Scintillator HCAL
Operating Experience and Calibration

Sebastian Schätzel, DESY

ECFA Meeting
Valencia, November 2006

CERN beam test in August and October 2006
4.5λ absorber stack, 2/3 instrumented (5000 channels)

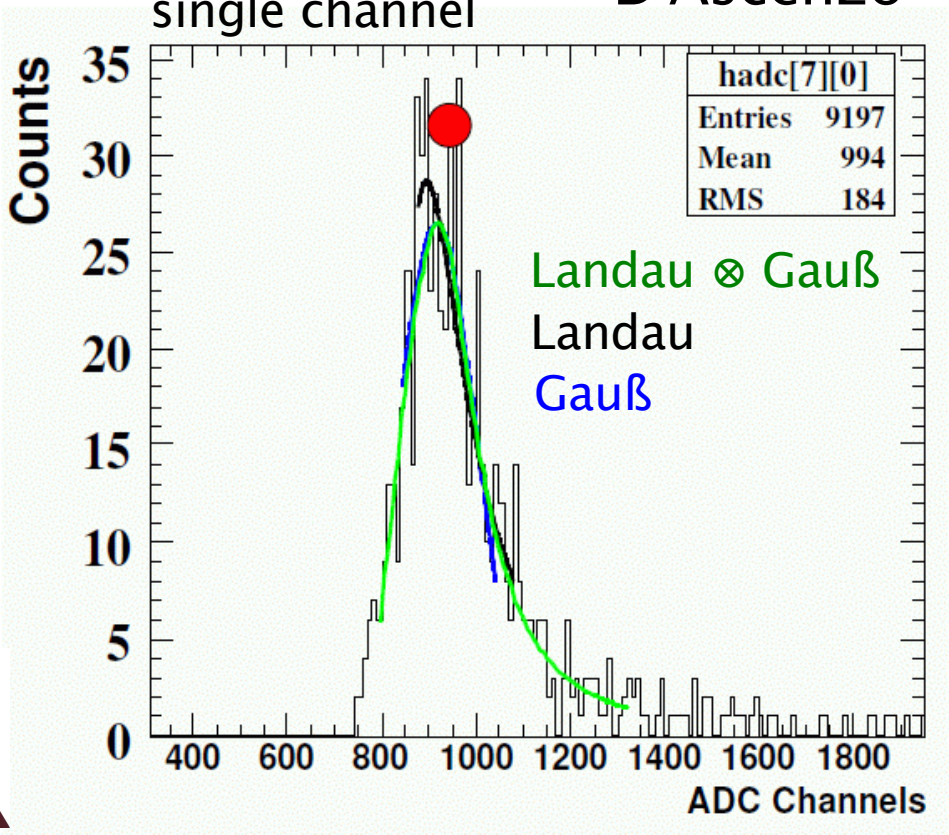
- Study and optimisation of detector noise
- Calibration of multi-channel system with LEDs
- Optimisation of SiPM operating voltage

Muon Runs: MIP Calibration

Nicola D'Ascenzo

MIP selection

- cell amplitude>pedestal+$2\sigma_{ped}$ (≈1/6 of a MIP)
- require 6 hits in cell tower of 15 layers



Fit with Landau ⊗ Gauß

Uncertainties

- An independent analysis (different selection and fit method) arrives at ~10% smaller coefficients;
- difference under study, for now use 10% systematic error

Applications

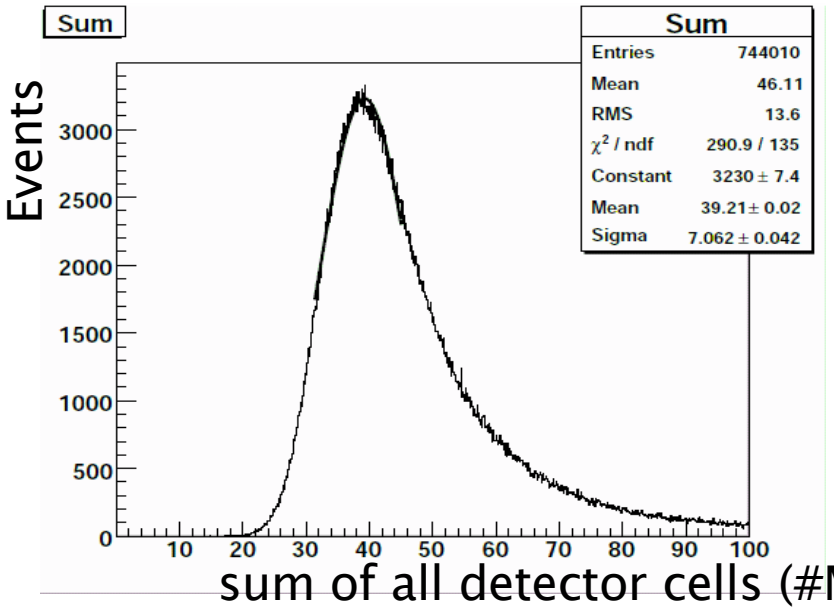
- noise threshold cut >0.5 MIP
- light yield analysis (photoelectrons/MIP)

Noise Situation in August

V.L. Morgunov

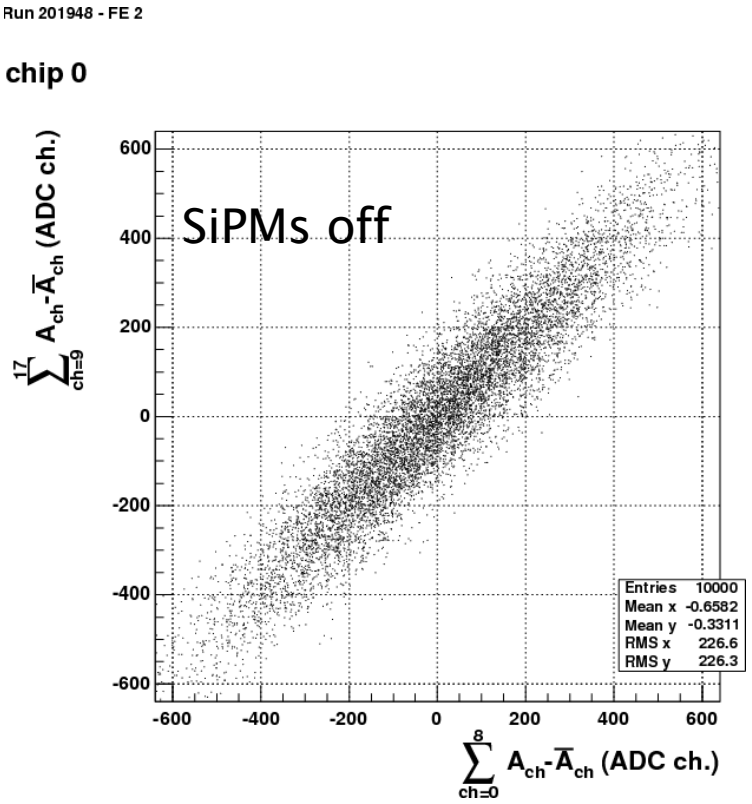
Muon selection:

- cut all cells <0.5 MIP
- require 9 hits in cell tower of 15 layers



expect 24 MIP hits (15x1.6 MIP average)
but see ≈20 more
→ additional hits could be noise

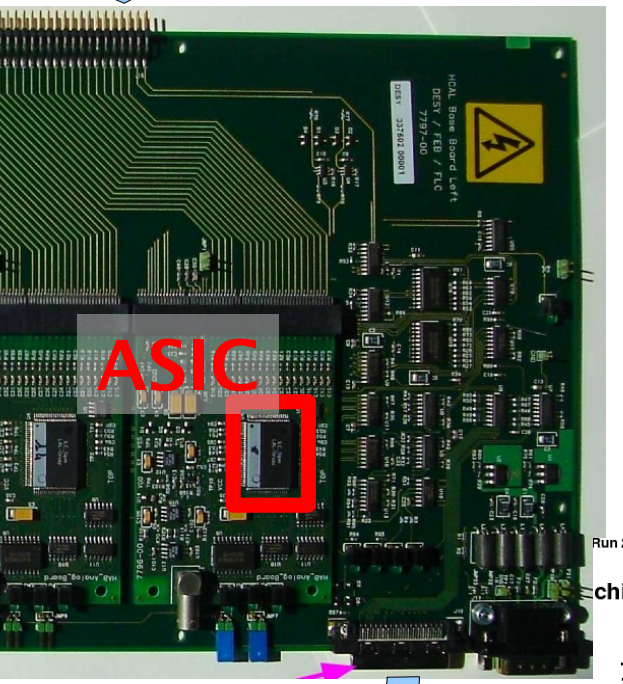
Correlated fluctuations
for channels of same ASIC:



→study read-out electronics

Improved read-out electronics for October run

IN (18 SiPMs per ASIC)

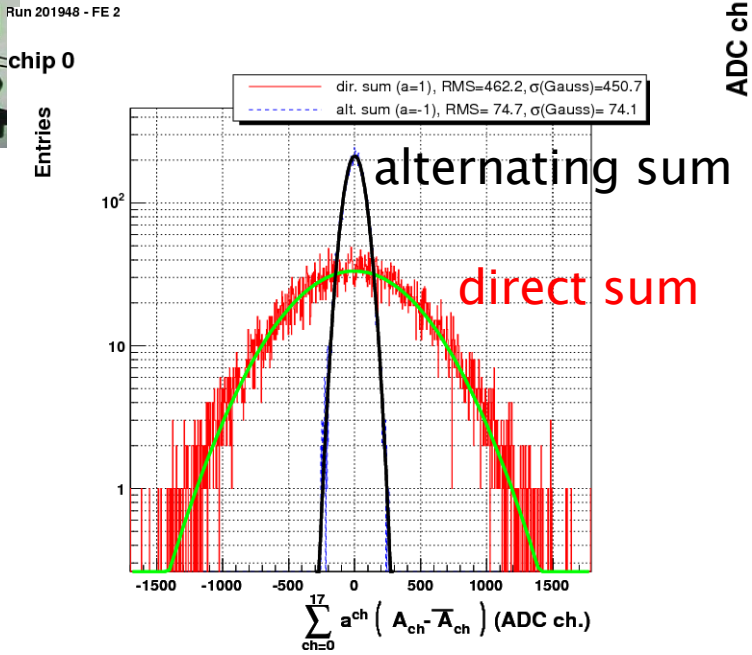


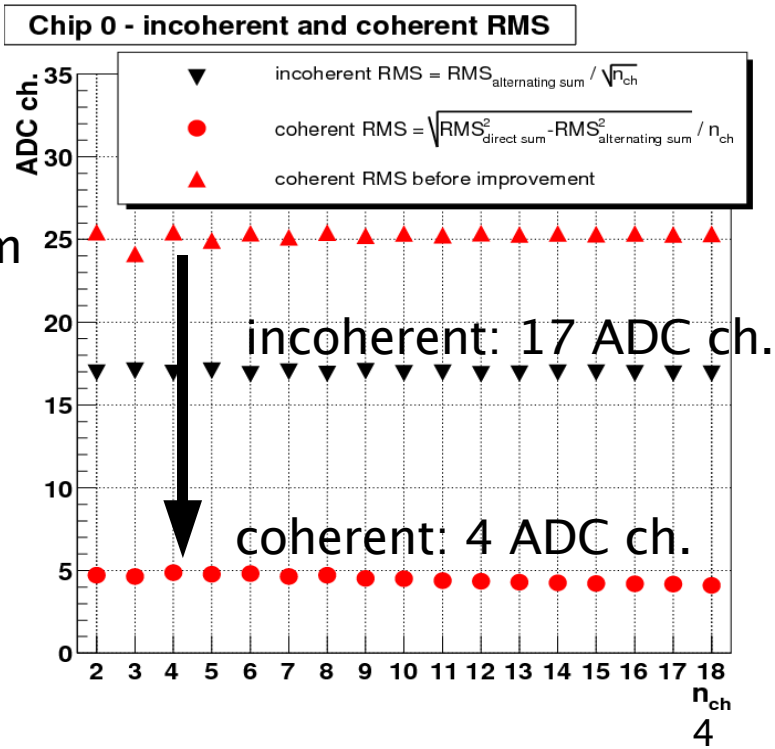
OUT
(to DAQ)

