Calibration and Monitoring System of Analog Tile HCAL

Sebastian Schätzel (DESY)

CALICE Meeting
12 October 2005

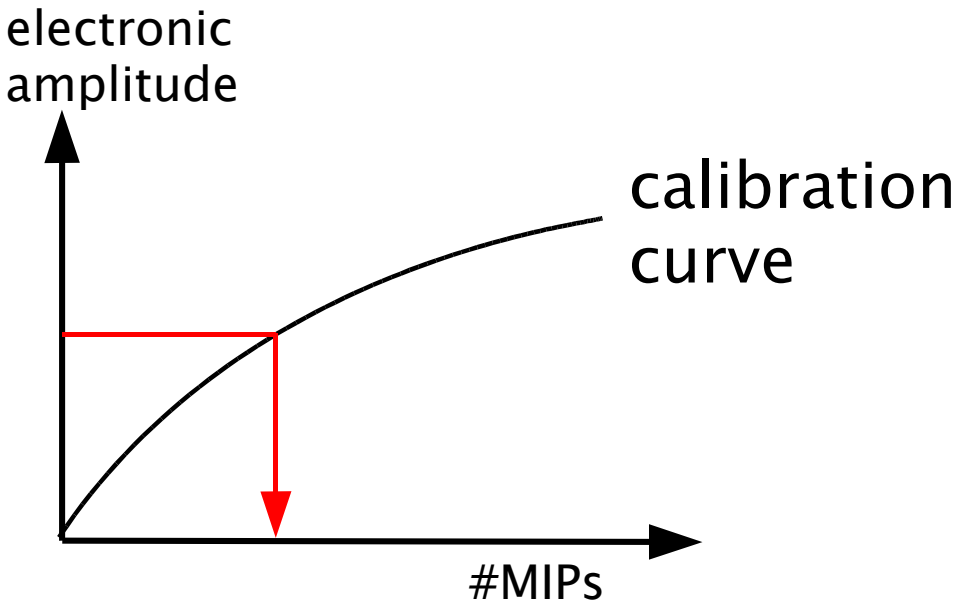
Introduction

AHCAL Signal chain:

particle shower → MIPs → scintillator → photons (UV)
→ SiPM (non-linear) → photo-electrons
→ amplification → electronic signal

Calibration:

convert detector signal
into number of MIPs
traversing the tile

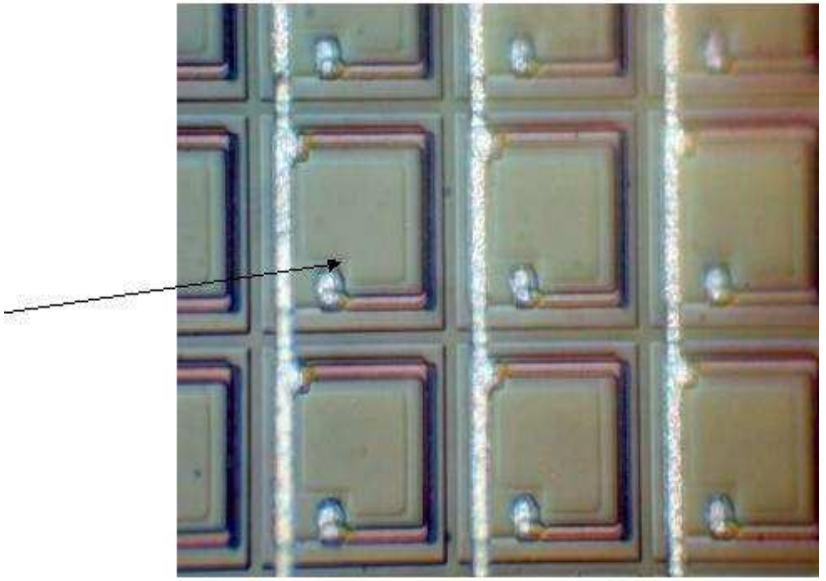


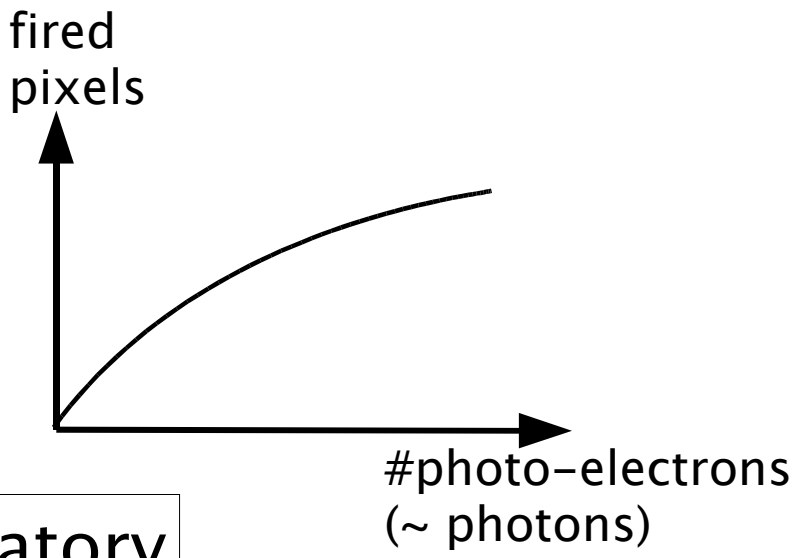
Monitoring:

monitor time-stability of
detector response to
fixed signals

SiPM non-linearity

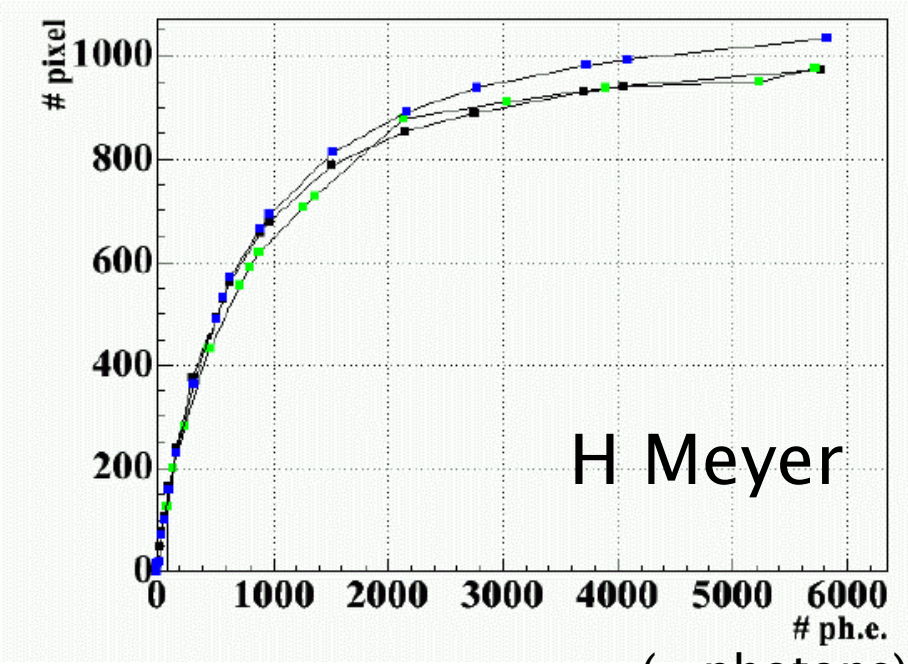
photon
↓ quantum eff.
photo-electron (p.e.)
↓ Geiger mode
avalanche discharge
↓ dead-time, pixel is blind to other photons
pixel fires



