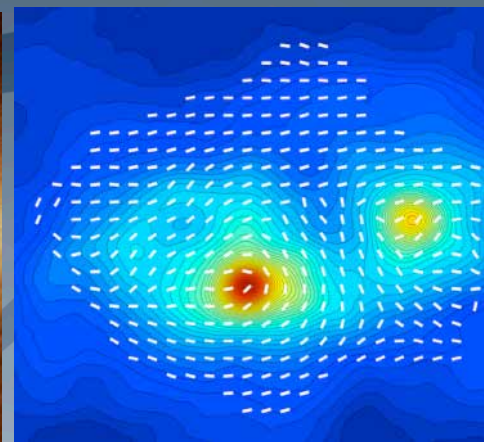
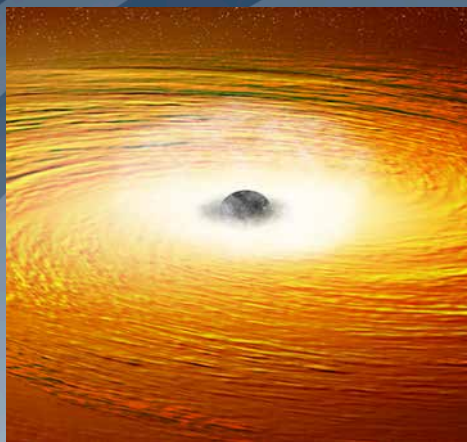
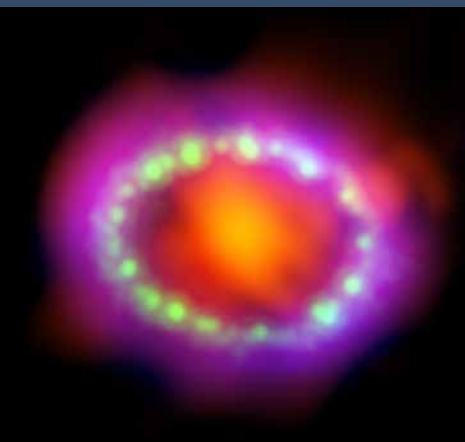


Astrophysics

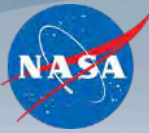


NASA Update

First JSTUC Meeting
September 14, 2017

Paul Hertz

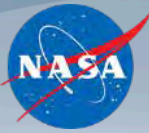
Director, Astrophysics Division
Science Mission Directorate
[@PHertzNASA](https://twitter.com/PHertzNASA)



NASA Astrophysics

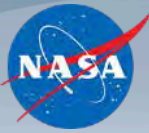
General Update

Astrophysics - Big Picture (1 of 2)



- **The FY17 appropriation and FY18 budget request provide funding for NASA astrophysics to continue its planned programs, missions, projects, research, and technology.**
 - Total funding (Astrophysics including Webb) remains at ~\$1.35B.
 - The NASA Astrophysics budget funds Webb for an October 2018 launch, WFIRST formulation, Explorers mission development, increased funding for R&A, operating missions, suborbital missions and new capabilities, continued technology development and mission studies.
 - FY17 Consolidated Appropriation is less than planning budget; reductions to plans required.
 - FY18 President's Budget Request balances current science and future missions; Congressional markups, if enacted, would put that balance at risk.
- **NASA continues to prioritize implementation of the recommendations of the 2010 Decadal Survey.**
 - National Academies' 2016 Midterm Assessment Report validates NASA's progress.
 - NASA is conducting large and medium mission concept studies for 2020 Decadal Survey.

Astrophysics - Big Picture (2 of 2)

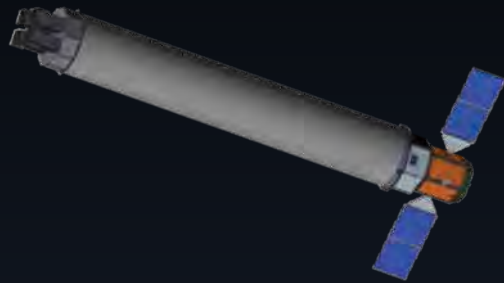


- **The operating missions continue to generate important and compelling science results, and new missions are under development for the future.**
 - Senior Review in Spring 2016 recommended continued operation of all missions (Chandra, Fermi, Hubble, Kepler, NuSTAR, Spitzer, Swift, XMM); next Senior Review is in 2019.
 - SOFIA is adding new instruments: HAWC+ instrument commissioned; HIRMES instrument in development; next gen instrument call planned.
 - ISS-NICER launched on June 3, 2017; ISS-CREAM launched on August 14, 2017.
 - NASA missions under development making progress toward launches: TESS (2018), Webb (2018), IXPE (2021), GUSTO (2021), WFIRST (mid-2020s).
 - Independent WFIRST technical/management/cost review underway; report expected by end of October 2017.
 - Partnerships with ESA and JAXA on future missions create additional science opportunities: Euclid (ESA; 2020), XARM (JAXA; 2021), Athena (ESA; 2028), LISA (ESA; 2034).
 - Explorer AOs are being released every 2-3 years: IXPE downselected in January 2017, GUSTO downselected in March 2017, MIDEX/MO missions selected for Phase A studies in August 2017, next SMEX/MO AO in Spring 2019.

