Investigation of the front end electronics for the proton radius experiments

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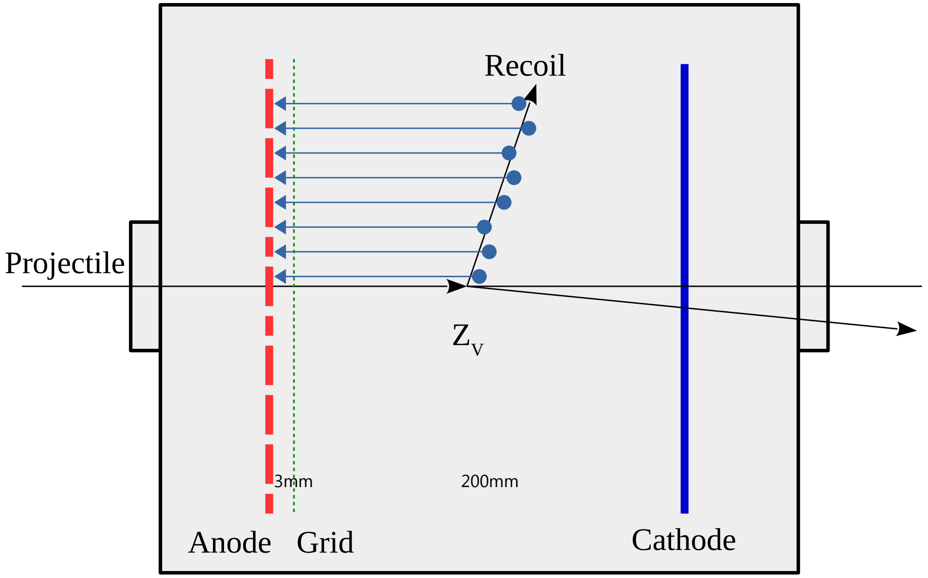
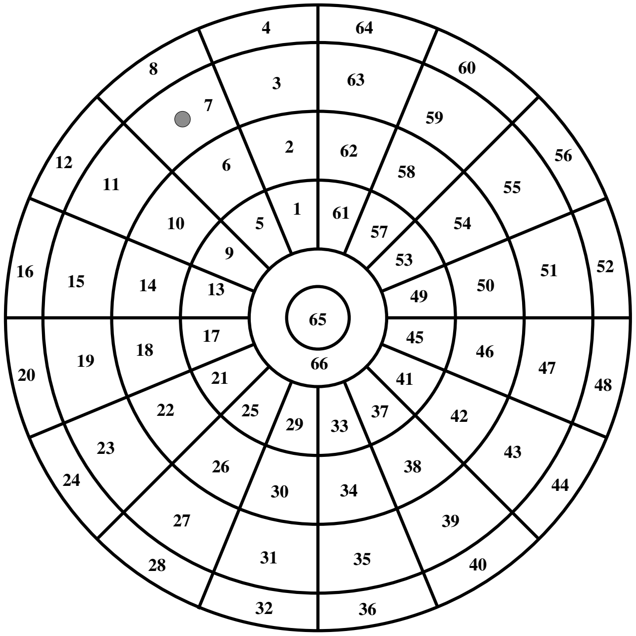
TPC Collaboration Meeting • 10 March 2020 • TU Mainz

