FoCal Prototype – Analysis Status

- introduction – a reminder
- recent results
  - calibration/corrections of beam test data
  - charge diffusion: cluster size/shower shape
  - hadron rejection studies (MC)
- summary

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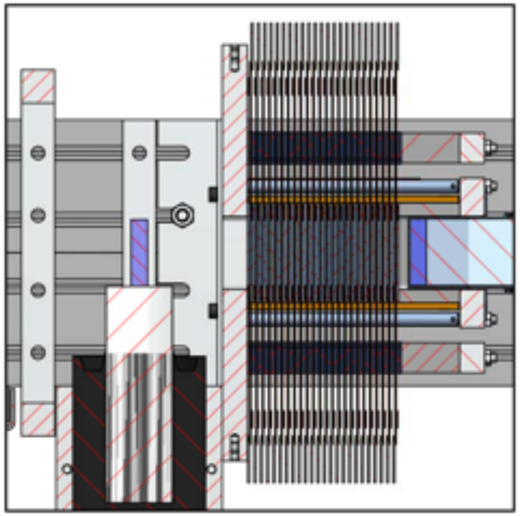
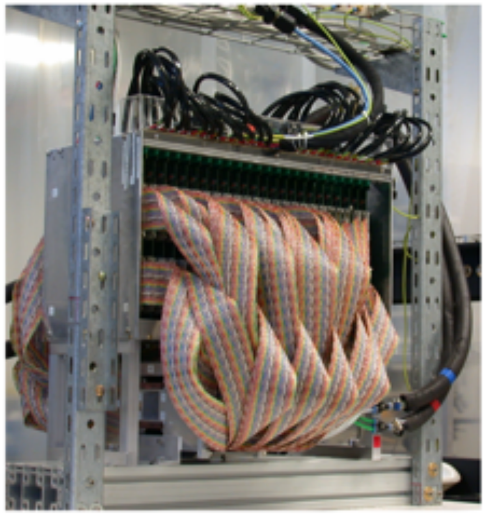
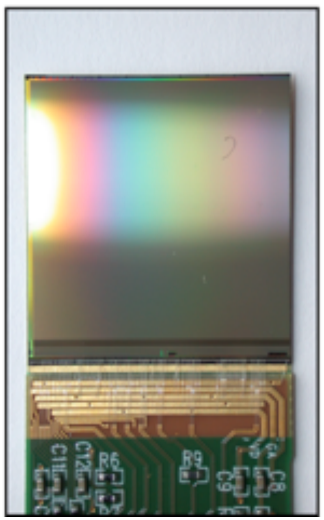
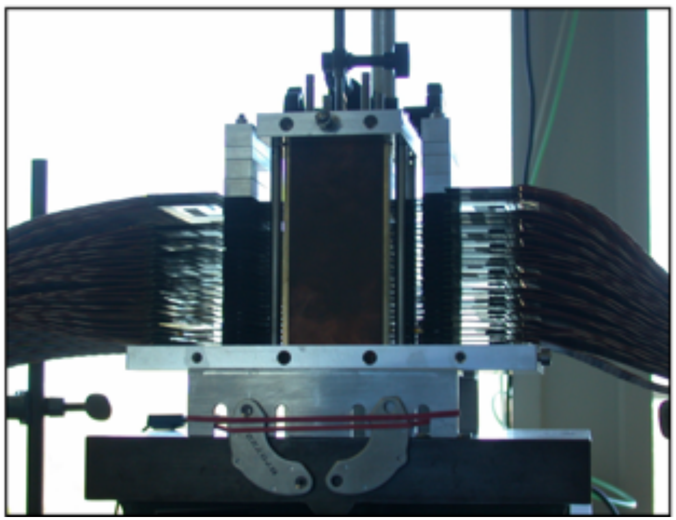
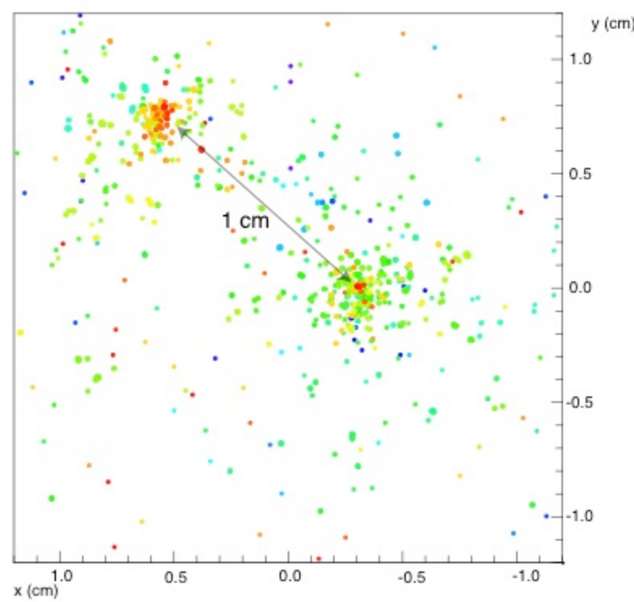
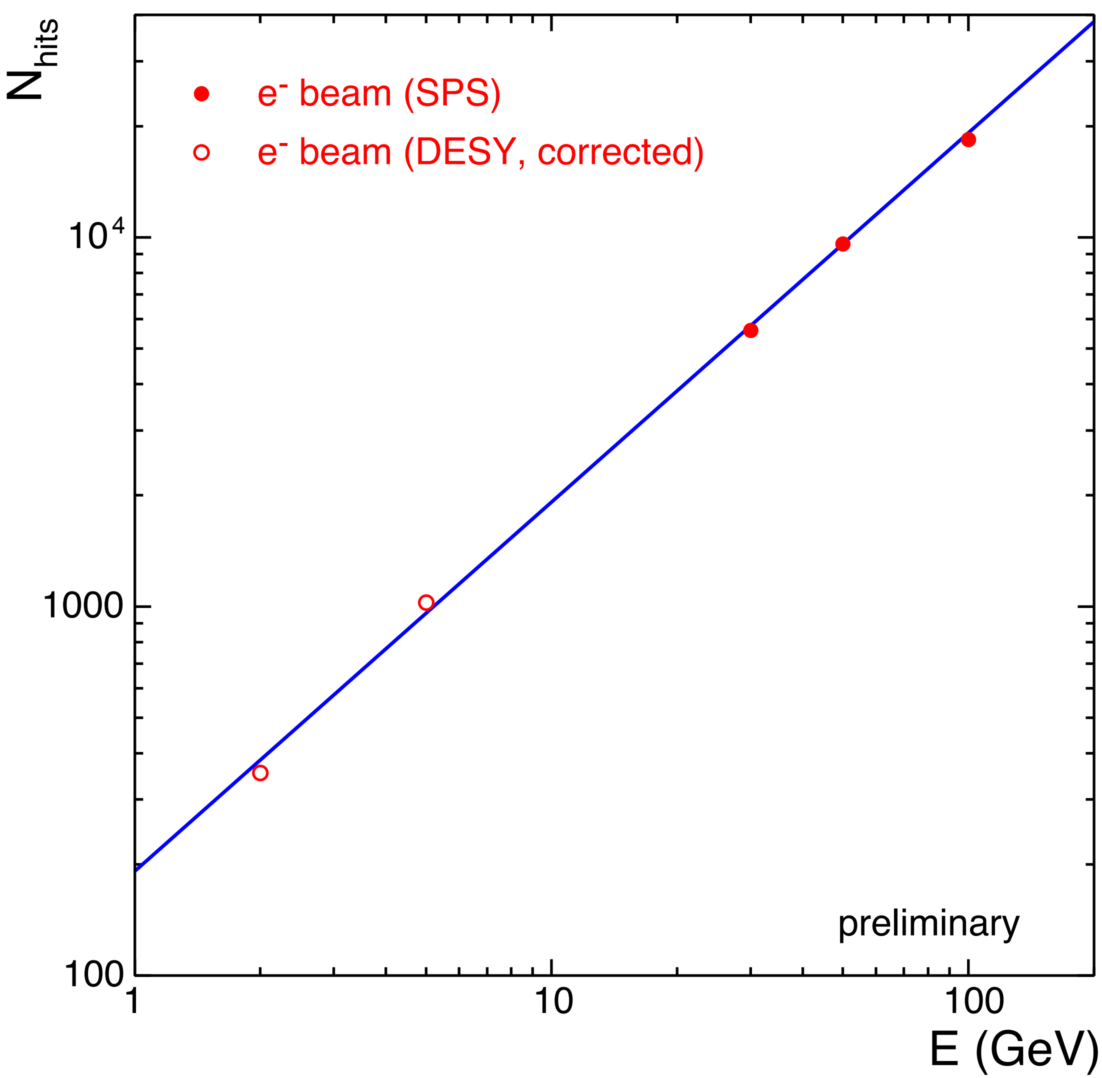
The FoCal Prototype

