Laboratoire d'Annecy de Physique des Particules

Calibration system

ECAL Upgrade II Workshop

December 12, 2022

JF Marchand

cnrs

UNIVERSITÉ SAVOIE MONT BLANC

How the calibration was done in run 2

- Energy computed as: $\boxed{E = \alpha \cdot E_{\text{ECAL}} + \beta \cdot E_{\text{PRS}} + \gamma}$
- **α coefficients can be obtained from π^0 calibration**
  - α set to 1 in the reconstruction, scaling done by changing directly the HV of the PMTs
- **β and γ coeff. computed from low multiplicity events in run 1 (ad hoc coefficients)**
- Other corrections (leakage, pile-up) computed from run 1 data, too

- **Absolute calibration**
  - Cesium scan for HCAL
  - Fine π^0 calibration for ECAL: Fully automatic since 2017
- **Relative calibration**
  - Reference file with LED amplitudes is adjusted after each absolute calibration
  - **After each fill**: Comparison with reference and automatic update of the HV
  - Fully automatic since 2015 for HCAL and since 2016 for ECAL

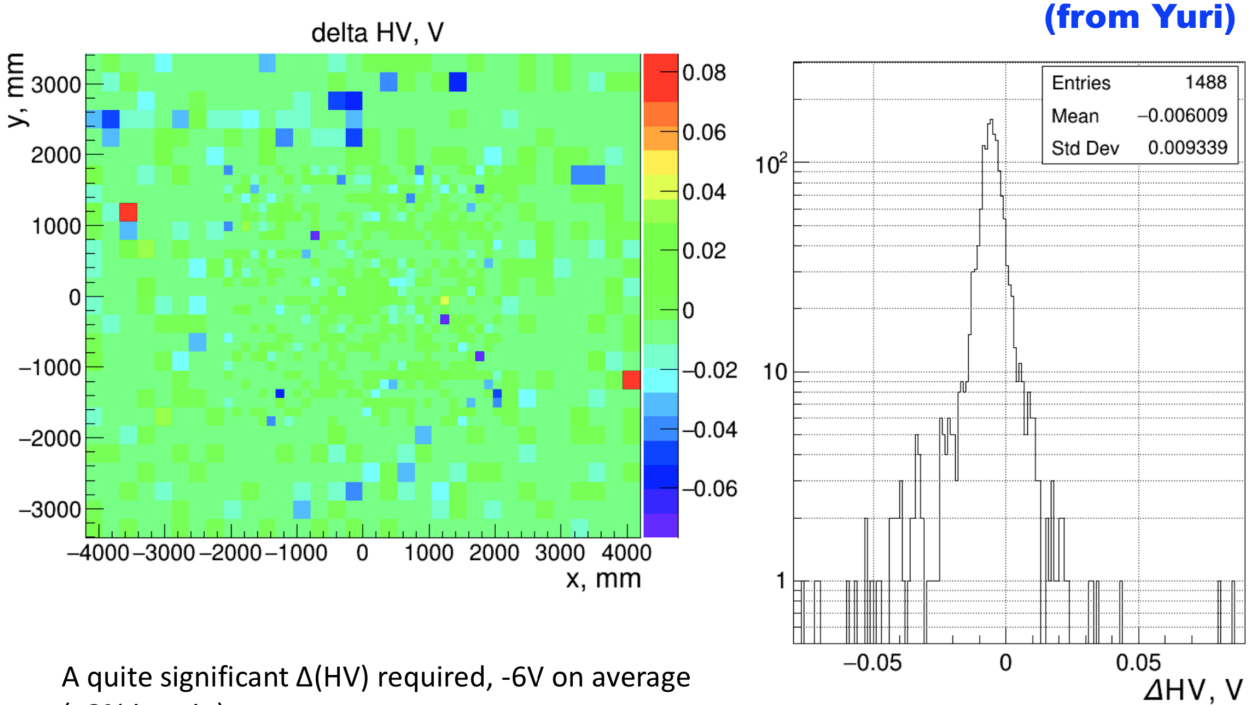
Absolute calibration

HCAL Cs scan

- A radioactive Cs^{137} source is used for calibrating the HCAL
- 6 stainless steel pipes are fed through holes in the calorimeter modules, being connected together in pipeline with C-shape tubes
- The radioactive source is driven by distilled water flow at the speed of about 40 cm/s

HCAL ^{137}Cs calibration 2018-06-18

(from Yuri)



A quite significant Δ(HV) required, -6V on average (~3% in gain).
The previous calibration was March 23, the reference taken Apr 22 – may be an explanation.
The next calibration is scheduled for September 18.

