Forward Endcap Status and Testbeam Results

Malte Albrecht

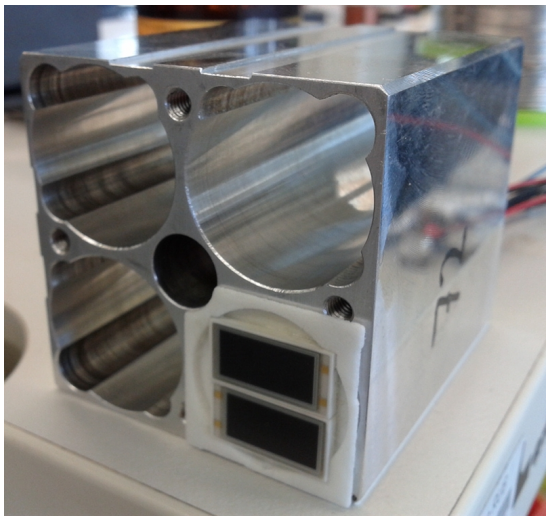
Ruhr-Universität Bochum
Institut für Experimentalphysik I

PANDA L. Collaboration Meeting
INFN Frascati, September 09th 2014

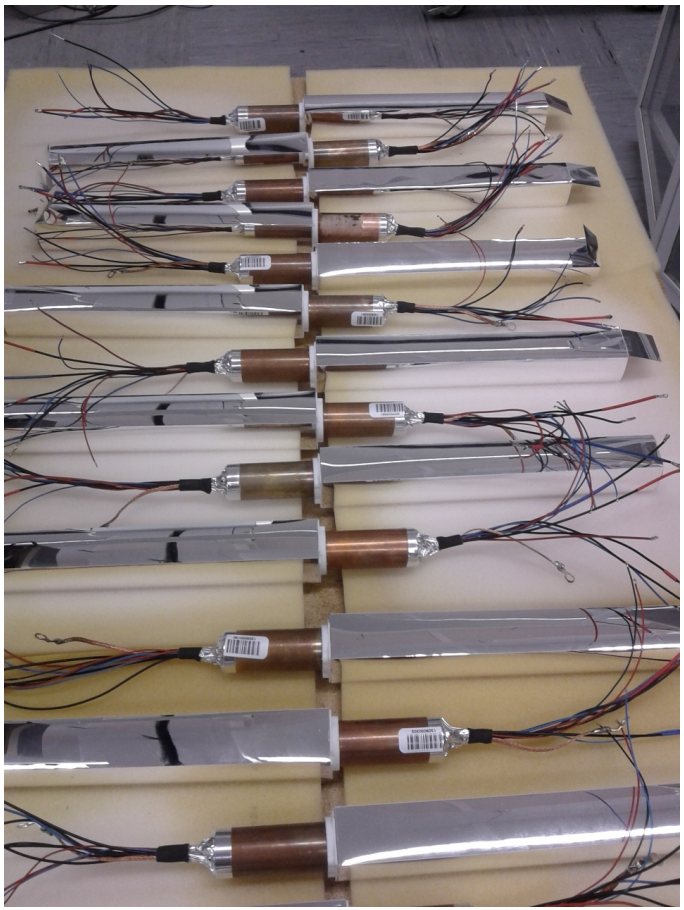
RUHR UNIVERSITÄT BOCHUM RUB

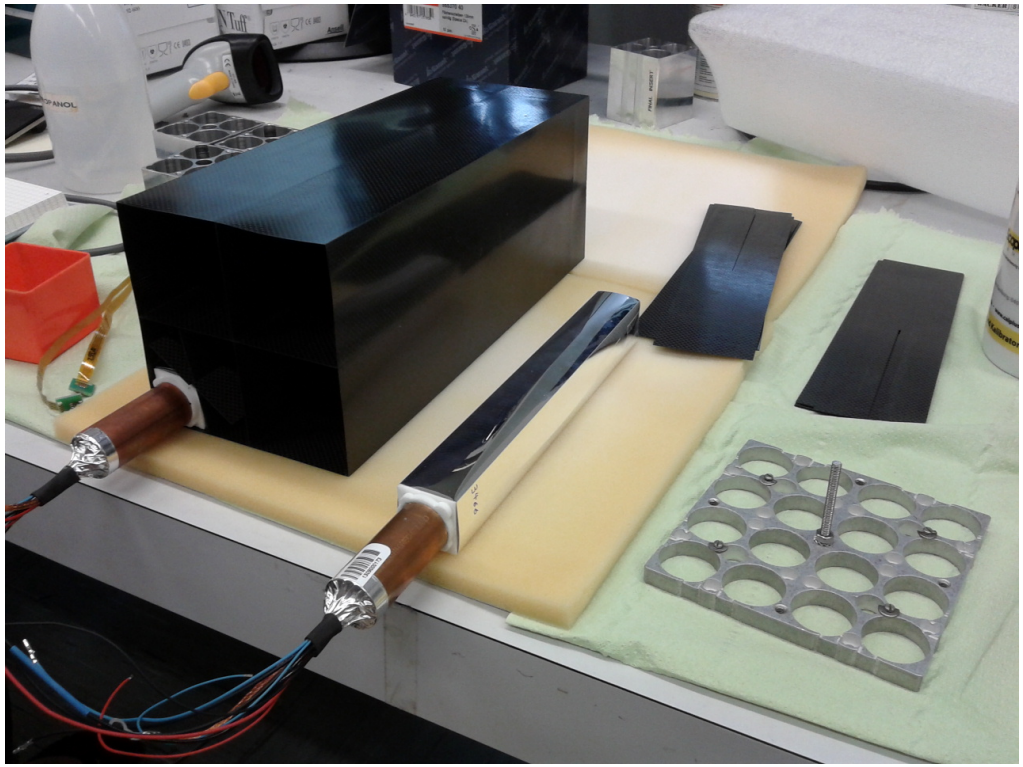
Final Subunits

- Two final endcap subunits have been produced, one equipped with APDs, the other with VPTTs
- Photodetectors are glued to the crystals with Dow Corning 3145 (irreversible)
- Photodetecor-preamplifier units are filled with Elastosil RT601 casting compound
- Both subunits were mounted to the Proto192 to test mounting, cabling and response at the ELSA beamtime



