# Status of Analysis for Tungsten HCAL Test Beam at CERN

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13.12.2010, CALICE Analysis Meeting

# Overview

- Test Beam Setup
- Cherenkov Counters
- Status of Work on Calibration
  - Inter Calibration
  - MIP Calibration
  - Gain Calibration
  - Dead and Noisy Channels
- Simulation Status

# What is different with Tungsten

## Benefits

- More contained showers $\rightarrow$ less leakage with same depth
- Smaller shower diameter $\rightarrow$ better separation of showers

## Goal: Experimental verification

- So far: Tungsten used in ECALs typically 1 $\lambda$ deep
- No experience with tungsten HCALs 4-9 $\lambda$
- Simulation of hadronic showers in tungsten not validated
  - No MC/data comparisons
  - No validation for high granularity
  - Low energy neutrons $\rightarrow$ effect time structure of shower
    $\rightarrow$ requirements for time stamping

## Final Goal:

Good energy resolution with Particle Flow using the whole detector

# W-HCAL

## Absorber Material

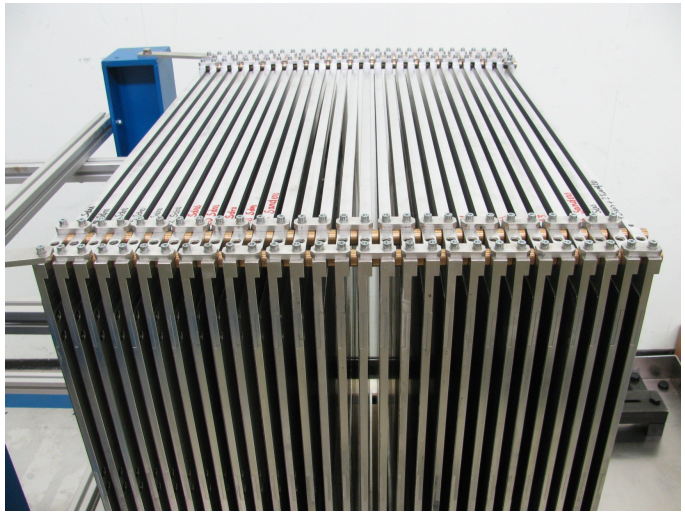
30 plates of 1 cm thick tungsten:
$\lambda_{int}$ (W) = 10 cm , $X_0$(W) = 0.35 cm

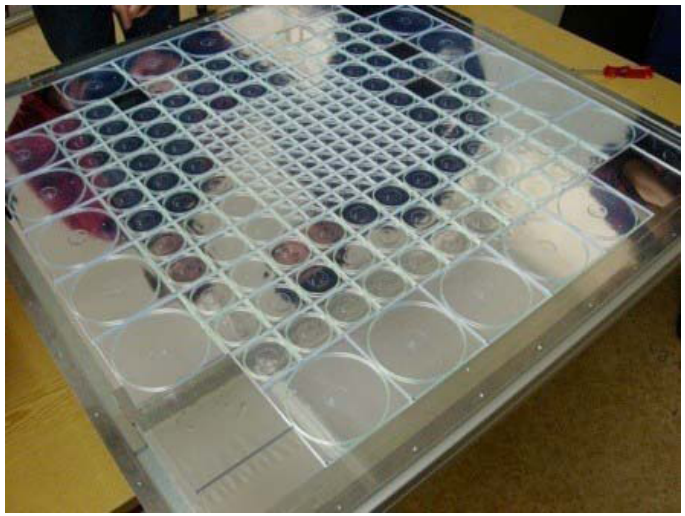
Compared to steel:

- Less visible energy (ionization)
- More neutrons (spallation, slow)

## Active Material

- Scintillator tiles: 3x3 $cm^2$, 6x6 $cm^2$
- Light collection via WLS fibres readout using multi-pixel SiPMs



