Optical Fiber Calibration System and **Adaptive Power Supply**

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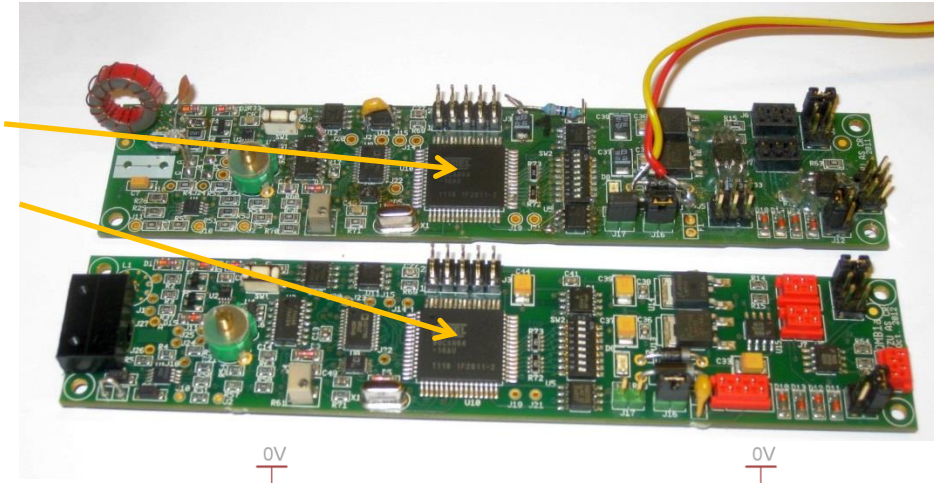
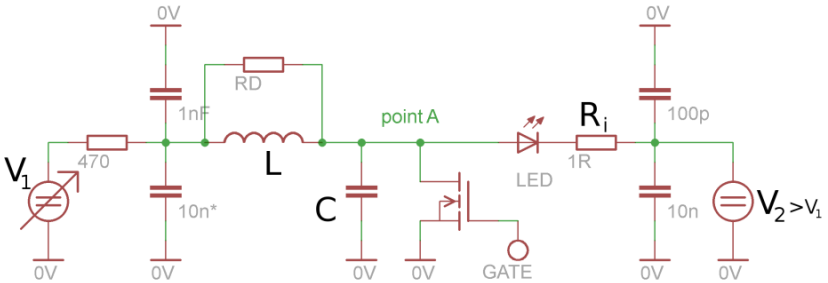
Introduction

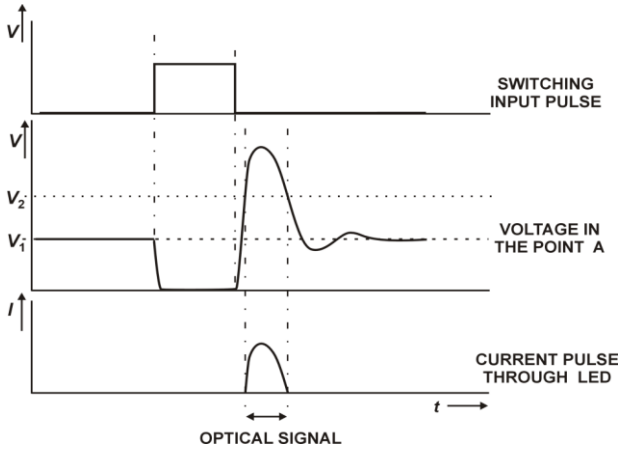
- The **A**nalogue **H**adron **CAL**orimeter
  - Physics prototype: 7608 channels with SiPMs
  - Ultimately: 8 millions of channels
  - Details → see talk by Oskar Hartbrich
- Challenge: **calibration**
  - short (<7ns) light pulses, tunable amplitude
  - Physics prototype
    - CMB (1 LED drives 19 optical fibers, 1 fiber illuminates 1 scintillator tile)
  - Engineering prototype
    - **Integrated** on HBU – 1 LED per 1 tile
    - **External option** – currently developed Quasi-resonant LED driver: QMB1A
      - Optical signal is transferred and distributed by the notched fibers
      - 3 fibers connected to 1 LED per
      - **1 notched optical fiber** illuminates 24 scintillating tiles
    - Details on electronics perspective → see my talk from last LCWS
- Another task (AIDA): SiPM gain stabilization (ADApower board)
  - Electronic details will be shown.
  - Experimental results → next talk by Gerald Eigen

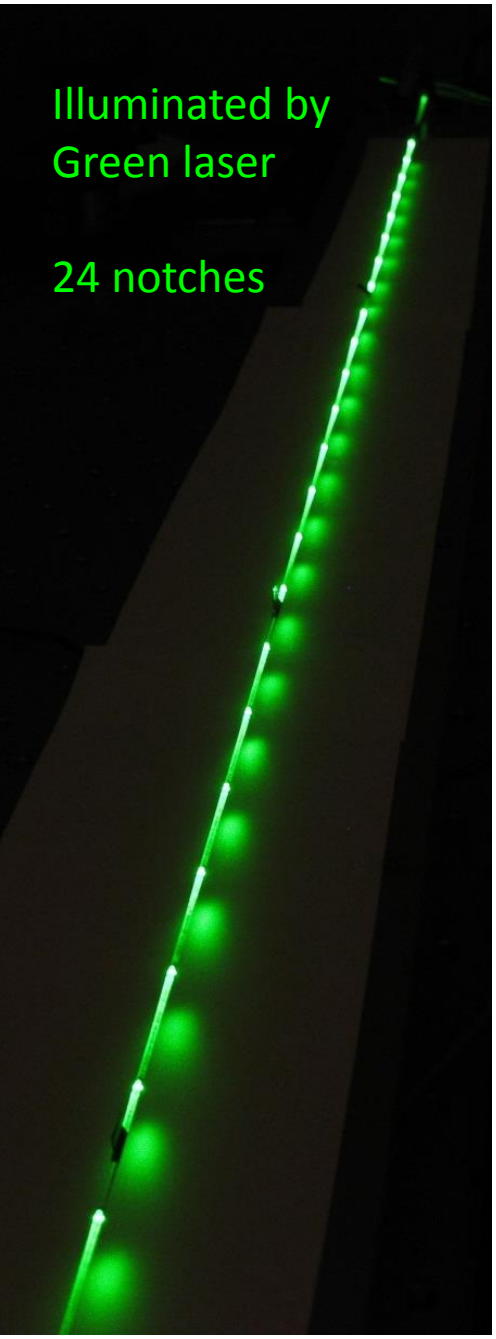
The LED driver – QMB1

- Quasi-Resonant LED driver
- Modular system
- Dec 2012: **QMB1a**
  - External coil pads (for ~30 ns pulses)
  - New connectors, minor changes for higher repetition rates and shorter pulses
  - Boards are performing well
  - Performance measurements ongoing
- Main parameters:
  - Smooth pulse shape (half-sine shape)
  - Variable amplitude (~1A peak)
  - Repetition rate up to 100 kHz
  - Fixed pulse width (2.4–3.5 ns)
  - PCB size 30 × 140 mm2



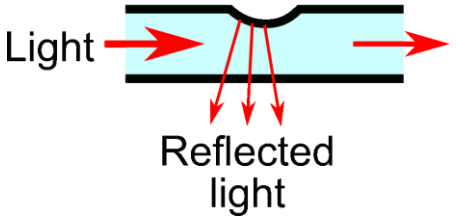




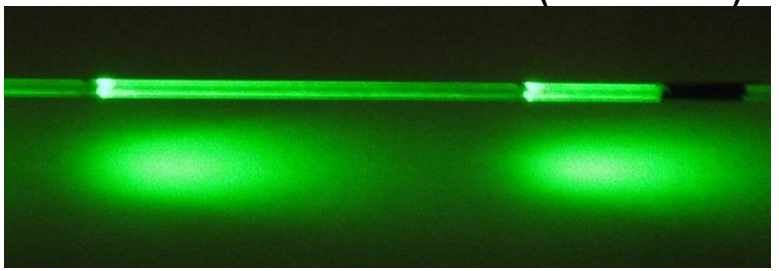


Distribution of light: Notched fiber

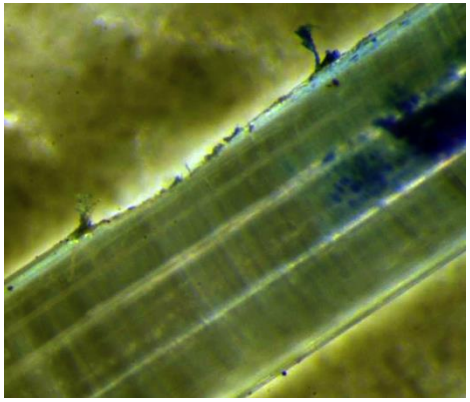
- Plastic optical fiber, 1 mm in diameter
- Light is emitted from the **notches**
- The **notch** is a special scratch to the fiber, which reflects the light to the opposite direction
- The size of the notch varies from the beginning to the end of the fiber to maintain homogeneity of the light emitted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



