Optical fibre calibration system

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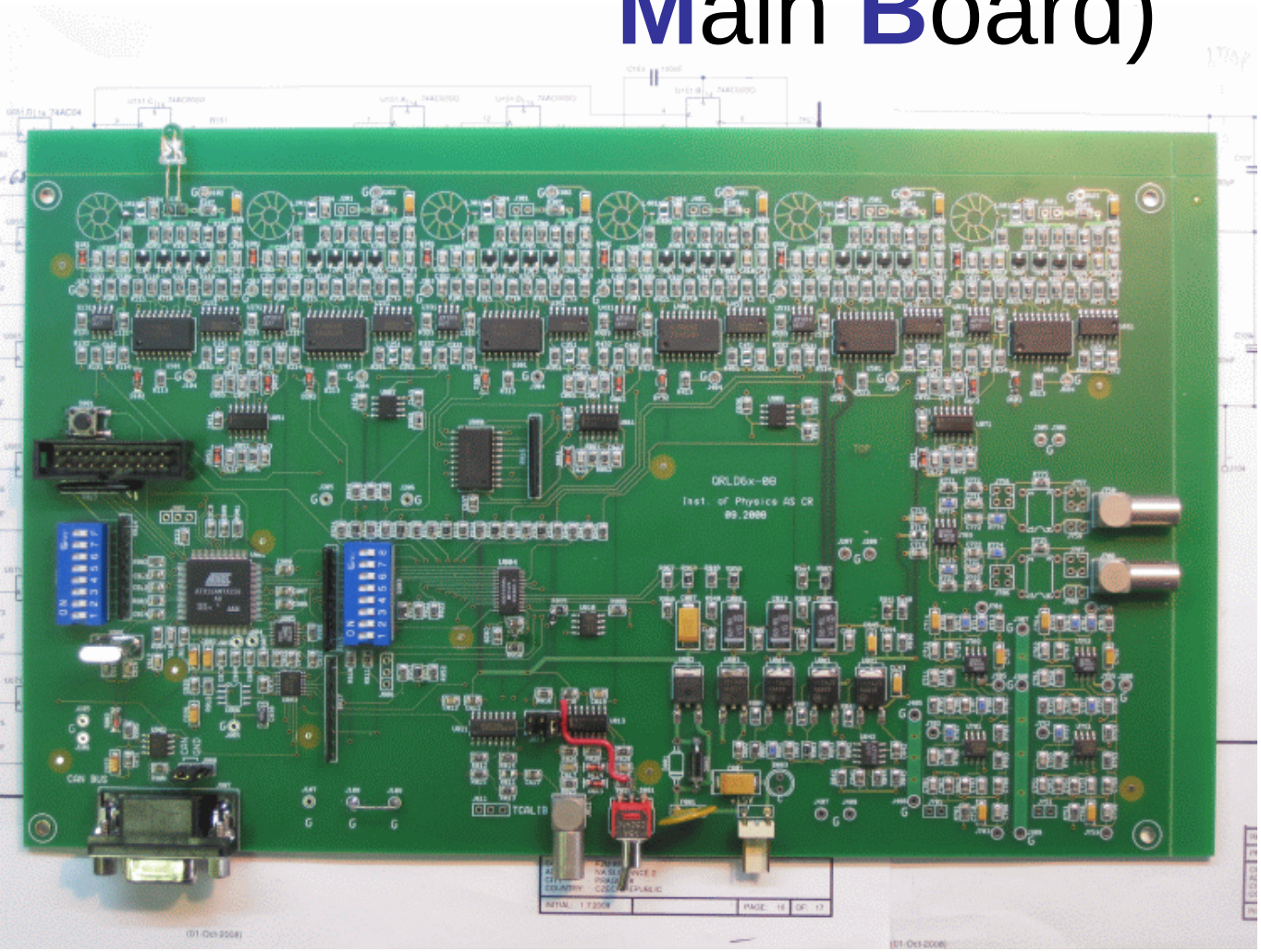
Outline

- Results from recent tests
  - LAB Test in December 2009
  - LAB Test in April 2010
  - Test at Testbeam DESY 2010
- Optical & electronics development

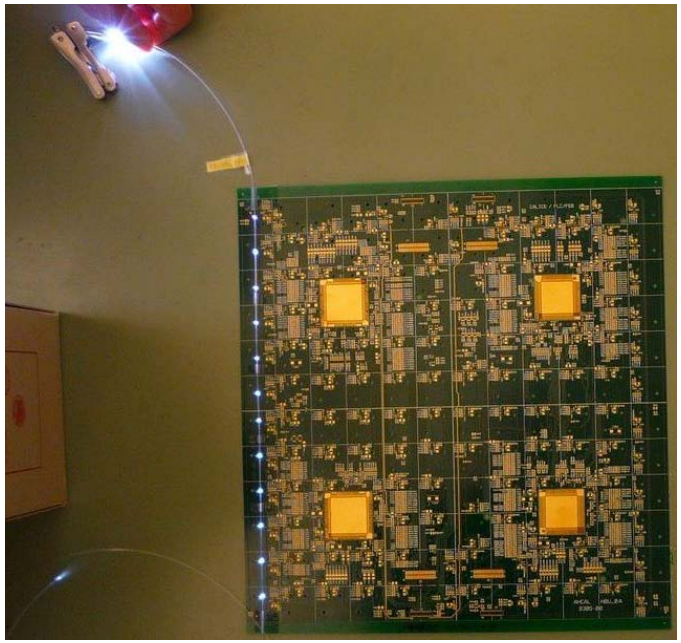
QMB6 (6-channel QR LED driver Main Board)

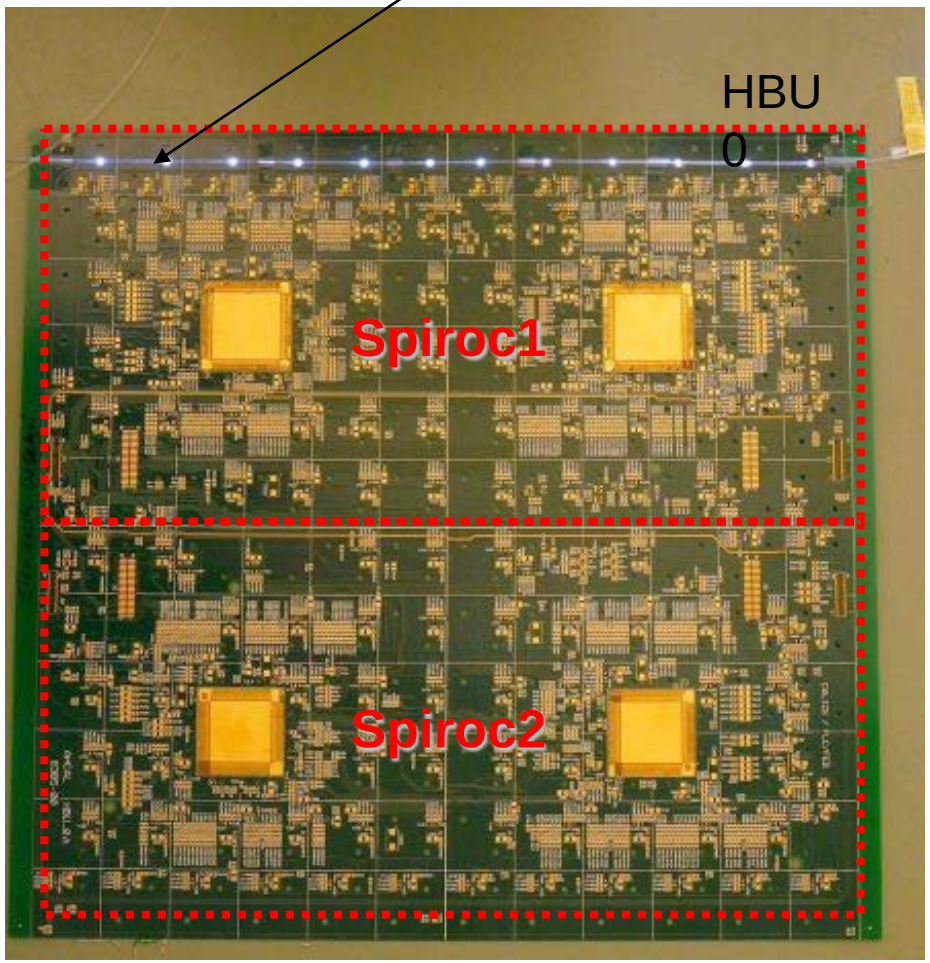


- 6 channels of QR LED driver
- Fixed pulse width, steerable amplitude
- 2 preamps for PinPhoto Diode
- Arm7 Microcontroller
- Canbus/dip-switch control
- Internal/TTL /LVDS trigger
- Temperature and voltage monitoring
- Single +15V power supply with onboard regulators

First test with fibre – plan

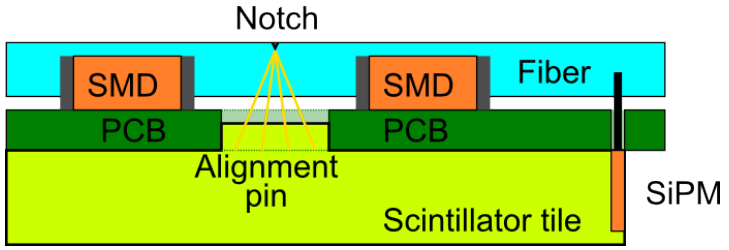
- Original plan was to use a special holes in the SPIROC1 HBU0 area
- 2 routes with holes exist in SPIROC1 area, each having a different distance among holes → Special fibre was manufactured for each route

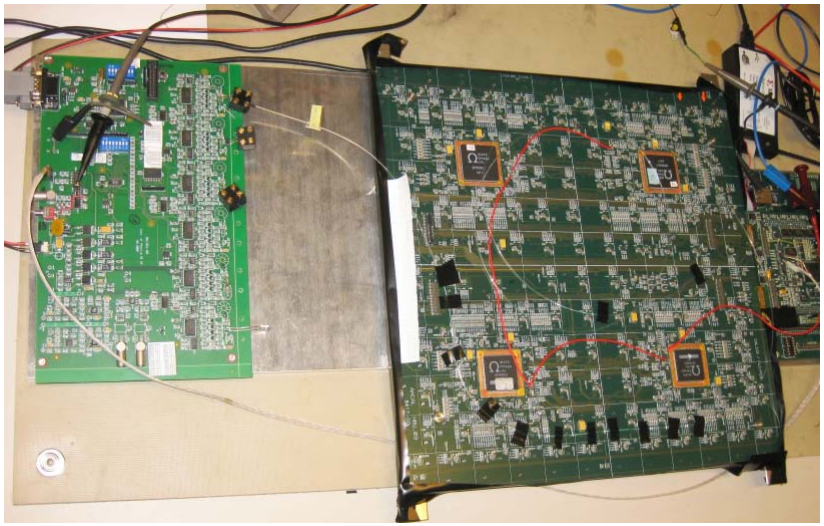




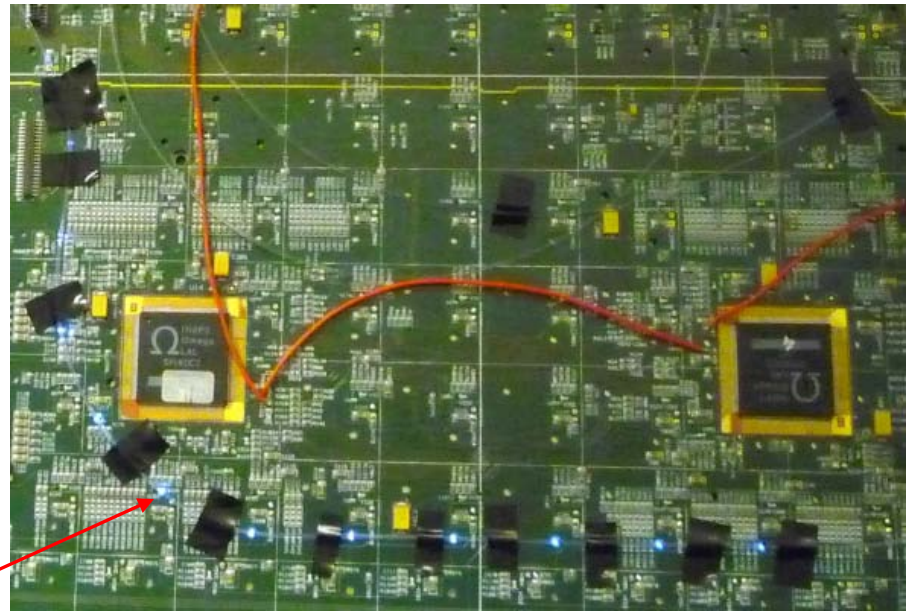
Test setup in Dec 2009

- We made an improvised setup
- Optimized criterion – maximize number of illuminated tiles through all holes (alignment pin, holes for integrated LED)
- Fibre fixed with strips of tape





