# Signal processors parameter setting effect on the solid state detector tailing

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## *Introduction*

In x-ray based analytical techniques the knowledge of the true input rate, and the true detection efficiency for each x-ray line is necessary. It is also desirable to have the cleanest spectrum possible, as it will simplify the evaluation, as well as improve the limit of detection. This is generally obtained by eliminating the unwanted events using discriminators. However, each event, including the rejected events need to be evaluated as well. We have developed a method for this aim and therefore can offer quality assurance at the signal processor level. Having discriminators, which are used to modify and improve spectra, means. discriminator settings need to set in such a way as to reach the optimal compromise between quality and throughput for the given use. We have developed an automatic optimization procedure, and present the foundation of that here. During this study we have found some important aspects of the spectrum evolution, which has relevance to detector models and Monte-Carlo simulations as well. It is also useful in teaching and training in system design.

In the first panel we report on the quality of our signal processor with various detectors.

In the second panel the basics of the auto-setup or optimization is presented.

In the third panel the components of the detector line shape and their origin is presented.

There is a large scatter in the X-ray analysis database suggesting methodological origin. In order to improve the methodology, detector response functions have been investigated by many researchers and analysts. The detector lineshape or response function is often used to validate the spectra.

Why is such validation necessary? The signal processing electronics that generates the spectra has to identify the events as good events, degraded events, noise triggered events or electronic disturbances, unrelated real events and all possible pile up combinations. Whether the applied procedures are adequate for the detector and noise environment has to always be validated. Typical high quality response functions measured on SDD, Si(Li), HPGe, and Cd Te detectors are presented in figures 1-4. The measurements were made with CSX (Cambridge Scientific X-ray) signal processors.

The constant line shape of the detector response function under varying noise conditions implies that the noisier events are rejected and thus the rejection ratio varies with noise.

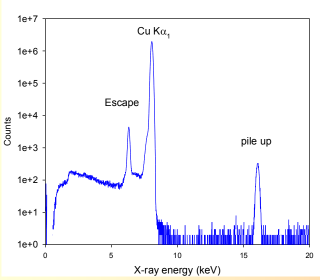

Figure 1. The response function of a Si(Li) detector for a quasi monochromatic CuKα1 radiation from a copper anode x-ray tube and x-ray monochromator. The tailing has the predicted shape.

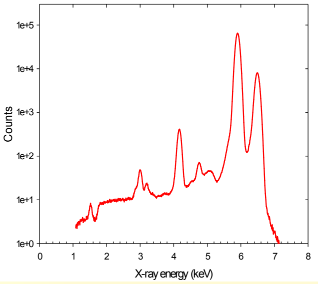

Figure 2. The response function of an SDD (Silicon drift detector), irradiated with an ${}^{55}$Fe radioactive source using a CSX3 signal processor.The electron escape edge near 1.8 keV is quite visible and should be present in any good quality spectrum.

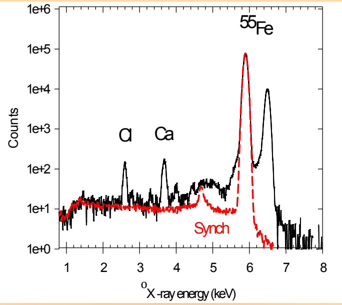

Figure 3. Response function of a HPGe detector for a monoenergetic x-ray radiation (dashed line) from a synchrotron monochromatized beam, and an ${}^{55}$Fe source (full line) measured at the same position.

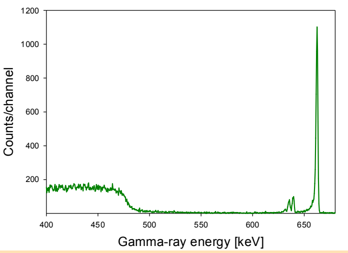

Figure 4. A spectrum of the 661.65 keV gamma line of ${}^{137}$Cs, measured with a CdTe PIN diode (3x3x1 mm$^3$). The well-resolved escape peaks demonstrate the resolution capability. The resolution was 1.9 keV for the 662 keV line or about ¼%.

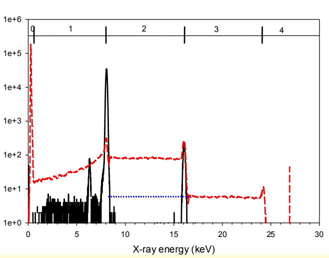

Figure 5. Spectrum of monochromatic Cu Kα1 radiation taken by a Si(Li) detector and a CSX4 signal processor in one setup mode shown in the region near the peak. In this setup mode we see 6 spectra - 4 of which are shown superposed here, accepted (black), total rejected (red), rejected by the fast pileup discriminator alone (magenta) and rejected by noise discriminator alone (blue). As can be seen these discriminators act to improve the quality of the line shape in the region of the peak shoulders - well below the FWHM resolution points.

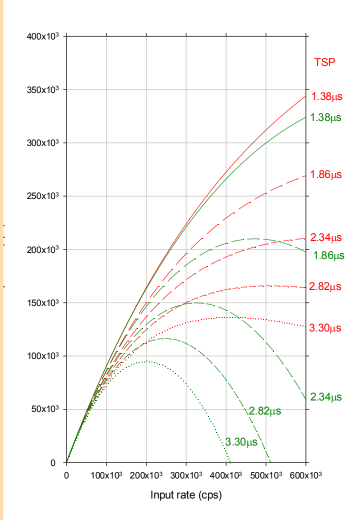

Figure 8. For the CSX2 processor the total OCR is given by the red curve. It was calculated for a preamplifier with 200 nanoseconds rise time, and a 400 nanoseconds ringing or overshoot time interval, which is excluded from the calculation of the energy of the x-ray event. The green curve gives the OCR in the accepted spectrum, when maximum pile up rejection is applied. However, setting the parameters will affect the level of noise and disturbances that are considered to be recognizable to the processor. This is a positive. However, it must be emphasized that the ICR is the sum of all events both real and noise.

The Cambridge Scientific signal processors (CSX units) provide a robust way to determine the fraction of single x-ray events lost from the analytical spectrum due to noise, rejected events and pileup. This allows analysis software the opportunity to correct for the losses and determine the *corrected* principal line intensities of interest in the spectrum, even at high input rates.

Recipes or algorithms can be easily developed to determine the number of lost true events based on information in the accepted and rejected event spectra.