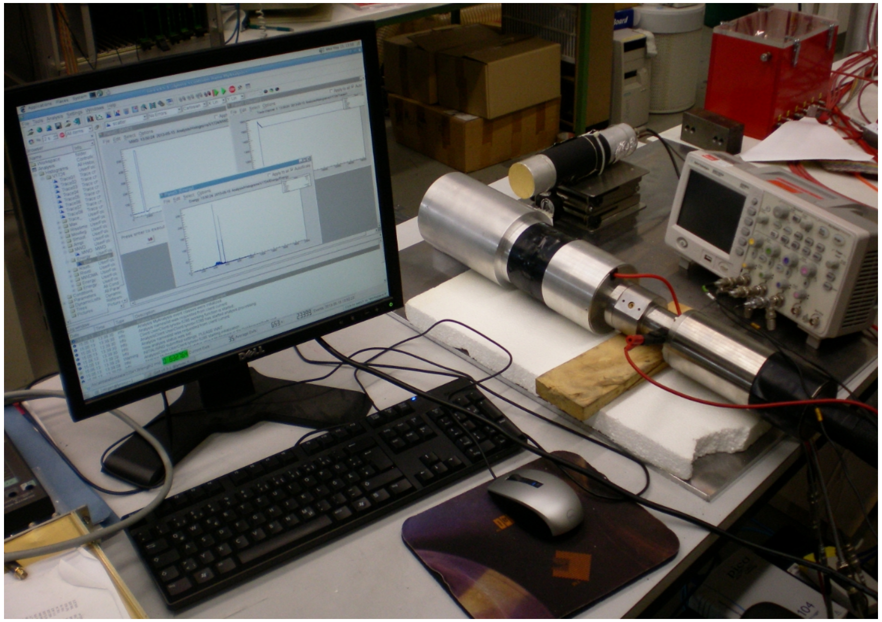
Status Report

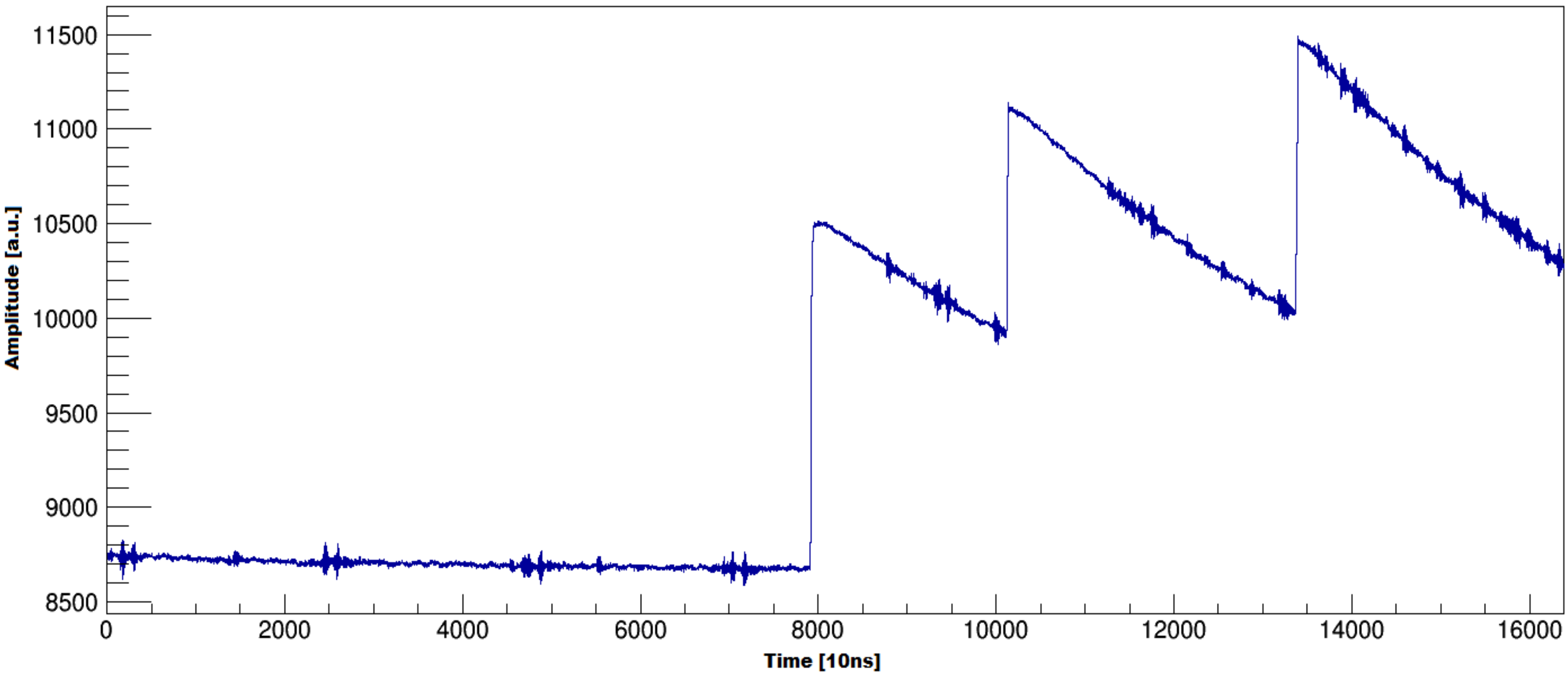
Pulse Shape Analysis of HPGe Detectors in Mainz

