



National Aeronautics and
Space Administration



NASA Astrophysics Update

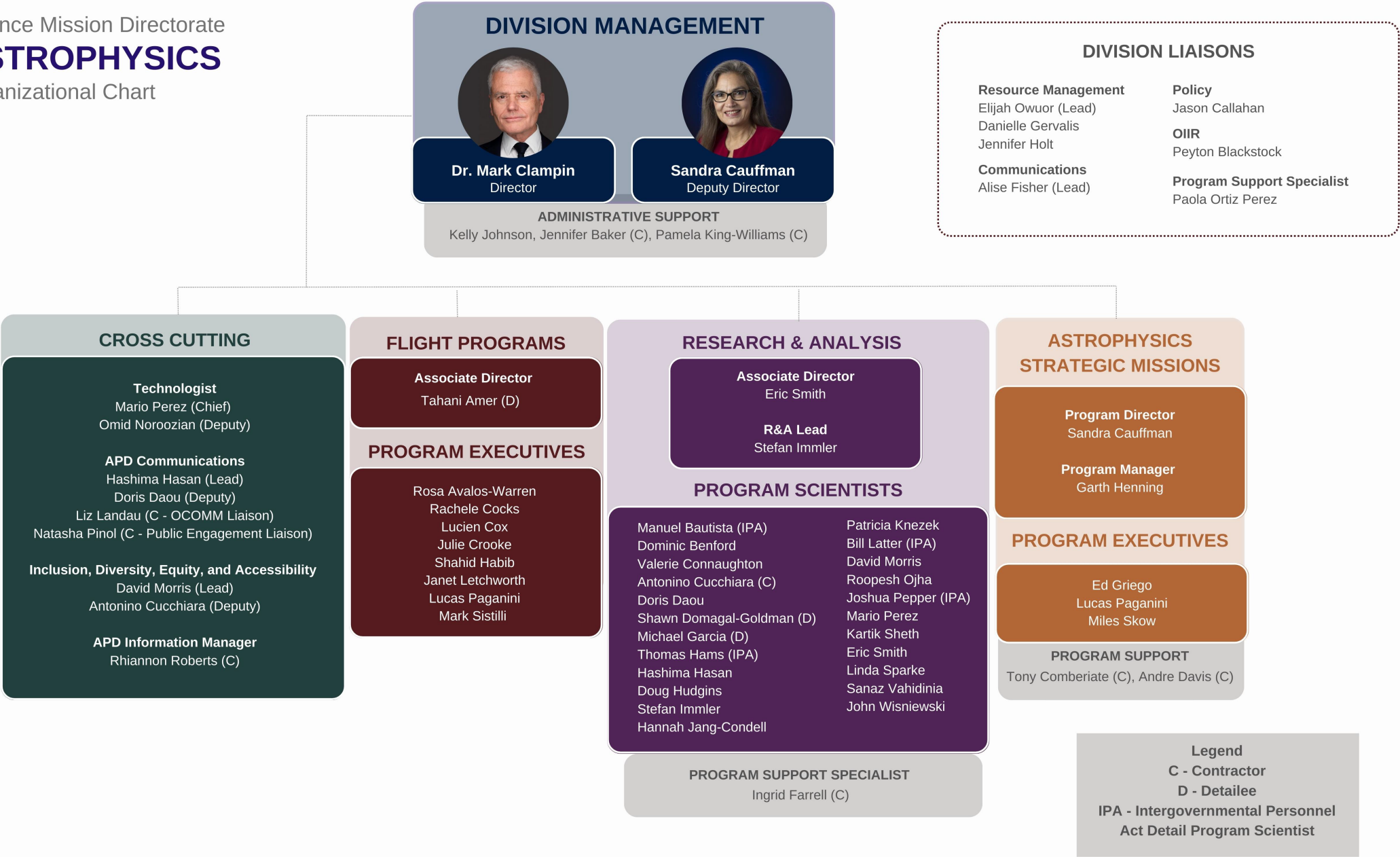
Committee on Astronomy and Astrophysics | October 13, 2023

Dr. Mark Clampin

Director, NASA's Astrophysics Division

Science Mission Directorate

Science Mission Directorate
ASTROPHYSICS
Organizational Chart



RESEARCH
~**350** U.S. Science PIs Funded
~**120** Individual Institutions Selected
~**\$130M** Awarded Annually

**SMALLSATS/
CUBESATS**
2 Science Missions Launched
9 Science Missions in Development
1 ISS-attached Science Mission
1 Balloon Mission

**TECHNOLOGY
DEVELOPMENT**
~**\$220M** Invested Annually

**REFEREED
PUBLICATIONS**
>23,680 Total Publications
(2018-Current)
>20,517 Hubble Publications
(1991-Current)
>407 Webb Publications
(July 2022-Current)

MISSIONS
14 Missions Operating
12 Missions in Development
2 Tech. Demos

**SOUNDING
ROCKETS**
15 Science Missions Launched
(Suborbital)
6 In Development

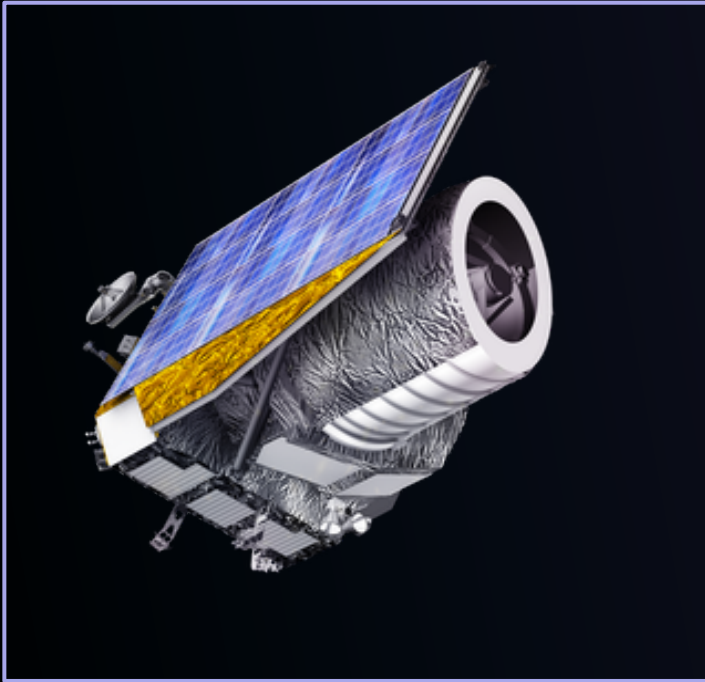
BALLOONS
20 Suborbital Balloons
Launched
21 Missions in Development

Astrophysics by the
NUMBERS

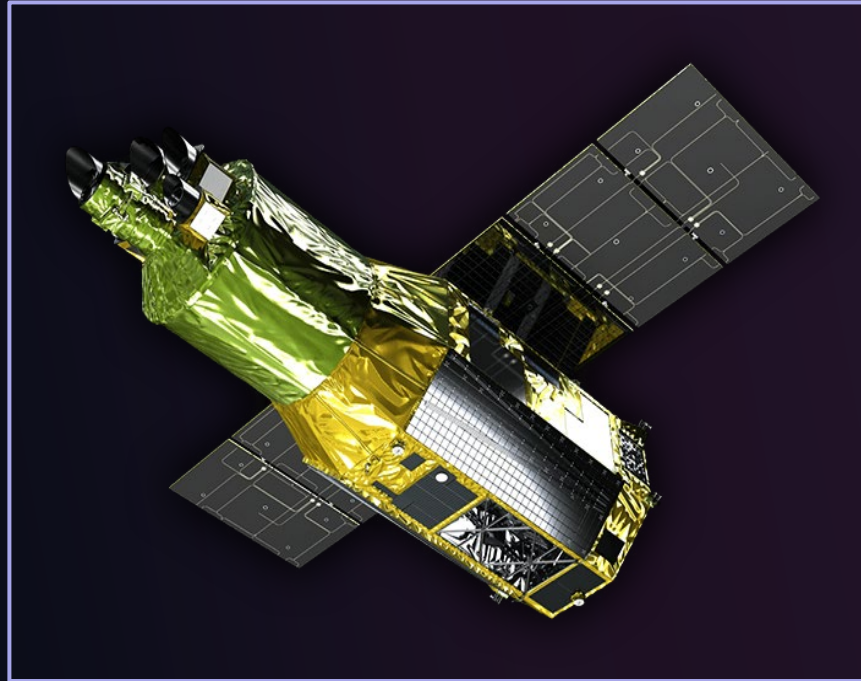
Astrophysics Mission Classes

DECADAL SURVEY	EXPLORER AO	SALMON AO	ROSES	
>\$1B	\$450M	\$80M	\$20M	\$5M
>\$2B LARGE CLASS Great Observatory or Flagship	~\$450M SMALL CLASS Medium Explorer (MIDEX) PICC \$300M*	\$80M SMALL CLASS Standard Mission of Opportunity **	\$20M SMALL CLASS Pioneers SmallSat **	\$20M SUBORBITAL Pioneers Balloon
~\$1.5B MEDIUM CLASS Probe PICC \$1B*	~\$225M SMALL CLASS Small Explorer (SMEX) PICC \$145M*	\$40M SMALL CLASS SmallSat Mission of Opportunity **	\$5M SMALL CLASS APRA CubeSat	\$10M SUBORBITAL APRA Balloon
				\$5M SUBORBITAL APRA Sounding Rocket

Astrophysics Division Launches: 2023



Euclid (launched)
Kennedy Space Center,
July 1, 2023



XRISM (launched)
Tanegashima, Japan
September 6, 2023



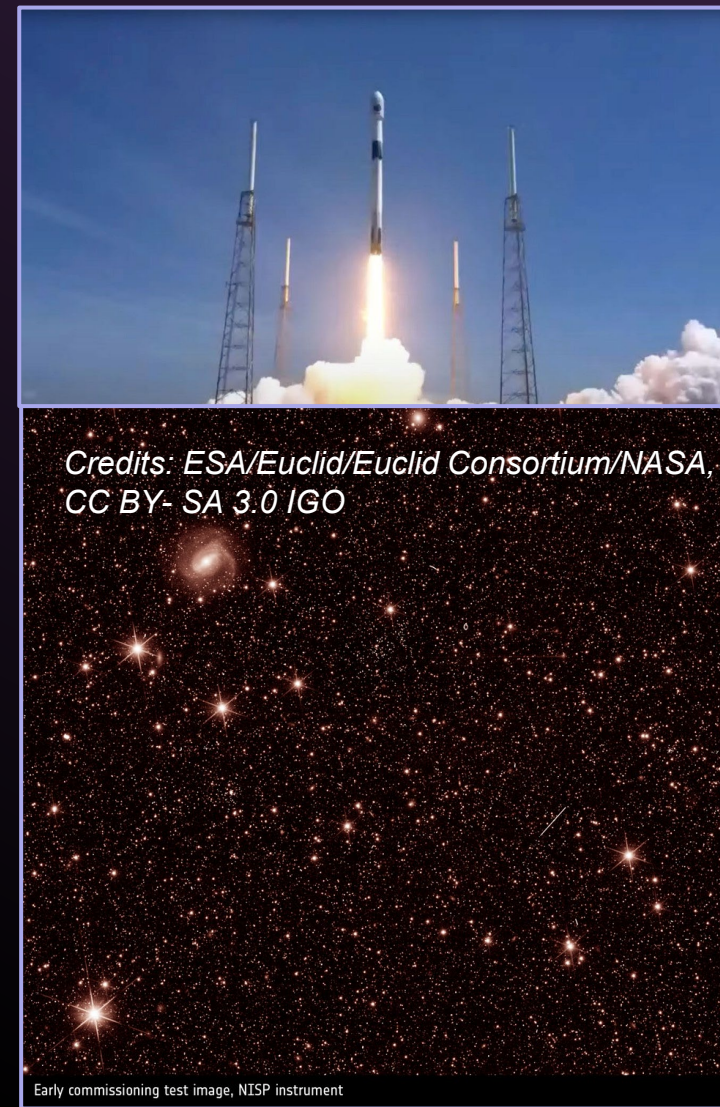
GUSTO (SMEX Balloon)
Antarctica,
December 2023

Euclid Launch (July 1, 2023 from Cape Canaveral)

- The two instruments aboard Euclid have captured their first test images.
- NASA contributed a 16 detector, focal-plane camera for the Near Infrared Spectrometer and Photometer (NISP) instrument.
- Observatory is currently in performance verification phase.
 - Earlier issues pertaining to the fine guidance software failing to lock on guide stars, and the stray sunlight contamination detected in the VIS instrument have been solved.
 - Fine guidance software patch was uploaded and has solved its guiding issues. The next six years of observation schedules have been redesigned to mitigate stray sunlight.
- Euclid will now complete science commissioning
- Science operation is expected in early 2024.



Euclid GNC status



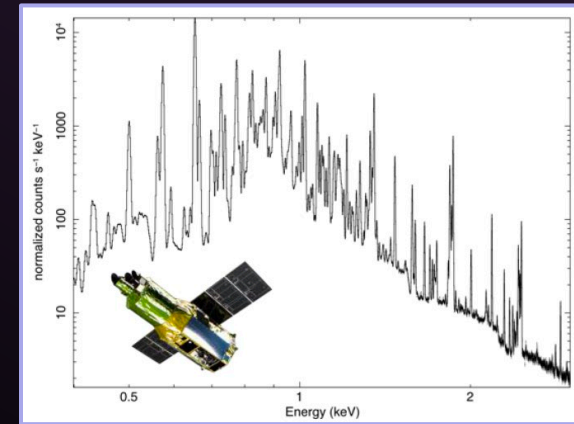
XRISM Launch (Sept. 7, 2023 from the Tanegashima Space Center, Japan)

The X-Ray Imaging and Spectroscopy Mission

- The commissioning is going well, and all aspects are nominal.
 - Sept.11- Oct. 6: Spacecraft commissioning
 - Oct. 7: Resolve check-out began
 - Oct.18: Resolve and Xtend check-out begins
 - Nov. 5: Resolve Gate Valve opens
 - Dec. 14 (TBC): End of commissioning
 - Mid-Dec. (TBC): First light/first observation
- The instruments onboard XRISM are
 - Resolve (a high-resolution X-ray spectrometer)
 - Xtend (a wide-field X-ray imager).
- The **combination** of Xtend's observations and Resolve's measurements provide a comprehensive view of extreme environments and energetic events.
- First/early release observations are planned for mid-December but since the instruments are not fully calibrated and pipeline tested yet, the early observations will be for press-release purposes and not of high scientific output at that time.



Simulated XRISM spectrum



≤ 7 eV spectral resolution

Webb Discovers Methane, Carbon Dioxide in Atmosphere of K2-18 b

- A new investigation with [James Webb Space Telescope](#) into K2-18 b, an exoplanet 8.6 times as massive as Earth, has revealed the presence of carbon-bearing molecules including methane and carbon dioxide.

