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Novel analysis techniques to address systematic resolution degradation in multiplexed arrays of transition-edge x-ray sensors

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Superconducting transition-edge sensors (TESs) have achieved high resolving power in single-pixel demonstrations with low photon count rates. However, numerous applications require large arrays of sensors capable of handling high per-pixel count rates. Implementing large TES arrays necessitates a multiplexed readout scheme, which can degrade energy resolution when operating in the high-count-rate limit. Two of the largest systematic effects are degradation in resolution from imperfect knowledge of the pulse arrival time between digital samples and cross talk between pixels sharing a common readout line. Currently, no universal approach has been presented for handling these effects in multiplexed arrays of TESs. If unaccounted for, these effects can significantly degrade the energy resolution by a factor of two or more beyond the intrinsic detector resolution. In this talk, we will present novel analysis techniques beyond the usual approach of optimal filtering the data to mitigate the degradation from these effects using two example case studies.

In the first example, we present x-ray spectra from a TES spectrometer installed on the soft x-ray U7A beamline of the National Synchrotron Light Source. Utilizing two different linear filters for energy and arrival time, we were able to improve the spectral resolution of the sensors by over 3.0 eV to achieve 1.7 eV FWHM for 390 eV incident photons.

In the second example, we present cross-talk behavior within a 240-pixel array running in an 8-row by 30-column time-division multiplexing format. This instrument is

operating with a broadband x-ray source producing photons from 1,500-16,000 eV in the NIST pulsed laser laboratory. In this system, cross-talk can degrade the resolution from approximately 4 eV to 8 eV as the per-pixel count rate is increased to 30 Hz. We have measured the cross-talk among all 240 pixels and identified the two largest contributing sources. Nondeterministic and additive behaviours are expected for inductive and time-delayed cross talk respectively. And using this information, we discuss a potential rejection scheme for time-delayed cross talk and corrections for inductive cross talk.