SADC and Shaper Tests for the Forward Endcap EMC

Malte Albrecht

Ruhr-Universität Bochum
Institut für Experimentalphysik I

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RUHR UNIVERSITÄT BOCHUM RUB

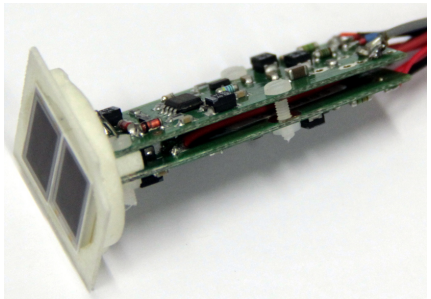
panda

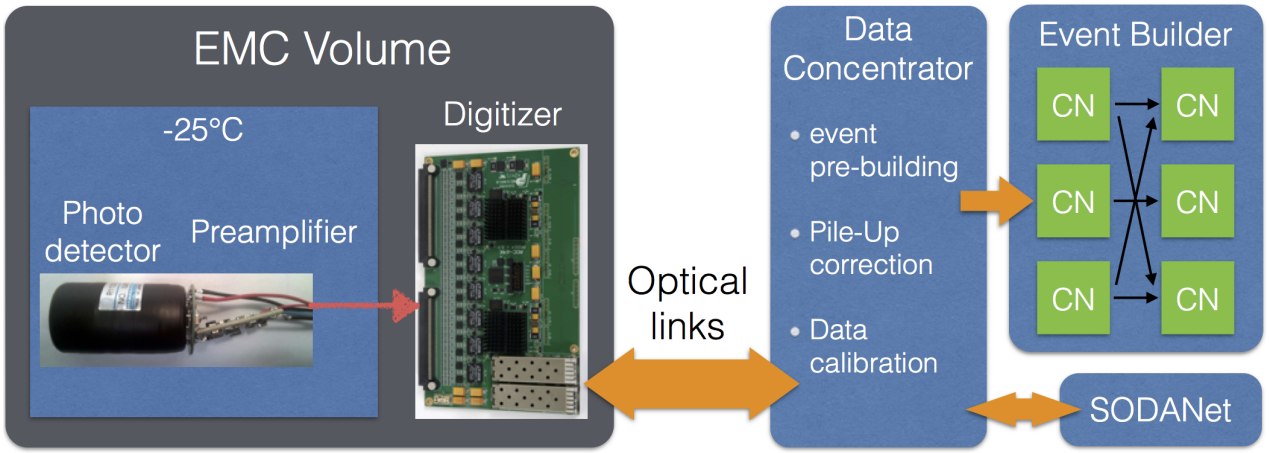
Reminder: Readout of the $\overline{\text{P}}$ANDA EMC

- Barrel and backward endcap:
  two APDs per crystal, readout w/ APFEL ASIC (GSI)
- Forward endcap: two APDs or one VPTT per crystal

→ All photodetectors read out w/ low-noise preamplifiers (U Basel)

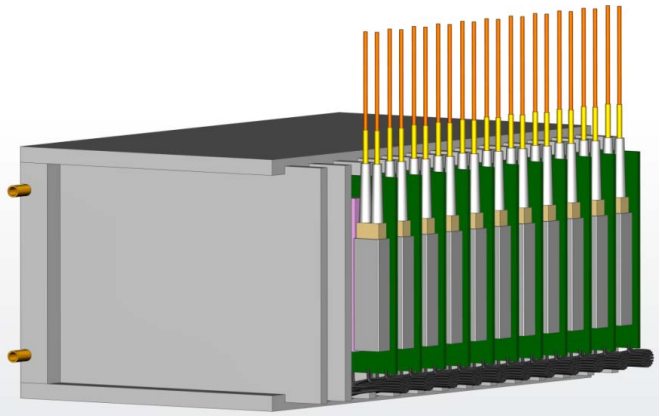
- Different preamplifier gains to accommodate for differences in photodetector gains:
  - APDs: 0.1 V/pC
  - VPTTs: 0.7...0.89 V/pC

