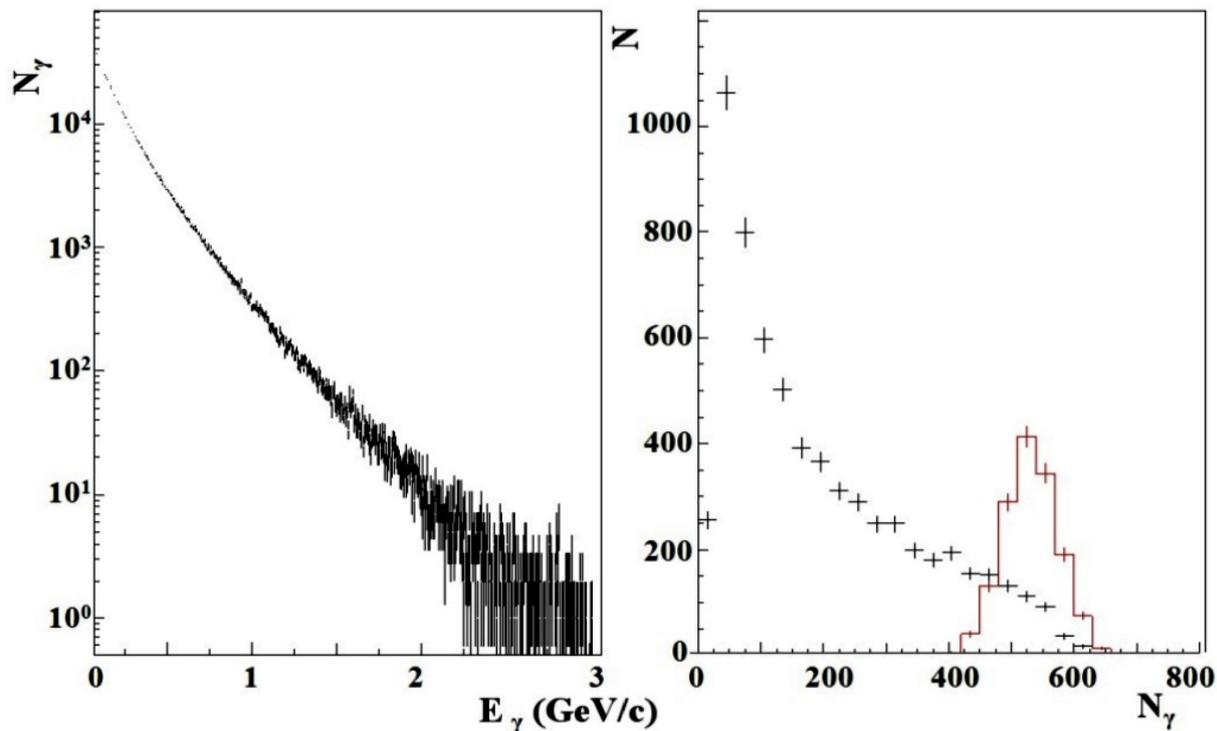
- ✓ De-confinement;
- ✓ Symmetry breaking;
- ✓ Antimatter;
- ✓ $\sqrt{s_{NN}} = 4-11$ GeV;
- ✓ Beams from p to Au ;
- ✓ $L \sim 10^{27}$ (Au), 10^{32} (p) [$\text{cm}^{-2}\text{c}^{-1}$];



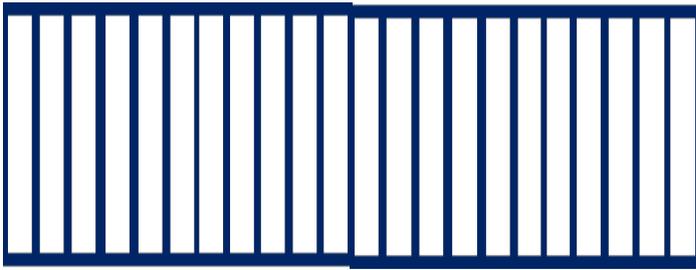
Electromagnetic calorimeter

The main goals of the ECal:

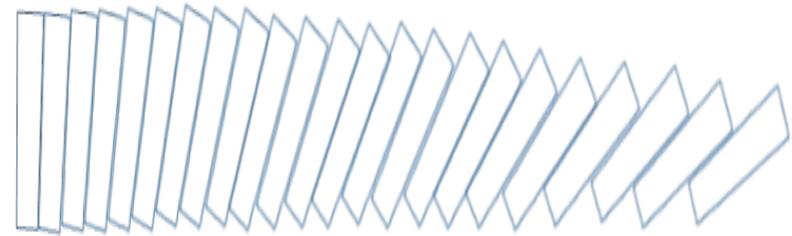
- Participation in particles identification;
- Measurements of the photons flux;
- Reconstruction of some decays with participation of the photons;



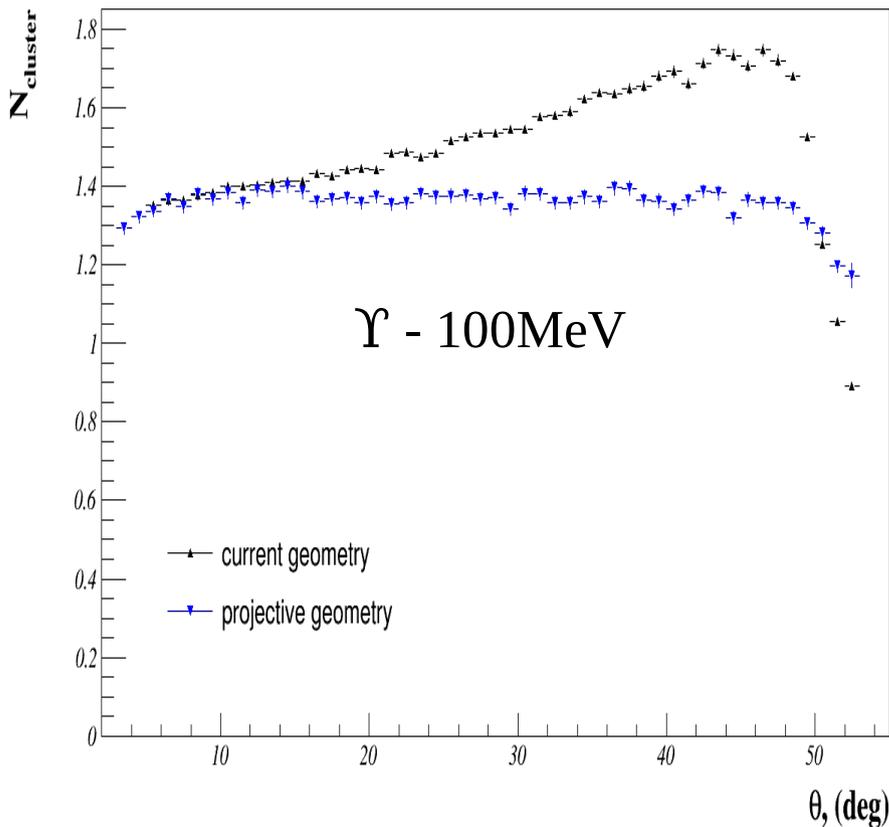
The energy spectrum of photons (left panel) and photon multiplicity distribution (right panel) in the central (red) and minimum bias (black) Au+Au collision (9 AGeV).



