Status of reconstruction in ECal

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Requirements on ECAL design from physics analyses

Prompt photons:

- interested in p_T > 3-4 GeV, high background from π^0, η, etc.
- Requirement: energy resolution at high (> 5 GeV) energies, π/γ separation

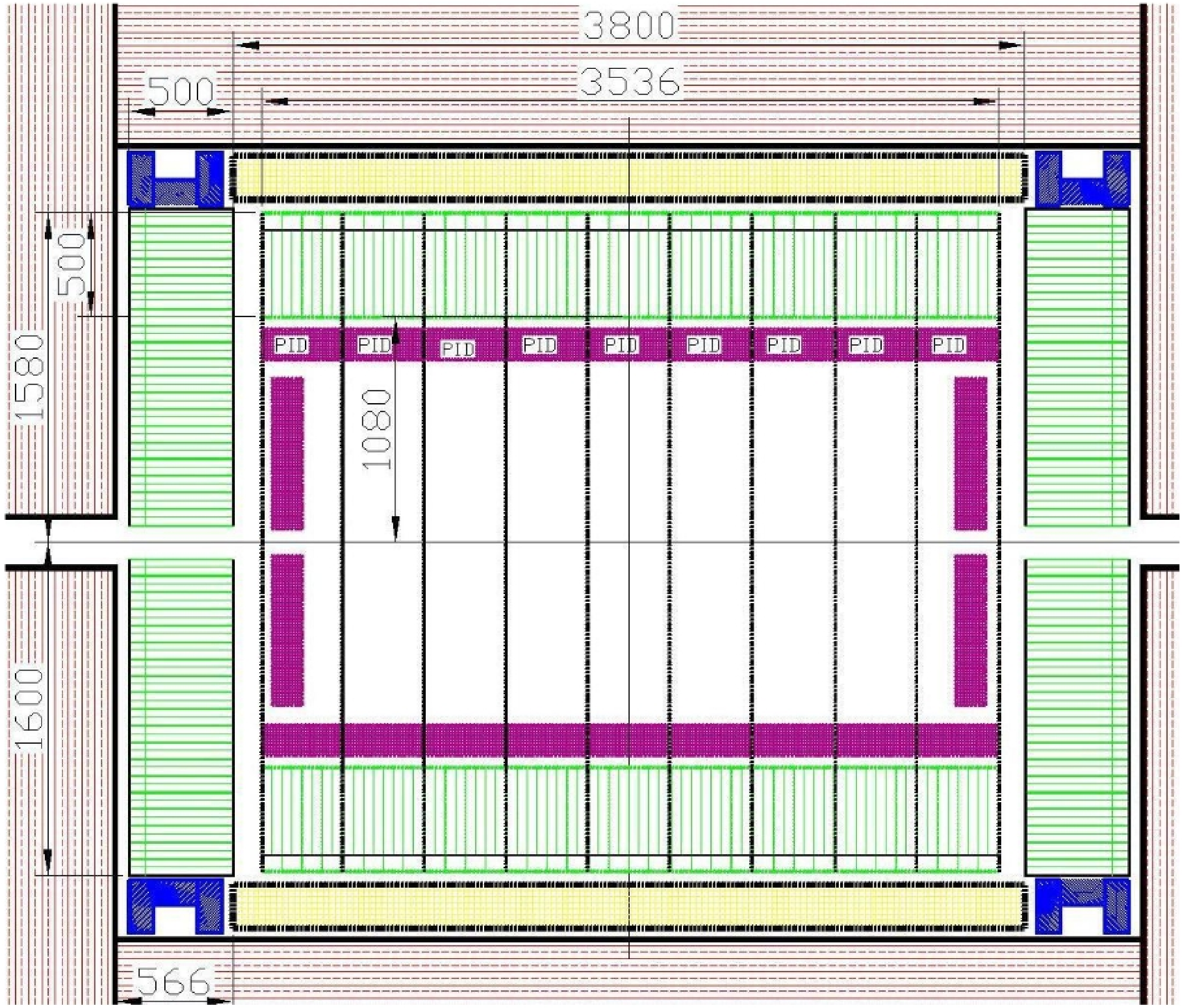
Charmonia (χ_{c1}, χ_{c2}):

