



# Astrophysics Division Update

Astrophysics Subcommittee

March 17, 2015

# Astrophysics

**Paul Hertz**

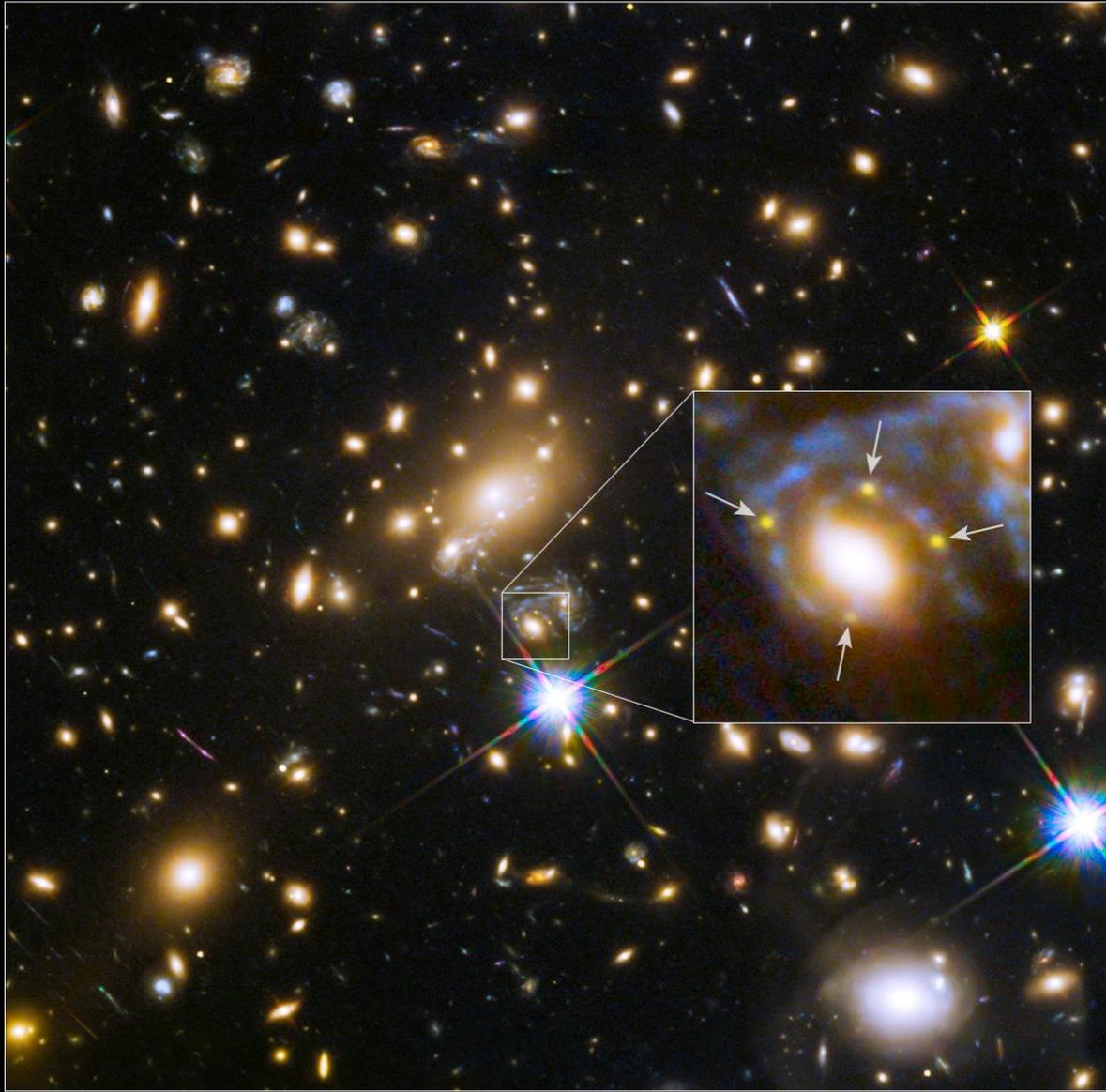
**Director, Astrophysics Division  
Science Mission Directorate**

**@PHertzNASA**

 **Hubble Sees Supernova Split into Four Images by Cosmic Lens**

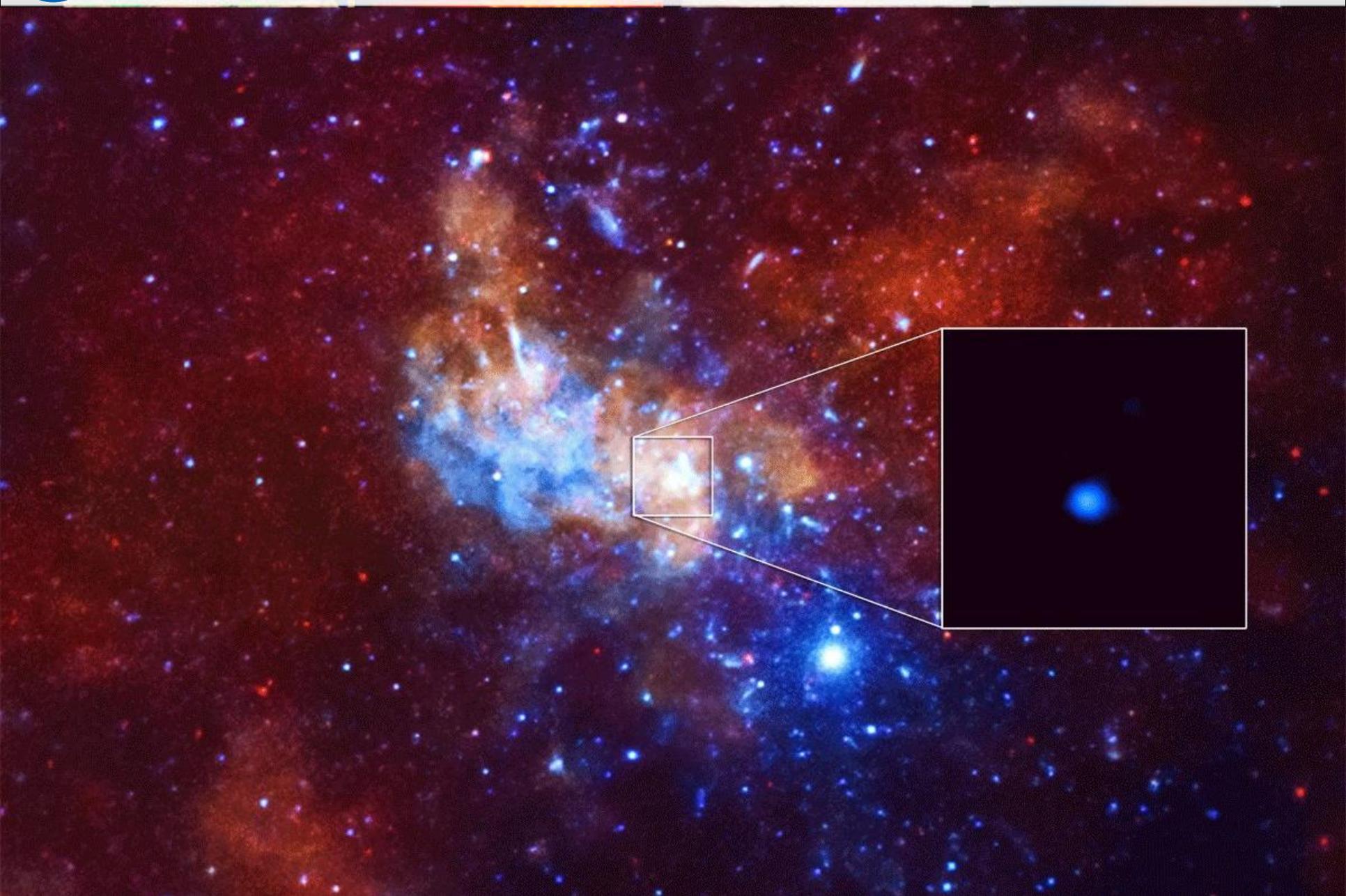
Supernova Refsdal  
Galaxy Cluster MACS J1149.6+2223

*Hubble Space Telescope*  
ACS/WFC ■ WFC3/IR





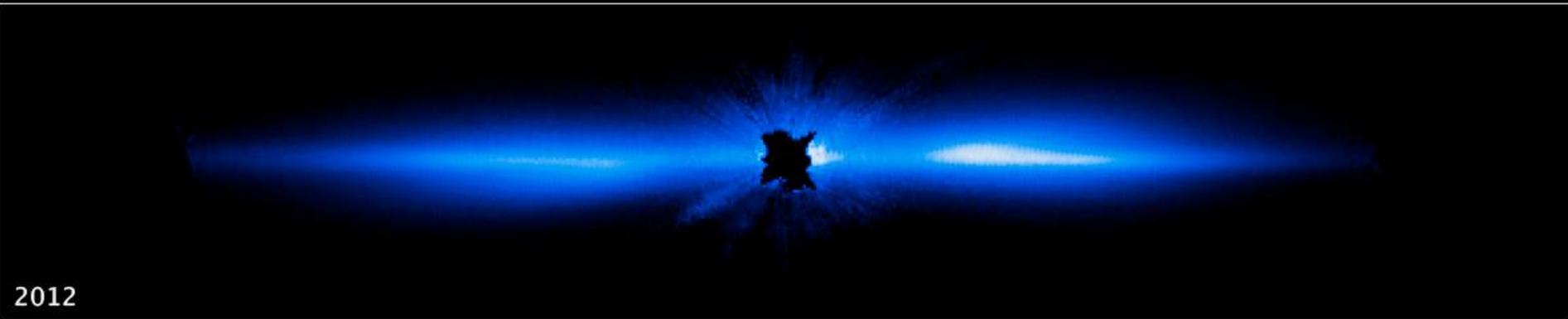
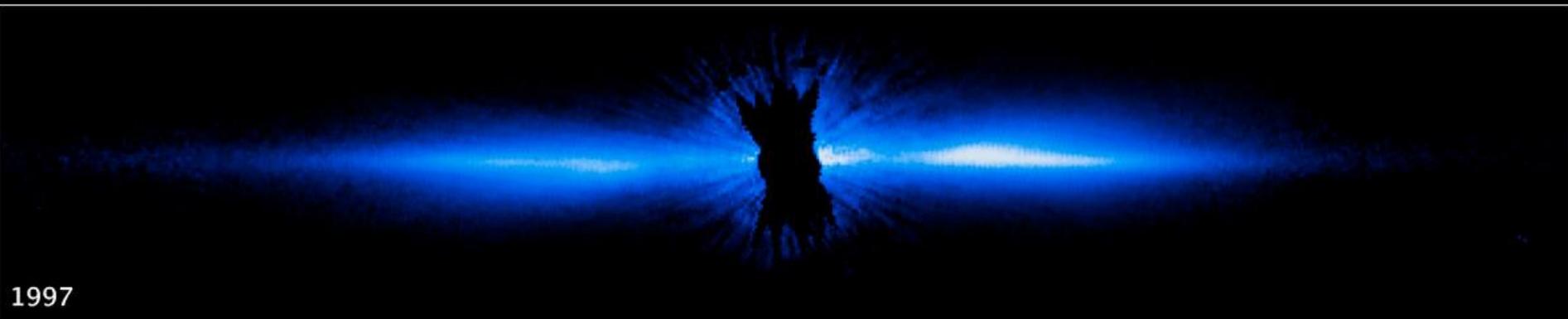
# NASA's Chandra Detects Record-Breaking Outburst from Milky Way's Black Hole