- activity at Utrecht/Nikhef:
  - full prototype, CMOS (MIMOSA)
  - 39Mpixels, 30μm pitch
- performed systematic tests:
  - test beam data from 2 to 250 GeV (DESY, PS, SPS)
  - cosmic muons

Linearity

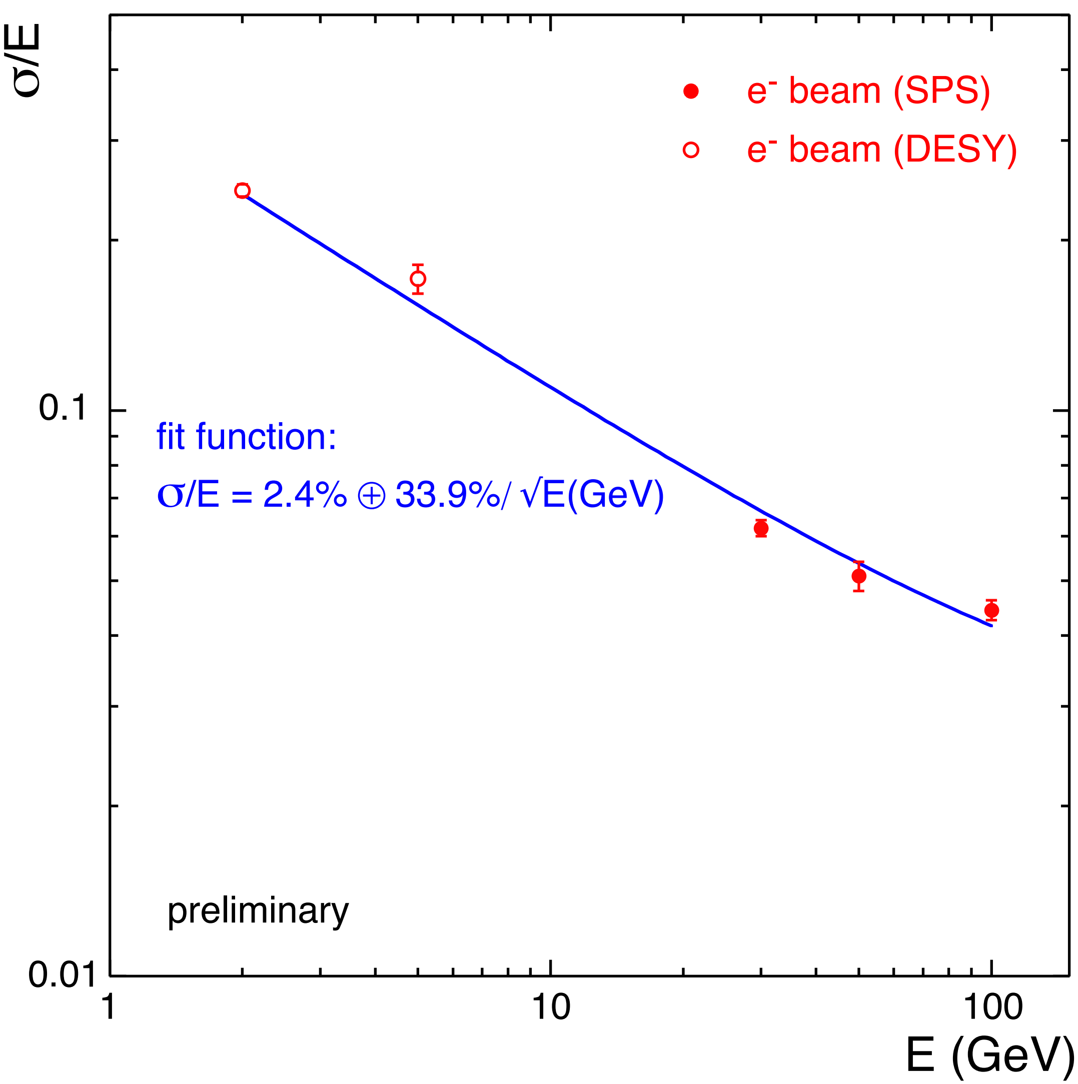


- reasonably good linearity
  - no obvious effect of saturation
- absolute calibration:
  - needs charge sharing in simulation

$$N_{\text{hits}} \approx 6 \cdot N_{\text{shower-particles}}$$

  - direct calibration with MIPs not possible

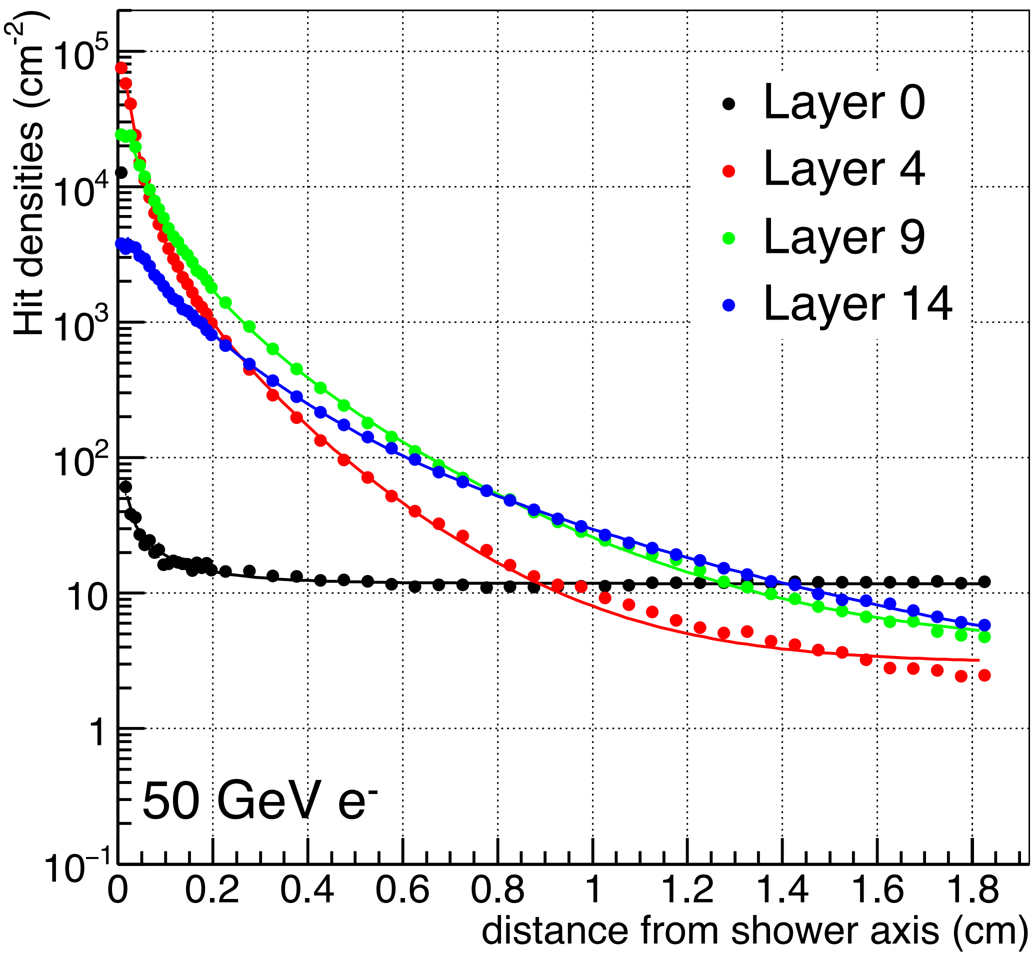
Energy Resolution



- resolution ≈2x worse compared to simulation
  - different sensor sensitivities not fully corrected
  - relative calibration: how?
    - so far: single correction factor per sensor

