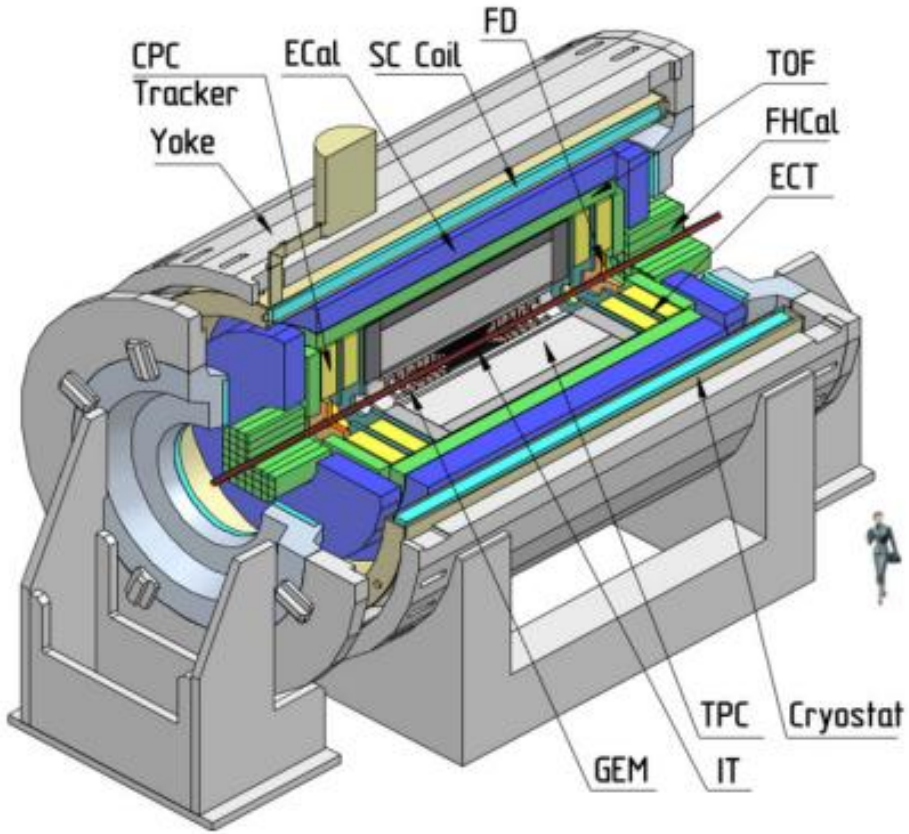
NRC «Kurchatov Institute», Moscow,
Russia



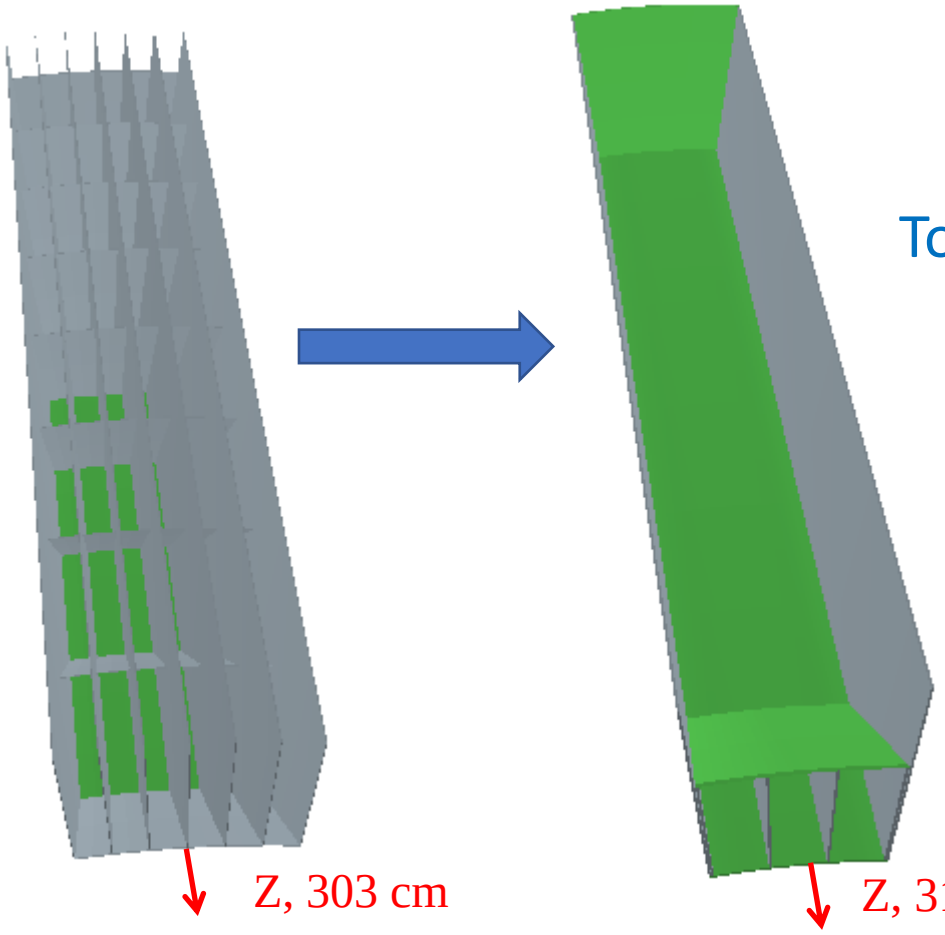
ECal geometry modification (version № 4)

