Study of a 3x3 module array of the ECAL0 calorimeter with an electron beam at the ELSA

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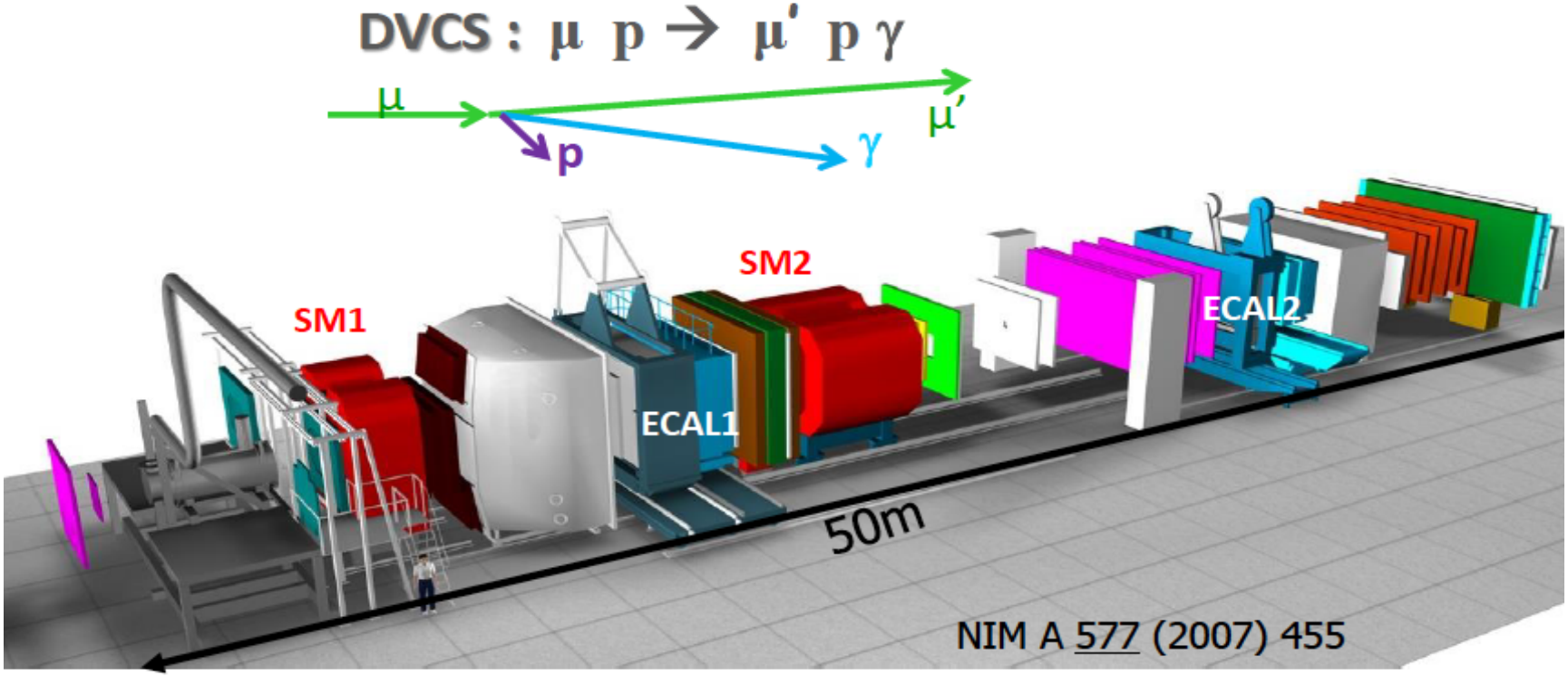
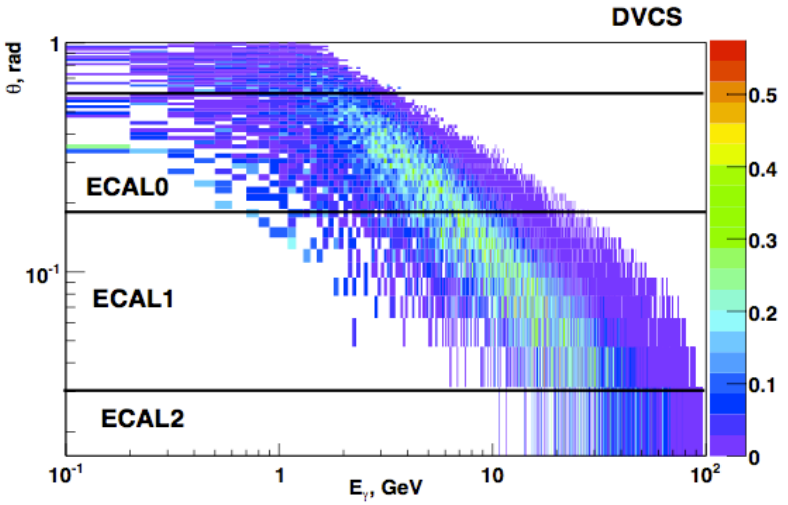
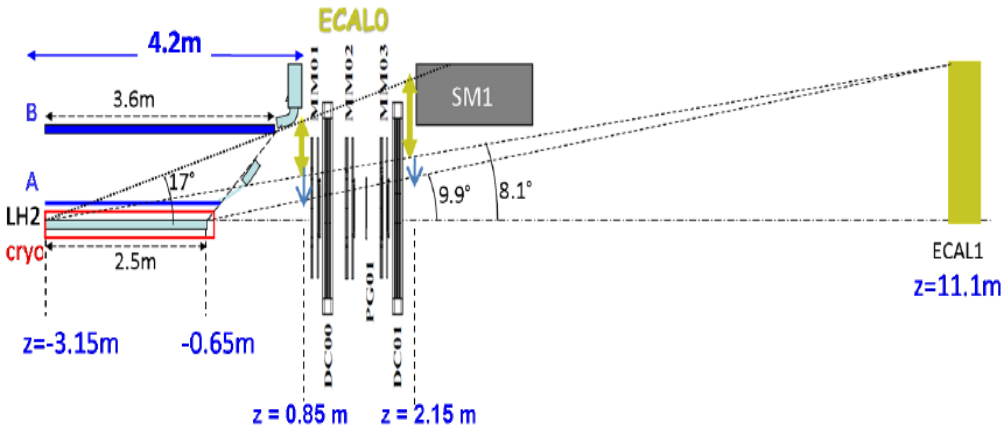


Muon beam at COMPASS gives an excellent possibility to study generalized parton distribution (GPD) via deeply virtual Compton scattering.
For low values of xB the photons are detected in the existing EM calorimeters, while for higher values of xB j an additional large angular acceptance calorimeter ECAL0 has to be added.