Online π^0 calibration in run 2

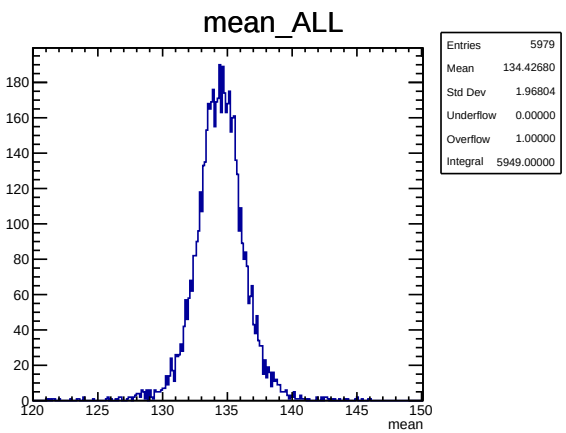
- NoBias events collected at the rate of 400 kHz
- Small DST files automatically produced at the end of each fill on HLT farm and accumulated
- 300 M NoBias events are required to launch the π^0 calibration
- π^0 calibration launched at the end of the fill as soon as the number of events is high enough and after small DST production is done for the current fill
- Full calibration needs 1-2 hours - The procedure is stopped in case the LHC is filled again before it finishes and relaunched after the following fill
- Ntuples are made from the small DST and calibration run on them
- Cuts used to make the ntuples:

$$\begin{cases} p_T^{\gamma} > 250 \text{ MeV} \\ p_T^{\pi^0} > 200 \text{ MeV} \times (7 - \eta) \end{cases}$$

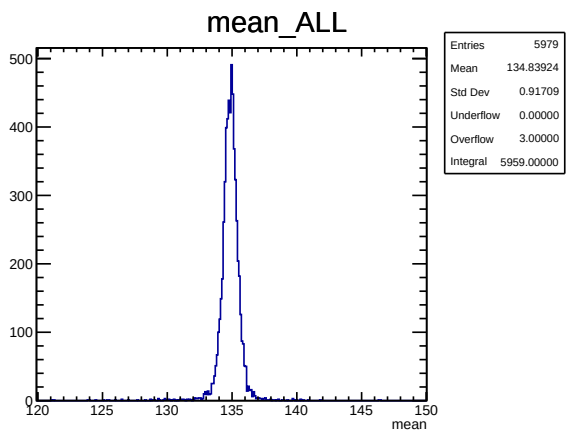
π^0 calibration procedure

- **First pass**: 7 iterations $\rightarrow$ First set of coefficients λ_1 $\rightarrow$ temporary DB
- **Second pass**: Full reconstruction using the temporary DB $\rightarrow$ 7 iterations $\rightarrow$ Second set of coefficients λ_2
- Then **PMTs HV modified** using $\lambda_1 \times \lambda_2$ through reference update

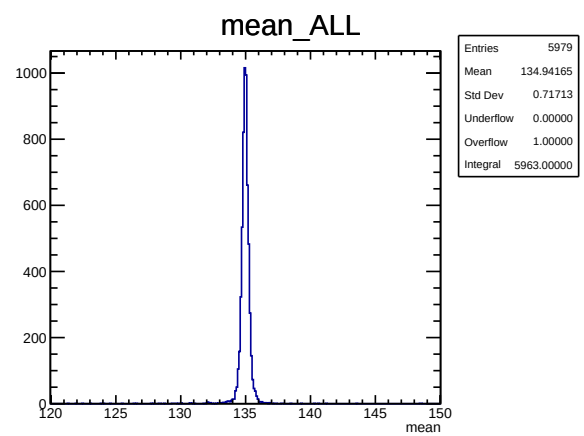
First pass $\rightarrow \lambda_1$



Second pass $\rightarrow \lambda_2$



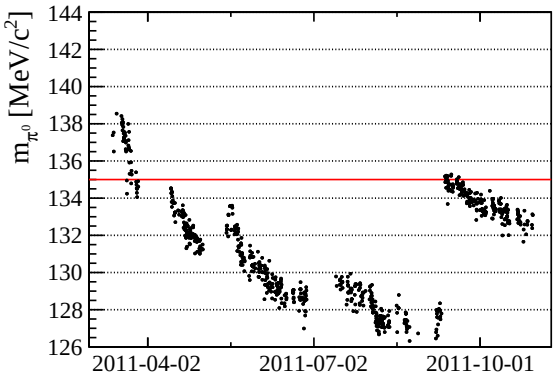
Final check ($\lambda_1 \times \lambda_2$)



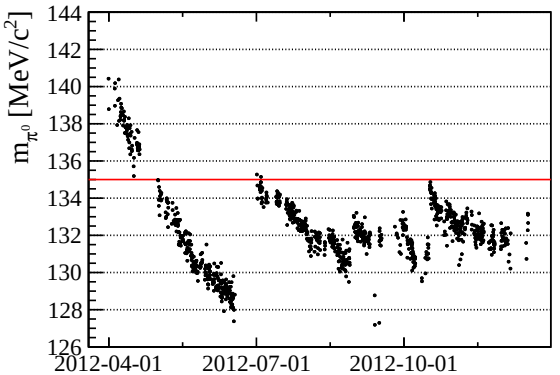
(Plots done using June 2016 data)

π^0 mass vs time (1/2)

