New SBD

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1. Some properties of new SBD.

■ Noise.

The noise can be measured from data in the abort gaps. The SBD puts out a signal that is corrected for base line shift and for cable dispersion. The bins are 0.2 ns wide.

From In[26]:=

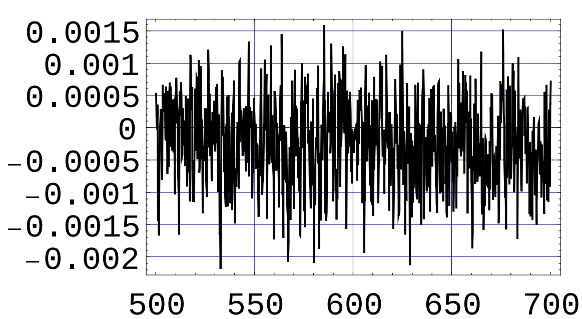

Figure 1

In[355]:=

```
{Sqrt[Variance[noise[[All, 2]]]],
 Mean[noise[[All, 2]]]}
```

Out[355]=

```
{0.000648648, -0.000234141}
```

The RMS noise on the data with 16 sweeps is 0.6 mV. This can a
by looking at the front and back end of the pulses just after accelera

From In[121]:=

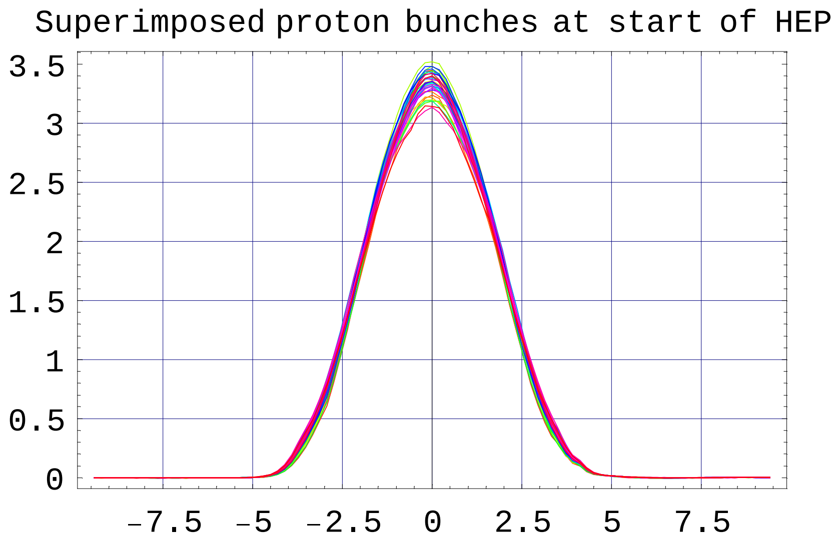

Figure 2

In[352]:=
```
{Mean[
  Sqrt[Variance[
    Table[dat[p[k]][[m, 2]],
     {m, 1, 10}, {k, 1, 36}]]]],
 Mean[
  Sqrt[Variance[
    Table[dat[p[k]][[m, 2]],
     {m, 90, 95}, {k, 1, 36}]]]]}
```

Out[352]=
```
{0.000582864, 0.000700445}
```

■ Centroid accuracy.

The following graph shows the variation in position of proton bunch 1 during a 30 hour store. The units along the bottom are 0.5 hours.

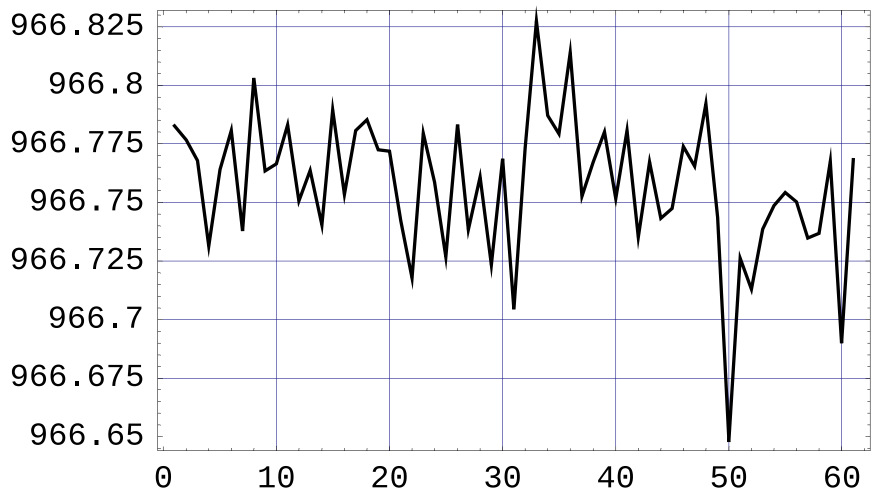

Figure 3

The next figure shows the distance between adjacent pbar bunches just after HEP

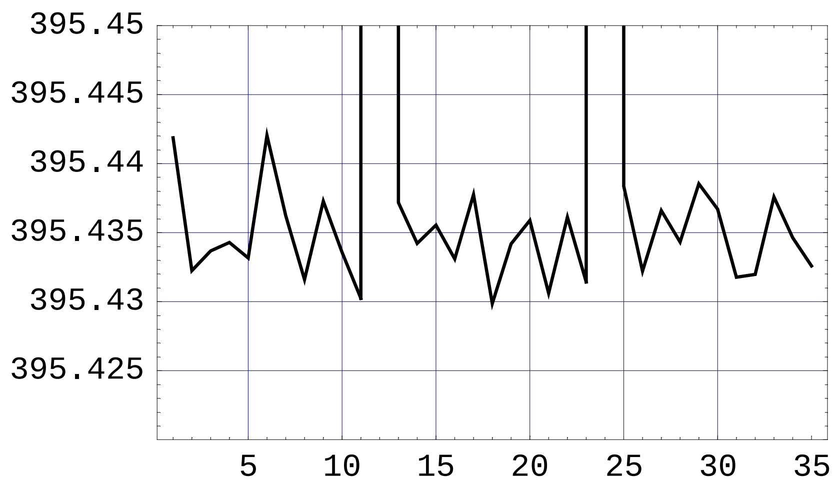

Figure 4

■ Reflections

There is a reflection at 2.5 buckets behind the main pulse caused by a splitter box. It is very small. analysis later.

Analysis functions

A set of analysis functions for n=10 is shown below.