HBU0

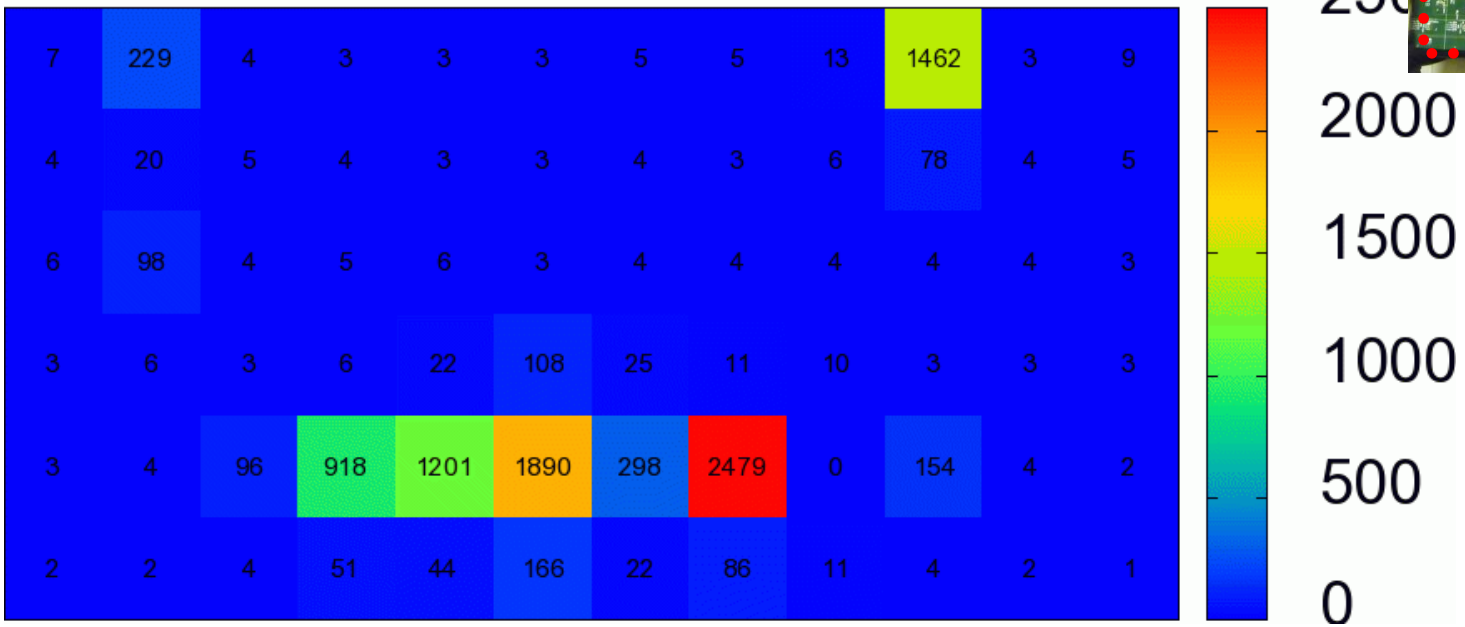


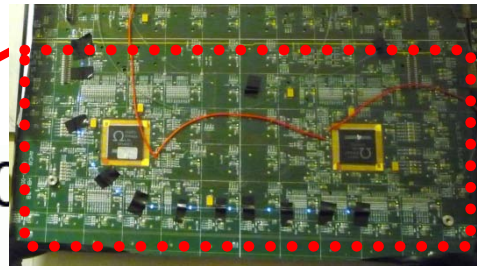
Illuminating notched fibre

First data – trace from the fibre

- Pure ADC data, no gain correction

Topological map of 12×6 scint. tiles. Each square represents mean of a fit to SPIROC2 ADC spectrum (low gain mode, Cf=400fF)

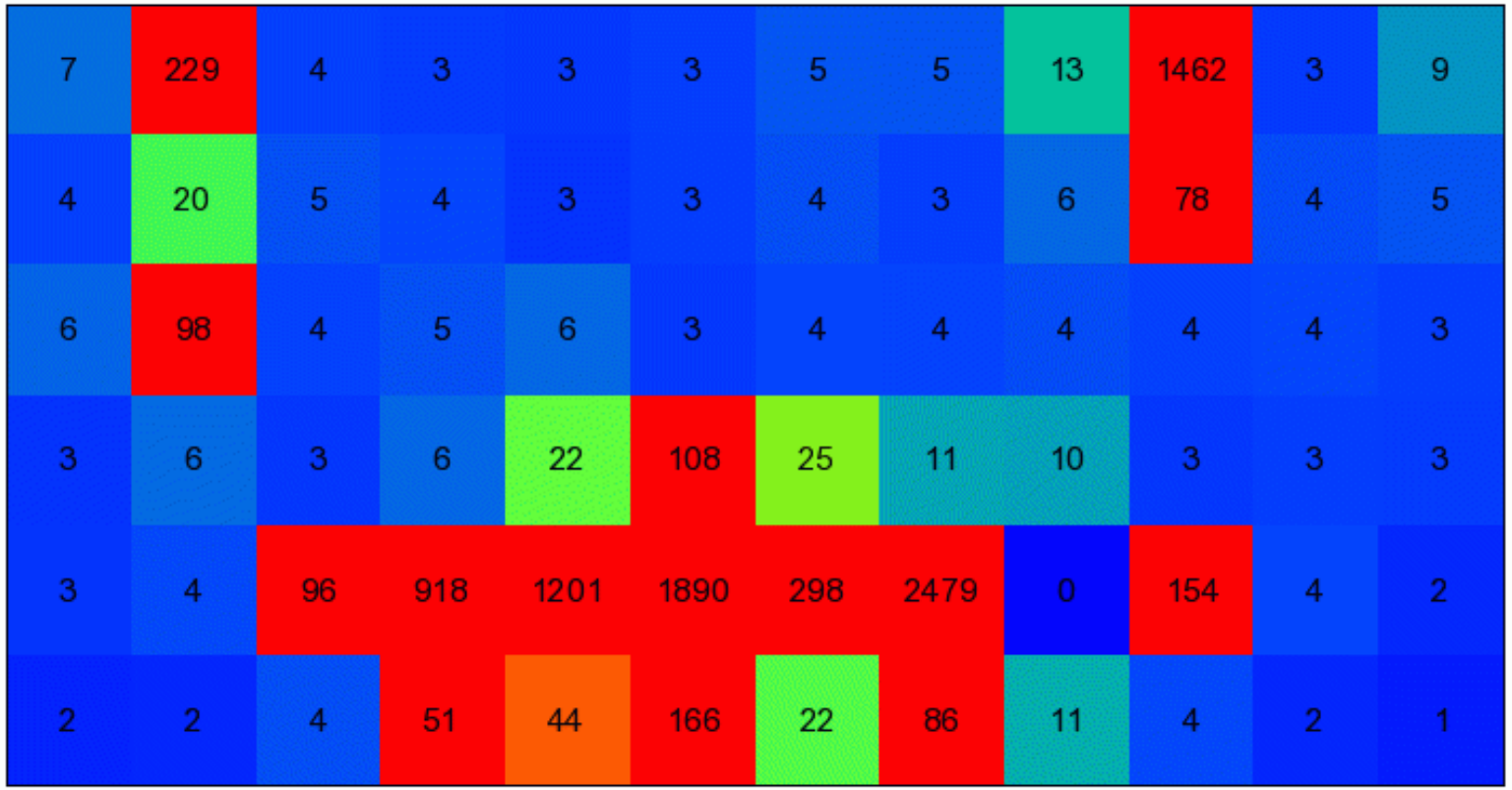


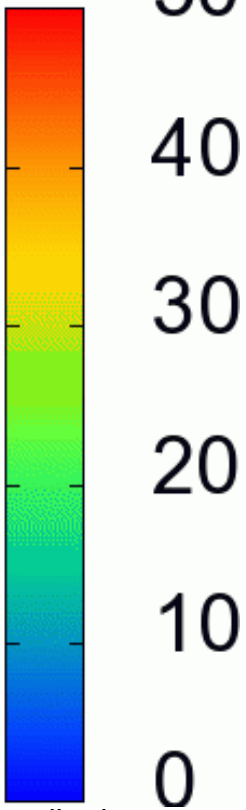


Optical Crosstalk? – Dec 2009

- Signal contribution from the neighboring tiles (noise)
- Possible reason: notches of the fiber were uncovered and shined under the cover

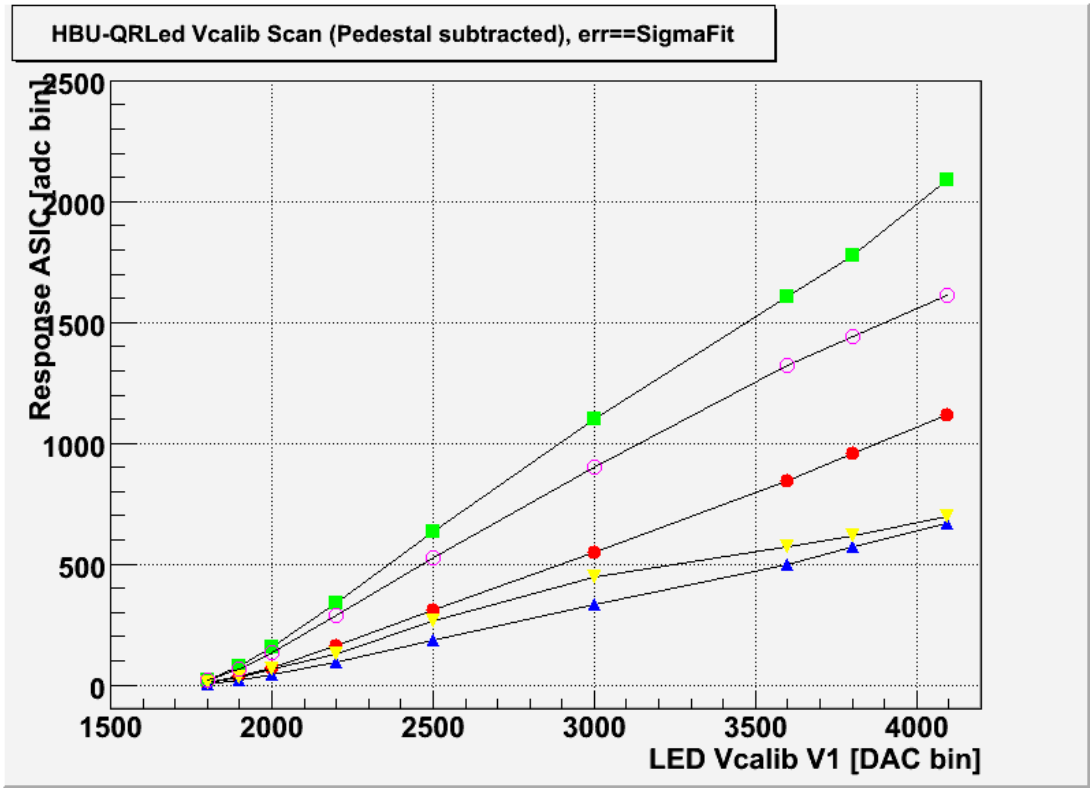
Fine scale of the topological map of 12×6 scint. tiles. Each square represents mean of a fit to SPIROC2 ADC spectrum (low gain mode, Cf=400fF)