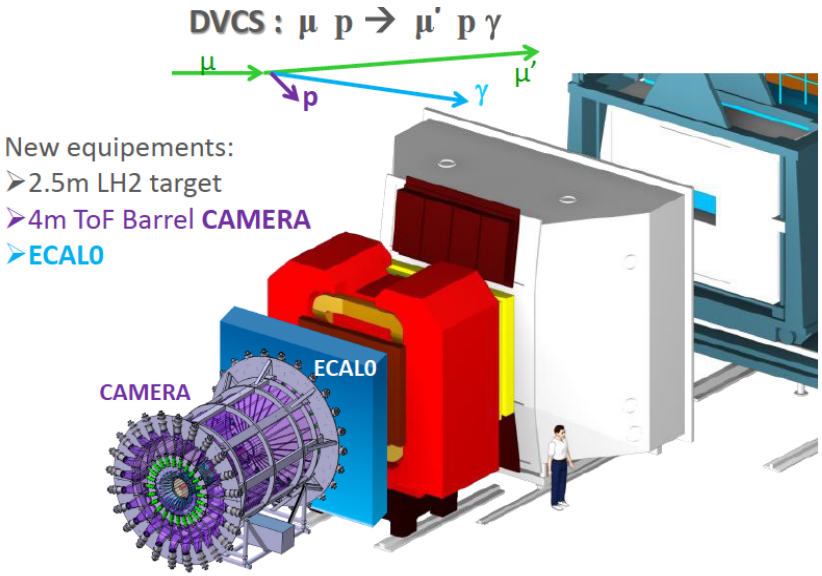


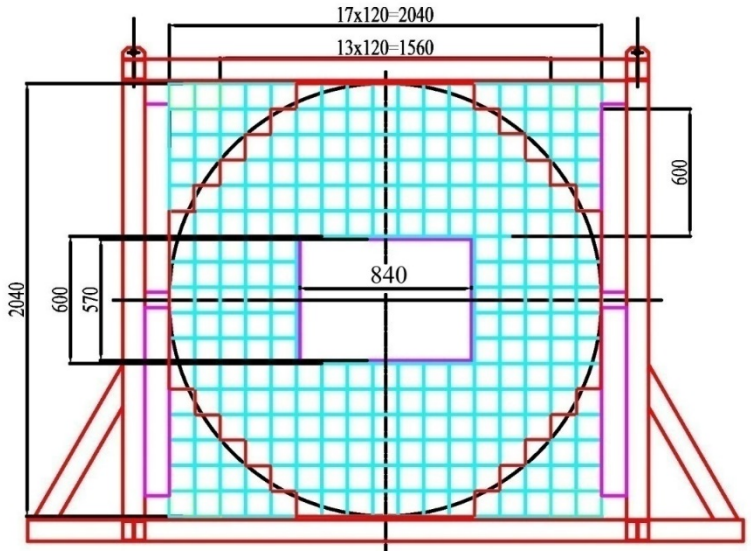


ECAL0 goals:

- Widen the range of angles available for measurments
- π0 and η background supression

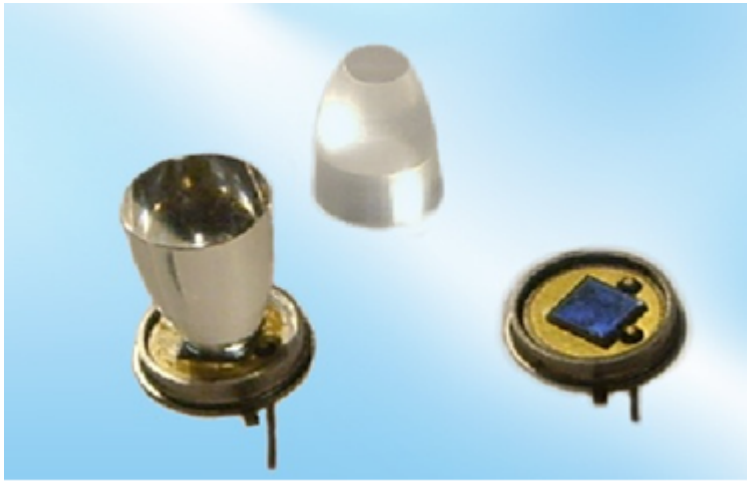
Requirements for ECAL0:





- The geometrical size is ~ 2x2 m2 with a central hole ~ 0.4-0.8 m2
- Total length of < 50 cm
- Located downstream of RPD, ECAL0 should cover the polar angular range of 0.15-0.6 Rad
- A modular structure
- Energy resolution ≤ 10.0%/√E (GeV)
- The photon detector should be insensitive to the magnetic field.

Multi-pixel Avalanche Photo Diodes

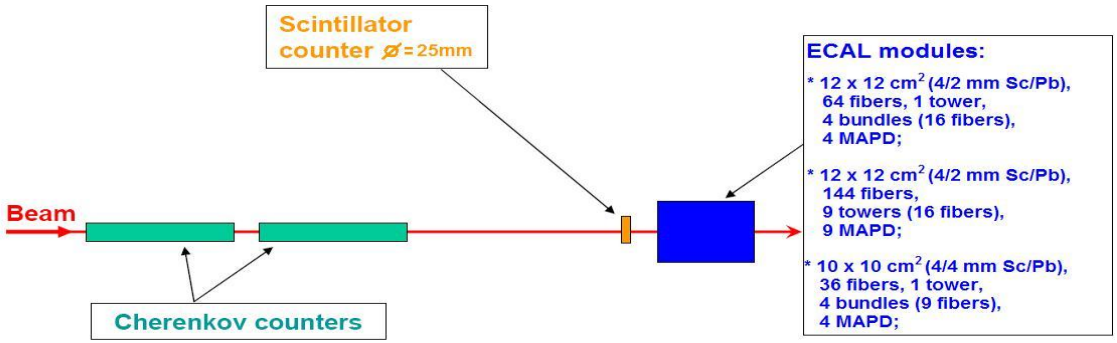


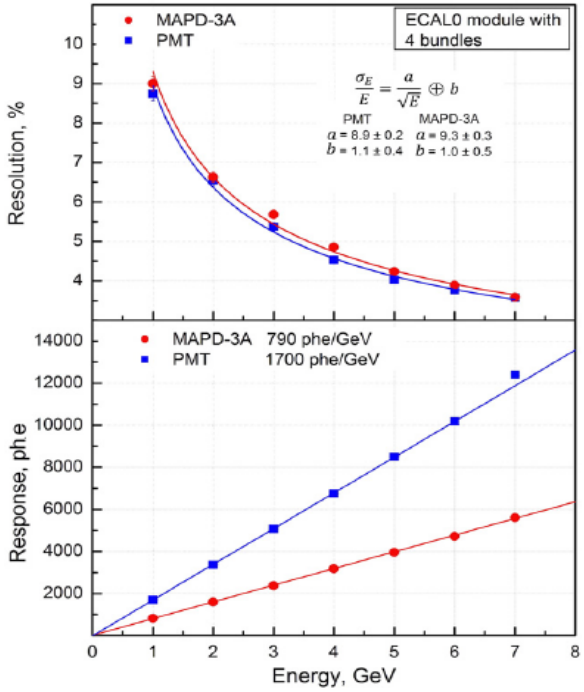
Stray magnetic field prevents use of PMT.

MAPD could be used instead of it.

Type	MAPD-3A	MAPD-3B	MAPD-3N
Size, mm^2	3×3	3×3	3×3
Pitch(pixel size), μ	8(3)	5(2)	8(5)
Number of pixels	≈135000	≈360000	≈135000
Bias voltage, V	≈66.5	≈70	≈90
Gain, $\times 10^4$	2-3	1-1.5	3-5
PDE, %, at λ=520 nm	12	10	30

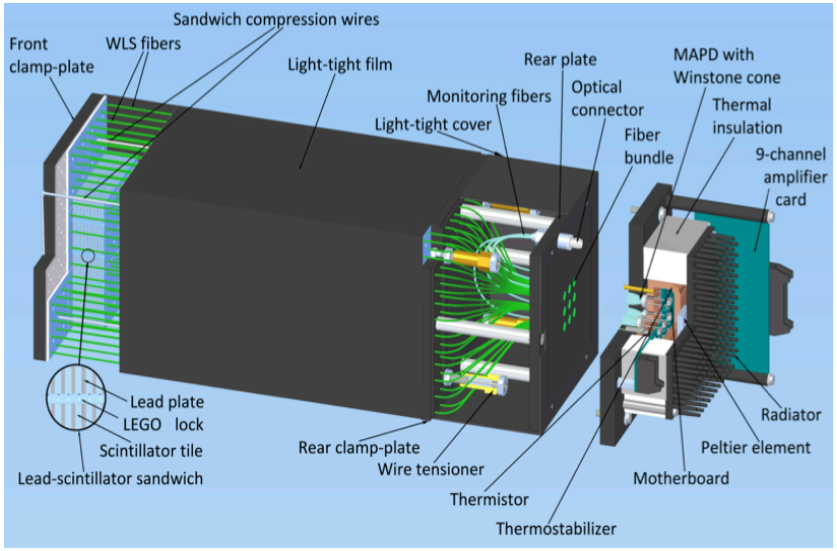
2007-2008 Tests of the ECAL LHCB modules (T9 PS)