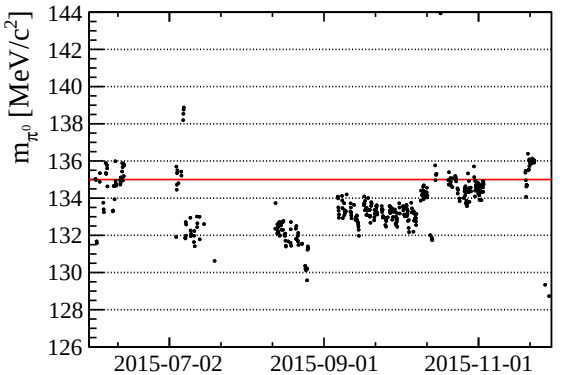
2011



2012



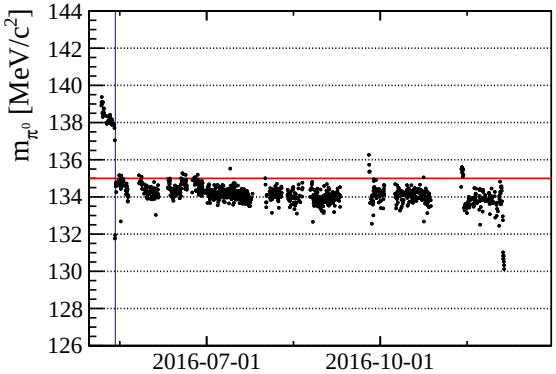
2015



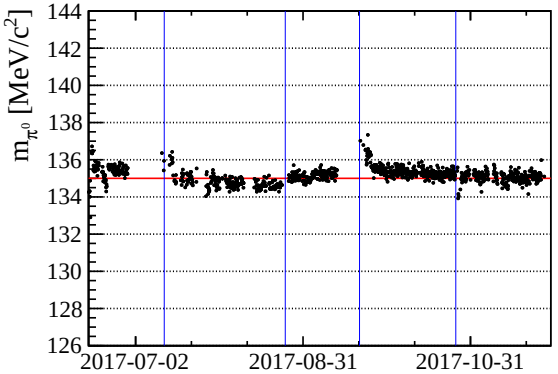
- Here: Online π^0 mass as a function of time
- During run 1, calibration was done by hand and corrections applied offline

π^0 mass vs time (2/2)

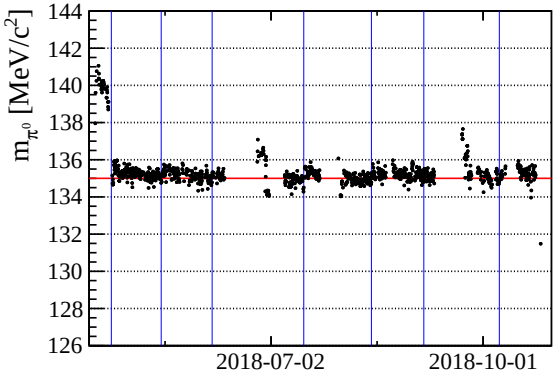
2016



2017

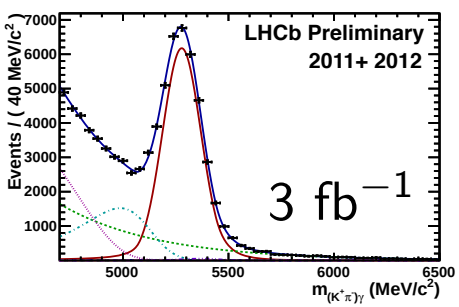


2018



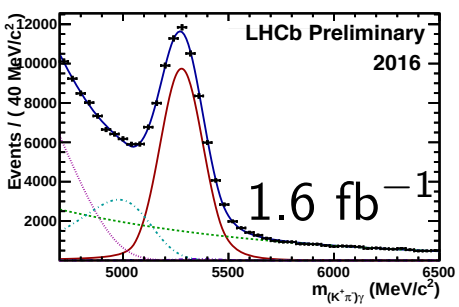
- π^0 calibration became fully automatic in 2017
- Offline re-calibration was needed for 2016