Kai Rittgen
10.12.2013

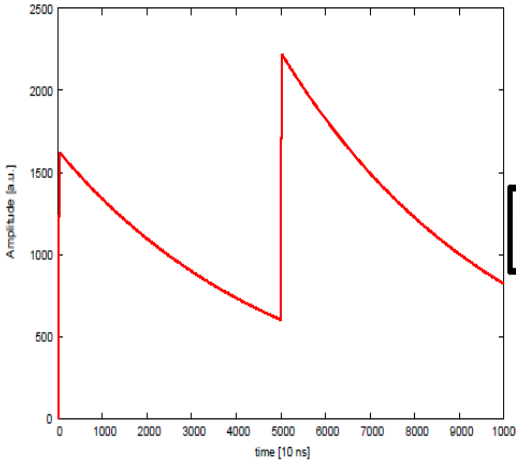


COSY Data Material

Trace from raw data material with pile-up effects



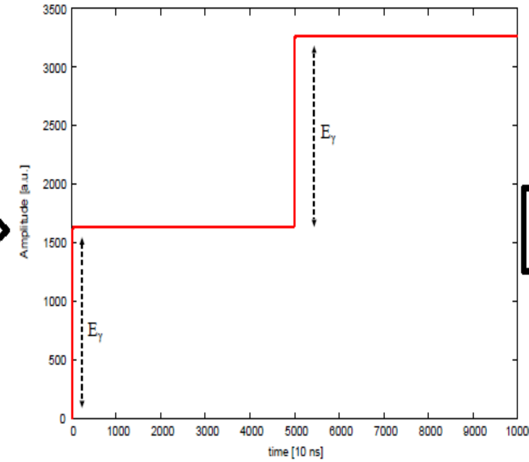
Moving Window Deconvolution



Preamplifier Signal

$$f(t) = A \exp\left(-\frac{t}{\tau}\right)$$

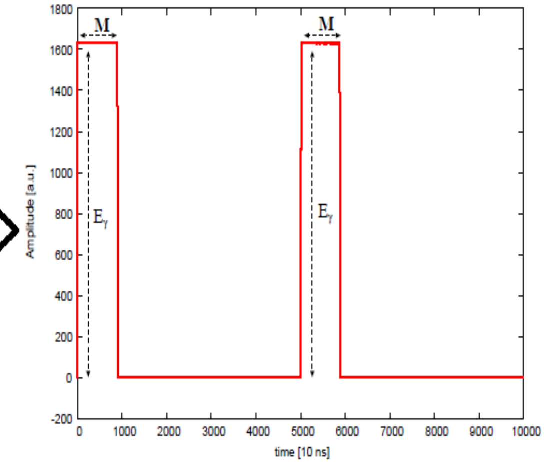
Deconvoluion



Deconvoluted Signal

$$A[n] = x[n] + \frac{1}{\tau} \sum_{k=-\infty}^{n-1} x[k]$$

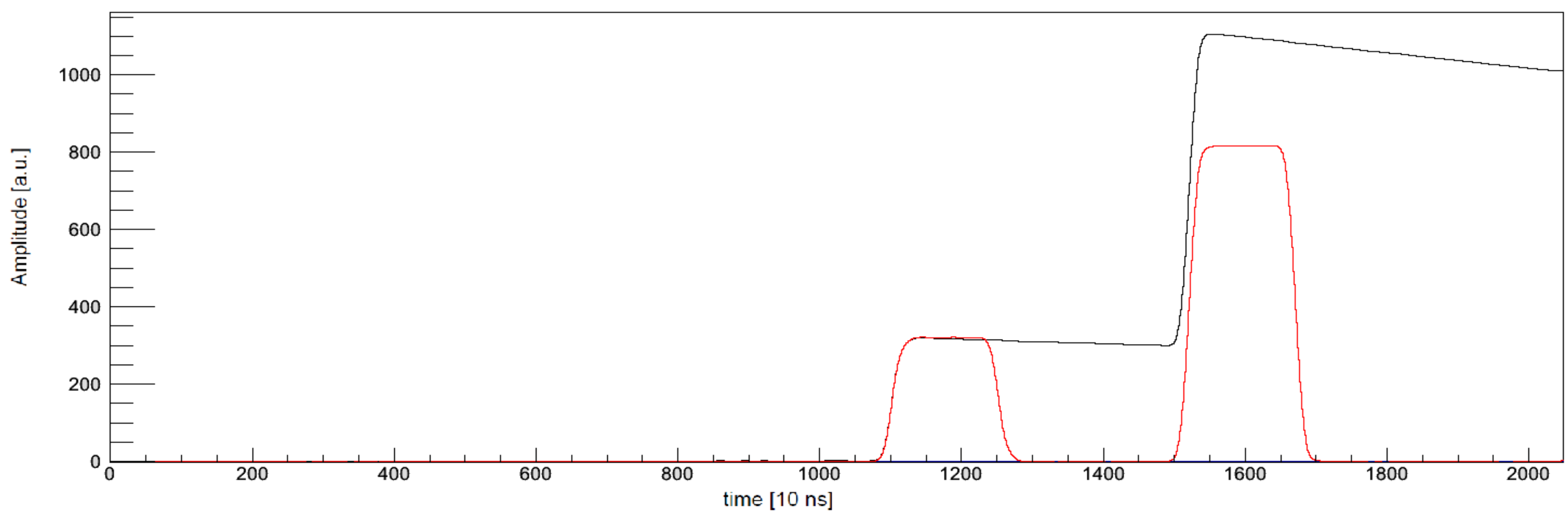
Moving Average



MWD - Signal

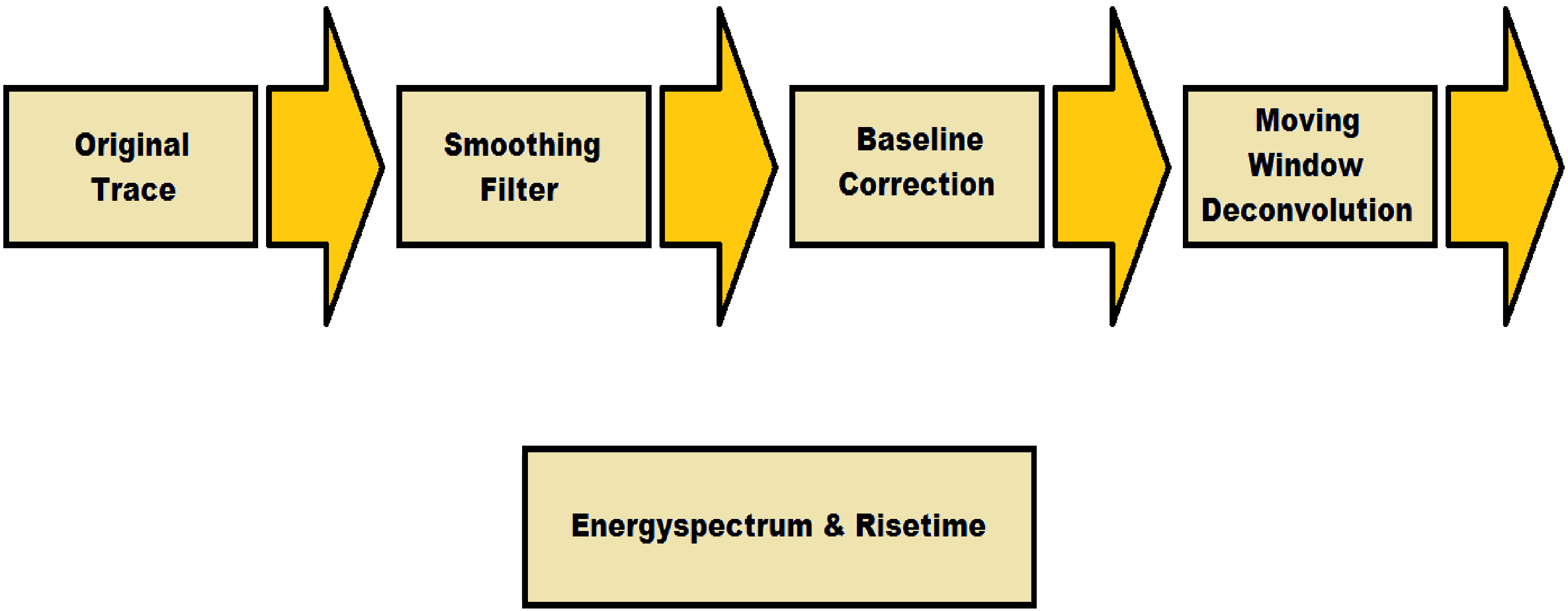
$$\mathrm{MWD}[n] = \mathrm{A}[n] - \mathrm{A}[n-M]$$

Digital Signal Processing for segmented HPGe Detectors Preprocessing Algorithms and Pulse Shape Analysis by Martin Lauer, 2004



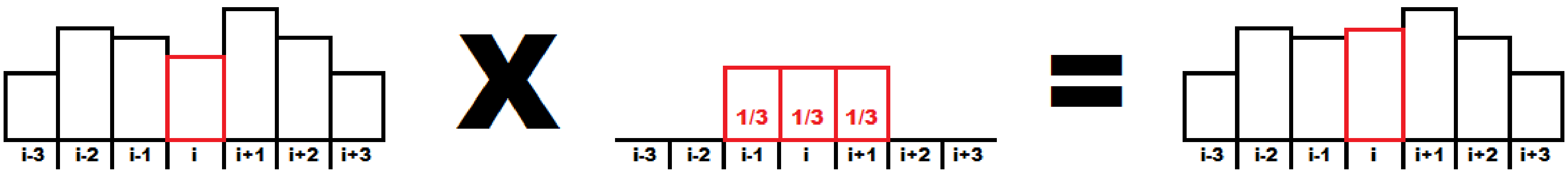
Algorithm

Steps of Algorithm

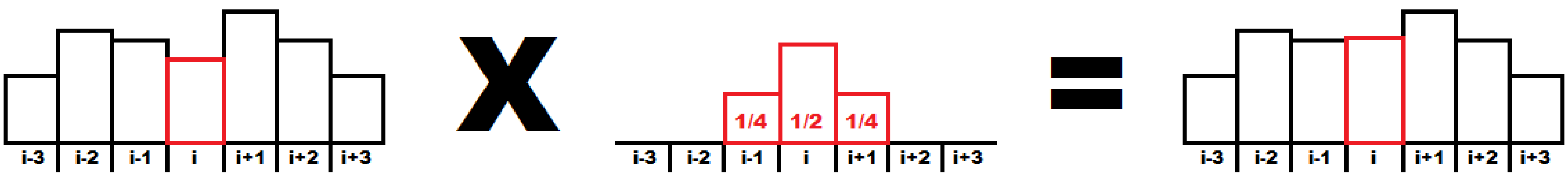


Smoothing

Mean Filter



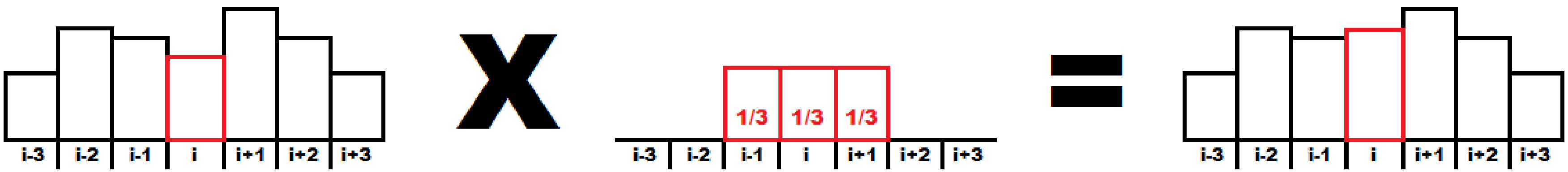
Weighted Average Filter



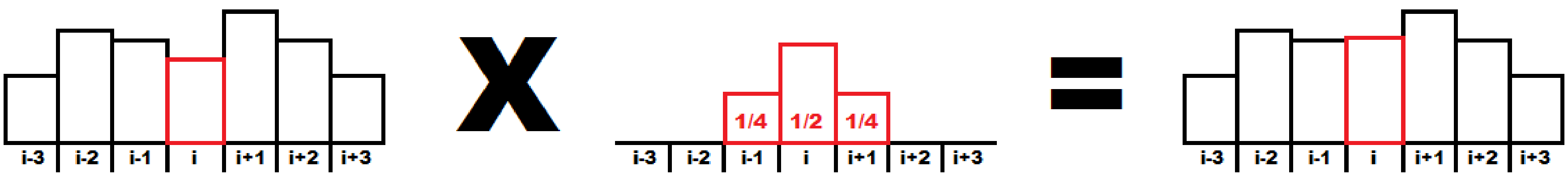
Central limit theorem

Smoothing

Mean Filter

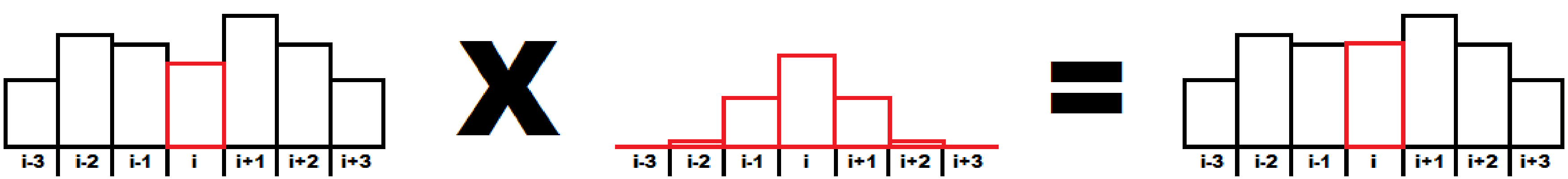


Weighted Average Filter



Central limit theorem leads to

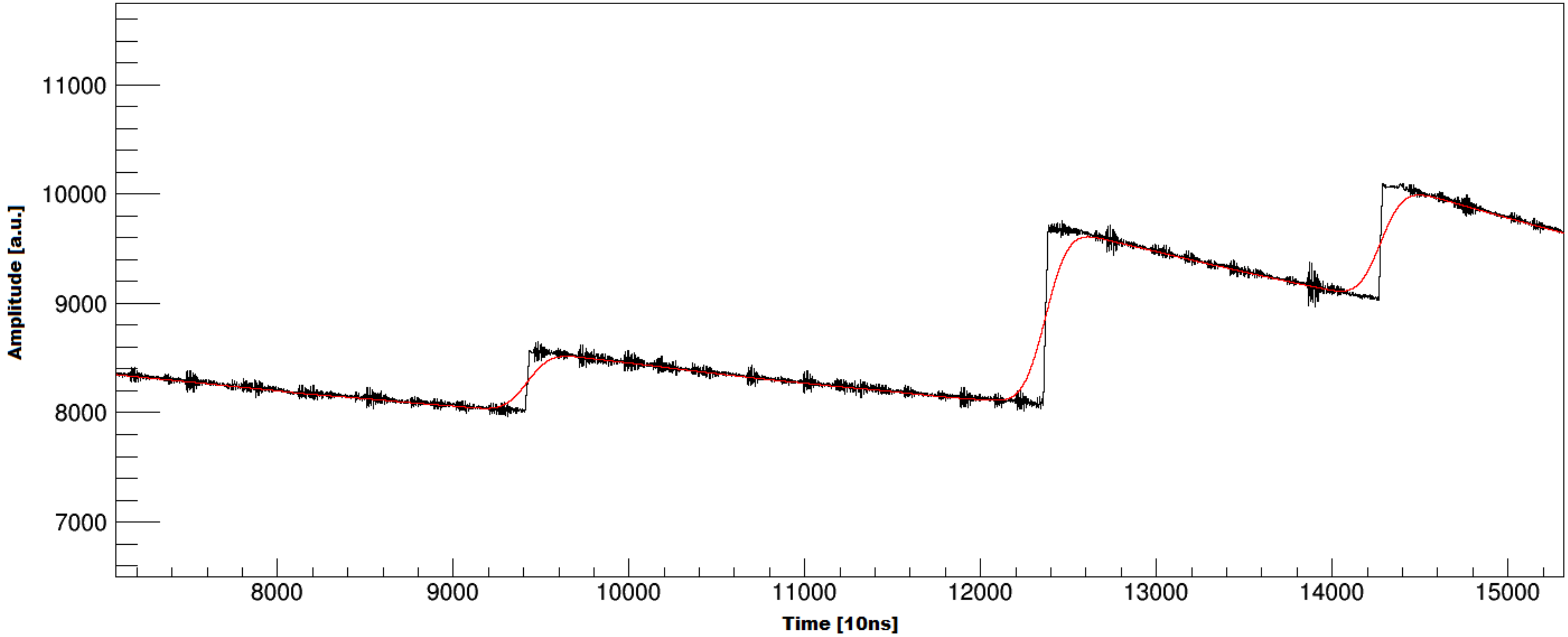
Gaussian Filter



Smoothing

Gaussian Filter with Sigma = 1µs

Low pass filter with cut-off-frequency $f_c = \dfrac{\sqrt{\ln(2)}}{2\pi \cdot \mathrm{Sigma}}$



