OPTICAL FIBER CALIBRATION SYSTEM & ADAPTIVE POWER SUPPLY

*

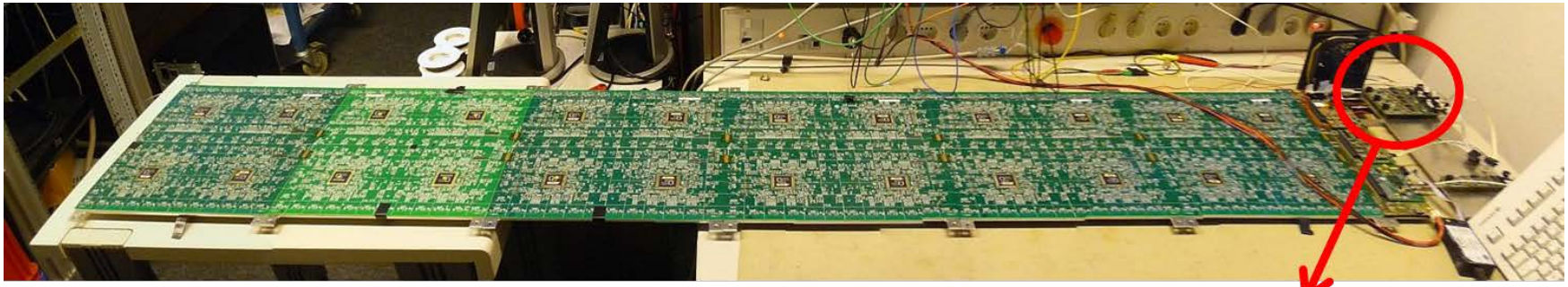
J. CVACH*, INSTITUTE OF PHYSICS, ASCR, PRAGUE

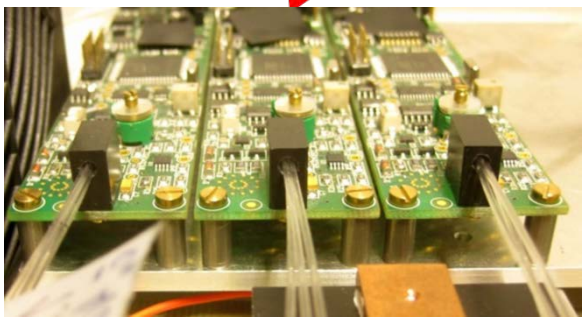
1. Introduction
2. LED driver
3. Notched fibres
4. Adaptive power supply
5. Summary

* On behalf of I. Polák, J. Smolík, J. Kvasnička, M. Janata, M. Kovalčuk from IPASCR and CALICE coll.

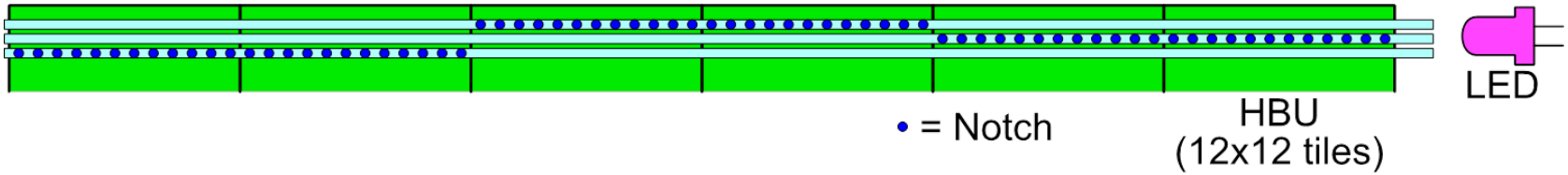
1. Introduction

- Progress since LCWS13
- Originally - an alternative calibration system for the CALICE AHCAL

