Introduction

One of the major research areas of modern physics is that of Quark Gluon Plasma (QGP), the predicted state of the universe shorty after the Big Bang. This state of matter is only achieved under extremely high energies though, which we can only achieve in special circumstances, in particle accelerators. The one that currently has the highest energies is CERN's Large Hadron Collider (LHC).

The LHC is a circular accelerator and works by accelerating and then colliding lead-ions, protons or a proton and a lead-ion. ALICE, one of the four large detectors of the LHC, is where analysis is done on extreme energy densities, where QGP is most likely formed. The big problem with ALICE right now is that its calorimeter has a very rough granularity. This is sufficient for measurements of single particles, but in extreme energy density these collisions generate high particle density and overlapping showers and information about the composition of these showers is lost.

This thesis will look into a proposed upgrade for the ALICE detector, called the Forward Calorimeter (FoCal), and specifically the mTower, a prototype digital sampling calorimeter. FoCal focusses on detection of direct photons emitted from these high energy collisions, which contain information of the initial state. FoCal should provide improved measurements of the properties of QGP and a better understanding of this state of matter.

mTower is based on a silicon-Tungsten sandwich structure made up from Monolithic Active Pixel Sensors (MAPS). In this design, the silicon layers are made up of the MAPS, small pixels of about 30 µm, which light up when a predefined threshold is reached by a passing particle. This way, the energy of a particle is then determined by the number of activated pixels, not by the energy deposited by the particle.

Because of the small size of the pixels even a modest calorimeter with a width of about 4 Moliere radii will already have 39 million pixels, allowing for a very precise measurement of the energy of the particle and its shower. Furthermore, the high granularity will make it possible to separate two showers close together and analyse the shower shapes.

For my research I helped with a week of data taking at the DESY test beam facility in Germany with the mTower prototype. From this data I looked at how precise the prototype was, in particular if it was linear in the energy of the incoming particles and its resolution. I also compared data taken when the particles hit the center of the detector versus when it hit further away from the center, looking at possible fall-off in the data.

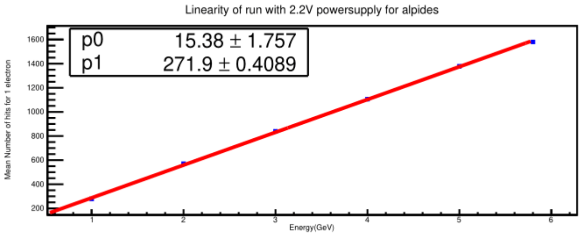
Results

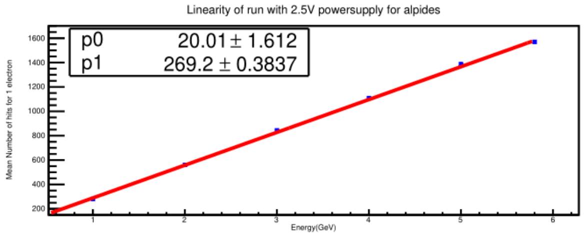
During the week of testing, there were 3 different voltages used for the ALPIDES. Respectively 2.2, 2.3 and 2.5V. As seen in Appendix A, the specific runs {1263, 1276,1262,1274,1261} were done in the different environment of 2.2 and 2.3V. This should have no effect on the data-taking of the chips, but still the linearity and resolution of these runs were tested against runs with 2.5V to the ALPIDES.

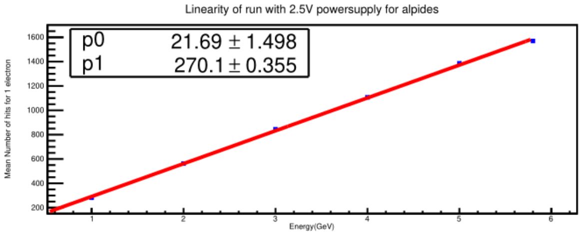
For the linearity and resolution at 2.2 and 2.3V the previously mentioned runs were used. At 2.5V two graphs were made, one using the runs {1336,1337,1335,1338,1333,1310} and one using {1343,1344,1341,1345,1339,1346}. Runs were chosen close together to minimize the influence of the test beam.

Linearity

For the Linearity of the runs the following was produced.







As seen, all 3 runs are linear, but the runs at lower voltage show a significant difference to the ones at a higher voltage. The slope of the two 2.5V runs are both within 2 standard deviations of each other, while the lower voltage runs has a significantly higher slope. The intersection is also much lower at lower voltages.