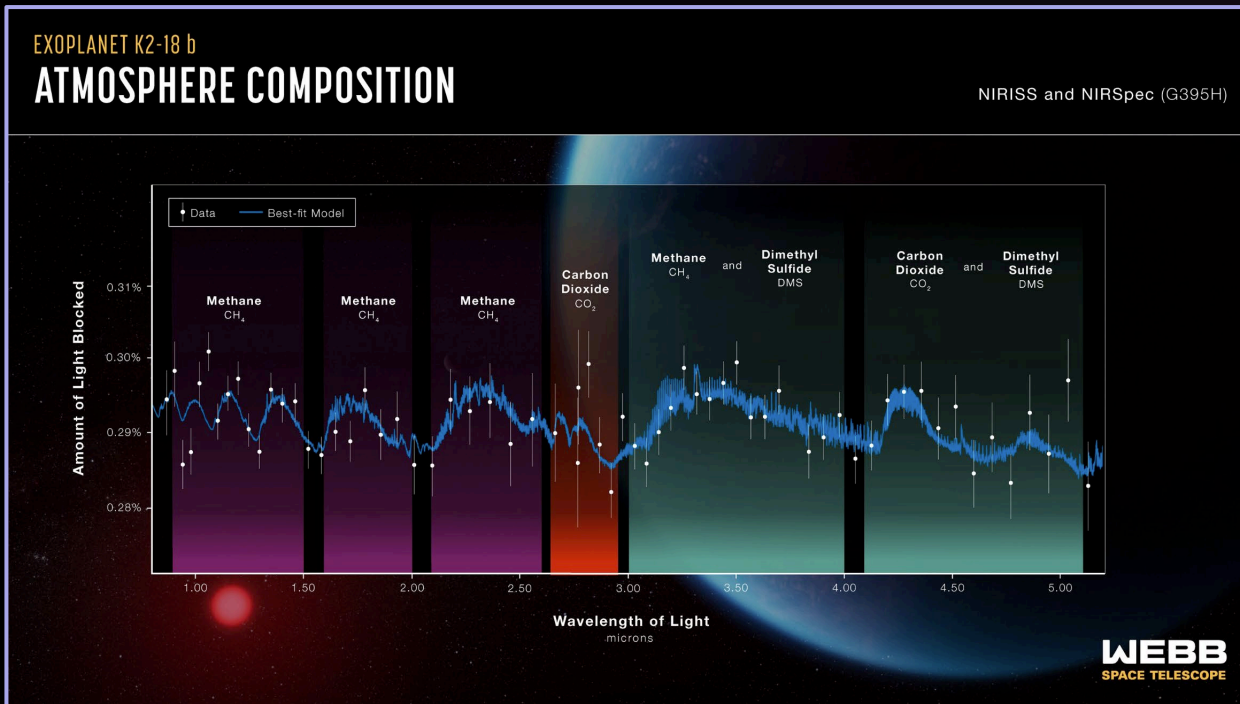


Illustration: NASA, ESA, CSA, Ralf Crawford (STScI), Joseph Olmsted (STScI).
Science: Nikku Madhusudhan (IoA)

- Webb's discovery adds to recent studies suggesting that K2-18 b could be a Hycean exoplanet, one which has the potential to possess a hydrogen-rich atmosphere and a water ocean-covered surface.
- These initial observations also provided a possible detection of a molecule called dimethyl sulfide (DMS). On Earth, this is only produced by life. The bulk of the DMS in Earth's atmosphere is emitted from phytoplankton in marine environments.
- MIRI observations later this Cycle will help determine if the DMS is actually present.

Webb's Wide-angle View of the Orion Nebula in ESASky

- New images of the Orion Nebula from Webb have been added to ESA's [ESASky](#) application

d072-135: an ionised circumstellar disk in the Orion Nebula

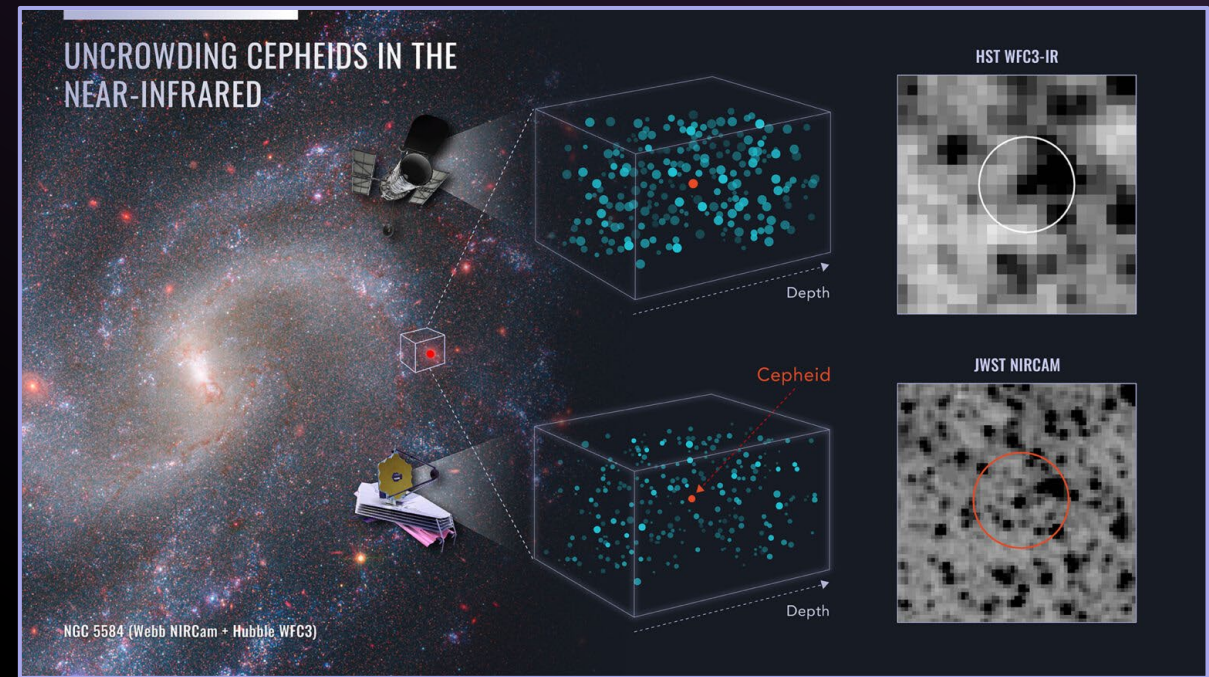
HST Orion Treasury Project, 2006
ACS: F435W, F555W, F658N, F777W, F850LP
NASA, ESA / Massimo Robberto et al.

JWST Orion GTO project, 2023
NIRCam: F140M, F162M, F182M, F187N, F212N
NASA, ESA, CSA / Mark McCaughrean & Sam Pearson



Webb Confirms Accuracy of Universe's Expansion Rate Measured by HST, Deepening Hubble Constant Tension

- Recently, Dr. Adam Riess presented his team's recent work using Webb observations to improve the precision of local measurements of the Hubble constant.
- Webb data confirmed the accuracy of 30 years of HST observations of Cepheids that were critical in establishing the bottom rung of the cosmic distance ladder for measuring the universe's expansion rate.
- With Webb confirming the measurements from Hubble, the Webb measurements provide the strongest evidence yet that systematic errors in Hubble's Cepheid photometry do not play a significant role in the present Hubble Tension.

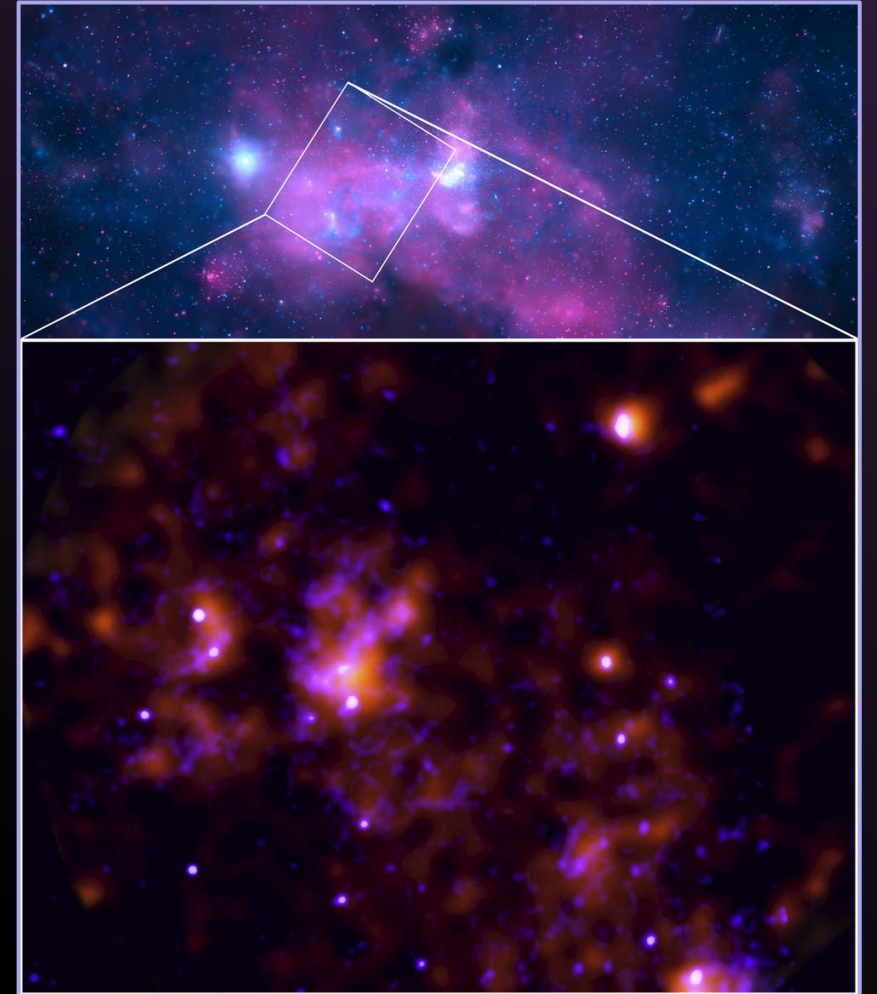


NGC 5584 is seen in a composite image from Webb's NIRCcam (Near-Infrared Camera) and Hubble's Wide Field Camera 3.

Image Credit: NASA, ESA, A. Riess (STScI), W. Yuan (STScI).

IXPE Finds that Milky Way's Central Black Hole Woke Up 200 Years Ago

- Imagery from the Imaging X-ray Polarimetry Explorer (IXPE) and Chandra X-ray Observatory have been combined to show X-ray data of the area around Sagittarius A*, the supermassive black hole at the core of the Milky Way galaxy.
- The combination of IXPE and Chandra data show that the X-ray light is bouncing off the molecular clouds
 - IXPE shows the X-rays are polarized.
- Those X-rays likely originated from Sagittarius A* during an outburst, but their path to us delays them by about 200 light-years.
- The IXPE mission will be extended by 20 months with a General Observer (GO) program from February 2024-September 2025.
 - NASA has released a ROSES22 program element



Credits: IXPE: NASA/MSFC/F. Marin et al; Chandra: NASA/CXC/SAO; Image Processing: L.Frattare, J.Major & K.Arcand

Mission Status

(Operating)



SPHEREx

Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer

- The SPHEREx mission will provide the first all-sky spectral survey (for every 6" on the sky).
- Over a two-year planned mission beginning in 2025, the SPHEREx team will analyze data on more than 490 million galaxies along with more than 9 million stars in the Milky Way in order to explore the origins of the universe.
- Both SPHEREx payload integration testing and spacecraft bus integration are ongoing.
- Systems Integration Review (SIR) planned for November 14-16, 2023 at JPL. SPHEREx schedule and budget to be reviewed.
- KDP-D: January 30, 2024
- SPHEREx launch planned for 2025



JPL Director Laurie Leshin poses with SPHEREx at JPL.

GUSTO

Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory

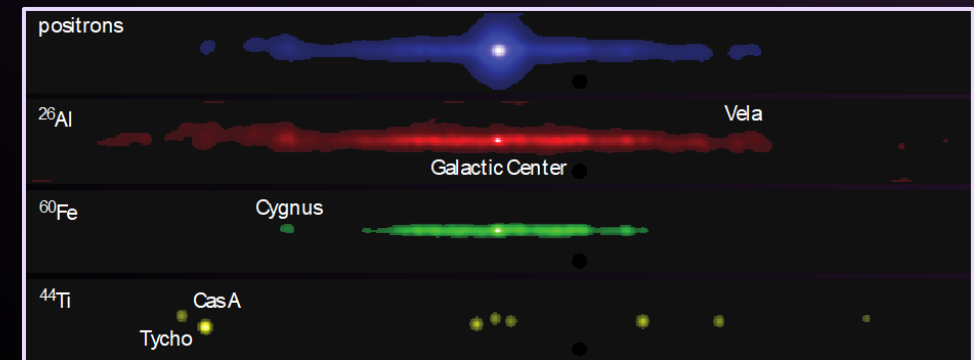
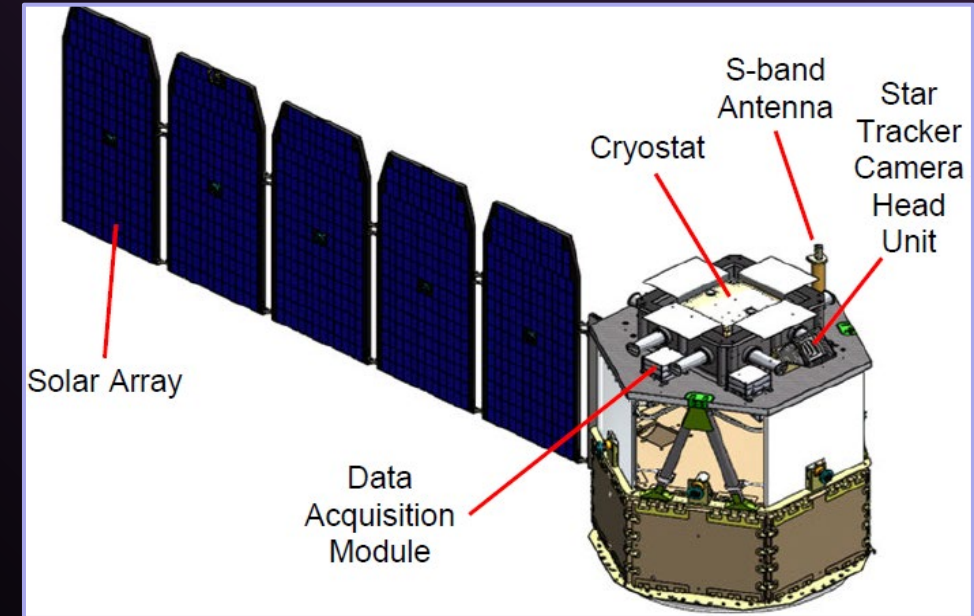
- GUSTO aims to provide a comprehensive understanding of the inner workings of the Milky Way and the Large Magellanic Cloud (LMC) by surveying them in 3 important far-infrared (THz) interstellar lines.
 - Provides a cost-effective approach to probe the full life-cycle of star formation and stellar evolution.
 - NASA's First Balloon Class D Explorer Mission
 - Pathfinder for future bold balloon programs
- PI is Dr. Christopher Walker (University of Arizona)
- ORR: Held on September 27, 2023
- Observatory shipment via aircraft to McMurdo leaving US around October 16 followed by team deployment
- Launch is scheduled for early December 2023 from Antarctica



The GUSTO Compatibility test was successfully conducted at CSBF on Aug 10

Compton Spectrometer and Imager (COSI)

- **PI: John Tomsick, UC Berkeley**
- COSI is Compton imaging spectrometer with cryogenic Ge detectors for 0.1-5 MeV gamma-rays
- COSI will provide an understanding of the positron excess; map ^{26}Al (half-life 60yr) to study element formation; make the first map of ^{60}Fe (half-life 2.6Myr, only source is core-collapsed SN) to trace past core collapse supernovae; and discover new young supernovae in ^{44}Ti (half-life 0.7Myr).
- COSI will use polarization to gain insight into extreme environments, such as accreting black holes (AGN and Galactic) and γ -ray bursts (GRBs).
- COSI will localize the γ -ray counterparts to GW events (short GRBs) and detect high-energy neutrino counterparts.
- System Requirements Review January 2023; Preliminary Design Review February 2023
- Launch Readiness Date: 2027