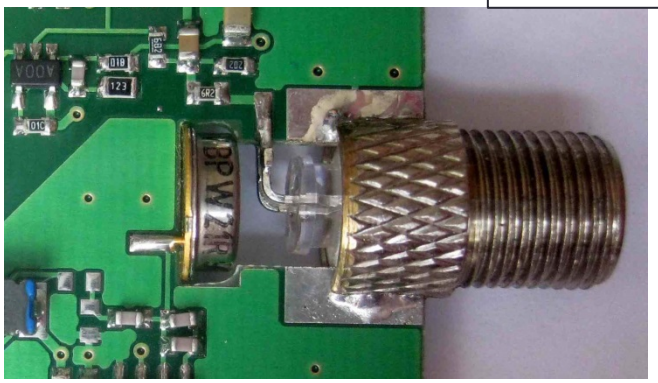




- Now we look for application outside of ILD
- LHCb – calibration of Scintillating Fibre Tracker in LHCb Upgrade program
- COMPASS - ECAL0 calibration



2. LED driver – QMB1a



Works on the principle of a DC-to-DC power converter, $V_{out} > V_{in}$

- Variable amplitude (0 - 1 A)
- Repetition rate up to 100 kHz
- Fixed pulse width (2.4–3.5 ns)
- Smooth pulse shape (half-sine shape)
- PCB size 30 × 140 mm^2 to match the size of tiles

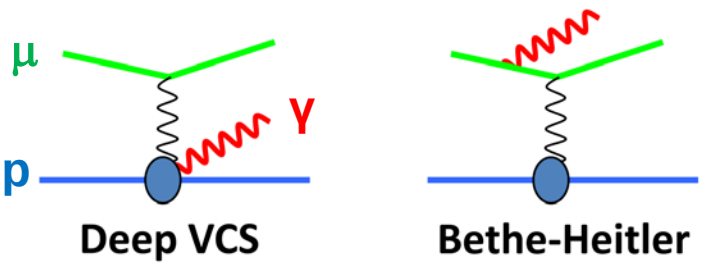
Modifications for COMPASS ECAL0, CERN

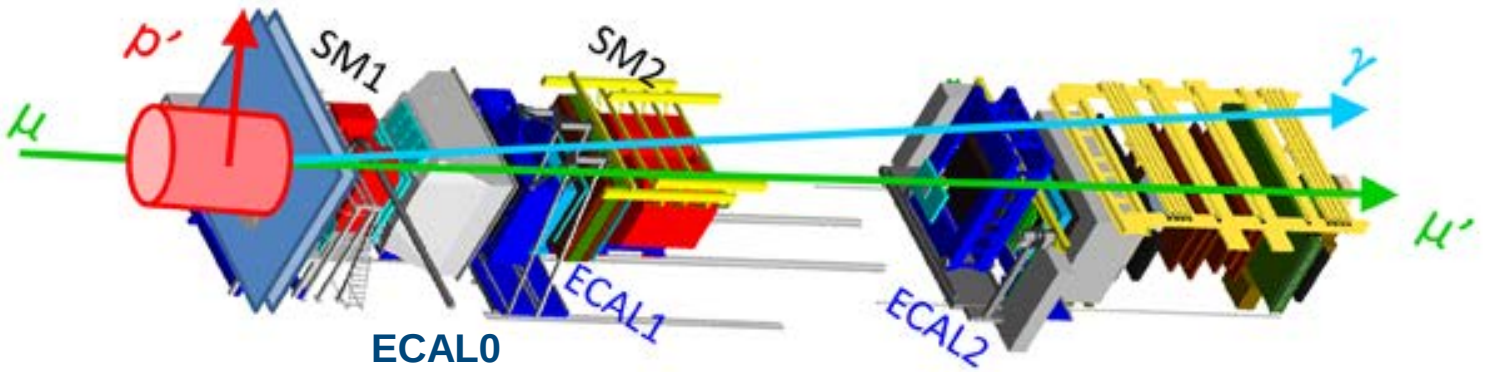
- Fixed amplitude (~1 A peak)
- Repetition rate ~ 1 Hz, steady
- Fixed pulse width (10 - 20 ns)
- Amplitude monitored by PIN diode close to LED for feedback to keep the constant light
- No restriction on the PCB size

COMPASS - II experiment

- Fixed target experiment at SPS
- Study of hadron structure, hadron spectroscopy with muon & hadron beams
- Polarised NH_3 target
- Data taking from 2002, resumed in 2014 with π beam
- Detector 60 m long, various subdetectors (incl. RICH, SciFi, pioneered GEMs)

