Particle Flow and Forward Calorimeter Performance for the CLIC Detector

André Sailer
On Behalf of the CLICdp Collaboration

CERN-EP-LCD

LCWS 2017
Strasbourg
October 25, 2017

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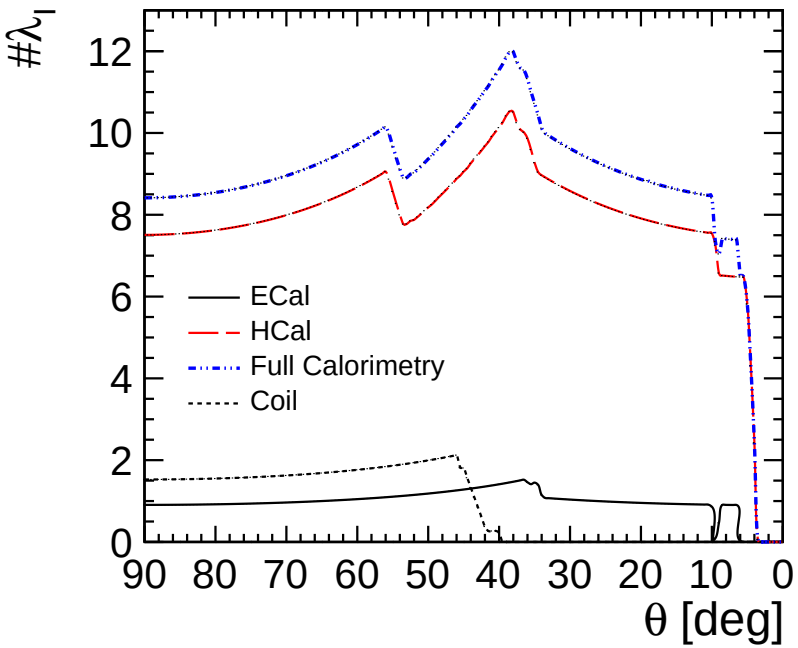
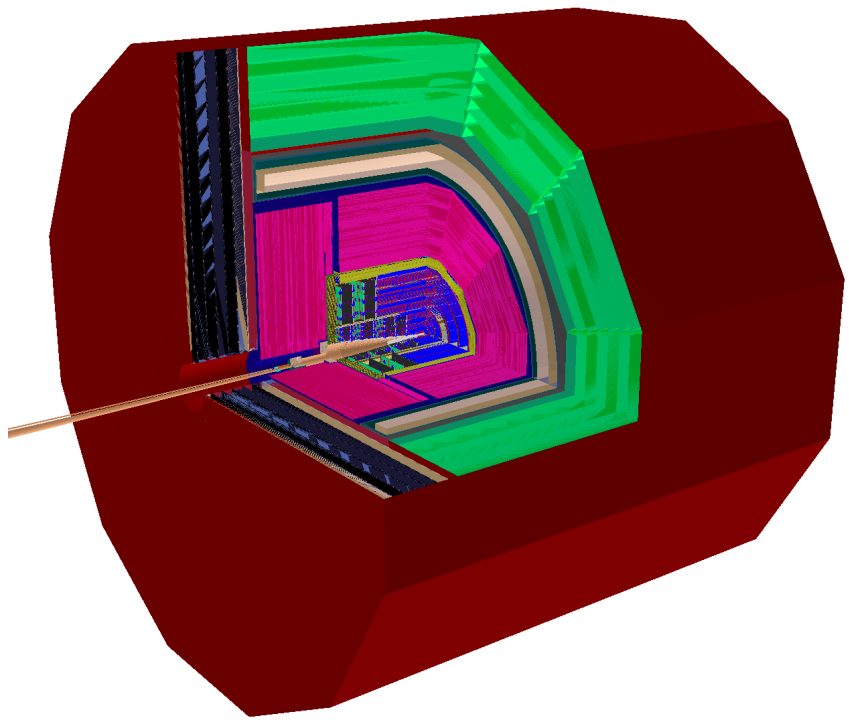
Calorimeter Parameter

- ECal: silicon/tungsten (1.9 mm)
- HCal: scintillator/steel (≈2 cm)
- LumiCal/BeamCal: 3.5 mm tungsten
- **CLICdp-Note-2017-001**