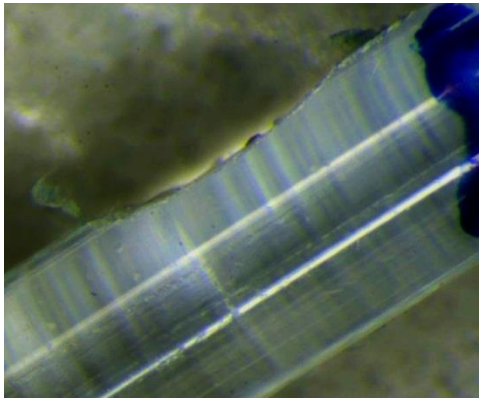
Emission from the fiber (side view)



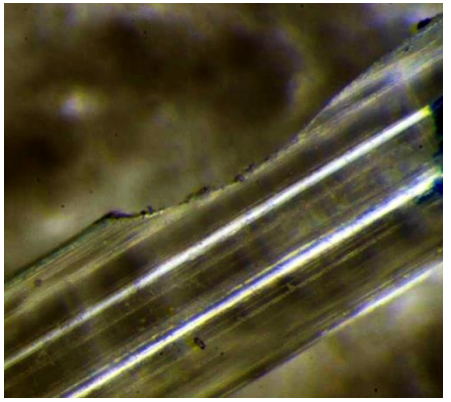
First notch



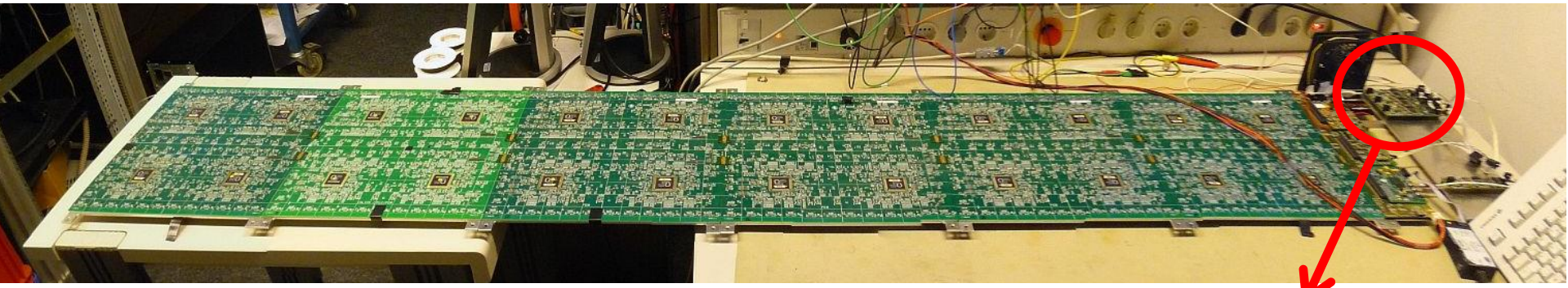
Middle notch



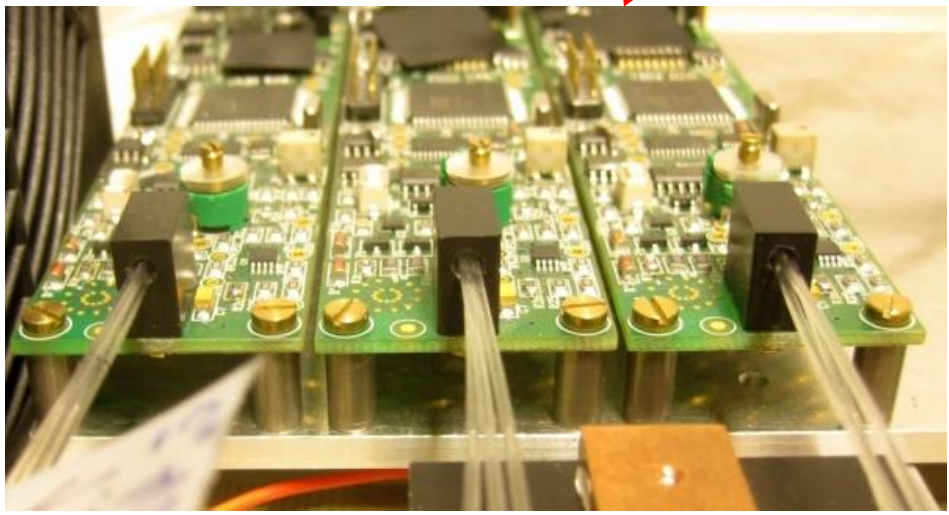
End position notch

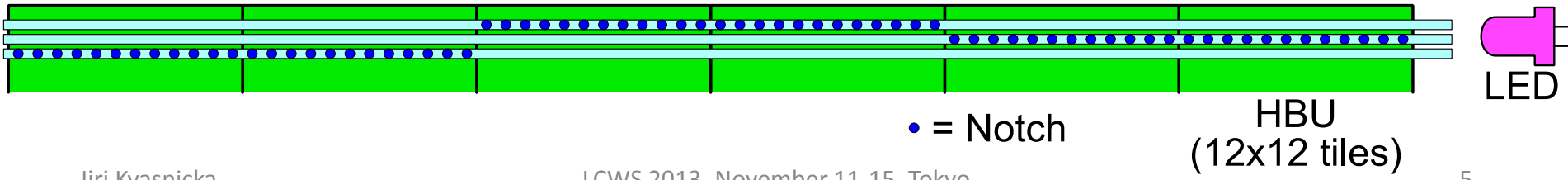


6-HBU setup



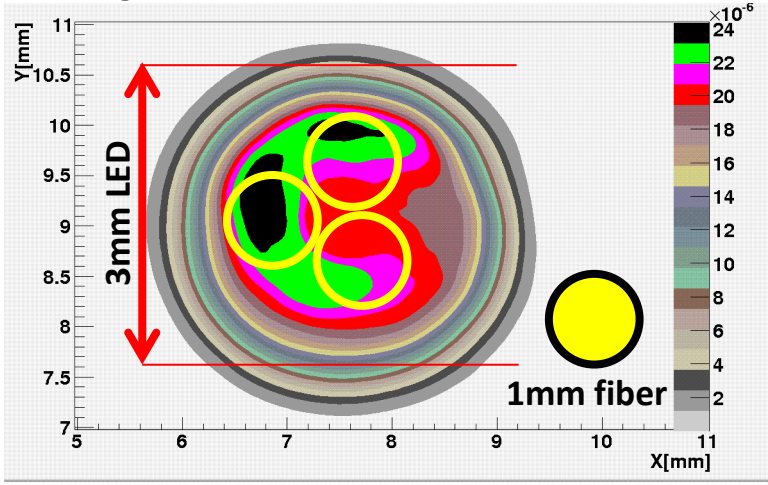
- Full setup with 6 HBU (2.2 m of electronics!)
- Data readout from all HBUs very stable
  - only 5 HBU equipped with tiles
- 3 row of tiles (3×72 tiles) illuminated by notched fibers and QMB1 LED drivers
- 1 row of tiles was illuminated by 1 QMB1 and 3 fibers (each fiber has 24 notches) → fiber triplet bundle (see next slide)
- SiPM biasing not fine tuned

