New ECal geometry

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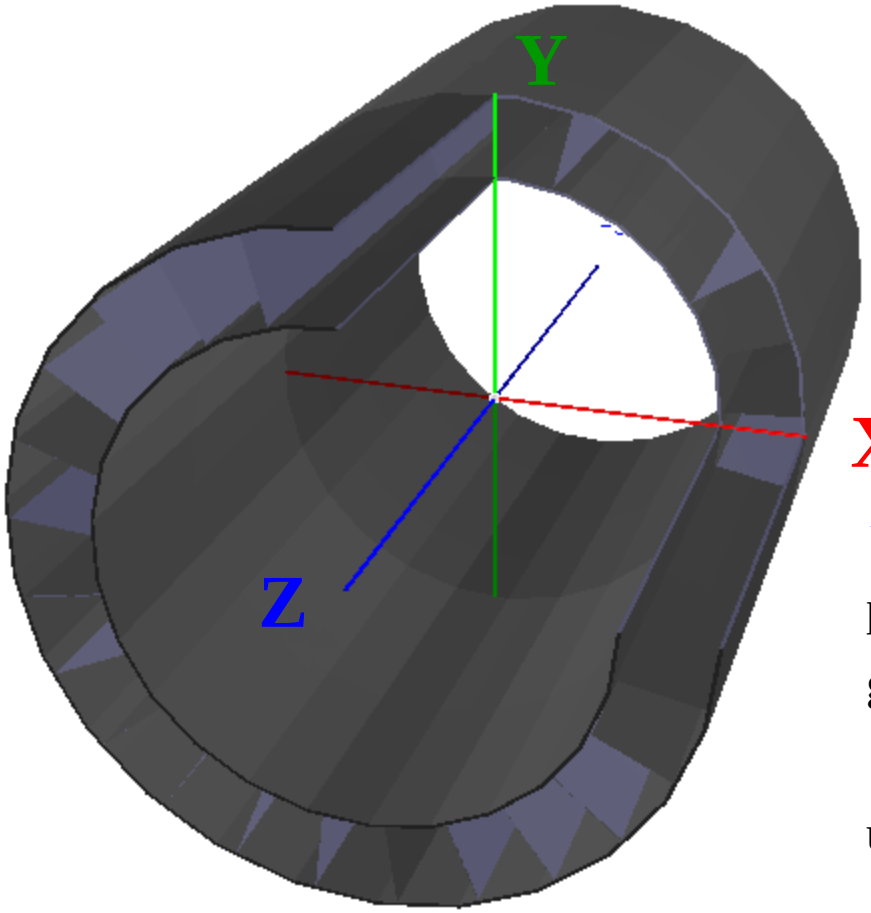
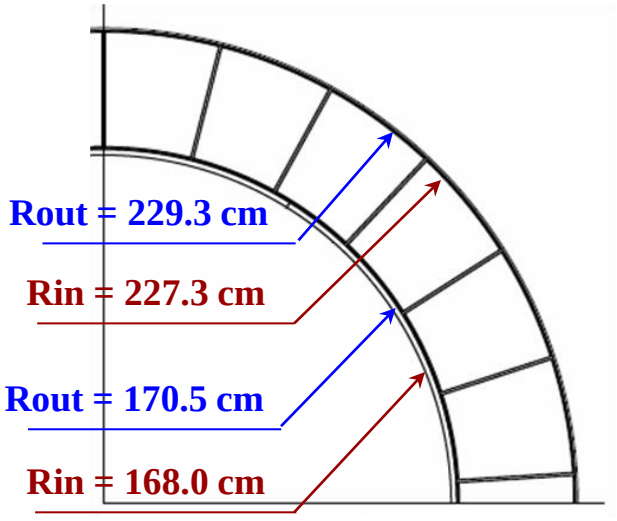
Version 2 and 3 comparison

ECal parameters	Version 2	Version 3
Number of nodes	~ 19×10^6	~ 16×10^6
ECal total weight* (tons)	~ 60	~ 65
Power Frame	No	Yes
Baskets	2×8 (no material)	2×25 (fiberglass)
Number of modules in basket	No	6×8
Tower radius in space (cm)	172	171.56
Total number of towers	43008 (336 × 128)	38400 (300 × 128)
Tower length (cm)	43.095	41.55
Number of tower types	64	64
Number of tower shapes	1	1÷3
Number of layers per tower	221	210

* Weight of the detector estimated in the ROOT – frame

MPD power frame





✓ Power frame supports ECal and TOF parts (radial edges width: 1cm + 0.2 × 2 cm gaps)

✓ Material – carbon composite. For MC used mixture (graphite + epoxy) :

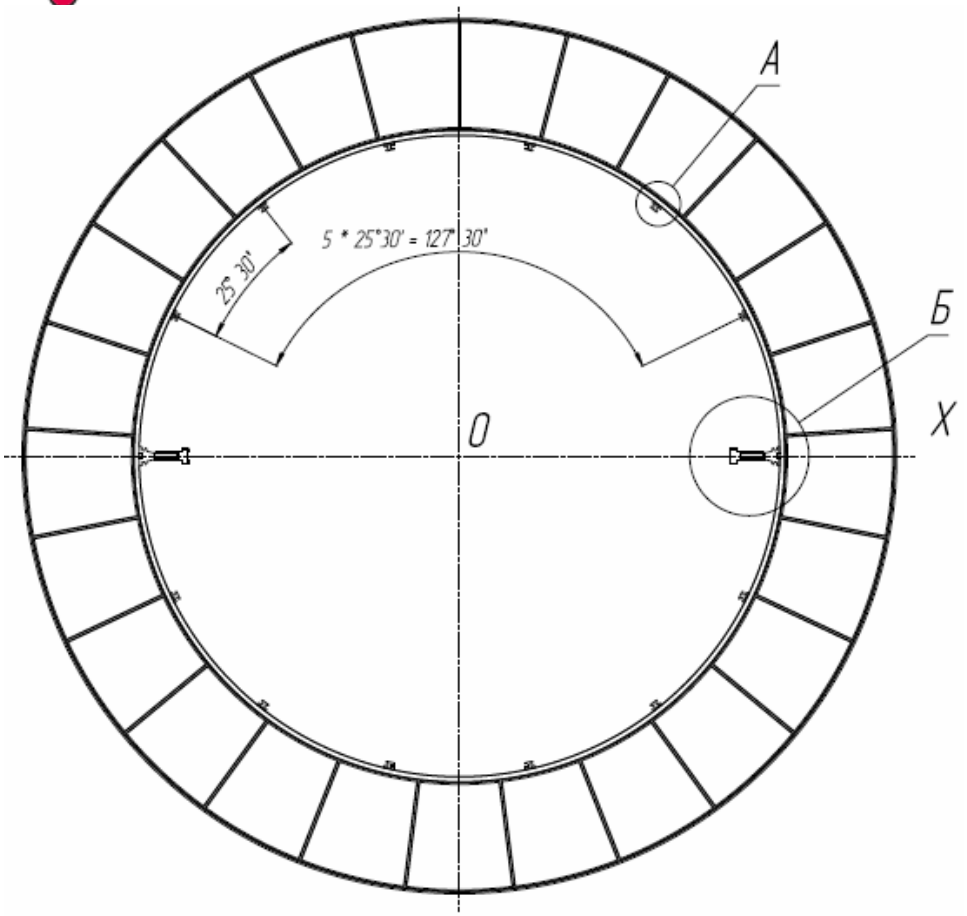
H (7.4 %) + C (80.9 %) + O (11.7%)

