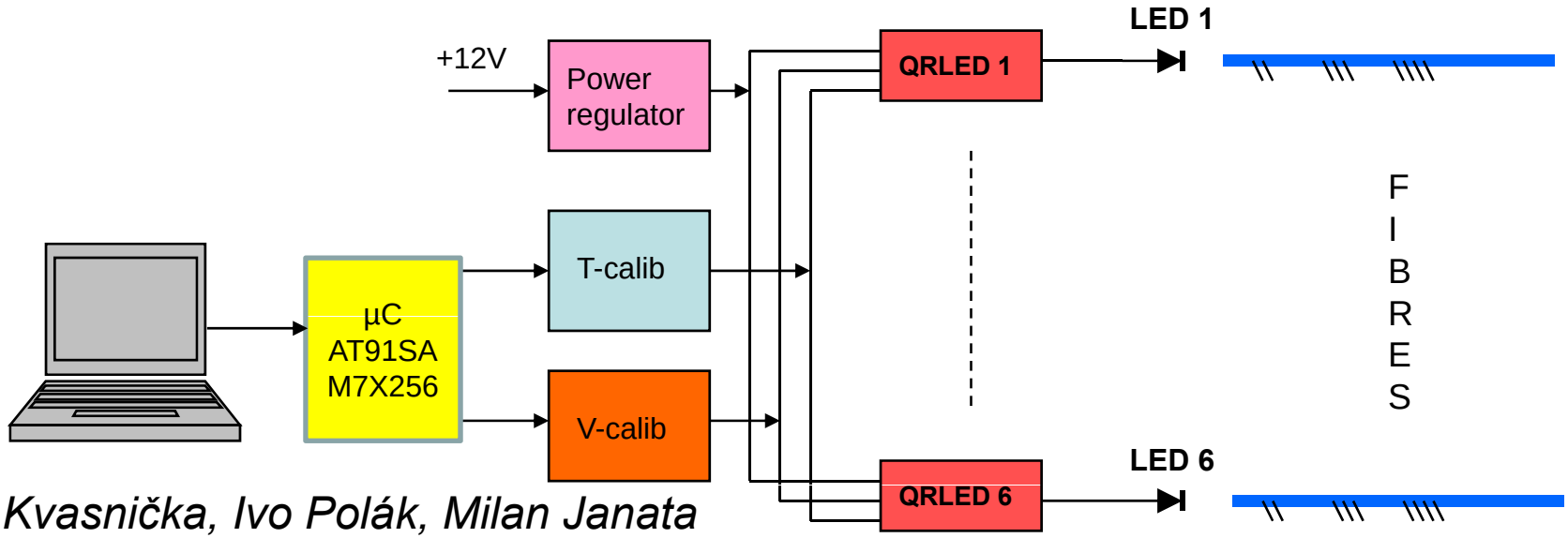
Calibration system with optical fibers for AHCAL

HCAL main meeting DESY

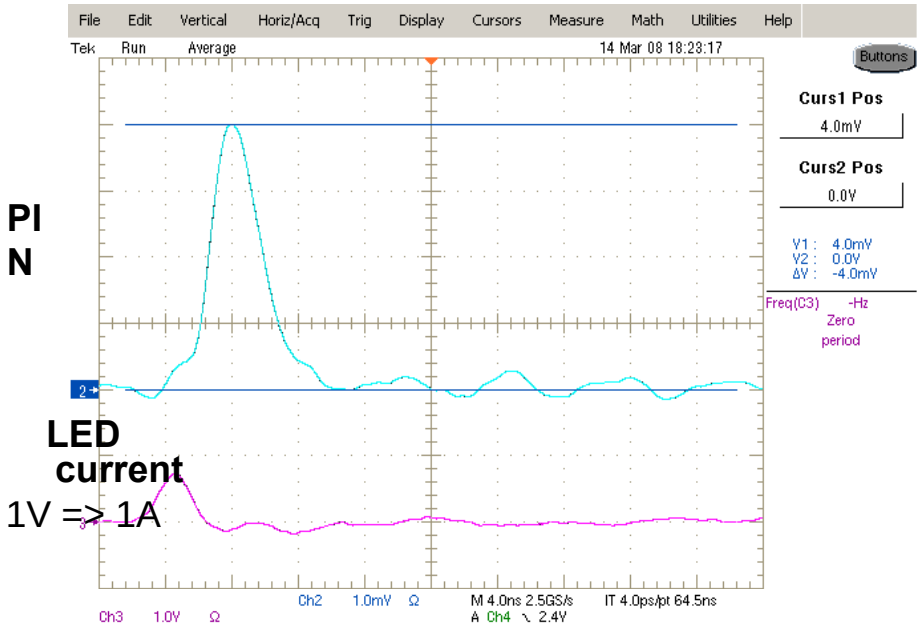
1. QRLed driver prototype
2. Optical system
3. Conclusions
4. Outlook

Multichannel LED driver

- 1 PCB with the communication module µC, power regulator, 6 channels of QRLed driver
- The communication module communicate with the PC via CAN bus or I2C
- The communication module controls the amplitude, LED Enables, and it monitors temperature and voltages
- LED pulse width is ~ 5 ns fixed, the tunable amplitude in range up to 50-100 MIPs is controlled by the V-calib signal
- 2 LEDs can be monitored by a PIN photodiode

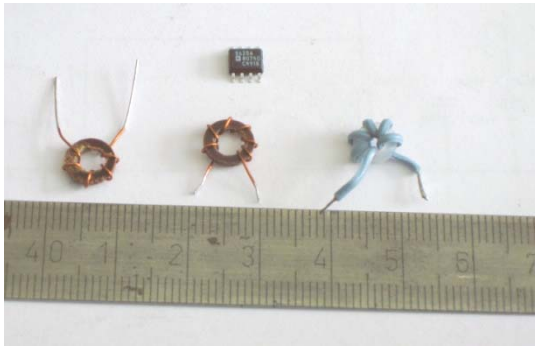


Test of principles with the Quasi resonant driver March 2008

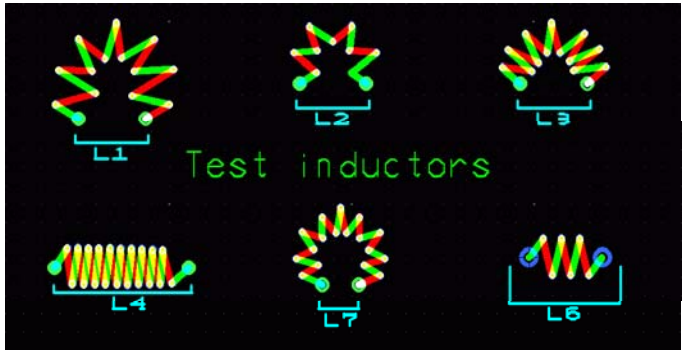


- **"Plane" inductor = toroidal inductor with non-magnetic core FR4** → (less sensitivity to external interference, produces less radiation)