Smoothing

Gaussian Filter with Sigma = 1µs

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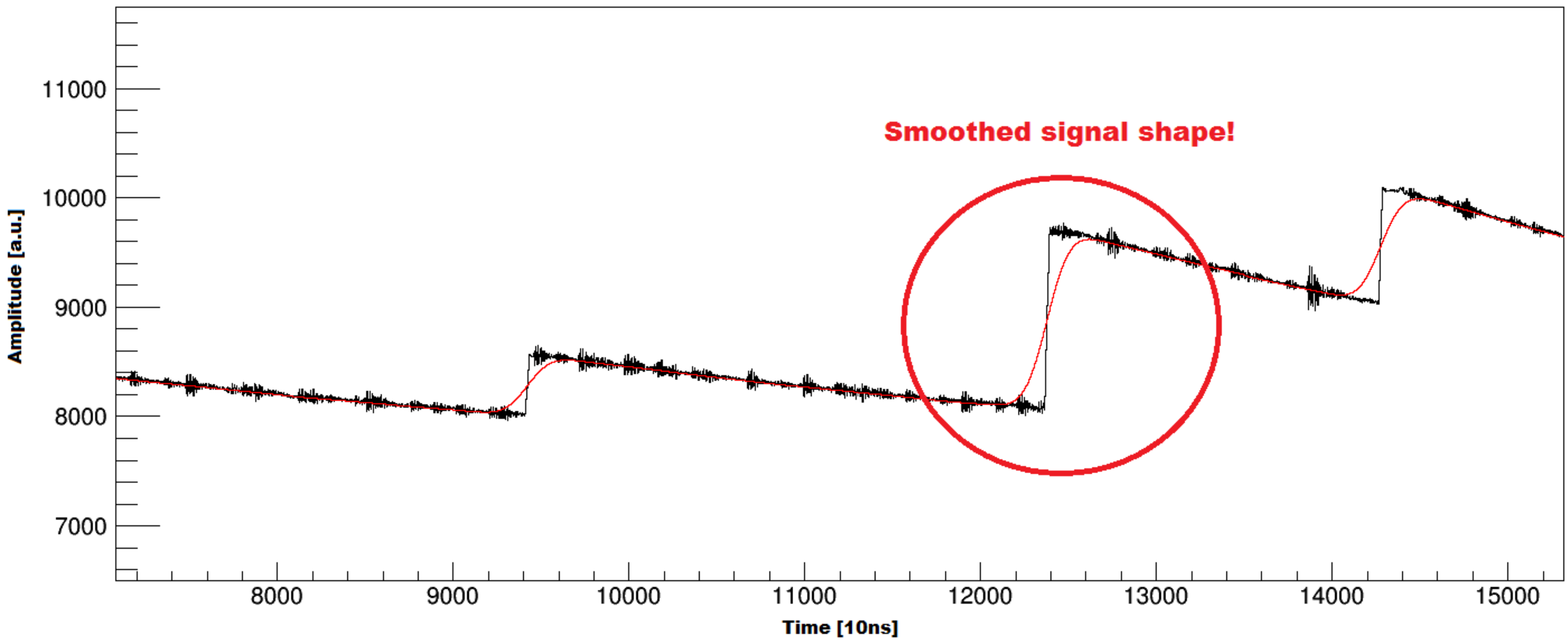


➡ **Find optimal value for Sigma or use *nonlinear Filter***

Smoothing

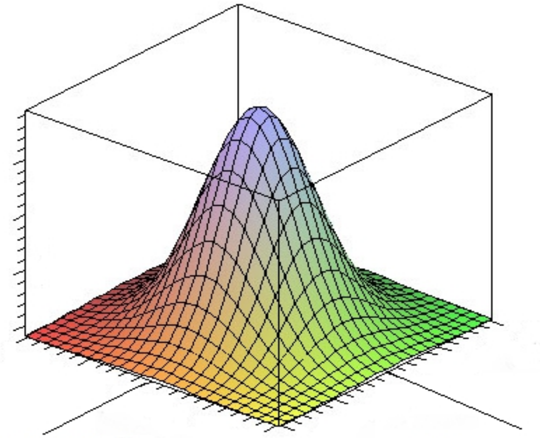
Bilateral Filter

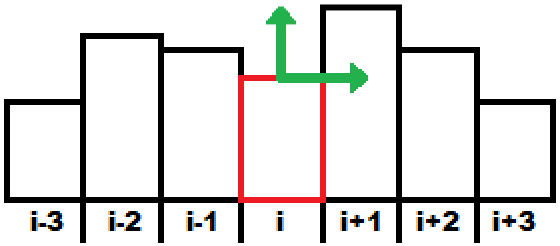
$$\text{Value}(i) = \frac{1}{N_i} \sum_{n \in S} G_1(\| i - n \|)\, G_2(\| \text{Value}(i) - \text{Value}(n) \|)\, \text{Value}(n)$$

With Normalization Term

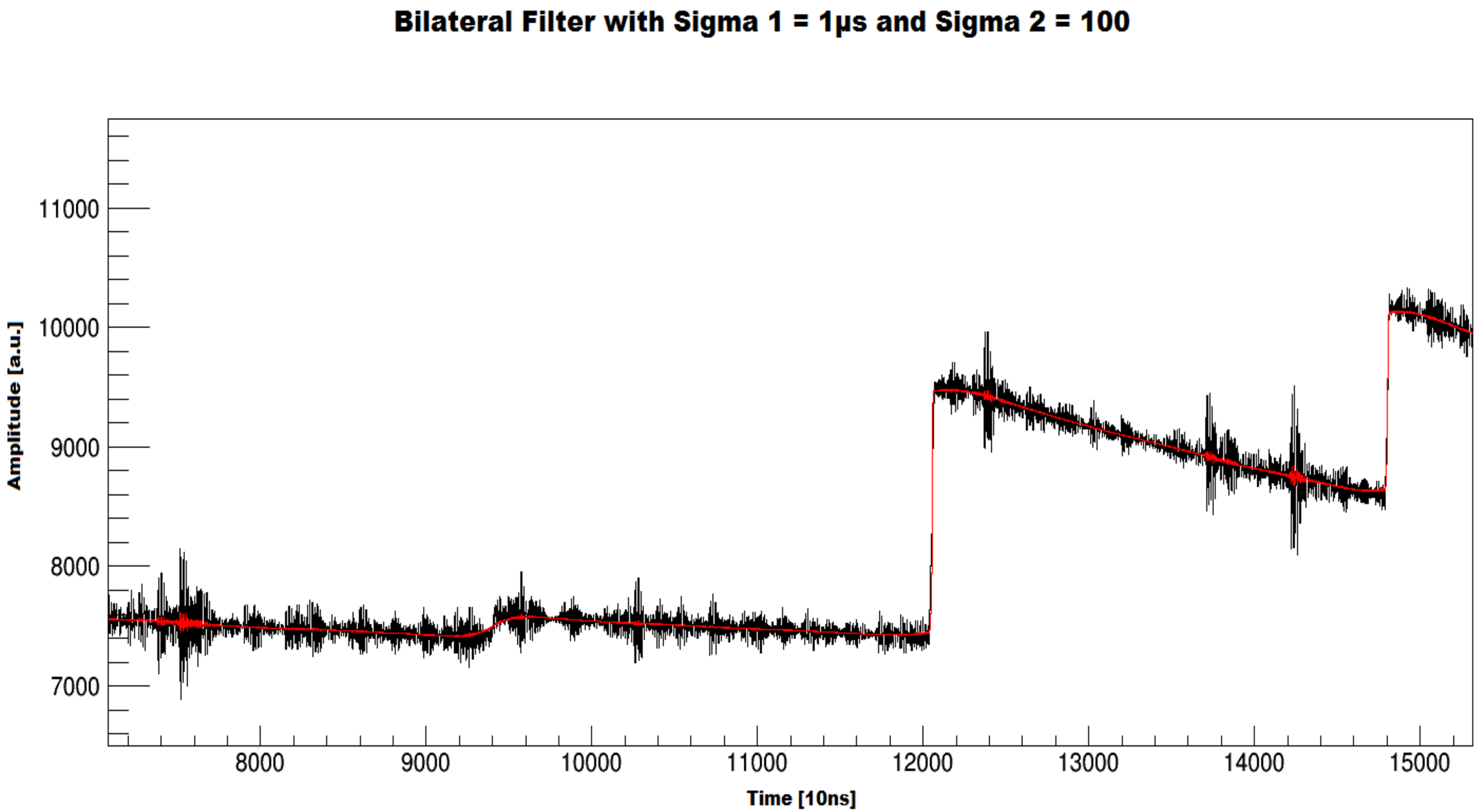
$$N_i = \sum_{n \in S} G_1(\| i - n \|)\, G_2(\| \text{Value}(i) - \text{Value}(n) \|)$$

i : Position of Bin
n : Position of Bin in neighborhood of i
S : Neighborhood of i
G_1: Gaussian filter (distance between i and n)
G_2: Gaussian filter (difference between Value(i) and Value(n))





