

SiD Hadron Calorimeter simulation

Single pions

Varying energy threshold

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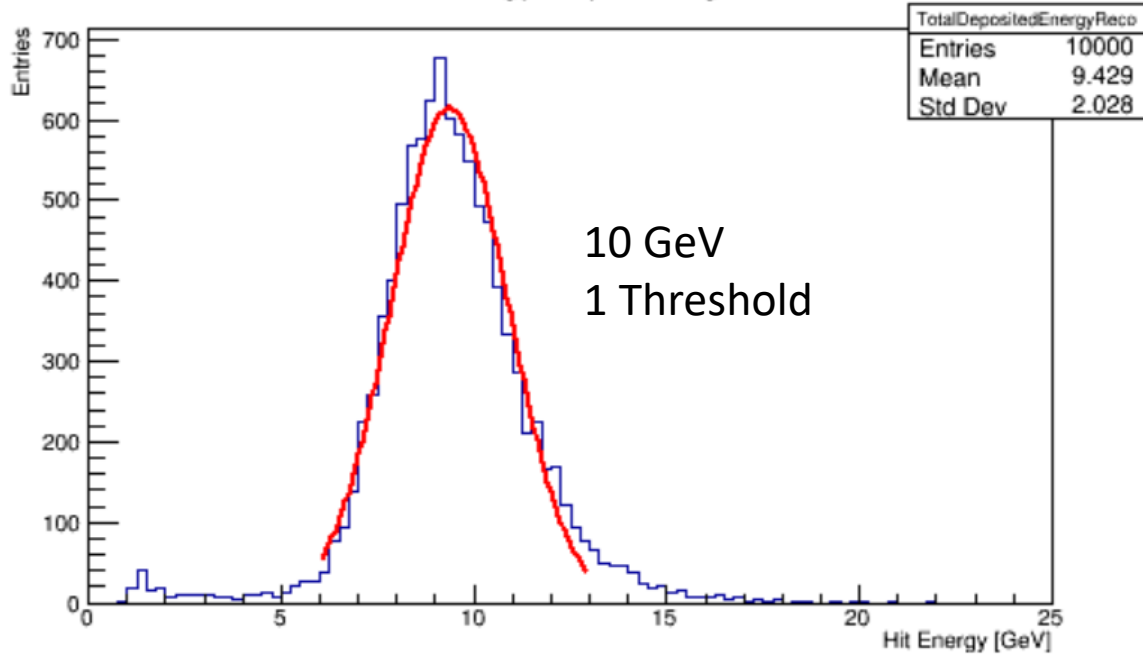
July 2021

SiD Hadron Calorimeter - Digitization

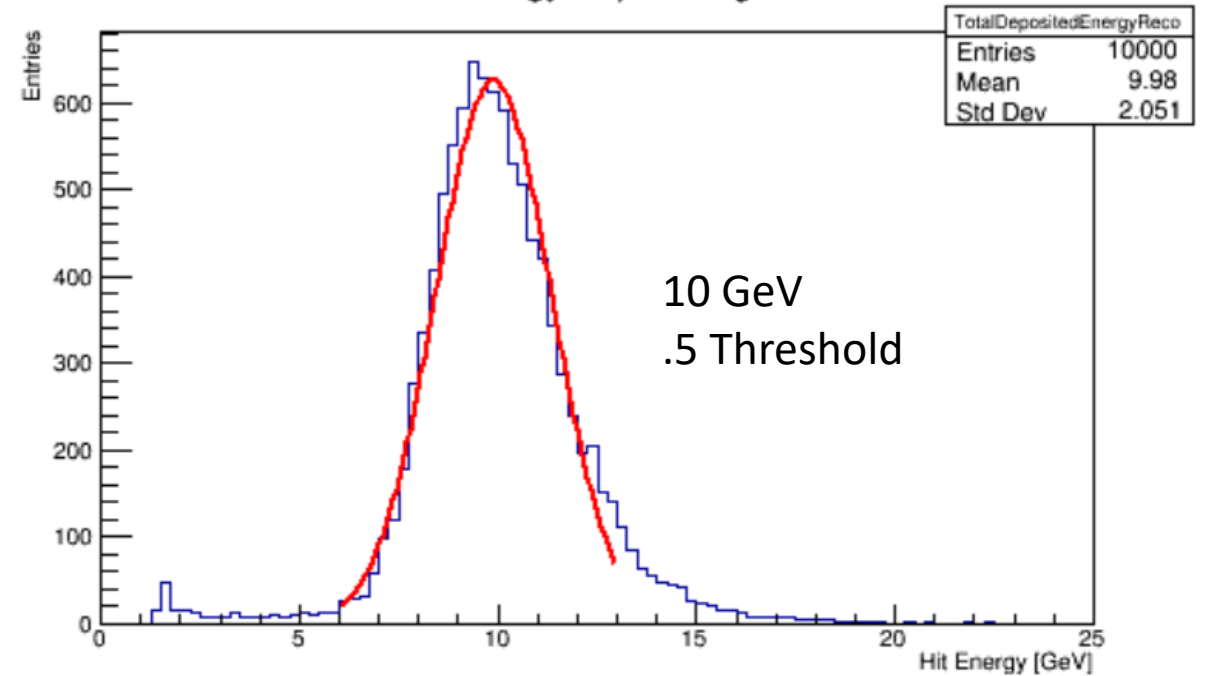
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<!-- digitisation for scintillator HCAL barrel hits -->
<processor name="HCalBarrelDigi" type="RealisticCaloDigiScinPpd">
  <parameter name="inputHitCollections"> HCalBarrelHits </parameter>
  <parameter name="outputHitCollections"> HCalBarrelDigi </parameter>
  <parameter name="outputRelationCollections"> HCalBarrelDigiRelation </parameter>
  <parameter name="threshold"> 0.5 </parameter>
  <parameter name="thresholdUnit"> MIP </parameter>
  <parameter name="timingCut"> 1 </parameter>
  <parameter name="timingCorrectForPropagation"> 1 </parameter>
  <parameter name="timingWindowMin"> -10 </parameter>
  <parameter name="timingWindowMax"> 100 </parameter>
  <parameter name="calibration_mip">0.0004825</parameter>
  <parameter name="elec_noise_mip"> 0.1 </parameter>
