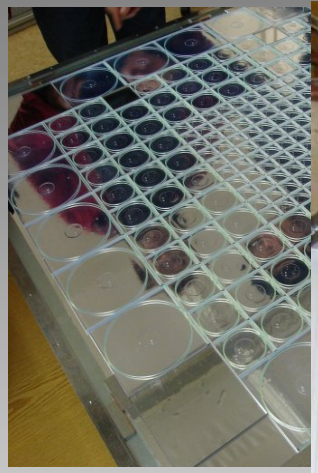
CALICE scintillator HCAL commissioning experience and test beam program

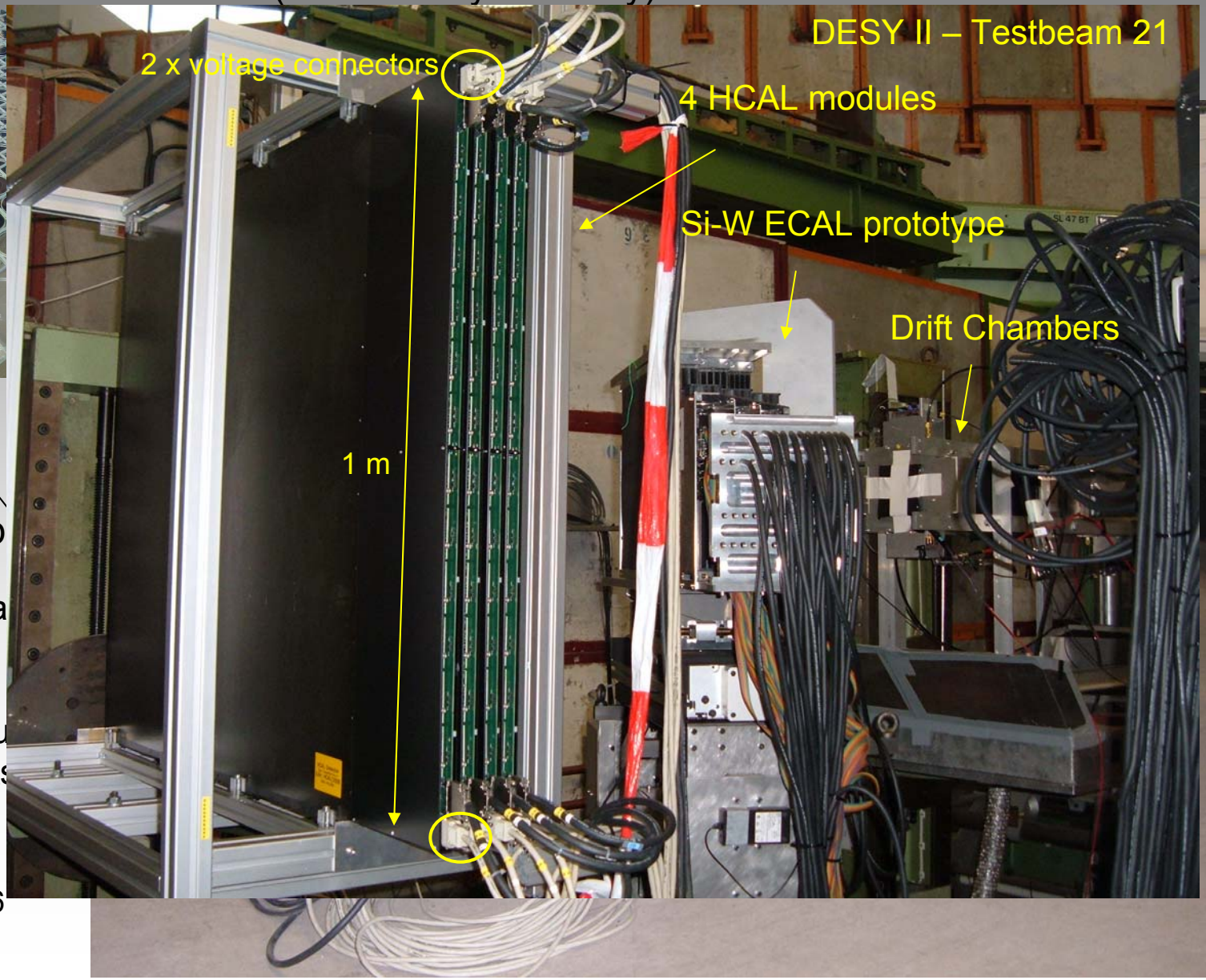
Erika Garutti

On behalf of the CALICE analog HCAL group

From production to test

(from beauty to reality)





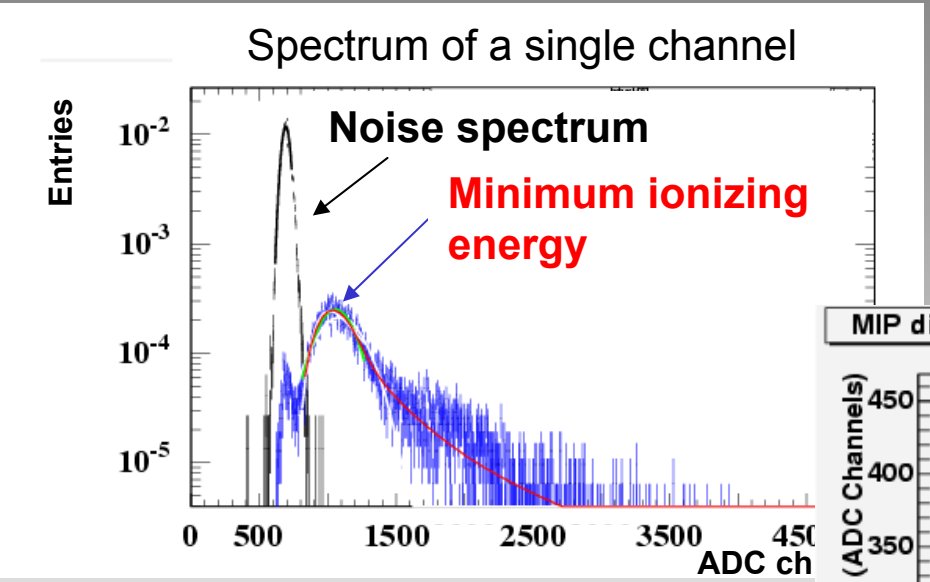
Cosmics set up

1x1 m^2 trigger pla
in coincidence

requires >3 modu
for telescopic cut
analysis

MIP calibration in the beam

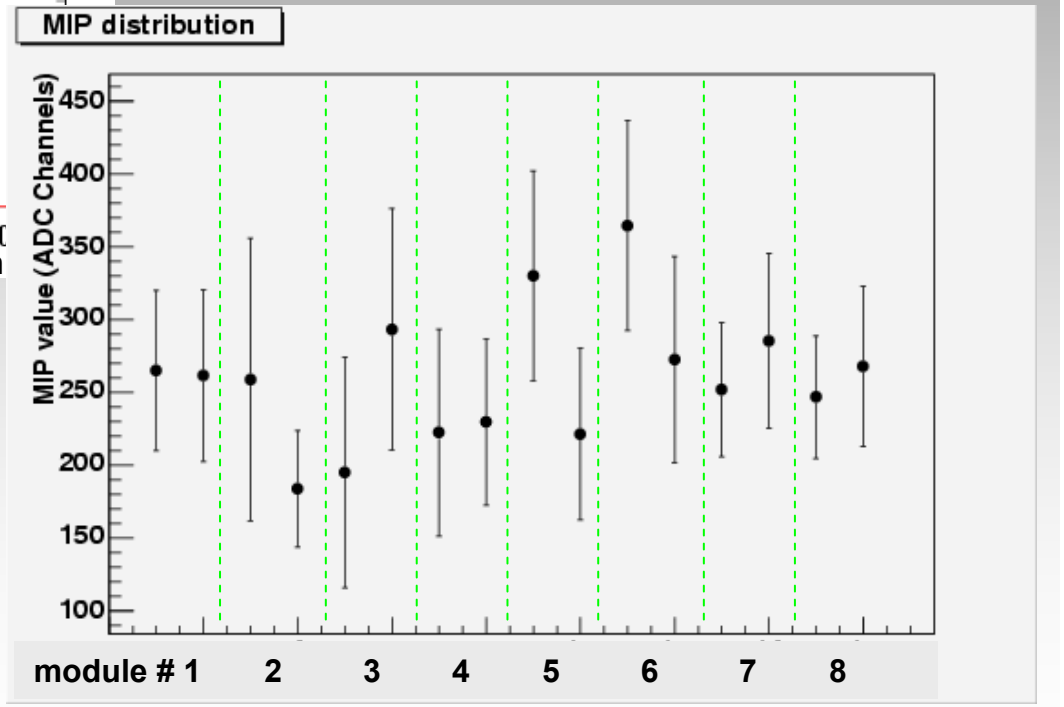
Clean MIP signal by shooting the beam in each tile