- Our participation together with Dubna group of A. Nagaytsev, Z. Krumstein on ECAL0, ready in 2016
- Shashlyk calo for γ's to study the generalized PDFs

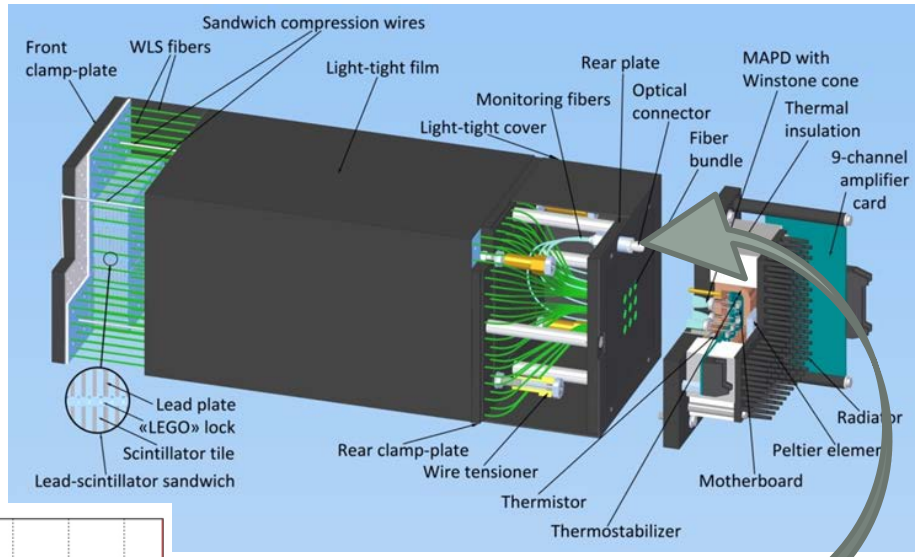




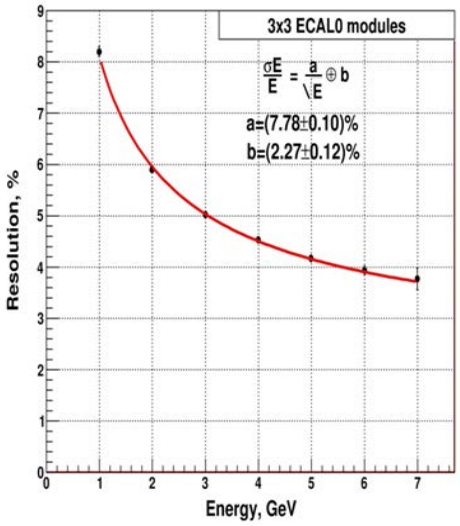
Electromagnetic calorimeter ECAL0

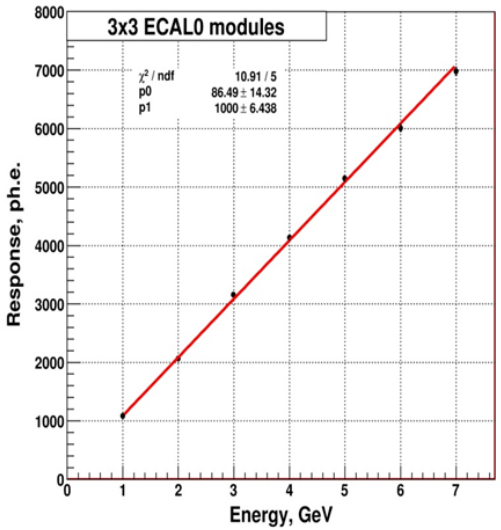
- 194 modules made as a sandwich read by WLS fibres going through 109 Pb & scint. perforated layers
- 9 polystyrene scint. tiles 40x40x1.5 mm^3 read by 16 fibres
- Thermo-stabilized by Peltier elements at 15±0.05°C
- 15 X_0, $\Delta E/E \sim 9\%/\sqrt{E} \oplus 1\%$

ECAL0 module



Here we connect with our fibre

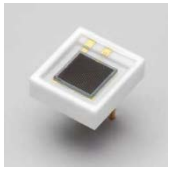




Beam tests in e- CERN T9 beam
3 x 3 modules with MAPD
Good resolution & linearity

