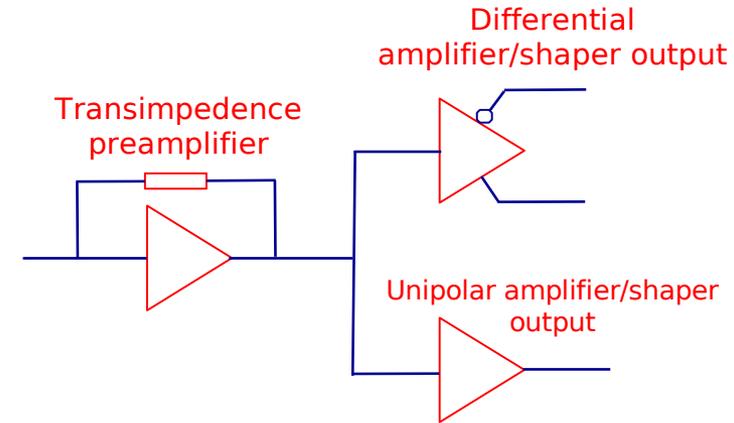
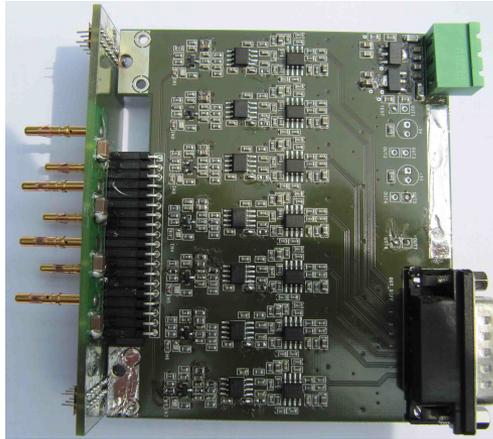


Front-end and Counting Algorithms on Cluster Counting

LNF GM December 2011

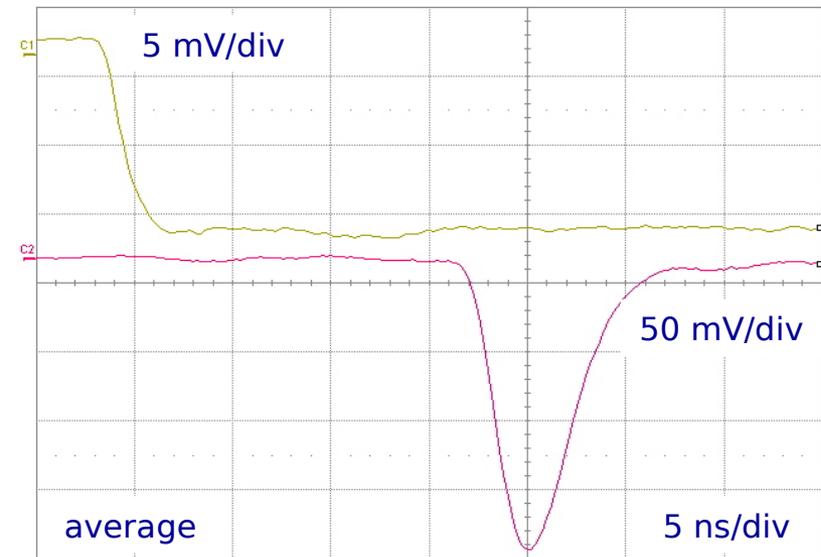
1. *Preamplifier Impulse response estimation*
1. *Garfield simulation*
1. *Convolution effects on the generated signal*
1. *Counting algorithms*
1. *Gaussian noise effects on counting algorithm*
1. *Conclusions*

Preamplifier Board



Preamplifier main features

- Number of channels : 7
- $Z_{in} \approx 60 \Omega$
- Gain $\approx 8.8 \text{ mV/fC}$
- Noise $\approx 2500 \text{ erms @ 250 MHz BW}$
- Rise time $\approx 2.4 \text{ ns}$
- Unipolar & Differential outputs ($50 \Omega - 110 \Omega$)
- Test input
- Supply Voltage : + 7V (310 mA) - 7V (190 mA)
- Power Dissipation : 490 mW/ch



1.8 pF injecting capacitance

Preamplifier Impluse Response Fitting



- Preamplifier board has been connected to the chamber and pulsed through a 1.8 pF internal capacitor.
- Output pulse has been fitted to find out the preamplifier impulse response.

Fitting function:

$$\text{Shape} = a1 * \exp(-((t-b1)/c1).^2) + a2 * \exp(-((t-b2)/c2).^2)$$

Where:

