DAQ System for Energy Dispersive Detectors

for X- and gamma-rays based on the MicroTCA.4 standard

Jan Timm

Workshop on beamline instrumentation for scientists and engineers

Hamburg, 9th Oct. 2018

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY

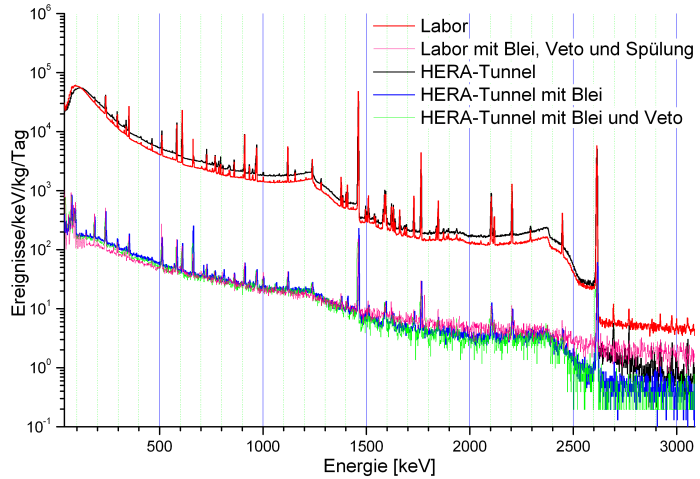
Agenda

01 Energy Dispersive Detectors
- Moving Pulse Shape Trigger

02 Hardware, Firmware and Software
- Firmware and Software
- Qt based GUI

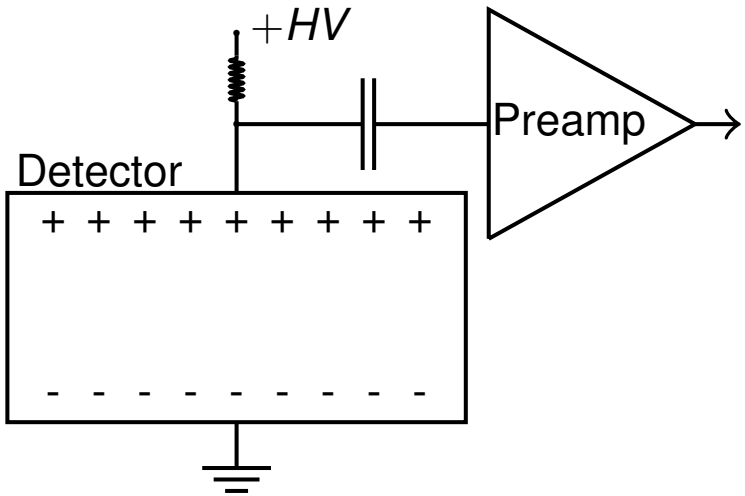
03 First Results

04 Summary and Outlook



Energy Dispersive Detectors

highly simplified model:
the deposited energy is proportional to the hight change of the signal



Detector types

- Cadmium (Zinc) Telluride (Cd(Zn)Te)
- Silicon Drift Detectors (SDD)
- Lithium-drifted Silicon (Si(Li))
- High Purity Germanium (HP-Ge)
- (Scintillator Detectors)

$\Rightarrow$ Different Output Levels, new µRTM

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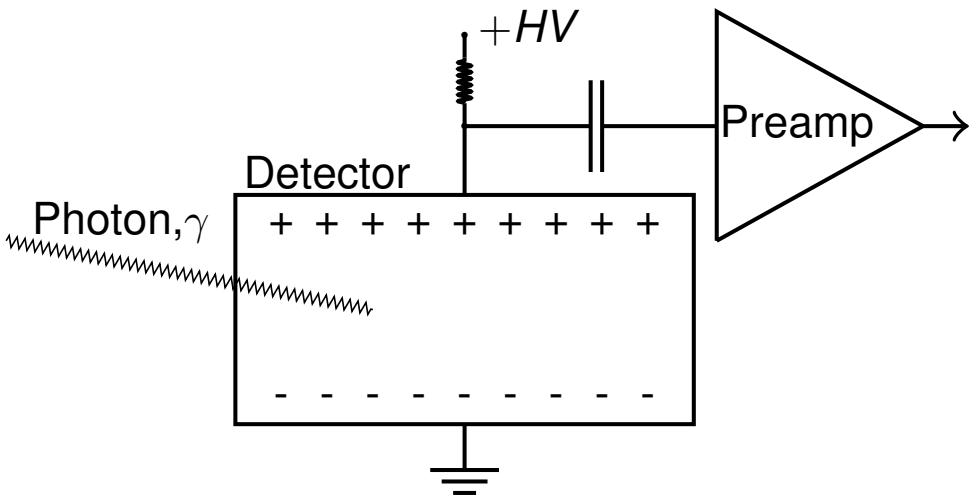

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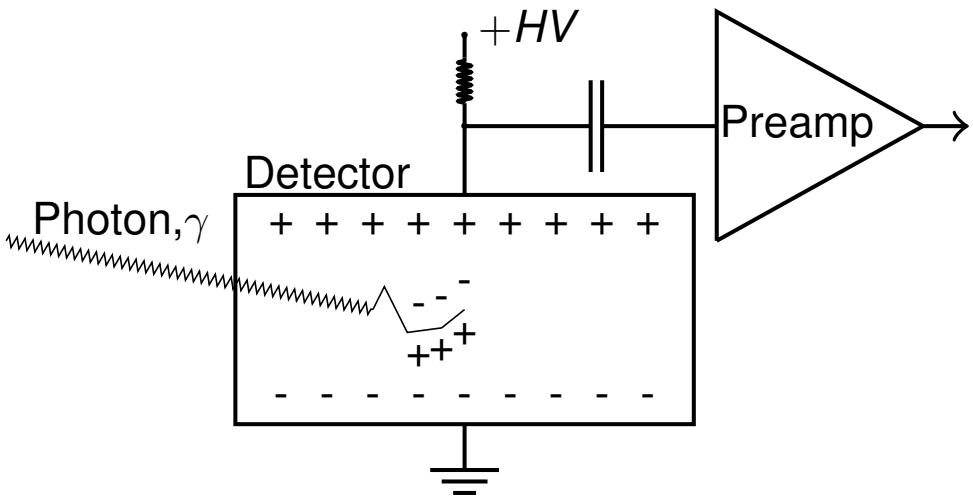

