



# The Decadal Timeline for NASA Astrophysics

X-ray Surveyor Workshop  
Washington DC  
October 6, 2015

# Astrophysics

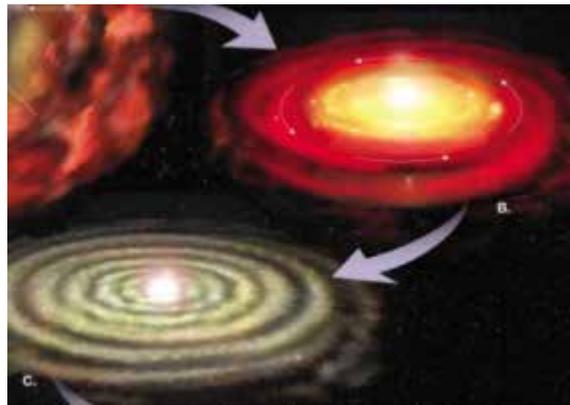
## Paul Hertz

Director, Astrophysics Division  
Science Mission Directorate



# Why Astrophysics?

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

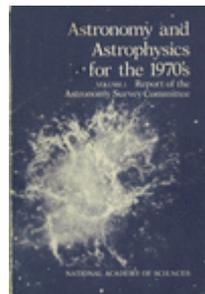


1. How did our universe begin and evolve?

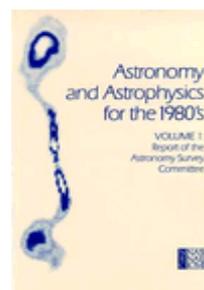
2. How did galaxies, stars, and planets come to be?

3. Are We Alone?

These national strategic drivers are enduring



1972



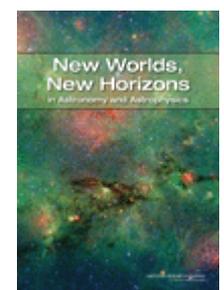
1982



1991



2001



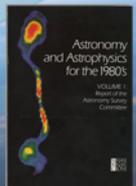
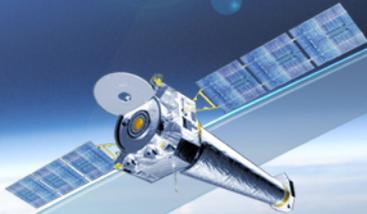
2010

# ASTROPHYSICS

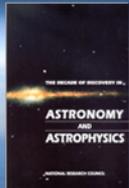
## Decadal Survey Missions



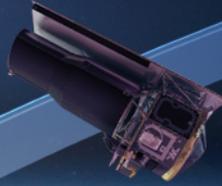
**1972**  
Decadal Survey  
*Hubble*



**1982**  
Decadal Survey  
*Chandra*



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



**2001**  
Decadal Survey  
*JWST*

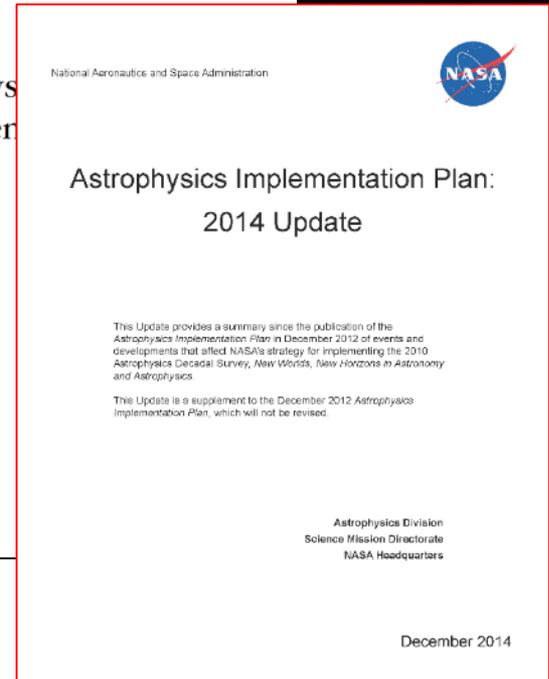
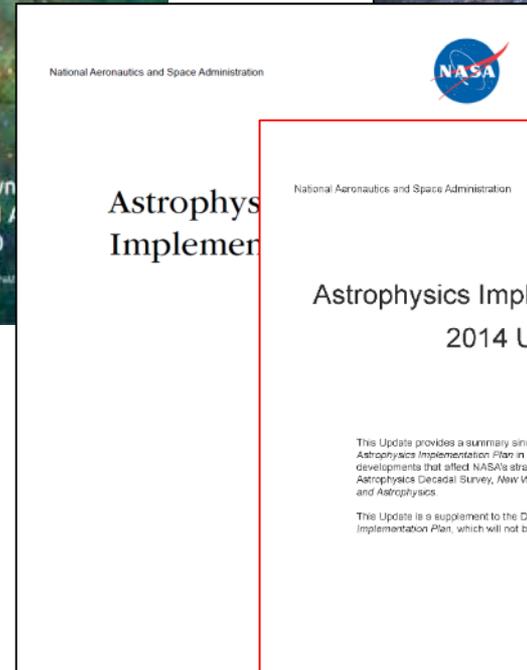
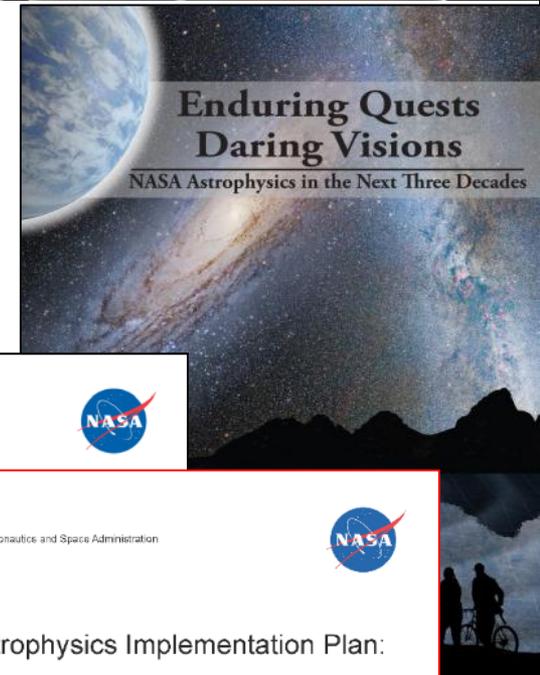
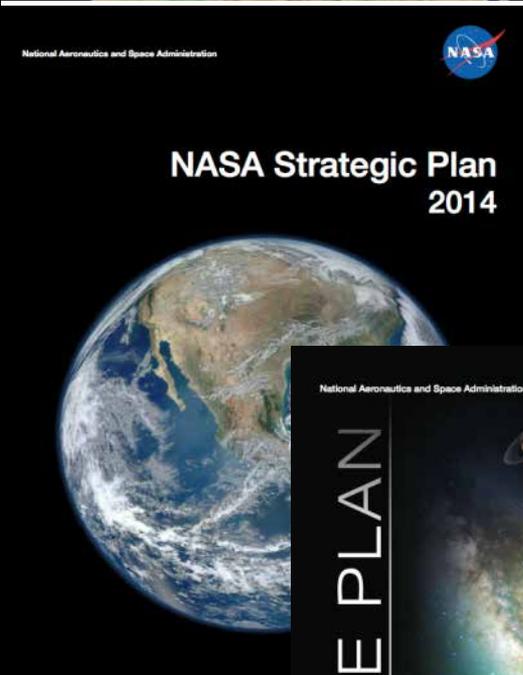