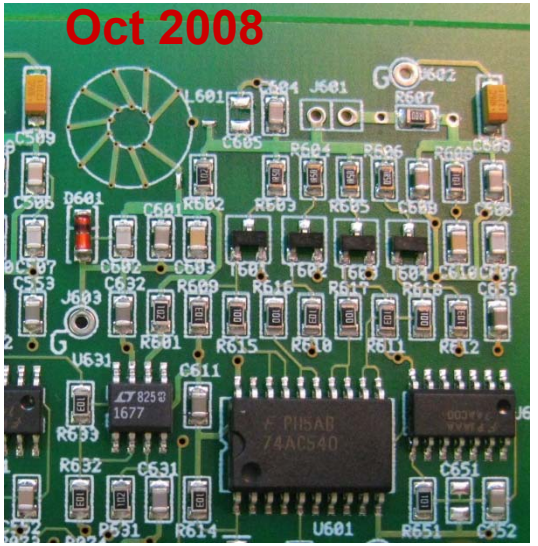
- Tuneable LED pulse amplitude
- Pulse width ~ 3 ns
- At higher LED current - afterpulsing
- Needs adjustment to different LED types



main HCAL, DEC11,2008



Ivo Polak, IP_ASCR, Prague



What was **done** on the prototype

- Communication module ready in June`08
- Optimization of the QRLed driver (adjustment for another UV-LED type) - July
- Design of PCB for analogue part, done in August - September
- PCB production – end of September
- Firmware tested in October and updated one used in November
- One LED driver tuning, PCB tests – October
- In parallel – innovation of the optical system
- **EUDET Report – December 9 – submitted**

EUDET-Report-2008 -07

Calibration prototype for the EUDET HCAL

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December 10, 2008

Abstract

The electronics producing a few nanoseconds long LED pulses tuneable in the amplitude and the optical system distributing the LED light to scintillators by a single optical fibre are described. The properties of the LED pulses are controlled by a computer connected via a CANbus to the controller on the board. We produced a prototype with 6 LED pulse drivers placed on a 4-layer PCB with dimension 250 x 147 mm^2. The pulse width is constant and 3 ns long. Its amplitude can be tuned from zero to 1.2 A. The pulse frequency can be set in the range up to 100 kHz. The LED light is distributed by a 1 mm diameter optical fibre. On the length of 2 m the fibre has every 30 mm a notch which flashes light with homogeneity of ±20 %. The system is foreseen for calibration of silicon photomultipliers embedded in scintillation tiles

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T the PCB by a freezing spray (to ~ -20° C) and observed a shift in position of the pulse by 1 ns at maximum. An amplitude change is around of a few percents.

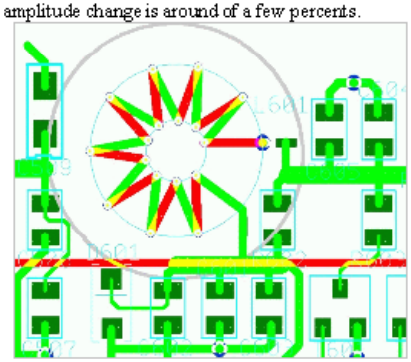


Figure 1 Detail of the inductor design on the PCB

3 Control of the Driver

The board is controlled by an AT91SAM7X256 microprocessor which provides a human interface bridge between the CANbus (or DIP-switches) and the control of six QRLED drivers. The architecture of the board is shown in Figure 4. Each QRLED driver is driven by a trigger signal, the LED voltage V_1 and the common LED bias voltage V_2. All variable voltages are generated by a 12-bit DAC (AD5328) with eight channels. Six DAC channels drive amplifier boosting voltages V_1 and one DAC channel generates common bias voltage V_2 for all QRLED drivers. The last DAC channel is connected back to ADC for testing and calibration. The DAC is controlled over the SPI bus.

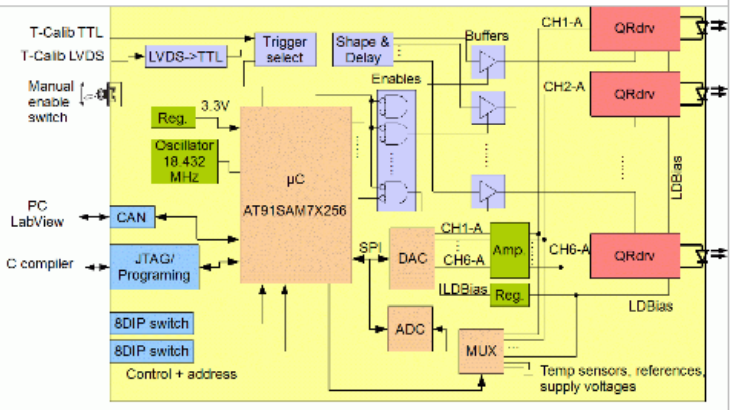
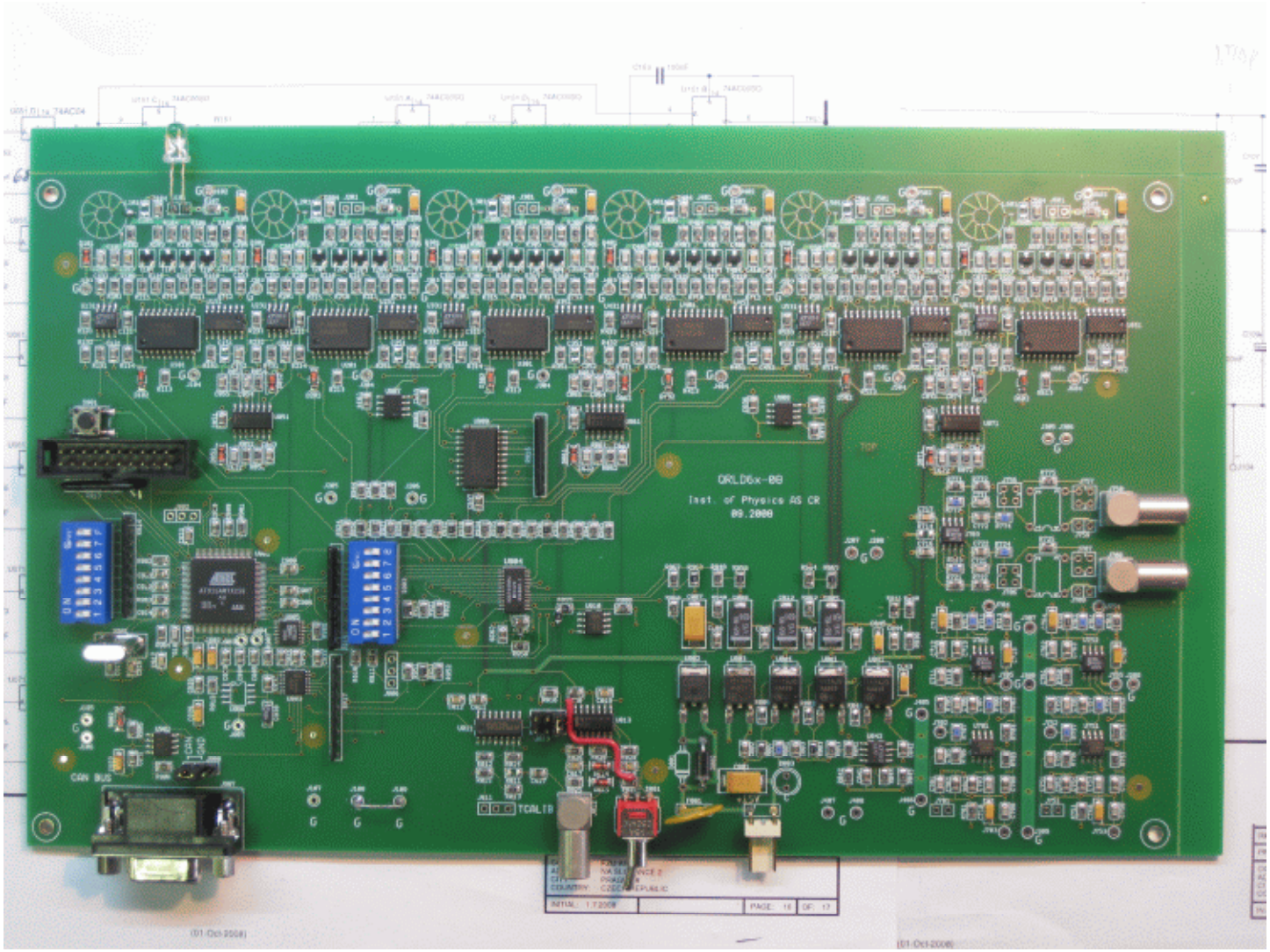


