Optical calibration system for EUDET AHCAL module

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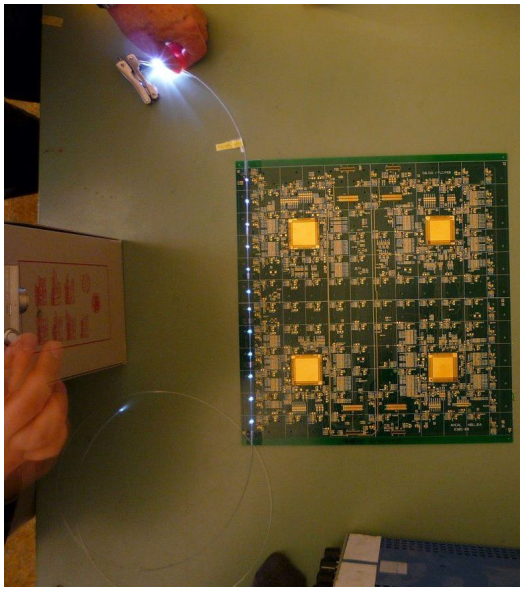
1. **Calibration system for SiPM photodetectors**
2. **QRLED driver photoelectron spectra**
3. **QRLED driver behaviour in strong magnetic field**
4. **Conclusions**

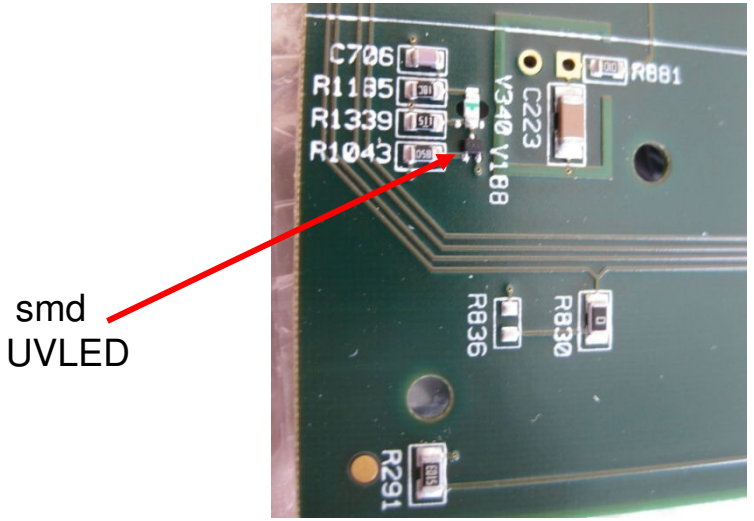
Flashing UVLED - 2 methods

- Light distributed by notched fibres



Institute of Physics ASCR, Prague
Kobe University

- Light distributed by microLED above scintillator distributed LEDs



DESY Hamburg
UNI Wuppertal

Notched fiber system

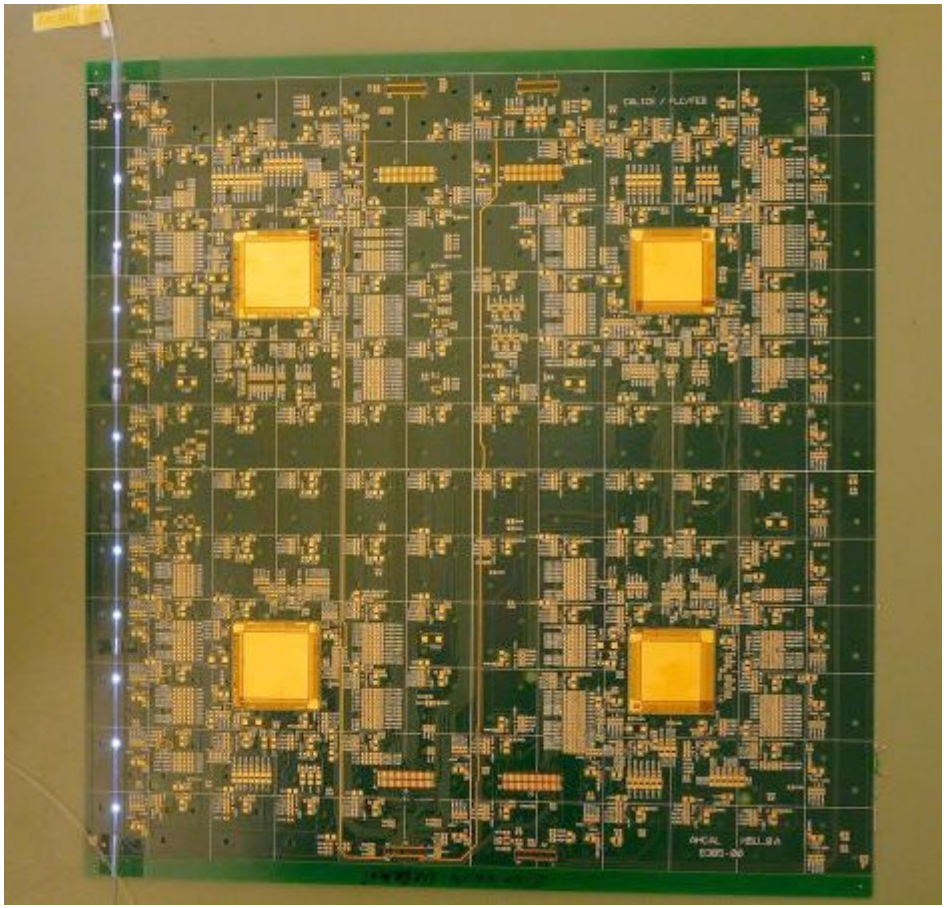
Advantage

- Tuneable amplitude of LED light from 0 to 50 mips
- Variation of LED amplitude does not affect the SiPM response readout
- LED circuit and LEDs enable optical pulses with around 5ns width
- Spread of light intensity from fibre notches can be kept under 20%