# NASA's Hubble detects Distortion of Circumstellar Disk by a Planet

Beta Pictoris ■ *Hubble Space Telescope* ■ STIS

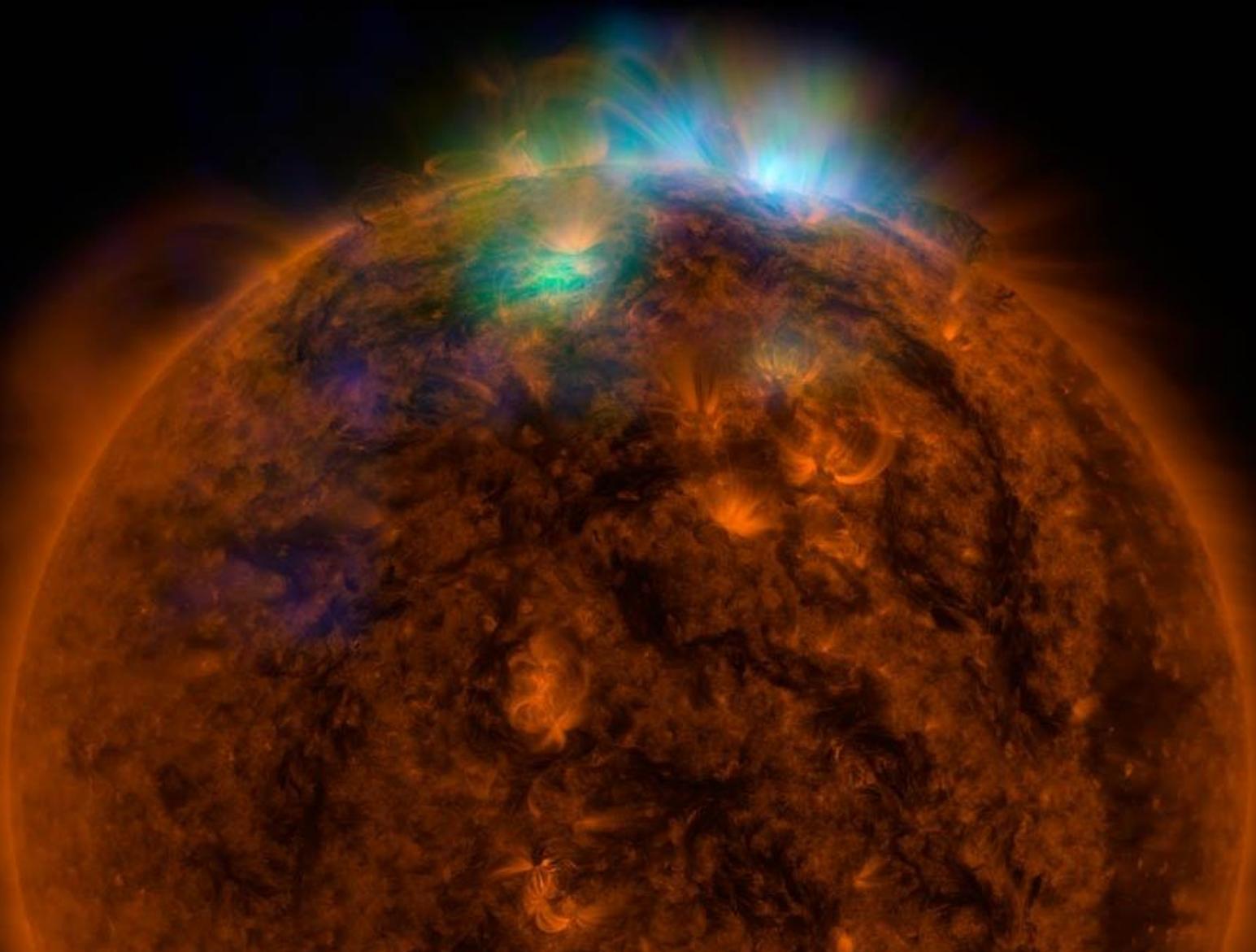


NASA and ESA

STScI-PRC15-06a



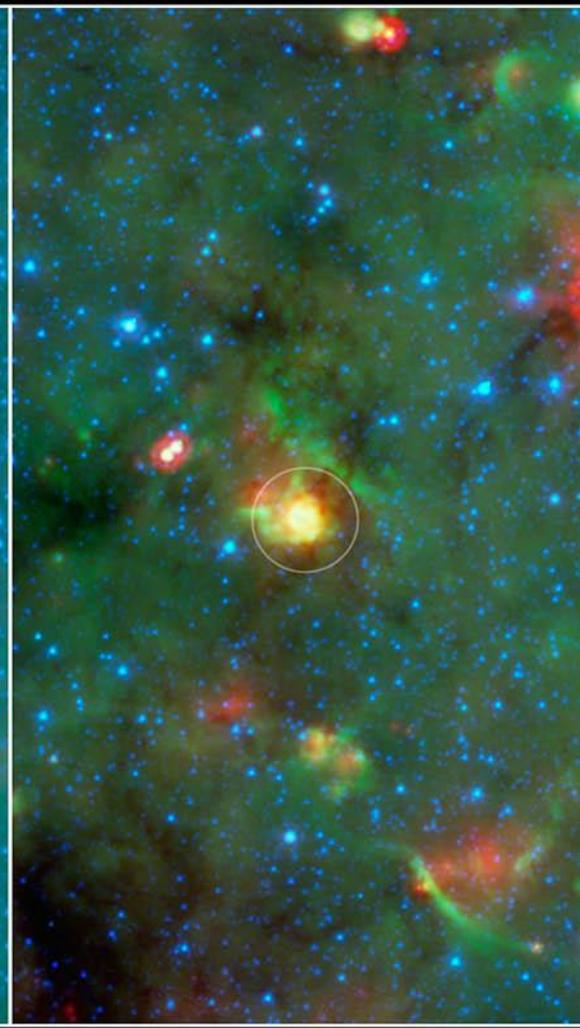
# Sun Dazzles In First-Ever NuSTAR High-Energy X-Ray Portrait



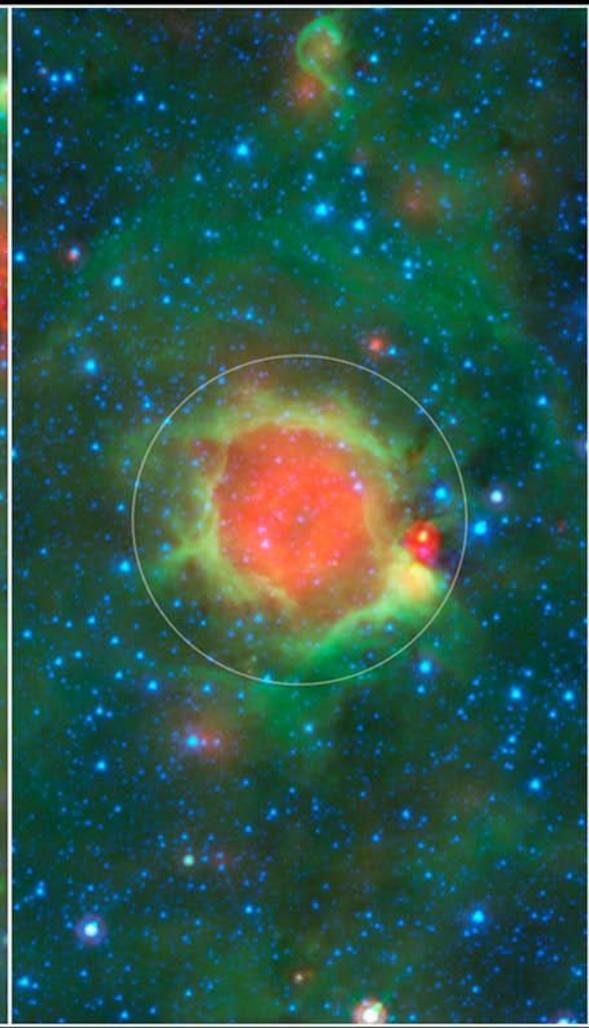
Protostar



“Yellowball”



Bubble



“Yellowballs” in Star Formation Sequence

NASA / JPL-Caltech

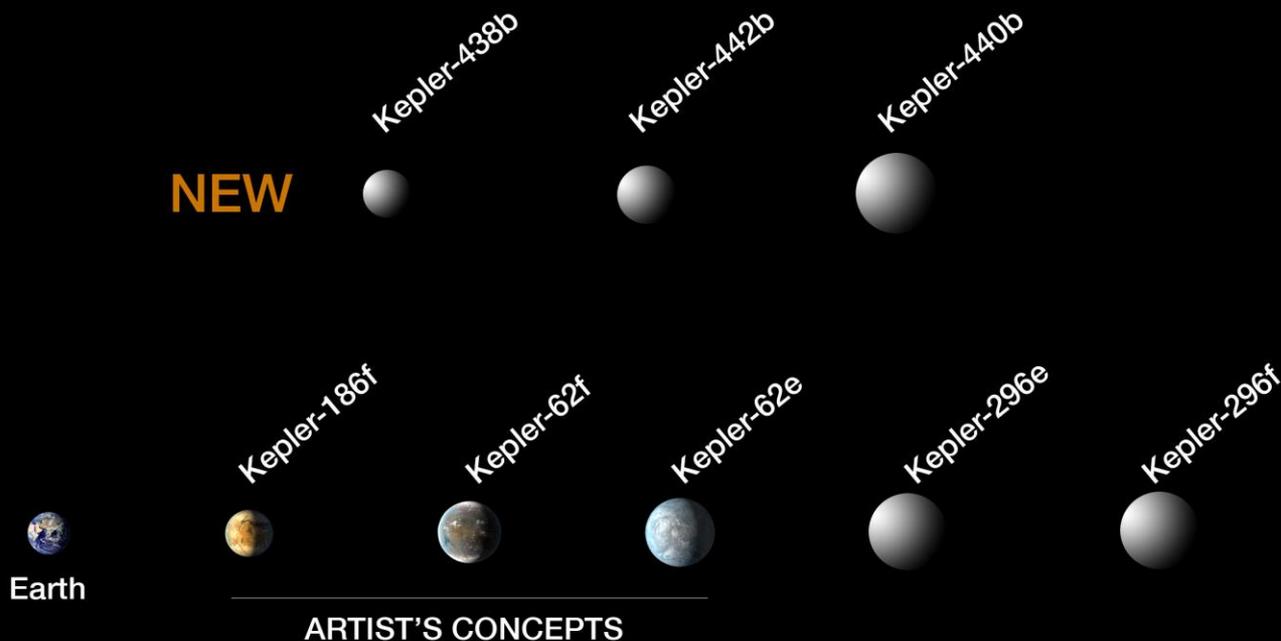
Spitzer Space Telescope • IRAC • MIPS

sig15-001



# NASA's Kepler Marks 1,000th Exoplanet Discovery, Uncovers More Small Worlds in Habitable Zones

## NASA Kepler's Hall of Fame: Small Habitable Zone Planets *As of January 2015*

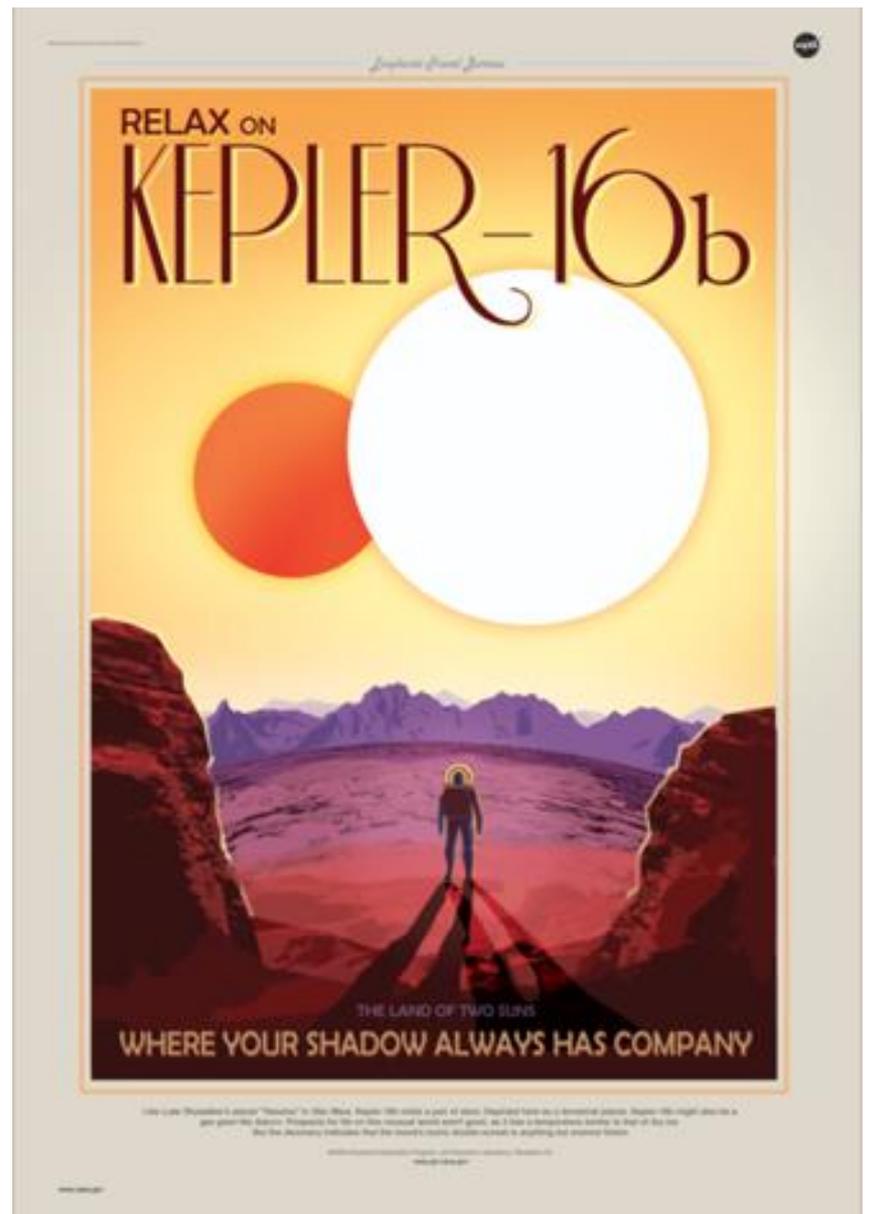




# The Exoplanet Travel Bureau



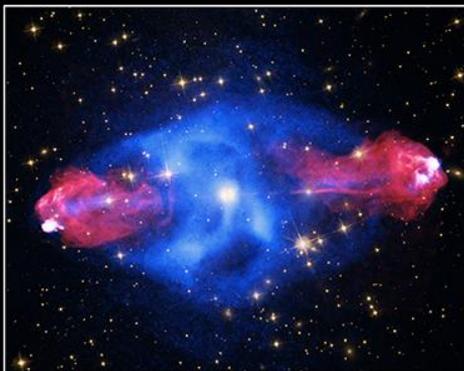
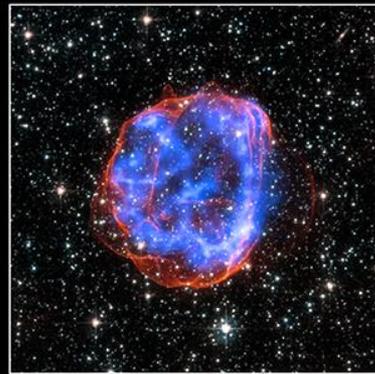
Kepler-186f is the first Earth-size planet discovered in the habitable zone around another star, which could mean liquid water on the planet's surface. It sits in both inner and outer "Goldilocks" zones, making it a prime candidate for a habitable planet very different from the planets on Earth. This discovery was made by NASA's Kepler space telescope.