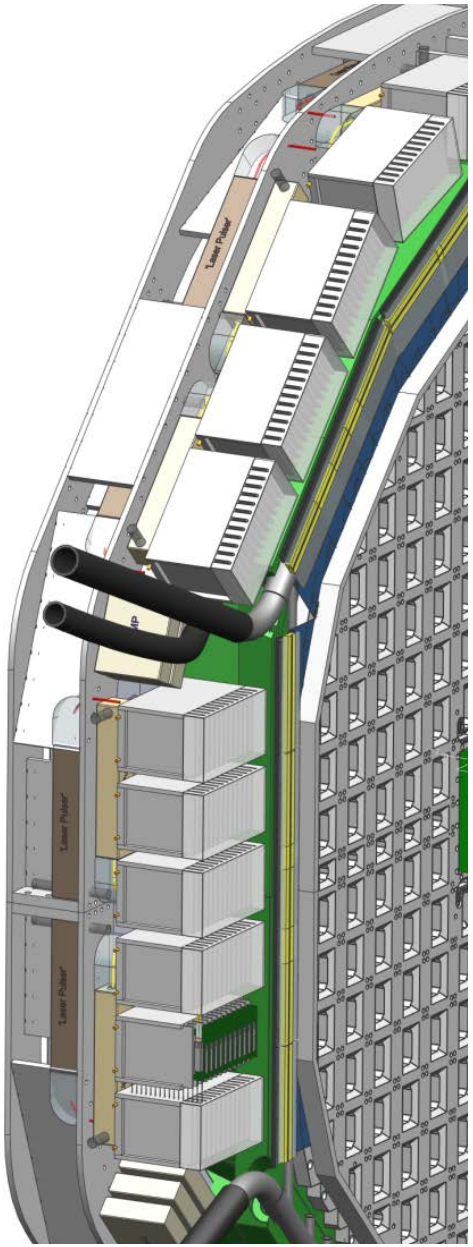




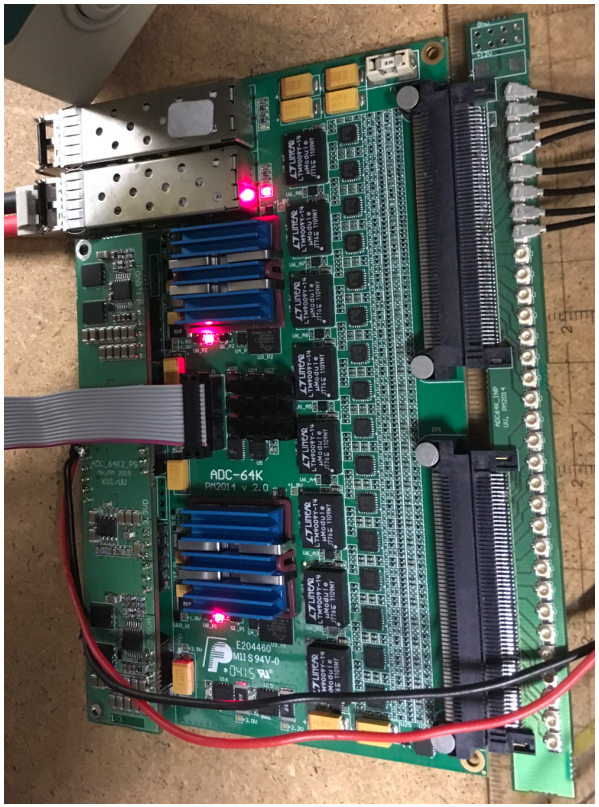
Reminder: Placement of ADCs in the FW endcap

- Custom cooling crates for ADC boards in development by KVI, Uppsala
- Cooling crates will be mounted to electronics / support frame of the endcap
- Detector signal cables are routed from cold to warm volume and connected to backplane PCB of the cooling crates





Reminder: Final Version of the $\overline{\text{P}}$ANDA SADC



- Design by P. Marciniewski (Uppsala)
- 32 single-ended 50Ω input signals
- Analog shaping and HIGH/LOW splitting

→ Input: Samtec high-density connectors

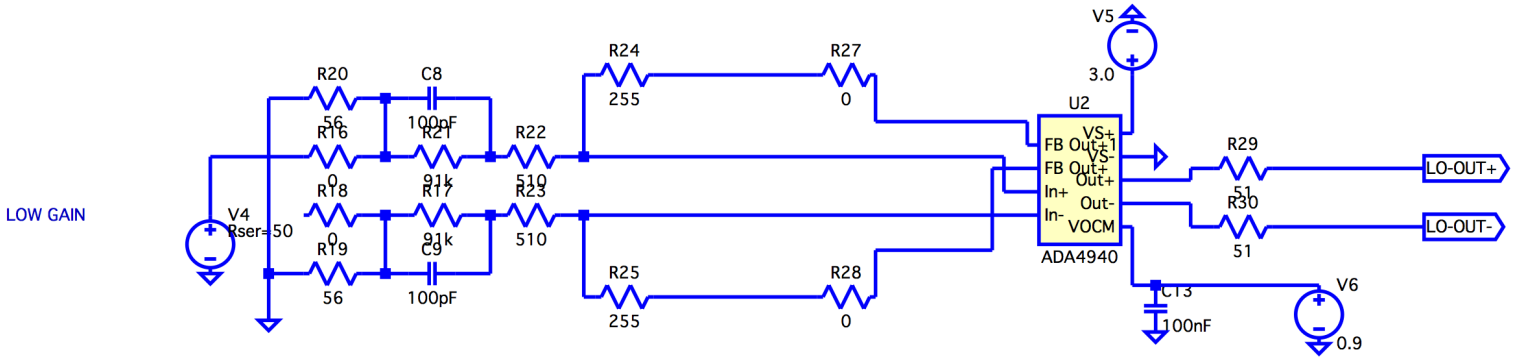
→ Analog input range: 0... 2.2 V (max. preamplifier output)