Production of APD Subunit



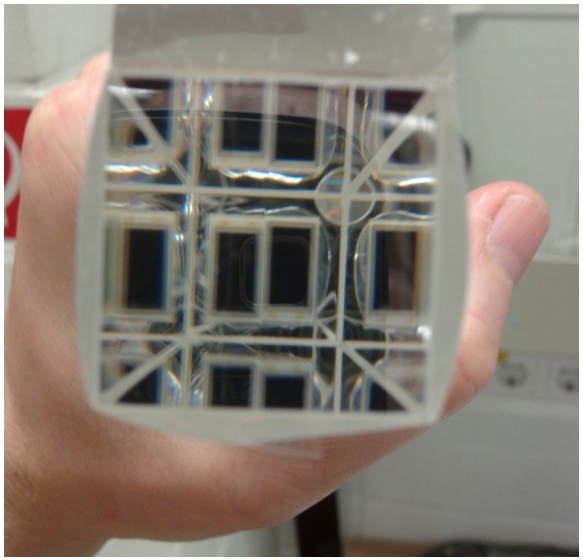


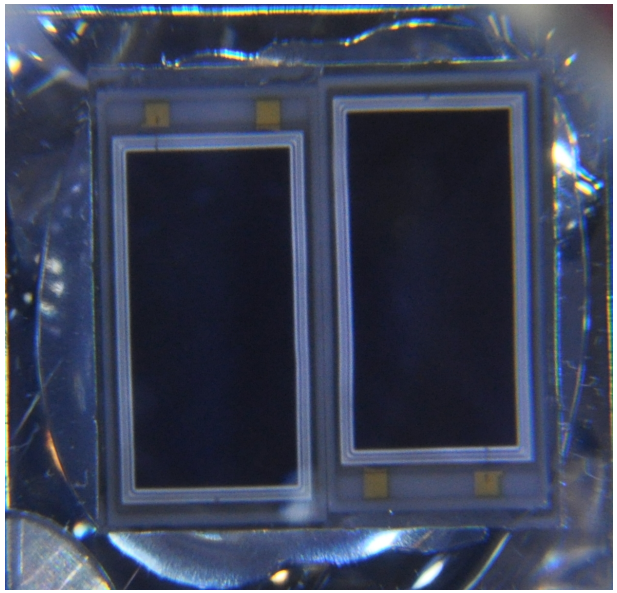
Glueing of APD-Units

- Each glueing is inspected and archived using a DSLR photo
- Illumination of glued surface through the crystal was problematic

→ Usage of a LED-illumination ring (made in Bochum) improved image quality drastically

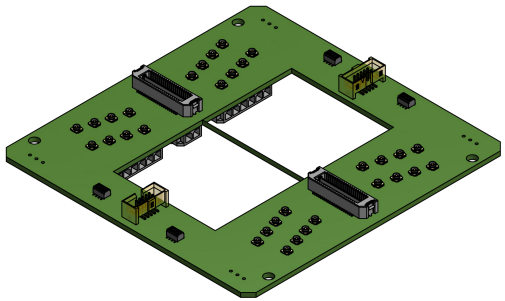
- Photos of glueings are archived in the Forward Endcap Production Database using the barcode of each unit

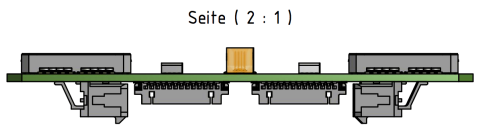


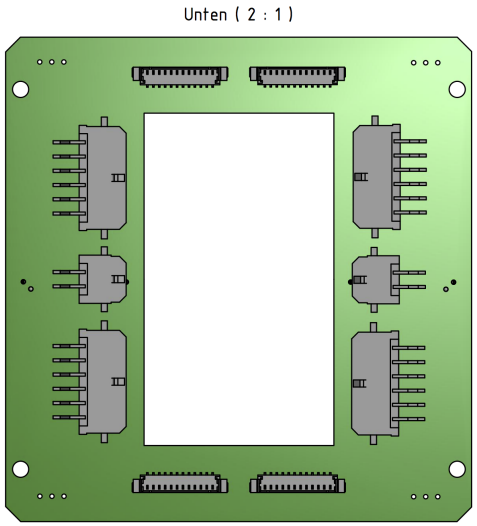


Subunit Production - Cables

No. of Cables	VPTT Subunit	APD Subunit
Signal	16	32
High Voltage	$2 \times 16 = 32$	$4 \times 16 = 64$
Low Voltage	$3 \times 16 = 48$	$3 \times 16 = 48$
GND Lead	16	16
Sensors	2	2
TOTAL	114	162

