

PULSE SHAPE ANALYZER/TIMING-SCA APPLICATION TO BETA MEASUREMENT

S.SELVI, C.CELIKTAS

*Department of Physics, Science Faculty, Ege University,
TR-35100, Bornova, Izmir, TURKEY*

Electrical noise contribution to pulse height distributions from beta sources due to BC-400 plastic scintillator(PS), preamplifier and spectroscopy amplifier was rejected by setting the electronic set-up processing of the modified beta spectrometer consisted of pulse shape analyzer/timing single channel analyzer (PSA/SCA) and related complementary equipments. Improved noise rejection performance was evaluated in terms of elimination practically only all of the noise band of C-14 and Tl-204 spectra obtained using the two alternate beta spectrometer.

1. INTRODUCTION

In beta spectroscopy, the noise is usually the point of interest, since the noise degrades the energy resolution for charged particle detection, influence of it and the degradation increases, especially lower energy region, and reduces detector's sensitivity to beta sources. The detector output cannot be utilized effectively without eliminating the noise, so they would likely be operated with noise discrimination. The discriminated spectrum loss not only the noise pulses but also beta pulses corresponding to the energy of noise band. In view of evaluations of the detector, the comparison of pure and scattered beta spectra with those obtained by theoretical methods, electron scattering characteristics of targets and investigations of beta transitions and actual beta radiation dose deposited at a tissue, it is essential to develop a method to noise suppression.

(PSA/SCA) can be applied instead of amplitude discriminators to discriminate only noise pulses. The PSD technique has been used to discriminate between gammas and neutrons [1-3] in liquid scintillator [3] and in NaI(Tl) and to reject pile-up and defective pulses [4-5], to separate recoils and reaction products from scattered projectiles [6-7], to suppress Compton continuum [8], to improve the energy resolution of a gas scintillation proportional counter [9], to discriminate gamma from low level particles [10-11], and from betas [12] and alphas from betas [13].

It may be mentioned here that this is the first application of PSA/SCA where it has been used to separate noise from beta pulse height distribution as to conserve the continuum.

2. EXPERIMENTAL SETUP

A schematic of one of the beta spectrometer setup used in this study is shown in fig. 1. In our experiments, plastic scintillators were preferred as the beta detectors, which consists of a cylinder of BC-400 (Bicron Corp.) with 7.62cm diameter and thickness varying between 0.3

and 3.0mm manufactured by REXON Inc., USA, since pulse height distributions measured with a spectrometer system based on a BC-400 plastic scintillator were more representative of theoretical expectations than those measured with systems based on solid state detectors [1] and in the setup, PSA generates an analog signal whose amplitude is nearly proportional to the fluorescent decay time produced by the interacting particle in PSA.

In the setup, the fall time of the pulse from Amplifier (AMP.), measured by PSA/SCA and Time to Pulse Height Converter (TPHC), is identical to the rise time of the pulse about 0.1ns which corresponds to the decay time of PS. It can be assumed that all good pulses have closely the same rise time and the pulses with equal rise time generate the same zero crossing time, independent of pulse height. Thus the PSA/SCA and the TPHC permit noise discrimination through the decay time of the amplified input pulse, since noise normally has very low amplitude and very high frequency as compared to the pulse height signal. The PSA/SCA and the coincidence gate produce trigger for the signal acquisition only if the PSA signal was larger than the SCA's "low level" (LL) trigger. The TPHC output signal coincidentally gated the MCA which monitored the delayed unipolar output of the AMP. The fall time cut value, causing only pulses with fall times larger than that the noise separation from beta spectra can be realized by adjusting the fall time cut value, causing only pulses with fall time larger than that value to be accepted in the spectrum, the PSA/SCA, the TPHC output signal coincidentally gated the MCA which monitored the delayed unipolar output of the AMP, and the Delay (DEL) precisely.

Figure 2 shows a block diagram of the second PSA/SCA electronics. The output pulse of the Preamplifier (PA) can be used also as the timing output, since the PS generates very fast signal. The fall time between the timing signal, which is started by the PA, the TFA and the CFD and the stop signal, produced via the constant-fraction method on the trailing edge of bipolar AMP input after processing through the PSA/SCA, was measured with the TPHC and monitored on the MCA, the energy spectrum of which was gated in coincidence mode. The second circuit adjustment was about the same as for the fall time except precisely setting of the TFA and the CFD.

