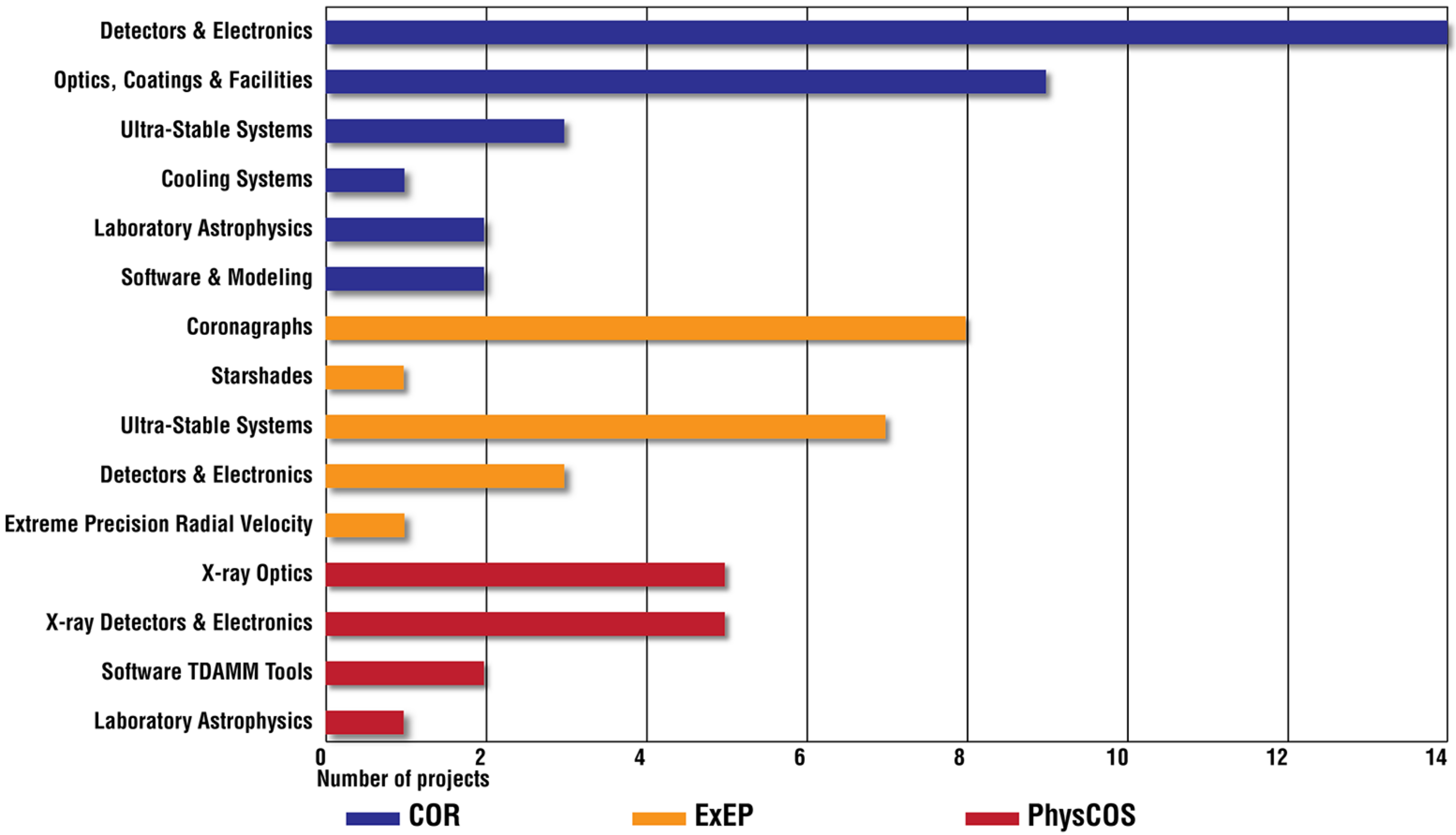
COR Technology Gaps and Portfolio Highlights

COPAG Session of AAS 245

Rachel Rivera

PhysCOS/COR Technology Development Manager

APD Strategic Technology Portfolio – 2025



The Program Office monitors and manages the PhysCOS and COR Strategic Astrophysics Technology (SAT), Roman Technology Fellowship (RTF), Internal Scientist Funding Model (ISFM) and Critical Technologies for Large Telescopes (CT4LT) technologies portfolio (44 projects)

