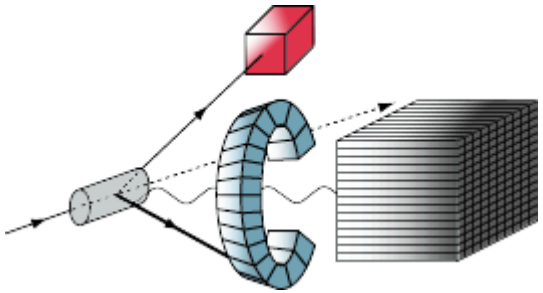
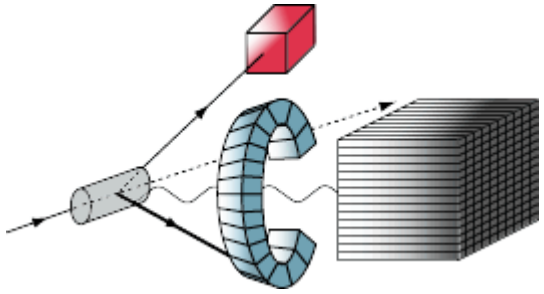


DVCS Software Waveform analysis

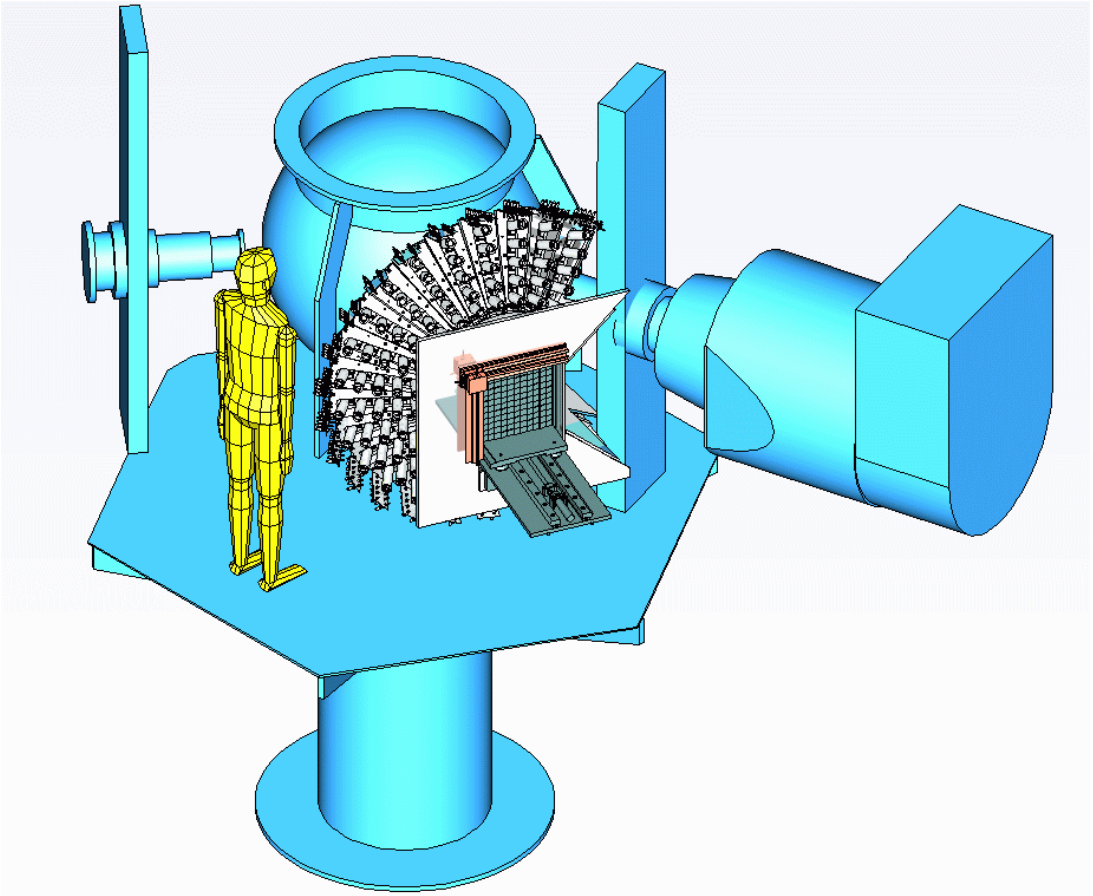
Hall A Analysis meeting

A. Camsonne

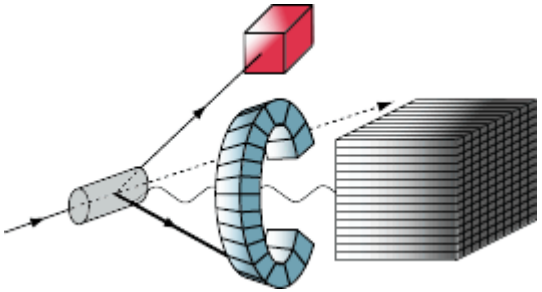
Université Blaise Pascal / LPC Clermont Ferrand