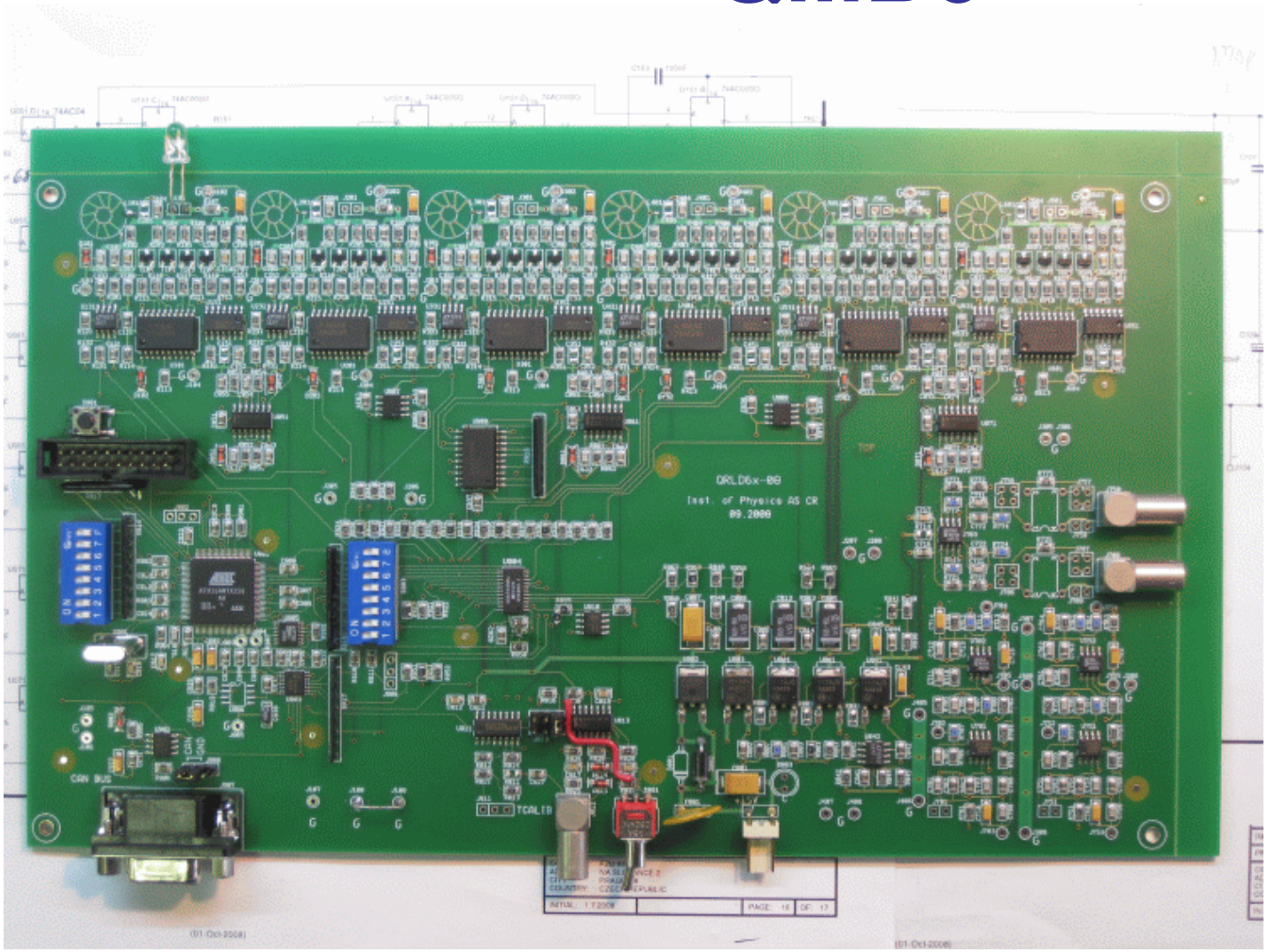
Disadvantage

- LED with control unit not fully integrated in the detector volume
- Notched fibre production is not trivial

Notched fibre routed at HBU0



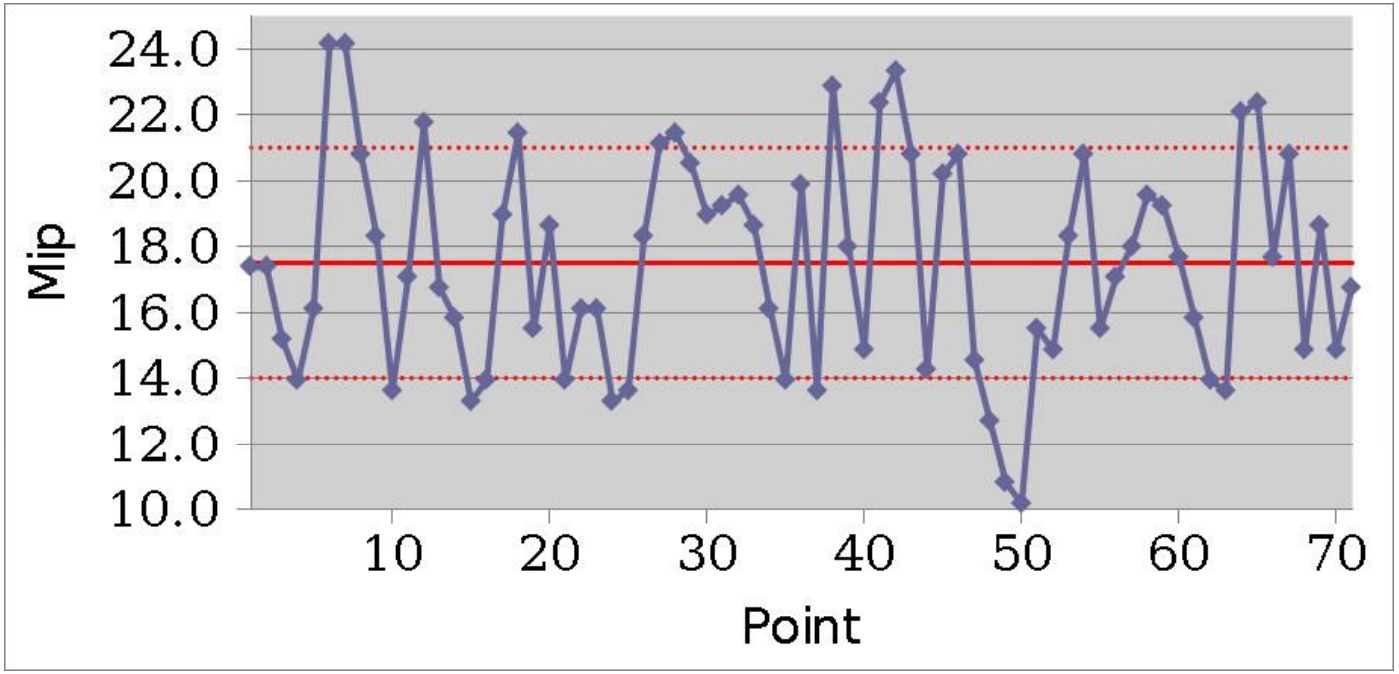
6-LED QR driver Main Board = QMB6



Consists of:

- 6 QR LED drivers
- 2 PIN PD preamps
- CPU + commun. module CANbus
- Voltage regulators
- Temperature and voltage monitoring

Light distribution system with notched fibres



- Light output from fibre via notches uniform over all 70 points (230 cm)
- Approaching ±20% proposed limit of light variation
- Notched fibre technology foreseen to improve

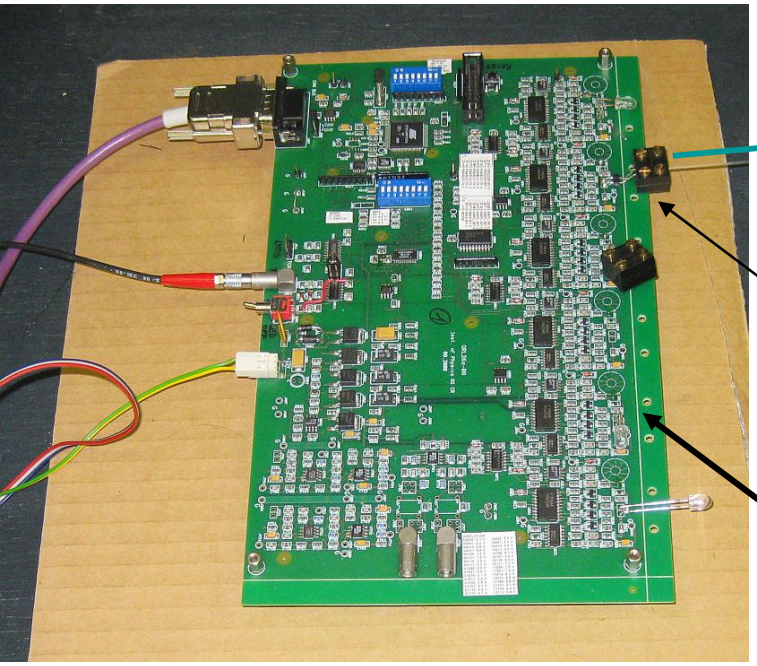
Setup for taking single p.e. spectra with notched fibre

