Edge Non-Uniformities in ^{90}Sr Tile Scans

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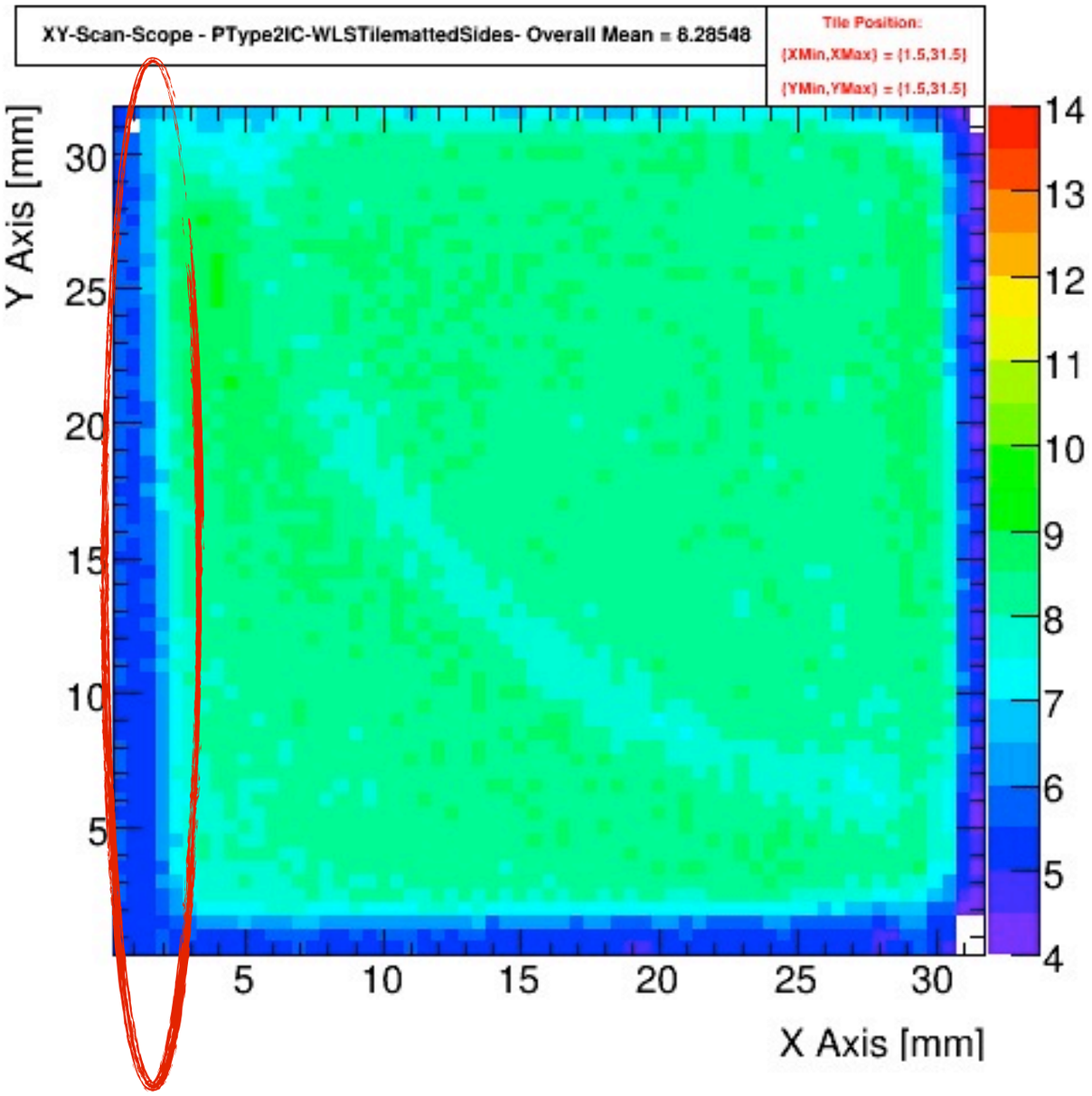
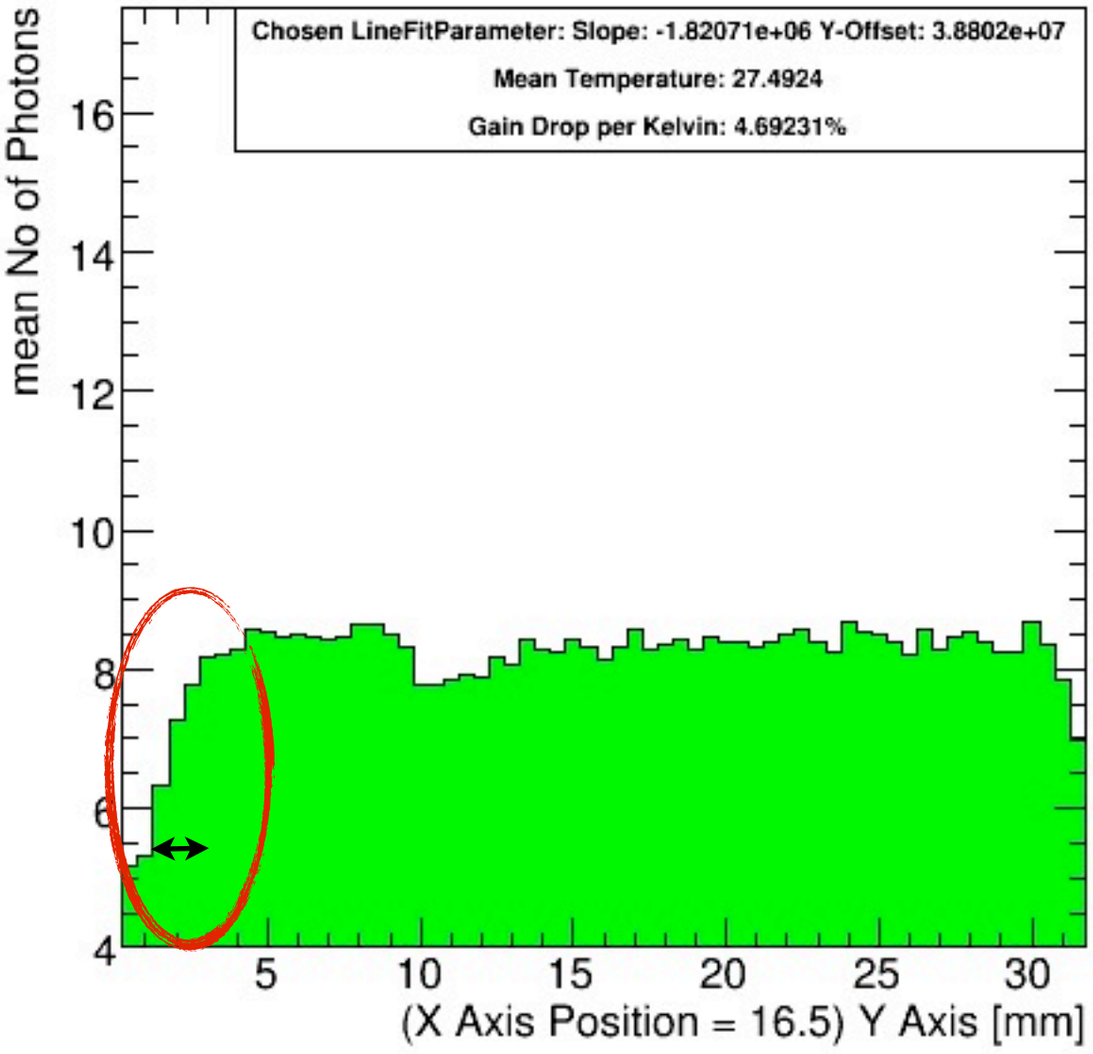
Calorimeter for ILC

Excellence Cluster Universe

Setting the Stage

- The issue: Tile scans show non-uniformities at the edges... Are these real?
  ... or do they come from the measurement itself?

