Fast Calibration UV LED system for CALICE scintillator based Tile Hadron Calorimeter

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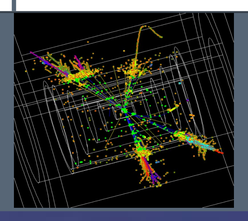
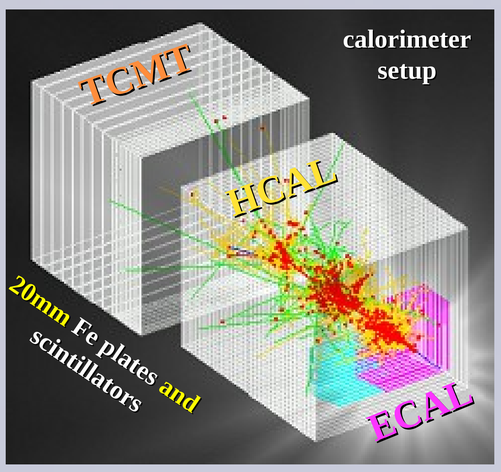


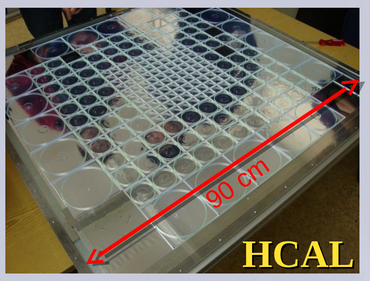
EXPERIMENT CALICE



Prototype of calorimeters tested at accelerators of CERN and FERMILAB

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

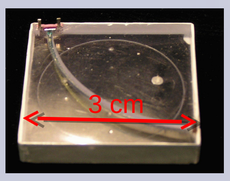
Our Prague group has responsibility for flashing calibration system for HCAL



1 m³ SCINTILLATOR CALORIMETER HCAL

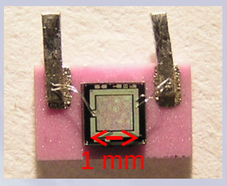
2005 till 2010, then as WHCAL at CERN

- 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



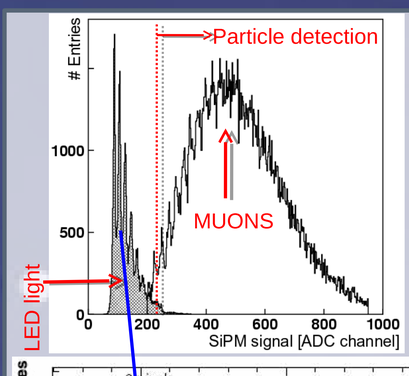
One scintillator tile consists:

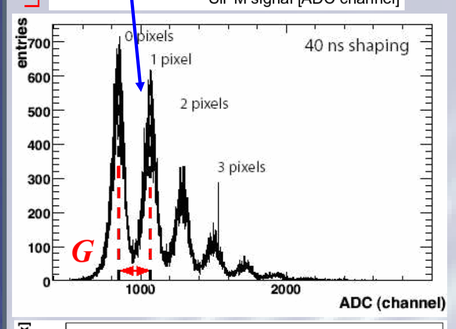
- WLS fibre (~380nm to ~500nm)
- SiPM photodetector

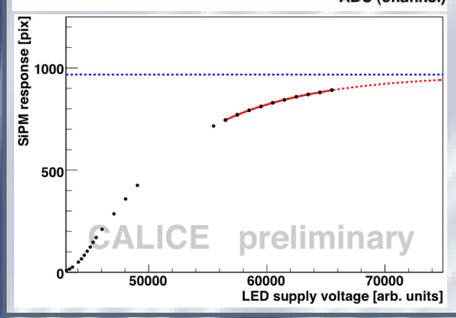


Photodetector:

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







Calibration procedure

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

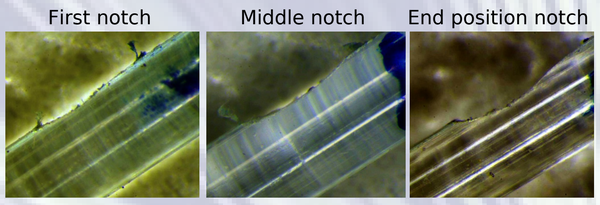
Gain is independent on the number of photons

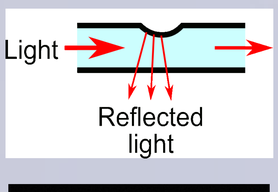
We can compensate the temperature and operational voltage influences

Non-linear or saturation curve of SiPM

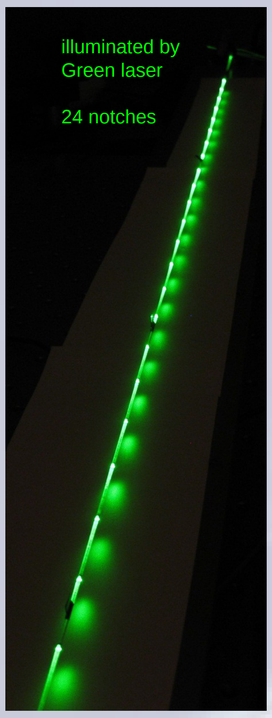
Offline, we correct for the nonlinearity of SiPM