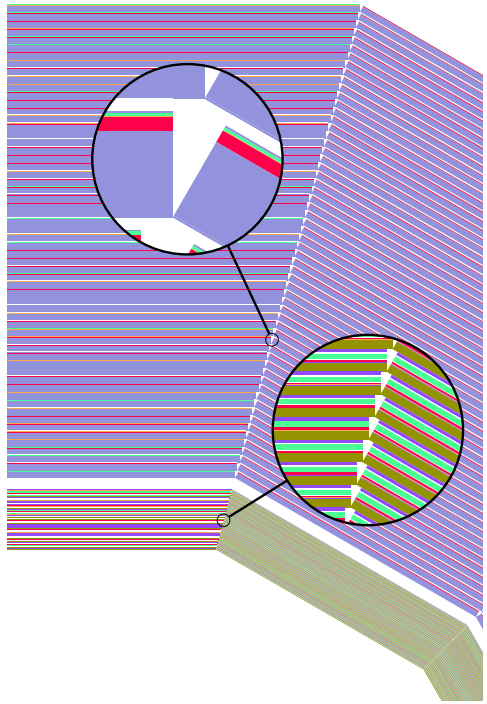
	R_{min}	R_{max}	Z_{min}	Z_{max}	N_{layers}
ECal Barrel	1500	1702		2210	40
ECal Endcap+Plug	260	1700	2307	2509	40
HCal Barrel	1740	3330		2210	60
HCal Endcap	250	3246	2539	4129	60
LumiCal	100	340	2539	2710	40
BeamCal	32	150	3181	3441	40

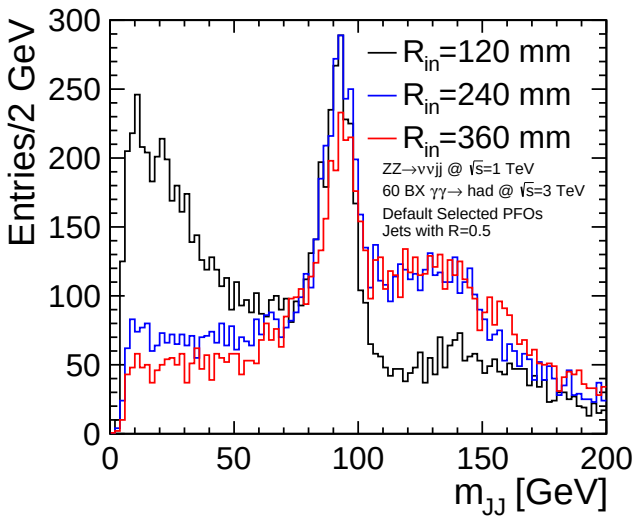


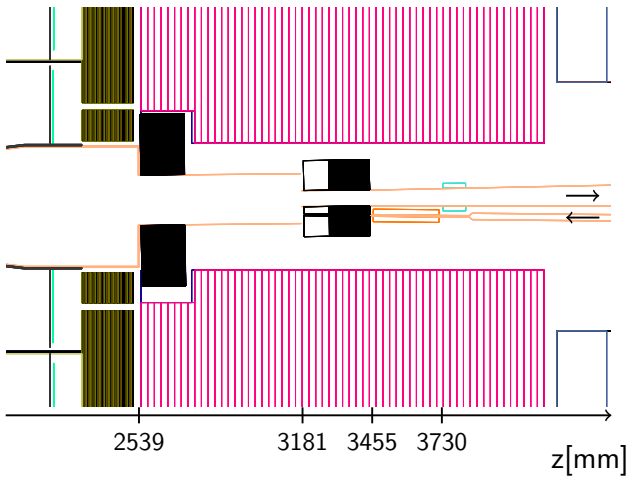


Calorimeter Shapes

- ECal/HCal: regular 12 sided polygons
- Overlap of the LumiCal and ECal endcap plug
- Cutout in the HCal for smaller HCal Endcap inner radius to increase coverage and decrease transverse leakage
  - Too small radii get overwhelmed by $\gamma\gamma \rightarrow$ hadron backgrounds





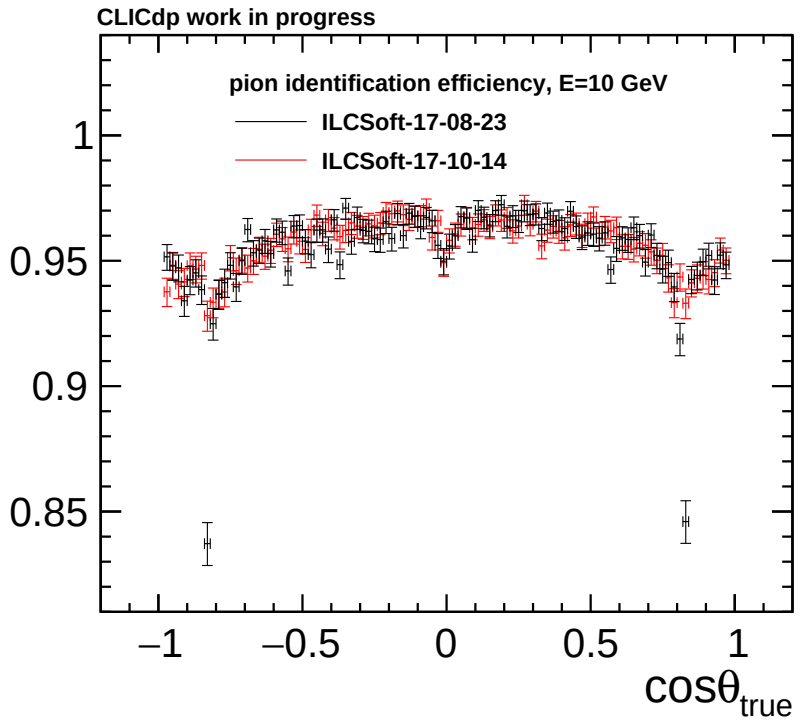


Current Status of Performance

- Focus on on-going studies and recently solved problems
- Comprehensive CLICdp note on all aspects of detector performance is being written

