# Status Report BWEC

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PANDA LX Collaboration Meeting

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# Feature Extraction from APFEL Signals

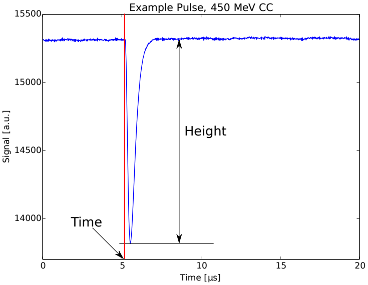
# Feature Extraction

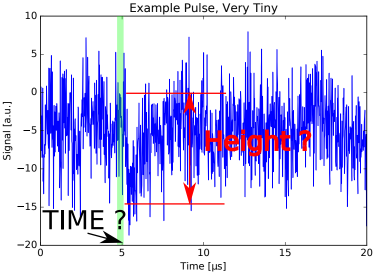
## Needed Information

- Time
- Energy (pulse height)

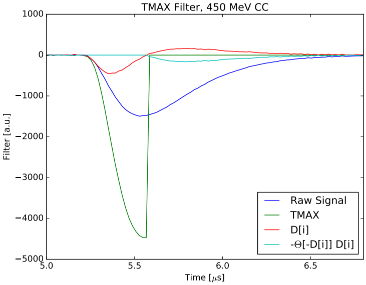
## Requirements on FE

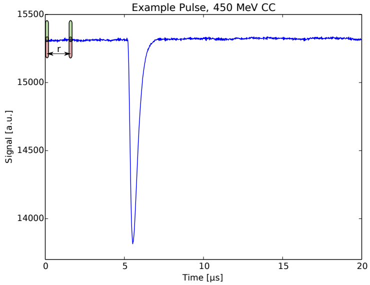
- Fast (calculation time)
- Sensitive to ASIC pulse shape
- Linear
- Threshold as low as possible
- Dead time as short as possible



# TMAX Filter




**Derivative:**

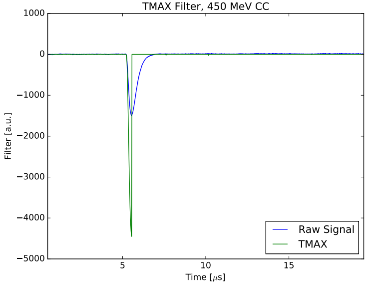
$$D[i] = T[i + {\color{red}r}] - T[i]$$

**Heaviside function $\Theta$:**

$$x \mapsto \begin{cases} 0: & x < 0 \\ 1: & x \geq 0 \end{cases}$$

**TMAX:**

$$F_{TMAX} = \sum_{i=0}^{N} D[i] - \Theta[-D[i]] \cdot D[i]$$



# TMAX Filter

## TMAX Filter

- Sensitive on rising edge
- Cancels out falling edge
- No overshoot
- Short dead time

**Derivative:**

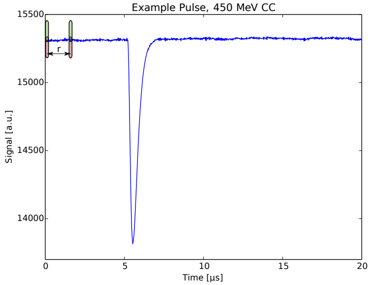
$$D[i] = T[i + {\color{red}r}] - T[i]$$

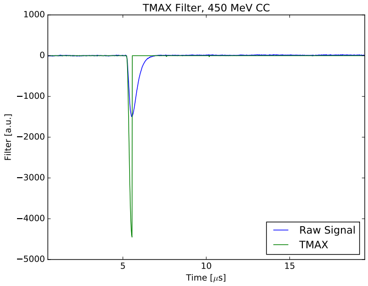
**Heaviside function $\Theta$:**

$$x \mapsto \begin{cases} 0: & x < 0 \\ 1: & x \geq 0 \end{cases}$$

**TMAX:**

$$F_{TMAX} = \sum_{i=0}^{N} D[i] - \Theta[-D[i]] \cdot D[i]$$



# TMAX Filter - Upgrade

## Upgrade

- Amplitude normalization
- Adding SMA in routine
  $\rightarrow$ new parameter "t"

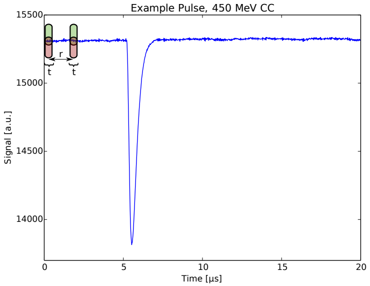
**Recursive calculation:**

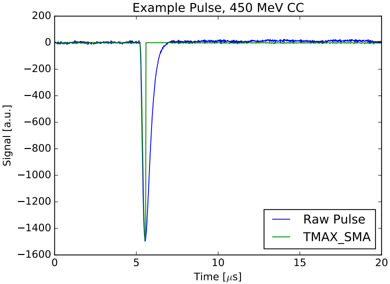
$$S_0 = \frac{1}{r \cdot t} \sum_{i=r}^{i<r+t} T[i] - \frac{1}{r \cdot t} \sum_{i=0}^{i<t} T[i]$$