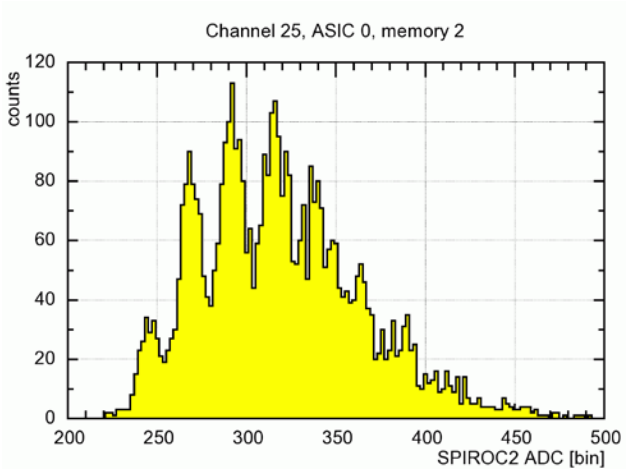




Dec 2009 summary

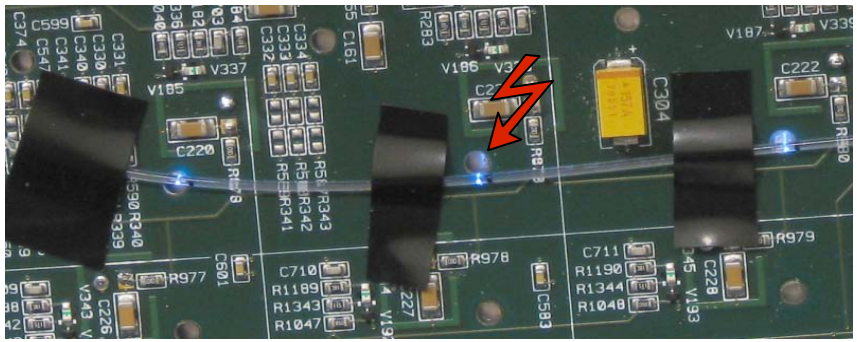
- We achieve to measure a nice single P.E. spectra, even with low statistics
- We identified the fibre track on HBU0
- We faced a big optical crosstalk
- No saturation visible in the scan over the V1 setting of QMB6
- Test of electrical crosstalk (QMB6 → HBU0) showed no such effect





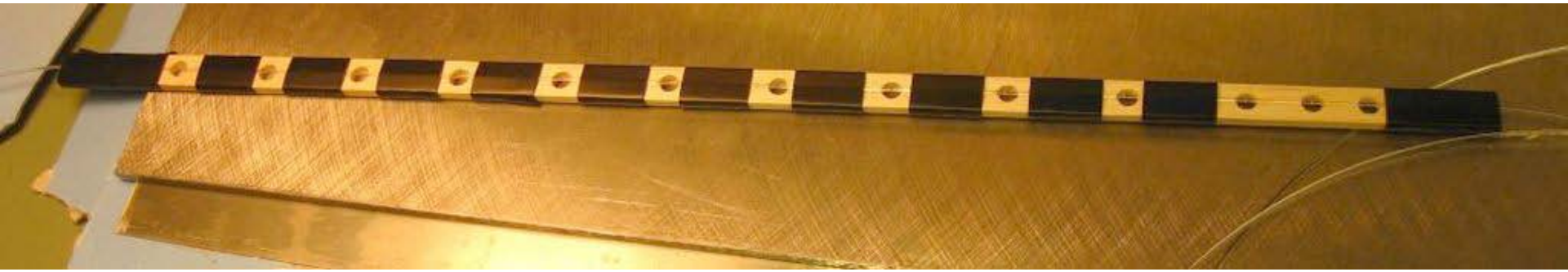
Tests with fibre holder – April 2010

- The fibre was held straight by a Balsa wood support
- Holes in the balsa used for correct placing on to of the HBU0
- Balsa wood – it was only for the test!
- We used a fibre with regular. It did not fit the tile alignment pin holes (on HBU0) properly.

