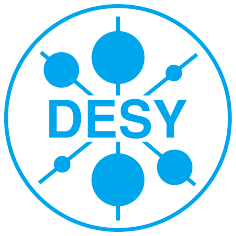
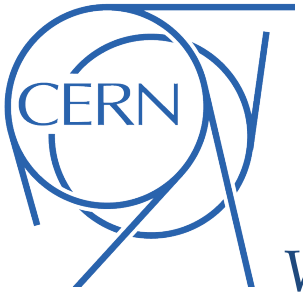
CALICE Tungsten HCAL Prototype status



Erika Garutti



Wolfgang Klempt

Erik van der Kraaij

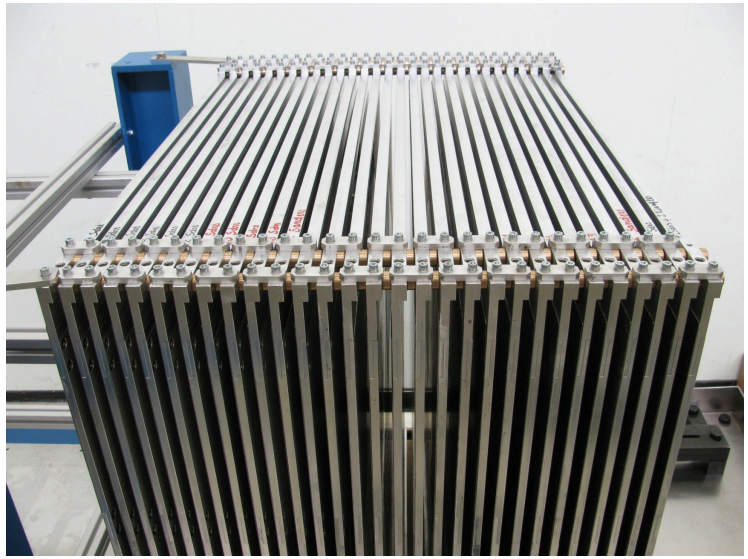
CERN LCD

International Workshop on Linear Colliders 2010, October 21

WHCAL experimental setup

CALICE hadronic calorimeter installed at CERN with:

- 30 plates of 1 cm thick tungsten as absorber
- 3x3 cm scintillator tiles as active material with SiPM for readout
- Alternative detector technologies will join in parallel with the normal data taking



Now being commissioned in a muon beam and will move in November to the T9 testbeam line at the CERN-PS (1-10 GeV).

Goal of the test:

- Prove the technology of using tungsten as absorber in an HCAL
- Validate hadronic shower simulations

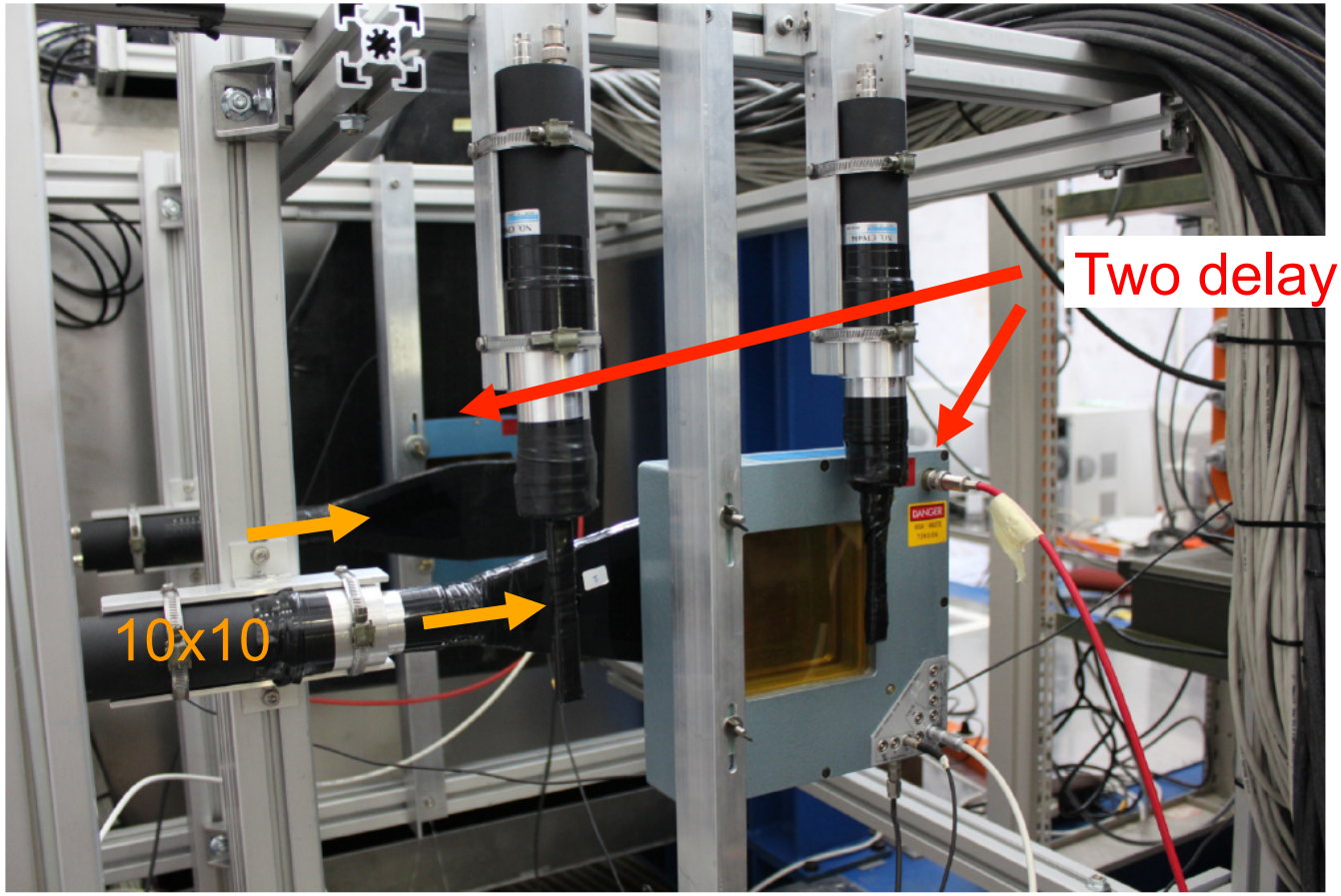
Installation in PS - T7 area

Muon flux originating from pions in a PS beamline ~30m away
- muon beam size ~1m
- Energy 1-10 GeV

