ScECAL + AHCAL Combined Analysis

Detailled MC simulations for the ScECAL

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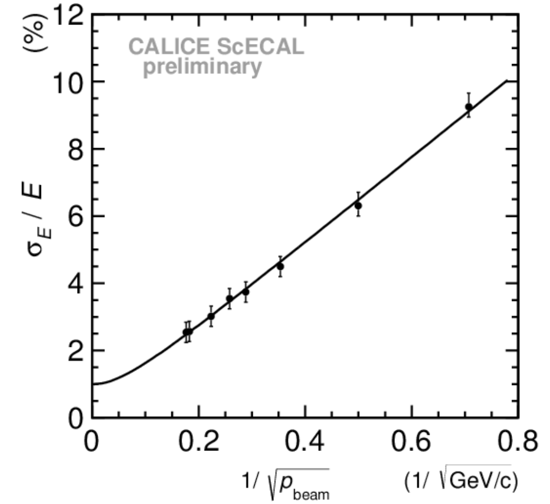
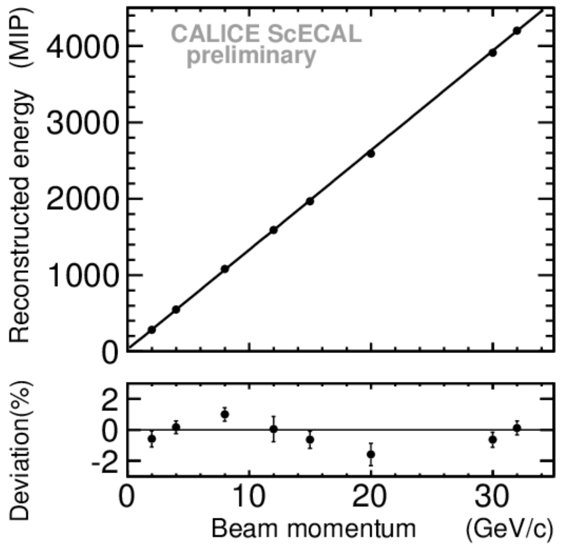
CALICE Meeting
KEK, 20.04.2015

Introduction

- **>** ScECAL + AHCAL Testbeam FNAL 2009
  - Muons, electrons, pions 2-32GeV
- **>** ScECAL EM analysis nearly complete
  - CAN 16c, paper in progress
  - Simulation not very detailed, not fully validated
- **>** Step-by-step to a realistic simulation
  - Sensor effects
  - Single cell spectra
  - Shower profiles
  - Reponse & resolution
- **>** Planned: Combined scintillator system analysis
  - Pion response and resolution (OH)
  - Particle separation with shower shapes (Mathias Goetze, BU Wuppertal)





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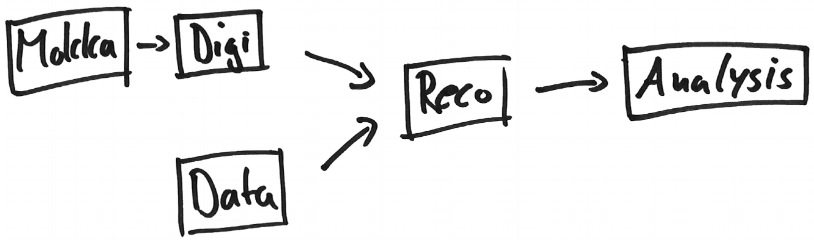
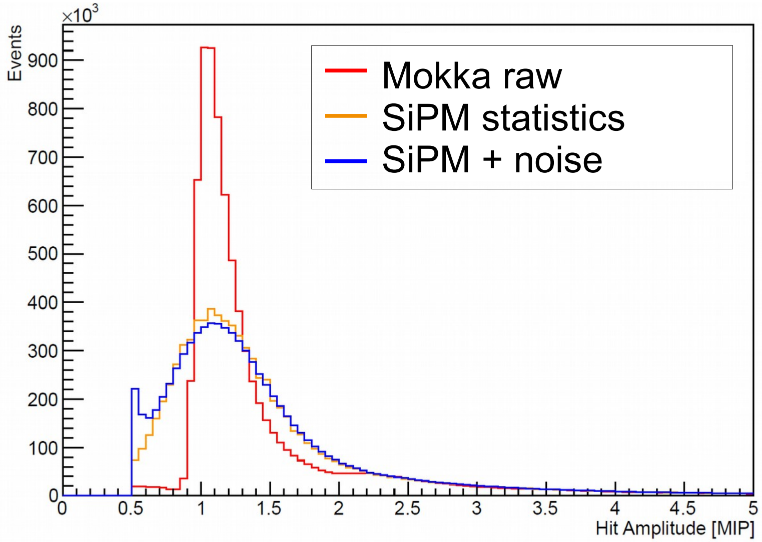
DESY

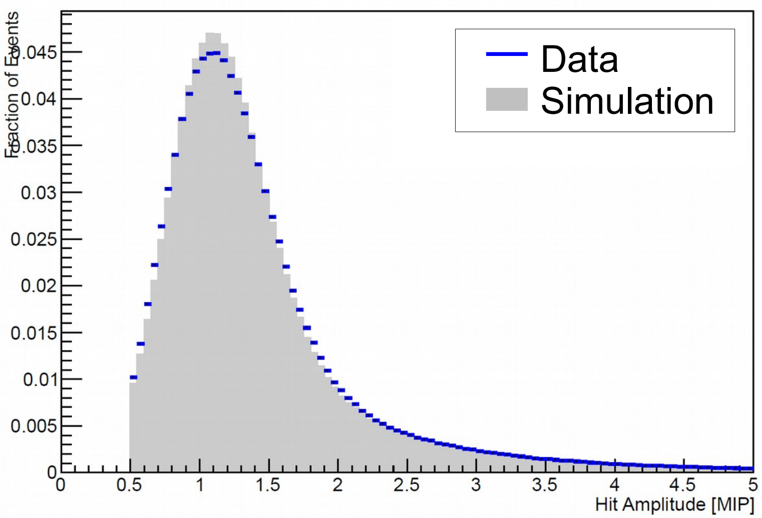
Digitisation

- Previously used raw Mokka depositions
- SiPM: finite number of pixels
  - Quantisation → statistics
  - Saturation
  - Noise (from data)
- Implemented new digitisation processor



- Good agreement between muon spectra
  - Data slightly wider than MC
    → Strip inhomogeneity not included





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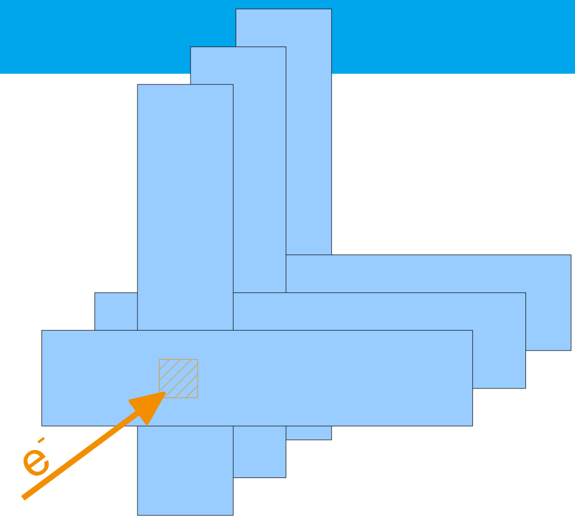
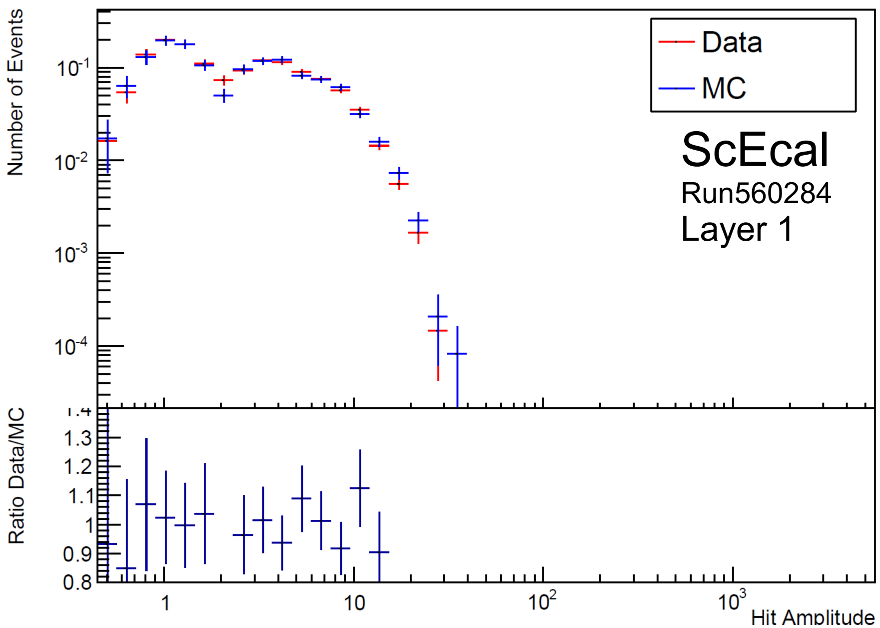
DESY