**Filter value:**

$$S_n = S_{n-1} + \frac{1}{r \cdot t}\left(-T[r+n] + T[r+t+n] + T[n] - T[t+n]\right)$$

$$F_{TMAX} {+}{=} S_n - \Theta[-S_n] \cdot S_n$$



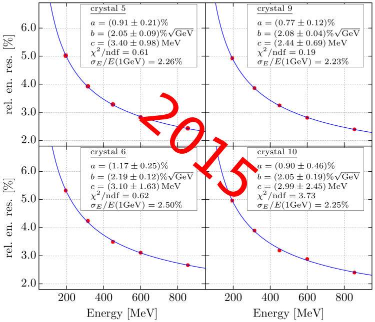
# Filter Performance Test

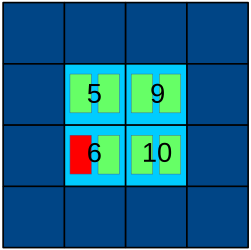
- Using beamtime data from July 2015 (five electron energies)
- Setting different thresholds and filter parameter for analysis
- Generate 3x3 sum spectra
  - Energy calibration
  - Energy resolution
- Impact of parameters on energy resolution and its terms

# Beamtime Data July 2015

## Setup and Data

- Electron beam energies:
  - 195 MeV
  - 315 MeV
  - 450 MeV
  - 600 MeV
  - 855 MeV
- APD gain:
  - $\frac{1}{G}\frac{\partial G}{\partial U} \approx 10\frac{\%}{V}$
- Energy resolution
  - $\frac{\sigma_E}{E}(1GeV) < 2.5\%$



# Parameter Scan - TMAX

## Parameters

- Derivation parameter r
  - 13 values
  - 3,4,5,...,15
- SMA parameter t
  - $t = 1$ (SMA off)
- Thresholds
  - 9 values
  - 0.05,...,15 [a.u.]
  - $\sim$ 0.04,...,11.5 [MeV]

