LED calibration and optical fiber distribution system

LCWS 2012, Arlington, 23/10/2012

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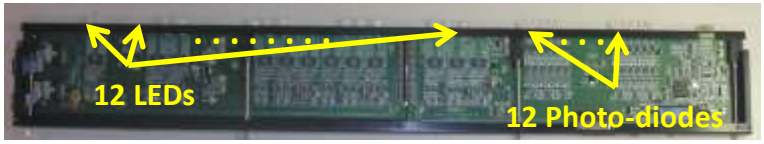
- ❑ QMB1 LED driver and notched fiber system
- ❑ Single photon spectra & gain performance @ HBU
- ❑ Amplitude scan and saturation

Institute of Physics AS CR

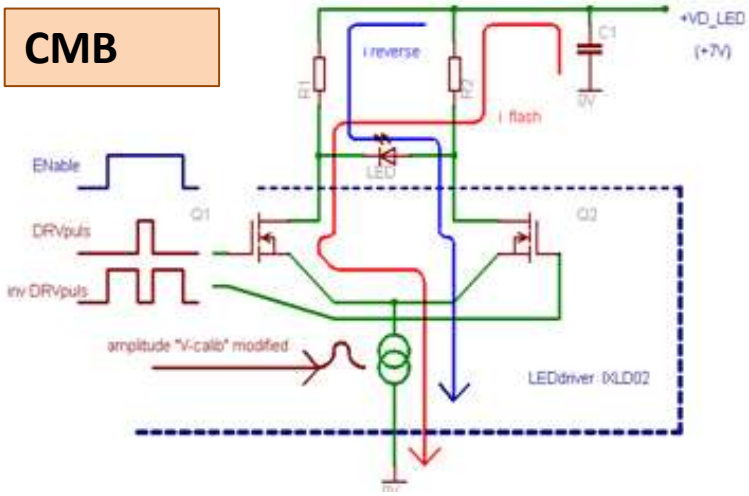
CALICE Calorimeter for ILC

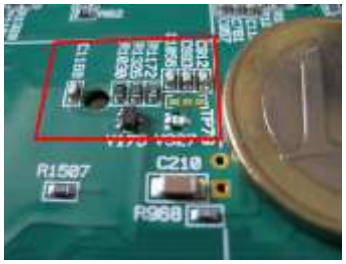
AHCAL calibration LED driver overview

- **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 1m^2 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)

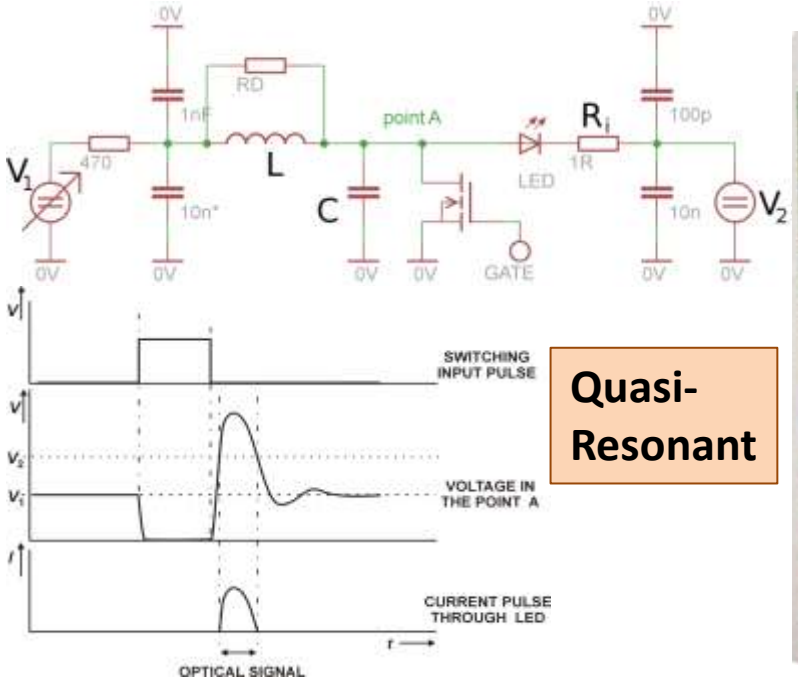


CMB



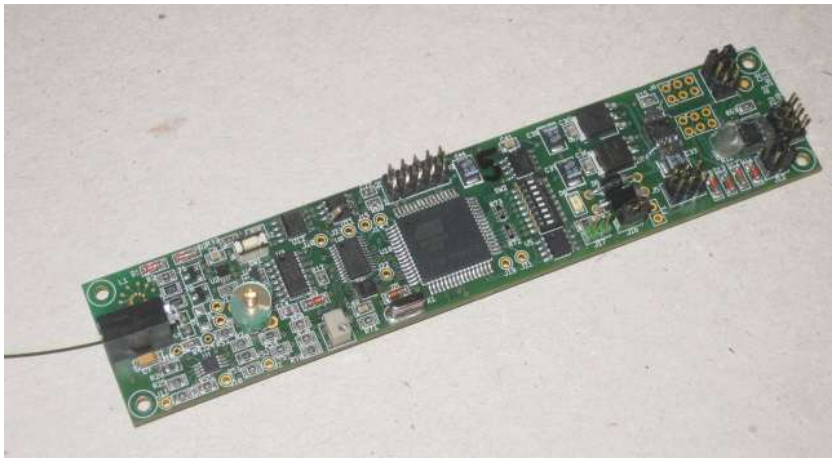


HBU-integrated



Quasi-Resonant

QMB1



More info on QMB can be found:

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

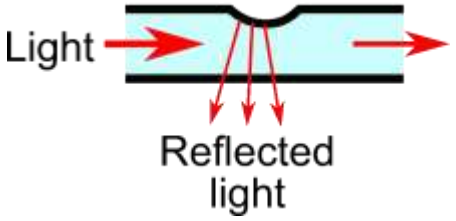
Quasi resonant Main Board

- Modular system, 1 LED per board
- Operation mode:
  - DAQ + CAN bus control
  - stand-alone mode
- LVDS Trigger distribution system
- Variable amplitude, zero to maximum (~1Amp) 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

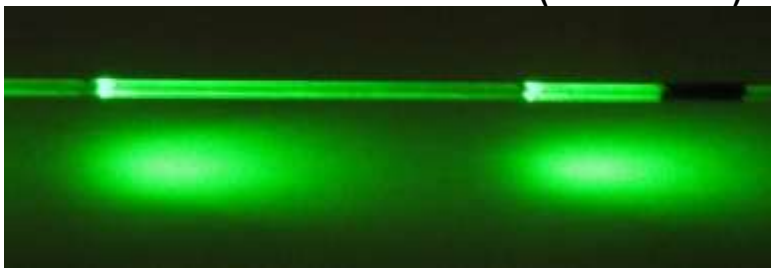
Single power 15V, 65mA

Distribution of light: Notched fiber

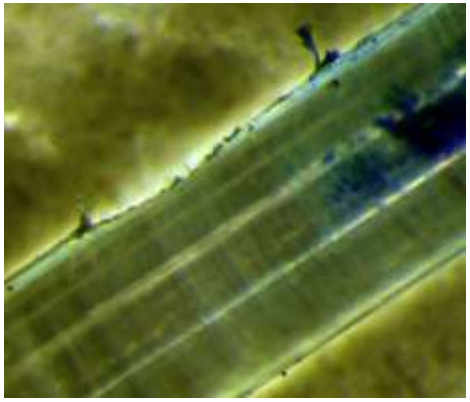
- Plastic optical fiber 1 mm in diameter
- Light is emitted from the **notches**
- The **notch** is a special scratch to the fiber, which reflects the light to the opposite direction
- The size of the notch varies from the beginning to the end of the fiber to maintain homogeneity of the light emitted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



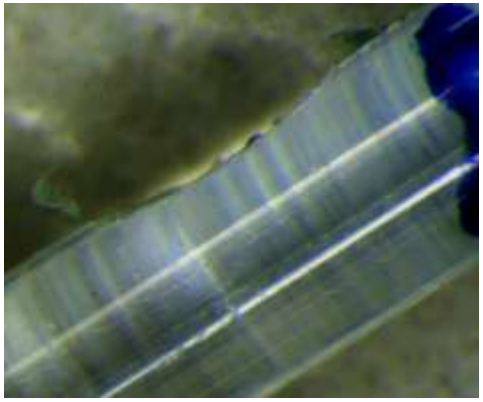
Emission from the fiber (side view)