Track Cluster Matching

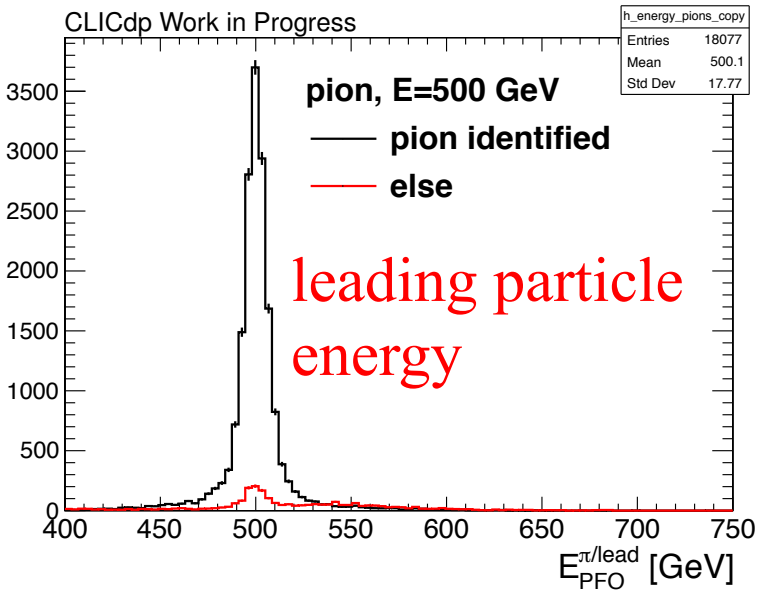
- Track–Cluster matching in PANDORAPFA based on track-state position and shower centre
- Lower efficiency at the barrel/endcap transition region, dependent on the calculated distance of the shower to the track-state on the barrel surface
  - Increasing the maximal allowed distance recovered efficiency
- Proper Fix:
  - `LCTrack` class in PANDORAPFA to hold multiple track states, check cluster position against all track-states
  - DDMARLINPANDORA fill track-state at calorimeter barrel and endcap if the track-state in the endcap would be above the inner radius of the ECal barrel



10 GeV charged pion reconstruction efficiency against polar angle

High Energy Cluster Reconstruction

- **500 GeV charged pions are generally well reconstructed (energy from track), but additional PFO is created**
- Total reconstructed energy with long tail to higher energies. Energy flow like behaviour of PANDORAPFA
- Total cluster energy overestimated
- Calibrating at 500 GeV removes superfluous cluster creation



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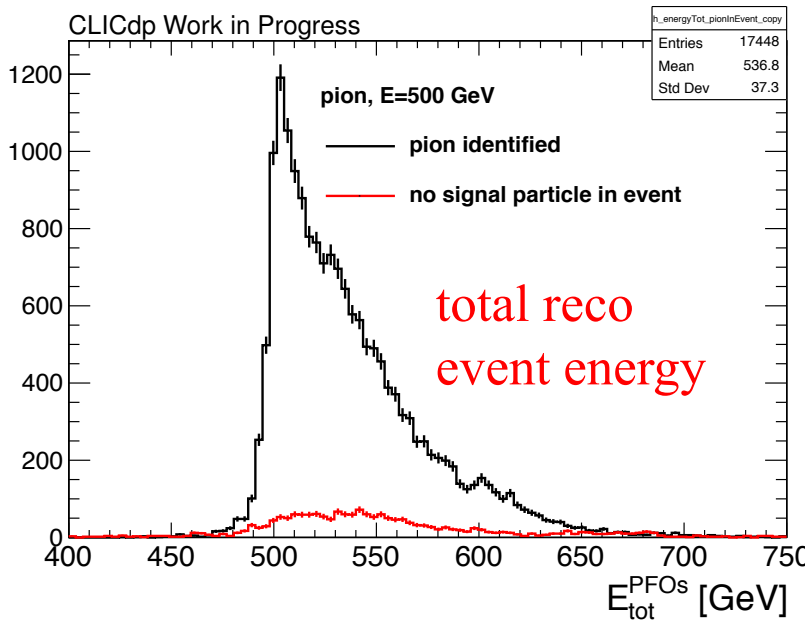