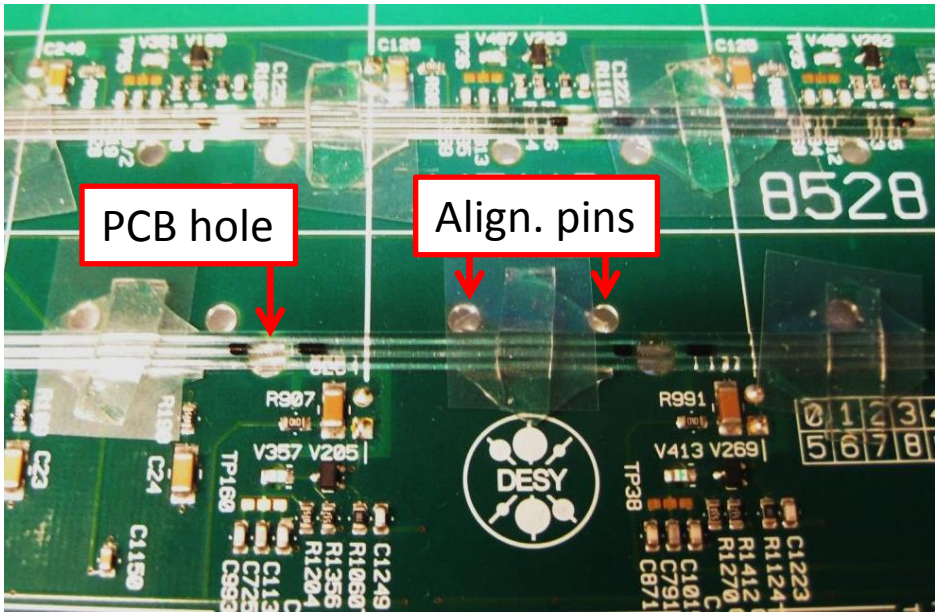


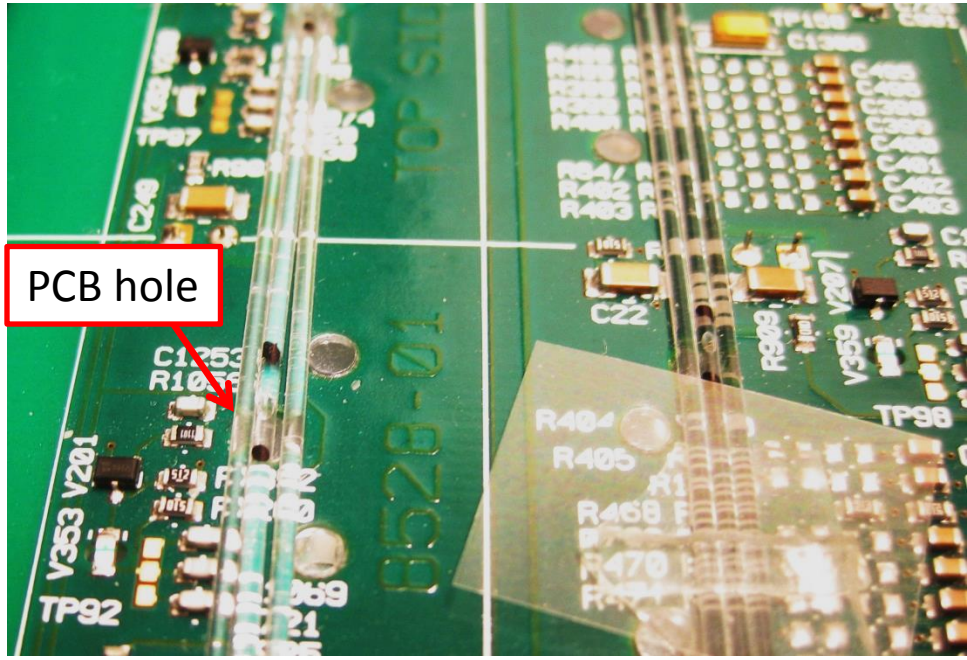


Notched fiber triplet

- Why 3 fibers with 24 notches instead of 1 fiber with 72 notches?
  - 24 notches can be produced with better precision
  - The manufacturer has a semi-automatic machine for 24-notched fibers
  - Figure: light collection vs. 1mm fiber position
- "Glued" manually by a TESA stickers
  - Stable for testing
  - **Not usable for the production** (it took us almost a day to install and de-install the fibers)

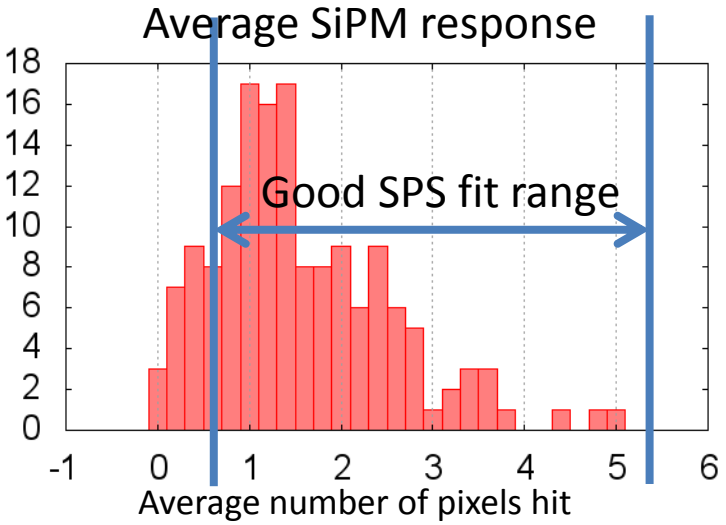


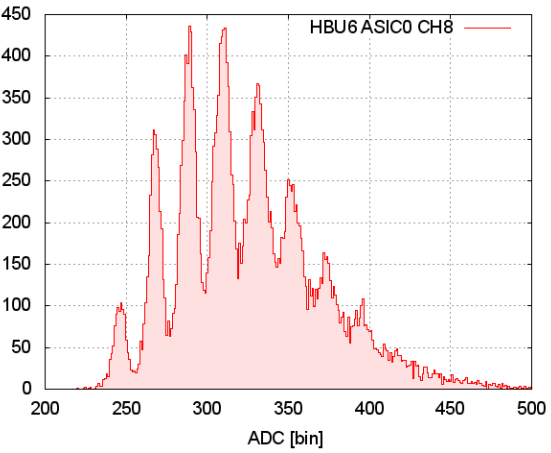




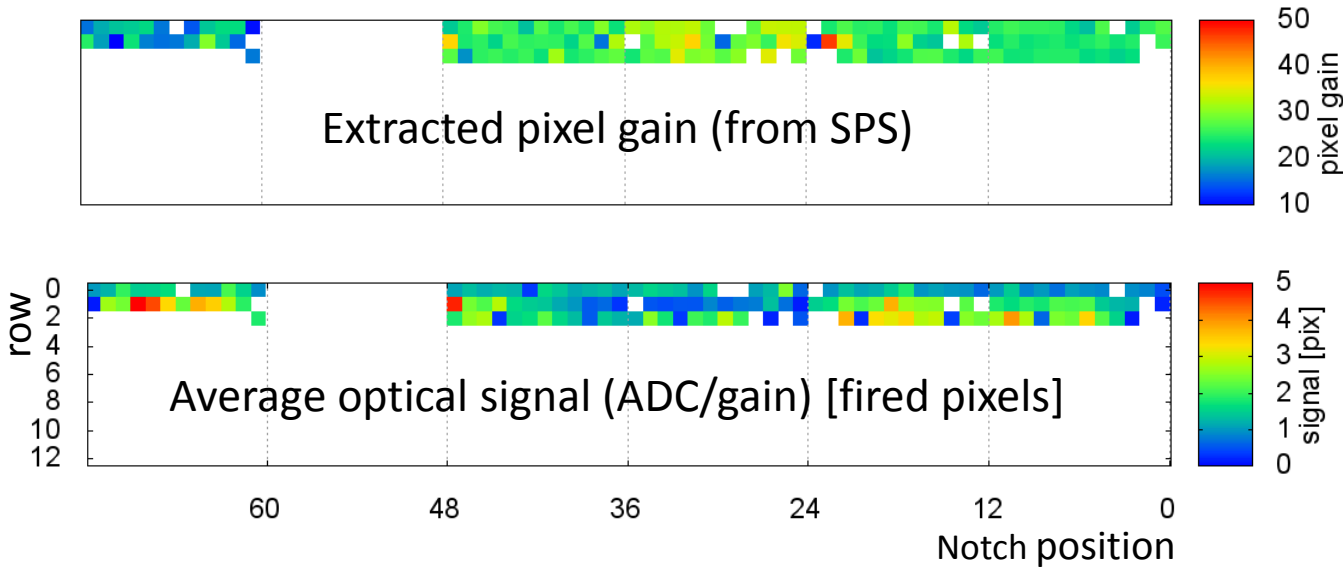
Results

- 153 working tiles (90.5% of assembled tiles)
- Gain was extracted from SPS, good fit with signal within 0.5–5 pixels range (noise-free channels even larger signal)
- Gain extraction successful for 92% of the tiles within a single run
- Some channels needed more light (especially tiles without holes in the PCB for the fiber)