Figure 2 The principal scheme of the QRLED driver

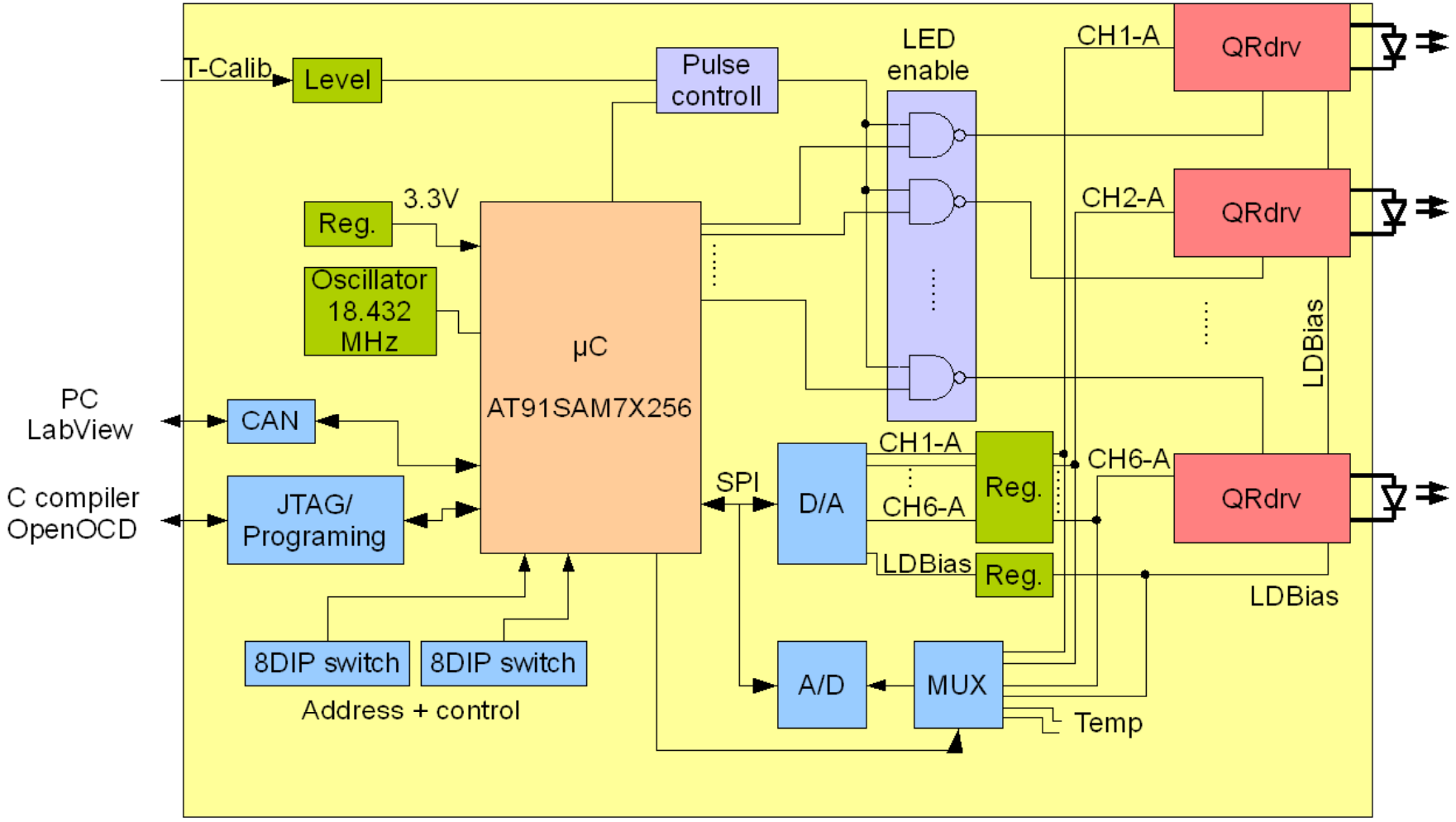
6-LED QR driver board



Consists:

- 6 QR LED drivers
- 2 PIN PD preamps
- CPU + comm module CANbus
- Voltage regulators
- temperature and voltage monitoring

A block diagram of the calibrator



Oscillograms of LED current

Oscillogram with PIN PD response

- **Green:** voltage at LED anode 4ns
- **Cyan:** PIN signal 4ns
- **Yellow:** LED current 0.5A/div 2.5ns