Notched fibers

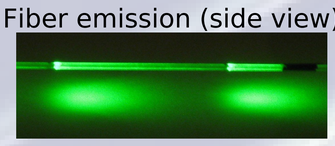




- Light is emitted from the **notches**
- Aim: 12 or 24 notches per fiber with light output spread <15%
- The **notch** is a special scratch to the fiber, which reflects the light to the opposite direction
- The size of the notch varies from the beginning to the end of the fiber to maintain homogeneity of the light output across the notches

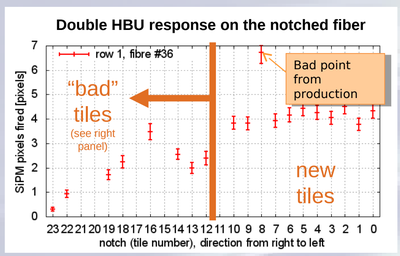


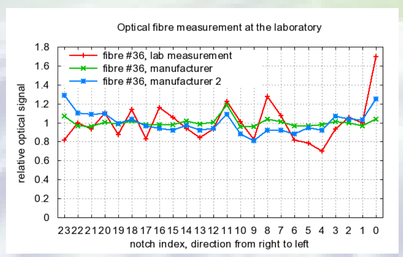
Fiber emission (side view)



- External company Safibra preparing the setup (semiautomatic) to produce precise notches in the fibers
- Test set of 24-notched fibers received and tested.
- We still see a measurement mismatch among manufacturer, lab test and test with HBU

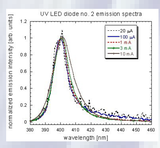
Notched fibre drilling machine (prototype)

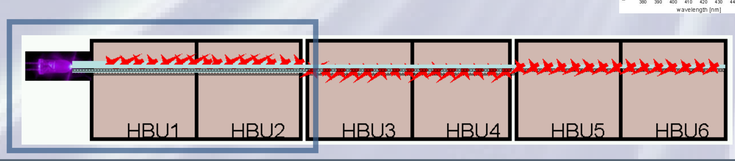




Dec 2012: ultimate test of the system

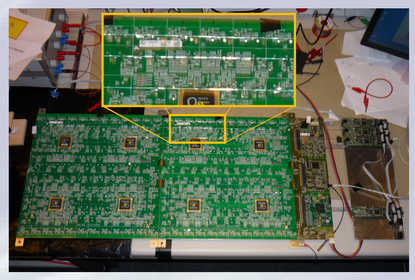
- full length of **6 HBU** (~2.2m)
- each row (72 tiles) illuminated by 1 LED
- each LED connects to three 24-notched fiber

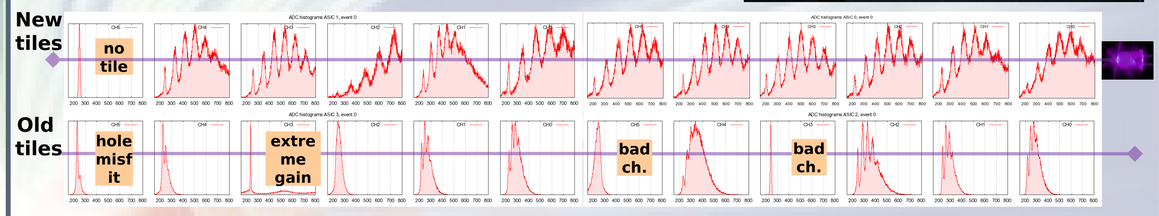




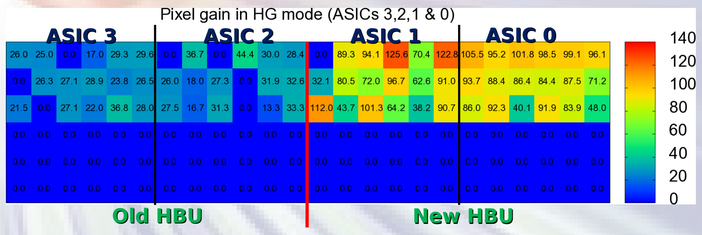
Tests of the Quasi-resonant driver

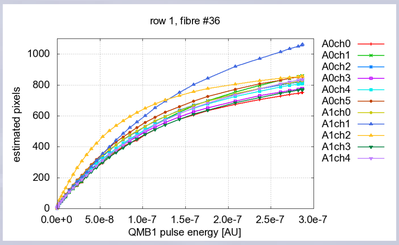
- Several tests were performed with different version of the driver (QMB6, QMB1) and different optical fiber length (12, 24 notches)
- Latest test: 2 HBU (see figure right →)
  - Only 3 top rows of HBU assembled with tiles
  - 2 sorts of SiPMs – different response of each HBU
  - each row (24 tiles) is illuminated by a fiber, connected to a QMB1 LED driver