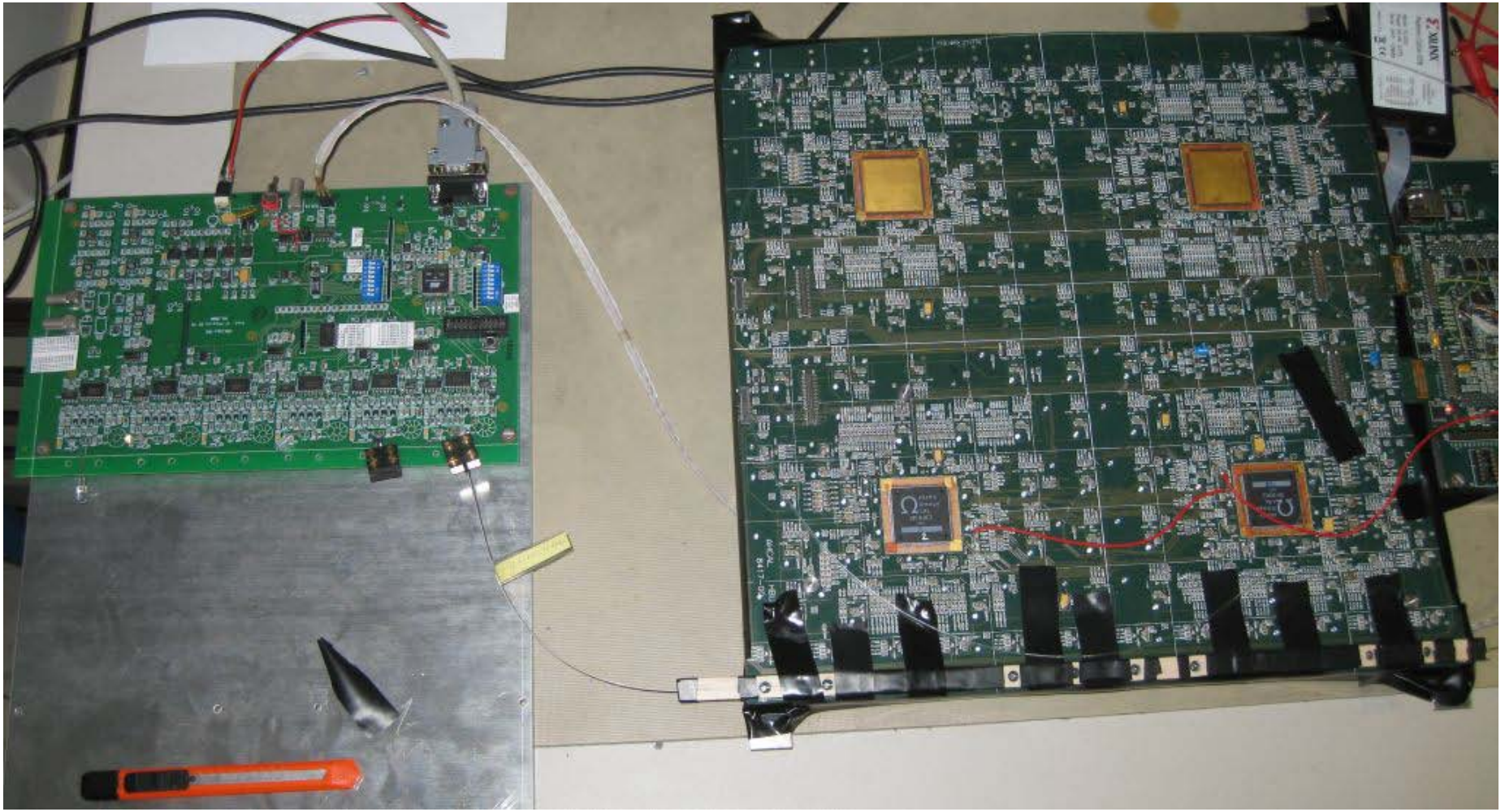


Dec 2009 – alignment problem

April 2010 – balsa support

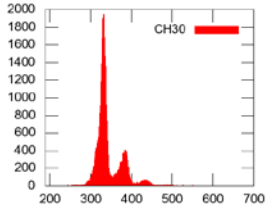


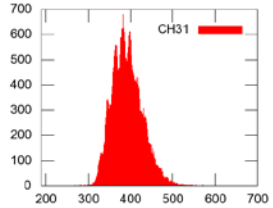
QMB6 + HBU0: optofibre-Balsa fixation

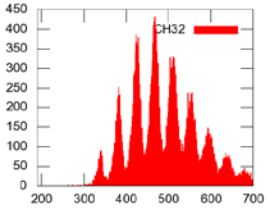


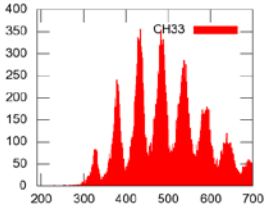
Single PE spectrum – April 2010

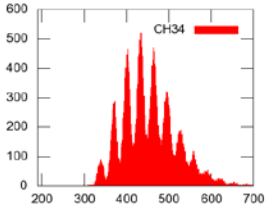
ASIC1

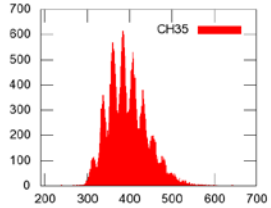




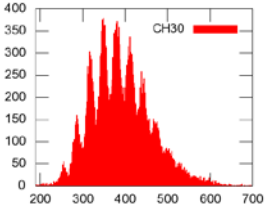


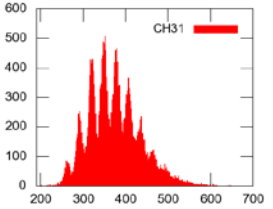


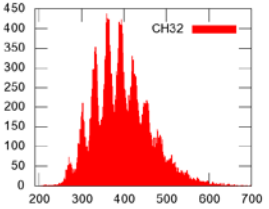


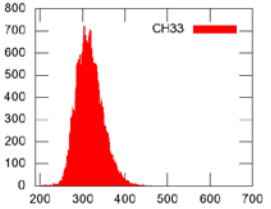


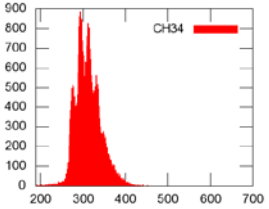
ASIC0

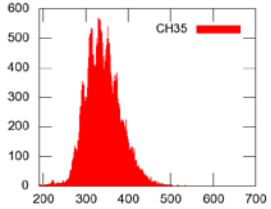




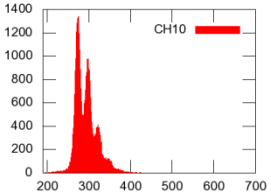


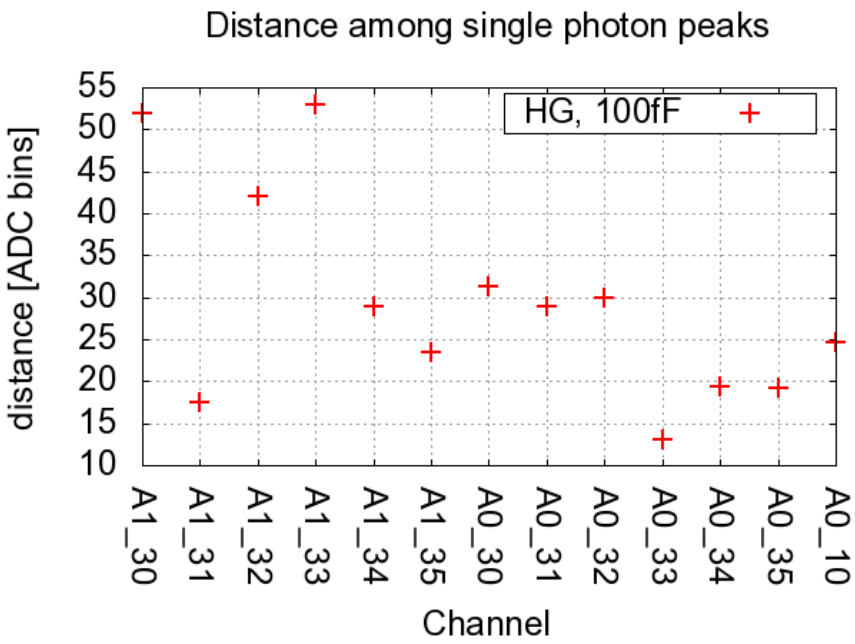






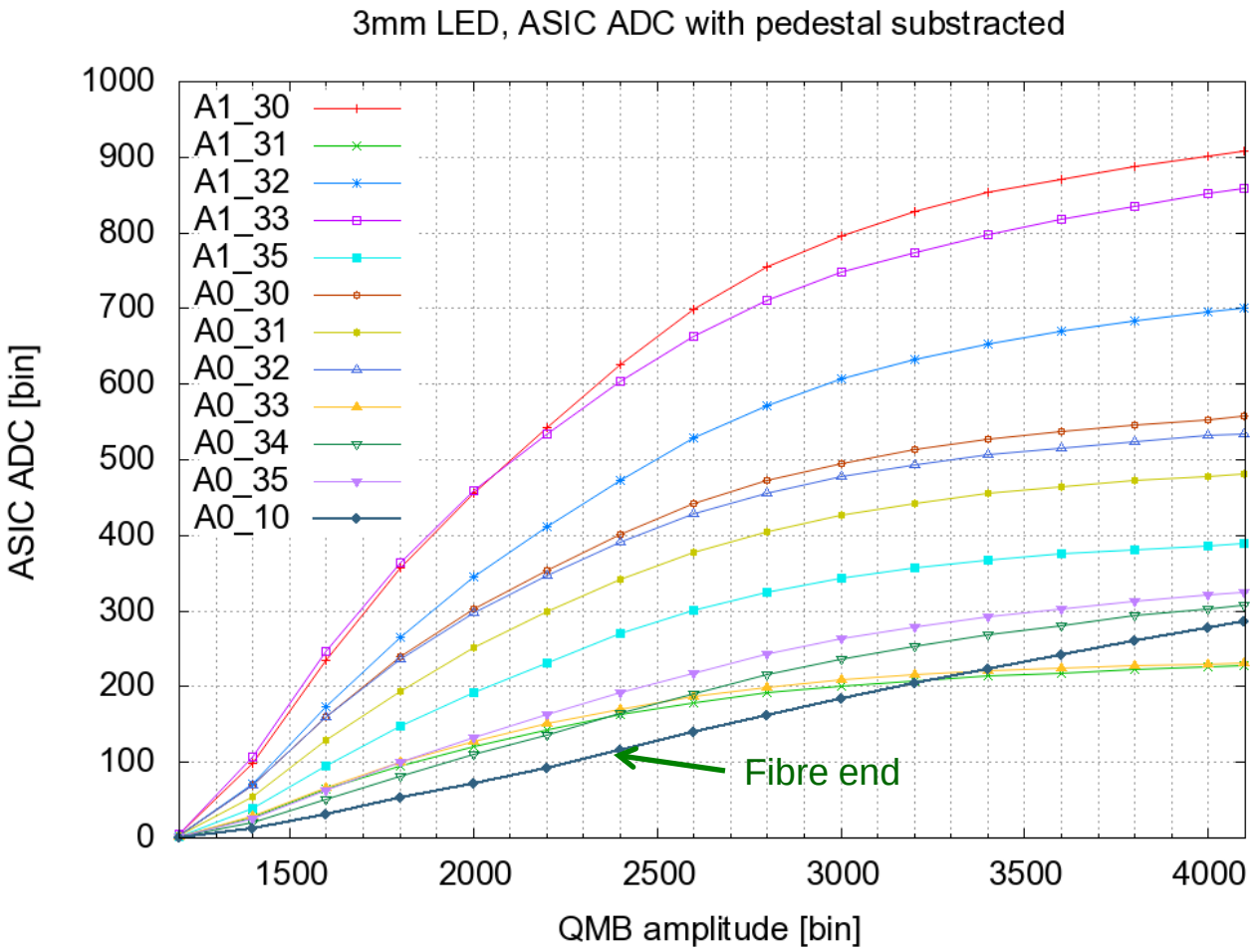
Fibre end





- HG mode, 100fF feedback capacitance
- Statistics of 50K events
- Distance measured by hand
- **Big spread** of single_photon_peak distance [ADC count / pixel] among the channels
- SiPM voltage settings wrong?

Amplitude scan – April 2010



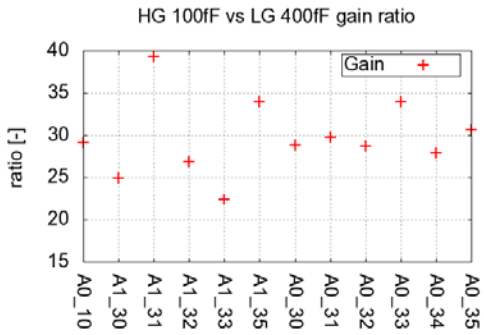
- RAW ADC data !
- Scan at LG, 400fF
- ASIC should not be saturated (range up to 4095 bins)
- Results have to be calibrated:
  1. Single PE peak distance
  2. HG/LG ratio
  3. LED optical power

HG vs LG radio measurements – April 2010

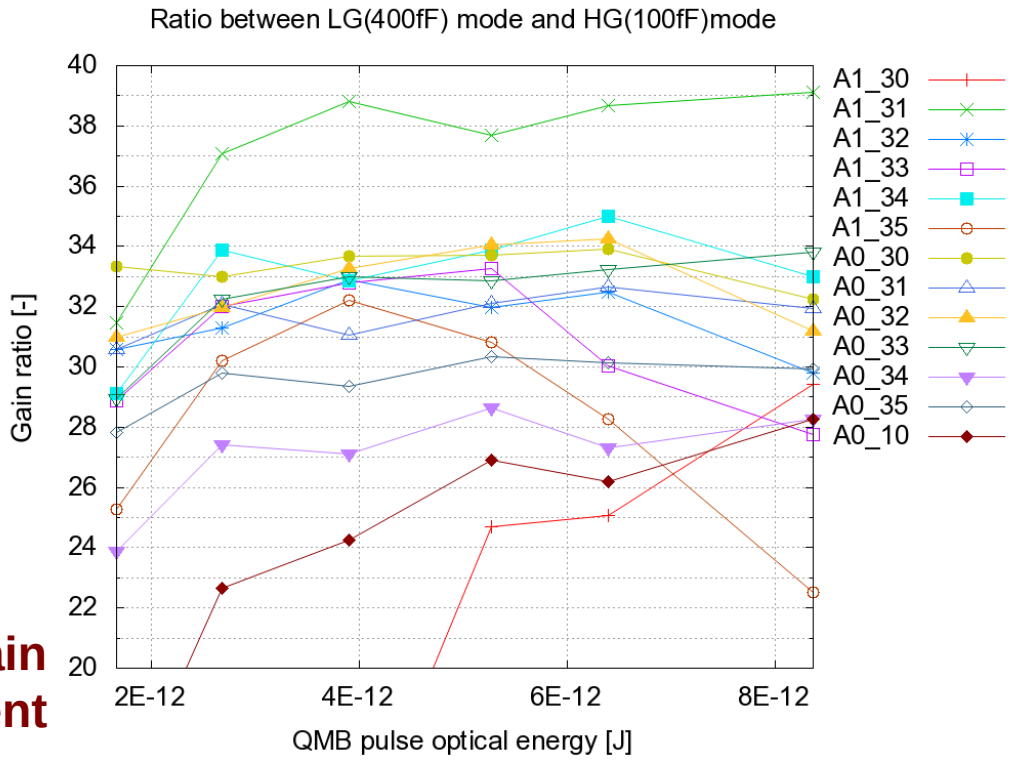
- 1st measurements were measured only in one fixed amplitude. Analysis showed, that **some channels were saturated** in HG mode.
- Therefore: we scanned the ratio in **several** (optical) amplitudes
- Data were taken at amplitudes, where
  - Signal is not saturated in HG mode
  - Signal is still reasonably high in LG mode
- Pedestal shifts during measurement! Discovered later, described here at following slides

Old data 29/4/2010

Big syst. error

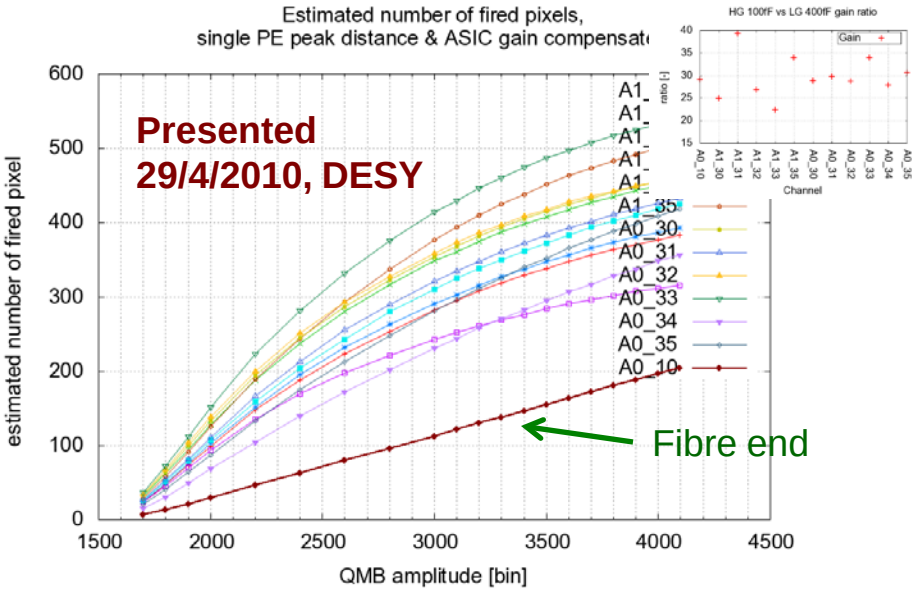


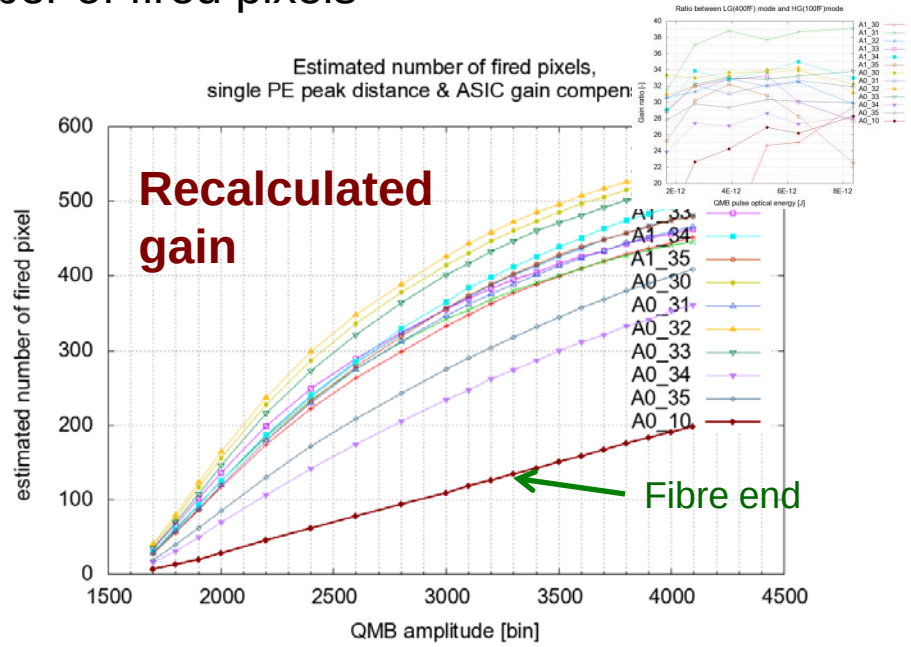
New gain measurement



Amplitude scan calibrated to pixels

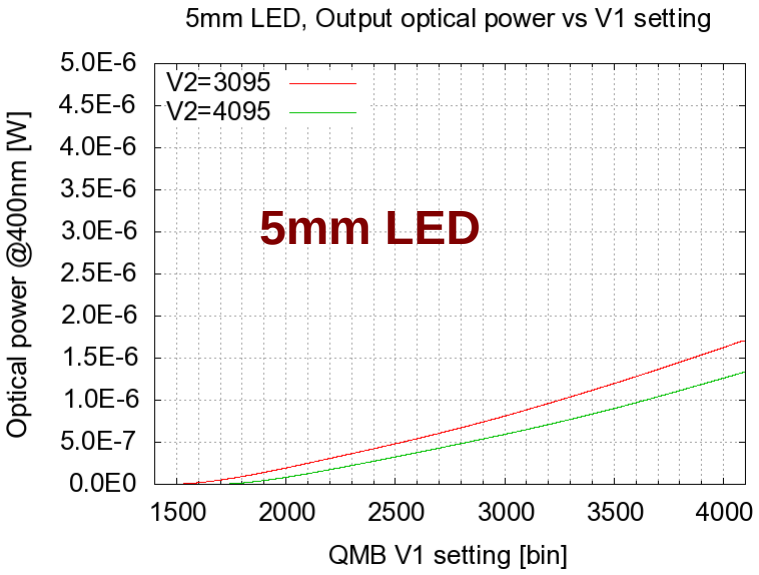
- From the distance between single photon peaks and from the **HG vs. LG ratio**, we are able to estimate the number of fired pixels

