National Aeronautics and Space Administration

NASA Headquarters Perspective

Astrophysics

Michael Garcia
NASA/HQ HST Program Scientist

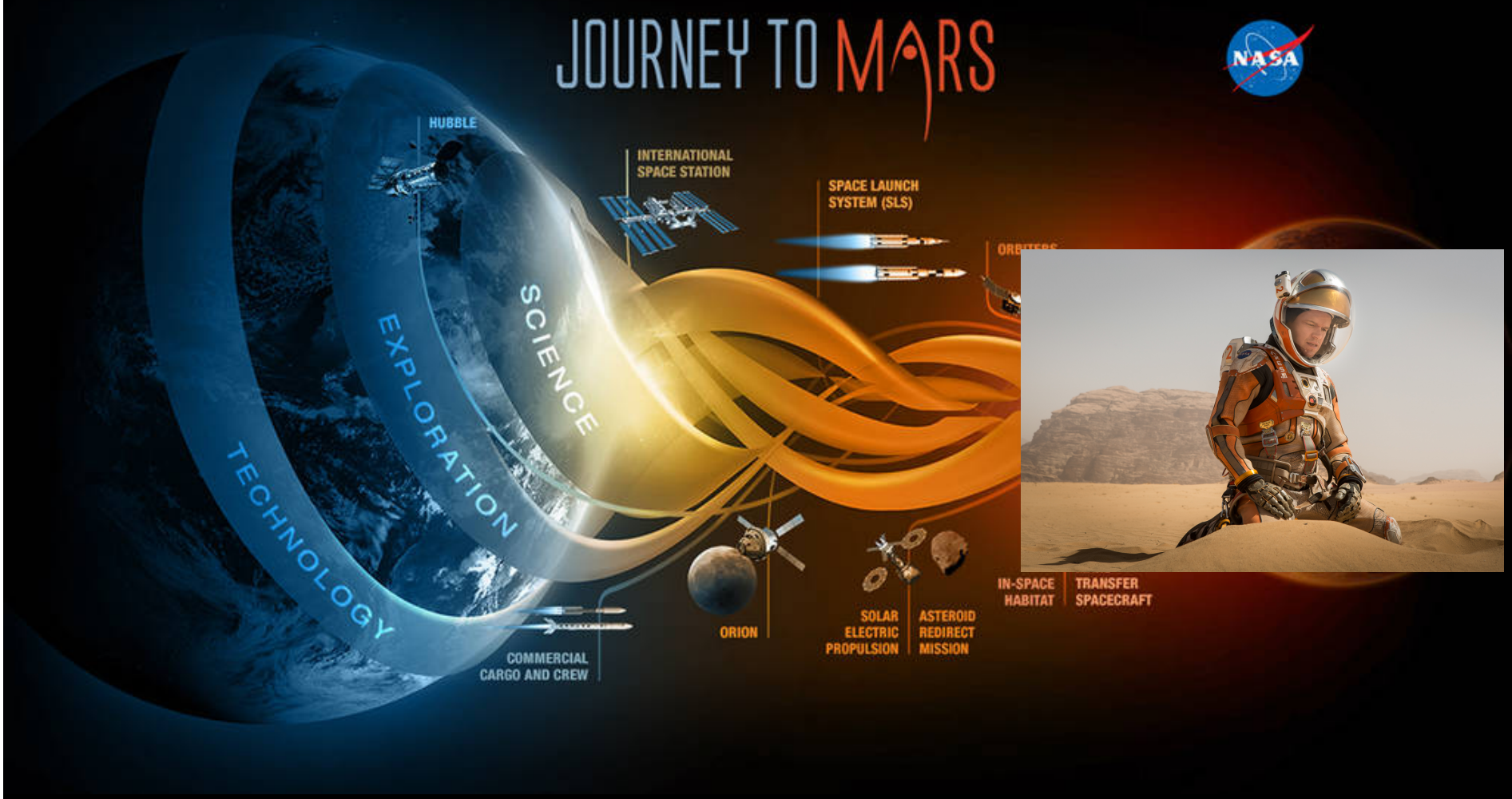
www.nasa.gov

STUC
November 5, 2016

STScI Director

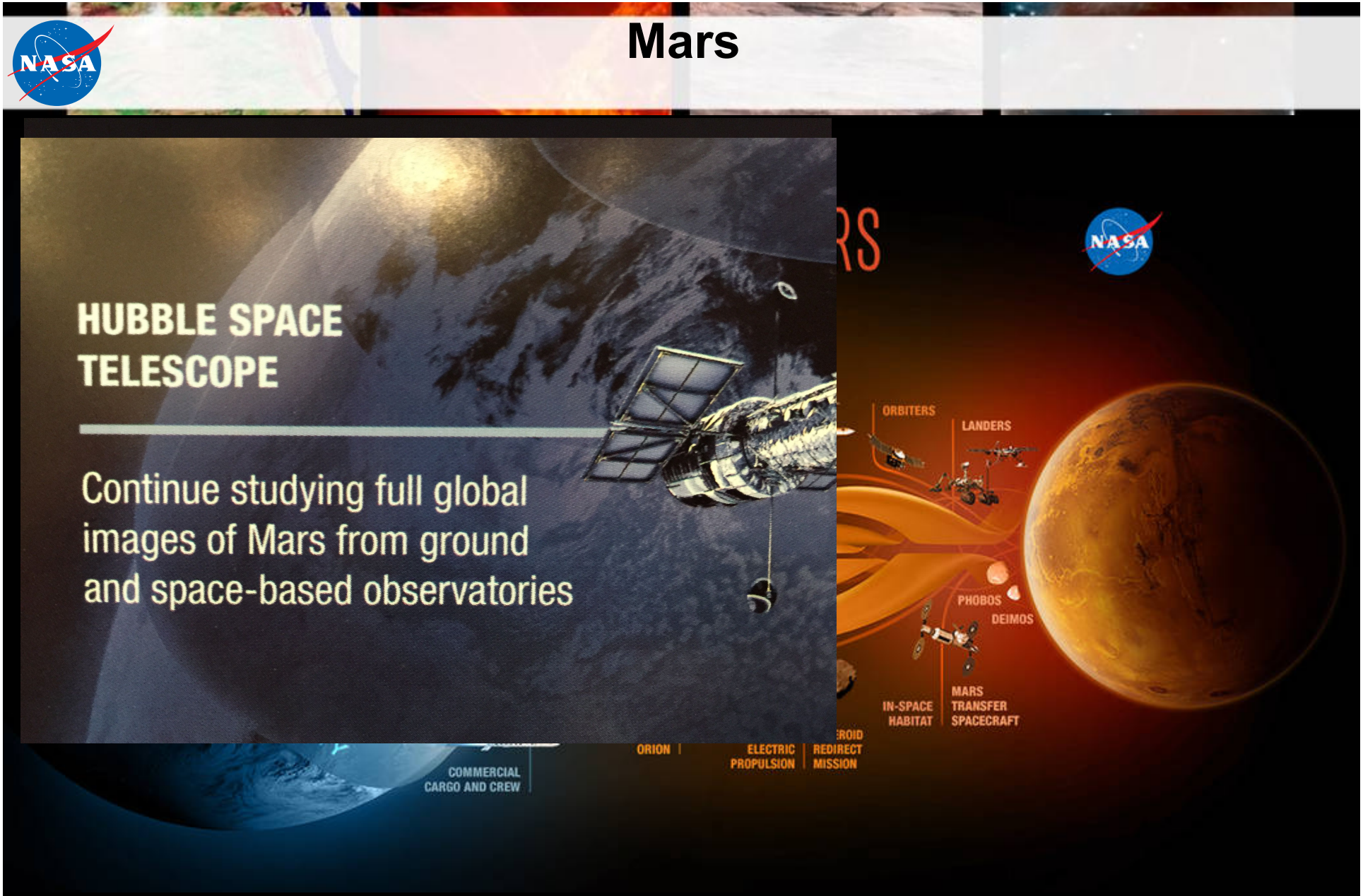
AURA Appoints New STScI Director

Mars


JOURNEY TO MARS
HUBBLE
INTERNATIONAL SPACE STATION
SPACE LAUNCH SYSTEM (SLS)
SCIENCE
EXPLORATION
TECHNOLOGY
COMMERCIAL CARGO AND CREW
ORION
SOLAR ELECTRIC PROPULSION
ASTEROID REDIRECT MISSION
IN-SPACE HABITAT
TRANSFER SPACECRAFT

Mars

HUBBLE SPACE
TELESCOPE
Continue studying full global
images of Mars from ground
and space-based observatories


