AHCAL: Status of Lateral Shower Shapes Analysis

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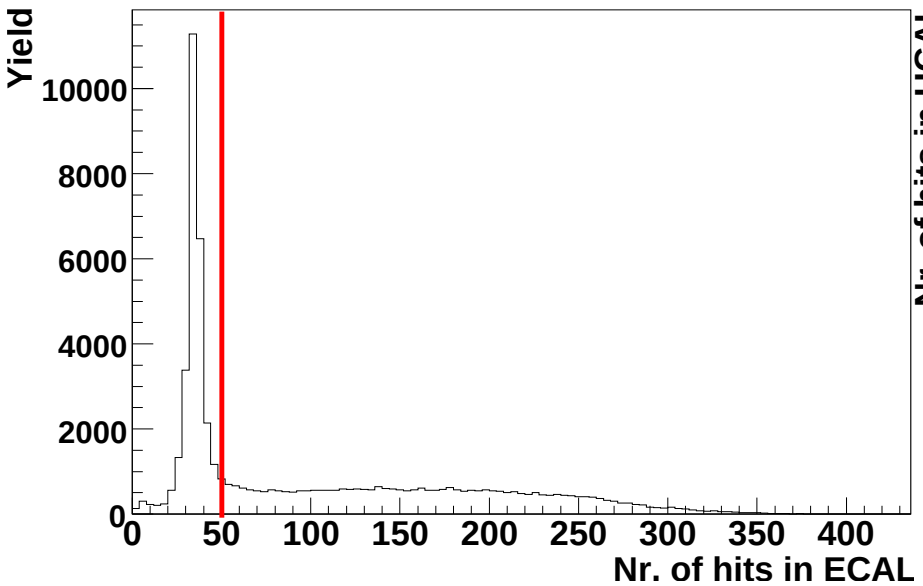
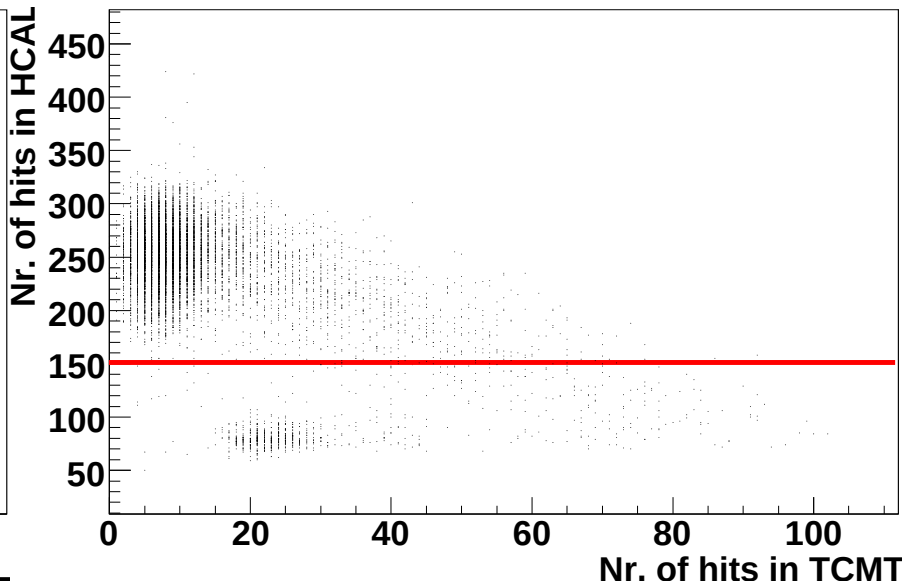
Overview

1. Data selection
2. Lateral shower profiles
3. Fractional energy deposition
4. Mean shower radius
5. Summary and outlook

Data selection

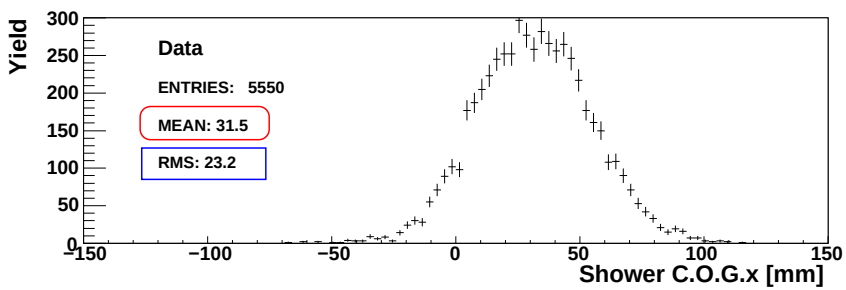
- Purpose: study **lateral** development of hadron showers
- Select: **18 GeV π^-** (CERN 2007)
- Concentrate on showers in AHCAL, i.e.
  - Reject showers starting already in ECAL: $nEcalHits < 50$
  - Discard MIP-type events in AHCAL: $nHcalHits > 150$ & $E > 0.5$ MIPs

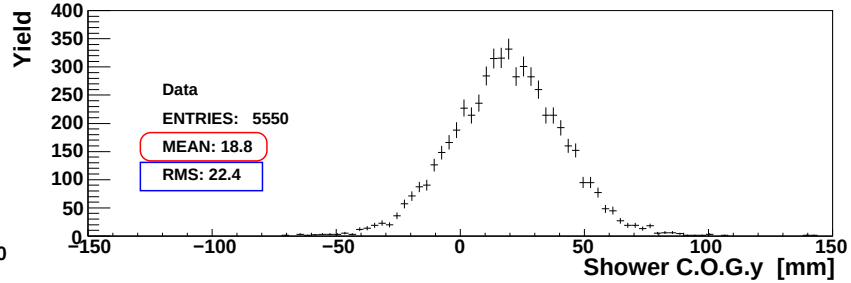


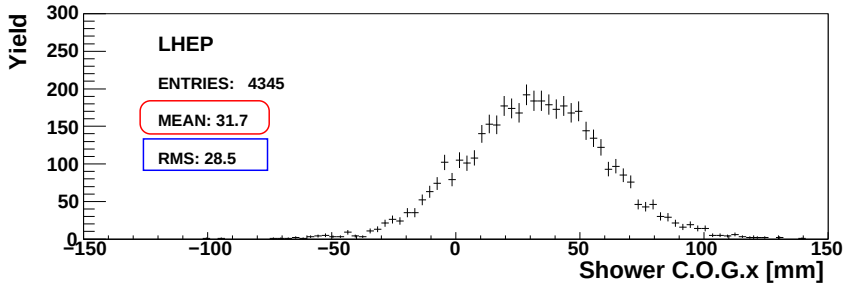


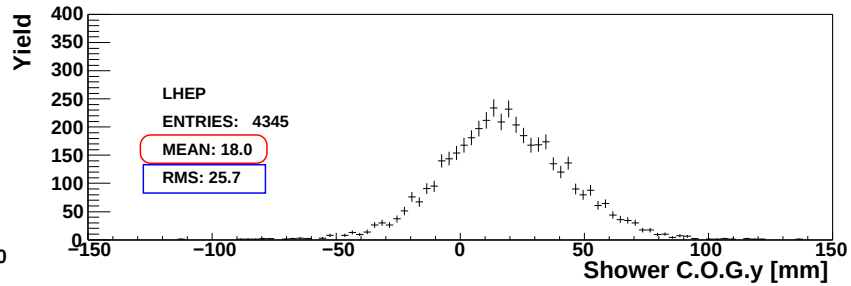
Monte Carlo samples

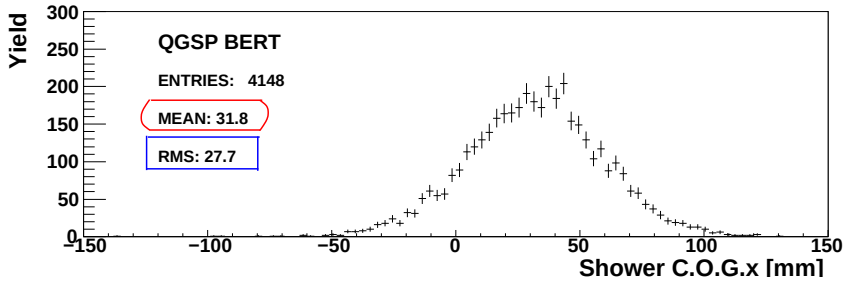
- Two GEANT4 models: LHEP and QGSP_BERT, 100000 events each
- Beam profile information from data:
  - **position** from shower center of gravity (C. O. G.) in AHCAL
  - **width** from profiles in DCH3
- Beam gun located in front of DCH3 (most far off from AHCAL)