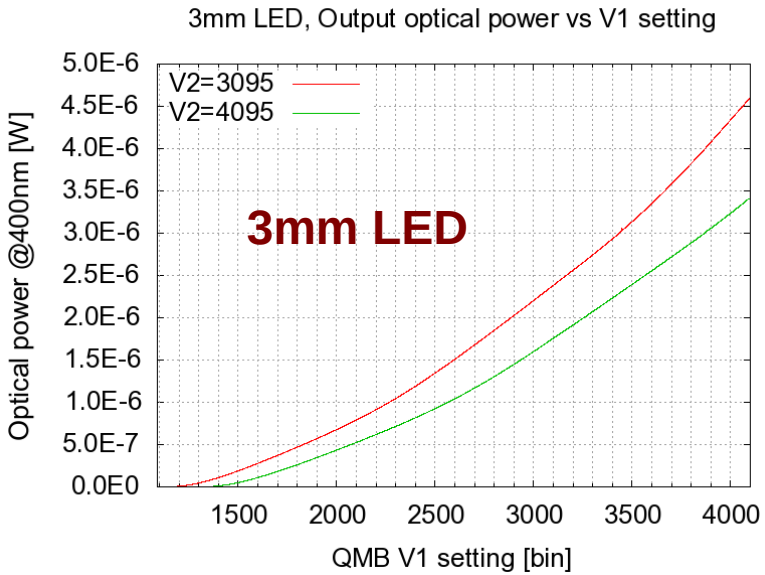




- New recalculation:
  - delivered optical power from the fibre is much more consistent
  - Curves are less crossing each other
- Next step (next slide): convert V1 value to optical power (energy)

Optical performance at Prague lab





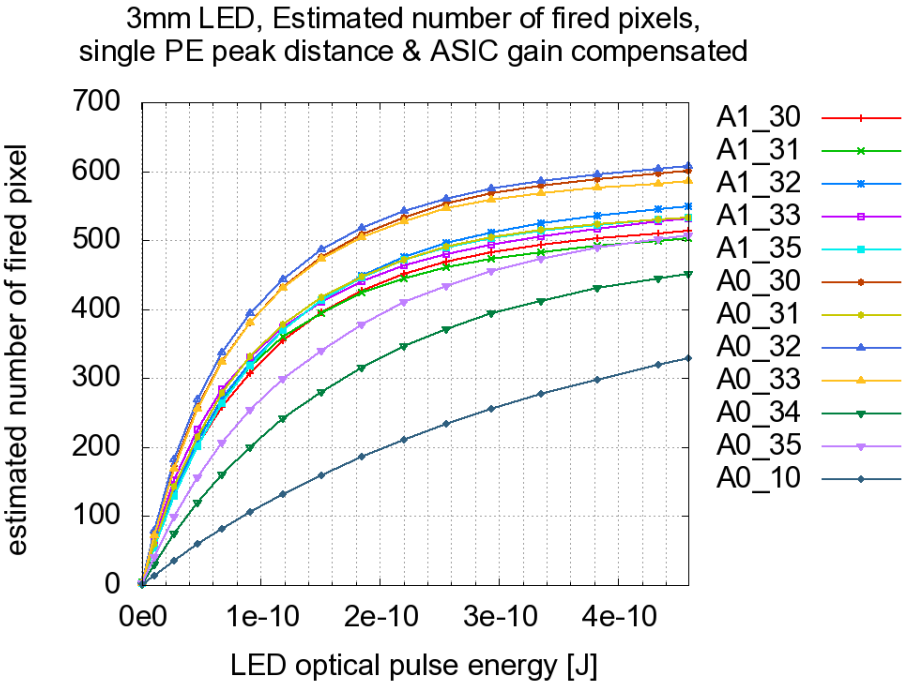
- Equipment at Prague: Flashing with 10kHz, measurement device: Thorlabs PM100D & S130VC
- Slope is not linear, especially at very low amplitudes due to electrical properties of the QR driver concept
- Reason of non-linearity: energy is stored in the inductor and the peak voltage has to rise above the V2 and the voltage drop of the UV LED

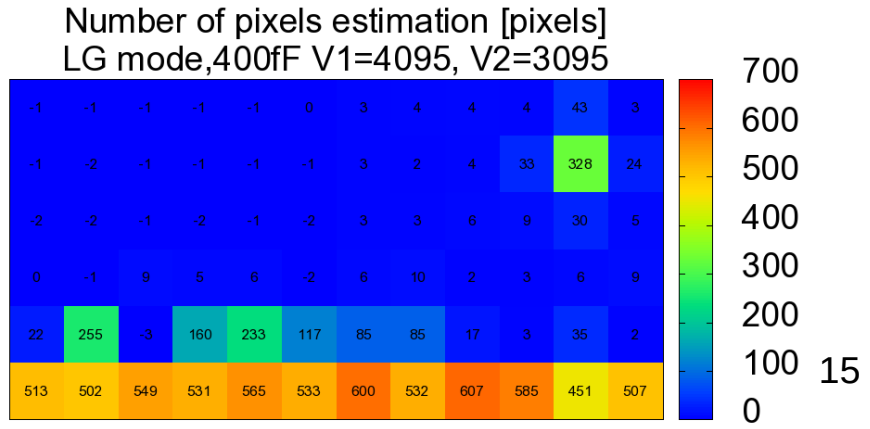
Amplitude scan corrected (2) – April 2010

- Linear extrapolation of the initial slope indicate the dynamic range of ~200 MIPs with 12-notched fibre

Final comments:

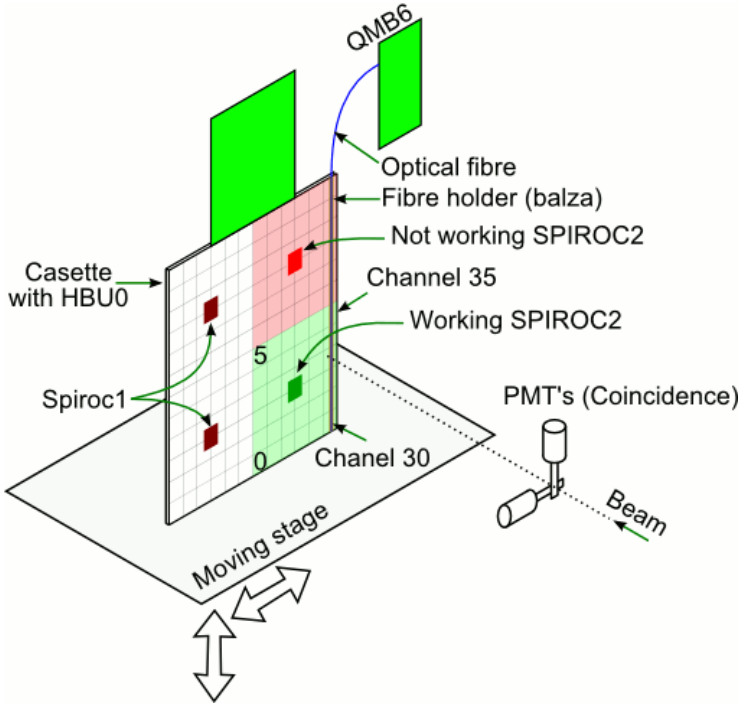
- The estimated number of fired pixels is larger than the real number of SiPM pixels
- Different shapes of saturation curve might indicate improper HG vs LG ratio
- Saturation curves does not match simple f(x)=1-exp(-x) function (unsuccessful fit)





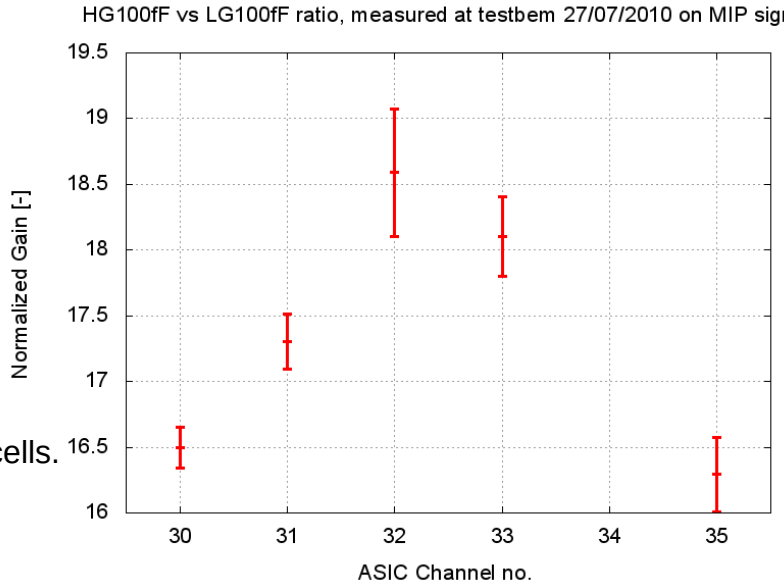
Eudet TB setup – Jul 2010,DESY

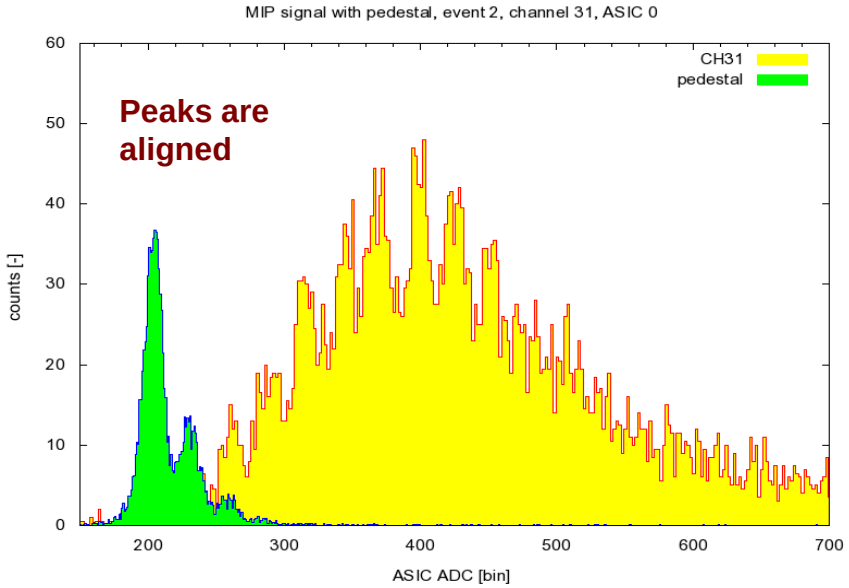
- ASIC0 (green) fully working
- Problems with ASIC1 (red) programming
- Beam trigger: coincidence of PMTs
- Channels 30..35 were illuminated by the notched fibre
- Control: Labview DIF + QMB6 labview control
- Modes of operation:
  - Trigger from beam trigger
  - Internal DIF trigger
  - Autotrigger not working at that time
- Measured data:
  - MIP signal in High gain and Low gain (channels 30..35)
  - Gain between MIP in HG and LG using MIP signal (channels 30..35)
  - Scan over various V1 setting of the QMB6
  - Scan of the hold value
  - Scan over the period if the internal trigger

