Paul Hertz
Dominic Benford
Lucien Cox
Daniel Evans
Shahid Habib
Patricia Knezek
Michael New
Rita Sambruna
Eric Smith
Felicia Chou
Jeanne Davis
Michael Garcia
Hashima Hasan
Elizabeth Landau
Mario Perez
Evan Scannapieco
Eric Tollestrup
Valerie Connaughton
Kristen Erickson
Ellen Gertsen
Douglas Hudgins
William Latter
Gregory Robinson
Kartik Sheth

National Aeronautics and Space Administration

NASA

EXPLORE SCIENCE

NASA Town Hall with bonus material

AAS 235th Meeting | January 5, 2020

Paul Hertz
Director, Astrophysics Division
Science Mission Directorate
@PHertzNASA

Posted at http://science.nasa.gov/astrophysics/documents

NASA Astrophysics Division

Division Director

Paul Hertz
Astrophysics Division Director

Jeff Volosin
Deputy Astrophysics Division Director

ASTROPHYSICS
NASA's Science Mission Directorate

Program Executives

E. Lucien Cox
SOFIA, GUSTO

Shahid Habib
COR, ExEP, PCOS Programs
ARIEL, Athena, Euclid, LISA

Jeff Hayes
Astrophysics Operating Missions

David Jarrett
WFIRST, XRISM

Mark Sistilli
Astrophysics Explorers Program
IXPE, SPHEREx, Balloons

Cross Cutting

Eric Smith
Chief Scientist
JWST

Jeanne Davis
Associate Director
ASM Program Manager

Mario Perez
Chief Technologist
SAT, XTF

Not Pictured

Lisa Wainio
Information Manager

Administrative Support

Kelly Johnson
Administrative Assistant

Not Pictured

Mathew Riggs
Administrative Assistant

Not Pictured

Jackie Mackall
Program Support Specialist

Ingrid Farrell
Program Support Specialist

Program Scientists

Dominic Benford
APRA Lead
WFIRST

Valerie Connaughton
APRA (High Energy)
XRISM

Dan Evans
PCOS Program
APRA (High Energy)
Fermi

Michael Garcia
APRA (UV/Optical), CubeSats/SmallSats
Hubble, Athena

Thomas Hams
APRA (Particle Astro)
Rockets/Balloons
GUSTO

Hashima Hasan
Education/Comms
Astrophysics Archives
Astro. Advisory Cmte

Douglas Hudgins
ExEP Program
ADAP Lead
ARIEL, TESS

Stefan Immler
Astrophysics Research Program Manager
Chandra, XMM

Not Pictured

Future

Patricia Knezek
APRA (UV/Optical)

William Latter
APRA (Lab Astro)
Spitzer, SPHEREx

Mario Perez
COR Program
APRA (UV/Optical)

Rita Sambruna
APRA (Fund. Phys.)
ADAP, LISA, NICER, Decadal Studies

Evan Scannapieco
ATP / TCAN Lead
FINESST, Swift

Kartik Sheth
SOFIA, NNFP

Linda Sparke
Astrophysics Explorers Program

Eric Tollestrup
APRA (SI/Submm)
Euclid, IXPE

Not Pictured

Future

Astrophysics Program Abbreviations: ASM – Astrophysics Strategic Missions; COR – Cosmic Origins; ExEP – Exoplanet Exploration Program; PCOS - Physics of the Cosmos

Why Astrophysics?

How did our universe begin and evolve?

How did galaxies, stars, and planets come to be?

Are we alone?

Enduring National Strategic Drivers

Astrophysics is humankind's scientific endeavor to understand the universe and our place in it.


+ SMEX/MO (2025), MIDEX/MO (2028), etc.
Formulation
Implementation
Primary Ops
Extended Ops
Spitzer
8/25/2003
WFIRST
Mid 2020s
Euclid (ESA)
2022
SXG (RSA)
7/13/2019
Webb
2021
Ariel (ESA)
2028
Chandra
7/23/1999
XMM-Newton
(ESA)
12/10/1999
TESS
4/18/2018
NuSTAR
6/13/2012
Swift
11/20/2004
Fermi
6/11/2008
IXPE
2021
XRISM (JAXA)
2022
SPHEREx
2023
Hubble
4/24/1990
ISS-NICER
6/3/2017
GUSTO
2021
SOFIA
Full Ops 5/2014
Revised November 24, 2019
+ Athena (early 2030s), LISA (early 2030s)

Outline

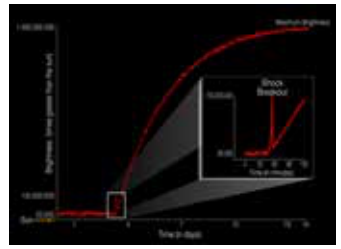
- Celebrate Accomplishments
  - Mission Milestones
- Committed to Improving
  - Building an Excellent Workforce
  - Research and Analysis Initiatives
- Program Update
  - Research & Analysis, Technology, Fellowships
  - ROSES-2020 Preview
- Missions Update
  - Operating Missions and Senior Review
  - Webb, WFIRST
  - Other missions
- Planning for the Future
  - FY20 Budget
  - Project Artemis
  - Supporting Astro2020
  - Creating the Future

NASA Astrophysics Celebrate Accomplishments

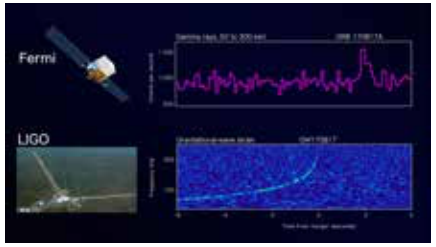
https://www.nasa.gov/2019

NASA Astrophysics Top Science Headlines
from the past four years (as selected by the NASA HQ staff)

Kepler is first to detect the shock breakout from a supernova
2016 Mar 21

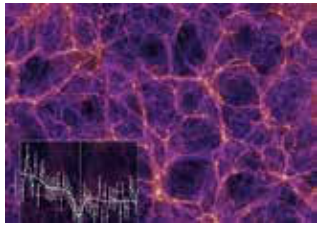


Spitzer detects seven Earth-sized planets orbiting TRAPPIST-1
2017 Feb 22

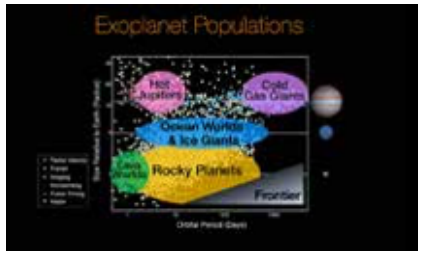


Fermi detects the gravitational wave source, kilonova GW70817
2017 Oct 6

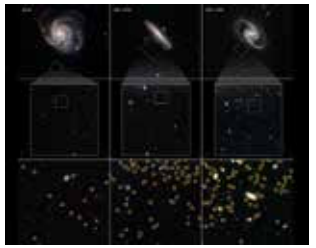
Kepler discovers that exoplanets are ubiquitous
2018 Oct 30



Chandra finds the missing mass in the warm interstellar medium
2019 Feb 14



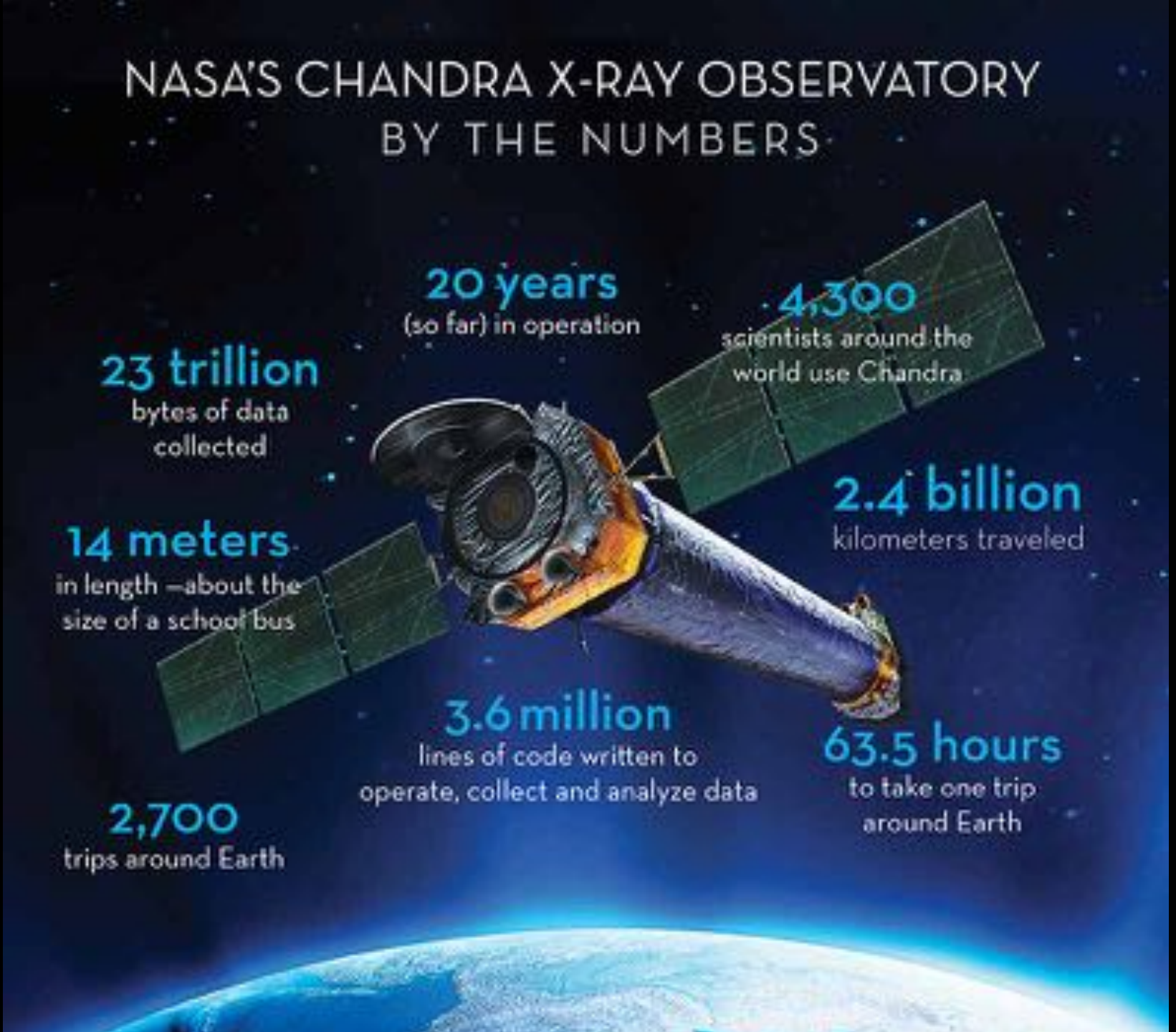
Hubble measurement of H0 disagrees with CMB measurement
2019 Jul 16



Hubble detects water in the atmosphere of a HZ exoplanet
2019 Sep 13

Does not include announcements from this meeting

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



https://chandra.harvard.edu/20th/

After 16.5 yrs of science exploration on the infrared cosmic frontier as one of NASA's Great Observatories, Spitzer will end 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.

NASA TV Press conference: January 22, 2020

Spitzer Space Telescope

Spitzer enabled discovery near and far, to the edge of the universe, yielding 8,700+ 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

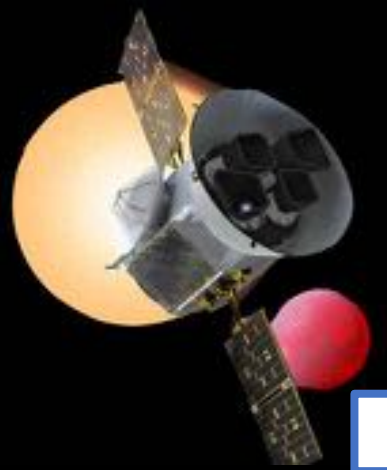
Spitzer's Scientific Legacy – Mon Jan 6 @ 10:00 AM in Room 320

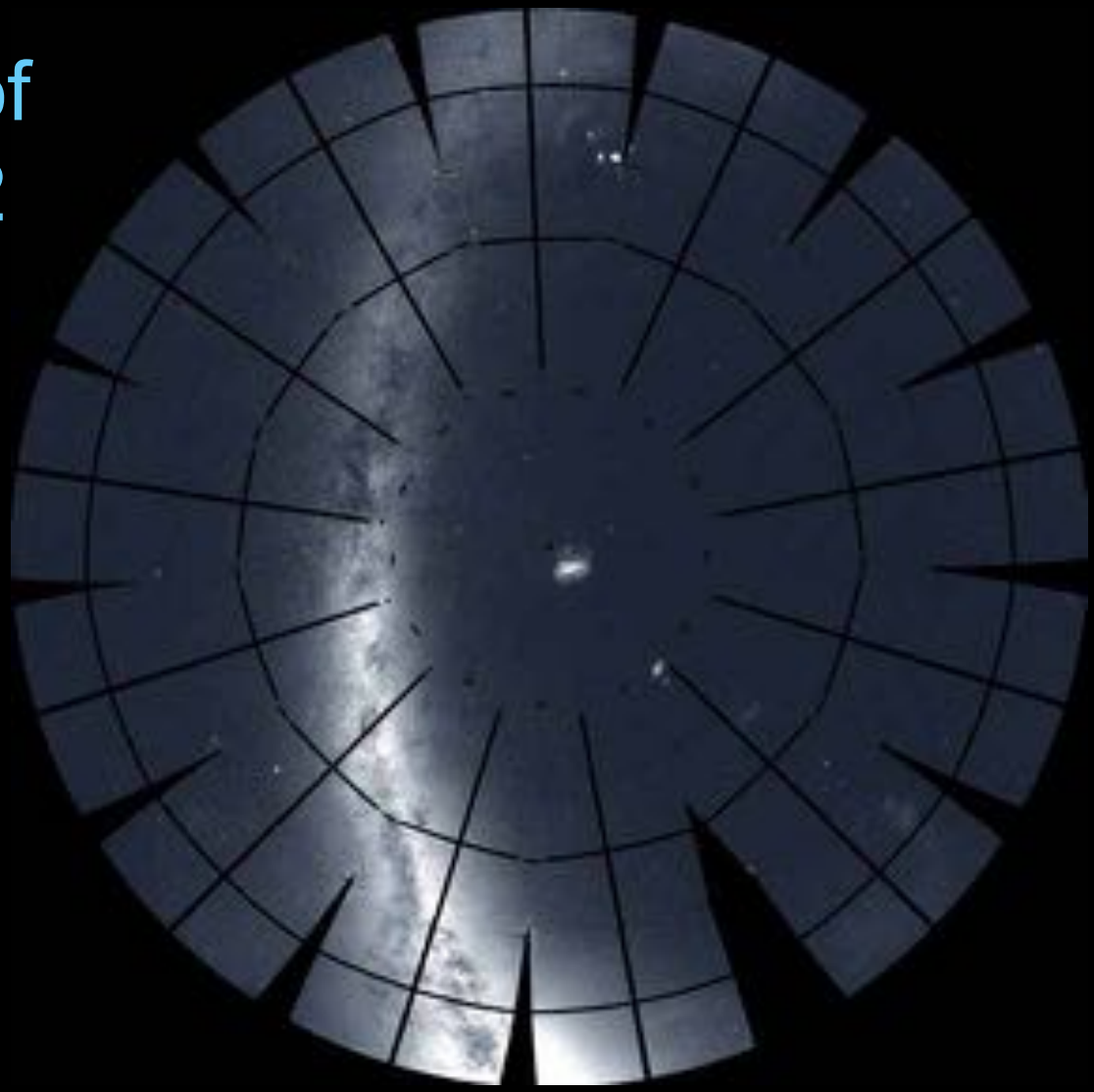
TESS Completes First Year of Prime Mission, Begins Year 2

1414 planet candidates
  34 confirmed planets
  + many discoveries in astrophysics
36 peer-reviewed publications
  +51 more submitted

Successful Guest Investigators Program
Cycles 1 and 2 for Prime Mission

Extended mission approved!
Cycle 3 proposal deadline 1/16/2020





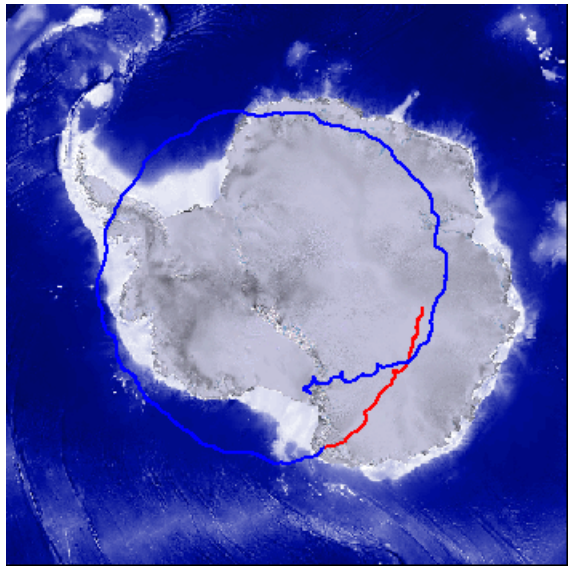
TESS observed southern hemisphere in Yr 1
Currently observing northern hemisphere for Yr 2
Current Sector: 18 of 26 in Prime Mission
Data from Sectors 1-16 all publicly available at MAST

TESS Town Hall – Mon Jan 6 @ 5:30 PM in Room 306AB

2019-2020 Antarctic Balloon Campaign

The Super Trans-Iron Galactic Element Recorder (SuperTIGER) instrument is used to study the origin of cosmic rays and was launched on Dec. 15, 2019. (Photo courtesy SuperTIGER team)

(Video courtesy SuperTIGER team)



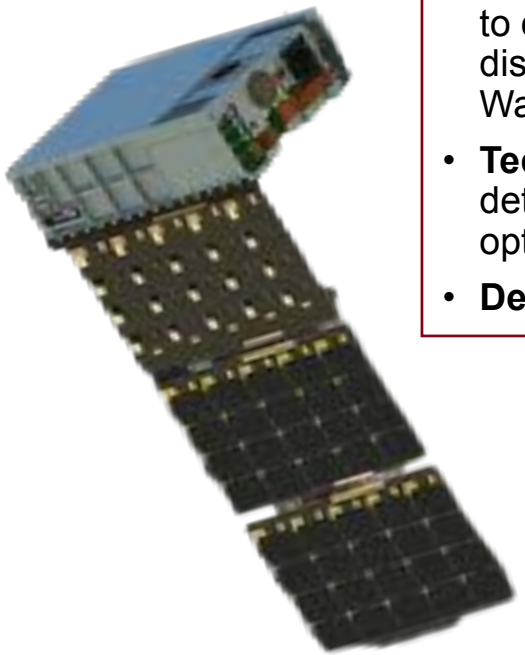
https://www.csbf.nasa.gov/antarctica/ice.htm

- **Upcoming balloon campaigns**: Winter 2019-2020 Antarctica, Spring 2020 New Zealand, Summer 2020 Palestine TX, Fall 2020 Fort Sumter NM, Winter 2020-2021 Antarctica

- **Upcoming sounding rocket campaigns**: 2020 White Sands Missile Range NM, 2021 Australia

NASA Astrophysics CubeSats

The Astrophysics Division is investing approximately $5M per year in a CubeSat initiative.



- **HaloSat,** PI: Phil Kaaret, U. Iowa
- **Science Objectives:** HaloSat is mapping soft X-ray oxygen line emission across the sky in order to constrain the mass and spatial distribution of hot gas in the Milky Way.
- **Technologies:** BCT S/C, COTS detectors, collimators with no optics.
- **Deployed**: Jul 13, 2018, from ISS

259 Special Session - Astrophysics Results from CubeSats and SmallSats – Mon Jan 6 @ 2:00 PM in Room 317B

Roman Technology Fellowship Program

- 19 current and recent fellows
- Typically in academia and National Laboratories
- Budget stable at about $1.3 M per year
- $300 K in startup funds for each fellow, over 3 years

Dr. Nancy Grace Roman
1925-2018

RTF fellows at the RTF Special Session held at the AAS meeting in June 2018: From the left: Erika Hamden (Caltech/U. Arizona), Cullen Blake (U. Pennsylvania), Brian Fleming (U. Colorado), and Abigail Vieregg (U. Chicago)

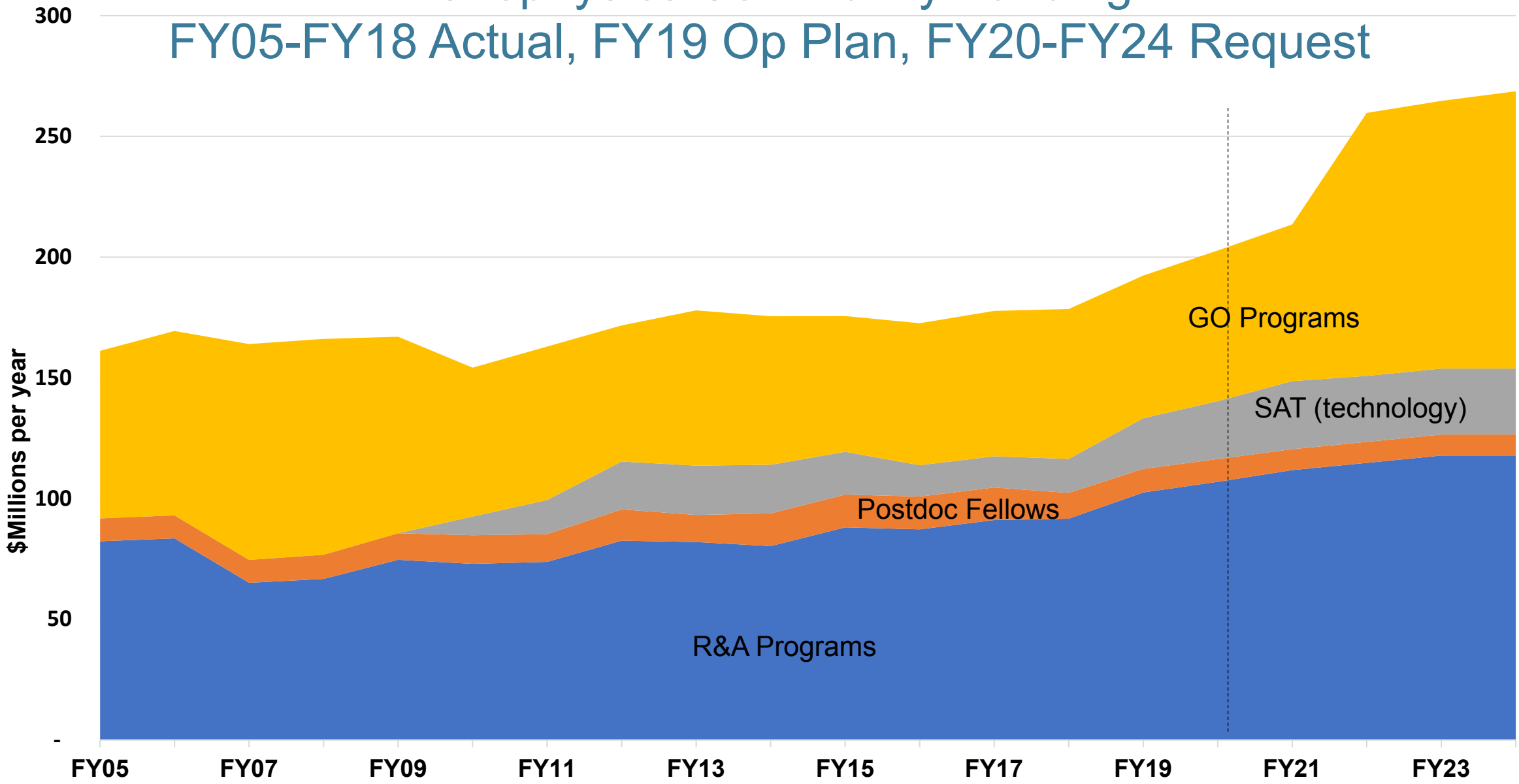
2019 Roman Technology Fellows selected in November 2019 (ROSES-2018):

Regina M. Caputo
(Ph.D. 2011), NASA-GSFC, Gamma-ray and Cosmic-ray astrophysics

Sarah N. Heine
(Ph.D. 2014), MIT, Bragg Reflector Optics and Gratings for Polarimetry

Gregory N. Mace
(Ph.D. 2014), UT Austin, Advanced Optics and Spectroscopy Applications

Astrophysics Community Funding
FY05-FY18 Actual, FY19 Op Plan, FY20-FY24 Request



Astrophysics Strategic Planning

To be updated in 2020 (per GPRAMA)

Astro2020 Decadal Survey underway

2018 update includes:
- Independent reviews of Webb & WFIRST
- Planning for 2020 Decadal Survey

https://science.nasa.gov/astrophysics/documents

NASA Events at the 235th AAS Meeting

Friday, January 3

NASA ExoPAG – 8:30 AM; Hilton Hawaiian Village - Coral Ballroom

Saturday, January 4

NASA ExoPAG – 8:30 AM; Hilton Hawaiian Village - Coral Ballroom
NASA Joint PAG – 1:00 PM; Hilton Hawaiian Village - Coral Ballroom
NASA PhysPAG – 3:00 PM; Hilton Hawaiian Village – Rainbow Room
NASA COPAG – 3:00 PM; Hilton Hawaiian Village - Coral Ballroom

Sunday, January 5

Webb Proposing: Integral Field Unit – 9:30 AM; Room 307B
NASA Great Observatories SAG – 9:30 AM; Room 323A
NASA Town Hall – 12:45 PM; Ballroom AB
Lynx X-ray Observatory – 1:00 PM; Room 303A
Parker Solar Probe – 2:00 PM; Room 313 C
So You Think You Want to be a NASA Mission Principal Investigator? – 2:00 PM; Room 323A
James Webb Space Telescope Town Hall – 6:30 PM; Room 313A

Monday, January 6

Origins Space Telescope – 9:00 AM; Room 307B
Webb Proposing: Grism Observing – 9:30 AM; Room 303B
Spitzer's Scientific Legacy – 10:00 AM; Room 320
CubeSats and SmallSats – 2:00 PM; Room 317B
LUVOIR Surveyor – 2:00 PM; Room 301A
TESS Town Hall – 5:30 PM; Room 306AB
STScI Town Hall – 7:00 PM; Room 313A

Monday, January 6

NASA Postdoctoral Program Meet and Greet – 7:00 PM; Sheraton Waikiki - Kohala/Kona Room

Tuesday, January 7

NASA PhysPAG Gravitational Wave SIG – 9:30 AM; Room 303A
NASA COPAG IR SIG/OST – 9:30 AM; Room 304AB
Webb Proposing: NIRSpec Micro-Shutter – 9:30 AM; Room 323A
NASA Univ of Learning & Education Efforts – 10:00 AM; Room 321A
NASA PhysPAG MMA SAG – 1:00 PM; Room 303A
NASA Science Engagement Opportunities – 1:00 PM; Room 303B
Habitable Exoplanet Observatory – 1:30 PM; Room 306AB
LISA Preparatory Science – 2:00PM; Room 323B
NASA Cosmic Dawn SAG – 2:00 PM; Room 323C
SOFIA Molecular Clouds and ISM Science – 2:00 PM; Room 324
Visualization of Research Data for the Public Presented by NASA's Universe of Learning – 5:30 PM: Room 307B
SOFIA Town Hall – 7:00 PM; Room 313B

