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

Study of alternative HCAL designs for SiD detector

Jan Blaha

Micromegas Physics Meeting, 18 May 2011, LAPP

UNIVERSITE CHAMBERY SAVOIE

cnrs

In2p3

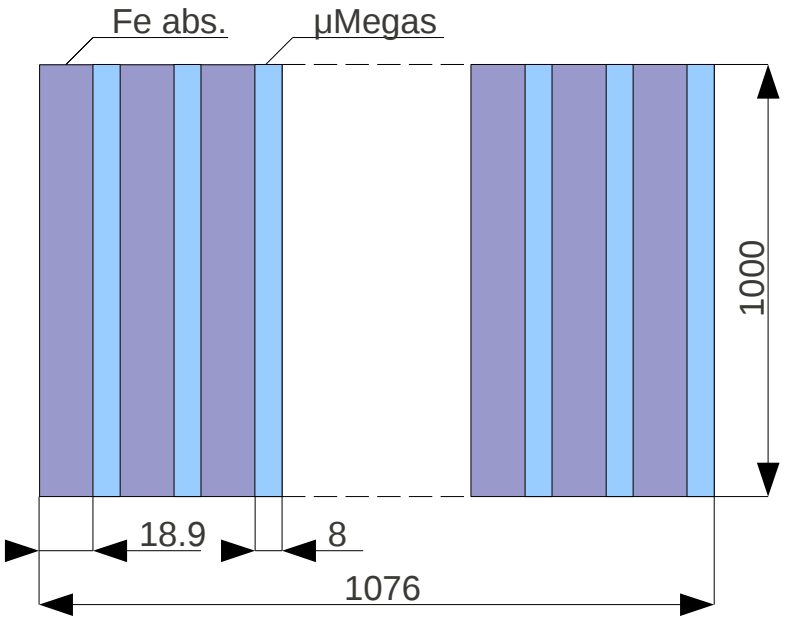
Objective

- 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

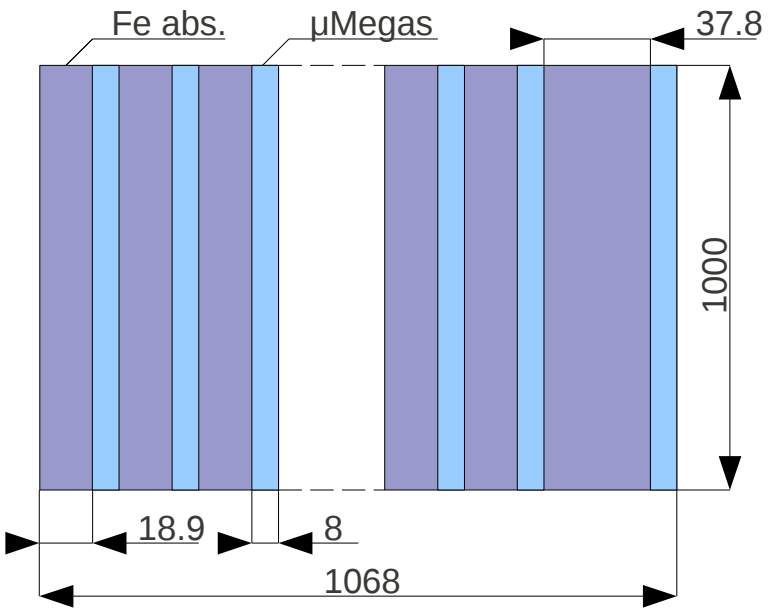


- 40 layers (4.5 λ):
  - 1.89cm Fe abs. + 0.8cm µMegas
- HCAL dimension:
  - 100 x 100 x 107.6cm^3
- µMegas:
  - 1 x 1cm^2 readout pads
  - 3mm gas gap + 5 mm passive components

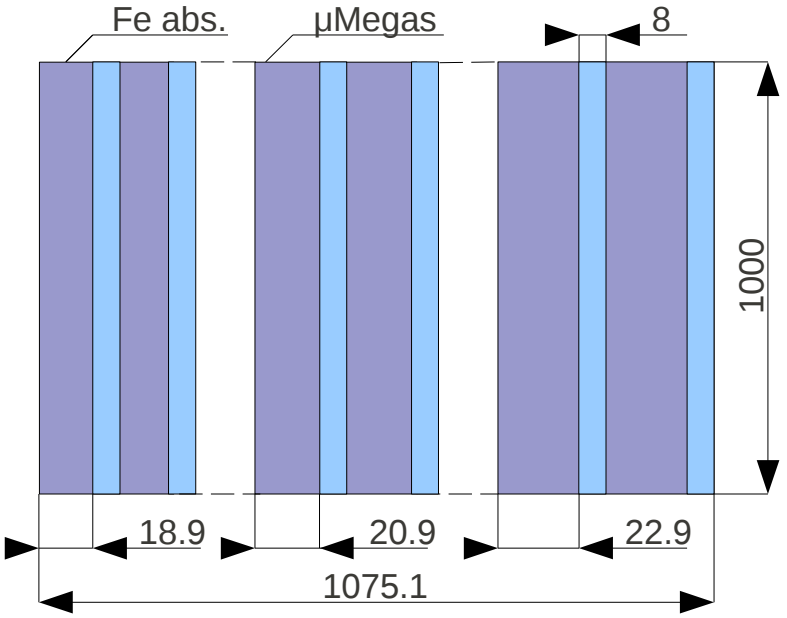
Consideration for alternative geometries:

- 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



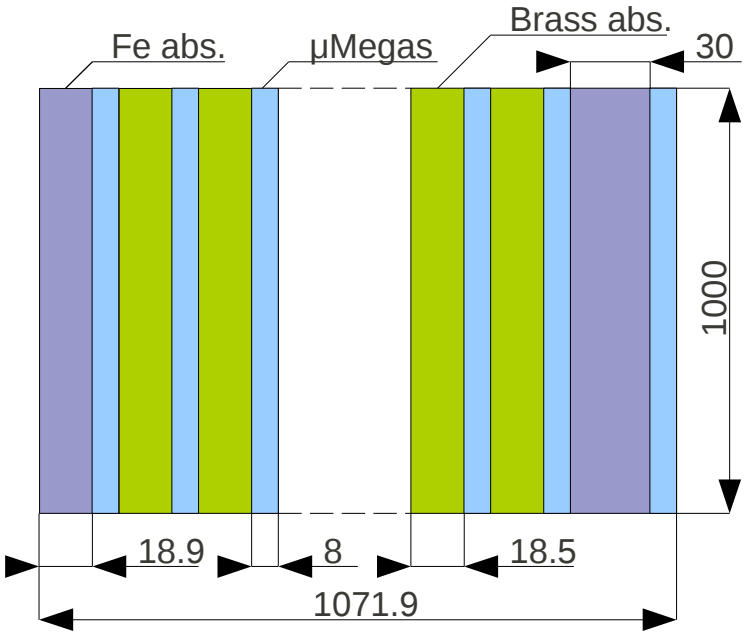
Description:

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

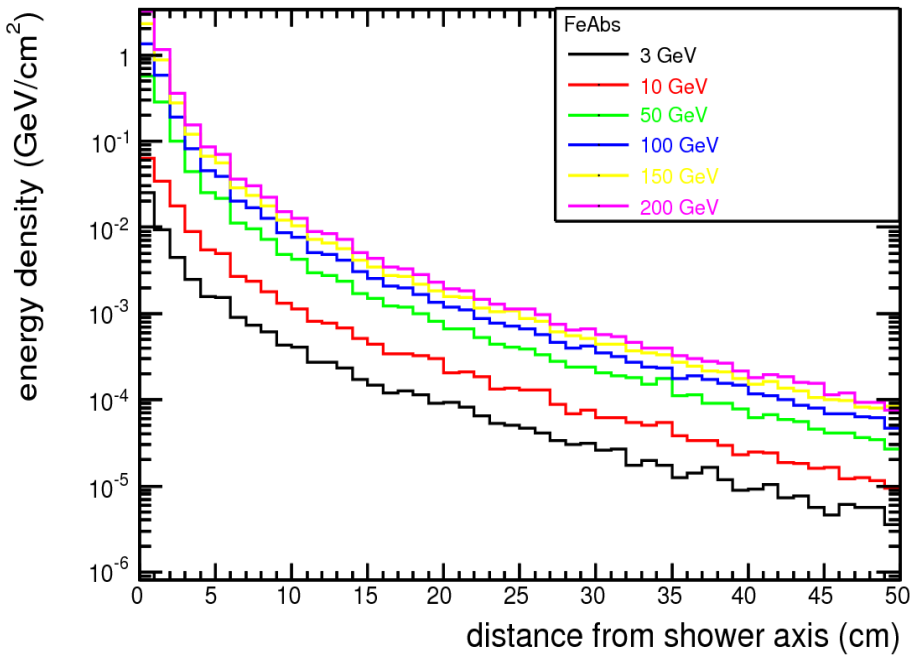
Simulation data:

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

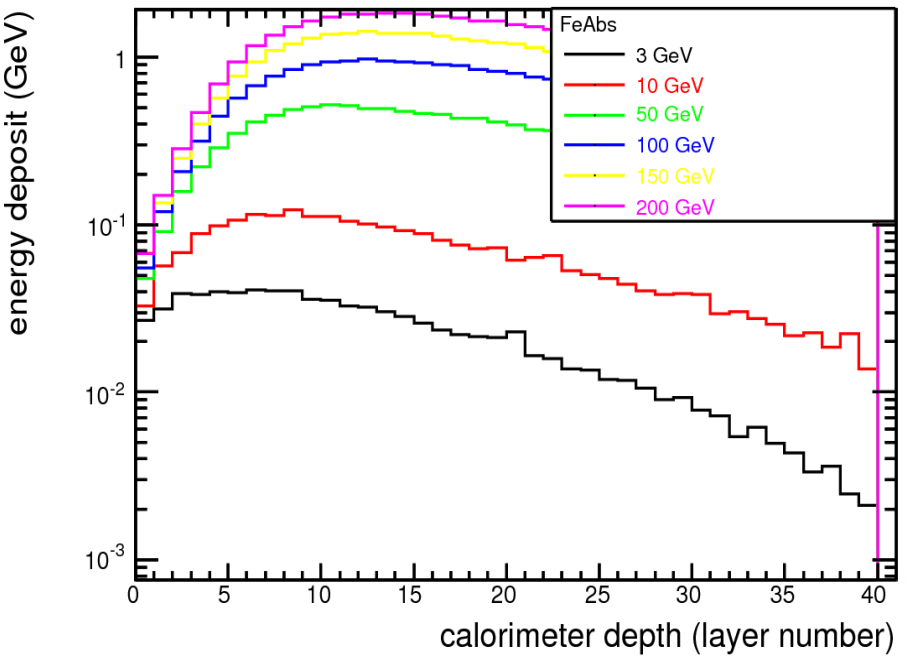
Energy shower profiles

Example for the standard HCAL geometry, 0.1 MIP MPV threshold

Lateral profile integrated over full depth



Longitudinal profile

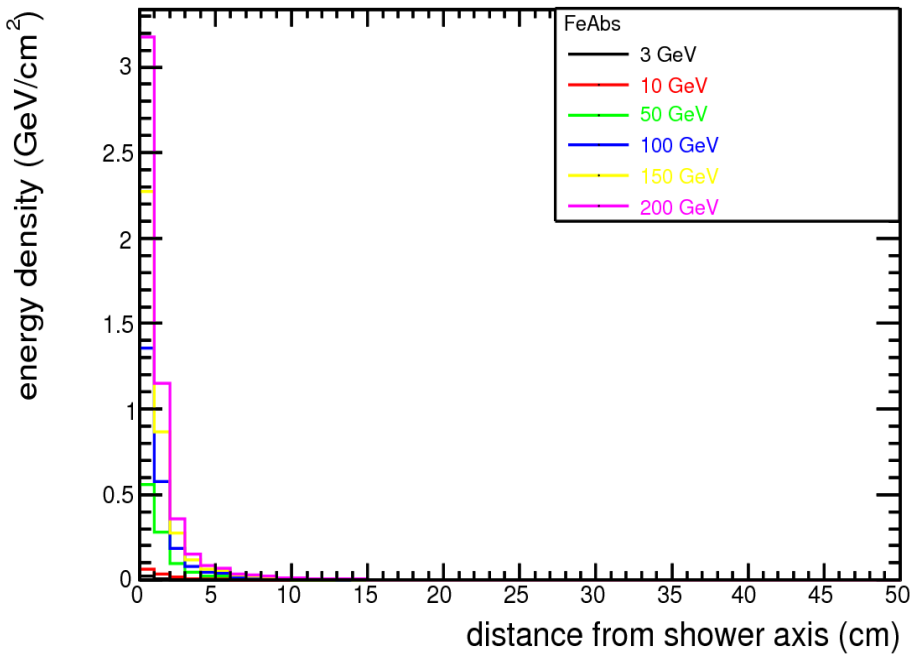


- Very small lateral leakage even for higher energy
- For energy 50 GeV and higher, the leakage at rear of the calorimeter needs to be taken into account and corrected for resolution study

