LED notched fibre system at AHCAL

Calibration system for SiPM

Ivo Polák

polaki@fzu.cz

1. Notched fibre light distribution systems
2. A Set-up, with provisional fibre layout
3. Toroidal inductor at PCB
4. LED optical power
5. Plans for 2010
6. Conclusions

Requirements to calibration system for SiPM based detectors

Generate uniform near-visible UV flashes

- controllable in amplitude 0 to max = twice SiPM saturation
- pulse width a few ns
- enabling each LED individually
- optical feedback from LED to PIN-PD signal channel

LED triggering from DAQ

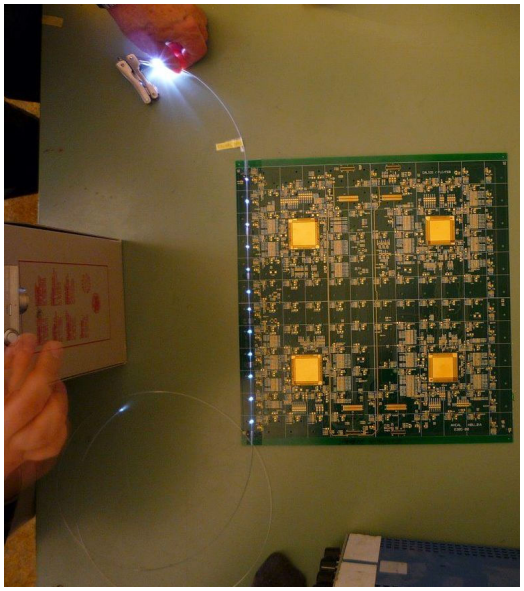
Readout temperature from sensors placed in the scintilator plane (12bits minimum)

Some (USB, CANbus,…) interface to Slow-control

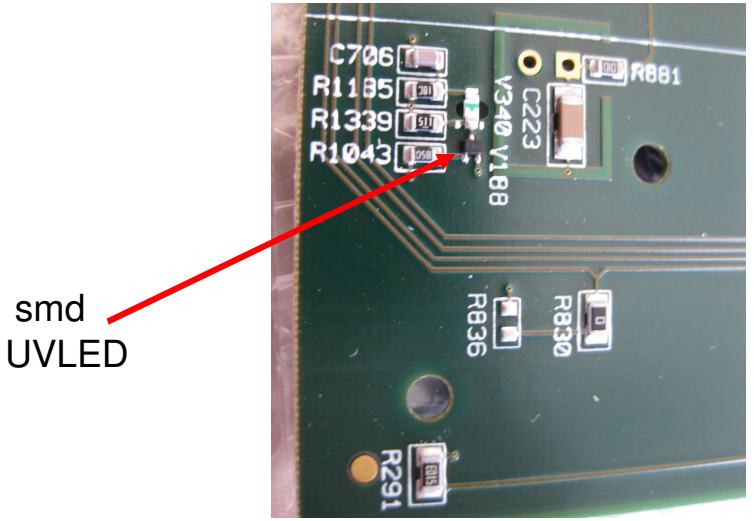
Stability in magnetic field

Flashing UVLED - 2 methods

- Light distributed by notched fibres



- Light distributed directly by microLED to the scintillator - distributed LEDs



Institute of Physics ASCR, Prague, (= FZU)
Shinshu University

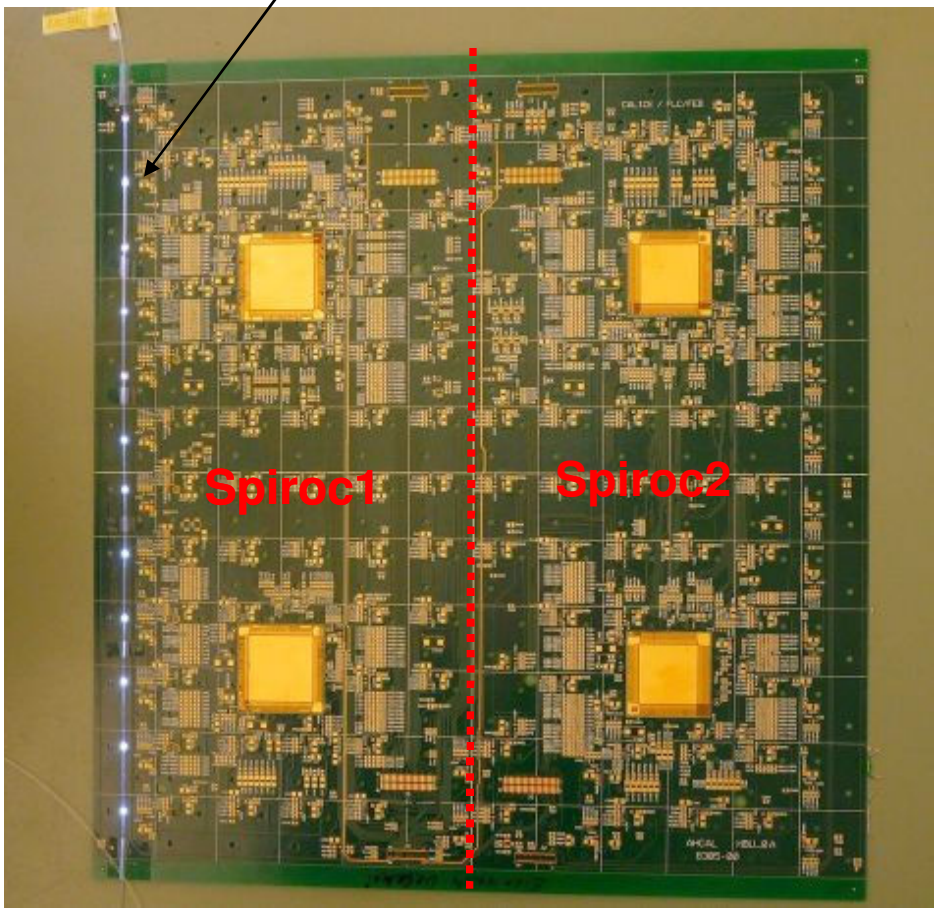
DESY Hamburg
UNI Wuppertal

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 5 ns width
- Spread of light intensity from notches can be kept under 20%
- disadvantage LED with control unit outside the detector volume
- Notched fibre production is not trivial

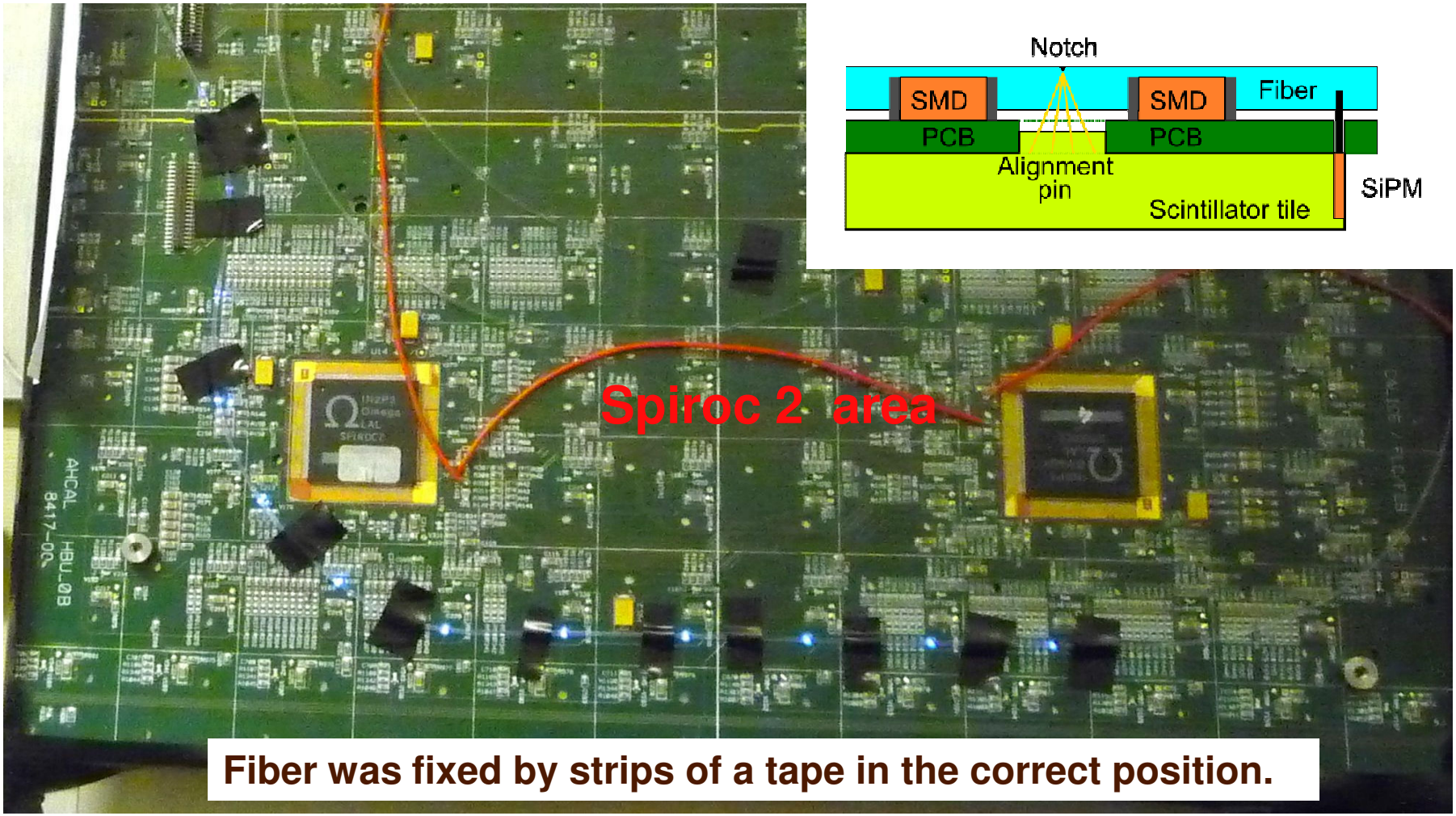
Nice idea, but... Spiroc1 area is not working

