Energy Histograms

Fluxes determination in calorimeters

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Outline

Introduction

The studies run in ILC require precision in the physics characteristics (energy, momentum...etc.) of key particles like the W,Z and the Higgs bosons. Some studies that quested the reconstruction of the weak-gauge bosons have shown that we almost need a resolution double that of ATLAS and CMS (about 3% is needed). This high quest of resolution made Particle Flow the paradigm on which ILD detector relies in reconstructing complex events.

Particle Flow requires high efficiency in the reconstruction of charged and neutral particles; however, it doesn't require high resolution of individual particles. This puts a demand for a tracker with high efficiency. A calorimeter with a high granularity is also required to separate the

individual particles with high precision because the imaging capability (the separation of individual particles) is not guaranteed by particle flow. This high granularity requires high power supply from the electronics [1].

Problem Statement

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It is obvious from the introduction that we have to calculate two things: the power required from the electronics and the precision in the imaging.

The power depends on two things: the energy deposited by each hit and the number of hits per each event above some energy threshold. Thus, it is necessary to calculate the energy distribution, its range, the energy threshold, and the number of hits above this threshold for each event.

On the other hand, imaging precision can be constrained through the distribution of the time of subhits weighted with their energy (energy as a function of time).

In total, we need 4 histogram sets:

1. Lower-scale energy (to get the low-energy distribution)
2. Upper-scale energy (to get the maximum range of energy)
3. Number of hits above the given energy threshold (to calculate the power of the electronics and the data volume)
4. Time weighted with energy of the subhits (to quantify the imaging capability of the detector)

Code

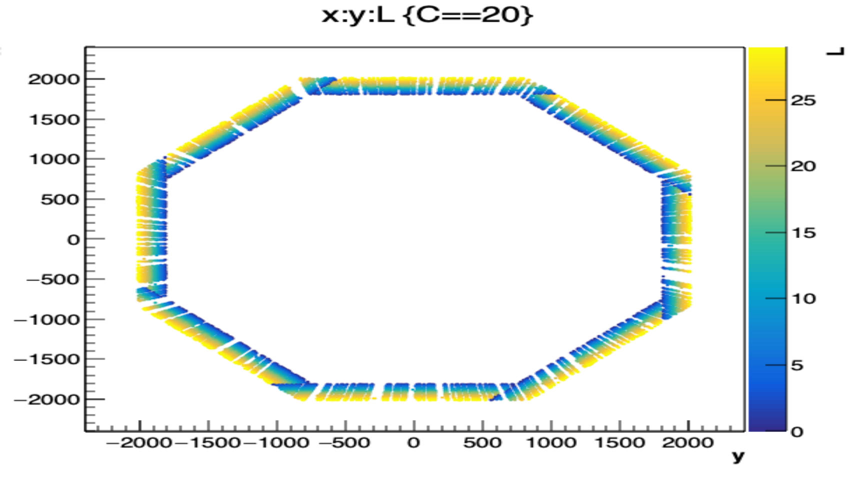
Code

The goal is to develop a code that can produce the desired histograms. However, the detector is extremely big composed of various systems with each system composed of collections then staves, modules, tower, ...etc. Thus, the code must be flexible enough to allow different selections. For example, we can produce the histograms for one system with a specific module and stave, layer...etc.

```
# dictionary_of_system = {"system":[["collections"],[["
    staves"],["modules"],["towers"],["layers"]],[time
    histogram bins,maximum range],[lower-scale energy
    histogram bins,maximum range],[upper-scale energy
    histogram bins,maximum range],[number-of-hits histogram
     bins,maximum range],[[energy threshold]]]
dictionary_of_system = {
    "SiECalEndcap": (
        ["ECalEndcapSiHitsEven", "ECalEndcapSiHitsOdd"],
        [["*"],["0","6"],["*"],["0:9","10:19","20:29"]],
        [[100, 8], [100, 0.001], [100, 0.03], [100, 35]],
        [[0.0002]]
    ),
    "SiECALBarrel": (
        ["ECalBarrelSiHitsEven", "ECalBarrelSiHitsOdd"],
        [["*"],["1","2","3","4","5"],["*"],["0:9","10:19","
    20:29"]],
        [[100, 8], [100, 0.001], [100, 0.03], [100, 35]],
        [[0.0002]]
    ),
}
```

