National Aeronautics and Space Administration

Astrophysics

Report to the Astronomy and Astrophysics Advisory Committee

www.nasa.gov

Paul Hertz

Director, Astrophysics Division

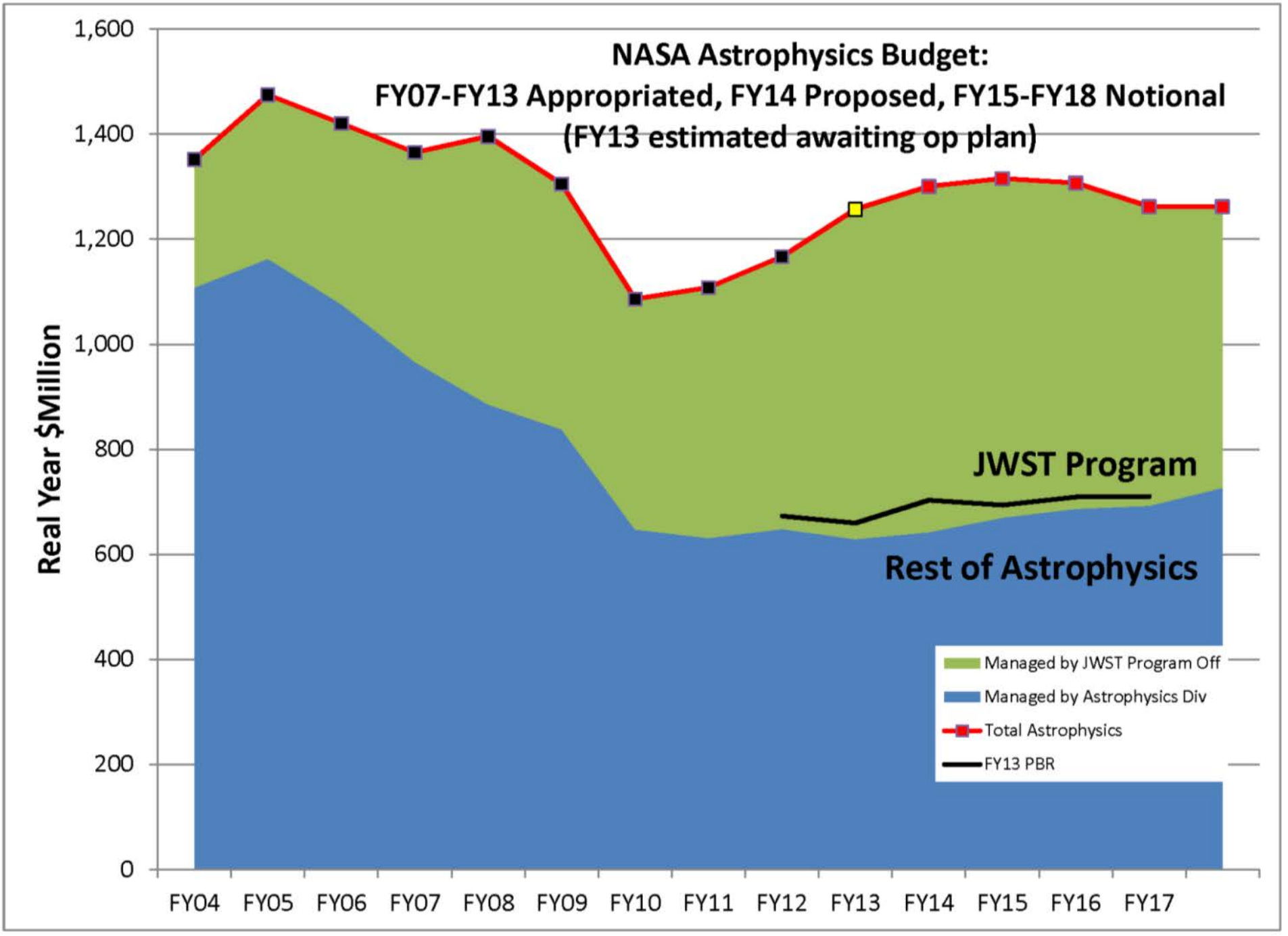
May 2, 2013

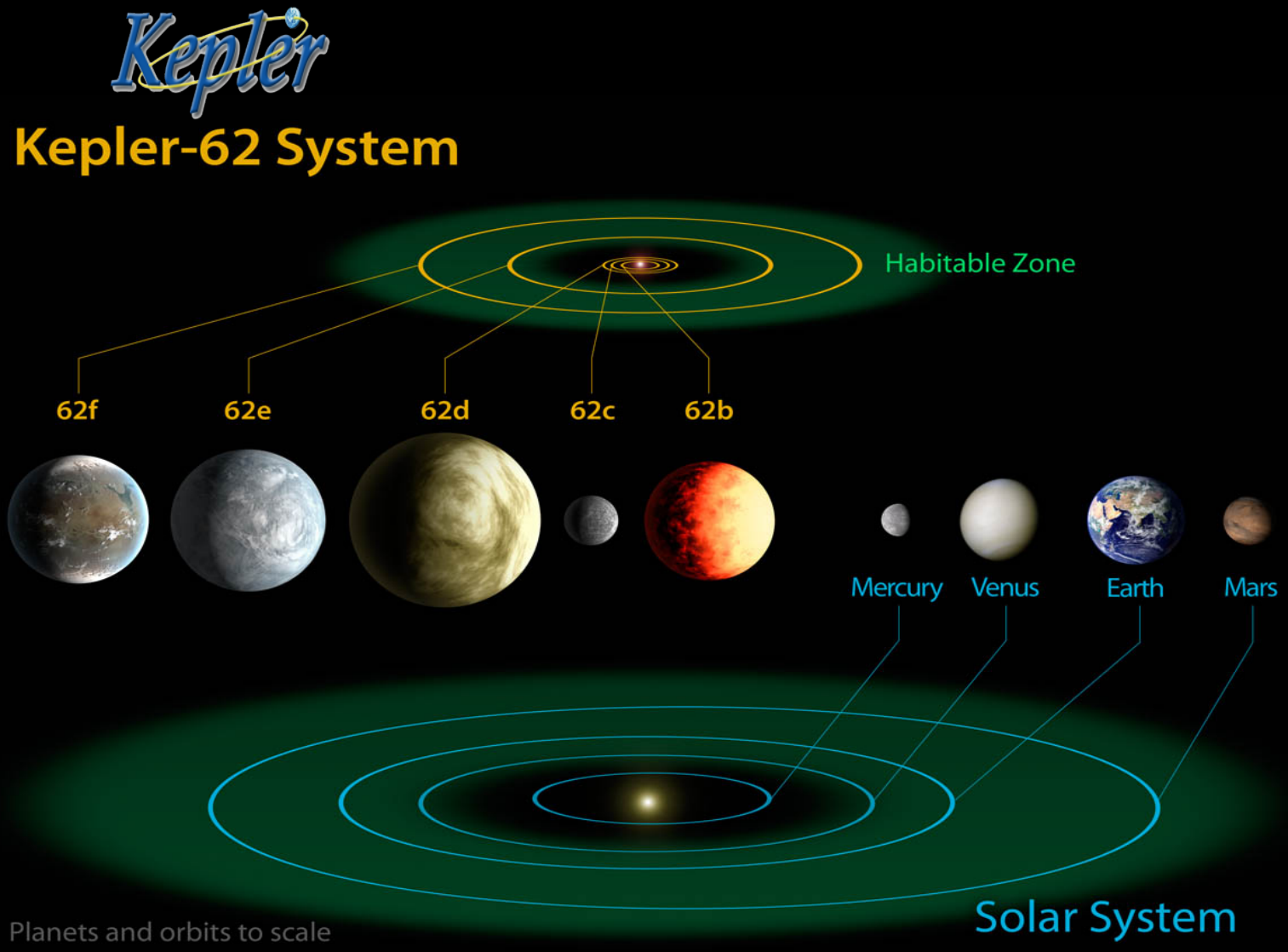
Astrophysics Division Update

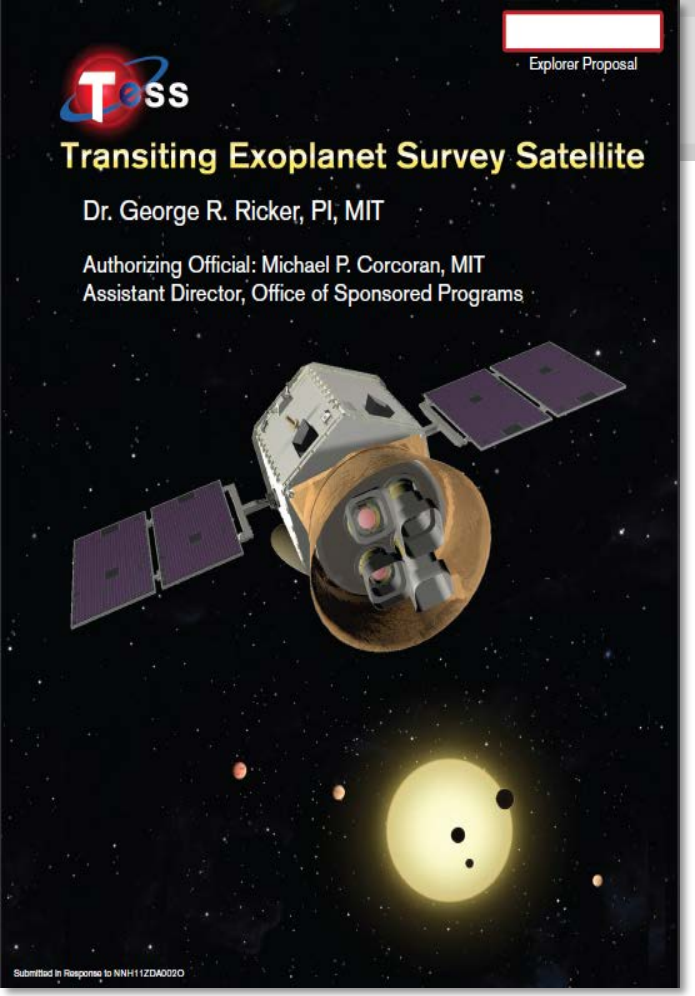
The Big Picture…..