From In[397]:=

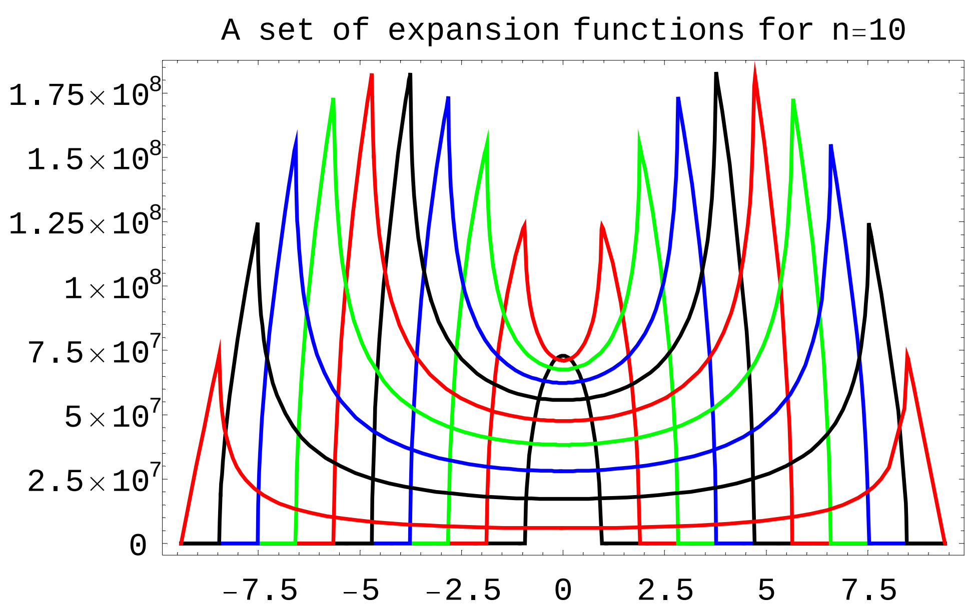

Figure 5

The following analysis requires the number of functions to be fixed. The ones shown above have been selected to give equal divisions in time. In the past we have used equal divisions in action. We note that the functions are symetrical about the origin. The input pulse should also be centered. As shown above, the center of the pulse can be measured to about 5 ps. Also, it is assumed that the input pulse has a zero base line, but there is noise as well as a baseline shift possible. In order to center the pulse to better than 0.1 ns (half the bin width) or correct the base line, the input must be processed.

Analysis

$$\mathrm{y[x]}=\sum_{n=1}^{\mathrm{Nf}} C_n\, f_n[x]$$

The data are $\mathrm{y}[x_i]$ at the points x_i. The answer for the least squares fit can be put in the form

$$\mathrm{C} = \mathrm{M} \,.\, \vec{y}$$

Where x is the input vector of measurements, M is a matrix that is number of measurements wide and number of functions deep...ie nonRectangular. It is only a function of the expansion functions evaluated at the measurement points. Once calculated it can be used for any input signal.

Example: 24 functions

Fix the number of functions to 24 and the data points to 97 and we will use a gaussian input whose sigma = 1.6 ns which matches the rms width of the proton pulses at HEP start.

■ tvec linear

From In[414]:=

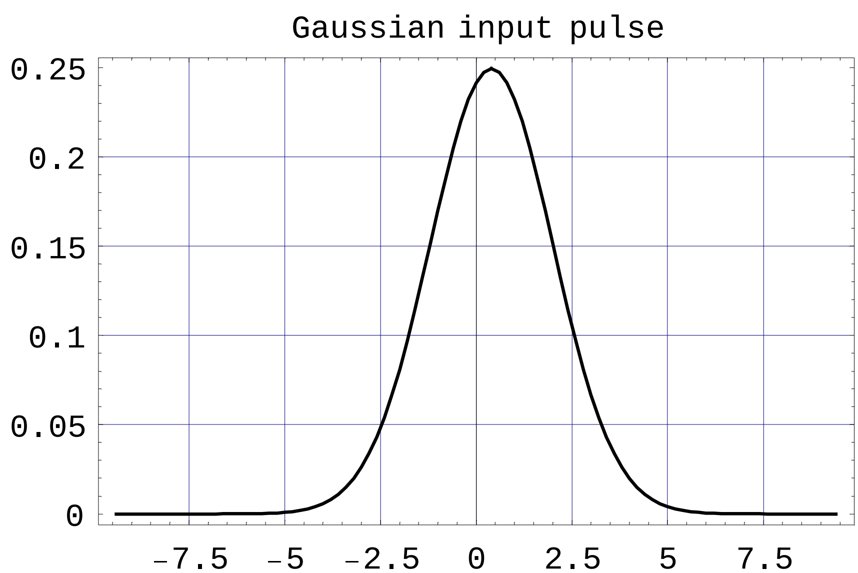

Figure 6

Gaussian input pulse

From In[413]:=

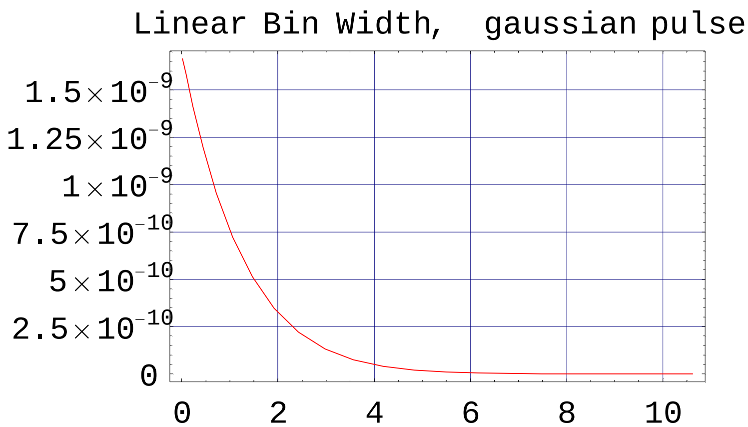

Figure 7

The fitted coefficients vs action or the phase space density.