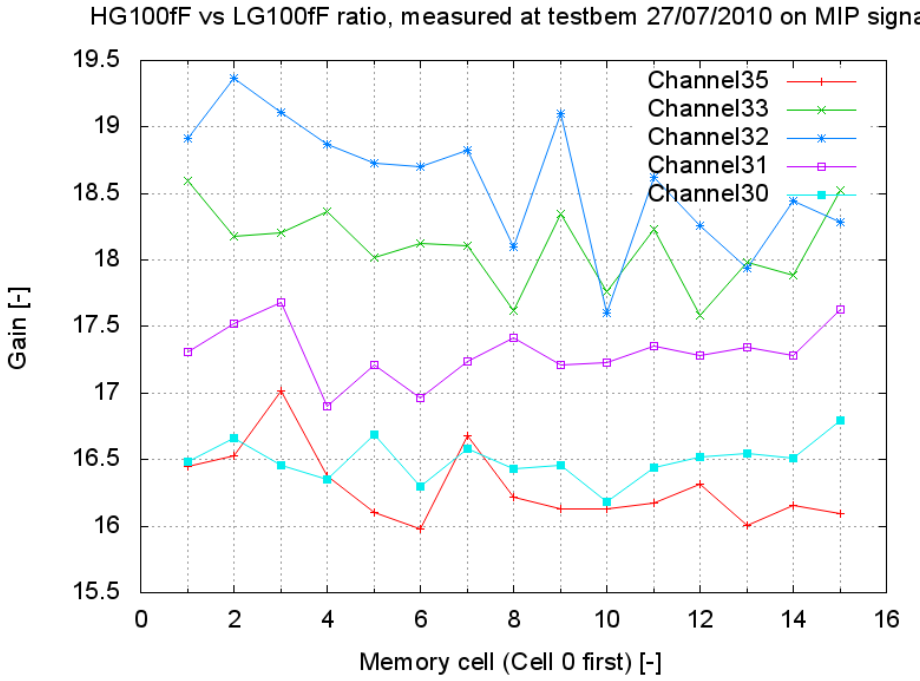


Gain calibration – MIP signal

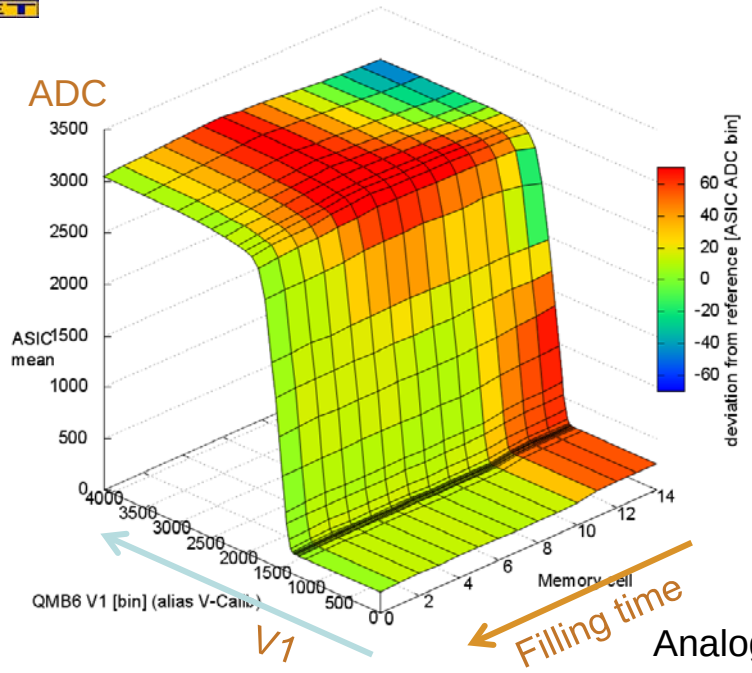
- Clear single P.E. spectrum observed only at channel 31.
- Other channels too noisy (?)
- “pedestal” from beaming of the tile 30
- Gain between HG and LG stable within 3-5% among all memory cells.
- Ratio HG/LG – important for calibration
  - MIP signal in High Gain and Low Gain
  - spread over ASIC channels
  - spread over memory cells (analysis error?)
  - ratio channel dependent and > 10(?)
  - Important parameter for energy scale setting

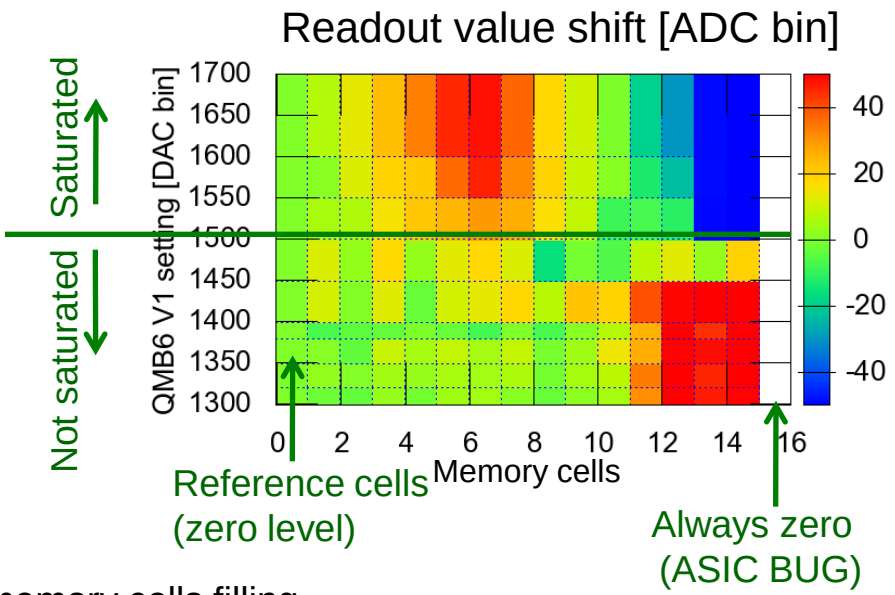






DESY test at TB – preliminary result

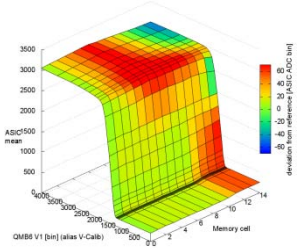




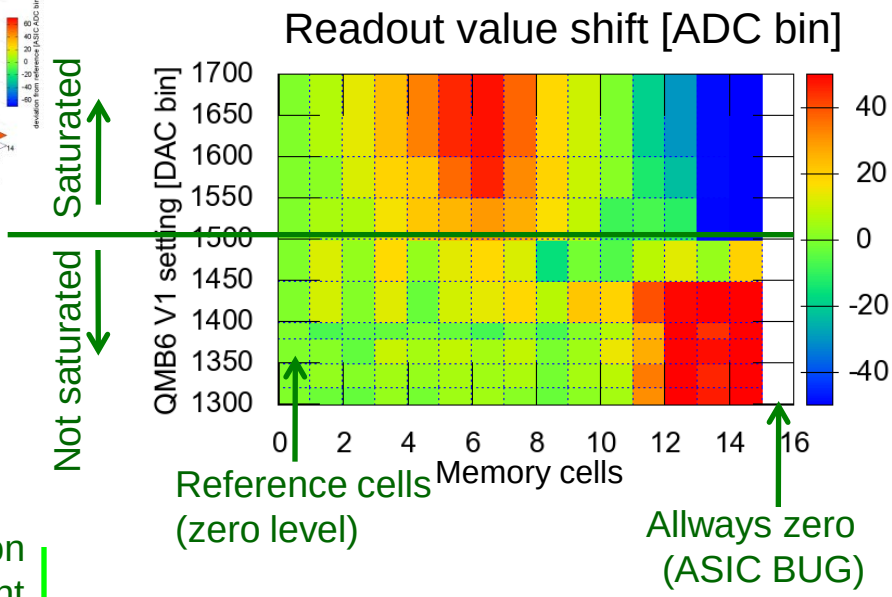
Analogue memory cells filling
1 ASIC channel – **high gain**:

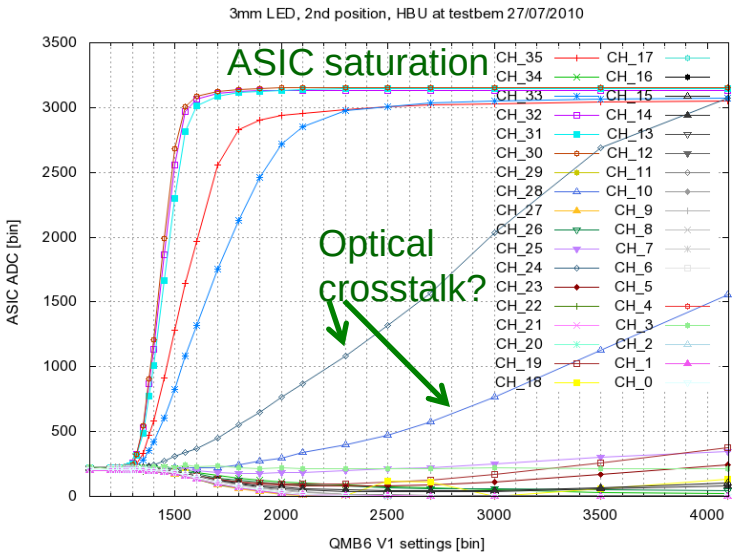
- scan over various V1 setting of the QMB6, (0 – 4000)
- ASIC ADC values averaged over a run
- reference value (green) - last filled memory cell
- decrease of pedestal during filling!

Pedestal shift



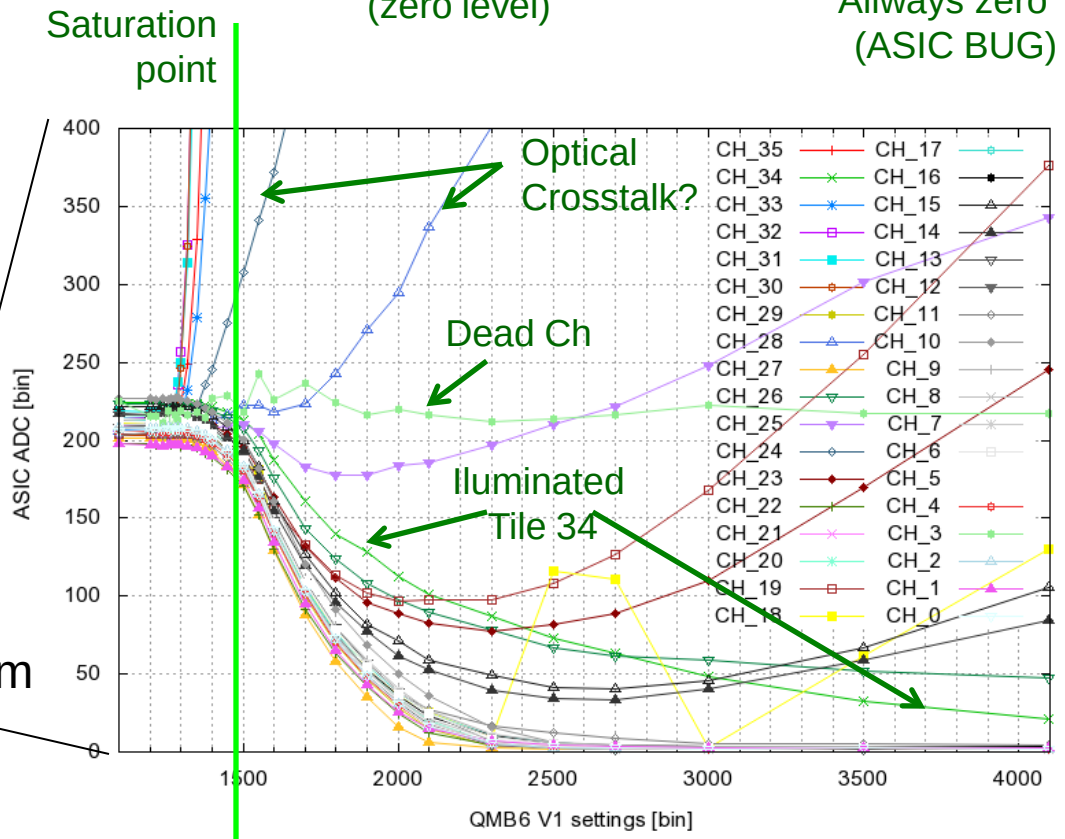
- Inconsistence among the analog memory cells – hard to predict the shift
- 1 dead channel discovered in ASIC1 (Ch. 3)
- 1 bad tile/channel (Ch. 34) – no response even at the beam
- Large pedestal shift in High gain
- Data analysis still in progress





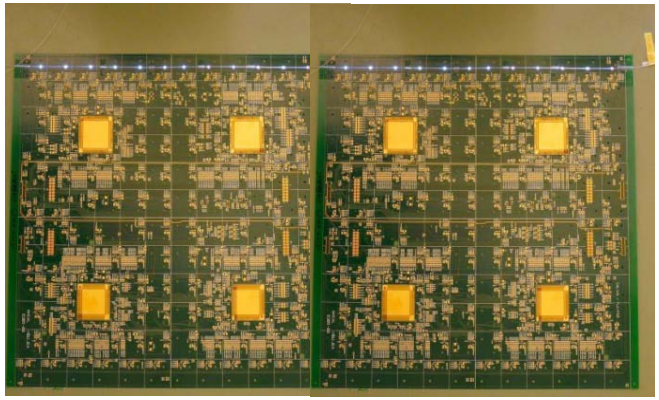
zoom

vas



1 row of cell iluminated:

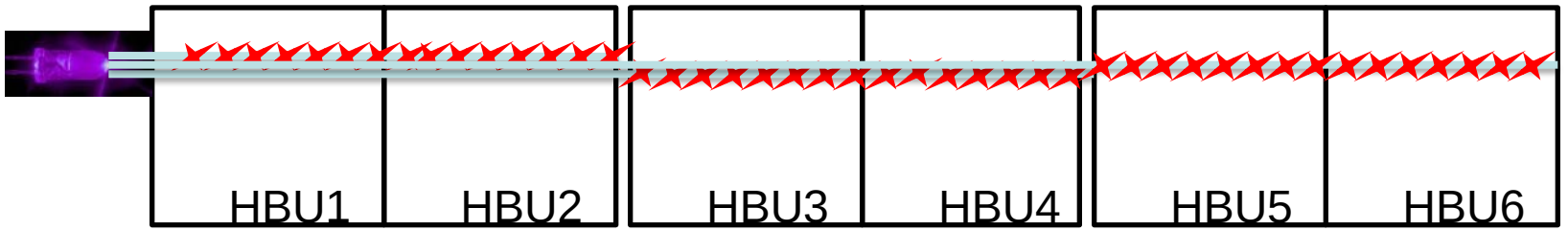
Optical developments



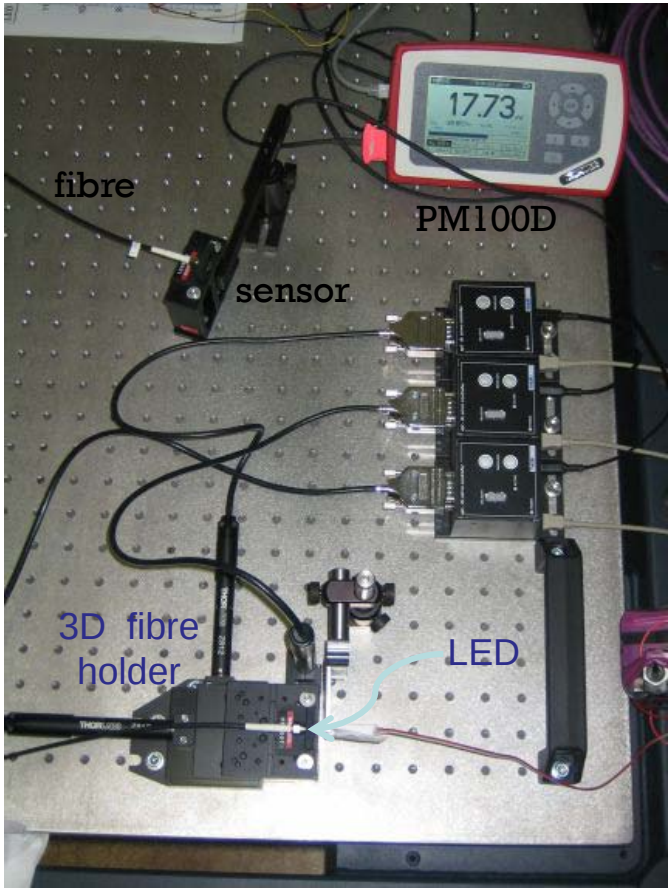
2 HBUs = 1 fibre with 24 notches

- Full length plane = 72 tiles in row
- Production of 1 fibre with 72 notches is tedious and expensive
- Agreement reached: 3 parallel fibres, each one with 24 notches (1 fibre for 2 HBUs)
- For final calorimeter we plan to use full length fibre with 72 notches – automation needed
- Order placed to SAFIBRA comp.: by the end of 2010 we shall get and test the first set of 3 fibres, beginning of 2011 – 3 more sets will be delivered

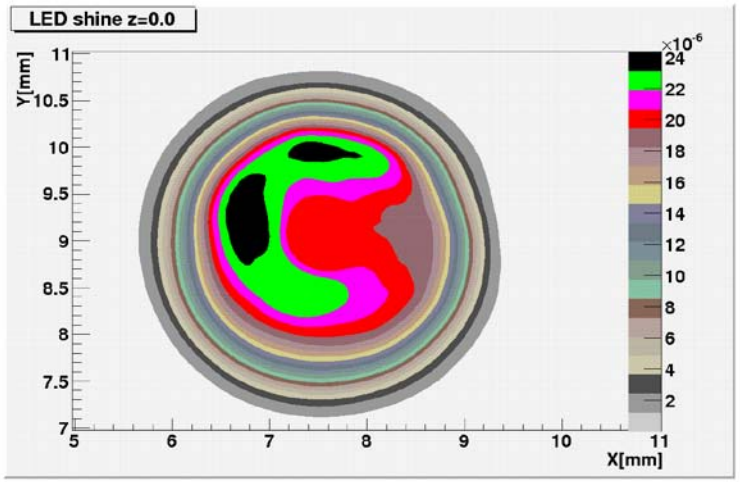
3 fibres receive light from 1 LED



Optical developments 2



Light intensity – surface 3 mm LED



- 1 LED for more fibres – distribution of light intensity on the LED surface?
- We scanned a 3 mm LED S130VC by the THORLAB set up + PM100D
- Light intensity shows asymmetry (chip position) – inhomogeneity ±10%
- ±15% observed for 5 mm LEDs used in 1m^3 HCAL calibration system
- Not a problem - inhomegeneity from notched fibres on ±20% level

Electronics development

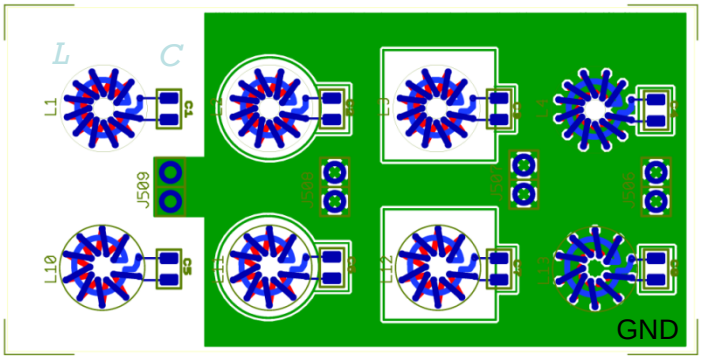
Higher inductance improves linearity behaviour of the of the QRLED driver
How to increase L?

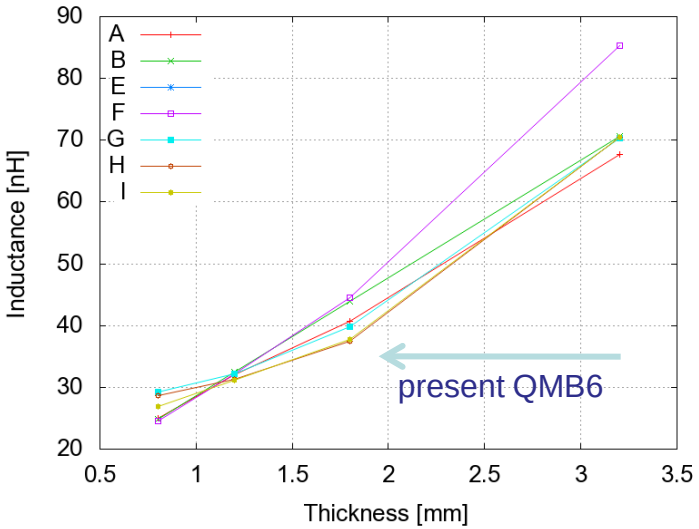
- toroid size: 11 and 9 coil turns, and diameter
- thickness of PCB: 0.8, 1.2, 1.8, 3.2 mm
- GND-plane geometry

Inductance *L* measured via resonance frequency with parallel capacitance *C* (200 pF)

- accuracy needs improvement
- dominant effect of PCB thickness
- impact of the coil diameter? - still to be tested

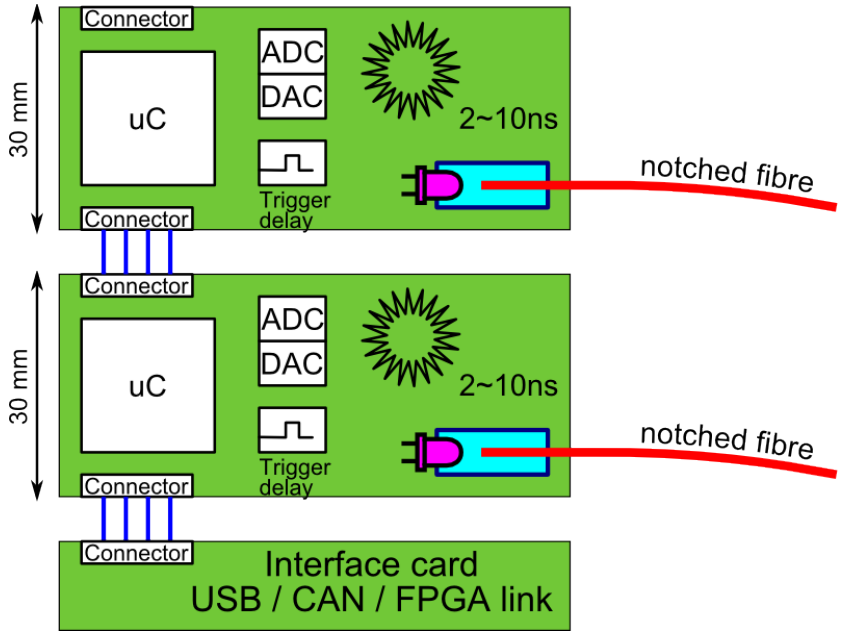
Next version of the LED driver – modular based on single channel modules





Outlook

- Focus: increase of the optical performance:
  - increase of the pulse width from the current 3.5 ns
  - Improvement of the optical coupling from LED into the fibre
  - Improvement of the transmission to the scintillation tile
- New QR LED driver prototype envisaged
  - only 1 electronic channel per board
  - different onboard inductors for different pulse width in range of 4 ~ 10 ns
  - 3cm PCB width to match the tile size
- Notched fibre production (Q4/10-Q1/11)
  - 4 sets by 3 notched fibres each with 24 notches



Thanks to my Prague colleagues J. Cvach, M. Janata, I. Polák, J. Smolík and M. Reinecke, M. Terwort and J. Zálešák for DESY tests support!

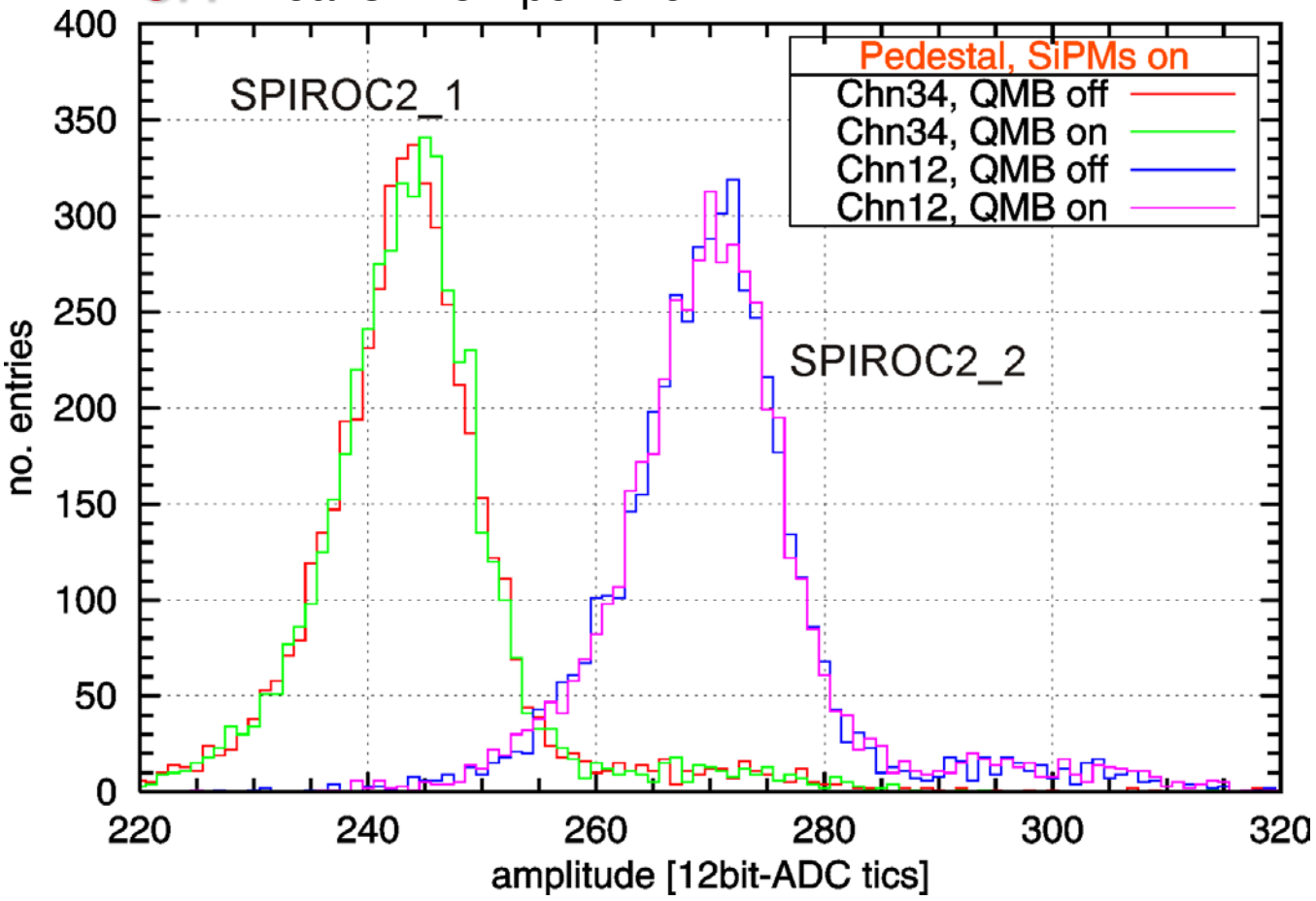
Thank you for your attention

- Questions?

