APFEL signals at Mainz

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EMC Session

Outline

- Introduction
- Setup overview
- Signal examples
- Pulse height extraction
- Data from last test beam

Introduction

Relative energy resolution

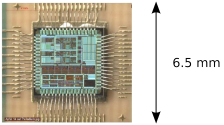
$$\frac{\sigma_E}{E} = a \oplus \frac{b}{\sqrt{E/\mathrm{GeV}}} \oplus \frac{c}{E}$$

- In this talk: electronic noise contribution c/E
- TDR requirement: $c = 1\ \mathrm{MeV}$

Single crystal energy threshold (E_{xtl})

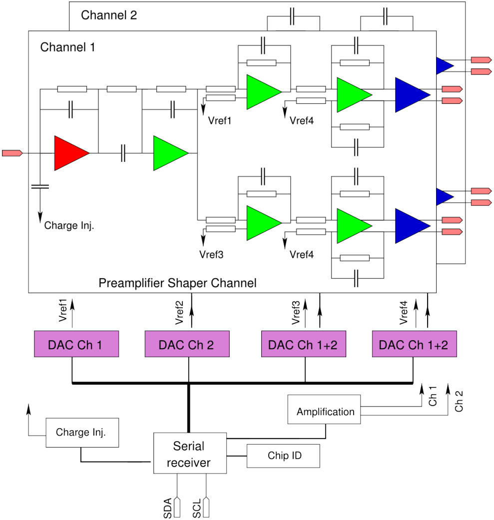
- Lowest energy distinguishable from noise
- Below E_{xtl}: contribution shower leakages
- TDR requirement: $E_{\mathrm{xtl}} = 3\ \mathrm{MeV}$

APFEL ASICs



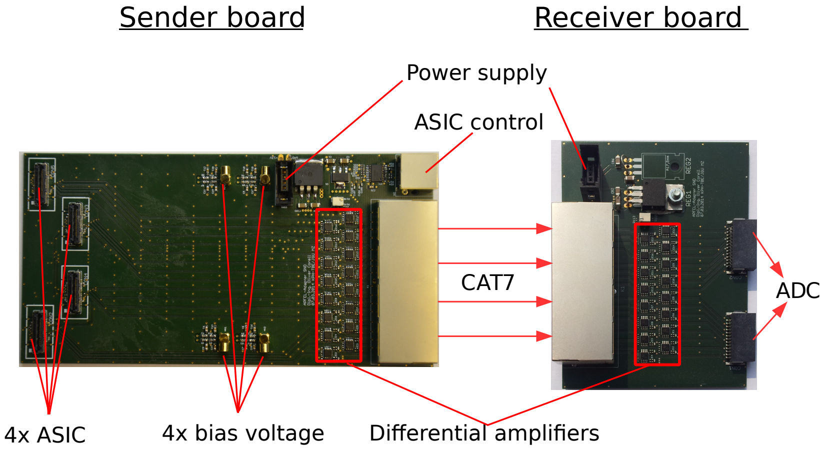
- reads out 2 APDs
- charge sensitive preamplifier
- shaper (pulse width $\sim \mu s$)
- 2 main amplifiers (2 gains)
- 4 differential output channels

- bonded on a FFC-board
- power and programming lines
- HV lines for the APDs
- output signal lines



P. Wieczorek, H. Flemming, IEEE Nucl.Sci.Symp.Conf.Rec. 2010, 1319-1322

Line Drivers



Readout and DAQ

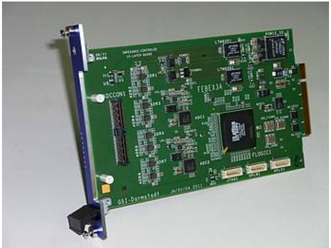
Sampling ADC

- Febex3a module from the GSI
- Sampling rate: 50 MSample/s
- Resolution: 12 bit
- Input range: -1 V ... $+1$ V

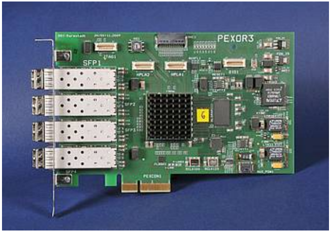
Data acquisition

- MBS system from the GSI
- PCI optical receiver (PEXOR) for ADC interface
- PCI trigger/dead time unit (TRIXOR/EXPLODER)
- Extensible with VME branch