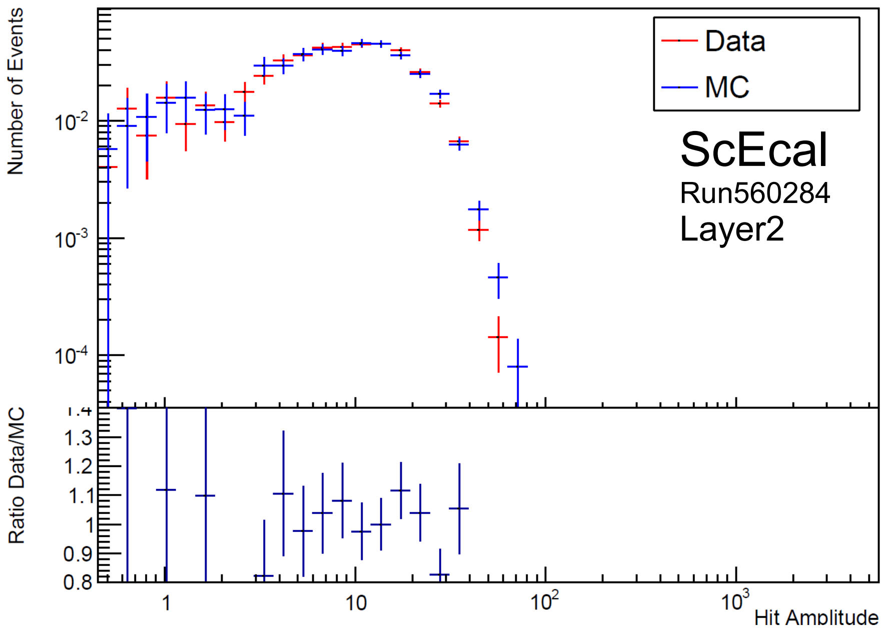
EM Shower Cell Spectra



- Compare single cell hit spectra
  - Tight CoG selection → low statistics
- Superficial upstream material
  - Beamline instrumentation modelled by 5mm Al plate in front of first layer

→ Excellent description of cell spectra in the first layers





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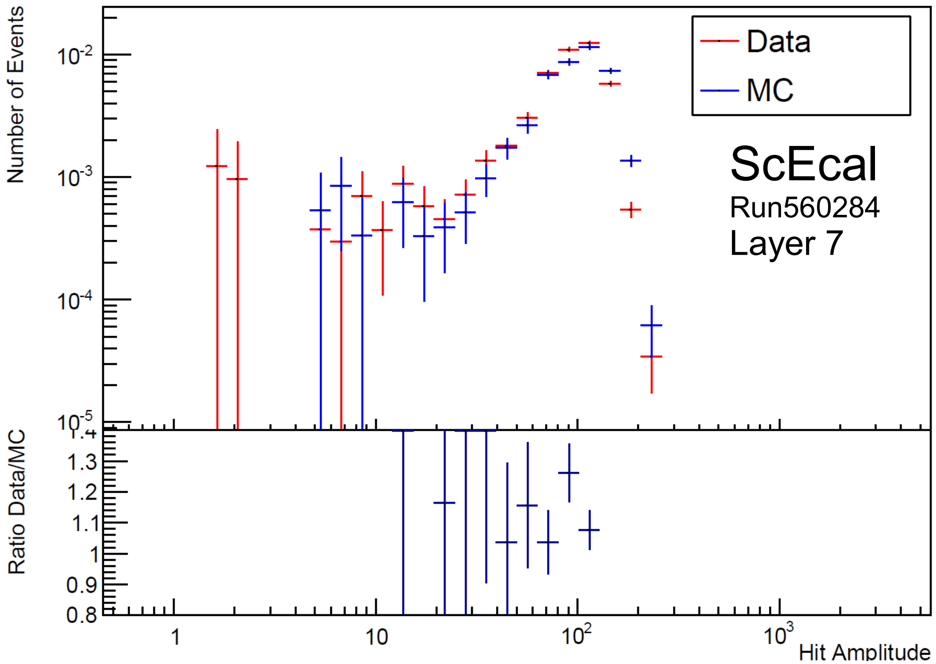
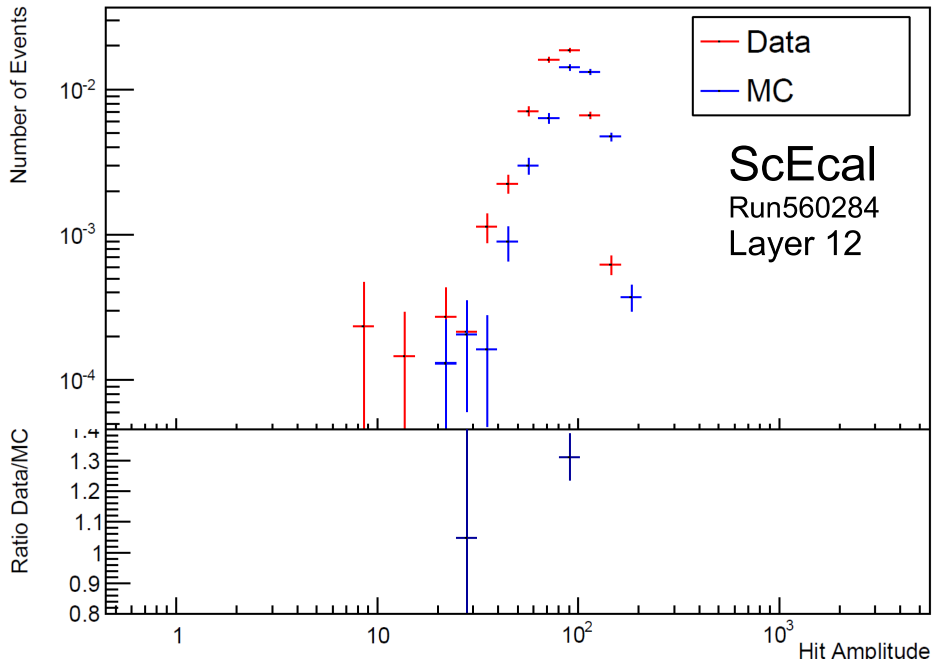
DESY

EM Shower Cell Spectra

- Good description also for deeper layers
  - Correct description of saturation effects?
- Single outliers are expected
  - Calibration
  - Not all calibration parameters available cellwise





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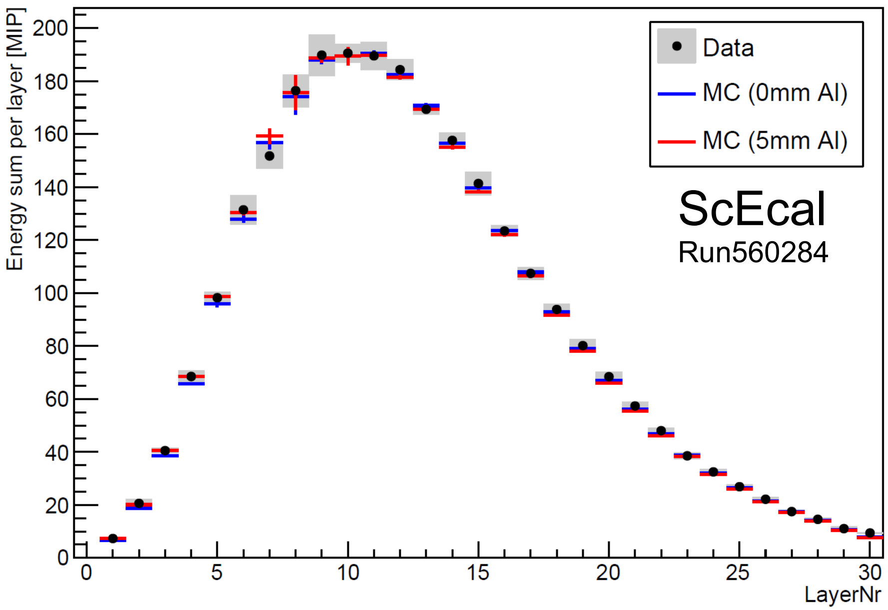
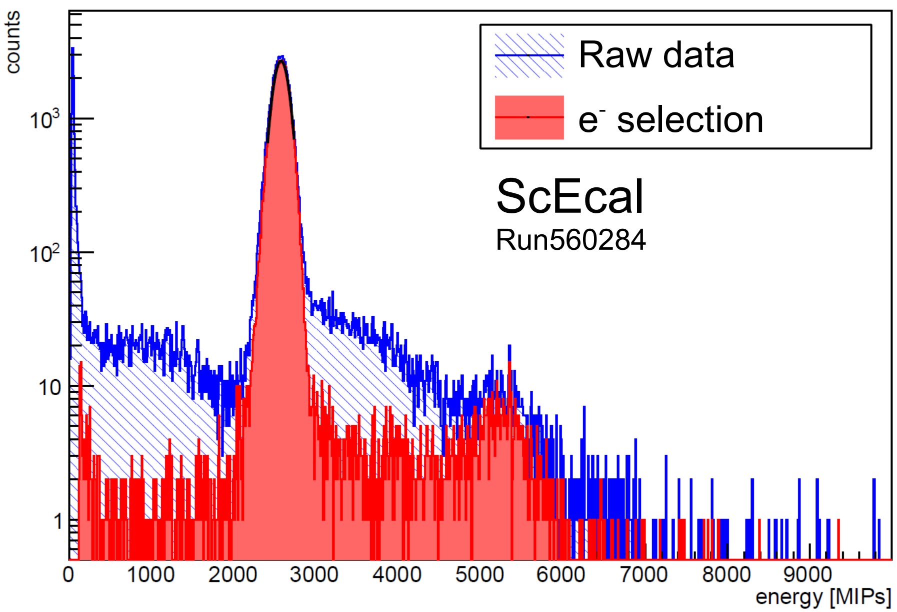
DESY