$$A1 = 0.479$$

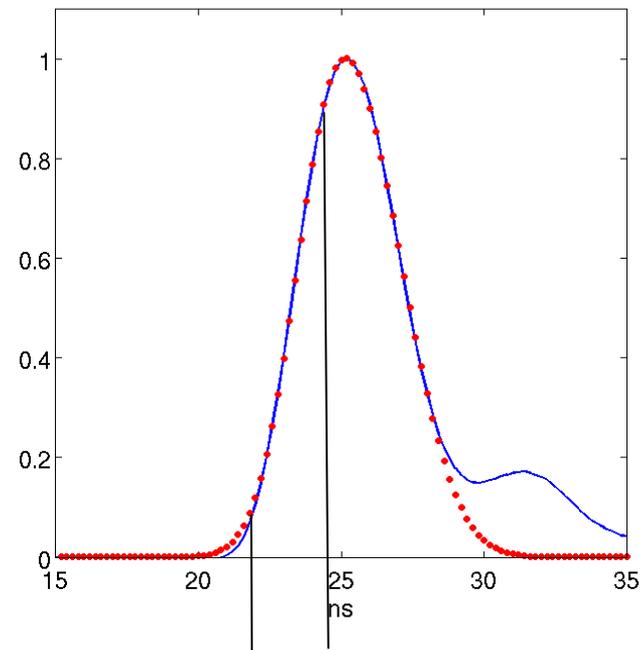
$$B1 = 24.367$$

$$C1 = 1.797$$

$$A2 = 0.691$$

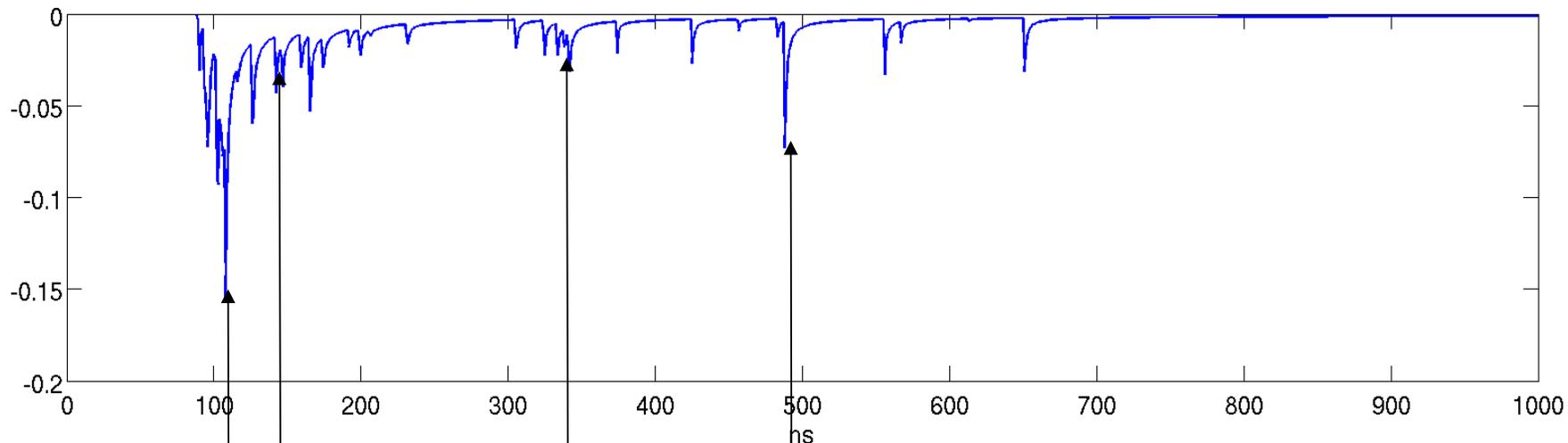
$$B2 = 25.983$$

$$C2 = 2.305$$

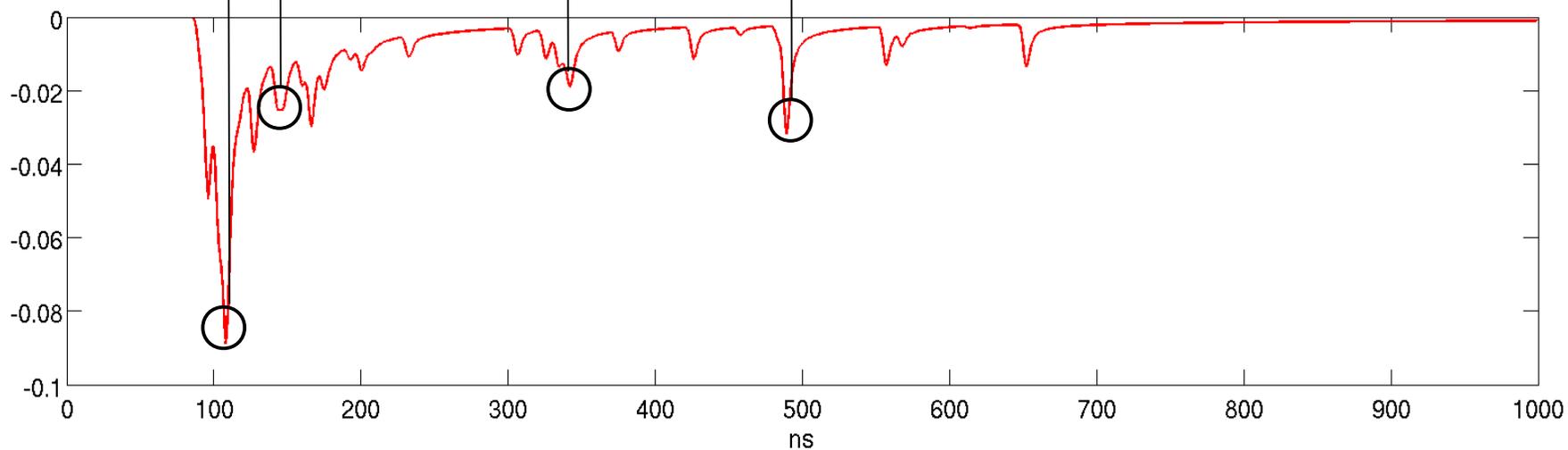


Preamplifier response convolution example #1

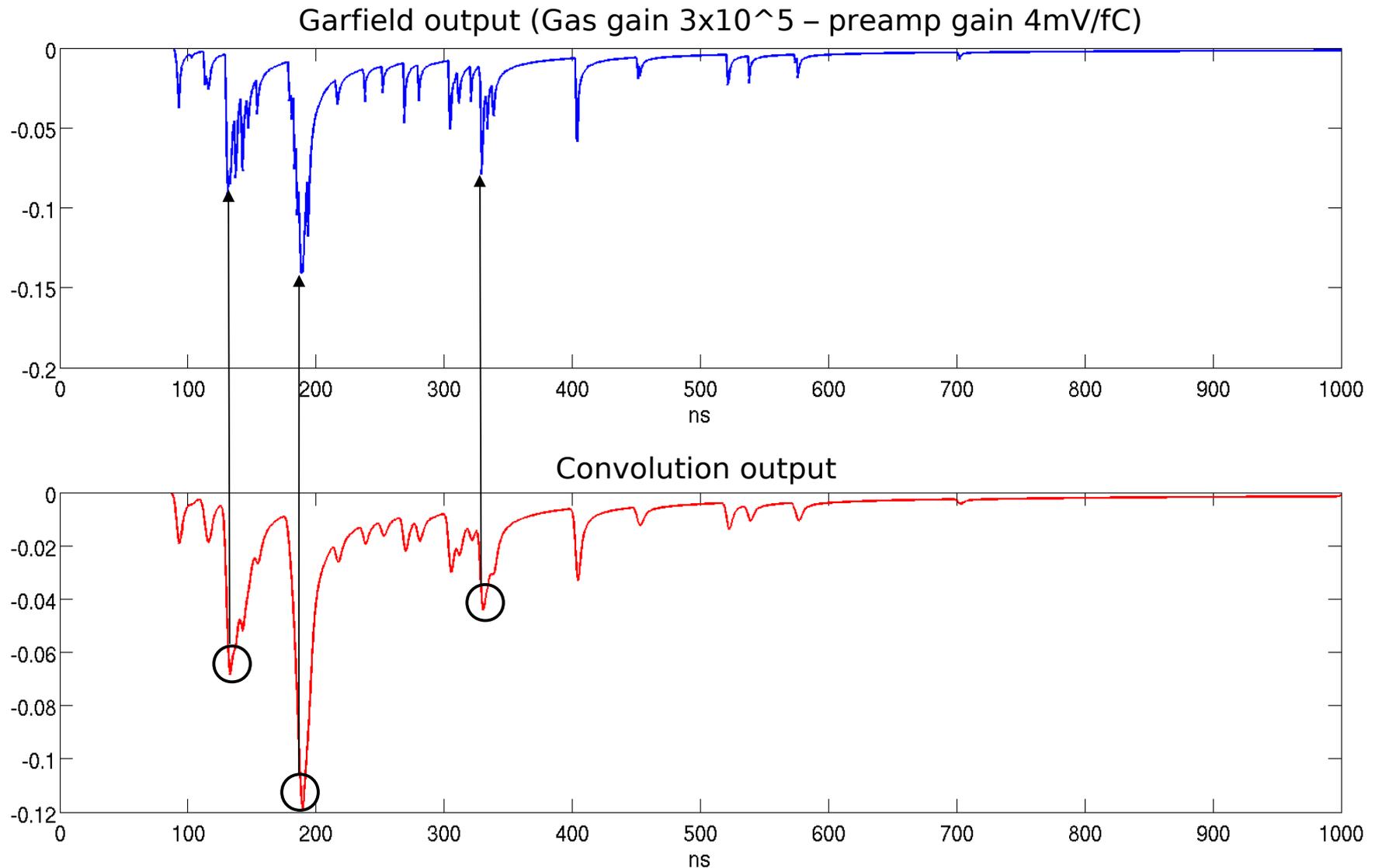
Garfield output (Gas gain 3×10^5 – preamp gain 4mV/fC)