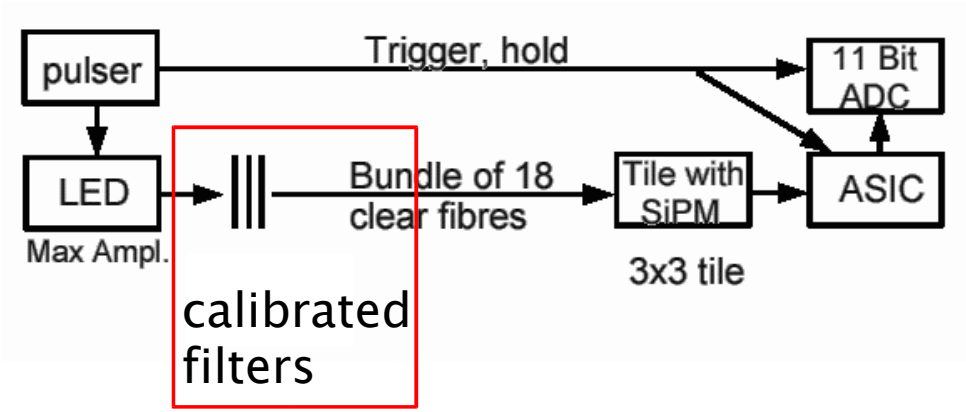


Measure saturation curve in laboratory and apply during operation

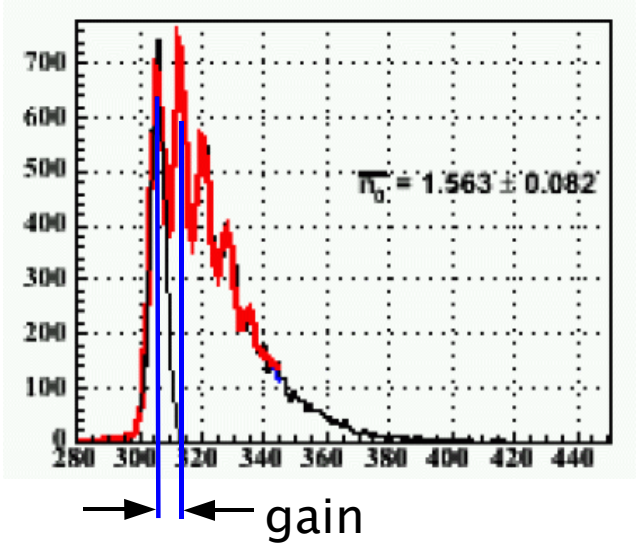
Lab measurement of SiPM non-linearity



(~ photons)

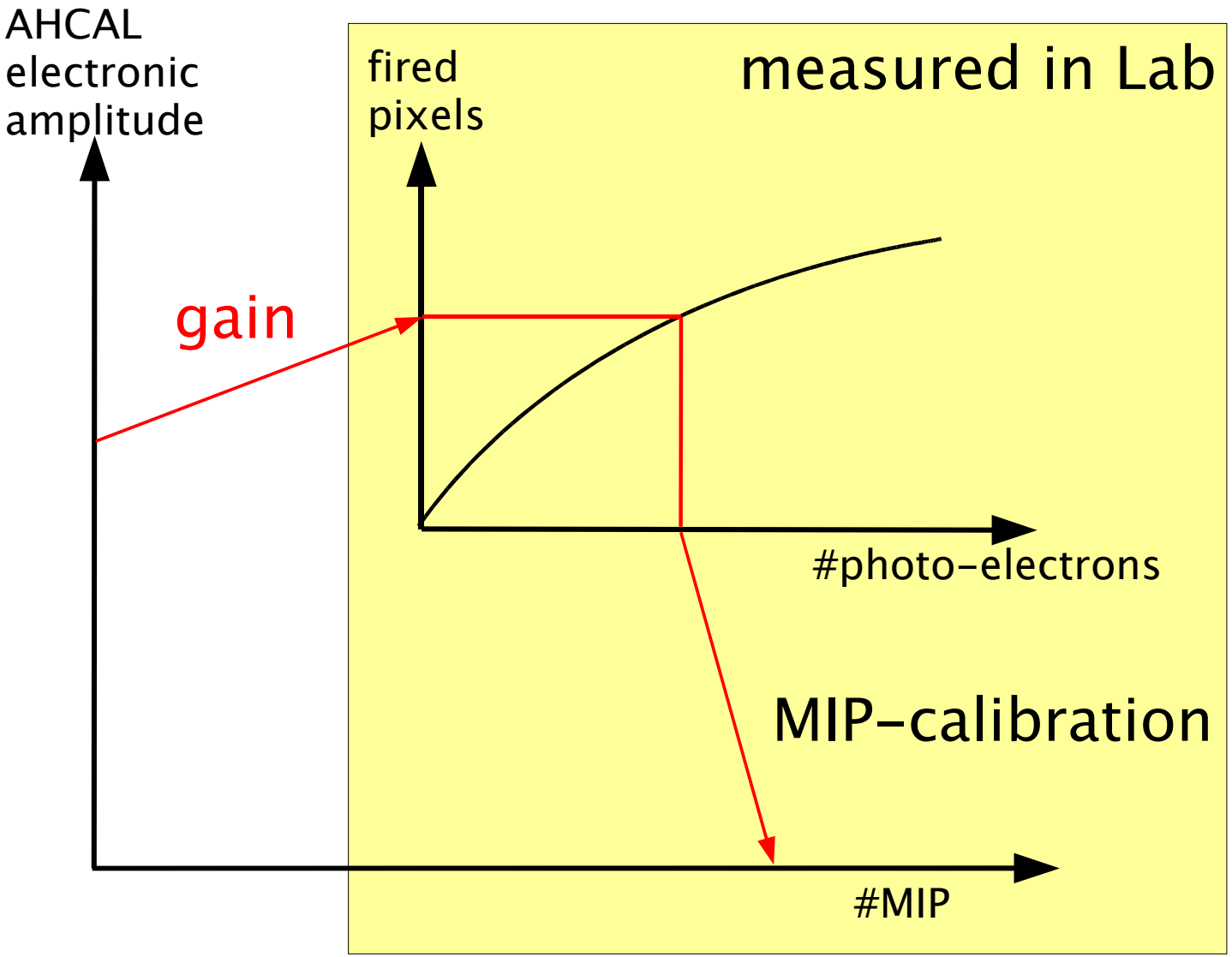


spectrum for strongest filter:



- relative light intensity known (calibrated filters)
- absolute calibration from linear part: 1 fired pixel = 1 p.e.
- #fired pixels from gain measurement

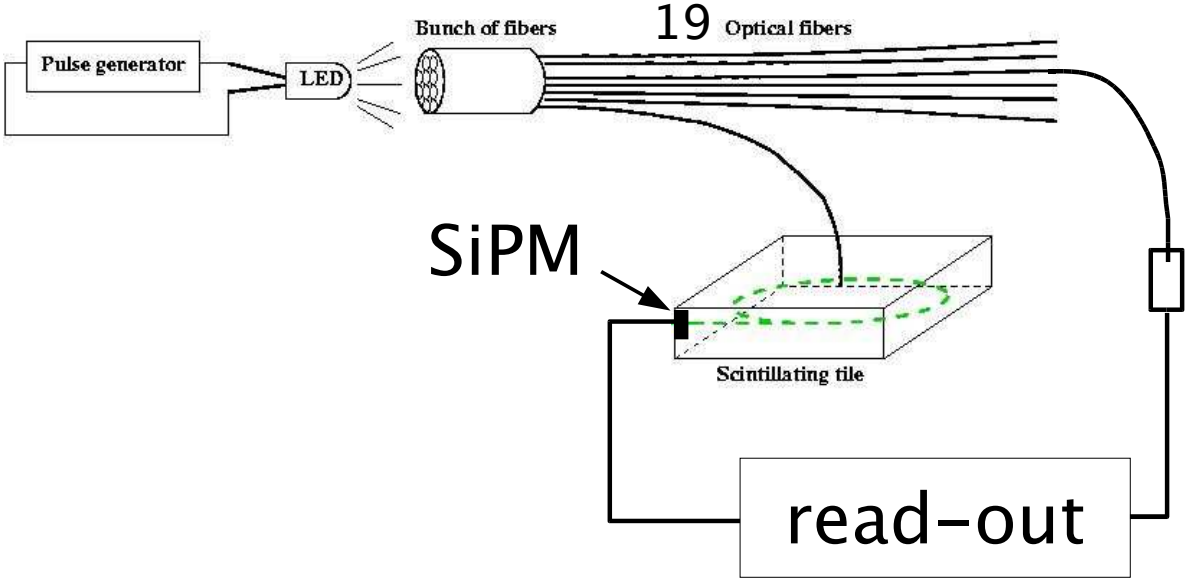
Calibration of AHCAL signals



HCAL-integrated LED system

use UV photons to excite scintillator

Operation Principle:

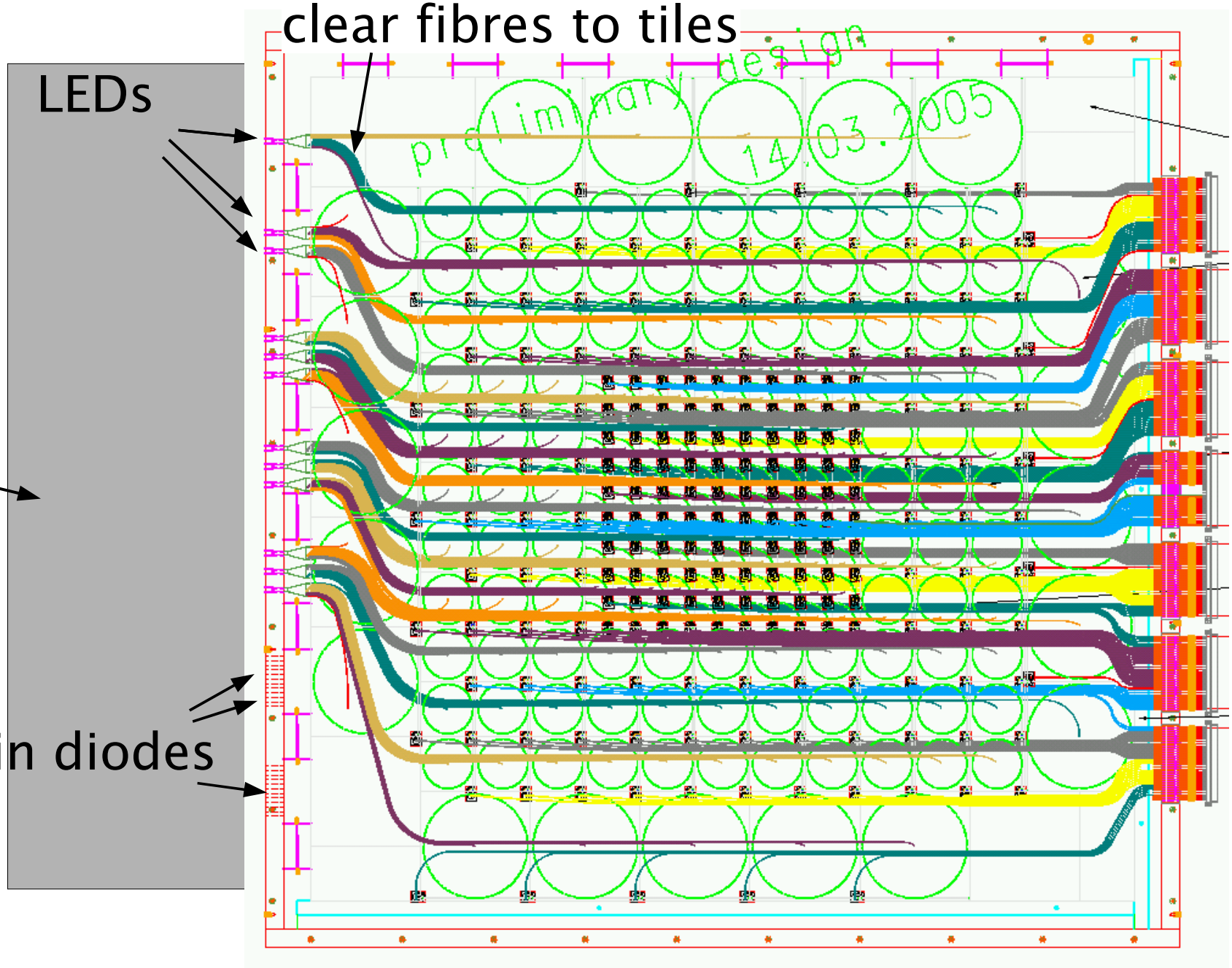


- 12 LEDs per module
- 1 LED connected to 18 tiles and 1 pin diode

LED intensity:

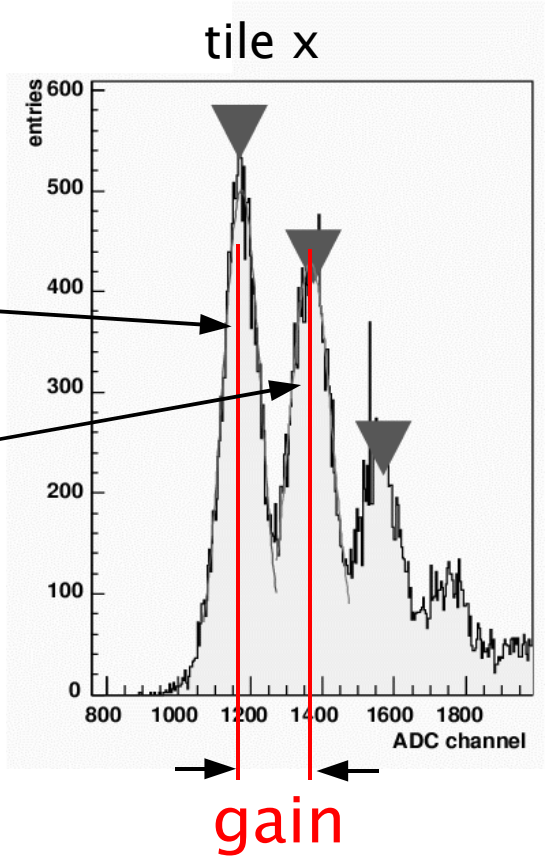
- can be varied by changing voltage
- measured with pin diode