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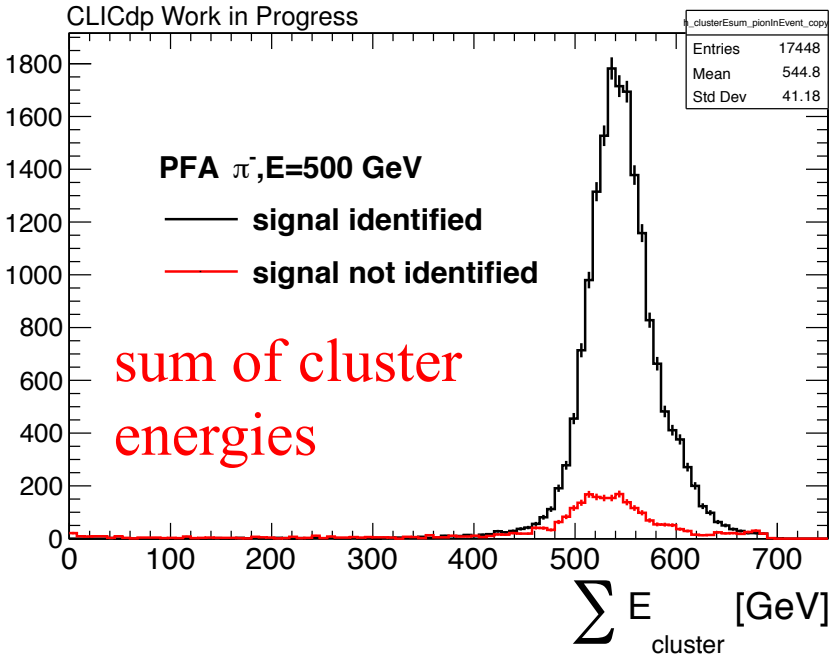

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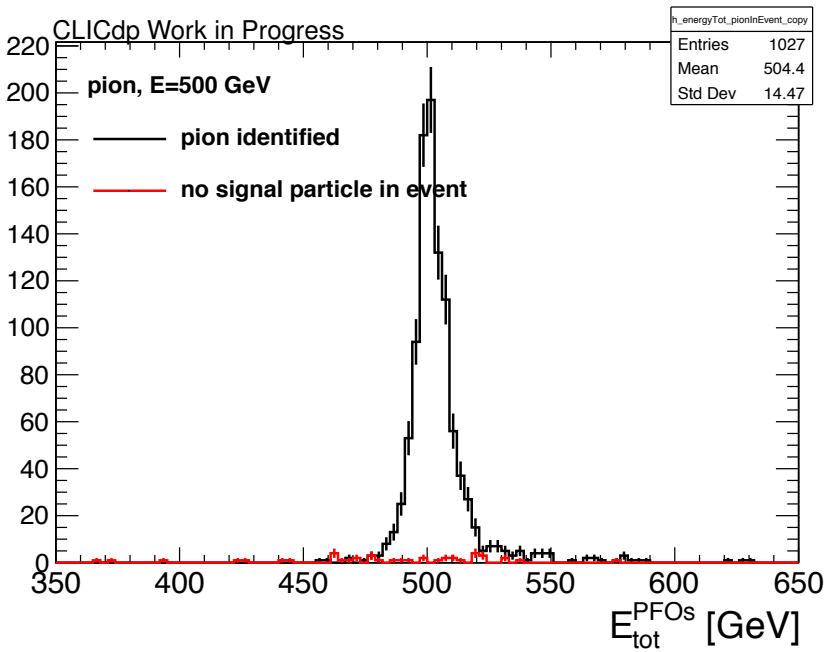

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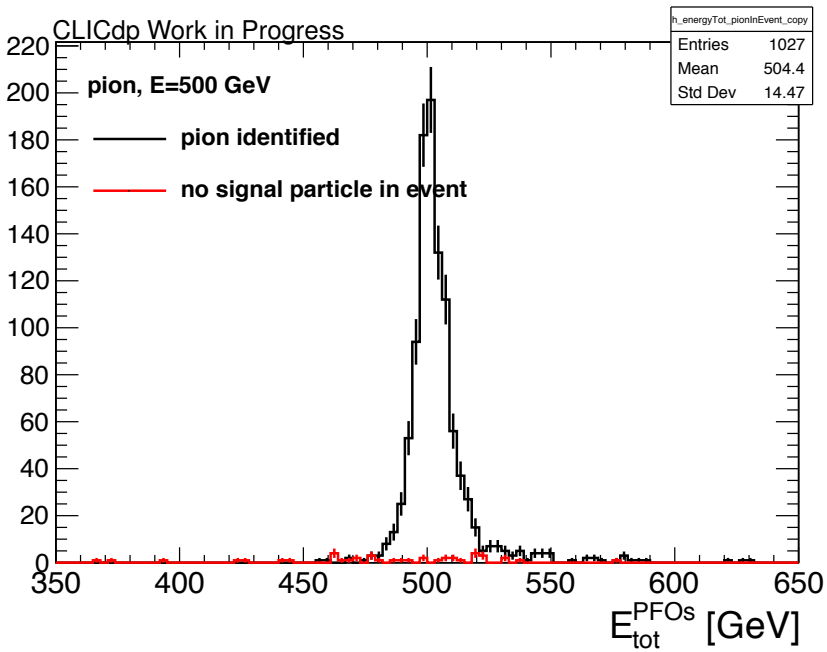
- Calibrating at 500 GeV removes superfluous cluster creation
- **Need non-linearity correction**