- **This remains a time of opportunity for NASA Astrophysics**
  - The FY14 NASA astrophysics budget request remains at a high level.
  - Large and small space-based observatories spanning the electromagnetic spectrum are currently studying the universe.
  - The James Webb Space Telescope, the highest priority of the community, is on schedule and fully funded for an October 2018 launch.
  - Two new Explorer projects have been downselected and are beginning development for launch in this decade.
  - Individual investigators are leading data analysis, theory, and technology development projects selected through open, competitive, peer reviewed solicitations.
  - We are preparing for the strategic mission that will be developed following JWST.

- **The budgetary future remains uncertain**
  - FY13 rescission and sequester has an impact.
  - Constrained budget request for FY14 and planning for FY15-FY18 means priorities must be set and choices must be made.


NASA Astrophysics Budget:
FY07-FY13 Appropriated, FY14 Proposed, FY15-FY18 Notional
(FY13 estimated awaiting op plan)
Real Year $Million
1,600
1,400
1,200
1,000
800
600
400
200
0
FY04
FY05
FY06
FY07
FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
FY16
FY17
JWST Program
Rest of Astrophysics
Managed by JWST Program Off
Managed by Astrophysics Div
Total Astrophysics
FY13 PBR


Kepler
Kepler-62 System
Habitable Zone
62f
62e
62d
62c
62b
Mercury
Venus
Earth
Mars
Planets and orbits to scale
Solar System

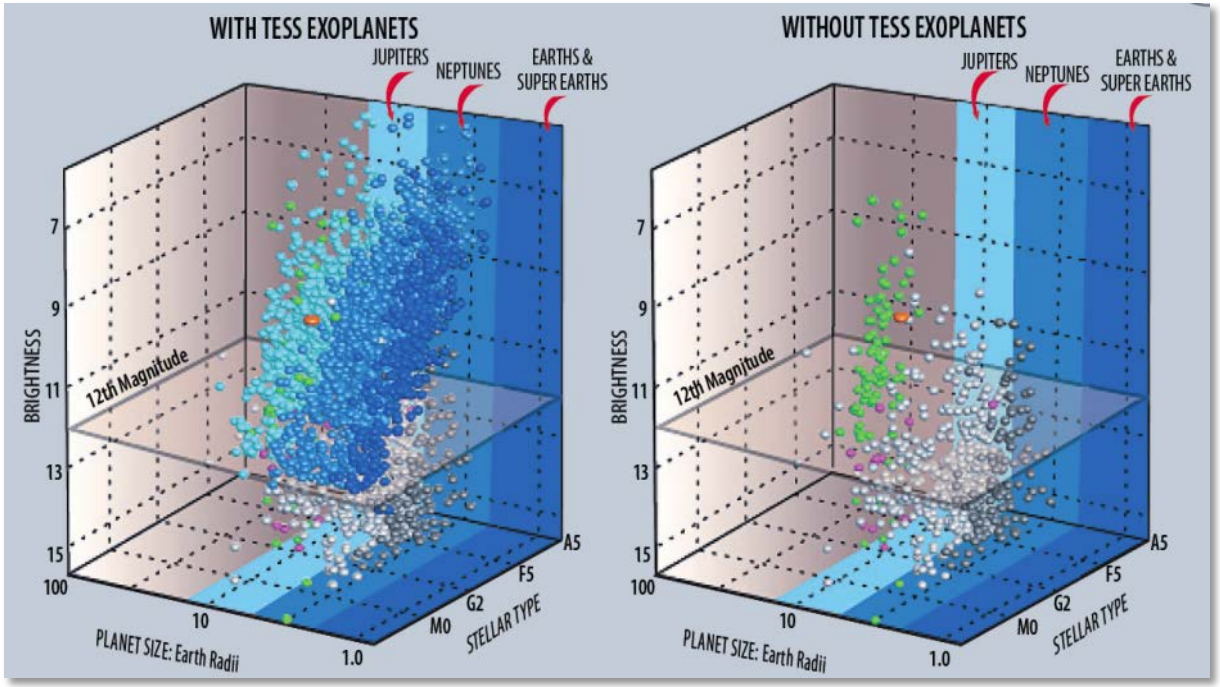


Transiting Exoplanet Survey Satellite

All-Sky, Two-Year Photometric Exoplanet Mapping Mission

Discover new worlds transiting the nearest and brightest stars

- **All-sky survey** of transiting extrasolar planets
- **Monitor >500,000 main-sequence stars**, focus on dwarfs of types F5 to M5.
- **Discover more than 2,000 new planets**, approximately 300 of which are expected to fall in Earth ($R_p \leq 1.25\ R_E$) and super-Earth ($R_p \leq 2.0\ R_E$) categories.
- **Provide the target list for JWST** future follow-up observations and future exoplanet characterization missions

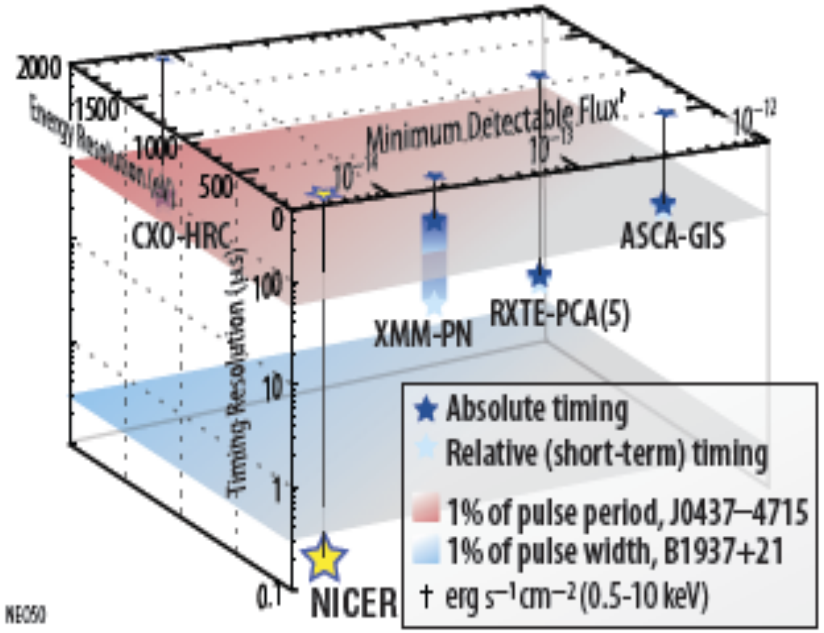


Instrument: Four WFOV CCD cameras with overlapping FOV of 23x90deg mounted in a common lens hood. Passively-cooled 600-1000nm 4096x4096 pixel FPA

Neutron Star Interior Composition ExploreR

Resolving the nature of matter at the threshold of collapse to a black hole

- Answer fundamental questions about **extremes in gravity, material density, and electromagnetism**.
- High resolution (5%-10%) mass and radius measurements will **resolve competing models of neutron star interiors**.
- ISS enables rapid response to Target of Opportunity triggers to **uncover the origins of the dynamic X-ray sky**.



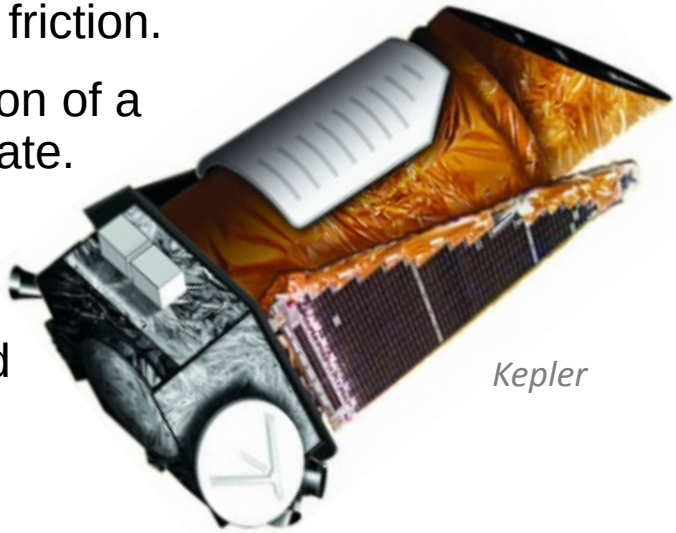
NICER plumbs unexplored depths in time resolution, spectral resolution, and sensitivity.

Mission: X-ray spectrometer on ISS/ExPRESS Logistics Carrier (ELC) to study neutron stars

Instruments: 56 grazing-incidence X-ray concentrators w/matching silicon drift detectors at -55 C. Photon counting rotation-resolved spectroscopy & timing, 0.2- 12 keV

Program Update - Kepler

- Announced additional 461 planet candidates (61 HZ candidates of all sizes, including one super-Earth around sun-like star) at AAS.
- Completed Quarter 15 Month 3 Science Data download.
- Elevated friction on wheel 4 seen in X-band on January 7.
- After observing persistence of elevated friction, wheel placed in rest position for 10 days starting January 17
- Reaction wheels restarted on January 27, less than 1 hour spent in low speed state.
- Returned to science mode on January 28.
- Wheel 4 exhibits erratic spikes on top of the elevated friction.
- Work continues with high priority on the implementation of a Thruster Controlled Safe Mode and the Point Rest State.
- Concepts for 2-RWA science operations under study.
- Using Kepler data, Dressing & Charbonneau reported that ~6% of cool stars have habitable zone planets.
- Kepler Press Conference on April 18.