Light-tight box

Notched fibre is laying on scintillator and taped to fix its position

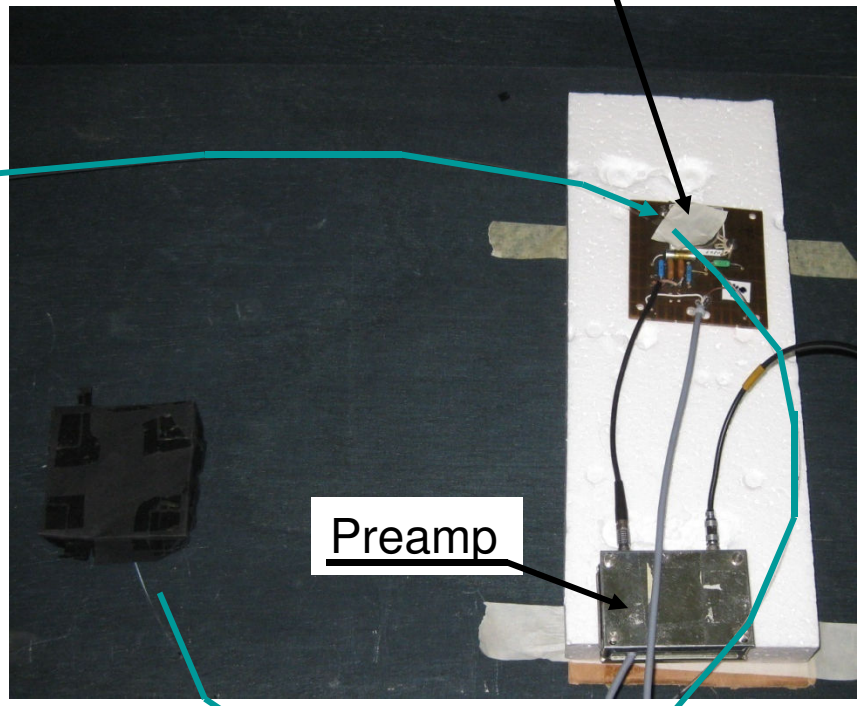
optical fibre

Sci + SiPM



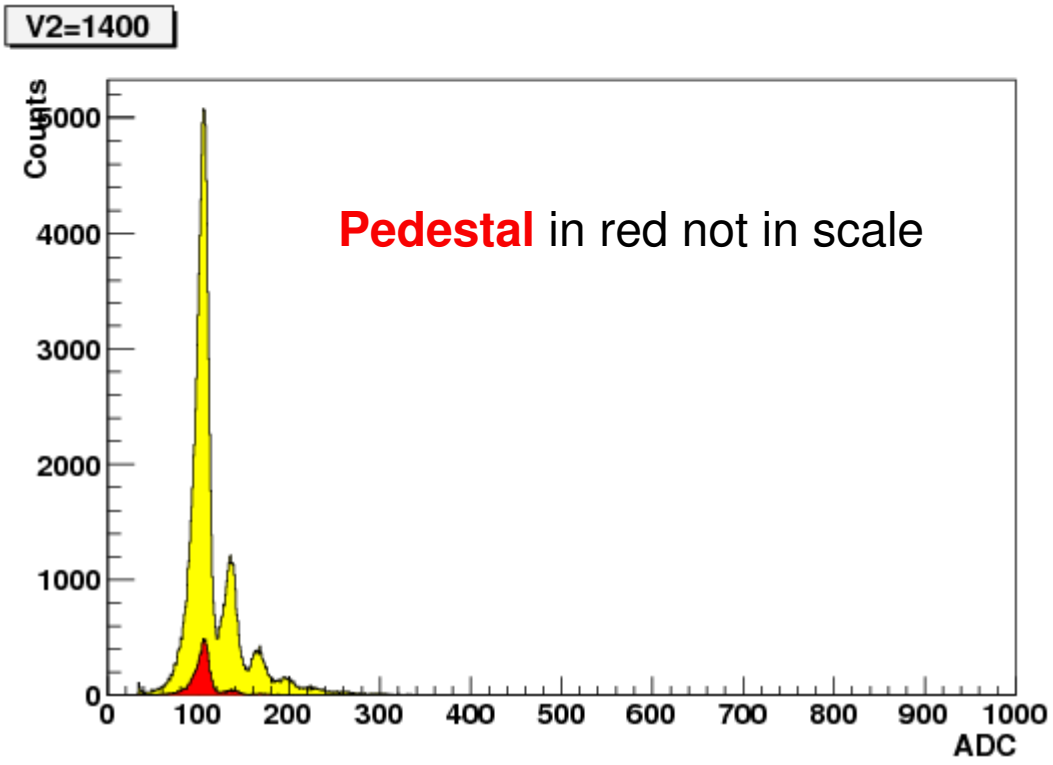
LED

QMB6



Preamp

P.E. spectra with increasing QRLED amplitude V2



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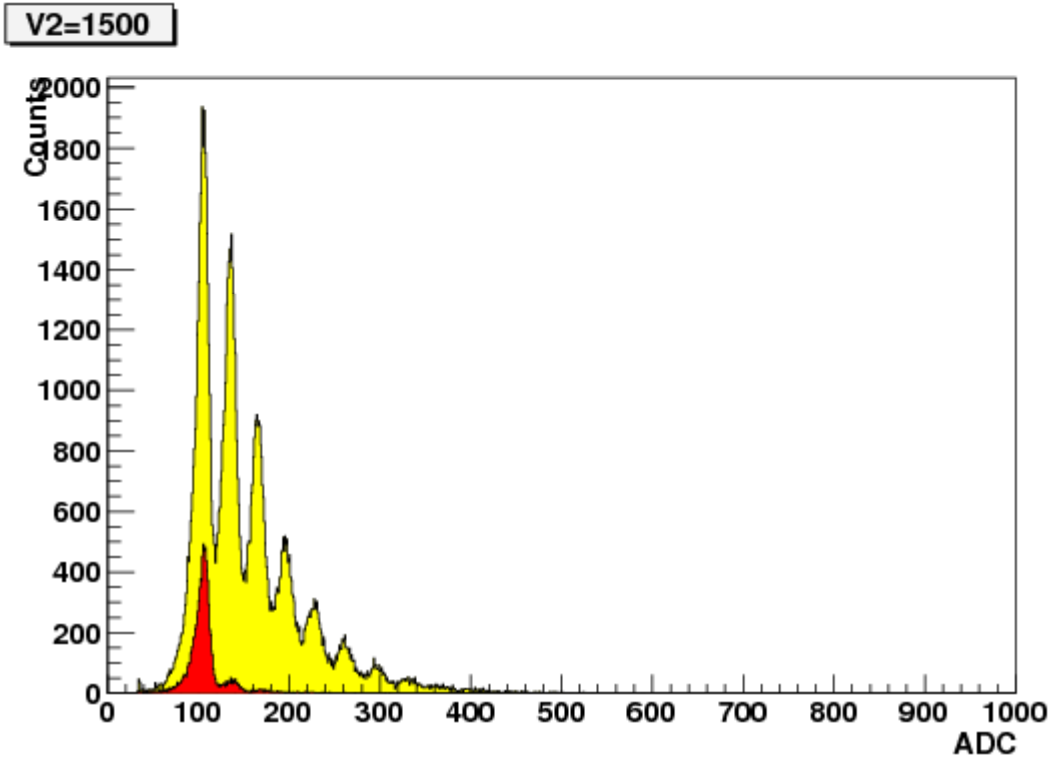

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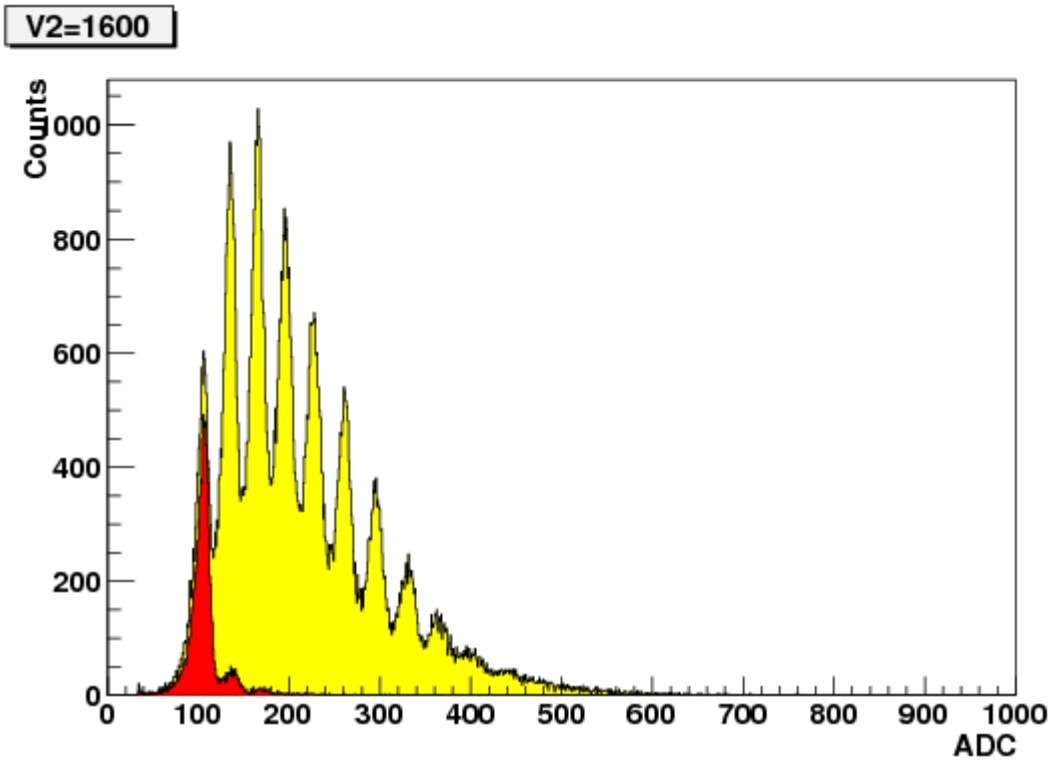