Two 50x50 cm^2 muon triggers installed

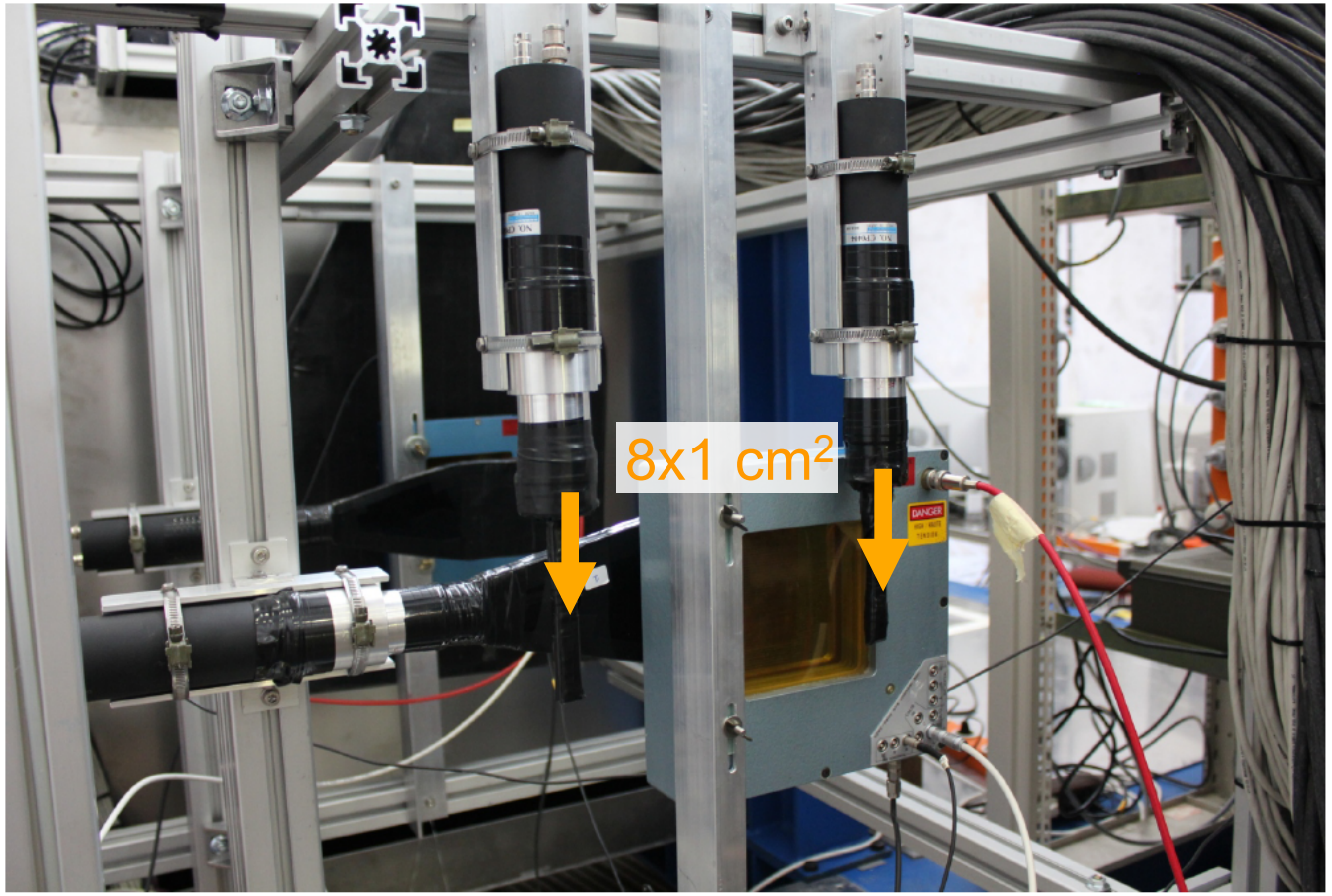
Three PCs for:
- DAQ
- Analysis
- Power control

Beam instrumentation



- 2 sets of trigger coincidences:
  - 10x10 cm^2
  - 50x50 cm^2 (one in front, one behind stack. Not on picture)
- 2 delay wire chambers commissioned. 3rd has now also been installed.