From In[413]:=

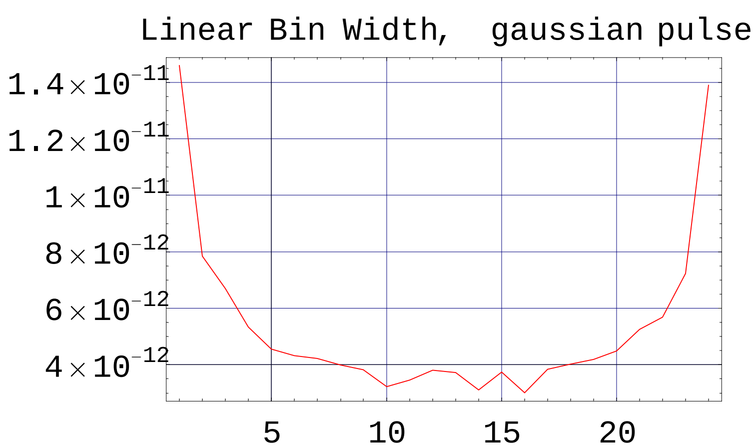

Figure 8

The 24 coefficients for 0.6 mv of gaussian noise alone. This plot is generated by generating 100 input cases and then taking the RMS value for each coefficient. The response is linear and so comparing with Fig 7 the noise contributes about a 1% uncertainty.

From In[413]:=

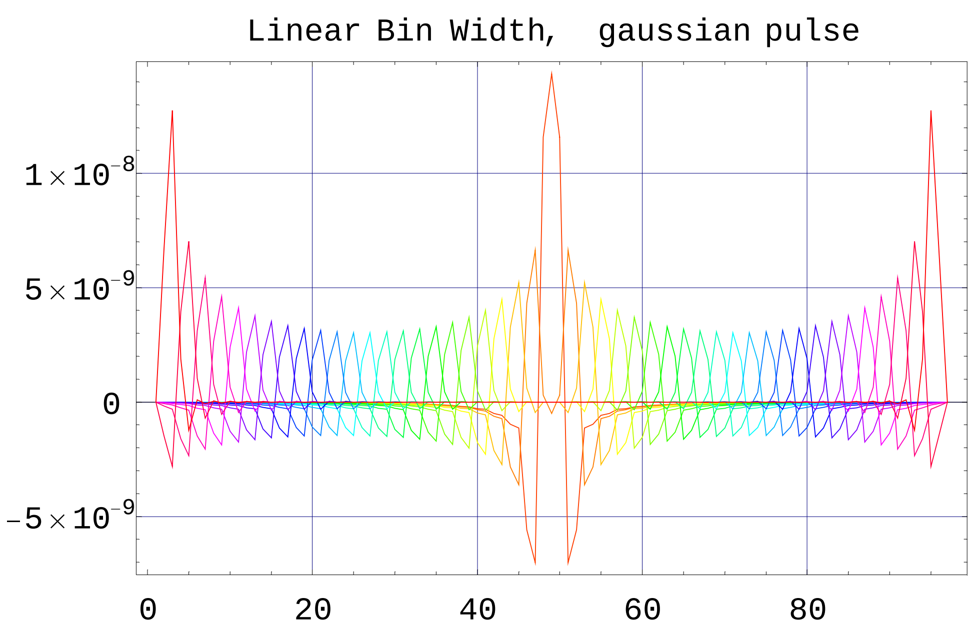

Figure 9

The figure shows the correlation of where the various coefficients are most sensitive to base line noise. The 24 coefficients have different colors. The horizontal is the index of x_i. The center of the rf bucket is in the center of the plot and it extents from +/- 9.4 ns.

From In[413]:=

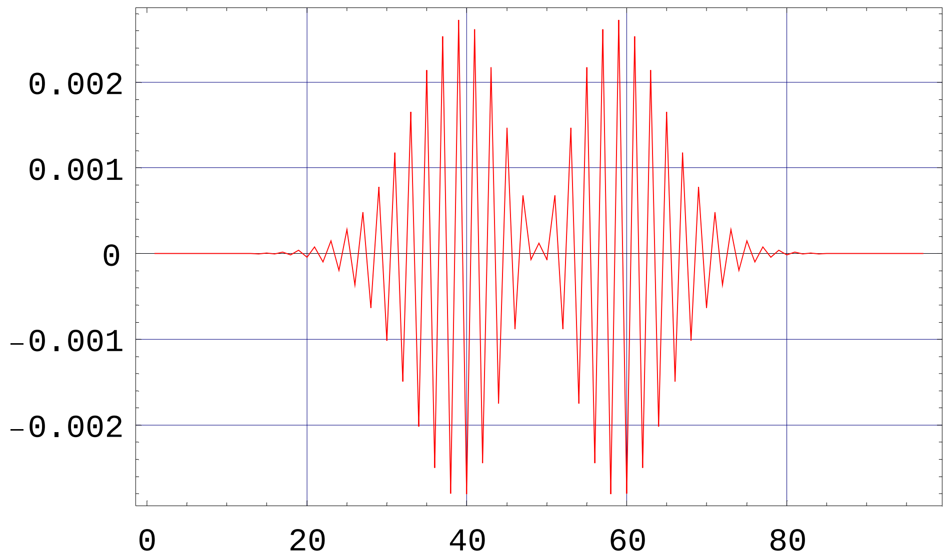

Figure 10

Fit residuals versus x_i index number. See comment under fig 9.

Varying the time divisions. Still 24 functions

We have studied various bid width divisions shown in the plot below. The results from the linear division are shown above.

From In[409]:=

Red: Linear Bin widths

Green: Nonlinear #1

Blue: Best

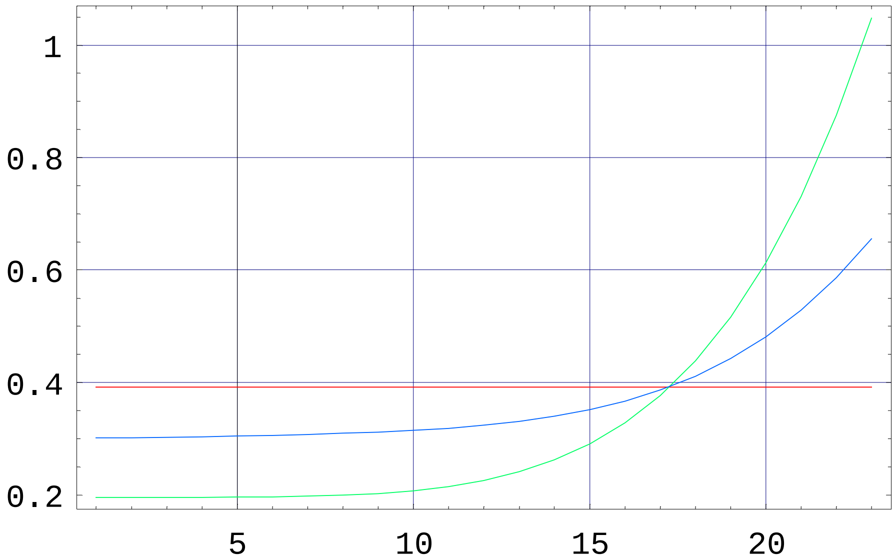

Figure 11

The plot below compares the different choices in regard to their noise sensitivity (see fig 8 above}