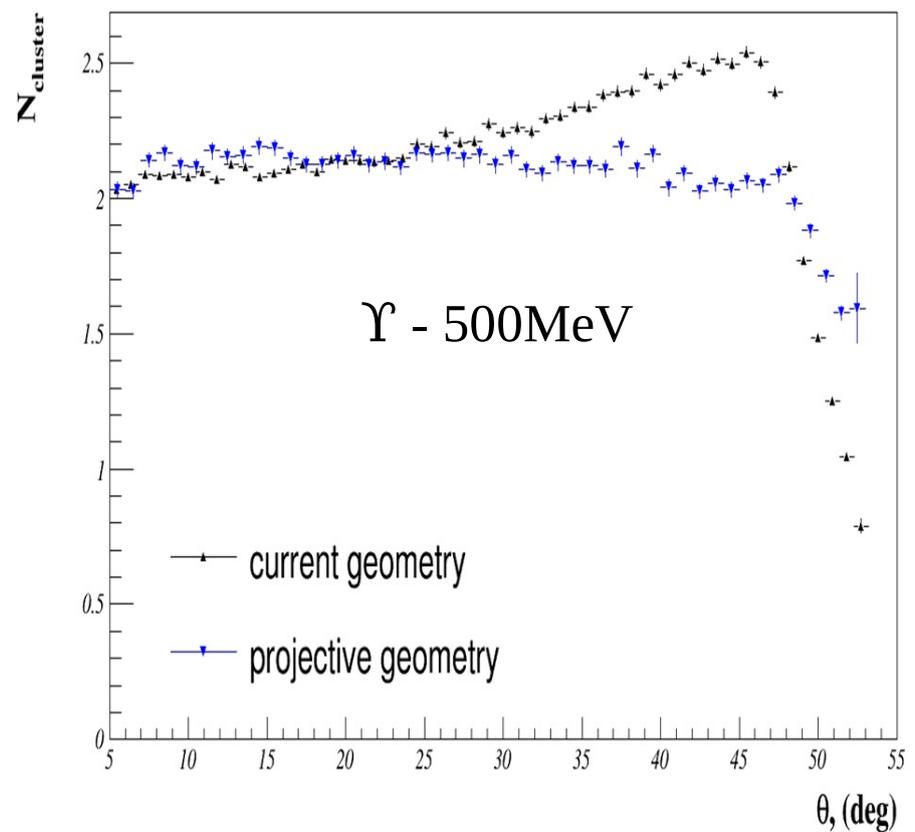
View of the some modules of the no projective geometry in the Z plane



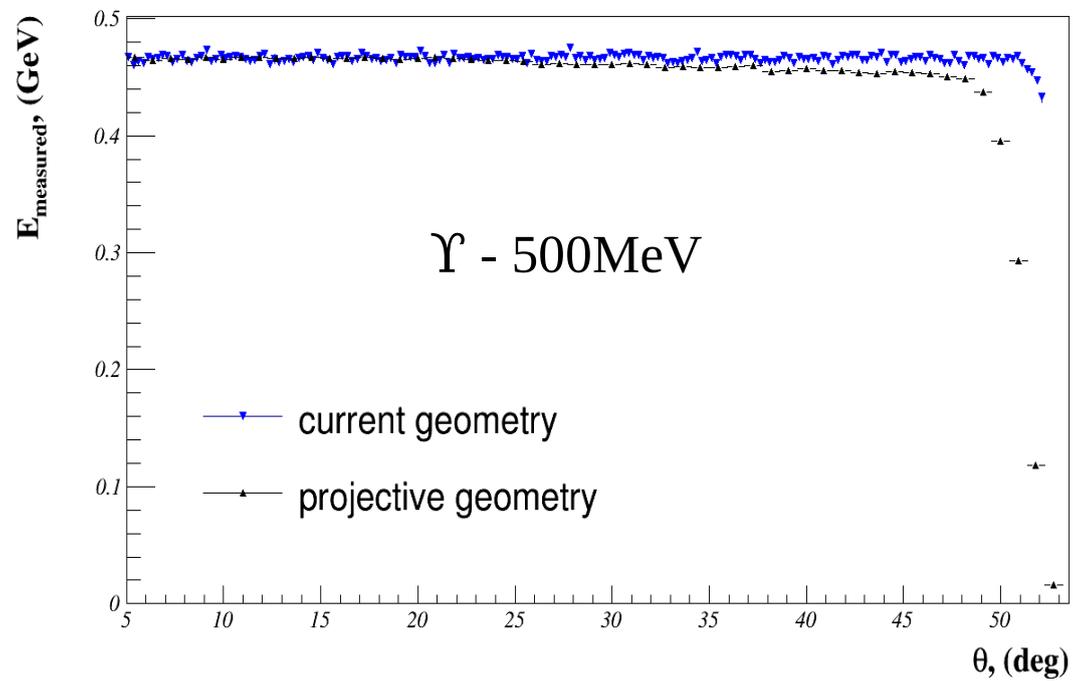
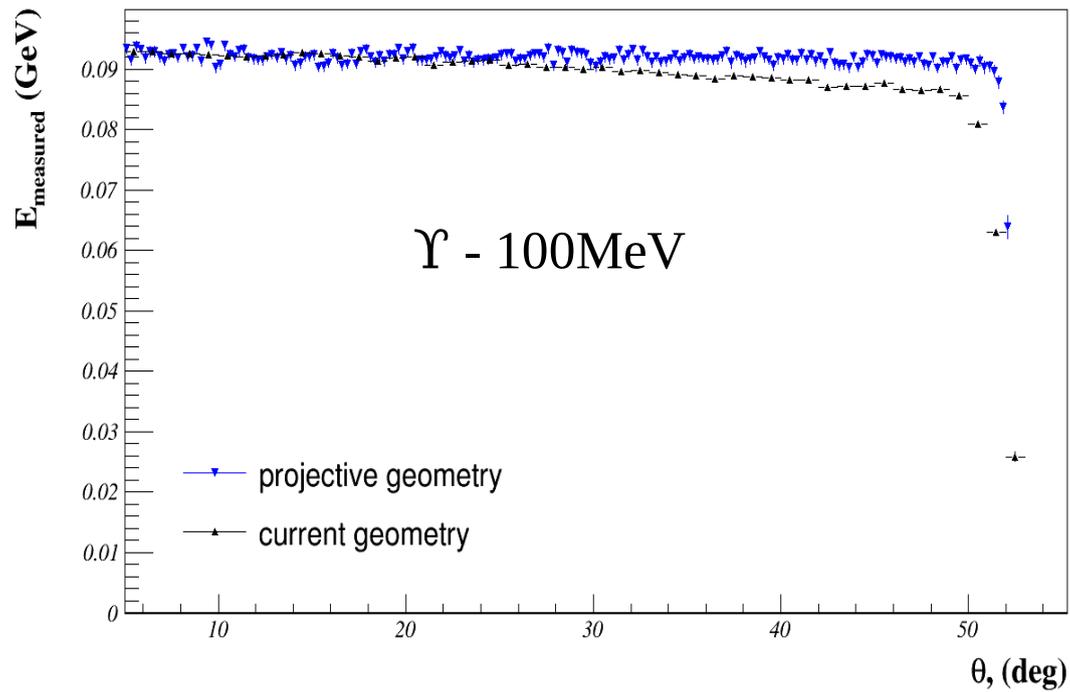
View of the some modules of the projective geometry in the Z plane.