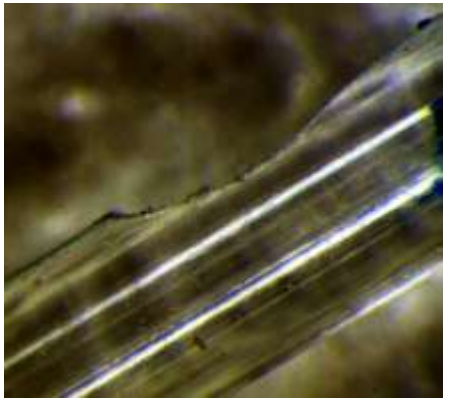
First notch



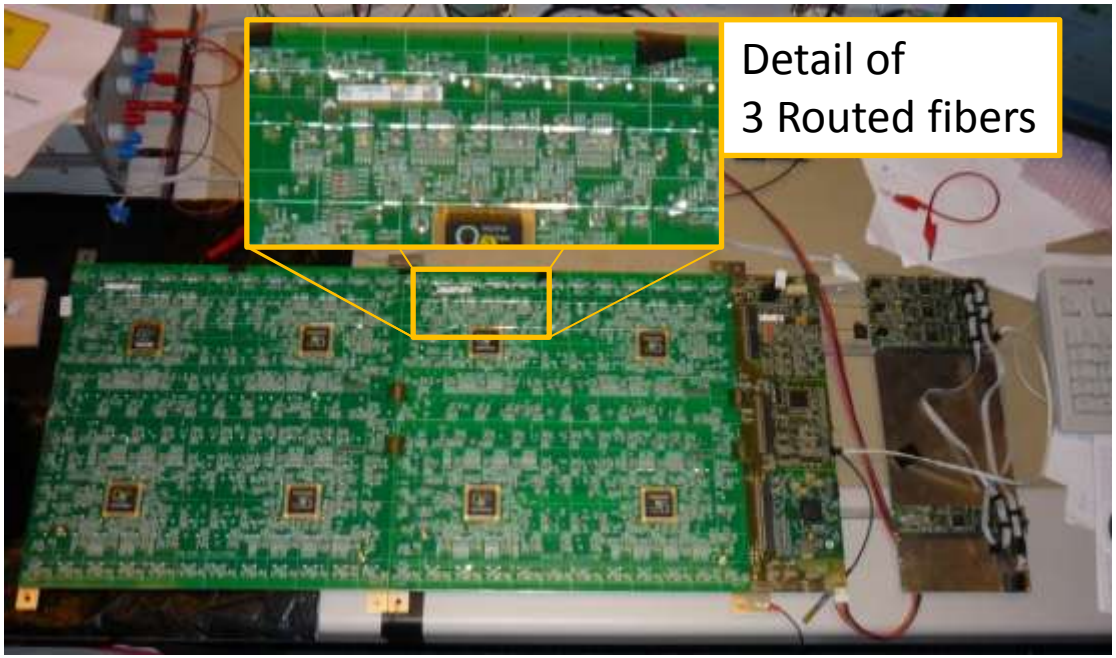
Middle notch



End position notch

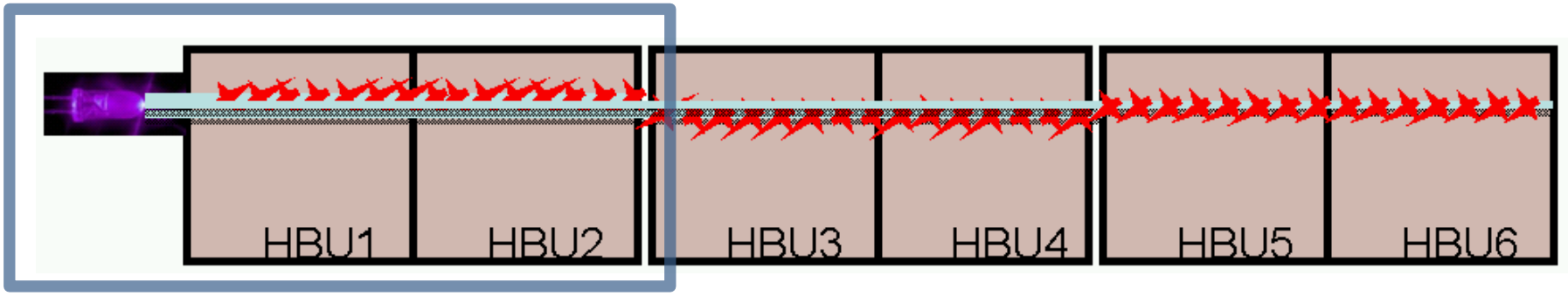


2nd Test @ DESY (May 2012)

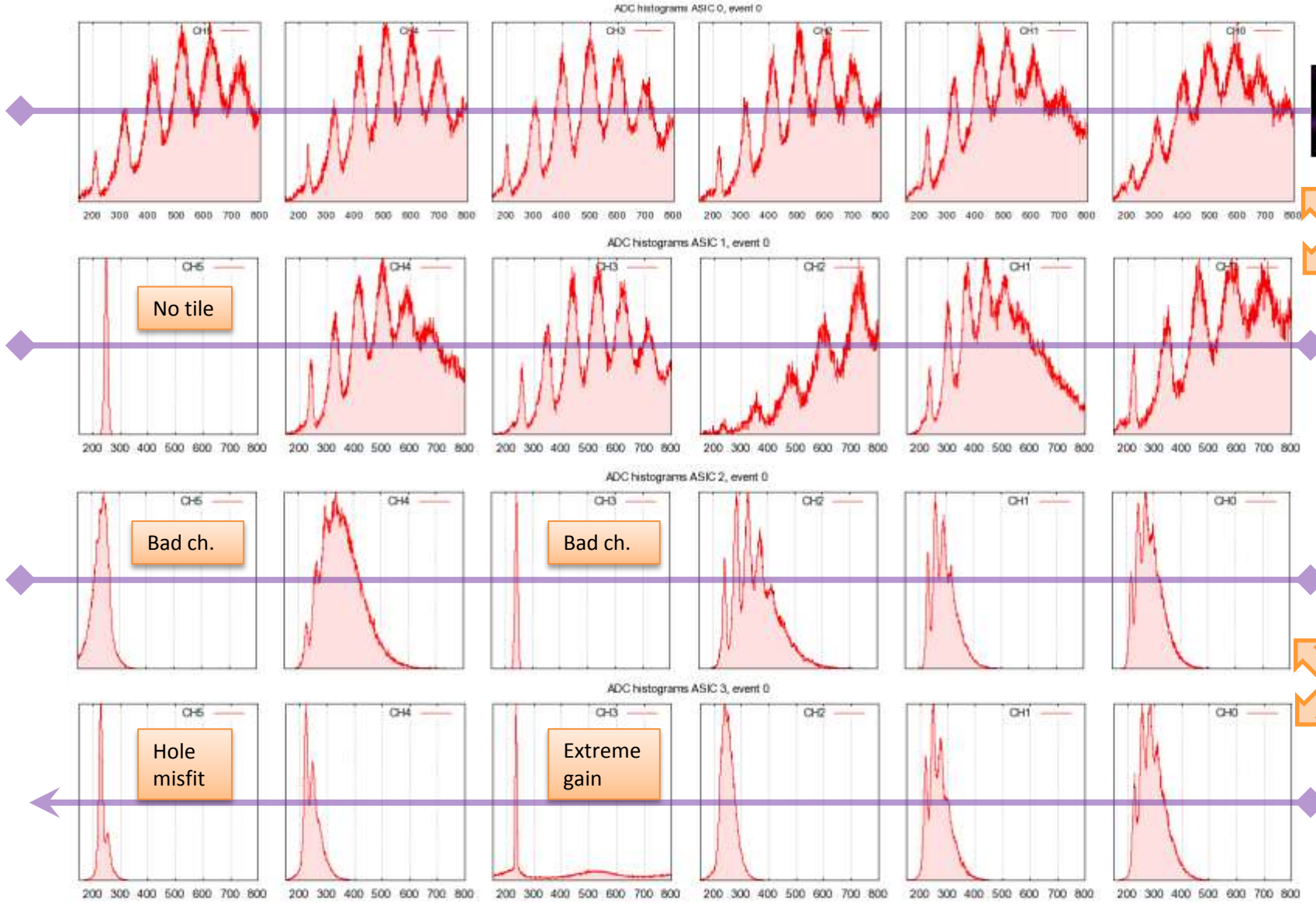


- Two HBU2 in one row, each had
  - 2 active SPIRoc2b ASICs (other 2 were not read out),
  - Assembled with 3 top rows of scintillators & SiPMs
- 3 notched test-fibers, 24 notches each.
- 3 QMB1 LED driver
- Different tiles & SiPMs on each HBU2 ('Old' and 'New' HBU) (see next slide)
- Low & High Gain 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

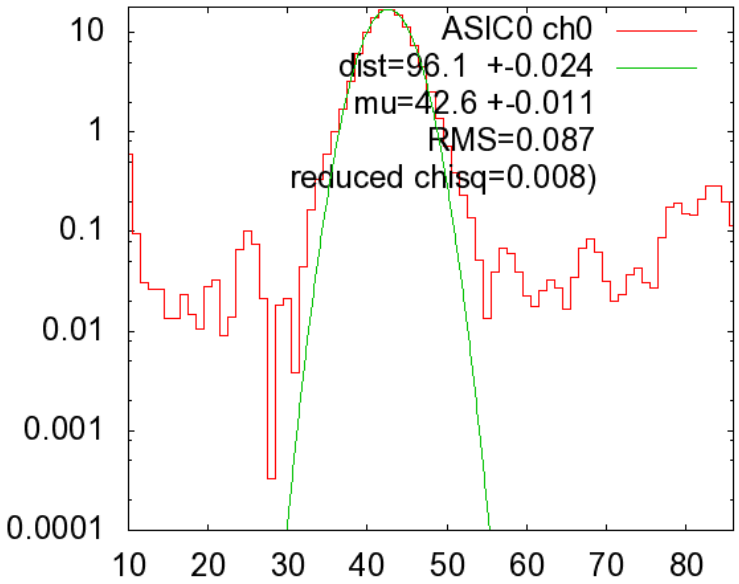
- Approx. 1/3 of final setup:
  - 3 notched fiber per 1 LED
  - Each fiber for 24 tiles
- **Full test with 6 HBU in Dec 2012**



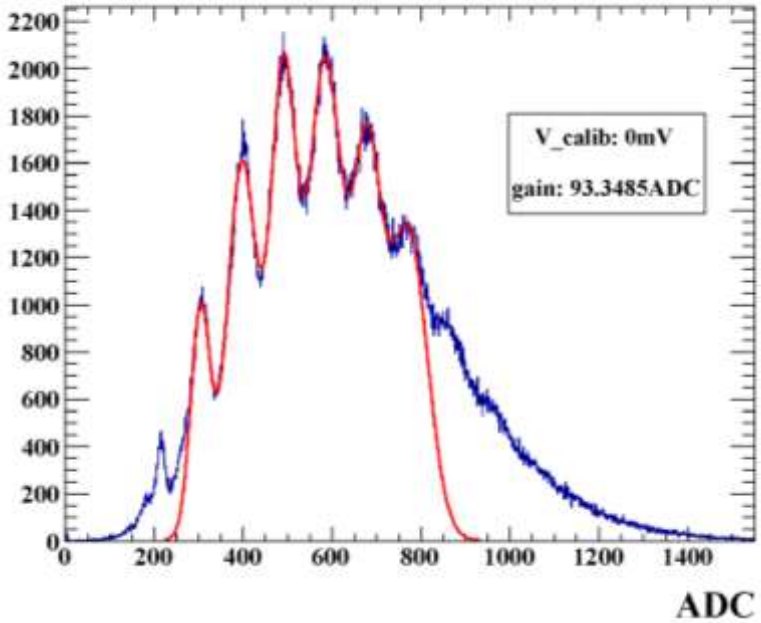
High Gain pixel spectra (1 fiber)