Convolution output

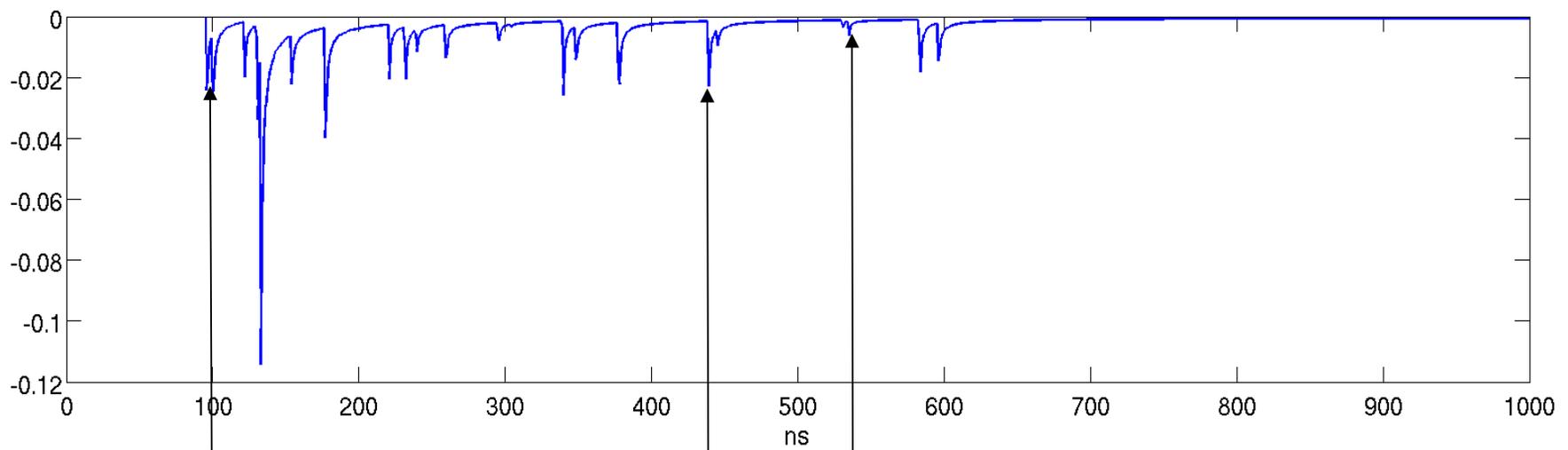


Preamplifier response convolution example #2

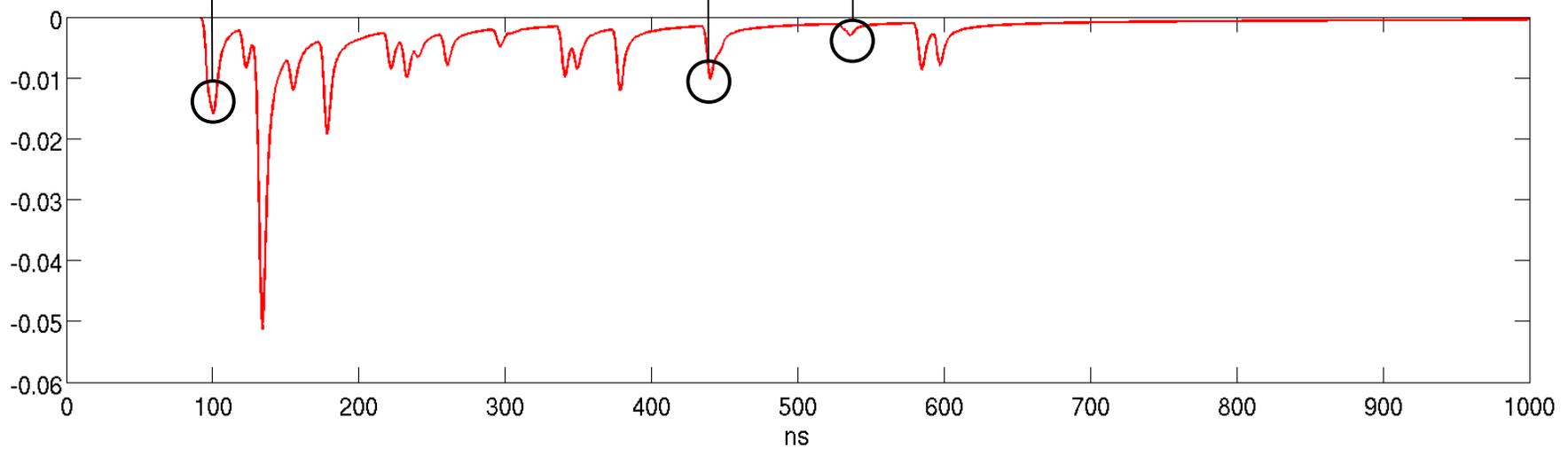


Preamplifier response convolution example #3

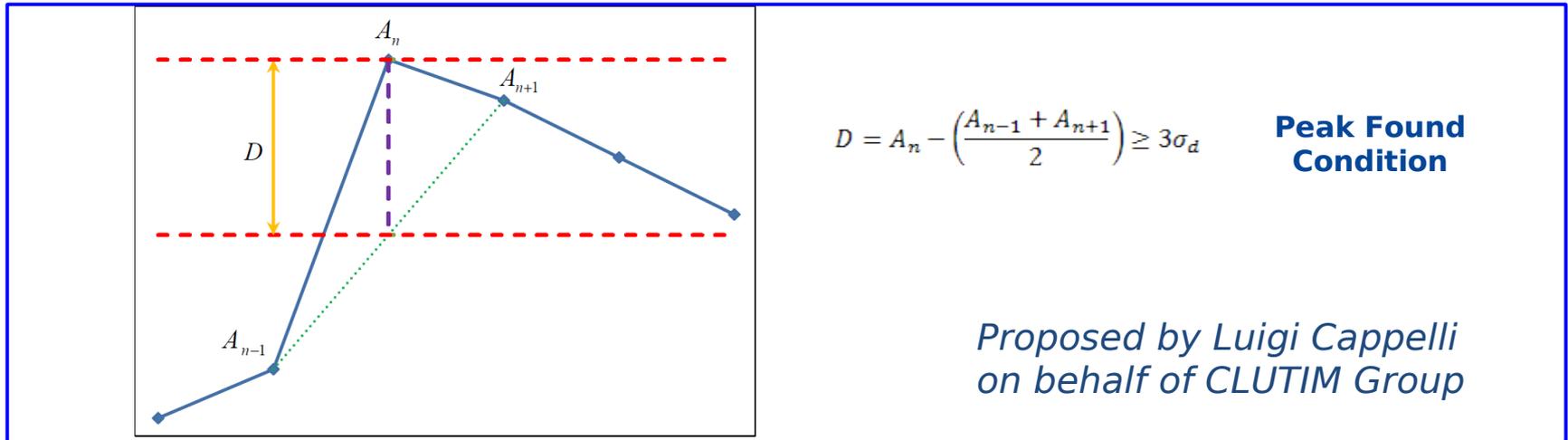
Garfield output (Gas gain 3×10^5 – preamp gain 4mV/fC)