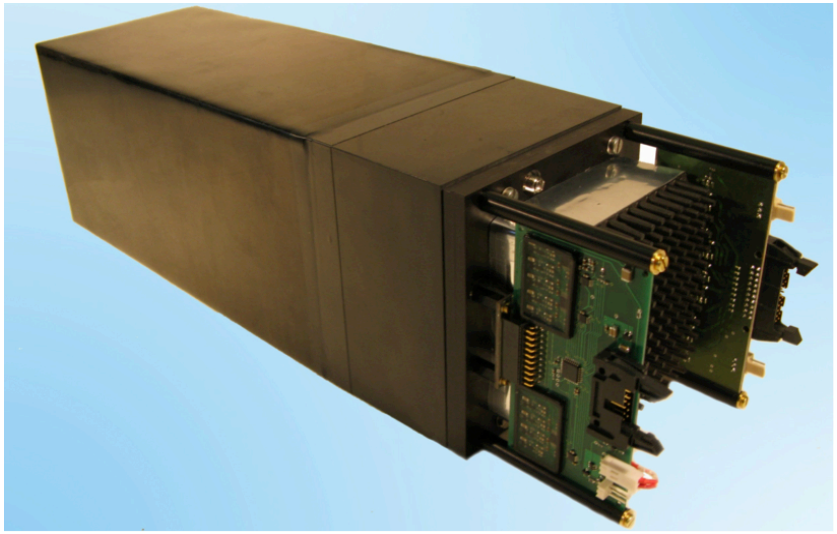




PMT - EMI9814B
MPD - 3A 3B 3N

Technology	Shashlyk
Scintillator	PSM - 115 ⊕ 2,5% p- terphenyl ⊕ 0:01% POPOP, 66 layers
Absorber	Lead,66 layers
Pb / Sc plates thickness, mm	2 / 4
Pb/Sc plates dimensions, cm	12.12x12.12
Moliere radius, cm	3,5
Radiation length, cm	1,64
Total thickness, cm	42 (25 X0)





R&D on ECAL0 module was performed in 2008-2011, resulting in final prototype tested in 2011.

256 modules have been already manufactured by ISMA Kharkov (56 modules in 2012 and 200 in 2013).

Technology	Shashlyk
Scintillator	Polystyrene Kharkov
Absorber	Lead
Number of layers	109
Sc / Pb plates thickness, mm	1.5/0.8
Pb/Sc plates dimension, cm	12.0 /3(4x4)
Moliere radius, cm	3.5
Radiation length, cm	1,64
Number of tower	9
Fiber	BICRON BCF91AMC d=1.2 mm
Number of fibers per tower	16
Diam. of bundle, mm	6.5
Light guide	Winston cone glued to photodetector
Photodetector	MAPD -3N
Total thickness, cm	25.2(~ 15 X0)
Temperature stabilization	Peltier cooler

Calibration at CERN

2011:

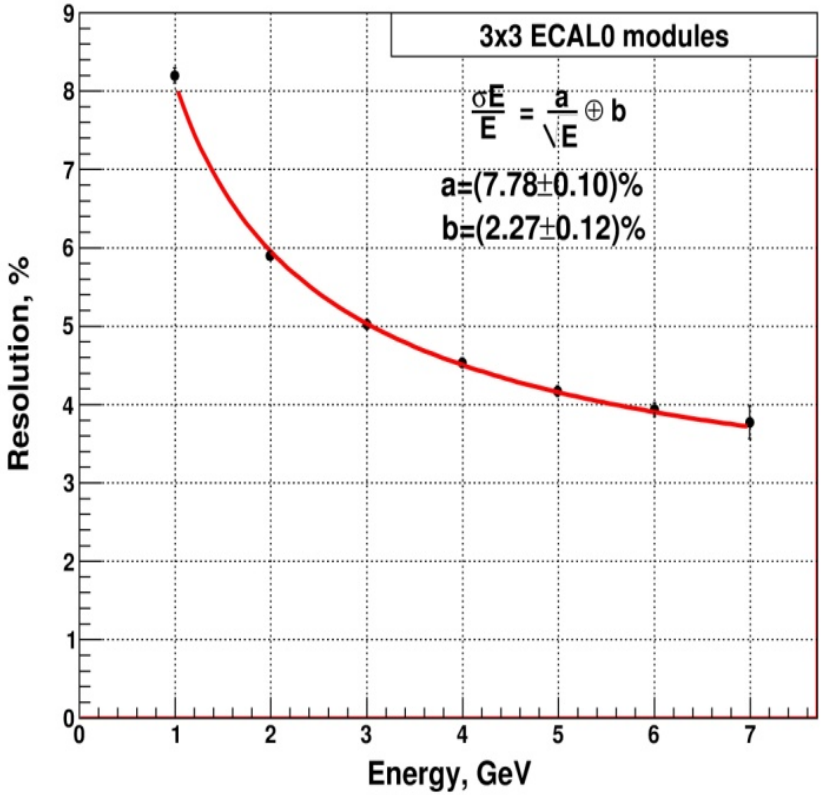
- ECAL0 prototype (3x3 matrix) cosmic muon tests
- ECAL0 prototype (3x3 modules matrix) T9 beam tests

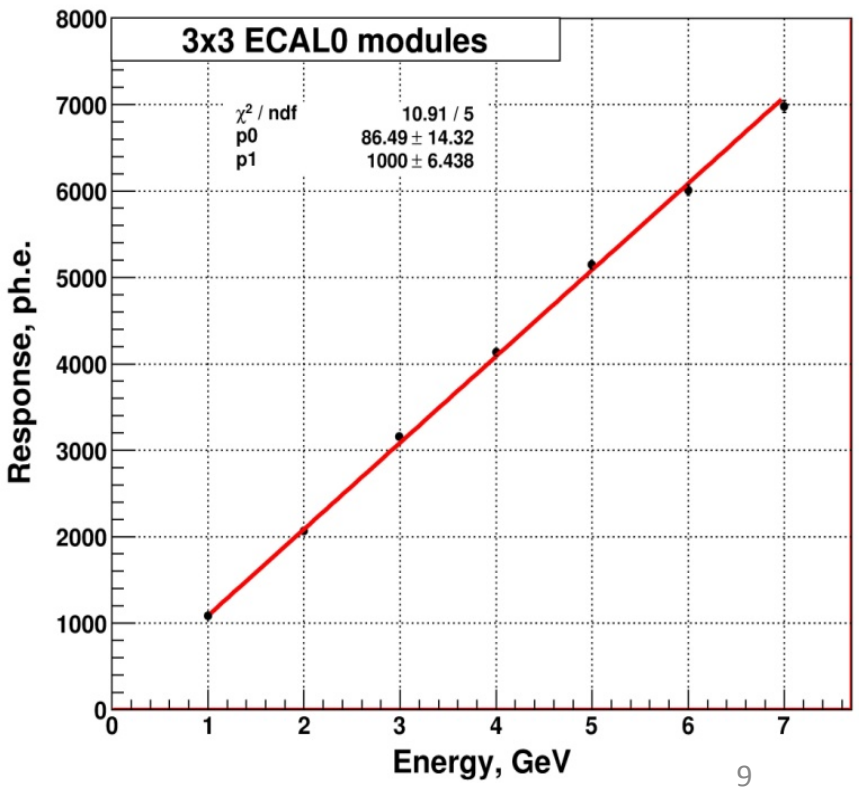
2012:

- Pilot run of a quarter-size detector prototype within COMPASS experiment in 2012 with π0 calibration;