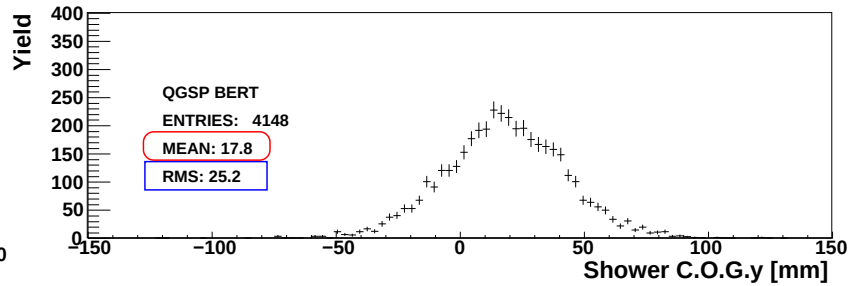








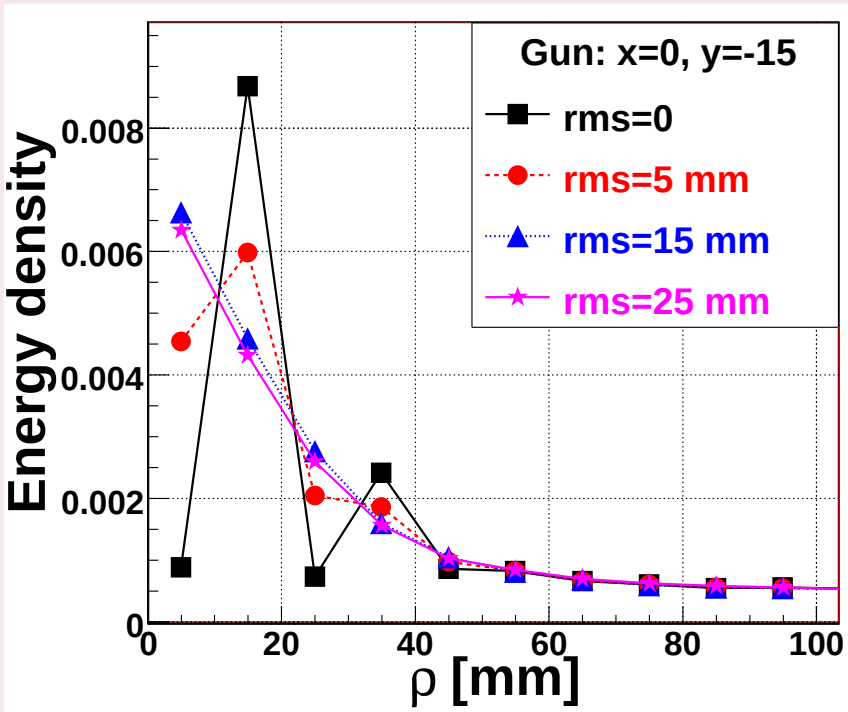




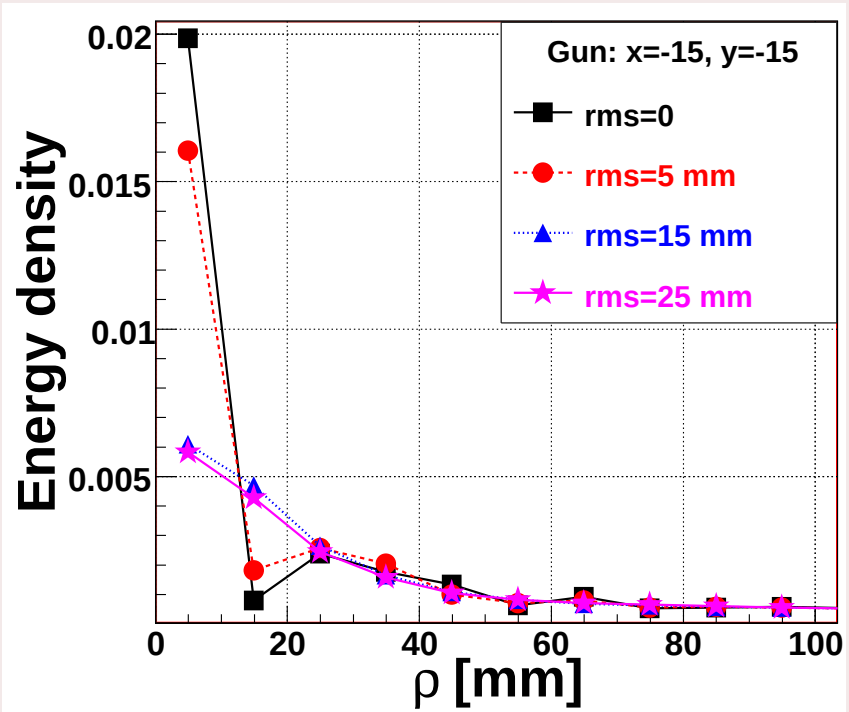
Monte Carlo samples: continued

- Beam profile in Monte Carlo: position ok, width - up to 5 mm difference compared to data
- But: Monte Carlo systematic studies of effect of RMS value on transverse profiles indicate small sensitivity for RMS $\geq$ 15 (example for layer 7)