Distribution of the number of clusters vs angle θ (Photons beam with energy 100MeV).



Distribution of the number of clusters vs angle θ (Photons beam with energy 500MeV).



Basic requirements:

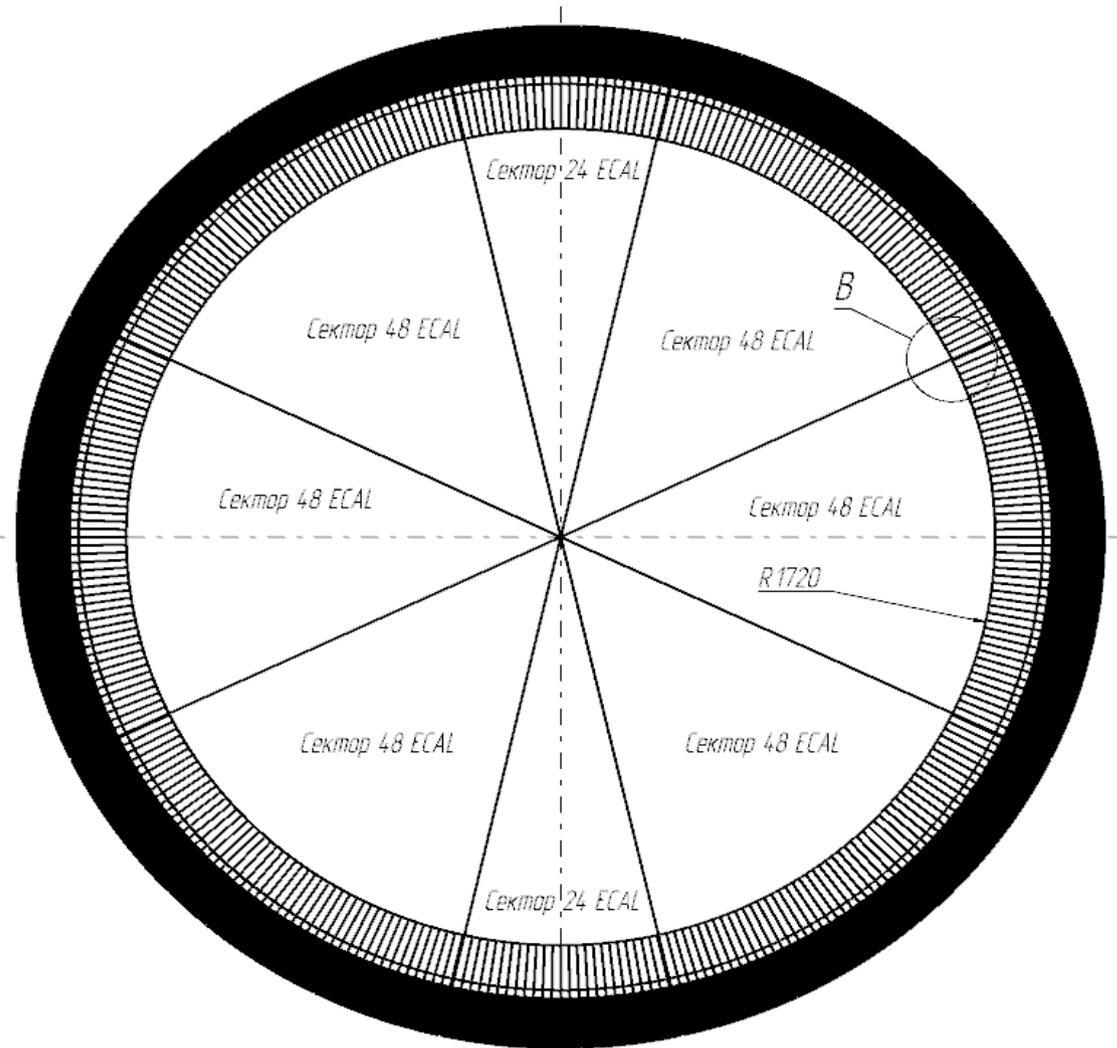
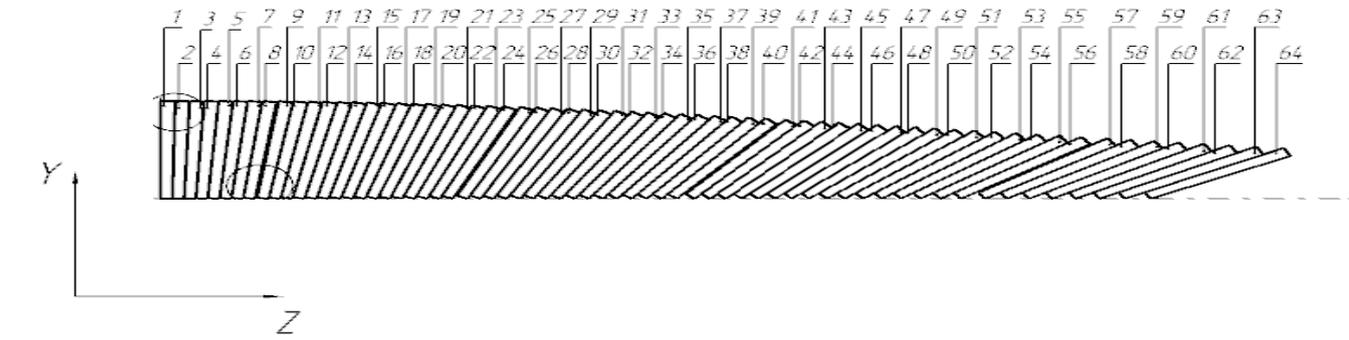
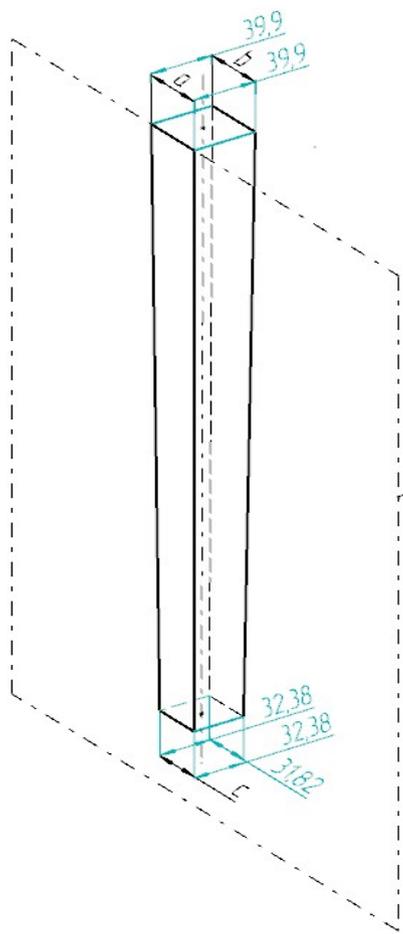
- high segmentation;
- large enough distance to the vertex;
- dense active medium with the small Molière radius;
- adequate space resolution;
- small shower overlaps;
- the particle occupancy should not exceed 5%;
- calorimeter must be able to operate in the magnetic field up to 0.5T;
- time resolution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

