Interpolating Pulse Shapes with Cubic Splines

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Abstract

A cubic spline interpolation provides a smooth description for pulse shapes with data points taken every 25 ns. However, the peak height, centre and width were found to be too sensitive to the phase of the readings.

1 Procedure

Using an electronic pulser, pulse shapes were recorded on all our front end boards and channels. The samples were spaced by 25 ns; however, we had a 1 ns control of the phase of the sampling. By recording 25 events, each differing in phase by 1 ns, and overlaying the points from all the events, a smooth, finely sampled pulse shape was visualised, from which the correct amplitude, centre and width of the pulse could be determined

The pulse shape was then visualised one event at a time, each with its own phase delay and a 25 ns sample spacing. A spline interpolation (see Numerical Recipes in C [1] for the algorithm used) was done on each of these data sets, and the pulse height, centre, and FWHM was determined from the appropriate cubic on the spline.

2 Results

All examples that follow are from our FEB 0, channel 0, with the DAC set at 5000, though the results were found to be generally true. Figure 1 is the finely sampled pulse shape, from which a height of 2848, a centre of 62 ns, and a FWHM of 45 were measured.

Figures 2 aptly illustrate the inadequacy of a spline interpolation for describing the peak. Fig. 2a is taken with a phase of 0 ns and fig. 2b with a phase of 10 ns. It should be stressed that the data in these plots are exactly the same as the data in fig. 1, the samples just selected with different phase delays.

The peak heights, centres, and FWHMs were measured for all 25 of these plots, each shifted in phase by 1 ns. Summary plots are shown in figures 3 - 5.

3 Conclusion

Clearly, the location of the sample points in relation to the peak centre influence both the height and the width of the interpolated peak. The tendancy of the cubic spline

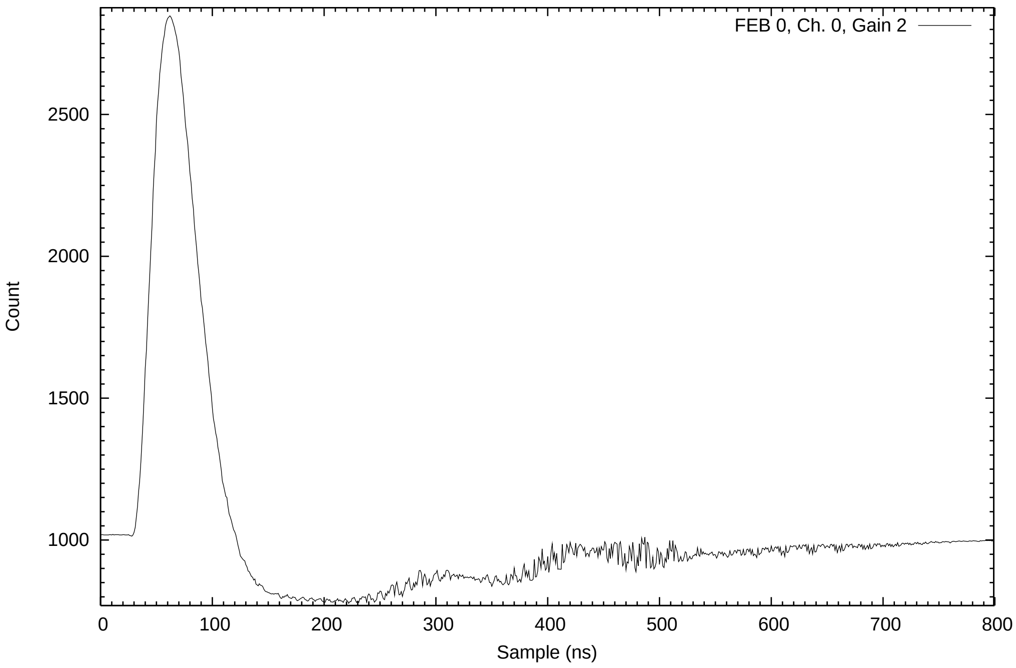

Figure 1: Finely sampled pulse shape, with peak of 2848 at 62 ns and a FWHM of 45 ns.

interpolation is to be as smooth as possible. Hence, we see that in fig. 2a, the peak is suppressed because the second and third samples are more evenly spaced about the peak centre, while in 2b, the peak is similar in height to that of fig. 1 only because the third sample happened to coincide with the peak centre.

Figures 3 - 5 show that this effect greatly affected the perceived peak height. The various "peaks" for this data run covered a range of about 200 counts. Considering that the pedestal is at about 1000 and the true height is at about 2850, this is a change in relative height of more than 10%. The motion of the centre was not as dramatic, moving through a range of about 8 ns, but is still significant. The FWHM, which moves out of phase with the peak height as a function of delay (for obvious reasons, if figs. 2 are studied), changed about 13 ns.

The conclusion is that a spline interpolation is inadequate for determining peak heights to any useful precision.

References

[1] Numerical Recipes in C, Cambridge University Press, 1992, pp. 113-116.