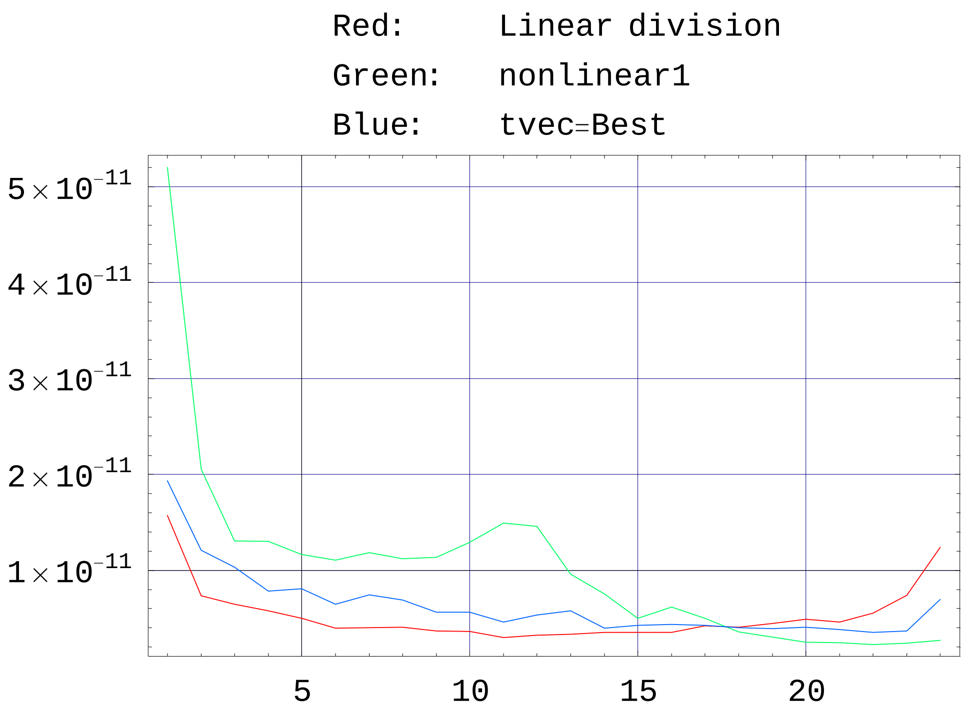

Figure 12

The fit residuals with the same color scheme are below. Note the spike in the blue. This seems to be caused by an unfortunate beating between the position of the data points relative to the divisions for the functions. It results in a poor fit to the data around t=0. The gaussian is .25 volts high so a residule of 1% is 2.5 mV.

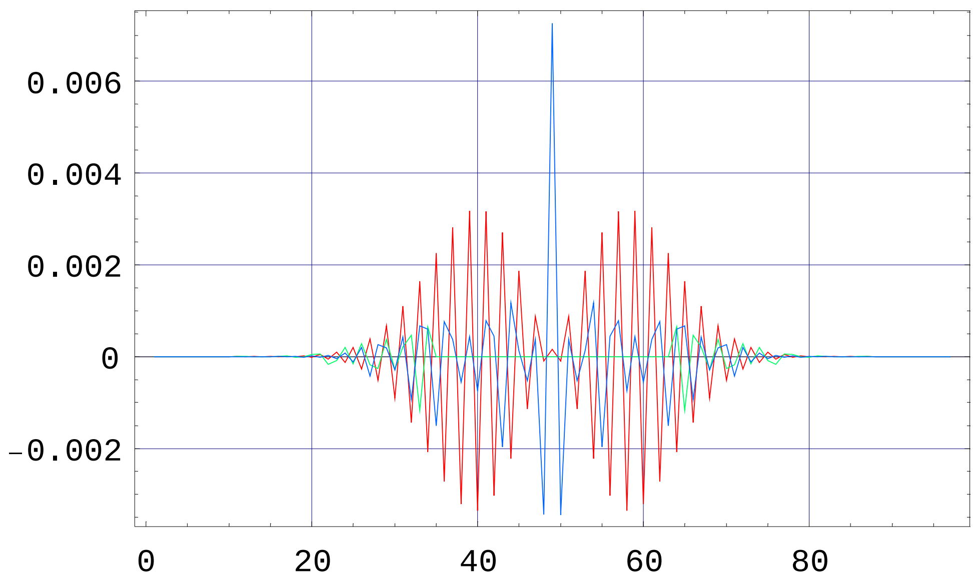

Figure 13

Test with real pbar data.

The following shows the sdame data using a reap pbar pulse at the start of HEP. The set of 36 is shown below and the analysis uses the smallest one.

From In[133]:=

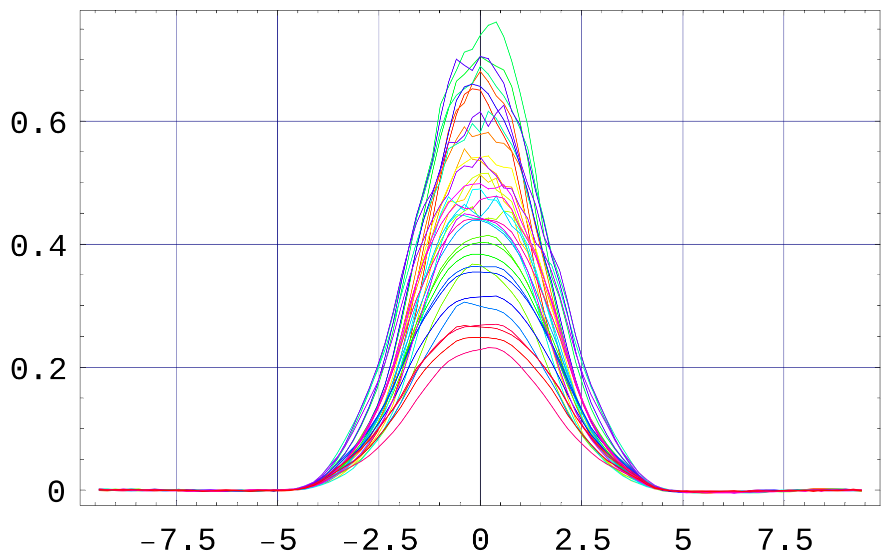

Figure 14

Coefficients for pbar[36]