compare_fct.py ThrScaPlot.py AutoScan.py play_ground.py default.xml

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  <TP_ACTIVE v="0"/>
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  <FILT_G v="120"/>
  <HIGH_GAIN_THR v="50"/>
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    <HD_FILT_W2 v="16"/>
    <HD_FILT_D v="16"/>
    <HD_FILT_G v="20"/>
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    <HIT_DET_LOW_GAIN_THR v="50"/>
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</baseline>
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    <POS_SIG v="0"/>
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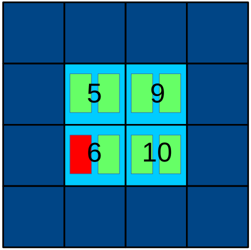
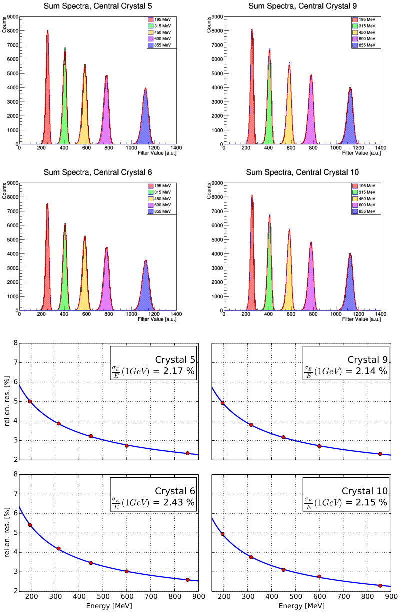
  </InOpt>
</inopt>
<outopt>
  <OutOpt version="1">
```

# Parameter Scan - TMAX

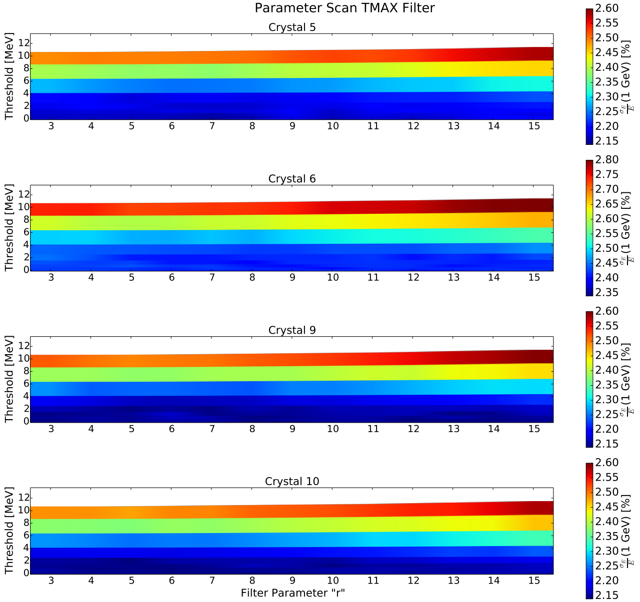
## Example

- r = 3 (derivation)
- t = 1 (SMA)
- Thr. = 0.5 [a.u.] (0.4 MeV)

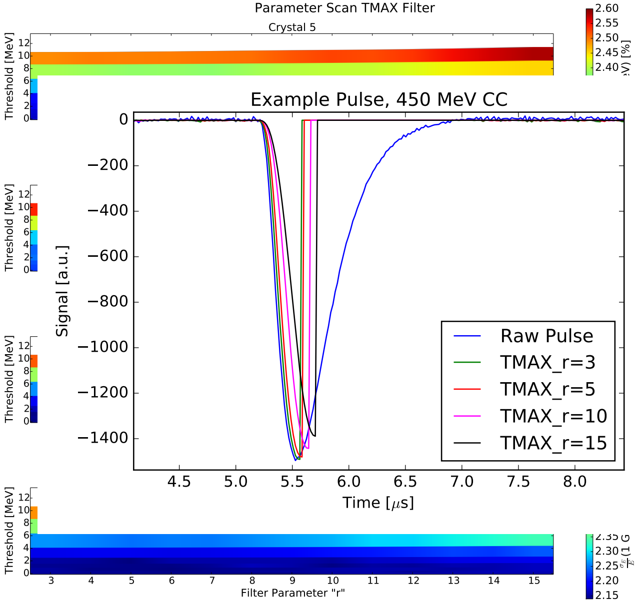


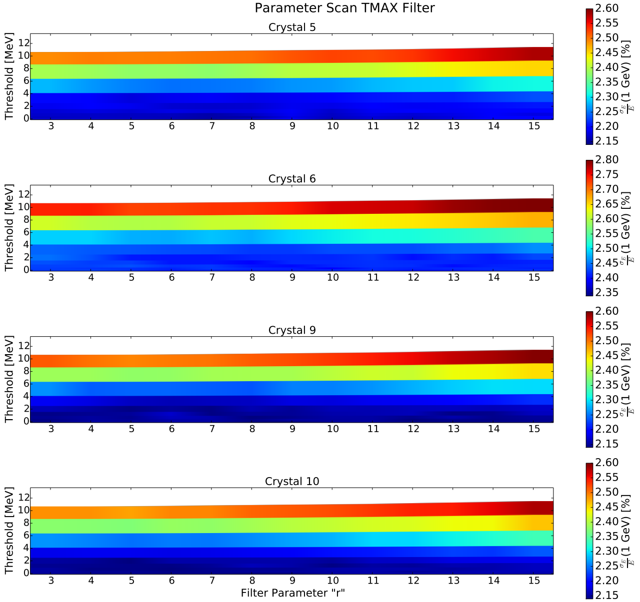
# Parameter Scan - TMAX - Energy Resolution at 1 GeV



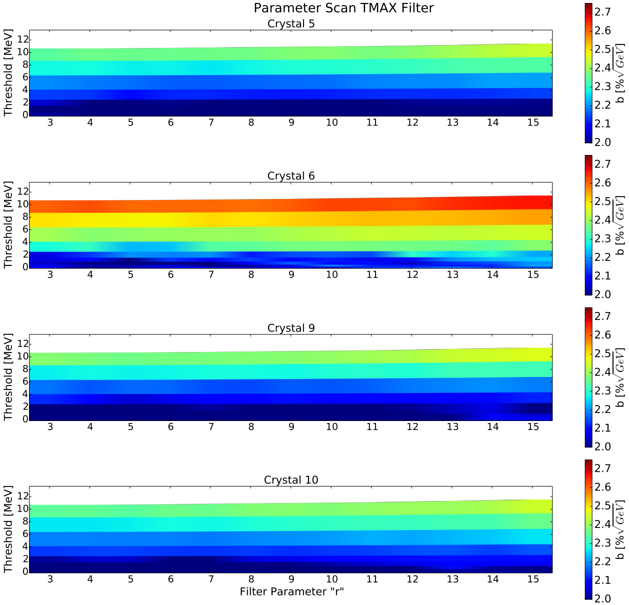
# Parameter Scan - TMAX - Energy Resolution at 1 GeV



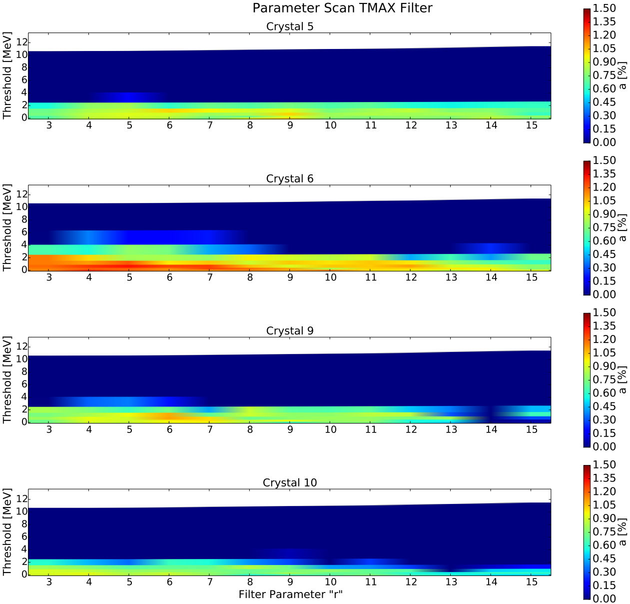