M.A. Martemianov

ECal geometry modifications

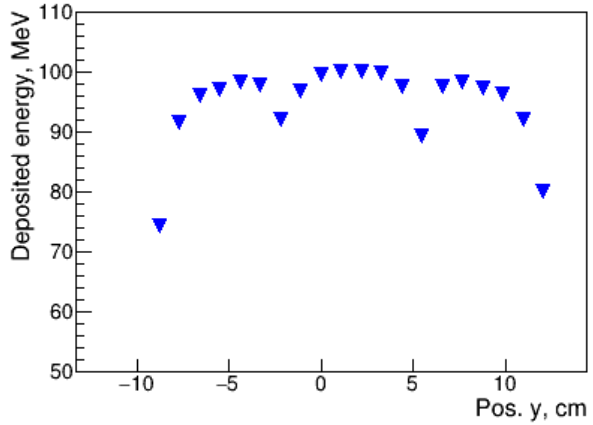
- Recently, the full design of the ECal / MPD was completed, but some aspects of the module supporting structure, their strength characteristics and electronics layout were under discussion in recent years. Now, all these problems are solved, and final version of the supporting structure (basket, power frame, etc) are in the manufacture process
- These modifications resulted in a slightly different arrangement of modules, but more homogeneous ECal structure.
- A new basket design and dural electronics support structure was implemented
- Details of the support structure outside the module area have been added to complete the surrounding passive materials that are the source of the backgrounds
- Other main geometry parameters, as structure of the separate modules and their total number remained the same one. Geometry hierarchy has the same structure as in version № 3
- ECal geometry is stored in the ROOT – file (~mpdroot/geometry/emc_v4.root)
- Reconstruction soft (MpdHitCreation, MpdClusterCreation) was changed and placed in ~/mpdroot/emc. It works faster, and useful to perform simulation of the ECal for calibration measurements

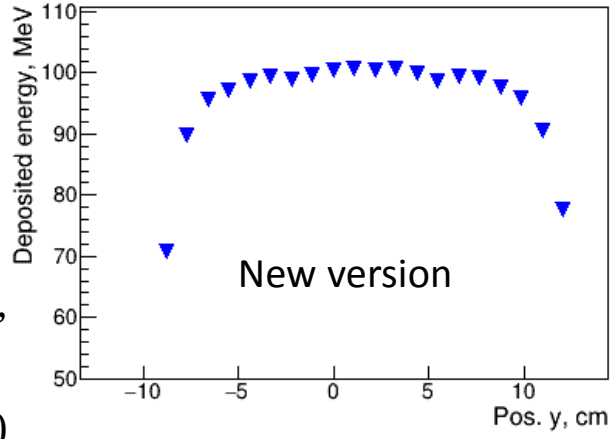
Basket modification



Basket (last version).
Top cover is not shown.

MC for stand of three modules on electron beam at 300 MeV

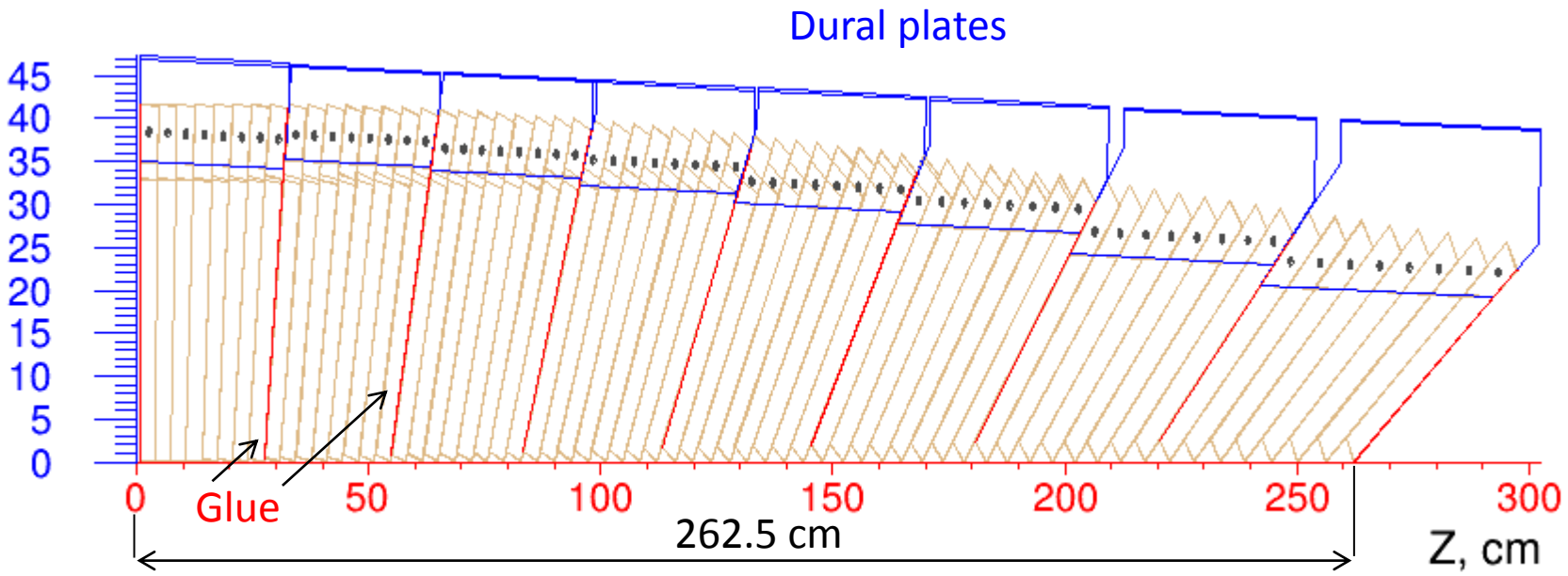




✓ To achieve strength requirements all modules in sector (basket) were separated by walls. But, both MC and calibrating measurements have shown large loss of the deposited energy

✓ New version of baskets has only outer walls produced from 6 mm fiberglass (ρ = 1.9 g/cm^3) that is thicker than at previous version (2 mm)