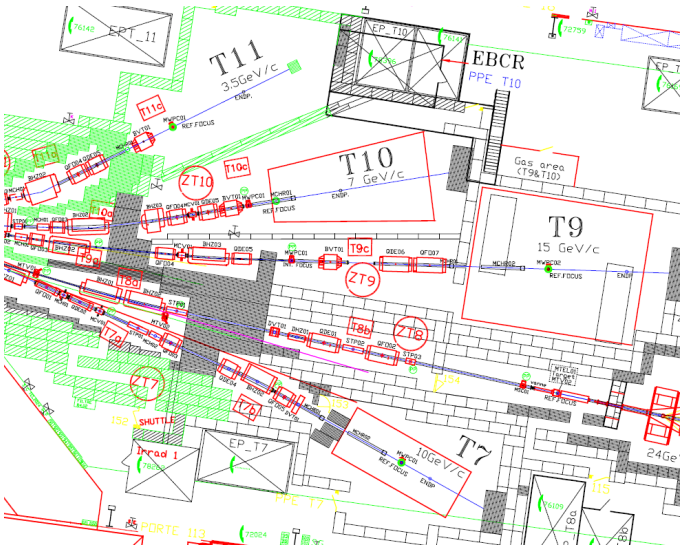


CALICE Calorimeter for ILC

# Beam at CERN/PS (T9) and Data Sets

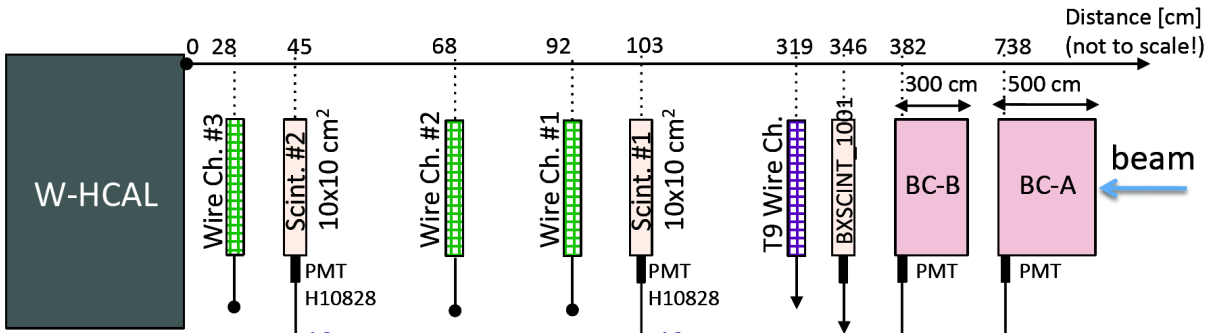
## 19 days of data taking

- Typical working mode: 2-3 spills per 45 seconds, 24-33 Hz DAQ rate
- 20 million events with energies between 2 and 10 GeV at 1 GeV intervals, positive and negative polarity