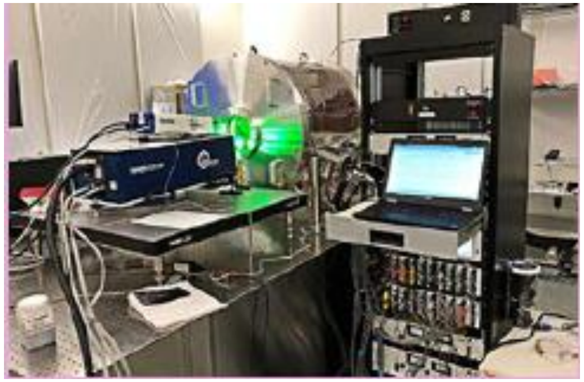
Current COR Technology Portfolio (1 of 2)

Funding Program	Project Title	PI Name	PI Inst	Technology Area	Signal Type
SAT2021	Development of a 30 mK ultra-low temperature Continuous Adiabatic Demagnetization Refrigerator (CADR) with a continuous 700 mK intermediate stage for heat intercept	Kimball, Mark	GSFC	Cooling System	X Ray, Far IR, Sub-mm
SAT2021	Ultrasensitive Far-IR Kinetic Inductance Detector Arrays: Maturation for Flight	Bradford, Charles	JPL	Detector	Far IR
SAT2021	Demonstrating Large Low Noise Transition Edge Sensor Arrays for Future FIR Space Missions	Staguhn, Johannes	JHU	Detector	Far IR
SAT2021	Ultra-stable Telescope Metrology Development for High-contrast Exoplanet Detection	Saif, Babak	GSFC	Metrology	UVOIR
SAT2021	Ultraviolet Spectroscopy for the Next Decade Enabled Through Nanofabrication Techniques	Randall McEntaffer	PSU	Optics	UVOIR
SAT2022	Scalable Microshutter Systems for Multi-object Spectroscopy	Scowen, Paul	GSFC	Optics	UVOIR
SAT2021	Advanced Al mirrors with passivated LiF for environmentally stable 1-meter class UV space telescopes	Quijada, Manuel	GSFC	Optical Coating	UVOIR
ISFM22	UV/Optical to Far-IR Mirror & Telescope Technology Development	Stahl, H. Philip	MSFC	Optics	UVOIR
SAT2022	Four megapixel sensor for ultra-low-background shortwave infrared astronomy	Bottom, Michael	UH	Detector	Near-IR
SAT2021	High Performance FUV, NUV, and UV/Optical CMOS Imagers	Hoenk, Michael	JPL	Detector	UV
SAT2021	Large Format, High Efficiency, UV/Optical/NIR Photon Counting Detectors	Nikzad, Shouleh	JPL	Detector	UVOIR
SAT2021	Advancing Readout of Large-Format Far-IR Transition-Edge Sensor Arrays	Rostem, Karwan	GSFC	Electronics	Far IR
SAT22	Characterizing Single-photon Sensing CMOS Image Sensors for NASA Missions	Figer, Donald	RIT	Detector	VIS
ISFM22	NASA Ames Laboratory Astrophysics Directed Work Package (LADWP) Round 2 ISFM	Sciamma-O'Brien, Ella	Ames	Lab Astrophysics	UV, IR, VIS
SAT22	Ultrasensitive Far-IR Kinetic Inductance Detector Arrays for Space	Hailey-Dunsheath, Steven	Caltech	Detector	Far IR

Current COR Technology Portfolio (2 of 2)