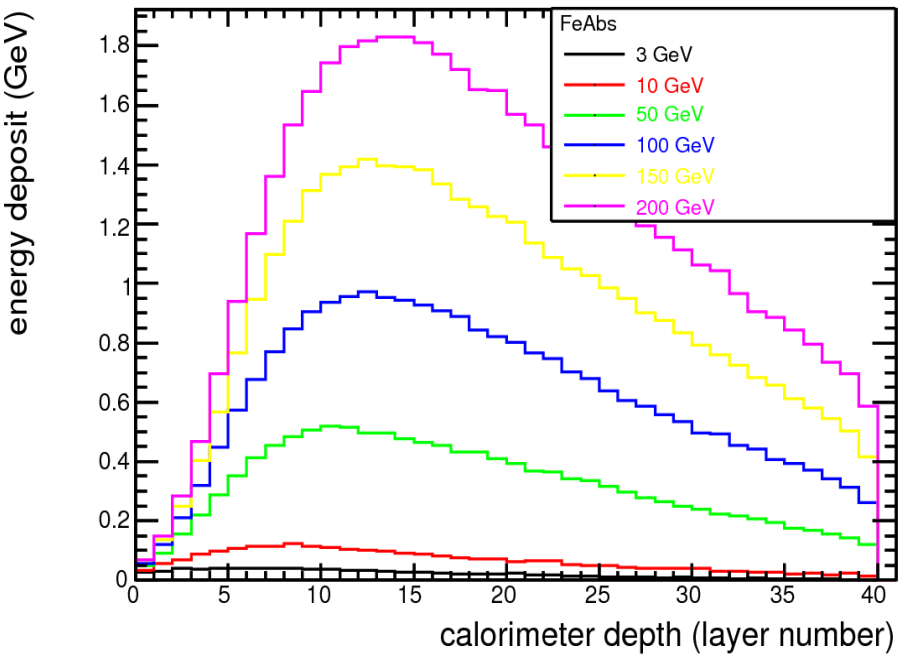
Energy shower profiles

Example for the standard HCAL geometry, 0.1 MIP MPV threshold

Lateral profile integrated over full depth



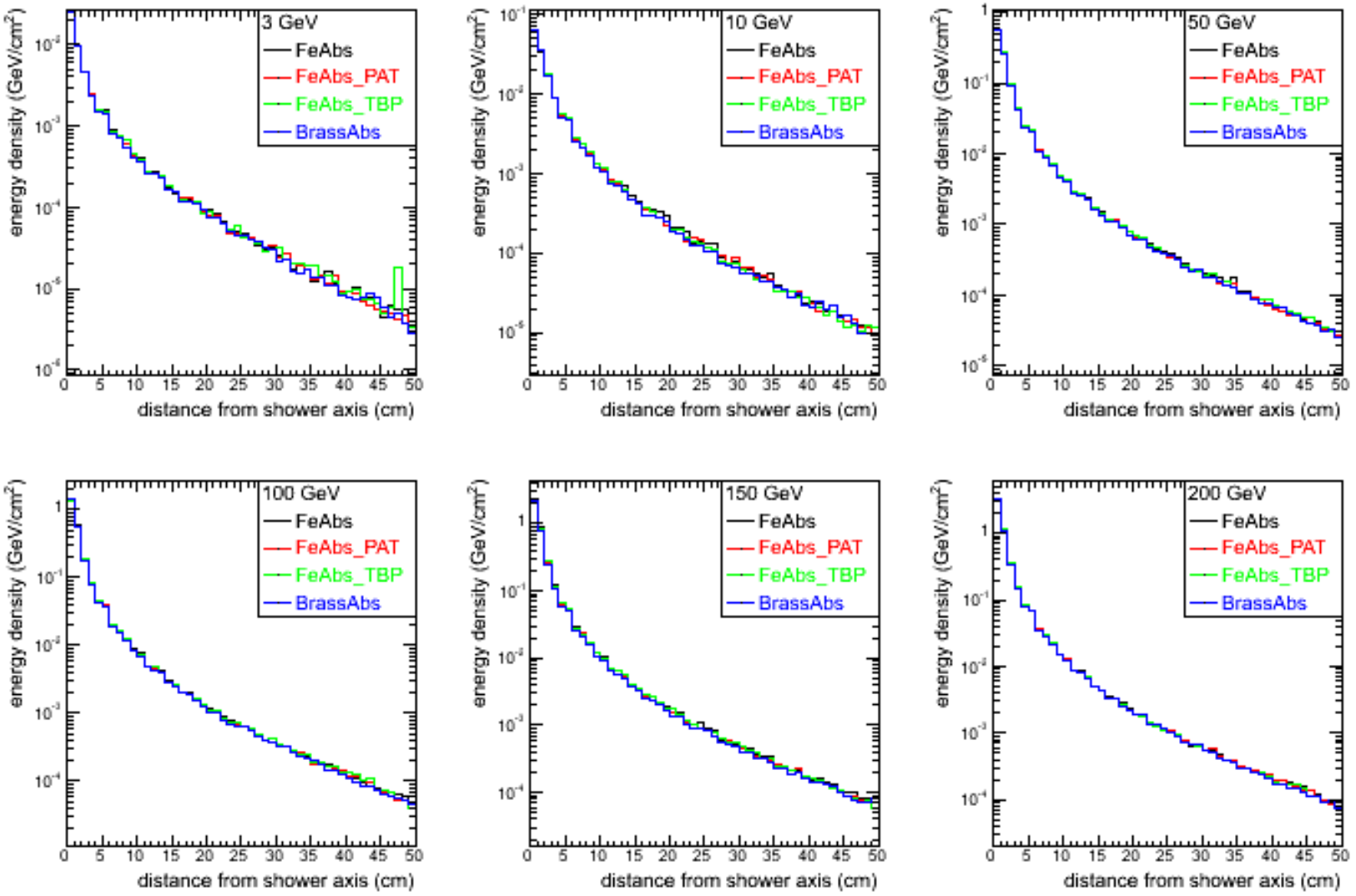
Longitudinal profile



- 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

Lateral profiles for different geometries

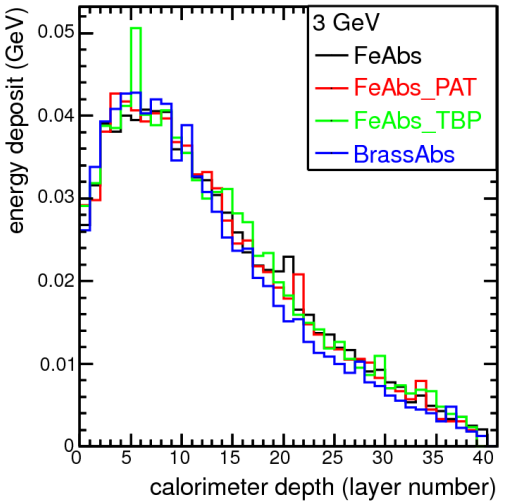
0.1 MIP MPV threshold

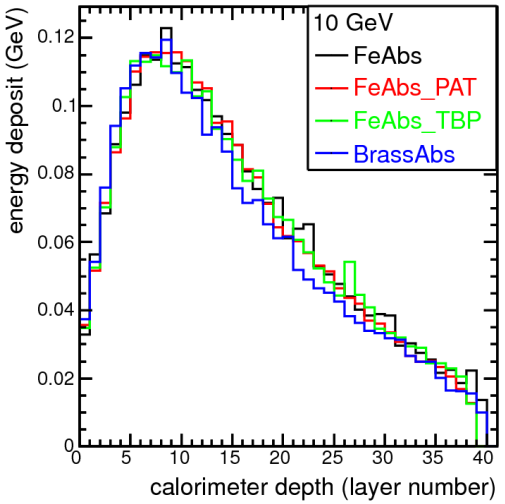


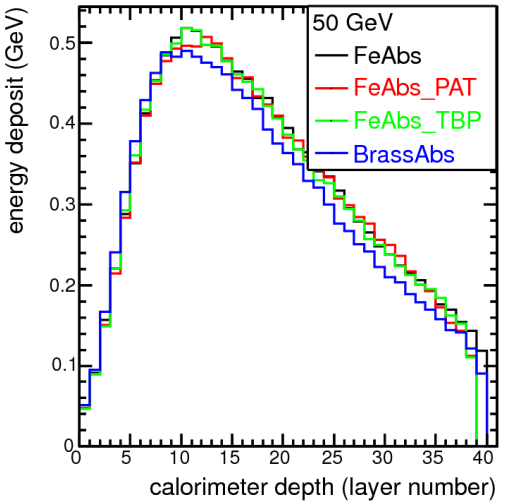
- Lateral profile integrated over the full HCAL depth is identical for all geometries