Appendix A

Hit Distributions of individual runs

1 GeV runs

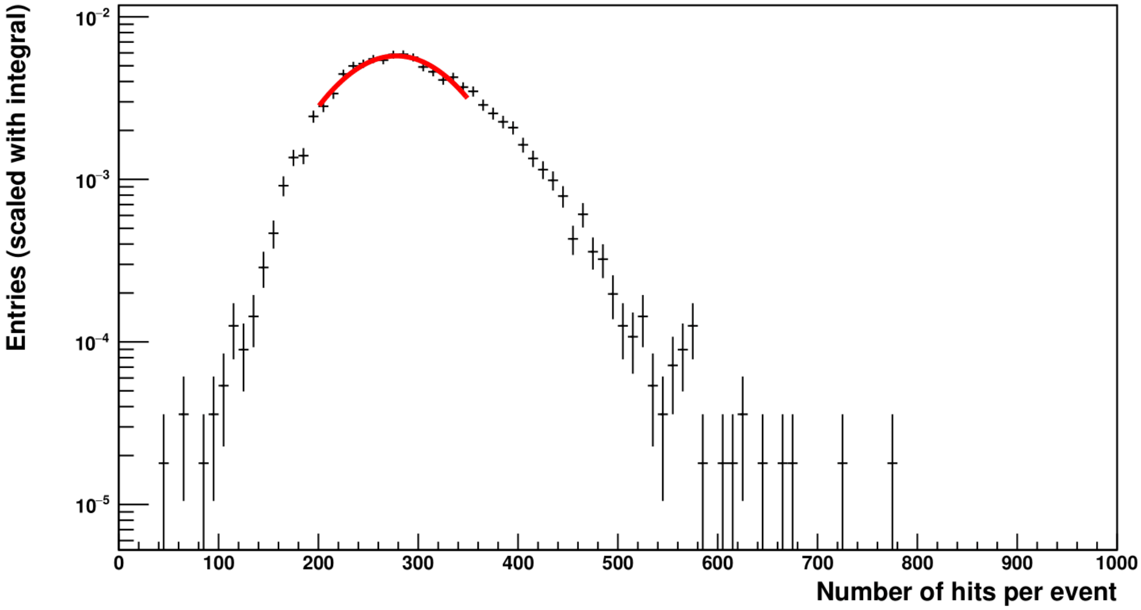


Figure 1: Run 1263

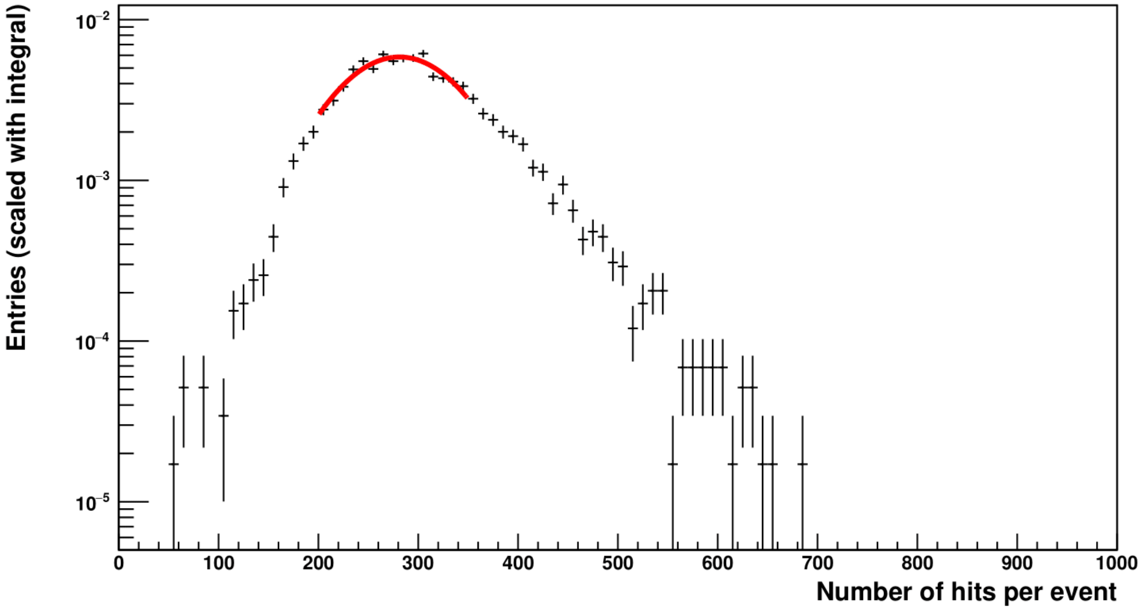