Funding Program	Project Title	PI Name	PI Inst	Technology Area	Signal Type
SAT22	Far-IR Detector Solutions for Low Noise, Large Format, Direct Absorption Kinetic Inductance Detector Arrays	Austermann, Jason	NIST	Detector	Far IR
SAT22	A High-Performance Ultraviolet Photon Counting Detector for Strategic Astrophysics Missions	Nikzad, Shouleh	JPL	Detector	UV
RTF23	The Advanced Astrophysics Spectroscopy Lab at LASP	Vorobiev, Dmitry	LASP	Facilities and Optics	UV
RTF23	Advancing & Qualifying UV Space Technology & Instrumentation	Hoadley, Keri	Univ of Iowa	Lab Characterization	UV
SAT23	Single-photon counting with SiSeRO to search for Earth-like planets	Estrada, Juan	U. of Chicago	Electronics	UVOIR
SAT23	Large-area ALD-protected aluminum mirror coatings for HWO	Hennessy, John	JPL	Coatings	UV
SAT23	Development of space-qualified signal-processing readout electronics for HWO and Origins Space Telescope detector arrays	Jamison-Hooks, Tracee	ASU	Electronics	UVOIR and Far-IR
SAT23	New techniques toward the nanofabrication of custom, blazed UV gratings to enable next-generation spectroscopy	Miles, Drew	Caltech	Optics	UV
SAT23	PHANTOM: Precision High-strain composites (HSCs) for AstroNomical Telescope OptoMechanics	Silver, Mark	MIT/LL	Structures	UVOIR
RTF24	Building the Foundations for Huge-N Lunar Radio Interferometry	Pober, Jonathan	Brown	Software	CMB
RTF24	Development of a Low EMI and Acoustic Background Characterization Testbed for Ultra-low Noise Transition Edge Sensor Bolometers	Connors, Jake	GSFC	Detectors	Far-IR
RTF24	Supporting technologies for large-scale kinetic inductance current sensor readouts	Szypryt, Paul	Colorado	Electronics	Visible, Near IR
RTF24	Build and Commission a new Space Optics Laboratory (SOL) at UMass Lowell	Mendillo, Christopher	Umass Lowell	Facilities	UVOIR
CT4LT	STABLE: Systems Technologies for Architecture Baseline	Glassman, Tiffany	Northrup Grumman	Structures	UVOIR
CT4LT	TechMAST: Technology Maturation for Astrophysics Space Telescopes	Carrier, Alain	Lockheed Martin	Modeling	UVOIR
CT4LT	ULTRA-CT: Ultra-stable Telescope Research and Analysis – Critical Technologies	Coyle, Laura	BAE	Optics	UVOIR

COR Technology Development & Test Facilities



Ultrastable Structures Lab (GSFC): This lab has a long history of making precise metrology measurements of specular and diffuse targets to advance the TRL of critical flagship mission components, e.g., optical tests of the JWST Backplane Stability Test Article using a high-speed electronic speckle interferometer proved the backplane stiffness met requirements. The lab maximizes stability using high-performance acoustic tiles, sand-filled walls, piezo isolators supporting a large Invar optical bench, and precision thermal control (±75 μK thermal stability over an hour). Recent in-air results demonstrated few-pm stability for mid-spatial, relative measurements of a 3” test article over multiple two-minute datasets.

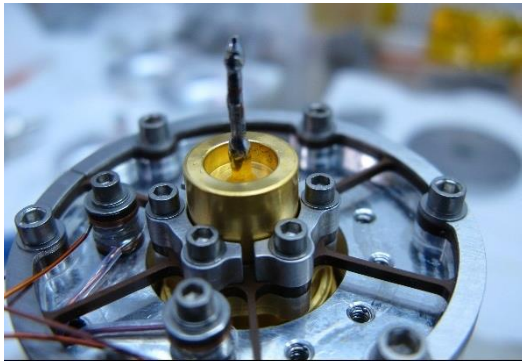
High-Contrast Imaging Testbed (HCIT) Laboratory (JPL): The HCIT is the world’s premiere facility for demonstrating and advancing space coronagraphs. It hosts two vacuum testbeds and one in air, with lasers, DMs, and other optical equipment. The facility was used to demonstrate technology for the Roman Coronagraph as well as SAT-funded starlight-suppression technologies that will be needed by HWO.

Vacuum UV Optical Characterization Testbed (LASP, U of Colorado): The facility optically characterizes advanced optical components, e.g., micromirror arrays and optical fiber bundles, as well as large mirror segments in the vacuum UV. The testbed measures reflectance and scatter of small optics and advanced optical devices with far-UV coatings, including the throughput and scattered light properties of digital micromirror device (DMD) arrays and two-axis micromirror arrays in the 100-200 nm regime. The team at LASP is also using this facility to explore and develop techniques for the optical characterization of large mirror segments with advanced UV mirror coatings (Al/eLiF/MgF_2, XeLiF, etc.) required for HWO.

