National Aeronautics and Space Administration

NASA Astrophysics Program Update

Astrophysics

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Astrophysics Subcommittee
November 14, 2014

www.nasa.gov

M82X-2: Suspected Black Hole Unmasked as Ultraluminous Pulsar by NuSTAR

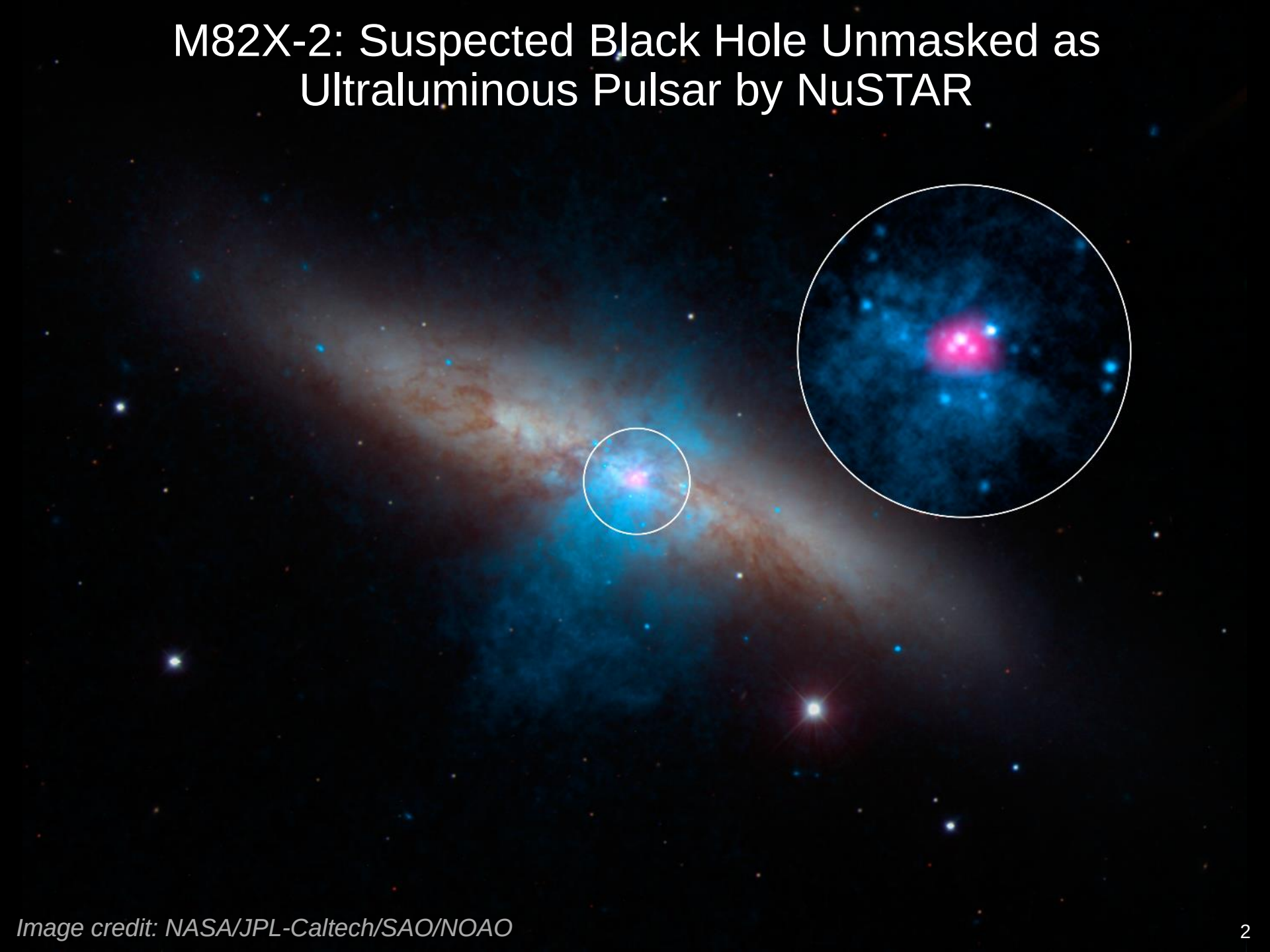
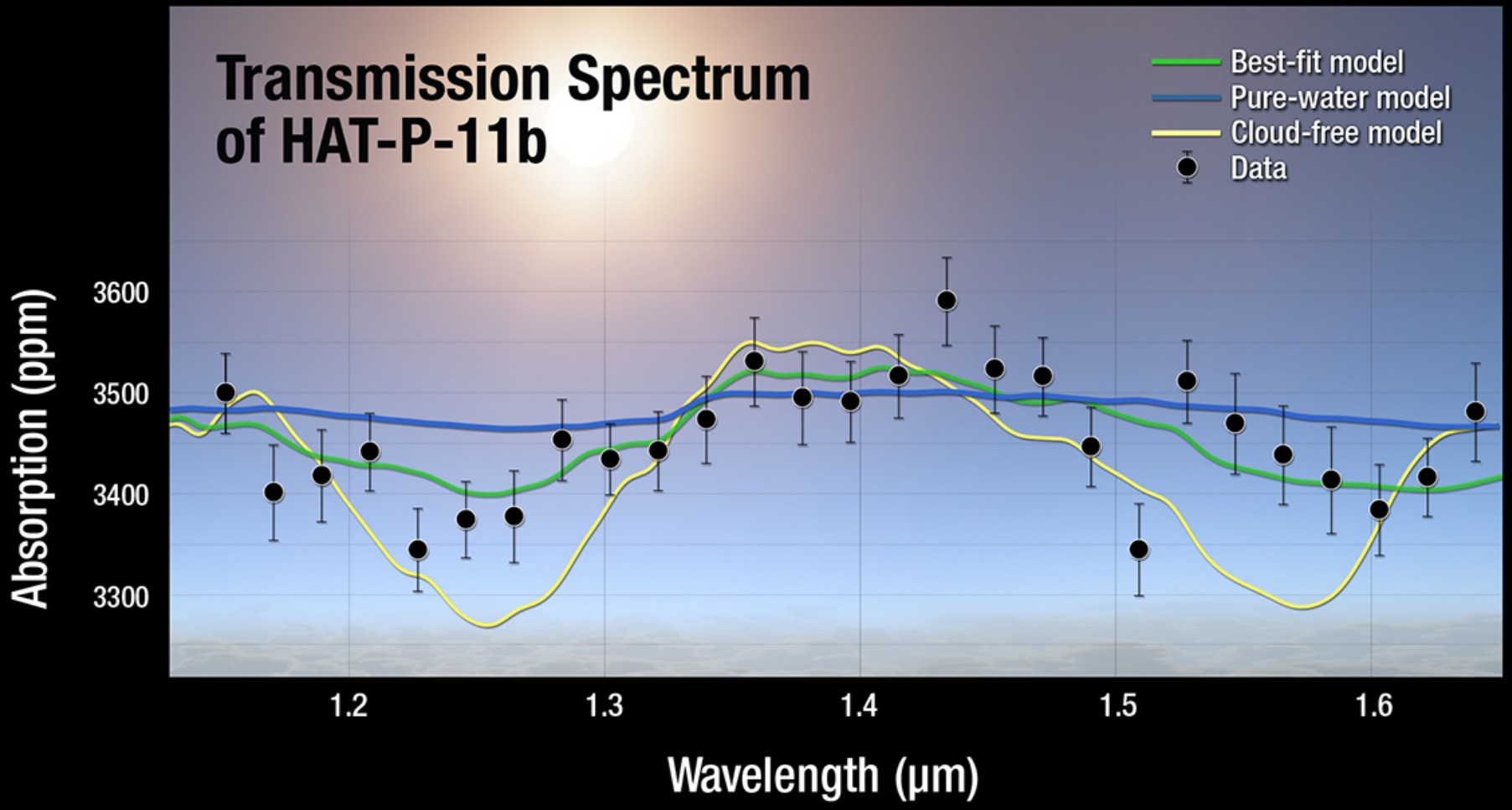


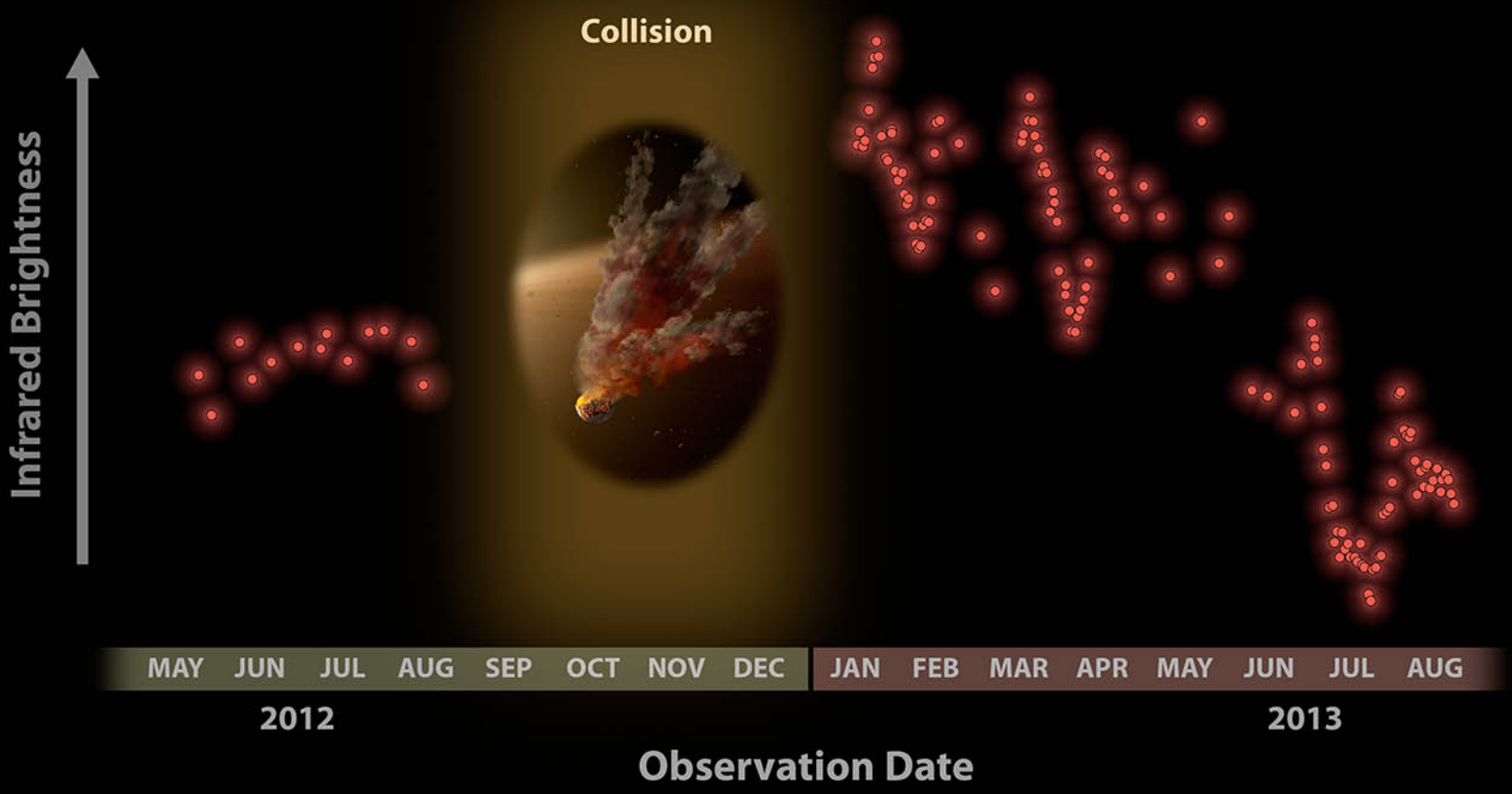
Image credit: NASA/JPL-Caltech/SAO/NOAO

Hubble, Spitzer and Kepler Telescopes Find Clear Skies and Water Vapor on Exo-Neptune



Credit: NASA, ESA, and A. Feild (STScI)

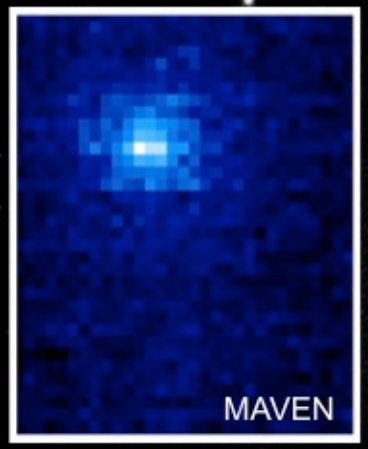
NASA's Spitzer Telescope Witnesses Asteroid Smashup



Infrared Detection of an Asteroid Smash-Up
NASA / JPL-Caltech / H. Y. A. Meng (Univ. of Arizona)

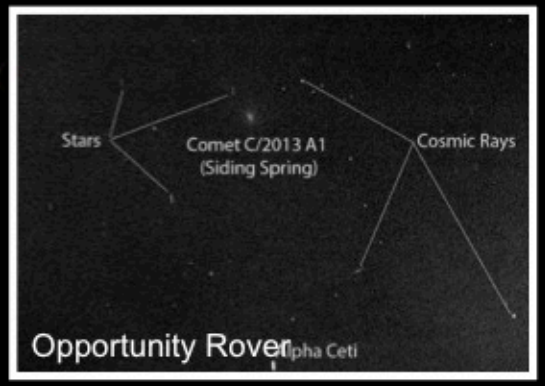
Spitzer Space Telescope • IRAC
ssc2014-06b

First Released Images of Comet Siding Spring from NASA's Mars and Space Assets



Hubble Space Telescope
Composite Image

Mars Reconnaissance
Orbiter - HiRISE



Comet C/2013 A1 Siding Spring made a close approach to Mars on October 19, 2014.

NASA Mars spacecraft took advantage of a unique and unexpected science opportunity for close study of a visitor from the edge of the solar system, along with possible effects on Mars' atmosphere.