RS
ORBITERS
LANDERS
PHOBOS
DEIMOS
IN-SPACE
HABITAT
MARS
TRANSFER
SPACECRAFT
ORION
ELECTRIC
PROPULSION
REDIRECT
MISSION
COMMERCIAL
CARGO AND CREW

Hubble 25th Anniversary Commendations

- To HST Team members – Government, Academic, Industry
- Over 1000 distributed via invitation, mailings continue
- 200+ to STScI employees
- 200+ to Ball Aerospace
- Planning ‘self-selection’ announcement

National Aeronautics and Space Administration

Presents this

Hubble 25th Anniversary Commendation to:

Makenzie Lystrup

of the

Hubble Space Telescope Industry Team

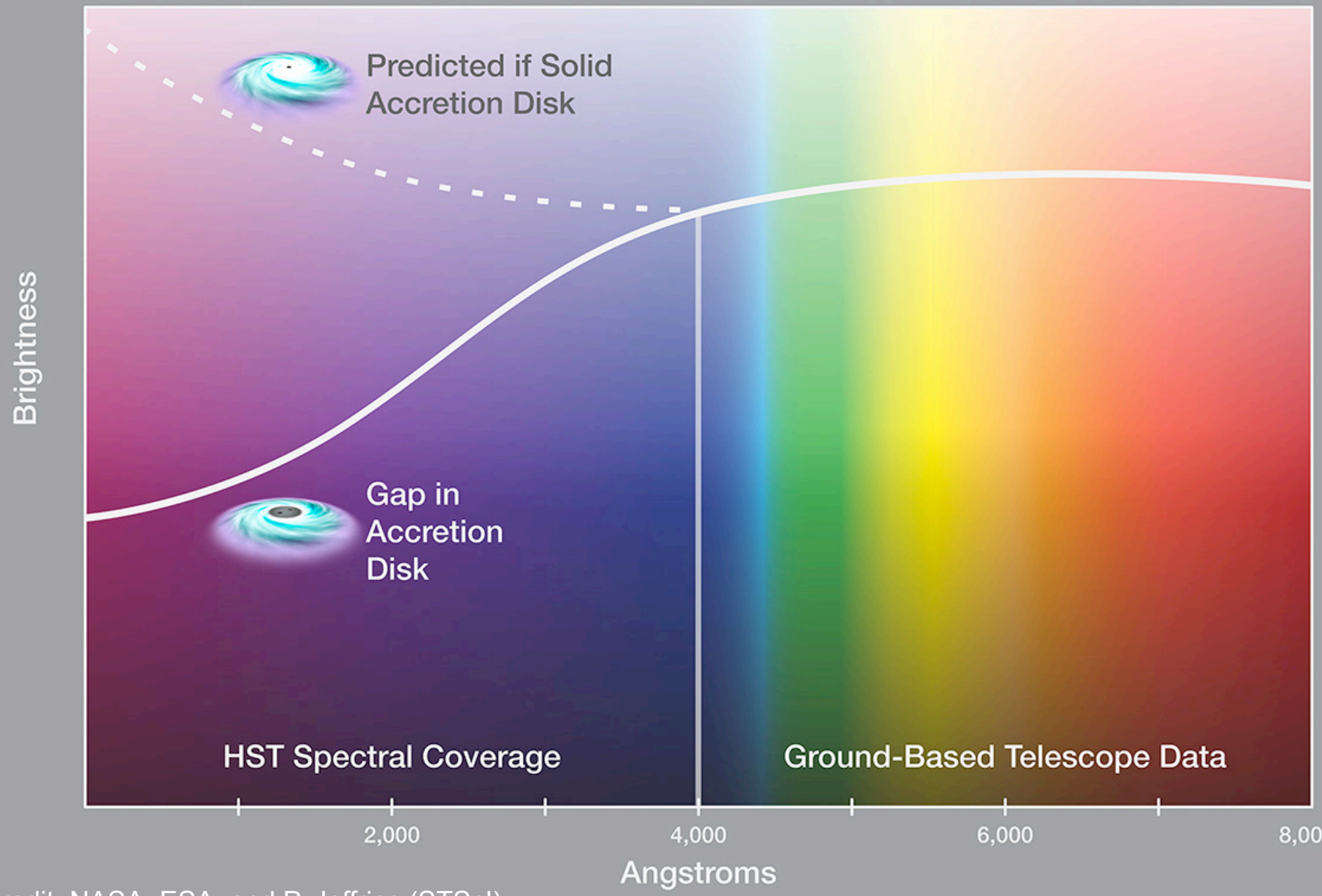
for contributions that rival the best that NASA has achieved in innovation and overcoming challenges

Signed and sealed in Washington, DC, this seventh day of October in two thousand fifteen

Charles F. Bolden, Jr.
Administrator

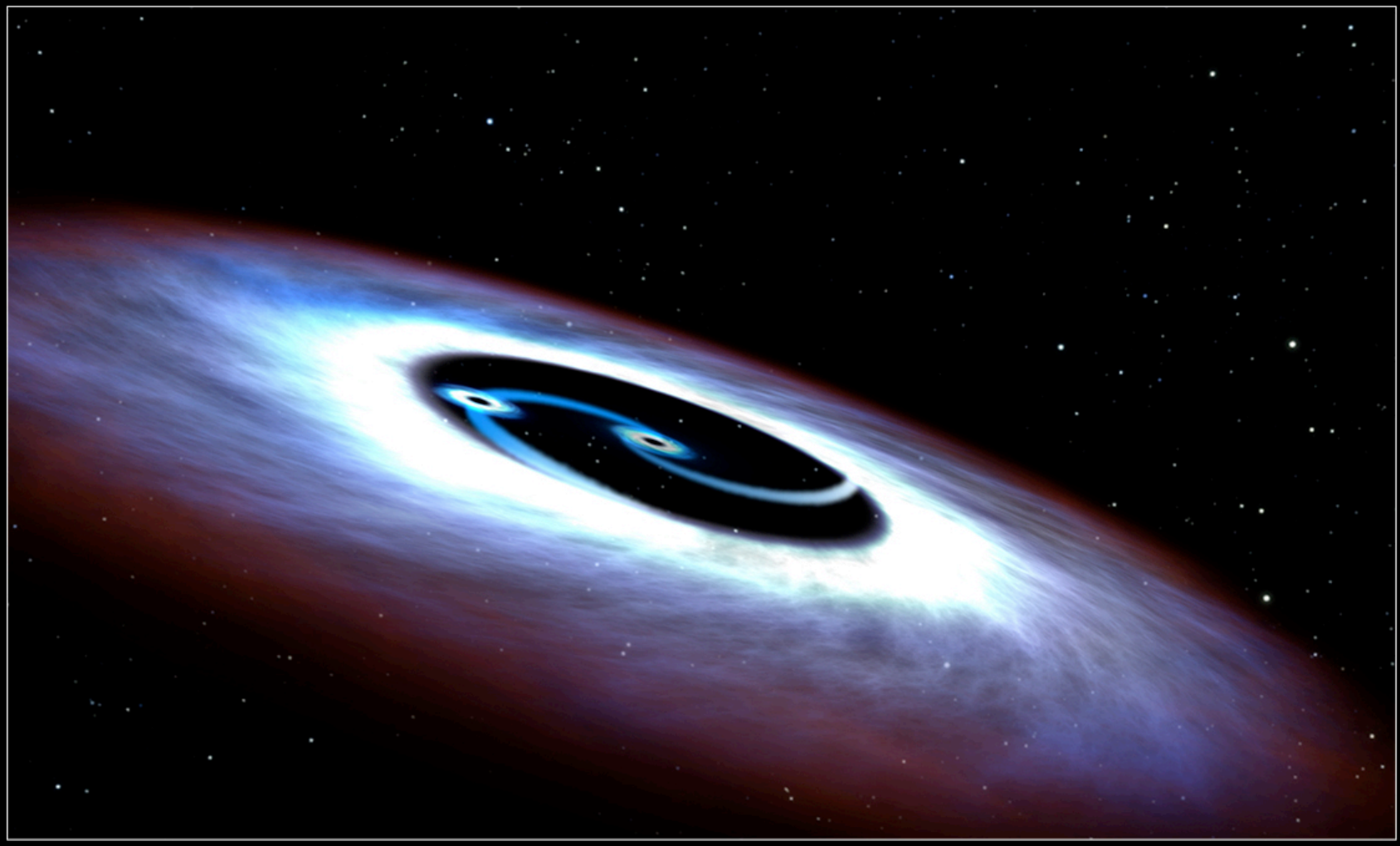
Hubble Finds That the Nearest Quasar is Powered by a Double Black Hole

Optical-to-UV Spectrum of Markarian 231



Credit: NASA, ESA, and P. Jeffries (STScI)