SPS: FFT vs. Multi-Gauss

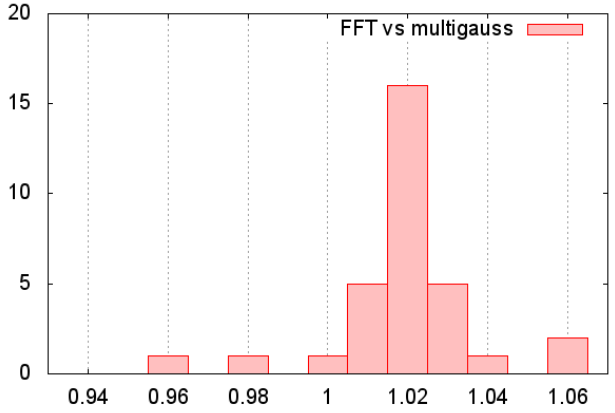


Thanks to Oskar Hartbrich

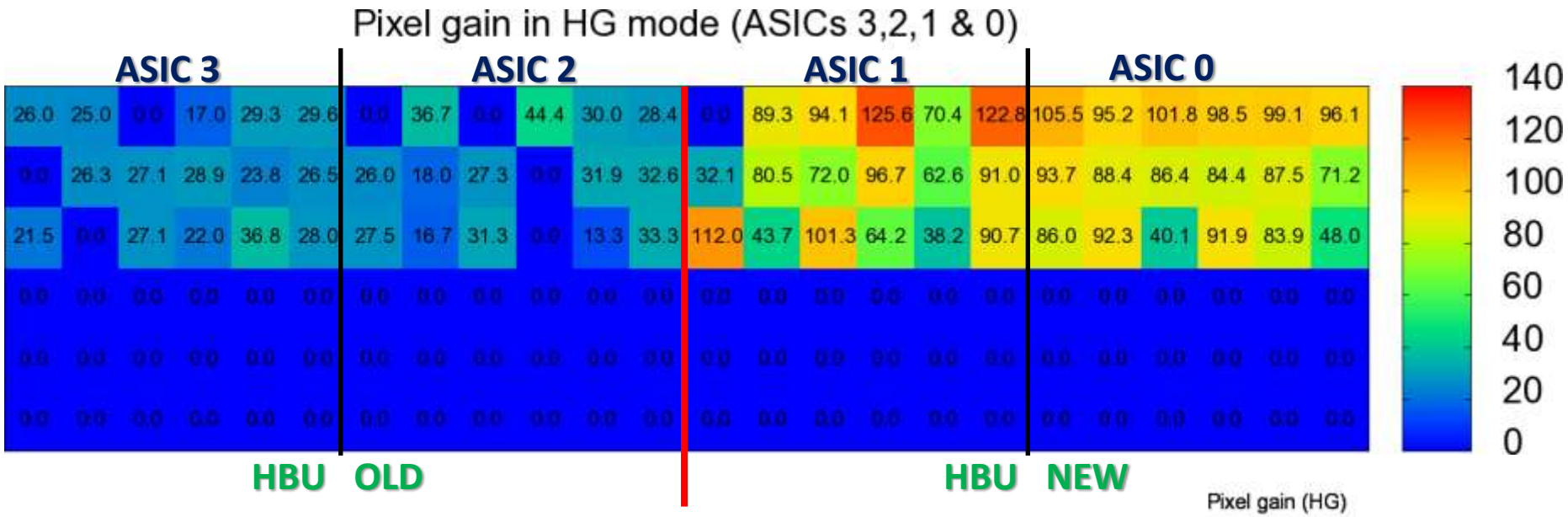


- Single peak distance measurement
  - Performing FFT & Gaussian fit to spectrum
- Advantage of FFT:
  - It's fast and gives
  - powerful even with very low statistic
  - fits have better success rate (100% vs. 94% at this case), even with worse SiPM (older tiles success rate 61%, compared to 21% with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

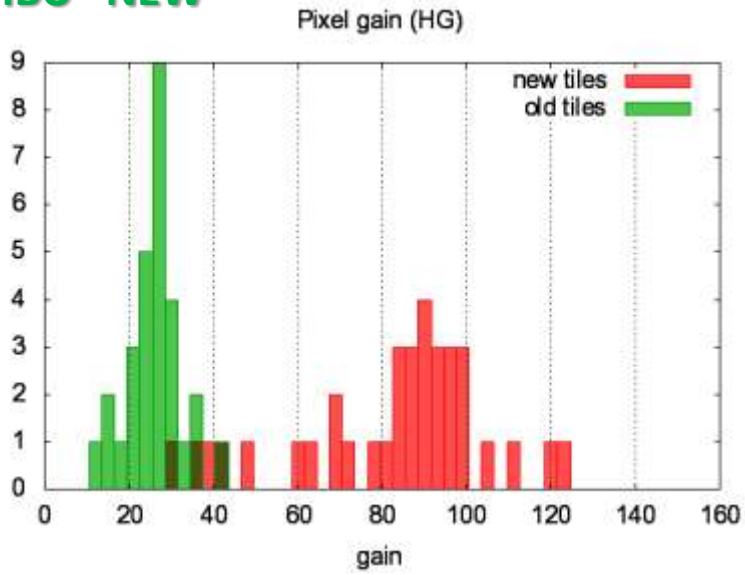
FFT overestimate compared to the multigauss fit histogram statistics on 33 tiles



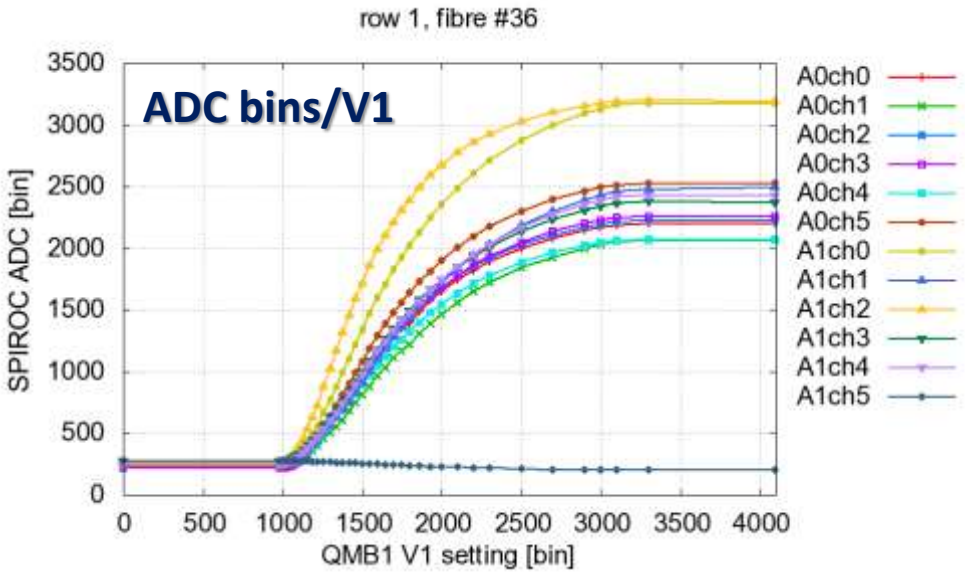
Pixel Gain in HG mode

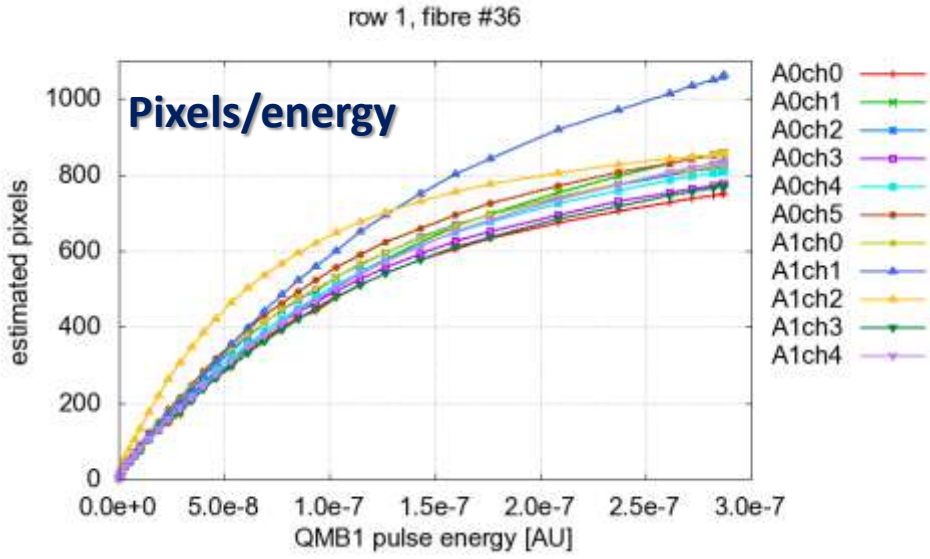


- Pedestal shift occurred, probably issue of SpiRoc2b ASIC chips, new ASICs should cure this problem
- Some pathological cases (no holes, impossible fixing, no tile) for few channels
- Differences of 'old' and 'new' tile-SiPM batches are visible
  - ITEP: LY of tile & SiPM 15 vs. 12 pix./MIP
  - Gain 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

