

National Aeronautics and Space Administration



# NASA Townhall AAS 222nd Meeting Indianapolis, IN

June 4, 2013

**Paul Hertz**

**Director  
Astrophysics Division  
Science Mission Directorate**

[www.nasa.gov](http://www.nasa.gov)

This presentation is posted at  
<http://science.nasa.gov/astrophysics/documents/>



# Outline

- Results of NASA's studies of potential use of the 2.4m telescope assets
- Division Update
  - New Explorer Missions
  - Operating missions including Kepler
  - Missions in development
  - Proposal opportunities
- President's FY14 Budget Request for NASA Astrophysics
  - Update on FY13 Appropriation
  - President's FY14 Budget Request
  - Astrophysics Implementation Plan and Roadmap
- Questions and Answers



## NASA use of 2.4m Telescope Assets for WFIRST

- Since Fall 2012, NASA has been studying potential uses of the 2.4m telescope assets that were made available to the Agency by the National Reconnaissance Office in mid-2012
- The studies included both (1) whether the telescope assets could be used to realize a mission that responds to the number one recommendation of the Astrophysics Decadal Survey for a wide field infrared survey telescope (WFIRST) and (2) an assessment of possible applications to other NASA objectives in science, technology, and human space flight
- The results of the studies were presented to the NASA Administrator and other senior officials across the Agency on May 30, 2013
- The focused astrophysics study showed that for approximately the same costs, the telescope assets would enable a WFIRST mission with significantly improved science capabilities relative to the design described in the Astrophysics Decadal Survey
- Use of the telescope assets would also enable the addition of an exoplanet imaging instrument to WFIRST that would enable imaging and characterization of planets around nearby stars up to a decade earlier than contemplated in the Decadal Survey



## NASA use of 2.4m Telescope Assets for WFIRST

- The Administrator directed the Science Mission Directorate to continue pre-formulation activities for a mission using the 2.4m telescope assets to prepare for a later decision as to whether a WFIRST mission would be undertaken with these optics
- No decision on a future wide field infrared survey mission is expected until early 2016
- There was no decision to proceed with design studies for any other concepts at this time
- The study report by the Science Definition Team is available at <http://wfirst.gsfc.nasa.gov/science>



## AFTA Study: Description

- Study to determine the value of using the existing 2.4m telescope assets to address the science objectives of WFIRST
  - Study called the Astrophysics Focused Telescope Assets (AFTA) study
  - Parallel study to assess other NASA uses of the telescope assets
  - Study initiated September 2012, reported to NASA Administrator on May 30
- Ground rules included
  - Use telescope assets “as is”; realize savings
  - Address decadal survey science objectives for WFIRST
  - Study options for coronagraph, servicing, optical comm
- Participants included
  - Science Definition Team (SDT) – Co-chaired by David Spergel (Princeton) and Neil Gehrels (GSFC)
  - Mission Study Office – GSFC
  - Telescope Study Team – JPL
  - Cost Assessment and Technology Evaluation – Aerospace Corp
- Current study report available at <http://wfirst.gsfc.nasa.gov/science/>



# AFTA Study: Conclusions

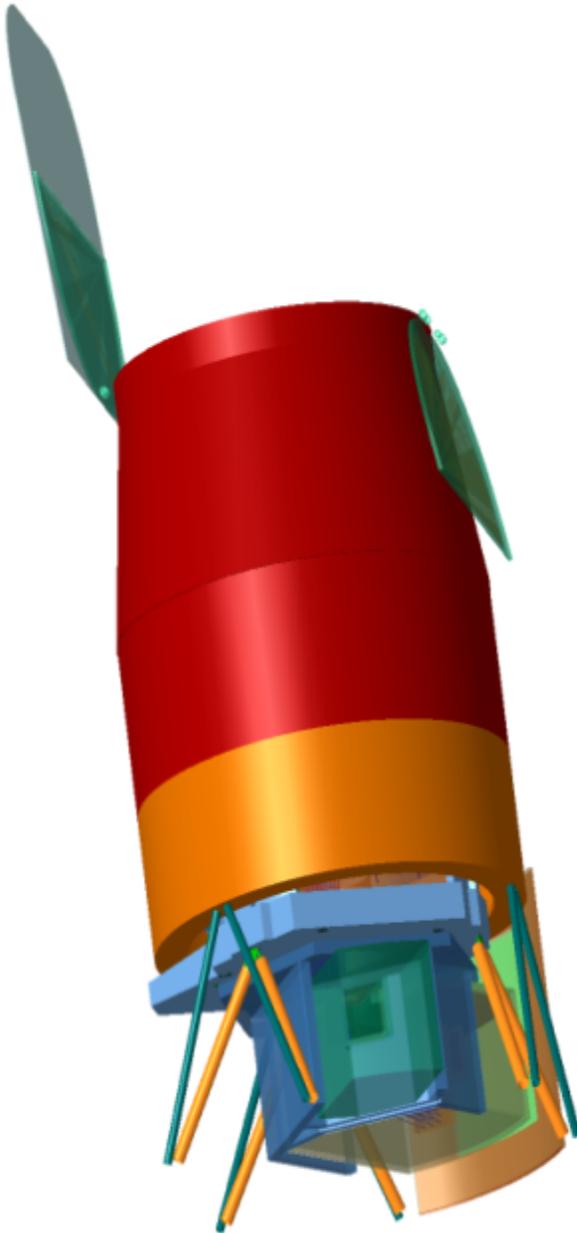
## AFTA is well matched to the WFIRST Requirements

- Existing Hardware: high quality mirror and optical system
- Easily used in Three Mirror Anastigmat
  - Wide field of view
  - 3rd mirror in Wide-Field Imager primary 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
- With a coronagraph as a second instrument, AFTA's 2.4m aperture enables richer scientific return at much lower cost than a dedicated smaller coronagraphic telescope mission

Study concluded that use of these telescope assets satisfy all mission requirements for WFIRST



# AFTA Study: Strawman Payload



## 2.4m Telescope with wide field-of-view

### 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)
- 4 filter imaging, grism + IFU spectroscopy
- 18 H4RG detectors (288 Mpixels)

***Requires focused tech. development***

### 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***



## AFTA Study: Findings of SDT

AFTA carries out the WFIRST science program (the top ranked decadal priority).

+

AFTA's larger aperture enables astronomers to make important contributions towards many of the enduring questions listed in the decadal survey through both surveys and peer-reviewed observing programs.

+

Equipped with a coronagraph, AFTA can image Jupiter and Saturn-like planets around the nearest stars. AFTA will be an essential stepping stone towards finding signs of life around nearby stars.