Run 1



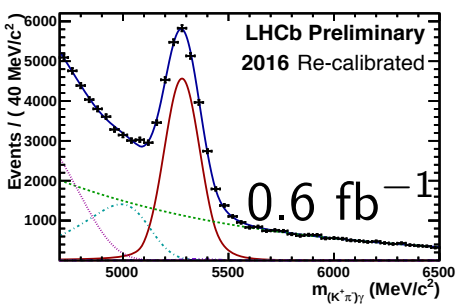
$\sigma = 90.7 \pm 0.6$ MeV

2016



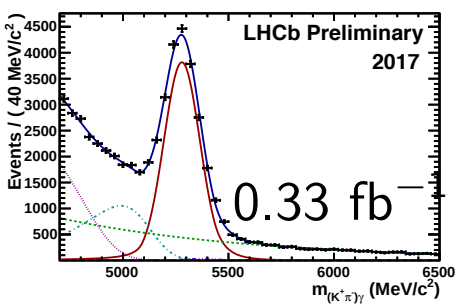
$\sigma = 101.3 \pm 0.1$ MeV

2016
offline re-calibration



$\sigma = 84.4 \pm 0.7$ MeV

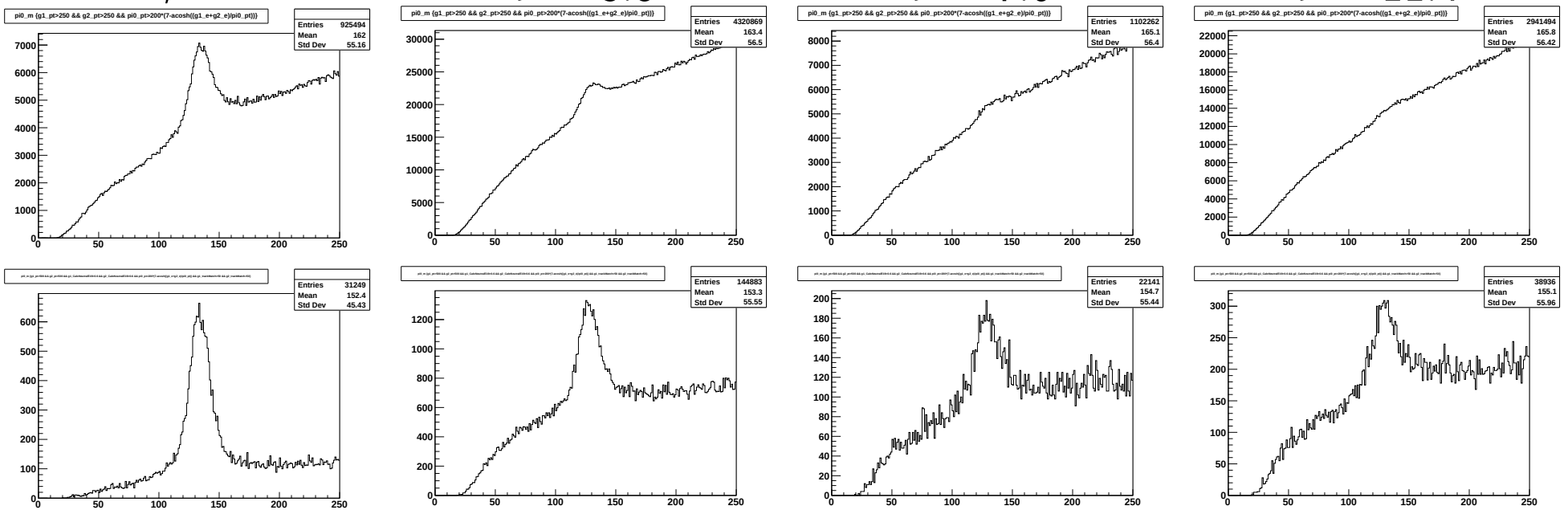
2017



$\sigma = 85.1 \pm 0.7$ MeV

Effects of pileup on π^0 mass

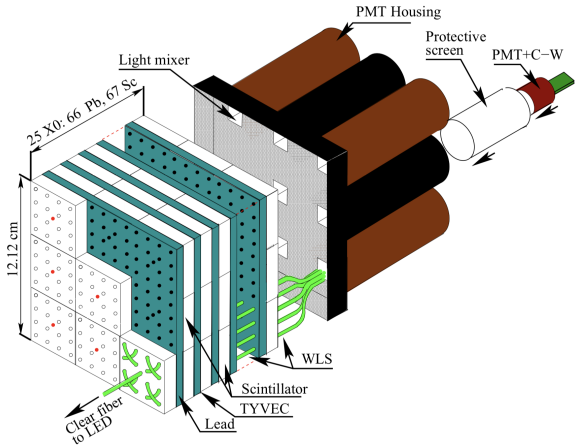
MC16, $\nu = 1.6$ | $\nu = 3.8$ | $\nu = 7.6$ | $\nu = 11.4$

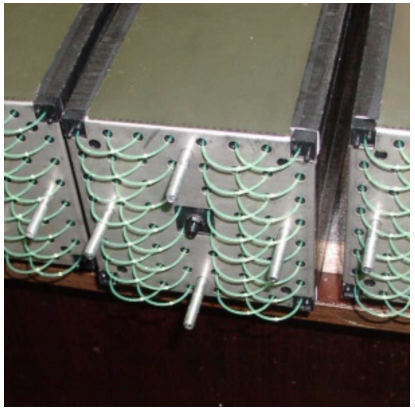


- Cuts applied:
  - First row: Minimal cuts $p_T^\gamma > 250$ MeV, $p_T^{\pi^0} > 200 \times (7 - \eta^{\pi^0})$ MeV
  - Second row: $p_T^\gamma > 500$MeV, $p_T^{\pi^0} > 200 \times (7 - \eta^{\pi^0})$ MeV, trackMatch>50, E19> 0.6
- $\mu = 0.699\nu$
  https://twiki.cern.ch/twiki/bin/view/LHCb/NuMuPileUp