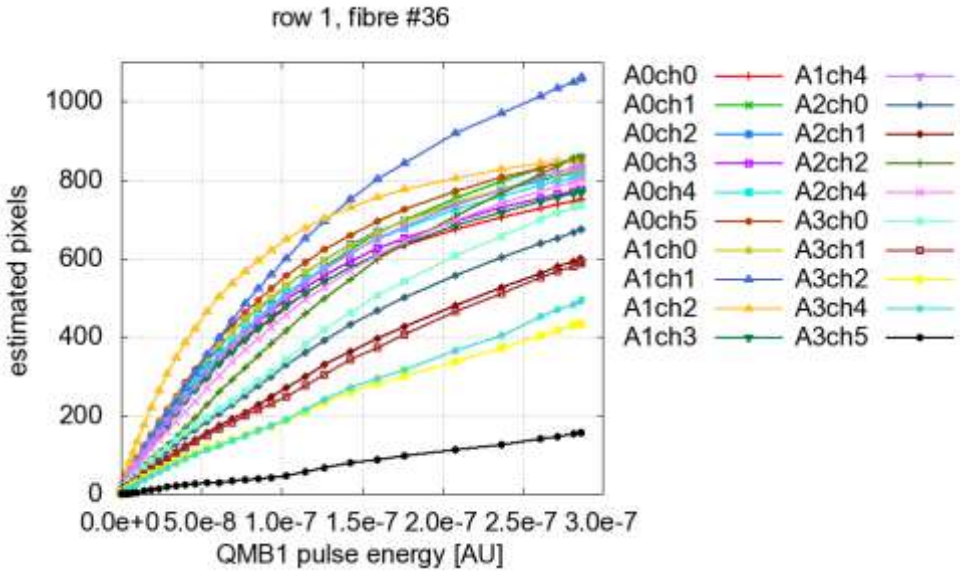


Saturation curves: row #1, HBU #0 &

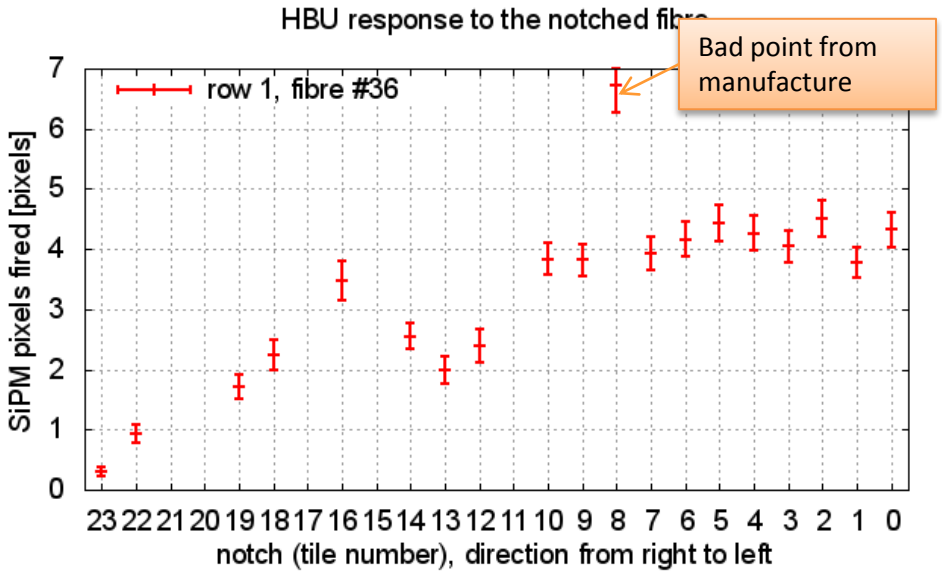


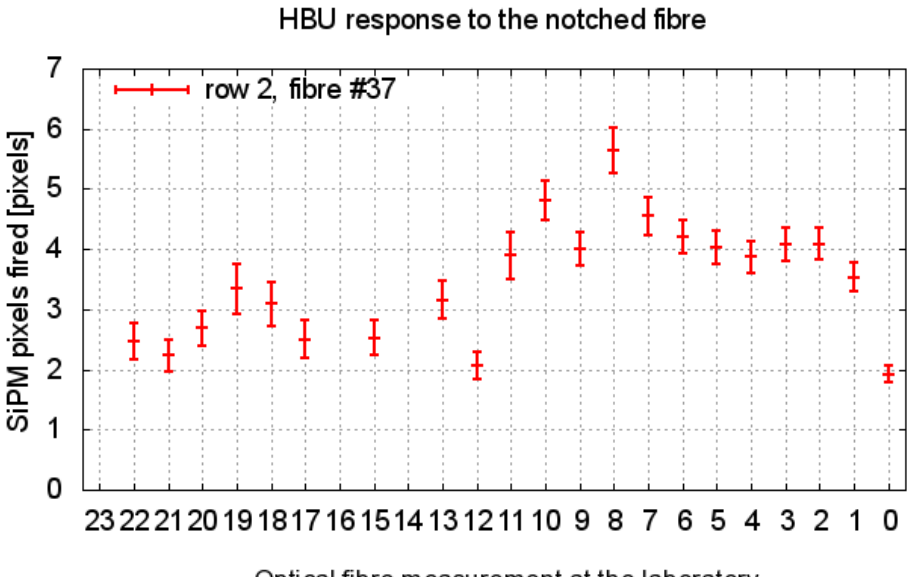


- Conversion to pixels:
  - pedestal subtraction,
  - pixel gain in LG
  - HG/LG ratio (different for each HBU, ~40 vs. ~20)
- Conversion to energy
  - Using optical power measurement in Prague
  - Max LED power is 0.55 nJ, but only fraction goes to fiber and notches

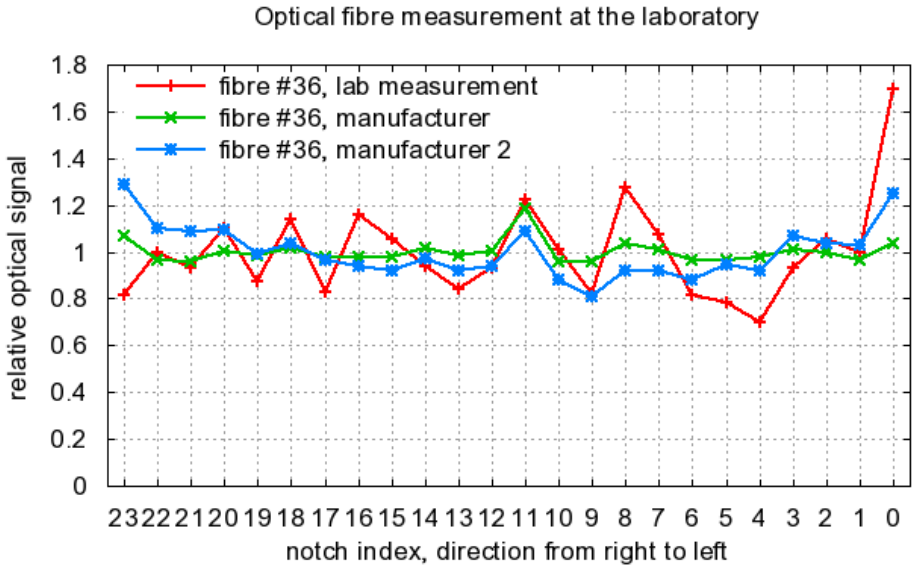


Notch light homogeneity





- 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

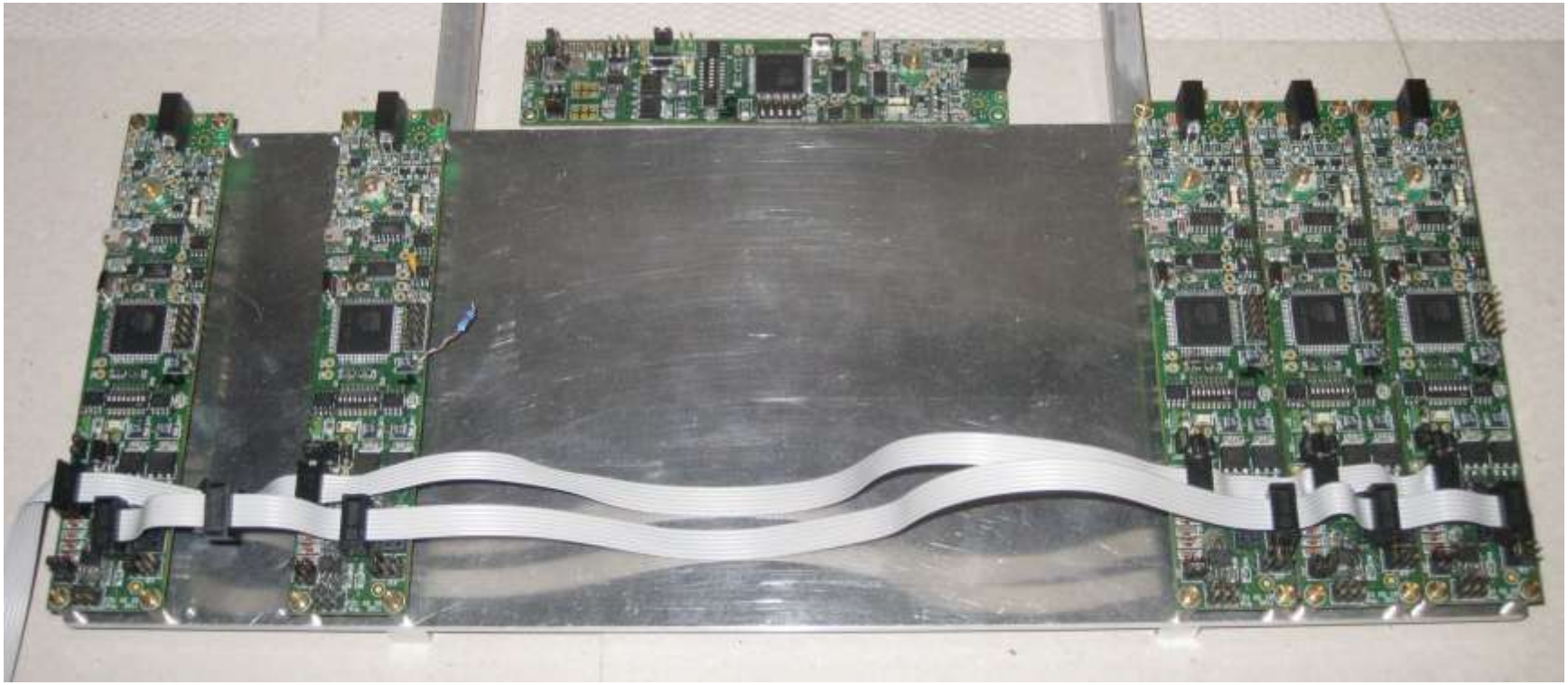


Conclusion

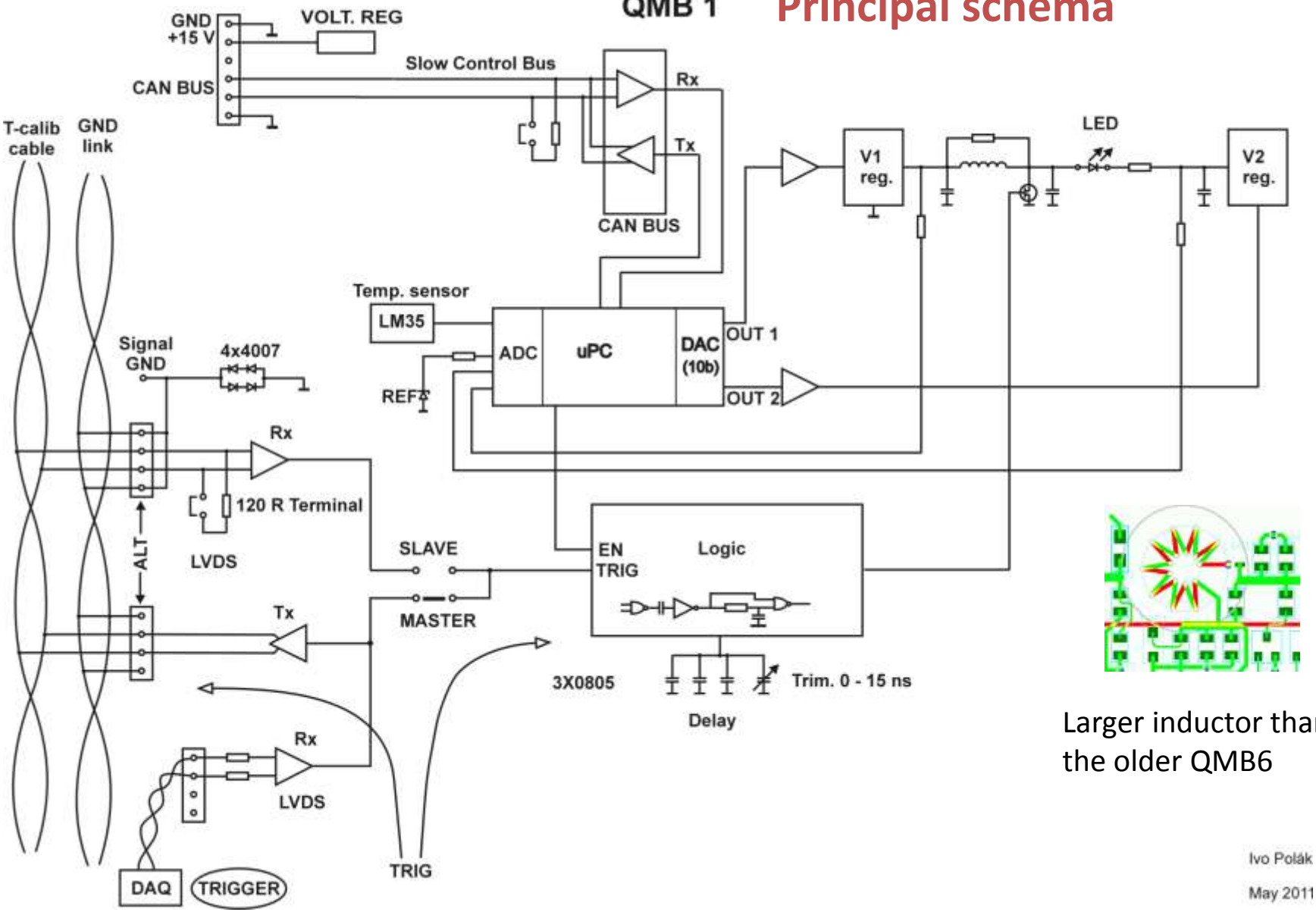
- Fiber-based calibration system tested in May at DESY
  - 3 QMB1 with 3 LED & 24-notch fibers routed on PCB
- Two HBUs connected in one row were provided
  - Readout was working – first step to multi-HBU readout
  - Unfortunately not the same sort of tiles – SiPMs
- Common characteristics measured: 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