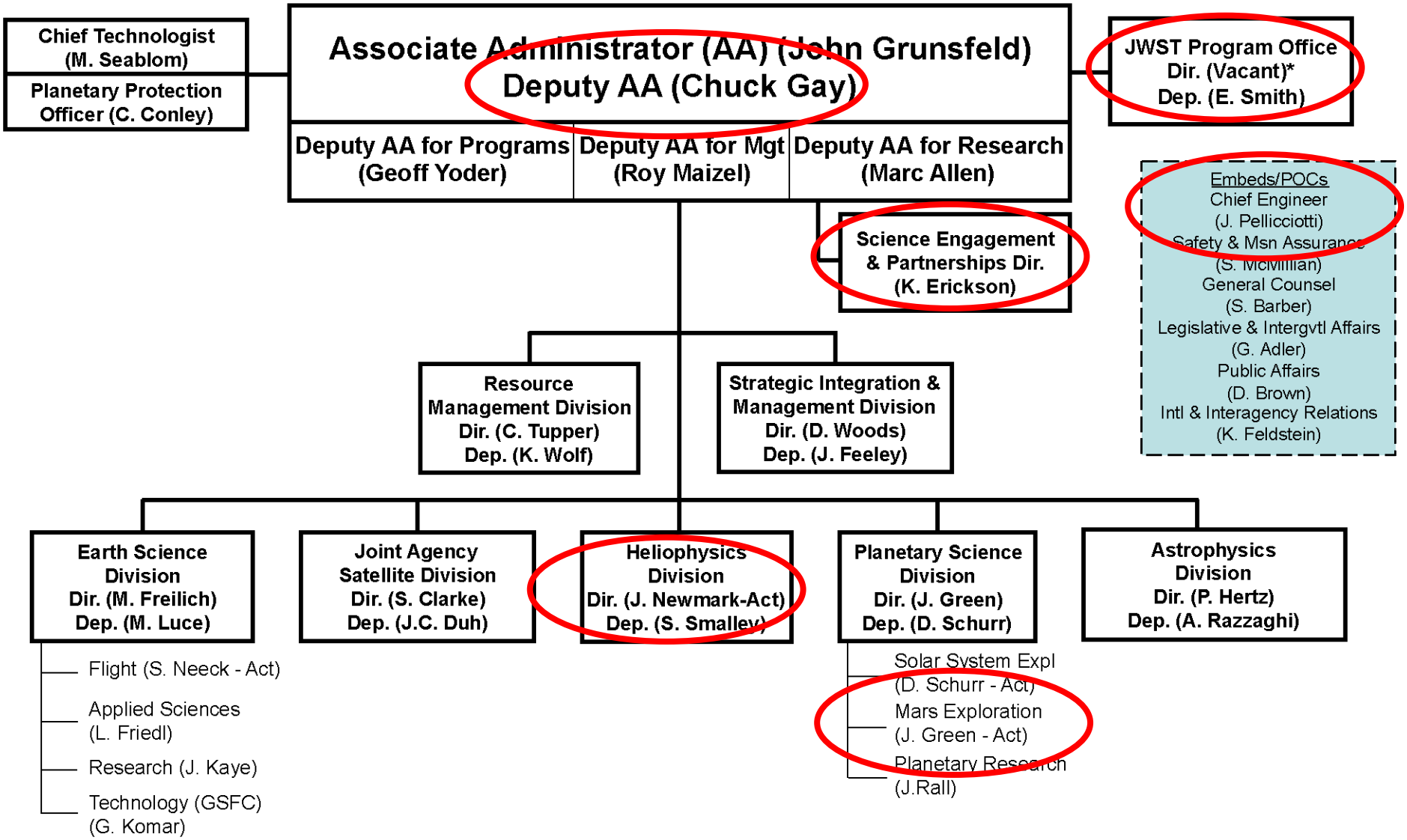
Early results probe the size and properties of the comet's nucleus and the properties of dust and gas in the comet's coma. Comet material also blanketed most of the northern hemisphere of Mars.

NASA space observatories that orbit the Earth also observed the comet and Mars during the close encounter.

Recent NASA Astrophysics HQ Announcements

- NASA Hubble to Begin Search Beyond Pluto for a New Horizons Mission Target (June 16)
- Swiftly Moving Gas Streamer Eclipses Supermassive Black Hole (June 19)
- Hubble Finds Dwarf Galaxies Formed More Than Their Fair Share of Universe's Stars (June 19)
- Testing Completed on NASA's James Webb Space Telescope Backplane (July 8)
- Hubble Spots Spiral Bridge of Young Stars Linking Two Ancient Galaxies (July 10)
- Leading Space Experts to Discuss the Search for Life Beyond Earth (July 10)
- NASA's Chandra X-ray Observatory Celebrates 15th Anniversary (July 22)
- Hubble Finds Three Surprisingly Dry Exoplanets (July 24)
- NASA's Fermi Space Telescope Reveals New Source of Gamma Rays (July 31)
- Hubble Shows Farthest Lensing Galaxy Yields Clues to Early Universe (July 31)
- NASA's Hubble Finds Supernova Star System Linked to Potential "Zombie Star" (August 6)
- NASA's NuSTAR Sees Rare Blurring of Black Hole Light (August 12)
- NASA's Chandra Observatory Searches for Trigger of Nearby Supernova (August 14)
- NASA's RXTE Satellite Decodes the Rhythm of an Unusual Black Hole (August 18)
- NASA Telescopes Uncover Early Construction of Giant Galaxy (August 27)
- NASA's Spitzer Telescope Witnesses Asteroid Smashup (August 28)
- Hubble Finds Supernova Companion Star After Two Decades of Searching (September 9)
- NASA's Chandra Finds Planet that Makes Star Act Deceptively Old (September 16)
- Hubble Helps Find Smallest Known Galaxy Containing a Supermassive Black Hole (September 17)
- NASA Telescopes Find Clear Skies and Water Vapor on Exoplanet (September 24)
- NuSTAR Telescope Discovers Shockingly Bright Dead Star (October 8)
- Hubble Maps Temperature and Water Vapor on Extreme Exoplanet (October 9)
- Hubble Finds Potential Jupiter Belt Targets for New Horizons (October 15)
- Hubble Finds Extremely Distant Galaxy Through Cosmic Magnifying Glass (October 16)
- Close Encounters: Comet Siding Spring Seen Next to Mars (October 23)
- NASA'S Chandra Observatory Identifies Impact of Cosmic Chaos on Star Birth (October 27)

SMD Organization



* Direct report to NASA Associate Administrator

October 2014

Astrophysics Staffing Changes

- Martin Still (BAERI) started a 2-year IPA assignment in October 2014.
- Keith Chamberlin (GSFC) started a 1-year detail assignment in October 2014.
- Linda Sparke starting a 1-year detail assignment to MSFC in December 2014.
- Advertised for a HQ civil servant program scientist new hire.

The Big Picture

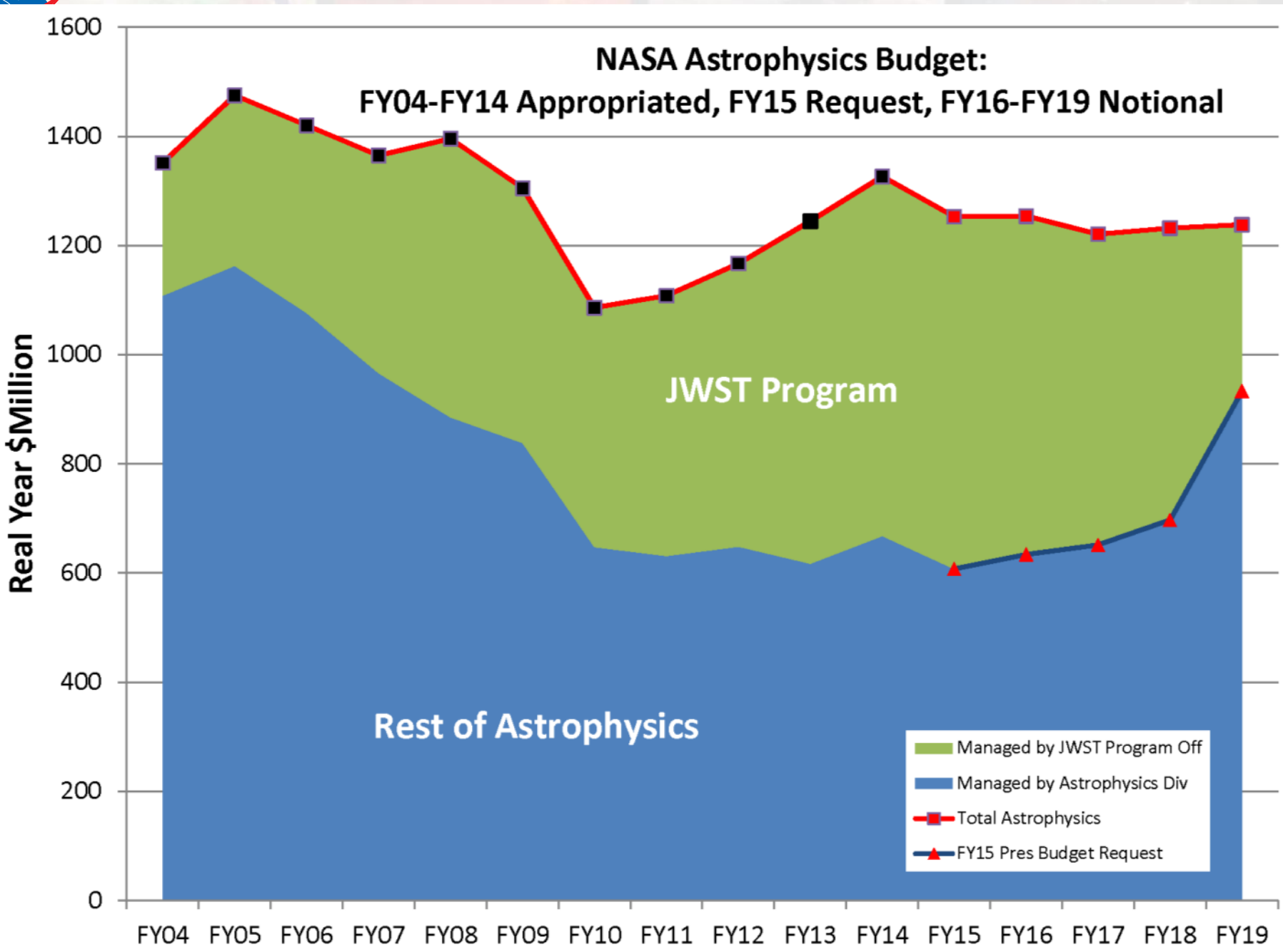
- We are addressing decadal priorities within budget constraints.
  - The budget for NASA astrophysics, which includes JWST, continues at $1.33B in FY14; the President has requested $1.25B in FY15 (the difference is mostly due to deletion of SOFIA from FY15 budget request).
  - JWST, the highest priority of the community, is making progress, remains on schedule, and is fully funded for an October 2018 launch.
  - NASA is preparing for a strategic Astrophysics mission to follow JWST as soon as funding becomes available. Preformulation of WFIRST/AFTA was funded in FY14 appropriation and is included in FY15 budget request.
  - SOFIA has completed development and has entered its operations phase.
  - NASA is developing new Explorer missions (NICER, TESS) and contributions to our international partners (LPF, ASTRO-H, Euclid).
  - NASA is discussing contributions to ESA's Athena and L3 GW observatory.
  - NASA is planning a robust Astrophysics Explorers Program with a SMEX AO in late CY2014 and an EX AO in ~FY2017.
  - Following the 2014 Senior Review, NASA plans to continue operating all currently operating missions, including Spitzer.
  - NASA continues to support individual investigators for data analysis, theory, and technology investigations through open, competitive, peer reviews.
- The budgetary future remains uncertain.
  - Priorities must be used to guide difficult budget choices.
  - The FY2015 budget request represents a ~10% decrease for the Astrophysics Division in FY15; the cost of operating SOFIA can not be accommodated within this reduced budget.

FY15 President's Budget Request

Outyears are notional

($M)	2013	2014	2015	2016	2017	2018	2019
Astrophysics	$617	$668	$607	$634	$651	$697	$993
JWST	$627	$658	$645	$620	$569	$535	$305

- **Supports pre-formulation of WFIRST/AFTA**, including technology development for detectors and coronagraph.
- Supports a growing Astrophysics Explorer program with continued development of ASTRO-H, NICER, and TESS, and initiation of the next Small Explorer mission.
- Supports operating missions: Hubble, Chandra, and other missions rated highly by the 2014 Senior Review.
- Continues a competed astrophysics research program and support of the balloon program.
- Seeks to work with current partner Germany and potential partners to identify a path forward for SOFIA with greatly reduced NASA funding. Unless partners are able to support the U.S. portion of SOFIA costs, **NASA will place the aircraft into storage by FY 2015**.
- **Supports the commitment to an October 2018 launch date for JWST**. Continues manufacturing of the flight sunshield structure and membranes. Completes and delivers the flight cryogenic cooler tower assembly. Delivers the Optical Telescope Element flight structure. Initiates integration of the 18 flight primary mirror segments. Conducts the final Integrated Science Instrument Module level cryo-vacuum test.

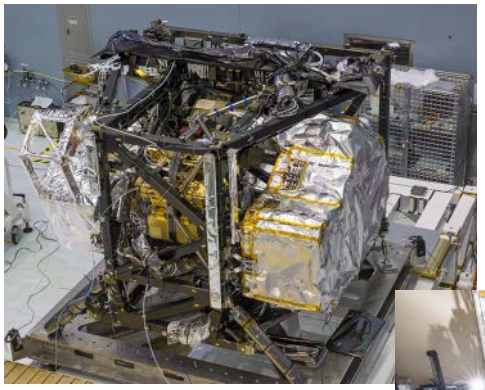

NASA Astrophysics Budget:
FY04-FY14 Appropriated, FY15 Request, FY16-FY19 Notional
Real Year $Million
1600
1400
1200
1000
800
600
400
200
0
JWST Program
Rest of Astrophysics
Managed by JWST Program Off
Managed by Astrophysics Div
Total Astrophysics
FY15 Pres Budget Request
FY04
FY05
FY06
FY07
FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
FY16
FY17
FY18
FY19

FY15 Budget Appropriation Status

- Administration request is $607M for Astrophysics and $645M for JWST.
- House appropriations bill and report includes:
  - Recommendation is $680M for Astrophysics (an increase of $73M) and $645M for JWST
  - Restores $5M reduction in Hubble operations
  - Rejects SOFIA termination; appropriates $70M (an increase of $58M) for SOFIA operations
  - Provides $30M (an increase of $15M) for EPO
- Senate appropriations committee markup and report includes:
  - Recommendation is $750M for Astrophysics (an increase of $143M) and $645M for JWST
  - Restores $23M reduction in Hubble operations
  - Provides $56M for WFIRST (an increase of $42M)
  - Rejects SOFIA termination; appropriates $87M (an increase of $75M) for SOFIA operations
  - Provides $42M (an increase of $27M) for EPO
- Continuing Resolution through December 11, 2014, funds the first 10 weeks of FY15 at the same levels as FY14.