SiECALBarrel (muons)

Figure: SiECALBarrel



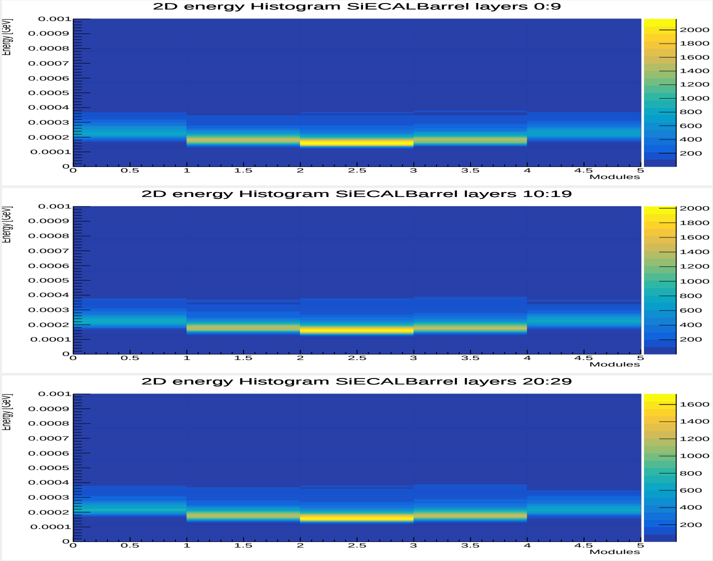
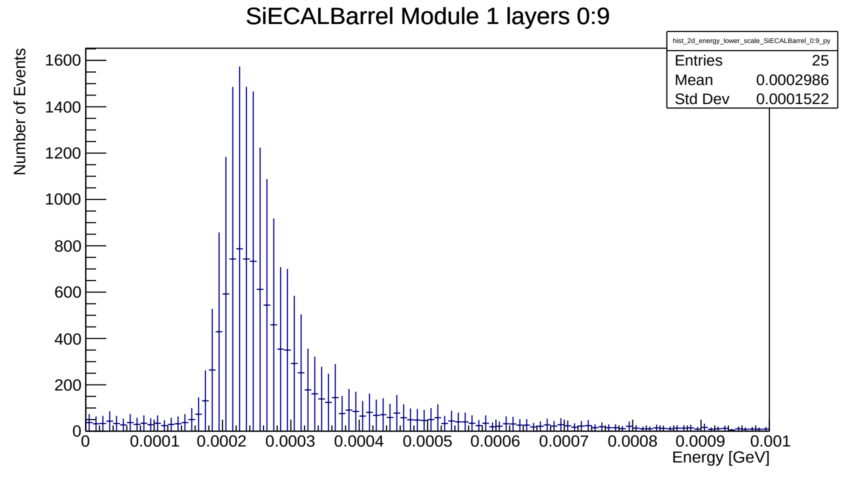
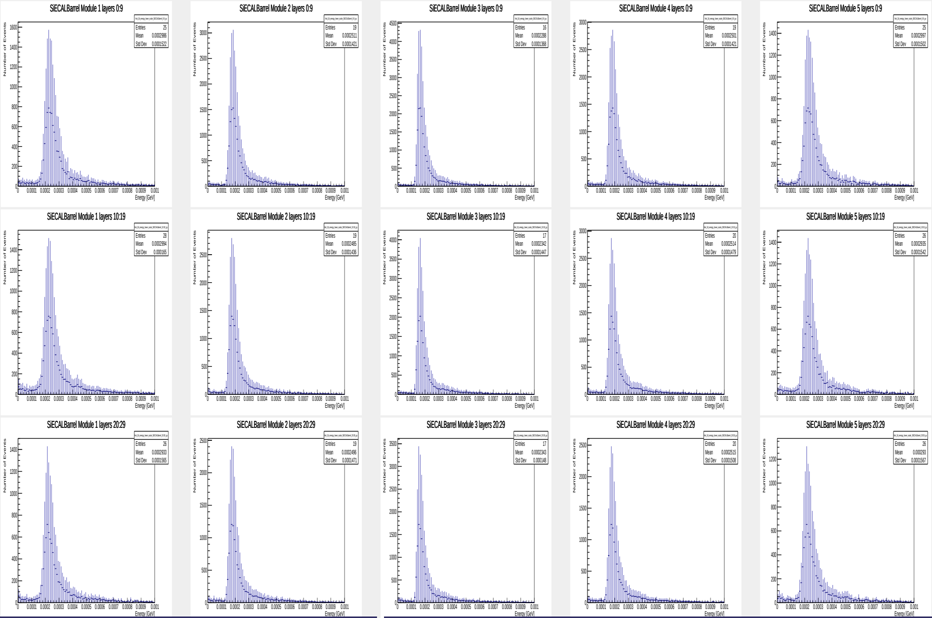