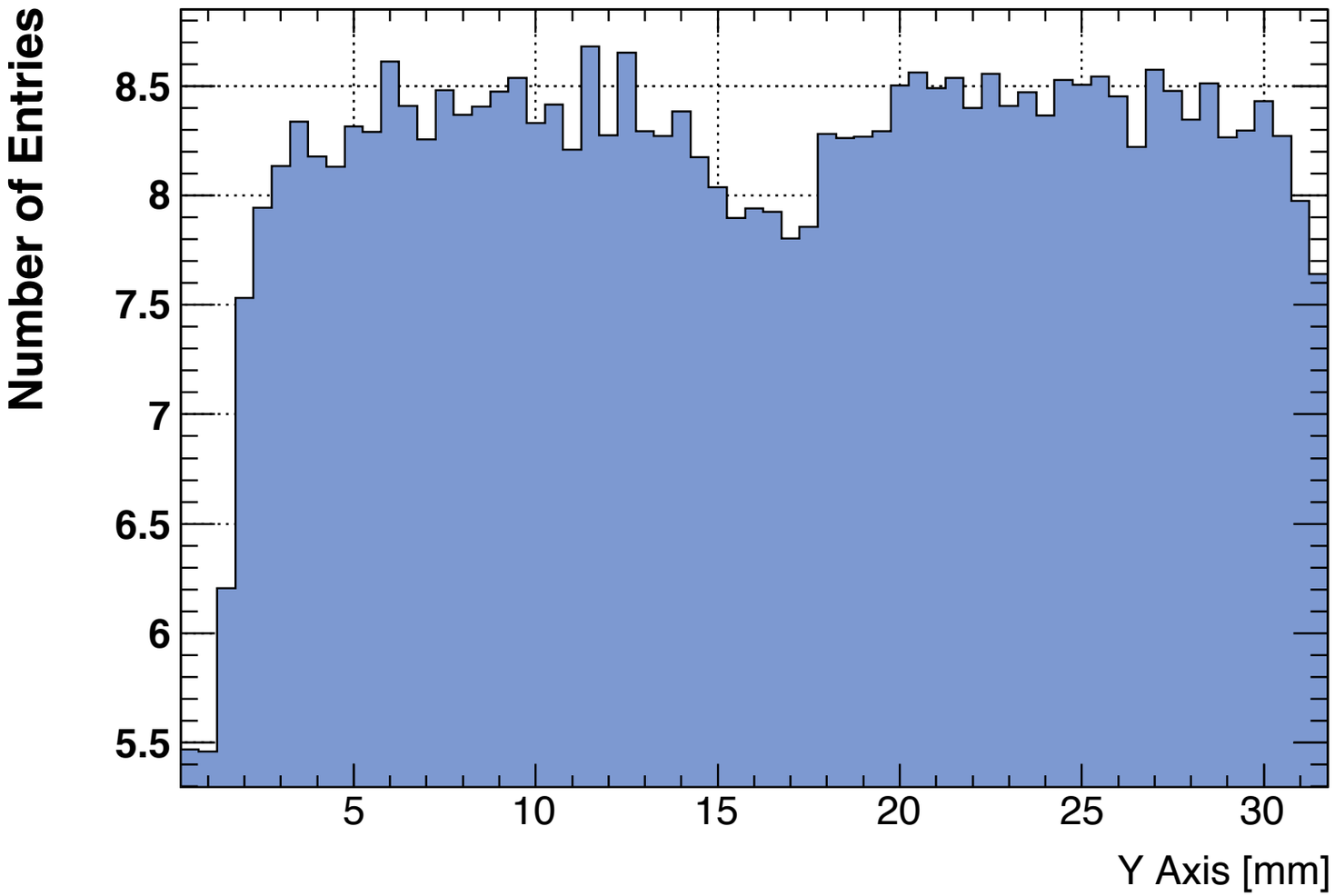




~ 2 mm wide edge

Looking Closer...

- Slight mis-alignment can make the edge appear softer than it really is...
  so, lets look at a single measurement row:

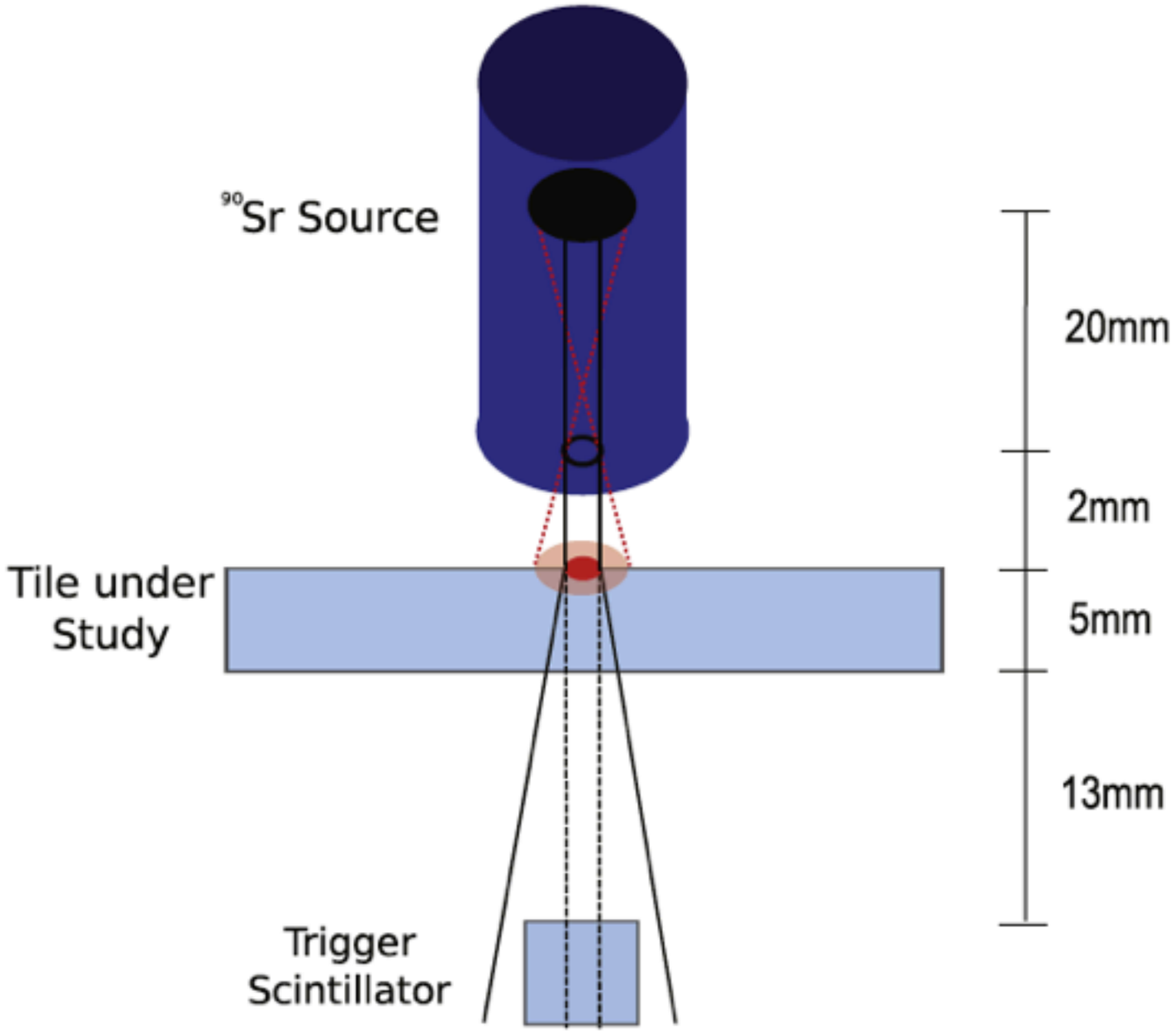


CALICE Tile

~ 1 - 2 mm: That seems to be the width of the edge

Where does it come from?