COR Technology Development Highlights

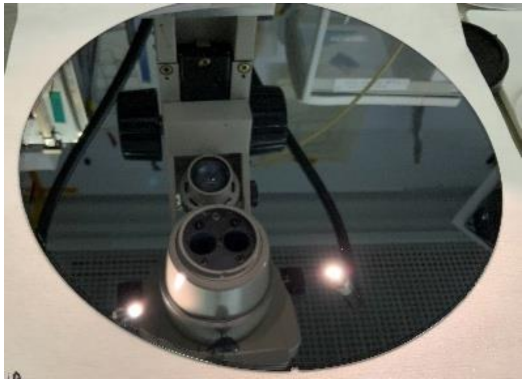
Development of an Ultra-Low-Temperature Continuous ADR (CADR) with a Continuous Intermediate Stage for Heat Intercept (M. Kimball, GSFC)

Future astrophysics observatories such as Origins, Lynx, and PICO are expected to include large superconductor-based focal planes cooled to near absolute zero (below -459°F!). Such observatories require unprecedentedly high cooling power at lower operating temperatures. Achieving this without liquid helium (which runs out, ending the mission), and without jitter that disturbs sensitive measurements, is extremely challenging. This project is developing CADR technology with a heat lift of 3 μW at 30 milliKelvin and 1.5 mW at 1 K, and stray magnetic fields of less than 2 μT, to enable such missions. The above three mission concepts all baselined this technology into their reference designs. The team recently assembled and characterized stage 4a, processed Stage 4b parts, procured a new paramagnetic material and integrated it as a drop-in replacement salt pill for their older CADR system, completed hysteresis heat measurements from the superconducting magnets, and is conducting a test program to deepen their understanding of the passive gas-gap heat switches used in the system.



High-Performance Far-UV, Near-UV, and UV/Optical CMOS Imagers (M. Hoenk, JPL)

This project's objectives are to fabricate, characterize, and mature CMOS detectors using nanoscale surface engineering to enable HWO requirements for multi-gigapixel mosaic, visible-blind, near-UV focal planes with large-format (8k×8k), low noise (< 2.5 e-), small pixels (5-10 μm), and broadband UVOIR response (>50% QE from 200 nm to 400 nm). This includes performance and radiation testing using JPL's UV detector characterization laboratory and Precision Projector Laboratory. Advanced CMOS designs from industry (Teledyne-e2v CIS120 and SRI Mk×Nk detectors) are subjected to JPL's molecular-beam-epitaxy delta-doping process and atomic-layer deposition of integrated multilayer antireflection (AR) coatings and out-of-band rejection filters. The team recently built and tested two cameras for performance, radiation, and on-sky testing of delta-doped CIS120 CMOS image sensors. SRI 1k×1k and 2k×4k detectors were then tested for technology infusion into NASA's MIDEX Ultraviolet Explorer (UVEX) mission.

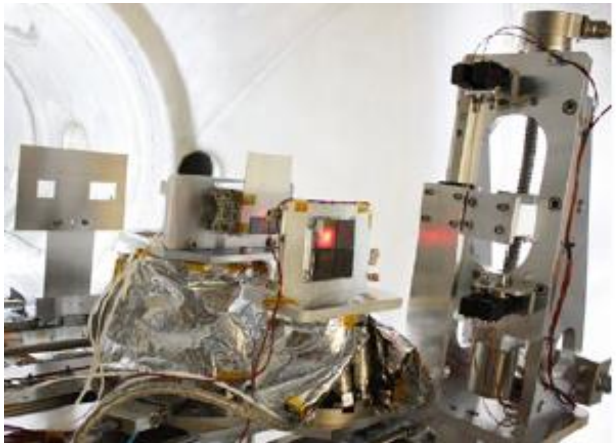


PhysCOS Technology Development Highlights

Next-Generation X-ray Optics: High Angular Resolution, High Throughput, and Low Cost (W. Zhang, GSFC)

Imaging astrophysical X-ray sources is crucial to studying the high-energy processes in the universe. Since X-rays can only be reflected at very shallow angles, X-ray telescopes use grazing-incidence reflections to focus photons on detectors several meters away. The project developed a process that carves sub-mm-thickness slices from commercial blocks of single-crystal silicon, then etches, polishes, trims, and coats them to make 10×10 cm^2 segments. Expecting this technology to reach its target resolution, the Lynx reference design baselined it, with nearly 40,000 segments to be assembled into a 3-m-diameter barrel, offering 30× larger collection area than Chandra, at an expected cost that would fit within a flagship-mission-level budget. The project recently achieved 2.8”-half-power-diameter images, and perfected a new method of polishing mirrors, reducing time and cost, scalable for mass production.

