Splitoff Recognition for the Forward Endcap

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Overview

- investigating photon reconstruction in the forward endcap for my master thesis
- mostly working within Ben Salisbury's restructured EMC code
- currently focusing on recognition of splitoff maxima

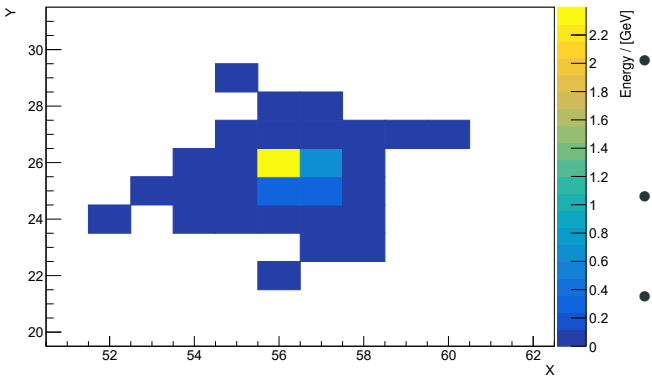
First Step

- developing a reliable way to identify splitoffs based on MC information

Goal

- developing splitoff recognition operating without the use of MC information

What are Splitoffs?



energy distribution in the calorimeter crystals

- statistical fluctuations cause additional maxima in the energy distribution
- splitoff maxima are assigned their own subclusters
- too many particles are reconstructed and the energy of the real particle is slightly distorted

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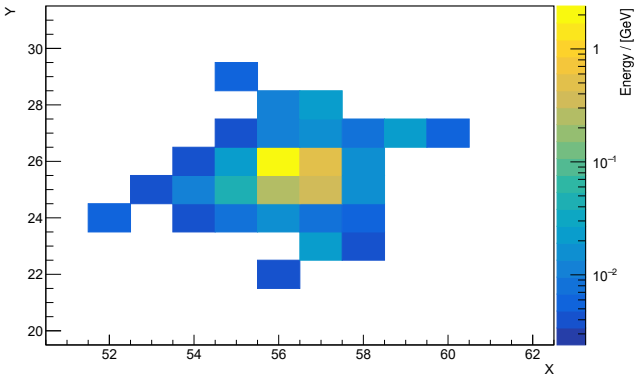

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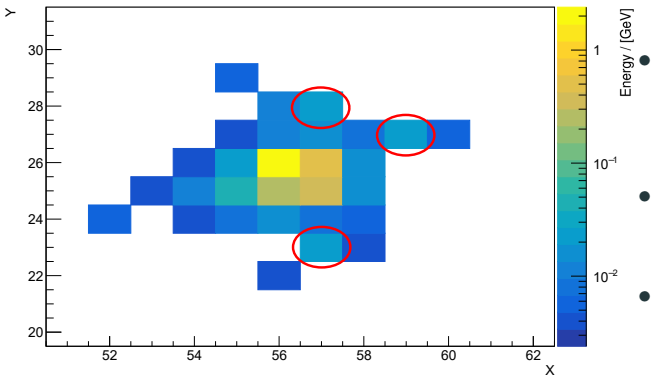

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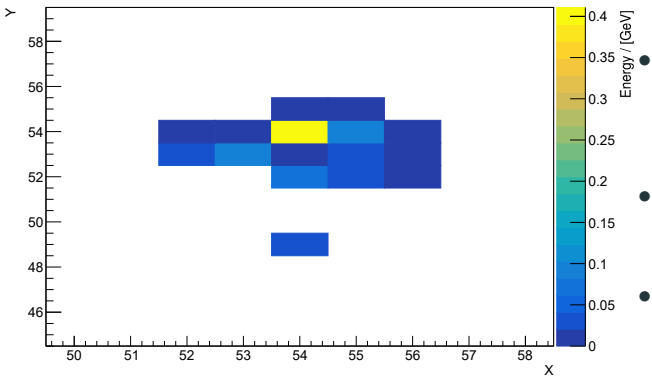