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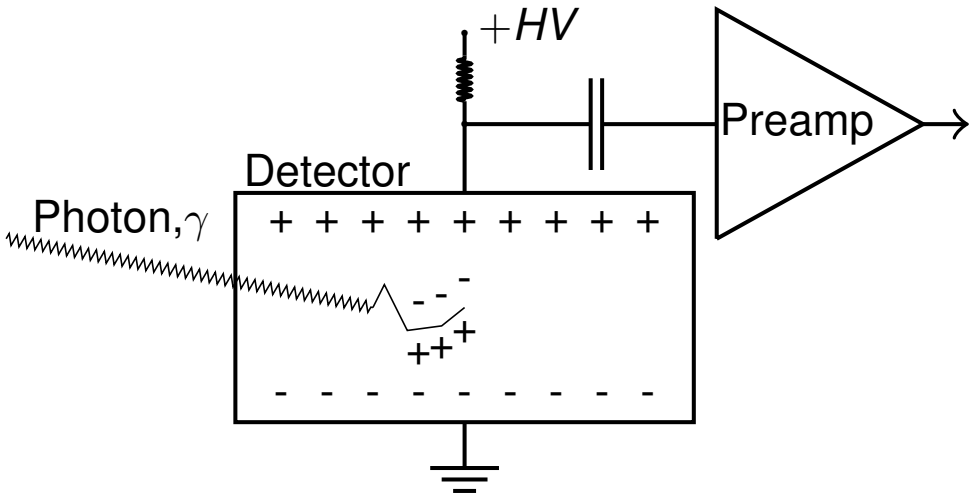

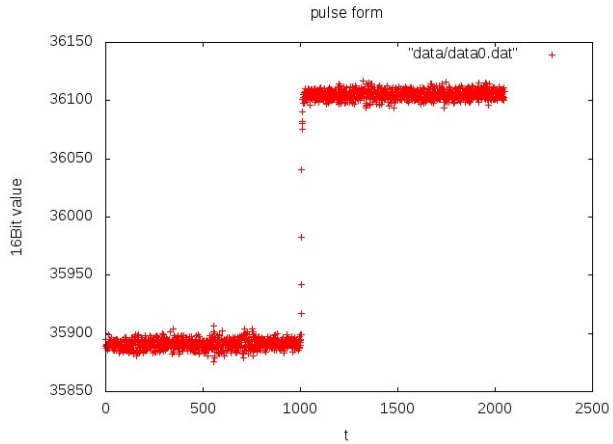

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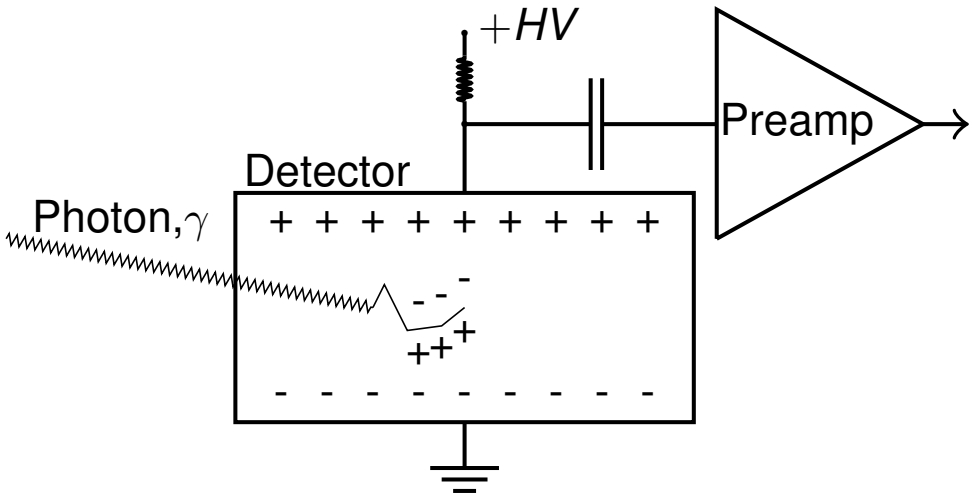

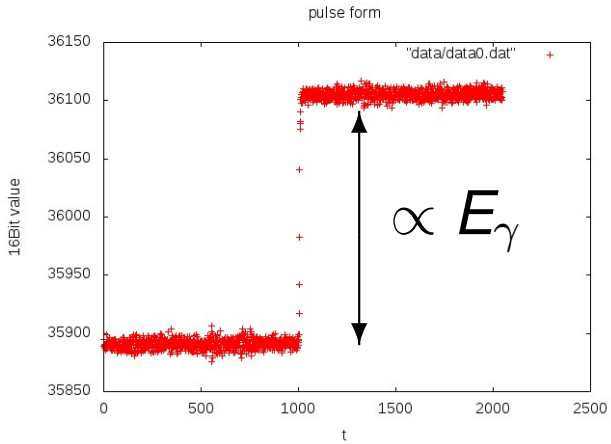

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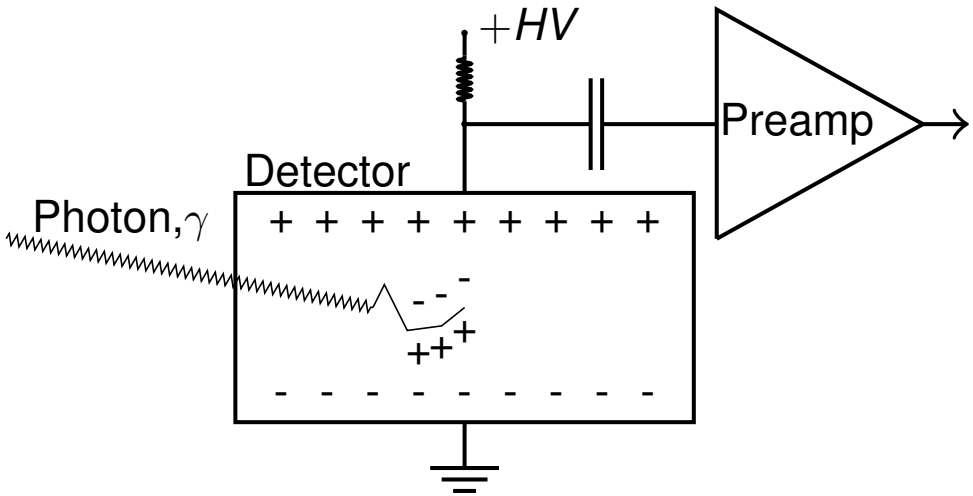