Module modification



➢ Towers are fixed into modules by special glue (thickness = 0.02 cm). Glue is a Ti – epoxy mixture : H (4.9 %) + C (46.1 %) + Ti (16.5 %) + O (32.5 %)

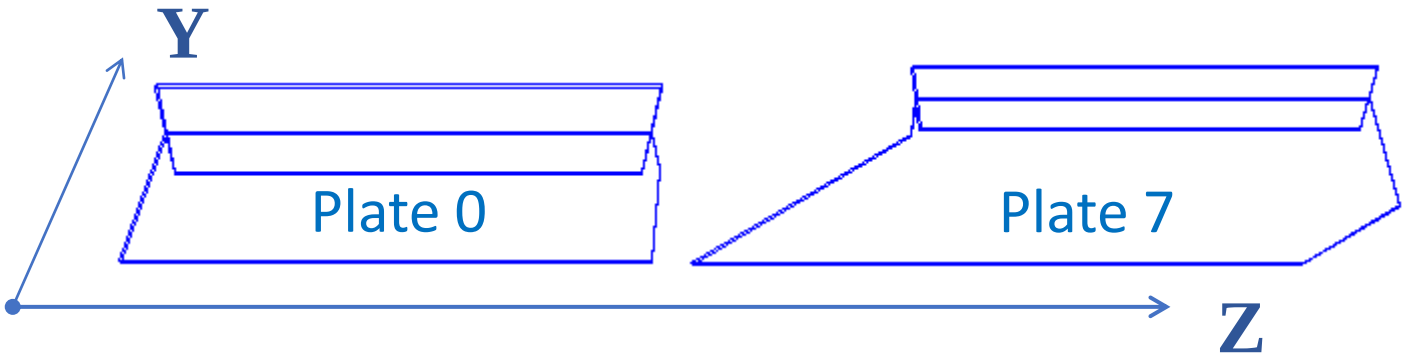
$\rho = 1.2$ g/cm^3, $X_0 = 26.51$ cm

➢ Dural plates are embedded in the tower matter of modules and are intended to fix the electronics

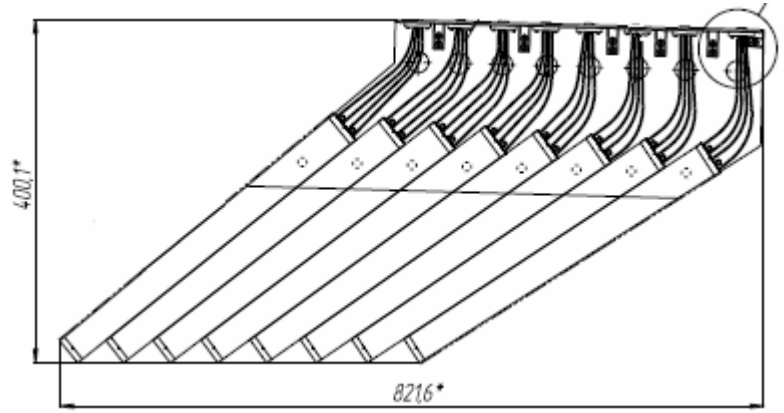
➢ Plates of 3mm thickness are different by sizes and shapes and made due to special drawing proposed in the JINR design department

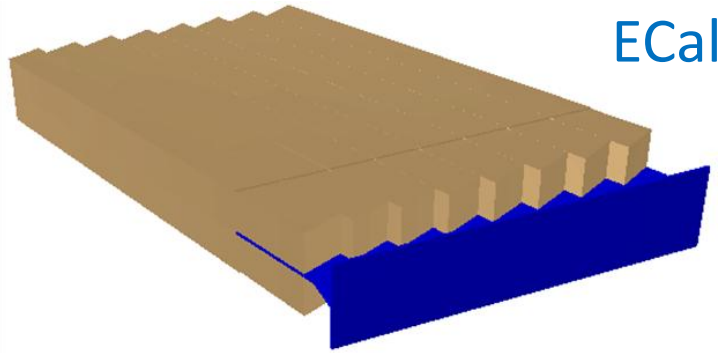
➢ MC (cosmic muons, test on the module assembling) gives 2 % loss of the deposited energy in comparison with previous geo-metry version (no plates)