Kepler-16b is a gas giant planet orbiting a pair of stars. It's the only planet in the habitable zone of a star system with two stars. It's also the only planet in the habitable zone of a star system with two stars. This discovery was made by NASA's Kepler space telescope.

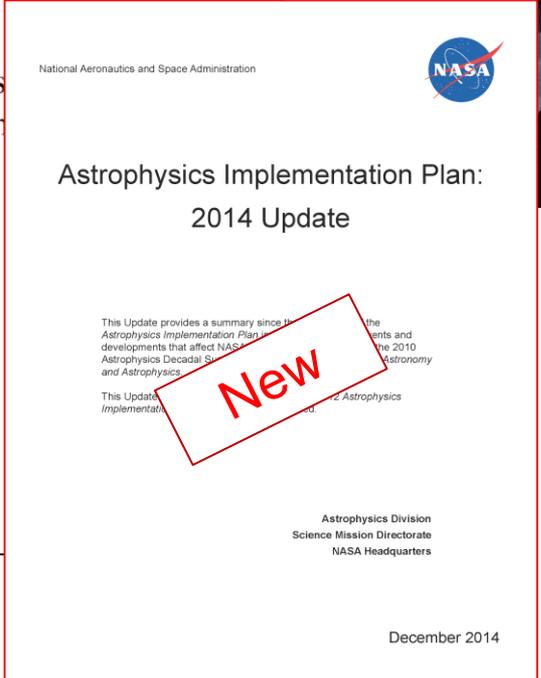
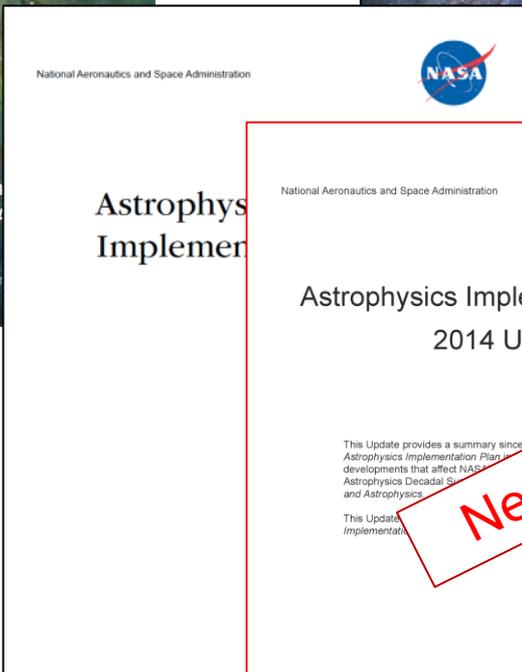
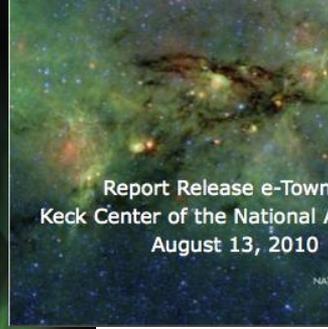
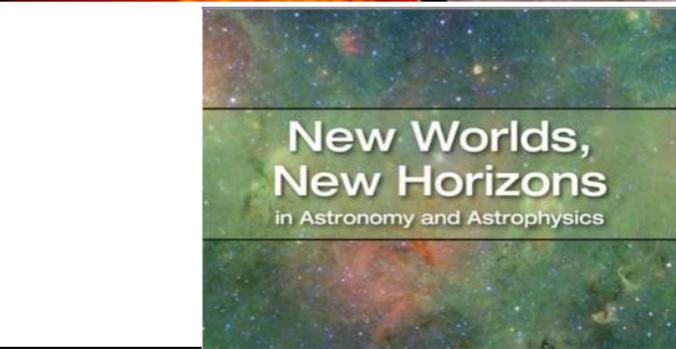
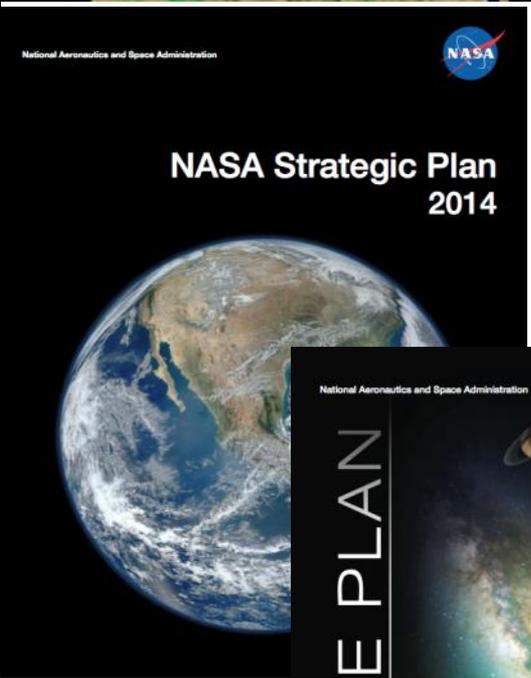


# Chandra Celebrates the International Year of Light





# Astrophysics Driving Documents



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



# Big Picture

- The FY15 appropriation and FY16 budget request provide funding for NASA astrophysics to continue its programs, missions, and projects as planned
  - The total funding (Astrophysics including JWST) is flat at ~\$1.3B through FY20
  - Fully fund JWST to remain on plan for an October 2018 launch
  - Fund continued pre-formulation and technology work leading toward WFIRST
  - Restore SOFIA to the budget with a reduction in FY15 and full funding beyond
  - Provide funding for SMD's education programs
- The operating missions continue to generate important and compelling science results, and new missions are under development for the future
  - Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, Spitzer, Suzaku, Swift, XMM-Newton continued following the 2014 Senior Review
  - SOFIA is in prime operations as of May 2014
  - Missions on track for launch include ISS-CREAM (2015), LISA Pathfinder (2015), ASTRO-H (2015), NICER (2016), TESS (2017), JWST (2018), Euclid (2020)
  - New Explorers being selected (SMEX in 2015, MIDEX in 2017), WFIRST being studied, NASA joining ESA's Athena and ESA's L3 gravitational wave observatory
- Update to the Astrophysics Implementation Plan has been released
- Progress being made against recommendations of the 2010 Decadal Survey
  - NRC Mid Decade Review (with NSF, DOE) to begin in early 2015
  - NASA initiating concept studies for 2020 Decadal Survey



# FY15 Appropriation

| (\$M)        | 2013 | 2014 | 2015  | 2016 | 2017 | 2018 | 2019 |
|--------------|------|------|-------|------|------|------|------|
| Astrophysics |      |      | \$685 |      |      |      |      |
| JWST         |      |      | \$645 |      |      |      |      |

- Provides \$77M more than the President's Budget Request for FY15
- Supports the commitment to an October 2018 launch date for JWST
- Includes \$50M for continued preformulation of WFIRST, an increase of \$36M over the Administration request and comparable to FY14
- Includes \$70M for continued SOFIA operations, a reduction of \$14M (17%) from FY14
  - Directs NASA to (a) seek partners to restore SOFIA to its full level, and (b) not terminate missions without a Senior Review
- Includes \$98M for Hubble operations, the same as FY14
- Includes \$38M for scientific ballooning, an increase of \$5M (15%) from FY14
- Includes \$42M for Education SMD-wide as a separate budget line (so E/PO is no longer budgeted as 1% of every mission)
- Does not specify the distribution of funding for the rest of Astrophysics, but the funding is adequate for Astrophysics to execute its program as planned in FY15.
  - Includes support as planned in FY15 for missions under development, operating missions, SMEX AO, R&A, etc.
  - Final budget numbers available when NASA operating plan approved



# NASA Anticipated Accomplishments in FY16

**SLS/Orion:**  
Complete structural build of major components and begin testing



**ISS:** Increase utilization with science and technology payload hardware to 70 percent; Complete the One-year crew increment



**Commercial Crew Program:** Conduct Commercial Crew transportation system test flight and other milestones

**Launch 13 science and cargo missions and one commercial crew test**



**Asteroid Redirect Mission:** Complete definition of the ARM robotic mission segment



**JWST:** Integrate the JWST mirror with science instruments (cameras and spectrographs)



**Aeronautics:** Complete Capstone UAS flight demo to deliver 5 years of results; enable FAA regulations on integration



**Space Tech:** Transform technology with six major in-space demos





# FY16 President's Budget Request

Outyears are notional planning from FY16 President's budget request

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

- Supports operating missions: Chandra, Fermi, Hubble, Kepler, NuSTAR, SOFIA, Spitzer, and Swift.
- Funds development of Explorer missions TESS and NICER. TESS will continue the search for exoplanets, scanning all of the sky for Exoplanets closer to Earth than those found by Kepler.
- Supports pre-formulation studies for WFIRST/AFTA.
- Maintains a competed astrophysics research program and support of the balloon program.
- Supports the commitment of an October 2018 launch date for JWST.
  - ❖ Will deliver the Integrated Science Instrument Module for integration;
  - ❖ Completes integration of flight primary mirror subassemblies onto the flight primary mirror backplane;
  - ❖ Completes acceptance testing of the cryocooler compressor assembly;
  - ❖ Completes spacecraft bus structure; and
  - ❖ Completes the sunshield structure manufacture and test.

\* Excludes "SMD STEM Activities" in all years.



