SuperSpec: On-Chip Direct-Detection Spectroscopy, Preparing for LMT Campaign

Joe Redford[1], Steve Hailey-Dunsheath[1], H.G. (Rick) LeDuc[2], Reinier Janssen[2], C.M. (Matt) Bradford[2,1], Ryan McGeehan[3], Kirit Karkare[3], Erik Shirokoff[3], Pete Barry[4], Jordan Wheeler[5], Jason Glenn[6], Phil Mauskopf[7], Carole Tucker[8], Ryley Hill[9], and Scott Chapman[9]

Wideband, direct-detection spectroscopy in the far-IR through millimeter is a compelling scientific opportunity on platforms ranging from ground-based to cryogenic orbital. Large-format spectroscopy in these bands is challenging, however, because it requires large arrays of sensitive detectors, and because conventional optical spectrometer designs are large and do not scale up gracefully.

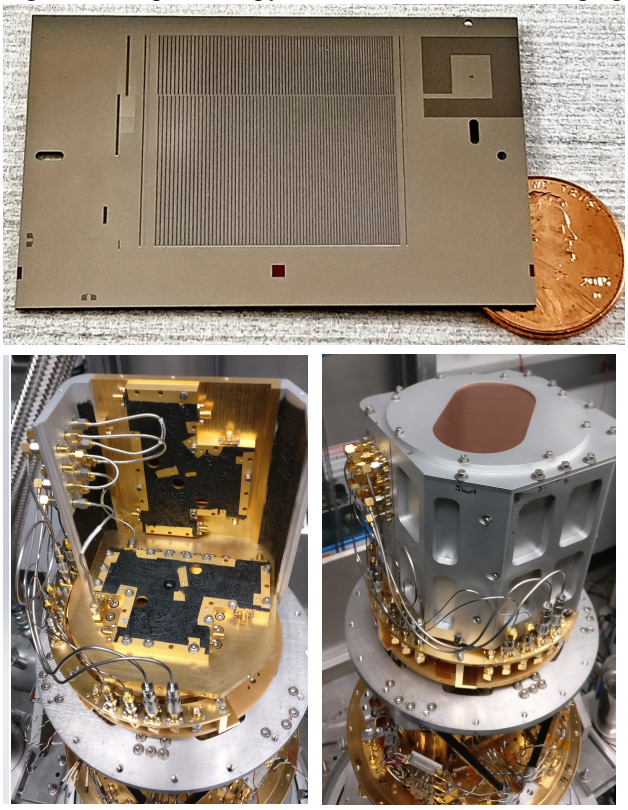

Fig. 1. *Top*: 300-channel SuperSpec chip covering the 200-300 GHz band. The feedline runs from right to left (~1/3 down from the top). The vertical structures are the KID capacitors. *Bottom*: Cold box of the demonstration instrument. It houses 6 chips to couple both polarizations of 3 beams (grid polarizer not shown here); they will be steered to the source with a chopping mirror at a pupil in the warm relay optics.

To address these challenges, we have developed a superconducting on-chip filterbank, SuperSpec. Radiation propagates on niobium on-silicon-nitride microstrip, and encounters a series of resonant filters, each coupling a narrow band to titanium-nitride kinetic inductance detector (KID). As Figure 1 shows, a full wideband spectrometer fits on a silicon chip a few square cm in size.

In previous 50-channel prototypes covering the 240 to 265 GHz band, we demonstrated good filterbank performance. and a limiting detector noise equivalent power of 7×10^{-19} W $Hz^{-1/2}$, comfortably photon-background-limited for any ground- or suborbital application. We have developed and are now producing full band (~200-300 GHz) 300-channel (Fig. 1) and 110-channel chips for scientific use.

We are preparing to deploy 6 chips in a demonstration instrument (Fig. 1, bottom) at the Grand Telescopio Millimetrico (GTM/LMT) on the 15,092' Sierra Negra in Mexico. The spectrometer chips are cooled to 220 mK, and each uses a single readout circuit operating between 100-450 MHz based on with ROACH-2 electronics. The instrument will be installed this summer with scientific observations in the fall. We will target dusty galaxies at intermediate and high redshifts in CO and [CII], respectively.

Future prospects for SuperSpec include steered multi-object spectrometers and large 2-D imaging spectrometers.

References

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[1] California Institute of Technology, Pasadena, CA 91125 USA.
[2] Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109 USA.
[3] University of Chicago, Chicago, IL 60637 USA.
[4] Argonne National Laboratory, Lemont, IL 60439 USA.
[5] National Institute of Standards and Technology, Boulder, CO 80305 USA.
[6] NASA Goddard Space Flight Center, Greenbelt, MD 20771 USA.
[7] Arizona State University, Tempe, AZ 85281 USA.
[8] Cardiff University, Cardiff CF10 3AT, United Kingdom.
[8] Cardiff University, Cardiff CF10 3AT, United Kingdom
[9] University of British Columbia, Vancouver, BC V6T 1Z4, Canada.

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