- The resolution of our scanning setup:



1 mm diameter pin hole
in lead casing:
angle of particle tracks up to 25 mrad

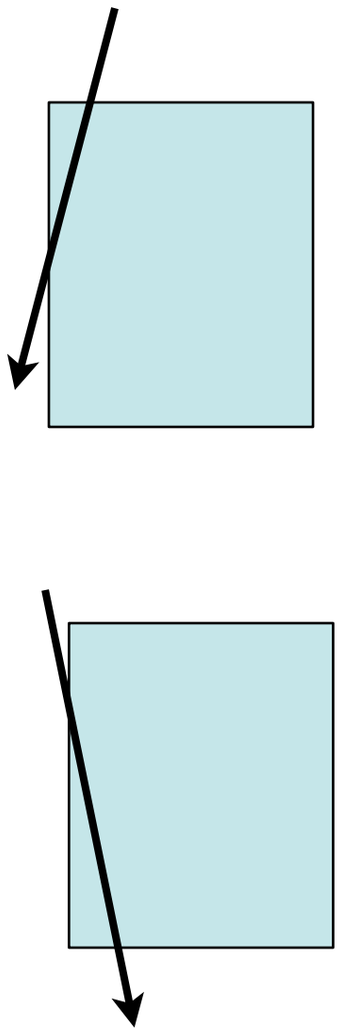
In addition: multiple scattering of electrons in scintillator (low energy!)

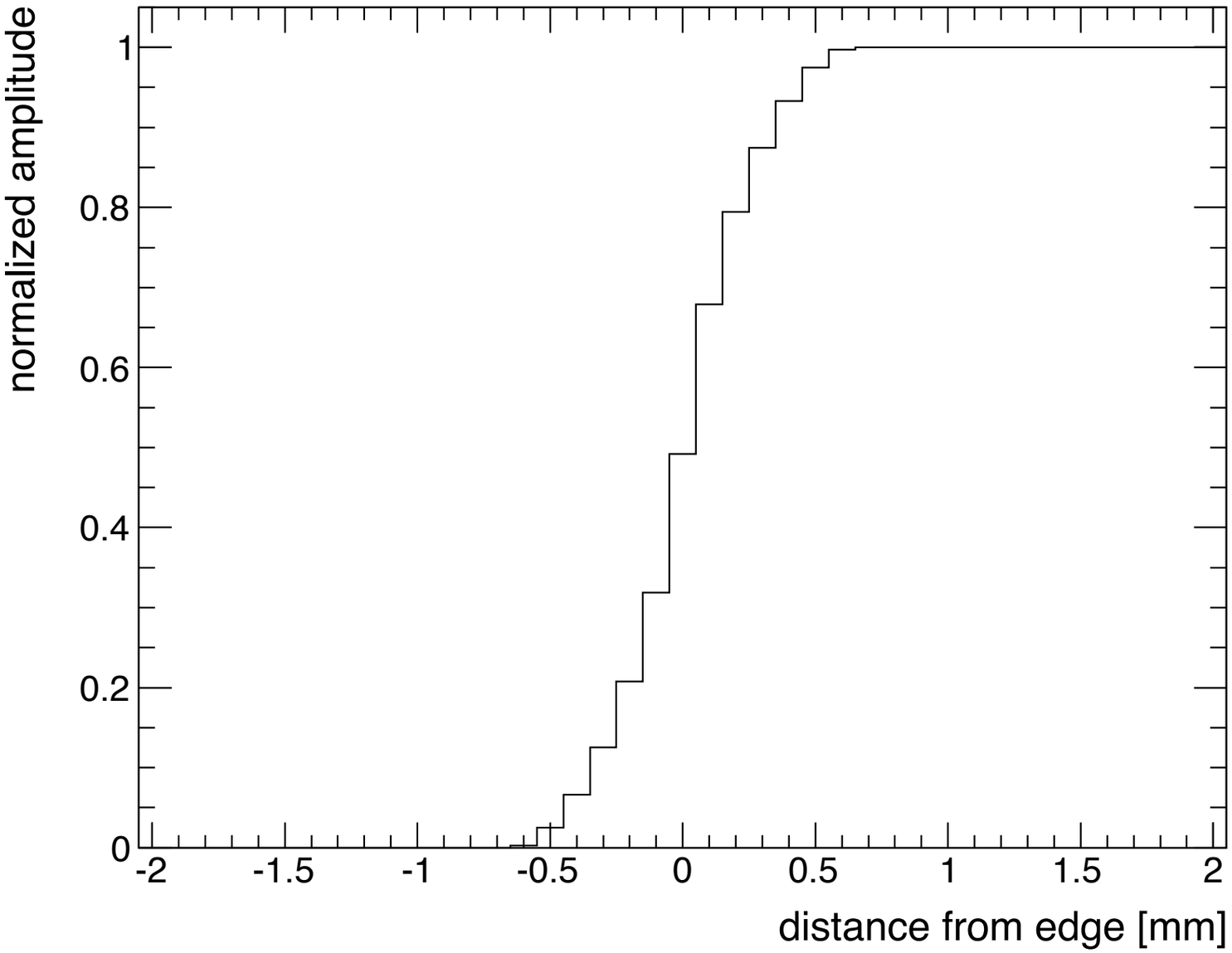
5 mm scintillator: 0.012 X_0 - large scattering expected at low energies (only 2 MeV!)

And: scanning in discrete steps
(.5 mm typically)

Where does it come from: Beam Divergence

- Simple toy simulation only taking into account 25 mrad beam divergence: Study distance covered in tile, as a function of source distance from edge





Edge: 1 mm wide (w/o effects from multiple scattering!)

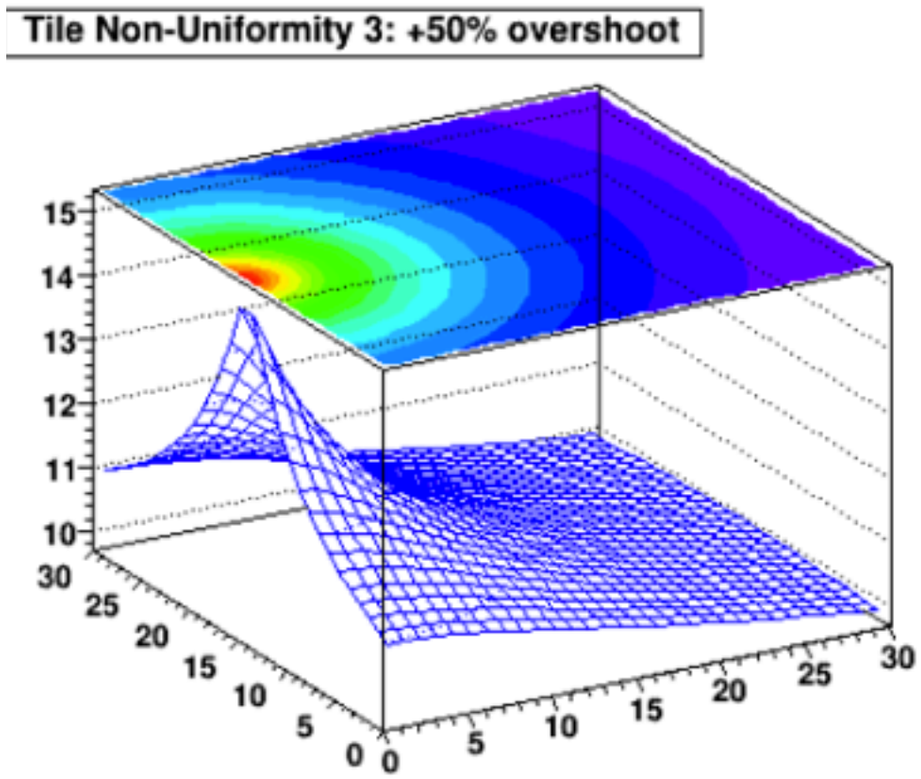
Tile Scanning: Edge Resolution Conclusions

