NASA Astrophysics Update

APAC Meeting | March 15, 2021

Paul Hertz
Director, Astrophysics Division
Science Mission Directorate
@NASAUniverse @NASAExoplanets

Highlights of 2020+

https://www.nasa.gov/content/hubbles-30th-anniversary

After 16.5 yrs of science exploration on the infrared cosmic frontier as one of NASA's Great Observatories, Spitzer ended its mission on Jan 30, 2020, 2:30 PST.

Engineering feats extended mission life post-cryo in 2009 and overcame challenges due to Spitzer's increasing distance from Earth.

Spitzer Space Telescope

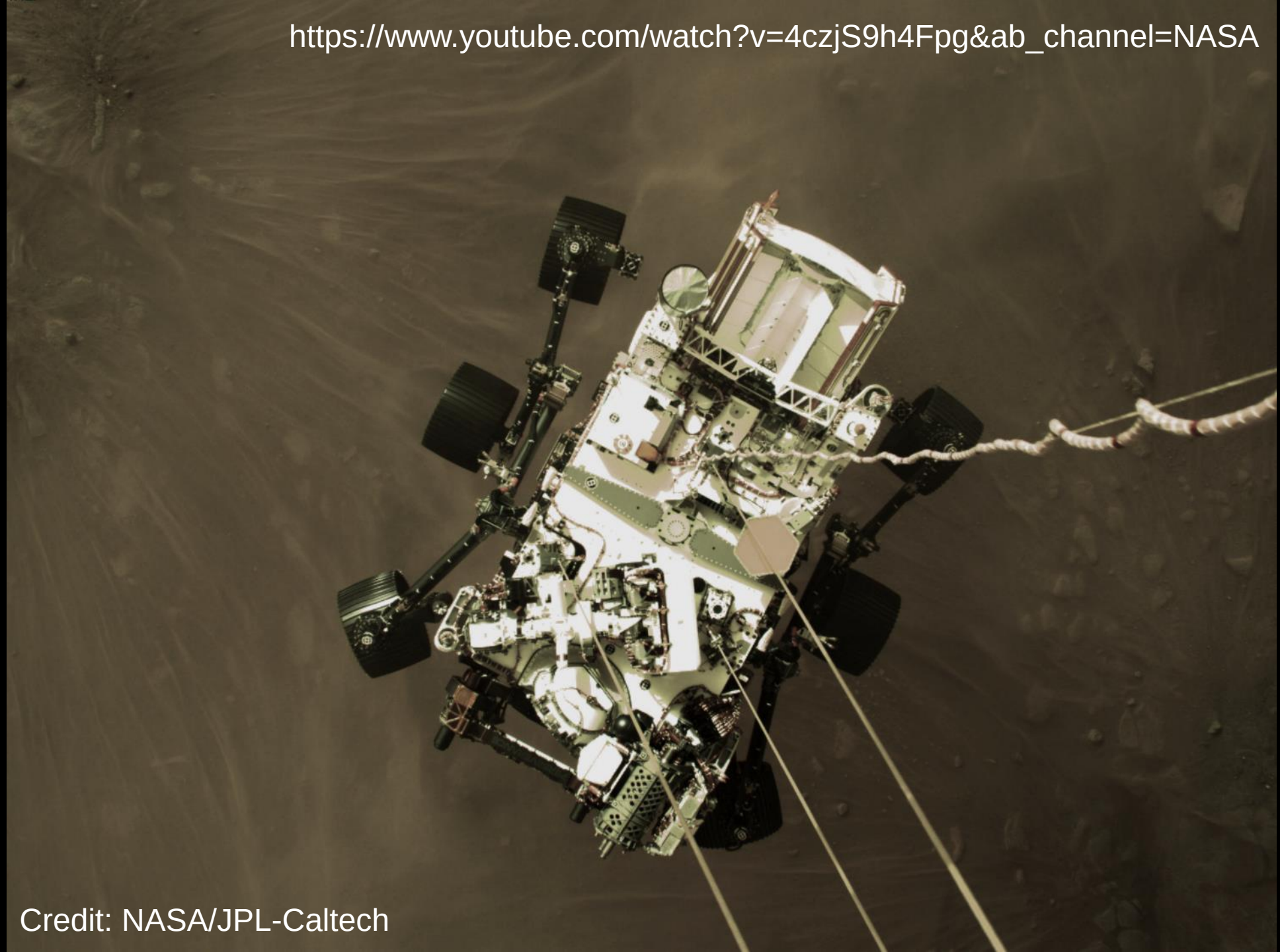
Spitzer enabled discovery near and far, to the edge of the universe, yielding 8,800+ refereed papers.

- First detection of light from an exoplanet
- First detection of molecules in exoplanet atmospheres
- Measurement of star formation history of the Universe to z>2, looking back >10 Gyr
- Measurement of the stellar mass of the Universe to z>8, looking back ~13 Gyr

www.spitzer.caltech.edu/final-voyage

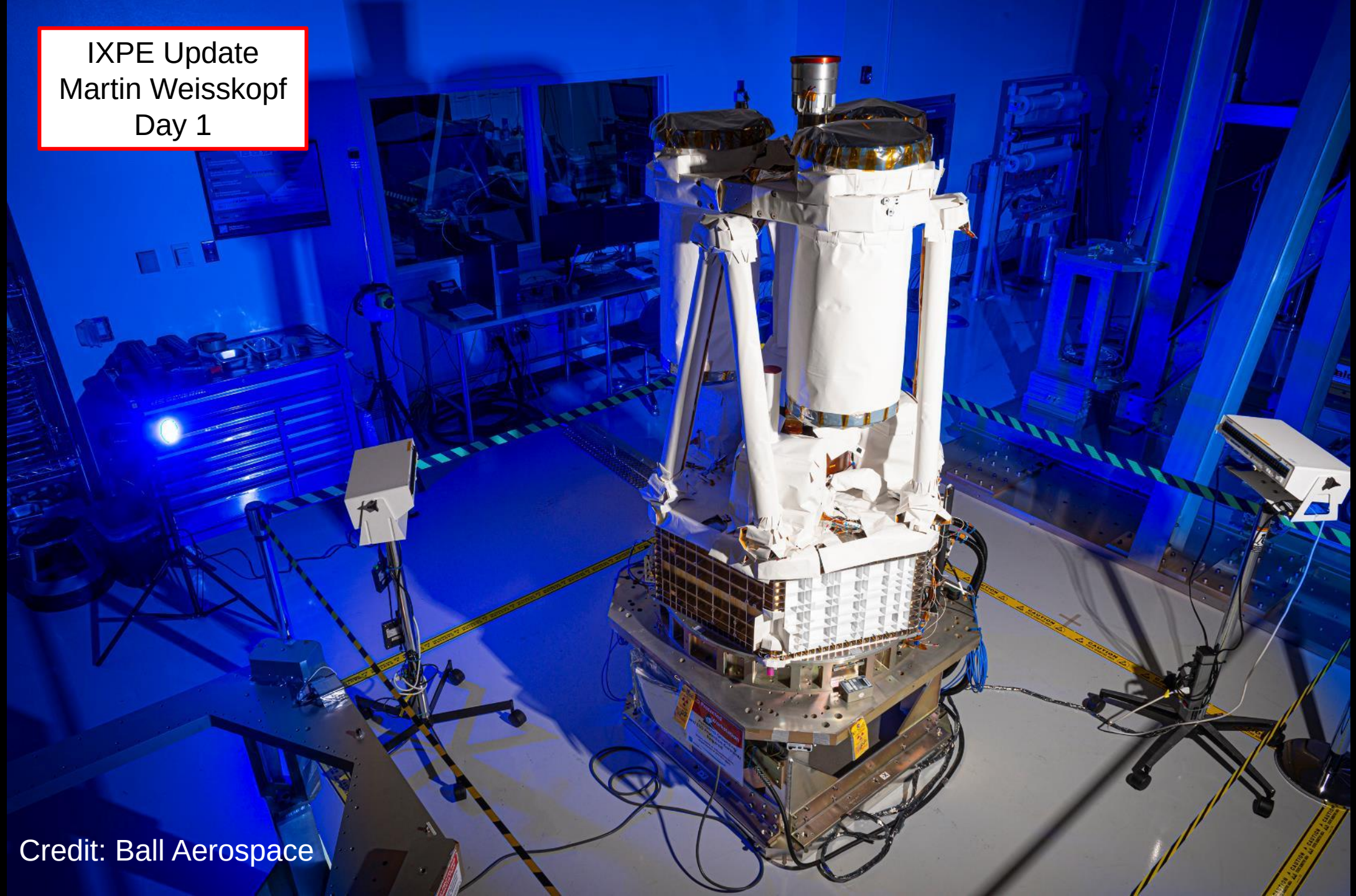
NASA's Mars 2020 Perseverance rover launched on the Atlas V-541 rocket from Launch Complex 41 at Cape Canaveral Air Force Station, Florida on July 30, 2020, at 7:50 a.m. ET. Perseverance (and the Ingenuity Mars helicopter tech demo) will land on Mars on February 18, 2021, around 3:30 pm ET.

https://www.youtube.com/watch?v=4czjS9h4Fpg&ab_channel=NASA



Credit: NASA/JPL-Caltech

A SpaceX Falcon 9 rocket carrying the company's Crew Dragon spacecraft is launched on NASA's SpaceX Crew-1 mission to the International Space Station with NASA astronauts onboard, Sunday, Nov. 15, 2020, at NASA's Kennedy Space Center in Florida. Credits: NASA/Joel Kowsky


IXPE Update
Martin Weisskopf
Day 1
Credit: Ball Aerospace

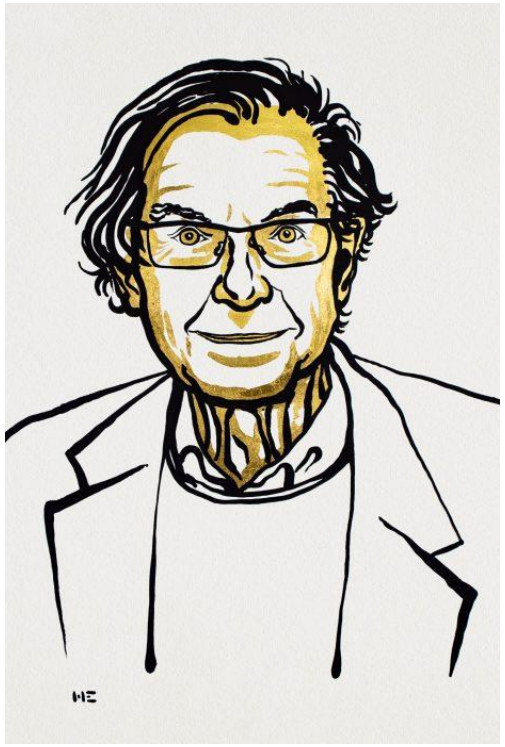
2020 Nobel Prize in Physics

2020 Black Holes (Penrose, Reinhard, & Ghez)

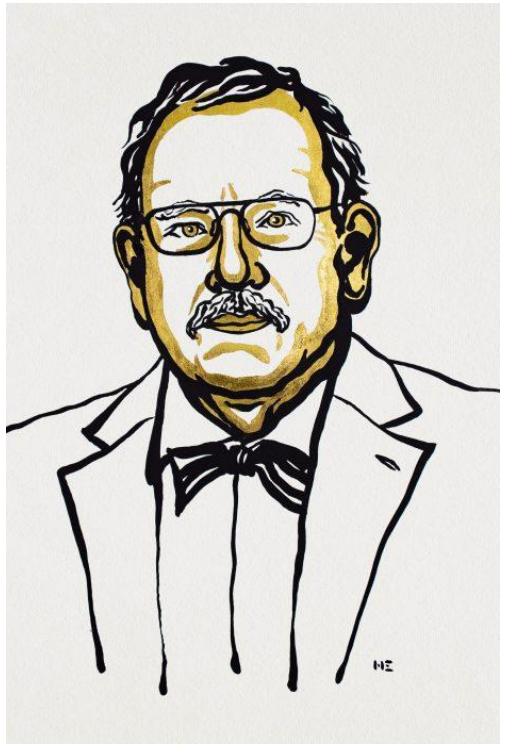
2019 Our Place in the Universe (Peebles, Mayor, & Queloz)

2017 Gravitational Waves (Weiss, Barish, & Thorne)

2011 Dark Energy (Perlmutter, Schmidt, & Riess)



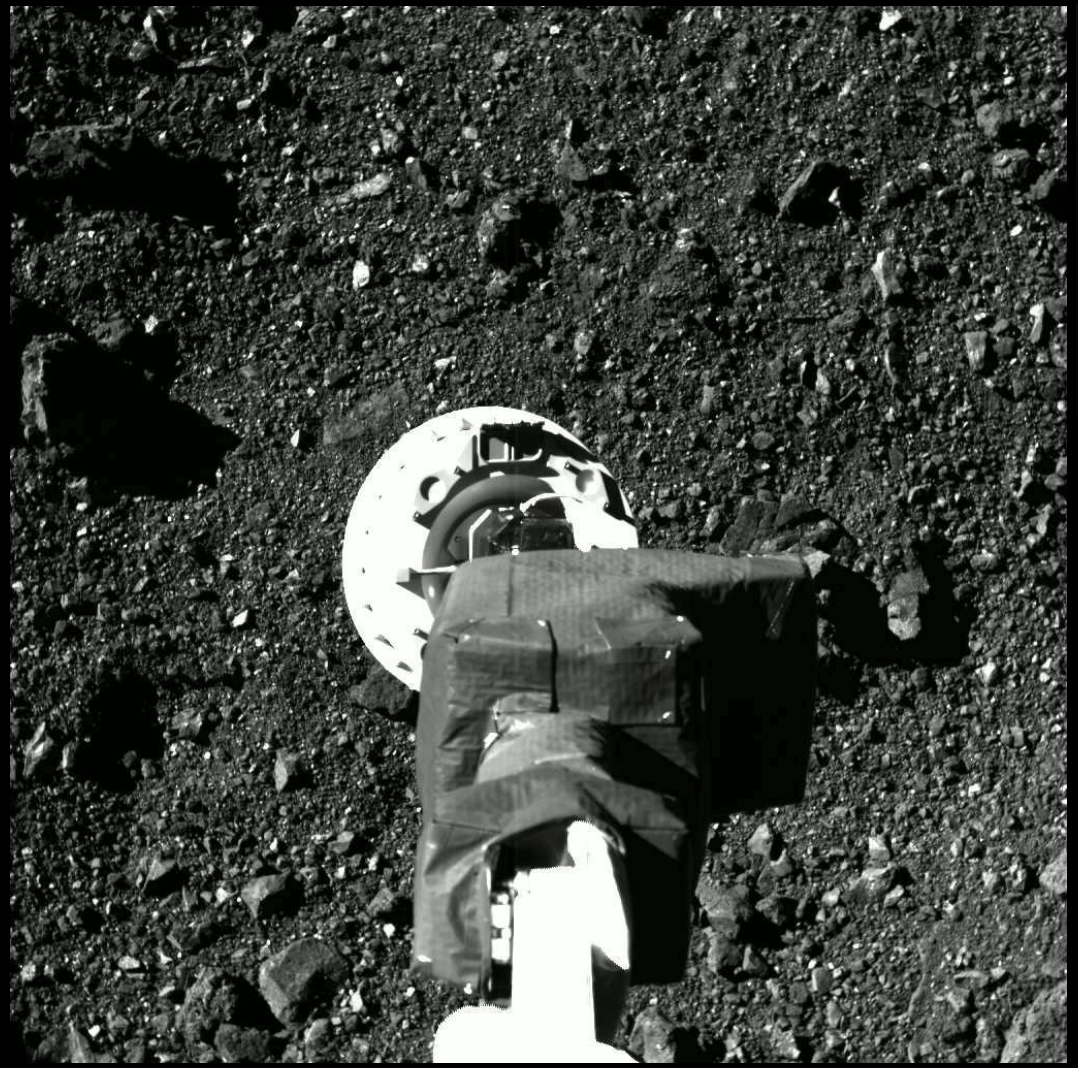
Roger Penrose
“for the discovery that black hole formation is a robust prediction of the general theory of relativity”



Reinhard Genzel
"for the discovery of a supermassive compact object at the centre of our galaxy"

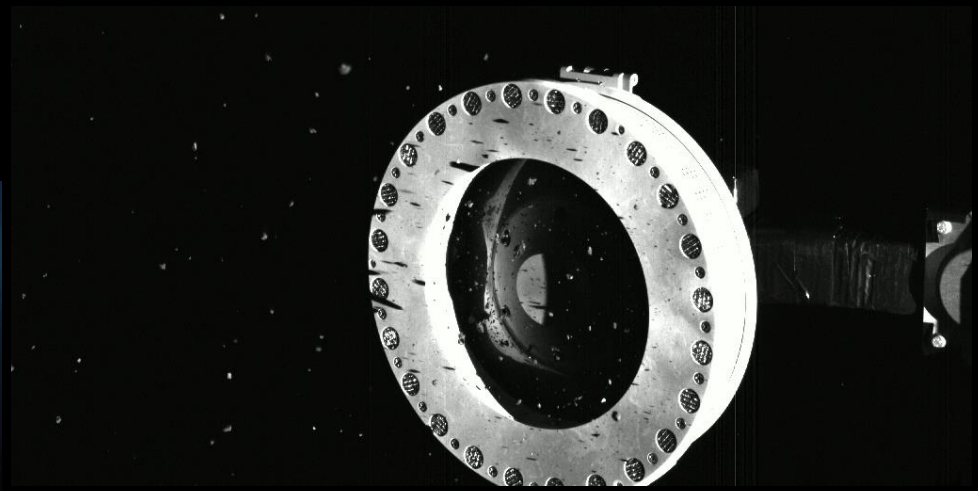
Andrea Ghez
"for the discovery of a supermassive compact object at the centre of our galaxy"

OSIRIS-REx

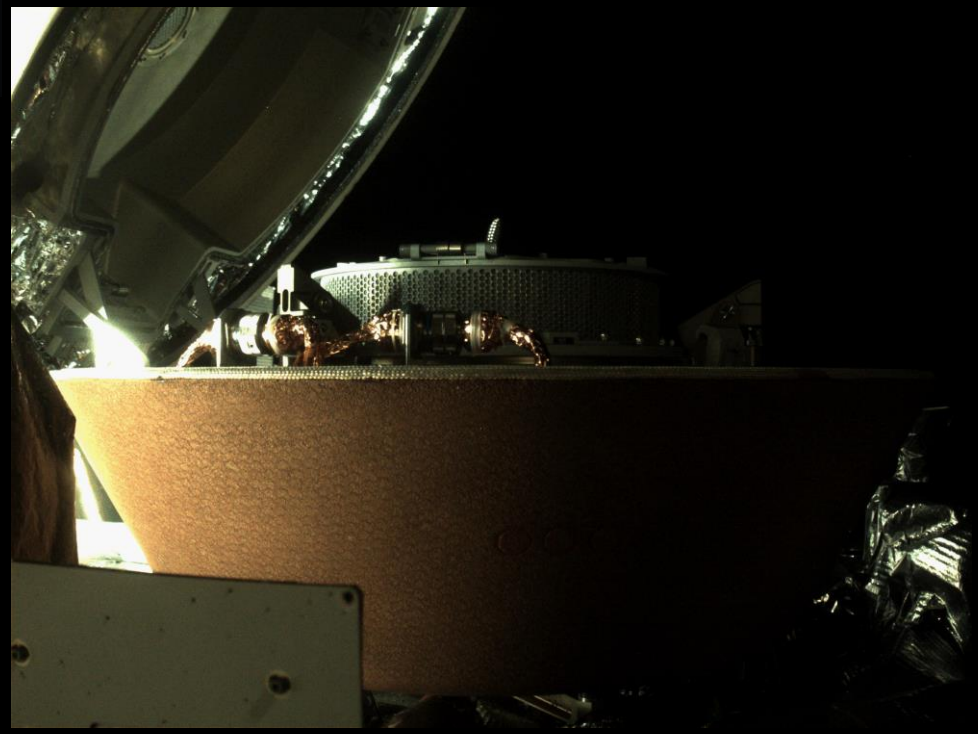


Touch-and-Go ('TAG') at Nightingale Crater Oct 20

Touch-and-Go Sample Acquisition Mechanism (TAGSAM) Oct 22



Sample stowed in Sample Return Capsule Oct 28



<u>OSIRIS-REx Future</u>
Apr 7, 2021 Close flyby
May 10, 2021 Depart Bennu
Sep 24, 2023 Earth return

The fully assembled and folded James Webb Space Telescope on the vibration table at Northrop Grumman Space Park (September 2020). This is the configuration that Webb will be in when it is mated to the Ariane 5 launch vehicle in 2021.