Tower shape changes

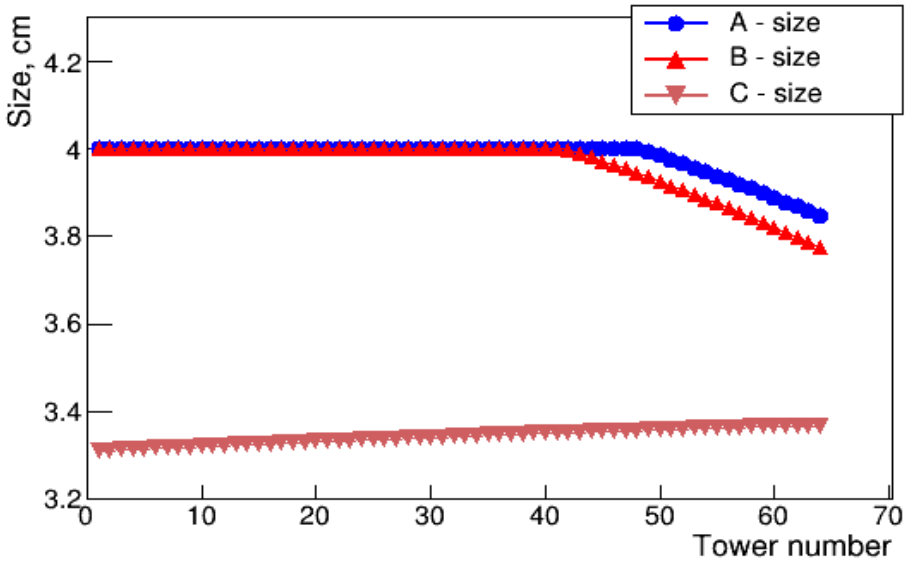


Scheme of ECal module 7

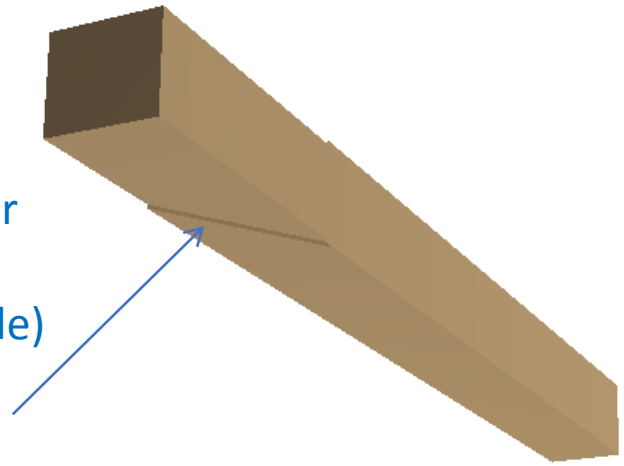




ECal module

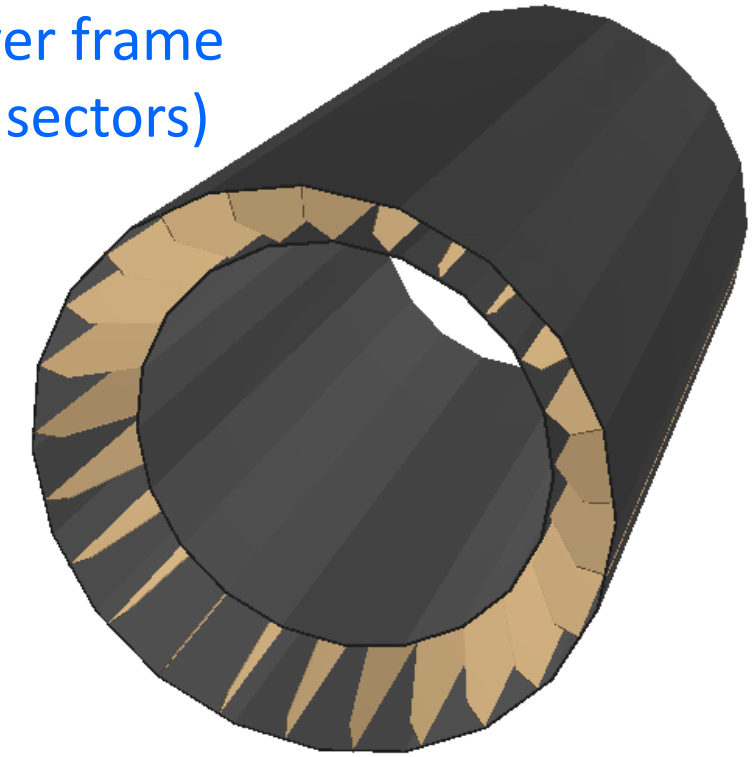


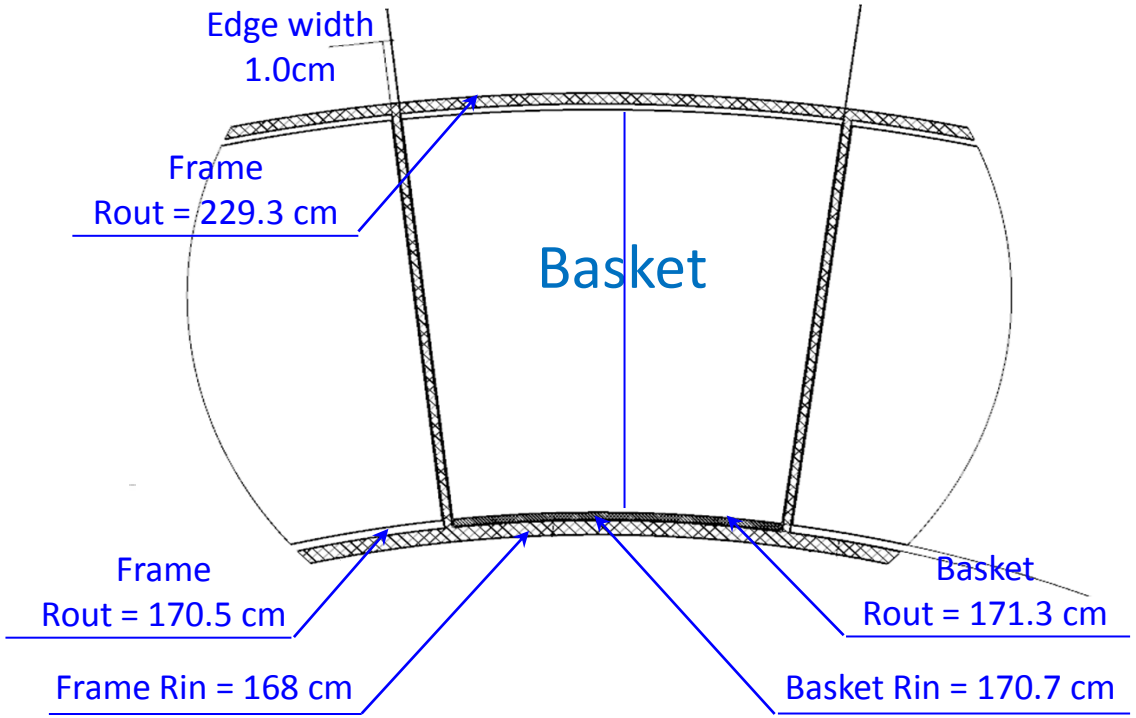
Two cut-outs for plates (on both tower upper side)



Large power frame modification

Power frame
(25 sectors)