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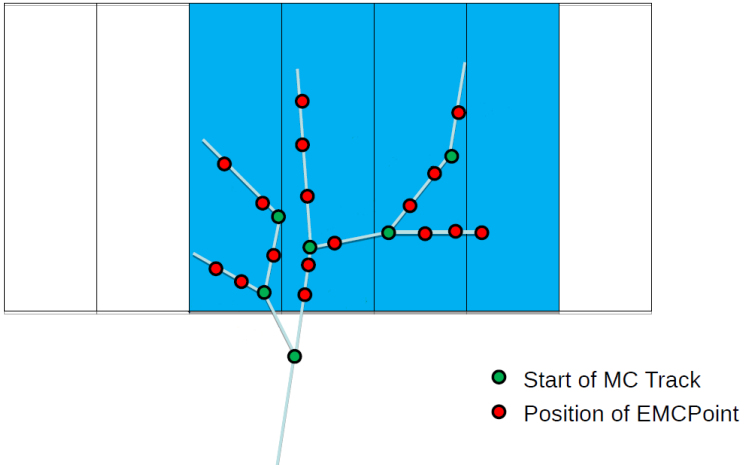
MC Track Matching

- in order to separate real maxima from splitoff maxima, the external MC tracks need to be matched to the calorimeter crystals
- initial implementation based on angles and crystal positions very unreliable

Idea

- match tracks based on energy depositions on MCPoint level
- algorithm for setting cluster Ids in the MCHitProductionProcess, written by T. Stockmanns, already fulfilling similar purpose
  $\rightarrow$ algorithm can be adapted to fit my needs

MC Track Matching Algorithm



[Talk "EMC MC Information" held by T. Stockmanns on 8/24/20]

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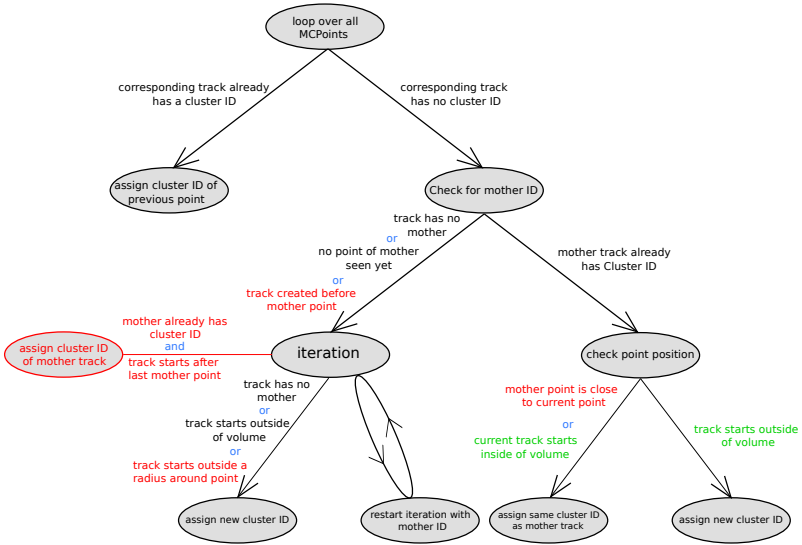

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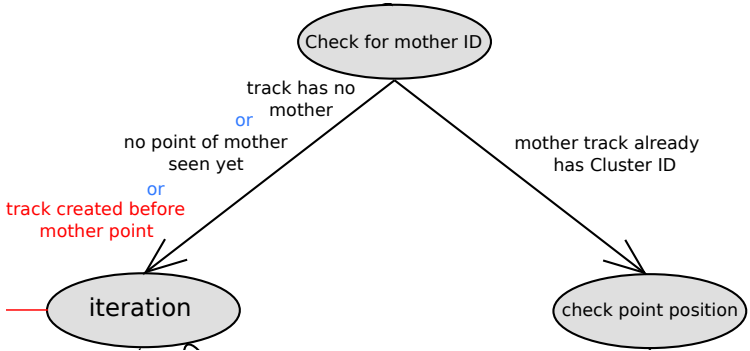