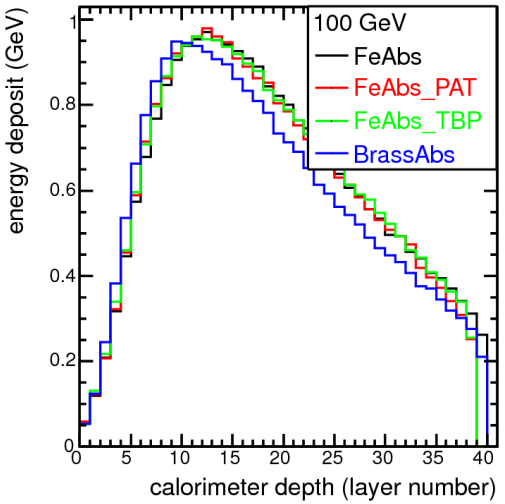
Long. profiles for different geometries

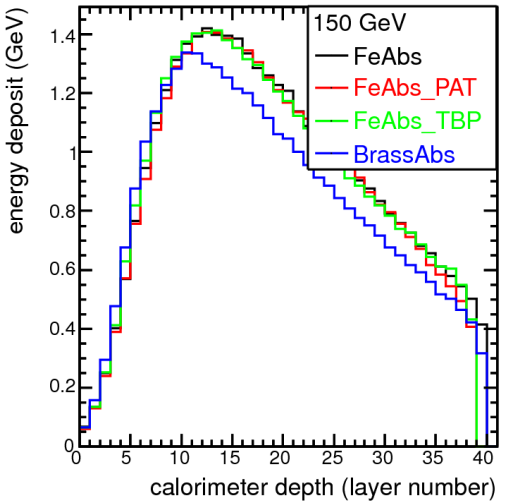
0.1 MIP MPV threshold

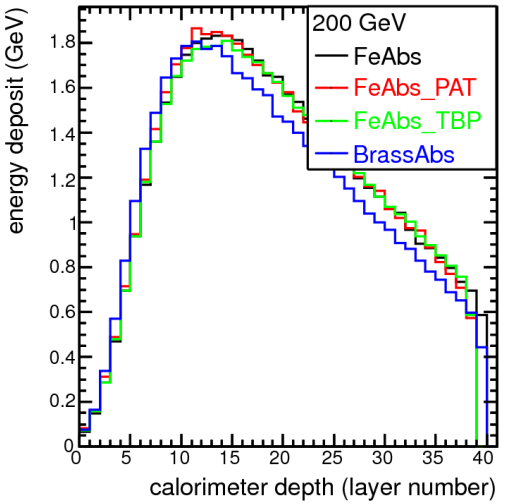










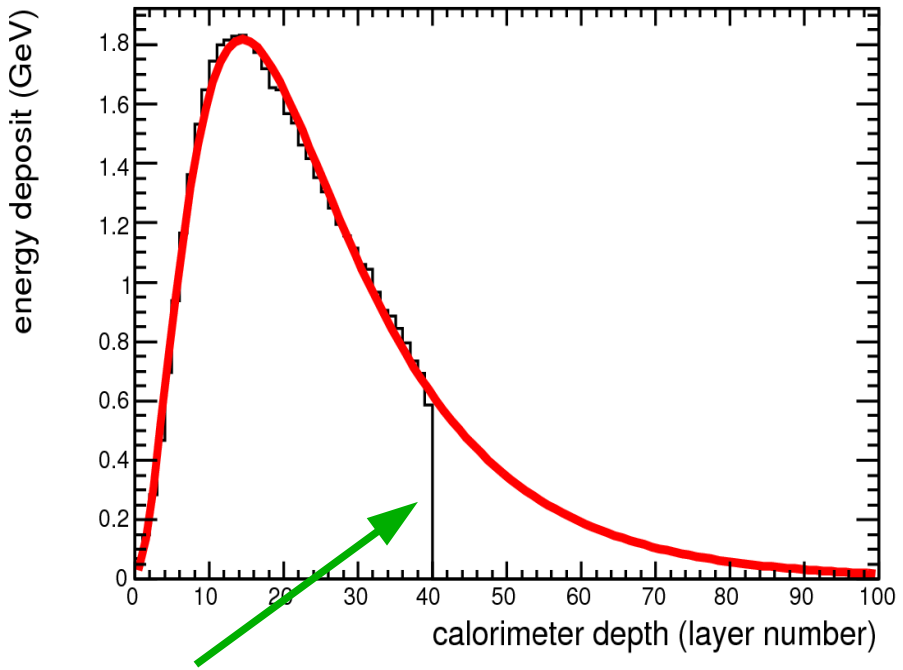


- Expected difference between Fe and Brass calorimeter is clearly seen (Brass has higher density and smaller X_0/λ)

Longitudinal profile parametrization

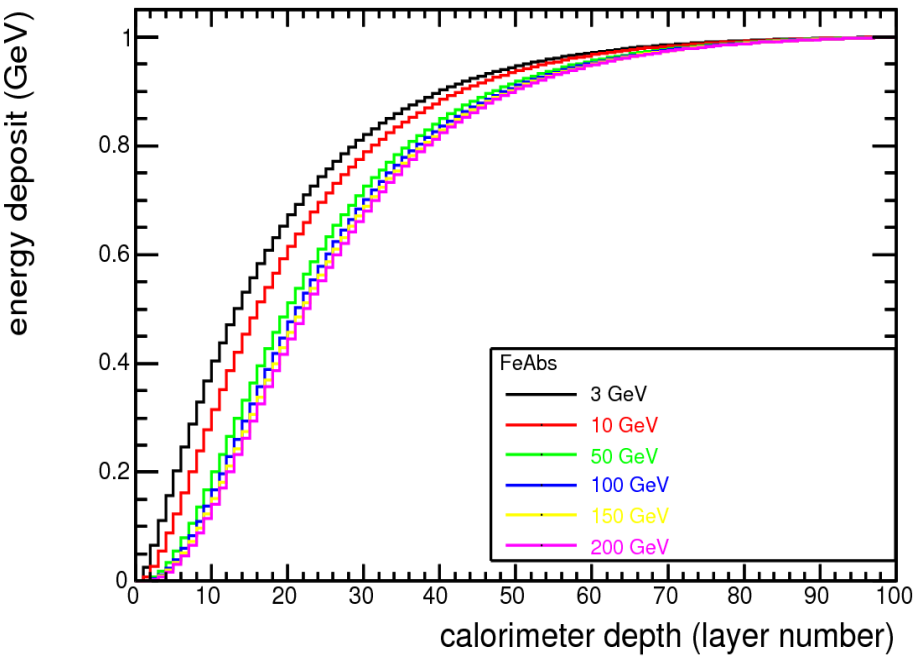
Example for the standard HCAL geometry, 200 GeV, 0.1 MIP MPV TH

Long. profile and fit, 200 GeV



Last layer (#40)

Long. containment

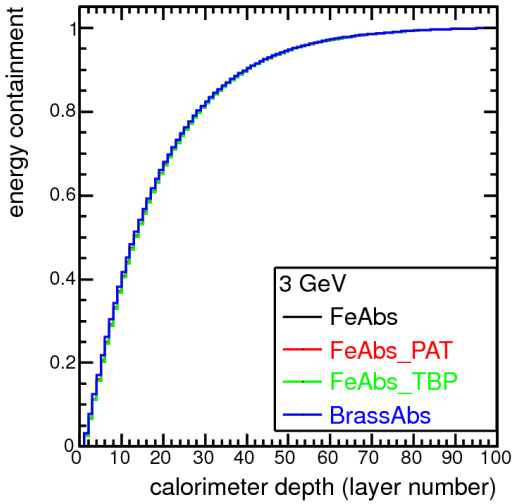


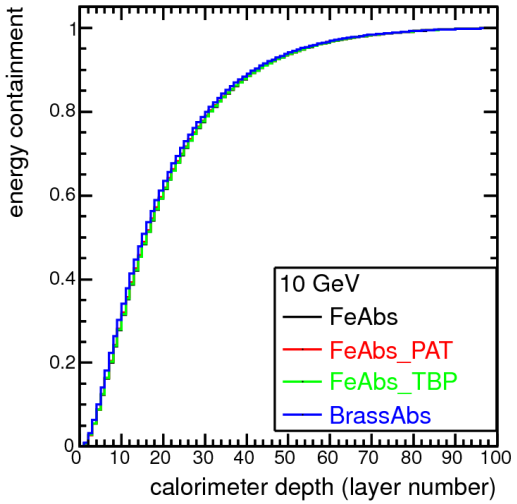
Analytical description:

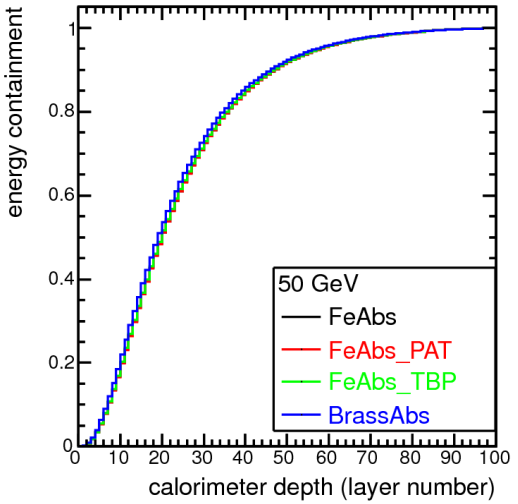
$$\frac{dE}{dz} = N\left\{\frac{wX_0}{a}\left(\frac{z}{X_0}\right)^a e^{-bz/X_0}\,{}_1F_1(1,1+a,(b-\frac{X_0}{\lambda})\frac{z}{X_0})+ \frac{(1-w)\lambda}{a}\left(\frac{z}{\lambda}\right)^a e^{-dz/\lambda}\,{}_1F_1(1,1+a,(d-1)\frac{z}{\lambda})\right\},$$

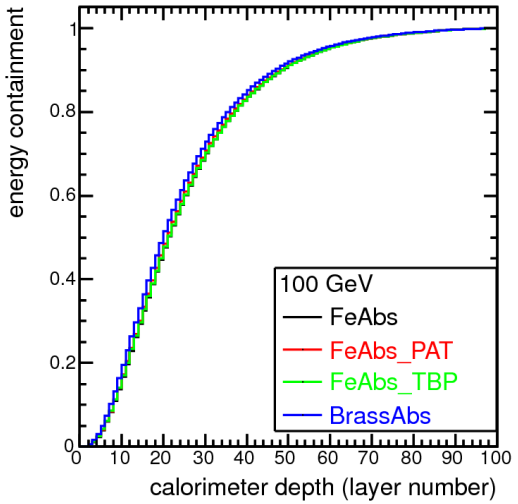
Long. containment for different geometries