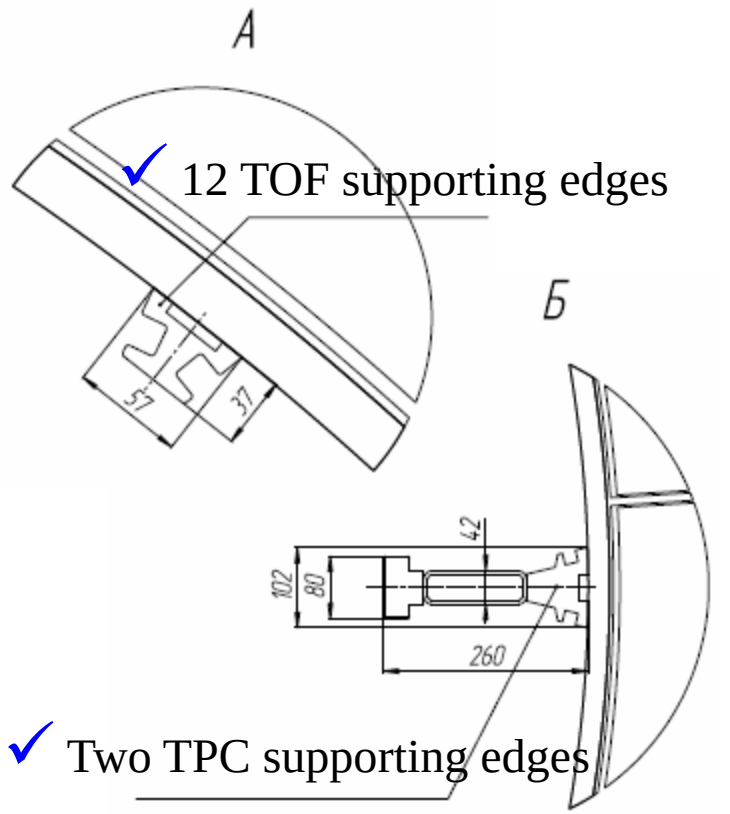
ρ = 1.38 g/cm^3, X_0 = 30.4 cm

✓ Low radial edge gives 8.2 % X_0 before ECal

✓ Power frame consists from 25 transverse and two radial edges

Power frame walls





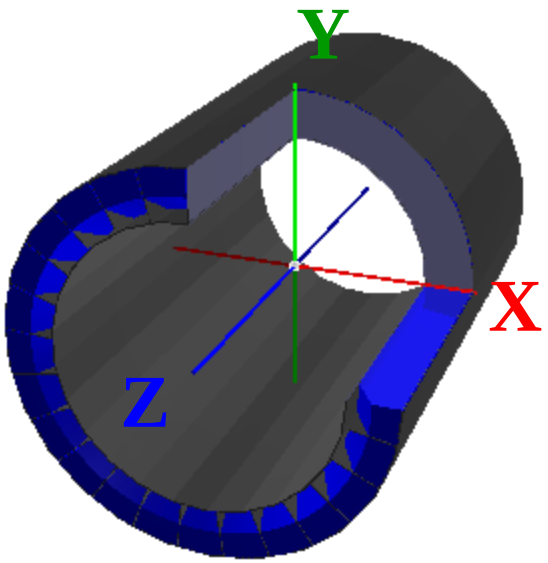
✓ 12 TOF supporting edges

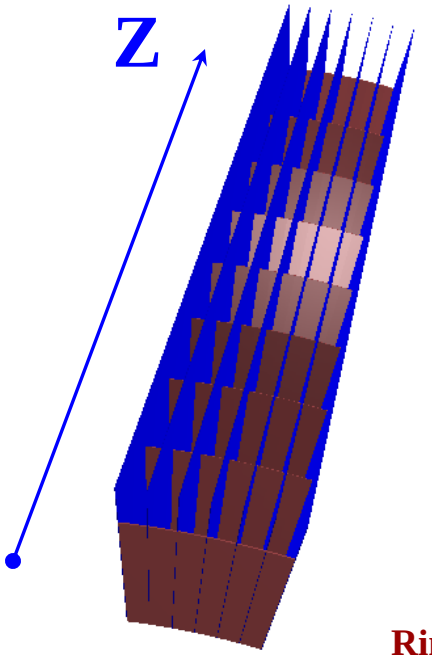
✓ Two TPC supporting edges

✓ Total radial length (R ~ 172 cm) is equal to 1080 cm

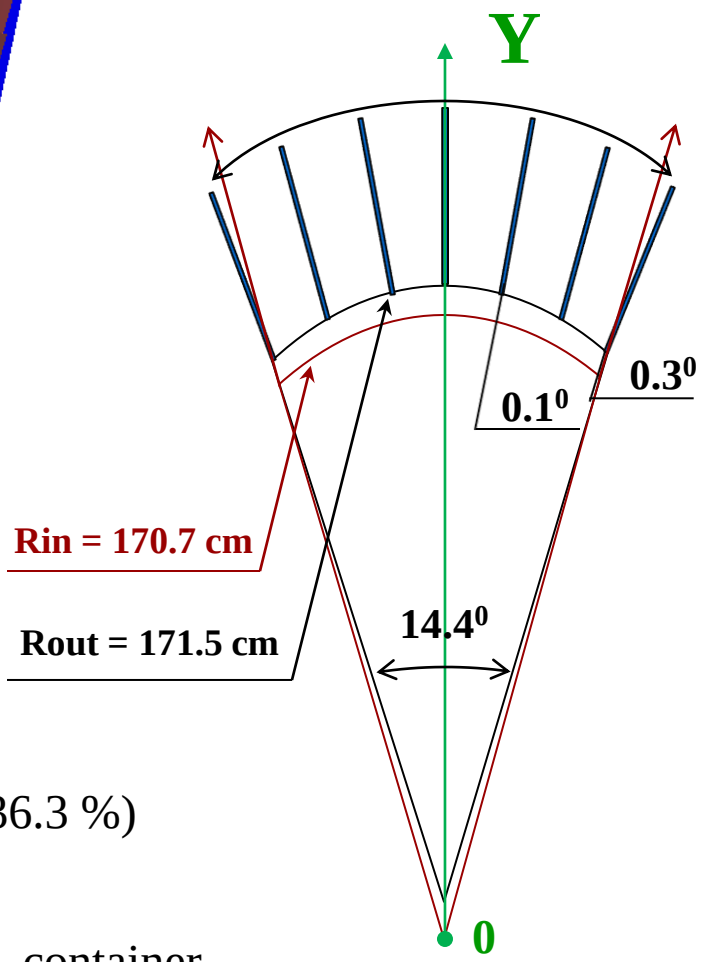
✓ Supporting edges are not synchronized (Number : 25 ECal (1.4 cm + 7×0.2cm); 12 TOF (5.7 cm); 2 TPC (10.2 cm)), so ECal efficiency loss ~ $23^0 + 24^0 + 7^0 \sim 54^0$ (14.8 %)

Baskets for ECal modules





Container XY – scheme

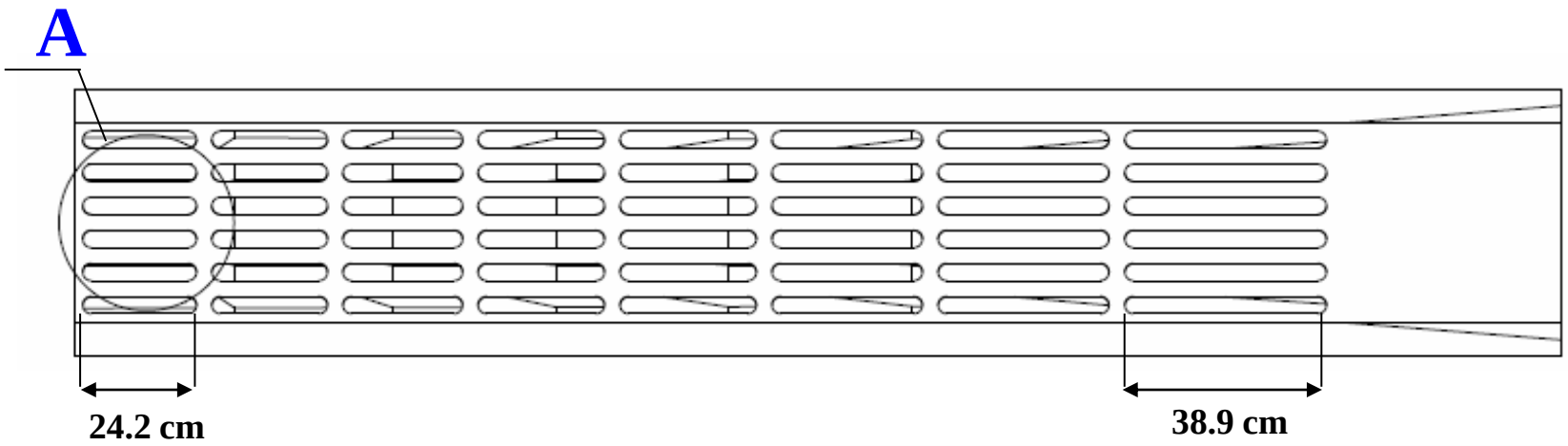


- 25×2 baskets move inside power frame
- Material – fiberglass :