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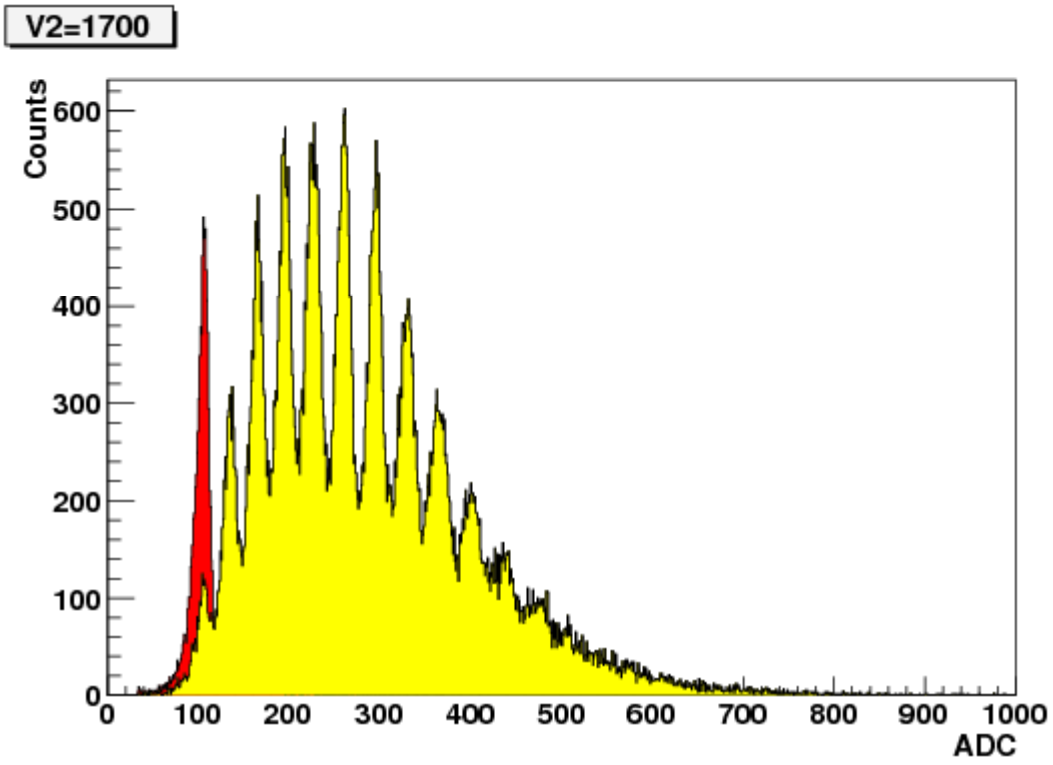
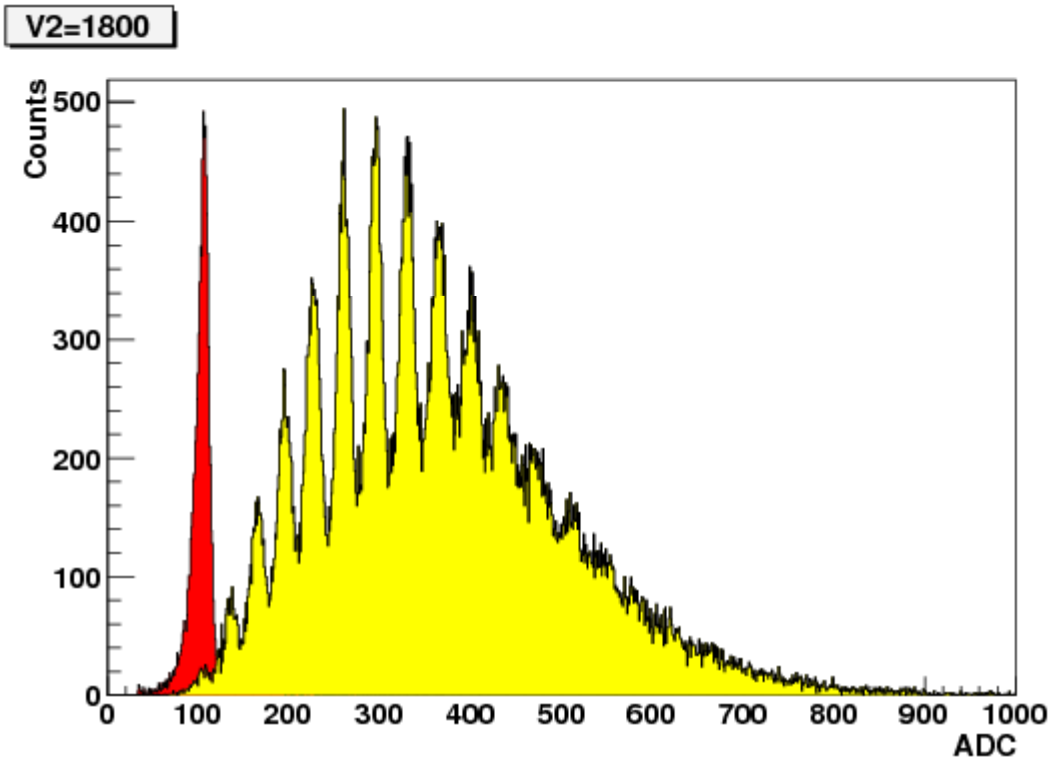