Wednesday, January 8

NASA PhysPAG X-ray SIG – 9:00 AM; Room 303A
Plenary Lecture: The Future of Infrared Astronomy in the Context of Spitzer, SOFIA, and JWST – 11:40 AM;
Multi-Messenger Astrophysics Town Hall – 12:45 PM; Room 313 A
NASA PhysPAG Gamma Ray SIG – 1:00 PM; Room 303A
The NASA Decadal Studies – 2:00 PM; Room 318A

NASA Astrophysics Committed to Improving


OPEN
COMPETITION
COMMUNITY
GUIDANCE
EFFECTIVE
PARTNERSHIPS
BALANCED
PORTFOLIO
PRINCIPLES
OF NASA SCIENCE
OPEN
ACCESS
COMMUNITY
INVESTMENT
LESSONS
LEARNED
PUBLIC
COMMUNICATION

[1] https://science.nasa.gov/researchers/new-pi-resources [2] https://science.nasa.gov/researchers/pi-launchpad

Building An Excellent Workforce

NASA achieves excellence by relying on diverse teams, both within and external to NASA, to most effectively perform NASA's work

NASA Science Mission Directorate

- Developed a PI resources webpage at https://science.nasa.gov/researchers/new-pi-resources
- Introduced pre-reviews of mission peer review panels to ensure diversity
- Added a code of conduct requirement for SMD-funded conferences to ROSES 2019
- Included career development positions and associated evaluation criteria as part of AOs
- Implemented a Code of Conduct and implicit bias training for all ROSES peer reviews
- Adopting dual anonymous reviews for all GO programs, and piloting them for other R&A programs, following successful demonstration by STScI for Hubble GO program
- Presented a national symposium by SMD AA Thomas Zurbuchen on lessons learned regarding mission proposal success
- Conducting workshops for potential mission PIs, see https://science.nasa.gov/researchers/pi-launchpad
- Is developing award terms and conditions mandating reporting harassment, similar to NSF's
- Is presenting information sessions at major conferences, including the Honolulu AAS Meeting, to support people developing their first proposal
- Tasked the Astro2020 Decadal Survey to "Assess the state of the profession. Identify areas of concern and importance [regarding] the future vitality and capability of the astronomy and astrophysics work force. Where possible, provide specific, actionable and practical recommendations to the agencies"

NASA is looking forward to specific, actionable, and practical recommendations

Inspiring Future Leaders

- Achieve excellence by relying on diverse teams, both within and external to NASA, to most effectively perform SMD's work
- Attract and retain talent by promoting a culture that actively encourages diversity and inclusion and removes barriers to participation
- Encourage development of future leaders, including the next generation of mission principal investigators, through targeted outreach and hands-on opportunities
- Support early-career scientists to build careers working with NASA
- Engage the general public in NASA Science, including opportunities for citizen scientists

So You Think You Want to be a NASA Mission Principal Investigator? – Sun Jan 5 @ 2:00 PM; Room 323A

Mission Principal Investigator Development

Seek to increase the diversity of mission principal investigators and develop the next generation of mission leaders to ensure that new ideas and mission concepts are brought forward

- NASA Science has:
  - Developed a consolidated PI resources webpage at https://science.nasa.gov/researchers/new-pi-resources, which also includes SMD presentation on lessons learned from past selections
  - Introduced a pre-reviews of mission peer review panels to ensure diversity and reduce conflicts of interest
  - Included career development positions and associated evaluation criteria as part Discovery and New Frontiers AOs
- Upcoming activities include:
  - Making videos and slides from the November 2019 workshop available
  - Looking to host two Launchpad Workshops per year

So You Think You Want to be a NASA Mission Principal Investigator? – Sun Jan 5 @ 2:00 PM; Room 323A

NASA Astrophysics Diversity and Inclusion

The NASA Astrophysics Division is actively taking steps to advance diversity, inclusion, and equal opportunity in the NASA workforce and among NASA grantee institutions.

NASA Astrophysics is committed to:

- Setting the expectancy of diversity and inclusion in the composition of: proposal teams, peer review panels, science and technology definition teams, and mission and instrument teams.
- Recruiting diversity on NASA-selected groups (e.g., advisory groups, peer review panels, science teams).
- Recruiting a diverse Astrophysics Division staff.
- Working with the NASA Office of the Chief Scientist and our peer review contractors to address unconscious bias in peer reviews.
- Establishing a Code of Conduct for peer review panel chairs and members
- Sharing best practices in peer reviews with other agencies.
- Observing the demographics of R&A proposers and awardees as an indicator of issues.

The demographics of R&A proposers and awardees – we notice that:

- The inferred gender balance of awardees does reflect that of proposers.
- The inferred gender balance of proposers does not always reflect that of the community.

Science Engagement

Vision: As a part of SMD's Science Activation (SciAct) program, Astrophysics brings the excitement of the science from its portfolio to provide content to help learners of all ages "do" science.

New NASA Science Engagement Opportunities – Tue Jan 7 @ 1:00 PM; Room 303B

- Hear from National Academy committee members who assessed NASA's SciAct program and from NASA SMD, including Kristen Erickson, Paul Hertz, and Hashima Hasan
- Find out about NASA's Universe of Learning and how you can participate in SciAct as a subject matter expert; come to splinter session or contact Denise Smith (STScI)
- Learn about opportunities to propose citizen science projects to NASA; come to splinter session or contact Marc Kuchner (GSFC)

Astrophysics social media sites have been consolidated under @NASAUniverse; cross cutting NASA science is consolidated under @NASAExoplanets, @NASASolarSystem, @NASASun, etc.

Research and Analysis Initiatives

Dual Anonymous Peer Review

- SMD is strongly committed to ensuring that review of proposals is performed in an equitable and fair manner that reduces the impacts of any unconscious biases

High-Risk/ High-Impact (HR/HI)

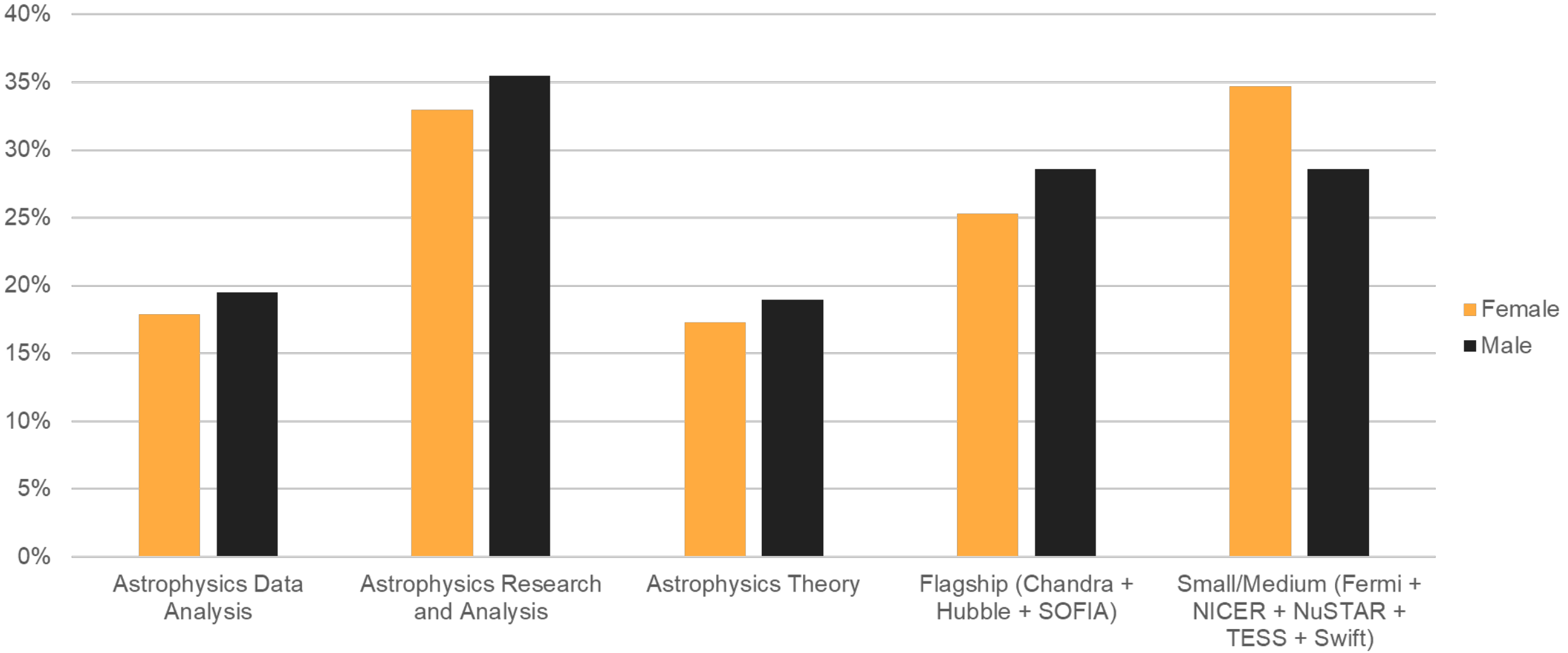
- To reinforce SMD's interest in High-Risk/High-Impact research, a special review process will be implemented in ROSES 2020 to review and select HR/HI proposals

Proposal Selection Metrics for ROSES 2018

- Overall, just under 50% of selections featured new PIs
- Majority of division selection rates were between 25 – 30%, and we are continuing to evaluate

https://science.nasa.gov/researchers/dual-anonymous-peer-review

Success Rate by (Inferred) Gender in Astrophysics Proposal Competitions (Past 5 Cycles)



Dual-Anonymous Peer Reviews in Astrophysics

NASA is strongly committed to ensuring that the review of proposals is performed in an equitable and fair manner that reduces or eliminates unconscious bias.

To this end, motivated by a successful pilot program conducted for the Hubble Space Telescope, all Astrophysics General Observer / General Investigator (GO/GI) proposals will be evaluated using dual-anonymous peer review.

In addition, the NASA Science Mission Directorate will conduct pilot programs in dual-anonymous peer review for non-GO/GI ROSES program elements in 2020.

- One ROSES program element from each Division will be conducted in 2020 using dual-anonymous peer review.
- Proposals submitted to the Astrophysics Data Analysis Program and the Habitable Worlds Program in 2020 will be evaluated using dual-anonymous peer review.

The Astrophysics Division is taking the following steps to ensure a smooth transition to dual-anonymous peer review:

- Create written guidance on how to write an anonymized proposal.
- Host a virtual Town Hall in Spring 2020 to discuss dual-anonymous peer review with the community.
- Run training sessions for panel levelers who provide guidance during dual-anonymous panel deliberations.
- Ensure that mission program staff are available to answer help desk questions about writing anonymized proposals during the run-up to proposal submission.

https://science.nasa.gov/researchers/dual-anonymous-peer-review

Rollout of Dual-Anonymous Reviews

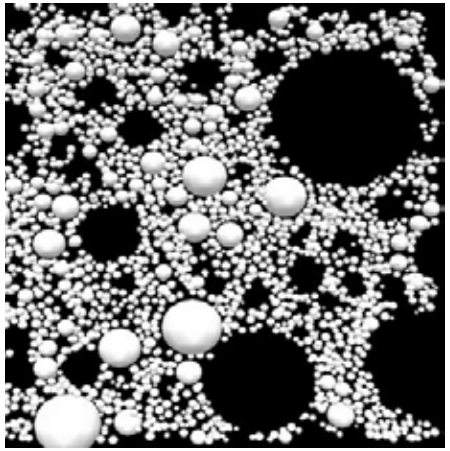
Format	Program	Proposal due date
Traditional	NICER Cycle 2	11/13/2019
Traditional	TESS Cycle 3	1/16/2020
Dual-Anonymous	NuSTAR Cycle 6	1/24/2020
Traditional	Fermi Cycle 13	2/19/2020
Dual-Anonymous	Hubble Cycle 28	3/4/2020
Traditional	Chandra Cycle 22	3/17/2020
Dual-Anonymous	Webb Cycle 1	5/1/2020
Dual-Anonymous	ADAP	5/14/2020
Dual-Anonymous	Swift Cycle 17	~9/2020
Dual-Anonymous	NICER Cycle 3	~11/2020
Dual-Anonymous	TESS Cycle 4	~1/2021
Dual-Anonymous	NuSTAR Cycle 7	~1/2021
Dual-Anonymous	Fermi Cycle 14	~2/2021
Dual-Anonymous	Hubble Cycle 29	~3/2021
Dual-Anonymous	Chandra Cycle 23	~3/2021

Request for Information:

Research That Falls in Gap between current SMD Solicitations

- Release Date: Dec 2, 2019 (Solicitation: NNH20ZDA003L)
- Response Date: Jan 31, 2020
- NASA SMD is soliciting information on research aligned with agency mission and SMD's Science Plan but falls in a gap between current solicitations, possibly because it's interdisciplinary or interdivisional
- Responses will be used by NASA to inform decision as to whether portfolio of current program elements in ROSES needs to be modified and/or expanded to provide the proper avenue for such research
- Full text of RFI and response instructions on the NSPIRES website

Strategic Data Management



- SMD will be implementing changes to enable open data, open source code, and open model
- Informed by community input through multiple workshops, RFI, and NASEM reports
- Recognize that this will be a step wise process with the first changes coming in ROSES 2020 and upcoming Senior Reviews
- Periodic evaluation to ensure effectiveness and consistency with current best practices
- Additional information on SMD's data activities is available at: https://science.nasa.gov/researchers/science-data

Keep Informed about NASA

NSPIRES mailing list – information about NASA solicitations

https://nspires.nasaprs.com/

Cosmic Origins mailing list, Exoplanet Exploration mailing list, Physics of the Cosmos mailing list – information about NASA missions and science

https://cor.gsfc.nasa.gov/cornews-mailing-list.php

https://exoplanets.nasa.gov/exep/exopag/announcementList/

https://pcos.gsfc.nasa.gov/pcosnews-mailing-list.php

NASA Astrophysics Federal Advisory Committees

Astrophysics Advisory Committee (APAC)
https://science.nasa.gov/researchers/nac/science-advisory-committees/apac

NAS Committee on Astronomy and Astrophysics (CAA)
http://sites.nationalacademies.org/bpa/bpa_048755

Astronomy and Astrophysics Advisory Committee (AAAC)
https://www.nsf.gov/mps/ast/aaac.jsp

Sign up to be a panel reviewer:

https://science.nasa.gov/researchers/volunteer-review-panels

Why Volunteer to Serve on a NASA Peer Review Panel?

- Personal professional development:
  - See how the whole review process works
  - Learn what constitutes excellent proposals
  - Network with your professional colleagues and NASA scientific staff
- Institutional achievement:
  - Improve at competing for NASA money
  - Increase knowledge of NASA's educational programs and research technology
- Investment in the future:
  - Help select the most transformative science
  - Ensure that all proposals receive a fair and competent review
- Sign up to be a panel reviewer:

  https://science.nasa.gov/researchers/volunteer-review-panels

Join the Astrophysics Team at NASA Headquarters

NASA seeks visiting Ph.D.-level scientists to serve as Program Scientists in the Astrophysics Division at NASA Headquarters in Washington, DC. With a budget of $1.5 billion annually, the Division is responsible for the nation's space-based astrophysics program.

NASA Program Scientists

- Manage scientific research grants programs
- Serve as the Headquarters science lead for missions
- Implement NASA's response to the 2020 Decadal Survey
- Gain insight into Federal astrophysics policy and programs and the proposal review process
- Run scientific programs with multimillion-dollar budgets

Visiting appointments last two years with renewals up to six years.

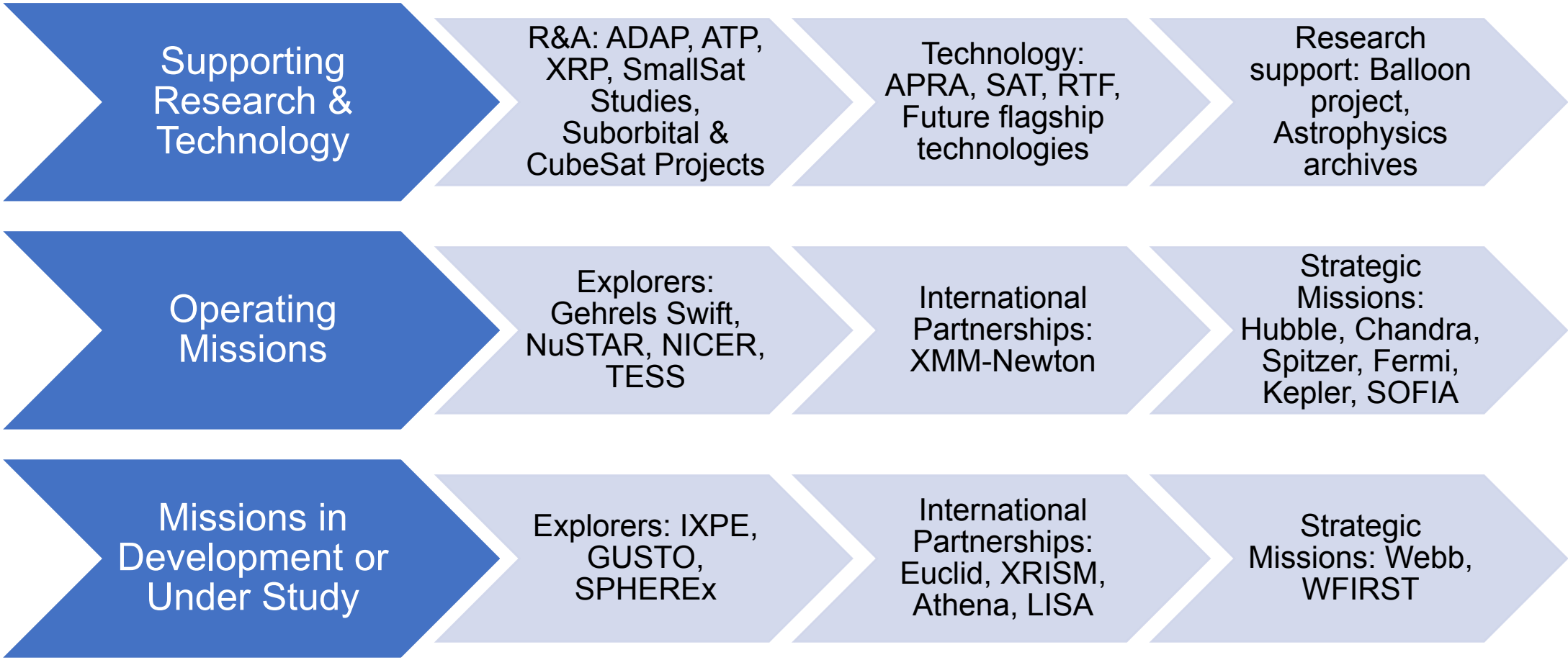
Positions are available from June 2020, though the start date is flexible. Applicants should email a curriculum vitae and cover letter as a single PDF file ASAP but no later than March 13, 2020 to hq-astrophysics-ipasearch@mail.nasa.gov. Decisions will be made on a rolling basis. For more information about the position, please contact Dr. Valerie Connaughton at valerie.connaughton@nasa.gov.

Please feel free to speak to any of us from HQ here about this exciting opportunity.

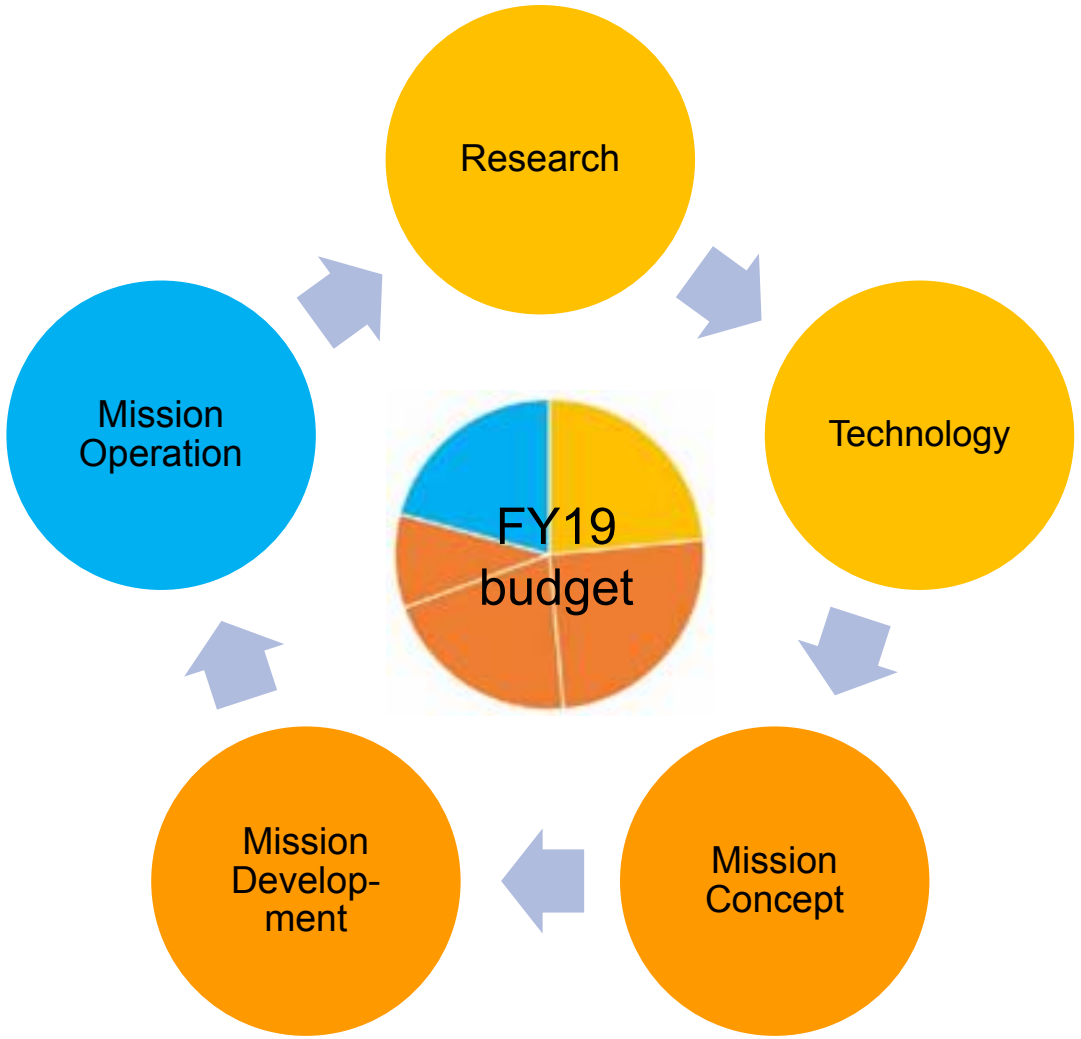
https://jobregister.aas.org/ad/330213f5

NASA Astrophysics Program Update

NASA Astrophysics Program Summary



NASA's Astrophysics Program



Large (Flagship) Missions

- Conduct compelling science that only the U.S. has the capability to lead

Medium (Probe) and Small (Explorer) Missions

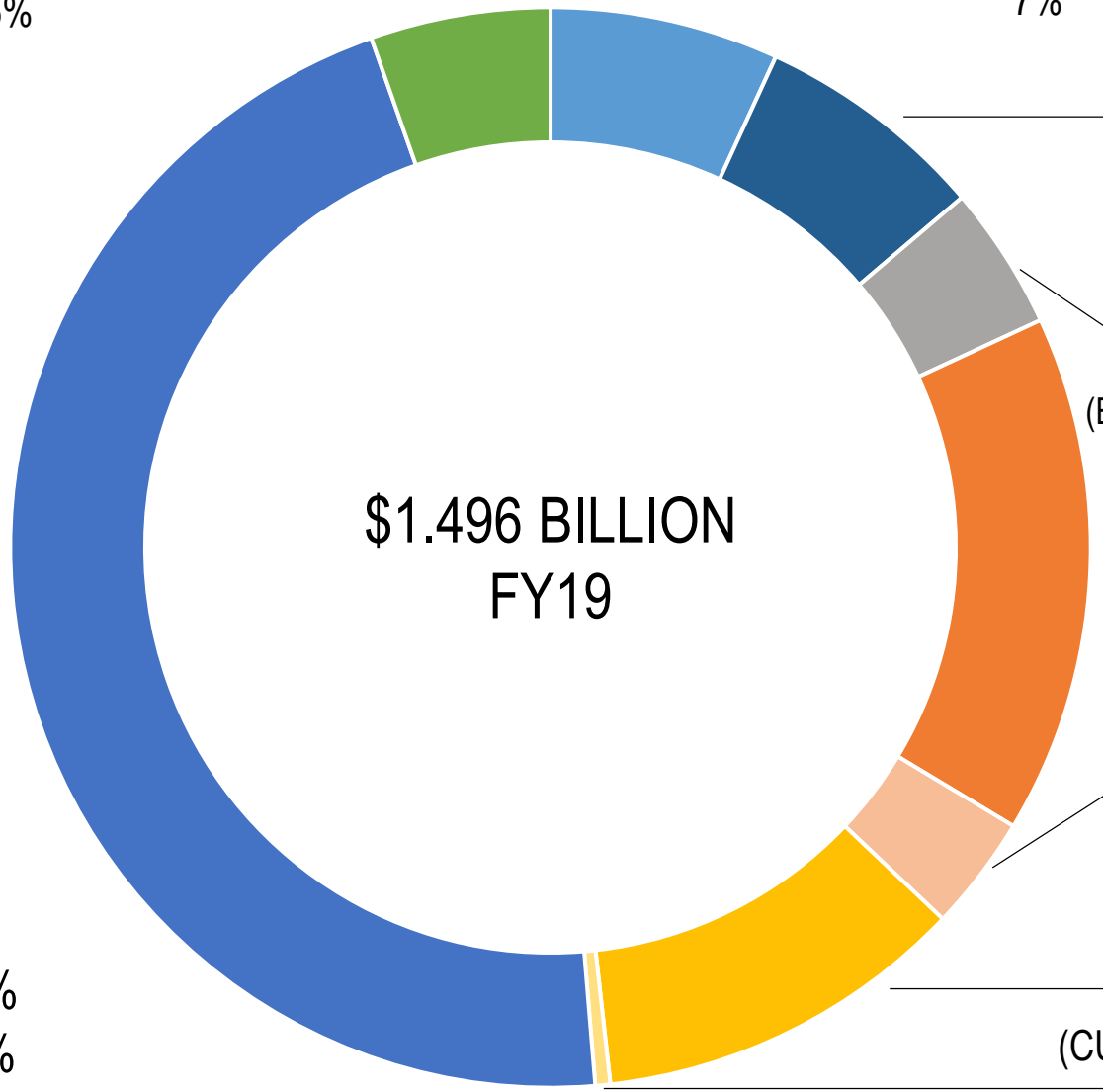
- Enable more focused or specialized capabilities and science objectives

