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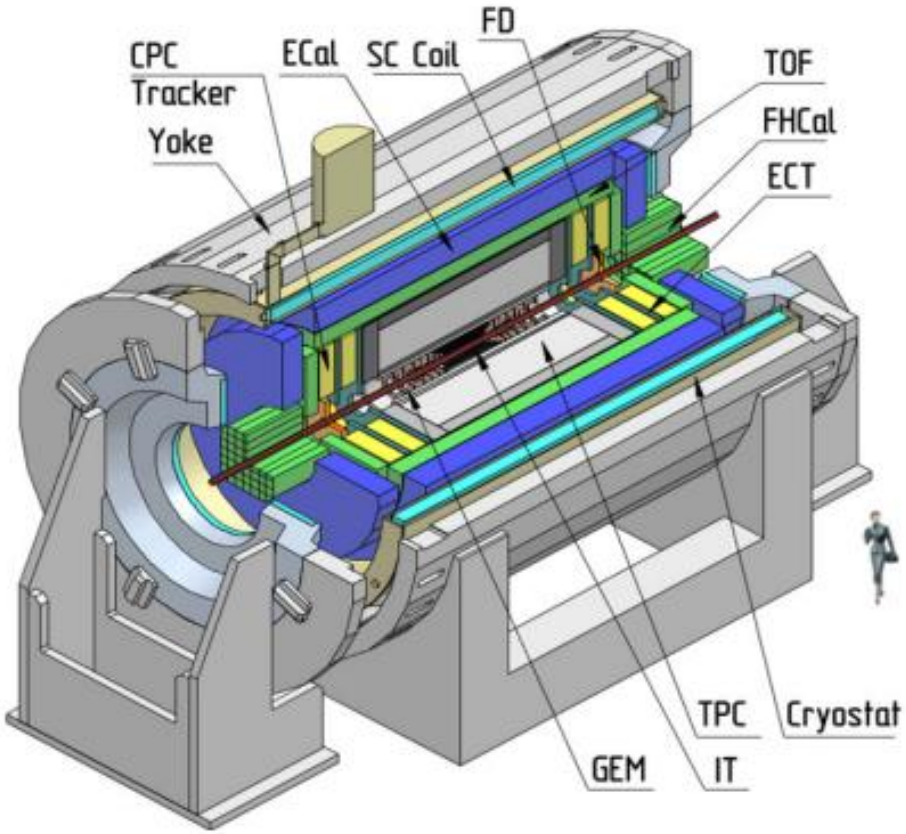

Simulation results of two calibration methods for MPD-ECAL

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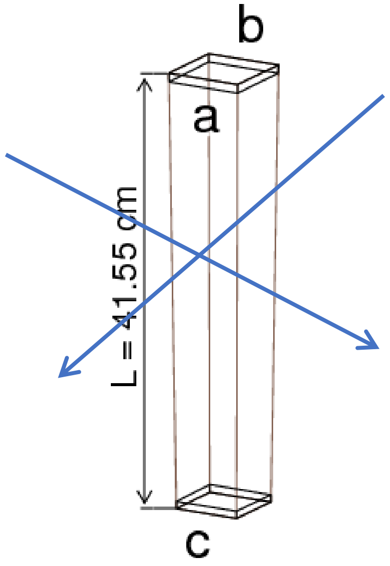
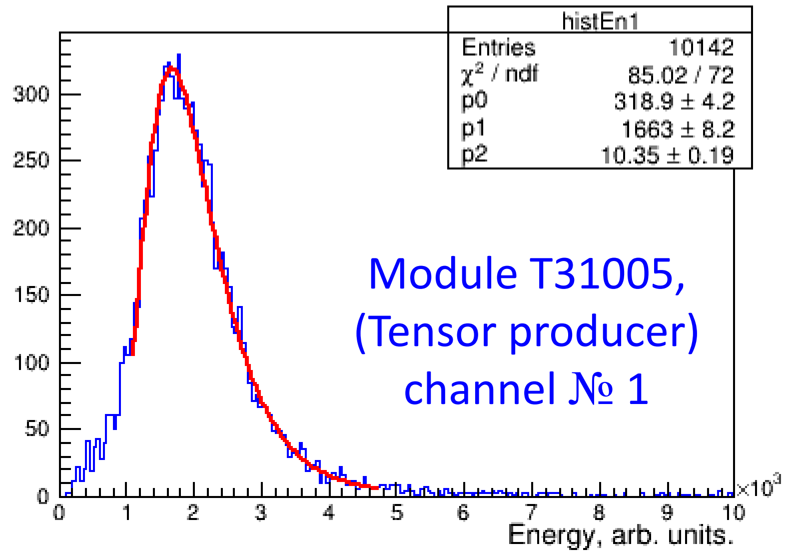
ECal geometry modifications

- Currently, the calibration of the entire number of calorimetric modules is being carried out by two different ways. In the first stage, a set of four modules is tested on cosmic muons installed in horizontal position using the same electronics for different modules. A large amount (> 1500) of such modules is tested yet.
- In the second stage, one basket (48 modules / 768 towers) with definite electronics is tested in vertical position. These calibration data can be used to align the signals from the towers in the future
- In the final stage, when all baskets will be installed into MPD detector, additional calibration procedure will be necessary
- This report considers the possibility of calibrating the calorimeter after its assembly on cosmic muons based on simulated data
- Simulation based in the frame of mpdroot with standard MPD setup and magnetic field.
- To produce cosmic muons, specific generator (class MpdCosmicGenerator) was created
- Based on simulated data, two possible calibration methods are considered, as well as algorithms for extracting the peak of deposited energy from cosmic muons in calorimeter towers
- Advantages and disadvantages of these methods are discussed, also dependence of the energy deposition peak from tower position in the ECal setup is studied