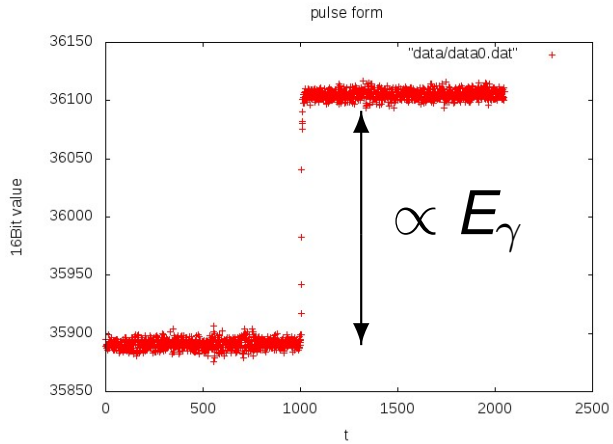

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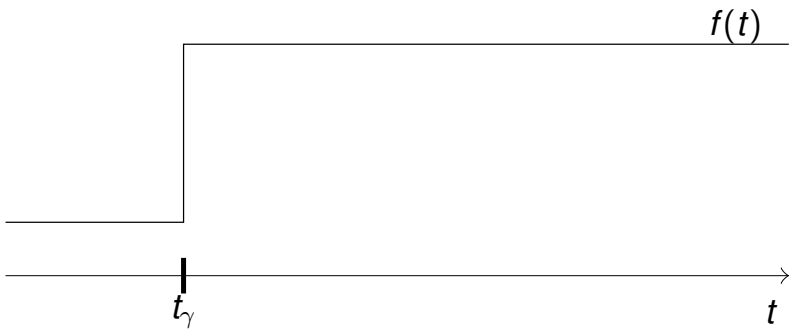
Detecting single photons

- Energy
- Time
- (Interaction depth)
- (Radiation type)
- ...

Moving Pulse Shape Trigger with Energy Reconstruction



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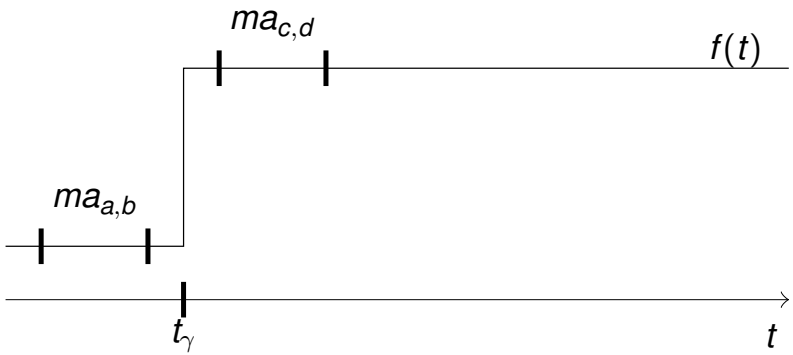

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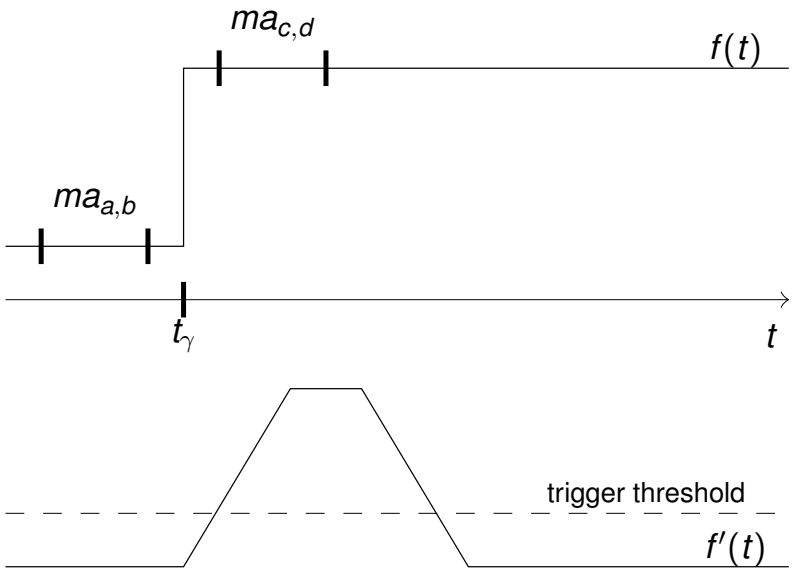

$$E \propto f'(t_d) = ma_{c,d} - ma_{a,b}$$

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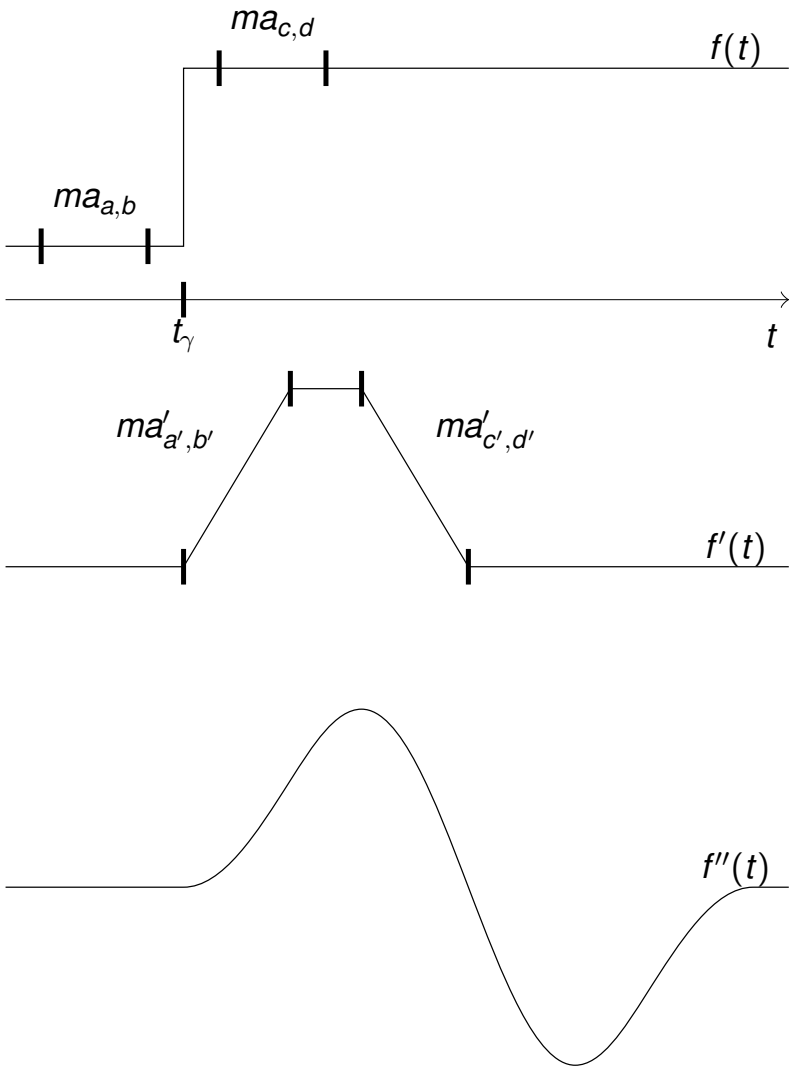