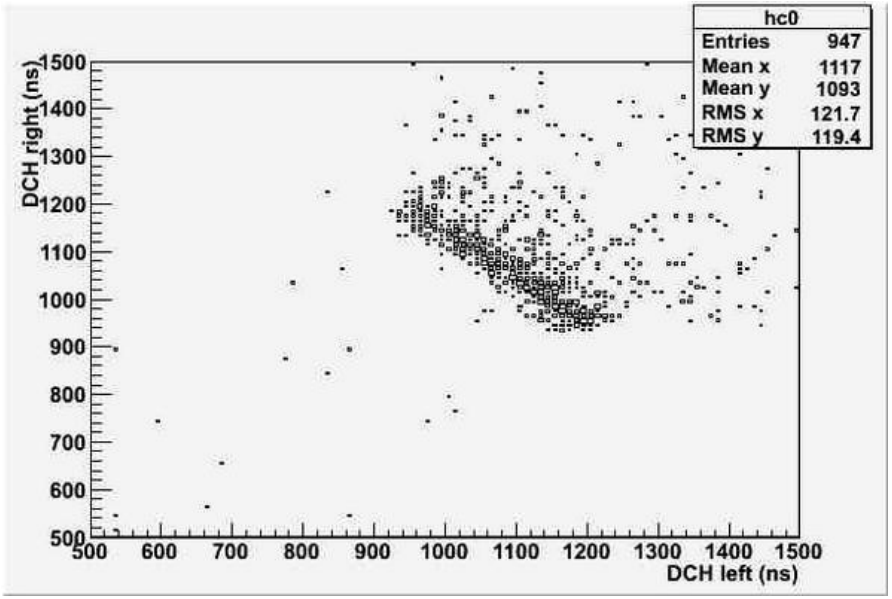
Beam instrumentation



- One set of 8x1 cm^2 to be used for finer measurements
- For now not in line with beam, but can easily be moved

Delay wire chamber commissioning

- The wire chambers have a delay line running back & forth from left to right, and a line running back & forth from up to down.
- The chamber gives four signals: time delay from the left, right, up and down sides.



LEFT-RIGHT (one chamber)

Tested correlation in time of hits from the left and right signal:

- As a particle hit is read out both sides, then the sum of the two distances (and hence times if the velocity is linear) should be a constant.
  - ➢ Chambers are working correctly

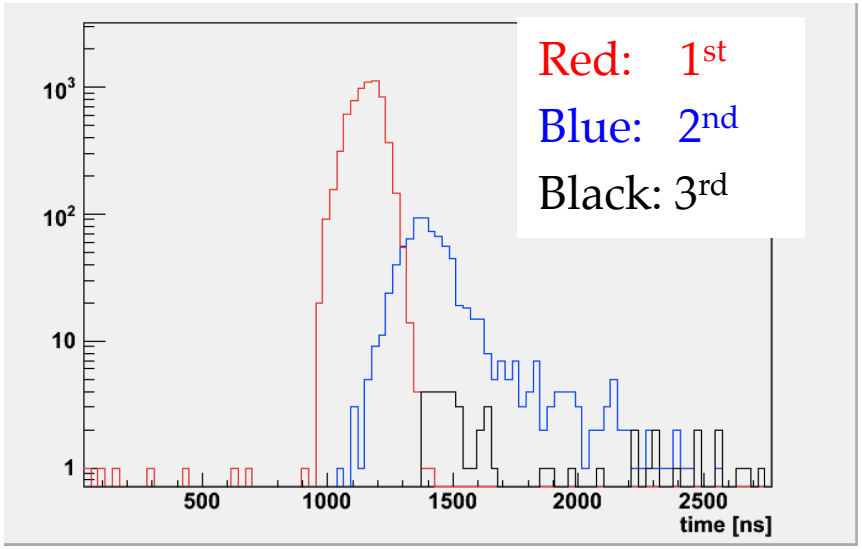
Delay wire chamber commissioning

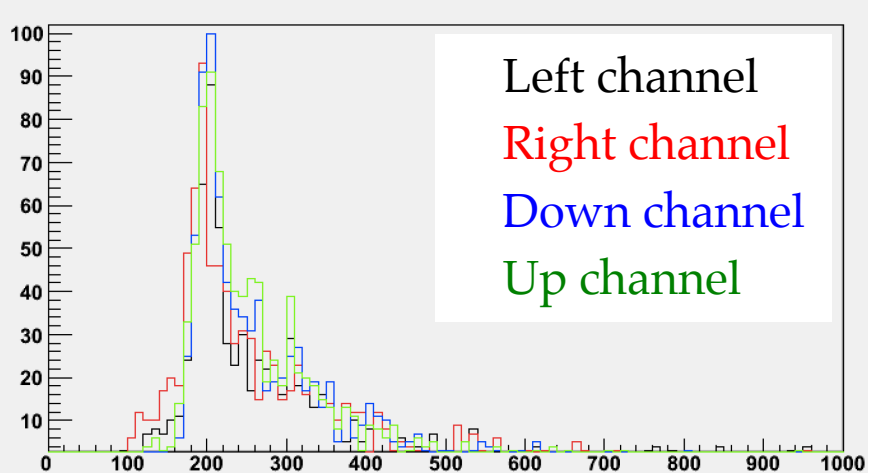
Calibration has been performed to convert the time signal to position measurements.

- Reconstructing of tracks made difficult by multiple hits.
- Time difference between 1st and 2nd hit peaks at 200 ns; most probably reflection.

- ➢ Will keep the time windows small to minimize #double hits on one channel
- ➢ 3rd wire chamber is being installed & commissioned at the moment. This will reduce combinatorics.