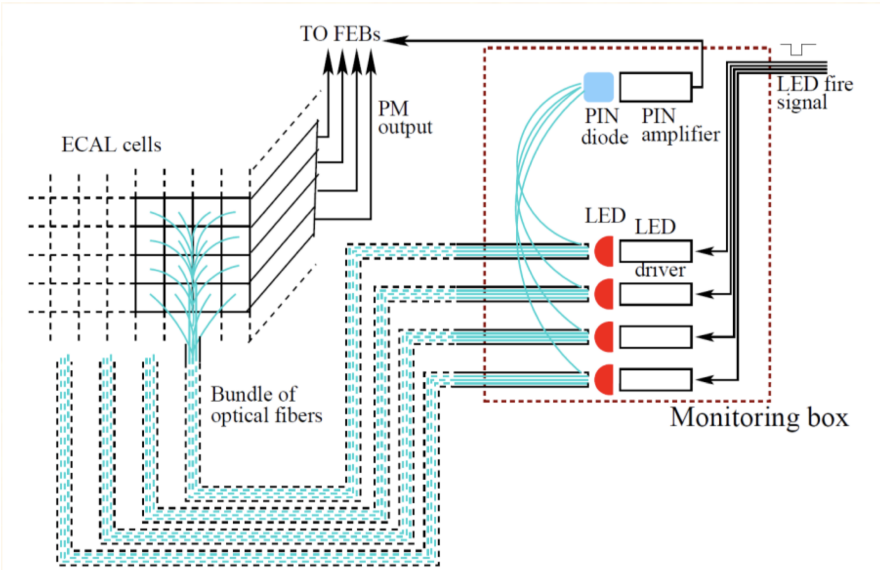
Relative calibration

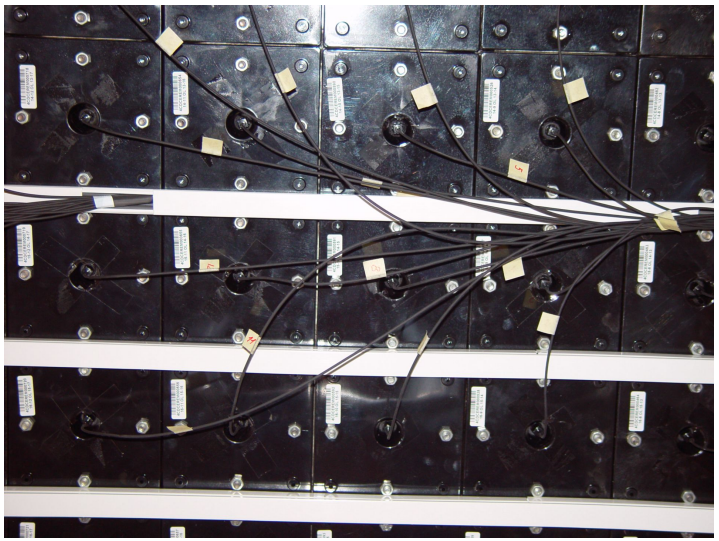
LED system - ECAL



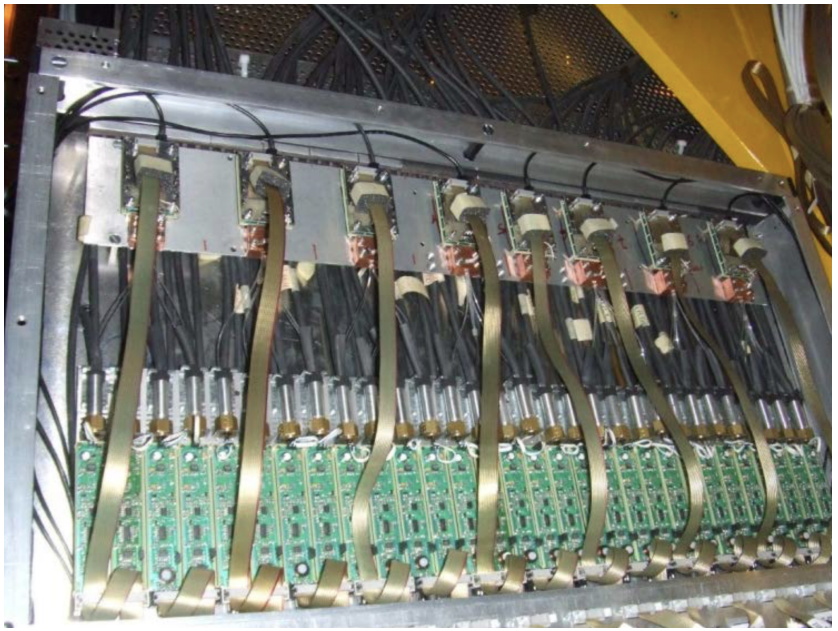


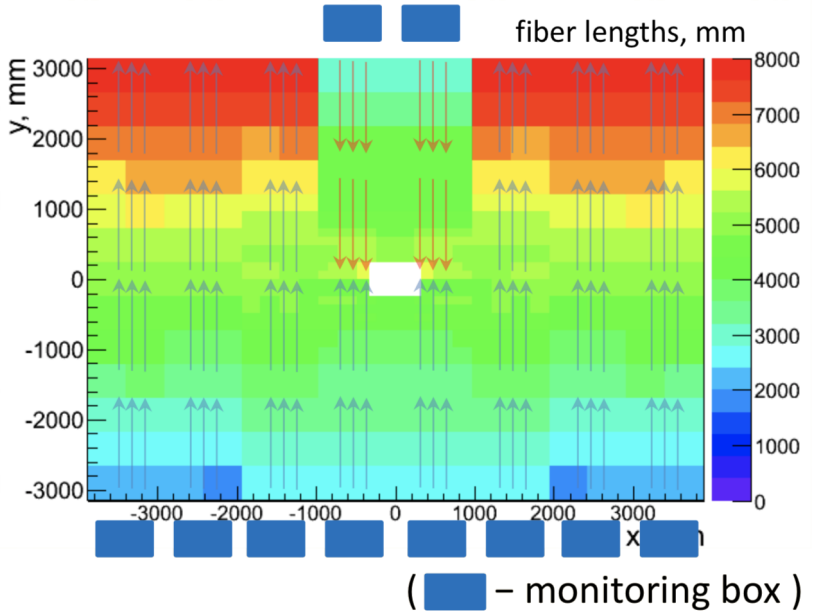
- The 6016 ECAL cells are served by 456 LEDs (16 or 9 cells per LED)
- The LED light is delivered to each PMT via a dedicated clear fiber
- LED flash magnitudes monitored by PIN photodiodes (1 per 4 or 2 LEDs)