  <parameter name="elec_range_mip"> 500 </parameter>
  <parameter name="CellIDLayerString"> layer </parameter>
  <parameter name="ppd_mipPe"> 15 </parameter>
  <parameter name="ppd_npix"> 1600 </parameter>
  <parameter name="ppd_npix_uncert"> 0 </parameter>
  <parameter name="ppd_pix_spread"> 0 </parameter>
  <parameter name="Verbosity" type="string"> WARNING </parameter>
</processor>
```

Minimum signal level

Event Energy Deposit DigiReco



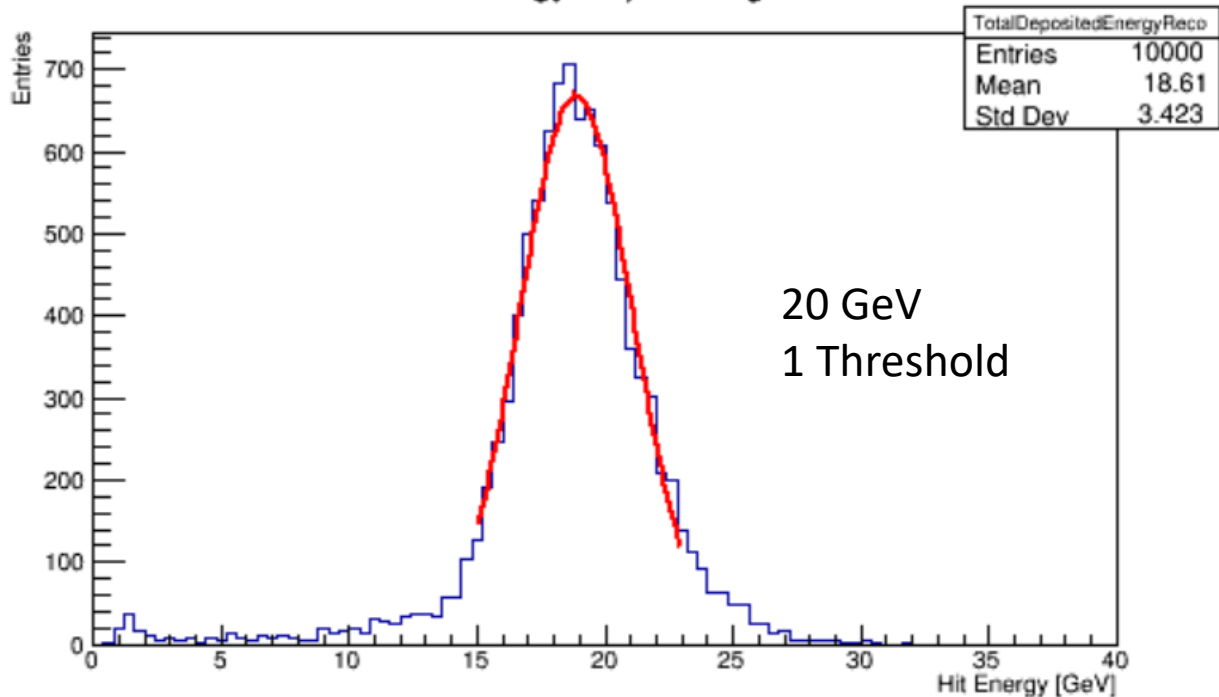
Event Energy Deposit DigiReco



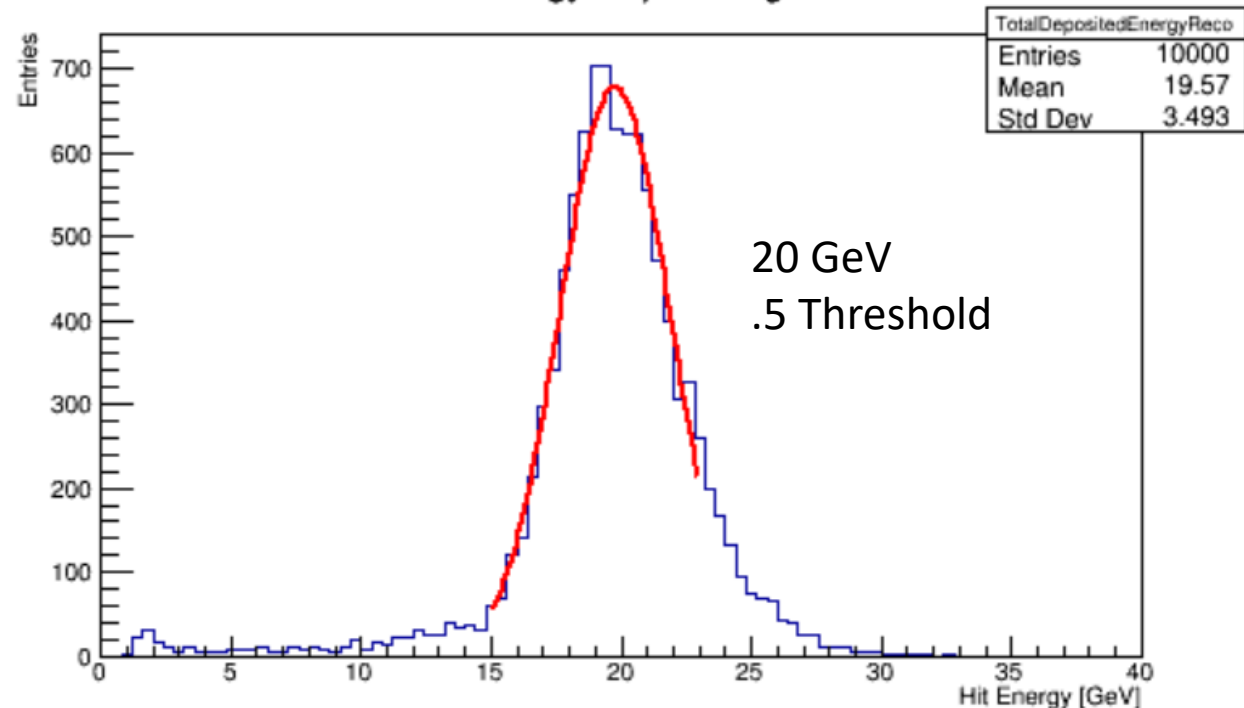
```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=146.439 FROM MIGRAD STATUS=CONVERGED 61 CALLS 62 TOTAL
EDM=1.90204e-07 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 6.14868e+02 8.46242e+00 3.80942e-02 4.15158e-06
2 Mean 9.36863e+00 1.75427e-02 1.00986e-04 -3.52797e-02
3 Sigma 1.51839e+00 1.56236e-02 1.56780e-05 1.02102e-02
Energy Resolution = 0.151838516975 +/- 0.0156235502089 tile size = 30
```

```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=140.49 FROM MIGRAD STATUS=CONVERGED 59 CALLS 60 TOTAL
