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SiD Scintillator HCAL updates

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Recap

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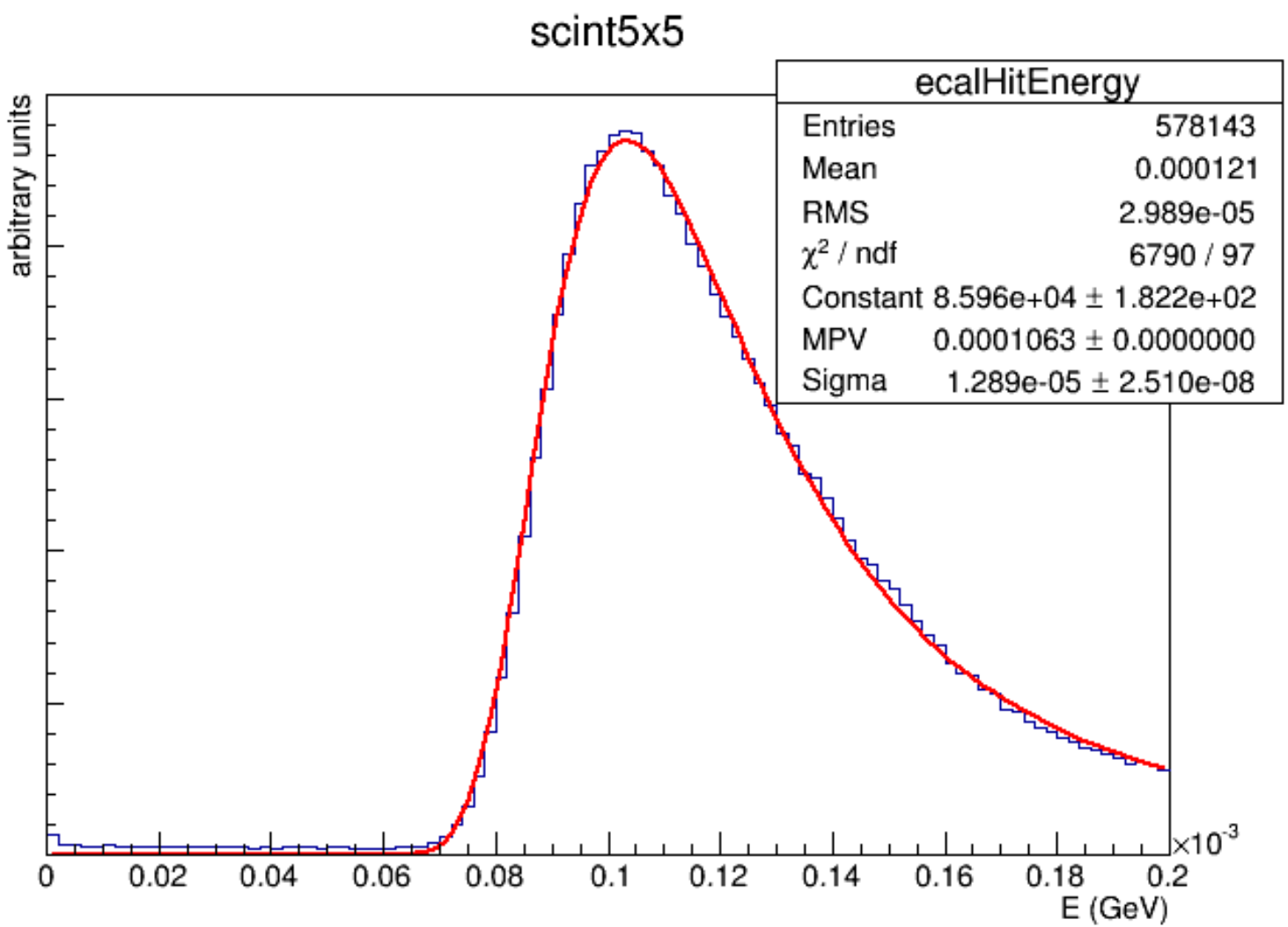
- Scintillator simulation in SiD was updated with better handling of the material response
- The default physics list changed from QGSP_BERT to FTFP_BERT
  - Calibration of the subdetectors needs to be re-done
- SiPM noise and other digitization is not yet implemented
  - Very nice presentation by Oskar Hartbrich on different effects that are relevant to calibration http://desy.de/~ohartbri/2015_04_20_CALICE_AHCAL.pdf
  - Looks like SiPM details are rather irrelevant in HCAL
  - Thanks to Felix for pointing us there


scint5x5
ecalHitEnergy
Entries 578143
Mean 0.000121
RMS 2.989e-05
χ² / ndf 6790 / 97
Constant 8.596e+04 ± 1.822e+02
MPV 0.0001063 ± 0.0000000
Sigma 1.289e-05 ± 2.510e-08
arbitrary units
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
×10⁻³
E (GeV)