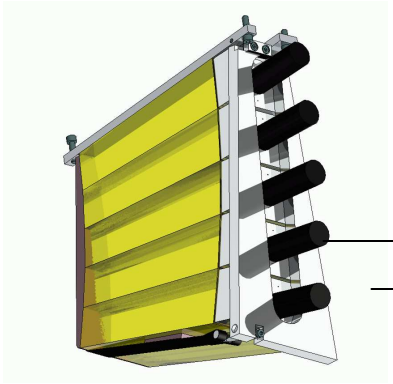


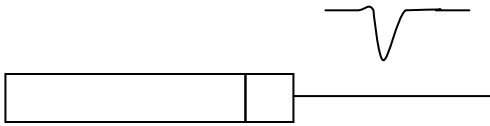
DVCS Setup

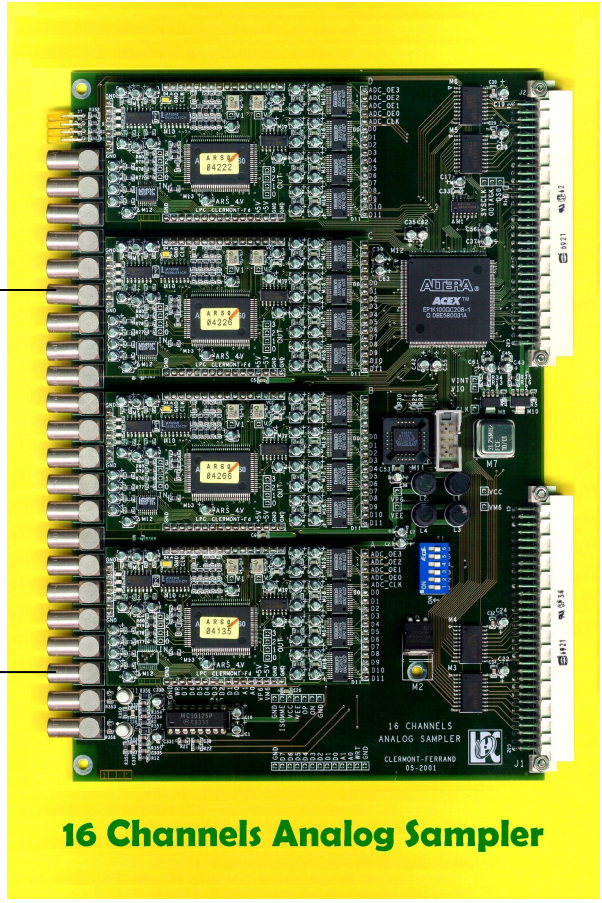


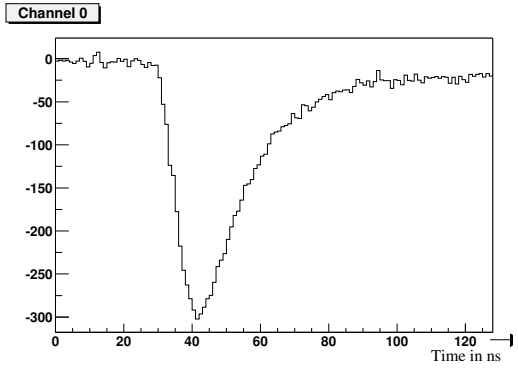
Analog sampler

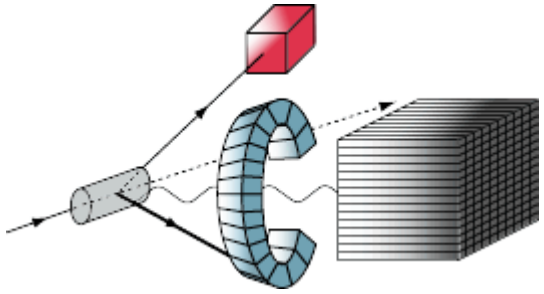










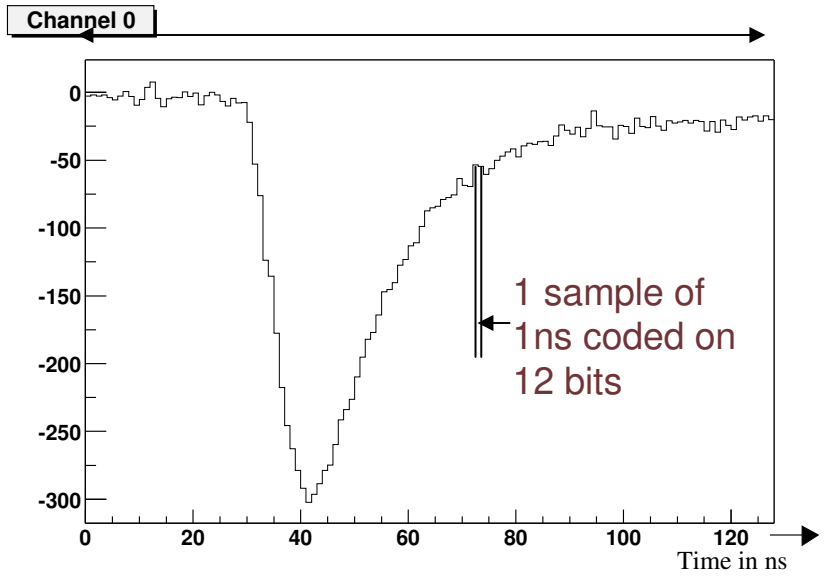


Overview

- Custom electronic built electronic module by LPC Clermont-Ferrand

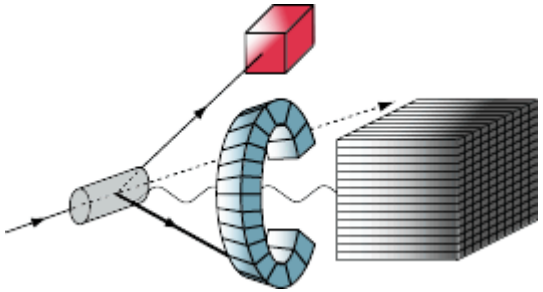
  based on a CEA Saclay chip (ARS) allows sampling of the signal at 1Ghz over 128 ns with 1 ns sample.

