

LED calibration and optical fiber distribution system

LCWS 2012, Arlington, 23/10/2012

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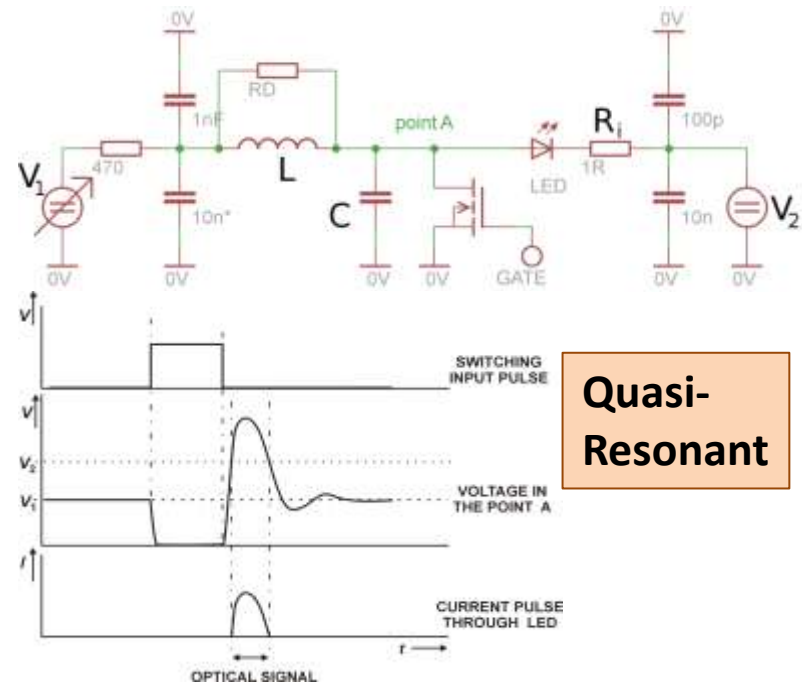
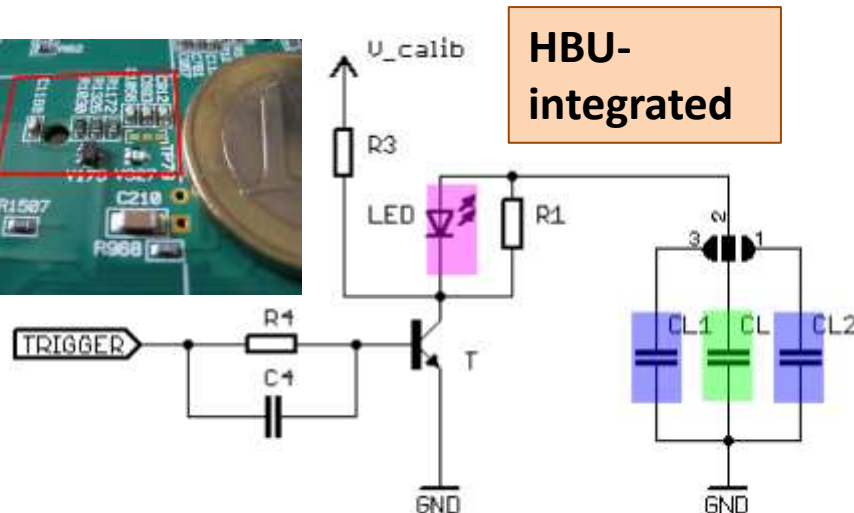
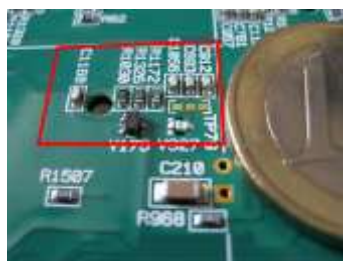
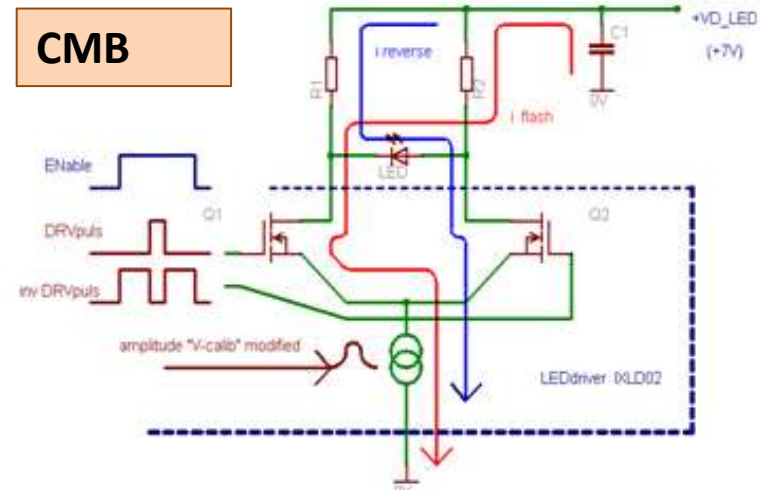
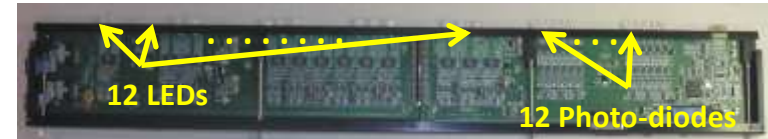
Institute of Physics, Prague

- ☐ QMB1 LED driver and notched fiber system
- ☐ Single photon spectra & gain performance @ HBU
- ☐ Amplitude scan and saturation



AHCAL calibration LED driver overview

- **CMB** – special driver (IXIS IXLD02), “rectangular” pulse with reverse bias
 - Trapezoidal current pulse profile,
 - Pulse length and amplitude is configurable
 - Works well since 2005 in AHCAL 1m² physical prototype
- **Integrated** on the HBU – discharge capacitor(s) through transistor
 - Low component usage allows each tile to have its LED
 - More sensitive to component selection, bigger spread in light yield – hard to control by a single common voltage
- **Quasi-Resonant**
 - 1A Current pulse shape is close to half-sine
 - Light is distributed by notched fiber (see next slides)



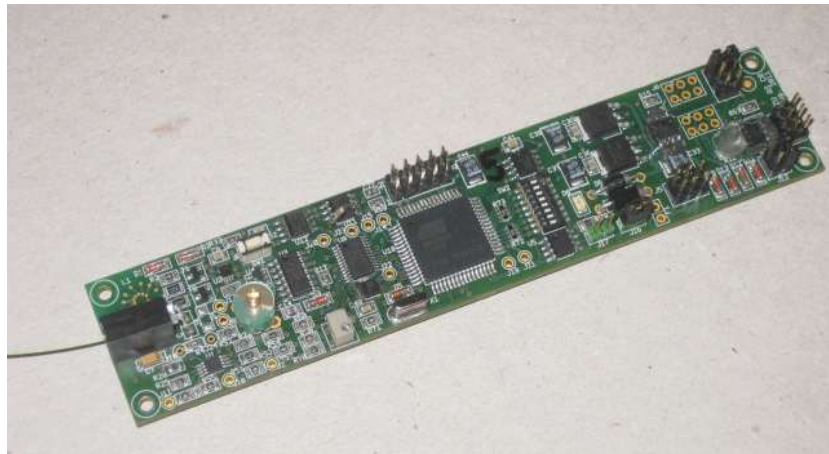
QMB1

More info on QMB can be found:

http://www-hep2.fzu.cz/calice/files/20110915-Polak_I.CALICE_Heidelberg.pdf

Quasi resonant Main Board

- Modular system, 1 LED per board
- Operation mode:
 - DAQ + CAN bus control
 - stand-alone mode
- LVDS Trigger distribution system
- Variable amplitude, zero to maximum (~ 1 Amp) smooth
- Electrical pulse width fixed to ~ 2.4 ns (UV or blue LED)
- Repetition rate up to 100 kHz
- Voltages and temperature monitoring
- Size of PCB: width 30mm, depth 140mm



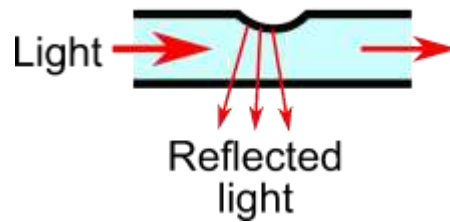
Single power 15V, 65mA

Illuminated by
Green laser

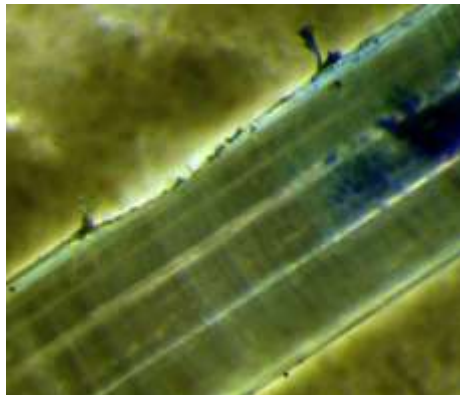
24 notches

Distribution of light: Notched fiber

- Plastic optical fiber 1 mm in diameter
- Light is emitted from the **notches**
- The **notch** is a special scratch to the fiber, which reflects the light to the opposite direction
- The size of the notch varies from the beginning to the end of the fiber to maintain homogeneity of the light emitted by the notches
- Performance will be shown in this talk



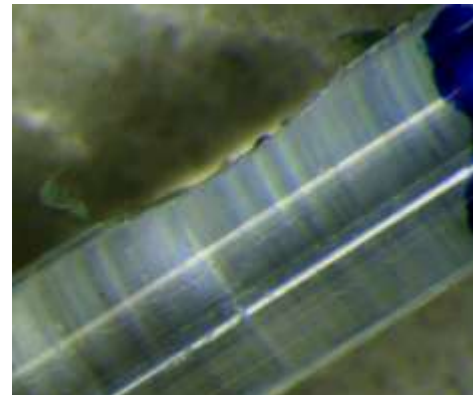
First notch



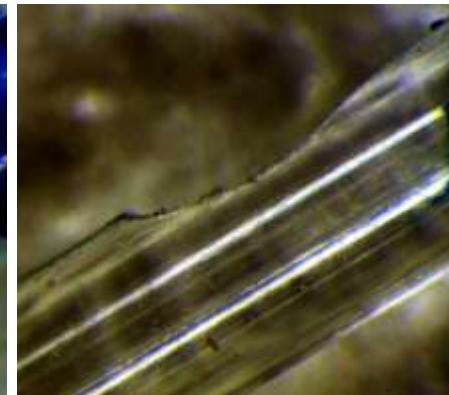
Emission from the fiber (side view)



