CALICE Tungsten HCAL Prototype status

Erika Garutti

Wolfgang Klempt

Erik van der Kraaij
CERN LCD

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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

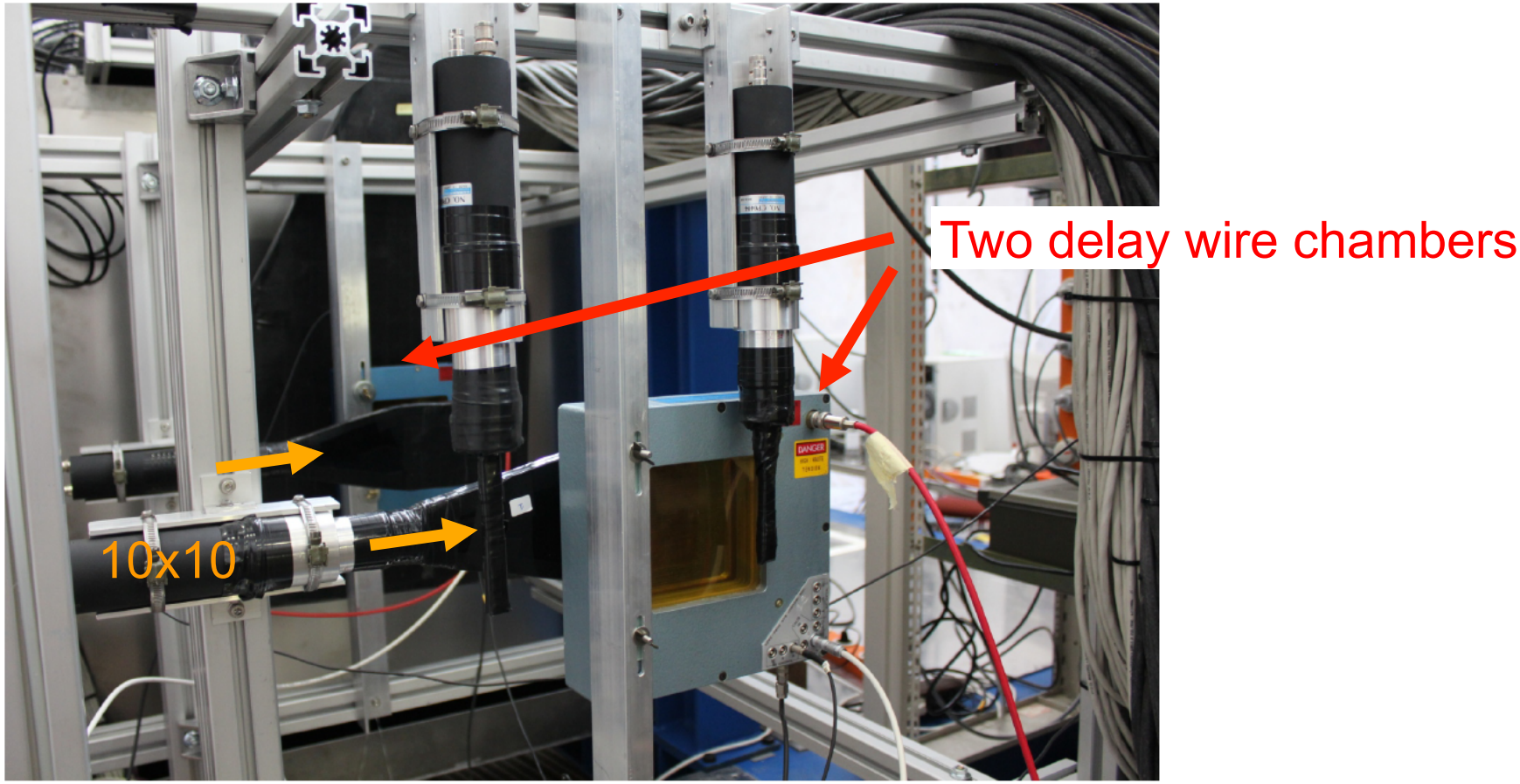
Installation in PS - T7 area

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

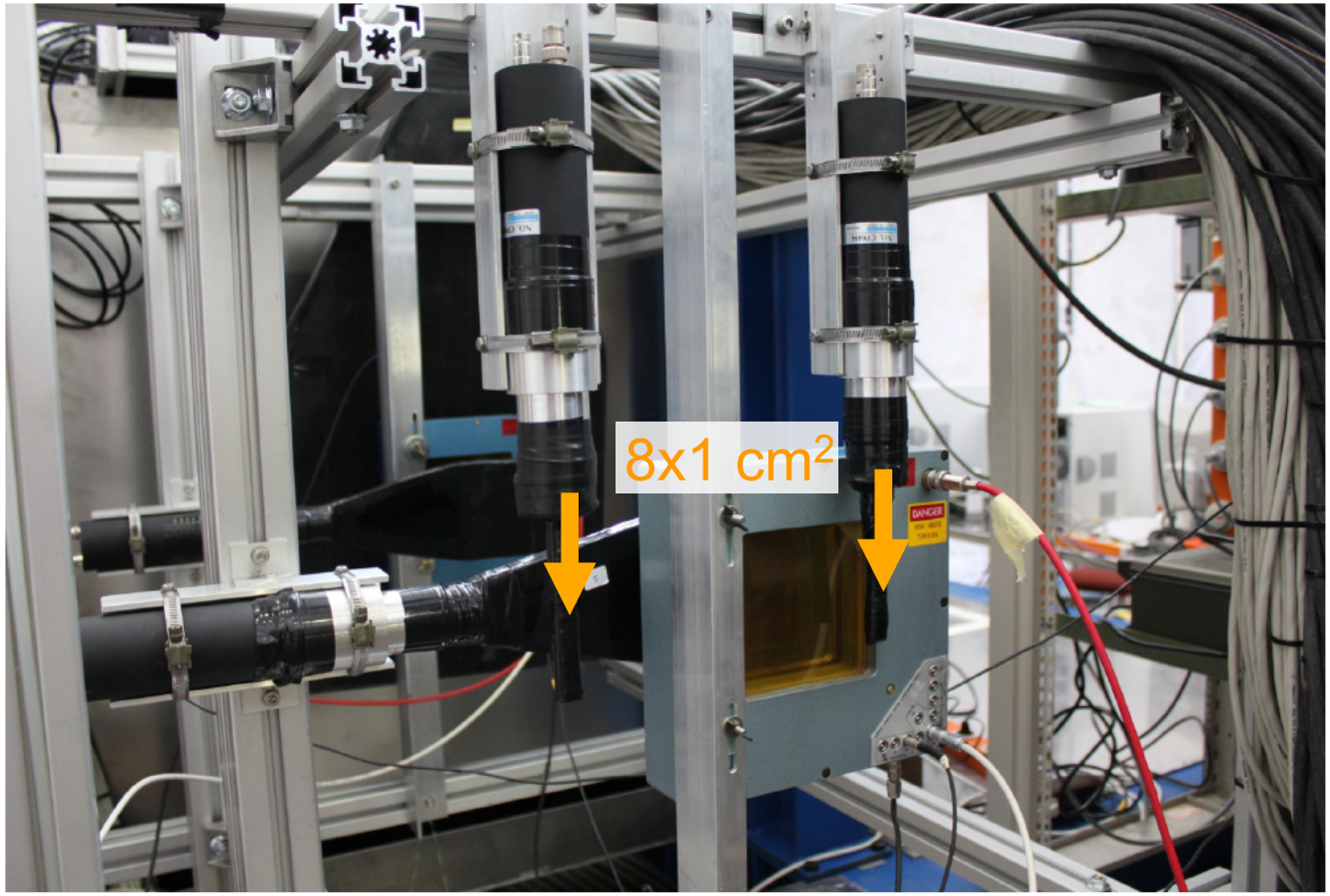
Three PCs for:
- DAQ
- Analysis
- Power control

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.

