Update on Feature-Extraction Tests

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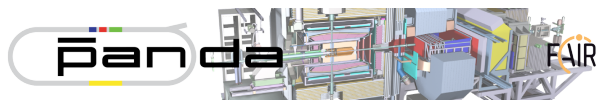
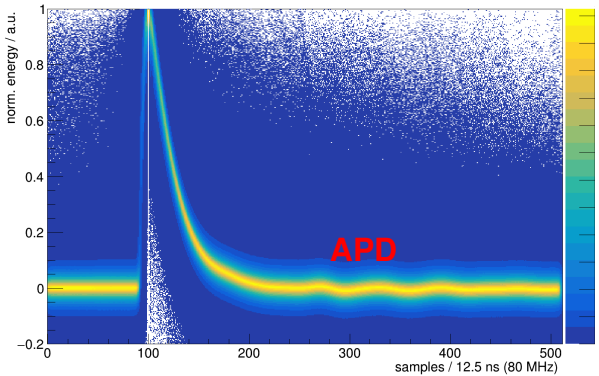
HISKP – University Bonn

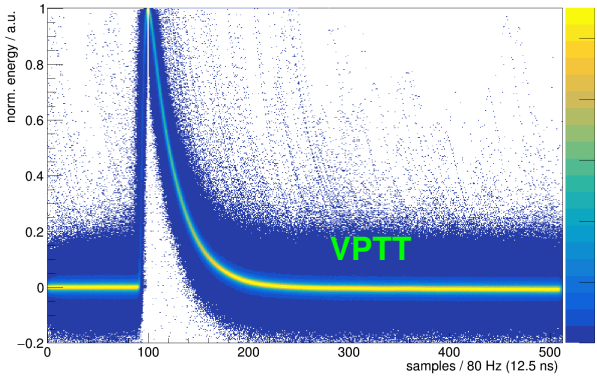


Measured Waveforms at −25 °C



- **APD:** ”**RINGING**” after pulse
  → **const. fraction** of pulse-height for **high-gain channel**
  → origin of ”ringing” visible in **preamplifier** pulse
  → considered to be not fixable
  ⇒ issue for feature-extraction

Measured Waveforms at −25 °C



- **APD:** ”**RINGING**” after pulse
  → **const. fraction** of pulse-height for **high-gain channel**
  → origin of ”ringing” visible in **preamplifier** pulse
  → considered to be not fixable
  ⇒ issue for feature-extraction
- **VPTT**-submodule
  → no ringing
- try to fix ”ringing” with signal deconvolution

Blind-Deconvolution

Basic Idea:

$$f = g * h \xrightarrow{\mathfrak{F}} \hat{f} = \hat{g} \cdot \hat{h}$$

$$\downarrow :\hat{f} :\hat{h}$$

$$H = \mathfrak{F}^{-1}\left[\frac{\hat{g}}{\hat{f}}\right] \xleftarrow{\mathfrak{F}^{-1}} \frac{1}{\hat{h}} = \frac{\hat{g}}{\hat{f}}$$

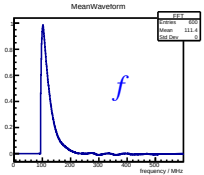
[Jan Schultes]

Deconvolution:

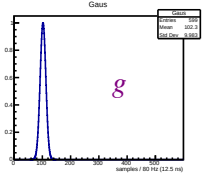
deconvolution of each measured waveform using H

$$g_{\text{event}} = f_{\text{event}} * H$$

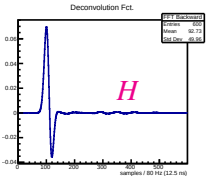
$$\text{BD}[n] = (f_{\text{event}} * H)[n] = \sum_k f_{\text{event}}[k] \cdot H[n-k]$$



- **mean waveform** of raw SADC-pulse

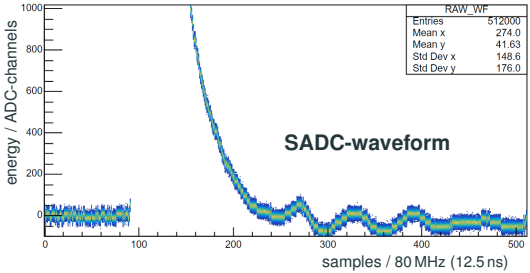


- **gaussian** fct. → chosen
  → σ limited by max. frequency
  → A to conserve peak-height



- **deconvolution** fct. H
  → determine **once**!

Deconvolution Example



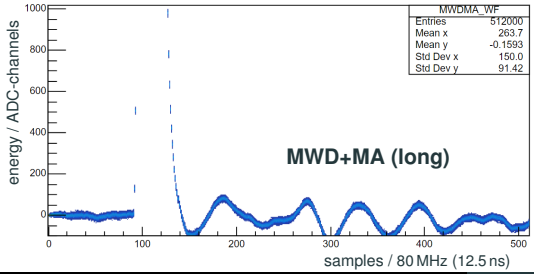
Simulation example:

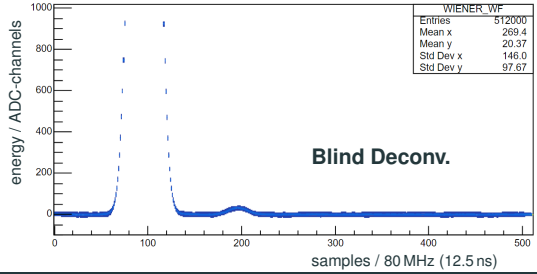
- 800 MeV @ sample 100
- 3 MeV @ sample 200

