HCal Calibration Status

On the hard way from the pit to physics analysis

Niels Meyer
CALICE Collaboration Meeting
13. February 2007

CERN data – Calibrations – Corrections

CERN Data Good For HCal

<u>Period I:</u>	25.Aug – 3.Sep	15 modules, 1 sampling
		nominal operation voltage
• electrons:	6 – 45 GeV	no ECAL in front
• pions:	6(30) – 80 GeV	without (with) ECAL in front

<u>Period II:</u>	13.Oct – 25.Oct	23 modules, 2 samplings
		operation voltage raised by 600 mV
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Divided into two sub-periods:

- Period IIa 13. - 18.Oct : detector heat-up
- Period IIb 18. - 25.Oct : cooled detector, more uniform conditions

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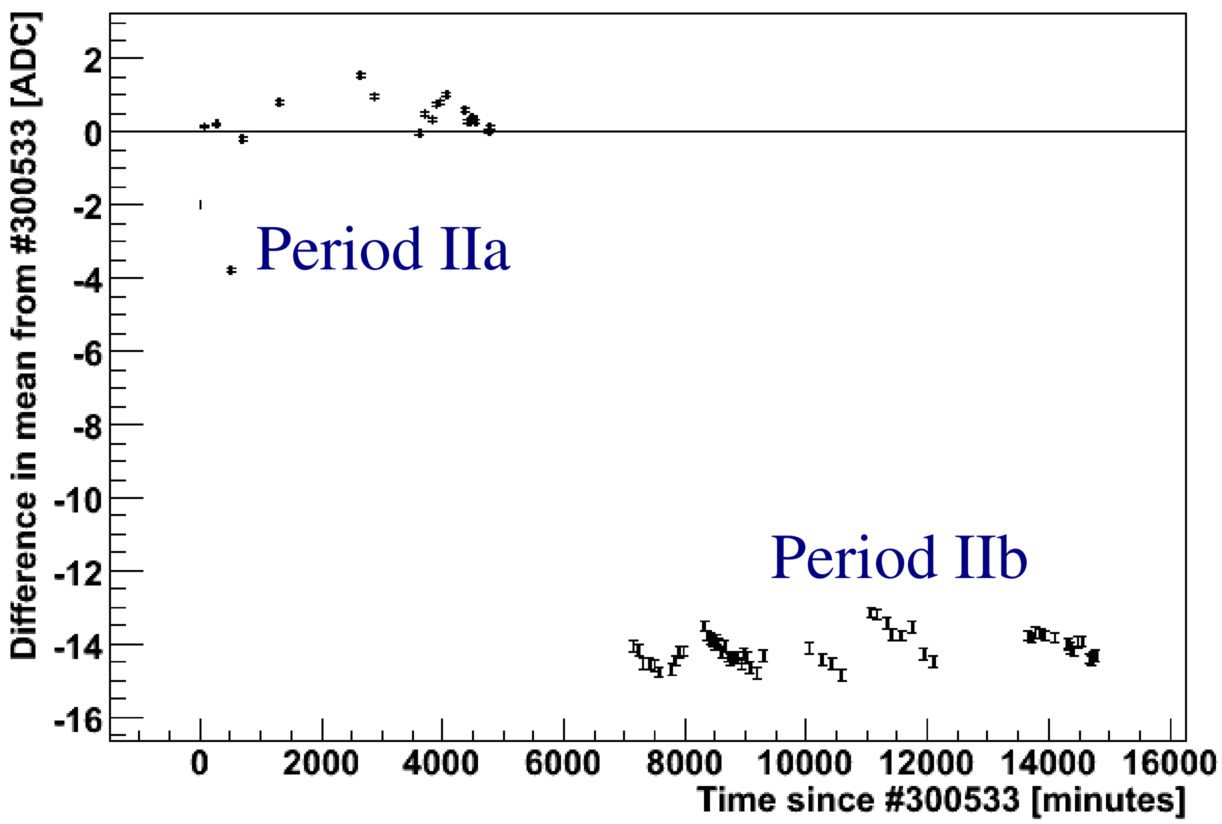
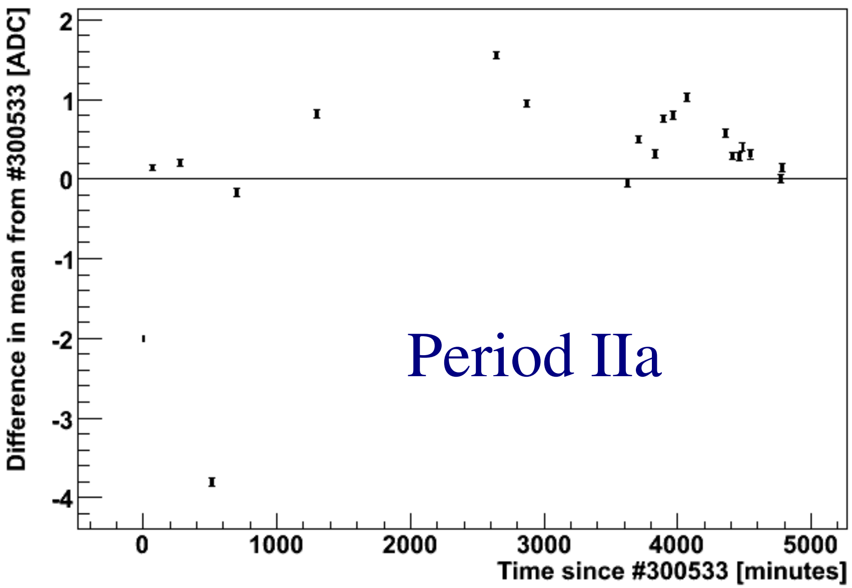
Running stability

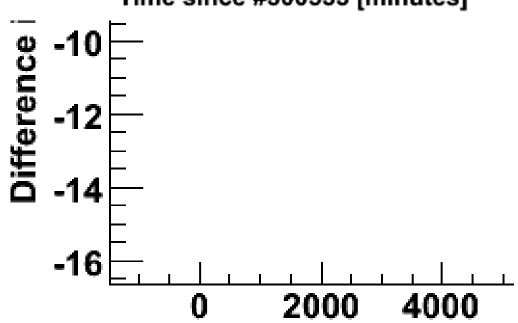
Long-term pedestal monitoring in October