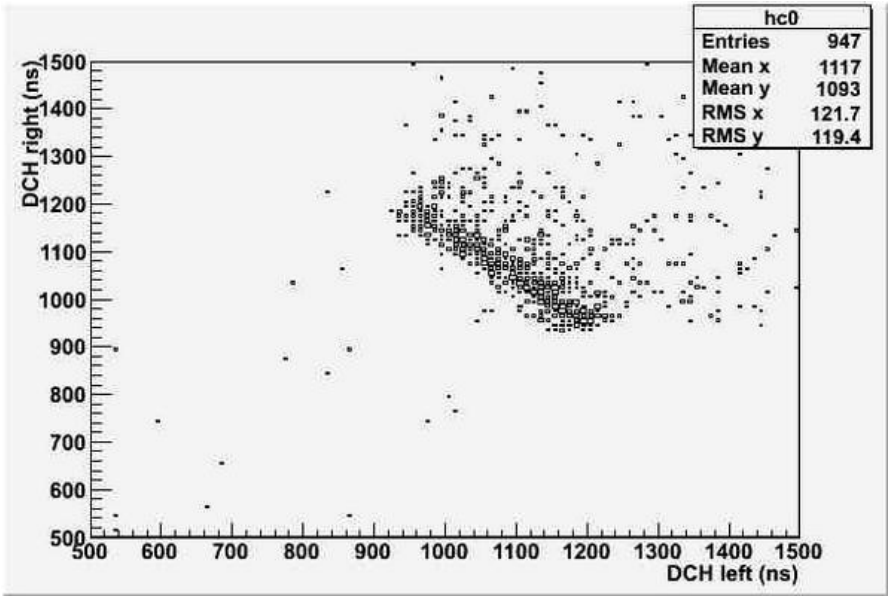
Beam instrumentation



- 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

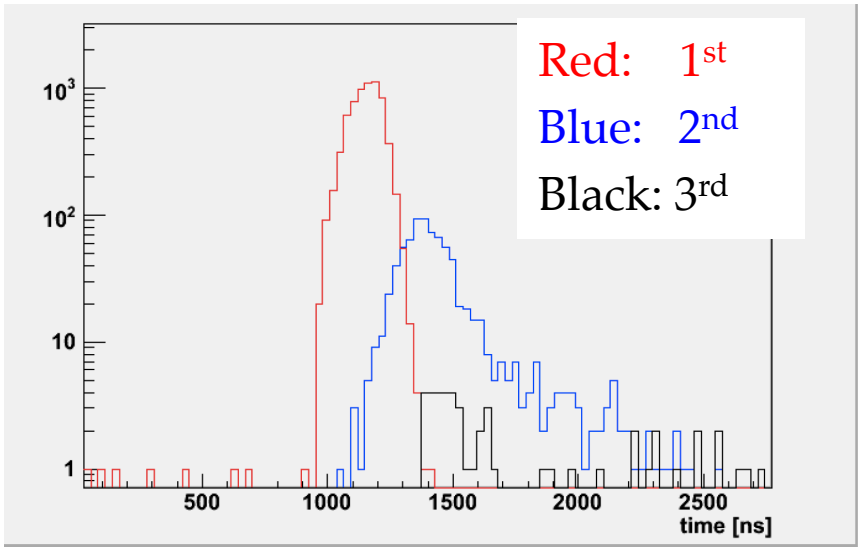
Delay wire chamber commissioning

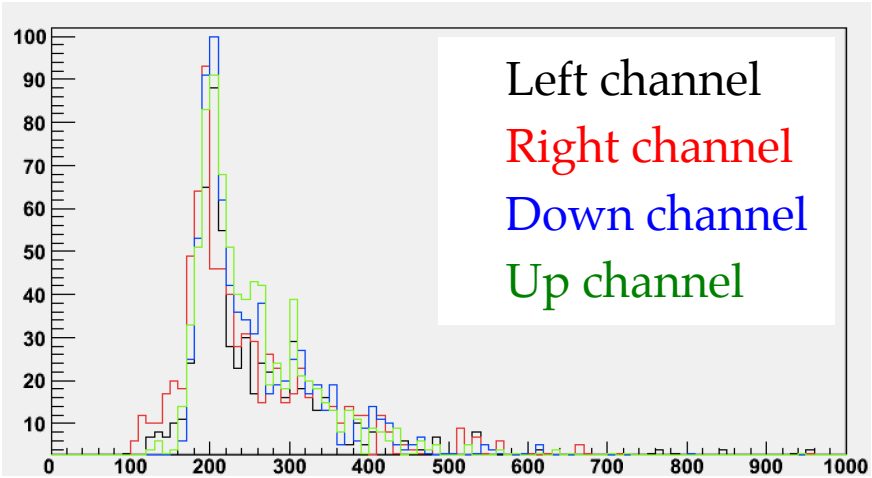
Calibration has been performed to convert the time signal to position measurements.

- 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



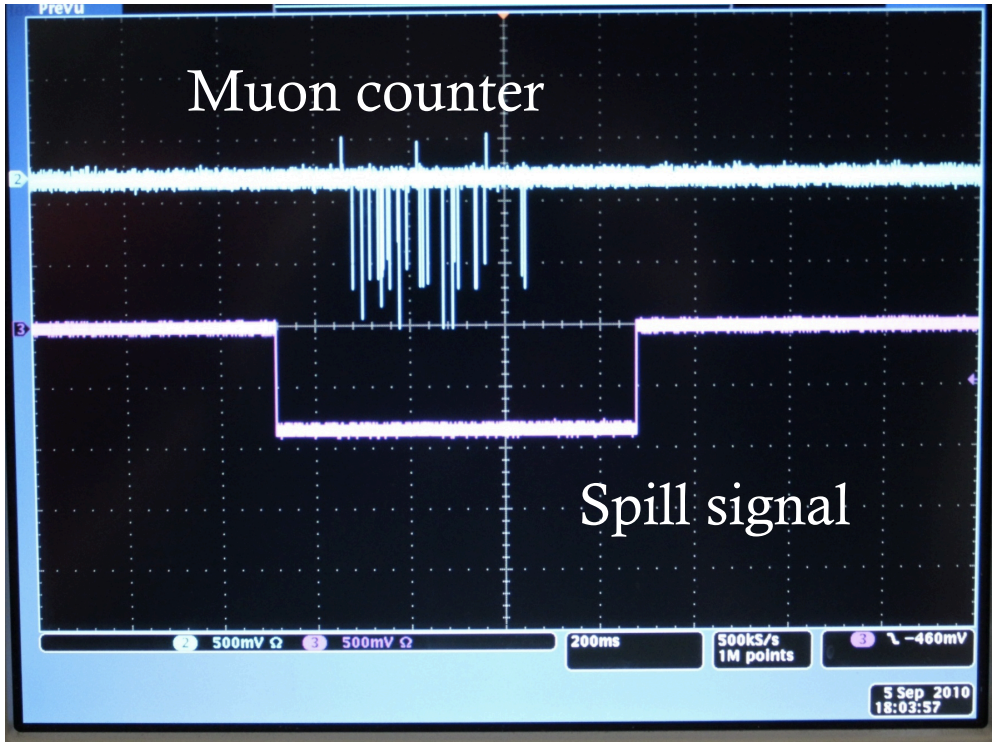


Time difference between 1st and 2nd hit [ns]

