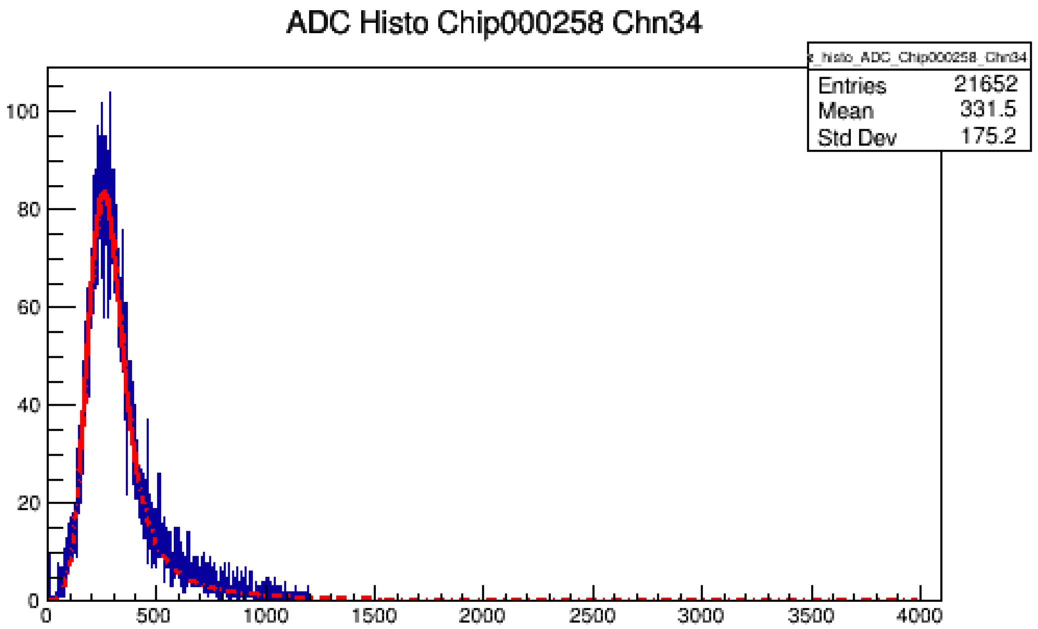
Measurement of MIP signals, determination of the Light Yield

The signal of minimum ionizing particles (MIPs) is used as a reference scale in many detectors, e.g. the AHCAL calorimeter prototype. In this exercise you will measure the signal of MIPs (mimicked by the electrons of the DESY testbeam) in ADC tics. From this you can determine the Light Yield, which describes how many pixels of the SiPM light up for a MIP passing the detector layer. In order to calculate this quantity, you need to know the value of the gain (how many ADC tics correspond to one pixel). You learn in another exercise how to measure that.



Goal:

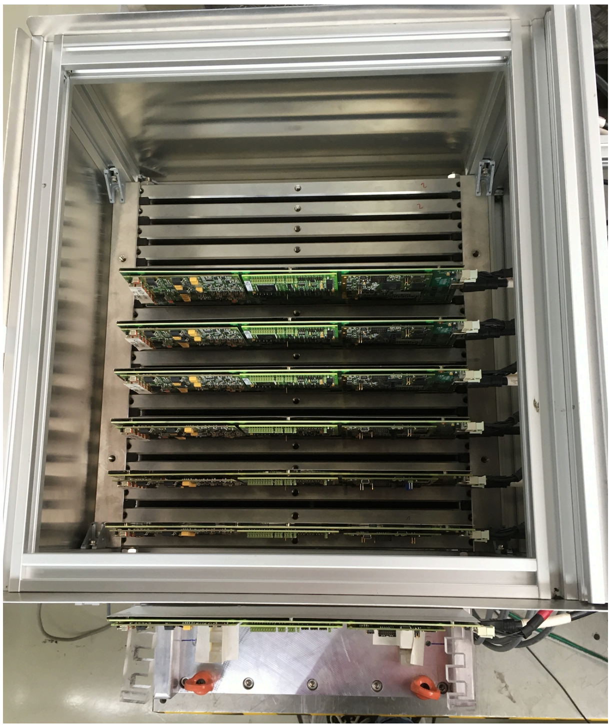
- Learn about MIP signals and Light Yield

Setup:

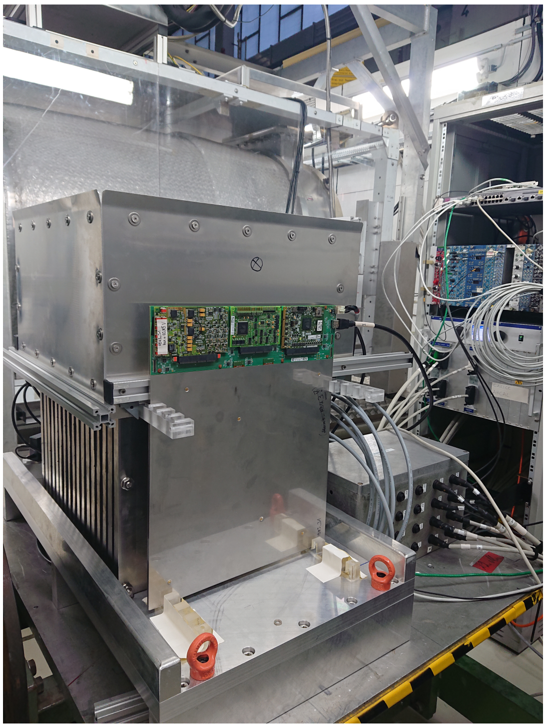
The setup for this measurement is rather complex:

- The detector has 7 layers, 1 in front of the absorber (sees MIPs) and 6 inside the absorber (see electromagnetic showers)
- The detector is configured with a LabView program on a Windows PC
- Runs are started and stopped with EUDAQ on a Linux PC
- The LabView and the Windows PC are inside the beam area. In order to access them during the measurement there is a Linux PC with a rdesktop connection to both in the beam hut.
- The data are copied to a computer farm, the NAF, from a different Linux PC.
- The data reconstruction and analysis are done on the NAF.

Photos of setup:



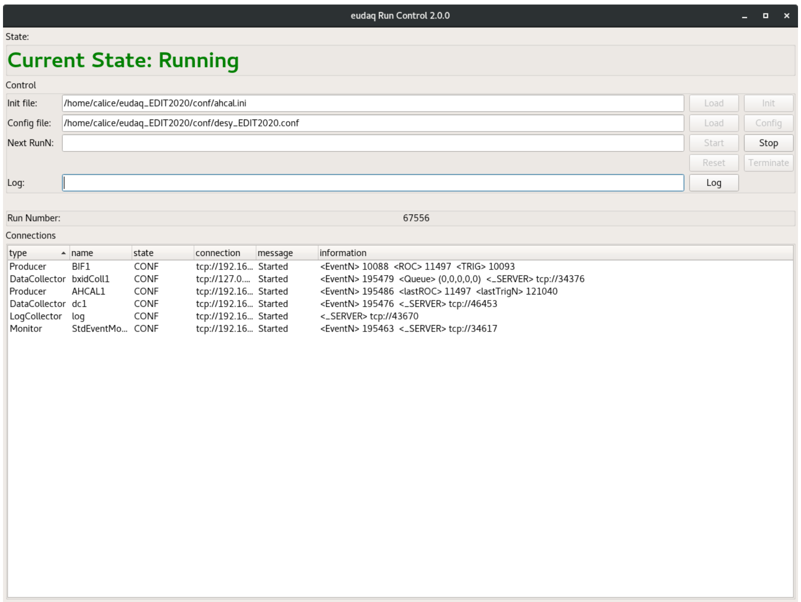
Top perspective



Front perspective

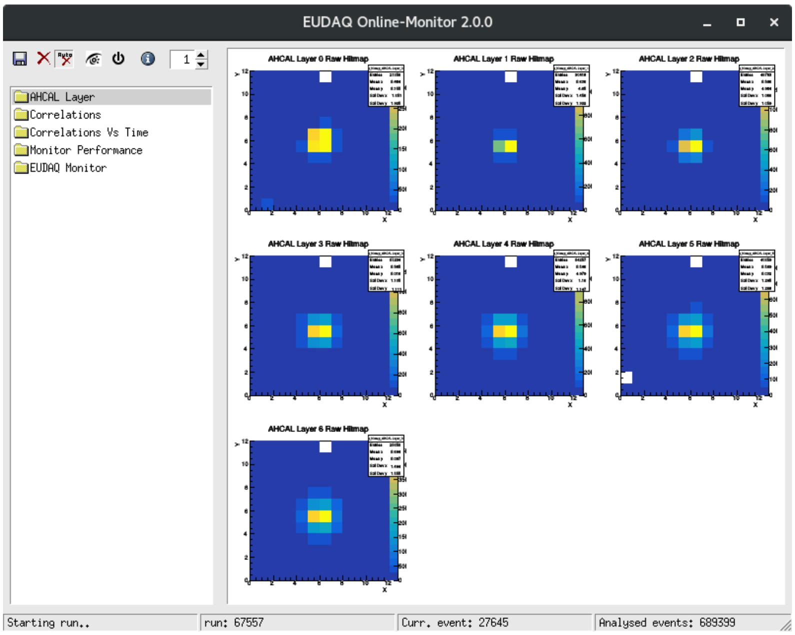
Data taking

- You will take the data together with the group analyzing the electromagnetic shower data.
- The data taking as well as the reconstruction takes some time, so it makes sense to start copying and reconstructing the data already directly after a run is finished. The reconstruction is different for the MIP and the shower data, so you will need to run your own reconstruction.
- For the MIP measurement, typically we use positrons with a beam energy of 3 GeV, where the beam rate is highest. Check if the energy has an influence! Take runs at 1 to 5 GeV in 1 GeV steps:
  - Choose the beam settings (steering of the testbeam magnet)
  - Start a new run in EUDAQ. Let it run for at least 200000 events (as counted for the bxidColl1 collector

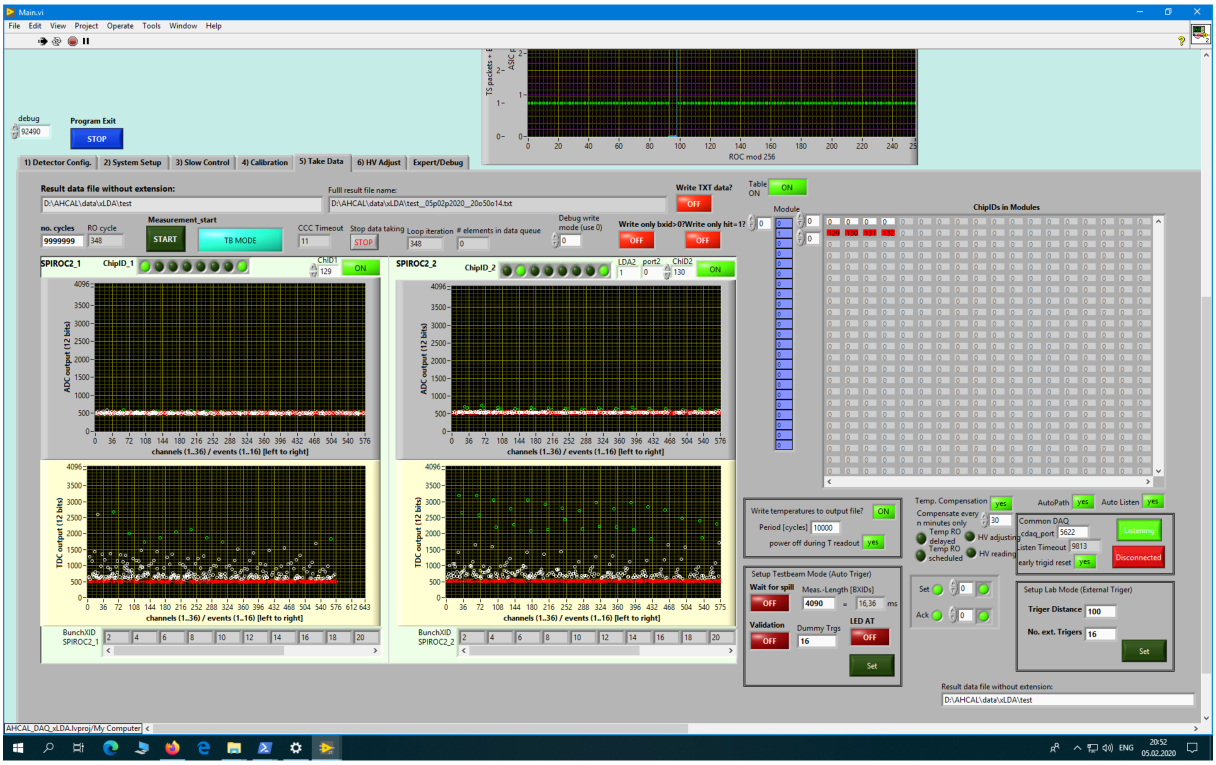


  - Take note of the settings (run number, beam energy, …)

- Check in the EUDAQ OnlineMonitor that the beam hits the detector in the center



- Check in LabView that the AHCAL is actually taking data (points are moving in the “Data Taking” tab)



Copying of the data

On the leftmost PC (flchcallab5) in the beam hut, the directories of the EUDAQ PC are mounted, such that you can copy the data to the mass storage of the NAF.