128 samples



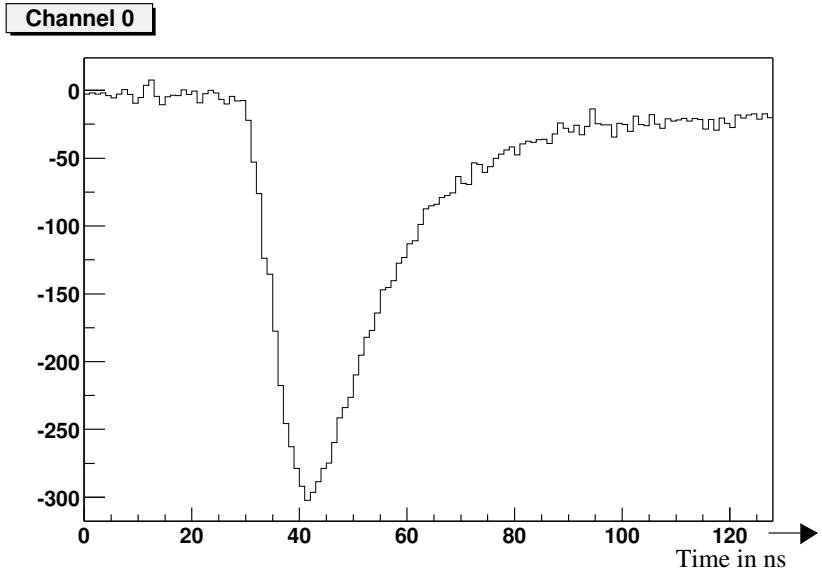
Equivalent to 128 fast ADCs put

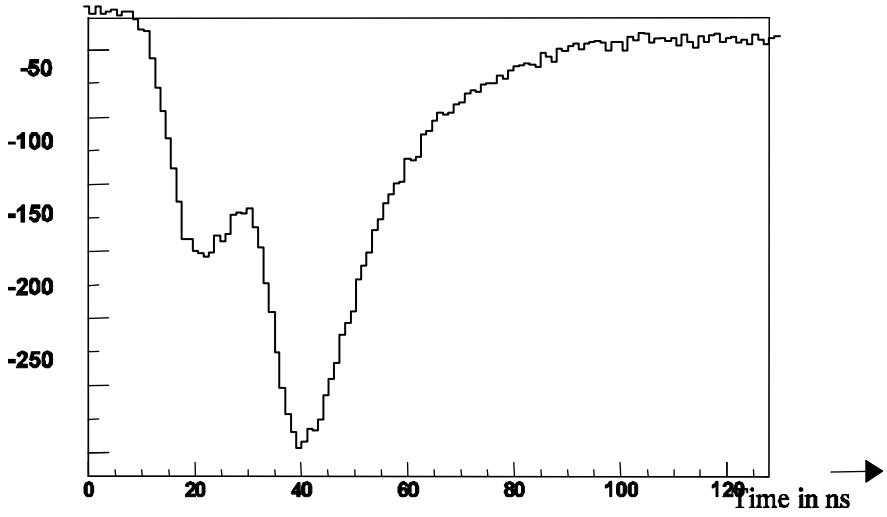
After each detector

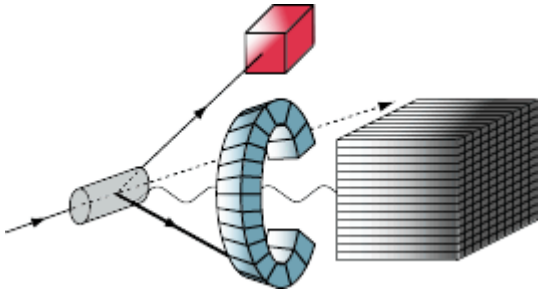


Waveform analysis

Main goal of the sampling system : to deal with pile-up events

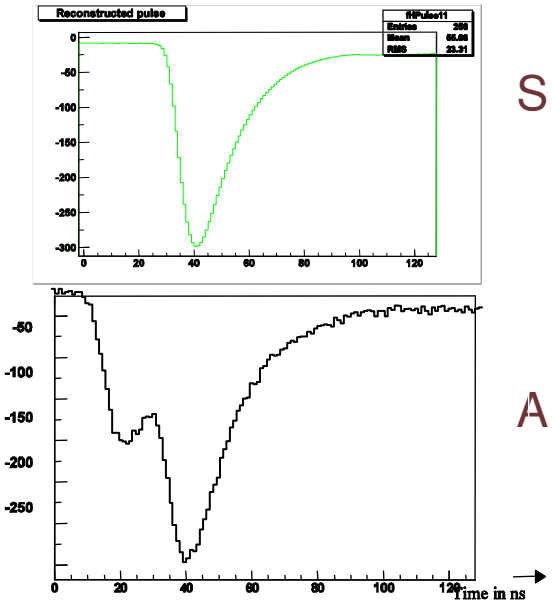






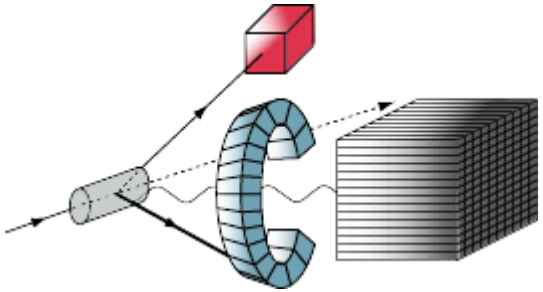
Waveform analysis

•First method available : minimization method



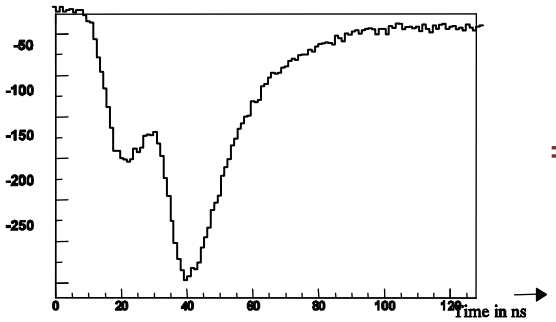
S the reference pulse : it is an array of 128 samples
noted S_t the samples number t.