# Parameter Scan - TMAX - Energy Resolution at 1 GeV



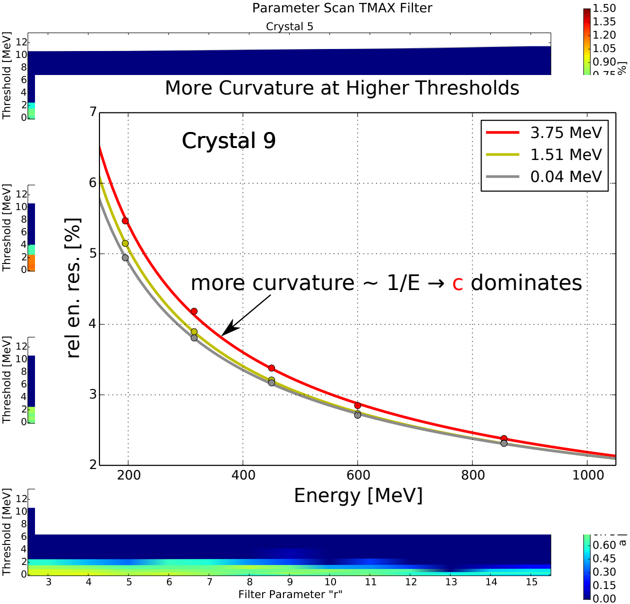
# Parameter Scan - TMAX - Statistical Term b



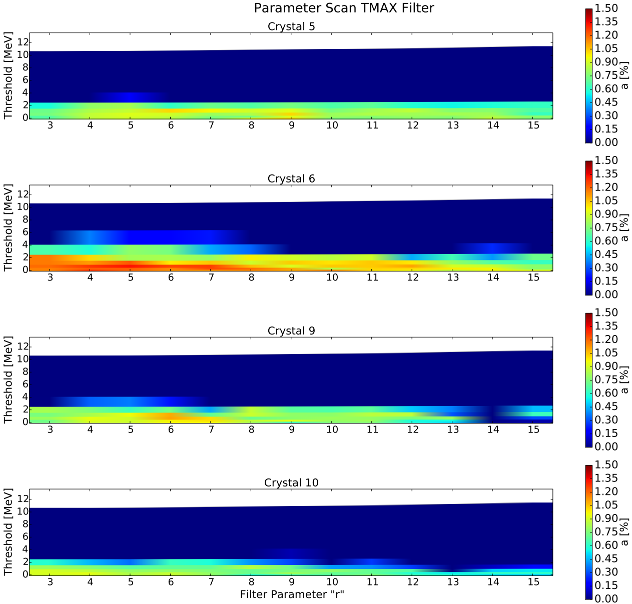
# Parameter Scan - TMAX - Constant Term a



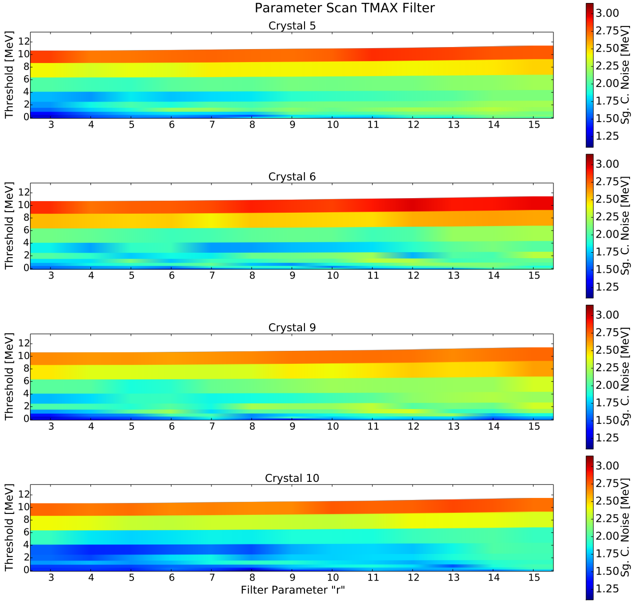
# Parameter Scan - TMAX - Constant Term a



# Parameter Scan - TMAX - Constant Term a



# Parameter Scan - TMAX - Single Crystal Noise $\propto$ c



# Comparison with TDR Requirements

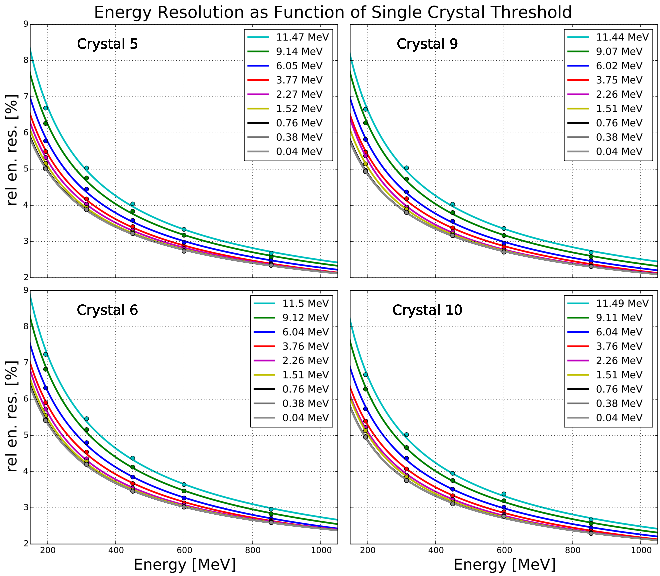
$$\frac{\sigma_E}{E} = a \oplus \frac{b}{\sqrt{E/GeV}} \oplus \frac{c}{E}$$

| | TDR | Achieved Values | Unit |
|---|---|---|---|
| a | $\leq 1$ | **0.7 - 1.1** | % |
| b | $\leq 2$ | **1.9 - 2.0** | % |
| $\sigma_{E,noise} \sim$c | 1 | **1.2 - 1.5** | MeV |
| $\frac{\sigma_E}{E}$(1 GeV) | $\leq 3$ | **2.15 - 2.5** | % |

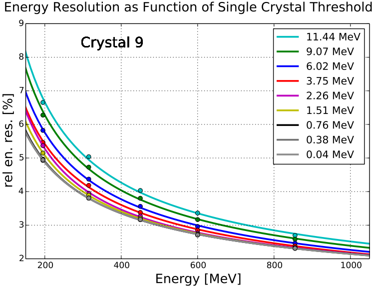
**TMAX Parameters and Threshold**

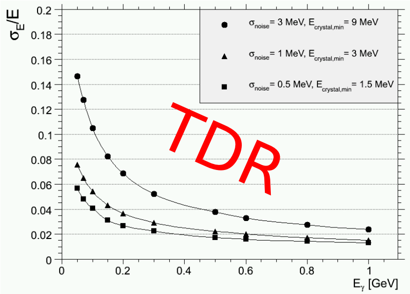
- r=3, t=1 (SMA=off)

# Comparison with TDR Requirements



# Comparison with TDR Requirements



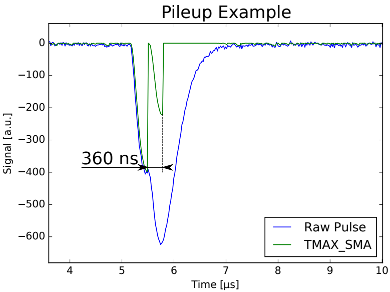

## TMAX Parameters

- r=3, t=1 (SMA=off)