- Formulation
- Implementation
- Primary Ops
- Extended Ops

**XMM-Newton (ESA)**  
12/10/1999

**Swift**  
11/20/2004

**Suzaku (JAXA)**  
7/10/2005

**Fermi**  
6/11/2008

**Planck (ESA)**  
5/14/2009

**Euclid (ESA)**  
2020

**Hubble**  
4/24/1990

**Kepler**  
3/6/2009

**Spitzer**  
8/25/2003

**Astro-H (JAXA)**  
2015

**Chandra**  
7/23/1999

**JWST**  
2018

**NICER (on ISS)**  
2016

**NuSTAR**  
6/13/2012

**TESS**  
2017

# Astrophysics Division Update

Recently Completed  
Herschel 2013  
GALEX 2013

**LISA Pathfinder (ESA)**  
2015

**SOFIA**  
Full Ops 2014

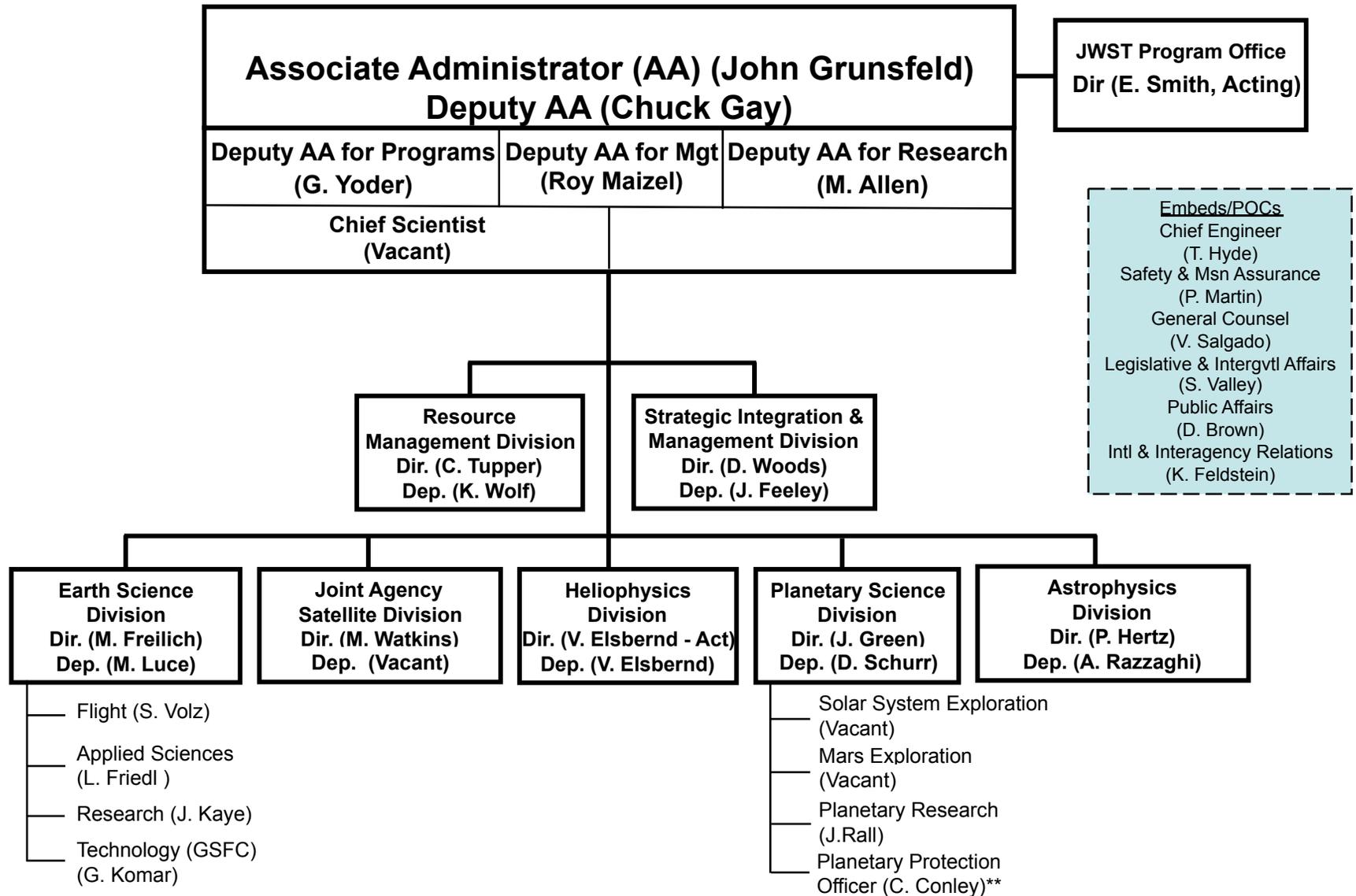


# The Big Picture.....

- **This remains a time of opportunity for NASA Astrophysics**
  - The President's request for the FY14 NASA astrophysics budget, which includes JWST, remains at a high level.
  - Large and small space-based observatories spanning the electromagnetic spectrum, including multiple Great Observatories, are currently observing 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 budget for FY15-FY18 means priorities must be set and choices must be made.



# SMD Organization



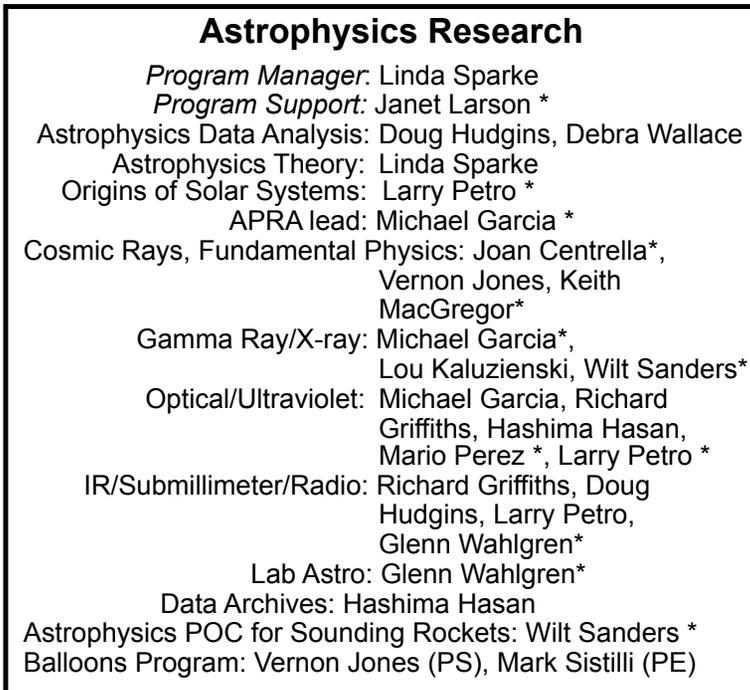
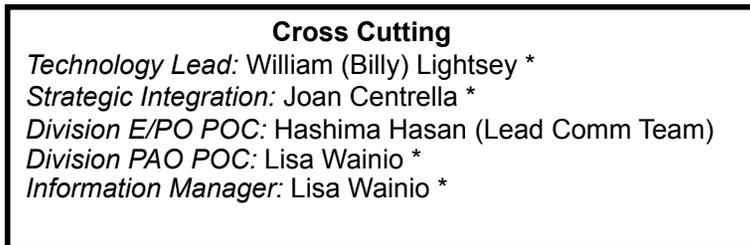
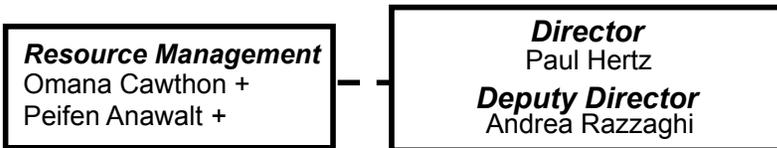
\* Direct report to NASA Associate Administrator