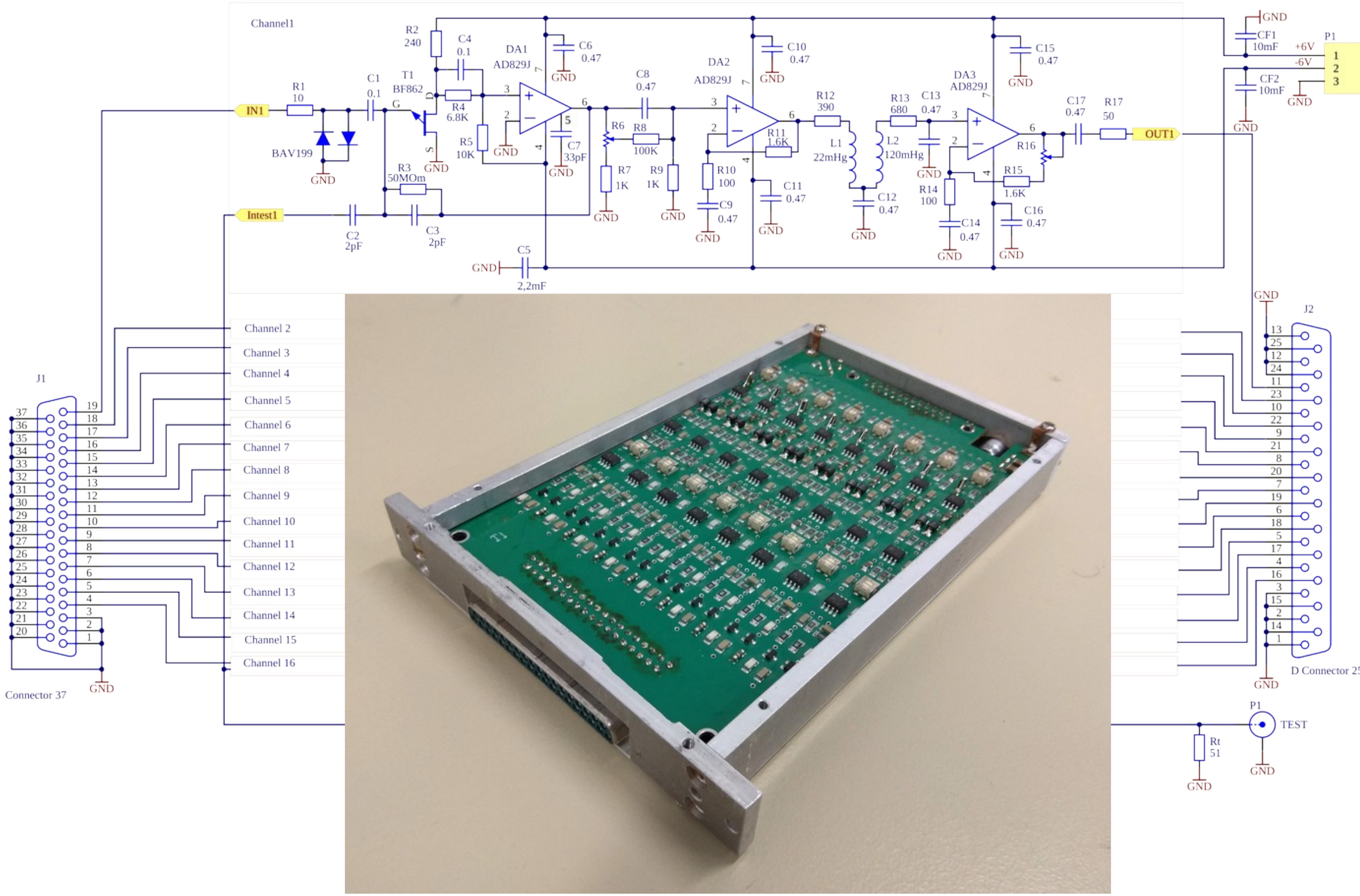
TPC prototype

Active target: gas target + ionization chamber





Front-end prototype

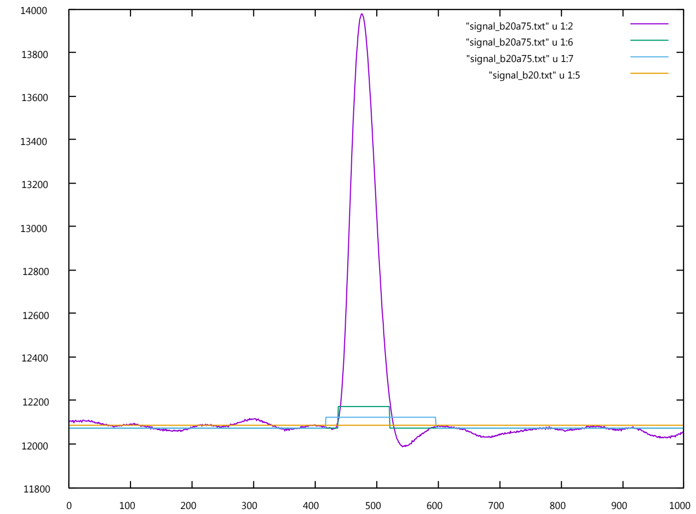


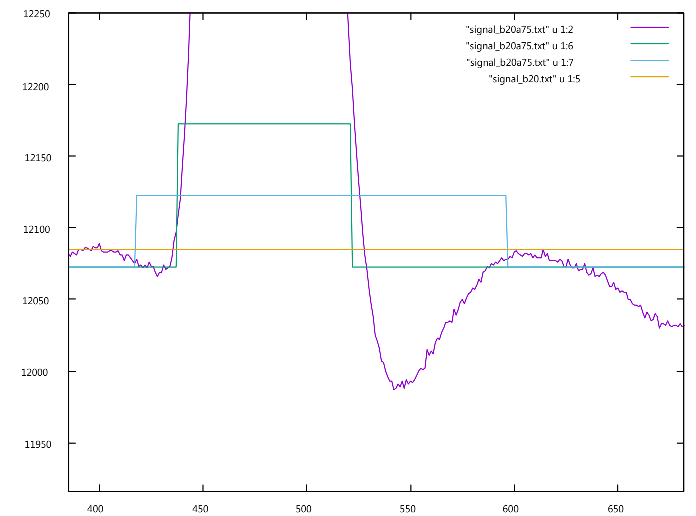
SIS3316 VME digitizers

- 16 channels per module
- 25 MHz (40 ns bin), up to 250 MHz
- 14 bit, 5 V (2 V) range
- Int./ext. trigger
- MAW energy/threshold