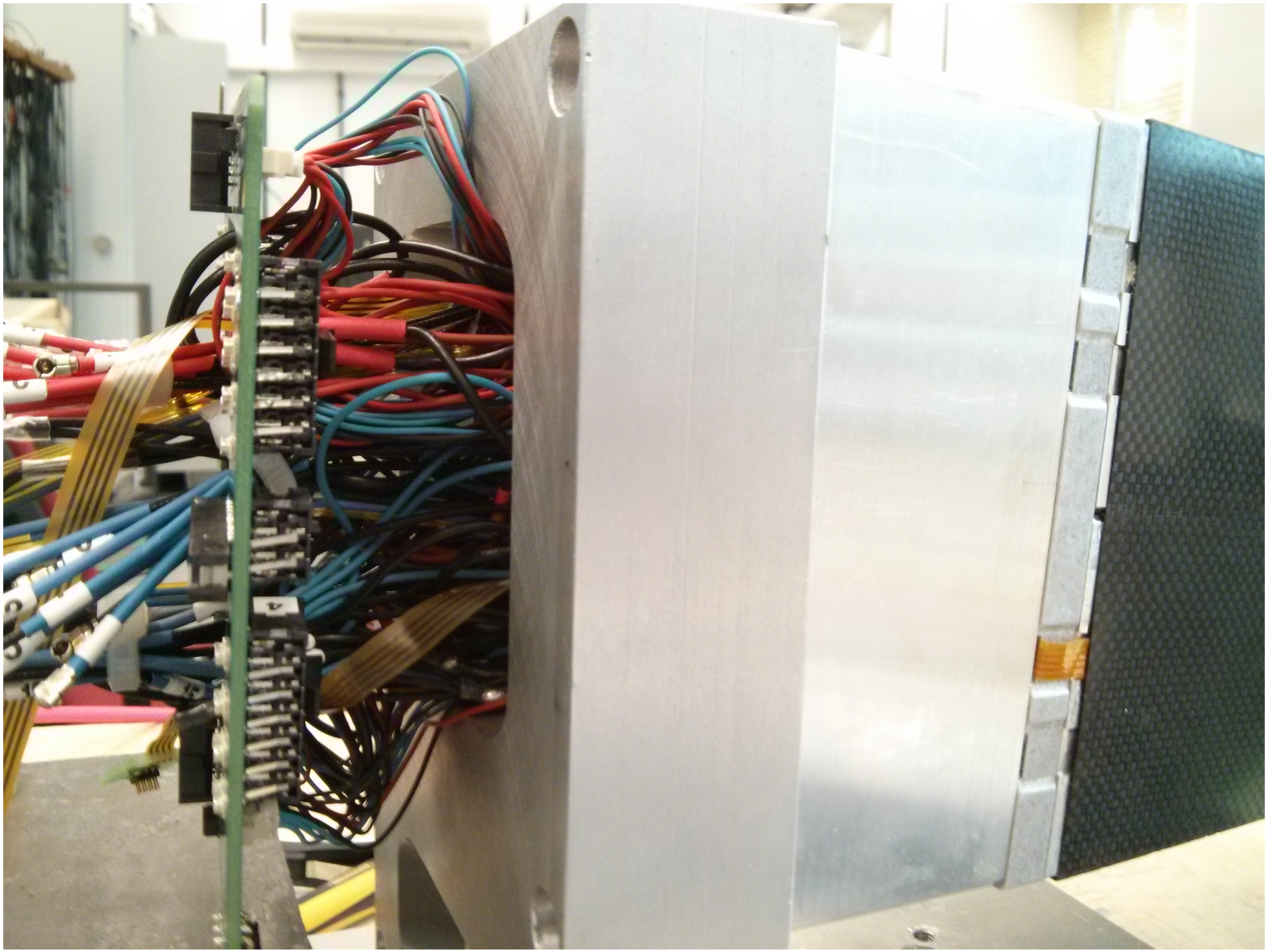




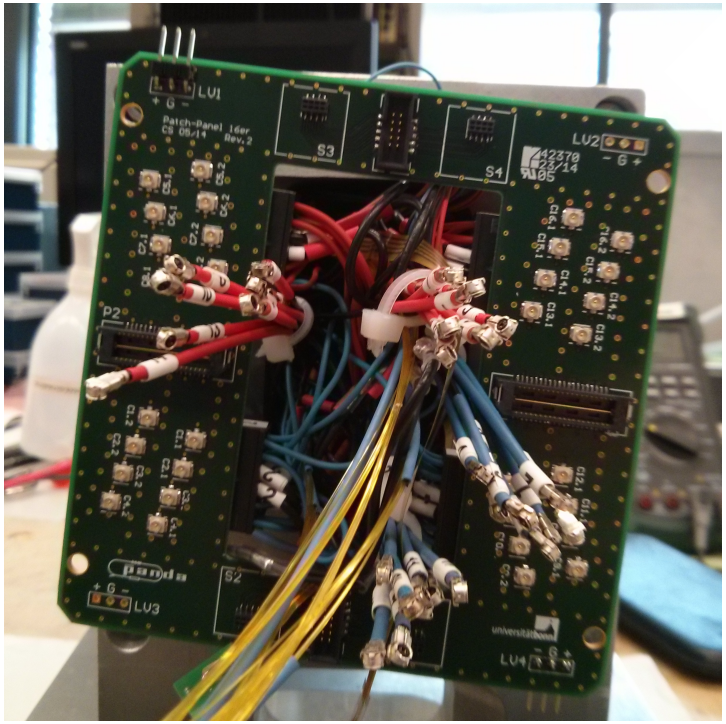


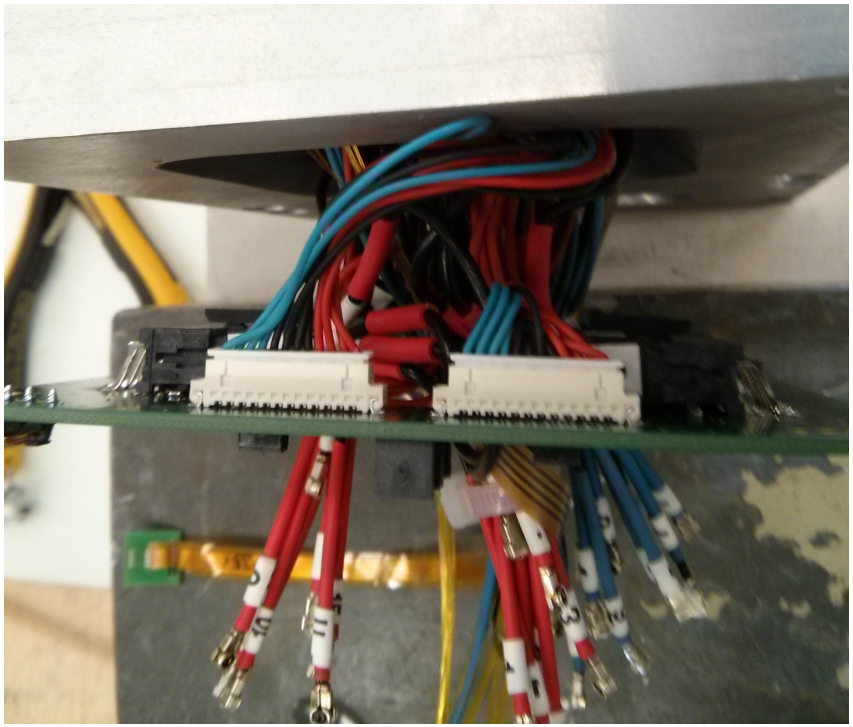
- Keep these cables short to make mounting of subunits easier
- Cables are connected to Patch-Panel PCB, which will be placed on the backplate for each subunit
  (Design presented on June CM by C.Schmidt)

Test: Mounting Subunit To Mini-Backplate



Test: Mounting Subunit To Mini-Backplate





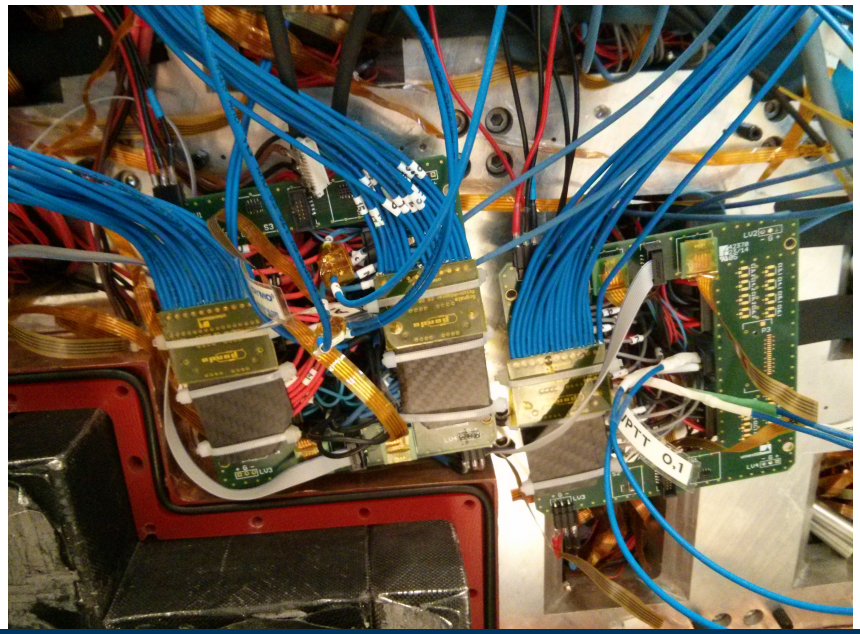
- Cabling of VPTT-Subunits works fine
- Mounting of APD-Subunit is problematic: Too many and too stiff cables
- PCB cannot be pushed/mounted to the backplate!