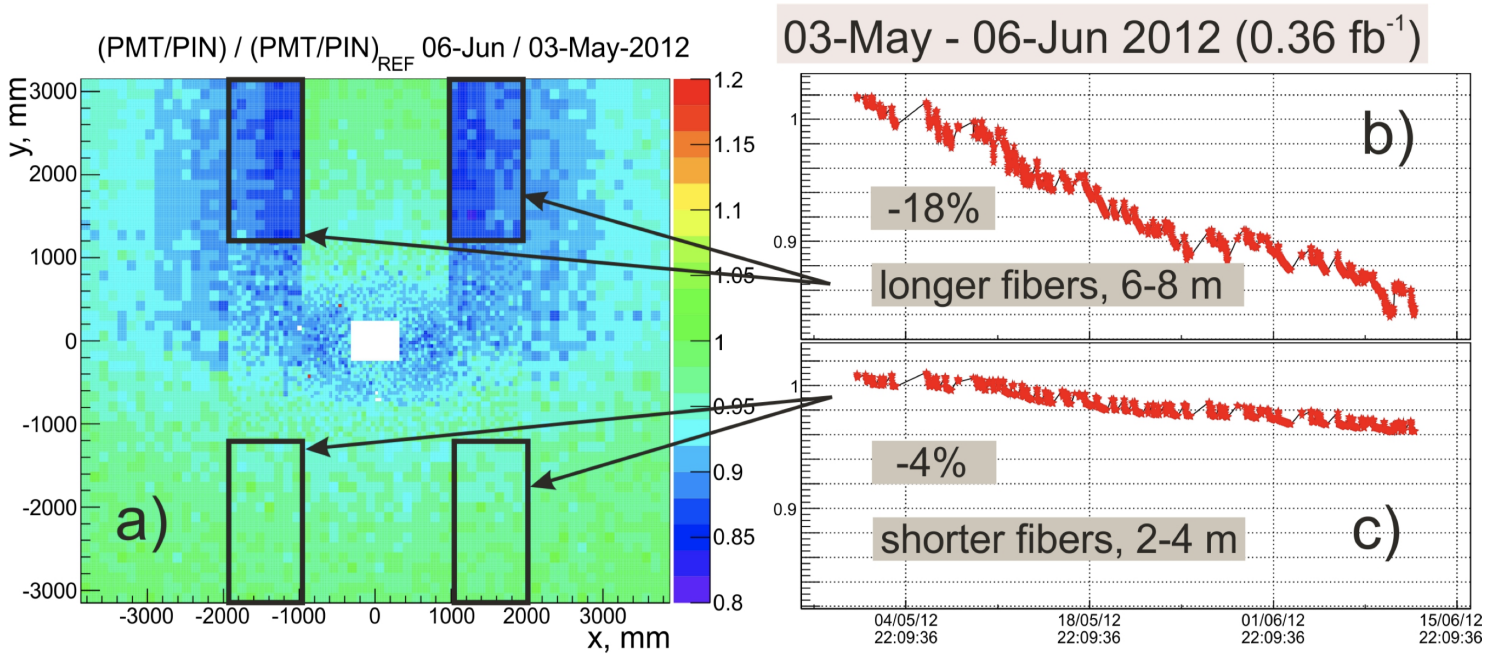
LED system - ECAL





- LEDs, LED drivers, PIN photodiodes and their amplifiers are installed inside monitoring boxes above and below ECAL
- LED light is transported to PMTs through optical fibers
- For mechanical reasons, 8 out of 10 monitoring boxes are placed below ECAL. The fiber lengths range from 2 to 8 m.