Notched fibre routed at HBU0, taps illuminates the scintillators via special holes

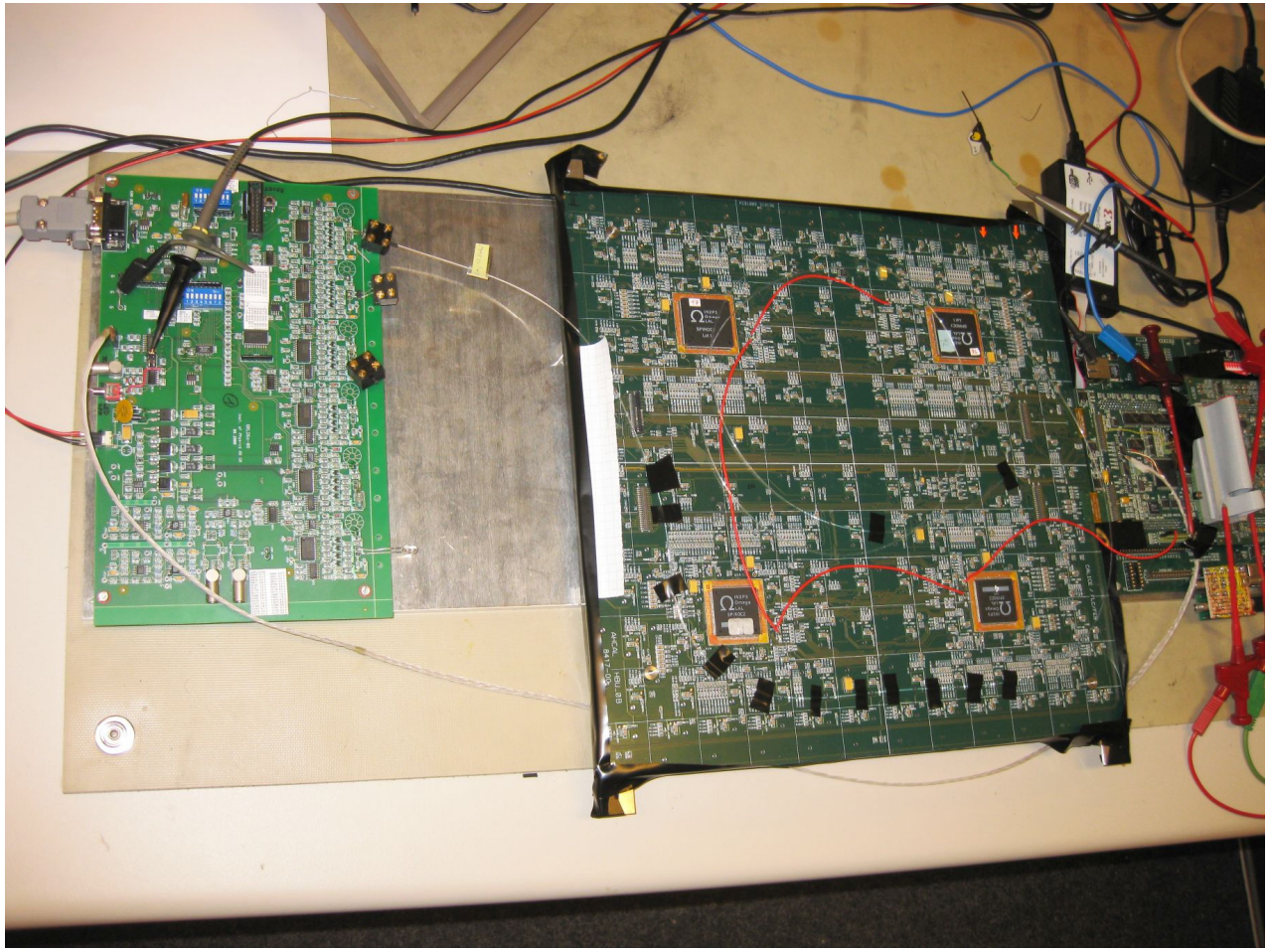


Notched fiber layout on HBU0 at DESY dec2009

- Picture: Notched fiber was illuminated by small pocket spotlight.
- Most of 12 notches are above alignment pins