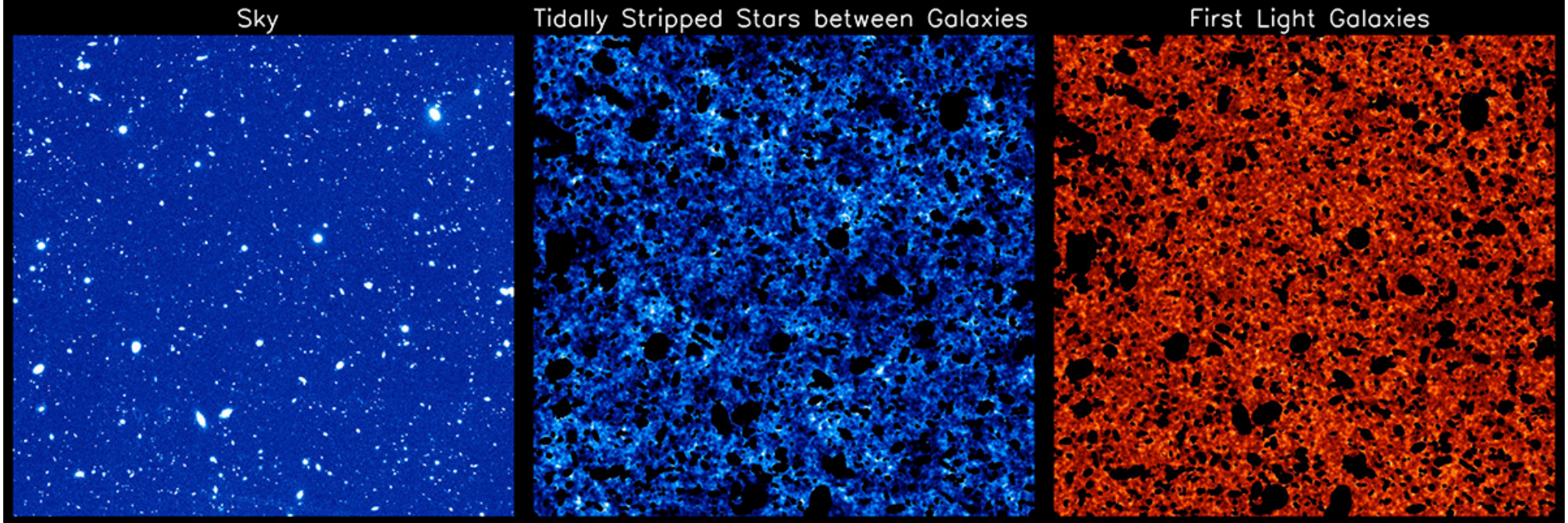
Hubble Finds That the Nearest Quasar is Powered by a Double Black Hole



Artist's View of a Binary Black Hole

NASA and ESA ▪ STScI-PRC15-31a

Hubble Uncovers Clues of Earliest Galaxies



Credit: NASA, ESA, and K. Mitchell-Wynne (University of California, Irvine)

Astrophysics - Big Picture

- **The FY16 budget request provides funding for NASA astrophysics to continue its programs, missions, and projects as planned**
  - The total funding (Astrophysics including JWST) is flat at ~$1.3B through FY20
  - Fully fund JWST to remain on plan for an October 2018 launch
  - Fund continued pre-formulation and technology work leading toward WFIRST; rate of progress depends on FY16 appropriation level
- **The operating missions continue to generate important and compelling science results, and new missions are under development for the future**
  - Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, Spitzer, Swift, XMM-Newton all operating well; next Senior Review is Spring 2016 for FY17+; Suzaku mission ended
  - SOFIA is in prime operations as of May 2014; Senior Review is Spring 2018
  - Missions on track for launch include LISA Pathfinder (2015), ASTRO-H (2015/2016), ISS-CREAM (2016), NICER (2016), TESS (2017), JWST (2018), Euclid (2020)
  - WFIRST being studied, New Explorers being selected (SMEX in 2015, MIDEX in 2017), NASA joining ESA's Athena and ESA's L3 gravitational wave observatory
- **Progress being made against recommendations of the 2010 Decadal Survey**
  - Update to the Astrophysics Implementation Plan released in December 2014
  - NRC Mid Decade Review (with NSF, DOE) underway; Jackie Hewitt (MIT) is chair; report expected in May 2016
  - NASA initiating large mission concept studies as input for 2020 Decadal Survey
- **All ongoing work continuing under FY16 Continuing Resolution**

2016 Senior Review (SR) Plans

	LRD	EOPM	
Hubble	1990		Delta SR; Hubble Panel Due Jan 22, 2016 Site Visit STScI March 8-10, 2016 NASA Direction: May-June 2016
Chandra	1999		Delta SR; Chandra Panel
XMM (ESA)	1999		Standard SR; Main Panel
Spitzer	2003		Standard SR; Main Panel
Swift	2004		Standard SR; Main Panel
Suzaku (JAXA)	2005		No review; EOM plan approved
Fermi	2008	2013	Standard SR; Main Panel
Kepler/K2	2009	2013	Standard SR; Main Panel
NuSTAR	2012	2014	Standard SR; Main Panel
SOFIA	2014	2019	Review NET 2018
LISA Pathfinder (ESA)	2015	2016	Out of cycle review, if needed

SMD Science Education Restructuring(KE)

Background – FY15 Budget provides $42M for NASA Science Education

- Why Restructure? To further enable NASA scientists and engineers to engage more effectively with learners of all ages. SMD will no longer have minimum of 1 percent set-asides through our missions, or issue disparate 3-year grants. But we are taking a strategic approach, building on our science-disciplined based legacy, and looking for new approaches given Stakeholder priorities.
- Objectives?
    - Enable STEM Education
    - Improve US Scientific Literacy
    - Advance National Educational Goals
    - Leverage Through Partnerships
- How? Through the competitive selection of organizations that utilize NASA data, products, or processes to meet education objectives; and by enabling our scientists and engineers with education professionals, tools, and processes to better meet user needs. Science Education Cooperative Agreement Notice posted

at https://nspires.nasaprs.com/

- Proposals submitted May 4, 2015
- Selections announced Sept 25, 2015

SMD Science Education Restructuring(KE)

Selections build upon legacy of excellence, balanced across diverse audiences, and fit within annual budget of $42M/year towards meeting NASA Science Mission Directorate's desired Outcome and Objectives

- 27 of 73 compliant proposals selected (37%) for negotiations leading to cooperative agreement awards

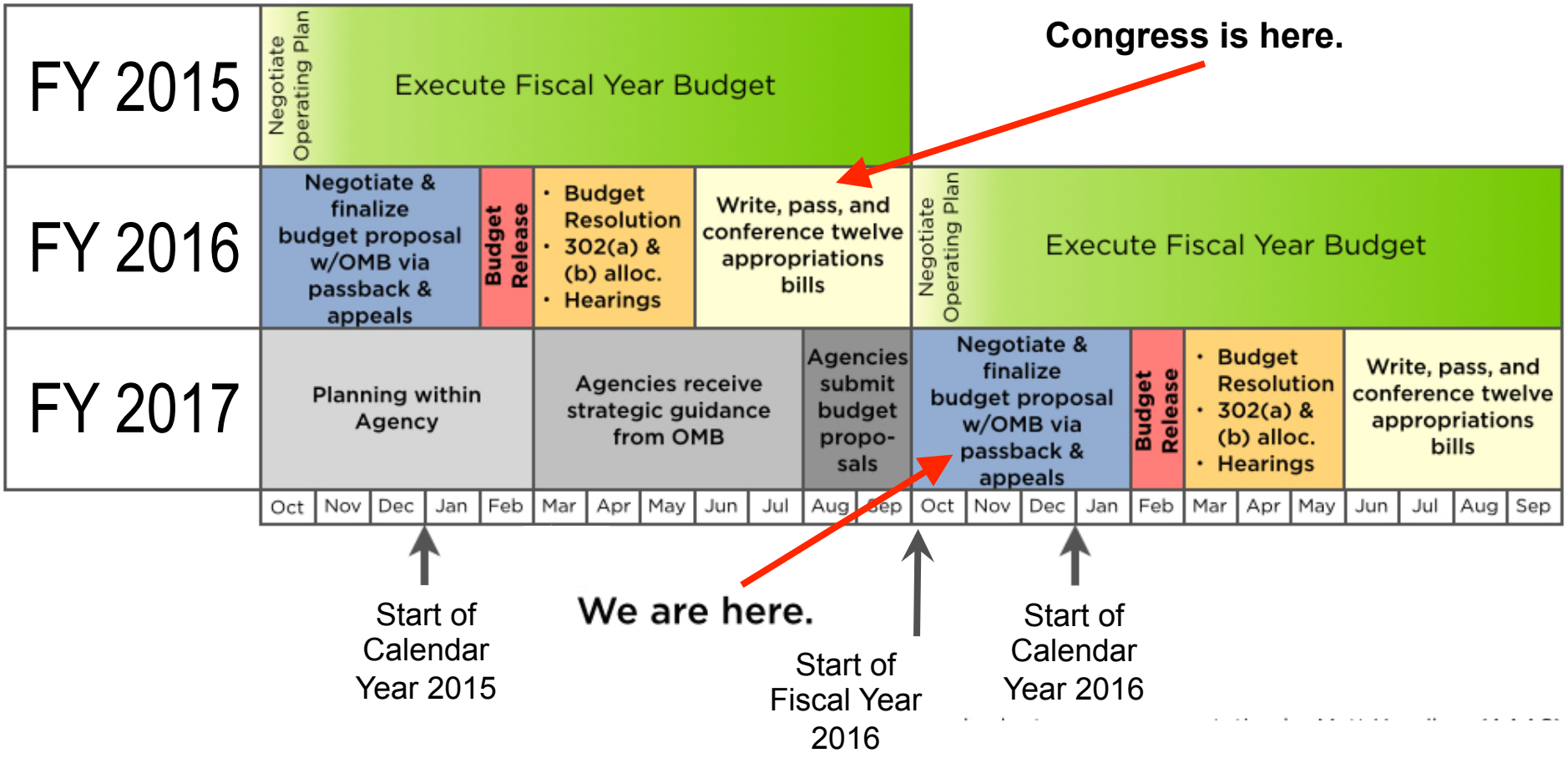
- 15 are from "Legacy" institutions (56%)