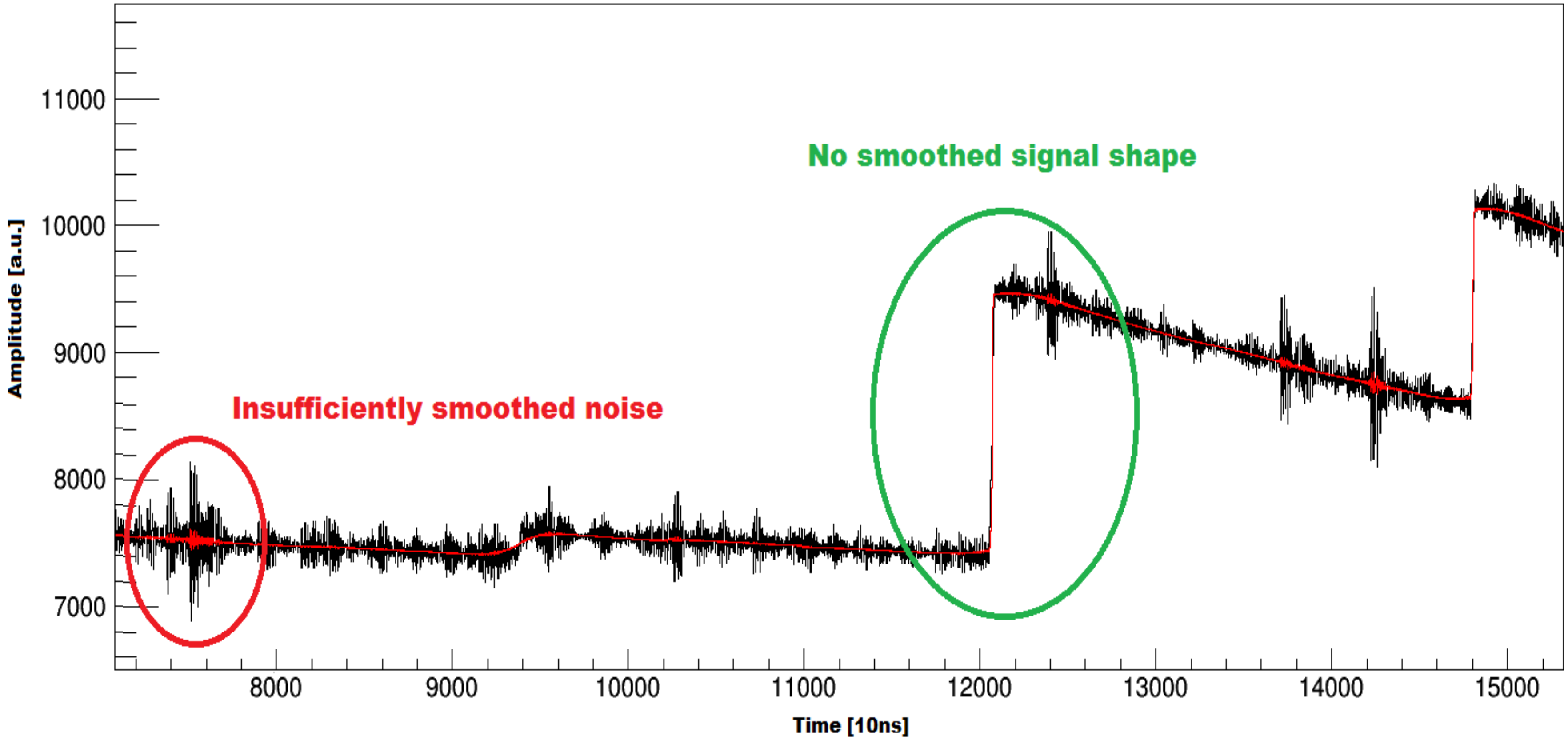
Smoothing



Bilateral Filter with Sigma 1 = 1µs and Sigma 2 = 100
Amplitude [a.u.]
11000
10000
9000
8000
7000
8000
9000
10000
11000
12000
13000
14000
15000
Time [10ns]