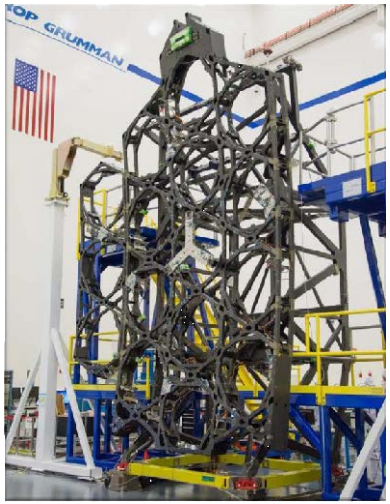
JWST Progress

- ISIM completed very successful 116 day cryovacuum test #2.
- First of 5 flight sunshields completed, two others being manufactured, 5 engineering sunshields successfully completed deployment testing.
- Spacecraft bus under construction.
- Pathfinder backplane has optics installed undergoing final assembly before 2015 testing at JSC.
- Program remains on track and within budget for October 2018 launch.

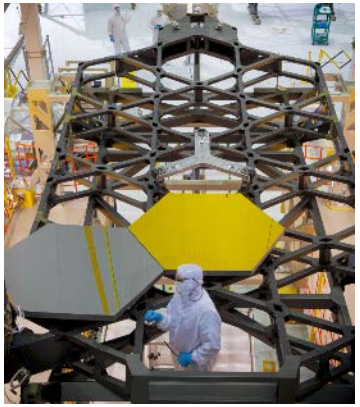


ISIM with all instruments

5 engineering sunshields deployed



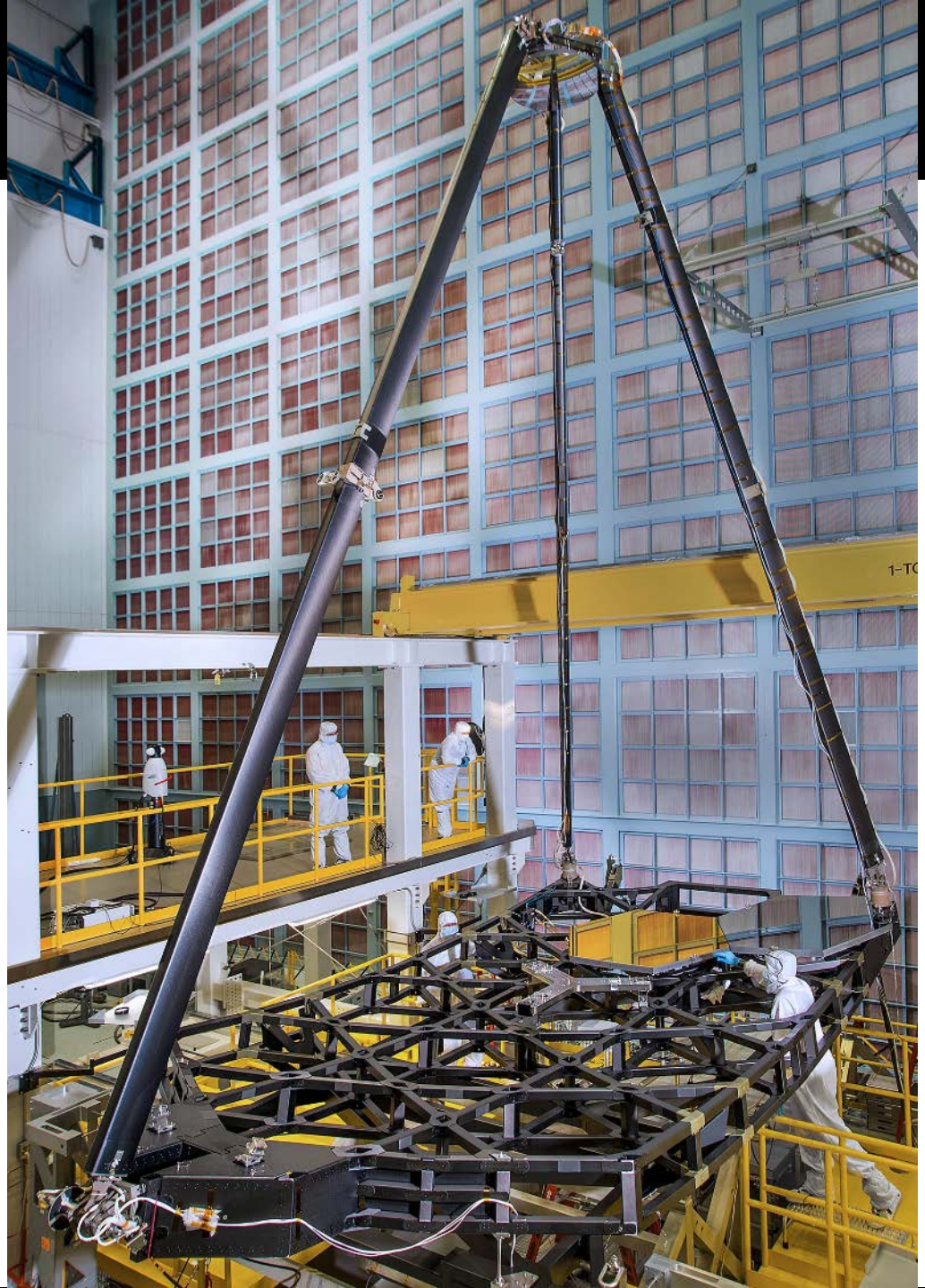
Flight telescope backplane & with one wing installed



Pathfinder (backplane center section with secondary mirror structure)

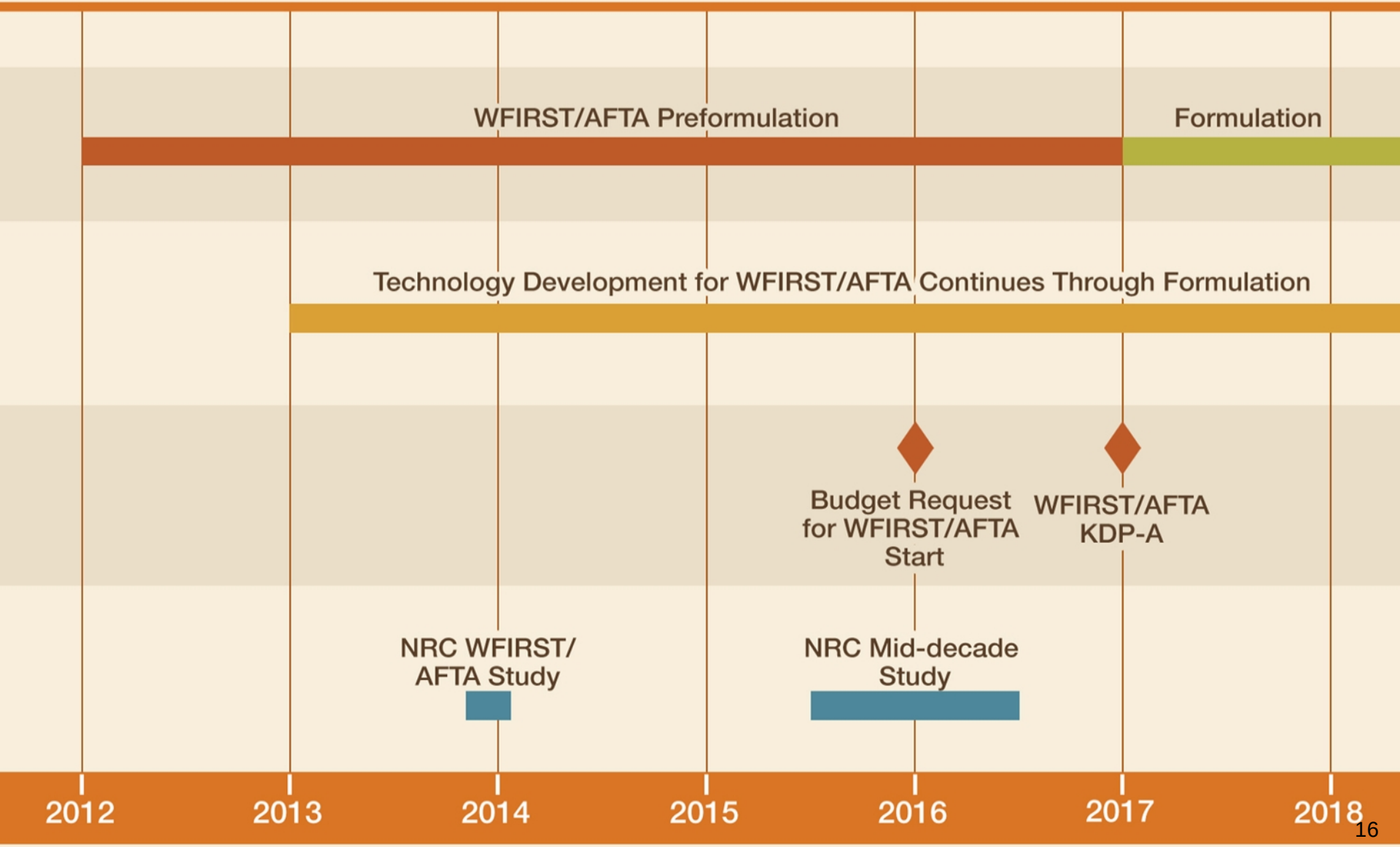
http://jwst.nasa.gov/

JWST Flight Sunshield Layer 3



Plan for WFIRST/AFTA Preformulation

Widefield Infrared Survey Telescope using Astrophysics Focused Telescope Assets



WFIRST / AFTA

Widefield Infrared Survey Telescope with Astrophysics Focused Telescope Assets

- FY14 appropriation ($56M) supports pre-formulation of WFIRST/AFTA, including technology development for detectors and coronagraph (with STMD).
- FY15 request ($14M) supports Agency/Administration decision for formulation to begin NET FY 2017, should funding be available.

- Recent NRC study on WFIRST/AFTA offers positive view of AFTA, with concerns about technology and cost risks.
- WFIRST Preparatory Science (WPS) is ROSES element that are relevant to WFIRST's goals and WFIRST-specific simulations and models.
  - Anticipate selecting ~12 proposals, total $1.8M in first year, by end of CY14.

http://wfirst.gsfc.nasa.gov/

CURRENT STATUS:

- May 2013, NASA Administrator Bolden directed study of WFIRST/AFTA and preserve option for FY17 new start if budget is available.
  - No decision expected before early 2016.
- Currently in pre-formulation phase.
  - AFTA endorsed by NRC study report released March 2014.
  - Interim SDT report posted April 30, 2014
  - SDT final report due Jan 2015.
- Maturing key technologies to TRL 5 by FY17 and TRL 6 by FY19.
  - H4RG infrared detectors for widefield imager.
  - Internal coronagraph for exoplanet characterization (two architectures identified December 2013; occulting mask coronagraph and phased induced amplitude apodization complex mask coronagraph).
- FY14 Appropriation and FY15 Request support technology development and assessment of the 2.4m telescopes, mission design trades, payload accommodation studies, and observatory performance simulations.

SOFIA Docked at Lufthansa (1 of 3)

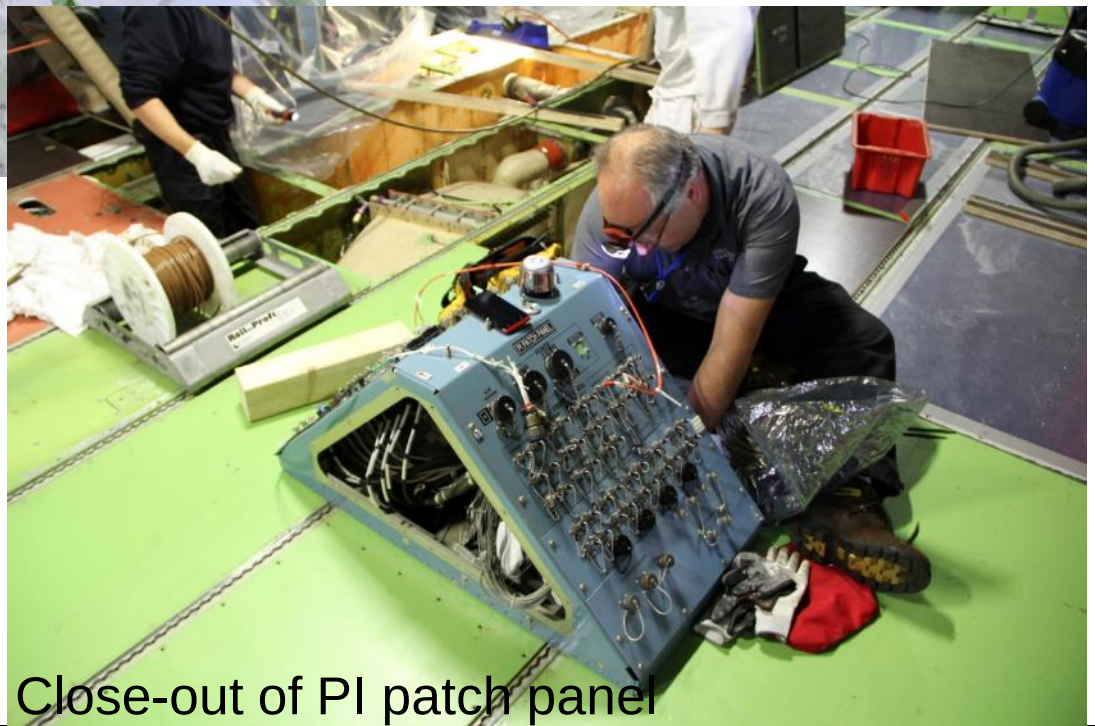
SOFIA Docked at Lufthansa (2 of 3)

