A slow control and TDC calibration system for the HADES RICH upgrade

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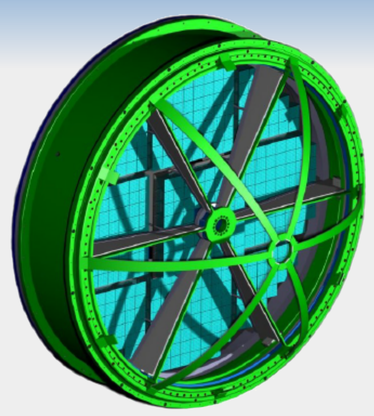
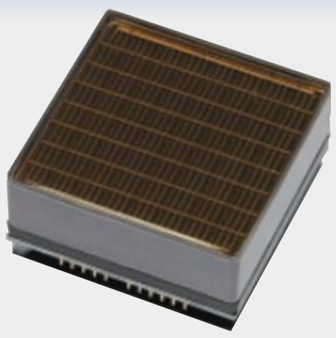
Motivation



The HADES RICH is upgraded for the upcoming beamtime with new Hamamatsu H12700 multianode photomultipliers (MAPMTs) and new front end electronis (FEE). The FEE is realisied with special designed DiRICH Boards which contain a FPGA based time to digital converter (TDC). Therefore a new slow control system and a FPGA based online calibration for the TDC is developed.

MAPMTs:
- High voltage power supply
- Requires magnetic field monitoring ~10mT

Front end electronics:
- Low voltage power supply
- Temperature control
- Temperature based TDC calibration



slow control system and LV power supply

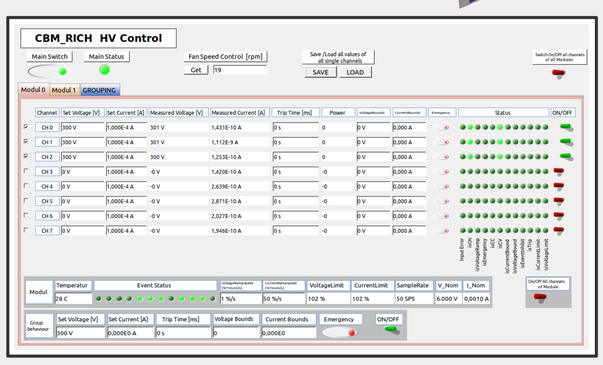
- **EPICS based slow control**
  - low and high voltage control
  - TRB3 board-temperature control
  - X-, Y-, Z-axis magnetic field measurement
  - temperature, pressure, humidity and light measurement
  - Control System Studio (CSS) used as GUI

- **Low Voltage Power Supply:**
  - TDK Lambda Genesis 60-40
  - IOC running on own computer
  - LAN connection between TDK Lambda and computer

high voltage power supply

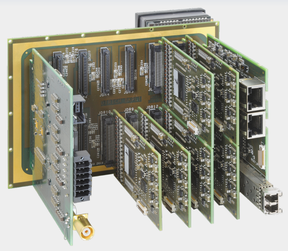
ISEG ECH 44A crate with 6 EHS F620n-F_SHV modules à 16 channels

- single channel floating ground
- CC24 master:
  - IOC running on CC24
  - connects EPICS via LAN
- IOC allows to control ...
  - ... each channel individually
  - ... pre-selected groups of channels
  - ... individually grouped channels
- voltage precision of 80mV
- current precision of 160nA



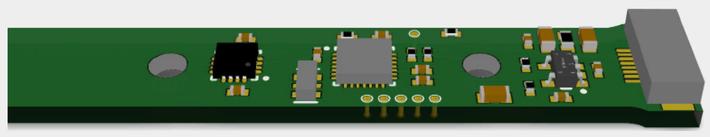
TRB temperature readout

- TRB temperature readout via EPICS slow control :
  - IOC based on TrbCmd instructions
  - communication via TrbNet
  - temperature readout of many TRB3 boards at one
  - small load for TrbNet

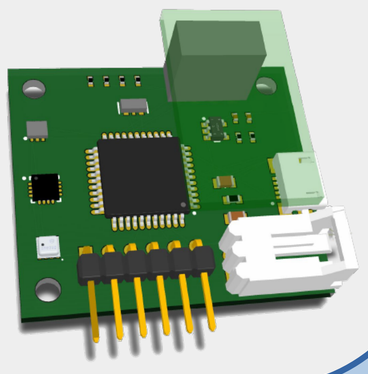


(environment-) sensor board

- magnetic field measurement board: 210 x 10 mm
  - ATmega168PA microcontroller
  - equipped with four 3-axis magnetic field sensors MLX90393
  - UART communication
  - possibility to shorten board to 40 x 10 mm
  → only 1 magnetic field sensor on board



