Laboratoire d'Annecy-le-Vieux
de Physique des Particules

Study of alternative HCAL designs for SiD detector

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In2p3

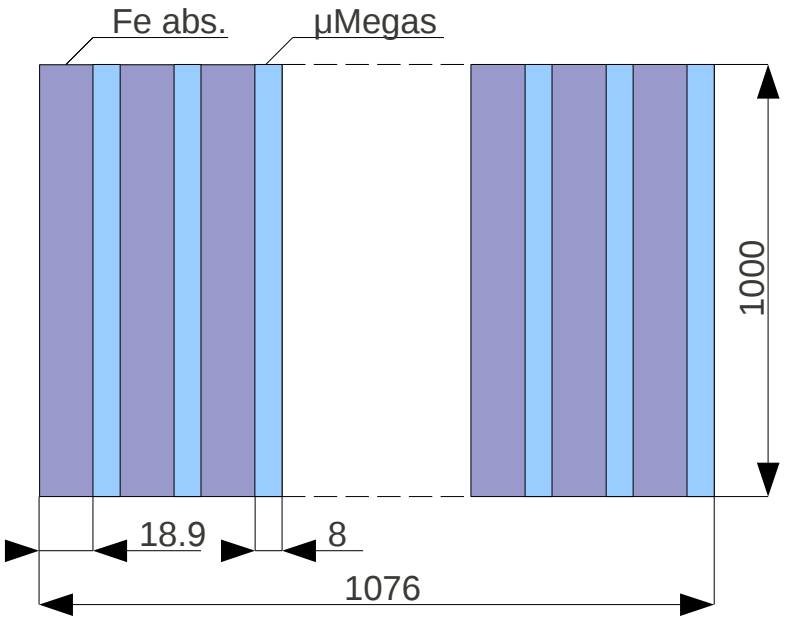
Objective

- The aim is to find an alternative HCAL design for the SiD detector. The new design should be less demanding on the side of calorimeter fabrication and construction, but it should fulfill the requirements on the calorimeter physics performance

- Three alternative HCAL geometries are being investigated and compared with the standard SiD HCAL design
- The study is focus on:
  - Energy shower profiles (lateral and longitudinal)
  - Shower containment and leakage corrections
  - Calorimeter responds and linearity
  - Energy resolution
  - ....

Calorimeter description

Standard SiD HCAL geometry

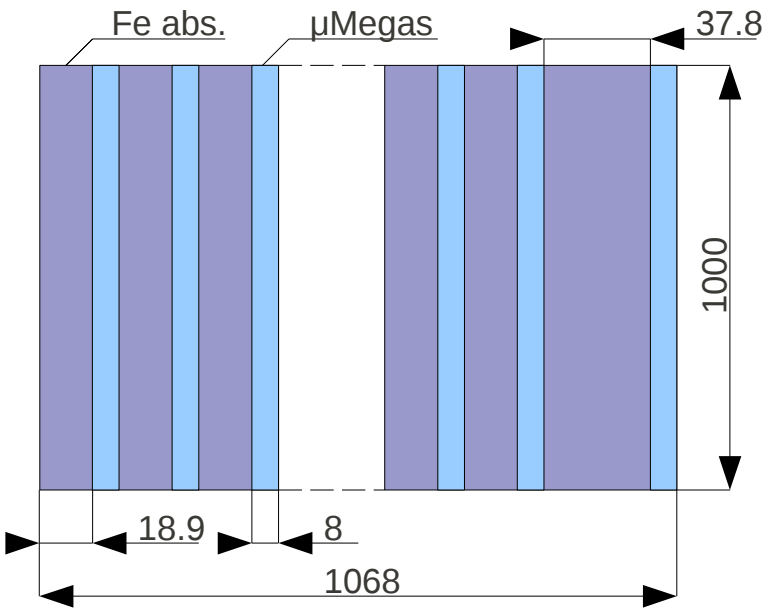


- 40 layers (4.5 λ):
  - 1.89cm Fe abs. + 0.8cm µMegas
- HCAL dimension:
  - 100 x 100 x 107.6cm^3
- µMegas:
  - 1 x 1cm^2 readout pads
  - 3mm gas gap + 5 mm passive components