EM Shower Profile

- 20GeV Run: Good description
  - Good agreement in energy sum
  - Effective electron selection
  - Small difference 0mm/5mm Al





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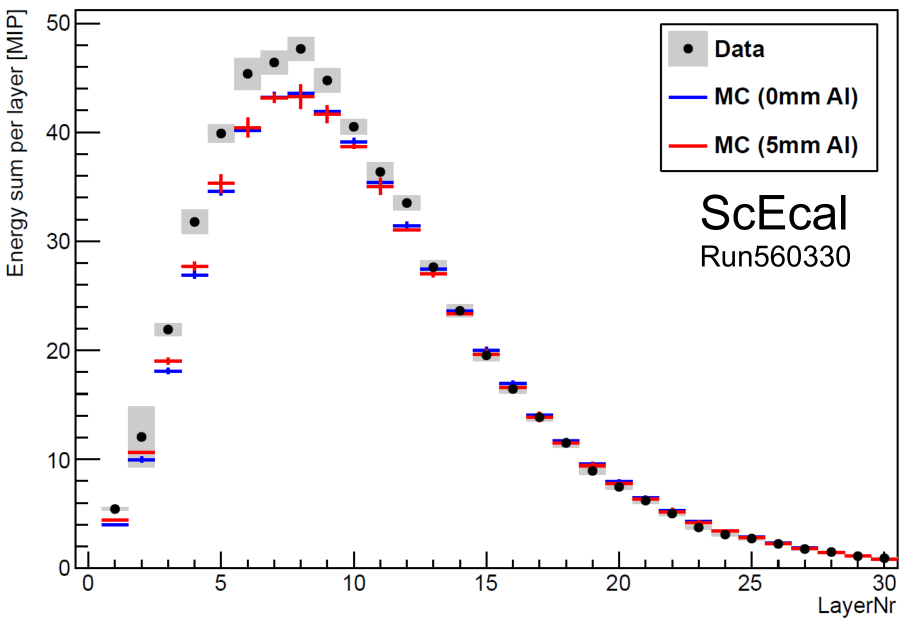
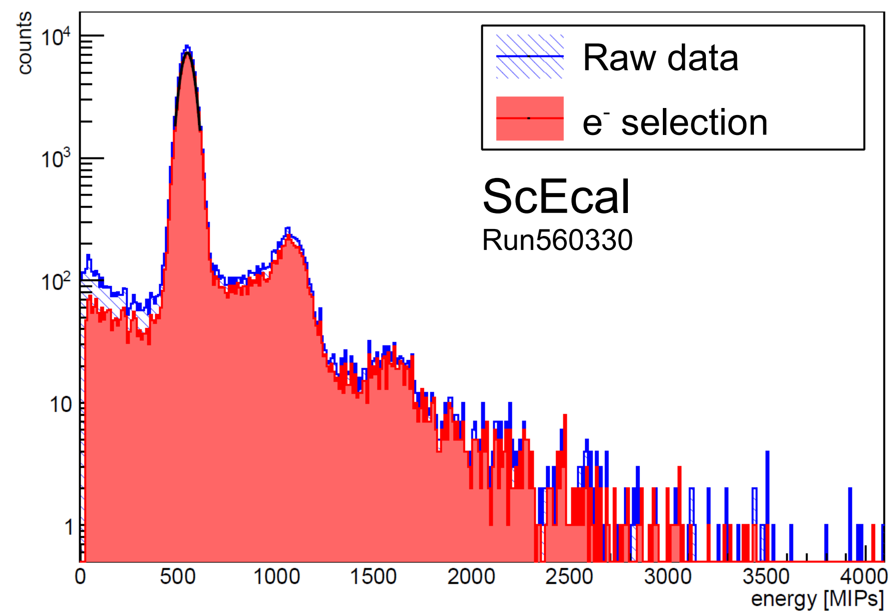
EM Schauerprofil

4GeV Run: Worse description

- Energy sum too low in simulation
- 5mm Al plate shifts profile in the correct direction, though not enough
- No clean electron selection → pion contamination
- Additional diffuse energy particles?





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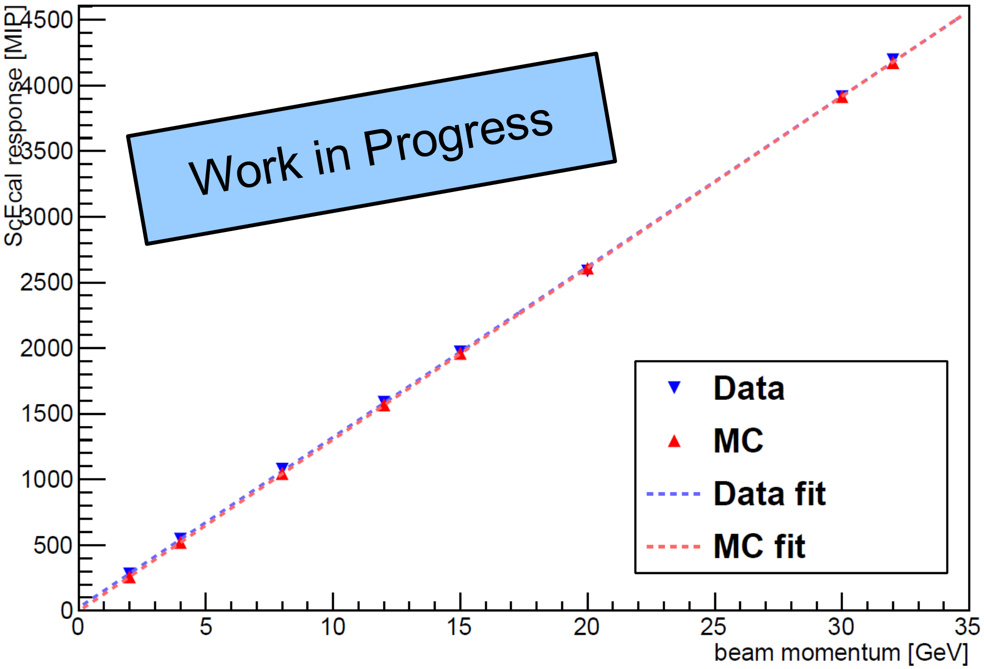
DESY

Response/Linearity

- Only one run per energy simulated, limited statistics
  - No systematics yet
- Good linearity in range 2-32GeV
  - <1.7% (<0.5%) residuals in data (MC)
- Fits: Excellent description of slope
  - Data: 129.9(±0.01)MIP/GeV +23.2 MIP
  - MC: 130.7(±0.02) MIP/Gev -3.7 MIP
  - Constant: beam contamination?



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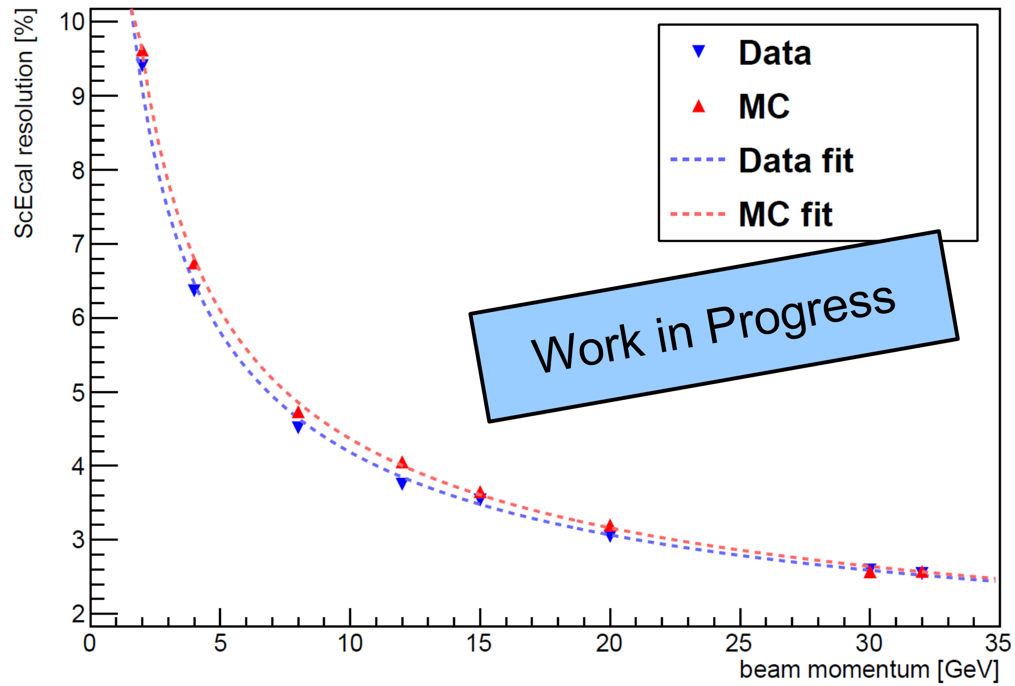
DESY

EM Auflösung

- Only one run per energy simulated, limited statistics
  - No systematics yet
- Single resolutions slightly worse in MC
  - Assumed beam momentum uncertainty correct?
- Fits: Stochastic term slightly higher in MC
  - Daten: 12.72(±0.06)% stoch. +1.15(±0.04)% const.
  - MC: 13.46(±0.08)% stoch. +0.97(±0.09)% const.