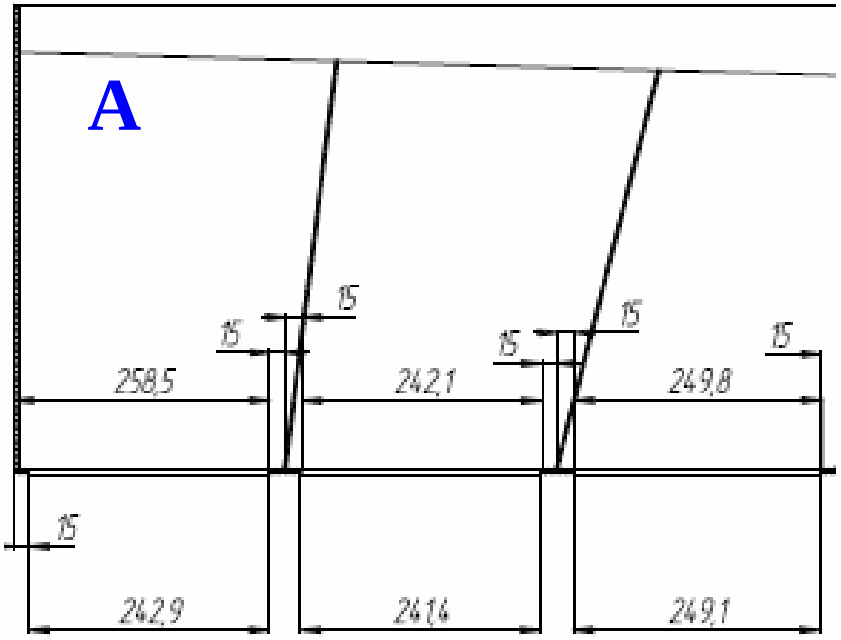
  H (5.8 %) + C (43.1 %) + Si (14.8 %) + O (36.3 %)

  $\rho = 1.9$ g/cm^3, $X_0 = 18.4$ cm
- Total weight of one container ~ 1200 kg (empty container weight ~ 60 kg)

Lower container wall

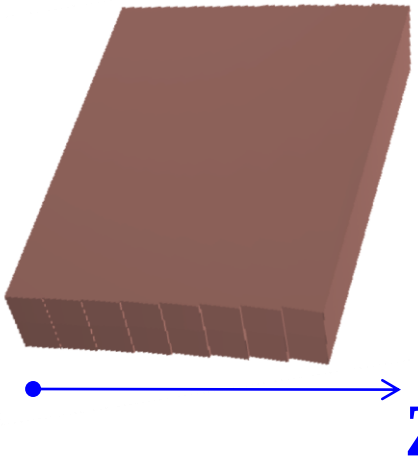


- ✓ Lower radial edge of container has a lattice structure to prevent background production (radial width = 0.8 cm)
- ✓ Lattice has a non-periodic hole size along OZ – axis, grid width is constant (3.0 cm)
- ✓ Non-periodic hole size duplicates tower projection on OZ – axis

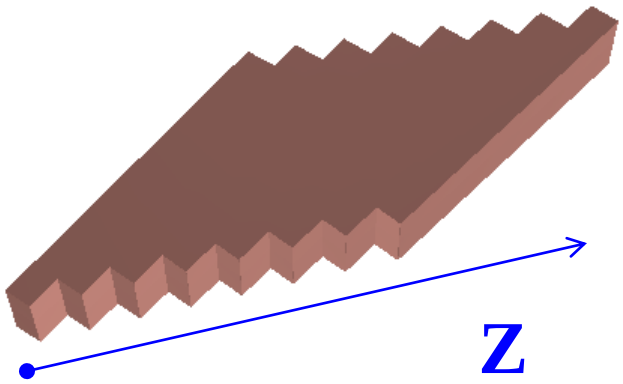


ECal module

First module in row



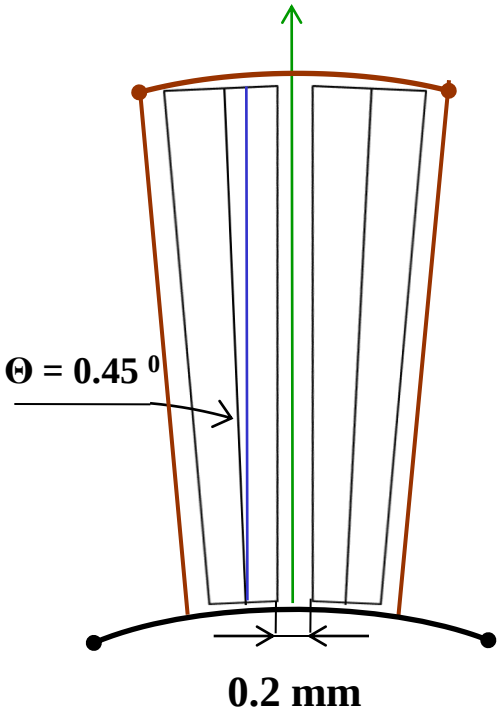
Last module in row



➢ Towers are merging into modules by special glue, which is included in the ECal geometry. 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



➢ Each basket has 6×8 modules

➢ Modules are constructing from 2×8 towers of different types

➢ Eight modules with different shapes have been approved

➢ In the GEANT4 geometry such shape can be describe by the polygon volume, which has 50 cross sections and repeated a shape of eight towers

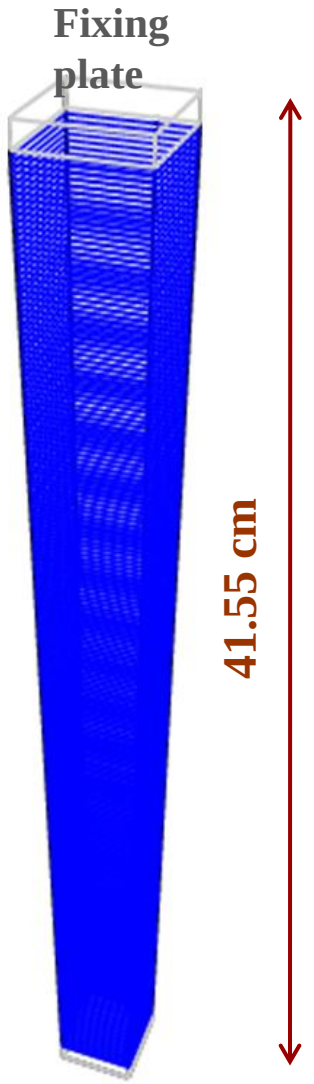
ECal tower

- ✓ Total number of towers : 38400
- ✓ Each tower has 210 lead (h = 0.3 mm) and scintillation plates (FscScint – C_9H_{10}, h = 1.5 mm)
- ✓ Each lead plate is coating of the $Ti2O_2$ paint (h = 0.05 mm) with parameters:

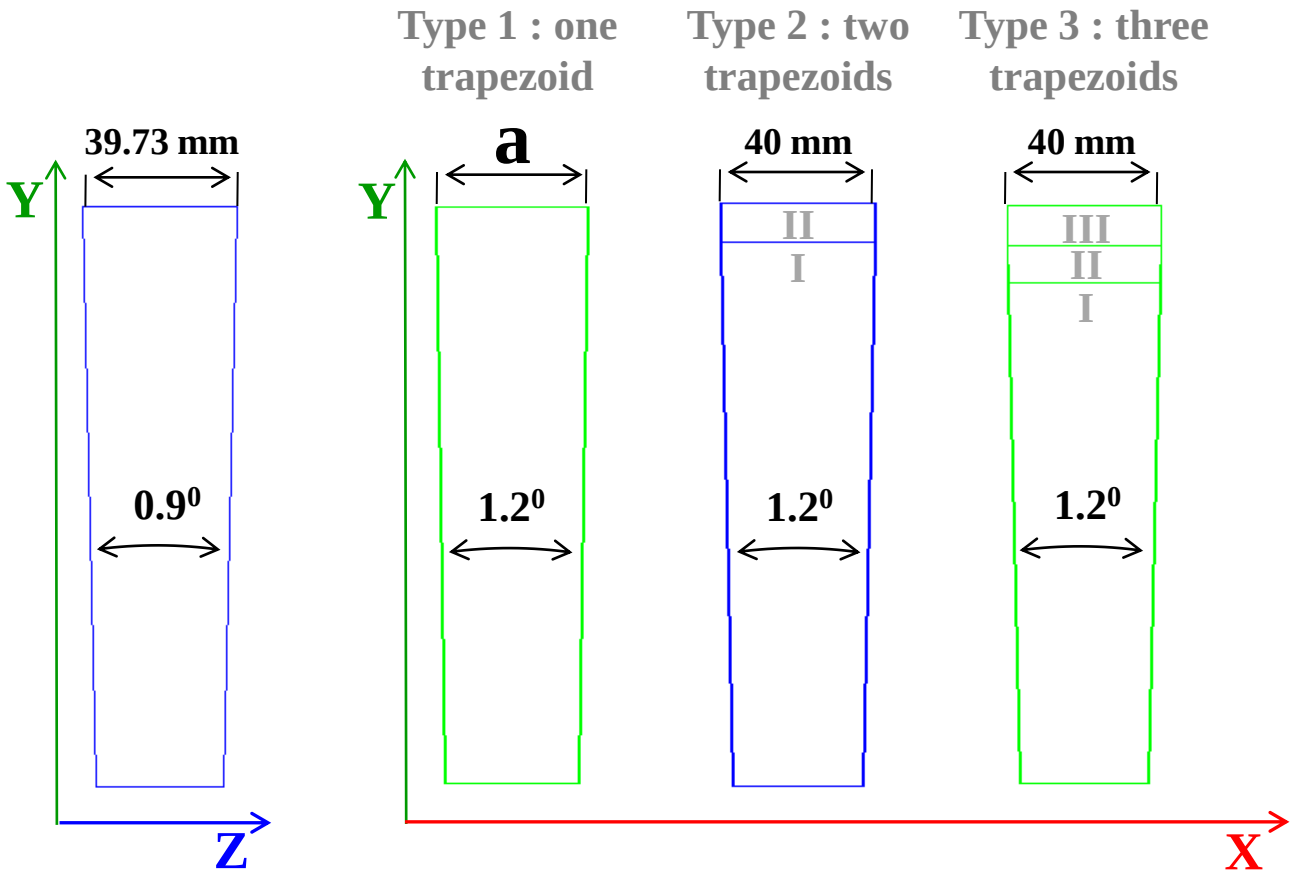
H (2.9 %) + C (17.2 %) + Ti (41.1 %) + O (38.9 %)

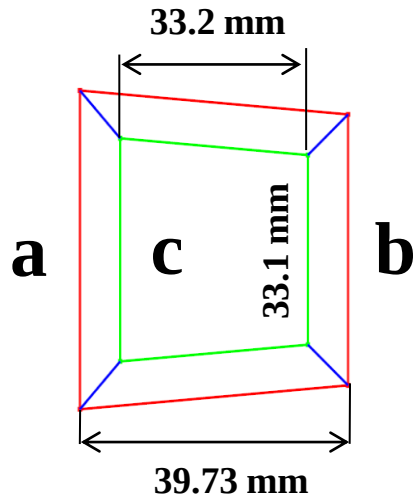
$\rho = 1.18$ g/cm^3, $X_0 = 20.49$ cm

- ✓ Tower is fixed by two plates on top and bottom (Kapton, h = 8 mm, $N_2C_{22}H_{10}O_5$, $\rho = 1.42$ g/cm^3, $X_0 = 28.4$ cm)
- ✓ Tower shape can be described by the GEANT4 class TGeoArb8 – arbitrary trapezoid with 2×4 vertices at two parallel planes perpendicular to central axis
- ✓ Sensitive volume in MpdRoot is a scintillation plate
- ✓ Towers give a main contribution to number of the GEANT4 elements; total number of nodes ~ 16×10^6



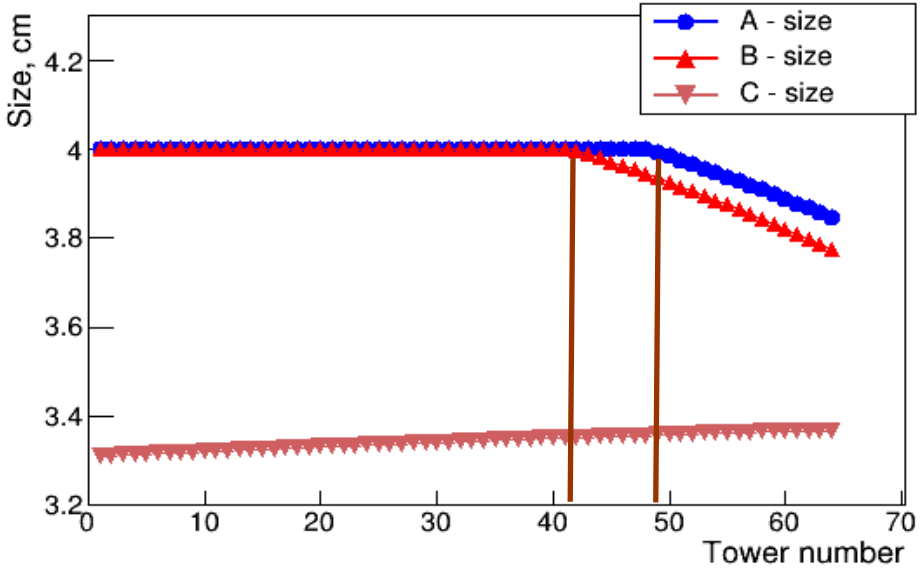
ECal tower types

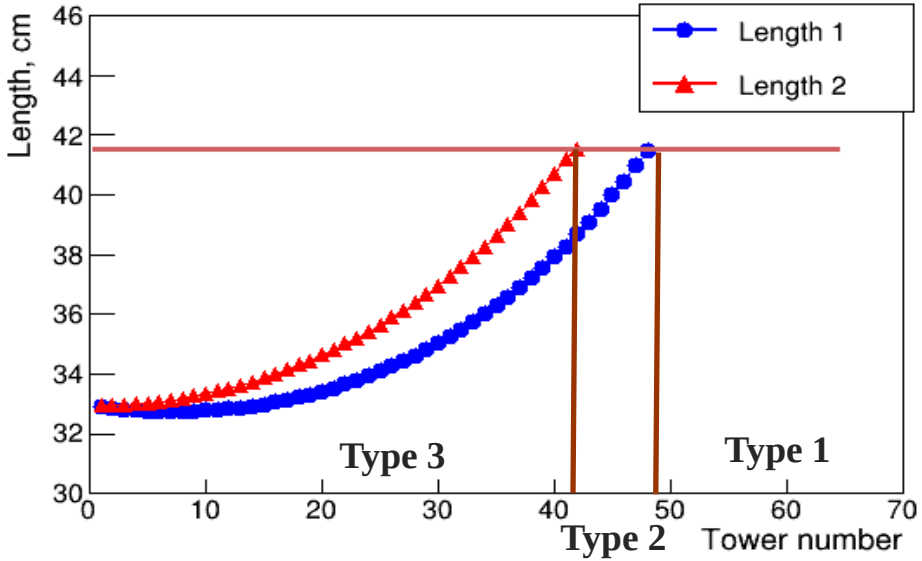




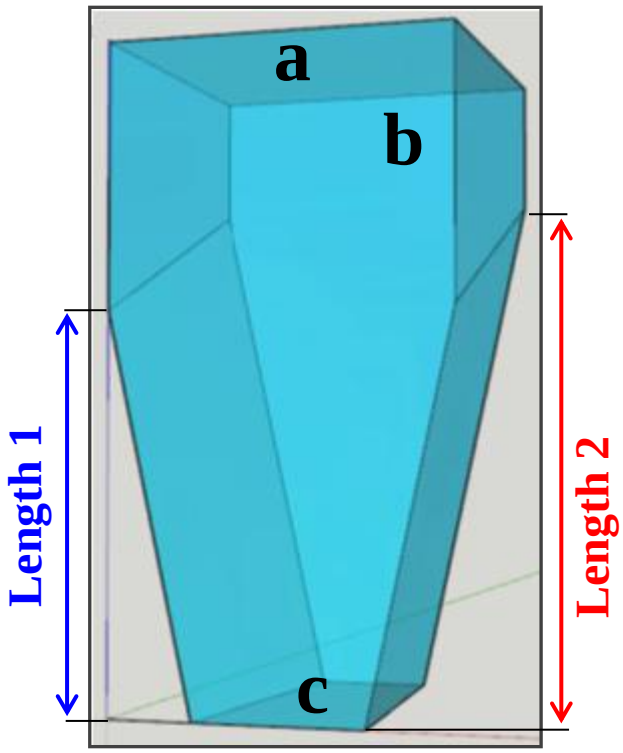
- ECal geometry has 64 trapezoids with different sizes (**a**, **b**, **c**) positioning along Z – axis
- As a result of the module milling, three types of tower shapes were selected
- For Type 2 and Type 3 we use compound volume, consisting from 2 and 3 trapezoids