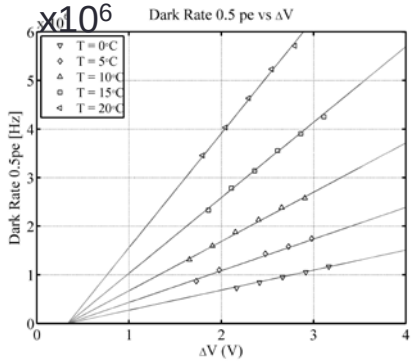
Photodetectors: MAPD vs. MPPC

- Two types considered:
  - MAPD 3N Zecotek, Singapore
  - MPPC S12572-010C Hamamatsu

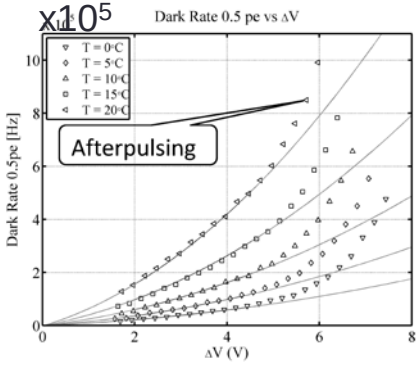


- Sensitive area 3 x 3 mm^2, reads 16 fibres
- Gain ~ 2.10^5
- # pixels 135 000 vs. 90 000
- Dark rate ~ 10^6
- Datasheet values differ from the reality – measurement done in 2014 (A. Richter et al., Warsaw University of Technology)
- Conclusions: MPPC looks as a good replacement for MAPD

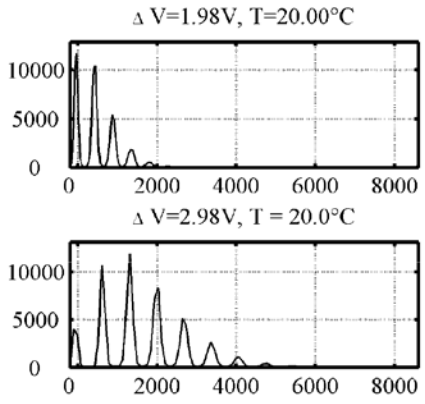
MAPD 3N

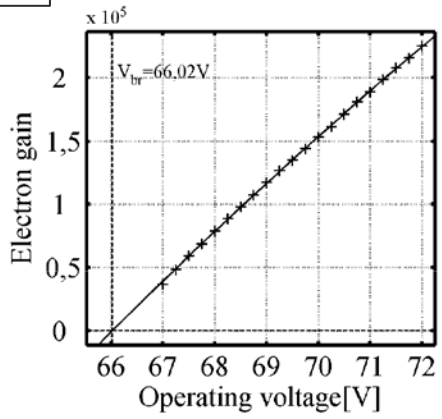


MPPC S12572-010C



MPPC S12572-010C





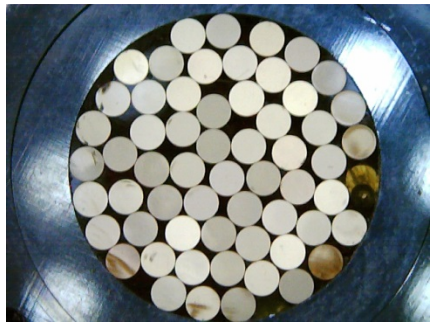
Monitoring system for ECAL0

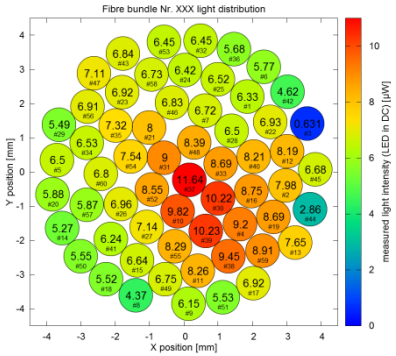
LED driver

- Variable amplitude for amplitude scan (option)
- No interest in single p.e. spectra
- One LED illuminates 50 modules – high intensity light
- Amplitude stability – PIN diode feedback is a must → averaging over > 10 pulses in μC
- Pulse width ~ 20 ns → external toroidal inductor
- Modification of the QMB1a is ongoing