EDM=1.32278e-07 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 6.26145e+02 8.51486e+00 3.83161e-02 7.73737e-05
2 Mean 9.88485e+00 1.78677e-02 9.57238e-05 -4.85297e-03
3 Sigma 1.46548e+00 1.45814e-02 1.45292e-05 1.33497e-01
Energy Resolution = 0.146548195568 +/- 0.0145813889161 tile size = 30
```

Event Energy Deposit DigiReco



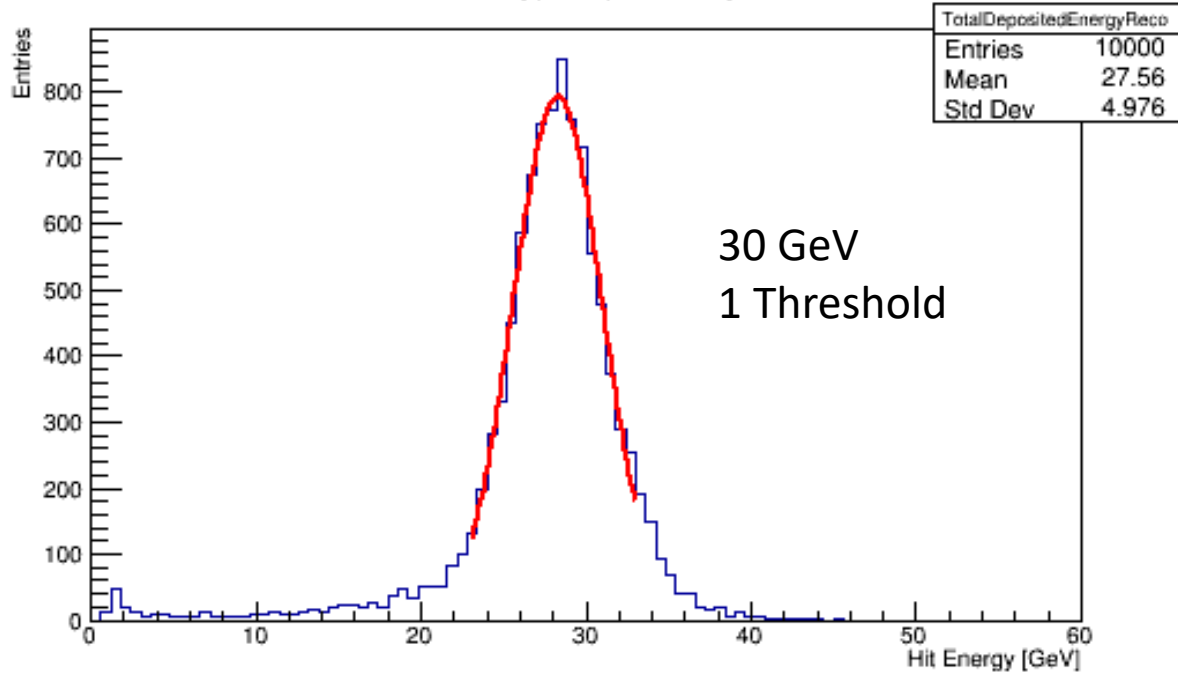
Event Energy Deposit DigiReco



```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=46.4982 FROM MIGRAD STATUS=CONVERGED 69 CALLS 70 TOTAL
EDM=3.43561e-08 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 6.67479e+02 9.65182e+00 2.40938e-02 2.00286e-05
2 Mean 1.88640e+01 2.75546e-02 9.25628e-05 6.53431e-03
3 Sigma 2.20281e+00 2.89019e-02 1.18676e-05 5.23434e-02
Energy Resolution = 0.110140312449 +/- 0.0289019477824 tile size = 30
```

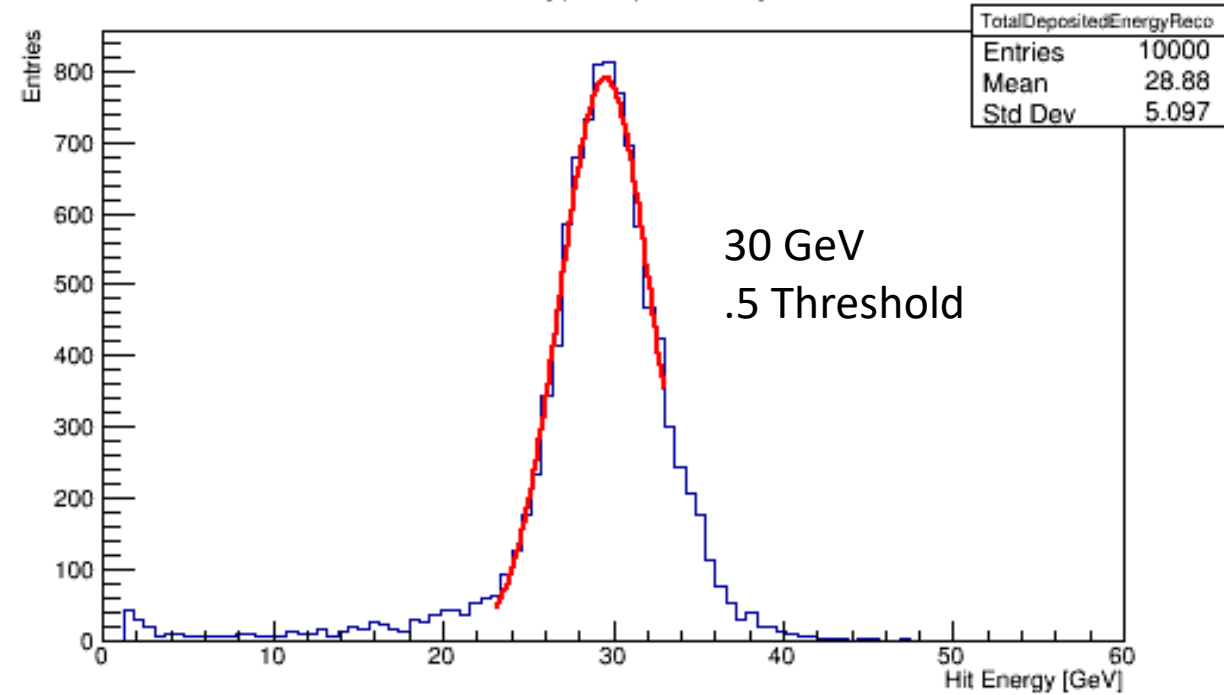
```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=57.4291 FROM MIGRAD STATUS=CONVERGED 69 CALLS 70 TOTAL
EDM=1.29299e-06 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 6.77927e+02 9.71029e+00 2.75654e-02 -1.71602e-04
2 Mean 1.97527e+01 2.92127e-02 9.88400e-05 -2.17566e-02