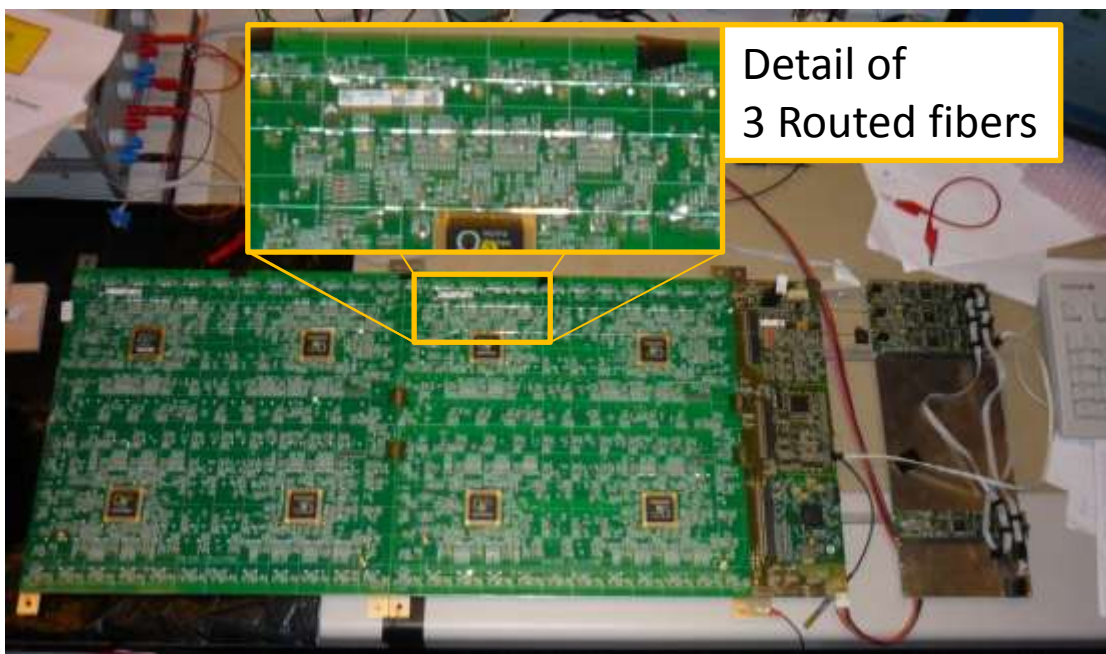
Middle notch



End position notch

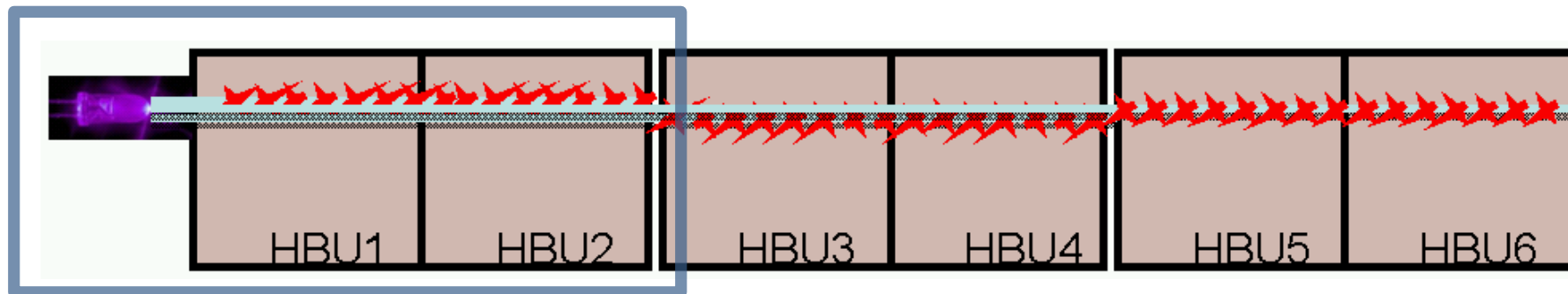


2nd Test @ DESY (May 2012)



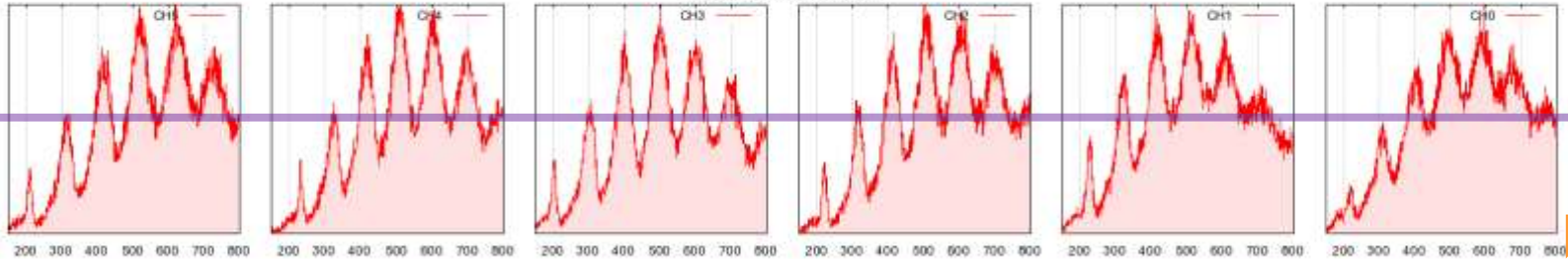
Detail of
3 Routed fibers

- Two HBU2 in one row, each had
 - 2 active SPIRoc2b ASICs (other 2 were not read out),
 - Assembled with 3 top rows of scintillators & SiPMs
- 3 notched test-fibers, 24 notches each.
- 3 QMB1 LED driver
- Different tiles & SiPMs on each HBU2 ('Old' and 'New' HBU) (see next slide)
- Low & High Gain running, goal was to measure the optical fiber
- Main results on next slides:
 - Single photon electron spectra
 - peak distance (gain)
 - Linearity & Amplitude scan
 - fiber results – light distribution
- Thanks to Mathias Reinecke for effort to set up the 2nd HBU2
- Approx. 1/3 of final setup:
 - 3 notched fiber per 1 LED
 - Each fiber for 24 tiles
- **Full test with 6 HBU in Dec 2012**



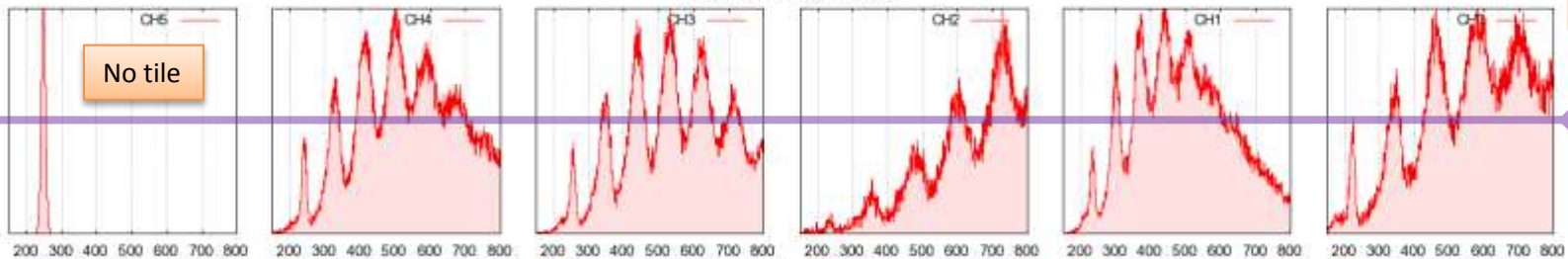
High Gain pixel spectra (1 fiber)

ADC histograms ASIC 0, event 0



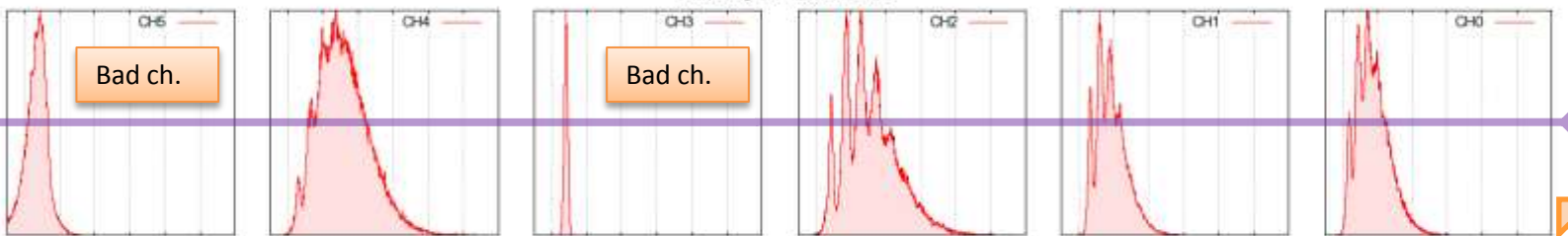
New tiles

ADC histograms ASIC 1, event 0



No tile

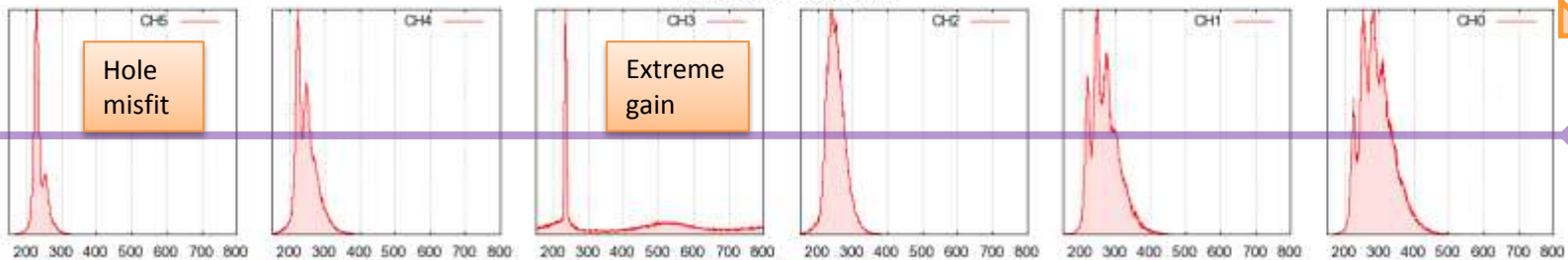
ADC histograms ASIC 2, event 0



Bad ch.