3. THE PERFORMANCE OF SPECTROMETERS

The pulse shape discriminations of the signals C-14 and Tl-204 beta sources from the BC-400 plastic scintillators connected to the spectrometers, shown in fig. 1 and fig. 2, were presented in fig.3, 4, 5 and 6. LL on the PSA/SCA is set to a minimum detectable energy during the measurements.

The pulse height spectra of C-14 betas, measured by the first beta spectrometer and compared with only the spectroscopy amplifier spectrum, appeared on the MCA, in fig. 3, show that the nature of continuum beta pulse height spectrum is conserved noise is separated. The similar pulse height spectra, which is slightly better in terms of the beta continuum conservation, can be seen fig. 4, detected by the second beta spectrometer without noise separation.

Figure 5 and 6 compare the pulse height spectra of Tl-204 betas, measured by the first and second beta spectrometer respectively with those measured without using the noise separator equipments.

The noise separation without distorting the beta continuum seem to be more succesfull in fig. 5 and fig. 6 comparing to fig. 3 and 4, since the low beta energy region of C-14 betas larger and normally contain much noise.

4. SUMMARY AND CONCLUSION

It has been that noise in beta spectra can be separated without deforming the original beta continuum distribution by using the two improved conventional the pulse rise time discrimination techniques. One of the PA output could be used as the timing signal as it is expected and the connection of it the TFA and CFD seem to be slightly better competitive with the PSA start output in fig. 1.

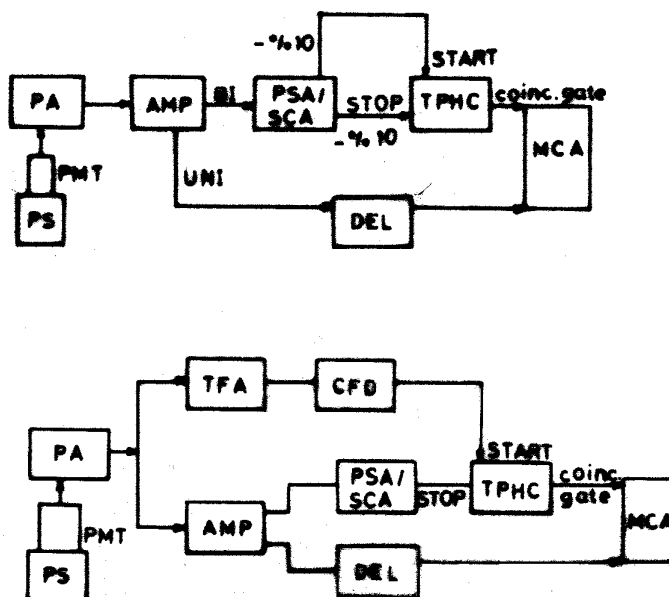
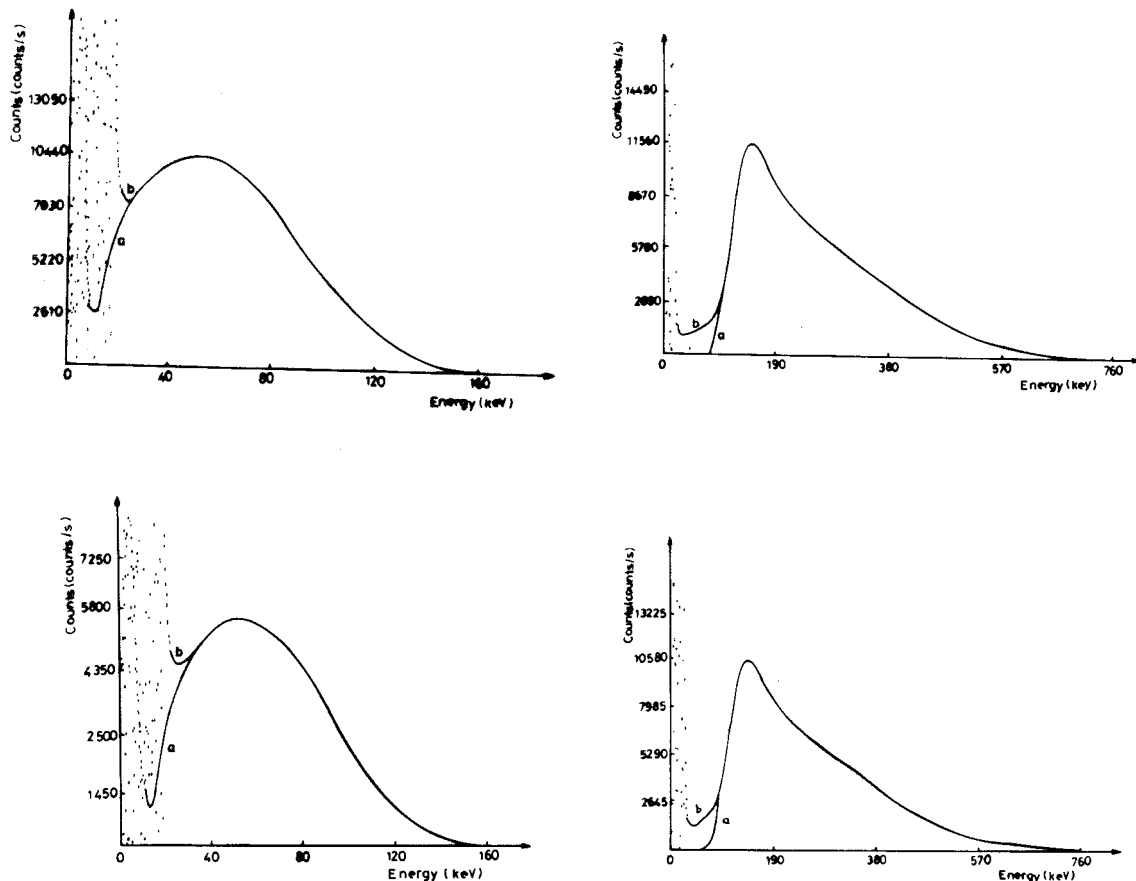