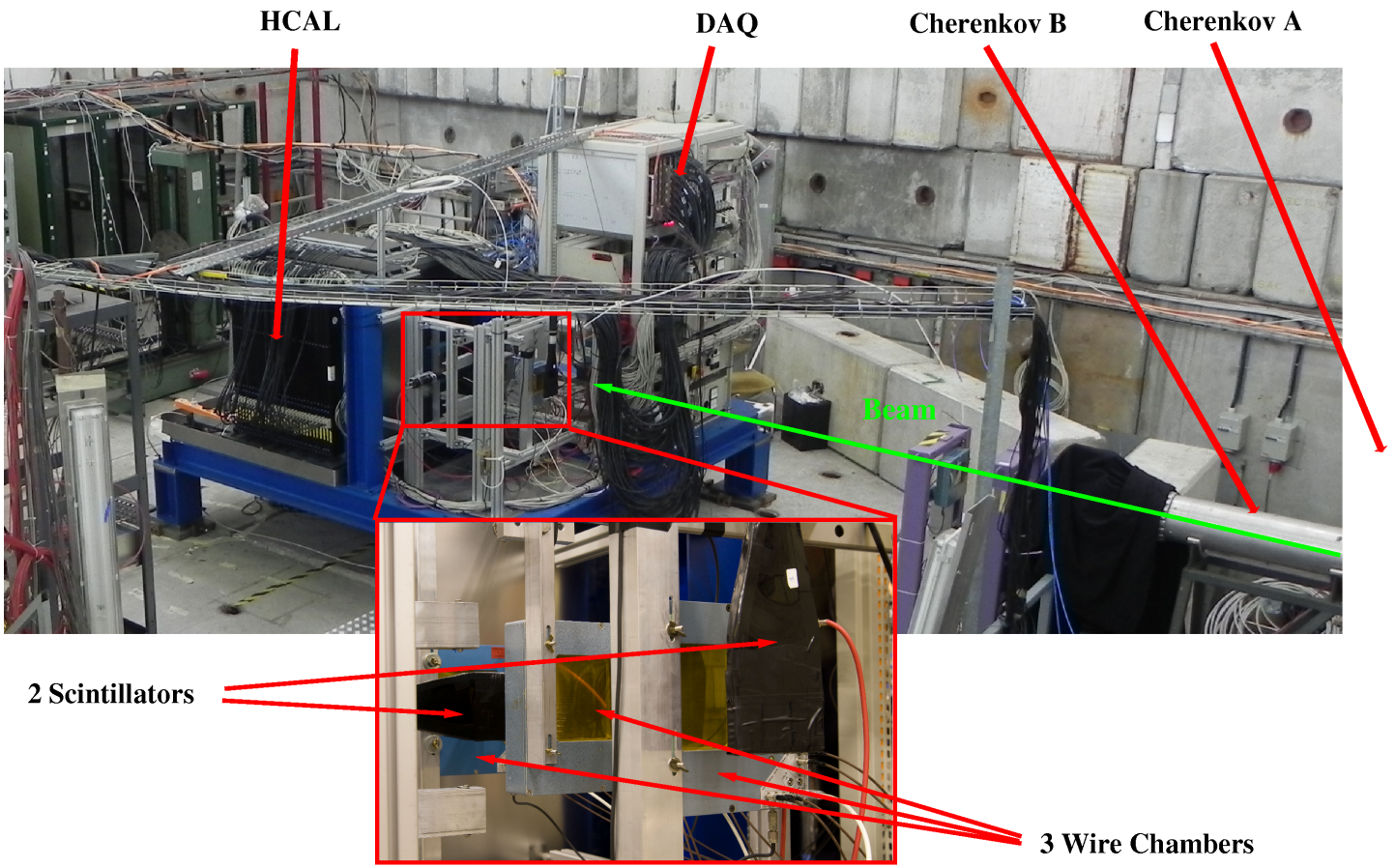



| Particle Mix in T9 | | | |
|---|---|---|---|
| p(GeV/c) | $e^+$ [%] | $\pi^+$ [%] | p [%] |
| 2 | 55 | 30 | 15 |
| 3 | 30 | 50 | 20 |
| 4 | 15 | 60 | 25 |
| 5 | 10 | 60 | 30 |
| 6 | 5 | 55 | 40 |
| 7 | 5 | 50 | 45 |
| 8 | 0 | 45 | 55 |
| 9 | 0 | 40 | 60 |
| 10 | 0 | 40 | 60 |

# Test Beam Setup




Trigger= coincidence of Scintillator #1 and #2



# Beam Instrumentation: Cherenkov I

## Setup

- 2 Cherenkov counters for particle ID to be used offline to select between electrons, pions and protons
- Gas: $C0_2$, Cherenkov A: 3m long, Cherenkov B: 5m long
- Pressure limit is 3 bar

| | Cherenkov threshold (atm) | | | | |
|---|---|---|---|---|---|
| Momentum (GeV/c) | electron | muon | pion | kaon | proton |
| 1.00 | 0.0004 | 13.23 | 23.02 | 348.82 | 880.9 |
| 2.00 | 0.0001 | 3.31 | 5.78 | 76.13 | 248.1 |
| 3.00 | 0.0000 | 1.47 | 2.57 | 33.06 | 113.3 |
| 4.00 | 0.0000 | 0.83 | 1.45 | 18.45 | 64.4 |
| 5.00 | 0.0000 | 0.53 | 0.93 | 11.76 | 41.4 |
| 6.00 | 0.0000 | 0.37 | 0.64 | 8.15 | 28.8 |
| 7.00 | 0.0000 | 0.27 | 0.47 | 5.98 | 21.2 |
| 8.00 | 0.0000 | 0.21 | 0.36 | 4.58 | 16.3 |
| 9.00 | 0.0000 | 0.16 | 0.29 | 3.61 | 12.9 |
| 10.00 | 0.0000 | 0.13 | 0.23 | 2.93 | 10.4 |

# Beam Instrumentation: Cherenkov II

## Note:

Online code uses too narrow search window for trigger time.
Use offline code for Cherenkov Flags.

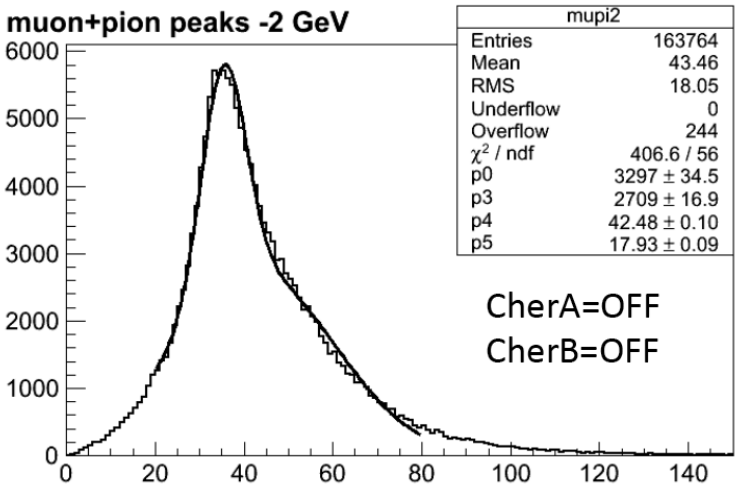
## Rule of Thumb for Most Common Pressure Settings

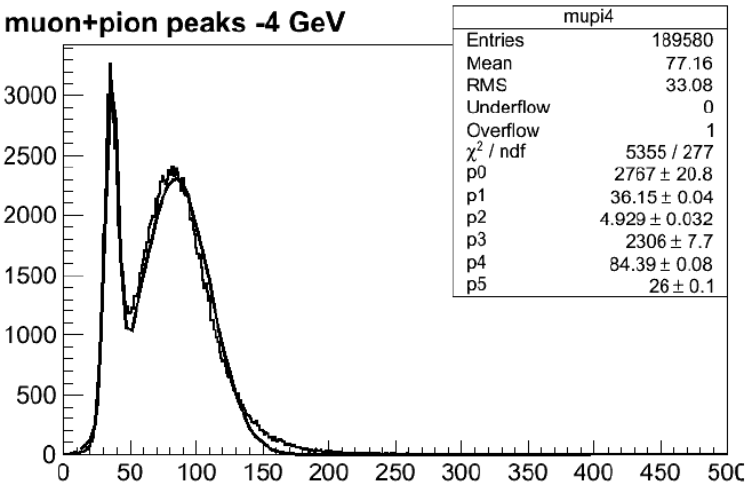
A off: Suppresses electrons
B on: Selects muons
Both off: Protons (only for positive E)
Muon and pion peaks overlap at lower energies!