20 GeV μ in the HCAL

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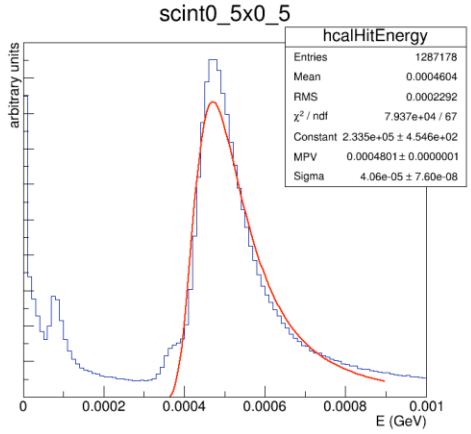
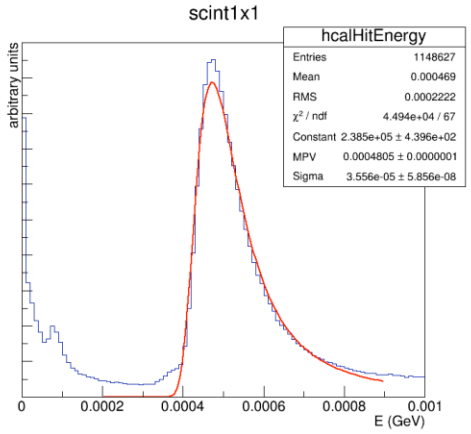
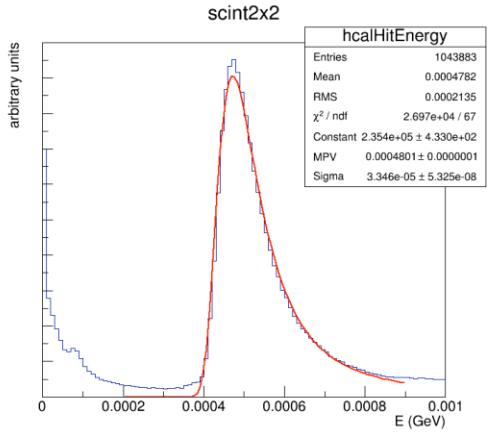
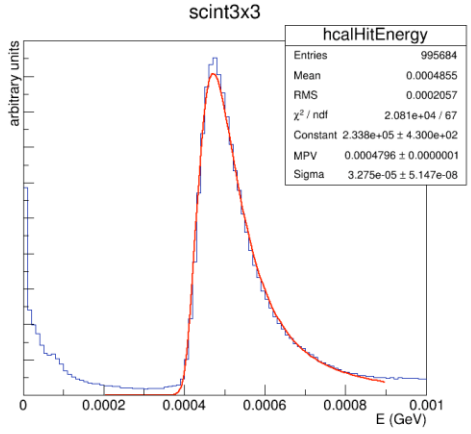
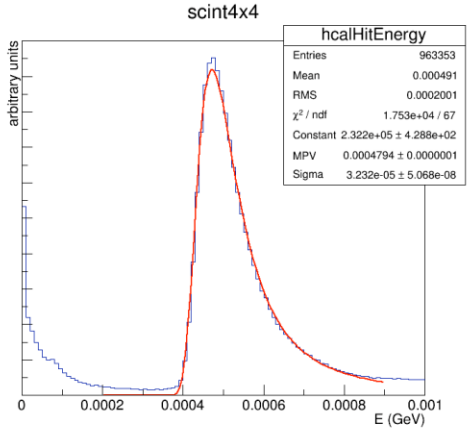
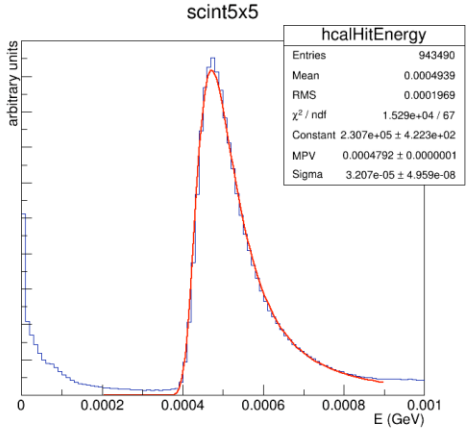