- Full run MCs in production at Uni Shinshu

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DESY

Sumary & Outlook

Summary

- Full SiPM digitisation implemented for ScECAL
- Good agreement on cell spectra, shower profile
  - Limited by electron selection purity at low energies
- Good agreement in response
- Acceptable agreement in resolution
  - MC slightly worse than data

Outlook

- Publish ScECAL EM paper
- Pions in scintillator calorimeter system

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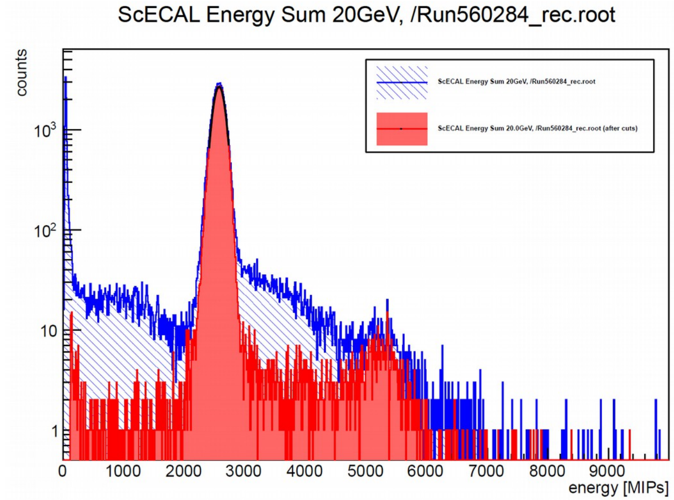
Special thanks to Katsu and all of the Uni Shinshu group for continued support and great hospitality!

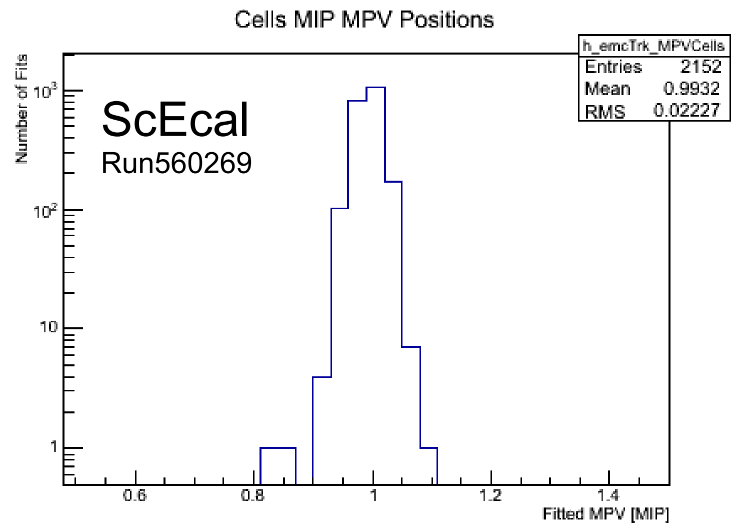
Backup

Data, Reconstruction and Selection

- Rebuilt ScECAL EM analysis
  - Event selection, result combination etc.
  - Identical results
  - Found/fixed bugs → CAN-16c



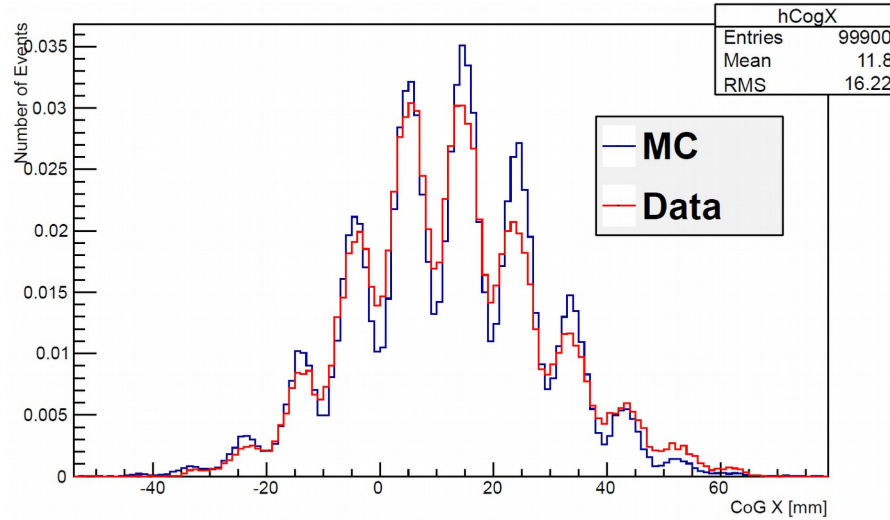
- ScECAL MIP calibration crosscheck
  - Correct mean
  - Good spread
    → Enables summing of MIP spectra

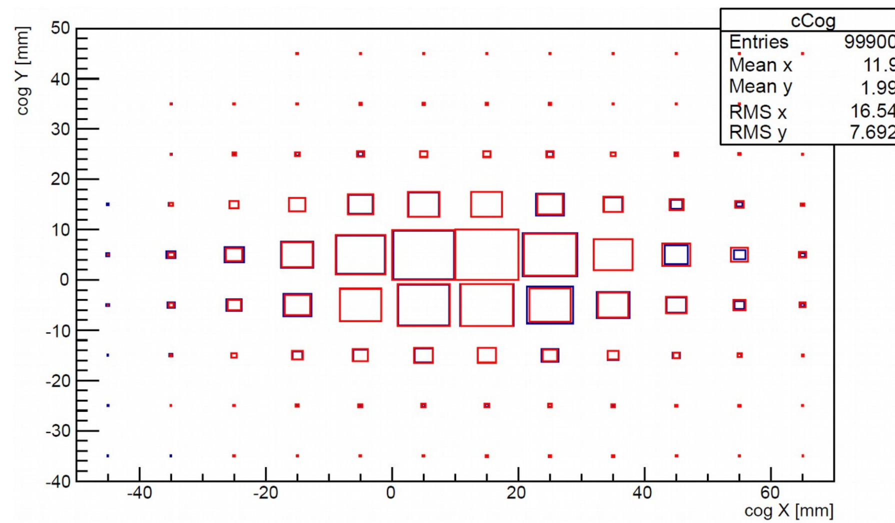


Beamprofile

- **>** Beamprofile different each run
  - Geant4 Gun parameters from Gaussian fit to data CoG distribution
- **>** Acceptable shape description
  - MC peaks too narrow

    → wrong upstream material?
    ... but first layer CoG looks fine
  - Perfect on 1*1cm^2 binning





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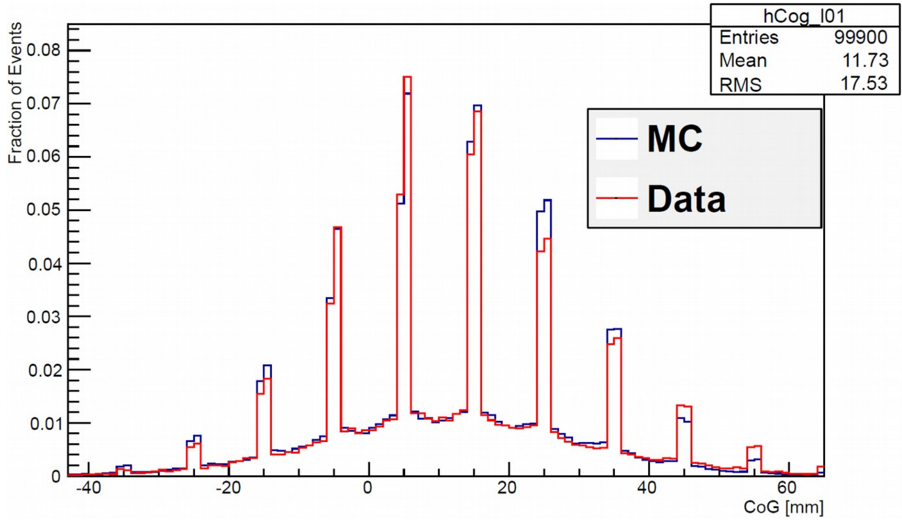