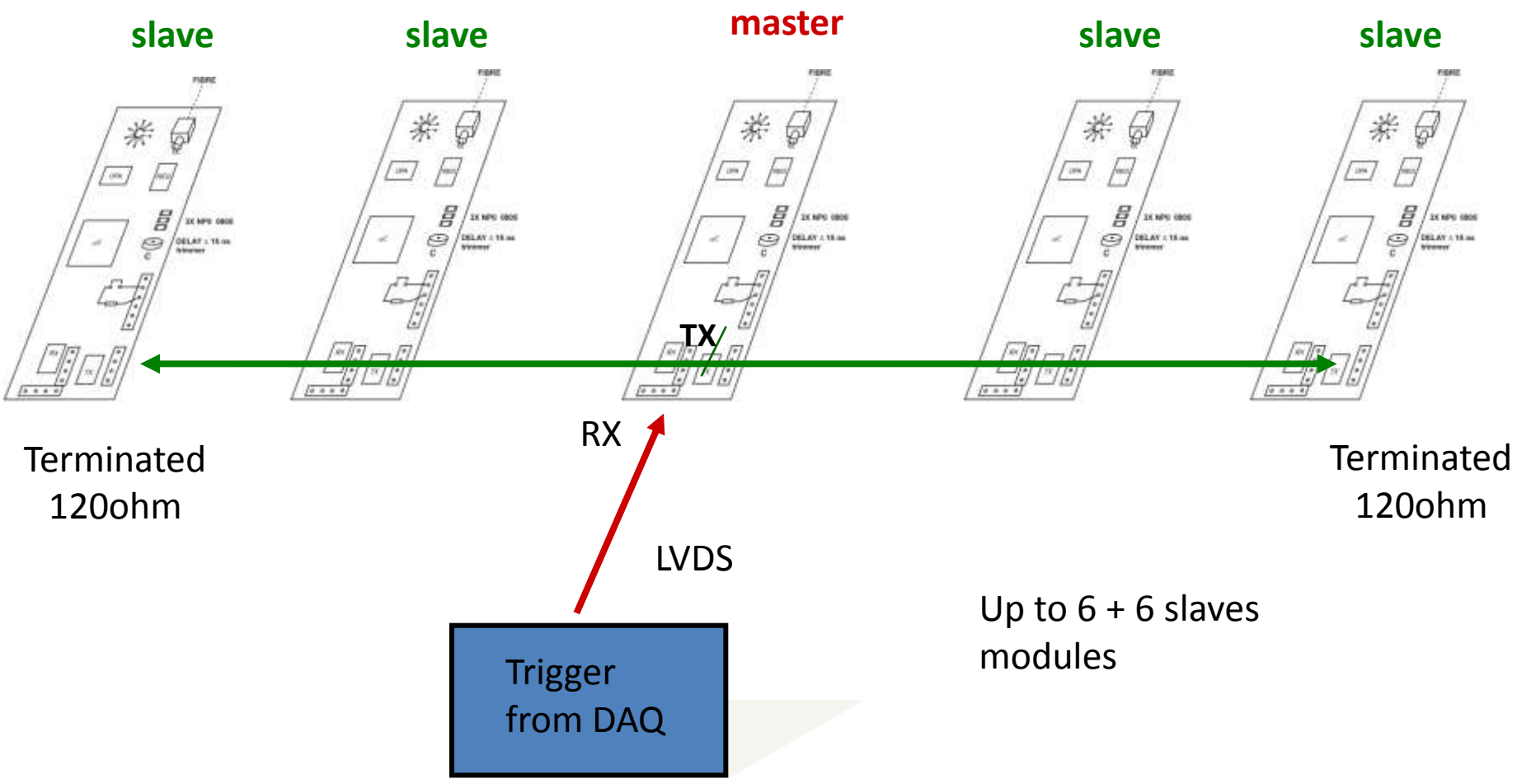


Principal schema

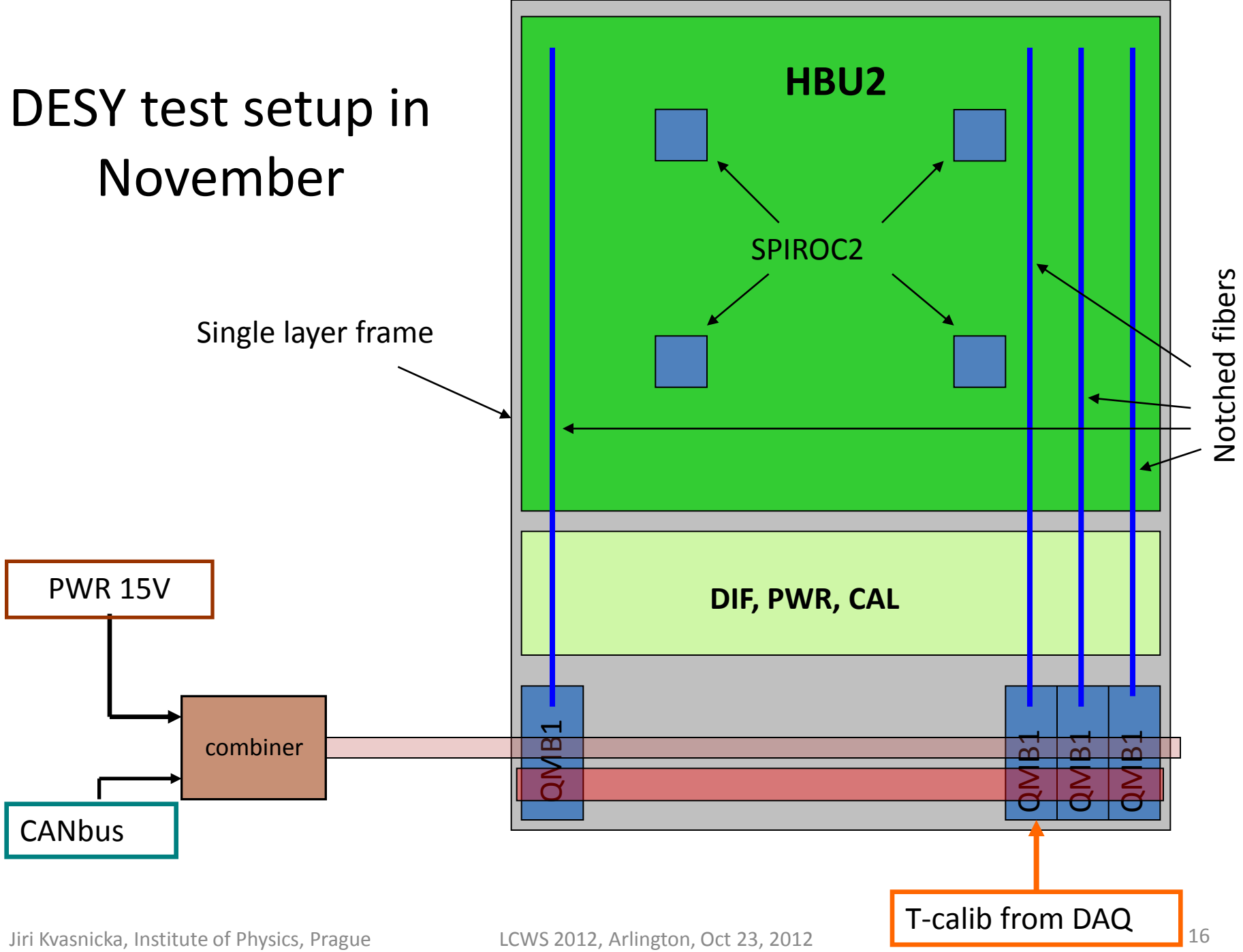


Larger inductor than the older QMB6

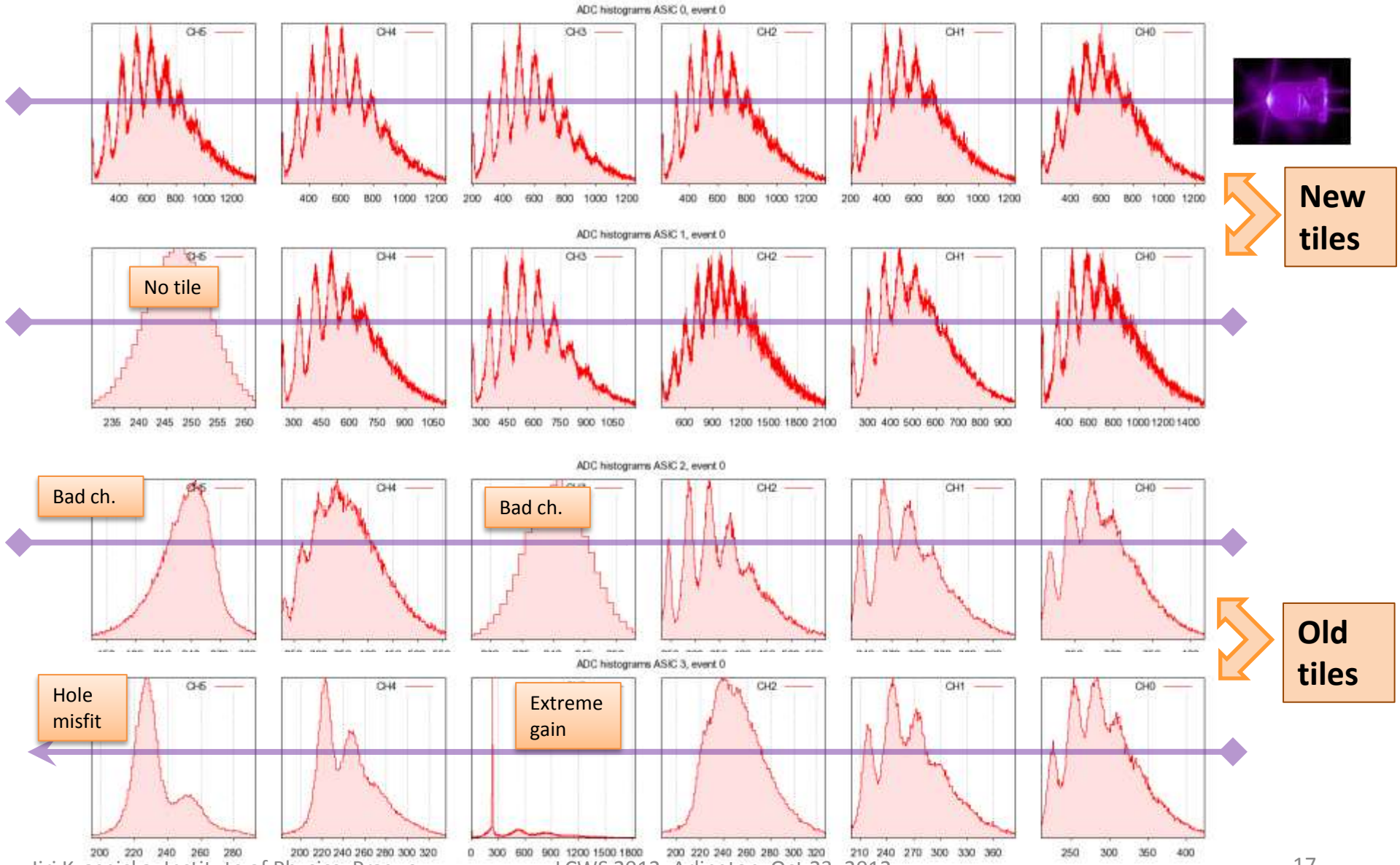
TRIGGER (T-calib) LVDS distribution to QMB1



