A Fast UV-LED QRdriver for Calibration system for SiPM based scintillator HCAL Detector
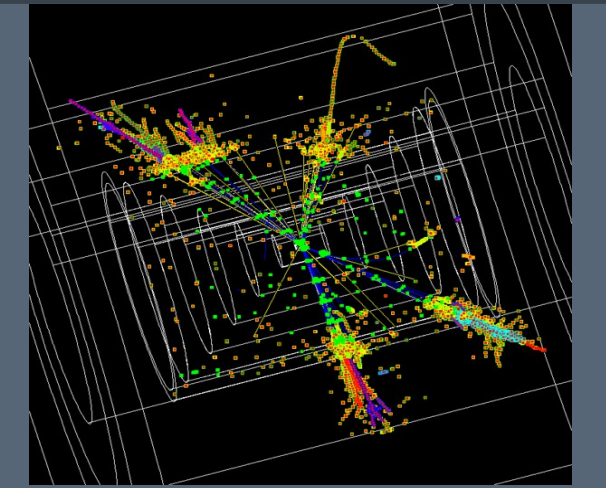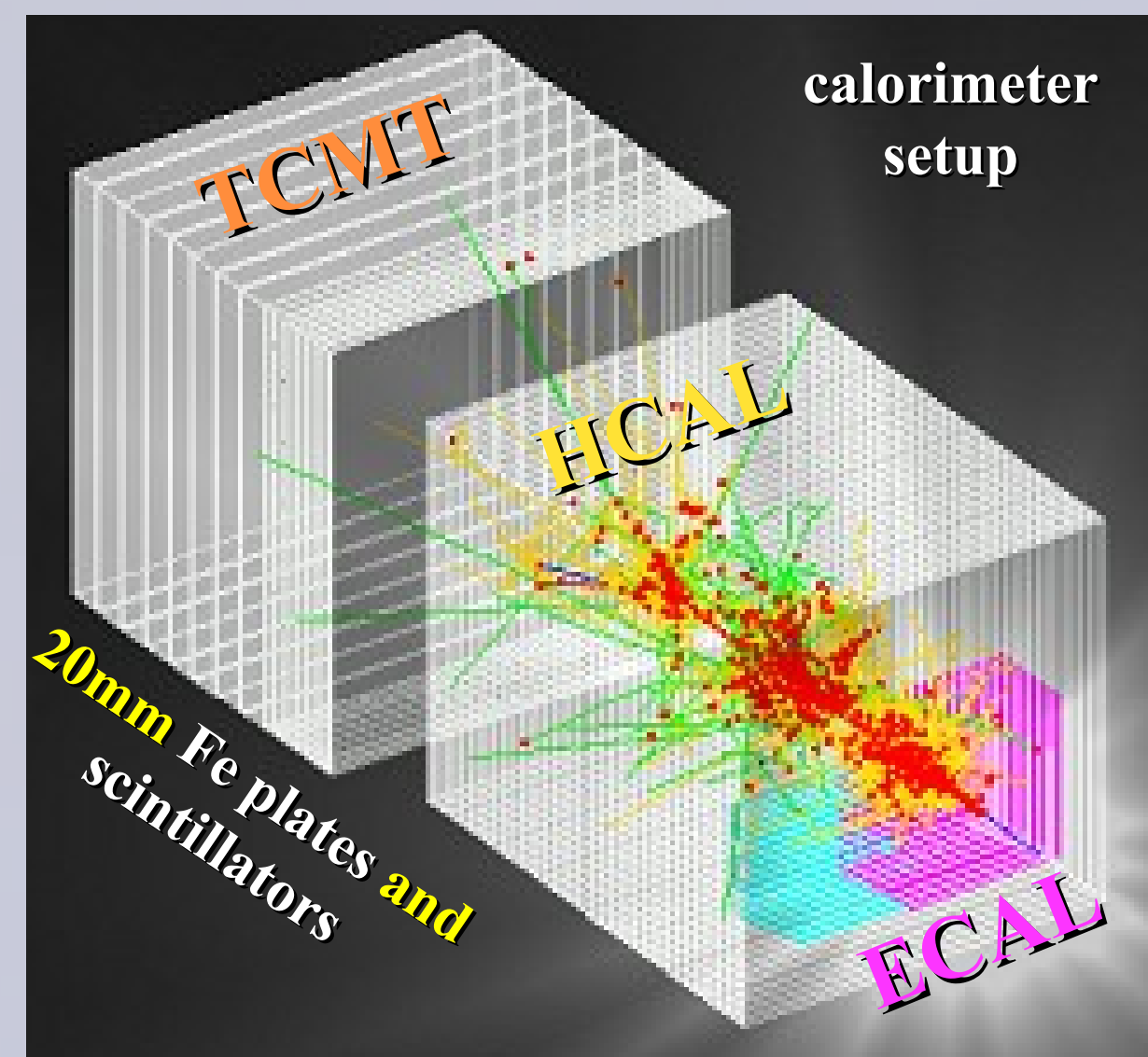
Ivo Polák and **Jiří Kvasnička** on behalf of the CALICE Collaboration
FZÚ - Institute of Physics of the ASCR, Na Slovance 2, CZ - 18221 Prague 8, Czech Republic, e-mail: polaki@fzu.cz
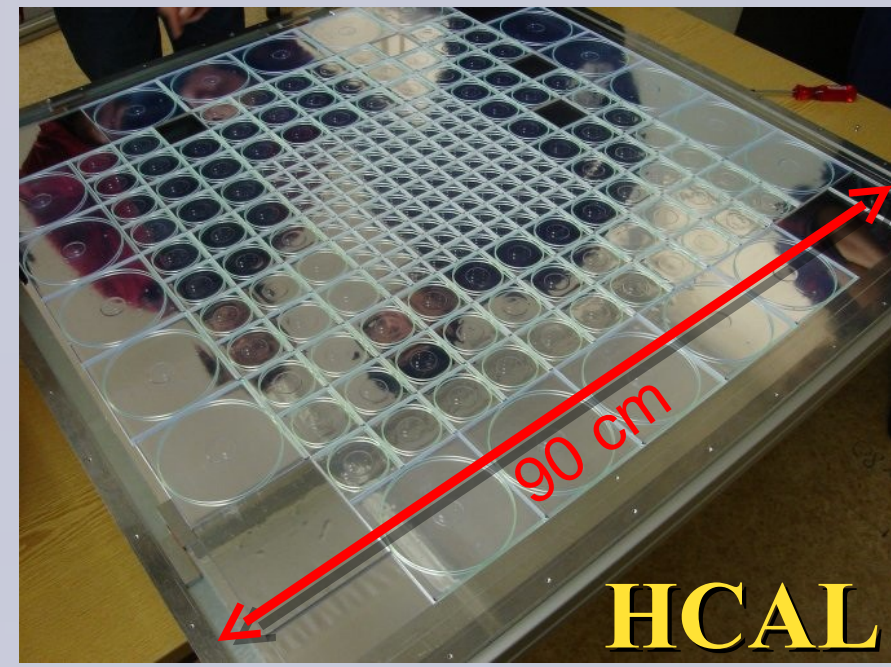
EXPERIMENT CALICE

calorimeter setup

TCMT
HCAL
ECAL
20mm Fe plates and scintillators

Prototype of calorimeters tested at accelerators of CERN and FERMILAB

- Si-W electromagnetic calorimeter (ECAL)
- Scintillator tile hadronic calorimeter (HCAL)
- muon tail-catcher (TCMT)