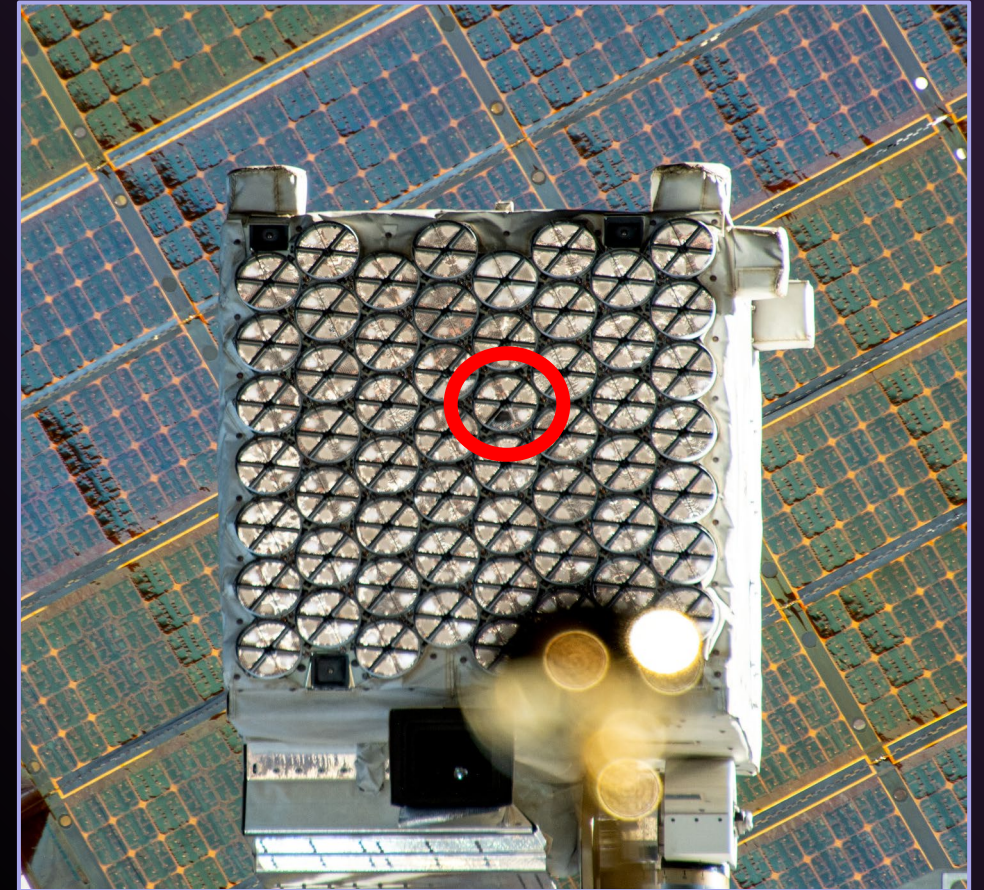


Simulated Radioactive Milky Way

NICER

The Neutron Star Interior Composition ExploreR

- NICER is deployed on an external site of the ISS truss offering a uniquely favorable view for Astrophysics observations.
- NICER has experienced increased optical loading due to a puncture in the thermal shield of the Sun Shade that occurred on May 22, allowing stray light to enter the usually dark optical bench where its sensitive detectors are located.
 - Nighttime observations seem to be unaffected and daytime observations are notably impacted.
 - Operational work-arounds restored daytime observation capabilities to ~50% of the former level.
 - The NICER and ISS teams are collaborating on repair strategies to plug the areas and reduce the stray light.
 - EVA and EVR options are available and could be implemented around summer 2024.

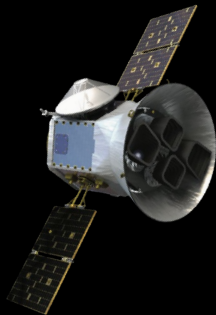


View of NICER from ISS Camera showing the array of Sun Shades with thermal shield damage

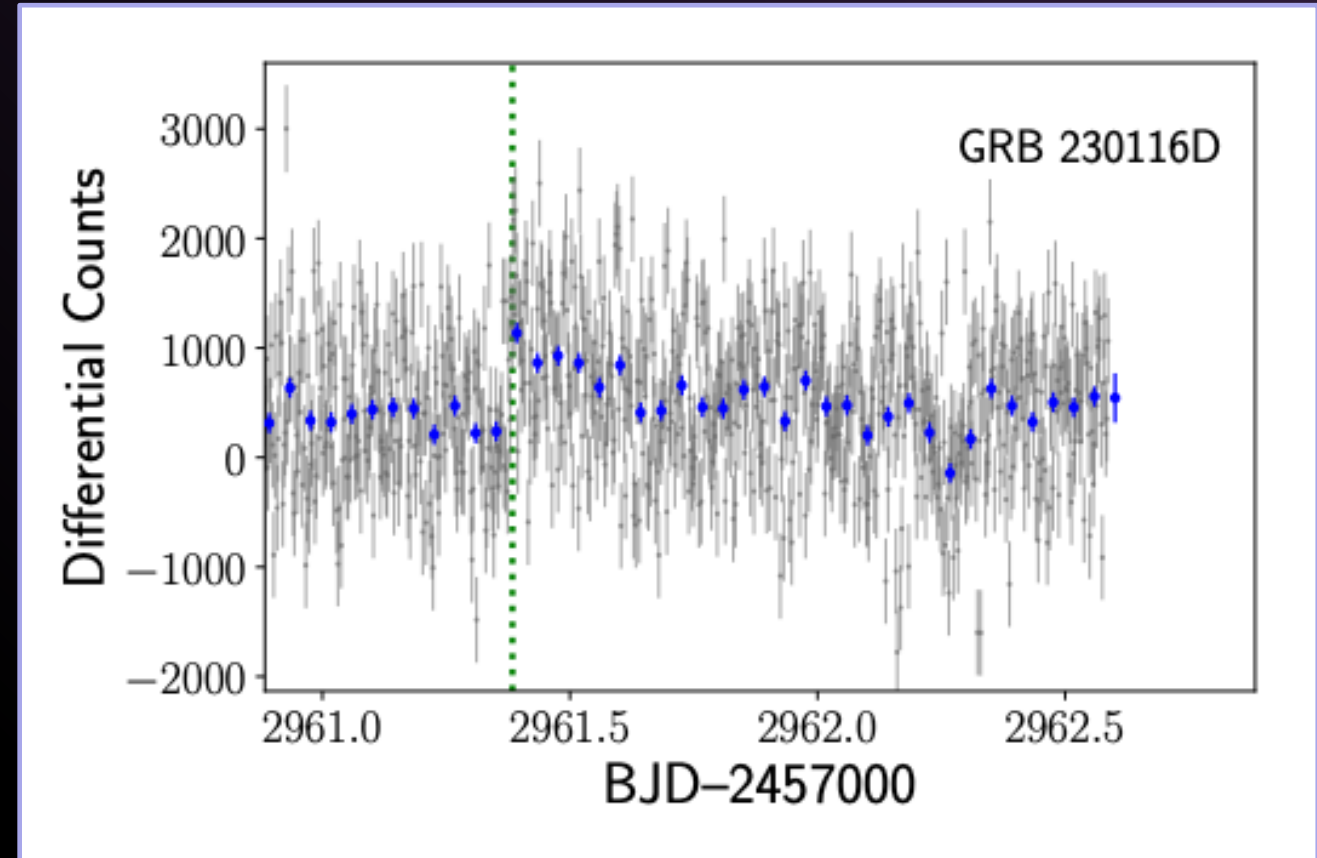
TESS

Transiting Exoplanet Survey Satellite

- Planet Count: 392 confirmed planets
 - 136 with radii $< 2.5 R_{\text{Earth}}$
 - 252 with radii $> 2.5 R_{\text{Earth}}$
 - 4 with unknown radii
 - 6,788 candidate planets
- Publication Count:
 - 1721 submitted, 1536 peer-reviewed
 - (41% exoplanets, 59% astrophysics)



TESS observed a gamma-ray burst!



“Gamma-Ray Bursts Observed by the Transiting Exoplanet Survey Satellite: Prompt Optical Counterparts and Afterglows of Swift-XRT Localized GRBs” (Jayaraman et al. 2023 arXiv:2308.05148.)

LISA

Laser Interferometer Space Antenna

ESA and NASA Partnership

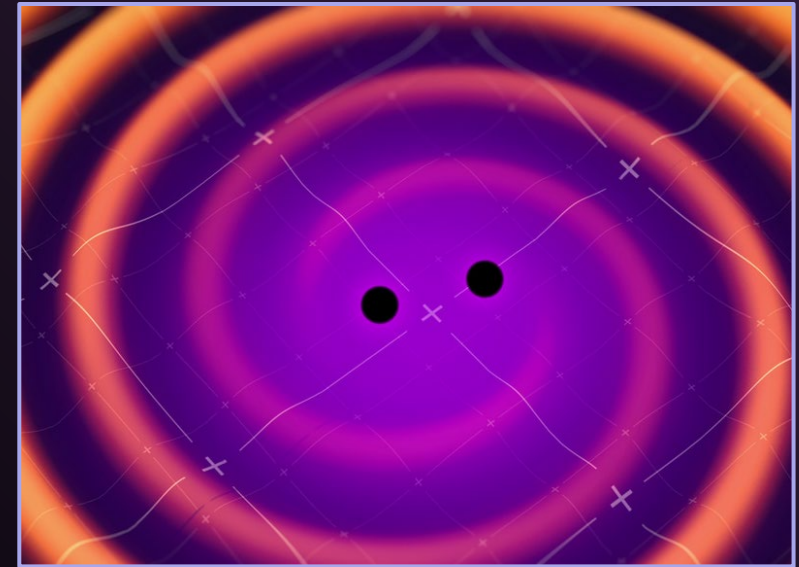
- LISA will be the first space-based gravitational wave observatory (LRD~2037)
- Sources in LISA's milliHertz band range from white dwarf binaries in our galaxy to merging massive black holes at extreme redshift

NASA Contributions:

- Stable telescopes to facilitate inter-spacecraft interferometry
- Laser Systems for interferometer light source
- Charge Management Device for test mass charge control
- Data analysis pipelines and support for science investigations

Status:

- NASA will transition from a pre-Phase A Study and development program, to the Explorers Office managed by GSFC.
- ESA approaching end of Phase B1, Mission Adoption milestone planned for early 2024.
- The LISA Preparatory Science Program (LPS) accepted proposals as part of ROSES-22.



Merging black holes produce gravitational waves that distort the fabric of spacetime.

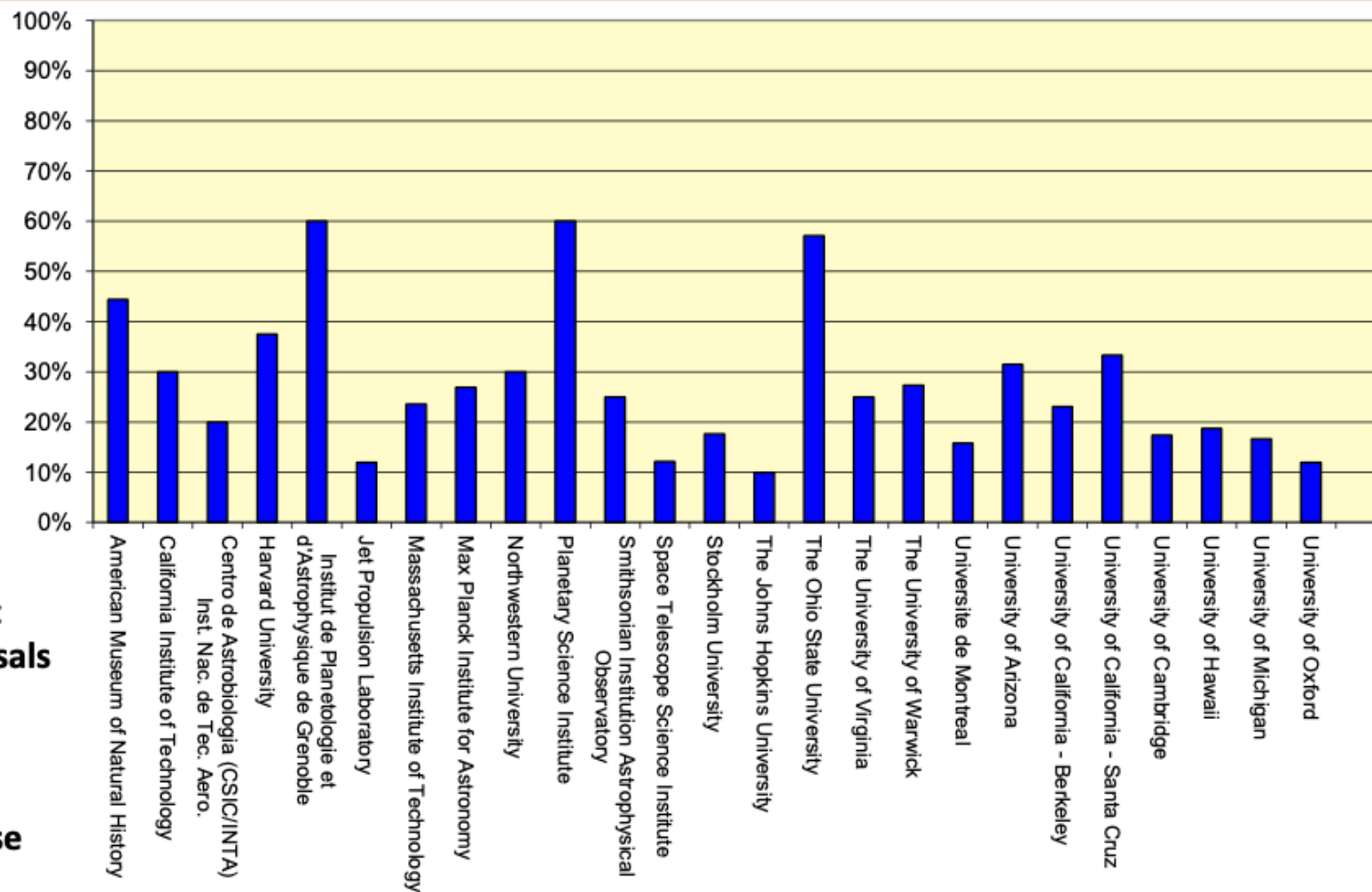
Credit: NASA/GSFC Conceptual Image Lab

James Webb Space Telescope

- James Webb Space Telescope continues to operate at full science capability
 - 14 months into its 5-year prime mission.
- Cycle 1 and Cycle 2 observations are well underway
 - Cycle 3 Call for Proposals was released August 16, 2023 with proposals due October 25, 2023.
 - Cycle 3 observations will begin July 1, 2024.
- As of early October 2023, over 400 articles have been published in peer-reviewed journals with “JWST” in the title or abstract.
- The Operations team has implemented a Micrometeoroid Avoidance Zone (MAZ) constraint to help minimize impacts on the primary mirror. Observations can still be scheduled in the MAZ but efforts are taken to minimize the time the observatory is pointed into the RAM direction.