SOFIA at maintenance station with engines removed (at right)

Aircraft interior with panels removed

SOFIA Docked at Lufthansa - Reassembly (3 of 3)

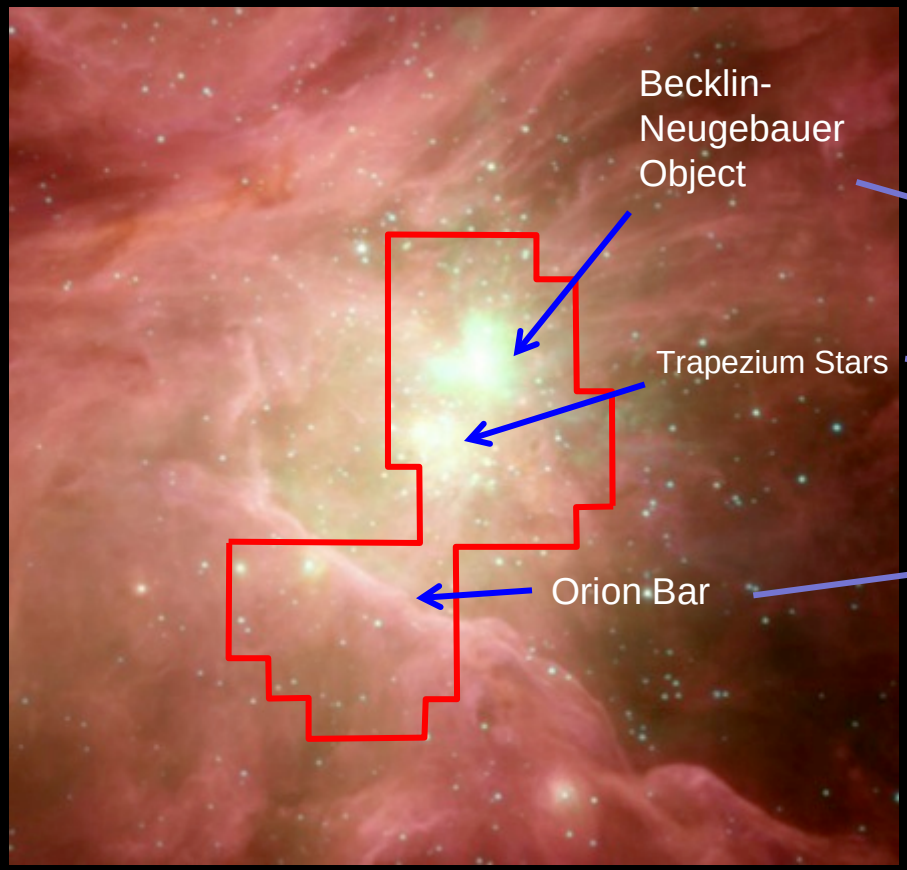
New Cockpit windows



Close-out of PI patch panel

Stratospheric Observatory for Infrared Astronomy

Orion Nebula



© Spitzer Observatory, Thomas Megeath

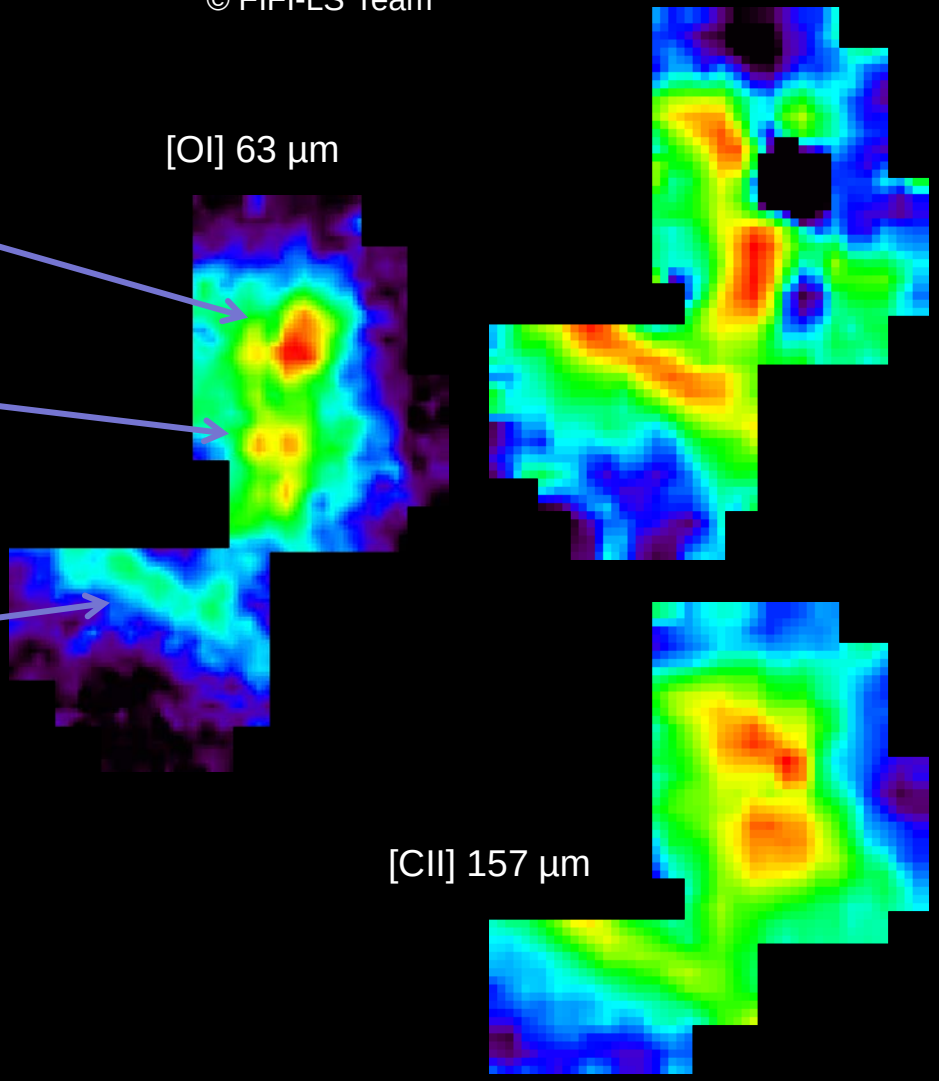
SOFIA / FIFI-LS

© FIFI-LS Team

[OI] 63 µm

[OI] 145 µm

[CII] 157 µm



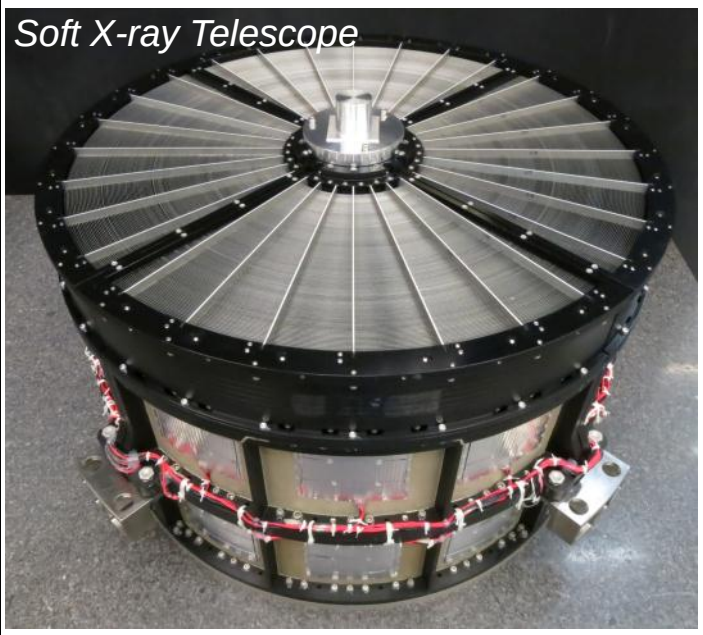
SOFIA
Stratospheric Observatory for Infrared Astronomy

- **World's Largest Airborne Observatory**
- 2.5-meter telescope
- Capable of observing from the visible to the far infrared
- 80/20 Partnership between NASA and the German Aerospace Center (DLR)
- Mission Ops based at NASA-Armstrong
- Science Ops based at NASA-Ames
- Six First-Generation instruments
  - Four U.S., two German
  - Imaging, Spectroscopy, and Photometry
- Limited Science Ops began in 2010
- Transitioned from Development Phase to Operational Phase in May 2014

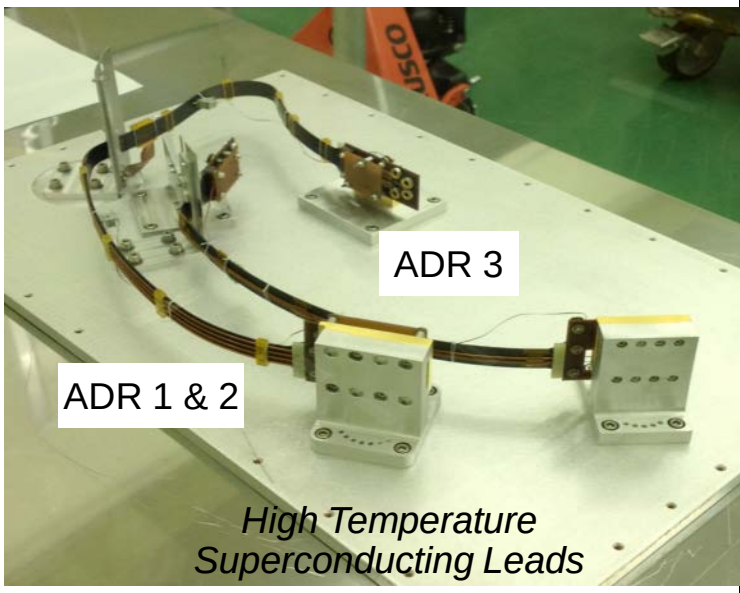
CURRENT STATUS:

- Achieved Full Operational Capability Feb 2014.
  - Began Cycle 2 science observations Feb 2014.
  - Cycle 3 investigations chosen - 2015 execution.
  - Commissioning of all six instruments underway
  - Demonstrated high cadence ops in April/May 2014.
  - Formally entered Operational Phase May 2014.
- Second generation instruments under development.
  - HAWC+: upgraded far infrared imager & polarimeter. (2016 commissioning)
  - upGREAT: multi-pixel heterodyne spectrometer (2015 commissioning)
- Astrophysics review June 2014 & IG report July 2014 suggested changes to increase scientific productivity
  - Do not concentrate on flight hours as sole metric.
  - Development of instruments increases productivity.
  - Appropriate funding of analysis should be revisited.
  - The pipeline is a bottleneck toward timely science.
  - SOFIA's unique capabilities are the region longer than 27 microns and very high spectral resolution.
- Arrived in Germany July 2014 for Heavy Maintenance Visit; continues through Nov 2014.
- President's FY15 budget request proposed to end funding and place SOFIA in storage.
  - NASA/DLR Working Group analyzed several scenarios to establish SOFIA's path forward.
  - Currently executing SOFIA's baseline schedule of operations and scheduled maintenance.
  - House and Senate proposed funding for FY15 ops.

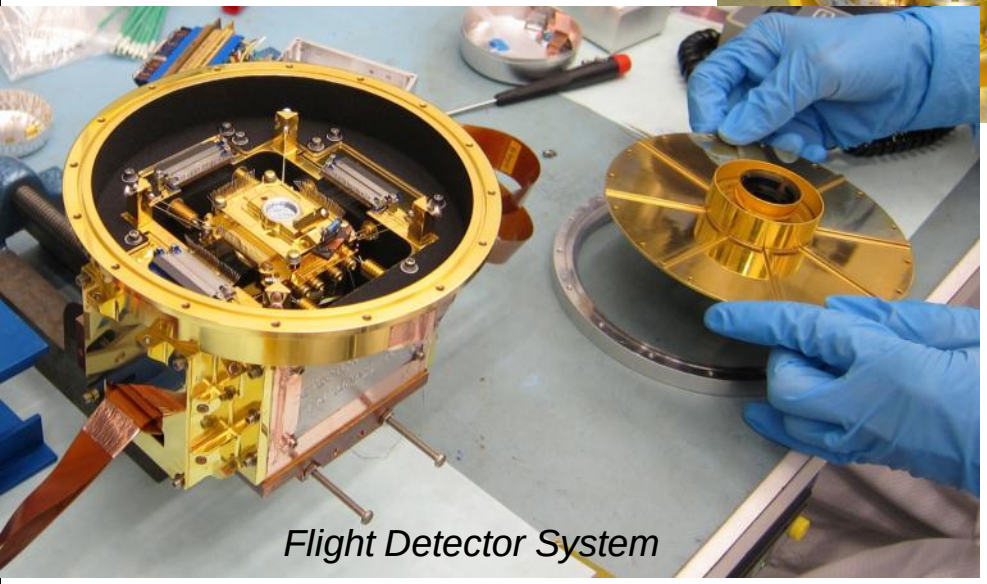
Program Update – ASTRO-H


Soft X-ray Telescope


ADR Assembly



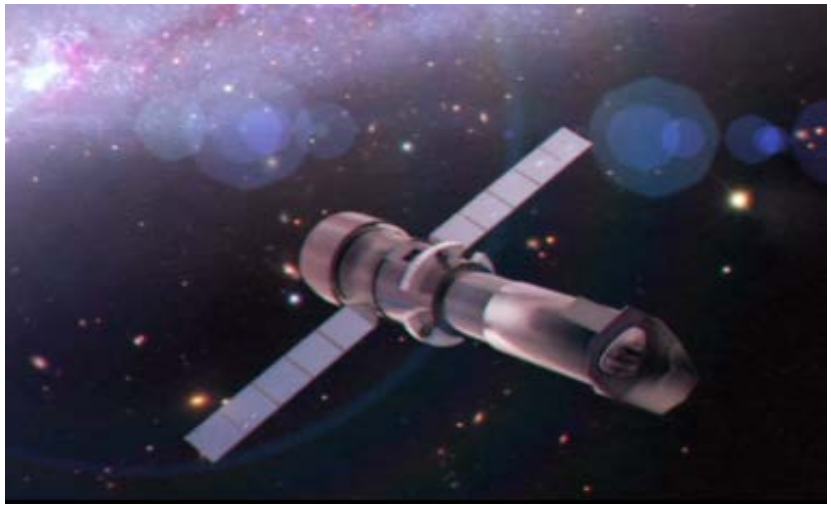
High Temperature Superconducting Leads


Flight Detector System


ADR Controller

Athena

Advanced **T**elescope for **H**igh **En**ergy **A**strophysics



- **Second ESA Cosmic Vision Large mission**
  - L-class with NASA/JAXA participation
  - Decadal Survey recommendation
  - Large X-ray mirror, X-IFU and WFI instruments
- **Launch Date:** 2028
- **Breakthrough Technologies**:
  - High Throughput, Wide FOV, High spectral resolution X-ray Astronomy
  - 10x Chandra area, 100x improved non-dispersive spectral resolution, 5x FOV.
- **Science Objectives**: The Hot and Energetic Universe:

How does ordinary matter assemble into the large scale structures that we see today?
How do black holes grow and shape the Universe?