Firmware to the processor, developed by Jiri Kvasnicka

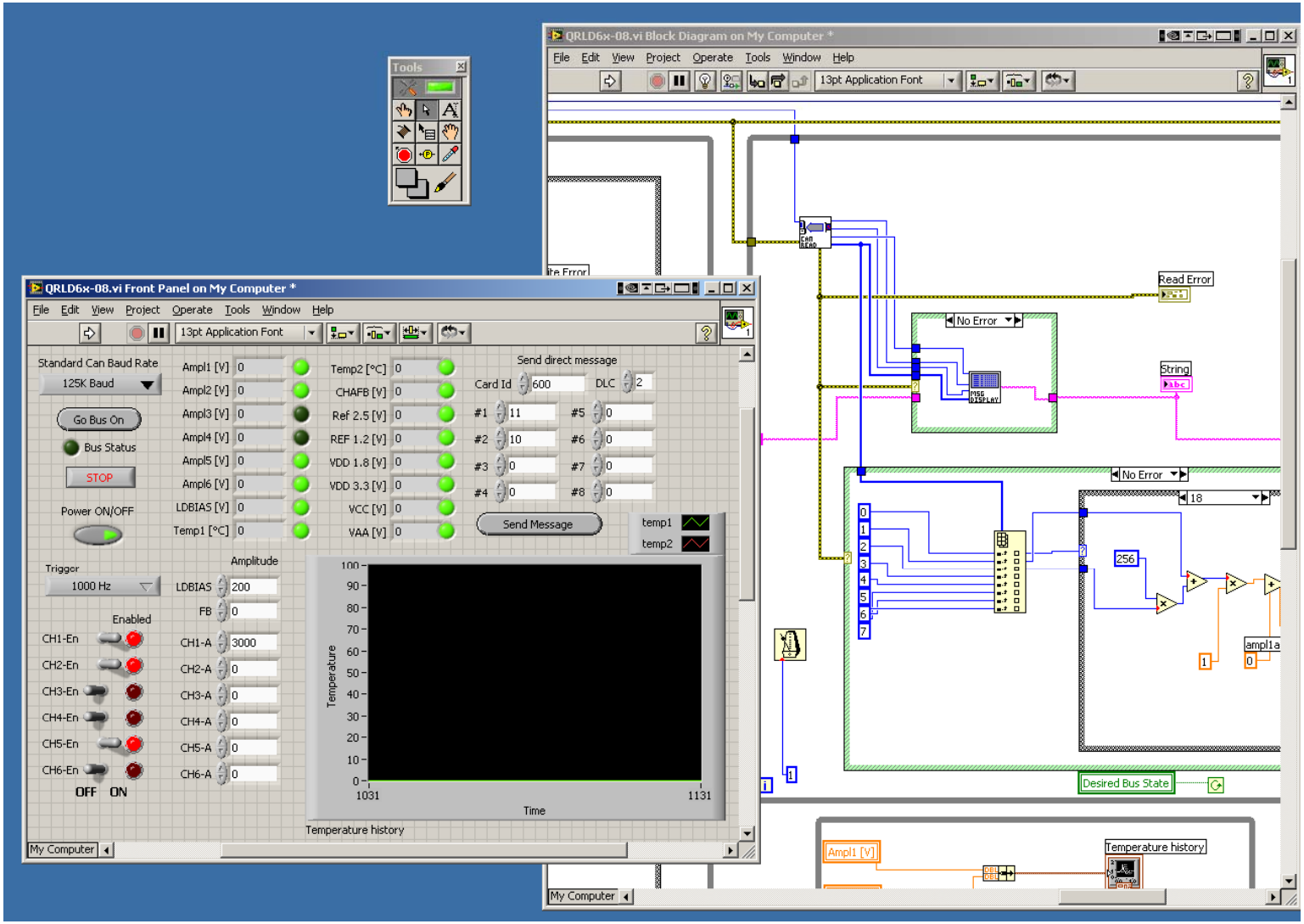
- **PC software control**
- - Built in Labview 8
- - Communicates to CANbus using Kvaser CANlib
- - QRLD6x prototype is controlled using a mouse-click GUI

- **GUI prototype capabilities**
- - Connect to the CANbus
- - Control of LED flash rate, internal rate generator
- - Selectable enable/disable of each channel
- - Set amplitude of each LED channel
- - Readout of all power supply voltages, 2 temperature sensors, reference voltages and channel amplitude voltage
- - Display history of temperature sensors with 1s update
- - Send a direct CAN message (for debug purposes)

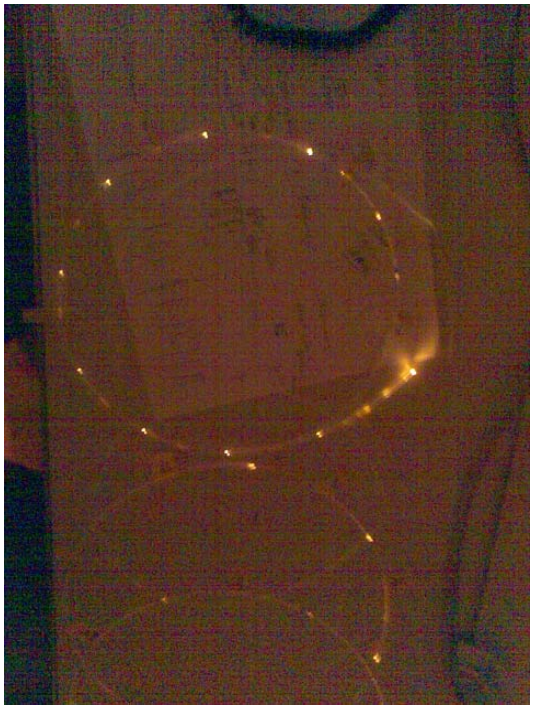
- **Firmware of the processor**:
- - AT91SAM7X256 - **ARM7TDMI core**
- - Written in pure C with arm-elf-gcc 4.2.2 compiler
- - YAGARTO toolchain with Eclipse IDE for editting and debugging
- - build on top of FreeRTOS Real-time operating system
- - implemented CAN driver at interrupt level with queue message passing
- - processes:
- --- processing CAN commands
- --- Multiplexer control and ADC readout
- --- Stand-alone mode board control

GUI of calibrator board

+ LabView flowchart



Development of the optical system



Idea: use one fibre for one row of tiles

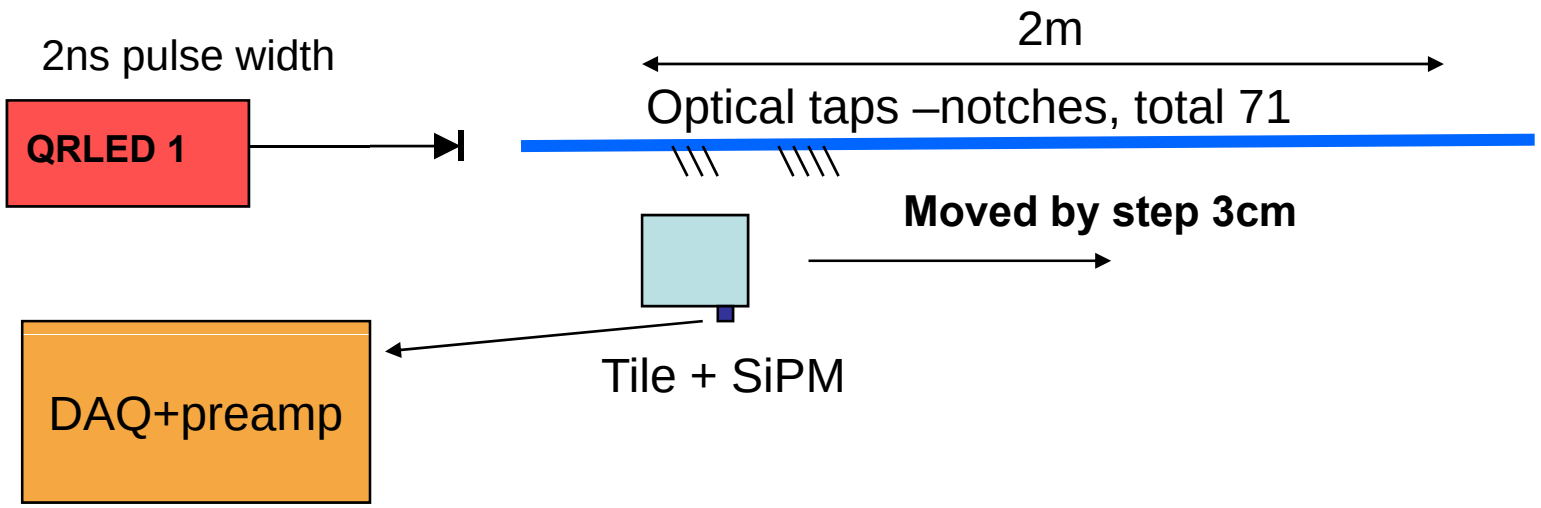
Problems:

- uniformity of distributed light
- enough intensity of distributed light
- concentration of LED light into one fibre

Two fibres:

- **Side-emitting** (FiberTech SLS600 series)
  - exponential fall of intensity
  - possibilities to buy at market
- **Notched fibre** (manually produced by Safibra comp.)
  - better uniformity of distributed light
  - need to mechanize production - R&D

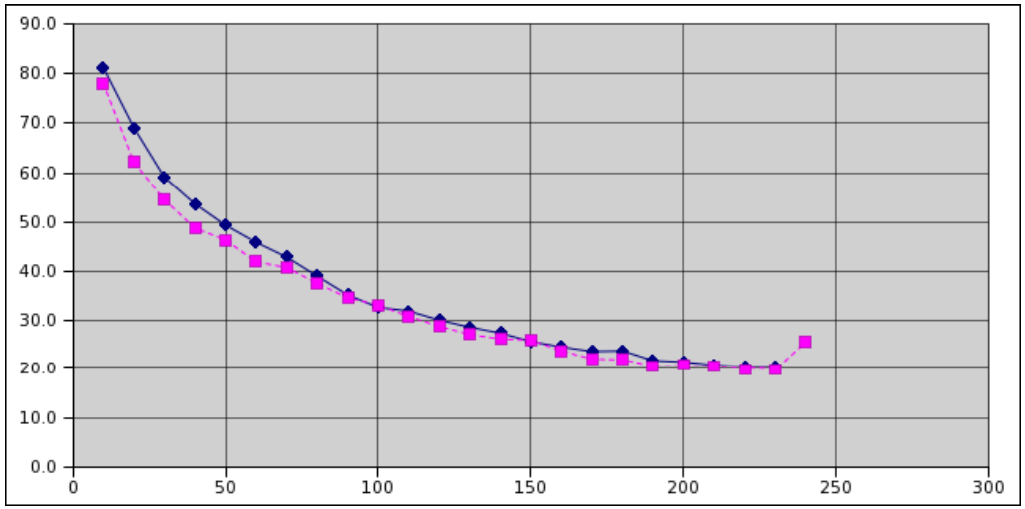
Test setup for notched and side-emitting fibers



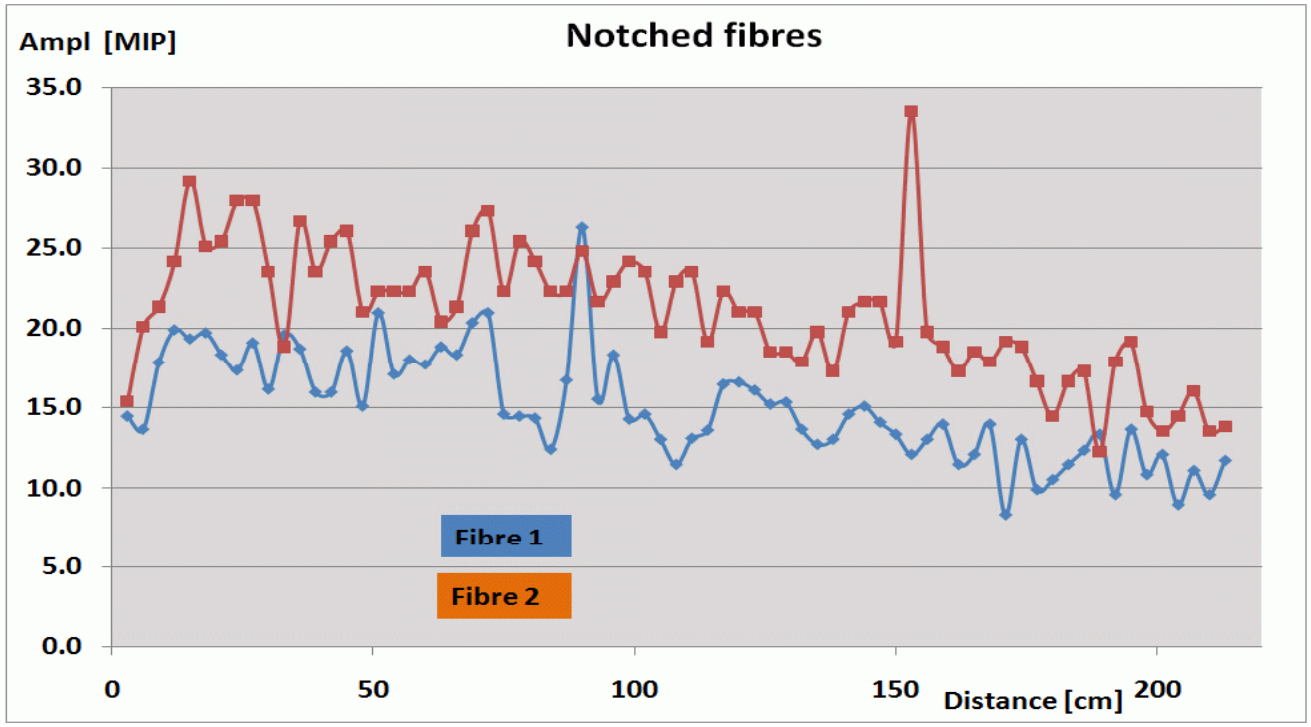
The fiber lays on the tile.