International Partnerships

- Use scientific synergies between NASA and its international partners for a win-win outcome

Supporting Research and Technology

- Lay the foundation of the NASA science program
- Invest in the US scientific community and National capabilities
- Maximize scientific output of missions
- Develop innovative ideas and next generation technology for future missions
- Develop the next generation of scientists, engineers, and innovators



MANAGEMENT
INCL. STEM ACTIVATION
5%

RESEARCH
(ADAP, APRA, ATP, ETC.)
7%

TECHNOLOGY
(SR&T, ATHENA, LISA, ETC.)
7%

INFRASTRUCTURE
(BALLOON PROGRAM, ARCHIVES, ETC.)
4%

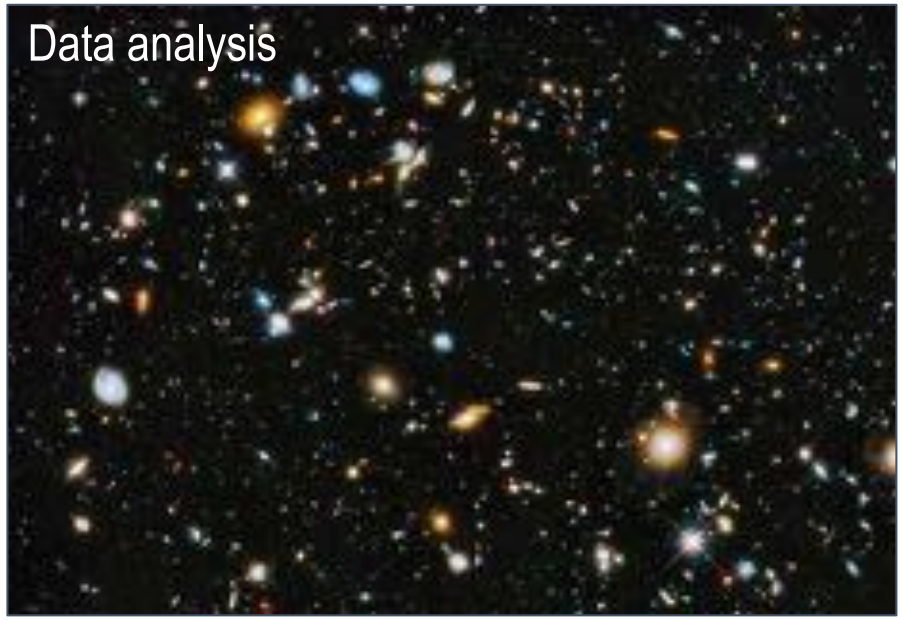
OP. MISSIONS
(INCL. GO PROGRAMS)
19%

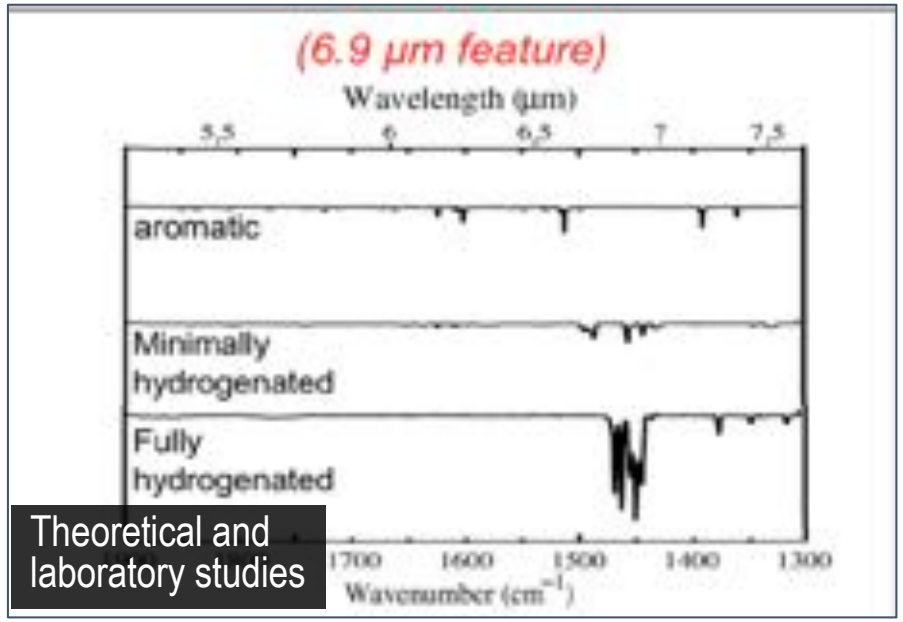
EXPLORERS
(CURRENT AND FUTURE, INCL. GO)
11%

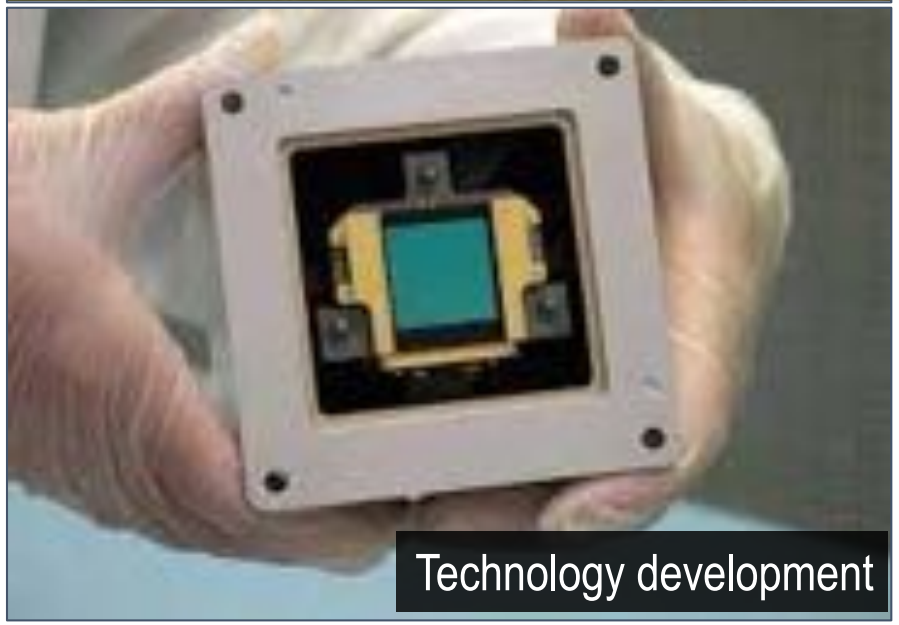
DEVELOPMENT
(WEBB, WFIRST)
46%

Quick Summary
Community support: 20%
Operating missions: 20%
Building missions: 55%
Management: 5%

Supporting Research and Technology







RESEARCH

~10,000 U.S. Scientists Funded
~3,000 Competitively Selected Awards
~$600M Awarded Annually

TECHNOLOGY DEVELOPMENT

~$500M Invested Annually

SMALLSATS/ CUBESATS

36 Science Missions
20 Technology Demos

EARTH-BASED INVESTIGATIONS

20 Airborne Missions
8 Global Networks

SOUNDING ROCKETS

16 Science Missions
5 Tech/Student Missions

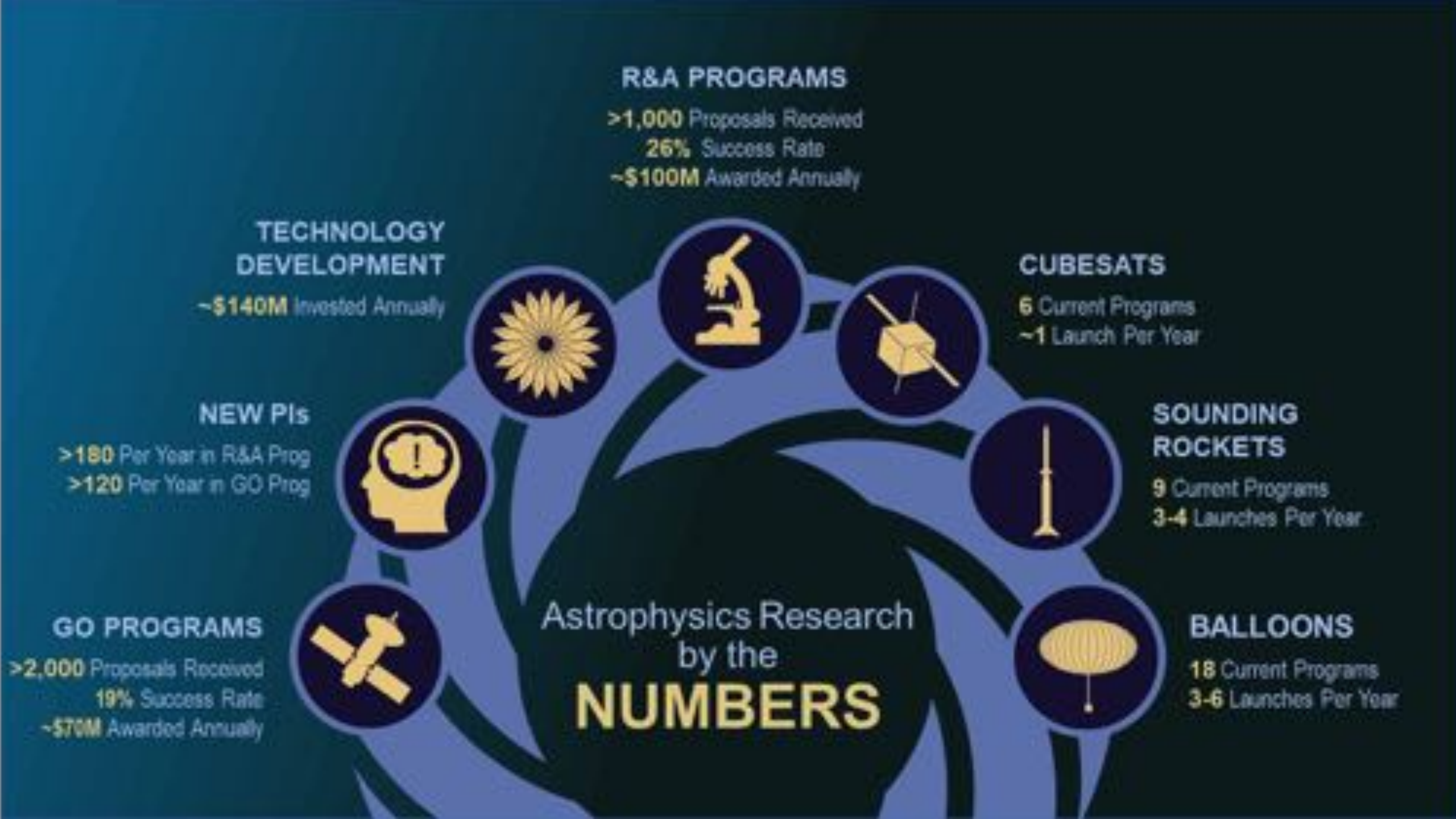
Science by the NUMBERS

SPACECRAFT

98 Missions
82 Spacecraft

BALLOONS

10 Science Missions
4 Technology/Student


R&A PROGRAMS
>1,000 Proposals Received
26% Success Rate
~$100M Awarded Annually
TECHNOLOGY DEVELOPMENT
~$140M Invested Annually
CUBESATS
6 Current Programs
~1 Launch Per Year
NEW PIs
>180 Per Year in R&A Prog
>120 Per Year in GO Prog
SOUNDING ROCKETS
9 Current Programs
3-4 Launches Per Year
GO PROGRAMS
>2,000 Proposals Received
19% Success Rate
~$70M Awarded Annually
BALLOONS
18 Current Programs
3-6 Launches Per Year
Astrophysics Research by the
NUMBERS

Astrophysics Research Elements

ROSES-20 Programs

Supporting Research and Technology

- Astrophysics Research & Analysis (APRA)
- Strategic Astrophysics Technology (SAT)
- Astrophysics Theory Program (ATP) (biennial, not this year)
- Theoretical and Computational Astrophysics Networks (TCAN) (triennial, this year)
- Exoplanet Research Program (XRP) (cross-div)
- Roman Technology Fellowships (RTF)
- FINESST Graduate Student Research Awards

Data Analysis

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

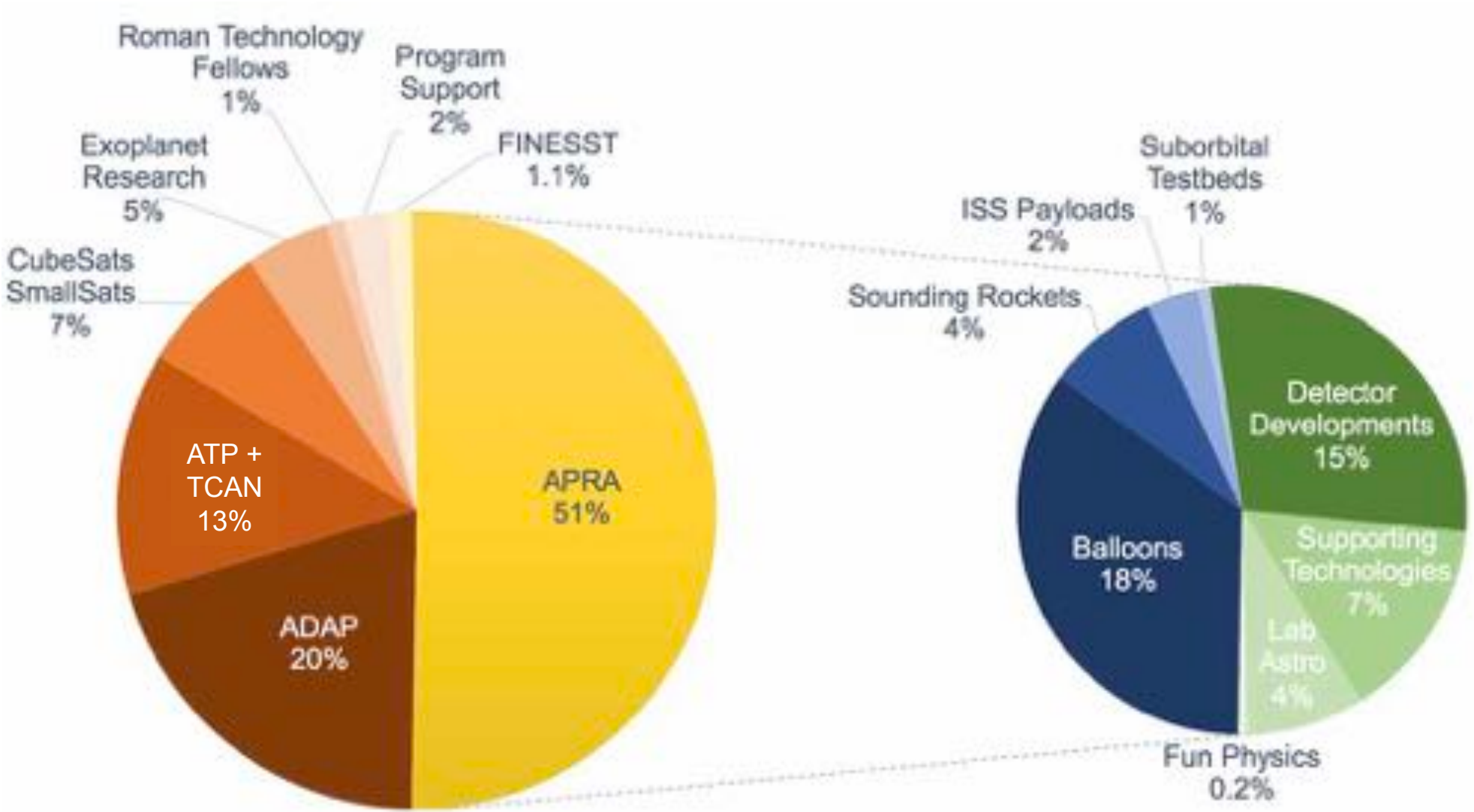
Mission Science and Instrumentation

- Sounding rocket, balloon, CubeSat, and ISS payloads solicited through APRA
- Astrophysics Science SmallSat Studies (occasional, not this year)
- XRISM Guest Scientists (one time)
- Astrophysics Explorers U.S. Participating Investigators (triennial, this year)

Separately Solicited

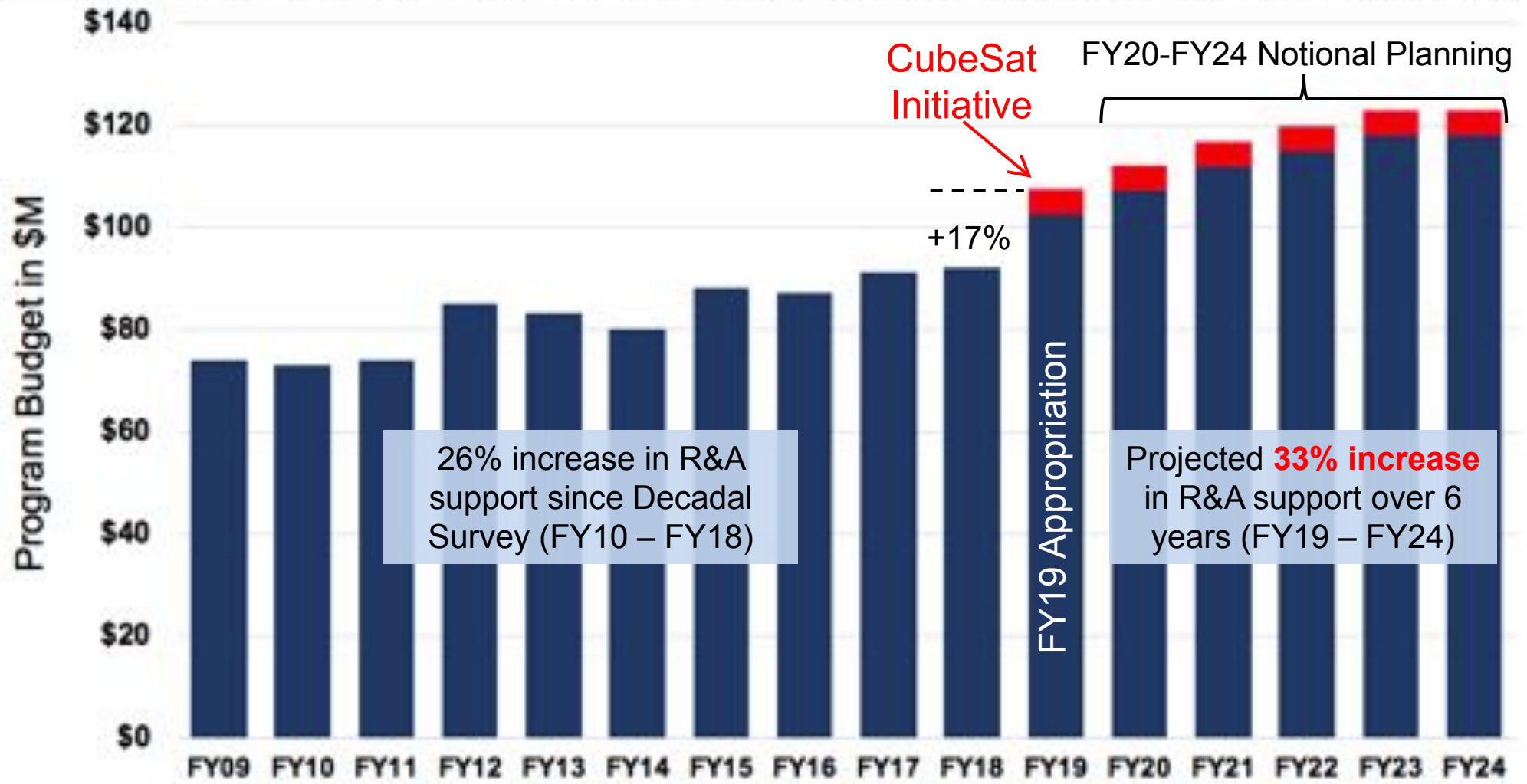
- GO/GI/Archive/Theory programs for:
  - Chandra
  - Hubble
  - SOFIA
  - Webb
- NASA Hubble Fellowship Program
- NASA Postdoctoral Program

FY19 R&A Elements
(excludes GO Programs and SAT)

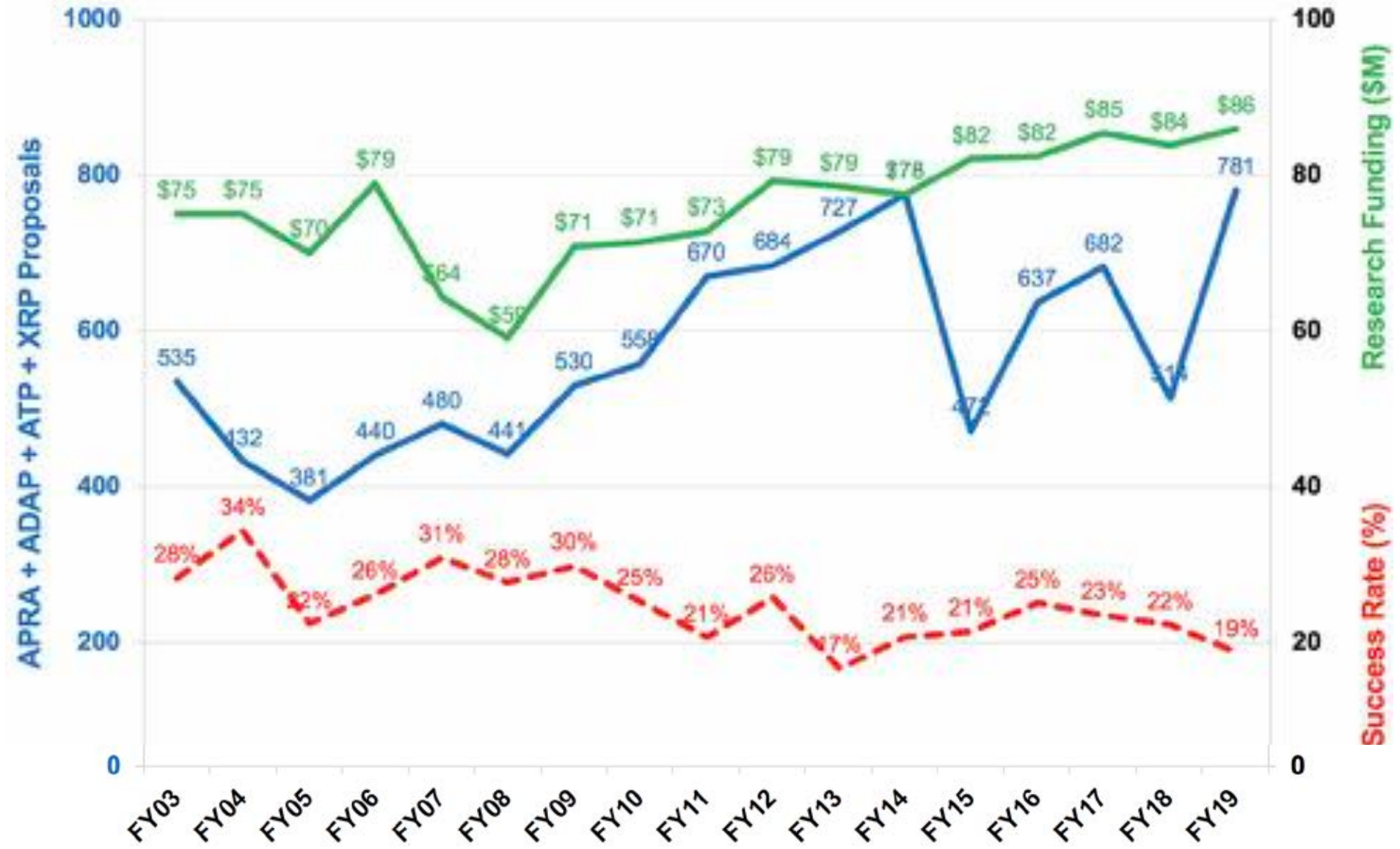


Growth in R&A Funding ($M)

Program	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
R&A	$74	$73	$74	$85	$83	$80	$88	$87	$91	$92	$103	$107	$112	$115	$118	$118
CubeSat											$5	$5	$5	$5	$5	$5
Total	$74	$73	$74	$85	$83	$80	$88	$87	$91	$92	$108	$112	$117	$120	$123	$123