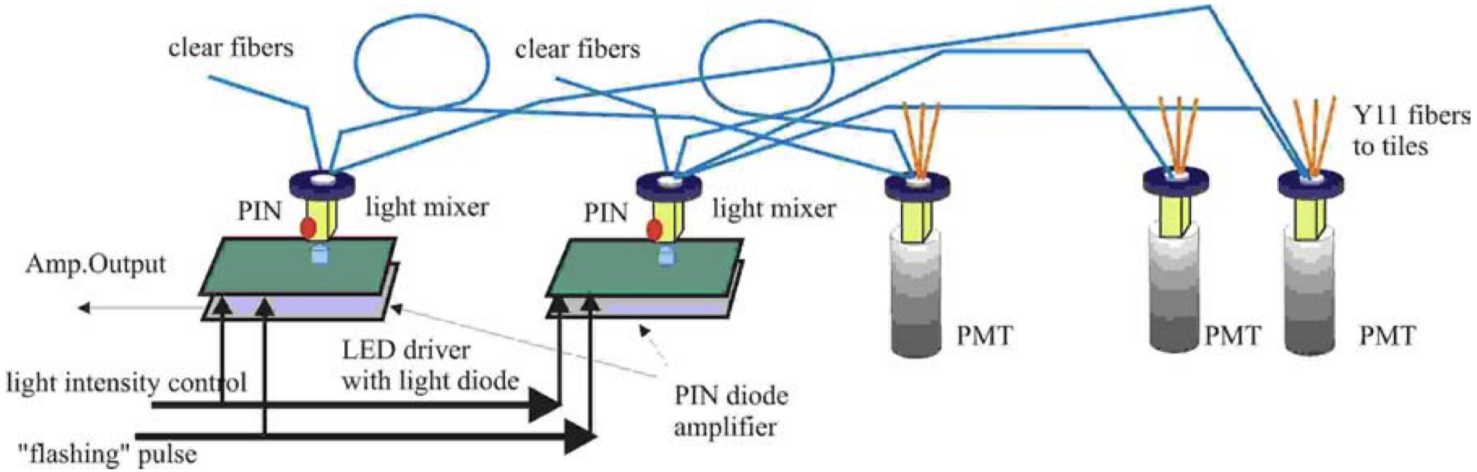
Radiation degradation of clear fibers



- Degradation of the clear fibers observed during run 1 (higher degradation of longer fibers, running from bottom to top)
- The degradation rate was estimated to $\approx 10\%/m$ for ≈ 7 krad at max
- The LED system was of a limited use for online gain corrections (% accuracy is desired)
- It was decided to replace the plastic fibers to rad hard quartz ones (with $< 1\%/m$ transparency loss for ≈ 100 krad), done in 2014, during LS1

(Expected integrated dose over the fiber lenght: 100 krad·m per year during run 2, $\times 2$ during run 3)

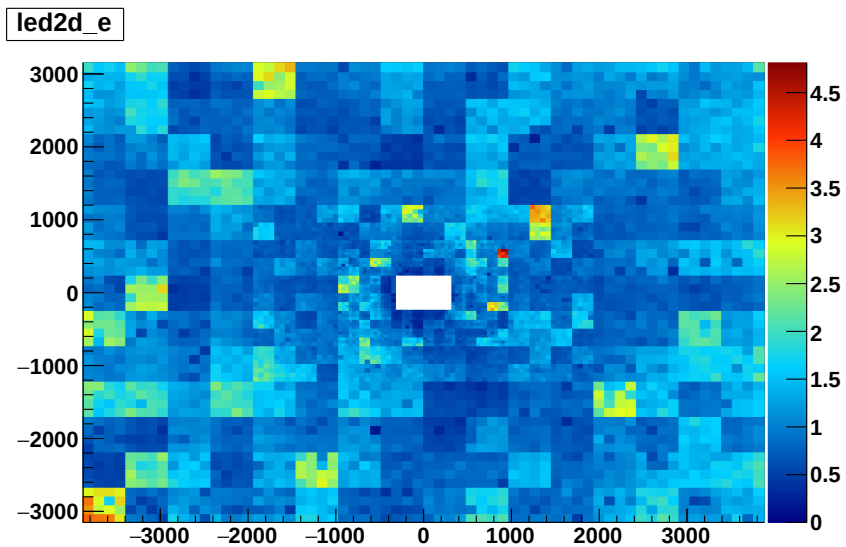
LED system - HCAL

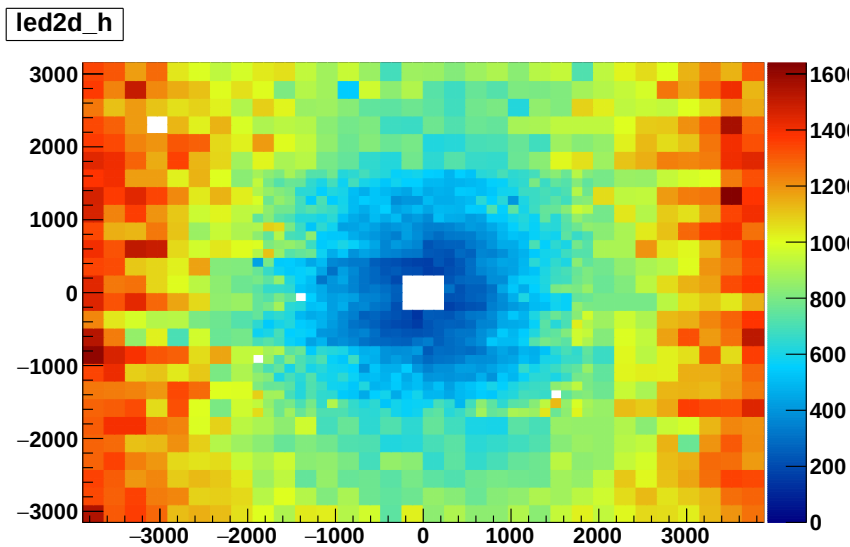


- Similar for HCAL
- Each HCAL module is equipped with 2 LEDs each illuminating every cell in the module (1488 cells in total)
- Clear fibres bring the light of both LEDs to each PMT via its light mixer
- 1 PIN diode monitors the stability of each LED
- The 2 LEDs in each of the 52 modules illuminate 16 or 40 cells and are controlled by 104 LED drivers