Figure 2: Run 1336

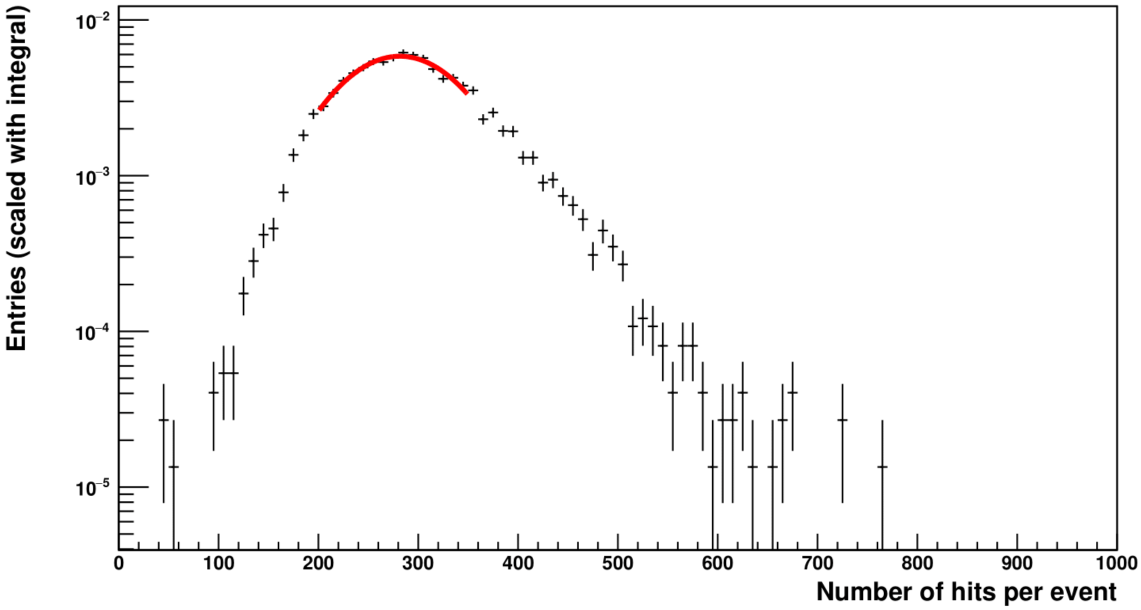


Figure 3: Run 1343

2 GeV runs

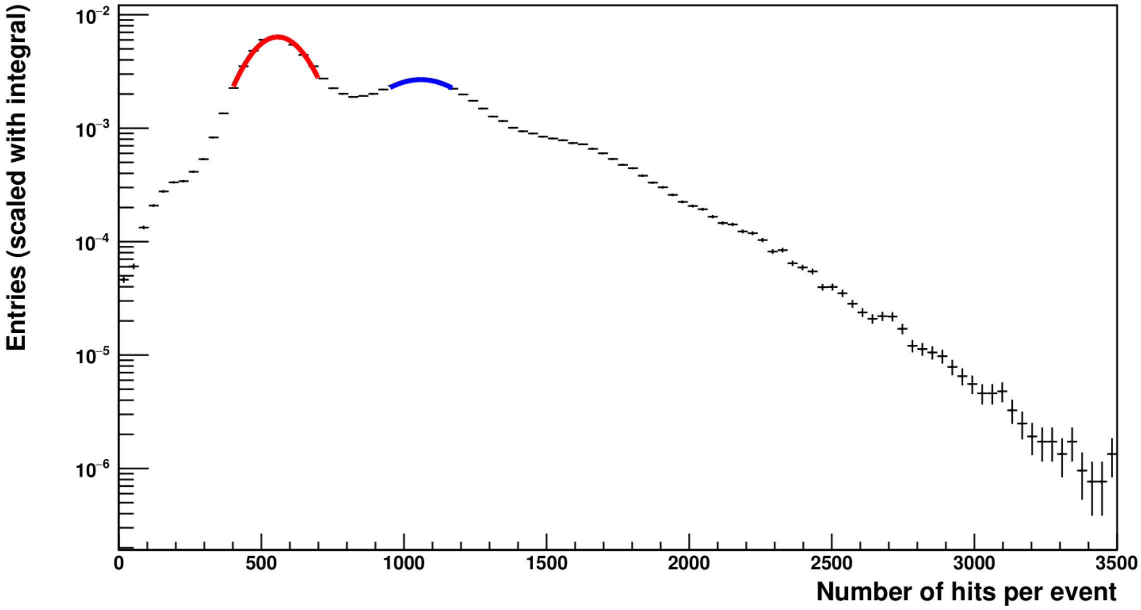


Figure 4:Run 1276