8 modules calibrated

Presented as ½ modules averages due to separate HV connections/settings

RMS of 20-25% within ½ module



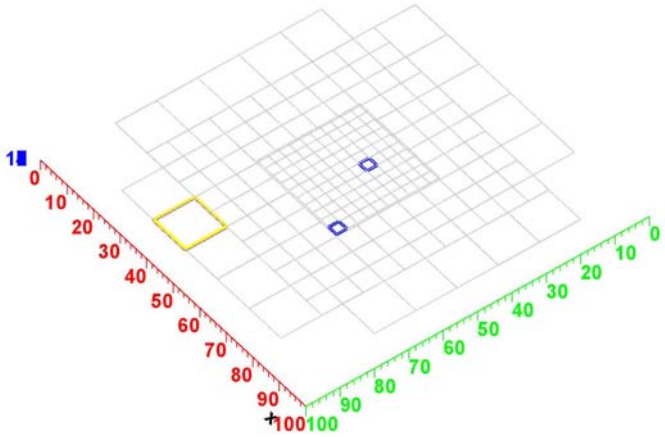
S/N separation ~ 7

Scan performed over the 216 tiles of each module

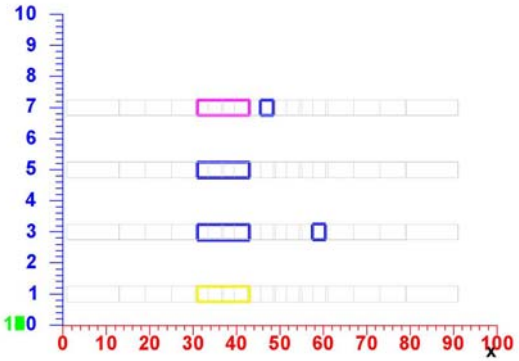
… ongoing calibration for modules 9-13

MIP from cosmics

Cosmic passing the 4 HCAL layers

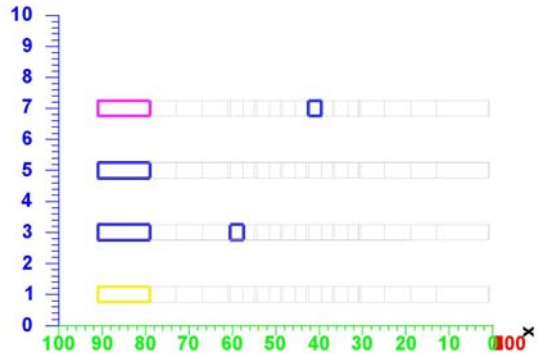


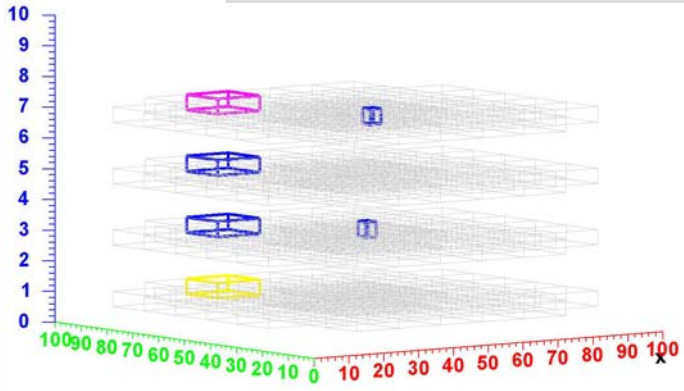
Threshold cut ½ MIP



Ongoing analysis of telescopic cuts

~ 40 noisy channels known in the first 2 produced modules:
➔ to be treated offline with higher cuts





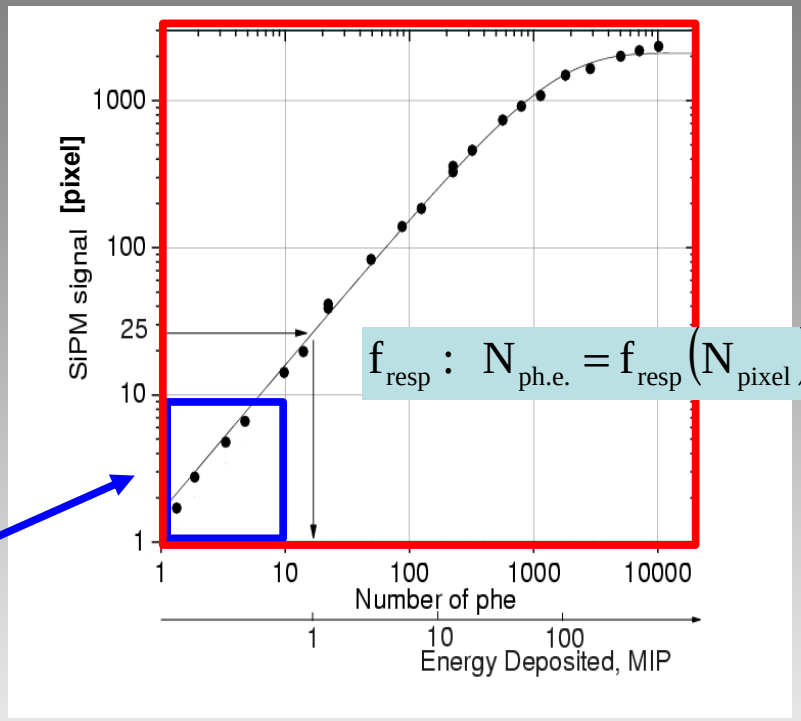
The calibration concept

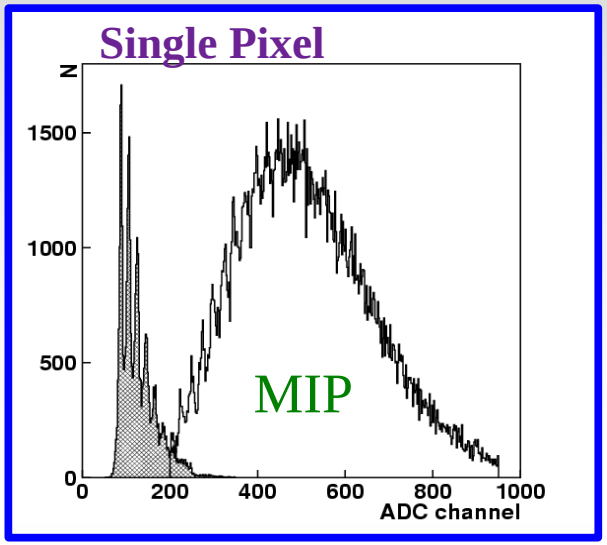
For a calorimeter with linear readout:

$E_{[GeV]} = A_{[ADC]} / A_{MIP} * E^{MC}_{MIP}$

BUT SiPM is nonlinear:

Energy = ADC counts
* gain (pixel calibration)
* SiPM response function
* light yield (MIP calibration)
* sampling

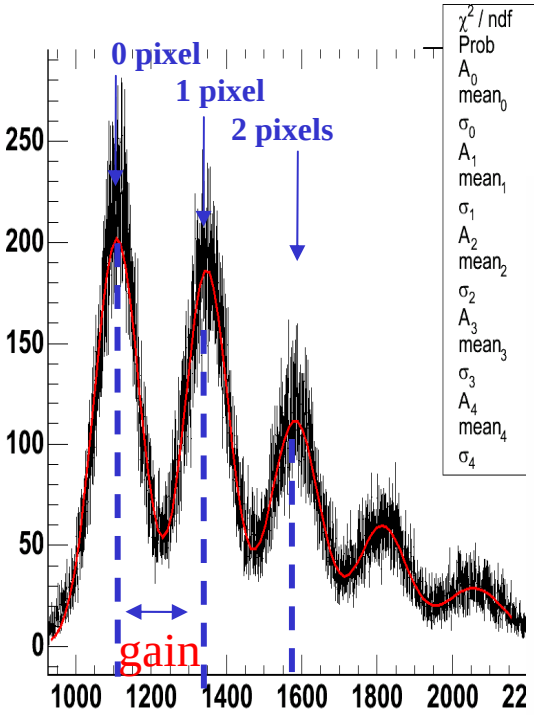




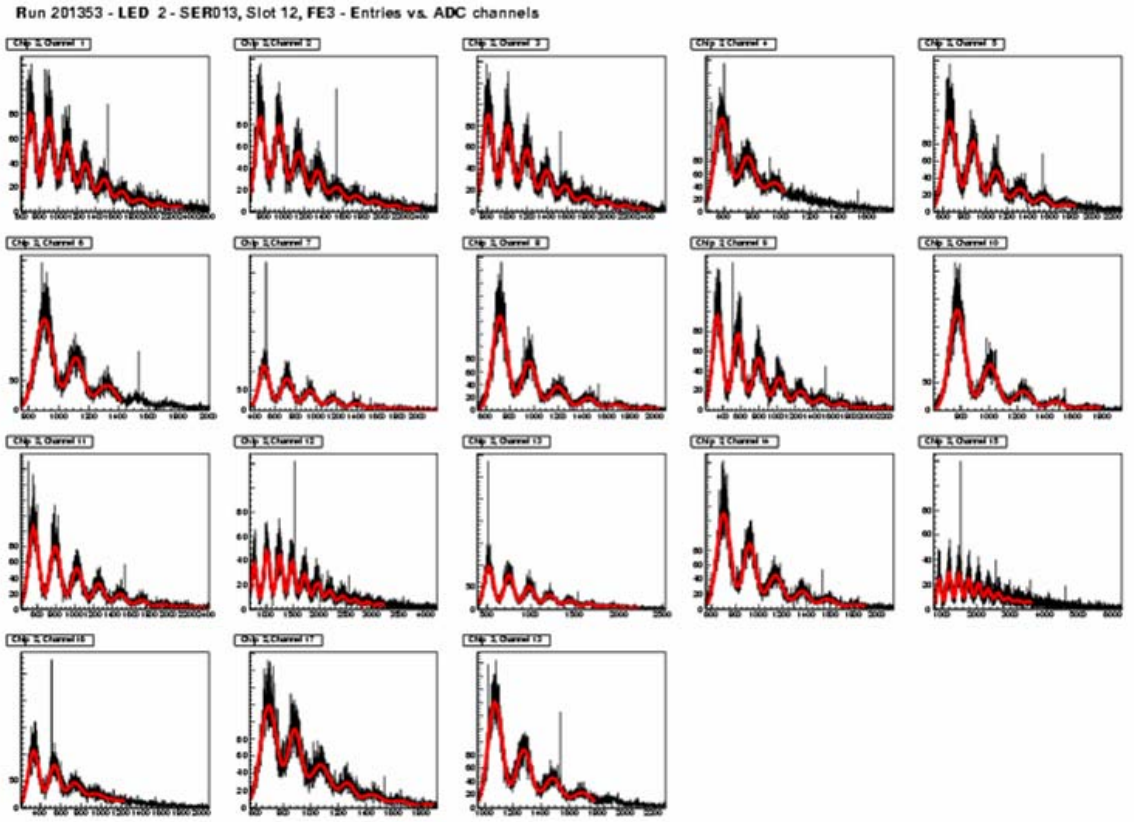
$$E_{[GeV]} = f_{resp}\left(\frac{A_{[ADC]}}{A_{MIP}} \cdot \frac{A_{MIP}}{G_{pixels}} \cdot I^{calib}_{phys}\right) \cdot \frac{1}{LY'} \cdot E^{MC}_{MIP} = N_{MIP} \cdot E^{MC}_{MIP}$$

$$LY'_{[ph.e./MIP]} = f_{resp}\left(LY_{[pix/MIP]}\right) = f_{resp}\left(\frac{A_{MIP}}{G_{pix}} \cdot I^{calib}_{phys}\right)$$

Gain calibration



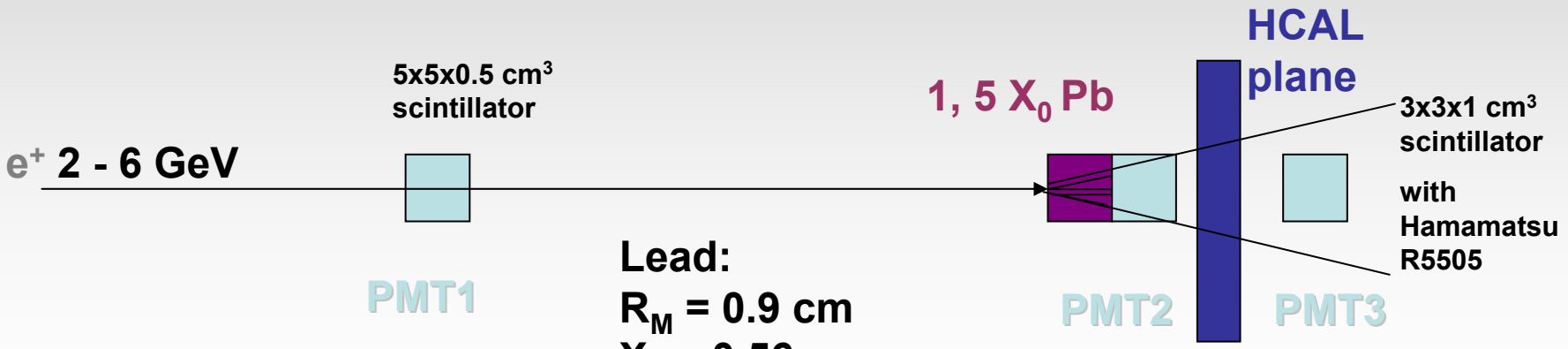
With low intensity LED light
S/N separation ~ 4
Dominated by electronic noise (ASIC)