From In[420]:=

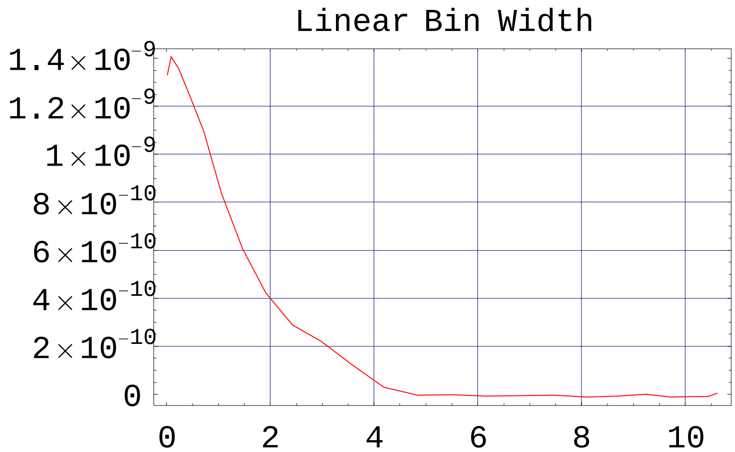

Figure 15

Residuals

From In[420]:=

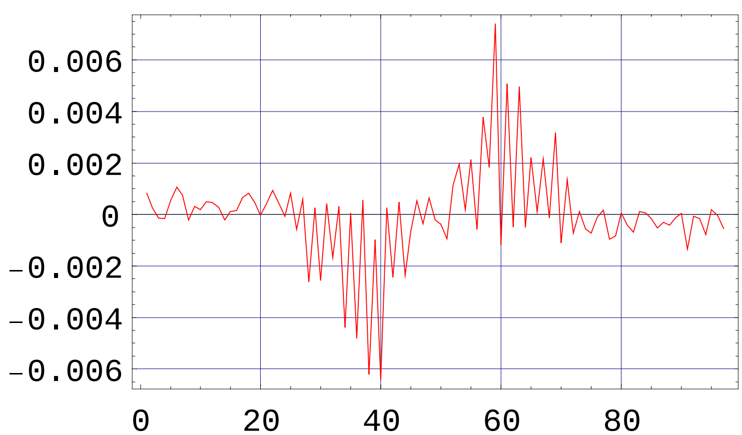

Figure 16

Comparisions of the various choises for the time division. Same color code as above. Note the blue spike and see the plot following for its effect.

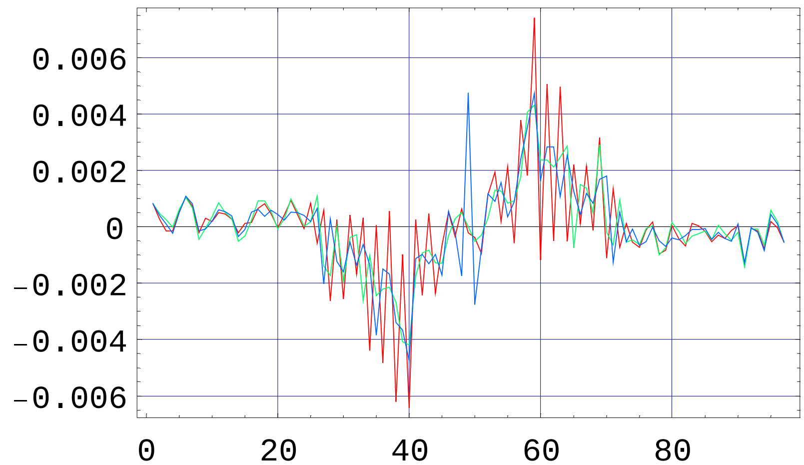

Figure 17

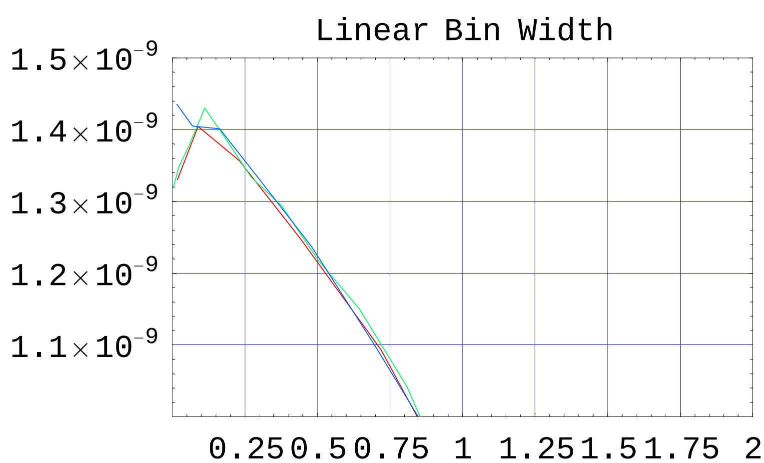

Figure 18

Use 47 functions with 189 data points at 0.1 ns

■ Gaussian input

First, the results with a gaussian input. Figure 19 is the phase space density and the next is the residuals. The residuals have been decreased by a factor of two and the fit if to 0.4%