Calibration techniques

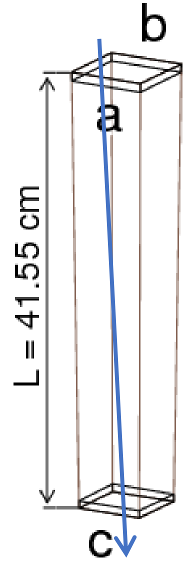
Method 1 : signal from inclined tracks





- ✓ Fast method, applicable for all tower rotation
- ✓ Energy deposition equal around 6 MeV, this value should be slightly depending from tower position
- ✓ Features of the applicability of this method on the full geometry of ECAL can be defined using MC calculations
- ✓ This method is used now for testing produced modules

Method 2 : signal from longitudinal tracks



- ✓ All muons in tower pass the same length
- ✓ Energy deposition equal around 60 MeV
- ✓ Method doesn’t depend from tower position
- ✓ It takes too long to collect the required statistics, possible not be applicable for highly inclined towers

Generator of the cosmic rays (muons)

✓ Parameterization of the cosmic ray spectra (atmospheric muons) obtained from experimental data and covers wide energy range

✓ Assuming a flat Earth is leads to $\cos^{N-1}$ dependence, where N – power of the energy distribution

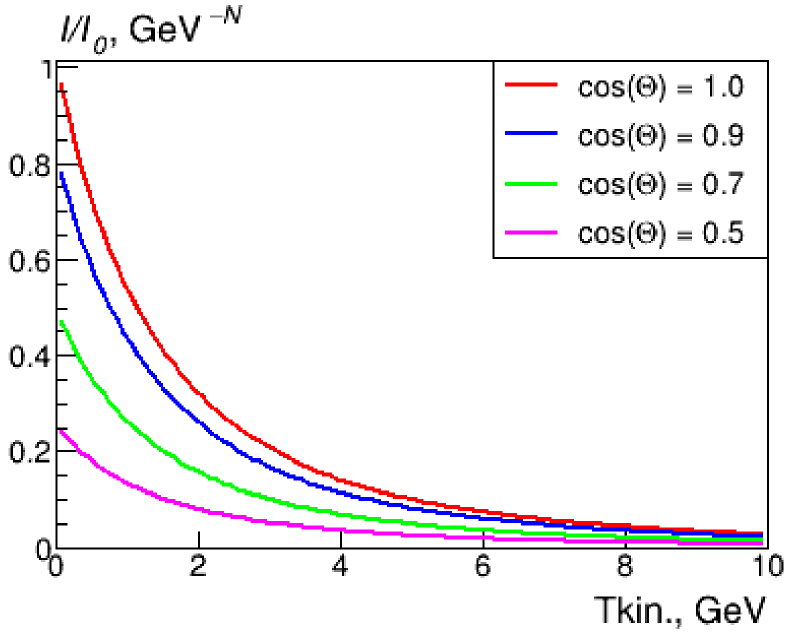
[P. Shukla, Int.J.Mod.Phys. A33 (2018) no.30, 1850175]

$$I/I_0 = (E_0 + E)^{-N} \times \cos^{N-1}\Theta/(1+E/854);$$
$$E_0 = 4.29, N = 3.01$$

✓cos Θ – zenith angle (Θ – angle between particle and perpendicular to the ground), E – energy; this formula is valid for muons, not for protons part

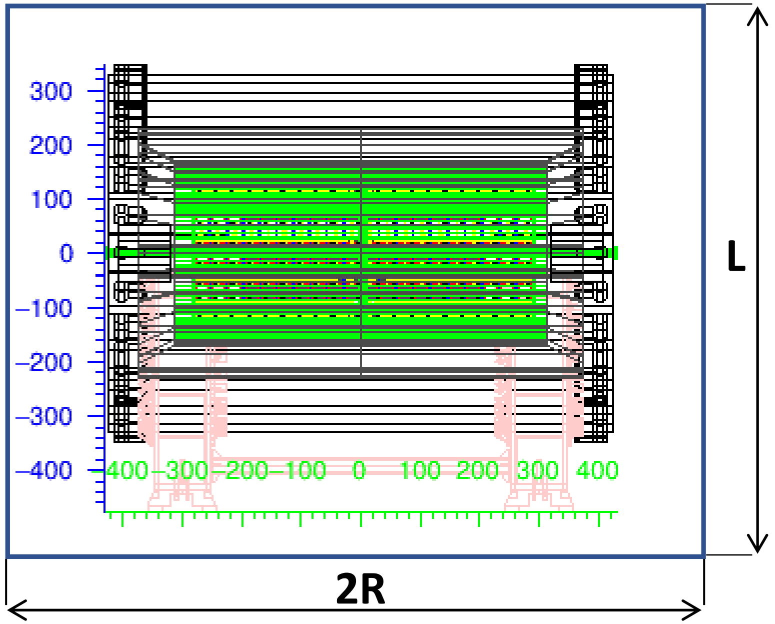
✓ This physical event generator was implemented in the frame of the mpdroot to produce 20x10^6 initial events in the standard root format