- The resolution of the edge position in our scanning setup is 1 mm from the beam divergence alone, multiple scattering is expected to contribute substantially (high energy formula not really applicable, would need G4 simulations to study further)
- Observed edges are 1 - 2 mm wide

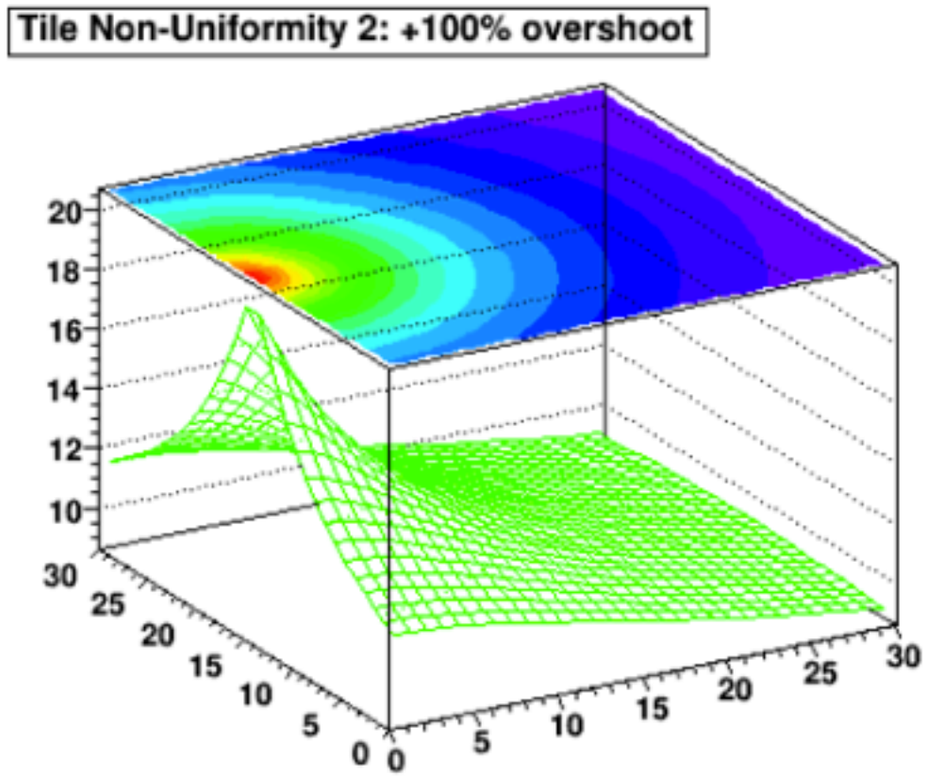
Our scan results are perfectly consistent with no efficiency loss close to to the edge, and do not support the hypothesis of a gradual increase in efficiency over 1 mm or more

The Effect of Non-Uniformities

- Geant4 Simulations with non-uniformities for directly couple tile w/o dimple: Unrealistically large non-uniformities!



Realistic for direct coupling w/o dimple

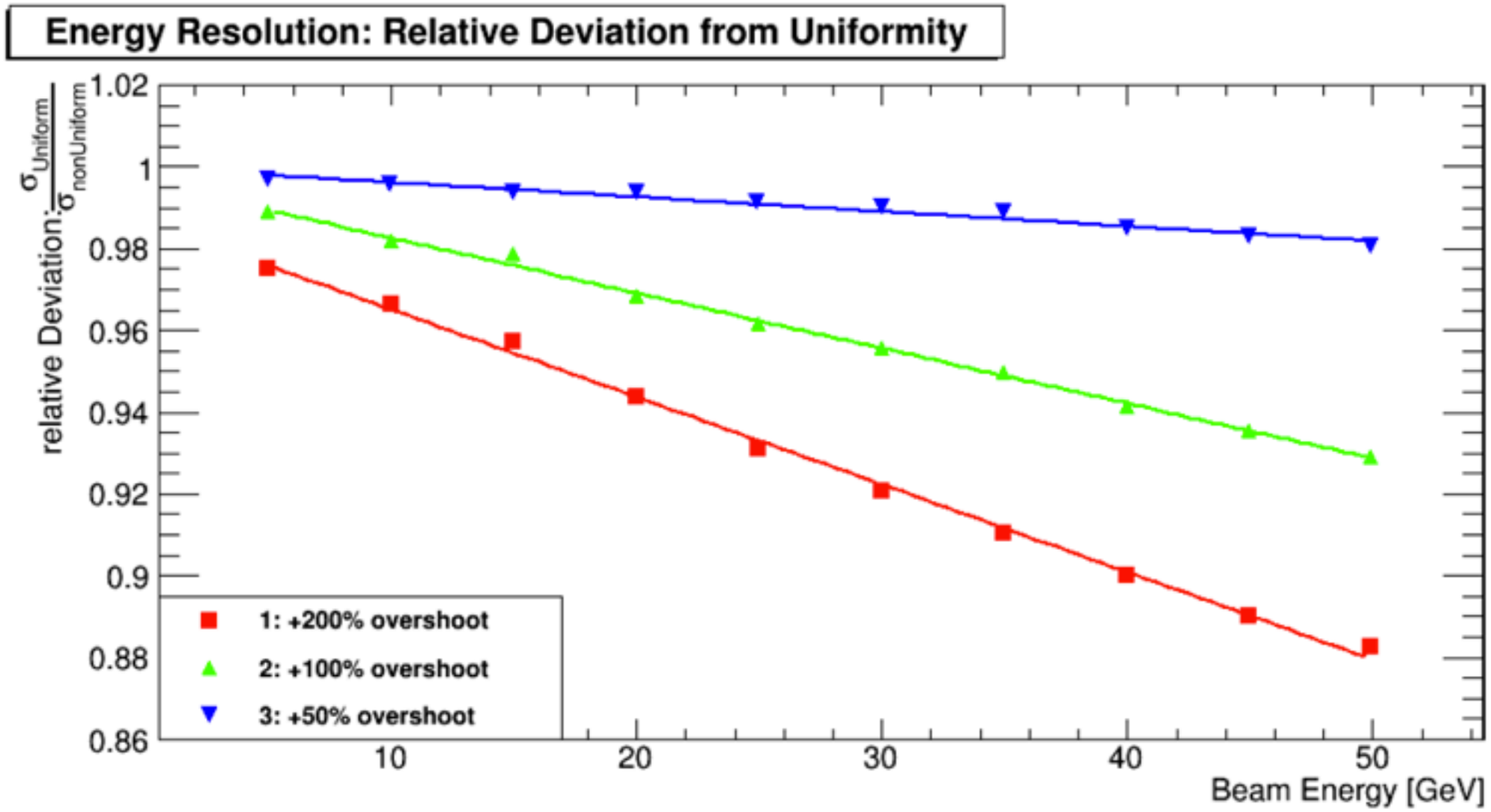


Factor 2 excess

(200%, factor 4 excess also studied)

