Electronics for On-Line Liquid Scintillation α-Particle Spectroscopy

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Recent developments in liquid scintillation counting now make α-particle pulse-height spectroscopy possible with energy resolution as good as 200 KeV FWHM[1,2]. Since the light output per MeV of decay energy is much greater for β– particles than for α-particles, it is necessary to use pulse shape discrimination, based on the different fractions of slow- and fast-decaying components of the α- and β-light pulses, to produce a clean α-energy spectrum.

In recent experiments we used this technique to study the chemical properties of transactinide elements. The α/β pulse-shape discrimination was implemented with a standard constant fraction discriminator on the fast (7-ns risetime) pulse from the photomultiplier tube (PMT) to start a time-to amplitude converter (TAC). This PMT signal was then shaped to undershoot by 10% to 20% of the full pulse amplitude. A zero-cross-discriminator was then used to stop the TAC, providing discrimination between α- and β-pulses. Using this pulse shape discrimination technique, we found the β-decay of large amounts (>1 kHz) of background activities caused pileup pulses which passed the pulse shape discrimination circuit.

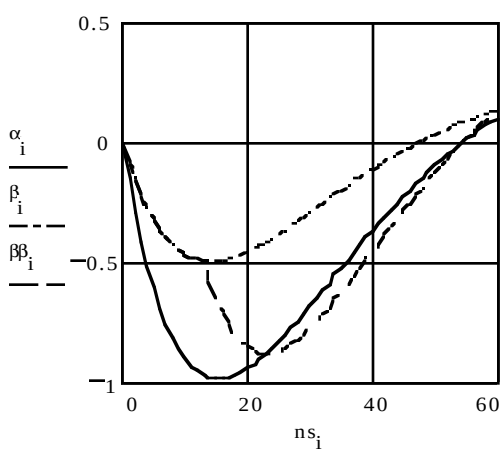

Fig. 1. Shaped pulses for the standard α/β pulse shape discrimination. The solid line is the shape for an α-pulse. The short dashed line is for a β pulse. The long dashes indicate a β-β pileup with the same zero cross time as the α.

In subsequent experiments an additional pulse shape discrimination technique[3] was used on the shaped pulse mentioned above, which acted as a fast pileup rejector. This pileup rejector was simply a CFD run with a fraction of 1.0 and a constant fraction delay equal to the full risetime of the shaped pulse (15ns), making it sensitive to the width of the pulse. The combination of this pileup rejector with the standard pulse shape discriminator allows the measurement of alpha decay rates as small as a few counts per hour in samples with beta background rates of well over 1 kHz.

Footnotes and References

1. W.J. McDowell, *Alpha Counting and Spectrometry using Liquid Scintillation Methods*, Technical Information Center, Office of Scientific and Technical Information, U.D. DOE, (1986).

2. B. Wierczinski, Doctoral Thesis, U.Mainz, (1994).

3. B. Wierczinski, et al., Nucl. Instr. Meth. A 370, 532 (1995).

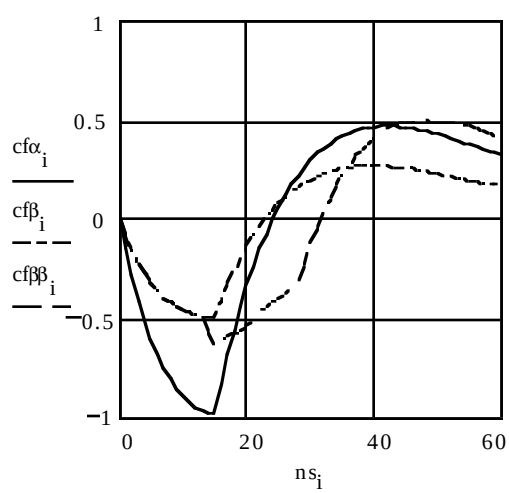

Fig. 2. The same pulses as in Fig.1, after passing through the f=1 CFD. Note that the zero-cross time of the β-β pileup (long dashes) pulse is well separated from that for the alpha pulse (solid line).