- environment sensor board: 30 x 31 mm
  - ATmega32U4 microcontroller
  - 3-axis magnetic field sensors MLX90393
  - humidity, pressure and temperature with BME280 sensor
  - light sensor TSL2591
  - communication via USB, UART or WIFI (ESP8266)



temperature dependent calibration of FPGA based time to digital converter (TDC)

- TRB3 and DiRICH board use TDC implemented in Lattice ECP5/ECP3 FPGA
- precision of TDC is temperature dependent
  → calibration is necessary
- until now: Software based calibration
  - linear calibration
  - exact calibration
- measurements for temperatures between 5°C and 50 °C were done
  - different calibration methods tested
  - linear calibration reaches a precision of 15 ps in mean
  - exact calibration reaches 10 ps
    → linear calibration is a good method and reaches an adequate precision
- A linear FPGA based calibration is implemented
- FPGA uses incoming data for two purposes:
  - calibrate the data with minimum and maximum values as well as slope values from lookup tables (LUT)
  - use new data to generate next calibration values
- own calibration for each channel of each FPGA
- no additional temperature information necessary

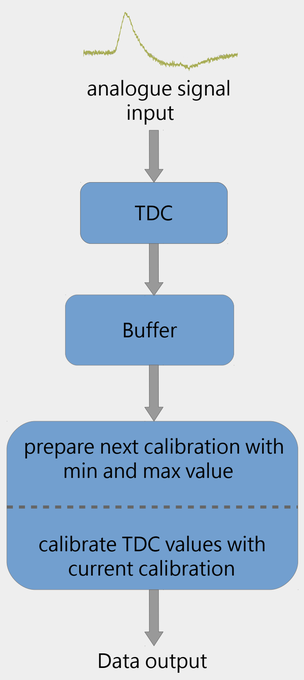
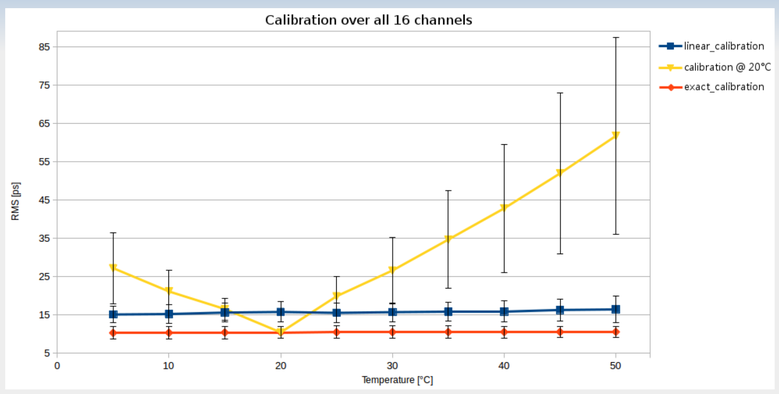
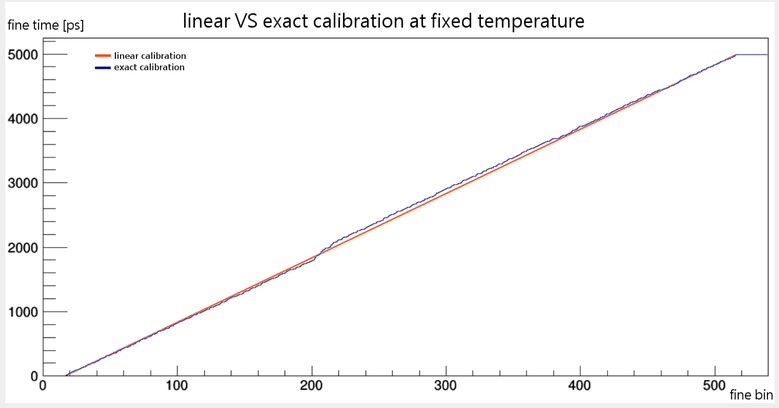


Figure: Box diagram of the FPGA based calibration.





Upper figure: RMS value for different calibration methods at different temperatures. The values are mean values over all 16 channels. Methods: linear calibration; calibration with exact calibration@20°C; exact calibration.
Lower figure: linear versus exact calibration for a fixed temperature.

Federal Ministry of Education and Research
05P15RGFCA

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