Fibre distribution system

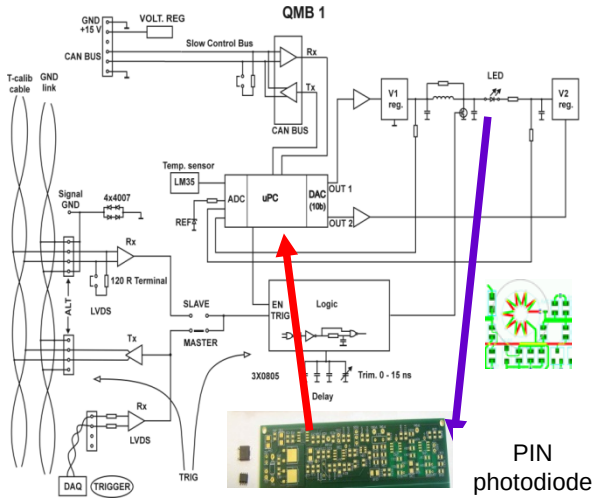
- High intensity 8 mm blue LED with optical connector → fibre bundle with 50 fibres with ∅ 1 mm
- Length fibres in bundle is 2.5 m
- See face of the bundle of fibres in a connector illuminated by daylight and a blue 8 mm LED





Monitoring system for ECAL0 at present

- Scheme of the new LED driver QMB1b and PCB for PIN preamp



- Tests of the fully equipped board
- 1% long term stability
- Interface CAN → USB
- Trigger LVDS → NIM
- SW interface module for PC
- Autumn 2015 – 4 channels for tests

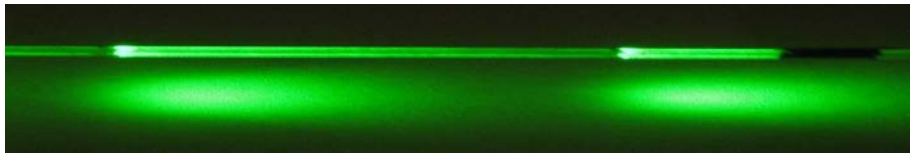
Optical distribution of LED light pulses

- Calibration light to 194 ECAL0 channels
- Light spread ~ 10%
- 10000 p.e. @ MPPC
- 4 connectors with 55 fibres in autumn 2015

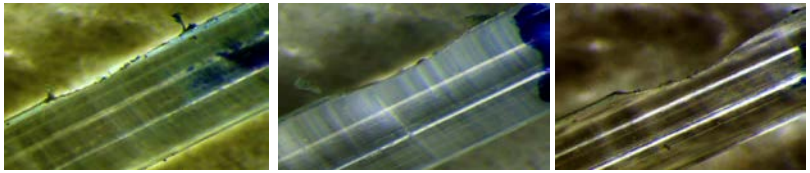
Fibre with connector on the ECAL0 side →