Bad ch.

ADC histograms ASIC 3, event 0



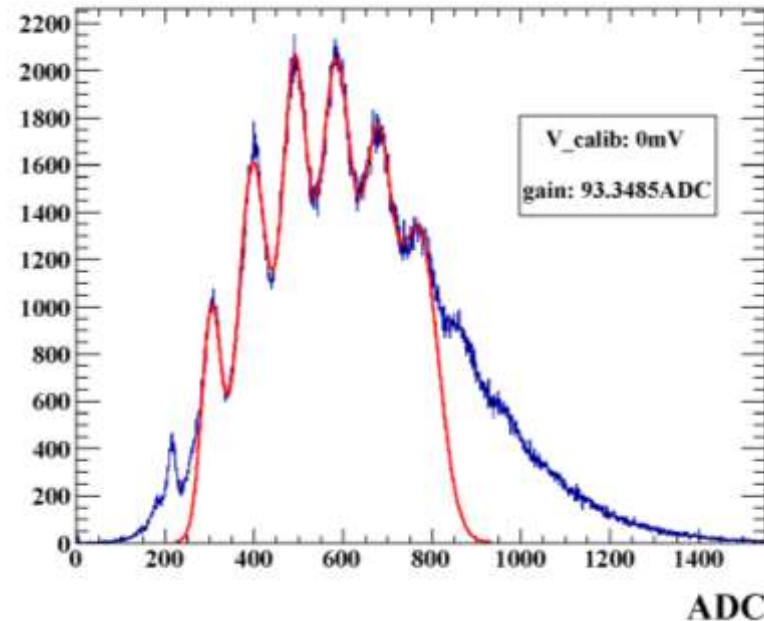
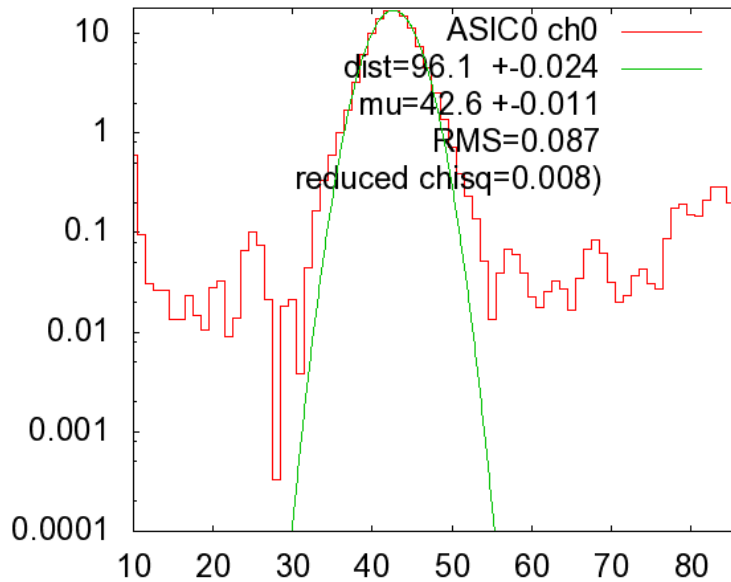
Hole misfit

Extreme gain

Old tiles

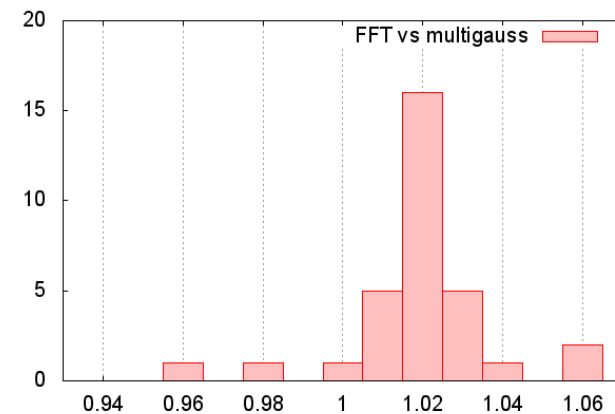
SPS: FFT vs. Multi-Gauss

Thanks to Oskar Hartbrich

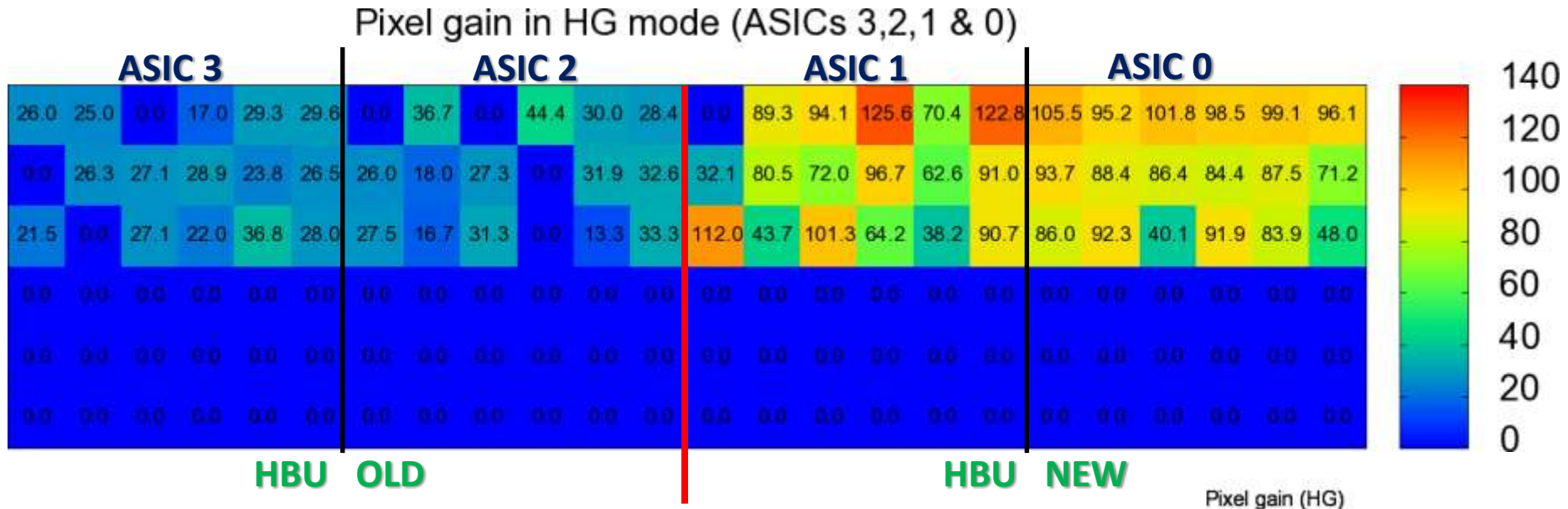


- Single peak distance measurement
 - Performing FFT & Gaussian fit to spectrum
- Advantage of FFT:
 - It's fast and gives
 - powerful even with very low statistic
 - fits have better success rate (100% vs. 94% at this case), even with worse SiPM (older tiles success rate 61%, compared to 21% with multigauss)
- Disadvantage of FFT:
 - FFT overshoots the gain distribution mean by 1-3%
- Multi-Gauss fit is more accurate (2x lower fit errors)

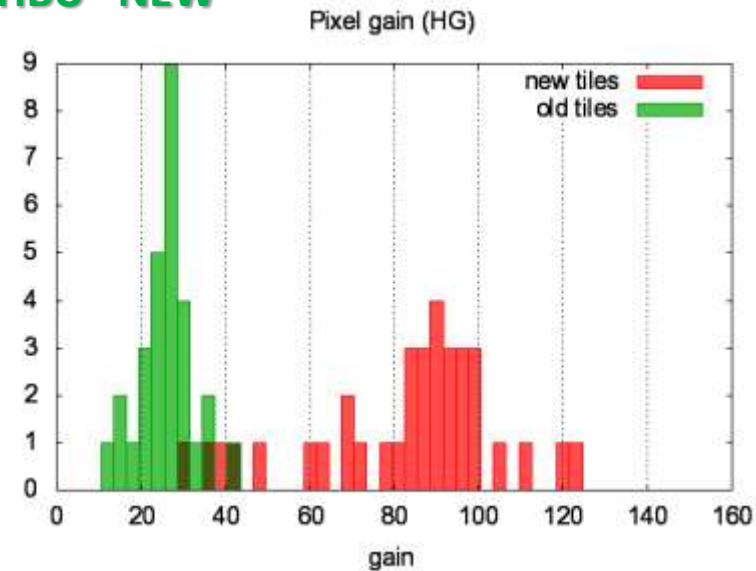
FFT overestimate compared to the multigauss fit histogram statistics on 33 tiles