\*\* Co-located from the Front Office



# Astrophysics Division Organization Chart

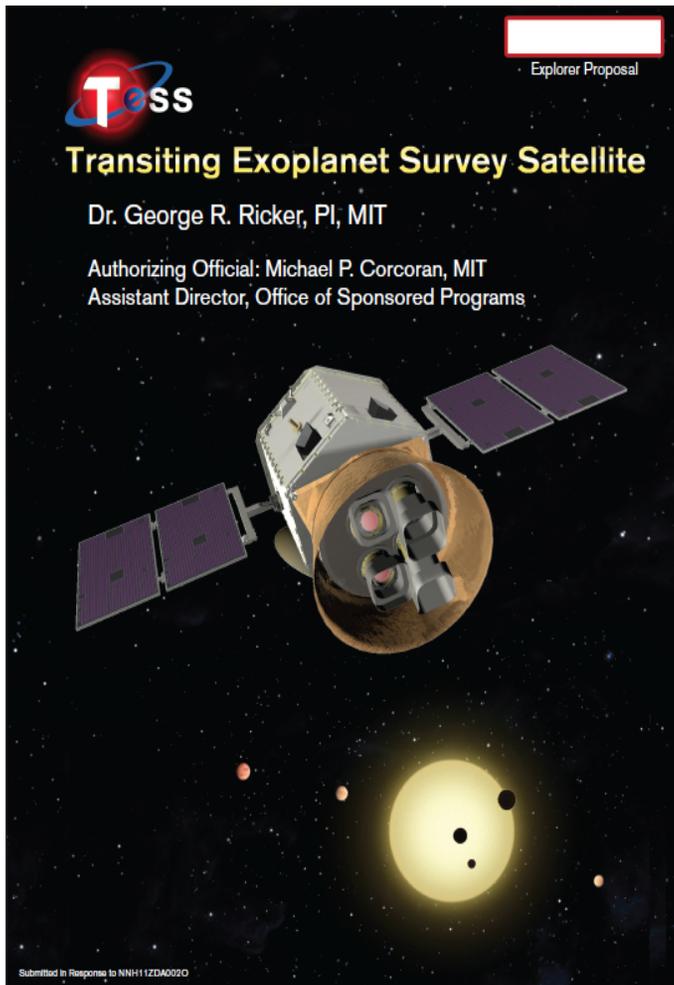
May 1, 2013



<b>Programs / Missions</b>		
	<u>Program Scientist</u>	<u>Program Executive</u>
<b>Exoplanet Exploration (EXEP)</b>		
<b>LEADS</b>	<b>Doug Hudgins</b>	<b>Tony Carro *</b>
Keck	Hashima Hasan	Mario Perez *
Kepler	Doug Hudgins	Tony Carro *
LBTI	Hashima Hasan	Mario Perez *
NExSci	Hashima Hasan	Mario Perez *
<b>Cosmic Origins (COR)</b>		
<b>LEADS</b>	<b>Michael Garcia *</b>	<b>John Gagosian</b>
Herschel	Glenn Wahlgren *	John Gagosian
Hubble	Richard Griffiths *	John Gagosian
JWST	Hashima Hasan	N/A
SOFIA	Glenn Wahlgren *	John Gagosian
Spitzer	Glenn Wahlgren *	Jeff Hayes *
<b>Physics of the Cosmos (PCOS)</b>		
<b>LEADS</b>	<b>Richard Griffiths *</b>	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	Jeff Hayes *
<b>Astrophysics Explorers (APEX)</b>		
<b>LEADS</b>	<b>Wilt Sanders *</b>	<b>Anne-Marie Novo-Gradac</b>
Astro-H	Lou Kaluzienski	Anne-Marie Novo-Gradac
NICER	Rita Sambruna	Jeanne Davis *
NuSTAR	Lou Kaluzienski	Mark Sistilli
Suzaku	Lou Kaluzienski	Jeff Hayes *
Swift	Michael Garcia *	Jeff Hayes *
TESS	Doug Hudgins	Mark Sistilli
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



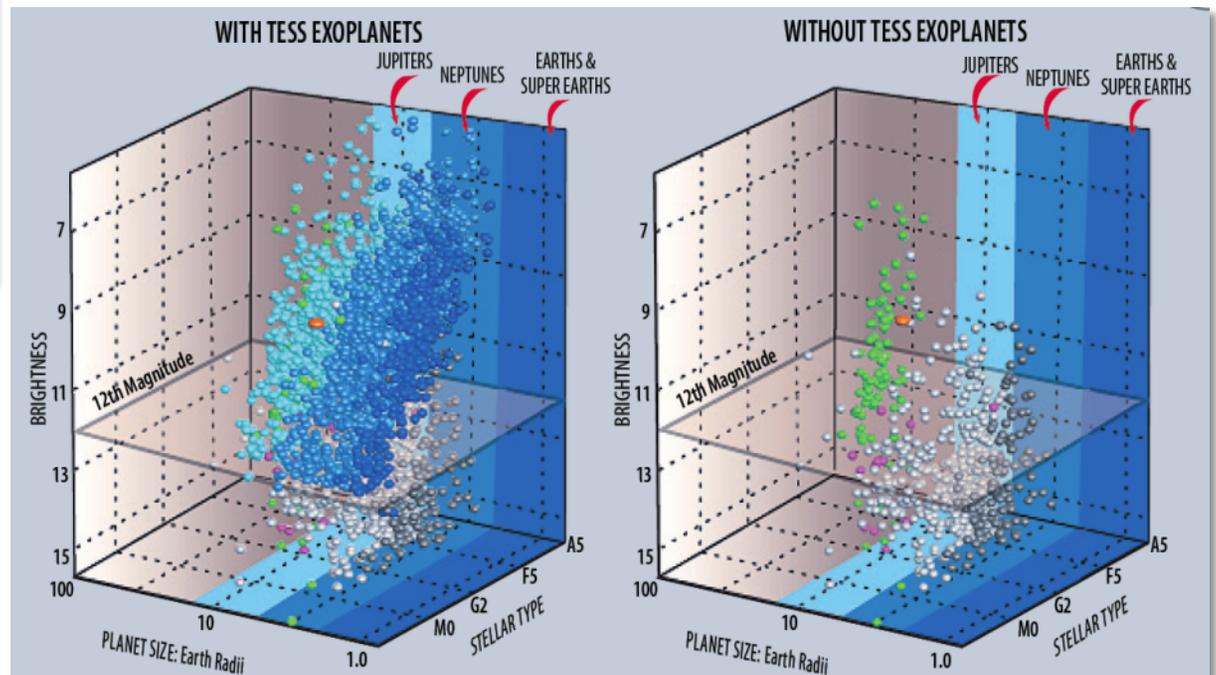
# Transiting Exoplanet Survey Satellite

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

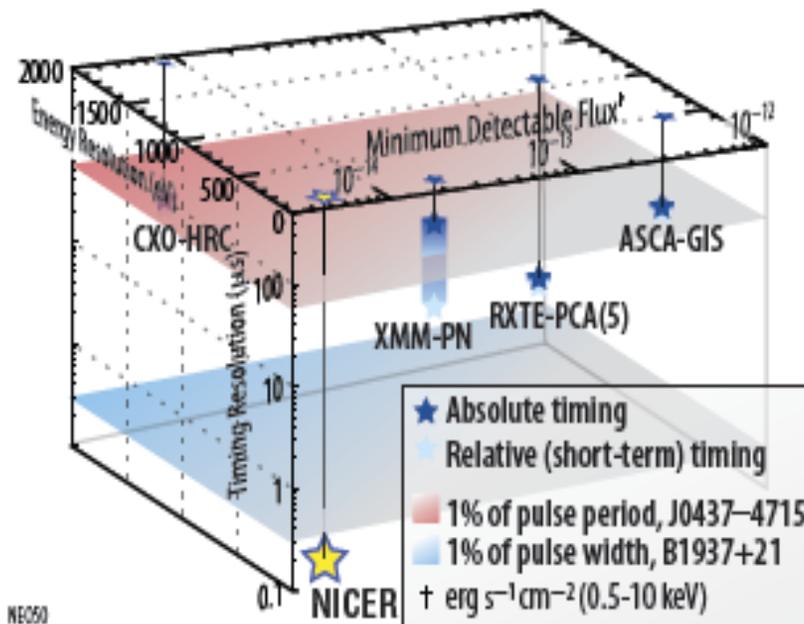




# Neutron Star Interior Composition Explorer

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 – Operating Missions

Mission	Launch	NASA approved through Date	Phase	May	Comments
<b>Hubble</b>	1990-04-24	2016-09-30	Prime	<b>G</b>	Cycle 21 TAC met. ~1000 proposals received.
<b>Chandra</b>	1999-07-23	2016-09-30	Ext	<b>G</b>	Cycle 15 TAC upcoming. ~650 proposals received.
<b>XMM-Newton</b>	1999-12-10	2015-03-31	Ext	<b>G</b>	ESA Senior Review later this year. Cycle 13 proposals due in October.
<b>GALEX</b>	2003-04-28	2012-02-07	Ext	<b>S</b>	GALEX returned to NASA April. Spacecraft passivation NET June 30 to allow engineering tests.
<b>Spitzer</b>	2003-08-25	2014-09-30	Ext	<b>G</b>	Cycle 10 proposals due August 2.
<b>Swift</b>	2004-11-20	2016-09-30	Ext	<b>G</b>	
<b>Suzaku</b>	2005-07-10	2015-03-31	Ext	<b>G</b>	Cycle 9 proposals due in Fall.
<b>Fermi</b>	2008-06-11	2016-09-30	Prime	<b>G</b>	Cycle 6 selections announced. More info in later chart.
<b>Kepler</b>	2009-03-07	2016-09-30	Ext	<b>R</b>	Wheel 4 failed on May 12. Spacecraft in Point Rest State. More info in later chart.
<b>Herschel</b>	2009-05-14	2013-05-14	Close out	<b>G</b>	Helium was depleted on April 29 (later than expected). S/C shutdown by ESA by mid-June.
<b>Planck</b>	2009-05-14	2013-08	Ext	<b>G</b>	LFI-only sky survey on track for October completion.
<b>NuSTAR</b>	2012-06-13	2014-08-01	Prime	<b>G</b>	Prime mission proceeding as planned.