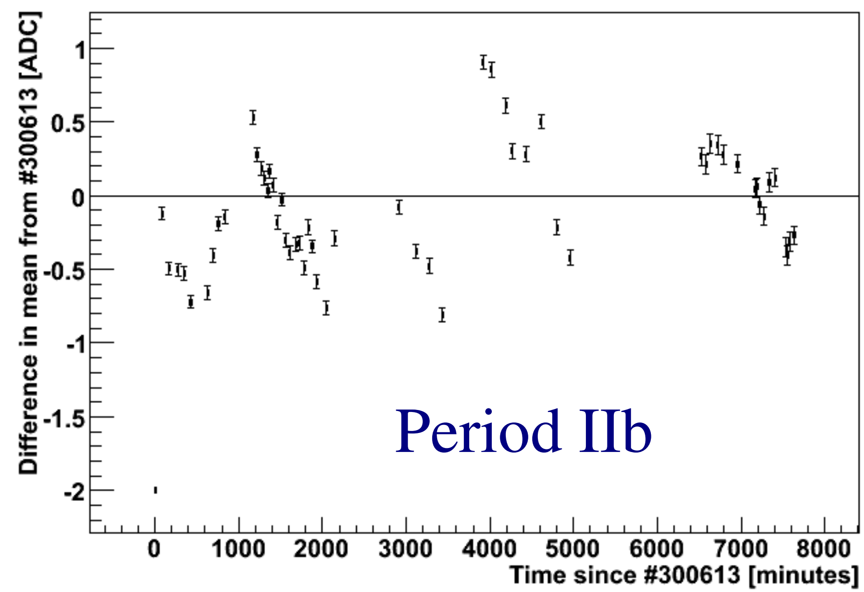


Running stability

Long-term pedestal monitoring in October shows great stability



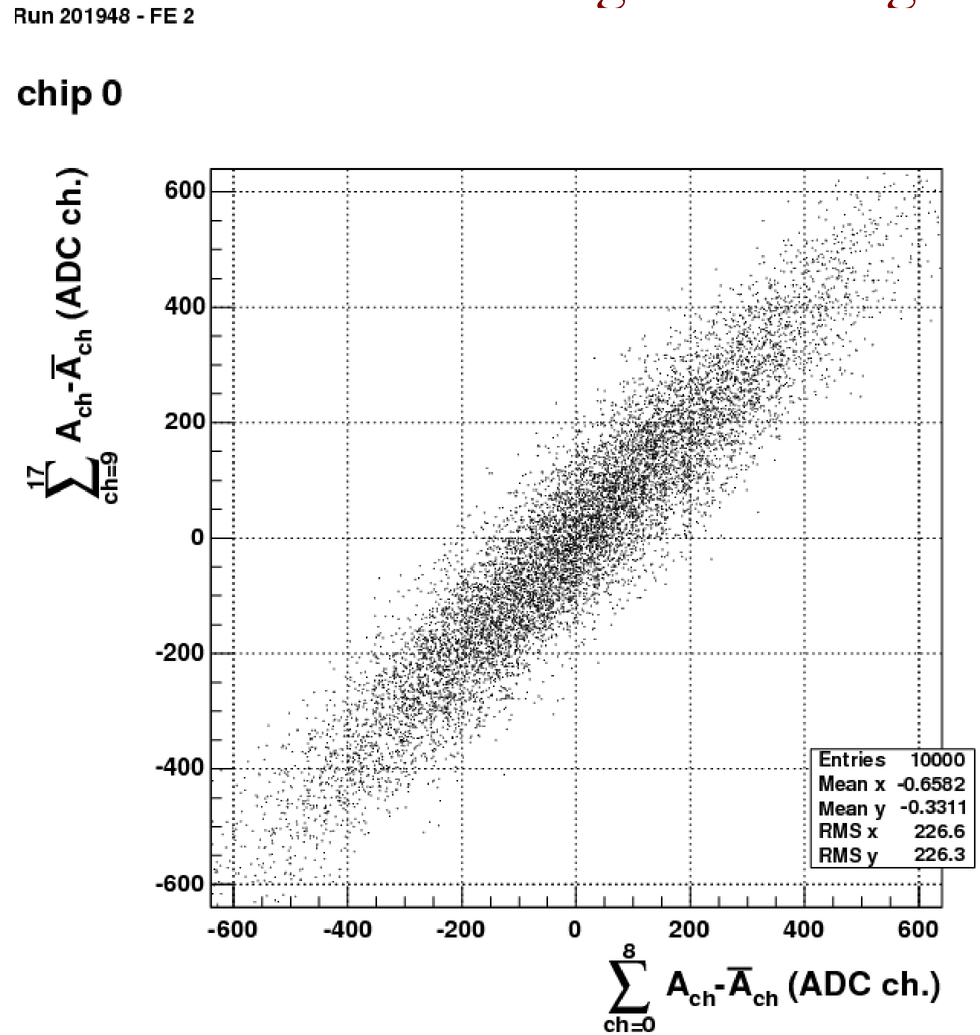




Coherent Noise

The fast-feedback success story – coherent noise in August running

- Found correlated pedestal movement of channels from same chip
- Confirmation of effect at DESY testbeam
- Hardware modification for October running



S. Schätzel

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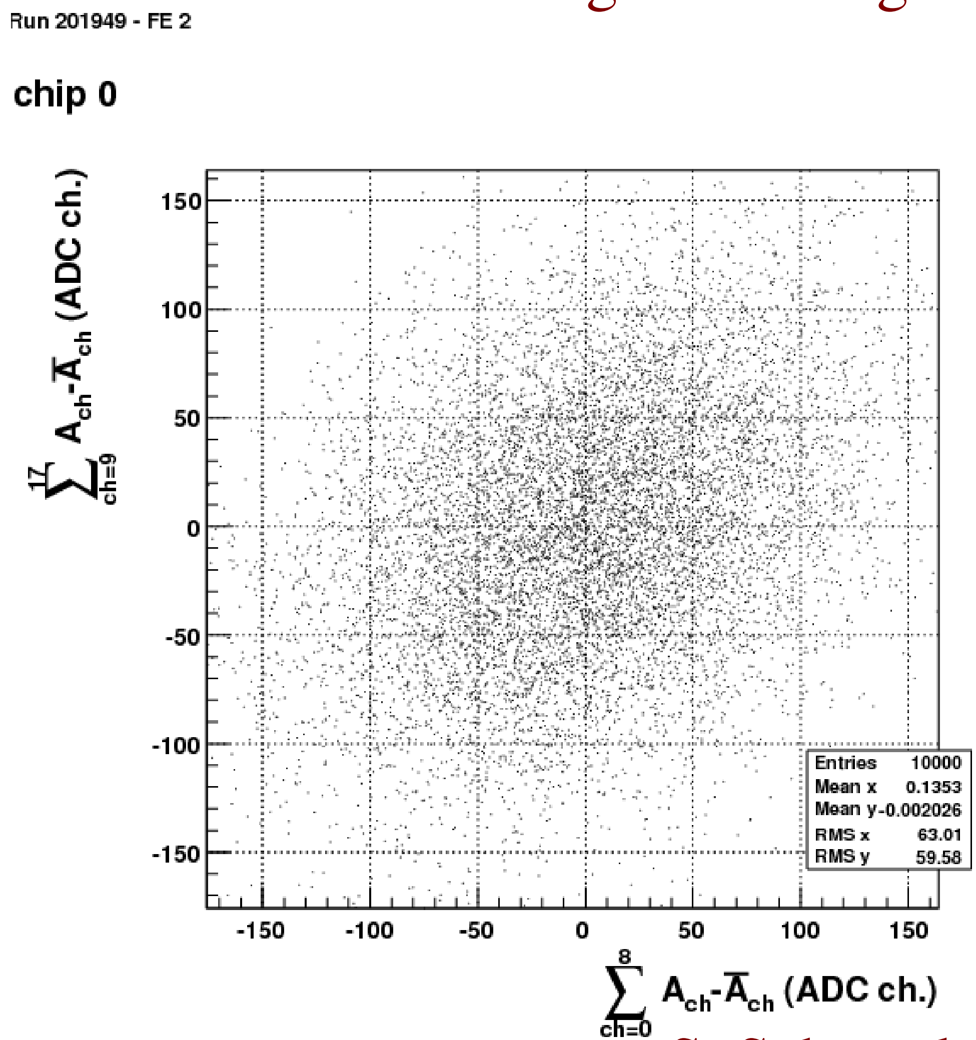
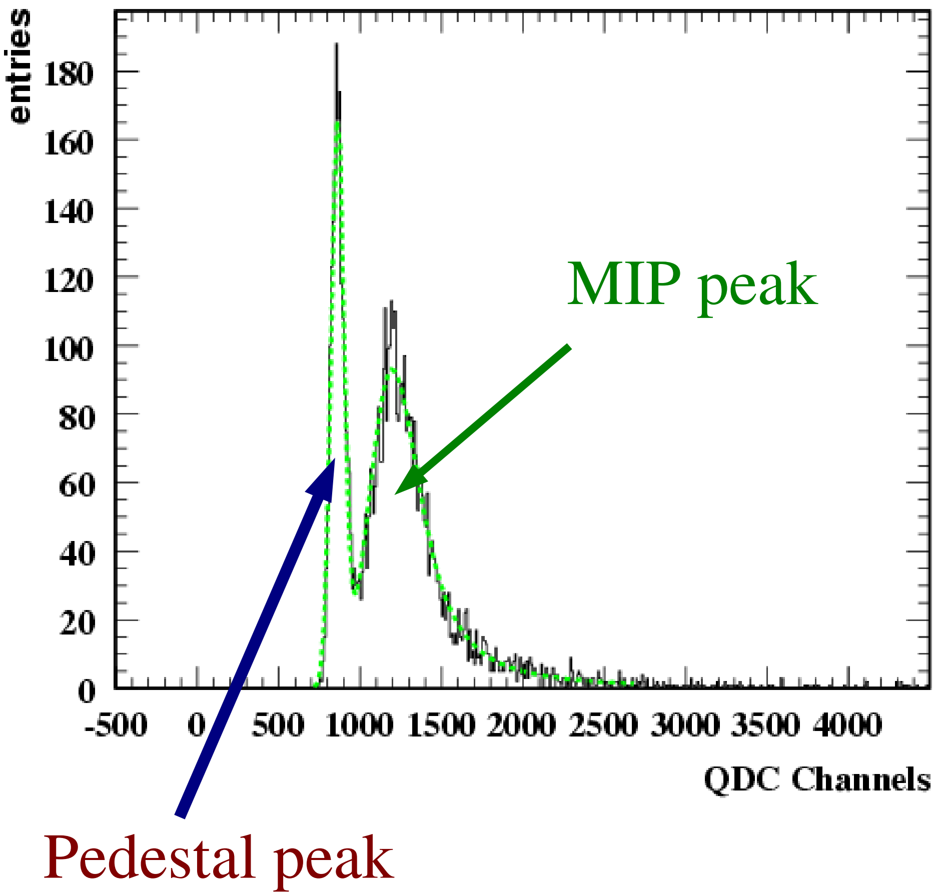


S. Schätzel

MIP Calibration



Fit the Landau (plus smearing) spectrum of muon response

Most important calibration measurement:

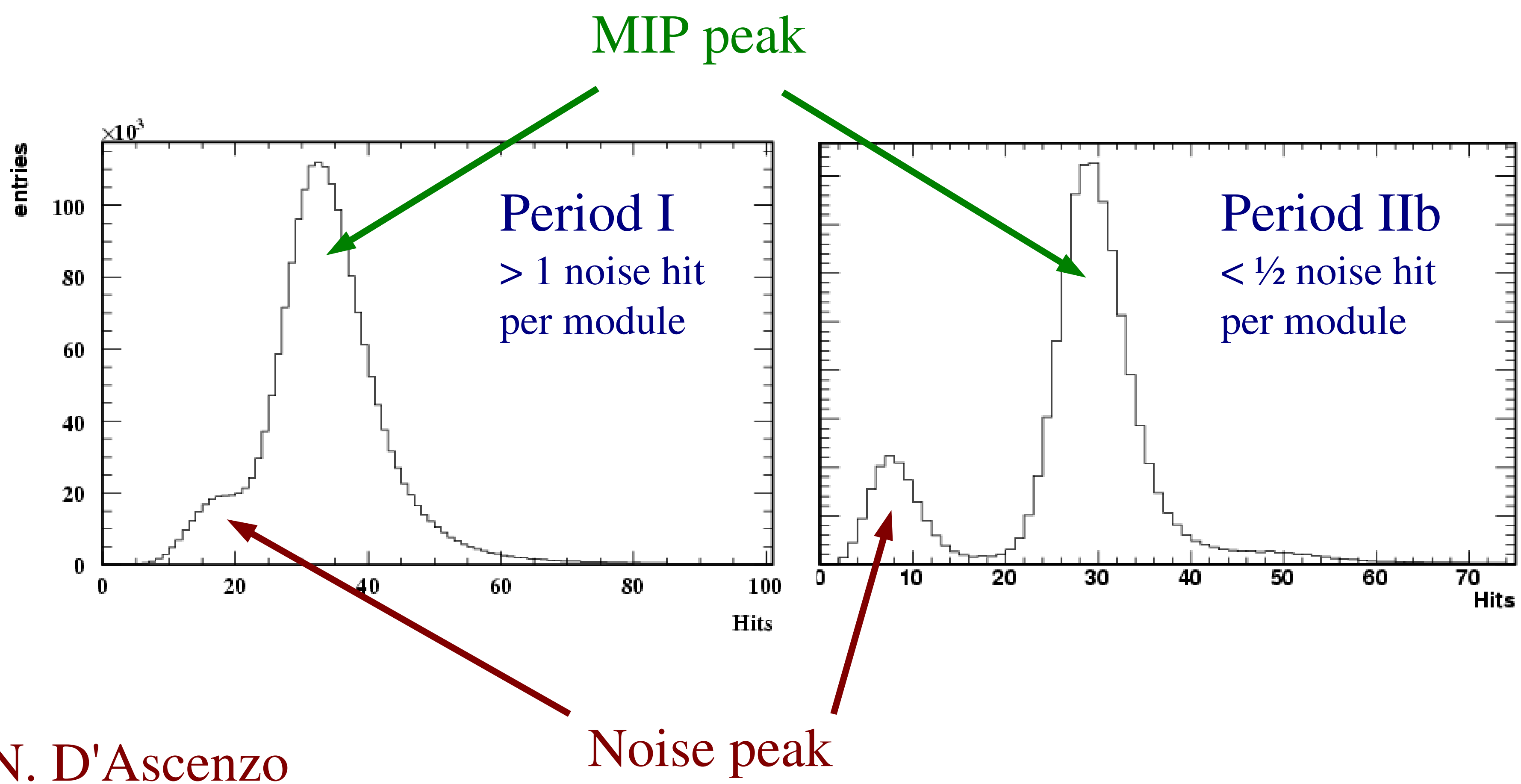
- Gauge to physics scale
- Zero suppression (reject amplitudes below ½ MIP)

Uncertainty on measurement linear on MIP uncertainty

More details on systetatic studies and results
⇒ talk by N. D'Ascenzo

Noise Occupancy

Most simple analysis: number of hits (i.e. cells with an amplitude of more than half a MIP) in muon events. Note the random triggers!



N. D'Ascenzo

EM Shower Analysis

First step to study HADRON showers is to understand our novel PROTOTYPE detector on the well understood EM SCALE

Muons were easy: smoking gun signatures, low hit amplitudes

To study electron response, two major things change:
- Event selection gets important (talks by B. Lutz, D. Ward, M. Ruan)
- Hit amplitudes are much larger, and SiPMs are non-linear devices

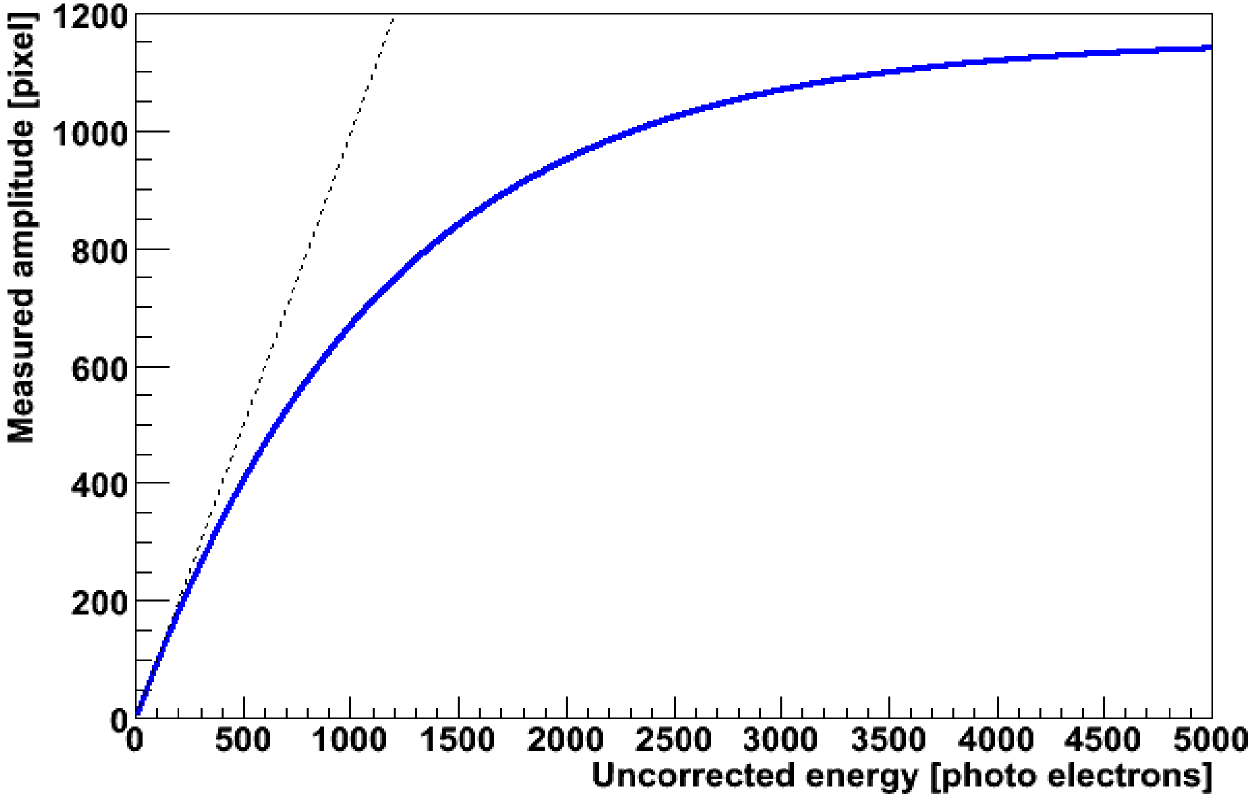
Various unknowns are connected: event selection, reconstruction, various corrections, and MC comparison

For first status see talks by O. Wendt (MC) and N. Wattimena (EM)

SiPM Saturation

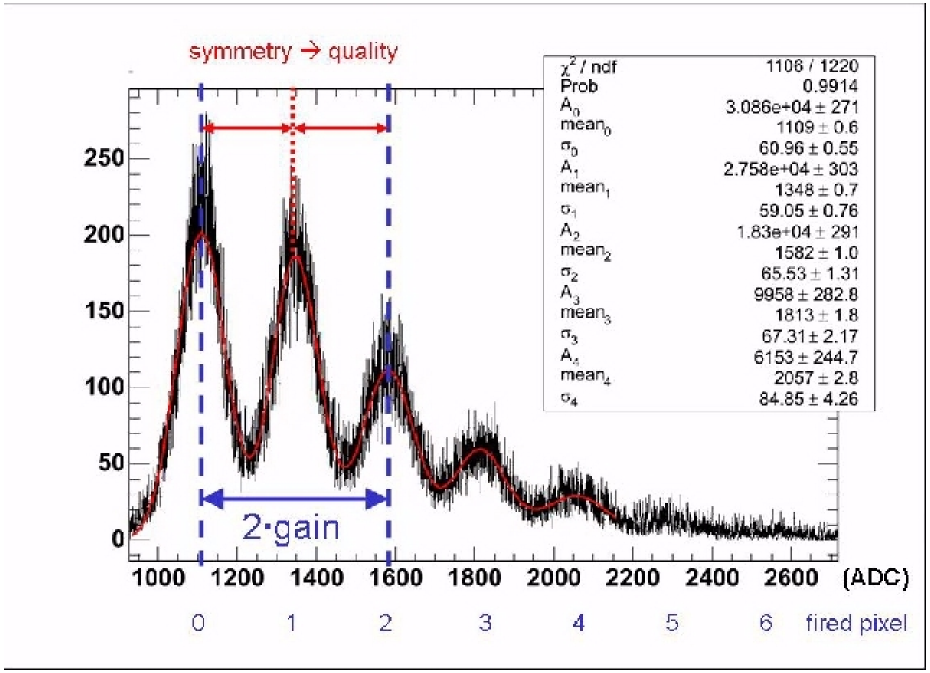
Idealized case: 34x34 equal pixels, unform photon flux, no x-talk:

$$N_{pix} = N_{tot} \, (1 - P \wedge N_{p.e.}) \quad \text{with} \quad P = (N_{tot} - 1) / N_{tot}$$