Our Prague group has responsibility for flashing calibration system for HCAL

1 m³ SCINTILLATOR CALORIMETER HCAL

90 cm
HCAL

2005 till 2010, then as WHCAL at CERN
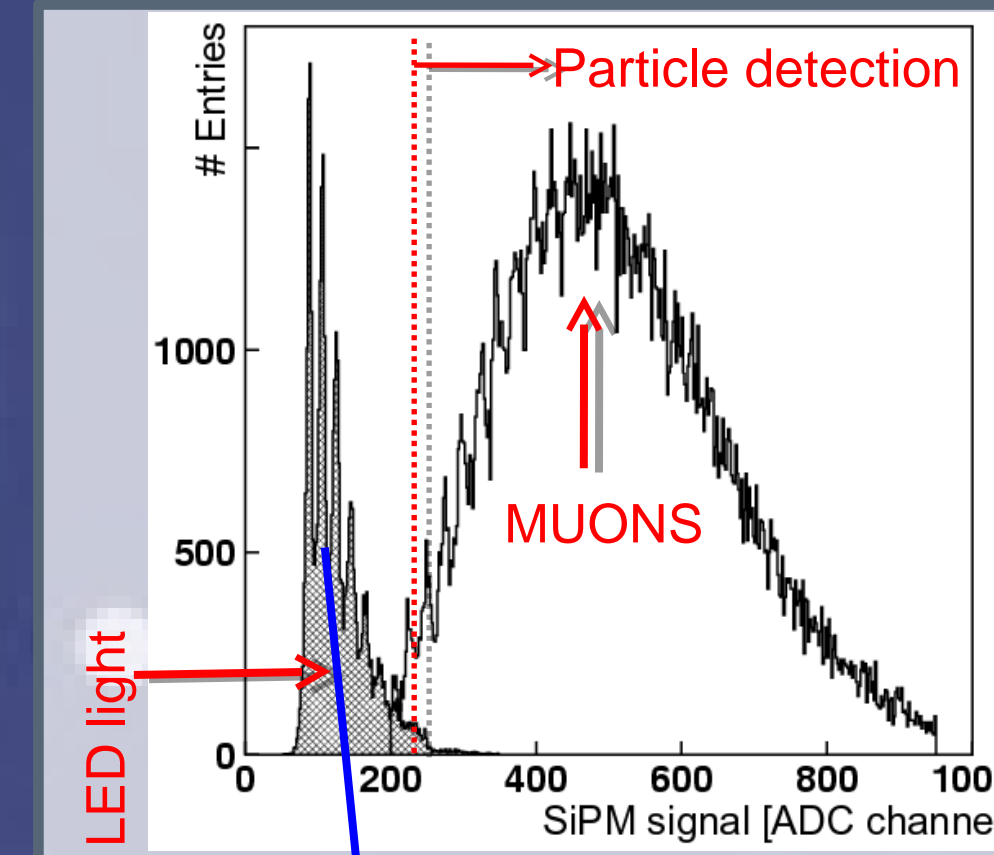- 38 layers, 2 cm Fe absorbers + 5mm scintillator tiles
- 7608 photo detectors SiPM

- A layer 216 scintillator tiles, 3x3, 6x6, 12x12 cm³, 5mm thick
- Calibration system with 12 LEDs monitored by PIN-Photo Diodes
- Optical flash is distributed by fiber bundle to each scintillator
- 5 temperature sensors per layer - integrated circuits LM35

3 cm
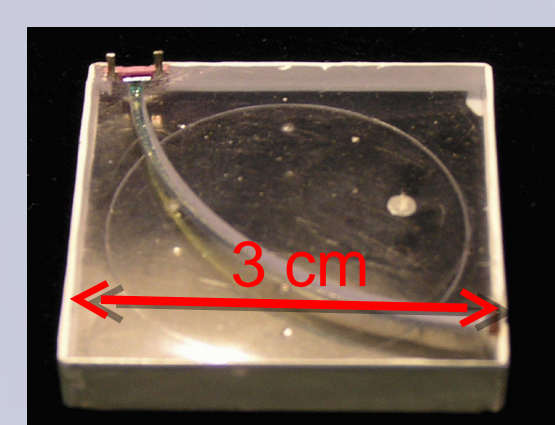
One scintillator tile consists:
- WLS fibre (~380nm to ~500nm)
- SiPM photodetector

1 mm
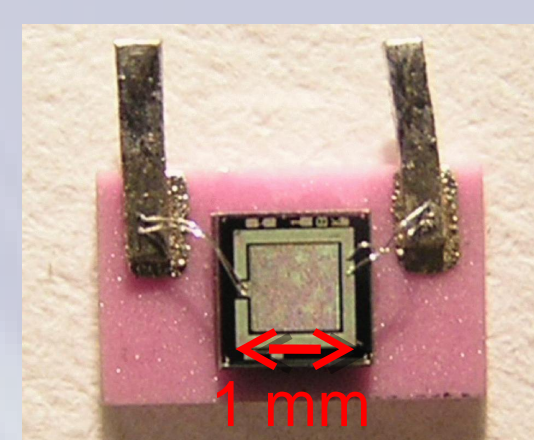
Photodetector:
- silicon photomultiplier SiPM
- 1156 pixels, each works in the Geiger mode
- Gain of SiPM ~10^5 to 10^6

Calibration procedure

→Particle detection
MUONS
LED light
Entries
SiPM signal [ADC channel]

entries
0 pixels
1 pixel
2 pixels
3 pixels
40 ns shaping
G
ADC (channel)

SiPM response [pix]
CALICE preliminary
LED supply voltage [arb. units]