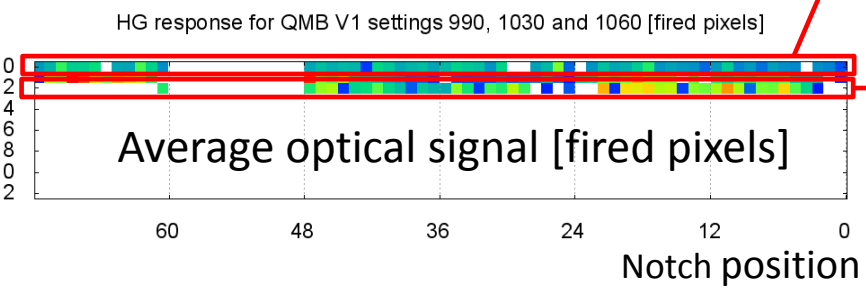


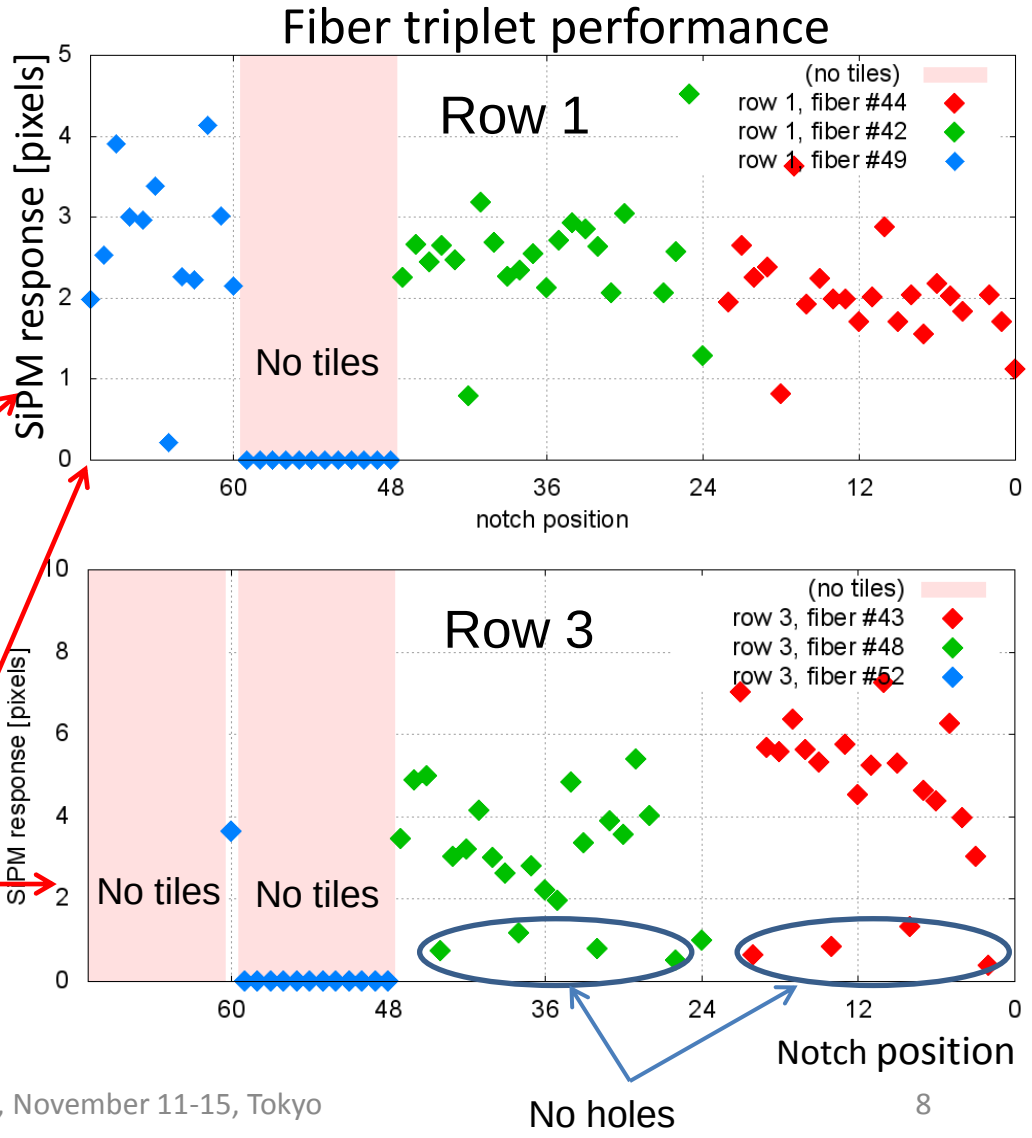
One of the best SPS



Notched fiber performance

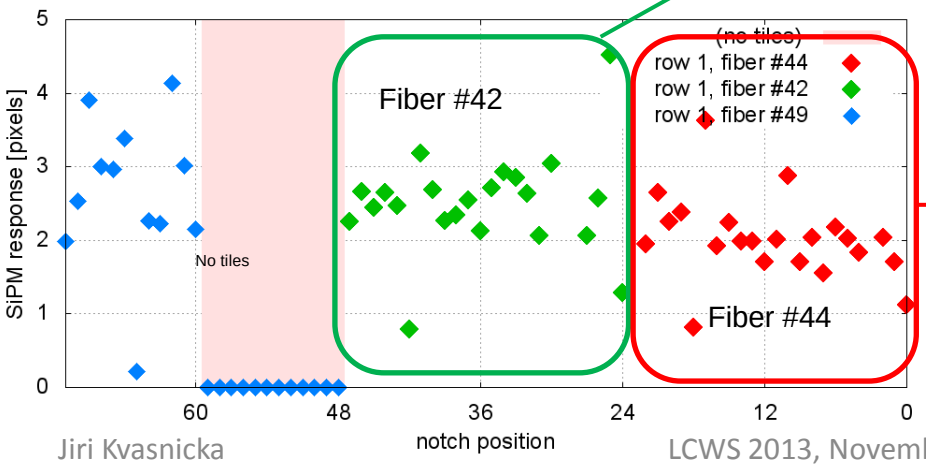
- First test with fiber triplets (2.2m total length)
- Fiber prototypes used, which have quality issues (personal changes at manufacturer)
- Light output along the fibers shown
- Missing holes in the PCB (due to ASIC) clearly seen, but still got some light from reflection