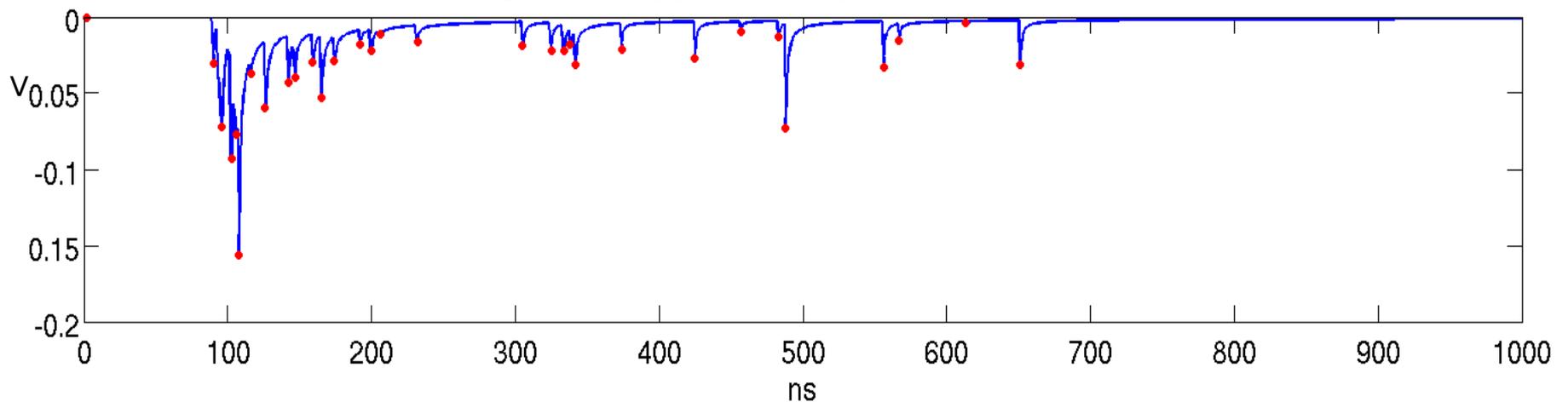
Convolution output



Cluster counting algorithm

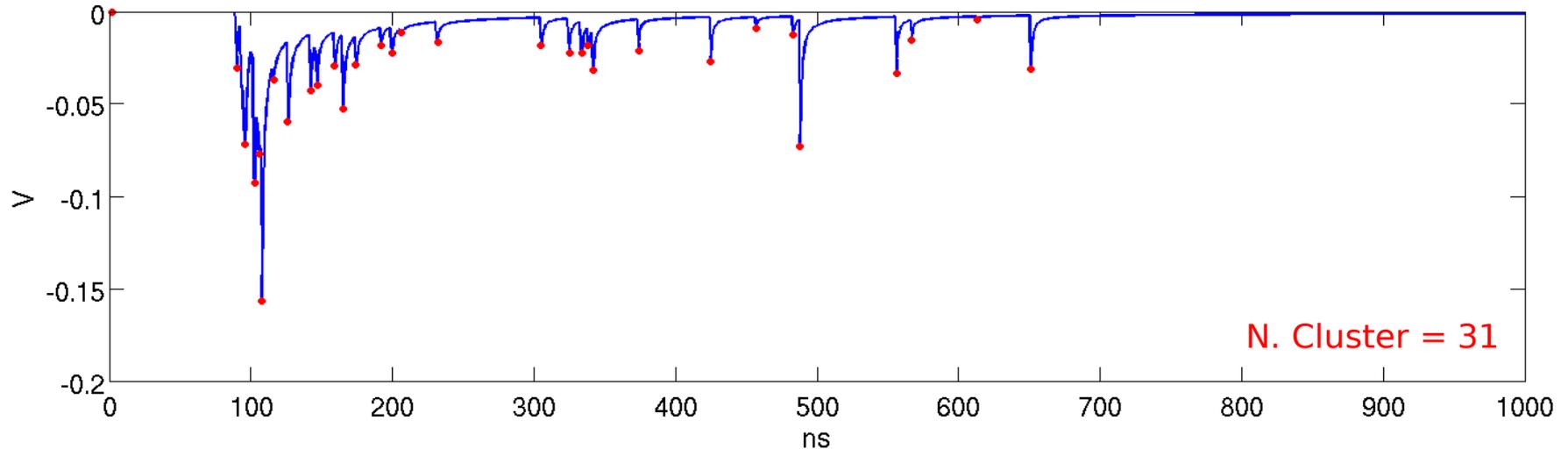


Algorithm applied to a garfield data set

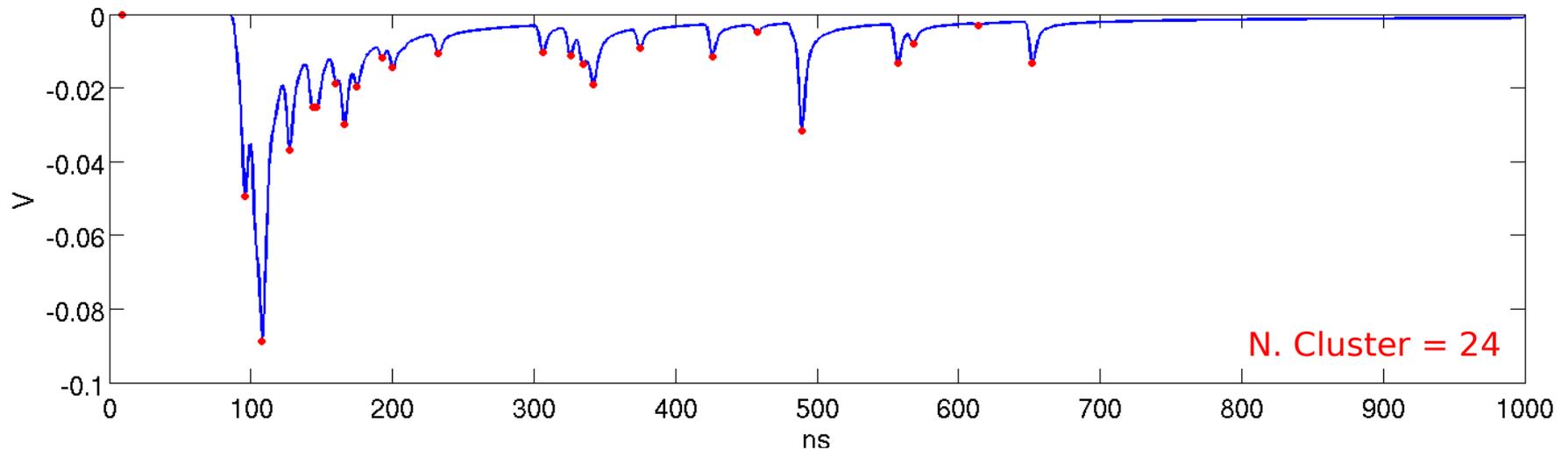


Counting Algorithm applied to example #1

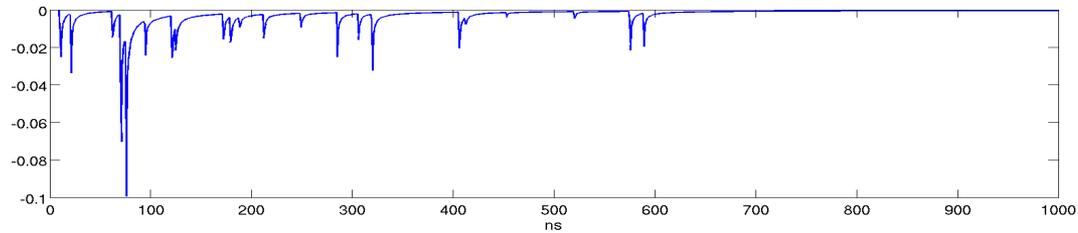
Garfield output (Gas gain 3×10^5 – preamp gain 4mV/fC)