Physical: cosmics or beam muons

LED: flashes with small amplitude

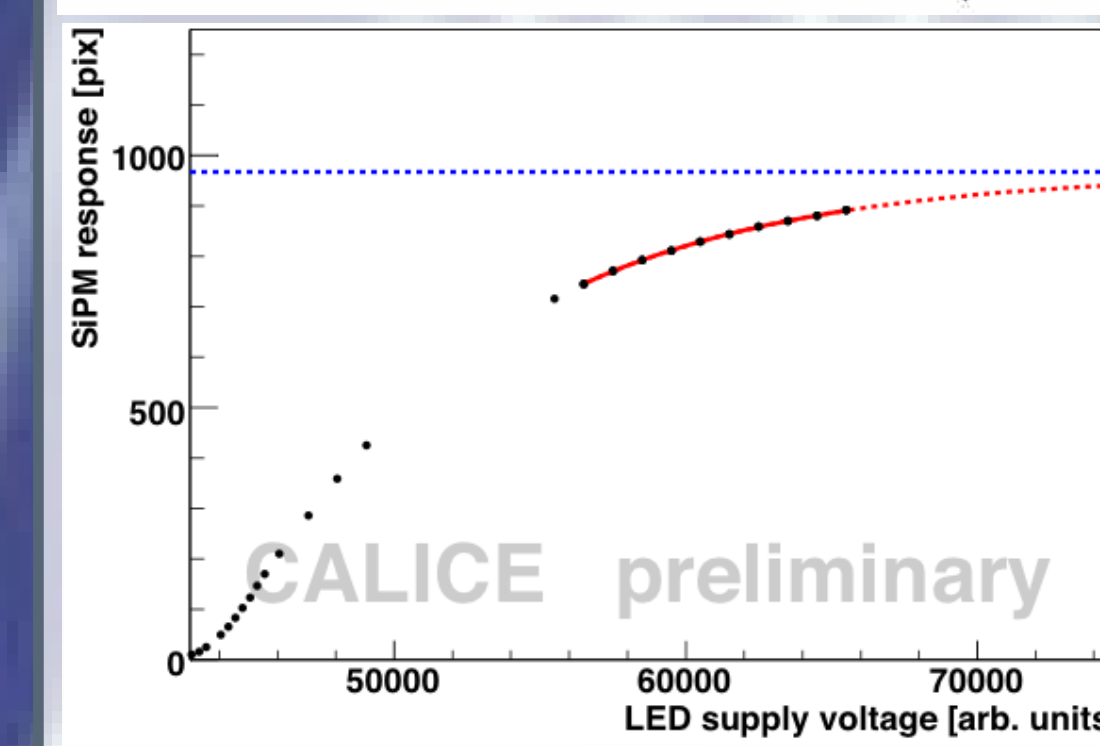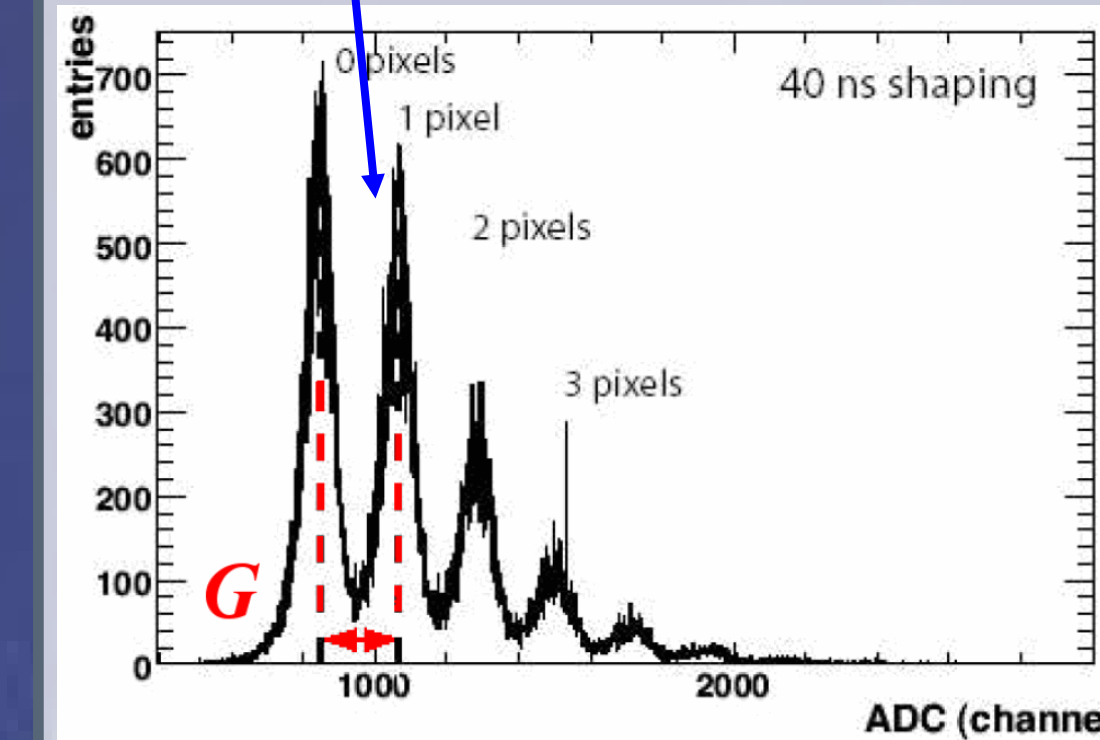LED flashes generate a clear single p. e. spectra

Gain is proportional to the distance between peaks

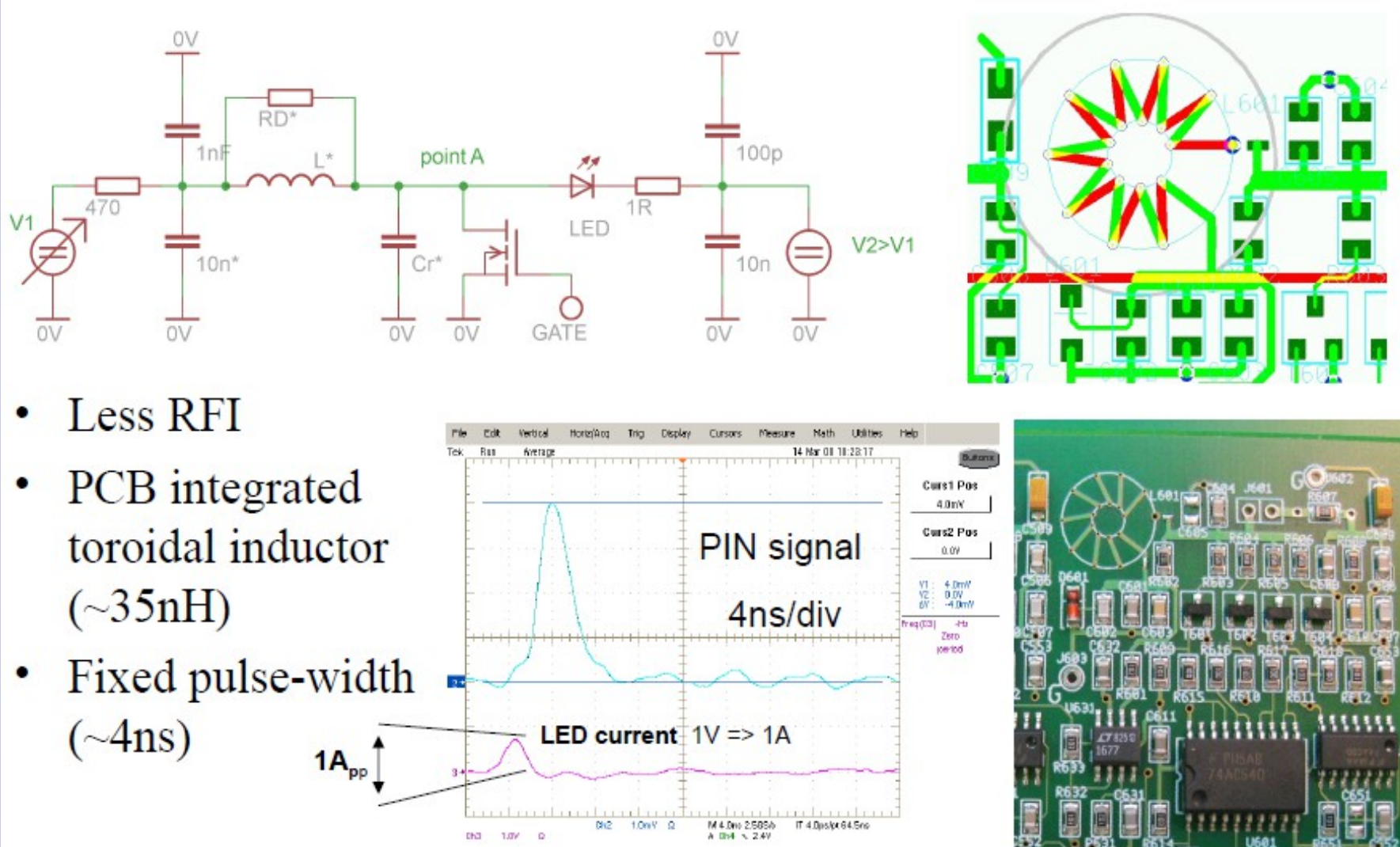Gain is independent on the number of photons