Astrophysics Explorers in Competitive Phase A

Arcus

PI: R. Smith/SAO



High resolution x-ray spectroscopy to explore the origin of galaxies

FINESSE

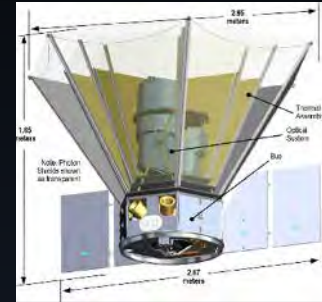
PI: M. Swain/JPL



NIR transit spectroscopy to explore exoplanet atmospheres

SPHEREx

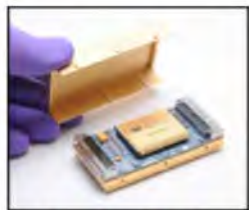
PI: J. Bock/Caltech



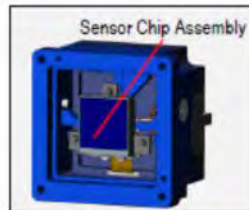
NIR spectral survey addressing cosmology, galaxy evolution, and origin of ices

CASE

PI: M. Swain/JPL



Cold Front End Electronics



Focal Plane Module

Contribution of detectors to ESA's ARIEL mission to explore exoplanet atmospheres

COSI-X

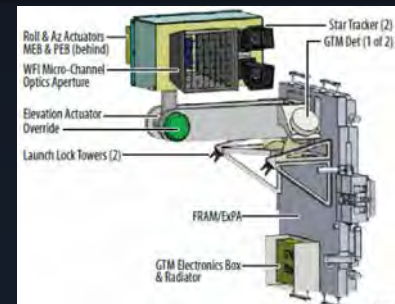
PI: S. Boggs/UCB



ULDB balloon mission to study origin of elements in the galaxy

ISS-TAO

PI: J. Camp/GSFC



All-sky x-ray survey to study transients and search for GW sources

FY17 Consolidated Appropriations Bill (H.R. 244)

- The FY17 Appropriation for Astrophysics resulted in a reduction of \$63.0M for Astrophysics (including Webb) relative to the FY16 funding level.

\$M	FY16 Actual	FY17 Request	FY17 Approp	
Webb	620.0	569.4	569.4	Planned decrease of \$50.6M
Astrophysics	762.4	781.5	750.0	Down \$31.5M from FY17 request
Astrophysics w/ Webb	1,382.4	1,350.9	1,319.4	Down \$63.0M from FY16 actual

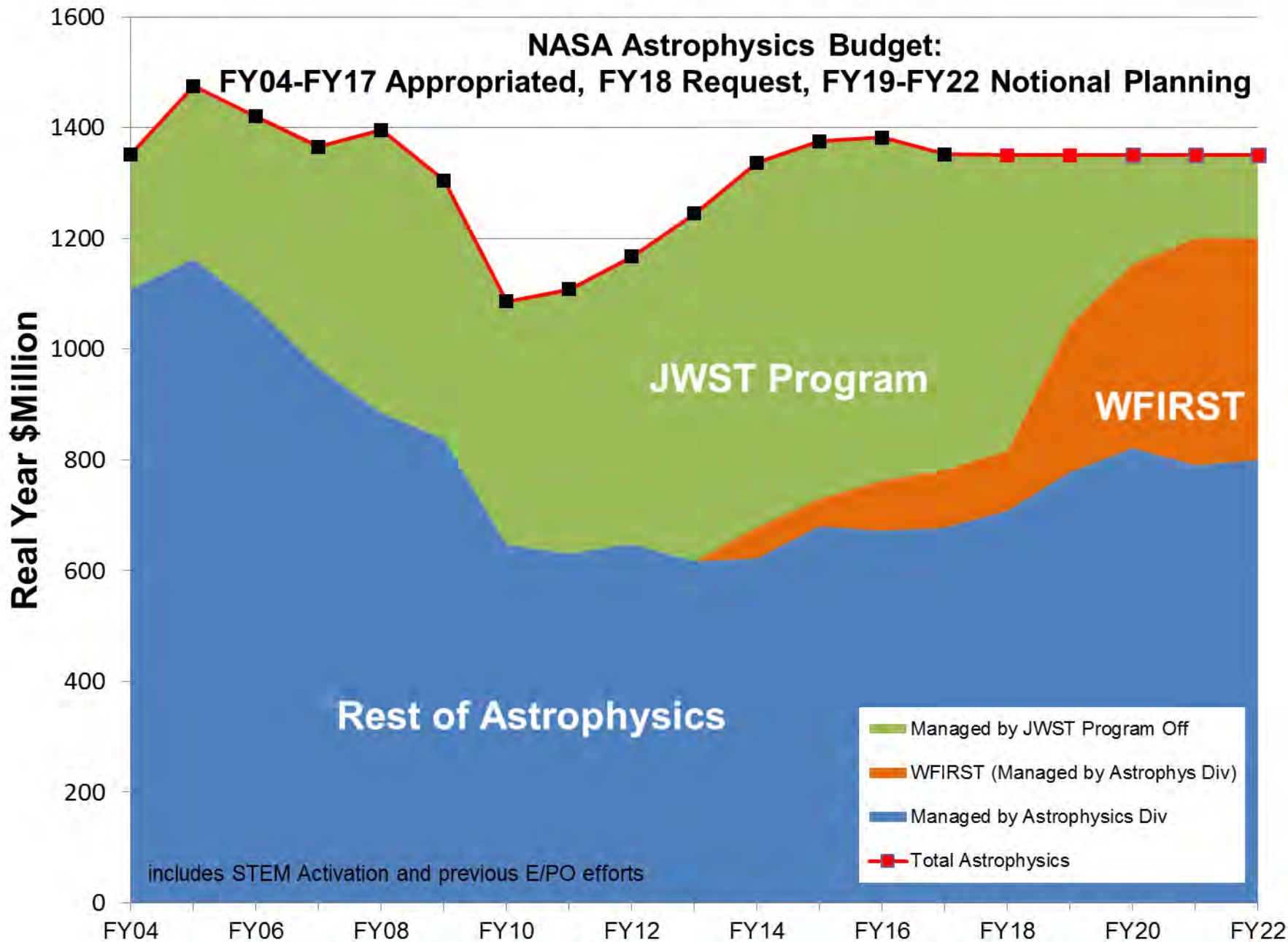
- HR 244 resulted in a reduction of \$31.5M for Astrophysics (including Webb) relative to the FY17 budget request.
- HR 244 also included directed increases in funding for WFIRST (+\$15M) and SOFIA (+\$1.4M) within the reduced total.
- HR 244 resulted in a reduction of up to \$47.9M for Astrophysics programs excluding Webb, Hubble, SOFIA, WFIRST, relative to the FY17 budget request.