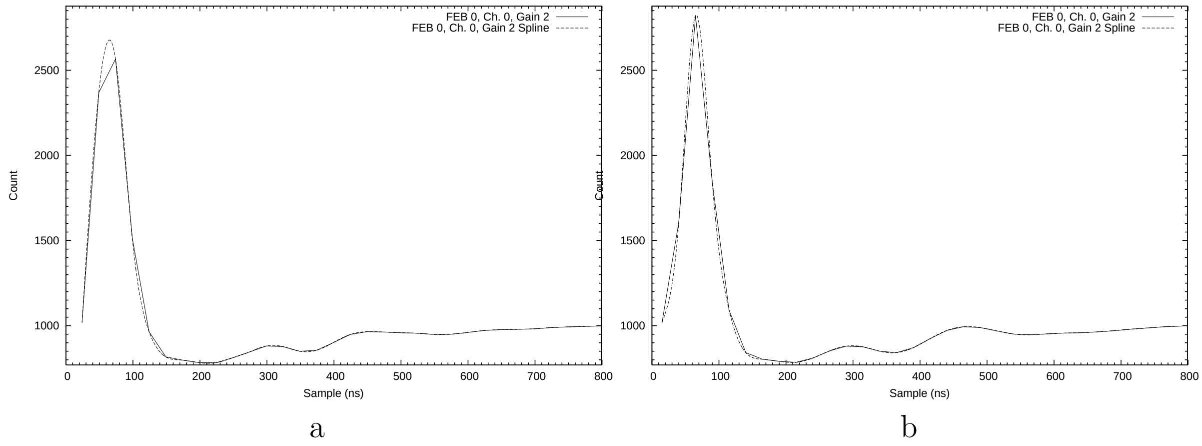

Figure 2: A spline interpolation of the same pulse data, sampled at phase delays of (a) 0 ns, and (b) 10 ns.

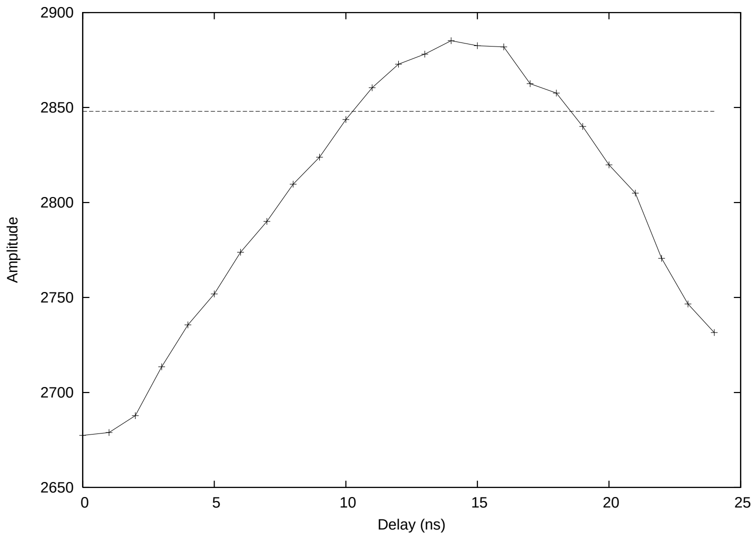

Figure 3: The peak amplitude, determined from the cubic spline interpolation, as a function of delay phase. The horizontal line is the true amplitude measured from fig. 1.

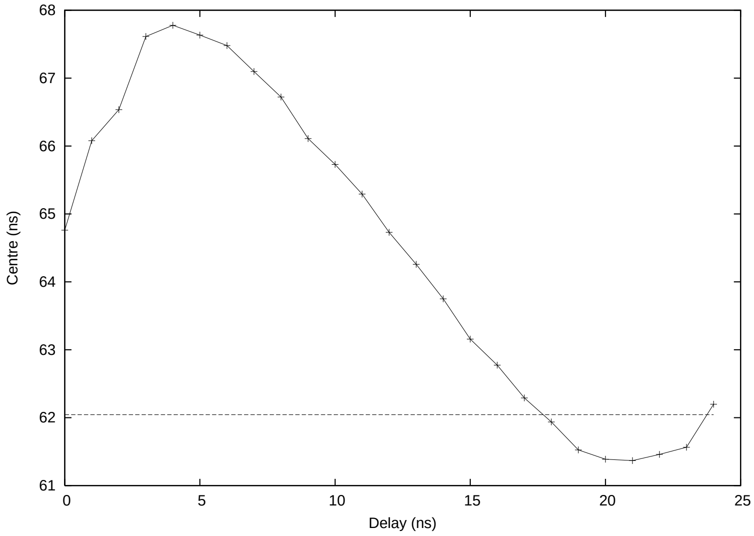

Figure 4: The centre of the peak (i.e., the time at which it reaches its maximum value) as a function of delay phase. The horizontal line is the true centre measured from fig. 1.

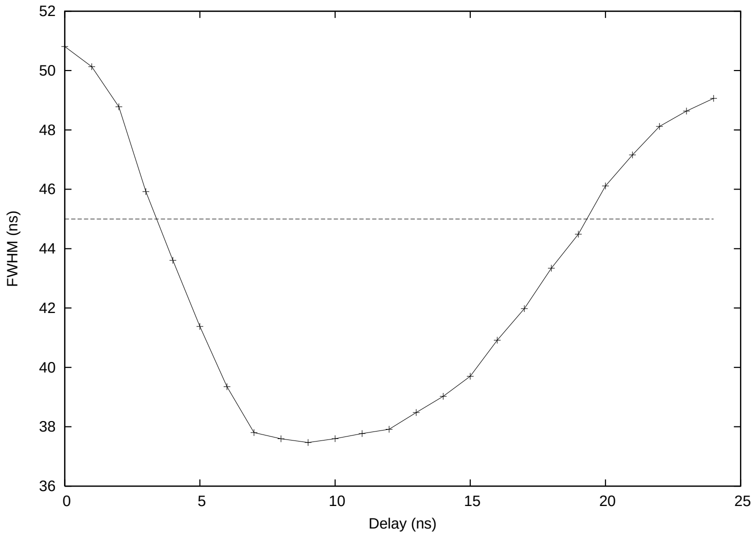

Figure 5: The FWHM of the peak as a function of delay. The horizontal line is the true FWHM measured from fig. 1.