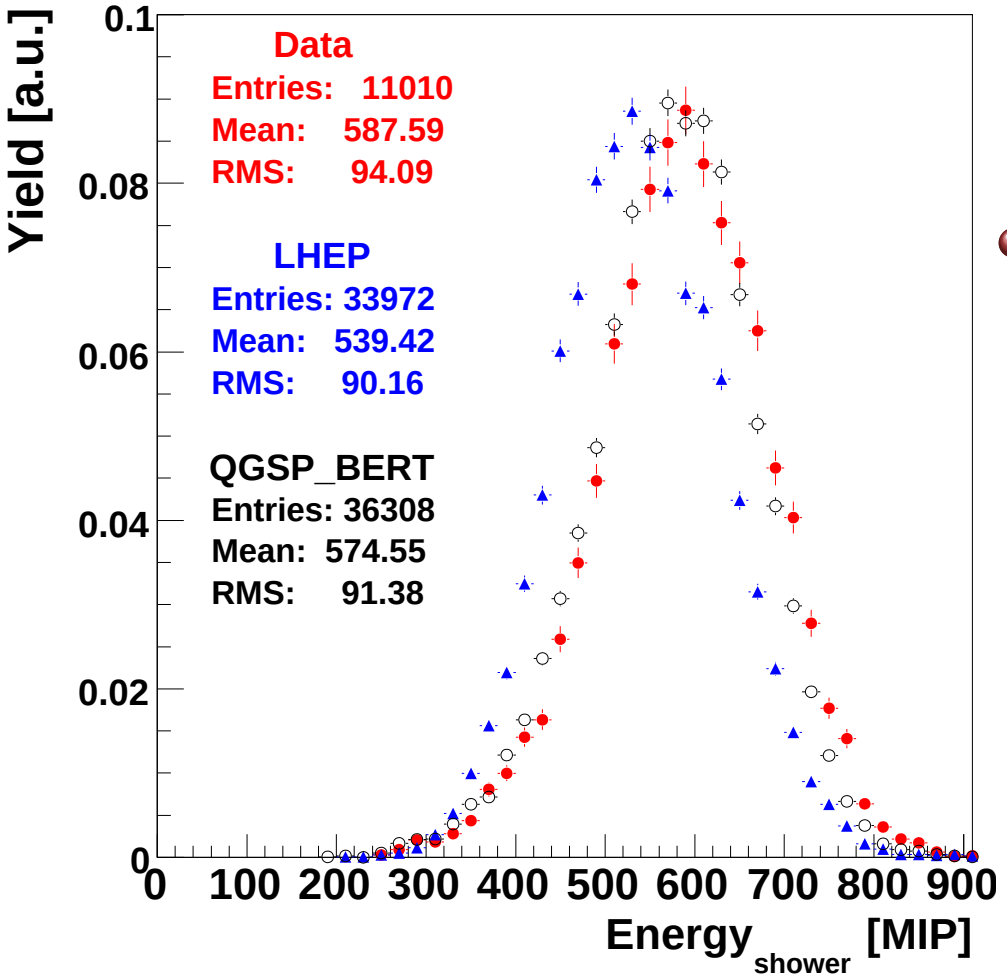
Tiles EDGE



Tiles MIDDLE



Results: hadron shower energy



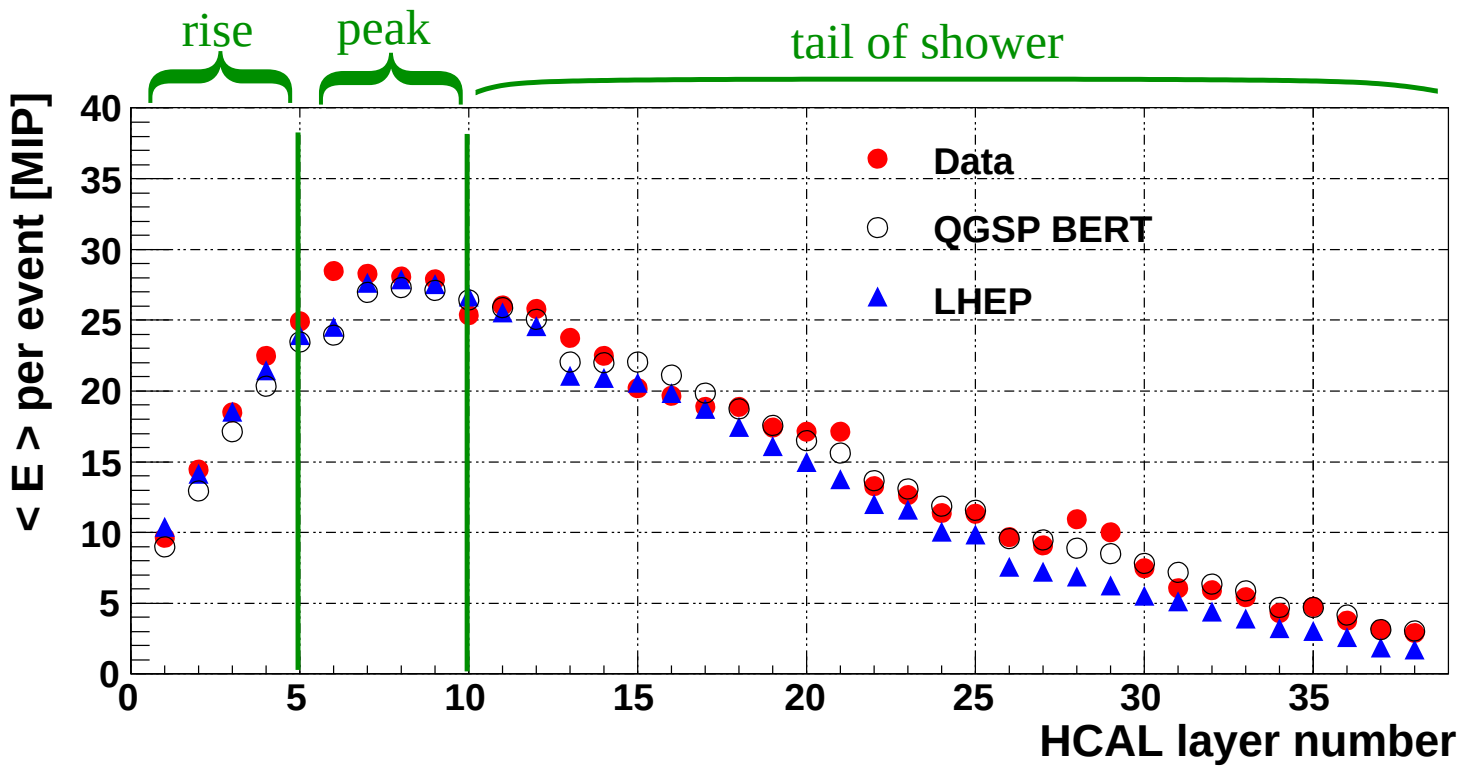
- Models predict different amounts of energy deposited in AHCAL

  $\Rightarrow$ In order not to be affected by the different energy scales, the following distributions normalised

  $\Rightarrow$ Shape comparison

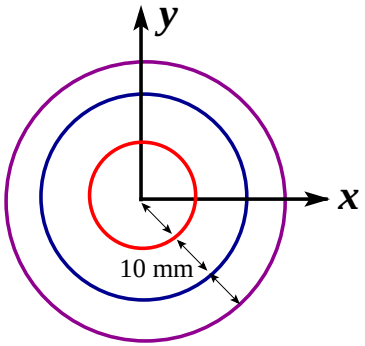
A note on results

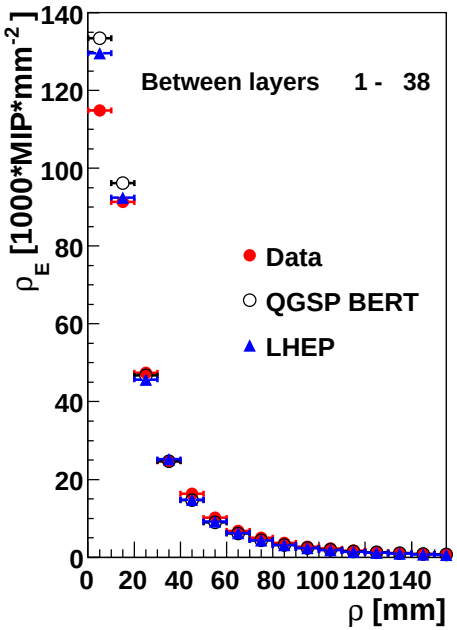
- Results presented for the whole AHCAL
- And, as control distributions, also for 3 different regions of the calorimeter, based on the longitudinal shower profile

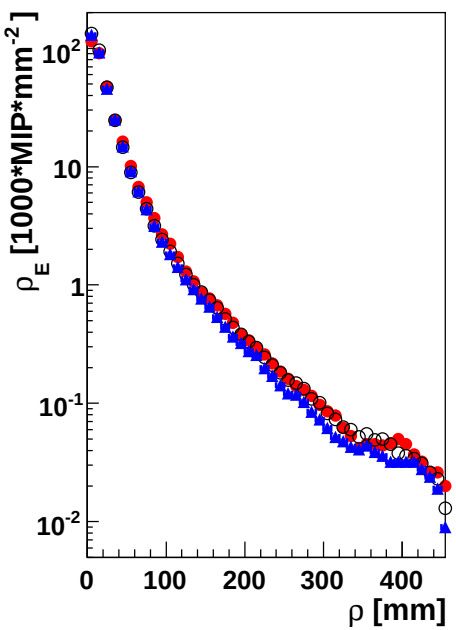


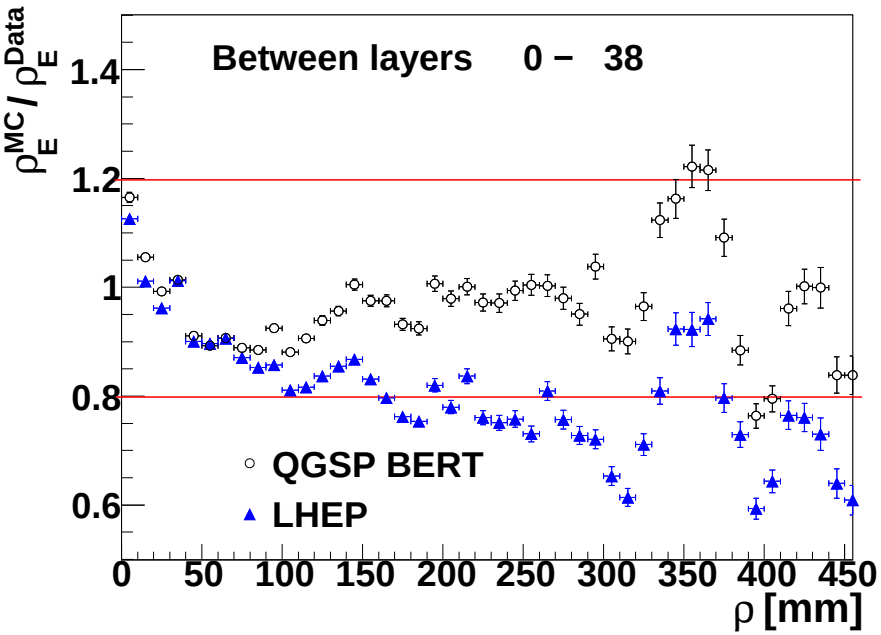
Results: lateral shower profiles

- Idea: reconstruct shower axis based on drift chamber information
- For every AHCAL hit *i*, calculate distance from shower axis: $\rho_i = \sqrt{(x_i - x_{track})^2 + (y_i - y_{track})^2}$
- Build rings of 10 mm radius around shower axis
- Measure **energy density** as energy sum per event / area of ring