Kepler

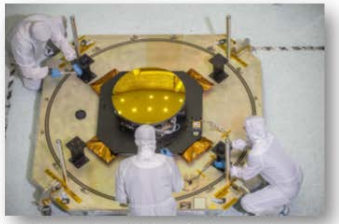
Program Update – JWST

Hardware Progress: Telescope

Primary Mirror Segment Deliveries Commence

Aft Optics System

Backplane Wings



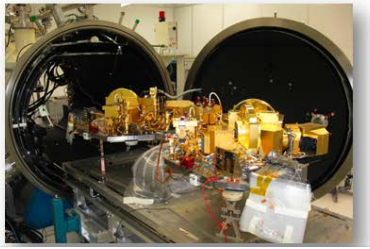
Secondary Mirror Delivered

Backplane Center Section Completed

Hardware Progress: Science Instruments

Mid Infrared instrument JPL/EC

Near Infrared Camera UA



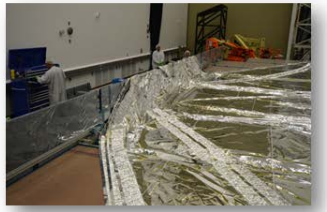
Fine Guidance Sensor CSA

Near Infrared Spectrograph ESA

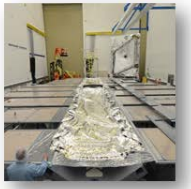
Hardware Progress: Spacecraft & Facilities

Sunshield Hole Punching

Chamber A



Sunshield Folding



Sunshield Deployment Testing

Primary Mirror Segment Assembly (PSMA) Installation Fixture (PAIF)

AFTA WFIRST DRM Study

AFTA is well matched to the WFIRST Requirements

- Existing Hardware: high quality mirror and optical system
- Easily used in Three Mirror Anastigmat (TMA)
  - Wide field of view
  - 3rd mirror in Wide-Field instrument
- AFTA's 2.4 m aperture + wide field imager meets (and exceeds) WFIRST requirements:
  - Higher spatial resolution enhances science capability
  - Larger collecting area enables more science in fixed time
- AFTA's 2.4m aperture enables richer scientific return at much lower cost than a dedicated smaller coronagraphic telescope mission

Study concluded that these assets satisfy all mission requirements.

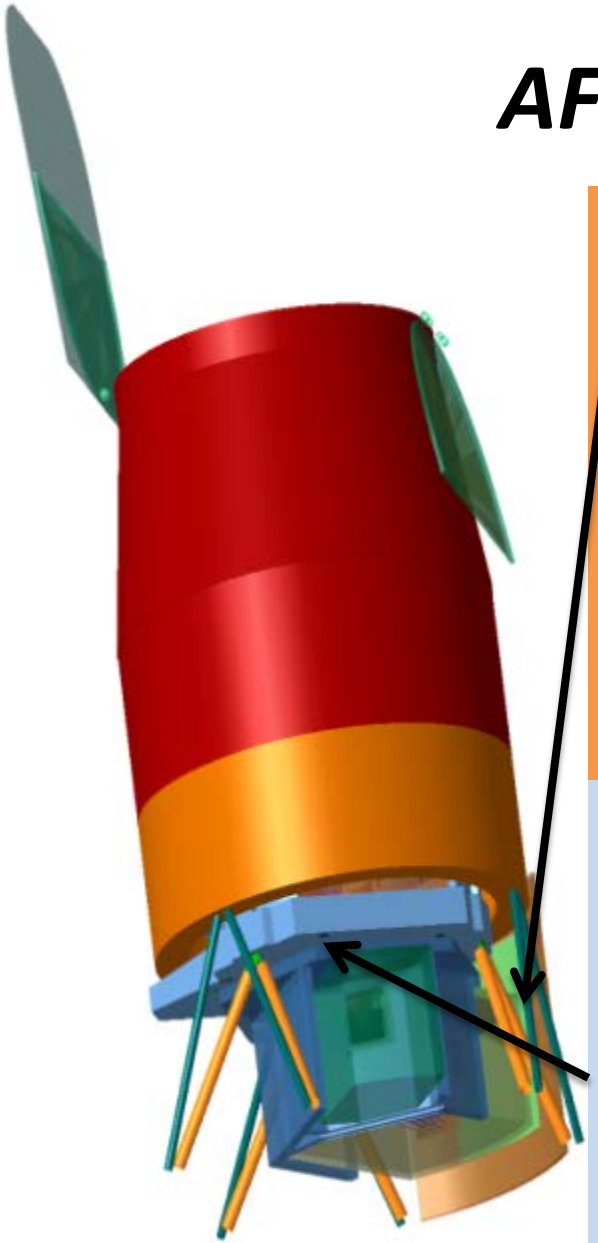
SDT Report due Apr 30, HQ presentation Apr 19.

SIP presentation May 30.

CATE due May 31.

If AFTA study is continued following SIP decision, SDT will continue leading up to CAA and mid-decadal reviews.

AFTA Instruments



Wide-Field Instrument

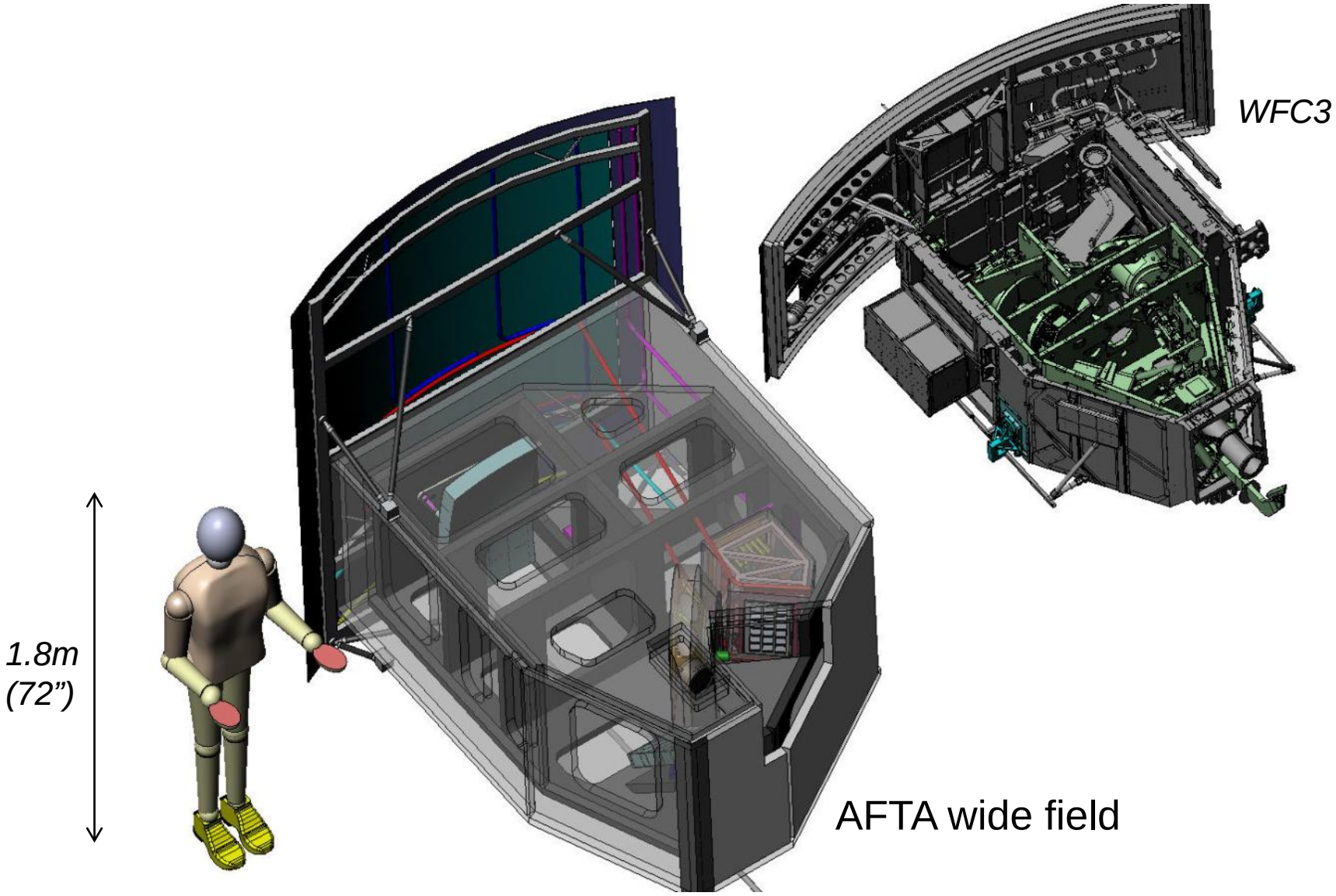
- *Imaging & spectroscopy over 1000s sq deg.*
- *Monitoring of SN and microlensing fields*
- 0.7 – 2.0 micron bandpass
- 0.28 sq deg FoV (100x JWST FoV)
- 18 H4RG detectors (288 Mpixels)
- 4 filter imaging, grism + IFU spectroscopy

Coronagraph (study option)

- *Imaging of ice & gas giant exoplanets*
- *Imaging of debris disks*
- 400 – 1000 nm bandpass
- 10^{-9} contrast
- 100 milliarcsec inner working angle at 400 nm