FY18 President's Budget Request

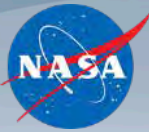


	Actual	Actual	Request	Notional			
Budget (in \$ millions)	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
Astrophysics Research	193	190	204	221	225	262	288
Cosmic Origins	196	210	192	190	142	158	156
Physics of the Cosmos	125	106	100	109	111	94	94
Exoplanet Exploration	141	153	176	351	473	476	440
Astrophysics Explorer	108	124	145	175	201	212	222
James Webb Telescope	620	569	534	305	197	150	150
Total Astrophysics	1382	1352	1350	1350	1350	1350	1350

- Supports an SMD-wide CubeSat/SmallSat initiative that uses smaller, less expensive satellites to advance science in a cost-effective manner.
- Reflects more efficient operations of the Hubble Space Telescope, without impact to science.
- Reflects efficiencies realized by the SOFIA in the past few years. SOFIA will participate in the 2019 Astrophysics Senior Review.
- Does not include WFIRST review recommendations.



FY18 Appropriation Markups



- Both Markups
 - Follow the Decadal Survey
 - Webb must be \$533.7M (= requested) but do not overrun
 - STEM Activation must be \$44.0M (= request); other language
- House Markup
 - Core R&A must be \$74.1M (= request)
 - SOFIA must be \$85.2M (+\$5.3M over request, = FY17 level); other language
 - WFIRST must be \$126.6M (= request) but spend \$20M on starshade technology
 - Language on high energy observatories, astrophysics probes, finding target(s) for interstellar probe
- Senate Markup
 - WFIRST must be \$150.0M (+23.4M over request); review; data w/ Hubble, Webb
 - Hubble must be \$98.3M (+\$15M over request)
 - At least \$10M on “life detection technology”; consistent with request (maybe)

	FY18 PBR	FY18 Markups	
Total Astrophysics	\$ 1,350.5 M	\$ 1,350.5 M	
Earmarked Projects	\$ 941.6 M	\$ 995.3 M	Webb, WFIRST, Hubble, SOFIA, R&A, STEM, Starshade (\$10M) *
Rest of Astrophysics	\$ 408.9 M	\$ 365.2 M	\$43.7M (13%) reduction