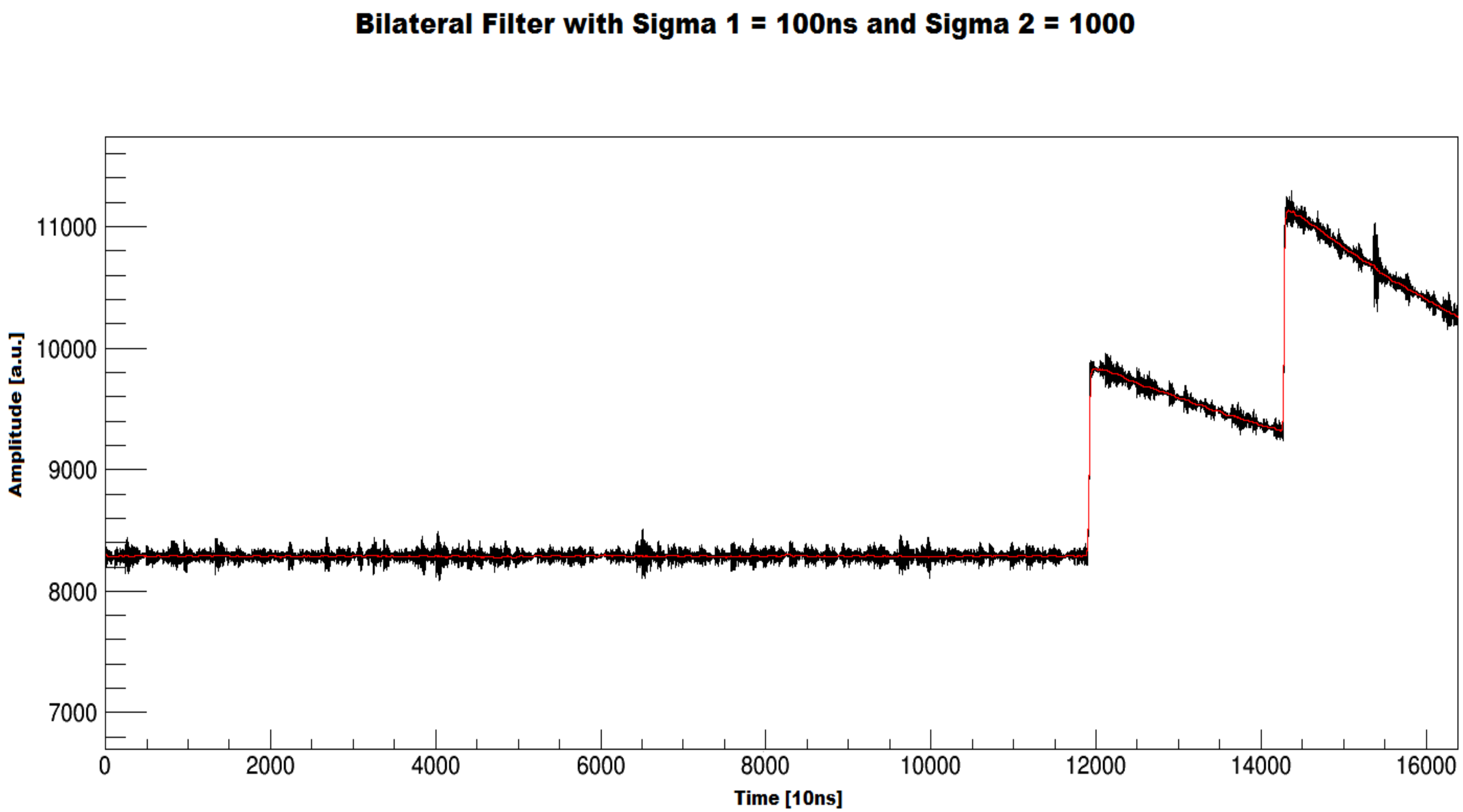
Smoothing

Bilateral Filter with Sigma 1 = 1µs and Sigma 2 = 100



➡ **Find Sigma 1 and Sigma 2 for best results**

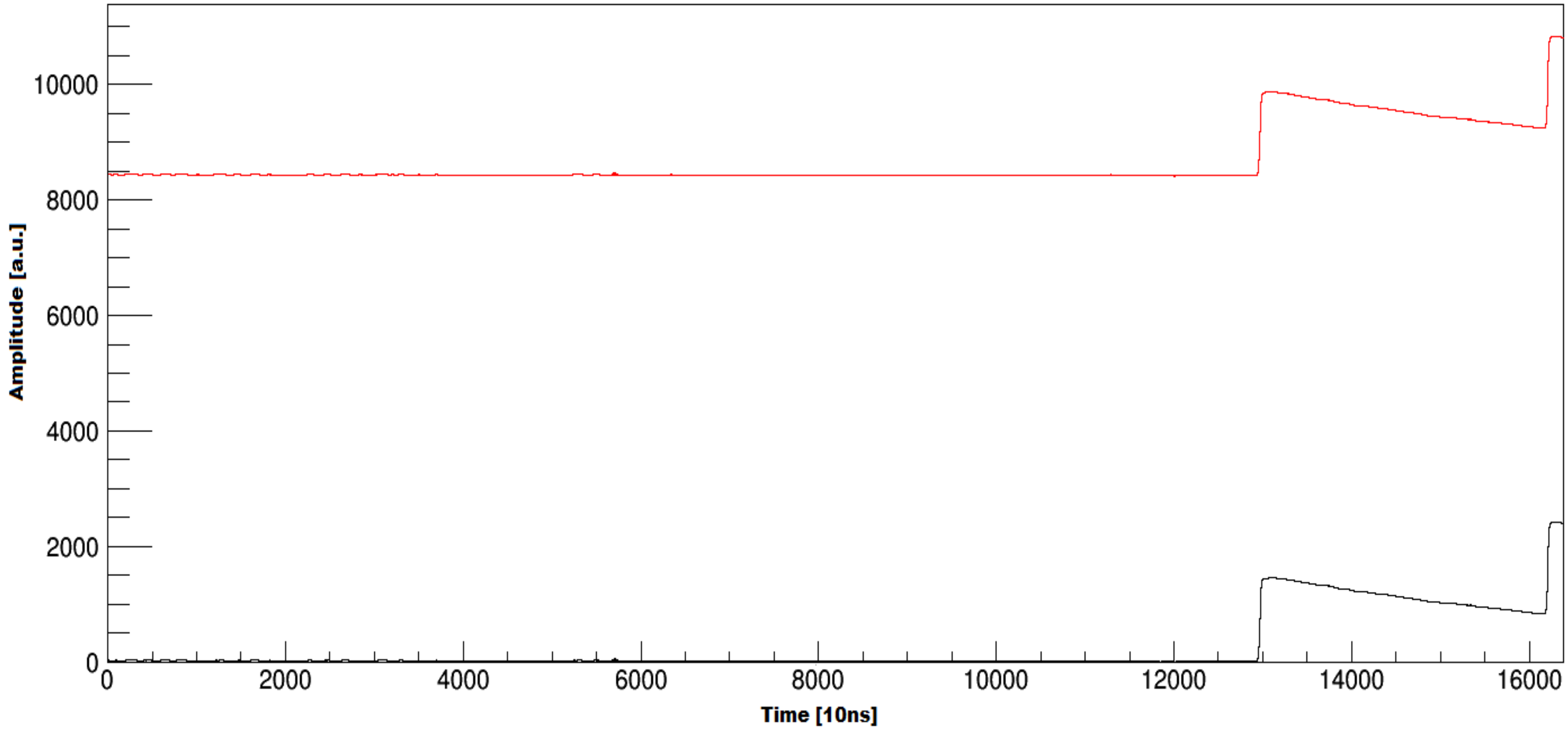
Smoothing



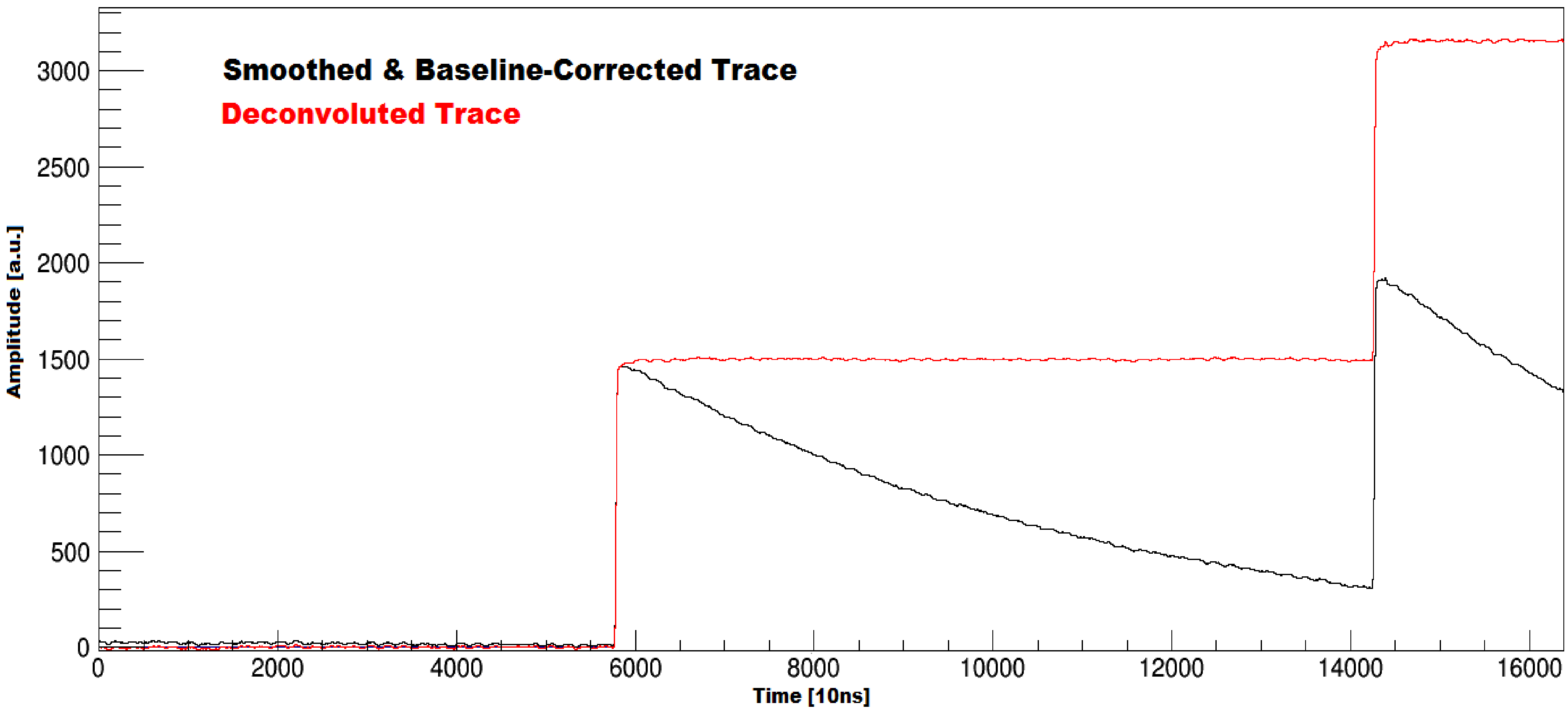
Bilateral Filter with Sigma 1 = 100ns and Sigma 2 = 1000
Amplitude [a.u.]
11000
10000
9000
8000
7000
0
2000
4000
6000
8000
10000
12000
14000
16000
Time [10ns]

Baseline Correction

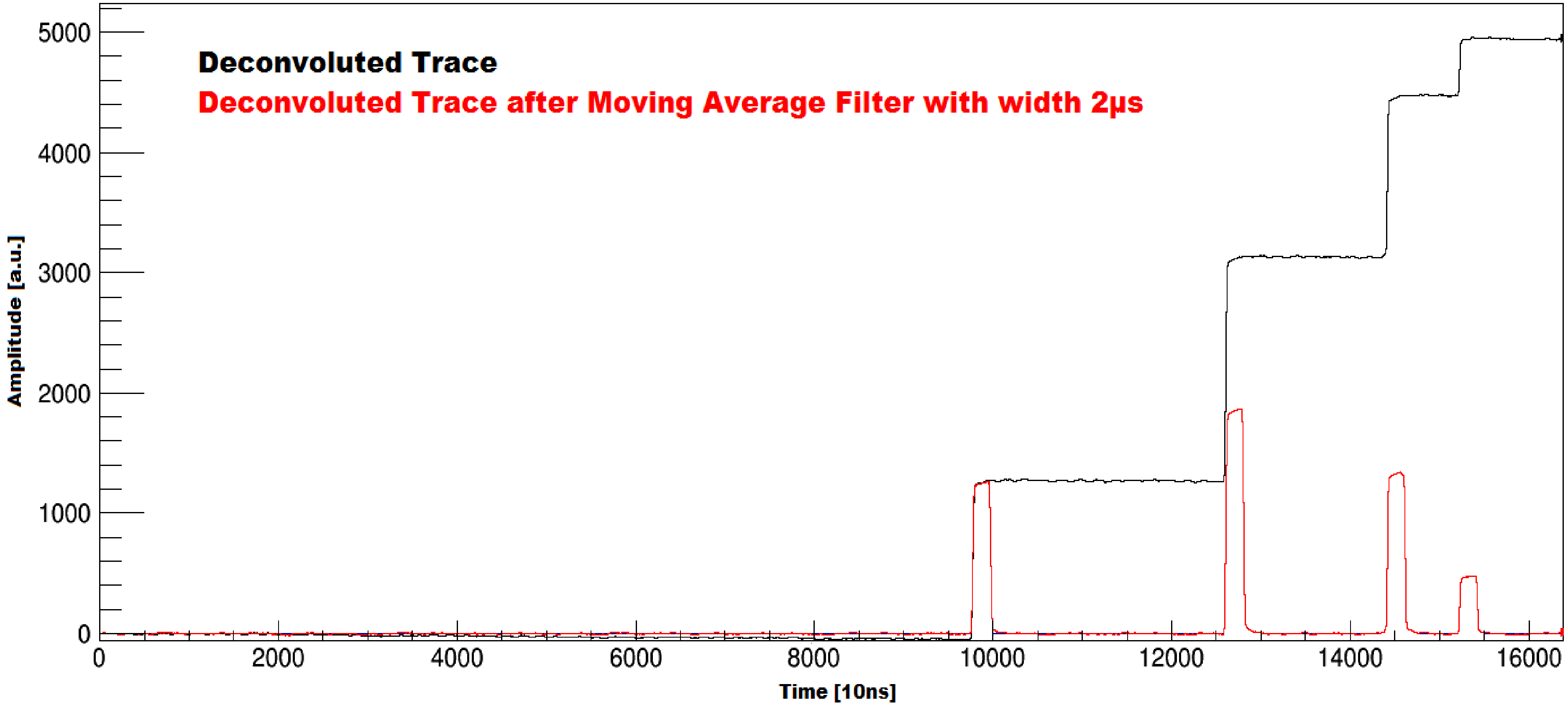
Subtraction of the mean of a defined minimum range from every data point



