FY24 Strategic Initiatives Research and Technology Development (SRTD)

Superconducting Detector Arrays for Imaging and Spectroscopy at Far and Mid-Infrared Wavelengths

Principal Investigator: Peter Day (389)**; Co-Investigators:** Henry Leduc (389), Byeong Eom (389), Charles Bradford (326), Andrew Beyer (389), Pierre Echternach (389), Reinier Janssen (326), Christopher Albert (389), Ritoban Basu Thakur (389), Jason Glenn (Goddard Space Flight Center)

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

Objectives: Optically demonstrate closely-packed, micro-lens coupled Kinetic Inductance Detector (KID) arrays with the required detector NEPs for both imaging and spectroscopy for a space mission with a cooled telescope in the wavelength range of 25-400 microns. We target the detector performance requirements for PRIMA, particularly an array for 25 microns, which is at the short- wavelength (and hence more difficult for superconducting detectors) end of PRIMA's range.

Background: The Astro 2020 Decadal Survey strongly endorsed a line of Astrophysics Probe missions. JPL has submitted a proposal for a mission called PRIMA that baselines mid- and far-infrared kinetic inductance detectors (KIDs), a superconducting detector technology originally developed at JPL [P. K. Day, H. G. LeDuc, B. A. Mazin, A. Vayonakis, J. Zmuidzinas. *Nature*, 425, 6960, 817–821 (2003)].

Approach and Results: The detector array is based on the lenslet-coupled lumped-element KID design (fig. 1) originally used for a small pathfinder instrument called MAKO [Swenson et al., 2012]. The lenslet arrays are fabricated lithographically by our partners at Goddard using gray-scale techniques and etching into a silicon wafer. They are then hybridized with the detector wafers made at JPL using a sub-micron epoxy bond layer. The hybridized detector arrays were measured in a dilution refrigerator test bed using a cryogenic black body calibrator.