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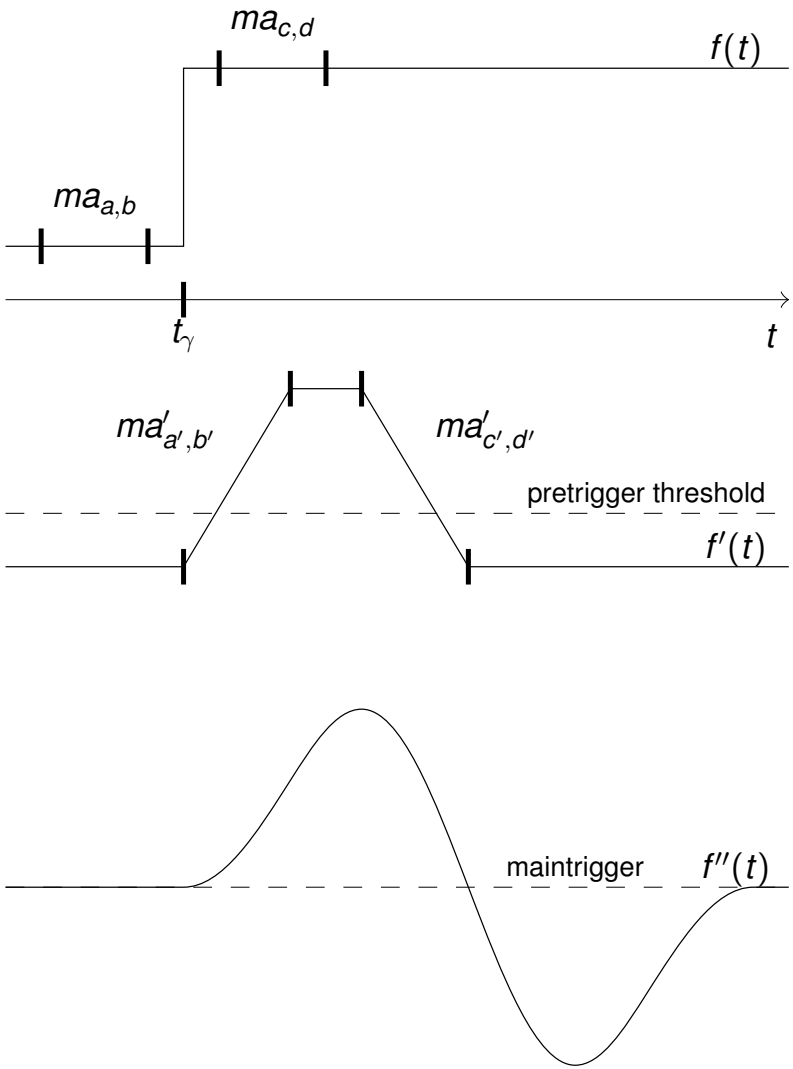

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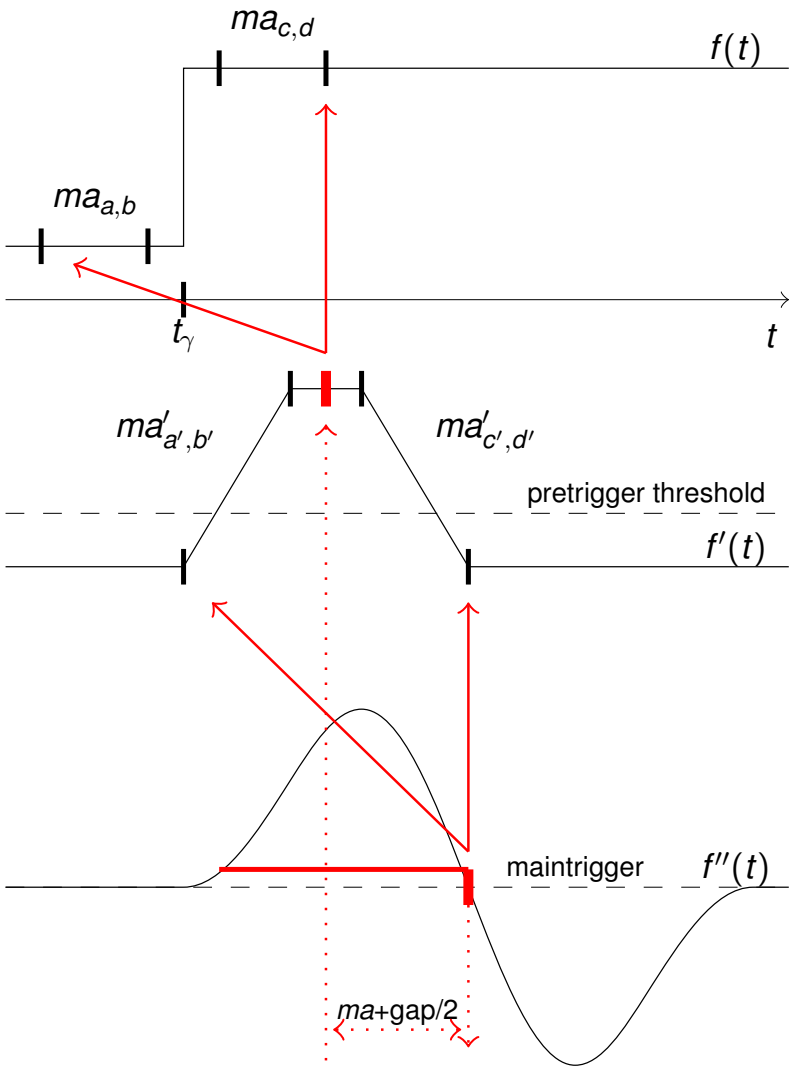


Trigger on falling edge of "2nd derivative"

with the condition that it was for the duration of two windows and one gap above zero.