2D energy Histogram SiECALBarrel layers 0:9
Energy [GeV]
Modules
2D energy Histogram SiECALBarrel layers 10:19
Energy [GeV]
Modules
2D energy Histogram SiECALBarrel layers 20:29
Energy [GeV]
Modules

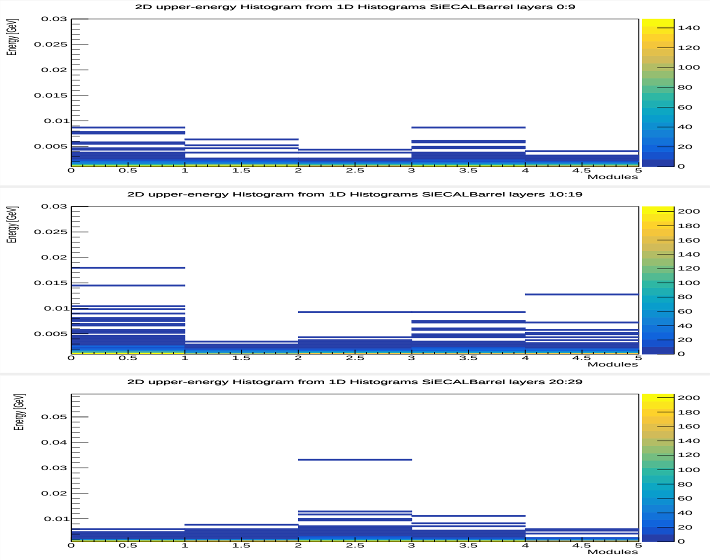
Figure: Example of Landau fit of one of the slices