# FY16 President's Budget Request

Outyears are notional planning from FY16 President's budget request

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

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

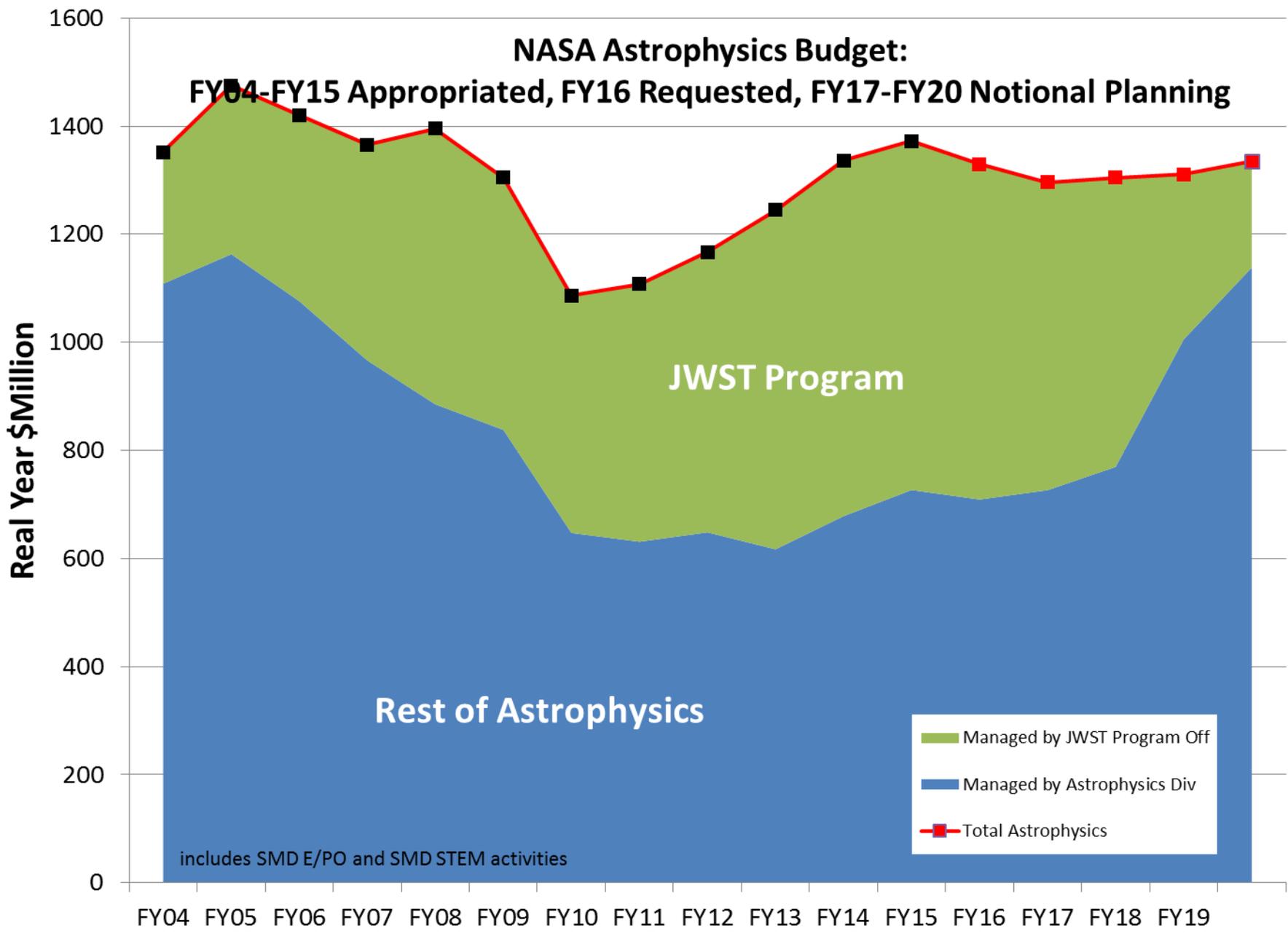
\* Excludes “SMD STEM Activities” in all years.



# NASA Astrophysics Budget:

FY04-FY15 Appropriated, FY16 Requested, FY17-FY20 Notional Planning

Real Year \$Million



Rest of Astrophysics

JWST Program

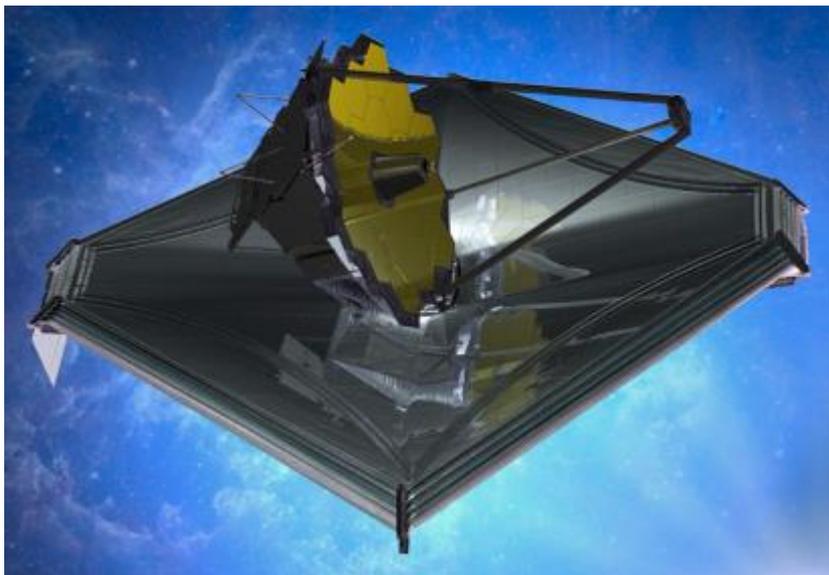
- Managed by JWST Program Off
- Managed by Astrophysics Div
- Total Astrophysics

includes SMD E/PO and SMD STEM activities



# JWST

## James Webb Space Telescope



### Large Infrared Space Observatory

Top priority of 2000 Decadal Survey

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

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

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

**Operations:** 2018 launch for a 5-year prime mission

**Partners:** ESA, CSA

### 2014 Accomplishments

- Highly successful second cryovacuum test of ISIM
- Deployment testing of full-scale engineering unit sunshield
- Spacecraft manufacturing initiated
- Telescope Pathfinder completed
- Telescope Flight Backplane completed

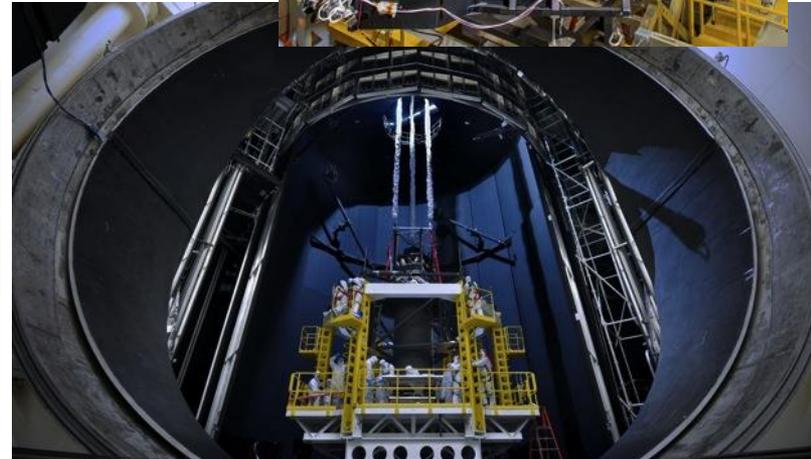
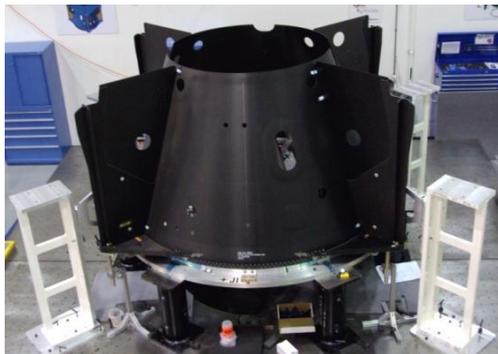
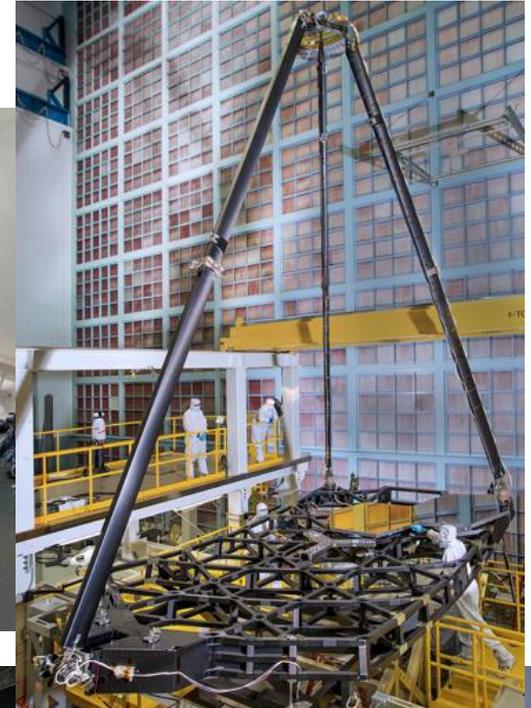
### 2015 Plans

- Complete Instrument hardware replacements, and test ISIM for the final time before integration into observatory
- Conducts tests at JSC in preparation for 2016 full telescope and instrument test
- Complete MIRI cryocooler
- Start Assembly of the Primary mirror

<http://jwst.nasa.gov/>



# JWST Hardware Progress



JWST remains on track for an October 2018 launch within its replan budget guidelines



# Hubble Space Telescope 25th Anniversary

## Sample of Events & Programs:

- Webcast event at National Air & Space Museum April 24
- Coordinated events worldwide April 24
- Family Day at Udvar-Hazy April 25
- Hubble 2020 STScI symposium
- Exhibits at museums around the world
- Exhibits at multiple airports
- Nationwide University lecture series
- Education programs in all 50 states
- SXSW exhibit (and other large events)
- Comprehensive traditional & social media outreach plans
- 'Ode to Hubble' video contest
- Planetaria clips
- Re-release of IMAX 'Hubble 3D'



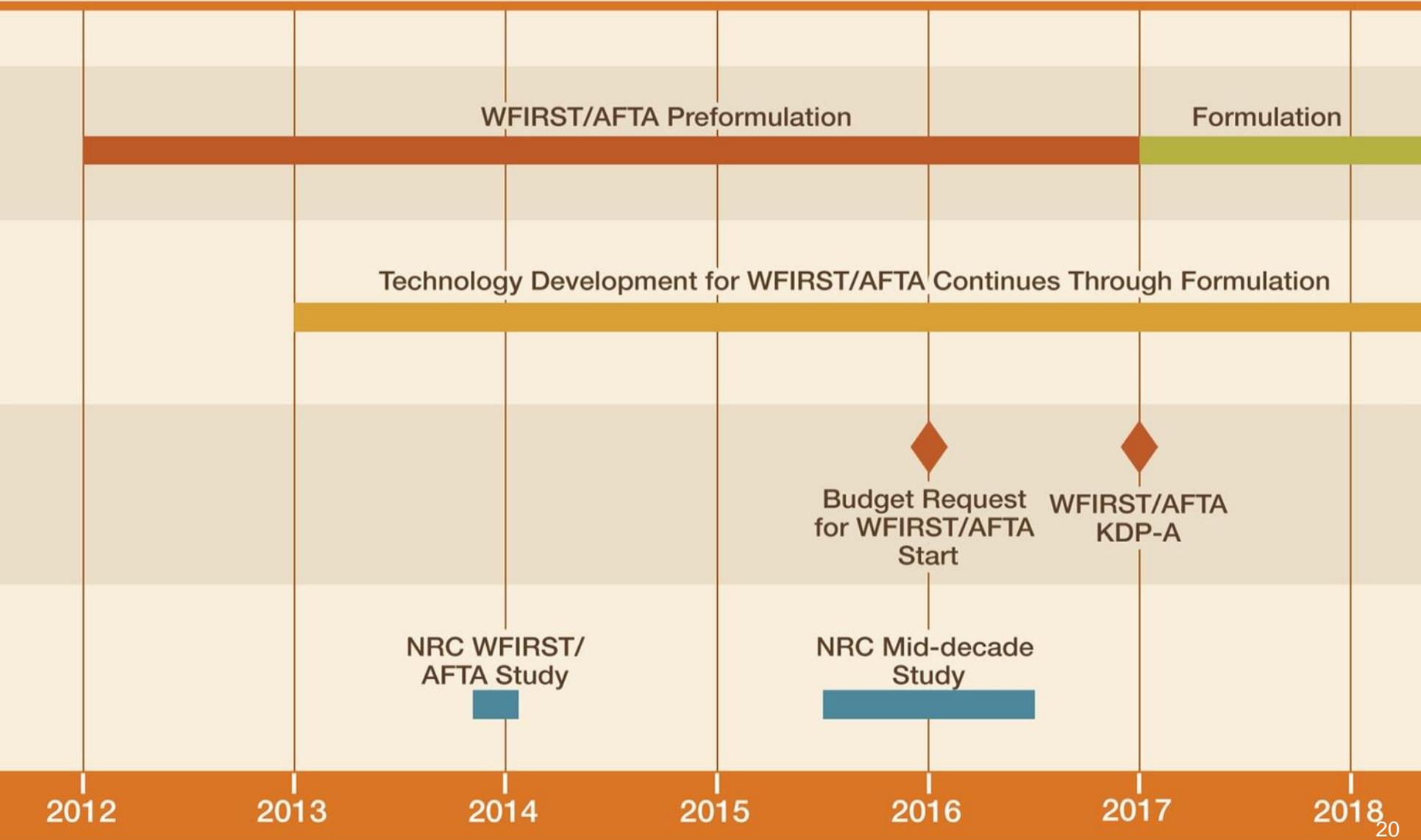
**Join the celebration: #Hubble25**



# Plan for WFIRST/AFTA Preformulation

## Widefield Infrared Survey Telescope using Astrophysics Focused Telescope Assets

### WFIRST/AFTA timeline





# WFIRST / AFTA

Widefield Infrared Survey Telescope with Astrophysics Focused Telescope Assets

## 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 CY 2016.
- Currently in pre-formulation phase.
  - Activities include technology development for detectors and coronagraph (with STMD), assessment of the 2.4m telescopes including risk mitigation, mission design trades, payload accommodation studies, and observatory performance simulations.
- Maturing key technologies 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).
- March 2014 NRC study on WFIRST/AFTA offers positive view of AFTA, with concerns about technology and cost risks.
- WFIRST Preparatory Science (WPS) funds ROSES proposals that are relevant to WFIRST's goals and WFIRST-specific simulations and models.
- SDT final report submitted January 31, 2015, and available online soon.