HCAL-integrated LED system

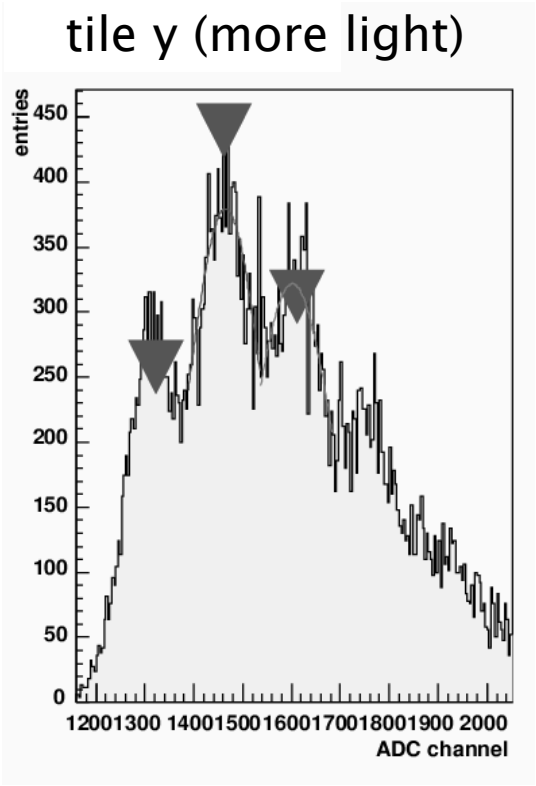


In situ gain measurement

distance of single p.e. peaks: low LED intensity



Problem:
too much light
washes out
peak structure



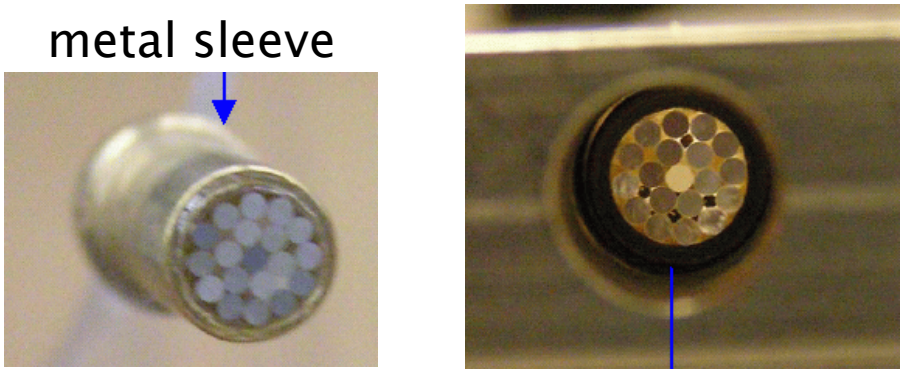
1 LED voltage setting gives single p.e. peaks in all 18 SiPMs?
→ intensity at tiles should vary less than factor ~3

Recent Progress on Light Uniformity

LED to fibre bundle coupling

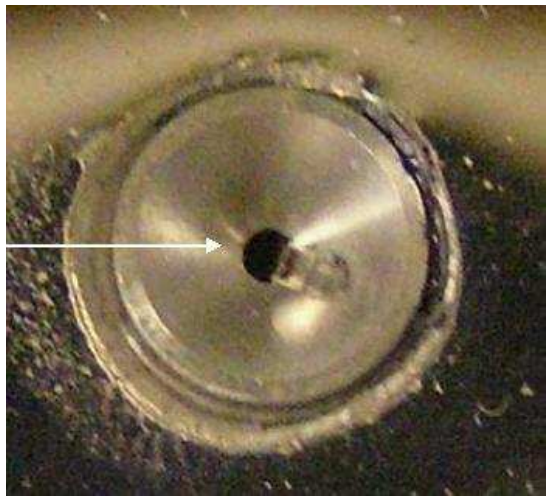
K Gadow

improved design:
- straight bundle end,
- centred in front of LE



coupling of fibre light into tiles:

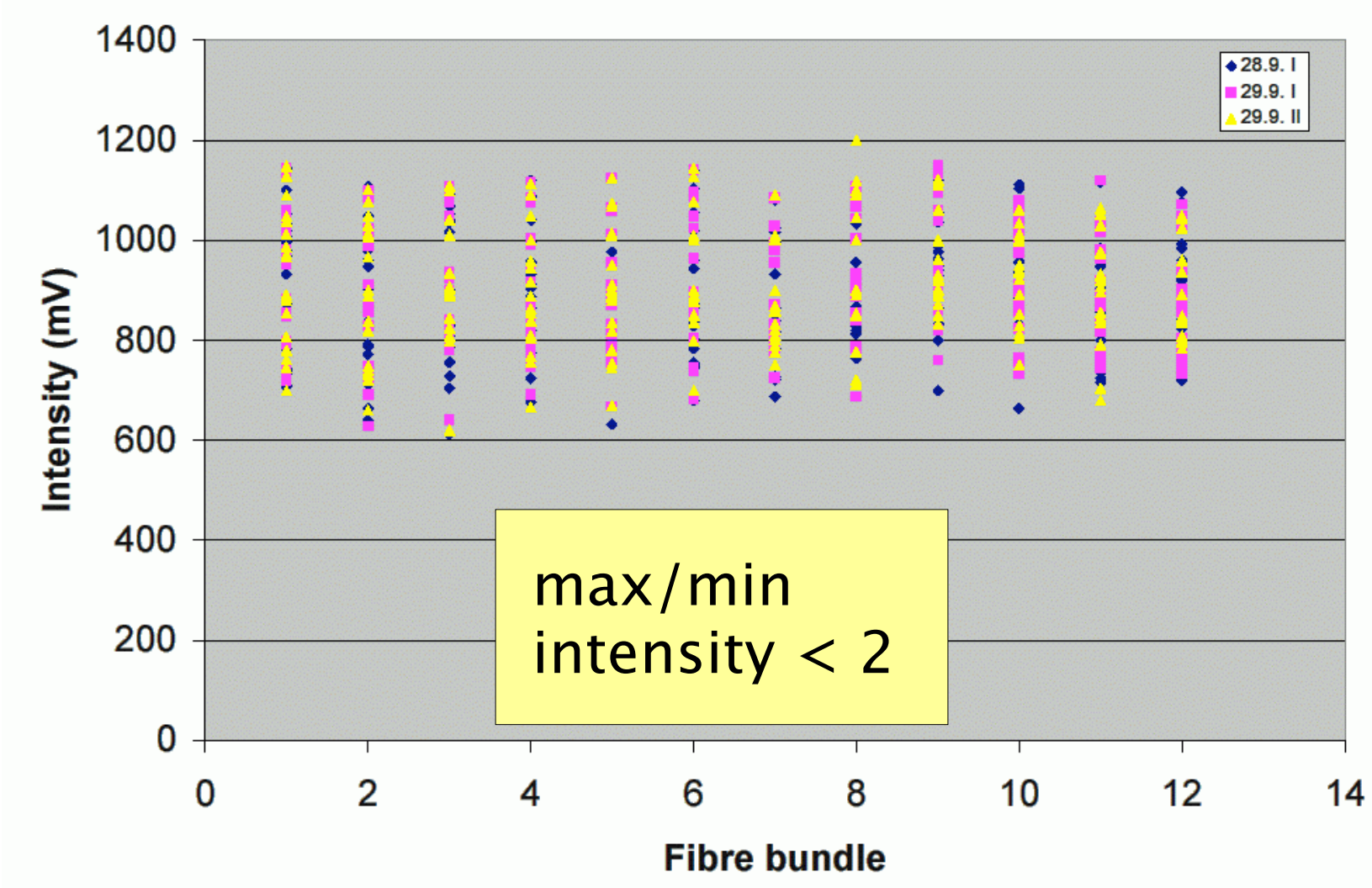
- Al alloy mirror cups
- mechanically robust