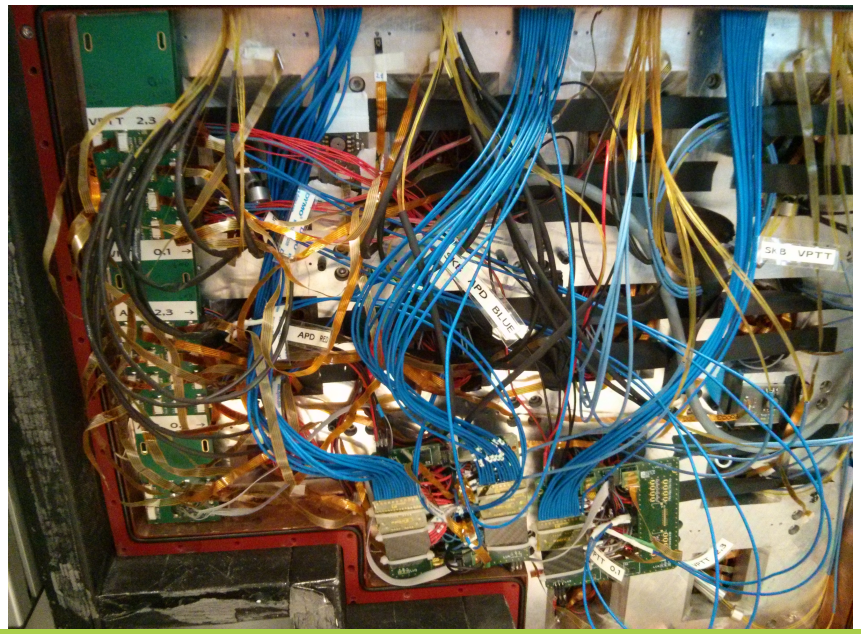
→ Need more flexible/thinner HV cables in APD subunits

Cabling and Routing in the Forward Endcap

- Used in Proto192 for the two final subunits:
  - Signal: 1×16 (VPTTs) or 2×16 (APDs) Huber&Suhner Enviroflex coaxial cable
  - HV: 4 H&S Enviroflex cables per subunit (4 VPTTs / 8 APDs)
  - LV: Standard AWG20 wire connected to pin header on PCB (needs to be changed in final version)
  - Sensors: 1 flat ribbon-cable (pitch: .5 mm) for 2 sensors

$\rightarrow$ Sophisticated routing scheme (including light fibres!) is needed





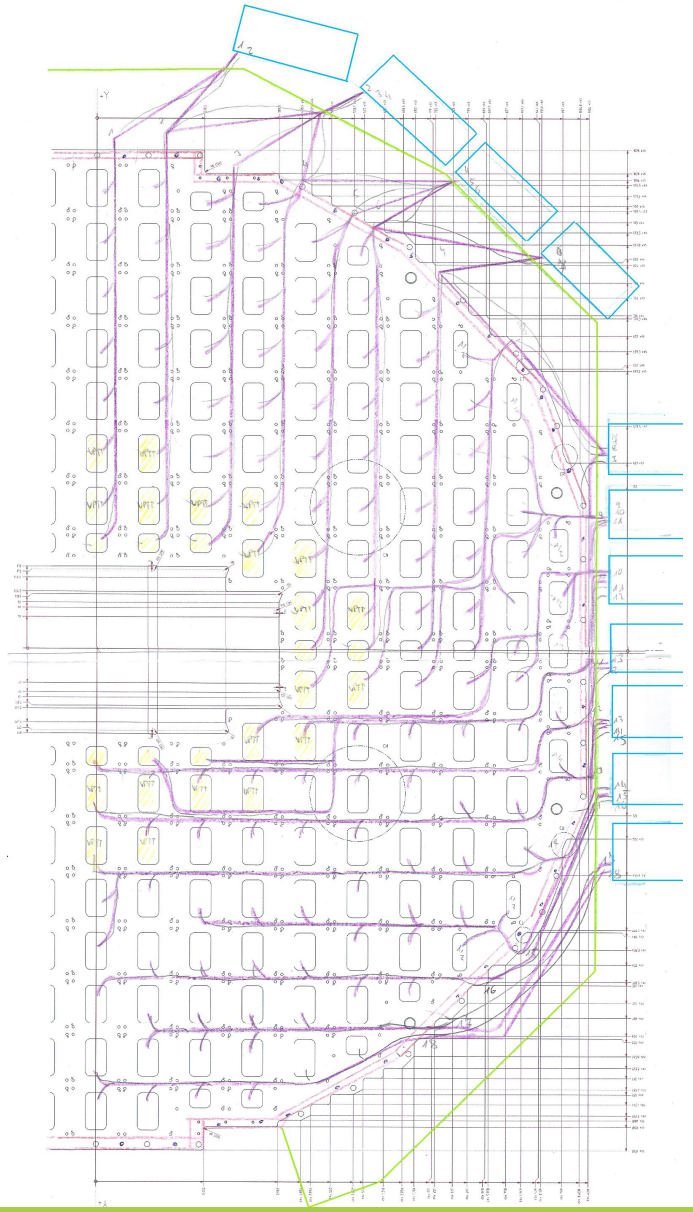
Cables and Routing in the Forward Endcap

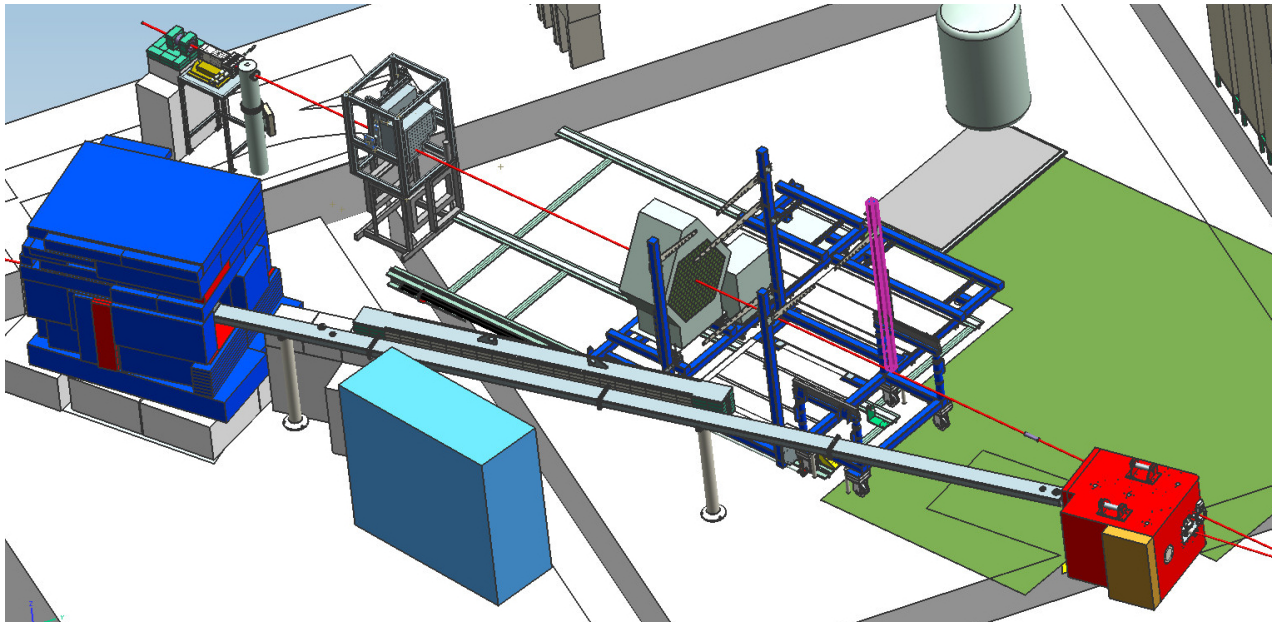
- Foreseen for FW endcap:
  - Signal: Feasibility of using H&S Enviroflex is being checked (Possible alternatives: Samtec FCF8 micro coax cable (AWG38); Nexans Filotex 50VMTX)
  - HV: H&S Enviroflex, as in Proto192
  - LV: under investigation
  - Sensors: as in Proto192