Setup QMB6 (QRLED system) + HBU0

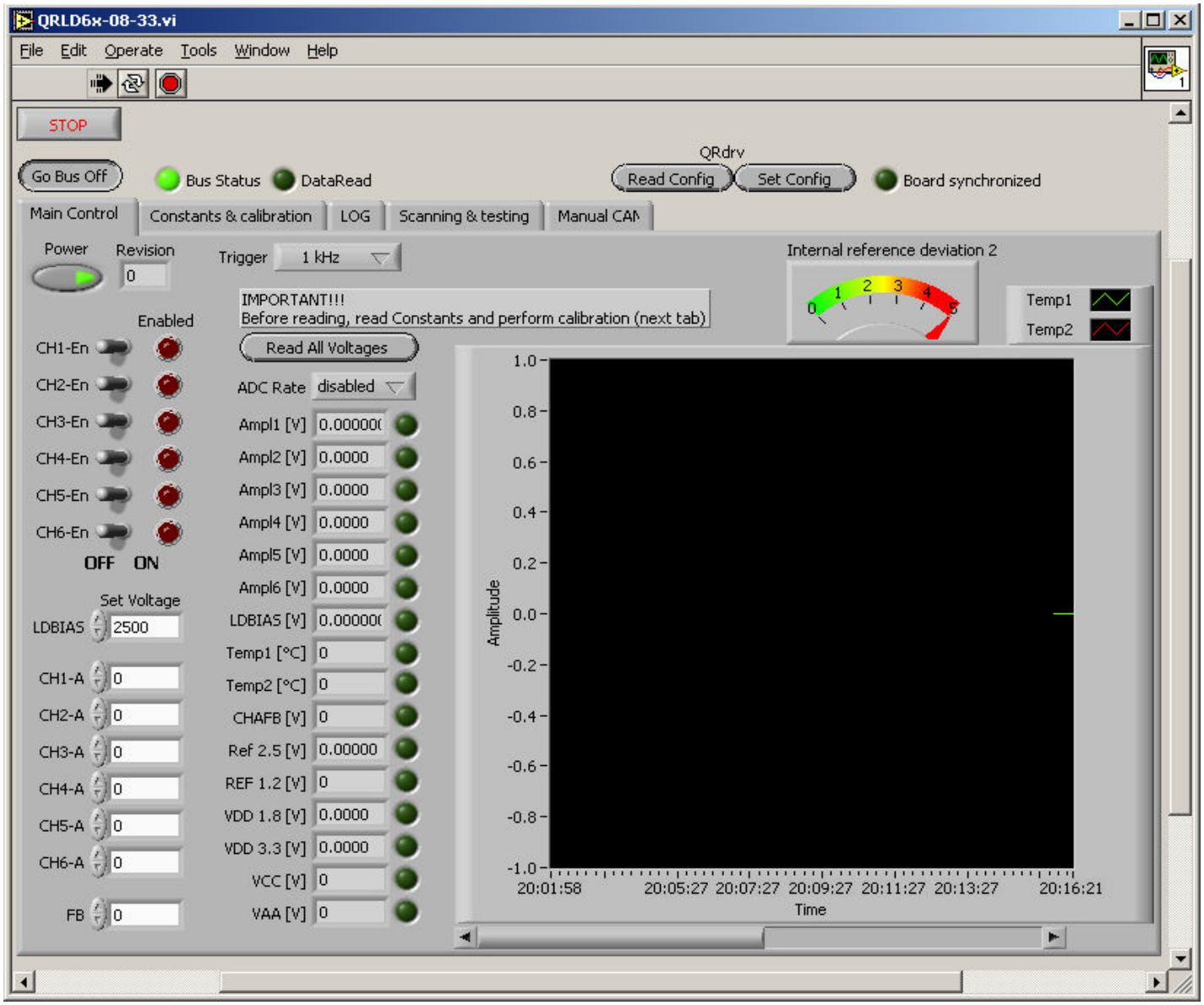


- From HBU0 (calib board):
  - signal T-calib LVDS only
  - 60ns Delay
  - power +15V/0.16A
  - CANbus slow-control
  - One UVLED 5mm
  - One Notched fibre

Control: LabView 8.2 exe-file, One PC with DAQ, USB --> CAN

Almost **plug and play**

Control panel of QMB6 in LabView 8.2



- Controls individual

LED amplitude

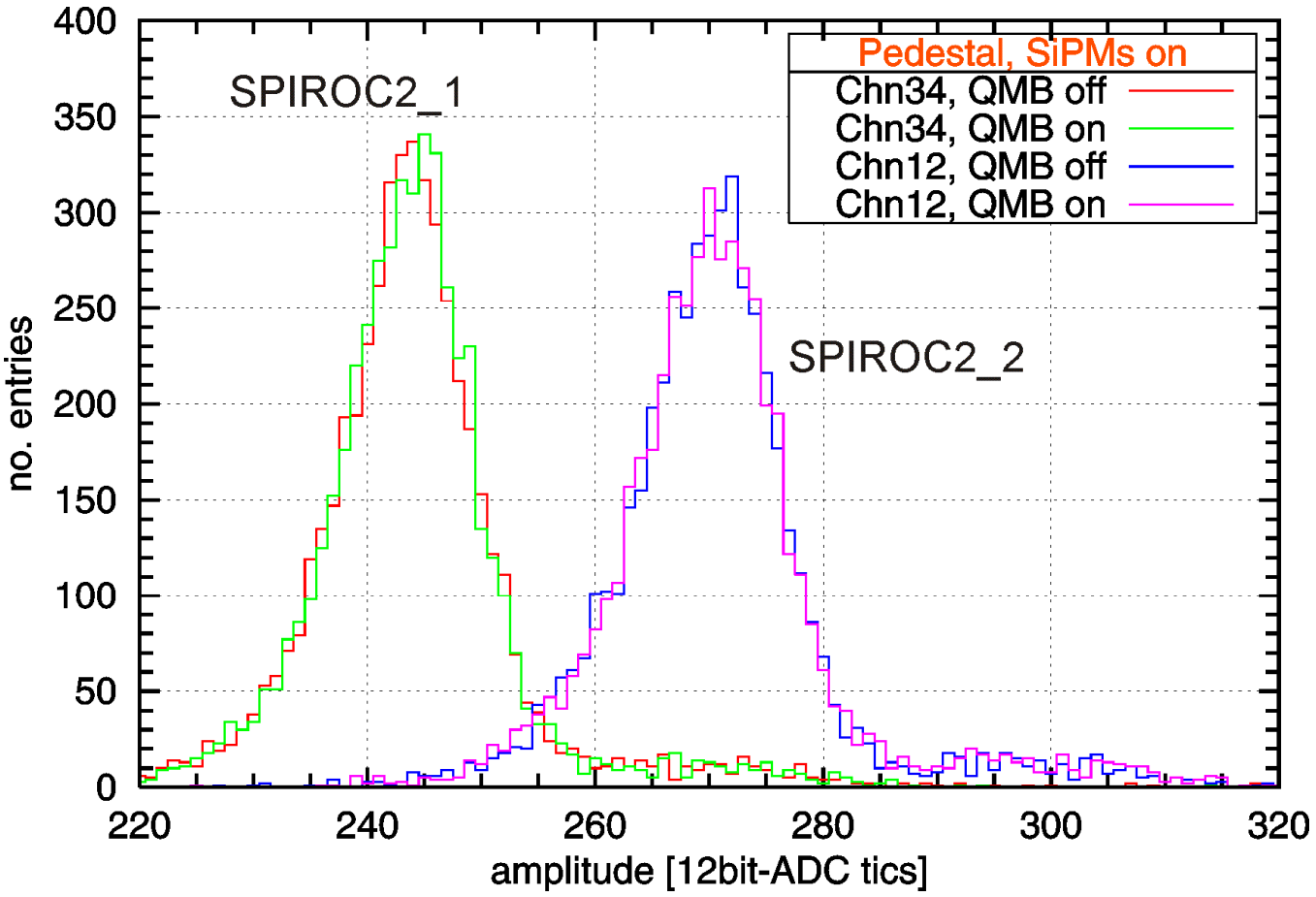
- LED Enables
- Trigger mode ext/internal
- Measure temperature
- CANbus control