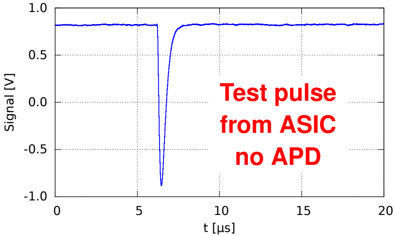
FEBEX



PEXOR



Signal examples



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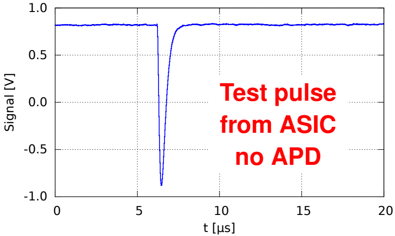
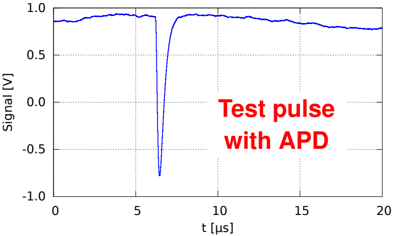
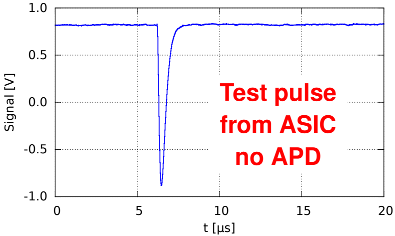
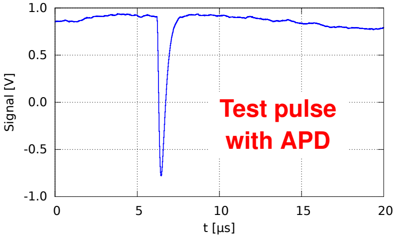
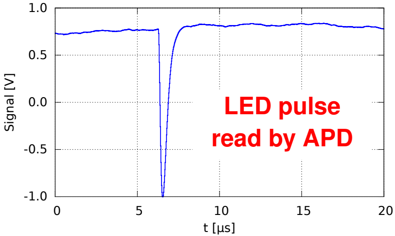




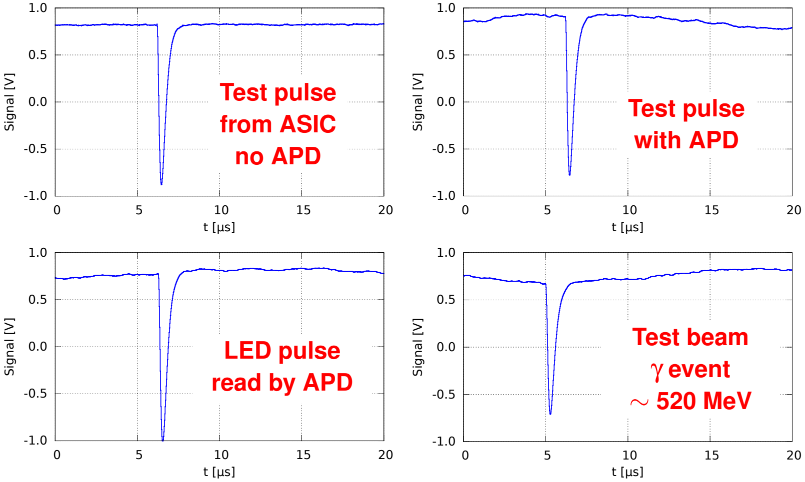
Signal examples





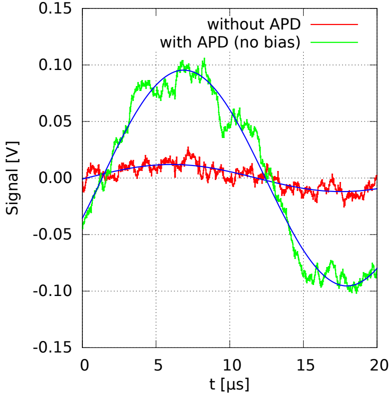


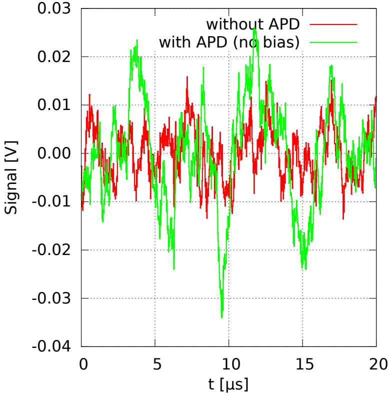
Signal examples



no extra noise from the detector!