Bunch of fibres, light-mixer and socket on the QMB1b side ↓

3. Notched fibres – milling machine

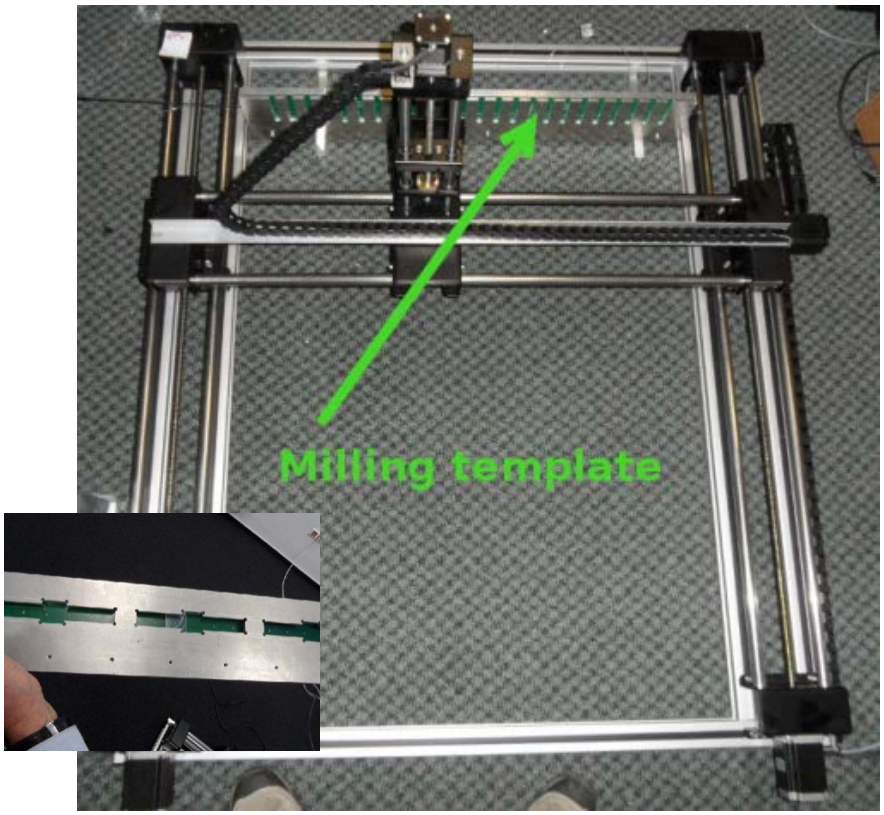


- 3d movement
- Steps in 10 μm, accuracy 15 μm
- Template configured for AHCAL tile geometry
- Depth of the notch increases from the beginning of the fibre to its end to maintain the same light intensity



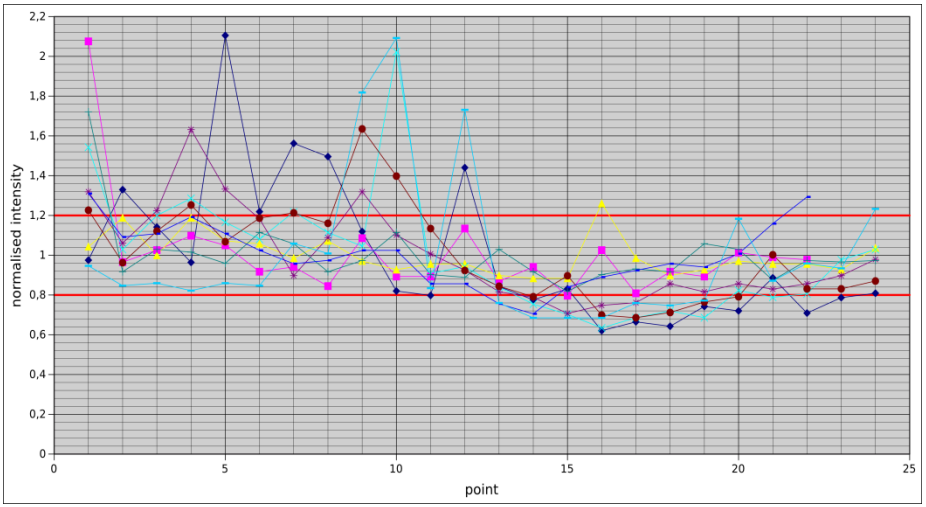
- Computer controlled milling of a notch in steps & measurement of light emitted from the notch
- Fully automatic milling of notches was foreseen
- Potentially not possible with the current machine