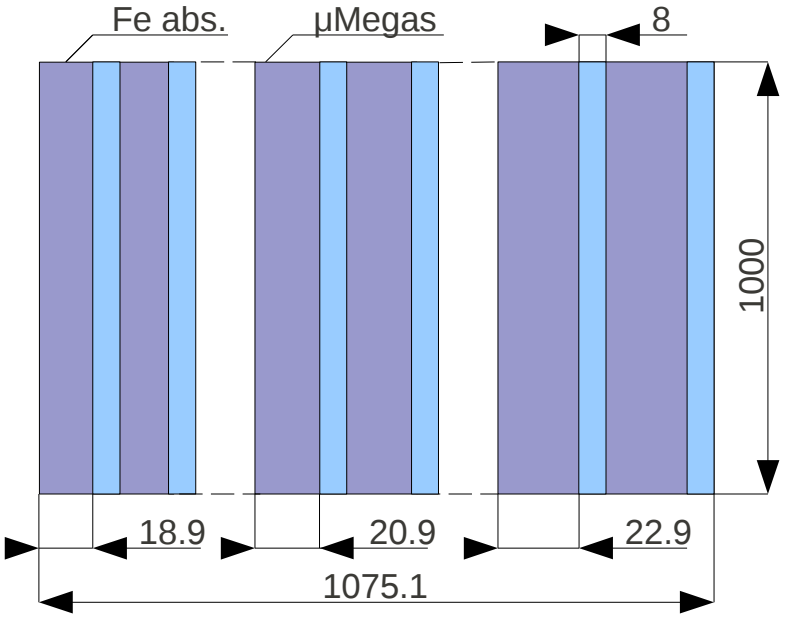
Consideration for alternative geometries:

- Keep same the overall HCAL dimensions (depth = 4.5 λ, 107.6 cm)
- Active part of HCAL is identical for all proposed geometries
- Passive part has been modified in order to improve HCAL mechanical support and to simplify its integration

1. HCAL with thick back plate



2. HCAL with progressive abs. thickness



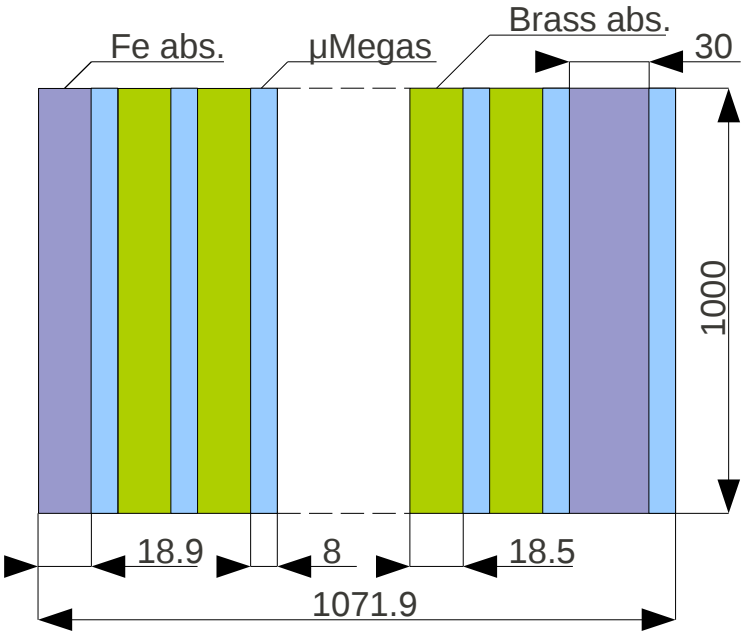
Description:

ad 1. 38 std. layers + 1 layer with double Fe abs. thickness

ad 2. 30 layers std layers + 5 layers with 2.09 cm Fe abs. + 4 layers with 2.29 cm Fe abs.

ad 3. 1. std. Layer + 38 layers with 1.85 Brass abs. + 1 layer with 3 cm Fe abs.

3. HCAL with Fe and Brass absorbers



Set-up

Material properties:

Material	ρ [g.cm^{-3}]	x_0 [cm]	λ [cm]	x_0/λ
Fe	7.87	1.76	16.78	0.11
Brass	8.32	1.52	16.36	0.09

Geometry details:

Geometry	# layers	Length [cm]	Depth [λ]
FeAbs	40	107.6	4.51
FeAbs_TBP	39	106.8	4.51
FeAbs_PAT	39	107.5	4.74
BrassAbs	40	107.2	4.57