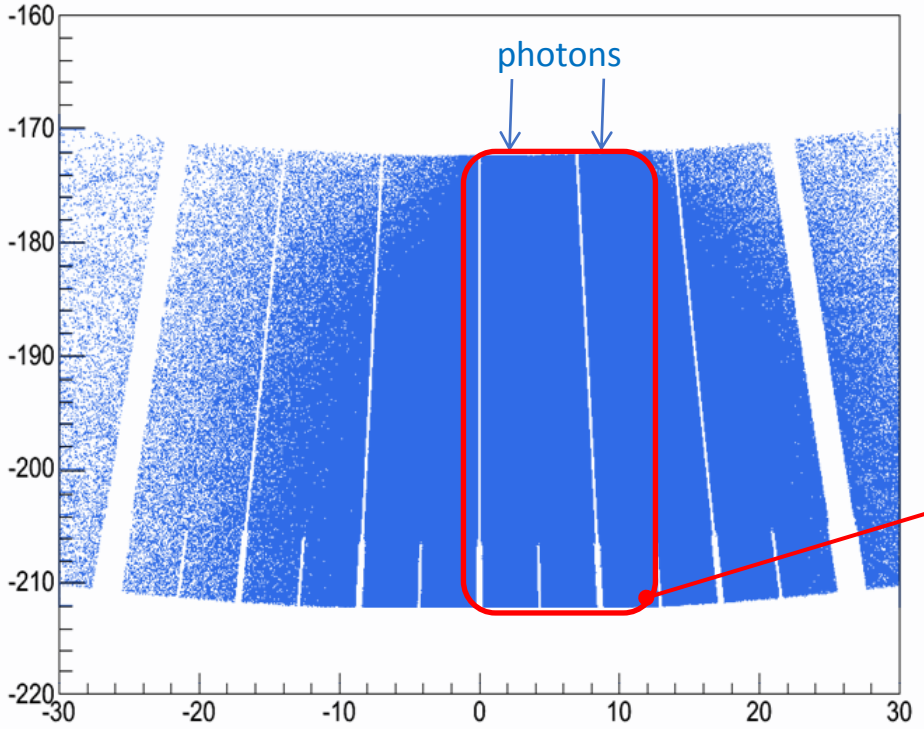


- ✓ Full power frame was implemented in version 4 : inner length = 624 cm, outer length = 746 cm
- ✓ Material – carbon composite. For MC used mixture (graphite + epoxy) :

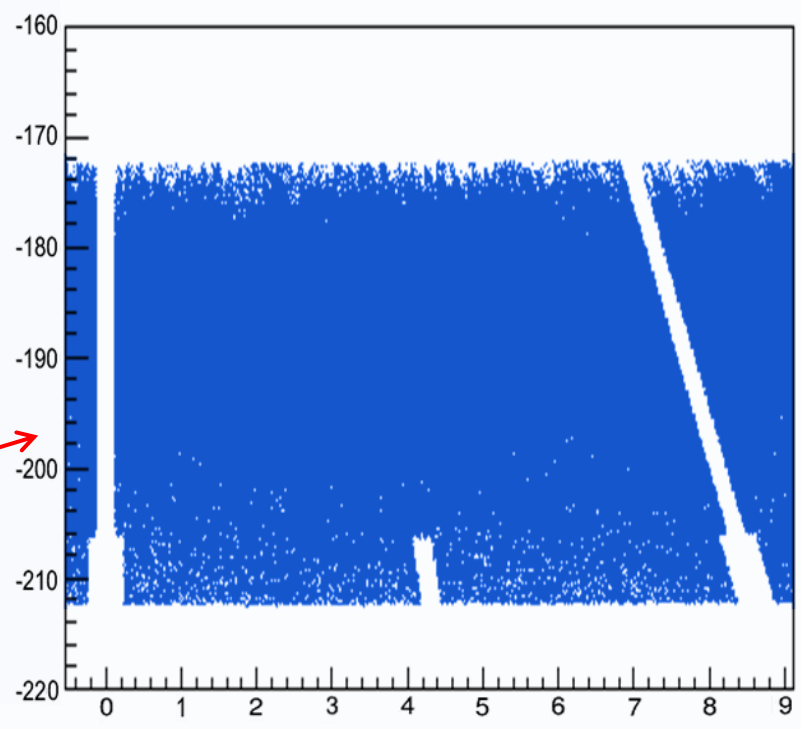
  H (7.4 %) + C (80.9 %) + O (11.7%), ρ = 1.38 g/cm^3, X_0 = 30.4 cm
- ✓ Modules are located at an inner radius ~ 171.3 cm (version3 radius = 171.56 cm)