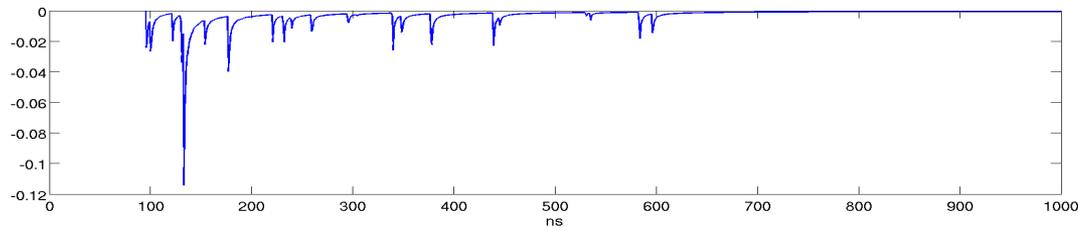
Convolution output



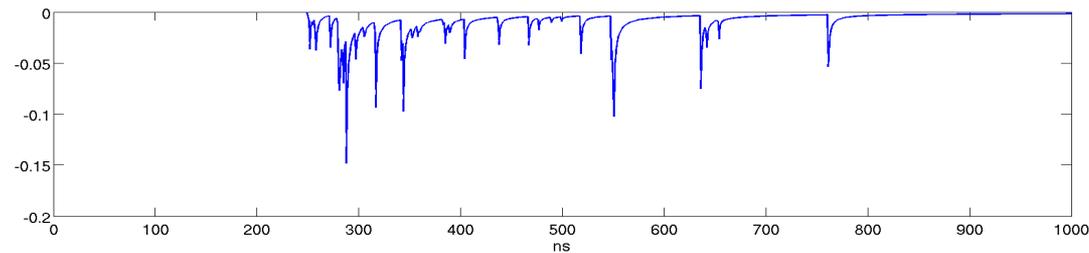
Garfield output (Gas gain 3×10^5 – preamp gain 4mV/fC)



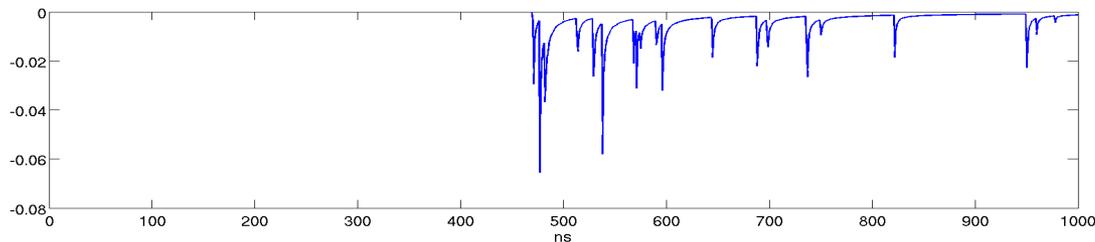
Impact parameter = 0 mm



Impact parameter = 2.5 mm



Impact parameter = 5.0 mm



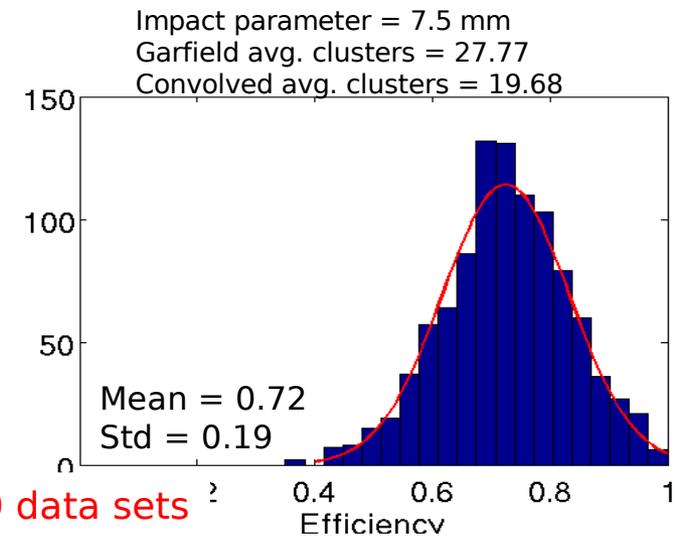
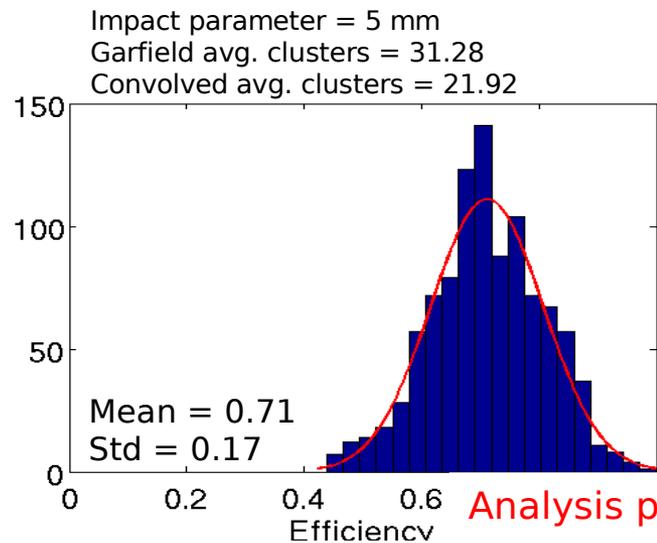
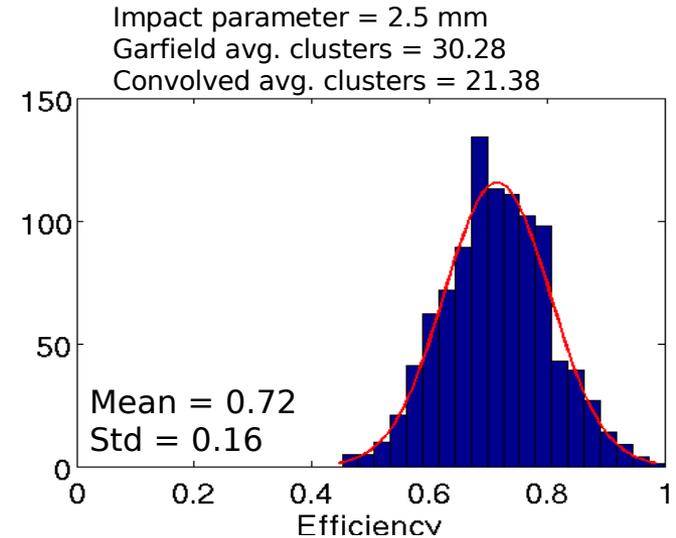
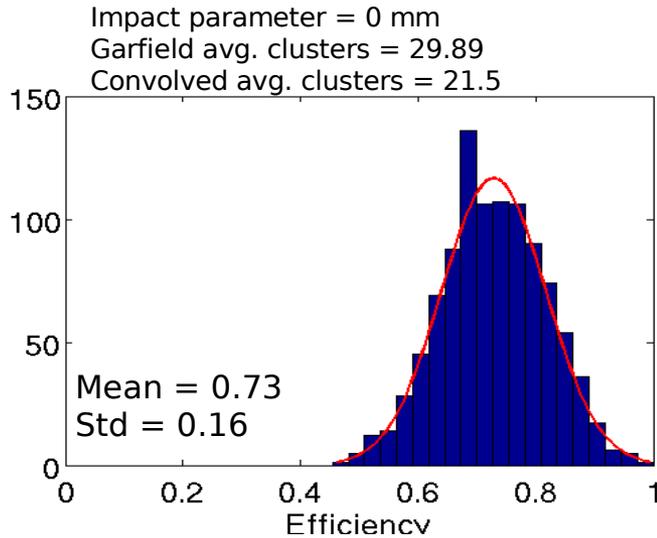
Impact parameter = 7.5 mm