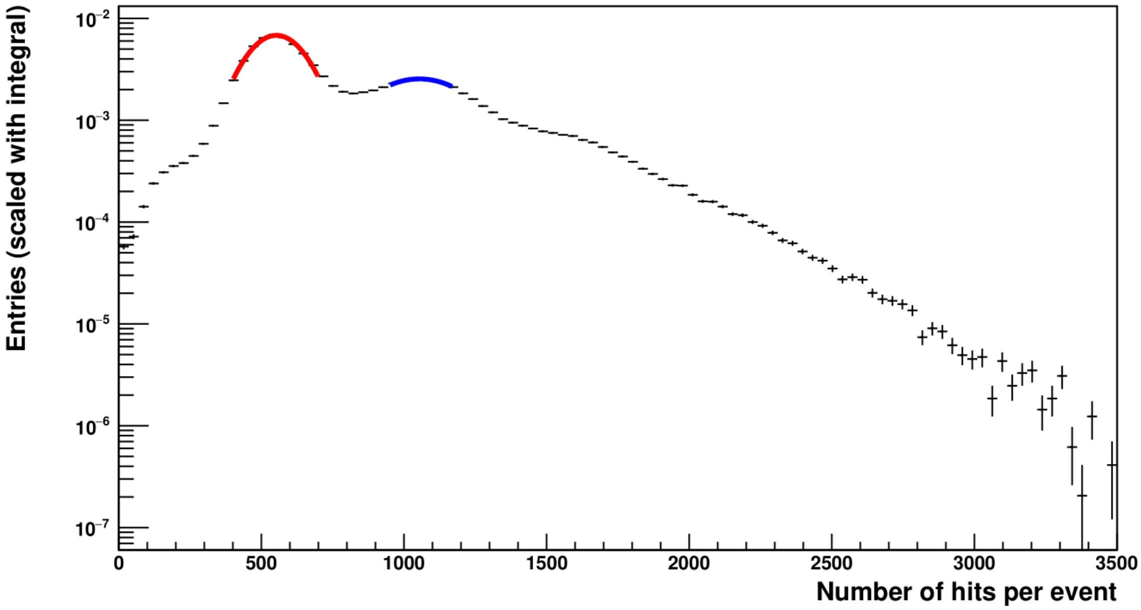


Figure 5:Run 1337

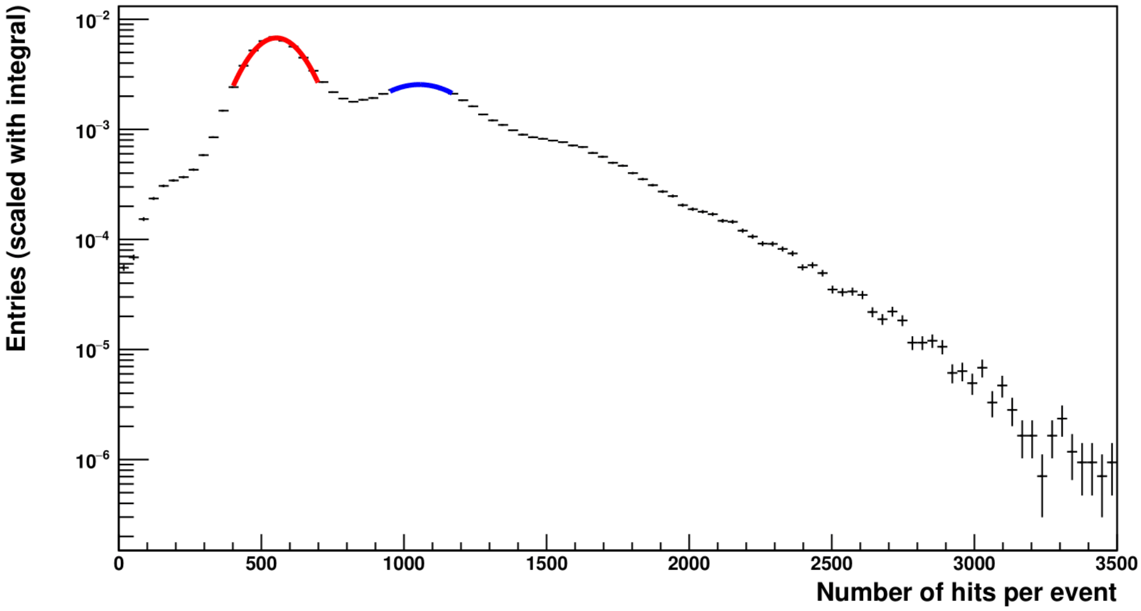


Figure 6:Run 1344

3 GeV runs

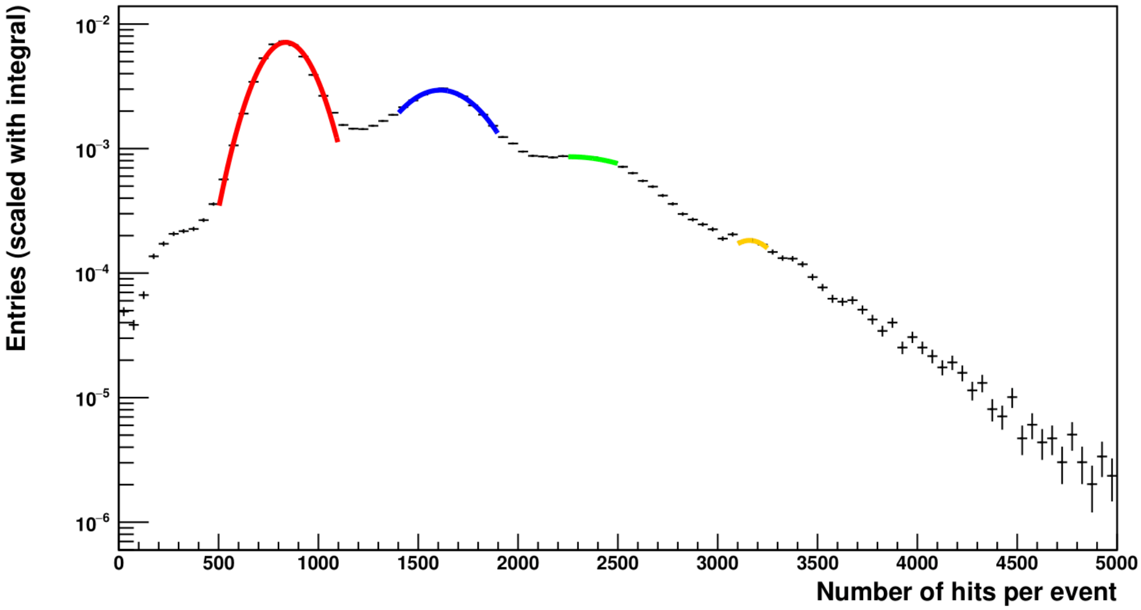