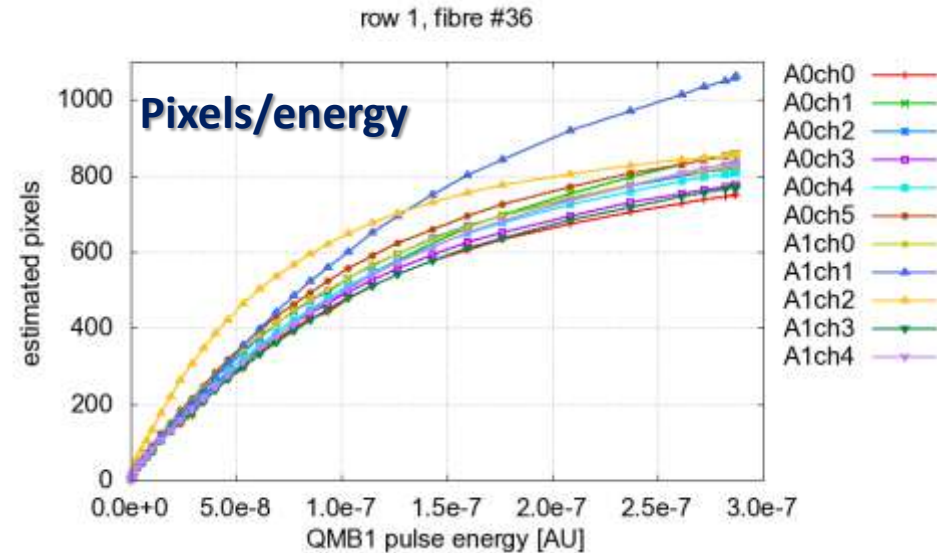
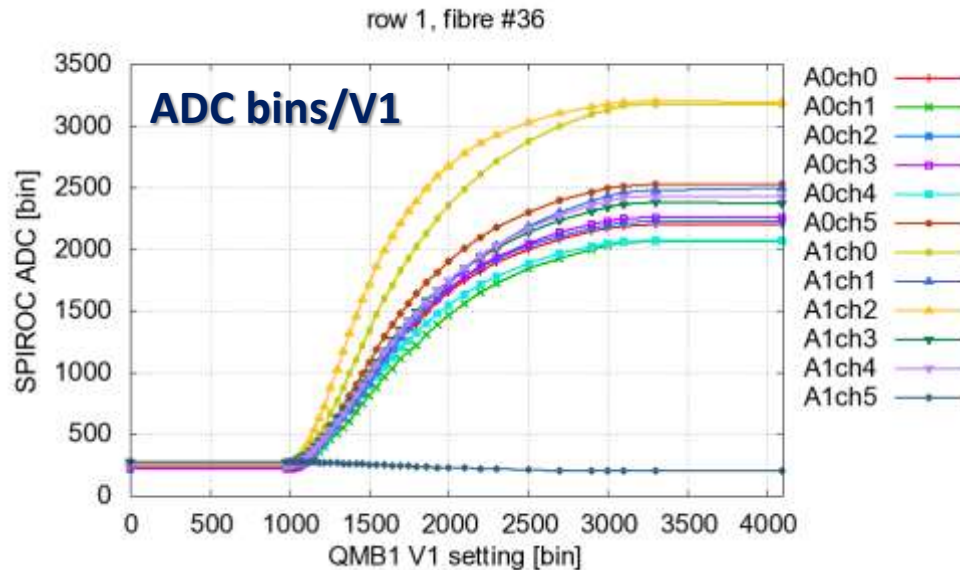
Pixel Gain in HG mode



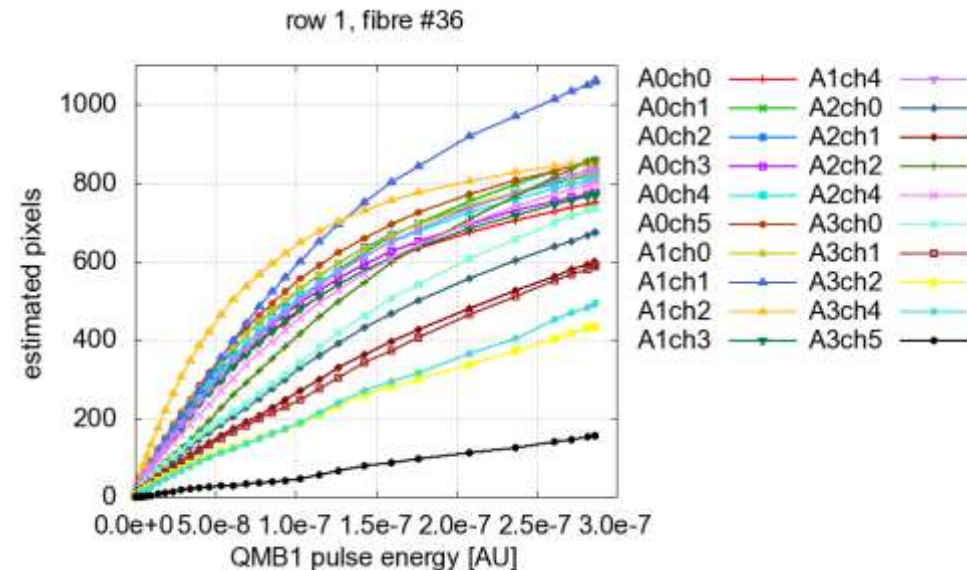
- Pedestal shift occurred, probably issue of SpiRoc2b ASIC chips, new ASICs should cure this problem
- Some pathological cases (no holes, impossible fixing, no tile) for few channels
- Differences of 'old' and 'new' tile-SiPM batches are visible
 - ITEP: LY of tile & SiPM 15 vs. 12 pix./MIP
 - Gain 2.0 vs. 1.5 M, U_{bias} 43V vs. 47V (not good working point, delay setup)
 - Physical number of pixels should be same
- In average ~3 times higher pixel gain, assuming same light intensity from notches



Saturation curves: row #1, HBU #0 &

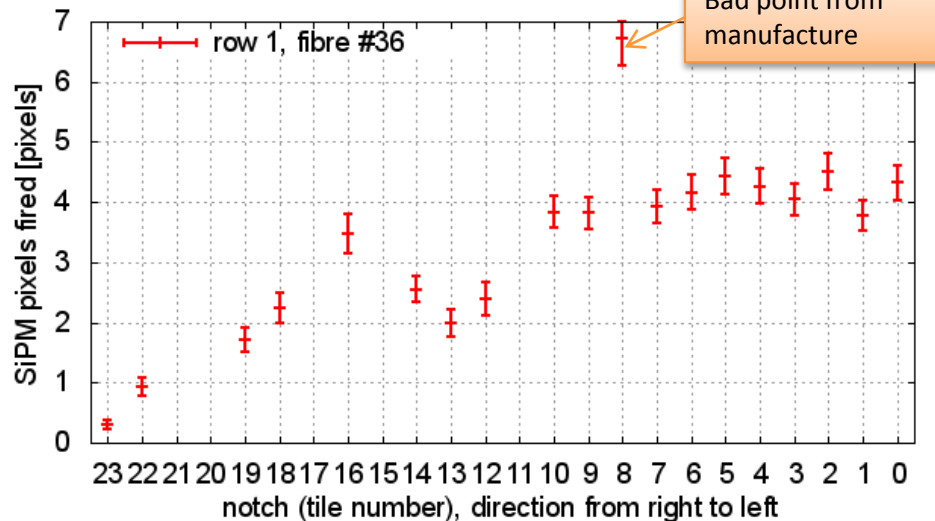


- Conversion to pixels:
 - pedestal subtraction,
 - pixel gain in LG
 - HG/LG ratio (different for each HBU, ~40 vs. ~20)
- Conversion to energy
 - Using optical power measurement in Prague
 - Max LED power is 0.55 nJ, but only fraction goes to fiber and notches

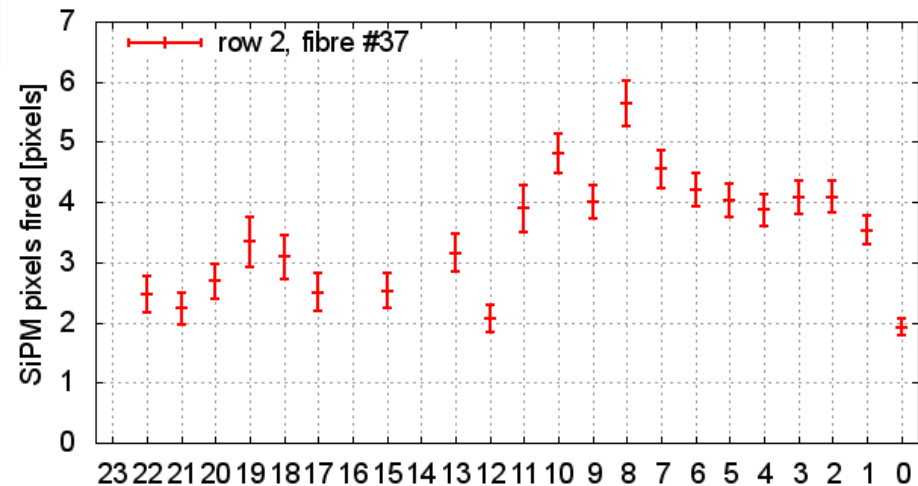


Notch light homogeneity

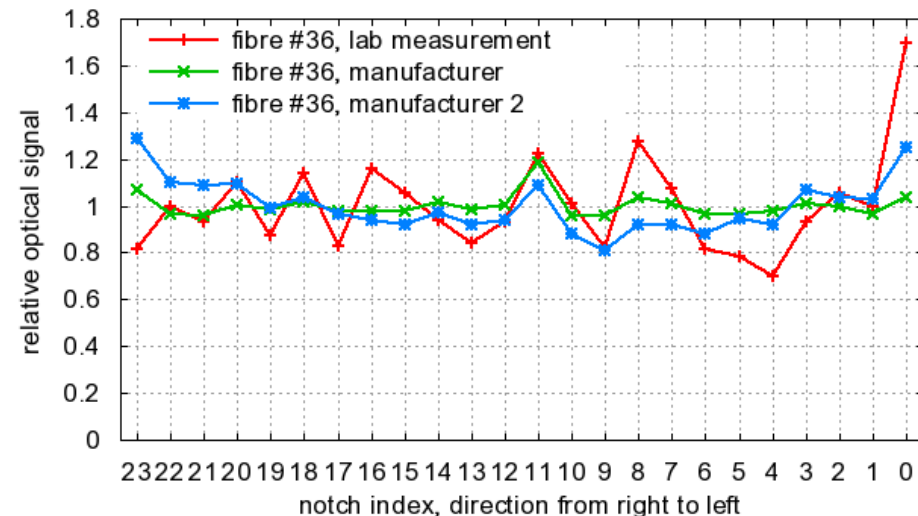
HBU response to the notched fibre



HBU response to the notched fibre



Optical fibre measurement at the laboratory



- Same light intensity input (LED power was equalized)
- study homogeneity of light coming from notches
- Significantly bigger response for 'new' tiles in units of pixels
- 1st fiber provides best result (omitting point#8, which was known to be higher)
 - light inhomogeneity within 18%,
 - average variation 6%, including optical coupling
 - Specification of fiber: all points should be within 15%
- 2nd fiber still ok, 3rd problematic due to old tiles
- Error bars are estimation of worst case error
 - (1.2 bins for pedestal subtracted signal, 2% on the ASIC linearity, 1~3% based on FFT resolution, 1 additional bit on peak distance)
 - Does not include uncertainties of fiber laying, fixing and coupling