# Conclusion - Feature Extraction

## Conclusion

- Derivation parameter r
  - Can be chosen small → even good for pileup detection
- SMA parameter t
  - Impact has to be studied
- Single crystal threshold
  - As small as needed, as high as possible. → save data load




r=3, t=1 (SMA=off)
→ Event rate ≈ **28 kHz**
(at 1% pileup probability)

## To Do

- Beamtime data from 2016 (better electronics → less noise)

# Baseline Adjustment for the APFEL Preamplifier

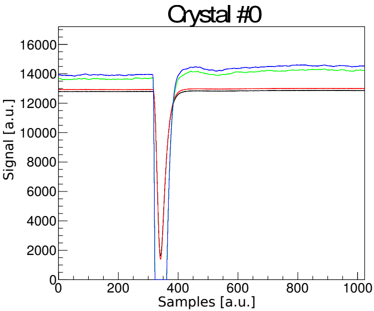
# Baseline Adjustment

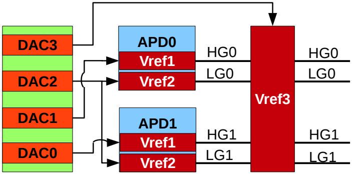
## Aim of BA

- Fit ASIC signals in ADC entrance area
- Exploit the full dynamic range

## Requirements on BA

- Automatic determination of ASIC DAC values
- Fast procedure (∼ 12000 ASIC x 4 channel)
- Automatic monitoring of baselines (temperature drift etc.)

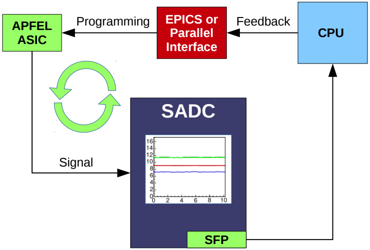


# Baseline Adjustment - Current Version

## Hardware

- BL readout via MBS DAQ
- Computer with adjustment routine
- ASIC programming:
  - Parallel interface and PCB
  - GSI HADCON via EPICS




## Software

- Python script
- Iterative algorithm

## PROTO16, 64 Channel

- $\sim$ 50 BL readouts