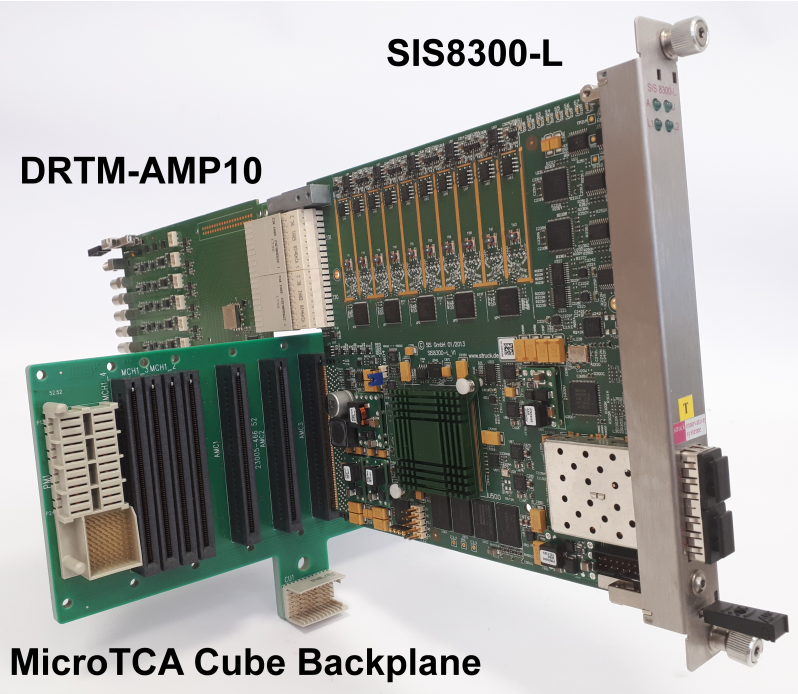
$$E \propto f'(t_d) = ma_{c,d} - ma_{a,b}$$

- Precise timing (E independent)
- High energy resolution (not the maximum)
- Low threshold
- FIR like filter: noise suppression and clean data
- High count rates

Realized in VHDL

Hardware

SIS8300-L and DRTM-AMP10



SIS8300-L by Struck

- 10 Channels, 125 MS/s, 16-bit ADC
- PCIe, 4 lane
- 4 x 4 GBit DDR3
- Virtex 6 FPGA

DRTM-AMP10 by DESY-MSK

- Adjustable amplification
- Control via SPI interface
- AC and DC coupling
- 50 Ω and 1k Ω
- GPIOs (gate, trigger, ...)

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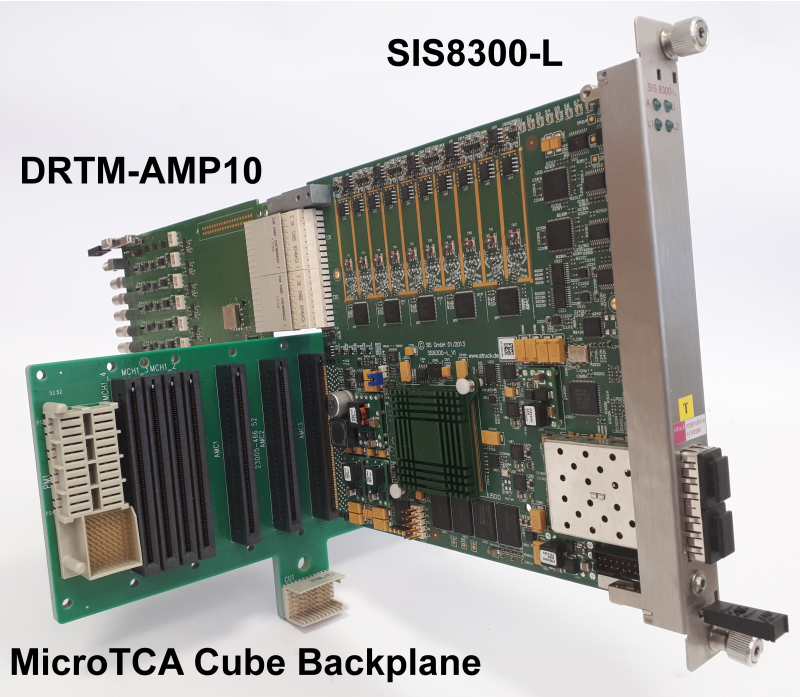

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SIS8900

- LEMO 00, 50 Ω
- -1 V to 1 V input range
- RJ45 Digital I/O

DRTM-AMP10 by DESY-MSK

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Implementation in Firmware

Firmware Application and Software Development Steps

MSK Firmware Framework

- Separate board and application logic
- Reuse already done work
- Simple updates and bug fixes
- Same application on different hardware

ChimeraTK

- DevicesAccess library
- ApplicationCore
- Bindings to DOOCs, EPICS, (TANGO), ...

