Improving Detectors for X-Ray Spectroscopy

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What does it mean to "improve" detectors for X-ray spectroscopy? The energy resolution at ^{55}Fe is the "flagship" specification but is indirectly related to the precision, accuracy, and detection limits of EDXRF and EDS instruments. Many recent improvements in X-ray detectors and electronics do not show up in simple specifications but have critical impacts on instrument performance in various applications. This paper will discuss improvements in several areas and the applications which most benefit from these.

Statham [1] posed the question: "Would a device that offered an excellent energy resolution of only 7 eV but could only acquire at 60 cps be more useful than a device that could acquire at 10,000 cps but gave much poorer resolution of 150 eV?" This was also explored in [2], which proposed a "figure of merit" based on the time required to achieve a statistical uncertainty. This "figure of merit" is still useful and will be applied to the range of detectors available today, including Amptek's 122 eV FWHM FAST SDD®, 139 eV 6 mm^2 SiPIN, 195 eV 25 mm^2 SiPIN, and 450 eV CdTe detectors.

In applications where the source is sufficiently intense, a high count rate is of primary importance but must be achieved without sacrificing spectral performance (i.e. resolution, peak shifting, minimizing sum peaks). We will discuss Amptek's recent developments in signal processing electronics. These maintain spectral quality up to 3 Mcps for the FAST SDD® and are equally important for SiPINs.

In applications where the source is less intense, count rates are also of primary importance but must be achieved by capturing as much flux as possible. This implies larger area detectors (such as Amptek's 150 mm^2), thin windows (down to 40 nm Si_3N_4), thicker detectors, or higher Z materials (e.g. CdTe detectors). The trade-offs and applications benefiting from these will be discussed.

In many applications today, the detection limit is central. This often depends less on resolution and more on factors such as peak to background and peak to tail ratios, photopeak shape (and its stability), and the spectral purity of the detector. Although less dramatic in the spectrum than ^{55}Fe FWHM or high count rates, improving these parameters can significantly improve analytical results. We will discuss recent efforts at Amptek which have resulted in significant improvements, particularly at low energies (e.g. the C K_α line) and at energies near the Ag and Sn K_α lines.

[1] P.J. Statham, *Quantifying benefits of resolution and count rate in EDX microanalysis*, in "X-ray spectrometry in electron beam instruments", ed. D. Williams, J. Goldstein, and D. Newbury, Plenum Press, p 101, 1995

[2] R. Redus, A. Huber, *Figure of merit for spectrometers for EDXRF*, X-Ray Spectrom. 41, p 401, 2012