3 Sigma 2.11094e+00 2.72203e-02 1.22830e-05 -3.24137e-01
Energy Resolution = 0.105547015893 +/- 0.0272202602393 tile size = 30
```

Event Energy Deposit DigiReco



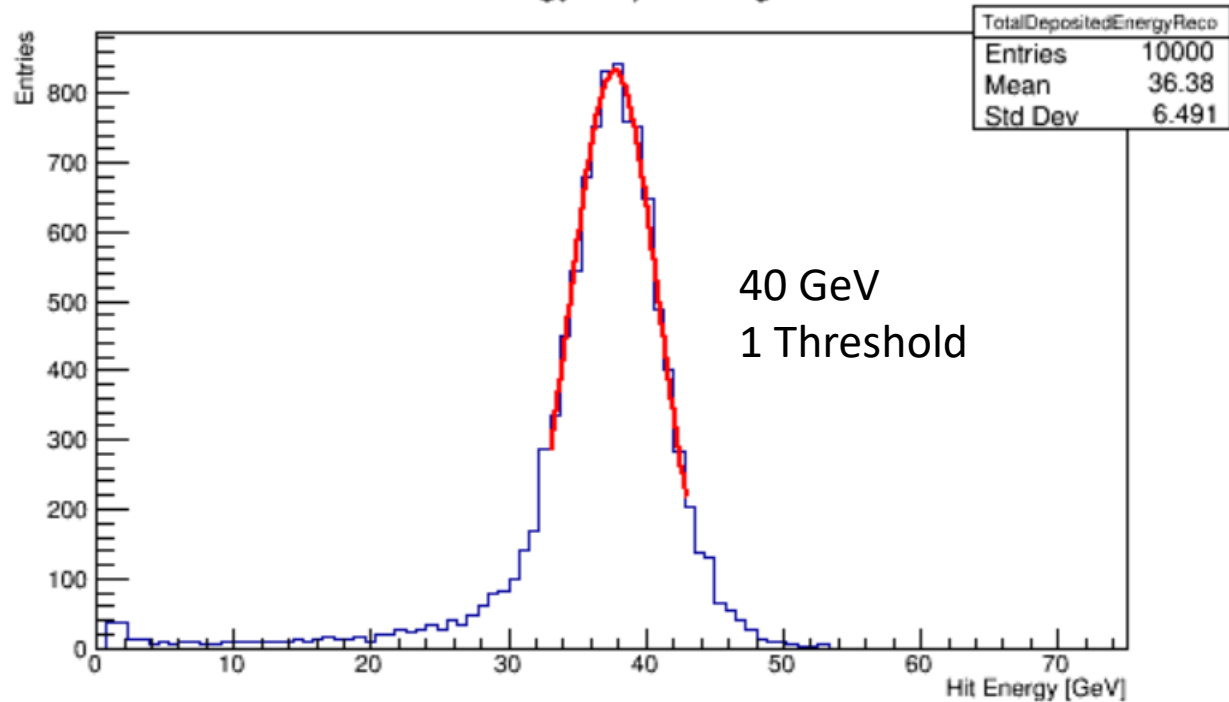
```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=24.609 FROM MIGRAD STATUS=CONVERGED 69 CALLS 70 TOTAL
EDM=1.32501e-08 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 7.93448e+02 1.16578e+01 2.13403e-02 1.86691e-05
2 Mean 2.82874e+01 3.53479e-02 8.58139e-05 -8.32531e-04
3 Sigma 2.71607e+00 3.72831e-02 9.05015e-06 2.89561e-02
Energy Resolution = 0.0905355523338 +/- 0.0372831154859 tile size = 30
```

Event Energy Deposit DigiReco

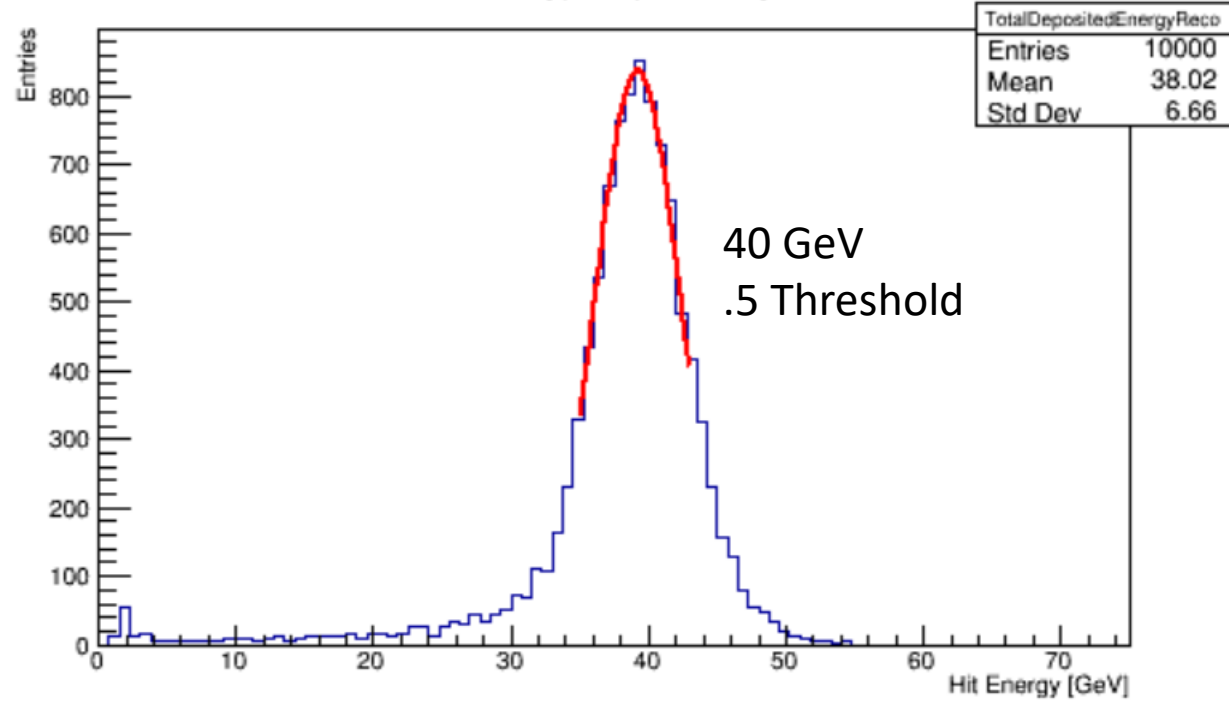


```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=24.2969 FROM MIGRAD STATUS=CONVERGED 77 CALLS 78 TOTAL
EDM=1.24585e-08 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 7.91138e+02 1.15717e+01 2.17374e-02 -6.62741e-06
2 Mean 2.95292e+01 4.43366e-02 8.87923e-05 -2.34442e-03
3 Sigma 2.70133e+00 4.13518e-02 9.13587e-06 2.05767e-02
Energy Resolution = 0.0900441671655 +/- 0.0413518326831 tile size = 30
```