- need to separate χ_{c1}, χ_{c2} from decay into $J/\psi\ \gamma$
- Requirement: energy resolution at low (< 1 GeV) energies

Online polarizability measurement:

- measure azimuthal asymmetry of π^0 production
- Requirement: energy and position resolution, π/γ separation

ECAL setup



- Sampling: 190 layers × (0.5 mm lead + 1.5 scintillator)
  - ~ 5-6% energy resolution @ 1 GeV
  - ~ 1-2% energy resolution @ 8 GeV
- Cell size:
  - barrel: 34 mm (φ) × 48 mm (Z)
  - endcaps: 40 mm × 40 mm
- Barrel inner radius: 1080 mm
  - minimal distance between γ's from π0 decay with energy of 8 GeV is about 4 cm
- Distance from primary vertex to endcaps ~ 1.8 m

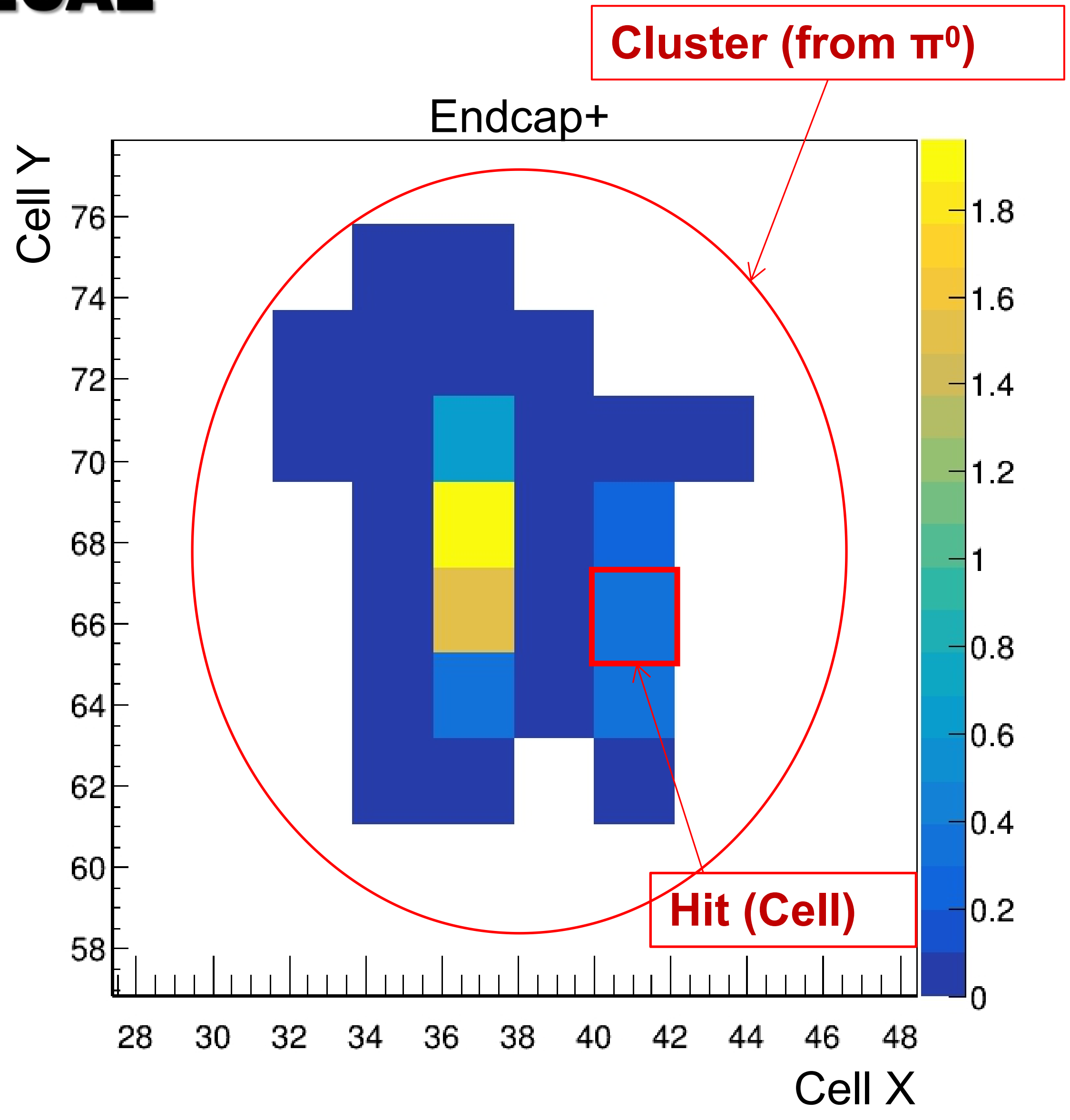