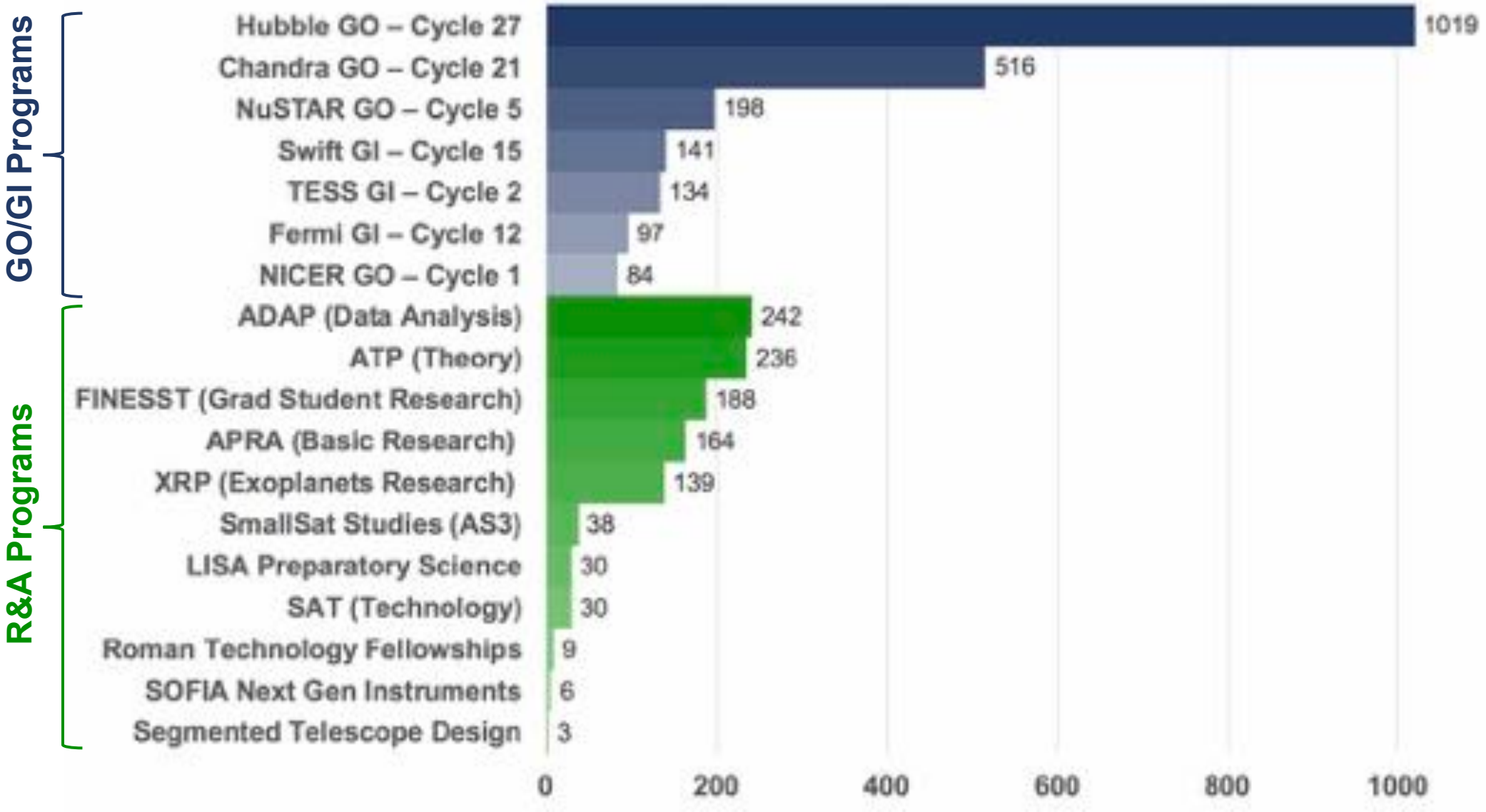


Total Number of Proposals and Average Success Rate



Total R&A funding in FY19 was $108M

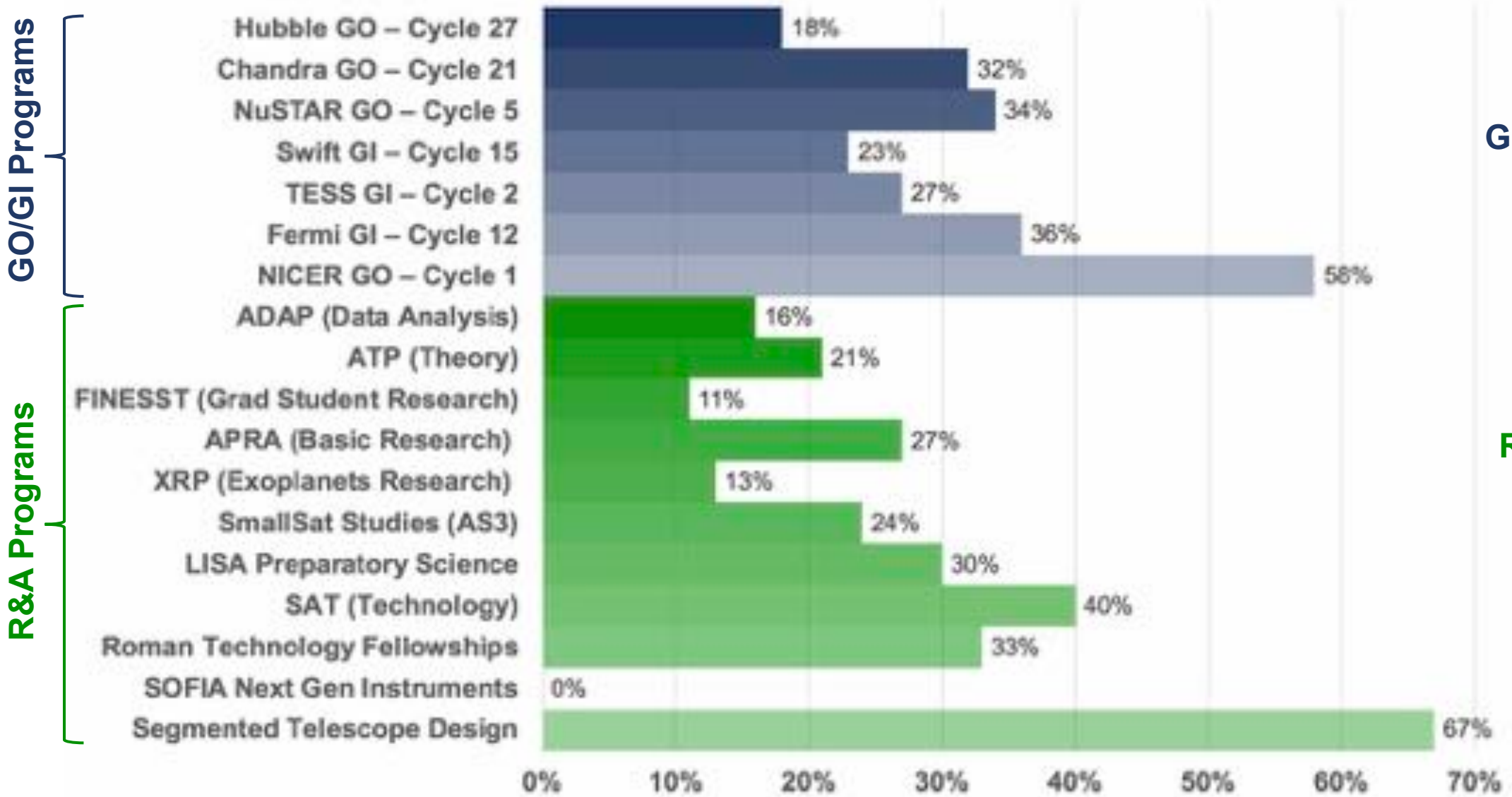
Number of Proposals



GO/GI Programs: 2190 proposals

R&A Programs: 1085 proposals

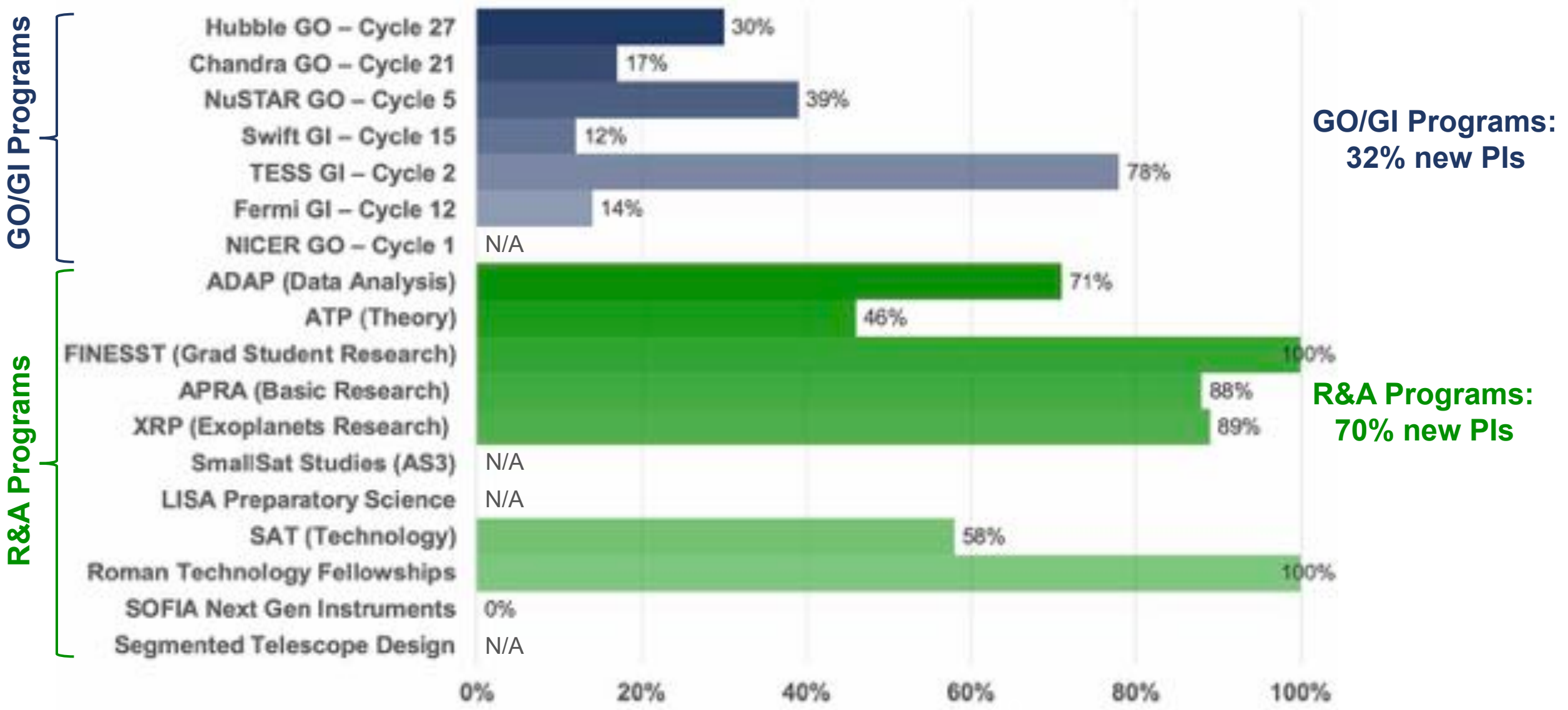
Selection Rates



GO/GI Programs: 26%

R&A Programs: 19%

New PIs (not funded by same Program within 5 Years)



Exoplanet Research Program (XRP)

Changes to the program in ROSES-19:

- Heliophysics and Earth Science joined the program
- Review managed collaboratively by all four divisions
- Selections are funding-blind (i.e. not tied to specific Divisions)
- 20 percent more proposals than last year!

Changes coming in ROSES-20:

- Consolidation of exoplanet proposals into XRP
  - Within Astrophysics (Appendix D): Exoplanet-related proposals from ADAP, ATP, etc. will move into XRP
    - Funding will move between programs to enable this
    - Exoplanet-related proposals will still be permitted in TCAN
  - Within Planetary Science (Appendix C): Exoplanet proposals in Habitable Worlds will move into XRP (better definition of the line between the two)
- Additional cross-divisional collaboration encouraged (Heliophysics and Earth Science participation, in particular)

Astrobiology Research

Research Coordination Networks
- Exoplanet System Science - NExSS
- Life Detection - NfoLD
- Prebiotic Chemistry and Early Earth Environments - PCE3
- Network for Ocean Worlds - NOW
- Earliest Cells to Multicellularity- ECM

Transition of NASA Astrobiology Institute (NAI) into Research Coordination Networks (RCNs)

The NAI concluded at the end of 2019; five RCNs will focus on different interdisciplinary science questions

Researchers may elect to become a member of one or more RCNs once they have received funding for a relevant project

New ROSES funding opportunity: Interdisciplinary Consortia for Astrobiology Research (ICAR)

Proposals that describe a multi-million dollar, five-year project with an interdisciplinary approach to a single, compelling question in astrobiology

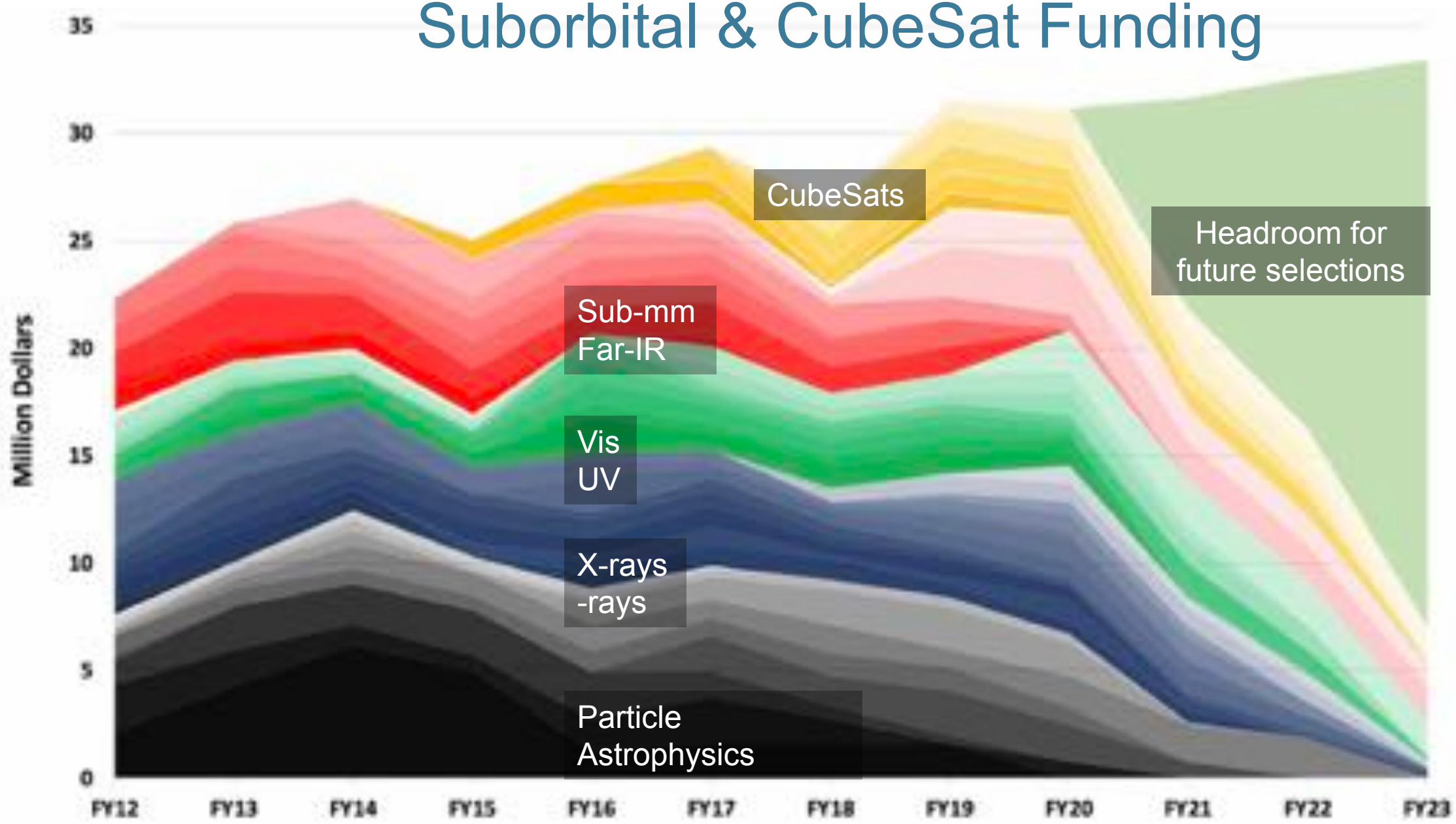
For projects larger than the scope of the individual research programs, but within the scope of the Research Coordination Networks.
Cycle 1 RCNs: NExSS, PCE3, ECM

See ROSES-19, Appendix C.23
Step 1 proposals due – January 31, 2020
Step 2 proposals due – April 3, 2020

Selected proposals will become part of the Research Coordination Network

Calls will occur every two years and will stagger RCN topics

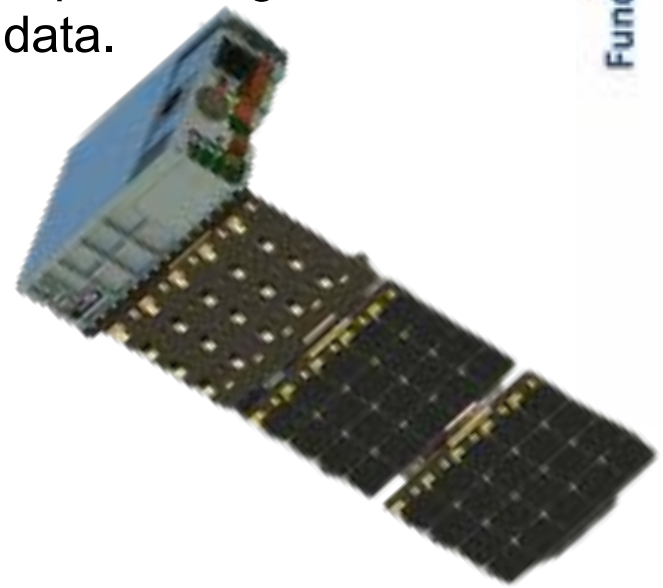
Suborbital & CubeSat Funding

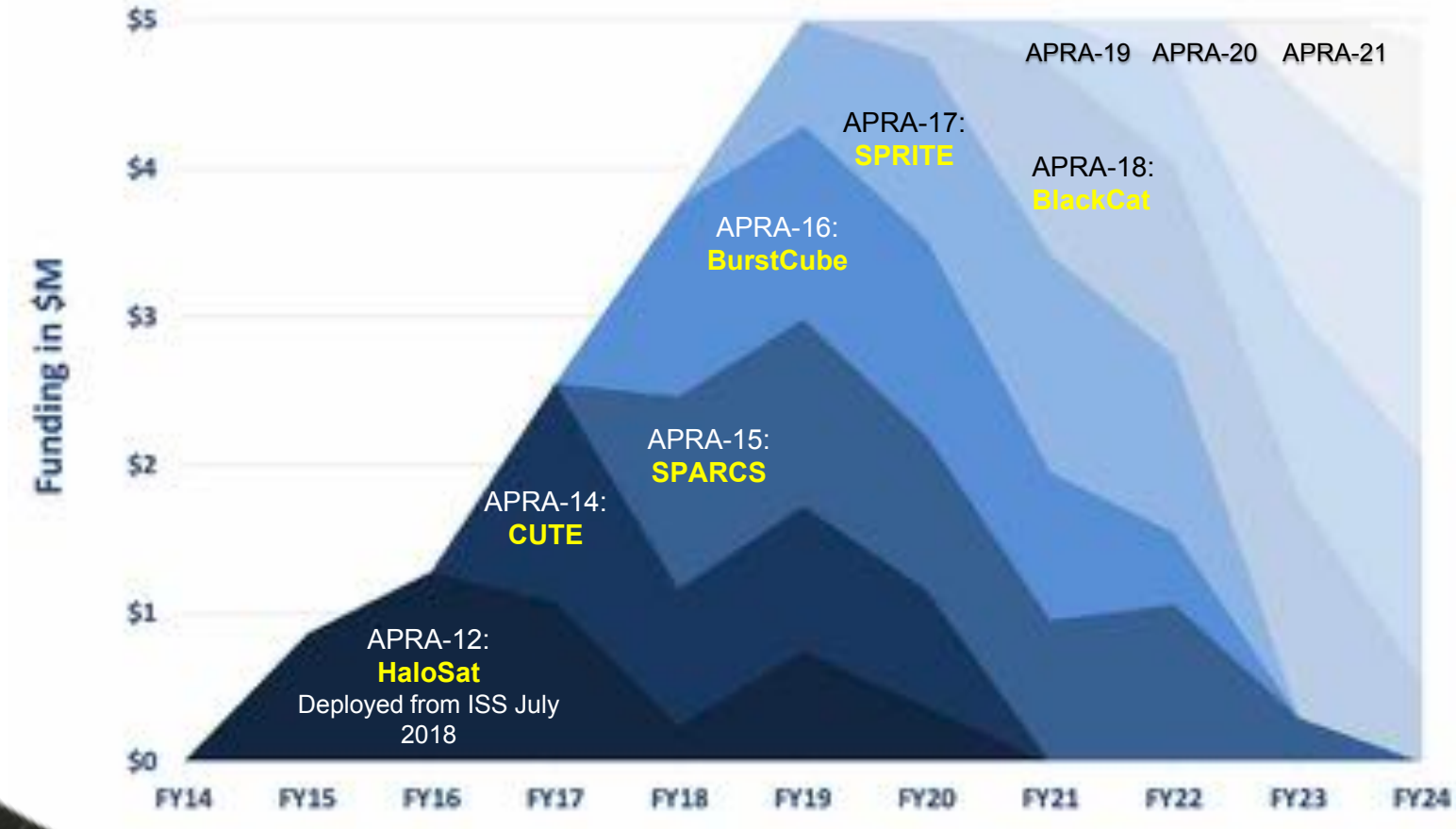


NASA's Astrophysics CubeSat Initiative

The Astrophysics Division is investing approximately $5M per year in a new CubeSat initiative.

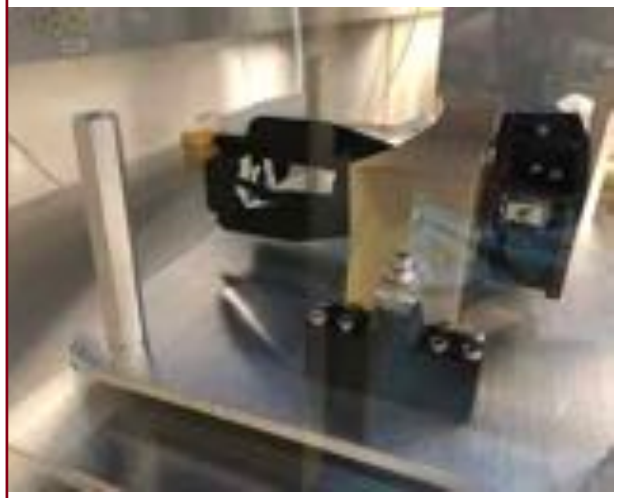
HaloSat, our first CubeSat, is in orbit and is producing excellent data.

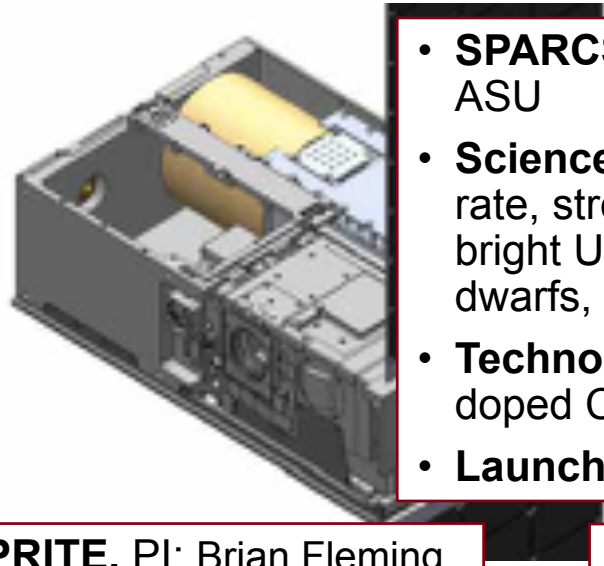




Five Astrophysics CubeSats in Development

- **CUTE,** PI: Kevin France, CU
- **Science Objectives:** The Colorado Ultraviolet Transit Experiment (CUTE) will take medium resolution UV spectra of 14 hot Jupiters during transit, in order to measure atmosphere being ablated away.
  Technologies: BCT S/C, COTS telescope and camera.
- **Launch**: Dec 20 on LandSat-9





- **SPARCS,** PI: Eygenya Shkolnik, ASU
- **Science Objectives:** Determine rate, strength and 2-band color of bright UV flares from 25 M dwarfs, effect on habitability?
- **Technologies:** BCT S/C, d-doped CCD, UV dichroic.
- **Launch**: September 2021

- **BurstCube,** PI: Jeremy Perkins (GSFC)
- **Science Objectives:** Rapid localizations for LIGO/Virgo detections with short GRBs; Search of g-ray transients.
- **Technologies:** Dillingr derived bus, Fermi-GBM like detectors.
- **Launch**: Fall 2021

- **SPRITE,** PI: Brian Fleming, CU
- **Science Objectives:** Determine ionization rate of IGM from galaxies and AGN, trace feedback within galaxies driven by star-forming regions, using low-resolution imaging UV spectrograph.
- **Technologies:** in house S/C, UV coatings, next-gen MCP.
- **Launch**: Fall 2022

- **BlackCat,** PI: Abe Falcone, Penn St.
- **Science Objectives:** GRB/Transient detection in 0.2-20keV with coded mask.
- **Technologies:** CMOS x-ray CCD
- **Launch**: FY2024

Astrophysics Technology Program Elements

Technology Inception & Experimentation APRA/RTF

- 46 projects awarded in 2019
- Solicitations planned in FY20, delayed 9 months
- Average award: $600K (3-5 years)
- Average selection rate: 28%
- Portfolio:
  - Supporting 19 Balloons and 10 Sounding Rockets Payloads
  - Detectors across wavelengths
  - Mirrors, coatings and gratings

Total: $50 M per year

Technology Maturation SAT & ISFM

Unified solicitation and selection starting in FY19 for the three Astrophysics themes. Portfolio has 49 active projects for a total of $28 M per year.