- It can work as Exe file

QMB6 **ON**/**OFF** test

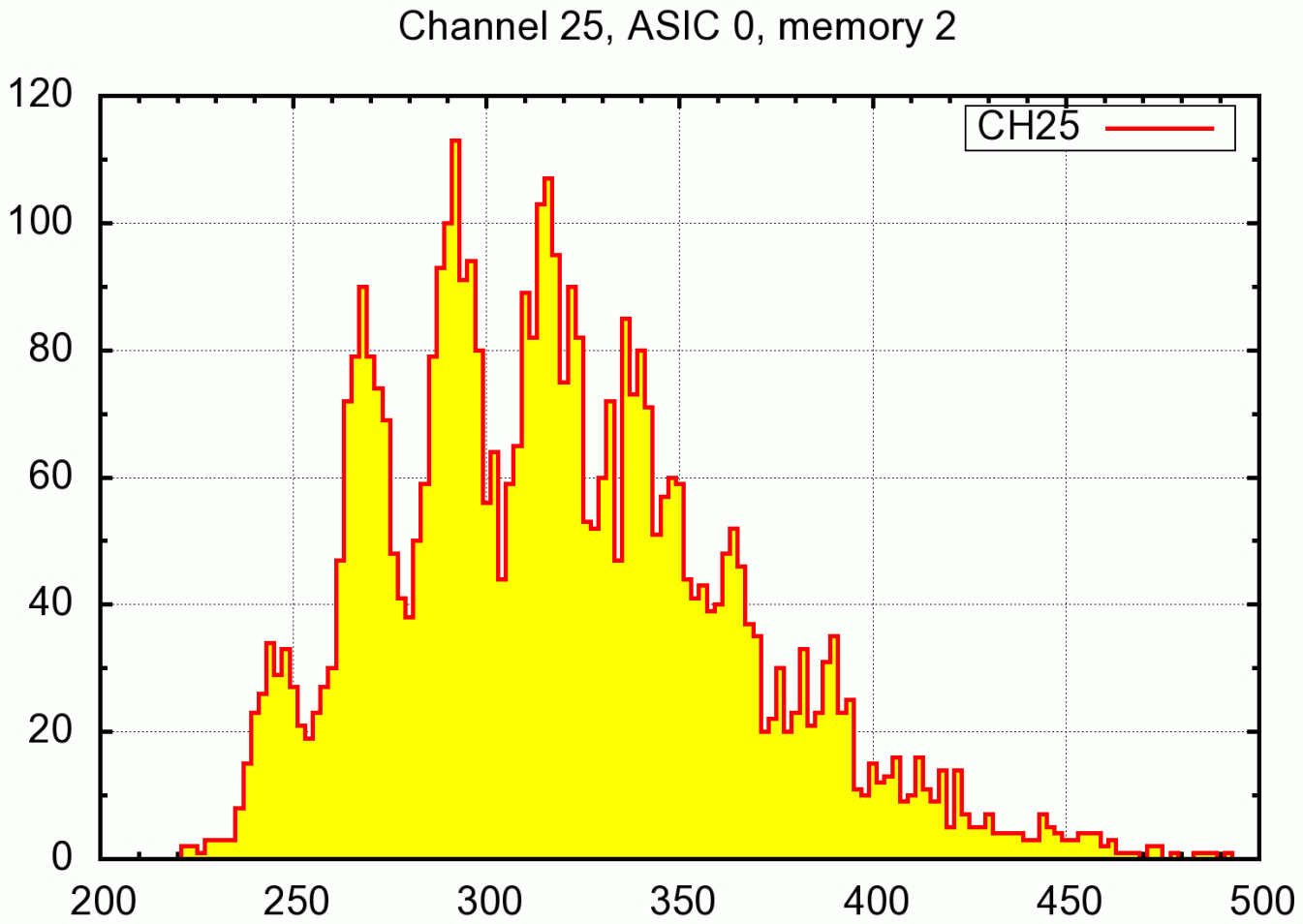
ON means T-calib on, LED off

OFF means +15V power off



NO pedestal shift!
NO unwanted ground coupling!

Single p.e. spectrum

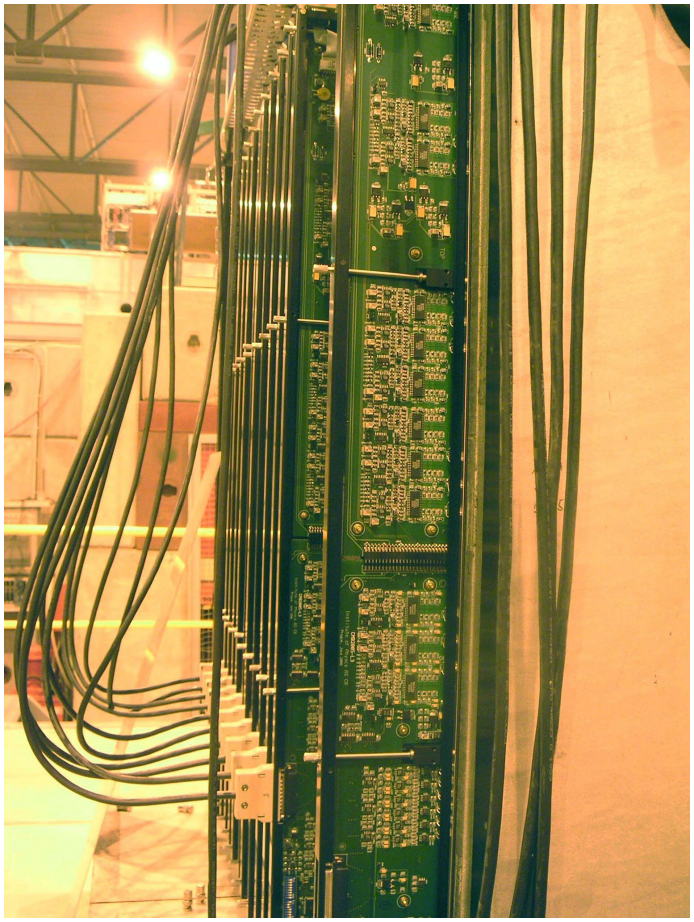


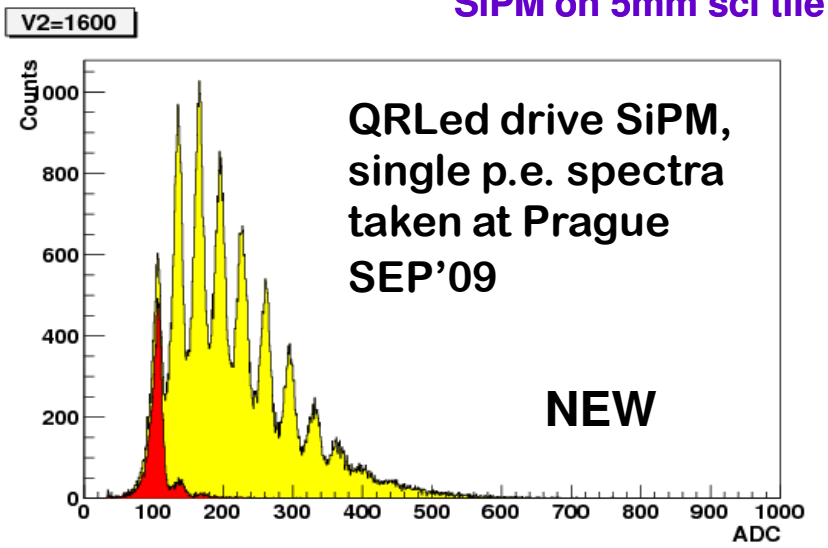
Calibration mode, High Gain

Low statistic there

Single photoelectron spectra with CMB and QRLED

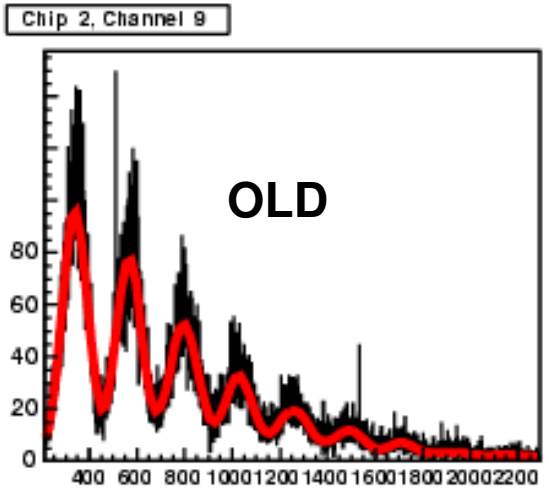
LED light 400nm to SiPM on 5mm sci tile





←CMB in tuning position at AHCAL TB 2007 CERN

one of the single p.e. spectra →

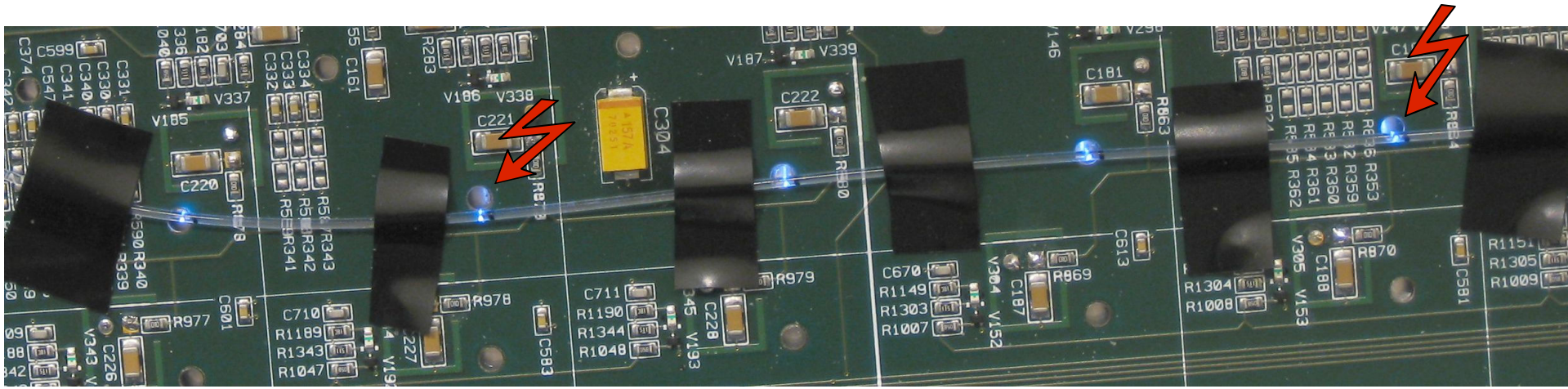


More info about CMB can be found at:

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

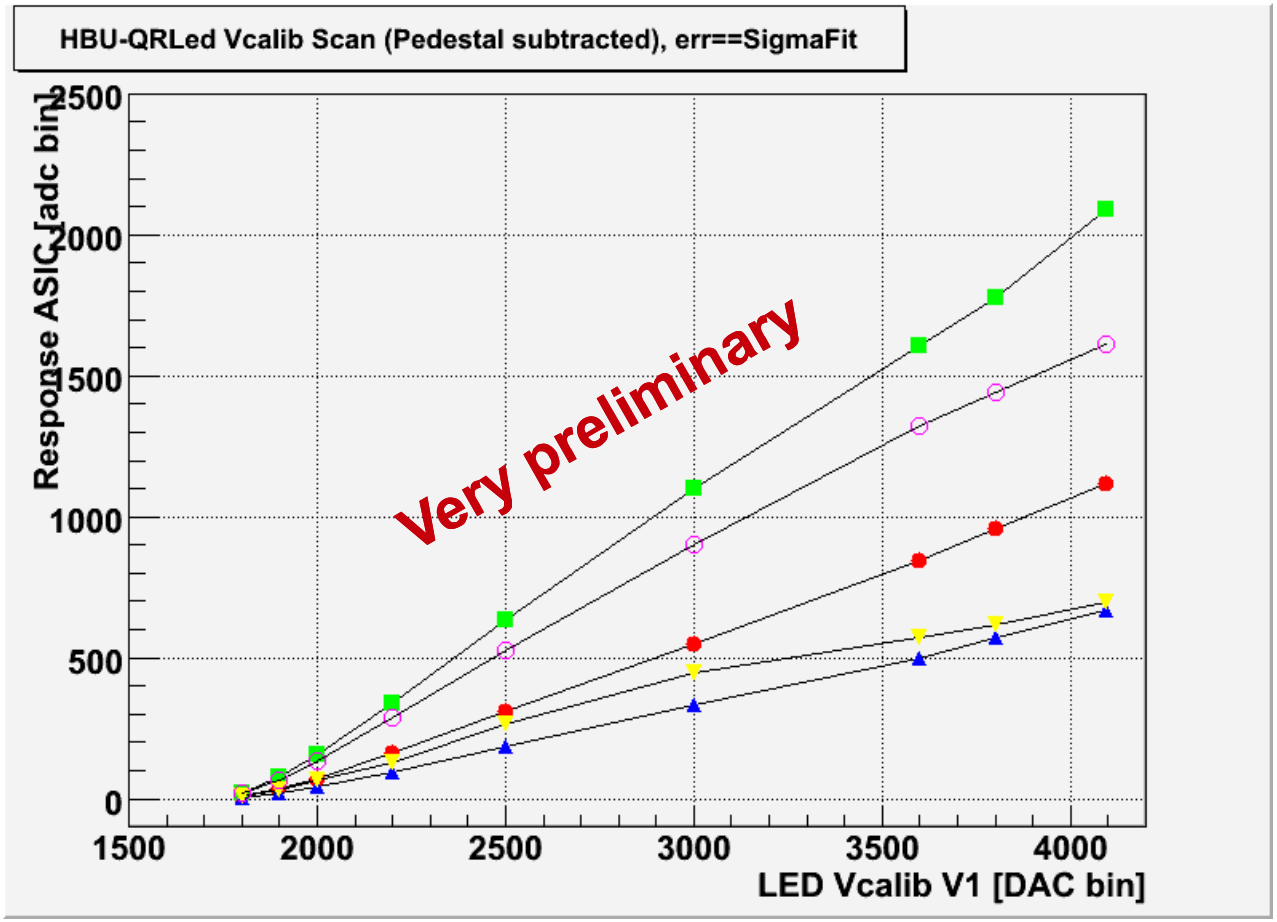
Next day we found a misalignment of the fibre

Electrical tape and bent fibre is not the right combination!



Linearity test (it means a saturation curve)

More details in talk of J. Kvasnicka, CALICE 2010 Arlington



Settings:

Cf = 400fF
Low gain mode

- We do not see saturation effect, yet.
- Better optical coupling alignement is a must. – strong misaligment effect
- Higher LED pulse can be made with larger pulse-width (3.7 → 7ns)

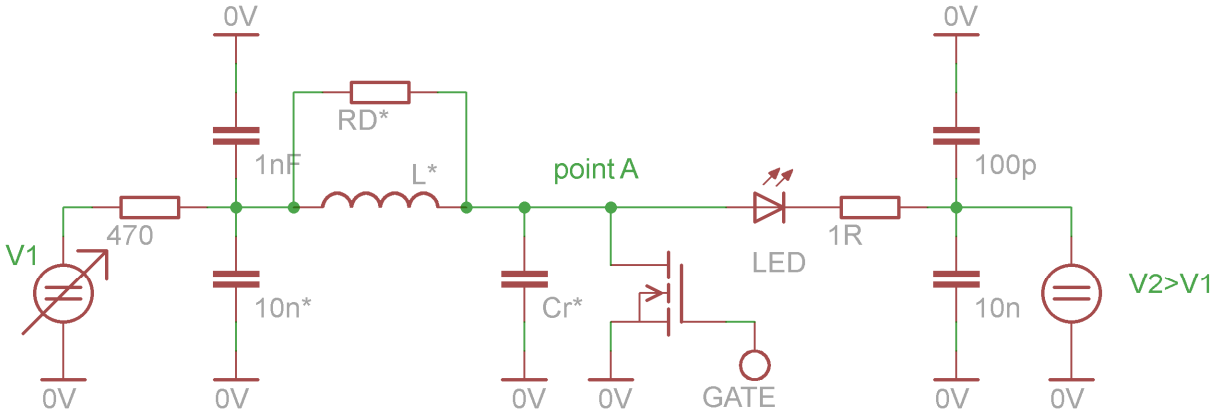
Conclusions to common test HBU0 with QMB6

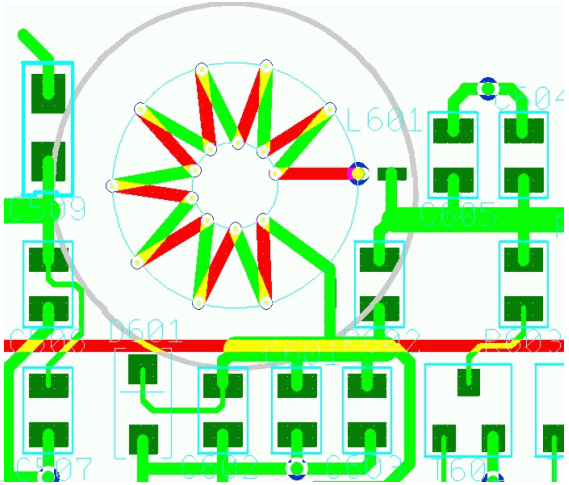
- Easy implementation, almost **plug and play** installation
- Both methods of light distribution are tested in HBU0 EUDET prototype
- With QMB6 we can see a nice single p.e. spectra, similar to distributed LEDs
- We do not see saturation of SiPM yet, better optical coupling is a must. We have to focus on this detail.
- We would like to make more tests in the future, focusing on the optical coupling
- We can integrate a few QRLED to new version of HBU
- Special thanks to Mathias Reinecke and FLC group.

GET more light!

Larger pulse →Larger inductor

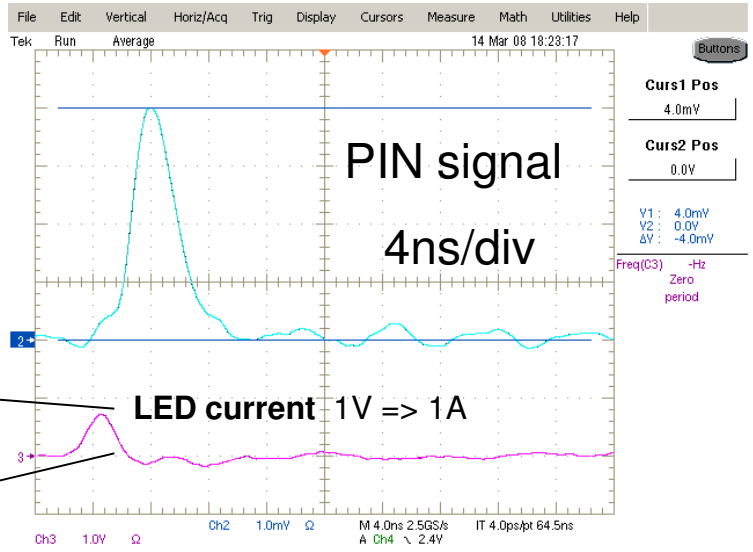
Quasi-Resonant LED driver

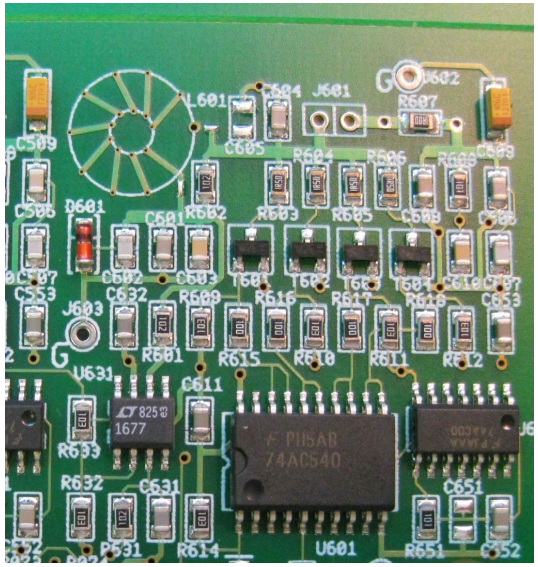




- Less RFI, not sensitive to **magnetic field – tested up to 4T**
- PCB integrated toroidal inductor (~35nH)
- Fixed pulse-width (~4ns)

To be increased, to get more light.