**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. 15



# Kepler and Exoplanets





# Program Update - Kepler

- **Safe-mode entered on May 12, clear indication of loss of reaction wheel #4.**
  - First fault was a loss of fine point control.
  - Safe-mode tripped later due to attitude and rate errors.
  - Commanding back to wheels and stopping rotation did not work.
  - Commanded back to TCSM (thruster control safe mode).
- **Configuration commanding to complete set-up for Point Rest State (loose standby attitude using thrusters) completed.**
  - Commanded transition to Point Rest State (PRS) May 15.
  - Fuel burn in PRS has been measured to be similar to science ops and will allow team to downlink more engineering data for analysis and to make plans on what to do next.
- **Science Processing continues and is on schedule.**
- **Second Kepler Science Conference planned for Nov 2013 (pending waiver approval).**
  - Due to budget and travel constraints the decision was made to modify the Second Kepler Science Conference to allow virtual attendance.
- **Schedule for go forward plan is being developed.** It will include attempted wheel recovery, definition of 2-wheel operations approach, scoping of implementation of 2-wheel operations, assessment of science capabilities under 2-wheel capabilities.





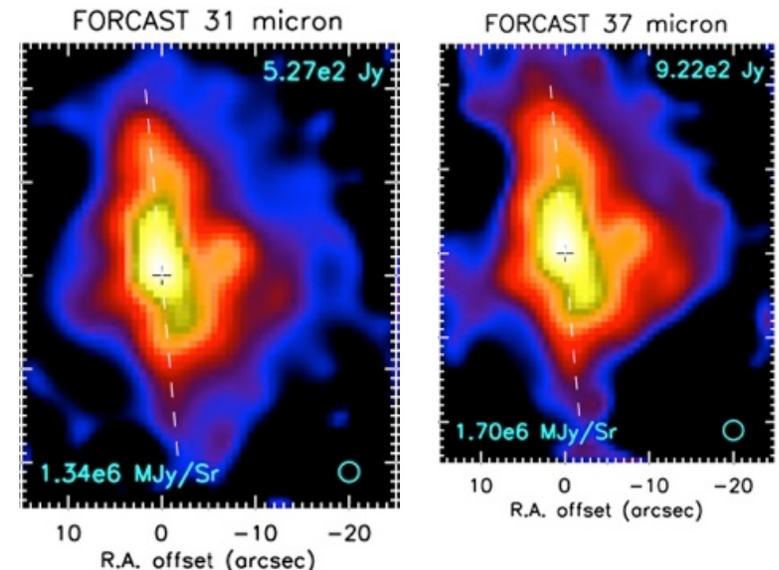
# Program Update – SOFIA

- Commenced Cycle 1 Science during April 11-12 flights with GREAT instrument.
  - Was the 100th SOFIA flight since start of flight testing in 2007.
- Released Cycle 2 Call for Proposals April 29.
  - Proposal due date June 28.
- Completed FORCAST Phase 1 commissioning Apr 3.
  - FORCAST Phase 2 commissioning began May 30.
  - FLITECAM to be commissioned next.
  - GREAT and HIPO already completed.
- Completed System Requirements Review for HAWC+ instrument.
- Southern Hemisphere deployment to New Zealand to occur in July 2013.
- Baseline plan established for 3<sup>rd</sup>-generation instrument call.
  - Release AO July 2014; select instrument by April 2015.



April 11, 2013

SOFIA's 100th flight

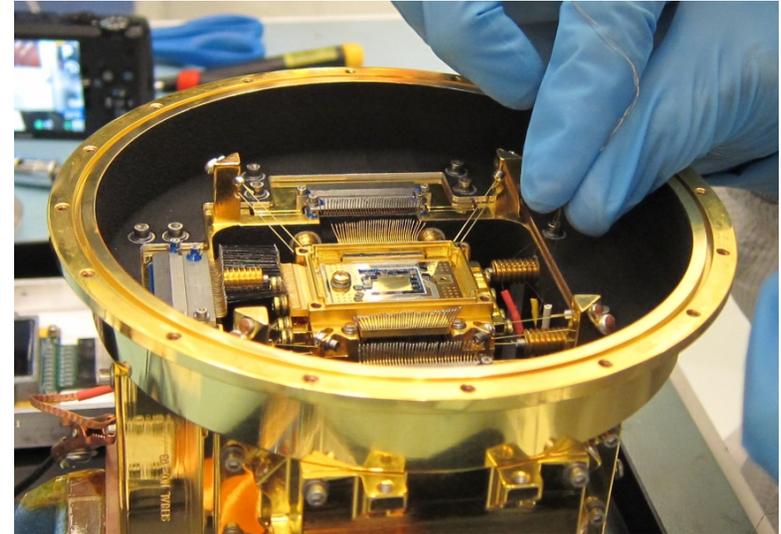


NASA SOFIA Science press release on FORCAST April 17 - images of structure of massive protostar G35

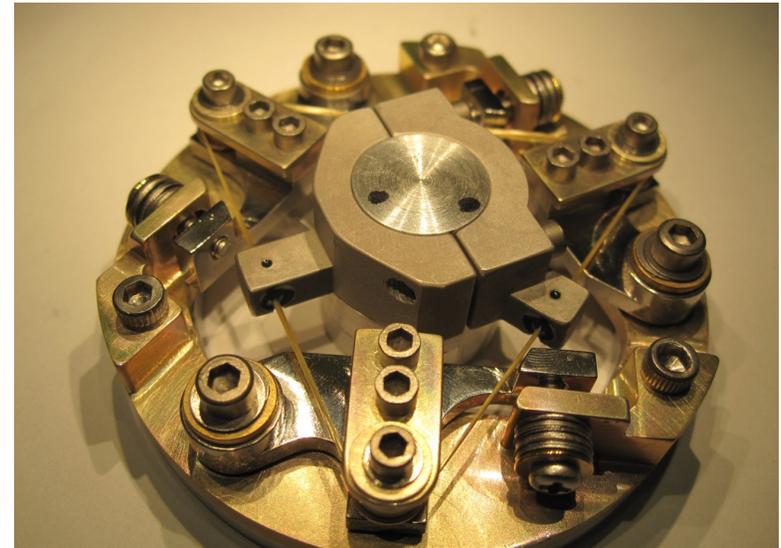


## Program Update - ASTRO-H

- New Launch Readiness Date of 2015 was announced by JAXA (was Feb 2014).
- Flight mirror #1 completed and was shipped to JAXA on March 21.
  - FM X-ray Mirror #2 nearing completion.
- FM spare detector assembly performance tests are complete.
- Unexpectedly large vibrations detected during instrument-level environmental testing (Nov-Dec 2012) which impacts resolution of SXS instrument.
- SXS instrument-to-spacecraft micro-vibration testing was conducted in Japan (March 18-23).
  - Data analysis underway.
- NASA and JAXA working together to resolve.