Light distribution, measured by moving scintillator with SiPM along the fiber

Side-emitting fibre,
light declines 4-times along 2m

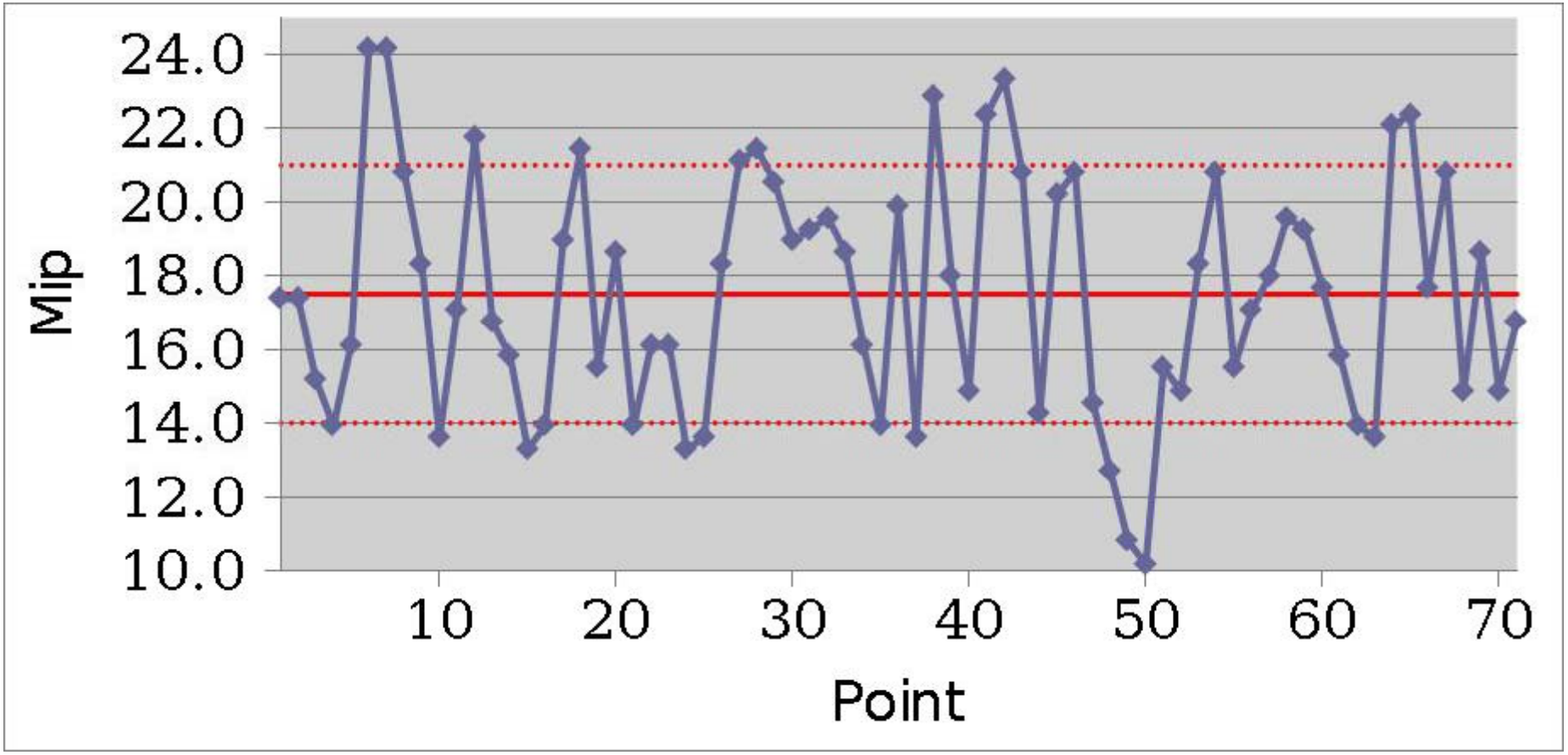


UV-LED 400nm, 2.5ns pulsewidth



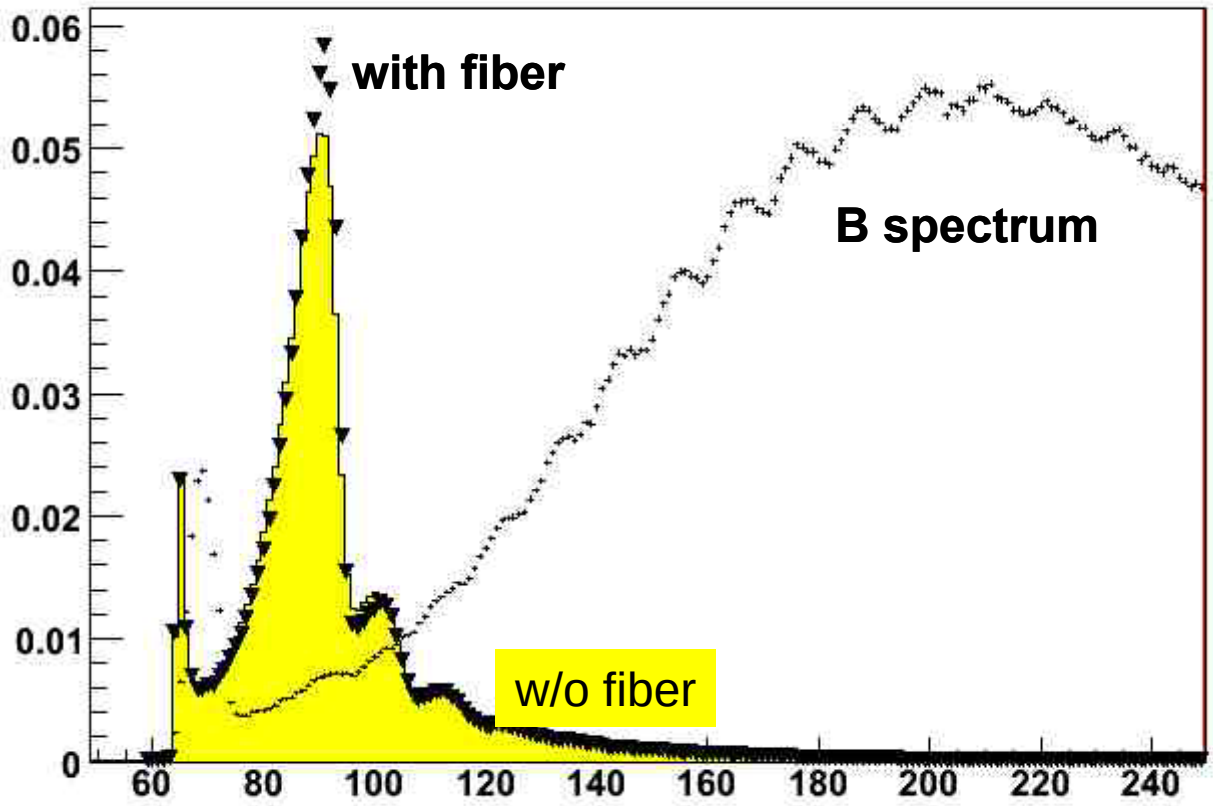
Notched fibre,
a light on taps
declines by **1.5** along 2m

Notched fiber prototype #3



- Light output from fiber via notches uniform over all 70 points
- Approaching ±20% proposed limit of light variation
- New (better) notched fiber is expected soon

Optical X-talk on MIP β-source



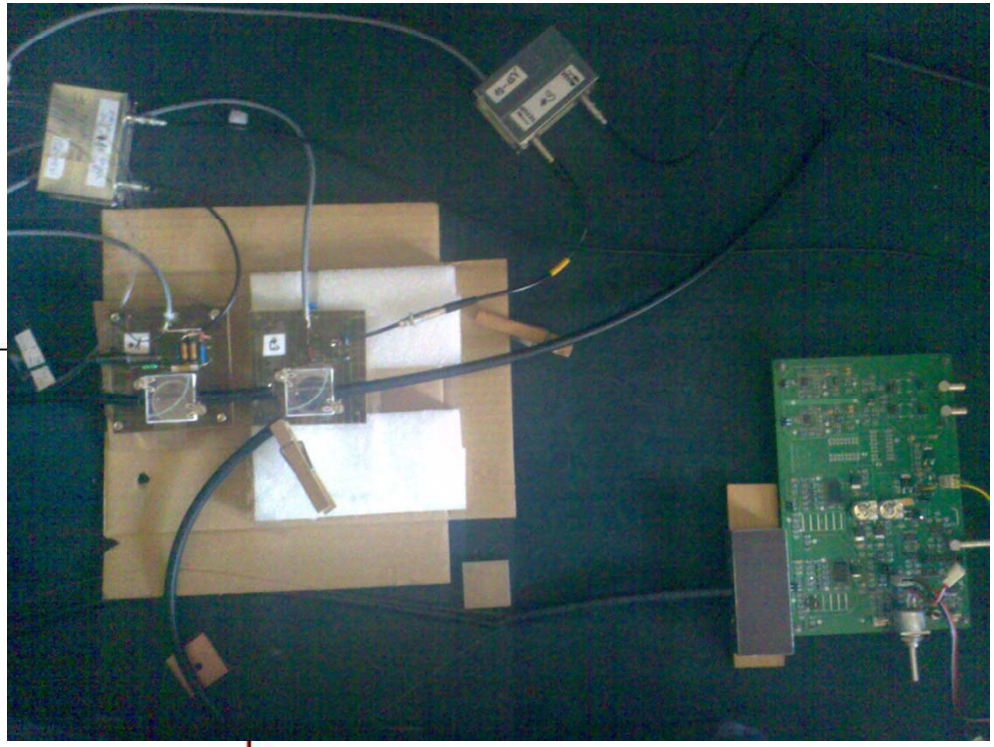
- Sr beta source to SiPM1
- triggered by coinc. w/PM
- notched fiber SiPM 1→2
- at length of 9 cm
- ½ MIP on position 135