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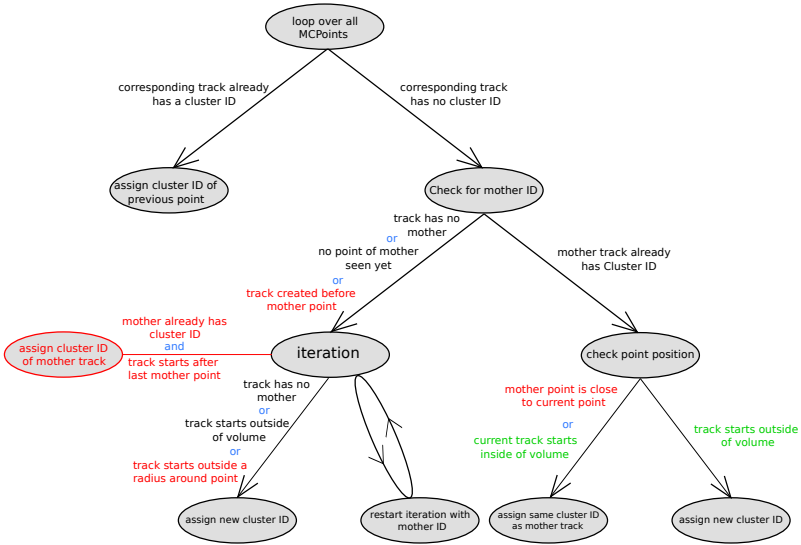

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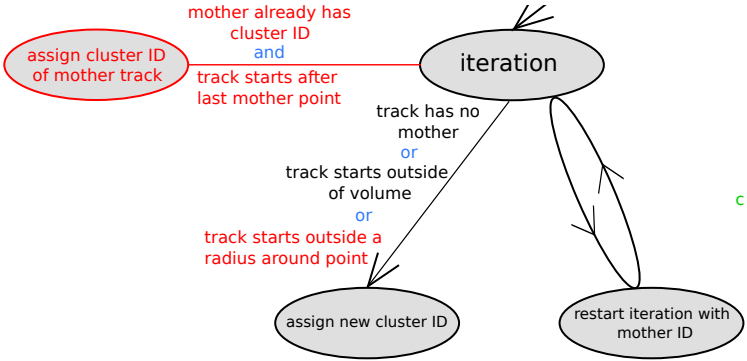

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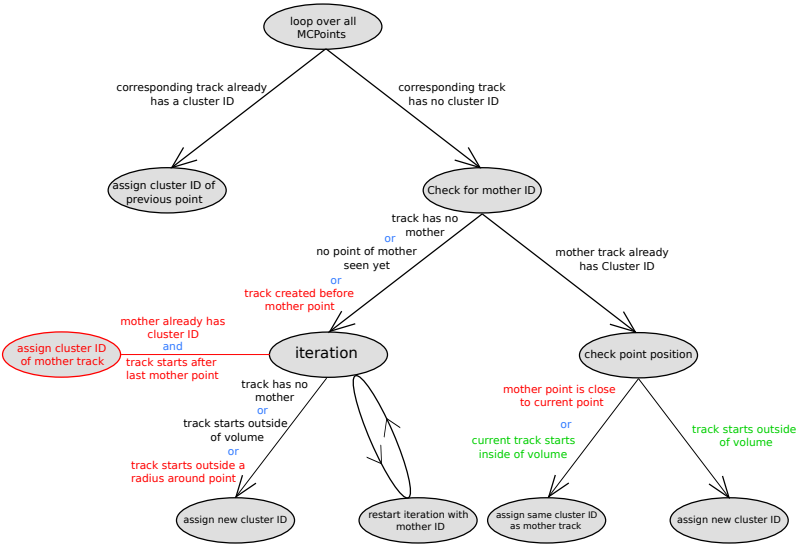