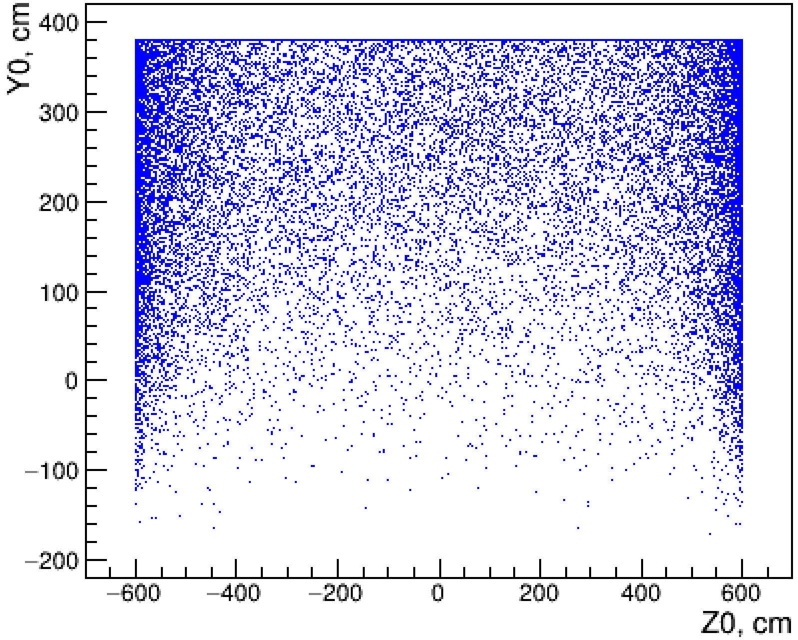
Cosmic muons energy spectra

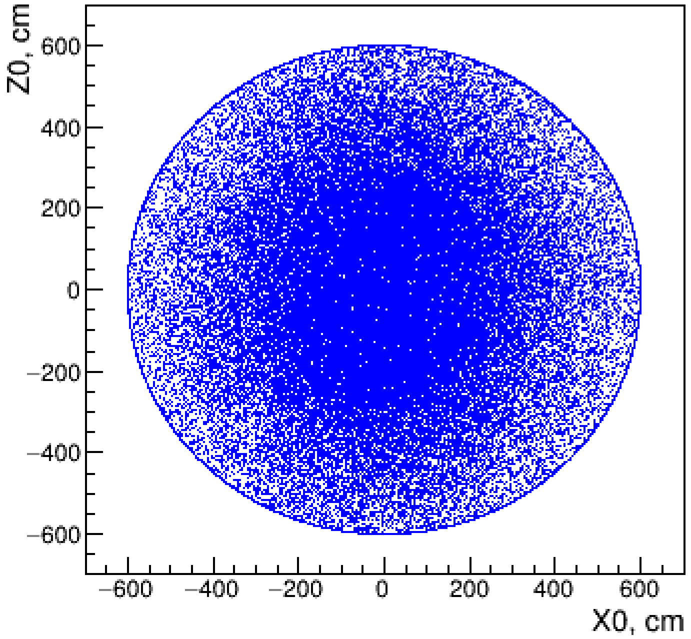


Initial position for generator

MPD setup

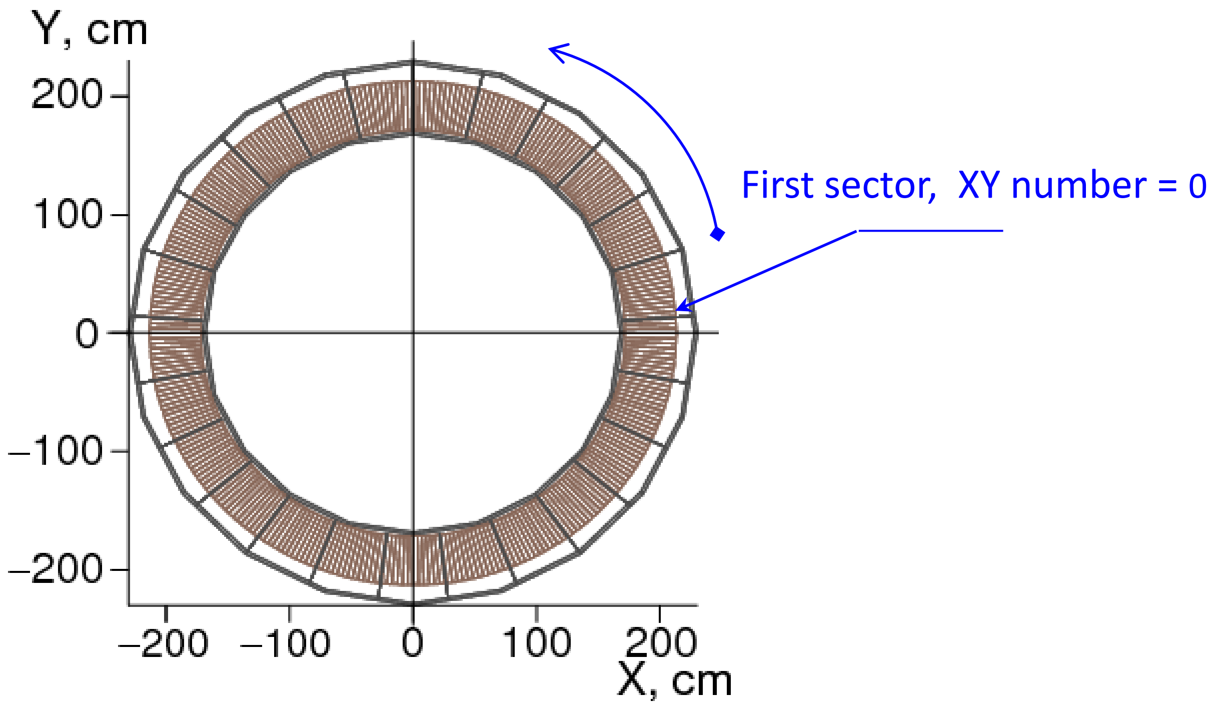


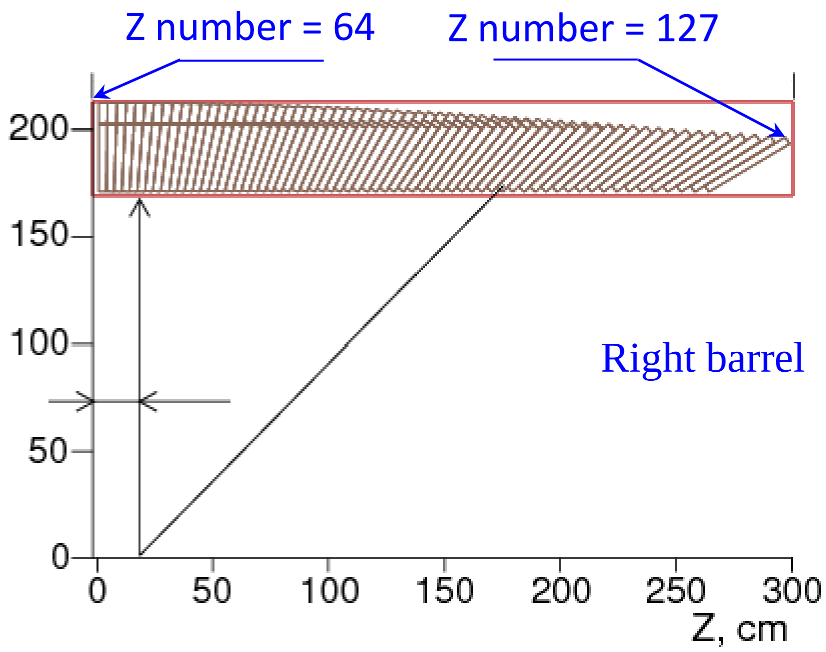




- Initial coordinates are defined by the surface of the cylinder (R = 600 cm, L = 760 cm) covering the experimental setup with some space margins
- To accelerate generation of cosmic tracks inside ECal, only those tracks are accepted for consideration that are directed to the ECAL area
- This cut suppress tracks produced in the bottom cylinder region with $Y_0 < 0$