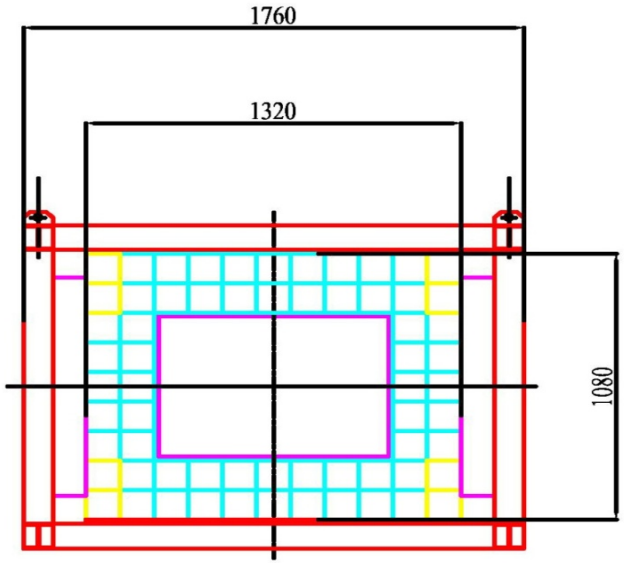
ECAL0 prototype (3x3 modules matrix) tests in 2011. T9 beam

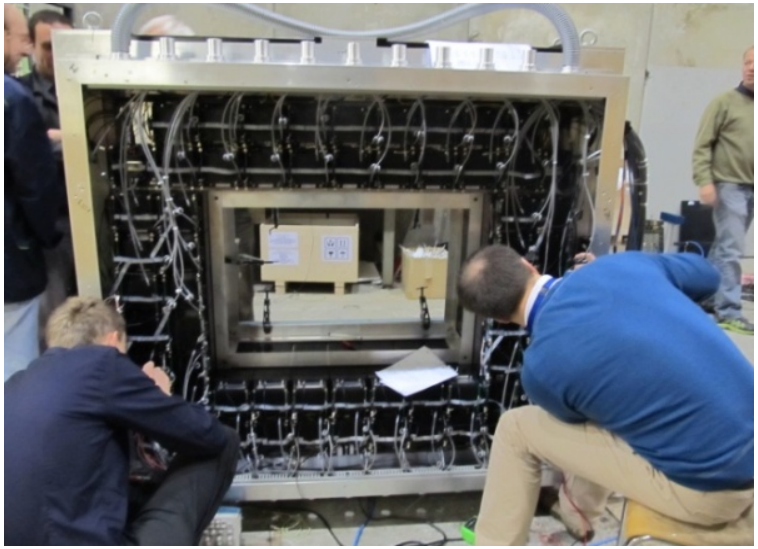
Every module of the matrix has been positioned at the center of the beam and the energy spectra have been measured at 4GeV.
Energy resolution vs energy at the center of the matrix have been measured.

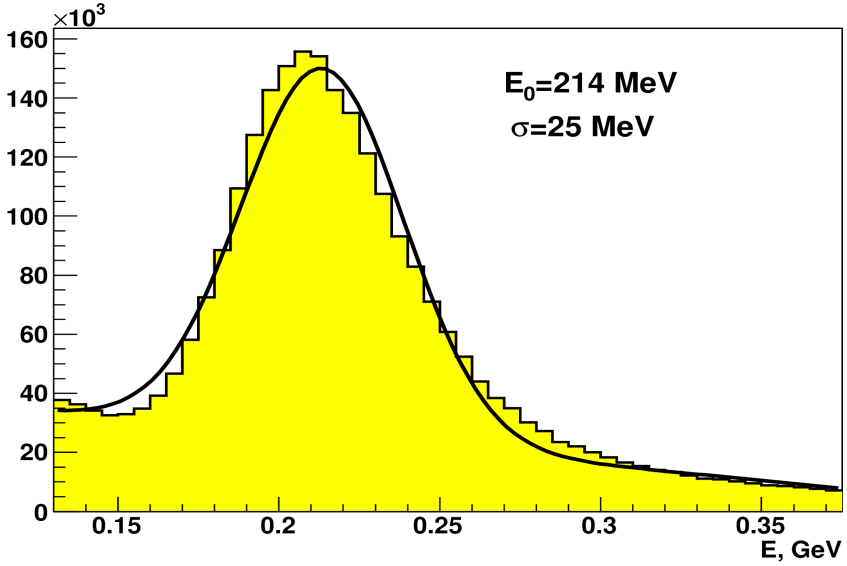


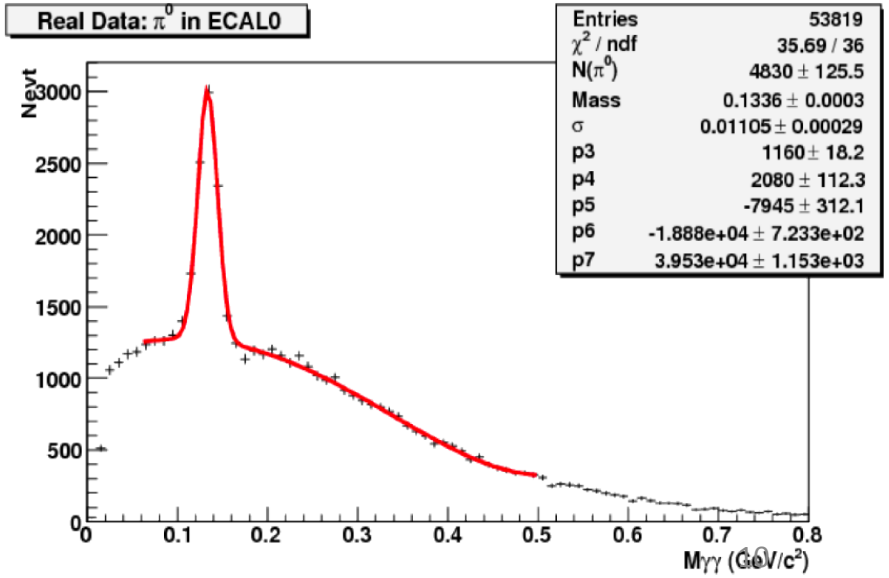


Quarter-size detector tests on COMPASS beam in 2012







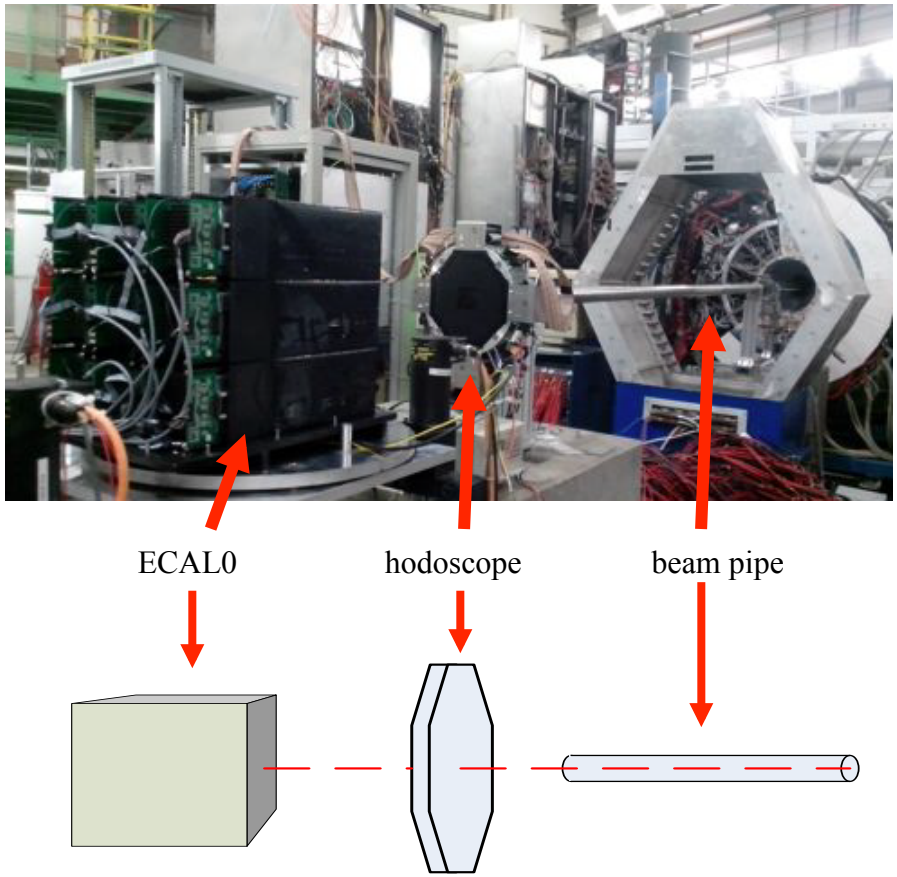


Study of a 3x3 module array of the ECAL0 calorimeter with an electron beam at the ELSA

The main goals for the tests to be done in Bonn at the ELSA were:

- to calibrate the energy response of the detector for electrons;
- to check the angular response of the detector over a range of 0 to 36 degrees with 6-degree step;
- to perform an energy scan over three points (3.2, 1.6 and 0.8 GeV) to cross-check previously collected data.