**2010**  
Decadal Survey  
*WFIRST*



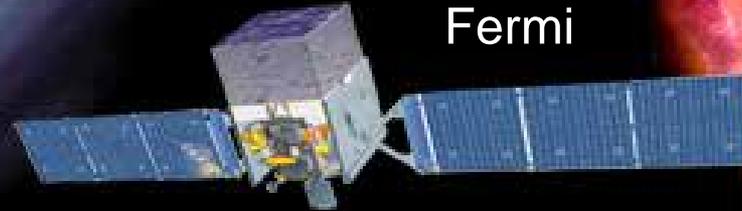


# Astrophysics Driving Documents



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

# Astrophysics Missions Launched Recently



Fermi

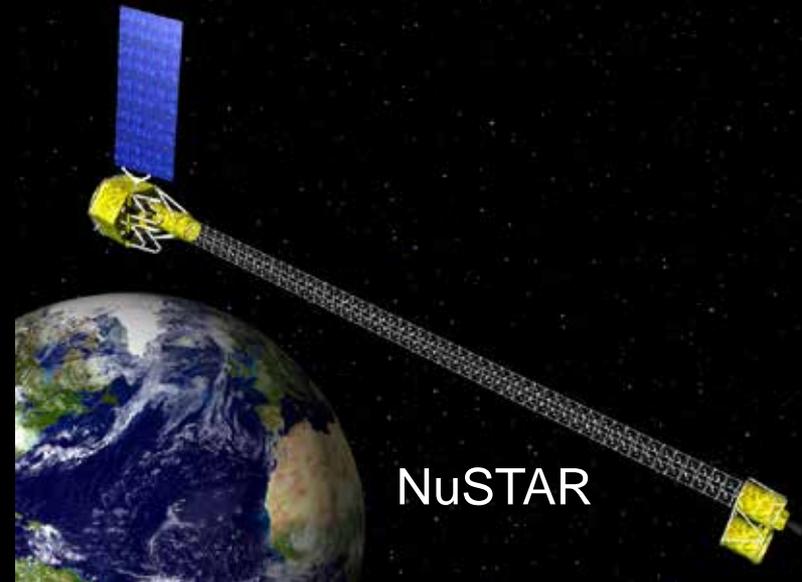
Fermi – June 2008  
Kepler – March 2009  
NuSTAR – June 2012  
SOFIA – May 2014 (full operations)



Kepler



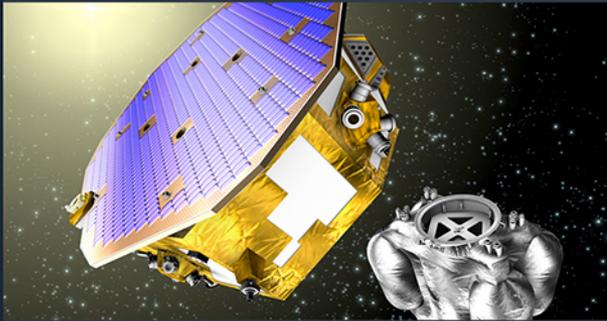
SOFIA



NuSTAR

# Astrophysics Missions in Development

## LISA Pathfinder <sup>12/2015</sup> ESA-led Mission



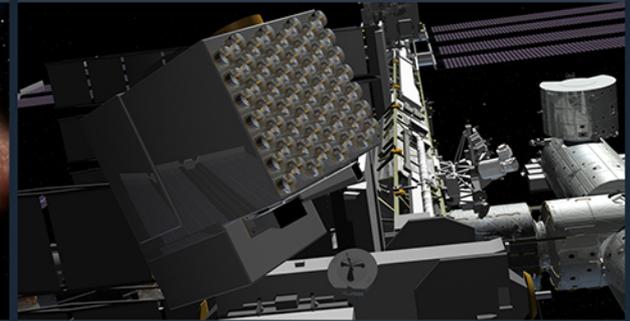
NASA supplied the ST7/Disturbance Reduction System (DRS)