Tower enumeration

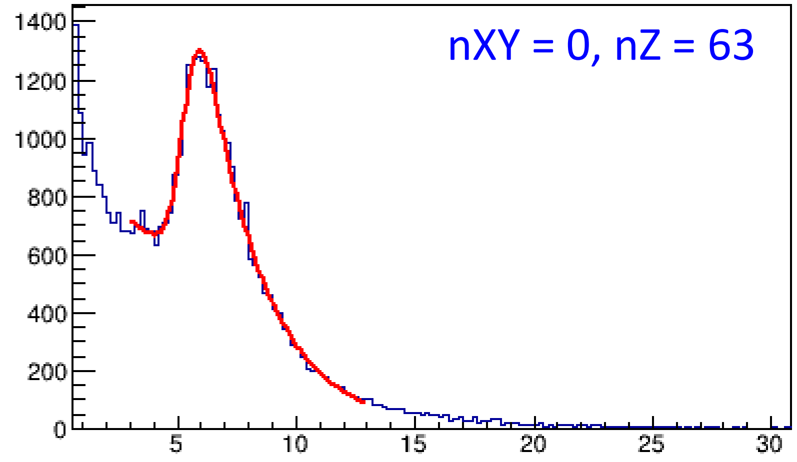


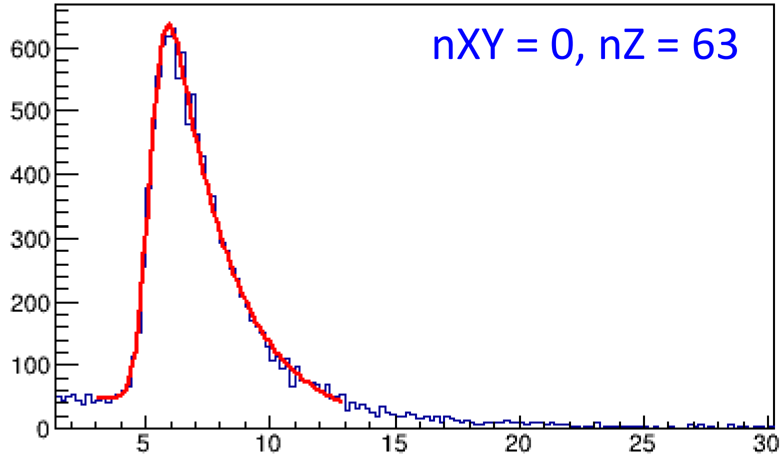


- Total number of towers : 38400
- Number of towers in *XY* plane (cross section transverse to *Z* – axis) : 300; step by ϕ – 1.2 deg. (ϕ start = 4.2 deg.)
- Number of towers in one line along *Z* – axis: 128; enumeration is starting from left barrel
- MC data were collected with total ECal geometry. To accelerate calculation signals from left/right barrels and from two adjacent towers in XY (same module) were summarized (number of such towers : 9600)