The Effect of Non-Uniformities

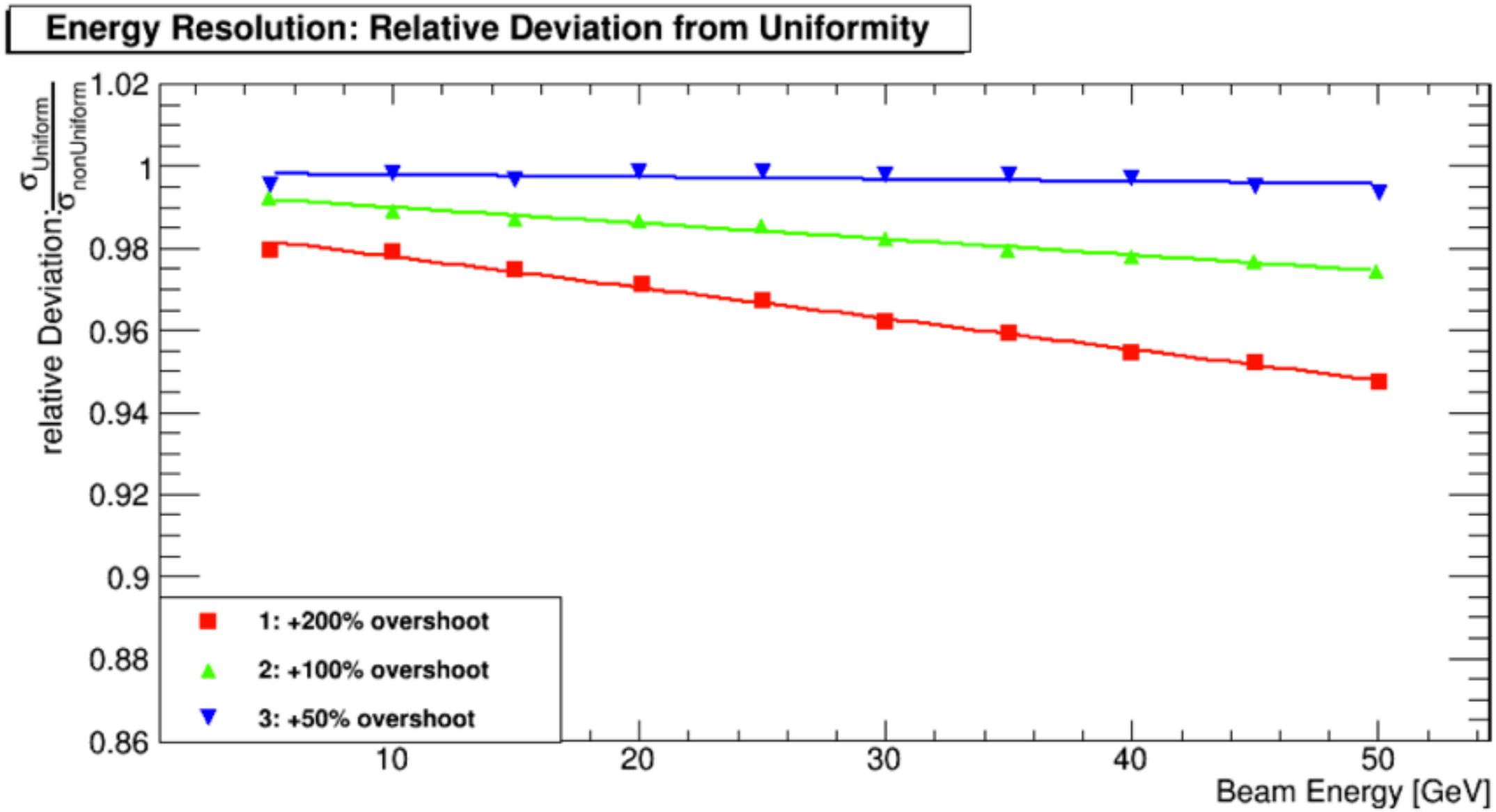
- All cells aligned: Channeling, layer to layer correlations



Effect increases with energy, 2% effect on resolution at 50 GeV

The Effect of Non-Uniformities

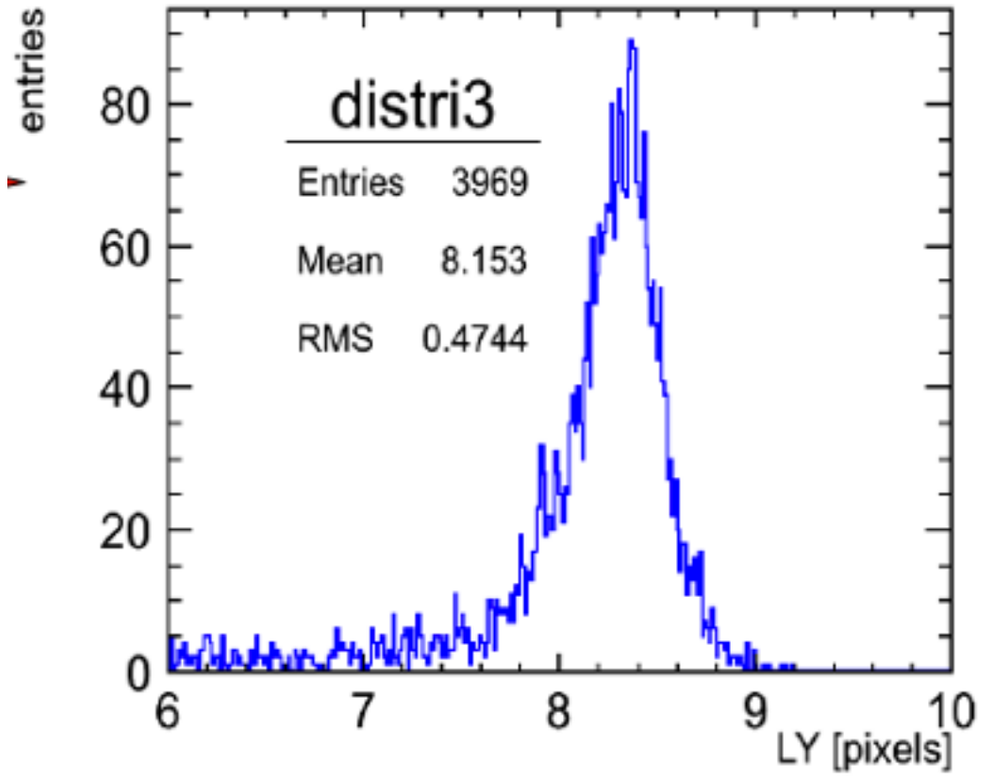
- Rotating cells in adjacent layers (periodicity of 4 layers): Comparable to staggered layers



