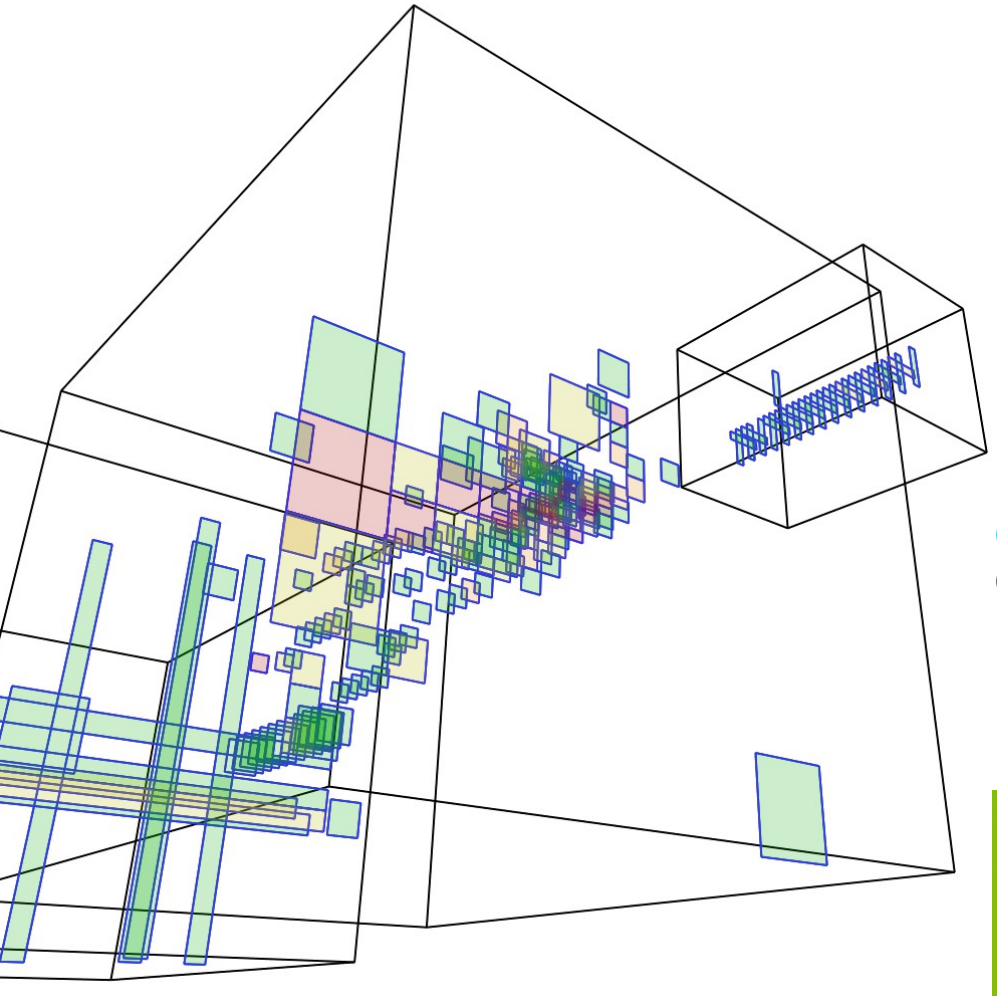
FNAL 2009 Analysis

Run 560498: 12GeV Pi^-



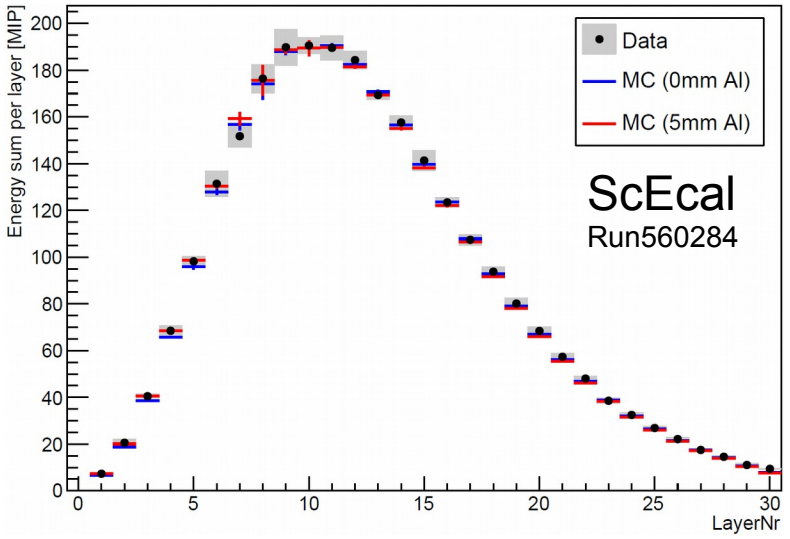
Oskar Hartbrich,
CALICE Meeting
11.09.2015

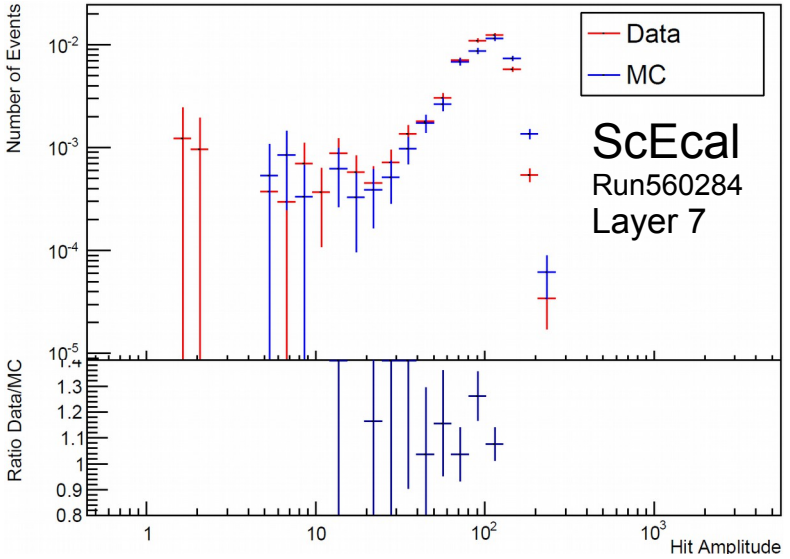
BERGISCHE UNIVERSITÄT WUPPERTAL

DESY

Introduction

- FNAL 2009:
  Combined scintillator calo testbeam
  - AHCAL integrity verified by various publications + crosschecks
  - ScEcal calibration, data quality, MC model less published
- Lots of crosschecks done with EM data
  - Longitudinal profile EM showers
  - Single cell spectra in EM showers
- Single pion energy resolution
  - Try to be as bottom-up as possible
  - First look at resolutions at all
  - Work in progress
- This talk MCs all
  QGSP_BERT in G4 9.6p3