Tower geometry check with MC points / I

One ECal basket (sector) X vs Y



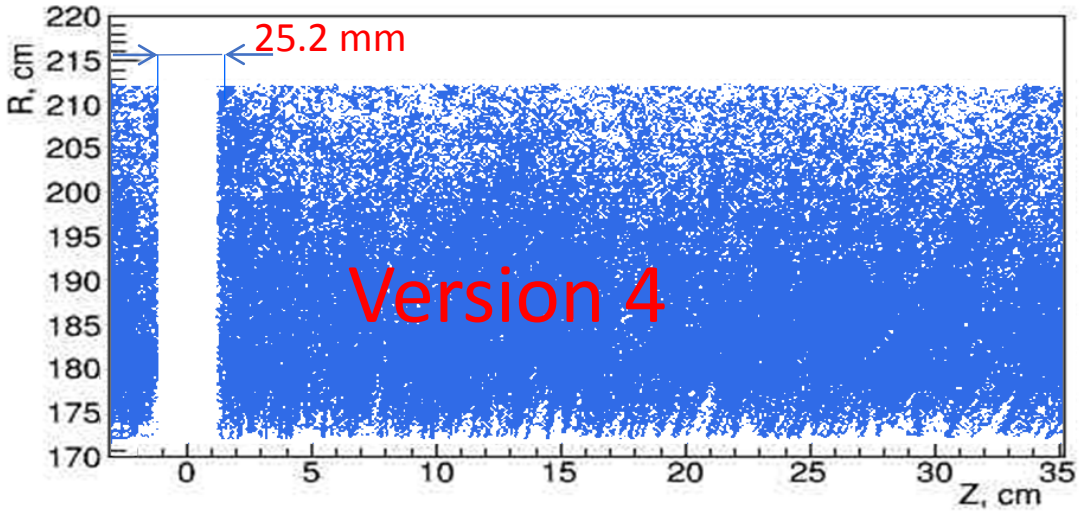
One ECal module X vs Y

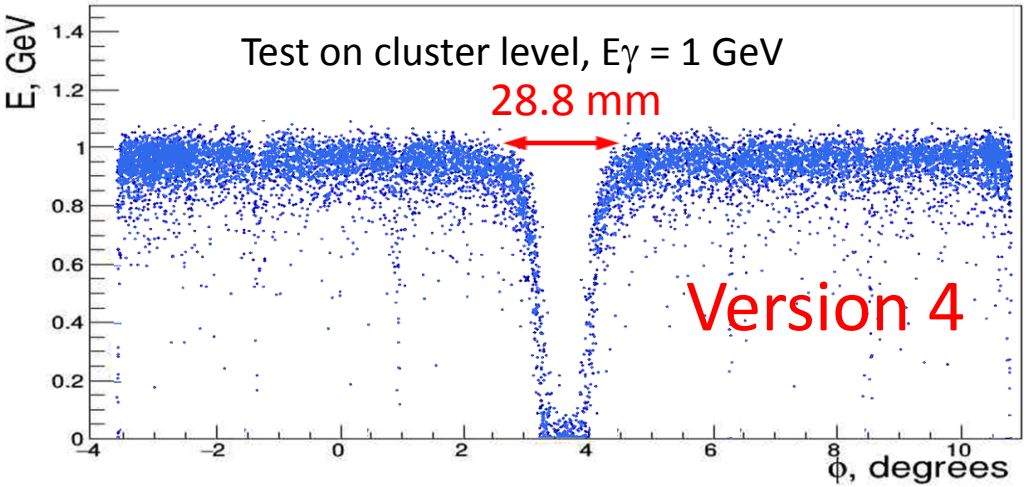


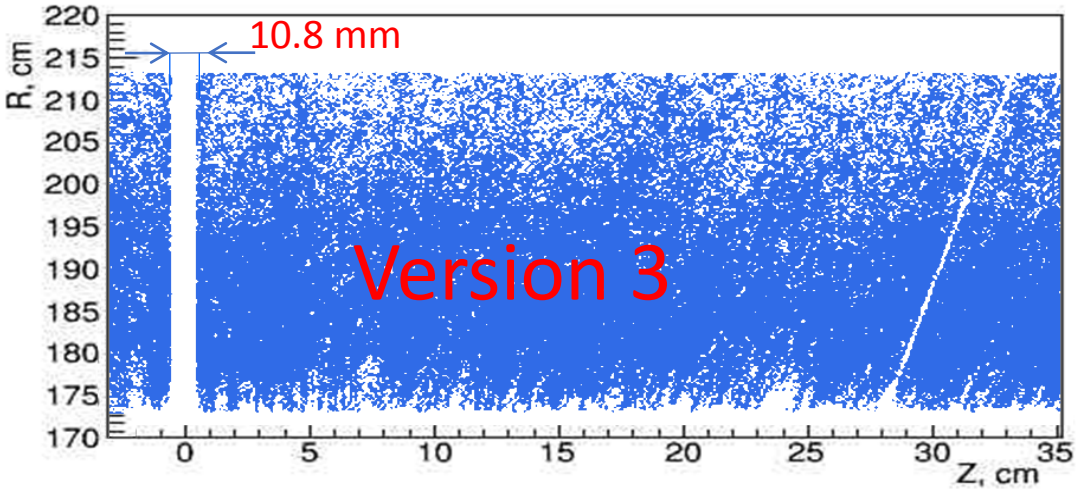
✓ Energy points in (6 modules) of the ECal are produced by 1 GeV photons. Passive elements of the calorimeter are visible: walls between sectors and modules, support plates in modules (left)

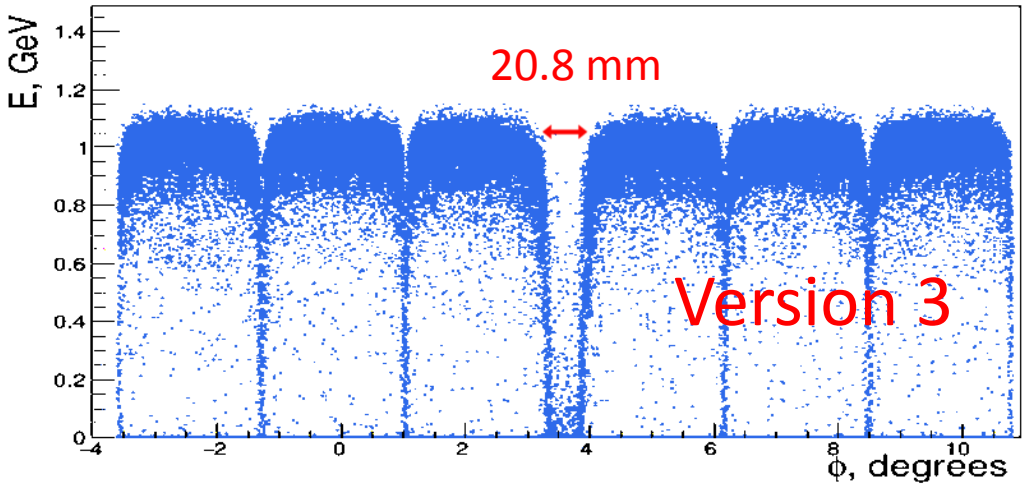
✓ One module view confirms the correct insertions of the passive material to the module for support of an electronics platform