Algorithm of reconstruction in ECAL

1) per-cell energy calibration: energy deposition in scintillator layers → energy deposition in the entire cell

2) clustering: identifying groups of neighboring cells

3) reconstruction: get particle position and energy from cluster

In future, it is possible to merge (2) and (3) in a fast reconstruction algorithm based on convolutional neural network



Reconstruction algorithm: simple case — <u>energy</u> reconstruction

- First approximation: sum of energies
- Correction: taking into account the longitudinal leakage, depends on energy and angle of incidence

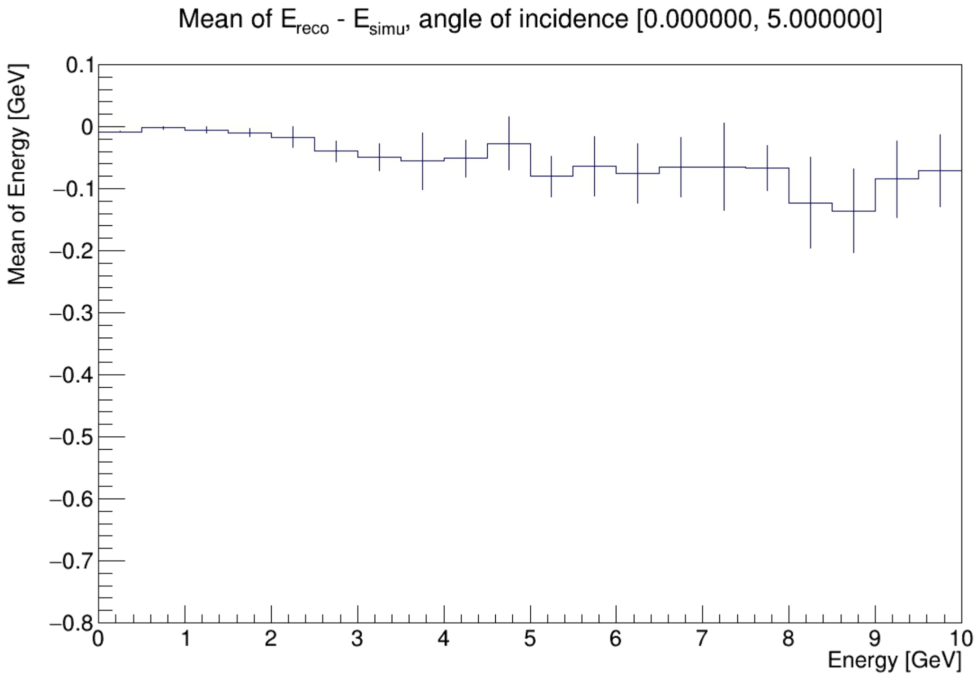
- Energy loss parametrization:

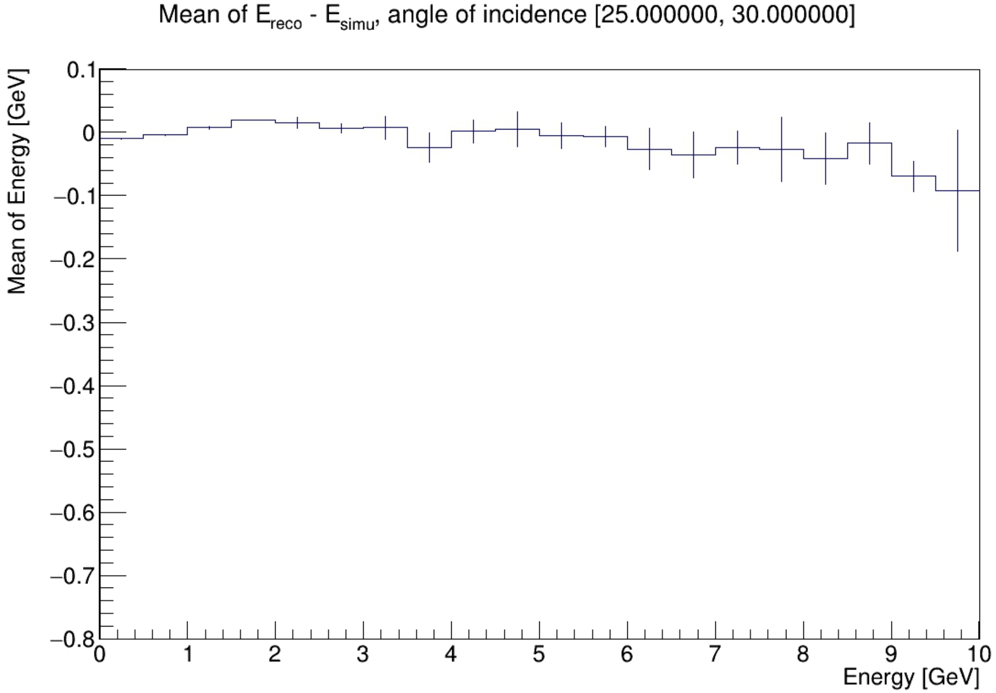
$$\epsilon_{loss} = a(\alpha) + b(\alpha)\ln(E/\mathrm{MeV})$$

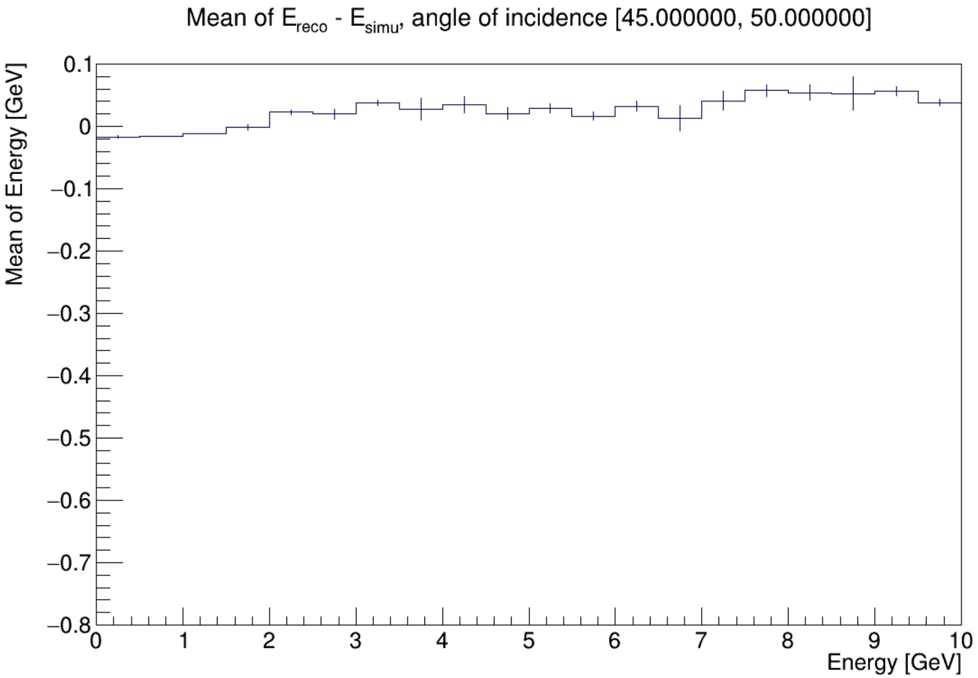
a(α), b(α) - slightly depend on angle of incidence α (linear dependence) and have physical meaning