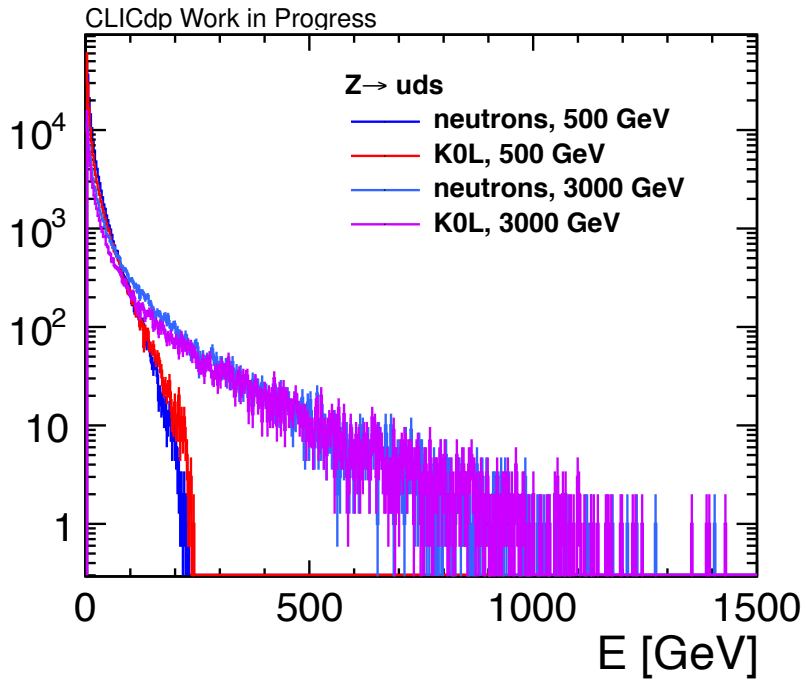


Software Compensation at CLIC Energies

Initial parameters and bins for weighting function do not cover sufficient energy range. By default

- Only applied for hadrons up to 100 GeV
- Highest weighting bin: 30 GeV/dm^3

Increase number of energy samples and extend binning for parameter extraction



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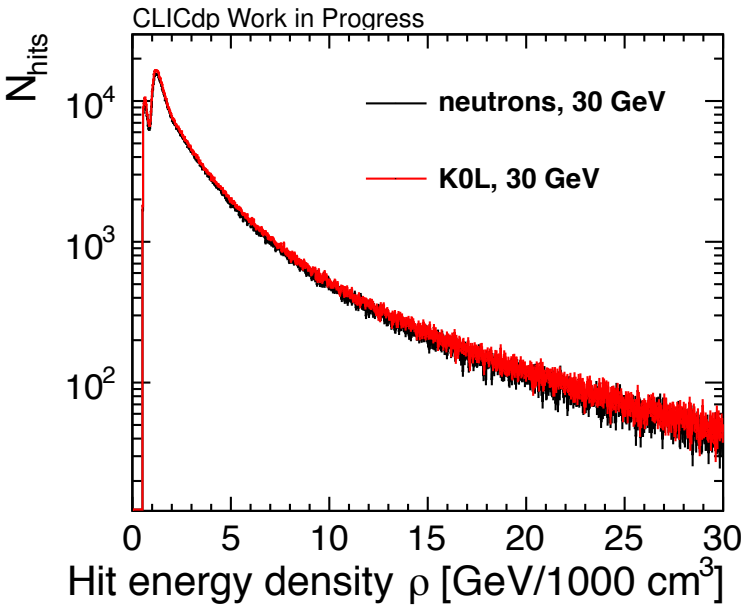