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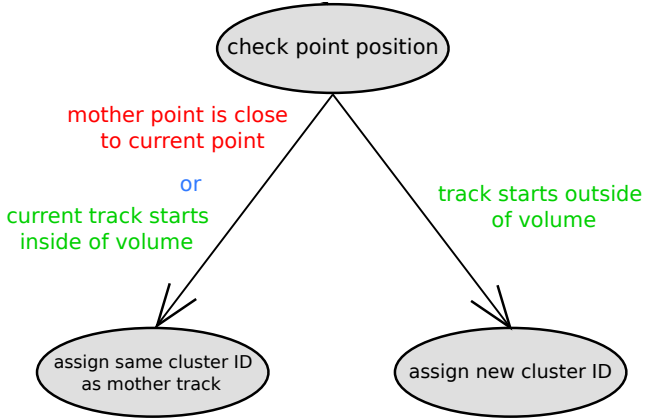
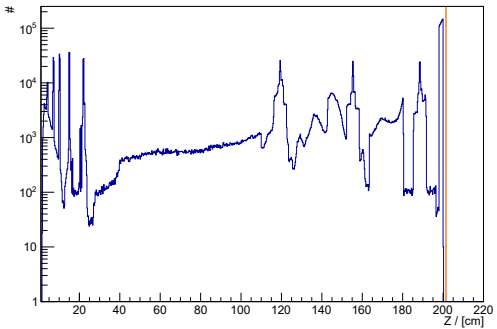


MC Track Matching Algorithm - the Volume



start vertices of tracks responsible for maxima seen in the forward endcap

- the track matching volume defines which tracks are considered external
- the size of the volume can be adjusted in the simulation script
- exemplarily set to only count tracks starting before $Z = 200$ cm as external

Splitoff Recognizer Class

- track matching algorithm stores all external tracks that deposited energy in a specific crystal in the corresponding BSEmcMCHit
- stored tracks need to be filtered for relevant ”maxima-causing” tracks

Splitoff Recognizer Filtering

- BSEmcMCHit must be the maximum in which the track left the most energy
- track must deposit at least $10\,\mathrm{MeV}$ in considered crystal
- crystal in which the track left the most energy must lie within the same cluster

Splitoff Recognizer Class

- give cluster and relevant parameters to recognizer class
- filter all tracks within that cluster
- receive external ”maxima-causing” tracks for maxima

```
for (BSEmcCluster *cluster : fClusterArray->GetVector()) {
  fRecognizer->SetParameters(cluster, fPositionPar, fDetectorName);
  fRecognizer->SetupParameters();
  fRecognizer->FilterTracks();
  for (const DigiInfo &max : cluster->GetMaximaDigis()) {
    std::vector<int> trackids = fRecognizer-> GetTracksForMaximum(max.fDetectorId);
  }
}
```

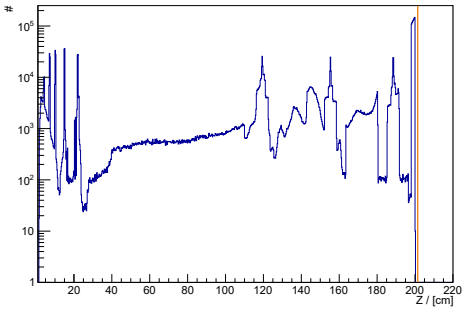
Results

- now it's time to look at some results of this splitoff recognition implementation
- a sensible size of the track matching volume still needs to be chosen

Simulation

- 2 photons with full PANDA setup
- Θ range 0° - 30°
- energy range 25 MeV - 4 GeV

Results - Track Matching - Volume starting at $Z = 200\ cm$



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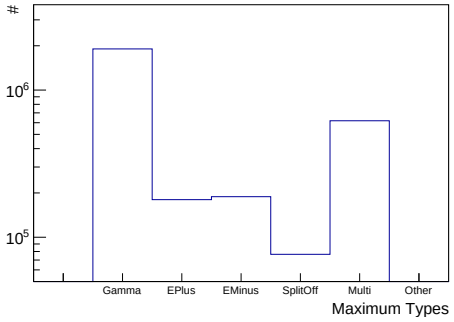
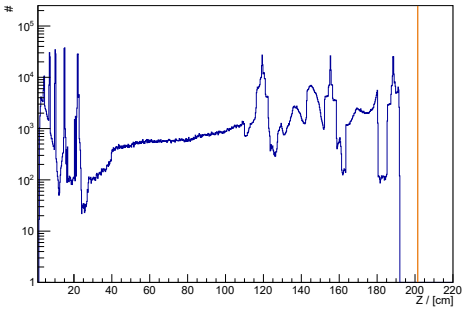
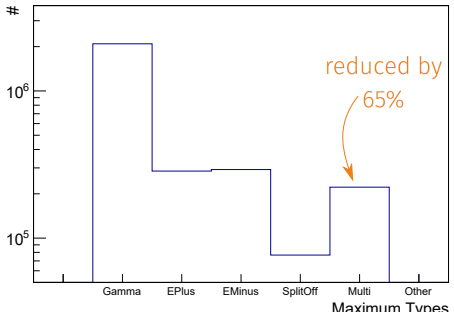