## ASTRO-H <sup>NET 11/2015</sup> JAXA-led Mission



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

## NICER <sup>8/2016</sup> NASA Mission



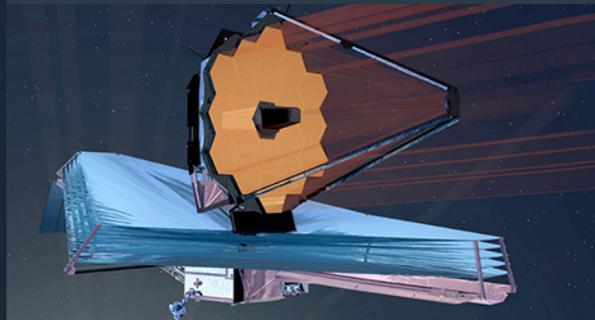
Neutron Star Interior Composition Explorer

## TESS <sup>8/2017</sup> NASA Mission



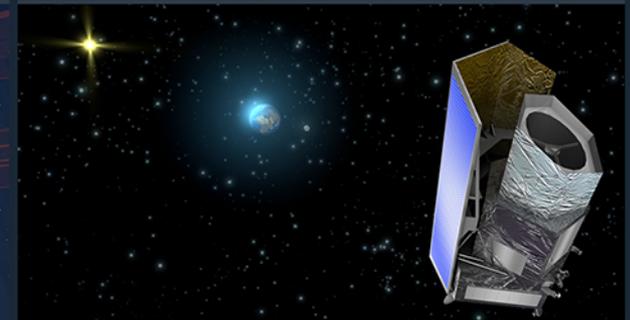
Transiting Exoplanet Survey Satellite

## JWST <sup>10/2018</sup> NASA Mission



James Webb Space Telescope

## Euclid <sup>2020</sup> ESA-led Mission



NASA is supplying the NISP Sensor Chip System (SCS)

# Astrophysics Missions in Pre-Formulation



SMEX / MO – 2019/2020

see next chart for list of selections

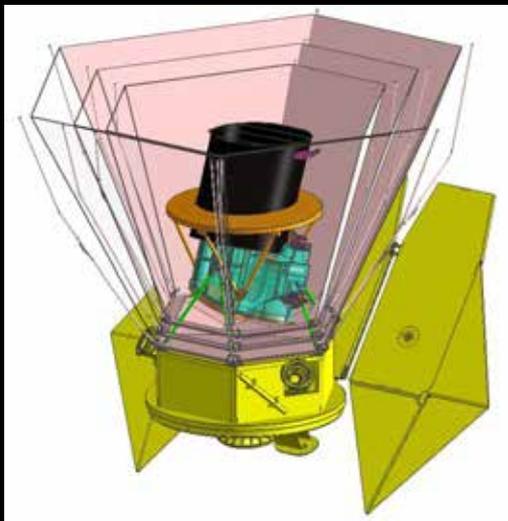
MIDEX / MO – 2022/2023

WFIRST-AFTA – NLT 2026

Athena – 2028

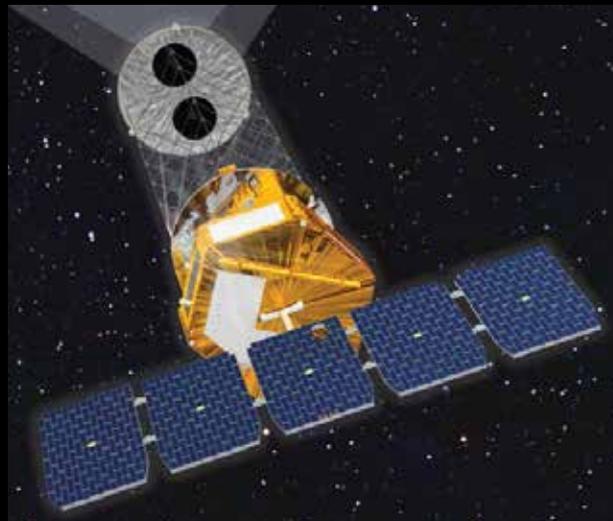
All launch dates notional

# Astrophysics SMEX/MO Missions in Formulation



## SPHEREx

PI: J. Bock, Caltech  
An All-Sky Near-IR  
Spectral Survey



## PRAXyS

PI: K. Jahoda, GSFC  
Polarimeter for Relativistic  
Astrophysical X-ray  
Sources



