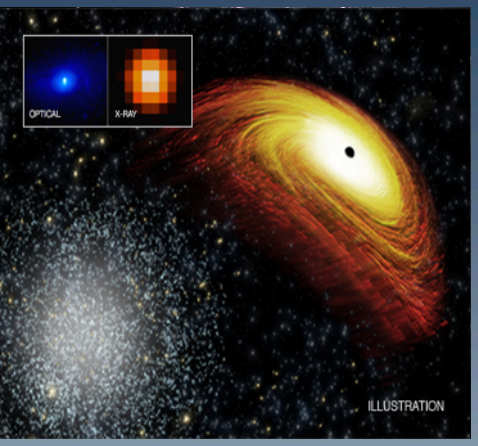
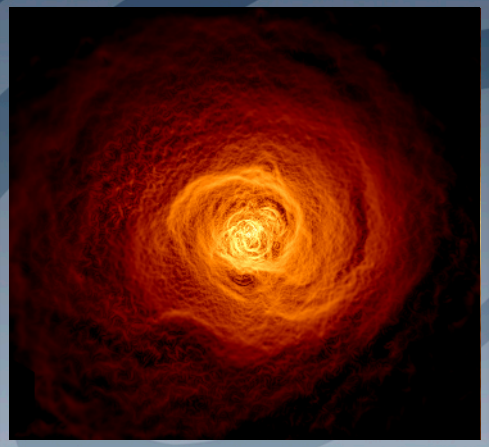
National Aeronautics and Space Administration

# Astrophysics



## NASA Astrophysics Update

Astrophysics Advisory Committee
October 18, 2017

**Paul Hertz**
Director, Astrophysics Division
Science Mission Directorate
*@PHertzNASA*

# Outline

# NASA Astrophysics

# Big Picture

# Big Picture (1 of 2)

- **The FY17 appropriation and FY18 budget request provide funding for NASA astrophysics to continue its planned programs, missions, projects, research, and technology.**
  - Total funding (Astrophysics including Webb) remains at ~$1.35B.
  - The NASA Astrophysics budget funds Webb for a Spring 2019 launch, WFIRST formulation, Explorers mission development, increased funding for R&A, operating missions, suborbital missions and new capabilities, continued technology development and mission studies.
  - FY17 Consolidated Appropriation was less than planning budget; reductions to plans required.
  - FY18 President's Budget Request balances current science and future missions; Congressional markups, if enacted, would put that balance at risk.
- **NASA continues to prioritize implementation of the recommendations of the 2010 Decadal Survey.**
  - National Academies' 2016 Midterm Assessment Report validates NASA's progress.
  - NASA is conducting large and medium mission concept studies for 2020 Decadal Survey.

# Big Picture (2 of 2)

- **The operating missions continue to generate important and compelling science results, and new missions are under development for the future.**
  - Senior Review in Spring 2016 recommended continued operation of all missions (Chandra, Fermi, Hubble, Kepler, NuSTAR, Spitzer, Swift, XMM); next Senior Review is in 2019.
  - SOFIA is adding new instruments: HAWC+ instrument commissioned; HIRMES instrument in development; next gen instrument call planned.
  - ISS-NICER launched on June 3, 2017; ISS-CREAM launched on August 14, 2017.
  - NASA missions under development making progress toward launches: TESS (2018), Webb (2019), IXPE (2021), GUSTO (2021), WFIRST (mid-2020s).
  - Independent WFIRST technical/management/cost review underway; report to be released October 19, 2017.
  - Partnerships with ESA and JAXA on future missions create additional science opportunities: Euclid (ESA; 2020), XARM (JAXA; 2021), Athena (ESA; 2028), LISA (ESA; 2034).
  - Explorer AOs are being released every 2-3 years: IXPE downselected in January 2017, GUSTO downselected in March 2017, MIDEX/MO missions selected for Phase A studies in August 2017, next SMEX/MO AO in Spring 2019.