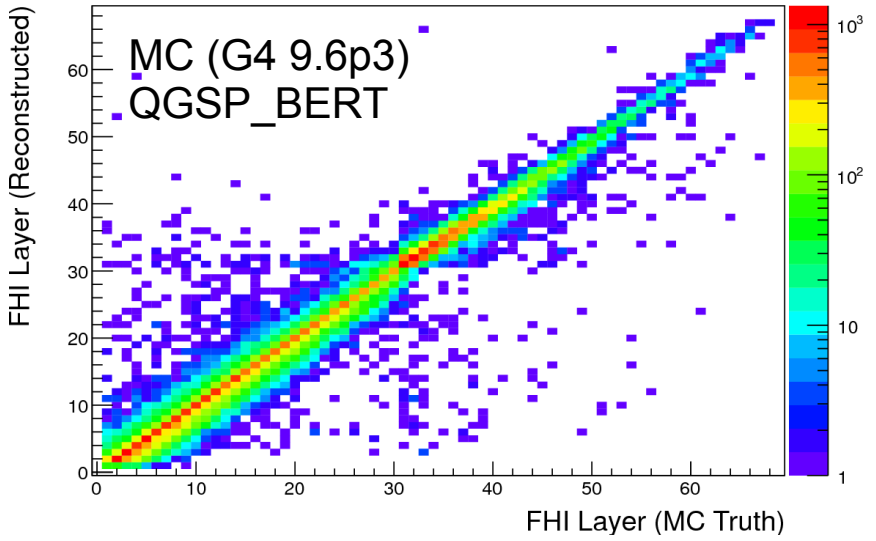


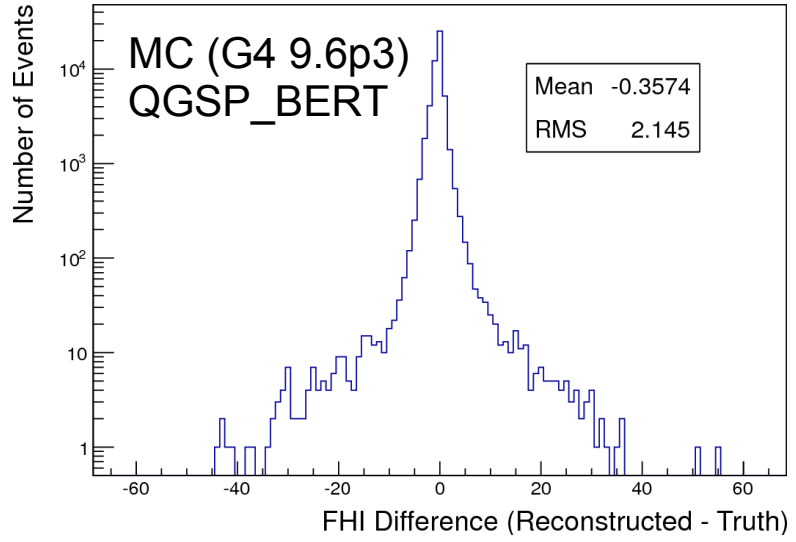


DESY

First Hadron Interaction – Reconstruction

- Based on Marina's FHI Algorithm
  - Unchanged in HCAL
  - Slightly different treatment in ECAL
  - No beam energy dependence in ECAL
- Good correlation truth/reco
- Good reconstruction performance
  - 50% reconstructed layer-perfect
  - 80% reconstructed layer ±1
  - 90% reconstructed layer ±2