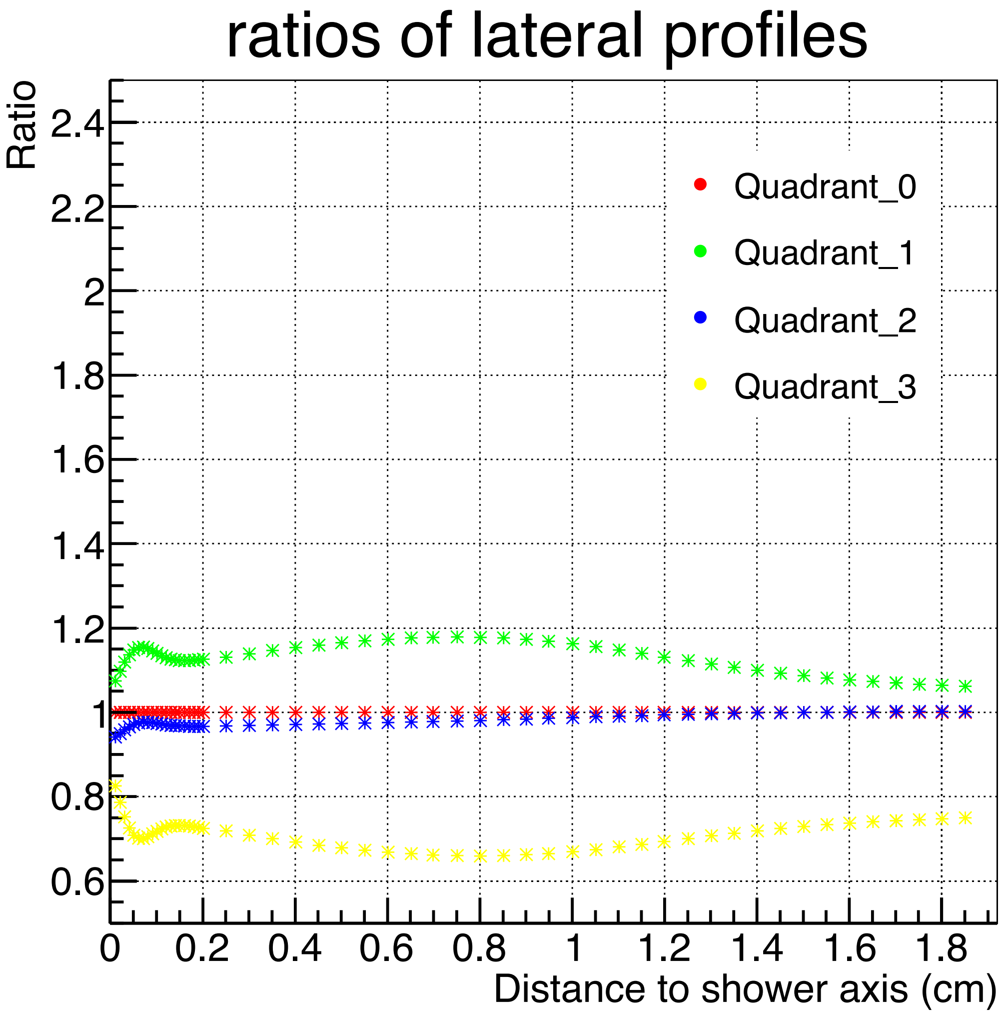
Recent Results

Shower Profiles



- very detailed shower shape information
- use distributions for corrections
  - improve calibration
- "geometric acceptance" correction for dead areas
  - calculate hit density only for active surface
  - can correct # of hits up for full shower (also possible event-by-event)