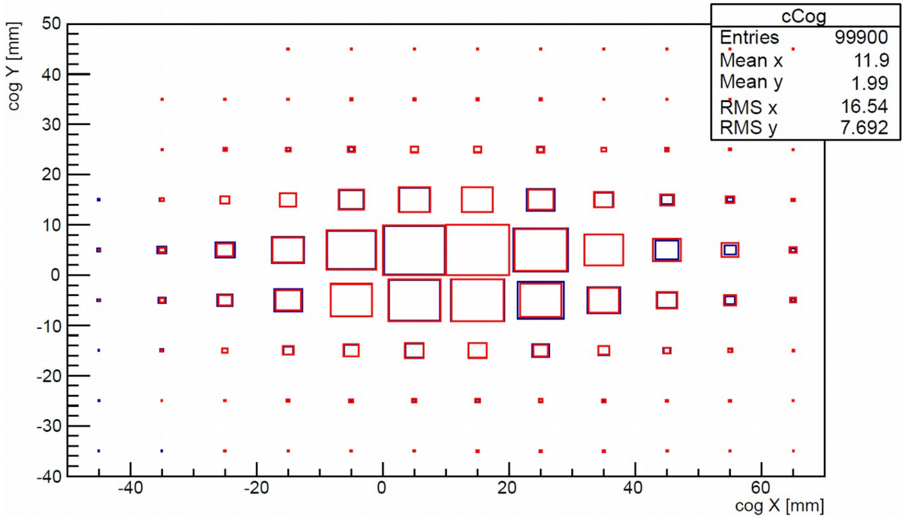

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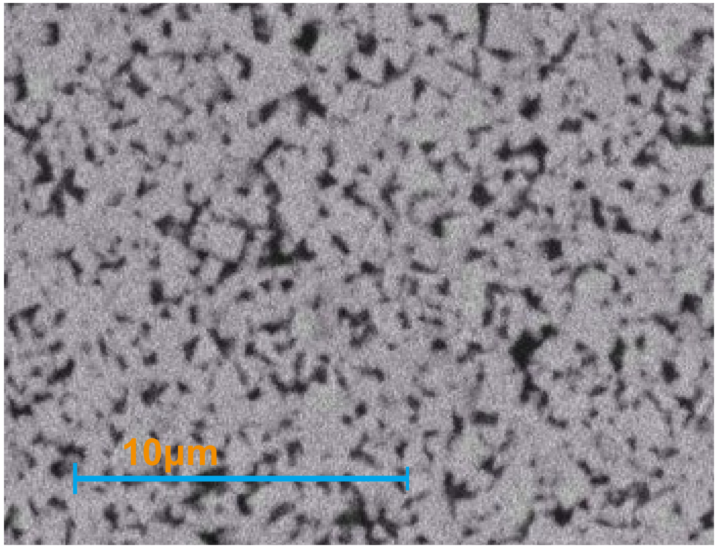
DESY

Absorber Composition

- “Tungsten” absorber composition unclear
- Measurements: (Katsushige Kotera, CALICE Asia 28.11.'12)
  - Density (caliper, micrometer, scale): 14.25±0.04 g/cm^3
  - XRD: WC & Co crystal lattices, *no* elementary W
  - BSEI: WC pebbles bonded by Cr
  - EDX: 88% WC, 12%Co (+ε% Cr) → 14.65±0.04 g/cm^3
- Densities do not match
  - Pixel counting in BSEI image: ~11% “black”
  - Mokka: 88% WC, 12% Co but ρ=14.25 g/cm^3
- Idea: calculate WC:Co ratio from density
  - Constrained equations as W:C = 1
  - Result: 80%WC, 20%Co



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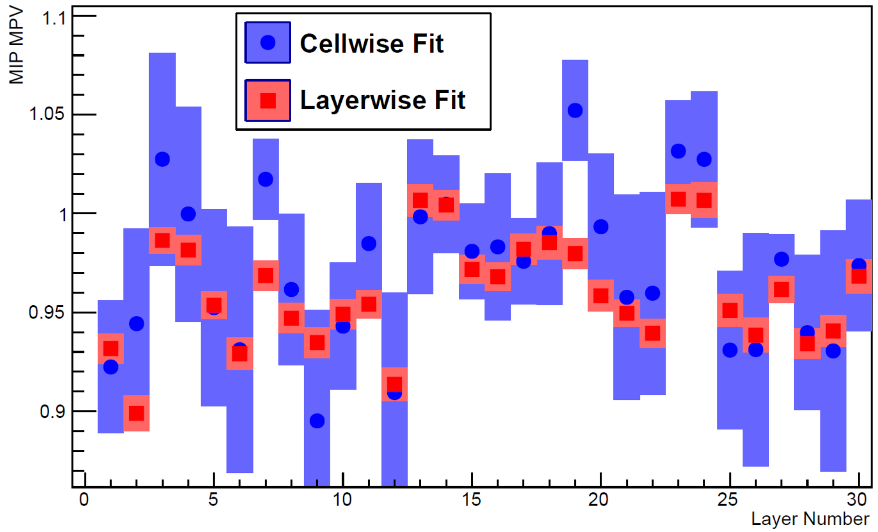
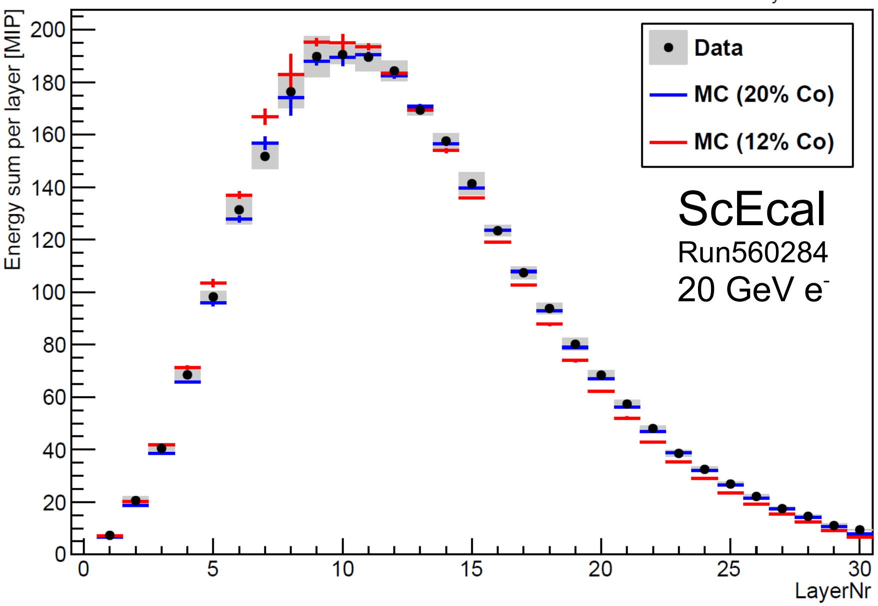
DESY

EM Showerprofile

- CAN-16 event selection
  - + Multi-particle suppression via Esum
- Layerwise MIP correction
  - Using muon contamination
  - Too few statistics for cellwise fits
- Uncertainties
  - CoG selection variation
  - Statistics (negligible)
- Run 560284 (20 GeV electrons)
  - Very nice MC/data shape
  - Response in agreement
  - Strongly favors 20% Co absorber





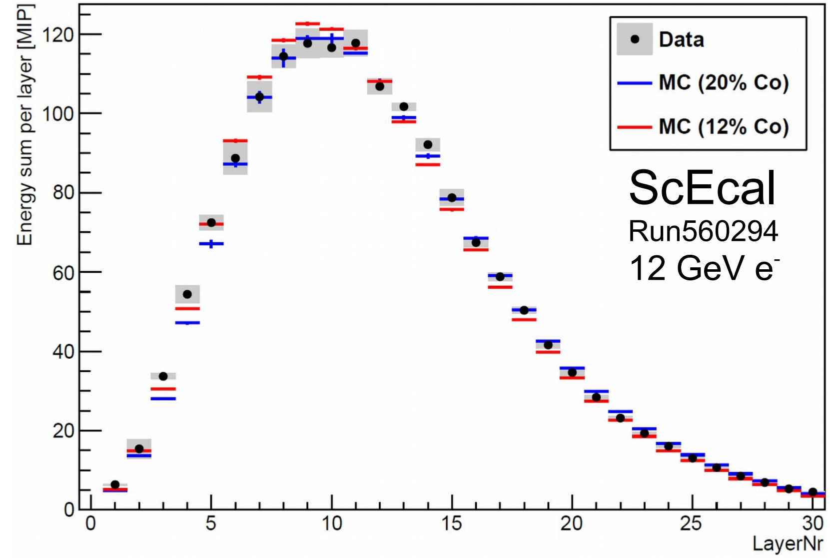
EM Showerprofile

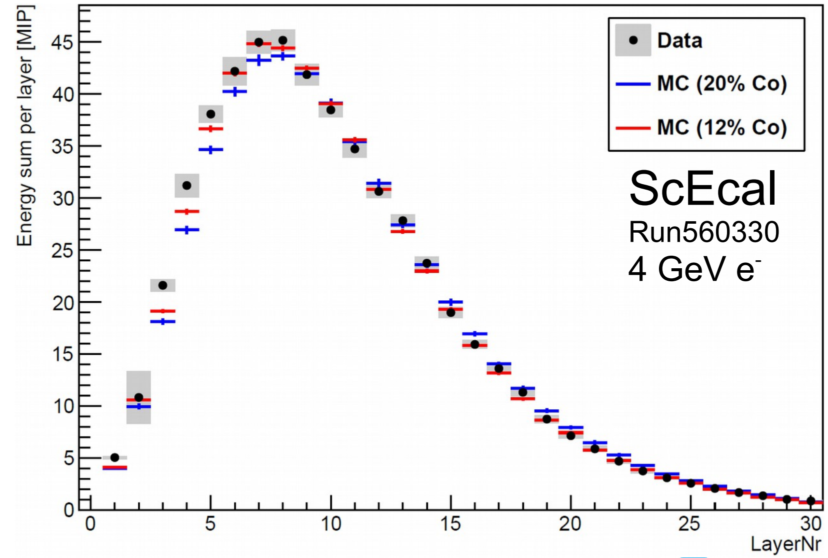
> Lower energy runs look worse
  - No layerwise MIP correction possible

> Run 560294 (12GeV electrons)
  - Worse electron selection performance
  - Slightly favors 20% Co absorber

> Run 560330 (4GeV electrons)
  - Very unclean selection
  - Does not favor any absorber
  - Shower starts too late in MC?