CURRENT STATUS:

- Selected as 2nd Large mission in ESA Cosmic Visions Program
- Currently in 2 year Assessment Phase
- NASA is involved in Study Phase via membership on ESA-chartered Athena Science Study Team
- NASA budgeting for a $100M-$150M hardware contribution, plus a US GO program and a U.S. data center
- NASA continues to invest in Athena technologies via SAT and directed investigations.
- NASA and ESA are discussing possible NASA contributions, such as:
  - Portions of the X-ray calorimeter instrument (X-IFU)
  - Portions of the Wide Field Imager
  - Portions of the X-ray Mirror
  - Contribution to science data center (U.S. node)

NASA/NSF Partnership for Exoplanet Research

- New Worlds, New Horizons:

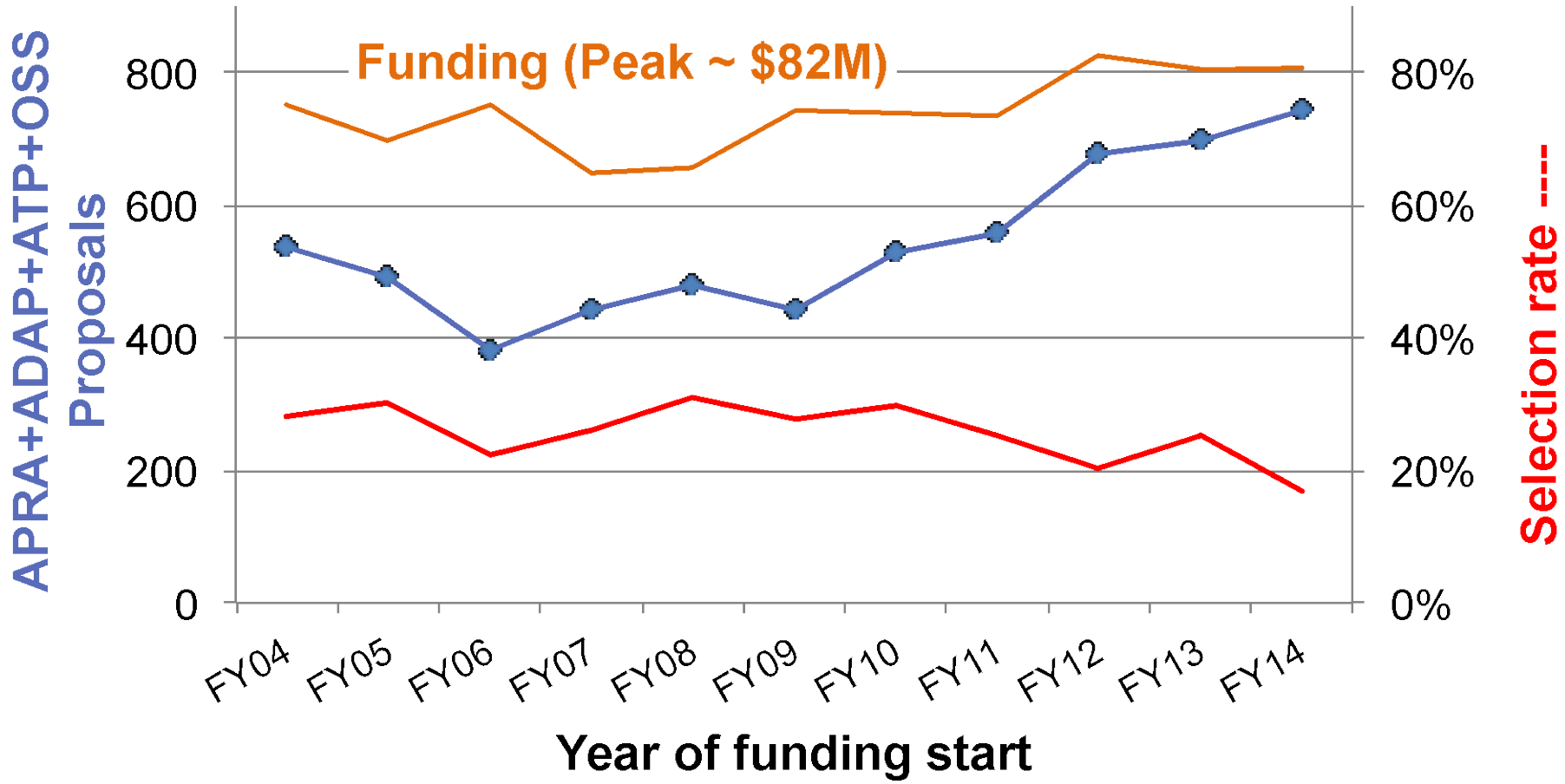
  "*NASA and NSF should support an aggressive program of ground-based high-precision radial velocity surveys of nearby stars to identify potential candidates … for a future space imaging and spectroscopy mission*".

- NASA Motivation: To provide US astronomical community with open access to a world-class precision radial velocity facility instrument that will enable:
  - follow-up observations in support of current NASA missions (e.g. K2, TESS, JWST)
  - pathfinder observations to inform the design and operation of future NASA missions (e.g. WFIRST-AFTA, NWNH "*New Worlds Mission*")
- Primary objective is to enable a community based exoplanet research program in support of NSF research interests and NASA mission goals (e.g. Kepler, K2, TESS, etc.).
- Partnership proposes to capitalize on the NOAO share of the WIYN consortium to implement a joint exoplanet research program that ultimately will focus on high precision radial velocities.

NASA/NSF Partnership for Exoplanet Research

- The program, as currently envisioned, would be carried out in two stages:
  - Stage 1. FY2015 – FY2018
    - Manage an exoplanet-targeted Guest Observer program with existing instrumentation on WIYN using NOAO share (40%) of WIYN time.
    - NASA to release solicitation in early CY 2015 for a facility-class extreme precision radial velocity spectrometer (EPRVS) for the WIYN telescope with the goal of commissioning in 2018.
  - Stage 2. FY2018 – TBD
    - Manage an exoplanet-targeted GO and guaranteed time program at WIYN with EPRVS instrument and existing instrumentation on WIYN
    - Develop and maintain a data management system to serve EPRVS data products.
    - Provide open community access to a cutting edge EPRVS instrument for observations that support NASA missions.
- Anticipated timeline:
  - Early December 2014 – issue community announcement of plan for a NASA solicitation for the construction of an EPRVS.
  - Early January 2015 – release of EPRVS solicitation as amendment to ROSES 2014 NRA
  - April 2015 – EPRVS proposal submission deadline
  - August 2015 – announcement of selection, initiation of project
  - FY2018 – commissioning of EPRVS and beginning of operations

Astrophysics ROSES selection rates



AAAC task force on R&A and demographics being led by Prisca Cushman (U. Minn).

Proposal Selections Since May 2013

Status: November 14, 2014

	Proposal Due Date	Notify Date	Days since received	Number received	Number selected	% selected
Spitzer GO Cycle 10+	Aug 2	Oct 22	81	137	38	28%
Swift GI Cycle 10	Sep 26	Dec 18	83	175	45	26%
Fermi Cycle 6	Jan 31, 2014	Jun 23	143	224	44	20%
Roman Tech Stage 2	Feb 1	Apr 21	79	2	1	50%
Chandra GO Cycle 16	Mar 13	July 17	140	636	192	30%
APRA / SAT	Mar 21	Sep 16 / Aug 18	179 / 160	177 / 18	38 / 10	22% / 56%
Hubble GO Cycle 22	Apr 11	Jun 23	111	1135	254	22%
ADAP (data analysis)	May 16	Oct 10	147	300	62	21%
Exoplanet Research	May 23	Oct 31	161	64	9	14%
ATP (theory)	July 11		126	216		
WFIRST (Preparatory Science)	July 11		126	53		
SOFIA GO Cycle 3+	July 18	Oct 29	103	153	73	48%
Kepler K2 GO – Cycle 1	Sep 23		52	93		
Roman Tech Stage 1	Nov 6		8	8		

+ Priority 1 proposals only

R&A Theory Program

- The Astrophysics Division will not solicit proposals for new Astrophysics Theory Program (ATP) investigations in ROSES-2015. The next proposal opportunity will be offered in ROSES-2016.
- Although there is a break in proposal opportunities, there is no break in funding opportunities and the level of ATP funding is not affected.

	Proposal Due Date	Selections Announced	Funding Initiated	Delay in Funding after Submission of Proposal
ROSES-2013	July 12, 2013	January 17, 2014	October 1, 2014 - July 1, 2015	15-25 months
ROSES-2014	July 11, 2014	NLT 180 days after proposal receipt (NLT January 7, 2015)	October 1, 2015 - July 1, 2016	15-24 months
ROSES-2015	Not solicited			
ROSES-2016	July 2016	NLT 180 days after proposal receipt (Early January 2017)	January - July 2017	6-12 months

SMD Education

Definitions

- **Education**.* Comprises those activities designed to enhance learning in science, technology, engineering, and mathematics (STEM) content areas using NASA's unique capabilities.

- **Communications**.* Comprises the comprehensive set of functions necessary to effectively convey - and provide an understanding of - the program, its objectives and benefits to target audiences, the public, and other stakeholders. This includes a diverse, broad, and integrated set of efforts. These efforts are intended to promote interest and foster participation in NASA's endeavors and to develop exposure to - and appreciation for - STEM.
  - Media services,
  - Multimedia products and services (including Web, social media, and non-technical publications), and
  - Public engagement (outreach) activities and events.

* Per NPD’s 1380.1 and 1388.1

SMD Science Education Objectives

- *Enable STEM Education*
- *Improve U.S. Scientific Literacy*
- *Advance National Goals*
- *Leverage through Partnerships*

SMD Education

- SMD intends to release a Cooperative Agreement Notice (CAN) soliciting team-based proposals for science education.
- The goal of the NASA SMD Science Education CAN is to meet the following NASA SMD Science Education Objectives: Enabling STEM education, improving U.S. science literacy; advancing National education goals; and leveraging science education through partnership.
- The schedule is as follows:

Draft CAN Release Date (target)	November 6, 2014
Final CAN Release Date (target)	NET December 2014
Preproposal Conference	~2 weeks after final CAN release
Notice of Intent to Propose Deadline	30 days after final CAN release
Electronic Proposal Submittal Deadline	90 days after final CAN release
Selections Announced (target)	Summer 2015
Projects Begin (target)	October 1, 2015

Astrophysics Education Transition Plan for FY15

- The Astrophysics Division has consolidated its Education programs into four science areas and assigned providers for each area as follows.
  - Cosmic Origins: Space Telescope Science Institute, Baltimore MD
  - Physics of the Cosmos: Chandra X-ray Center, Boston MA
  - Exoplanet Exploration: Jet Propulsion Laboratory, Pasadena CA
  - SOFIA Airborne Astronomy Ambassadors: Armstrong Flight Research Center, CA
- During the period of the FY15 continuing resolution (through December 11, 2014), funding levels for Astrophysics E/PO are being maintained at the same annualized level as FY14.

Preparing for the 2020 Decadal Survey

- Objective 1: Provide information to the Decadal Survey committee to enable prioritization of large missions
  - Science case
  - Strawman design reference mission with options/switches
  - Technology readiness assessment
  - Cost box

- Objective 2: Initiate technology development for candidate large missions so that technology will be ready when needed
  - Technology needs to be at TRL-5 when it is time to start the highest priority large mission in the 2020 Decadal Survey
  - This will be the next large mission after WFIRST/AFTA, and could be started when funding becomes available as WFIRST/AFTA approaches launch

Preparing for the 2020 Decadal Survey

- Step 1: Identify (large or strategic) mission concepts to study
- Step 2: Initiate studies
- Step 3: Conduct studies
- Step 4: Identify technology requirements to motivate early technology development
- Step 5: Deliver results to 2020 Decadal Survey committee

Preparing for the 2020 Decadal Survey

Step 1: Identify (large or strategic) notional mission concepts to study

- There are a limited number of legitimate candidates for the highest priority mission after WFIRST
- Use community process to identify the missions before forming STDTs
- Proposed Plan: Ask each PAG (Program Analysis Group) to recommend 1-2 missions for study
  - The three Astrophysics PAGs (Cosmic Origins PAG/COPAG, Exoplanet Exploration PAG/ExoPAG, Physics of the Cosmos PAG/PhysPAG) provide analysis for the Astrophysics Subcommittee in the science areas of each of the three science-based astrophysics programs
  - Must draw candidates from NWNH, SMD Science Plan, and 30-yr Visionary Roadmap
  - Astrophysics Subcommittee will collect input and provide list of candidates to Division Director
  - Division Director will select studies

Notional Timelines to Identify Studies

Timeline A	Timeline B	
January 2015	Summer 2015	Announcement of this process including presentation to the Astrophysics Subcommittee, formal charges to the PAGs, and presentation to the NRC Mid-Decade Review Committee.
January 2015 - June 2015	Summer 2015 - December 2015	Community discussion and input led by the PAG Executive Committees. Each PAG will determine an appropriate process for community discussion and input.
June 2015	January 2016	Meetings of the PAGs in conjunction with the meeting of the American Astronomical Society / Meetings of the PAGs at a NASA-sponsored Astrophysics PAG jamboree in June 2015. Each PAG will finalize its report identifying 1-2 mission concepts to the Astrophysics Subcommittee following these PAG meetings. These public reports will be submitted to the Astrophysics Subcommittee.
Summer 2015	Spring 2016	Meeting of the Astrophysics Subcommittee to suggest a consolidated list to the Astrophysics Division Director.
Fall 2015	Late Spring 2016	Decision by the Astrophysics Division Director identifying the small number of candidate missions that will be studied by NASA as input for the prioritization process of the 2020 Decadal Survey.