Effect increases with energy, 0.3% effect on resolution at 50 GeV

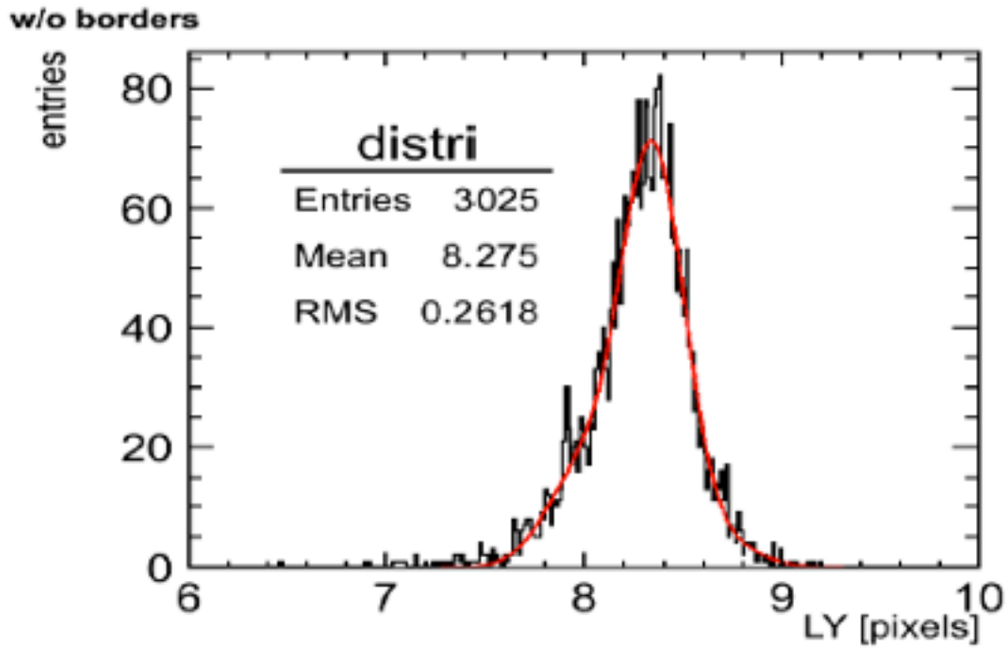
Simulating the CALICE Tiles

- Recent work by Marco Ramilli, using CALICE tile scan from Christian Soldner



scan is converted to 1D histo

Edge effects are removed



⇨ Use as pdf to weight energy deposits in each cell

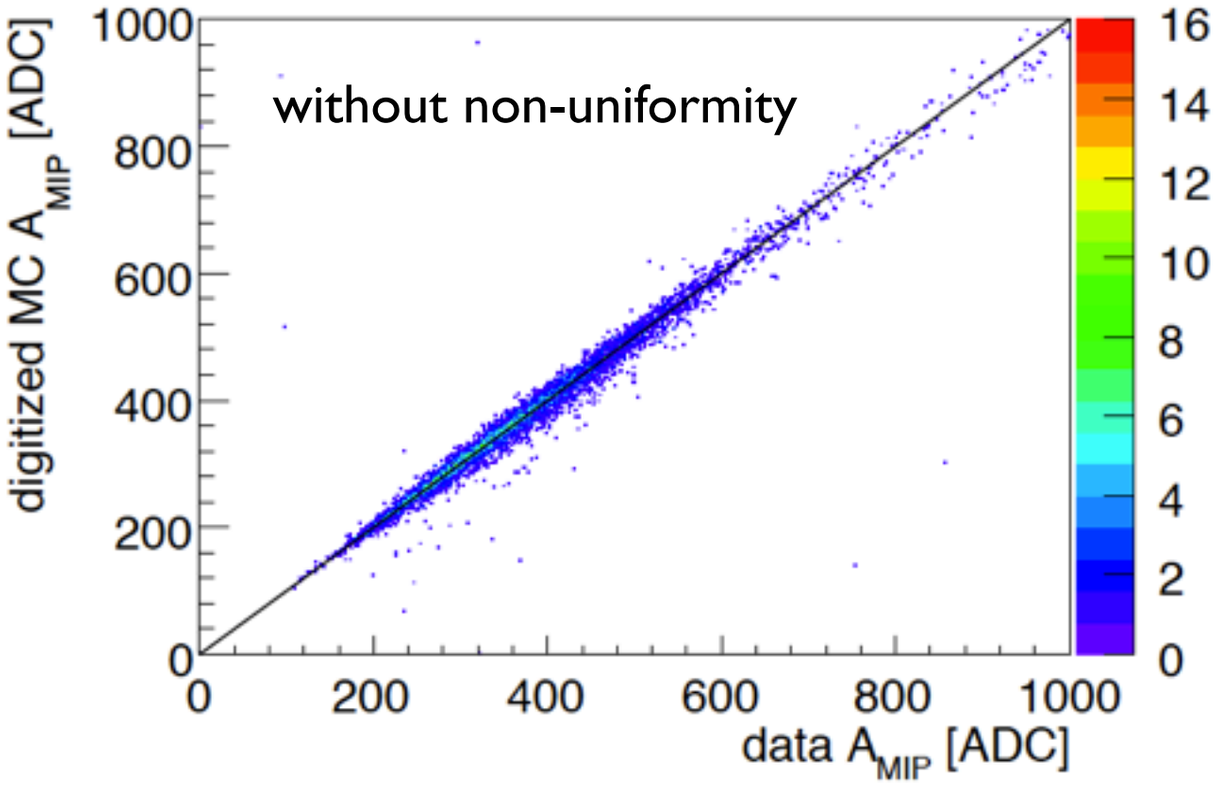
Does not consider spreading of energy deposits in the cell over active area: Potential overestimation of effect of non-uniformity

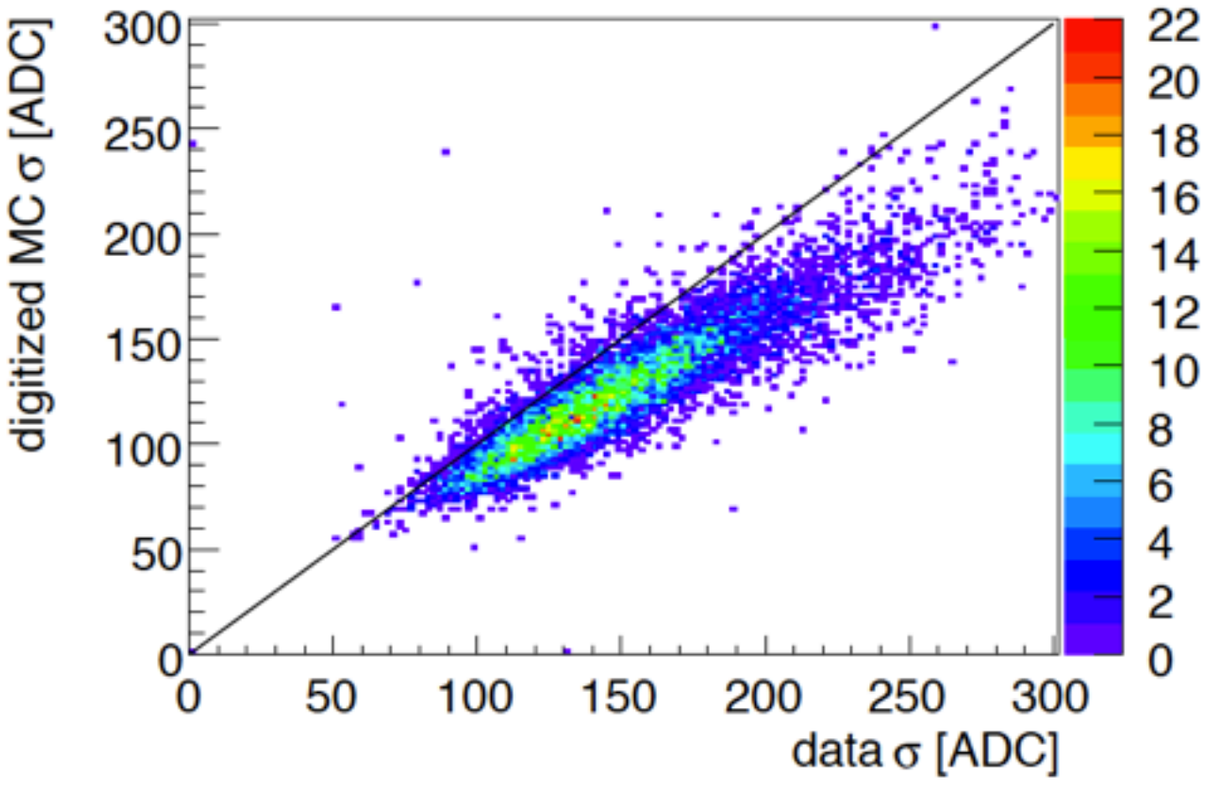
Absolutely no cell-to-cell or layer-to-layer correlation of non-uniformities: Potential underestimation of effect