Calorimeter typ SHASHLYK



Parameters of main module	
Transverse size, mm ²	40x40
WLS fibers	16
Number of layers	220
Led absorber thickness, mm	0.3
Polystyrene scintillator thickness, mm	1.5
Molière radius, mm	62
Radiation length, X ₀	11.8
Effective radiation length, mm	32.4

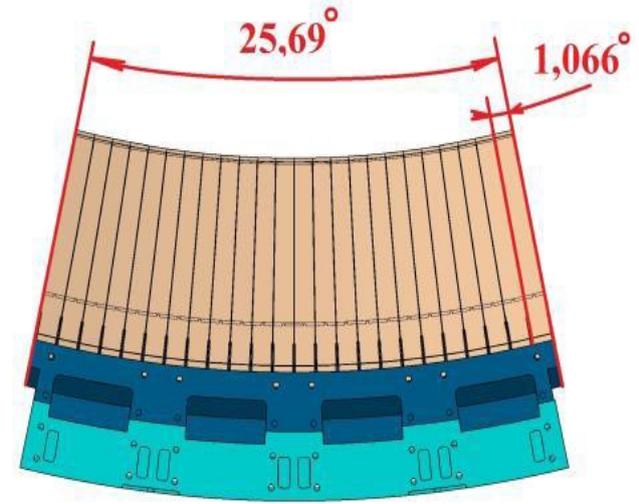
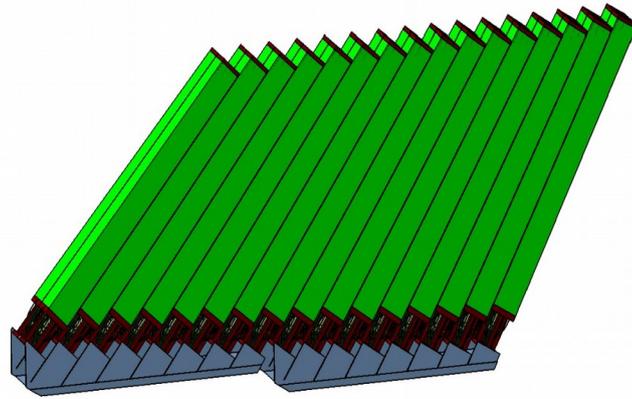
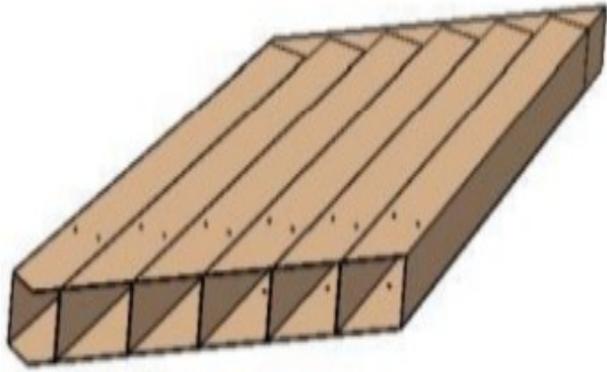
Every module will be cut of the both side in Phi and Theta plane.