Notional Timelines to Identify Studies

	Timeline A	Timeline B
ROSES-15: APRA and SAT proposals due in March 2016, selected in Fall 2016, funded in FY2017	Mission concept studies identified in time for proposals to address perceived technology needs.	
ROSES-16: APRA and SAT proposals due in March 2017, selected in Fall 2017, funded in FY2018	STDT interim reports released in time for proposals to address technology needs identified by the STDTs.	STDT interim reports released in time for proposals to address technology needs identified by the STDTs.

	Timeline A	Timeline B
Pros	• Earlier start to studies • Earlier identification of technology development requirements	• PAG meetings take place in association with January 2016 AAS meeting
Cons	• Requires stand-alone PAG Jamboree in Summer 2015; less community involvement without associated AAS meeting	• Later start to studies and identification of technology development. requirements

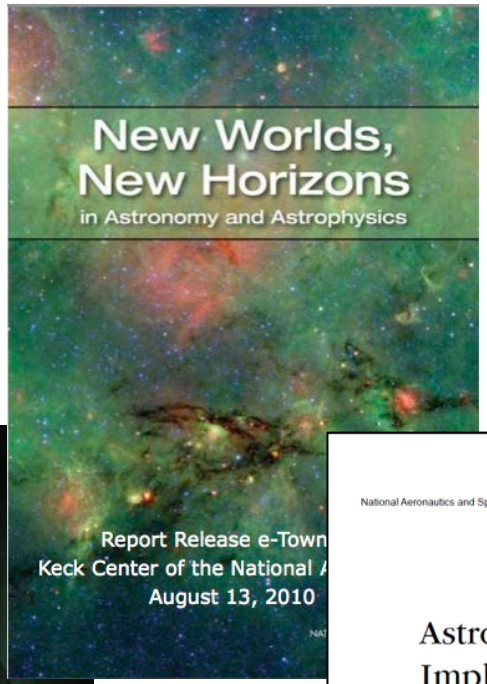
Preparing for the 2020 Decadal Survey

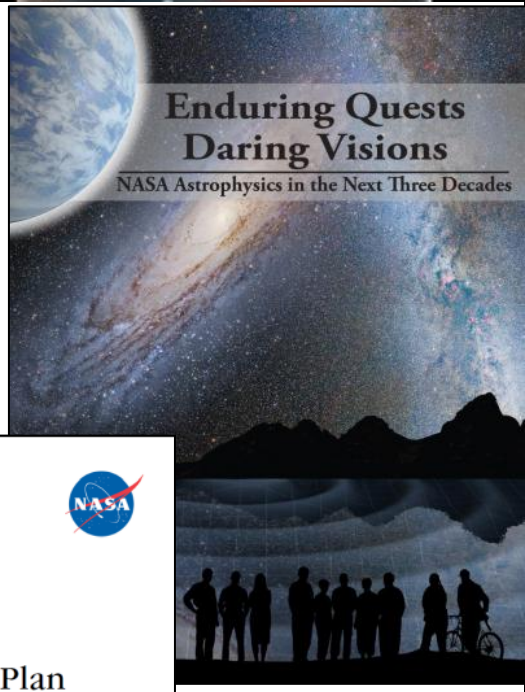
- Step 2: Initiate studies
  - Form science and technology definition team (STDT)
  - Assign Center-based study office
- Step 3: Conduct studies
  - Desired outcomes
    - Science case
    - Strawman DRM with options/switches
    - Technology readiness assessment
    - Cost box
- Step 4: Interim report to identify technology requirements to motivate early technology development
- Step 5: Deliver results to 2020 Decadal Survey committee
  - Deliver as public STDT report
  - Deliver when Decadal Survey committee requires mission input

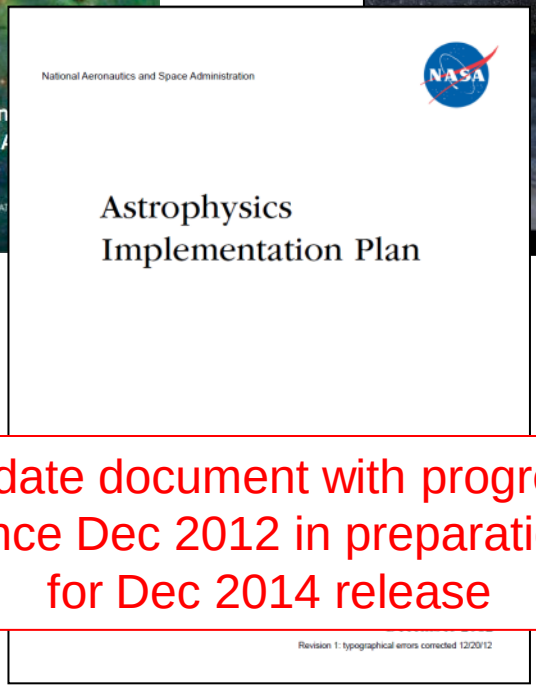
Preparing for the 2020 Decadal Survey

• Announce/socialize process with community	Now
• Start PAG process to identify STDTs	2015
• Identification of STDTs/Call for STDT members	2015/2016
• Start of STDTs	2015/2016
• Interim reports / influence SAT selections	2017
• Submission of reports to Decadal Survey Committee	2019

Astrophysics Driving Documents







Update document with progress since Dec 2012 in preparation for Dec 2014 release

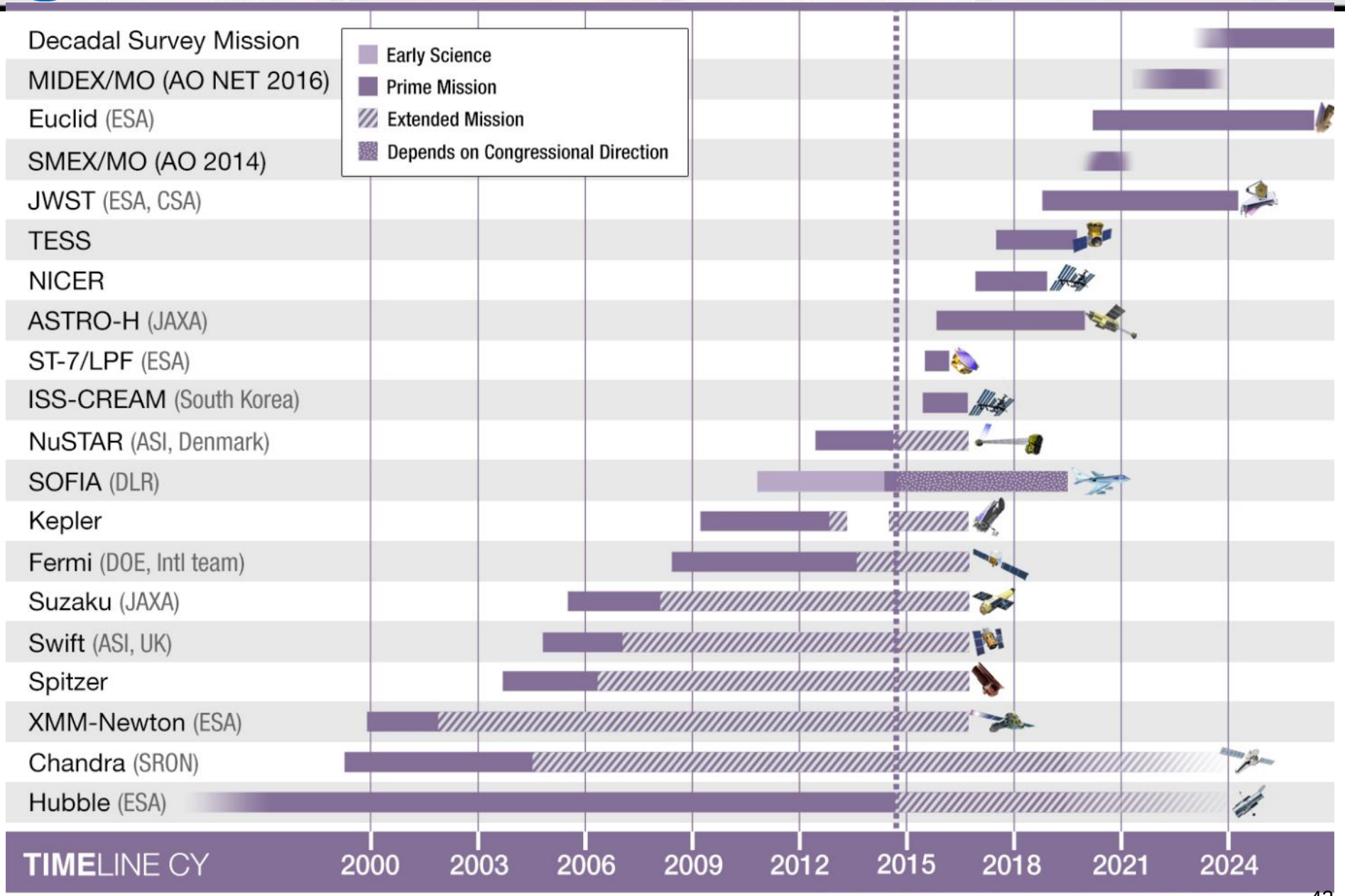
http://science.nasa.gov/astrophysics/documents

BACK-UP

NASA Astrophysics

Recently Completed
Planck 2013
Herschel 2013
GALEX 2013

Astrophysics Timeline



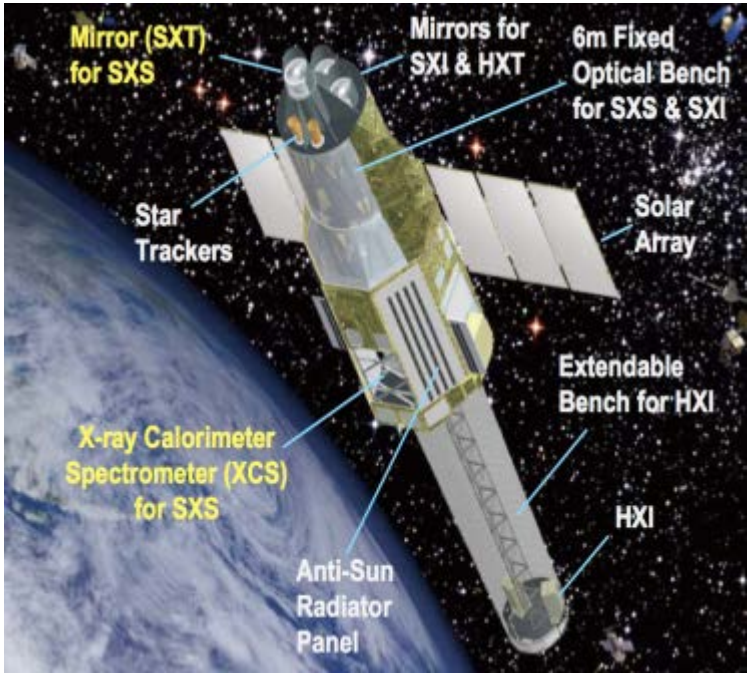
Kepler
Kepler Space Telescope

- **NASA's first space mission dedicated to the search for extrasolar planets, or exoplanets**
- **PI:** W. Borucki, NASA Ames Research Center
- **Launch Date:** March 6, 2009
- **Payload:** 0.95-meter diameter telescope designed to measure the tiny dimming that occurs when an orbiting planet passes in front of ('transits') a star
- **Scientific objectives:**
  - conduct census of exoplanet systems
  - explore the structure and diversity of extrasolar planetary systems
  - determine the frequency of habitable, Earth-sized planets in our galaxy

CURRENT STATUS:

- Kepler "K2" mission concept was approved for operations through FY2016 after completion of the 2014 Senior Review.
  - Kepler is conducting observations along the ecliptic, changing its orientation four times per year.
  - The first 75-day Campaign commenced in June 2014. Campaign 2 began in late August and will conclude in mid-November.
  - Targets are selected via proposals from the community. Campaigns 4 and 5 proposal deadline was late September.
- From 2009-13, Kepler continuously monitored 100 sq. deg. field in constellations of Cygnus and Lyra for 4+ years.
  - These observations ended after failure of 2nd reaction wheel.
- Analysis of first 3 years of Kepler data has revealed:
  - 3845 exoplanet candidates orbiting 2658 unique stars.
  - 989 candidates confirmed as planets to date
  - More than 100 planets discovered in their star's "habitable zone".
  - two dozen of the habitable zone planet candidates are less than twice the size of the Earth.
- Analysis of the full (4+ year) Kepler data set ongoing

ASTRO-H
Soft X-ray Spectrometer and Soft X-ray Telescope Mirrors



- **Explorer Mission of Opportunity**
- **PI**: R. Kelley, Goddard Space Flight Center
- **Launch Date**: Nov 2015 on JAXA H-IIA
- **Science Objectives**: Study the physics of cosmic sources via high-resolution X-ray spectroscopy. The SXS will enable a wide range of physical measurements of sources ranging from stellar coronae to clusters of galaxies.
- **Operations**: Prime Mission is 3 years

CURRENT STATUS

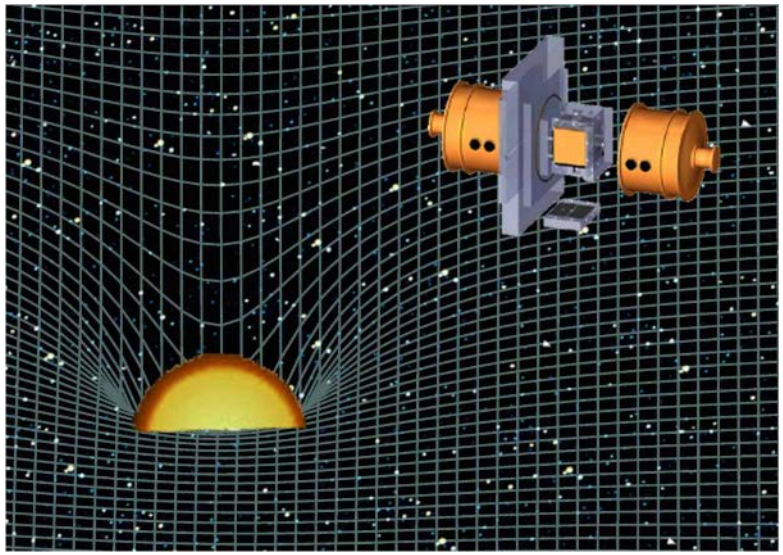
The U.S. is providing instrument contributions to the JAXA ASTRO-H mission.