18 SiPM illuminated by
1 LED
all chan. calibrated at once

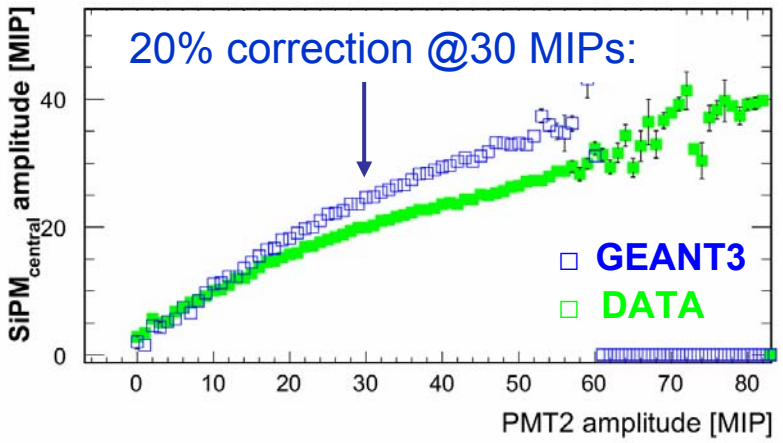
Energy of beam shower

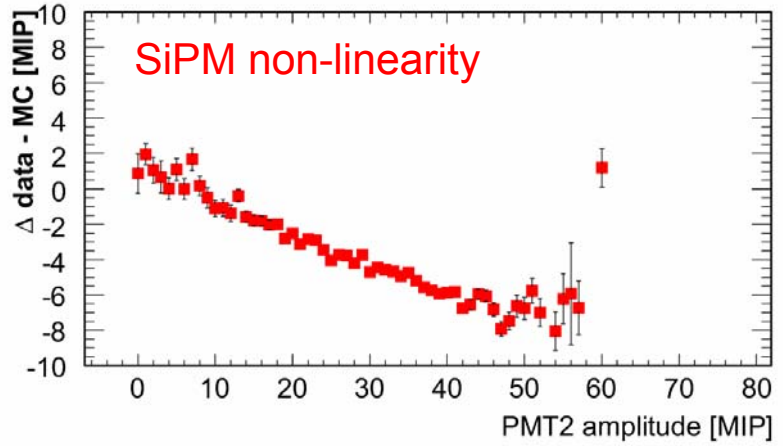
- HCAL plane scanned with e^+ 2-6 GeV and monitored by LED
  ➔ MIP calibration, LY calibration
- Beam scan on plane surface (with 1 X_0 lead) ~ <6 MIPs> at PMT2
  ➔ check uniformity of module response
- Beam scan on plane surface (with 5 X_0 lead) ~ <30 MIPs> at PMT2
  ➔ check SiPM saturation correction
- Comparison of PMT, SiPM with MC
  ➔ check the corrections

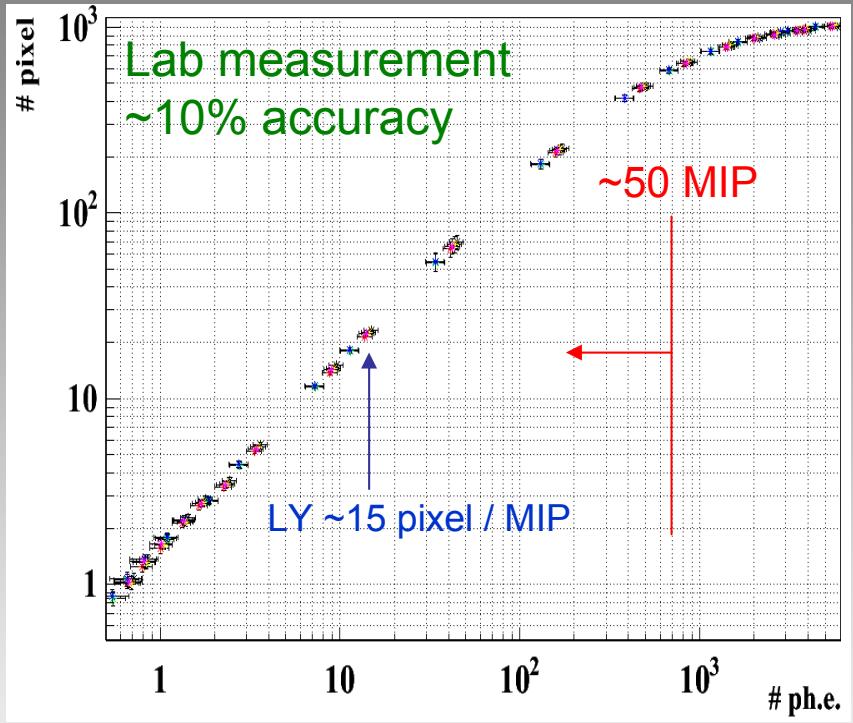


Shower analysis

Shower produced by 5 GeV beam through 5 X_0 absorber





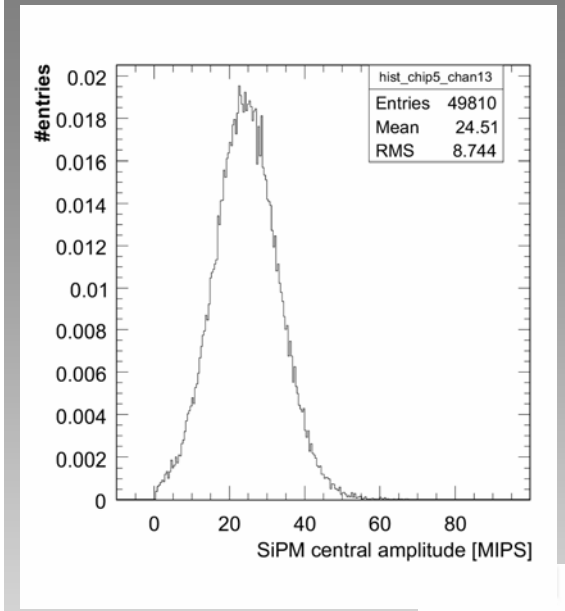


SiPM response function

describes:

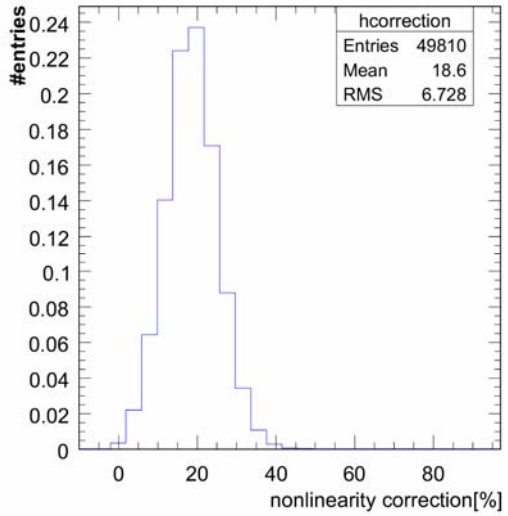
- Geiger discharge efficiency
- effective number of pixels
- inter-pixels crosstalk