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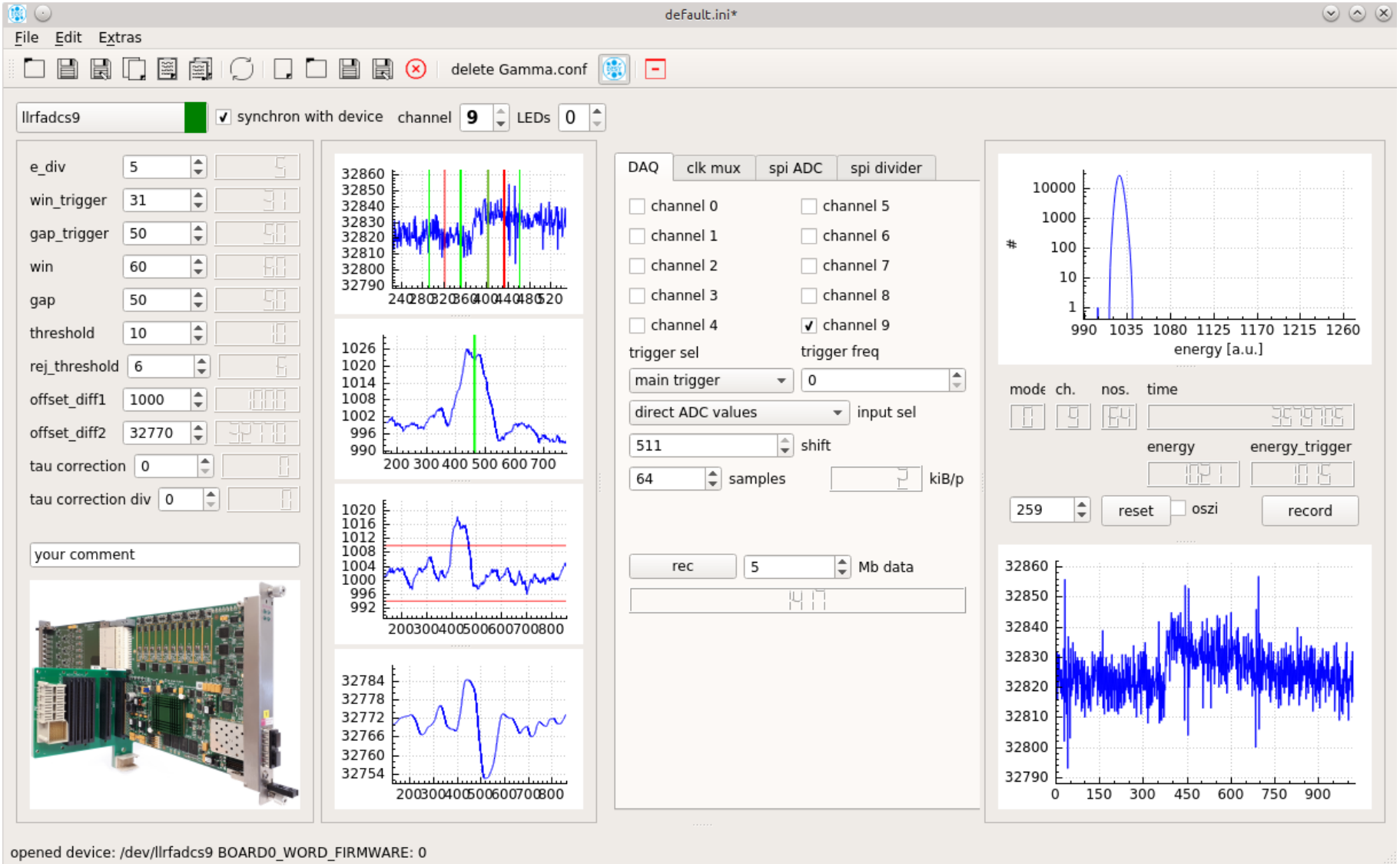
Software for Gamma Application

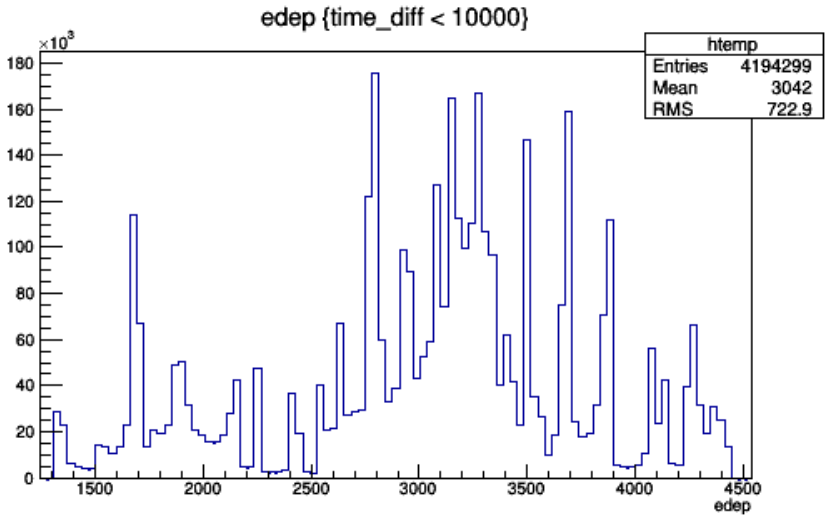
- New driver (+ fast DMA access)
- Qt based GUI
  - Set/get all Parameters
  - Simulate parameter changes on real data
  - Data acquisition
  - Various data structures:
    - Histogram
    - RIO
    - Event data (time, energies, samples (8 up to 2048), ...)
    - ROOT, HDF5, raw, ASCII

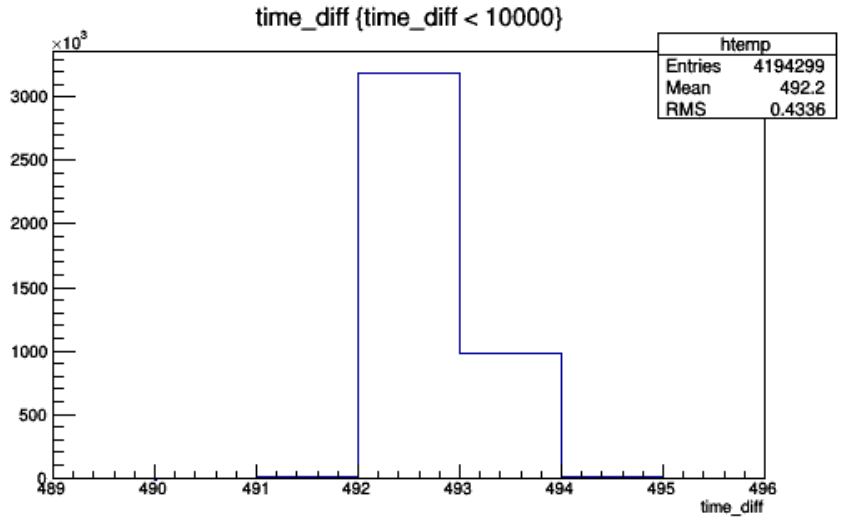
Qt based GUI


default.ini*
File Edit Extras
delete Gamma.conf
llrfadcs9
synchron with device
channel 9
LEDs 0
e_div 5
win_trigger 31
gap_trigger 50
win 60
gap 50
threshold 10
rej_threshold 6
offset_diff1 1000
offset_diff2 32770
tau correction 0
tau correction div 0
your comment
DAQ
clk mux
spi ADC
spi divider
channel 0
channel 1
channel 2
channel 3
channel 4
channel 5
channel 6
channel 7
channel 8
channel 9
trigger sel
main trigger
trigger freq
0
direct ADC values
input sel
511
shift
64
samples
kiB/p
rec
5
Mb data
mode
ch.
nos.
time
energy
energy_trigger
259
reset
oszi
record
energy [a.u.]
opened device: /dev/llrfadcs9 BOARD0_WORD_FIRMWARE: 0