view from below

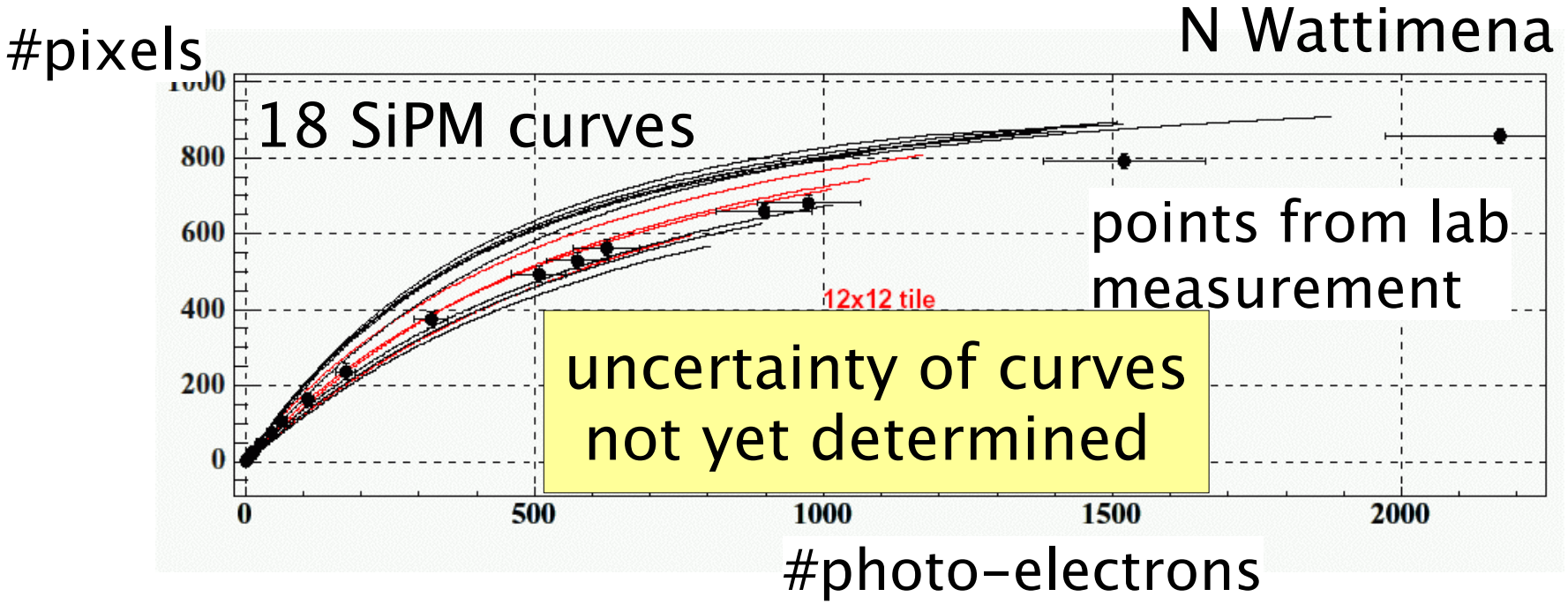
also studied but found to be ok:
LED light emission anisotropy

Light Uniformity in Test Module



→ single p.e. peaks should be visible in all 18 SiPMs (to be demonstrated)

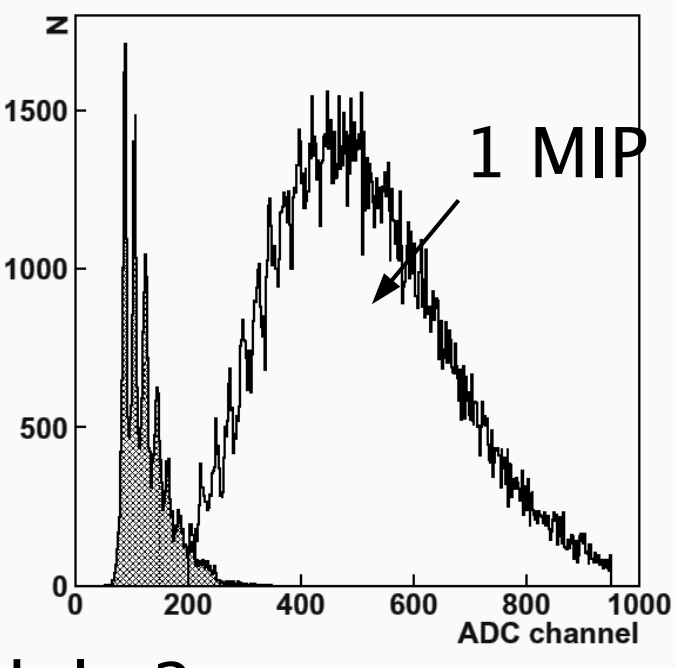
Study of in situ measurement of SiPM non-linearity



- LED intensity varied with DAQ
- intensity measured with pin diode (a.u.)
- absolute calibration from linear part of curve
- to come: study of uncertainties

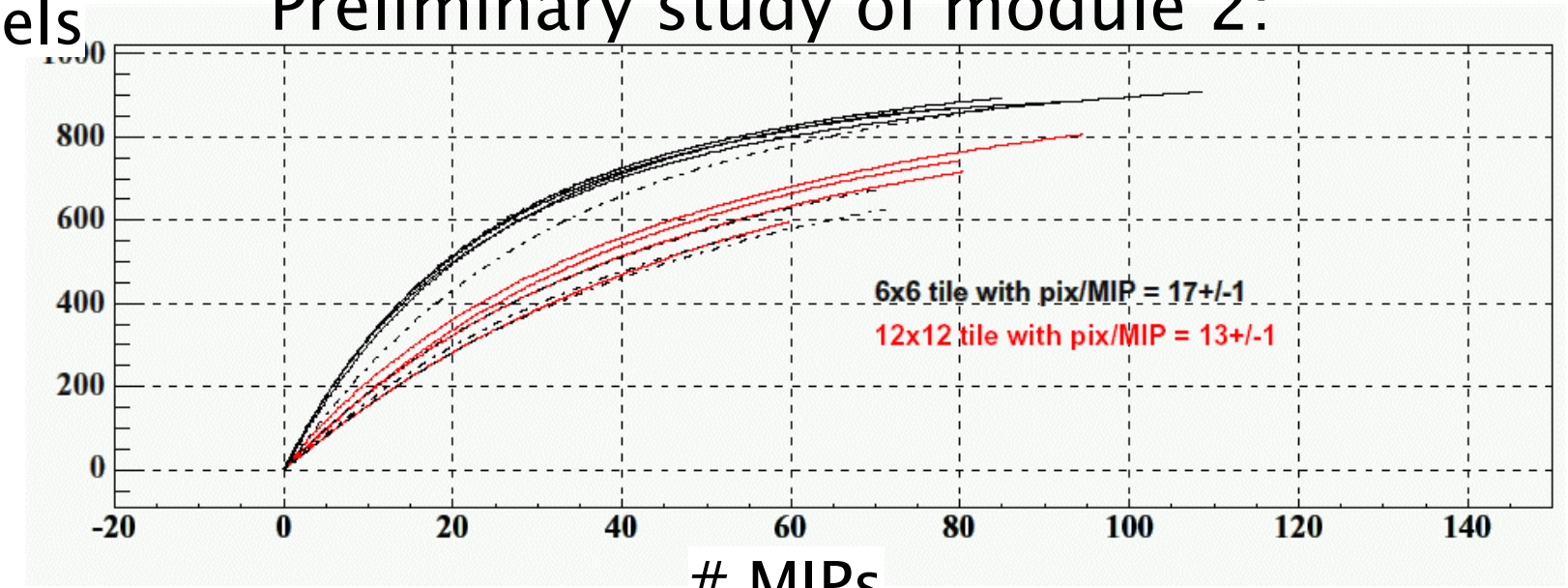
MIP Calibration (Lab)

simultaneous lab measurement
of p.e. peaks and MIP (β-source)



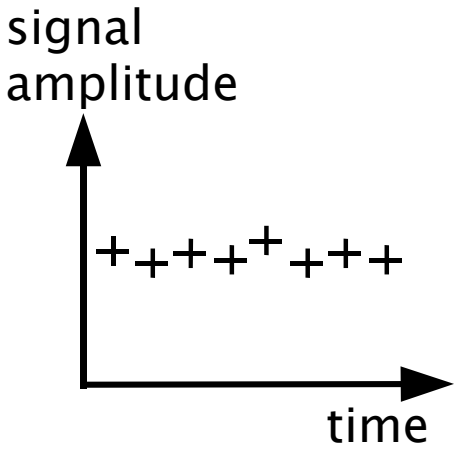
1 MIP = 15(2) p.e.
(different for every tile)

Preliminary study of module 2:



Monitoring of response to 3 MIP LED intensity

- monitor time-stability of
  Scintillator+WLS capture+transfer to SiPM
- fixed UV LED signal corresponding to ≈3 MIP (± ≈50%)
- LED intensity stability measured with pin diode
- measure with 1% precision
  (determined by statistics)