Requires focused tech. development ASAP for 2021 launch

Wide field Instrument Shares Architecture and Heritage with HST/WFC3



FY14 President's Budget Request

FY13 Appropriation

- Congress appropriated $659M for Astrophysics and $628M for JWST
  - Astrophysics appropriation is $10M over FY13 PBR, earmarked for WFIRST
  - JWST appropriation is what was requested
- Rescission (~1.8%), Sequester (~5%), and other budget adjustments will result in an FY13 Astrophysics budget significantly lower
  - Exact amounts applied to Astrophysics are not public until the operating plan has been submitted to Congress and agreed upon
  - Estimating the reduction at 6.8% is a ROM estimate to astrophysical accuracy
- Astrophysics will take reductions in the following areas first
  - Reduce carry-over for operating missions, includes rephasing of GO funds
  - Rephase unneeded FY13 reserves for developing missions
  - Rephase R&A funding until FY14 for some PIs, reduced selections
  - Slow down development of future Explorers
- Impacts will include
  - Lowered R&A selection rates in 2013 (for FY14 funding)
  - Delays in future Explorer AOs
  - Other reductions in FY14 where funding requirements were deferred

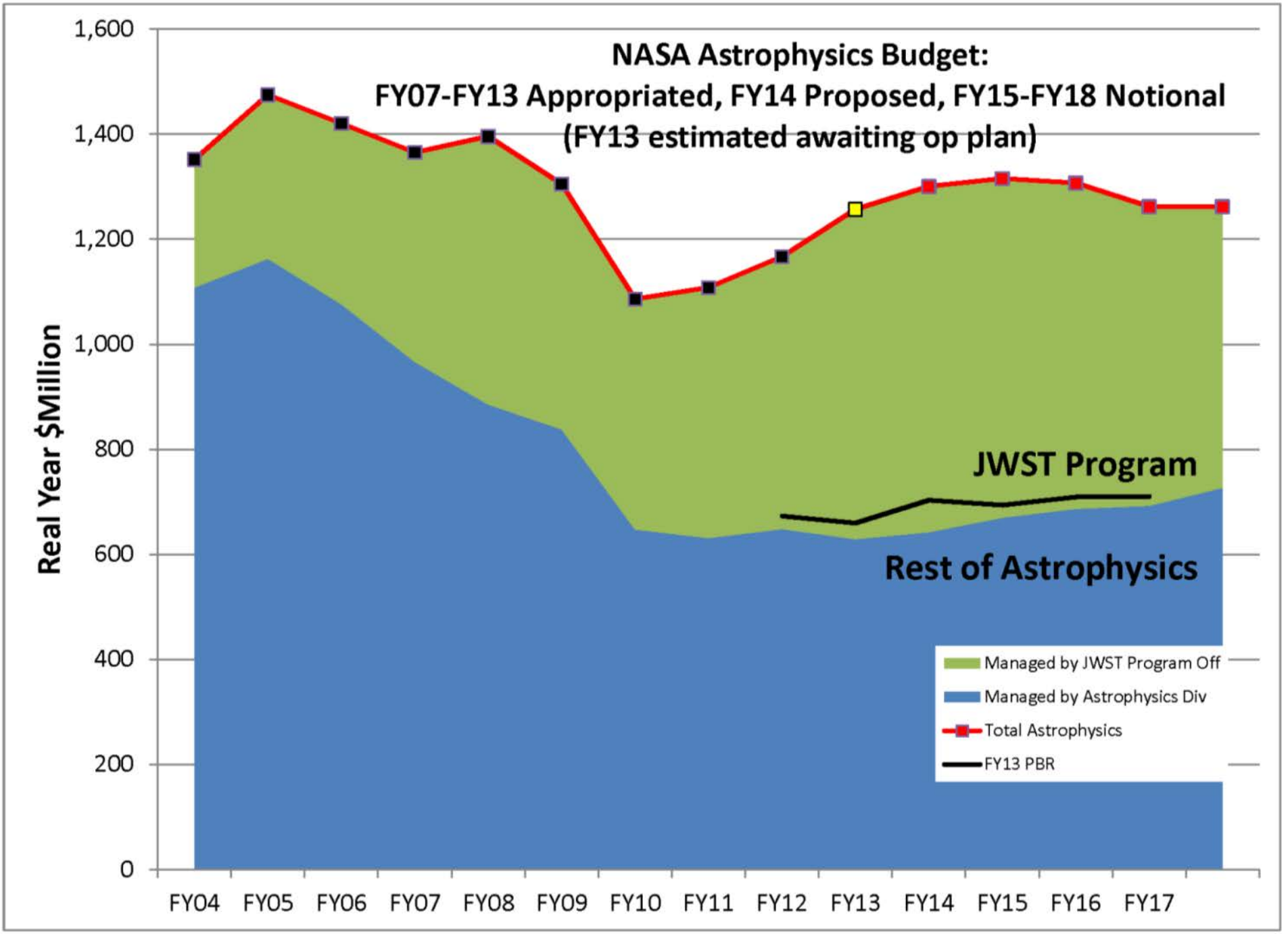
Astrophysics Budget Features

What's changed (since the President's FY13 budget request)

- A new Explorer mission (TESS) and a new Explorer Mission of Opportunity (NICER) downselected for development leading to flight
- New Euclid project created in PCOS program to fund hardware procurement and US science team
- Spitzer, Planck, Chandra, Fermi, XMM, Kepler, Swift, and Suzaku extended per the recommendation of the 2012 Senior Review
- Efficiencies in Fermi mission operations implemented in FY14, ahead of schedule and resulting in a significant reduction of operating costs, and the Fermi GO program canceled for one year (FY14)
- Budget does not support selections for the 2012 Astrophysics Explorer Mission of Opportunity AO

What's the same

- JWST funded to maintain progress toward 2018 launch
- Hubble, SOFIA, NuSTAR, Astro-H, ST-7, Balloons, R&A, Archives
- Budget for large decadal survey mission begins to grow in FY17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FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
FY16
FY17
JWST Program
Rest of Astrophysics
Managed by JWST Program Off
Managed by Astrophysics Div
Total Astrophysics
FY13 PBR

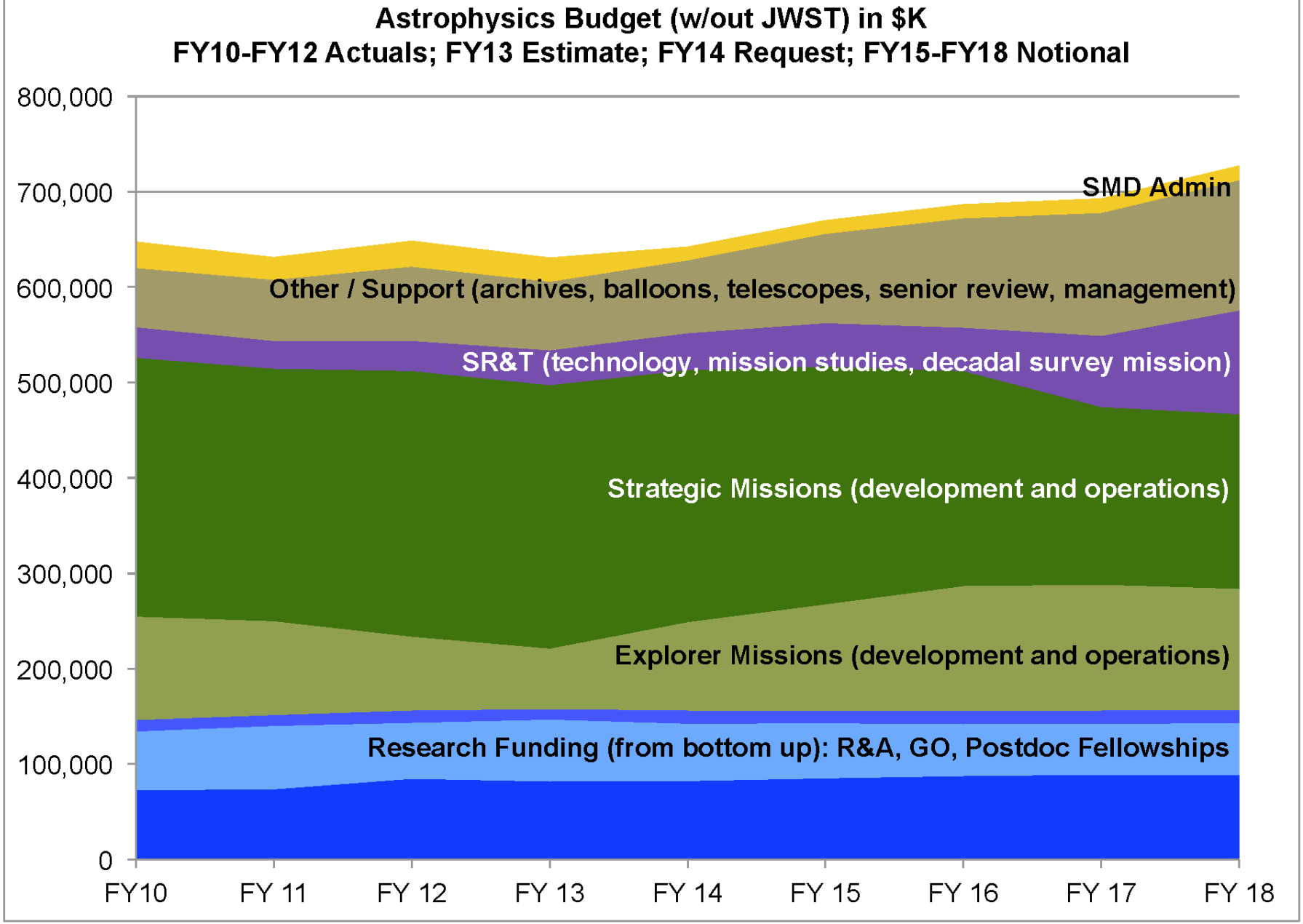
FY14 Budget Request for Astrophysics

- **Reduction in Fermi Budget**
  - In response to the recommendations of the 2012 Senior Review, reductions were planned for the Fermi Gamma-ray Space Telescope to take advantage of operational efficiencies. These reductions were planned to be phased in over three years.
  - The FY14 PBR requests less funding for Fermi than planned. The savings from operational efficiencies will need to be realized immediately (in FY14).
  - In addition, due to a need to realize additional savings in FY14 that exceed those attainable through operational efficiencies alone, the Fermi Guest Observers program will be eliminated for one year (FY14).
  - NASA is working with DOE and its international partners on Fermi to make the necessary changes in Fermi operations.