⇒ Need to know amplitude in pixels for possibility of correction

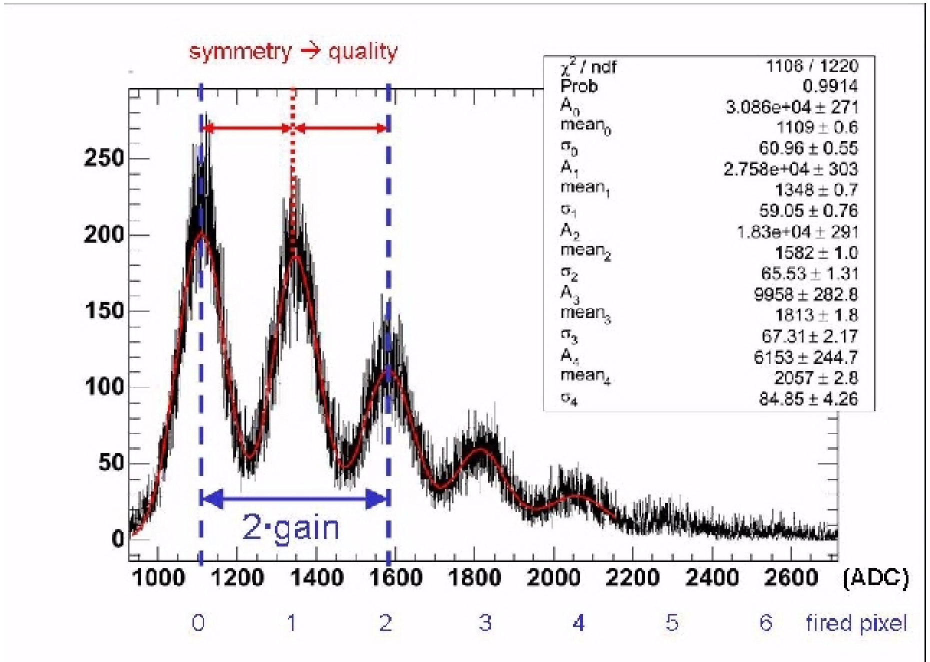
Gain Calibration



Use high electronics gain to resolve and fit single photons (not visible with standard gain)

B. Lutz

Gain Calibration

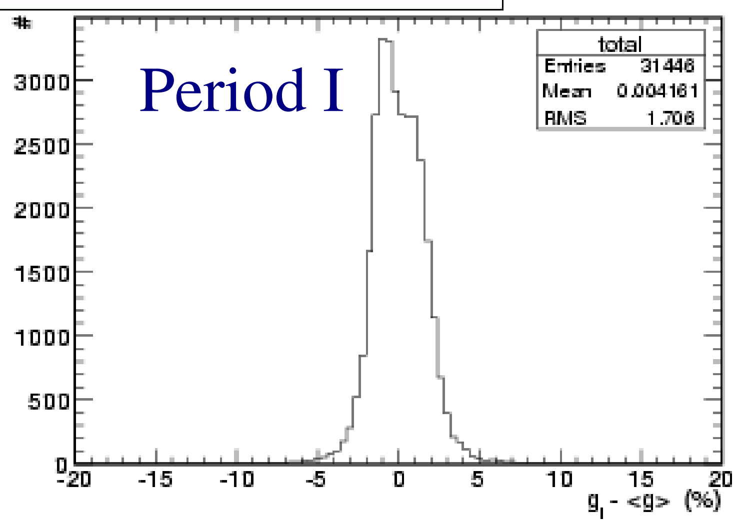


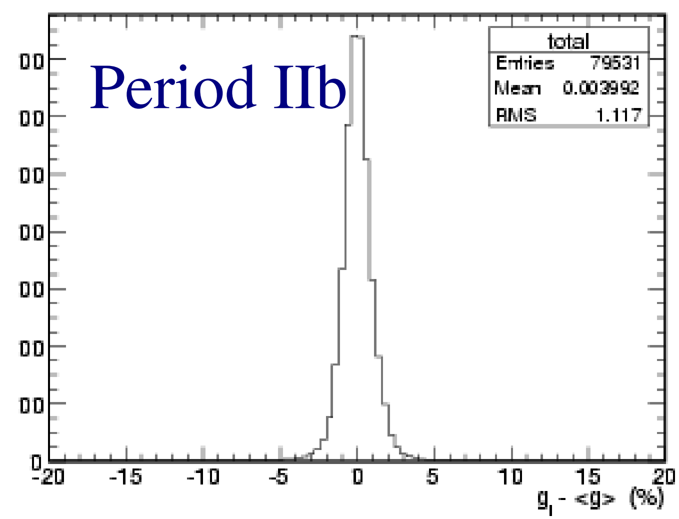
Use high electronics gain to resolve and fit single photons (not visible with standard gain)

Very stable operation during Periods I & IIb

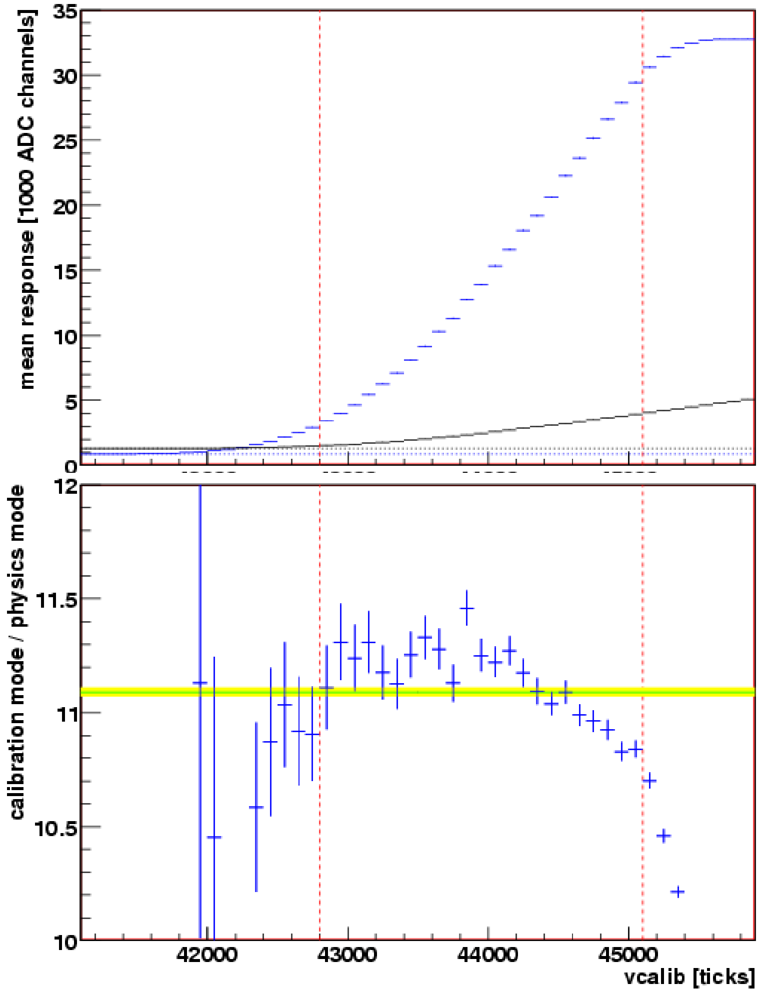
Success rate:
Per. I: 96.7%
Per. IIb: 97.0%

B. Lutz





Electronics Inter-Calibration



Relate high and standard electronics gain by comparing mean response to LED at reasonable light intensities