Summary

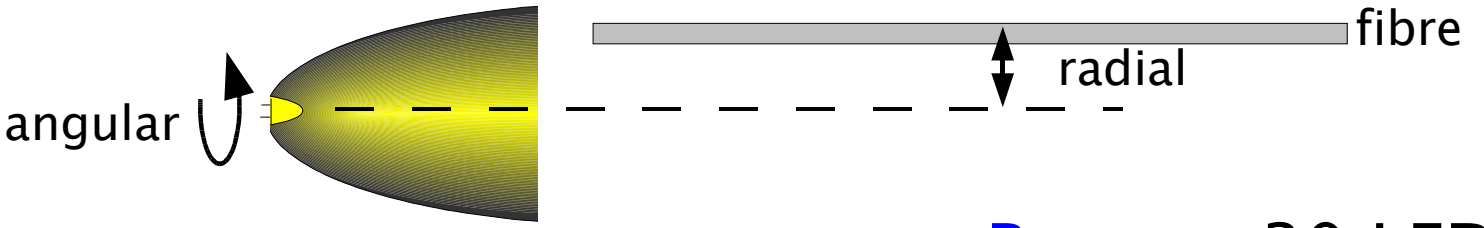
- special LED light uniformity requirements from SiPMs met (recent improvement)
- SiPM saturation measurement in lab & in situ
- LEDs provide sufficient saturation reach

Outlook

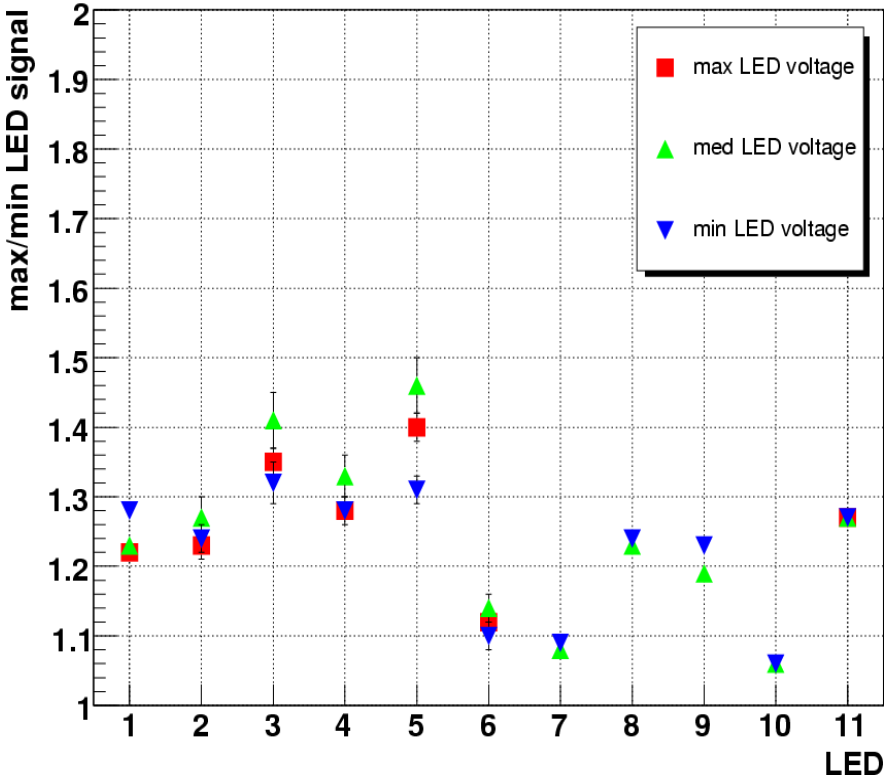
- working demonstration of calibration and monitoring system (Hall 5)
- determine length of gain and monitoring runs vs. measurement precision
- software to automatise these runs