We can compensate dG/dT of SiPM by adaptive voltage regulator to get dG/dT < 1% in range 15 to 35°C

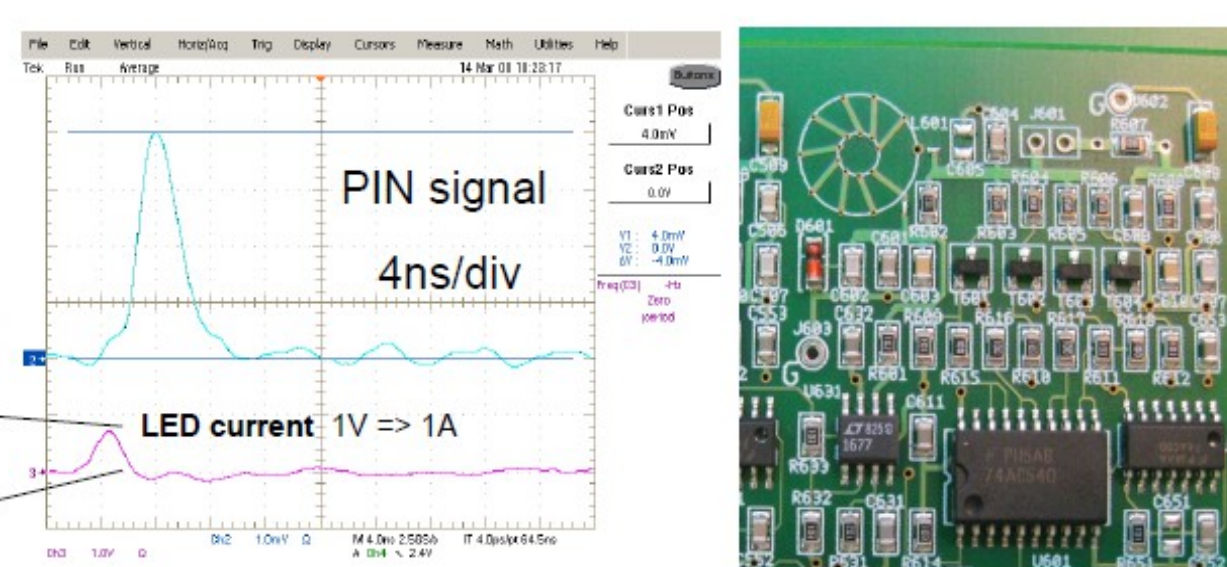Non-linear or saturation curve of SiPM

Offline, we correct for the nonlinearity of SiPM

Quasi-Resonant LED driver

point A
LED
GATE
V2>V1

- Less RFI
- PCB integrated toroidal inductor (~35nH)
- Fixed pulse-width (~4ns)

PIN signal 4ns/div
LED current 1V ⇒ 1A
1A pp

Block scheme of QMB1

QMB 1
VOLT. REG +15 V
GND
CAN BUS
GND link
T-calib cable
Rx
Tx
CAN BUS
V1 reg.
V2 reg.
LED
Signal GND
4x4007
Temp. sensor LM35
ADC
µPC
DAC (10b)
REF1
OUT 1
OUT 2
Rx
120 R Terminal
LVDS
Tx
SLAVE
MASTER
EN TRIG
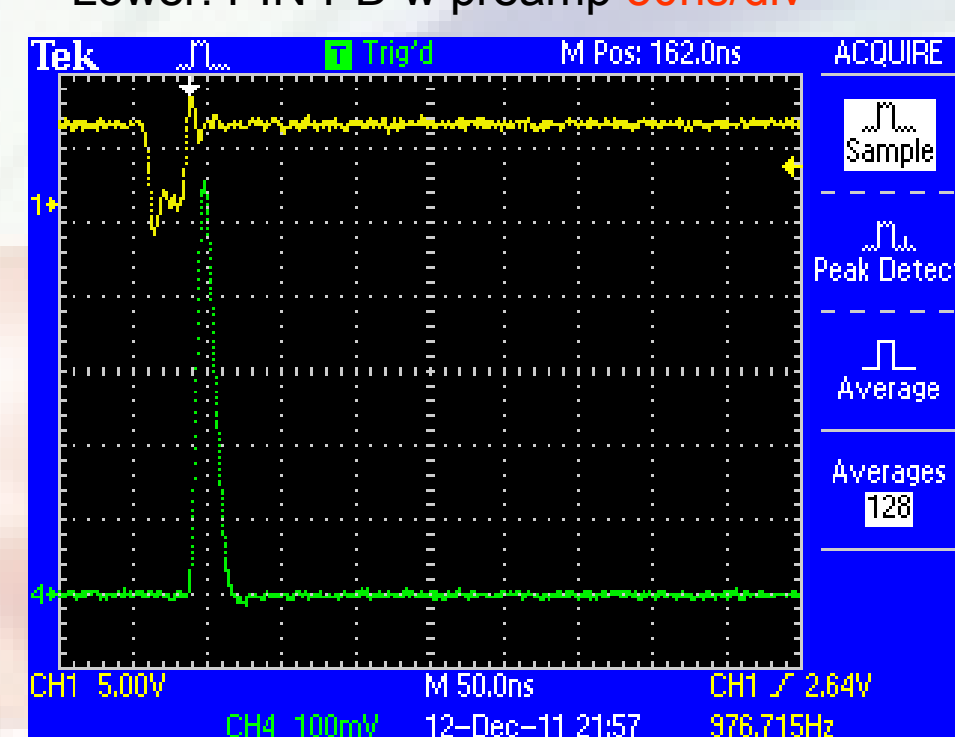Logic
3X0805
Delay
Trim. 0 - 15 ns
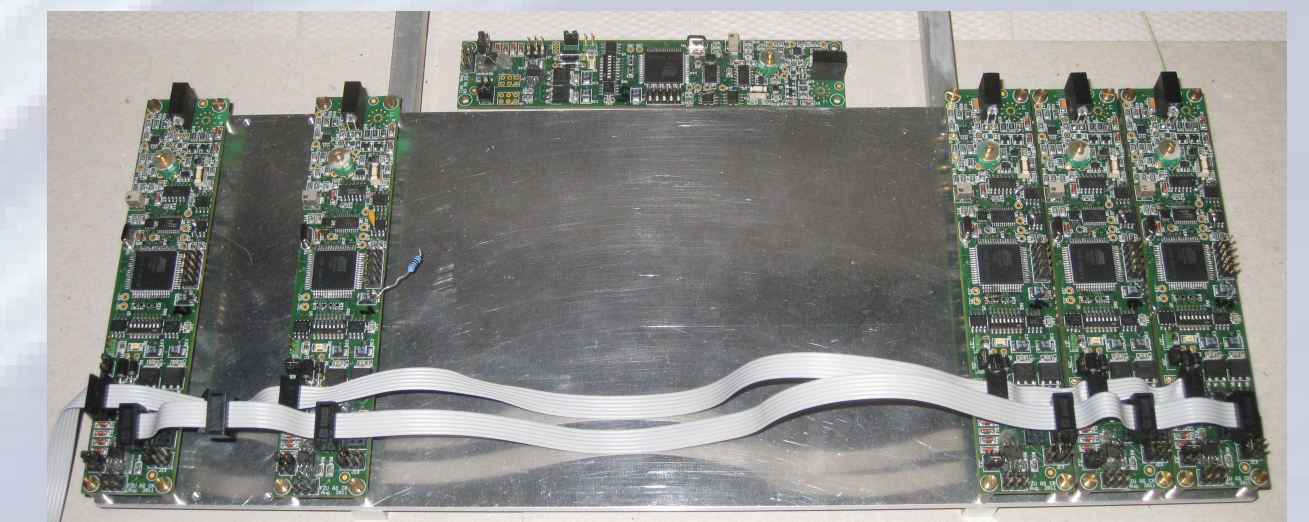Rx
LVDS
TRIG
DAQ
TRIGGER