FM Spare Detector Assembly being prepared for functional testing

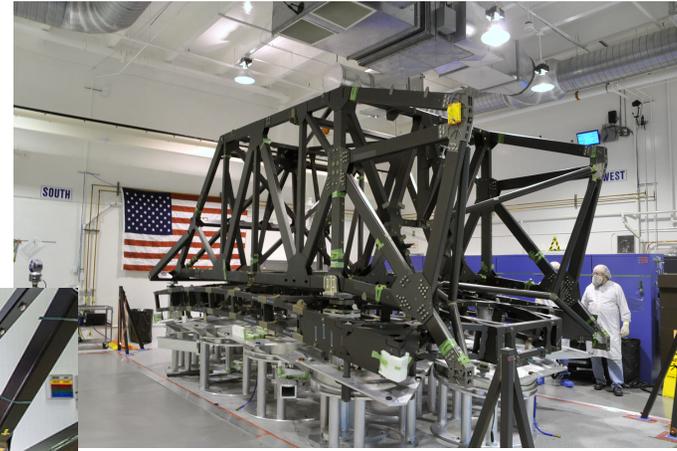
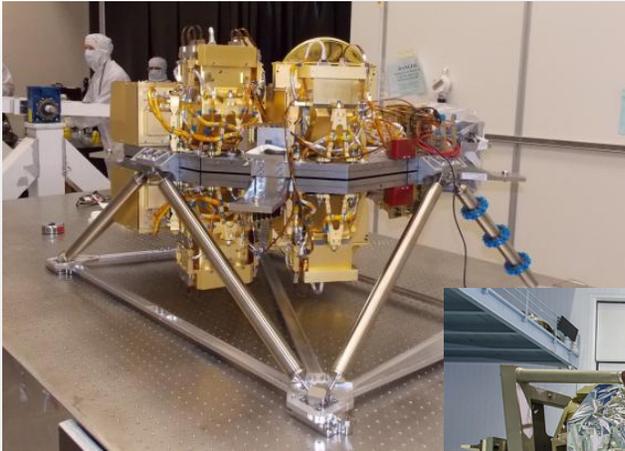


FM ADR Salt Pill Lateral Suspension

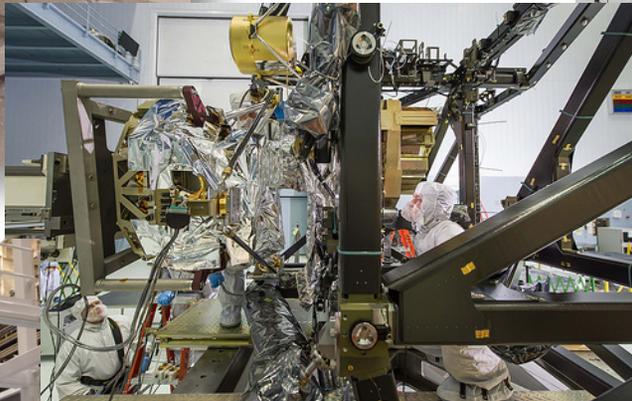


# Program Update - JWST

NIRCam modules mated



Backplane Center Section and Backplane Support Fixture



MIRI and FGS/NIRISS installed in ISIM



Cleanroom construction At JSC continues on schedule



Full-scale Engineering Sunshield Complete



# 2013 NASA Astrophysics Fellows

## Sagan Fellows

<u>Name</u>	<u>Host Institution</u>
Jared Males	Univ of Arizona, Tucson
Katja Poppenhaeager	CfA
Avi Shporer	JPL
Jacob Simon	SWRI
Jennifer Yee	Caltech

## Einstein Fellows

<u>Name</u>	<u>Host Institution</u>
Claude-Andre Faucher Giguere	UC Berkeley
Javiera Guedes	Princeton Univ
James Guillchon	Harvard Univ
Rutger van Haasteren	JPL
Yan-Fei Jiang	SAO
Tim Linden	University of Chicago
Mario Manuel	Univ of Michigan, Ann Arbor
Selma De Mink	Carnegie Observatories
Krzysztof Nalewajko	Univ of Colorado, Boulder
Maria Petropoulou	Purdue University
Luke Roberts	Caltech
Alexander Tchekhovskoy	LBNL

## Hubble Fellows

<u>Name</u>	<u>Host Institution</u>
Rachel Bezanson	Univ of Arizona, Tucson
Francesca DeMeo	Harvard College Observatory
Ruobing Dong	LBNL
Jacqueline Faherty	Carnegie Inst of Washington
Renyu Hu	JPL
Andreas Kuepper	Columbia Univ
Emily Levesque	Univ of Colorado, Boulder
Adam Miller	JPL
Philip Muirhead	Boston Univ
Ondrej Pejcha	Princeton Univ
Joseph Richards	LBNL
Pier-Emmanuel Tremblay	STScI
Jonathan Trump	Penn State Univ
Daniel Weisz	UC Santa Cruz
Jessica Werk	UC Santa Cruz
Zhaohuan Zhu	Princeton Univ
Adi Zitrin	Caltech



# Proposal Selections Since January 2013

Status: June 4, 2013

	Proposal Due Date	Notify Date	Days since received	Number received	Number selected	% selected
Nancy Grace Roman Technology Fellowships	Nov 8	Mar 5	117	12	2	17%
Fermi Guest Investigator Cycle 6	Jan 18	May 16	118	233	50	21%
Kepler Guest Observer Cycle 5	Jan 18	April 15	87	63	25	40%
TCAN with NSF	Feb 14		[110]	101		
Kepler Participating Scientist	Mar 1		[95]	30		
Hubble General Observer Cycle 21	Mar 1		[95]	1097		
Chandra General Observer Cycle 15	Mar 14		[82]	636		
APRA	Mar 22		[74]	182		
SAT	Mar 22		[74]	39		
ADAP	May 17		[18]	274		
Origins of Solar Sys.	May 23		[12]	130		



## Upcoming Proposal Due Dates

<b>Research Announcement</b>	<b>Notice of Intent Due Date</b>	<b>Proposal Due Date</b>
SOFIA General Observer – Cycle 2	N/A	Jun 28, 2013
Astrophysics Theory (ATP)	May 14, 2013	Jul 12, 2013
Spitzer General Observer -- Cycle 10	May 31, 2013	Aug 2, 2013
SWIFT Guest Investigator – Cycle 10	N/A	Sep 26, 2013
Nancy Grace Roman Technology Fellowships in Astrophysics	Sept 06, 2013	Nov 07, 2013
Fermi Guest Investigator – Cycle 7	N/A	Jan 16, 2014
Kepler Guest Observer – Cycle 6	Dec 06, 2013	Jan 16, 2014
Hubble General Observer – Cycle 22		TBD
Chandra General Observer – Cycle 16		TBD
Astrophysics Research and Analysis (APRA)	Jan 24, 2014	Mar 21, 2014
Strategic Astrophysics Technology (SAT)	Jan 24, 2014	Mar 21, 2014

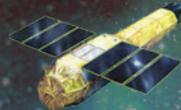
- Formulation
- Implementation
- Primary Ops
- Extended Ops



**XMM-Newton (ESA)**  
12/10/1999



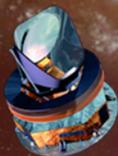
**Swift**  
11/20/2004



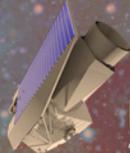
**Suzaku (JAXA)**  
7/10/2005



**Fermi**  
6/11/2008



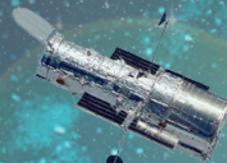
**Planck (ESA)**  
5/14/2009



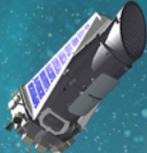
**Euclid (ESA)**  
2020



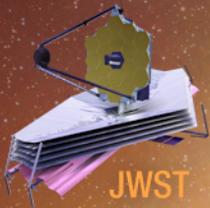
**Spitzer**  
8/25/2003



**Hubble**  
4/24/1990



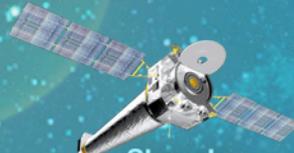
**Kepler**  
3/6/2009



**JWST**  
2018



**Astro-H (JAXA)**  
2015

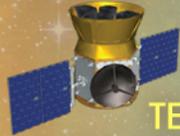


**Chandra**  
7/23/1999

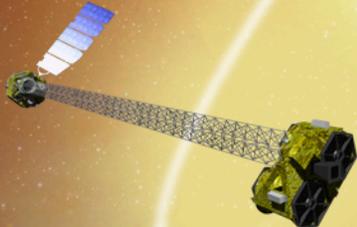


**NICER (on ISS)**  
2016

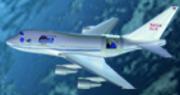
**NuSTAR**  
6/13/2012



**TESS**  
2017



**LISA Pathfinder (ESA)**  
2015



**SOFIA**  
Full Ops 2014

# FY14 President's Budget Request

Recently Completed  
Herschel 2013  
GALEX 2013



# 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 FY14 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.
- Budget does not support selections for the 2012 Astrophysics Explorer Mission of Opportunity AO.
- Additional information on Fermi and Explorer in later charts.

