National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

Technology for Future Far-IR Missions: Demonstration of (Large-Format) KID Arrays and On-Chip Spectroscopy with SuperSpec

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Strategic Focus Area: Long-Wavelength Detectors | **Strategic Initiative Leader:** Charles Lawrence

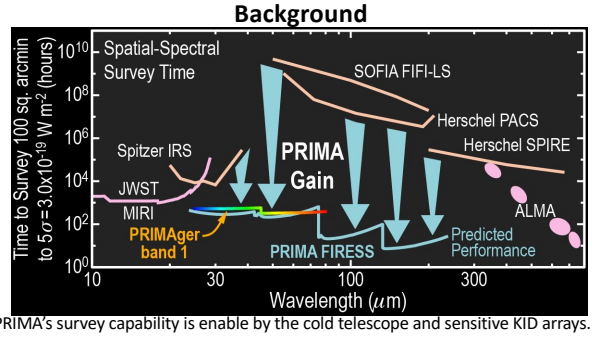
Objectives

Our objective is to demonstrate new large format, ultrasensitive kinetic inductance detector arrays that demonstrate readiness for future cryogenic far-infrared astrophysics missions, most importantly our probe PRIMA. In addition to these conventional, planar arrays for classical spectrometers, we are demonstrating a new on-chip superconducting photonic spectrometer with an integrated array of high-sensitivity KIDs, this will greatly reduce the of a wideband direct-detection spectrometer. Specifically, we aim to:

1) Demonstrate an optical noise-equivalent power (NEP = measured noise over measured response) of 2.0×10^{-19} W $Hz^{-1/2}$ or better in a direct-absorbing thin-film aluminum KID detector which multiplexing suitable for a PRIMA spectrometer.

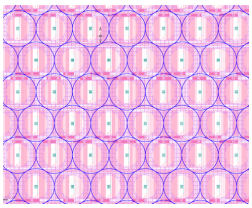
2) Demonstrate the SuperSpec on-chip spectrometer technology at the Large Millimeter Telescope (LMT).

Background



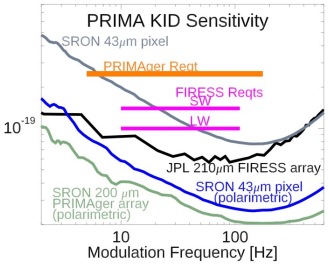
PRIMA's survey capability is enable by the cold telescope and sensitive KID arrays.

Approach & Results 1: PRIMA KID Arrays

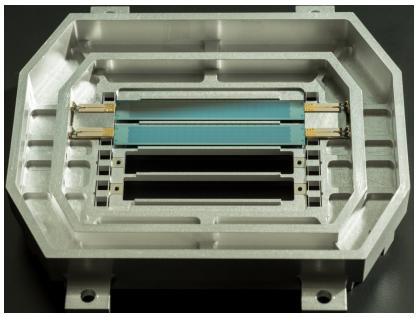


Detector NEP [W $Hz^{-1/2}$]

PRIMA long-wave 1008 pixel subarray Pixel design from Echternach / van Berkel and array layout from Janssen. Pitch is 0.9 mm.

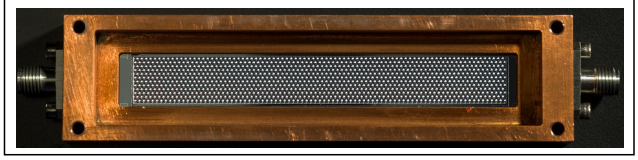


Noise equivalent power measurements, black is an example pixel on this brassboard device.

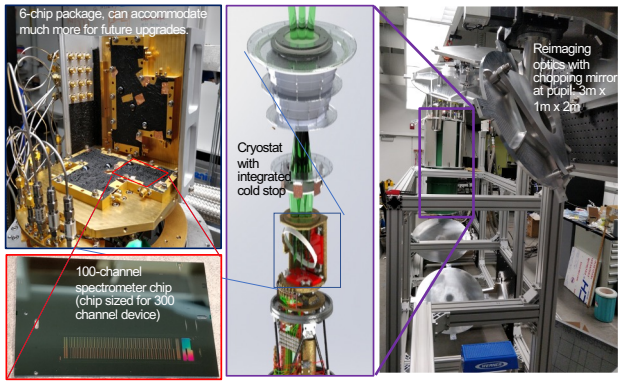


Left shows two subarrays mounted in flight-like housing which uses flexure for CTE compliance and stray-light control. (credit R. Calvet and M. Foote for design). Resonator yield is >90% on these subarrays.

Bottom shows single subarray hybridized with matching lens array from GSFC. Optical testing of this array is underway now.



Approach & Results 2: SuperSpec Chip Spectrometer



We have developed a demonstration instrument fielding 6 chips coupling 3 beams in both polarizations, it is shown in Figure 4. Through this task, we finished the integration, including screening new chips, integrating the readout electronics and software, and assembling and testing the warm optics (Figure 5). As Figure 5 also shows, the instrument is now being shipped to the Large Millimeter Telescope in Mexico. This shipment has unfortunately been delayed due to problems with customs in Mexico, as well as a forest fire on the LMT site which has damaged transformers and left the observatory without main line power for many months.

Significance and Benefits to JPL and NASA

We are setting the stage for future far-IR spaceborne astrophysics, in particular our Probe PRIMA. This program has helped to develop the flight-like arrays for PRIMA which meet the sensitivity requirements at the long-wavelength end. Short-wavelength KID development is still underway. With the on-chip spectrometer, we both demonstrate JPL KIDs in a scientific application, and pave the way to massive imaging spectroscopy in the millimeter and long-submillimeter bands.

National Aeronautics and Space Administration

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Publications:
We presented 2 papers at the low-temperature detectors conference, and the two written proceedings are in preparation now.
L. Foote et al., & E. Kane et al.

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