DESY test setup in November



High Gain pixel spectra, auto scaled



Notched fibers

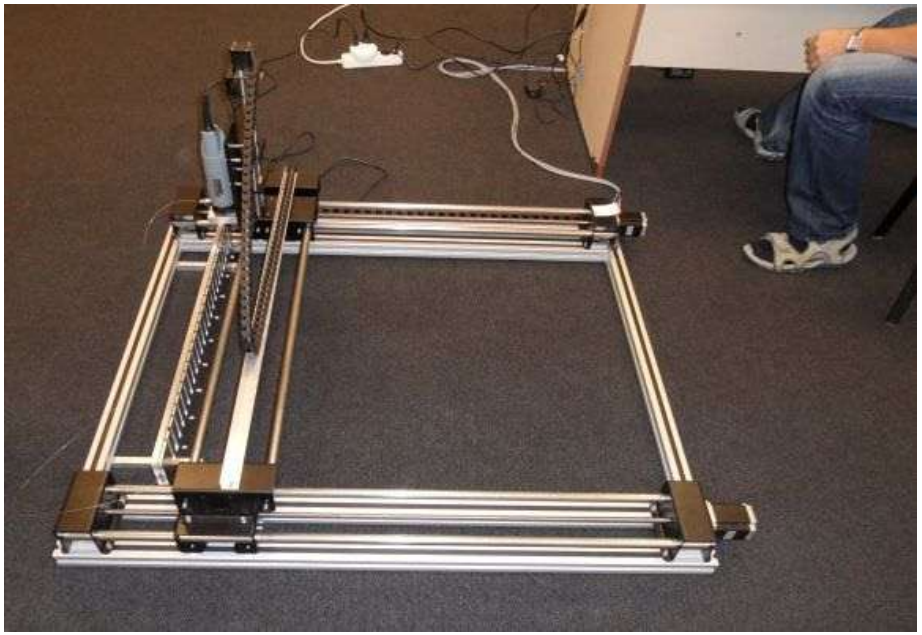
Semi-automatic tool

Now in operational debugging & SW development stage

Frame with x-y stepper motors

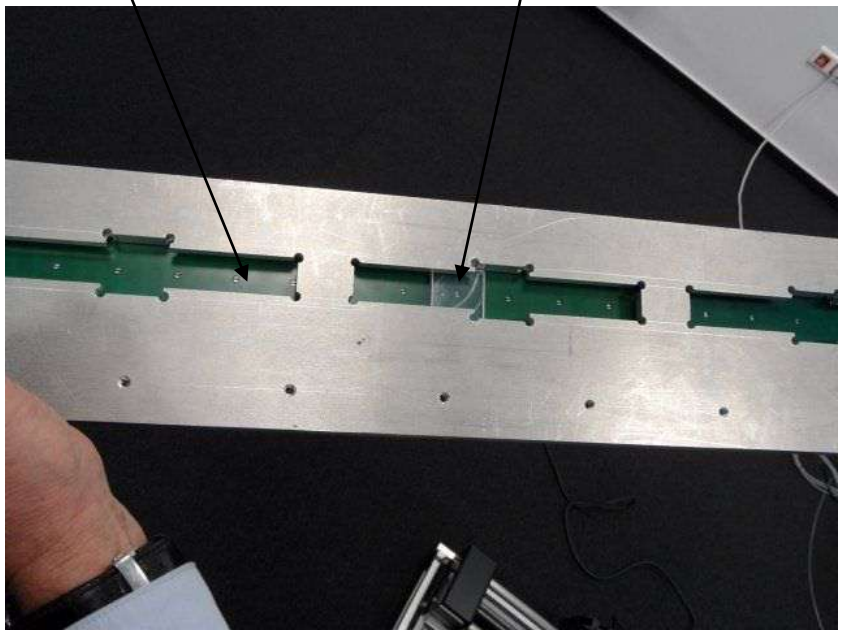
Drill machine used as milling cutter to groove the notch

Alu/PCB Template with moving scintillator tile



PCB with 3mm holes

Scintillator tile w SiPM

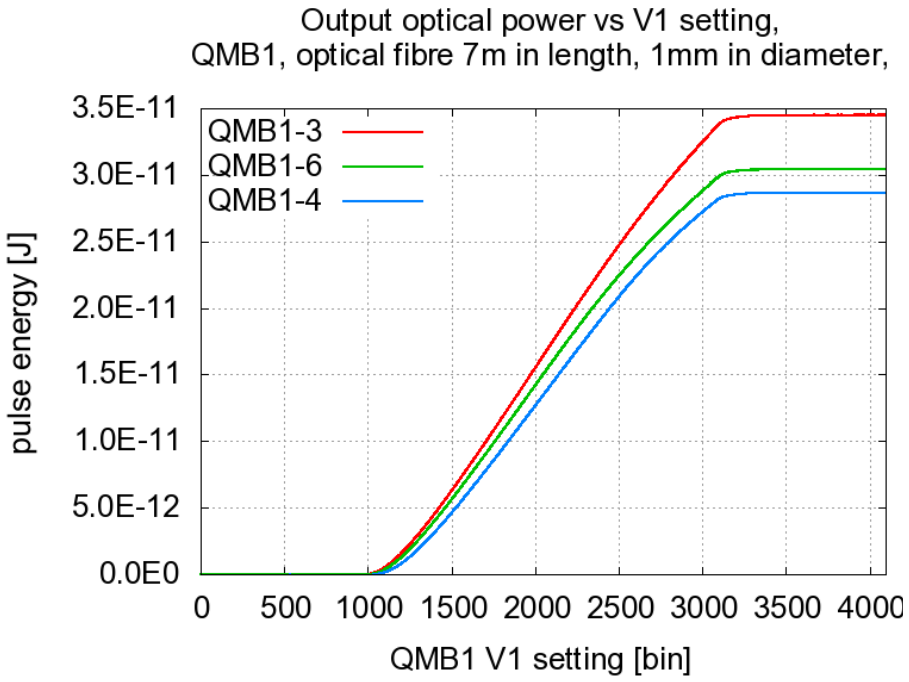


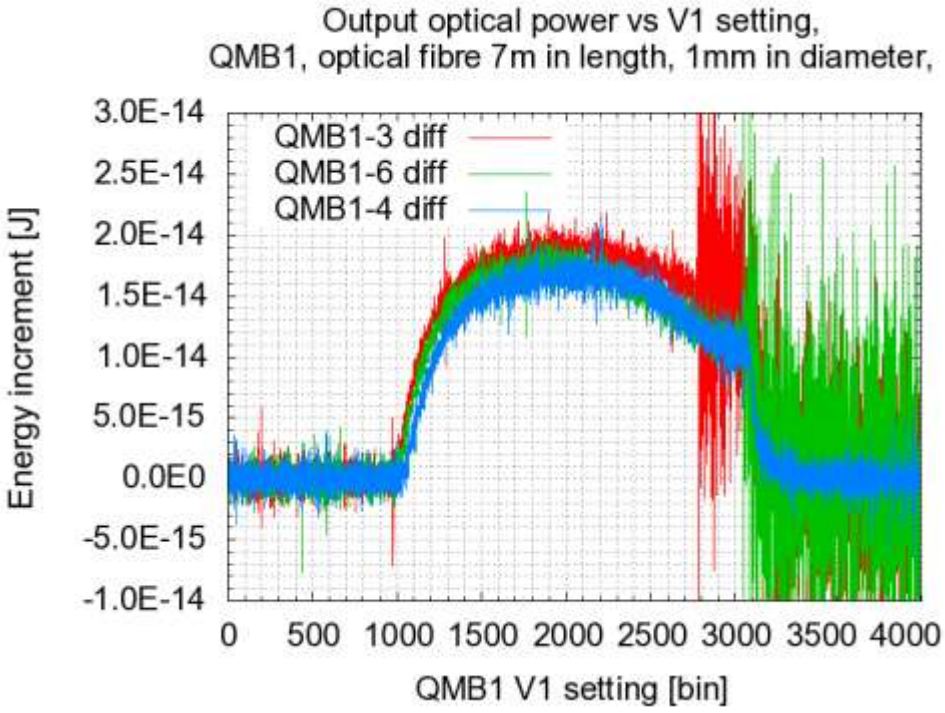
QMB1 linearity, amplitude scan

Standard LED pulses 3ns,

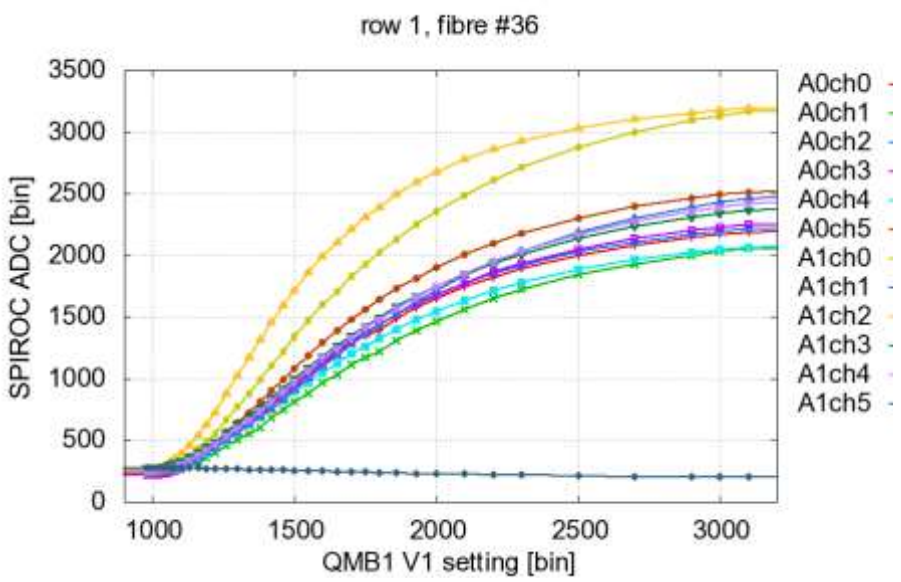
PWR measured by optical power meter ThorLabs PM100D