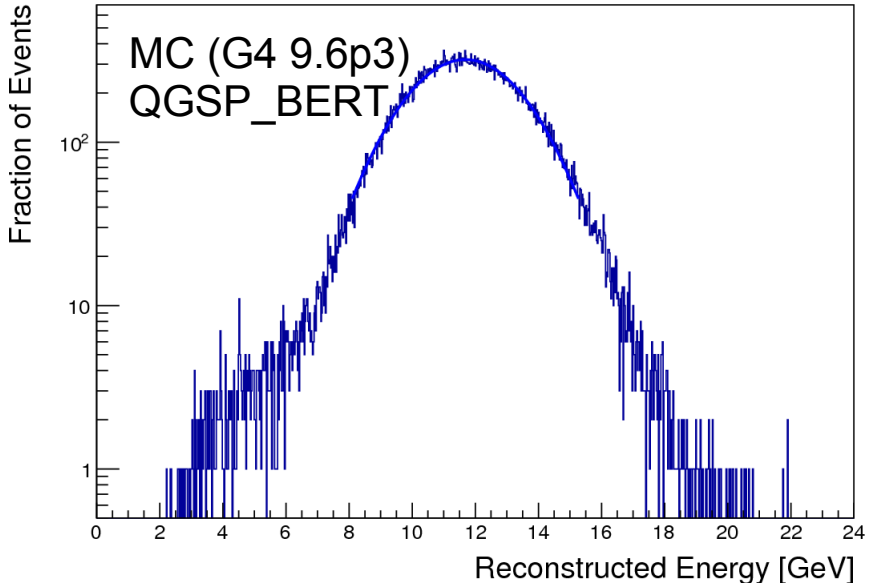
Energy Weights – Chi2 Optimisation

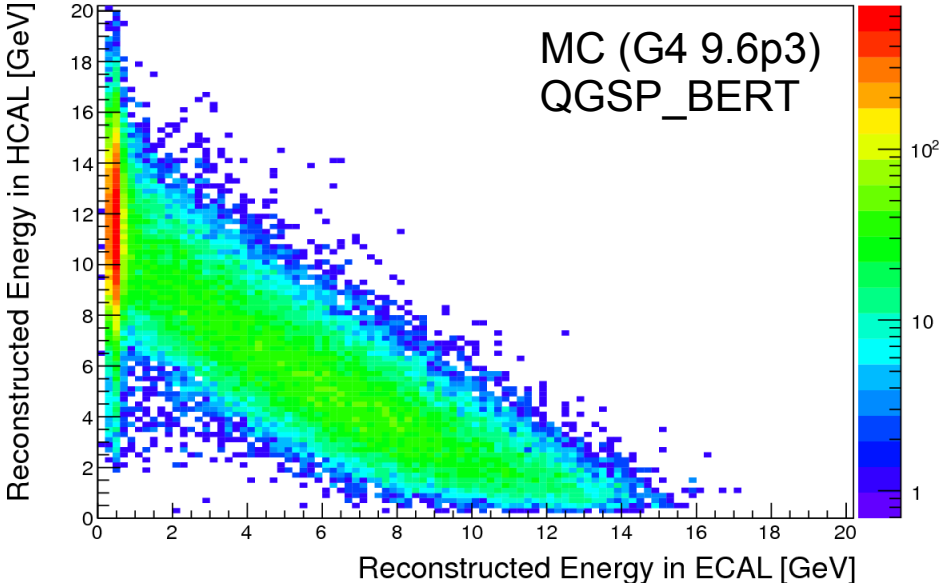
- Need to find proper weights a, b for ECAL/HCAL depositions

$$E_{\mathrm{rec}} = a \times E_{\mathrm{ECAL}} + b \times E_{\mathrm{HCAL}}$$

- Standard approach: Chi2 minimisation

$$\chi^2 = \sum_{\mathrm{events}} \left(E_{\mathrm{rec}}(a,b) - E_{\mathrm{beam}}\right)^2$$



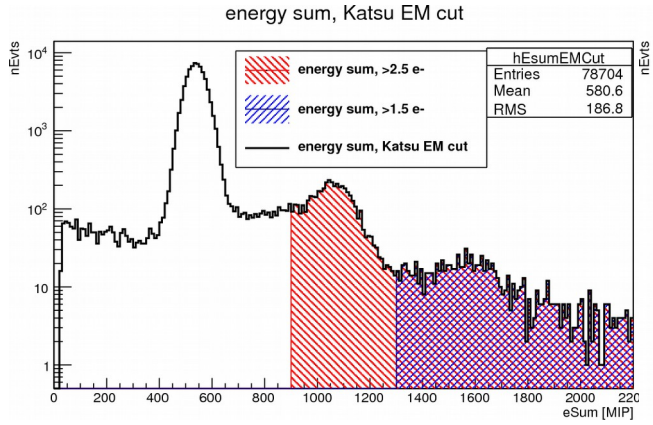


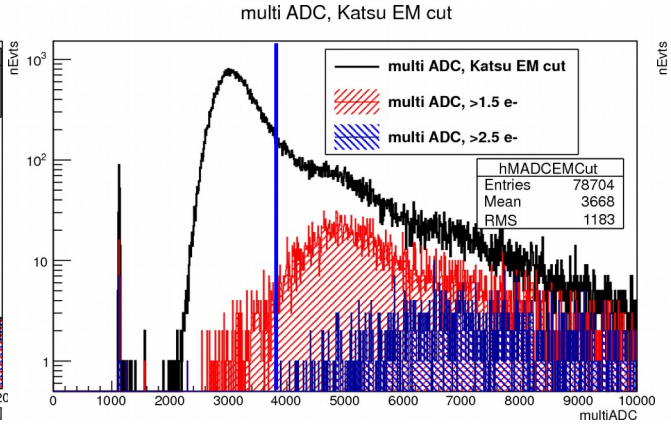
Event Selection

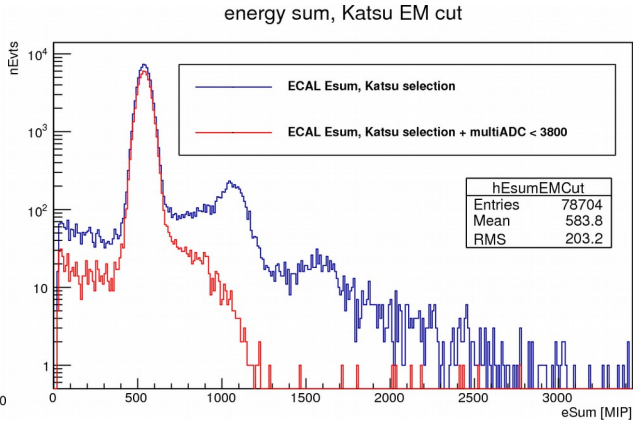
- Generally taken from Clemens'/Nils' Theses
  - Did not include any ECAL, only general selection applicable
- Beam quality cuts (data only)
  - Trigger scintillators
  - Multiplicity counter
- Pion selection cuts
  - Cherenkov counter (data only)
  - Muon rejection (single long track in HCAL)
  - Empty event rejection
  - Preshower/electron rejection: FHI layer cut
- Multi particle suppression
  - Clemens' cuts not (immediately) applicable
  - Needed?

Multi Particle Rejection – Multiplicity Counter

- Multiplicity counter: Scintillator paddle with 16bit readout
  - Only covers central 20x20cm^2
- Use 4GeV electron run
  - Can select 1-, 2-, 3-electron events from E_{sum}
  - Separation of multi particle contributions in multiplicity counter spectrum
- Significant contamination left
  - Try other ways (Clemens: cluster parameters)