Figure 7:Run 1262

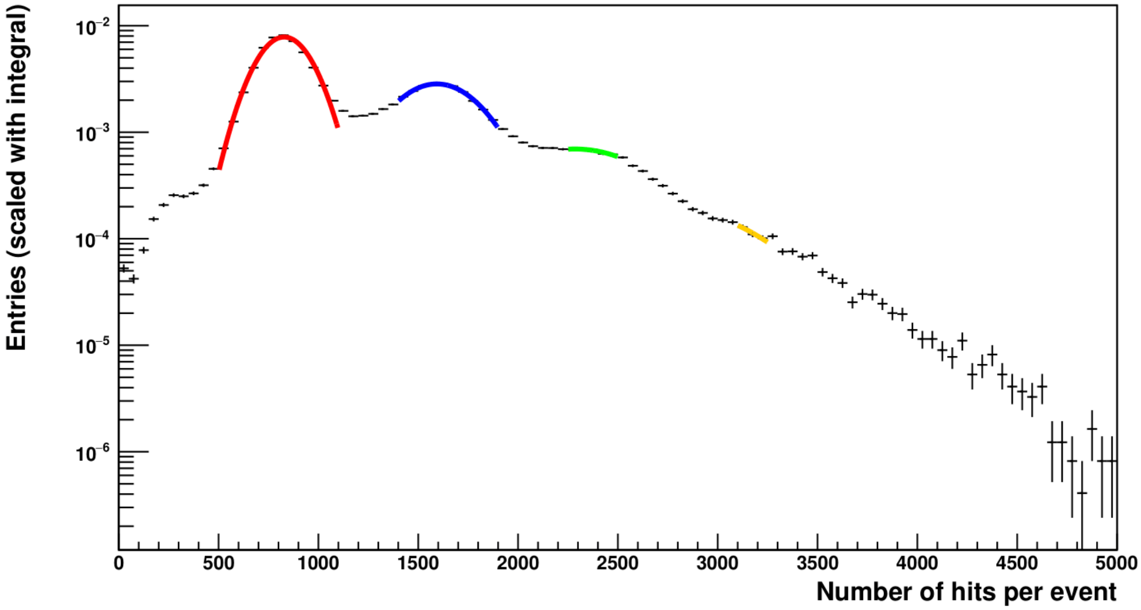


Figure 8:Run 1335

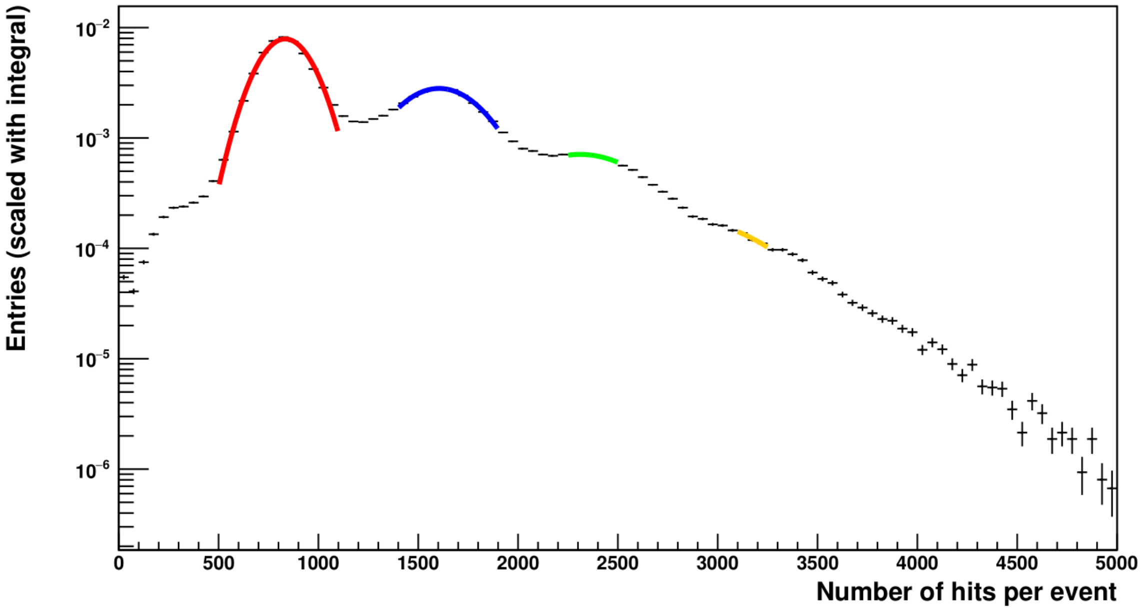


Figure 9:Run 1341

4 GeV runs