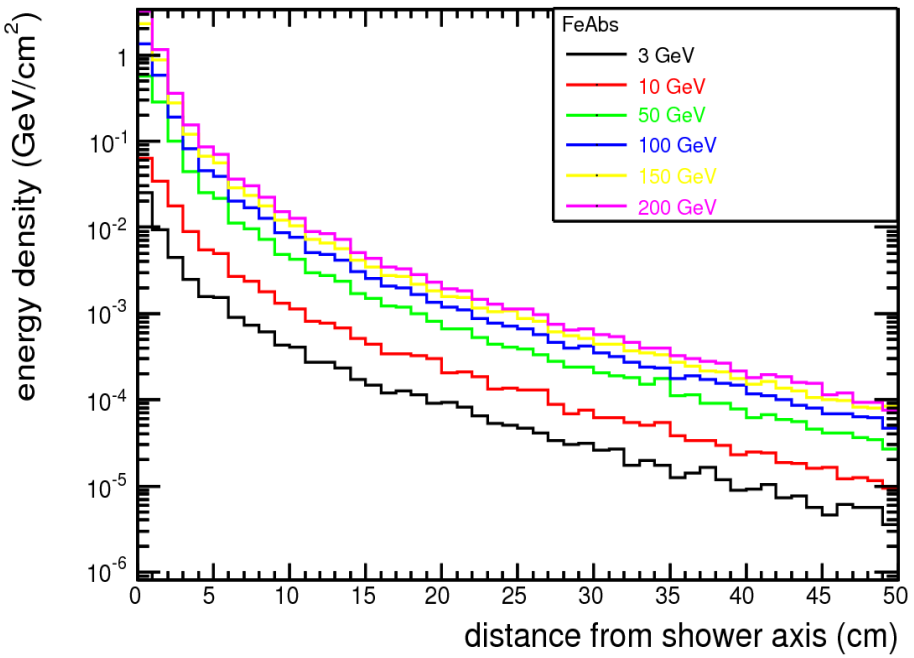
Simulation data:

- 10 kevents of negative single pions
- Chosen energies: 3, 10, 50, 100, 150, 200 GeV
- QGSP_BERT physics list

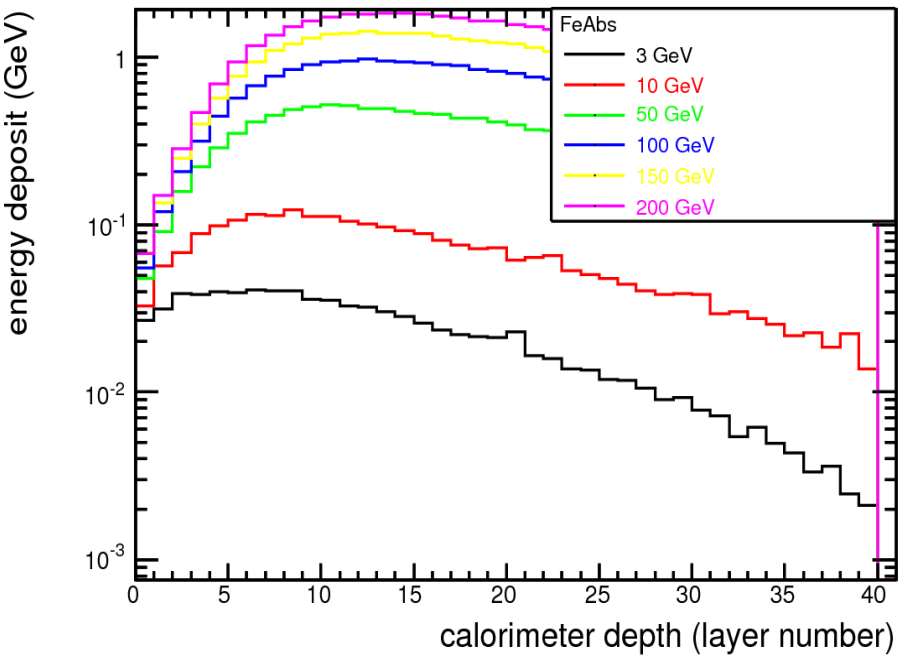
Energy shower profiles

Example for the standard HCAL geometry, 0.1 MIP MPV threshold

Lateral profile integrated over full depth



Longitudinal profile



- Very small lateral leakage even for higher energy
- For energy 50 GeV and higher, the leakage at rear of the calorimeter needs to be taken into account and corrected for resolution study