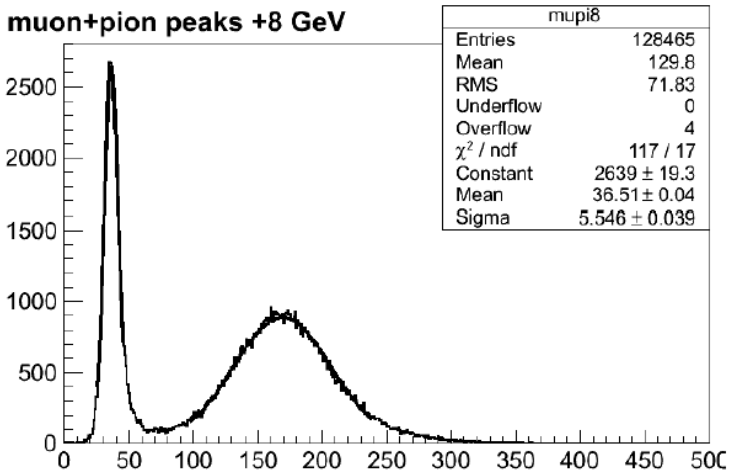
Example of particle selection:

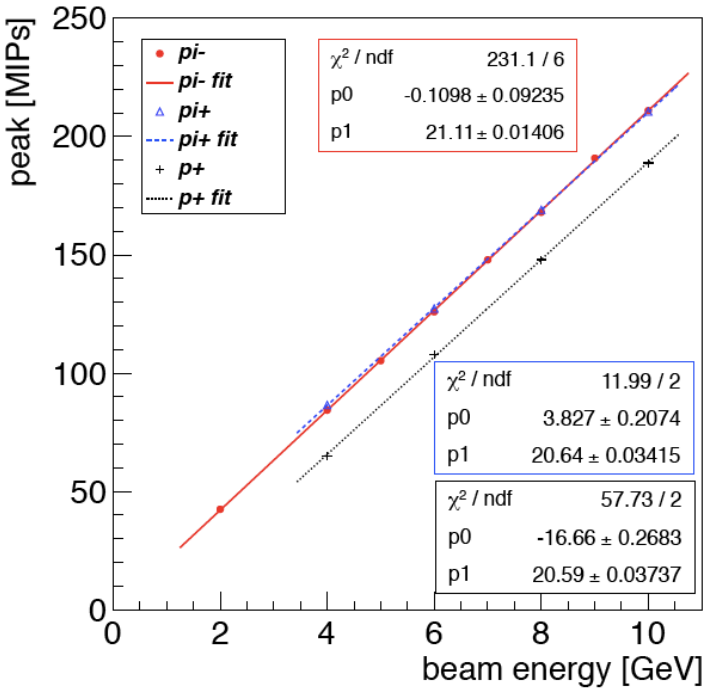
| E [GeV] | Cher A [bar] | Cher B [bar] | particle selection | | |
|---|---|---|---|---|---|
| | | | $\mu$ | $\mu + \pi$ | $p$ |
| -2 | 1 | 3 | A off & B on | A off & B off | - |
| -4 | 0.6 | 3 | - | A off & B on | - |
| -8 | 0.25 | 3 | - | A off & B on | - |
| -10 | 0.2 | 3 | - | A off & B on | - |
| 4 | 0.6 | 3 | - | A off & B on | A off & B off |
| 8 | 0.35 | 3 | - | A off & B on | A off & B off |
| 10 | 0.2 | 3 | - | A off & B on | A off & B off |