Additional filtering of op-amp supply lines to ASIC

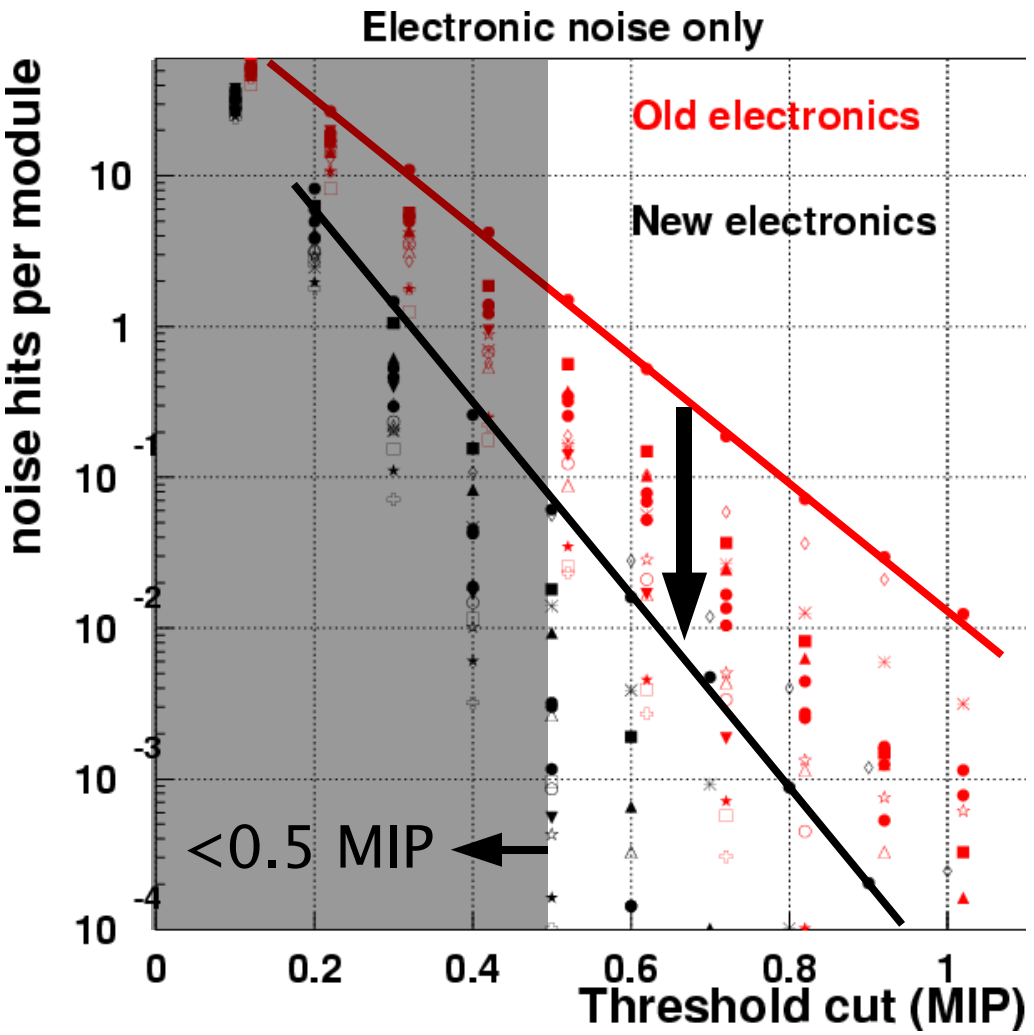
reduction of electronics noise (SiPM off):

- coherent noise reduced by factor 6
- total noise reduced by factor 1.8
- coherent noise = ¼ of white noise





Improved noise after modification



integrated over 13 modules:

Noise >0.5 MIP per event for 13 modules

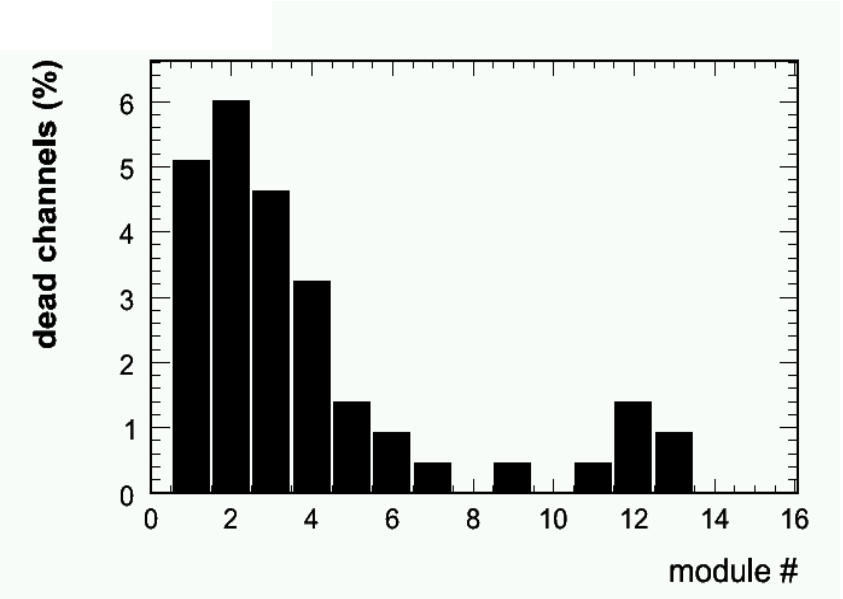
	read-out electronics	
	old	new
SiPMs off	2	0.1
SiPMs on	20 →	11

noise in detector halved!

11 hits>0.5 MIP
→ 11 hits x 0.7 MIPs/hit≈8 MIPs

x 68 MeV deposited/MIP
≈0.5 GeV

Channels without signal



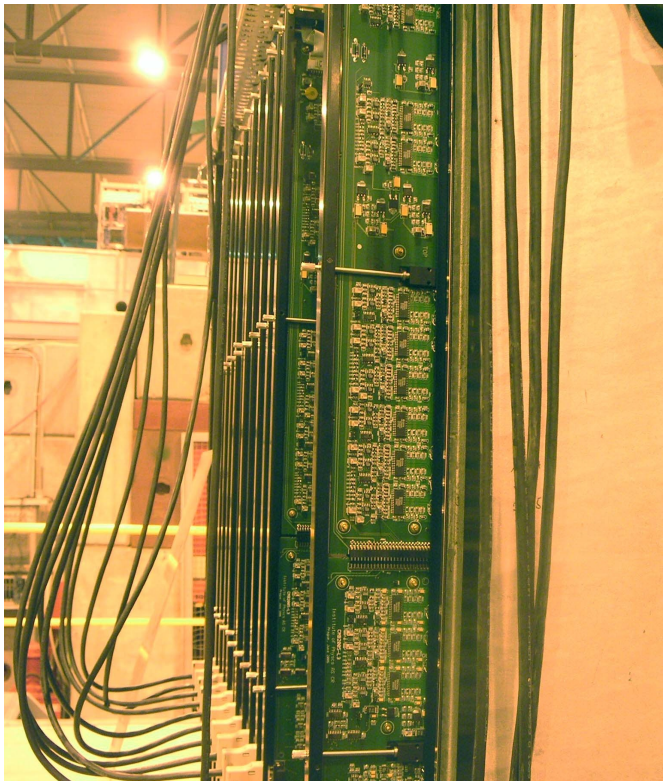
- mostly broken soldering contacts to SiPM
- production learning curve: from 5% for first modules to <1%