Counting Algorithm @ different impact parameters

Efficiency = Mnc/Rnc

Rnc = Real Number of Clusters

Mnc = Measured Number of Cluster after convolution and noise addition



Analysis performed on 1000 data sets

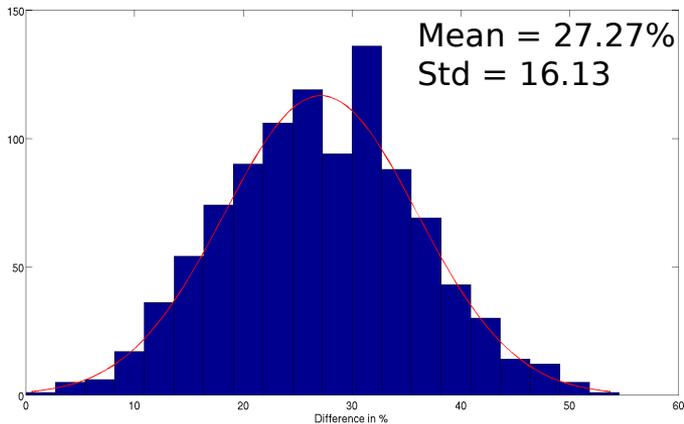
Counting Algorithm @ different impact parameters

$$\% \text{ of Detected Cluster} = (R_{nc} - M_{nc}) / R_{nc} * 100$$

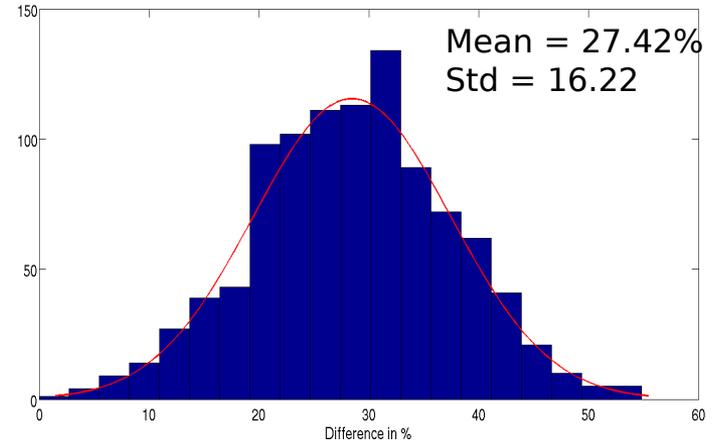
R_{nc} = Real Number of Clusters

M_{nc} = Measured Number of Cluster after convolution and noise addition

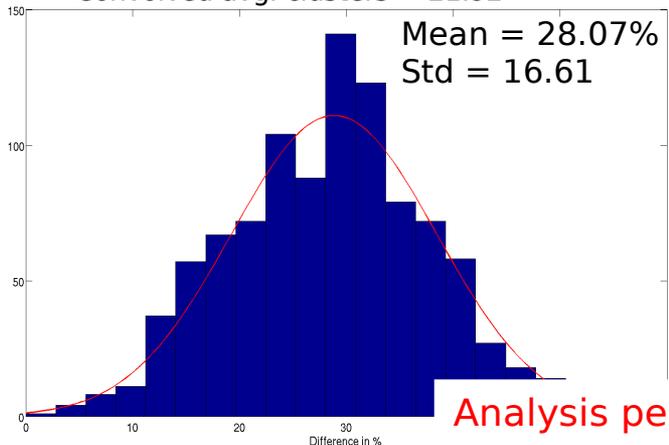
Impact parameter = 0 mm
 Garfield avg. clusters = 29.89
 Convolved avg. clusters = 21.5



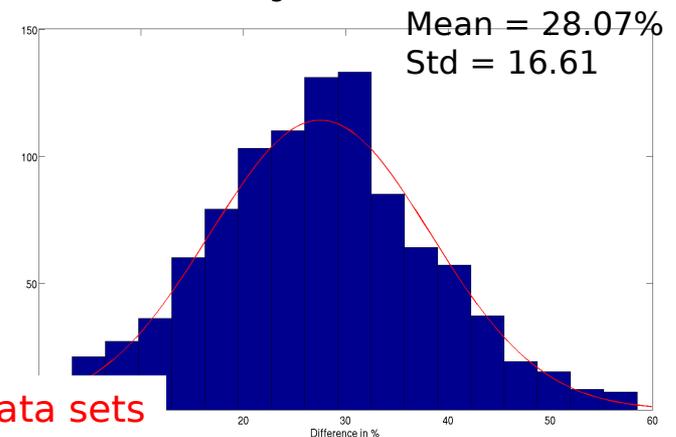
Impact parameter = 2.5 mm
 Garfield avg. clusters = 30.28
 Convolved avg. clusters = 21.38



Impact parameter = 5 mm
 Garfield avg. clusters = 31.28
 Convolved avg. clusters = 21.92



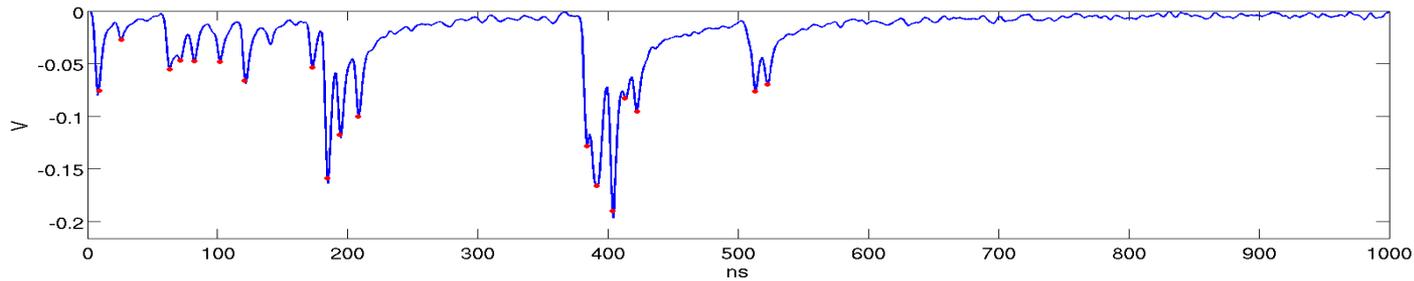
Impact parameter = 7.5 mm
 Garfield avg. clusters = 27.77
 Convolved avg. clusters = 19.68