Shower analysis

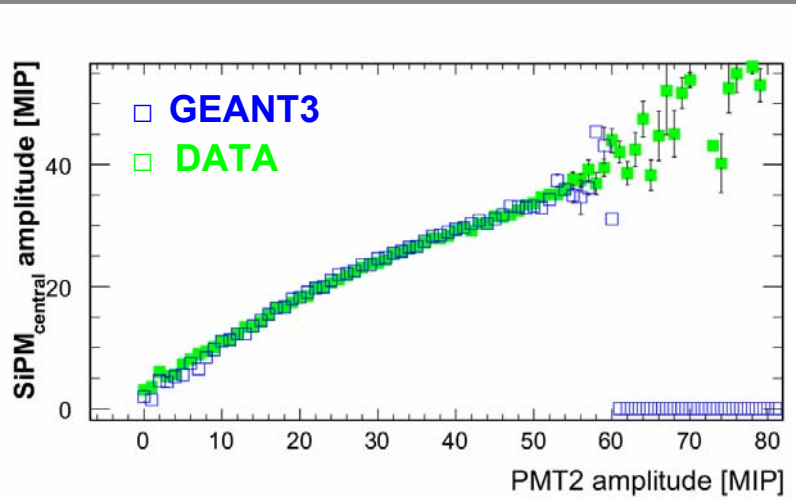


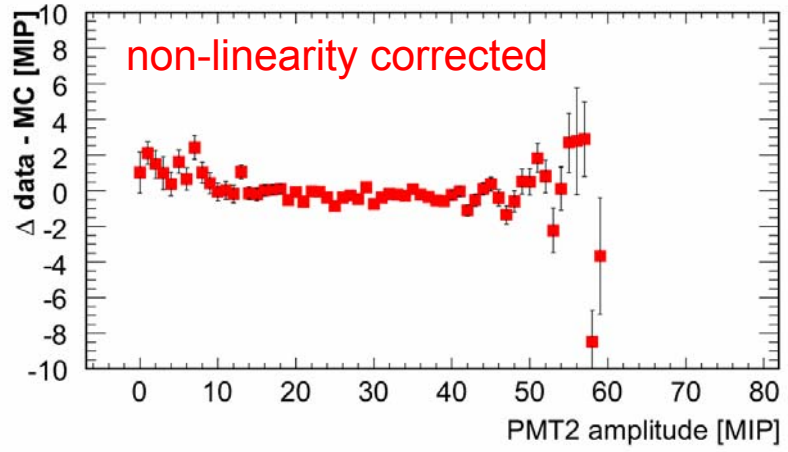
largest hit fraction between 15-35 MIP

➔ 10% to 25% correction is needed



after correction





Response function universality

Ideally:

Correct “all” SiPM with one unique response function calibrated in one point

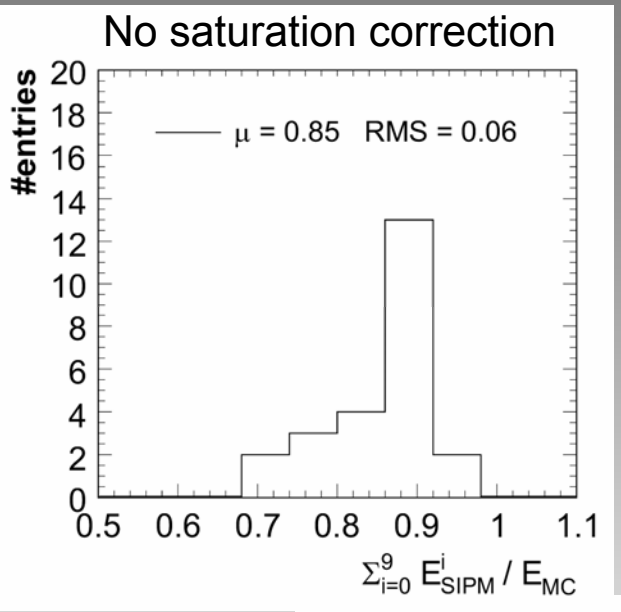
➔ using the Light Yield

$$LY_{[pixel/MIP]} = \frac{A_{MIP}}{G_{pixel}} * \frac{A^{calib}_{LED}}{A^{physics}_{LED}}$$