Technology Maturation for a High-Sensitivity and High-Resolving Power X-ray Spectrometer (M. Schattenburg, MIT)



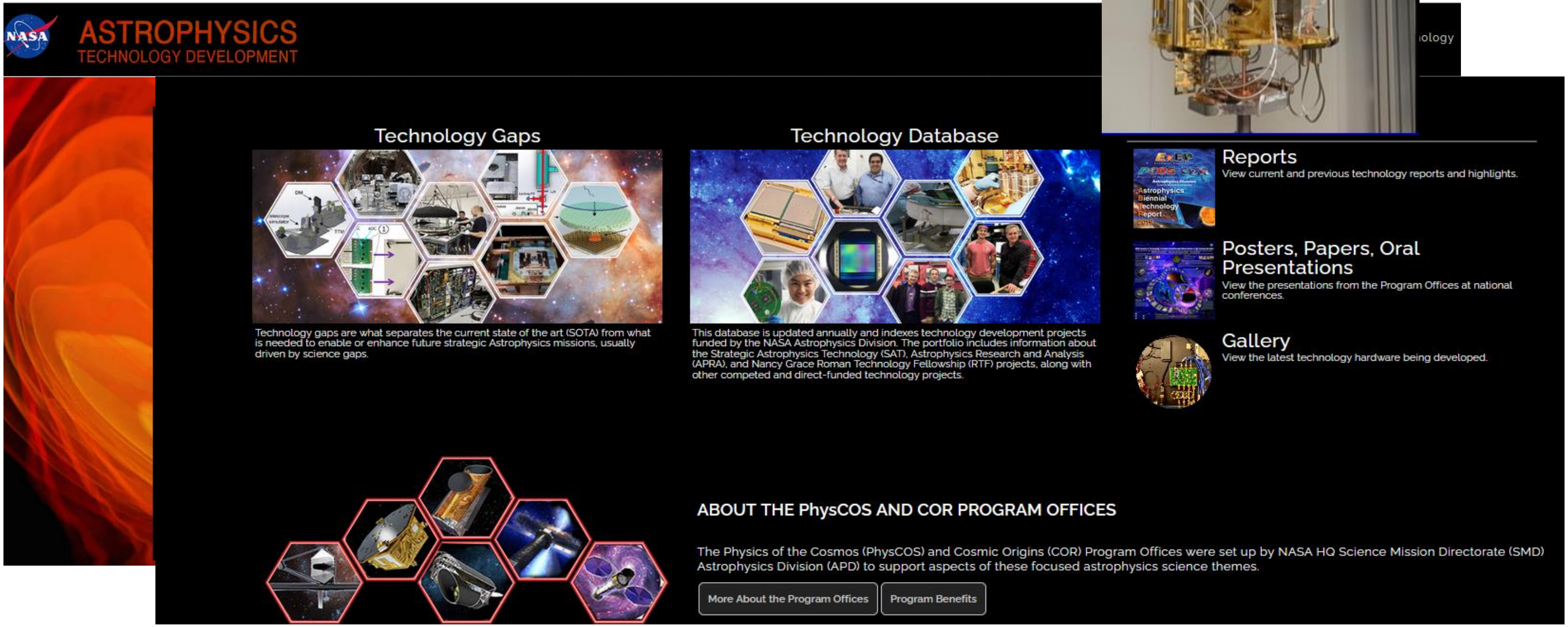
An improved Critical-Angle X-ray Transmission Grating Spectrometer with higher diffraction efficiency and resolving power in combination with grazing-incidence X-ray mirrors and CCD detectors, promise an order-of-magnitude improvement in both efficiency and resolving power over existing spectrographs, enabling absorption- and emission-line spectroscopy needed to study the large-scale structure of the universe, cosmic feedback, the interstellar and intergalactic media, and stellar activity across all stellar types and lifecycles. In collaboration with MIT/LL and Smithsonian Astrophysical Observatory (SAO), the team fabricated multiple 4- and 6-µm-deep flight-like CAT grating facets from 200-mm Silicon-on-Insulator (SOI) wafers using volume production tools; confirmed resolving power of 8,000-13,000 for individual and co-aligned grating facets; patterned new enhanced-SOI wafers with 10× better thickness control; and demonstrated increased diffraction efficiency from chemically thinned grating bars.