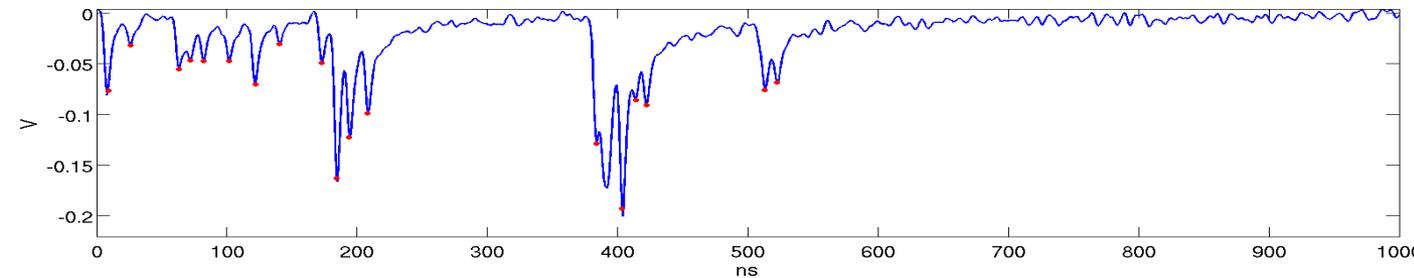
Analysis performed on 1000 data sets

Noise Effect on Convolved Signal

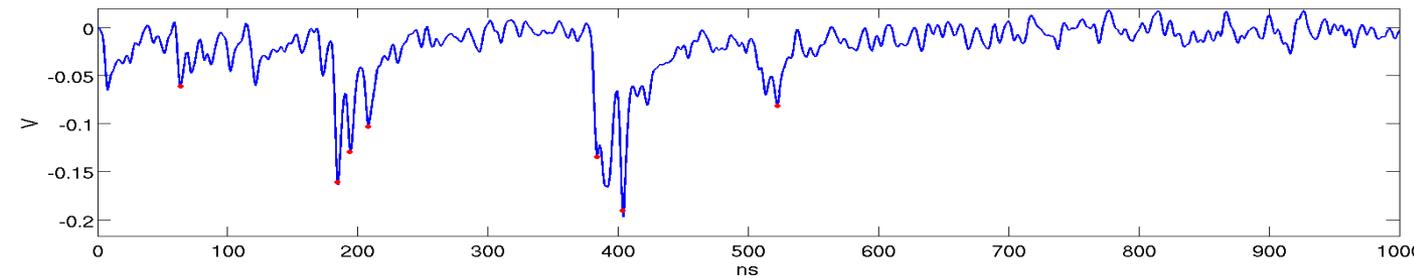
SNR evaluated considering single electron cluster average amplitude (~10mV)



SNR=10



SNR=6

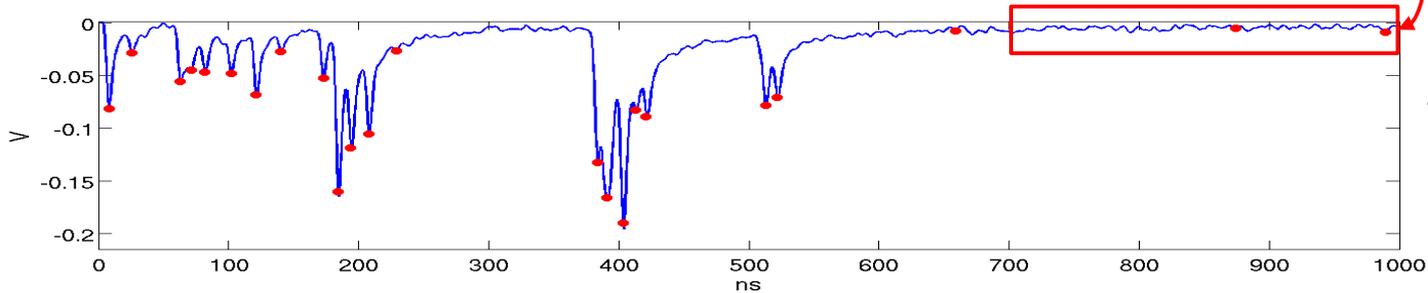


SNR=2

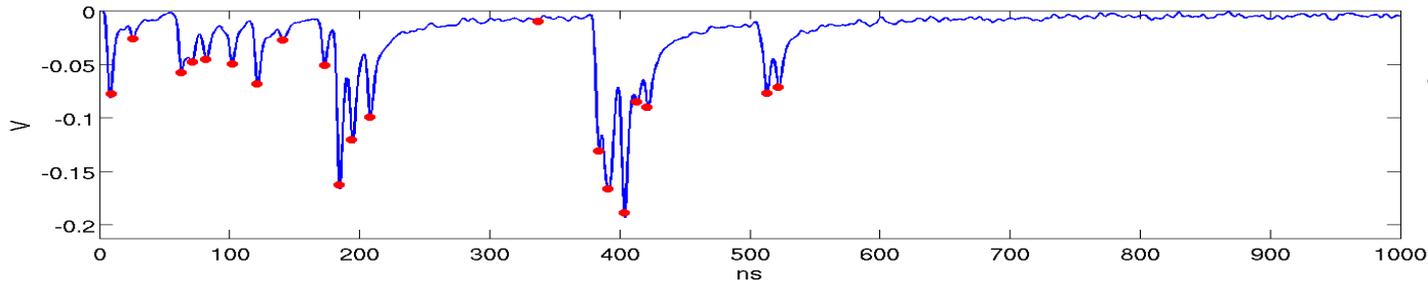
SNR=Signal Amplitude/Noise RMS

Threshold effect on cluster counting at constant SNR

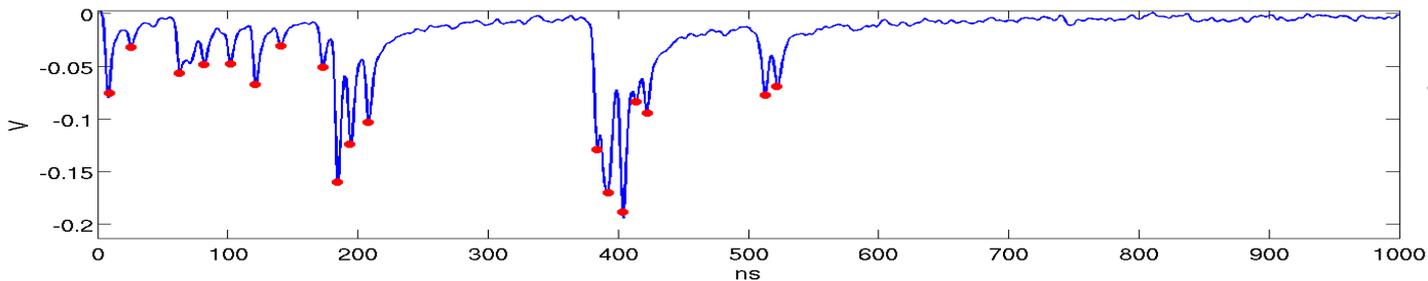
The RMS of the noise is evaluated on the last 300 samples



Thr = $0.8 * RMS_{Noise}$
N. clusters = 23



Thr = $1.0 * RMS_{Noise}$
N. clusters = 20



Thr = $1.5 * RMS_{Noise}$
N. clusters = 18

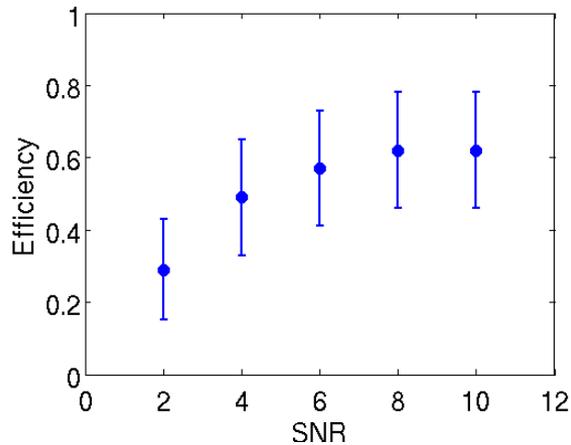
Detected Clusters vs SNR at 1.5* sigma threshold