LED autoupdate, since 2015

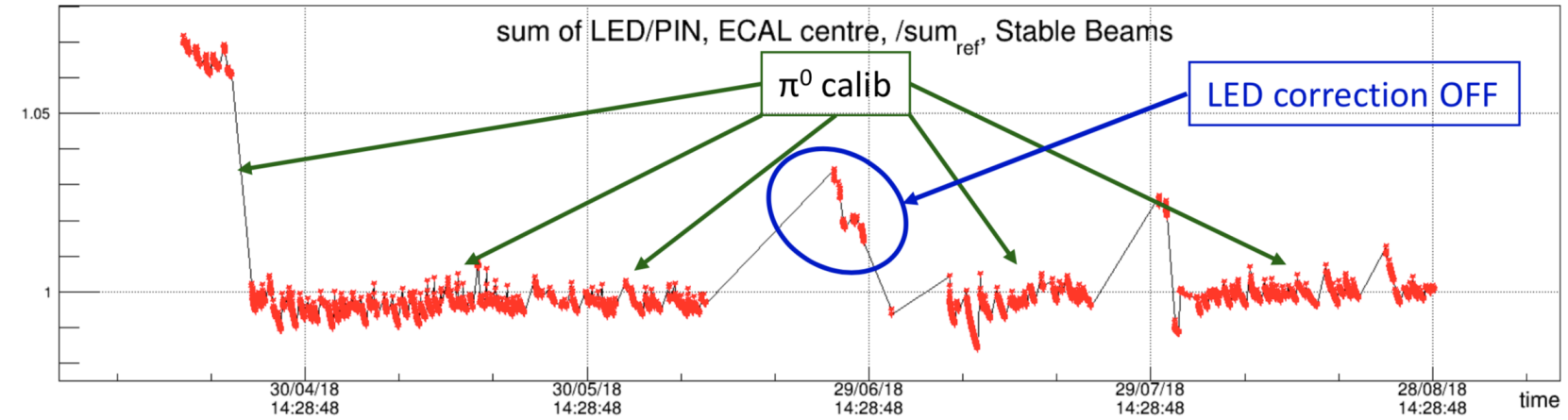
- Relative calibration by comparing the LED data to a reference
- References ROOT files are produced after each π^0 calibration for Ecal and Cs scan for Hcal
- Comparison with the reference is done after each fill
  - Check if LED data starts after begin of fill + 2 hours
  - Minimum of 90 min of LED data mandatory
  - Merging the corresponding Savesets
  - Ratio of merged savesets to reference
  - Automatic HV update

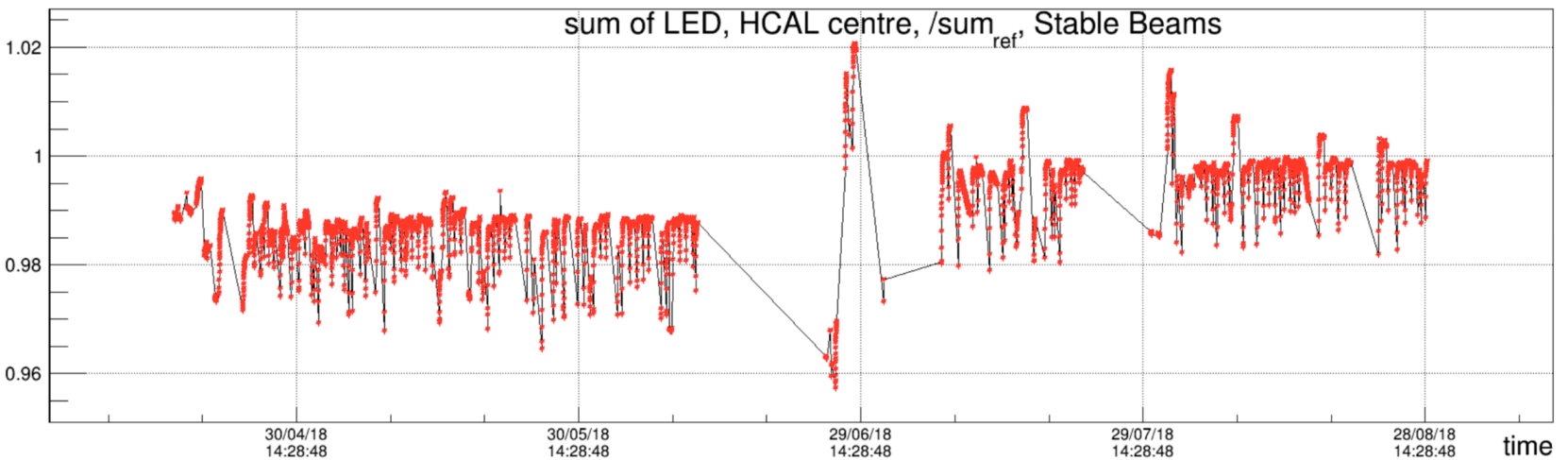




Last references files used in 2018

ECAL/HCAL LED monitoring





106 LED based corrections; 5 ECAL π^0 calibrations. **(from Yuri)**

Summary

- Calorimeters calibration in run 2 was presented here
  - Absolute calibration using Cs scan/π^0
  - Relative calibration using LED
- High pileup will give extra challenges, at least for π^0
  - Already in run 3 where cuts are adapted