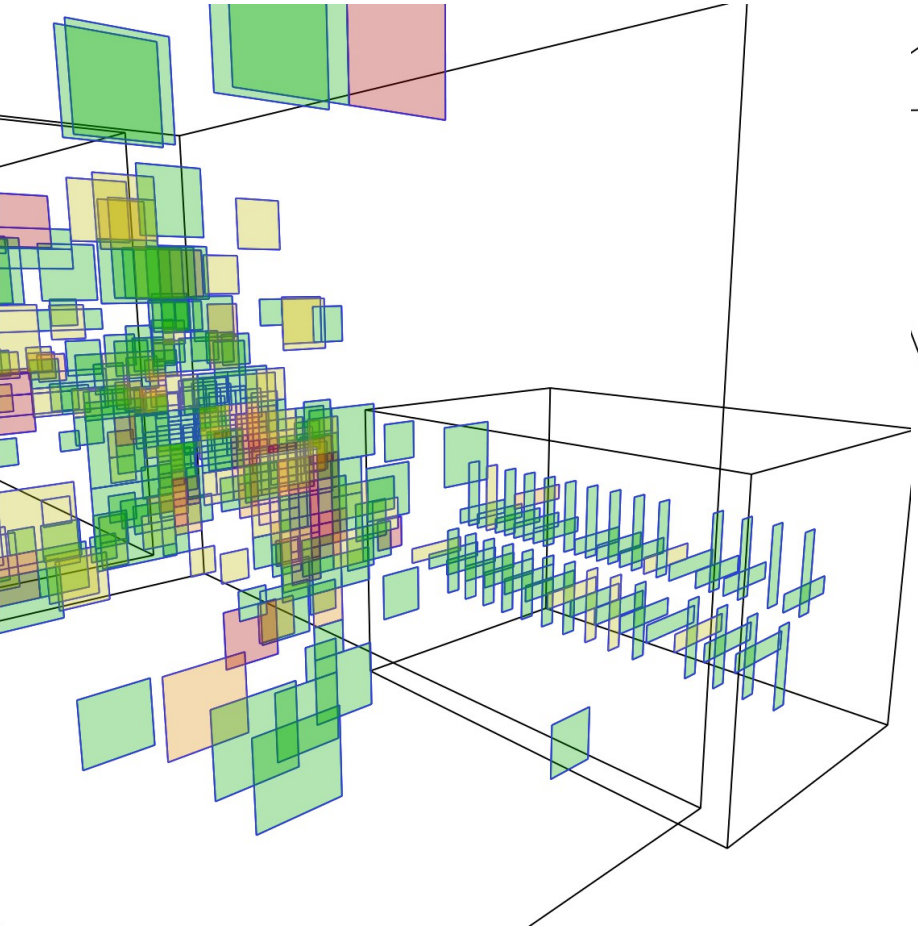


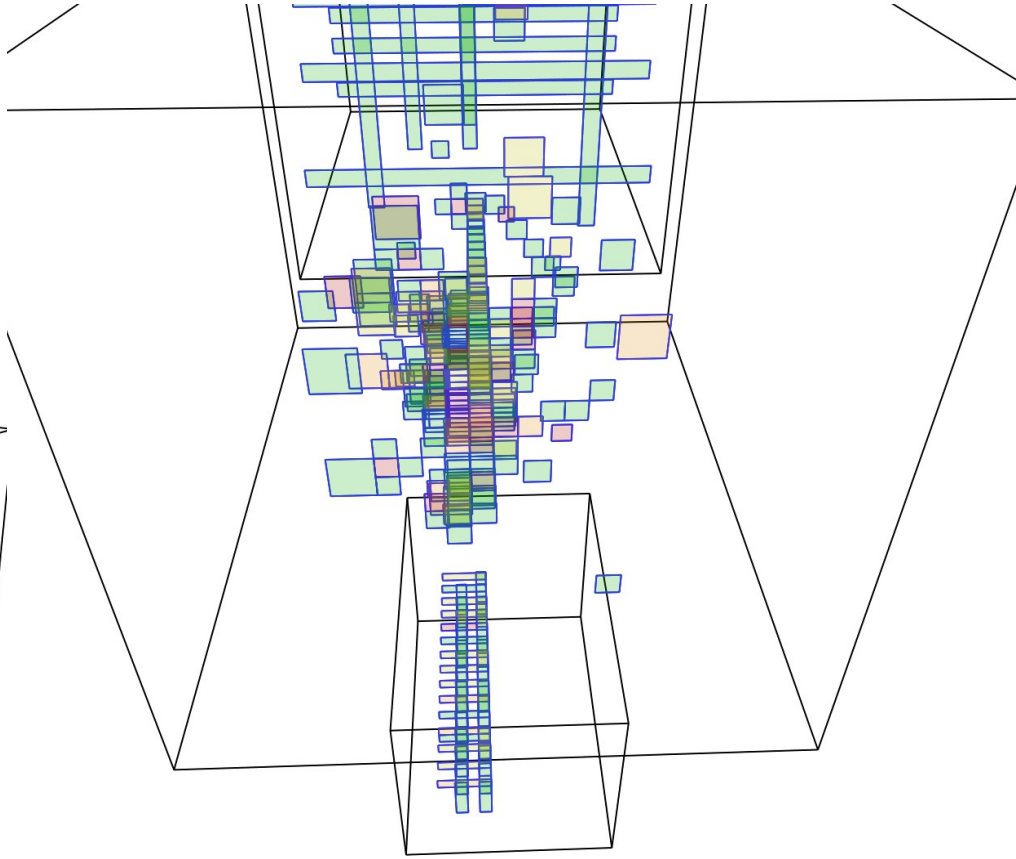




Multi Particle Rejection – Event Displays

- Events in top 1% E_{rec}