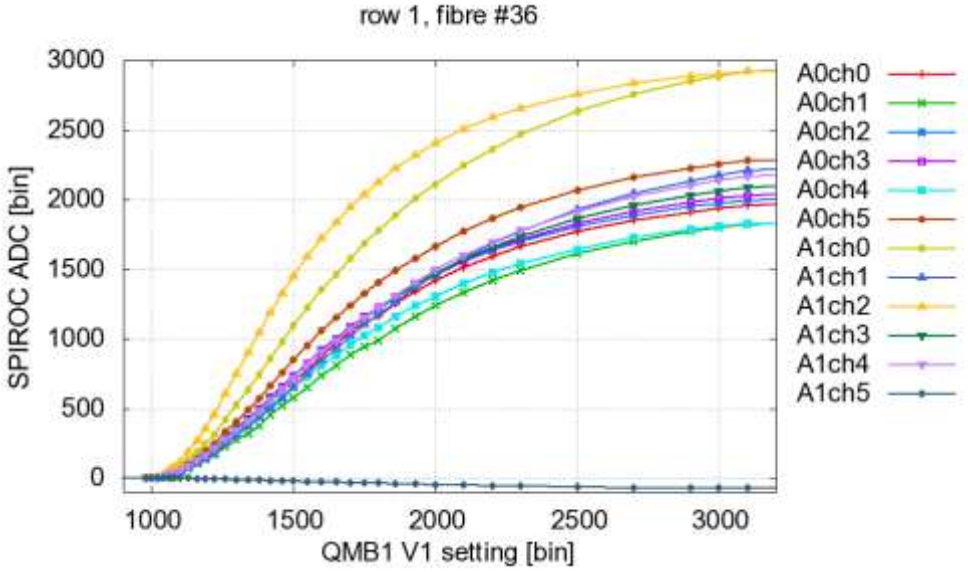
Differential Nonlinearity

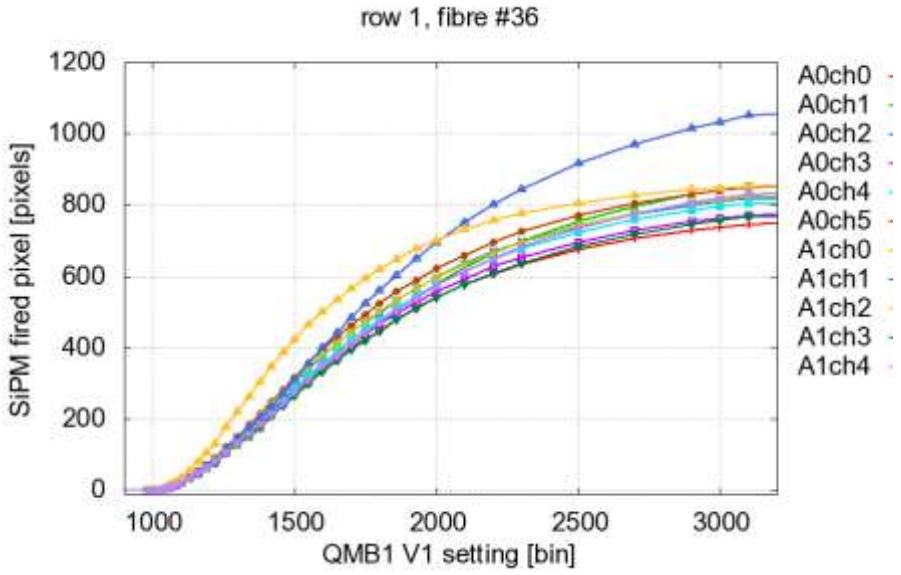


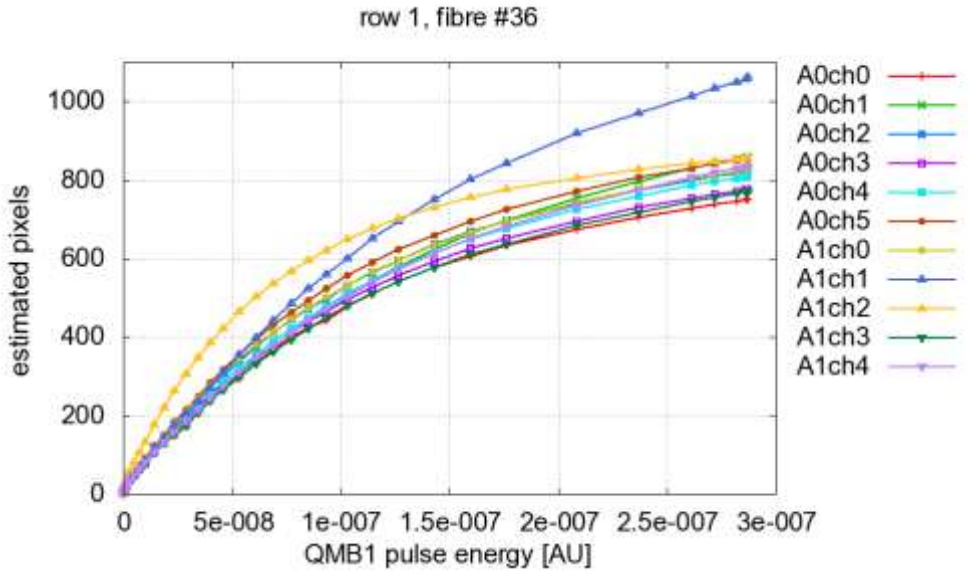


Saturation curves: procedure

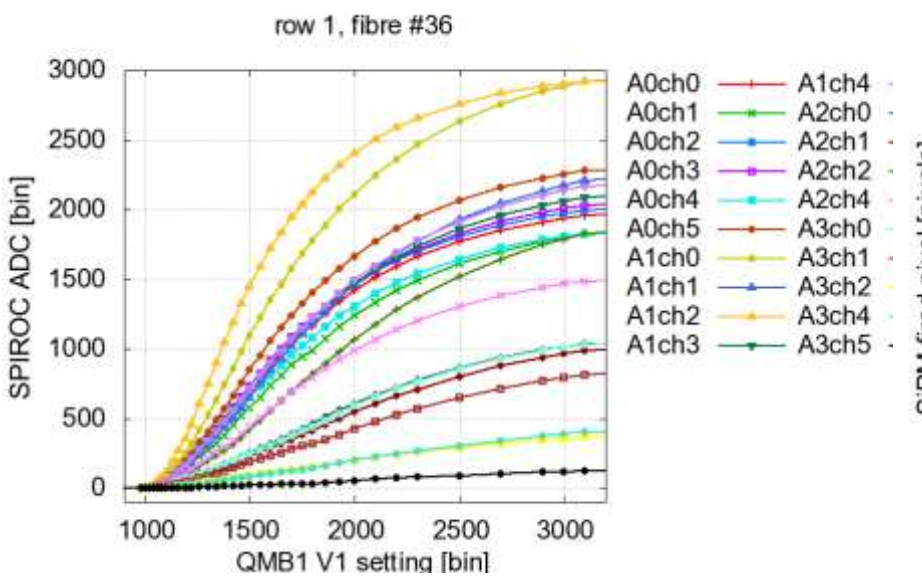


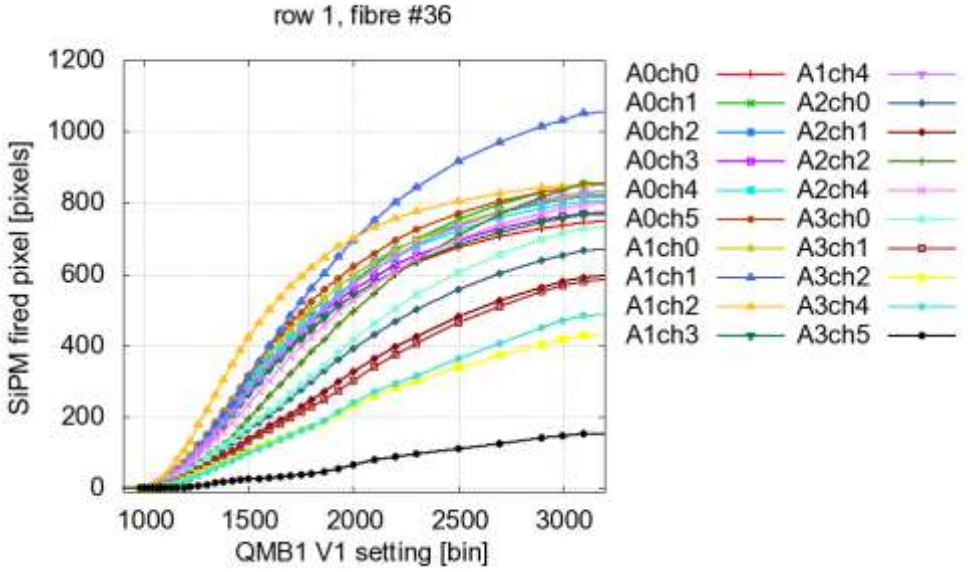


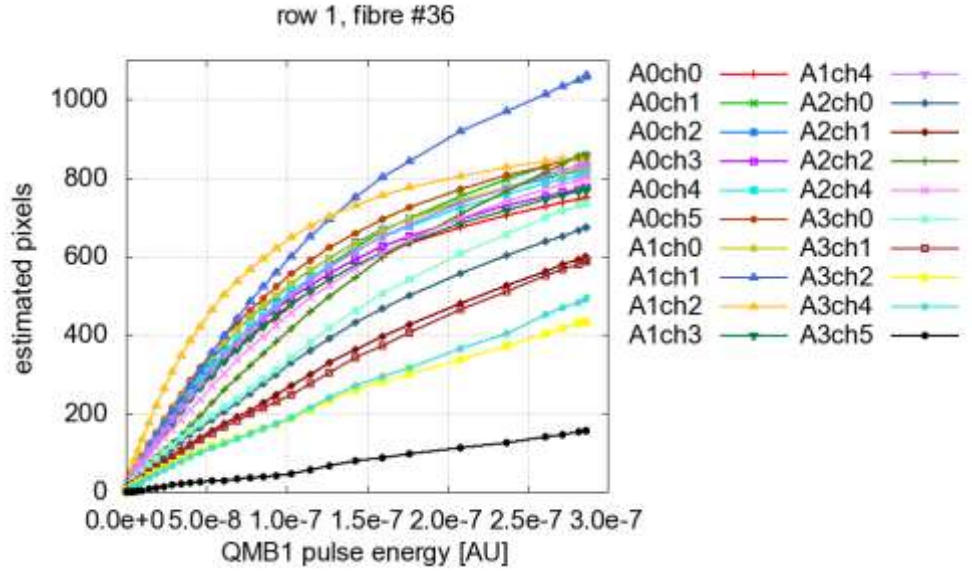




Saturation curves: All HBUs

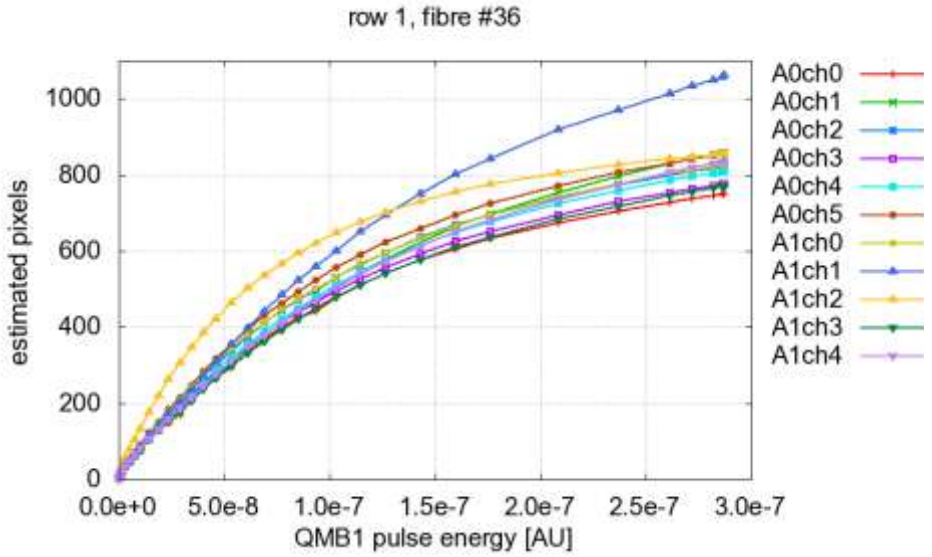


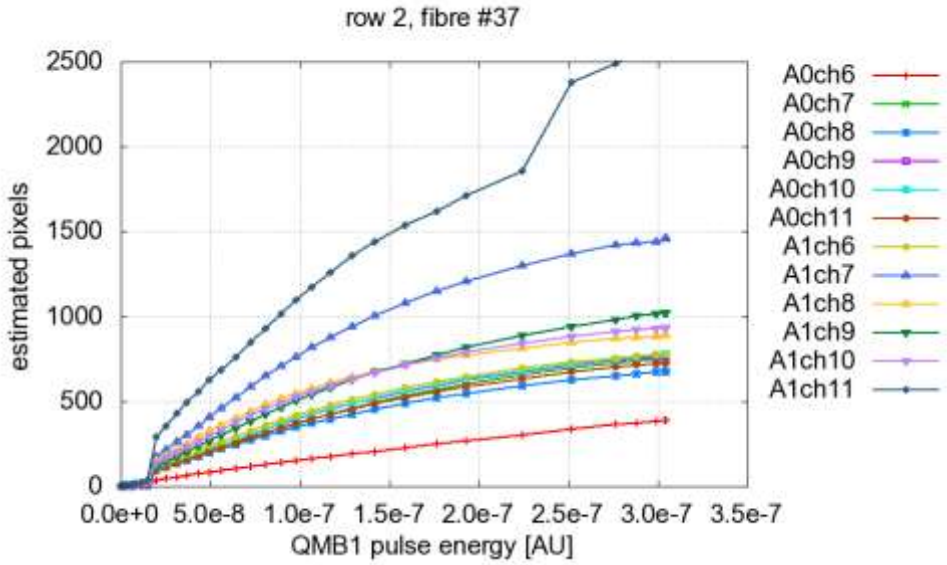


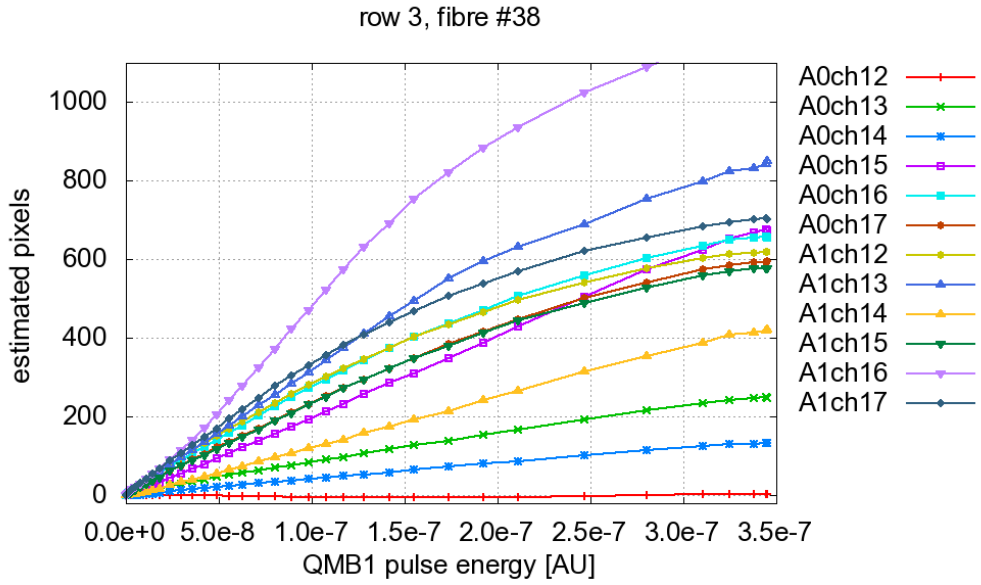


- scaling factor HG/LG ~40