Quasi resonant Main Board QMB1

Modular system, 1 LED per board
Operation mode:
- DAQ + CANbus control
- stand-alone mode
- LVDS Trigger distribution system
- Trigger rate up to 300kHz
- Low jitter (<250ps),
- Excelent amplitude stability, mostly degraded by LED
- Variable amplitude, zero to maximum (~1Amp)smooth wave
- Pulse width fixed to ~ 5ns (UV or blue LED) or versions 1.6ns and 30ns
- Voltages and temperature monitoring
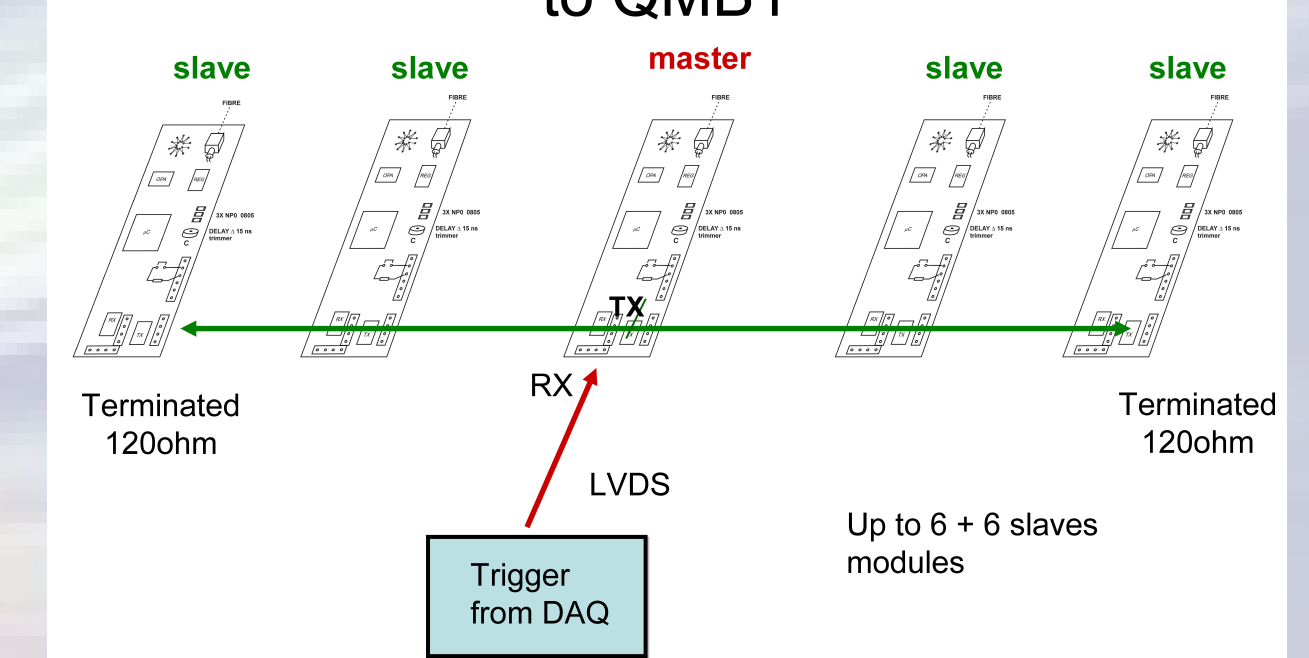- Size of PCB: width 30mm, depth 140mm
- Single power 15V/ 65mA

Upper: PIN-PD w preamp 10ns/div
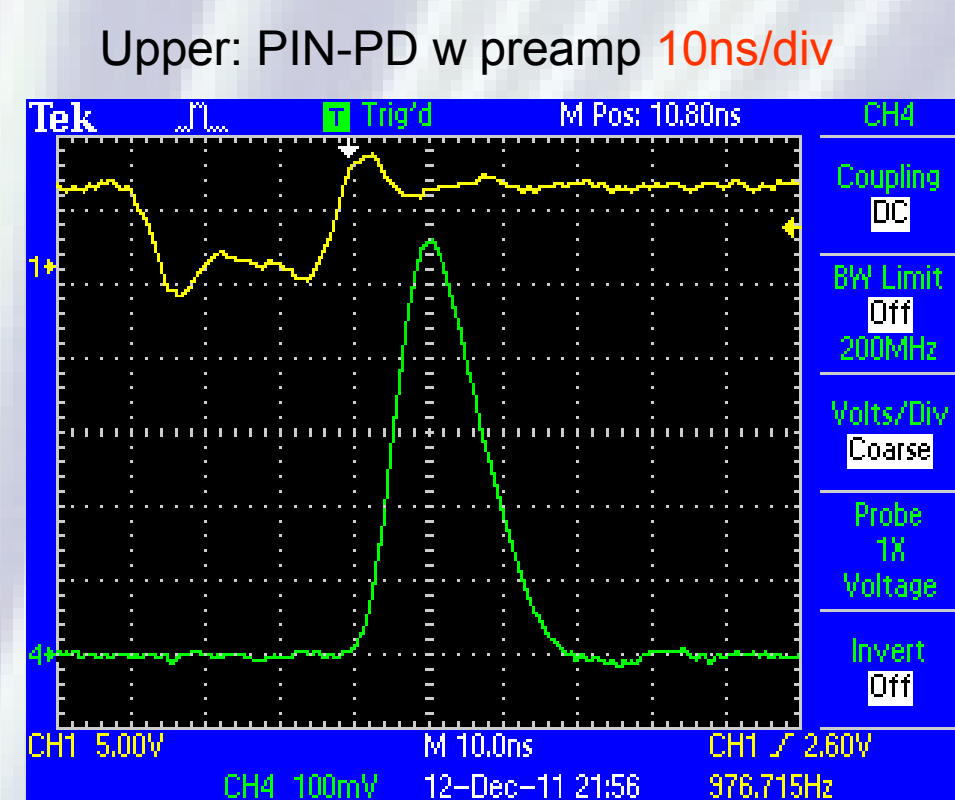
Maximal LED amplitude, LED airgap to PIN-PhotoDiode.
Lower: PIN-PD w preamp 50ns/div