CNC-multi-tool ML 1000F

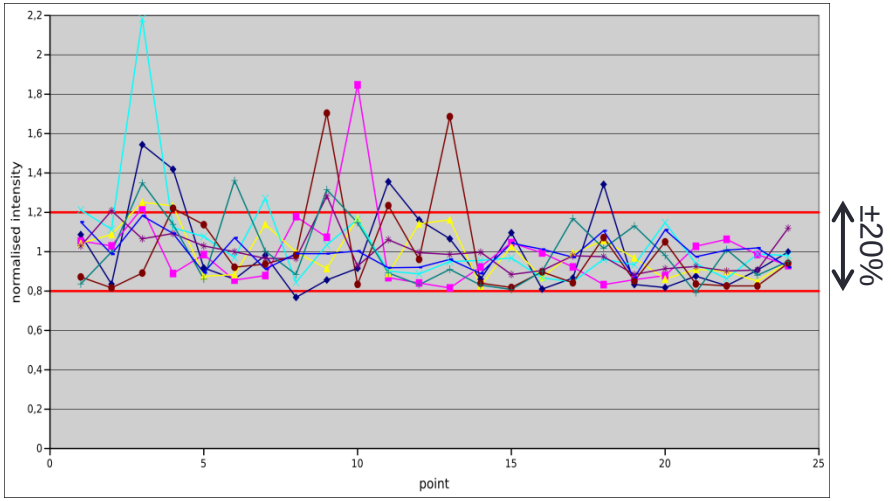


Notched fibres – spread of light

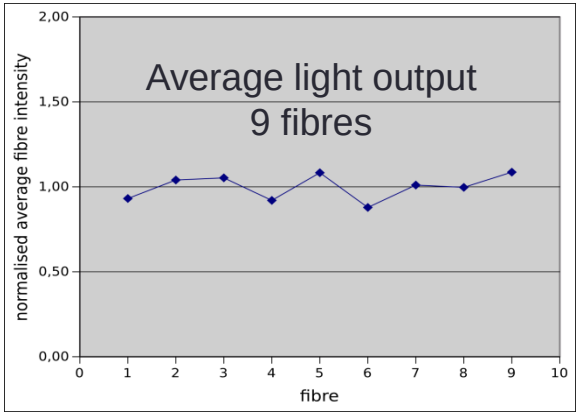
DESY tests in 2013



Production in 2014

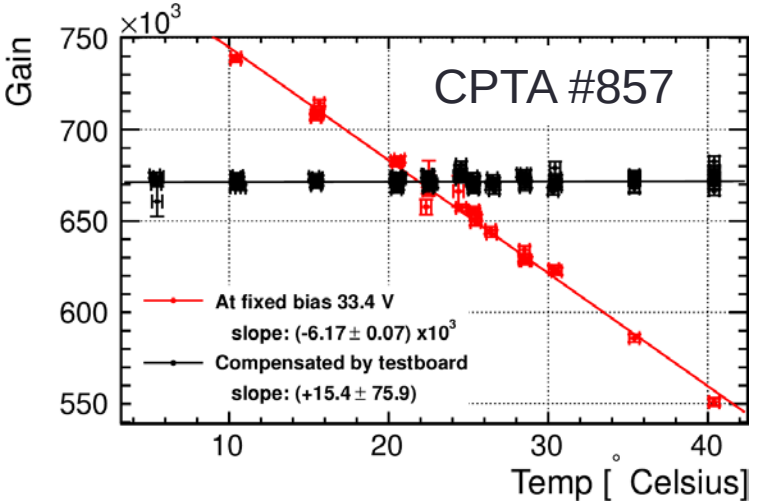


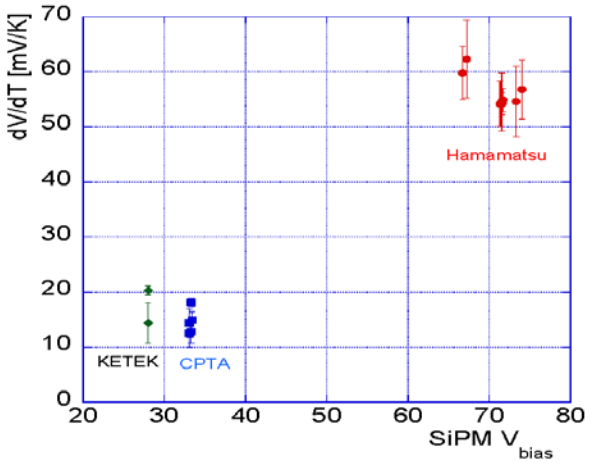
- No significant improvement in time
- Goal for the spread of light ±15% not reached!
- σ of light over 24 notches is 5% - good!
- Light output from different fibres is homogenous →
- Proposal on the design of a new instrument
- Cost estimate 20 k€



4. Adaptive power supply for SiPMs

- Gain stabilization at 1% level at variable temperature of environment
- AIDA-MS-45: together with Uni Bergen → successfully fulfilled – see talk of G. Eigen at Vienna 2014 AIDA annual meeting & AIDA-NOTE-2014-002
- Temperature correction applied via analog electronic feedback
- Provide regulated DC voltage 15-90 V (or up to 450 V)
- ΔV/ΔT slope for a SiPM set in the range 5-100 mV/°K
- Tested on KETEK, CPTA sensors, they cluster into 2 groups: dV/dT ↗ V_{bias}
- More demanding task – gain stabilization in the whole AHCAL → AIDA II