> Need to look at more runs
  - Improve electron selection for low energies?





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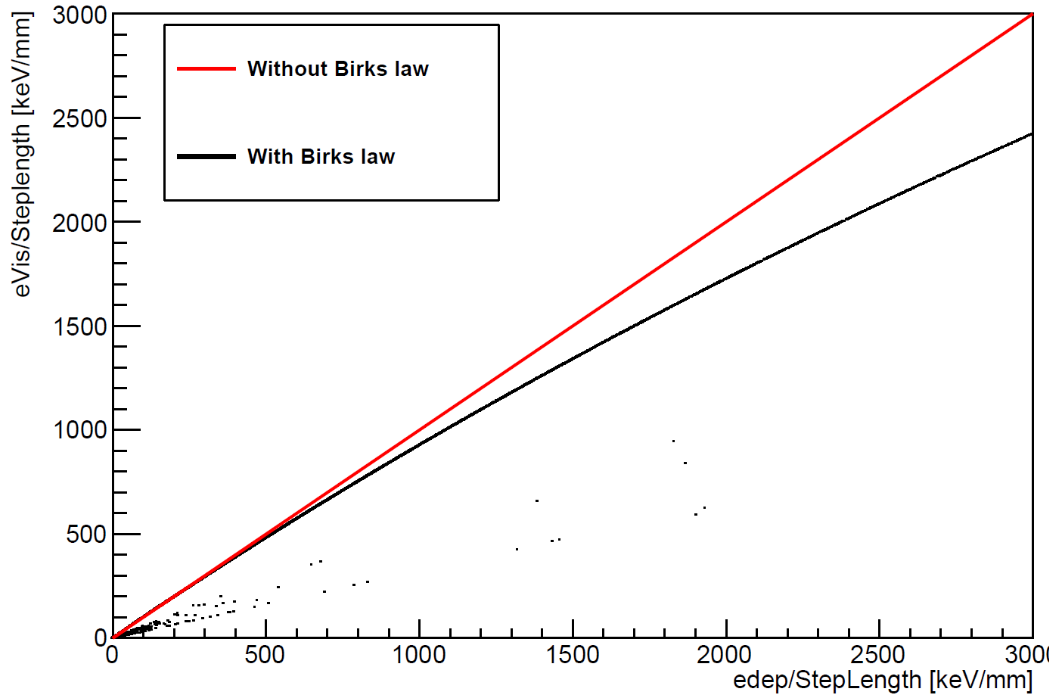
DESY

Birks' Law

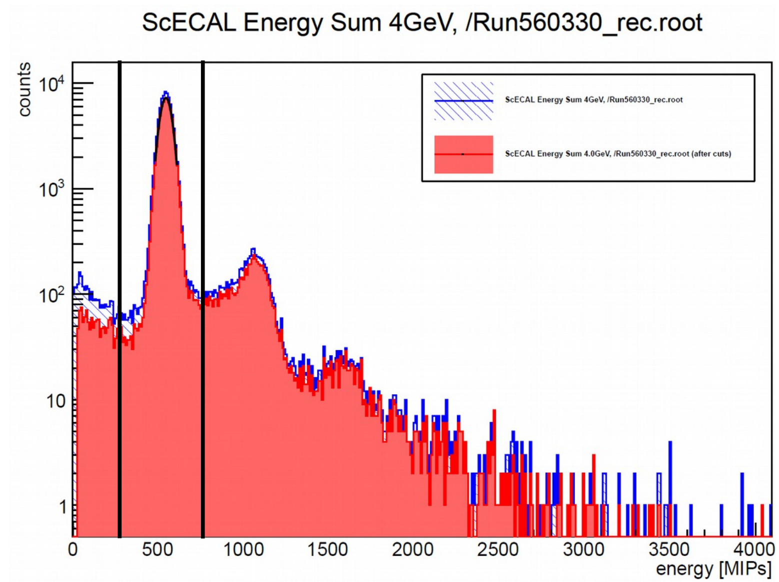
- Birks' Law: saturation in organic scintillator
  - Should influence high amplitude hits more than small amplitude hits
  - Using AHCAL standard parameter for now, scintillator material to be checked

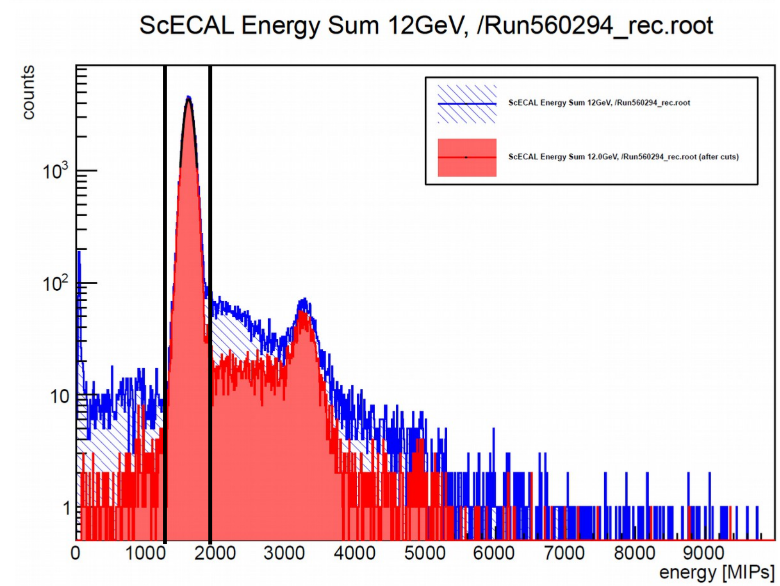


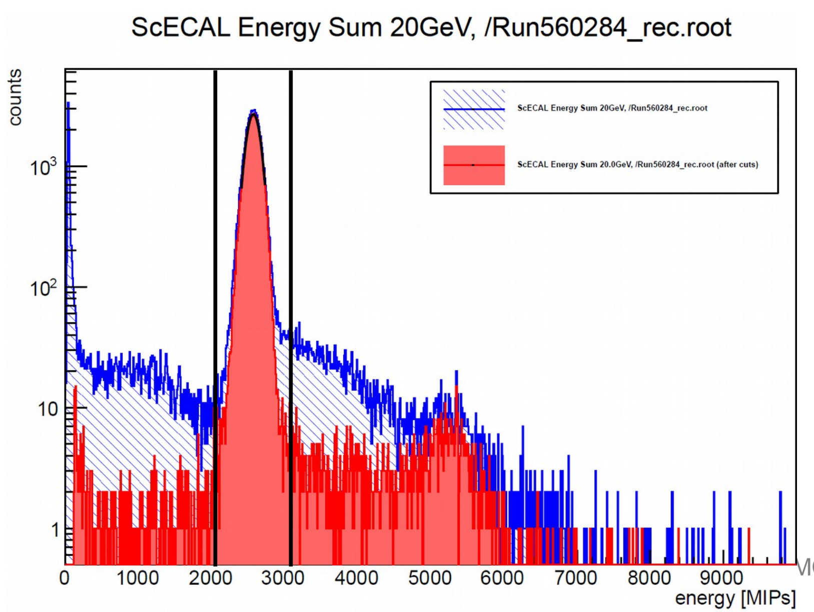
CAN-16 Electron Selection

> Selection

- Shower maximum layer <20 (pion suppression)
- CoGx/y cut (lateral leakage)
- Beam energy dependent cut on deposition in shower maximum
- AHCAL energy cut (pion, muon suppression)
- Efficiency on data typically ~70%
- Efficiency on electron MC >95%