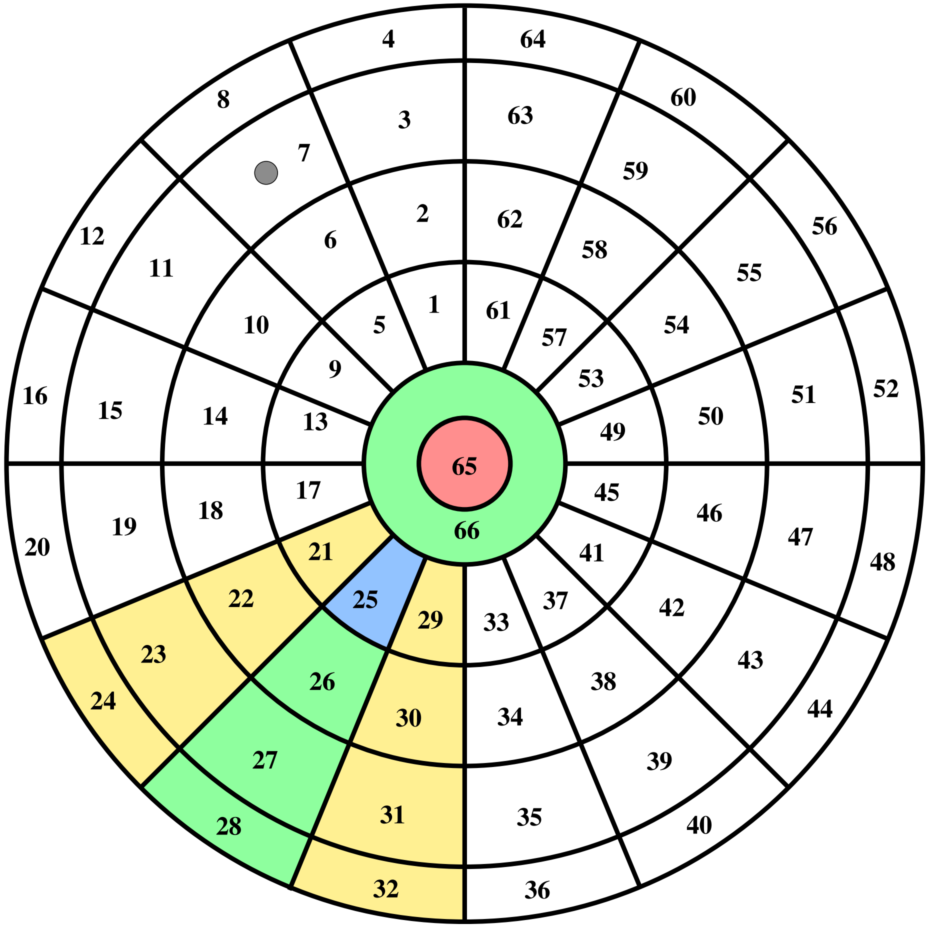
Individual signal analysis

- Signal smoothing
- Peak search
- Obtaining time parameters by slope differentiation
- Pedestal correction
- Peak raw signal integration → energy