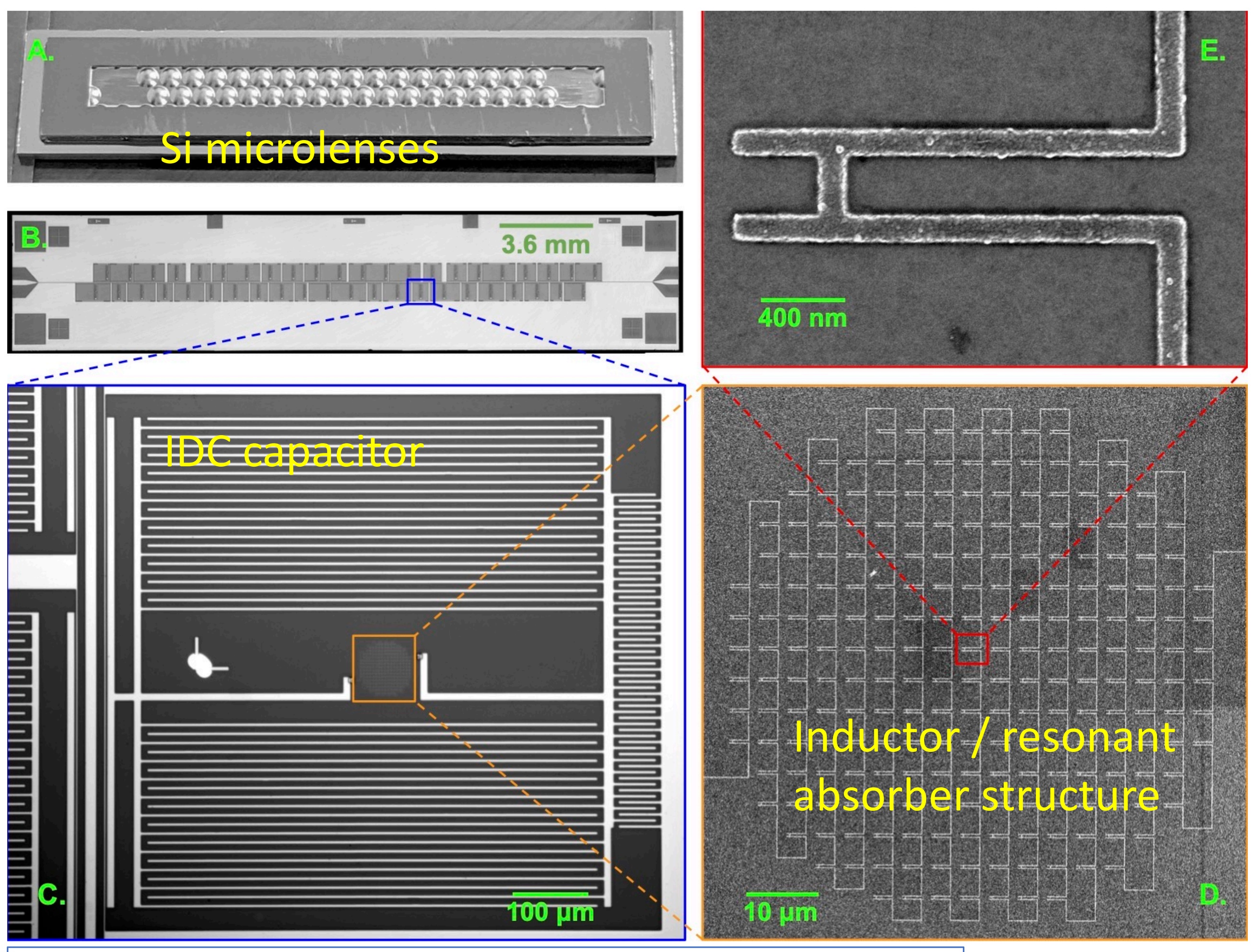

Fig 1. Array and λ = 25-micron KID pixel layout

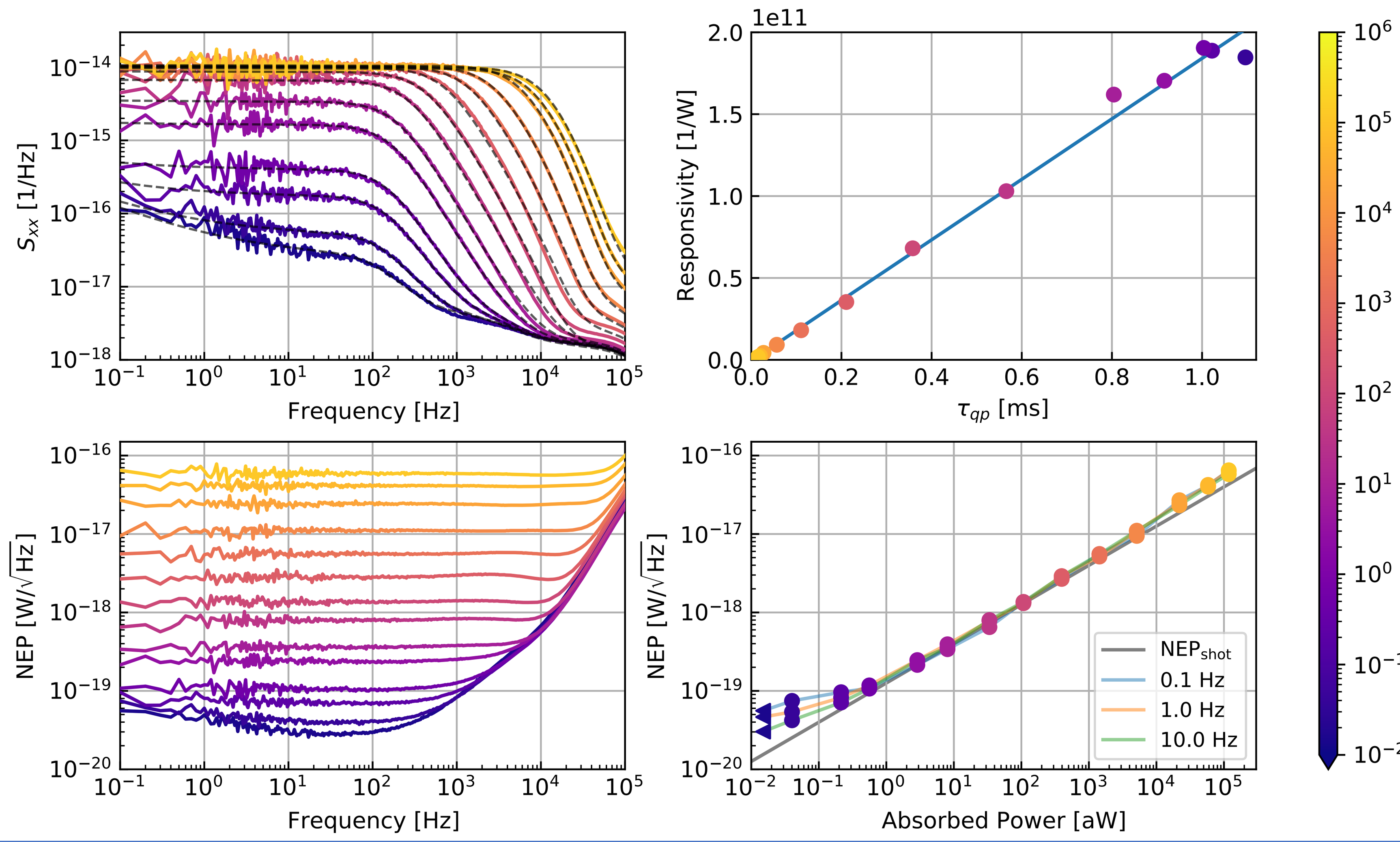

Fig 2. Noise, optical responsivity and NEP of the 25-micron band KID versus absorbed optical power