Conclusion

- **Fiber-based calibration system tested in May at DESY**
 - 3 QMB1 with 3 LED & 24-notch fibers routed on PCB
- **Two HBUs connected in one row were provided**
 - Readout was working – first step to multi-HBU readout
 - Unfortunately not the same sort of tiles – SiPMs
- **Common characteristics measured: HG, LG, amplitude scan**
- **FFT is successfully applied on p.e. spectra to extract SiPM gain -> result from more point (with less accuracy)**
- **Wide range of light intensities provided**
- **Homogeneity of 24-notch fibers looks reasonable**
- **Upgrade of QMB1(v2.0) is foreseen in end of 2012**
- **Full test with 6 HBU2 in Dec 2012**

Backup

Frame with 5 (and 1 spare) QMB1

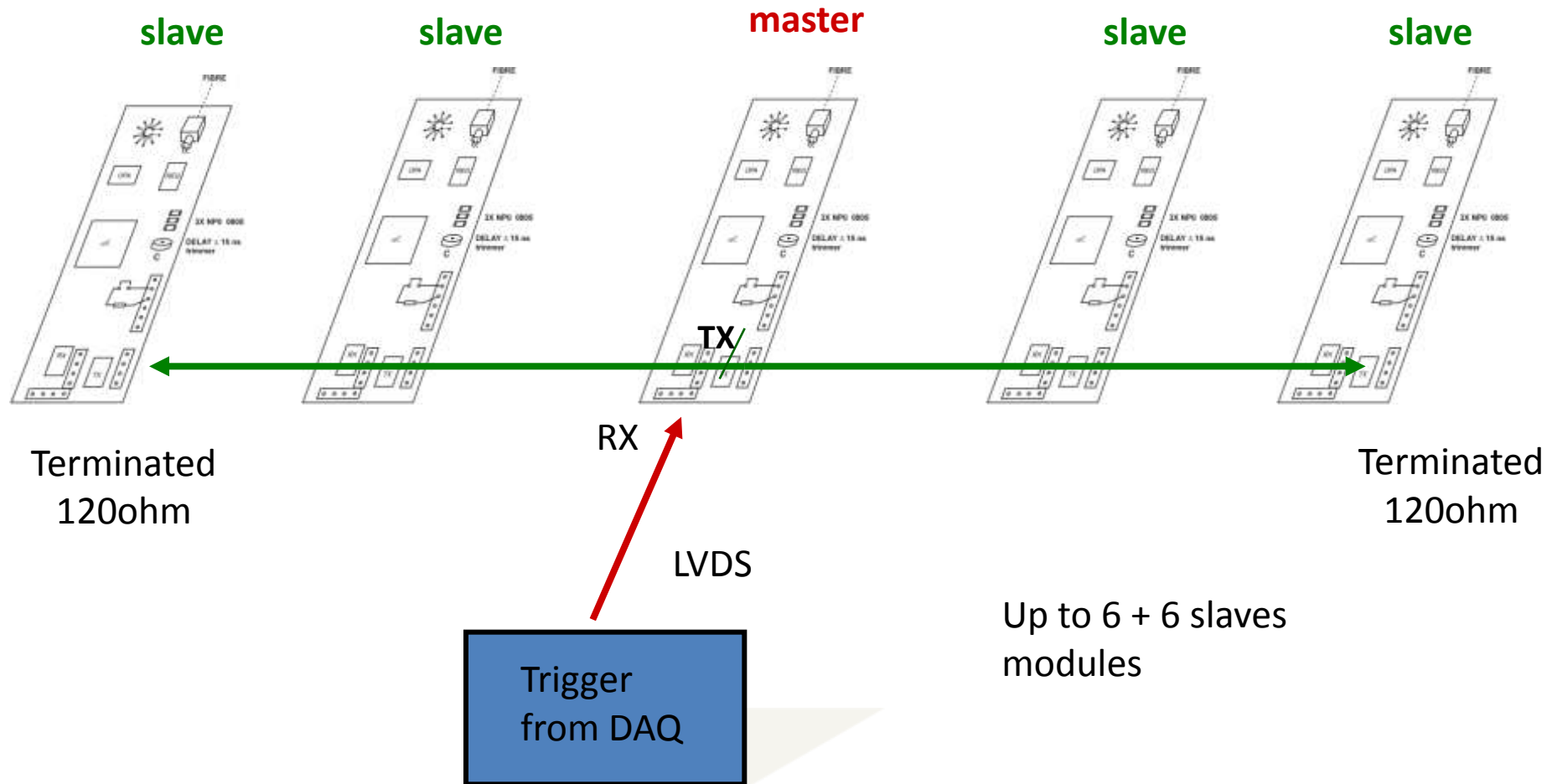


Principal schema

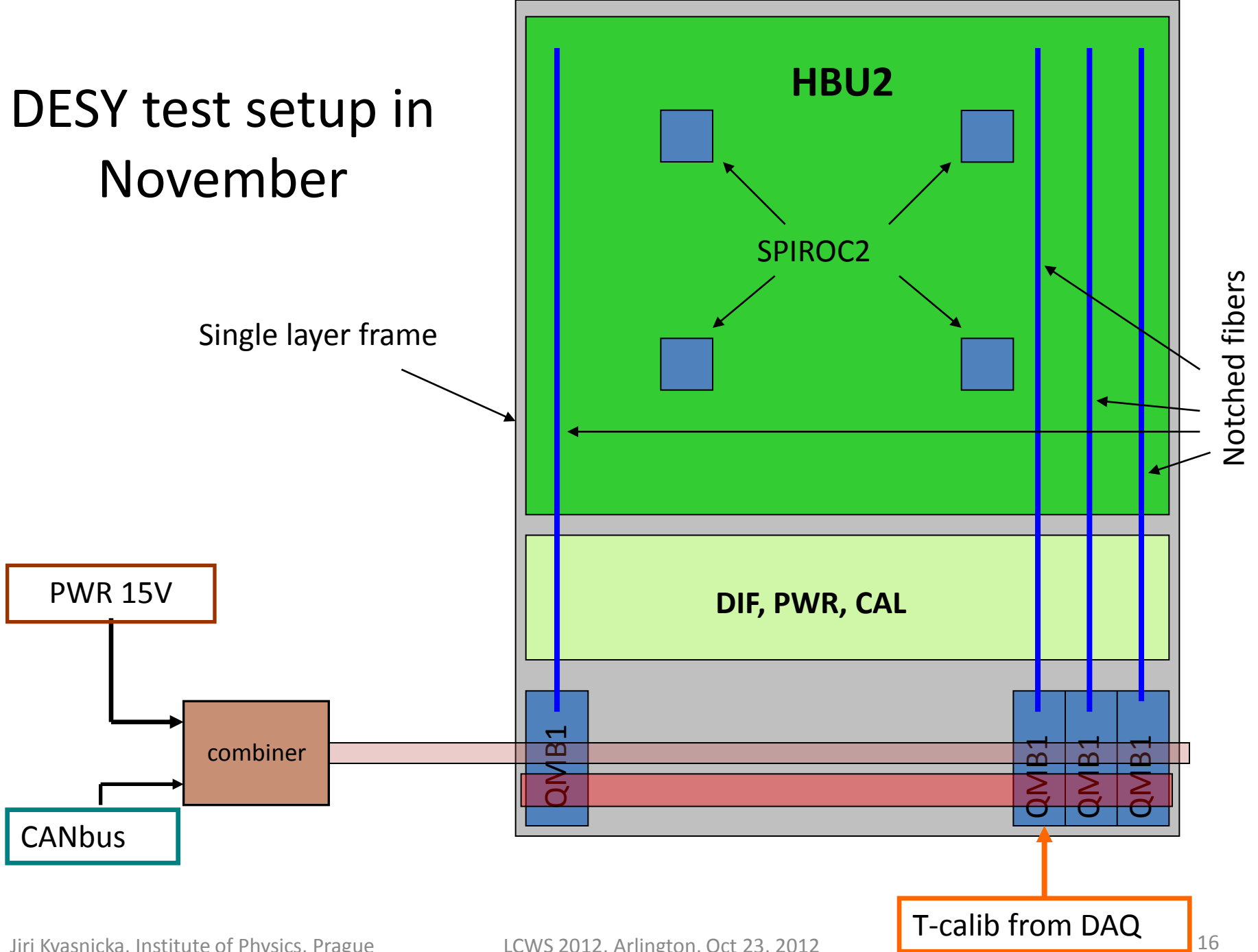


Larger inductor than the older QMB6

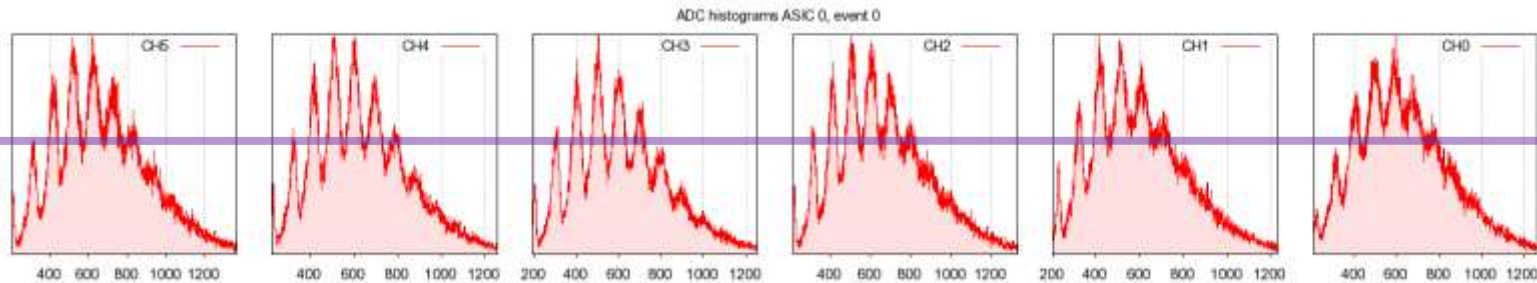
TRIGGER (T-calib) LVDS distribution to QMB1



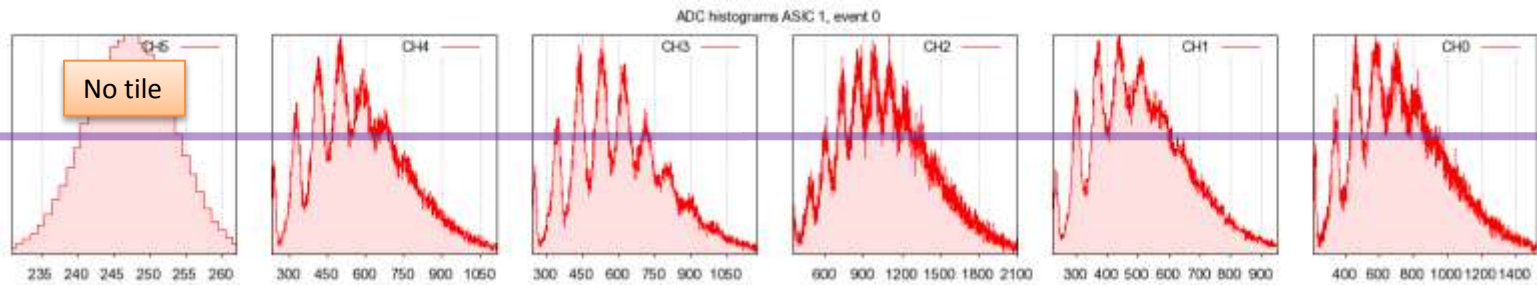
DESY test setup in November



High Gain pixel spectra, auto scaled



New tiles



Bad ch.