* Combined House and Senate markups

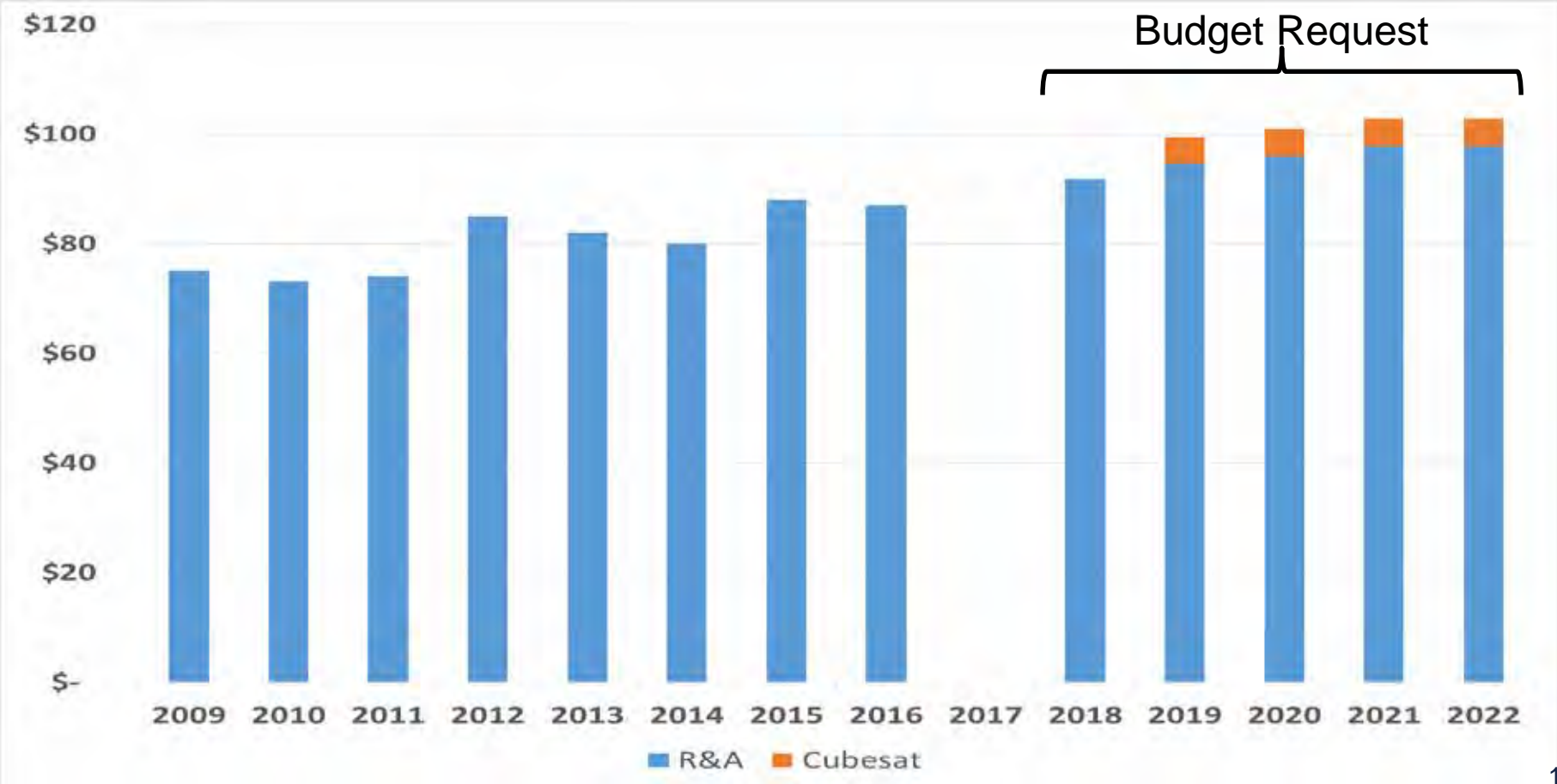
Proposed Future R&A Budget



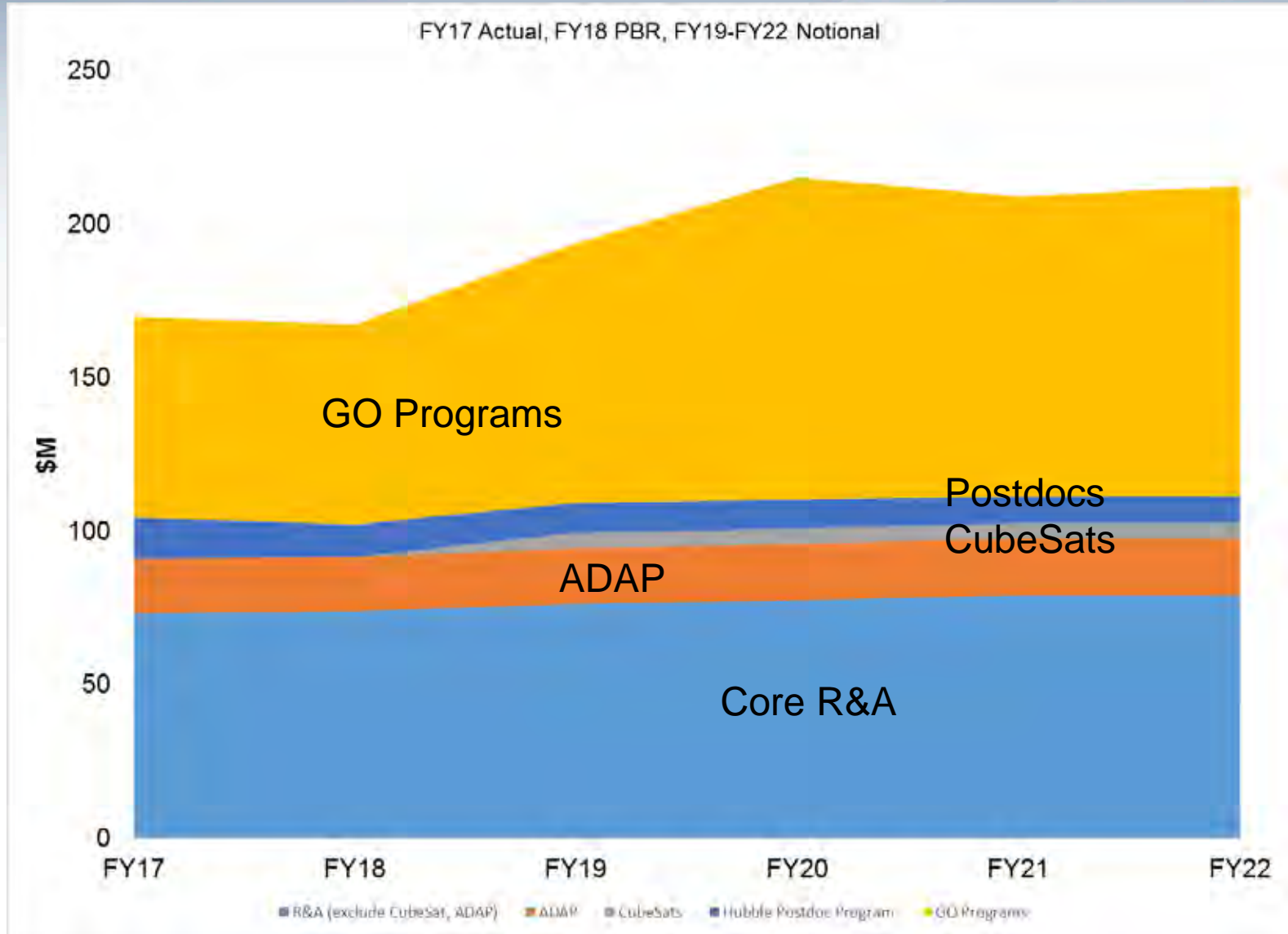
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
R&A	\$ 75	\$ 73	\$ 74	\$ 85	\$ 82	\$ 80	\$ 88	\$ 87		\$ 92	\$ 95	\$ 96	\$ 98	\$ 98
Cubesat											\$ 5	\$ 5	\$ 5	\$ 5
Total	\$ 75	\$ 73	\$ 74	\$ 85	\$ 82	\$ 80	\$ 88	\$ 87		\$ 92	\$ 100	\$ 101	\$ 103	\$ 103