Arrival time for multiple hits on one channel



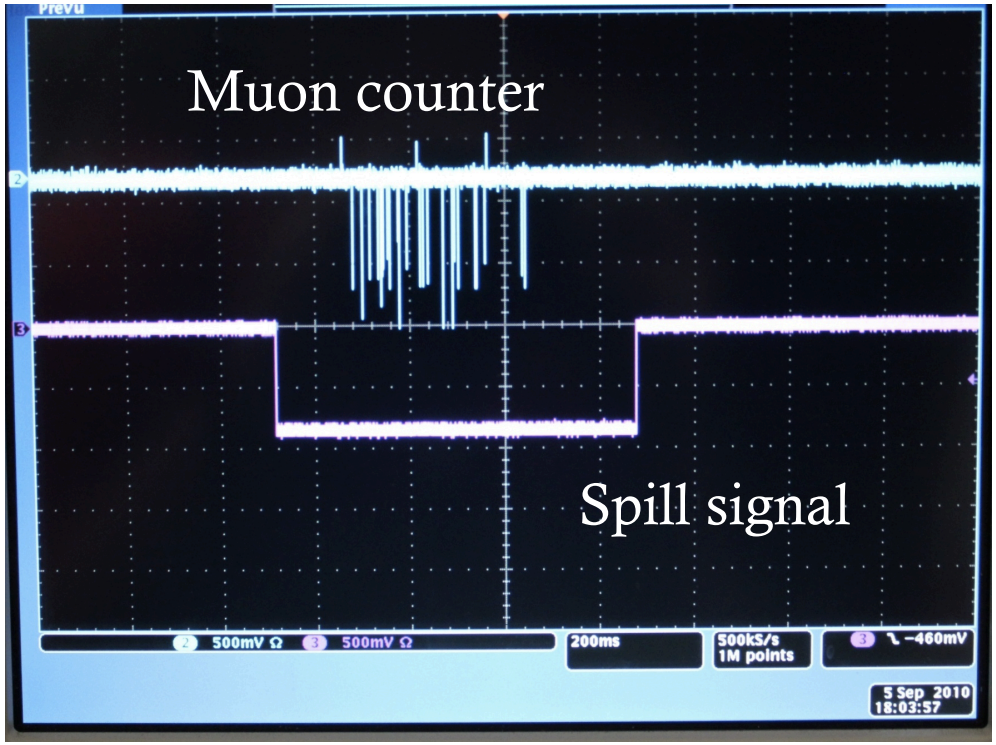


Time difference between 1st and 2nd hit [ns]

Triggering and event rate

Muon spills come in ~300 ms window, every 45 sec.

- Relative timing measured and adjusted where needed for triggers and wire chambers.
- Using scintillator triggers:
  - Coincidence of the two 10x10 cm^2 results in ~350 counts/spill
  - Coincidence of the two 50x50 cm^2 results in ~1000 counts/spill



- DAQ Rate: 8 Hz (1 ms deadtime / event)

Calorimeter commissioning

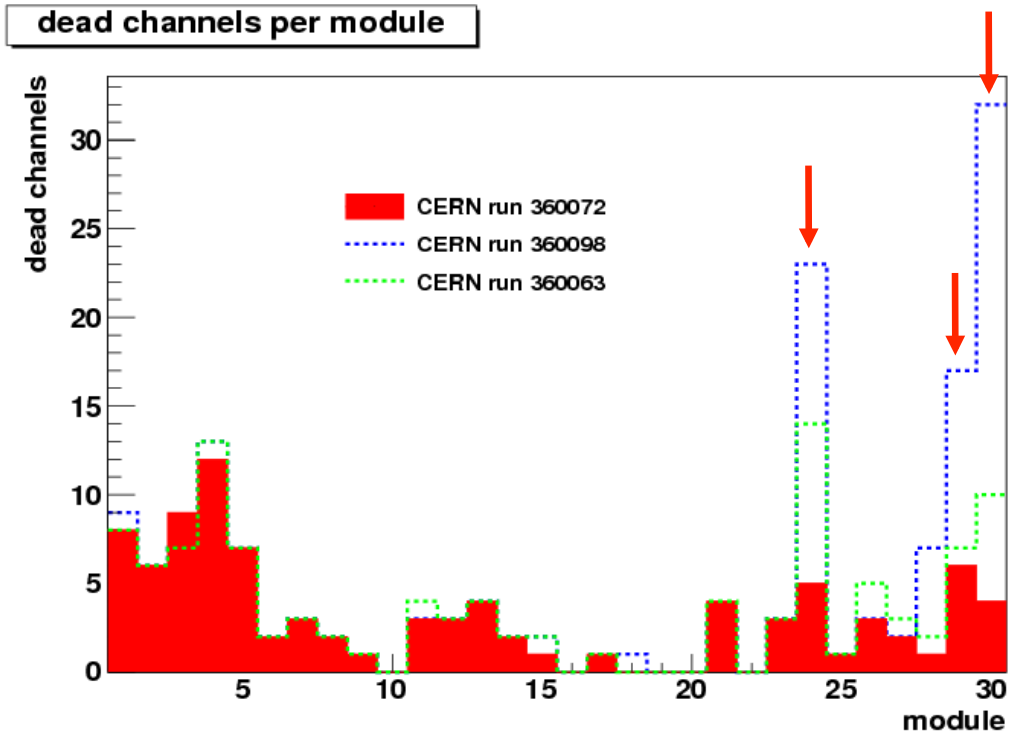
Installation done 30 Aug. – 3 Sept.

- Noise level consistent with previous installations in testbeams at CERN (2006/2007) and FNAL (2008)
- Large number of dead channels in modules 24/29/30.

  (definitions: module = active layer, channel = 1 scintillator tile with SiPM)

- Not yet clear why, the channels sometimes recover.
- These channels were known from last FNAL runs to be malfunctioning
- Yet during pre-assembly at DESY the last few months they showed no problems.