Webb Update
Eric Smith &
Neill Reid
Day 2

The final deployment of Webb's sunshield on Earth (Northrop Grumman Space Park, December 2020). Webb will undergo folding and stowing before shipment and mating to the Ariane 5 in 2021.

Webb Update
Eric Smith &
Neill Reid
Day 2

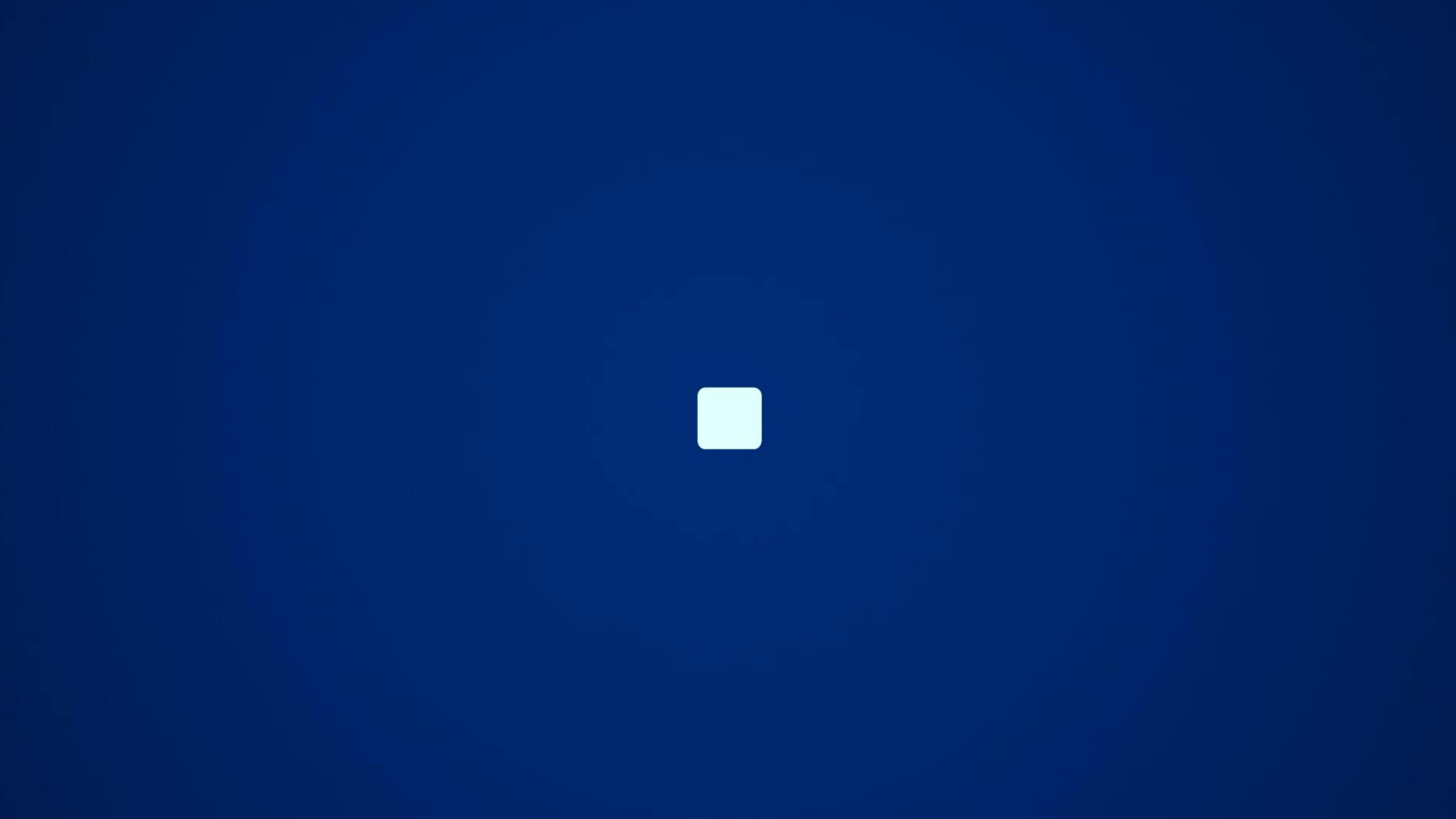
Nancy Grace Roman Space Telescope

Roman Update
Dominic Benford & Julie McEnery
Day 2

SCIENCE HIGHLIGHT

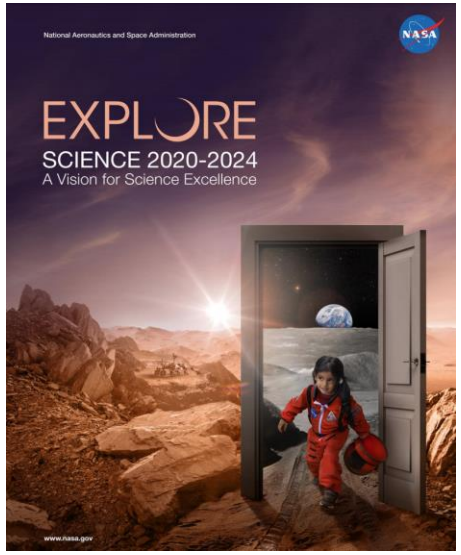
February 28, 2020 – NASA confirmed the Wide Field Infrared Survey telescope (WFIRST) for development

May 20, 2020 – NASA named its Wide Field Infrared Survey Telescope (WFIRST), in honor of Nancy Grace Roman, NASA's first chief astronomer, who paved the way for space telescopes focused on the broader universe



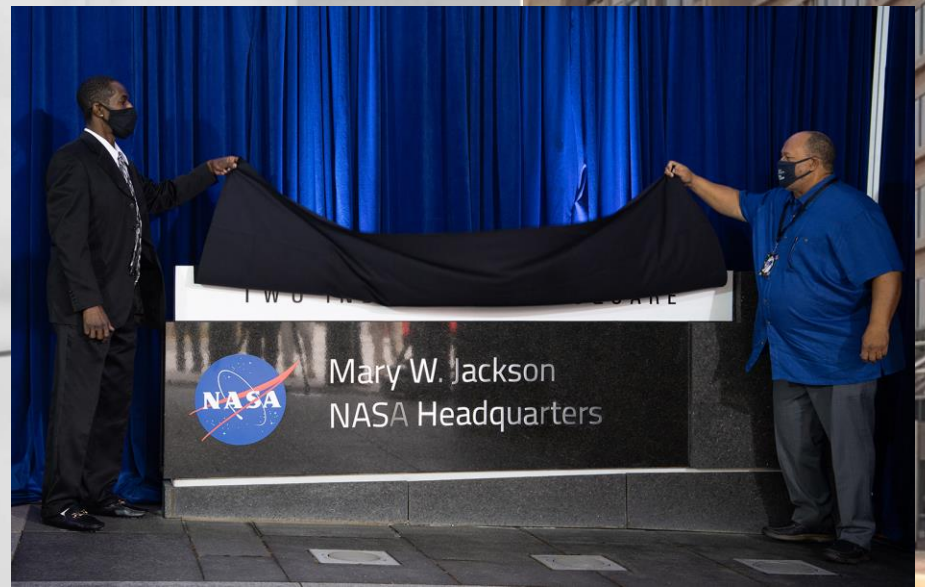
Improving Inclusion at NASA

Inclusion – NASA is committed to a culture of diversity, inclusion, and equity, where all employees feel welcome, respected, and engaged. To achieve the greatest mission success, NASA embraces hiring, developing, and growing a diverse and inclusive workforce in a positive and safe work environment where individuals can be authentic. This value will enable NASA to attract the best talent, grow the capabilities of the entire workforce, and empower everyone to fully contribute.



Strategy 4.1: Increase the diversity of thought and backgrounds represented across the entire SMD portfolio through a more inclusive and accessible environment.

ROSES: SMD's goals are to develop a workforce and scientific community that reflects the diversity of the country and to instill a culture of inclusion across its entire portfolio.


Mary W. Jackson
NASA Headquarters

Building Excellent NASA Teams Requires Inclusion and Diversity

- At NASA, we recognize that excellence is only achieved with inclusive and diverse teams. We are creating a multi-pronged approach.

SMD Initiatives
Kartik Sheth
Day 3

Directorate level: Standing up a long-term activity focused on sustained engagement, systemic, and lasting changes. Hosting incubator workshops and implementing actions from those workshops focused on short-term changes to how we are operating and how we grow our leaders. Studying barriers to inclusion in mission leadership. Adopting a Code of Conduct to improve the inclusion and process of our panels and teams.

APD Initiatives
Evan Scannapieco
Day 3

Division level: Division task forces working to align division-level practices with the NASA core value and SMD science strategy. Examining the R&A process for better inclusion and diversity. Piloting inclusion plans as an evaluation criterion for R&A programs. Workshop to increase interactions with Minority Serving Institutions.

- Proposal Processes: Recognizing we have influence through our calls for proposals and what we reward in our selections. Piloting dual-anonymous peer review and seeking to expand that. Actively looking into how we can be a model for inclusivity.

Join the Astrophysics Team at NASA HQ

The Astrophysics Division within NASA's Science Mission Directorate (SMD) anticipates one or more openings this spring for a scientist to serve as a civil servant Program Scientist at Headquarters in Washington, DC. The Program Scientist will work as part of a diverse and agile team whose core values include excellence, integrity, transparency, teamwork and a growth mindset toward stewarding the nation's space-based astrophysics program.

NASA Program Scientists

- Solve problems in implementing a balanced program across the breadth of astrophysics;
- Orchestrate peer reviews in all areas of astrophysics research;
- Collaboratively define a long-term vision for the program;
- Communicate, engage, and build consensus with multiple stakeholders; and
- Manage multiple responsibilities using effective management and organizational skills.

https://jobregister.aas.org/ad/21dc4e8f

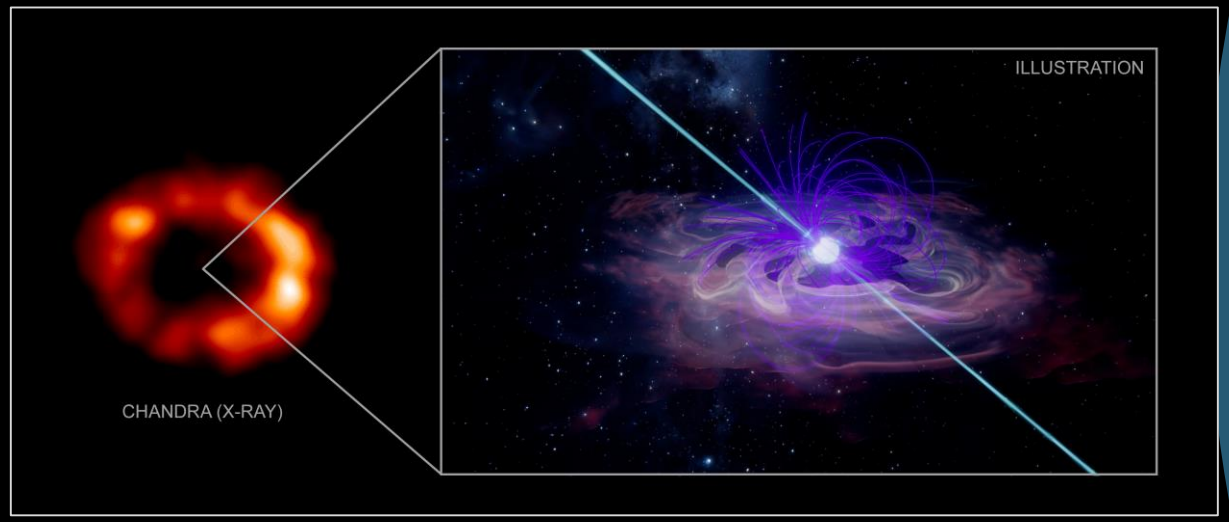
https://science.nasa.gov/about-us/job-opportunities

This will be a Direct Hire Authority (DHA) announcement through https://www.USAJOBS.gov/, so it will only be open for 3 workdays.

APAC Recommendations from October 2020 Meeting

Reclusive Neutron Star May Have Been Found in Famous Supernova

Released: February 23, 2021



Credit: NASA's Goddard Space Flight Center

Caption: The panel on the left contains a 3D computer simulation, based on Chandra data, of the supernova debris from SN 1987A crashing into a surrounding ring of material. The artist's illustration (right panel) depicts a pulsar wind nebula, a web of particles and energy blown away from a pulsar, which is a rotating, highly magnetized neutron star.

E. Greco et al., https://arxiv.org/abs/2101.09029

SCIENCE HIGHLIGHT

- Since astronomers captured the bright explosion of a star on February 24, 1987 in the Large Magellanic Cloud, a small companion galaxy to our own Milky Way, researchers have been searching for the squashed stellar core that should have been left behind.
- A group of astronomers may have finally found it using data from NASA space missions and ground-based telescopes. Data from Chandra and NuSTAR provide evidence for the existence of a structure known as a "pulsar wind nebula" at the center of the Supernova 1987A.
    - A pulsar wind nebula is a cloud of charged particles and magnetic fields created by a rapidly spinning neutron star.
- With Chandra and NuSTAR, the team found relatively low-energy X-rays from the supernova debris crashing into surrounding material. The team also found evidence of high-energy particles, using NuSTAR's ability to detect higher-energy X-rays.
- The Chandra and NuSTAR data also support a 2020 result from ALMA that provided possible evidence for the structure of a pulsar wind nebula in the millimeter wavelength band.
- The stellar debris surrounding the pulsar plays an important role by heavily absorbing its lower energy X-ray emission, making it undetectable at the present time.
- The model predicts that this material will disperse over the next few years, which will reduce its absorbing power. Thus, the pulsar emission is expected to emerge in about 10 years, revealing the existence of the neutron star.

APAC Recommendations

	APAC Recommendation	NASA Response
1	Black, Indigenous, and People of Color (BIPOC) representation must be explicitly and deliberately brought into positions of leadership and authority at the Astrophysics Division (APD), the Science Mission Directorate (SMD), and Centers supported within the portfolio.	All NASA personnel actions are taken with the principles of inclusion and diversity in mind.
2	The APAC advises NASA APD consider incentives to investigators to diversify their teams and provide meaningful diversity plans as part of major proposals to Programs.	As a pilot initiative, NASA APD will require Astrophysics Theory Program (ATP) proposals to include an inclusion plan (see separate slide).
3	The APAC requests a full briefing on the optional and voluntary demographic information of proposers to APD announcement of opportunities collected by the NASA Office of the Chief Scientist at its next meeting.	Presentation by Louis Barbier on Day 3
4	The APAC looks forward to a more detailed report on the impact of the Dual Anonymous Peer Review (DAPR) process in Research Opportunities in Space and Earth Sciences (ROSES) on early career scientists, first-time proposers, first-time institutions, and any other community or demographic type information that can be legally gathered.	Presentation at a future meeting

ATP Inclusion Criterion Pilot Program

ROSES-21 will be amended to add the following change to the Astrophysics Theory Program (ATP)

All proposals should include an inclusion plan. This section will address:

- Plans for creating and sustaining a positive and inclusive working environment for those carrying out the proposed investigation, and
- Contributions the proposed investigation will make to the training and development of a diverse and inclusive scientific workforce.

The inclusion plan will be evaluated for adequacy and completeness. The evaluation of the inclusion plan includes the following factors:

- Does the inclusion plan adequately communicate the goal of a positive and inclusive working environment for the investigation team? Does the inclusion plan provide adequate processes for creating and sustaining a positive and inclusive working environment for the investigation team? Are these processes likely to be successful in achieving the goal.
- Does the inclusion plan adequately describe the contribution of the proposed investigation to the training and development of a diverse and inclusive workforce? Does the inclusion plan provide an adequate plan for achieving the identified contribution? Is the plan likely to be successful in realizing the identified contribution?