- 3 selections support the 2017 Total Solar Eclipse, allowing for one full academic year of preparation

- Negotiations will be based on either full selection or partial selections based on peer evaluations or funding limitations

- Awards planned to be completed by the end of calendar year 2015

Nominal Federal Budget Cycle



Adapted by Kevin Marvel (AAS)
https://aas.org/files/budgetprocess_adaptedfromaaas.jpg
from budget presentation by Matt Hourihan (AAAS)
http://www.aaas.org/page/presentations

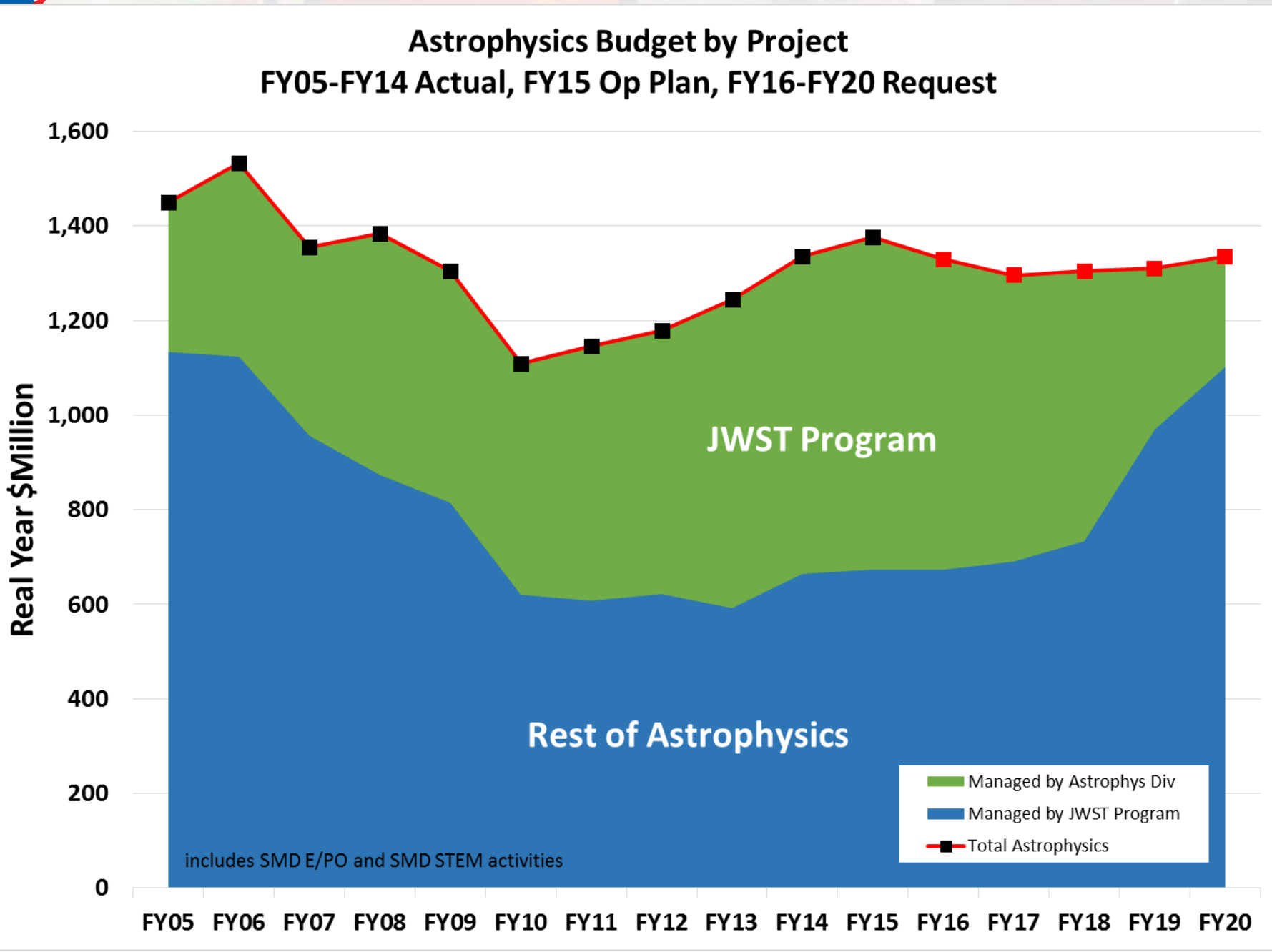
FY16 President's Budget Request

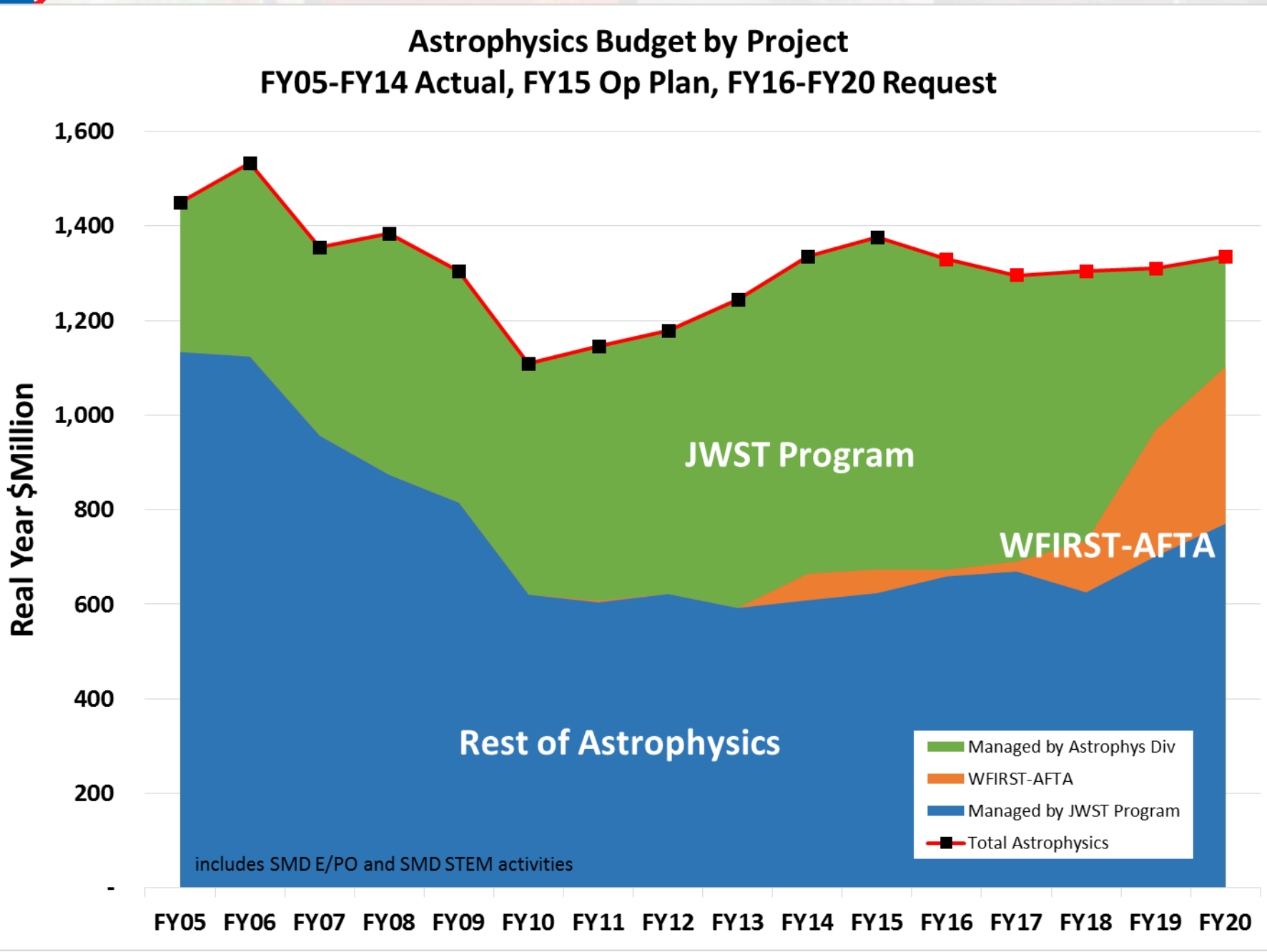
Outyears are notional planning from FY16 President's budget request

