National Aeronautics and Space Administration

Advancing Ultraviolet Detectors: Dark current characterization towards fundamental understanding of silicon detectors for future astronomical missions

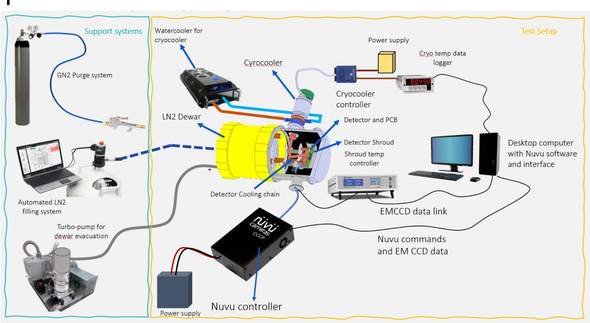
Principal Investigator: Shouleh Nikzad (389); Co-Investigators: Erika Hamden (U of Arizona), Aafaque Raz Khan (U of Arizona)

Program: FY21 SURP **Strategic Focus Area: Focal planes**

Objectives: The objective of this effort is to understand a fundamental property of silicon detectors that is currently not well understood. The thermal noise (dark current) in Si detectors, which should decrease exponentially with temperature, has been observed to plateau below around a detector temperature of -110°C. This plateau is responsible for a noise floor that limits the signal to noise ratio (SNR) and overall performance that can be achieved with these detectors. While observed in all Si devices, the high gain amplification of this noise in Electron Multiplying Charge-Coupled Devices (EMCCDs) in this project allows for a robust measurement of this noise.

Background: Previous measurements with EMCCDs (Kyne et al. 2016), found the dark current plateau ~ -110 °C and effect also observed in other CCDs. The plateau could be due to a combination of ambient IR from the dewar, low level light leaks, and/or a non- temperature dependent component that varies with substrate voltage. By developing an innovative setup which eliminates the thermal blackbody emission from the detector dewar and ambient environment, dark current can be measured with and without the IR blackbody noise to investigate the contributions to the dark current plateau.

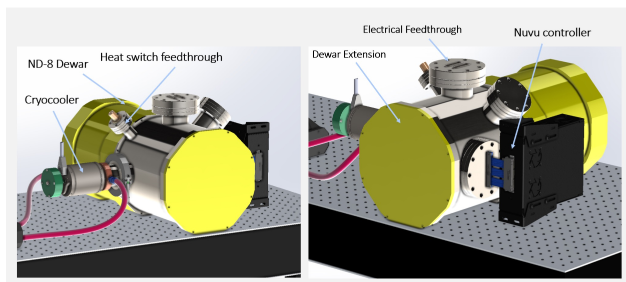
Approach and Result: This SURP effort was led by a graduate student Aafaque Raza Khan at UArizona. A light tight vacuum test setup that can both cool the detectors and control the ambient environment immediately seen by the detector to test the hypothesis of this effort for the reason the dark current plateaus at -~110 °C.



Conceptual Layout of the dark current test setup showing the two independent cooling chains along with the vacuum and LN2 support systems.

Significance/Benefits to JPL and NASA:

A better characterization and understanding of Si detectors is of great importance to the broad detector community. The specific UV EMCCDs in investigation have been identified as critical technology for recent flagship concepts, astrophysics, and planetary missions.



3D CAD views of the test setup showing the dewar with extension, cryocooler and the Nuvu controller

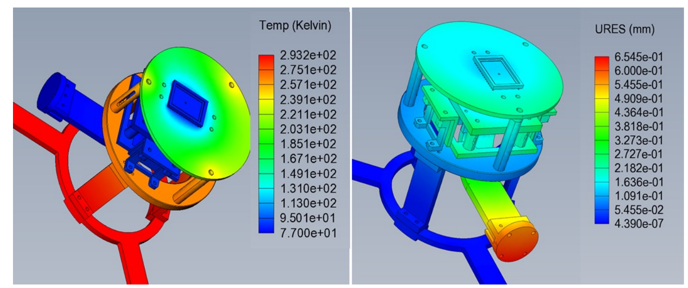
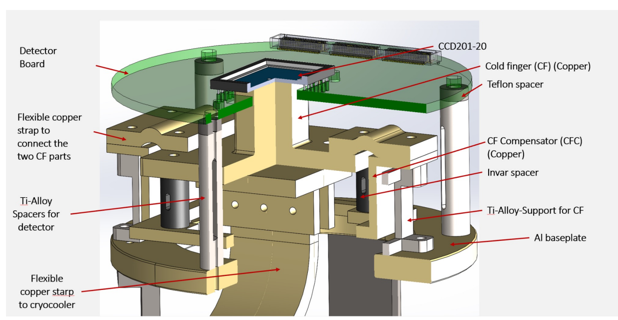


Figure shows one of the several cases simulated for Thermo-elastic deformation studies results. Left: Temperature distribution in the detector cooling chain assuming thermal shroud at 23 deg Celsius with detector cooled to 77 K. Right: Thermal deformation of of the detector cooling chain assembly based on the temperature distribution from the thermal study in the left panel



3D CAD views of detector cooling chain showing the two-part cold finger arrangement with invar space and the copper straps.

Nearly all electronic and mechanical parts for the setup are available at the UoA lab. The last component, the NÜVÜ feedthrough and an updated PCB for the FEE are underway. UoA team is working on assembly and testing of the setup with mechanical grade detectors before the electrical grade detectors are integrated for dark current characterization. JPL provided the detector test samples, review of the design, device physics expertise, and information on operating the detector controller.

PI/Task Mgr Contact
Email: Shouleh.Nikzad@jpl.nasa.gov

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

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