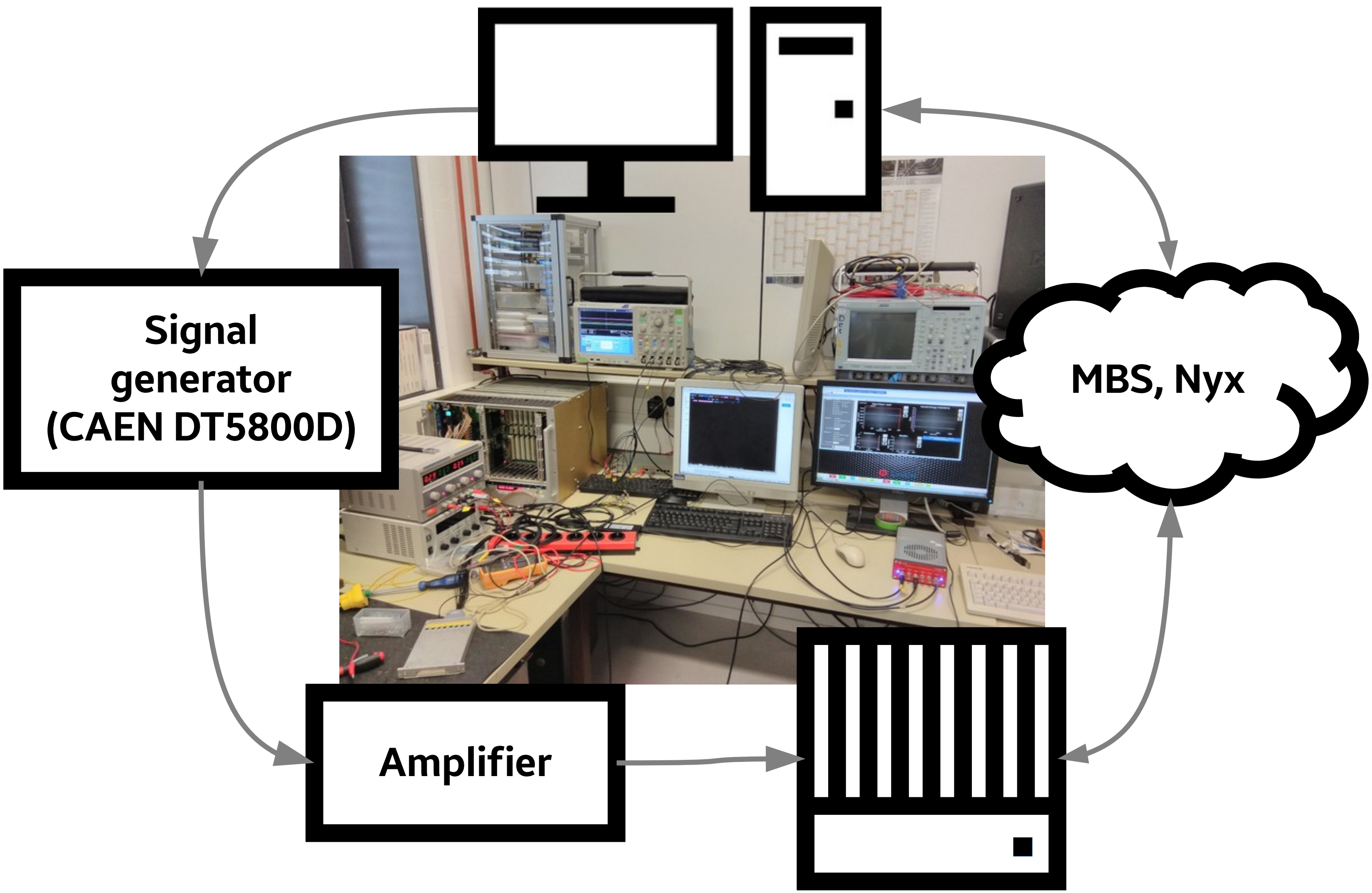


Recoil track search

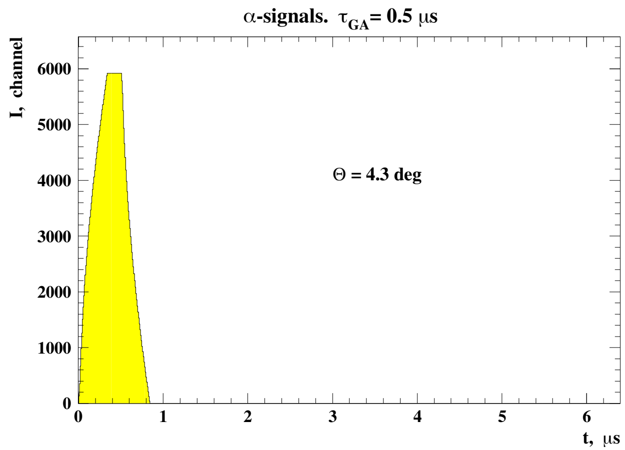


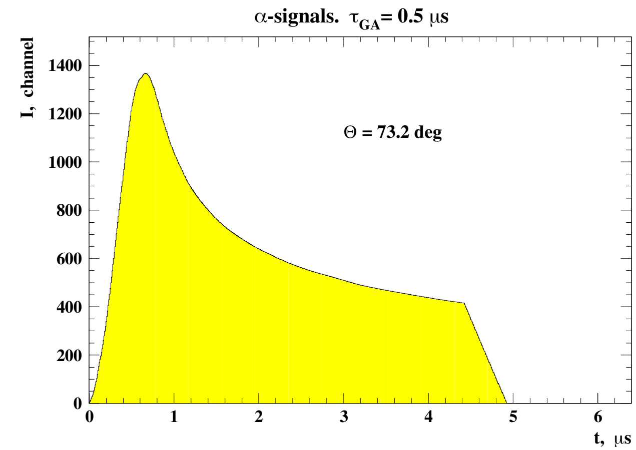
- Initial algorithm implementation
- Tested in beam experiments with different detector orientation