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

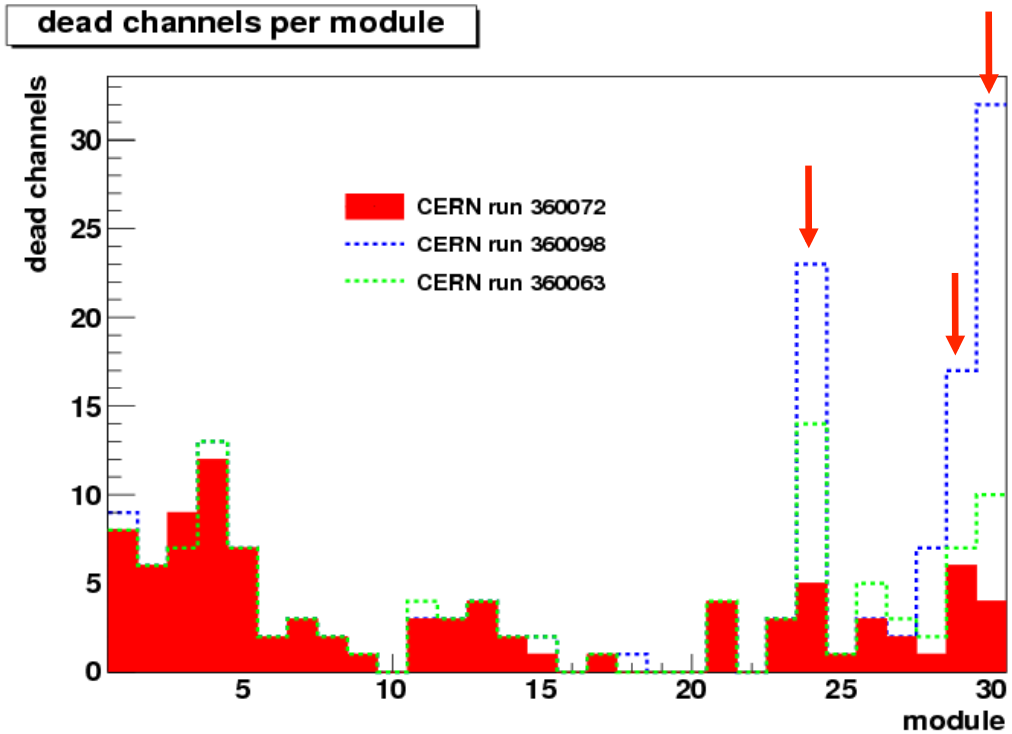
Installation done 30 Aug. – 3 Sept.

- 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

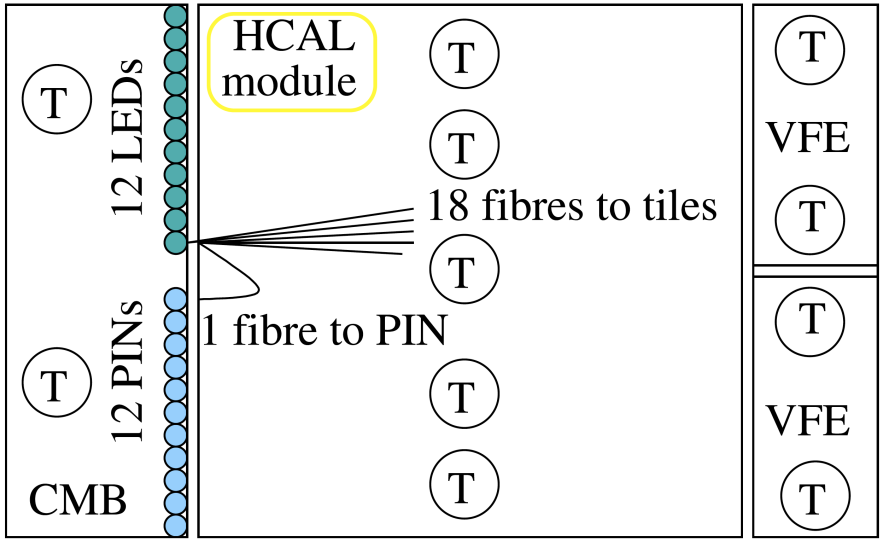
SiPM response depends on temperature and voltage