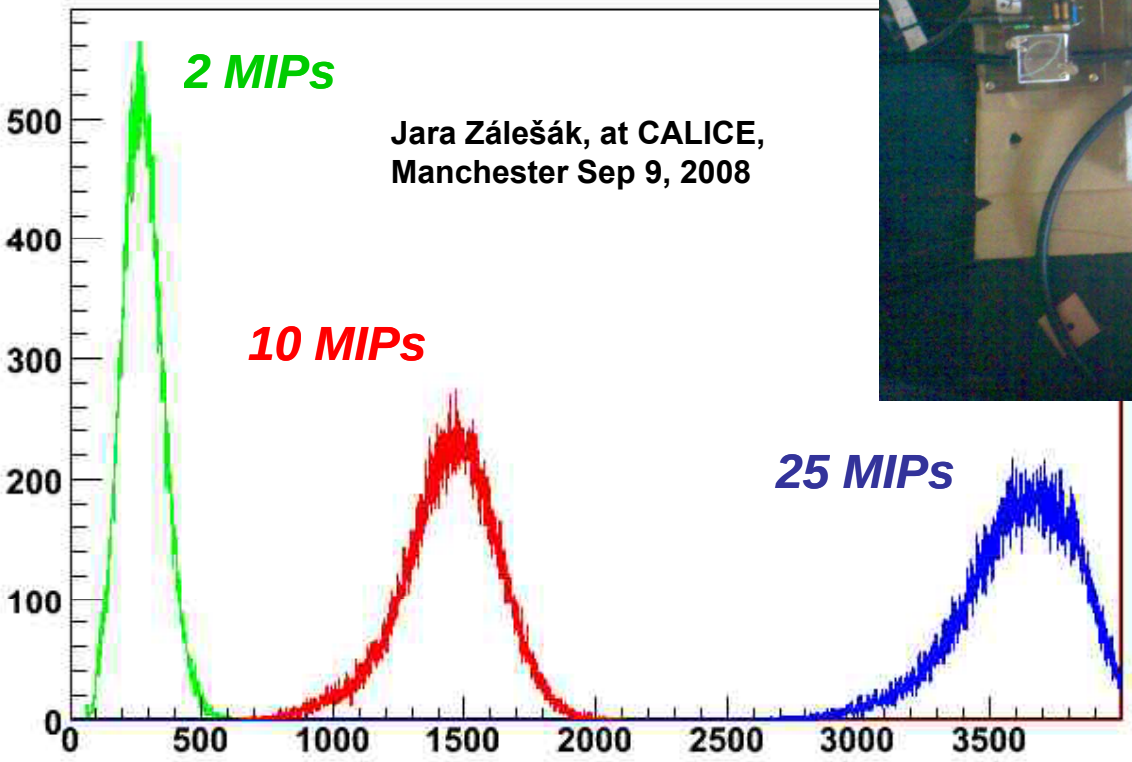
Jara Zalesak, at CALICE, Manchester Sep 9, 2008

- Normalized spectra w/ and w/o fiber are same
- NO optical X-talk visible for MIP beta spectra

Optical X-talk on LED light

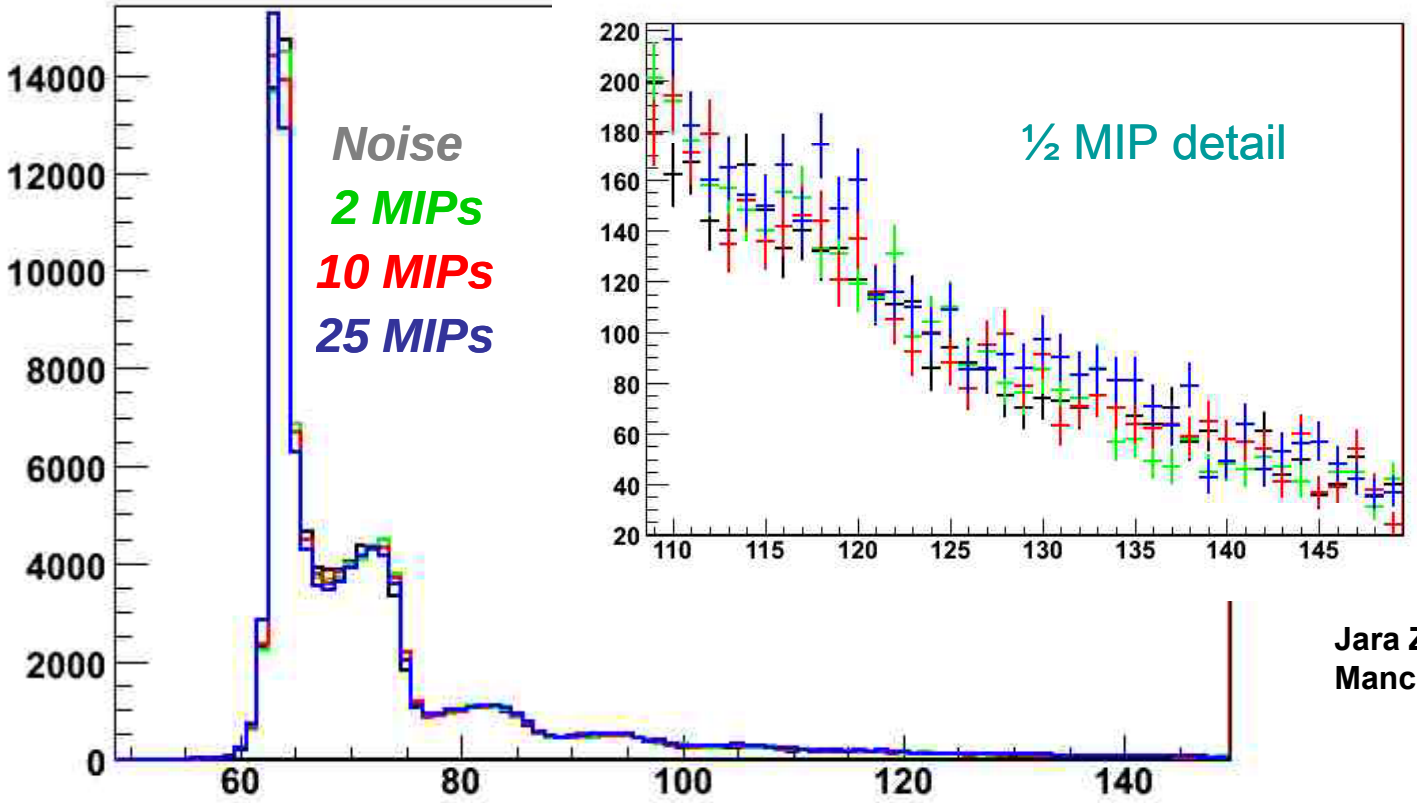
- Much more light to tile (up to 25 Mips)
- not particle but tunable amplitude
- better triggering