Tower parameters





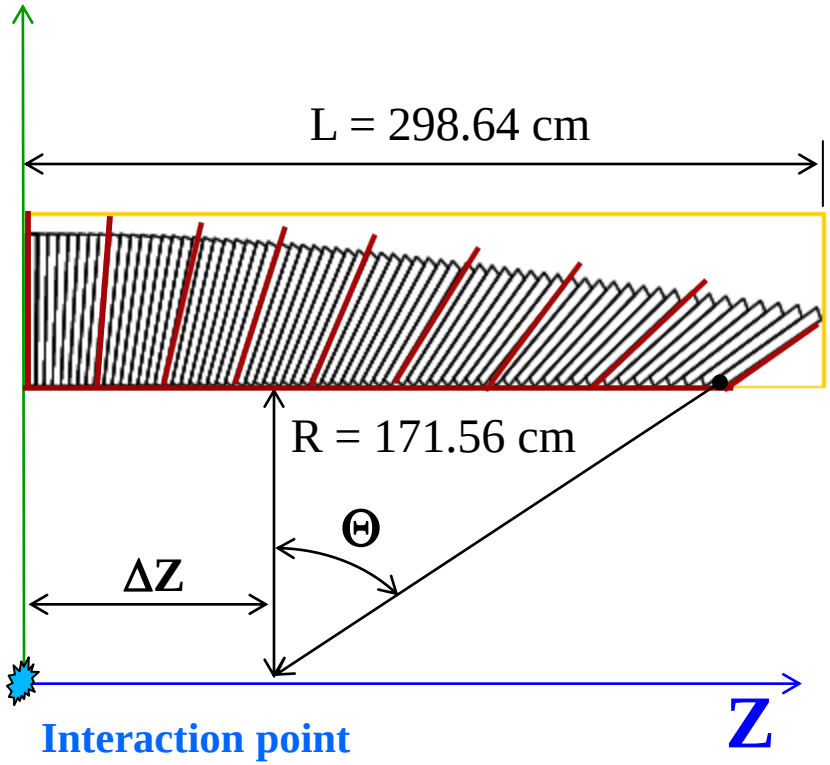
Tower: Type 3

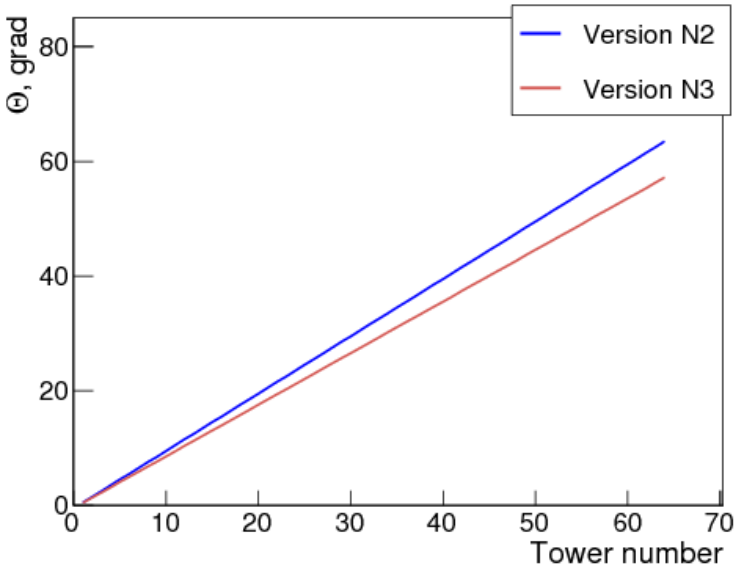


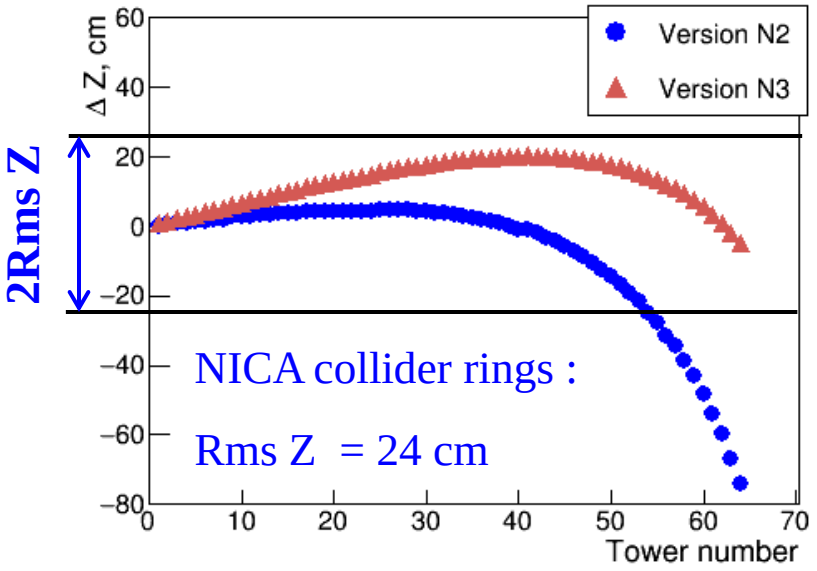
✓ A, B and C parameters are calculated precisely on a basis of two milling angles

✓ Three trapezoids : towers 1 ÷ 41; two trapezoids : towers 42 ÷ 48; one trapezoid : towers 49 ÷ 64