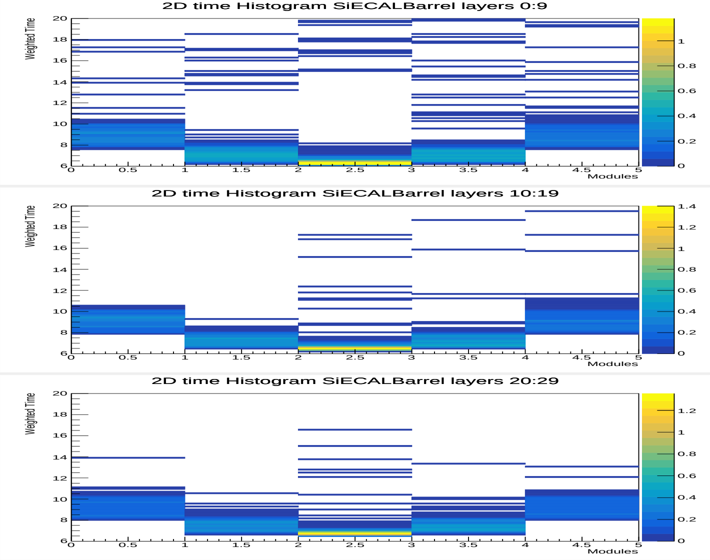
Lower-Scale Energy

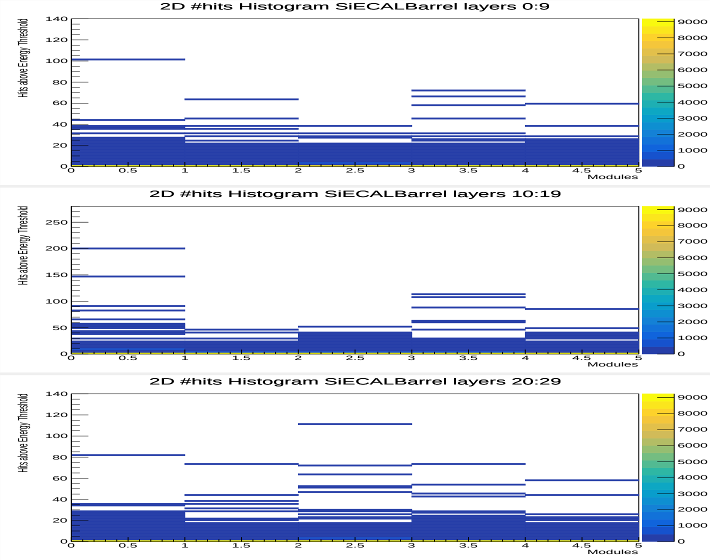


Upper-Scale Energy



Time


2D time Histogram SiECALBarrel layers 0:9
Weighted Time
Modules
2D time Histogram SiECALBarrel layers 10:19
Weighted Time
Modules
2D time Histogram SiECALBarrel layers 20:29
Weighted Time
Modules


2D #hits Histogram SiECALBarrel layers 0:9
Hits above Energy Threshold
Modules
2D #hits Histogram SiECALBarrel layers 10:19
Hits above Energy Threshold
Modules
2D #hits Histogram SiECALBarrel layers 20:29
Hits above Energy Threshold
Modules

ScECalEndcap (muons)