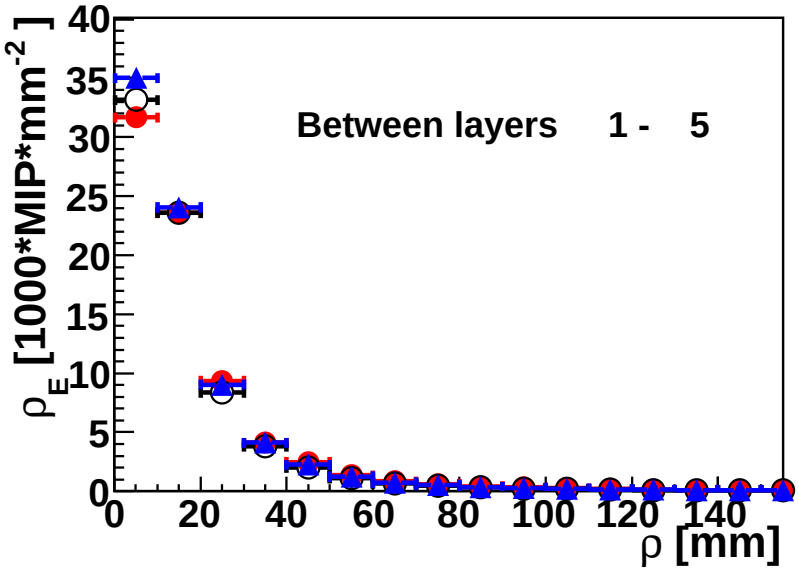


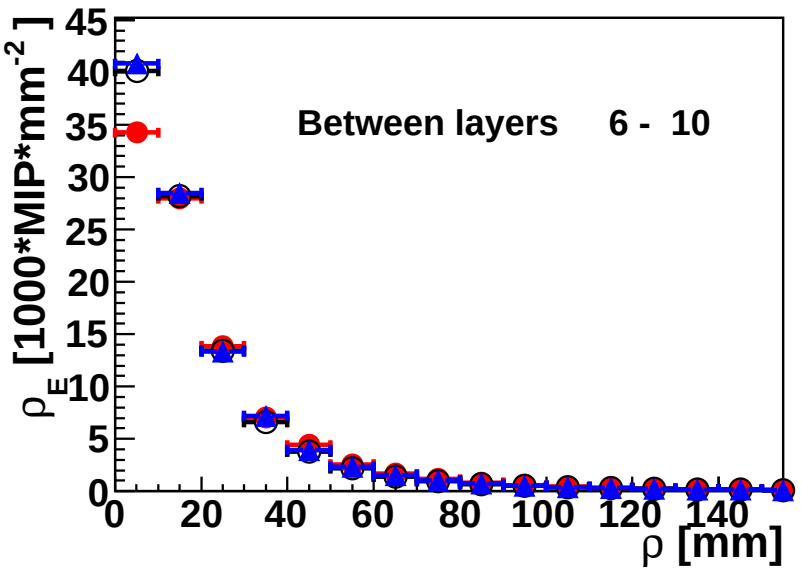


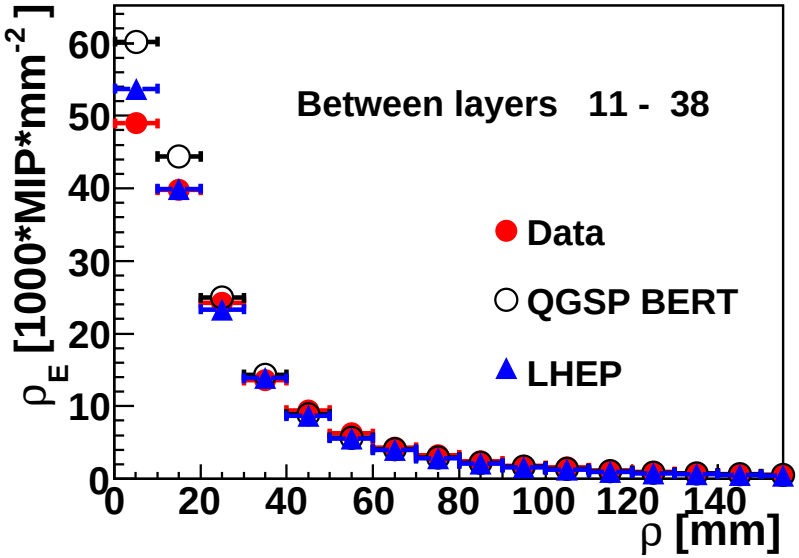




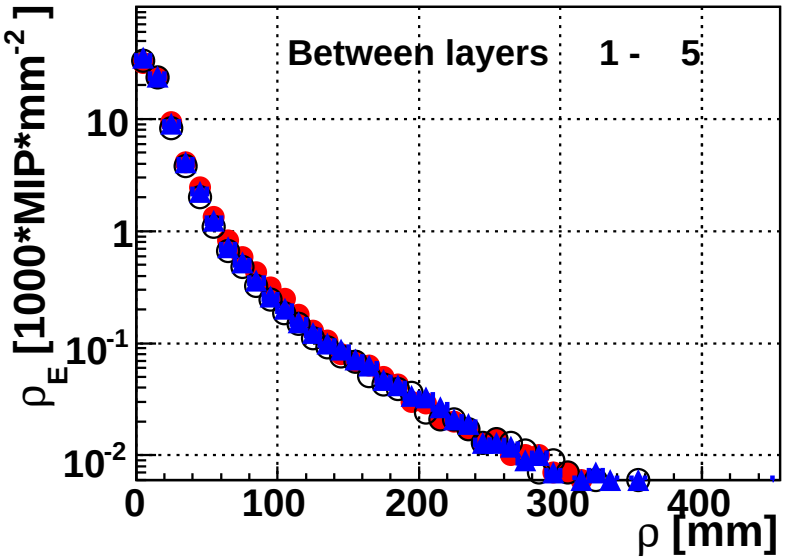
Lateral shower profiles - calorimeter regions - core