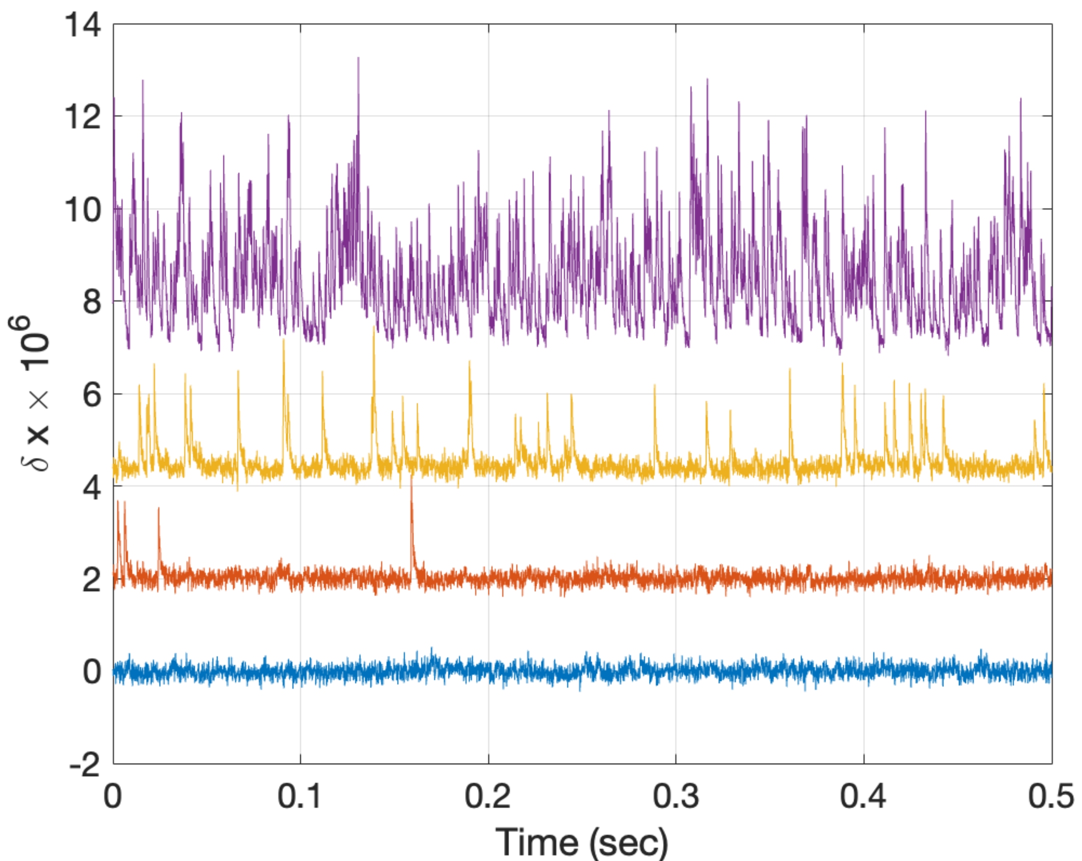

Fig 3. Time streams from low to high photon flux

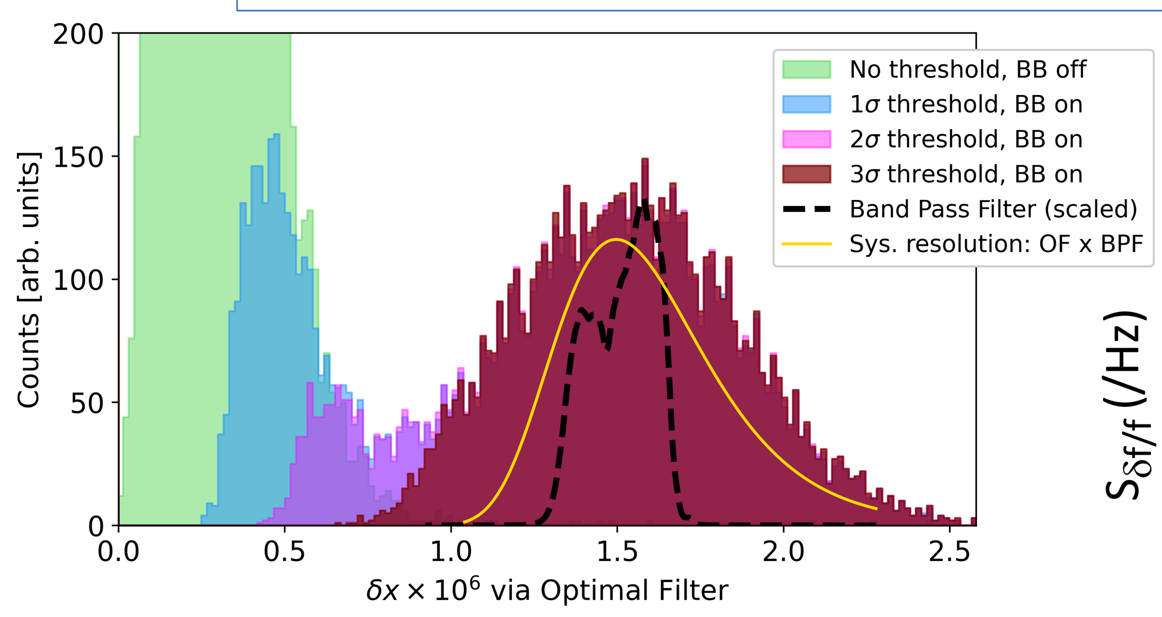

Fig 4. Histogram of detected pulse heights, showing a well resolved population from 25-micron photons events. With a suitable trigger level, the dark count rate is < 10 mHz, corresponding to a photon-counting mode NEP < 3x10^{-22} W/Hz$^{1/2}$