Event Energy Deposit DigiReco



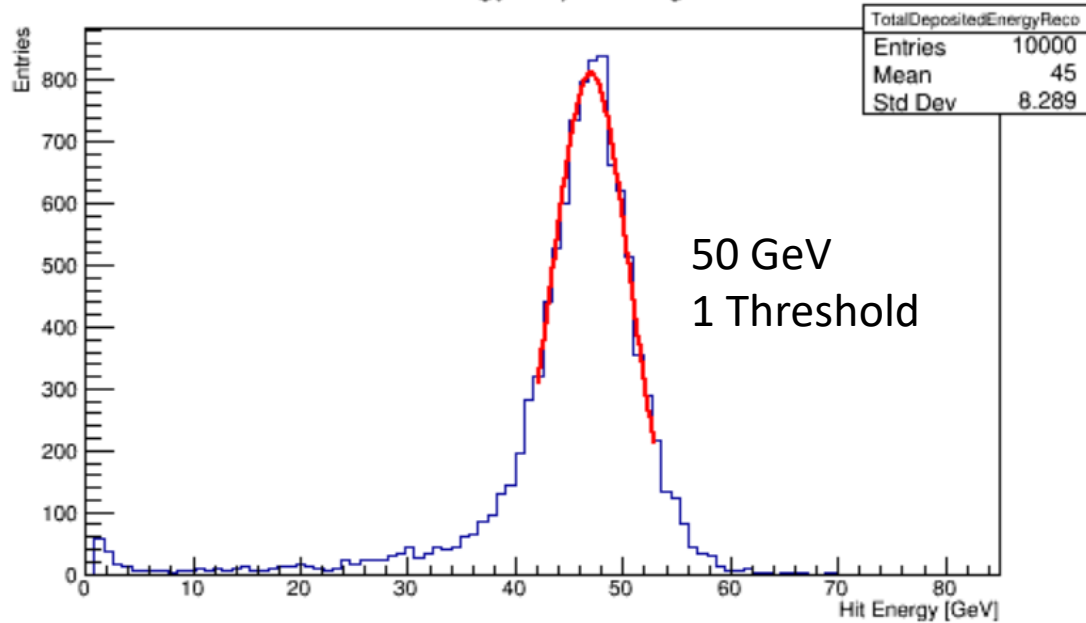
Event Energy Deposit DigiReco



```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=6.42898 FROM MIGRAD STATUS=CONVERGED 78 CALLS 79 TOTAL
EDM=7.74854e-08 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 8.31685e+02 1.29866e+01 1.25660e-02 -2.32886e-05
2 Mean 3.77073e+01 4.85996e-02 6.43232e-05 8.21193e-04
3 Sigma 3.19711e+00 6.09381e-02 7.20249e-06 1.60143e-02
Energy Resolution = 0.0799277060741 +/- 0.0609380730704 tile size = 30
```

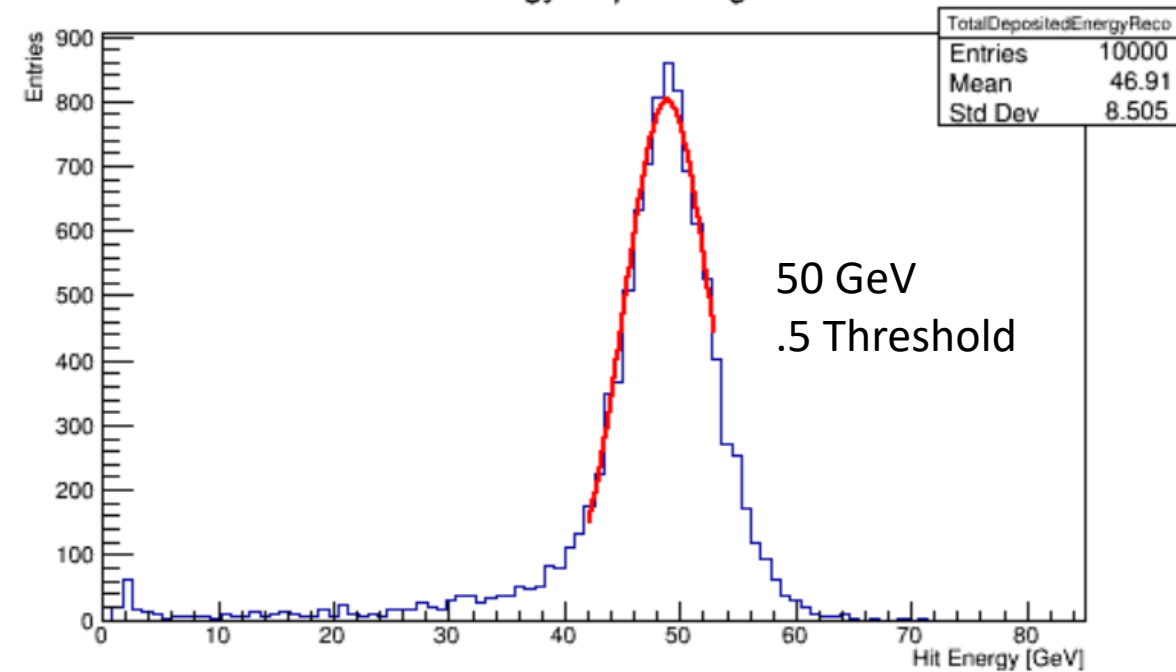
```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=3.36623 FROM MIGRAD STATUS=CONVERGED 87 CALLS 88 TOTAL
EDM=1.06814e-06 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 8.37114e+02 1.44369e+01 1.04226e-02 1.07250e-04
2 Mean 3.92348e+01 6.11253e-02 6.12801e-05 2.49598e-03
3 Sigma 3.10570e+00 9.58505e-02 9.56700e-06 1.49466e-01
Energy Resolution = 0.0776425482738 +/- 0.0958505119404 tile size = 30
```

Event Energy Deposit DigiReco



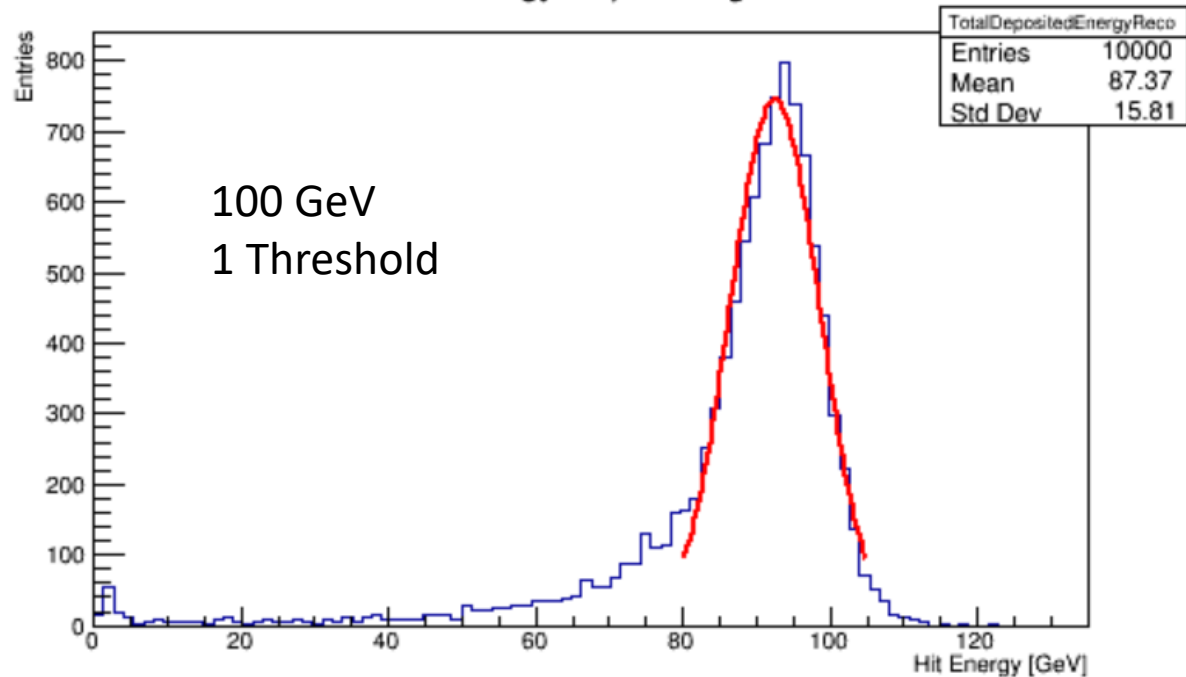
```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=17.3144 FROM MIGRAD STATUS=CONVERGED 78 CALLS 79 TOTAL