First Results with a Pulse Generator

BNC DB-2 and with SIS8300L, SIS8300 and DRTM-AMP10, old Vortex





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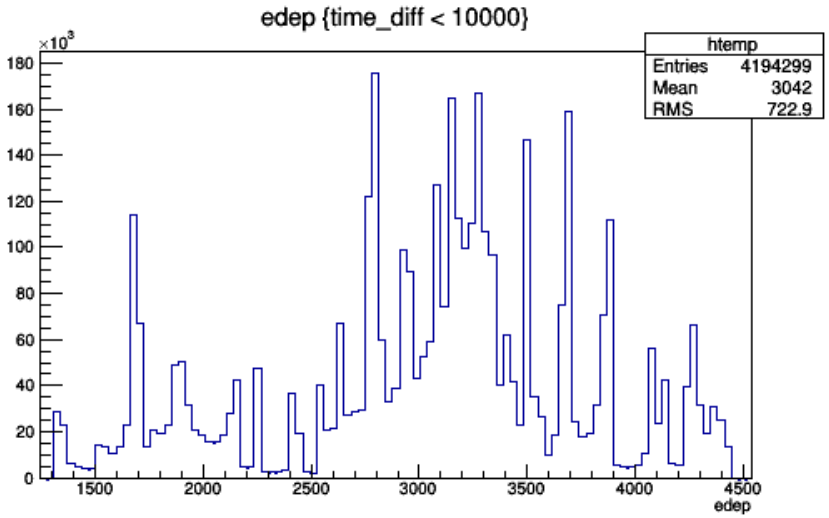