Feedback will be provided to the proposers as part of the panel review summaries. The feedback will not be folded into the adjectival ratings or selection recommendations in the current ROSES cycle, but may in future cycles. NASA plans to invite comments from proposers regarding this pilot process after they receive their review comments.

APAC Recommendations

	APAC Recommendation	NASA Response
5	The APAC advises APD to publicize broadly the DAPR process and the impact of DAPR results, and these items should be included in community briefings and Town Halls.	DAPR has been publicized at all SMD Community Town Halls and at all Astrophysics Town Halls
6	The APAC encourages all Program Analysis Groups (PAGs) to make their Executive Committees as diverse and inclusive as possible.	Concur
7	The APAC intends to again feature a status of the profession session as an agenda item at its next meeting.	Day 3 of this meeting (see below)
8	The APAC requests that APD and SMD undertake internal discussion to explore and understand what a stand-up of a Cultural Ethics/Protocol Office that includes BIPOC from inception might entail and report out at the next APAC status of the profession session.	This discussion has not taken place

PI Launchpad
Erika Hamden
Day 2

SMD Initiatives
Kartik Sheth
Day 3

APD Initiatives
Evan Scannapieco
Day 3

Demographic Data Collection
Louis Barbier
Day 3

APAC Recommendations

	APAC Recommendation	NASA Response
9	The APAC requests the Astrophysics Division assess and to report out potential impacts on its mission if workforce constraints [recent Administration policy directives that adversely impact segments of the NASA workforce, including foreign students and scientists associated with US academic institutions, research institutes, and NASA Centers] are mandated and maintained over an extended period into the future.	The Astrophysics Division does not have the expertise nor the capability to conduct such an assessment.
10	The APAC requests the Astrophysics Division report out the institutional demographics resulting from the latest round of SmallSat and Pioneers program selections.	Included in this presentation
11	The APAC strongly endorses the use of Dual Anonymous Peer Reviews (DAPR), as their effectiveness at mitigating bias without muddying the evaluation process has now been demonstrated for various types of proposal reviews. The APAC advises that the Astrophysics Theory program also be included in the DAPR without delay.	The Astrophysics Theory Program (ATP) will be conducted in 2021 using dual-anonymous peer review.

APAC Recommendations

	APAC Recommendation	NASA Response
12	The APAC requests that the Astrophysics Division continue to assess and present potential impacts due to COVID19 at a future APAC meeting.	Included in this presentation
13	The APAC also requests information from the Webb project to determine whether mid-cycle proposals would increase the science return from the mission.	Presentation by Eric Smith & Neill Reid on Day 2
14	The APAC recommends analyzing whether Cubesat calls could be made every two years, instead of on the current yearly cycle.	CubeSats are only one component of APD's annual APRA solicitation.
15	The APAC recommends an assessment and reporting whether investigators might benefit from NASA management of the spacecraft buss, drawing on a common inventory of high Technical Readiness Level (TRL) commercial busses.	See separate chart
16	The APAC requests updates on advances in aerostat technologies and other long-duration balloon projects that might enable general guest-observer science using large aperture telescopes with arcsecond pointing precisions across the electromagnetic spectrum.	Presentation by Thomas Hams on Day 1

NASA Management of Small Busses

Response provided by Florence Tan, Chair of SMD Small Spacecraft Working Group

- NASA managed spacecraft has been a frequent suggestion for CubeSats from the Astrophysics and Heliophysics community.
- One of NASA's goals is to have teams other than NASA be capable of developing spaceflight hardware and leading spaceflight missions.
- In certain circumstances, it may be advantageous to provide PIs with a NASA managed spacecraft.
  - In that case, the recommendation requires a non-trivial evaluation of status and trades to provide a comprehensive assessment. However, there really needs to be a sustained flow of SmallSat projects in order for NASA to be able to actively support these missions.
- Mandating this seems excessive as some teams are capable of providing this service themselves.
  - PIs can choose to team with NASA to provide and manage the spacecraft bus, as the WFF SSO and ESTO's INVEST program have been doing to great success.
  - External PIs are as good, and in some cases even better, than NASA at acquiring and managing a commercial spacecraft bus.
  - Inserting NASA into the loop between the payload and the spacecraft, when neither the payload or the spacecraft are being built by NASA, may be less efficient than the PI acquiring the bus and managing the spacecraft/payload build.

APAC Recommendations

	APAC Recommendation	NASA Response
17	The APAC recommends that the Astrophysics Division consider adding a formal process for proposing piggyback payloads, potentially across disciplines.	Presentation by Thomas Hams on Day 1
18	The APAC request a detailed presentation describing the Balloon Roadmap at its next meeting as appropriate.	Presentation by Carolyn Kierans on Day 1
19	The APAC recommends the Astrophysics Division commence dialogues within the Science Mission Directorate and the Agency at large to ensure best-practice planetary protection protocols are developed to enable beneficial, shared-use of the lunar environment.	SMD's Exploration Science Strategy and Integration Office (ESSIO) has led this effort. APAC may request a briefing at their next meeting should this be a prioritized topic.
20	The APAC recommends clearer communications with the community to alert them that laboratory astrophysics opportunities have been shifted to Exoplanet Research Program (XRP), while general exoplanet related hardware development remains within APRA.	Current ROSES-21 language does not shift laboratory astrophysics opportunities from APRA to XRP. Further clarifications are planned.
21	The APAC desires to continue discussion with Astrophysics Division management about programmatic balance across the Exoplanet Research Program (XRP) in light of the forthcoming Decadal Survey priorities.	Discussion at a future APAC meeting after receipt of the 2020 Decadal Survey

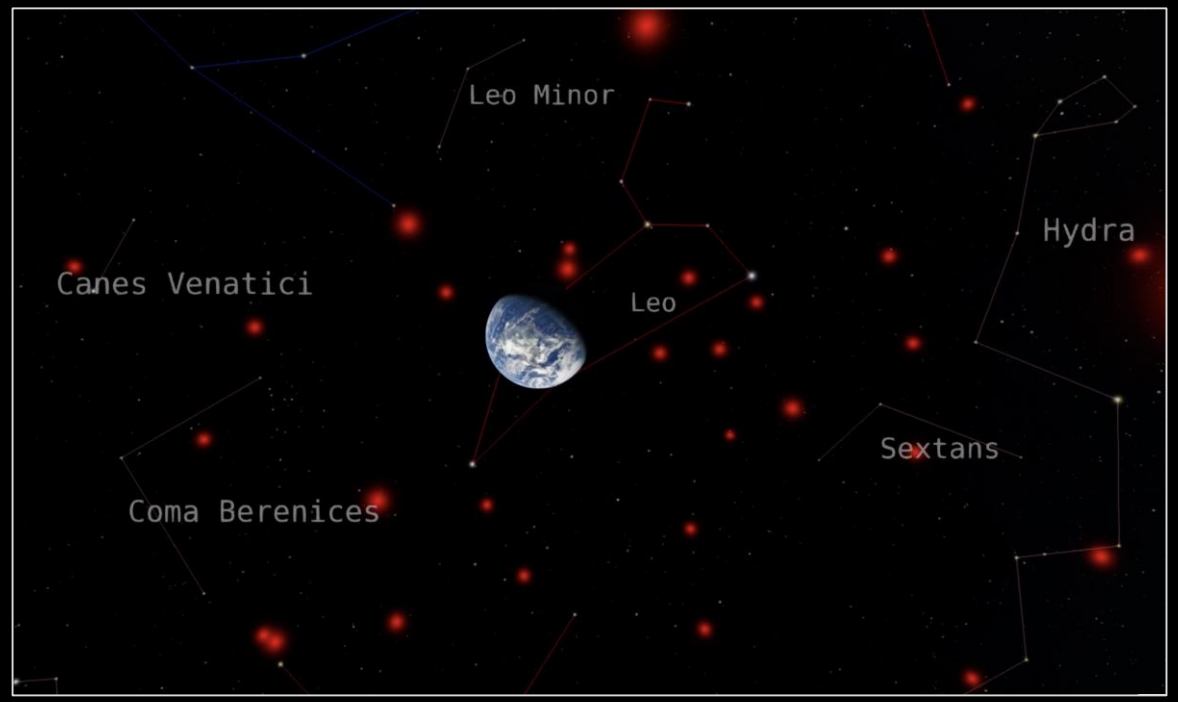
APAC Recommendations

	APAC Recommendation	NASA Response
22	The APAC recommends the PAGS continue their cross-PAG interactions, convening joint discussions at relevant professional meetings and convening cross-PAG SAGs as appropriate.	Report by PAG Executive Committee Chairs on Day 2
23	The APAC recommends the Astrophysics Division leverage cloud-computing services independently approved for NASA usage by other directorates to advance scientific computing needs of its investigators and Centers.	• APD made its archives aware of the February 2021 call for High End Computing users to propose for NASA cloud. • APD is working with our mission data archives to develop a plan for the Astrophysics Science Platform, assisted by a team from Booz Allen Hamilton. We anticipate leveraging NASA-negotiated access to cloud-computing services as an integral part of this Platform. • APD is developing a Science Information Policy that will align with the SMD policy and, among other things, speak to leveraging of NASA-approved cloud computing services. There will be a splinter session “The New NASA Science Mission Directorate Scientific Information Policy” at the 238th AAS meeting on Jun 9 from 12:00 noon to 1:30 pm EDT to discuss this policy and solicit community feedback.

Non-Mission Program Update

Citizen Scientists Help Create 3D Map of Cosmic Neighborhood

Released: January 13, 2021



Credit: NASA/Jacqueline Faherty (American Museum of Natural History)/OpenSpace

Caption: Citizen scientists and professional astronomers collaborated to find brown dwarfs in the neighborhood of our solar system. This image shows Earth surrounded by the nearest brown dwarfs, shown in red, against the backdrop of surrounding constellations.

SCIENCE HIGHLIGHT

- Is our solar system located in a typical Milky Way neighborhood? Scientists have gotten closer to answering this question, thanks to the NASA-funded Backyard Worlds: Planet 9 project, a “citizen science” collaboration between professional scientists and members of the public.
- Scientists tapped into the worldwide network of 150,000 volunteers to find new examples of brown dwarfs. These objects are balls of gas that are not heavy enough to be stars, since they can’t power themselves through nuclear fusion the way stars do. Telescopes can detect brown dwarfs because they emit heat, in the form of infrared light, left over from their formation.
- By making a complete map of these objects, scientists could find out whether different kinds of brown dwarfs are evenly distributed in our solar system’s neighborhood. The result of the new citizen science effort is the most complete map to date of L, T and Y dwarfs in the vicinity of the solar system. The map encompasses a radius of 65 light-years, or about 400 trillion miles, with “close neighbors” inhabiting space within about 35 light-years, or 200 trillion miles. These brown dwarf varieties can have temperatures of up to thousands of degrees Fahrenheit, but the Y dwarfs, which are the coolest, may have below-freezing temperatures and clouds made of water.
- Professional astronomers then used Spitzer to observe 361 local brown dwarfs of types L, T, and Y, and combined them with previous discoveries to make a 3D map of 525 brown dwarfs. Of the seven objects nearest to our solar system, three are rare types of brown dwarfs. The rest are normal stars: red dwarfs Proxima Centauri and Barnard’s Star, and Sun-like stars Alpha Centauri A and B.

2021 Astrophysics Research Program Elements

ROSES-21:

Supporting Research and Technology

- Astrophysics Theory Program (ATP), every other year
- Astrophysics Research & Analysis (APRA)
- Strategic Astrophys Tech (SAT) (dependent on Astro2020)
- Roman Technology Fellowships (RTF)

Data Analysis

- Astrophysics Data Analysis (ADAP)
- GO/GI programs for Fermi, Swift, NuSTAR, TESS, NICER

Mission Science and Instrumentation

- Astrophysics Pioneers (smallsat science investigations)
- Suborbital payloads solicited through APRA
- XRISM Guest Scientist New
- Roman Research and Support Opportunities New

Cross Divisional

- Exoplanets Research Program (XRP)
- Citizen Science Seed Funding Program New
- Topical Workshops, Symposia and Conferences (TWSC)
- Graduate Student Research Awards (FINESST)

Not in ROSES-21:

Separately Solicited

- GO/GI/Archive/Theory programs for Hubble, Chandra, SOFIA, Webb
- NASA Hubble Fellowship Program (NHFP)
- NASA Postdoctoral Program (NPP)
- Support for XMM-Newton U.S. PIs selected by ESA

Not Solicited this Year

- Theoretical and Computational Astrophysics Networks (TCAN), every three years
- Astrophysics Explorers U.S. PIs (APEX USPI), every two to three years

Red – evaluated using dual-anonymous peer reviews

R&A Update
Stefan Immler
Day 2

From Open Data to Open Science

All NASA mission science data are public

Publications funded by NASA, including peer review journal articles, are open access and freely available to the public

NASA has initiated an open science data initiative that is making targeted investments in cloud computing, open-source software, Artificial Intelligence/Machine Learning, and open data search and discovery services

- Includes two new ROSES calls targeted at supporting open-source tool development and the opening of legacy software

NASA is developing a policy to ensure that the results of its Federally funded scientific research and technology development are shared openly; this policy will cover:

- Information produced by NASA Science Missions
- Information produced by NASA research awards: includes, but not limited to, experiments, research on sub-orbital platforms, field campaigns, or citizen science projects
- NASA-funded publications, data, and software created in the pursuit of scientific knowledge

Draft will be released for public comment

SMD Data Policy
Steve Crawford
Day 1

Science Activation 2.0 – Astrophysics

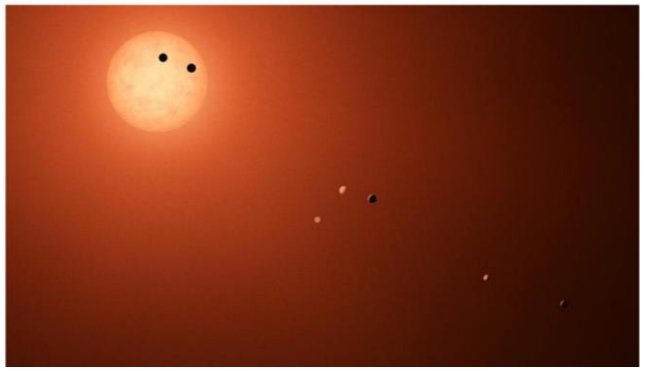
Cosmic Data Stories

PI: Alyssa Goodman; Science PI: Pat Udomprasert
Institution: Harvard University

NASA Community College Network

PI: Simon Steel
Institution: SETI Institute
https://www.seti.org/nasa-community-college-network

NASA's Universe of Learning



PI: Denise Smith
Institution: Space Telescope Science Institute
https://www.universe-of-learning.org/

NASA's Neurodiversity Network

PI: Lynn Cominsky
Institution: Sonoma State University
https://www.neurodiversitynetwork.net/

Airborne Astronomy Ambassadors

PI: Dana Backman (SETI Institute)
https://www.seti.org/aaa

NASA Hubble Fellowship Program

- Starting with the academic year 2022-2023, host institutions must offer their Hubble Fellows the opportunity to be employees
- The Program extended a waiver on host institution residency requirement to reduce the impact of COVID on current Fellows
- NASA Astrophysics is conducting an independent review of the Program this summer to look for ways to improve it
- Some current and former Hubble Fellows have self-organized and formed a working group to study diversity and inclusion
  - In collaboration with the Program Leads, the working group has collected demographic information on all current and former Fellows
  - The working group is presently developing recommendations for the independent program review
- 24 new Hubble Fellows have all confirmed acceptance.
  - 7 Sagan Fellows, 8 Einstein Fellows, and 9 Hubble Fellows
  - The majority of the new fellows are women
  - A number of the new fellows are members of historically underrepresented groups
  - A public announcement is planned for later this month

Virtual PI Launchpad

Another PI Launchpad is (finally) happening

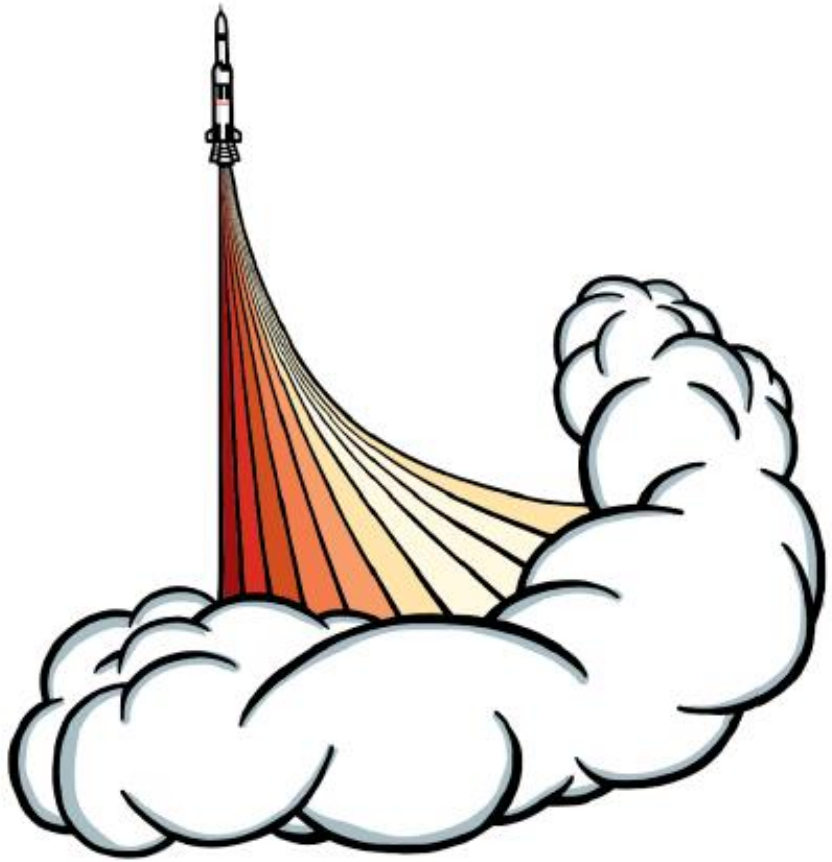
- Virtual sessions over 2 weeks: 1 week asynchronous content, 1 week interactive, ~2-3 hours per day

Key Dates:

- Application posted on NSPIRES in the next week- be on the lookout!
- Deadline for applications is March 22nd
- Notifications by May 3rd
- Launchpad will be From June 14th to Jun 25th

Content from 2019 workshop is online now!