### Widefield Infrared Survey Telescope

Top priority of 2010 Decadal Survey

**Science themes:** Dark Energy, Exoplanets, Large Area Near Infrared Surveys

**Mission:** 2.4m widefield telescope at GEO, uses existing AFTA hardware to image 0.28 deg<sup>2</sup> at 0.8-2.0 μm

**Instruments (design reference mission):**  
Wide Field Instrument, Coronagraph Instrument

- FY15 Budget Request and Appropriation support pre-formulation of WFIRST/AFTA
- Plans support Agency/Administration decision for formulation to begin NET FY 2017, should funding be available.

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



# 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

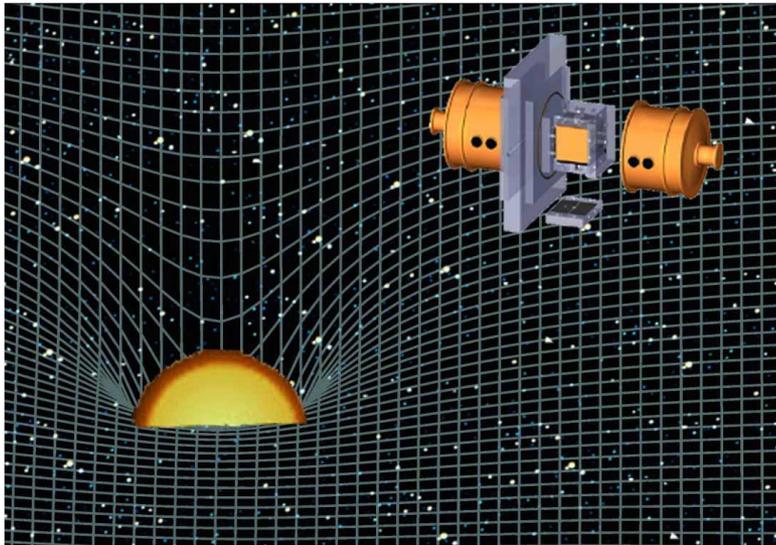
### CURRENT STATUS:

- Kepler "K2" observation method 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 fourth 75-day Campaign commenced in February 2015 and runs until April 2015.
  - Targets are selected via proposals from the community. Cycle 2 proposals (covering Campaigns 6-7) were due February 27, 2015
  - December 18, 2014: First confirmed planet discovery using K2 observation method
- 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 4 years of Kepler data has revealed:
  - Approximately 4200 exoplanet candidates
  - Over 1000 candidates confirmed as planets to date
  - More than 100 planets discovered in their star's "habitable zone".
- Analysis of the full (4+ year) Kepler data set ongoing.



# 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 (date TBD)
- Operational life: 2 months
- Data Analysis: 12 months

### CURRENT STATUS:

- Ongoing tests at Airbus UK testbed
- Extended mission being discussed
- Spacecraft has shipped from Airbus to IABG for the environmental test - arrived in early March.
- NASA analysis team is supporting as needed.
- System level thermal vacuum test in April/May 2015
- System level acoustics and mass properties in May 2015
- Shipping in August to launch site



# ASTRO-H

## Soft X-ray Spectrometer and Soft X-ray Telescope Mirrors



### 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 in the FM Dewar and has successfully performed during all testing activities.
- Completed FM Dewar cryo performance testing in December with excellent results.
- Supporting additional dewar testing in preparation for integration onto spacecraft.

### UPCOMING EVENTS:

- March 19-20 – Systems Integration review
- March 25 2015 - SXS dewar integration onto spacecraft
- Summer 2015 (TBD) – Start of spacecraft testing

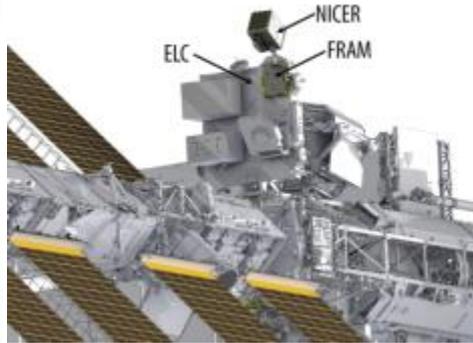
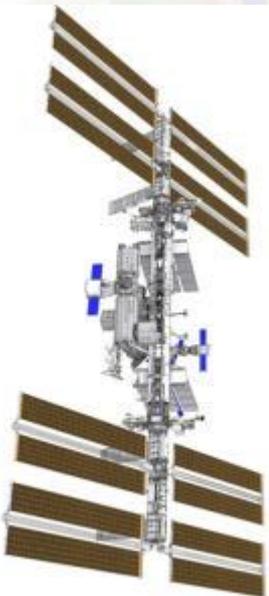
- **Explorer Mission of Opportunity**
- **PI:** R. Kelley, Goddard Space Flight Center
- **Launch Date:** Nov 2015 on JAXA H-IIA
- **Science Objectives:** Study the physics of cosmic sources via high-resolution X-ray spectroscopy. The SXS will enable a wide range of physical measurements of sources ranging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



# 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

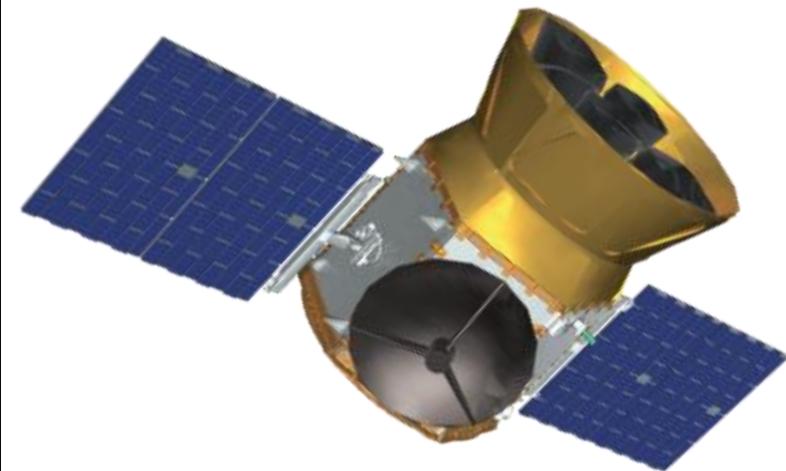
### CURRENT STATUS:

- Project successfully passed Critical design review (CDR) September 2014
- Design is maturing quickly; engineering test units of many subsystems have been developed and tested. Fabrication has started on the instrument optical bench, detector subassemblies, and pointing system, and electrical subsystem
- Integration of the x-ray timing instrument to start in March 2015, to support testing, beginning in June 2015



# 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 nearby, bright stars.

**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:** 3-year science mission after launch.

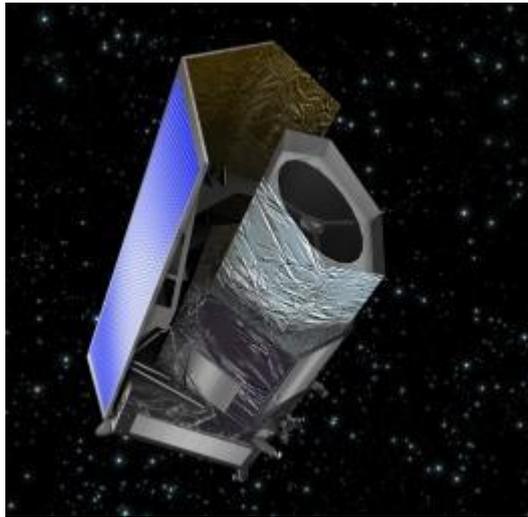
### CURRENT STATUS:

- Downselected April 2013.
- Major partners:
  - PI and science lead: MIT
  - Project management: NASA GSFC
  - Instrument: Lincoln Laboratory
  - Spacecraft: Orbital Science Corp
- Agency launch readiness date NLT June 2018 (working launch 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



### CURRENT STATUS:

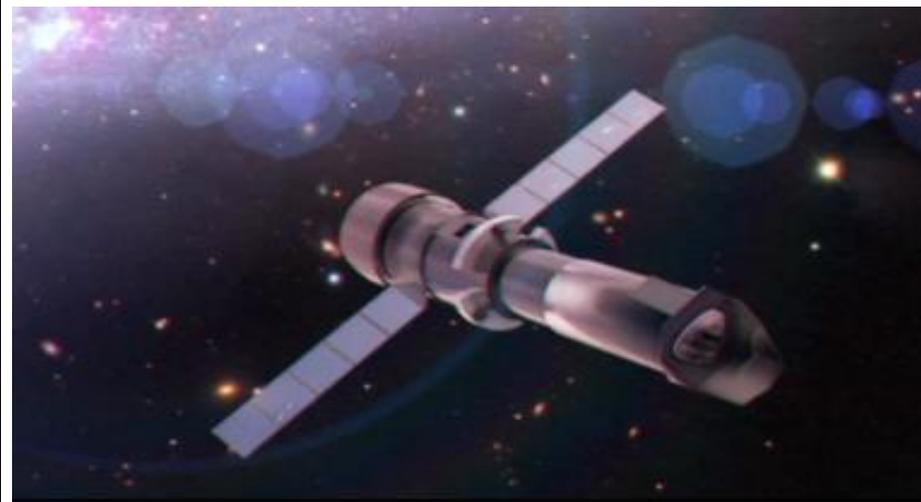
- Currently in implementation phase.
- ~50 U.S. scientists are members of the Euclid Science Team that will analyze the data, and make maps of the sky.
- NASA is providing the sensor assembly for the NISP instrument.
  - First experimental manufacturing run for the Euclid near-infrared detectors was completed in FY 2014 (ESA) and are currently being evaluated and characterized.
  - NASA has initiated the buy for the flight infrared detectors. First lot is complete with a better than expected yield, moving into hybridization phase and growing the second lot of layers. NASA will test and characterize the near-IR flight detectors.
  - Final proposal for detector contract received from Teledyne in February 2015.
- 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

- **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.



# Athena

## Advanced Telescope for High Energy Astrophysics



### CURRENT STATUS:

- Selected as 2<sup>nd</sup> Large mission in ESA Cosmic Visions Program
  - Currently in 2 year Study Phase
  - NASA and US community involved in Study Phase via membership on ESA-chartered Athena Science Study Team and Science Working Groups
  - NASA budgeting for a \$100M-\$150M hardware contribution, plus a US GO program and a U.S. data center
  - NASA and ESA are discussing possible NASA contributions, such as:
    - Sensor array to the X-ray Integral Field Unit
    - Portions of the X-ray Mirror
    - Contribution to science data center (U.S. node)
  - NASA continues to invest in Athena technologies via SAT and directed investigations.
- **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?



# 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/NSF Partnership using NOAO share of WIYN telescope
  - Enable a community based exoplanet research program in support of NSF research interests and NASA mission goals (e.g., Kepler, K2, TESS, JWST, WFIRST, etc.).
  - Provide US astronomical community with open access to a world-class precision radial velocity facility instrument
- Anticipated timeline:
  - 2015-2018 – Exoplanet-targeted Guest Observer program with existing instrumentation on WIYN using NOAO share of WIYN time starting 2015B
  - 2015-2018 – NASA funded development of facility-class Extreme Precision Doppler Spectrometer (EPDS) for the WIYN telescope
    - January 2015 – EPDS solicitation as amendment to ROSES 2014 NRA
    - August 2015 – announcement of selection, initiation of project
    - 2017/2018 – commissioning of EPDS and beginning of operations
  - 2018-TBD – Exoplanet-targeted Guest Observer and guaranteed time program at WIYN with EPDS instrument and existing WIYN instruments



# 2014 Astrophysics Explorers AO

- AO released September 17, 2014.
  - Small Explorer (SMEX), cost cap \$125M + LV (or \$175M)
  - Mission(s) of Opportunity, cost cap \$65M for space, \$35M for suborbital-class
  - US Participating Investigators
- Notice of intent were due October 15, 2014.
  - NASA received ~30 NOIs
- Proposals received December 18, 2014.
  - NASA received ~25 proposals (total of all three categories)
- Step 1 Selections expected ~Summer 2015
- Step 2 Downselections expected ~early 2017
- Launch Readiness Date NLT end of 2020

