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Silicon Drift Detectors (SDD): x-ray spectrometry and spectrum imaging above 100 kHz output count rate, and what to do with all this data

The performance of the silicon drift detector (SDD) is advancing at an astonishing rate. The device builders have reached the third generation in SDD design. An SDD-3 operating at ~250 K actually outperforms conventional energy dispersive spectrometers (EDS) operating at ~ 80 K in resolution (for a given detector size) and matches or betters EDS in peak stability with input count rate. The great advantage of the SDD is its capacity to process deposited charge pulses at rates at least ten times greater than the EDS. Output count rates above 100 kcps with high quality spectrometry can be routinely achieved, with levels of 400 kcps or more possible. This speed makes x-ray spectrum imaging really attractive, and we can now obtain the "3-minute egg x-ray spectrum image": 128x128 pixels, with 10 ms dwell per pixel and 1.3 ms overhead (spectrum storage and beam positioning) yielding in 185 seconds a 2048 channel spectrum, 2 bytes deep at each pixel. At 220 kcps output count rate, this "3-minute egg" spectrum image contains sufficient counts to provide useful information even for minor constituents (e.g., ~ 5 weight %).

Now that we can mass produce x-ray spectrum images, we are facing a surfeit of data. We need efficient, rapid software tools to aid us in mining this pile. NIST has been investigating a class of software tools that rapidly determine "derived spectra", which are spectrum-like displays (intensity vs. channel number) in which the x-ray intensity at a particular channel is calculated from all of or a subset of the intensities measured at the pixel locations for that channel. The very familiar SUM spectrum, in which the counts at all pixels that constitute a particular channel are added, is an example of a derived spectrum. The SUM spectrum is useful for finding dominant features in a spectrum image. We have found that the MAXIMUM PIXEL spectrum, created by finding the maximum value at any pixel in a particular channel, can locate extremely rare events, down to the single pixel level without any prior assumptions. This is like finding the needle in the haystack without knowing in advance that you were looking for a needle! Other algorithms for derived spectra are being tested, following what appears to be a rich vein of possibilities.