Measurement setup



A low-intensity electron beam source, the ELSA accelerator;

A Sci-Fi hodoscope for system triggering, high-resolution electron position readout and beam monitoring;

A 9-module ECAL0 matrix installed on an automated moving platform for spatial and angular scanning;

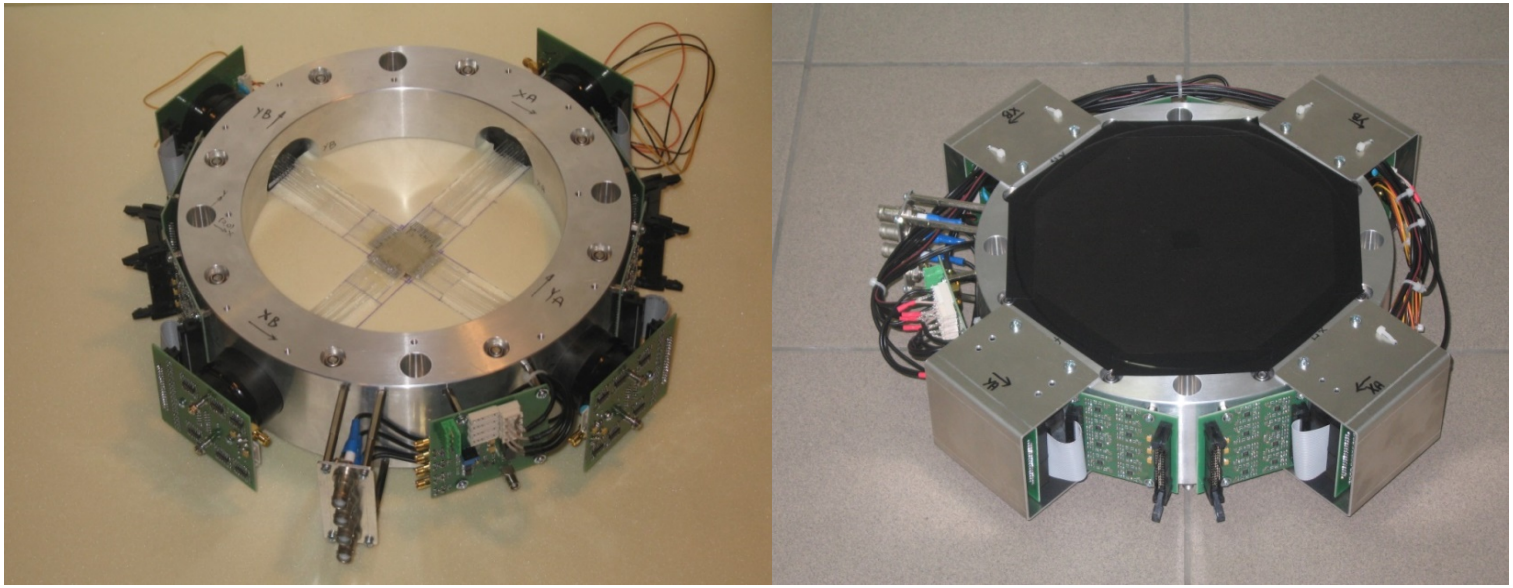
The moving platform allowed high-precision positioning over two axes (x,y better than 0.5 mm)

Hodoscope

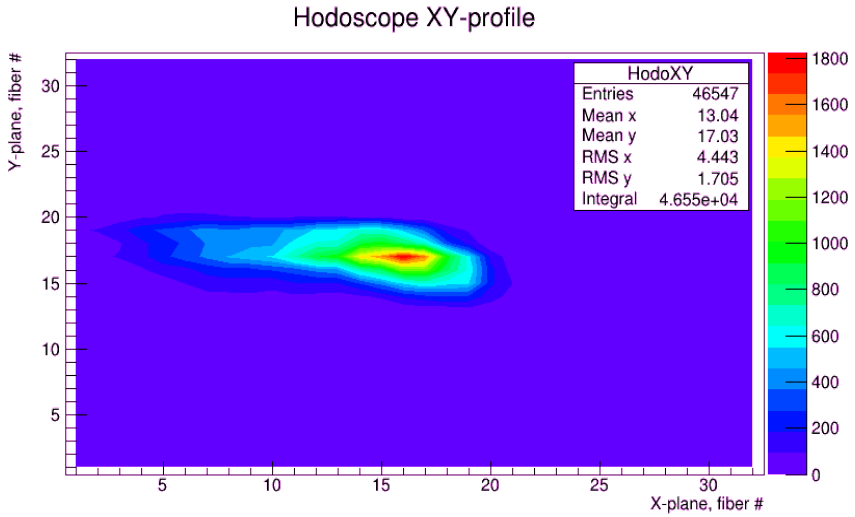
Accurate read-out of the position of incident electrons and system triggering.

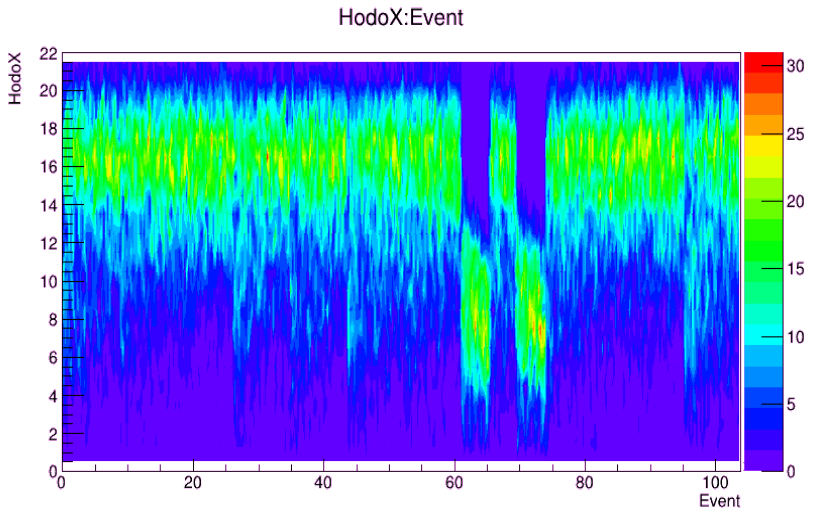
Two-plane Sci-Fi detector with approx. 23 x 23 mm.