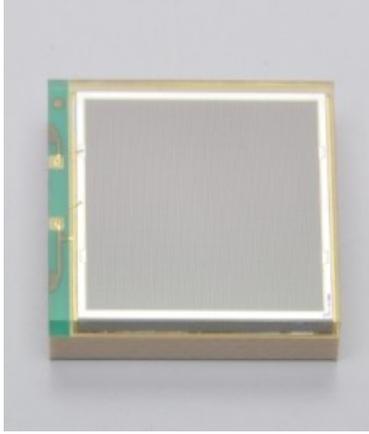
The barrel part will consist of two Chambers. Each of them will consist of eight sectors:

- two of them - 24 modules in Phi plane;
 - six of them - 48 modules in Phi plane;
- Every row in sector will be composed with 64 modules in Theta plane.

The ECal Barrel part will have 43008 modules (channels).



Detecting head

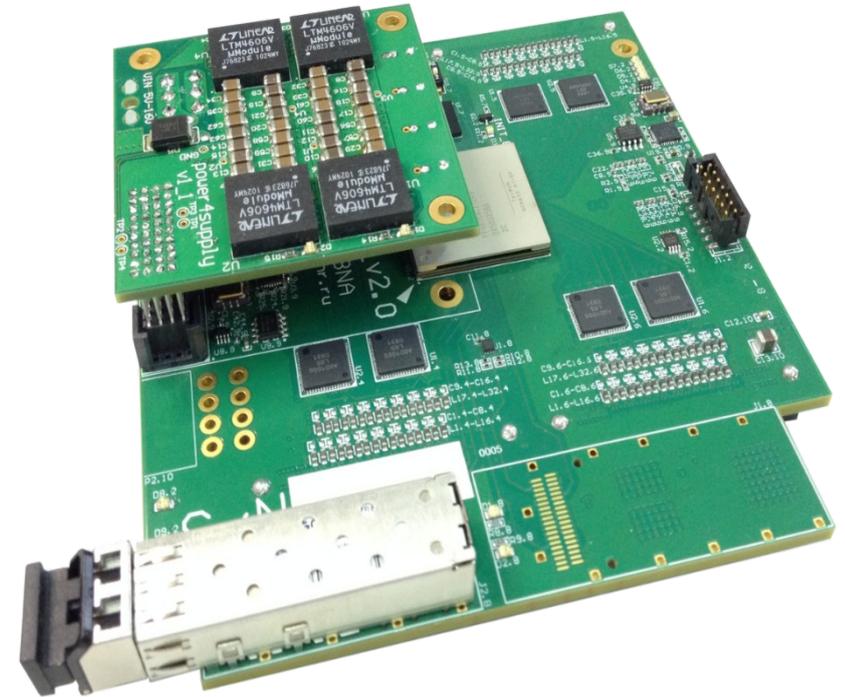


HAMAMATSU S13360-6025PE
MAPD counter

Slow Control

- High Voltage with temperature measurement and correction;
- LED Generator - for the continuous monitoring;
- Temperature and pressure - Temperature sensors will be located along the ECal sectors. Through these sensors Slow Control system will take temperature conditions around ECal under constant attention.

Front-End (FE) electronics

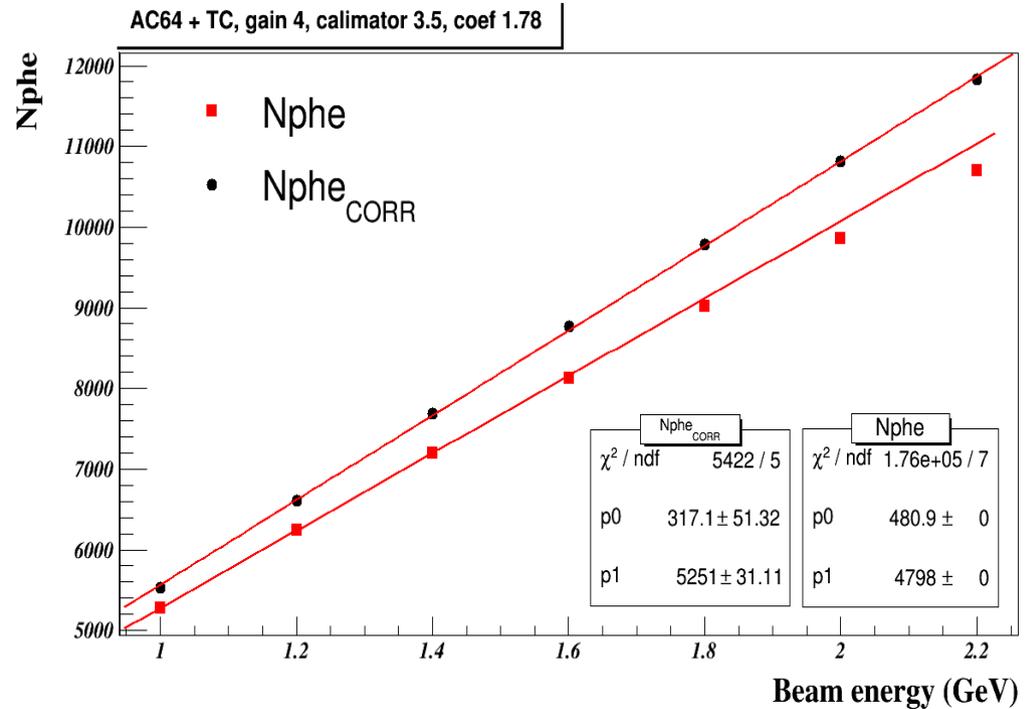
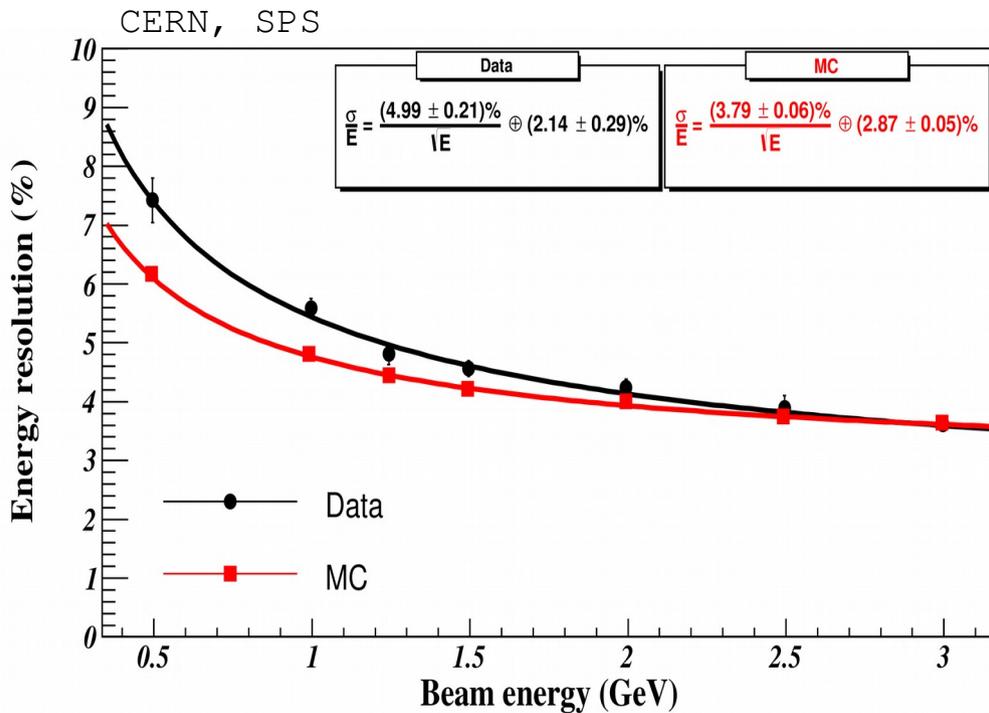