Proposal Institutional Acceptance Fraction



Only shows
Institutions that
have ≥ 3 Proposals
approved
55% of the
Recommended
Hours from these
26 Institutions

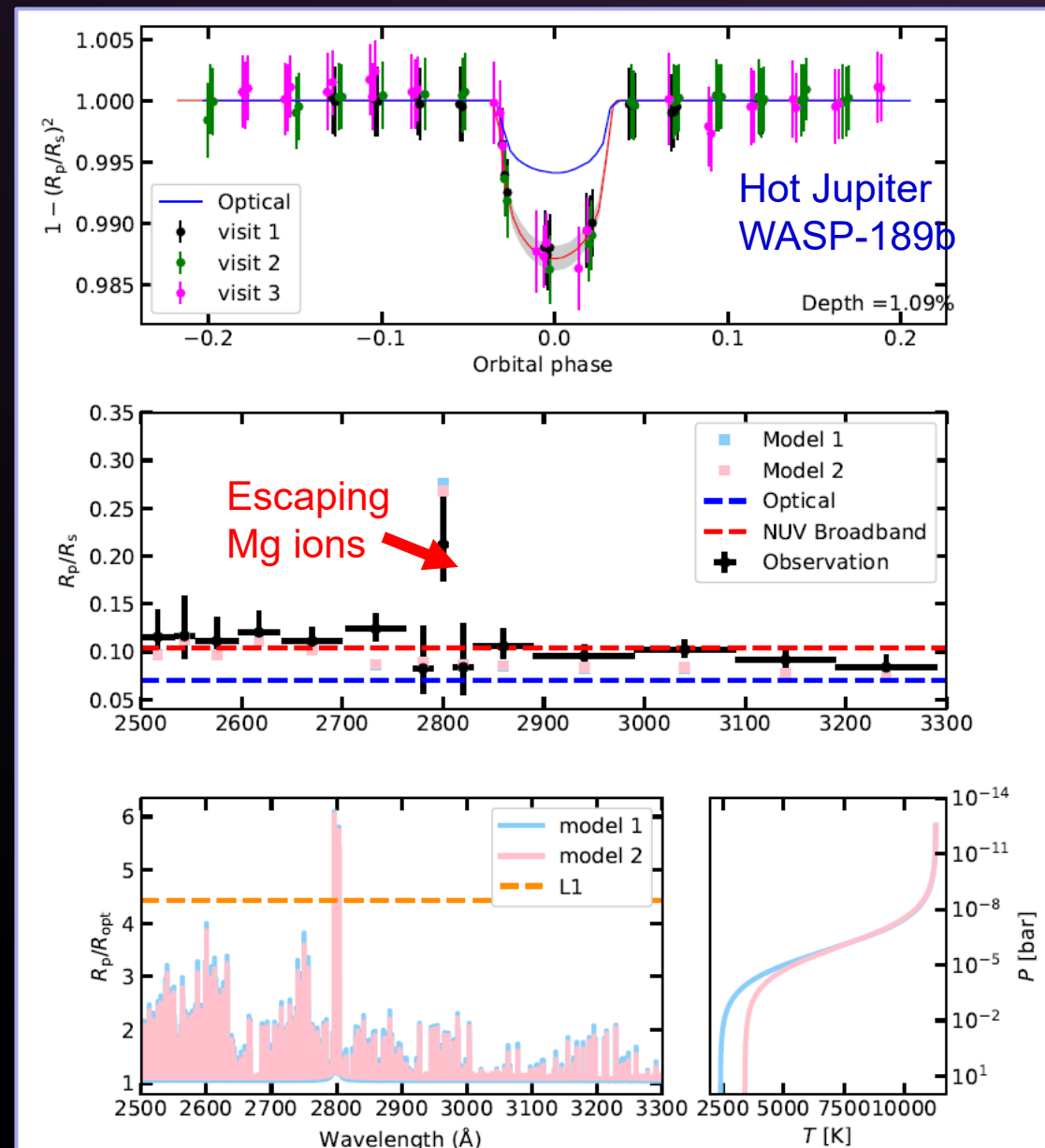
Pioneers

- Five Pioneers projects are currently underway, four selected from Pioneers-2020 and an additional selection from Pioneers-2021.
 - **PUEO** – Long Duration Balloon to detect the highest energy neutrinos, PI Abigail Viergg, U. of Chicago
 - **Pandora** – Smallsat, Optical and IR characterization of exoplanet host stars, PI Elisa Quintana, GSFC
 - **Aspera** – Smallsat, UV mapping of IGM via OVI line imaging, PI Carlos Vargas, U. of Arizona
 - **StarBurst** – Smallsat GRB ASM, detecting NS/NS mergers along with LIGO, PI Daniel. Kocevski, MSFC
 - **TIGERISS** – ISS payload, measuring ultra-heavy (r-process) CR, PI Brian Rauch, Washington U.
- There are highly meritorious possible selections from Pioneers-2022, but selections are being deferred pending clarification of the FY24 and FY25 budgets.
- After soliciting under ROSES-2020, ROSES-2021, and ROSES-2022, we are taking a pause in this new program and will not solicit under ROSES-2023, but expect to solicit under ROSES-2024

CUTE

The Colorado Ultraviolet Transit Experiment

- NASA's first UV/optical astronomy and first exoplanet transit spectroscopy cubesat
 - PI – Kevin France, CU Boulder/LASP
- Launched September 2021, extended mission ongoing now
- Acquired 6 – 11 near-UV transit observations of six hot Jupiters
- Data delivered for archiving at NExSci
- Science and mission publications in the peer-reviewed literature



Budget



Federal Budget Process Overview

Date	Item
March CY	Program Planning & Budget Exercise instructions for FY+2 to projects (i.e., in CY XXXX, working FY XXXX+2)
May	Projects response to PPBE guidelines
July	SMD recommendations to NASA Office of the Chief Financial Officer (OCFO)
August	NASA budget decisions
September	NASA budget to Office of Management & Budget (OMB)
~November	OMB markup & passback
~February CY+1	President's FY +1 budget announced
March CY+1	Congressional authorization committees
August CY+1	Congressional appropriations committees
September CY+1	Congressional conference committee
October CY+1	President signs budget (begins FY+1)



FY+2
Not Public
FY+2: Information is Not Public

FY+1
Public
FY+1: Information is Public

FY24 Presidents Budget

- Bipartisan Budget Agreement (Signed by the President June 3)
 - Expected to keep fiscal year 2024 non-defense non-VA spending government-wide flat at fiscal year 2023 levels and increase fiscal year 2025 non-defense non-VA spending government by 1%. Beyond fiscal year 2025, the agreement has no budget caps, only non-enforceable appropriations targets.
 - It is possible NASA's final fiscal year 2024 appropriation could be significantly below the \$27.2 billion President's request, which represented a \$1.8 billion increase, or 7%, above fiscal year 2023, to continue support for our priorities in Artemis, climate, science, and technology for future missions.
 - Both draft appropriations bills (House and Senate) are significantly below even the FY23 levels.
- NASA has deemed it prudent to plan for an FY24 budget lower than the FY24 Presidential Budget Request
- APD has taken steps consistent with the expectation that we'll have to stay roughly within our FY23 enacted budget levels during a CR.

Astrophysics Division Director's Perspective

- Balance Portfolio of Missions and Science
 - Decisions made based on APD principles document for handling reduced budgets
 - Current considerations include:
 - 2010 Decadal Program of Record: Roman
 - 2021 Decadal Survey recommendations
 - e.g. Habitable Worlds Observatory, TDAMM, and Probe mission
 - Maintaining healthy R&A program
 - Large missions in extended operations
- Protect Missions in Development, Future Missions & International Partnerships
 - Ensure that the Agency commitment to Roman continues to be met i.e. Cost and Schedule
 - Maintain international partnerships
 - Maintaining Explorer Program cadence



ASTROPHYSICS FLEET

PRE-FORMULATION

PROBE ~2033
LISA ~2037
ATHENA TBD

COMPETED PHASE-A

MO (LEAP/ MOONBEAM)
MIDEX (UVEX /STAR-X)

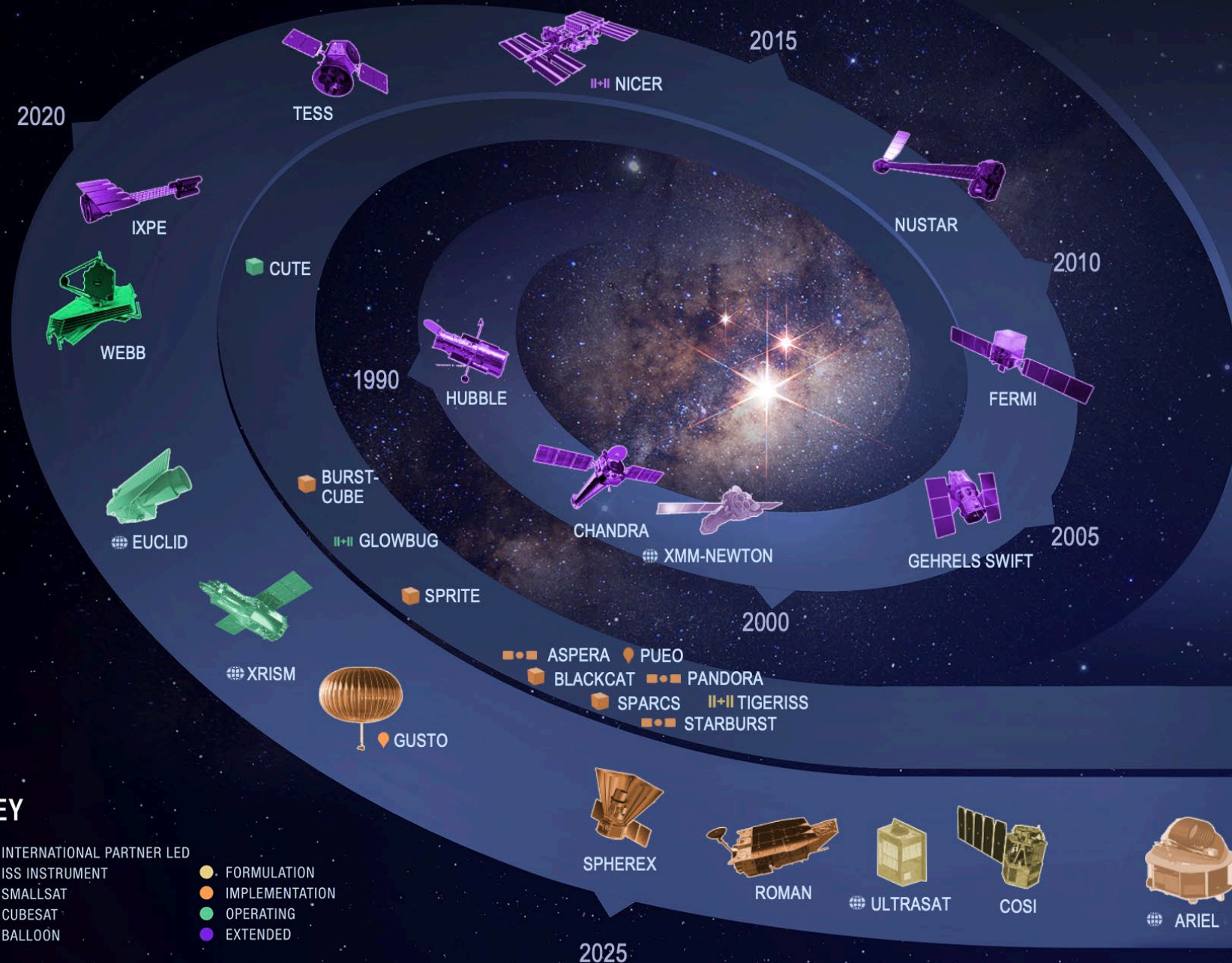
VERY SMALL MISSIONS

TRADITIONAL MISSIONS

KEY

INTERNATIONAL PARTNER LED
ISS INSTRUMENT
SMALLSAT
CUBESAT
BALLOON

FORMULATION
IMPLEMENTATION
OPERATING
EXTENDED





ASTROPHYSICS FLEET

PRE-FORMULATION

PROBE ~2033
LISA ~2037
ATHENA TBD

COMPETED PHASE-A

MO (LEAP/ MOONBEAM)
MIDEX (UVEX /STAR-X)

Missions in Prime Science Operations

VERY SMALL MISSIONS

TRADITIONAL MISSIONS

2020



WEBB

CUTE

1990



EUCLID

GLOWBUG



XRISM

2015

2010

2005

2000

2025

KEY

- INTERNATIONAL PARTNER LED
- ISS INSTRUMENT
- SMALLSAT
- CUBESAT
- BALLOON

- FORMULATION
- IMPLEMENTATION
- OPERATING
- EXTENDED



ASTROPHYSICS FLEET

PRE-FORMULATION

PROBE ~2033
LISA ~2037
ATHENA TBD

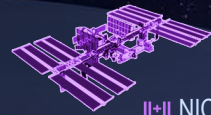
2020



IXPE

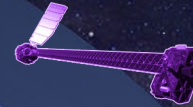


TESS



NICER

2015



NUSTAR

2010



FERMI

2005



GEHRELS SWIFT

2000



XMM-NEWTON



CHANDRA



HUBBLE

1990

Missions in Extended Science Operations

VERY SMALL MISSIONS

TRADITIONAL MISSIONS

KEY

- INTERNATIONAL PARTNER LED
- ISS INSTRUMENT
- SMALLSAT
- CUBESAT
- BALLOON

- FORMULATION
- IMPLEMENTATION
- OPERATING
- EXTENDED

2025



ASTROPHYSICS FLEET

PRE-FORMULATION

PROBE ~2033
LISA ~2037
ATHENA TBD

COMPETED PHASE-A

MO (LEAP/ MOONBEAM)
MIDEX (UVEX /STAR-X)

Missions in Formulation & Development

VERY SMALL MISSIONS

TRADITIONAL MISSIONS

KEY

- INTERNATIONAL PARTNER LED
- ISS INSTRUMENT
- SMALLSAT
- CUBESAT
- BALLOON

- FORMULATION
- IMPLEMENTATION
- OPERATING
- EXTENDED

2025



SPHEREX



ROMAN



ULTRASAT



COSI



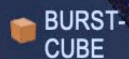
ARIEL



GUSTO



SPRITE



BURST-CUBE

- ASPERA
- BLACKCAT
- SPARCS
- STARBURST
- PUEO
- PANDORA
- TIGERISS

2015

2010

2005

2000

1990

2020

Astrophysics Division FY24 Budget Decisions

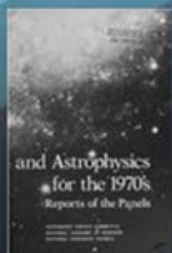
- Expectation that FY24 budget stays at enacted FY23 budget levels
- Adjustments to APD budget includes reductions in large, extended-operations missions
 - Chandra
 - Hubble
- Protecting Missions in Development, Future Missions & International Partnerships
 - Ongoing commitment to delivery of Roman on cost and schedule
 - Ongoing Explorer missions in development
 - International partnerships:
 - LISA transitions to management by Explorers office following ESA adoption
 - ATHENA investments are reduced pending ESA reformulation and change in US contributions
 - Technology investments for Habitable Worlds Observatory

Astrophysics Division Budget Outlook

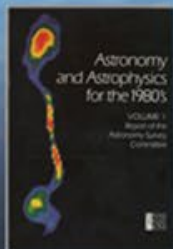
- Currently on CR until Nov 17th
- FY25 & beyond are embargoed pending President's Budget for FY25
- FY24 appropriations are yet to be determined
 - Further reductions may be required but working to FY23 enacted levels
- Budget environment remains volatile