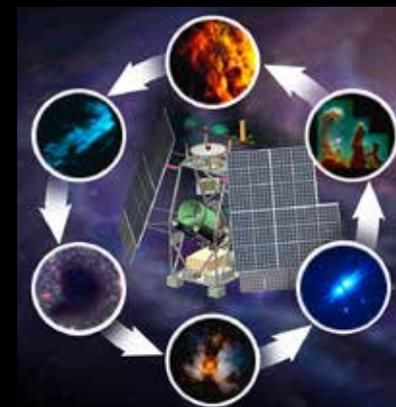
## IXPE

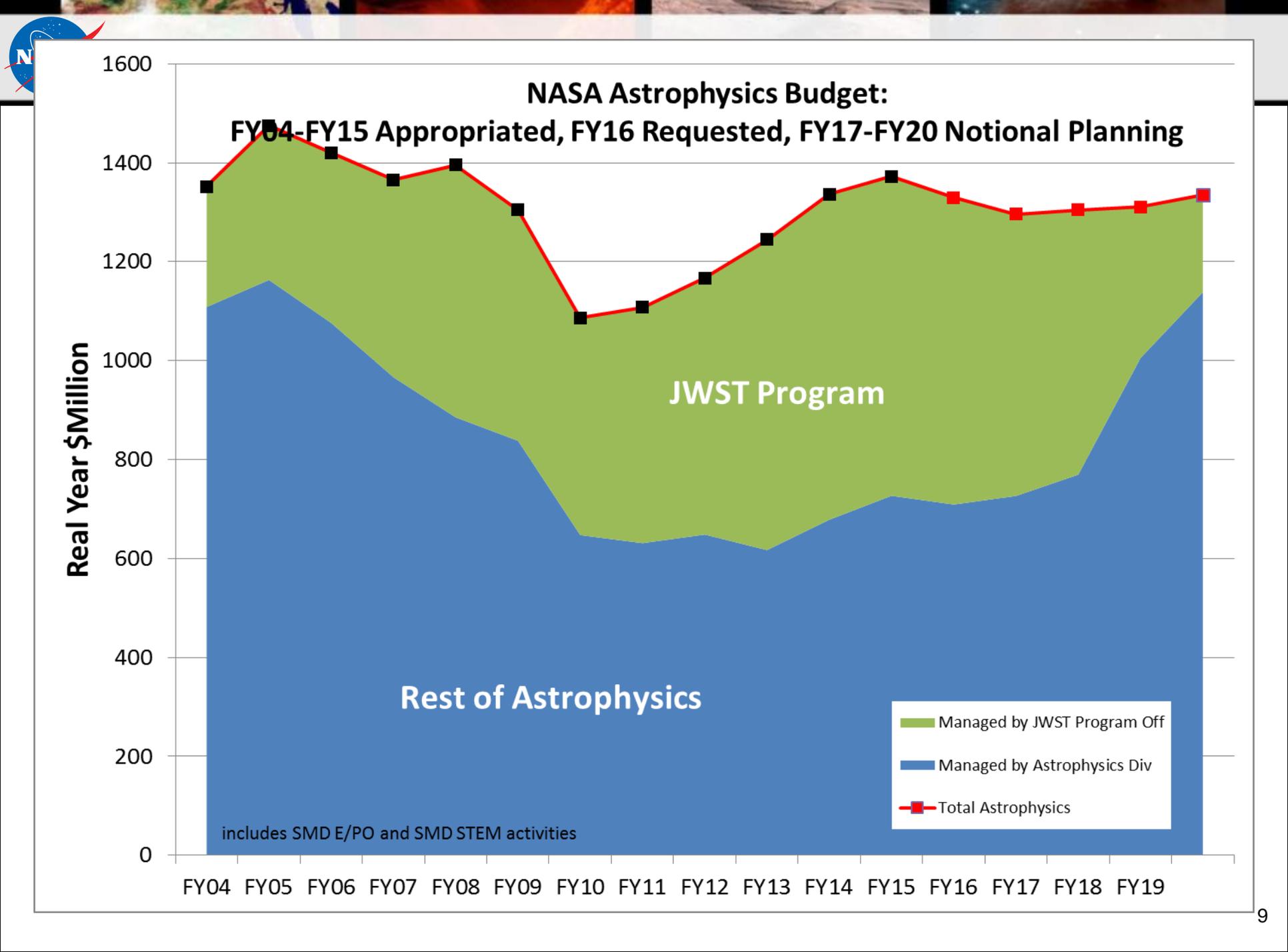
PI: M. Weisskopf, MSFC  
Imaging X-ray Polarimetry  
Explorer



PI: A. Lee, UC Berkeley  
US Participation in JAXA's  
LiteBIRD CMB Polarization Survey

PI: C. Walker, U. Arizona  
GUSTO: Gal/Xgal U/LDB Spectroscopic  
- Stratospheric Terahertz Observatory