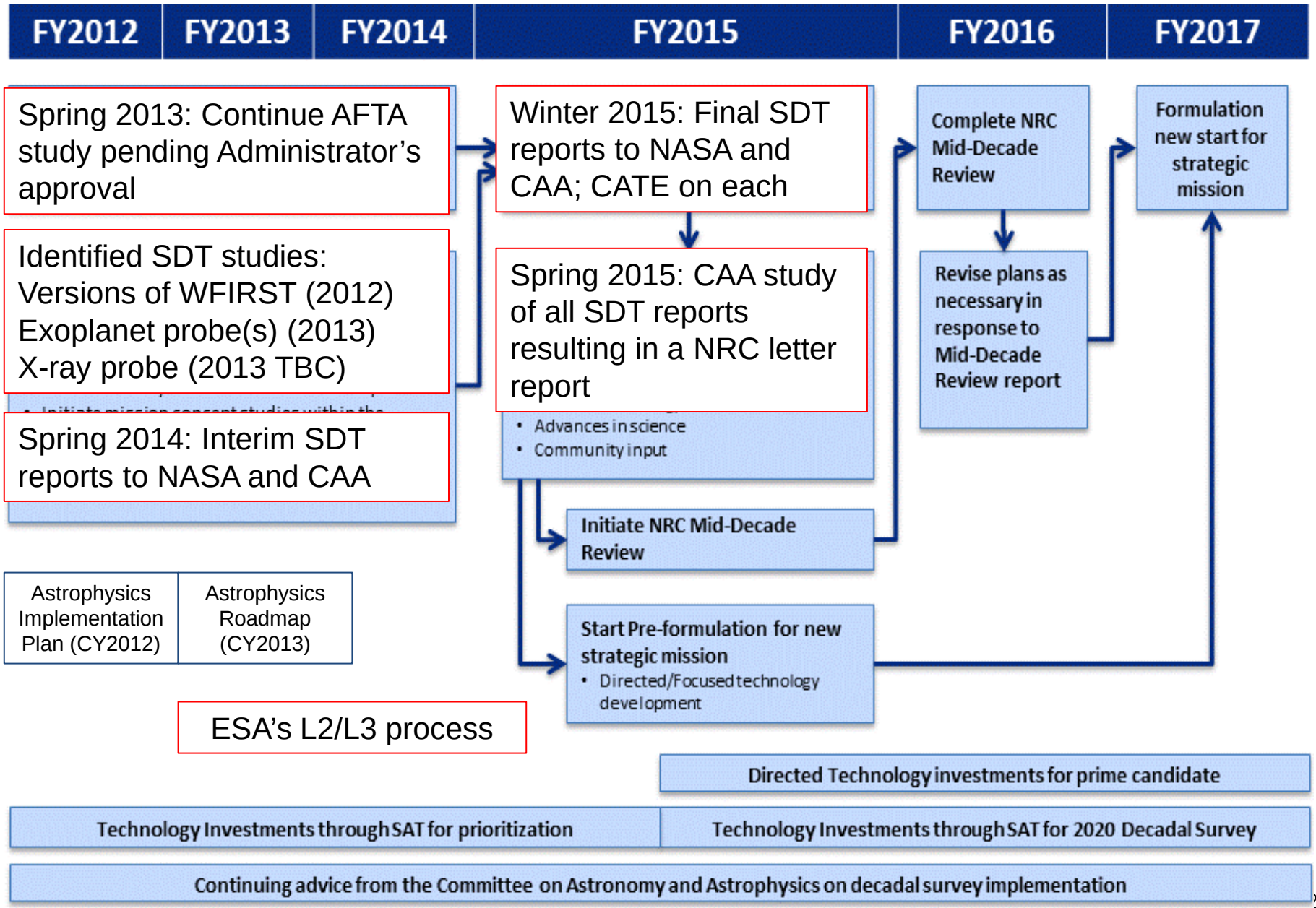
FY14 Budget Request for Astrophysics

- **Reduction in Astrophysics Explorer Budget**
  - The Astrophysics Explorer Program continues to support missions in development and missions in operation. We continue to implement a science rich program including the recent selections of TESS and NICER.
  - The pace of how we implement the program, however, will have to be adjusted to stay within the funding profile requested for the Astrophysics Explorer Program in the President's FY14 budget request.
  - The President's FY14 budget request for the Astrophysics Explorer Program does not support the selection of an astrophysics mission of opportunity from the 2012 Astrophysics Explorer Mission of Opportunity AO.
  - We will complete the evaluation of the proposals, but will not make a selection. Once the evaluation of proposals is completed, we will put on hold any further selection activities for this AO.

Astrophysics Balance (w/out JWST)



Astrophysics Near-term Strategy



Astro2010 Decadal Report Status - Response

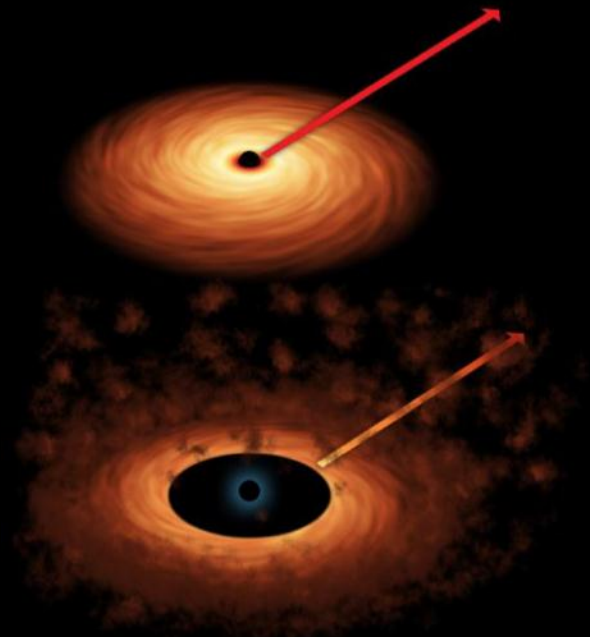
Program Scale	Recommendation	Current Response FY14
Large	**WFIRST**	DRM1 and DRM2 completed in FY12; AFTA DRM completed in FY13; detector technology development begun in FY13; continued pre-formulation and technology development in FY14; decision regarding new start in FY15
Large	**Explorer** Augmentation	Impacted by sequester and budget reductions; EX AO in 2010; SMEX AO in 2014/2015; EX AO in 2016/2017; each AO has a mission and a MO
Large	**LISA** Technology	CST completed in FY12; technology supported through SAT; ST-7/LPF supported; will pursue partnership with ESA if a GW mission is selected for L2/L3 mission
Large	**IXO** Technology	CST completed in FY12; technology supported through SAT; X-ray probe SDT planned for 2013; will pursue partnership with ESA if an X-ray mission is selected for L2/L3 mission
Medium	**New Worlds Technology**	Technology supported through TDEM/SAT; SDTs started in FY13; AFTA coronagraph study in FY13; will consider partnership with ESA if an exoplanet mission is selected for L2/L3 mission; working with STMD on early-stage technology
Medium	**Inflation Probe Technology**	Technology supported through APRA including multiple suborbital payloads; will consider partnership with ESA if a CMB mission is selected for L2/L3 mission
Small	**Astrophysics Theory Program** Augmentation	Impacted by budget reductions
Small	(Definition of) a **future UV-optical space capability**	RFI in FY12; technology supported through APRA, SAT, and working with STMD
Small	**Intermediate Technology Development** Augmentation	SAT program initiated and funded for prioritized investments
Small	**Laboratory Astrophysics** Augmentation	Augmentation started in FY12 including selection of large consortium; impacted by budget reductions
Small	**SPICA** mission (U.S. contributions to JAXA-led)	Candidate for future Explorer Mission of Opportunity
Small	**Suborbital Program** Augmentation	Technology augmentation for balloon program; continued development of ULDB balloon platforms; ISS payload selections; future is impacted by budget reductions
Small	**Theory and Computation Networks** (NASA, NSF, DOE)	First NASA-NSF call in 2013 for FY14 funding
N/A	**Additional core program augmentations**	Impacted by budget reductions

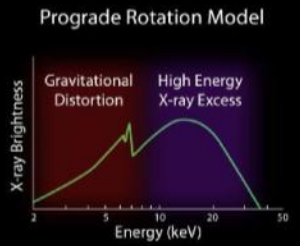

Formulation
Implementation
Primary Ops
Extended Ops
XMM-Newton (ESA)
Swift
Suzaku (JAXA)
Fermi
Planck (ESA)
Euclid (ESA)
Spitzer
Hubble
Kepler
Astro-H (JAXA)
Chandra
Herschel (ESA)
JWST
NICER (on ISS)
NuSTAR
TESS
LISA
Pathfinder (ESA)
SOFIA

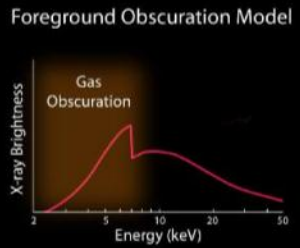
Questions?

