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# A simple method for rise-time discrimination of slow pulses from charge-sensitive preamplifiers

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ABSTRACT

Performance of a simple method of particle identification via pulse rise-time discrimination is demonstrated for slow pulses from charge-sensitive preamplifiers with rise times ranging from 10 to 500 ns. The method is based on a comparison of the amplitudes of two pulses, derived from each raw preamplifier pulse with two amplifiers with largely differing shaping times, using a fast peak-sensing ADC. For the injected charges corresponding to energy deposits in silicon detectors of a few tens of MeV, a rise-time resolution of the order of 1 ns can be achieved. The identification method is applicable in particle experiments involving large-area silicon detectors, but is easily adaptable to other detectors with a response corresponding to significantly different pulse rise times for different particle species.



## 1. Introduction

Pulse-shape discrimination is a well-known technique often used to identify particles according to their atomic and mass numbers. The method is based on the characteristic time-dependence of the electrical or optical response they generate in the detectors. There are different physical effects responsible for the sensitivity of different detectors on the species of impinging particles. Accordingly, many different pulse-shape discrimination methods have been devised. In particular, the sensitivity of semiconductor detectors to different particles is due to the variation of the ionization density along the particle track in the detector material and the resulting temporal variation of the charge collection rate in the applied electric field.

The present study is inspired by the actual demand of measuring rise times of pulses produced by charged particles in large-area silicon detectors now used in multidetector arrays such as the CHIMERA telescope array [1]. The study focuses on an idea of measuring rise times of slow pulses from charge-sensitive preamplifiers by shaping (filtering) these pulses with two different timing constants, one of which is much longer than the relevant maximum rise time, while the other is of the order of the shortest rise time expected in the particular application. With proper shaping, the amplitude of the "slow" pulse (representing the total charge injected into the preamplifier) will be virtually independent of the rise time of the raw preamplifier pulse, while the amplitude of the "fast" pulse (representing the fraction of charge injected on a short timescale) will show a distinct dependence on the rise time of the preamplifier pulse. Subsequently, the amplitudes of both shaped pulses can be digitized by fast peak-sensing analog to digital converters (ADCs), such as, e.g., the Phillips 7164 [2] or Silena [3] modules. Alternatively, depending on the available data acquisition, both shaped pulses can be stretched and their amplitudes be measured using current-integrating ADCs (QDC). Ultimately, the rise time is determined, event-by-event, from the ratio of "fast" to "slow" pulse amplitudes.

## 2. The test setup

A block diagram of the test setup is shown in Fig. 1. As depicted in this diagram, calibrated charge was injected into an ORTEC 142A charge-sensitive preamplifier, with three different rates, resulting in preamplifier output signals that had nominal rise times of 50, 100, and 200 ns, respectively. Charge pulses were obtained by charge-terminating pulses from a precision ORTEC 448 pulse generator. Different pulse rise times were employed as defined by the rise time settings of the pulse generator, while the decay time was fixed at 50 μs. A typical pulse with a nominal (set on the pulse generator module) rise time of 100 ns is illustrated in Fig. 2. It is seen to have an actual rise time close to nominal.

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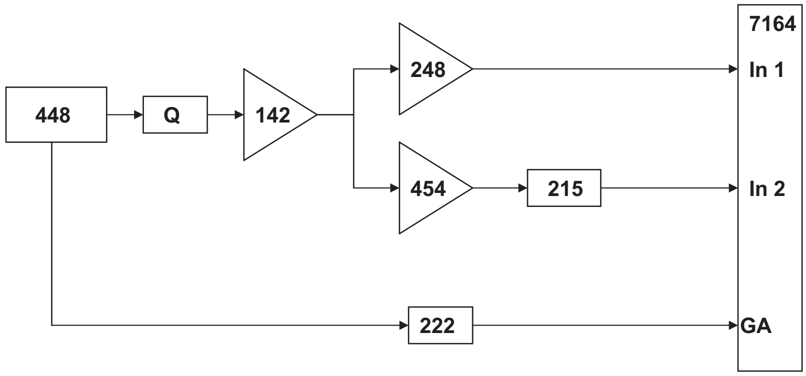


458 – ORTEC 448 Precision Pulser; 50, 100, 200 ns Risetimes; 50 μs Decay Time
Q – 4.438 pF Charge Terminator
142 – ORTEC 142A Current-Integrating Preamplifier
248 – TENNELEC TC248 Spectroscopy Amplifier; 1 μs Shaping
454 – ORTEC 454 Timing-Filter Amplifier; 50 ns Integration; 10, 20, 50 ns Differentiation
222 – LeCroy 222 Dual Gate and Delay Generator
215 – TENNELEC TC253 Delay Amplifier; 1.5 μs Delay
7164 – Phillips 7164 Peak Sensing ADC

**Fig. 1.** Block diagram of the electronic setup used to determine the performance of the pulse-shape discrimination method.