types of maxima seen in the forward endcap

Results - Track Matching - Volume starting at $Z = 192\ cm$



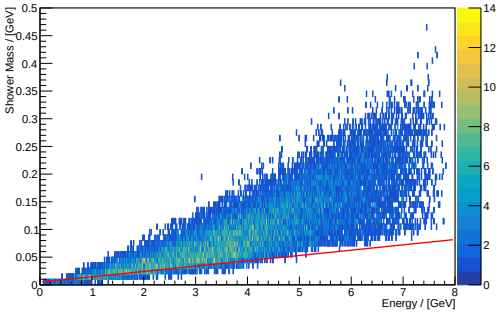
start vertices of tracks responsible for maxima seen in the forward endcap



types of maxima seen in the forward endcap

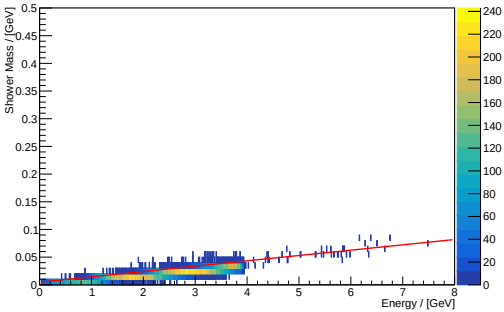
Results - Separation by Shower Mass - only Forward Endcap simulated

96% correctly identified



shower mass vs cluster energy for 2 PED clusters not containing splitoff maxima

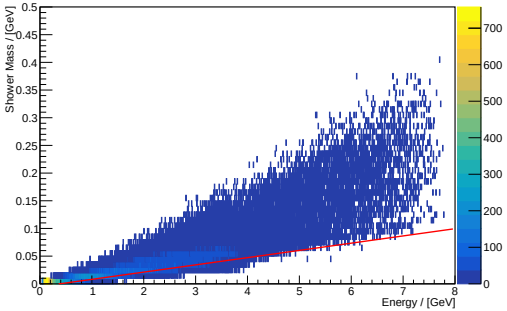
97% correctly identified



shower mass vs cluster energy for 2 PED clusters containing splitoff maxima

Results - Separation by Shower Mass - full PANDA Setup simulated

92% correctly identified



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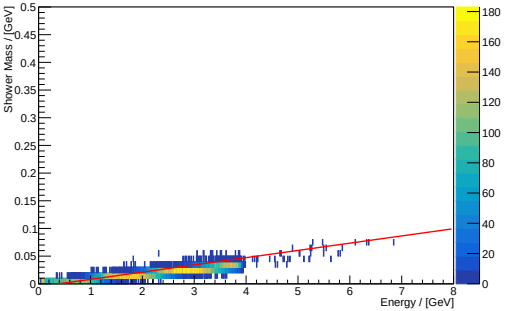

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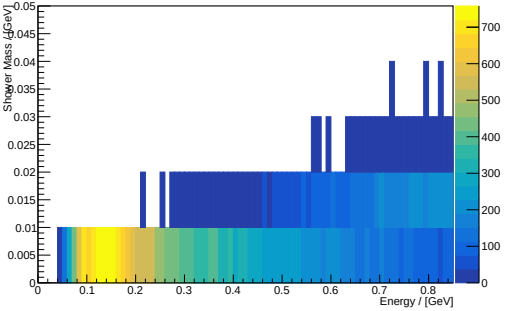

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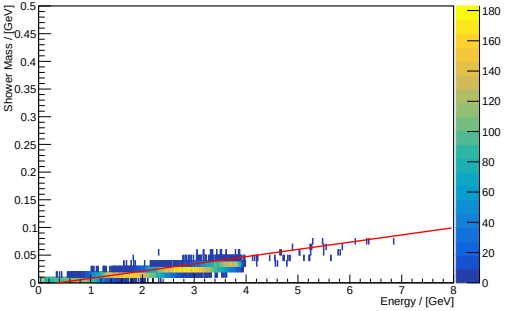