A the experimental signal : also an array of 128 samples
A_t the sample number t.



Waveform analysis

We make the assumption that the signal is a linear combination of reference shapes translated in time and a constant level called b :



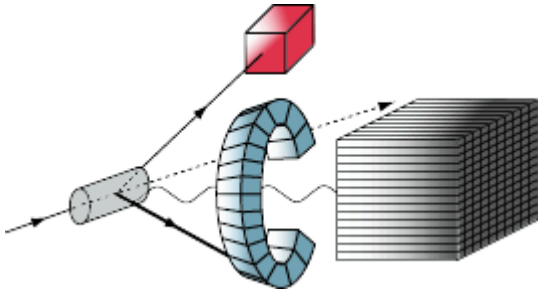
=

384 samples

a1 *

a2 *

b *



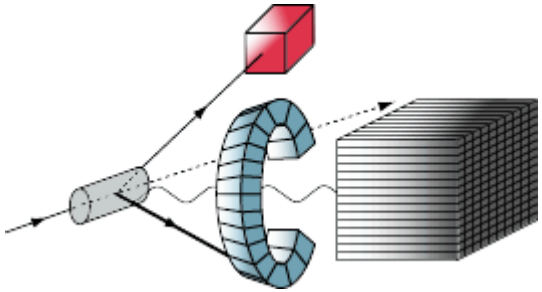
Waveform analysis

For example if we look for two pulses and a constant level

$$A_t = a_1 * S_{t-t_1} + a_2 * S_{t-t_2} + b$$

(most general case we are dealing with) , we have three parameters a1,a2 and b to minimize , by computing the $\chi 2$:

$$\chi^2(a_1, a_2, t_1, t_2, b) = \sum_{t=1}^{128} (A_t - a_1 S_{i-t1} - a_2 S_{i-t2} - b)^2$$



Mimization

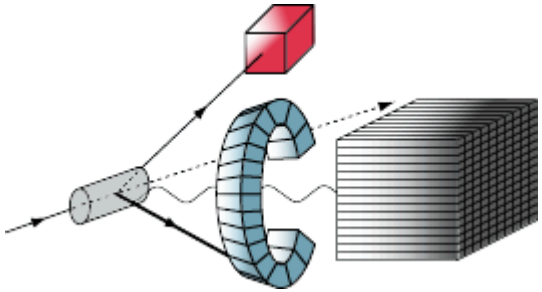
By computing the minimization, we get the following linear system to solve :

$$\begin{matrix} \frac{d\chi^2}{da_1} \\ \frac{d\chi^2}{da_1} \\ \frac{d\chi^2}{da_1} \end{matrix} = \sum_{t=0}^{n} \left[\begin{pmatrix} 2S_{t-t_1}^2 & -2S_{t-t_2}S_{t-t_1} & -2S_{t-t_1} \\ -2S_{t-t_2}S_{t-t_1} & 2S_{t-t_2}^2 & -2S_{t-t_2} \\ -2S_{t-t_1} & -2S_{t-t_2} & 2 \end{pmatrix} \begin{pmatrix} a1 \\ a2 \\ b \end{pmatrix} - 2A_t \begin{pmatrix} S_{t-t_1} \\ S_{t-t_2} \\ 1 \end{pmatrix} \right]$$

For the minimization on a1 and a2, we thus have

$$\sum_{t=0}^{n} \left[\begin{pmatrix} S_{t-t_1} & -S_{t-t_2}S_{t-t_1} & -S_{t-t_1} \\ -S_{t+t}S_{t-t_1} & S_{t-t_2} & -S_{t-t_2} \\ -S_{t-t_1} & -S_{t-t_2} & 1 \end{pmatrix} \begin{pmatrix} a1 \\ a2 \\ b \end{pmatrix} - A_t \begin{pmatrix} S_{t-t_1} \\ S_{t-t_2} \\ 1 \end{pmatrix} \right] = \begin{matrix} 0 \\ 0 \\ 0 \end{matrix}$$

$$\begin{pmatrix} \sum_{t=0}^{n} S_{t-t_1} & \sum_{t=0}^{n} -S_{t-t_2}S_{t-t_1} & \sum_{t=0}^{n} -S_{t-t_1} \\ \sum_{t=0}^{n} -S_{t-t_2}S_{t-t_1} & \sum_{t=0}^{n} S_{t-t_2} & \sum_{t=0}^{n} -S_{t-t_2} \\ \sum_{t=0}^{n} -S_{t-t_1} & \sum_{t=0}^{n} -S_{t-t_2} & \sum_{t=0}^{n} 1 \end{pmatrix} \begin{pmatrix} a1 \\ a2 \\ b \end{pmatrix} = \begin{pmatrix} \sum_{t=0}^{n} A_t S_{t-t_1} \\ \sum_{t=0}^{n} A_t S_{t-t_2} \\ \sum_{t=0}^{n} A_t \end{pmatrix}$$

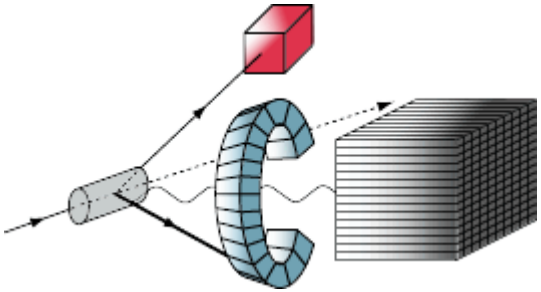


Algorithm

The program has 3 thresholds on the value of chi : χ_0^2, χ_1^2, χ_2^2.