- https://science.nasa.gov/researchers/pi-launchpad



PI Launchpad
Erika Hamden
Day 2

COVID-19 Impacts (R&A)

NASA is focused on continuing our research programs and providing stability

- Virtual review panels for ROSES solicitations and AO mission evaluations are going well
  - All peer reviews through December will be conducted virtually; virtual reviews have been held over the past year with no adverse effect on the quality of the reviews
  - NASA is thinking about continuing virtual review panels, at least in part, even after in-person meetings cease to pose a health hazard
- R&A management and supporting work at NASA HQ continues as normal via telework
  - R&A Program Officers have reached out to currently funded PIs and are working with them to protect the most vulnerable team members (early career, students, postdocs, non-tenured faculty)
  - No Astrophysics ROSES-20 solicitations were canceled, two solicitations had delayed due dates (TCAN, ADAP)
  - PIs are notified and funding is released to PIs just as fast as during previous years
- Since the start of the pandemic, ~15 Astrophysics R&A peer reviews have been conducted as virtual reviews
  - NuSTAR Cycle 6 and ADAP were our pilot programs for dual-anonymous peer reviews
  - Going forward, more R&A peer reviews will be dual-anonymous to help mitigate biases

COVID-19 Mitigations (R&A)

NASA does not want the pandemic to derail careers of future leaders; we are focused on mitigating impacts

Within current funding constraints, NASA will prioritize augmentations and funded extension requests for existing awards

- NASA issued a ROSES call for funded extensions (ROSES-20, Appendix E.10)
- This initiative must be funded from the current R&A Program; size of commitment is approximately 15% of funding available for new awards in FY21. There will be 15% fewer new awards in FY21
- Received ~170 COVID recovery funding extension requests for a total of ~$20M. Proposals are being reviewed.

Within current funding constraints, SMD will continue to support 124 NASA Postdoctoral Program (NPP) fellowships

- The March 2021 call is limited to applicants who already have permission to work in the US because of the inaccessibility of J-1 visas
- Since some slots will be used to extend current Fellows, SMD will supplement the funding for the NPP to maintain the pre-existing competitive level

Government-wide flexibility for paying salaries of researchers, even if they could not work because of COVID, expired on September 30. NASA has established a process to consider extending this flexibility to pay salaries on a case-by-case basis

https://science.nasa.gov/researchers/covid-and-awards

Mission Program Update

NASA Missions Unmask Magnetar Eruptions in Nearby Galaxies

Released: January 13, 2021

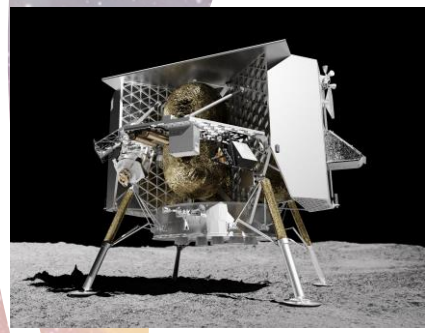
Credit: NASA's Goddard Space Flight Center/Chris Smith (USRA/GESTAR)

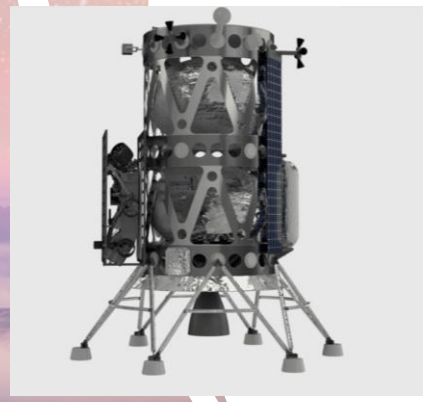
Caption: This artist's concept shows a magnetar with magnetic field (wispy lines) and a giant flare.

SCIENCE HIGHLIGHT

- On April 15, 2020, a brief burst of high-energy light swept through the solar system, triggering instruments on several NASA and European missions. Now, multiple international science teams conclude that the blast came from a magnetar located in a neighboring galaxy.
- This finding confirms long-held suspicions that some gamma-ray bursts (GRBs) – cosmic eruptions detected somewhere in the sky almost daily – are in fact powerful flares from magnetars relatively close to home. The April 15 event, GRB 200415A, is a game changer because, for the first time, the burst's estimated location is almost entirely within the disk of one galaxy – NGC 253, located 11.4 million light-years away. This is the most precise position yet established for a giant flare located well beyond our galaxy.
- Astronomers explain the observations of GRB 200415A with a sequence of events. A magnetar is a city-sized ball containing more mass than the Sun and boasting the strongest magnetic fields known.
  - A sudden reconfiguration of this field, possibly caused by a starquake, produced a quick, powerful pulse of X-rays and gamma rays.
  - The event also ejected a blob of matter, which followed the pulse and moved slightly slower, at about 99% the speed of light.
  - After a few days, they both reached the boundary, called a bow shock, where a steady outflow from the magnetar causes a pile-up of interstellar gas.
  - Light from the flare passed through, followed many seconds later by the fast-moving cloud of ejected particles. They interacted with gas at the bow shock, creating shock waves that accelerated particles and produced high-energy gamma rays.

Astrophysics and Artemis





Every opportunity for lunar science is open to astrophysics – if you have a great idea, propose it

Artemis enables astrophysics

- All science opportunities enabled by Project Artemis include astrophysics
- Most important criterion for proposals remains the astrophysics science merit

There are many opportunities to propose astrophysics that uses Artemis capabilities

- Lunar surface astrophysics experiments can be proposed to the PRISM program of small landed payloads (in ROSES)
  - PRISM 2021 due date has passed (Feb 23, 2021); several astrophysics proposals received
  - Two lunar surface astrophysics experiments have been selected and manifested for 2021:
    Low-frequency Radio Observations from the Near Side Lunar Surface Instrument (PI: R. MacDowall, GSFC)
    Next Generation Lunar Retroreflectors (PI: D. Currie, University of Maryland)
- Astrophysics Explorers Mission of Opportunity calls (including 2021 call for Explorers MO) allow proposals for cislunar smallsat missions
- APRA and Pioneers calls (in ROSES) allow proposals for cislunar cubesats and smallsats

Astro2020 Decadal Survey will identify any compelling astrophysics that is both a high priority and enabled by the capabilities being developed within the Artemis program

Interagency MOUs

In October 2020, NASA and DOE signed a Memorandum of Understanding (MOU)

- The memorandum of understanding highlights potential areas for collaboration
- NASA and DOE also established three working groups that focus on lunar surface infrastructure, space nuclear power and propulsion, and science and innovation
- https://www.nasa.gov/press-release/nasa-department-of-energy-expand-on-more-than-50-years-of-collaboration

In January 2021, NASA and NSF signed a Memorandum of Understanding (MOU)

- NASA and NSF will continue working together to advance NASA- and NSF-sponsored science programs in astrophysics, planetary science, astrobiology, quantum technology, heliophysics, and Earth science, with special emphasis on those activities that continue to make use of NSF-managed facilities, including those in the Antarctic
- NASA and NSF are united in their efforts to broaden participation in science and engineering
- https://www.nasa.gov/press-release/nasa-nsf-sign-agreement-to-advance-space-earth-biological-physical-sciences

Joint activities still require separate Implementing Arrangements (IAs)

Joint NASA-DOE RFI

On January 21, DOE Office of Science jointly with NASA Science Mission Directorate released a Request for Information (RFI) related to high energy physics and space-based astrophysics

- The RFI is to gather information from the community in three specific, focused areas aligned with the science goals of both of the Agencies including the scientific and technology benefits and obstacles, how to will make use of each agency's capabilities, infrastructure and resources, and other pertinent information.
- The information received will inform DOE and NASA regarding the potential development of mutually beneficial partnerships and collaborative activities.

Three focused areas:

- Sensitive radio telescopes or sensors in the radio quiet environment of the Moon's far side to explore the early eras of the universe or to test the standard cosmological model
- Space-based probes of fundamental physics in the microgravity environment of the International Space Station (ISS)
- Enhance or extend the science reach of the Rubin Observatory, the Roman Space Telescope, and the Euclid mission when considered together, including development of a common library of simulations and/or capabilities to enable joint processing and analysis

https://www.federalregister.gov/documents/2021/01/21/2021-01236/request-for-information-related-to-high-energy-physics-and-space-based-astrophysics

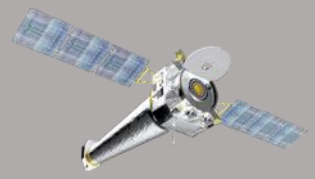
This RFI, which closed on March 8, is part of a wider DOE/NASA effort to investigate collaborative activities as part of the MOU signed in October 2020

Astrophysics Missions in Operations

Hubble 4/90
NASA Strategic Mission

Operations Nominal

Chandra 7/99
NASA Strategic Mission



Operations Nominal

XMM-Newton 12/99
ESA-led Mission

Operations Nominal (ESA)

Gehrels Swift 11/04
NASA MIDEX Mission

Operations Nominal

Fermi 6/08
NASA Strategic Mission

Operations Nominal

NuSTAR 6/12
NASA SMEX Mission

Operations Nominal

SOFIA 5/14
NASA Strategic Mission

SOFIA Update by Margaret Meixner & Naseem Rangwala on Day 1

Operations Nominal

ISS-NICER 6/17
NASA Explorers Miss. of Oppty

Operations Nominal

TESS 4/18
NASA MIDEX Mission

Operations Nominal

Balloon Program
Four Campaigns per Year

Balloon Program Update by Thomas Hams on Day 1

Operations Planned Spring 2021

Sounding Rockets
Worldwide Campaigns

Operations Nominal

Data Archives
HEASARC, IPAC, MAST, etc.

Operations Nominal

Hubble Space Telescope

Hubble ✓
@NASAHubble

At ~4:00 a.m. EST on Sunday, the Hubble Space Telescope went into safe mode due to an onboard software error. All science systems appear normal and Hubble is safe and stable. The team is working plans to safely return it to normal science operations.

8:28 PM · Mar 7, 2021 · Sprinklr

Hubble ✓
@NASAHubble

The Hubble Space Telescope has been moved into a pre-science state with a plan of returning to normal operations by tonight. The telescope entered safe mode on March 7 due to an onboard software error.

More information: go.nasa.gov/3ezEGPN

5:44 PM · Mar 11, 2021 · Sprinklr

Hubble ✓
@NASAHubble

At 8:00 p.m. EST Thursday, the Hubble Space Telescope returned to conducting science operations.

> **Hubble** ✓ @NASAHubble · Mar 11
> The Hubble Space Telescope has been moved into a pre-science state with a plan of returning to normal operations by tonight. The telescope entered safe mode on March 7 due to an onboard software error.
>
> More information: go.nasa.gov/3ezEGPN

8:40 PM · Mar 11, 2021 · Twitter Web App

More information: https://go.nasa.gov/3ezEGPN

Astrophysics Mission Classes

Updated January 28, 2021

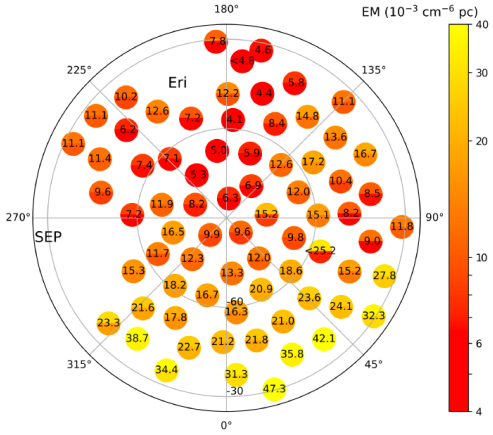
*PI Cost Cap **Includes ISS-attached Experiments

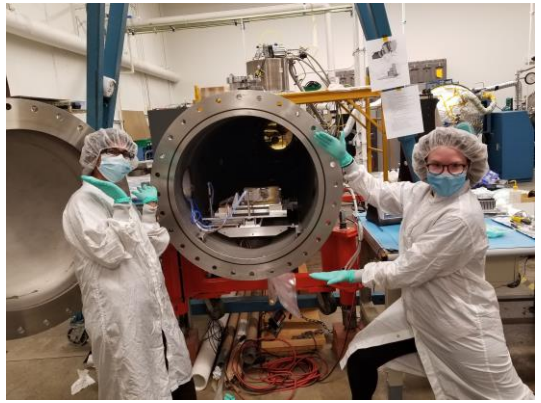
CUTE Update
Kevin France
Day 1

Astrophysics CubeSats

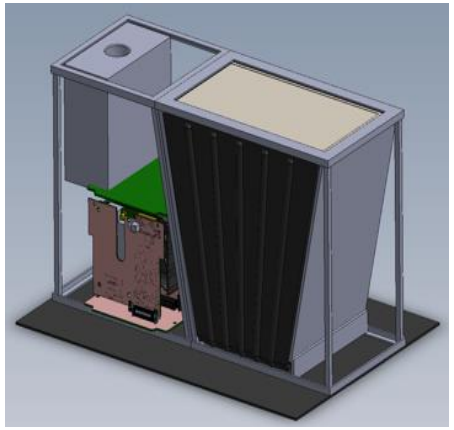
Solicited annually in ROSES/APRA, ~1 new start per year, ~<$5M each total cost

HaloSat: PI Phil Kaaret (U of Iowa), Launch May 2018, Reentered Jan 2021, OVII/OVIII lines in Galaxy halo, determine mass and structure of Galaxy halo

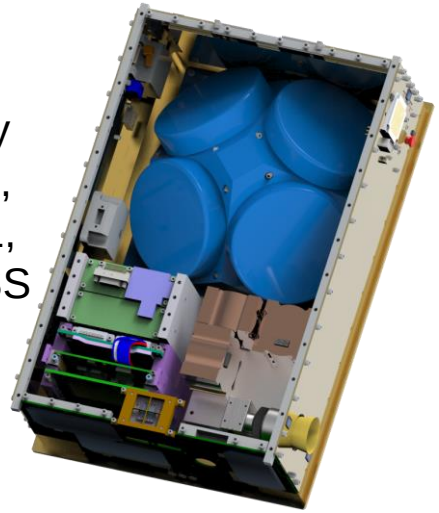




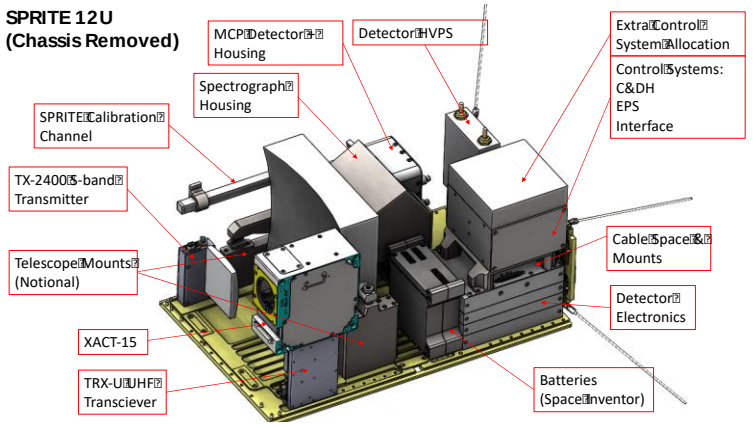
CUTE: PI Kevin France (CU), Launch Sep 2021, UV Imaging of hot Jupiter ablation, (Arika Egan & Ambily Suresh in lab)



BlackCat: PI Abe Falcone (Penn St U), Launch NET Mar 2024, 2-20 KeV wide FOV localization of X-ray transients, real-time 'cell phone' downlink



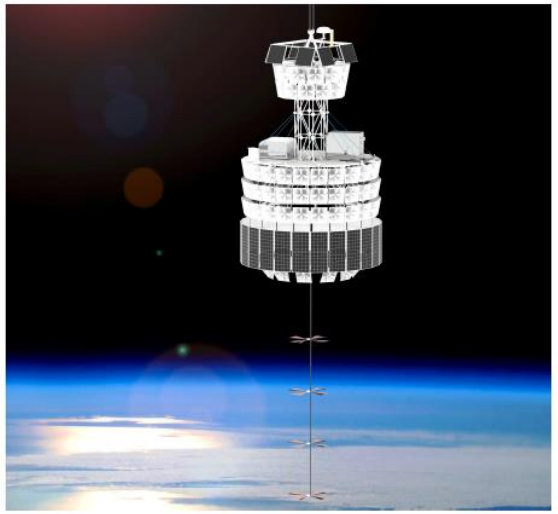
BurstCube: PI Jeremy Perkins (NASA GSFC), Launch NET Dec 2021, GRB monitor w/ TDRSS real-time event notification

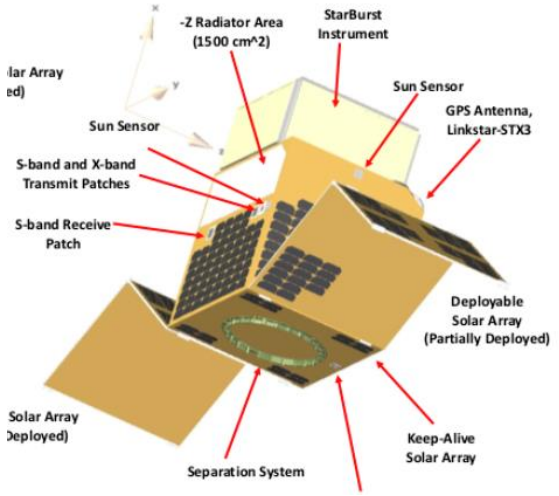


SPRITE, PI Brian Fleming (CU), Launch NET Jan 2023, UV spectra of ionizing radiation from star forming galaxies