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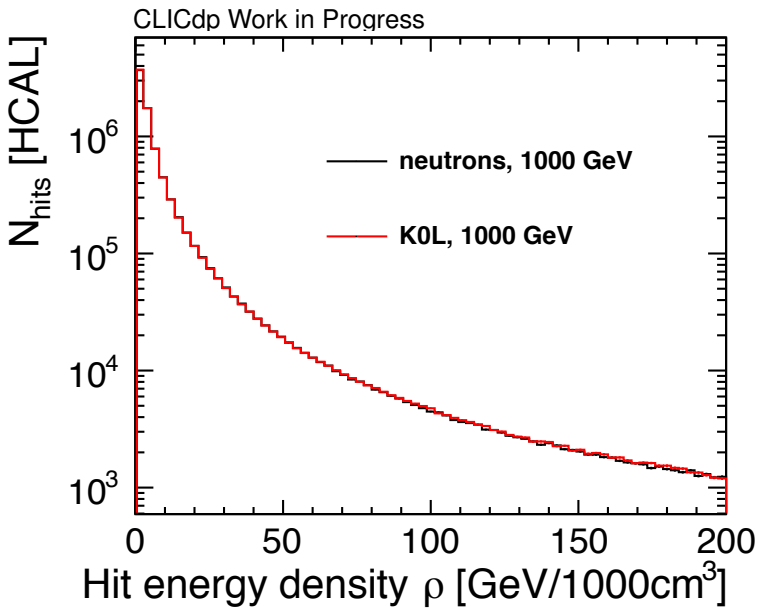

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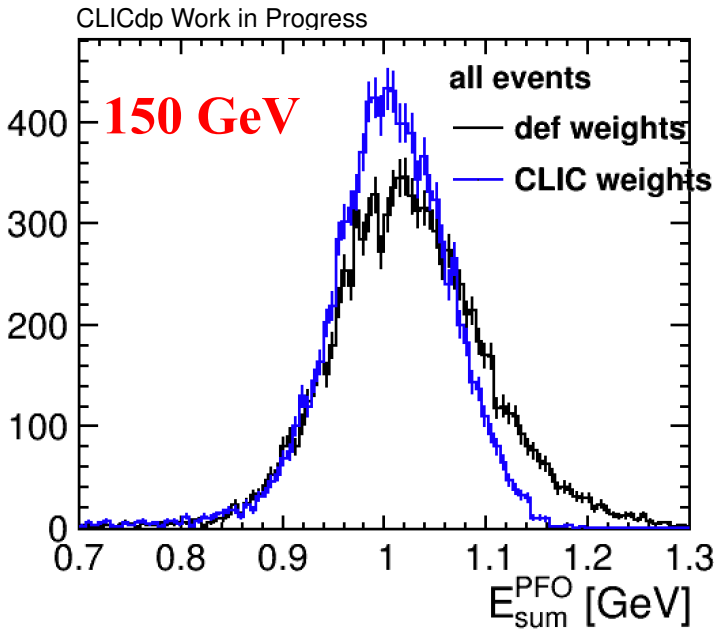
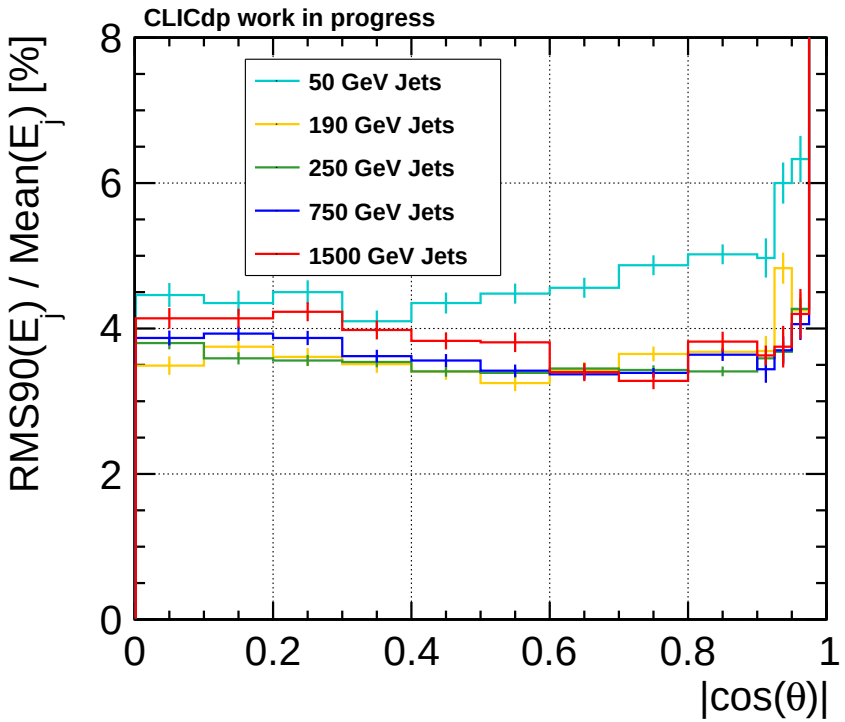


Jet Energy Resolution

- Applying software compensation improves jet energy resolutions compared to hadronic energy truncation
- Offers some non-linearity correction as well