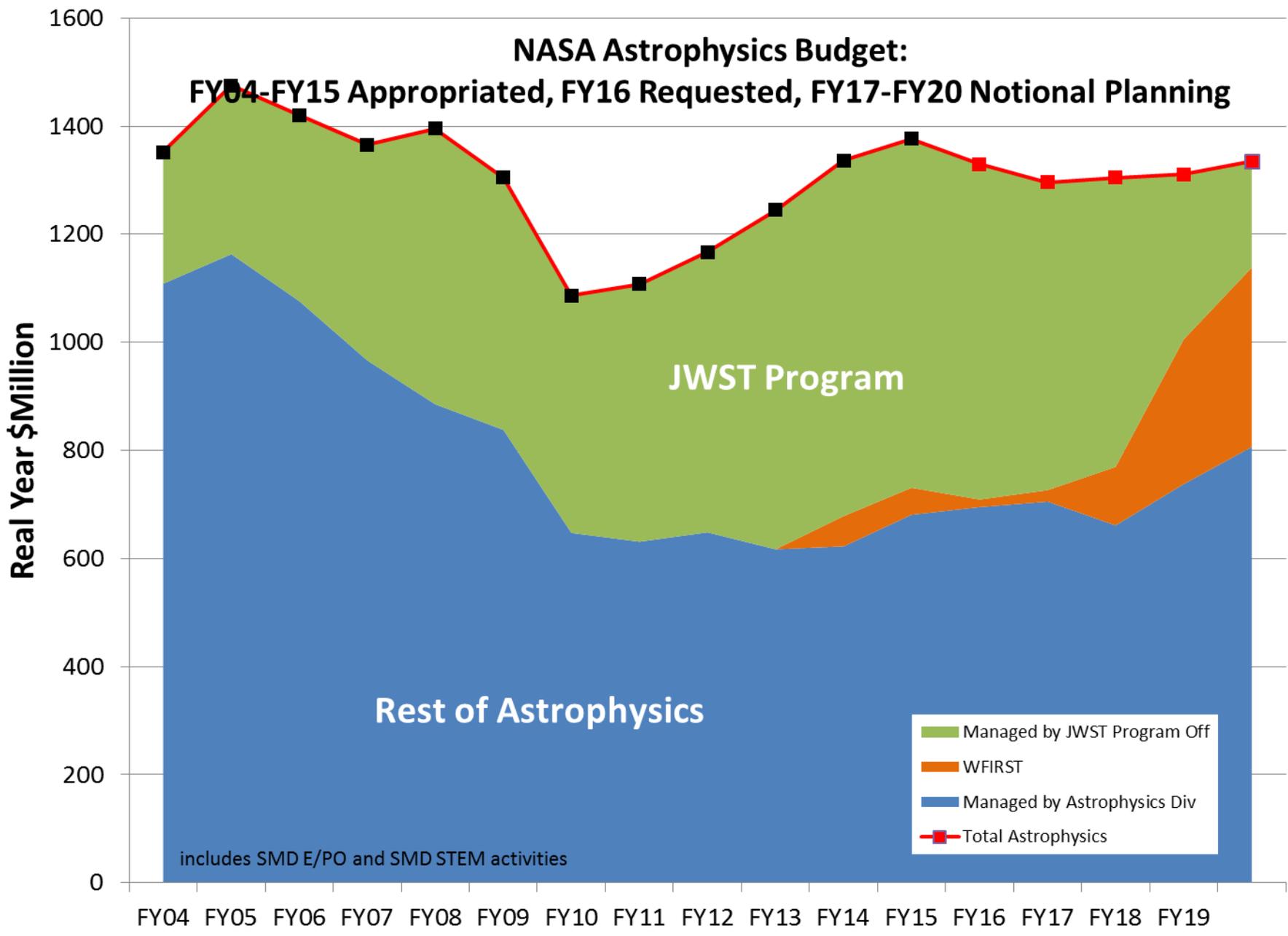




# NASA Astrophysics Budget:

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

Real Year \$Million



Rest of Astrophysics

JWST Program

includes SMD E/PO and SMD STEM activities

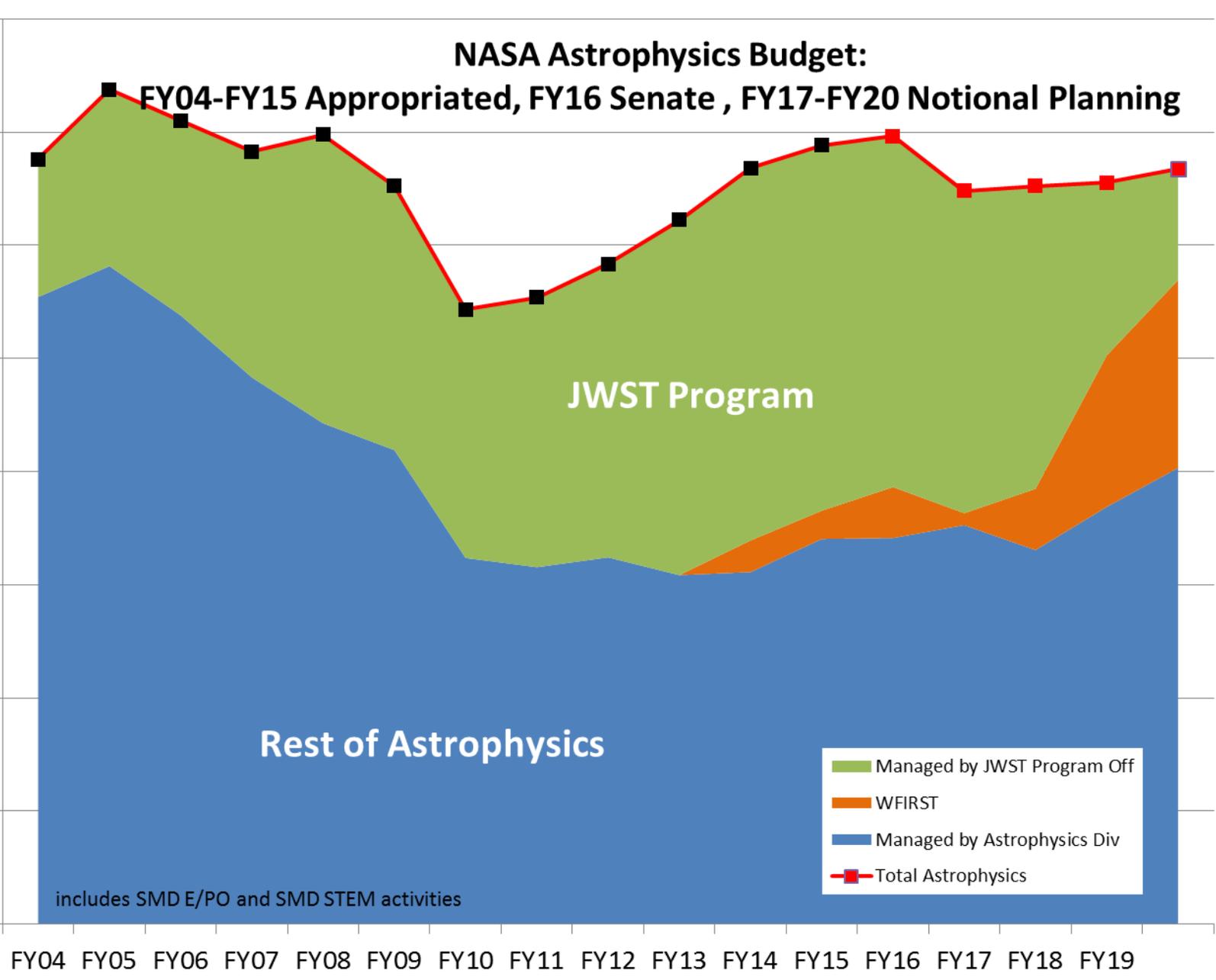
- Managed by JWST Program Off
- WFIRST
- Managed by Astrophysics Div
- Total Astrophysics