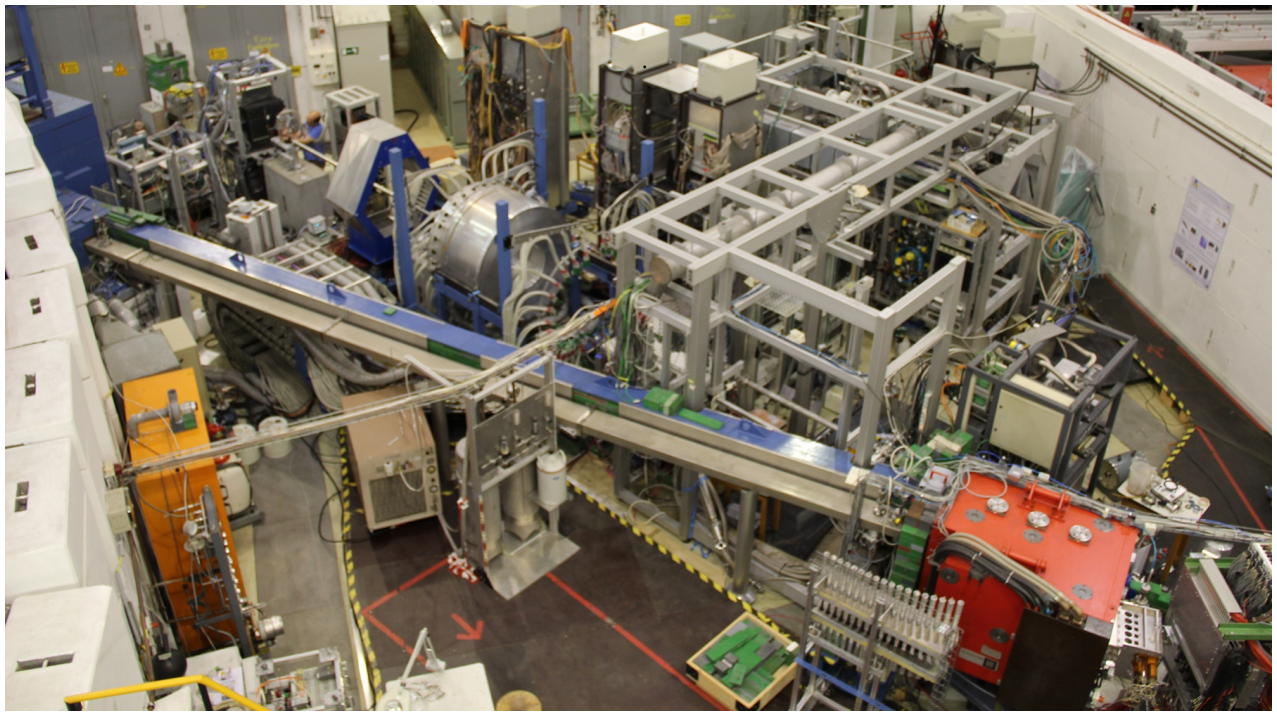
Diameter	**0.6mm**	**1.2mm**	**1.8mm**
Attenuation @700Mhz	**-3dB/m**	**-1.9dB/m**	**-1.3dB/m**
Conductor wires	**7**	**1**	**7**

Routing Scheme

- only $\approx 30\,\text{mm}$ space between backplate and insulation
- Current idea for the routing scheme:
  - Light Fibres, high voltage, low voltage and sensor cables will be routed **vertically** as well as **horizontally** below and inbetween the Patch-Panel PCBs, directly on the aluminium backplate
  - Signal cables will be routed both **vertically** and **horizontally** in a layer **on top of** the PCBs