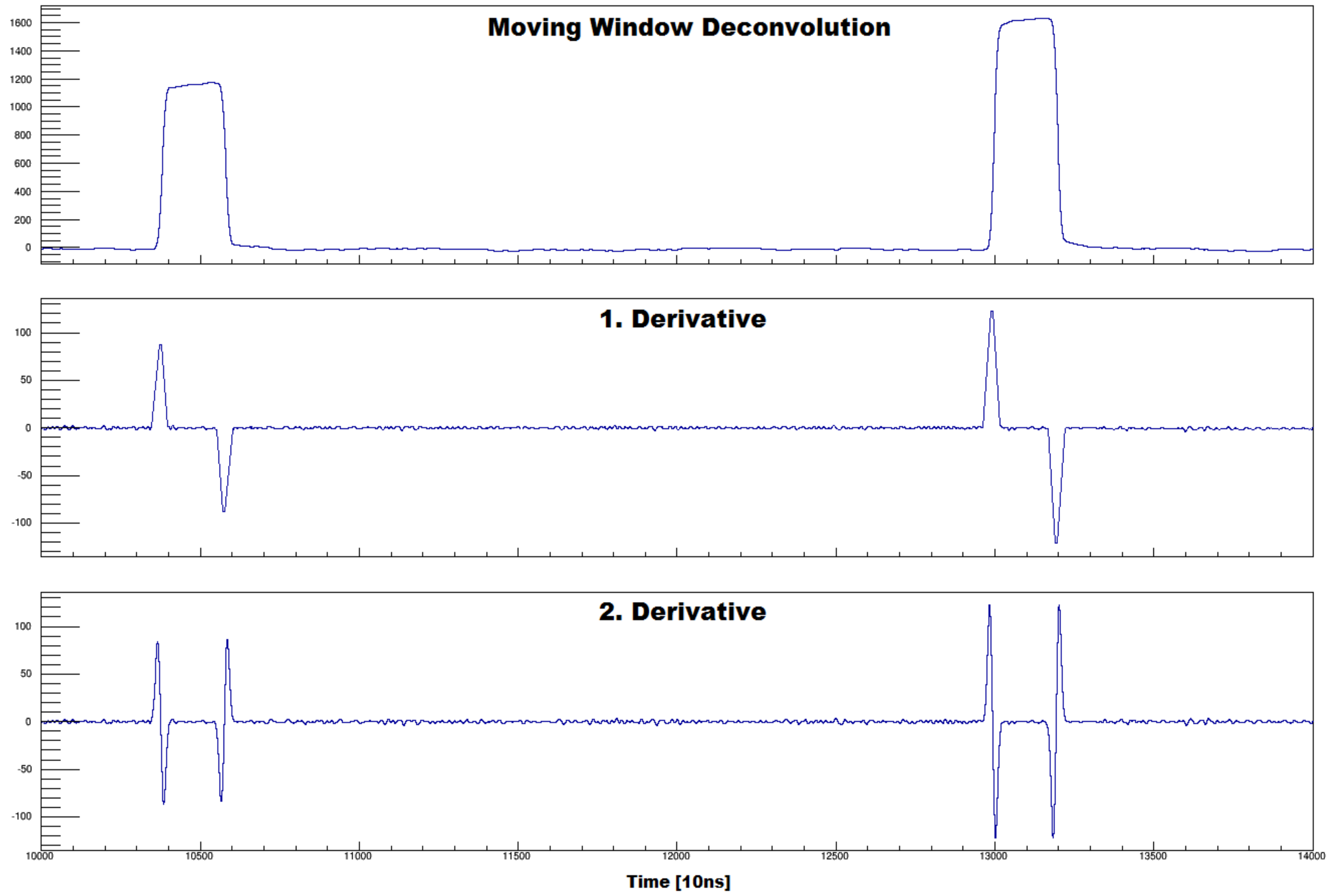
Deconvolution



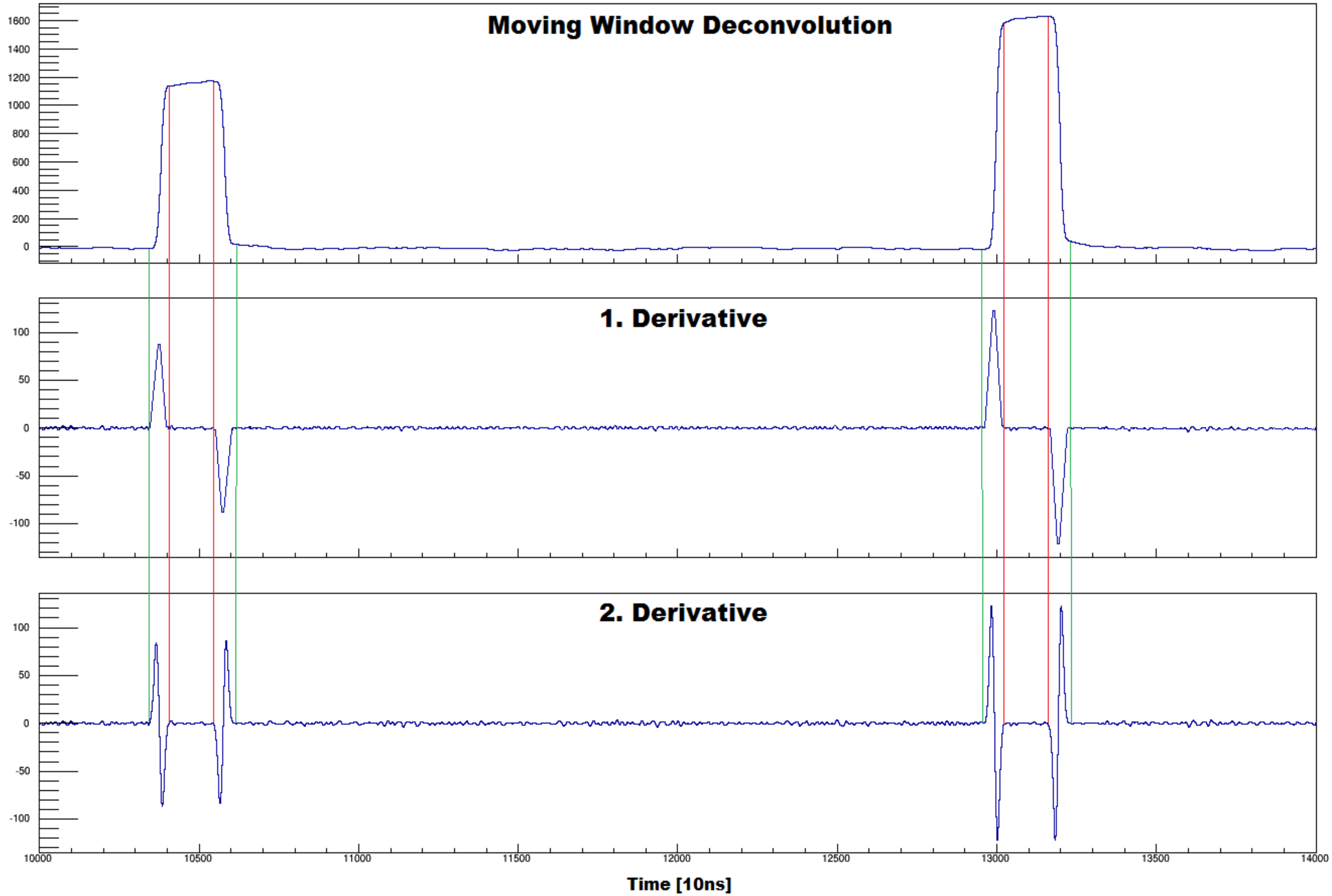
Moving Average Filter



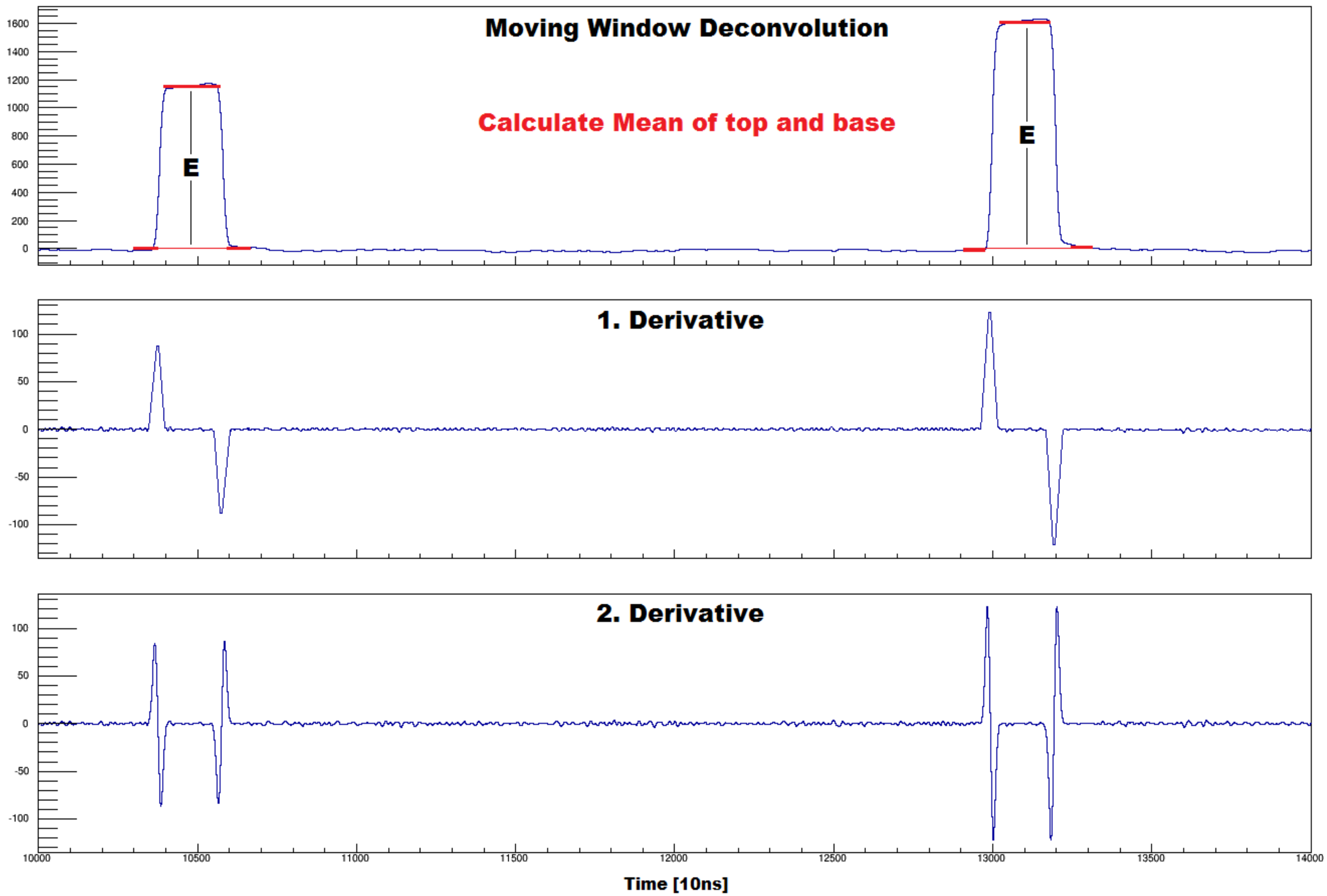
Energyspectrum



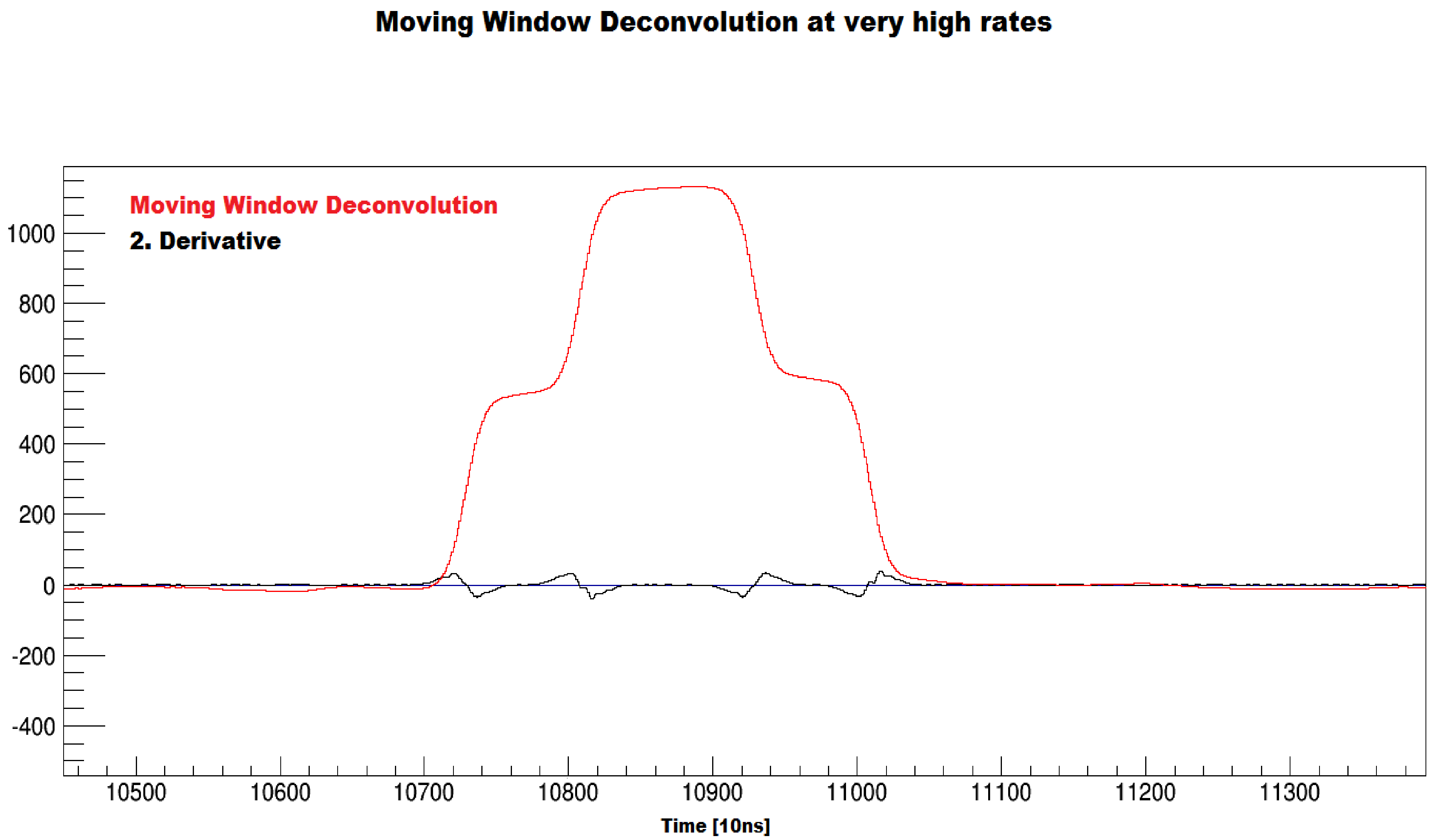
Energyspectrum



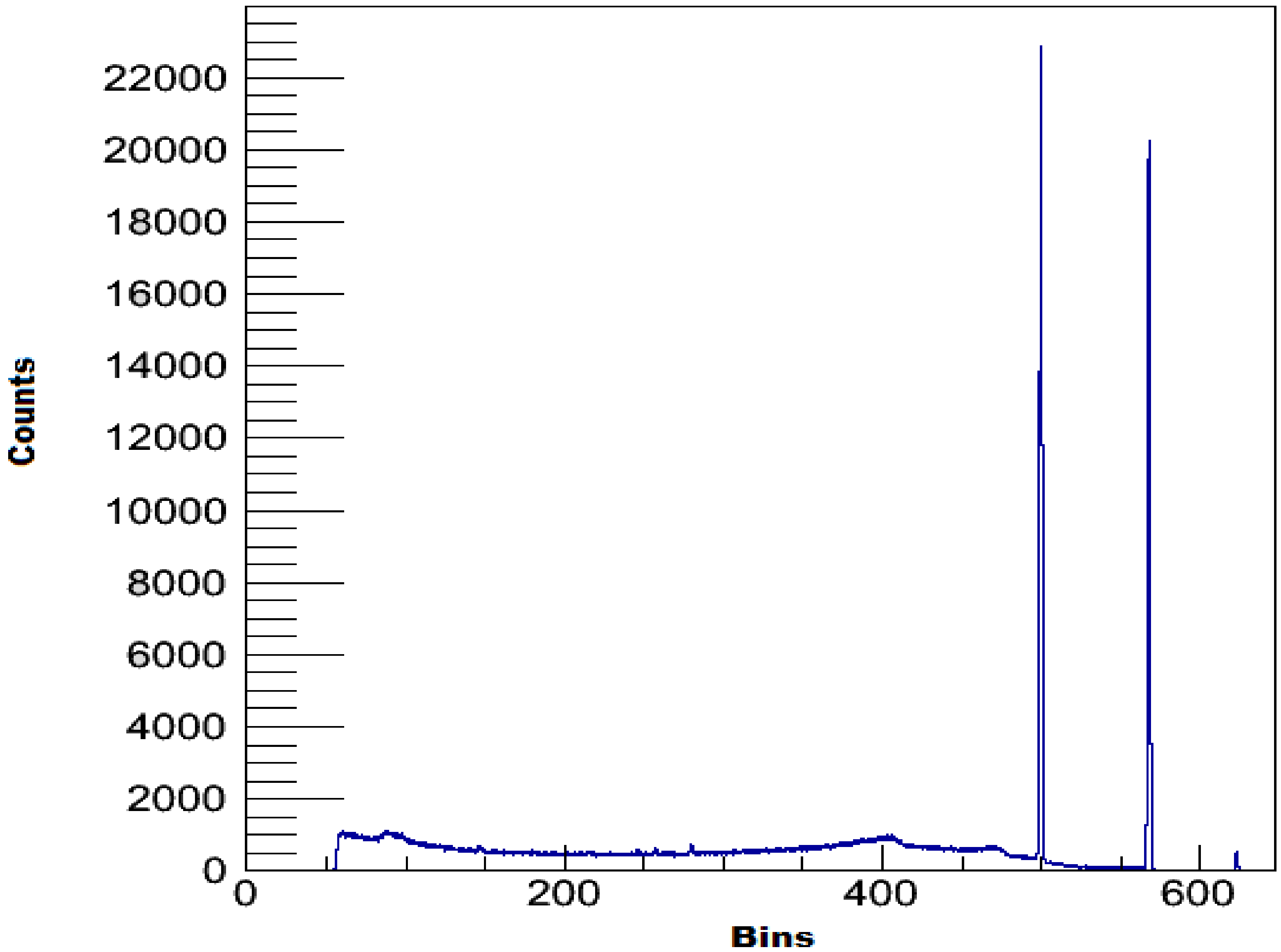
Energyspectrum



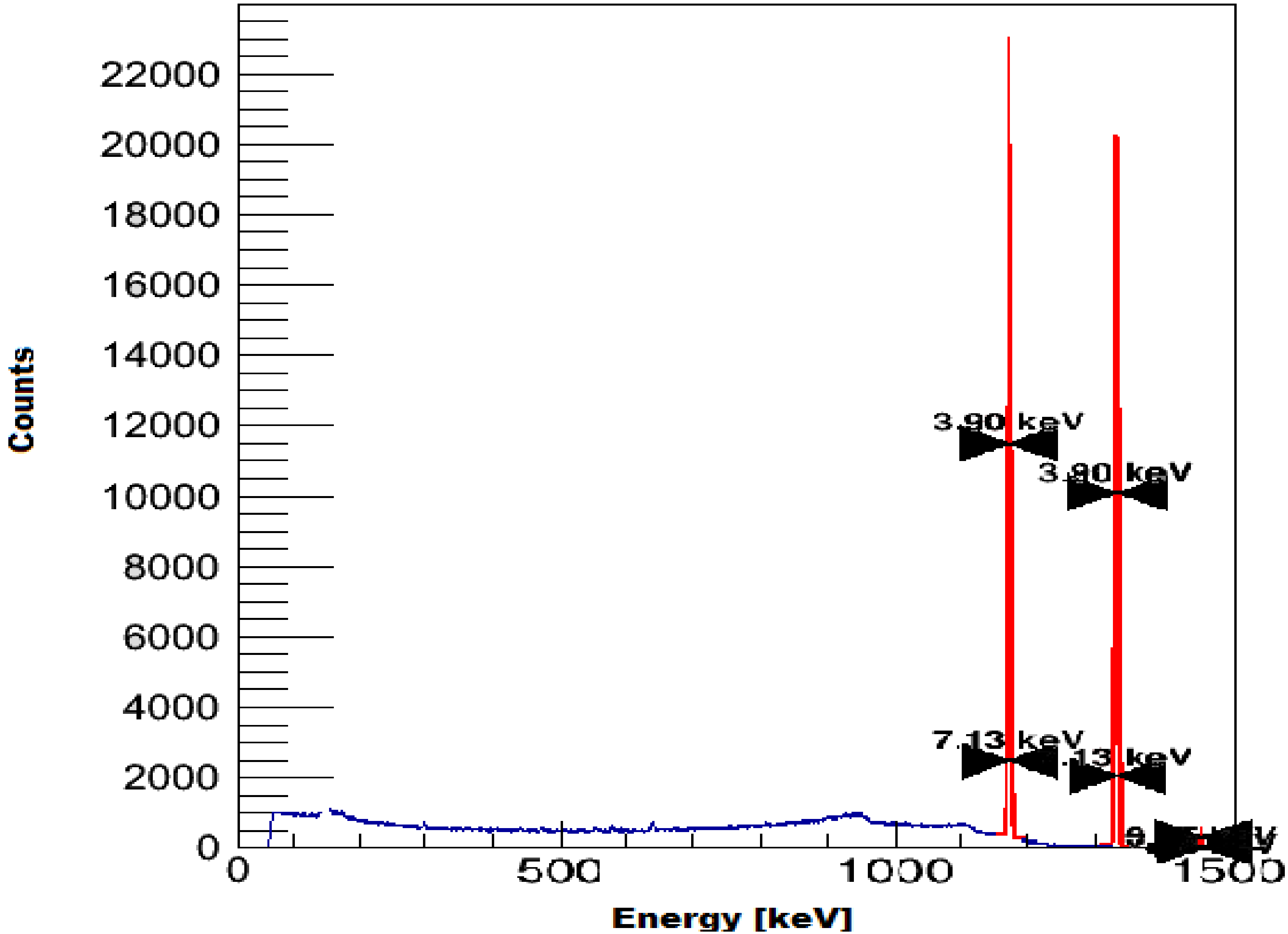
Energyspectrum



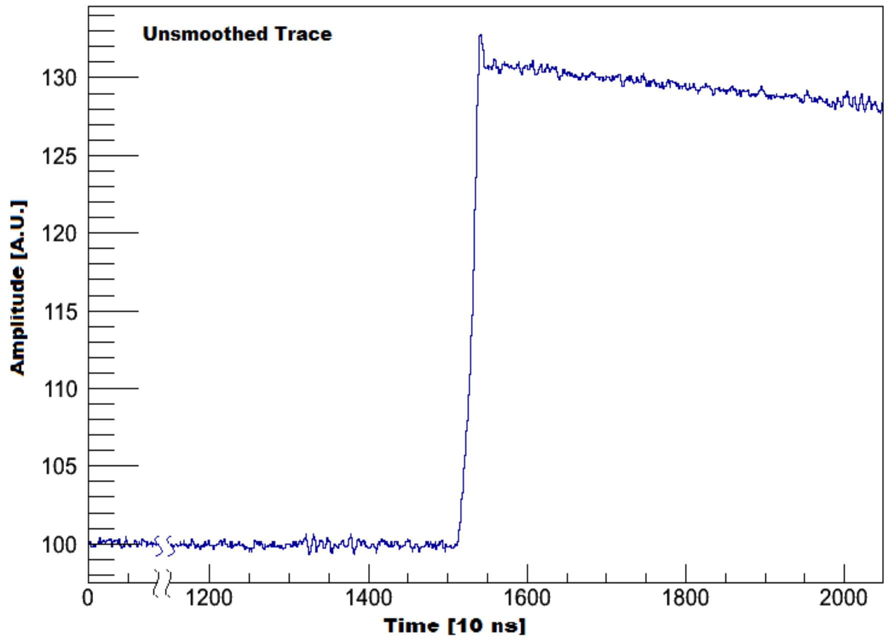
Spectrum of ^{60}Co

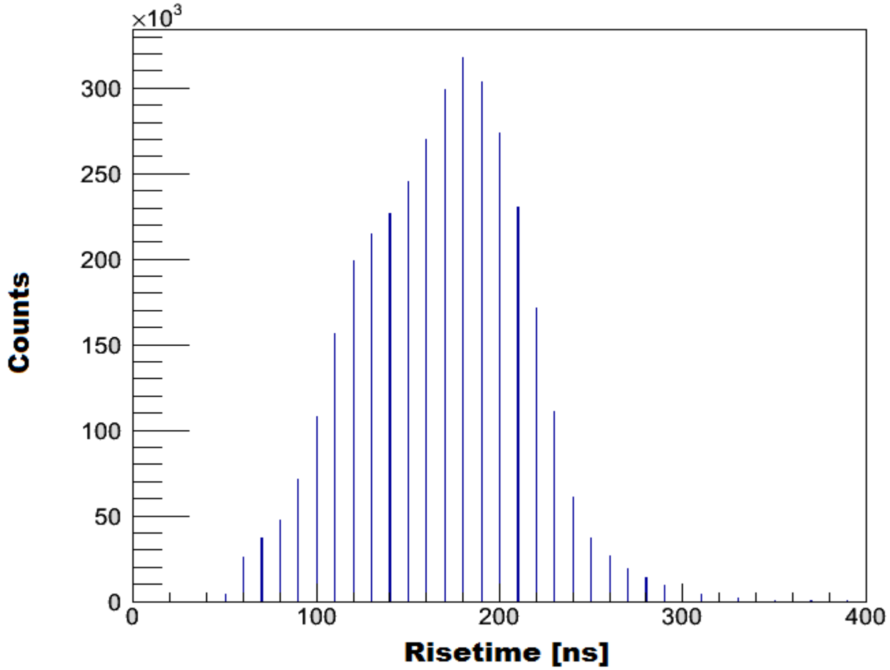


Spectrum of ^{60}Co

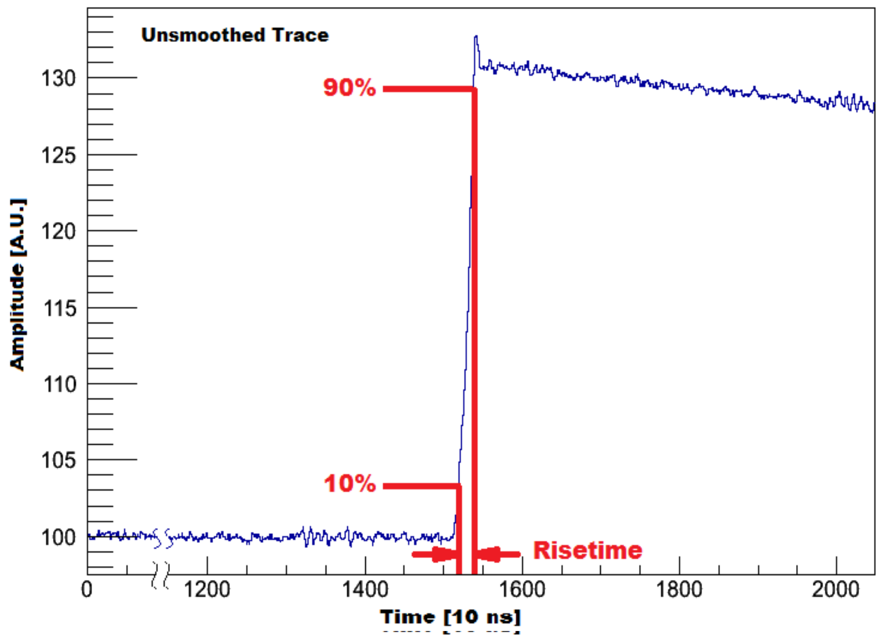


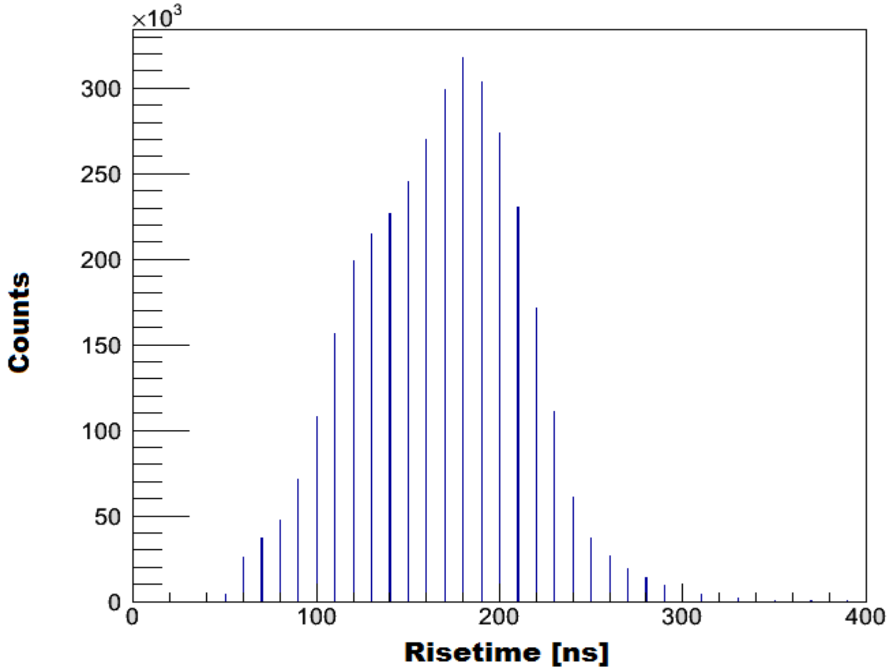
Risetime


Unsmoothed Trace
Amplitude [A.U.]
Time [10 ns]
100
105
110
115
120
125
130
0
1200
1400
1600