# NASA Astrophysics Budget:

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

Real Year \$Million

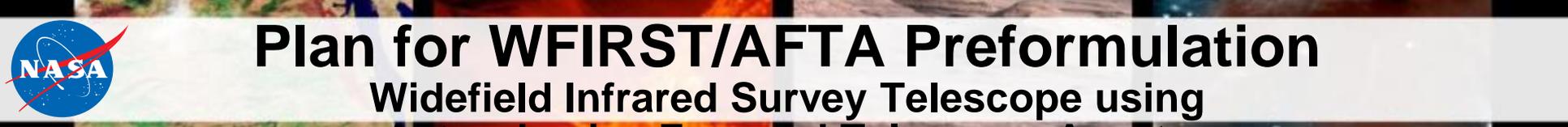


Rest of Astrophysics

JWST Program

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

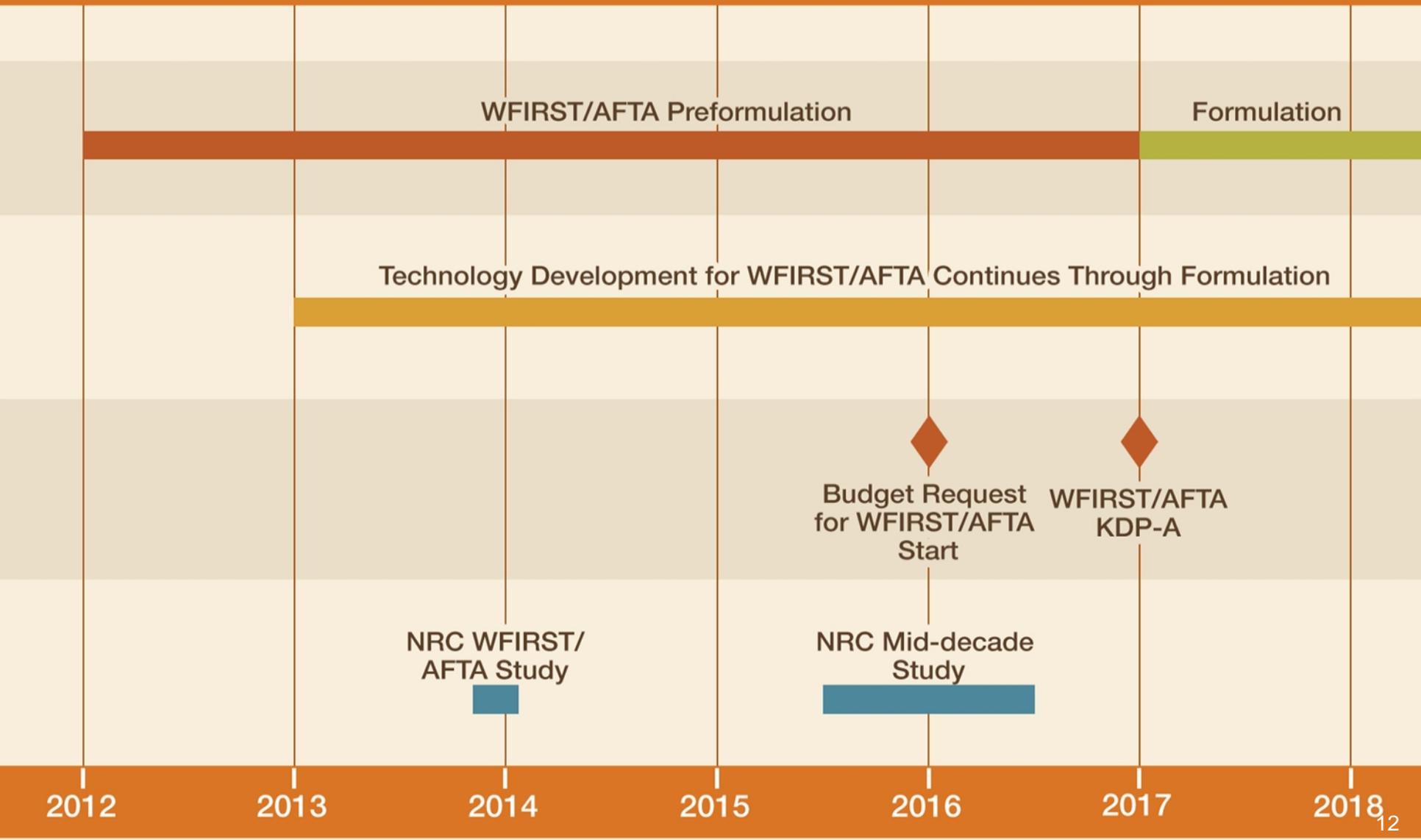
includes SMD E/PO and SMD STEM activities



# Plan for WFIRST/AFTA Preformulation

## Widefield Infrared Survey Telescope using Astrophysics Focused Telescope Assets

### WFIRST/AFTA timeline





# 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:**

Complete JWST	JWST remains within budget guidelines and on track for an October 2018 launch.
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. Budget line established for an Astrophysics Decadal Strategic Mission.
Large-scale 2. Augmentation to Explorer Program	Astrophysics Explorers planned budget increased to support cadence of four AOs per decade including SMEX AO in Fall 2014 and MDEX 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	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 2. Inflation Probe Technology Development Prog	Balloon-borne investigations plus strategic astrophysics technology (SAT) investments. Studying partnership on JAXA's LiteBIRD.



# 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 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.

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 (e.g., WFIRST coronagraph, Athena).

Small-scale. Future Ultraviolet-Visible Space Capability

Strategic Astrophysics Technology (SAT) and Astrophysics R&A (APRA) investments; mission concept studies.

Small-scale. SPICA (U.S. contribution to JAXA-led)

Not supported as a strategic contribution; candidate for Explorer Mission of Opportunity.