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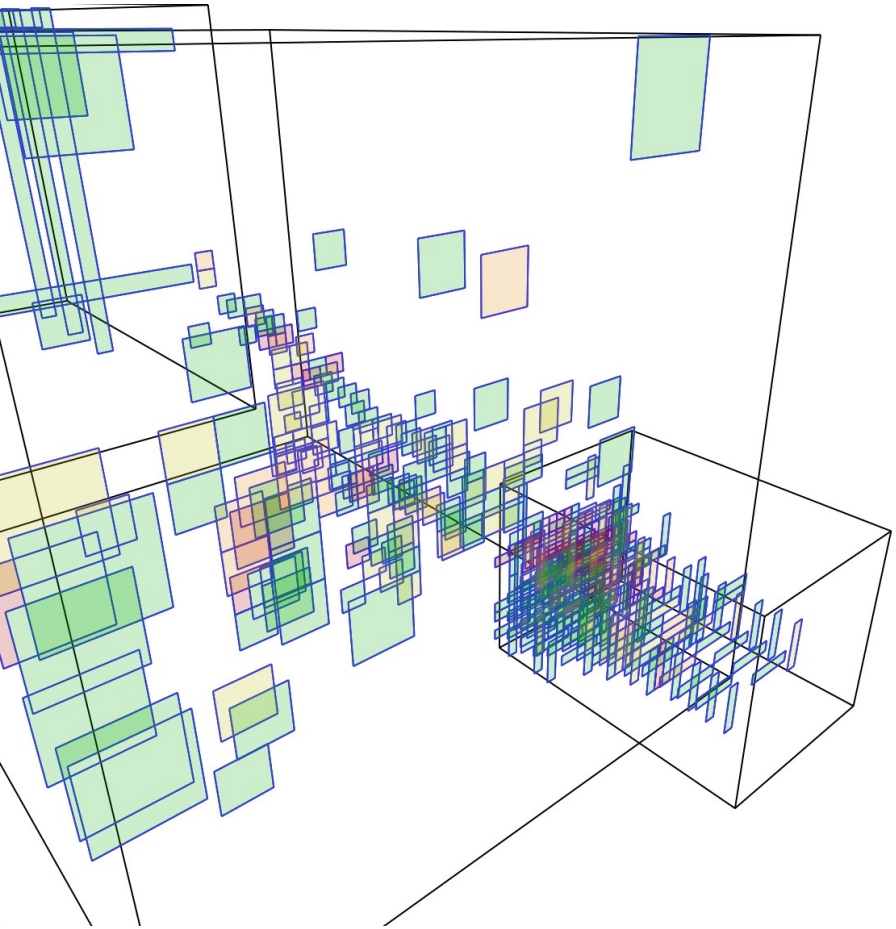
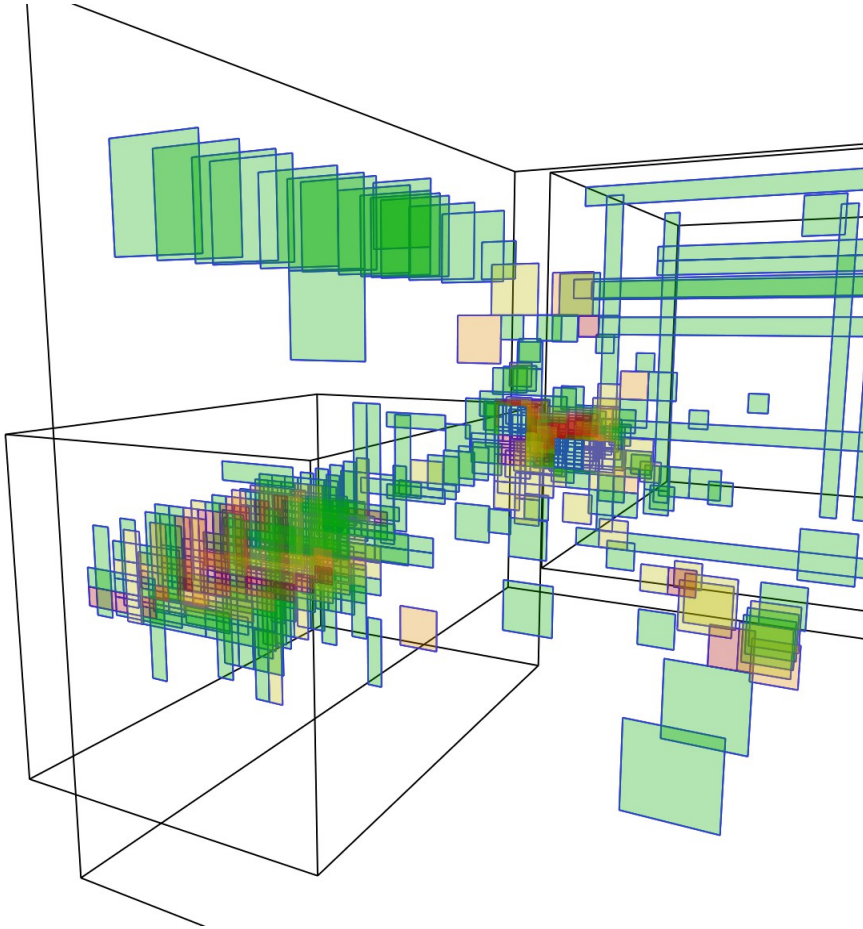
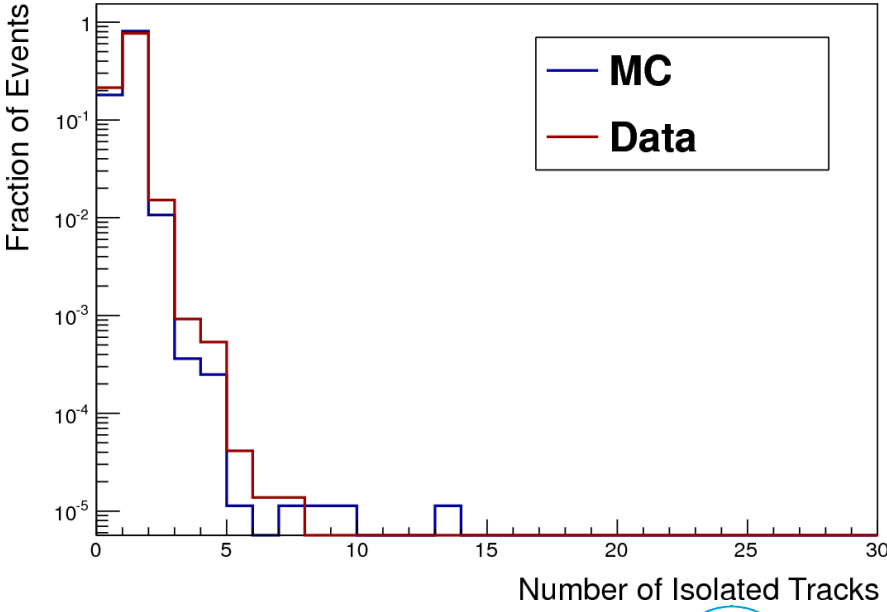