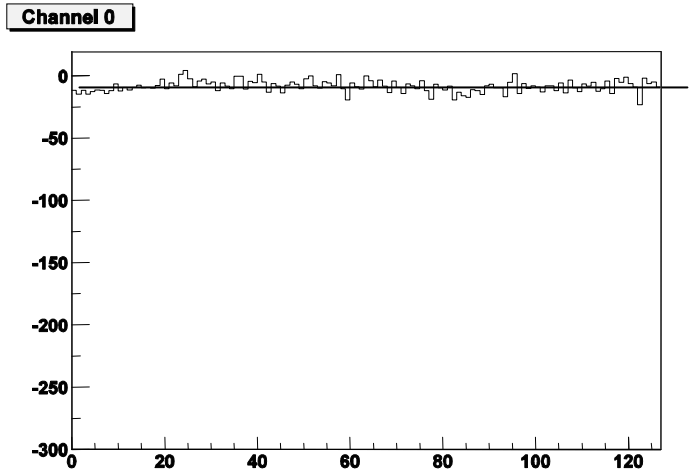
The program go through the following steps for each event

- Look for only a constant level, if $\chi^2 < \chi_0^2$ else
- Look for a constant level and a pulse, if $\chi^2 < \chi_1^2$ else
- Look for a constant level and two pulse, if $\chi^2 < \chi_2^2$ threshold else
- The event has more than two pulse