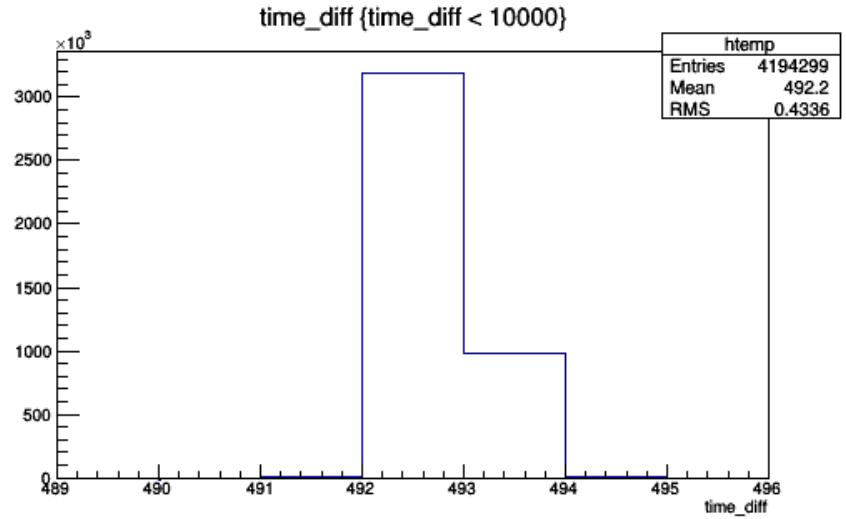

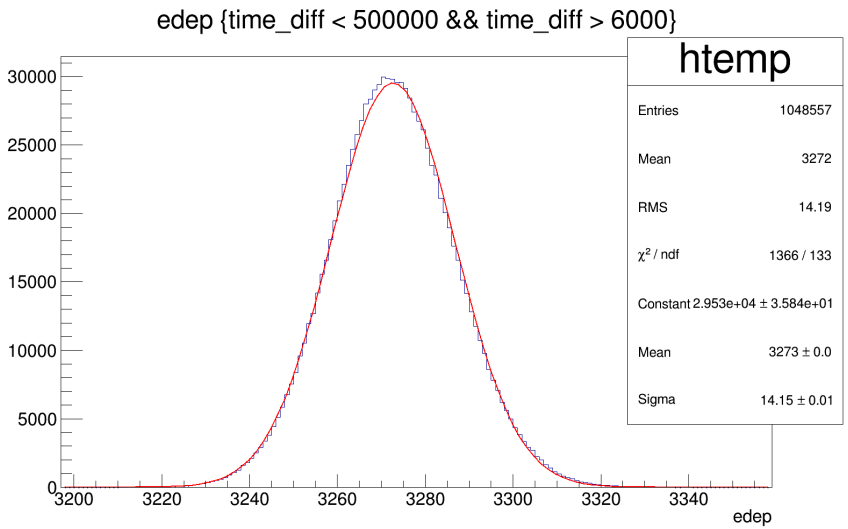

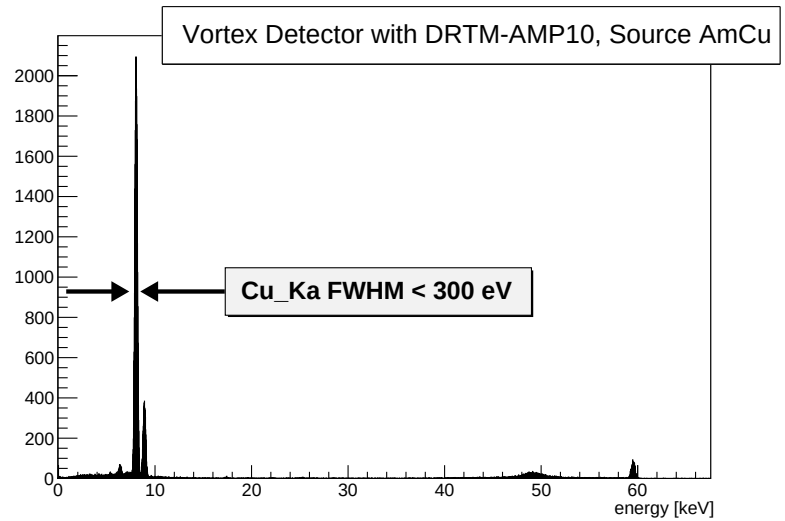

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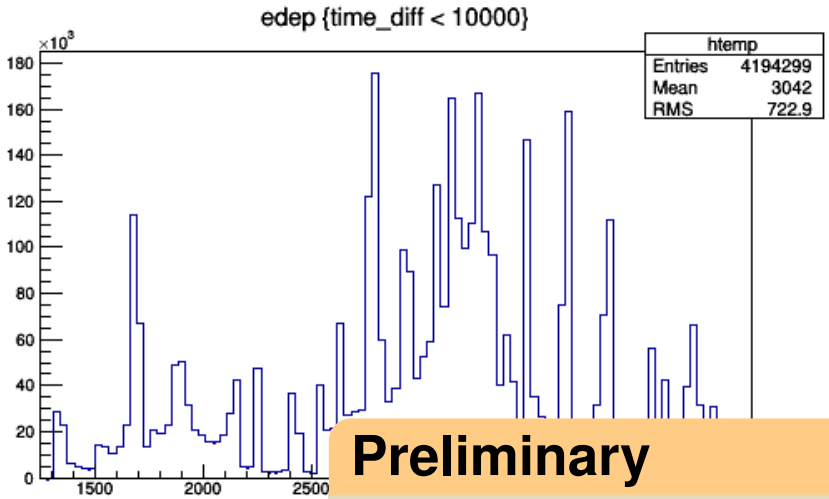
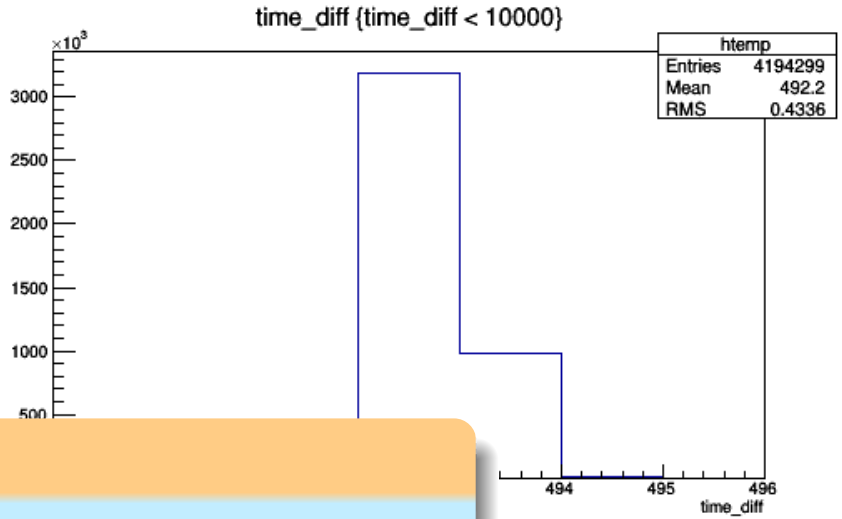
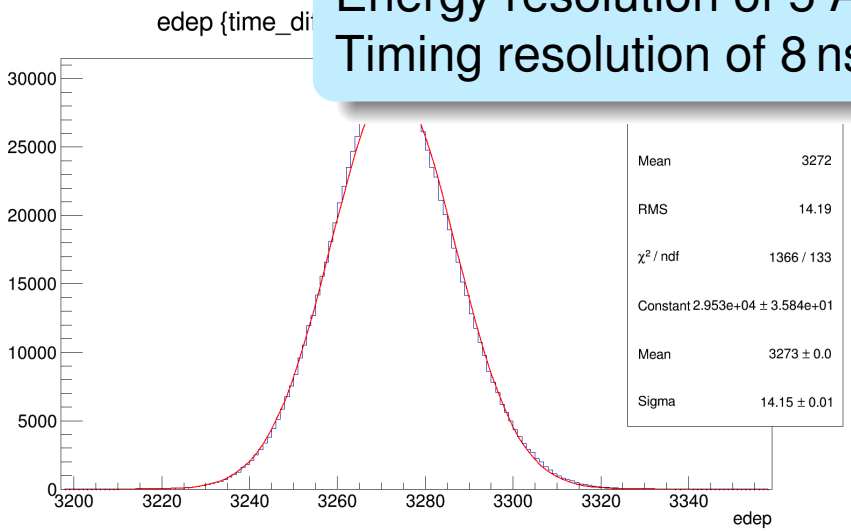
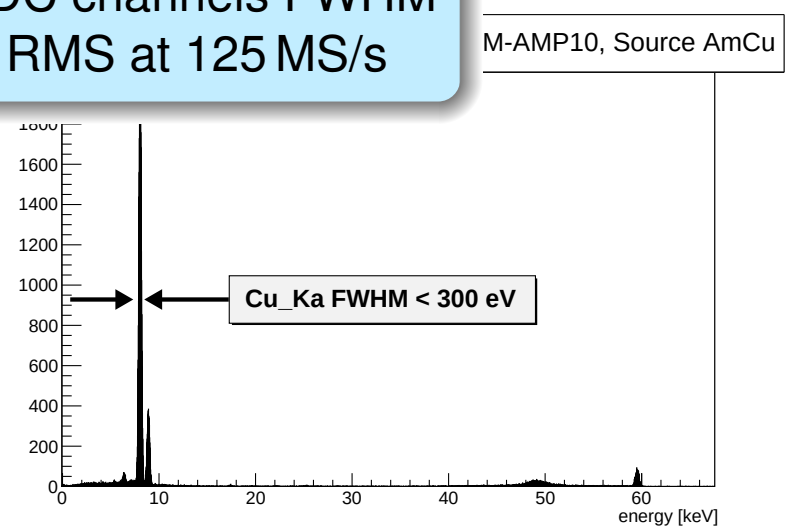




Preliminary

Energy resolution of 5 ADC channels FWHM
Timing resolution of 8 ns RMS at 125 MS/s





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  - Precise timing information and high energy resolution at high count rates
  - Low threshold
  - Noise suppression and clean data
  - No dead/conversion time, only limited by pile up
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- First tests with Vortex, Amptek, Ortec
- First tests with detectors at count rates above $1.8 \cdot 10^6$ cps
- First test with Germanium 100 Pixel Detector

Outlook

- Fluorescence Mapping etc.
- Synchronization with PETRA III Bunches
- Various operation modes
  - Histogram
  - Raw samples
  - Reduced Data
  - (Full Mode)
- Tango Server, EPICS Record. . .

Thanks To

Martin Tolkiehn (P24),
Hans-Thomas Duhme, Michael Fenner, Frank Ludwig, Holger Schlarb (MSK)
Struck Innovative Systeme GmbH

and thank you for your attention.

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