1800
2000

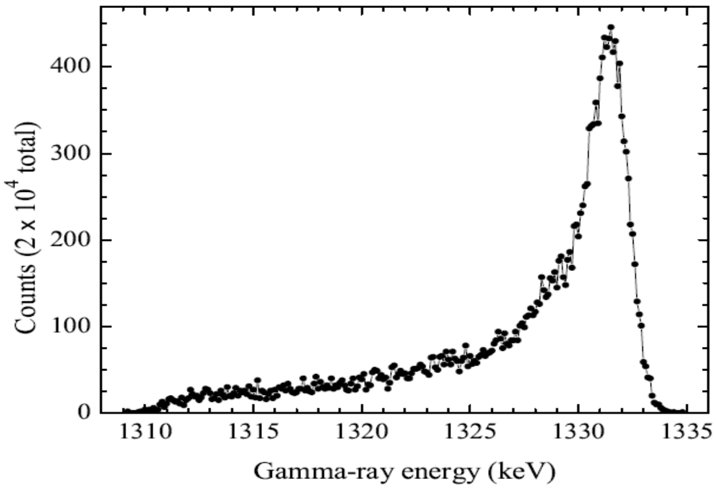

$\times 10^3$
Counts
Risetime [ns]
0
50
100
150
200
250
300
0
100
200
300
400

Risetime

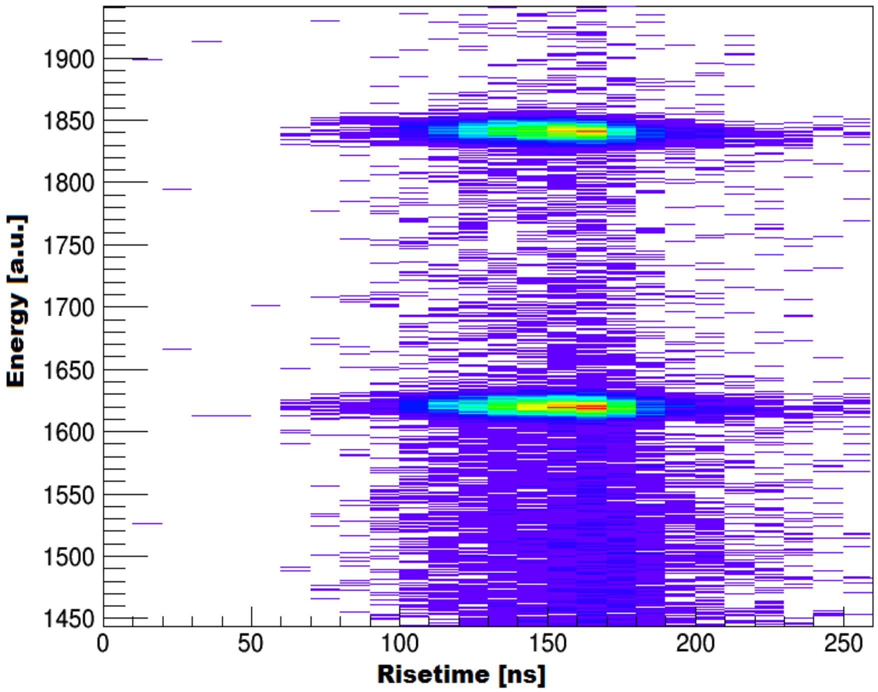

Unsmoothed Trace
90%
10%
Risetime
Amplitude [A.U.]
130
125
120
115
110
105
100
0
1200
1400
1600
1800
2000
Time [10 ns]


$\times 10^3$
300
250
200
150
100
50
0
Counts
0
100
200
300
400
Risetime [ns]

Examination of neutron damages



Peak corresponding to the 1332 keV ^{60}Co spectral line obtained by the n-type detector model for a neutron fluence of 10^{10} cm^{-2}.
C. DeW. Van Siclen, E. H. Seabury, C. J. Wharton, and A. J. Caffrey



Changes in Correlation?