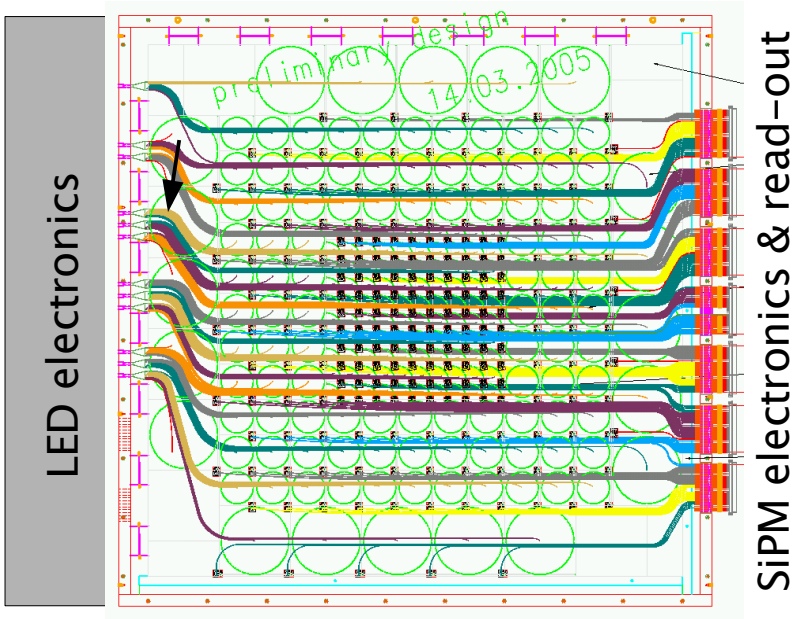
Light Calibration System

SiPM is novel technology

- Scintillator HCAL is one of first field tests
- Operating stability has to be monitored
- semiconductor: voltage and temperature dependent response