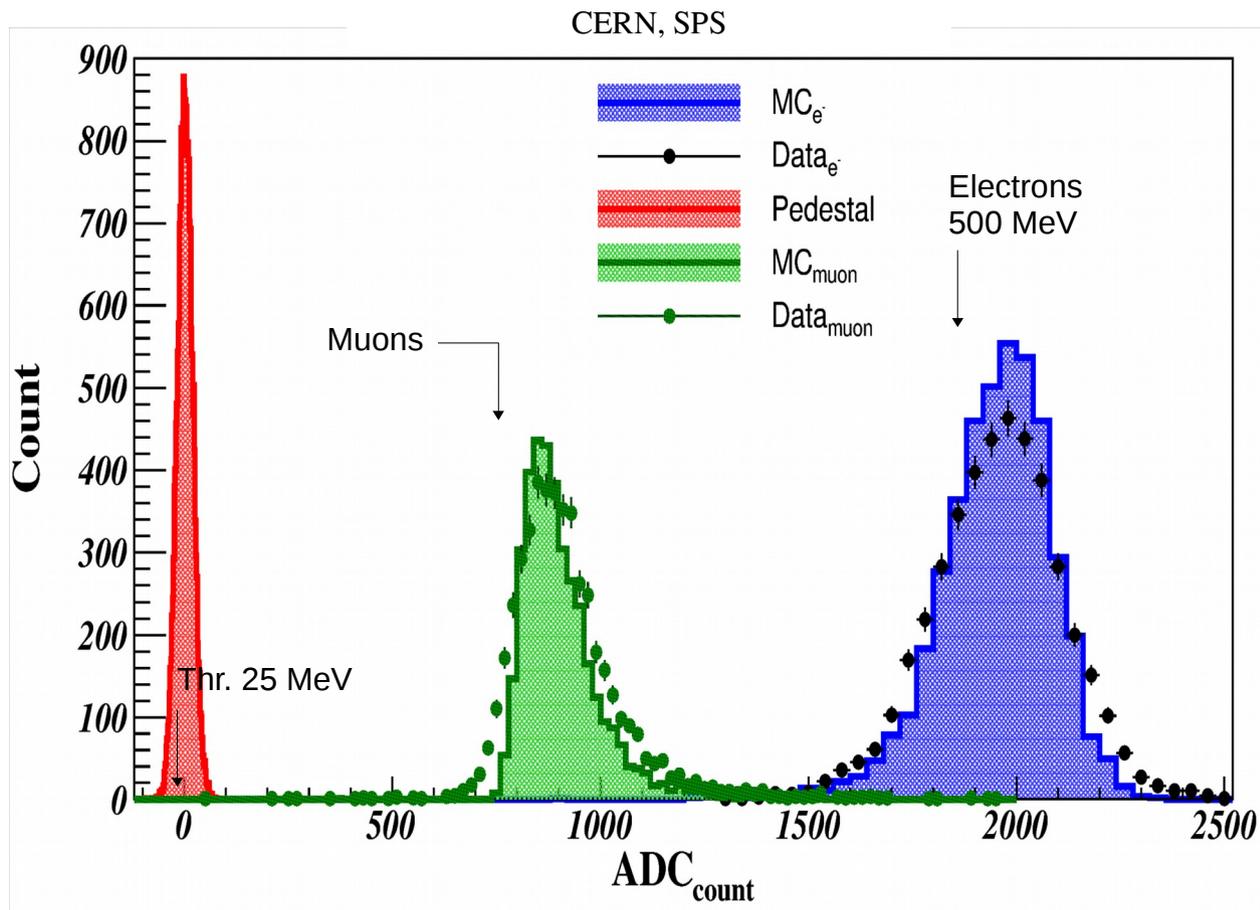
- ADC 64 channel board.
- It quantize analogue input signal and samples it at fixed time intervals;
- Zero suppression logic is based on baseline estimation and threshold value;
- ADC board allows to be integrated to the White Rabbit system. White Rabbit provides sub-nanosecond accuracy and picoseconds precision of synchronization for large distributed systems.