Energy shower profiles

Example for the standard HCAL geometry, 0.1 MIP MPV threshold

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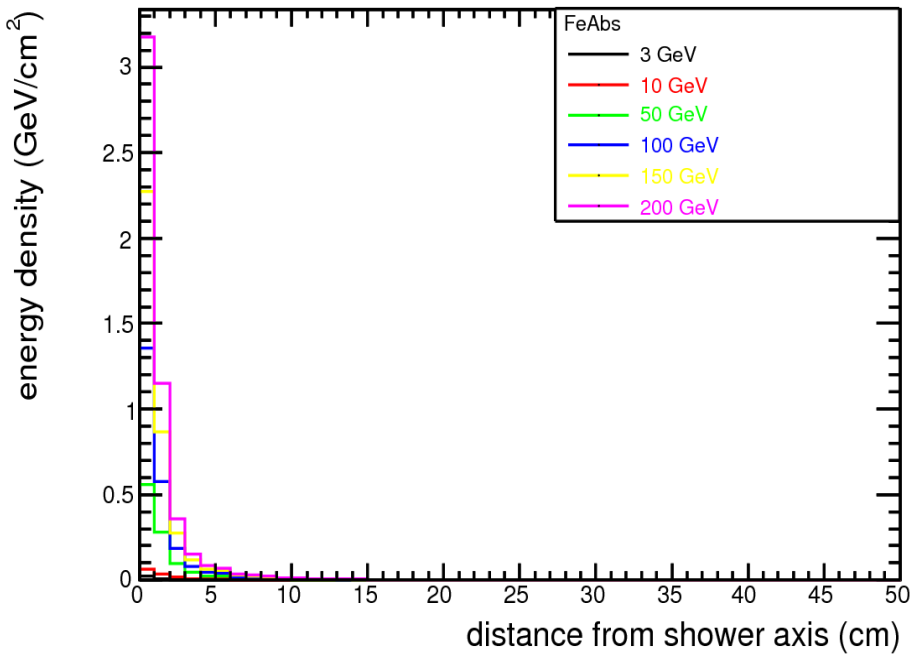
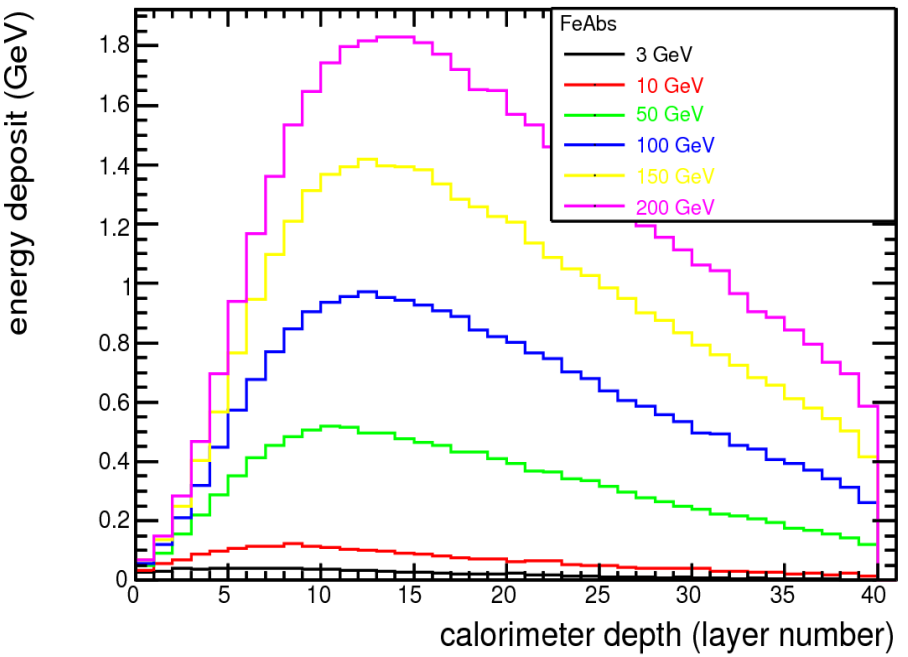