Polynomial Fit of Peaks in Correlation

Correction of Energyspectrum

Summary & Outlook

Original Trace → Smoothing Filter → Baseline Correction → Moving Window Deconvolution →

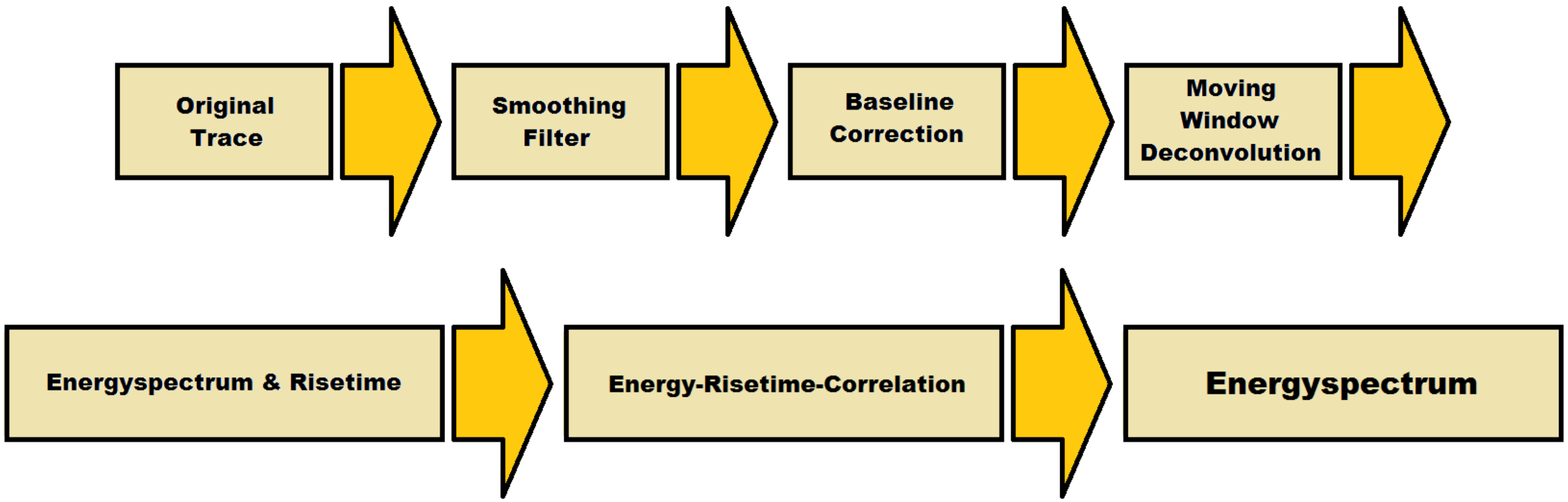
Energyspectrum & Risetime → Energy-Risetime-Correlation → Energyspectrum

In Progress:

Examination of Energyresolution in dependency of

- Smoothing Methods
- Smoothing Parameters
- Window Width of Moving Average Filter
- Neutron Damages

Summary & Outlook



In Progress:

Examination of Energyresolution in dependency of

- **Smoothing Methods**
- **Smoothing Parameters**
- **Window Width of Moving Average Filter**
- **Neutron Damages**

Thanks for your attention!