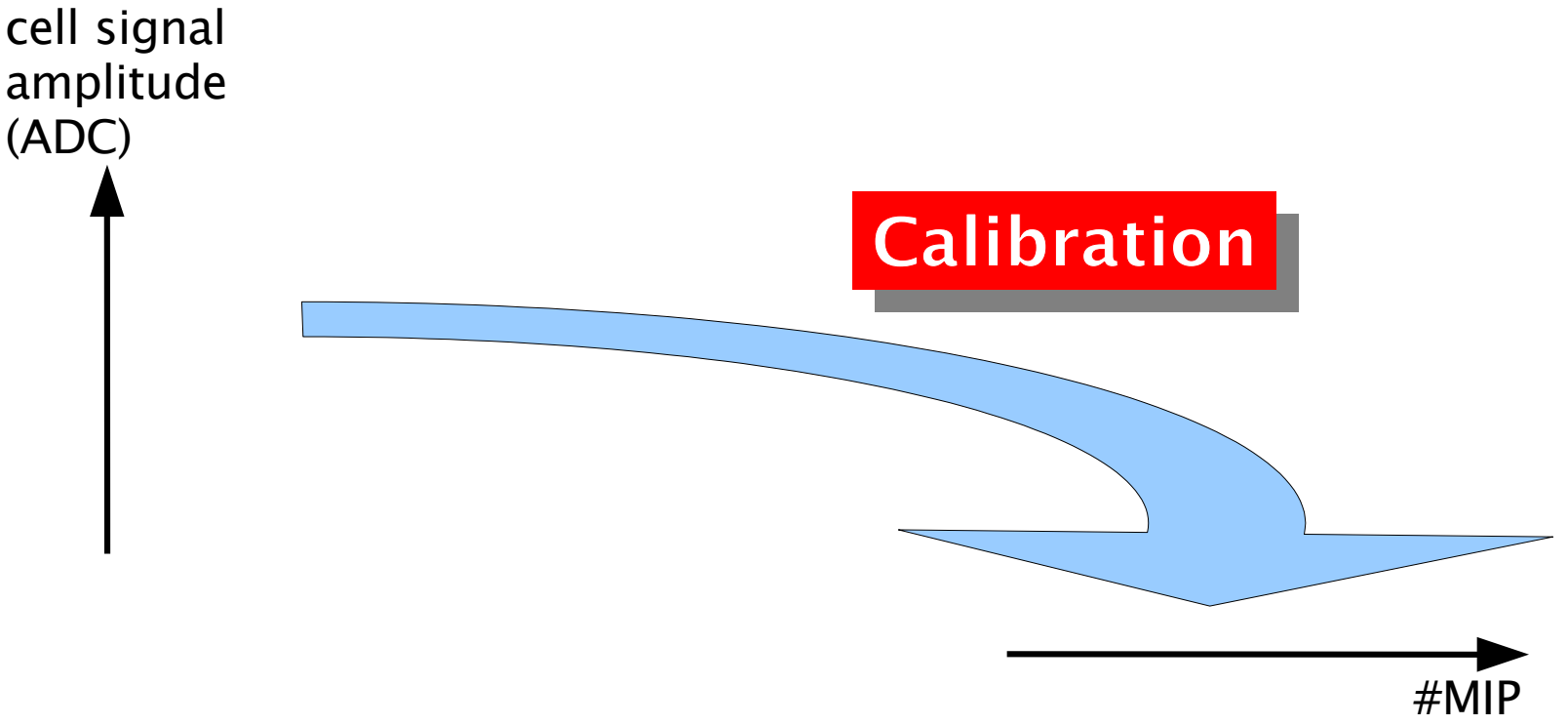
Solution: UV LED light injection system





Calibration of Detector Signals

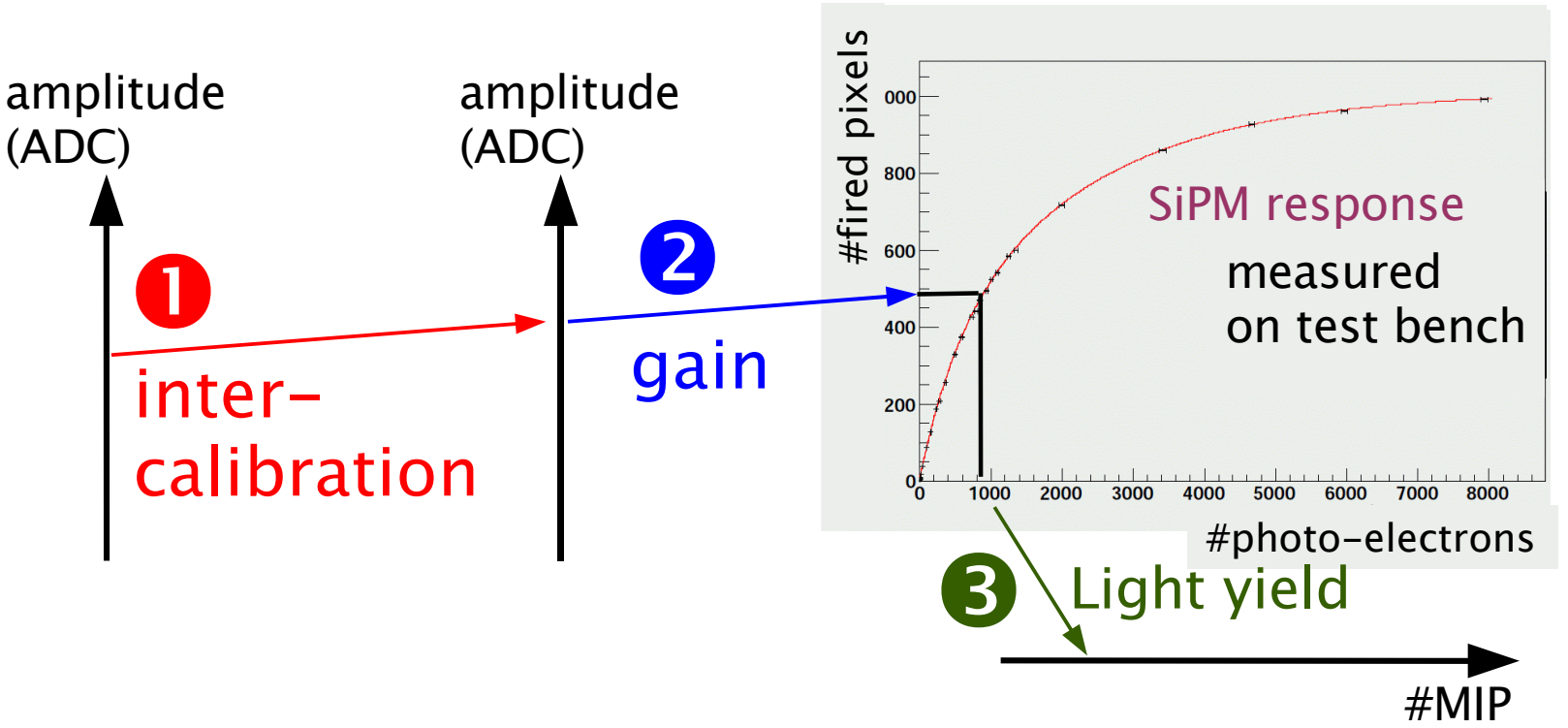
Measurement



Calibration of Detector Signals

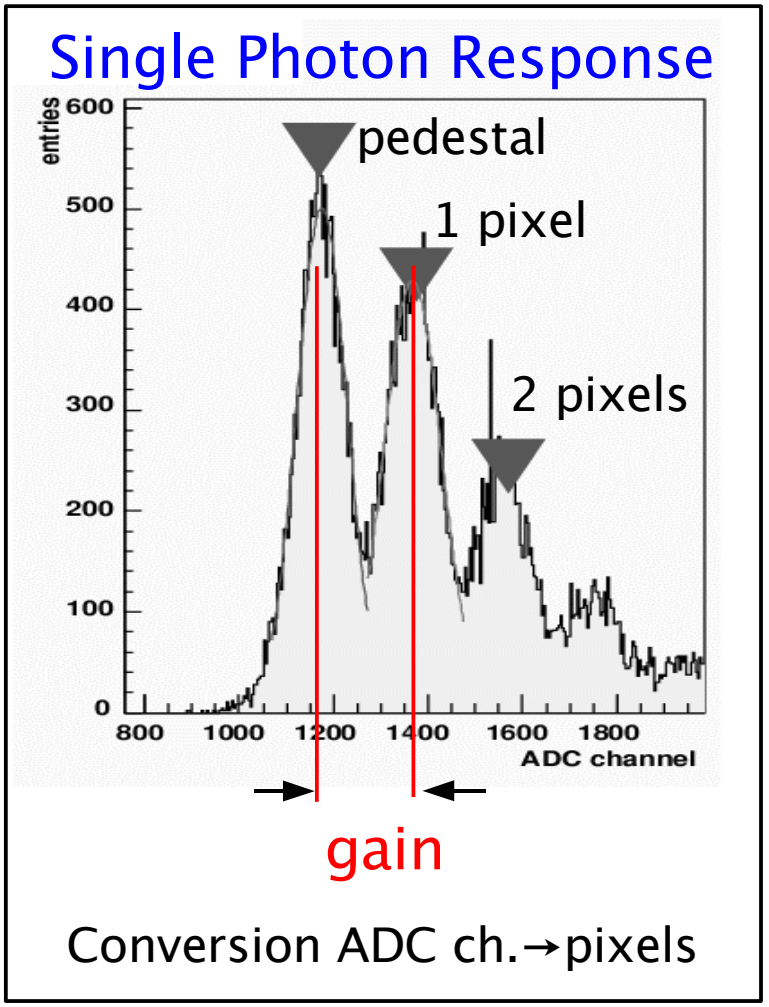
Measurement

higher ASIC amplification
to resolve single pixels



Physics

SiPM Gain Measurement with LED System



Method: fire single SiPM pixels with low LED intensity

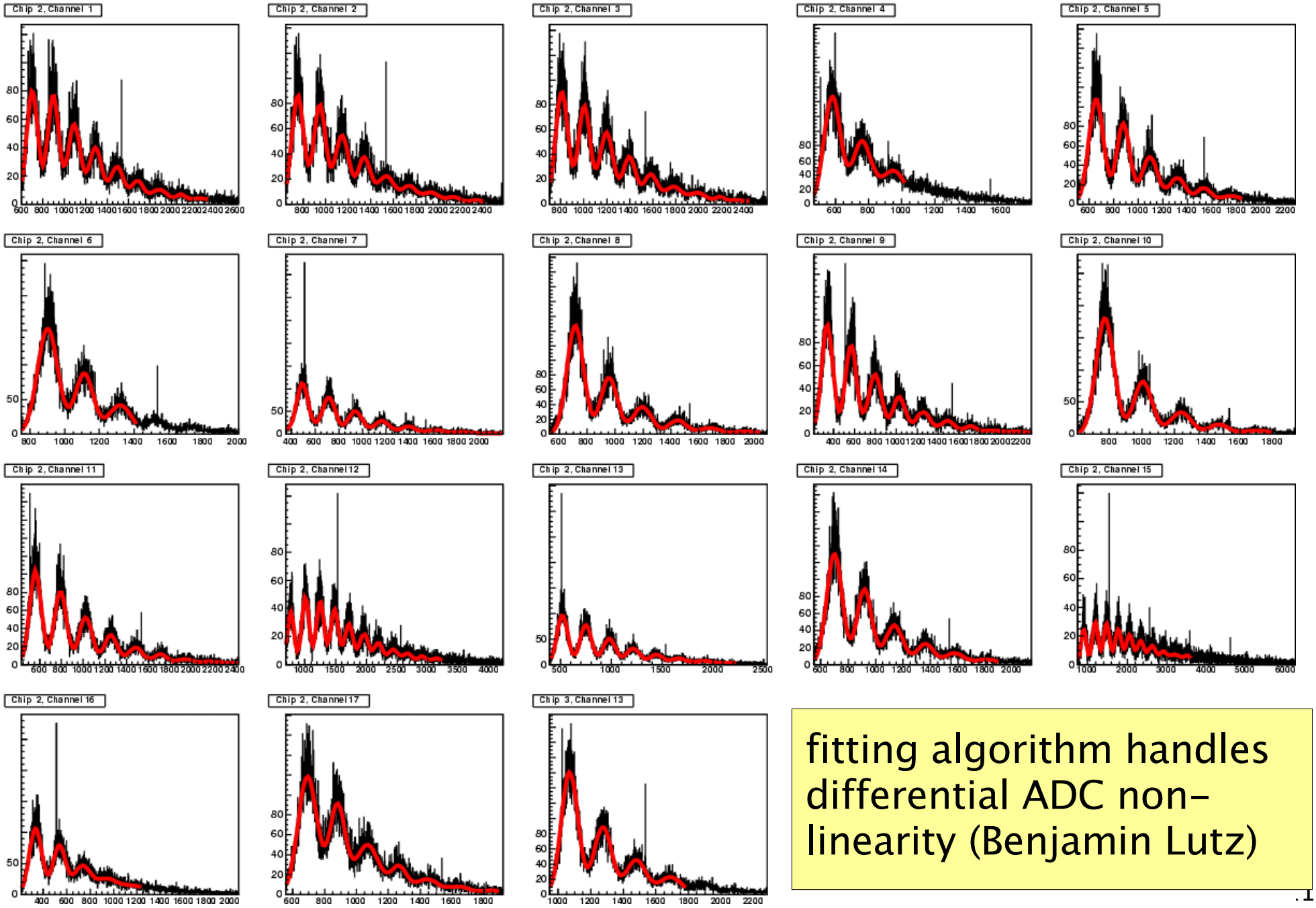
Challenge: calibrate 5000 channels in minimal time