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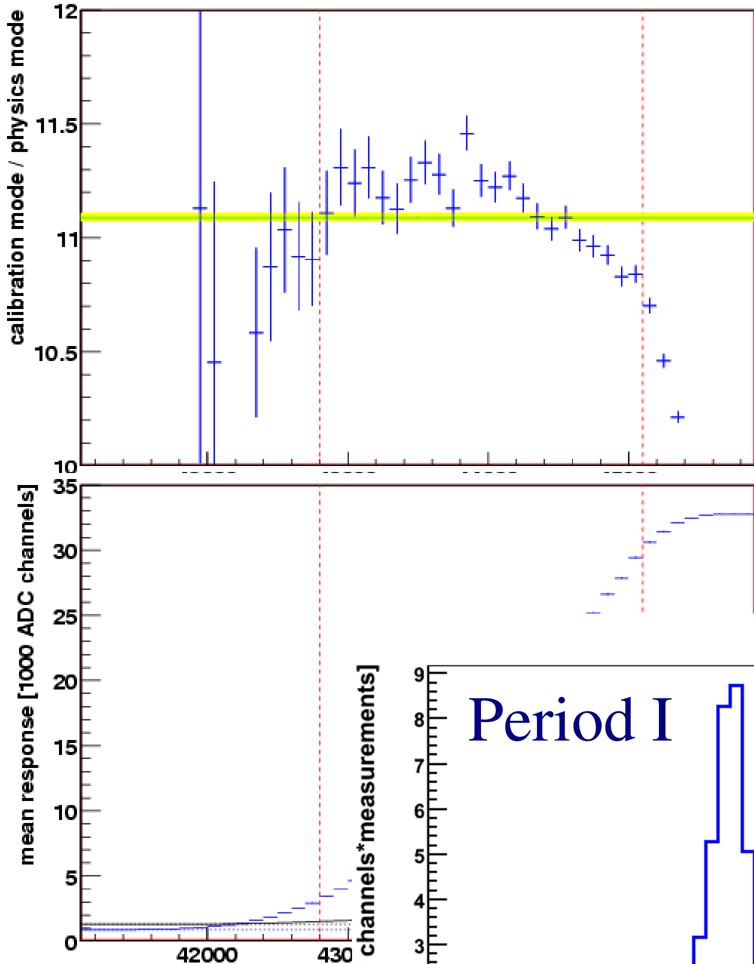
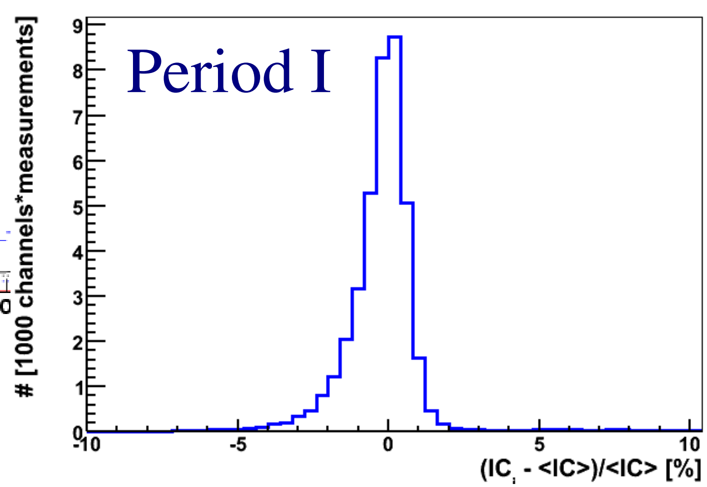
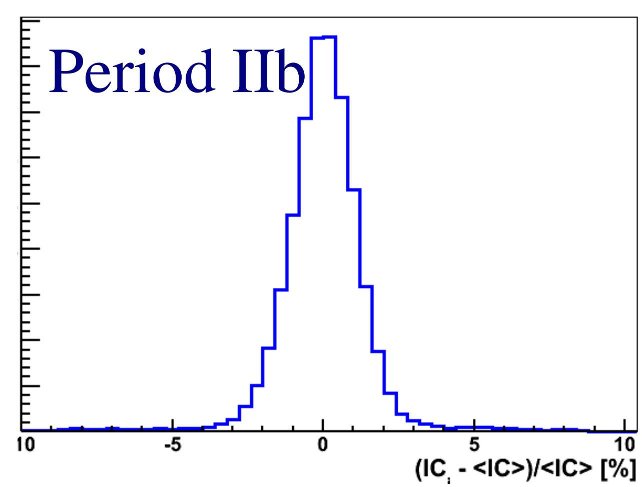


Relate high and standard electronics gain by comparing mean response to LED at reasonable light intensities

Equally uniform than CM gain

Success rate I / IIb: 98.7% / 99.4%



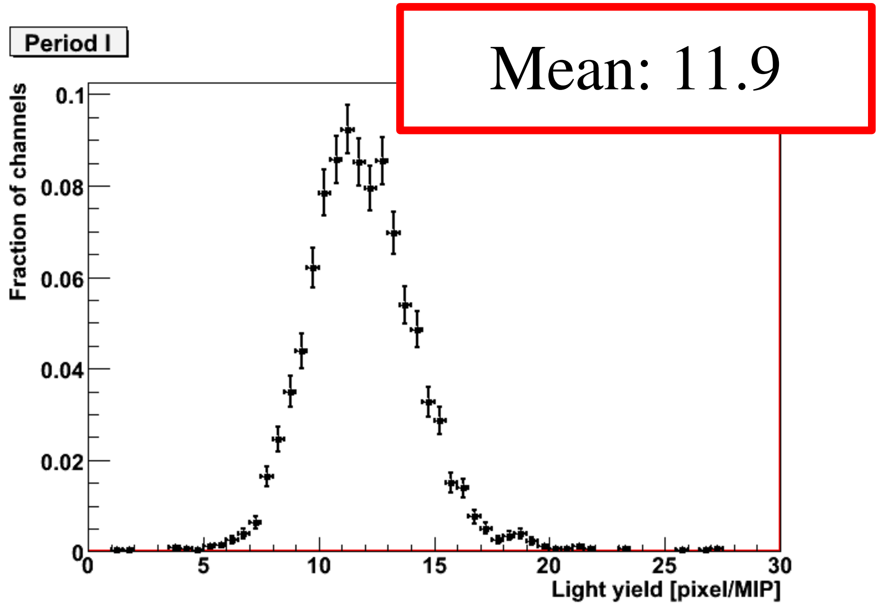


Light-Yield Calibration

Light-yield is [pixels / MIP] and relates physics to SiPM response, therefore being an important cross-check

At the testbeam: LY = MIP * IC / gain

SiPM operation voltage is chosen at ITEP to reach 15 pixel/MIP w/o tile, varyfied for sub-sample upon arrival at DESY w/ tile



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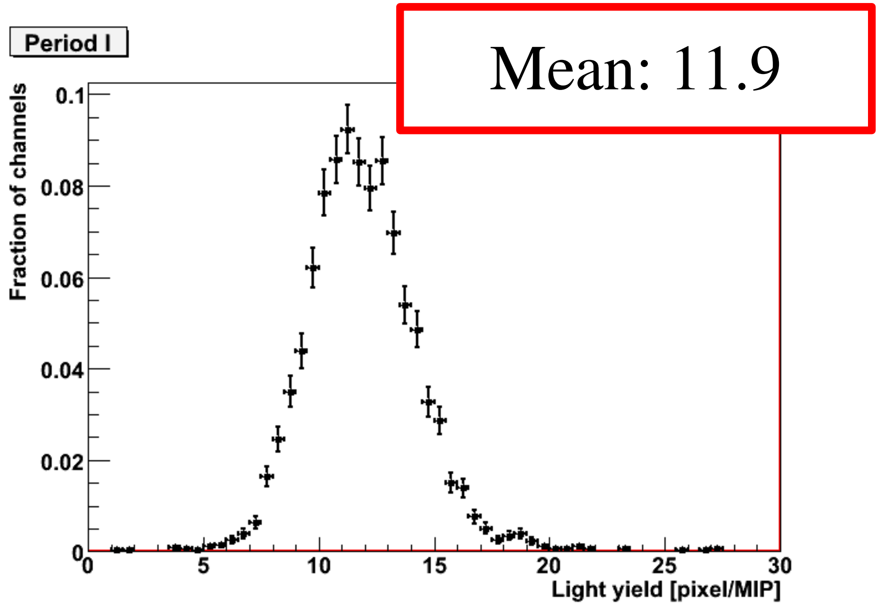
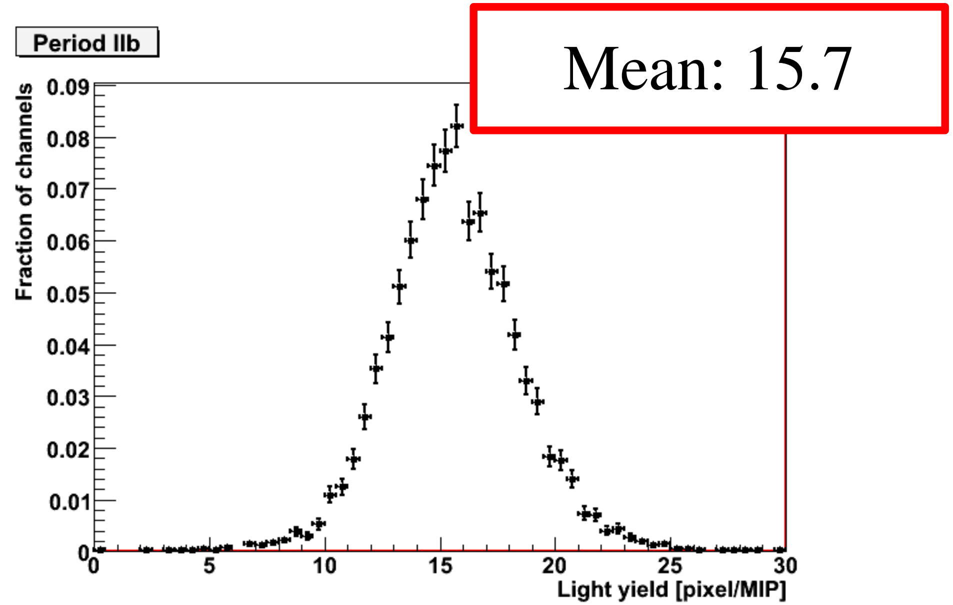




Calibration Performance

Channels (out of 3240 / 4968) which could not be calibrated for various reasons (dead, noisy, long discharge, no LED, ...):

	MIP	gain	IC	any
Period I	63 (12)	108 (12)	43 (9)	123 (15)
Period IIb	329 (131)	149 (89)	32 (17)	347 (132)

Numbers in brackets refer to Module 1:
Fraction of uncalibrated channels <10% in P.I → >50% in P.IIb
This decay of performance is not understood, yet