P.E. spectra with increasing QRLED amplitude V2



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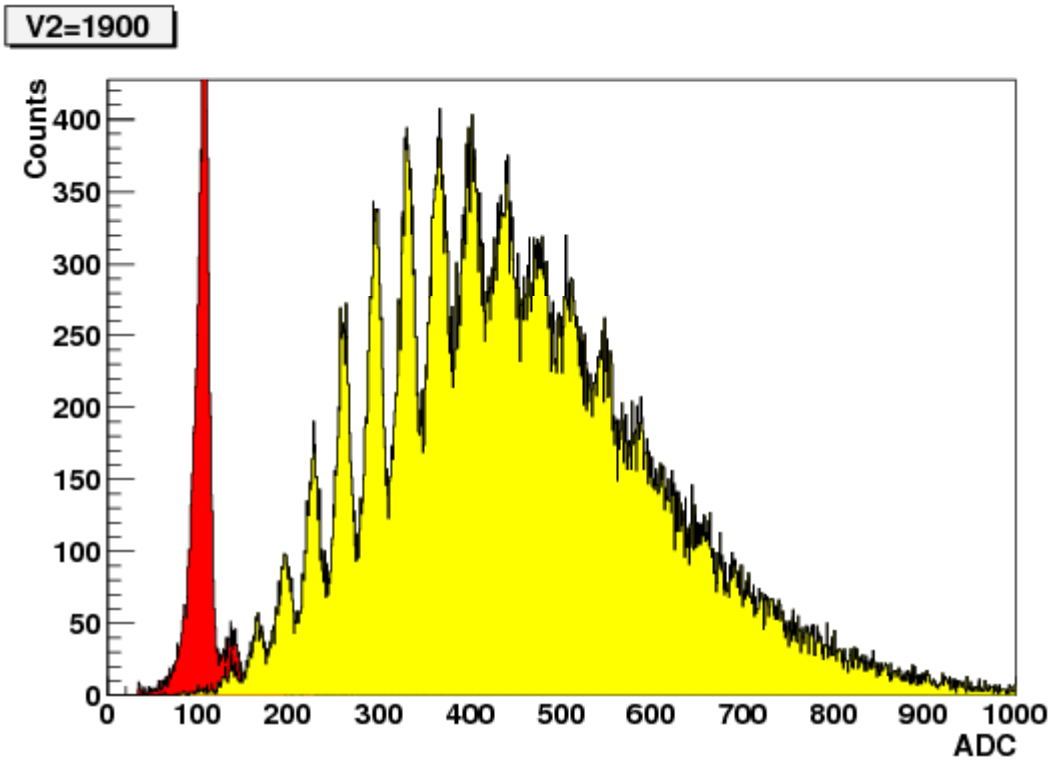
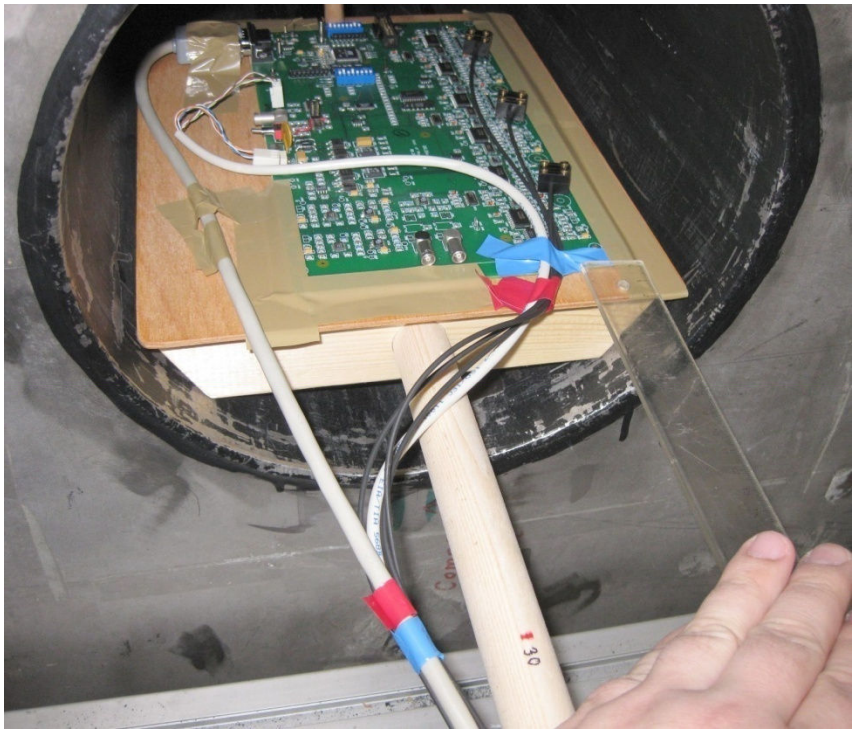


QRLED generates beautiful p.e. spectra in SiPM

QMB6 in superconductive solenoid

(magnetic field 0 to 4 T) DESY Hamburg, February 2009



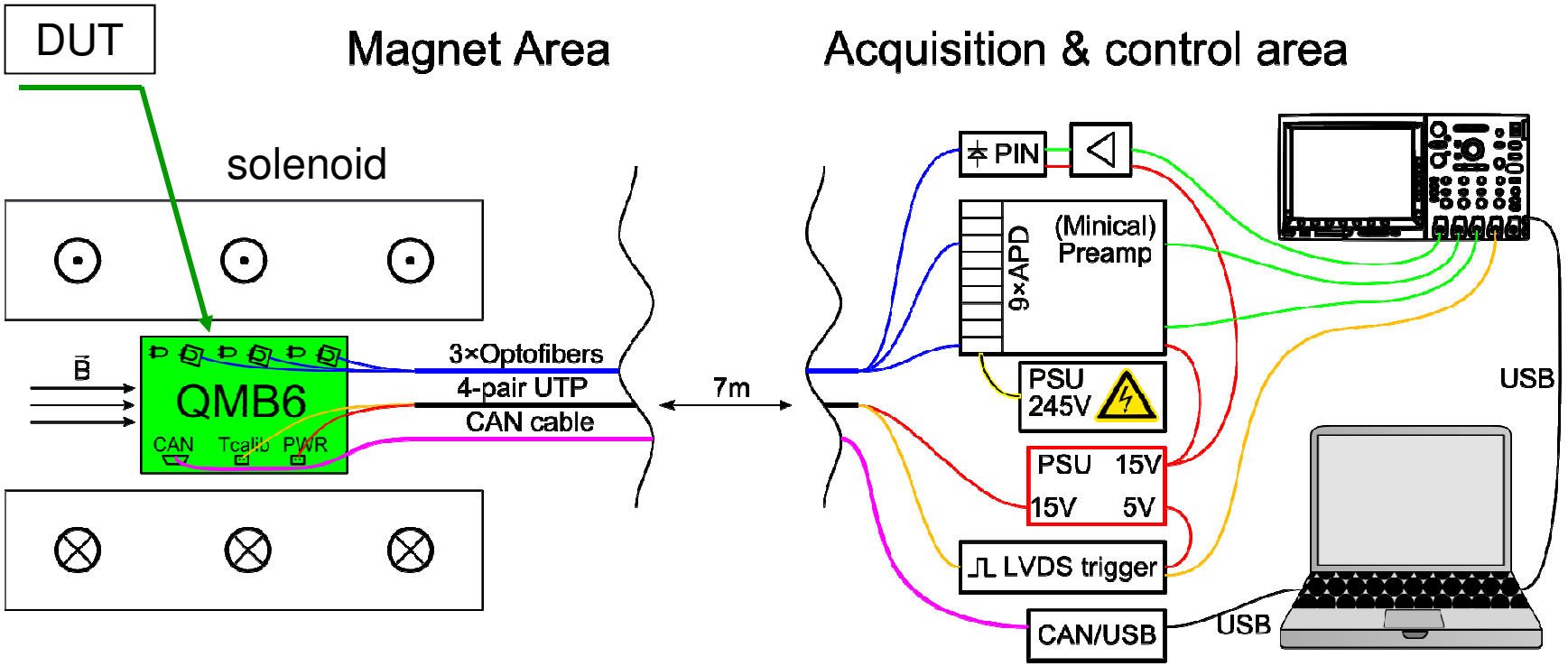
Details of 4 T magnetic tests can be found at

http://www-hep2.fzu.cz/calice/files/magnet5.jara_29.pdf

- Air core inductor can be sensitive to external magnetic field
- We performed tests of QMB6 in variable magnetic field

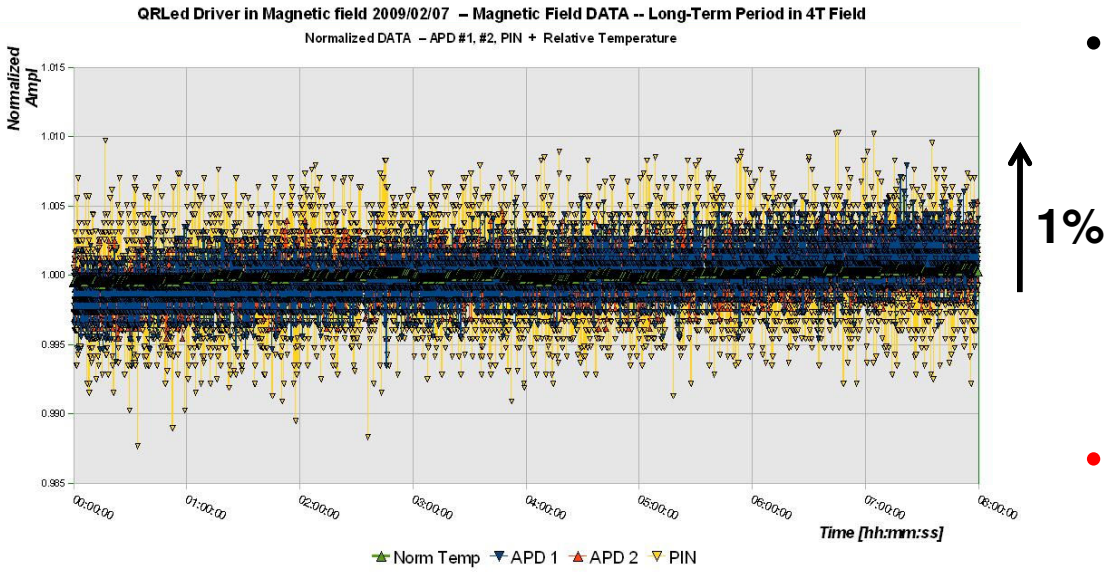
- 3 LED flash into 3 opto-fibre cables
- CANbus cable and T-calib + Power in other cable
- The setup was mounted on non-magnetic wooden paddle, to be moved in/out of solenoid bore.
- Two black end-cups were used to optically screen the setup.