high light intensity washes out pixel structure

distribute light uniformly from 1 LED to 18 SiPMs

dGain/dT ≈ 2%/K

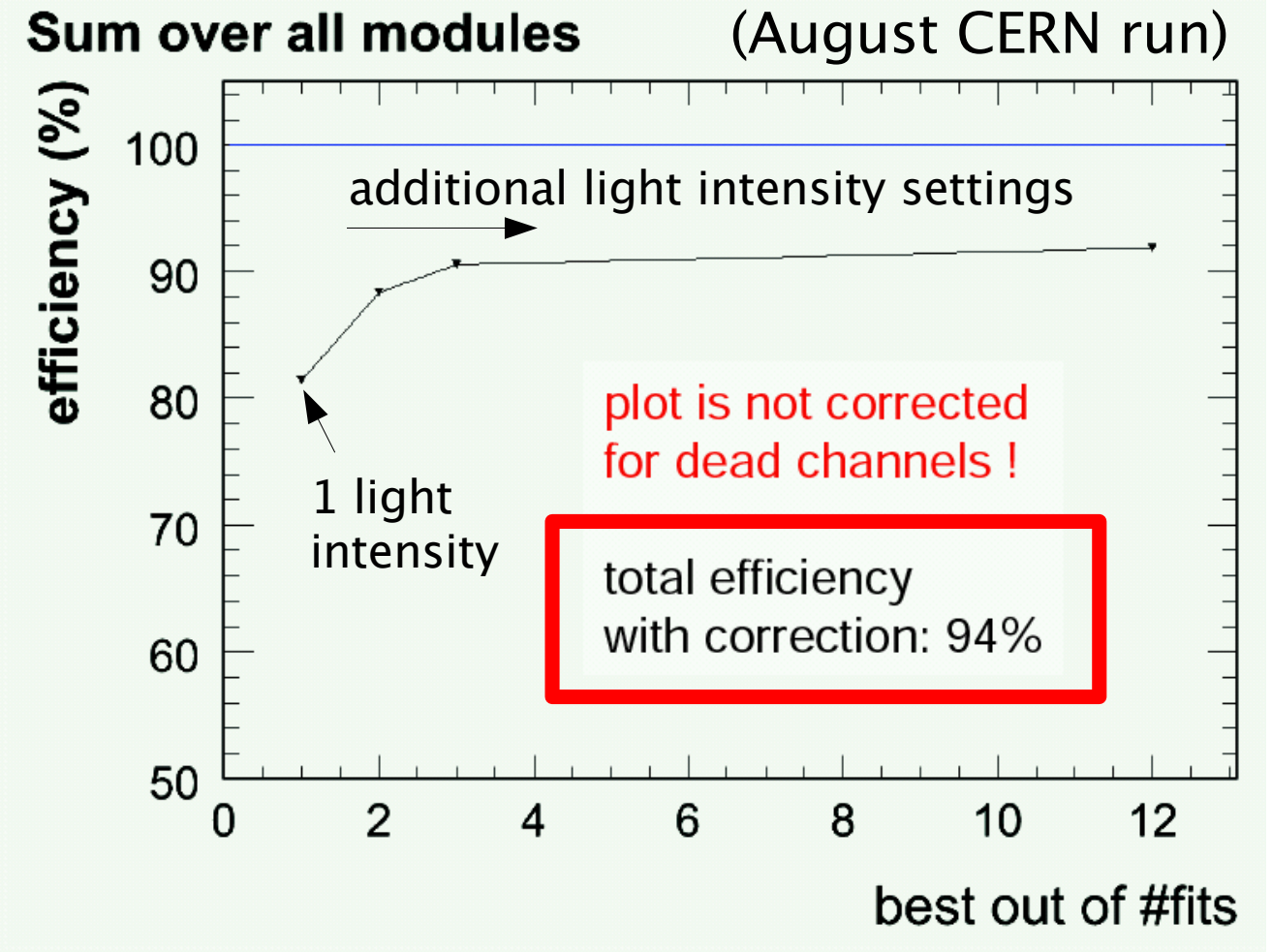
Run 201353 - LED 2 - SER013, Slot 12, FE3 - Entries vs. ADC channels



fitting algorithm handles differential ADC non-linearity (Benjamin Lutz)