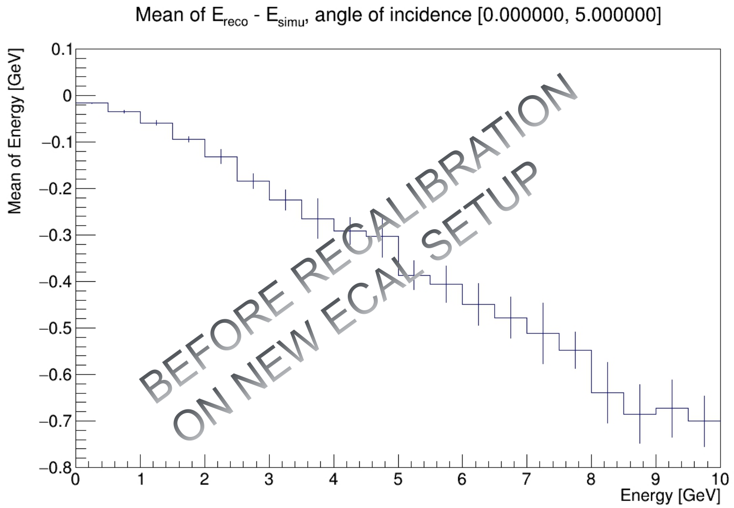
- Previous version:

$\epsilon_{loss} = a(\alpha) + b(\alpha)E + c(\alpha)E^2$, where a(α), b(α), c(α) linearly depend on angle









Miscalibrations within 1%

Reconstruction algorithm: simple case — position reconstruction

- First approximation: weighted sum of centers of cell positions → position is defined at center of cell (not final!)
- Correction: taking into account depth of shower maximum, depends on energy

Shower depth parametrization:

$$d_{shower}/\mathrm{cm} = a + b\ln(E/\mathrm{MeV})$$

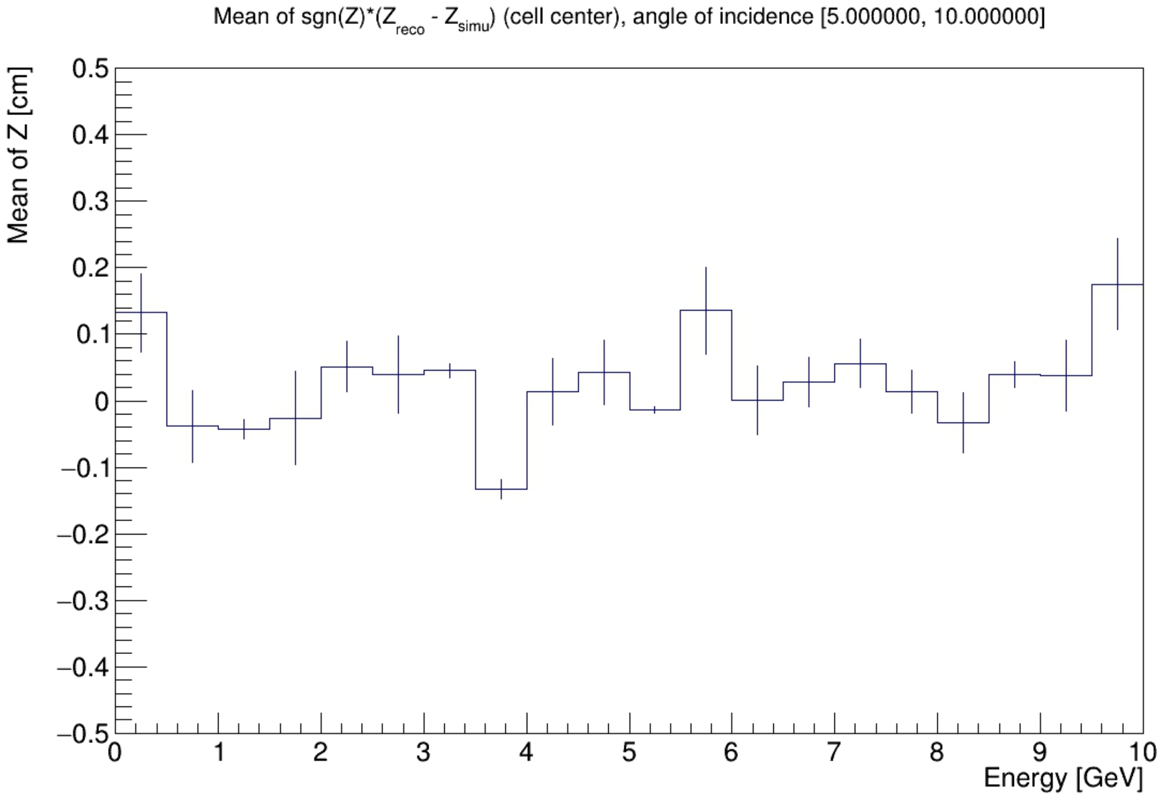
Then, coordinate correction:

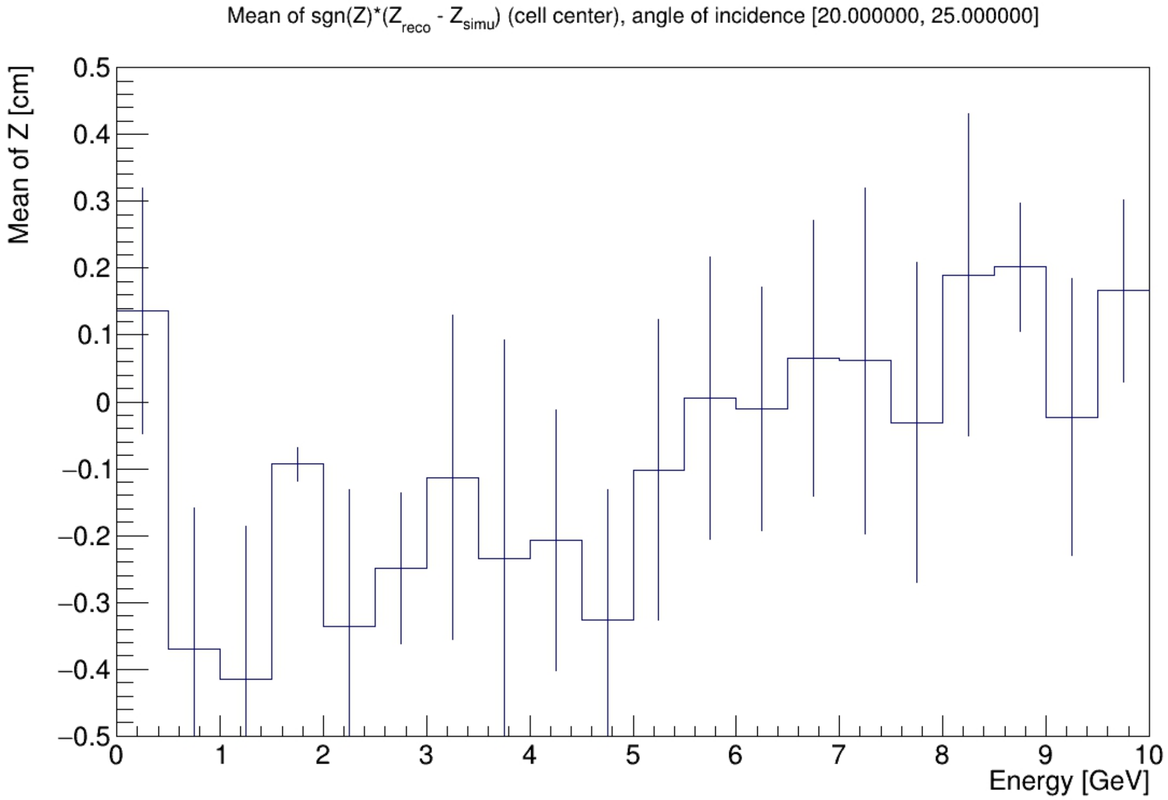
$$\Delta Z = (d_{shower} - \frac{d_{module}}{2\cos\alpha})\sin\alpha$$