- 12 new projects awarded in FY19
- Next solicitation planned in FY20, currently TBD
- Average award: $1.6M (3 years)
- Average selection rate: 30% (in FY19, historically is 29%)

Directed Technologies

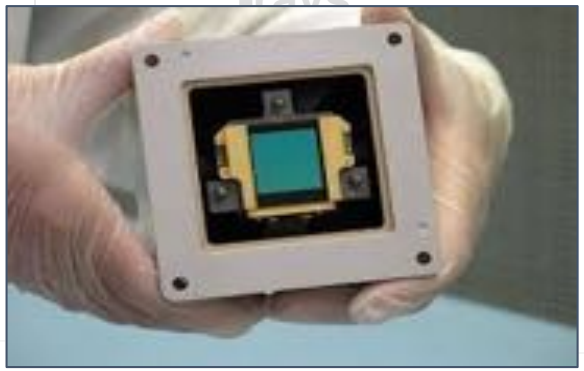
- WFIRST Coronagraph
- Exoplanets Probes: Exo-C & Exo-S
- LISA
- Athena
- Euclid
- NN-Explore – NEID
- SmallSats and CubeSats

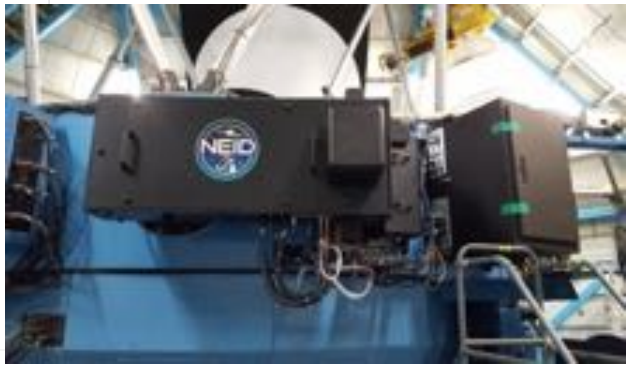
Total: $85 M in FY19

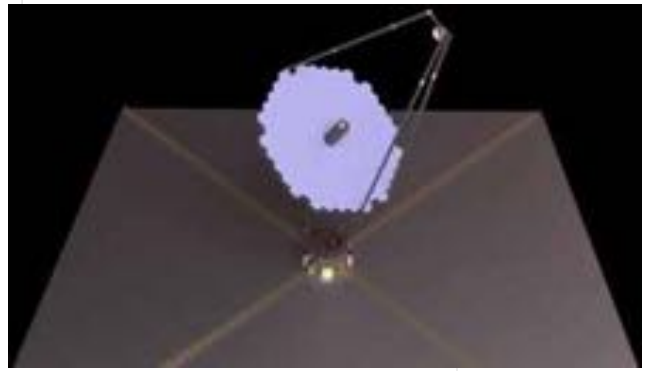
Pre-Decadal Initiatives

- In-Space Assembled Telescope (iSAT)
- Coronagraph and UltraStable Testbeds
- Starshade Technology
- Four Large Mission Concepts – Technology Roadmaps
- Ten Probe Mission Concepts
- Segmented Mirror Telescope Program (STMP)

Total: $25 M in FY19







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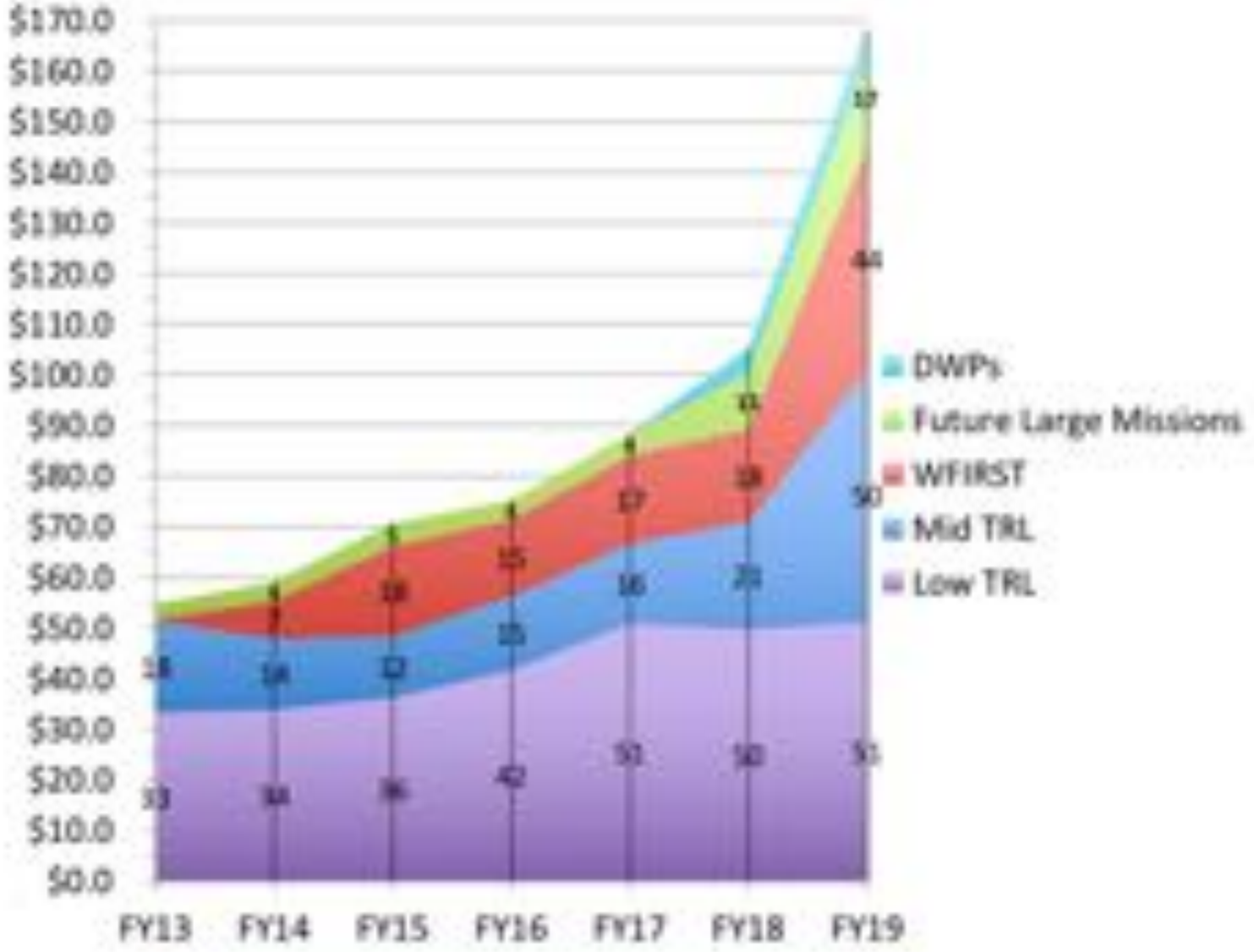
- *Portfolio:*
  - *Supporting 19 Balloons*
    Sounding Rockets Pay
  - *Detectors across wave*
  - *Mirrors, coatings and gr*

Total: $50 M per year

Astrophysics Technology Funding FY13-FY19



cadal Initiatives

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Large Mission Concepts –
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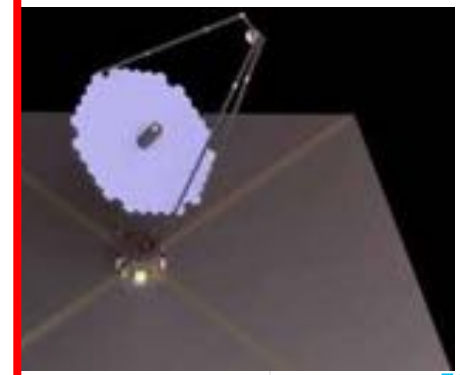
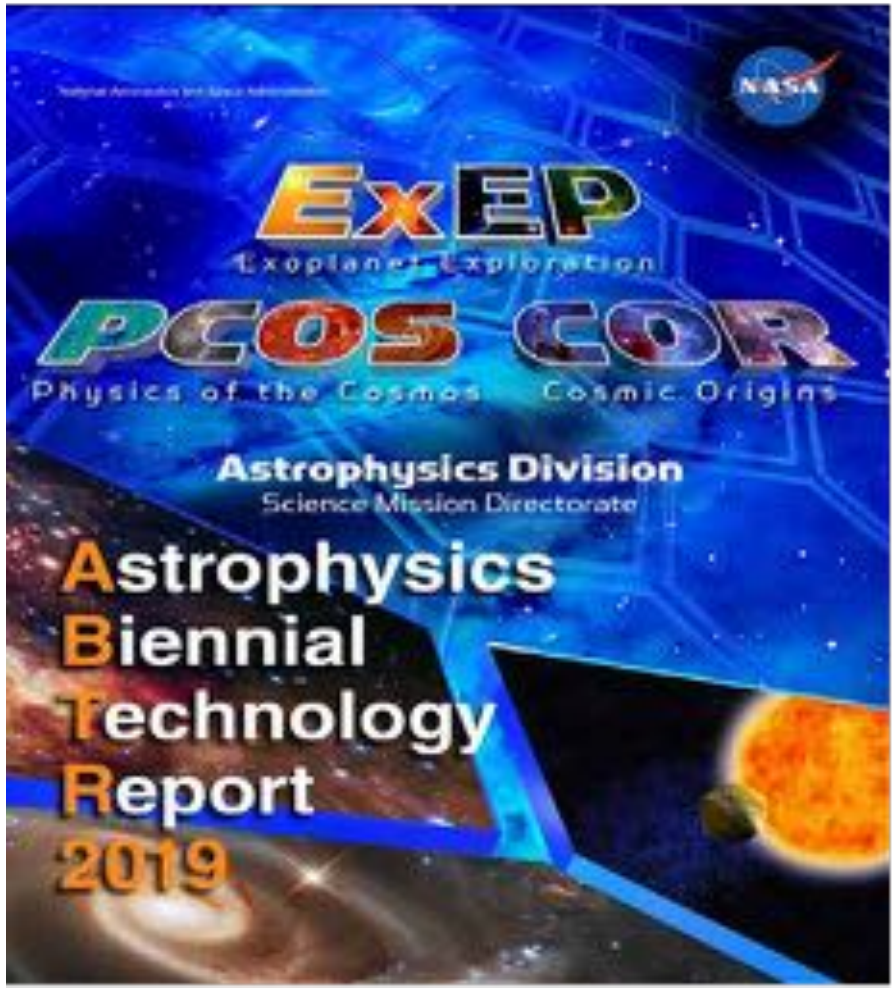
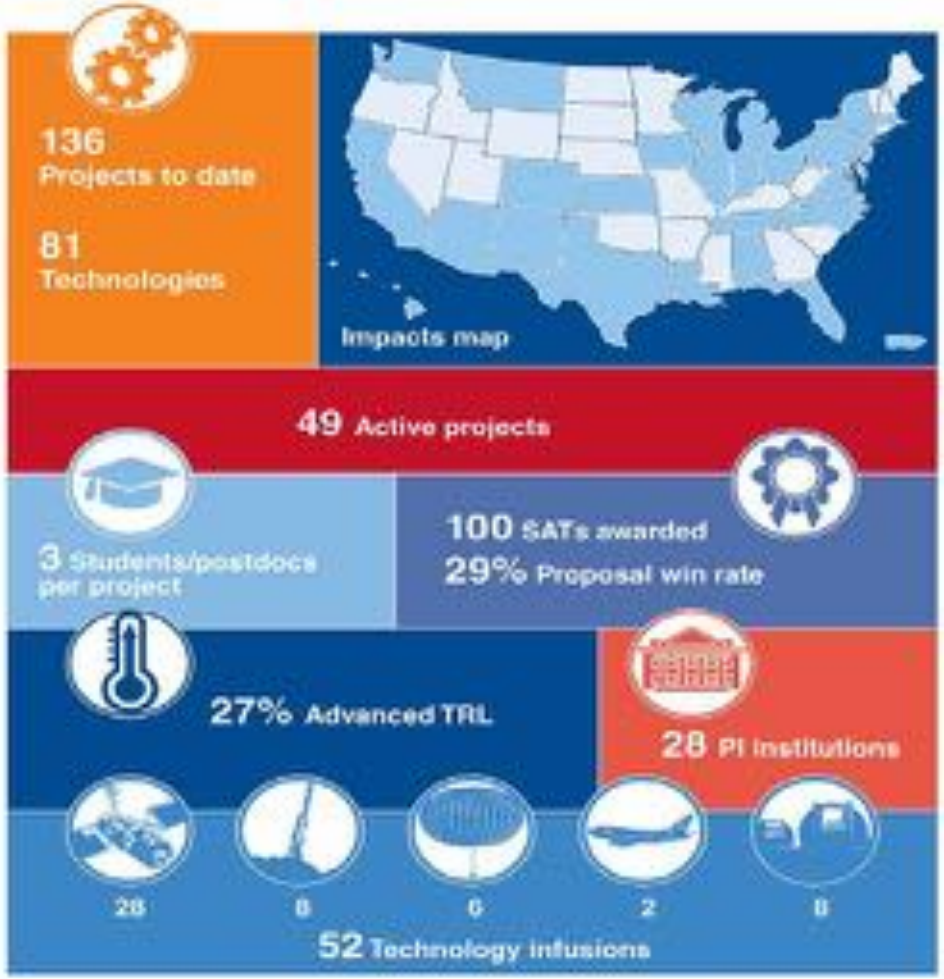
robe Mission Concepts
ented Mirror Telescope
am (STMP)
M in FY19



Integrated Strategic Technology Portfolio





Astrophysics Biennial Technology Report: https://apd440.gsfc.nasa.gov/technology.html

Database of Astrophysics technology projects: http://www.astrostrategictech.us/

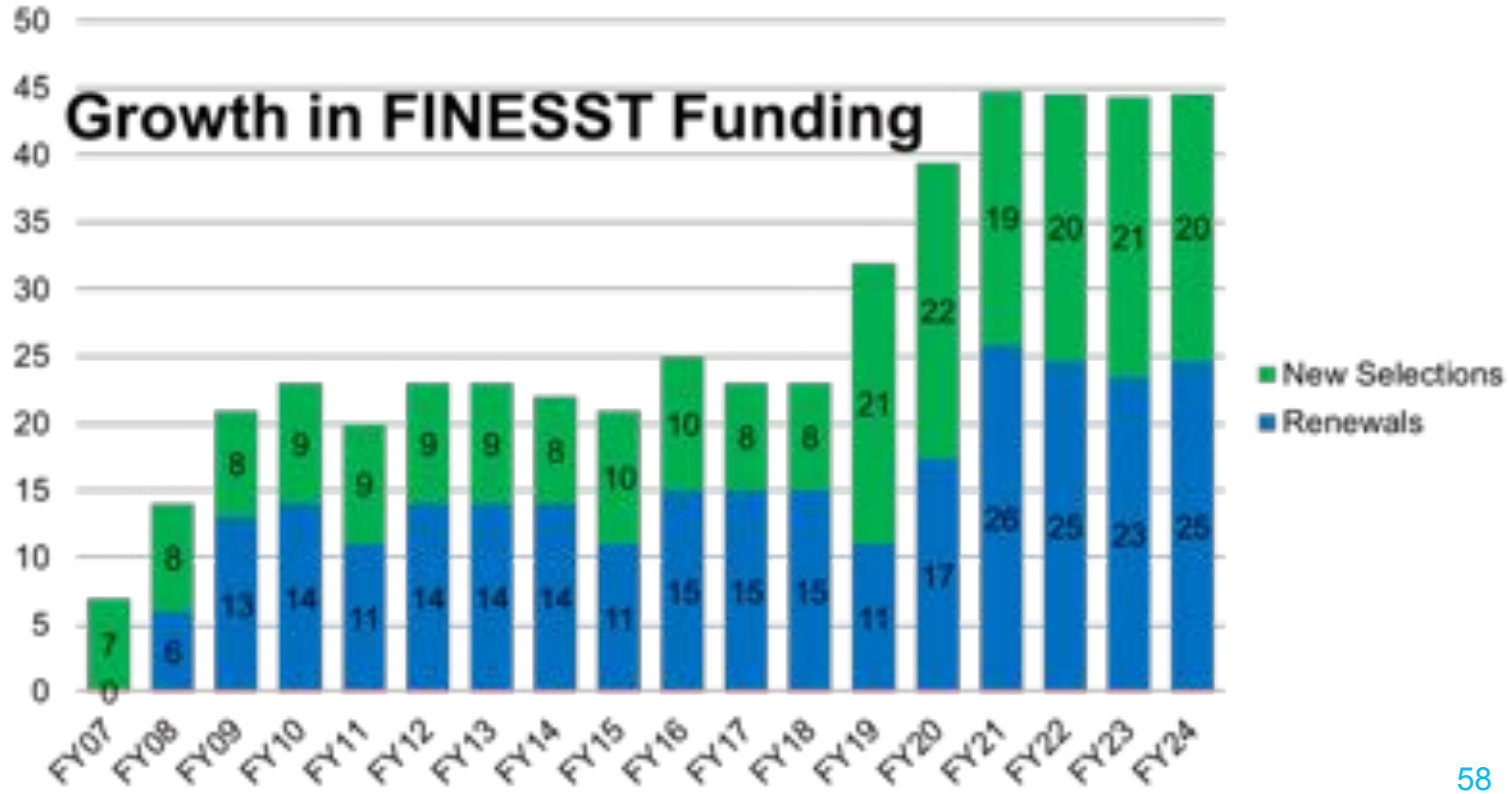
Graduate Student Research Awards

NASA Earth and Space Science Fellowship (NESSF) program name is changing to Future Investigators in NASA Earth and Space Science and Technology (FINESST) in 2019 to more accurately capture the nature of awards.

Historically Astrophysics has funded 24 NESSF / FINESST fellows at any given time. With 150-200 proposals received annually, the selection rate has been ~6%.

Community input has led to us doubling the Astrophysics NESSF / FINESST program effective in 2019.

Astrophysics will now be funding 45-48 NESSF / FINESST Fellows at any given time. The selection rate will be ~10%.



NASA Hubble Fellowship Program

It has been thirty years since the first Hubble Fellows were selected.

Fellows are asking for the assurance of parental leave and the option of saving for their eventual retirement with the assistance of their employer.

- Fellows who are employees of their host institutions typically have these benefits.
- Stipendiary fellows to do not receive employee benefits even though the NHFP is willing to pay the full cost of the employee benefits package.

The Space Telescope Science Institute (STScI) and NASA are proposing a change to the requirements for NHFP host institutions.

> *Starting with academic year 2022-2023, in order to host new NASA Hubble Fellowship Program (NHFP) Fellows, host institutions must offer their NHFP Fellows the opportunity to be employees. Employee status is being required to afford NHFP Fellows the same leave, vacation, retirement and health benefits (as applicable) given by these institutions to their postdoctoral fellows hired on grants or contracts as employees. Host institutions are also encouraged, but not required, to offer Fellows the option of choosing to be a stipendiary fellow rather than an employee if that is a better match to the Fellow's needs.*

STScI is soliciting comments from host institutions. Direct any questions or comments on this policy to nhfp@stsci.edu by March 18, 2020.

Astrophysics ROSES-20 Due Dates

	Program Element	NOIs due	Proposals due
D.1	Astrophysics Research Program Overview	N/A	N/A
D.2	Astrophysics Data Analysis	03/31/2020	05/19/2020
D.3	Astrophysics Research and Analysis	10/23/2020	12/17/2020
D.4	Astrophysics Theory Program	Not solicited this year	
D.5	Neil Gehrels Swift GI Cycle 17	N/A	09/25/2020
D.6	Fermi GI Cycle 14	N/A	02/19/2021
D.7	Strategic Astrophysics Technology	TBD	TBD
D.8	Nancy Grace Roman Technology Fellowships	See D.3	
D.9	NuSTAR GO Cycle 7	N/A	01/22/2021
D.10	TESS GI Cycle 4	N/A	01/15/2021
D.11	NICER GO Cycle 3	N/A	11/12/2020
D.12	XRISM Guest Scientist	TBD	TBD
D.13	U.S. Participating Investigator	TBD	TBD
D.14	Theoretical and Computational Astrophysics Networks	N/A	05/28/2020
E.2	Topical Workshops, Symposia, and Conferences	N/A	Rolling due date
E.3	Exoplanets Research	03/27/2020	05/29/2020

Astrophysics ROSES-20 Due Dates

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D.1	Astrophysics Research Program Overview	N/A	N/A
D.2	Astrophysics Data Analysis	03/31/2020	05/19/2020
D.3	A		/2020
D.4	A		ar
D.5	N		2020
D.6	Fermi GI Cycle 14	N/A	02/19/2021
D.7	Strategic Astrophysics Technology	TBD	TBD
D.8	Nancy Grace Roman Technology Fellowships	See D.3	
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D.13	U.S. Participating Investigator	TBD	TBD
D.14	Theoretical and Computational Astrophysics Networks	N/A	05/28/2020
E.2	Topical Workshops, Symposia, and Conferences	N/A	Rolling due date
E.3	Exoplanets Research	03/27/2020	05/29/2020

The XRISM Guest Scientists and U.S. Participating Investigator programs are new this year.

Astrophysics ROSES-20 Due Dates

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D.3	Astrophysics Research and Analysis	10/23/2020	12/17/2020
D.4	Astrophysics Theory Program	Not solicited this year	
D.5	N		2020
D.6	R		2021
D.7	S		D
D.8	N		
D.9	N		2021
D.10	TESS GI Cycle 4	N/A	01/15/2021
D.11	NICER GO Cycle 3	N/A	11/12/2020
D.12	XRISM Guest Scientist	TBD	TBD
D.13	U.S. Participating Investigator	TBD	TBD
D.14	Theoretical and Computational Astrophysics Networks	N/A	05/28/2020
E.2	Topical Workshops, Symposia, and Conferences	N/A	Rolling due date
E.3	Exoplanets Research	03/27/2020	05/29/2020

XRP has been expanded to include all exoplanet research. Exoplanet research is no longer solicited in ATP and ADAP.

Astrophysics ROSES-20 Due Dates

	Program Element	NOIs due	Proposals due
D.1	Astrophysics Research Program Overview	N/A	N/A
D.2	Astrophysics Data Analysis	03/31/2020	05/19/2020
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D.4	Astrophysics Theory Program	Not solicited this year	
D.5	Neil Gehrels Swift GI Cycle 17	N/A	09/25/2020
D.6	Fermi GI Cycle 14	N/A	02/19/2021
D.7	S		D
D.8	N		
D.9	N		2021
D.10	TESS GI Cycle 4	N/A	01/15/2021
D.11	NICER GO Cycle 3	N/A	11/12/2020
D.12	XRISM Guest Scientist	TBD	TBD
D.13	U.S. Participating Investigator	TBD	TBD
D.14	Theoretical and Computational Astrophysics Networks	N/A	05/28/2020
E.2	Topical Workshops, Symposia, and Conferences	N/A	Rolling due date
E.3	Exoplanets Research	03/27/2020	05/29/2020

ATP is not being solicited this year.
TCAN is being solicited this year.

Astrophysics ROSES-20 Due Dates

	Program Element	NOIs due	Proposals due
D.1	Astrophysics Research Program Overview	N/A	N/A
D.2	Astrophysics Data Analysis	03/31/2020	05/19/2020
D.3	Astrophysics Research and Analysis	10/23/2020	12/17/2020
D.4	Astrophysics Theory Program	Not solicited this year	
D.5	Neil Gehrels Swift GI Cycle 17	N/A	09/25/2020
D.6	Fermi GI Cycle 14	N/A	02/19/2021
D.7	Strategic Astrophysics Technology	TBD	TBD
D.8	Nancy Grace Roman Technology Fellowships	See D.3	
D.9	N		2021
D.10	T		2021
D.11	NICER GO Cycle 3	N/A	11/12/2020
D.12	XRISM Guest Scientist	TBD	TBD
D.13	U.S. Participating Investigator	TBD	TBD
D.14	Theoretical and Computational Astrophysics Networks	N/A	05/28/2020
E.2	Topical Workshops, Symposia, and Conferences	N/A	Rolling due date
E.3	Exoplanets Research	03/27/2020	05/29/2020

APRA and RTF have new due dates in the Fall.

Astrophysics ROSES-20 Due Dates

	Program Element	NOIs due	Proposals due
D.1	Astrophysics Research Program Overview	N/A	N/A
D.2	Astrophysics Data Analysis	03/31/2020	05/19/2020
D.3	Astrophysics Research and Analysis	10/23/2020	12/17/2020
D.4	Astrophysics Theory Program	Not solicited this year	
D.5	Neil Gehrels Swift GI Cycle 17	N/A	09/25/2020
D.6	Fermi GI Cycle 14	N/A	02/19/2021
D.7	Strategic Astrophysics Technology	TBD	TBD
D.8	Nancy Grace Roman Technology Fellowships	See D.3	
D.9	NuSTAR GO Cycle 7	N/A	01/22/2021
D.10	TESS GI Cycle 4	N/A	01/15/2021
D.11	N		2020
D.12	X		D
D.13	U		D
D.14	Theoretical and Computational Astrophysics Networks	N/A	05/28/2020
E.2	Topical Workshops, Symposia, and Conferences	N/A	Rolling due date
E.3	Exoplanets Research	03/27/2020	05/29/2020

The dates and constraints for SAT have not yet been determined.

Astrophysics ROSES-20 Due Dates

	Program Element	NOIs due	Proposals due
D.1	Astrophysics Research Program Overview	N/A	N/A
D.2	Astrophysics Data Analysis	03/31/2020	05/19/2020
D.3	Astrophysics Research and Analysis	10/23/2020	12/17/2020
D.4	Astrophysics Theory Program	Not solicited this year	
D.5	Neil Gehrels Swift GI Cycle 17	N/A	09/25/2020
D.6	Fermi GI Cycle 14	N/A	02/19/2021
D.7	Strategic Astrophysics Technology	TBD	TBD
D.8	Nancy Grace Roman Technology Fellowships	See D.3	
D.9	NuSTAR GO Cycle 7	N/A	01/22/2021
D.10	TESS GI Cycle 4	N/A	01/15/2021
D.11	NICER GO Cycle 3	N/A	11/12/2020
D.12	XRISM Guest Scientist	TBD	TBD
D.13	U		D
D.14	T		2020
E.2	T		ue date
E.3	Exoplanets Research	03/27/2020	05/29/2020

ADAP and the GO/GI programs will be conducted using dual anonymous peer review.

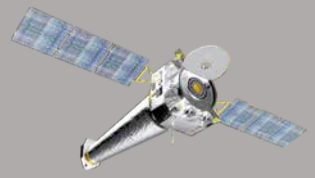
NASA Astrophysics Missions Update

Astrophysics Operating Missions

Hubble 4/90
NASA Strategic Mission

Hubble Space Telescope

Chandra 7/99
NASA Strategic Mission



Chandra X-ray Observatory

XMM-Newton 12/99
ESA-led Mission

X-ray Multi Mirror - Newton

Spitzer 8/03
NASA Strategic Mission

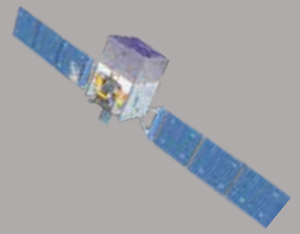
Mission ending Jan 30, 2020

Spitzer Space Telescope

Gehrels Swift 11/04
NASA MIDEX Mission

Neil Gehrels Swift Gamma-ray Burst Explorer

Fermi 6/08
NASA Strategic Mission

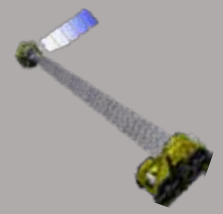


Fermi Gamma-ray Space Telescope

Kepler 3/09
NASA Discovery Mission

Mission Complete!

NuSTAR 6/12
NASA SMEX Mission



Nuclear Spectroscopic Telescope Array

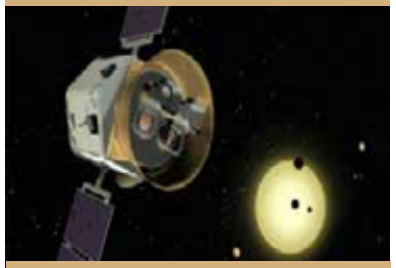
SOFIA 5/14
NASA Strategic Mission

Stratospheric Observatory for Infrared Astronomy

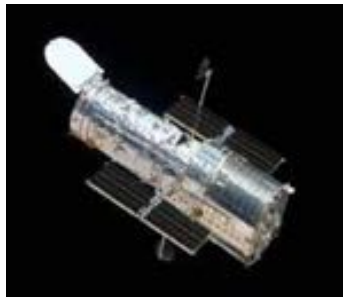
ISS-NICER 6/17
NASA Explorers Miss. of Oppty

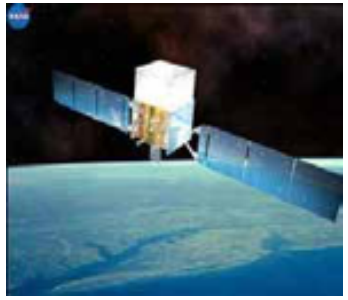
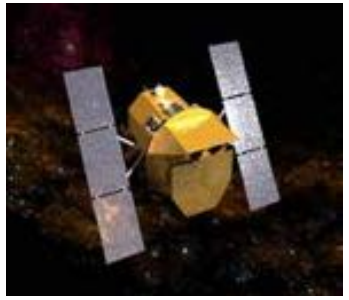
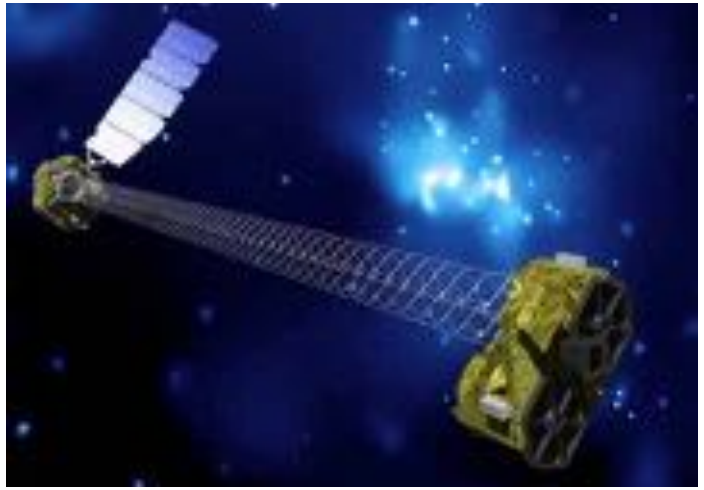
Neutron Star Interior Composition Explorer

TESS 4/18
NASA MIDEX Mission



Transiting Exoplanet Survey Satellite



Senior Review 2019

All missions were extended for three years. The next Senior Review for Astrophysics Operating Missions will be in 2022.