From In[248]:=

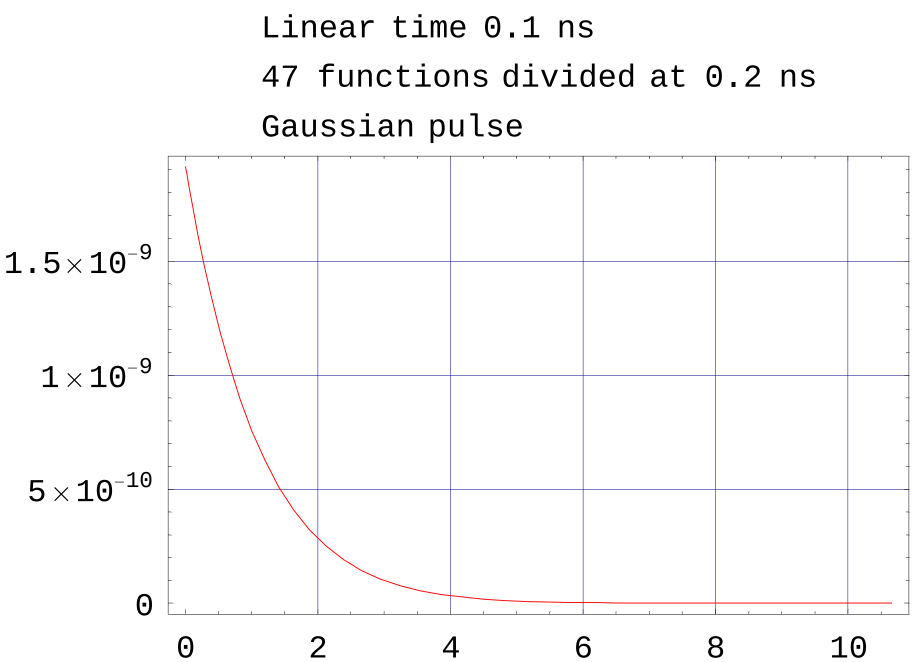

Figure 19

From In[248]:=

Linear time 0.1 ns
47 functions divided at 0.2 ns
Gaussian pulse

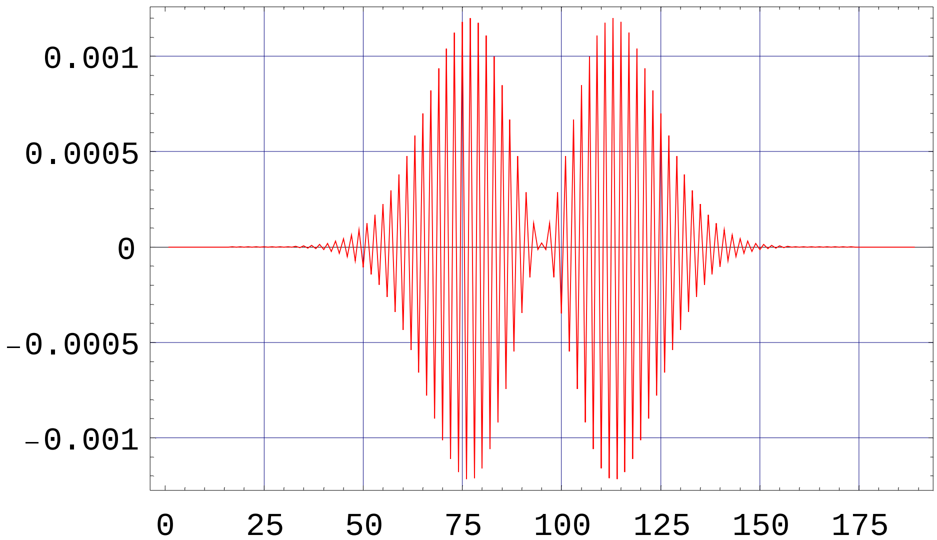

Figure 20

■ proton pulse in

From In[189]:=

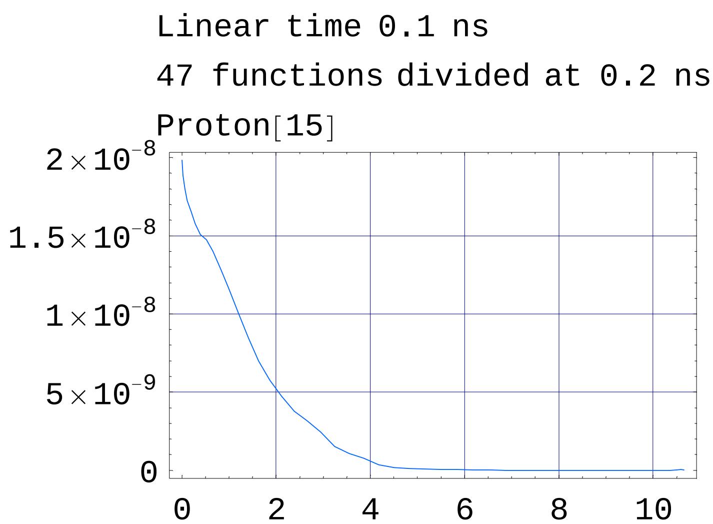

Figure 21

Residuals for proton pulse.