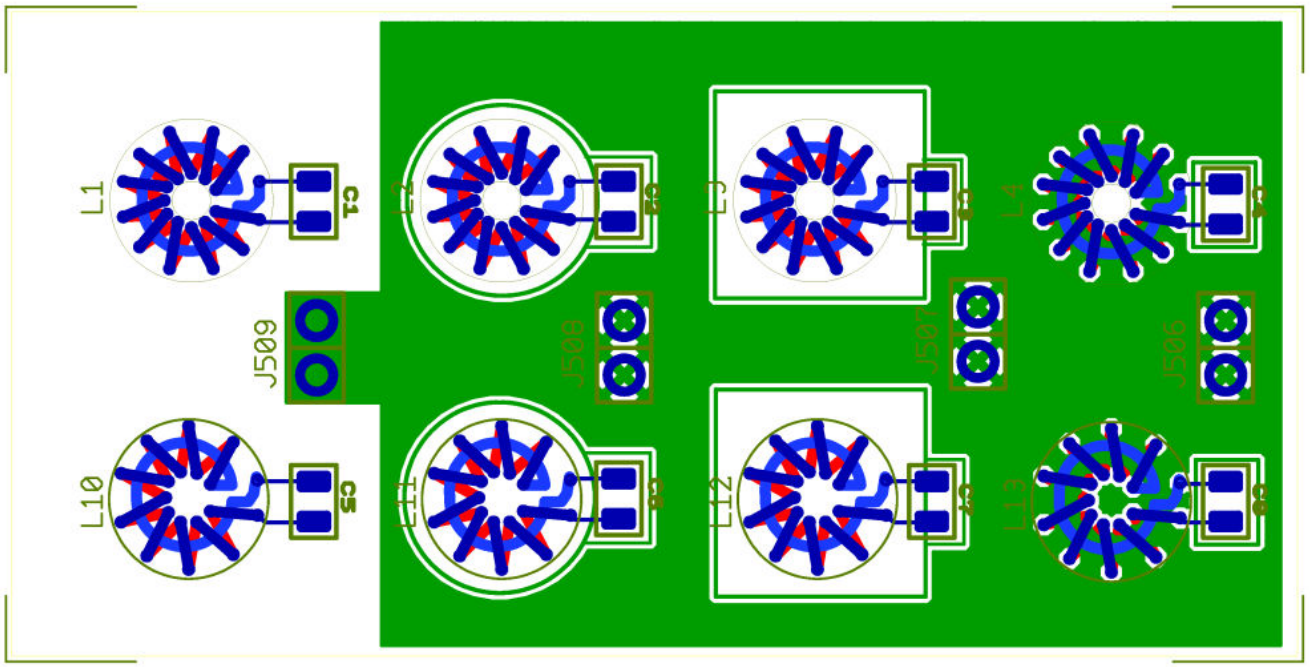


Test PCBs with toroidal inductor

1. Test mechanical dimension, thickness of PCB on inductance
2. test GND-plane influence

30 x 60 mm^2 4 layers

3 PCB thicknesses: 0.65, 1.6, 3.2mm



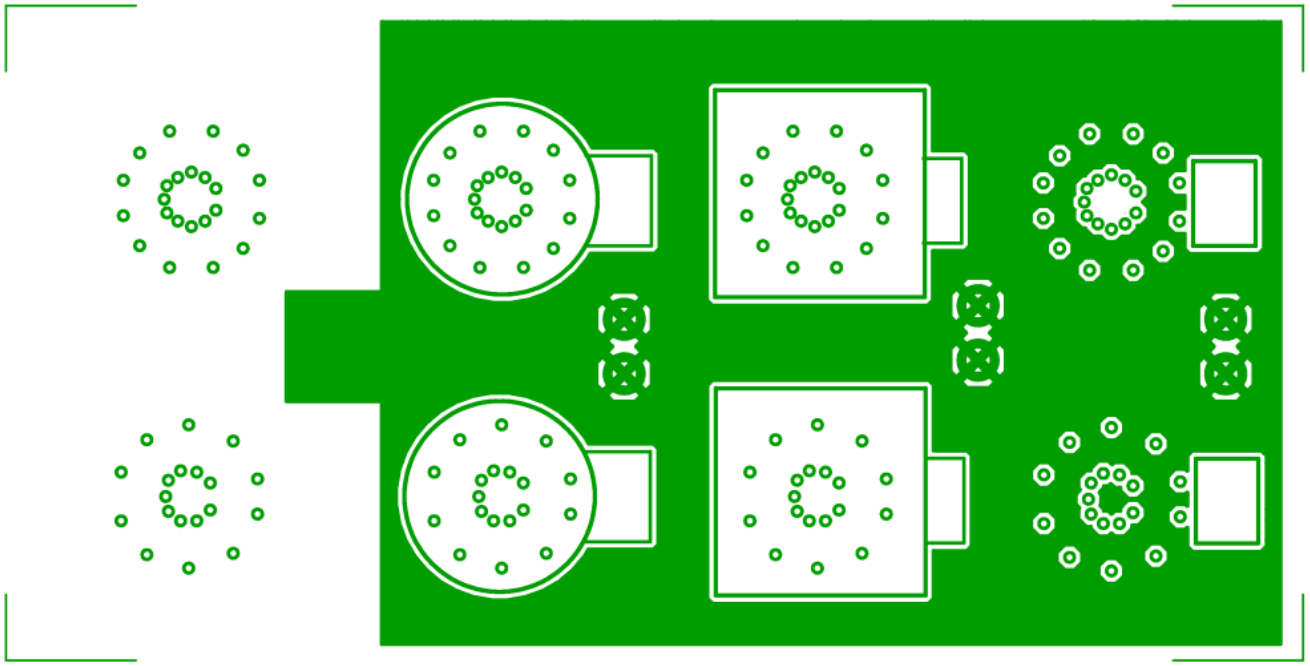
← 11 turns

← 9 turns

Ground plane, an effect of different coupling to the coil

CAM350 V 10.2.0 : Tue Mar 23 15:35:07 2010 - (Untitled) : CopperInner1

Inner layer 1

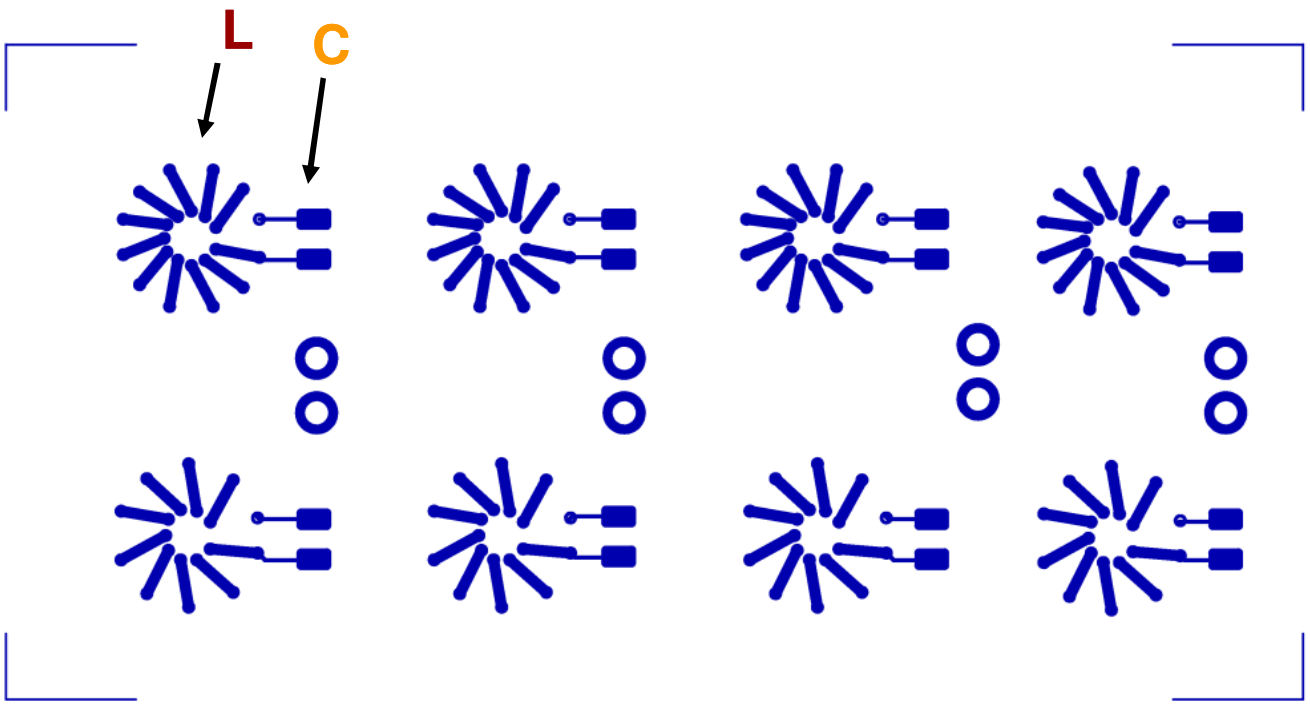


Top layer, pads at right are for smd capacitors

1. First to measure resonant frequency of parasitic capacitors, only.

2. To get value of **L**, we add larger parallel **C**, all 100pF with tolerance 1%, And measure the resonance frequency by GDO meter.

