



NASA SBIR 2021 Phase I Solicitation

S1.05 Detector Technologies for Ultraviolet (UV), X-Ray, Gamma-Ray Instruments

Lead Center: JPL

Participating Center(s): GSFC, MSFC

Scope Title:

Detectors

Scope Description:

This subtopic covers detector requirements for a broad range of wavelengths from UV through to gamma ray for applications in Astrophysics, Earth Science, Heliophysics, and Planetary Science. Requirements across the board are for greater numbers of readout pixels, lower power, faster readout rates, greater quantum efficiency, single photon counting, and enhanced energy resolution. The proposed efforts must be directly linked to a requirement for a NASA mission. These include Explorers, Discovery, Cosmic Origins, Physics of the Cosmos, Solar-Terrestrial Probes, Vision Missions, and Earth Science Decadal Survey missions. Proposals should reference current NASA missions and mission concepts where relevant. Specific technology areas are:

- Large-format, solid-state single-photon-counting radiation-tolerant detectors in charge-coupled device (CCD) or complementary metal-oxide-semiconductor (CMOS) architecture—including 3D stacked architecture—for astrophysics, planetary, and UV heliophysics missions.
- Solid-state detectors with polarization sensitivity relevant to astrophysics as well as planetary and Earth science applications, for example, in spectropolarimetry as well as air quality and aerosol monitoring.
- UV detectors for O₃, NO₂, SO₂, H₂S, and ash detection. Refer to National Research Council's Earth Science Decadal Survey (2018).
- Significant improvement in wide-band-gap semiconductor materials (such as AlGaIn, ZnMgO, and SiC), individual detectors, and detector arrays for astrophysics missions and planetary science composition measurements. For

example, SiC avalanche photodiodes (APDs) must show:

- Extreme-UV (EUV) photon counting, a linear mode gain $>10 \times 10^6$ at a breakdown reverse voltage between 80 and 100 V;
- detection capability of better than 6 photons/pixel/s down to 135 nm wavelength.
- Solar-blind (visible-blind) UV, far-UV (80 to 200 nm), and EUV sensor technology with high pixel resolution, large format, high sensitivity and high dynamic range, and low voltage and power requirements—with or without photon counting.
- UV detectors suitable for upcoming ultra-high-energy cosmic ray (UHECR) mission concepts.
- Solar x-ray detectors with small independent pixels (10,000 count/s/pixel) over an energy range from <5 to 300 keV.
- Supporting technologies that would help enable the X-ray Surveyor mission that requires the development of x-ray microcalorimeter arrays with much larger field of view, $\sim 10^5$ to 10^6 pixels, of pitch ~ 25 to $100 \mu\text{m}$, and ways to read out the signals. For example, modular superconducting magnetic shielding is sought that can be extended to enclose a full-scale focal plane array. All joints between segments of the shielding enclosure must also be superconducting. Improved long-wavelength blocking filters are needed for large-area, x-ray microcalorimeters.
- Filters with supporting grids are sought that, in addition to increasing filter strength, also enhance electromagnetic interference (EMI) shielding (1 to 10 GHz) and thermal uniformity for decontamination heating. X-ray transmission of greater than 80% at 600 eV per filter is sought, with infrared transmissions less than 0.01% and ultraviolet transmission of less than 5% per filter. A means of producing filter diameters as large as 10 cm should be considered.
- Detectors with fast readout that can support high count rates and large incident flux from the EUV and x-rays for heliophysics applications, especially solar-flare measurements.

Expected TRL or TRL Range at completion of the Project: 3 to 5

Primary Technology Taxonomy:

Level 1: TX 08 Sensors and Instruments

Level 2: TX 08.1 Remote Sensing Instruments/Sensors

Desired Deliverables of Phase I and Phase II:

- Research
- Analysis
- Prototype
- Hardware

Desired Deliverables Description:

Phase I deliverables: results of tests and analysis of designs, as described in a final report.

Phase II deliverables: prototype hardware or hardware for further testing and evaluation is desired.

State of the Art and Critical Gaps:

This subtopic aims to develop and advance detector technologies focused on UV, x-ray, and gamma ray spectral ranges. The science needs in this range span a number of fields, focusing on astrophysics, planetary science, and UV heliophysics. A number of solid-state detector technologies promise to surpass the traditional image-tube-based detectors. Silicon-based detectors leverage enormous investments and promise high-performance detectors, while more complex material such as gallium nitride and silicon carbide offer intrinsic solar blind response. This subtopic supports efforts to advance technologies that significantly improve the efficiency, dynamic range, noise, radiation tolerance, spectral selectivity, reliability, and manufacturability in detectors.

Relevance / Science Traceability:

Missions under study: Large Ultraviolet Optical Infrared Surveyor (LUVOIR), Habitable Exoplanet Observatory (HabEx), Lynx, New Frontier-IO, Discovery-IVO

- LUVOIR- Large UV/Optical/IR Surveyor: <https://asd.gsfc.nasa.gov/luvoir/>
- Habitable Exoplanet Observatory (HabEx): <https://www.jpl.nasa.gov/habex/>
- The LYNX Mission Concept: <https://wwwastro.msfc.nasa.gov/lynx/>
- NASA Astrophysics: <https://science.nasa.gov/astrophysics/>
- The Explorers Program: <https://explorers.gsfc.nasa.gov/>

References:

- About Cosmic Origins (COR): <https://cor.gsfc.nasa.gov/>
- Planetary Missions Program Office: <https://planetarymissions.nasa.gov/>
- Explorers and Heliophysics Projects Division (EHPD): <https://ehpd.gsfc.nasa.gov/>
- NASA Astrophysics Roadmap: https://smd-prod.s3.amazonaws.com/science-red/s3fspublic/atoms/files/secure-Astrophysics_Roadmap_2013_0.pdf
- NASA Heliophysics Roadmap: https://smd-prod.s3.amazonaws.com/science-red/s3fspublic/atoms/files/2014_HelioRoadmap_Final_Reduced_0.pdf
- Planetary Science Decadal Survey 2013-2022: "Vision and Voyages for Planetary Science in the Decade 2013-2022," <http://solarsystem.nasa.gov/2013decadal/>
 - Decadal Survey: "Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space (2018)," <https://science.nasa.gov/earth-science/decadal-surveys>