($M)	2014	2015	2016	2017	2018	2019	2020
Astrophysics*	$678	$685	$689	$707	$750	$986	$1,118
JWST	$658	$645	$620	$569	$535	$305	$198

- Continues preformulation of WFIRST-AFTA as the "Astrophysics Decadal Strategic Mission."
- Grows Astrophysics Research and Analysis (including Astrophysics Data Analysis Program) from ~$80M/yr to ~$90M/yr in FY16.
- Supports completion of missions under development, including LPF/ST7, ASTRO-H, NICER, TESS, and Euclid.
- Enables selection of a SMEX mission and an Explorer Mission of Opportunity from the 2014 AO, and notional release of a MIDEX AO in late CY16/early FY17.
- Provides full funding for SOFIA operations and places SOFIA into the 2016 Astrophysics Senior Review. (Subsequently SOFIA was deferred to the 2018 Senior Review.)
- Plans for the 2016 Astrophysics Senior Review.
- **Plans for continued Hubble operations through FY20 providing overlap with JWST**.
- Plans for mission concept studies and technology development (within the three Program SR&T budgets) leading up to the 2020 Decadal Survey.

* Excludes "SMD STEM Activities" in all years.


Astrophysics Budget by Project
FY05-FY14 Actual, FY15 Op Plan, FY16-FY20 Request
Real Year $Million
1,600
1,400
1,200
1,000
800
600
400
200
0
JWST Program
Rest of Astrophysics
includes SMD E/PO and SMD STEM activities
Managed by Astrophys Div
Managed by JWST Program
Total Astrophysics
FY05
FY06
FY07
FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
FY16
FY17
FY18
FY19
FY20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400
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JWST Program
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Rest of Astrophysics
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WFIRST-AFTA
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Total Astrophysics
FY05
FY06
FY07
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FY11
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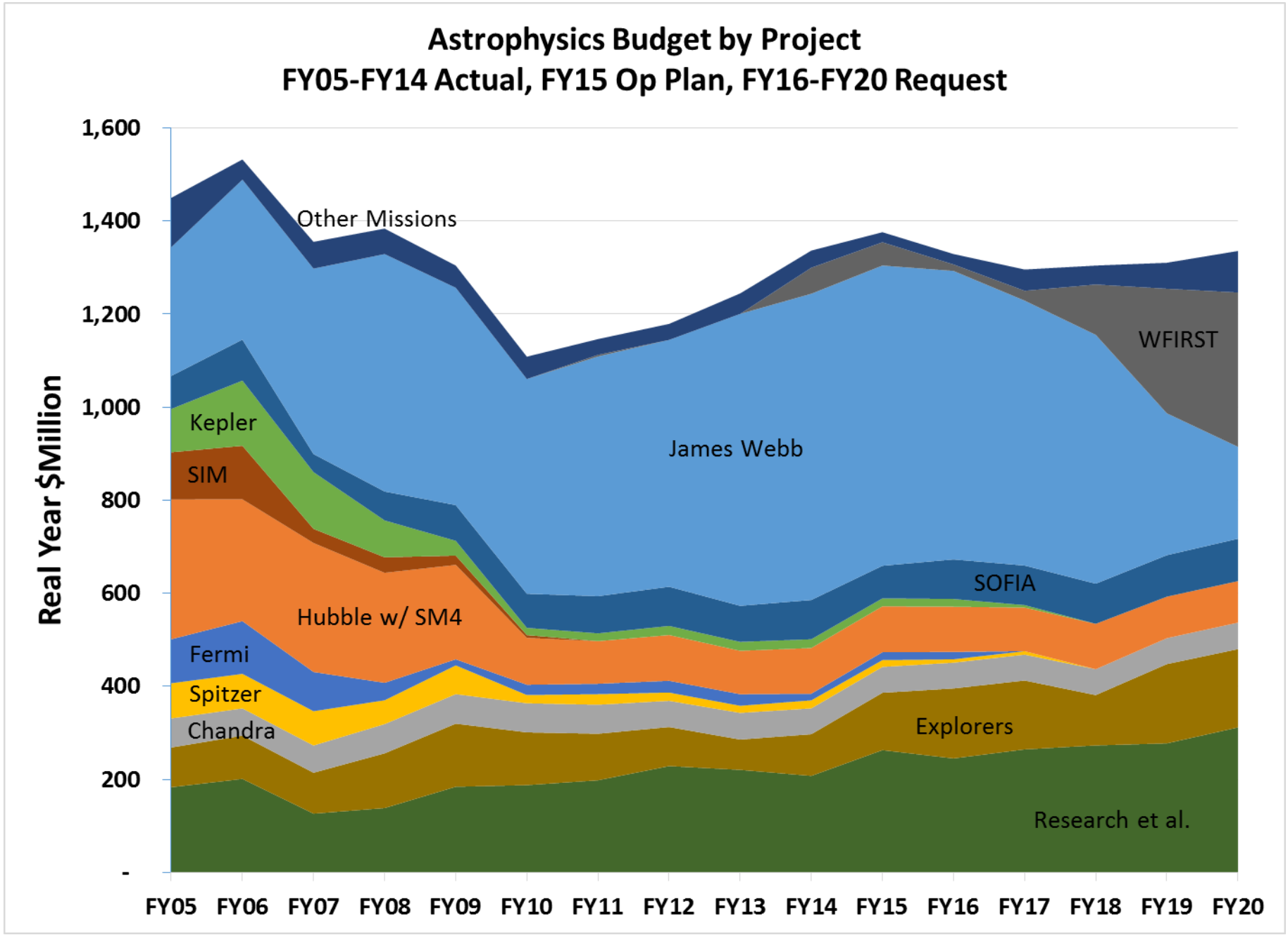
FY17
FY18
FY19
FY20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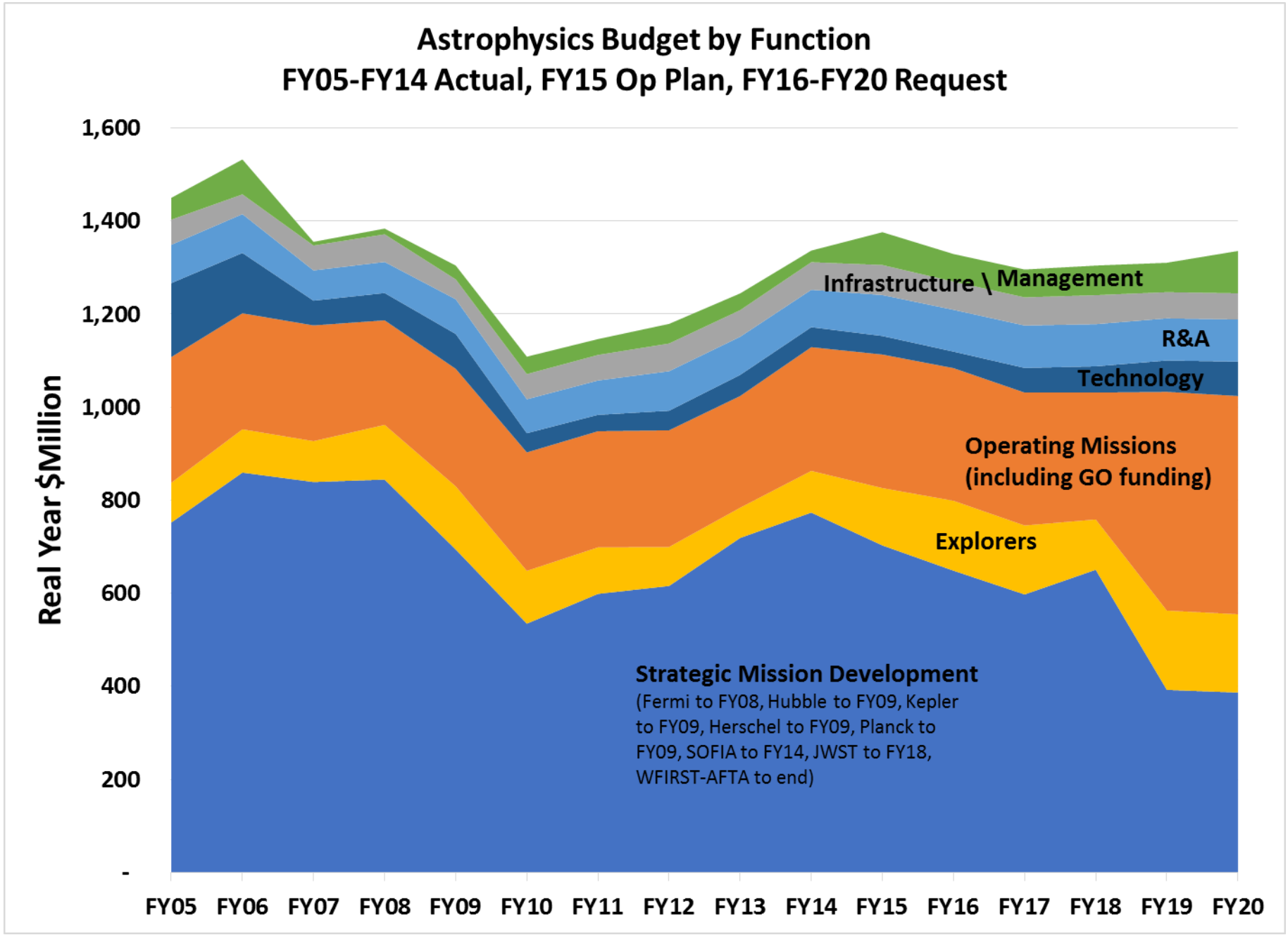
Real Year $Million
1,600
1,400
1,200
1,000
800
600
400
200
-
Other Missions
Kepler
SIM
Hubble w/ SM4
Fermi
Spitzer
Chandra
James Webb
WFIRST
SOFIA
Explorers
Research et al.
FY05
FY06
FY07
FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
FY16
FY17
FY18
FY19
FY20