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



# 2015 ROSES and GO Due Dates

| Proposal Opportunity                    | Due Date      | Reference  |
|---|---------------|--|
| Fermi Guest Investigator – Cycle 8      | January 22    | ROSES-14   |
| Kepler K2 Guest Observer – Cycle 2      | February 27   | ROSES-14   |
| Chandra X-ray Observatory – Cycle 17    | March 17      | <a href="http://chandra.harvard.edu">chandra.harvard.edu</a>         |
| Astrophysics R&A (APRA)                 | March 20      | ROSES-14   |
| Strategic Astrophysics Technology (SAT) | March 20      | ROSES-14   |
| Hubble Space Telescope – Cycle 23       | April 10      | <a href="http://www.stsci.edu/hst">www.stsci.edu/hst</a>             |
| Astrophysics Data Program (ADAP)        | May 15        | ROSES-15   |
| Exoplanet Research Program (XRP)        | May 22        | ROSES-15   |
| SOFIA – Cycle 4                         | ~June         | <a href="http://www.sofia.usra.edu">www.sofia.usra.edu</a>           |
| Spitzer Space Telescope – Cycle 12      | August        | <a href="http://ssc.spitzer.caltech.edu">ssc.spitzer.caltech.edu</a> |
| Kepler K2 Guest Observer – Cycle 3      | September 23  | ROSES-15   |
| Swift Guest Investigator – Cycle 12     | September 25  | ROSES-15   |
| N.G. Roman Technology Fellowships (RTF) | November 6    | ROSES-15   |
| NuSTAR Guest Observer – Cycle 2         | November 16   | ROSES-15   |
| Astrophysics Theory Program (ATP)       | Not this year |  |



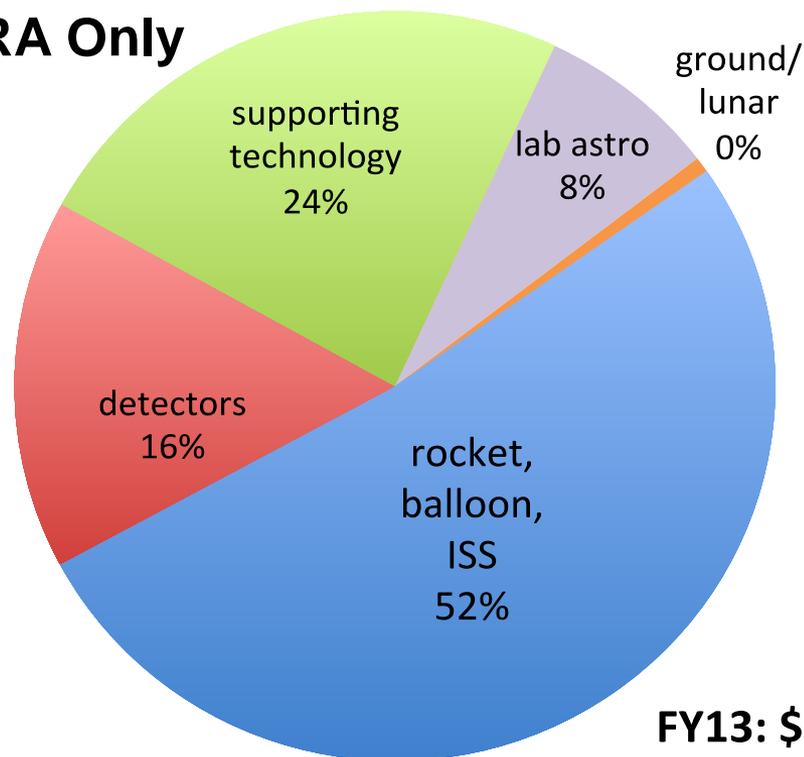
# Astrophysics Research Program Funding

## Snapshot: Most Recent Year

|              | Proposals<br>Rec'd | Year-1<br>\$M | Proposals<br>selected | Success<br>Rate |
|--------------|--------------------|---------------|-----------------------|-----------------|
| APRA-13      | 179                | 10.0          | 44                    | 25%             |
| SAT-13       | 18                 | 5.4           | 10                    | 56%             |
| ADAP-14      | 300                | 7.5           | 62                    | 21%             |
| XRP-14       | 62                 | 1.3           | 11                    | 18%             |
| ATP-14       | 214                | 4.4           | 29                    | 14%             |
| <b>TOTAL</b> | <b>773</b>         | <b>28.6</b>   | <b>156</b>            | <b>20%</b>      |

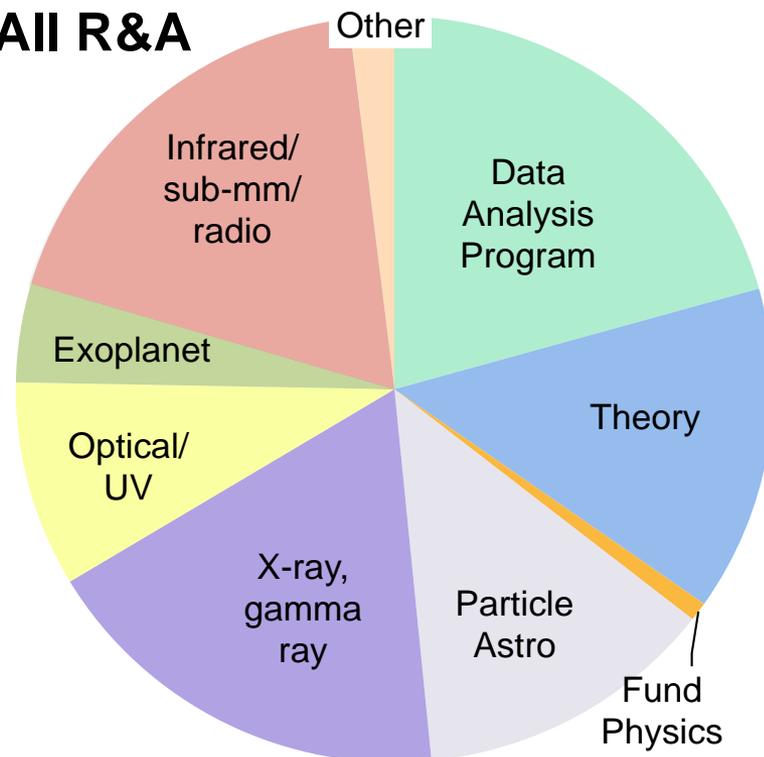
Does not include  
RTF, TCAN, WPS,  
GO programs

### APRA Only



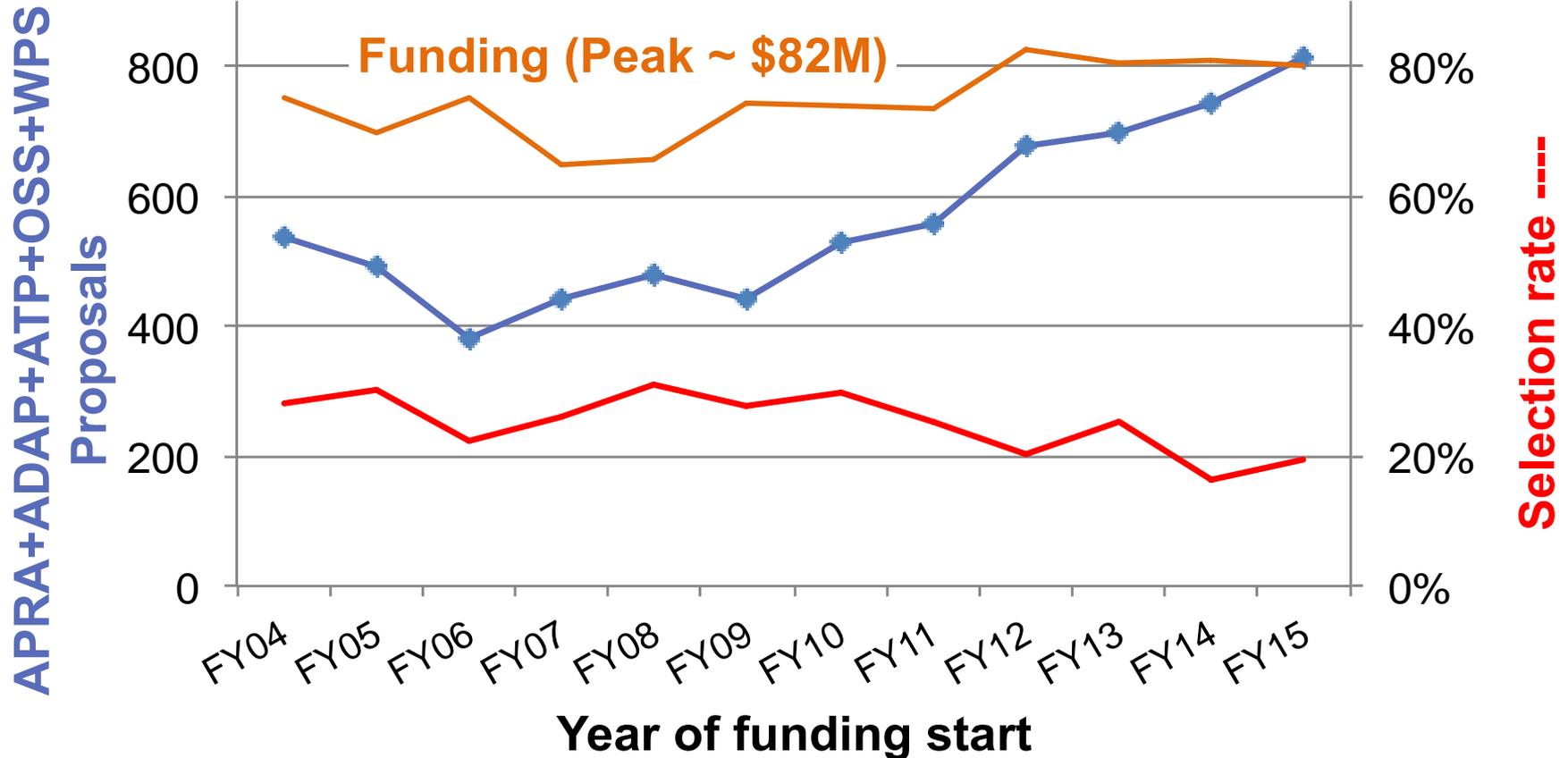
**FY13: \$47.7M**

### All R&A





# Astrophysics ROSES selection rates



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



# SMD Science Education

- Education is funded in the FY15 NASA Appropriation Act at \$42M SMD-wide as a separate budget line (so E/PO is no longer budgeted as 1% of every mission).
- SMD will compete and consolidate education activities for FY16.
- SMD has released 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 objectives: Enabling STEM education; Improving U.S. science literacy; Advancing National education goals; and Leveraging science education through partnership.
- The schedule is as follows:

|  |   |
|--|---|
| CAN Release Date                       | February 4, 2015  |
| Preproposal Conference                 | February 27, 2015   |
| Notice of Intent to Propose Deadline   | March 9, 2015   |
| Electronic Proposal Submittal Deadline | May 4, 2015   |
| Selections Announced (target)          | ≤ 120 days after receipt of proposals, with initial awards distributed in FY 2015 |



# Planning for the 2015-2016 Mid-Decade Review

- The NASA Authorization Act of 2005 requires assessments of NASA's science programs that include mid-decade reviews.
  - The Astrophysics Mid-Decade Review will be during 2015-2016
  - Study will be co-sponsored by NASA, NSF, and DOE (the Agencies)
- Given the funding circumstances that are substantially below those assumed in the Decadal Survey, the committee's review will describe:
  - The most significant scientific discoveries, technical advances, and relevant programmatic changes in astronomy and astrophysics since the Decadal Survey;
  - How well the Agencies' programs address the strategies, goals, and priorities outlined in the Decadal Survey and other NRC reports;
  - Progress toward realizing these strategies, goals and priorities; and
  - Any actions that could be taken to maximize the science return of the Agencies' programs.
- The Agencies are in the process of charging the NRC, and formation of the Study Committee will begin soon.