- Soft X-ray telescope mirrors (SXT-S and SXT-I) – Both delivered.
- Calorimeter Spectrometer Insert (CSI) – delivered and integrated on to the FM Dewar and has success-fully been tested at the 2-stage and 3-stage modes.
- Completed early FM Dewar cryo performance testing in June with excellent results (>90% response efficiency).
- High Temperature Superconductor (HTS) leads were delivered to JAXA on July 16.
- Science Data Center Meeting held September 27-28, 2014 (ISAS).
- Successfully completed warm Dewar aliveness testing with NASA-provided FM hardware.

UPCOMING EVENTS:

- November – JAXA CDR 2
- December – FM XBOX and ADRC to JAXA
- Jan 2015 – FM Dewar deliver to spacecraft

ST-7/LISA Pathfinder
ST-7/Disturbance Reduction System (DRS)

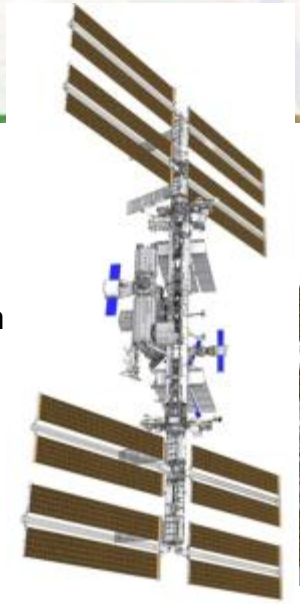


- ESA Mission with NASA Collaborating
- Project Category: 3 Risk Class: C
- DRS flies on the ESA LISA Pathfinder spacecraft
- Sun-Earth L1 halo orbit
- Drag-free satellite to offset solar pressure
- Payload delivery: July 2009 – COMPLETE
- Launch date: July 31, 2015
- Operational life: 2 months
- Data Analysis: 12 months

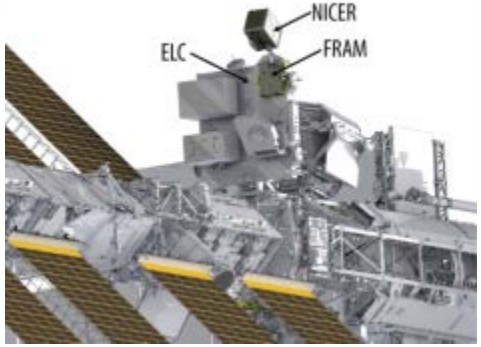
CURRENT STATUS:

- JPL executing life tests at Airbus UK
- Launch vehicle loads exceed DRS test levels, under review
- NASA DRS experiment mission investigators have requested for extra spacecraft data needed for analysis. Current plan is ESA gives only experiment data
- Extended mission being discussed
- Spacecraft assembly is still ongoing
- System level thermal vacuum test in March 2015
- System level acoustics and mass properties in May 2015
- Shipping in June to launch site
- Launch July 31, 2015

NICER
Neutron Star Interior Composition Explorer



Intl Space Station (ISS)

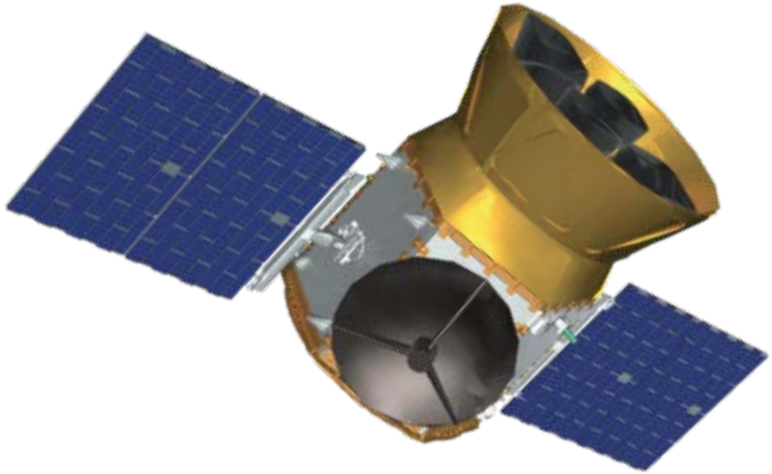


- **Explorer Mission of Opportunity**
- **PI:** Keith Gendreau, GSFC
- **Launch:** October 2016 on Space-X Falcon 9
- **Science Objectives:** Perform high-time-resolution and spectroscopic observations of neutron stars in the .2-12 keV energy range to study the physics of ultra-dense matter in the core of neutron stars.
- **Instrument:** X-ray Timing Instrument uses X-ray concentrators and detectors to detect X-ray photons and return energy and time of arrival.
- **Platform:** Located externally on the ISS, ExPRESS Logistics Carrier 2, Starboard 3 site
- **Operations:** Operated on a non-interference basis for 18 months
- **SEXTANT** for Pulsar navigation demo funded by NASA's Space Technology Mission Directorate

CURRENT STATUS:

- Downselected April 2013.
- Science team and project management both led by NASA GSFC.
- Development progressing on plan.
- The Preliminary Design Review successfully completed in December 2013.
- NICER passed Confirmation (KDP-C), for approval to enter implementation phase, on February 24, 2014.
- All major contracts have been awarded for optics, pointing system and star tracker.
- Design is maturing quickly; engineering test units of the optics have been manufactured and tested.
- Critical design review (CDR) successfully completed September 15-18, 2014.

TESS
Transiting Exoplanet Survey Satellite



Standard Explorer (EX) Mission

PI: G. Ricker (MIT)

Mission: All-Sky photometric exoplanet mapping mission.

Science goal: Search for transiting exoplanets around the closest and brightest stars in the sky.

Instruments: Four wide field of view (24x24 degrees) CCD cameras with overlapping field of view–operating in the Visible-IR spectrum (0.6-1 micron).

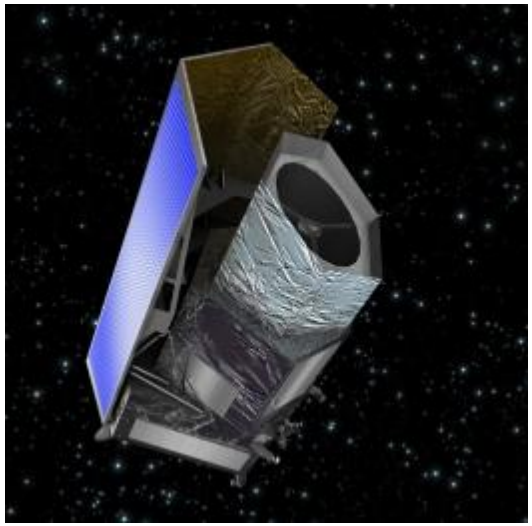
Operations: 2017 launch with a 2-year prime mission

CURRENT STATUS:

- Downselected April 2013.
- Major partners:
  - PI and science lead: MIT
  - Project management: NASA GSFC
  - Instrument: Lincoln Laboratory
  - Spacecraft: Orbital Science Corp
- Tentative launch readiness date August 2017.
- High-Earth elliptical orbit (17 x 58.7 Earth radii).
- Development progressing on plan.
  - Systems Requirement Review (SRR) successfully completed on February 12-13, 2014.
  - Preliminary Design Review (PDR) successfully completed Sept 9-12, 2014.
  - Confirmation Review, for approval to enter implementation phase, successfully completed October 31, 2014.

Euclid

A visible and near-infrared telescope to explore cosmic evolution



- **ESA Cosmic Vision 2015-2025 Mission**, M-Class with NASA participation.
- 1.2-m mirror, visible & near-IR images, spectra
- **Launch Date**: Mar 2020
- **Science Objectives**:
  - Euclid will look back 10 billion years into cosmic history.
  - Probe the history of cosmic expansion (influenced by dark energy and dark matter) and how gravity pulls galaxies together to form the largest structures.
  - The shapes of distant galaxies appear distorted because the gravity of dark matter bends their light (gravitational lensing). Measuring this distortion tells us how the largest structures were built up over cosmic time.
  - Measuring how strongly galaxies are clumped together tells us how gravity influences their motions, and how dark energy has affected the cosmic expansion.

CURRENT STATUS:

- Currently in implementation phase.
- ~50 U.S. scientists are members of the Euclid Science Team that will analyze the data, and make maps of the sky.
- First experimental manufacturing run for the Euclid near-infrared detectors was completed in FY 2014 (ESA) and are currently being evaluated and characterized.
- NASA will initiate the buy for the flight infrared detectors in FY15.
- NASA will test and characterize the near-IR flight detectors.
- NASA is funding the ENSCI (Euclid NASA Science Center at IPAC). ENSCI will
  - Support all segments of US community on Euclid to enhance science utilization
  - Integrate into Euclid Science Ground System provided by the Euclid consortium to gain/contribute expertise in pipelines

2014 Astrophysics Explorer AO

- Community Announcement released on November 12, 2013, indicating NASA will solicit proposals for SMEX missions and Missions of Opportunity.
- Draft AO July 14, 2014, comments received August 4, 2014.
  - NASA received ~70 comments.
- Final AO released September 17, 2014.
- Preproposal Conference held October 7, 2014.
- Notice of intent were due October 15, 2014.
  - NASA received ~30 NOIs
- Proposals due December 18, 2014.

For additional info: http://explorers.larc.nasa.gov/APSMEX/.

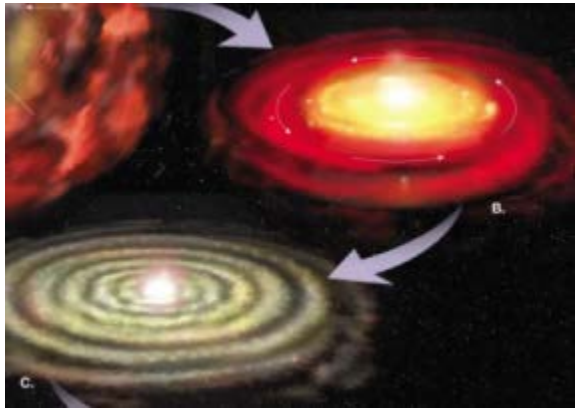
FY15 Planned Accomplishments

- The **TESS** Explorer Mission will be confirmed to begin implementation (KDP-C) in FY15.
- The **ISS-CREAM** experiment will be launched to the International Space Station (KDP-E) in FY15.
- The Step 1 selection (KDP-A) will be made for the next Small Astrophysics **Explorer** and Explorer Mission of Opportunity in FY15.
- ESA's **LISA Pathfinder** with NASA's ST-7 experiment will launch (KDP-E) in FY15.
- The **WFIRST/AFTA** science definition team report will be completed in FY15.
- Manufacture, assembly, and test of the **Euclid** flight detectors will continue in FY15.
- JAXA's **ASTRO-H** mission spacecraft system level test will take place in FY15.
- The Astrophysics **Archives Senior Review** will be held in FY15.
- **Hubble** will achieve 25 years of operation in FY15.
- The NRC **Mid-Decade Review** will begin in FY15.
- Four **Balloon** campaigns will be conducted in FY15.
- Five **Sounding Rockets** with Astrophysics payloads will launch in FY15.

Why Astrophysics?

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

1. How did our universe begin and evolve?

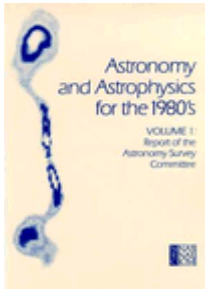


2. How did galaxies, stars, and planets come to be?

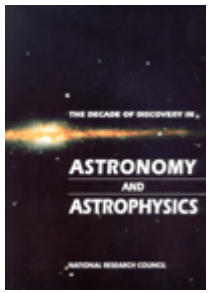
3. Are We Alone?