All in all a very fair study - No effect on reconstructed energy observed (variations on 10^{-4} level) !

Non-Uniformity and Muons

- This has been studied by Sebastian Richter a while ago using scans performed at ITEP with electrons monitored by wire chambers
  - Comparing MPV and width of MIP single cell energy depositon for data and MC:





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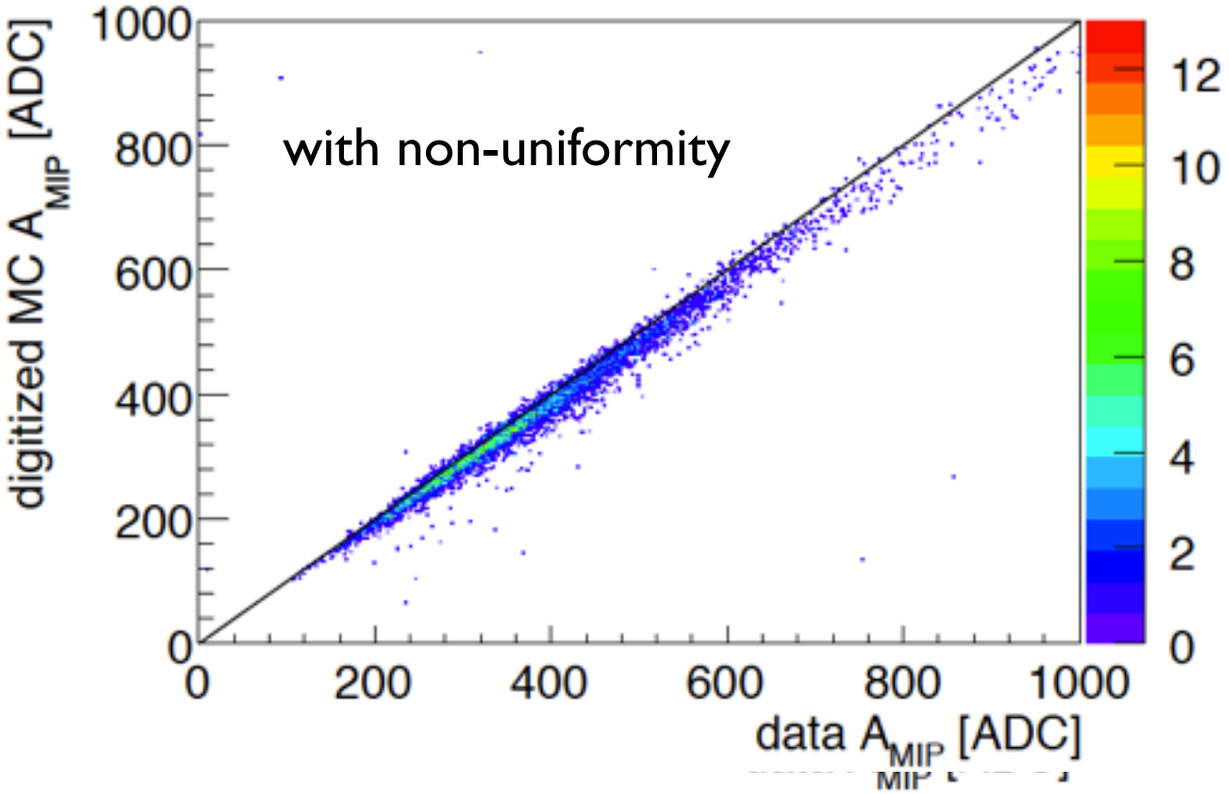
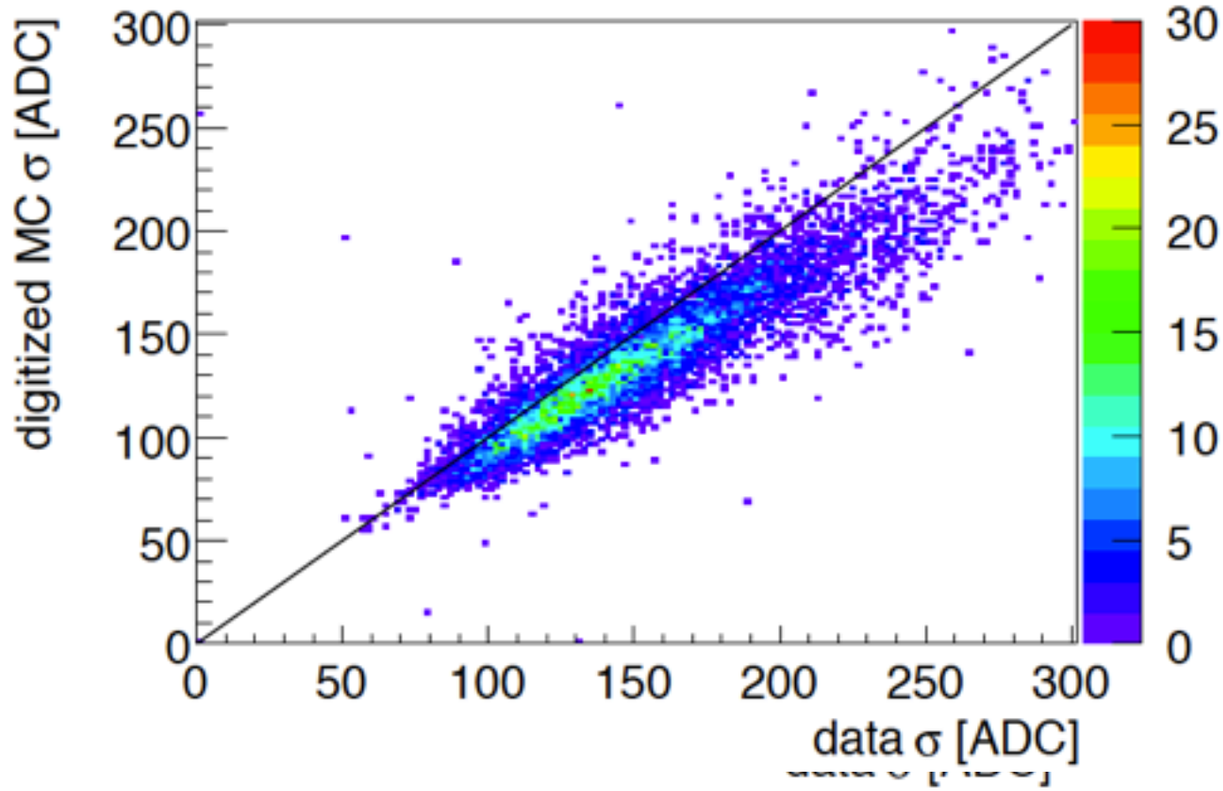
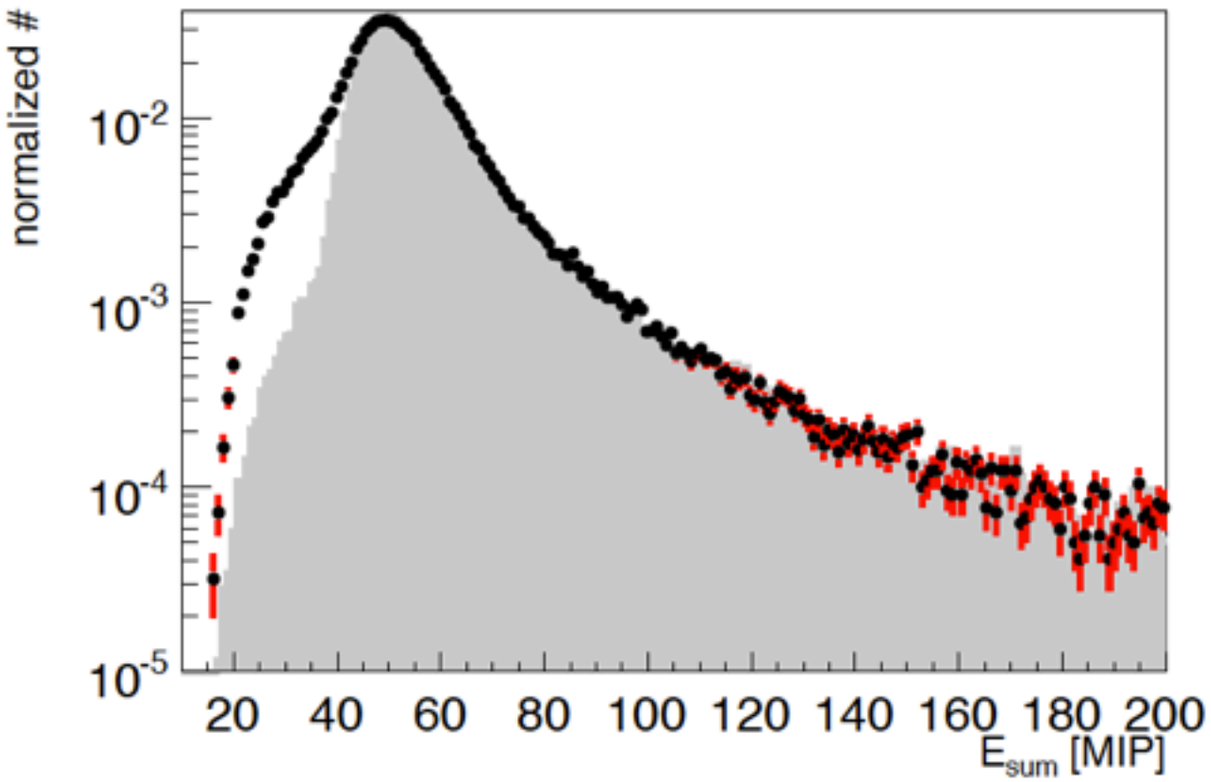