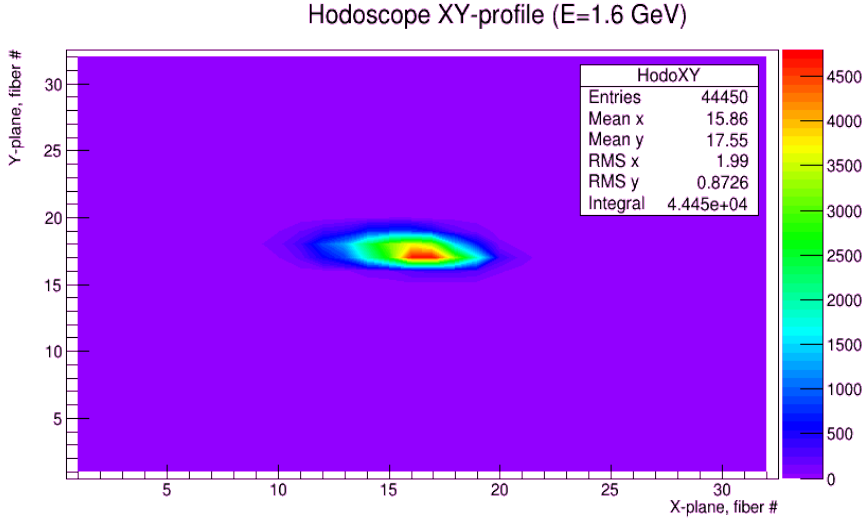
32 channels in each plane, giving position resolution of 0.7 mm with fibre diameter of 1.2 mm.

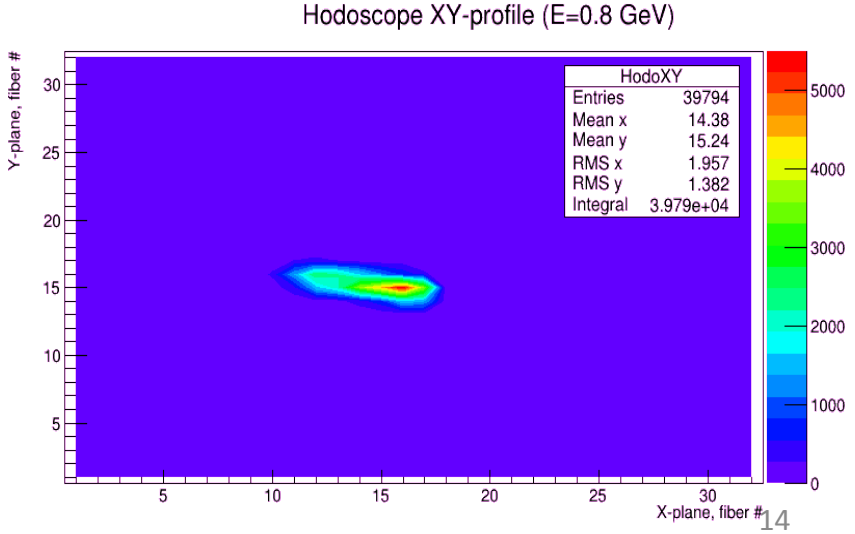


Beam profile

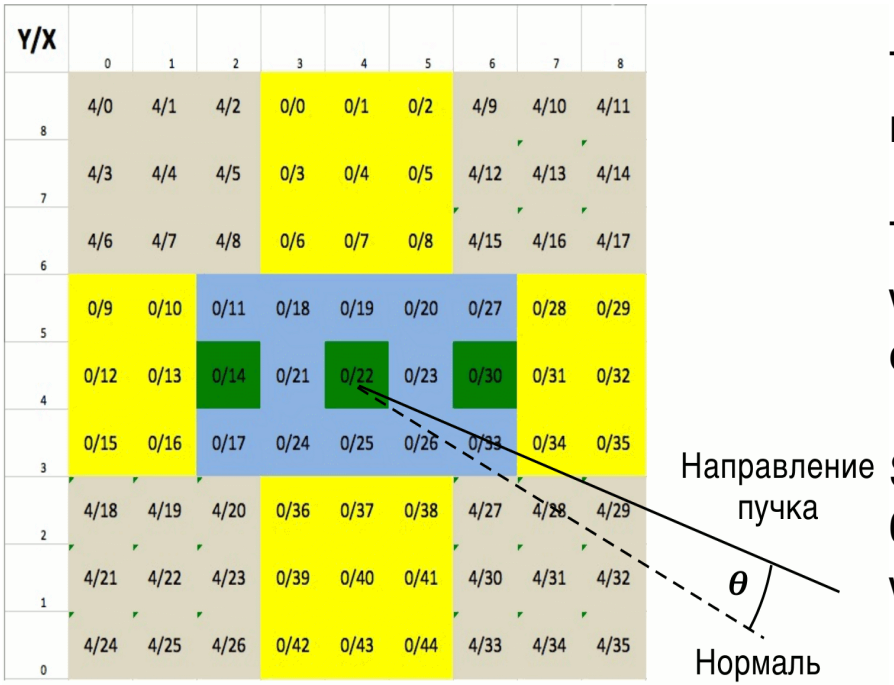








Program of the tests

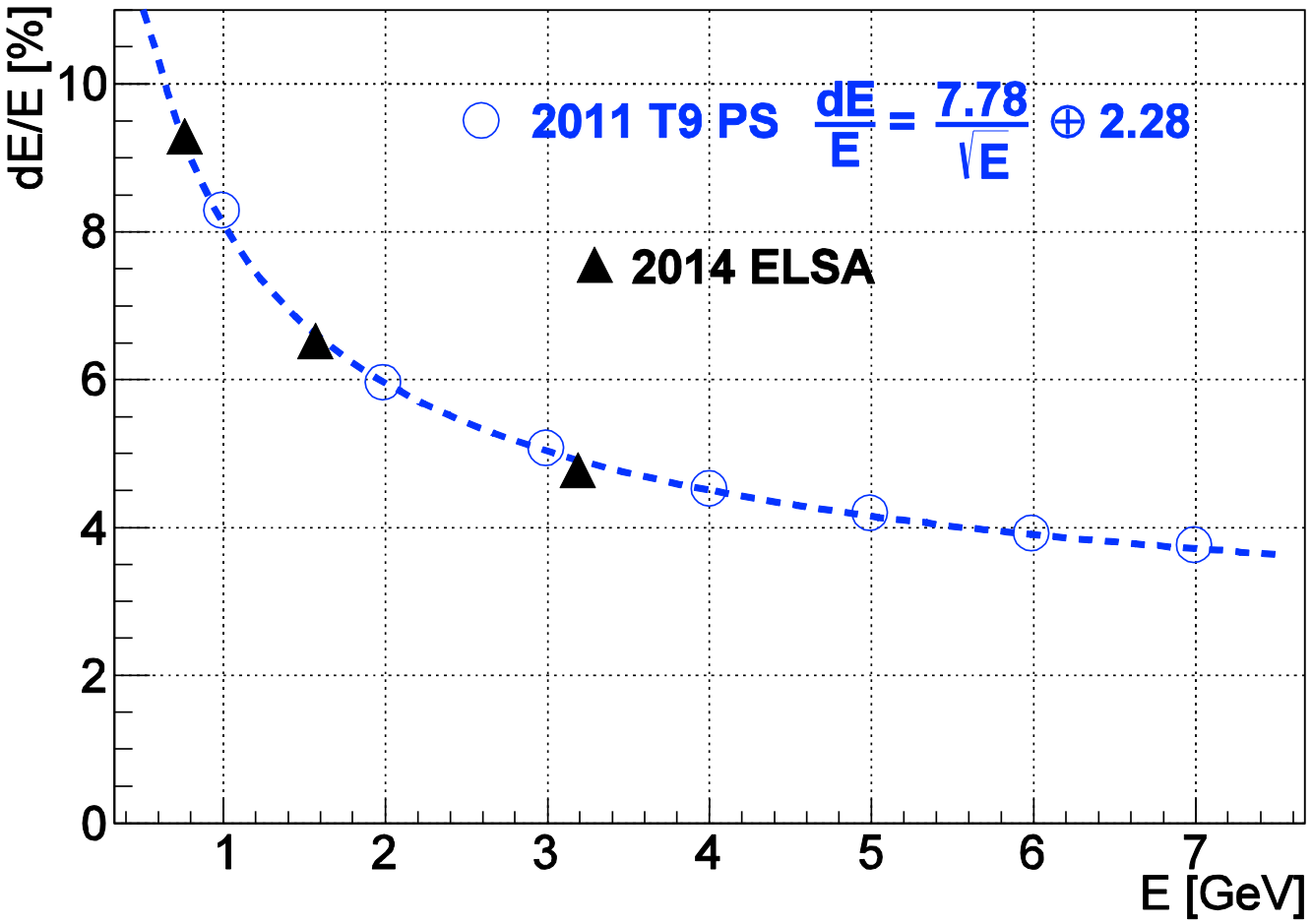


The first part was to scan the whole matrix (81 channels) with 3.2 GeV beam

The second part was the angular scan, which was performed for three different energies: 3.2, 1.6 and 0.8 GeV.