Test results

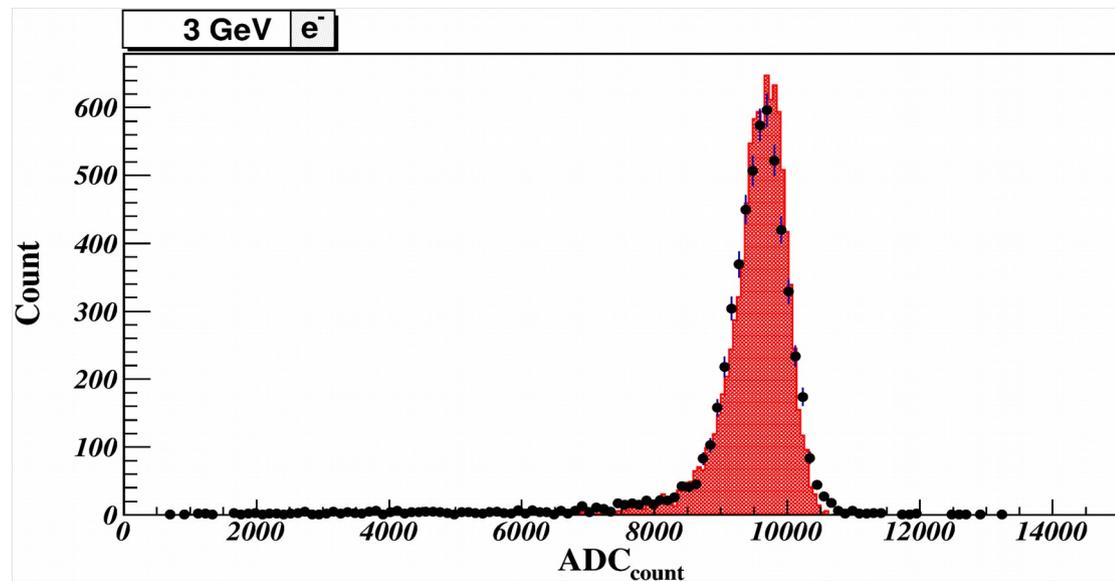
Test beams in DESY (Hambrug, Germany) and in SPS, CERN.

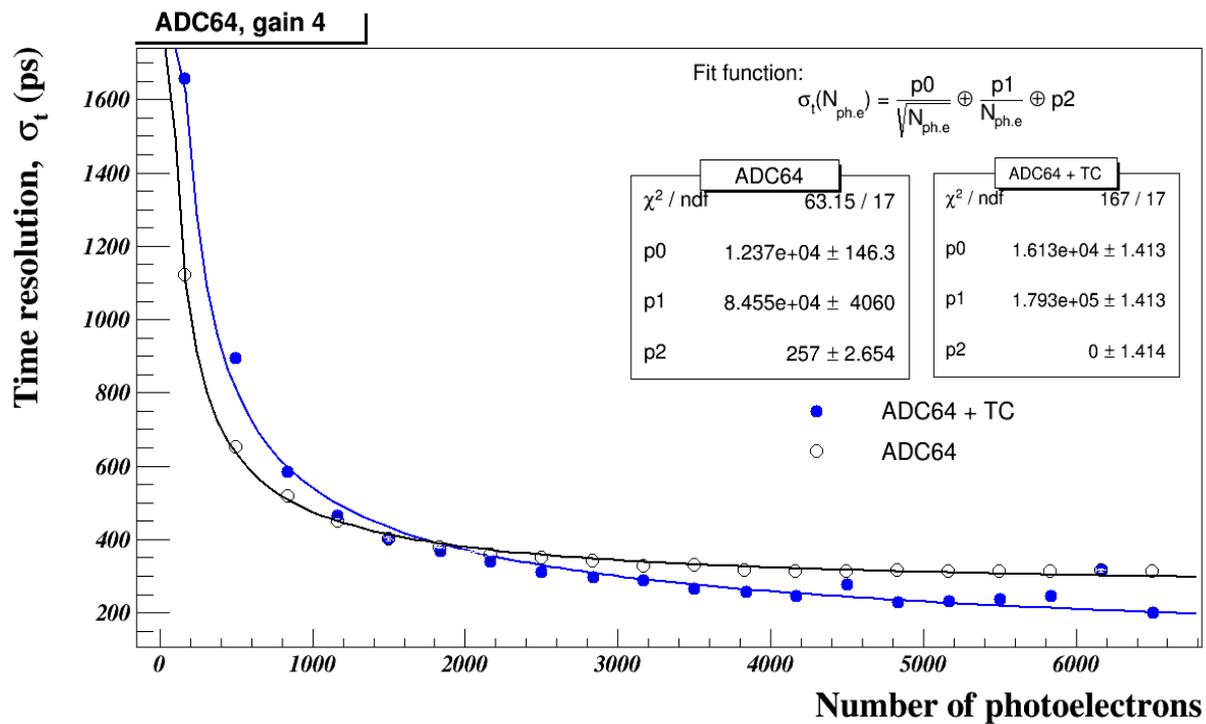
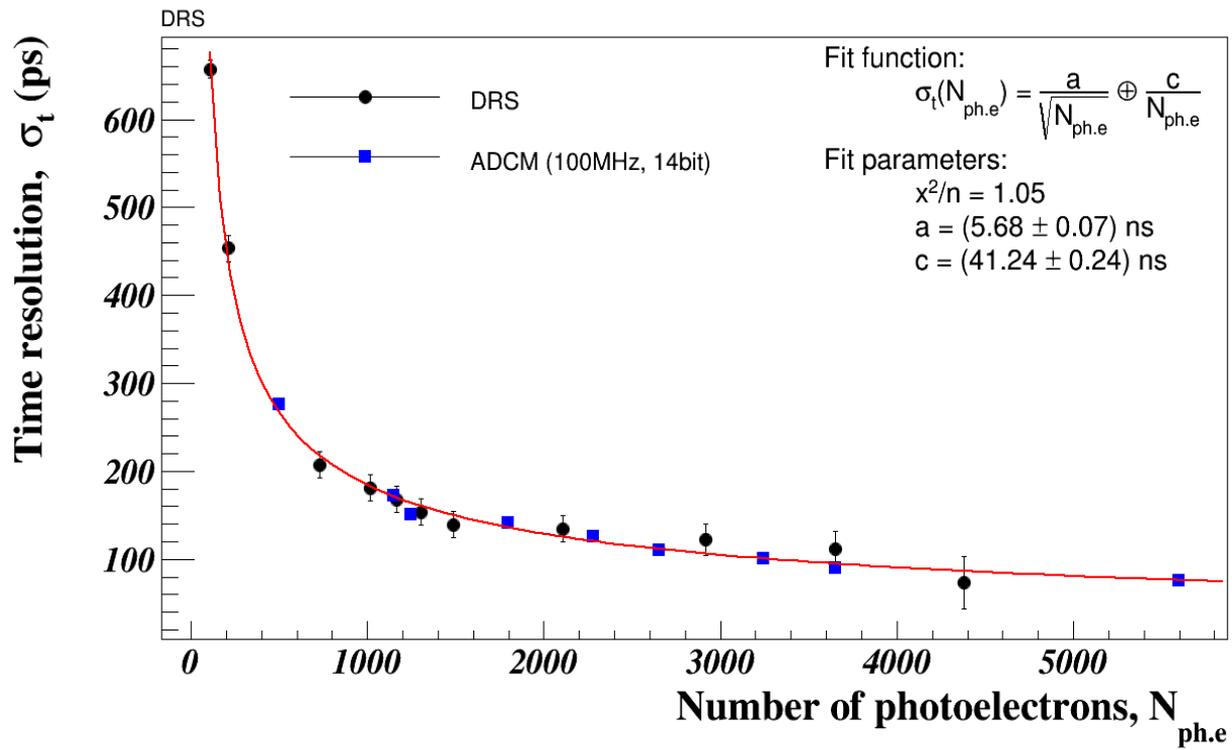
- at DESY - electrons energy range (1-6 GeV);
- at CERN - use muons and very small energy spread in the beam;
- <2 GeV - experimental results are slightly worse of the MC expectations;