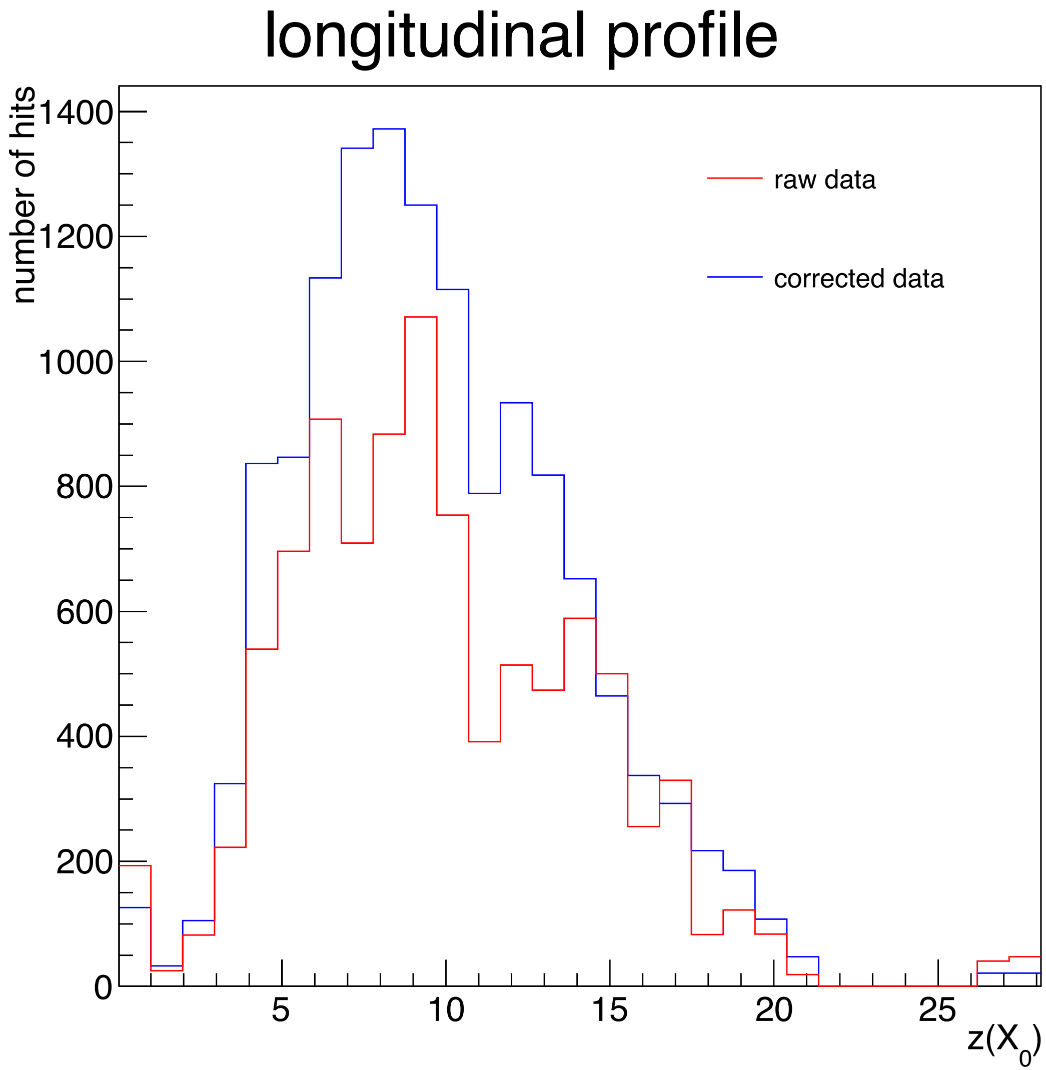
Equalising Response per Layer



- true distributions for all sensors in one layer should be identical
  - choose reference sensor closest to expected longitudinal profile
- differences due to different sensitivity
- use distributions for corrections
  - obtain calibration factors

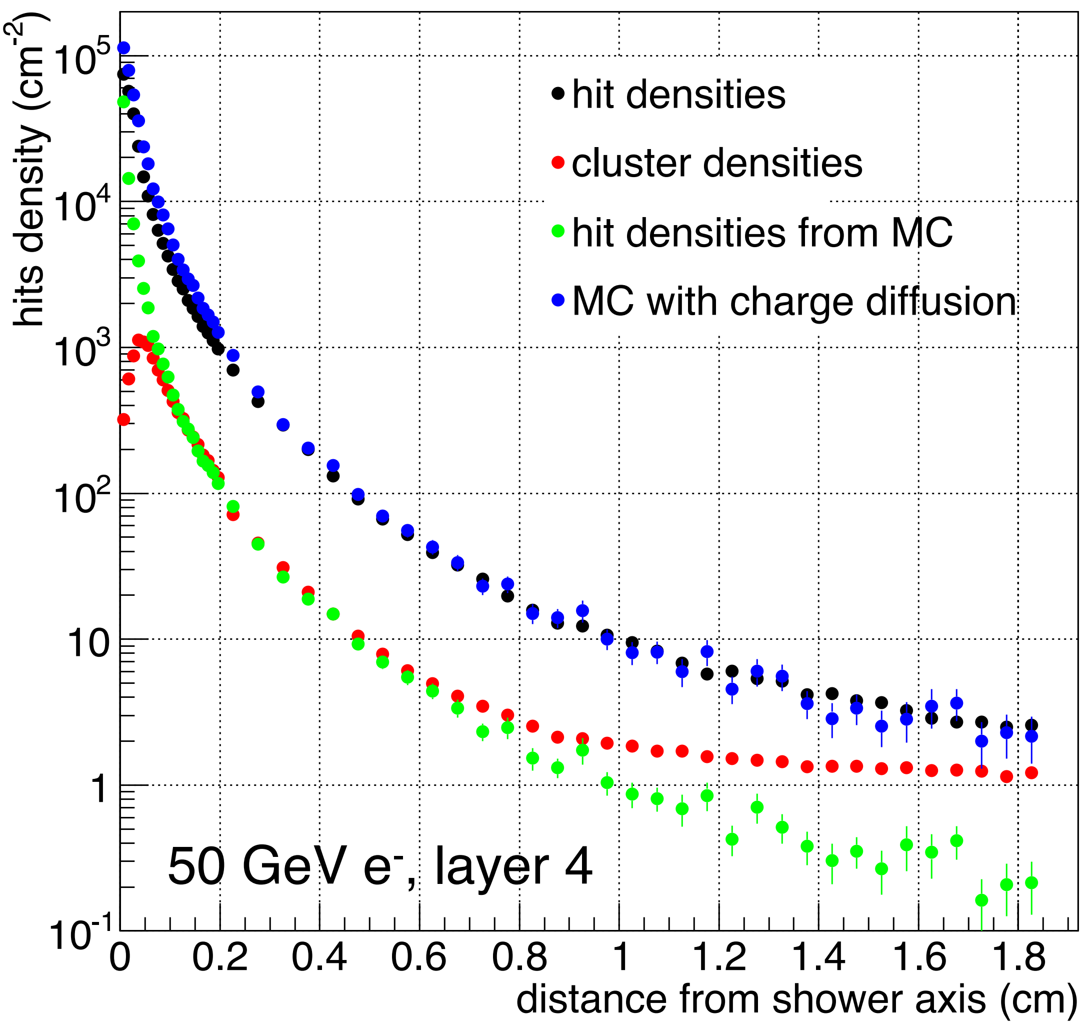
$$C_{l,q} = \frac{\int_0^{r_{\max}} \rho_{l,q}(r)\, 2\pi r dr}{\int_0^{r_{\max}} \rho_{l,\mathrm{ref}}(r)\, 2\pi r dr}$$