- Adjustment time $\sim$ 100 s

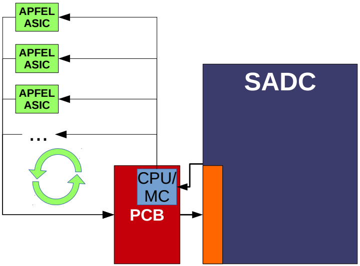
# Baseline Adjustment - Scaling

## Hardware

- Adapter PCB on ADC entrance (ADC PCB has to be modified)
- Micro controller or CPU

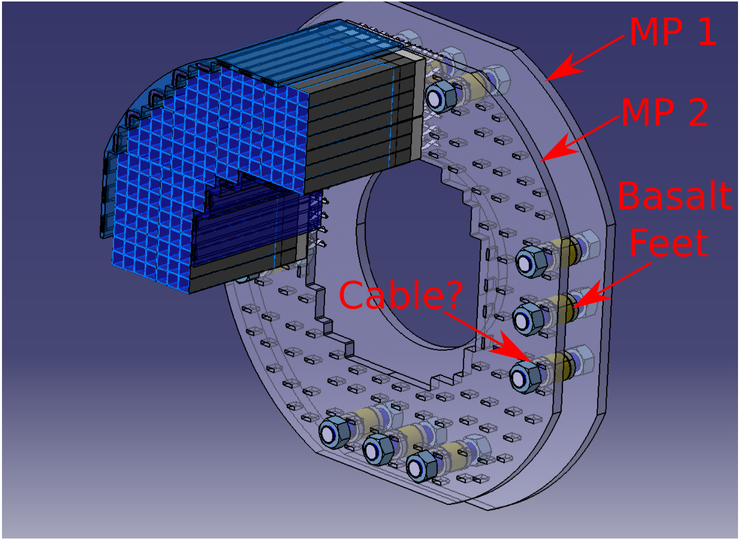
## Software

- Adjustment routine adapted to micro controller
- Or it runs on CPU



# Final Subunit Design for the BWEC

# Old Design - Issues



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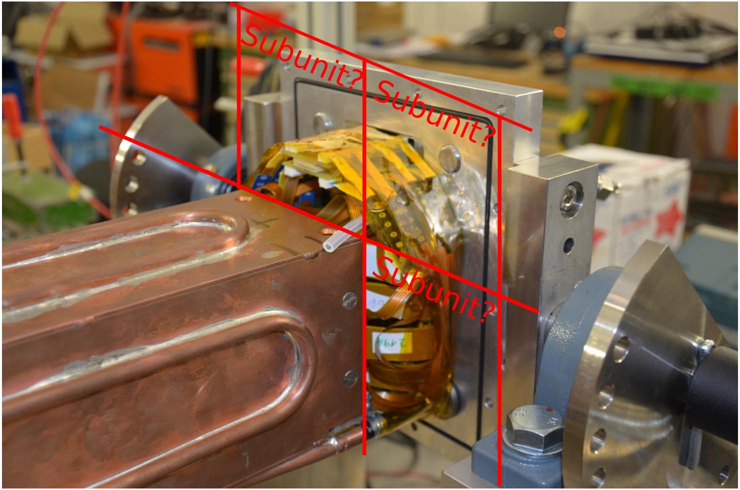

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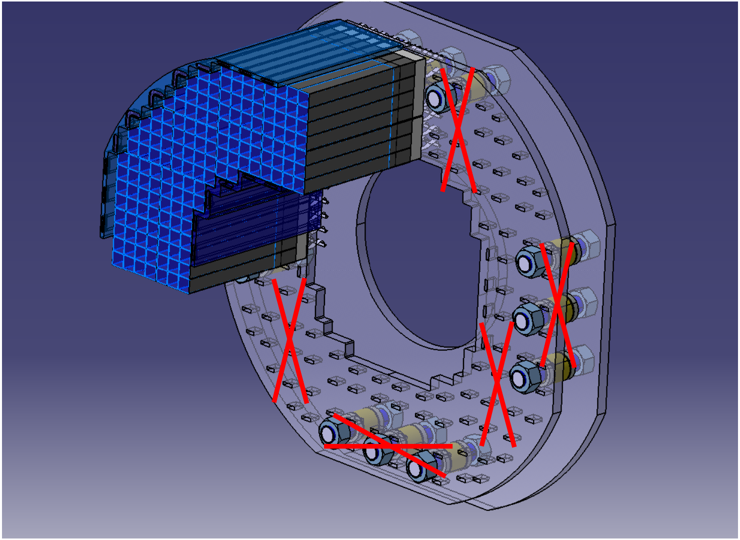
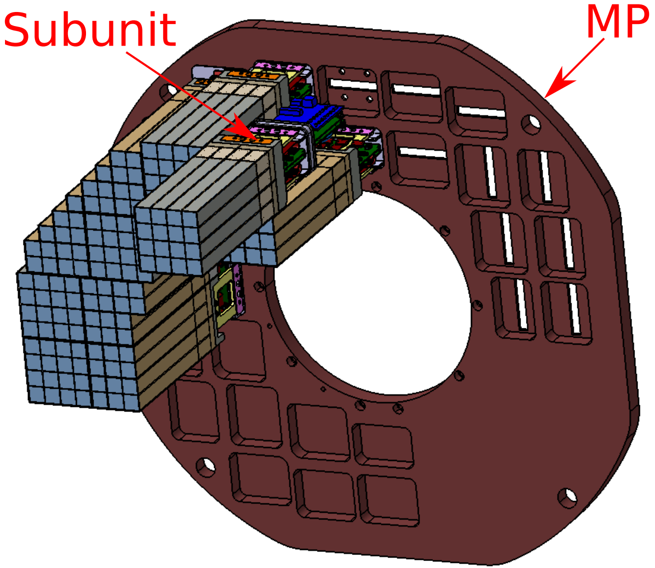
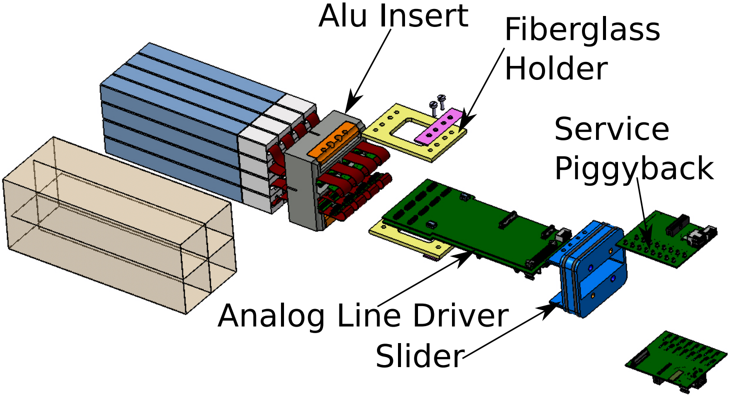


# New Design

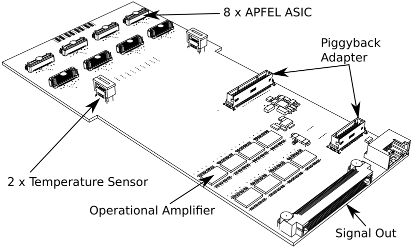


# New Design


Alu Insert
Fiberglass Holder
Service Piggyback
Analog Line Driver
Slider

# New Design

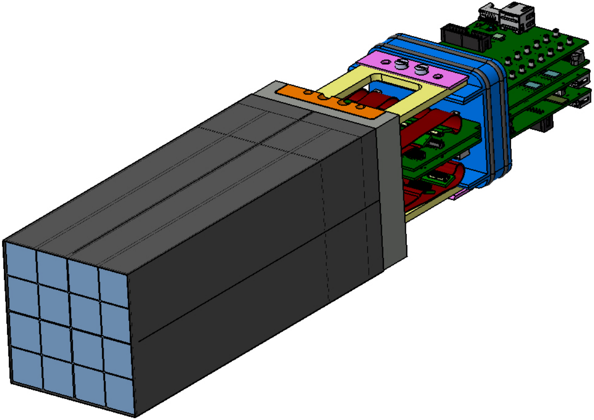
Analog Line Driver



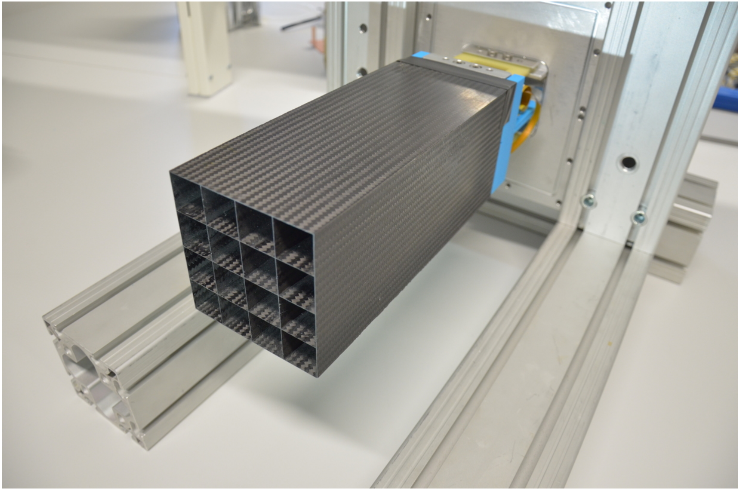

Service Piggyback

- HV input
- HV splitter/trimmer
- THMP connector
- ASIC control connector
- Line driver adapter

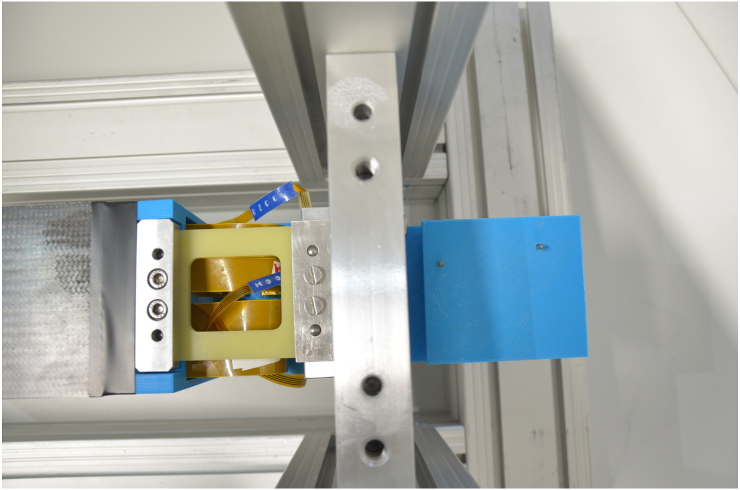
# New Design



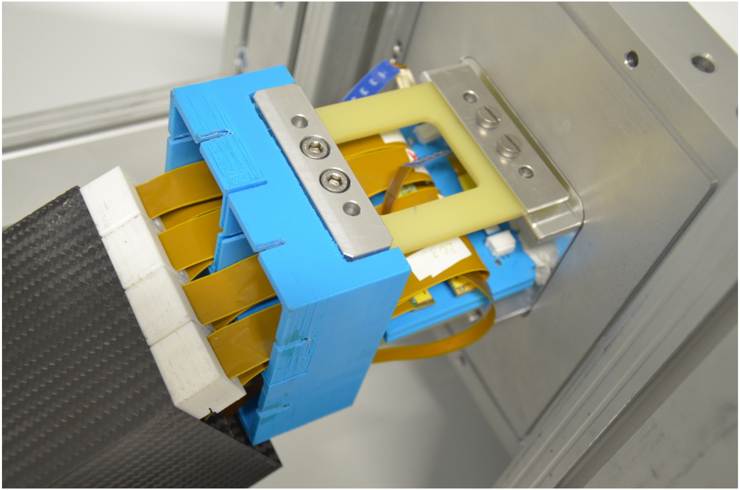