Lower-Scale Energy

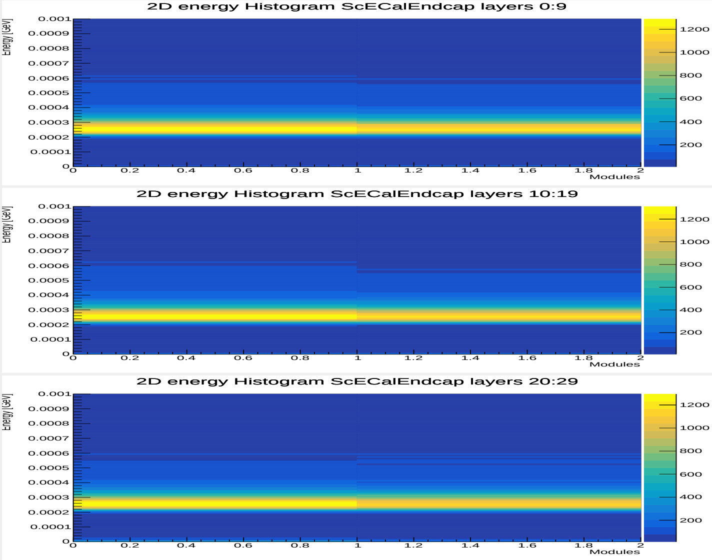
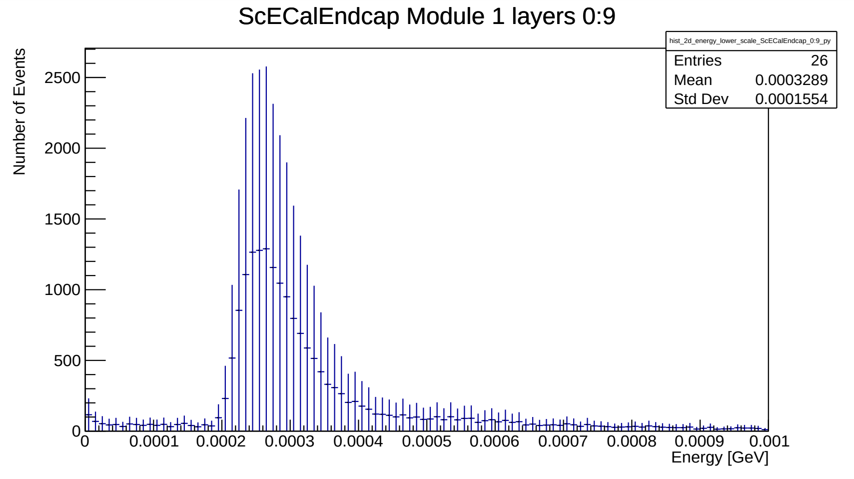
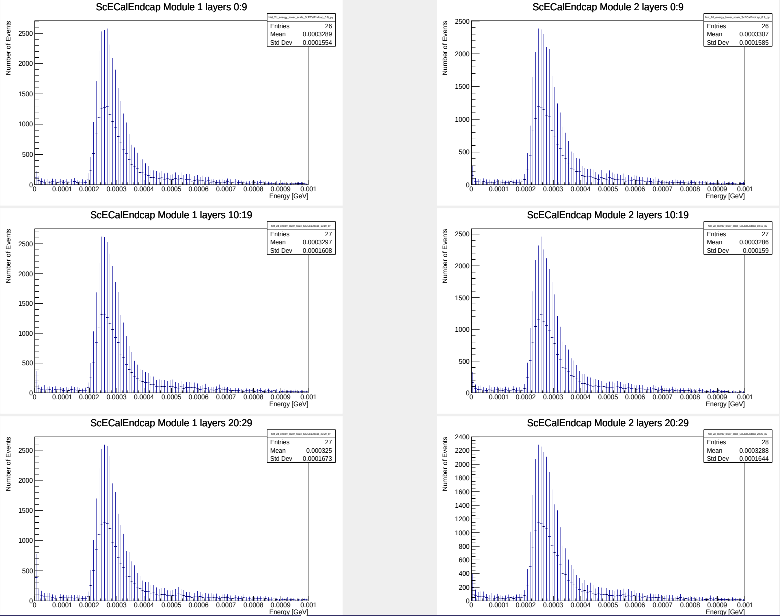


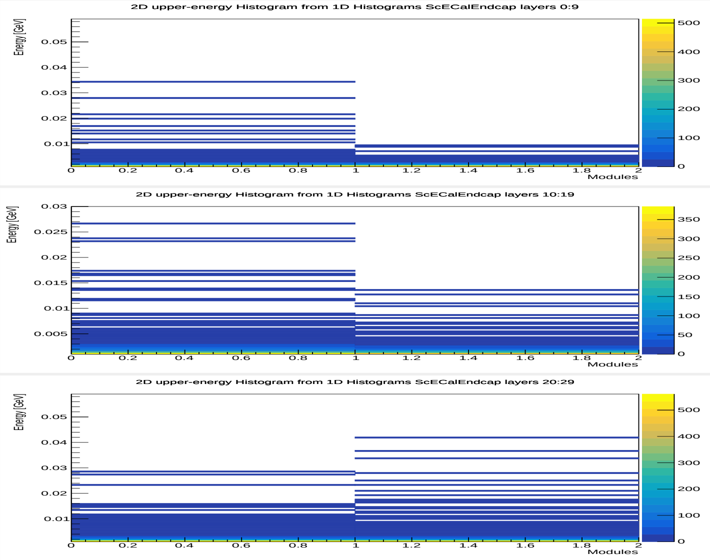
Figure: Example of Landau fit of one of the slices