Astrophysics

Decadal Survey Missions



1972
Decadal Survey
Hubble



1982
Decadal Survey
Chandra



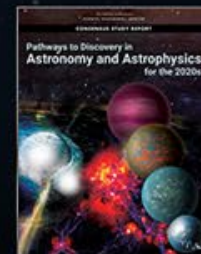
1991
Decadal Survey
Spitzer



2001
Decadal Survey
Webb



2010
Decadal Survey
Roman



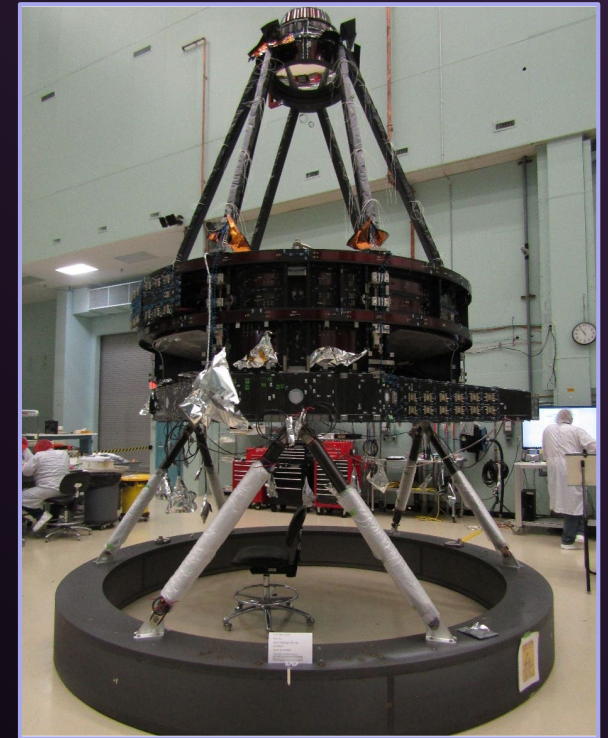
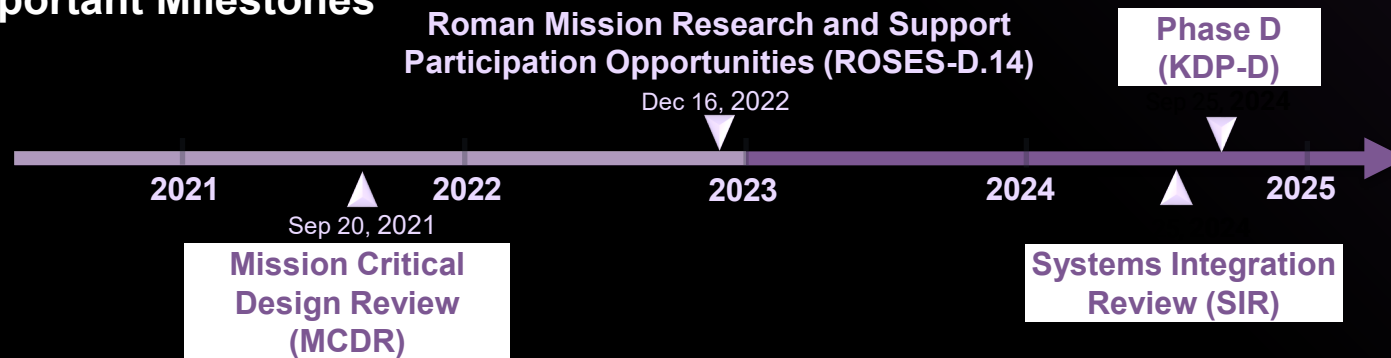
2021
Decadal Survey

Nancy Grace Roman Telescope

Astrophysics' next flagship mission

- The Forward Optical Assembly (FOA) is complete, and the Integrated Optical Assembly (IOA) integration is underway at L3 Harris.
- Northrop Grumman completed the Instrument Carrier (IC) structure assembly and delivered to NASA's GSFC on Sep 19.
- The project team has completed assembly of the Wide Field Instrument and began environmental testing at Ball's largest thermal vacuum facility (aka. the Titan chamber).

Important Milestones



Completed Forward Optical Assembly at L3H

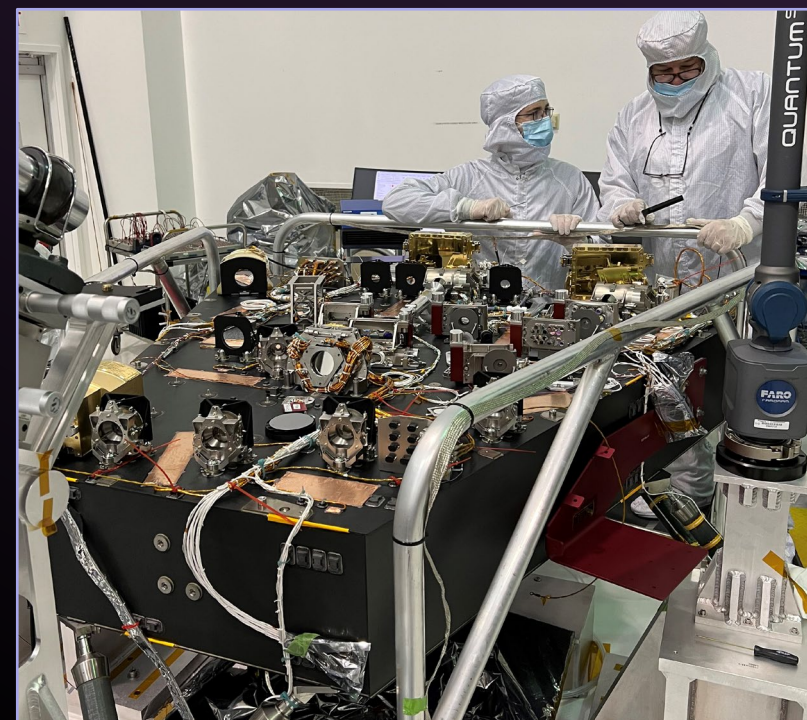


Roman's Instrument Carrier delivered to GSFC

Roman Coronagraph Instrument (CGI)

Technology Demonstration on Nancy Grace Roman Space Telescope

- The Coronagraph Instrument is one of two instruments aboard the Nancy Grace Roman Space Telescope
 - It will demonstrate the first high-performance space coronagraph system (utilizing active wavefront control) capable of imaging gas giant exoplanets, like our Jupiter, in reflected starlight
 - Active optics include a pair of Deformable Mirrors for precision wavefront control
- The optical bench and electronics pallet of the Coronagraph instrument were mechanically integrated at JPL on Jul 27.
- Schedule:
 - ~October/November – Functional testing
 - ~February/ March – Thermal vacuum testing
 - ~May – Arrives at GSFC for observatory integration



All flight optical components installed on the CGI Optical bench. Supporting electronics to be installed in coming weeks.

Credits: Jet Propulsion Laboratory

Roman Science Community Engagement – The Plan

1. Community definition and ownership of Core Community Surveys

- Core community surveys: large ambitious surveys to address Astro2010 science objectives
- Community defined: Broad, inclusive process; Astrophysics included in all decisions
- Community owned: Not directed by any single team; data have no proprietary access

2. Ability for people to engage with Roman project / Science Centers / science community independently of proposal selection

- Via technical joint working groups and community-led science collaboration

3. Science community funding

- Variety of award sizes and durations
- Multiple funding opportunities between now and launch for support for people at US institutions to work independently or with existing science teams/consortia
- Long term, stable support of teams to allow development of software/pipelines etc in partnership with Roman Science centers

Roman Science Community Engagement – Status

1. Defining Roman Observing plan

- Core Community Survey Definition
 - Community process well underway, large response from broad science community is enabling identification of observations that can meet diverse science needs.
- Early survey definition
 - Provides option to define a General Astrophysics survey in parallel with the core community surveys
 - Committee now completing work of evaluating community submitted white papers
 - Report imminent, if recommended to proceed, will define the specifics of the survey via an open community process

2. Community Working Together

- Technical working groups - Calibrations, data processing pipelines, software, simulations etc. now open to all
- Community discussions on forming science collaboration

Roman Science Community Engagement – Status

3. Supporting the Community

- Solicitation for funding Roman preparatory science work released as part of ROSES-22; 90 proposals reviewed in May; selections have been made and have been announced.
 - Provides for Project Infrastructure Teams
 - Support the community in major science investigations of enduring value
 - Provides Wide Field Science teams
 - Targeted work across the broad range of science with Roman
 - Provides for a Coronagraph Community Participation Program
 - Preparation for the technology demonstration work with the CGI

Astrophysics Probe

- The PI cost cap is \$1B; AO requires a General Observer/Guest Investigator (GO/GI) Program during the 5-year prime mission. For a pointed observatory, 70% of observing time is allocated for GO. A survey observatory will make data available as soon as practicable.
- This is a two-step AO: because the Probes are more complex than previous Explorers, and this is the first one, the competitive Phase A studies will last 12 months
- In response to the recommendation of Astro2020, Astrophysics will accept proposals for:
 - A far-infrared imaging and/or spectroscopy mission
 - An X-ray probe
- Proposing teams should check the Q&As frequently at <https://explorers.larc.nasa.gov/2023APPROBE/>

Release of final AO:	July 2023
Proposals due:	NET mid-November 2023

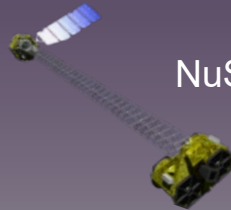


Astrophysics Explorers Program

Selected before 2011



Gehrels
Swift



NuSTAR

4 AOs per decade



PROBE
2023
Proposals due
11/16/23

SMEX
2025

Small and Mid-Size Missions



TESS



IXPE



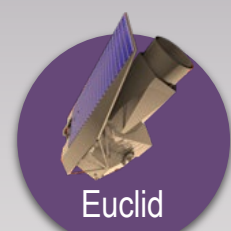
SPHEREx



COSI

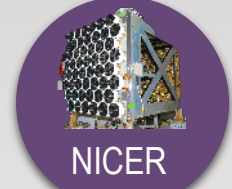


STAR-X
UVEX



Euclid

Missions of Opportunity



NICER



GUSTO



ARIEL



LEAP
MoonBEAM

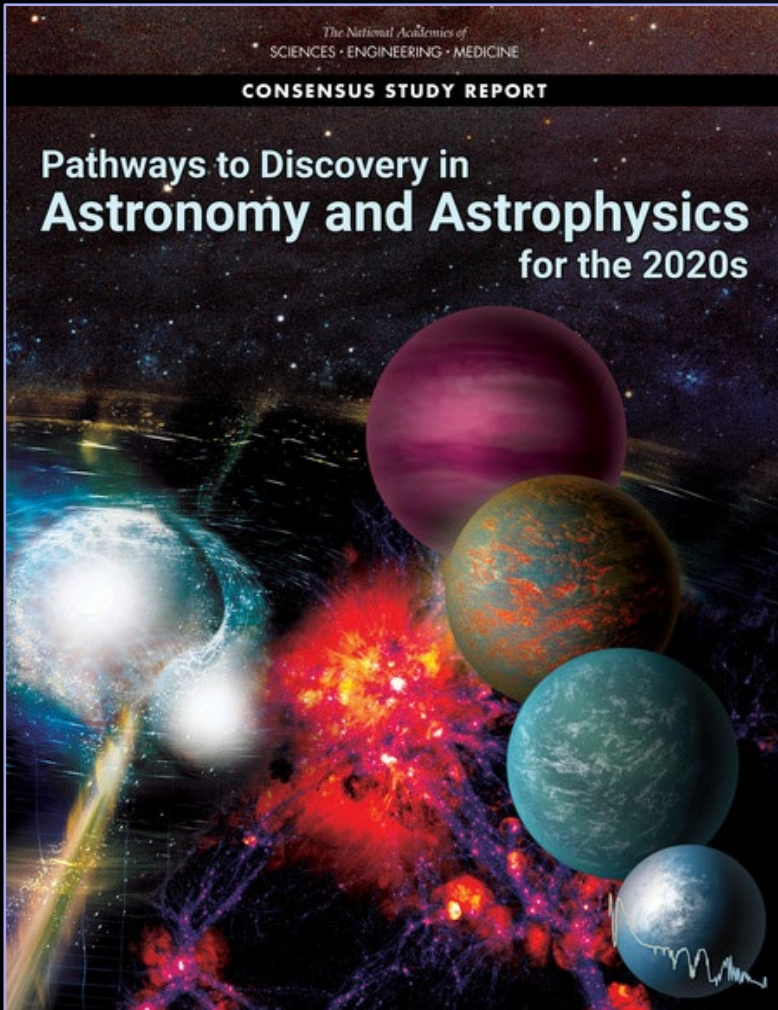


XRISM

Habitable Worlds Observatory



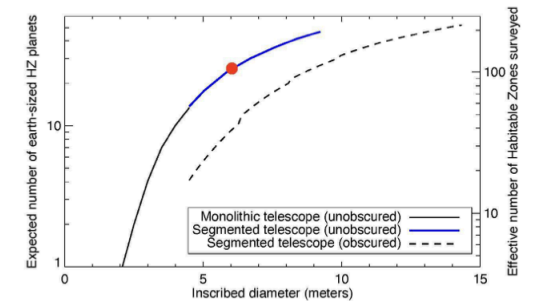
Decadal Survey



A Future IR/Optical/UV Telescope Optimized for Observing Habitable Exoplanets and General Astrophysics

IR/O/UV Telescope Characteristics

- ~6 m off-axis inscribed diameter provides robust sample of ~25 spectra of potentially habitable planets, and would be transformative for general astrophysics
- Estimated cost: 11B\$
- Target launch: first half of 2040's

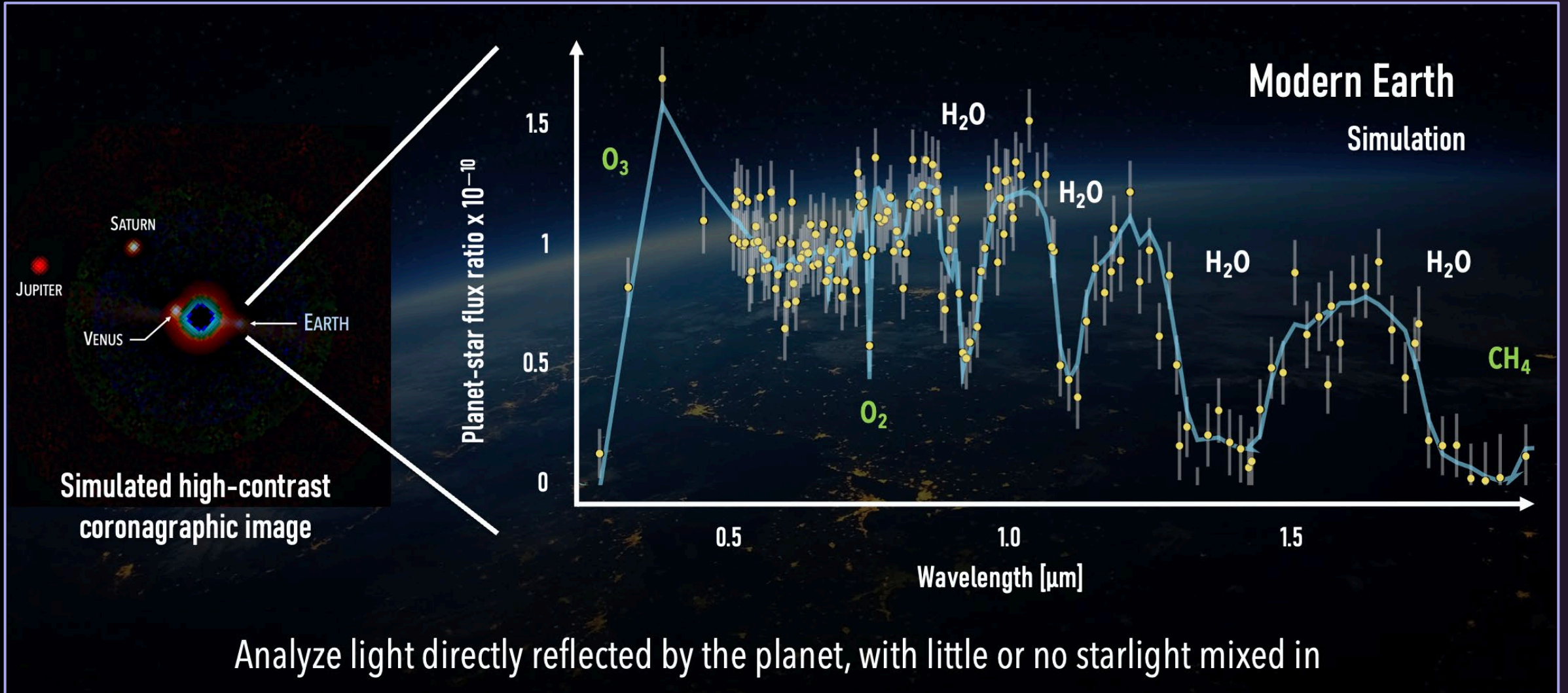


The scientific goals of this mission, when achieved, have the potential to change the way that we as humans view our place in the Universe

With sufficient ambition, we are poised to make this transformational step

This is a quest at the technical forefront, and of an ambitious scale that only NASA can undertake, and where the U.S. is uniquely situated to lead

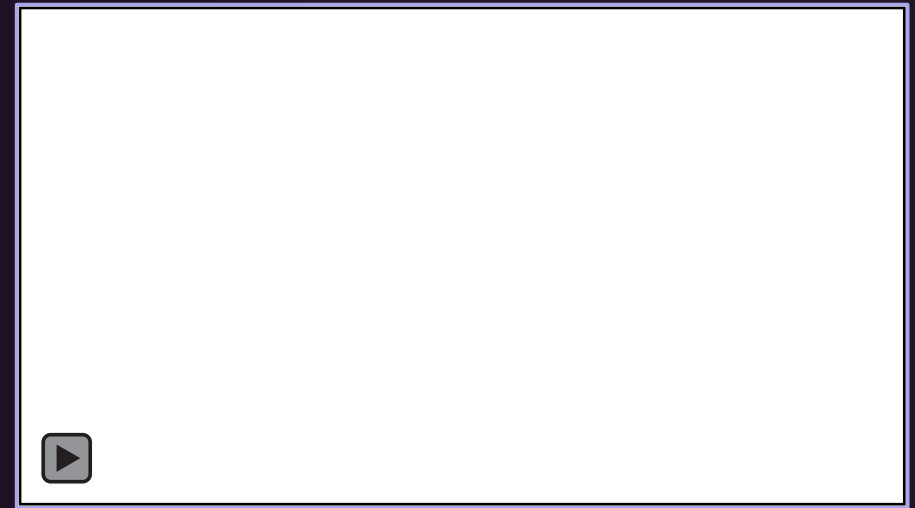
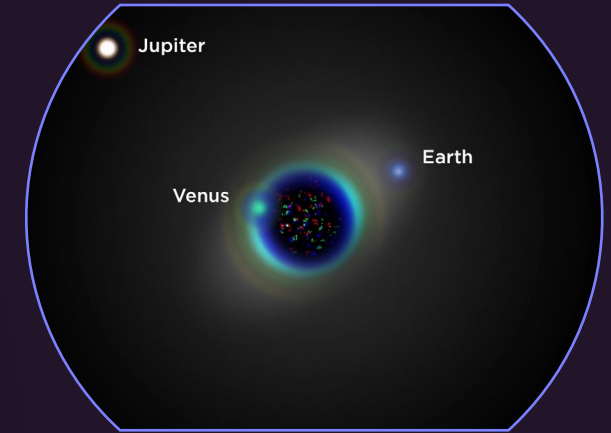
How Will it Search for Life?