Tower Z – position

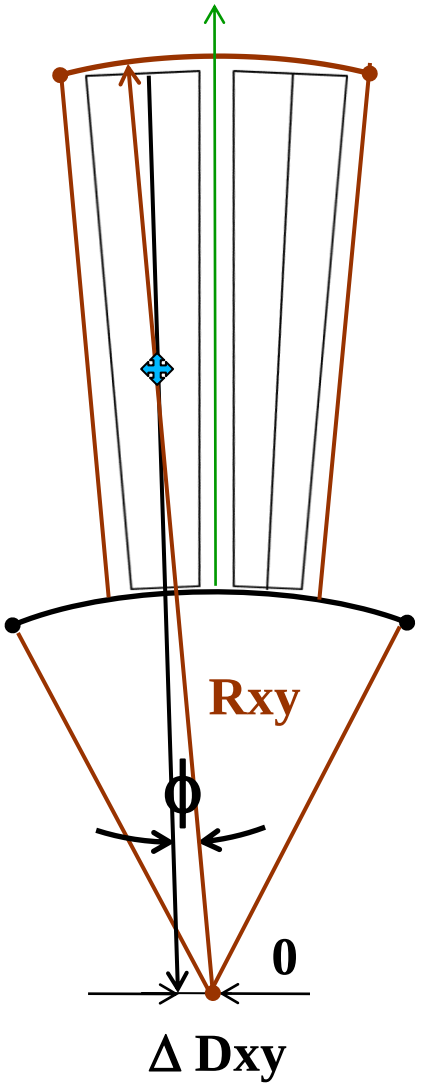


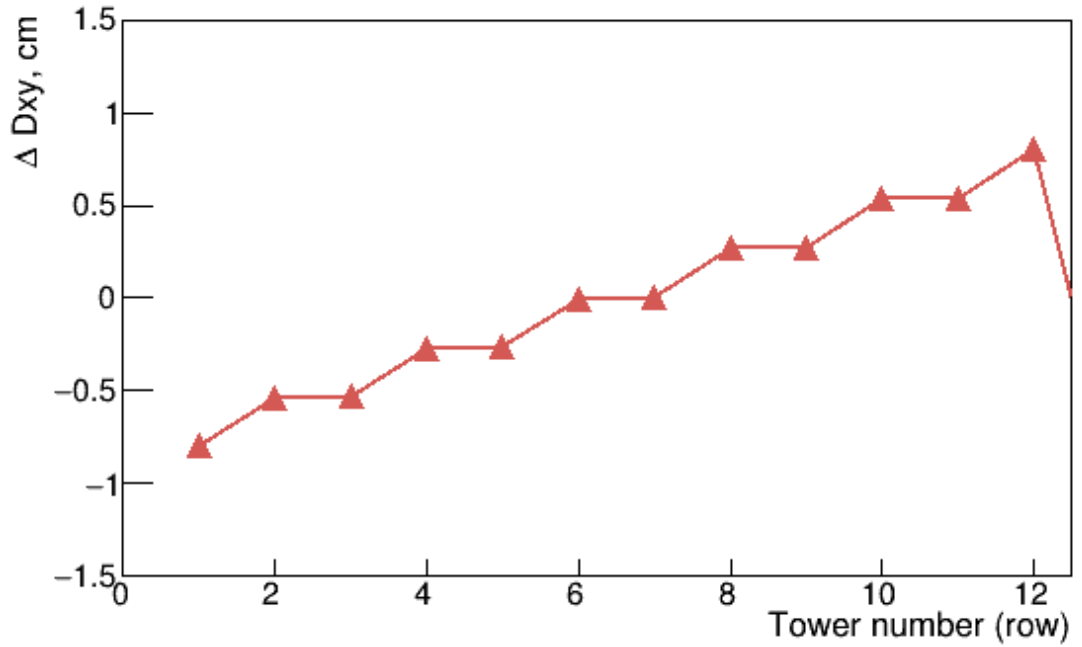




- ✓ Each container has 8 modules
- ✓ Modules is combined from 2×8 towers
- ✓ 64 different towers are placed along Z – axis at different Θ - angles

Tower XY - position

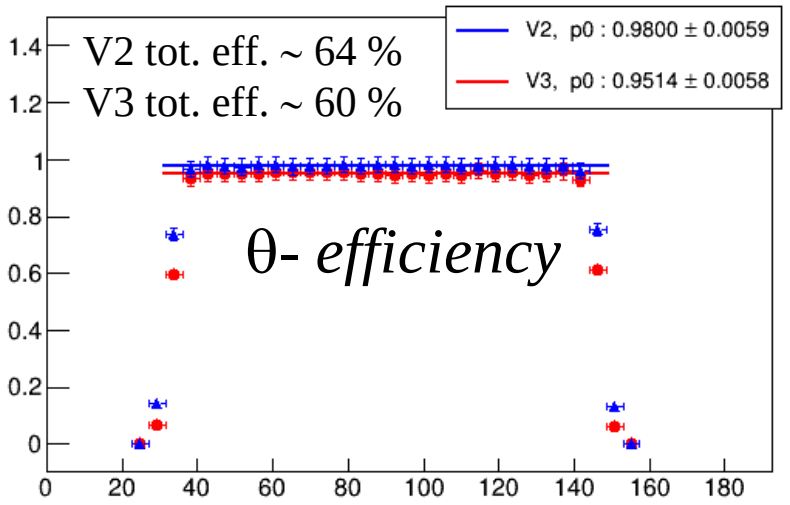


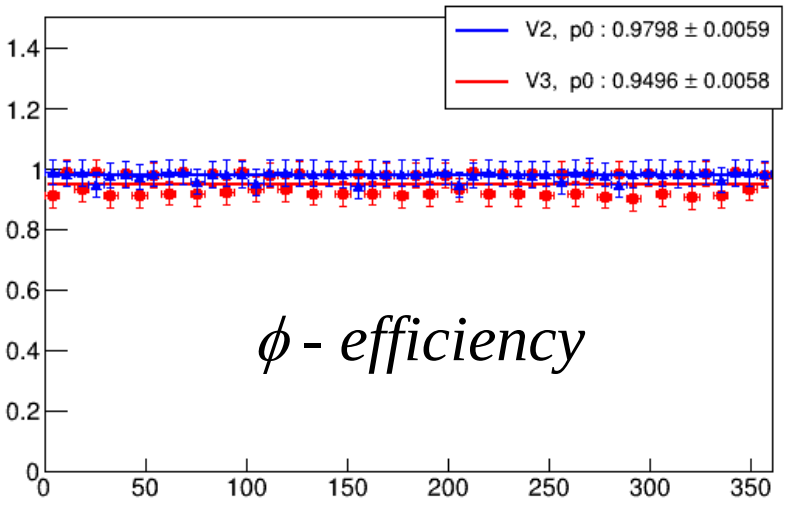


- Generally, the ECal geometry was planned to be a projective, but small asymmetry for towers position in XY plane is presented
- Displacement of towers in XY plane can be estimated by formula : $\Delta Dxy = \phi \times Rxy$ (Rxy – radius of the tower center)
- This effect is related to a special milling of towers and different edges of the supporting structure