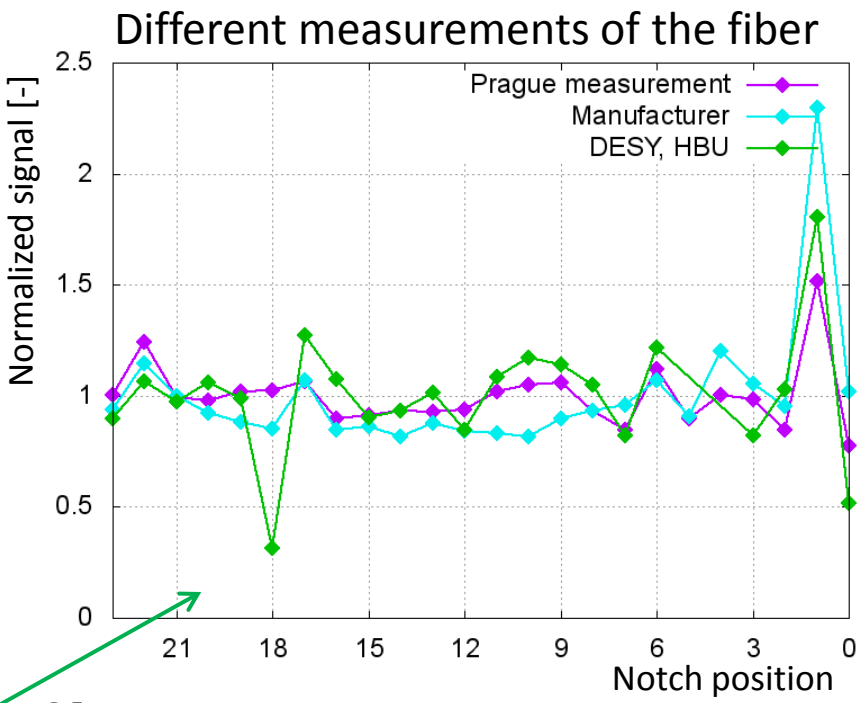


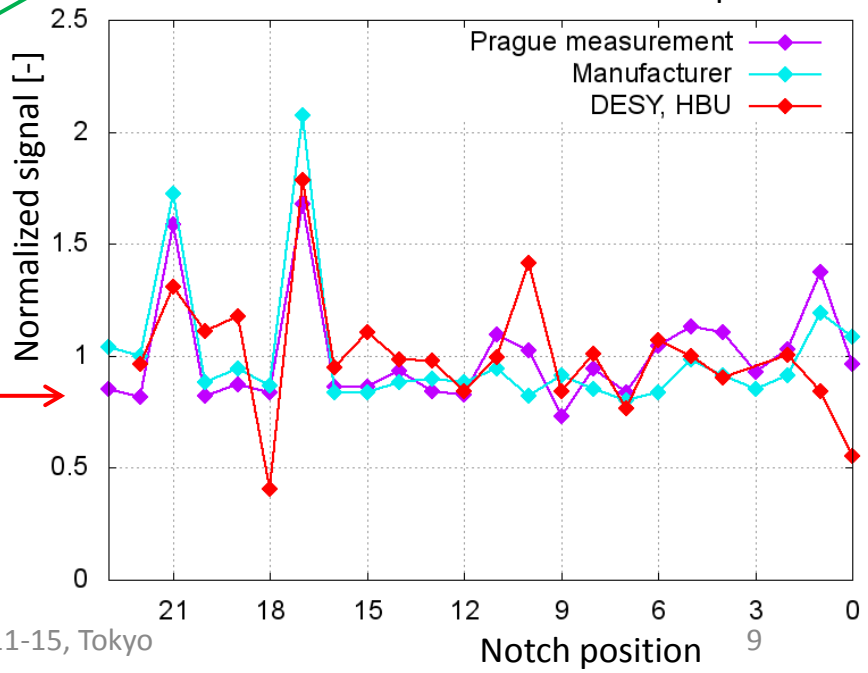


Fiber performance (2)

- Fibers were measured:
  - During manufacturing
  - In our institute Lab
  - At DESY on HBU
- We finally came to measurements agreement
- Some troubles at the starting point (systematically lower, because fiber is lifted due to the connector)
- Some points do not match (HBU vs. Lab) for unknown reason
- For the fiber production, notches will have <15% spread limit

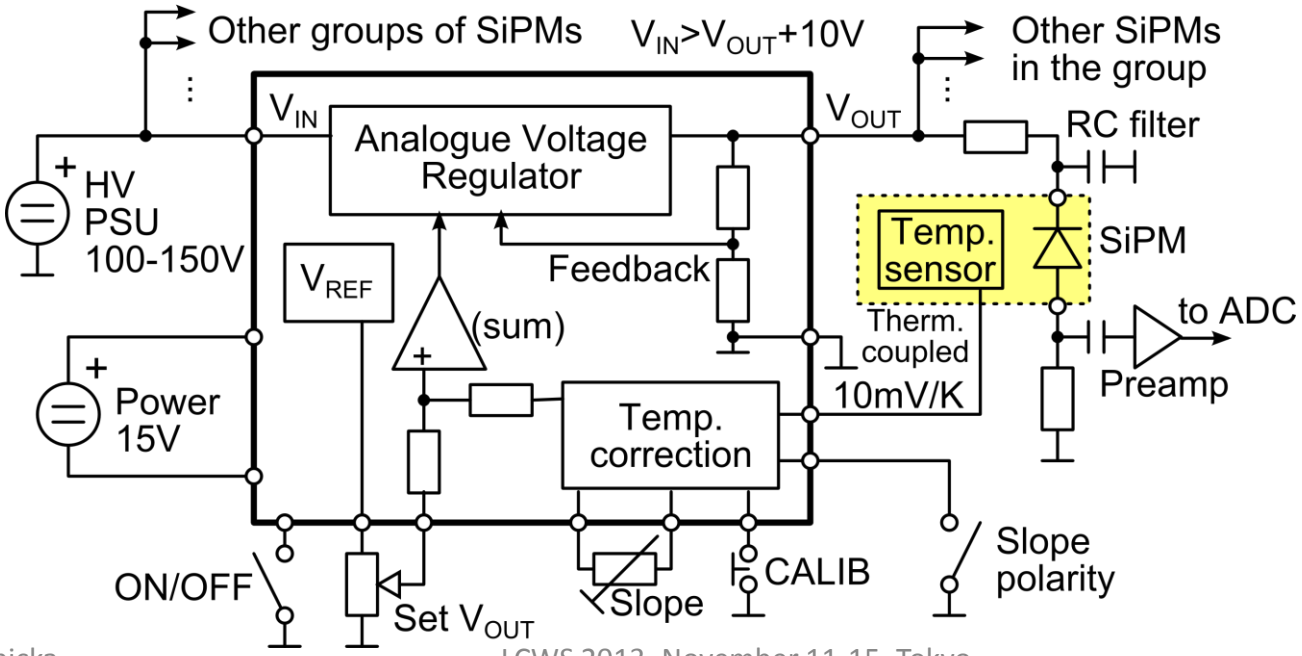




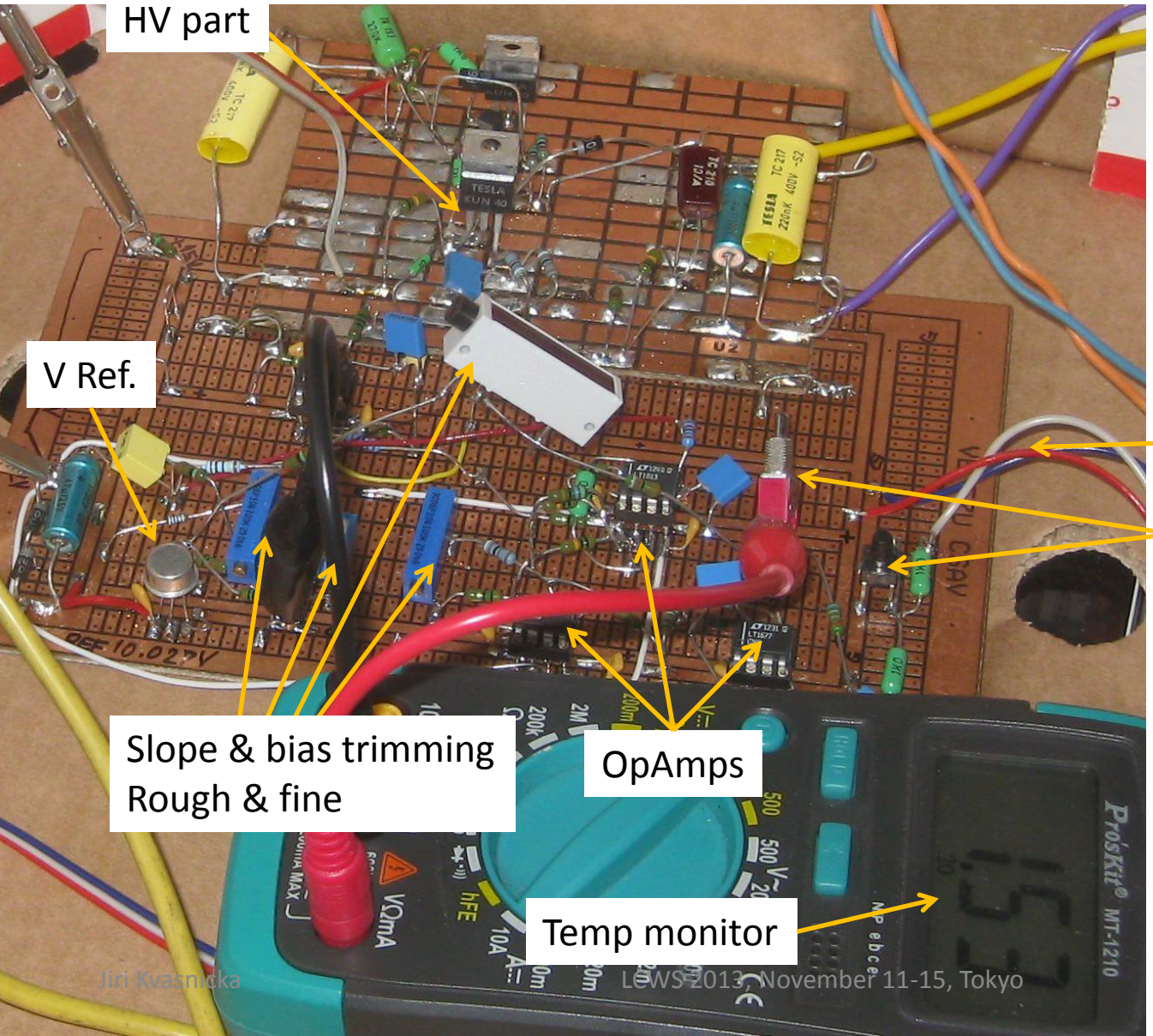


Adaptive Power Supply

- The gain of SiPM depends on bias voltage and temperature
- We want to keep gain constant → adjust bias according to temperature
- Goal: to build a regulator, that keeps the gain constant (<1%)
- Linear slope 1 to 100mV/K (measured @CERN – see G. Eigen's talk)
- Designed for positive compensation slope (dV/dT), negative possible
- V_{out}: 10 to 85 V
- Analog feedback. Temp sensor has to be thermally coupled