→ ADC: 64 channels, 80 MS/s

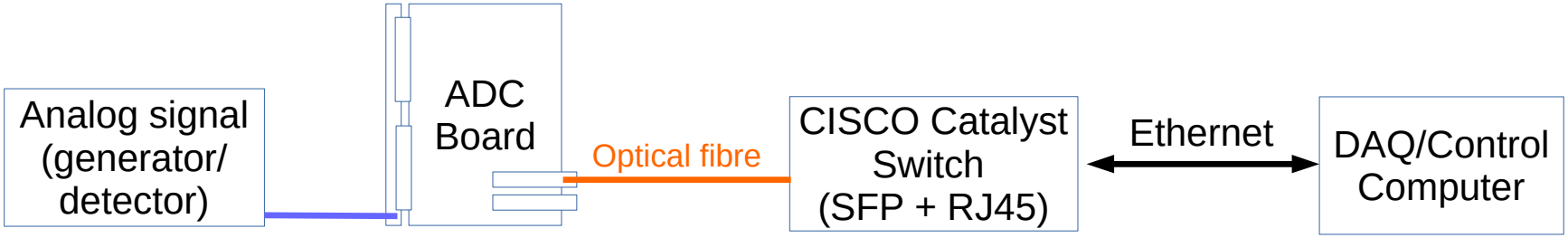
→ Resolution: 14-bit

→ Readout: 2× optical interfaces (SFP, 2 Gb/s)

- Component values for analog shaping stage have to be fixed soon!



Lab Setup for Performance Tests

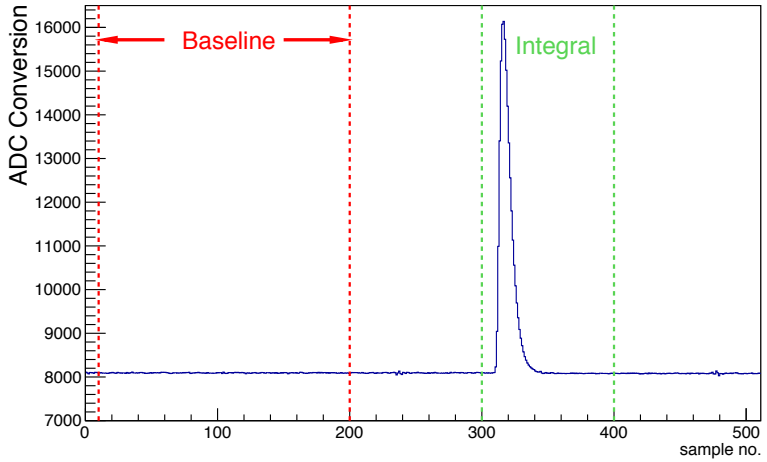


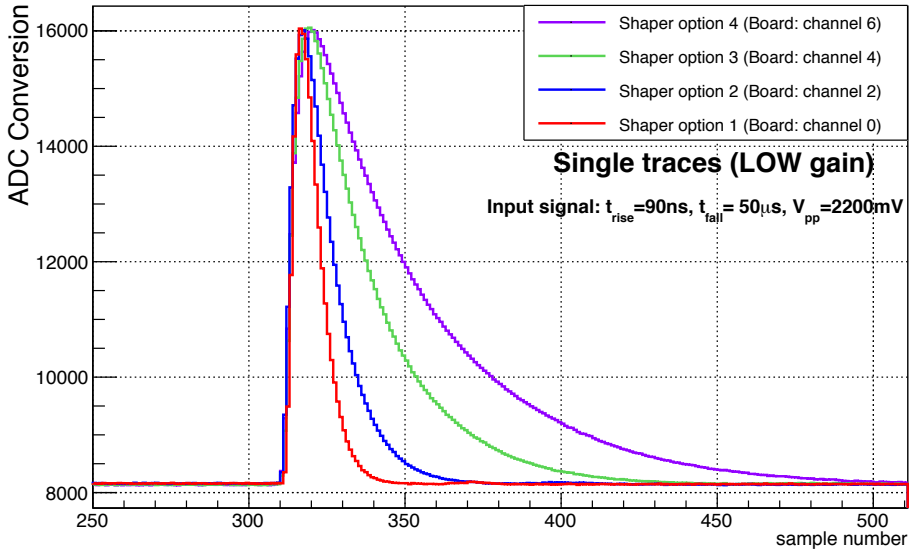
- Firmware by J. Müllers (HISKP, Bonn) for direct readout of the ADC board via ethernet
- Cisco Catalyst 3750 switch (RJ45 + SFP)
- Analog input signals:
  - Tektronix Arbitrary Waveform Generator
  - CAEN DT5800 Detector Emulator ('Basel Preamp'-signal shape: 90ns rise time, 50μs fall time, variable amplitude, programmable amplitude spectrum, periodic or poisson time distribution, pile-up, white noise with variable amplitude, ...)
  - EMC subunit equipped with APDs and VPTTs (final units) incl. PWO crystals in climate chamber @ -25°C