EDM=9.29661e-08 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 8.10616e+02 1.29441e+01 1.95349e-02 -2.57343e-05
2 Mean 4.70338e+01 5.48921e-02 1.14227e-04 1.65917e-03
3 Sigma 3.58522e+00 6.93347e-02 1.13607e-05 1.62118e-02
Energy Resolution = 0.0717043025443 +/- 0.0693347102253 tile size = 30
```

Event Energy Deposit DigiReco

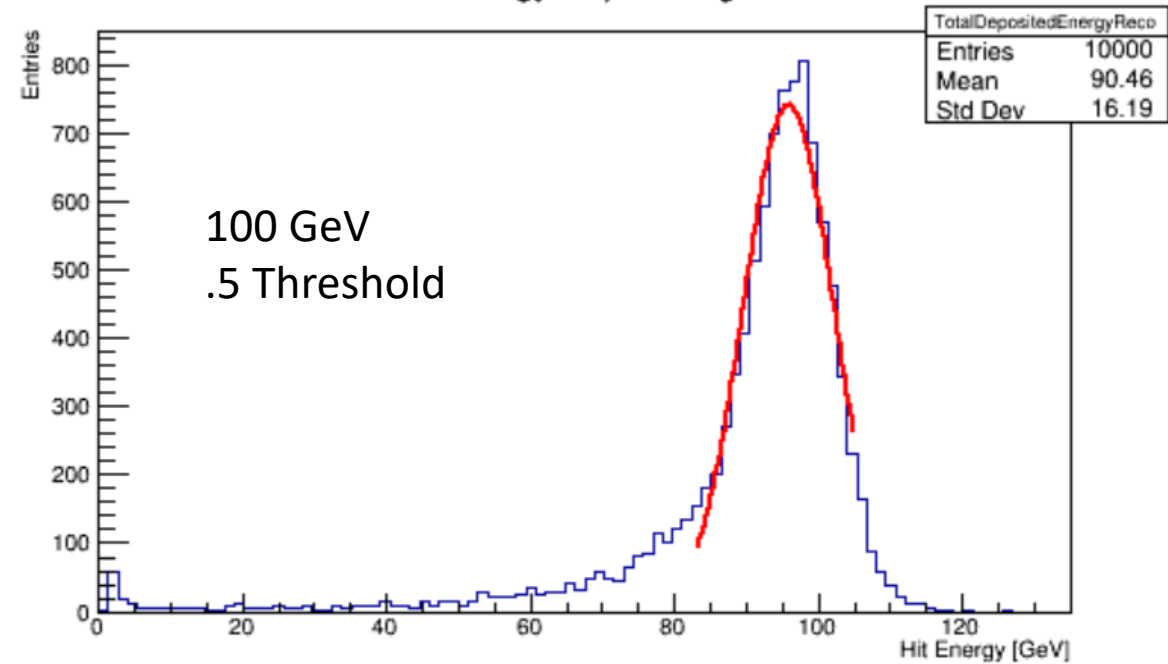


```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=23.7073 FROM MIGRAD STATUS=CONVERGED 85 CALLS 86 TOTAL
EDM=8.76108e-09 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 8.01763e+02 1.24812e+01 2.28515e-02 6.69519e-06
2 Mean 4.88649e+01 7.77594e-02 1.41971e-04 -1.00238e-04
3 Sigma 3.72929e+00 8.21797e-02 1.30057e-05 1.94380e-02
Energy Resolution = 0.0745858555982 +/- 0.0821796579784 tile size = 30
```


Event Energy Deposit DigiReco



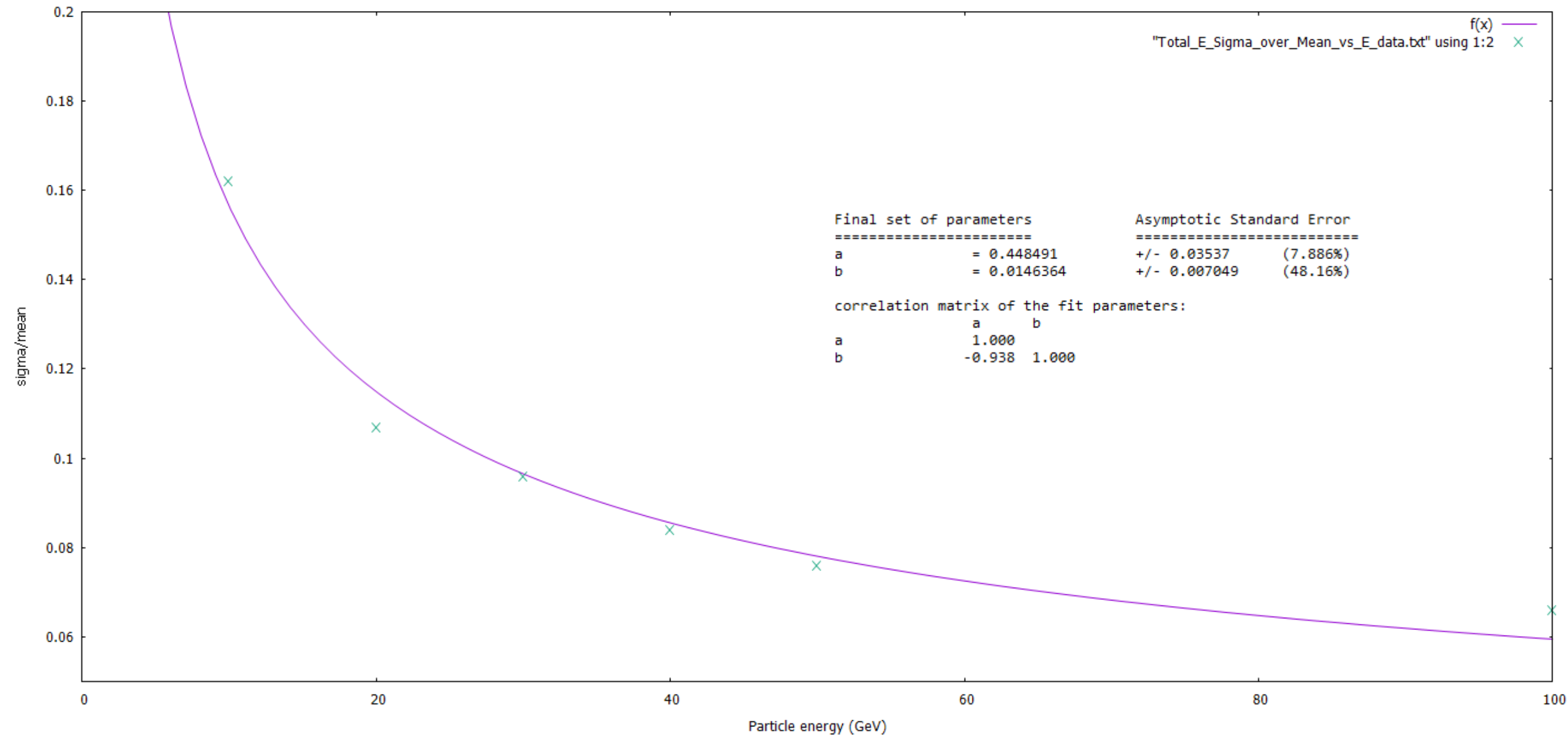
Event Energy Deposit DigiReco



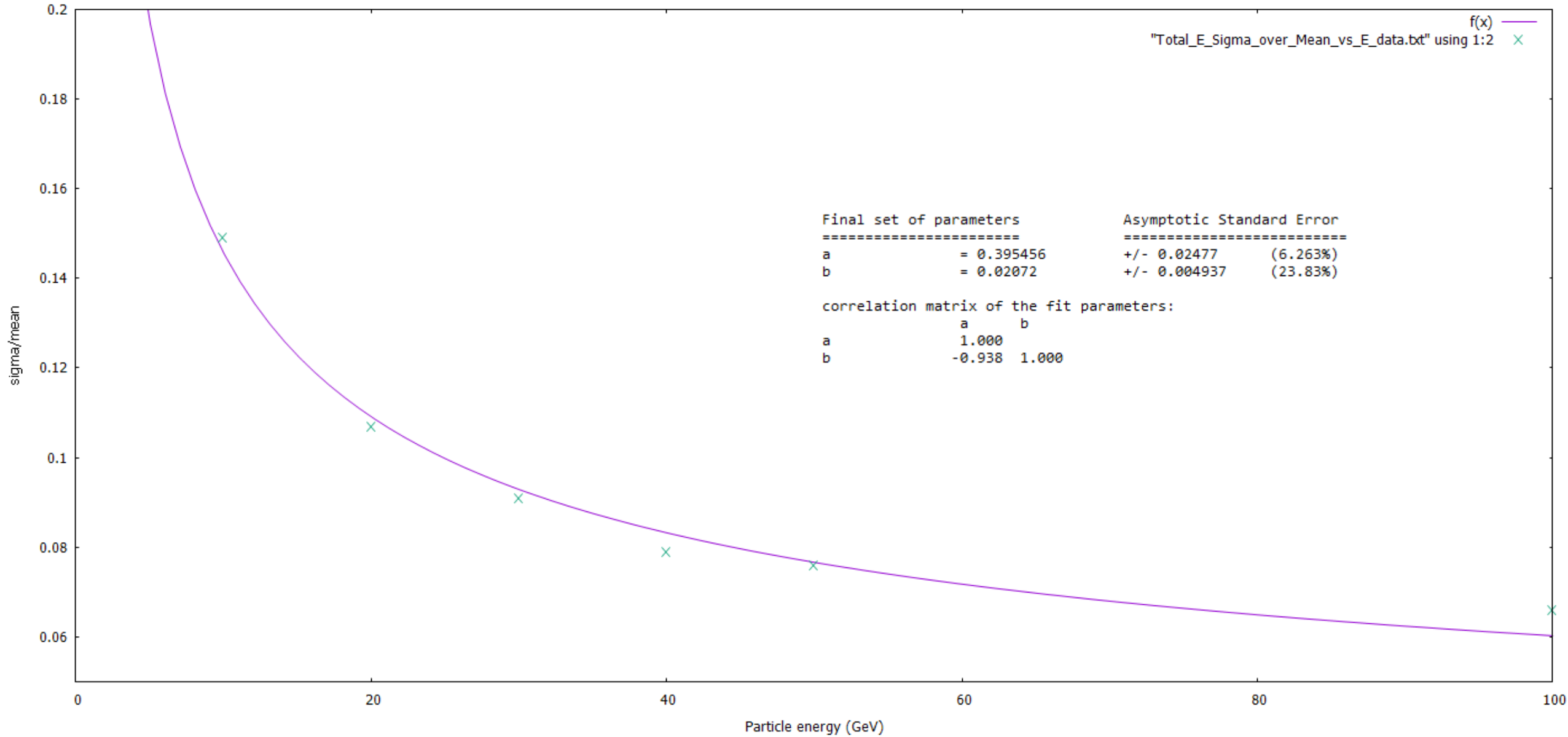
```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=92.2558 FROM MIGRAD STATUS=CONVERGED 68 CALLS 69 TOTAL