First ADApower testboard

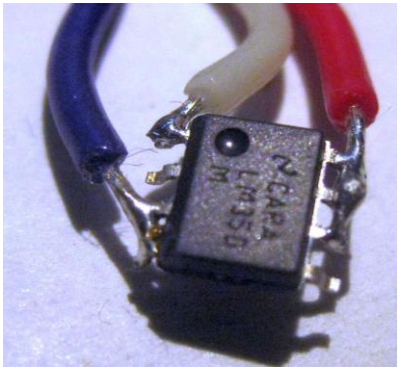


- Fully functional
- Complete Results: see talk by Gerald

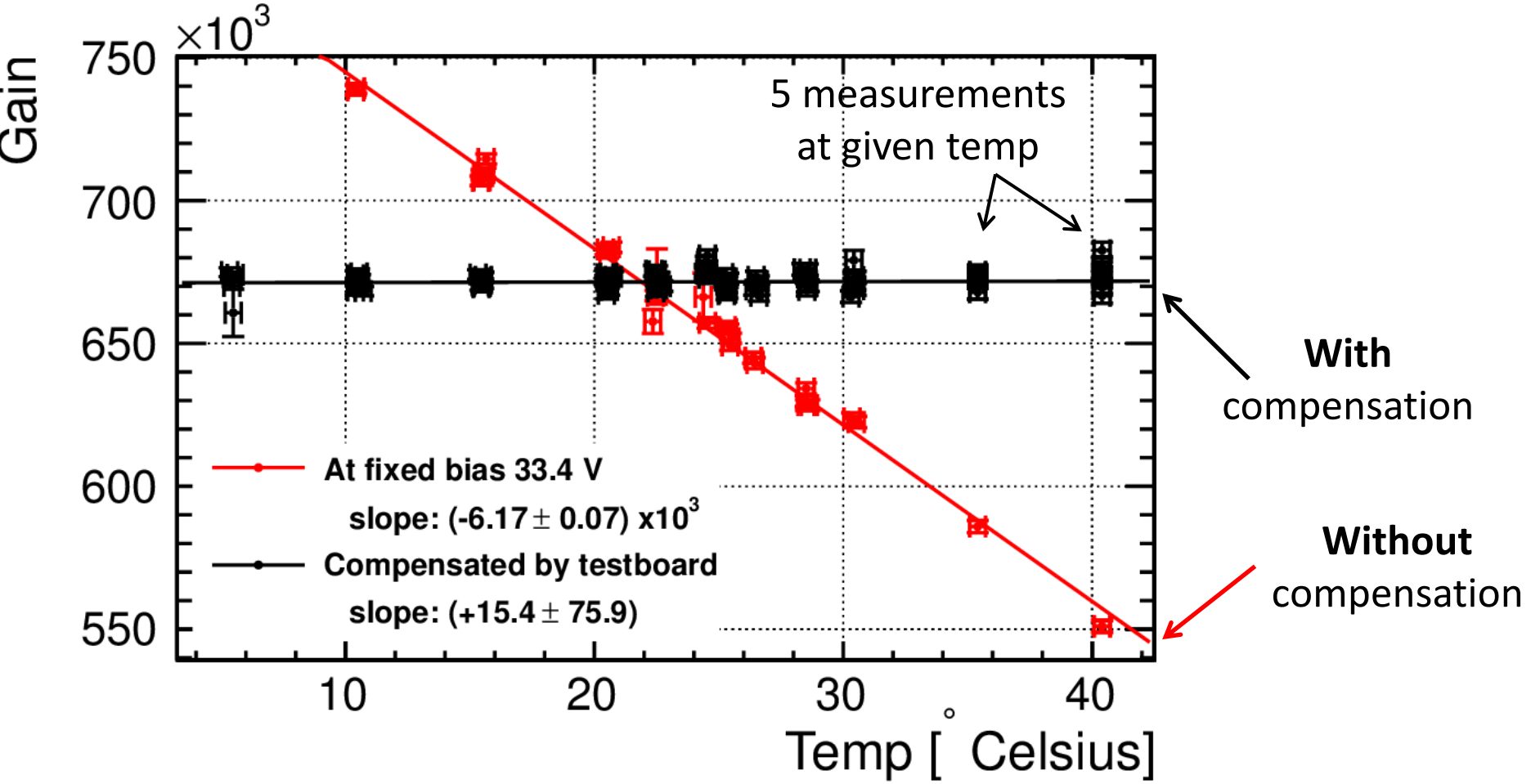
2m cable to temp. sensor

Switches for configuration

LM35D temp sensor
10 mV/°C



Results with the testboard



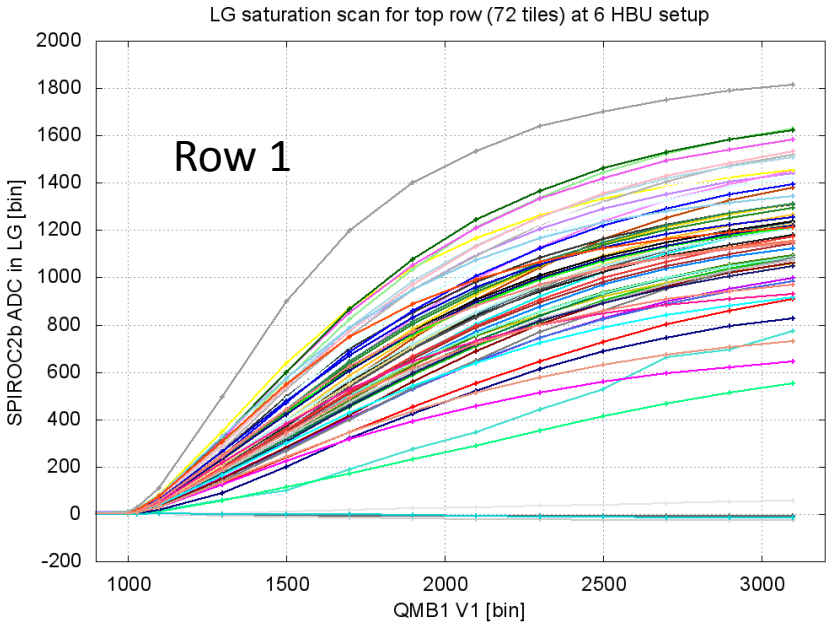
Summary

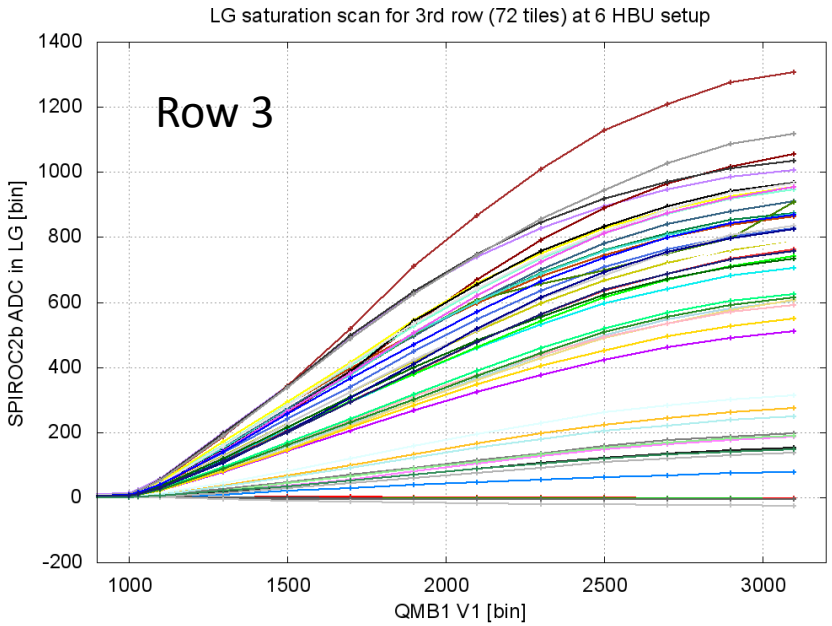
- We have illuminated the full length of the 6-HBU setup by the LEDs
  - Setup worked smoothly and stable
  - First test of full length illumination (72 tiles) by a single LED and 3 notched fibers
  - Beautiful Single Pixel Spectra taken
    - Gain extracted for 92% of tiles in a single run
    - Some channels required more light for gain extraction (no holes in PCB, fiber lifted
  - SiPM saturation seen
  - Fiber to HBU gluing tuned
    - Good for tests
    - Not suitable for production – high assemble time
- Adaptive power supply for SiPM was developed and tested
  - Functionality proven with the test circuit
  - Prototype is expected to be manufactured in December 2013
  - Current phase – PCB design & components final selection and ordering