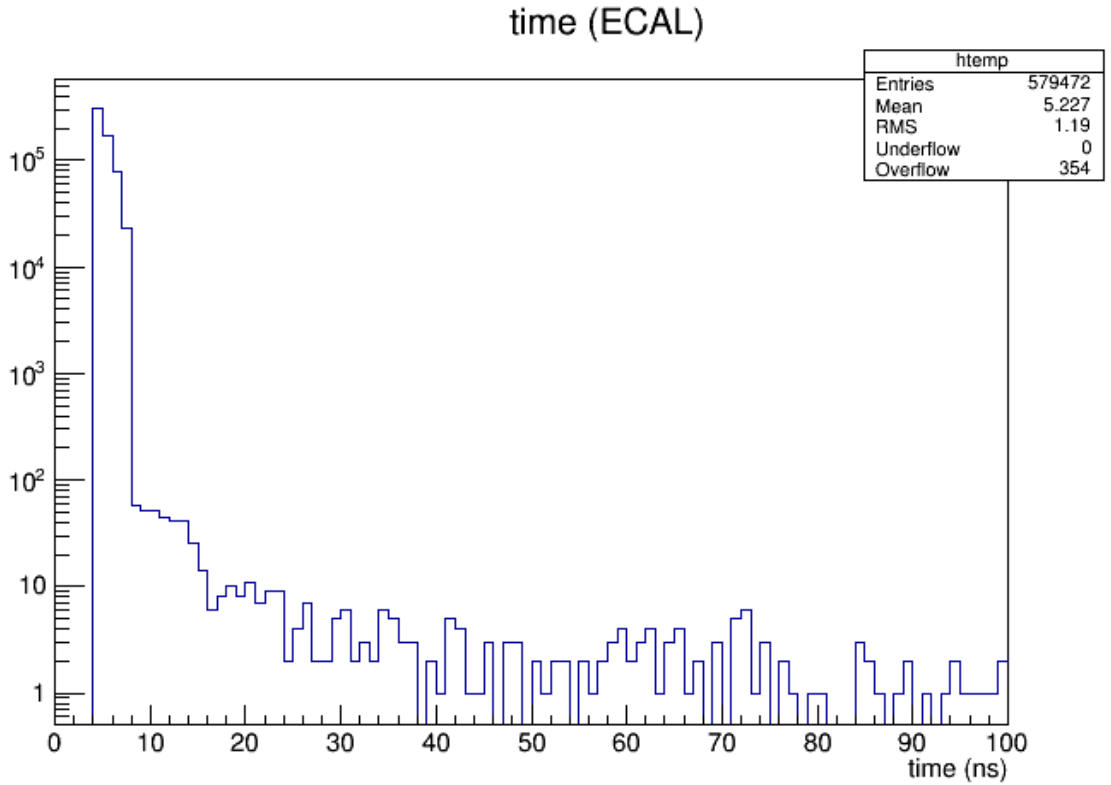




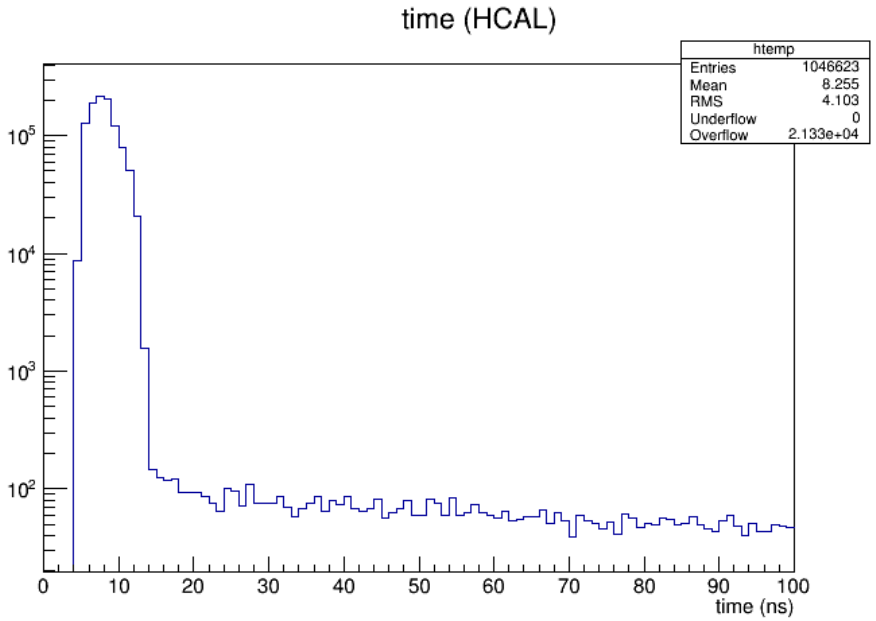


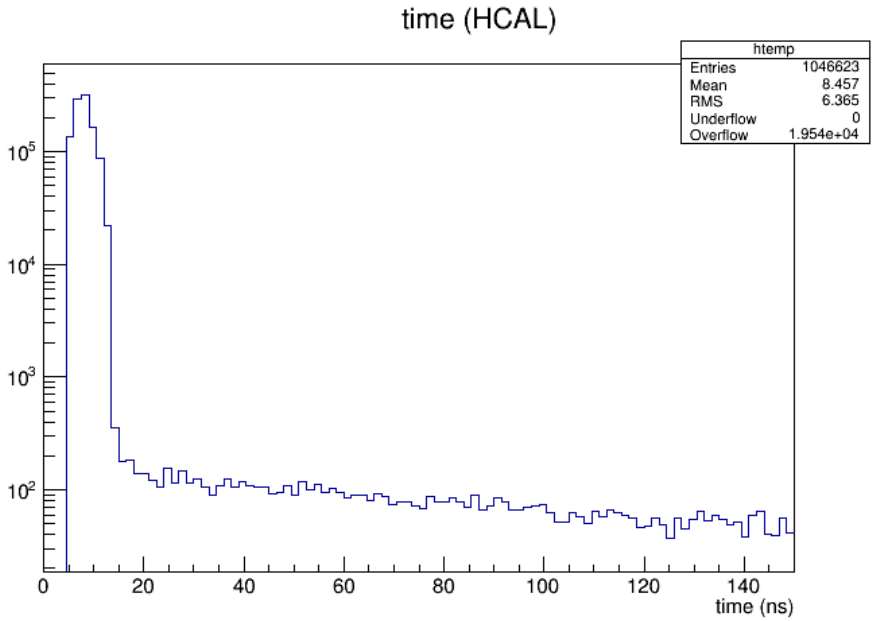


ECAL Time


time (ECAL)
htemp
Entries 579472
Mean 5.227
RMS 1.19
Underflow 0
Overflow 354
10^5
10^4
10^3
10^2
10
1
0 10 20 30 40 50 60 70 80 90 100
time (ns)

HCAL Time


time (HCAL)
htemp
Entries 1046623
Mean 8.255
RMS 4.103
Underflow 0
Overflow 2.133e+04
10^5
10^4
10^3
10^2
0 10 20 30 40 50 60 70 80 90 100
time (ns)


time (HCAL)
htemp
Entries 1046623
Mean 8.457
RMS 6.365
Underflow 0
Overflow 1.954e+04
10^5
10^4
10^3
10^2
0 20 40 60 80 100 120 140
time (ns)

Cross-check: ECAL

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sidloi3 (QGSP_BERT)

# determined from single muons
# values are RAW energy
ECalMip_MPV = 9.6E-5
ECalMip_sig = 1.2E-5
# Cut at values less than MPV-3*sigma
ECalMip_Cut = 6.0E-5
timeCut = 100.

New Values (FTFP_BERT)

# determined from single muons
# values are RAW energy
ECalMip_MPV = 1.06E-4
ECalMip_sig = 1.29E-5
# Cut at values less than about MPV-3*sigma
ECalMip_Cut = 6.5E-5
timeCut = 150.

Note: Muon system still RPC-based

Time cut changes efficiency from 98.0% to 98.1%. Change motivated by consistency with DESY studies.

Cross-check: HCAL

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sidloi3_scint (QGSP_BERT)