Learn more about the Technology Program

PhysPCOS/COR Technology Website

https://apd440.gsfc.nasa.gov/technology.html

- Technology gaps list and tech gaps process
- Links to other Program Office resources
- Published papers and posters
- Annual galleries of hardware developed by SAT projects



Learn more about the Technology Program

AstroTech database– search our portfolio

http://www.AstroStrategicTech.us/

- **Over 900 records of SATs, ISFMs, APRAs, RTFs, and other directed work**
- **Query your search:**
  - PI name
  - Signal Type
  - Technology
  - Institution

Example Query

You have searched for :
Funding Program All
Portfolio Manager PCOS
Project Status: Active
Technology Type: Detector
Signal Type: Sub-mm
Research Area: Detector Development

There are 8 record(s) found.

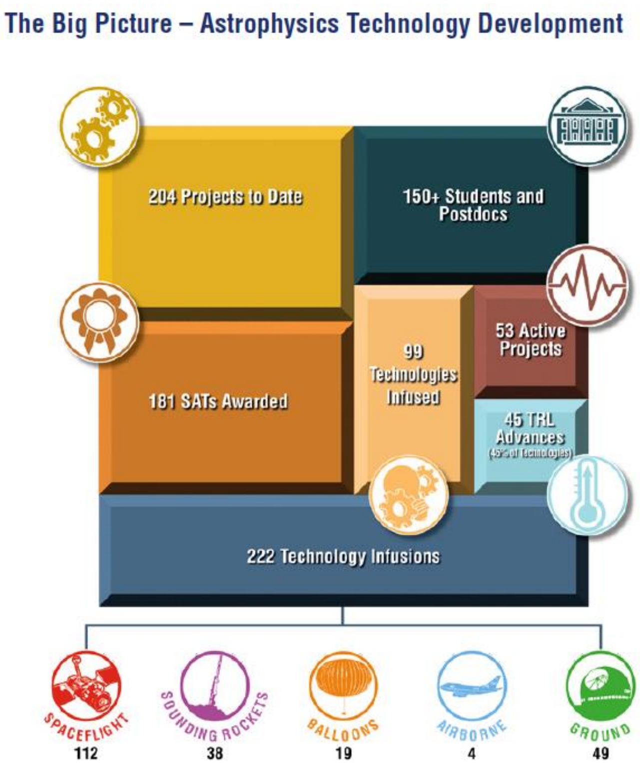
Results in columns below can be sorted by clicking the column heading.
Click here to export search results below into an Excel Spreadsheet.

▲ Portfolio Manager	Funding Program	Project Title	PI Name	PI Org	Research Area	Research Category	Technology Area	Signal Type	Start FY	End FY	Project Status	TRL*	Project Description
HQ	APRA2018	Quantum-limited Amplifiers for Large Array Readout of Superconducting Detectors	Vissers, Michael	National Institute of Standards and Technology	Detector Development	Technology Development	Detector	Sub-mm	2020	2023	Active	N/A	Abstract & Reports
HQ	APRA2020	Quantum limited amplifiers for detector readout and coherent receivers	Day, Peter	Jet Propulsion Laboratory	Detector Development	Technology Development	Detector	Sub-mm	2022	2024	Active	N/A	Abstract & Reports

Learn more about the Technology Program

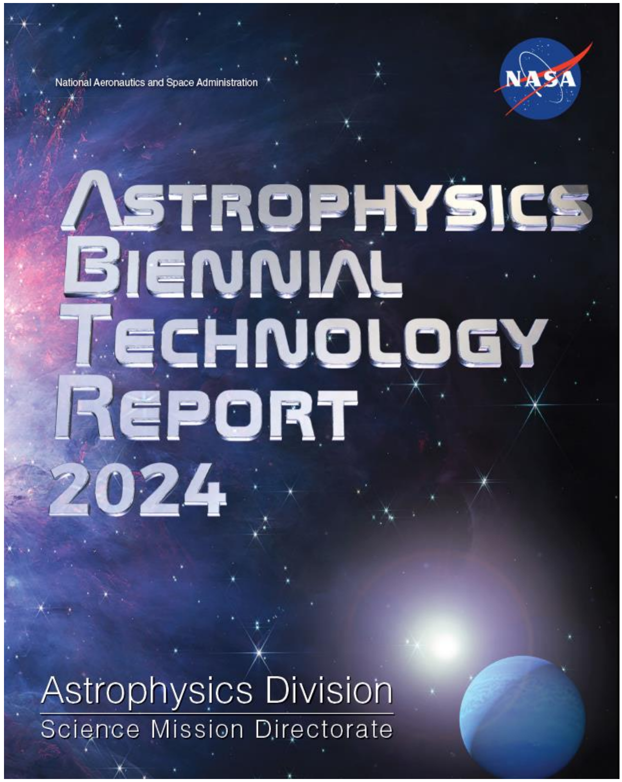
Astrophysics Biennial Technology Report (ABTR)
https://apd440.gsfc.nasa.gov/images/tech/2022_ABTR.pdf