All numbers in \$M

FY2018 President's Budget Request

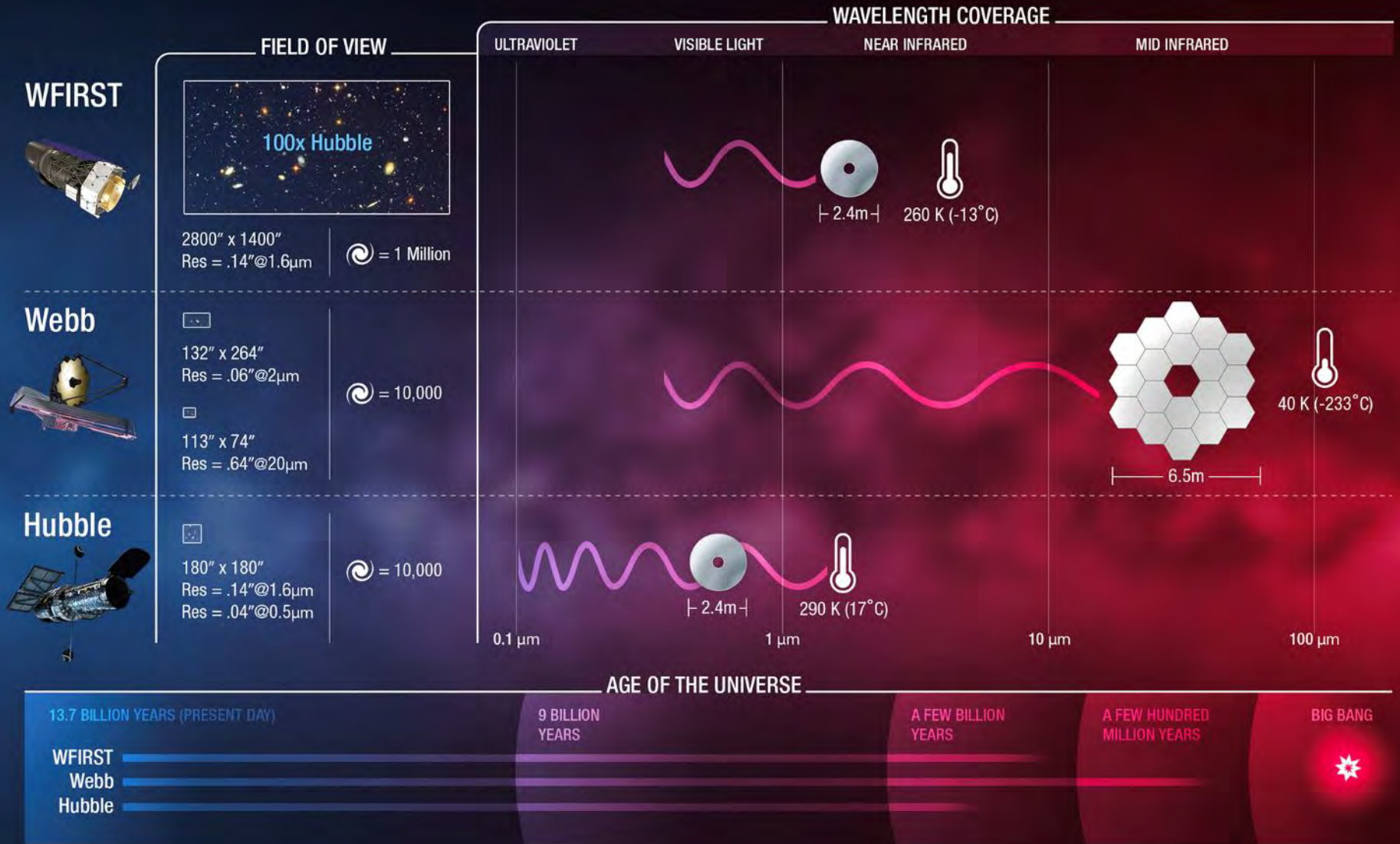


Total Community Support



GO programs funded from Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, SOFIA, Spitzer, Swift, TESS, Webb, XARM, XMM; does not include possible extensions following the 2019 Senior Review.

GREAT OBSERVATORIES



- WFIRST is a mission conducting major surveys for the community along with a guest observer program for individuals or small groups.

- The existing Formulation Science Working Group (FSWG) is in place only during formulation. It will be disbanded in early 2021. Present plans from the FSWG only establish a design reference mission – no time allocated.

0%
Allocated

- All WFIRST observing time is available – no particular survey implementations or investigators have been selected yet.

Time
100%
Available

- All data provided in the WFIRST archive are publicly available – there will be no proprietary period.

Data
100%
Public

- A new “Operations Science Working Group” will be selected via an open competition to conduct the survey observations.

Participation
100%
Open

- None of the WFIRST observing time has been set aside for a specific survey, investigator, or observation

- WFIRST project is making excellent technical progress
 - At a mature stage of design for end of Phase A
 - Prepared to conduct Systems Requirements Review (SRR) and KDP-B after incorporation of recommendations from WIETR
 - Discussions ongoing for international contributions from ESA, CSA, JAXA, and CNES; contributions will be meaningful but modest
- Two National Academies studies recommended that NASA conduct an independent technical/management/cost (TMC) review of WFIRST before beginning Phase B and before proceeding to the Preliminary Design review
 - The studies are the 2014 WFIRST/AFTA study (F. Harrison et al.) and the 2016 Astrophysics Midterm Assessment (J. Hewitt et al.)
- WFIRST Independent External Technical/management/cost Review (WIETR) is ongoing
- WFIRST project, including technical / cost / schedule, will be assessed for changes after receipt of WIETR report
 - WIETR report expected by the end of October 2017

WFIRST Independent External TMC Review (WIETR)

Orlando Figueroa	CTS (NASA-Ret)	Roger Brissenden	Harvard/Smithsonian David
Charbonneau	Harvard/Smithsonian	Eileen Dukes	CTS
Daniel Eisenstein	Harvard/Smithsonian	Dave Kusnierkiewicz	JHU/Applied Physics Lab
William Green	CTS	Lynne Hillenbrand	Caltech
Anne Kinney	Keck Observatory	James Lloyd	Cornell University
Dimitri Mawet	Caltech	<u>Analysis</u>	
Pete Theisinger	CTS (JPL-Ret)	<i>Bob Bitten</i>	<i>Aerospace</i>
Peter Michelson	Stanford University	<i>Gary Rawitscher</i>	<i>NASA/SMD</i>
Mark Saunders	CTS (NASA-Ret)	<i>Justin Yoshida</i>	<i>Aerospace</i>