# determined from single muons
# values are RAW energy
HCalMip_MPV = 1.1E-3
HCalMip_sig = 1.0E-4

# Cut at values less than MPV-3*sigma
HCalMip_Cut = 6.0E-4

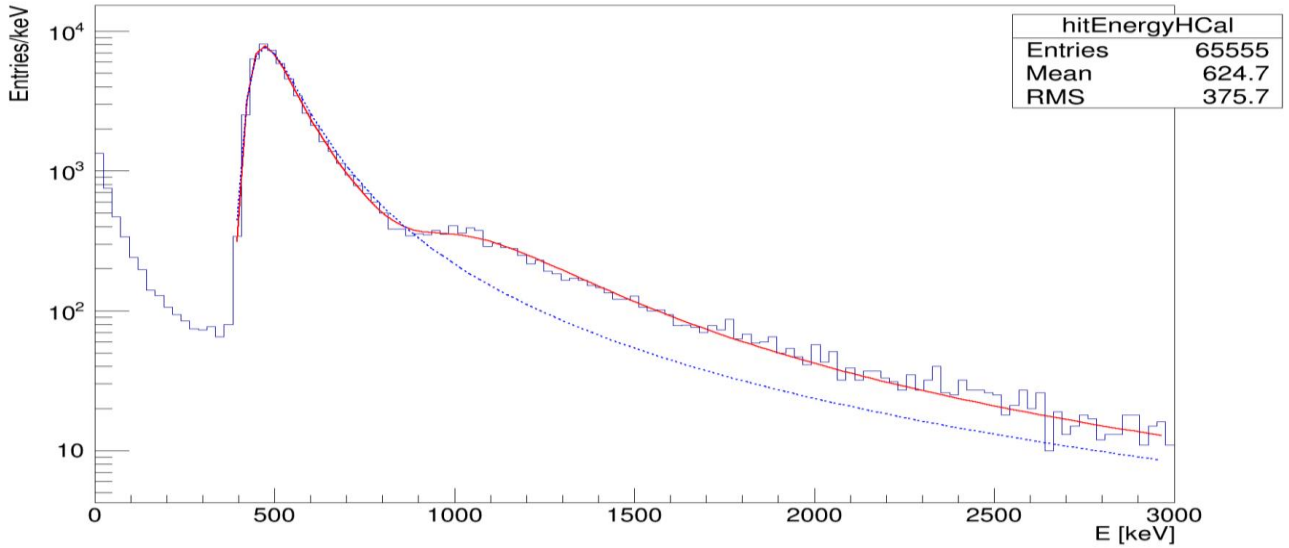
New Values (FTFP_BERT)

# determined from single muons
# values are RAW energy
HCalMip_MPV = 4.8E-4
HCalMip_sig = 3.2E-5

# Cut at values less than MPV-3*sigma
HCalMip_Cut = 3.8E-4

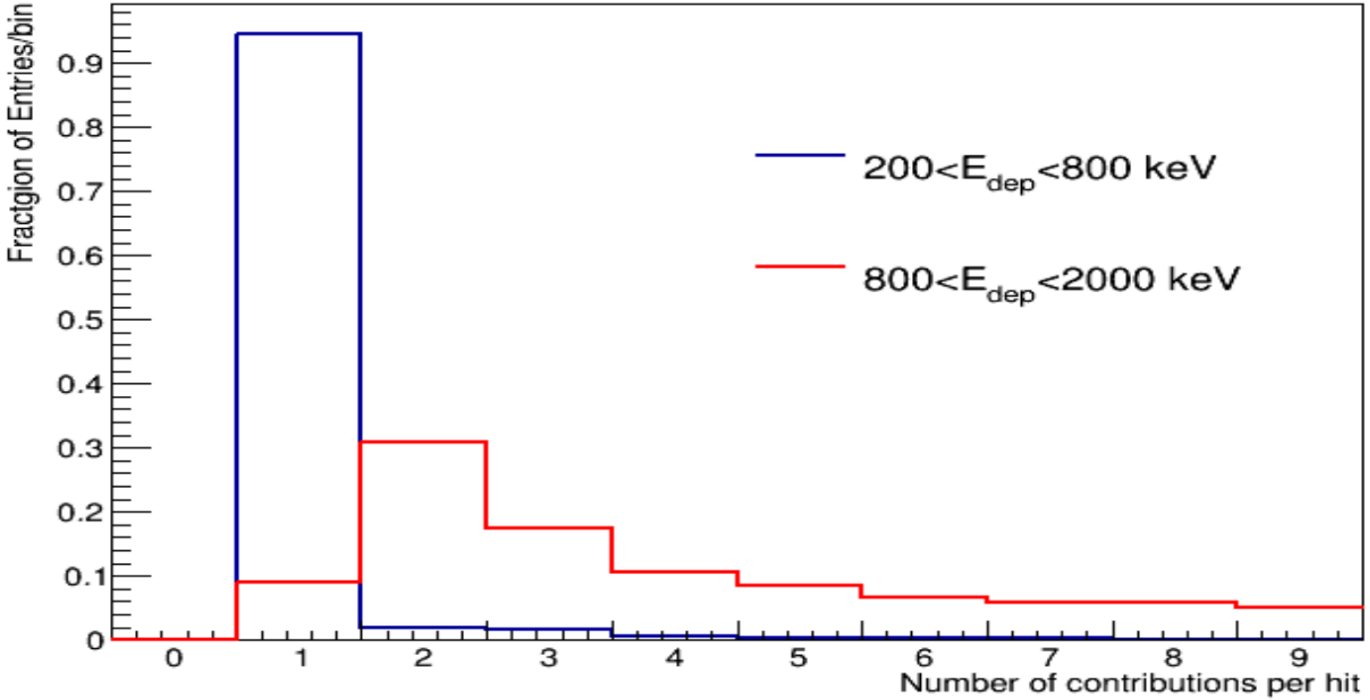
ILD cuts at ½ MIP. 3 sigma looks more reasonable…
These studies use the same MIP cut for all tile sizes (same thickness)