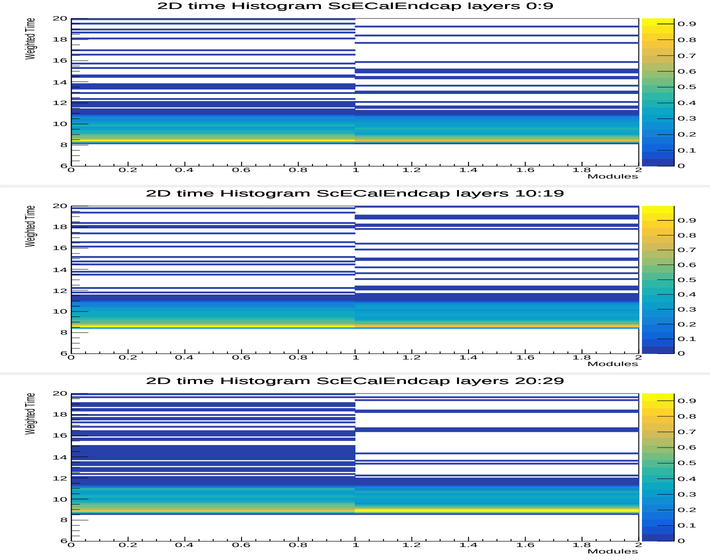
Lower-Scale Energy



Upper-Scale Energy



Time


2D time Histogram ScECalEndcap layers 0:9
2D time Histogram ScECalEndcap layers 10:19
2D time Histogram ScECalEndcap layers 20:29
Weighted Time
Modules

Number of hits above the threshold

SiECALBarrel ($ee \to ZH$)

