Forward Endcap Analog Electronics

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Outline

Forward Endcap Calorimeter Overview

- Target electromagnetic calorimeter part
  closing the calorimeter barrel in beam (forward) direction
- Elliptic hole around beam pipe
- Contains 3856 $PbWO_4$ crystals of the same shape
  (quarters of frustums of pyramids)
- Two types of photo detectors for scintillation light detection

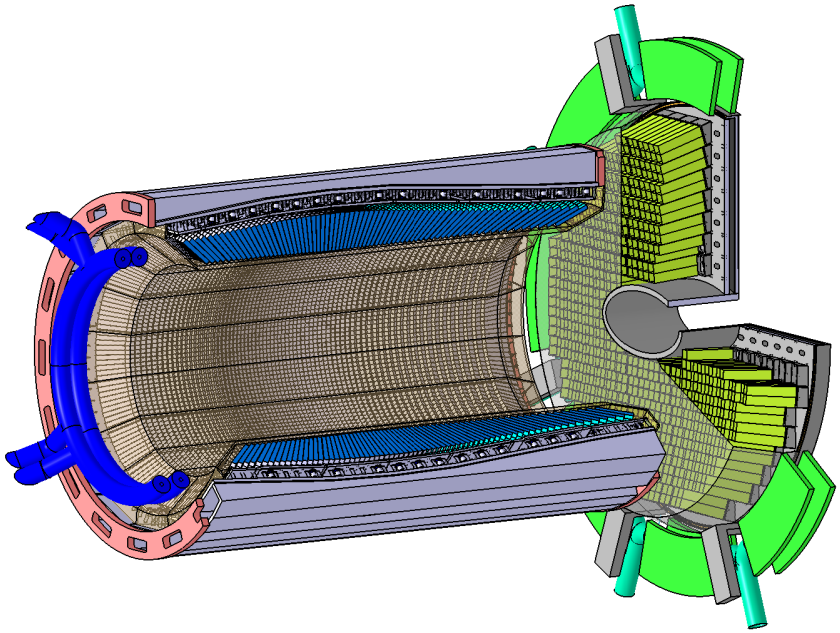
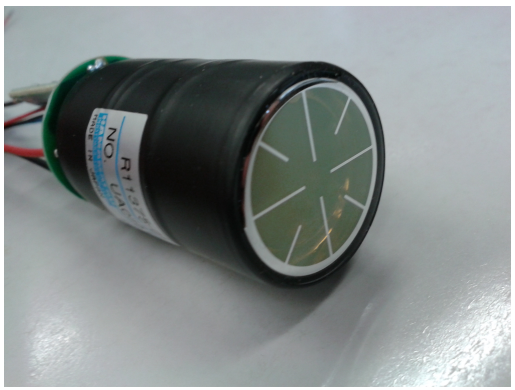


Photo Detectors

- Two types of photo detectors for forward endcap:
  - Inner 768 crystals region:
    - One vacuum photo tetrode (VPTT) per crystal
    - VPTT type: Hamamatsu R11375 MOD, gain 50, C = 20 pF
    - Gain loss at full B-field (1.0 T) up to 50 %
    - Radiation hardness, coping with high count rates
  - Outer 3088 crystals region:
    - Two avalanche photo diodes (APDs) per crystal
    - APD type: Hamamatsu S11048(X5)
    - Operated at gain 200, C = 270 pF
    - Gain independent of B-field
- In total $768 + 2 \times 3088 = 6944$ photo detectors to be read out



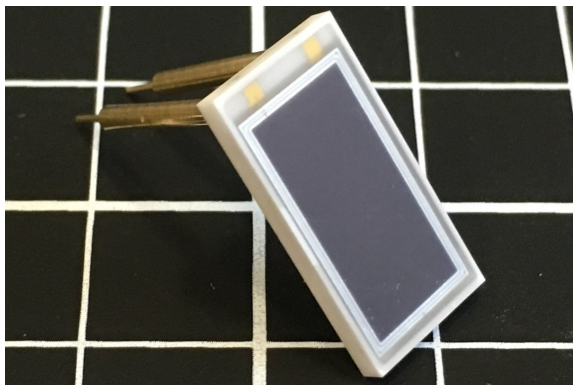
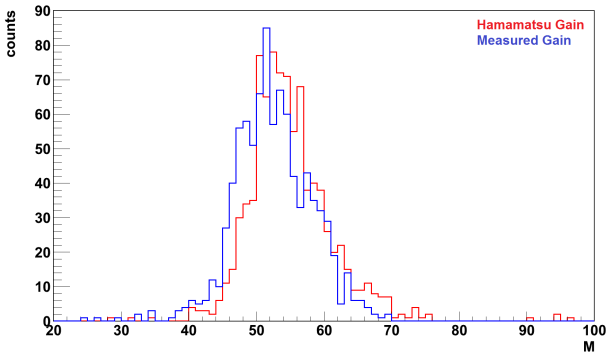