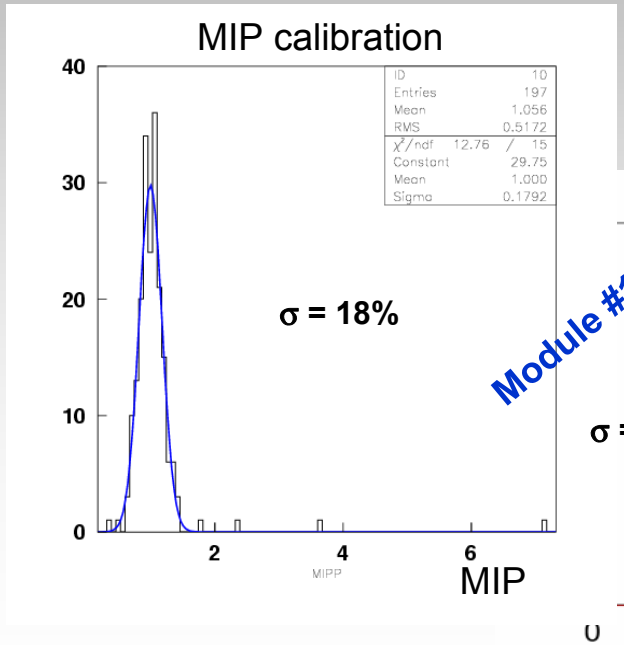
Gain calibration

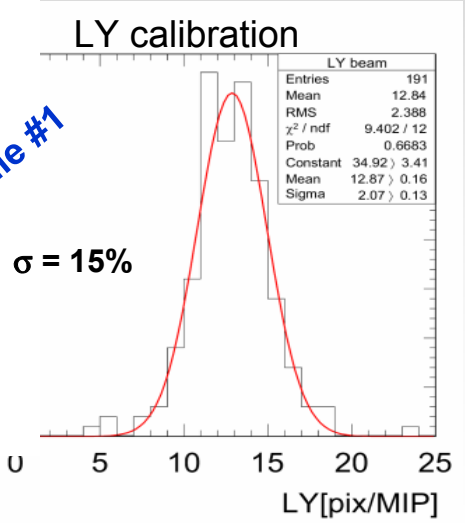
MIP calibration

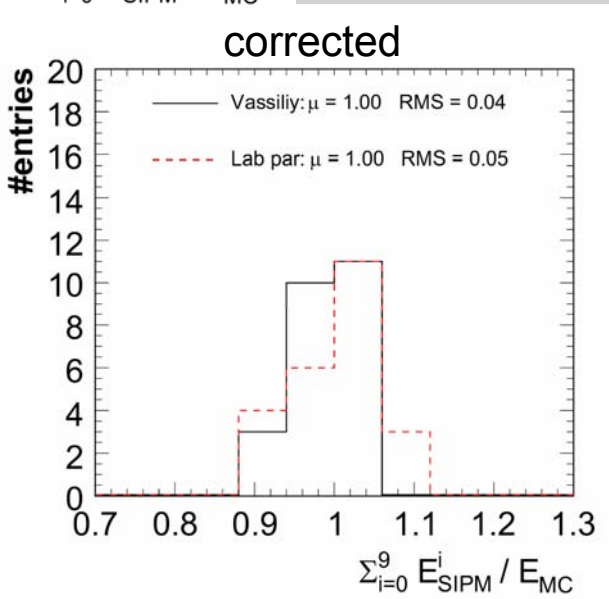
Inter calibration



24 tile matrices tested with EM shower from $5X_0$ absorber



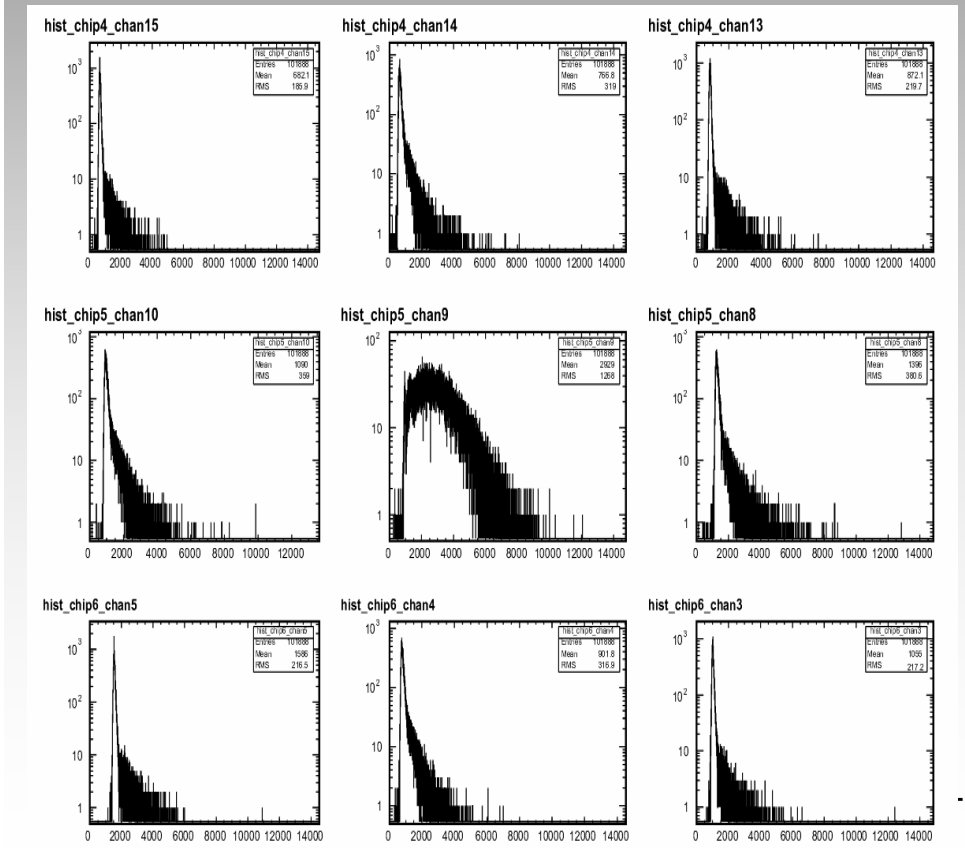




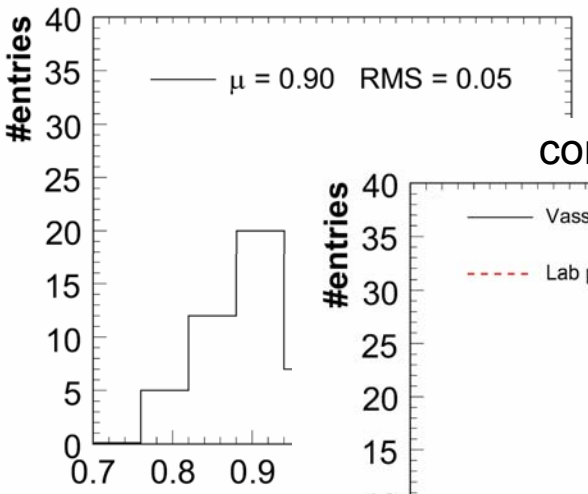
Uniformity studies

Scan of HCAL plane with 3 GeV beam and $1X_0$ in front

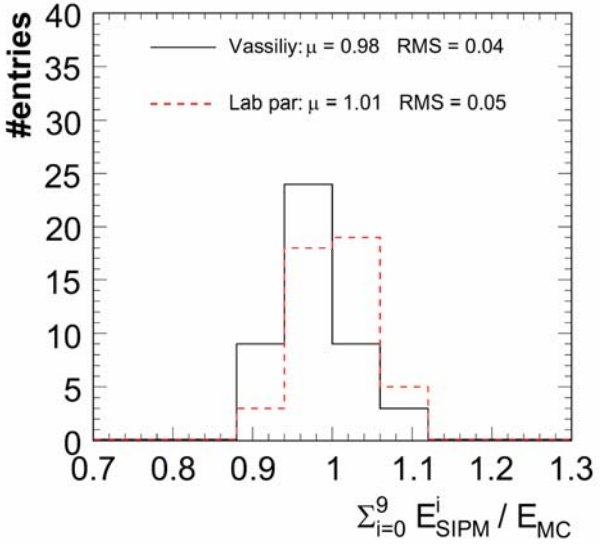
➔Energy = Σ shower energy on a 3x3 matrix of tiles (~99% of E)



No saturation correction



corrected



45 tile matrices tested:
- average in agreement with MC
- 5% spread over the HCAL core w/o temperature & pedestals corrections

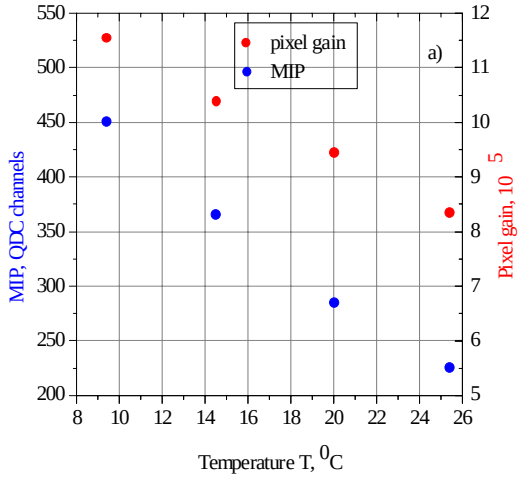
➔Good uniformity within the accuracy

Monitoring of T variations

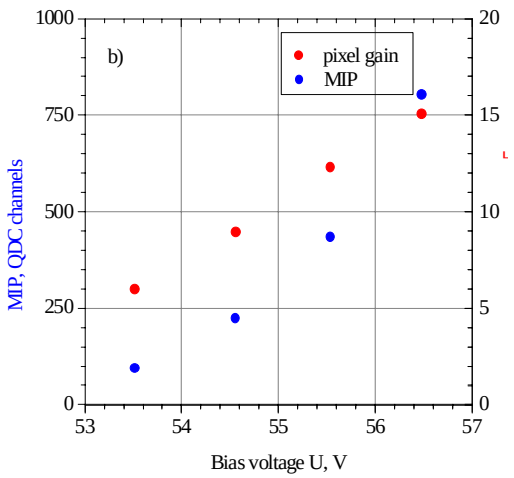
SiPM response is T and V dependent

MEPHI: direct measurement of SiPM in controlled setup

Temperature



Bias Voltage



Gain (G)

$$\frac{dG}{dT} \sim -1.7 \frac{\%}{K}$$

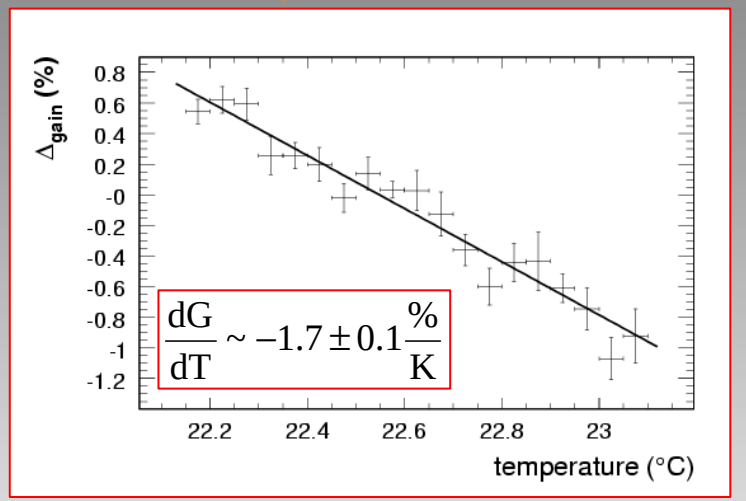
$$\frac{dG}{dV} \sim 2.5 \frac{\%}{0.1V}$$