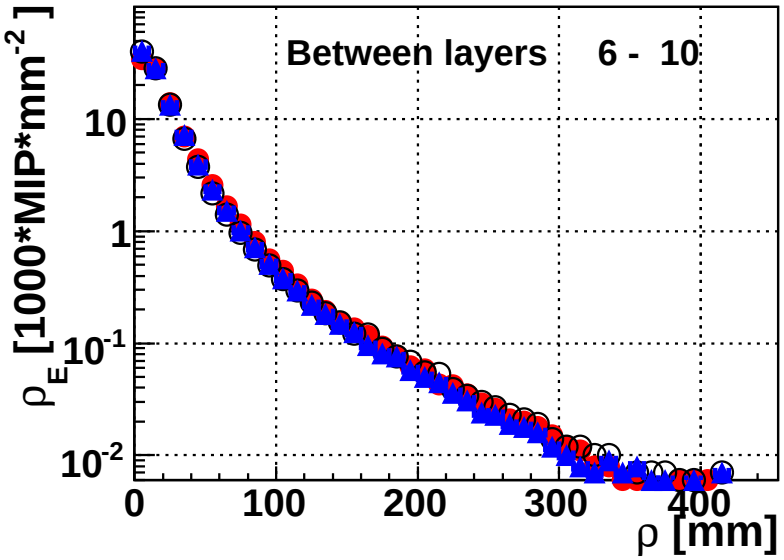


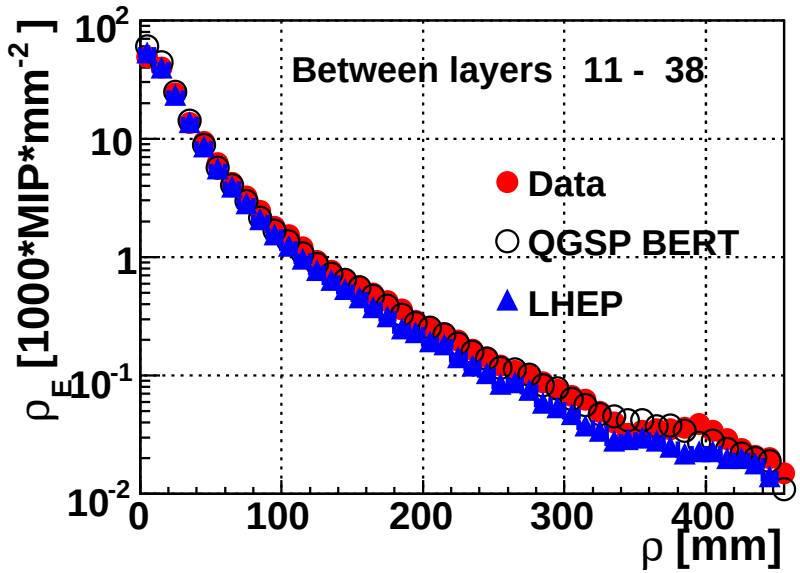




Lateral shower profiles - calorimeter regions - log

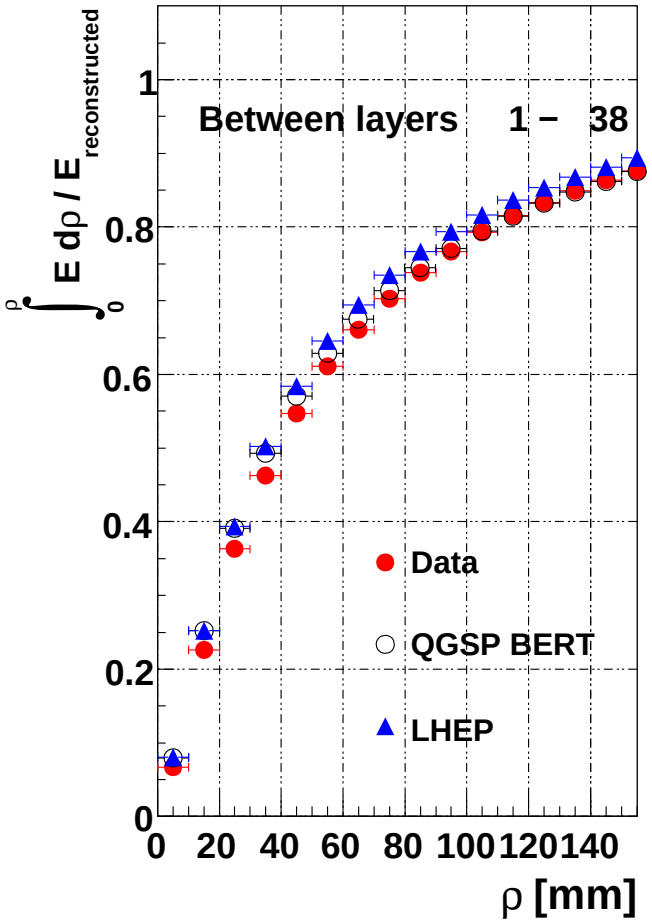


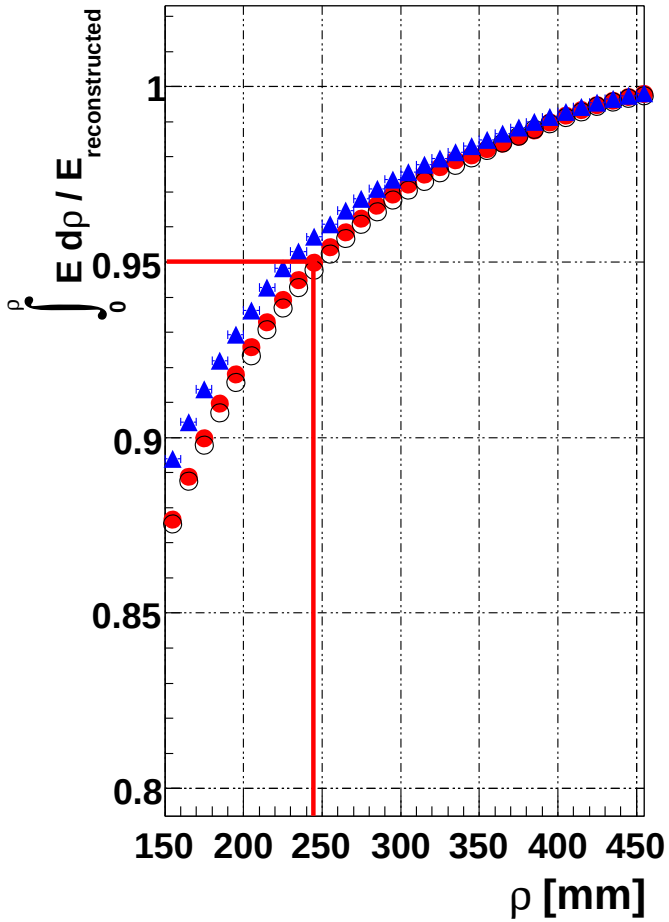




Results: fractional energy deposition

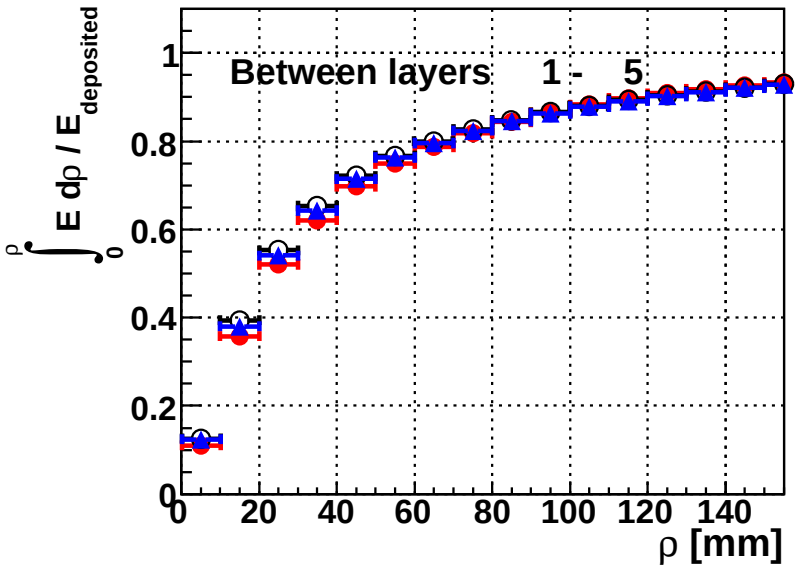
- Calculated in every ρ_i bin via energy integration from lowest bin up to the ρ_i bin, then normalised to the total energy deposited in the AHCAL