Edep per hit (CLIC HCal Barrel, 10 GeV μ^- @ θ=90°, uniform in φ)



- Secondary peak visible at ~1000 keV (2x peak at ~500 keV)
- No apparent dependence in phi/theta /layer etc
- Sum of two Landau distributions (red) matches much better than single landau (blue)
- No layers with twice the thickness
- -> Secondaries (but no secondary MC contributions visible per hit!)
- => Had to turn detailed shower on: **act.HitCreationMode = 2** (simple calorimeter action)

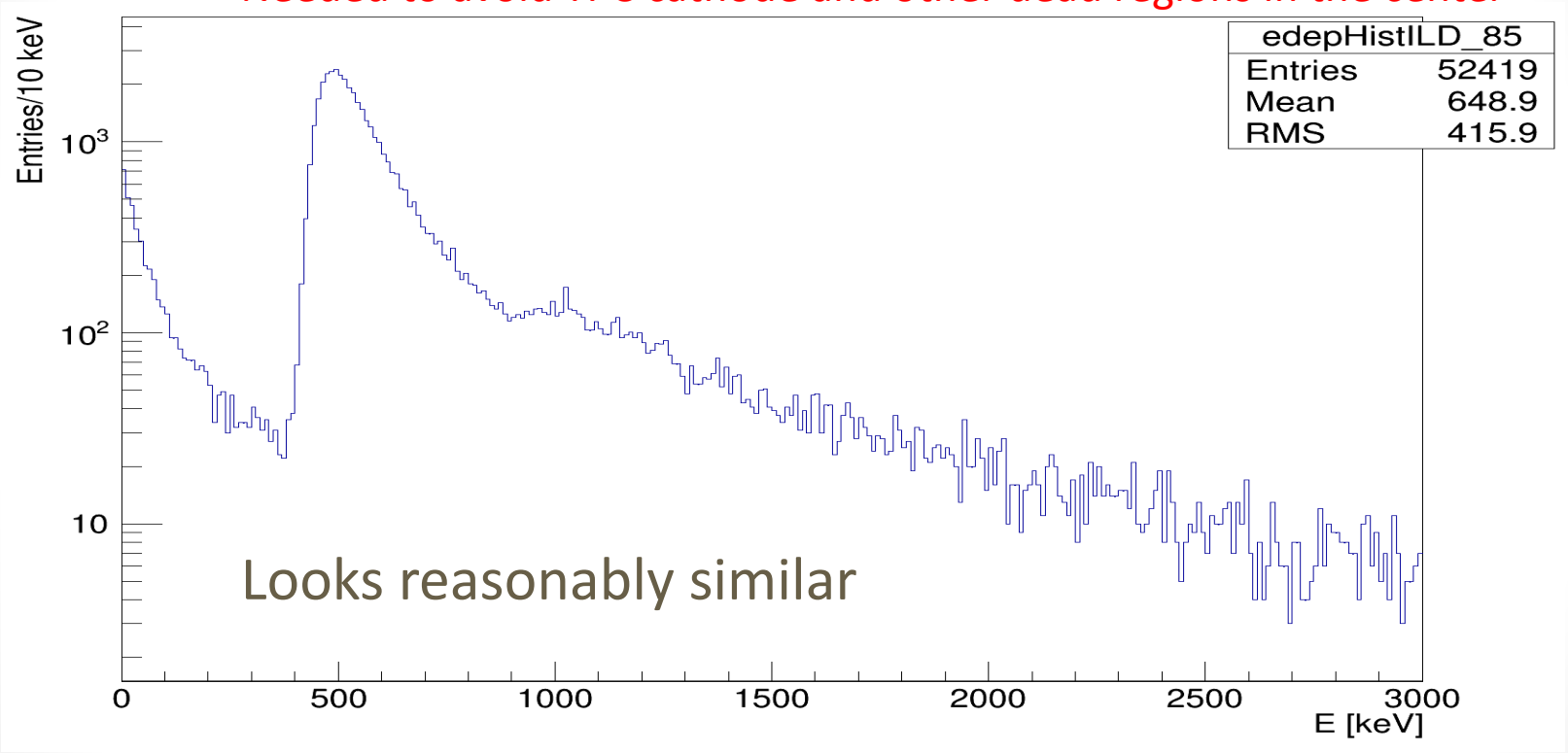
Number of Contributions per Hit:
Clearly, the second landau comes from secondaries