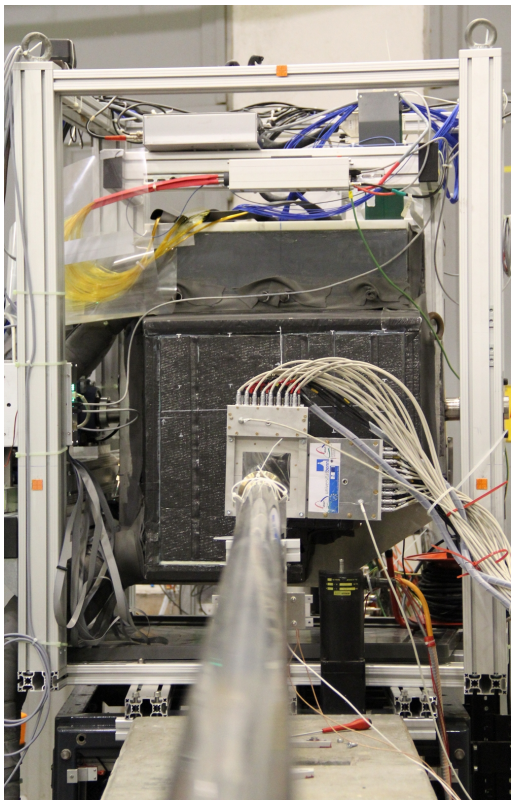




ELSA Beamtime - Setup and Measurement Program

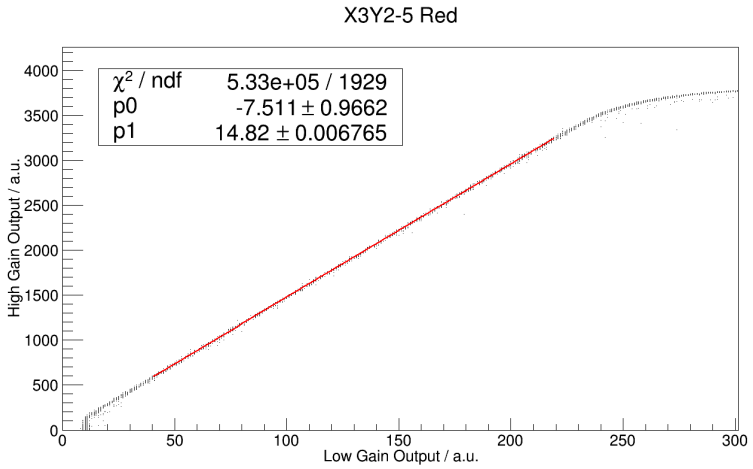
- Used direct electron beam delivered by ELSA (tagger magnet turned off)
- Energies: 1.25, 2.4, 3.2 GeV
- Fibre hodoscope in front of Proto192 for triggering and tracking
- Proto192 mounted on XY-table
- Shot centrally in each of the 32 crystals with all 3 energies for calibration
- Additional measurements with high rates
- Goal of beamtime:

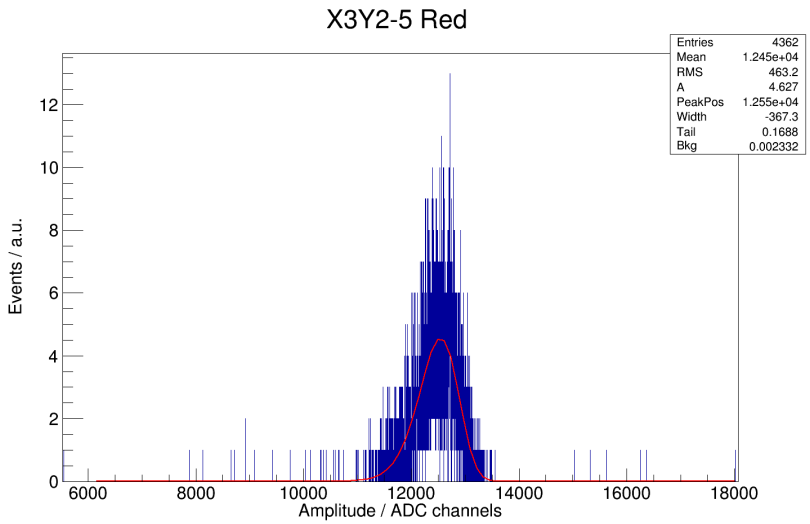
→ Measure response of APD and VPTT units to finally fix design/amplification factor of preamplifier



Analysis

- Detailed analysis and calibration of data is in progress
- Performed MC simulation with fully featured Proto192 geometry (Geant4) as for previous beamtimes
- Simulations for all energies / targetted crystals finished
- High-Gain/Low-Gain calibration finished
- Energy calibration is being prepared



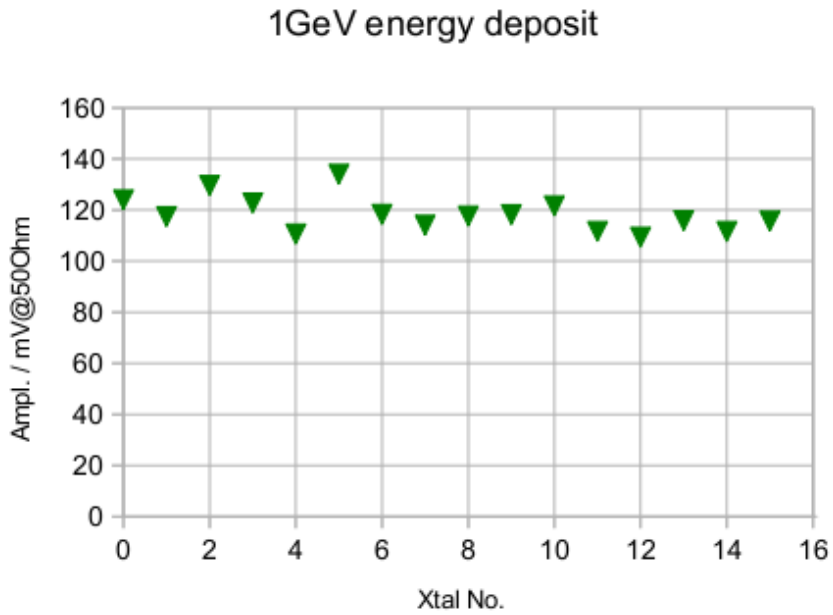


Response of VPTTs: Calculation vs. Measurement

$$U_{\text{Preamp}}(50\Omega) = \text{LY} \cdot \frac{A_{\text{cath.}}}{A_{\text{xtal}}} \cdot G_{\text{VPTT}} \cdot \text{QE}_{\text{VPTT}} \cdot G_{\text{Preamp}}$$

- $LY \approx 380$ Ph/MeV at -25° C
- $\frac{A_{\text{cath.}}}{A_{\text{xtal}}} = \frac{201.1\,\text{mm}^2}{676\,\text{mm}^2}$
- $G_{\text{VPTT}} \approx 48$
- $\text{QE} = 23\%$
- $G_{\text{Preamp}} = 0.46\,\text{V/pC}$

$\Rightarrow \; U_{\text{Preamp}}(50\Omega) = 92\,\frac{\text{mV}}{\text{GeV}}$



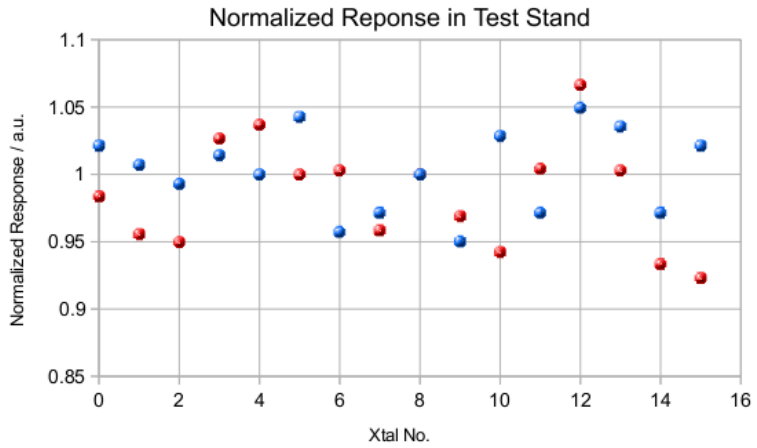
- Response is (only!) 30% larger than expected (maybe due to reflective foil, ...)
- Largest signals to be expected (w/o magnetic field!) $\approx 1.5\,\text{V@50}\Omega \rightarrow$ could use higher gain of preamp?