Astrophysics Pioneers-2020 Selections

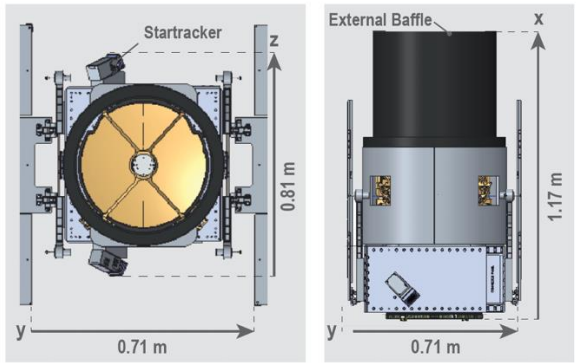
PUEO: A Long-duration Balloon-borne Instrument for Particle Astrophysics at the Highest Energies (PI Abigail Vieregg, U. Chicago)

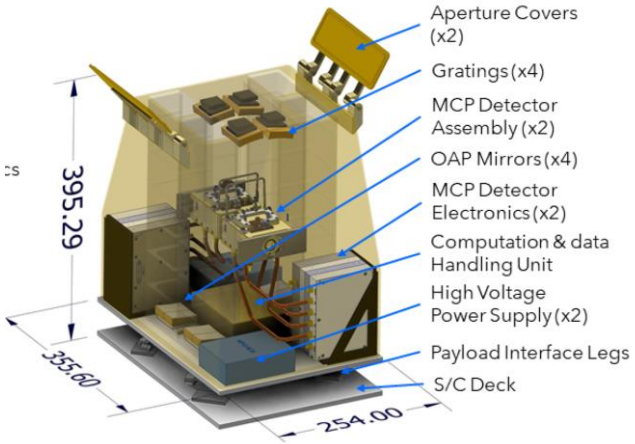




StarBurst: Gamma-ray ASM, Simultaneous detection of NS/NS mergers with LIGO (PI Daniel Kocevski, NASA MSFC)

Pandora: Multiwavelength Characterization of Exoplanets and their Host Stars (PI Elisa Quintana, NASA GSFC)

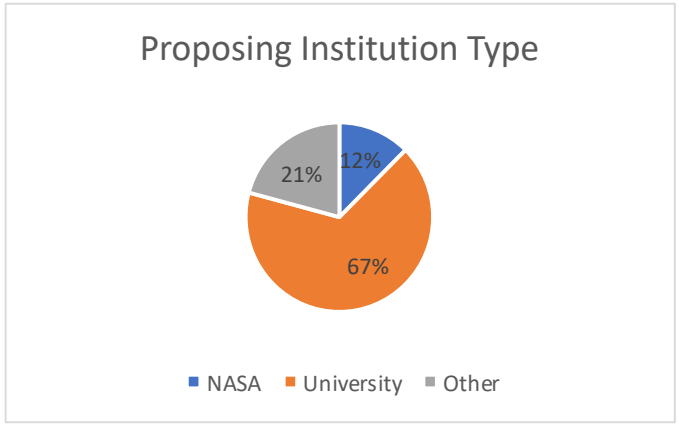


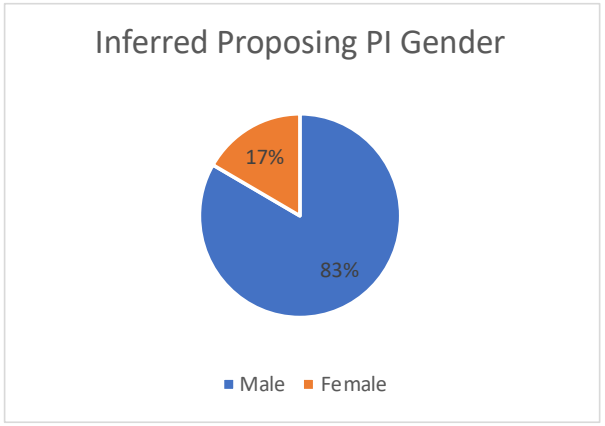


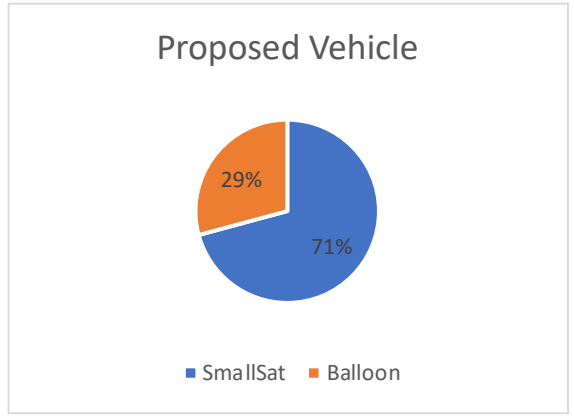
Aspera: IGM Inflow/outflow from galaxies via OVI 10^5K emission line imaging (PI Carlos Vargas, U. Arizona)

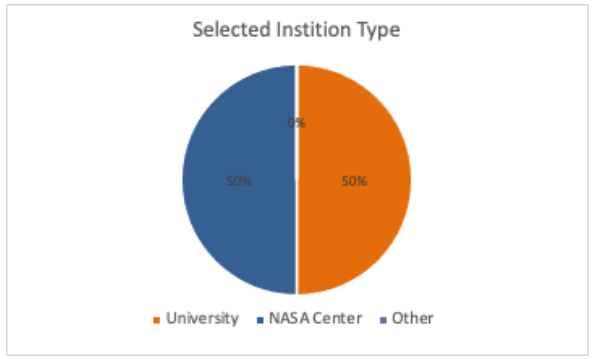
https://www.nasa.gov/feature/nasa-selects-4-concepts-for-small-missions-to-study-universe-s-secrets

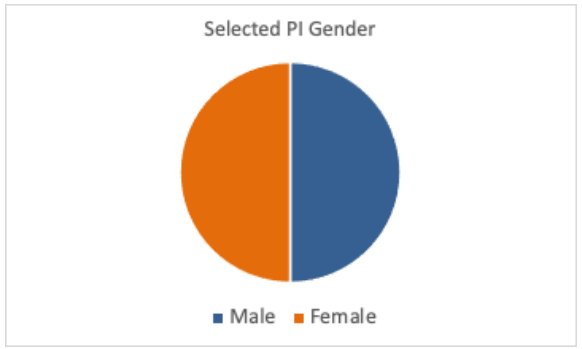
Pioneers 2020 Demographics

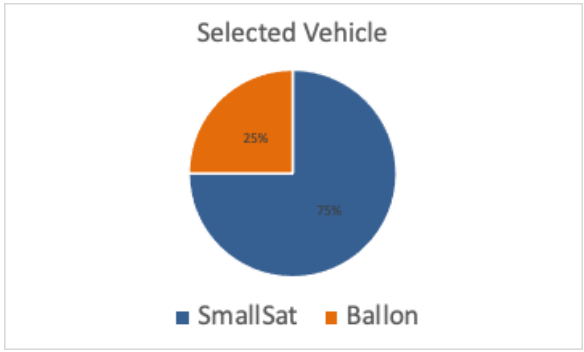




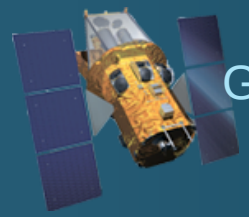








Astrophysics Explorers Program



Gehrels
Swift

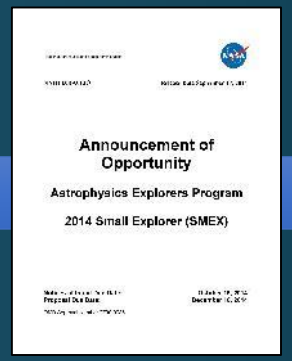
NuSTAR

SMEX 2019 Downselect
Phase A Studies due Mar 4, 2021
Downselect decision Fall 2021

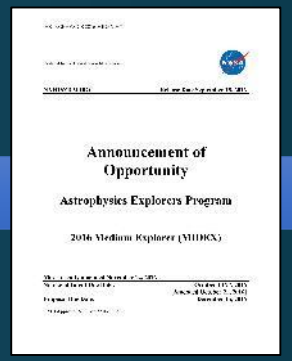
MIDEX 2021
Comm Ann release Sep 29, 2020
Draft AO release Jan 6, 2021
Comments due Feb 25, 2021
Final AO release August 2021
NOIs due October 2021
Proposals due December 2021
ALL FUTURE DATES TARGETS

4 AOs per decade

MIDEX
2011



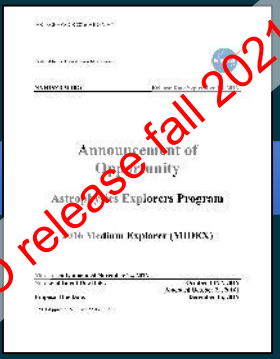
SMEX
2014



MIDEX
2016

Downselect fall 2021

SMEX
2019



AO release fall 2021

MIDEX
2021

Small and
Mid-Size
Missions

TESS

IXPE

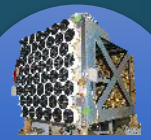
SPHEREx

ESCAPE
COSI

Directed
2013

Euclid

Missions of
Opportunity



NICER

GUSTO

ARIEL

Dorado
LEAP

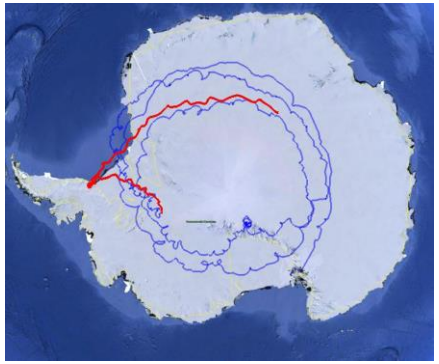
Directed
2017

XRISM

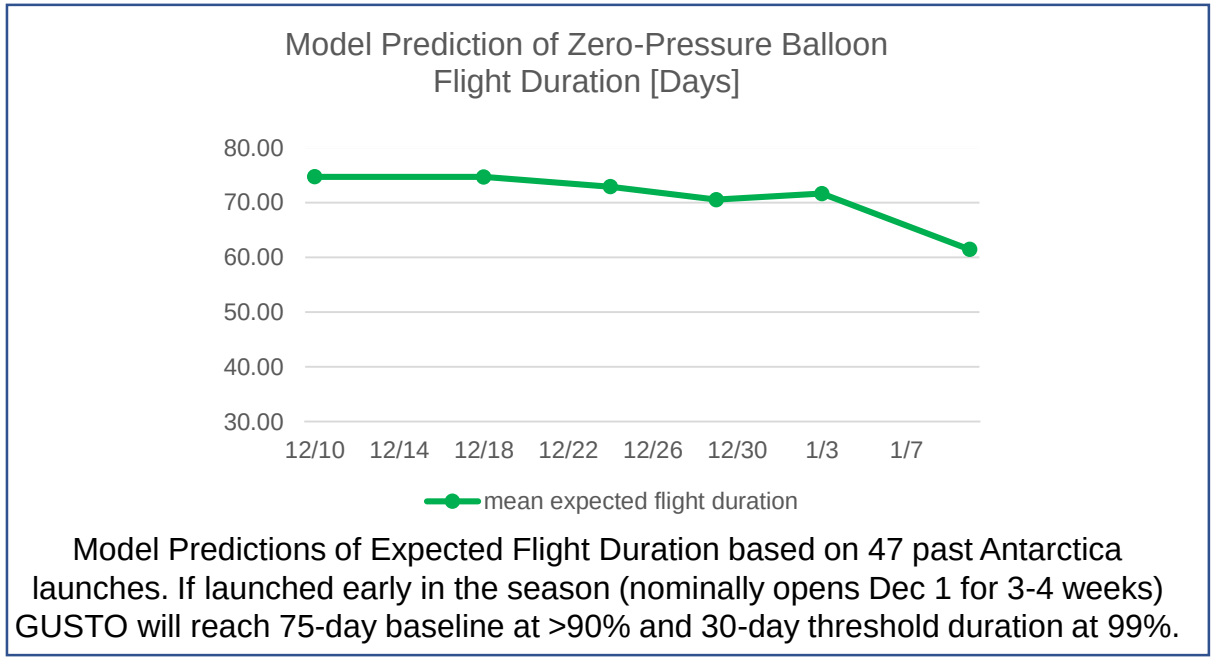
GUSTO Suborbital Explorer

- GUSTO, led by PI Chris Walker (University of Arizona), is an Astrophysics Explorer Mission of Opportunity balloon mission, launched from McMurdo Station, Antarctica, on a 75 day mission.
- Plan was to use a super-pressure balloon (SPB)
  - SPB is resilient against day/night cycles
  - Due to COVID, the two qualification flights were canceled so SPB has not been qualified
- NASA had decided to fly GUSTO from McMurdo in 2021 on a zero-pressure balloon (ZPB)
- The ZPB offers:
  - Higher lift capacity
  - Higher flight altitude (39 km vs 33.5 km)
  - Less stringent surface weather conditions for launch operations than SPB
  - More launch opportunities
- GUSTO mission needs to be completed before mission experiences day/night cycles
- National Science Foundation (NSF) announced that the 2021/2022 Antarctic field program will again be maintenance-only due to COVID restrictions
  - NASA is determining the impact on GUSTO

GUSTO Payload



SuperTIGER zero-pressure balloon trajectory in blue (launched 12/8/12 and terminated 55 days later) and extrapolation flight up to 75 days duration in red.



Model Predictions of Expected Flight Duration based on 47 past Antarctica launches. If launched early in the season (nominally opens Dec 1 for 3-4 weeks) GUSTO will reach 75-day baseline at >90% and 30-day threshold duration at 99%.

Imaging X-ray Polarimeter Explorer

IXPE Update
Martin Weisskopf
Day 1

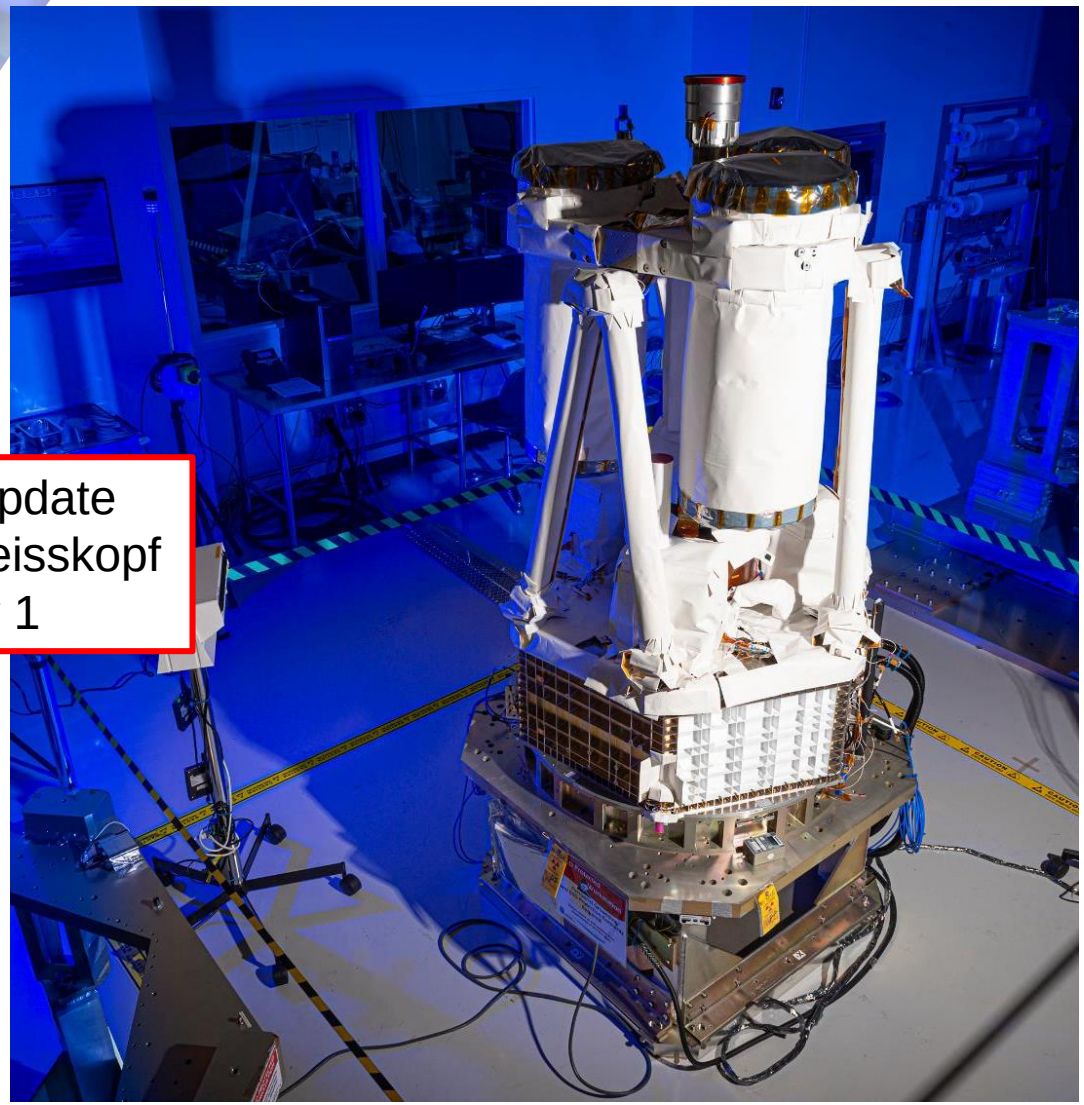


Image credits: Ball Aerospace

KDP-D successfully passed on November 2, 2020

All observatory elements have been delivered to Ball Aerospace, Boulder CO

Observatory integration began December 7, 2020

Observatory vibration and TVAC testing test planned for spring 2021.

Observatory I&T completion planned for early mid-August 2021.