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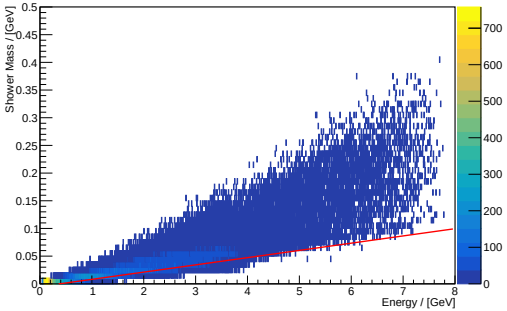

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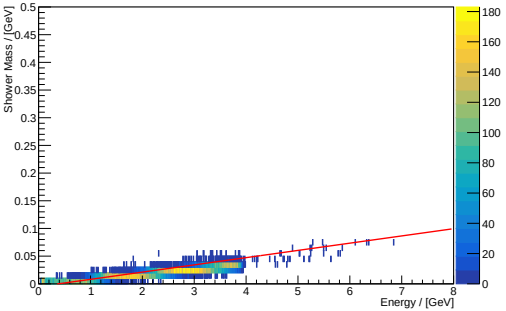


shower mass vs cluster energy for 2 PED clusters containing splitoff maxima

Results - Maximum Threshold

- most splitoff maxima have very low energies
- most real maxima in that region are caused by secondary particles

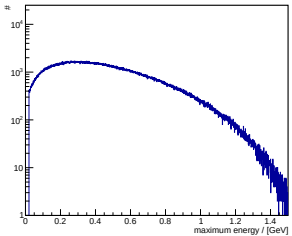
$\rightarrow$ investigate maximum threshold

Simulation

- $p\bar{p} \rightarrow 6\gamma$ with full PANDA setup
- 1.5 GeV beam energy
- 2.25 million events

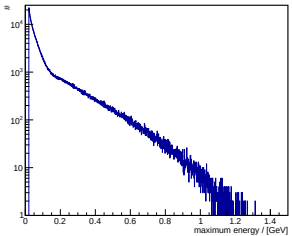
Results - Maximum Threshold 20 *MeV*

1.048m maxima



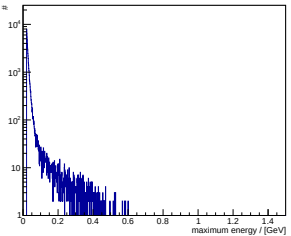
energy of maxima caused by primary particles

780k maxima



energy of maxima caused by secondary particles

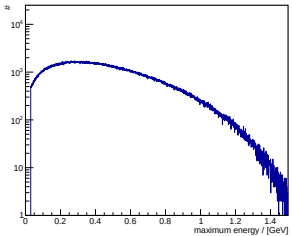
59k maxima



crystal energy of splitoff maxima

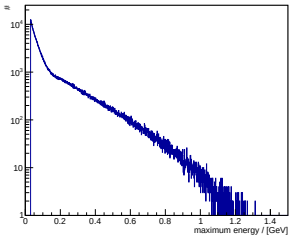
Results - Maximum Threshold 30 *MeV*

1.044m maxima - 4k cut



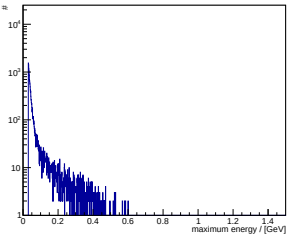
energy of maxima caused by primary particles

613k maxima - 167k cut



energy of maxima caused by secondary particles

18k maxima - 41k cut



crystal energy of splitoff maxima

Summary

Implementation

- track matching algorithm identifies external tracks depositing energy in crystals
- definition of external tracks can be optimized by adjusting track matching volume
- splitoff recognizer class filters linked tracks for relevant ”maxima-causing” tracks

Results

- tracks created within Endcap Disc DIRC produce many ”Multi-maxima”
  $\rightarrow$ are now considered internal tracks
- separation by shower mass shows some promise
- change of the maximum threshold would cut most splitoffs - adjustment reasonable?

Thanks for your Attention!