# Cherenkov: First Results



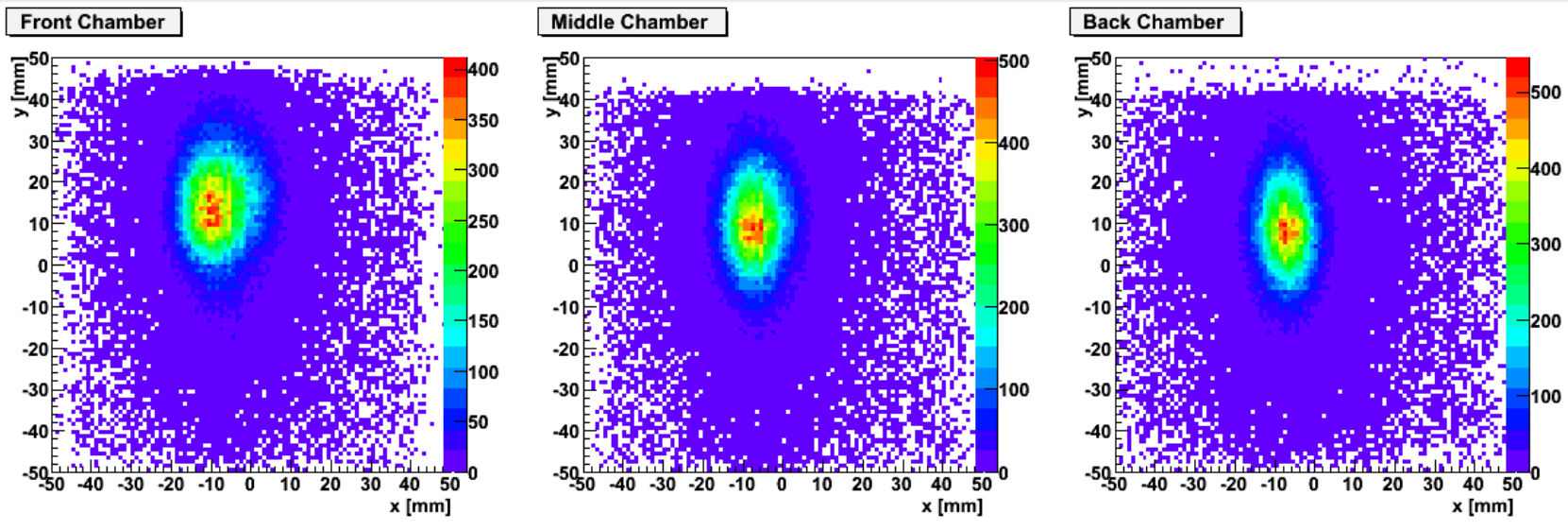




(talk by D. Dannheim)