→ 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

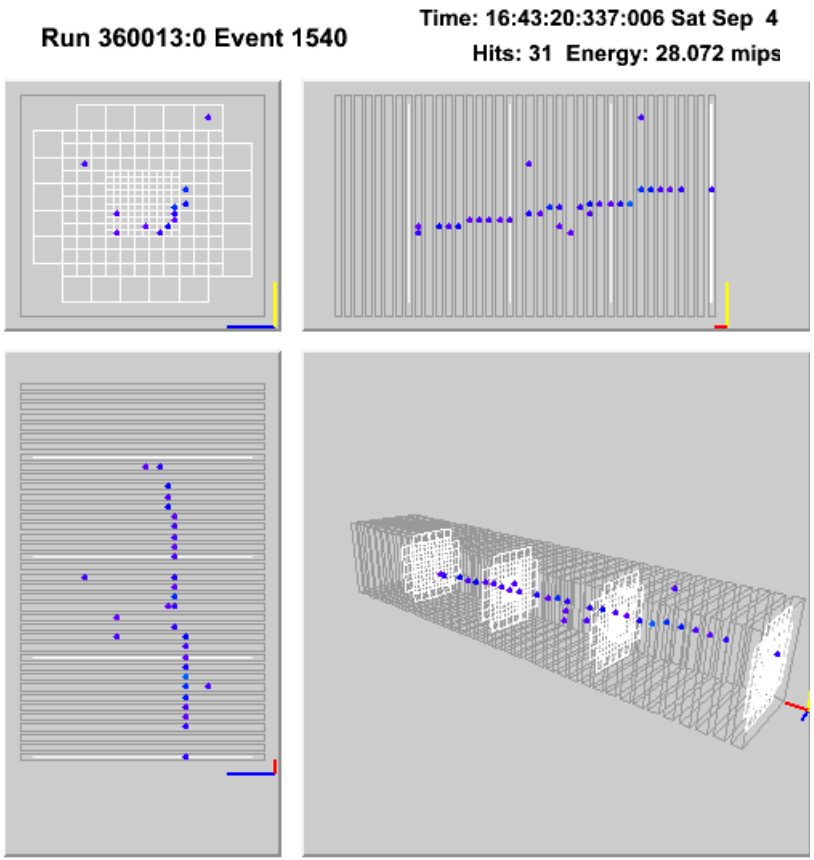


CMB: Calibration and Monitoring board

T: Temperature sensor

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

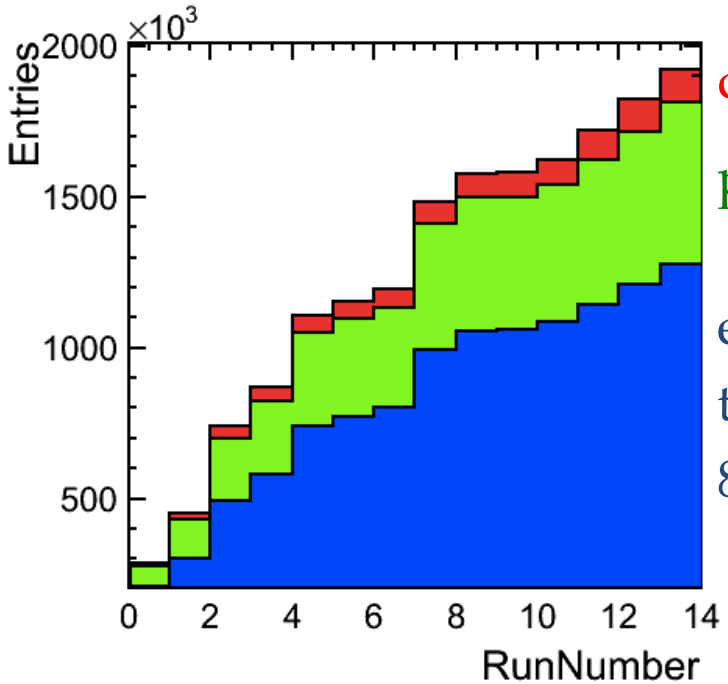
Muon events recorded



Not all muons come in perpendicular

- Will need to take angle into account in calibrations

In 14 runs collected ~2 million events:



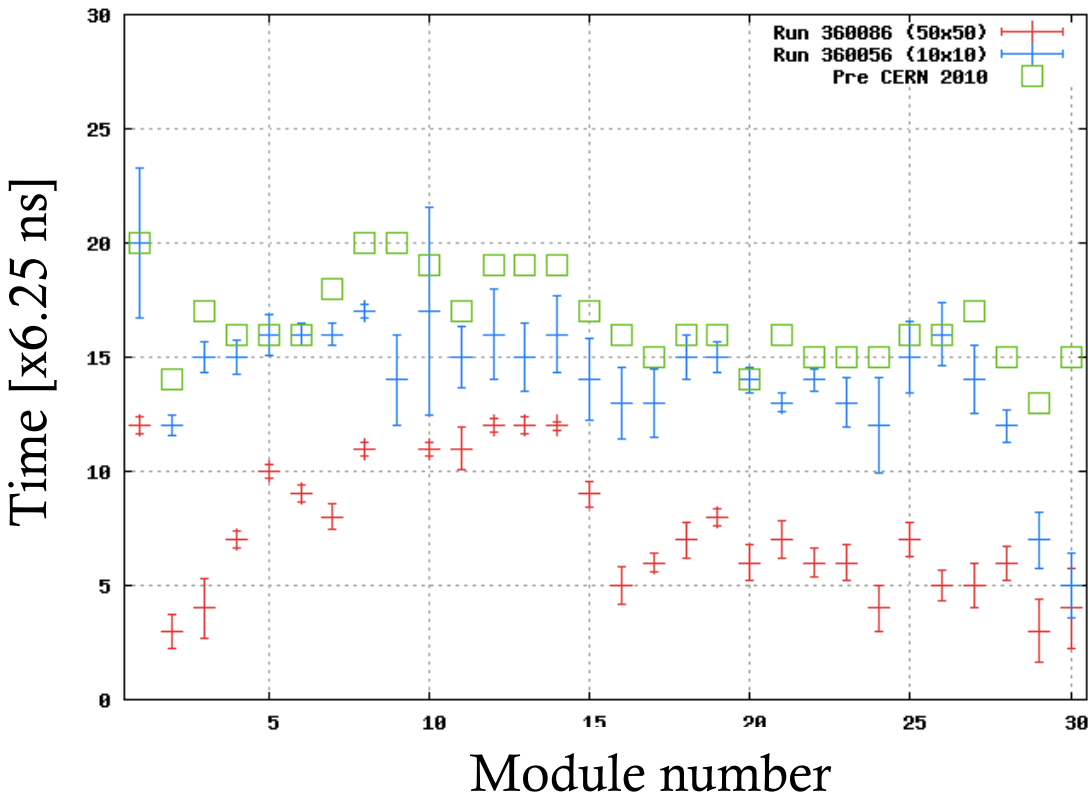
calib. & physics

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

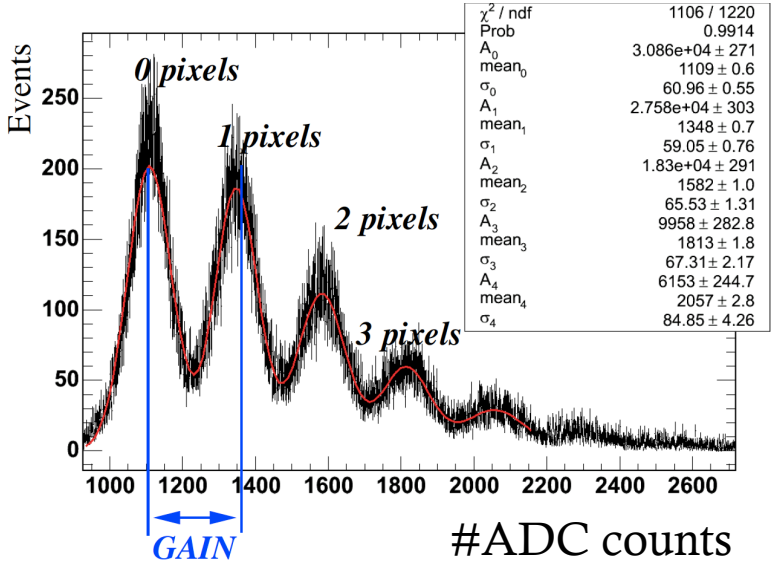
- gain = #ADC per pixel

Gain calibration procedure:

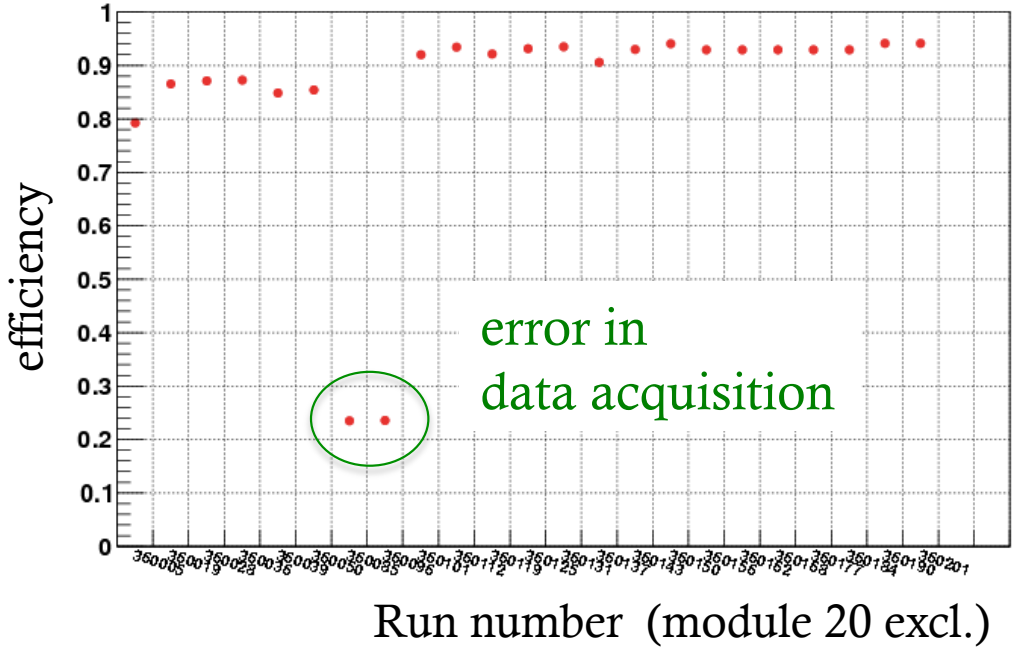
- use the LED system and take spectra at low intensity light for all channels