## **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.



# FY14 Budget Request for Astrophysics

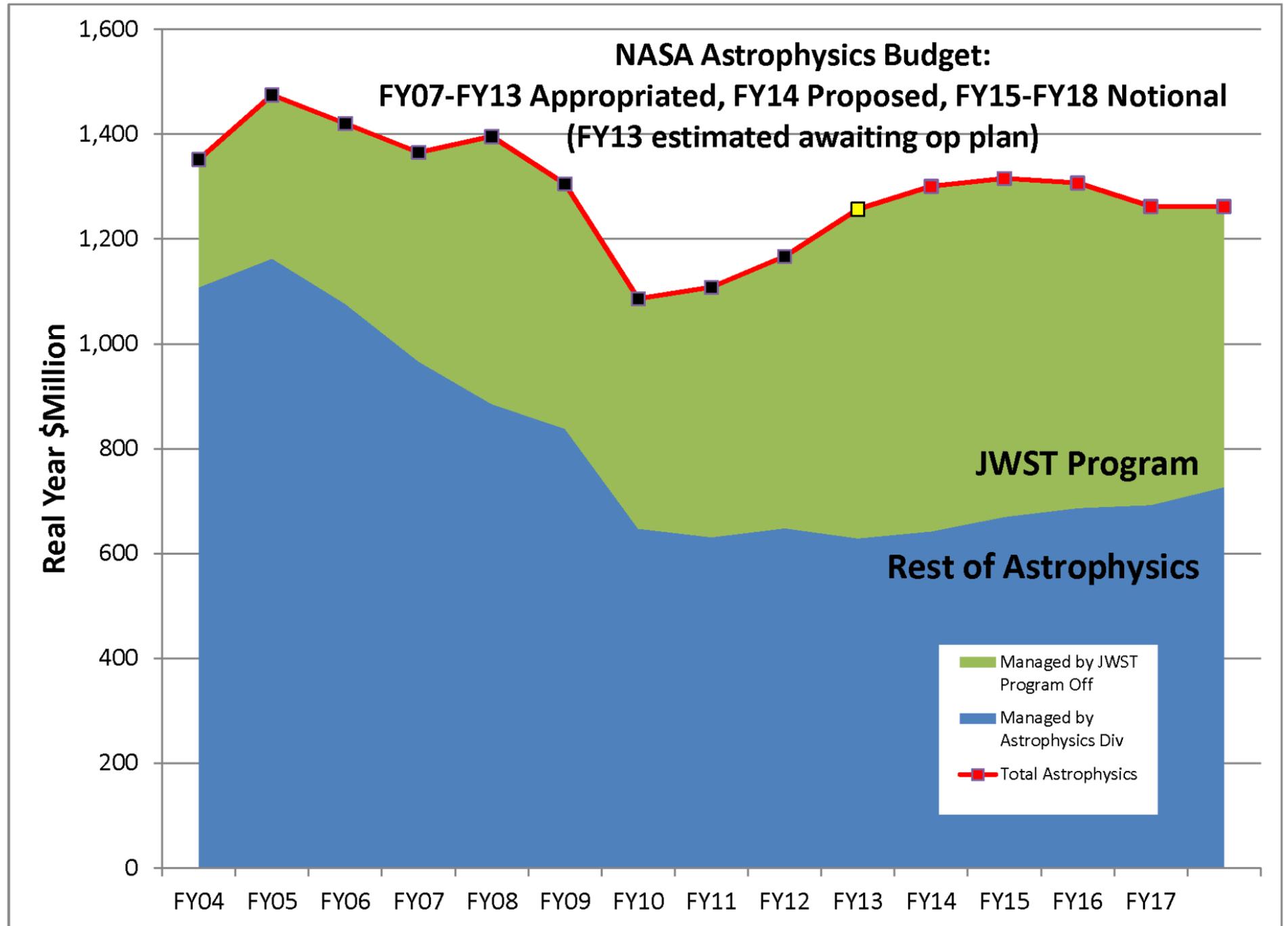
- **Reduction in Fermi Budget**

- 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, funding of accepted Cycle 7 proposals to the Fermi Guest Observers program will be deferred until early FY15.
- NASA is working with DOE and its international partners on Fermi to make the necessary changes in Fermi operations.



# FY14 Budget Request for Astrophysics

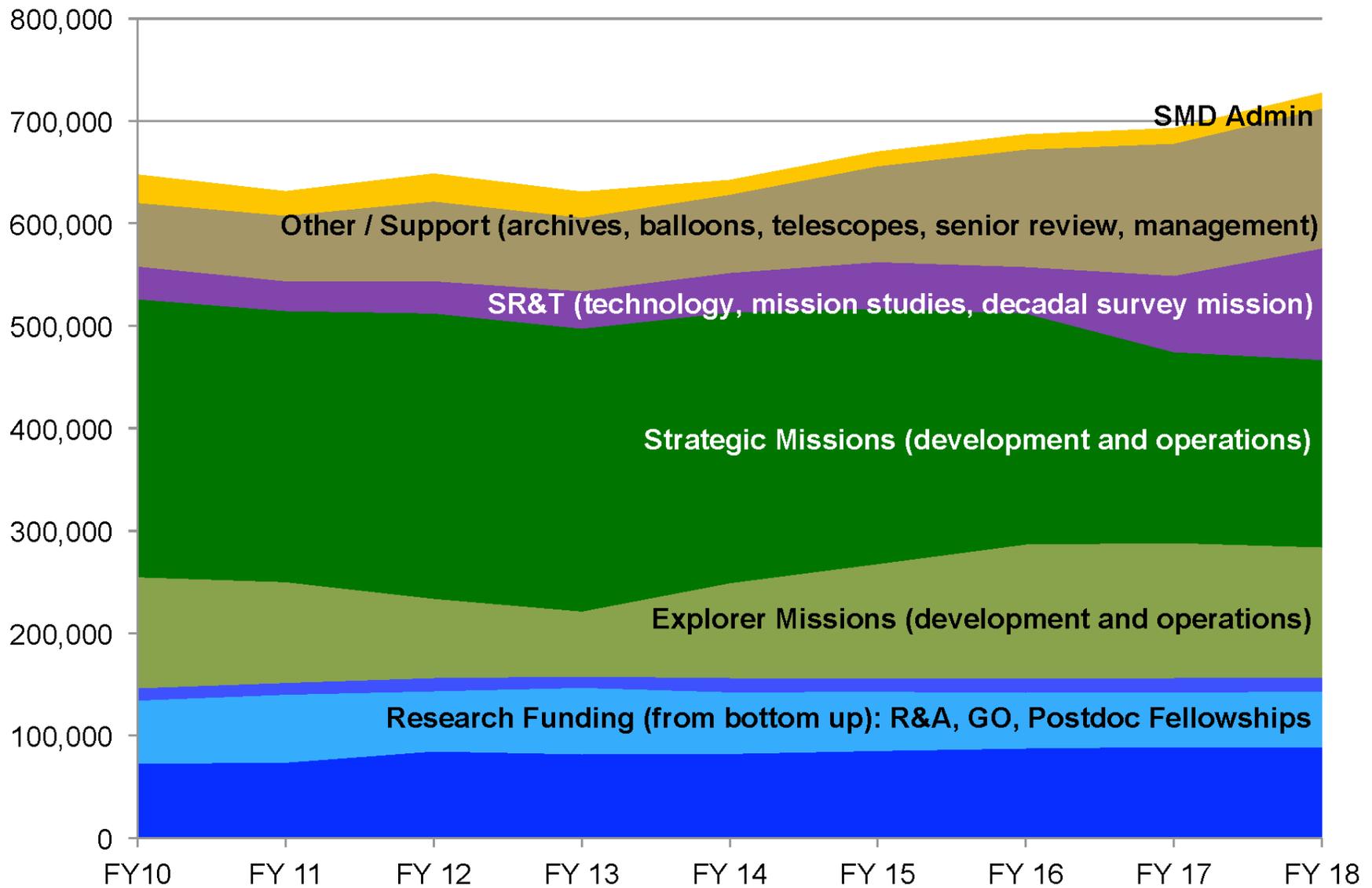
- **Reduction in Astrophysics Explorer Budget**
  - The Astrophysics Explorer Program continues to support missions in development and missions in operation. We continue to implement a science rich program including the recent selections of TESS and NICER.
  - The pace of how we implement the program, 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.
  - The next Astrophysics Explorer AO is for SMEX + Mission of Opportunity. The AO is anticipated for 2014 or 2015, depends on available budget. A formal announcement regarding the next Astrophysics Explorer AO is planned for late summer 2013.