From In[189]:=

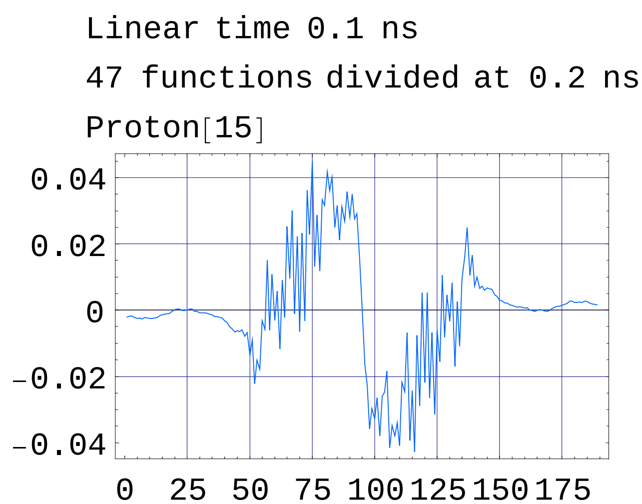

Figure 22

■ pbar pulse in

From In[199]:=

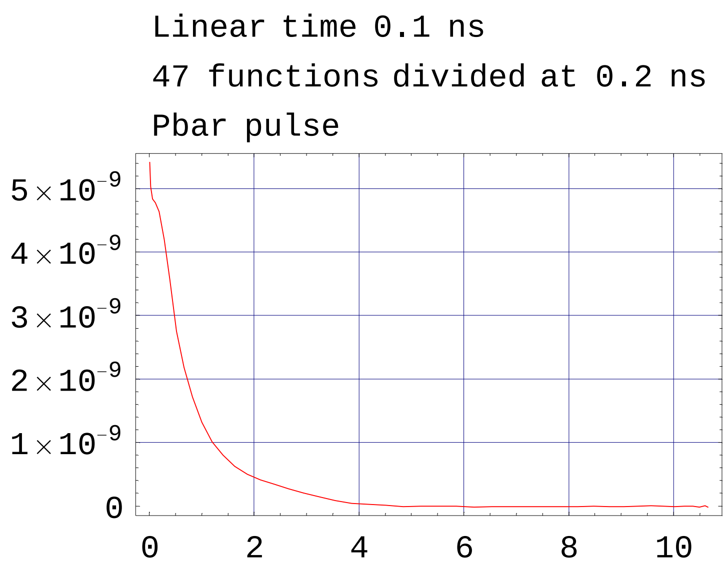

Figure 23

From In[199]:=

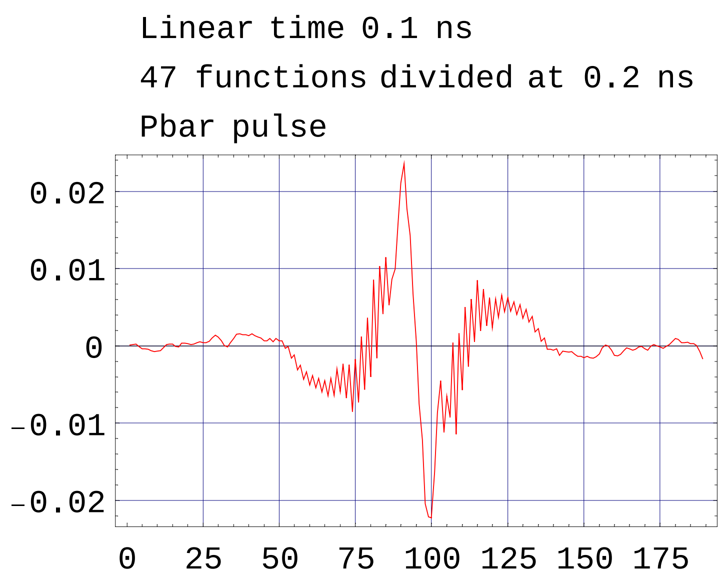

Figure 24

■ Symetry of pulses

From In[425]:=

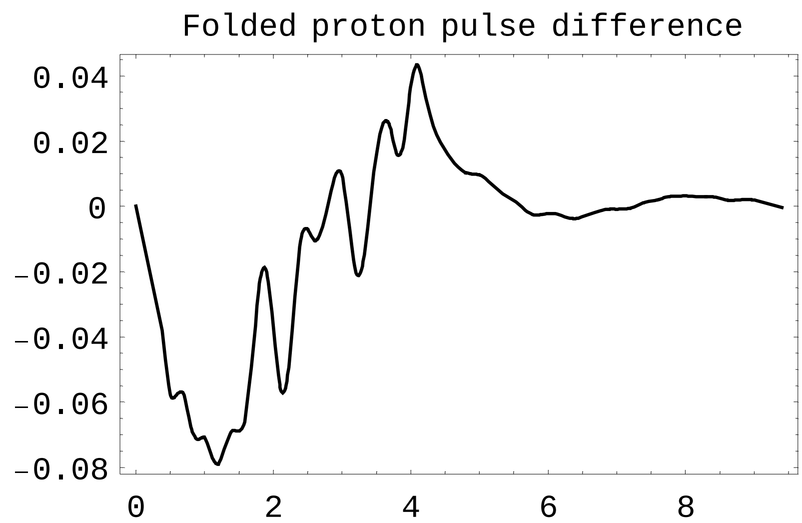

Figure 25

From In[421]:=

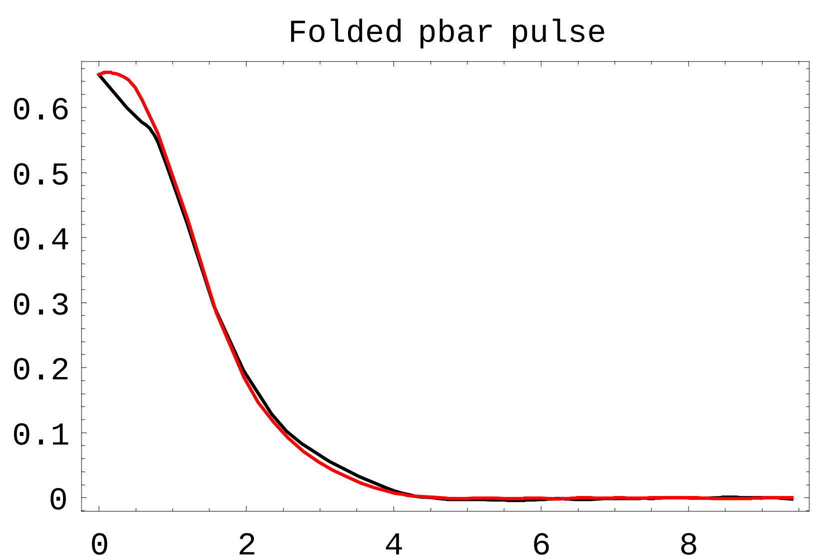

Figure 26

Effect of off center pulse.

We will use a gaussian pulse slightly off center to study the sensitivity to centering. The following curve shows the fractional deviation of the coefficients for a 0.4 ns shift. This shift is acurately propotional to the square of the shift. Only the first out to 8 eV-sec are shown. The effect is much smaller for a sigma of 2.5 ns.

From In[426]:=

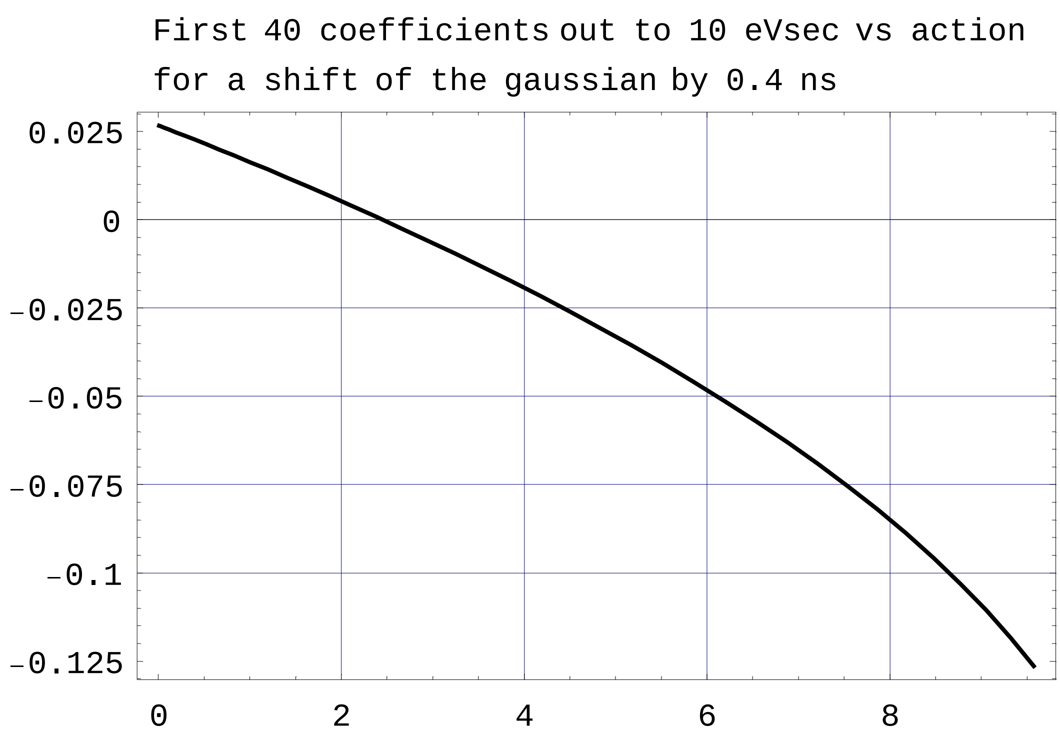

Figure 27

■ Shifted proton pulse by o.2 ns

Comparison of residuals after shifting the proton pulse by 0.2 ns.