High SiPM Gain Calibration Efficiency

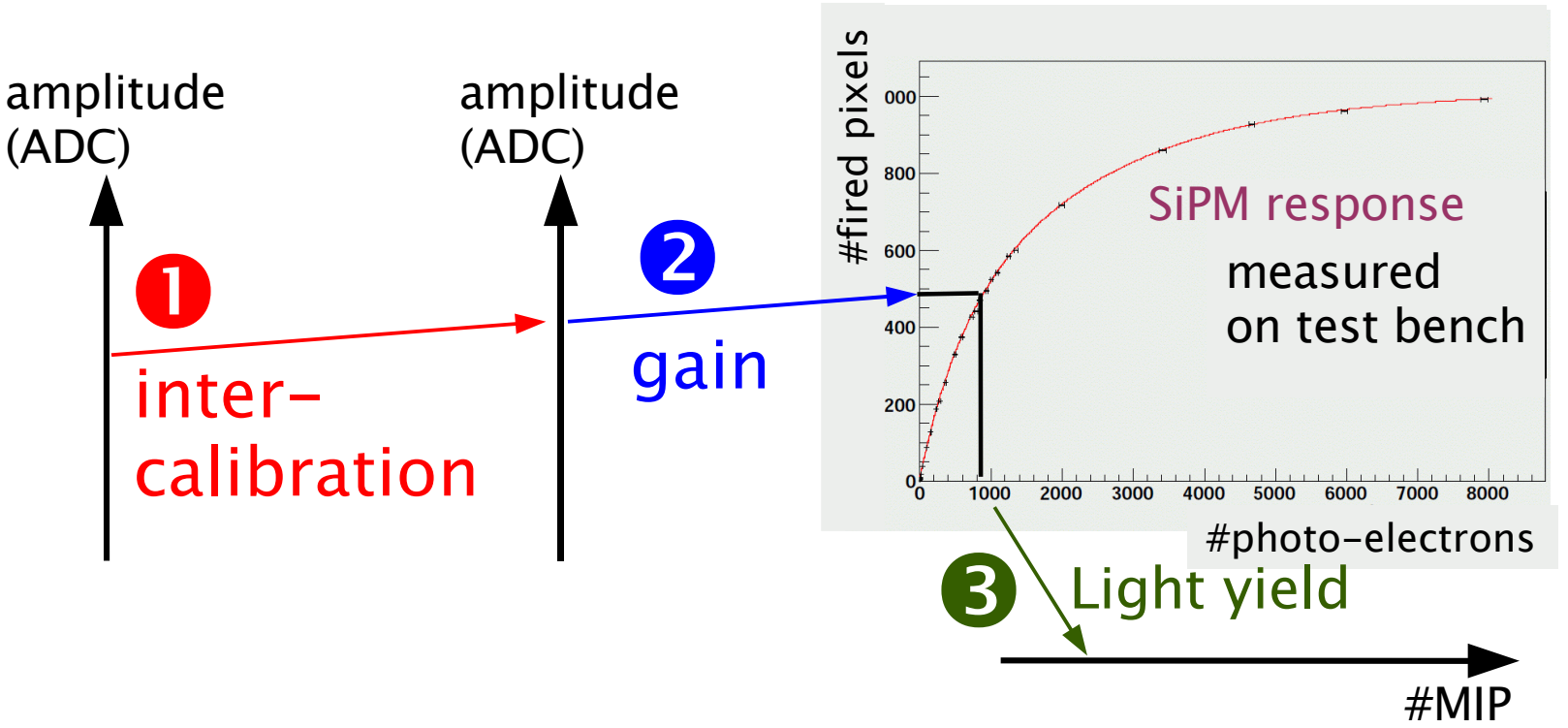
94% of all channels calibrated



Calibration of Detector Signals

Measurement

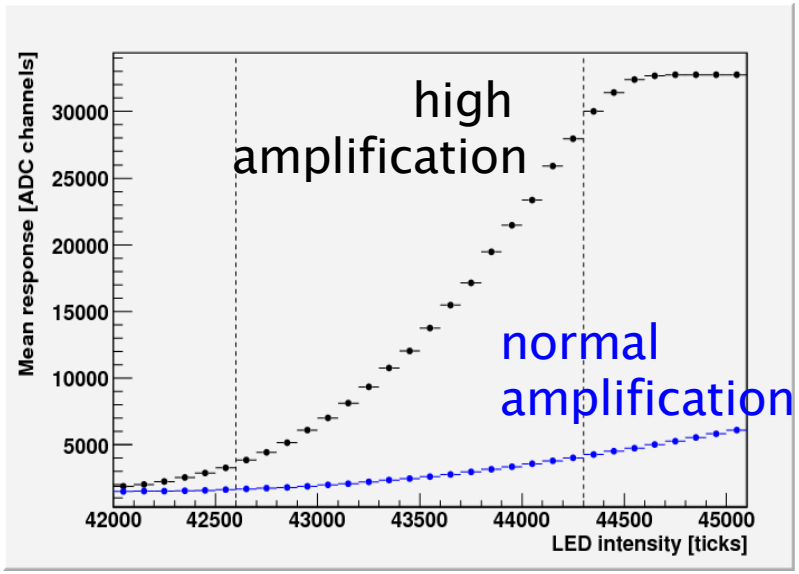
higher ASIC amplification
to resolve single pixels