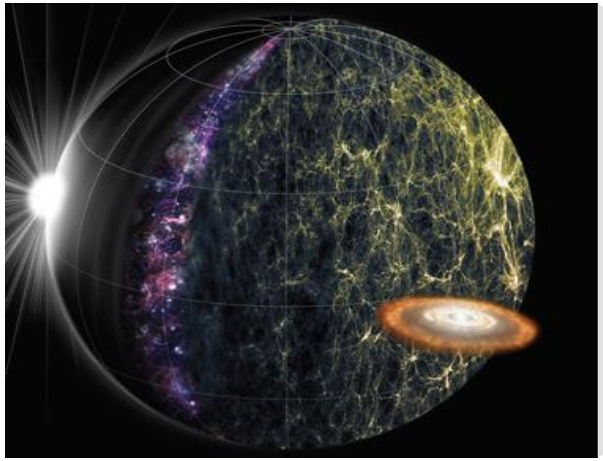
Ship to KSC mid-October 2021.

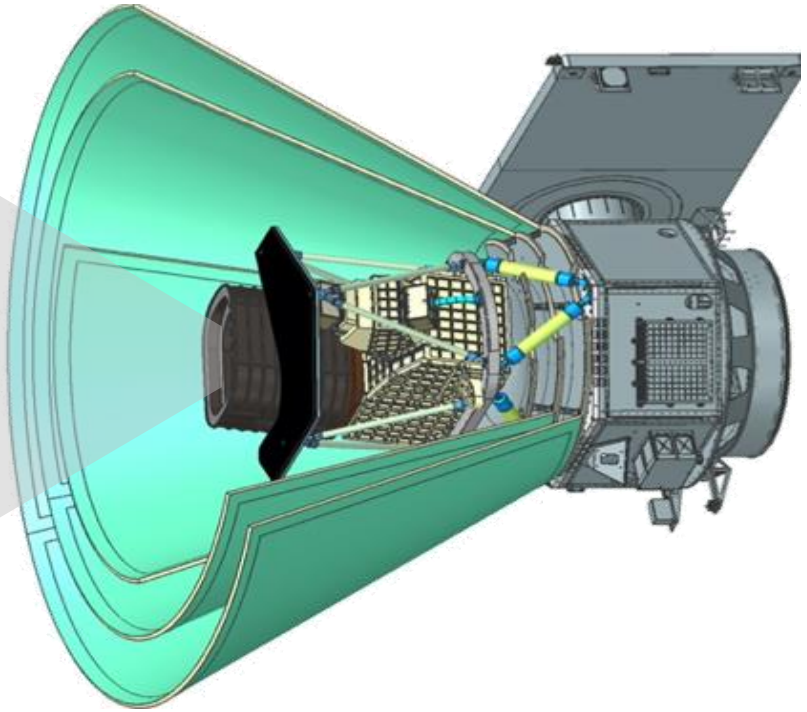
Revised launch date is November 2021

https://ixpe.msfc.nasa.gov/

SPHEREx

Spectro-Photometer for the History of the Universe, Epoch of Re-ionization, and Ices





Confirmation Review (KDP-C) December 2020

Critical Design Review (CDR) September 2021

Begin Observatory Integration and Test (I&T) Summer 2023

Working Launch Readiness Date (LRD) June 2024

Agency Commitment Launch Date April 2025

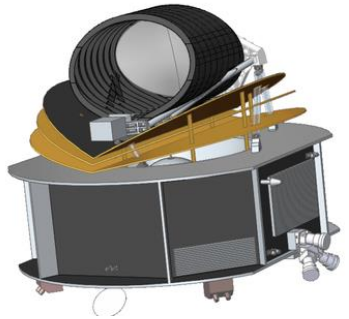
International Partner-led Missions

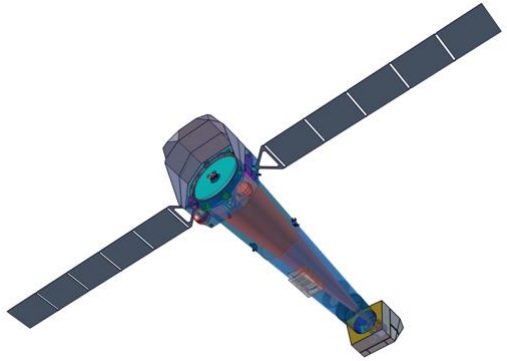
Euclid (ESA) 2022
Currently in I&T, all NASA components integrated

XRISM (JAXA) 2023
Currently in I&T, NASA travel complicated by COVID

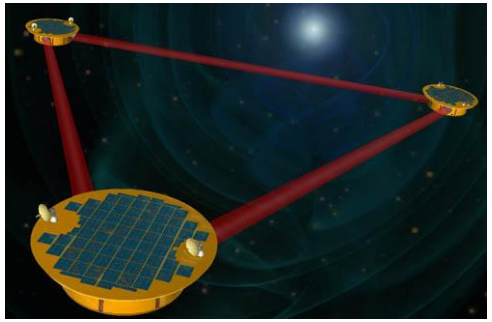
Ultrasat (ISA) 2024
NASA discussing providing RideShare access to space

ARIEL (ESA) 2029
Currently in preliminary design phase, passed ESA adoption





Athena (ESA) 2030s
LISA (ESA) 2030s
NASA and ESA settling contributions, NASA conducted independent cost review



SOFIA Germany Campaign Completed

SOFIA Update
Margaret Meixner &
Naseem Rangwala
Day 1

- Maintenance completed on schedule; post-maintenance check flight on Jan 29.
- Ferry flight from Hamburg to Cologne, Germany, for science deployment on Feb 4.
- Science Operations started on Feb 7 from Cologne, Germany and completed on March 13.

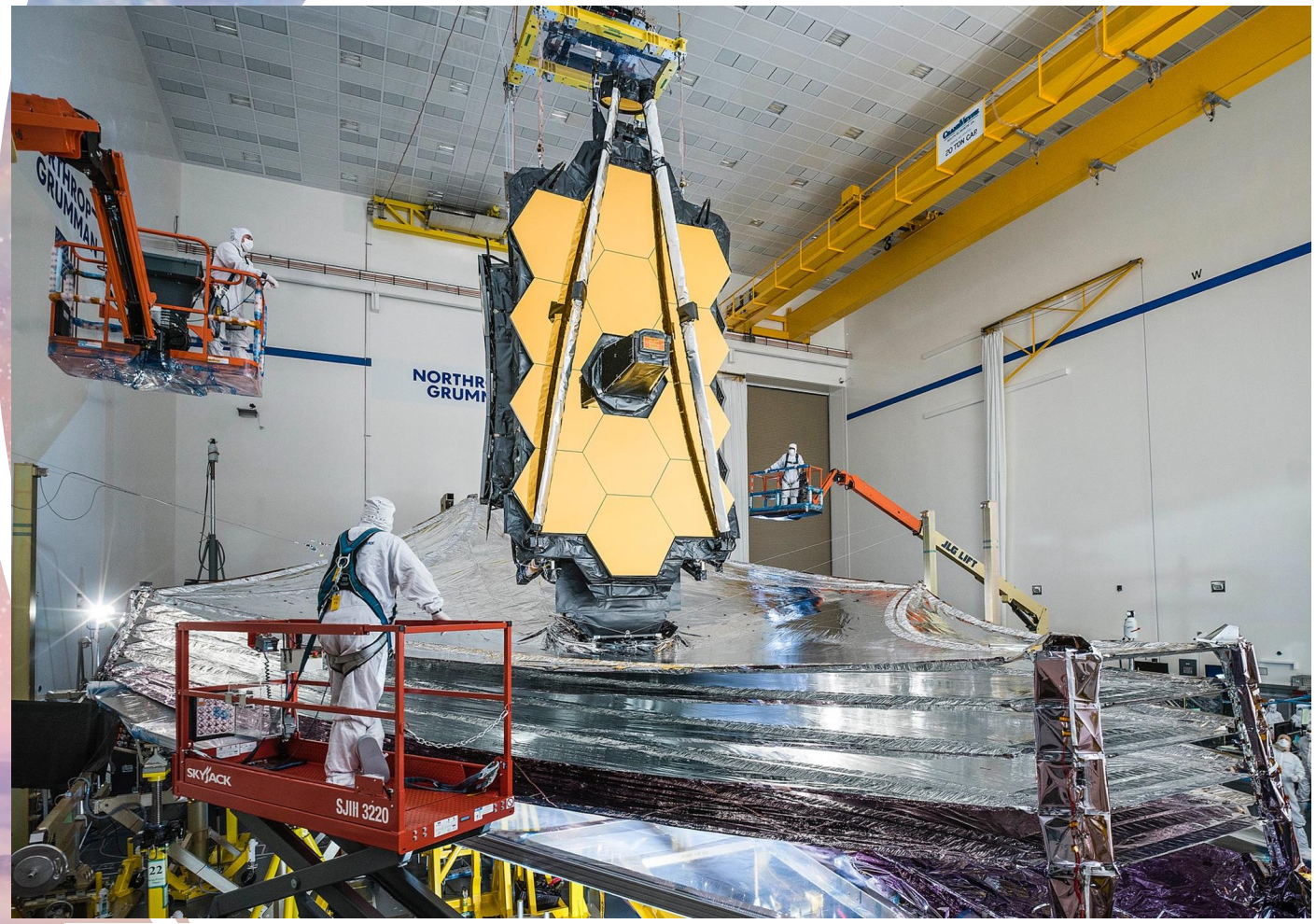
Preflight meeting in the covid era.

A new view for SOFIA

- Over 100 staff in Cologne supporting the deployment.
- NASA leased Terminal 2 (the whole thing), so plenty of room for social distancing.
- 15 science flights accomplished.

James Webb Space Telescope

Webb Update
Eric Smith &
Neill Reid
Day 2



The final deployment of Webb's sunshield on Earth (Northrop Grumman Space Park, Dec. 2020). Webb will undergo folding and stowing before shipment and mating to the Ariane 5 in 2021.

2020 Accomplishments

- Work continues at Northrop Grumman, but at lower efficiency due to social distancing practices required by COVID19 response
- Changed launch date from March 2021 to October 2021
- Conducted several mission rehearsals at the STScI mission operation center
- Completed Observatory-level environmental tests
- Completed Observatory-level post environmental test deployments
- Received 1173 proposals in the Cycle 1 GO call

2021 Plans

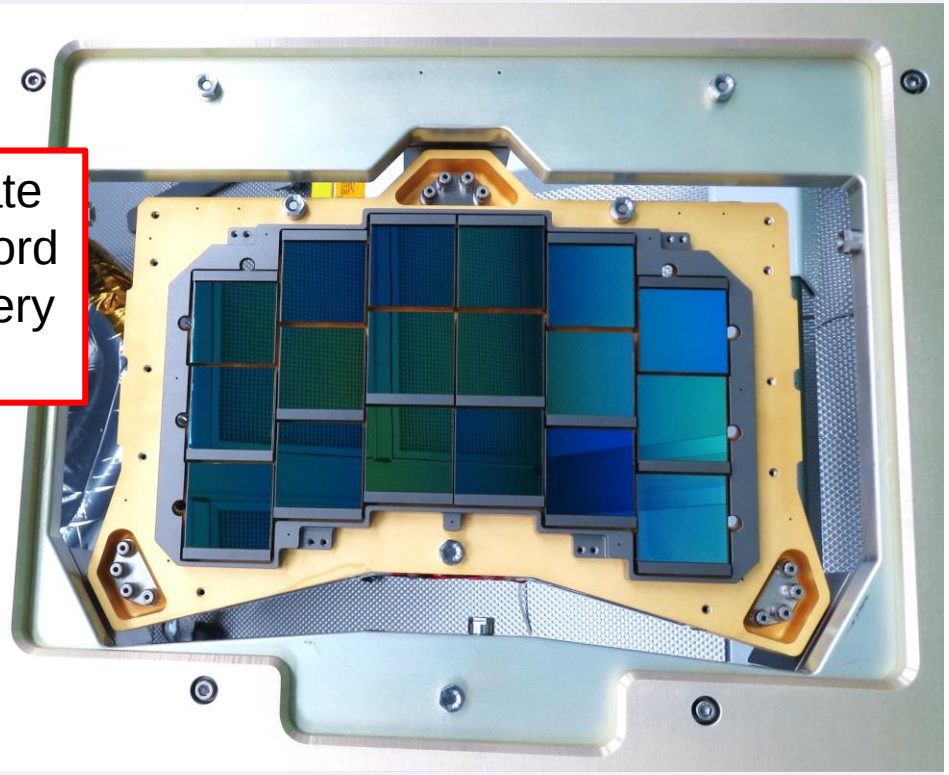
- Final stow after post environmental deployments
- Ready Observatory for shipping to launch site
- Additional mission rehearsals at STScI
- Launch Webb in October 2021

Roman Space Telescope

Roman making excellent progress on its most urgent elements; Mission Critical Design Review planned for end of this summer

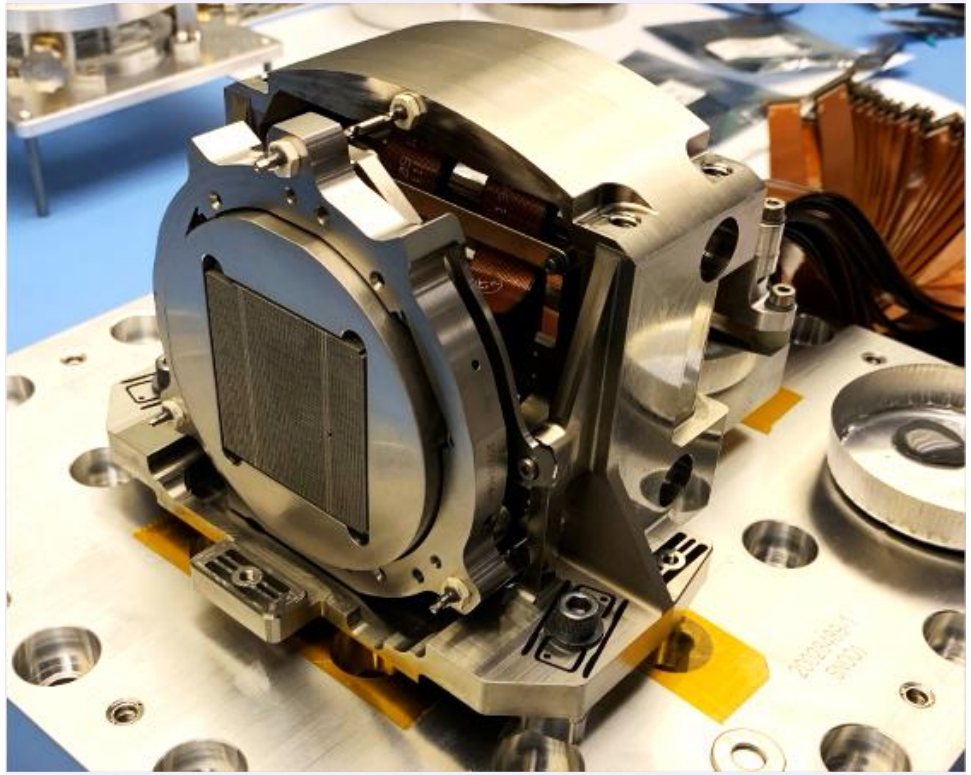
Roman Update
Dominic Benford & Julie McEnery
Day 2

Roman Wide Field Instrument critical technology: state-of-the-art infrared detectors



300 Mpixel Focal Plane Array Test Unit; Production well underway: 17 of 18 flight candidate detectors already in hand

Roman Coronagraph Instrument critical technology: deformable mirrors



Deformable Mirror TRL-6 Model; technology has been demonstrated; two flight candidate actuators already in hand

Roman Space Telescope

Roman Update
Dominic Benford & Julie McEnery
Day 2

Opportunities for participation in Roman offered in ROSES-2021

- Key Project Teams: Science teams to conduct scientific investigations using the data from the major surveys identified by the Astro2010 Decadal Survey
- Coronagraph Community Participation Program: Investigators to work with the coronagraph instrument team to plan and execute tech demo observations
- Wide Field Instrument Preparatory Science: Investigators to work on science preparation activities related to mission performance verification and science operations preparation

All Roman observing time is available through open processes

- Major Legacy Surveys will be defined using a community-driven open process
- Key Projects – funded science investigations using these surveys –openly competed
- Roman observing time will be available for General Observer (GO) projects
- All data will be available to the community with no period of limited access

https://roman.gsfc.nasa.gov/

Astrophysics Missions in Development

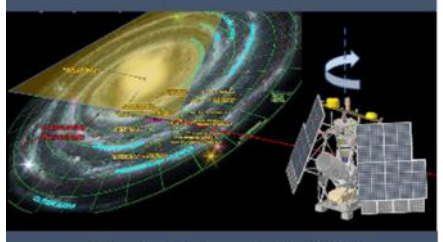
Webb 2021
NASA Mission

James Webb
Space Telescope

IXPE 2021
NASA Mission

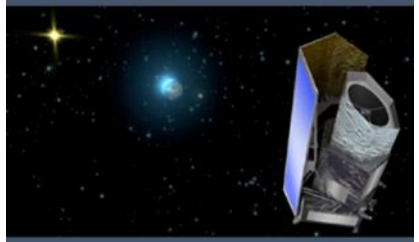
Imaging X-ray
Polarimetry Explorer

GUSTO 2021
NASA Mission



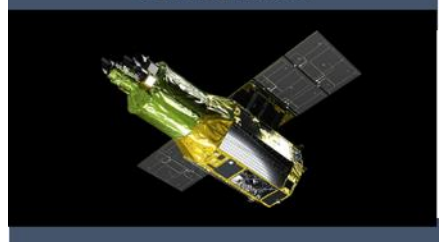
Galactic/ Extragalactic ULDB
Spectroscopic Terahertz Observatory

Euclid 2022
ESA-led Mission



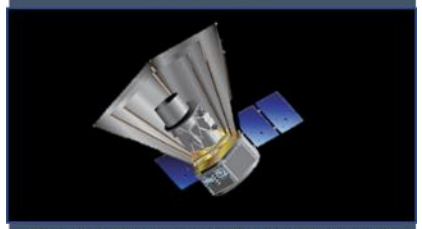
NASA is supplying the NISP
Sensor Chip System (SCS)