Multi Particle Rejection – Cuts

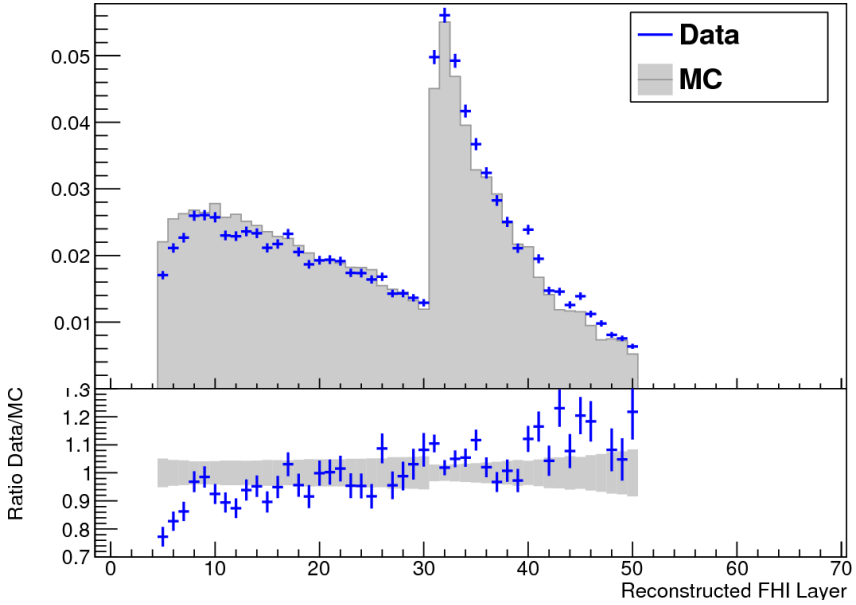
- Multiple particles in ScEcal: Find their primary tracks
- Reconstruct all tracks from overlapping strips
  - Require isolation, hit efficiency, starting from beginning of ECAL etc.
- Select events with exactly one isolated track in ECAL
  - Efficiency in MC: 93%, data: 87%. (Resolution bias in MC <0.1%)
- Reject events with beam-parallel tracks in outer HCAL
  - Efficiency MC: 92%, data: 88%. (Resolution bias in MC <0.1%)
- Apply selection, check event display: No obvious multi particle events left

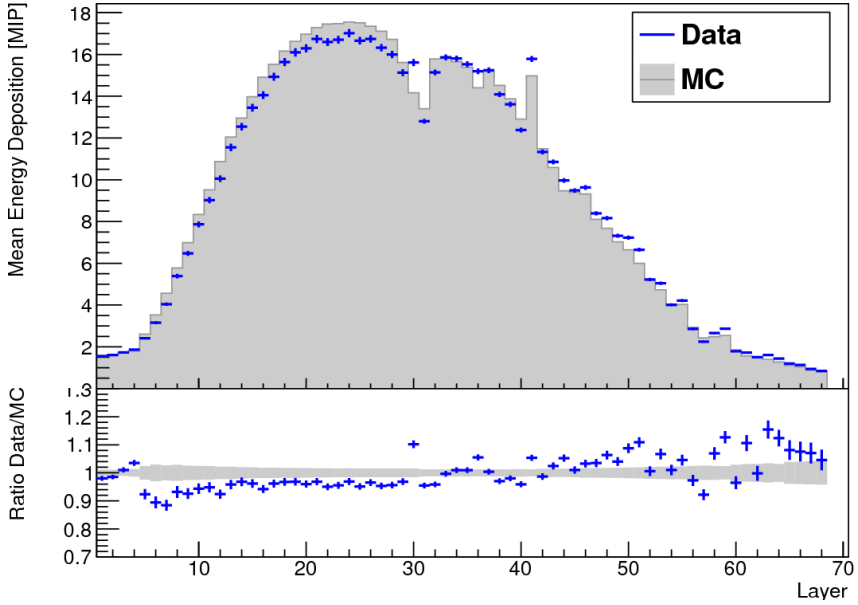


DESY

Profiles MC vs. Data

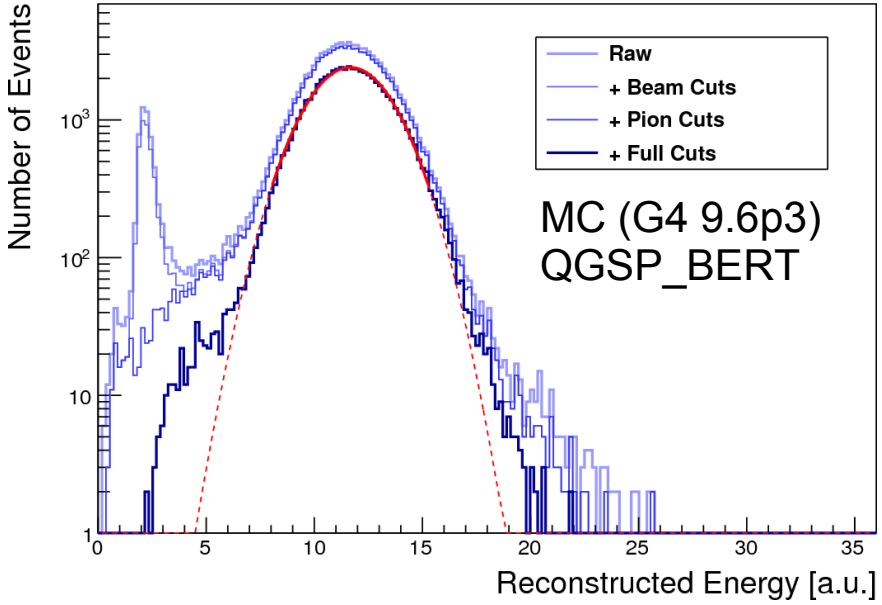
- Reconstructed FHI layer looks ok
  - Slight FHI overestimation in ScEcal
  - Dip in first layers from isolated track criterium
- Longitudinal shower profile
  - Consistent 5% MC overestimation in ScEcal