Longitudinal profile



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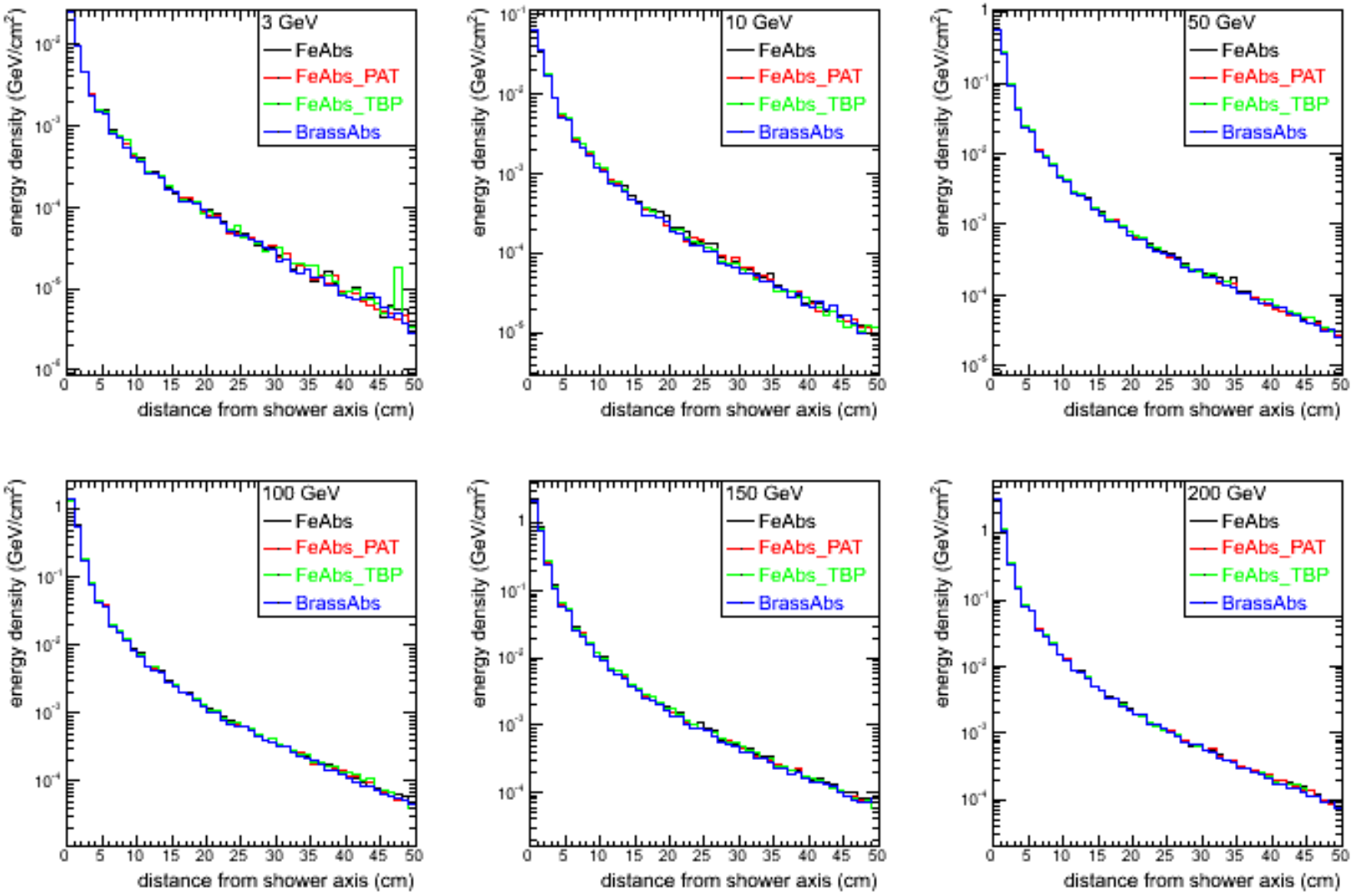
Lateral profiles for different geometries