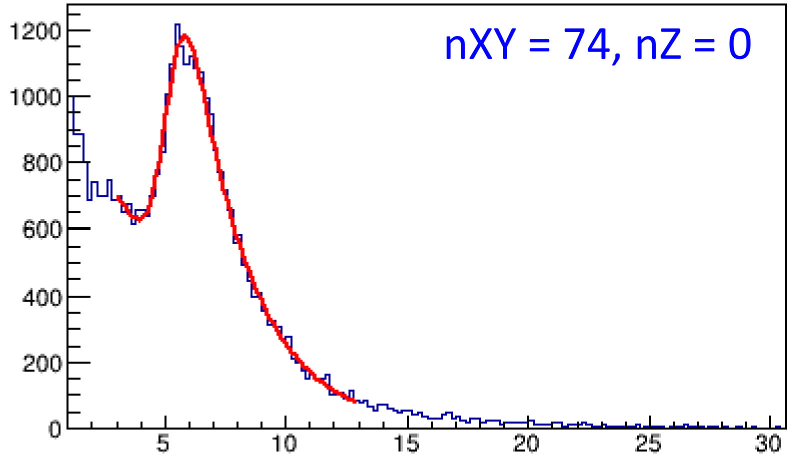
Selection of the tower signal

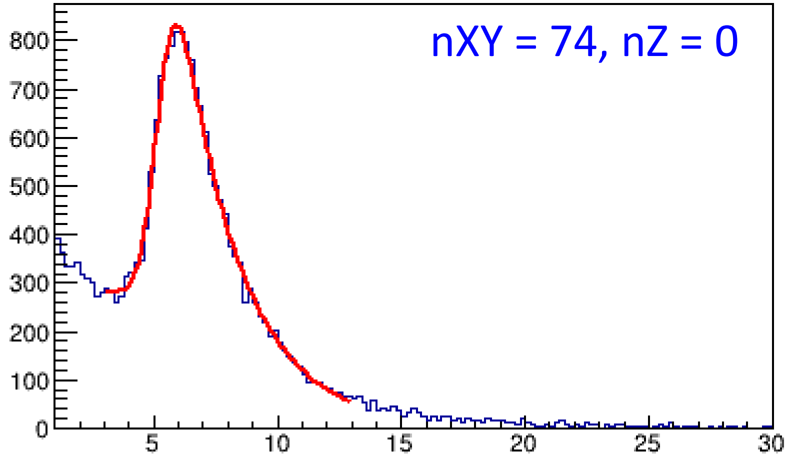
No selection | Typical view | Selection





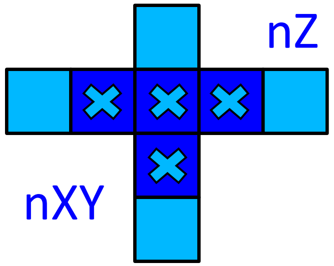
Border view





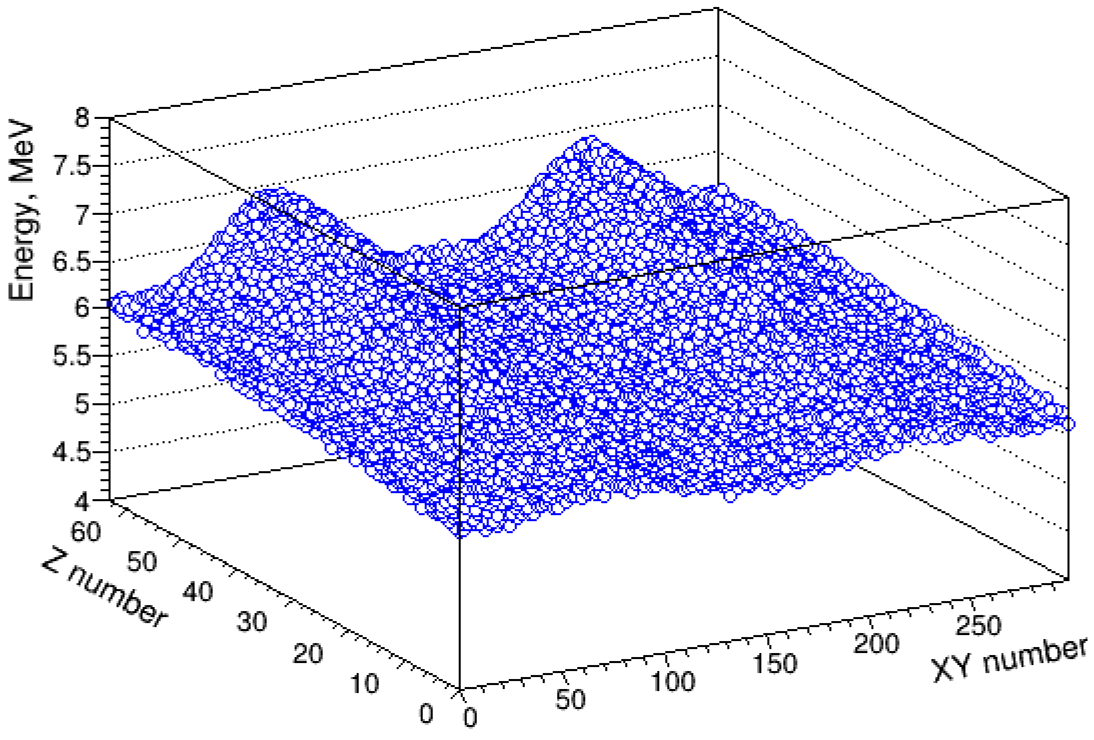
Energy, MeV

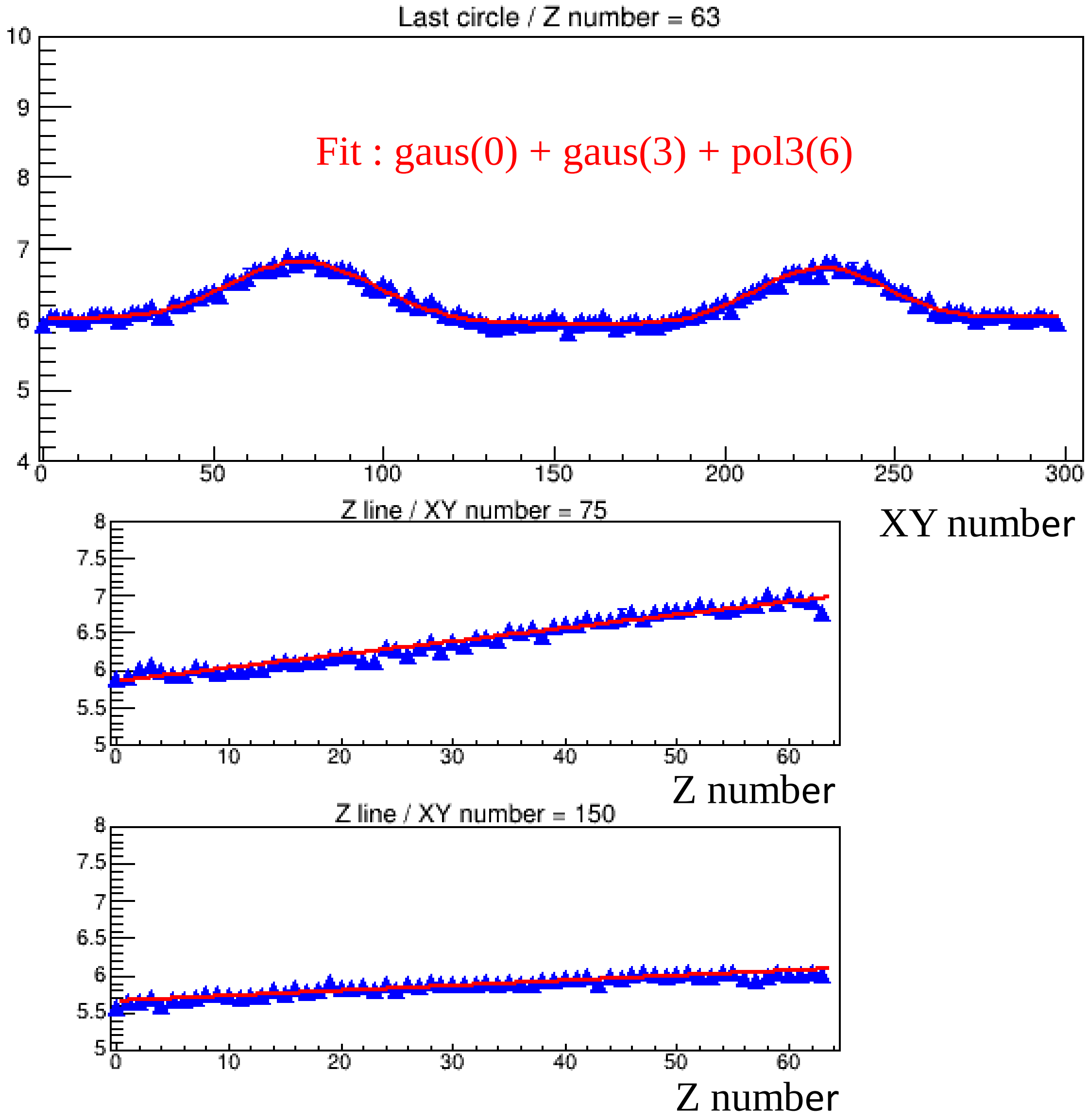
- ✓ Selection : triggered more than three, considered central (XY line and Z line are based on OR logic)



- ✓ It gives a good suppression of the low-energy background
- ✓ Border line of towers shows less background suppression, but the main peak is clearly visible due to the tower incline
- ✓ For all towers: total number of selected events : 0.9×10^8