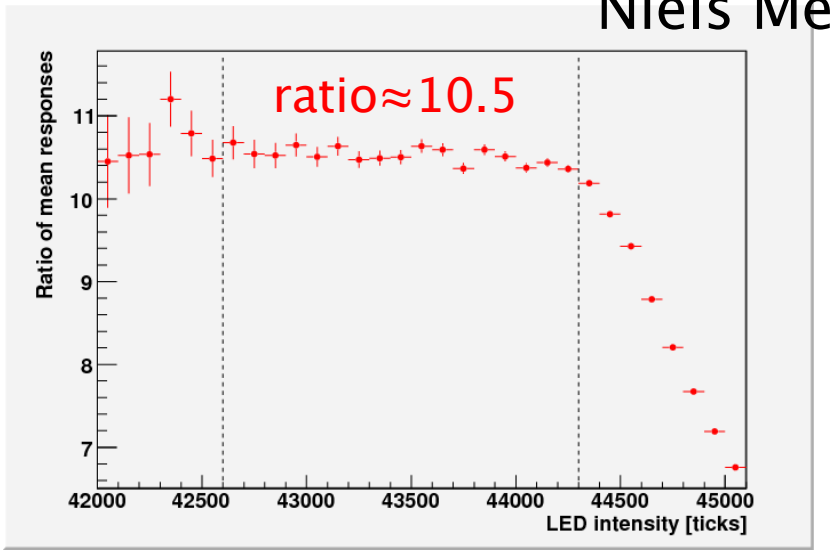
Physics

ASIC Intercalibration with LED System

Method: measure fixed LED signal with high/low ASIC amplification



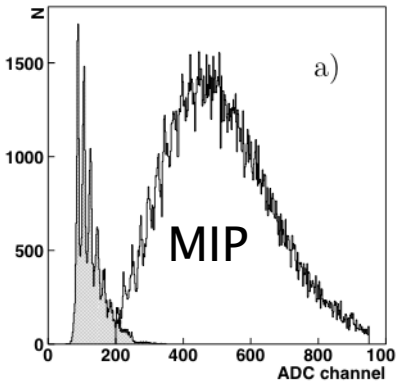
Niels Meyer



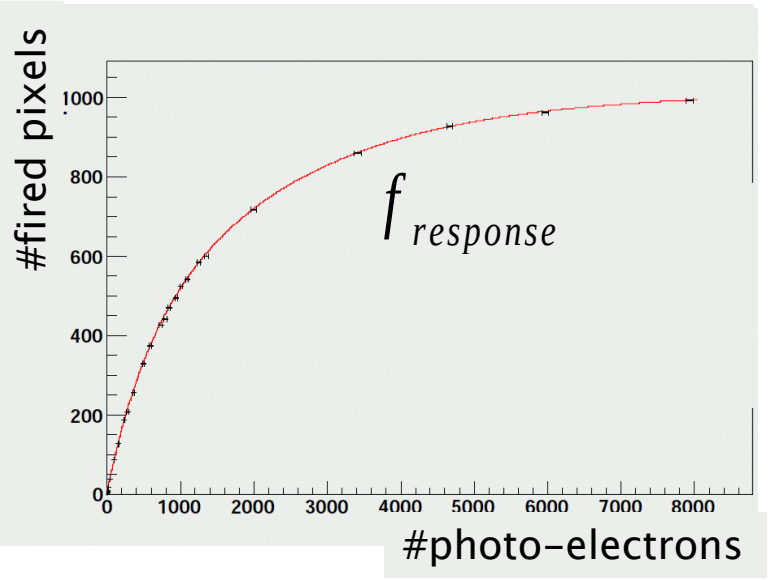
99.5% of all channels intercalibrated

ratio independent of light amplitude within ASIC linearity

Light yield analysis



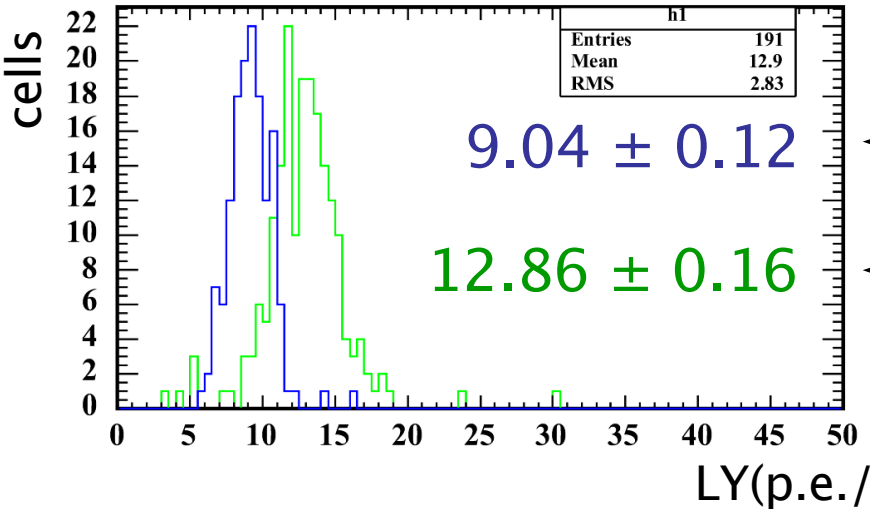
Marius Groll



$$LY'(\text{pixel}/MIP) = \frac{A_{MIP} \times \text{Intercalibration}}{\text{Gain}}$$

Apply response function to get photoelectrons/MIP

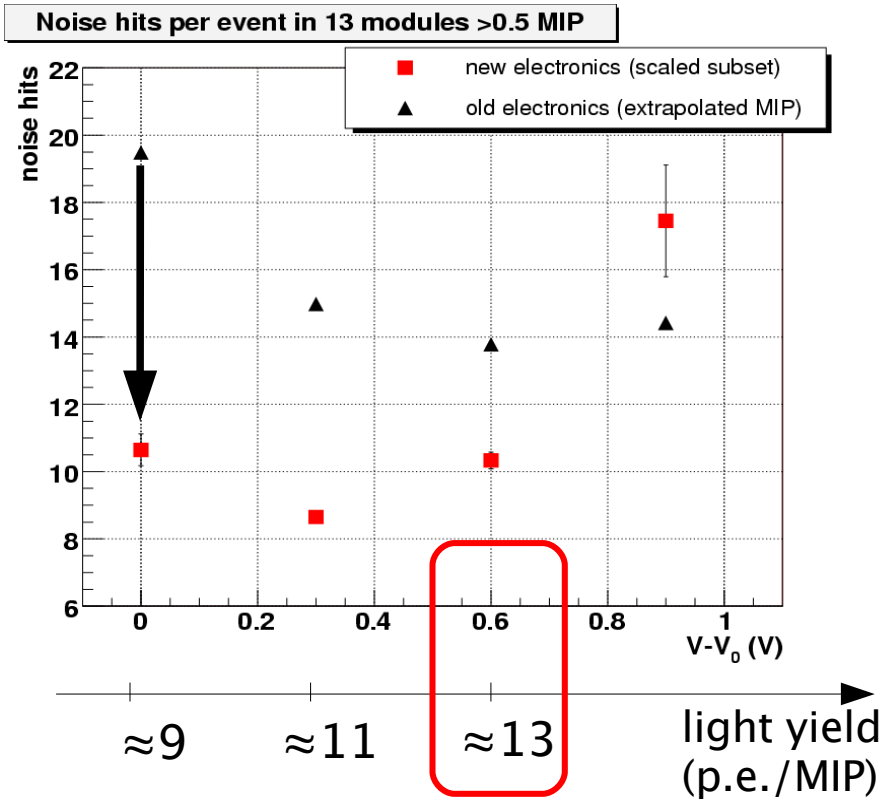
Results:



August SiPM operating voltage

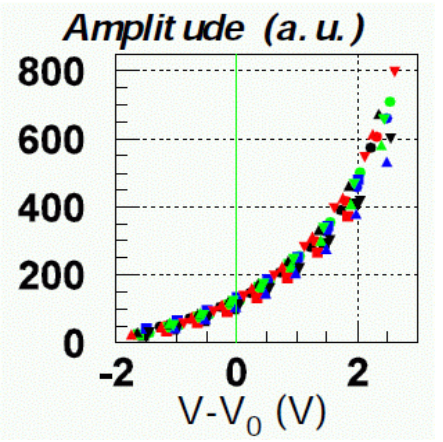
+0.6V

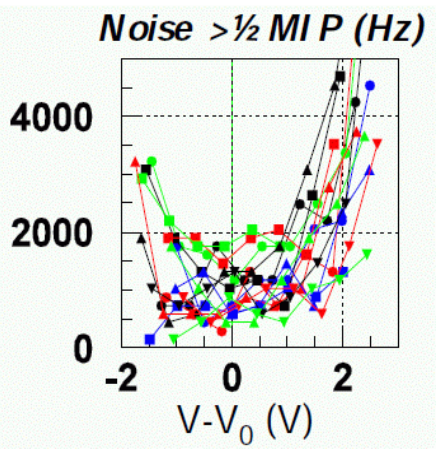
Optimal SiPM operating voltage



Test bench SiPM measurements:

Eugeny Tarkovsky (ITEP)





better S/N at higher voltage

voltage increased by 0.6V for October run

to compensate for temperature difference ITEP/CERN and voltage drop along SiPM cables

Conclusions

Scintillator HCAL operates very reliably in beam test data taking

Initial noise suppressed by improving read-out electronics

LED system routinely used for calibration and optimisation

- study SiPM response under voltage changes
- SiPM gain and ASIC intercalibration measured with high efficiency and precision
- light yield analysis provided essential input for optimisation of SiPM working point

Outlook: investigation of SiPM temperature stability with the LED system