- Formulation
- Implementation
- Primary Ops
- Extended Ops



Spitzer
8/25/2003



Kepler
3/7/2009



WFIRST
Mid 2020s



LISA Pathfinder (ESA)
12/3/2015



Webb
2018



Chandra
7/23/1999



Euclid (ESA)
2020



XMM-Newton (ESA)
12/10/1999



TESS
2018



Swift
11/20/2004



NuSTAR
6/13/2012



IXPE
2020



Hubble
4/24/1990



Fermi
6/11/2008



GUSTO
2021



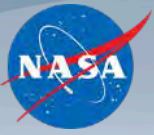
SOFIA
Full Ops 5/2014



ISS-NICER
6/3/2017



ISS-CREAM
2017

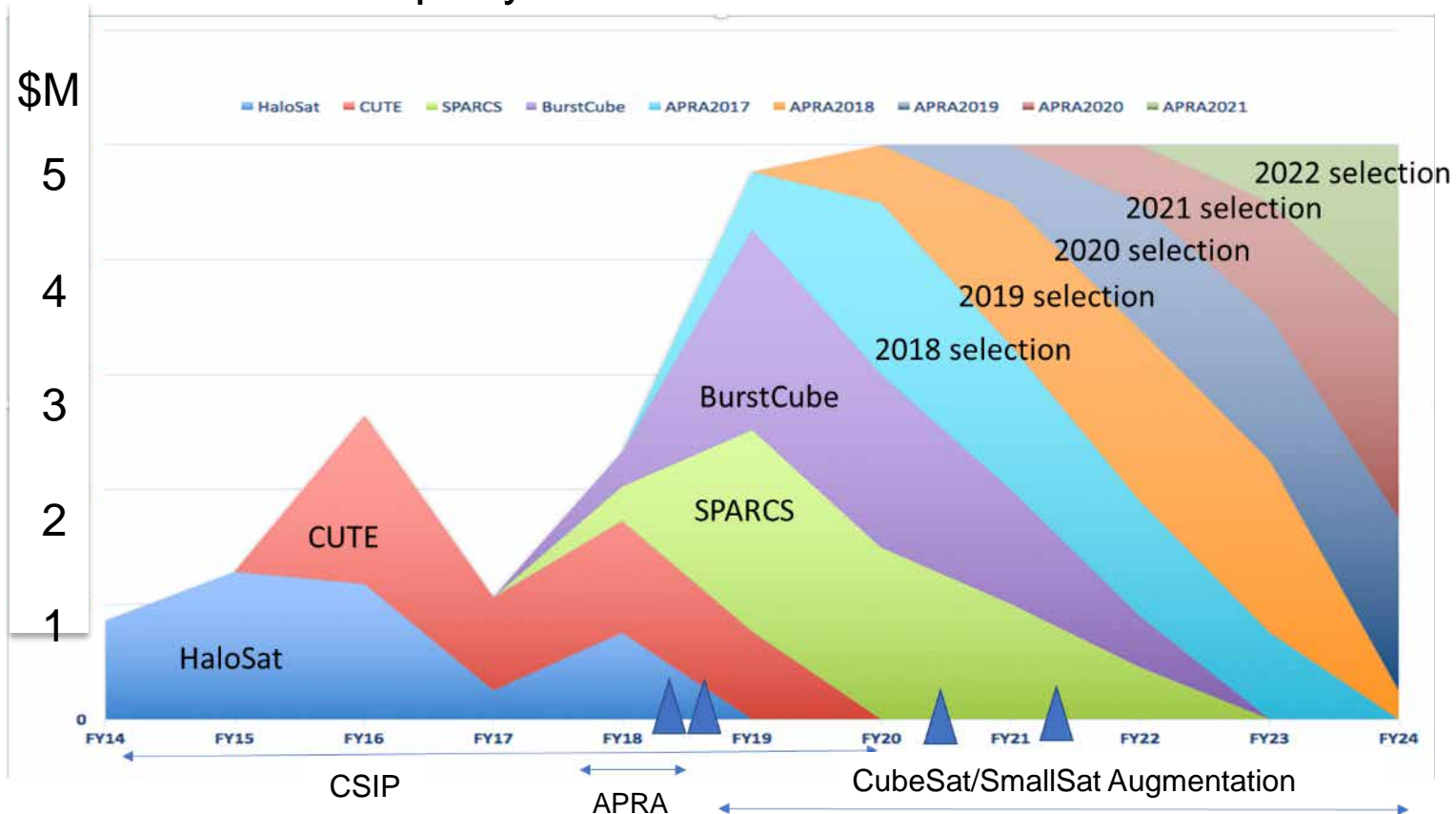


Backup

Astrophysics CubeSats



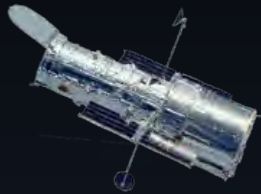
- Astrophysics CubeSats are implemented as part of the R&A program
 - CubeSat proposals are submitted just like proposals for balloon payloads and sounding rocket payloads
- Astrophysics selected two CubeSats under the CubeSat Initiative Program (CSIP)
- The CubeSat/SmallSat augmentation will support ~1 astrophysics CubeSat selection per year



Astrophysics Missions in Operation

Hubble
NASA Mission

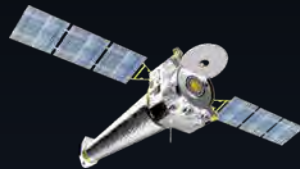
4/1990



Hubble Space Telescope

Chandra
NASA Mission

7/1999



Chandra X-ray Observatory

Spitzer
NASA Mission

8/2003



Spitzer Space Telescope

Swift
NASA Mission

11/2004



Swift Gamma-ray Burst Explorer

Fermi
NASA Mission

6/2008



Fermi Gamma-ray
Space Telescope

Kepler
NASA Mission

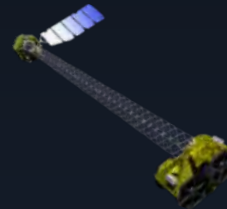
3/2009



Kepler Space Telescope

NuSTAR
NASA Mission

6/2012



Nuclear Spectroscopic
Telescope Array

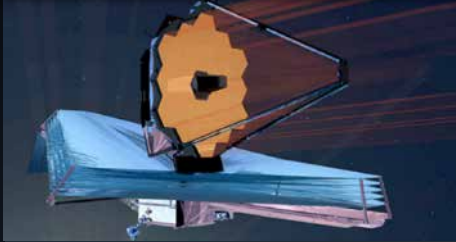
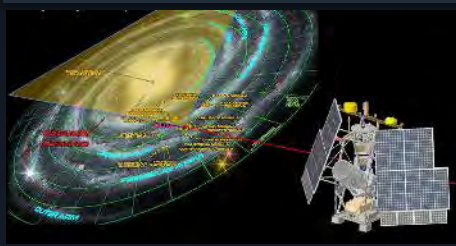
SOFIA
NASA Mission