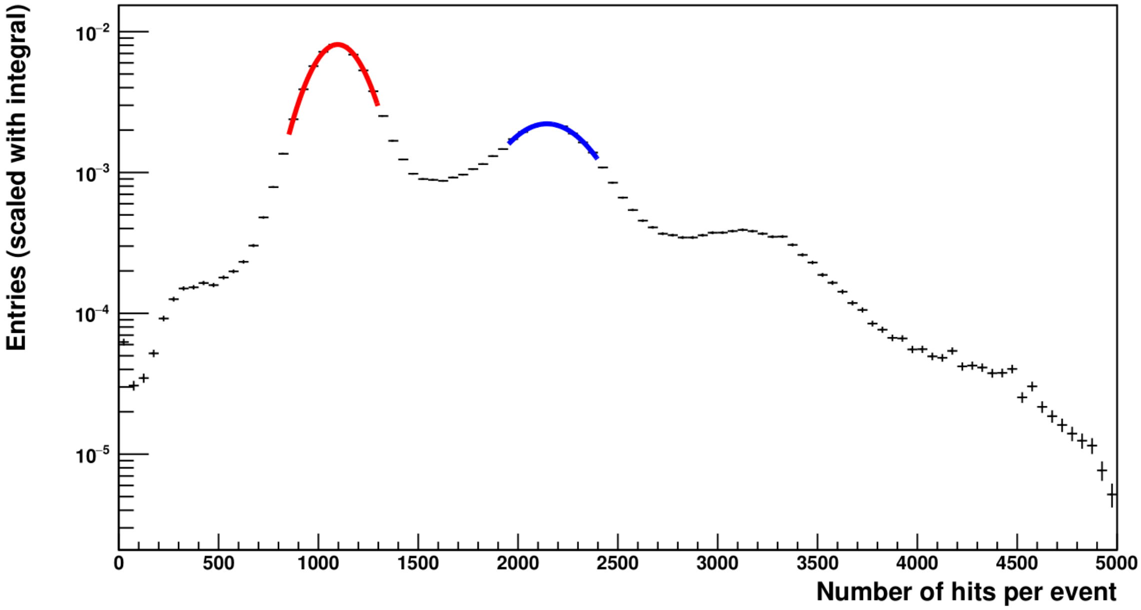


Figure 10:Run 1274

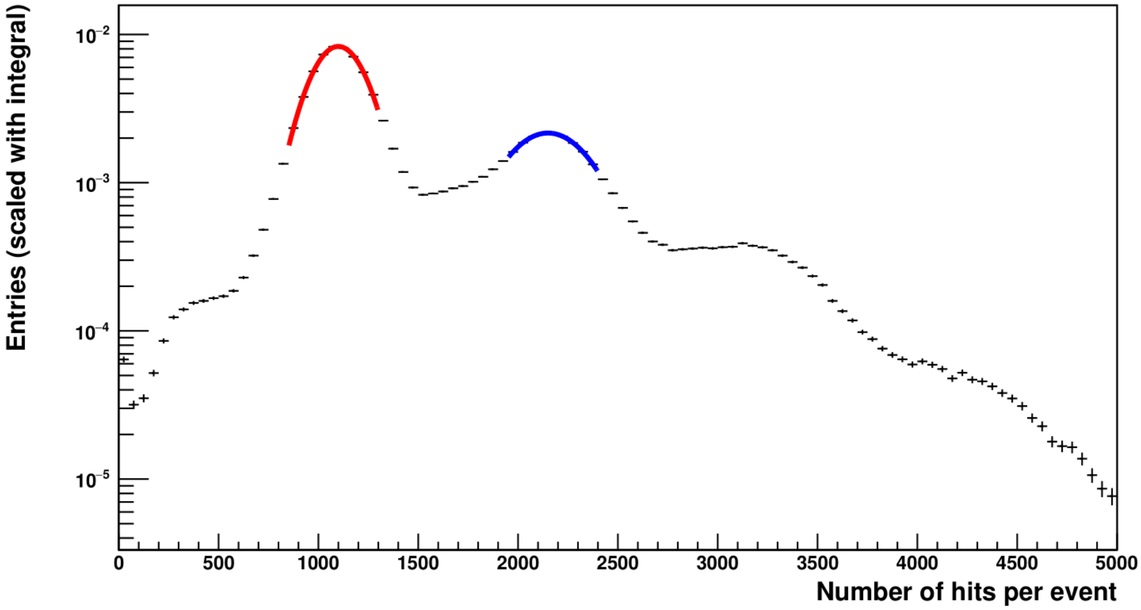


Figure 11:Run 1338

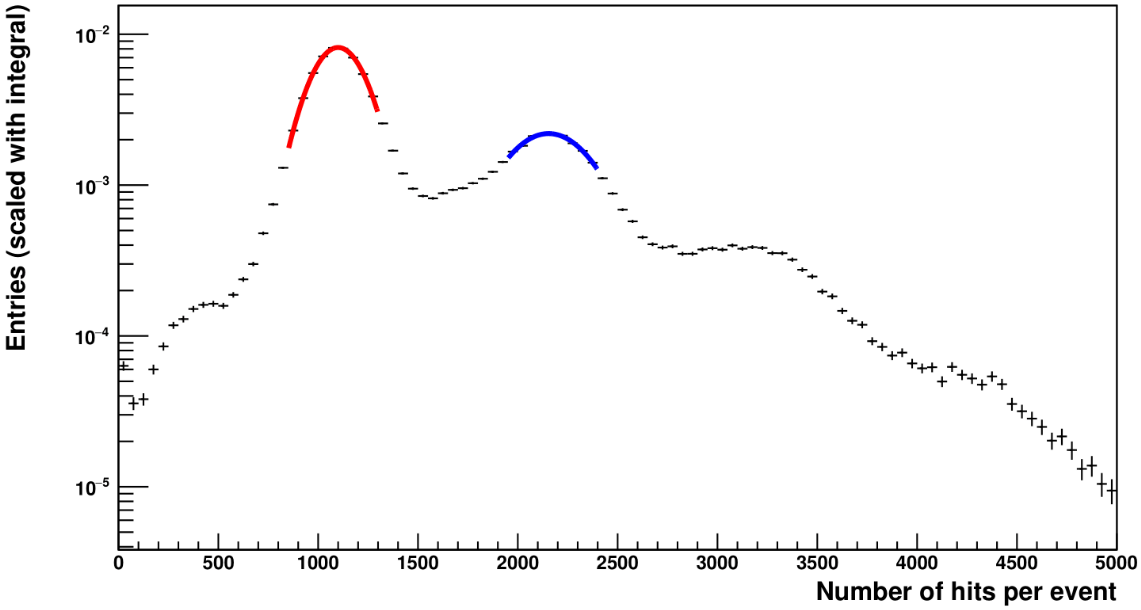


Figure 12:Run 1345