Astrophysics Budget by Function
FY05-FY14 Actual, FY15 Op Plan, FY16-FY20 Request
Real Year $Million
1,600
1,400
1,200
1,000
800
600
400
200
-
FY05
FY06
FY07
FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
FY16
FY17
FY18
FY19
FY20
Infrastructure \ Management
R&A
Technology
Operating Missions
(including GO funding)
Explorers
Strategic Mission Development
(Fermi to FY08, Hubble to FY09, Kepler
to FY09, Herschel to FY09, Planck to
FY09, SOFIA to FY14, JWST to FY18,
WFIRST-AFTA to end)

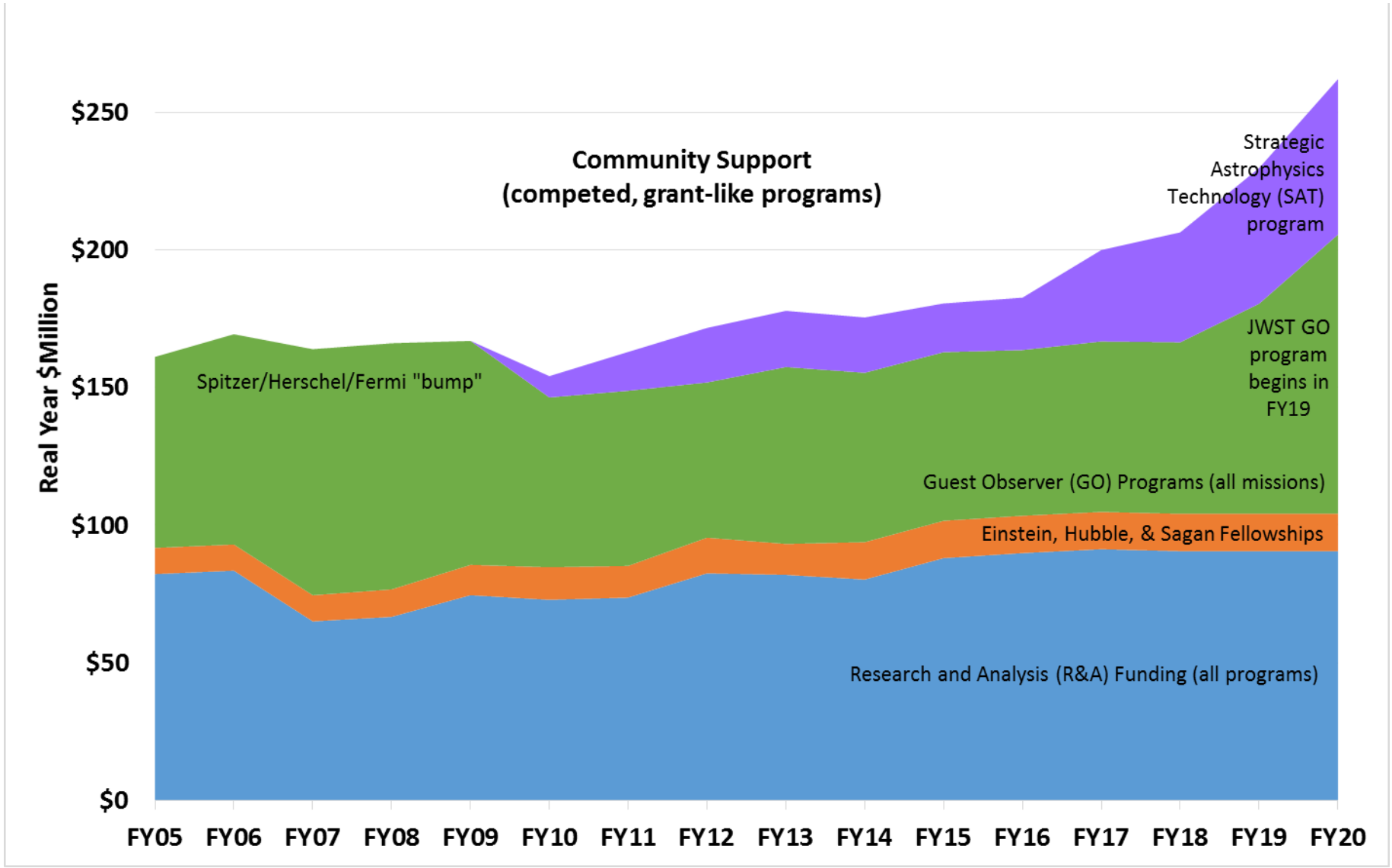
FY16 Congressional Appropriation Markups

$M	FY15 Approp	FY16 Pres Request	FY16 House Budget	Delta House vs Request	FY16 Senate Budget	Delta Senate vs Request
Status			Appropriation passed full House		Appropriation sent from Committee to Senate	
NASA	18,010.2	18,529.1	18,529.1	0	18,289.5	-239.6
SMD	5,244.7	5,288.6	5,237.5	-51.1	5,295.0	+6.4
JWST	645.4	620.0	620.0	0	620.0	+0
Astrophysics w/ SMD Education	726.8	709.1	735.6	+26.5		
Astrophysics w/ out SMD Ed	684.8	689.1			730.6	+41.5
WFIRST	50.0	14.0	49.8	+35.8	90.0	+76.0
Hubble	**98.6**	**97.1**			**98.3**	**+1.2**
SOFIA	70.0	85.2			85.2	+0
Rest of Astrophysics	634.8	675.1	653.8	-21.3	653.8	-35.7
SMD Education	42.0	20.0	32.0	+12.0	42.0	+22.0