Lower-Scale Energy

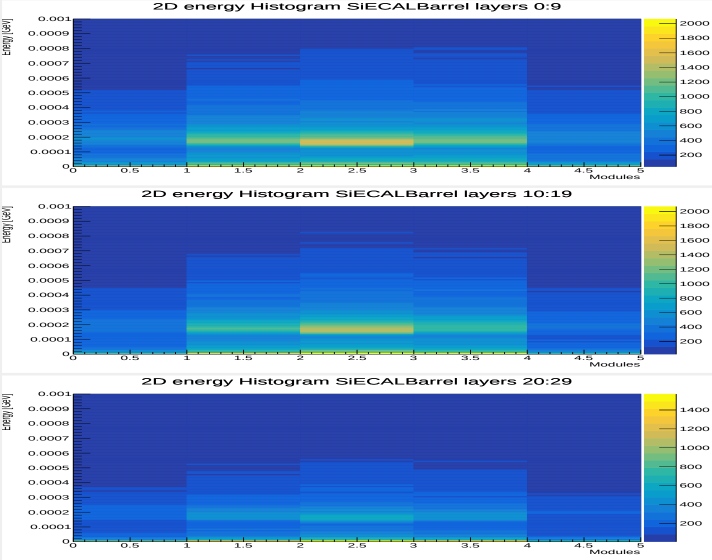
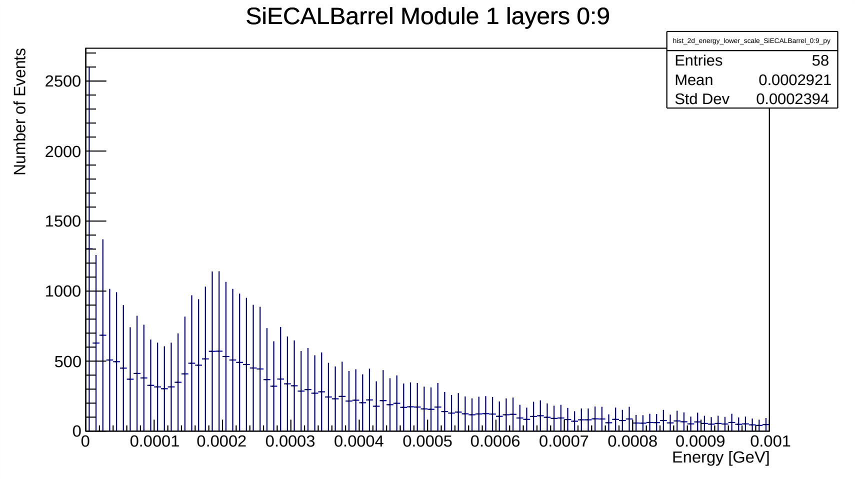
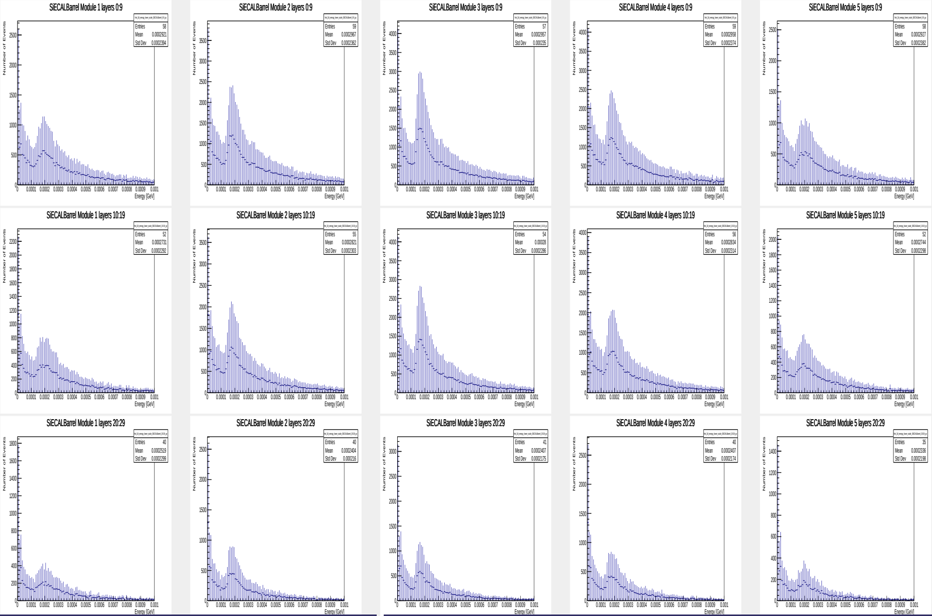


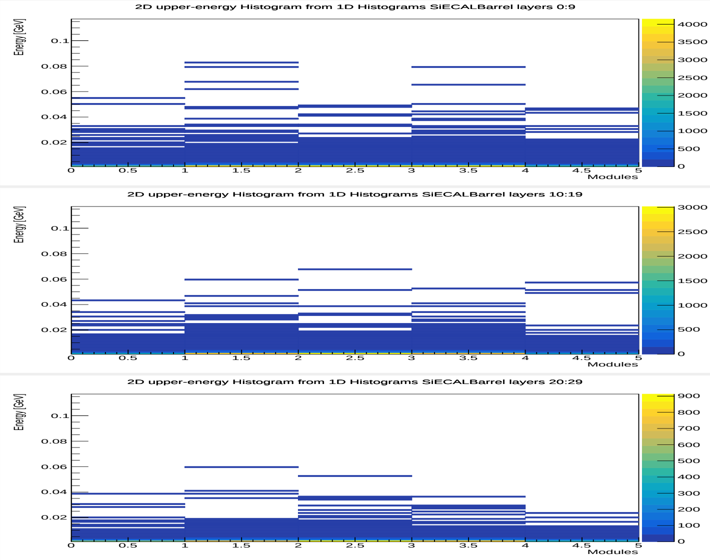
Figure: Example of Landau fit of one of the slices