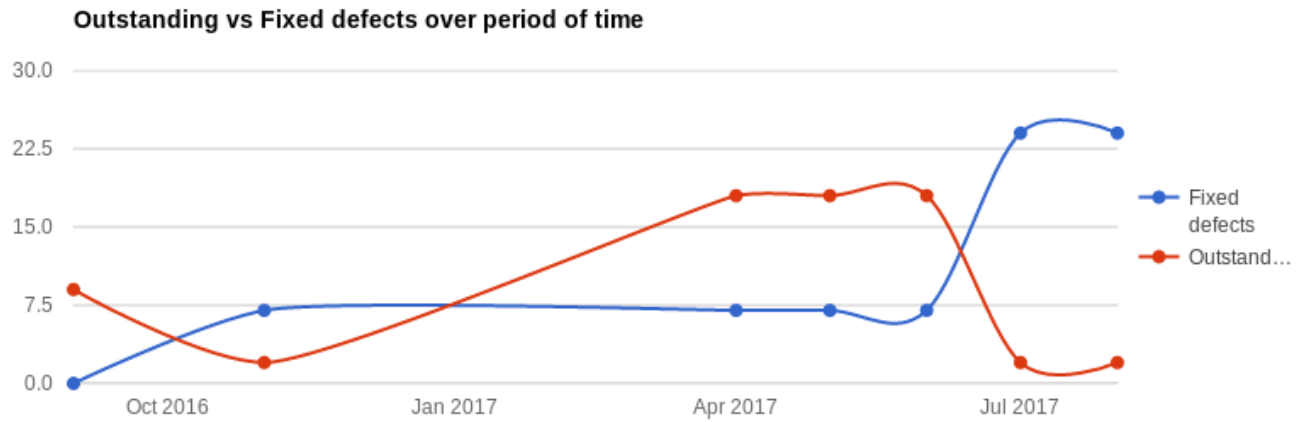


Jet Energy Resolution with not fully calibrated software compensation

LumiCal Reconstruction: Current Status

LumiCalReco

- Fiducial volume cuts no longer applied by default – cluster was not written out if too close to the edge of the detector
- Fixed some memory issues; adapted to changes in dependencies; fixed some compiler warnings and *coverity* issues

