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High count-rate study of transition-edge sensor X-ray microcalorimeters

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We are developing transition-edge sensor (TES) microcalorimeter arrays with high count-rate capability and high energy resolution. We fabricated a microcalorimeter array on a solid substrate where the TESs have a dimension of 35x35 um^2. We tested two devices with different transition temperatures (Tc) with X-rays from a Fe-55 source at event rates up to 1000 counts per second (cps), and analyzed the data using the modified event grade method. The original event grade method is an efficient tool for analyzing X-ray data with frequent pile-ups. It first classifies the X-ray pulses into three groups—high, mid, and low resolution groups—based on the pulse arrival times, and then each group is analyzed separately to obtain a combined spectrum of the three with the highest possible energy resolution and throughput (fraction of processed pulses). In our modified event grade method, the pre-trigger levels of each X-ray pulse were used as the criterion for pulse classification instead of their arrival times. Furthermore, we

corrected for the non-linear dependence of pulse-heights on pre-trigger levels in the low resolution group, which also improved the combined energy resolution. Using this method, we achieved compelling results even at very high count-rates. For example, 4.2 eV FWHM with 99% throughput was achieved for 6 keV X-rays of 750 cps per pixel. This method will work with not only TES microcalorimeter data but also those from other types of detectors. We will also discuss the effect of decay time constant on combined resolutions and throughputs based on the measurements of two devices with different Tc's.