Linearity of QMB1

Output optical power vs V1 setting,
QMB1, optical power 7m in length, 1mm in diameter
pulse energy [J]
QMB1 V1 setting [bin]
QMB1-3
QMB1-6
QMB1-4
QMB1-3 (logscale)
QMB1-6 (logscale)
QMB1-4 (logscale)

In 2013 we are developing 3 versions of **QMB1** with **1.6 ns**, **3.5 ns** and long pulse **30 ns**. Long pulse version is coming with external toroidal inductor.
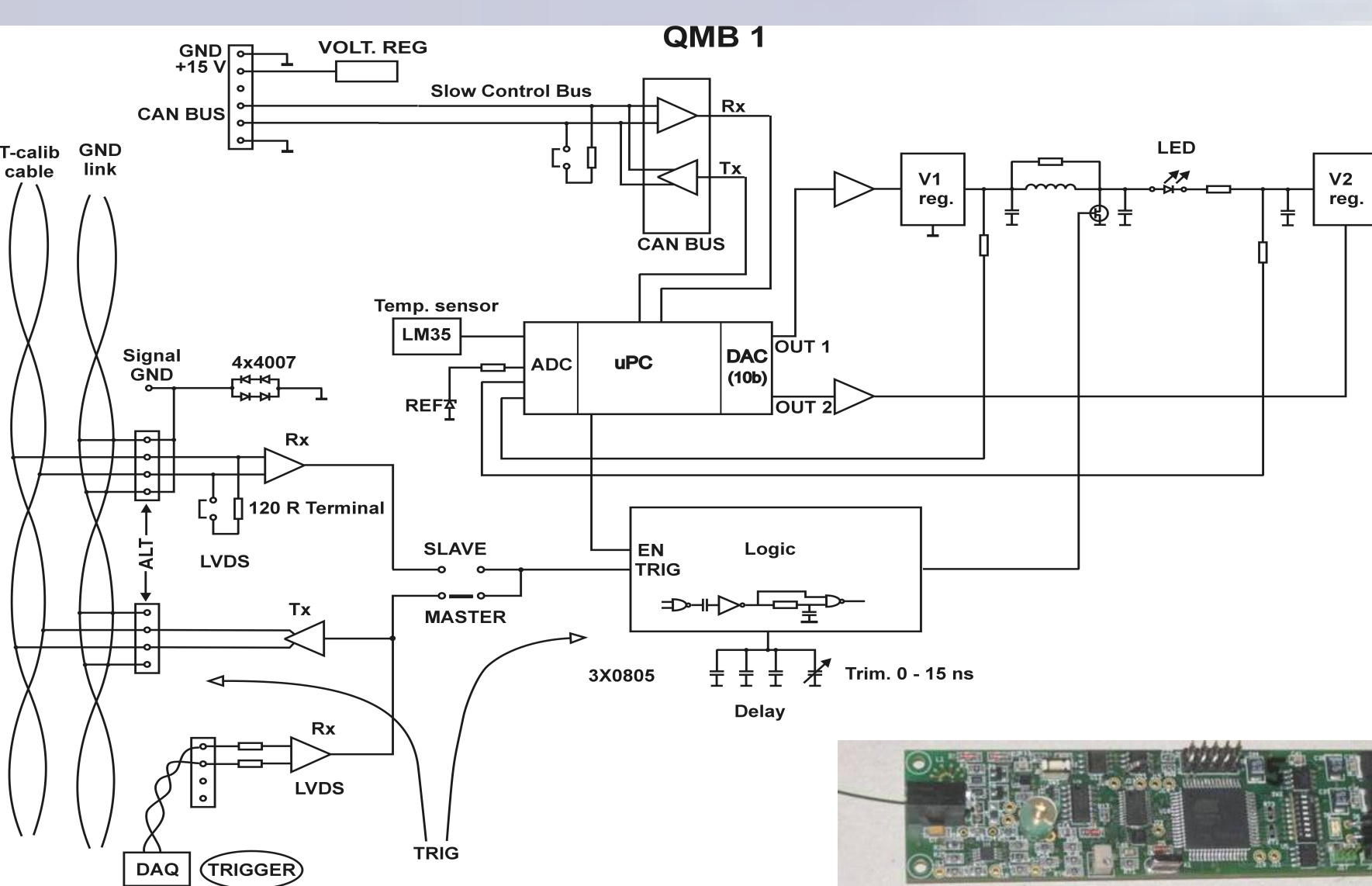
A frame with five QMB1 boards
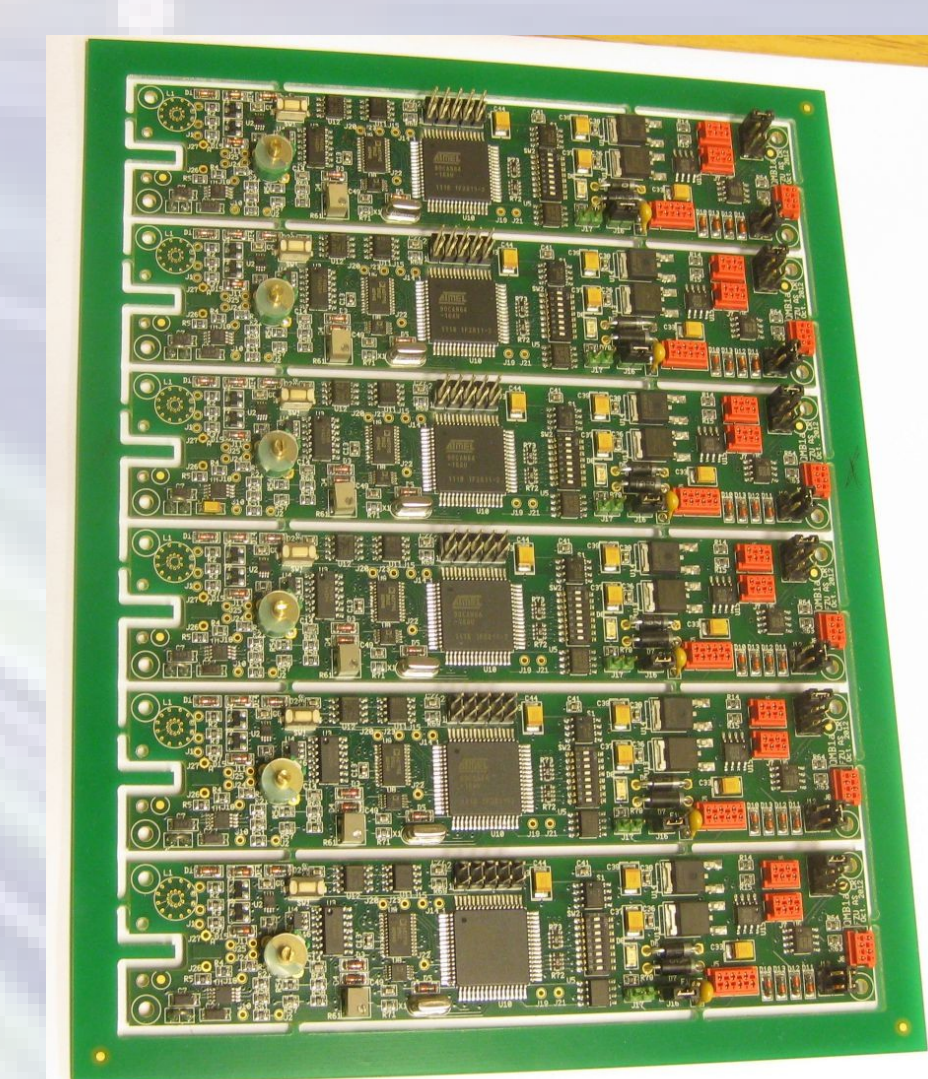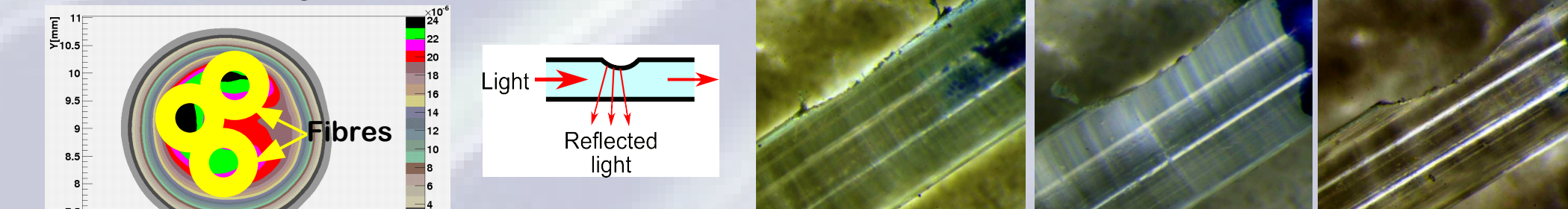(and 1 spare)