CAM350 V 10.2.0 : Tue Mar 23 15:35:07 2010 - (Untitled) : CopperTop



$$f = \frac{1}{2\pi\sqrt{(L \cdot C)}}$$

After recalculating, we can see a spread of L and parasitic C (effect of GND layer)

GDO = Grid Dip Meter, handy instrument to measure resonant frequency of LC circuit

Toroidal inductor test PCB

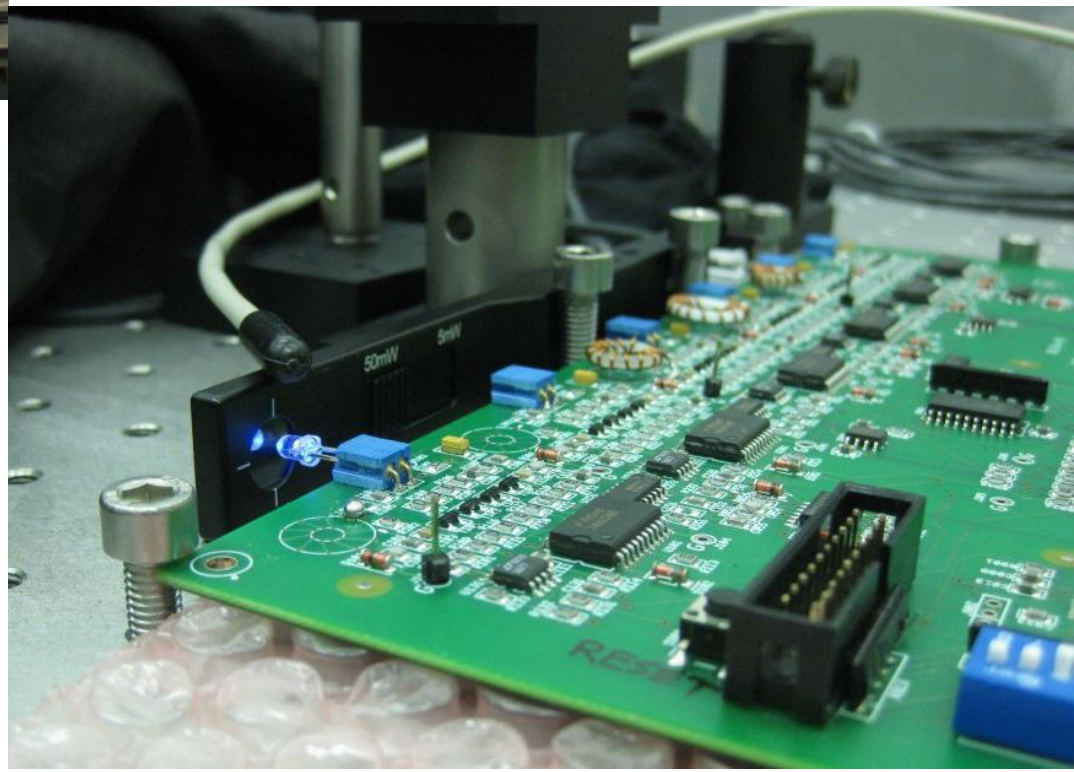
Data is missing here, ☹

…delayed PCB delivering, to be tested in April

stay tuned !

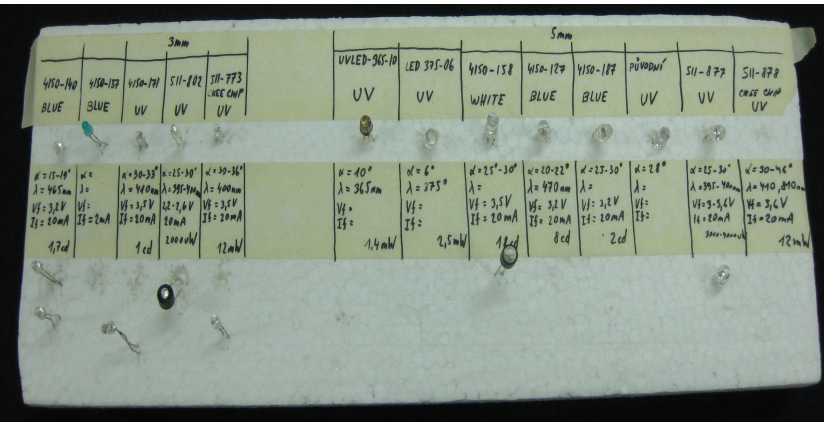
LED, optical power test DC and pulsed

Optical Power Meter PM100D with Si sensor S130D by Thorlabs



Prague, March 2010

Some LEDs intended to calibration



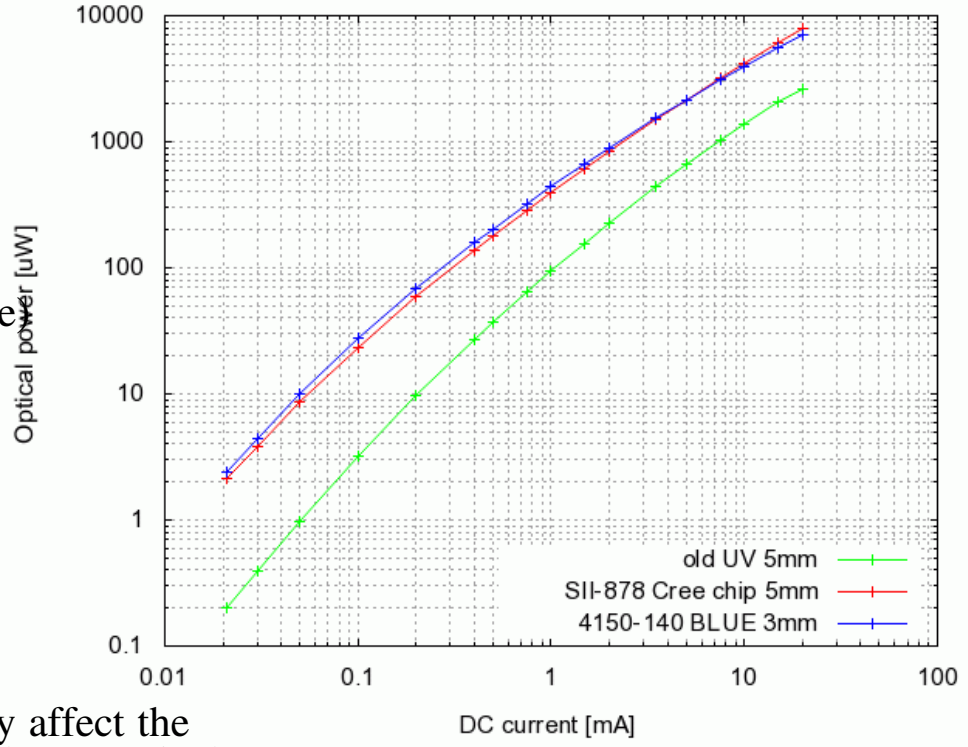
Optical Power transformation efficiency at "old CMB" 400nm LED 5mm