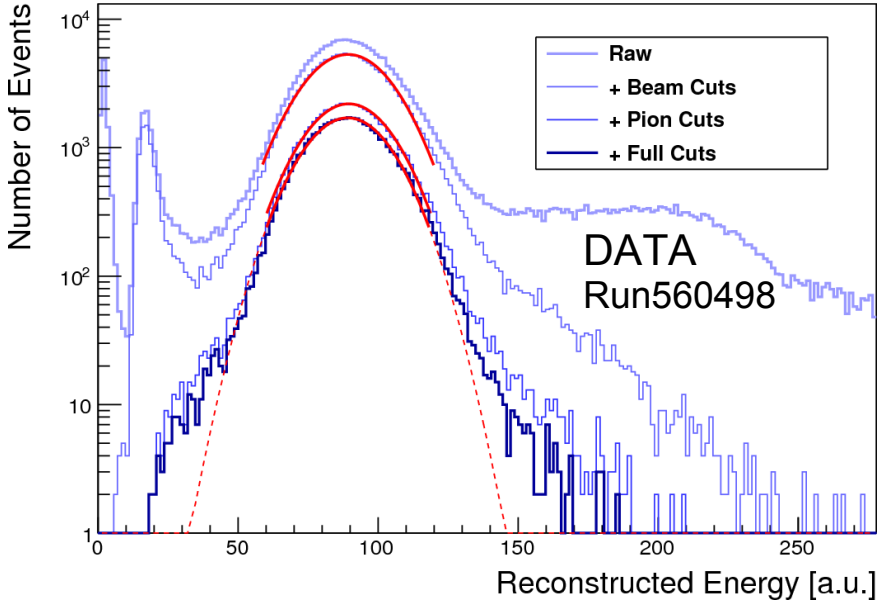




FNAL Pion Selection & Resolution

- Multi particle cuts slighly reduce high energy tail in data
- Chi^2 optimised energy weights very similar in MC and data
- Preliminary energy resolution 12 GeV Pi$^-$:
  - Full selection: MC: 15.6% Data: 16.4%
  - FHI in HCAL: MC: 16.4% Data: 16.5%





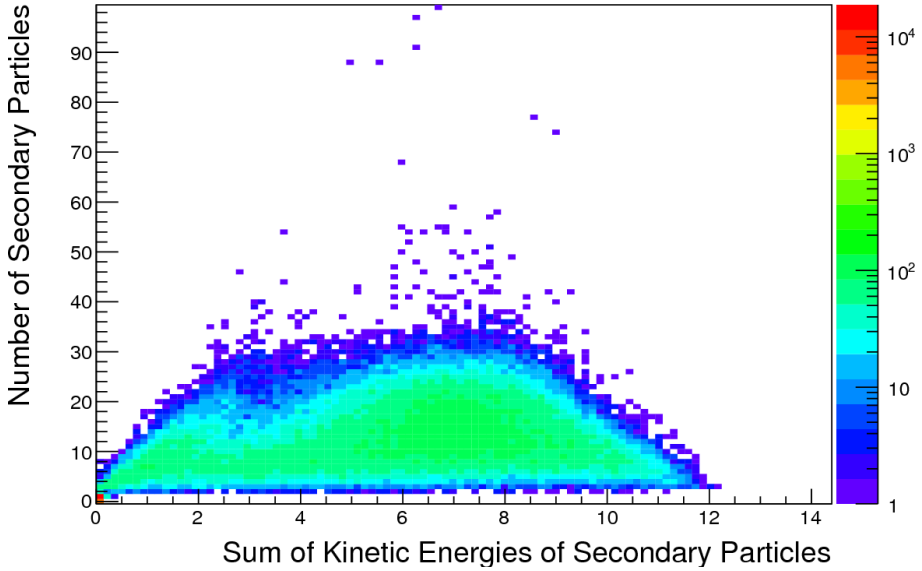
Summary

- FHI reconstruction works for combined system
  - Good correlation and error vs. MC truth
  - Acceptable in MC vs. data
- Event selection works
  - From Clemens/Nils
  - Current multi particle suppression cuts work ok, but can be improved in efficiency
- Energy Resolutions MC vs. data acceptable for current status
  - Switch to G4 10.x, try different physics lists
  - Longitudinal profile → ScECAL absorber, calibration
  - Remnants from beam impurities → Higher energy runs
- Response, other runs, systematics … lots to do

Backup

First Hadron Interaction – MC Truth

- Definition of MC truth not straightforward
  - Quasi inelastic interactions
  - Weird G4 behaviour



Final definition of "true" FHI:

- Remove leading pion from step
  - Look at all (including primary) pions in step
  - Project each pion momentum to previous step's primary pion
  - Remove pion with highest projected momentum
- Sum up kinetic energies of remaining secondaries
- Accept event if sum(E_{kin})>E_{beam}/3

Energy Weights – Chi2 Optimisation

- Need to find proper weights a, b for ECAL/HCAL depositions

$$E_{\mathrm{rec}} = a \times E_{\mathrm{ECAL}} + b \times E_{\mathrm{HCAL}}$$

- Standard approach: Chi2 minimisation

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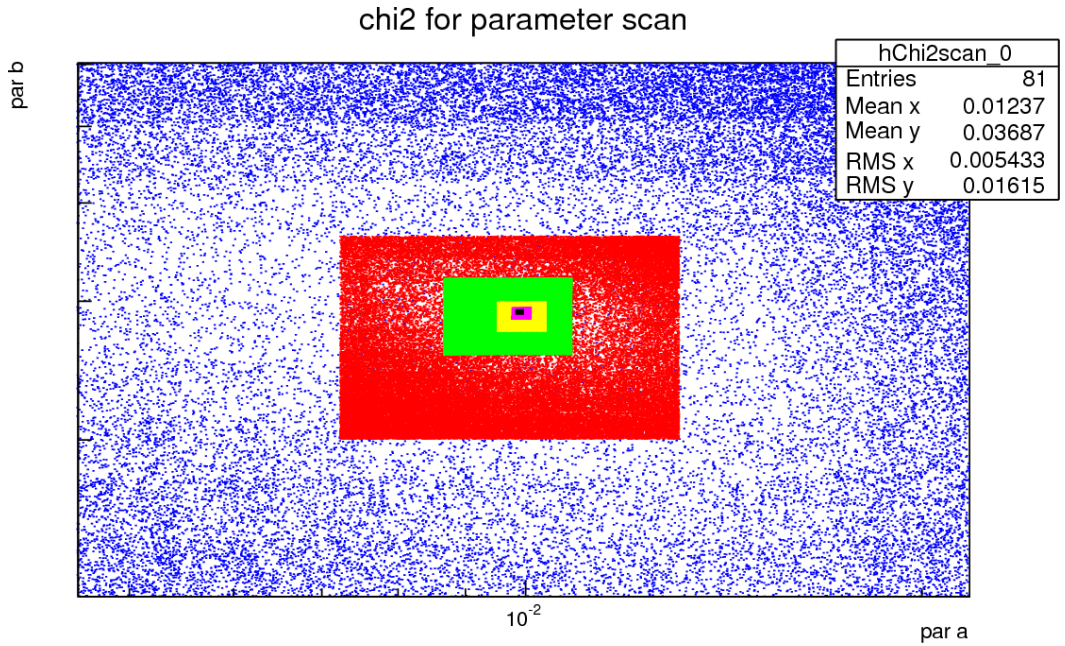
  - Use iterative parameter scan
  - (Better: Minuit)