# New Design - Prototype



# New Design - Prototype



# New Design - Prototype



# Conclusion - New Subunit Design

## Done

- Cable and board space issues solved ✓
- Get rid of mounting/cabling issues due to basalt feet ✓
- Real modular subunit system ✓
  (also important for $\bar{\text{P}}$ANDA phase 0)
- First APFEL signal tests with new line driver prototype ✓
- Final boards are already in production ✓

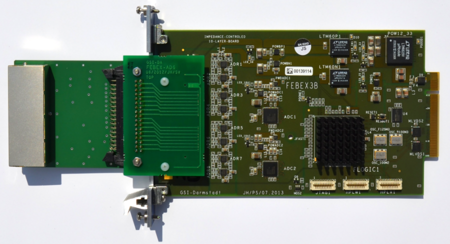
## To Do

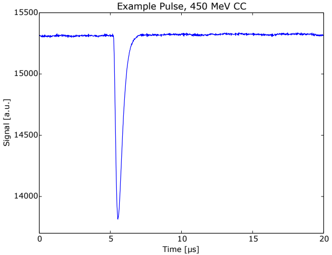
- Load tests
- Update PROTO16 with new system
- Detailed electronics tests
- Beam tests

# Backup

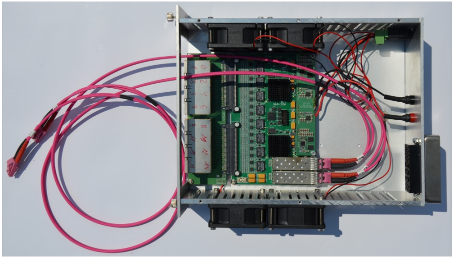
# Mainz ADC Collection

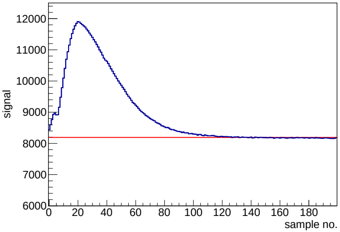
## FEBEX 14 bit, 50 MSa/s, 16 diff. input channels






## Uppsala ADC 14 bit, 80 MSa/s, 64 diff. input channels

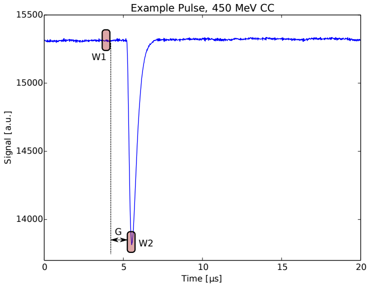




# Trapeze Filter

## Trapeze Filter

- Robust and efficient filter
- Saving calculation time
- Already implemented on FEBEX FPGA ($W_1 = W_2$)

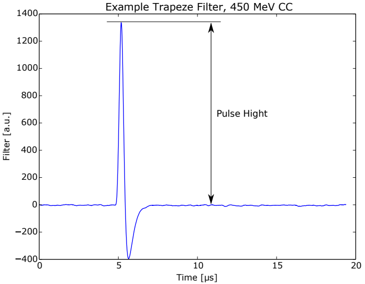



**Recursive calculation:**

$$S_0 = \frac{1}{W_1}\sum_{i=0}^{W_1} T[i] - \frac{1}{W_2}\sum_{i=W_1+G}^{W_1+W_2+G} T[i]$$