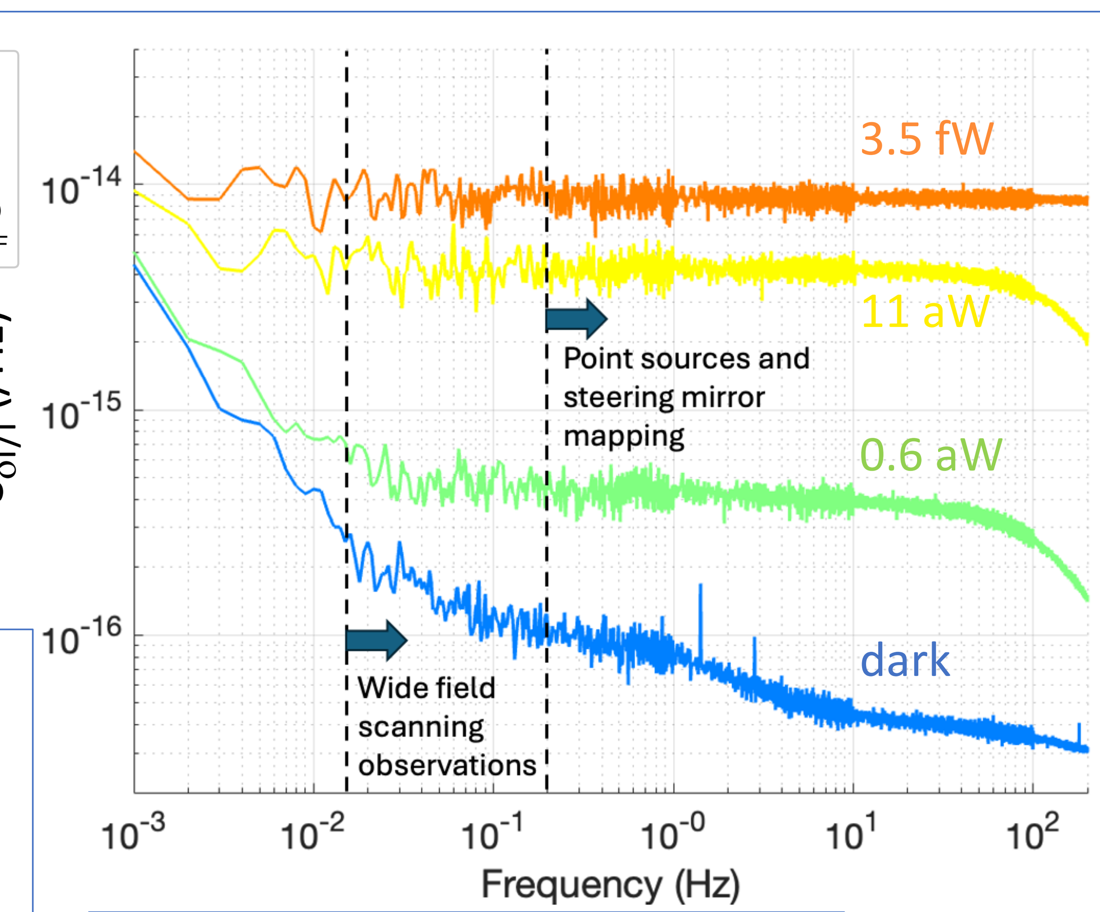

Fig 5. Low frequency noise spectra

Significance/Benefits to JPL and NASA: These results establish an approach to detectors meeting the requirements of the proposed Astrophysics Probe mission PRIMA as well as the Flagship mission concept Origins Space Telescope.

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

RPD-000 Clearance Number: CL#00-0000

Publications:

Day, P. K., Cothard, N. F., Albert, C., Foote, L., Kane, E., Eom, B. H., ... & Leduc, H. G. (2024). A 25-micron single photon sensitive kinetic inductance detector. *arXiv preprint arXiv:2404.10246*. (Accepted by PRX).

PI/Task Mgr. Contact Information:

818-354-9356 Peter.K.Day@jpl.nasa.gov