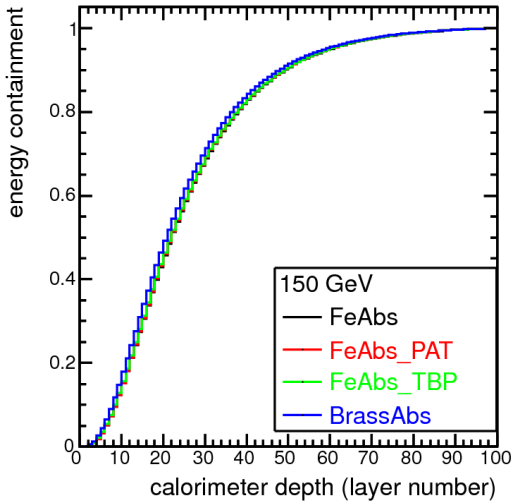
0.1 MIP MPV threshold

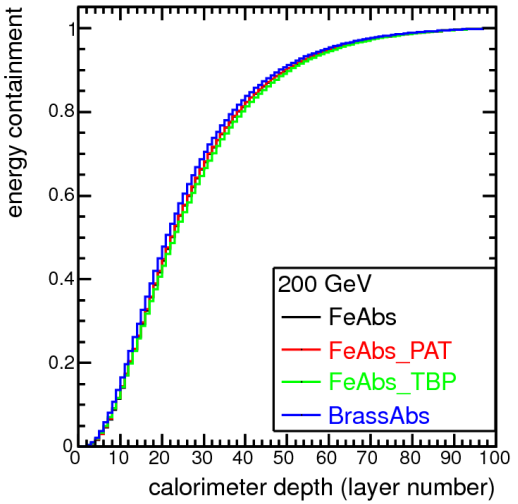






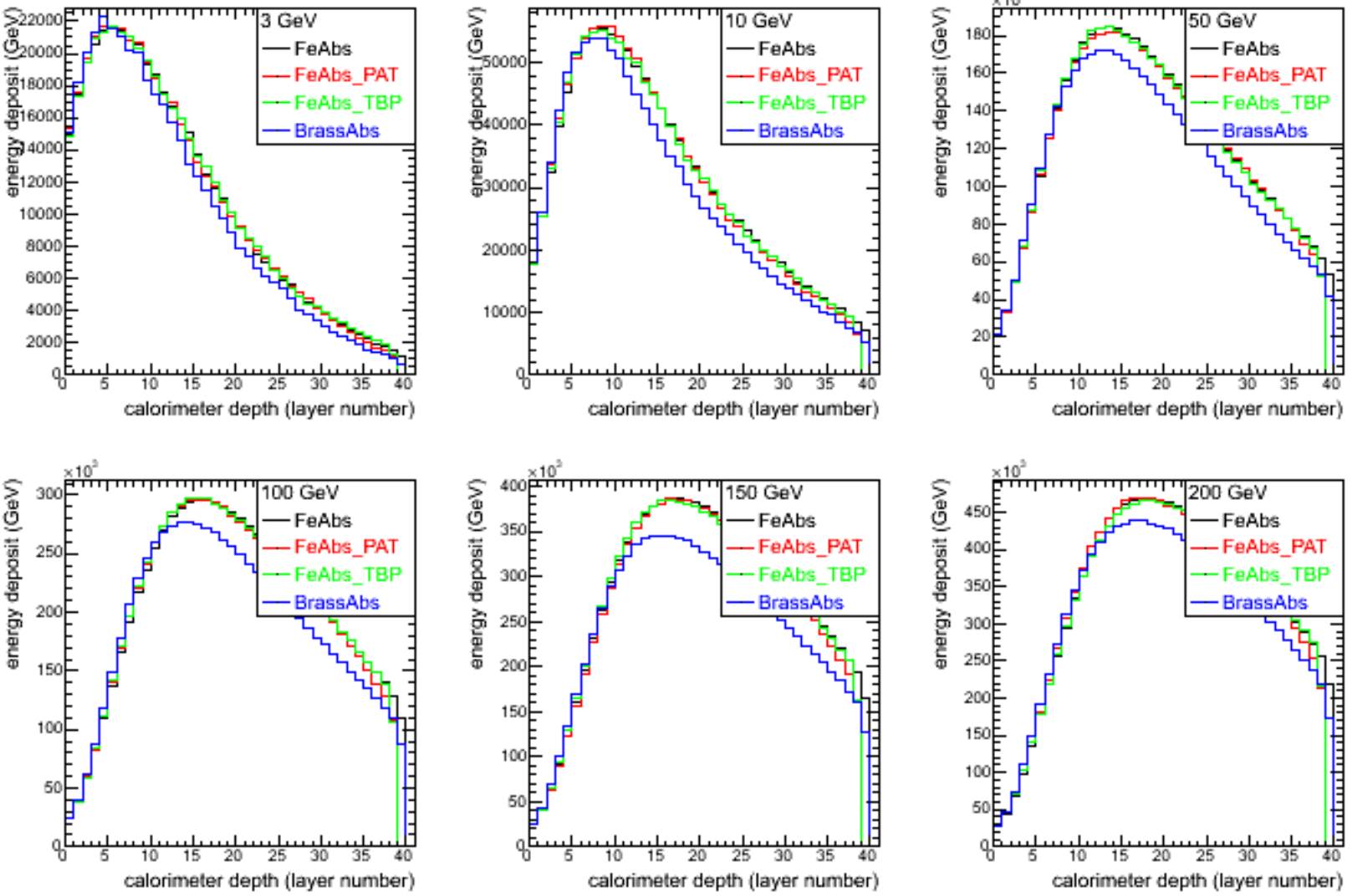






Long. profiles for digital readout

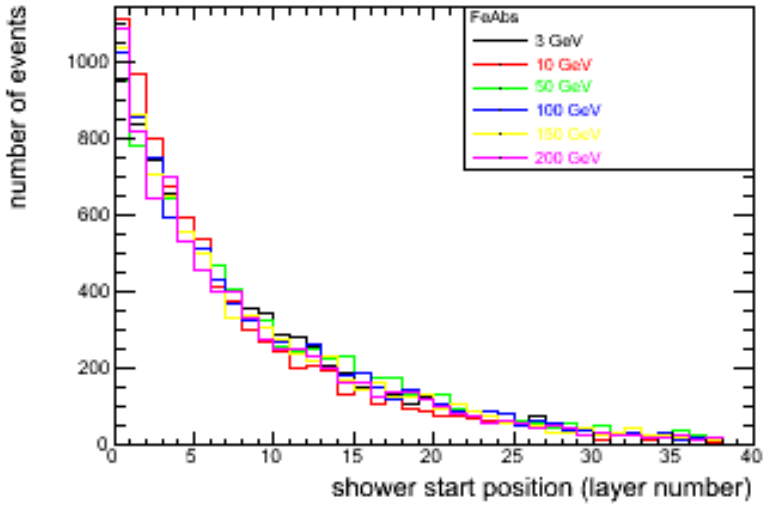
10 kevents, 0.1 MIP MPV threshold

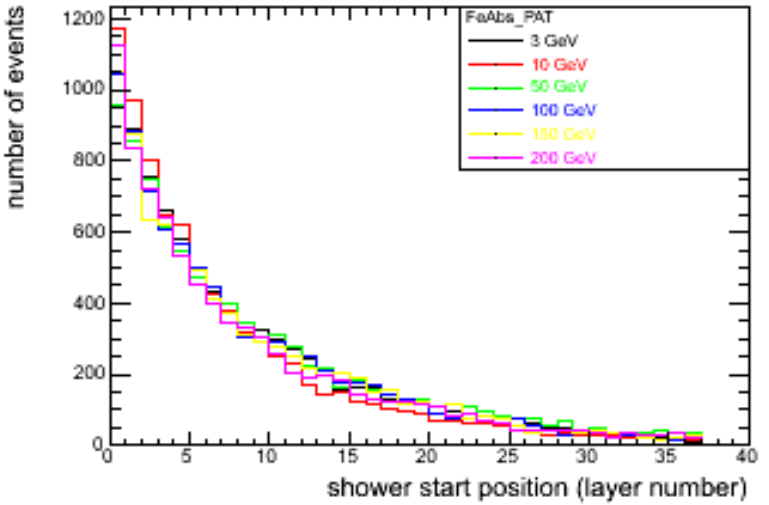


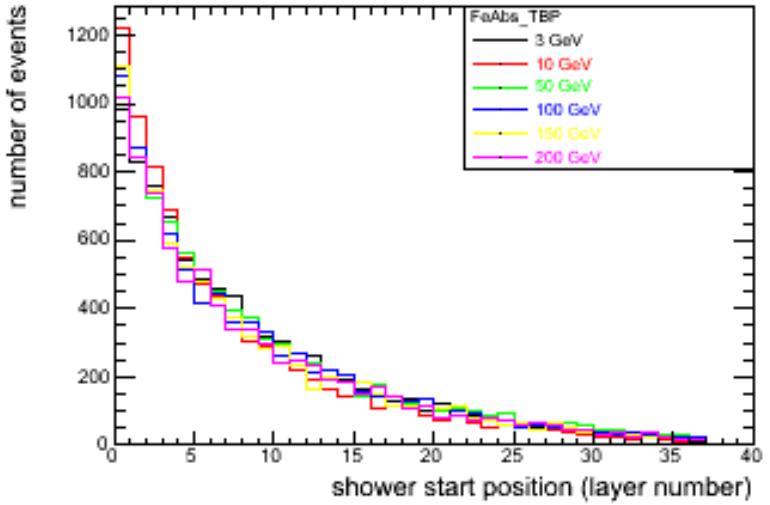
- Only several hits in a shower for low energies → shower start position can be misleaded by noisy hits.