Seven angle settings (0-36 degrees with 6^o step) and 15 various beam positions were scanned for each energy.

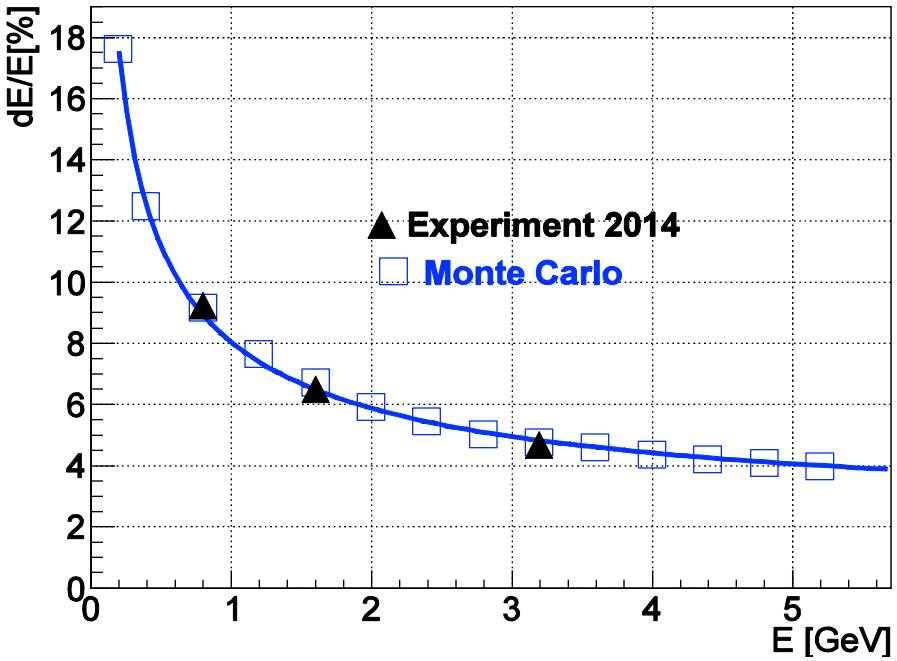
Comparing the data of 2011 and 2014

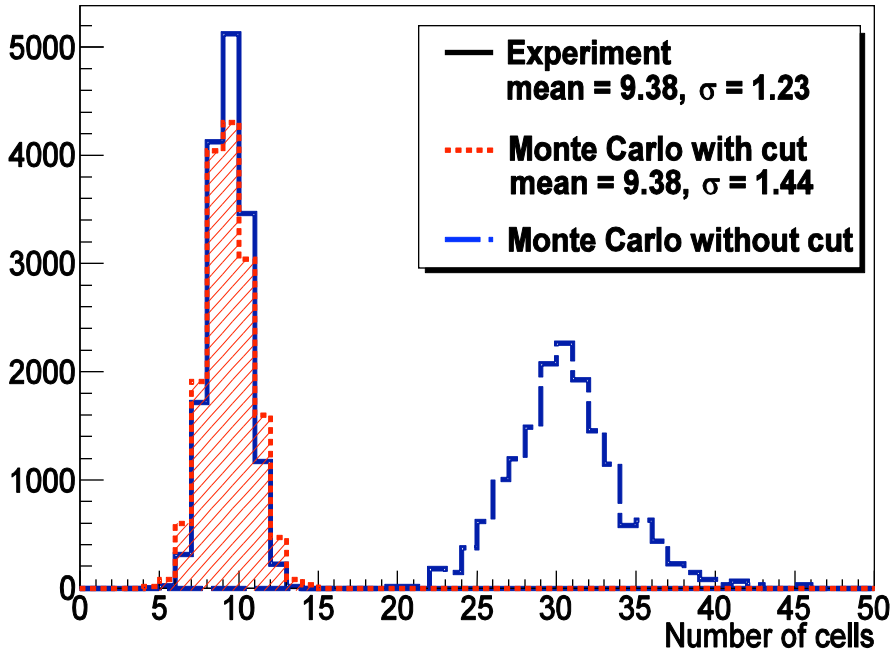


Monte Carlo simulation

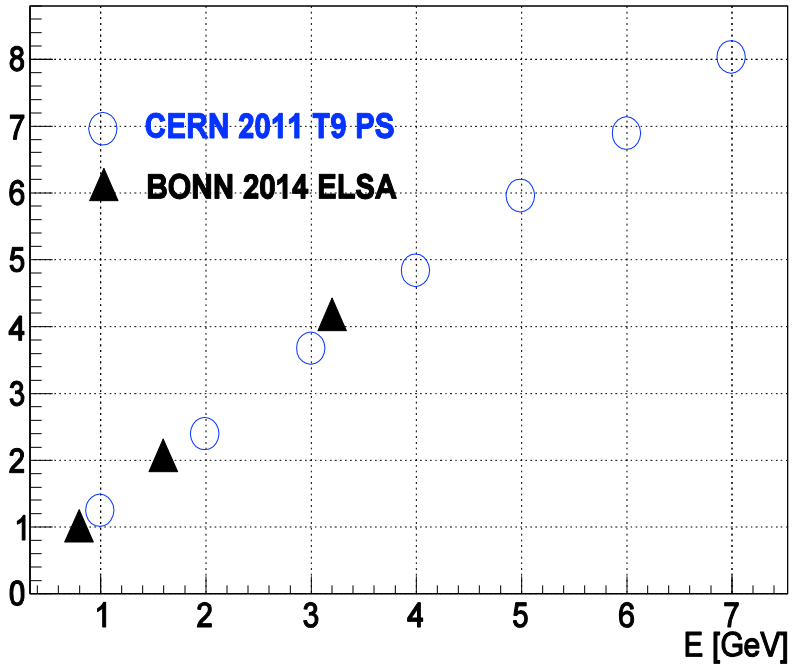
- Monte Carlo simulation was made with Geant4
- Geometry description includes all fibers, holes and steel fastening rods
- Physics list: QGSP_BERT
- Statistical fluctuations of photoelectrons were taken in account
- Different values of energy cut in towers were simulated in order to find the more realistic one