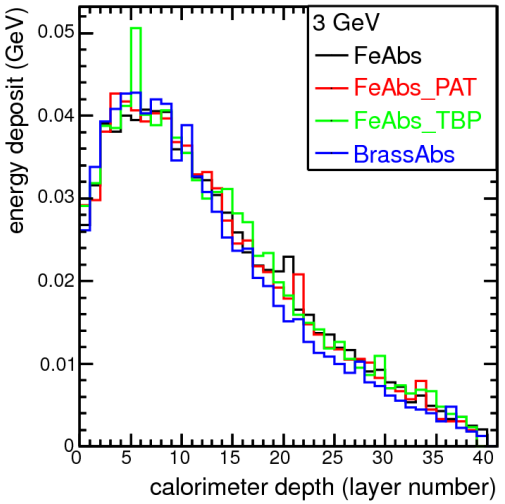
0.1 MIP MPV threshold

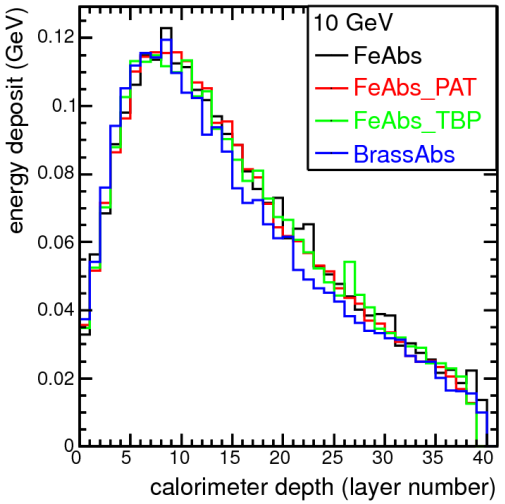


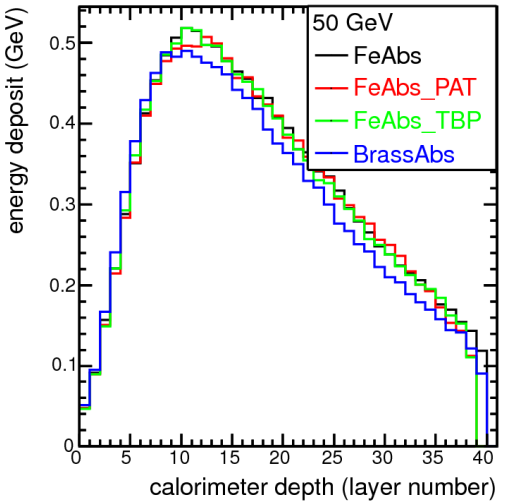
- Lateral profile integrated over the full HCAL depth is identical for all geometries