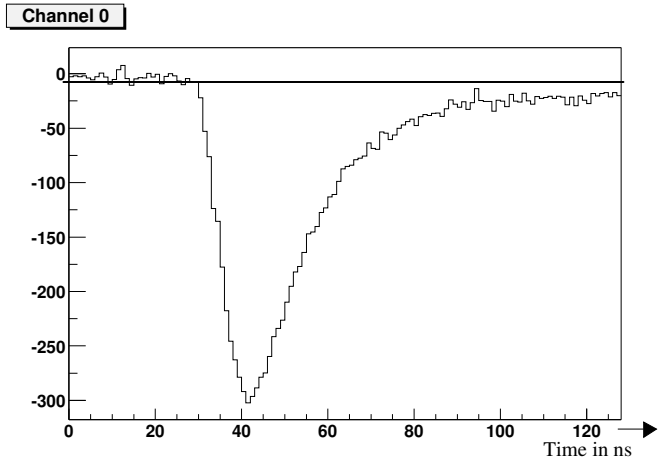


Algorithm

Fit the signal with a simple constant

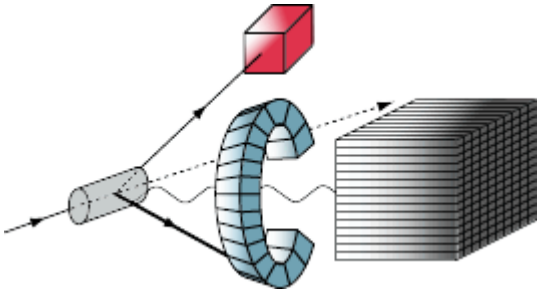


OR



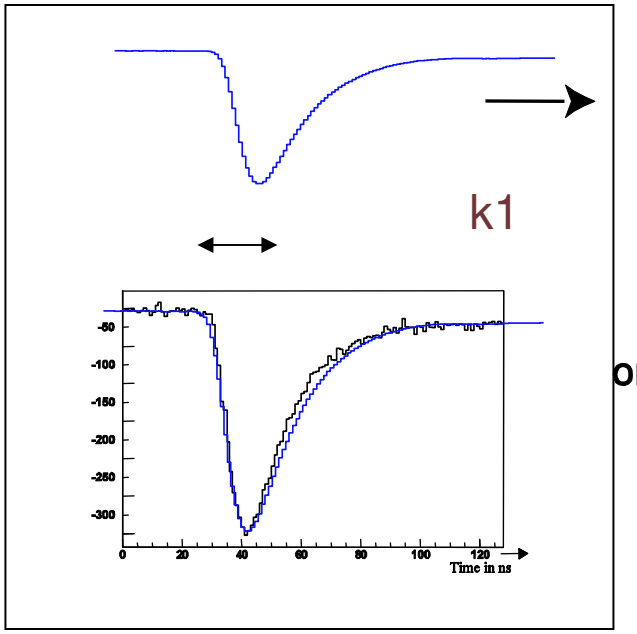
$\chi^2 < \chi_0^2$

$\chi^2 > \chi_0^2$



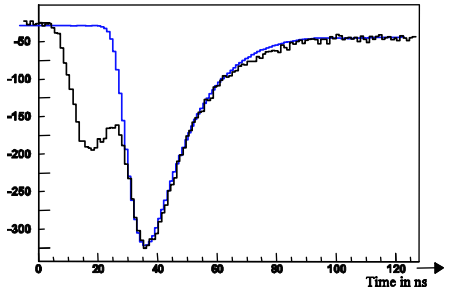
Algorithm

Reference shape



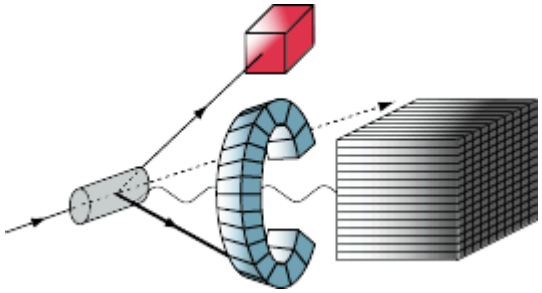
or

Translation in time in a selected time window and minimization on the amplitude

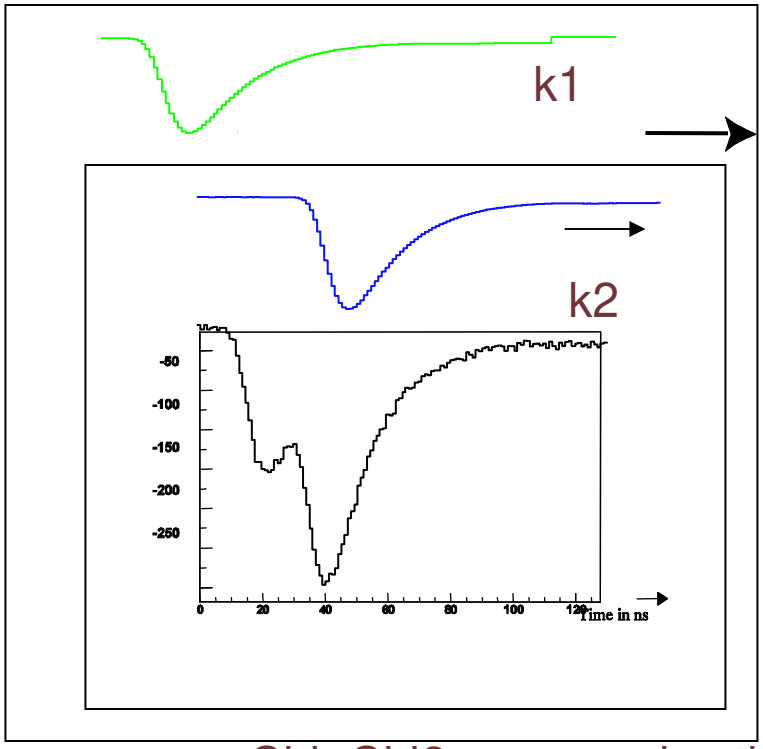


$\chi^2 < \chi_1^2$

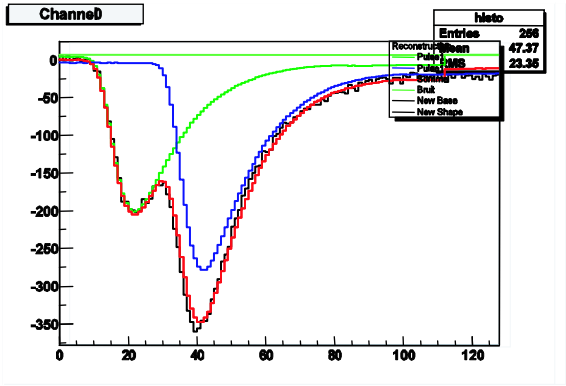
$\chi^2 > \chi_1^2$



Algorithm

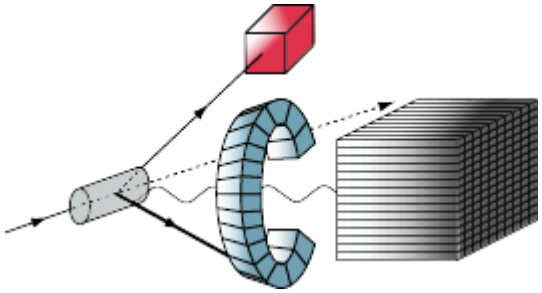