Previous version:

- $\Delta Z = Za(\alpha) + Z^3 b(\alpha)$, where a(α) and b(α) are second-degree polynomials of α

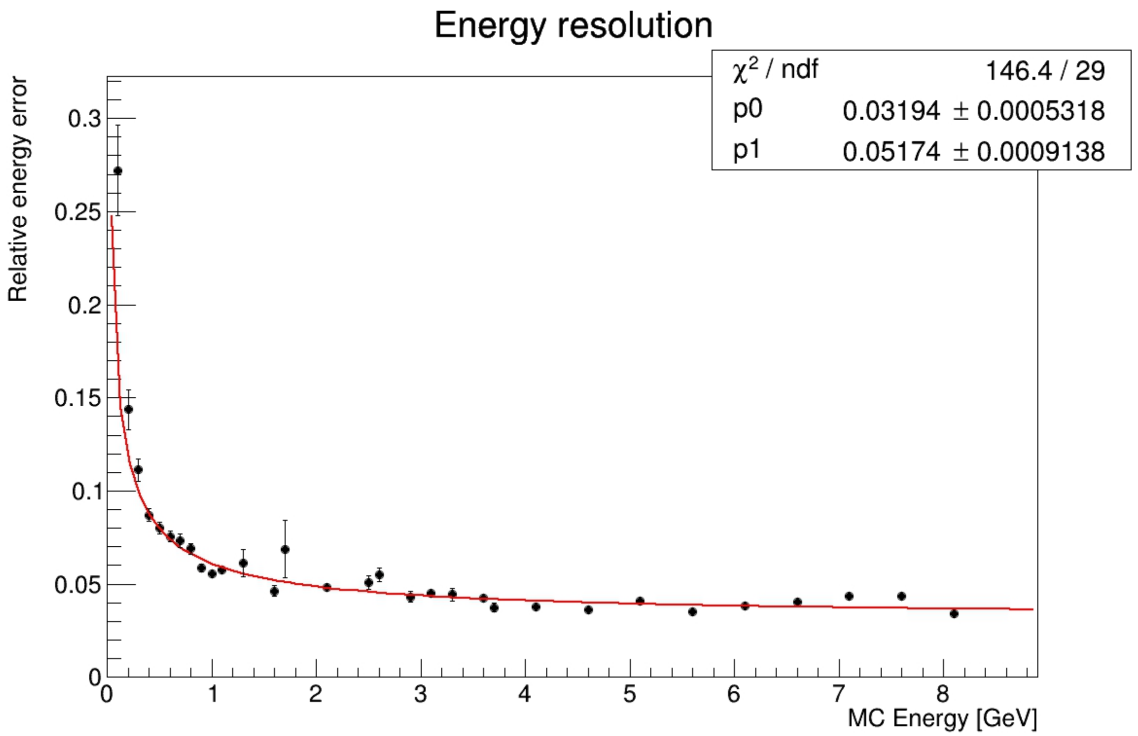
“real” reconstruction: bias in Z coordinate