→ **simulate 1k waveforms** and apply deconvolution

⇒ blind deconvolution: no ringing + pile-up well visible

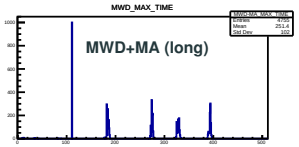
⇒ MWD + MA: ringing covers pile-up pulse

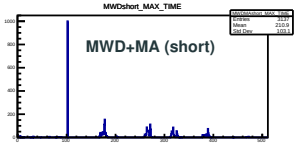


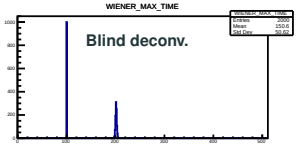


Peakfinder

peaktime

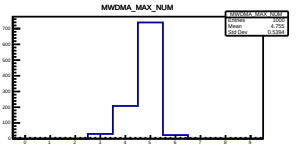


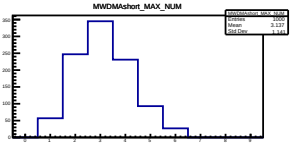


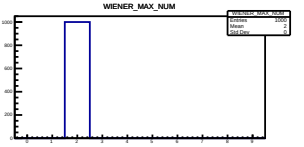


samples / 80 MHz (12.5 ns)

number of peaks







peaks

peakfinder ⇒ require # rising samples

- choose thr. as low as possible such that max. pulse is found but **no artifacts**
- choose thr. as high as possible such that **3 MeV** is still **safely found** but noise is suppressed

→ optimal case: both criteria fulfilled

⇒ blind deconvolution: **check!**

⇒ not fulfilled for MWD + MA due to ringing

Pile-Up Detection

Use peakfinder:

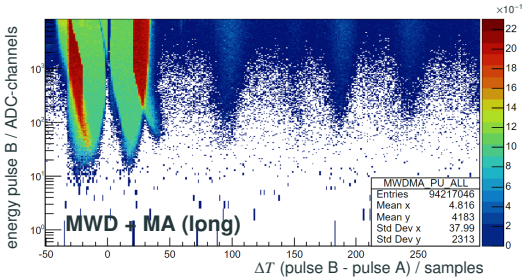
- get **int./max. ratio** from extracted features
- derive upper int./max. ratio from simulation via

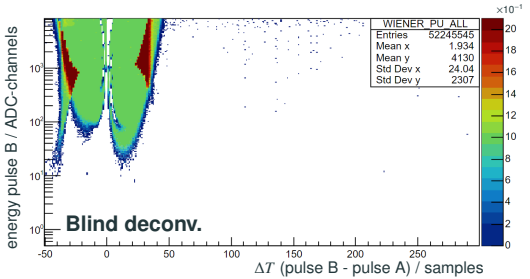
→ **compare measured ratio** with boundary

Pile-up simulation:

- **pulse A fixed** at $t_A = 0$ samples with 1000 ADC – channels
- **pulse B** with **variable** position and height

⇒ get number of found **peaks flagged as pile-up**





DPM-Simulation

Assume: $L = 2 \times 10^{32}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$

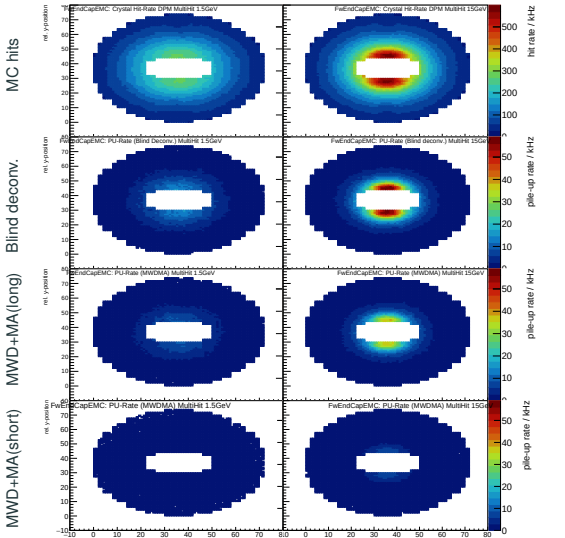
1 1.5 GeV $c_0{}^{-1}$: $\sigma \approx 100$ mb
→ event rate ≈ 20 MHz ($\Delta t = 50$ ns)

2 15 GeV $c_0{}^{-1}$: $\sigma \approx 50$ mb
→ event rate ≈ 10 MHz ($\Delta t = 100$ ns)

PRELIMINARY RESULTS
(assume APD waveform also in inner region):

⇒ single crystal **hit rate up to 600 kHz**
⇒ **pile-up rate up to 60 kHz**

pile-up influenced by adjusting width of integral window
→ (minor) influence on energy resolution



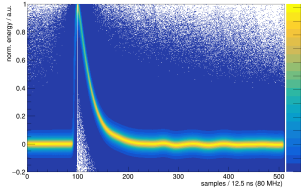
Summary and Outlook

Summary:

- **blind deconvolution** can eliminate ringing
- **peakfinder** works reliable down to 3 MeV
- **DPM-simulation:** single crystal particle rate up to 600 kHz and pile-up rate of 60 kHz

Outlook:

- further **investigate ringing**
  → APD low-gain channel
- **blind deconvolution implementable?**
  → test new feature extraction algorithm with beam
  → improve algorithm iteratively



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