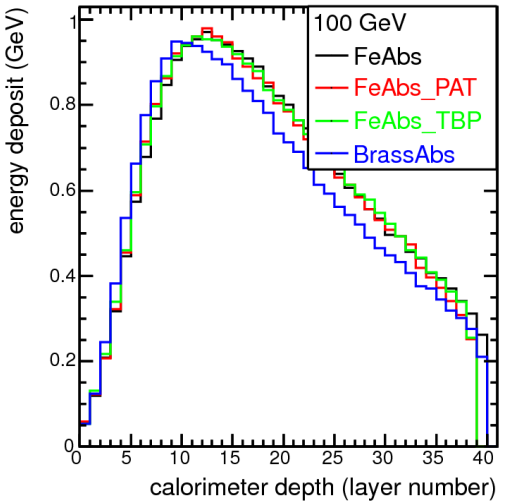
Long. profiles for different geometries

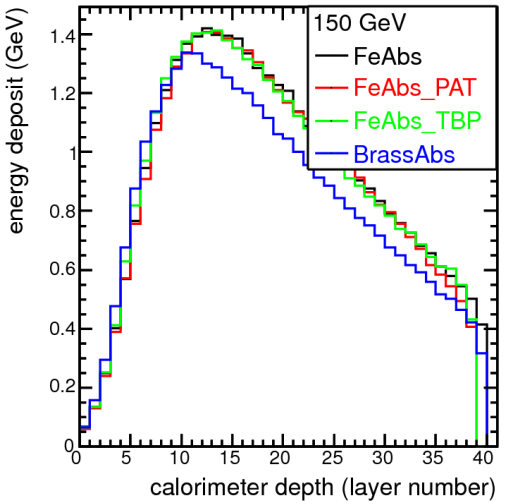
0.1 MIP MPV threshold

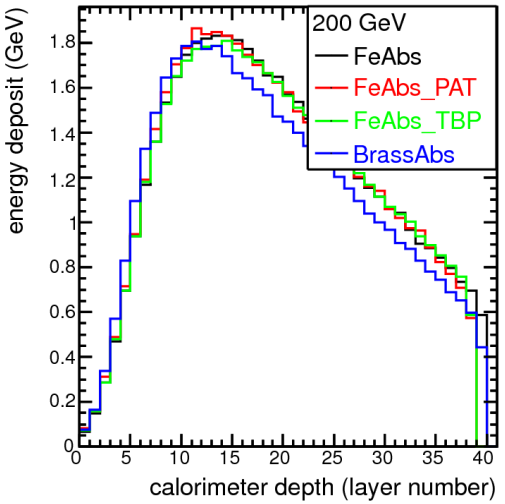










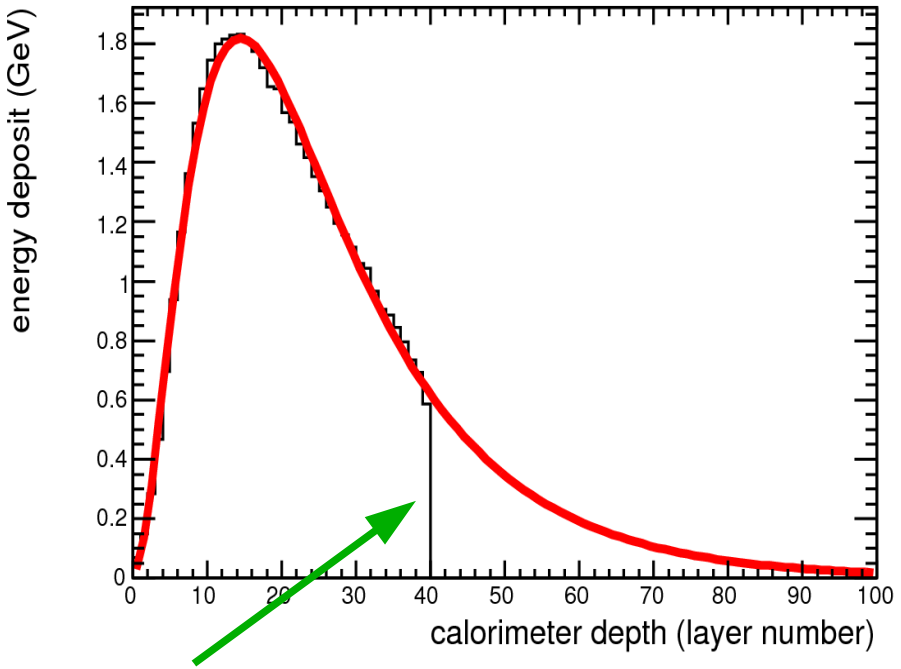


- Expected difference between Fe and Brass calorimeter is clearly seen (Brass has higher density and smaller X_0/λ)

Longitudinal profile parametrization

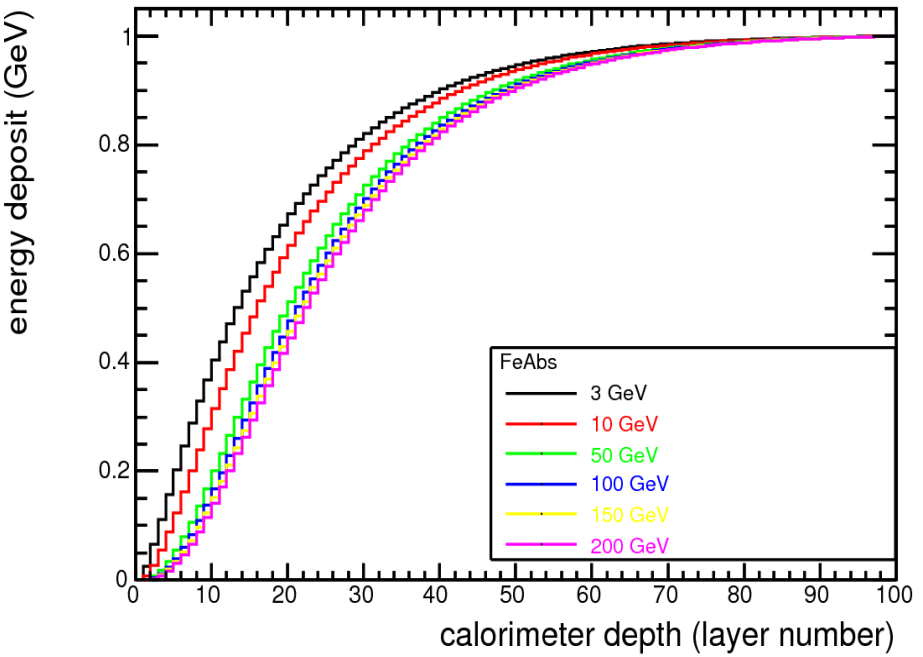
Example for the standard HCAL geometry, 200 GeV, 0.1 MIP MPV TH

Long. profile and fit, 200 GeV



Last layer (#40)

Long. containment

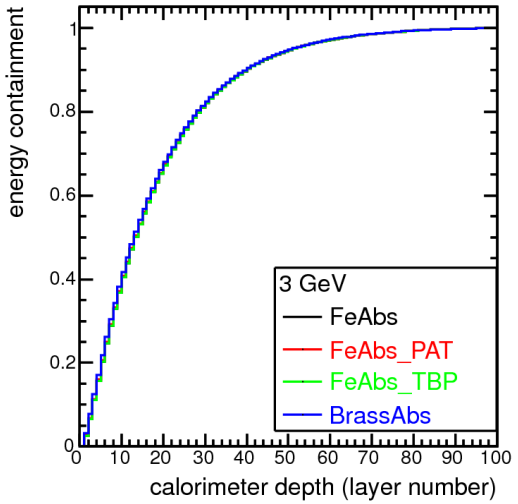


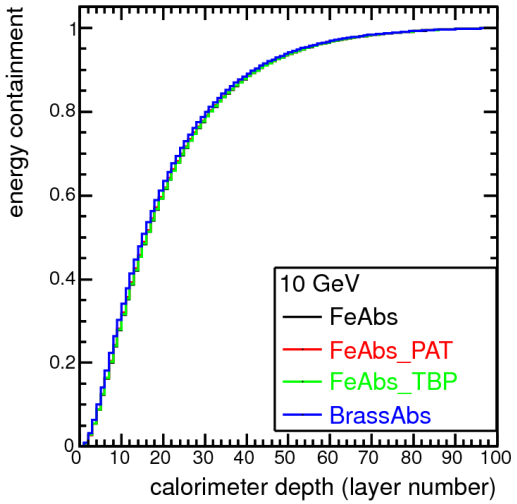
Analytical description:

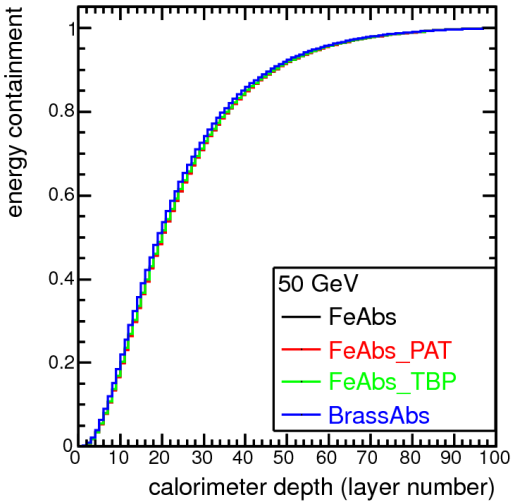
$$\frac{dE}{dz} = N\left\{\frac{wX_0}{a}\left(\frac{z}{X_0}\right)^a e^{-bz/X_0}\,{}_1F_1(1,1+a,(b-\frac{X_0}{\lambda})\frac{z}{X_0})+ \frac{(1-w)\lambda}{a}\left(\frac{z}{\lambda}\right)^a e^{-dz/\lambda}\,{}_1F_1(1,1+a,(d-1)\frac{z}{\lambda})\right\},$$

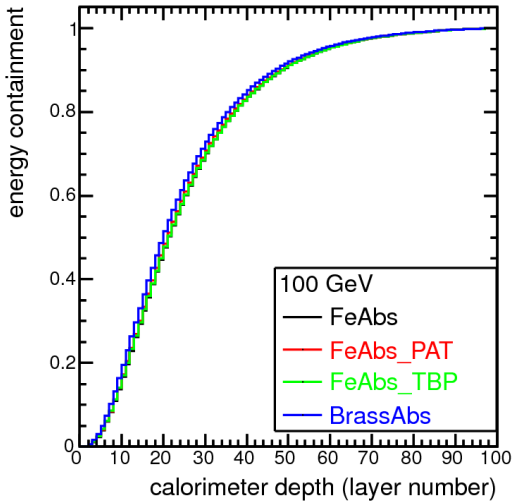
Long. containment for different geometries

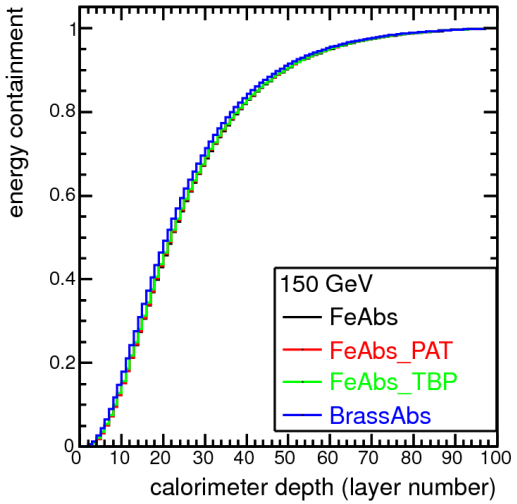
0.1 MIP MPV threshold

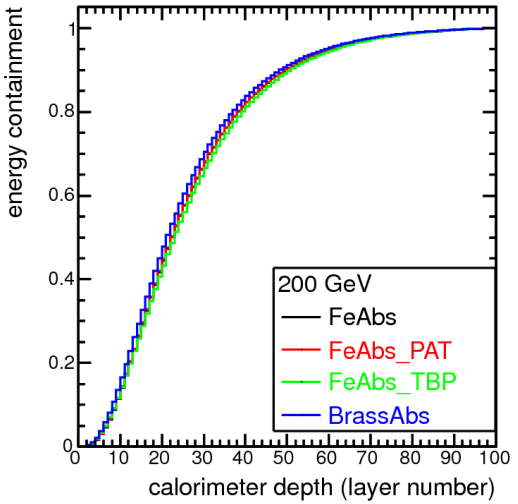












Summary

Three alternative HCAL geometries have been proposed, data have been generated and studied

Longitudinal and lateral shower shape behave as expected. No significant difference among the proposed geometries has been found.

To do list:

- Calorimeter response and linearity
- Energy resolution
- ...