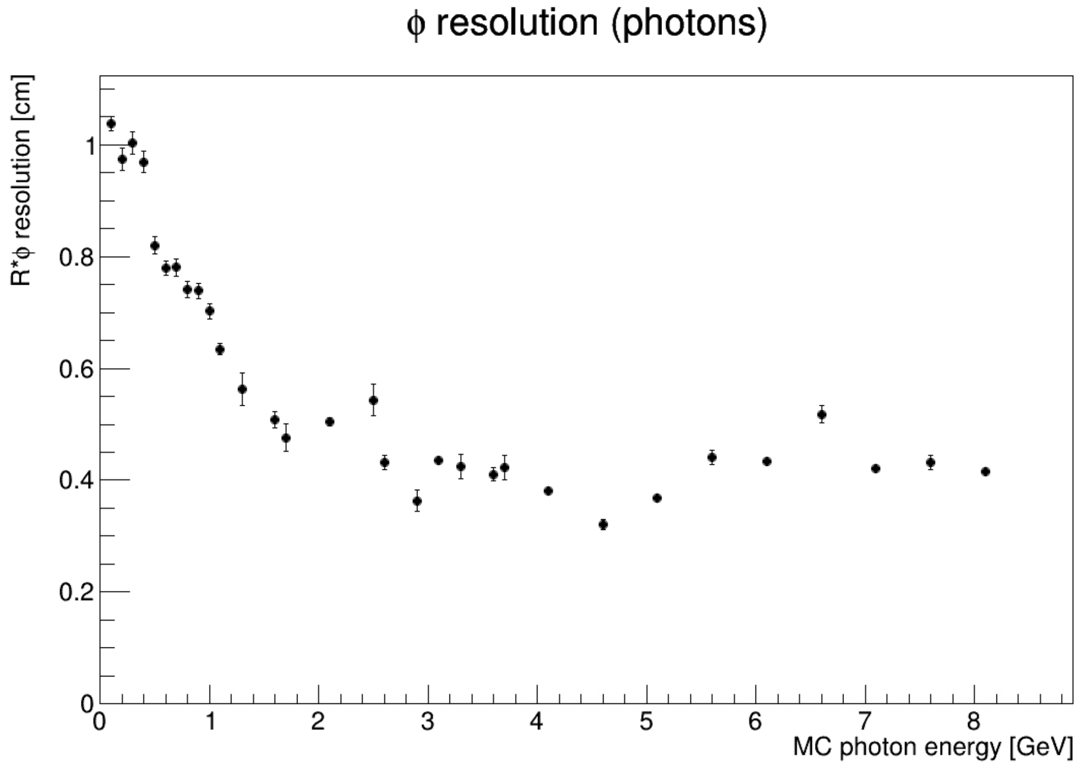




Performance of ECAL

https://git.jinr.ru/AndreiMaltsev/spdroot-testing-scripts





Resolution at low energies should be (cell size)/sqrt(12)

Conclusions

- A big disadvantage of the current “real” ECAL reconstruction: calibrations have to be remade each time the geometry changes
- After change of number of layers and cell size, reconstruction quality has decreased
- New calibrations have been produced for new geometry, with new, more meaningful parametrizations along along with scripts for testing

Future steps:

- update the parametrizations in SPDROOT
- add an alternative option: “phast” ECAL reconstruction: smear ECAL response according to resolutions
- implement the π/γ separation algorithm into the framework
- testing scripts: detailed plots for different parts of ECAL and different angles/energies