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# Analysis of Digitized Waveforms in a Prototype of the SLD Central Drift Chamber*

C. Hodges [a], W. B. Atwood [b], J. Carr [c], G. Chadwick [b], S. Csorna [d],
T. Hansl-Kozanecka [b], G. Mundy [a], U. Nauenberg [c], R. S. Panvini [d], C. Y. Prescott [b],
T. W. Reeves [d], L. S. Rochester [b], S. Salomon [a], K. Simpson [a], A. Steiner [a], C. C. Young [b]
[a] *San Francisco State University, San Francisco, California 94132*
[b] *Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305*
[c] *University of Colorado, Boulder, Colorado 80309*
[d] *Vanderbilt University, Nashville, Tennessee 37235*

## ABSTRACT

100 MHz waveform digitizers have been used to measure drift times and charge division positions of charged particles in a prototype of the SLD central drift chamber at SLAC. Test beam results show performance to be equivalent to conventional timing and charge integration techniques.

In order to handle the high cell occupancy that may occur in the Central Drift Chamber (CDC) of the SLD detector, waveform digitizers (WFD) will be used on both ends of the sense wires. WFD's which digitize at 100 MHz should provide resolution in drift distance, charge division position and total ionization sufficient to meet the stringent requirements of SLD provided a low drift velocity gas is used. The gas mixture currently used is 92% $CO_2$: 8% isobutane and has a drift velocity of 9 $\mu$m/ns.

The design of the SLD CDC has been described in detail in the SLD Design Report.[1] In this paper we present results derived from WFD's used in parallel with conventional first-electron sensitive TDC's (LeCroy model 2228A) and charge integrating ADC's (LeCroy model 2249W). The conventional electronics is capable of measuring only a single pulse in an event. The performance of the CDC prototype using this electronics has been described in more detail in another contribution to this conference.[2]

The CDC prototype setup used for these WFD investigations consisted of sense wires equipped at each end with low noise, low input impedance preamps. Signals from the preamps are amplified in a postamp-discriminator module. The analog output of the postamp is split and fed to both the gated charge integrating ADC and the WFD. The discriminator output is fed to the TDC which has a least count of 2.5 ns.

A typical readout of the digitized sense wire signal from a single charged particle is shown in Fig. 1. The waveform analysis measures the drift time by finding the time that the pulse amplitude crosses a constant level threshold. The resolution is then improved by using a two bin linear interpolation with one bin on each side of the threshold crossing. For events selected to have a single charged particle in the chamber, a comparison of WFD times to TDC times indicated that the average timing error is less than 2.8 ns, corresponding to an error in the reconstructed drift distance of approximately 25 $\mu$m. A more relevant resolution may be obtained by fitting a track to WFD timed hits as was done in Ref. 2. Resolutions obtained in this manner for drift times measured with both WFD's and TDC's as a function of drift distance are shown in Fig. 2. The waveform results are only slightly degraded compared to the TDC. Improvements to the WFD modules can reduce the average timing error to less than 2.0 ns. Using these improvements and a more sophisticated timing algorithm should lead to an even smaller average timing error.

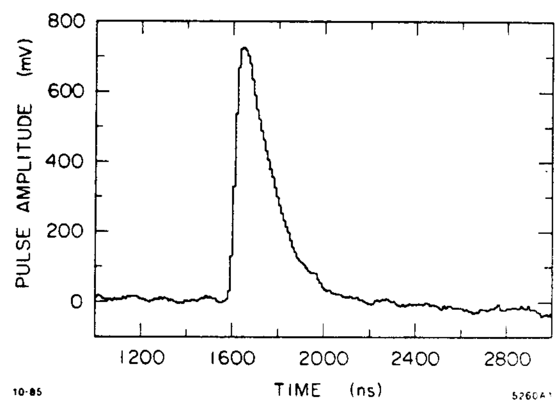


Fig. 1. A typical 100 MHz Waveform Digitizer (WFD) readout for a single pulse event.