# Progress Toward Decadal Survey Priorities

The NASA FY15 Appropriation, the President's FY16 Budget Request, and the notional out year budget planning guidance in the President's FY16 Budget Request, 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. Budget line established for an Astrophysics Decadal Strategic Mission.   |
| Large-scale 2. Augmentation to Explorer Program           | Astrophysics Explorers planned budget increased to support decadal cadence of AOs including SMEX AO in Fall 2014 and MIDEX AO in late 2016/early 2017.  |
| Large-scale 3. LISA                                       | Discussing partnership on ESA's L3 gravitational wave observatory and participating in ESA-led assessments in 2014-2015. Strategic astrophysics technology (SAT) investments plus support of LISA Pathfinder.   |
| Large-scale 4. IXO  | NASA is pursuing a partnership on ESA's L2 Athena X-ray observatory; the Athena study phase, with U.S. participation, is underway. Strategic astrophysics technology (SAT) investments.   |
| 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. Established partnership with NSF to develop extreme precision Doppler spectrometer as facility instrument. Exozodi survey using LBTI. |



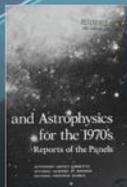
# Progress Toward Decadal Survey Priorities

The NASA FY15 Appropriation, the President's FY16 Budget Request, and the notional out year budget planning guidance in the President's FY16 Budget Request, support:

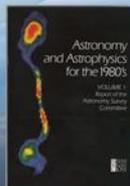
|  |  |
|--|--|
| Medium-scale 2. Inflation Probe Technology Development Program | Balloon-borne investigations plus strategic astrophysics technology (SAT) investments.   |
| Small-scale. Research Program Augmentations                    | Increased annual R&A budget by 10% from FY10 to FY12 and another 10% from FY14 to FY16. 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

## Decadal Survey Missions



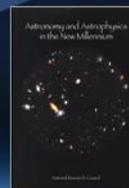
**1972**  
Decadal  
Survey  
*Hubble*



**1982**  
Decadal  
Survey  
*Chandra*



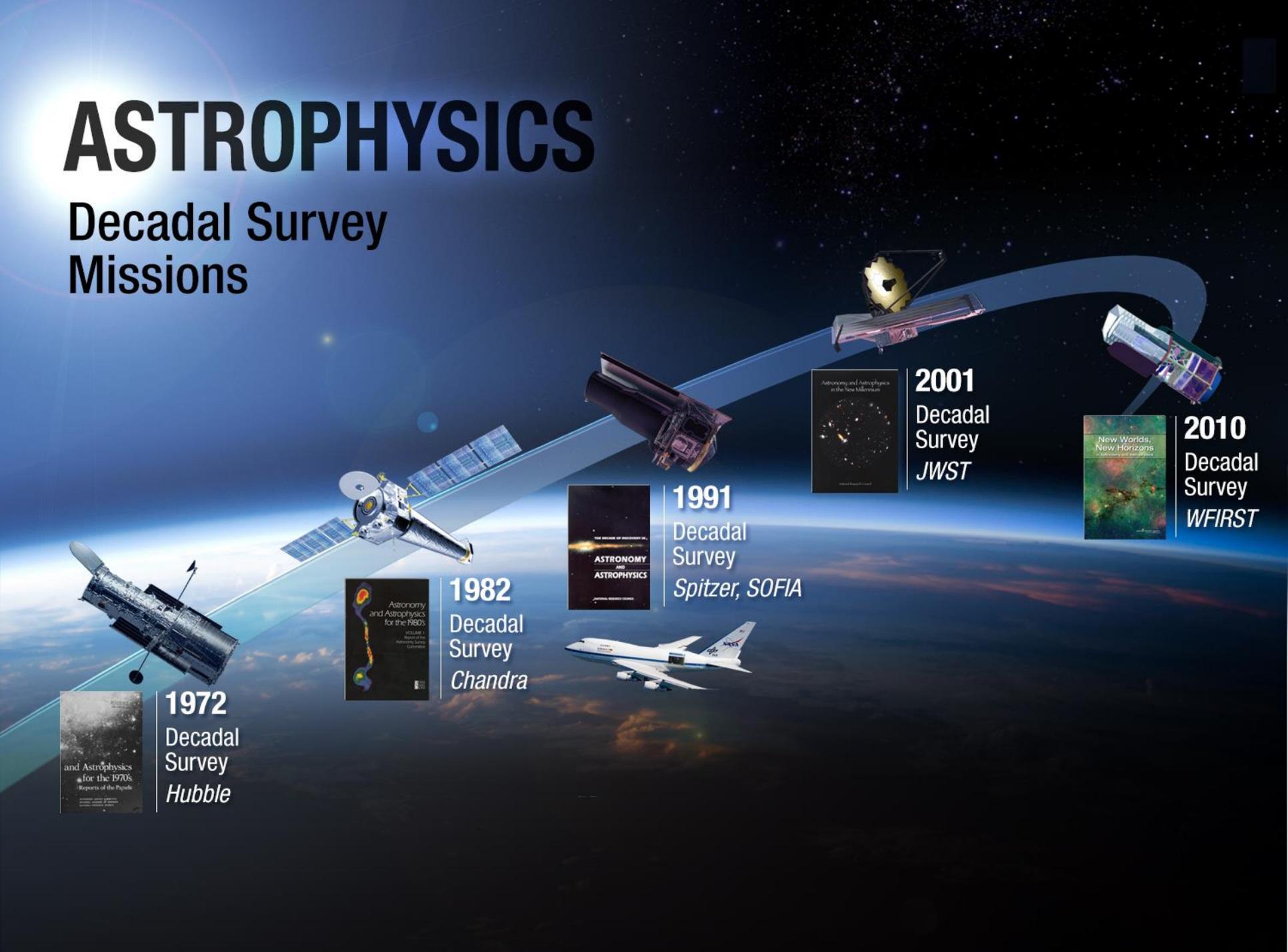
**1991**  
Decadal  
Survey  
*Spitzer, SOFIA*



**2001**  
Decadal  
Survey  
*JWST*



**2010**  
Decadal  
Survey  
*WFIRST*





# Preparing for the 2020 Decadal Survey Large Mission Concepts

- The 2020 Decadal Survey will prioritize large space missions to follow JWST and WFIRST.
  - To enable this prioritization, NASA needs to provide information on several candidate large space mission concepts for consideration by the 2020 Decadal Survey Committee.
- What information needs to be provided to the Decadal Survey committee to enable prioritization of large missions
  - Science case
  - Strawman design reference mission with strawman payload
  - Technology development needs
  - Cost requirements assessment
- NASA needs to initiate technology development for candidate large missions so that technology will be ready when needed.
  - Technology needs to be sufficiently mature when it is time to start the highest priority large mission in the 2020 Decadal Survey.
  - The next large mission after WFIRST could be started when funding becomes available as WFIRST approaches launch in the early or mid-2020s.



# Preparing for the 2020 Decadal Survey Large Mission Concepts

## Part A – 2015

- Identify a small set of candidate large mission concepts to study
  - NASA draws a small set of candidate mission concepts from existing roadmap and strategic documents
  - Incorporate community input through the three Astrophysics Program Analysis Groups (PAGs)

## Part B – 2016-2019

- Initiate studies
  - Includes community-based Science and Technology Definition Teams
- Conduct studies
  - Includes NASA Center-provided engineering teams
- Identify technology requirements to motivate early technology development
  - Enables funding through existing Astrophysics technology programs
- Deliver results to 2020 Decadal Survey committee

*Planning for the 2020 Decadal Survey: An Astrophysics Division White Paper*  
available at <http://science.nasa.gov/astrophysics/documents>



# Preparing for the 2020 Decadal Survey

## Large Mission Concepts

Part A: Identify a small set (~3-4) of large mission concepts to study

- The community has invested considerable resources in discussing notional classes of mission concepts for consideration as large missions following JWST and WFIRST and in parallel with the ESA-led missions Euclid, Athena, and L3.
  - The 2010 Decadal Survey, *New Worlds New Horizons in Astronomy and Astrophysics*.
  - The 2014 Astrophysics Visionary Roadmap, *Enduring Quests, Daring Visions*.
- NASA has drawn an initial small set of 4 candidate mission concepts from the missions discussed in these strategic documents.
- I am charging the Astrophysics PAGs to solicit community input for the purpose of commenting on the small set, including adding or subtracting large mission concepts; each PAG will submit a report regarding the small set of large mission concepts for consideration by the NAC Astrophysics Subcommittee.
- At its Fall 2015 meeting, the NAC Astrophysics Subcommittee will consider the three PAG reports and submit a report to NASA on the small set of large mission concepts for study.
- The Director of the NASA Astrophysics Division will decide which large mission concepts will be studied as input for the 2020 Decadal Survey.



# Preparing for the 2020 Decadal Survey Large Mission Concepts

The initial short list (in alphabetical order):

- **FAR IR Surveyor** – The Astrophysics Visionary Roadmap identifies a Far IR Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution.
- **Habitable-Exoplanet Imaging Mission** – The 2010 Decadal Survey recommends that a habitable-exoplanet imaging mission be studied in time for consideration by the 2020 decadal survey.
- **UV/Optical/IR Surveyor** – The Astrophysics Visionary Roadmap identifies a UV/Optical/IR Surveyor as contributing through improvements in sensitivity, spectroscopy, high contrast imaging, astrometry, angular resolution and/or wavelength coverage. The 2010 Decadal Survey recommends that NASA prepare for a UV mission to be considered by the 2020 Decadal Survey.
- **X-ray Surveyor** – The Astrophysics Visionary Roadmap identifies an X-ray Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution.



# Preparing for the 2020 Decadal Survey Thinking about Probes

- What was done 10 years ago?
  - Origins Probes Mission Concepts (2004)
    - ROSES call for quick (~9 month) paper concept studies
    - ~9 concepts selected in 2004; total funding ~\$1M (\$100K average)
  - Astrophysics Mission Concepts Study (AMCS; 2007)
    - ROSES call for ~1 year paper concept studies
    - Nineteen (+1) ASMC concepts selected in 2007; total funding \$13M (\$700K average)
  - Was this effective? Efficient? Appropriately impactful?
- Possibilities this time
  - Real mission concept studies
    - Just like we are doing for large mission concepts
    - How would we select them? Where does funding come from?
  - Paper mission concept studies
    - Just like AMCS, but limited to Probes
  - Self selected, self funded
    - Anybody can submit a white paper to the 2020 Decadal Survey
- Awaiting input from the PAG reports



# Recommendations from Nov 2014

The APS is satisfied with the AIP [Update] as presented and encourages the ApD to present it to the community and begin implementation as soon as possible.

Presented at Seattle AAS meeting and every opportunity since. Division is implementing as presented.

After some discussion about how potential missions might be selected for development funding, the APS recommended that the ApD Director solicit advice from the PAGs. Paul Hertz will draft a letter to the PAGs requesting their input on mission concepts worthy of early concept funding. The PAGs will be asked to use “Enduring Quests, Daring Visions: A Thirty-Year Roadmap for NASA Astrophysics” as a starting point since it is based on recent solicitations from the astrophysics community and another such solicitation would be an unwelcome new burden.

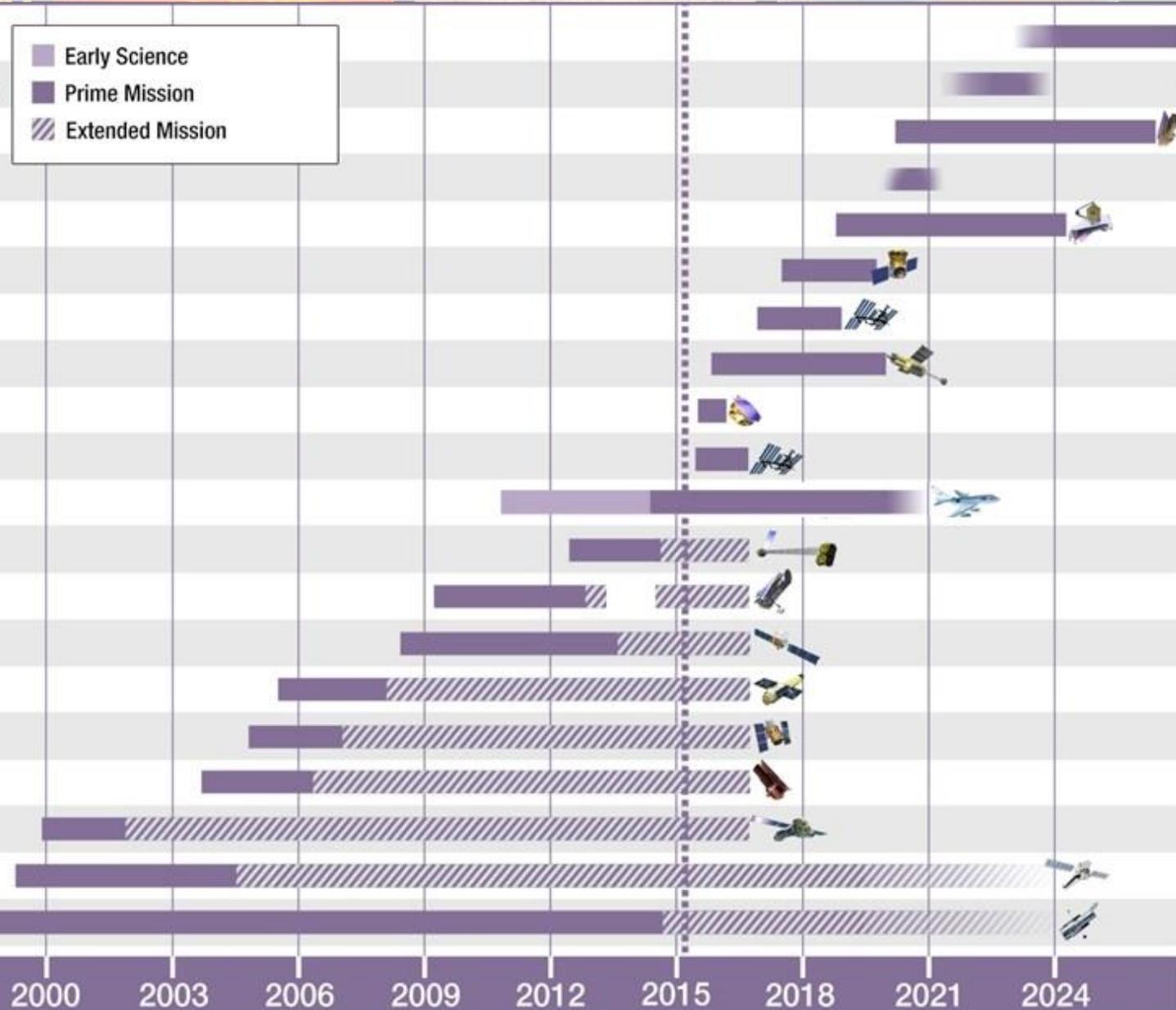
Based on discussions with APS (Nov 2014) and PAG Ecs (Dec 2014), NASA provided the starting set of mission concepts. “Planning for the 2020 Decadal Survey: An Astrophysics Division White Paper” was published to the community in Dec 2014. PAGs charged at joint PAG meeting prior to Seattle AAS meeting.