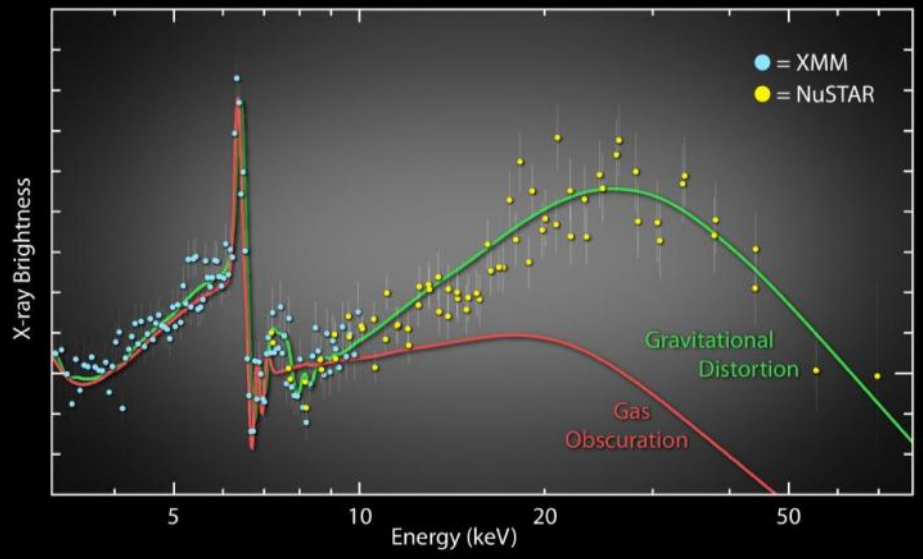
Backup

NuSTAR Helps Solve Riddle of Black Hole Spin

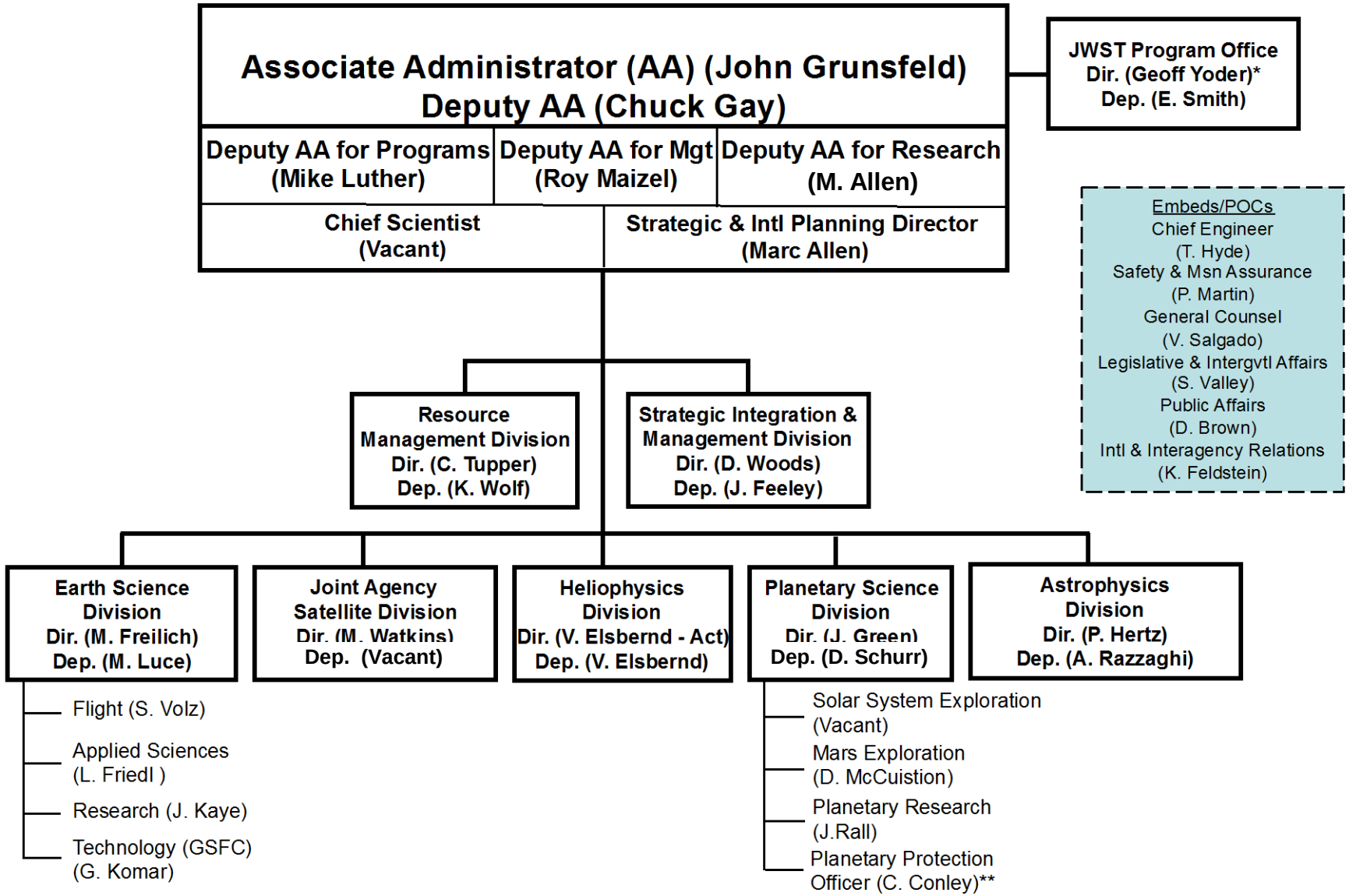








SMD Organization



* Direct report to NASA Associate Administrator
** Co-located from the Front Office

April 2013

Astrophysics Division Organization Chart

Resource Management
Omana Cawthon +
Peifen Anawalt +

Director
Paul Hertz
Deputy Director
Andrea Razzaghi

Lead Secretary: Leslie Allen (acting)
Secretary: Christie Ashley *
Program Support Specialist: Sheila Gorham

Cross Cutting
Technology Lead: William (Billy) Lightsey *
Strategic Integration: Joan Centrella *
Division E/PO POC: Hashima Hasan (Lead Comm Team)
Division PAO POC: Lisa Wainio *
Information Manager: Lisa Wainio *

Astrophysics Research

Program Manager: Linda Sparke
Astrophysics Data Analysis: Doug Hudgins, Debra Wallace
Astrophysics Theory: Linda Sparke
Origins of Solar Systems: Larry Petro *
APRA lead: Michael Garcia *
Cosmic Rays, Fundamental Physics: Joan Centrella*, Vernon Jones, Keith MacGregor*
Gamma Ray/X-ray: Michael Garcia*, Lou Kaluzienski, Wilt Sanders*
Optical/Ultraviolet: Michael Garcia, Richard Griffiths, Hashima Hasan, Mario Perez *, Larry Petro *
IR/Submillimeter/Radio: Richard Griffiths, Doug Hudgins, Larry Petro, Glenn Wahlgren*
Lab Astro: Glenn Wahlgren*
Data Archives: Hashima Hasan
Astrophysics POC for Sounding Rockets: Wilt Sanders *
Balloons Program: Vernon Jones (PS), Mark Sistilli (PE)

February 11, 2013

Programs / Missions

	Program Scientist	*Program Executive*
Exoplanet Exploration (EXEP)		
LEADS	**Doug Hudgins**	**Tony Carro ***
Keck	Hashima Hasan	Mario Perez *
Kepler	Doug Hudgins	Tony Carro *
LBTI	Hashima Hasan	Mario Perez *
NExScI	Hashima Hasan	Mario Perez *
Cosmic Origins (COR)		
LEADS	**Michael Garcia ***	**John Gagosian**
Herschel	Glenn Wahlgren *	John Gagosian
Hubble	Richard Griffiths *	John Gagosian
JWST	Hashima Hasan	N/A
SOFIA	Glenn Wahlgren *	John Gagosian
Spitzer	Glenn Wahlgren *	John Gagosian
Physics of the Cosmos (PCOS)		
LEADS	**Richard Griffiths ***	Lia LaPiana
Chandra	Wilt Sanders *	Lia LaPiana
Euclid	Richard Griffiths *	Lia LaPiana
Fermi	Lou Kaluzienski	Lia LaPiana
Planck	Joan Centrella *	Lia LaPiana
ST-7/LPF	Wilt Sanders *	Anne-Marie Novo-Gradac
XMM-Newton	Lou Kaluzienski	Lia LaPiana
Astrophysics Explorers (APEX)		
LEADS	**Wilt Sanders ***	**Anne-Marie Novo-Gradac**
Astro-H	Lou Kaluzienski	Anne-Marie Novo-Gradac
GALEX	Larry Petro *	Anne-Marie Novo-Gradac
NuSTAR	Lou Kaluzienski	Mark Sistilli
Suzaku	Lou Kaluzienski	Anne-Marie Novo-Gradac
Swift	Michael Garcia *	Anne-Marie Novo-Gradac
WISE	Hashima Hasan	Anne-Marie Novo-Gradac

\+ *Member of the Resources Mgmt Division*
* *Detailee, IPA, or contractor*
JWST now part of the JWST Program Office.