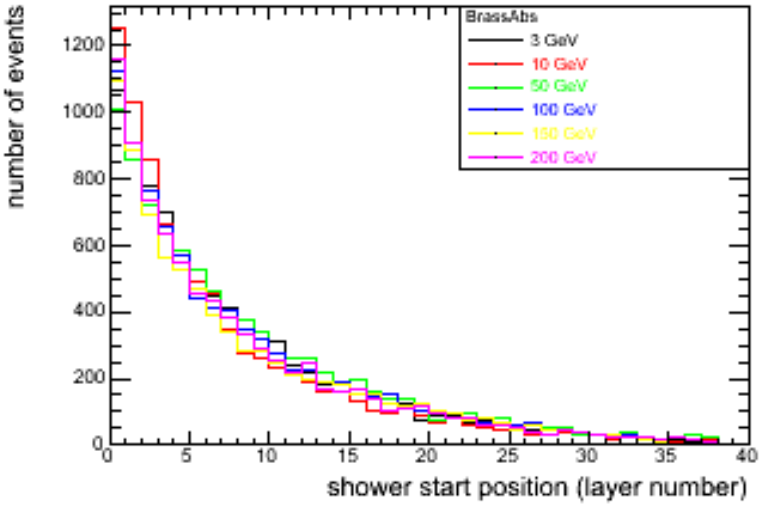
Number of events vs. shower start

0.1 MIP MPV threshold





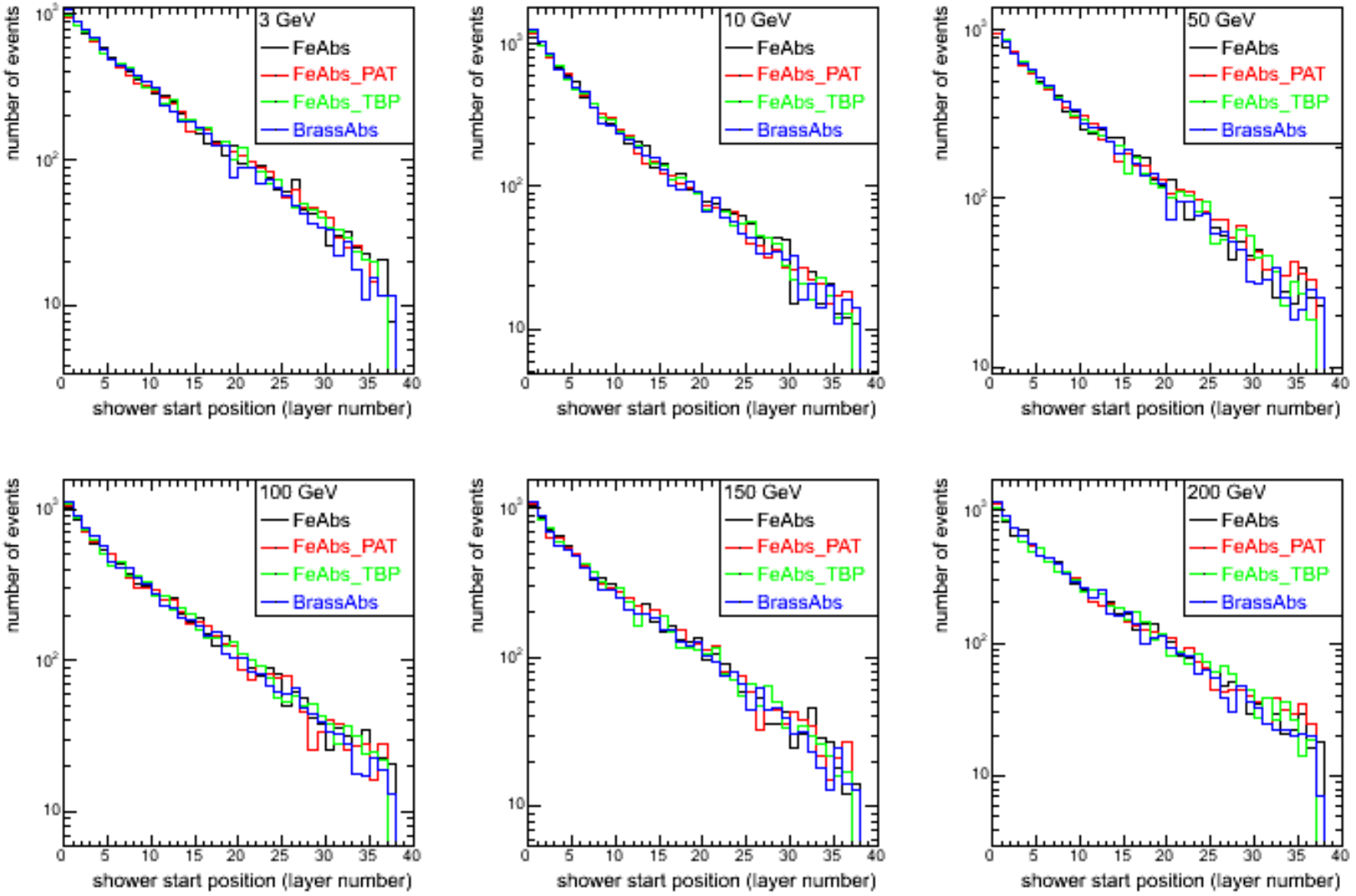




- Probability of the interaction decrease exponentially with calorimeter depth

Number of events vs. shower start

0.1 MIP MPV threshold

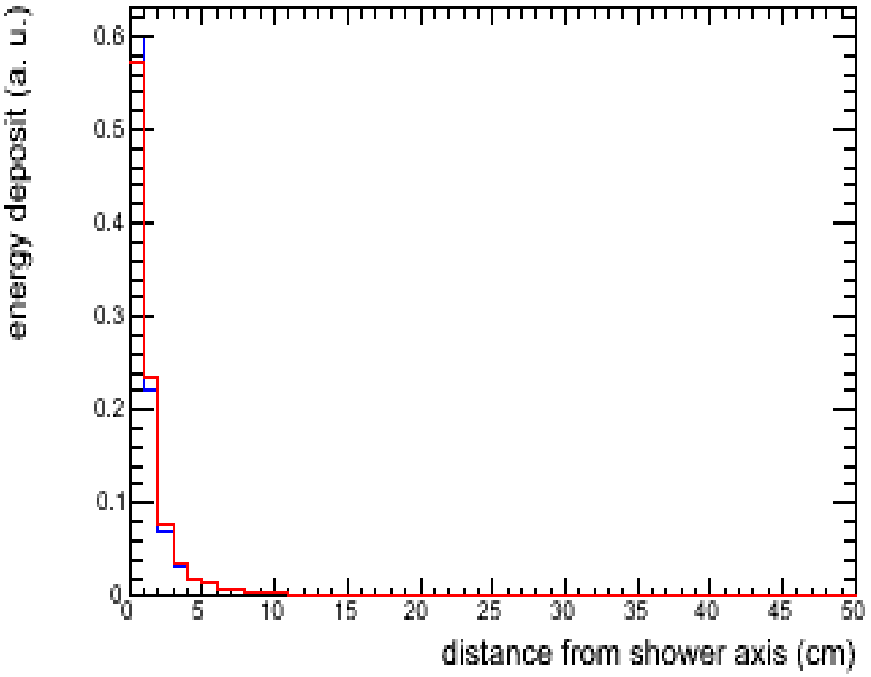


- Dependency should follows -1/λ

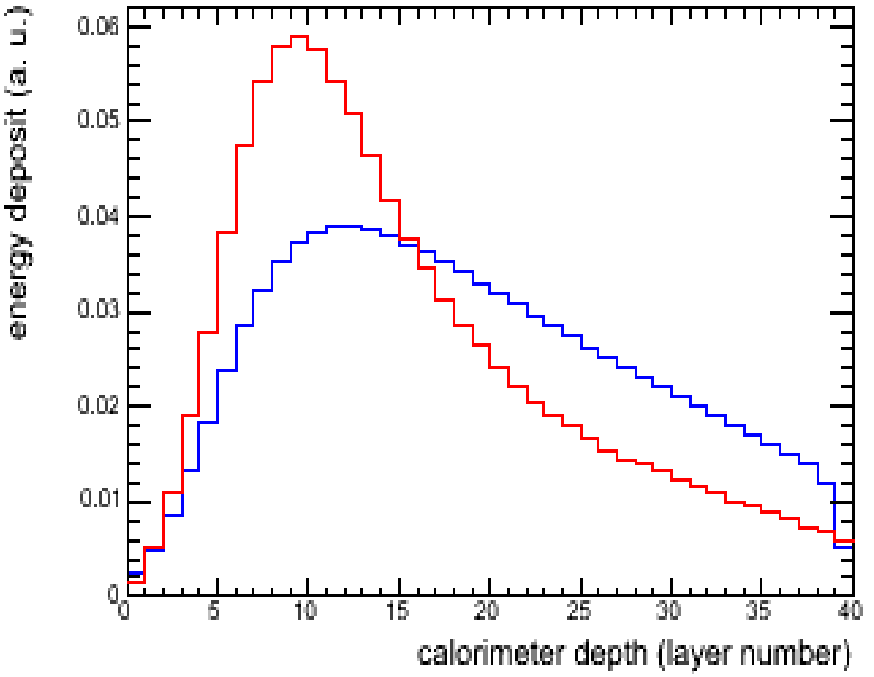
Number of events vs. shower start

10 GeV pions, standard HCAL geometry, 0.1 MIP MPV threshold

Lateral profile



Longitudinal profile



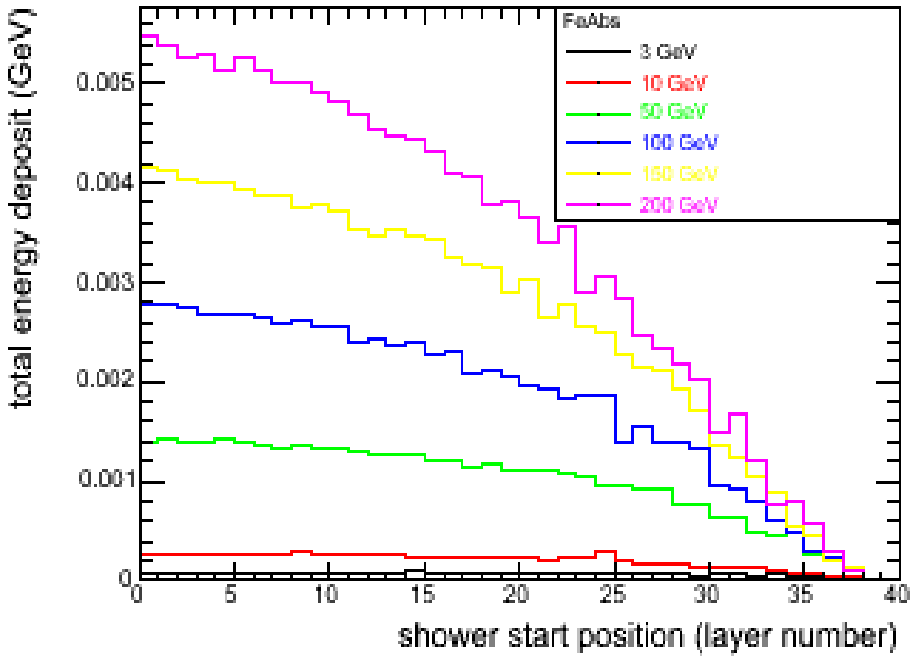