# Beam Instrumentation: Tracking

## Setup

3 wire chambers to measure the beam profile and provide extrapolation to HCAL

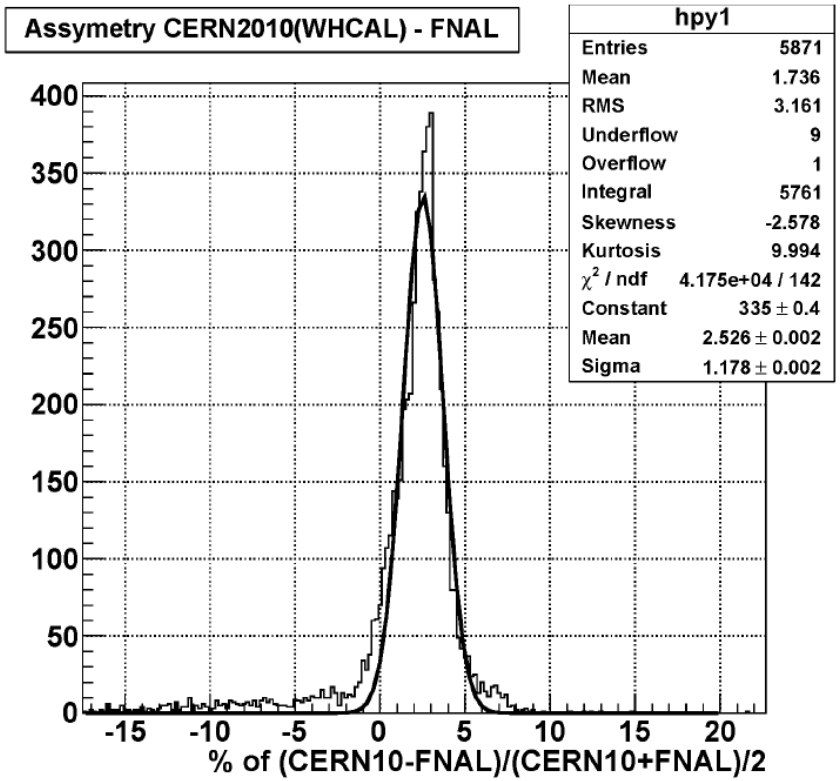



## Status

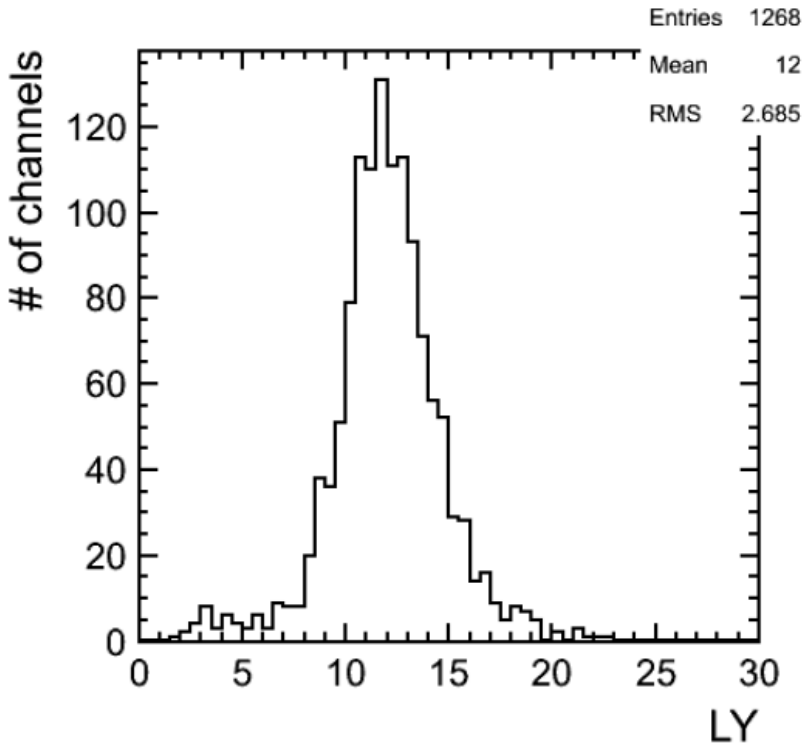
Code is finished.
Needs tuning of error matrices in DB for efficiency (at the moment at 70%).

# Status of Inter Calibration

- First version of IC constants for CERN 2010 obtained
- Idea: Use values obtained in T9, and the one from T7 as systematics




Shape of IC distribution similar to FNAL
Shift to higher IC values

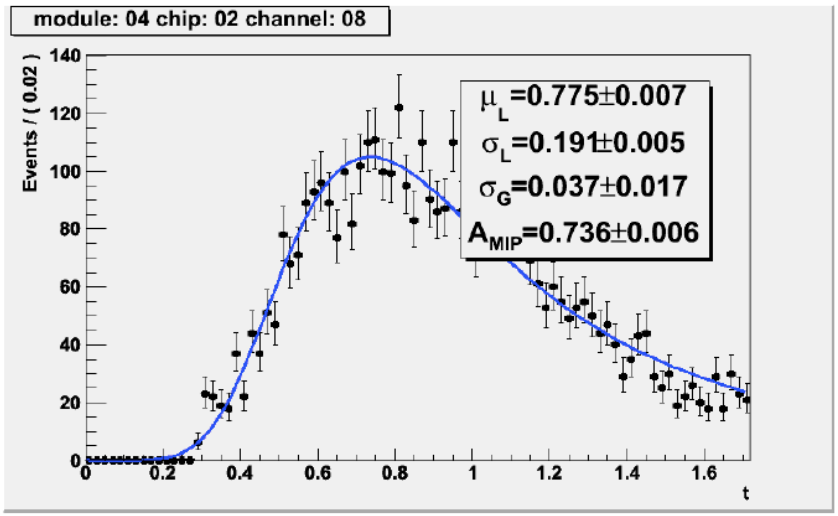



Light yield just for one run
$\rightarrow$ mean of 12 (before: LY=13)

(talk by J. Zalesak)

# Status of MIP Calibration

- Updated and improved performance of the code from Andrea
- Previously: No MIP cut applied
  Now (due to technical reasons of disk space):
  Apply 0.3 MIPs cut (based on CERN 2007 old calibrations)
  $\rightarrow$ introduces no bias as verified by Andrea