Backup Slides

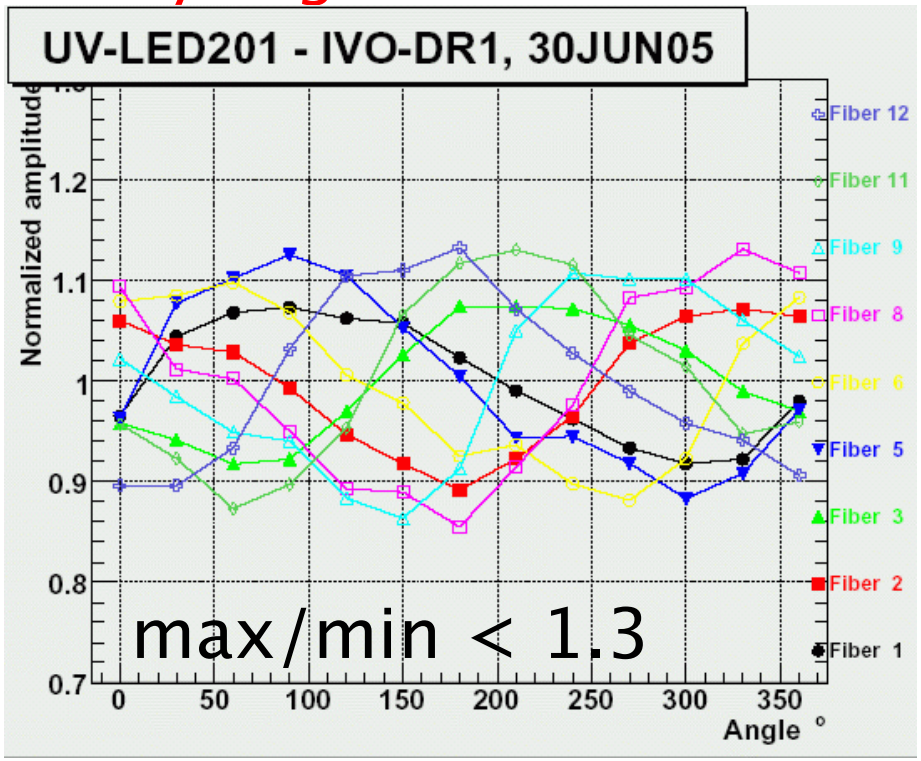
LED Light Cone Measurements



DESY, 11 LEDs
radial and angular variation



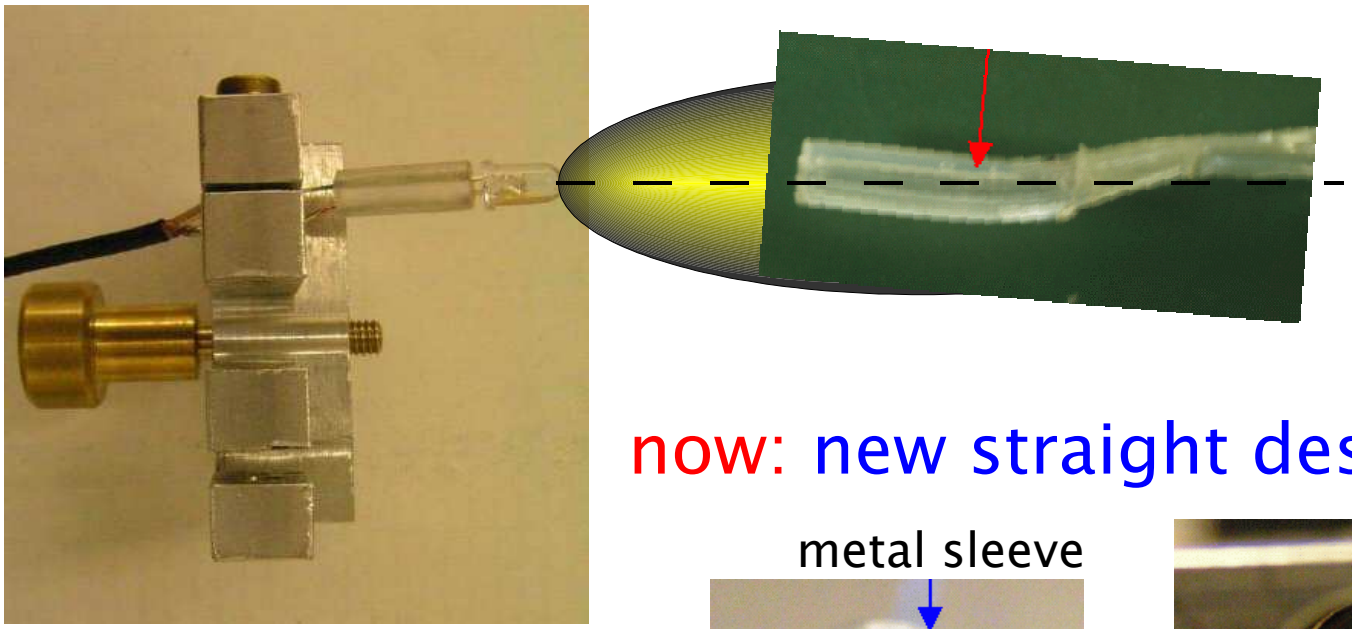
Prague, 30 LEDs
only angular variation

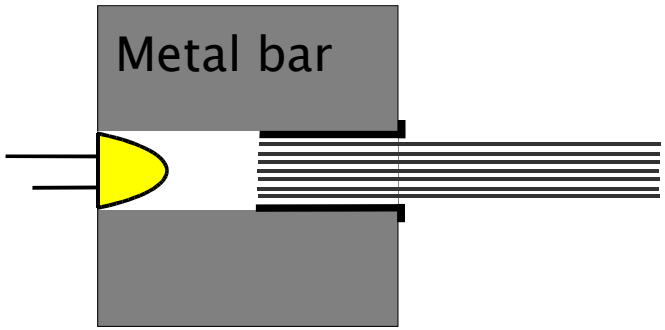


LED contribution: Factor <1.5

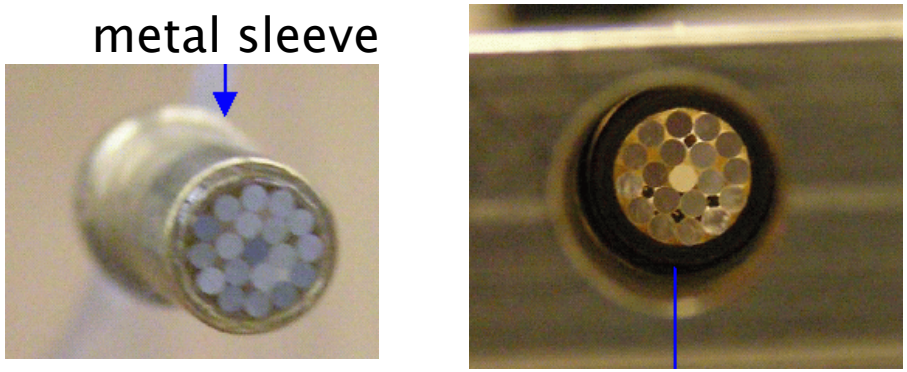
Study: LED/fibre Coupling

was: glued fibre bundle ends banana-shaped,
bundle not aligned with LED axis:





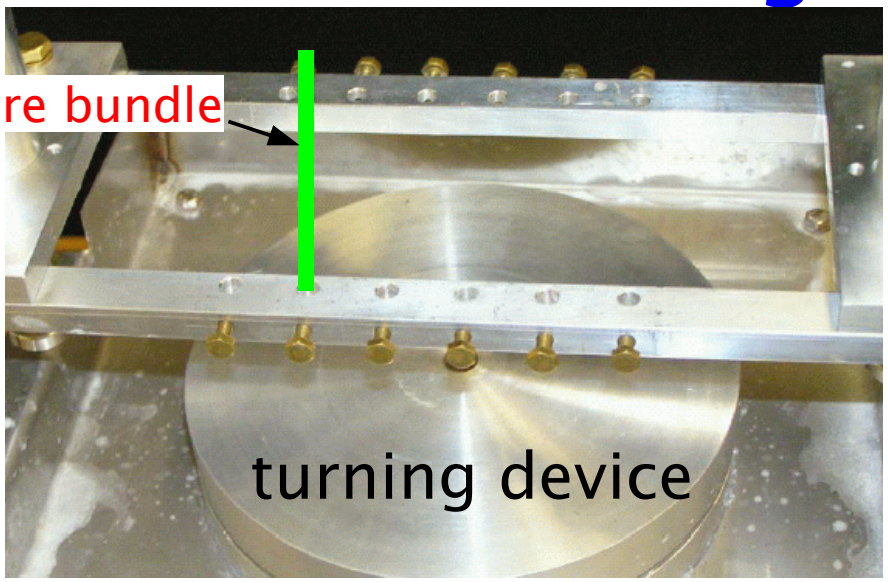
now: new straight design:



sleeve centres bundle end in cassette

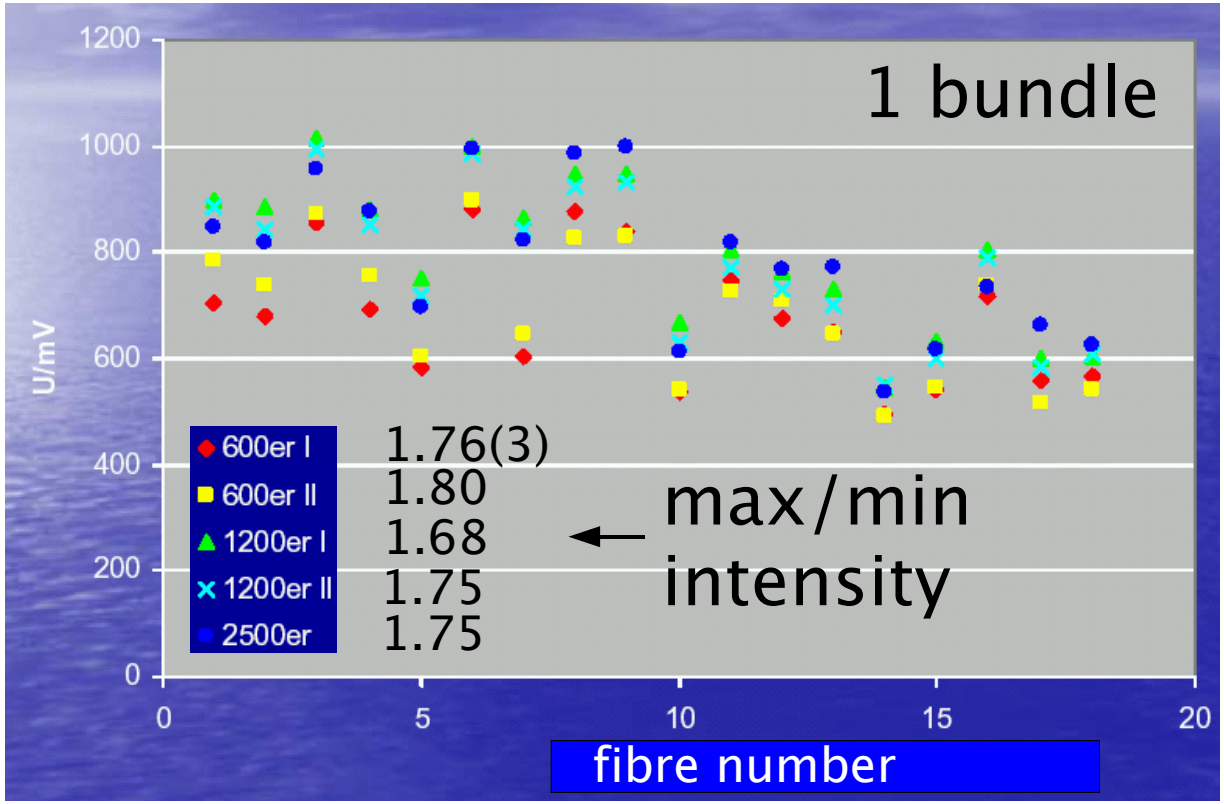
Study: Glued Bundle End Surface Polishing

polished with abrasive paper
with machine (before: manually)



more light for finer
paper granularity
(2500 is finest)