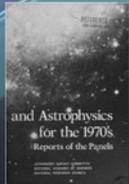


# NASA Plans for ESA's Athena Mission

- In 2014 ESA selected the Athena mission for the L2 opportunity as the 2<sup>nd</sup> large mission in the Cosmic Vision Programme, launching in 2028.
  - Formulation of the mission by ESA is underway, and a strawman design mission was completed in 2014. ESA plans an instrument AO in CY2016.
- NASA is pursuing a partnership with ESA as the best way to realize some of the compelling science prioritized by the 2010 Decadal Survey for IXO.
- NASA intends to provide up to \$100-150M in components of the two instruments and/or the observatory.
  - NASA issued an RFI to assess interest by U.S. organizations in providing hardware for the Athena mission.
  - NASA appointed a US scientist to the Athena Science Study Team and US scientists to the Athena Science Working Groups.
    - Membership in Athena Science Working Groups re-opened Oct 1, applications due Dec 31.
  - NASA has agreed with the instrument proto-consortium to provide the sensor array for the X-ray Integral Field Unit (microcalorimeter).
  - NASA is considering a proposal for contributions to the Wide Field Instrument (imager).
  - NASA is considering providing use of test facilities, specifically the X-ray Cryogenic Facility (XRCF) at MSFC for calibration.
  - NASA also plans for funding US members of the Athena science team, a US science data center, and US general observers during operation.

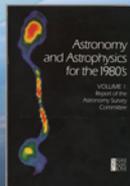
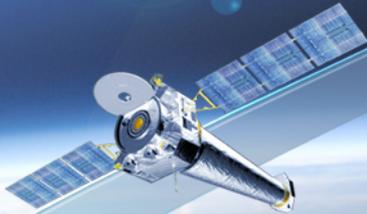
# ASTROPHYSICS

## Decadal Survey Missions



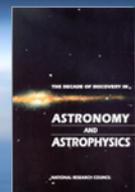
**1972**  
Decadal Survey  
*Hubble*

Launch: 1990



**1982**  
Decadal Survey  
*Chandra*

Launch: 1999



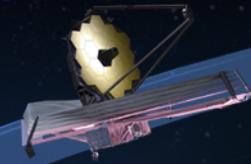
**1991**  
Decadal Survey  
*Spitzer, SOFIA*