Figure 1. Schematic diagram of spectrometer electronics. Key to the electronic units: PA(Ortec 113 Preamplifier), AMP(Ortec 472 Sepctroscopy Amplifier), PSA/SCA(Ortec 552 Pulse Shape Analyzer/timing Single Channel Analyzer), TPHC (Ortec 437A Time to Pulse Height Converter), DEL (Ortec 427A Delay Amplifier), MCA (Ortec Maestro Trump-8k Multicahnnel Anayzer mounted in a PC).

Figure 2. Block diagram of the second beta-particle spectrometer. Key to the electronic units: TFA (Ortec 454 Timing Filter Amplifier), CFD (Ortec 463 Constant Fraction Discriminator).



This page is for the figure 3, 4, 5 and 6.

Acknowledgement

This study were supported by EBILTEM, Center of Science and Technology, Ege University and TUBITAK, The Scientific and Technical Research Council of TURKEY.

REFERENCES

1. Gale G.Simons, Jack F.Higginbotham, Nucl.Instr.and Meth. A293 (1990) 551-4.
2. Robert E.Home, Nucl.Instr.and Meth. 190 (1991) 309-11.
3. G.H.Share, J.D.Kurfess and R.B. Theus, Nucl.Instr.and Meth. 148 (1978) 531-3.
4. K.A.Sjöland, P.Kristiansson, Nucl.Instr.and Meth. B94 (1994) 333-7.
5. G.White, F.A.Smith and C.F.Coleman, Nucl.Instr.and Meth. A234 (1985) 535.
6. A.J.H.Maas, S.S.Klein, D.P.L.Simons, M.J.A de Voigt, Nucl.Instr.and Meth. B118 (1996) 268-73.
7. S.S.Klein and H.A.Rijken, Nucl.Instr.and Meth. B66 (1992) 393-6.
8. B.Aspacher, A.C.Rester, Nucl.Instr.and Meth. A338 (1994)511-5.
9. S.P.Garg, K.B.S.Murthy and R.C.Sharma, Nucl.Instr.and Meth. A336(1993) 200-5.
10. M.Omori, Nucl.Instr.and Meth. A337 (1993) 116-21.
11. M.Omori, Nucl.Instr.and Meth. A335 (1993) 553-60.
12. M.Palazzolo, P.Prati, G.Ricco and M.Tauti, Health Phys. 62/2 (1992) 15-161.
13. T.A.Devol, S.B.Chatoo, R.A.Fijeld, Nucl.Instr.and Meth. A425 (1999) 228-31.