Modern microwave SQUID multiplexers with scalable readout

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New Transition-Edge Sensor (TES) microcalorimeter applications, such as x-ray spectroscopy for beamline science and direct measurement of neutrino mass, call for sampling rates between 300 kHz and 2 MHz per pixel. To read out more than a couple of pixels at this speed requires much larger output bandwidth than existing multiplexing techniques provide. Large scale bolometric applications will also require a dramatic improvement in total output bandwidth. We plan to meet these needs with a microwave SQUID multiplexer (Mates, APL, 2008), which provides GHz of output bandwidth.

In previous work, we demonstrated microwave SQUID multiplexing of two gamma-ray sensors, the first application of this technique to TES microcalorimeters (Noroozian, APL, 2013). While a successful proof-of-principle, this result used non-scalable, homodyne techniques to demultiplex at room temperature. We now present a demonstration of multiplexing eight TES microcalorimeters using a scalable, open-architecture readout solution. These results pave the way for large-scale (1,000-10,000 pixel), high-speed TES arrays.

In addition to developing the room-temperature readout electronics, we have continued to design, fabricate, and test improved microwave SQUID multiplexer circuits. We will present advances in noise (below 20 pA/sqrt(Hz)), reduction in crosstalk, and expansion of per-pixel bandwidth (up to 1 MHz), that meet the demands of modern TES applications.