Efficiency = M_{nc}/R_{nc}

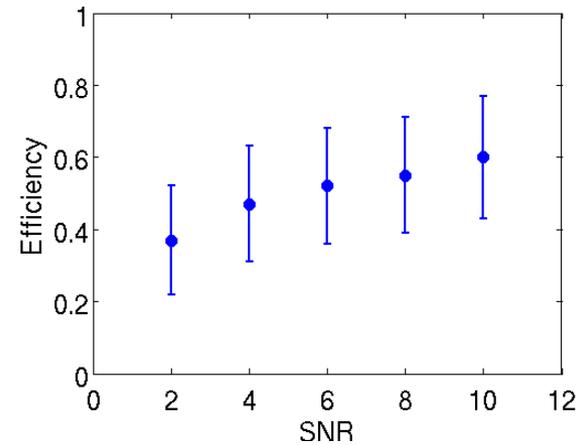
R_{nc} = Real Number of Clusters

M_{nc} = Measured Number of Cluster after convolution and noise addition

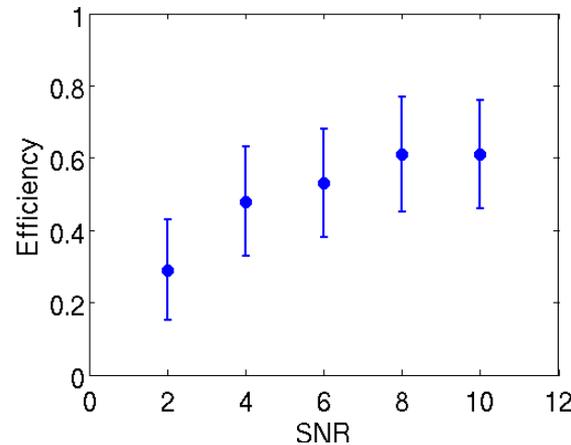
Impact parameter = 0 mm



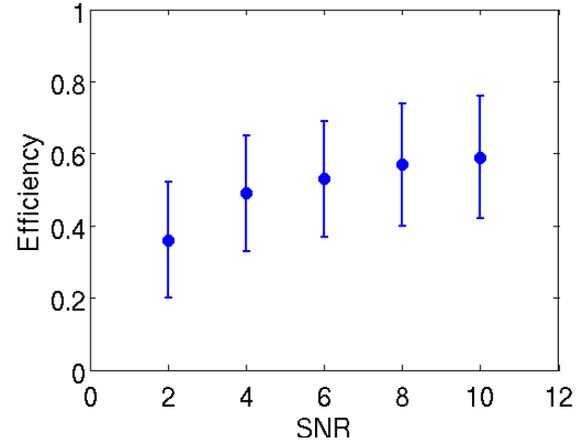
Impact parameter = 2.5 mm



Impact parameter = 5 mm



Impact parameter = 7.5 mm



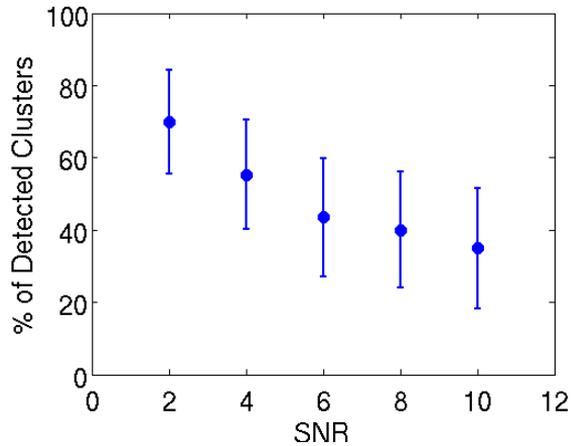
Detected Clusters vs SNR at 1.5* sigma threshold

$$\% \text{ of Detected Cluster} = (R_{nc} - M_{nc}) / R_{nc} * 100$$

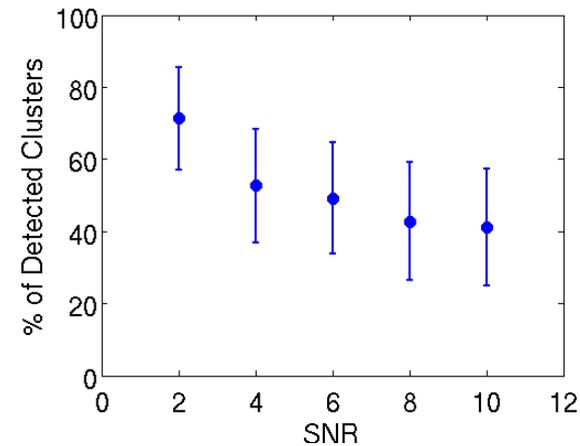
R_{nc} = Real Number of Clusters

M_{nc} = Measured Number of Cluster after convolution and noise addition

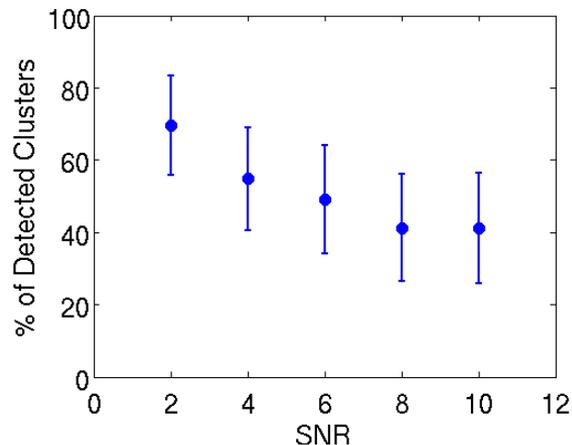
Impact parameter = 0 mm



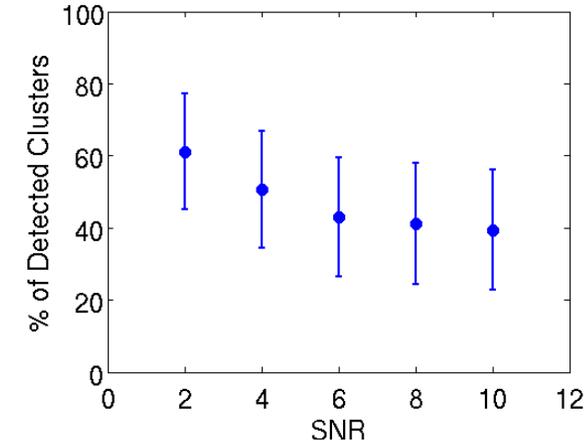
Impact parameter = 2.5 mm



Impact parameter = 5 mm



Impact parameter = 7.5 mm



Garfield output has not been tuned to real signals in particular concerning gas amplification fluctuation.

We have carried out a cluster counting feasibility study using an algorithm that can be easily implemented on an FPGA.

The analysis have been performed using data set based on garfield simulations at different impact parameters.

Results show that after garfiled data convolution with preamplifier response there is a loss of about 28% in detected clusters for different impact parameters.

The addition of Gaussian noise with different SRN increase the counting inefficiency from 40% (SNR=10) to about 70% (SNR=2). In any case results show huge fluctuations in the counted clusters due to the noise contribution.