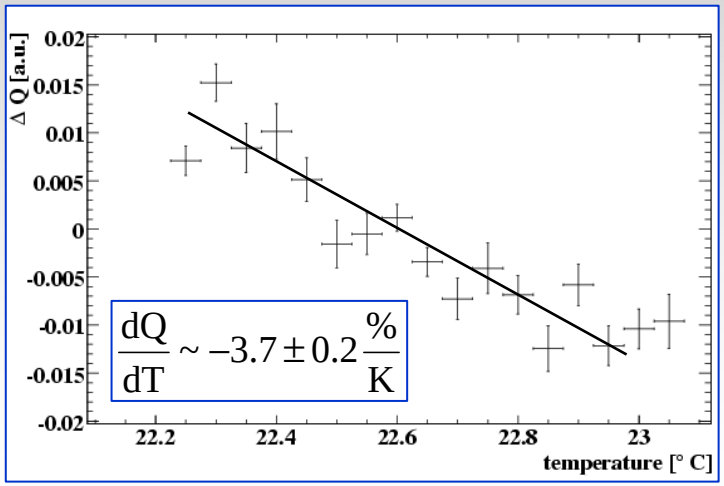
Total Charge (Q) = G*PDE

$$\frac{dQ}{dT} \sim -4.5 \frac{\%}{K}$$

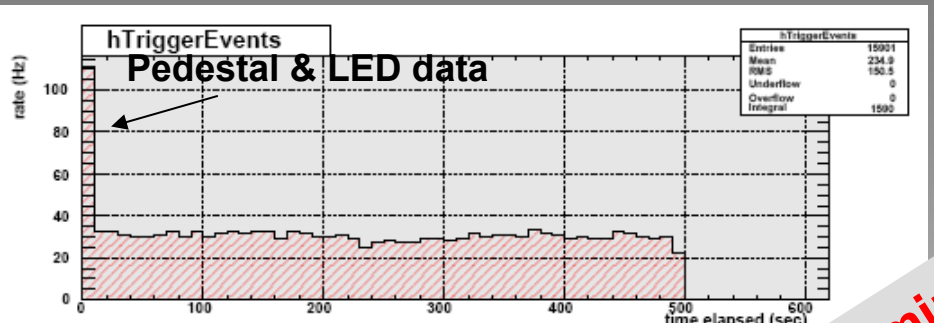
$$\frac{dQ}{dV} \sim 7.0 \frac{\%}{0.1V}$$

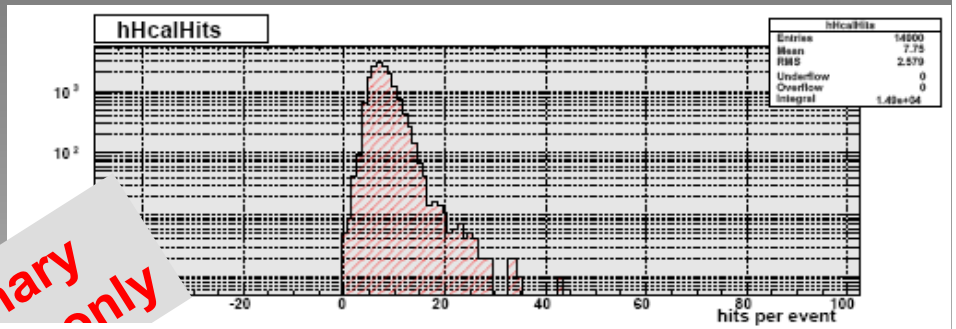
Monitoring of ~ 50 SiPM in HCAL module during 2 weeks cosmics run

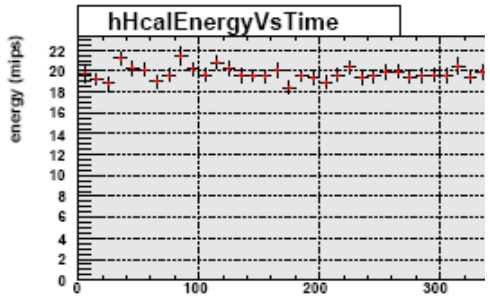




Preparing the Online Display



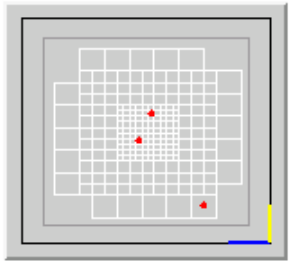


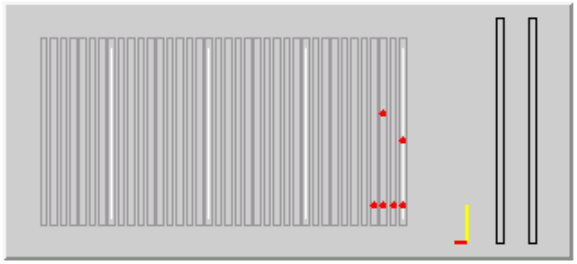


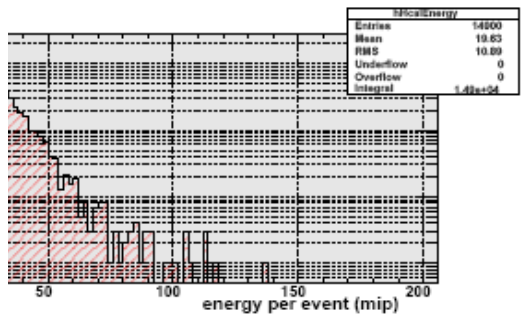
Run 220124 Event 2630

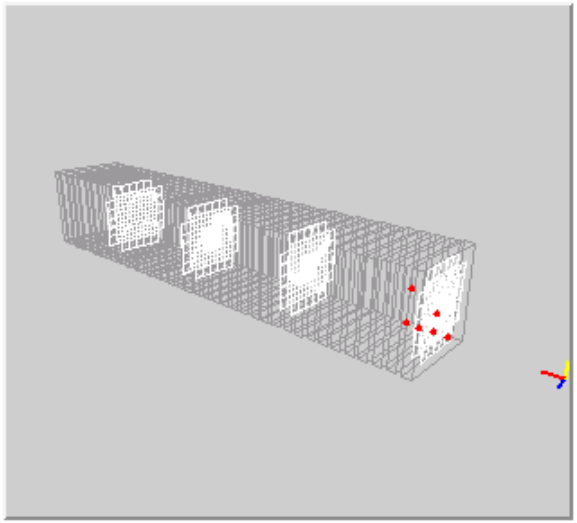
Time: 20:03:03:734:556 Fri May 5 2006

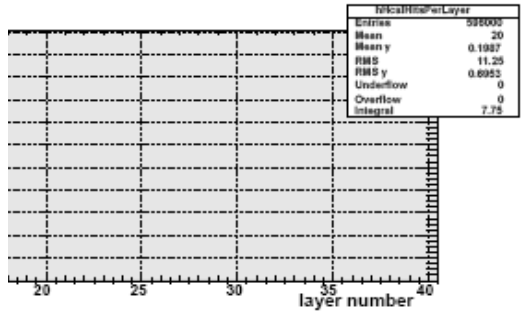
DaqEvent info ...