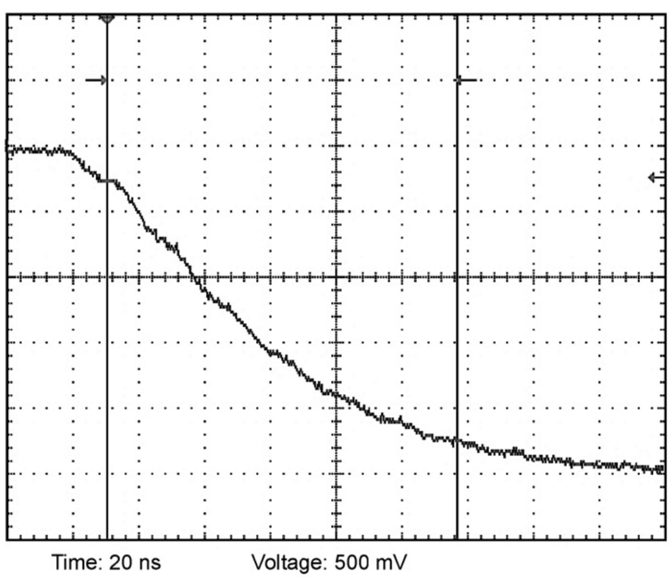


**Fig. 2.** Appearance of the leading edge of a typical pulse from the charge-sensitive preamplifier with nominally 100 ns rise time.

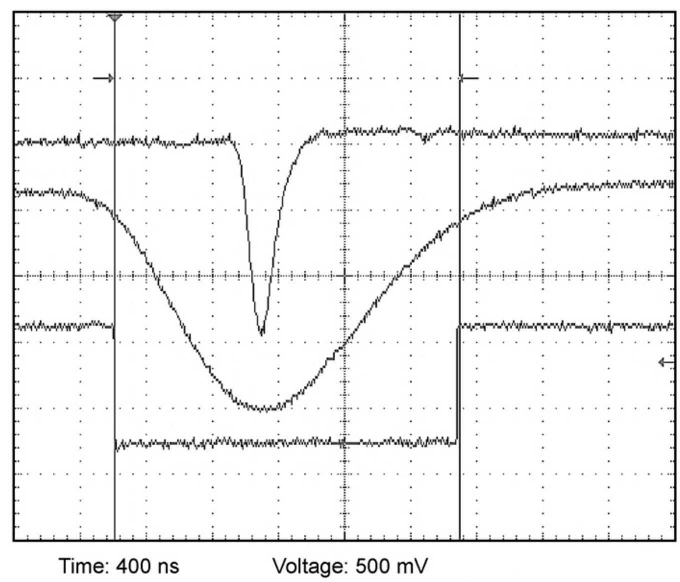


**Fig. 3.** The timing diagram of the "fast" and "slow" spectroscopic pulses and of the ADC gating pulse.

The output signal from the preamplifier was routed into two spectroscopic channels characterized by different shaping times. The "slow" channel had a shaping time fixed at 1 μs, while for the "fast" channel differentiation times of 10, 20, and 50 ns were explored. The integration time of the ORTEC 454 timing filter amplifier (TFA) used in the "fast" channel was fixed at 50 ns.

To be able to use a common ADC gate for both, fast and slow pulses, a TC215 delay amplifier was used in the fast channel to delay the output pulse from the ORTEC 454 TFA. The resulting timing of fast and slow pulses at the input of the peak sensing Phillips 7164 ADC is illustrated in Fig. 3. The present setup requires a peak sensing ADC capable of digitizing pulses with 50-ns short rise times, hence the choice of the Phillips 7164 ADC module.

## 3. Results and analysis

The measurements were performed for series of pulses with rise times of 50, 100, and 200 ns and for shaping times for the "fast" response of 10, 20, and 50 ns. To assess the effect of inherent fluctuations in the amount of charge ($Q$) injected into the preamplifier, the latter charge was varied in the range from 0.222 to 3.55 pC, corresponding to energy deposits in a silicon detector in the range from 5 to 80 MeV.

Results of the measurements are illustrated in Figs. 4, 5, 6 and 7. Fig. 4 illustrates the dependence of the amplitude ($Q_F$) of the "fast" pulse on the injected charge ($Q$), as measured for different shaping and rise times denoted by time constants RC and RT, respectively. As seen in this figure, shorter RC shaping times