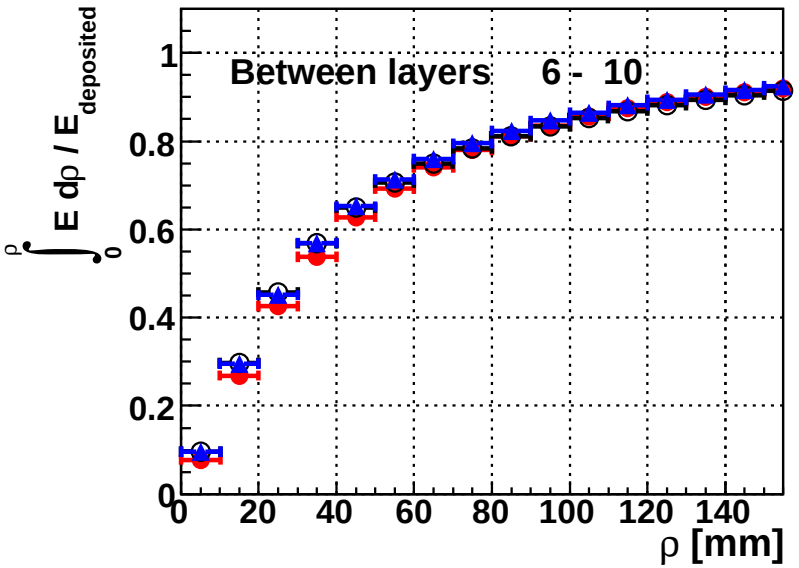


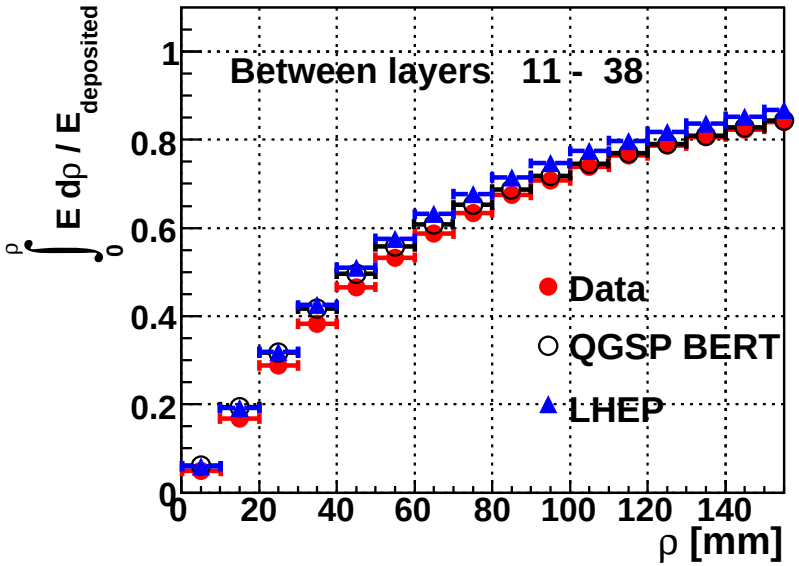


- The radius of the shower containing 95 % of the total deposited energy is approx. 25 cm

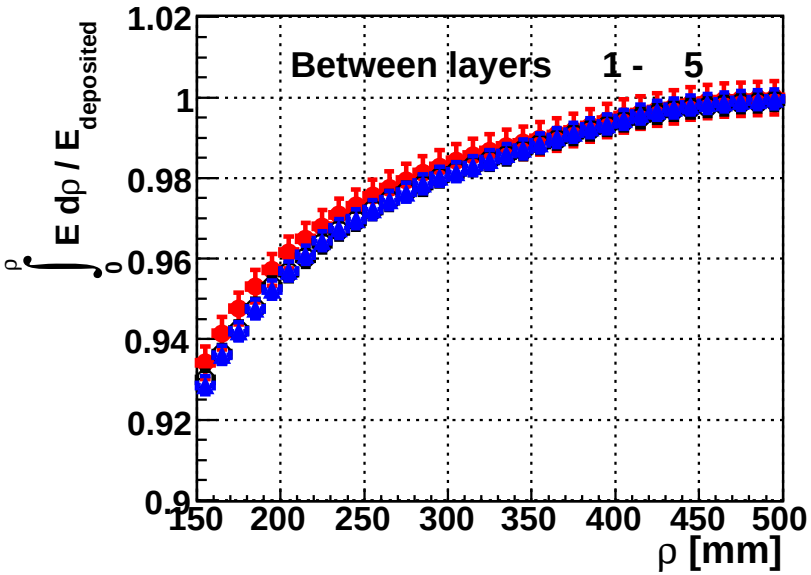
Fractional E deposition - calo. regions - core