Bad ch.

Hole misfit

Extreme gain

Old tiles

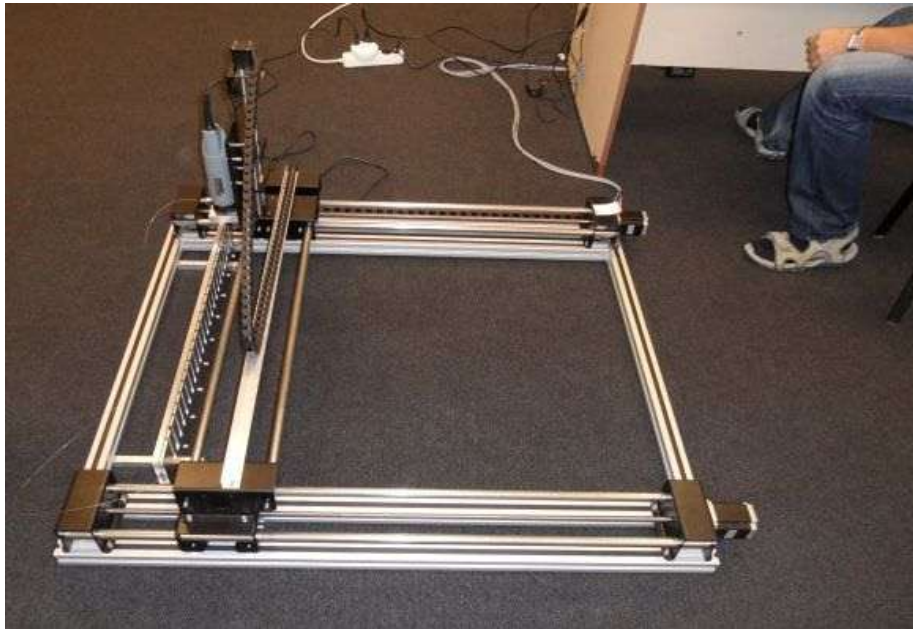
Notched fibers

Semi-automatic tool

Now in operational debugging &
SW development stage

Frame with x-y stepper motors

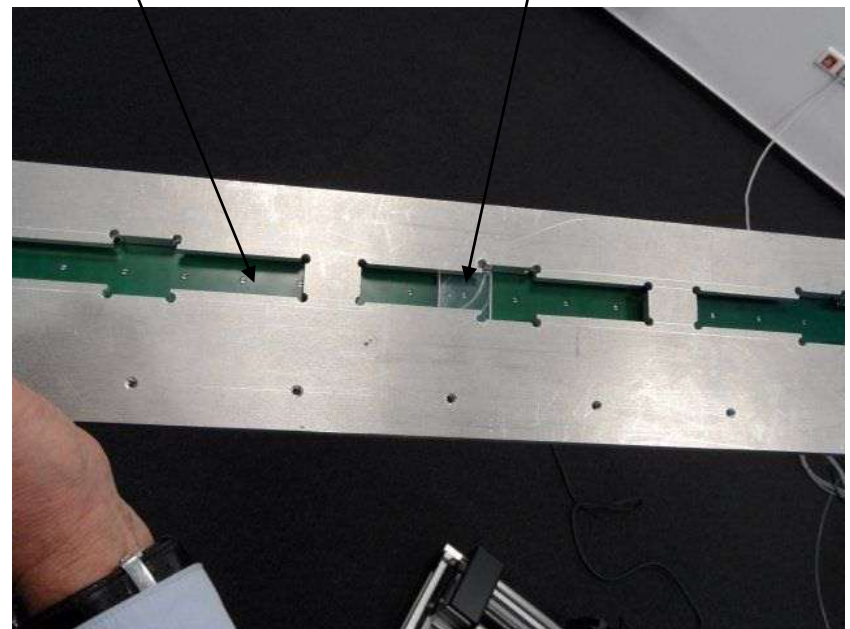
Drill machine used as milling cutter to
groove the notch



Alu/PCB Template with moving
scintillator tile

PCB with 3mm holes

Scintillator tile w SiPM



QMB1 linearity, amplitude scan

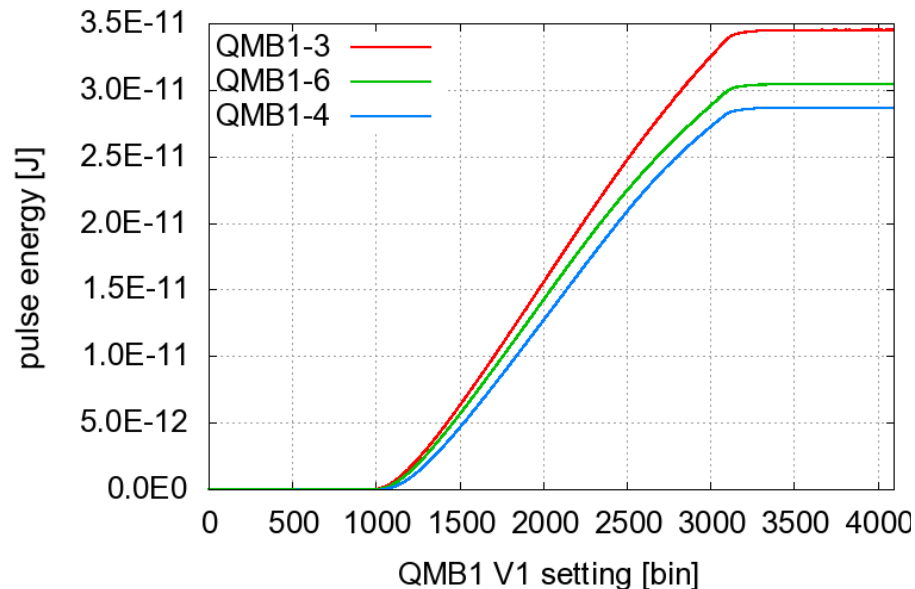
Standard LED pulses 3ns,

PWR measured by optical power meter Thorlabs PM100D

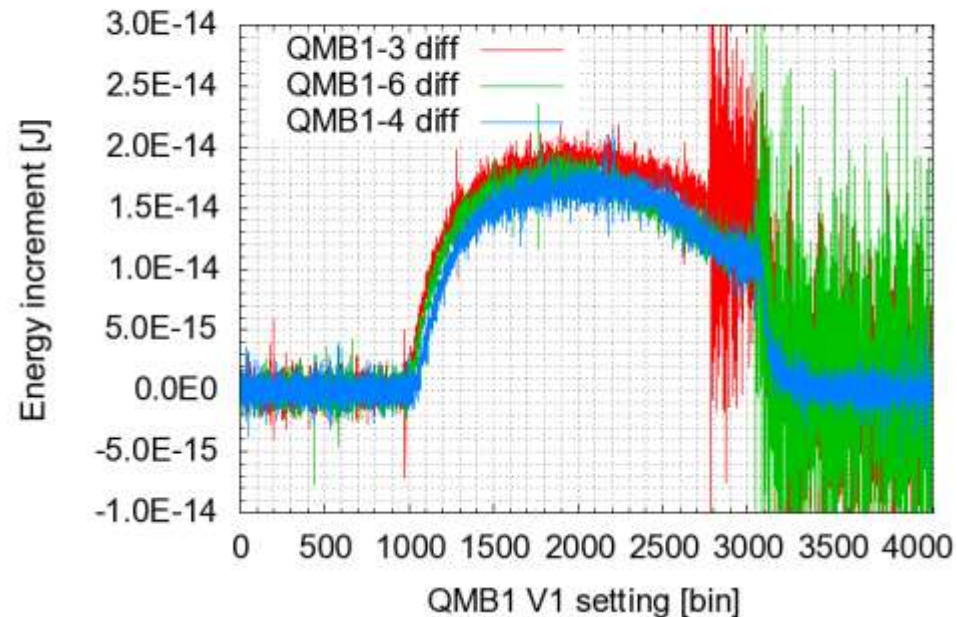


Differential Nonlinearity

Output optical power vs V1 setting,
QMB1, optical fibre 7m in length, 1mm in diameter,