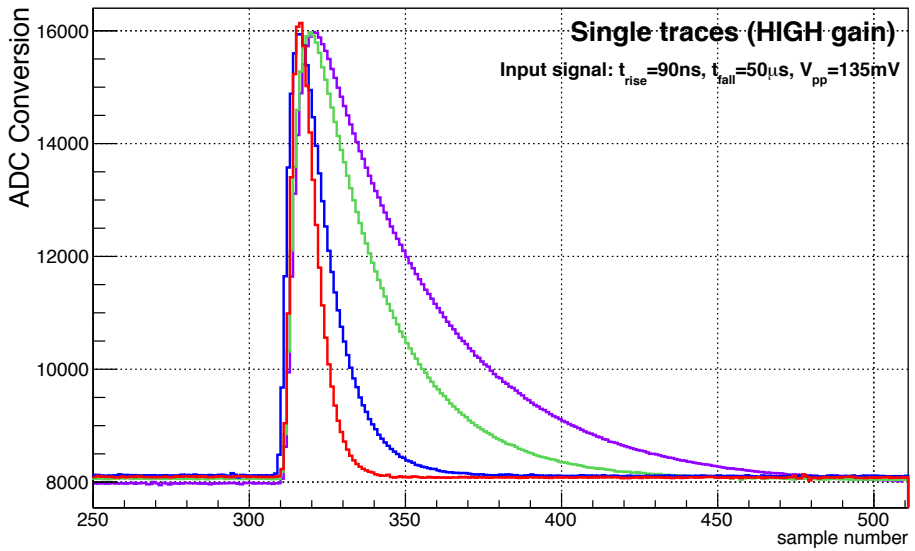
Waveform Analysis

- Recording raw waveforms
- Extraction of noise from pre-signal samples
- Extraction of pulse amplitude and integral in fixed range
- First few channels on ADC board equipped with different versions of analog filters