Launch: 2003, 2014



**2001**  
Decadal Survey  
*JWST*

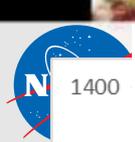
Launch: 2018



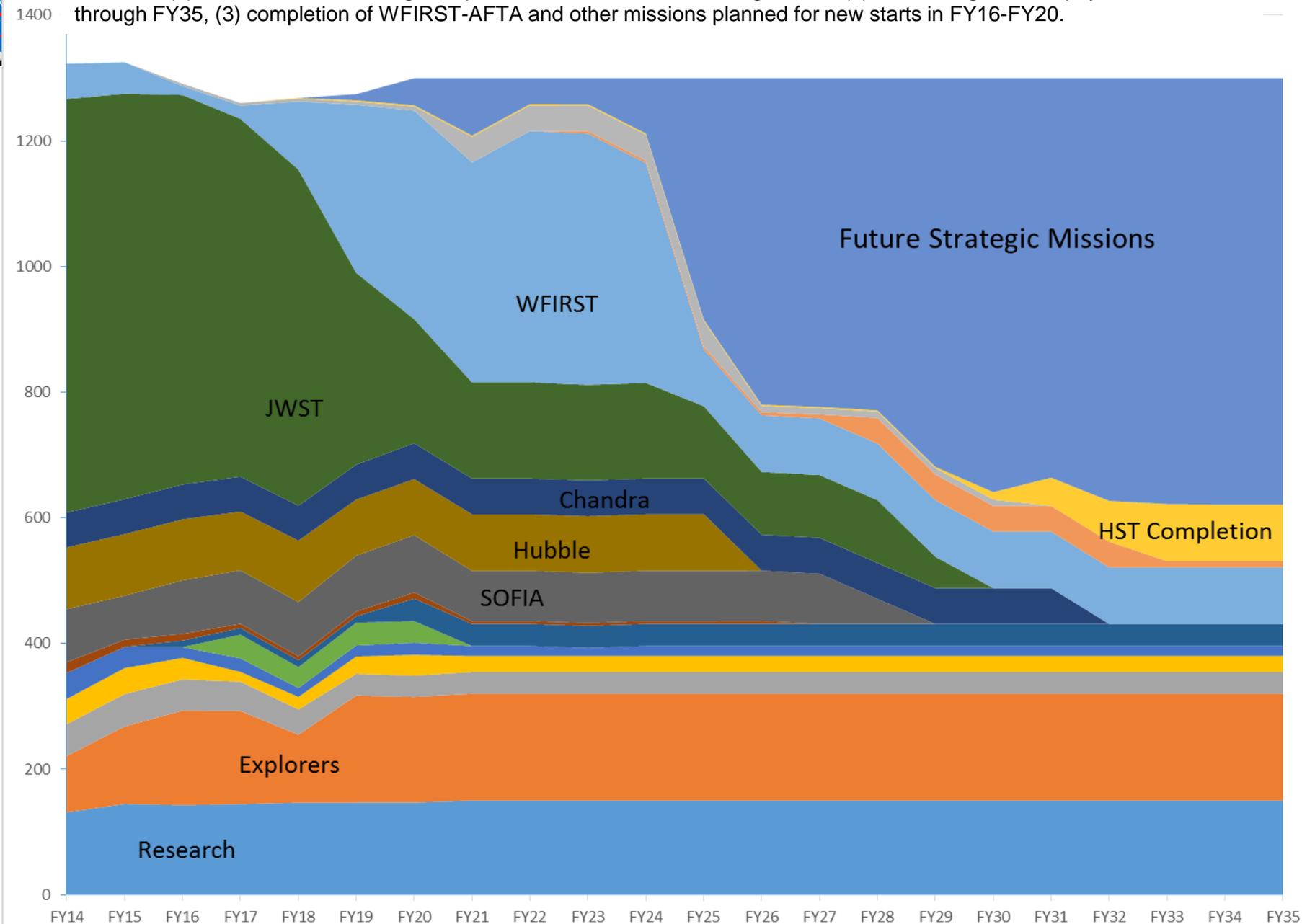
**2010**  
Decadal Survey  
*WFIRST*

Launch: mid-2020s





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





# Preparing for the 2020 Decadal Survey Large Mission Concepts

- Study 3-4 large mission concepts as candidate prioritized large missions
  - Science case
  - Technology assessment
  - Design reference mission with strawman payload
  - Cost assessment
- Charge to the PAGs (January 2015)
  - “I am charging the Astrophysics PAGs to solicit community input for the purpose of commenting on the small set [of large mission concepts to study], including adding or subtracting large mission concepts.”
- NASA Plan for Community Input
  - 2015: PAGs gather community input on selecting concepts for study



# Preparing for the 2020 Decadal Survey Large Mission Concepts

## Community workshops

- January 3, 2015: PAGs charged by Hertz @ AAS, Seattle. All PAGs meet.
- February 10-11, 2015: ExoPAG SIG #1 meeting @ JPL, Pasadena
- March 10, 2015: COPAG Virtual Town Hall
- March 19, 2015: Joint PAG EC meeting @ STScI, Baltimore
- April 11-14, 2015: PhysPAG SIGs meet @ Am Phys Soc, Baltimore
- June 2, 2015: ExoPAG Virtual Meeting
- June 3-5, 2015: COPAG Far-IR Workshop @ Pasadena
- June 13-14, 2015: ExoPAG meeting @ AbSciCon, Chicago
- June 25-26, 2015: COPAG UV/Vis SIG meeting @ Greenbelt
- July 1, 2015: PhysPAG session @ HEAD Symposium, Chicago
- July 3, 2015: Joint PAG EC Chair telecon
- July 13, 2015: Joint PAG EC Chair telecon with Paul Hertz
- July 14, 2015: ExoPAG Virtual Meeting
- August 7, Joint PAG Splinter Session @ IAU GA, Honolulu
- August 18, 2015: ExoPAG Virtual Meeting
- August 20, 2015: COPAG Virtual Town Hall
- August 31, 2015: Joint PAG Present @ AIAA Space 2015 Pasadena
- October 7, 2015: Deliver reports to Paul Hertz
- October 21-22, 2015: Astrophysics Subcommittee Meeting



# 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 Large Mission Concepts

- Study 3-4 large mission concepts as candidate prioritized large missions
  - Science case
  - Technology assessment
  - Design reference mission with strawman payload
  - Cost assessment
- Charge to the PAGS (December 2014)
  - “I am charging the Astrophysics PAGs to solicit community input for the purpose of commenting on the small set [of large mission concepts to study], including adding or subtracting large mission concepts.”
- NASA Plan for Community Input
  - 2015: PAGs gather community input on selecting concepts for study
  - 2016: Appoint STDT and Center study office, STDT assesses technology
  - 2017: Fund technology development through SAT, STDT develops DRM
  - 2018: STDT submits DRM for cost assessment
  - 2019: STDT issues report and provides input to Decadal Survey



# 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 ~\$1M (\$100K average)
  - Astrophysics Mission Concepts Study (AMCS; 2007)
    - ROSES call for ~1 year concept studies with mission design lab run
    - ~19 ASMC concepts selected in 2007; total \$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, with or without mission design lab run
    - Just like AMCS or Origins Probes, 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



# Preparing for the 2020 Decadal Survey Thinking about Probes

- Suggestion for the Decadal Survey: Recommend a Probe AO
  - Similar to Planetary Science Division's New Frontiers AO
  - Recent Probe-class missions include
    - Spitzer, Fermi, Kepler
    - New Horizons, JUNO, OSIRIS-Rex (New Frontiers missions)
  - Community identifies to the Decadal Survey mission concepts that could plausibly be done as Probes
  - Decadal Survey prioritizes a short list of mission concepts that should be accomplished on a Probe budget for the Probe AO
  - NASA issues a Probe AO and selects a Probe proposal that is responsive in a compelling manner to Decadal Survey identified science objectives for one of the mission concepts (determined by peer review) and can be accomplished as a Probe (determined by TMC review)
- Funding allotted to Probes "slows down" the large mission(s) that follow WFIRST
- NASA Astrophysics expects to announce a path toward Probe input for the Decadal Survey by the January 2016 AAS meeting

# Astrophysics Timeline

Decadal Survey Mission

MIDEX/MO (AO NET 2016)

Euclid (ESA)

SMEX/MO (AO 2014)

JWST (ESA, CSA)

TESS

NICER

ISS-CREAM (South Korea)

ASTRO-H (JAXA)

ST-7/LPF (ESA)

SOFIA (DLR)

NuSTAR (ASI, Denmark)

Kepler

Fermi (DOE, Intl team)

Suzaku (JAXA)

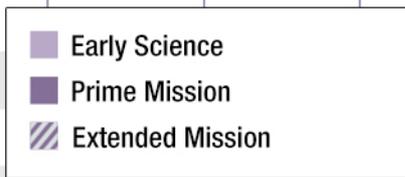
Swift (ASI, UK)

Spitzer

XMM-Newton (ESA)

Chandra (SRON)

Hubble (ESA)



TIMELINE CY

2000 2003 2006 2009 2012 2015 2018 2021 2024