Translation of two pulses and minimization on their amplitudes



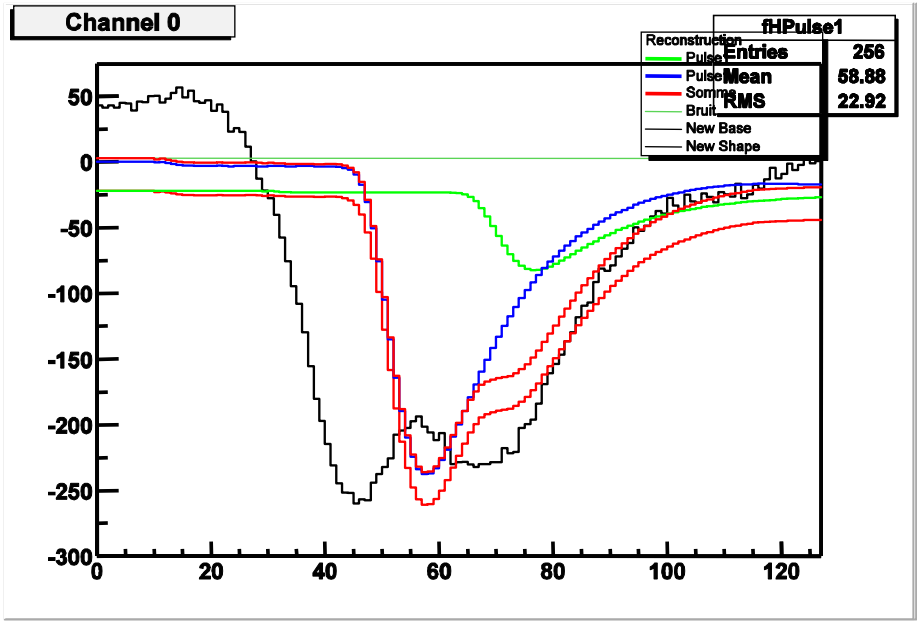
Chi<Chi2

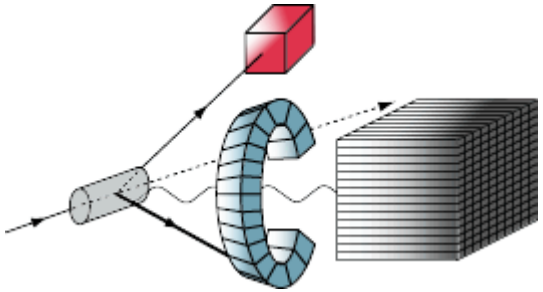
else the event has more than two pulses



Algorithm

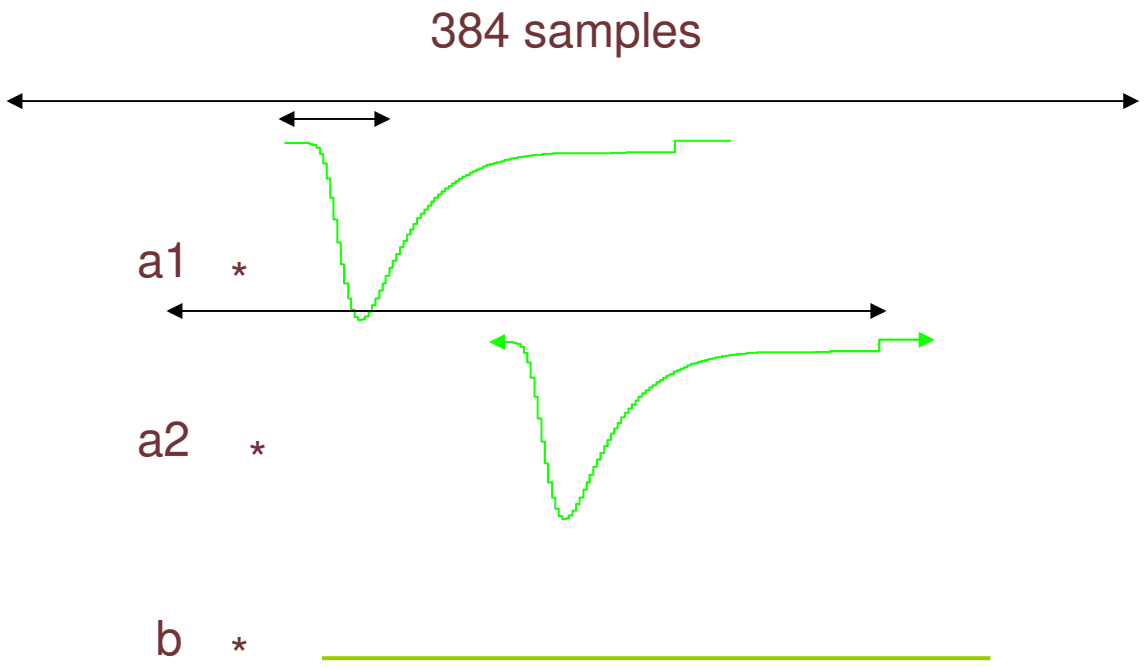
else the event has more than two pulses

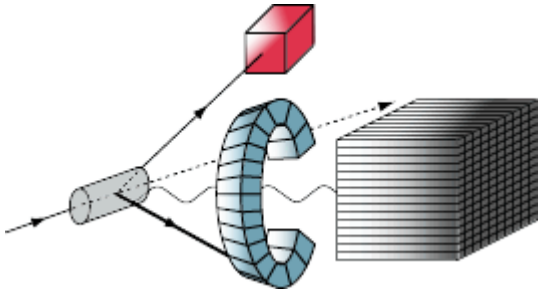




2 pulses

To save some time, the translation in time is made in time windows

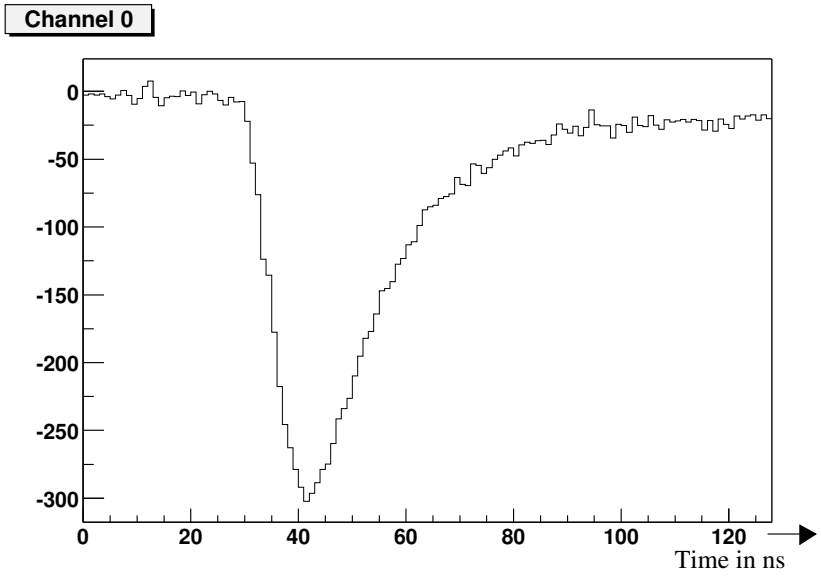


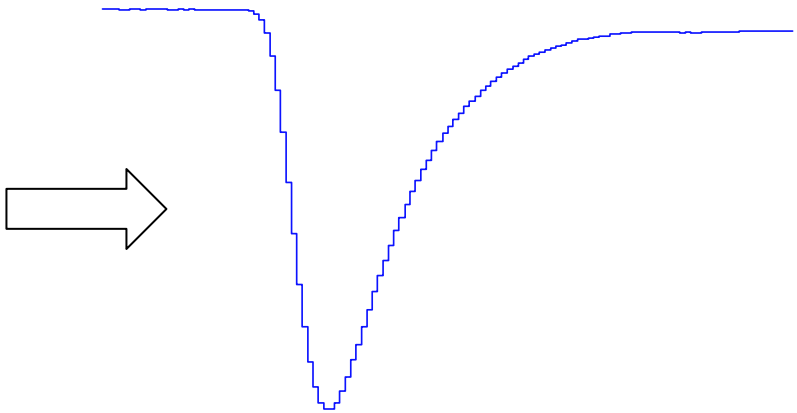


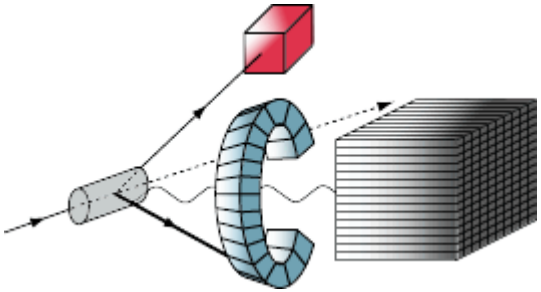
Reference shape