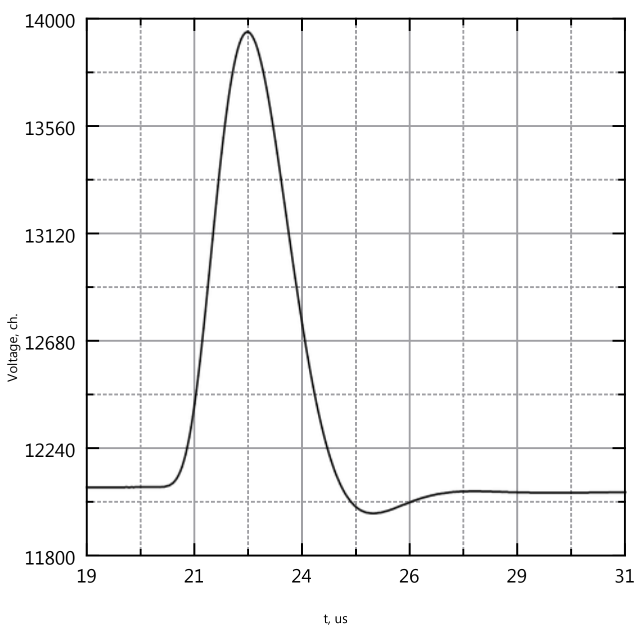
Test station at GSI

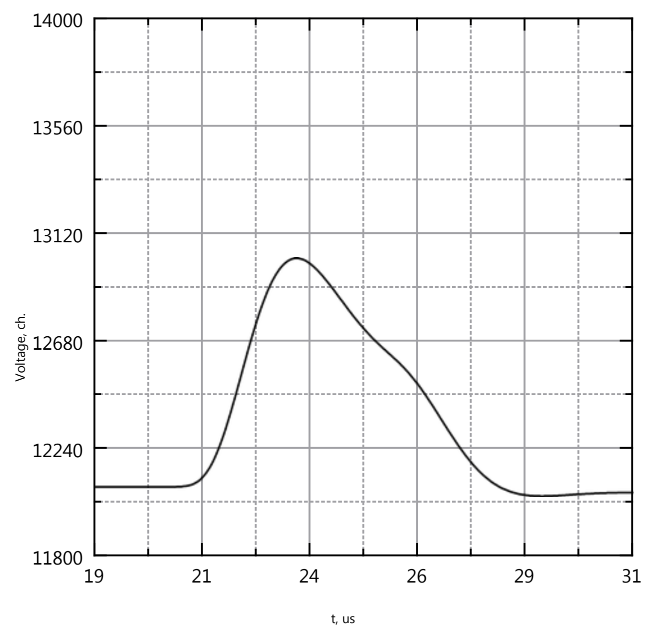


Generated amplifier input signals



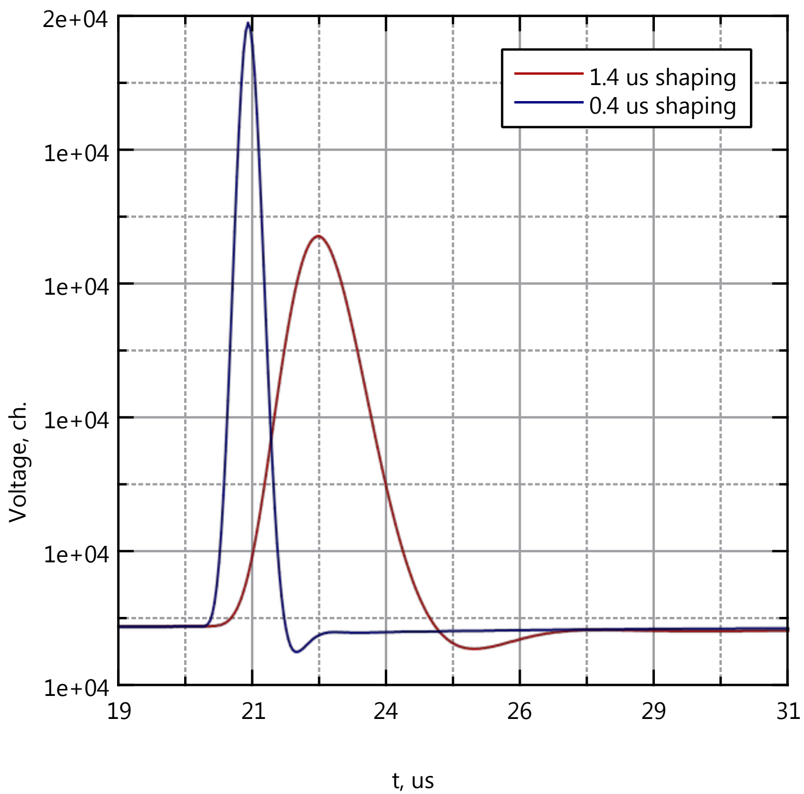




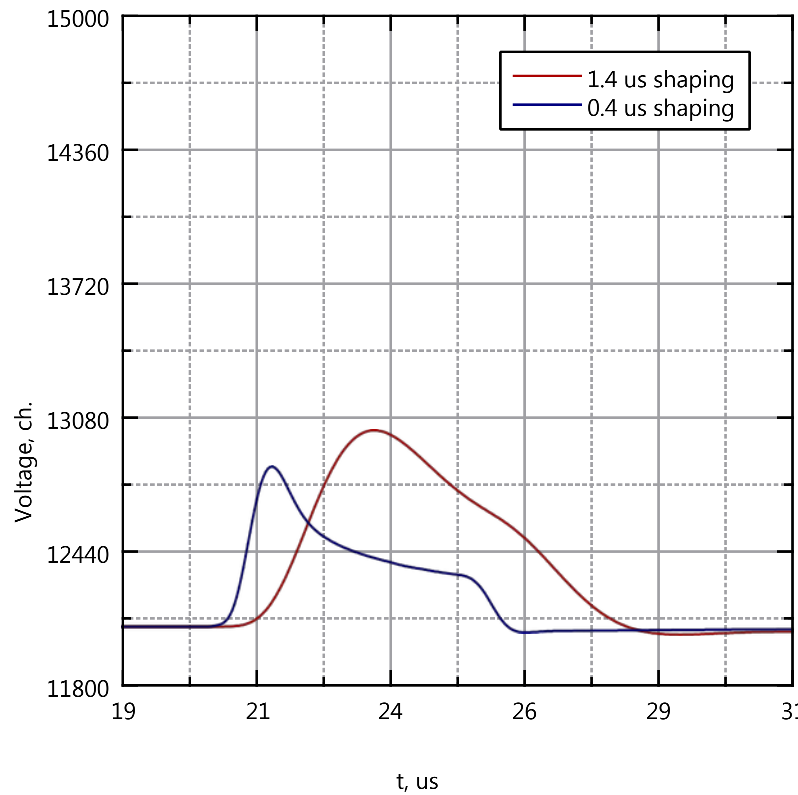