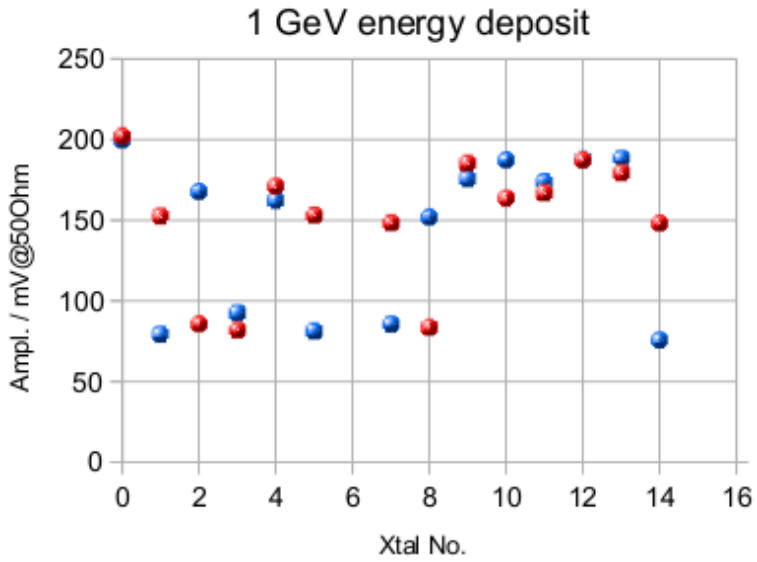
Response of APDs

- Yield measured in the lab
  - $+20°$ C
  - APDs operated at $M = 100$ voltage (Hamamatsu)
  - Used blue light pulser and PIN diode reference system

  → Nicely homogeneous response of all APDs (variations ≈7%)
- Yield measured at beamtime
  - $-25°$ C
  - Shared HV for 8 APDs
  - Matching performed with $M = 200$@ $-25°$ C voltages from Frankfurt/GSI

  → Response shows two 'groups' of APDs with large difference in response (factor of 2!)