5/2014



Stratospheric Observatory
for Infrared Astronomy

Astrophysics Missions in Development

<p>ISS-NICER 6/2017 NASA Mission</p>	<p>ISS-CREAM 8/2017 NASA Mission</p>	<p>TESS 3/2018 NASA Mission</p>	<p>Webb 10/2018 NASA Mission</p>
<p>Launched!</p> 	<p>Launched!</p> 		
<p>Neutron Star Interior Composition Explorer</p>	<p>Cosmic Ray Energetics And Mass</p>	<p>Transiting Exoplanet Survey Satellite</p>	<p>James Webb Space Telescope</p>
<p>Euclid 2020 ESA-led Mission</p>	<p>IXPE 2020 NASA Mission</p>	<p>GUSTO 2021 NASA Mission</p>	<p>WFIRST Mid 2020s NASA Mission</p>
			
<p>NASA is supplying the NISP Sensor Chip System (SCS)</p>	<p>Imaging X-ray Polarimetry Explorer</p>	<p>Galactic/ Extragalactic ULDB Spectroscopic Terahertz Observatory</p>	<p>Wide-Field Infrared Survey Telescope</p>

Astrophysics Missions under Study

XARM

JAXA-led Mission

2021



NASA is supplying the SXS Detectors, ADRs, and SXTs

Athena

ESA-led Mission

Late 2020s

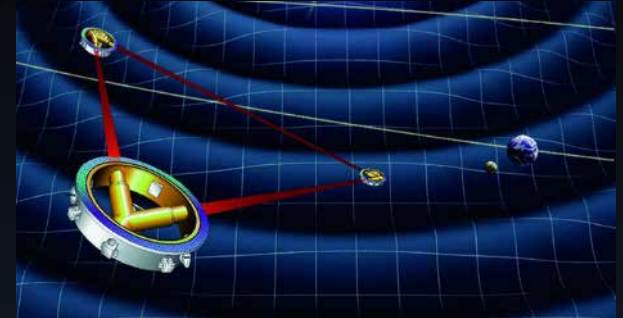


NASA is supplying elements for both instruments

LISA

ESA-led Mission

Mid 2030s



NASA is developing technology for both the payload and the mission

Preparing for the 2020 Decadal Survey Large Mission Concepts

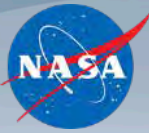


	Community STDT Chairs	Center Study Scientist	Study Lead Center	HQ Program Scientist
Habitable Exoplanet Imaging Mission www.jpl.nasa.gov/habex	Scott Gaudi* Sara Seager	Bertrand Mennesson	JPL	Martin Still
Large UV/Optical/IR Surveyor asd.gsfc.nasa.gov/luvoir	Debra Fischer* Bradley Peterson	Aki Roberge	GSFC	Mario Perez
Lynx X-ray Surveyor wwwastro.msfc.nasa.gov/lynx	Feryal Ozel* Alexey Vikhlinin	Jessica Gaskin	MSFC	Dan Evans
Origins Space Telescope asd.gsfc.nasa.gov/firs	Asantha Cooray* Margaret Meixner	David Leisawitz	GSFC	Kartik Sheth

* Astrophysics Advisory Committee member

<http://science.nasa.gov/astrophysics/2020-decadal-survey-planning/>

Selected Probe Mission Concept Studies



PI	Affiliation	Short title
Jordan Camp	NASA GSFC	Transient Astrophysics Probe
Asantha Cooray	Univ. California, Irvine	Cosmic Dawn Intensity Mapper
Bill Danchi	NASA GSFC	Cosmic Evolution through UV Spectroscopy Probe
Jason Glenn	Univ. of Colorado	Galaxy Evolution Probe
Shaul Hanany	Univ. of Minnesota	Inflation Probe
Richard Mushotzky	Univ. of Maryland	High Spatial Resolution X-ray Probe
Angela Olinto	Univ. of Chicago	Multi-Messenger Astrophysics Probe
Peter Plavchan *	Missouri State Univ.	Precise Radial Velocity Observatory
Paul Ray	Naval Research Lab	X-ray Timing and Spectroscopy Probe
Sara Seager *	MIT	Starshade Rendezvous Mission

* Partial Selections

The Selection Document and Probes Implementation Plan are posted at <https://science.nasa.gov/astrophysics/2020-decadal-survey-planning>