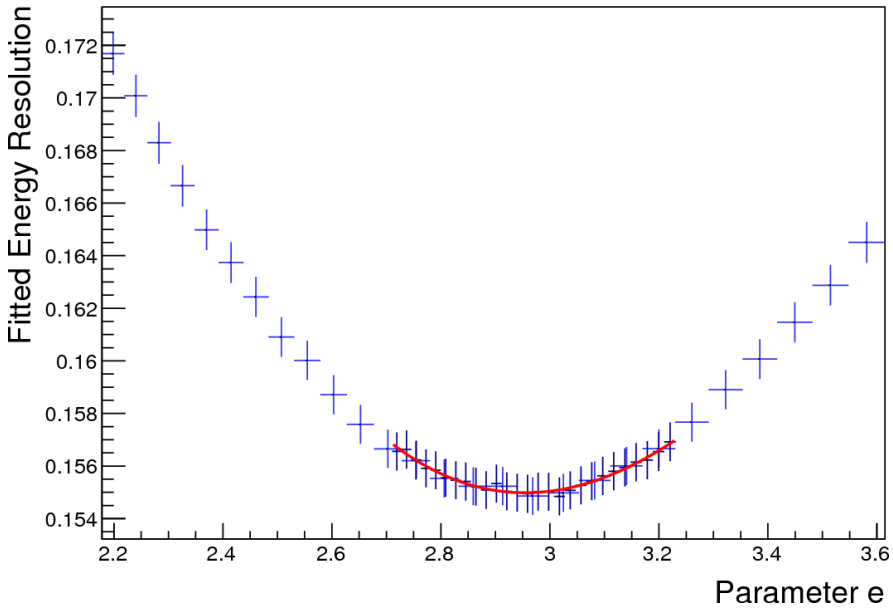


Energy Weights – Fit Resolution Optimisation

- Different approach: Optimise fitted energy resolution
  - Rewrite E_{rec} to two linear independent variables

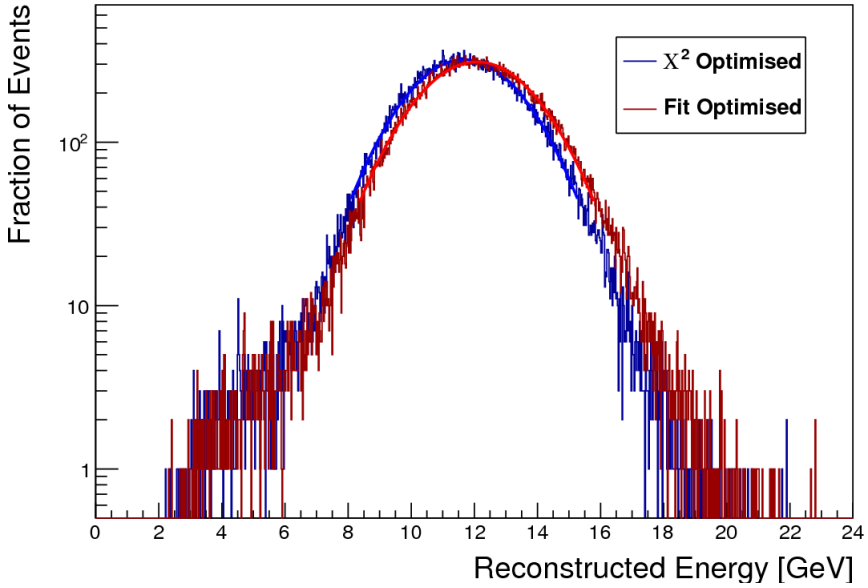
$$E_{\mathrm{rec}} = s \times \left({}^{1}/_{e} \times E_{\mathrm{ECAL}} + E_{\mathrm{HCAL}} \right)$$

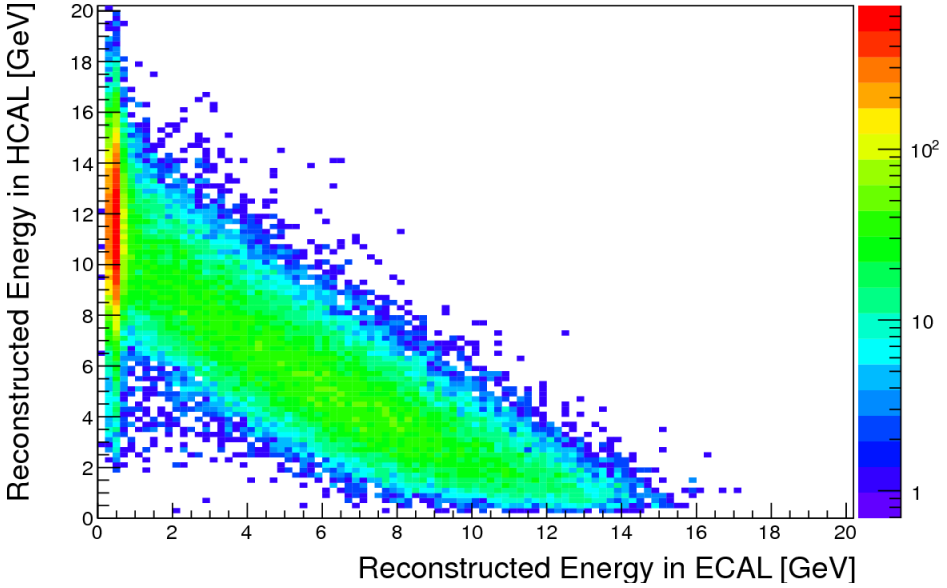
  - Optimise e, then choose s that $E_{rec} = E_{beam}$
- Iterative scanning
  - Less stable than Chi2 approach
  - logParabola fit
  - Better: Minuit



Energy Reconstruction

- Similar resolution for both approaches
  - <0.1% absolute resolution difference
- Chi2 optimised response 11.6GeV
  - Why?
  - Fit optimised response 12.0GeV by construction





Multi Particle Rejection – Cuts