Kelly Johnson on detail until Aug. 2013.
Rita Sambruna on detail until Sept. 2013

Astrophysics - Missions in Formulation & Implementation

Project	Overall previous months				March 2013					Comments
	-4	-3	-2	-1	O	T	C	S	P	
Physics of the Cosmos	G	G	G	G	G	G	G	G	G	
ST-7 (2015)	G	G	G	G	G	G	G	G	G	LRD moved to 2015.
Euclid (2020)	G	G	G	G	G	G	G	G	G	ESA/JPL TAA approved.
Astrophysics Explorer	G	G	G	G	G	G	G	G	G	
Astro-H (2015)	Y	Y	Y	Y	Y	G	Y	Y	Y	JAXA working vibration/microphonics issue and schedule.
TESS, NICER	G	G	G	G	G	G	G	G	G	Downselection announced April 5.
Cosmic Origins	G	G	G	G	G	G	G	G	G	
SOFIA (ongoing)	Y/G	Y/G	Y/G	Y/G	Y	Y/G	G	Y/G	Y	Resumption of science flights in April 2013.
Exoplanet Exploration	G	G	Y	Y	G	R	G	G	G	Kepler wheel friction persists with elevated friction spikes.
Balloon Prog (ongoing)	G	G	G	G	G	G	G	G	G	Sweden campaign to begin in late May with Superpressure balloon test flight.

O: Overall, C: Cost, S: Schedule, T: Technical, P: Programmatic

G On plan, adequate margin

Y Problems, working to resolve within planned margin

R Problems, not enough margin to recover

Astrophysics – Operating Missions

Mission	Launch	End Date	Phase	-4	-3	-2	-1	this mon	Comments
Hubble	1990-04-24	2016-09-30	Prime	G	G	G	G	G	Cycle 21 GO Call had a 6:1 oversubscription rate.
Chandra	1999-07-23	2016-09-30	Ext	G	G	G	G	G	Cycle 15 GO Call had a 5.2:1 oversubscription rate.
XMM-Newton	1999-12-10	2015-03-31	Ext	G	G	G	G	G	
GALEX	2003-04-28	2012-02-07	Ext	S	S	S	S	S	GALEX on loan to Caltech since May 2012 and returned to NASA in mid-April. Decommissioning to take place NLT April 30.
Spitzer	2003-08-25	2014-09-30	Ext	G	G	G	G	G	
Swift	2004-11-20	2016-09-30	Ext	G	G	Y	G	G	U of Rome antenna at Malindi providing support since Feb 8, 2013. No nighttime passes.
Suzaku	2005-07-10	2015-03-31	Ext	G	G	G	G	G	
Fermi	2008-06-11	2016-09-30	Prime	G	G	G	G	G	
Kepler	2009-03-07	2016-09-30	Ext	Y	Y	R	Y	Y	Science collection continues, but elevated friction persists with elevated friction spikes.
Herschel	2009-05-14	2013-05-14	Prime	G	G	G	G	G	Helium is projected to run out in early April 2013.
Planck	2009-05-14	2013-08	Ext	G	G	G	G	G	ESA & NASA Press event March 21 - CMB data.
NuSTAR	2012-06-13	2014-08-01	Prime	G	G	G	G	G	Malindi ground station now being backed up by KSAT Singapore ground station. No nighttime Malindi passes.

Note: End dates beyond 2014 are pending approval in the 2014 Senior Review process.

G On plan, adequate margin

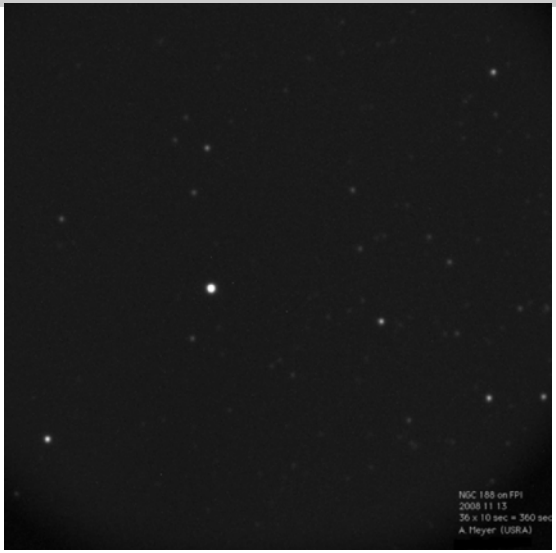
Y Problems, working to resolve within planned margin

R Problems, not enough margin to recover

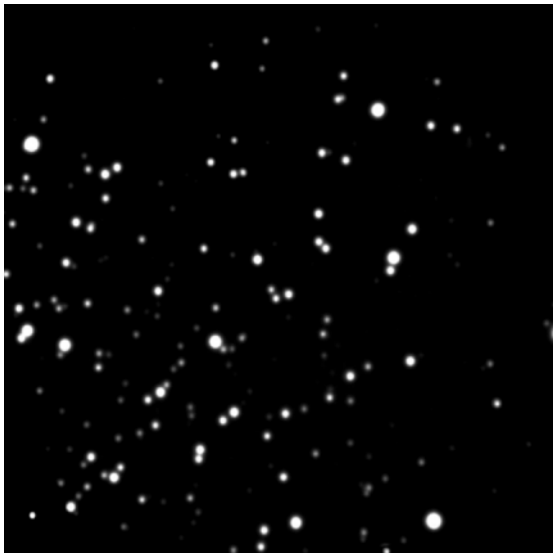
S Space Act Agreement. GALEX on loan to Caltech.

Program Update – SOFIA

- Completion of observatory V&V flights delayed until May due to Mission Communication and Control System S/W bug.
  - Does not prevent instrument commissioning and science flights from proceeding.
- First four Cycle 1 Airborne Astronomy Ambassadors flew on board during commissioning/ V&V flights in February; next Airborne Astronomy Ambassadors scheduled to fly in June.
- SSPC met March 14-15 at Ames; stated general support for maintaining high rate of new instrument calls.
- FORCAST instrument commissioning phase 1 completed April 4.
- Cycle 1 Science began April 11 with GREAT instrument.
  - Successful GREAT commissioning and science flights on both April 11 (Flight #100) and April 12 (Flight #101).
  - On Flight #101, combined science instrument/observatory performance was good with 60% on source efficiency, 3 times better than during the Early Science phase. Preliminary performance data indicates pointing/tracking well within 1 arc-seconds.
- SRB Review: Program Implementation Review (PIR) scheduled for June 17-20.
- Southern Hemisphere deployment to New Zealand to occur in July 2013.
- Baseline plan established for 3rd-generation instrument call
  - Release AO July 2014; select instrument by April 2015



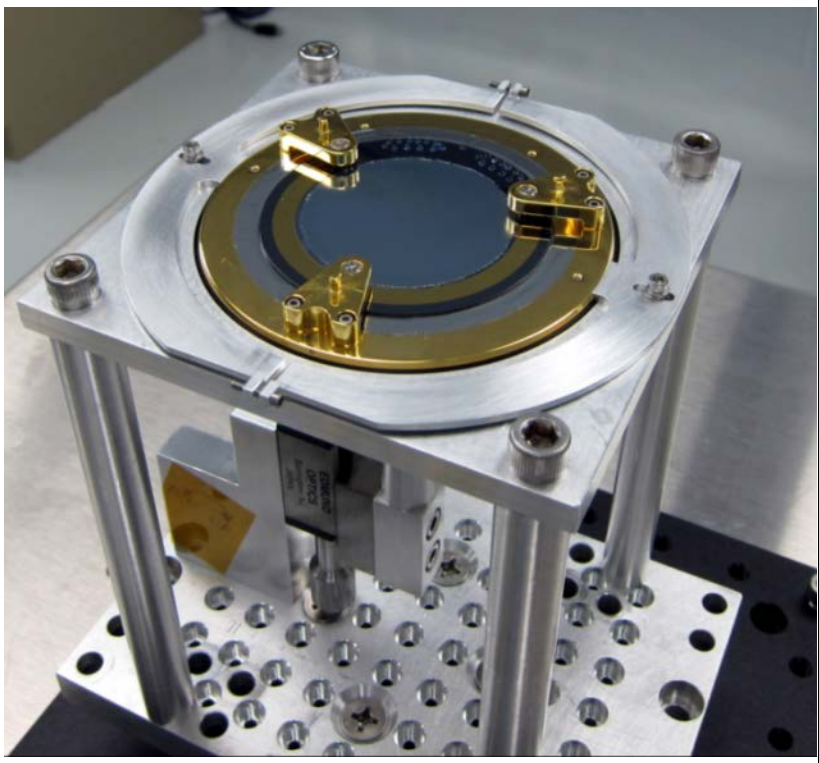
Star field image taken with original Focal Plane Imager



Similar Star field with upgraded detector

Program Update – Astro-H

- New official Launch Readiness Date of 2015 was announced by JAXA (was Feb 2014).
- Flight mirror #1 completed Acceptance Review and was shipped to JAXA on March 21.
- SXS instrument-to-spacecraft micro-vibration testing was conducted in Japan (March 18-23). NASA team provided support.
- Vibrations must be reduced to acceptable levels for the mission to meet minimum science requirements.
  - JAXA has formally requested assistance from NASA to address vibration issue. The Project is working to identify best path to accommodate JAXA request within ITAR restrictions.
- Instrument Manager (IM) Cynthia Simmons has been reassigned to another project as of March 18, 2013. Deputy IM Jim Pontius has taken over as IM.
- SMD Program Management Council released remaining UFE to project in response to changing JAXA schedule.
- Later this calendar year, the SMD Program Management Council will review the overall cost impacts of the new JAXA schedule.



FM Dewar Main Shield X-ray Filter Installed in Carrier Mount

ROSES Selections Since October 2012

Status: April 25, 2013

	Proposal Due Date	Notify Date	Days since received	Number received	Number selected	% selected
Astrophysics Theory Program	Jul 13	Dec 6	146	181	28	15%
Euclid Science Team	Aug 31	Nov 7	68	8	3	38%
Swift Guest Investigators	Sep 26	Dec 18	83	158	45	28%
Nancy Grace Roman Technology Fellowships	Nov 8	Mar 5	117	12	2	17%
Fermi Guest Observer	Jan 18	[1]	97	233		
Kepler Guest Observer	Jan 18	[2]	97	62		
TCAN with NSF	Feb 14	[3]	70	101		
Kepler Participating Scientist	Mar 1	[3]	55	30		
APRA	Mar 22	[4]	34	182		
SAT	Mar 22	[4]	34	39		

[1] Peer review in March; [2] Peer review in April; [3] Peer review in May; [4] Peer review in June.