TRIGGER (T-calib) LVDS distribution to QMB1

slave slave master slave slave
Terminated 120ohm
TX
RX
LVDS
Trigger from DAQ
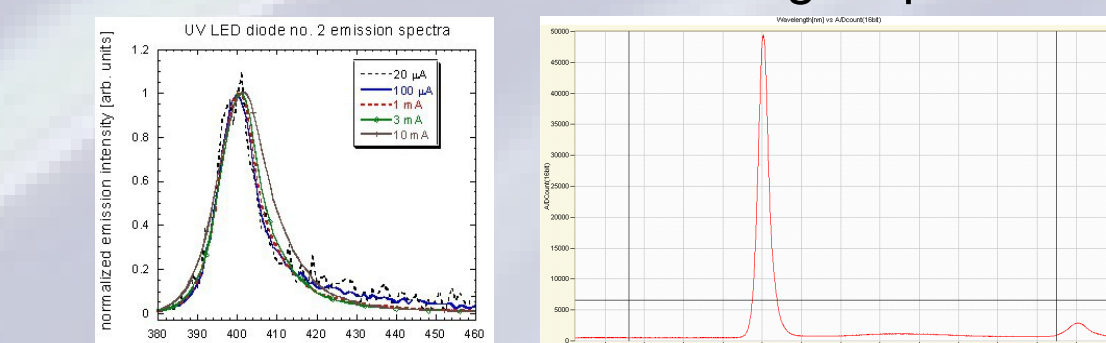Up to 6 + 6 slaves modules
Terminated 120ohm

6x QMB1A

- QMB1A is upgrade to QMB1 fixing bugs and better layout at LED driver with respect to RF roules
- PCBs after assembly in the frame
- Red connectors are for
  - Trigger LVDS distribution
  - PWR
  - CANbus
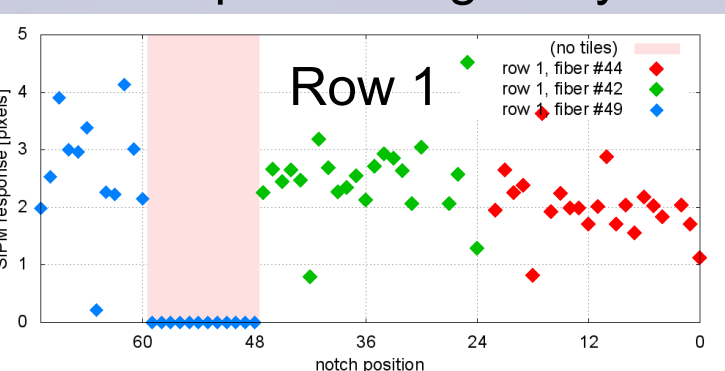- Tested on main parameters and firmware implemented.