- Hubble — No change to budget guideline
- Chandra — Selected overguides: Audit fees, labor & GO (inflation)
- TESS — Extended mission w/ full funding & continued GO program
- Swift — Selected overguides: New tools for Targets of Opportunity and Ultraviolet-Optical Telescope
- Fermi — Operations w/out Department of Energy
- NICER — Extended mission w/ reduced ops & new GO program
- NuSTAR — Phase out legacy science and replace with GO science
- XMM-Newton — No change

Not in 2019 Senior Review: Kepler, SOFIA, Spitzer

SOFIA

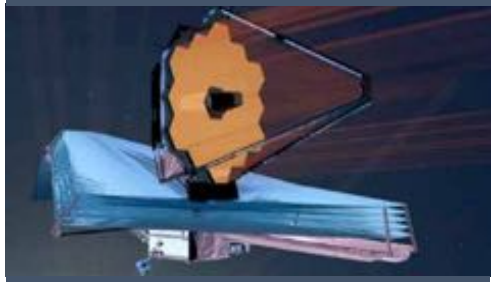
Stratospheric Observatory for Infrared Astronomy

SOFIA Town Hall – Tue Jan 7 @ 7:00 PM in Room 313B

- SOFIA's 5-year prime mission ended at the end of FY19 (Sep 30, 2019)
- NASA conducted two reviews of the SOFIA project in 2019 aimed at increasing the science productivity of SOFIA in FY20 and beyond
  - Review of SOFIA's maintenance and operations paradigm
  - Review of SOFIA's science progress and science prospects
- Summary of reviews and NASA response posted at: https://science.nasa.gov/astrophysics/documents
- Based on the reviews, SOFIA project is making change to improve productivity:
  - 8 hour flights for Cycle 8 for the months when the observing conditions are poor (Spring, Fall).
  - A larger fraction of observing time doing legacy programs – 5 diverse "pilot legacy" programs selected. If successful, project may do more and larger legacy programs.
  - Maximizing and emphasizing collection of high-quality data.
    - Efforts include: maximizing time in the stratosphere, strict/robust technical evaluation, prioritizing collection of large, and homogeneous data sets, exploring different operational models for SOFIA to maximize observing during the time of the year when observing conditions are optimal.
  - Starting Cycle 8, SOFIA will adopt a policy for finishing priority 1 & 2 programs, once started.
- HIRMES, the next SOFIA science instrument, continues development
  - After a continuation review in Dec 2018, delivery anticipated Dec 2020.

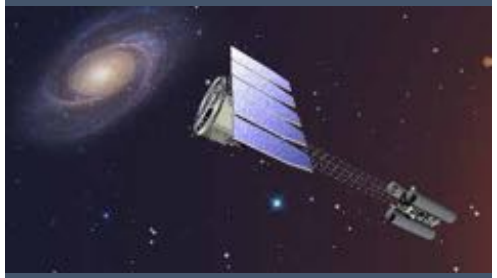
Astrophysics Missions in Development

Webb — 2021
NASA Mission



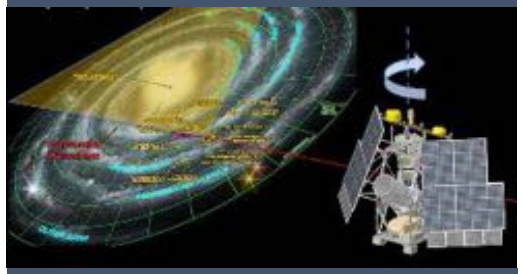
James Webb
Space Telescope

IXPE — 2021
NASA Mission



Imaging X-ray
Polarimetry Explorer

GUSTO — 2021
NASA Mission

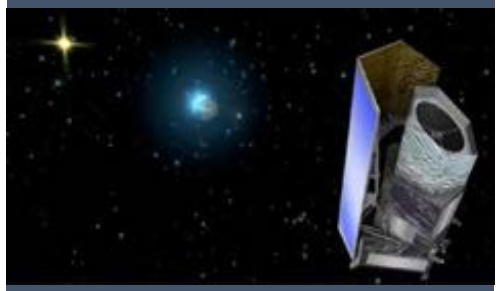


Galactic/ Extragalactic ULDB
Spectroscopic Terahertz Observatory

XRISM — 2022
JAXA-led Mission

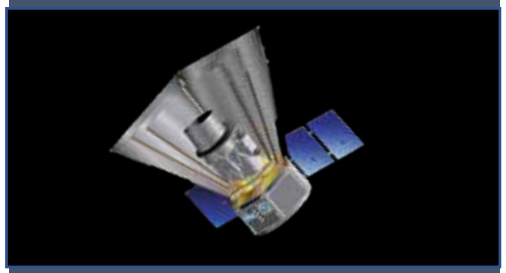
NASA is supplying the SXS
Detectors, ADRs, and SXTs

Euclid — 2022
ESA-led Mission



NASA is supplying the NISP
Sensor Chip System (SCS)

SPHEREx — 2023
NASA Mission



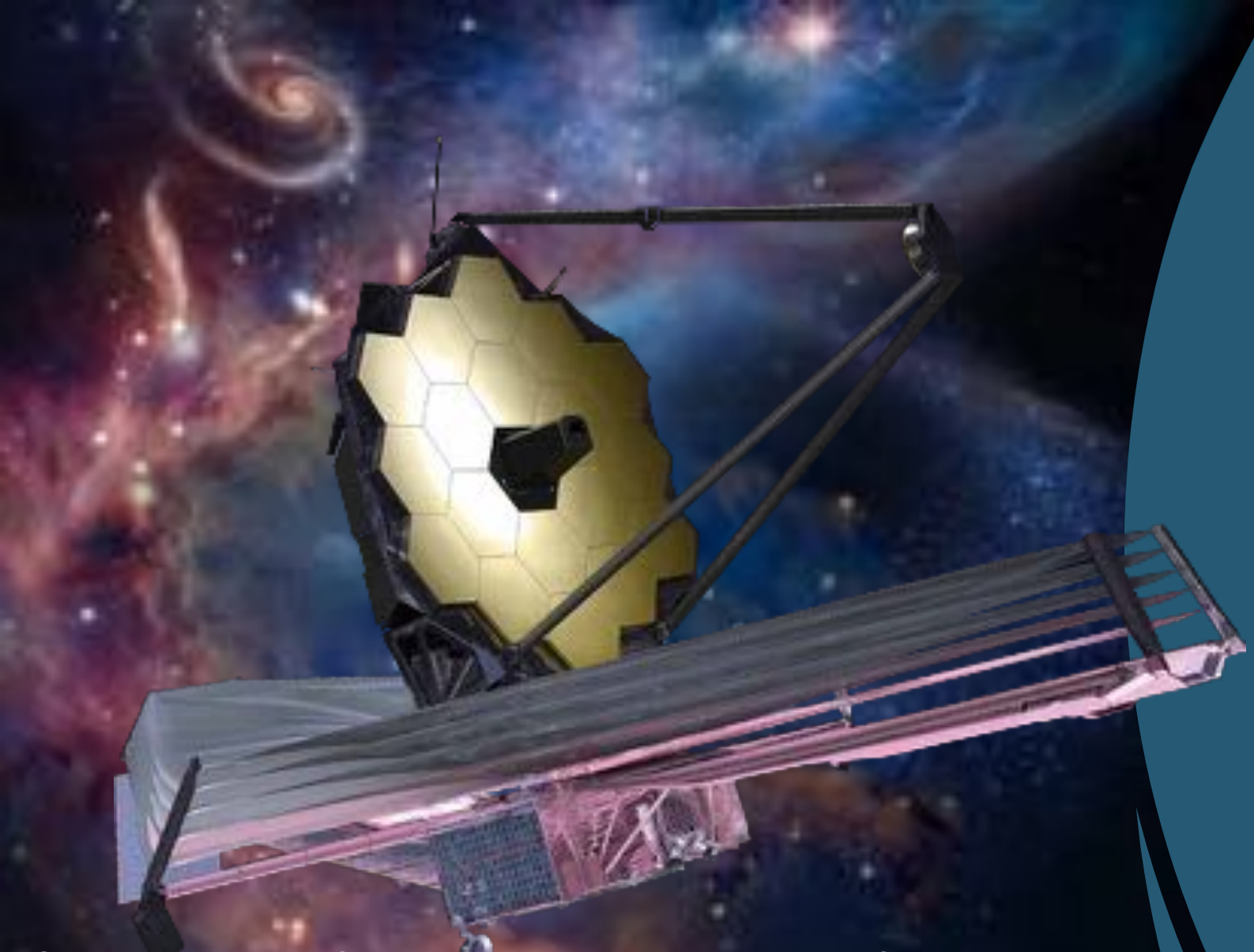
Spectro-Photometer for the History of
the Universe, Epoch of Reionization,
and Ices Explorer

WFIRST — Mid 2020s
NASA Mission

Wide-Field Infrared
Survey Telescope

ARIEL — 2028
ESA-led Mission

NASA is supplying the CASE
fine guidance instrument



Webb

The James Webb Space Telescope

An international mission to seek first light of stars and galaxies in the early universe and explore distant planets

Seeking Light from the First Stars and Galaxies

Exploring Distant Worlds—Exoplanets & the Outer Solar System

Led by NASA, in partnership with ESA and CSA

Science program defined through peer-review, including future key projects

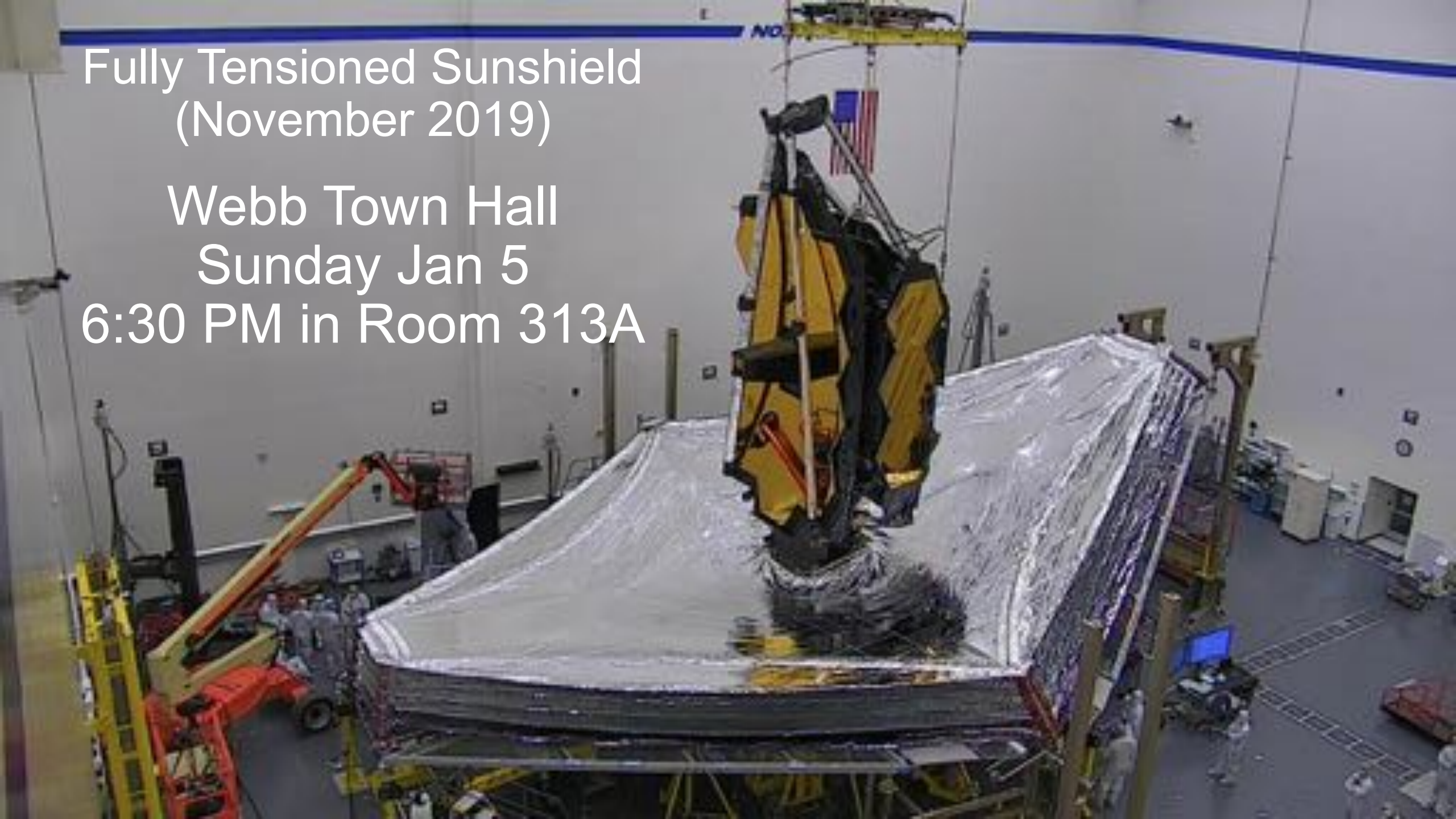
Observations spanning a wide variety of Astrophysics are already in the works through the Guaranteed Time Observers programs and the Early Release Science program

The Webb observatory in the clean room in Redondo Beach, CA in August 2019 before observatory environmental testing and observatory deployment tests

Webb

The James Webb Space Telescope

- Science payload completed three months cryogenic testing at end of 2017
- Spacecraft and sunshield integration completed January 2018
- Spacecraft element including sunshield completed environmental testing May 2019
- Science payload and spacecraft integration completed August 2019
- Test deployment of sunshield completed November 2019
- Environmental testing of full observatory in Spring 2020
- Webb overrun covered using offsets from Astrophysics Probes


Fully Tensioned Sunshield
(November 2019)
Webb Town Hall
Sunday Jan 5
6:30 PM in Room 313A

Wide-Field Infrared Survey Telescope

Science Program

- Cosmology : Dark energy and the fate of the universe – wide field surveys to measure the expansion history and the growth of structure
- Exoplanet Demographics: The full distribution of planets around stars through a microlensing survey
- Astrophysics: Wide-field infrared surveys of the universe through General Observer and Archival Research programs

Technology development for the characterization of exoplanets through a Coronagraph Technology Demonstration Instrument

WFIRST: Wide-Field Infrared Survey Telescope

WFIRST is fully funded in FY20

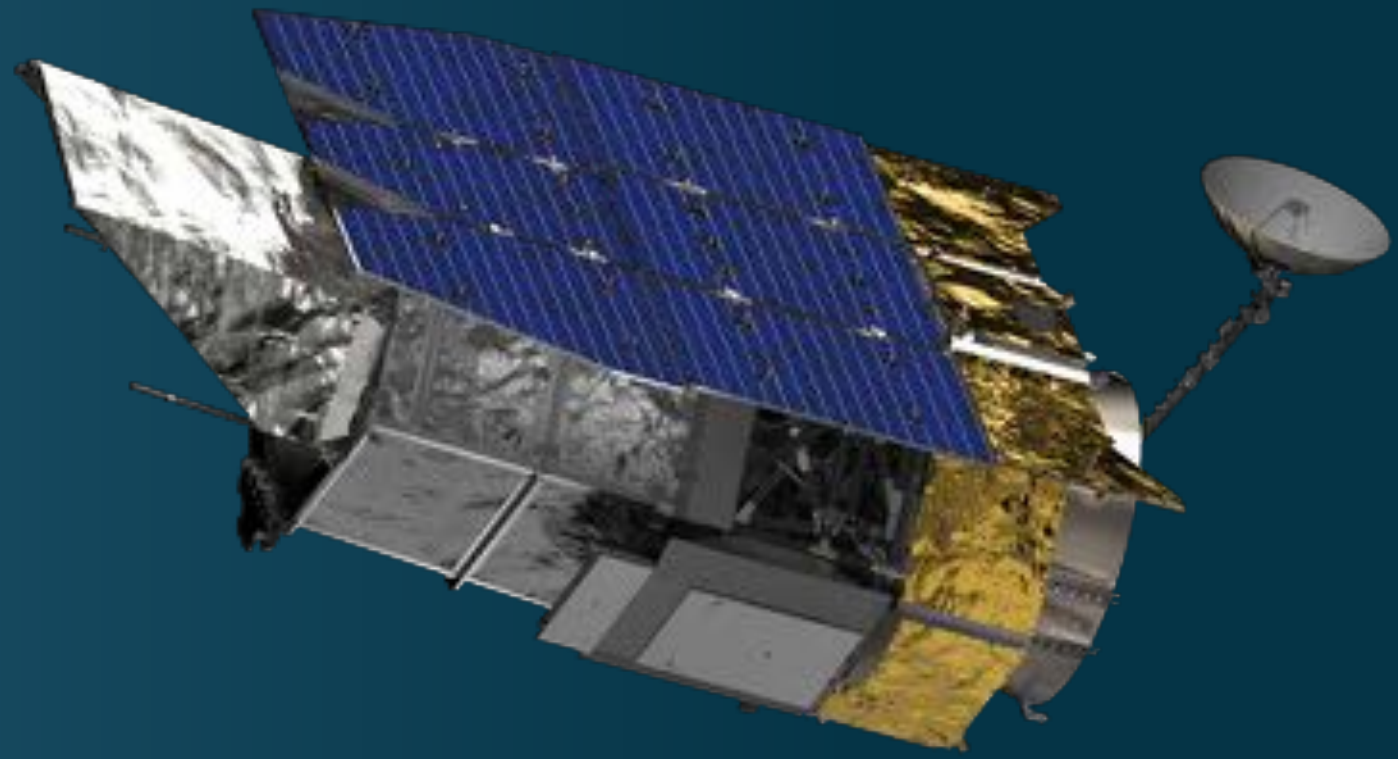
Nov 2019 -– Completed Preliminary Design Reviews

Early 2020 – Complete Confirmation Review and begin Implementation (Phase C)

2020: Flight hardware being developed: mirror being figured, detectors being fabricated, spacecraft subsystems being delivered, coronagraph demo unit in testbed

2021 – Complete Critical Design Reviews

Mid-2020s – Launch



WFIRST field-of-view is 100x Hubble field-of-view

WFIRST is 100 to 1500 times faster than Hubble for large surveys at equivalent area and depth

Wide-Field Infrared Survey Telescope

- **NASA continuing work on WFIRST as planned**
  - Work continues under CR in anticipation of FY20 appropriation; both Senate and House bills include robust support for WFIRST
  - WFIRST remains on the plan approved at the beginning of Phase B: Lifecycle cost range remains $3.2B -$3.9B, launch range remains late 2025 - 2026
  - Formal cost and schedule commitments, including Headquarters held reserves to increase confidence level to 70%, will be made at Confirmation in early 2020
- **Major milestones completed in 2019:**
  - Completed Preliminary Design Reviews for all primary mission elements (Wide Field Instrument, Coronagraph, Optical Telescope, Instrument Carrier, Spacecraft)
  - WFIRST mission passed Preliminary Design Review (gate for entering Phase C)
  - Additional major contracts awarded: Instrument Carrier (NGIS), Science Operations Center (STScI), numerous spacecraft components
  - Long-lead hardware making excellent progress; telescope refiguring proceeding as expected; several flight candidate detectors already in hand
- **Work Plan for 2020**
  - NASA confirmation of mission; enter implementation phase (Phase C)
  - Significant engineering test unit fabrication and testing

WFIRST is for You

All WFIRST observing time is available through open competition

- Some WFIRST observing time will be used for the core dark energy and exoplanet surveys mandated by the Astro2010 Decadal Survey
- Some WFIRST observing time will be used for additional GO-driven key projects using WFIRST's unique wide-field imaging, spectroscopic, and time domain capabilities
- Some WFIRST observing time will be used for smaller, individual GO programs
- Some WFIRST observing time will be used for the Coronagraph technology demonstration
- All data will be available to the community with no period of limited access

WFIRST observing program will be based on community input

- Both NASA and STScI will be convening community groups to provide input on balance among observing programs and on trades during development, integration, and test

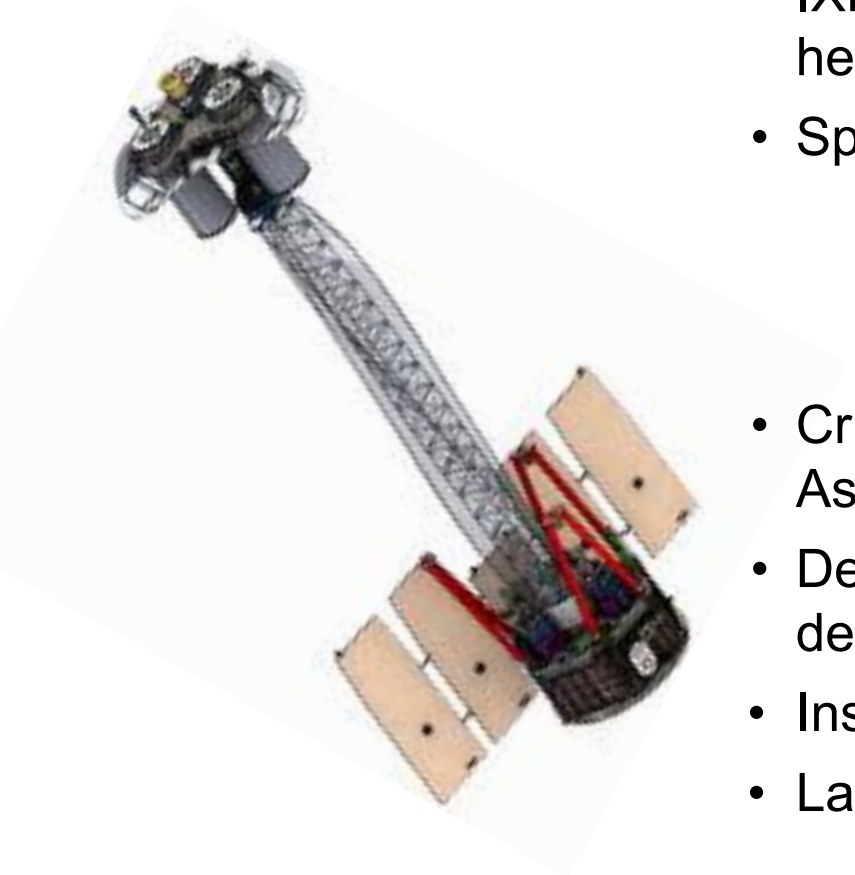
WFIRST General Observers / Archival Researchers Program

- Use WFIRST for conducting wide-field infrared surveys of the universe
- Use data from WFIRST legacy surveys to conduct compelling astrophysics investigations
- Calls for proposals to be issued before launch and subsequently

WFIRST Coronagraph Participating Scientist Program

- Develop observing plans for demonstrating coronagraph capabilities
- Work with instrument team to process data from tech demo observations
- Call for proposals to be issued well before launch

Imaging X-ray Polarimetry Explorer (IXPE)



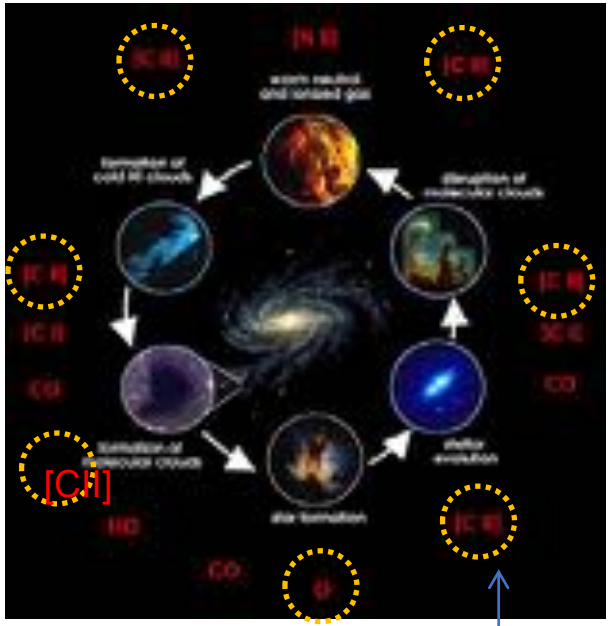
- IXPE Project successfully completed Critical Design Review (CDR) held on June 25-28 at Ball Aerospace.
- SpaceX Falcon 9 chosen as the launch vehicle for IXPE mission.
  - Falcon 9 launch from KSC (~28.5 degree latitude) will execute a major orbital plane change to IXPE science-required zero degree orbital inclination.
- Critical vibration re-testing of modified engineering Modular Mirror Assembly (MMA) successfully completed at MSFC.
- Development of Italian X-ray detector units (DU) is ongoing, with the delivery of first flight DU in December 2019
- Instrument and spacecraft integration beginning in Spring 2020
- Launch currently planned for April 2021

GUSTO Suborbital Explorer

GUSTO (Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory), led by PI Chris Walker (University of Arizona), is an Astrophysics Explorer (MO) balloon mission and is an advanced version of the STO-2 balloon payload.

GUSTO uses large-scale surveys & spectral diagnostics of the Interstellar Medium (ISM) to answer key questions about the full Life Cycle of the ISM and massive star formation.

GUSTO Payload



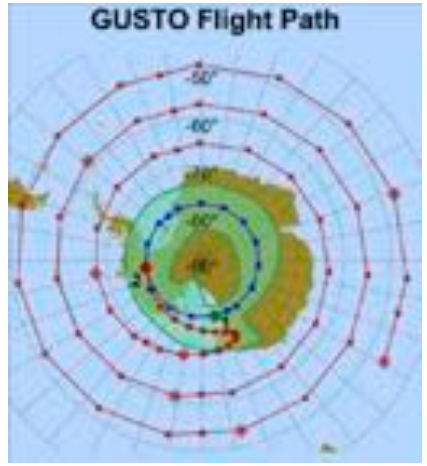
GUSTO Lines

Brightest Line in the Far-IR over cosmic times.

~300 dedicated SOFIA flights would be required to equal the GUSTO survey

<u>Milestones:</u>

Mission Preliminary Design Review: Nov 15, 2018
Confirmation Review (KDP-C): Mar 12, 2019
Mission Critical Design Review (CDR): Oct 2019
Pre Ship Review / Mission Readiness Review: Jul 2021
Launch from McMurdo Station, Antarctica: Dec 2021



Flight Strategy, Launch (Dec 2021) from McMurdo on a superpressure balloon and allow payload to leave the continent. Instrument recovery preferred, but optional. Target survey duration 75 day, accept-able base-line 20 days, cryogenic for 100 days.