- DC mode

  Power consumption 3.3V*20mA = 66 mW
  Optical power @400nm = 2.6 mW
  Efficiency = **4%** **but temperature runaway**

- Pulse mode (1Hz, 2.7ns current pulse)

  Power dissipation at LED = 10nW
  (very rough scope measurement)
  Optical power @400nm = 0.5nW
  Efficiency = 5%



- Results
  - Flashing with 3ns pulses does not drastically affect the efficiency of transformation of electrical pulse to optical (compared to DC)
  - Peak pulse optical power is ~70x higher than DC
  - Optical energy in pulse ~2nJ ~→ 4x10^9 photons

Test setup: Optical Power Meter PM100D with Si sensor S130D by Thorlabs

More informations on LED can be found at http://www-hep2.fzu.cz/calice/files/ECFA_Valencia.Ivo_CMB_Devel_nov06.pdf

Plans for the 2010

Main focus: Increase of the optical performance:

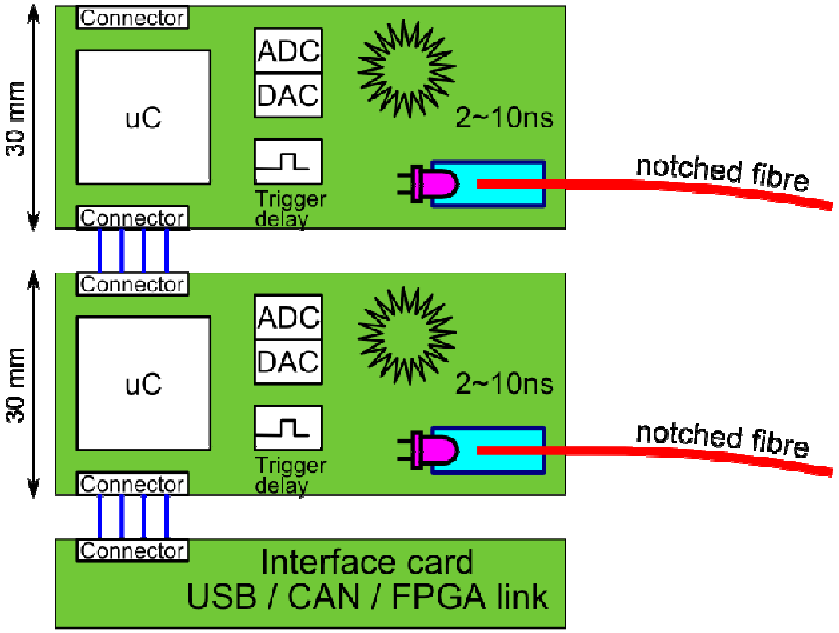
- Extend the pulse width from current 3.5 ns
- improve optical coupling from LED into the fiber
- improve the transmission to the scintillation tile

New QR LED driver prototype (Q3/2010)

- 1 channel per board
- different onboard inductors for different pulse width in range of 4 ~ 10 ns
- 3cm PCB width to match the tile size

Notched fiber production (Q4/2010)

- 6 new notched fibers with 72 notches each
- dimensions of the notches need to be synchronized with HBU



Conclusion

- Prague group is working further on notched fibre calib system.
- Two optical methods for SiPM calibration in AHCAL under investigation

  Notched fibres

  Distributed LEDs

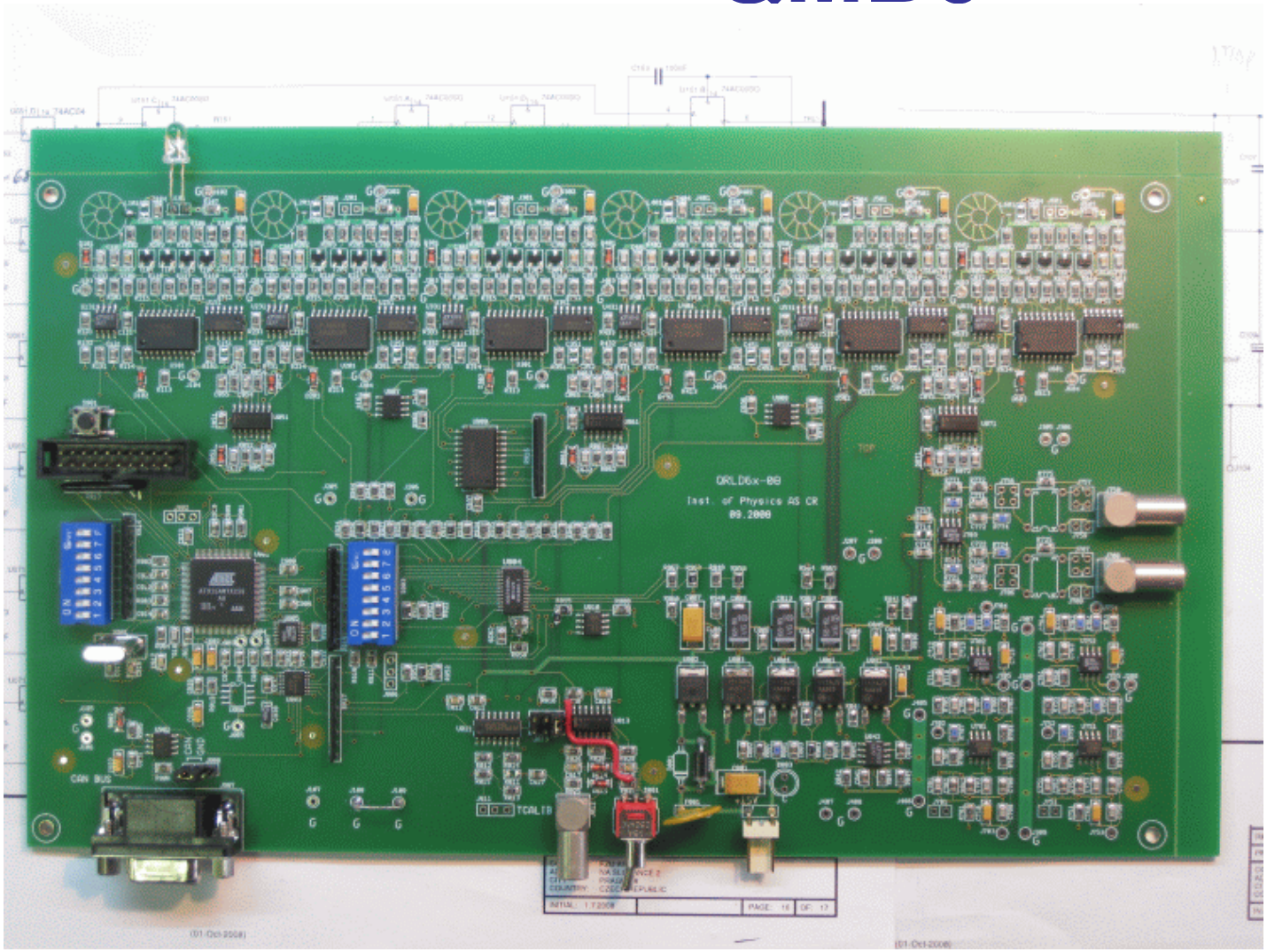
  For each method UVLED driver has been developed, still recent optimizing to be done
- QRLED driver has tunable light amplitude and generates clear p.e. spectra
- QRLED driver is not sensitive to magnetic field in the range 0 ÷ 4 T
- Both methods will be tested in HBU0 EUDET prototype

Back up

Ref: 1. http://www-hep2.fzu.cz/calice/files/ECFA_Valencia.Ivo_CMB_Devel_nov06.pdf

2. http://www-hep2.fzu.cz/calice/files/Polak-ALCPG09.Ivo_calibLED_ALCPG09e.pdf

6-LED QR driver Main Board = QMB6



Consists:

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

Details of distributed LEDs

Small UV LED, smd size 1206 and 0603