EDM=2.07733e-08 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 7.45499e+02 1.09114e+01 3.89610e-02 -1.51820e-05
2 Mean 9.24762e+01 7.72503e-02 3.53769e-04 -2.05202e-03
3 Sigma 6.09420e+00 7.18674e-02 1.45608e-05 -4.62668e-02
Energy Resolution = 0.0609420390404 +/- 0.0718674017944 tile size = 30
```

```
Info in <TCanvas::MakeDefCanvas>: created default TCanvas with name c1
FCN=82.9165 FROM MIGRAD STATUS=CONVERGED 76 CALLS 77 TOTAL
EDM=4.96371e-09 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 7.40942e+02 1.14320e+01 3.72089e-02 -1.17328e-05
2 Mean 9.58408e+01 8.63406e-02 3.77400e-04 -5.81283e-05
3 Sigma 6.27533e+00 9.66445e-02 1.81759e-05 -1.38789e-02
Energy Resolution = 0.0627532785573 +/- 0.0966444811441 tile size = 30
```


Single pions – MIP threshold 1.0



Single pions – MIP threshold 0.5



Deviation of fitted mean energy from nominal vs. threshold

Nominal	Fit mean	% deviation	
10	9.37	-6.3	Threshold 1.0
20	18.86	-5.7	
30	28.29	-5.7	
40	37.71	-5.7	
50	47.03	-5.9	
100	92.48	-7.5	
10	9.88	-1.2	Threshold 0.5
20	19.75	-1.3	
30	29.53	-1.6	
40	39.23	-1.9	
50	48.86	-2.3	
100	95.85	-4.2	

SiD Hadron Calorimeter - Reconstruction

```
<!-- reconstruction for scintillator HCal barrel hits -->
<processor name="HCalBarrelReco" type="RealisticCaloRecoScinPpd">
  <parameter name="inputHitCollections"> HCalBarrelDigi </parameter>
  <parameter name="inputRelationCollections"> HCalBarrelDigiRelation </parameter>
  <parameter name="outputHitCollections"> HCalBarrelReco </parameter>
  <parameter name="outputRelationCollections"> HCalBarrelRecoRelation </parameter>
  <parameter name="calibration layergroups"> 100 </parameter>
  <parameter name="calibration_factorsMipGev">0.022065151036</parameter>
  <parameter name="ppd_mipPe"> 15 </parameter>
  <parameter name="ppd_npix"> 1600 </parameter>
  <parameter name="CellIDLayerString"> layer </parameter>
  <parameter name="Verbosity" type="string"> WARNING </parameter>
</processor>
```

SiD Calorimeter Calibration

- Lowering MIP threshold improves correspondence between nominal and reconstructed energies.
- Some improvement in energy resolution.
- Change to lower threshold (some time penalty?)
- Adjust “MIPGeV” parameter value in reconstruction?