From In[309]:=

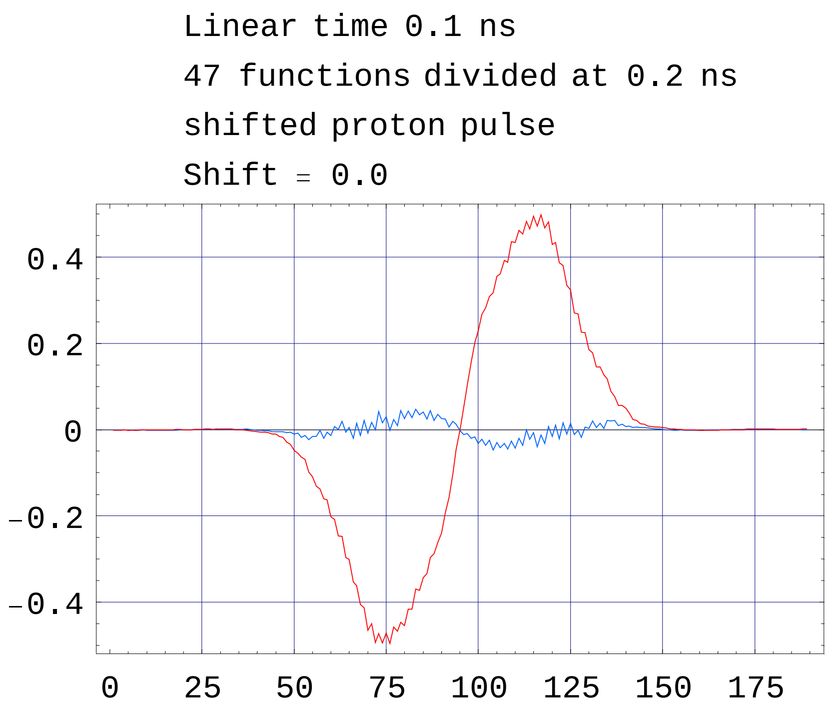

Figure 28

Compare the coefficients of shifted and unshifted pulse vs action.

From In[319]:=

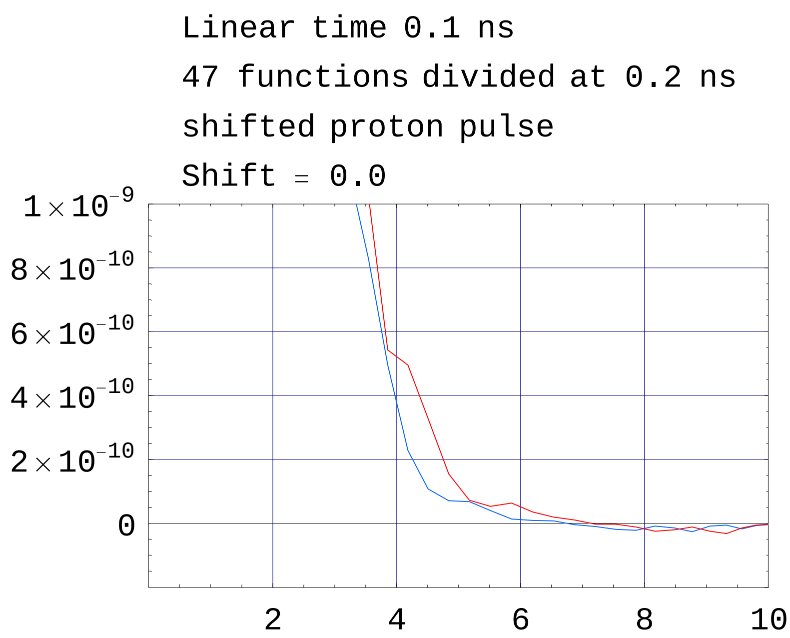

Figure 29

From In[429]:=

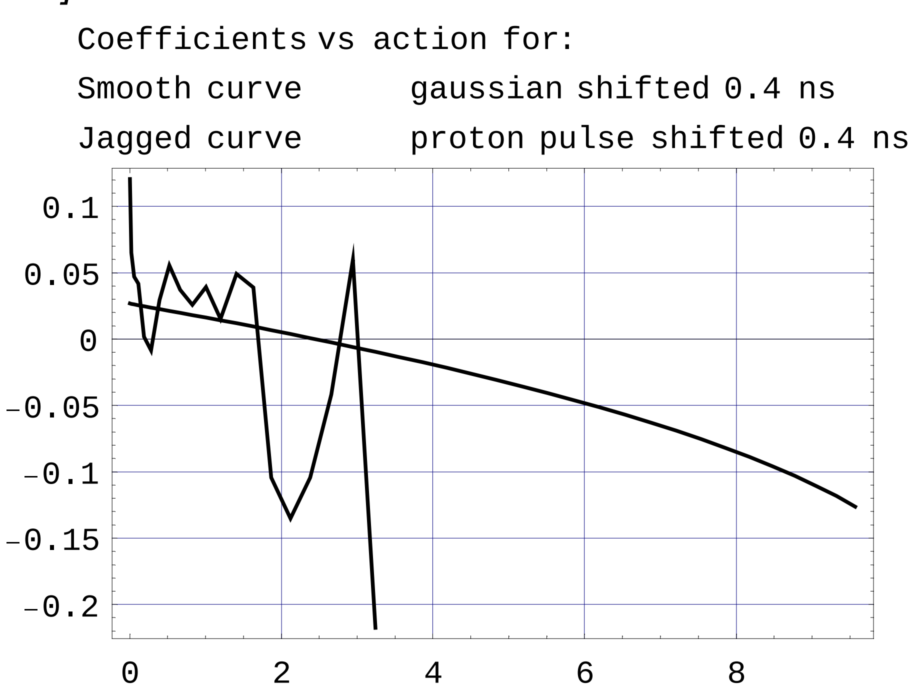

Figure 30