- LED light to SiPM1
- notched fiber SiPM 1→2
- at length of 9 cm
- ½ MIP on position 135

Optical X-talk on LED light - results



Jara Zalešák, at CALICE, Manchester Sep 9, 2008

- No differences in response from various amplitudes
- NO optical X-talk visible for large amount of light in tile
- no dependence on chosen pair of notches and light input direction

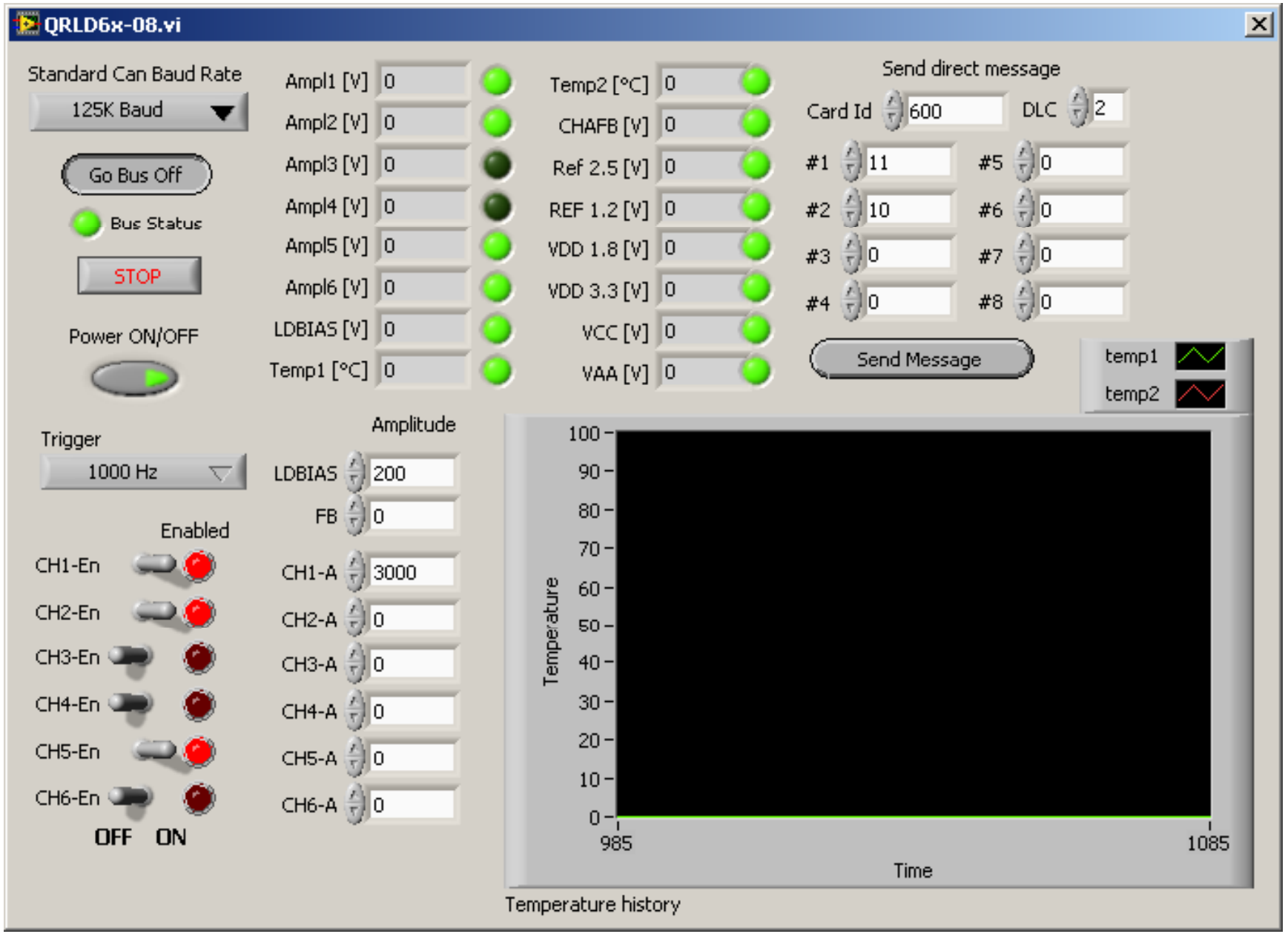
Conclusions

- We designed a QR-Led driver with 6 channels and communication module – we call it multichannel LED driver
- First tests shows good properties, very similar to previous tests with external toroidal inductors
- LED current pulse signal is 2.5ns – too short, needs increase of an inductor 48nH → ~120nH
- GUI and firmware was developed for the control of the QR-Led driver
- Report in November
- We have got and measured the fibres with the notches with reasonable homogenity of the light output
- We do not expect optical crosstalk (> 1 to 2 %) between tiles from notch coupling

Outlook

- 4T magnetic field tests at DESY FEB 09
- System integration to HBU prototype
  - 3 fibres:
    - 2 fibres at the upper position (on top of PCB)
      - 3mm holes in HBU-PCB, alternately: pure hole / gold plated holes
    - 1 fibre at the lower position (below scintillator, groove in the Al sheet)
  - Assistance at the assembly and tuning of the prototype (~ APR 09)
- We need 2pcs of 3x3 cm tiles with SiPM for tests with notched fibers in Prague!

Backup slides


QRLD6x-08.vi
Standard Can Baud Rate
125K Baud
Go Bus Off
Bus Status
STOP
Power ON/OFF
Trigger
1000 Hz
Enabled
CH1-En
CH2-En
CH3-En
CH4-En
CH5-En
CH6-En
OFF ON
Ampl1 [V] 0
Ampl2 [V] 0
Ampl3 [V] 0
Ampl4 [V] 0
Ampl5 [V] 0
Ampl6 [V] 0
LDBIAS [V] 0
Temp1 [°C] 0
Temp2 [°C] 0
CHAFB [V] 0
Ref 2.5 [V] 0
REF 1.2 [V] 0
VDD 1.8 [V] 0
VDD 3.3 [V] 0
VCC [V] 0
VAA [V] 0
Amplitude
LDBIAS 200
FB 0
CH1-A 3000
CH2-A 0
CH3-A 0
CH4-A 0
CH5-A 0
CH6-A 0
Send direct message
Card Id 600
DLC 2
#1 11
#2 10
#3 0
#4 0
#5 0
#6 0
#7 0
#8 0
Send Message
temp1
temp2
Temperature
Time
985
1085
Temperature history