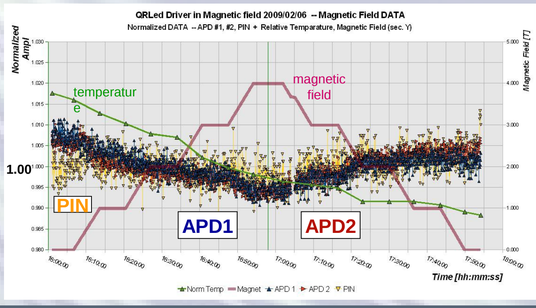
- New tiles: peak distance calculation was 100% successful in a single run
- Old tiles: Mostly smeared Single Pixel Spectrum prevented deeper analysis (saturation) because of the uncertainty of the pixel distance calculation and pedestal shift
- Saturation was observed on most channels



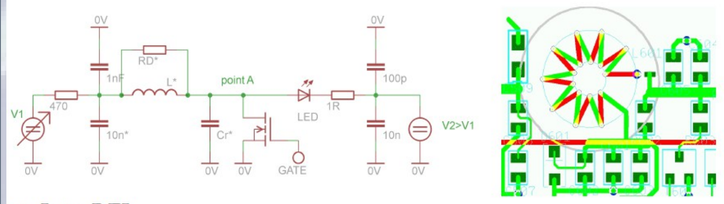


QMB6 in superconductive solenoid

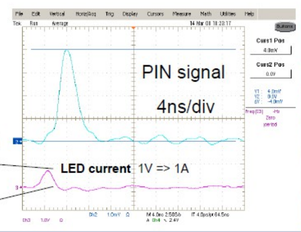
DC magnetic field **0 to 4T**
Air core inductor can be sensitive to external magnetic field.
We performed tests of QMB6 in variable magnetic field. **EFFECT < 1%** over 4T
3 LED flashed into 3 fibre cables; CANbus cable and T-calib + Power in other cable.
The setup was mounted on non-magnetic wooden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

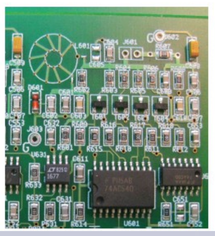


Quasi-Resonant LED driver



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



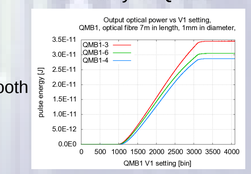


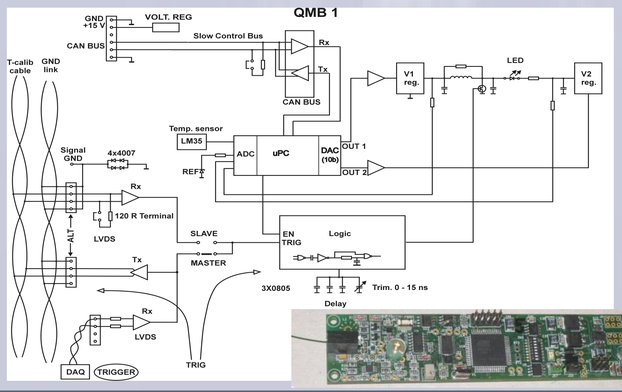
2012 / 2013 we are developing 3 versions of QMB with 1 ns, 5 ns and long pulse 30 ns. Long pulse version is coming with external toroidal inductor.

Quasi resonant Main Board **QMB1**

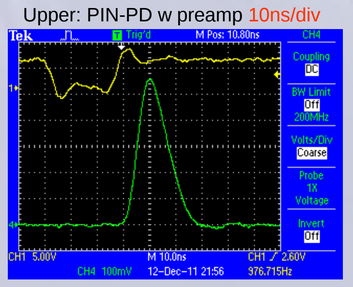
Modular system, 1 LED per board
Operation mode:
DAQ + CANbus control
stand-alone mode
LVDS Trigger distribution system
Variable amplitude, zero to maximum (~1Amp)smooth
Pulse width fixed to ~ 5ns (UV or blue LED)
Voltages and temperature monitoring
Size of PCB: width 30mm, depth 140mm

Linearity of QMB1

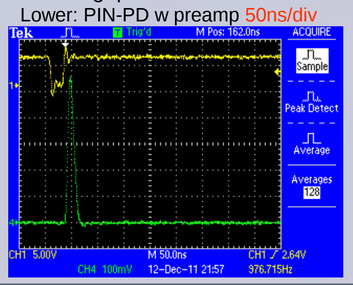




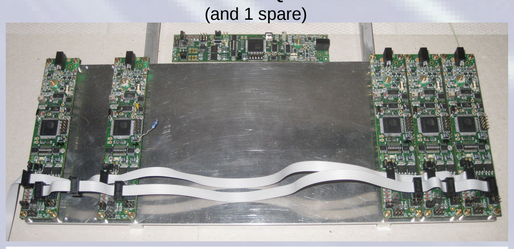
Upper: PIN-PD w preamp 10ns/div



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



A frame with five QMB1 boards
(and 1 spare)



TRIGGER (T-calib) LVDS distribution to QMB1