Legend:

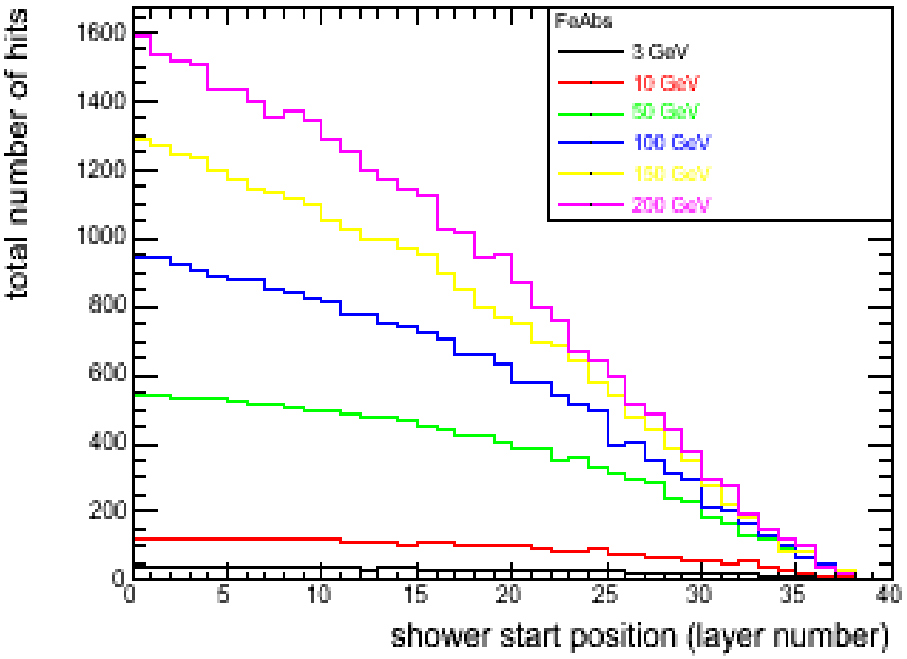
- Profiles for all events
- Profiles for events where shower start within the first 3 layers

→ important for event selection for the miniHCAL

Total energy/hits vs. shower start

Example for the standard HCAL geometry, 0.1 MIP MPV threshold

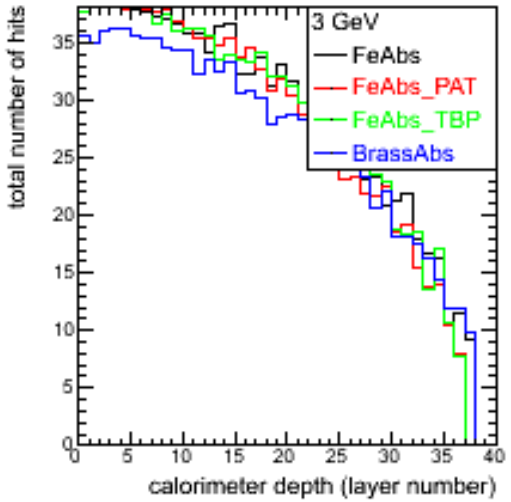


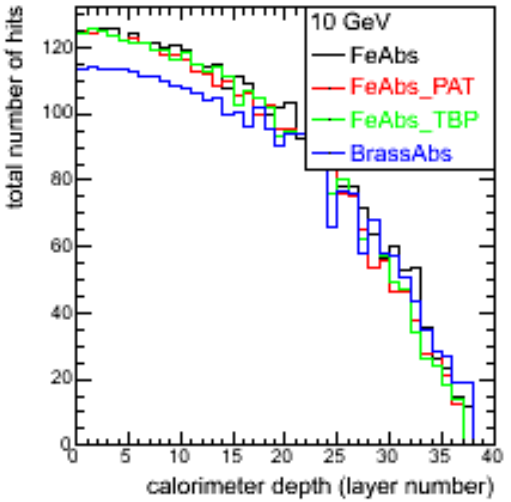


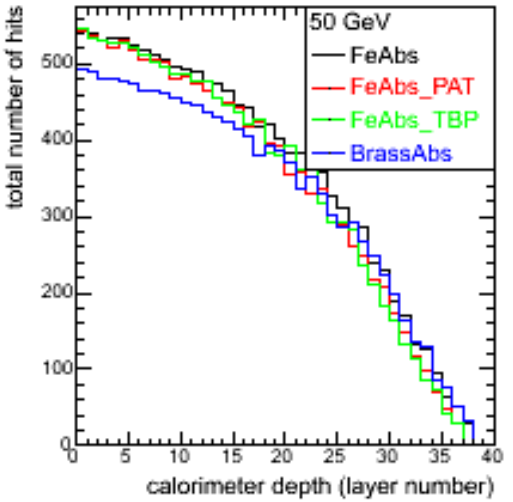
- Total deposited energy or number of counted hits decrease due to the leakage. Sharp fall off is seen when a shower core passes the rear edge of the calorimeter