QMB6 **ON**/**OFF** test – Dec 2009

ON means T-calib on, LED off

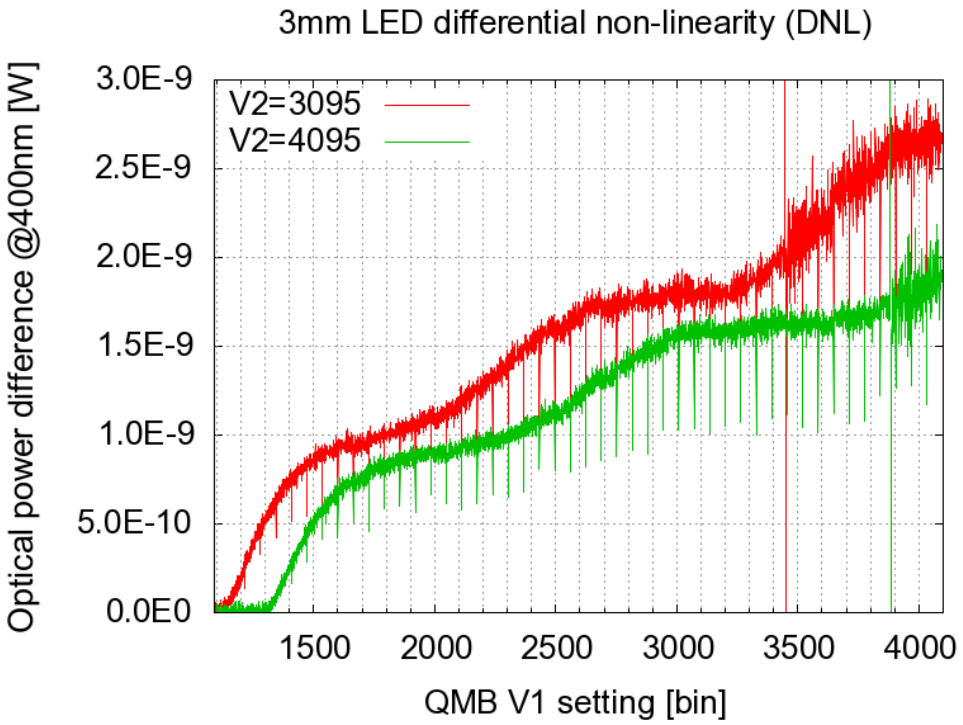
OFF means +15V power off



NO pedestal shift

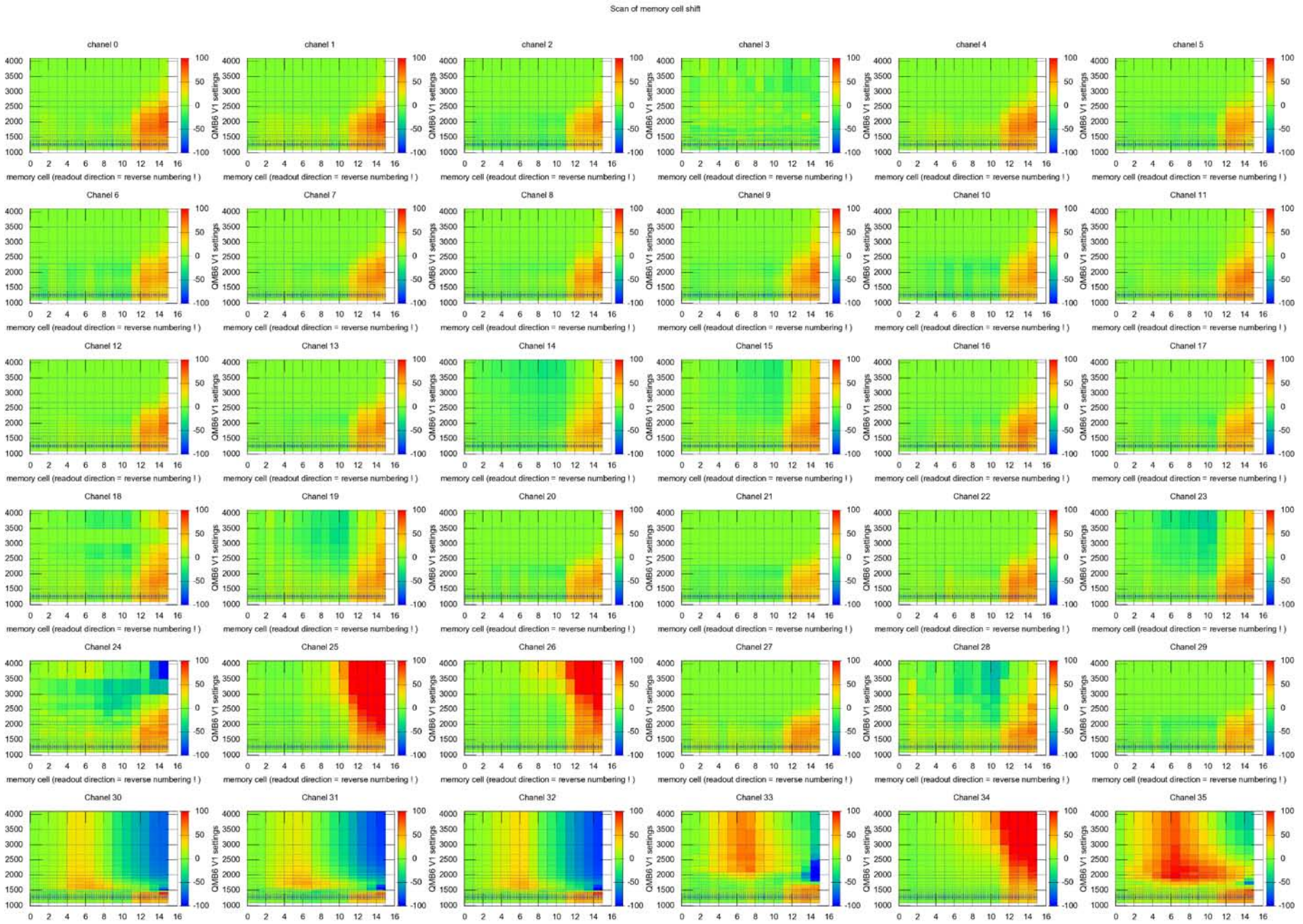
NO unwanted ground coupling

Backup: Multi-peaks of non-tuned LEDs



Derivation of
the amplitude scan

- “steps” in DNL graph correspond to secondary peaks. These peaks are unwanted, because they make optical pulse longer.
- Reason: incorrectly damped resonance of QRLED driver


Scan of memory cell shift
chanel 0
chanel 1
chanel 2
chanel 3
chanel 4
chanel 5
Chanel 6
Chanel 7
Chanel 8
Chanel 9
Chanel 10
Chanel 11
Chanel 12
Chanel 13
Chanel 14
Chanel 15
Chanel 16
Chanel 17
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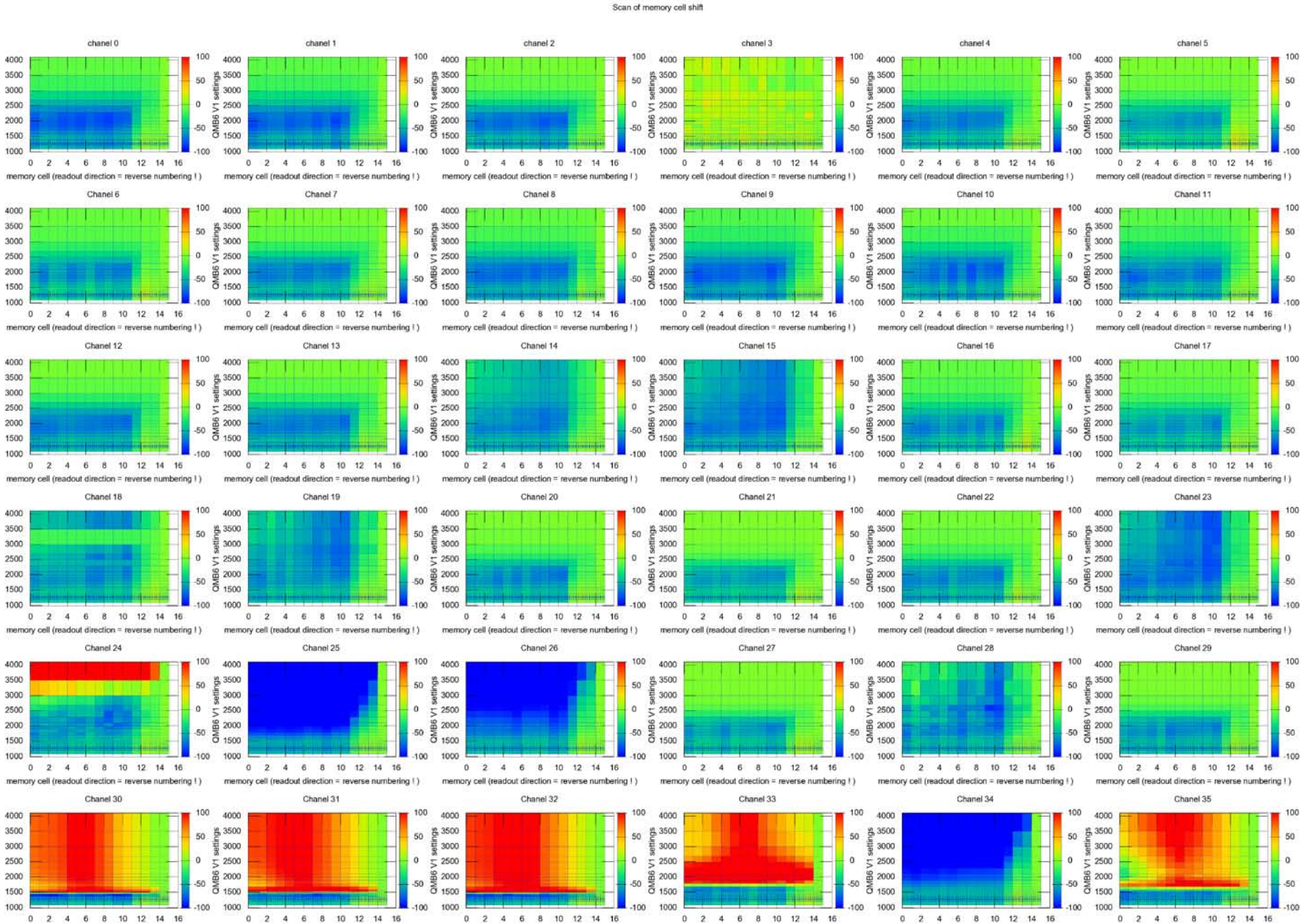
Chanel 26
Chanel 27
Chanel 28
Chanel 29
Chanel 30
Chanel 31
Chanel 32
Chanel 33
Chanel 34
Chanel 35
QMB6 V1 settings
memory cell (readout direction = reverse numbering !)


Scan of memory cell shift
chanel 0
chanel 1
chanel 2
chanel 3
chanel 4
chanel 5
Chanel 6
Chanel 7
Chanel 8
Chanel 9
Chanel 10
Chanel 11
Chanel 12
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Chanel 33
Chanel 34
Chanel 35
QMB6 V1 settings
memory cell (readout direction = reverse numbering !)