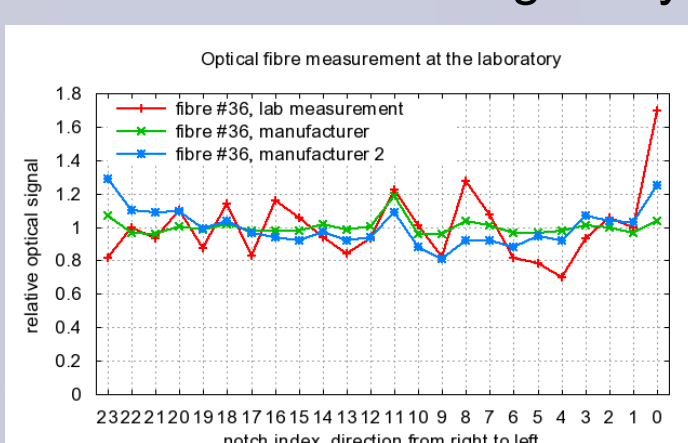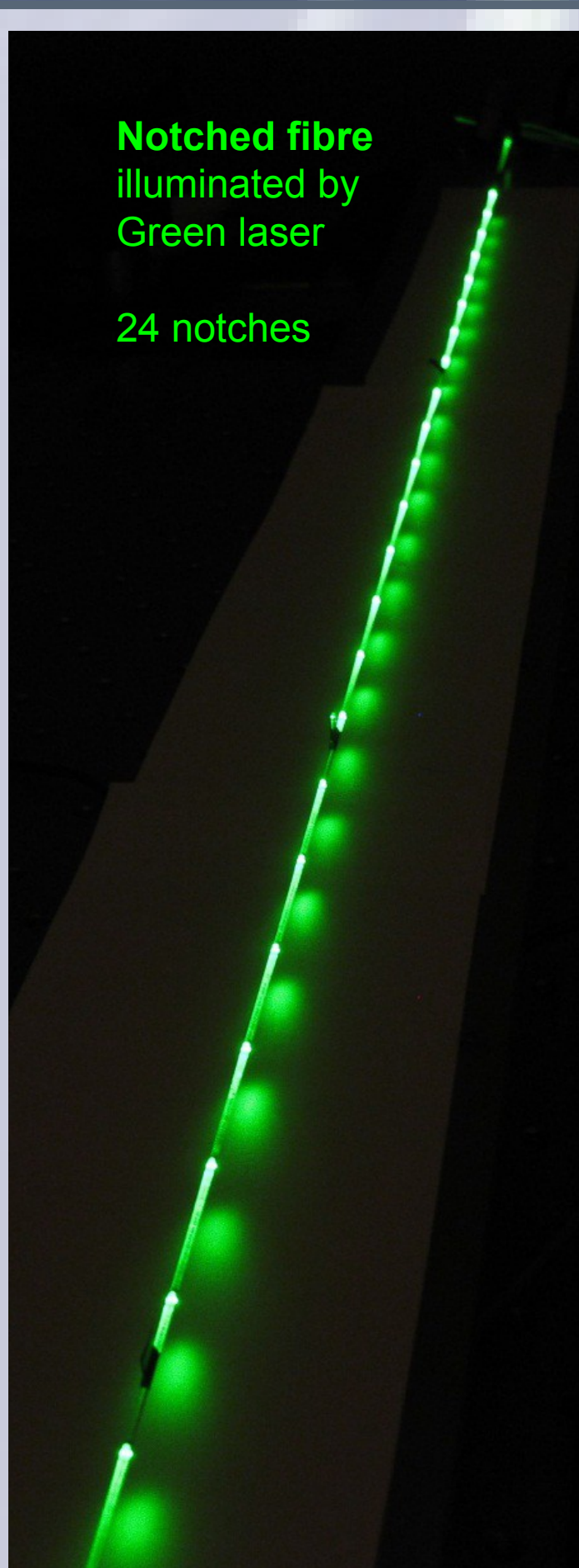## 3mm UV-LED light output profile

Fibres
Light
Reflected light

First notch Middle notch End notch

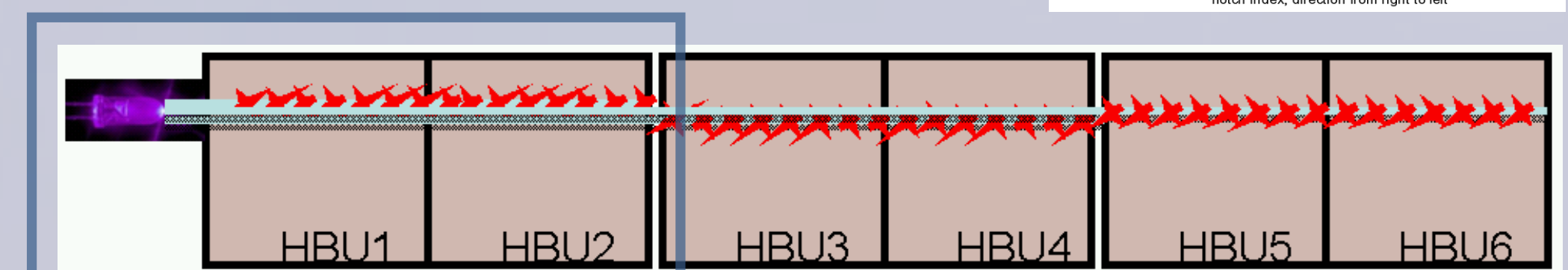Notched fibre illuminated by Green laser
24 notches

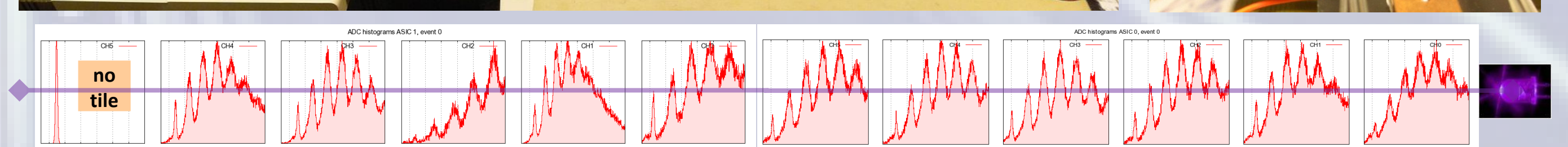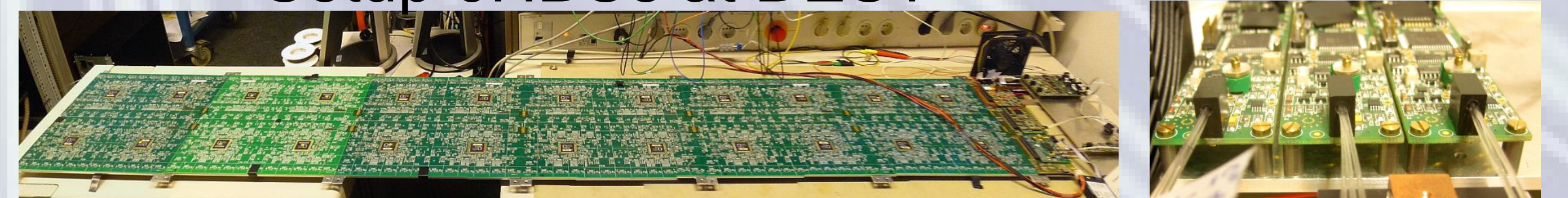### 5 and 3mm UV-LED wavelength spectrum

Fibre triplet homogeneity

Row 1

- Light is emitted from the **notches**
- Aim: 12 or 24 notches per fiber with light output spread <15%
- 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 output across the notches

Notched Fibre homogeneity

HBU1 HBU2 HBU3 HBU4 HBU5 HBU6

Setup 6HBUs at DESY

no tile

HBU2 8528

Extracted pixel gain (SiPMs not calibrated)
Signal

- Full setup with 6 HBU (2.2 m of electronics!)
- only 5 HBU equipped with tiles at that time
- 3 row of tiles (3×72 tiles) illuminated by notched fibers
- Each row of tiles was illuminated by one QMB1 with 3 fibers (each fiber has 24 notches)
- Bundles of 3 fibers = triplet
- Fibers fixed by the TESA sticky pads for the test

QMB6 in 4T magnet

DC magnetic field **0 to 4T**
Air core inductor can be sensitive to external magnetic field.
We performed tests of QMB6 in variable magnetic field. EFFECT < 1% over 4T
3 LED flashed into 3 fibre cables; CANbus cable and T-calib + Power in other cable.
The setup was mounted on non-magnetic wooden paddle, to be moved in/out of solenoid bore.

temperatur
magnetic field
PIN
APD1 APD2
Time [hh:mm:ss]