Response to Decadal Survey

Habitable Worlds Observatory

- **Decadal Survey (ASTRO2020) priority science areas**
 - Are there habitable planets harboring life elsewhere in the universe?
 - Survey sun-like, nearby stars for habitable planets and search for evidence of life
- **Primary Technical Approach**
 - ≥ 6 meter Segmented mirror telescope
 - Active control of telescope/coronagraph to achieve system stability at level of ~ 10 pm over control cycle
 - Coronagraph achieving contrast levels of 10^{-10}
- **Habitable Worlds Observatory**



The Habitable Worlds Observatory

Big Picture Strategy

- **Build to schedule:** Mission Level 1 Requirement e.g. Planetary mission strategy
- **Evolve technology:**
 - Build upon current NASA investments and TRL-9 technology
 - Segmented optical telescope system from JWST
 - Coronagraph from Roman 's coronagraphic imager program
- **Next Generation Rockets:**
 - Larger telescope aperture sizes
 - Leverage opportunities offered by large fairings to facilitate mass & volume trades
- **Planned Servicing:** Robotic servicing at L2
- **Robust Margins:** Design with large scientific, technical, and programmatic margins
- **Mature technologies first:** Reduce risk by fully maturing the technologies prior to development phase.

Strategic Approach

Decades of research-based consensus on megaprojects

Independent
Research Papers

Mission Concept
Reports

GAO Report on
Major Projects

SMD Internal Study
on Flagship
Projects

National Academy
Recommendations

Challenges and Potential Solutions to Develop and Fund NASA Flagship Missions

Robert E. Bitten
The Aerospace Corporation
2319 E. El Segundo Blvd.
El Segundo, CA 90245
310-336-1917
robert.e.bitten@aero.org

Stephen A. Shinn
NASA Goddard Space Flight Center
8800 Greenbelt Road
Greenbelt, Maryland 20771
301-286-5994
stephen.a.shinn@nasa.gov

Debra L. Lemmons
The Aerospace Corporation
2319 E. El Segundo Blvd.
El Segundo, CA 90245
310-418-7082
debra.lemmons@aero.org

Abstract—Large, strategic “Flagship” missions have unique characteristics that lead to challenging developmental difficulties for the National Aeronautics and Space Administration (NASA). Missions such as the Hubble Space Telescope (HST), James Webb Space Telescope (JWST), and the Mars Science Laboratory (MSL) had technical and programmatic challenges that led to significant schedule delay and subsequent cost growth. Although NASA has instituted policies that have reduced cost growth for some “typical” NASA science missions, NASA Flagship missions remain a distinct challenge due to their requirement to provide unprecedented science or tackle bold exploration goals, typically while concurrently developing new technologies. The unique challenges presented by Flagship missions make it extremely difficult to fully predict cost and schedule given that the technical and programmatic advances needed to meet performance requirements are unprecedented. This paper addresses why Flagship missions are unique and proposes a new programmatic approach to develop and fund Flagship missions.

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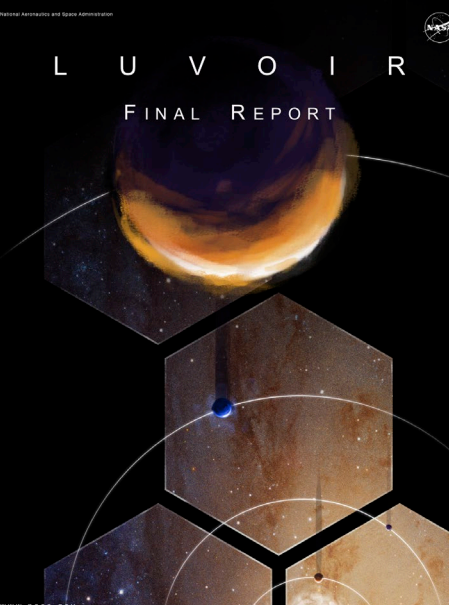
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4. FLAGSHIP COST GROWTH.....3
5. COULD COSTS HAVE BEEN ANTICIPATED?.....7
6. A POTENTIAL NEW APPROACH.....7
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1. DEFINITION OF FLAGSHIP MISSIONS

According to Merriam-Webster’s Dictionary, a Flagship is: 1) the ship that carries the commander of a fleet or subdivision of a fleet and flies the commander’s flag, or 2) the finest, largest, or most important one of a group of things. [1] In many ways, National Aeronautics and Space Administration (NASA) Flagship missions incorporate both

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L U V O I R
FINAL REPORT



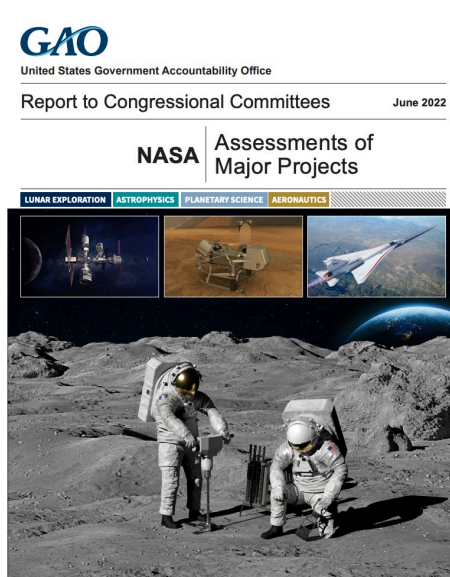
www.nasa.gov

GAO
United States Government Accountability Office

Report to Congressional Committees June 2022

NASA Assessments of Major Projects

LUNAR EXPLORATION ASTROPHYSICS PLANETARY SCIENCE AERONAUTICS



GAO-22-105212

LMS

Large Mission Study Report

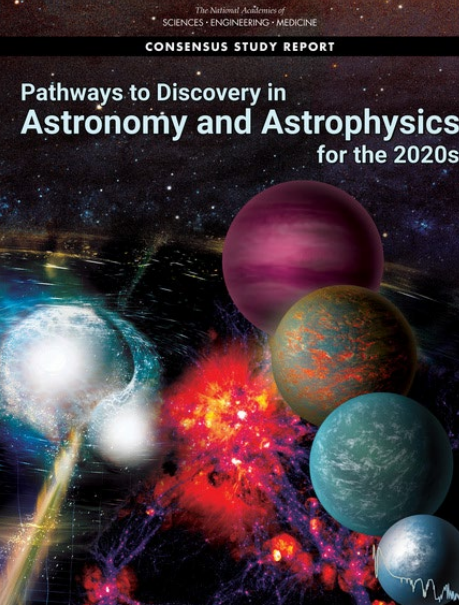
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CONSENSUS STUDY REPORT

Pathways to Discovery in
Astronomy and Astrophysics
for the 2020s



What have We Done?

NASA ROSES solicitation: System-Level Segmented Telescope Design

HWO Technology
Development through NASA
ROSES Solicitation

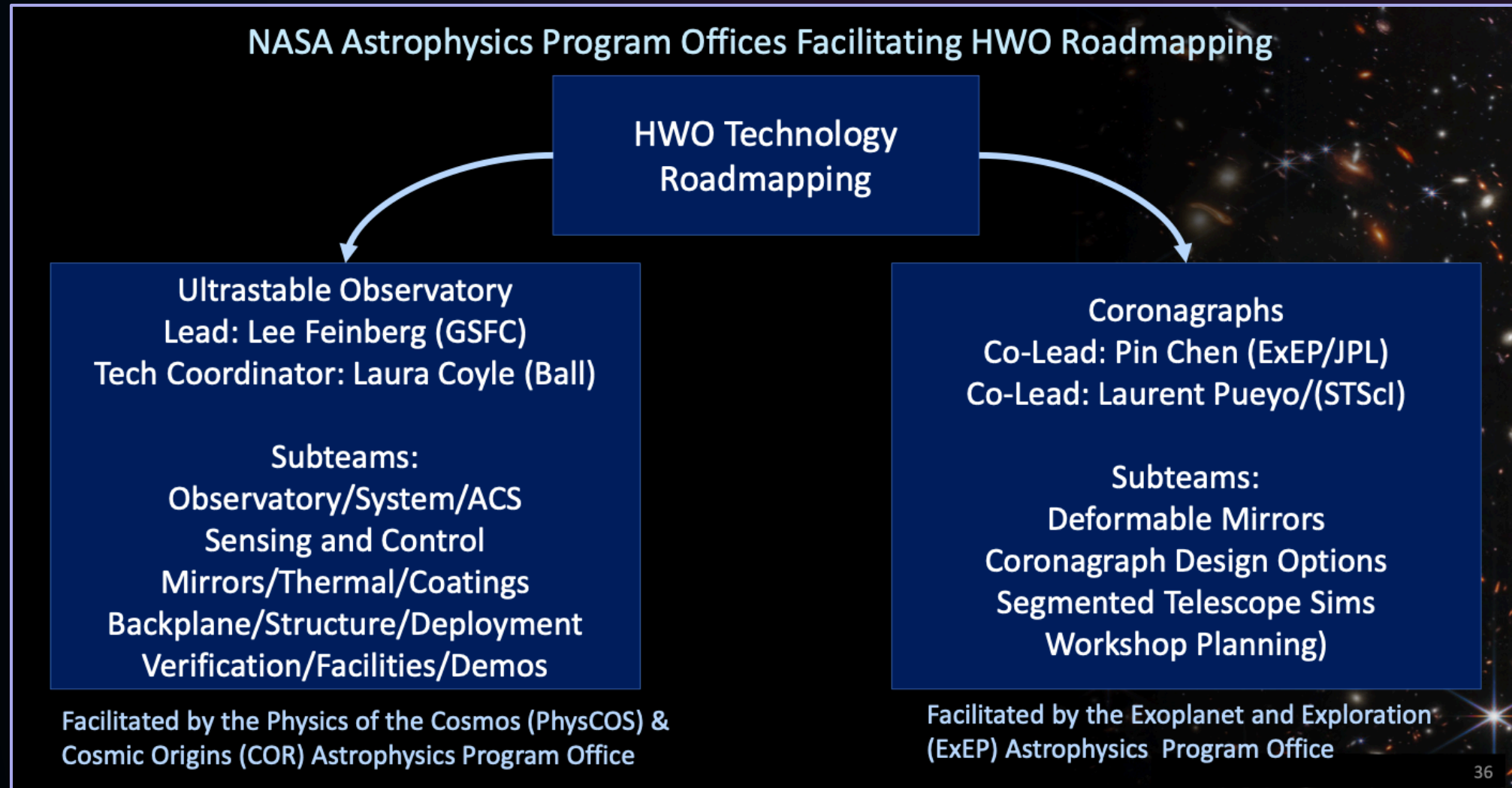


Ultra-Stable Large Telescope Research and
Analysis – Technology Maturation (ULTRA-TM)



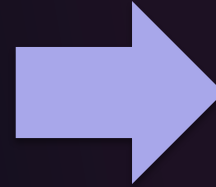
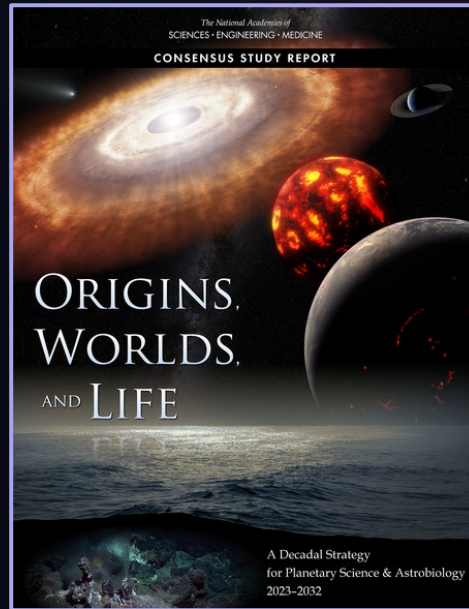
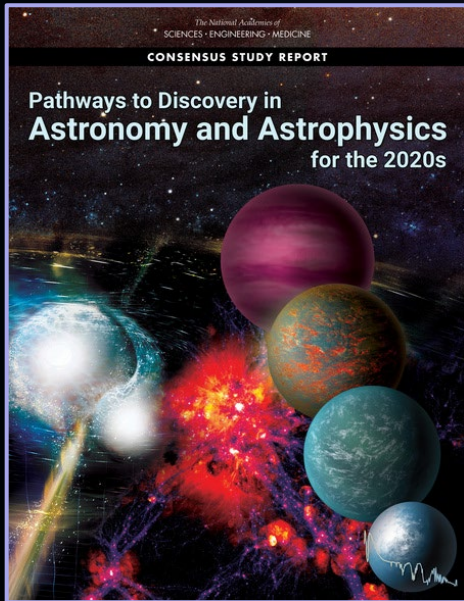
Technology Maturation for Astrophysics
Space Telescopes (TechMAST)

What Are We Doing Now?