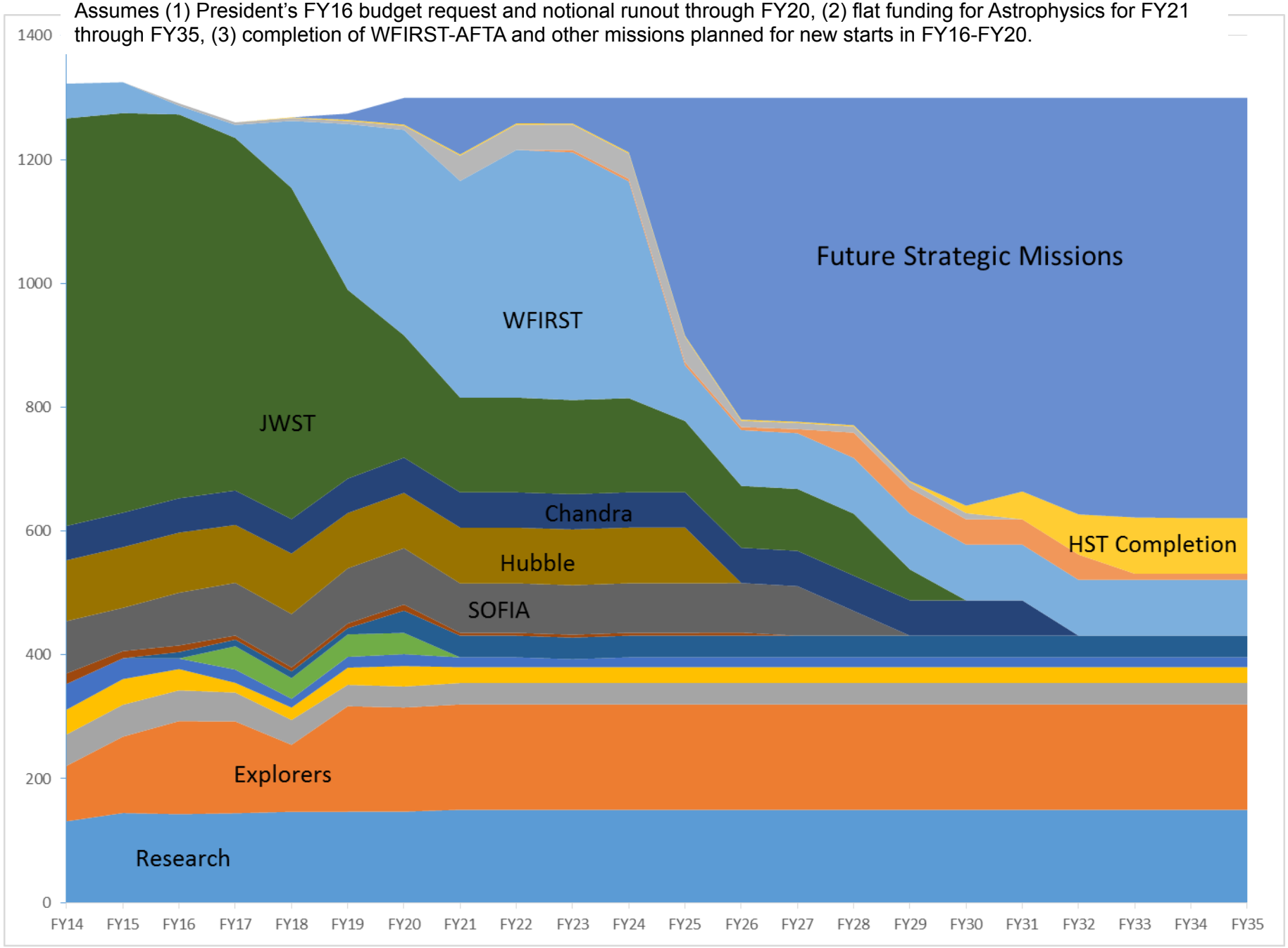
FY16 Congressional Appropriation Markups

Astrophysics Project	House Language (paraphrased)	Senate Language (paraphrased)
All	Follow the Decadal Survey	Follow the Decadal Survey
JWST	Do not overrun	Do not overrun
WFIRST	Include coronagraph; accelerate exoplanet program	Accelerate formulation start, with goal of KDP-A by January 15, 2016
Hubble		**Hubble is wonderful**
SOFIA	Do not put SOFIA in 2016 Senior Review; do not terminate SOFIA	Any SOFIA participation in 2016 Senior Review is only for practice
Explorers		Increase AO frequency to at least every 3 years with goal of every 2 years
Kepler		Kepler has revolutionized the pace of planet finding
SMD Education	Reallocate funds among Divisions	APD should administer SMD-wide education activities

Response to Recommendations: Core Research



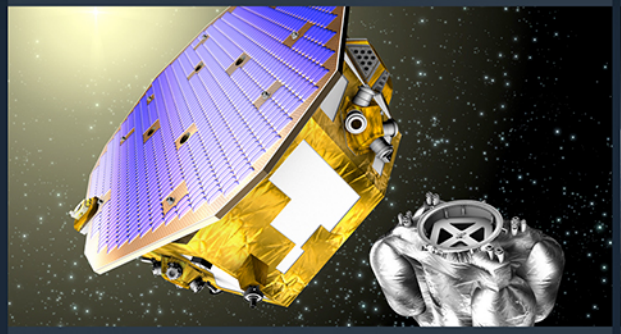
Assumes (1) President's FY16 budget request and notional runout through FY20, (2) flat funding for Astrophysics for FY21 through FY35, (3) completion of WFIRST-AFTA and other missions planned for new starts in FY16-FY20.



Astrophysics Missions in Development

LISA Pathfinder
12/2015

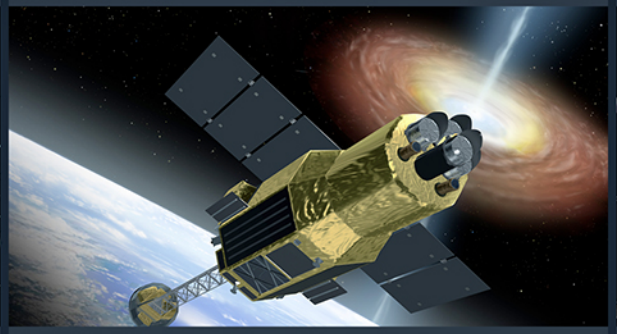
ESA-led Mission



NASA supplied the ST7/Disturbance Reduction System (DRS)