Deposited energy vs tower position

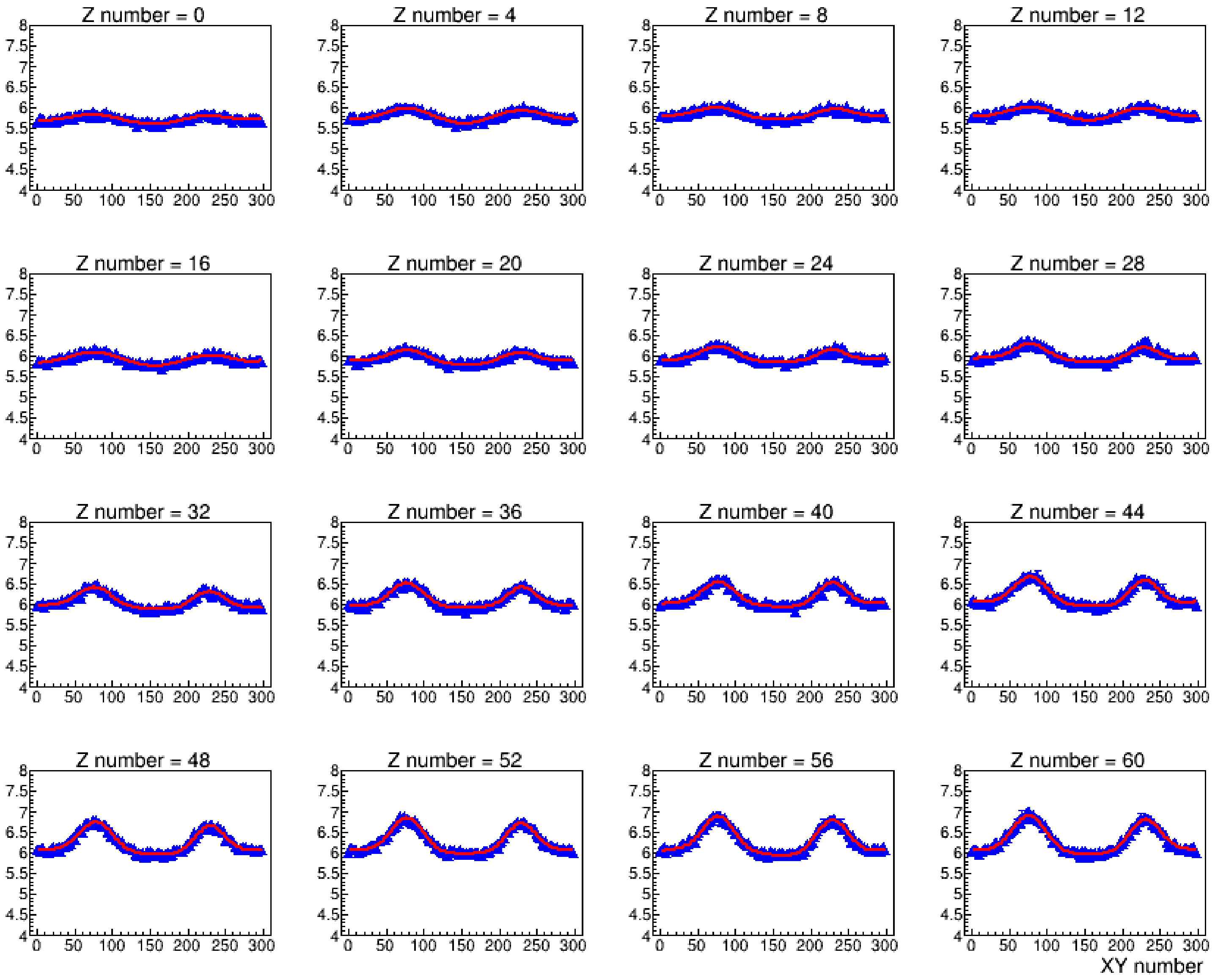


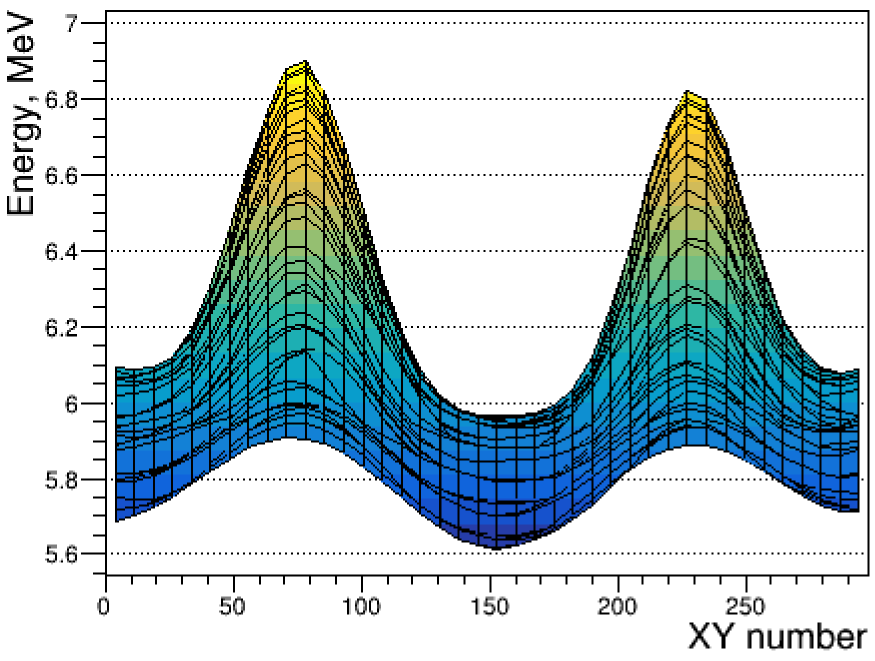


- 3Dim shows mean deposited energy versus tower position
- Dependence is not flat and can be fitted by a set of functions
- At fixed Z position every slice is described by :