Technology Report published every other year—next ABTR will be in 2026



The 2024 report includes:

- New SAT Awards
- About Astrophysics Technology Program
- Program success metrics and technology infusion information
- Technology development and test facilities
- Technology portfolio summaries and highlights
- Tech Gaps and Prioritization Tiers



Technology Gap Prioritization

- **Gaps next solicitation currently scheduled to have a June 1, 2026 due date for gap entries**
- **The gaps are split among the three Program Offices based on the science most impacted**
- **Three gap lists scrubbed with help of PhysPAG EC, COPAG EC, and ExoTAC by July 1, 2026**
- **Gaps prioritized by Technology Management Boards by August 2026 using four criteria:**
  - Strategic alignment
  - Impacts and benefits
  - Urgency
  - Scope of applicability
- **The three lists (PhysCOS, COR, ExEP) are merged into a unified Astrophysics technology gaps list**
- **List published in Astrophysics Biennial Technology Report (ABTR) and PO website in October**

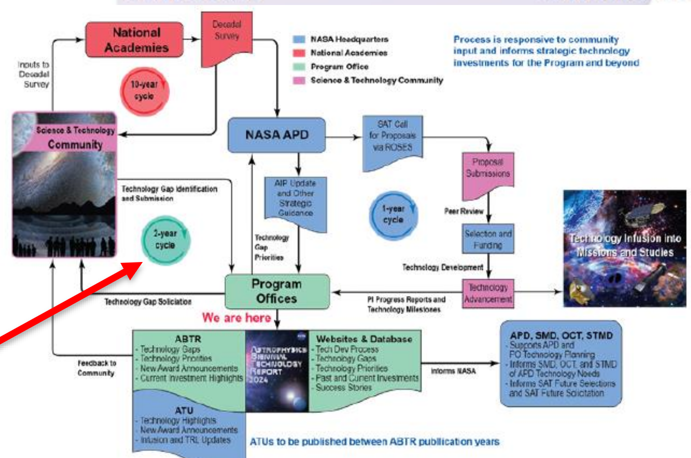
2024 Astrophysics Tech Gaps List (informed by Astro2020 and HWO START/TAG)

Tier-1 Technology Gaps

Coronagraph Contrast and Efficiency in the Near IR
Coronagraph Contrast and Efficiency in the Near UV
Coronagraph Stability
Cryogenic Readouts for Large-Format Far-IR Detectors
Fast, Low-Noise, Megapixel X-ray Imaging Arrays with Moderate Spectral Resolution
High-Bandwidth Cryogenic Readout Technologies for Compact and Large-Format Calorimeter Arrays
High-Efficiency, Low-Scatter, High- and Low-Ruling-Density, High- and Low-Blazed-Angle UV Gratings
High-Efficiency X-ray Grating Arrays for High-Resolution Spectroscopy
High-Performance Sub-Kelvin Coolers
High-Reflectivity Broadband Far-UV-to-Near-IR Mirror Coatings
High-Resolution, Lightweight X-ray Optics
High-Throughput, Large-Format Object-Selection Technologies for Multi-Object and Integral-Field Spectroscopy
Integrated Modeling for HWO: Multi-Physics Systems Modeling, Uncertainty Quantification, and Model Validation
Large-Format, High-Resolution Far-UV (100–200 nm) Detectors
Large-Format, High-Resolution Near-UV (200–400 nm) Detectors
Low-Stress, Low-Roughness, High-Stability X-ray Reflective Coatings
Mirror Technologies for High Angular Resolution (UV/Visible/Near IR)
Optical Blocking Filters for X-ray Instruments
Scaling and Metrology for Advanced Broadband Mirror Coatings for HWO
Segmented-Pupil Coronagraph Contrast and Efficiency in the Visible Band
UV Multi-Object Spectrograph Calibration Technologies
UV Single-Photon Detection Sensitivity
Visible/Near-IR Single-Photon Detection Sensitivity