XRISM: X-ray Imaging and Spectroscopy Mission

XRISM/Resolve CSI – Dewar Integration
Nov 25, 2019 in Niihama, Japan

Sumitomo Heavy Industries, Ltd.

- Passed the Integrated Systems Preliminary Design Review which was held in Japan in March 2019.
- Resolve instrument currently integrated in flight Dewar in Japan, preparing for environmental testing.
- Remaining US-built hardware to be delivered to JAXA in stages throughout 2020.

- Call for US Performance Verification phase Participating Scientists planned for ROSES 2020.
- XRISM launch, by JAXA, currently planned for early 2022.

Euclid

Near Infrared Spectrometer and Photometer - fully populated focal plane includes NASA provided 16 (2K x 2K each) Sensor Chip Systems

Science Program Includes

- Dark Energy and Dark Matter
- Initial conditions of the Universe
- Conduct deep NIR survey to explore high redshift
- Relationship between dark matter and baryons

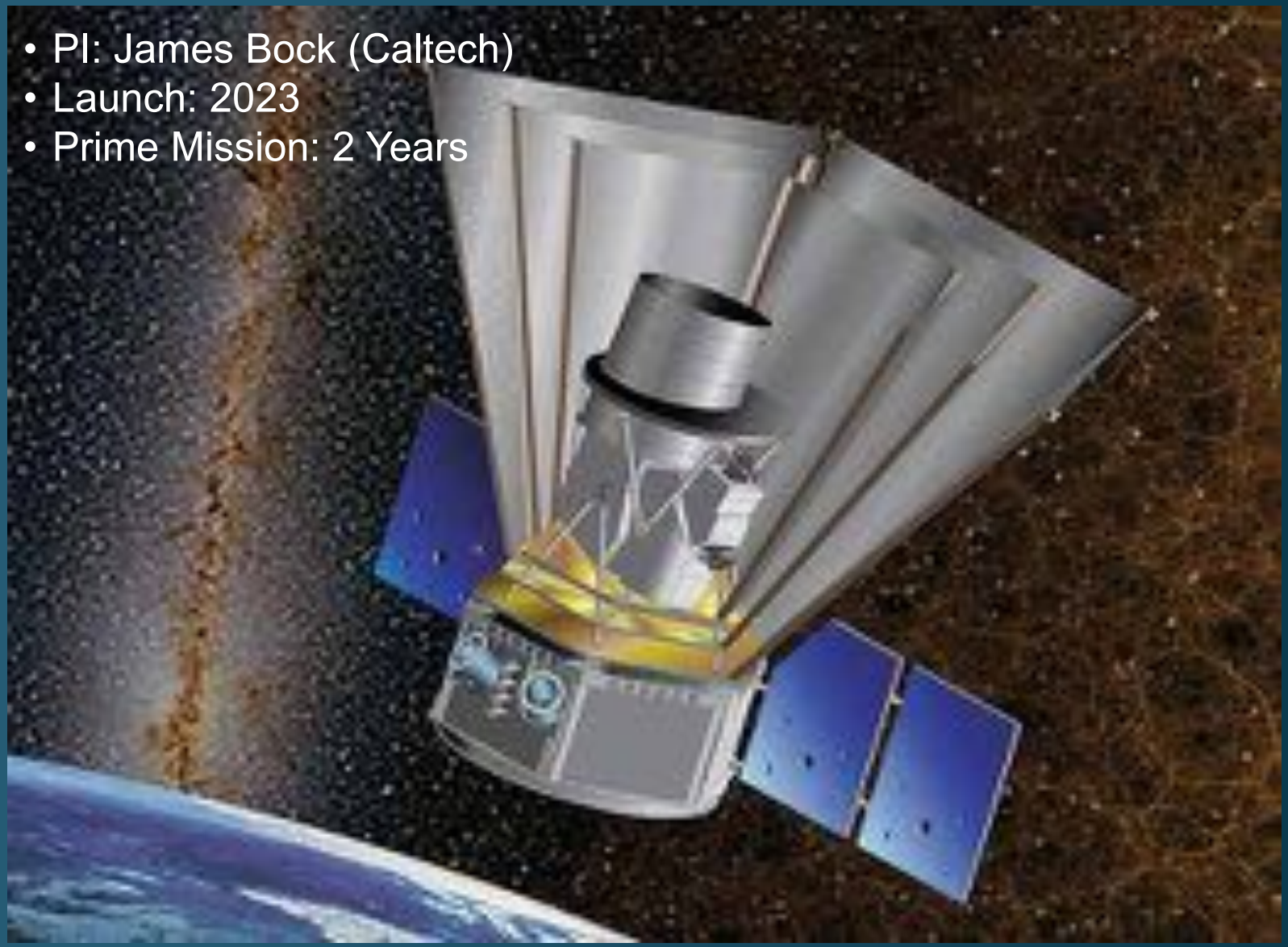
ESA led mission with NASA partnership

- Completed mission CDR in November 2018
- NASA completed all flight hardware Sensor Chip Systems deliveries in June 2019 for the NISP instrument focal plane
- Mission In Assembly, Integration and Test phase
- Mission Launch ~ June 2022

Science Participation

- US Euclid Science teams integrated into Euclid Consortium science planning activities
- General US science participation to be through archival data research after Euclid data products release

Spectro-Photometer for the History of the Universe Epoch of Reionization and Ices Explorer (SPHEREx)



- PI: James Bock (Caltech)
- Launch: 2023
- Prime Mission: 2 Years

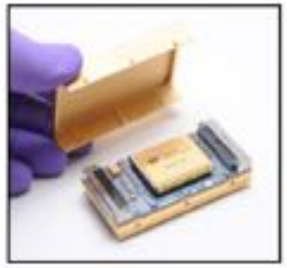
Science Highlights include:

- Survey the entire sky every 6 months
- Optical and infrared survey mission (96 bands/pixel)
- Observe hundreds of millions of galaxies
  - Measure redshifts to probe the statistical distribution of inflationary ripples
  - Measure spatial fluctuations in the Extragalactic Background Light to support studies of the origin and history of galaxy formation.
- Survey Galactic Molecular Clouds for water and organic molecules (H_2O, CO, CO_2, CH_3OH)

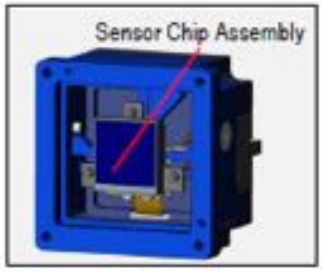
Partner Mission of Opportunity: ARIEL

Contribution to ARIEL Spectroscopy of Exoplanets

PI Mark Swain (JPL)

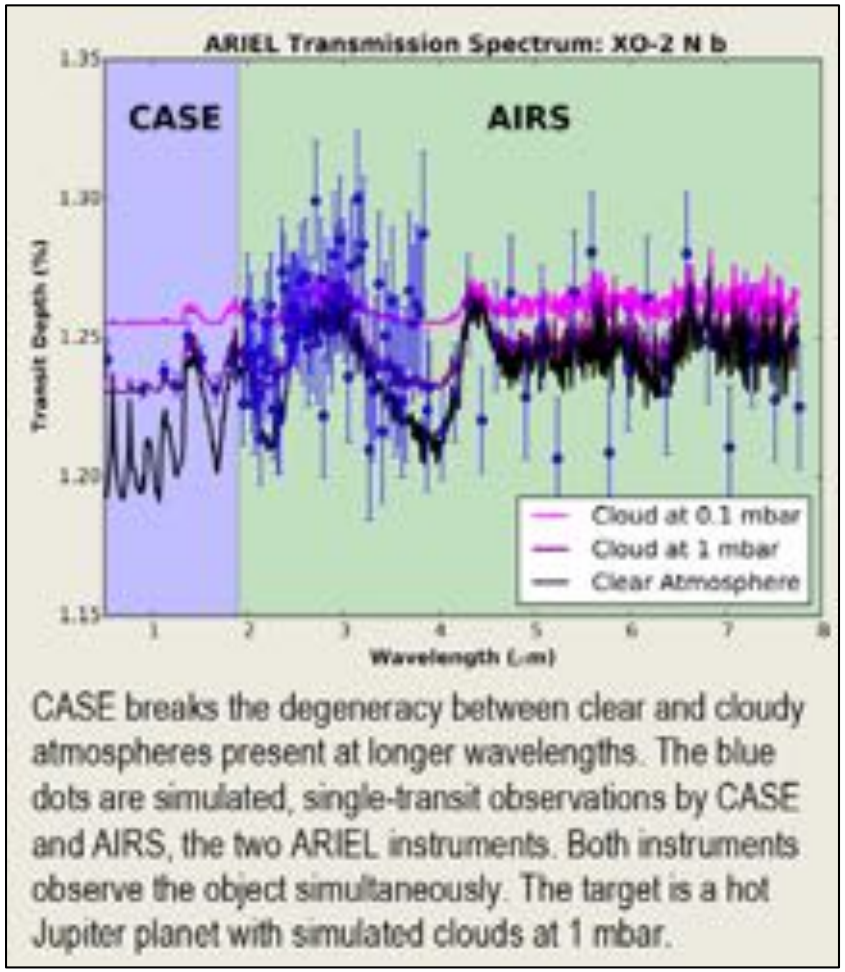


Cold Front End Electronics



Focal Plane Module

CASE detectors and electronics would provide fine guidance for ARIEL; blueward data (0.5μm-2μm) enables studies of aerosols (clouds and hazes) which are important for the energy budget of the atmosphere.



CASE breaks the degeneracy between clear and cloudy atmospheres present at longer wavelengths. The blue dots are simulated, single-transit observations by CASE and AIRS, the two ARIEL instruments. Both instruments observe the object simultaneously. The target is a hot Jupiter planet with simulated clouds at 1 mbar.

ARIEL: ESA M4 mission for Infrared Spectroscopy of Exoplanet Atmospheres

PI Giovanna Tinetti (UK)

Launch in 2028 to L2 for 4-yr mission; primary mirror 1.1m x 0.7m; CASE photometry complements AIRS spectroscopy 2μm-8μm.

ARIEL is next step beyond Kepler and TESS; will obtain spectra of hundreds of warm transiting exoplanets to study atmospheric chemistry and energy budget

LISA Update

- The LISA mission successfully passed ESA's Mission Confirmation Review (MCR) in November 2019.
- One of NASA's contribution, the Charge Management System, developed at UFl, has passed its technology readiness level 5 review with flying colors in November 2019
  - The CMS TRL 4 device was delivered to U. Trento where it was integrated with the torsion pendulum for system-level testing of charge control
  - This is the 1st delivery of NASA to Europe
- The NASA LISA Science Study Team (NLST) was refreshed with the addition of 7 new members:

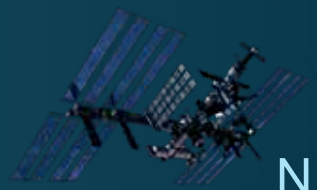
  Jeremy Darling (U Colorado / CASA)
  Matthew Digman (Ohio State)
  Kayhan Gultekin (Michigan)
  Zoltan Haiman (Columbia)
  Xin Liu (U. Illinois)
  Krista Lynne Smith (Stanford / SMU)
  Marcelle Soares-Santos (Brandeis)
- Many thanks to former members C. Hogan, B. Kamai, and G. Mueller*

*now member of the LISA Core Team

Astrophysics Explorers Program

Swift

NuSTAR



NICER

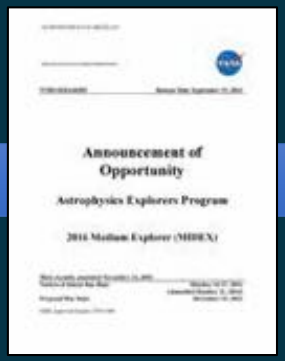
TESS

MIDEX 2011

SMEX 2014

MIDEX 2016

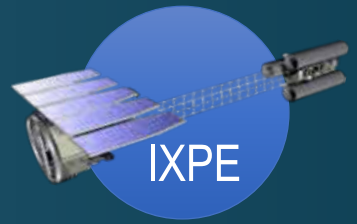
SMEX 2019



MIDEX 2021

Small and Mid-Size Missions

TESS



IXPE

SPHEREx

Missions of Opportunity

NICER

GUSTO

MO TBD

Directed 2017

XRISM

Astrophysics Science SmallSat Studies

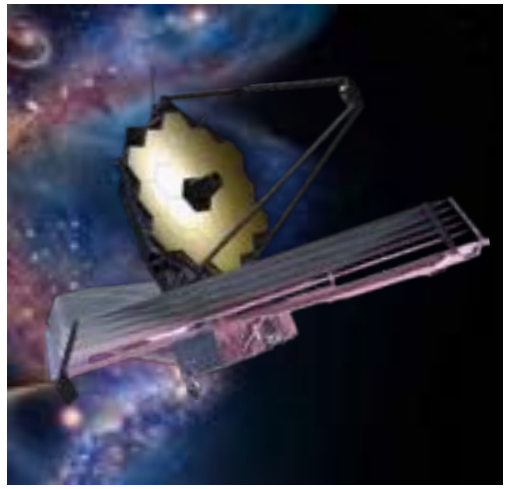
- NASA selected 9 Astrophysics Science SmallSat Studies in ROSES 2018. These studies were reported out at a special session of the June 2019 AAS meeting in St. Louis
- The 2019 Astrophysics Explorers Mission of Opportunity AO includes SmallSats and CubeSats launched using rideshare on ESPA or ESPA Grande; proposals are currently under evaluation along with other Small Explorer and Explorer Mission of Opportunity proposals
- A second Astrophysics Science SmallSat Studies solicitation is included in ROSES 2019; proposals are currently under evaluation
- NASA has selected 6 Astrophysics CubeSats through ROSES/APRA:

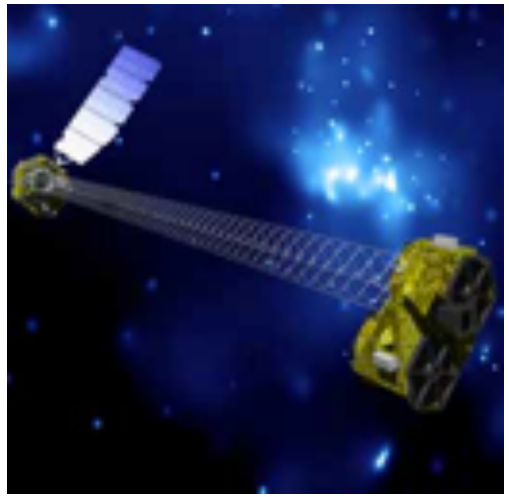
Astrophysics Results from CubeSats and SmallSats

Monday Jan 6 @ 2:00 pm in Room 317B

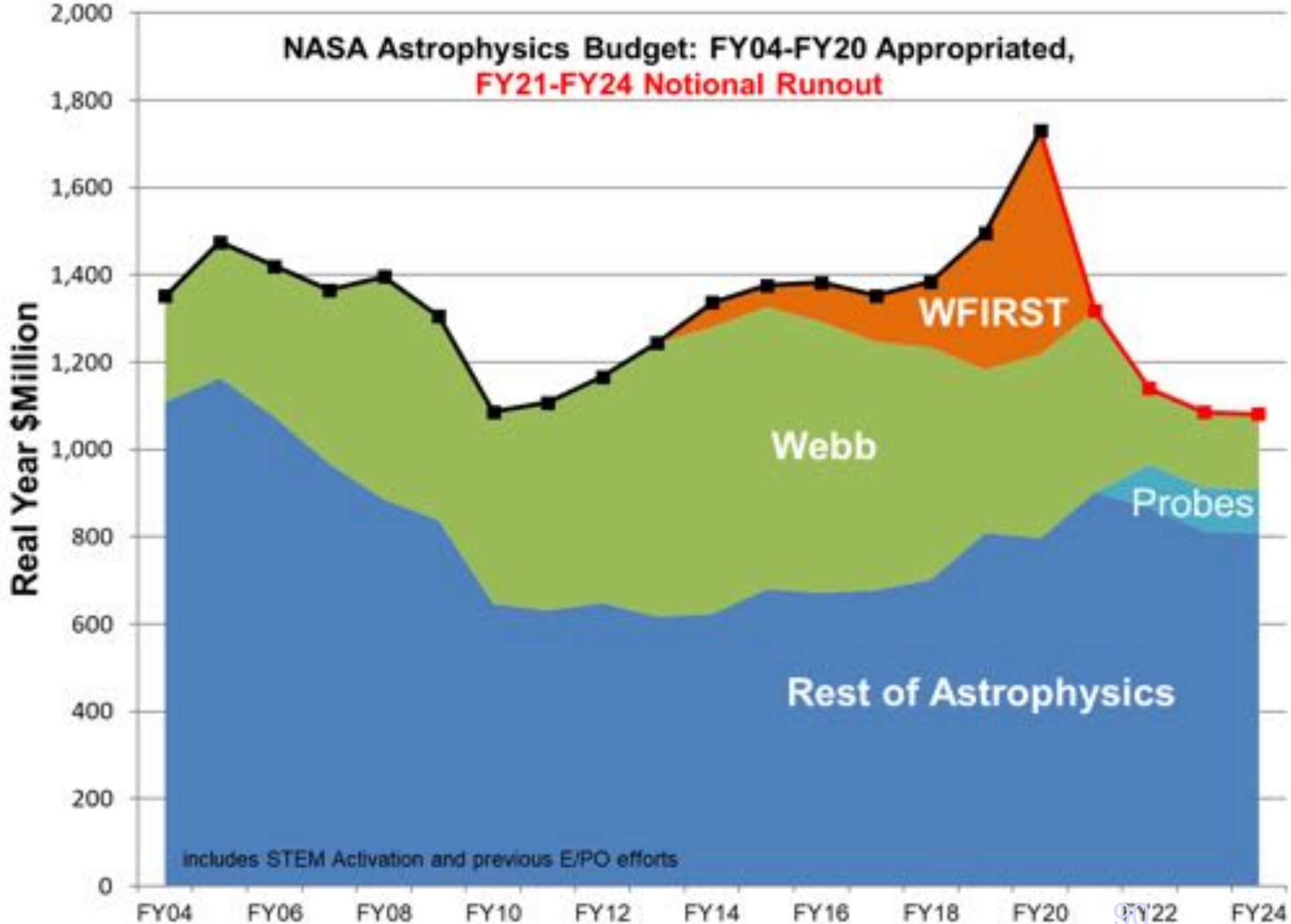
NASA Astrophysics Planning for the Future

FY20 Appropriation

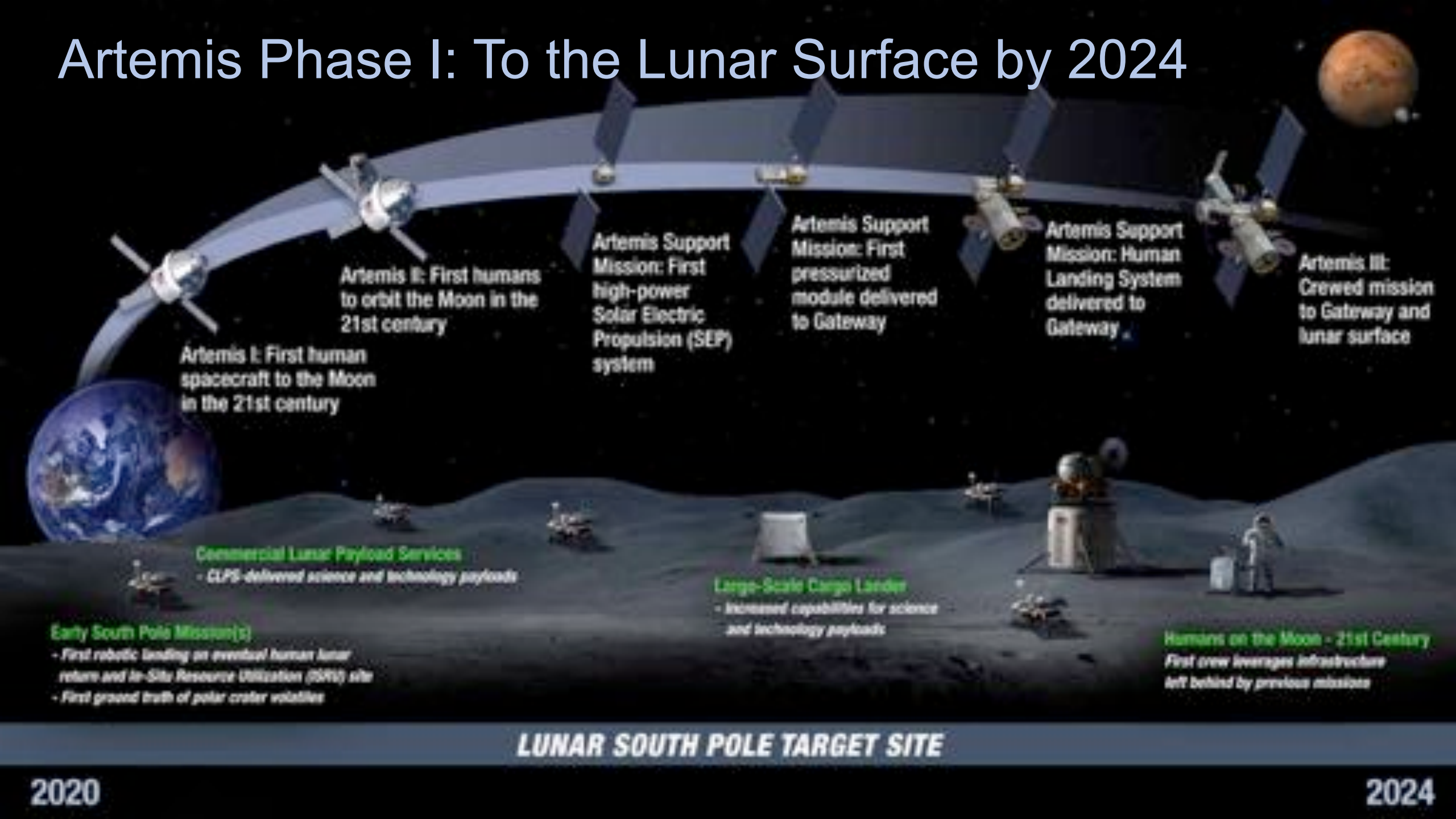




- FY20 appropriation for NASA Astrophysics (including Webb Telescope) is $1.73B; up by $233M from FY19 appropriation and by $532M from FY20 President's Budget Request
- Fully funds Webb for replan to March 2021 launch readiness date
- Fully funds WFIRST through KDP-C and into Phase C
- Specifies funding levels for Hubble, SOFIA, and the Astrophysics Research Program
- Provides adequate funding to continue with the rest of the planned Astrophysics programs and projects including:
  - Operating missions with GO programs as planned following the Senior Review
  - Development of Explorers missions (IXPE, GUSTO, SPHEREx) and international contributions (Euclid, XRISM, ARIEL, Athena, LISA)
  - Initiation of Phase A studies for selected SMEX and MO proposals from the 2019 Announcement of Opportunity
  - Continued technology development for the future


NASA Astrophysics Budget: FY04-FY20 Appropriated,
FY21-FY24 Notional Runout
Real Year $Million
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
WFIRST
Webb
Probes
Rest of Astrophysics
includes STEM Activation and previous E/PO efforts
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
FY24

Artemis Phase I: To the Lunar Surface by 2024



Astrophysics and Artemis

All science opportunities enabled by Project Artemis will include astrophysics

- Commercial Lunar Payload Services (CLPS)
  - 14 U.S. companies selected to bid on specific task orders to deliver NASA payloads to Moon's surface
  - All payload calls include astrophysics; two astrophysics payloads selected to date
    - Internal NASA call: Low-frequency Radio Observations from the Near Side Lunar Surface instrument (PI: Robert MacDowall, GSFC)
    - ROSES call: Next Generation Lunar Retroreflectors (PI: Douglas Currie, University of Maryland)
    - Both are among five payloads manifest on Intuitive Machines Lander for NET July 2021
- Astrophysics Explorers Missions of Opportunity
  - 2019 AO included opportunities enabled by Project Artemis
  - Future calls will solicit proposals that leverage Artemis capabilities, such as Gateway as a platform and cis-lunar communications infrastructure, to conduct compelling astrophysics investigations

Intuitive Machines Lander

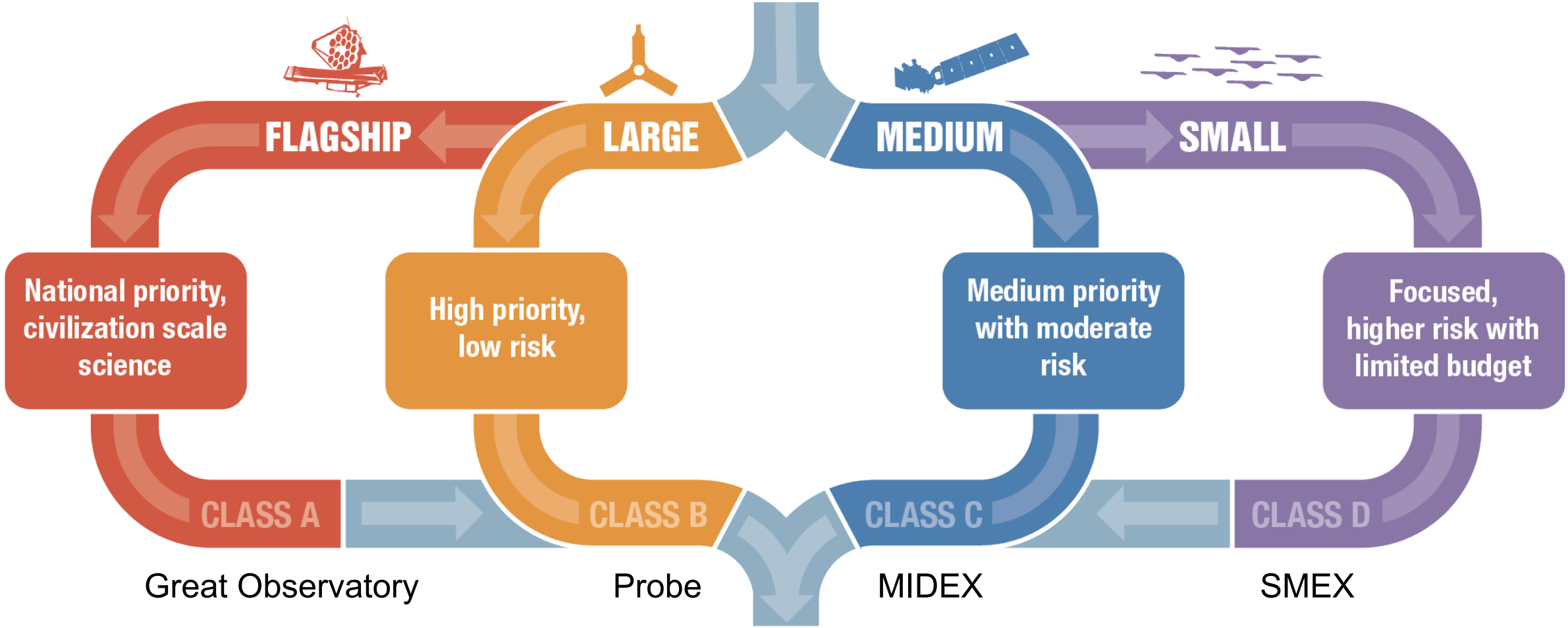
Most important criterion for all proposals that leverage Artemis remains the astrophysics science merit