# Astrophysics Timeline

Decadal Survey Mission  
MIDEX/MO (AO NET 2016)  
Euclid (ESA)  
SMEX/MO (AO 2014)  
JWST (ESA, CSA)  
TESS  
NICER  
ASTRO-H (JAXA)  
ST-7/LPF (ESA)  
ISS-CREAM (South Korea)  
SOFIA (DLR)  
NuSTAR (ASI, Denmark)  
Kepler  
Fermi (DOE, Intl team)  
Suzaku (JAXA)  
Swift (ASI, UK)  
Spitzer  
XMM-Newton (ESA)  
Chandra (SRON)  
Hubble (ESA)

Early Science  
Prime Mission  
Extended Mission



TIMELINE CY

2000 2003 2006 2009 2012 2015 2018 2021 2024



# Backups



# Astrophysics 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  | FY 2015           | 15-24 months                                  |
| ROSES-2014 | July 11, 2014     | NLT 180 days after proposal receipt (NLT January 7, 2015) | FY 2016           | 15-24 months                                  |
| ROSES-2015 | Not solicited     |   |                   |   |
| ROSES-2016 | July 2016         | NLT 180 days after proposal receipt (Early January 2017)  | FY 2017           | 6-12 months                                   |

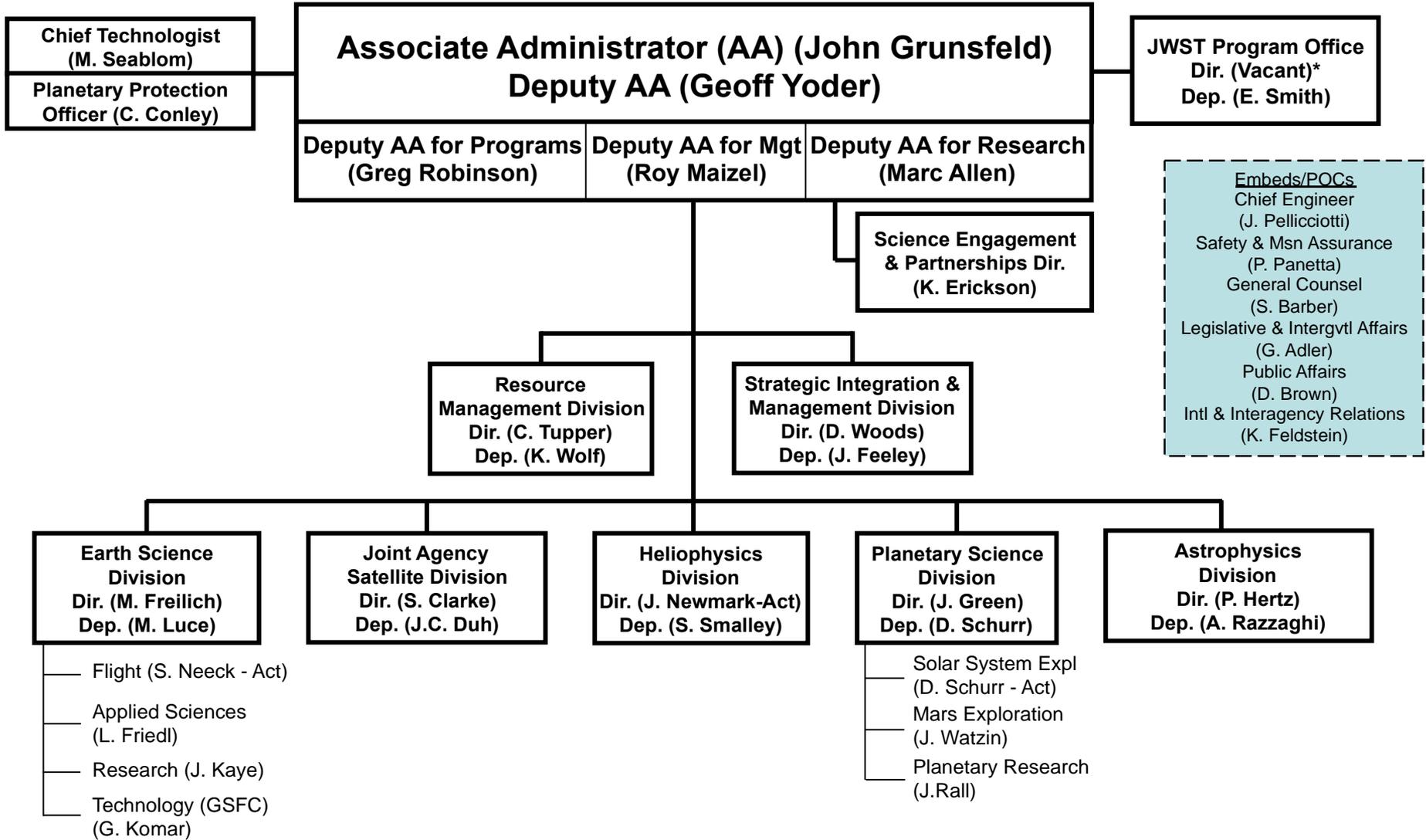


# FY15 and FY16 Planned Accomplishments

- The **TESS** Explorer Mission was confirmed to begin implementation (KDP-C) in Oct 2014
- SOFIA completed its Heavy Maintenance Visit in Dec 2014
- The **WFIRST/AFTA** science definition team final report completed Jan 30.
- JAXA's **ASTRO-H** mission to begin spacecraft system level test (KDP-D) in FY15 [~April 2015]
- The Astrophysics **Data Archives Senior Review** will be held in FY15 [spring 2015]
- The NRC **Mid-Decade Review** will begin in FY15 [spring 2015]
- A Critical Design Review (CDR) for NASA's contribution to ESA's **Euclid** will be held in FY15 [~Mar 2015]
- **Hubble** has achieved 25 years of operation in FY15 [Apr 2015]
- **TESS** will complete its Critical Design Review (CDR) in FY15
- The **ISS-CREAM** experiment will be launched to the International Space Station (KDP-E) in FY15/FY16 [LRD under review]
- **SOFIA** program management will transition from Armstrong Flight Research Center (AFRC) to Ames Research Center (ARC) in FY15 [NLT summer 2015]
- The Step 1 selection (KDP-A) will be made for the next Small Astrophysics **Explorer** and Explorer Mission of Opportunity in FY15 [summer 2015]
- ESA's **LISA Pathfinder** with NASA's ST-7 experiment will launch (KDP-E) in FY15/FY16 [NET Jul 2015]
- **NICER** will begin system level test (KDP-D) in FY15/FY16 [~Sep 2015]
- JAXA's **ASTRO-H** mission will launch (KDP-E) in FY16 [NET Nov 2015]
- NASA will select its contribution to ESA's L2 **Athena** mission study in FY16 [ESA AO in spring 2016]
- The Astrophysics **Operating Missions Senior Review** will be held in FY16 [spring 2016]
- Four **Balloon** campaigns are planned in FY15, and four campaigns are planned in FY16
- Five Astrophysics **Sounding Rocket** payloads are planned in FY15, and several are planned in FY16



# SMD Organization



\* Direct report to NASA Associate Administrator

# Astrophysics Division - Science Mission Directorate

February 3, 2015

## Resource Management

Omana Cawthon+  
Clemencia Gallegos-Kelly+

## Director

Paul Hertz

## Deputy Director

Andrea Razzaghi

Lead Secretary: Kelly Johnson

Secretary: Leslie Allen

Program Support Specialist: Jackie Mackall

## Cross Cutting

Technology Lead: Billy Lightsey\*

Division E/PO POC: Hashima Hasan (Lead Comm Team)

Division Public Affairs POC: Lisa Wainio\*

Information Manager: Lisa Wainio\*

Hubble 25 Coordinator: Amber Straughn\*

## Astrophysics Research

Program Manager: Wilt Sanders\*

Program Support: Janet Larson\*

Astrophysics Data Analysis: Doug Hudgins

Astrophysics Theory: Keith MacGregor\*

Exoplanet Research: Mario Perez\*

APRA lead: Michael Garcia\*

Cosmic Rays, Fund Physics: Vernon Jones, Keith MacGregor\*

Gamma Ray/X-ray: Michael Garcia\*, Stefan Immler\*,

Lou Kaluzienski, Rita Sambruna, Wilt Sanders\*

Optical/Ultraviolet: Michael Garcia\*, Hashima

Hasan, Mario Perez\*, Martin Still\*, Debra Wallace\*

IR/Submillimeter/Radio: Dominic Benford\*, Doug

Hudgins, Eric Tollestrup\*

Lab Astro: Vacant

Theory & Comp Astro Net: Keith MacGregor\*

Roman Tech Fellows: Billy Lightsey\*

Data Archives: Hashima Hasan(PS), Debra Wallace(PE)

Astrophysics Sounding Rockets: Wilt Sanders\*

Balloons Program: Vernon Jones(PS), Mark Sistilli (PE)

## Programs / Missions

|                                      | <u>Program Scientist</u> | <u>Program Executive</u>     |
|--------------------------------------|--------------------------|------------------------------|
| <b>Exoplanet Exploration (EXEP)</b>  |                          |                              |
| <b>Program</b>                       | <b>Doug Hudgins</b>      | <b>John Gagosian</b>         |
| Keck                                 | Hashima Hasan            | Mario Perez*                 |
| Kepler/K2                            | Debra Wallace*           | Keith Chamberlin*/Jeff Hayes |
| LBTI                                 | Hashima Hasan            | Mario Perez*                 |
| NExSci                               | Hashima Hasan            | Mario Perez*                 |
| <b>Cosmic Origins (COR)</b>          |                          |                              |
| <b>Program</b>                       | <b>Mario Perez*</b>      | <b>Jeanne Davis</b>          |
| Herschel                             | Dominic Benford*         | Jeff Hayes                   |
| Hubble                               | Michael Garcia*          | Jeff Hayes                   |
| JWST                                 | Hashima Hasan            | N/A ^                        |
| SOFIA                                | Eric Tollestrup*         | John Gagosian                |
| Spitzer                              | Keith Macgregor*         | Jeff Hayes                   |
| <b>Physics of the Cosmos (PCOS)</b>  |                          |                              |
| <b>Program</b>                       | <b>Rita Sambruna</b>     | <b>Jeanne Davis</b>          |
| Athena                               | Michael Garcia*          | Jeanne Davis                 |
| Chandra                              | Stefan Immler*           | Jeff Hayes                   |
| Euclid                               | Eric Tollestrup*         | Keith Chamberlin*            |
| Fermi                                | Keith MacGregor*         | Jeff Hayes                   |
| Planck                               | Rita Sambruna            | Jeff Hayes                   |
| ST-7/LPF                             | Wilt Sanders*            | Keith Chamberlin*            |
| XMM-Newton                           | Stefan Immler*           | Jeff Hayes                   |
| <b>Astrophysics Explorers (APEX)</b> |                          |                              |
| <b>Program</b>                       | <b>Wilt Sanders*</b>     | <b>Mark Sistilli</b>         |
| ASTRO-H                              | Lou Kaluzienski          | Jeanne Davis                 |
| NICER                                | Rita Sambruna            | Jeanne Davis                 |
| NuSTAR                               | Lou Kaluzienski          | Jeff Hayes                   |
| Suzaku                               | Stefan Immler*           | Jeff Hayes                   |
| Swift                                | Martin Still*            | Jeff Hayes                   |
| TESS                                 | Doug Hudgins             | Mark Sistilli                |
| WFIRST/AFTA                          | Dominic Benford*         | John Gagosian                |

+ Member of the Resources Mgmt Division

\* Detailee, IPA, or contractor

^ JWST now part of the JWST Program Office.

Linda Sparke on detail to MSFC