→ Four different shaping options

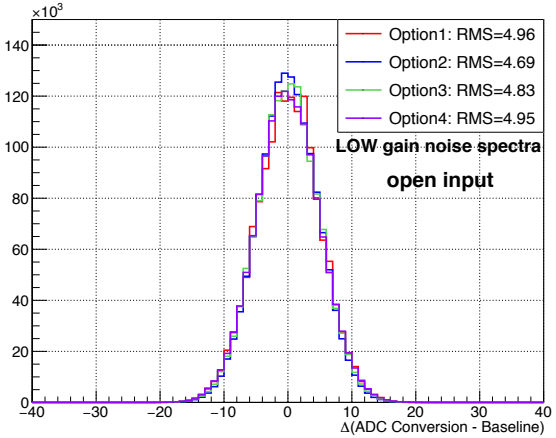


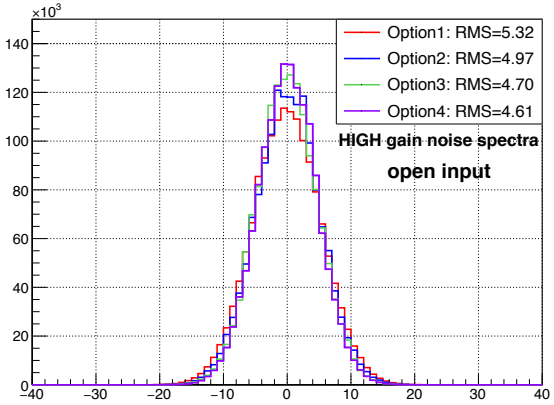




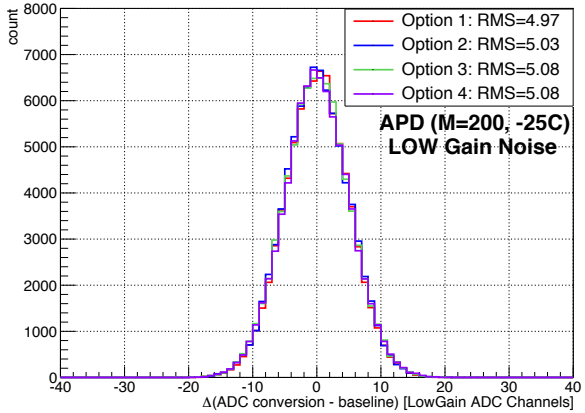
ADC Performance: Noise

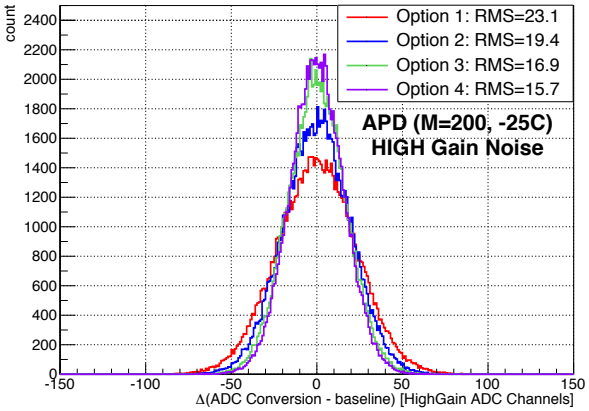
Open input



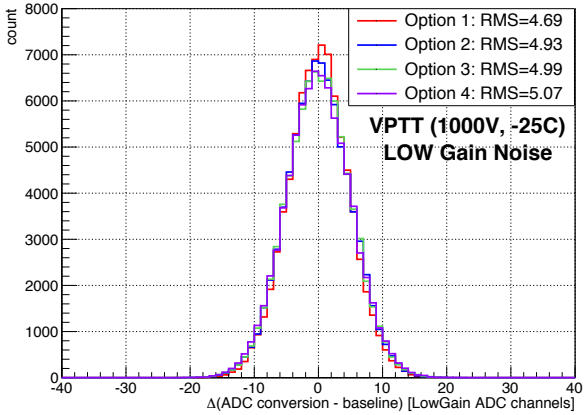


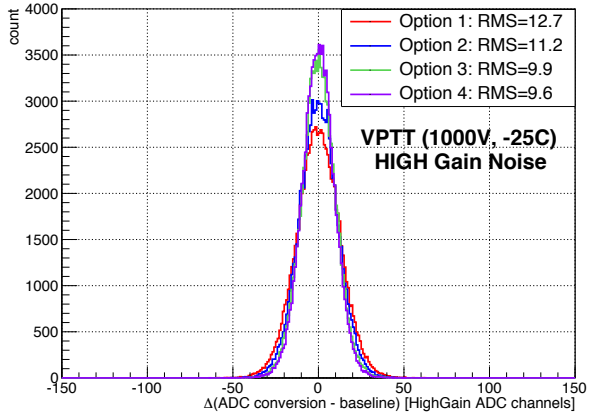
APD M=200,-25°C





VPTT -25°C

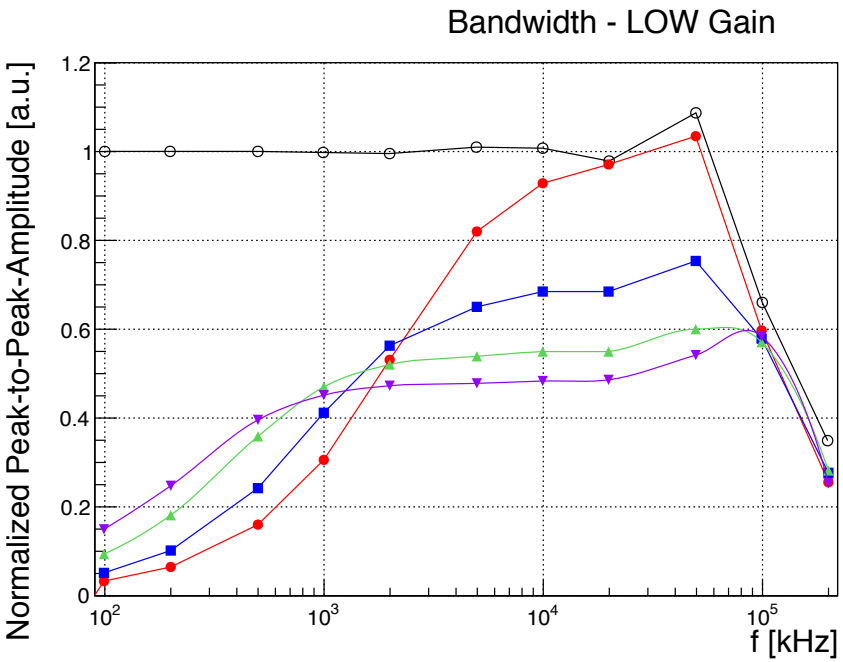


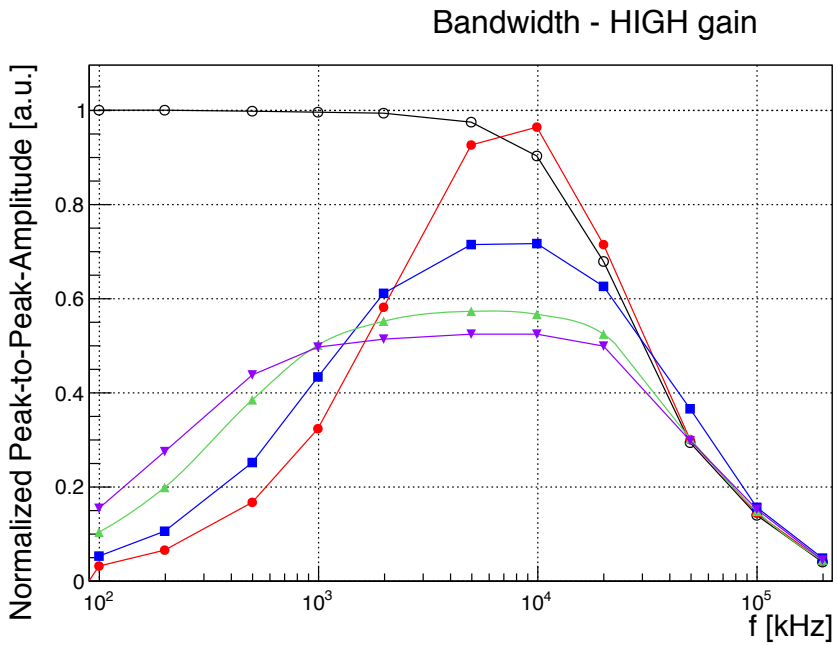


LO:	$\approx$ 5ch.$\approx$7.3 MeV	$\approx$ 5ch.$\approx$7.3 MeV	$\approx$ 5ch.$\approx$7.3 MeV
HI:	$\approx$ 5ch.$\approx$0.5 MeV	(16..23)ch.$\approx$(1.5..2.1) MeV	(10..13)ch.$\approx$(0.9..1.2) MeV