Setup for measurements in magnet



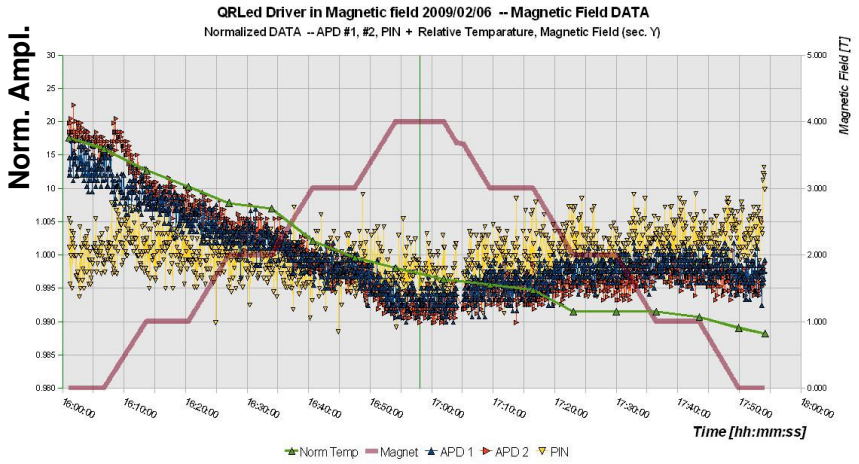
Magnet control is not shown.

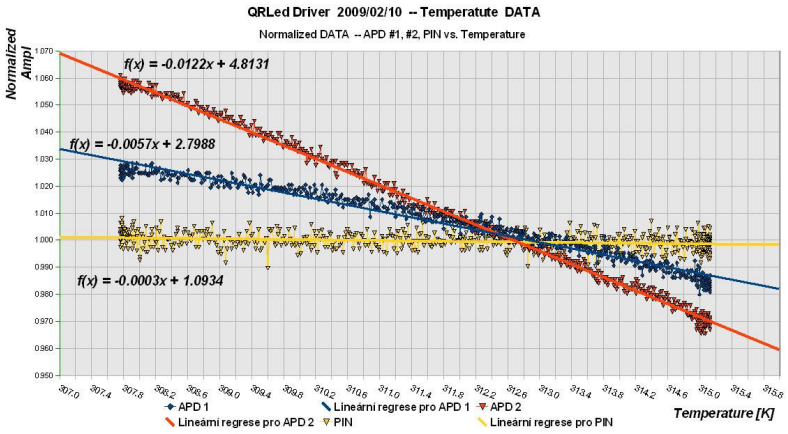
Start-up of measurements



- Two test positions of QMB6 in the magnet bore with respect to field lines
  - Parallel
  - Slant
- Long term stability of the system in 4 T
  - A few ‰ slope explained by the temperature variation at 0.1% level
- **Stable behaviour of the setup**

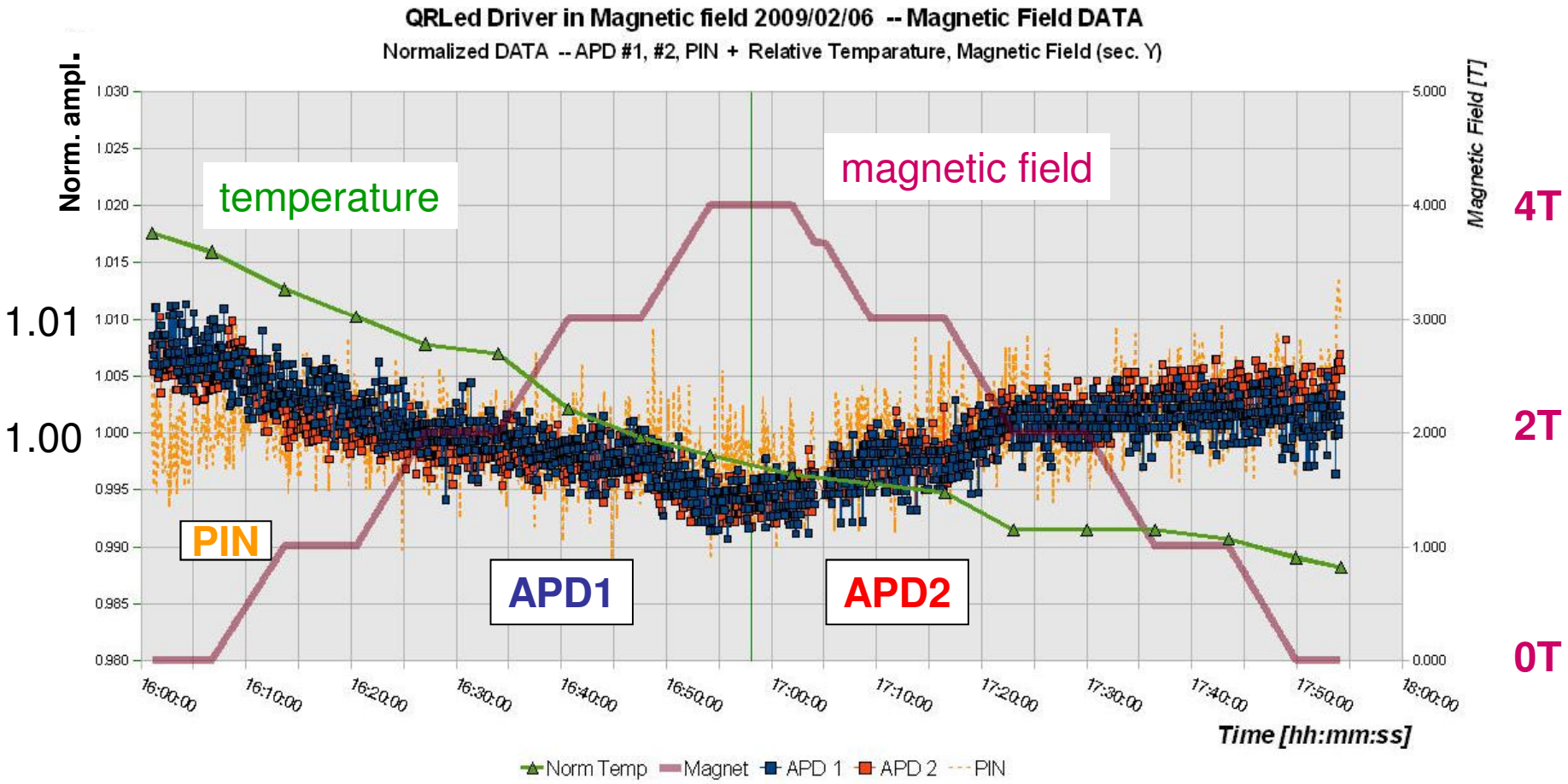
QRLED (APD) response to *B* (*t*)





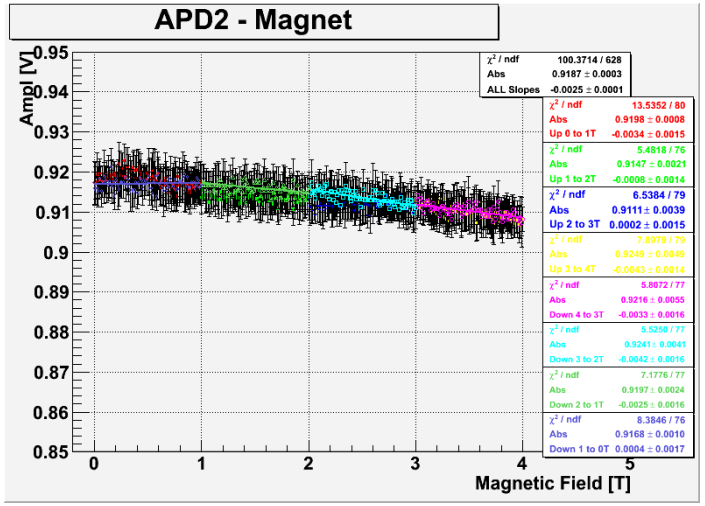
- The temperature (green line) was decreasing throughout the scan
- Temperature dependence of two APDs shows different slope
  - Due to different distance of APDs to temperature sensors (data sheet: gain spread < 1.5)
- PIN diode temperature dependence stable
- Extracted slopes from the linear fits were used to correct measured QRLED response