Geometry check with MC points and clusters / II



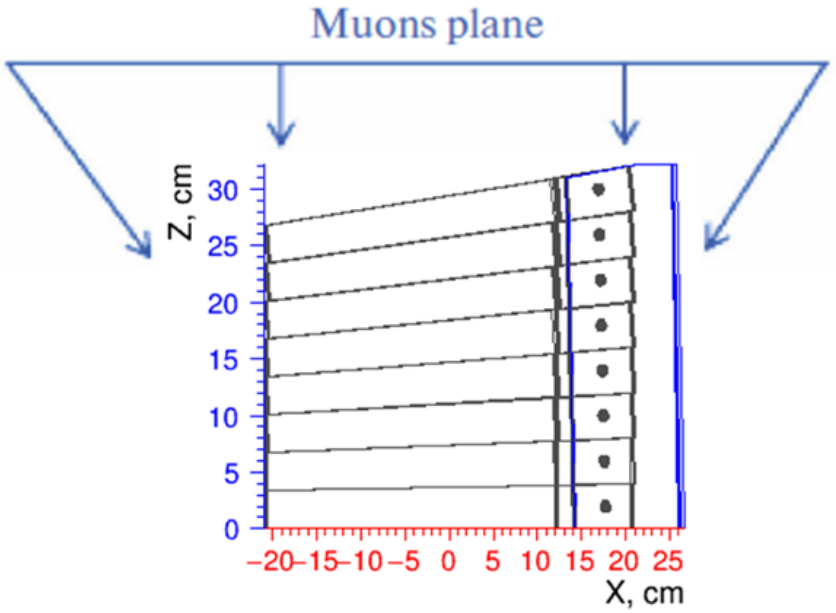


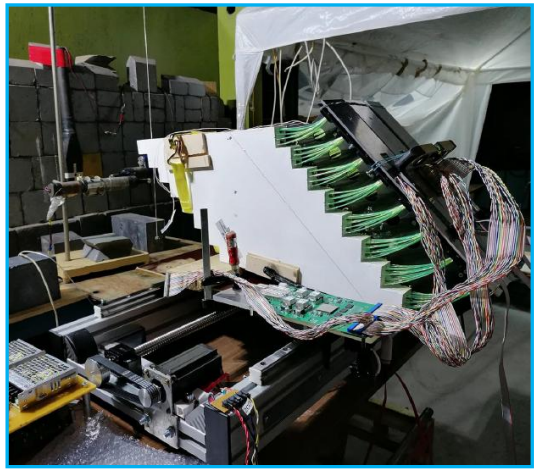


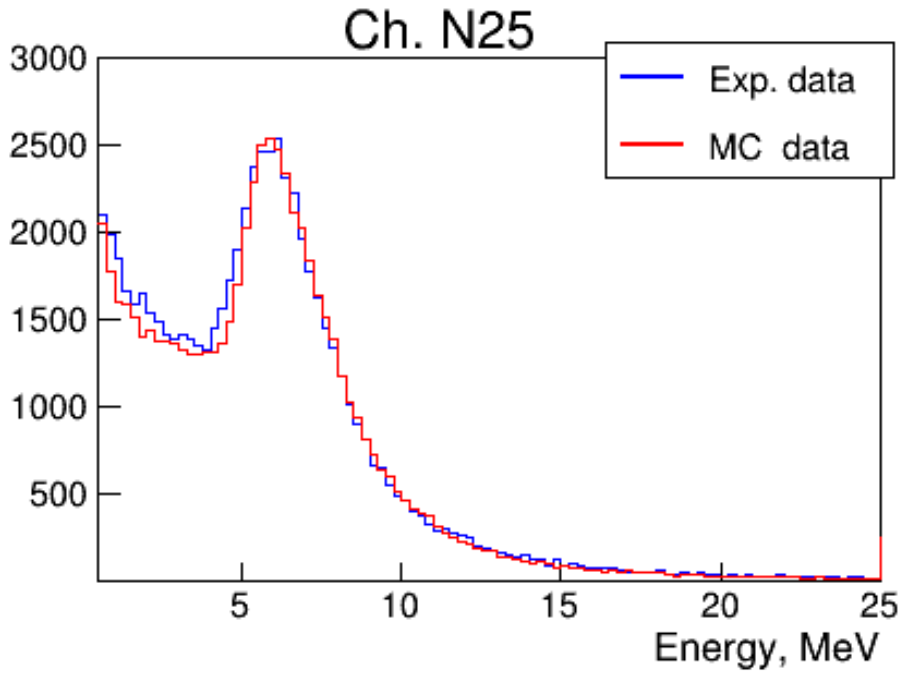


✓ Plots show Geant4 points for 1GeV γ's . Basket parameters in version 4 has been significantly changed. There are only outer walls (thickness = 0.6 cm), but in the center one wall has thickness = 1.2 cm that results in an inactive space around 25 mm in Z-direction

MC and cosmic data comparison







✓ Experimental setup has an assembly of three modules (48 towers, 6 in YZ × 8 in XZ – planes)