# Astrophysics Balance (w/out JWST)

Astrophysics Budget (w/out JWST) in \$K  
FY10-FY12 Actuals; FY13 Estimate; FY14 Request; FY15-FY18 Notional





# Science Budget Request Summary

	FY2012	* FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
<b>Science Total</b>	<b>5073.7</b>	<b>5115.9</b>	<b>5017.8</b>	<b>5017.8</b>	<b>5017.8</b>	<b>5017.8</b>	<b>5017.8</b>
<b><u>Earth Science</u></b>	<b><u>1760.5</u></b>		<b><u>1846.1</u></b>	<b><u>1854.6</u></b>	<b><u>1848.9</u></b>	<b><u>1836.9</u></b>	<b><u>1838.1</u></b>
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
<b><u>Planetary Science</u></b>	<b><u>1501.4</u></b>		<b><u>1217.5</u></b>	<b><u>1214.8</u></b>	<b><u>1225.3</u></b>	<b><u>1254.5</u></b>	<b><u>1253.0</u></b>
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
<b><u>Astrophysics</u></b>	<b><u>648.4</u></b>		<b><u>642.3</u></b>	<b><u>670.0</u></b>	<b><u>686.8</u></b>	<b><u>692.7</u></b>	<b><u>727.1</u></b>
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
<b><u>James Webb Space Telescope</u></b>	<b><u>518.6</u></b>		<b><u>658.2</u></b>	<b><u>645.4</u></b>	<b><u>620.0</u></b>	<b><u>569.4</u></b>	<b><u>534.9</u></b>
<b><u>Heliophysics</u></b>	<b><u>644.8</u></b>		<b><u>653.7</u></b>	<b><u>633.1</u></b>	<b><u>636.8</u></b>	<b><u>664.3</u></b>	<b><u>664.6</u></b>
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



# Astrophysics Program Content

	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
				<i>(FY15-18 estimates are notional)</i>			
<b>Astrophysics</b>	<b>648.4</b>		<b>642.3</b>	<b>670.0</b>	<b>686.8</b>	<b>692.7</b>	<b>727.1</b>
<u>Astrophysics Research</u>	<u>165.5</u>		<u>147.6</u>	<u>170.6</u>	<u>192.3</u>	<u>207.2</u>	<u>218.5</u>
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
<u>Other Missions and Data Analysis</u>	<u>65.3</u>		<u>49.1</u>	<u>69.4</u>	<u>87.9</u>	<u>101.3</u>	<u>112.7</u>
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
<u>Cosmic Origins</u>	<u>239.9</u>		<u>228.0</u>	<u>216.5</u>	<u>193.1</u>	<u>196.7</u>	<u>194.1</u>
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
<u>Other Missions And Data Analysis</u>	<u>57.4</u>		<u>44.3</u>	<u>36.9</u>	<u>19.7</u>	<u>23.4</u>	<u>24.0</u>
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
				<i>(FY15-18 estimates are notional)</i>			
<u>Physics of the Cosmos</u>	<u>108.3</u>		<u>110.4</u>	<u>107.5</u>	<u>100.0</u>	<u>82.8</u>	<u>86.4</u>
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
<u>Exoplanet Exploration</u>	<u>50.8</u>		<u>55.4</u>	<u>59.4</u>	<u>57.7</u>	<u>60.7</u>	<u>90.7</u>
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

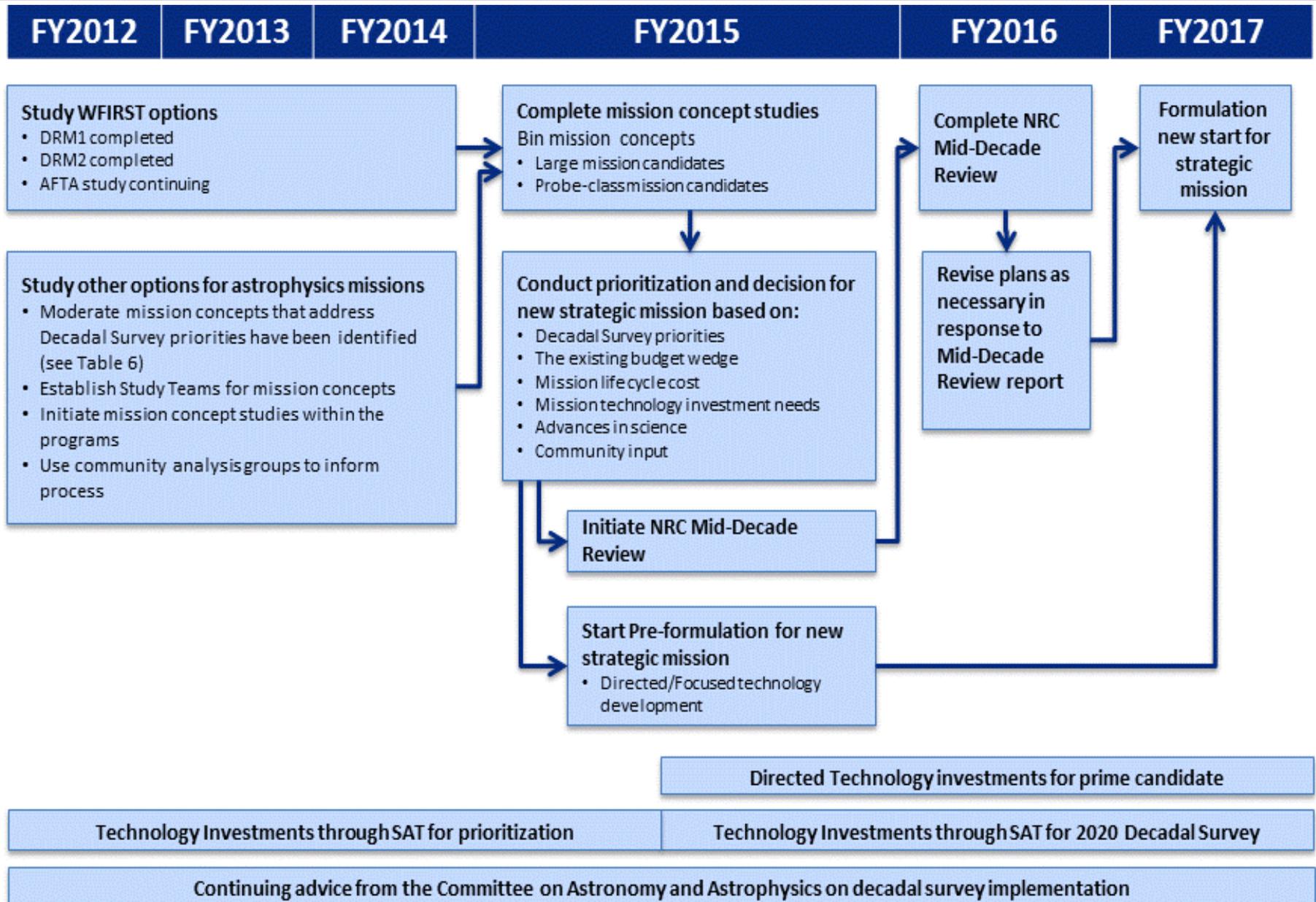


# Astrophysics Program Content (cont'd)

	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018
				<i>(FY15-18 estimates are notional)</i>			
<u>Astrophysics Explorer</u>	<u>83.9</u>		<u>100.9</u>	<u>116.0</u>	<u>143.8</u>	<u>145.3</u>	<u>137.4</u>
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 Anisotropy 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