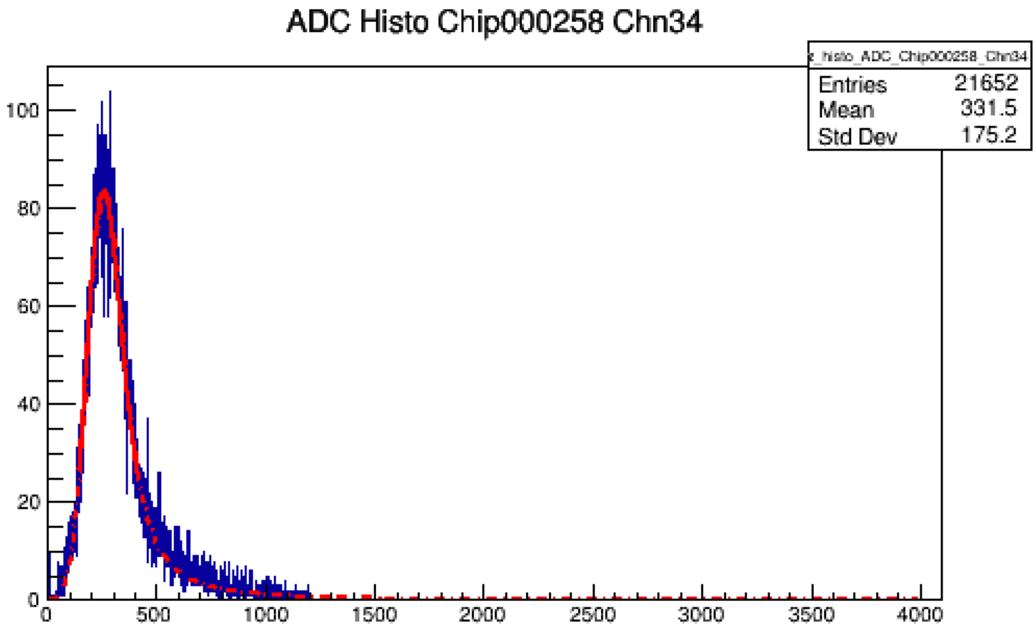
- In /home/calice/EDIT2020/data the directories are mounted, and there is a script to copy the data, copyData.sh
    - Change to that directory: *cd /home/calice/EDIT2020/data*
    - Edit copyData.sh to use your user account (school06 or school07, the following examples will be given for school06) and the run(s) you want to copy
    - Run it: *./copyData.sh*

Analyse the data

The analysis proceeds in several steps:

- **Generating a ROOT Tree from the raw data:** First, the recorded raw data (slcio format) has to be converted into a ROOT tree featuring for example the required information about ADC hit amplitudes of a specific channel.
- **Pedestal subtraction, histogram filling and fitting**: In this step the pedestals are subtracted from the MIP amplitudes (they have been measured before with a high statistics sample, and the values are stored locally on a .txt file). After that, for each channel the amplitude distribution is filled into a histogram and **fitted with the convolution of a Landau distribution and a Gaussian.**
    - do you know why this functional form?

  The most probable value of the fitted function is used as the MIP calibration value for the channel, which is applied in the reconstruction of the shower analysis part to convert the energy to the MIP scale.



- For the mip analysis, open a connection to the NAF:
    - In a new terminal: *ssh -X school07@naf-ilc11.desy.de*
    - Initialise software by *source init_software.sh*
- Change to the directory with the scripts: *cd mip_spectra*
- Edit get_root_tree_MIPS.sh:
    - Put the absolute path of the file you want to process (/nfs/dust/ilc/user/school07/EDIT2020/TBExercise/data/[file].xml)
    - Put the output folder (create before in the same directory, a new folder for each energy is required.)
- Run it: ./get_root_tree_MIPS.sh to create the ROOT tree

- Run the mip_extractor program to do the pedestal subtraction, fill the histograms and perform the fits:
  mip_extractor [output_folder]/mip_tree.root AT_Pedestal_Table.tsv [output_folder]
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- The program creates two files of interest in the output folder:
  - *mipfits.tsv* - A table of the fitted channels featuring the following fit parameters:
    - MPV: Most Probable Value (maximum of fit)
    - lw: Landau width
    - gw: Gaussian width
  - *fitted_mip_spectra.root* - a ROOT file with all fitted spectra of the channels
- Look at the fits: How many channels could be fitted properly with sufficient statistics? What is the MIP value (MPV)?
- Compare the MIP values from file *mipfits.tsv* for different beam energies. For this you have to repeat the previous steps for each measured beam energy.
- Calculate the light yield with the gain values provided in *gain_values.tsv*. What do you think about this value, is it small or large?