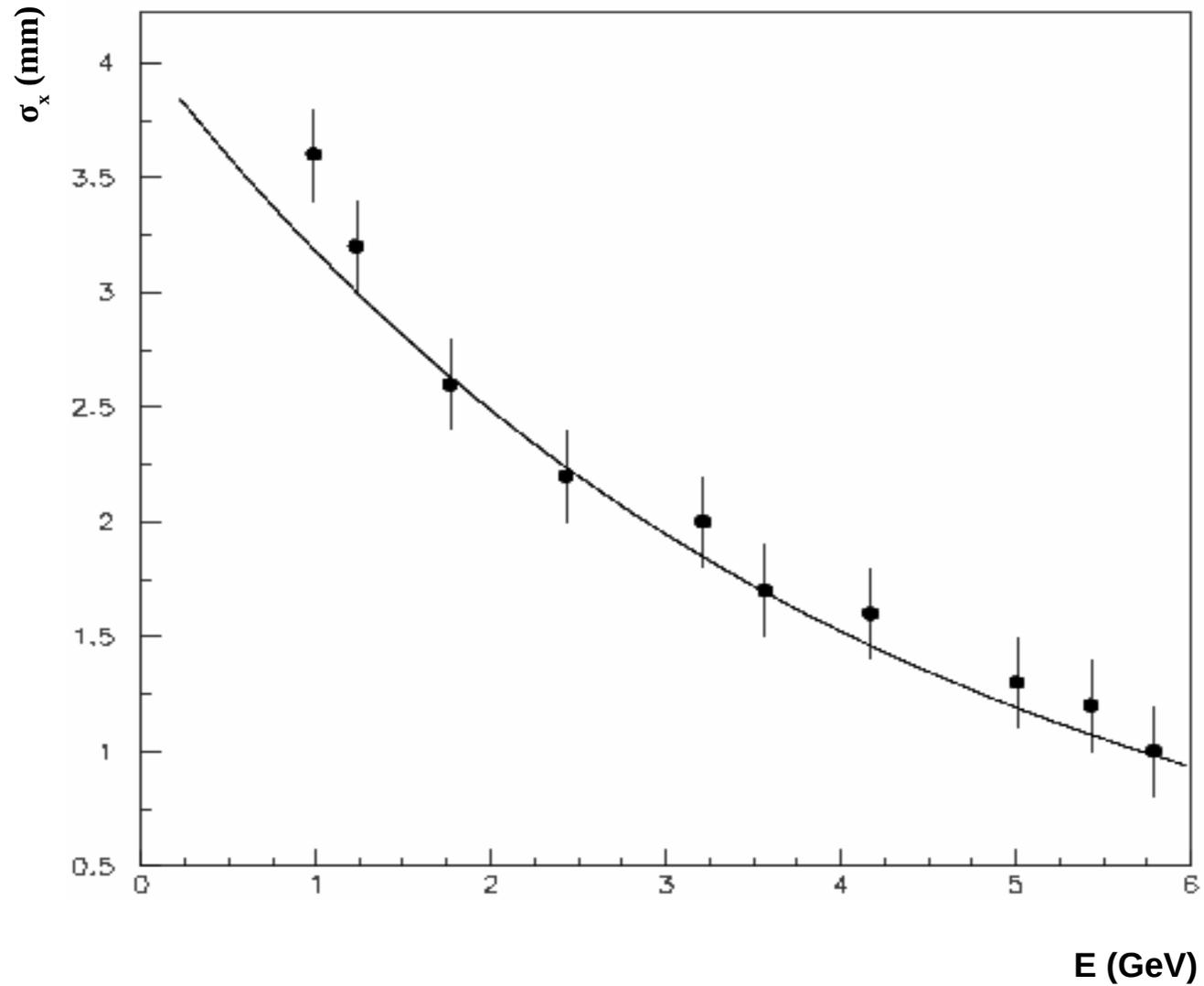




- MIP energy deposition is much higher than the noise of electronics - such particles can be effectively restarted by the calorimeter;
- Electronics threshold clearly can be set below 25 MeV;







Allow quite accurate measure the position of electromagnetic shower.
The possibility to correct nonlinearity and to achieve a coordinate resolution on level 4-1 mm.

Summary:

- ✓ As a result of MC study a new optimal design has been proposed. This design allows to avoid effect of distortion of energy resolution with polar angle.
- ✓ Mechanical design of projective geometry for barrel ECal has been developed.
- ✓ Front-End electronic to readout to MAPD (SiPM) photodetectors has been developed and tested.
- ✓ Beam test results correspond to MC estimation.