5 GeV runs

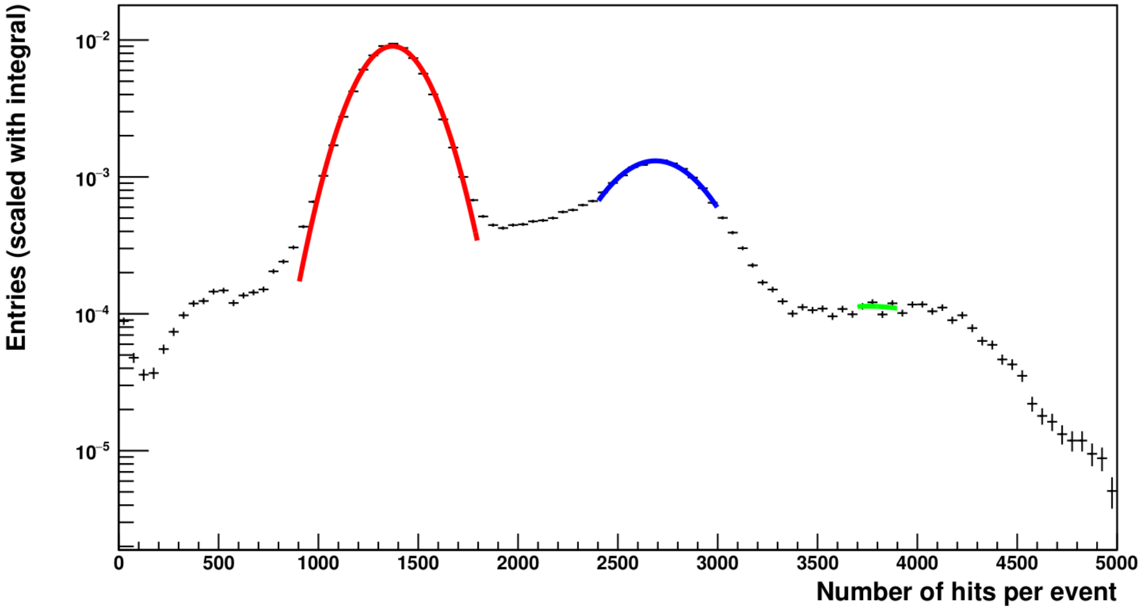


Figure 13:Run 1261

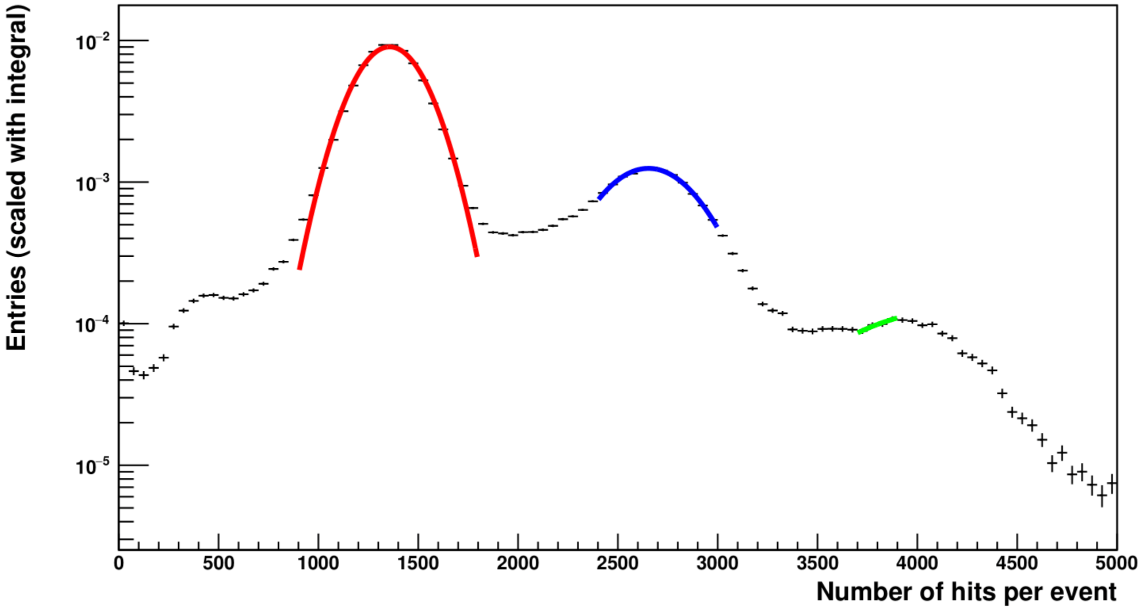


Figure 14:Run 1333

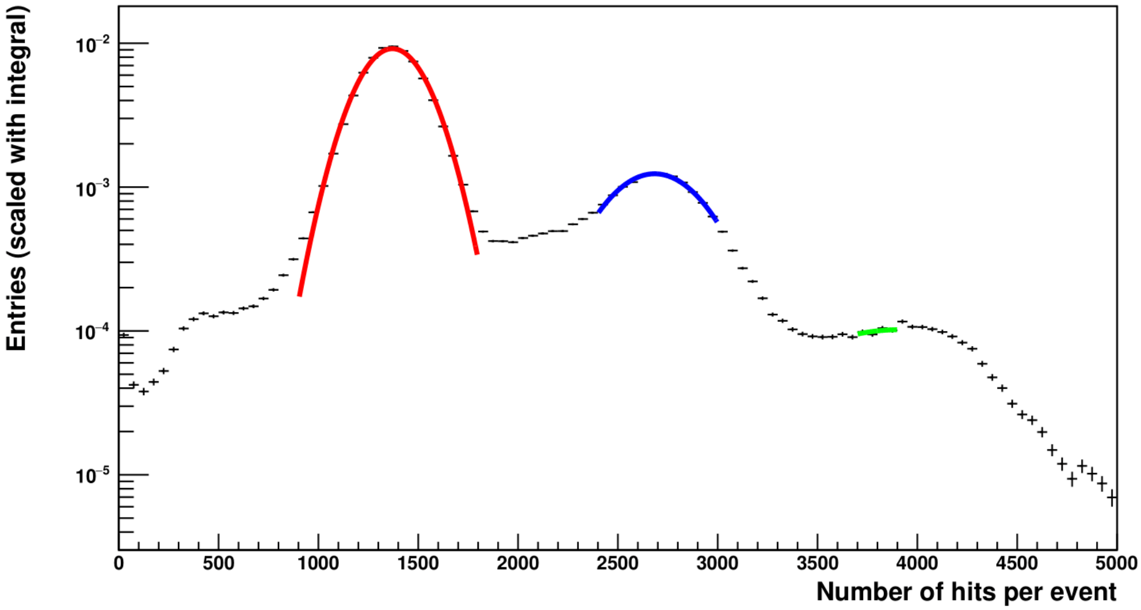