**Filter value:**

$$F_n = S_n = S_{n-1} + \frac{1}{W_1}\left(T[W_1+n] - T[n-1]\right) - \frac{1}{W_2}\left(T[W_1+G+n-1] - T[W_1+W_2+G+n]\right)$$



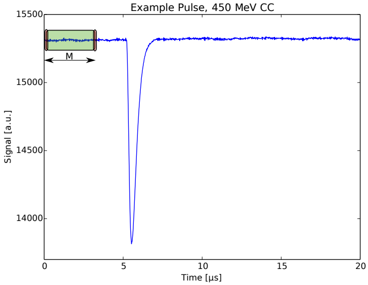
# MWD Filter

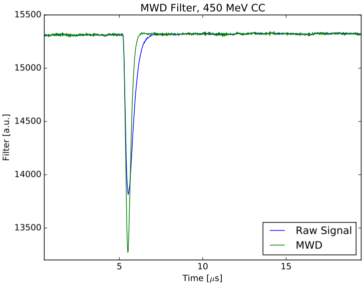
## MWD Filter

- Robust and efficient filter
- Shortening of pulse shape
- Smoothing (SMA)
- No overshoot
- Baseline correction needed

**MWD:**

$$F_{MWD}[i] = \underbrace{T[i] - T[i-M]}_{\text{Differentiation}} + \underbrace{\frac{1}{\tau}\sum_{j=i-M}^{i-1} T[j]}_{\text{Moving Average}}$$



# Smoothing via Simple Moving Average

## SMA

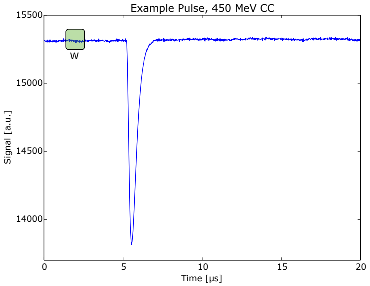
- Smoothing of high frequency noise
- Investigation of influence of baseline averaging

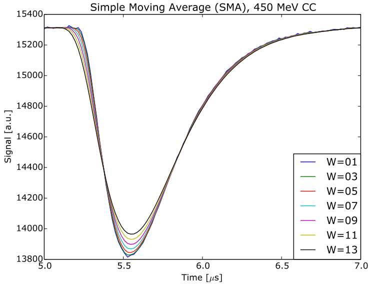
**Filter value:**

$$F_n = \frac{1}{W} \sum_{i=n}^{n+W} T[i]$$

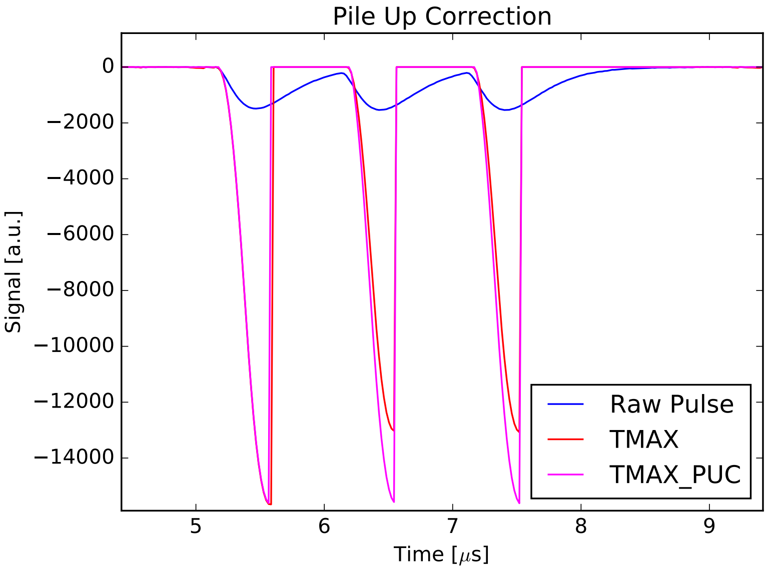
**Time delay:**

$$t_{delay} = \frac{W-1}{2}$$

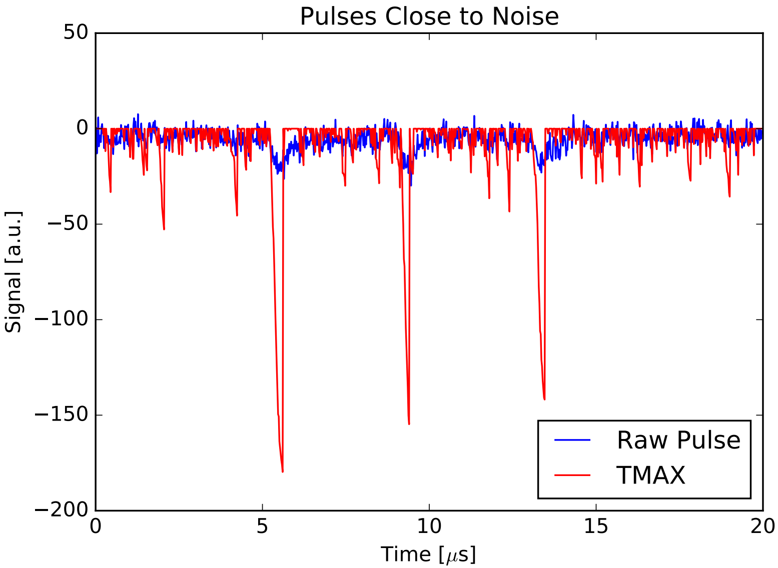


# Pile Up Correction 1 $\mu$s



# Signals Close to Noise



# Baseline Adjustment - Scaling: Method 1

## Hardware

- BL readout via PANDA DAQ
- Micro controller
  - possibly HADCON

## Software

- Adjustment routine adapted to micro controller