Preliminary Calibration



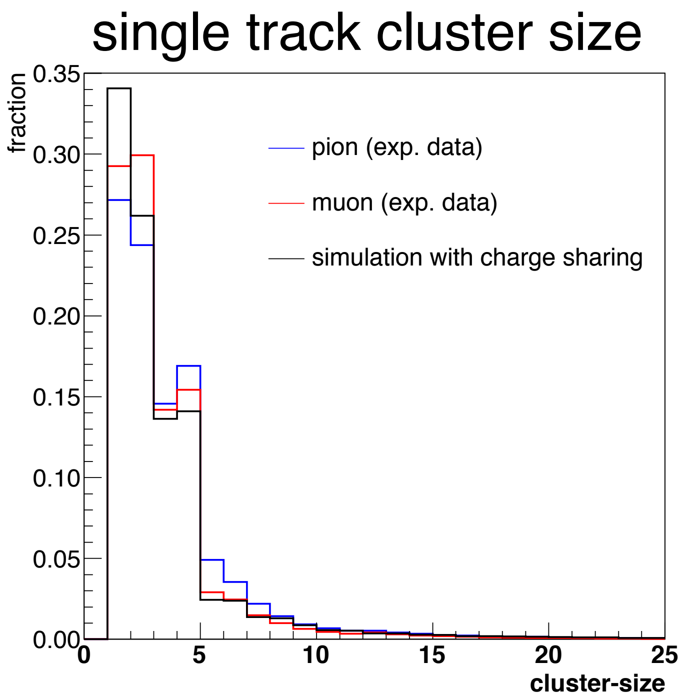
- much better description of longitudinal shape
  - can exploit in analysis
- some improvement in energy resolution
  - further calibration work in progress

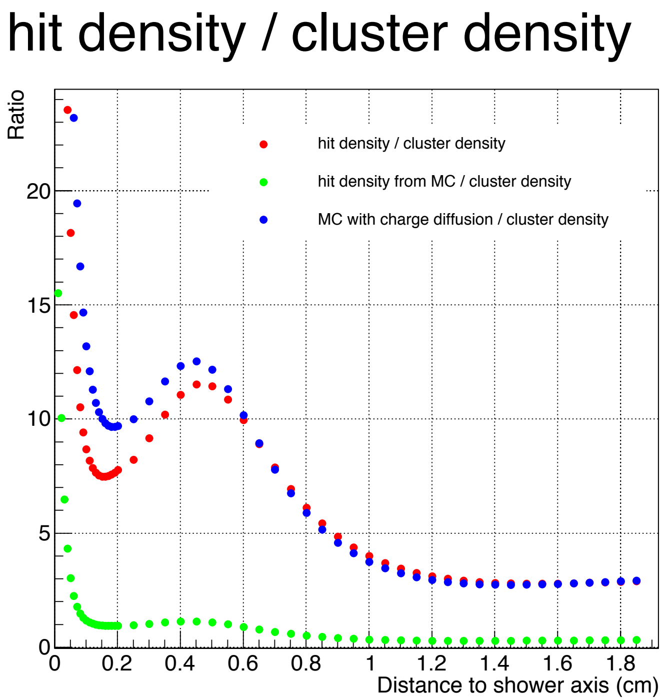
MC Description of Shower Profiles



- comparison of lateral shower shapes to simulation
  - hit densities from pure GEANT simulation (no charge diffusion) not sufficient
  - simple Gaussian diffusion yields good description
  - not possible with universal threshold for all layers