- OLD HBU: asics A2 and A3
- Performance of 'OLD' HBU card much worse, no saturation reached

Saturation curves: All rows

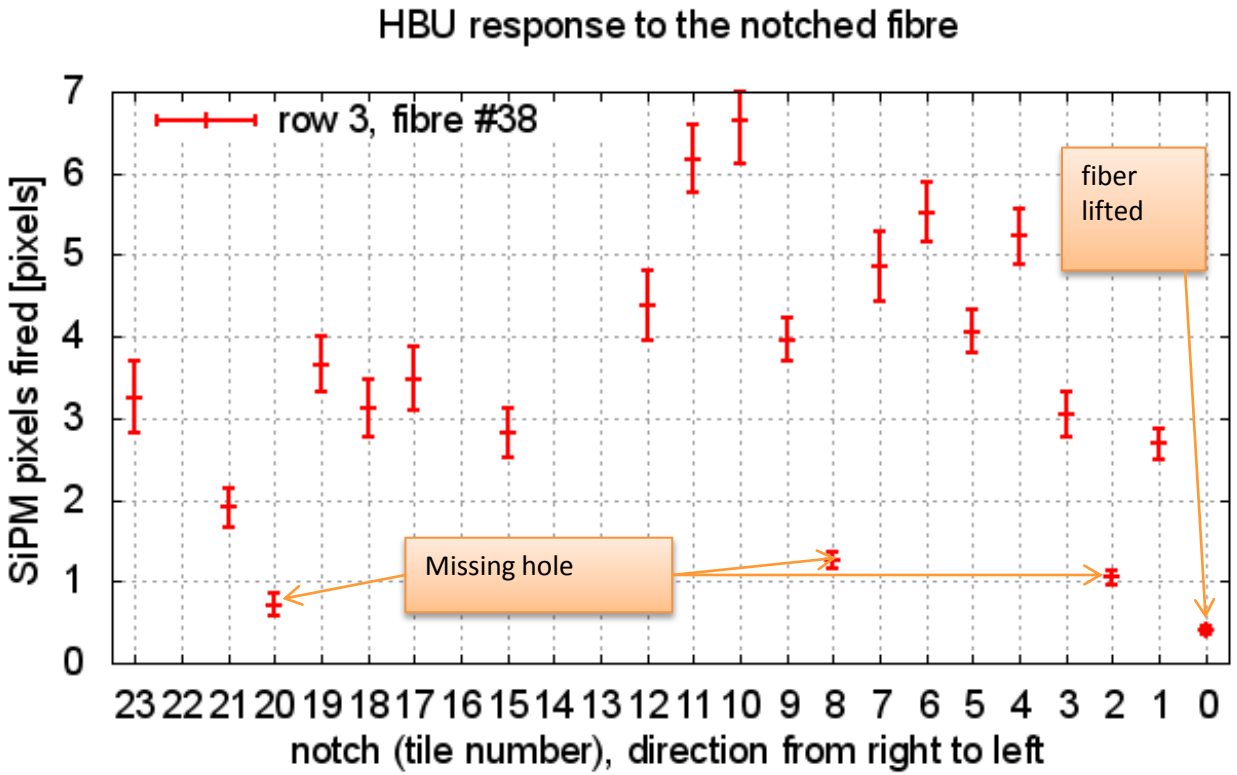






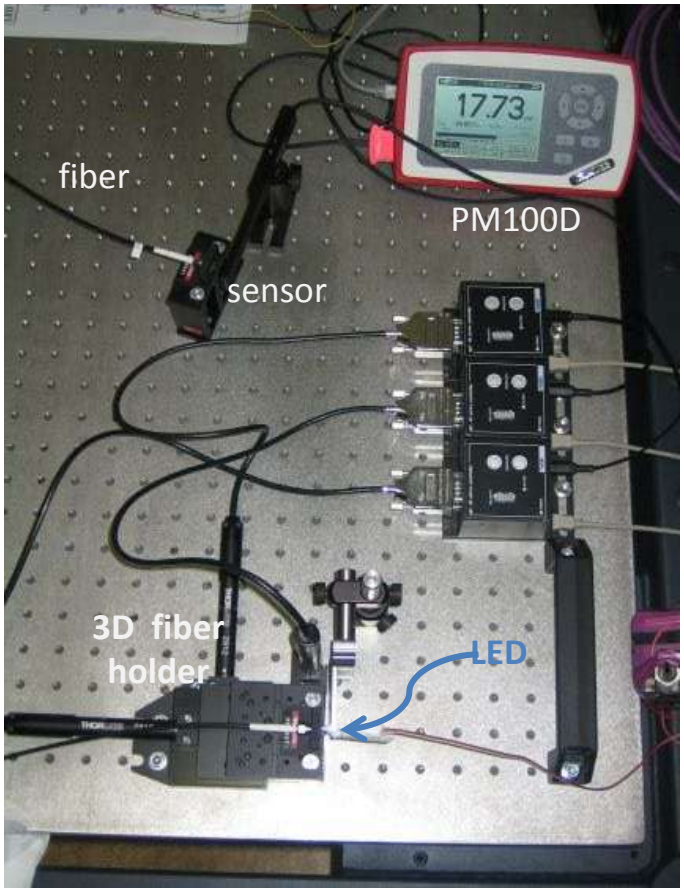
- Response variation for fibers
- 1st (outermost) best
- 2nd some problem with resetting of card slow control
- 3rd problems with fiber routing, misalignment of fiber notch and holes in HBU PCB

Notch light homogeneity - row 3



Light coupling

Test setup



3mm LED