These national strategic drivers are enduring

1972



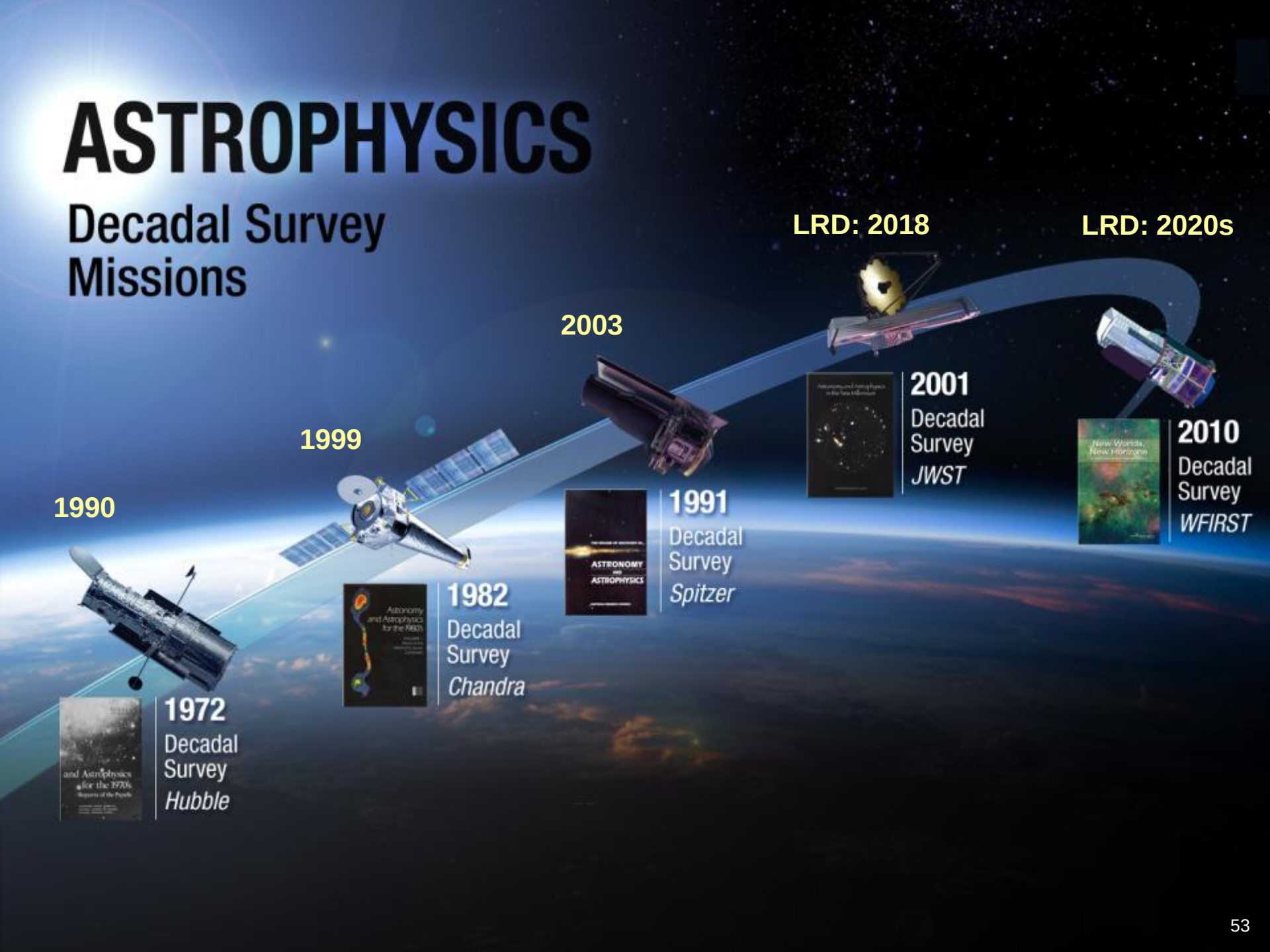
1982



1991

2001

2010


ASTROPHYSICS
Decadal Survey
Missions
LRD: 2018
LRD: 2020s
2003
1999
1990
2001
Decadal
Survey
JWST
2010
Decadal
Survey
WFIRST
1991
Decadal
Survey
Spitzer
1982
Decadal
Survey
Chandra
1972
Decadal
Survey
Hubble

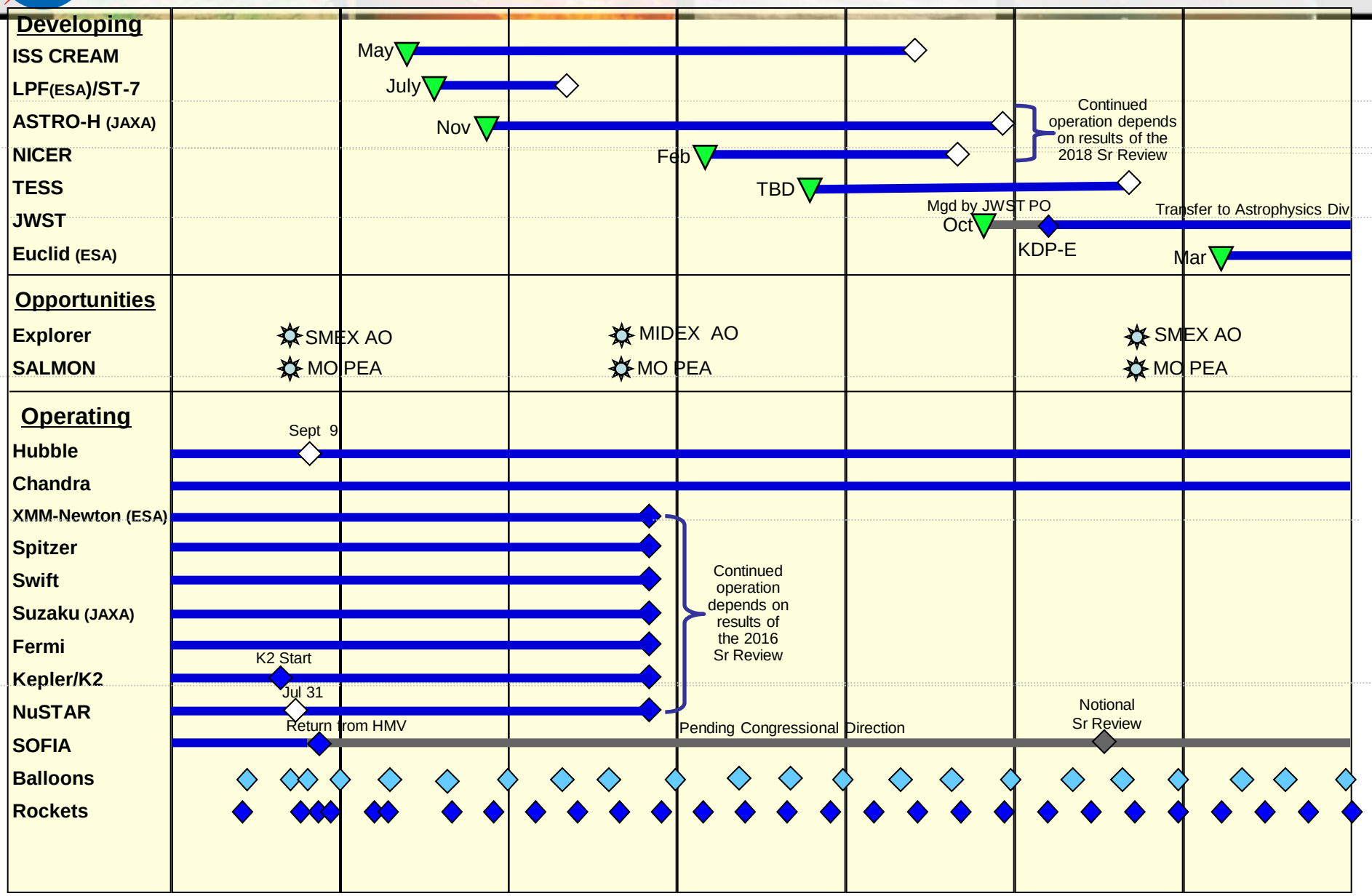
Progress Toward Decadal Survey Priorities

The NASA FY14 Appropriation, the President's FY15 Budget Request, and its notional out years support:	
Large-scale 1. WFIRST	Preformulation and focused technology development for WFIRST/AFTA (a 2.4m version of WFIRST with a coronagraph) are underway to enable a new start NET FY2017. Planning budget proposed for an Astrophysics Decadal Strategic Mission.
Large-scale 2. Augmentation to Explorer Program	Astrophysics Explorers planned budget increased to ~$150M/yr by FY16; supports decadal cadence of AOs including AO for SMEX AO in Fall 2014 (FY2015) and EX AO in ~FY2017.
Large-scale 3. LISA	Strategic astrophysics technology (SAT) investments including LISA Pathfinder plus discussing partnership on ESA's L3 gravitational wave observatory – participating in ESA-led assessments in 2014-2015.
Large-scale 4. IXO	Strategic astrophysics technology (SAT) investments plus pursuing partnership on ESA's L2 Athena X-ray observatory. Athena study phase, with U.S. participation, is underway.
Medium-scale 1. New Worlds Technology Development Program	Focused technology development for a coronagraph on WFIRST, strategic astrophysics technology (SAT) investments, and exoplanet probe mission concept studies.

Progress Toward Decadal Survey Priorities

The NASA FY14 Appropriation, the President's FY15 Budget Request, and its notional out years support:	
Medium-scale 2. Inflation Probe Technology Development Program	Three balloon-borne investigations plus strategic astrophysics technology (SAT) investments.
Small-scale. Research Program Augmentations	Increased annual R&A budget from $74M (FY10) to $82M (FY12 and beyond). Within R&A: established Theoretical and Computational Astrophysics Networks (TCAN) program with NSF; funding available for astrophysics theory; funding available for lab astrophysics; funding available for suborbital payloads.
Small-scale. Intermediate Technology development Augmentation	Established competed Strategic Astrophysics Technology (SAT) program element; directed technology funding for WFIRST and other large-scale decadal priorities.
Small-scale. Future Ultraviolet-Visible Space Capability	Strategic Astrophysics Technology (SAT) investments.
Small-scale. SPICA (U.S. contribution to JAXA-led)	Not supported as a strategic contribution; candidate for Explorer Mission of Opportunity.

Astrophysics Science Mission Events



Looking toward the 2015 Mid-Decade Review

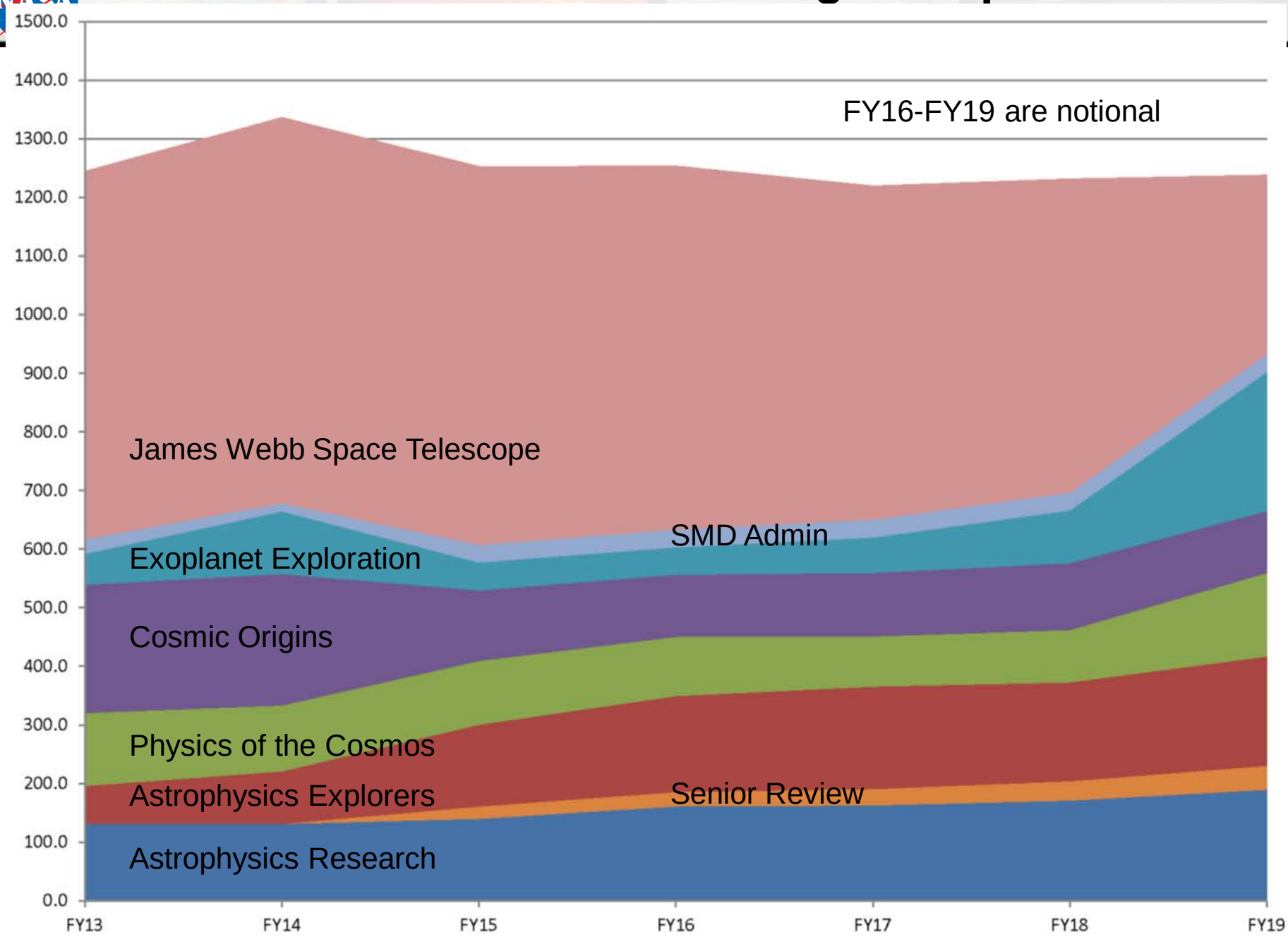
The usual charge to a mid-decade review (paraphrased)

- Assess how NASA is doing implementing the recommendations and priorities of the Decadal Survey, in the context of post-Survey changes and constraints

Directions in *New Worlds, New Horizons* relevant to NASA (paraphrased)

- LISA: If LISA is not L1, or LISA Pathfinder is not successful, or equal partnership is not possible, then conduct review to reconsider LISA's prioritization. (p.9, p.213)
- IXO: If IXO is L1, conduct review then (maybe) invest immediately in technology. By mid-decade, invest aggressively in technology. (p. 214, p. 215)
- New Worlds: If precursor science is favorable, conduct review then (maybe) downselect technology and invest to ready a mission for the 2020 decadal survey. (p.20, p.195, p.216)
- Inflation Probe: If B-mode detected, conduct review then (maybe) invest in technology for an all-sky mission. (p.198, p.217)
- DSIAC: Conduct review to see whether any contingencies have occurred and recommend action. (p.102)

President's FY15 Budget Request



Astrophysics FY 2015 Budget Request

				Notional			
	FY 2013 Op Plan	FY 2014 Op Plan	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Astrophysics	617.0	668.0	607.3	633.7	651.2	696.8	993.0
Astrophysics Research	155.8	134.9	191.0	216.2	221.2	234.6	261.2
Cosmic Origins	218.9	224.2	120.3	106.4	108.2	114.2	105.8
Physics of the Cosmos	124.5	112.6	108.8	100.9	86.6	89.4	142.4
Exoplanet Exploration	52.8	106.7	47.5	46.4	60.4	89.8	237.3
Astrophysics Explorers	65.1	89.6	139.7	163.7	174.9	168.7	186.4
James Webb Space Telescope	627.6	658.2	645.4	620.0	569.4	534.9	305.0
Astrophysics + JWST	1,244.6	1,326.2	1,252.7	1,253.7	1,220.6	1,231.7	1,298.0