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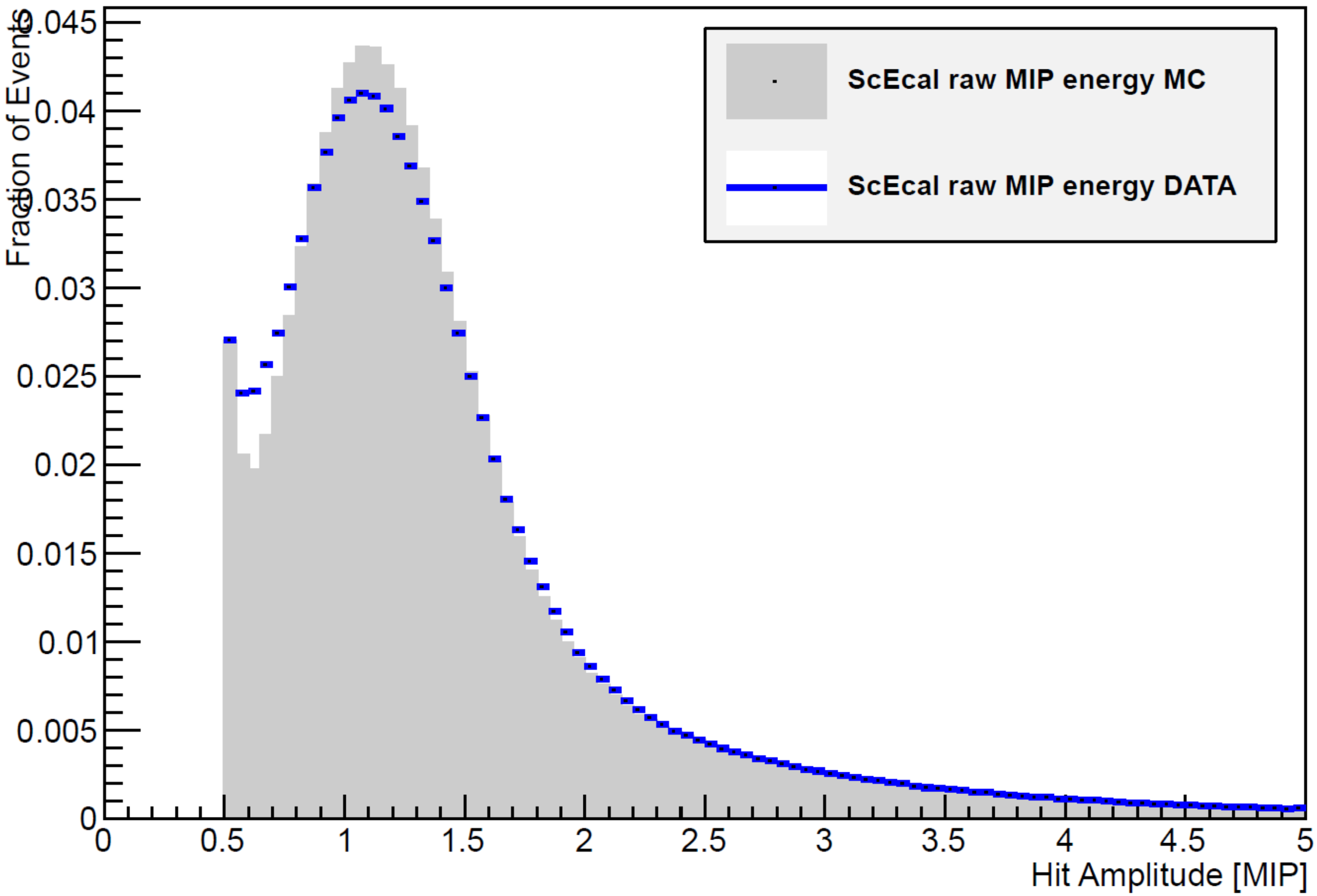
DESY

MIP shape MC/data

> All ScEcal cells, no selection



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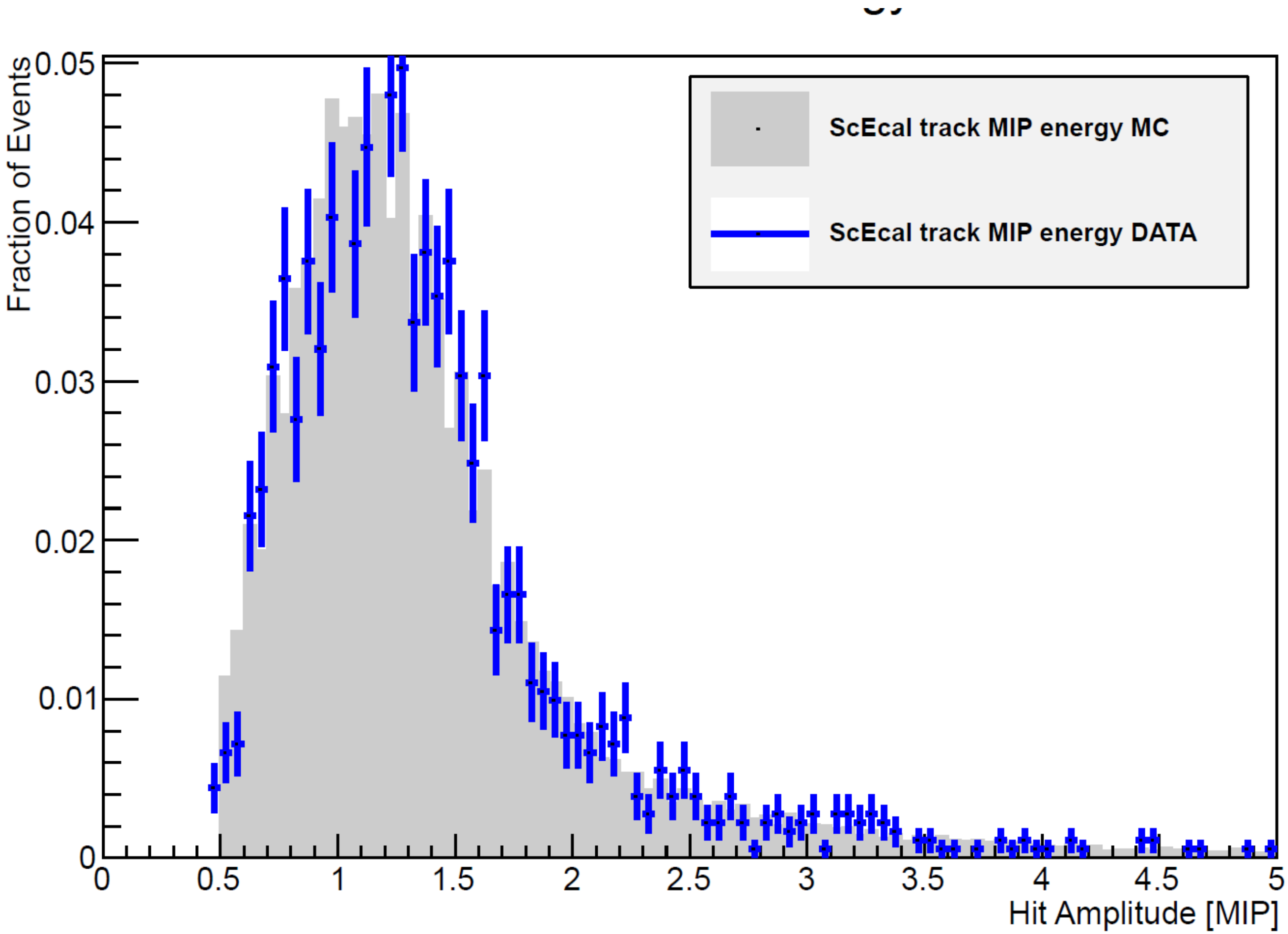
DESY

MIP shape MC/data

> Single central ScEcal cell, only hits on tracks



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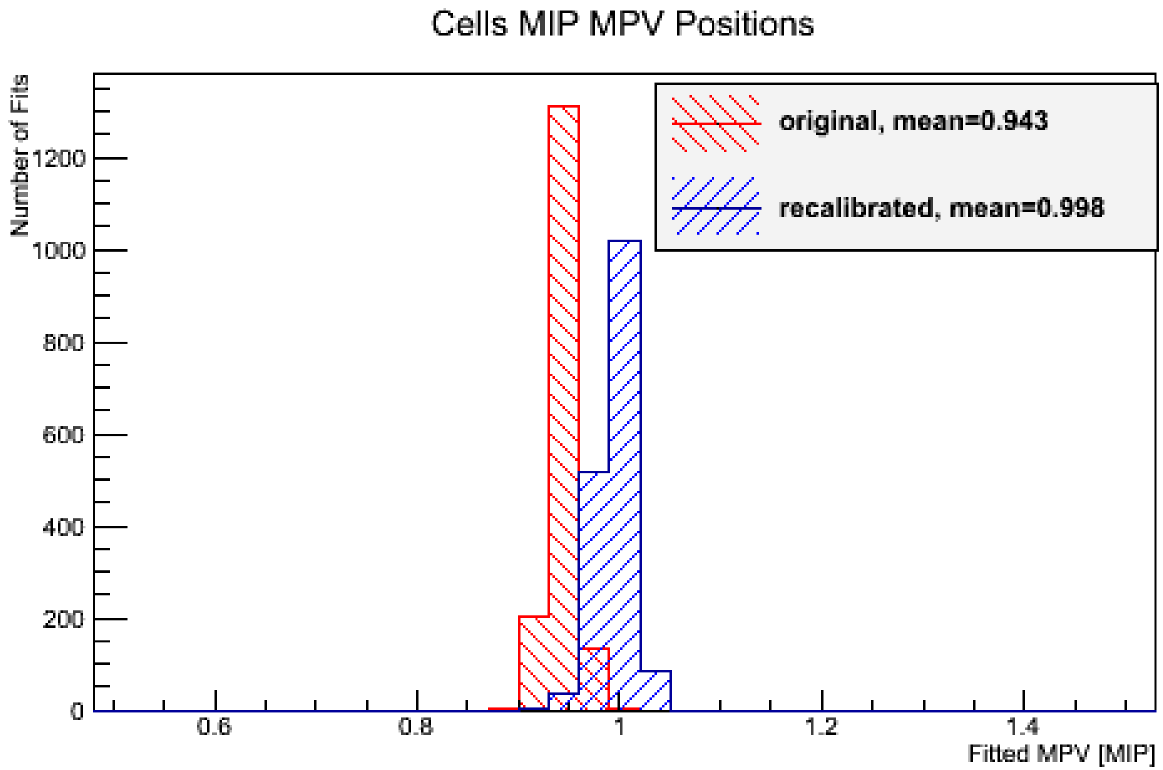
DESY