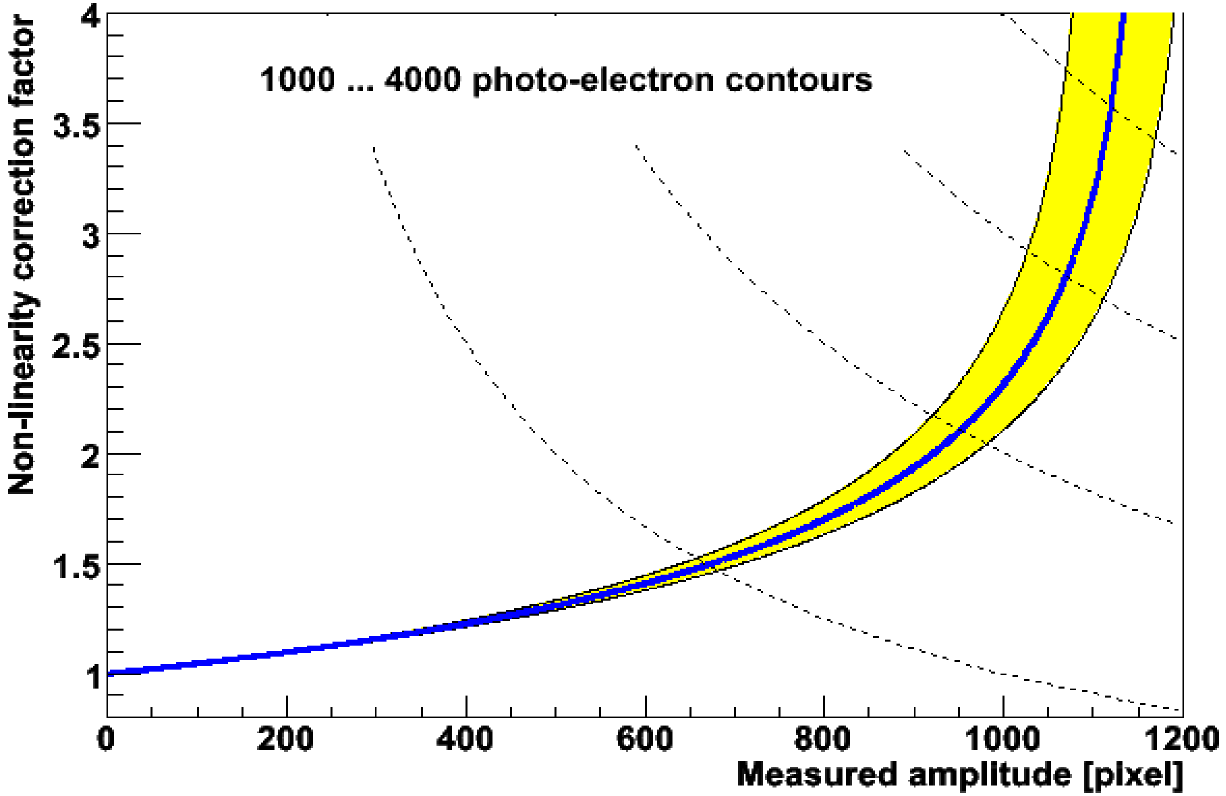
The good news: All other modules behave very well

Few percent non-calibrated channels partially still could be recovered with some effort

Non-Linearity Correction

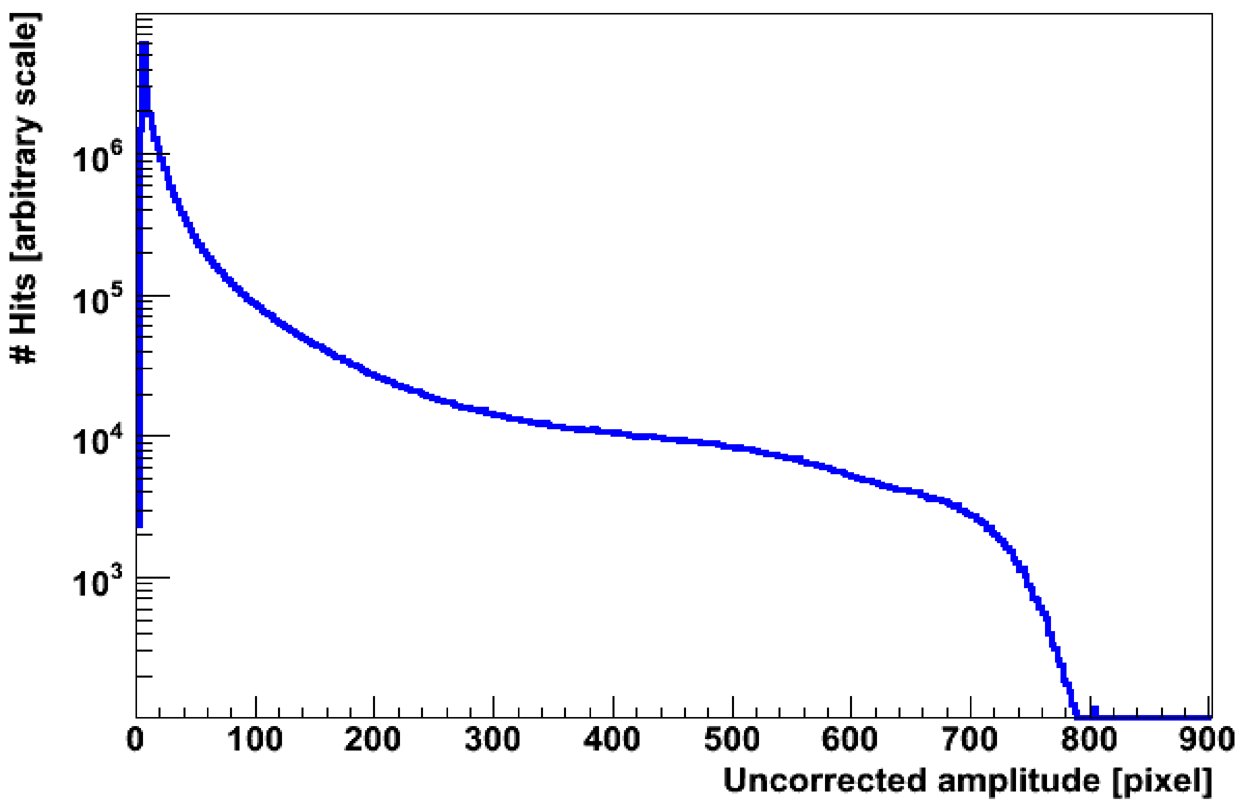
Correction factor derived from inverted saturation curve

Even moderate uncertainties (assume 5%) on the pixel scale result in large uncertainties of the correction factor at high amplitudes
⇒ special treatment for high amplitudes needed



Non-LinearityCorrection Scale

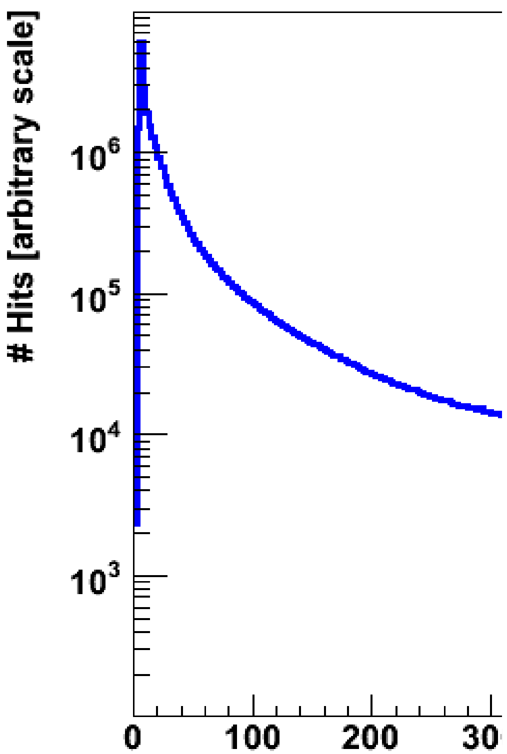
Example: 30 GeV electron showers from Period I