Figure 15:Run 1339

5.8 GeV runs

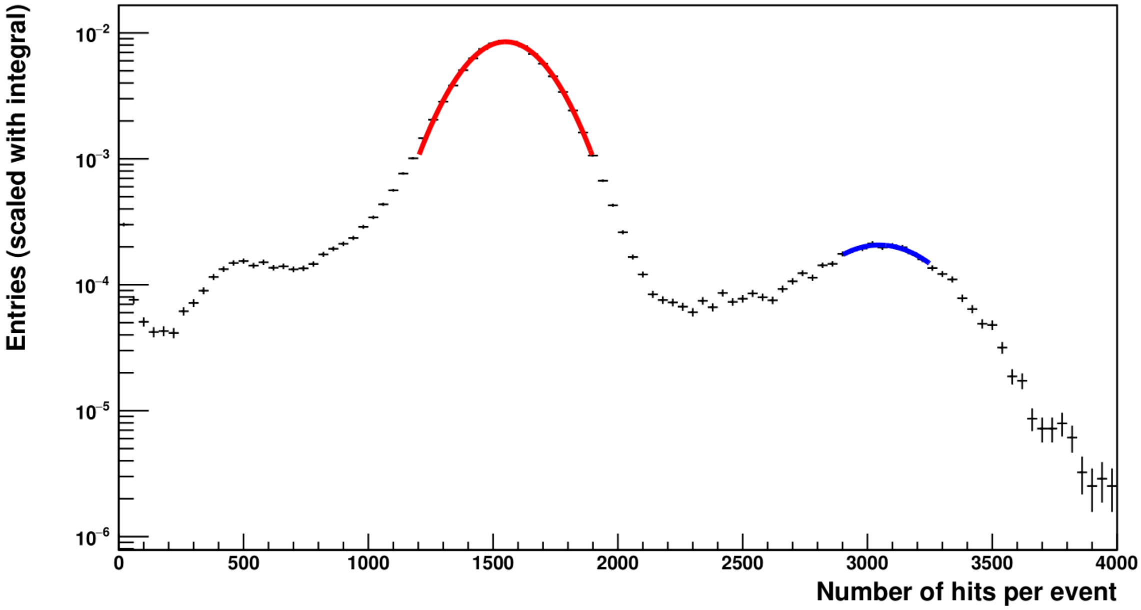


Figure 16:Run 1310

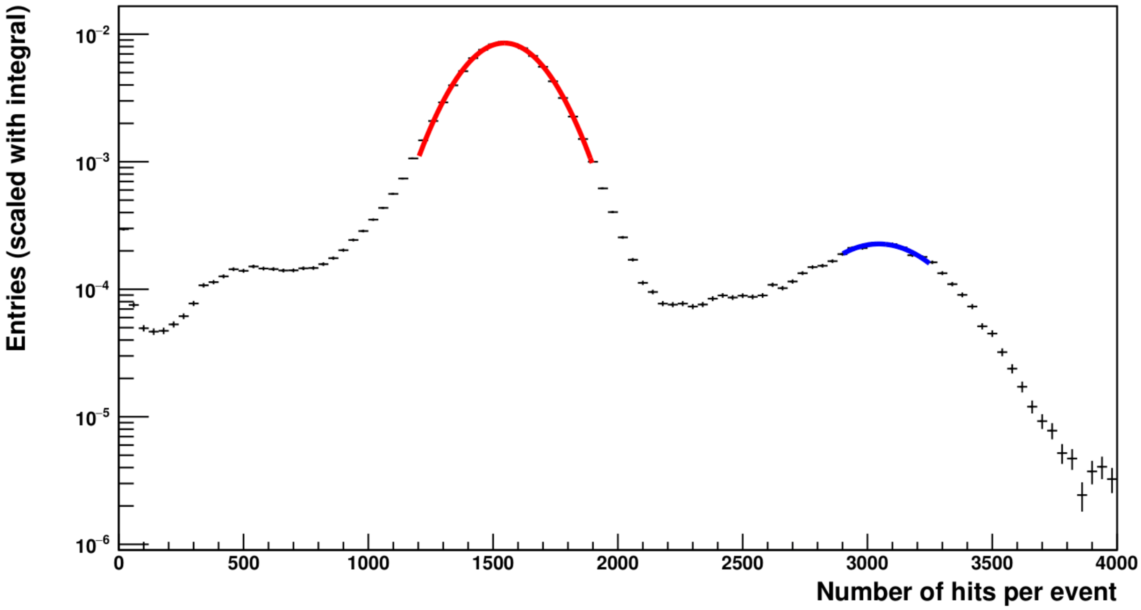


Figure 17:Run 1346