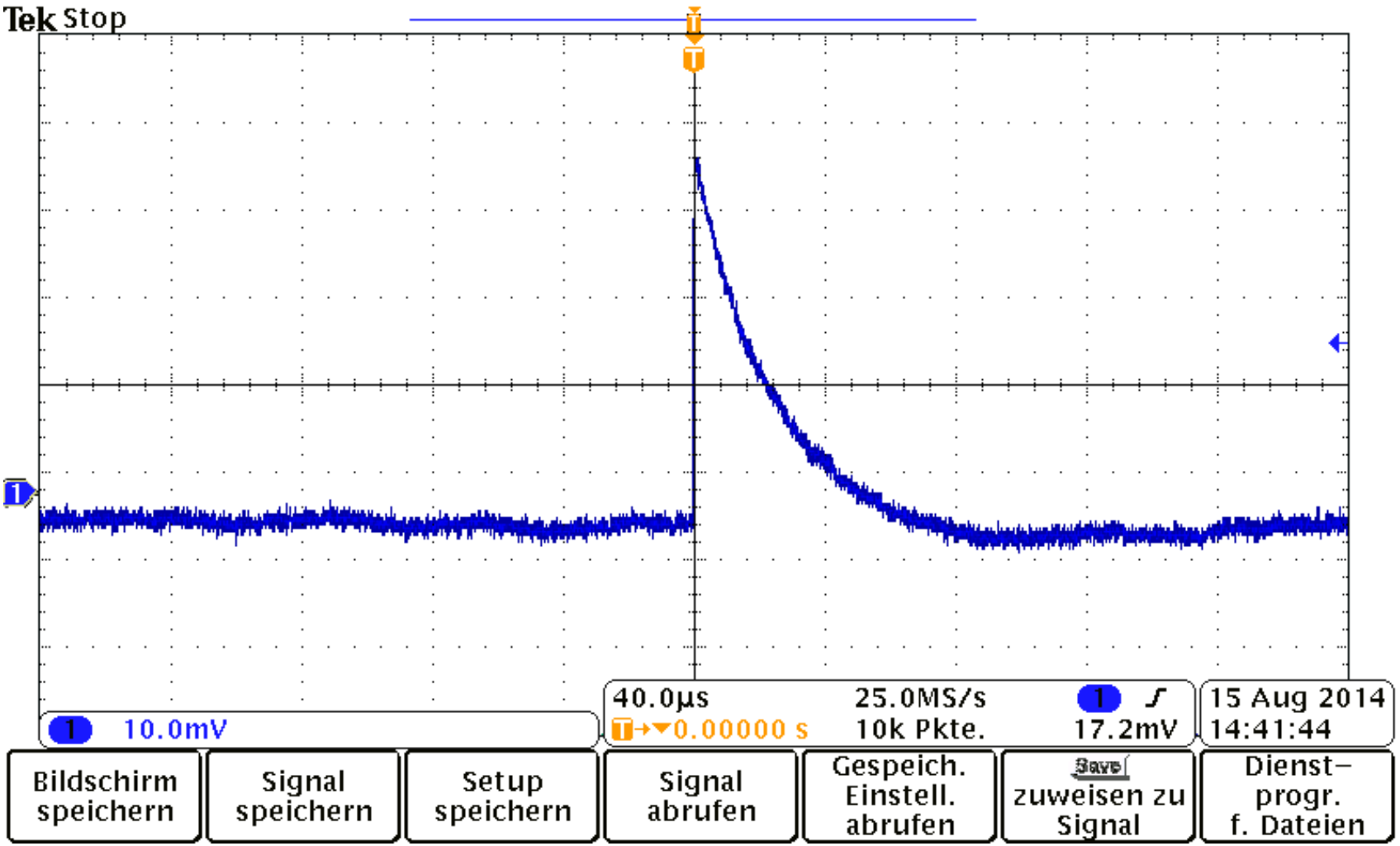


Ringing of APD Preamplifiers

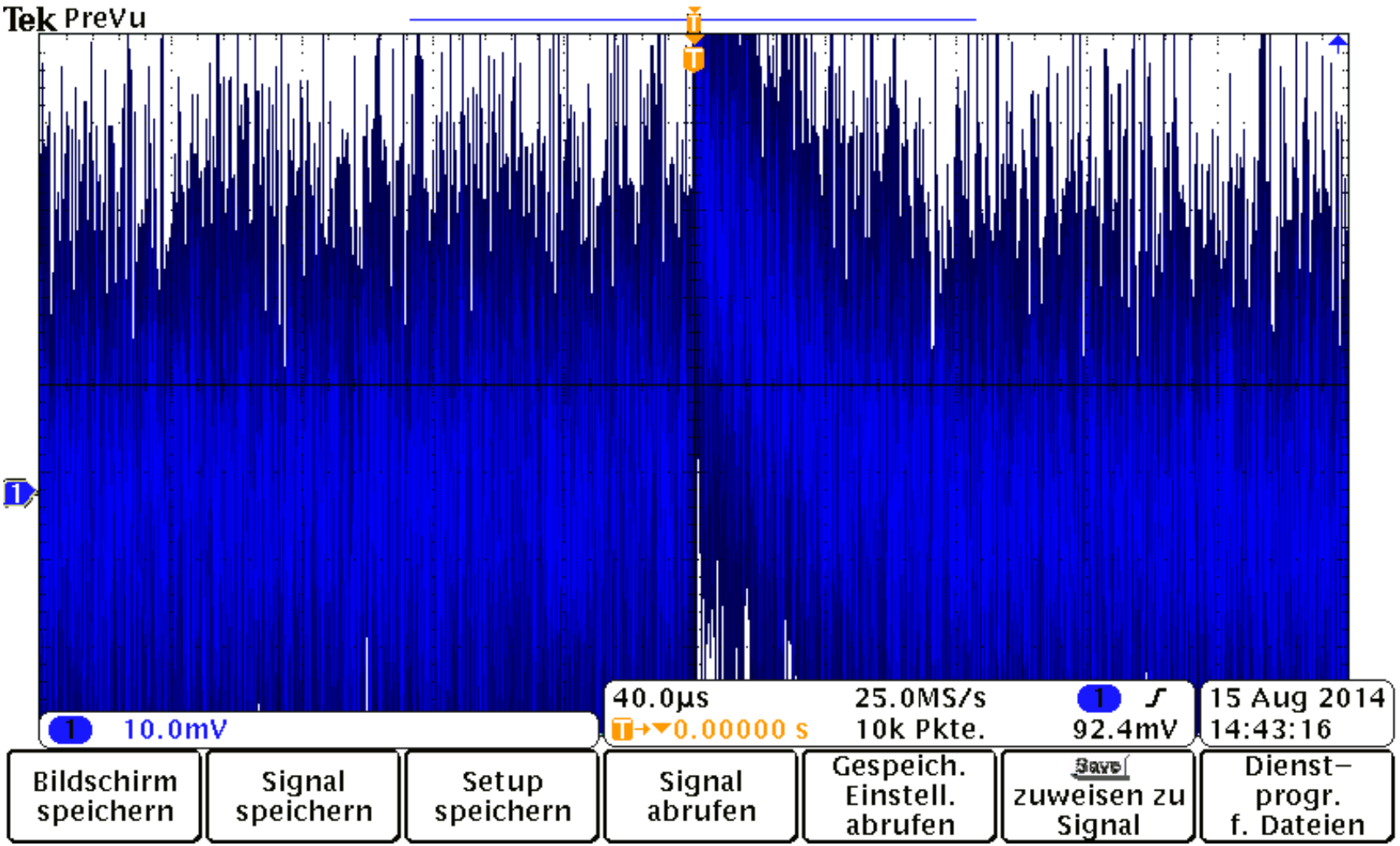
- Observed massive HF-induced ringing of APD preamplifiers (lab + beamtime)
- Triggered by large HF-spike, **all** 32 APD preamps start ringing
- Light pulser (blue diode) produces such a spike (rapid capacitor discharge) $\rightarrow$ no measuments with LP and APDs were possible
- Source of the problem not yet fully understood: Characteristics of latest APDs? Behaviour of preamp?

$\rightarrow$ Trying to solve that problem together with Basel colleagues

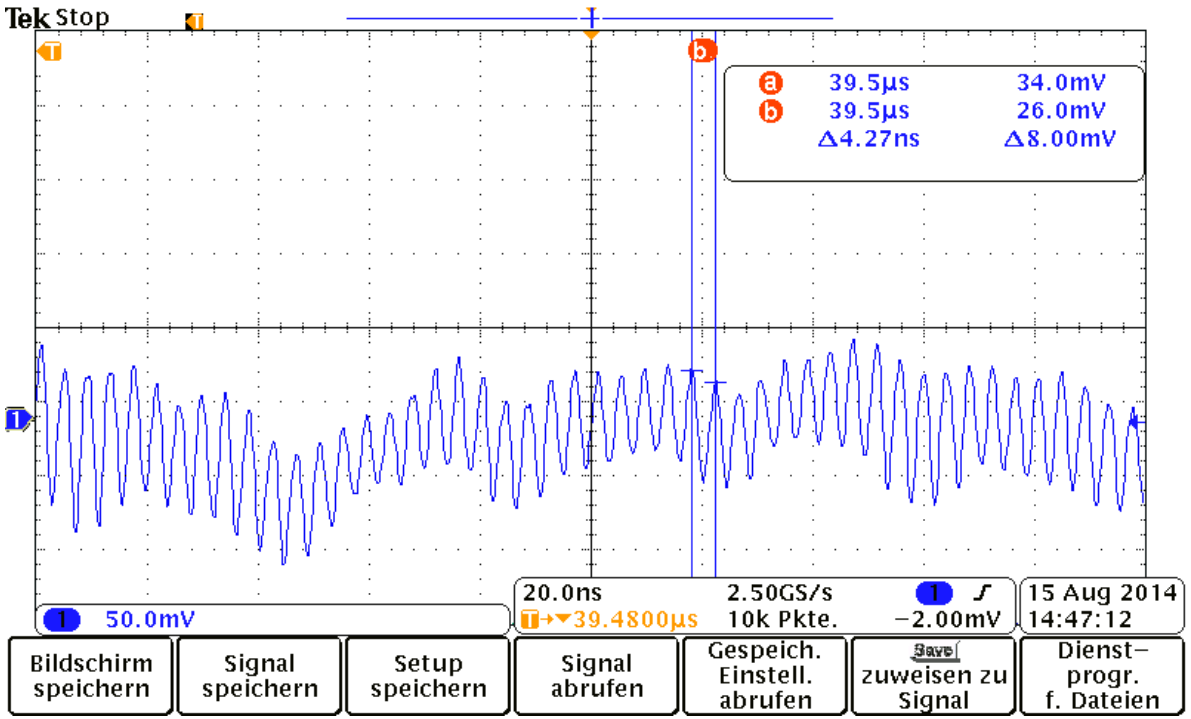
Blue Light Pulser on APD - Preamp Output Signal



Blue Light Pulser on APD - Preamp RINGING



Blue Light Pulser on APD - RINGING (Zoom)



- No rail-to-rail ringing
- Typically around 200-400 mV pp.
- Frequency: $\approx 230\,\mathrm{MHz} \rightarrow$ resonance frequency of OP-amp circuit

Summary

- Analysis of beamtime data is ongoing
- Production of final VPTT subunits can start: Mechanics, cables and electronics are almost fixed
- **Second batch of 100 VPTTs has arrived at U Bonn last week!**
- Response of APDs needs to be understood
- Ringing of APD preamps is being investigated
- Routing scheme for cables in the cold volume of the endcap is being planned