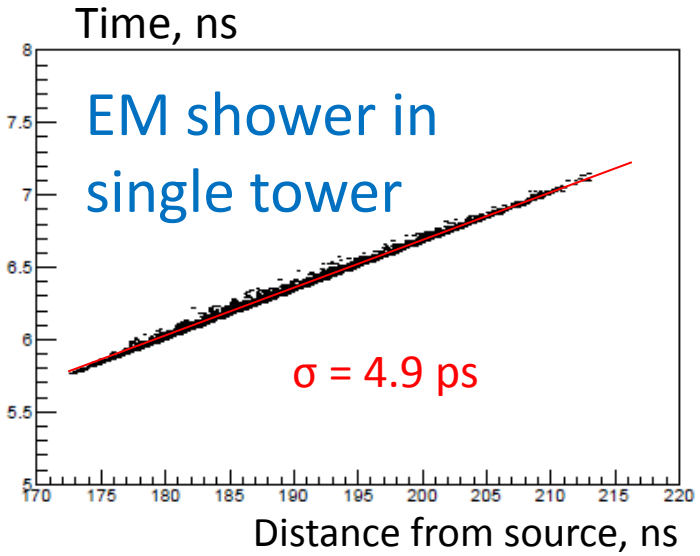
✓ Primary calibration was done on cosmic to align the response of each tower

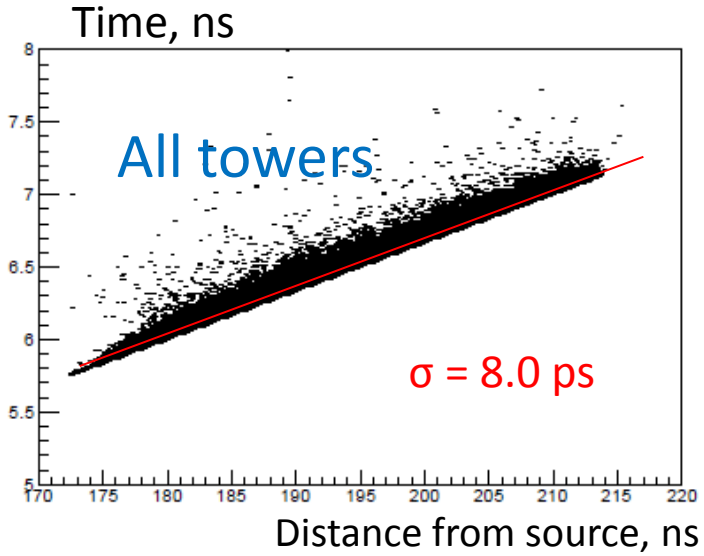
✓ Cosmic ray generator : ray flux at sea level has $\cos^{N-1}\Theta$ (N = 3.01) dependence, muons are produced as function of energy (0 – 10 GeV) and zenith angle (Θ) [*P. Shukla, Int.J.Mod.Phys. A33 (2018) no.30, 1850175*]

✓ For horizontal towers, a mean energy deposition in one tower ~ 6 MeV. Experimental and MC data (version 4) are in a good agreement

✓ Comparison experimental data with MC gives conversion factor from ADC to MeV

MC time hit definition





✓Software for MPD / ECal updated. It works fast and useful to make simulation for calibration

✓Time for 1 GeV photons

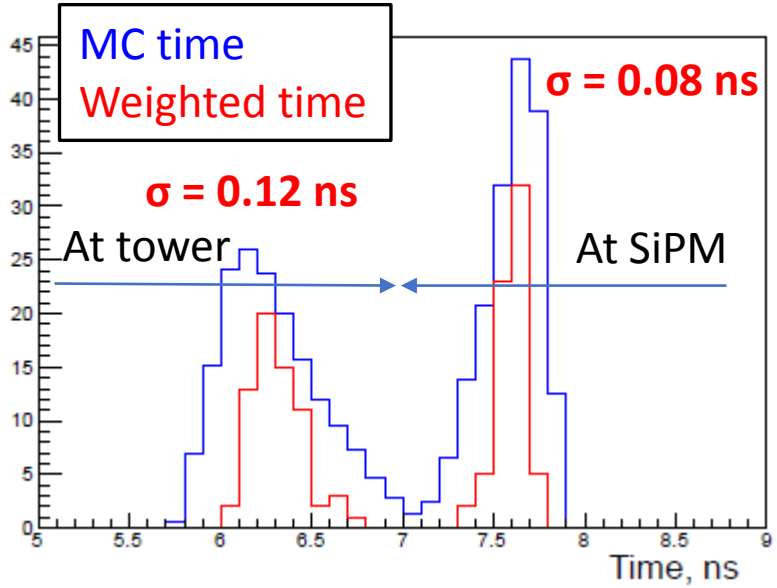
✓ Energy-weighted time spread of electromagnetic shower is on the level of few ps

✓ In the MpdHitCreation file new definition of time for separate tower was used

✓ For each MC point in tower we calculate the time for photons to reach SiPM through the WLS fibers

✓ time = $time_{MC}$ + (0.5×tower_length – localZ_pos.) ×Coeff_ref./Clight, where tower_length = 41.55 cm; localZ_pos – local position of point in the tower; Coeff_ref. = 1.6 (WLS fiber refraction coefficient)

✓Final hit time is weighted by energy of each point time in one tower



Conclusion

1. Additional modification of the ECal basket implemented in the past year leads to more homogeneous structure of the ECal. This improvement caused a change of all tower coordinates along OZ – axis, which are presented in the new version of the ECal geometry. Also, new geometry has supporting dural plates to fix electronic parts, which is an essential part of one module. Total number of modules (2400 / 2400x16 = 34800 towers) and their design remained the same

2. New geometry is stored in the emc_v4.root file. The quality of the ECal geometry was tested in the environment mpdroot for overlaps on the level of 10^{-5} cm. All modified files are in the development version of the mpdroot in git.jinr.ru › nica › mpdroot

3. Two MpdRoot classes (MpdHitCreation and MpdClusterCreation) gives us a possibility to estimate the physical parameters of calorimeter and useful for calibration of the ECal modules. Geometry hierarchy has the same structure as in version № 3 and can be used with other reconstruction soft (emcKI). MpdHitCreation has an modified time definition which takes into account light delay in WLS fibers.

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Thank you for attention