Cluster Sizes

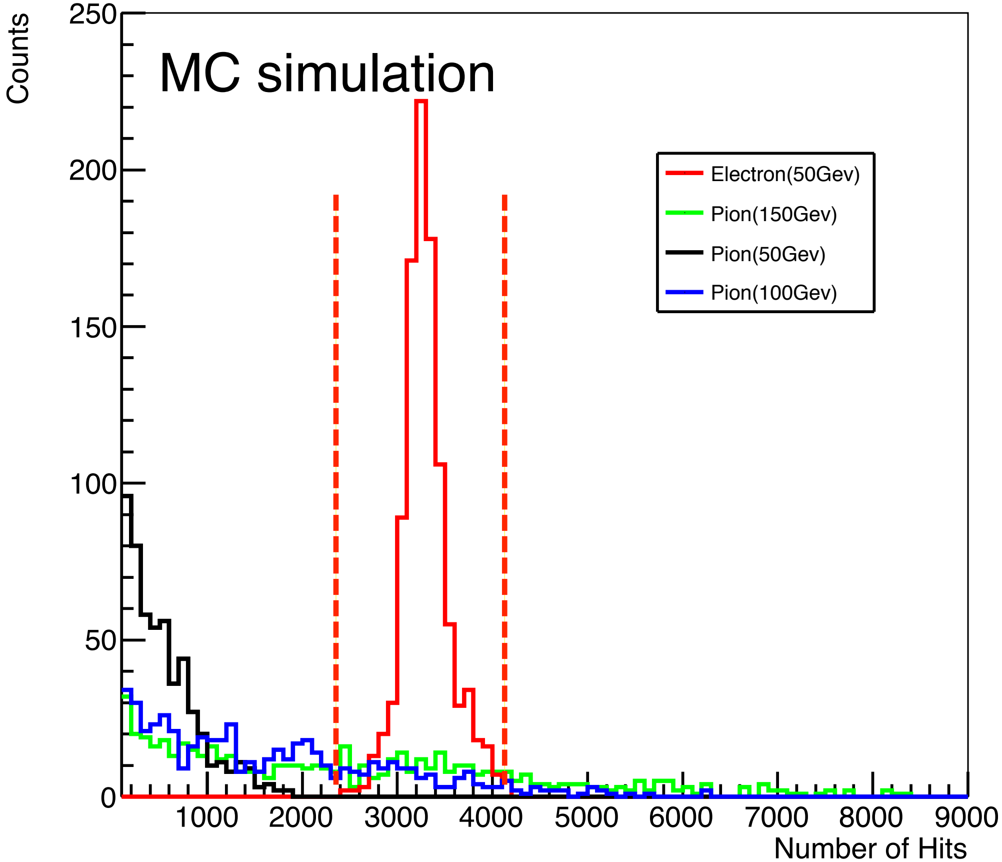




- simple charge diffusion model can describe cluster size for MIPs
  - average cluster size ≈ 2-3
- cluster size in showers
  - different from MIPs, depends on hit density
  - can be reproduced by tuned MC with diffusion
- interplay of
  - merging of clusters
  - larger clusters for larger angles
  - relative admixture of noise clusters
  - …?
- not the same in all layers
  - different thresholds?
  - need better modeling?

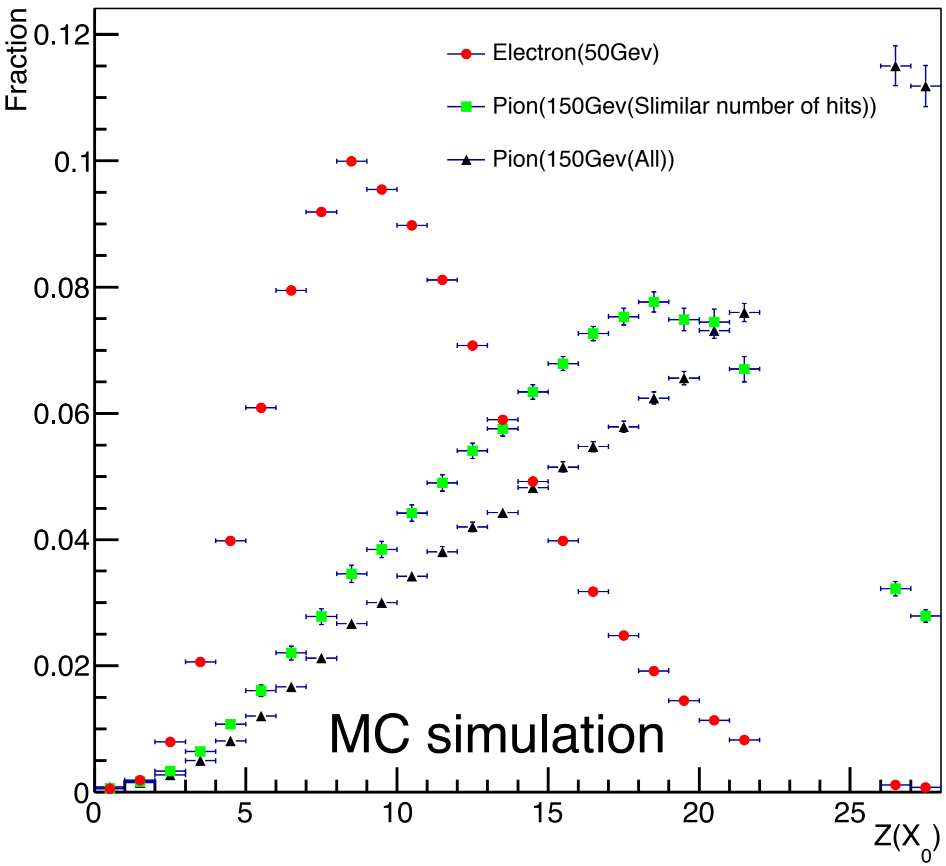
Electron/Hadron Separation

Response to Pions



- Monte Carlo study
- distributions of number of hits for electrons and pions
  - most pions have little energy deposit, small # of hits
    - tracks (MIPs) not shown
  - hadron contamination is suppressed
- some pions have similar amplitude as EM showers
  - further suppression?