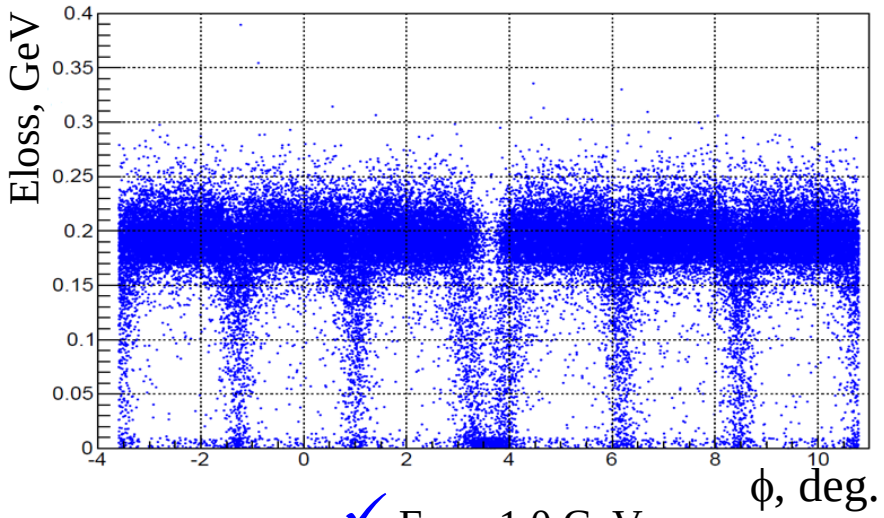
New ECal parameters

✓ ECal geometry efficiency, Eγ = 1.0 GeV

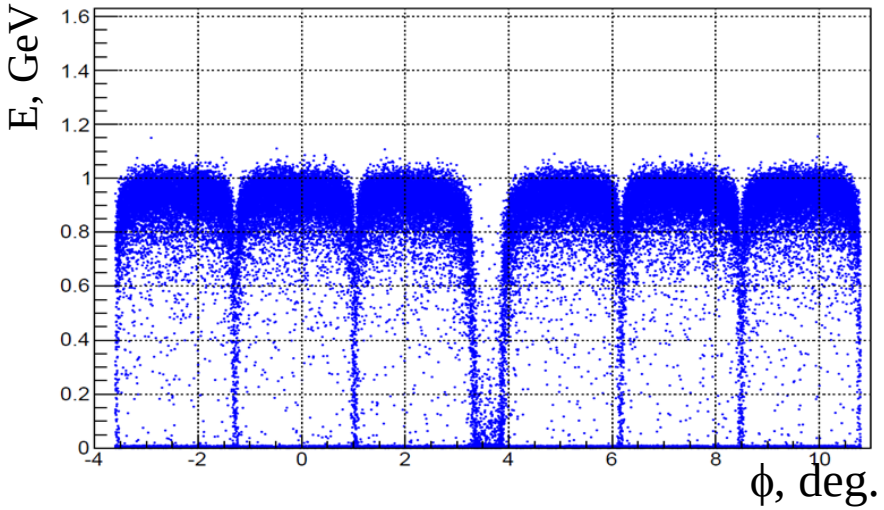




✓ P muons = 1.0 GeV/c

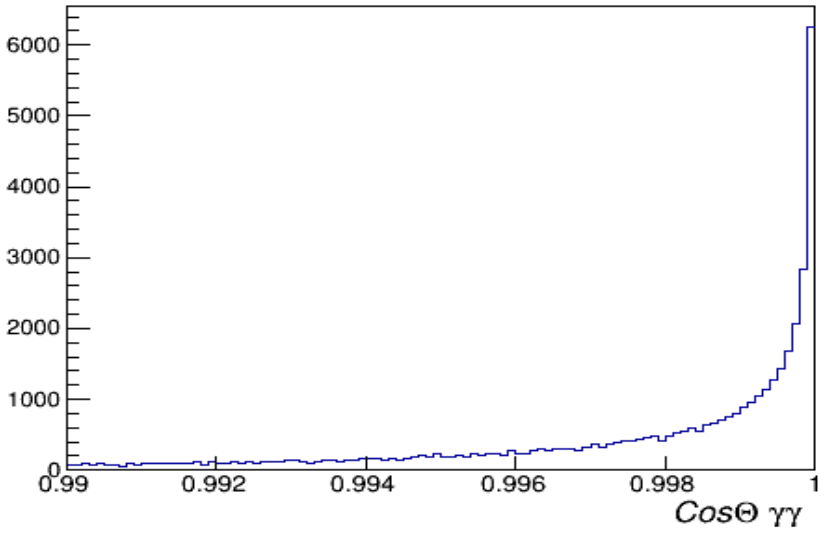


✓ E γ = 1.0 GeV



New physics ECal parameters

Cos $\theta_{\gamma\gamma}$ - angle between cluster and real γ directions

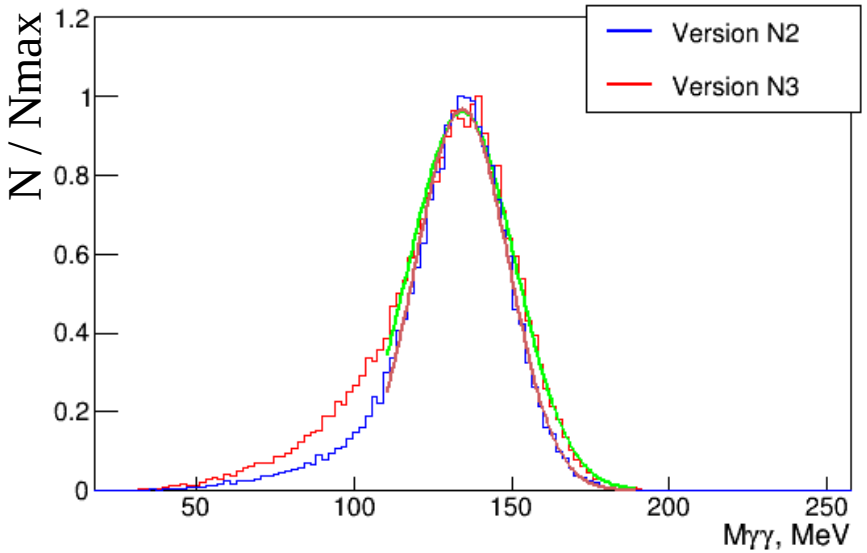


- NICA collider rings :

  Rms Z (at bunch length 60 cm) : 24 cm

- Rms X = Rms Y = 0.0 cm
- Gaussian smearing vertex along Z - axis

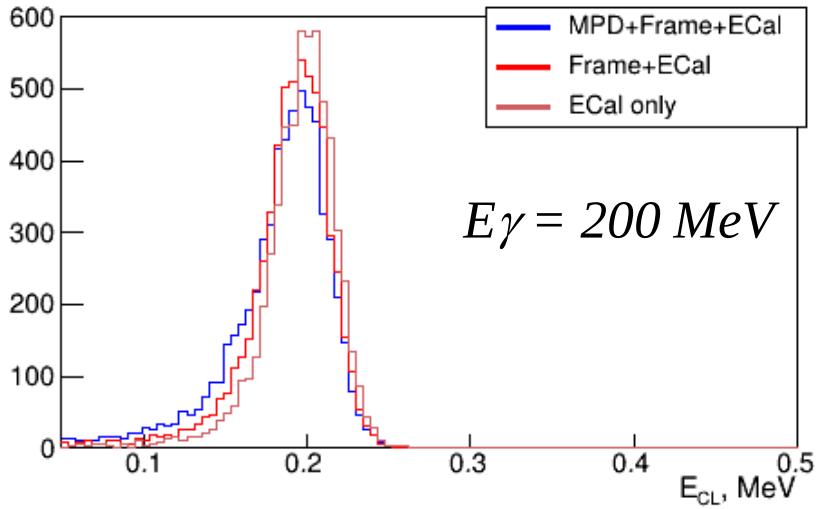
✓ π^0 invariant mass , p (π^0) = 0.2 GeV

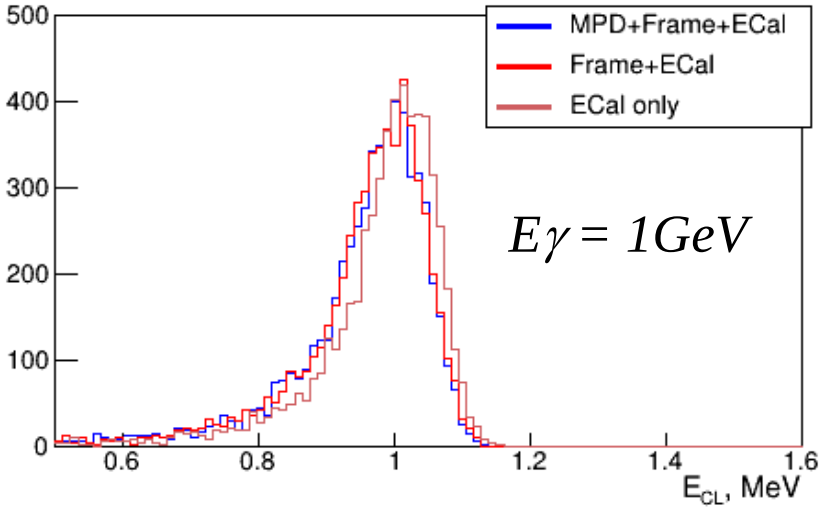


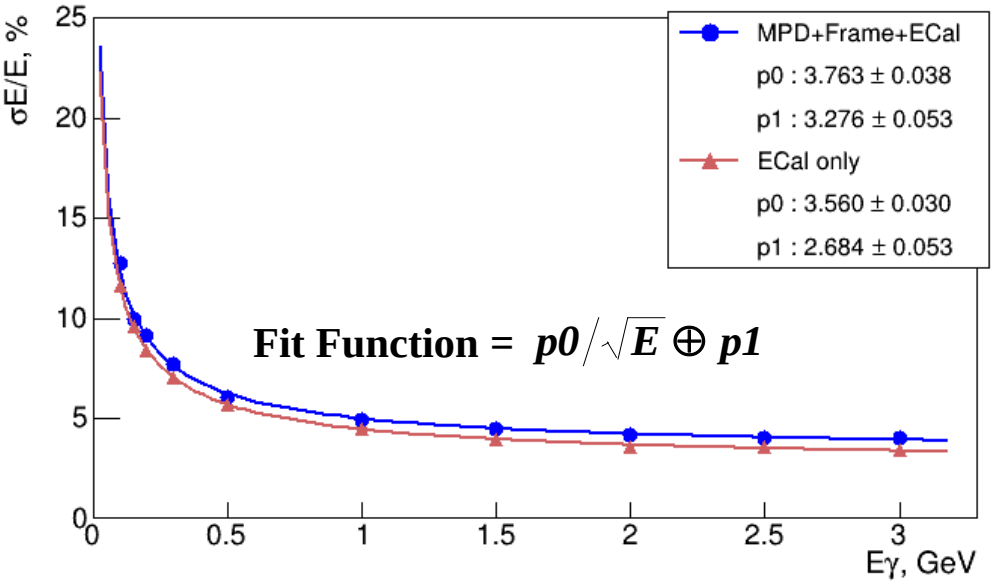
✓ New ECal geometry efficiency goes down, but not significantly in comparison to the previous