Tier-2 Technology Gaps

Advanced Cryocoolers
Broadband X-ray Detectors
Compact, Integrated Spectrometers for 100 to 1000 µm
Cryogenic Far-IR to mm-Wave Focal-Plane Detectors
Far-IR Imaging Interferometer for High-Resolution Spectroscopy
Far-IR Spatio-Spectral Interferometry
Heterodyne Far-IR Detector Systems
High-Performance Computing for Event Reconstruction
High-Resolution, Direct-Detection Spectrometers for Far-IR Wavelengths
High-Throughput Focusing Optics for 0.1-1 MeV Photons
High-Throughput UV Bandpass Standalone and Detector-Integrated Filters and Bandpass Selection
Improving the Calibration of Far-IR Heterodyne Measurements
Large-Format, High-Spectral-Resolution, Small-Pixel X-ray Focal-Plane Arrays
Large-Format, Low-Noise and Ultralow-Noise, Far-IR Direct Detectors
Low-Power Readout and Multiplexing for CMB Detectors
Millimeter-Wave Focal-Plane Arrays for CMB Polarimetry
Optical Elements for a CMB Space Mission
Starshade Deployment and Shape Stability
Starshade Starlight Suppression and Model Validation
Stellar Reflex Motion Sensitivity: Astrometry
Stellar Reflex Motion Sensitivity: Extreme Precision Radial Velocity
Warm Readout Electronics for Large-Format Far-IR Detectors



The Astrophysics strategic technology development process starts with the National Academies' Decadal Survey recommendations, and APD's programmatic guidance. Based on these, the process matures and enables infusion of key technologies into Astrophysics missions and beyond.

onductor Detectors
n Photomultipliers
tometric Precision of Time-Domain and
s
nt Technology
ounting Light Detectors
MB Spectrum Measurement
larrowband Imaging Capability

2-year technology gap prioritization cycle

More info at apd440.gsfc.nasa.gov/technology.html

COR-Specific Technology Gaps

Tier 1 COR Technology Gaps

1. Cryogenic Readouts for Large-format Far-IR Detectors
2. High-Efficiency, Low-Scatter, High- and Low-Ruling-Density, High- and Low-Blazed-Angle UV Gratings
3. High-Performance, Sub-Kelvin Coolers
4. High-Reflectivity Broadband Far-UV-to-Near-IR Mirror Coatings
5. High-Throughput, Large-Format Object-Selection Technologies for Multi-Object and Integral Field Spectroscopy
6. Large-Format, High-Resolution Far-UV (100-200 nm) Detectors
7. Large-Format, High-Resolution Near-UV (200 - 400 nm) Detectors
8. Scaling and Metrology for Advanced Broadband Mirror Coatings for HWO
9. UV Multi-Object Spectrograph Calibration Technologies

Tier 2 COR Technology Gaps

10. Advanced Cryocoolers
11. Compact, Integrated Spectrometers for 100 to 1000 µm
12. Cryogenic Far-IR to mm-Wave Focal-Plane Detectors
13. Far-IR Imaging Interferometer for High-Resolution Spectroscopy
14. Far-IR Spatio-Spectral Interferometry
15. Heterodyne Far-IR Detector Systems
16. High-Resolution, Direct-Detection Spectrometers for Far-IR Wavelengths
17. High-Throughput UV Bandpass Standalone and Detector-Integrated Filters and Bandpass Selection
18. Improving the Calibration of Far-IR Heterodyne Measurements
19. Large-Format, Low-Noise and Ultralow-Noise, Far-IR Direct Detectors
20. Warm Readout Electronics for Large-Format Far-IR Detectors

Tier 3 COR Technology Gaps

21. Large-Aperture Deployable Antennas for Far-IR/THz/sub-mm Astronomy for Frequencies Above 100 GHz
22. Large Cryogenic Optics for the Mid IR to Far IR
23. Photometric and Spectro-Photometric Precision of Time-Domain and Time-Series Measurements
24. Precision Timing Measurement Technology
25. UV/Optical/Near-IR Tunable Narrowband Imaging Capability

More info at apd440.gsfc.nasa.gov/technology.html

Back-Up