- fit single photon spectra
- Gain is difference between 2 single photon peak

➢ Gain values extracted and consistent with previous testbeam

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



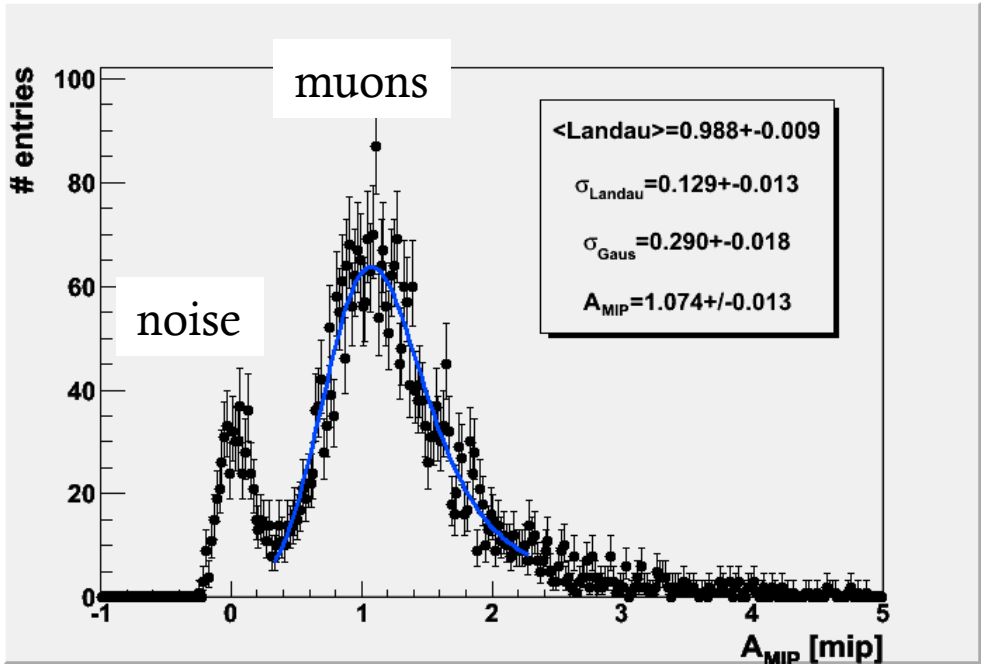
calibrated # channels / total # channels:



MIP energy calibration

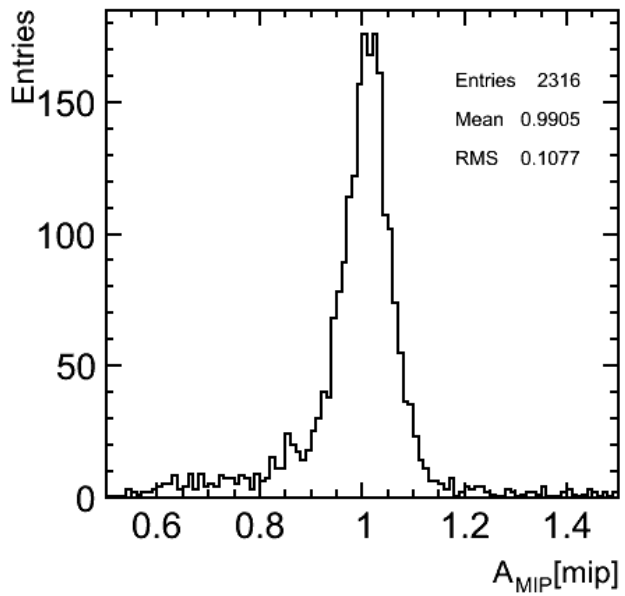
- Selecting straight tracks, and applying calibration from 2007, a single channel results in →
- Each entry is the energy deposited, expressed in MIP energy as defined in 2007
  - Small noise distribution
  - Fit convolution of a Landau and a Gauss distribution:

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

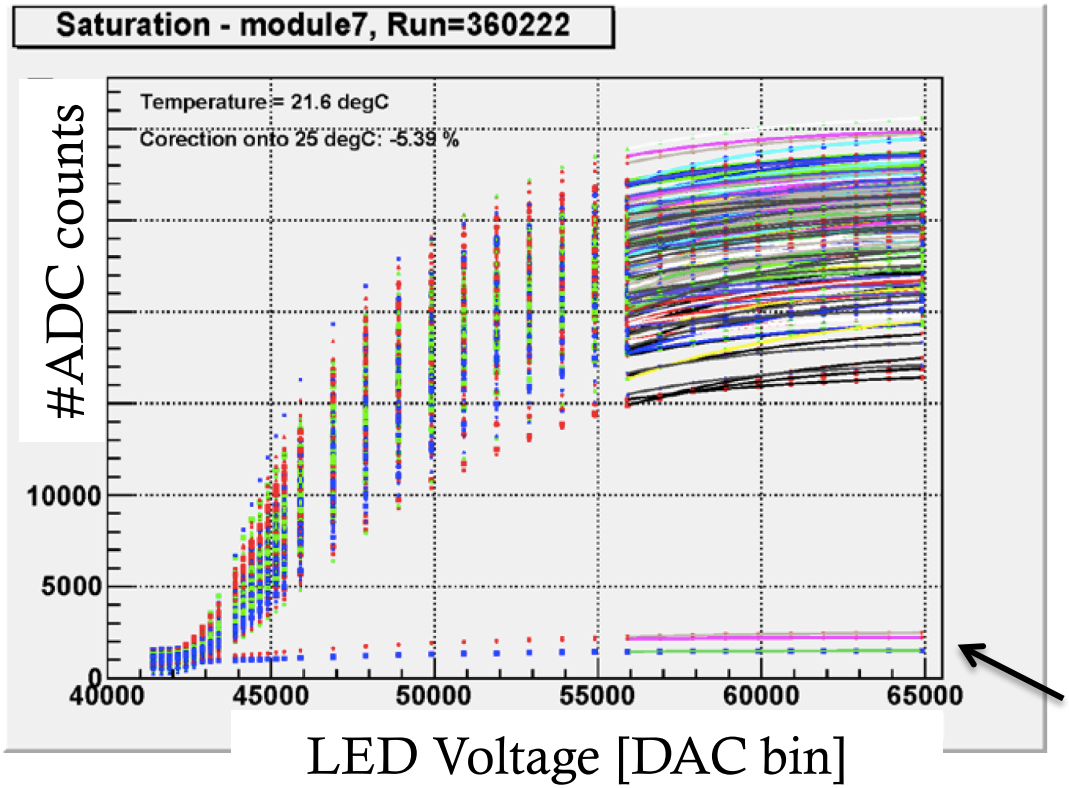
➢ Beginning of November the entire setup will be lifted to the other side of the hall to be placed in PS testbeam.