All software for online and first level analysis getting ready

Courtesy of
G. Mavromanolakis

The CERN summer schedule

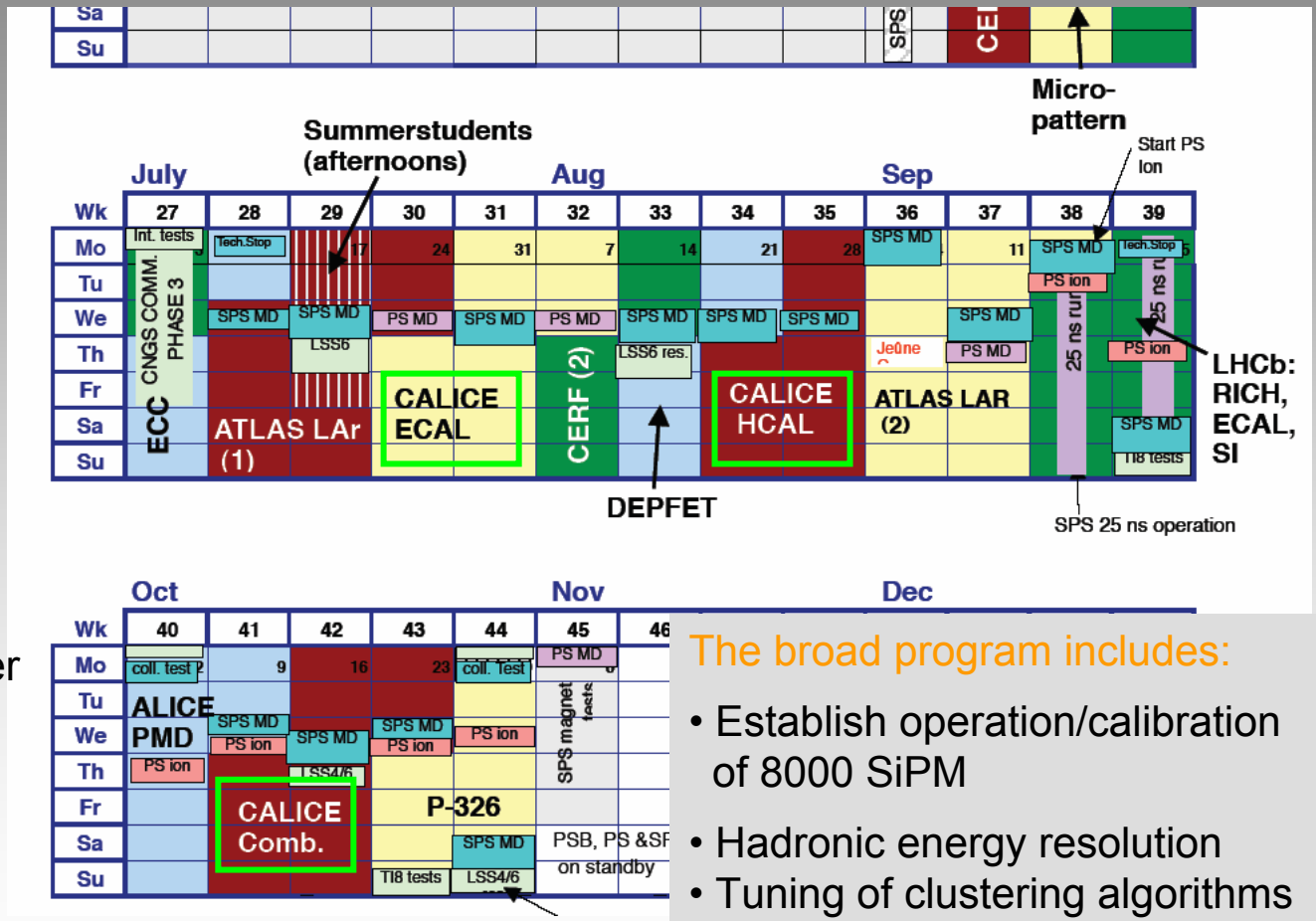
Draft schedule for CERN North Area beam-line H6

Beam: e/μ/π/p
6-200 GeV

~ 6 weeks in total

intense program for the CALICE collaboration

Test of:
Si-W ECAL +
Scintillator HCAL +
Tail catcher & muon tracker



The broad program includes:

- Establish operation/calibration of 8000 SiPM
- Hadronic energy resolution
- Tuning of clustering algorithms
- Comparison of all existing MC models to data with unprecedented granularity

Summary & Outlook

- up to 16 HCAL modules will be calibrated with e-beam and cosmics before July'06
  - results for 8 already presented (~216*8 ~ 1700 SiPM)

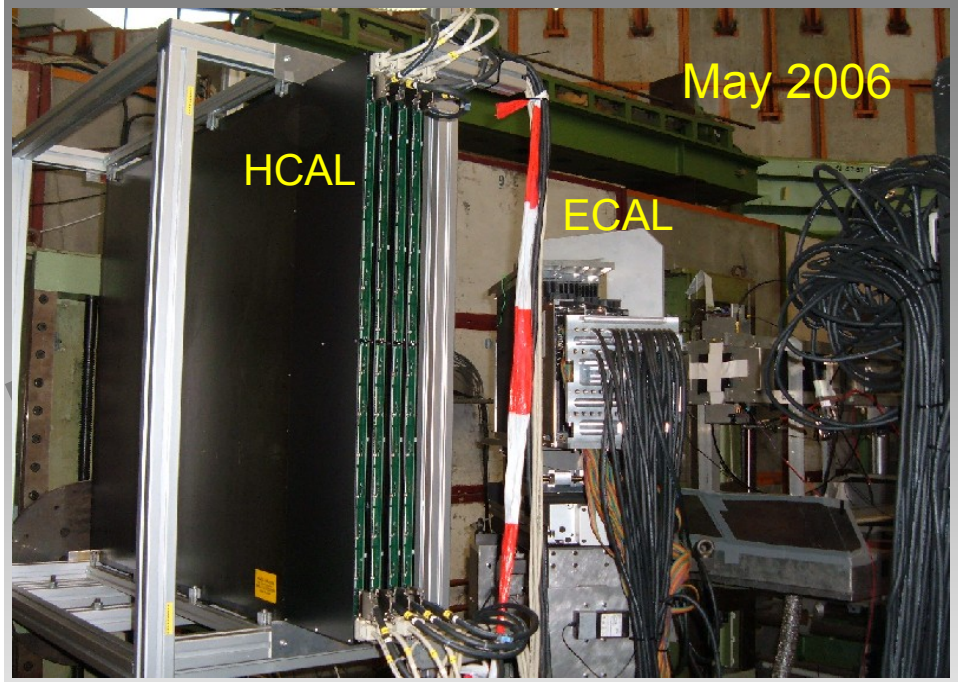
- shower maximum reconstruction allows
  - tile uniformity checks: < 5% in HCAL core
  - check of response function universality:
    5% agreement on 24 SiPM with ~20% non-linearity correction

- temperature variations in SiPM operation monitored with LED monitoring system
  - expected gain and SiPM response variations with temperature confirmed

- the HCAL prototype will be tested at the CERN test beam starting from July '06

… a lot of physics data to follow

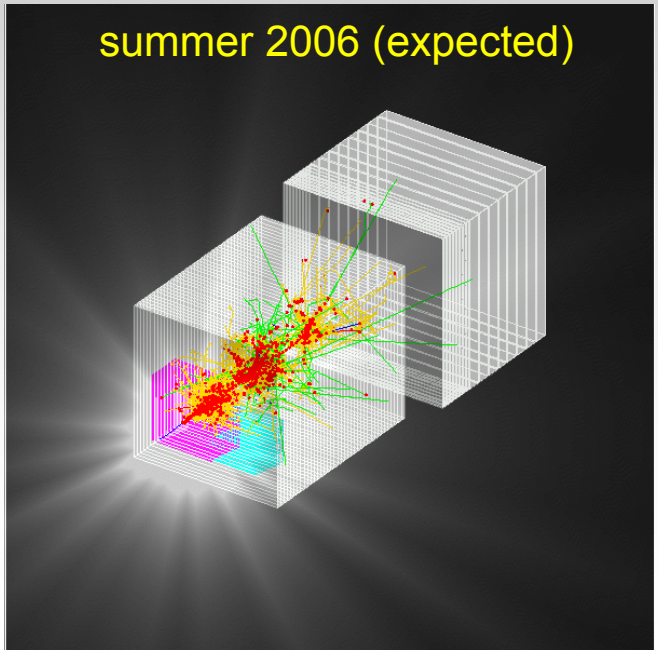
A project in full swing



ECAL and HCAL prototypes are being commissioned:
16 modules ready by end of June
~14 more modules expected by Oct.

Summer 2006: CERN test beam
study hadronic showers (6 - 200 GeV)

Summer 2007: FermiLab test beam
extend energy range
technology comparison with Digital HCAL



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