Obtained 74% from the old MIP value

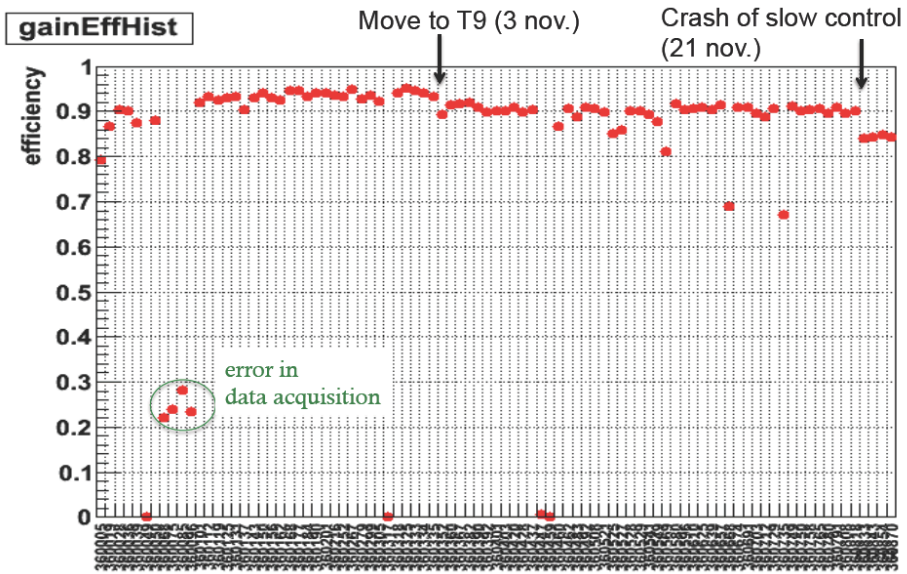
**Next Steps:**

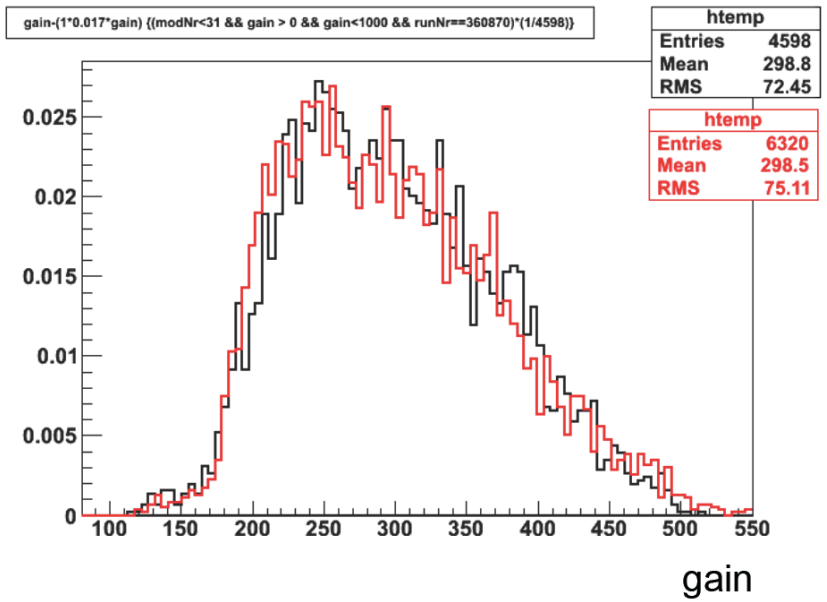
- Understand shift in MIP value
- Check influence of angle for the MIP finder (in T7, muons have 3-4 degrees)
- Extract MIP values for all muon runs

(talk by C. Grefe)

# Status of Gain Calibration

- First values already in DB (help from N. Feege and C. Guenter)
- Docu at https://twiki.cern.ch/twiki/bin/view/CALICE/CERN2010



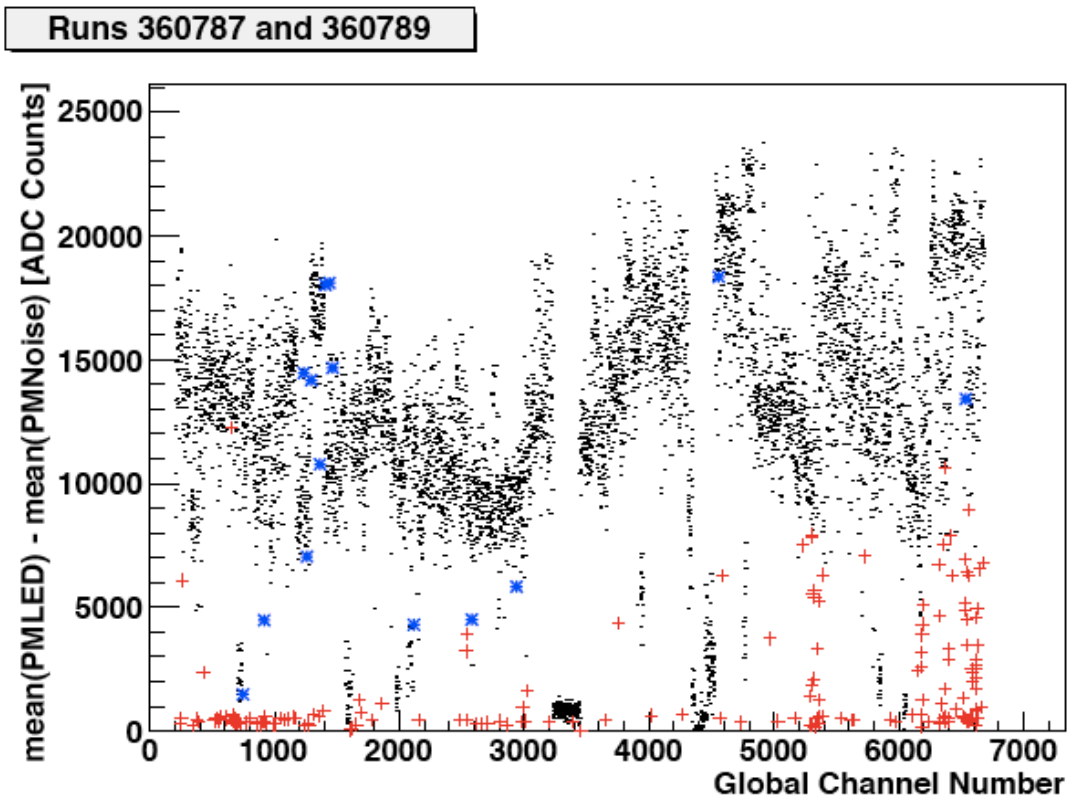

- Dead modules after move from T7 to T9 and
- Crash of slow control effected gain