- reference shape made by iteration

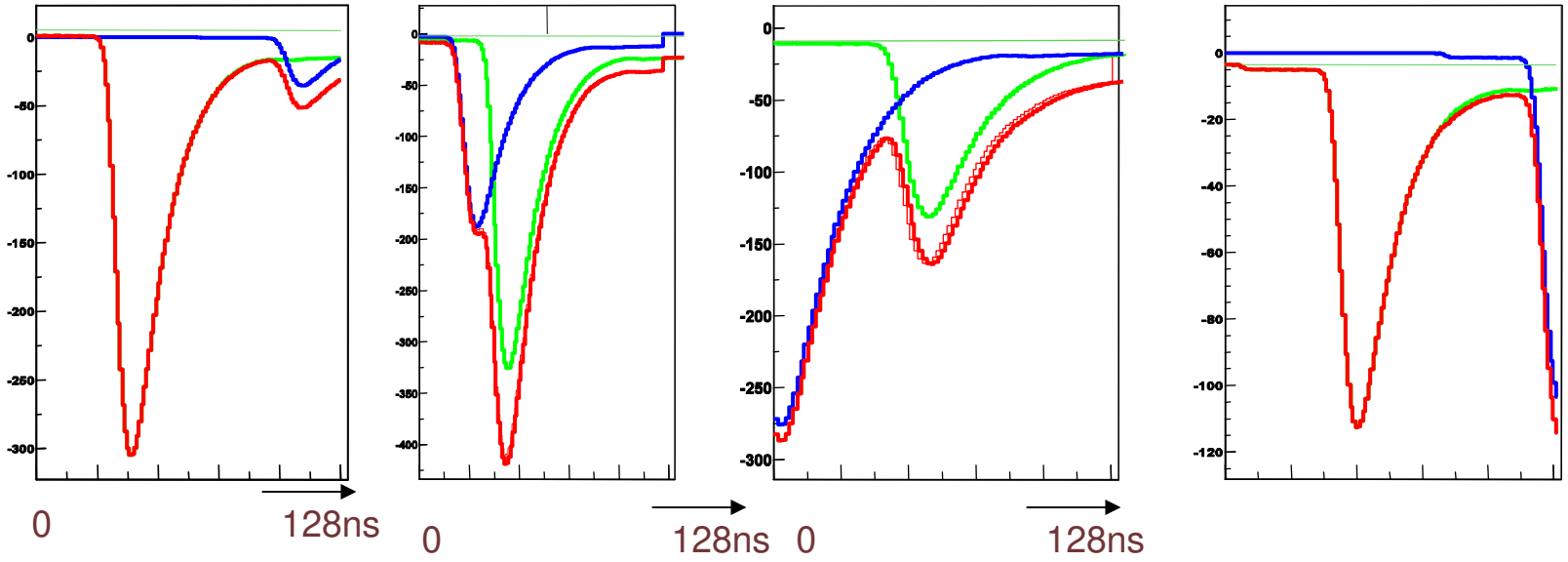
We use a experimental signal as reference shape to select one pulse event and we redo the reference by making a mean profile

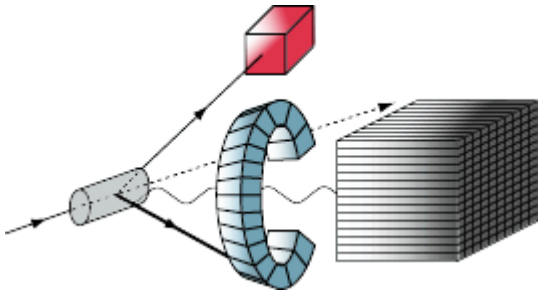






Examples





Waveform analysis

Conclusion

- first algorithm works well in most cases
- issues
  - •Need for a good tune of the constant
  - •Speed issue : depends on the width of the time window when looking for two pulses but in case of DVCS we will mostly look for one good pulse but code not optimized yet
- •Other method are being investigated (Fourier)