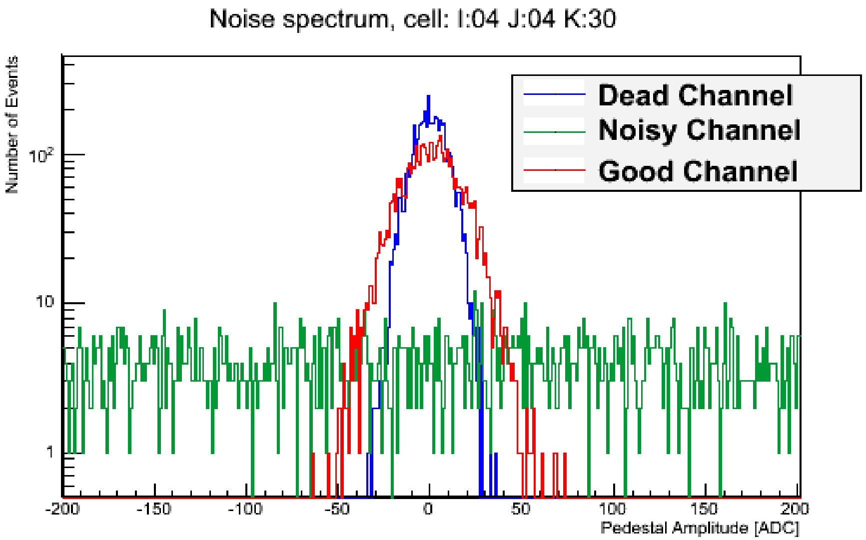
MC MIP distribution

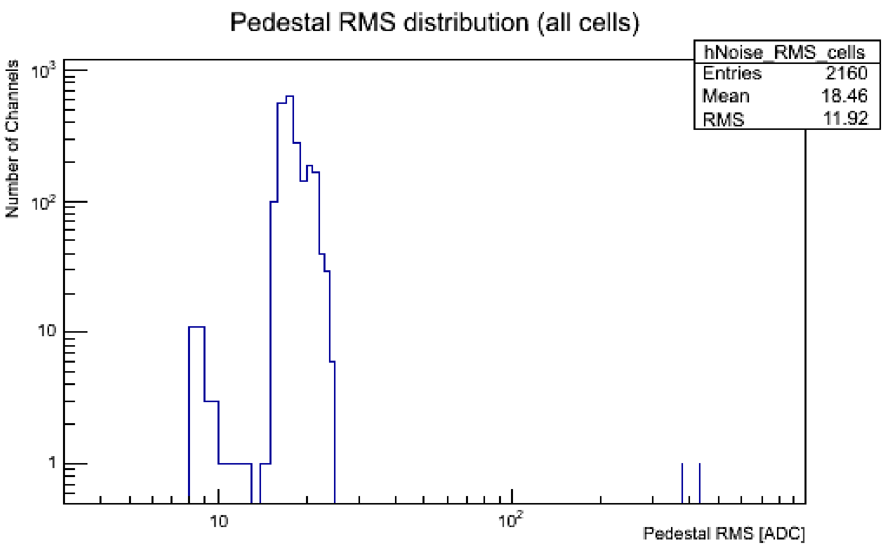
- Run MIP analysis on simulated digitised and reconstructed muon sample
- MIPs peak at ~0.95, retuning of MIP2GeV factor needed
  - MIP peak at ~1 after lowering MIP2GeV by ~5%



Dead/noisy channel treatment

- **>** Dead channel never gives signal
  - Switch off in MC
- **>** Noisy channel gives random signal
  - Switch off in data and MC
- **>** Identify by pedestal width
  - Too narrow pedestal: dead channel
  - Too wide pedestal: noisy channel
- **>** Small number of faulty channels
  - 2-3 noisy channels per run
  - One run with 18 dead channels identified
  - To be written to DB





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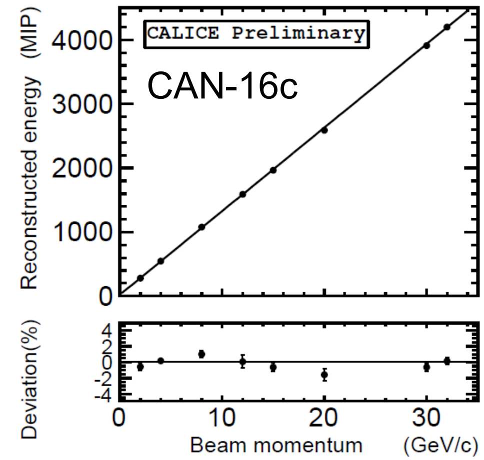
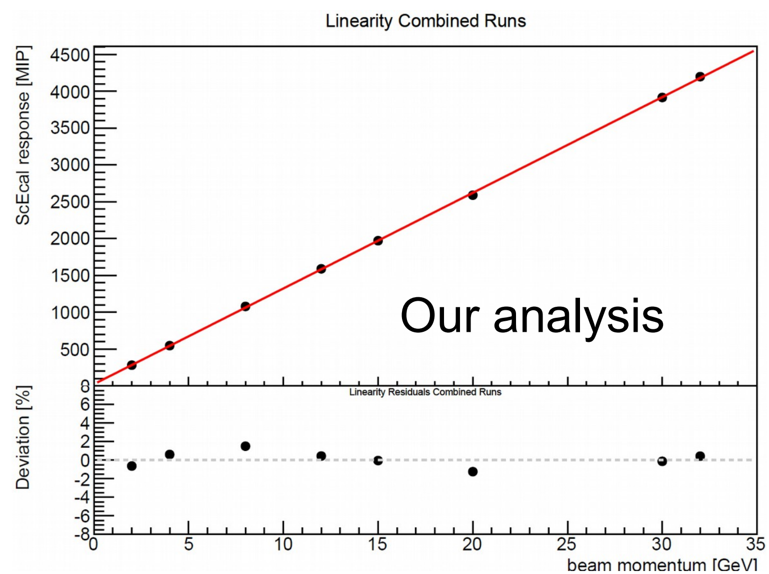
DESY

EM Analysis

- Reimplemented EM Analysis from CAN-16
  - Same runs, cuts, result combination technique
  - Systematics not included
- Comparison our analysis to CAN-16c
  - Identical linearity, deviation <1.8%
  - Very similar resolutions:
    CAN-16c: 12.8%/√E ⊕ 1.14%
    Our analysis: 12.72%/√E ⊕ 1.10%





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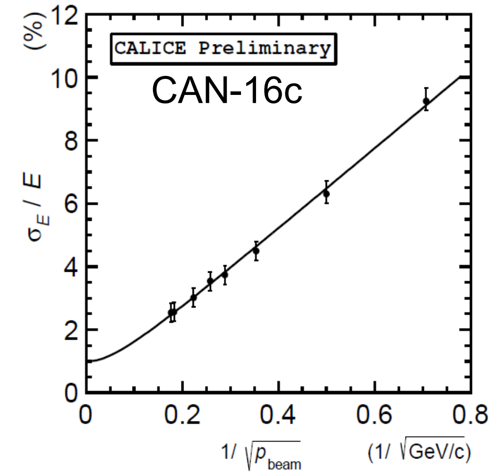

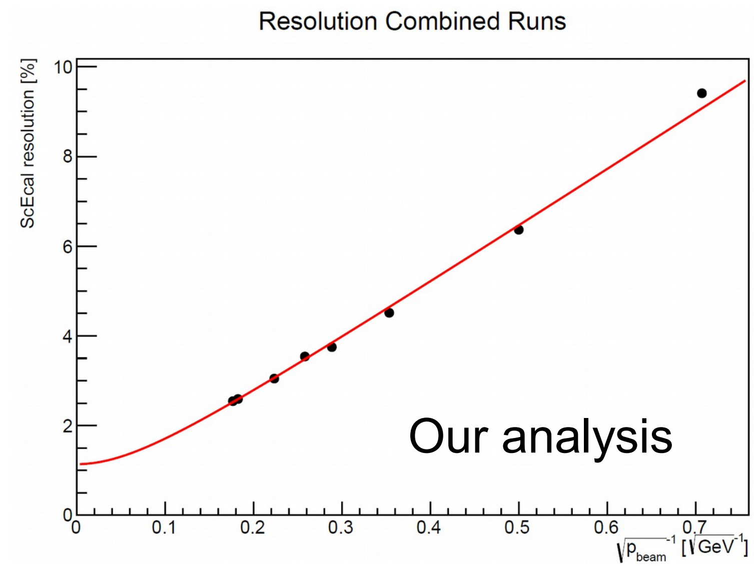

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