QRLED response to magnetic field 0 ÷ 4T

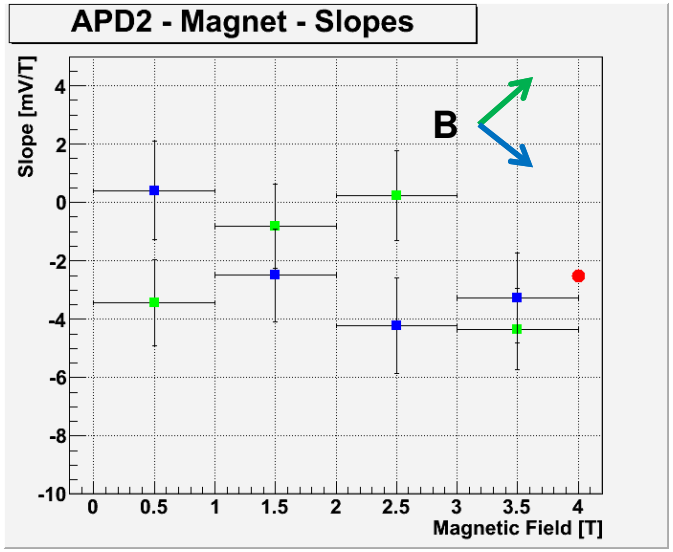


Implications from the observed light intensity variations with *B*

- Amplitude decreases linearly with *B* increase
- The same dependence for ramping up/down $(\Delta A/A)/\Delta B$ ~ - 0.2%/T
- The same for parallel and slant positions



- Assuming magnetic field stability in ILD magnet at the level 5×10^{-4} (accuracy of the CMS magnetic field) → relative light ampl. change ~ 10^{-6}
- Assuming magn. field inhomogeneity (CMS solenoid) ~ 0.3T/4T = 7.5% → calibration light amplitude variation ≤ 2×10^{-4} in the magnet volume
- Compare to typical calibration light variation at the level of 10^{-1} (optical contacts)



QMB6 has negligible sensitivity to B !!! ☺

EUDET Memo finished

- We conclude that the relative change of the amplitude of the QRLED driver does not exceed level of 3 per mile for 1 Tesla field change
- The amplitude time stability of the calibration light is better than 2×10^{-6} (part a day meas.)
- The maximal relative change of the calibration light amplitude inside the CMS solenoid from the QRLED driver will be smaller than 3×10^{-4}

Magnetic field tests of the QRLED driver

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October 06, 2009

Abstract

The QRLED driver produces short ~ 5 ns long electrical pulses for LEDs. It is foreseen as a source of the tuneable LED light for calibration of SiPMs in the EUDET analogue calorimeter module. The short electrical pulses are created in the toroidal inductance made directly on the PCB. This design results from the requirement on the minimal height of the electronic circuitry in the compact EUDET module. We measured the behaviour of the signal shape of the QRLED on variation of the magnetic field up to 4 T. The strength of the magnetic field is close to the field foreseen in the ILD detector.

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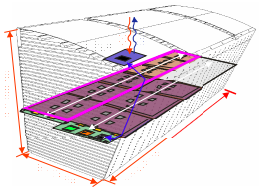
[2] Czech Technical University, Prague, Czech Republic

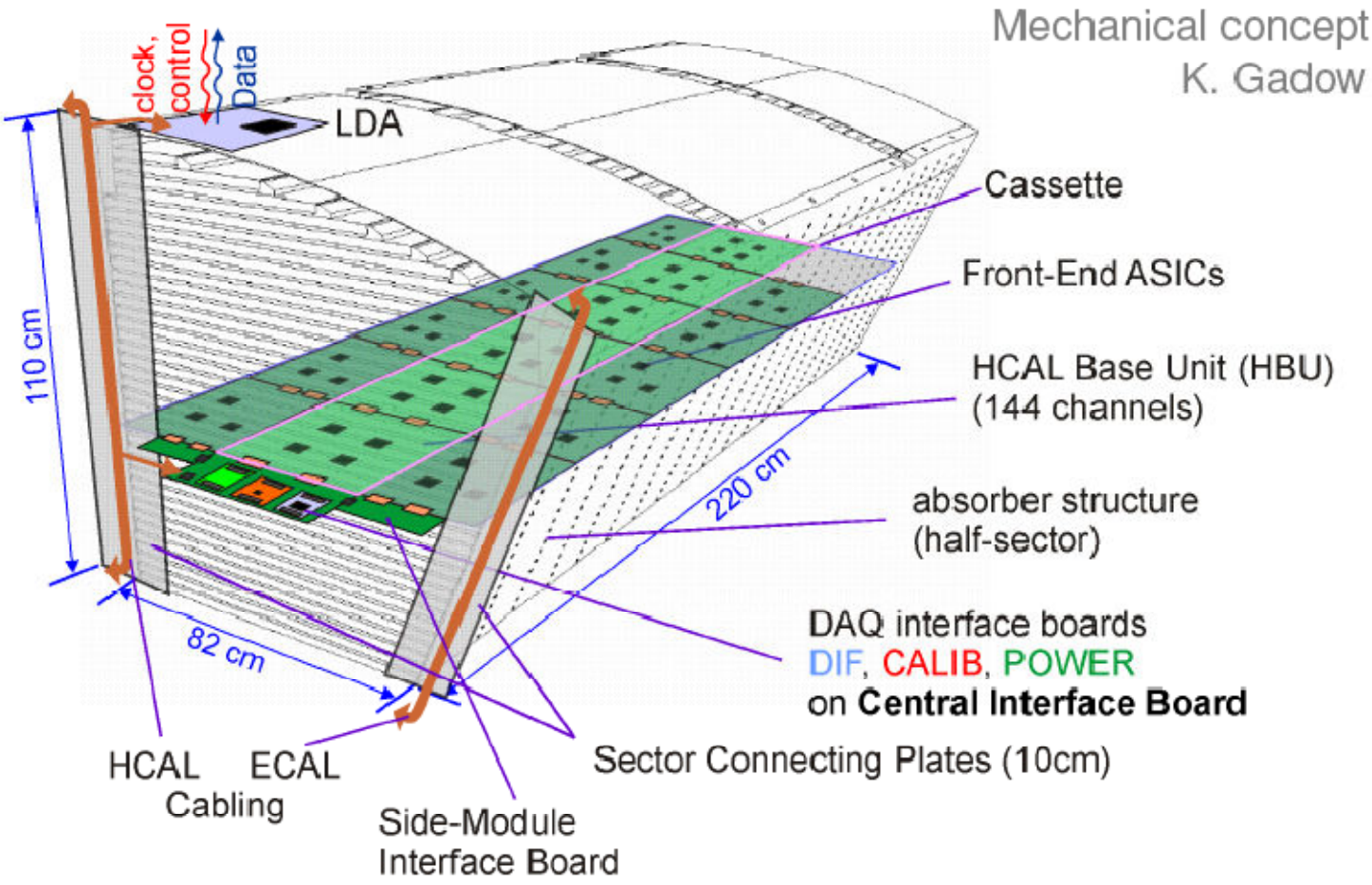
Conclusions

- Two optical methods for SiPM calibration in AHCAL under investigation
  - Notched fibres
  - Distributed LEDs
- For each method UVLED driver has been developed
- QRLED driver has tunable light amplitude and generates clear p.e. spectra
- QRLED driver is not sensitive to magnetic field in the range 0 – 4 T
- Both methods will be tested in HBU0 EUDET prototype