➢ Plans for repair at CERN before November testbeam



Calibration & monitoring system

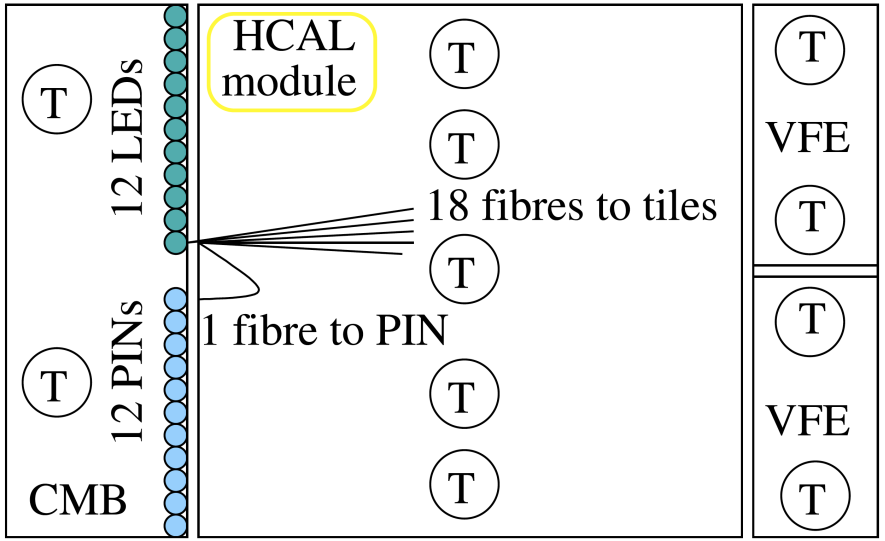
SiPM response depends on temperature and voltage

→ Temperature sensors

→ LED monitoring system

One LED illuminates 18 SiPMs and one PIN to monitor the LED signal.

- Functionalities of the LED system:
  - Gain calibration (see later)
  - Provide full dynamic range for checking the SiPM response function

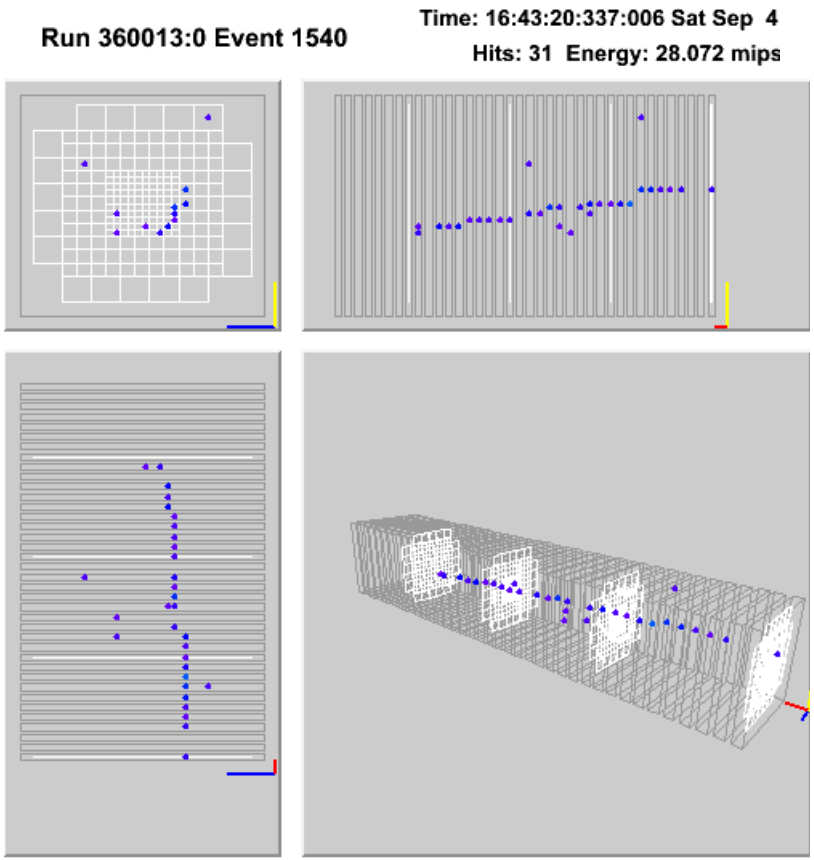


CMB: Calibration and Monitoring board

T: Temperature sensor

➢ LED system tested and operational, except for one module (#20). This CMB has been removed for repair.

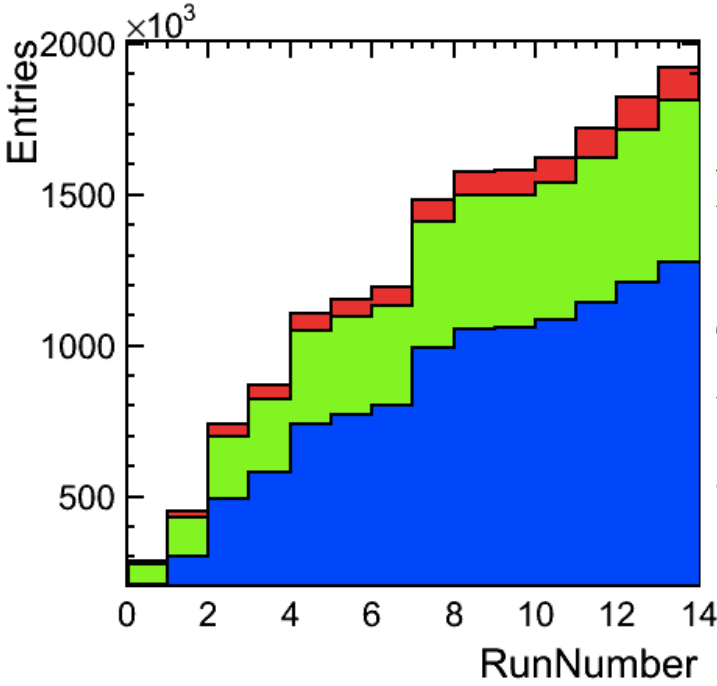
Muon events recorded



Not all muons come in perpendicular

- Will need to take angle into account in calibrations

In 14 runs collected ~2 million events:



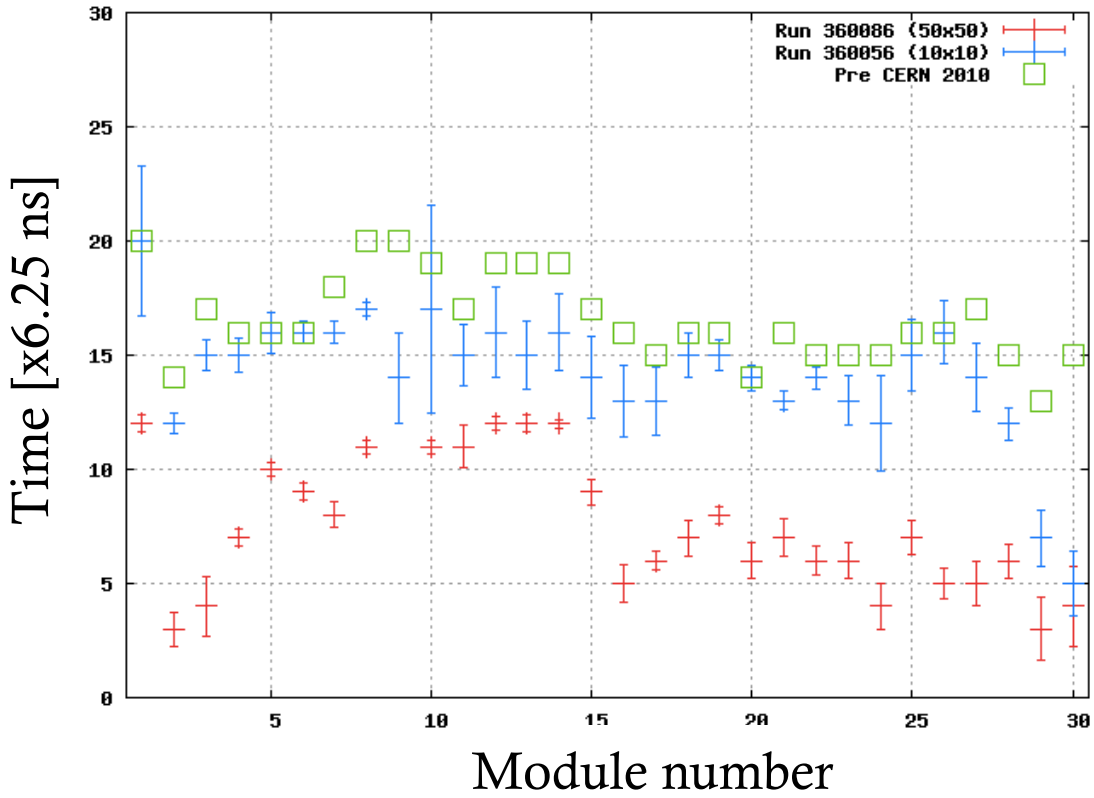
calib. & physics

physics events

events having a track with at least 8 hits in a row (~60%)

Trigger delay scan

- The signal from the SiPM is readout after amplifier & shaper, at its maximum value. → Need to determine the **delay values** ('hold value')
- This has been done already at previous testbeams.
  - Compared with those results the delay values for all modules should differ by the same amount:



GREEN distribution is results from previous testbeam. RED and BLUE are two runs taken this month with the two trigger setups

→ Delay (induced by trigger setup) is similar for all modules.

Gain calibration

Measured amplitude is converted to digital counts: #ADC

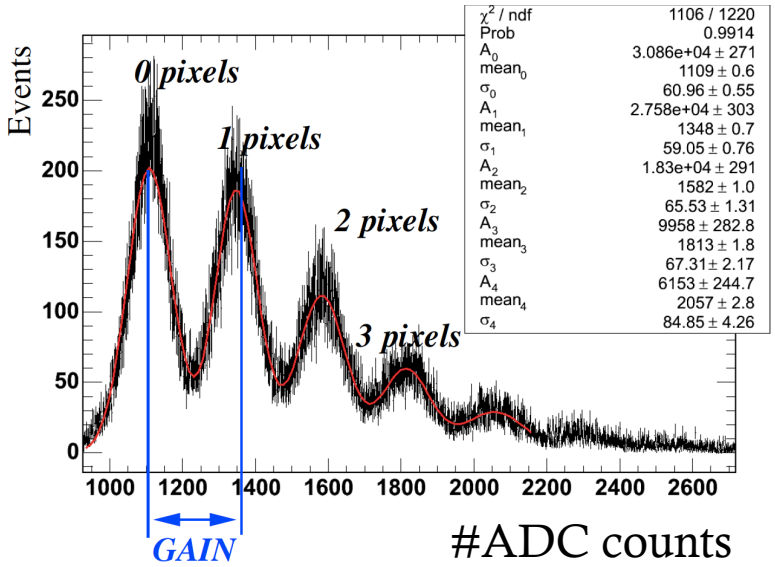
- gain = #ADC per pixel

Gain calibration procedure:

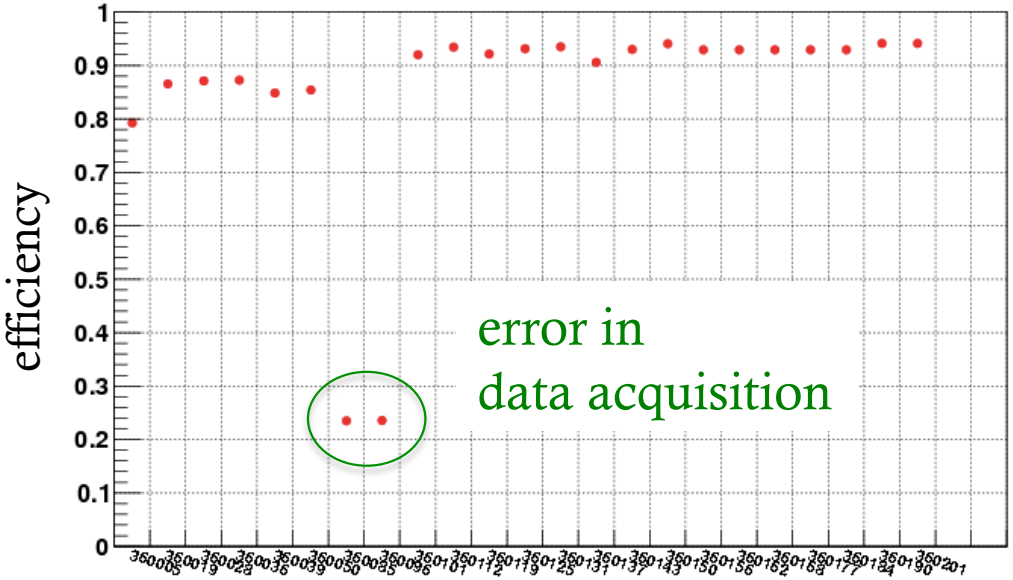
- use the LED system and take spectra at low intensity light for all channels
- fit single photon spectra
- Gain is difference between 2 single photon peak

➢ Gain values extracted and consistent with previous testbeam

➢ Extraction efficiency in last runs at 95%, almost the level it was for previous testbeam.



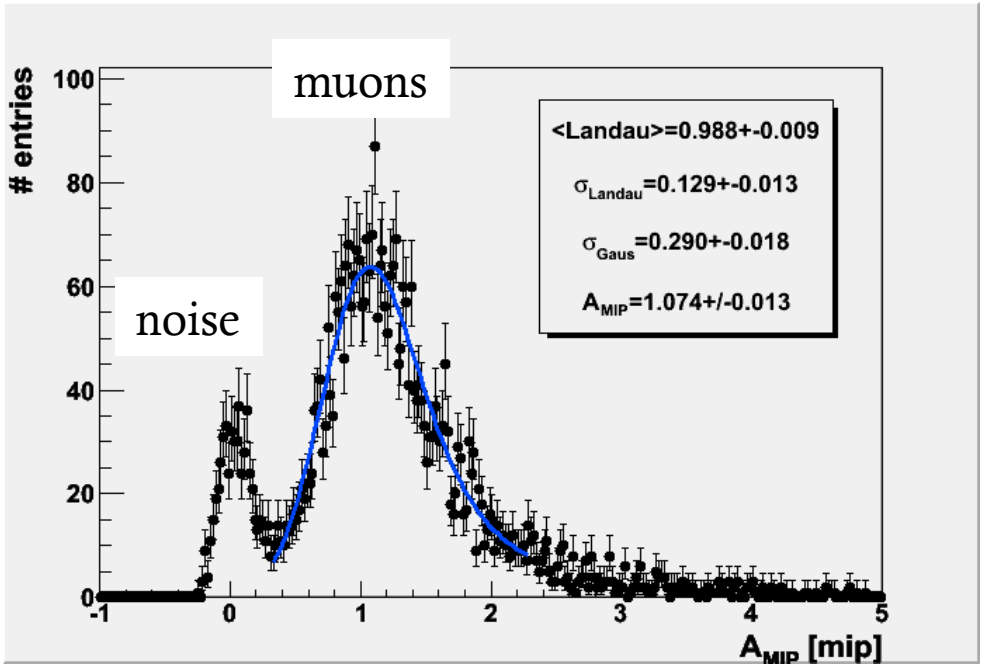
calibrated # channels / total # channels:



MIP energy calibration

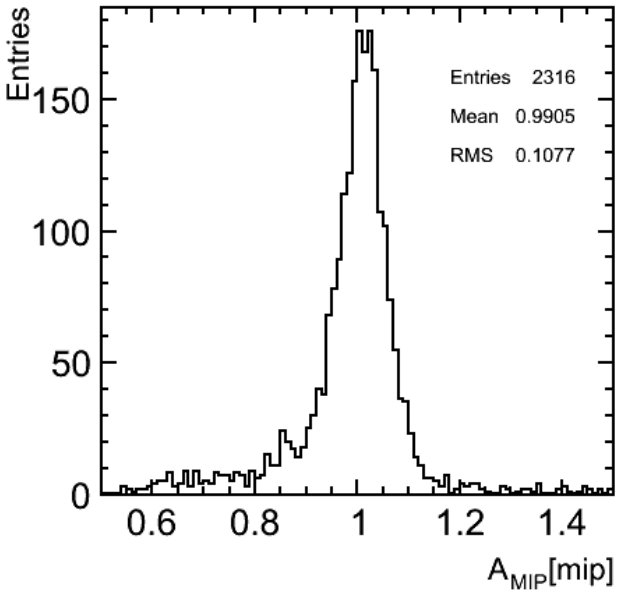
- Selecting straight tracks, and applying calibration from 2007, a single channel results in →
- Each entry is the energy deposited, expressed in MIP energy as defined in 2007
  - Small noise distribution
  - Fit convolution of a Landau and a Gauss distribution:

    $A_{MIP} = 1.074 \pm 0.013$ mip



Extracting this average for each channel results in →

- Calibration from 2007 looks reasonable
- Temperature corrections not yet applied to data



Conversion from signal to energy takes more steps than shown – see talk by Zalesak later.

Summary

- Calorimeter installed and operational
  - LED system operational (apart from 1 CMB)
  - Repair of 3 modules will be done before moving to T9
- Wire chambers are commissioned
- Trigger system timed, DAQ rate ~8Hz.