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



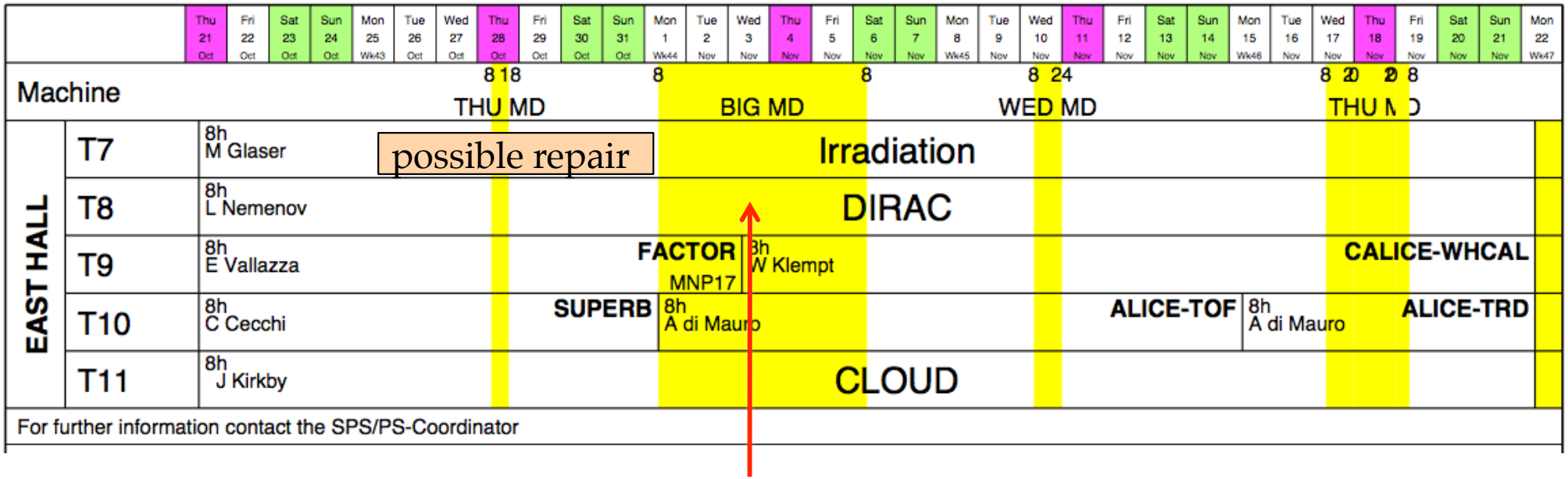
Two dead channels

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

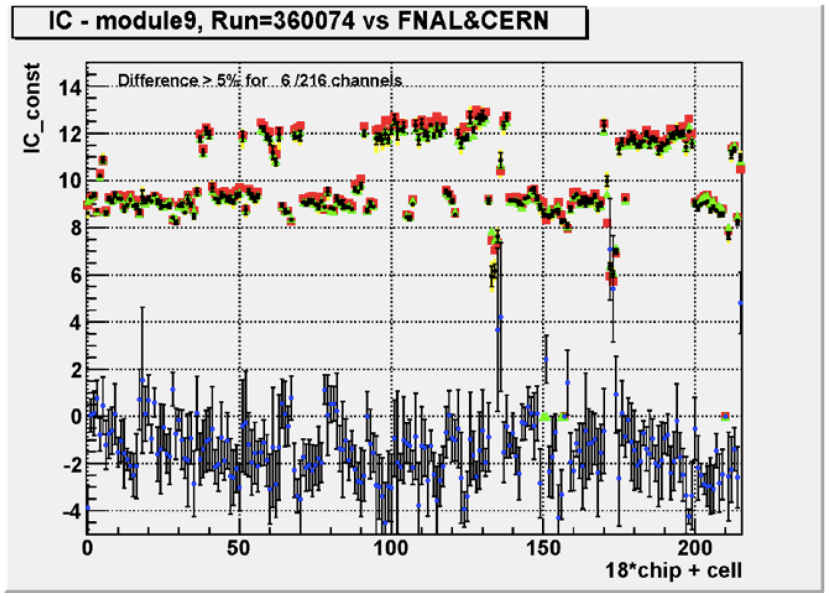
PS Schedule

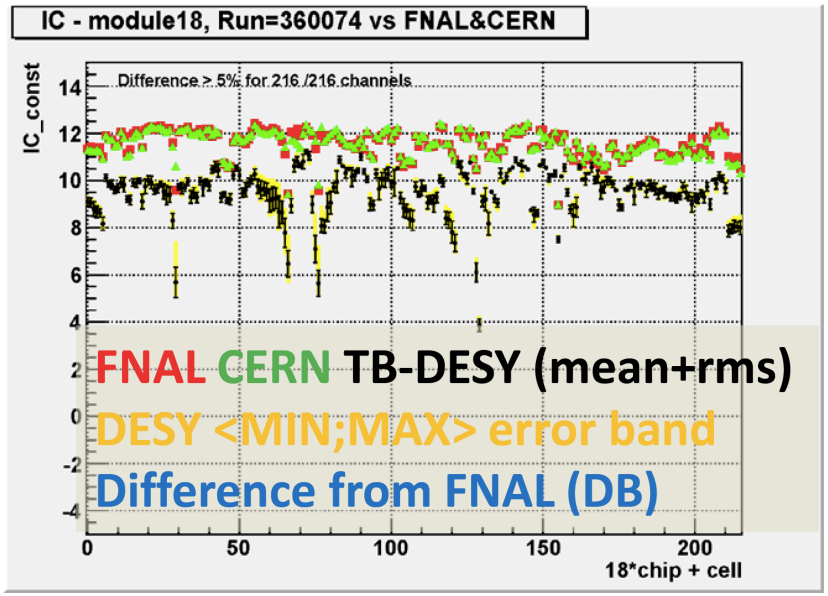


W-AHCAL move to T9

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

Intercalibration





- **InterCalibration: ic = CM/PM for single Vcalib point**
- Points defined as mean & rms over 1000 events for each Vcalib
- $IC = (\sum w_j * ic_j) / \sum w_j$, $w_j = 1/\mathrm{sqrt}(rms^2_c + rms^2_p)$
- each point satisfied criteria: A_{CM} = <1000-30000>, A_{PM} >200 bins
- **W-AHCAL TB-CERN2010: runs# 200073/074**