XRISM 2023
JAXA-led Mission



NASA is supplying the SXS
Detectors, ADRs, and SXTs

SPHEREx 2024
NASA Mission

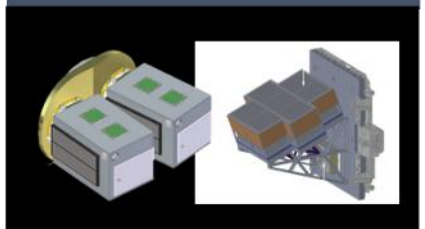


Spectro-Photometer for the History of
the Universe, Epoch of Reionization,
and Ices Explorer

SMEX ~2025
NASA Mission

COSI or ESCAPE

Mission of Opportunity ~2025
NASA Mission



Dorado or LEAP

Roman 2026
NASA Mission

Nancy Grace Roman
Space Telescope

ARIEL 2029
ESA-led Mission

NASA is supplying the CASE
fine guidance instrument

Launch dates are current project working dates; Agency Baseline Commitment launch date could be later; impacts of COVID-19 not yet known

COVID-19 Impacts – Missions

Many missions are expected to stay within their cost commitments (known as the ABC or Agency Baseline Commitment, which includes HQ held reserves above project budget)

- ABC is set at Confirmation Review
- In astrophysics, this includes NASA contributions to Euclid and XRISM

Some missions have experienced challenges that affect cost and schedule commitments

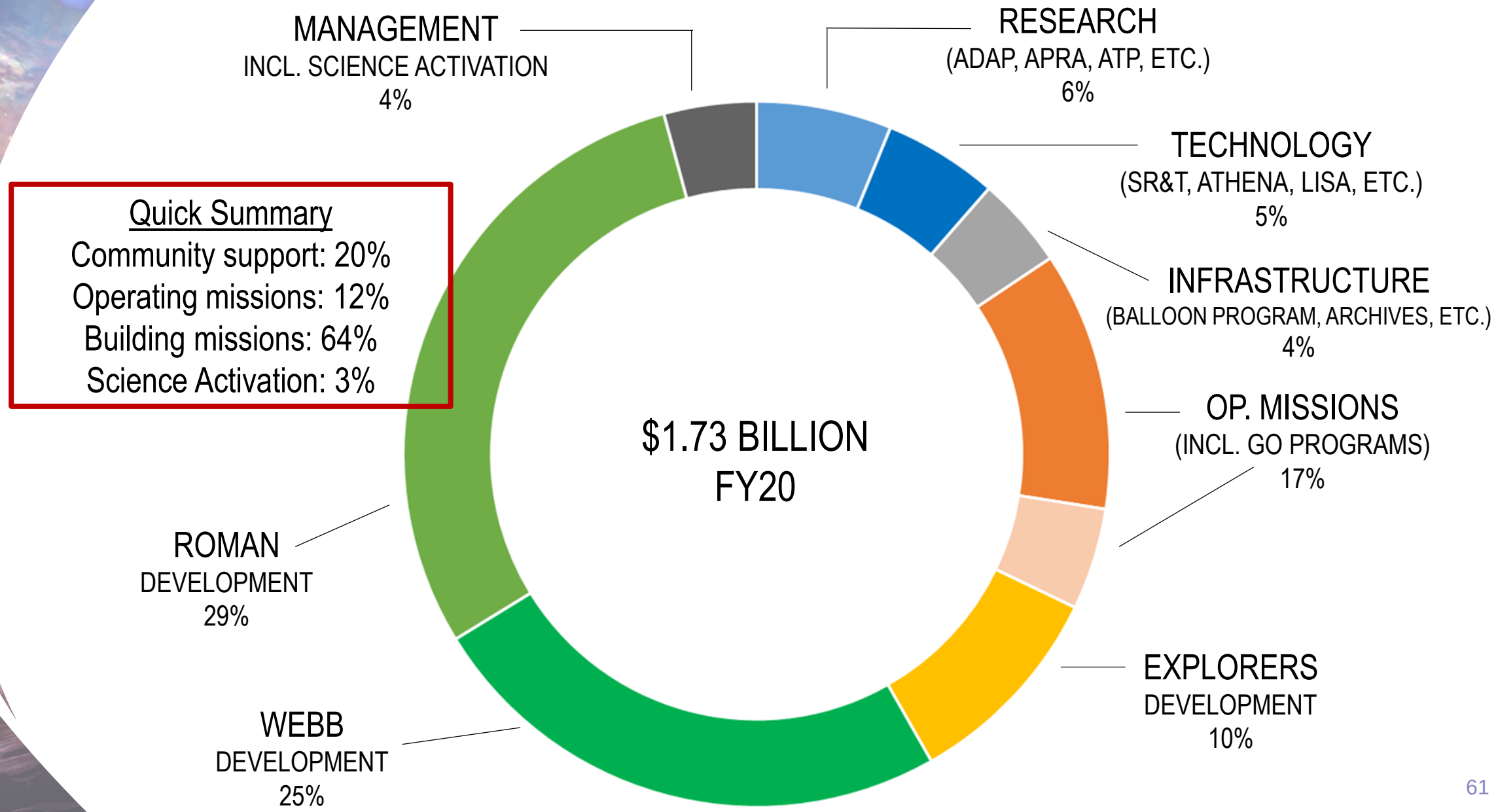
- In astrophysics, this includes Webb, Roman, and IXPE
- Missions that have been Confirmed since COVID began (e.g., SPHEREx), or will be Confirmed in the future (e.g., future Explorers) have assumed impacts from COVID included within their cost and schedule commitments

To date, challenges to Flagships (Webb, Roman) have been accommodated with no impact to Explorers or R&A

- Challenges to Explorers have been accommodated within the Explorers Program

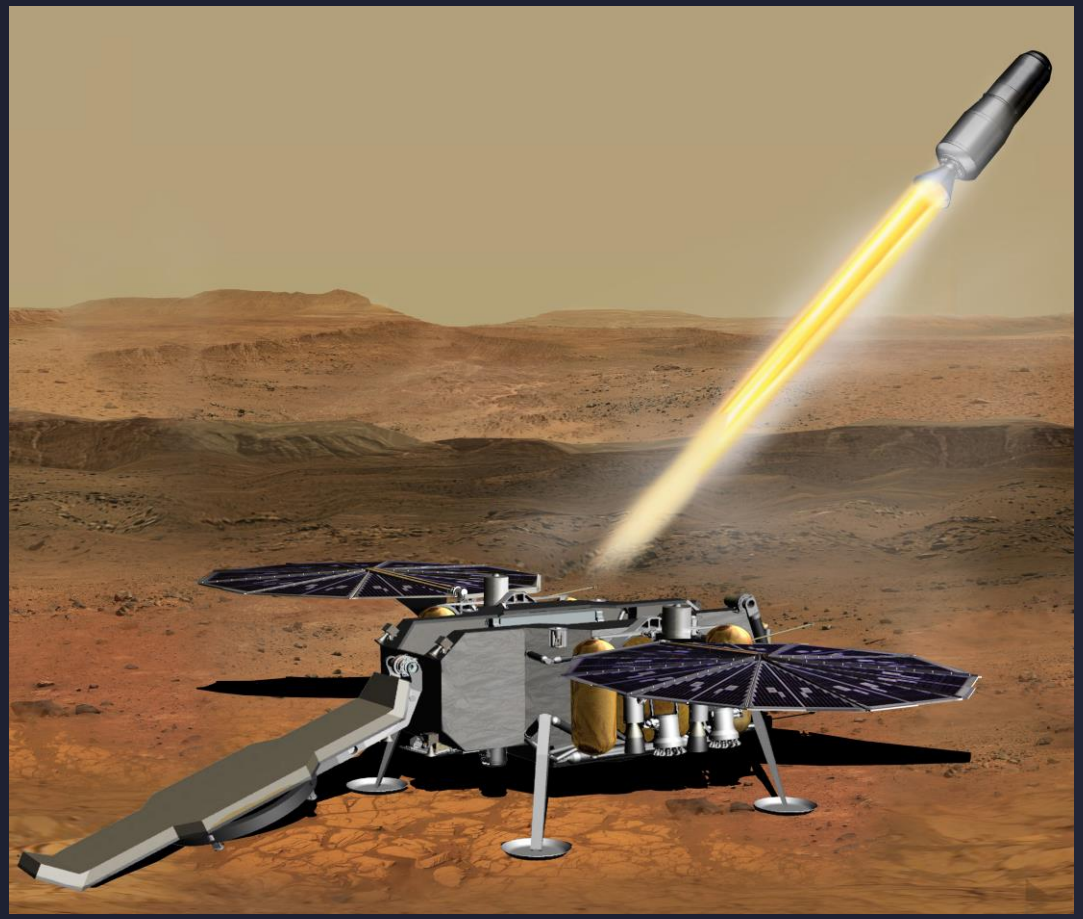
Planning for the Future

Astrophysics Budget – FY20 Actual



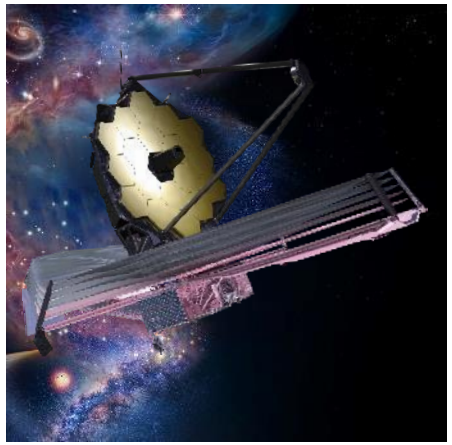
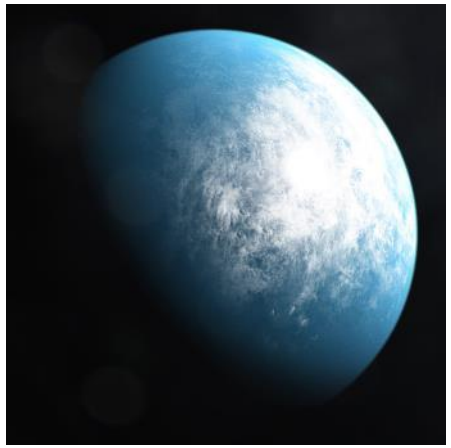
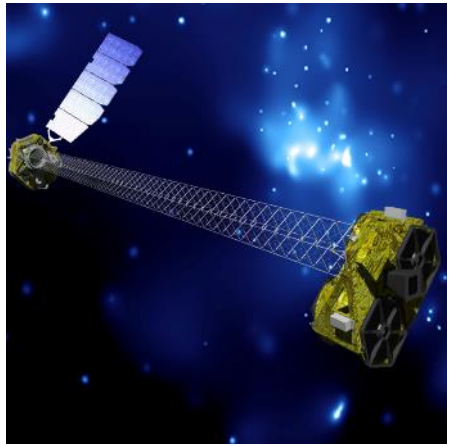
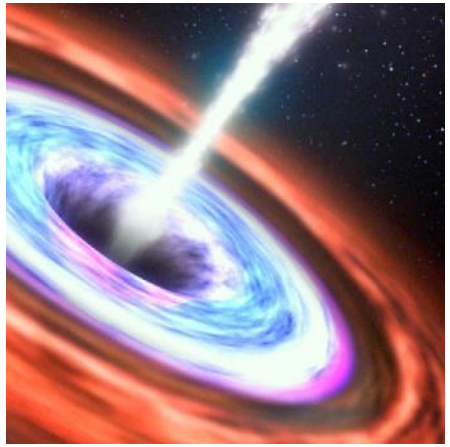
Quick Summary
Community support: 20%
Operating missions: 12%
Building missions: 64%
Science Activation: 3%

FY21 Science Appropriations Highlights



- FY 2021 Consolidated Appropriations Act signed into law December 27, 2020
- Continued strong support for Science with a $7.3 B budget
  - $994 M above the FY21 President's Budget request
  - $162 M above the FY 2020 enacted level
- Continued funding for Roman, PACE, CLARREO PF, SOFIA
- Funding to support decadal priorities such a Mars Sample Return mission, Europa Clipper, and development of new Earth observation missions
- Includes funding for new Biological and Physical Science Division

Astrophysics FY21 Appropriation

The FY 2021 NASA Budget Request included no funding ($0) for the Roman Space Telescope and only close out funding ($12M) for SOFIA

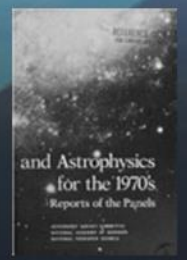
The FY 2021 Omnibus Appropriation Bill

- Provides $1.77B for Astrophysics (including the James Webb Space Telescope)
- Directs $414.7M for Webb, same as the request
- Directs $505.2M for Roman, $505.2M more than the request
- Directs $93.3M for Hubble, $5M more than the request
- Directs $85.2M for SOFIA, $73.2M more than the request
- Directs $10M for “search for life technology development”

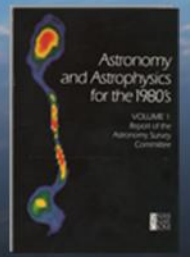
The total funding provided is an increase of $525.2M over the request

Astrophysics

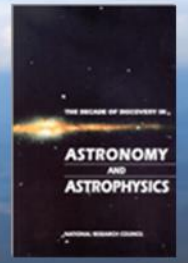
Decadal Survey Missions



1972
Decadal Survey
Hubble



1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer

2001
Decadal Survey
Webb

2010
Decadal Survey
Roman

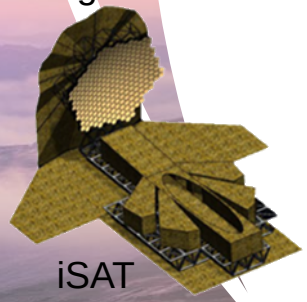
?

2021
Decadal Survey

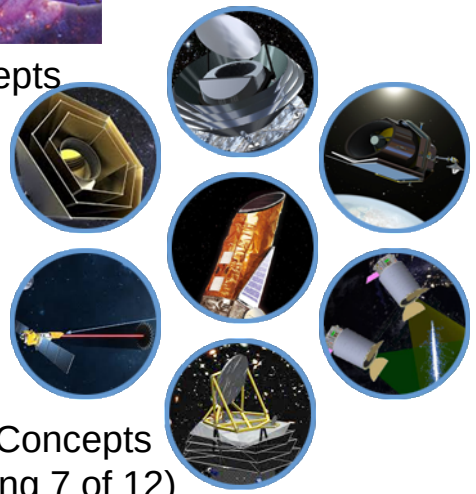
Technology Development and Risk Reduction Activities

Completed
Large Mission Concept Studies / Probe Mission Concept Studies / In-Space Assembly of Telescopes (iSAT) Study / Large Mission Management Study / STMD Technology Collaborations
Ongoing
Segmented Mirror Technology Program / Binary Star Coronagraph Technology / Deformable Mirrors / Starshade Technology / Extreme Precision Radial Velocity Research and Technology / Detectors (at all wavelengths) / X-ray Mirrors / Cryocoolers
Testbeds (Coronagraph, Ultrastable, X-ray & Cryogenic)
PI-led Strategic Astrophysics Technology (SAT) Advancements

Large Mission Concepts



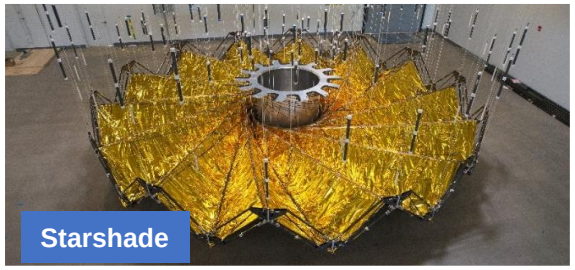
iSAT Concept



Probe Concepts (Showing 7 of 12)

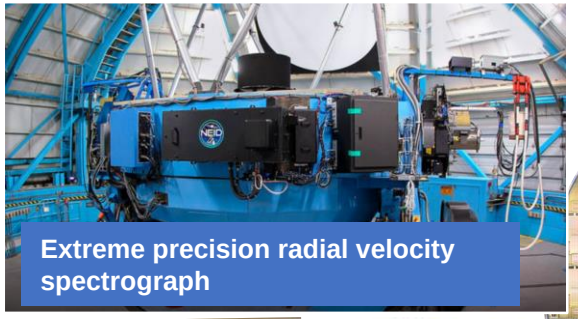
Coronagraph Testbed

Large mirror development

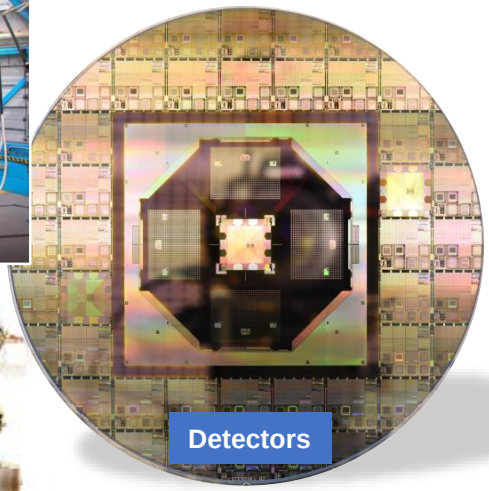


Starshade

X-ray mirror development



Extreme precision radial velocity spectrograph



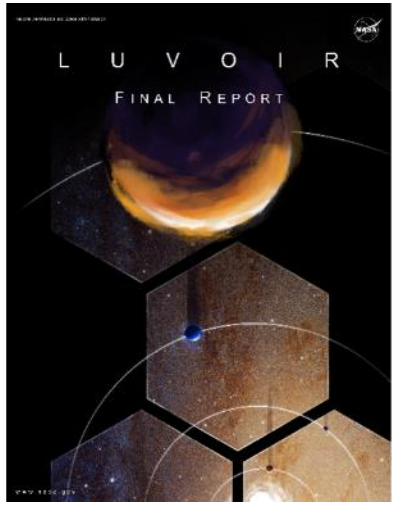
Detectors

Deformable Mirror

Cryocooler

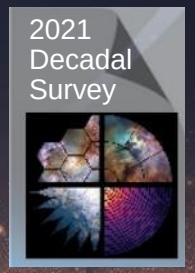
For more information on technology development activities, see the Astrophysics Technology Development Database (http://www.astrostrategictech.us/)