Amplifier shaping time: 1.4 and 0.4 μs

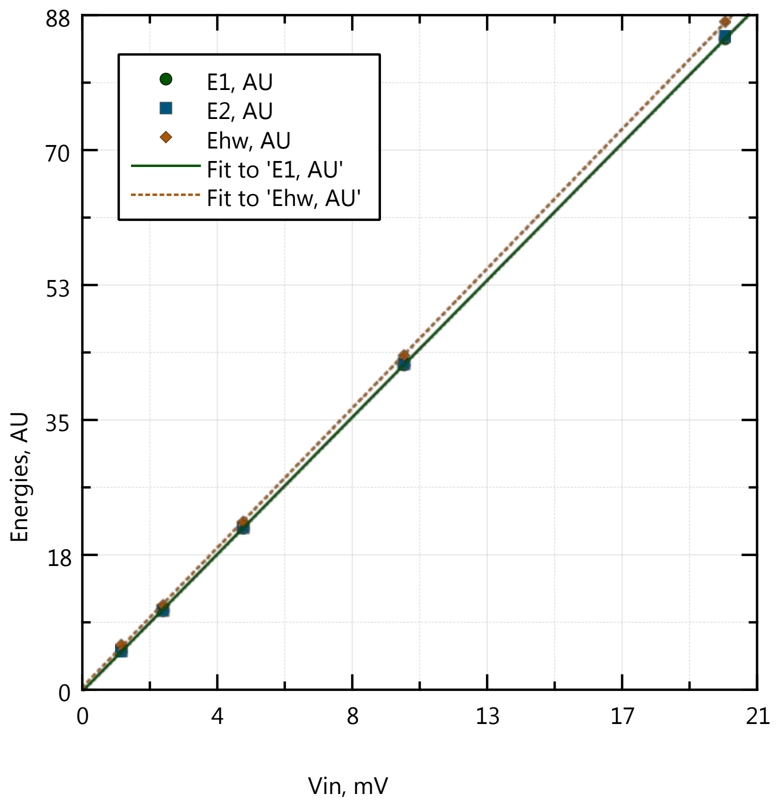
4.3° recoil

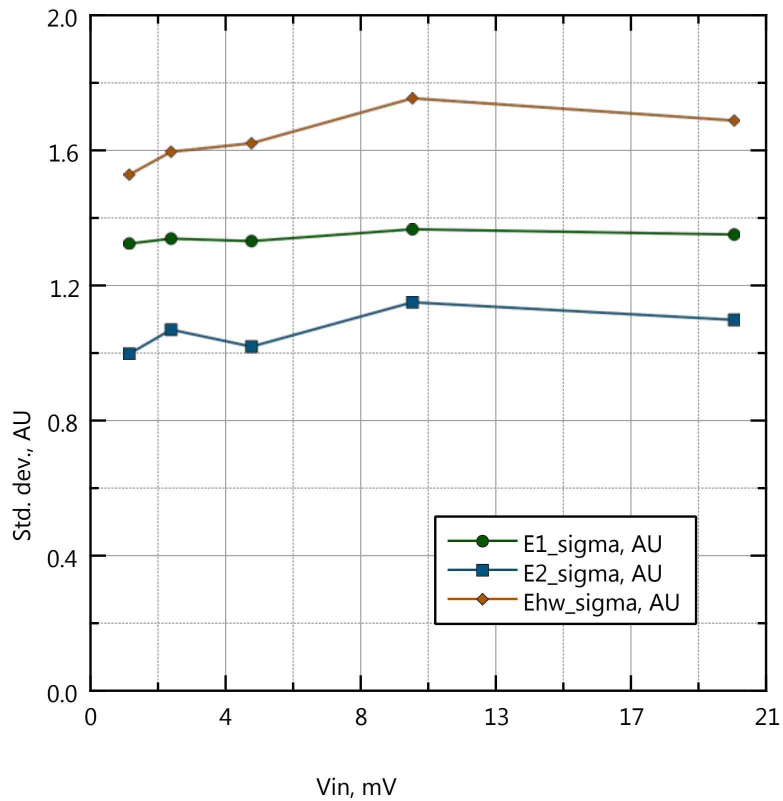


73.2° recoil



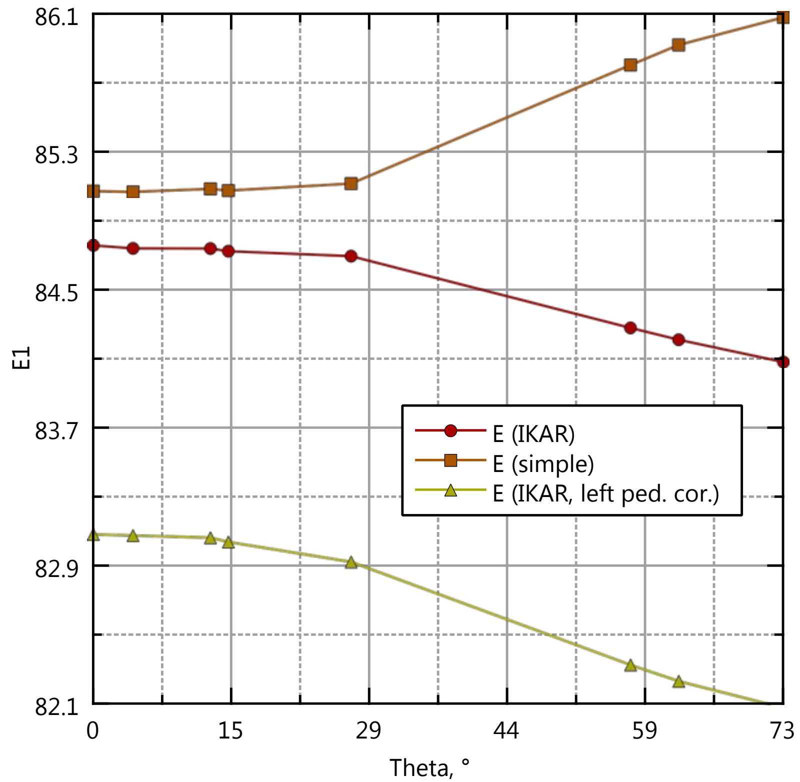
Results: energy vs. V_{in} (short signal)