ASTRO-H
11/2015 NET

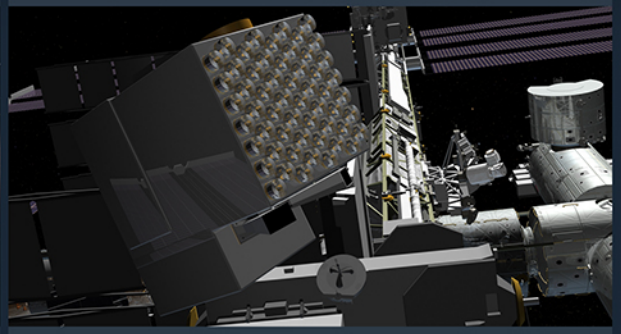
JAXA-led Mission



NASA supplied the Soft X-ray Spectrometer (SXS) instrument

NICER
8/2016

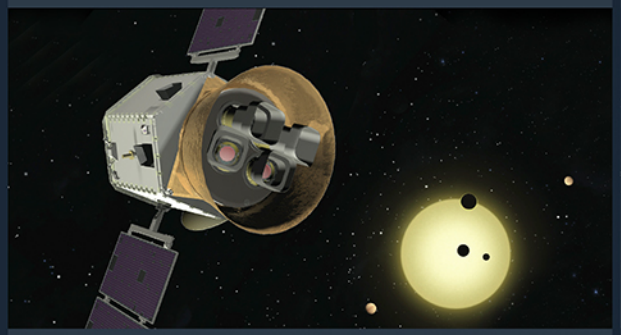
NASA Mission



Neutron Star Interior Composition Explorer

TESS
8/2017

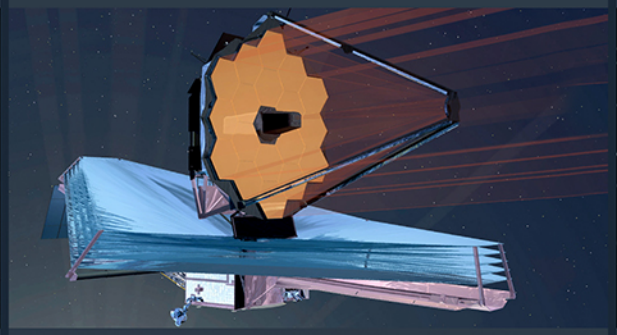
NASA Mission



Transiting Exoplanet Survey Satellite

JWST
10/2018

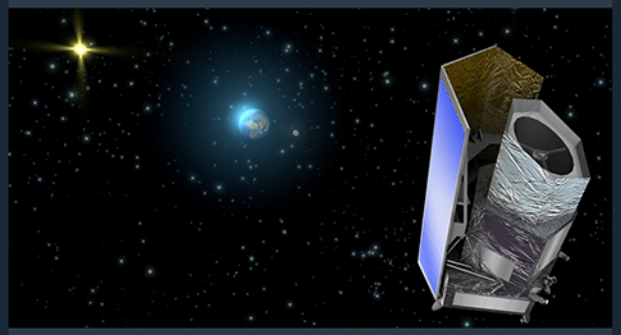
NASA Mission



James Webb Space Telescope

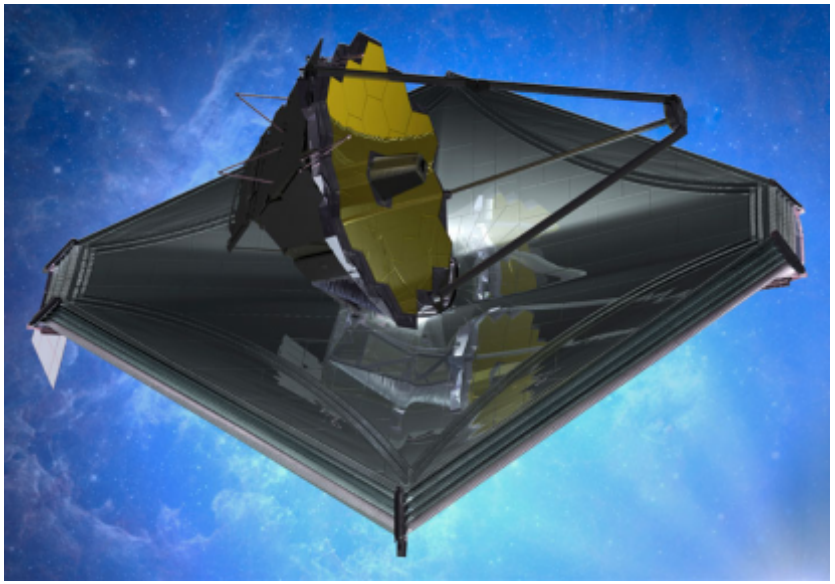
Euclid
2020

ESA-led Mission



NASA is supplying the NISP Sensor Chip System (SCS)

JWST
James Webb Space Telescope



Large Infrared Space Observatory

Top priority of 2000 Decadal Survey

Science themes: First Light; Assembly of Galaxies; Birth of Stars and Planetary Systems; Planetary Systems and the Origins of Life

Mission: 6.5m deployable, segmented telescope at L2, passively cooled to <50K behind a large, deployable sunshield

Instruments: Near IR Camera, Near IR Spectrograph, Mid IR Instrument, Near IR Imager and Slitless Spectrograph

Operations: 2018 launch for a 5-year prime mission

Partners: ESA, CSA

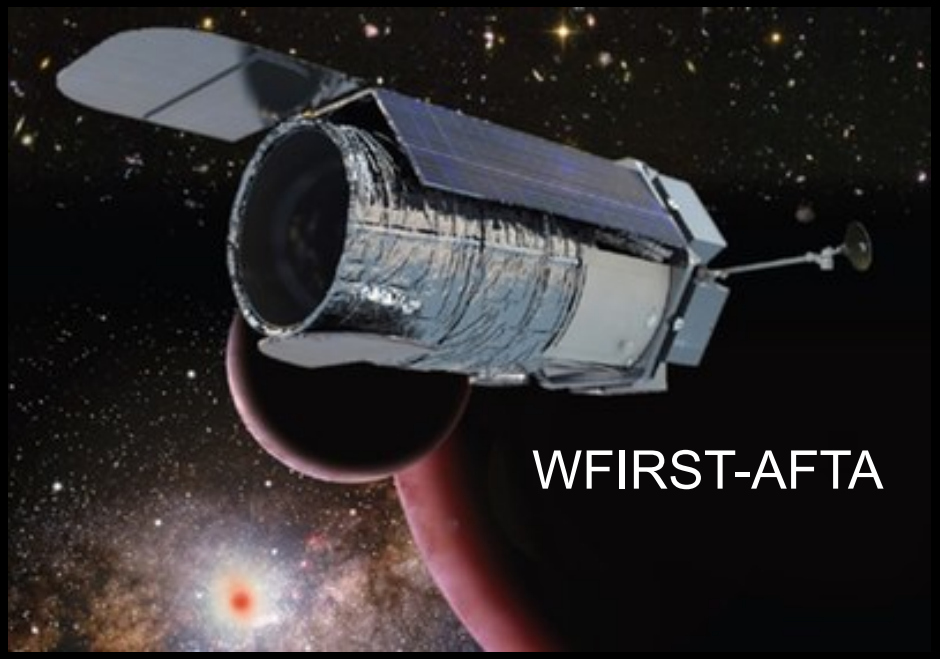
FY2015 Accomplishments

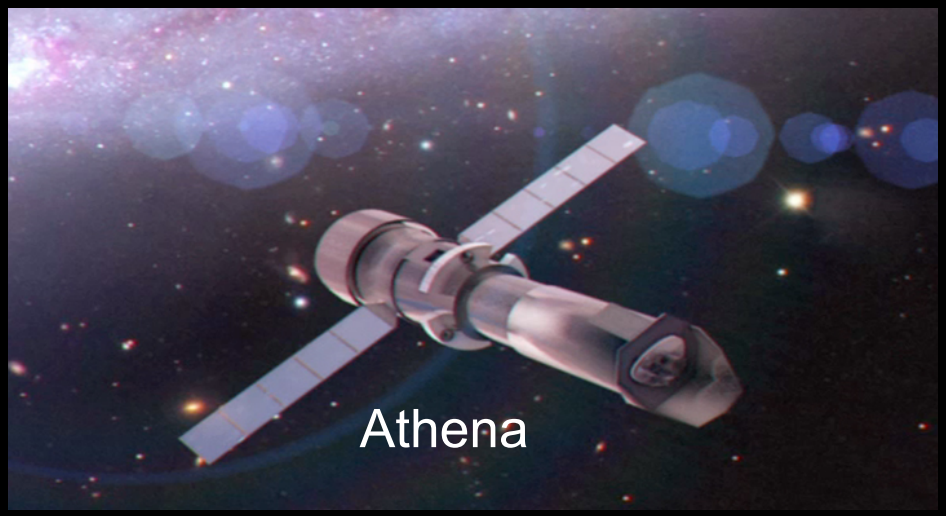
- Completed instrument hardware replacements, and prepared ISIM for its final test before integration with the telescope
- Completed MIRI cryocooler flight units
- Conducted tests at JSC in preparation for 2016 full telescope plus ISIM test
- Delivered spacecraft bus structure to I&T

FY2016 Plans

- Assemble the Telescope
- Complete ISIM testing and integrate with the telescope
- Complete sunshield membrane manufacturing
- Begin integration of spacecraft bus components (e.g. electronics, propulsion) with the spacecraft bus structure

Astrophysics Missions in Pre-Formulation





SMEX / MO – 2019/2020
see next chart for list of selections

MIDEX / MO – 2022/2023

WFIRST-AFTA – NLT 2026

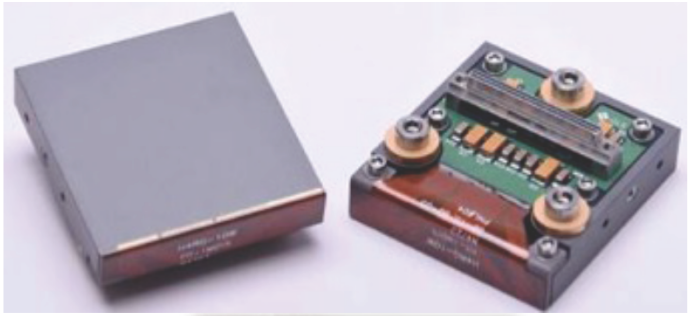
Athena – 2028

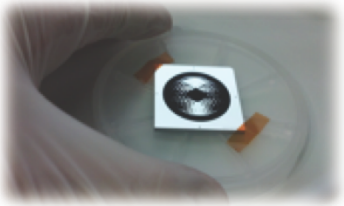
All launch dates notional

Executive Summary

- Huge progress on WFIRST over the past two years
- SDT studies & NRC Harrison committee report confirm that WFIRST-AFTA exceeds NWNH requirements in all areas.
- $107M in FY14 & 15 has enabled major steps forward and NRC-Harrison committee recommendations have been addressed (H4RGs, coronagraph, mission design). Planning against $56M in FY16, exact amount depends on appropriations.
- Coronagraph on track, technology development on schedule. Wide Field detector technology development on schedule
- MCR scheduled for Dec 8-9. Prepared for start of formulation (KDP-A) as early as January 2016.
- SDT 2014 & 15 studies completed
- Preparatory Science teams selected
- Pasadena conferences held
- Special session at AAS's & IAU
- Science team NRA released
- Industry study RFIs received
- Significant international interest (Canada, ESA, Japan, Korea)

WFIRST H4RG-10





Shaped-Pupil Coronagraph Mask