Astro2020 Decadal Survey Status




- Large Mission Concept Studies presented to Astro2020 in November 2019
- Probe Mission Concept Studies submitted to Astro2020 in November 2019
- Last public meeting of the Steering Committee on August 25, 2020
  - Agencies presented updated programmatic and budget guidance
  - Co-Chairs stated publicly that report will be delivered by Spring 2021
- NASA is planning ahead for implementing the Decadal Survey
  - Reducing risks of large missions via technology development
  - Planning underway for recommendations in R&A, archives, suborbital, etc.
  - Developing options for Probe and flagship risk reduction activities
  - Holding a wedge in out year planning budget for new initiatives

MARS 2020



DART

Landsat 9

Webb

IXPE

2021 – A Year of Science

O-REx

Peregrine

Nova-C

Lucy

GOES-T

LAUNCH
LANDING
DEPARTURE

Backup

FY21 Science Appropriations Division Highlights

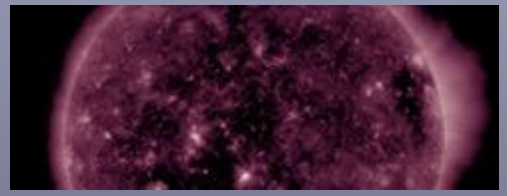
Planetary Science

- $40M above the FY21 Request
- Additional funds for Planetary Defense supporting DART and Near Earth Object Surveillance Mission
- Additional funding for Mars Sample Return and New Frontiers/Dragonfly
- Strong support for Lunar Discovery and Exploration, as well as Commercial Lunar Payload Services
- Europa Clipper given permission to use CLV in the event of SLS incompatibility

Astrophysics

- $525M above the FY21 Request
- Restores funding to continue development of Nancy Grace Roman Telescope
- Additional funding for continued operation of SOFIA
- Strong support for Science Activation, an SMD-wide education program

Heliophysics



- $118M above the FY21 Request
- Additional funds for Research
- Increased funding for Living with a Star, including space weather applications and GDC
- Additional funds for Solar Terrestrial Probes, including MMS and DYNAMIC
- Additional funds for Heliophysics Explorers

Earth Science

- $232M above the FY21 Request
- Strong support for Earth System Science Pathfinder Missions and Venture-class missions, including GLIMR and GeoCARB
- Restores funding for PACE and CLARREO PF
- Additional funds for Research
- Strong support for Designated Observable missions, as recommended by decadal survey

FY 14-21 Science Appropriations Summary

($M)	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY21 Omnibus Bill
Science	**5,140.2**	**5,243.0**	**5,584.1**	**5,762.2**	**6,211.5**	**6,816.6**	**7,143.1**	**7,301.0**
Earth Science	1,822.1	1,784.1	1,926.6	1,907.7	1,921.0	1,931.0	1,971.8	2,000.0
Planetary Science	1,342.3	1,446.7	1,628.0	1,827.5	2,217.9	2,746.7	2,712.6	2,700.0
Astrophysics	677.1	730.7	762.4	782.9	850.4	1,121.6	1,306.2	1,356.2
JWST	658.2	645.4	620.0	569.4	533.7	304.6	423.0	414.7
Heliophysics	640.5	636.1	647.2	674.7	688.5	712.7	724.5	751.0
Biological & Physical Science							5.0	79.1

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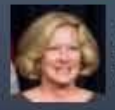

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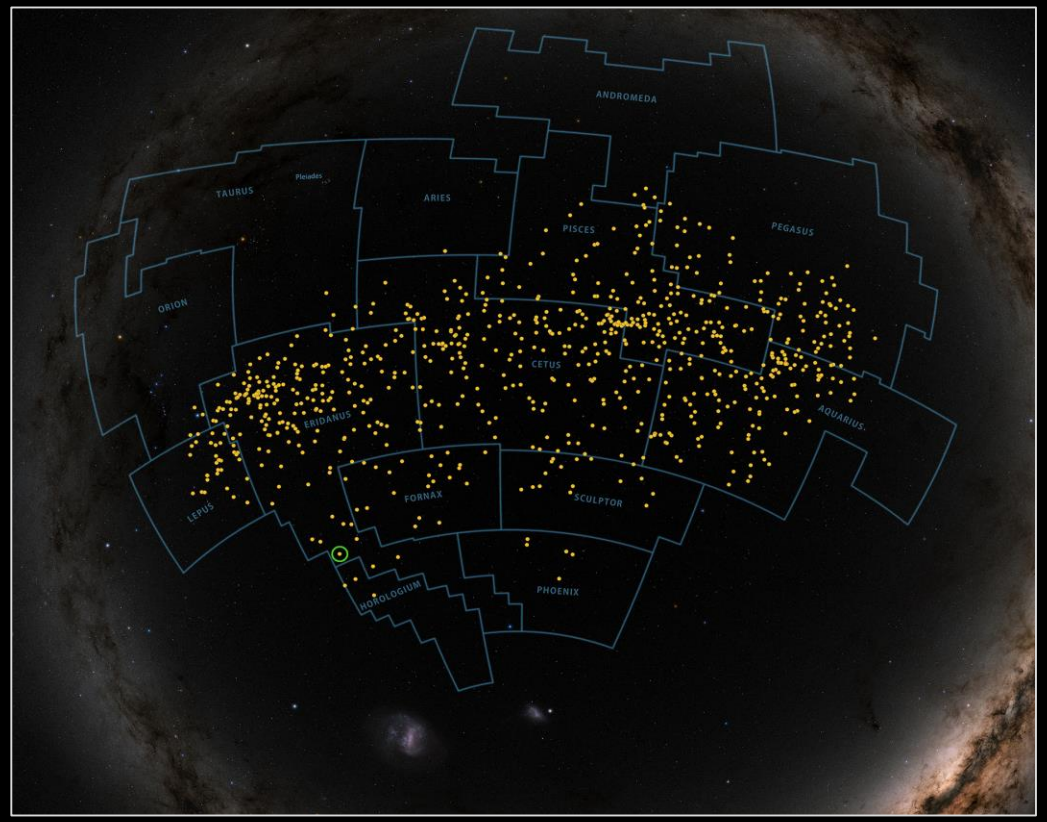
TESS Discovers New Worlds in a River of Young Stars

Released: February 12, 2021



Credit: NASA's Goddard Space Flight Center

Caption: The Pisces-Eridanus stream spans 1,300 light-years, sprawling across 14 constellations and one-third of the sky. Yellow dots show the locations of known or suspected members, with TOI 451 circled. TESS observations show that the stream is about 120 million years old, comparable to the famous Pleiades cluster in Taurus (upper left).

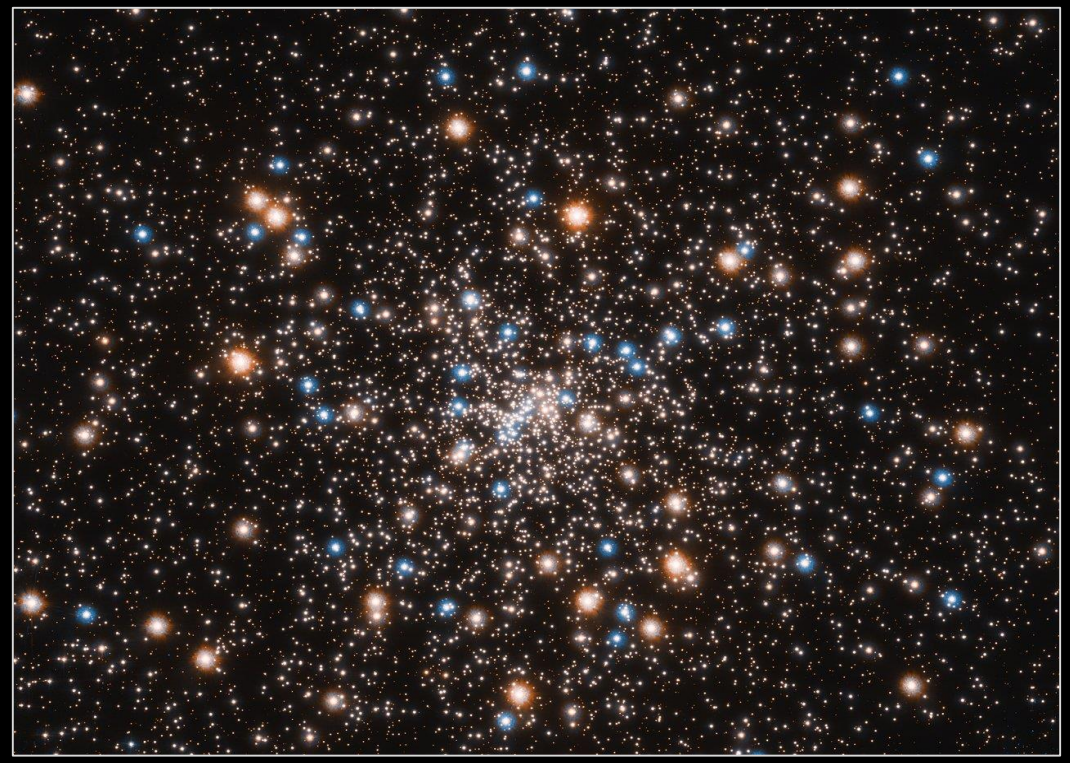
E. R. Newton et al., https://arxiv.org/abs/2102.06049

SCIENCE HIGHLIGHT

- Using observations from the Transiting Exoplanet Survey Satellite (TESS), an international team of astronomers has discovered a trio of hot worlds larger than Earth orbiting a much younger version of our Sun called TOI 451.
- The system resides in the recently discovered Pisces-Eridanus stream, a collection of stars less than 3% the age of our solar system that stretches across one-third of the sky.
- Stellar streams form when the gravity of our Milky Way galaxy tears apart star clusters or dwarf galaxies. The individual stars move out along the cluster's original orbit, forming an elongated group that gradually disperses.
- The TESS measurements revealed overwhelming evidence of starspots and rapid rotation among the stream's stars. Based on this result, researchers found that the stream was only 120 million years old – similar to the famous Pleiades cluster.
- The young star TOI 451 lies about 400 light-years away in the constellation Eridanus. It has 95% of our Sun's mass, but it is 12% smaller, slightly cooler, and emits 35% less energy. TOI 451 rotates every 5.1 days, which is more than five times faster than the Sun.
- TOI 451's most distant planet orbits three times closer than Mercury ever approaches to the Sun, so all of these worlds are quite hot and inhospitable to life as we know it. Temperature estimates range from about 2,200 degrees Fahrenheit (1,200 degrees Celsius) for the innermost planet to about 840 F (450 C) for the outermost one.
- TOI 451 b orbits every 1.9 days, is about 1.9 times Earth's size, and its estimated mass ranges from two to 12 times Earth's. The next planet out, TOI 451 c, completes an orbit every 9.2 days, is about three times larger than Earth, and holds between three and 16 times Earth's mass. The farthest and largest world, TOI 451 d, circles the star every 16 days, is four times the size of our planet, and weighs between four and 19 Earth masses.

Hubble Uncovers Concentration of Small Black Holes

Released: February 11, 2021



Credit: NASA, ESA, and T. Brown and S. Casertano (STScI)
Acknowledgement: NASA, ESA, and J. Anderson (STScI)

Caption: In this Hubble image of globular cluster NGC 6397, the cluster's blue stars are near the end of their lives. These stars have used up their hydrogen fuel that makes them shine. Now they are converting helium to energy in their cores, which fuses at a higher temperature and appears blue. The reddish glow is from red giant stars that have consumed their hydrogen fuel and have expanded in size. The myriad small white objects include stars like our Sun.

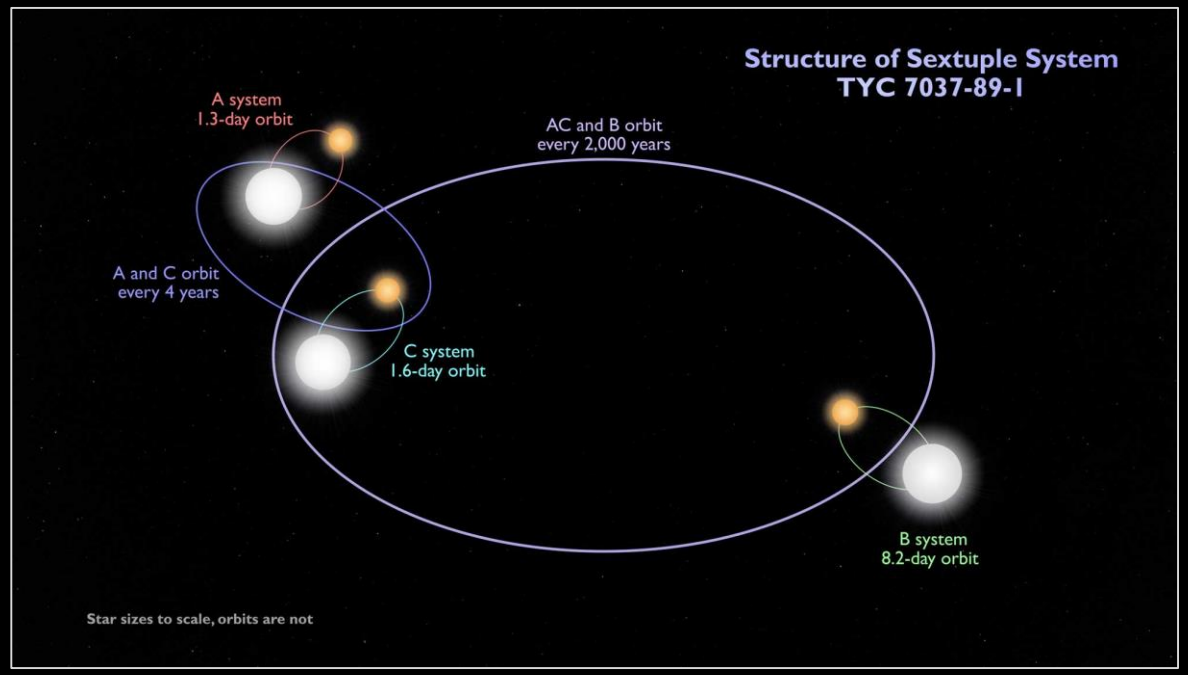
E. Vitral & G. A. Mamon, https://arxiv.org/abs/2010.05532

SCIENCE HIGHLIGHT

- Hubble researchers went hunting for an intermediate-mass black hole (IMBH) in the nearby globular cluster NGC 6397 and came up with a surprise.
- Because a black hole cannot be seen, they carefully studied the motion of stars inside the cluster that would be gravitationally affected by the black hole's gravitational tug.
- The amplitudes and shapes of the stellar orbits led to the conclusion that there is not just one hefty black hole, but a swarm of smaller black holes – a mini-cluster in the core of the globular cluster.
- Why are the black holes hanging out together?
- A gravitational pinball game takes place inside globular clusters where more massive objects sink to the center by exchanging momentum with smaller stars, that then migrate to the cluster's periphery.
- The central black holes may eventually merge, sending ripples across space as gravitational waves.

First Six-star System Where All Six Stars Undergo Eclipses

Released: January 27, 2021



Credit: NASA's Goddard Space Flight Center

Caption: This schematic shows the configuration of the sextuple star system TYC 7037-89-1. The inner quadruple is composed of two binaries, A and C, which orbit each other every four years or so. An outer binary, B, orbits the quadruple roughly every 2,000 years. The orbits shown are not to scale.

B. P. Powell et al., https://arxiv.org/abs/2101.03433

SCIENCE HIGHLIGHT

- TYC 7037-89-1 is the first six-star system ever found where all of the stars participate in eclipses, a discovery made by NASA's Transiting Exoplanet Survey Satellite (TESS).
    - The system is located about 1,900 light-years away in the constellation Eridanus.
- Discovery enabled by Prism, a high performance computing facility at GSFC designed specifically for applying artificial intelligence and machine learning (AI/ML) to science
- The system, also called TIC 168789840, is the first known sextuple composed of three sets of eclipsing binaries, stellar pairs whose orbits tip into our line of sight so we observe the stars alternatively passing in front of each other.
    - The stars in the A and C systems orbit each other roughly every day and a half, and the two binaries orbit each other about every four years.
    - The B binary's members circle each other about every eight days, but the pair is much farther away, orbiting around the inner systems roughly every 2,000 years.
- The primary stars in all three binaries are all slightly bigger and more massive than the Sun and about as hot. The secondaries are all around half the Sun's size and a third as hot.
- Astrophysicists are very interested in eclipsing binaries because their structure aids detailed measurements of the stars' sizes, masses, temperatures, and separation as well as the distance to the system.

Magnetic Chaos Hidden Within the Whirlpool Galaxy

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Credit: NASA, the SOFIA science team, A. Borlaff; NASA, ESA, S. Beckwith (STScI) and the Hubble Heritage Team (STScI/AURA)

Caption: Magnetic field streamlines detected by SOFIA are shown over an image of the Whirlpool galaxy from NASA's Hubble Space Telescope.

SCIENCE HIGHLIGHT

- Not all appears as it would seem in the Whirlpool galaxy. One of the best-studied spiral galaxies Messier 51, is influenced by powerful, invisible forces.
- Located 31 million light-years away in the constellation Canes Venatici, the galaxy's arms are strikingly visible as they reach out along the central spine structure, displaying swirling clouds of gas and dust that are massive star-making factories. But new observations by NASA's Stratospheric Observatory for Infrared Astronomy, or SOFIA, shows a more complicated picture.
- Radio telescopes previously detected neatly-drawn magnetic fields throughout the length of the galaxy's massive arms. But under SOFIA's infrared gaze for the first time those lines give way to a chaotic scene in the outer spiral arms.
- Using a far-infrared camera and imaging polarimeter instrument called the High-Resolution Airborne Wideband Camera, or HAWC+, researchers found that the magnetic fields in the outskirts of the galaxy no longer follow the spiral structure and are instead distorted.
- What's causing all this magnetic pandemonium? A nearby, yellowish galaxy called NGC 5195 tugging at the outermost tip of one of the arms adds to the turmoil, possibly strengthening the magnetic fields.