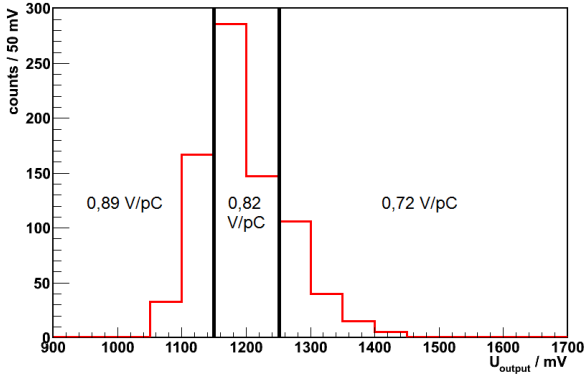
Photo Detector Readout: Preamplifiers

- Dedicated discrete photo detectors
  for APD and VPTT readout
- Designed by Basel University (M. Steinacher, W. Erni)
- Low noise, low power consideration
- AC-coupled J-FET input stage, operational amplifier
- Low power consumption:
  quiescent 45 mW, full load (rate) 90 mW
- (Voltage divider for VPTT electrodes supply consumes
  additional 20 mW at 1000 V supply voltage)
- Single ended, buffered output stage,
  max. output voltage + 2.2 V into 50 Ω with +/- 6 V supply
- Precise 50 Ω termination needed (connectors, PCBs)
- Baseline will shift to negative voltages at high rate:
  AC coupling of adjacent stage (shaper)!

VPTT Preamplifiers

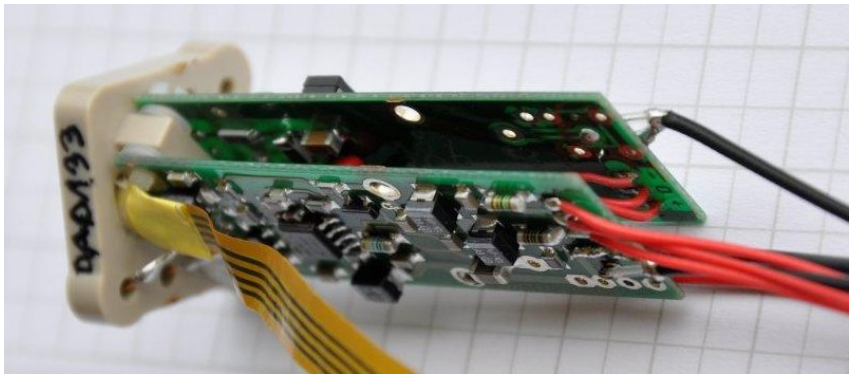
- VPTT preamps manufactured with three different gains according to VPTT gain distribution
  - Grouping VPTTs (gain, QE) and preamps (gain) to similar responding units
  - Preamp gains chosen to give maximum output of about +2 V into 50 Ω for maximum (12 GeV) single crystal energy deposit (full dynamic range coverage w/o clipping)
- Mechanical outline according to space requirements (short board combined with long detector tube)





APD Preamplifiers

- Similar design as VPTT preamp
- One gain version only:
  detector gain (200) adjusted by APD bias voltage
- Much lower gain figure needed compared to VPTT preamps
- Hence much tighter negative feedback loop
- There is still some fine tuning going on
  to get the preamps stable at -25 ^{o}C
- Balancing preamp gain vs. APD gain not an option (S/N)
- Mechanical outline allows sandwich mounting of two preamps
  for single crystal readout



Signal Shaping

- We need to shape the preamp signals:
  - Preamp output signals: 80 ns rise time, 25 μs fall time
  - Required S/N only achievable with additional shaping
- Several shaping circuits tested in the past (Proto 192)
  - Full analog hardware shaping designs (KVI)
  - Some of them too sensitive to pulse shape (scintillation vs. light pulser)
  - Single differentiator stage plus digital integration (promising lab test)
- Test of different shaping strategies to be carried out in Bochum:
  - Modified ADC board prepared by Pawel in order to test different shaping strategies (hardware high pass, digital int., etc.)
  - Massive problems to get complete read out running (TRBs!)

Summary

- For the Forward Endcap EMC
  we need 13888 14 bit-ADC channels:
  - 768 photo tetrode equipped crystals, 2 gain ranges each: 1536
  - 3088 2-APD equipped crystals, 2 gain ranges per APD: 12352
  - This corresponds to 217 64-channel ADC boards
- ADC boards need to include hardware high pass shaping stage (digital low pass filtering)
  - AC coupling of preamp output mandatory (rate dependent baseline shift)
  - Conversion of +2.2 V maximum output voltage to maximum ADC input voltage (1 V)
  - Precise 50 Ω termination
- In order to carry out any 'full readout chain' measurements the handling of the TRBs has to be modified for smooth (non-)expert operation