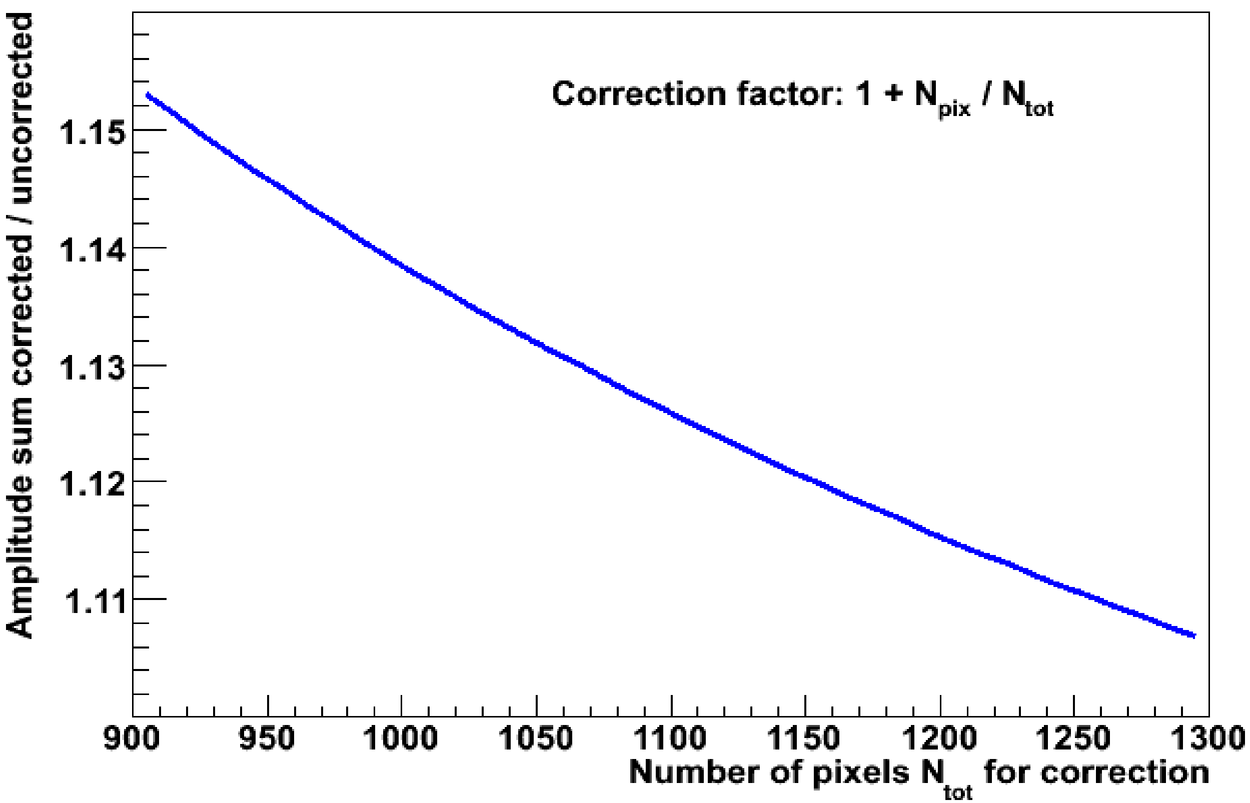


Non-LinearityCorrection Scale

Utilize correction validated at DESY (electron up to 6 GeV):

First term of series expansion, use N_{tot} as free parameter



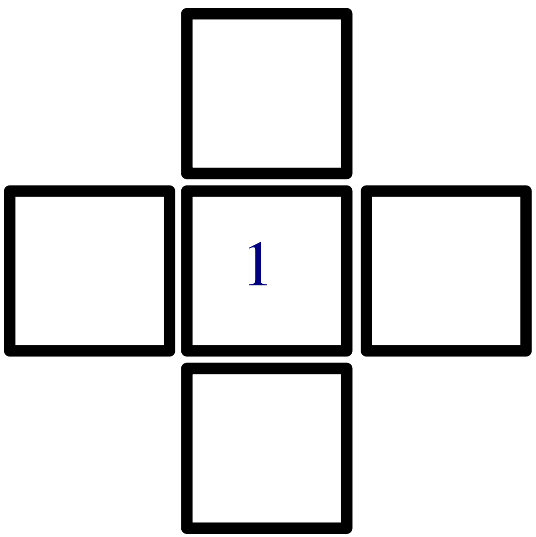


Uncertainty on pixel scale not important, but scale of correction is!

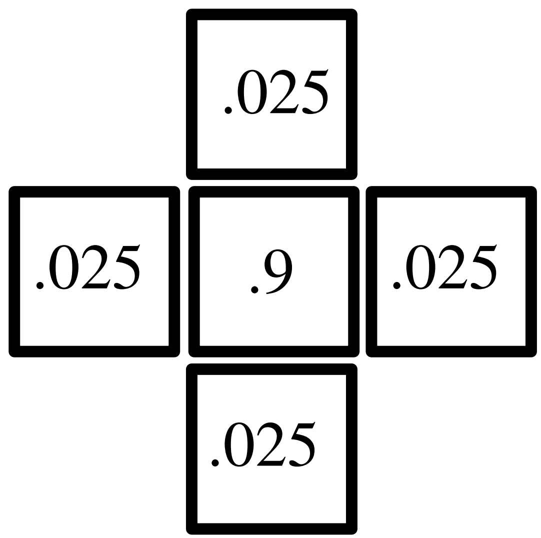
Light Cross-Talk

It is known that the HCal tiles are not light tight from single-module tests at DESY: About 10% of light leaks out of tile

Example MIP calibration: Muon through middle tile in sketch



Light production from MIP passage



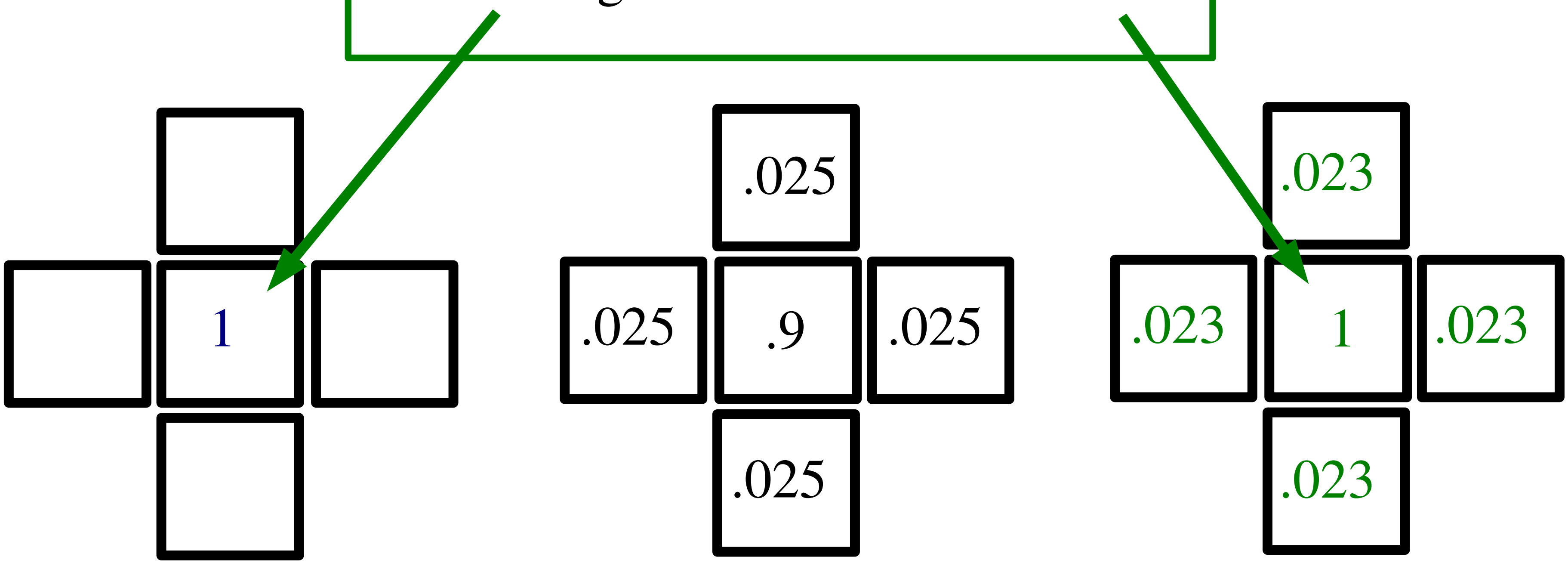
Light detection

Light Cross-Talk

It is known that the HCal tiles are not light tight

Easy example: sketch

Define scale:
A MIP signal is calibrated as 'MIP'



Light production from MIP passage

Light detection

MIP calibration

Light Cross-Talk

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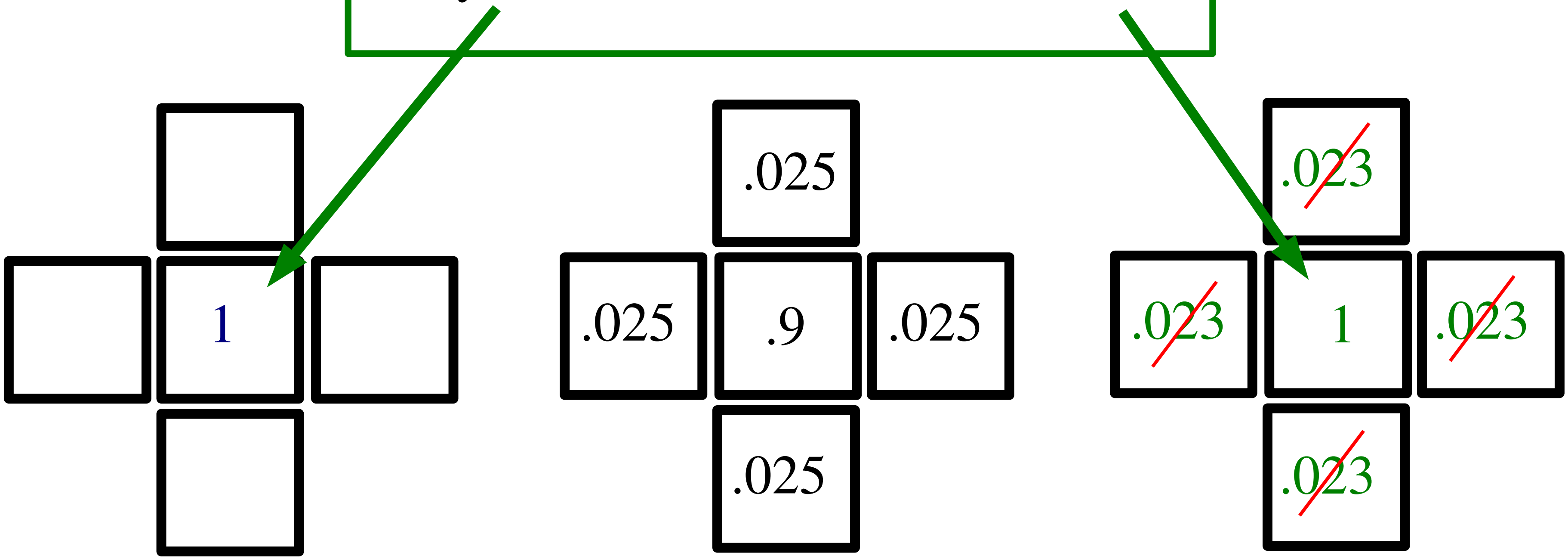
Easy example: … sketch