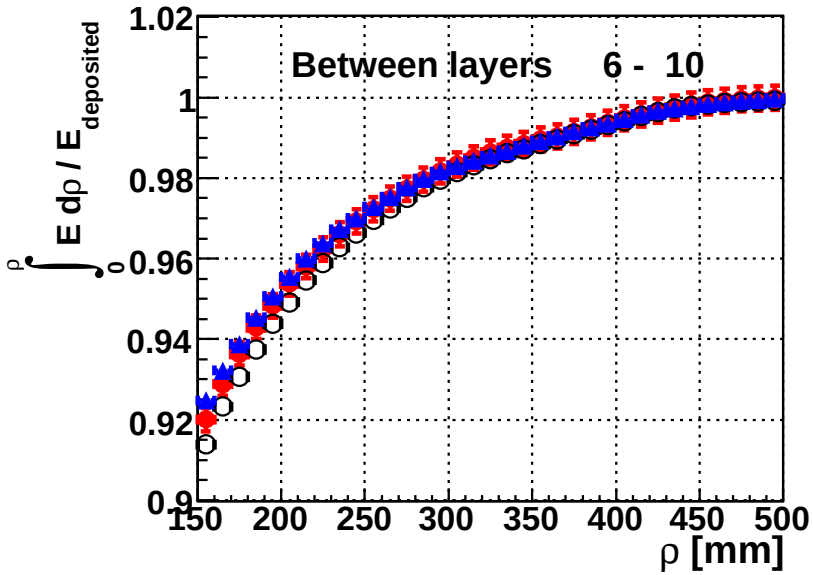


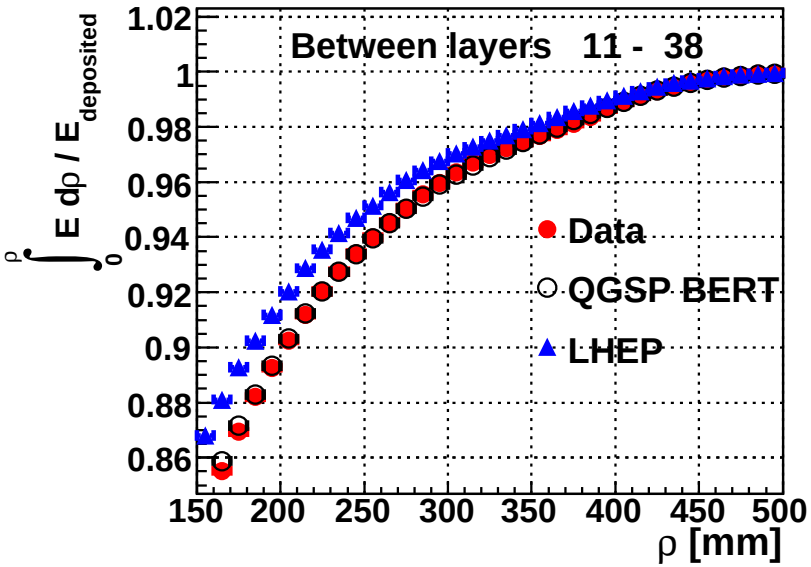




Fractional E deposition - calorimeter regions - tail



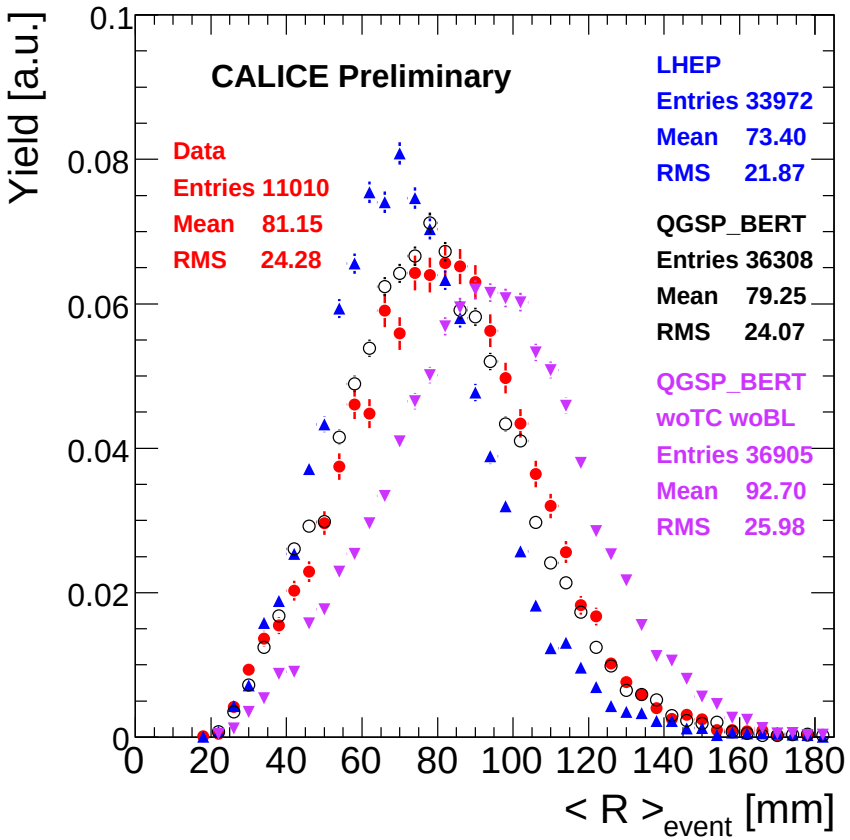


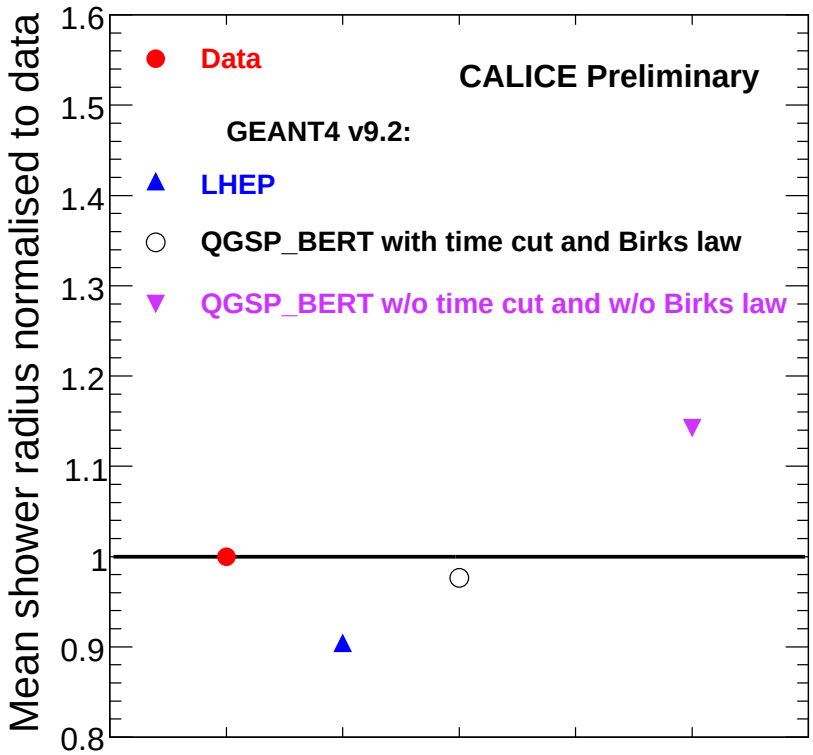


Mean shower radius

$$\langle R \rangle_{event} = \frac{\sum_i E_i \cdot \sqrt{(x_i - x_{track})^2 + (y_i - y_{track})^2}}{\sum_i E_i}$$

- Comparison of data with Monte Carlo, with and without physics and detector effects (see Beni's talk in Daegu)





Summary

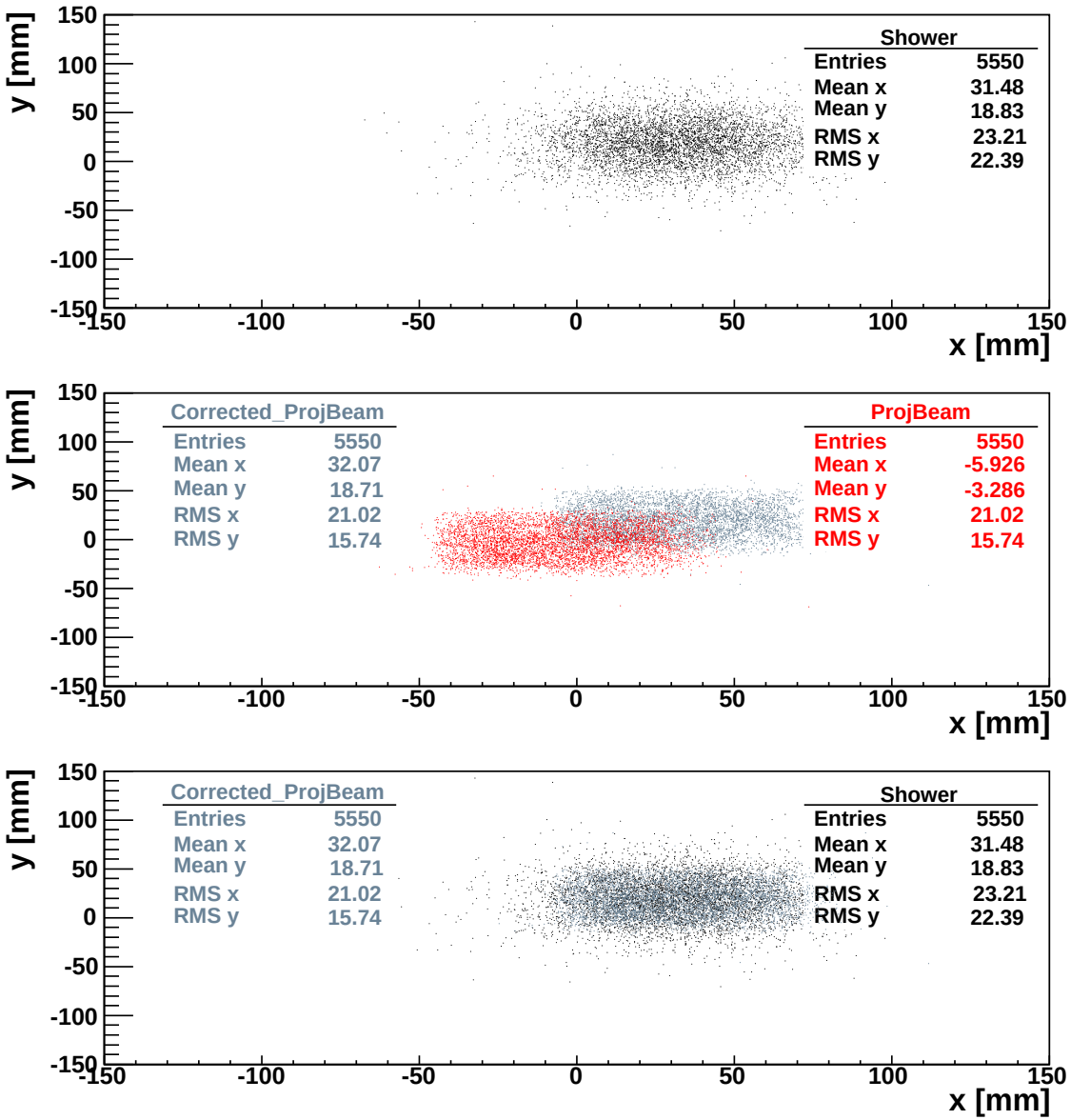
- Lateral development of hadron showers investigated with high granularity CALICE AHCAL
- Analysis procedure presented: data selection, analysis algorithm, beam profiles in Monte Carlo
- Results proposed for release:
  - lateral shower profiles in the whole calorimeter
  - fractional energy in the whole calorimeter
  - shower radius (and normalisation to data)

Outlook

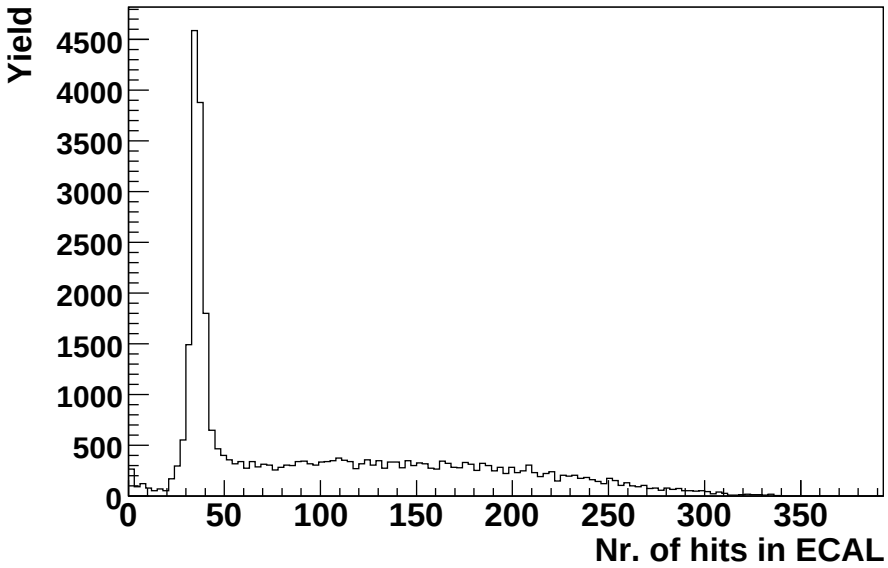
- Evaluate systematical uncertainties
- Extract different contributions in shower development
- Analysis with respect to the start of the shower
- Higher energy points