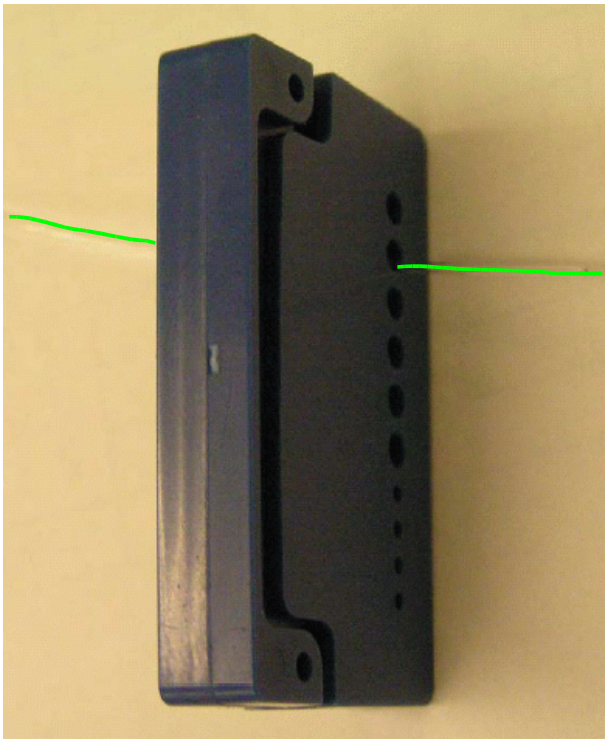
max/min does not
improve with
finer granularity

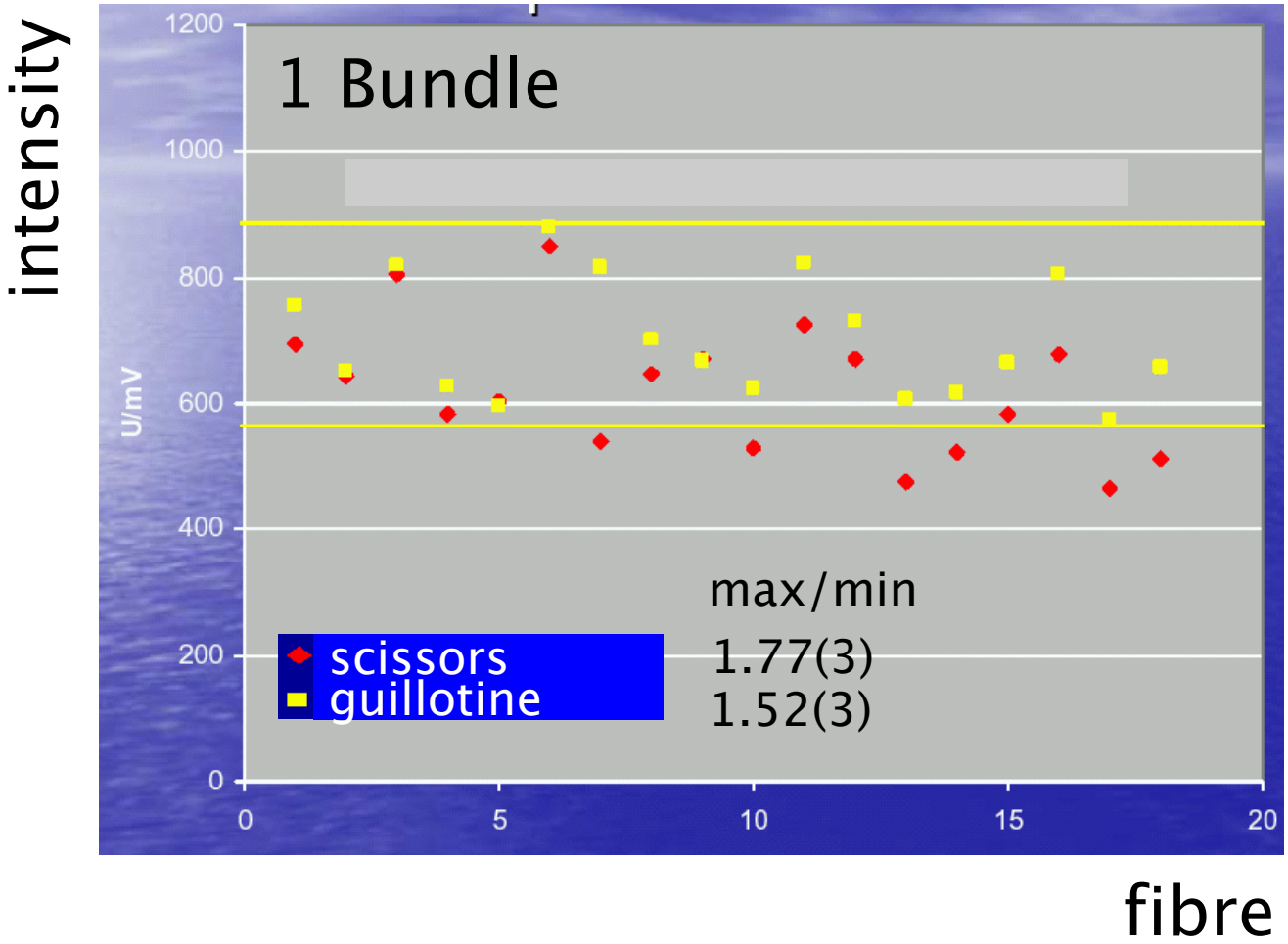


Study: Loose Fibre Ends

before: cutted with scissors
and manually polished

now: guillotine knife

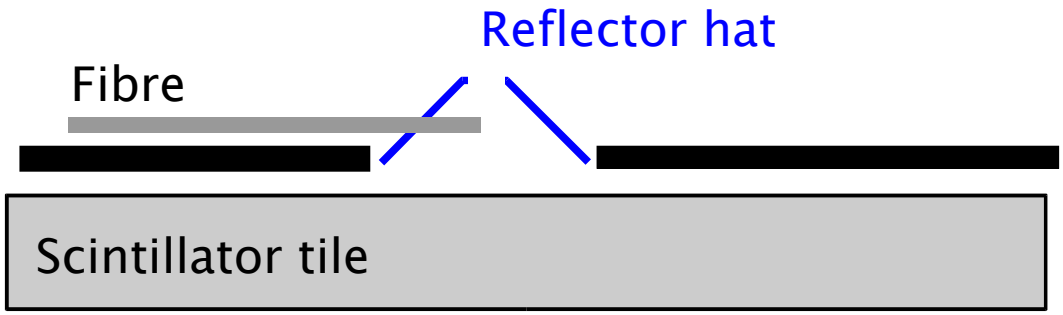




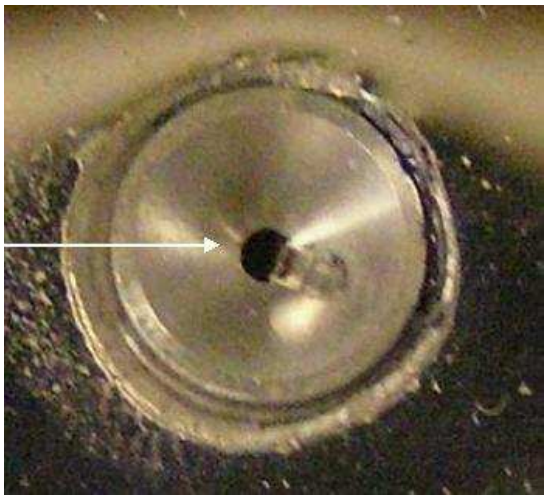
max/min improved

Study: Fibre/Tile Coupling

90 degrees reflection of fibre light to tile



reflector hat



view from below

mechanically robust coupling

material: AlCuMgPb

ageing tests under way