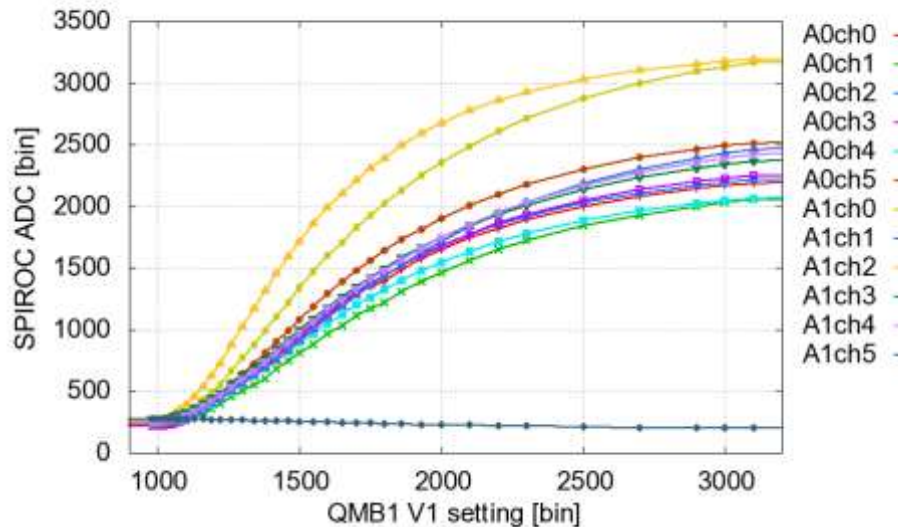


Output optical power vs V1 setting,
QMB1, optical fibre 7m in length, 1mm in diameter,