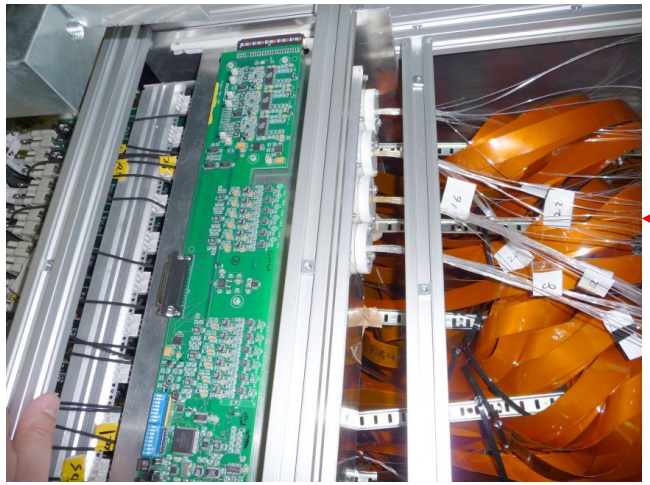
Back up

General mechanical concept AHCAL EUDET module



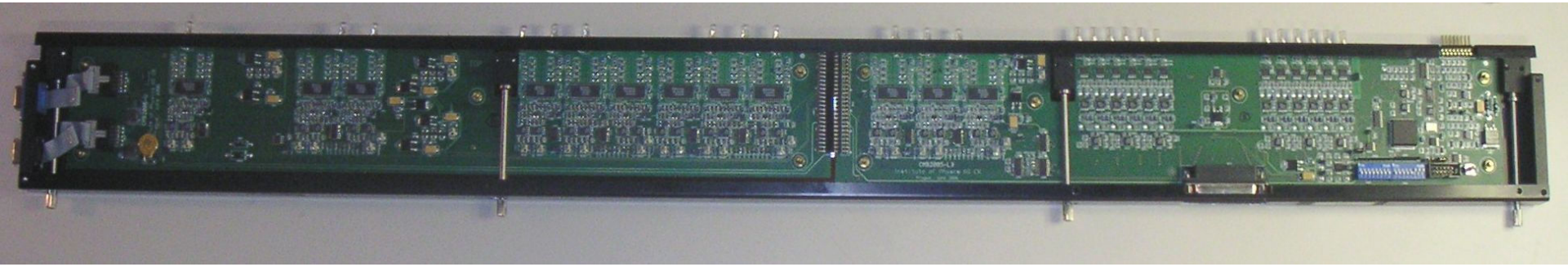


CMB = Calibration Monitoring Board

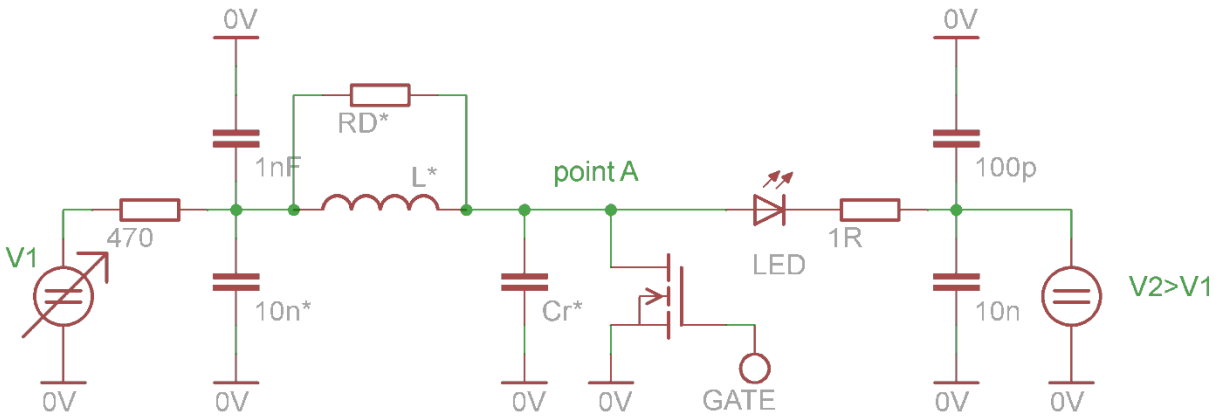


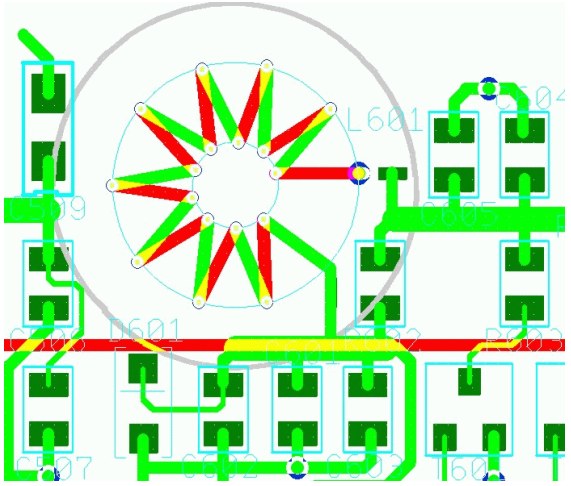
- CMB used in AHCAL 1m^3 prototype
- 38 layers in AHCAL detector at at three TB facilities DESY/CERN/FNAL (2006 to 2009)
- One CMB used in Japanese SciECAL detector (TB 2009)
- 12 LEDs / 12PIN PD
- Steering of amplitude and pulse width of LED by T-calib and V-calib signals
- Temperature and voltage readout in slow control, CANbus control

- Relevant links:
- http://www-hep2.fzu.cz/calice/files/ECFA_Valencia.Ivo_CMB_Devel_nov06.pdf

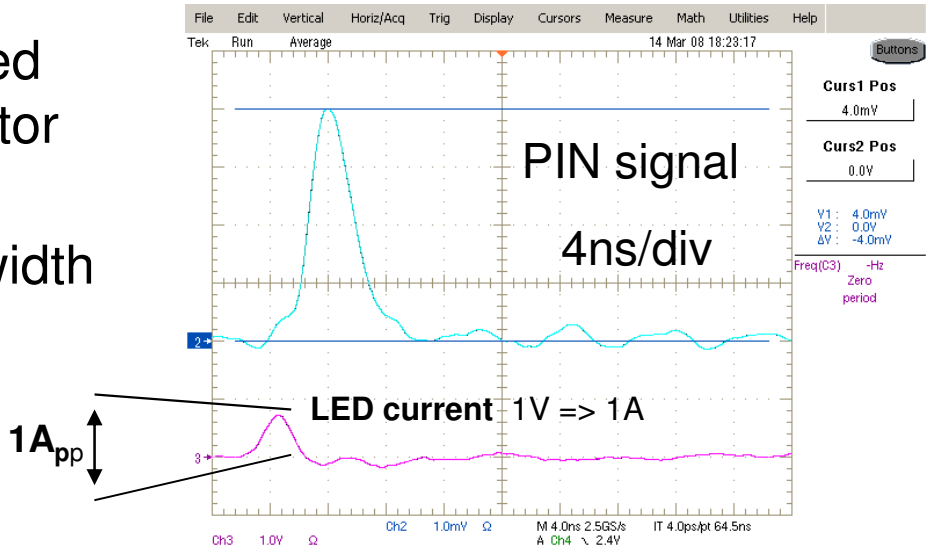


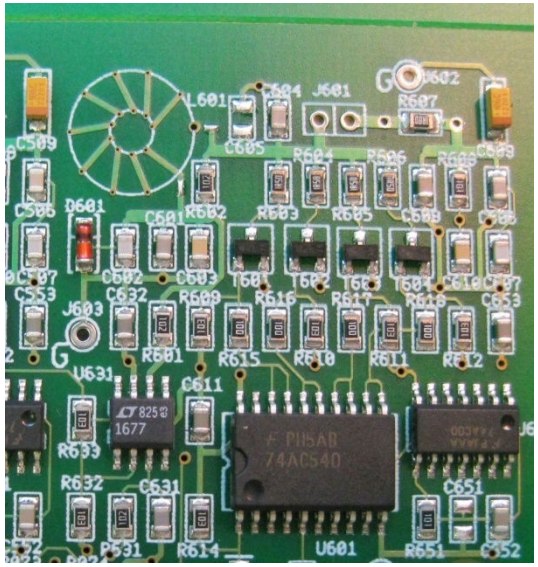
Quasi-Resonant LED driver





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





QRLED Pedestal UVLED →SiPM