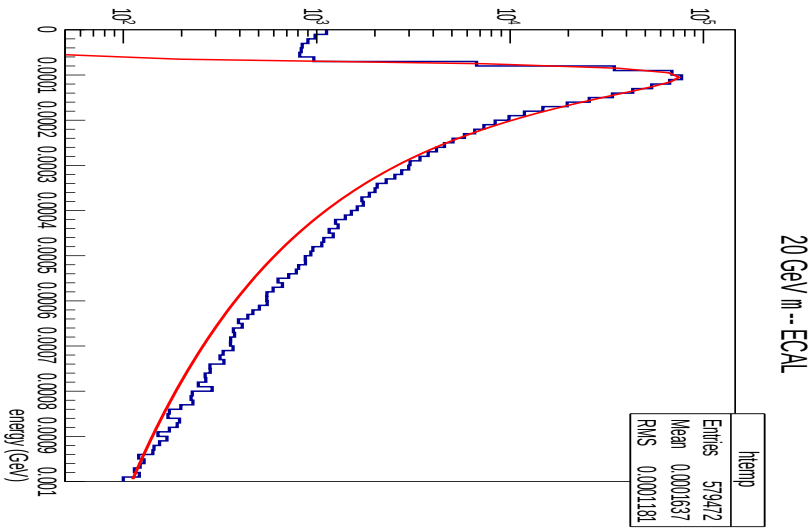
So everything looks OK. Move to other variables -> But first, a look at ILD

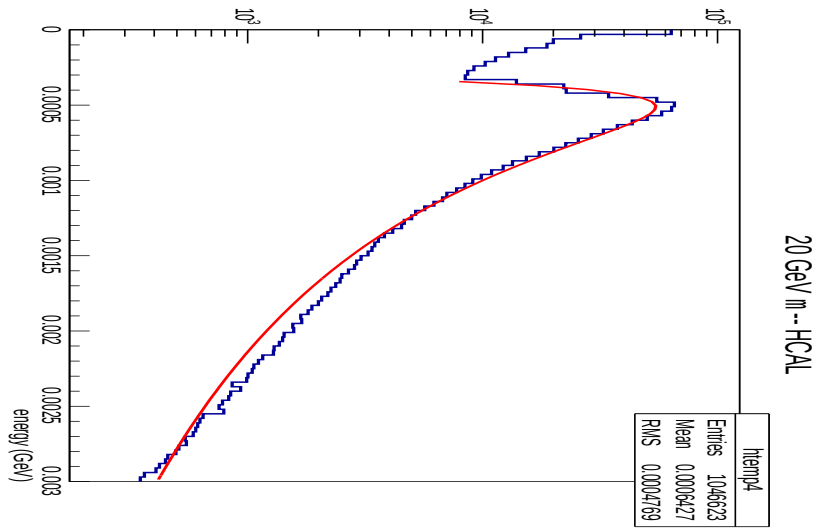
ILD HCal (10 GeV μ^- @ θ=85°, uniform in φ)

Needed to avoid TPC cathode and other dead regions in the center



Raw hit energies in SiD





No secondaries visible in either detector

Calibrated energies (lcsim cal-calib output)

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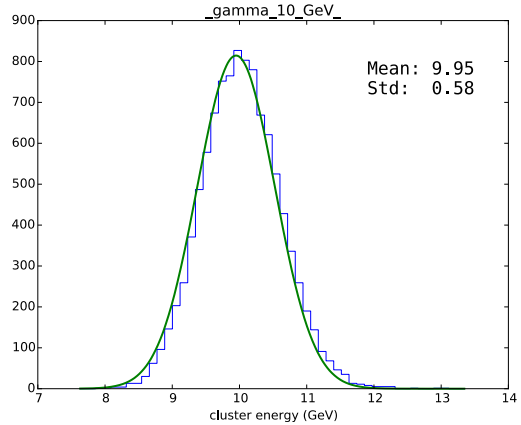
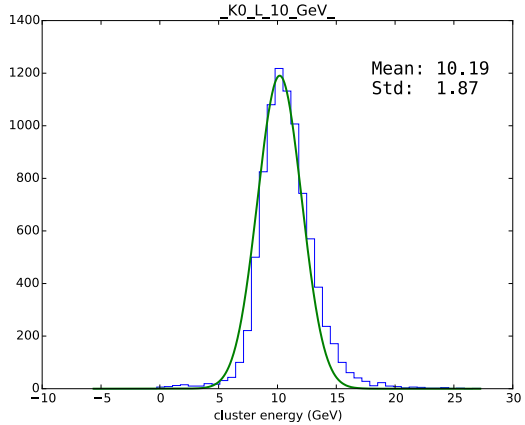
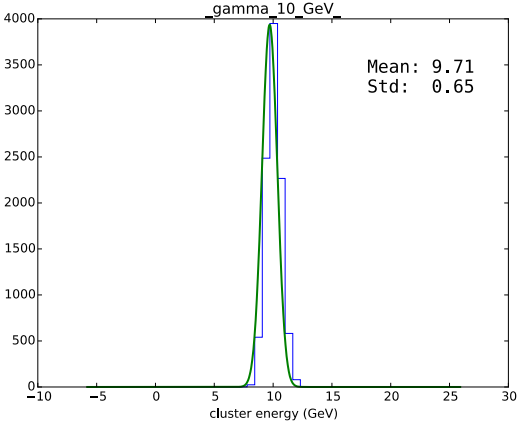