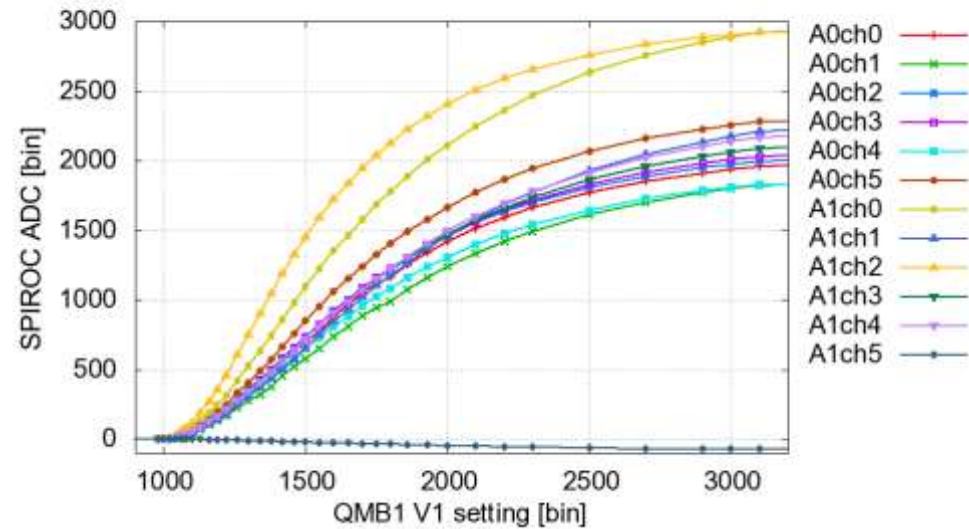


Saturation curves: procedure

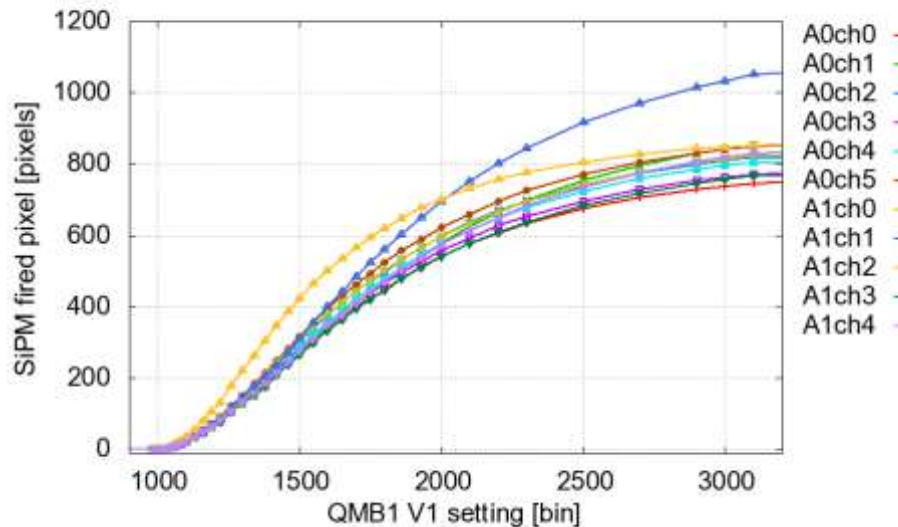
row 1, fibre #36



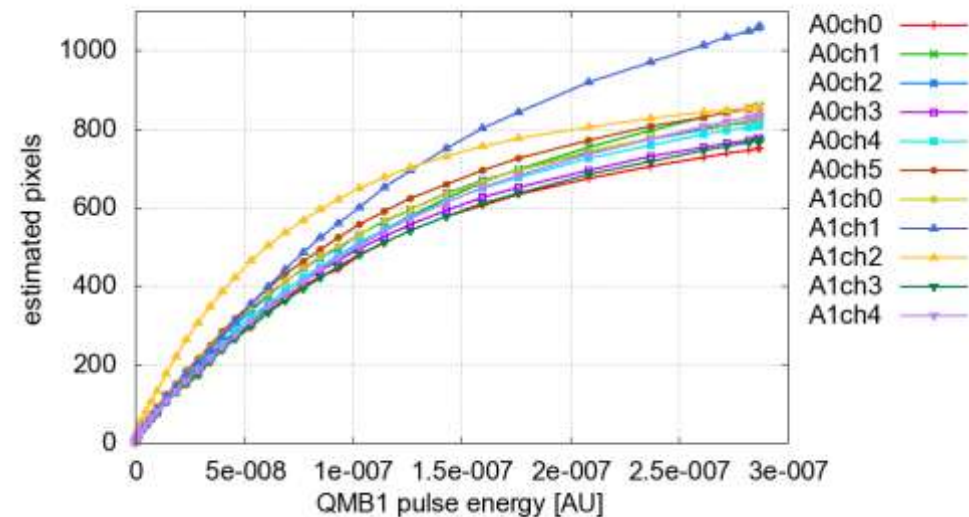
row 1, fibre #36



row 1, fibre #36

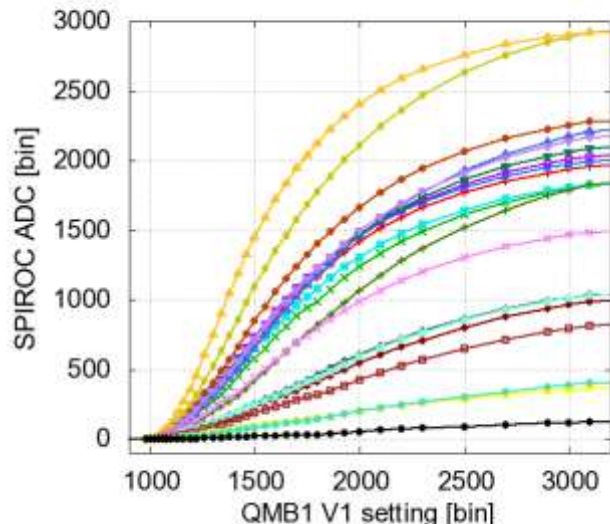


row 1, fibre #36

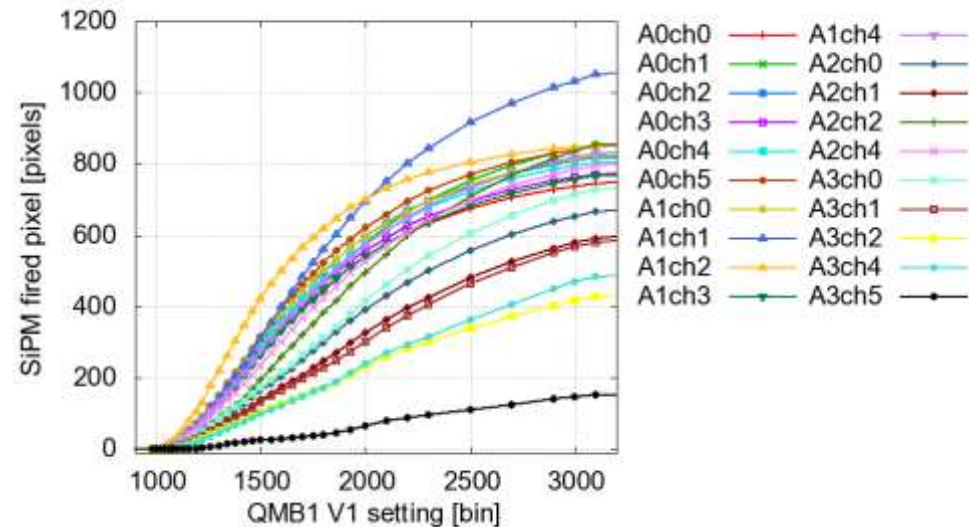


Saturation curves: All HBUs

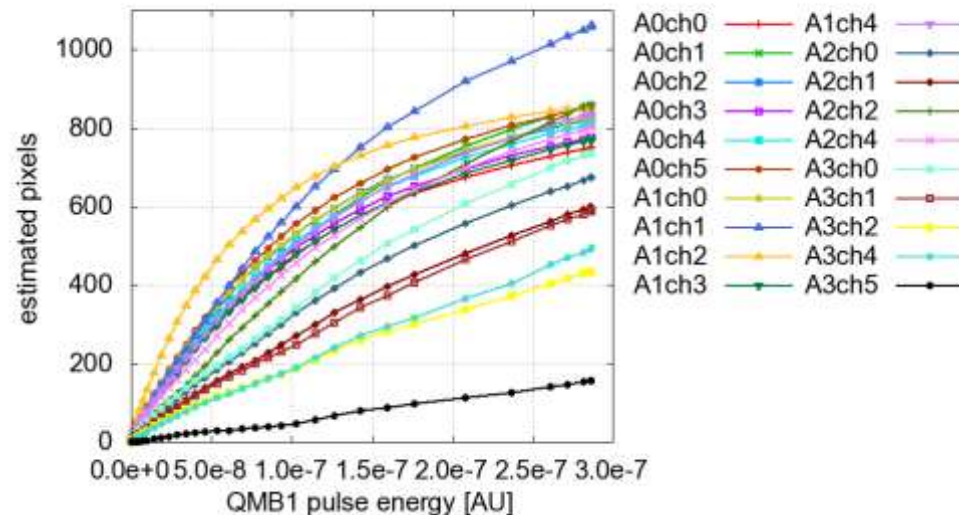
row 1, fibre #36



row 1, fibre #36



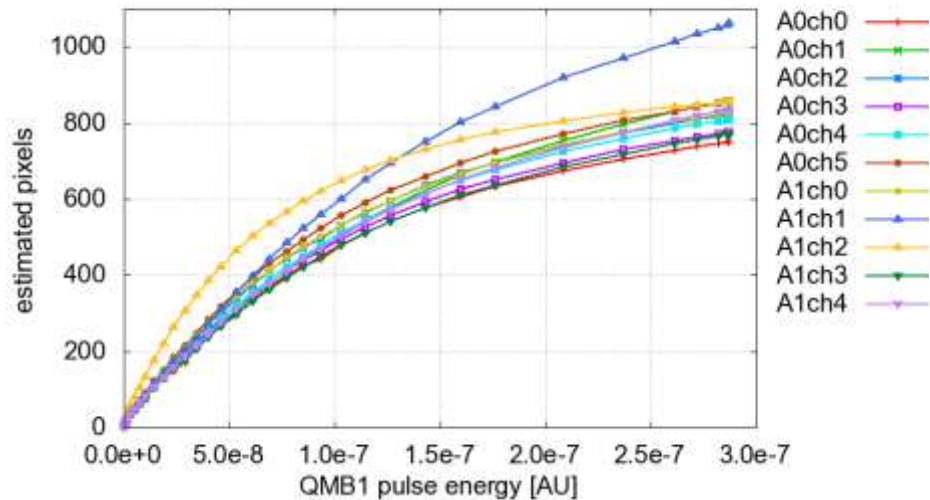
row 1, fibre #36



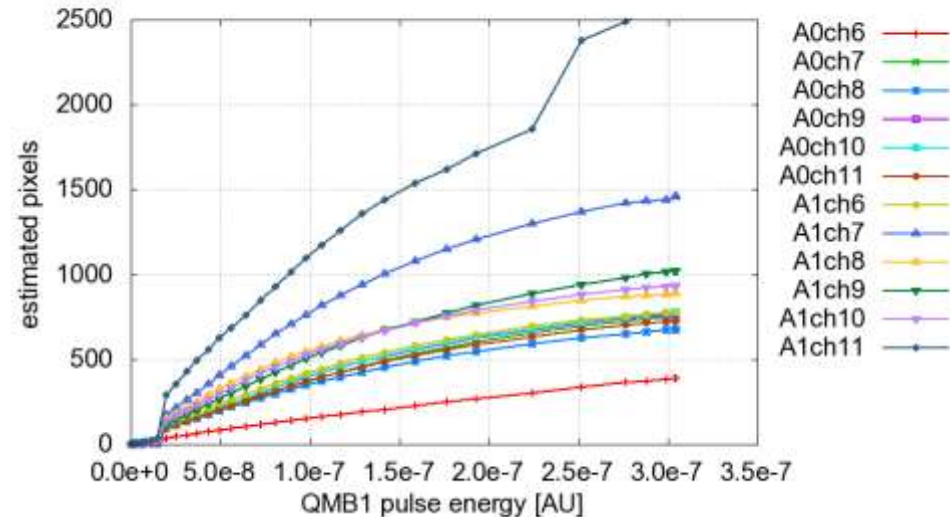
- scaling factor HG/LG ~ 40
- OLD HBU: asics A2 and A3
- Performance of 'OLD' HBU card much worse, no saturation reached

Saturation curves: All rows

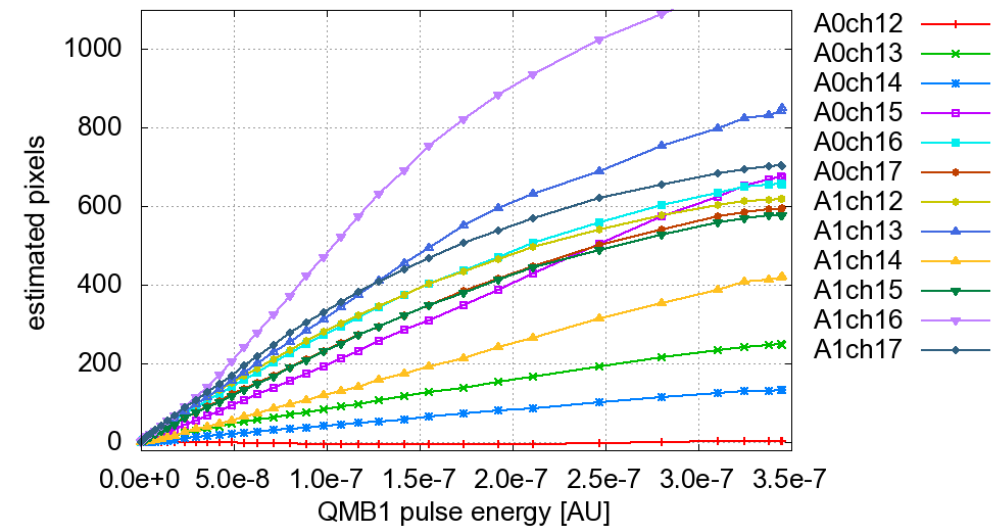
row 1, fibre #36



row 2, fibre #37

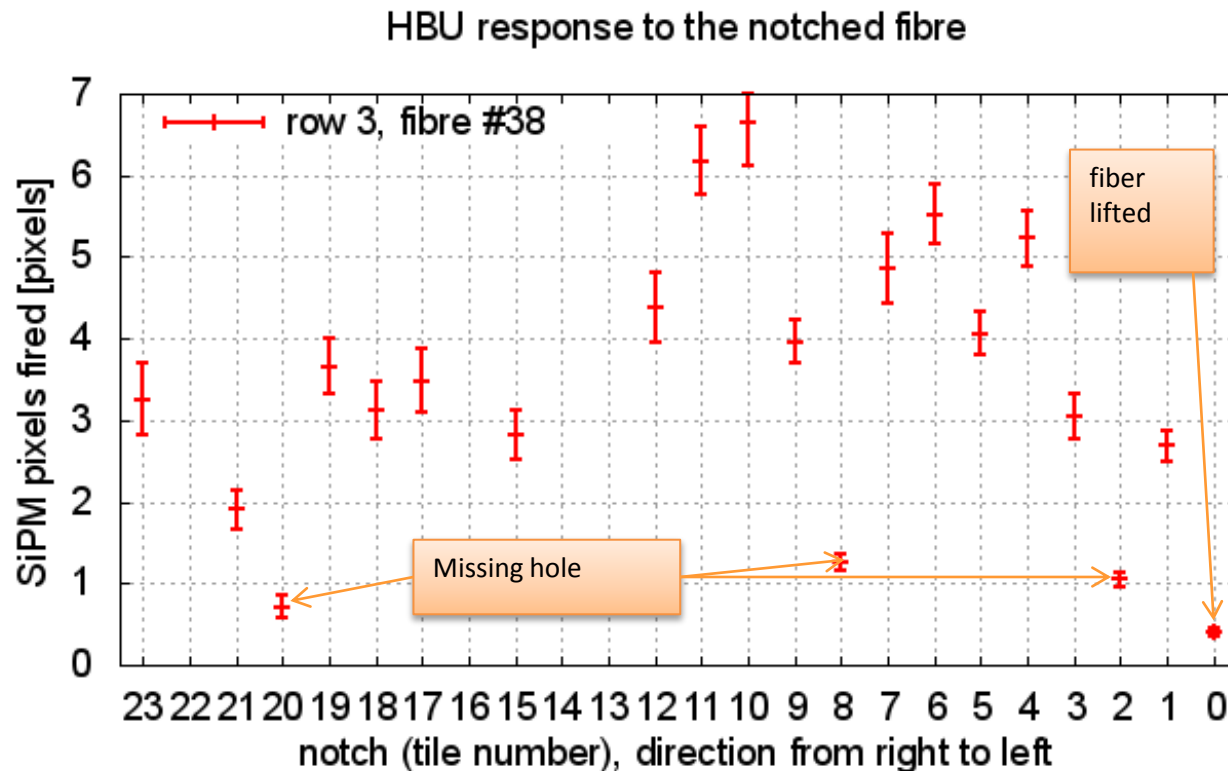


row 3, fibre #38



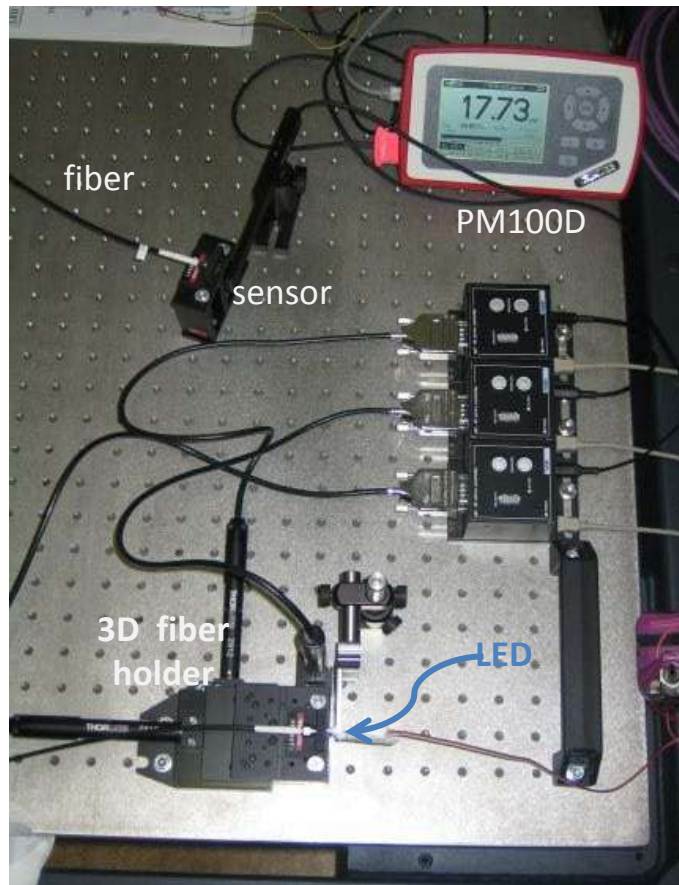
- Response variation for fibers
- 1st (outermost) best
- 2nd some problem with resetting of card slow control
- 3rd problems with fiber routing, misalignment of fiber notch and holes in HBU PCB

Notch light homogeneity - row 3



Light coupling

Test setup



3mm LED