✓ π^0 – invariant mass demonstrates a small enlargement in width and more essential increase of the low energy tail due to new design features

Energy resolution

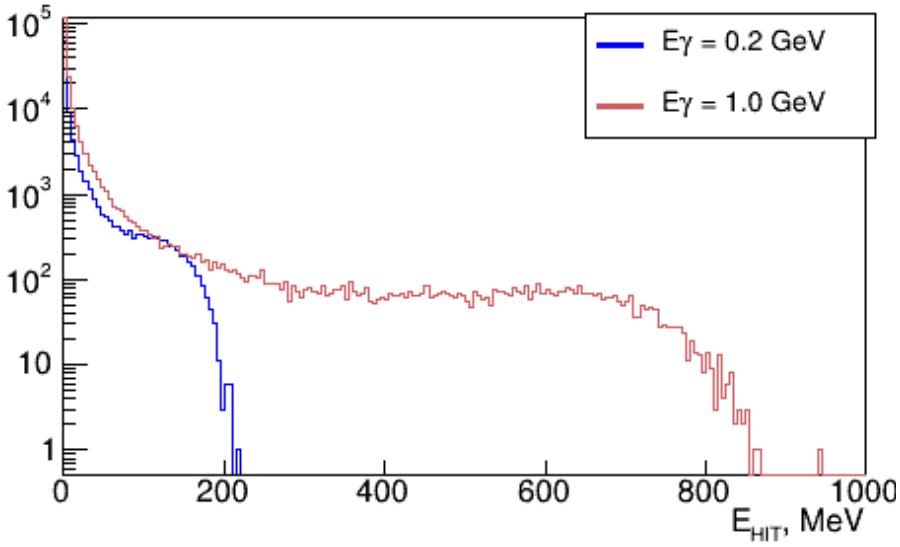


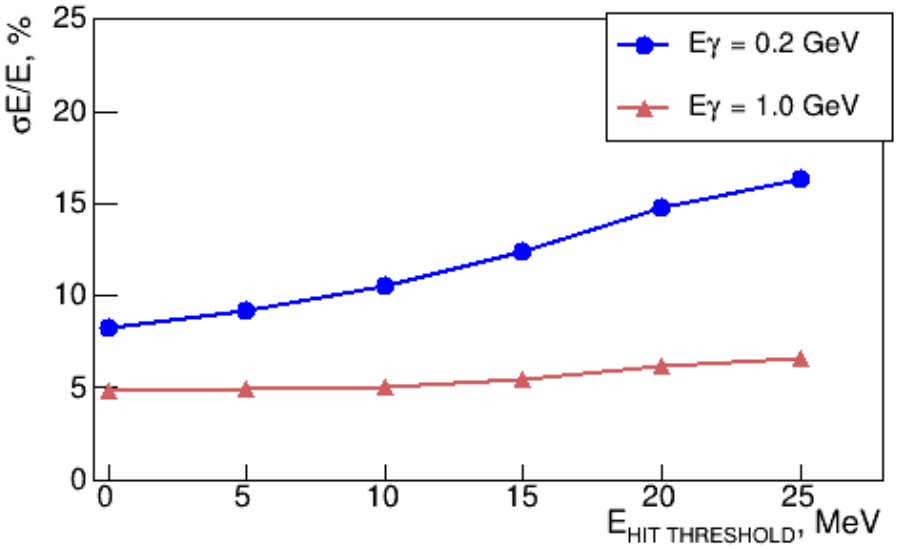




- ✓ Energy resolution is defined for two cases : MPD (TPC and TOF) + Power Frame + ECal and ECal only
- ✓ Contribution of the Power Frame is not significant
- ✓ MPD deterctor parts are slightly corrupted the energy resolution of ECal

Energy threshold



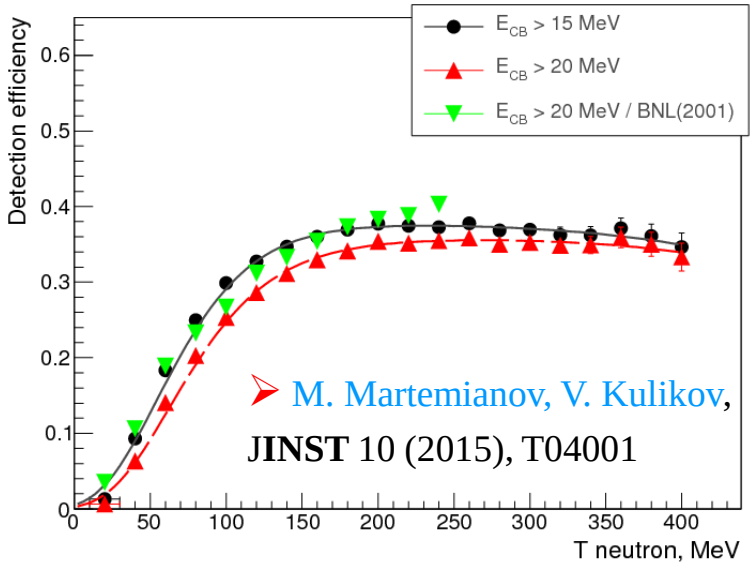


- ✓ Right slide – energy deposit of γ's in ECal tower (hit) at different energies (Eγ = 0.2, 1.0 GeV)
- ✓ Left slide – energy resolution of the cluster vs hit thershold at different Eγ
- ✓ Threshold growing for a hit leads to an increase in the energy resolution
- ✓ This effect is more sufficient for γ's with low energies

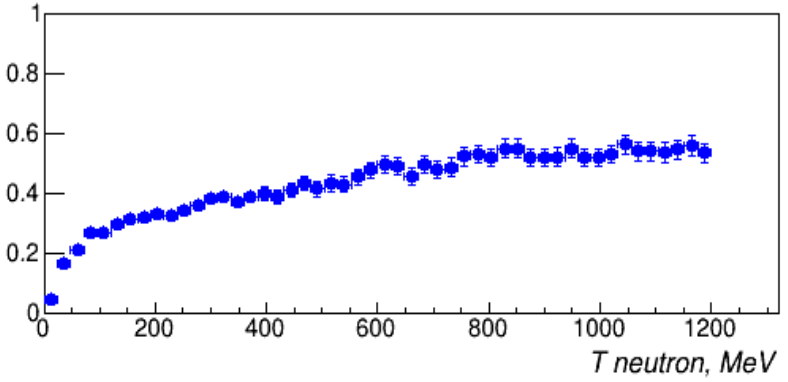
Neutron registration by ECal

- ✓CB calorimeter at Mainz (A2 experiment) installed on the MAMI photon facility
- ✓CB : NaI crystals, length of 40.7 cm
- ✓ Neutron efficiency obtained in the A2 experimental data close to MPD / ECal simulation
- ✓So, neutrons gives a significant background to the neutral component
- ✓EM shower has a compact time in ECal and many cells are fired; hadronic shower has a big time difference between energy depositions in the early and late stages
- ✓An effective way to separate neutrons from light particles and photons will be investigated
- ✓ Possible way to separate photos and neutrons is a correct investigation of time shapes

Detection efficiency at CB / A2



MC detection efficiency at MPD/ECal



Conclusion

1. Quasi-spherical ROOT - geometry of ECal was done for MpdRoot software. It consists from 16×10^6 elements and includes power frame, 25 baskets, specific ECal modules, which combined from 2×8 towers. New geometry was proposed by the VBLHEP Design Department including special materials for different ECal parts.

2. New geometry is stored in the emc_v3.root file. The quality of the ECal geometry was tested in the ROOT frame for overlaps on the level of 10^{-5} cm.

3. Software is placed to GIT in https://git.jinr.ru/mmartemi/EmcReco

mpdroot/geometry : media.geo – new materials, emc_v3.root – new geometry

mpdroot/macro/mpd/geometry/create_rootgeom_emc_v3.C – file to create new geomerty

mpdroot/emc: simple software for new geometry

Thank You