Decadal Survey Planning

- NASA's highest aspiration for the 2020 Decadal Survey is that it be ambitious
  - The important science questions require new and ambitious capabilities
  - Ambitious missions prioritized by previous Decadal Surveys have always led to paradigm shifting discoveries about the universe

Town Hall – Implementing Astro2020
Tuesday, 12:45 pm, Ballroom AB

BALANCED MISSION PORTFOLIO



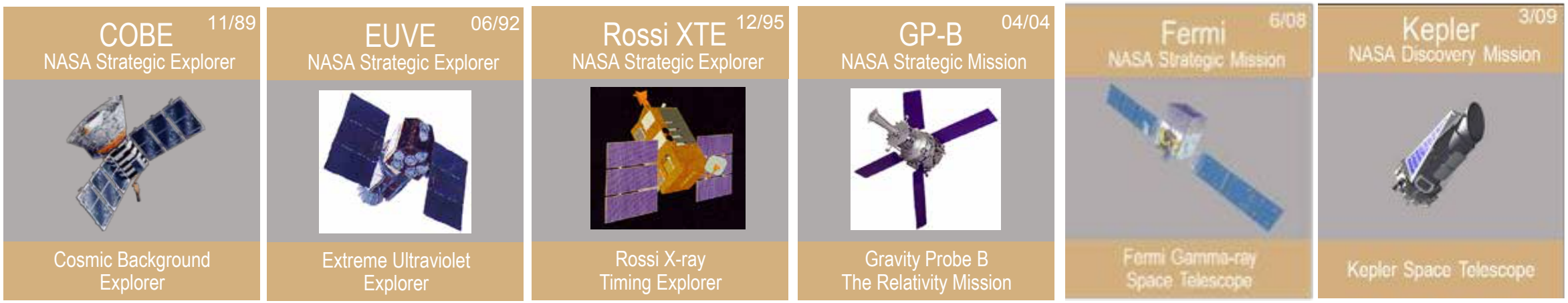
Great Observatory | Probe | MIDEX | SMEX

GREAT SCIENCE

+ SmallSats (Class D Tailored)
  Suborbital-class (Research Class)

Medium Mission Concepts (Probes)

Probes are strategic missions that have had a strong impact on astrophysics, either through a focused investigation or as a broadly-capable observatory



NASA funded probe studies are available at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

NASA's independent assessment of probe studies by the Probes Cost Assessment Team (PCAT) is available at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

Options for 2020 Decadal Survey

- Do not recommend a medium mission in Astro2020
- Recommend specific probe(s) as medium-size strategic missions
- Recommend several specific science concepts for an AO (similar to New Frontiers)
- Recommend an unconstrained AO (i.e., Super-Explorer)

Astrophysics

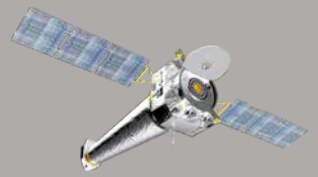
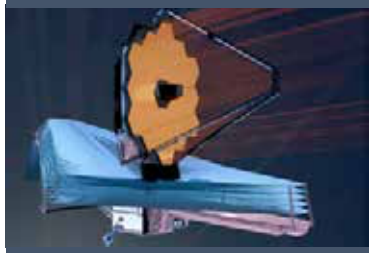
Decadal Survey Missions

Why Flagships

Flagships enable paradigm shifting science

Flagships drive US capabilities and contribute to US leadership

Flagships create stakeholder support that drives the NASA budget

Hubble 04/90 NASA Great Observatory	Compton 05/91 NASA Great Observatory	Chandra 09/99 NASA Great Observatory	Spitzer 8/03 NASA Great Observatory	Webb 2021 NASA Mission	WFIRST Mid 2020s NASA Mission
					
Hubble Space Telescope	Compton Gamma Ray Observatory	Chandra X-ray Observatory	Spitzer Space Telescope	James Webb Space Telescope	Wide-Field Infrared Survey Telescope

“NASA should continue to plan for large strategic missions as a primary component for all science disciplines as part of a balanced program.”
– Powering Science: NASA's Large Strategic Science Missions (NASEM, 2017)

Flagship Fraction of Astrophysics Budget

All dollars inflated to FY18$.
Development only, no ops.

Large mission fraction (left scale)

Inflation adjusted Astrophysics budget (right scale)

Current planning budget (without WFIRST beyond FY19)

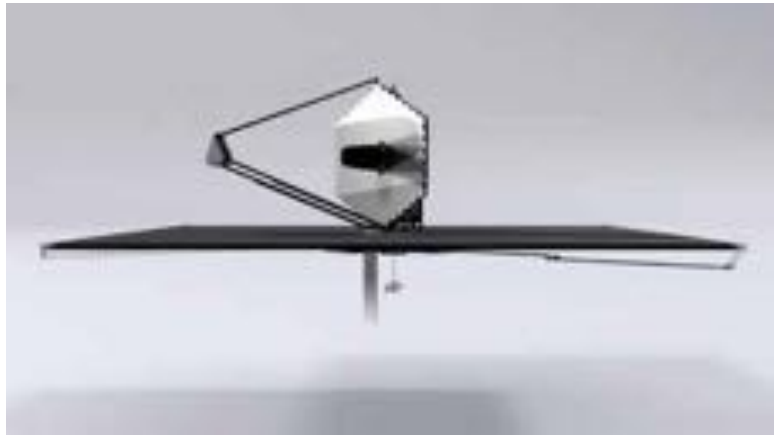
What if WFIRST is funded as needed on top of FY20 President's Budget Request?

Large Mission Concepts

"NASA should ensure that robust mission studies that allow for trade-offs (including science, risk, cost, performance, and schedule) on potential large strategic missions are conducted prior to the start of a decadal survey. These trade-offs should inform, but not limit, what the decadal surveys can address." – Powering Science: NASA's Large Strategic Science Missions (NASEM, 2017)

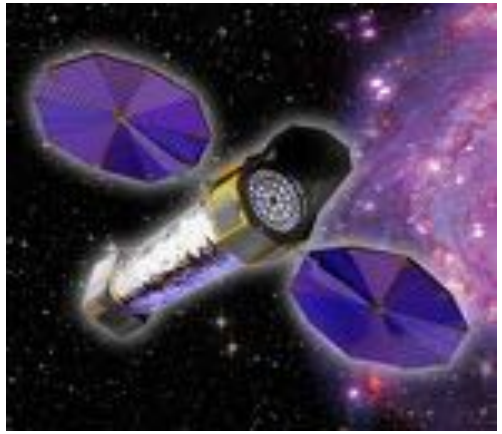
HabEx

Tuesday
1:30 pm
Room 306AB



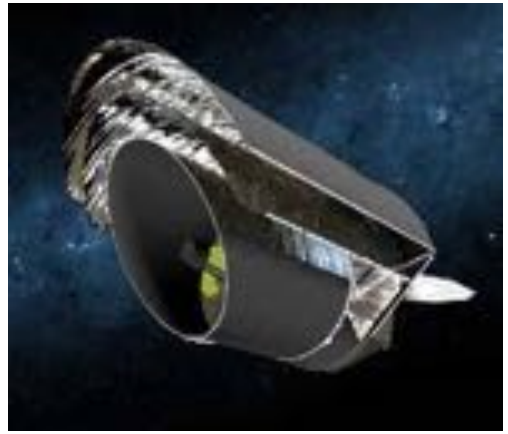
LUVOIR

Monday
2:00 pm
Room 301A



Lynx

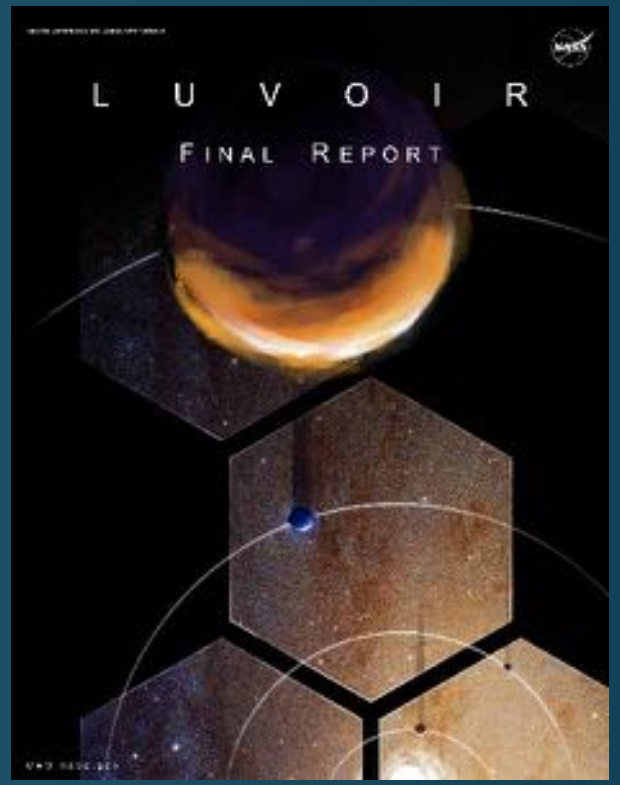
Sunday
1:00 pm
Room 303A



Origins

Monday
9:00 am
Room 307B

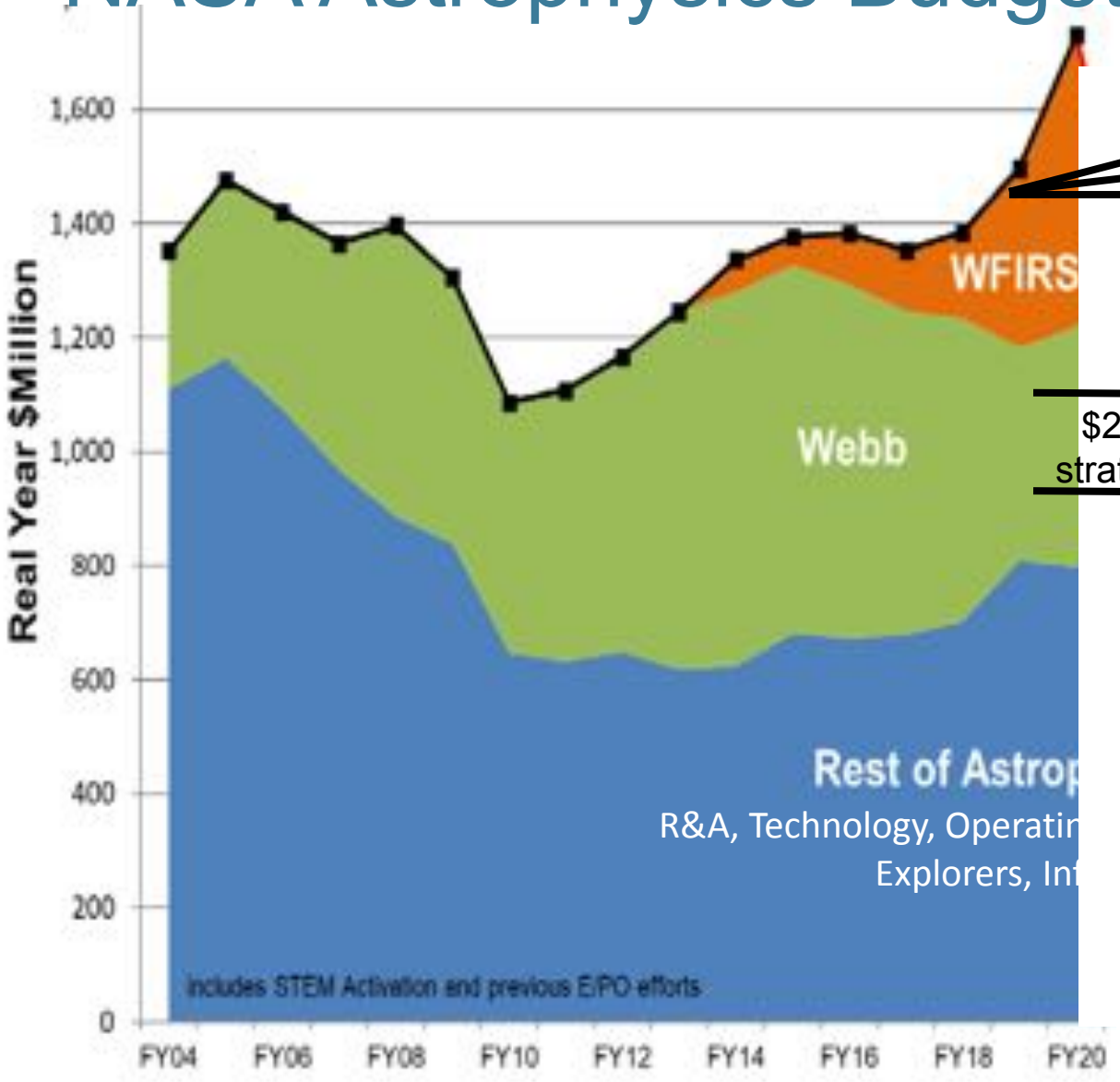
Large Mission Concepts

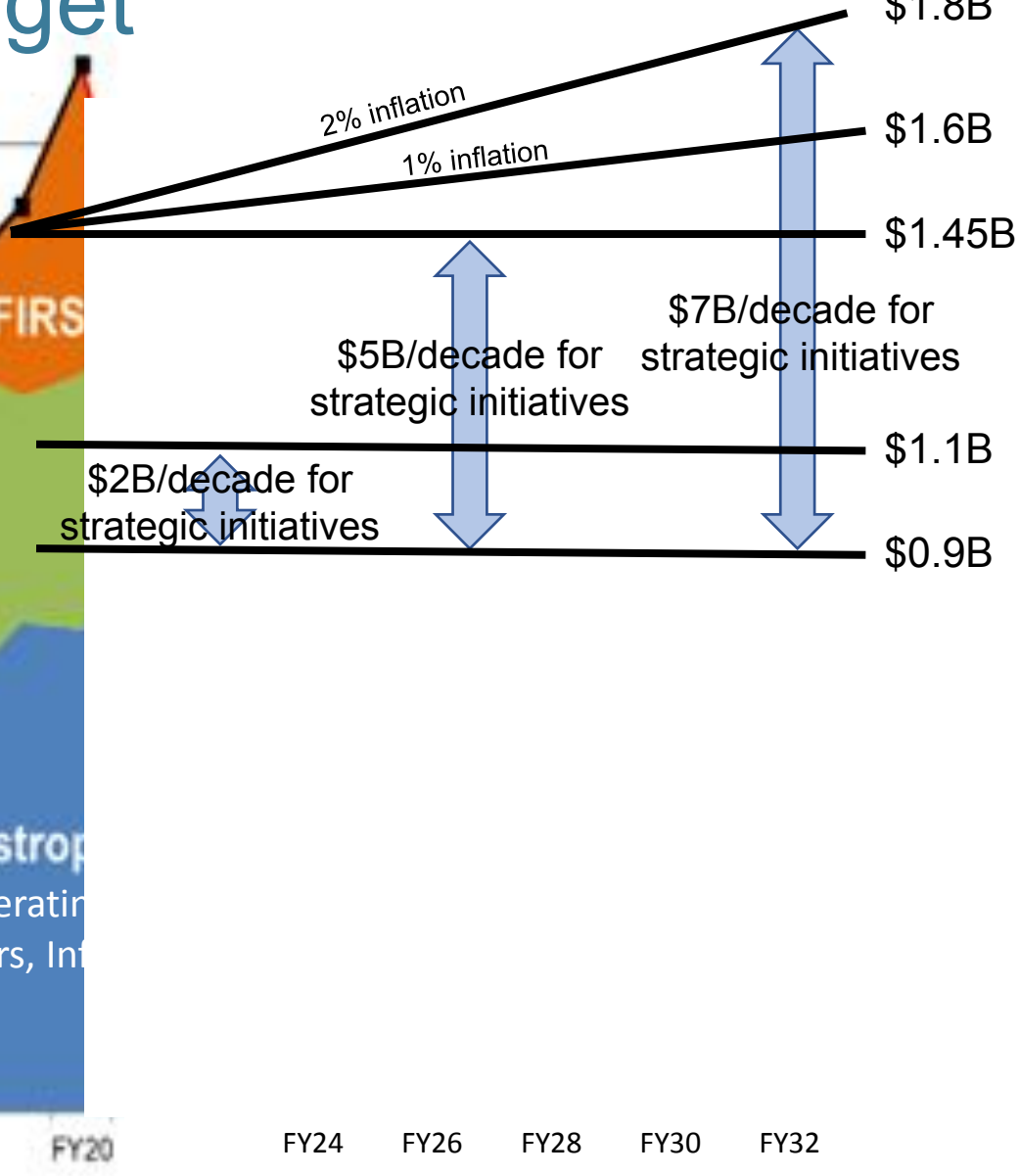


NASA's independent assessment of large mission concept studies by the Large Mission Concept Independent Assessment Team (LCIT) is available at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

Links to the concept study reports are posted at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning and at https://www.greatobservatories.org/

NASA Astrophysics Budget





Average of recent* appropriations plus inflation

Average of recent* appropriations

Runout of FY20 Budget Proposal

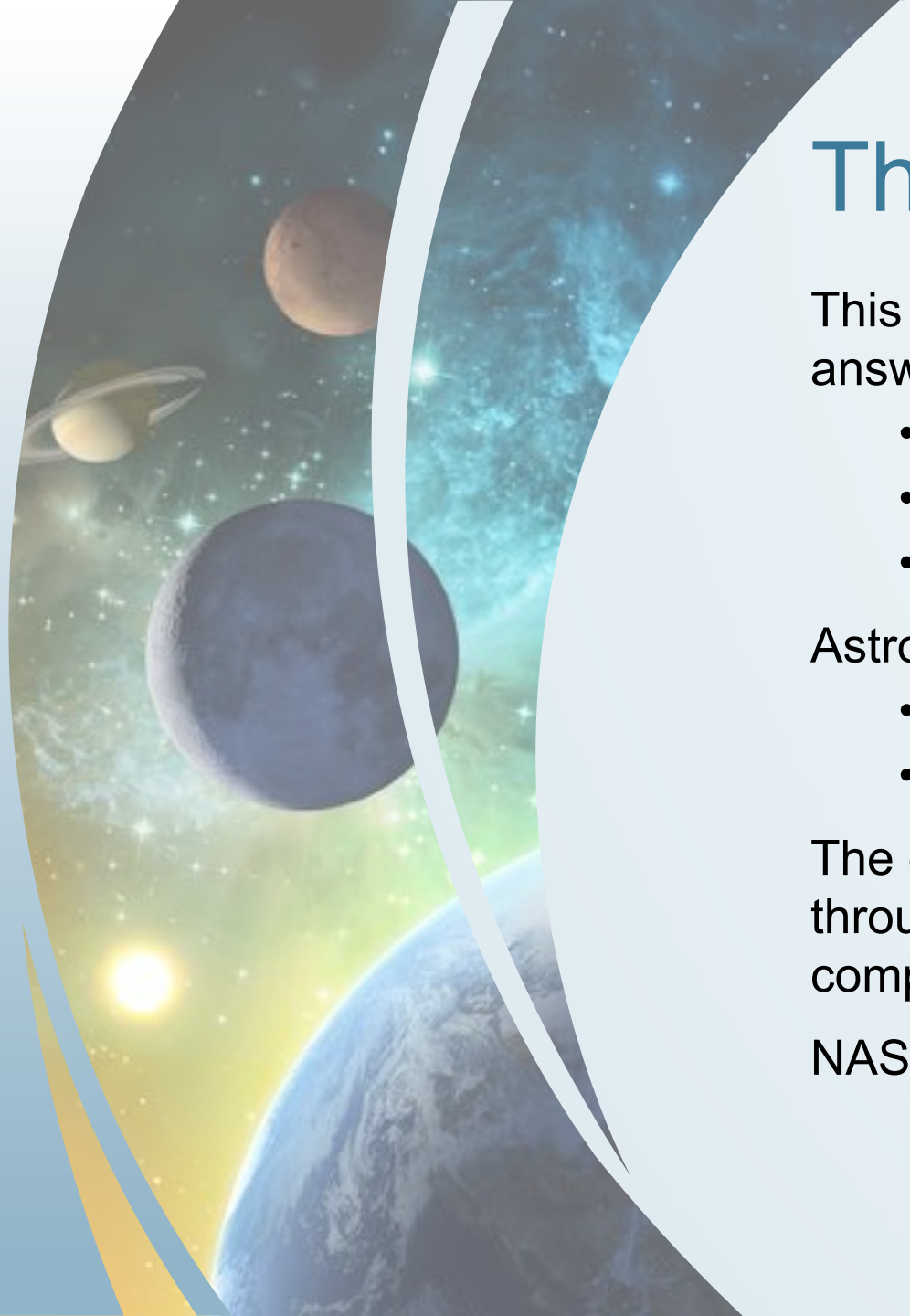
Current program including Webb operations and 4 Explorers/decade

* Does not include FY20 appropriation

Decadal Survey Goal

- NASA's highest aspiration for the 2020 Decadal Survey is that it be ambitious
  - The important science questions require new and ambitious capabilities
  - Ambitious missions prioritized by previous Decadal Surveys have always led to paradigm shifting discoveries about the universe
- If you plan to a diminishing budget, you get a diminishing program
  - Great visions inspire great budgets

Carpe Posterum



The Future

This is an exciting time for Astrophysics – we are pursuing the answers to the biggest questions

- How did the universe begin and evolve?
- How did galaxies, stars, and planets come to be?
- Are we alone?

Astrophysics is multiwavelength and multimessenger

- NASA has 10 operating astrophysics missions*
- NASA is developing 11 astrophysics missions*

The community will select NASA's future observatories through the 2020 Decadal Survey and through peer review of competed missions (like Explorers)

NASA is ready to realize the community's priorities

* includes partner-led missions


NASA
EXPLORE
with us

BACKUP

Astrophysics Program Content (FY20 Request)

	Actual FY 18	Enacted FY 19	Request FY 20	Out-years FY 21	FY 22	FY 23	FY 24
Astrophysics	**850.4**	**1,191.6**	**844.8**	**902.4**	**965.2**	**913.5**	**907.7**
Astrophysics Research	203.1	222.8	250.7	309.3	302.5	299.1	298.8
Astrophysics Research and Analysis	74.1	83.4	86.6	90.2	92.2	94.2	94.2
Balloon Project	36.6	40.2	44.8	44.8	44.8	44.8	44.8
Science Activation	44.0	45.0	45.6	45.6	45.6	45.6	45.6
Other Missions and Data Analysis	48.5	54.2	73.7	128.7	119.9	114.5	114.2
Astrophysics Data Curation and Archival	18.2	17.9	21.2	21.2	21.5	22.0	22.0
Astrophysics Data Program	17.6	19.1	20.4	21.6	22.6	23.6	23.6
Astrophysics Senior Review				33.5	20.5	27.3	31.6
Contract Administration, Audit & QA Svcs	12.7	4.5	12.7	12.7	12.7	12.7	12.7
Astrophysics Directed R&T		12.7	19.4	39.7	42.7	28.9	24.3
Cosmic Origins	211.2	222.8	185.3	173.9	181.7	121.7	121.7
Hubble Space Telescope (HST)	98.3	98.3	83.3	93.3	98.3	98.3	98.3
Stratospheric Observatory for Infrared Astronom	85.2	85.2	73.0	60.0	60.0		
Other Missions and Data Analysis	27.7	39.3	29.0	20.6	23.4	23.4	23.4
Cosmic Origins SR&T	15.5	24.9	17.1	18.4	18.4	18.4	18.4
SIRTF/Spitzer	11.2	13.0	8.5	1.0			
Cosmic Origins Future Missions	1.0	0.8	2.2	0.0	3.8	3.8	3.8
Astrophysics Strategic Mission Prog Mgmt		0.5	1.2	1.2	1.2	1.2	1.2

Astrophysics Program Content (FY20 Request)

	Actual FY 18	Enacted FY 19	Request FY 20	Out-years FY 21	FY 22	FY 23	FY 24
Physics of the Cosmos	118.0	151.2	148.4	128.5	123.3	117.8	117.4
Euclid	19.8	17.2	13.7	11.0	8.9	9.9	10.3
Physics of the Cosmos Future Missions	0.2	0.9	2.0	1.1	3.8	3.5	3.7
Chandra X-Ray Observatory	56.9	60.9	58.4	58.4	58.4	58.4	58.4
Fermi Gamma-ray Space Telescope	13.0	16.5	14.0				
XMM	2.5	4.5	3.5				
Physics of the Cosmos SR&T	20.9	45.7	50.9	52.1	46.3	40.1	39.0
PCOS/COR Technology Office Management	4.6	5.6	5.9	5.9	6.0	6.0	6.0
Exoplanet Exploration	200.8	367.9	46.4	44.3	45.6	46.1	48.5
WFIRST	150.0	312.2					
Kepler	10.0	8.9	1.3				
Keck Operations	6.2	6.4	6.7	6.9	7.0	7.2	7.4
Large Binocular Telescope Interferometer	1.8						
Exoplanet Exploration SR&T	26.4	32.3	29.1	30.0	28.9	28.9	28.6
Exoplanet Exploration Tech Office Mgmt	5.3	7.5	6.5	6.8	7.3	7.7	7.7
Exoplanet Exploration Future Missions	1.0	0.6	2.8	0.6	2.4	2.2	4.7

Astrophysics Program Content (FY20 Request)

	Actual FY 18	Enacted FY 19	Request FY 20	Out-years FY 21	FY 22	FY 23	FY 24
Astrophysics Explorer	117.4	227.0	214.1	246.4	312.0	328.8	321.4
Imaging X-Ray Polarimetry Explorer	23.5	57.0	70.2	45.3	7.4	4.5	0.5
X-Ray Imaging and Spectroscopy Mission	22.0	27.8	29.7	25.7	22.5	17.6	15.8
GUSTO	4.7	12.6	11.1	7.8	6.3	1.0	
Nuclear Spectroscopic Telescope Array	4.8	8.5	7.8				
Neil Gehrels Swift Observatory	3.9	7.0	5.5				
Transiting Exoplanet Survey Satellite	33.5	7.7	5.0	0.2			
Neutron Star Interior Composition Explor	2.1	3.8					
Astrophysics Explorer Future Missions	11.8	95.1	84.8	154.2	267.0	295.1	299.2
Astrophysics Explorer Program Managemen	11.1	7.6		13.3	8.8	10.7	5.9
James Webb Space Telescope	**533.7**	**304.6**	**352.6**	**415.1**	**175.4**	**172.0**	**172.0**

SMD Organization Chart