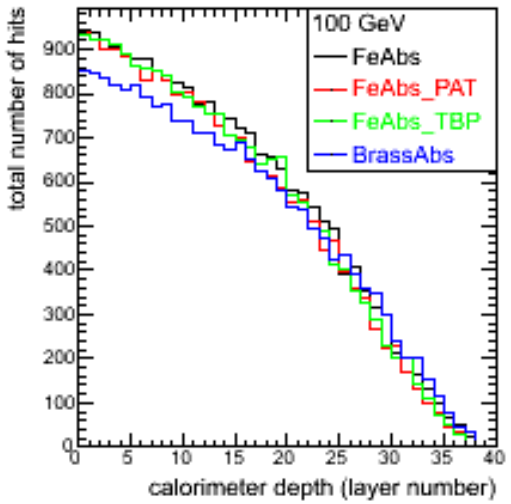
Total number of hits vs. shower start

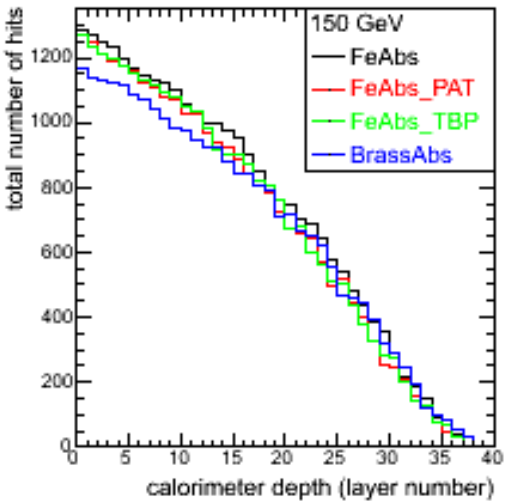
Digital readout, 0.1 MIP MPV threshold

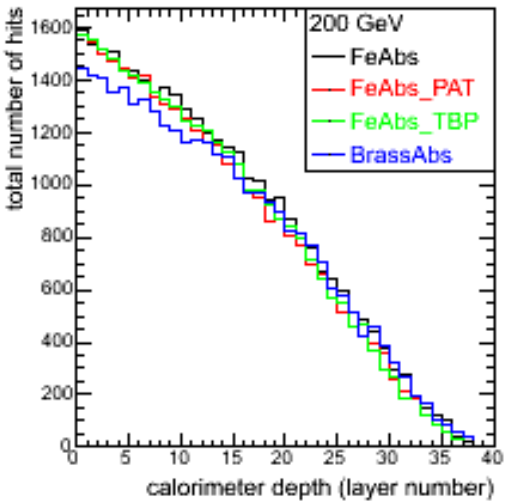






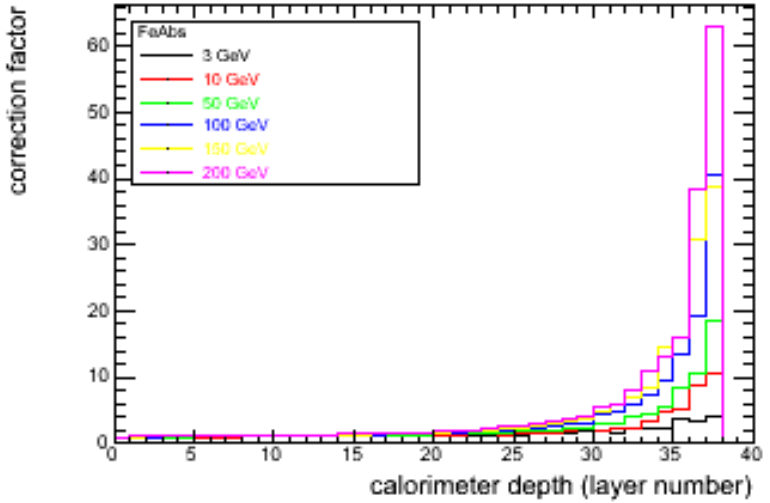


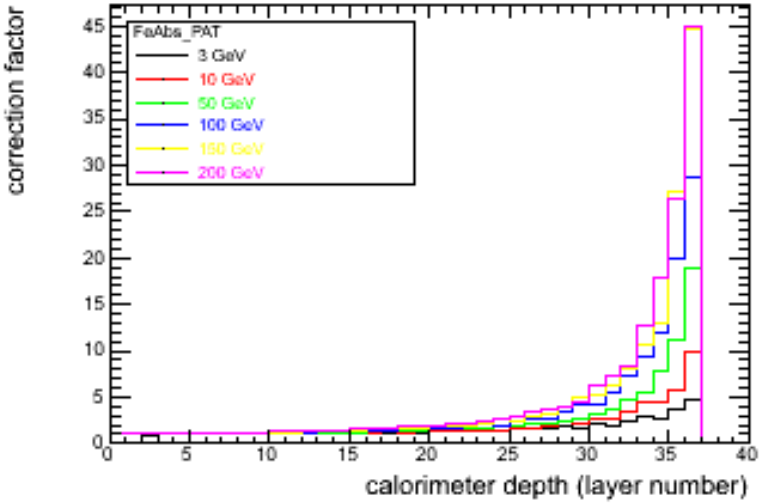


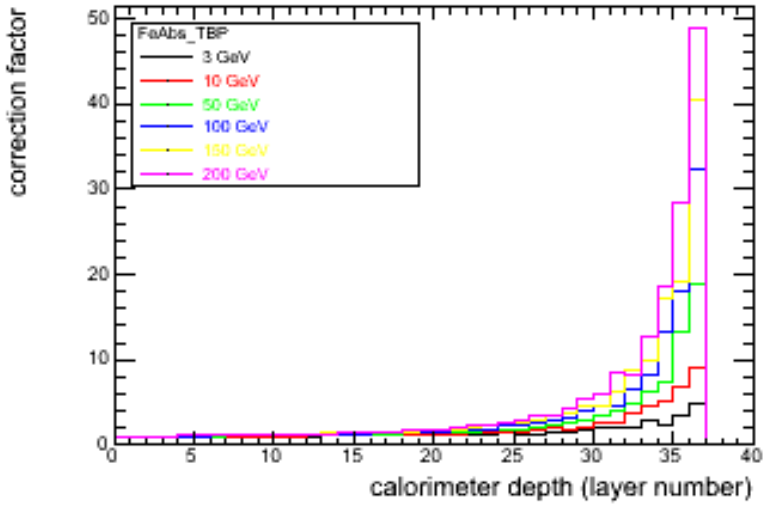


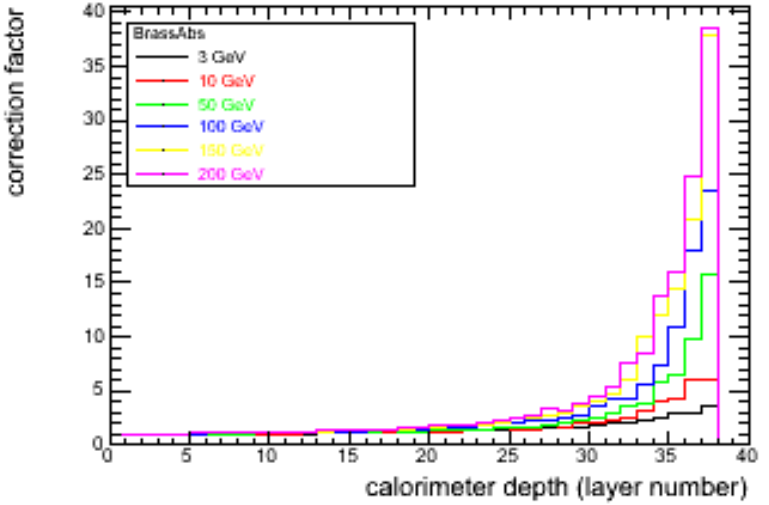
Correction factor for long. leakage

Digital readout, 0.1 MIP MPV threshold









Correction factor for long. leakage

Digital readout, 0.1 MIP MPV threshold