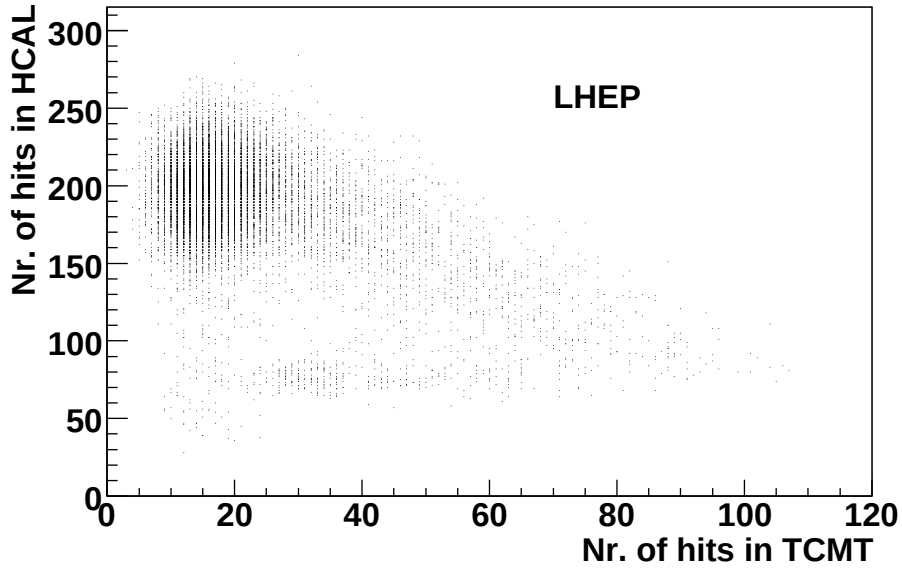
Back-up slides

Beam profile: data vs Monte Carlo

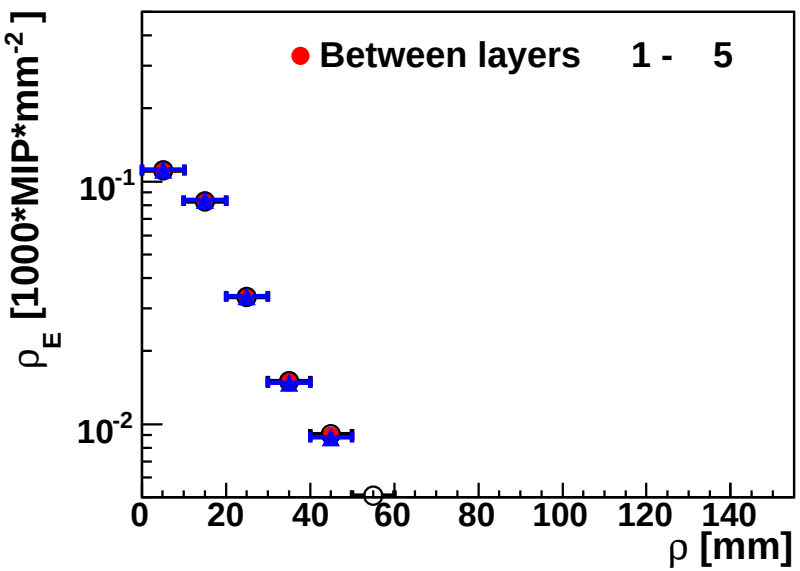


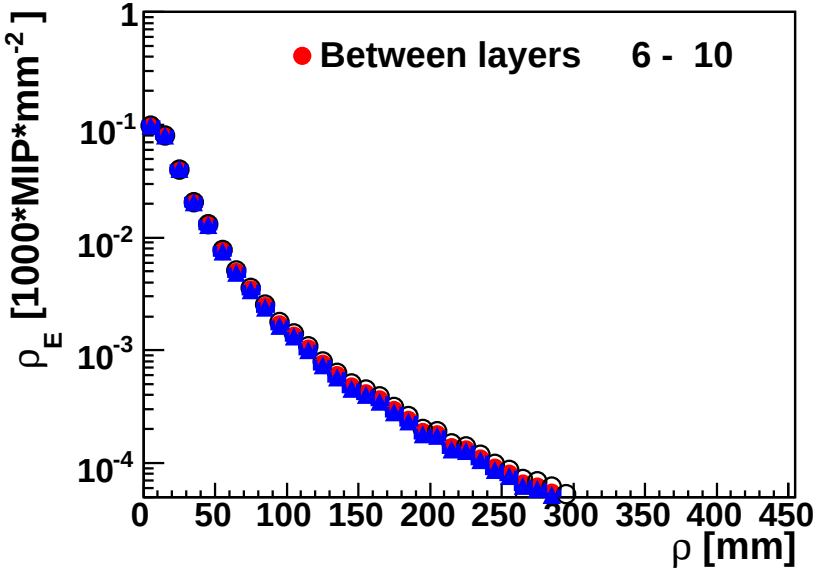
Monte Carlo: cuts

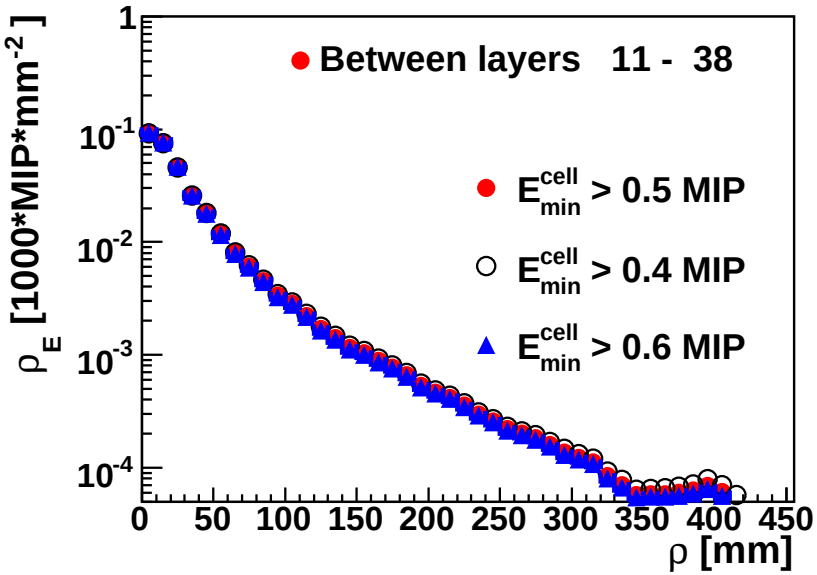


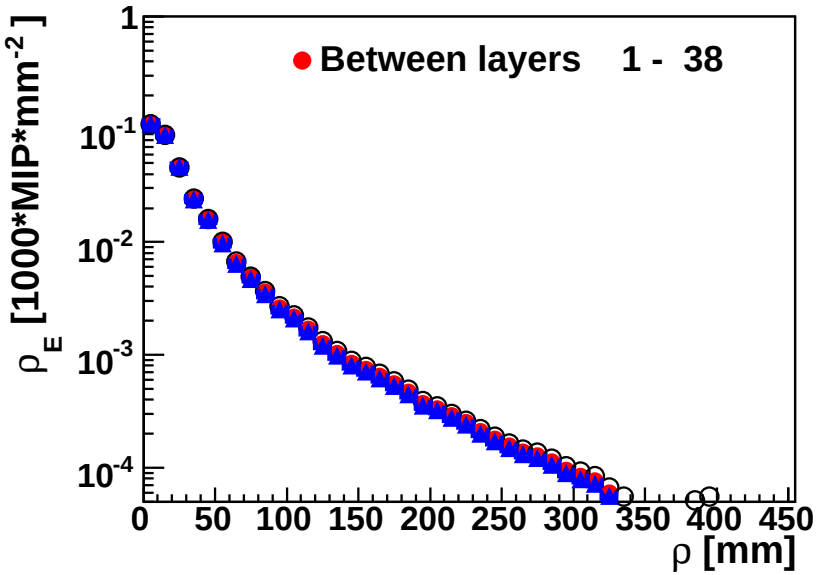


Transverse profile: threshold cut $E > 0.5$ MIPs









Shower radius: cuts