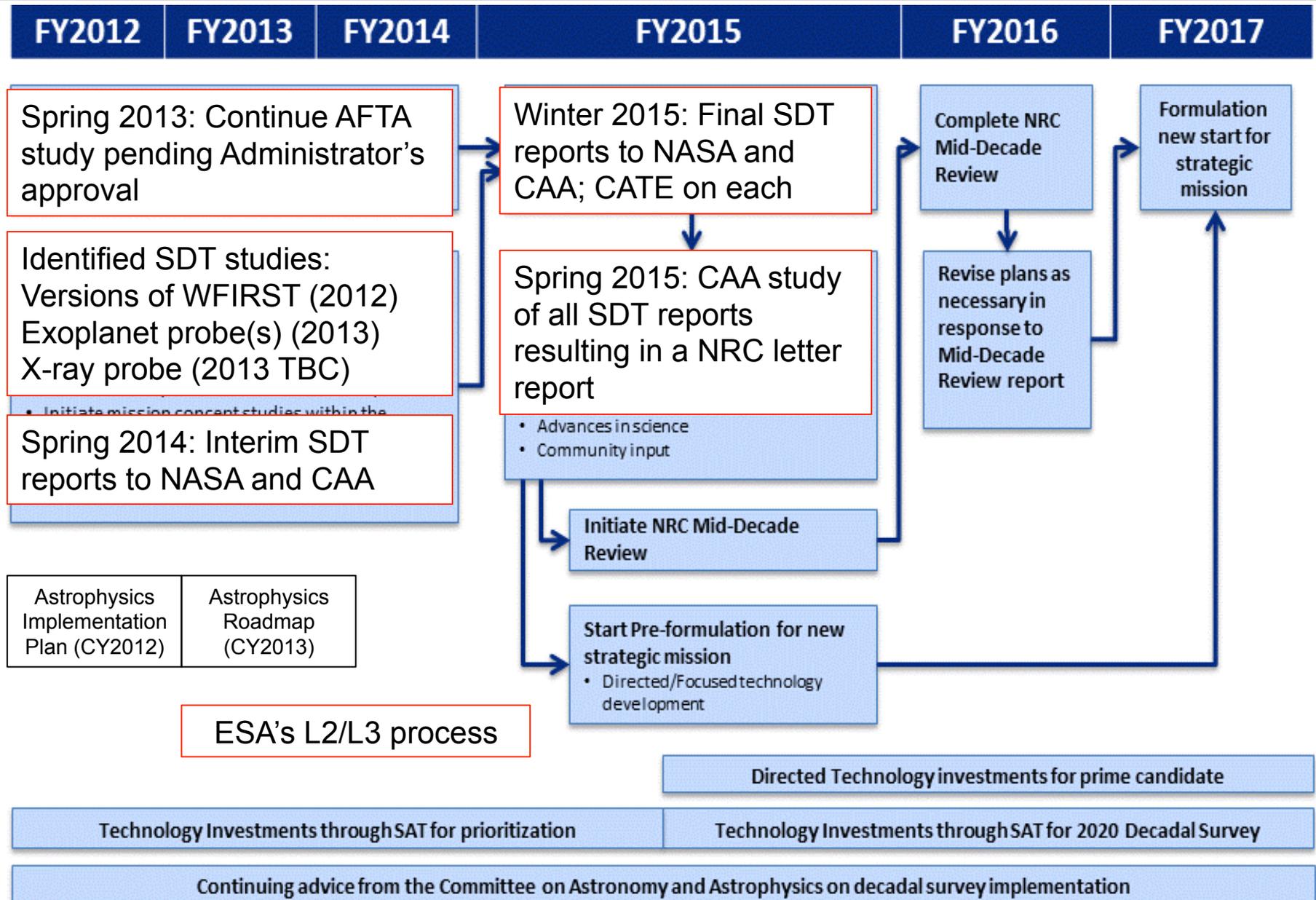


# Astrophysics Near-term Strategy





# Astrophysics Near-term Strategy





# Astro2010 Decadal Report Status - Response

Program Scale	Recommendation	Current Response FY14
Large	<b>WFIRST</b>	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	<b>Explorer</b> 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	<b>LISA</b> 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	<b>IXO</b> 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	<b>New Worlds Technology</b>	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	<b>Inflation Probe Technology</b>	Technology supported through APRA including multiple suborbital payloads; will consider partnership with ESA if a CMB mission is selected for L2/L3 mission
Small	<b>Astrophysics Theory Program</b> Augmentation	Impacted by budget reductions
Small	(Definition of) a <b>future UV-optical space capability</b>	RFI in FY12; technology supported through APRA, SAT, and working with STMD
Small	<b>Intermediate Technology Development</b> Augmentation	SAT program initiated and funded for prioritized investments
Small	<b>Laboratory Astrophysics</b> Augmentation	Augmentation started in FY12 including selection of large consortium; impacted by budget reductions
Small	<b>SPICA</b> mission (U.S. contributions to JAXA-led)	Candidate for future Explorer Mission of Opportunity
Small	<b>Suborbital Program</b> Augmentation	Technology augmentation for balloon program; continued development of ULDB balloon platforms; ISS payload selections; future is impacted by budget reductions
Small	<b>Theory and Computation Networks</b> (NASA, NSF, DOE)	First NASA-NSF call in 2013 for FY14 funding
N/A	<b>Additional core program augmentations</b>	Impacted by budget reductions



# Astrophysics Roadmap

- Community abstracts received on March 25
- 1<sup>st</sup> face-to-face meeting at Goddard March 27-28
- Virtual Town Hall held May 6-7
  - 36 abstracts chosen for presentation
  - ~ 100 people connected to participate both days
- Community input: abstracts on science and technology challenges submitted by community
  - The abstracts (all the ones that the authors allowed to be made public; this is nearly all of them) are available at: <https://scienceworks.hq.nasa.gov/web/astrophysics-roadmap/abstracts>
  - Town hall presentation are available at: <https://scienceworks.hq.nasa.gov/web/astrophysics-roadmap/home>
- 2<sup>nd</sup> face-to-face meeting at JPL June 10-11
- July 16-17 Astrophysics Subcommittee meeting
  - Roadmap chair will present themes to APS for discussion and approval
- September – November: report writing, submit to Astrophysics Subcommittee
- December: report release



# Community Participation

## PhysPAG

- Executive Cmte: 7 members
- SAGs: 5 Active
- Chair: John Nousek
- Website: <http://pcos.gsfc.nasa.gov/physpag>

## COPAG

- Executive Cmte: 9 members
- SAGs: 5 Active
- Chair: In progress
- Website: <http://cor.gsfc.nasa.gov/copag>

## ExoPAG

- Executive Cmte: 10 members
- SAGs: 3 Active
- Chair: Scott Gaudi
- Website: <http://exep.jpl.nasa.gov/exopag>

## Science and Technology Definition Teams (STDTs) in Progress:

- AFTA use of telescope assets: 20 members
- Exoplanet Probe w/ Internal Coronagraph: 10 members
- Exoplanet Probe w/ External Occulter: 10 members
- X-ray Probe: To be formed later in 2013

Preliminary reports from the studies are due Spring 2014

Final reports from the studies are due in January 2015.

## Advisory Committees (and next meetings):

- NRC Committee on Astronomy and Astrophysics (CAA): TBD
- NASA Advisory Council's Astrophysics Subcommittee (APS): July 16-17
- Astronomy and Astrophysics Advisory Committee (AAAC): Nov 13-14

# Astrophysics Missions timeline

Last updated: April 15, 2013