The Science, Technology, Architecture Review Team (START): Involve the Community

Responsibility: HWO Scope



Objectives:

HWO Goals, objectives, & observations

Quantify all science objectives

Identify performance breakpoints

Build in robust margins

Roadmap Science Traceability Matrix (STM)

SELECTED CO-CHAIRS



Courtney Dressing

University of California, Berkeley



John O'Meara

W. M. Keck Observatory

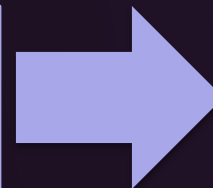
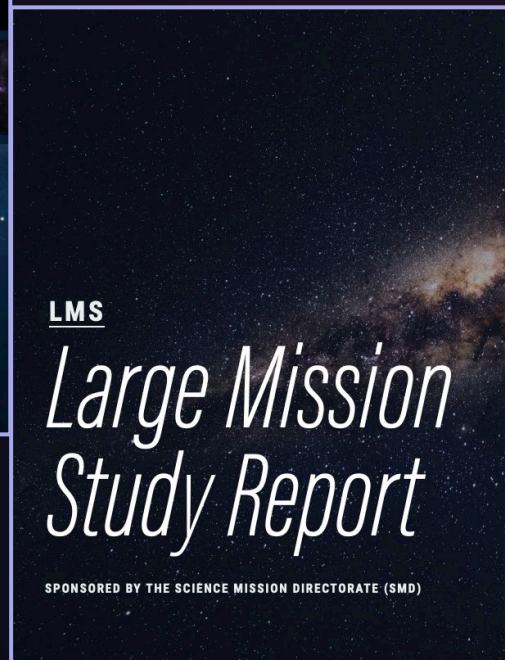
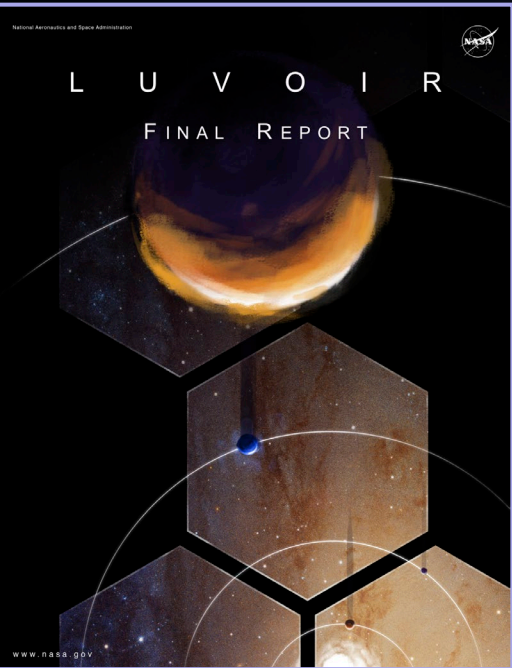
Additional Activities:

Mentoring

Super START: Science Analysis

Precursor Science

The Technical Assessment Group (TAG): **Involve the Community**



Responsibility:
HWO Responsiveness

Objectives:
Evolved Architecture Analyses
Aerospace Landscape Survey
Architecture Trade Deep Dives
Build in Robust Margins

Acting groups:
The TAG + Mentoring
Super TAG: Engineering Analysis
Aerospace Landscape Teams
Architecture Trades Teams

START Team Membership

Name	Institution
Charlie Atkinson (ex-officio)	Northrop Grumman
Giada Arney	GSFC
Natasha Batalha	Ames
Eric Burns	LSU
Jessie Christiansen	NExScI
Courtney Dressing (Co-Chair)	UC Berkeley
Matthew East (ex-officio)	L3Harris
Kevin France	CU-Boulder
Scott Gaudi	Ohio State University
Renyu Hu	JPL
Alina Kiessling	JPL
Janice Lee	STScI
Bruce Macintosh	UCO
Eric Mamajek (ex-officio)	ExEP

Name	Institution
Alison Nordt (ex-officio)	Lockheed Martin
John O'Meara (Co-Chair)	W. M. Keck Observatory
Jim Oschmann	retired
Rachel Osten	STScI
Chris Packham	UTSA
Lynnae Quick	GSFC
Swara Ravindranath (ex-officio)	COR
Jason Rhodes	JPL
Jane Rigby	GSFC
Ty Robinson	U of A
Dmitry Savransky	Cornell University
Evan Scannapieco	ASU
Evgenya Shkolnik	ASU
Erik Wilkinson (ex-officio)	Ball Aerospace

Time-Domain and Multi-Messenger Astronomy Update



Upcoming TDAMM missions

- Compton Spectrometer and Imager (COSI) Launch Readiness Date (LRD) August 2027
- NEO Surveyor – TDAMM aspect of Planetary IR mission LRD NET June 2028
- NASA Participation in Israeli Space Agency's ULTRASAT LRD June 2026
- Downselect of Explorers in 2024
- Pioneers: StarBurst LRD 2026, PUEO 2024, TIGERISS 2026
- SmallSats & ISS: GlowBug launched to ISS 3/15/23, BurstCube early 2024, BlackCat LRD 2024.
- Roman Space Telescope
- LISA – NASA contribution to ESA mission
- APRA: suborbitals such as AdAPT & technology development

Infrastructure

- Operating missions: Ongoing study of the possibility optimizing the NASA fleet for TDAMM through centralized planning, proposal submission, Target-of-opportunity initiation, and science-driven coordination of observations
- HQ studying future of Space Communications as TDRSS is replaced by commercial solution
 - Impact agency-wide - TDAMM is a science driver, particularly of Demand Access Service (DAS)
- HQ directed funding for 2 NASA center-based TDAMM projects:
 - Upgrade of General Coordinates Network (GCN) at GSFC
 - Development of multi-mission design & analysis tools at MSFC

TDAMM GOF Motivation, Study Deliverables and Mission

“answering the science questions of the next decade requires a multi-wavelength and multi-messenger approach [and] the synergy of space, ground and even underground facilities.” (Astro 2020, 2-47)

In October 2020, the Physics of the Cosmos Program embarked on a study to consider the organizational, programmatic and technical aspects of implementing a TDAMM General Observer Facility (GOF).

The study shall deliver a report and supporting materials with the following content:

1. A set of top-level requirements and architecture concept models for a TDAMM GOF.
2. Processes for TDAMM community engagement, proposal solicitations and award management.
3. A motivating set of TDAMM science cases and an analysis of the associated agreements, tools, process flows and interfaces necessary to support those cases.
4. One or more implementation strategies for the Phase 1 TDAMM GOF to achieve an initial operating capability by FY26.
5. A best-value recommendation for a particular implementation strategy if more than one option is evaluated.

The mission of the TDAMM GOF is to foster “all of astrophysics” science cases using complex time-sensitive observations beyond the capabilities of any individual observatory or mission team.

TDAMM General Observer Facility Study Activities

The study team is engaging stakeholders throughout the science lifecycle, seeking to identify opportunities where enhanced coordination would improve efficiency or TDAMM scientific outcomes.

Strategic Coordination	Tactical Coordination	Operational Coordination	Archival Coordination
Timescale: 1+ Years	Timescale: Hours-Months	Timescale: Seconds-Hours	Timescale: Permanent
- Establish & sustain a TDAMM Call for Proposals - Engage PhysPAG/SIG/SAGs to identify and validate science cases and follow-up observation needs. - Establish & sustain a common architecture for coordinated space-based follow-up operations. - Advise new missions about TDAMM Astrophysics Enterprise interfaces and best practices. - Support Senior Review Board, Decadal and other strategic planning activities.	- Survey the existing coordination fora and agreements among missions. - Survey the set of tools used by General Observers to construct TOO requests and to predict observing parameters. - Investigate tactical mission science planning processes. - Develop and document the information flows, activities, and interfaces needed to improve tactical multi-mission coordination.	- Investigate and document the information flows, activities, and interfaces between astrophysical alert systems (e.g., GCN) and individual mission Flight, Science and Mission Operations Centers. - Identify science and mission state, status, and constraint parameters that would be needed for tactical multi-mission coordination.	- Investigate whether current archives allow sufficient metadata tagging and discovery of datasets associated with a TDAMM science proposal. - Assess whether spatial and temporal search parameters and visualizations are adequate for TDAMM archival research.

General Coordinates Network (GCN)

Modernizing NASA's transient alert broker - serving the astronomical community since 1992

GCN serves as TDAMM infrastructure distributing transient alerts to the astronomical community from space-based missions (NASA, non-NASA) and ground-based observatories including the gravitational wave network and neutrino observatories.



New Web Portal: <https://gcn.nasa.gov>

GCN Notices – machine readable alert messages with fixed schema

- Now streaming via Kafka data streaming protocol
- Self-managed subscriptions to receive alerts via email
- Beginning to onboard new notice types in new system

GCN Circulars – human-written observation reports

- Complete overhaul of backend and frontend coming soon
- Self-managed subscriptions
- New submitters approved via peer endorsement
- Web form for submitting
- New searchable archive

The new GCN

- Operates in the cloud with high reliability and uptime
- Is open source on <https://github.com/nasa-gcn>
- Has many enhancements and new features in development

Multi-messenger Astrophysics Community Tools and Support

- **Objectives:** 1) develop standard software toolkits for gamma-ray missions, 2) develop multi-mission subthreshold search tools, and 3) modernize interplanetary network localization
- **Progress:** Plan for software release established
- Plan for unit testing and documentation is based on predecessor software development
- Standard software toolkit development
 - Expand the GBM data tools for us with other gamma-ray missions with release of new Gamma-ray Data Tools
 - Initial release only supports GBM. More missions soon.
- Subthreshold search – Generalization for public release underway
- IPN modernization – engaged with the GTN SAG to determine community priorities & development underway
- TDAMM application – these tools will serve many smallsat/cubesat teams and broaden the access to their results for the community, increasing the number of potential joint gamma-ray/gravitational wave events

International & Interagency

- Splinter meeting involving 9 space agency leads held last August
- 2nd splinter held last week welcoming 2 more space agencies + NSF (Phys & Ast)
- Discussion on possibilities for collaboration quickly homed in on the need for coordination, standards, data access, other infrastructure issues.
 - We agreed that further discussion on these issues was desirable
 - One or more working groups to be established to advance in these areas

Community

- PhysCOS sponsored 2022 TDAMM workshop in Annapolis MD
 - TDAMM White Paper produced by Scientific Organizing Committee of Annapolis meeting and workshop participants, and presented at scientific meetings:
- Physics of the Cosmos Program Analysis Group (PhysPAG):
 - New Science Interest Group (SIG) on TDAMM being spun up – HEAD splinter session 3/26/23 - cross-PAG interest
 - New Science Analysis Groups (SAGS) on 2 TDAMM-related issues:
 - The future of Gamma-Ray Transient Networks – kickoff January 2023:
 - TDAMM Science Drivers for next-generation (post-TDRSS) Space Communications (presented here).





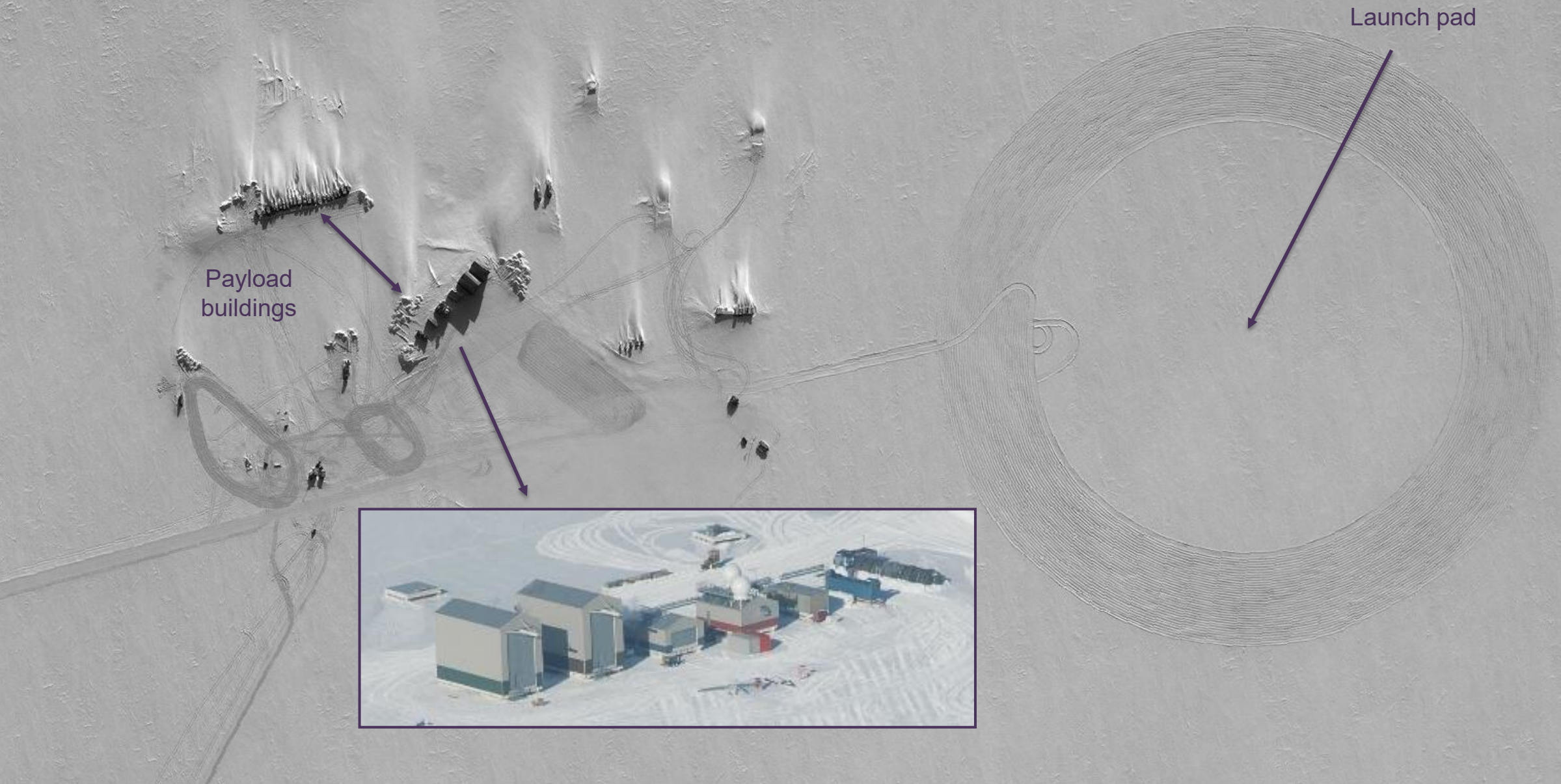
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IDEA Update

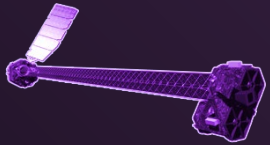


LDB Camp near William's Field (McMurdo Station, Antarctica)



Operating Missions

- Nuclear Spectroscopic Telescope Array (NuSTAR)
 - In its 11th year since launch, NuSTAR continues to study the universe in high energy X-rays to better understand the dynamics of black holes, exploding stars and the most extreme active galaxies.
- Neil Gehrels Swift Observatory (Swift)
 - Community interest for Swift science remains strong as it was demonstrated by the number of proposals for cycle 20 (178, which is 20% increase compared to cycle 19 and 2022).
 - The Swift BAT XRT and UVOT instruments are nominal, and the spacecraft is operating with 5 reaction wheels. The battery is performing nominally and the rest of the S/C is operational.
- Fermi Gamma-ray Space Telescope (Fermi)
 - Fermi continues to deal with risk conjunction with constellation satellites
 - Fermi enabled accurate measurement of a Neutron star mass from "spider" millisecond binary using "gamma-ray eclipse" method.
 - Fermi 3rd LAT Pulsar catalog (more 150 objects) has been published providing key baseline for future Gravitational Wave detection using Pulsar Timing technique.



Balloon Launches

- The balloon engineering test flight was successfully flown on Aug. 19 for ~5 hours.
 - Payload included a range of engineering, student and science areas.
- The GRAPE (Gamma-Ray Polarimetry Experiment) balloon payload was successfully flown on Aug. 27 for ~5 hours.
 - Additional payload included:
 - ComPair (Compton Pair Telescope) prototype astrophysics gamma-ray telescope
 - IRCSP (Infrared Channeled Spectro-Polarimeter) Earth observation payload
- The High-Altitude Student Platform (HASP) balloon mission was successfully flown on Sept. 7 for ~13 hours.
 - Payload included six student experiments.



The GRAPE (McConnell/Univ. New Hampshire) astrophysics balloon after launch in Albuquerque, NM

ATHENA

Advanced Telescope for High Energy Astrophysics

ESA and NASA Partnership

- ATHENA will look deep into the X-ray Universe, studying the evolution of super-massive black holes and hot gas in and out of galaxies over the life of the Universe.