Baselines





- Hum frequency ∼40 kHz
- Introduced by the line driver
- Gets amplified by closing ASIC input

- Subtraction the $\sin$ function
- Noise level like expected from the ASIC design

Signals summary

Status

- Noise from line drivers: only the slow 40 kHz hum
- Amplified when ASIC input closed
- No extra noise from APDs and detector

To do:

- Find the cause and eliminate the hum
- Doable in the in the lab (no need for beam)

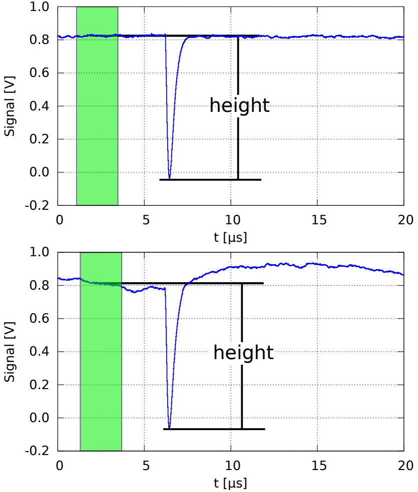
In the mean time:

- We have data from last year beam time
- Try to extract information from them
- Need to handle the signals offline

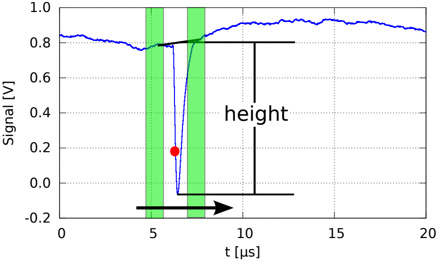
Pulse height determination

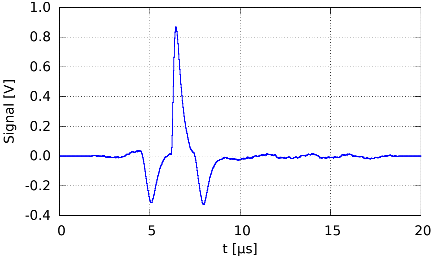
- Easiest approach:
  simple "baseline restoration"
  - calculate baseline on a window
  - find the maximum
  - subtract the baseline

- Not feasible with the hum
  $\Rightarrow$ adds much more noise



Two-windows filter





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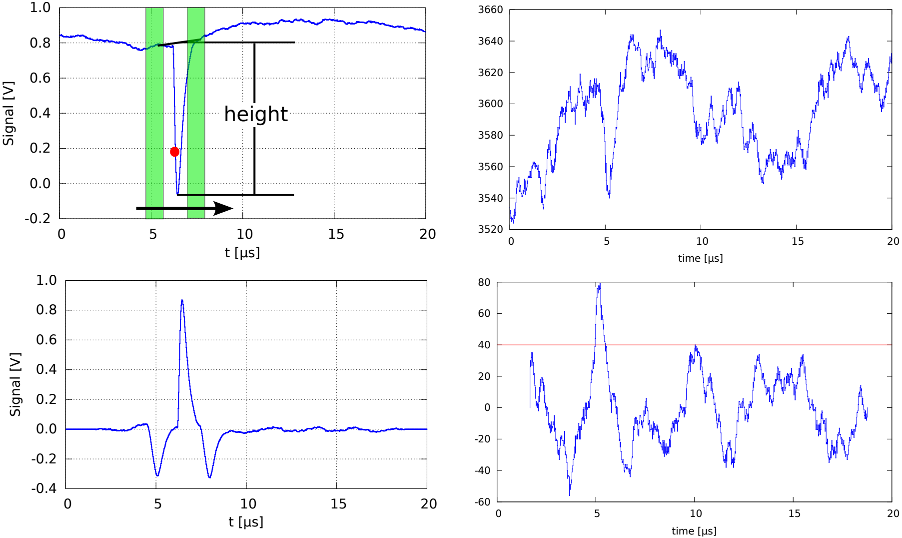
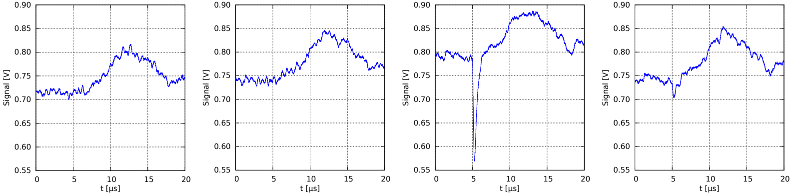
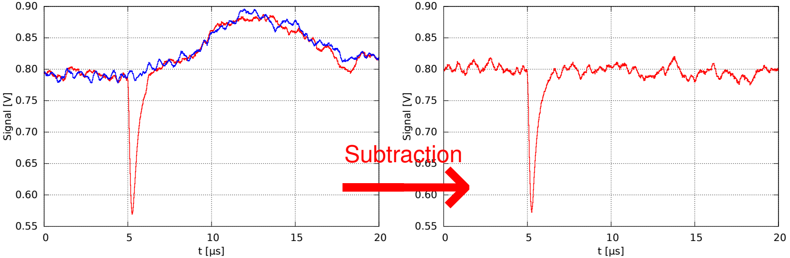