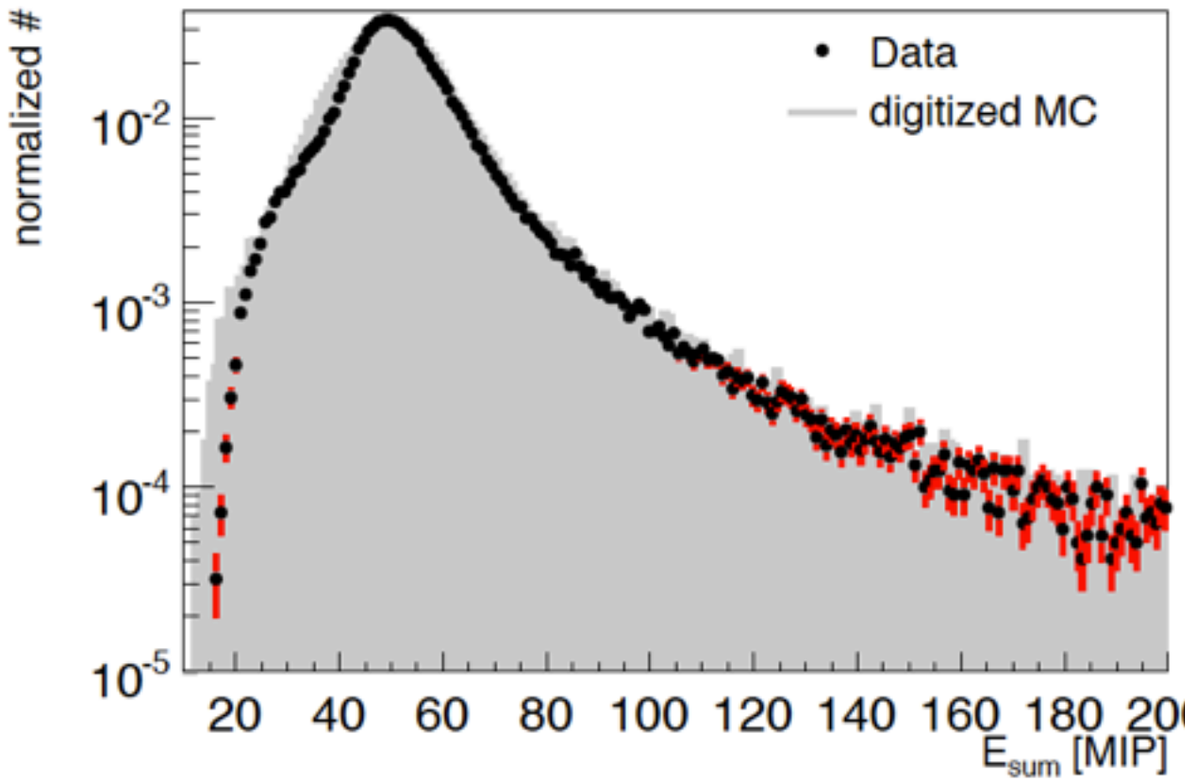


Including tile non-uniformities significantly improves the description of the width of the muon peak (MPV is not affected, as expected)

Non-Uniformity and Muons

- Significant effect on the energy distribution - energy sum in the AHCAL for muon events: Much better agreement of data and MC with non-uniformities included





Inclusion of non-uniformities is necessary to correctly describe the response to muons...

... but for particle showers they do not matter, due to the spread of particles across all many tiles and the loss of tile-to-tile correlations

Conclusions

Conclusions from Simulations

- The influence even of large non-uniformities on the energy resolution for hadrons is small
  - Significant reduction if cells are not aligned from layer to layer
  - Effects smaller at low energy
- Also applies to fibers and other non-uniformities: No noticeable effect expected, localized non-uniformities do not matter.
- For muons they do matter... but not for the MPV, so not for the calibration.

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- The influence even of large non-uniformities on the energy resolution for hadrons is small
  - Significant reduction if cells are not aligned from layer to layer
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Conclusions from Tile Scans

- ^{90}Sr scans have inherent smearing of more than 1 mm
  - Could be solved with beam tests with higher energies and tracking telescopes, if absolutely wanted
- Large non-uniformities at the tile edges very likely do not exist:
  There is no uniformity problem in the AHCAL!