Status:

- Mission is being reformulated by ESA, whilst retaining flagship-level science. NASA has reiterated support for Athena and willingness to reprioritize its contributions.
- Rachel Osten (STScI) and Lía Corrales (U. Michigan) selected as the NASA representatives to the Athena Science Redefinition Team (SRDT). Andy Ptak (NASA Athena PS) selected as Mission Redefinition Team (MRT) point-of-contact.

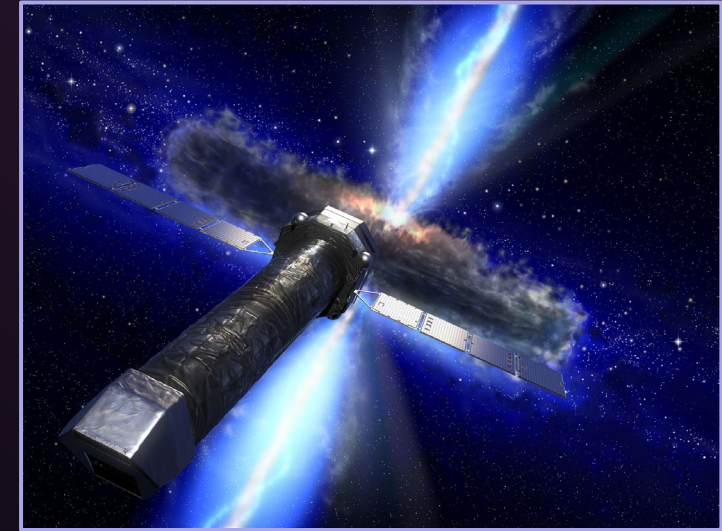
Current “NewAthena” mission concept

Effectively dependent on the US contribution of a 50K → 4K cryocooler to the X-IFU

Mission profile results in reductions to performance relative to original Athena, but retains a large X-ray mirror, the X-IFU calorimeter with at least 4 eV energy resolution, and the Wide-Field Imager (WFI)

Budget Impacts

- In light of deferred Adoption date ~ (2027) , FY24 contains significant slowdown to Athena.
- With planned switch to a cryocooler as a NASA contribution, the FY24PBR Athena budget withdraws support for the XRCF testing element.



Artist's concept of ATHENA.
Credit: ESA

ARIEL/CASE

Atmospheric Remote-sensing Infrared Exoplanet Large survey Contribution to ARIEL Spectroscopy of Exoplanets

ESA and NASA Partnership

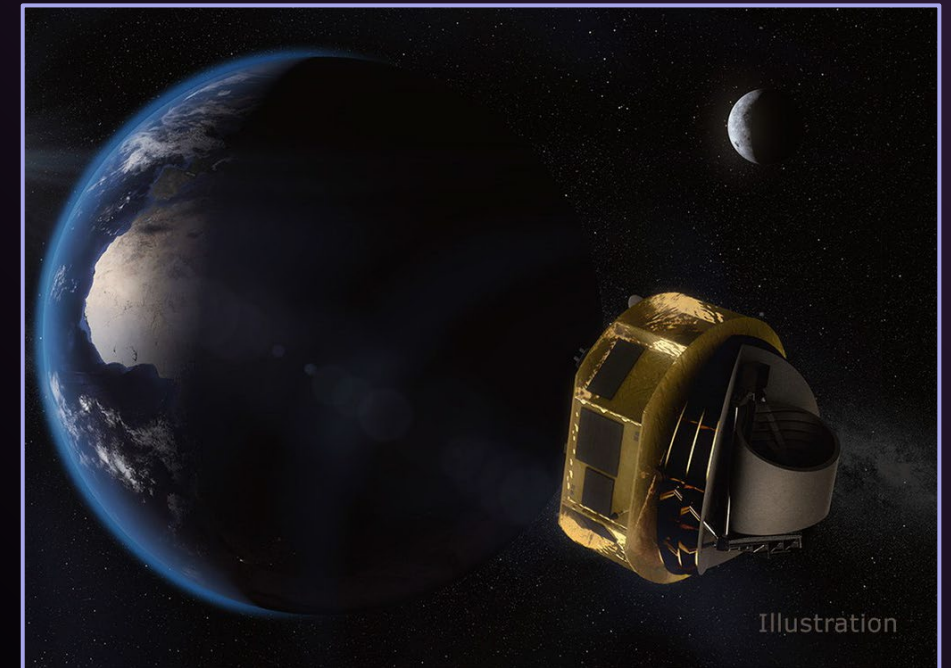
- ARIEL with the CASE, which provides the optical and near-infrared science capabilities and fine guidance sensors will survey and characterize the atmospheres of ~1000 exoplanets.

NASA Contributions:

- Detectors and cold front-end electronics
- Packaging
- Thermal Management
- Cryoflex cables for ARIEL Fine Guidance System
- Providing US participation in science team, mission survey design, and scientific discoveries

Status:

- Project has entered Phase C in February 2023



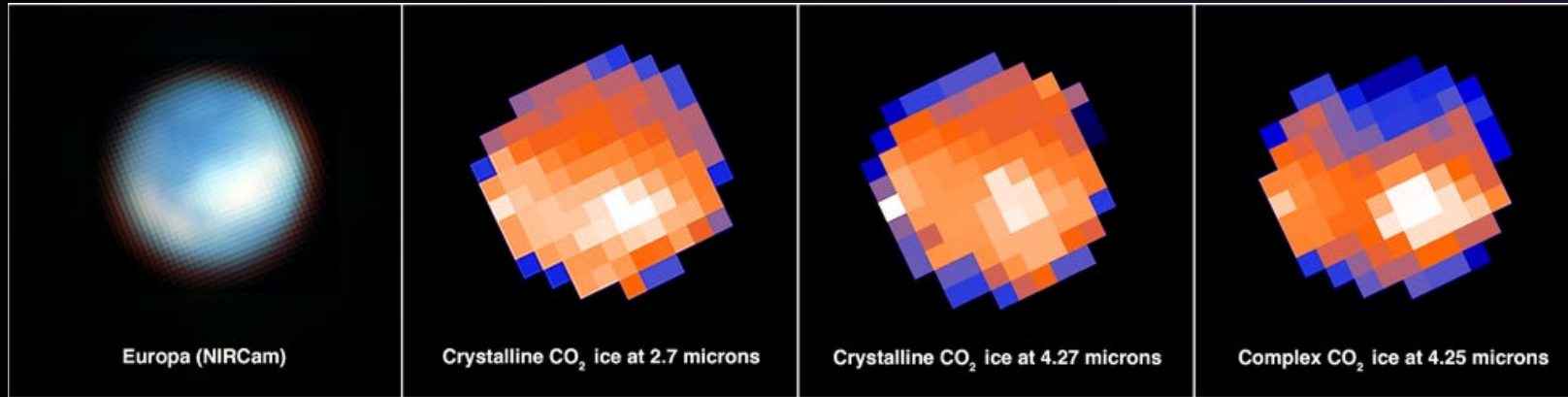
*An artist's concept showing ARIEL in orbit.
Credit: ESA/STFC RAL Space/UCL/Europlanet Science Office*

James Webb Space Telescope

MIRI Count Rate Loss

- In April 2023, the MIRI MRS team identified a drop in count rates at long wavelengths for flux standards, as well as in backgrounds counts.
 - Effect increases with wavelength; most severe in Channel 4C (~50% count rate loss)
 - Exponential decline, that appears to be stabilizing
- In July 2023, new imager data revealed that a similar issue is visible in our long wave imager filters
 - Effect is measurable in from F1280W onwards & increases with wavelength; F2550W shows a reduction of 18% in count rate
 - Temporal trend not very well constrained; additional observations are planned to address this.
- 3 public statements have been released via STScI (JWST Observer News) and NASA (Webb blog) with numbers, plots and advice for users.
- The root cause is under investigation, a time-dependent correction has been implemented in the calibration pipeline for MRS, additional standard star observations are being taken.

Webb Finds Carbon Source on Surface of Europa



*Credits: Science Credit: Geronimo Villanueva (NASA/GSFC), Samantha Trumbo (Cornell Univ.), NASA, ESA, CSA.
Image Processing Credit: Geronimo Villanueva (NASA/GSFC), Alyssa Pagan (STScI)*

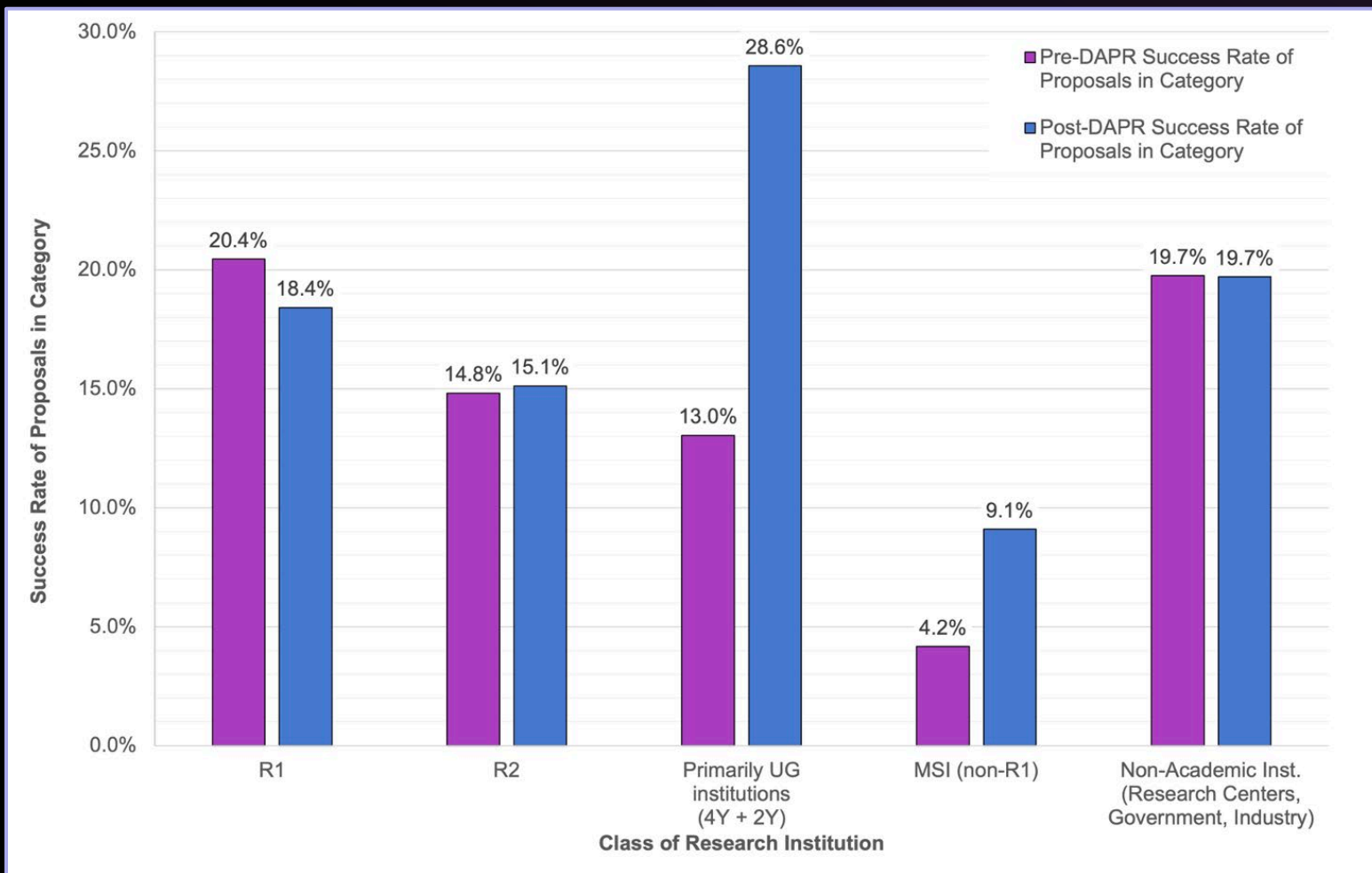
- Astronomers using data from JWST have identified carbon dioxide in a specific region on the icy surface of Europa.
- Analysis indicates that this carbon likely originated in the subsurface ocean and was not delivered by meteorites or other external sources. Moreover, it was deposited on a geologically recent timescale.
- This discovery has important implications for the potential habitability of Europa's ocean.



On-going & Planned IDEA Initiatives in APD

- Inclusion Plans in ROSES-22:
 - Piloting continues - APRA, LISA, SAT, TCAN, Roman, Precursor Science – lots of lessons being learned
 - IP assessment criteria are not part of evaluation criteria but if IP is inadequate, funding released only after IPs are judged to be adequate
- ROSES-23 has new standardized language and various programs across SMD will continue to pilot this effort (ATP, APRA, maybe SAT)
 - SMD plans another community workshop in late 2023 early 2024
 - Lessons learned and Inclusivity Best Practices Workshop being held with community members (UIUC and JPL-326 so far)
 - ROSES-23 APD panel mechanics/evaluations has changed to adequately respond to the community's feedback received after the six ROSES-22 solicitations.

New Data on Impact of Dual-Anonymous Peer Review (DAPR)



- The data comes from the ADAP, ATP, and XRP.
- Overall, selection rates pre- and post-DAPR are basically the same.
- Most of the differences shown may not be significant but the factor of two changes in selection rates for Primarily UG and non-R1 MSIs look to be.
- These changes are precisely one of the expected benefits of DAPR.

On-going & Planned IDEA Initiatives in APD

Continued

- [Statement of Principles by APD](#) developed and shared across NASA Astrophysics ecosystem
- Regular attendance at National Society of Black Physicists (NSBP) and Society for Advancement of Chicanos and Native Americans in Science (SACNAS) meetings
- Attendance to the 2024 Emerging Research Network/AAAS meeting to engage with HBCUs administrators/faculty about current and new opportunities
- Special sessions will be held at next AGU and AAS meetings to discuss Inclusion best practices and lessons learned
- Other previous APD pioneering efforts:
 - [Code of Conduct for review panels](#) developed by APD, now adopted SMD-wide!
 - Changes in language to Senior Review (SR) aligned with NASA's core value of Inclusion – our changes to SR adopted SMD-wide!
 - Changes to AO language



Statement of Principles



Code of Conduct



SMD Inclusion Plan Resource Page

Community Engagement

Astrophysics Division Efforts Past and On-Going

- We must ensure that people from all over our nation are aware and engaged
- NASA Astrophysics (APD) launched a virtual and in person (when possible) “road tour” to visit with historically excluded communities.
 - The first of these events was with universities and other NASA stakeholders in Puerto Rico on March 7th
 - Follow-up visit by APD technical officers expected in fall 2023 to build community engagement
 - Continuing engagement by APD technical officers and leadership expected in spring 2024 to encourage more proposals to APD programs from Puerto Rico
- Multiple Astrophysics team members are actively engaged at the Science Mission Directorate level in IDEA working groups including sub-group focused on Community Engagement and Inclusion.

HWO START Goals and Member Selection Process

- The START Goals: Quantify all Astro2020 HWO science goals; fill out the Science Traceability Matrix (short of requirements definition), and roadmap the research that will allow a Project to define requirements. START Co-chair capabilities required expertise in:
 - Leading diverse/inclusive teams
 - Leading community-facing initiatives
 - Demonstrated knowledge of mission studies
 - Experience in HWO-related science/engineering
 - Diversity of intellectual expertise and of demographic backgrounds.
- START Member capabilities required expertise in:
 - Demonstrated commitment to fostering diverse and inclusive teams
 - Commitment to community-facing activities
 - Capability to conduct analyses outside team meetings (if applicable)
 - Capable to serve as a mentor (if applicable)
 - Expertise in HWO-related science/engineering/technology
 - Achieve “team balance” to ensure coverage of institution types and knowledge base
 - Self-identified diversity of team members or their suggested means to diversify input to the START was considered