barrel

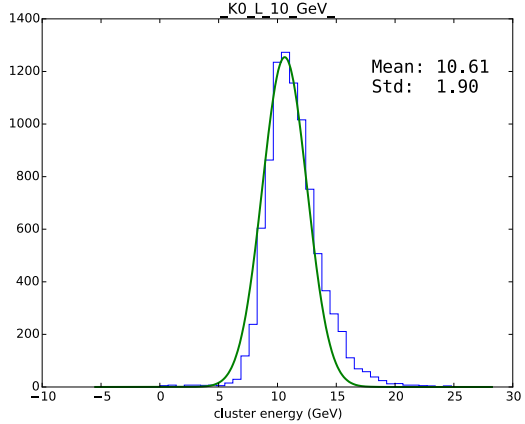


Photons look reasonable, but not great.

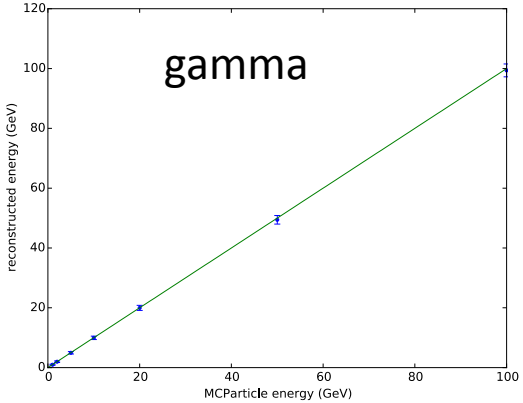
K0L are shifted.



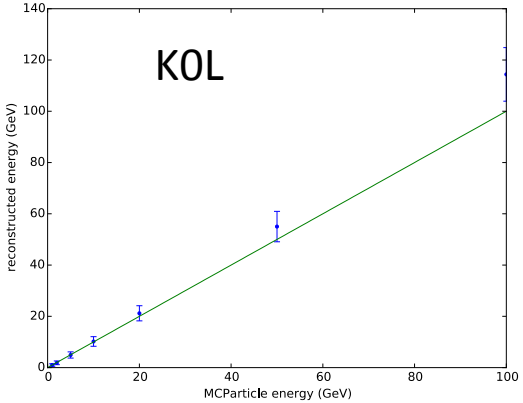
endcap

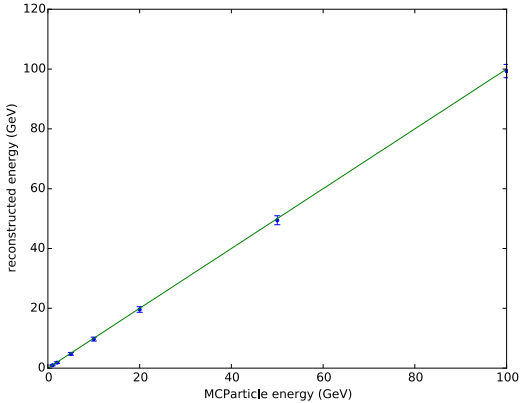


Linearity plots, example: 1x1 cm^2

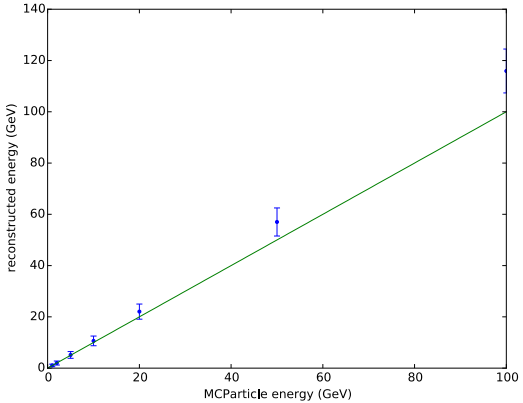


barrel





endcap



Summary

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- New Physics list has been implemented
- Birks now law handled by Geant4 (new hit type in lcdd)
- Time constant changed to 150 GeV, consistent with ILD/CALICE

- Calibration of the detectors re-done with cal-calib package.
- Photons are (maybe) OK, neutral hadrons are biased.

- Look further into the details of the showers. How can we improve the calibration? Will move to the back burner for a while. More effort needed.