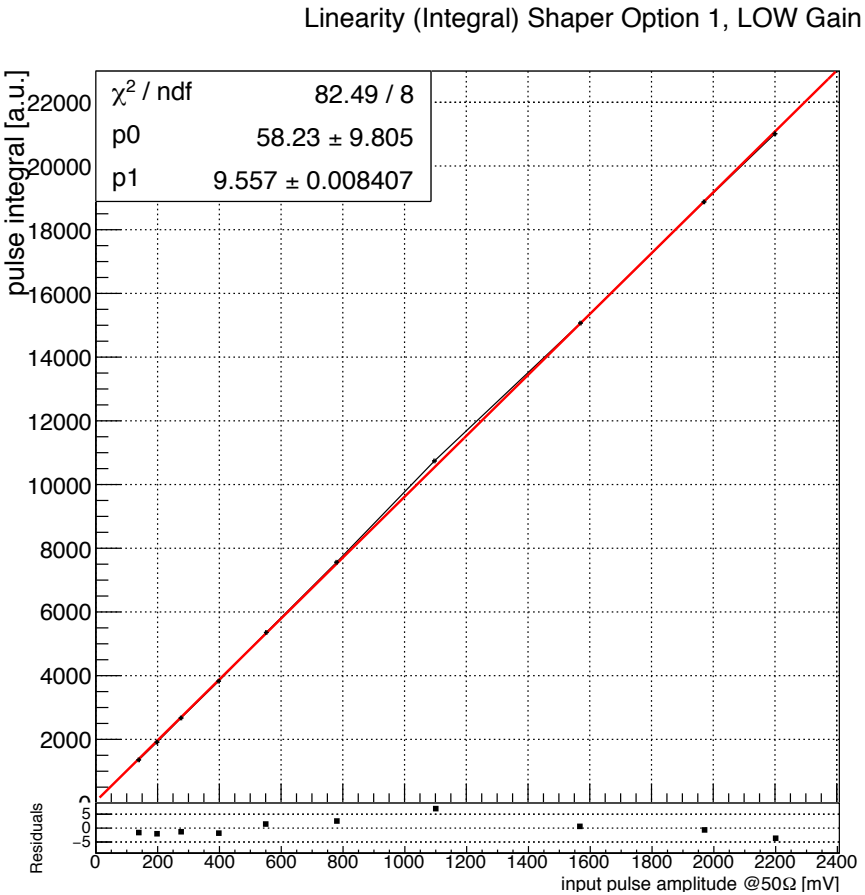
ADC Performace: Bandwidth

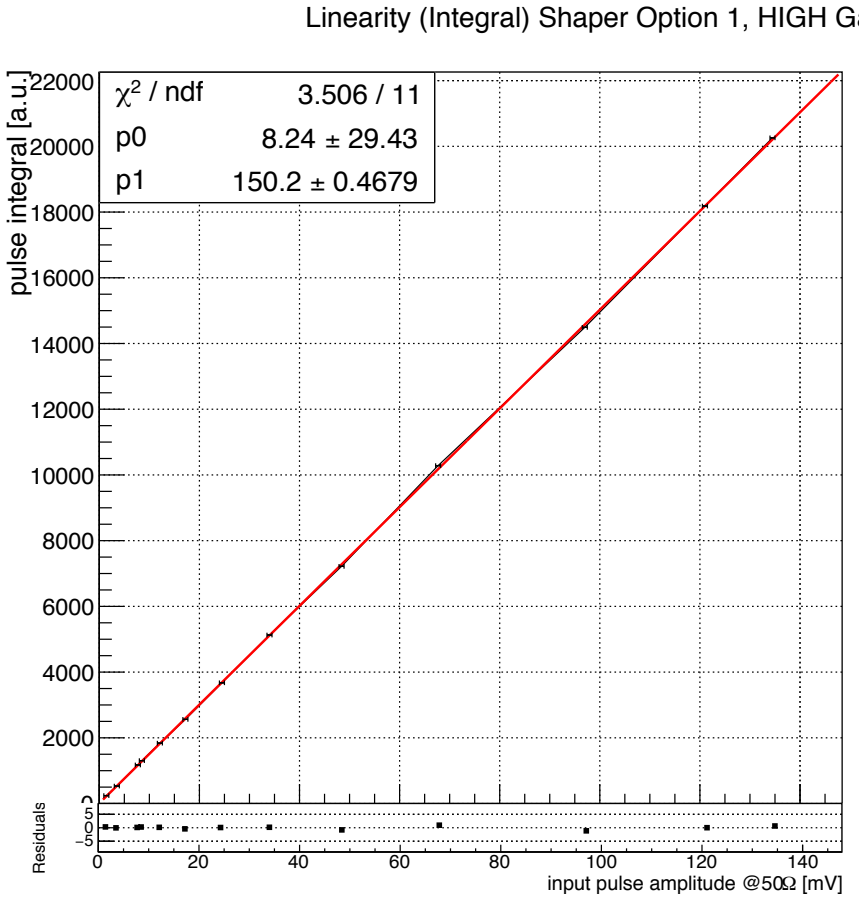
- Input signal: Sine wave (Tektronix AFG)
- $f = (0.1..200)\,\mathrm{MHz}$
- Gray curve: no shaper (APFEL version)
- Colored curves: four shaper options as on previous slides