FY 2014 SMD Program/Budget Strategy

- Provide the most productive Earth & space science program for the available resources
  - Guided by national priorities
  - Informed by NRC Decadal Surveys recommendations
  - Incorporating new ideas and partnerships
  - Increase cross-directorate collaboration on strategic projects (Mars 2020, NEOs)
- Responsibly manage the national investment in robotic space missions, with adherence to NPD 7120
  - Confirm new missions only after sufficient technology maturation and budgets at an appropriate confidence level
  - Take aggressive steps with missions that do not stay within budget
  - Aggressively manage JWST to the cost and schedule baseline
- Increase efforts to detect and study NEOs in support of future agency initiatives
- Begin Mars 2020 mission to build on Curiosity's discoveries
- Plan for land imaging capability beyond LDCM, Climate Sensors (previously on JPSS-2), and DSCOVR Earth observing instruments
- Implement the Administration's proposed STEM initiative

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Recent Cost and Schedule Performance

All spacecraft launching from August 2011 - August 2014

	Original Baseline			Revised Baseline			Actual/Current		Change From Latest Baseline	
	Estab.	LRD	Dev $	Estab.	LRD	Dev $	LRD	Dev $	LRD	Dev Cost
Juno	2008	Aug-11	742				8/5/11	710	--	-4%
GRAIL	2008	Sep-11	427				9/10/11	398	--	-7%
Suomi NPP	2006	Apr-08	593	2011	Feb-12	815	10/25/11	768	- 4 mos	-6%
MSL	2007	Sep-07	1069	2010	Nov-11	1720	11/26/11	1769	--	3%
NuSTAR *	2009	Feb-12	110				6/13/12	116	+4 mos	5%
RBSP	2009	May-12	534				8/30/12	(a) 531	+ 3 mos	(a) -1%
LDCM	2010	Jun-13	583				2/11/13	(a) 577	- 4 mos	(a) -1%
IRIS *	2010	Jun-13	141				Jun-13	140	--	--
LADEE	2011	Nov-13	168				Nov-13	176	--	5%
MAVEN	2011	Nov-13	567				Nov-13	(a) 551	--	(a) -3%
GPM	2010	Jul-13	555	2012	Jun-14	519	Jun-14	509	--	-2%

* IRIS and NuSTAR are too small (<$250M LCC) to be subject to MPAR reporting, but are included here for completeness.

(a) In the upcoming Operating Plans for FY12 and FY13 funds, NASA expects to report even better performance (greater underruns) on RBSP, LDCM and MAVEN.

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Science Budget Request Summary

	FY2012	* FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
Science Total	**5073.7**	**5115.9**	**5017.8**	**5017.8**	**5017.8**	**5017.8**	**5017.8**
Earth Science	**1760.5**		**1846.1**	**1854.6**	**1848.9**	**1836.9**	**1838.1**
Earth Science Research	441.1		443.3	483.1	483.4	485.1	476.5
Earth Systematic Missions	879.9		787.5	811.2	861.9	839.1	833.3
Earth System Science Pathfinder	183.3		353.6	293.1	232.2	237.4	250.0
Earth Science Multi-Mission Operations	168.6		171.7	174.3	177.9	179.0	182.0
Earth Science Technology	51.2		55.1	56.2	55.1	56.1	56.1
Applied Sciences	36.4		35.0	36.7	38.4	40.1	40.1
Planetary Science	**1501.4**		**1217.5**	**1214.8**	**1225.3**	**1254.5**	**1253.0**
Planetary Science Research	174.1		220.6	233.3	229.1	230.4	232.2
Lunar Quest Program	139.9		17.7				
Discovery	172.6		257.9	268.2	242.3	187.5	215.0
New Frontiers	143.7		257.5	297.2	266.5	151.0	126.2
Mars Exploration	587.0		234.0	227.7	318.4	504.7	513.2
Outer Planets	122.1		79.0	45.6	24.4	26.4	26.4
Technology	161.9		150.9	142.8	144.7	154.4	140.0
Astrophysics	**648.4**		**642.3**	**670.0**	**686.8**	**692.7**	**727.1**
Astrophysics Research	165.5		147.6	170.6	192.3	207.2	218.5
Cosmic Origins	239.9		228.0	216.5	193.1	196.7	194.1
Physics of the Cosmos	108.3		110.4	107.5	100.0	82.8	86.4
Exoplanet Exploration	50.8		55.4	59.4	57.7	60.7	90.7
Astrophysics Explorer	83.9		100.9	116.0	143.8	145.3	137.4
James Webb Space Telescope	**518.6**		**658.2**	**645.4**	**620.0**	**569.4**	**534.9**
Heliophysics	**644.8**		**653.7**	**633.1**	**636.8**	**664.3**	**664.6**
Heliophysics Research	166.7		195.7	163.0	167.5	172.1	174.1
Living with a Star	196.3		216.2	277.7	332.6	353.9	374.4
Solar Terrestrial Probes	216.0		146.6	68.7	48.9	50.1	27.9
Heliophysics Explorer Program	65.8		95.2	123.7	87.9	88.2	88.2

FY 2015-FY 2018 estimates are notional

* FY2013 reflects pre-appropriation "annualized CR" rate; pending Operating Plan will be less than $4.8B after rescissions and sequestration

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Astrophysics Program Content

	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
				(FY15-18 estimates are notional)			
Astrophysics	**648.4**		**642.3**	**670.0**	**686.8**	**692.7**	**727.1**
Astrophysics Research	165.5		147.6	170.6	192.3	207.2	218.5
Astrophysics Research and Analysis	68.6		65.7	68.3	70.2	71.5	71.5
Balloon Project	31.6		32.9	32.8	34.2	34.3	34.3
Other Missions and Data Analysis	65.3		49.1	69.4	87.9	101.3	112.7
Keck Single Aperture	2.3						
Astrophysics Data Analysis Program	16.4		17.0	17.0	17.6	17.6	17.6
Astrophysics Data Curation and Archival	20.0		18.2	19.1	19.1	19.1	19.1
Astrophysics Senior Review				13.9	24.5	35.8	41.0
Education and Public Outreach	12.9						
Contract Administration, Audit & QA Svcs	13.7		13.9	14.0	14.5	14.5	14.5
Astrophysics Directed R&T				5.4	12.3	14.3	20.5
Cosmic Origins	239.9		228.0	216.5	193.1	196.7	194.1
Hubble Space Telescope (HST)	98.3		96.3	92.3	88.2	88.2	83.9
SOFIA	84.2		87.4	87.3	85.2	85.1	86.2
Other Missions And Data Analysis	57.4		44.3	36.9	19.7	23.4	24.0
Spitzer	17.8		16.3	14.2			
Herschel	24.3		12.2	5.5	2.7	1.0	
Cosmic Origins SR&T	10.2		12.8	13.1	13.3	18.6	19.2
Cosmic Origins Future Missions	1.0		0.4	1.6	1.0	1.0	2.0
Cosmic Origins Program Management	4.1		2.6	2.6	2.7	2.8	2.9

Astrophysics Program Content (cont'd)

	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
				(FY15-18 estimates are notional)			
Physics of the Cosmos	108.3		110.4	107.5	100.0	82.8	86.4
Euclid	1.0		15.1	9.3	3.7	4.0	5.0
Chandra X-Ray Observatory	56.4		55.0	55.8	55.4	55.6	55.6
Fermi Gamma-ray Space Telescope	25.3		14.3	18.6	20.7		
Planck	7.1		6.2	4.1			
XMM-Newton	2.1		1.9	1.0			
Physics of the Cosmos SR&T	13.3		15.3	14.9	16.4	19.3	20.8
Physics of the Cosmos Program Mgmt	3.0		2.7	2.8	2.8	2.9	3.0
Physics of the Cosmos Future Missions	0.3			1.0	1.0	1.0	2.0
Exoplanet Exploration	50.8		55.4	59.4	57.7	60.7	90.7
Kepler	19.6		18.7	18.0	18.3		
Large Binocular Telescope Interferometer	2.0		2.9	2.0	0.5	0.5	
Keck Operations	3.2		5.8	6.0	6.1	6.1	6.2
Keck Interferometer	0.4						
Exoplanet Exploration SR&T	18.4		22.2	26.0	26.1	34.3	34.3
Exoplanet Exploration Program Mgmt	5.6		4.6	5.4	5.5	5.6	5.7
Exoplanet Exploration Future Missions	1.5		1.2	2.0	1.2	14.2	44.4

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Astrophysics Program Content (cont'd)

	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
				(FY15-18 estimates are notional)			
Astrophysics Explorer	83.9		100.9	116.0	143.8	145.3	137.4
Astro-H (SXS)	16.2		1.3	0.9	0.9		
Swift	4.3		4.8	5.0	5.1		
Wide-Field Infrared Survey Explorer	4.5		0.2				
Suzaku (ASTRO-E II)	0.3		0.3	0.3			
Nuclear Spectroscopic Telescope Array	15.6		1.3	0.4			
GALEX	0.5						
Wilkinson Microwave Anistropy Probe	1.0						
Gravity and Extreme Magnetism SMEX	33.2						
Astrophysics Explorer Future Missions	2.7		86.0	105.8	130.9	137.9	133.4
Astrophysics Explorer Program Mgmt	5.6		7.0	3.5	6.8	7.4	4.0

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Astrophysics Missions timeline

Last updated: April 15, 2013