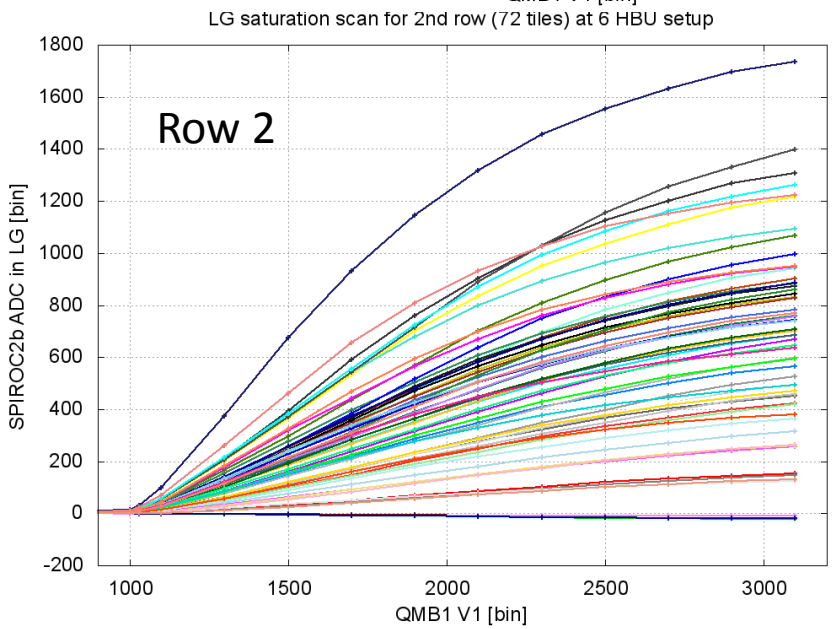
Backup slides

Saturation curves

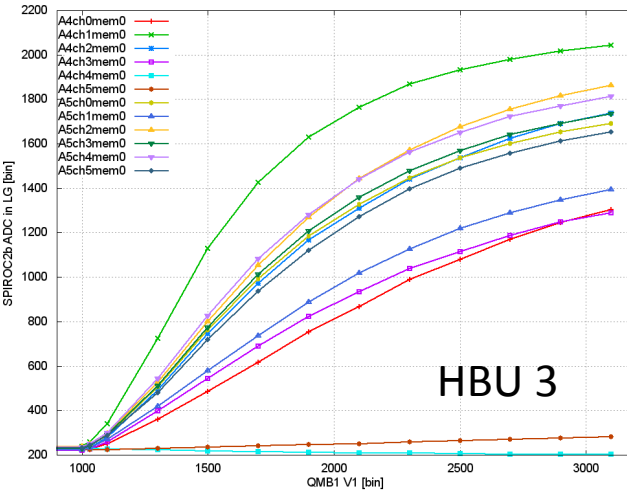
- Each row: 3 fibers

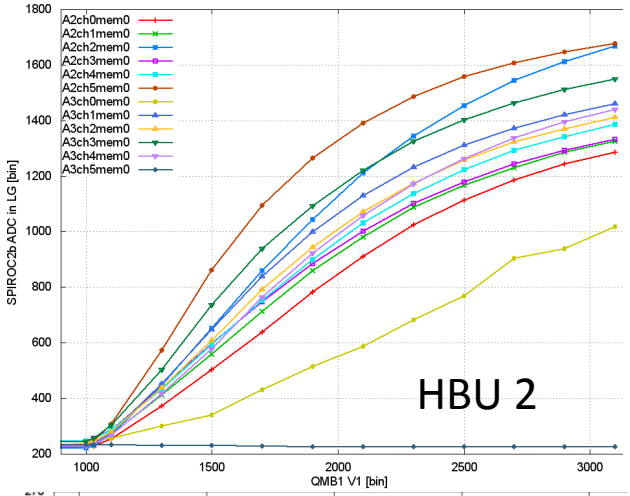


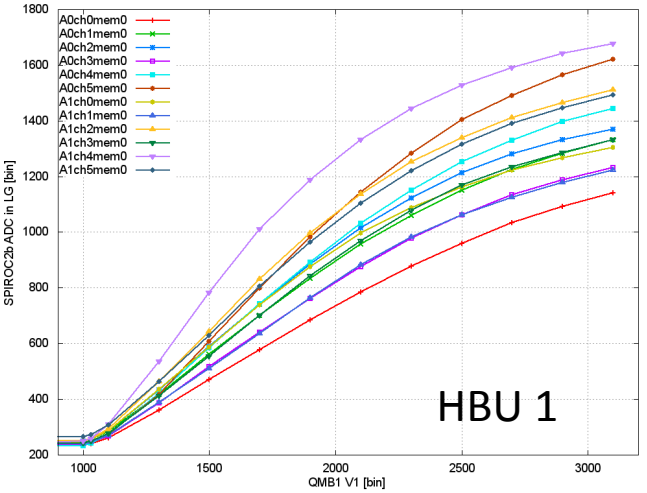


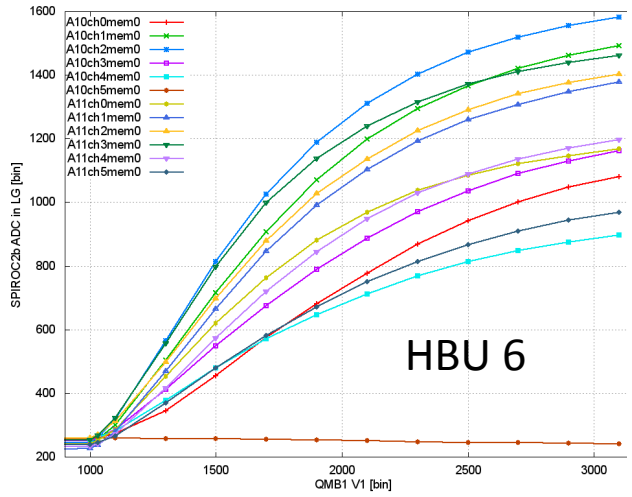


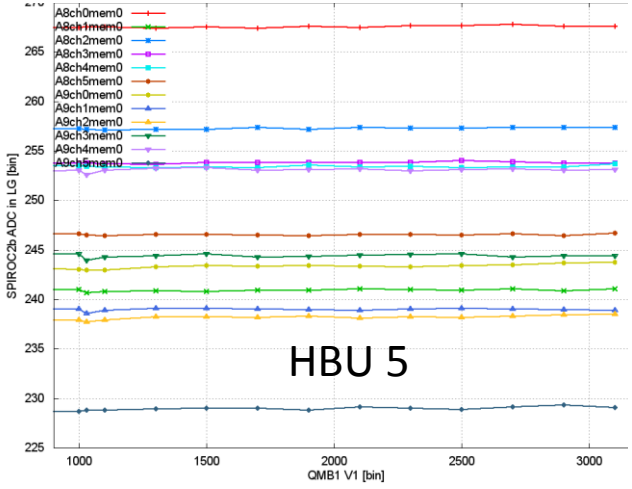
Saturation curves of row1

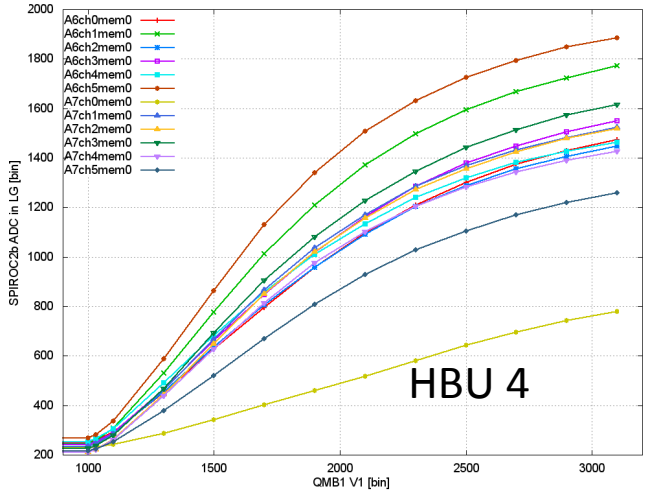


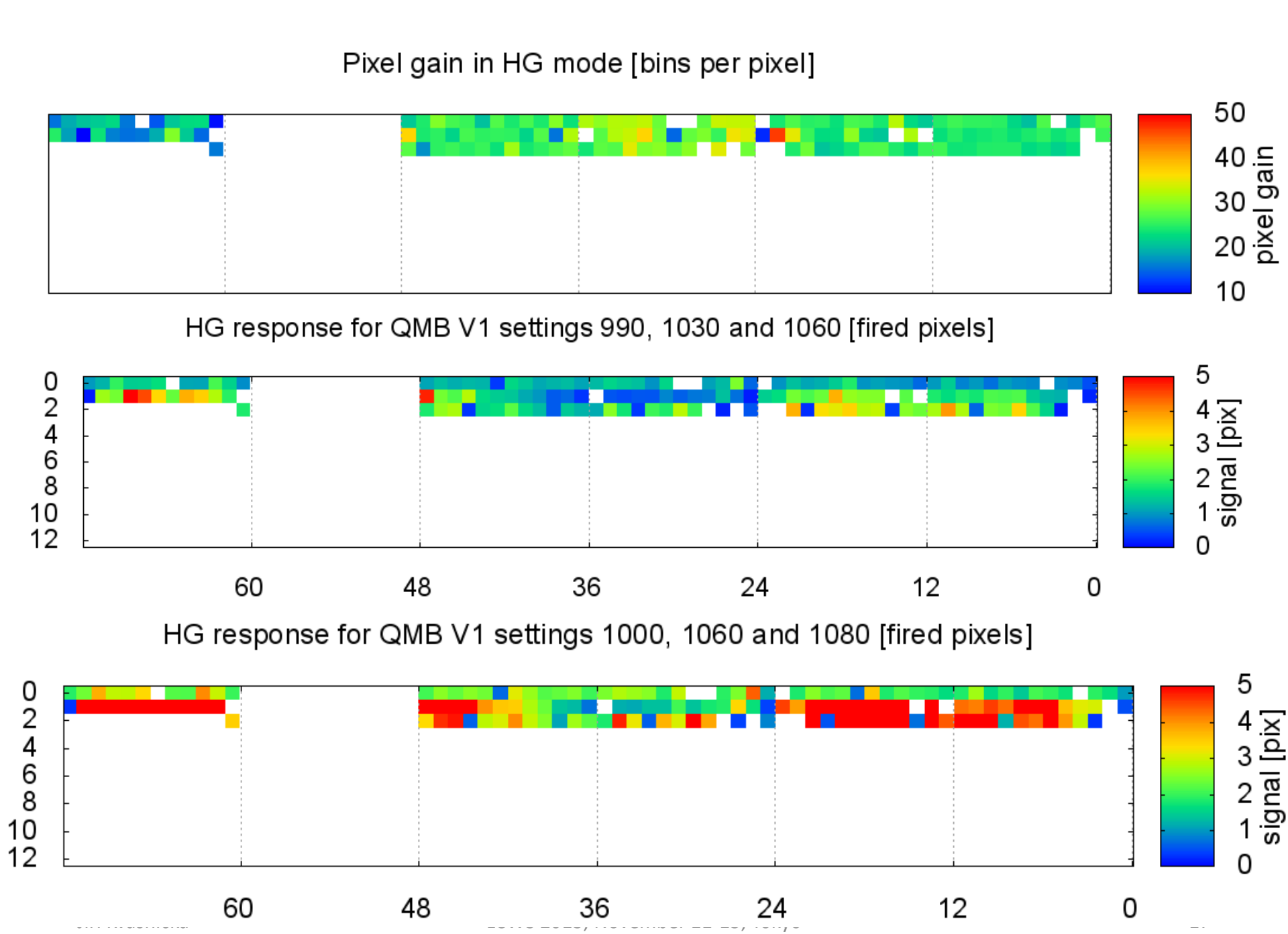








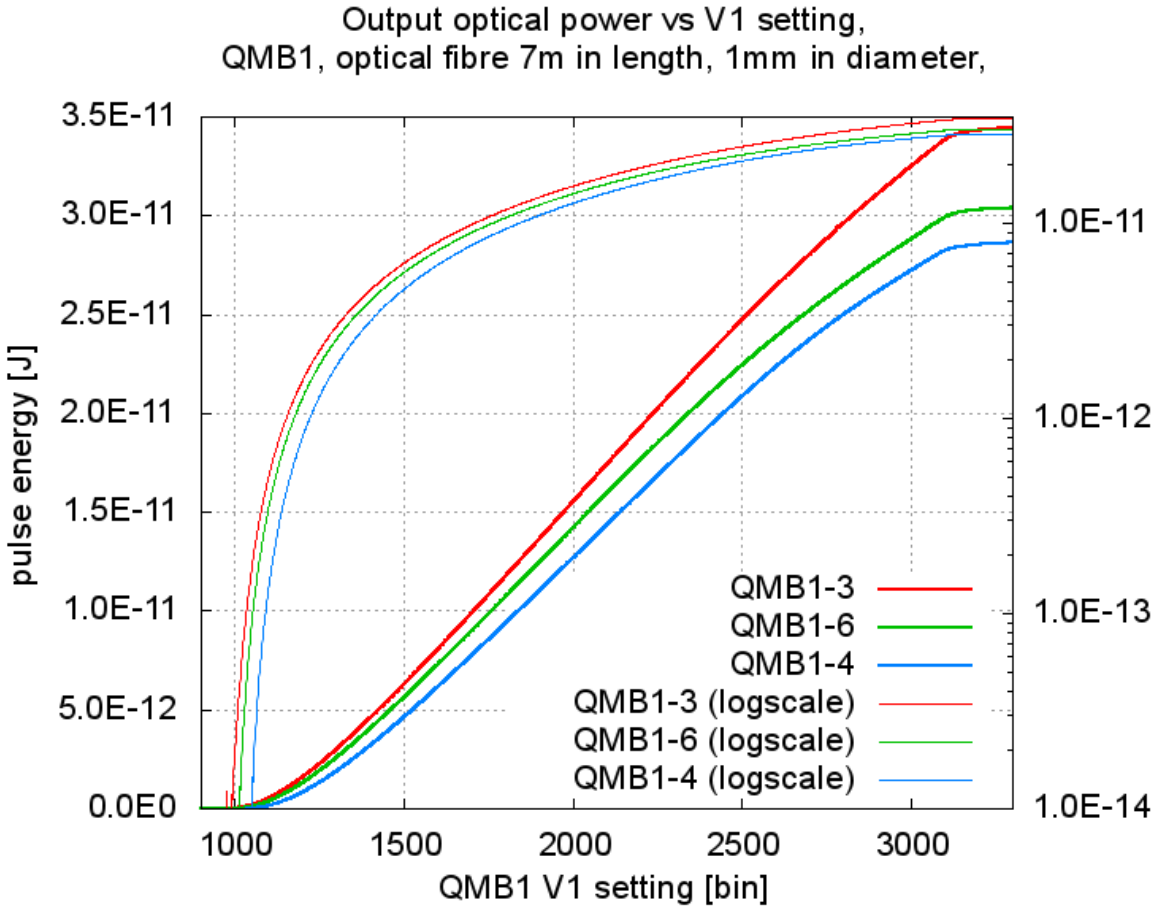



Pixel gain in HG mode [bins per pixel]
50
40
30
20
10
pixel gain
HG response for QMB V1 settings 990, 1030 and 1060 [fired pixels]
0
2
4
6
8
10
12
60
48
36
24
12
0
5
4
3
2
1
0
signal [pix]
HG response for QMB V1 settings 1000, 1060 and 1080 [fired pixels]
0
2
4
6
8
10
12
60
48
36
24
12
0
5
4
3
2
1
0
signal [pix]

TESA Kleberpads fiber holder

QMB1 optical power

- Each UV LEDs has a slightly different threshold
- Output power is not linear to the voltage settings



Temperature sensor coupling