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A FASTER APPROACH TO SPECTRUM IMAGING AND ELEMENTAL MAPPING IN STEM.

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We have successfully designed and tested a faster method of spectrum imaging, or a simultaneous acquisition of energy selected signals required for elemental mapping

Our HB601UX (manufactured by Vacuum Generators, UK) was outfitted with the PEELS 666 spectrometer from Gatan Inc. The detection system of this device was equipped with a 1024 channel photo diode array (PDA). The speed of acquisition either for spectra or elemental imaging at each pixel was limited by the readout time of the PDA, which was in the neighborhood of 20ms. This posed no hardship for the acquisition of spectra at a single pixel. However, for imaging it meant a compromise between the size of the image (i.e. the number of pixels per image) and the total time required for acquisition. For the acquisition of even a single STEM image of 480x480 pixels it would take a minimum of 76 minutes. Such times are not tractable for the routine examination and elemental mapping of biological tissue sections.

In our system the PDA is temporarily swapped with a Hamamatsu Model H7260 photomultiplier. In general, photomultiplier tubes are fast, have low noise and high sensitivity. In a suitable scintillator, a high energy electron produces a rapid burst of light containing many photons, making it relatively easy to detect and count single electrons with a PMT. Due to limitations in sensitivity and noise characteristics, single electron counting could not be obtained using the PDA.

The Hamamatsu Model H7260 is a multianode 32 channel linear array, which has a spacing of 1 mm between anodes. It has good sensitivity and low dark noise characteristics. In addition, this assembly was easy to mount and coupled optically to the scintillator. To take advantage of the STEM electronics (see below), the array was divided into four groups containing 6 anodes which were coupled by us. The bottom 8 anodes were unused, since they extended outside the 25mm spectrum dispersion window of the Gatan scintillator. Thus this arrangement created the equivalent of four photomultipliers covering the spectral window.

The capabilities of the microscope electronics were extended to process the four acquisition channels that had been built into the STEM. This involved writing image acquisition software for four channels. Moreover, two additional discriminators had to be built and installed. The result was the simultaneous processing of four energy loss signals as the beam scanned across the specimen, from amplification, discrimination, counting to storage in memory, at the full range of acquisition times of the STEM, from 5 μsec/pixel to 5.2 msec/pixel. A two parameter background fit for elemental mapping can now be done quickly, with the acquisition of two pre-edge signals with either one or two channels positioned on the edge of interest.

The signal characteristics of all four channels are shown in Fig. 1. There is some cross-talk between the channels, the size of which is indicated in Table 1. Since the relative amount of cross-talk had been determined, the solution of four linear equations (matrix inversion) permits the correction for signal loss to other channels and determination of the true energy loss signal in each of the four regions.

Fig.1

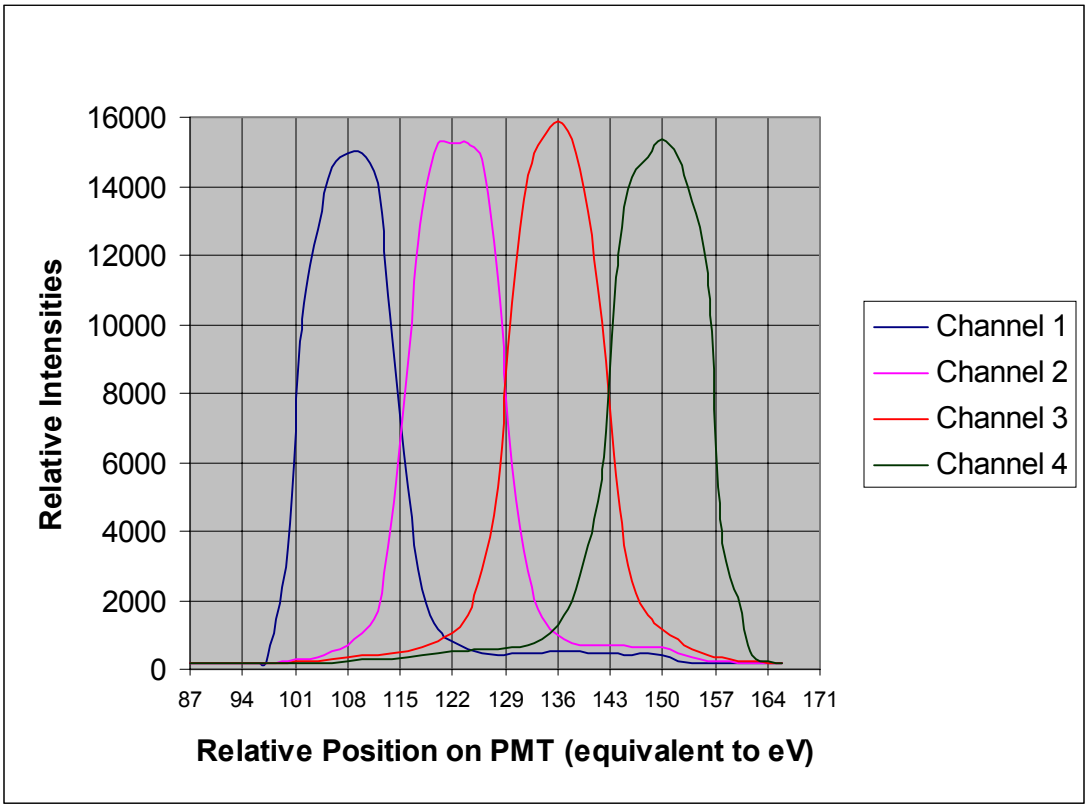

Table 1. Quantitative characterization of the cross-talk between the four signal acquisition channels of the H7260 PMT.

		Relative Intensities for various beam positions			
		Ch1	Ch2	Ch3	Ch4
Beam Position	1	0.949685	0.0448	0.003711	0.001804
	2	0.063108	0.874053	0.053685	0.009154
	3	0.005202	0.074824	0.857264	0.06271
	4	0.002379	0.035961	0.03491	0.92675

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