Values similar with FNAL ones (corrected for temperature)

(talk by E. Van der Kraaij)

# Status of Noisy/Dead Channels

- Cleaning up of code and move to use of ROOT trees in progress
- Decision of best definition of noisy/dead in progress
- New values for DB within 1 week possible

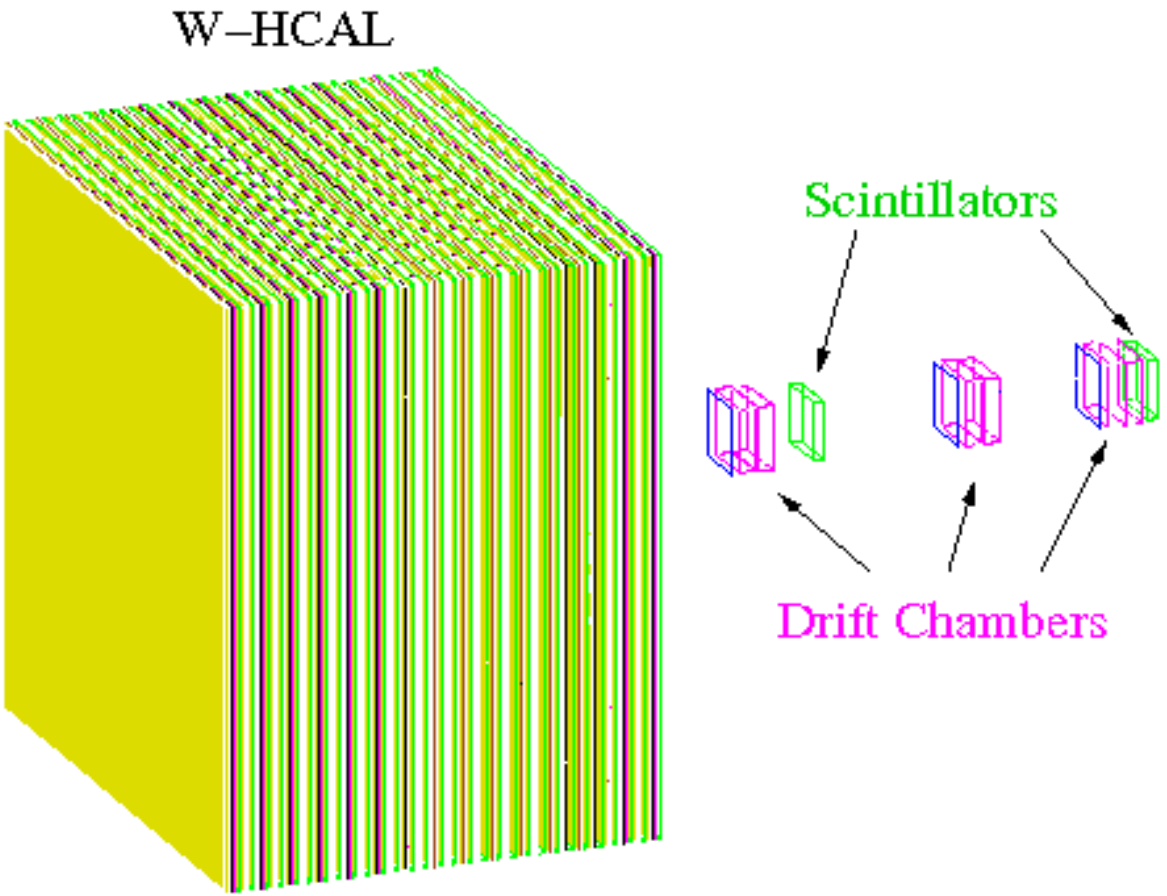



- Red: Dead channels (RMS(PMNoise) < 20.5)
- Blue: Noisy channels (RMS(PMNoise) > 130)
- Many channels with mean < 6000
- Module 15 is completely off (ch. 3200 - 3400)

(talk by M. Killenberg)

# Status of Simulation

Mokka model implemented:
TBCern2010 (build with the help of Gabriel Musat)




talk by J. Nardulli

# Summary & Issues

## Calibration is on the way

First preliminary full set should be available within 1-2 weeks

## Issues: Analysis

- Understand IC shift to higher values
- Understand the 30% shift in MIP value
- Investigate problems with some channels during calibration
- Understand proton data selection
- Effect of slow control crash on data

## Issues: Hardware

- Dead modules 6 and 15 after move to T9, check LED?
- Slow control crash: Replace the old machine?
- Temperature sensors: Calibration lost after slow control crash