- Data transfer, conversion & analysis in progress
  - First results consistent with previous testbeam results
  - Gain calibration extraction efficiency at 95%

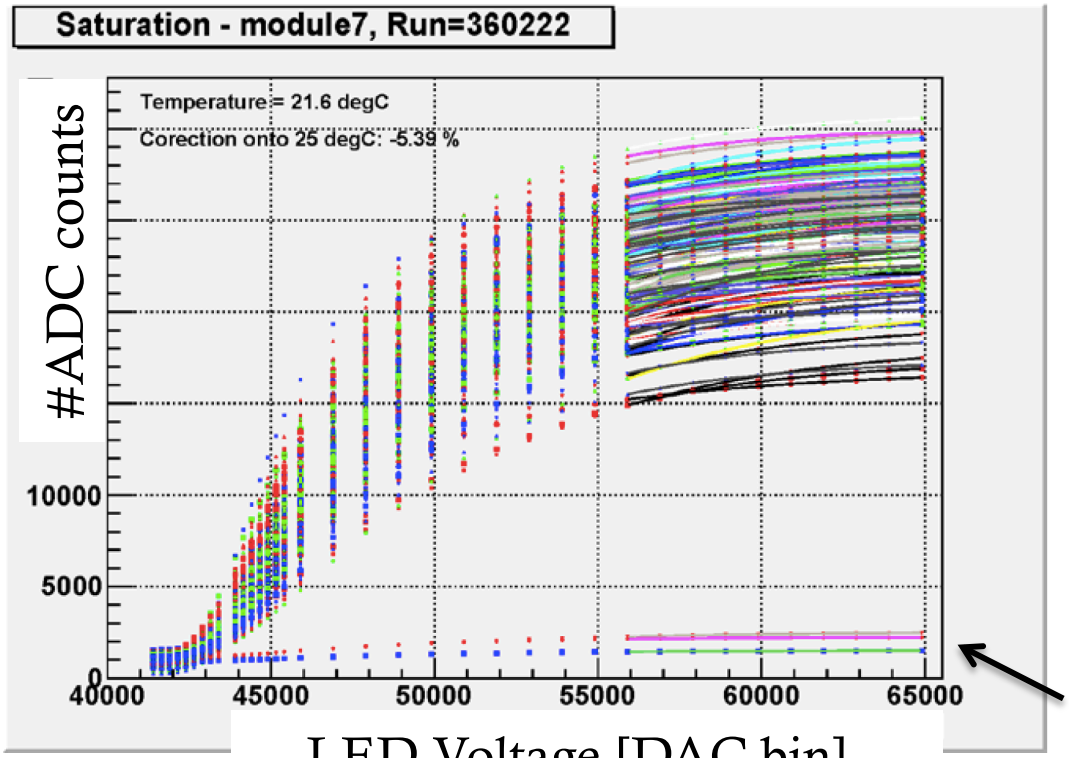
➢ Beginning of November the entire setup will be lifted to the other side of the hall to be placed in PS testbeam.

Backup

Saturation scans

One module (1 m^2) consists of 216 scintillator tiles of different sizes, with for each tile one SiPM measuring the light.

- SiPM signal is the sum of signals from fired pixels.
  - With limited number of pixels and recovery time (20-500 ns) this result in a non-linear response curve



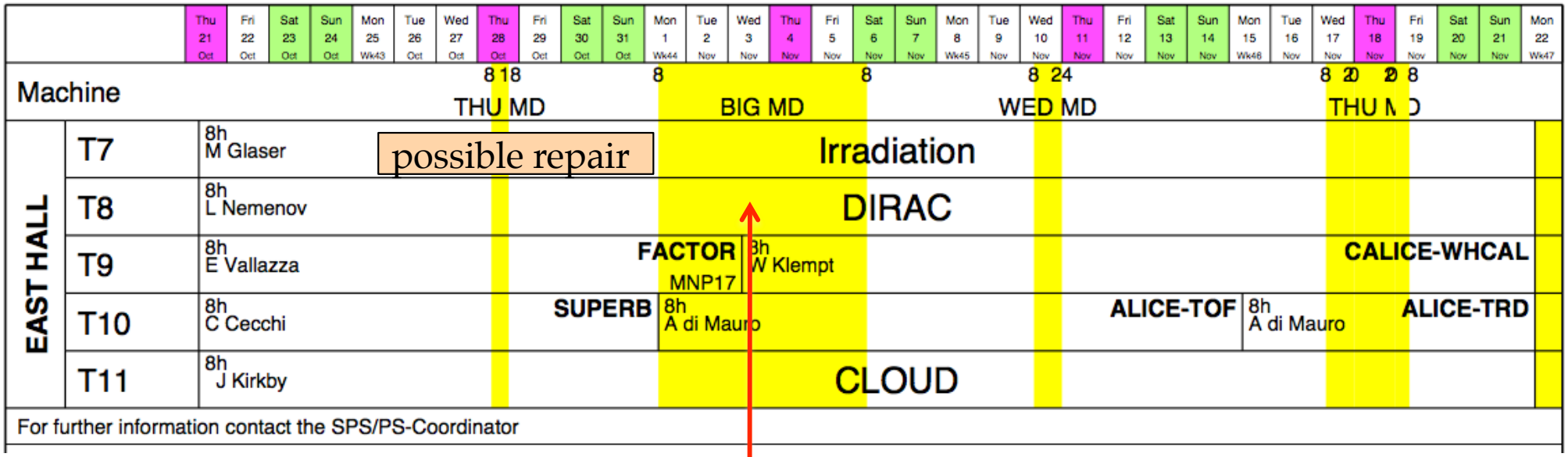
To extract this response curve, each SiPM is illuminated with increasing intensity

← Spread in #ADC saturation approximately factor 2

- As expected from the large variety of SiPM

Two dead channels

PS Schedule



W-AHCAL move to T9

- W-AHCAL will "fly" to T9 on the 3rd of November
- After commissioning, official CALICE testbeam starts on the 6th of Nov.