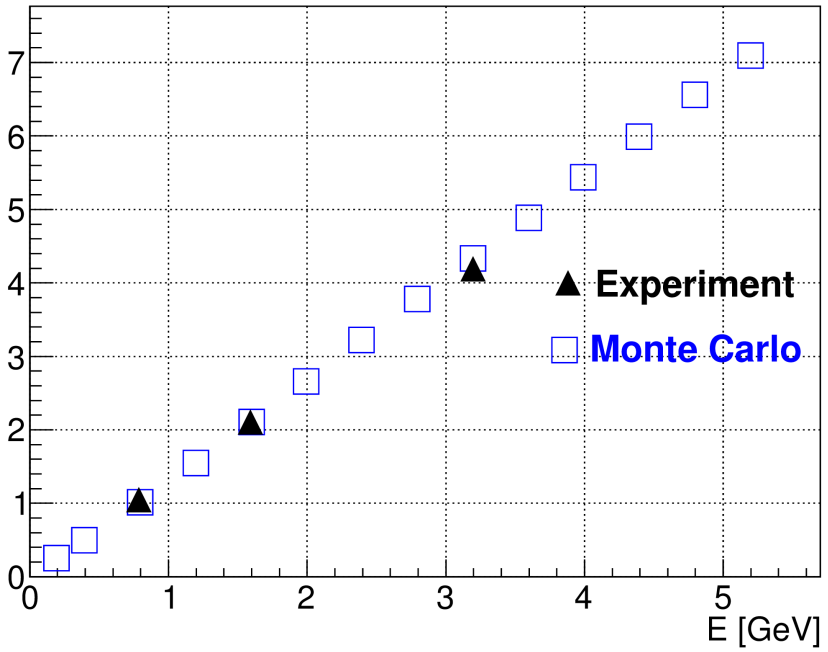
Comparing experiment and Monte Carlo



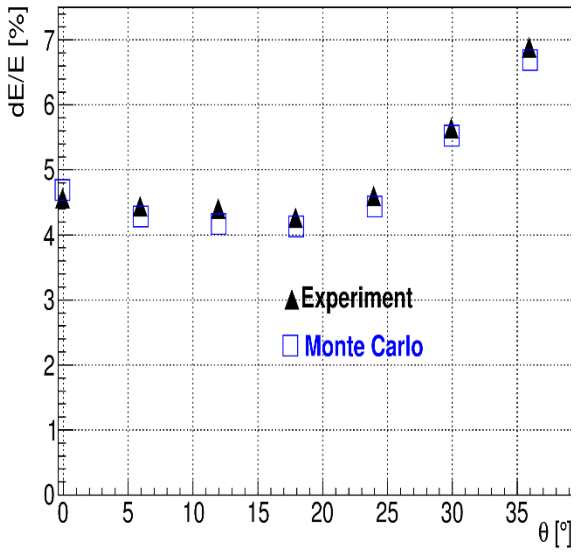


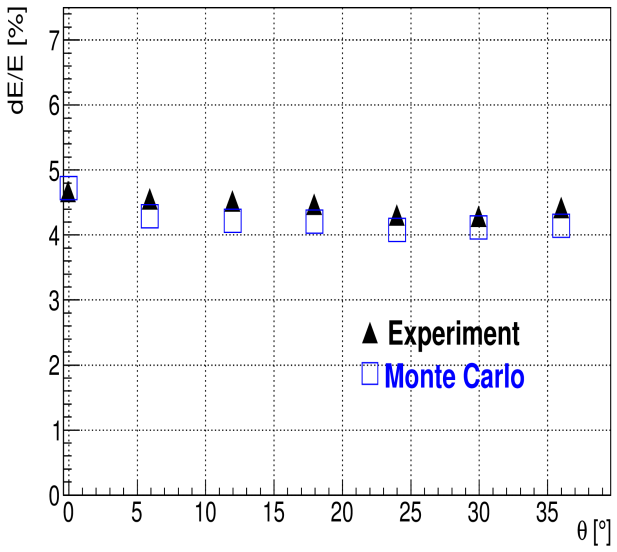
Linearity

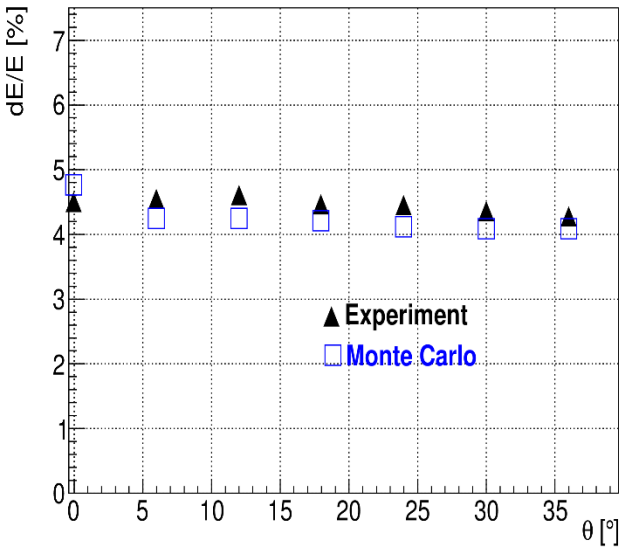

CERN 2011 T9 PS
BONN 2014 ELSA
E [GeV]


Experiment
Monte Carlo
E [GeV]

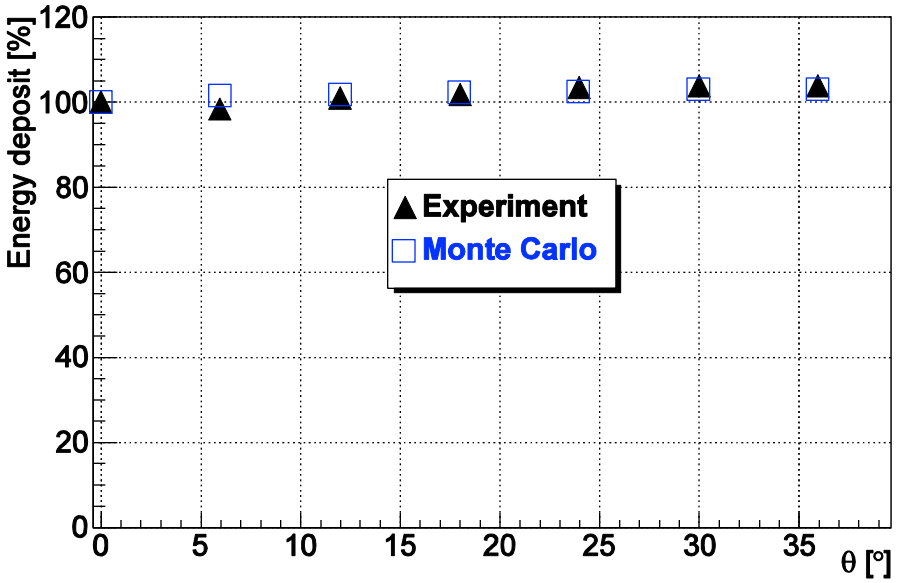
Angular response

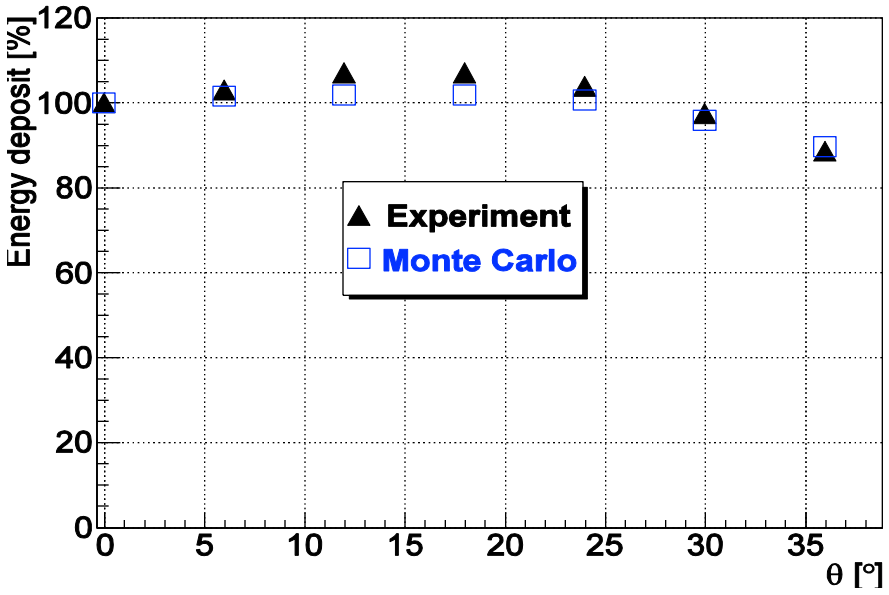






Angular response





Summary

ECAL0 is able to register gamma with big angle of incidence (up to 0.6 rad).

Results will be used for optimization of clusters reconstruction.

Results show good agreement with Monte Carlo simulation. That allows us to use it for more precise cluster reconstruction.