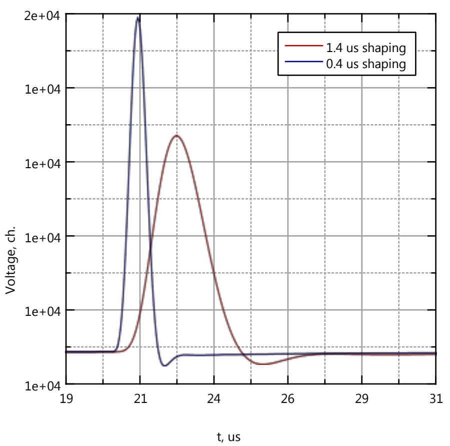




1 AU ≈ 27 keV

Results: integral vs. signal width



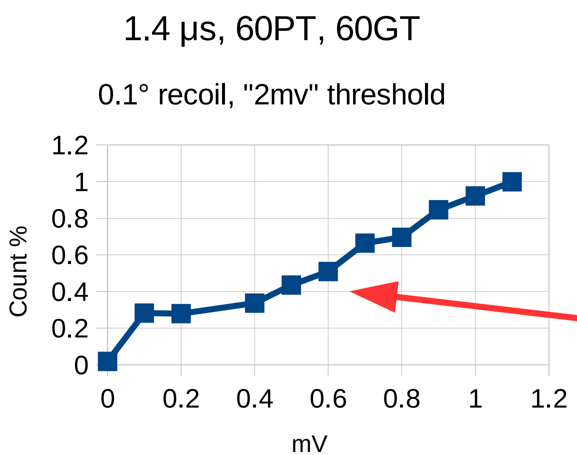


- Energy must be corrected
- Individual channel calibration required

1 AU ≈ 27 keV

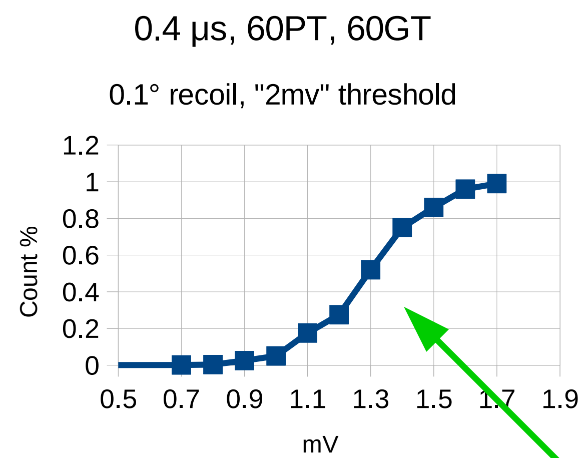
Results: FADC trigger thresholds

1.4 µs shaping



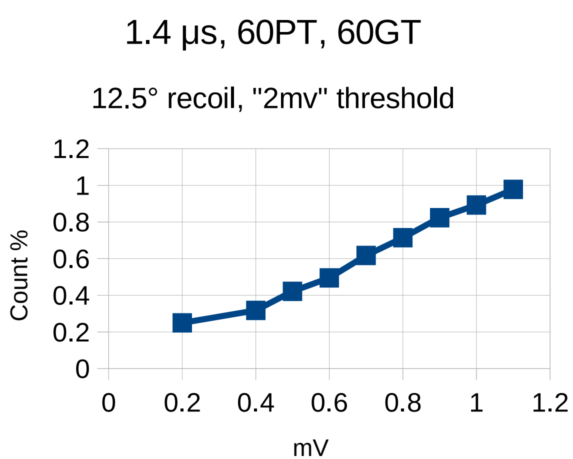
~60 keV

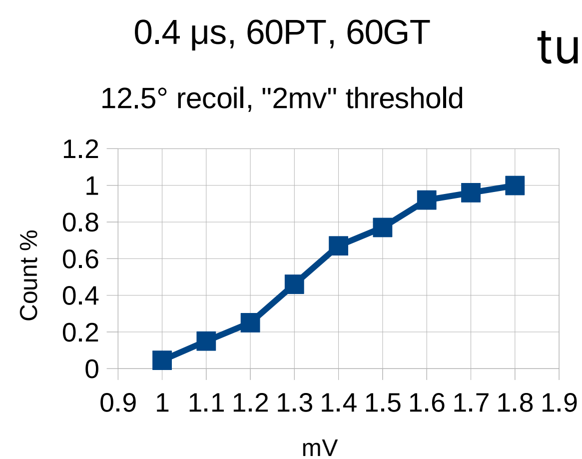
0.4 µs shaping



0.1° recoil

tuning in progress



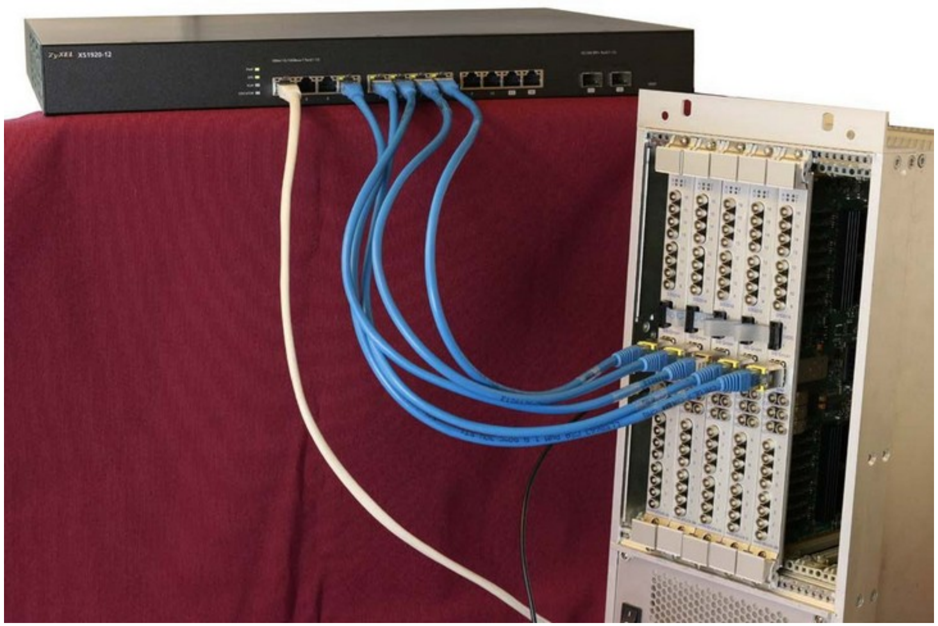


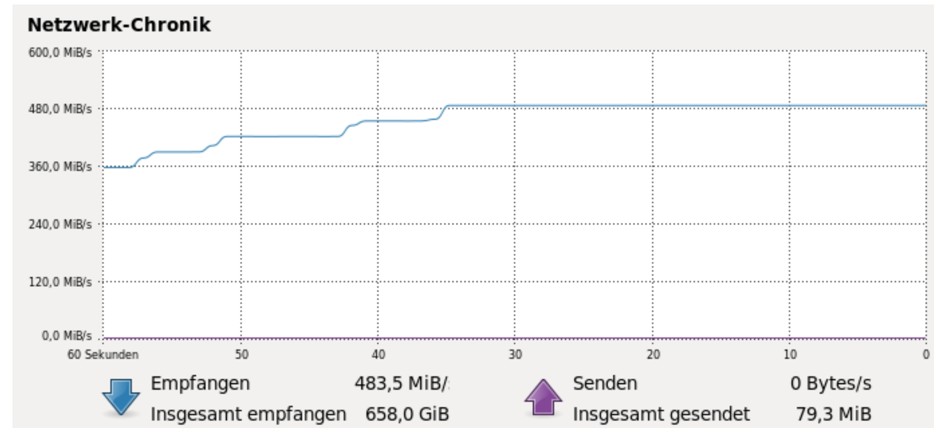
12.5° recoil

Shaping time optimization

- time vs. energy resolution
- full integration vs. beam influence minimization
- smaller shaping for beam anode?

Fast FADC readout





- 5 FADCs with 1 Gbit/s Ethernet
- 10 Gbit/s PC link
- ~480 MB/s throughput achieved
- 20x faster than current setup

SIS3316 10G Switch Test by SIS GmbH

Conclusions

- High time and energy resolution requirements
- Energy must be corrected
- Thresholds may be lowered
- Time resolution studies with generator are in progress
- Algorithm optimization needed for smaller shaping time (noise filters, possibly higher sampling rate?)
- Goal: final front-end electronics recommendation this year

Thank you!

CAEN DT5800D Digital Detector Emulator

- 2 analog outputs
- 16 bit D/A converter
- 125 Msamples/s
- Constant/Poisson rate
- 4096 points to store waveforms
- White noise, 1/f noise emulation
- Random Walk (baseline drift)
- Interference generation
- USB, Windows control app

Moving average window