ADC Performace: Linearity

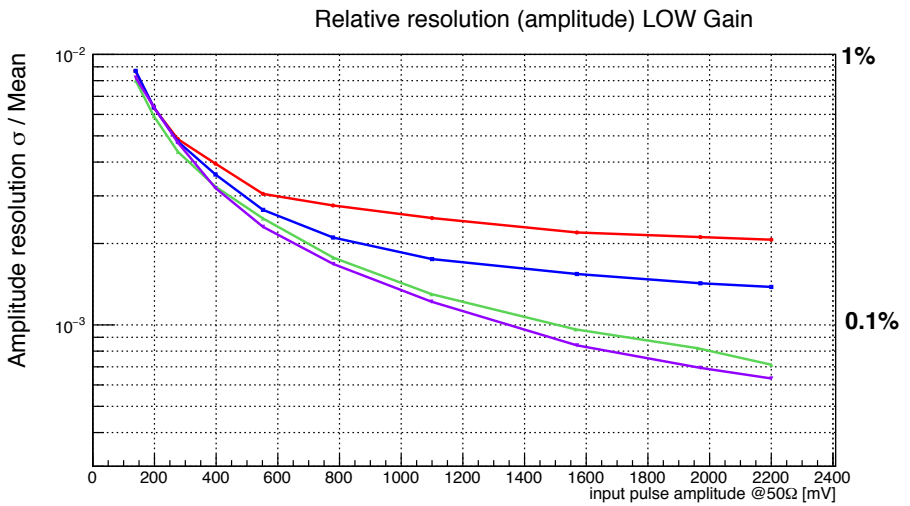


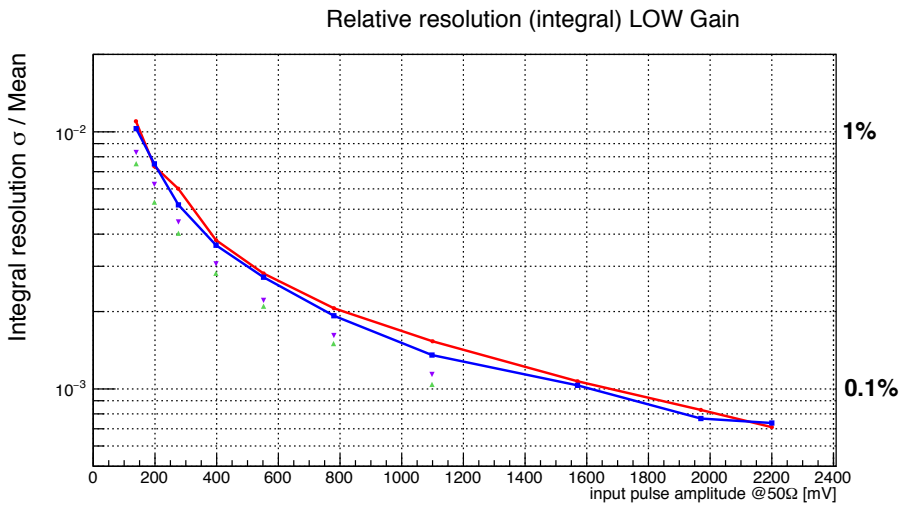


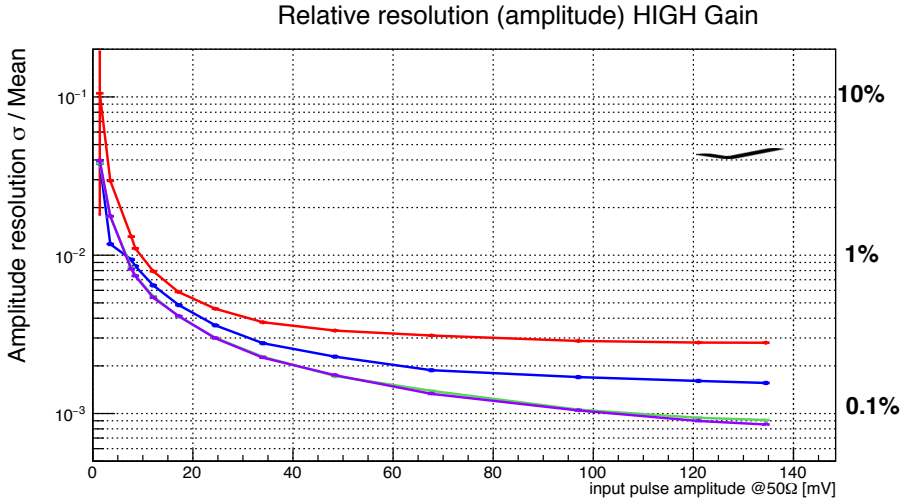
- Preliminary results regarding integral linearity:

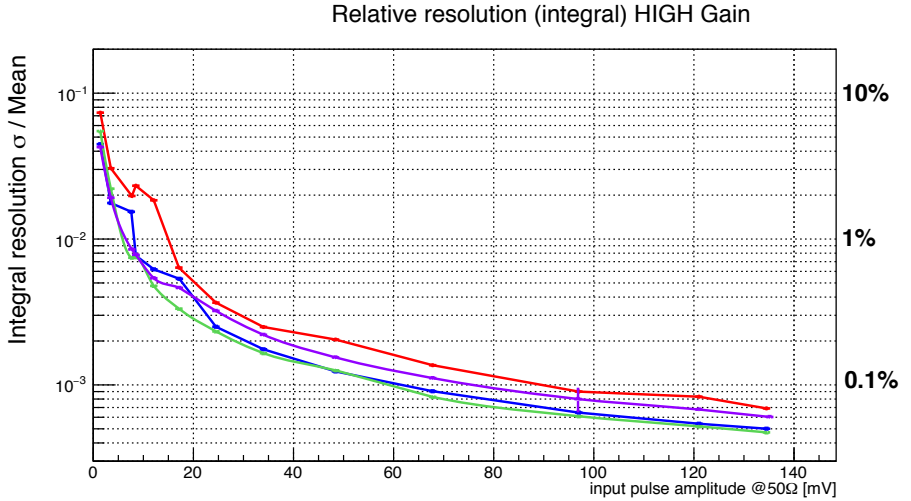
→ Difficulty to reliably generate very small pulses, otherwise: Good linearity of high- and low gain branches for the complete range

ADC Performace: Resolution









Resolution measured for pulses generated w/ CAEN Detector Emulator using nominal pulse shape, no additional noise

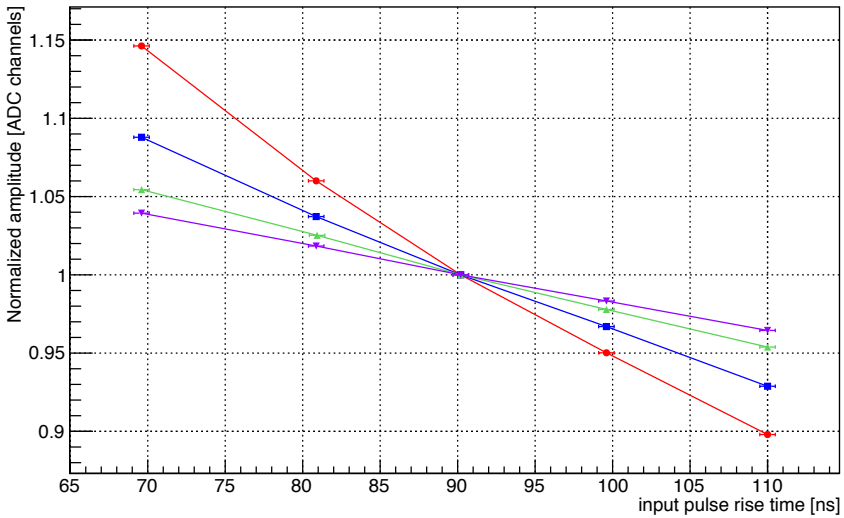
ADC Performace: Rise-time Variation

- Pulse shape may vary in operation
- Nominal shape: $t_{\text{rise}} = 90\,\text{ns}$, $t_{\text{fall}} = 50\,\mu\text{s}$
- Studied dependency of extracted pulse amplitude and integral for preamplifier output rise-times between 70 and 110 ns

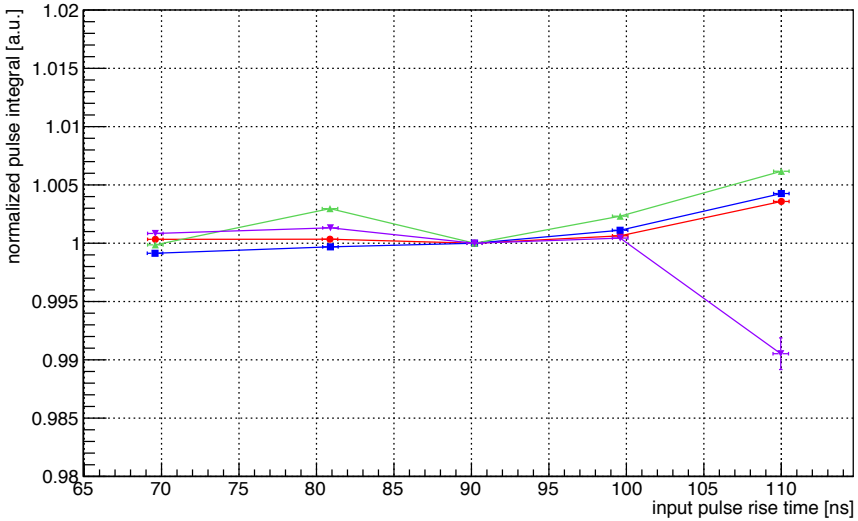
$\rightarrow$ Pulse amplitude is strongly pulse shape dependent (as expected)

$\rightarrow$ Pulse integral is stable on a level well below 1%

Normalized rise time dependency (amplitude), LOW Gain



Normalized rise time dependency (integral), LOW Gain



Outlook

- ADC production is started:

→ We have to decide for one of the shaper options until **February 2017** (??)

- Study pile-up resolution for all different shaper options

→ Development and performance test of different algorithms needed (KVI ?)

- Crosstalk measurements (can be done in the lab now)