Longitudinal Shape

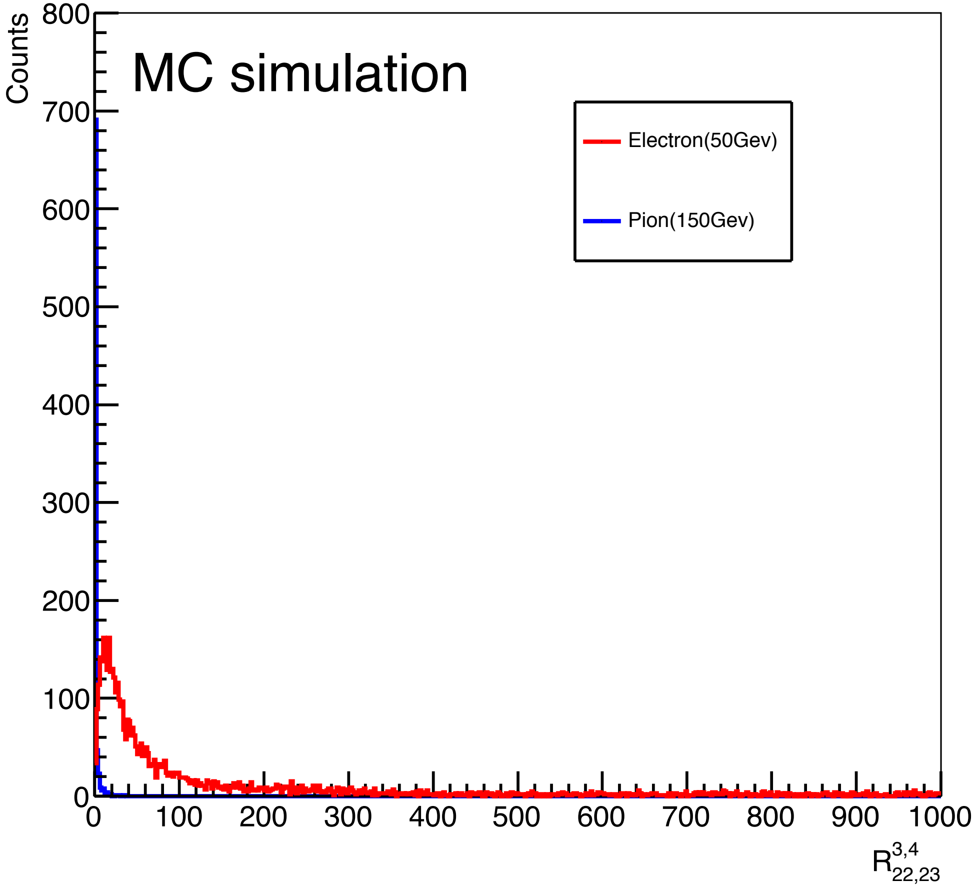


- significantly different longitudinal shapes for hadronic showers
  - exploit for hadron rejection
- cut variable used in first attempt

$$R^{3,4}_{22,23} = \frac{H_3 + H_4}{H_{22} + H_{23}}$$

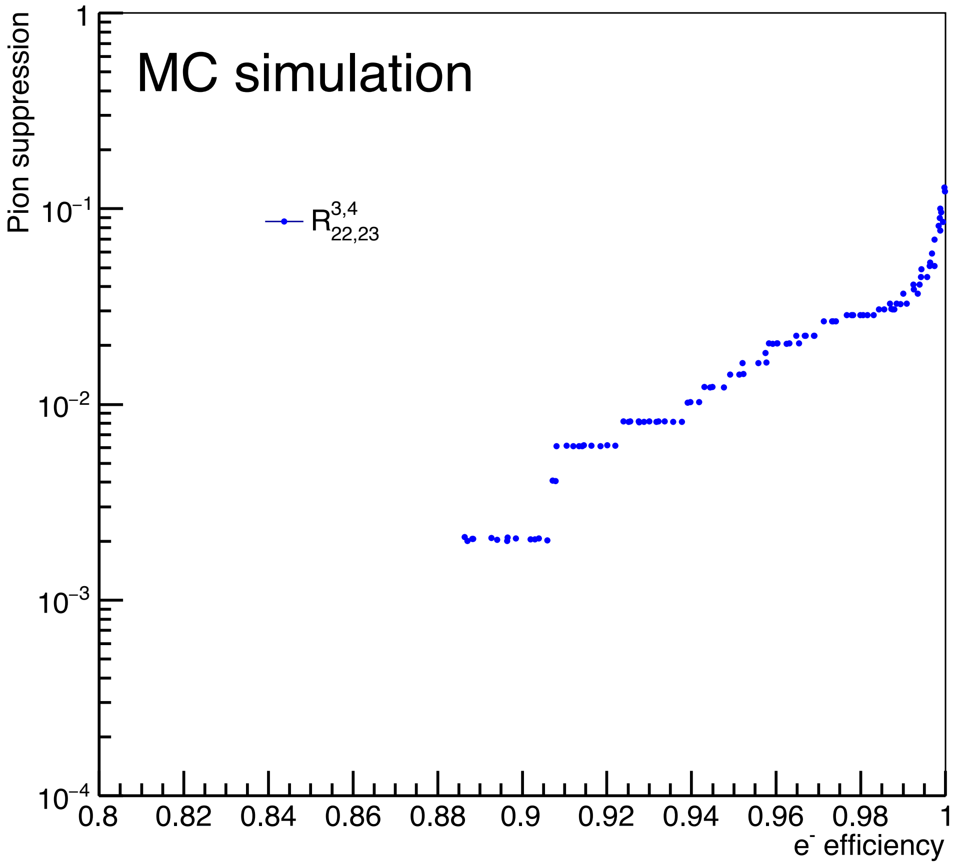
  - to be optimised
- apply also to data in future
  - limited hadron ID in beam

Longitudinal Shape Parameter



- significant difference for pions vs. electrons
  - should work event-by-event
  - caveat: so far only a few discrete pion energies
- should provide good discrimination power

Hadron Suppression



- for different cuts on shape parameter calculate pions suppression and electron efficiency
  - for given energies, obtain pion suppression by x30 with 99% e^- efficiency
  - need to redo for realistic hadron spectrum
- charge diffusion not implemented
  - no strong influence expected

Summary on Prototype R&D

- demonstrated satisfactory basic properties
  - good linearity, narrow shower distributions
- next steps need better microscopic understanding
  - modeling of charge diffusion under way
- info will be used in more advanced studies
  - calibration methods
  - model of showers
  - particle ID
  - …