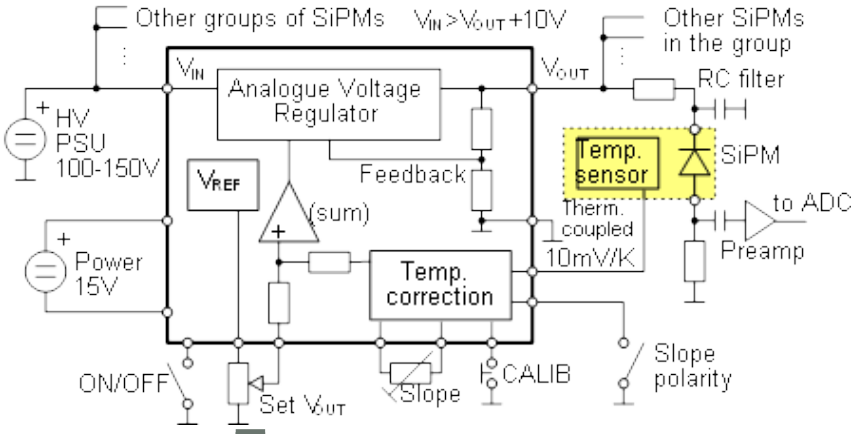




ADApower box

Modification of Power & DIF board

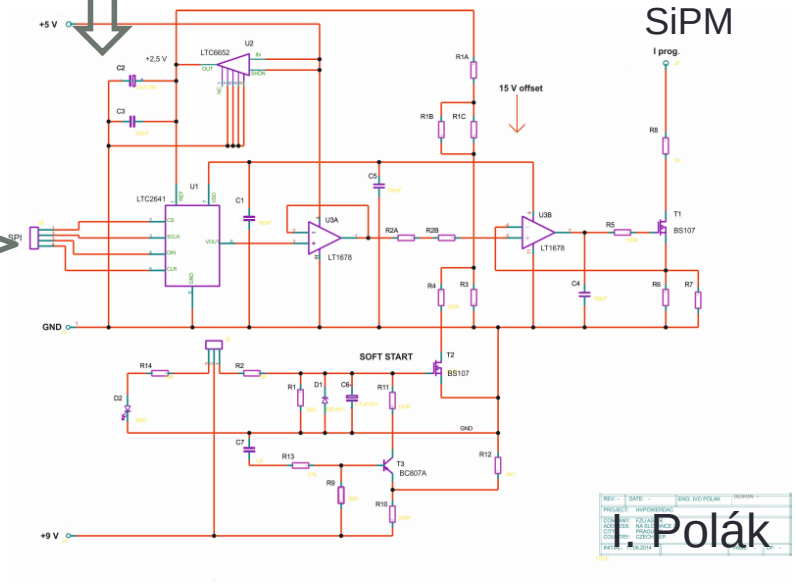
ADApower box



- Analog circuit solution is more advanced over ADC → μP → DAC version (digital solution via slow control)
- ADC and DAC should have at least 16 bit resolution with proper linearity and fidelity – not easy task
- 16 bit DAC can control HV regulator in steps of 1 mV (65535 x 1 mV = 65.5 V) in range of 15 to 80 V
- Solution currently under discussion I. Polák ↔ M. Reinecke

ON/OFF & V_{OUT} Set is controlled by DAC circuit

μP in PWR board



5. Summary

- We are trying to adapt our experience with LED calibration + notched fibre light distribution system to another experiments
  - Improved QMB1b LED driver (with the PIN feedback) selected for upgrade of COMPASS experiment with ECAL0 calorimeter
  - Interest for notched fibre light distribution in the LHCb Upgrade Scintillating Fibre Tracker
- Survey for the improved machine for notched fibre milling
- Work on adaptive HV power board is ongoing (analog/digital) for AHCAL
- The new task for temperature compensation SiPM gain included in the foreseen AIDA II project