  2 Gaussians + 3rd degree polynomial function

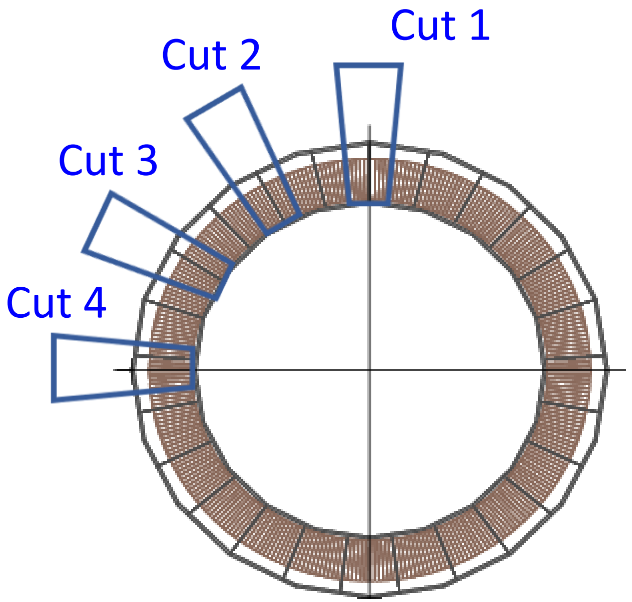
Tower deposed energy approximation

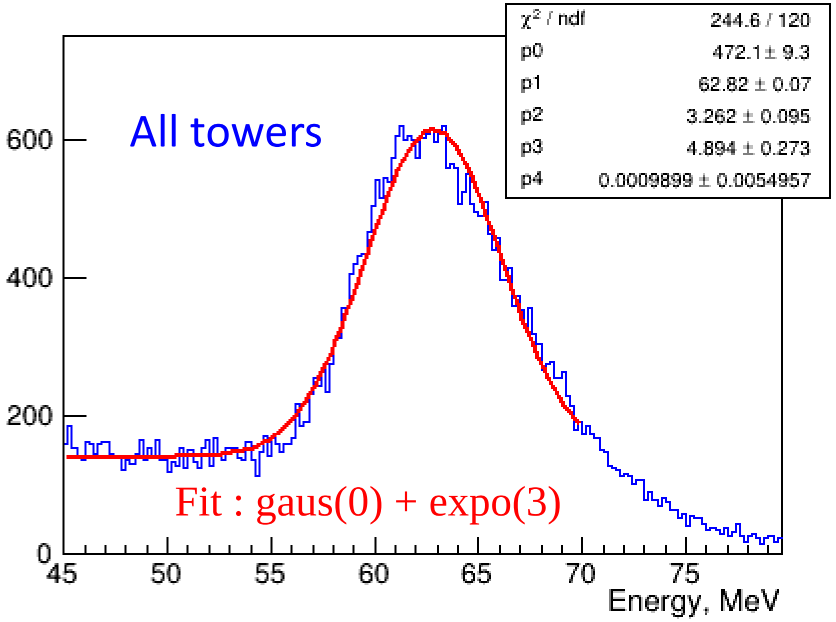


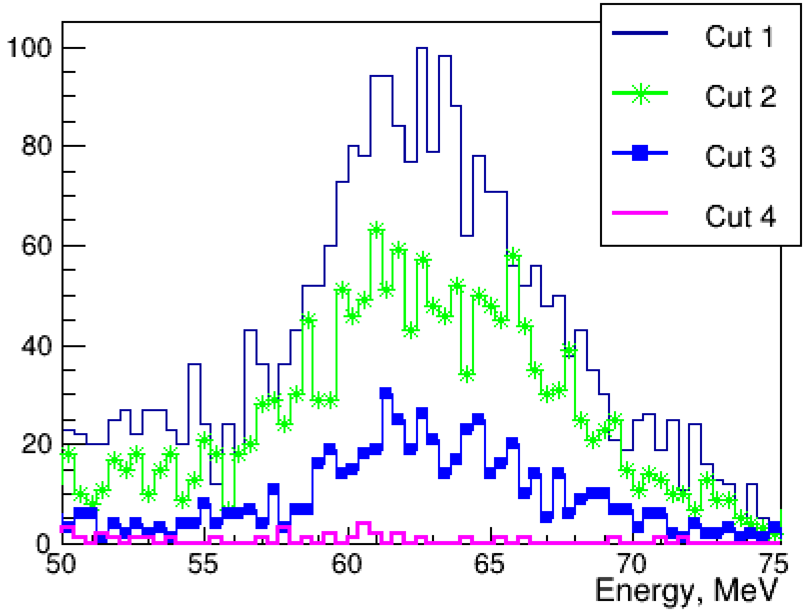


- Fitting procedure were done in XY plane for each Z – number
- Final result – array of the resulting functions with size equal to 64
- 3Dim profile of array looks smooth

Signal from longitudinal cosmic muons

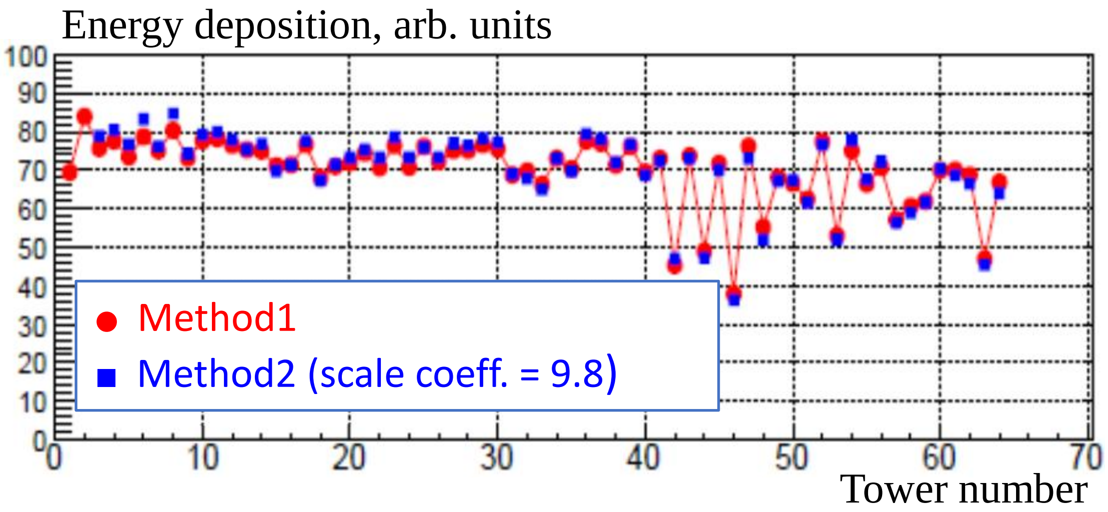


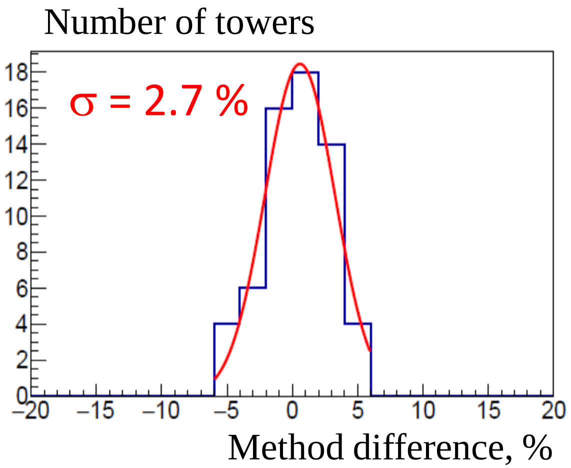




- The central tower is triggered, there is no signal in the neighboring towers
- In this case, an energy deposition should be the same for all towers in the complete ECal assembly
- Tower signal is taking into account in that case the deposited energy > 1 MeV
- For all towers: total number of selected events (sum under energy deposition peak) ~ 20×10^3
- Cut 1 – Cut 4 means different limit on iXY number and all iZ numbers (width equals to 10 line along iZ)
- Signal is absolutely suppressed for Cut 4, that corresponds to the horizontal component of cosmic muons

Comparison of two methods (exp. data)





- ✓ Data were collected on cosmic data measurements during a long time data taking
- ✓ Experimental setup was represented by one cluster (one line : 2×64 towers) located horizontally
- ✓ Plots shows data from first 4 modules (64 towers) in the beginning of cluster
- ✓ Two peak were found and fitted by the same functions
- ✓ Positions of these two peaks show the same behavior and can be compared using definite scale factor
- ✓ Methods are in good agreement with accuracy of 2.7 %

Conclusion

- Two methods of the ECal calibration were tested on MC data. For this task , cosmic generator were done to collect data in the frame of the mpdroot. Total number of the generated events is 20×10^6
- For inclined muon tracks, were energy deposition energy is ~ 6 MeV, simple selection was implemented to obtained a good view of the energy deposition distribution. This method depends from tower position in the total ECal setup. Peak location as a function of the tower position is defined and described by a set of the fitted functions
- Next method, based of the registration of the longitudinal tracks, was also tested. Selection by the absence of signals in neighboring towers made it possible to identify such a peak with an average energy release in the region ~ 60 MeV
- Both method are applicable for vertical position of the towers. For inclined towers, especially at angles around 90^0, second method cannot be applied

Thank you for attention