Baseline subtraction

One driver board

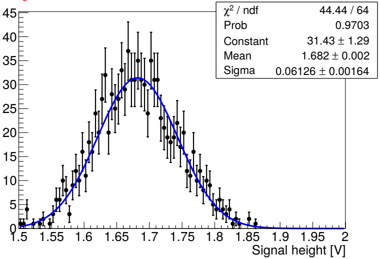


All channels hum in phase!

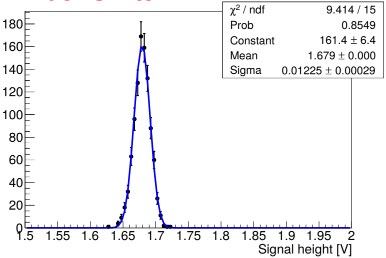


Relative resolution

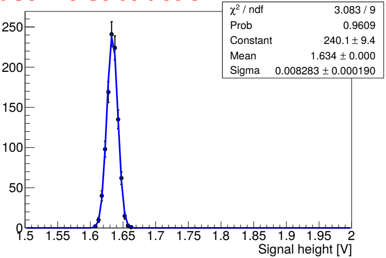
Simple baseline restoration:



2-windows filter:

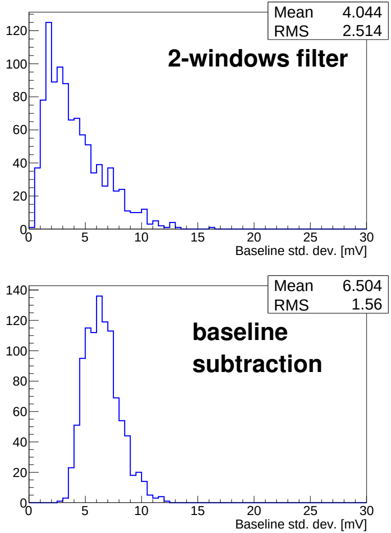


baseline subtraction:



- σ at every pulse height
  $\Rightarrow$ Parameter c of σ_E/E
- Upper limit without hum: 10 mV
  $\Rightarrow$ $\sim$3 MeV (TDR wants 1 MeV)
- Possible solution: higher APD gain
  (higher bias voltage)

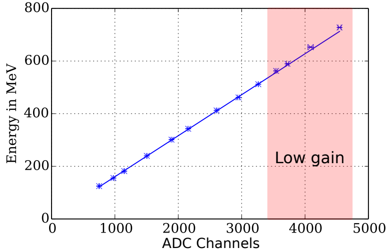
Baseline width



- Calculate std. dev. of the baseline
- 2-Windows: broader
- Subtraction: higher mean value
- Current threshold: 35 mV
- Expected w/o hum:
  - similar to baseline subtraction
  - reduced by a factor $\sqrt{2}$
- Reasonable threshold: 20 mV
  $\Rightarrow$ $E_{\text{xtl}} \sim 6$ MeV (TDR wants 3 MeV)
- Possible solution: higher APD gain

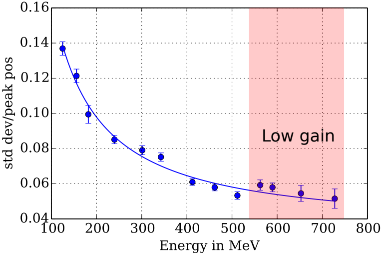
Results from beam test

Energy calibration:



- Test beam at MAMI (2014)
- Array of 16 crystals (Proto16)
- Beam energy 855 MeV
- Tagged γs
- 13 different energies

Relative energy resolution:



- 2-windows filter used
- good linearity (ASIC high/low gain ratio to be improved)
- relative energy resolution at 1 GeV: 4.5%
- E_{xtl} used: 11 MeV (conservative!)

Summary

We have:

- prototype with ASIC/line drivers/DAQ
- some issues to solve with the signal transmission
- beam data

We are doing:

- trying to solve signal transmission issues
- using offline filtering to extract information

Current estimation:

- Noise term $c = 3$ MeV
- Single crystal threshold $E_{\mathrm{xtl}} = 6$ MeV

We plan:

- operate APDs at higher gain
- next beam test: June

Backup

Energy spectra