After zero-suppression:
'Physics' and 'calibration' look alike



Light production from MIP passage

Light detection

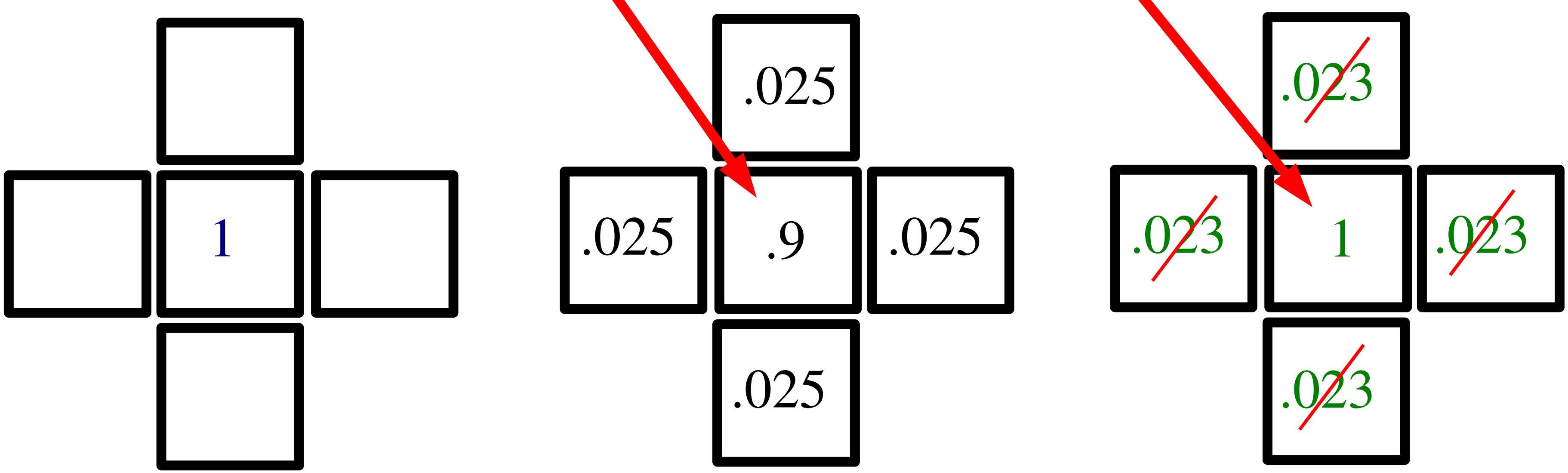
MIP calibration and zero suppression

Light Cross-Talk

It is known that the HCal tiles are not light tight

Easy example: … sketch

But be aware:
90% of MIP signal is one 'MIP'



Light production from MIP passage

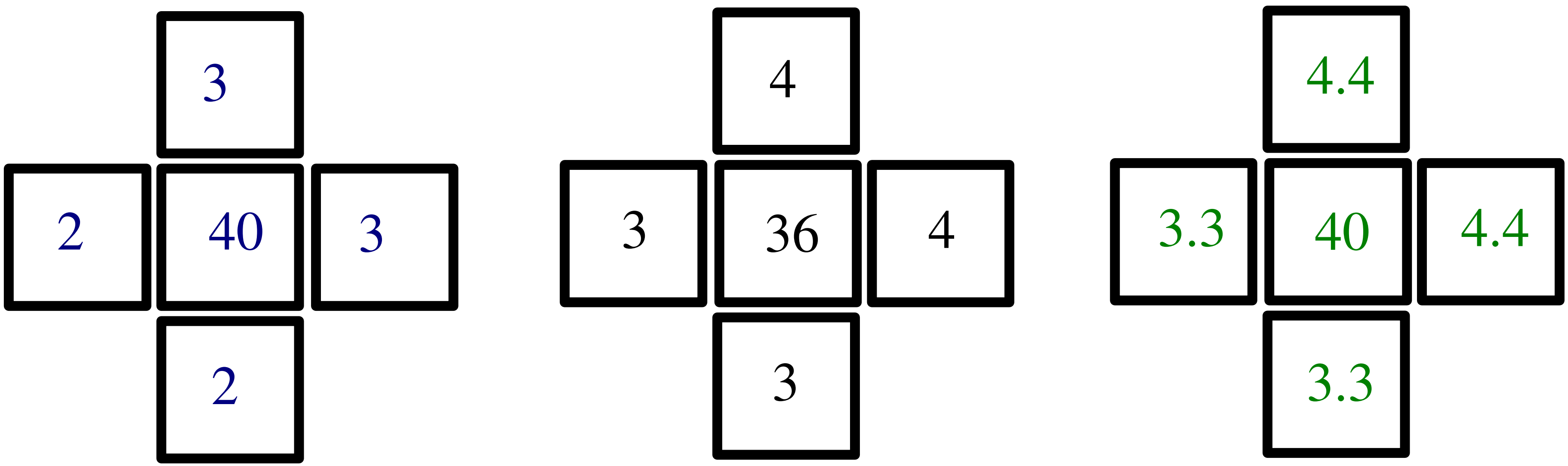
Light detection

MIP calibration and zero suppression

Light Cross-Talk

However, the picture looks different in showers, where neighbouring tiles are above threshold even without light leakage

A typical EM shower in the same sketch:



Light production in MIP equivalents

Light detection

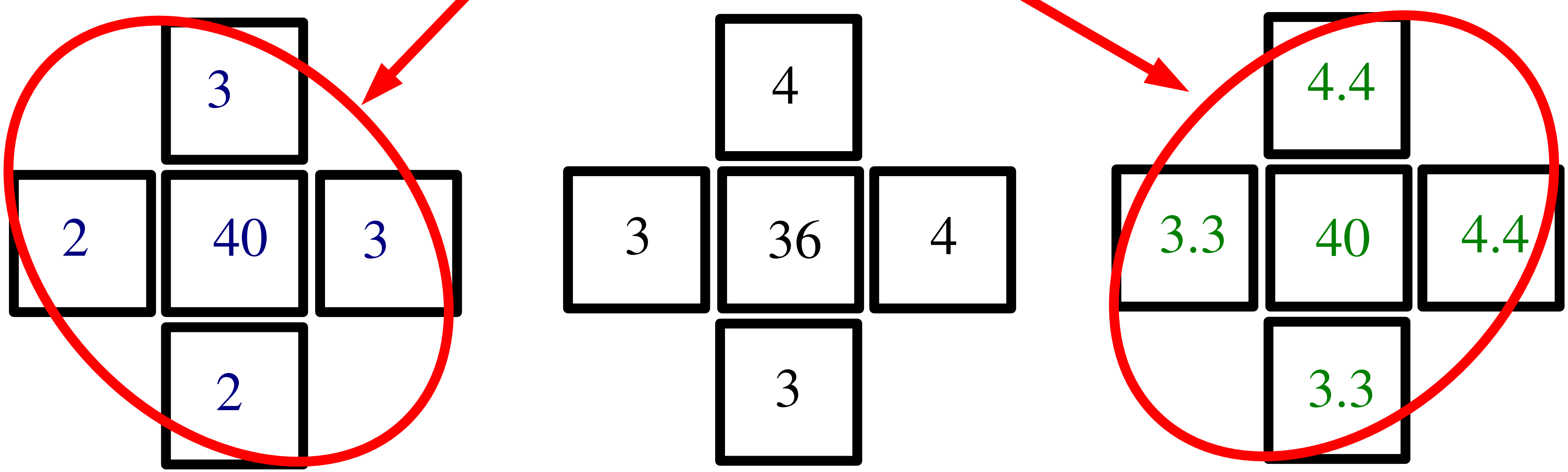
MIP calibration and zero suppression

Light Cross-Talk

This has severe implications on higher amplitudes in showers

A typical EM s

Neighbouring tiles above threshold
lead to over-estimated total energy:
50 MIP become ~55 'MIP'



Light production in MIP equivalents

Light detection

MIP calibration and zero suppression

Summary and Outlook

Calibrations:

MIP, gain and, electronics intercalibration available

Good accuracy for physics analysis of stable detector operation

Correction for varying conditions to come (talk by S. Schätzel)

Corrections:

Tests at DESY with low beam energy and PMT as linear scale

Only linear scale at CERN is beam energy, so non-linearity correction at higher energies can only be done iteratively

Light cross-talk affects reconsructed energy scale as well, interplay of non-linearity and light cross-talk, even more iterations needed