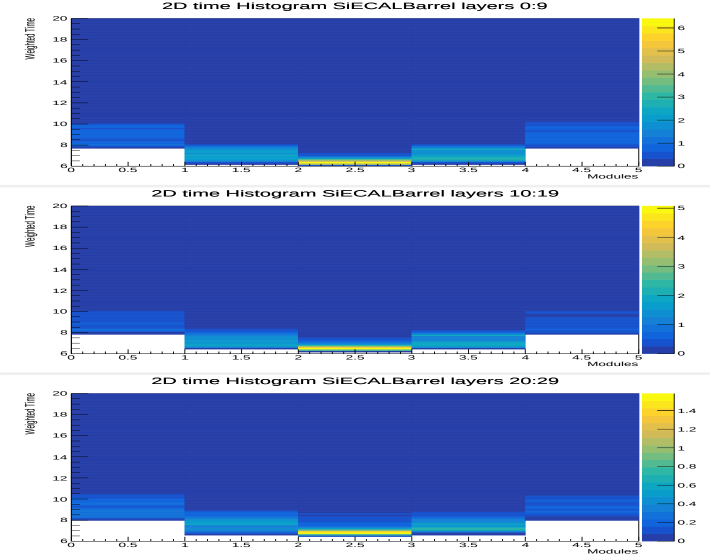
Lower-Scale Energy



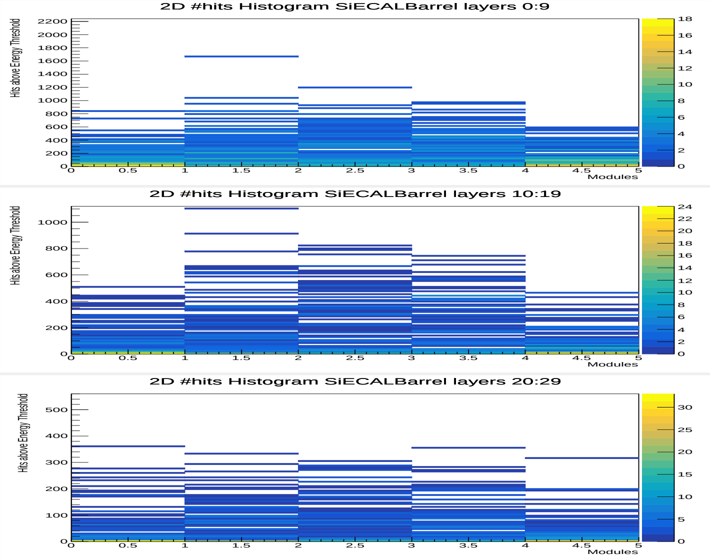
Upper-Scale Energy



Time


2D time Histogram SiECALBarrel layers 0:9
2D time Histogram SiECALBarrel layers 10:19
2D time Histogram SiECALBarrel layers 20:29
Weighted Time
Modules

Number of hits above the threshold

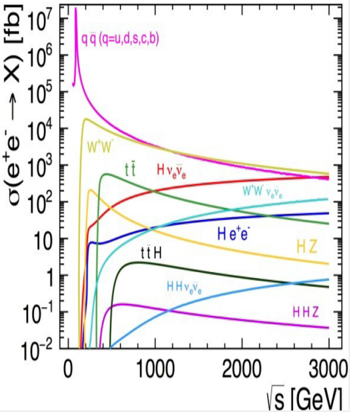


What was done:

- Developed a tool to decode the information of the hits from LCIO and create readable histograms.
- The tool was made flexible to create histograms for any set of selections on the compartments of the detector.
- A wide spectrum of histograms was created for muons and $ee \rightarrow qqH$ on energy of 240 GeV.

What to do:

- Add as input the cross section and instantaneous luminosity from which the time can be calculated. Then, scaling the histograms by this time will make the Y-axis of the histograms be the rate of hits/subhits instead of being the number of hits/subhits.
- Run for all the decays and machine backgrounds.
- Test for various energies.



Thank You!

References I

[1] T. I. Collaboration and contact Ties Behnke, *The ild detector at the ilc*, 2019. arXiv: `1912.04601 [physics.ins-det]`.