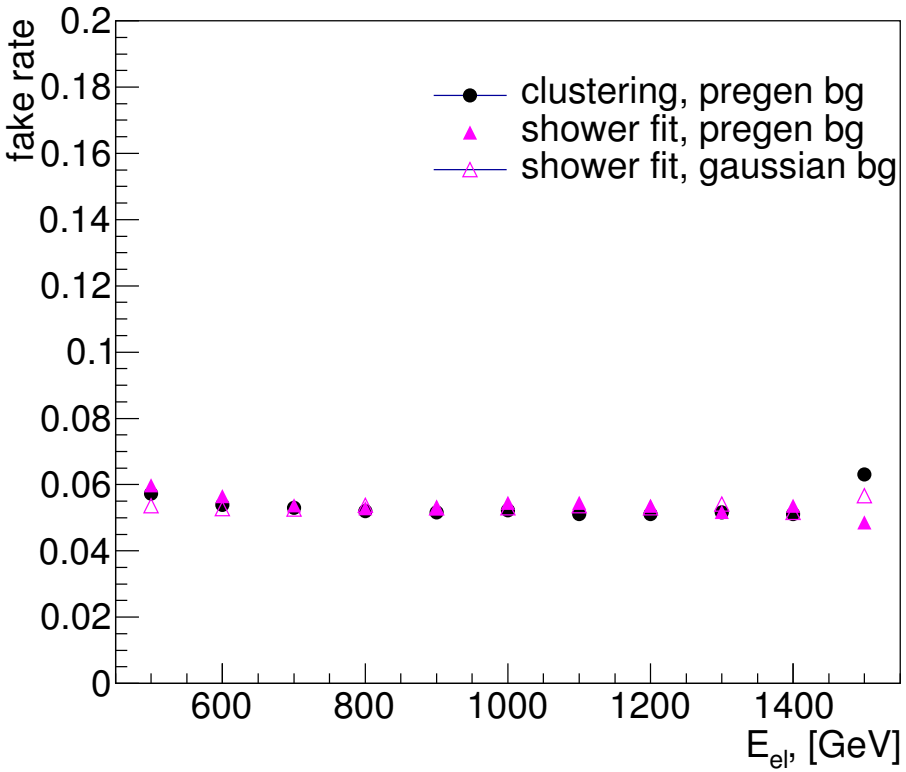


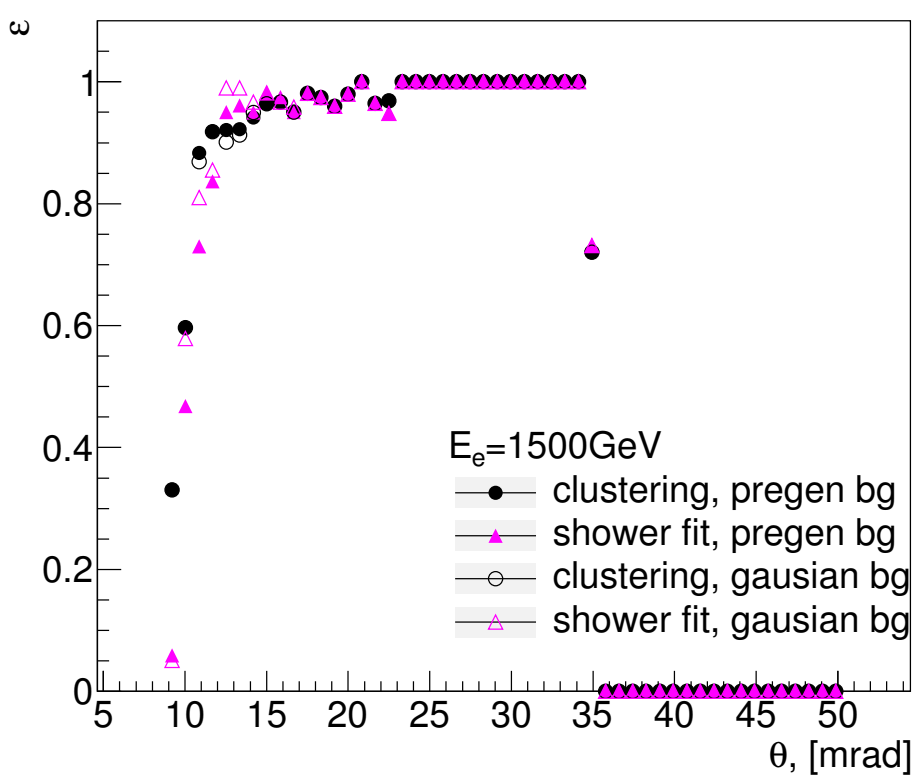
- Polar angle reconstruction much worse than from previous studies. Though need tuning of reconstruction parameters
- Need to check reconstruction performance with overlay. Problems seen in FCCee (Georgios Voutsinas) reconstruction, that all energy is clustered

BeamCal Reconstruction

BeamCal Reconstruction Efficiency

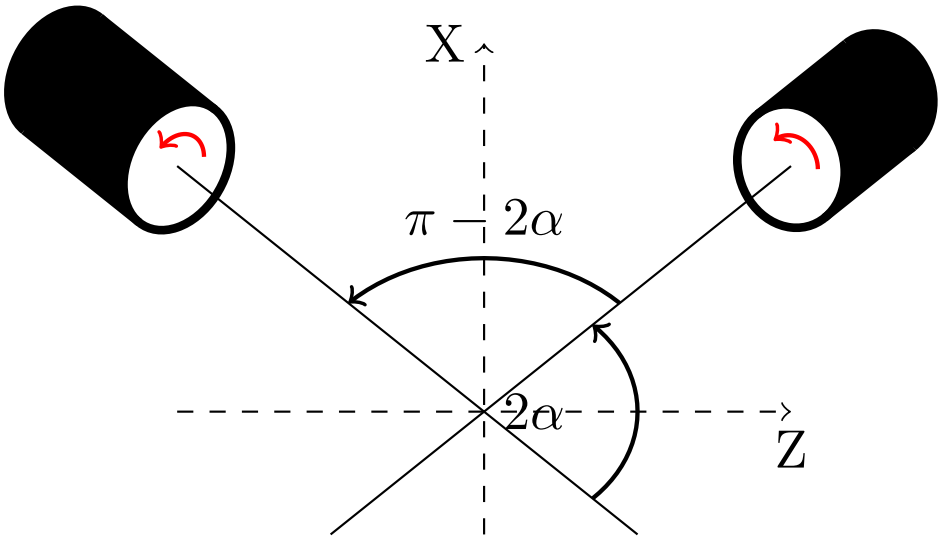
- Fake rate and reconstruction efficiency of 1.5 TeV electrons with 40 BX of CLIC 3 TeV incoherent pair background
- Reconstruction can be tuned to reduce fake rate or increase efficiency





BeamCal: Cluster Position Issue

- Fixed position of reconstructed cluster on the backward side
  - *Local coordinates* azimuthal angle rotation differently than global coordinate system
  - Cluster position wrongly calculated based on pad IDs
- Added test to check reconstructed cluster position automatically for forward and backward direction

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Start 1: t_BeamCalReco
1/1 Test #1: t_BeamCalReco .......   Passed   27.79 sec
100% tests passed, 0 tests failed out of 1
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Summary

- On going work to optimise calorimeter performances
- Software compensation showing improvements, but need some work to extend to higher energies
  - Might solve non-linearity issue along the way
- Forward calorimeter reconstruction included in default reconstruction

Many thanks to Matthias Weber for all of the ECal/HCal material