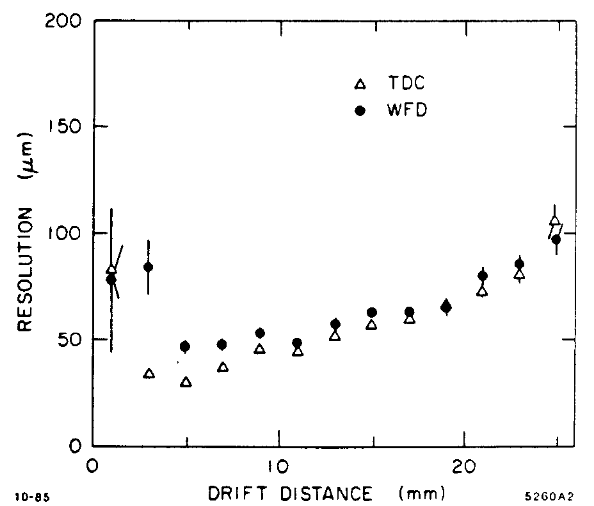


Fig. 2. Average drift resolution as a function of drift distance for both TDC and WFD timed hits.

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The measurement of the position of a track along the sense wire by charge division is expected to be limited ultimately by the thermal noise coming from the resistive sense wire.[2] The average resolution found using WFD charge division was 11 mm, which compares well with the 12 mm resolution seen when using the ADC's. These resolutions are what was expected considering the relatively high (90 Ohm) input impedance of the preamps in use at this time.

Waveform analysis is particularly well suited to resolving multiple tracks. Figure 3 shows the hit pattern of a multi-track event using WFD timing. The tracks are easily identified and have residuals of 60 $\mu$m on the average. The efficiency at multiple pulse finding has been estimated using single track data by summing the readouts of two single track events. In these simulated events, the two-pulse separation is known and can be varied. The efficiency of finding both pulses in the simulated two track event as a function of the two track separation is shown in Fig. 4. The waveform efficiency is better than 90% when the pulses are separated by only 1 mm. The small inefficiency at large two-pulse separation is primarily a result of an unusually small trailing pulse being lost in the tail of a much larger leading pulse.

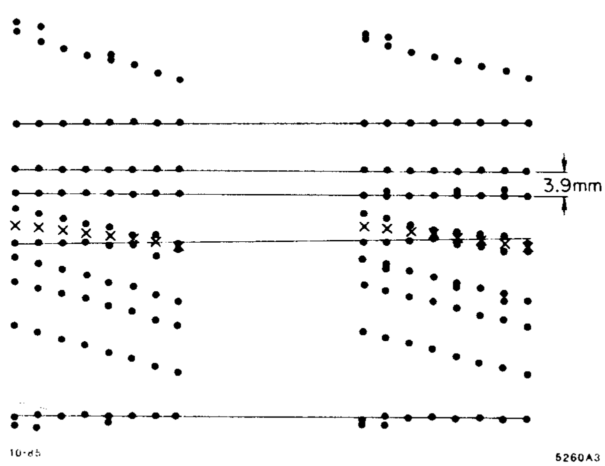


Fig. 3. A multitrack hit pattern using WFD timed hits. The sense wires are shown as X's. The reconstructed hits and their up/down ambiguity as solid dots. The average resolution for the fitted tracks far from the sense wires is 60 $\mu$m. The up/down ambiguity is resolved by linking the fitted tracks between the two cells.

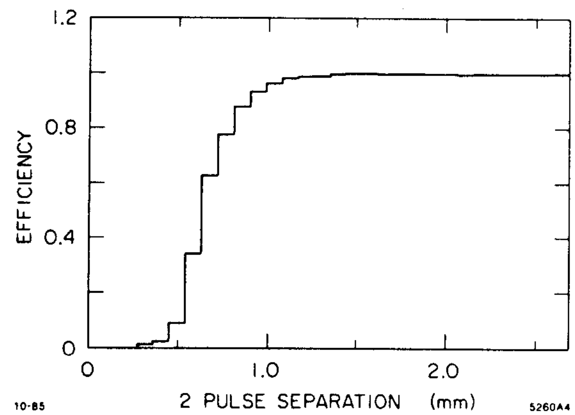


Fig. 4. Efficiency for finding 2 pulse events as a function of pulse separation. A constant 9 $\mu$m/ns drift velocity has been used to set the horizontal scale.

## REFERENCES


1. SLD Design Report, SLAC Report 273, May 1984.
2. C.C. Young, *Performance of the SLD CDC Prototype*, presented at this conference.