# Administrator Nominee

- Jim Bridenstine (R-OK)
  - Representative of Oklahoma's First Congressional District
  - Sponsor of the American Space Renaissance Act (H.R. 4945)
  - Serves on the House Armed Services Committee and the Science, Space and Technology Committee

  - Nine years active duty in the United States Navy
  - Lieutenant Commander in the U.S. Navy Reserve
  - Active member of the Oklahoma Air National Guard

  - Executive Director of the Tulsa Air and Space Museum & Planetarium
  - Business/Economics/Psychology major at Rice University
  - MBA from Cornell University
  - Business experience in real estate, ranching, aerospace, and defense contracting

Source: https://bridenstine.house.gov

# APAC Requests & Recommendations

| July 2017 | | |
|---|---|---|
| 1 | The APAC would like to understand how the reduction in proposal numbers will be implemented and the metrics and standards that are going to be used to judge whether the new civil servant funding model was a success or not in the three-year review. The APAC also requests more information on how setting limits on the number of proposals submitted by NASA Center scientists will be implemented. | Presentation by Dan Evans at October 2017 APAC meeting. |
| 2 | The APAC recommends that the APD continues to ensure that any future directed work is truly best done at the centers. | NASA concurs. |
| 3 | The APAC would like to better understand HEO's timeline, particularly with regards to serviceability and on-orbit assembly, so that we can make well-informed, specific suggestions . | Presentation by Jason Crusan at October 2017 APAC meeting. |
| 4 | The APAC requests additional information about the photometric stability expected due to the focus drift anomaly identified by the TESS team. This information can be provided as a simple presentation or a white paper to be distributed to the APAC. The APAC further requests that they be kept informed as the TESS focus issue and its impacts on TESS science are better understood. | White Paper provided to APAC members prior to October 2017 APAC meeting. |

# APAC Requests & Recommendations

| July 2017 | | |
|---|---|---|
| 5 | The APAC requests that APD provide the success rates as a function of gender of the PIs of core R&A research programs, the fraction of proposals in each core R&A research program as function of gender of the PI, and the fraction of peer reviewers as a function of gender. In general, the APAC would like to see a summary of the efforts of the APD to encourage diversity amongst PIs and research teams funded by the core R&A programs | Initial response in Paul Hertz Division Update at October 2017 APAC meeting.<br><br>Standalone presentation at future APAC meeting.<br>. |
| 6 | The APAC requests a joint presentation from the three program Chief Technologists that addresses the strategic technology gaps in each subject area, the progress that is being made to close these gaps, and the chief impediments to closing these gaps in a timely manner . | Presentation by Thai Pham and Brendan Crill at October 2017 APAC meeting. |
| 7 | The APAC requests a presentation from the NASA Ames Small Spacecraft Systems Virtual Institute on their activities at a future APAC meeting . | Presentation by Ames Small Spacecraft Systems Virtual Institute will be scheduled at a future APAC meeting.<br><br>CubeSat presentation by Larry Kepko at October 2017 APAC meeting. |

# NASA Astrophysics Diversity and Inclusion

- The NASA Astrophysics Division is actively taking steps to advance diversity, inclusion, and equal opportunity in the NASA workforce and among NASA grantee institutions.
- NASA Astrophysics is committed to:
  - Setting the expectancy of diversity and inclusion in the composition of: proposal teams, peer review panels, science and technology definition teams, and mission and instrument teams.
  - Working with the Office of the Chief Scientist to produce a short video on unconscious bias in peer reviews for future distribution to panelists.
  - Discussing best practices in peer reviews with other agencies.
  - Recruiting a diverse Astrophysics Division staff.
  - Observing the demographics of R&A proposers and awardees.
  - Promoting diversity on HQ-selected groups (e.g., APAC, PAGs, etc.)
- The Spring 2018 APAC meeting should expect a detailed report on these aspects.

# SmallSats for Astrophysics

- SMD released a Request for Information (RFI) on September 28, 2017, seeking information to inform decisions regarding Astrophysics SmallSats.
- Under Topic 1 ("Science Mission Concepts"), NASA is asking the astrophysics community to envision missions advancing compelling astrophysics science that can be realized involving SmallSats at a cost between that of Astrophysics CubeSats (APRA) and Astrophysics Explorers Missions of Opportunity.
- Under Topic 2 ("Advanced Technology Concepts"), NASA solicits ideas for compelling astrophysics science involving SmallSats for which significant investments in instrument and/or spacecraft technologies would be required.
- Responses due November 30, 2017

- RFI is posted in Fed Biz Opportunities at

https://www.fbo.gov/notices/2f68a3d8a7a55cf1f165ebeefdc29890

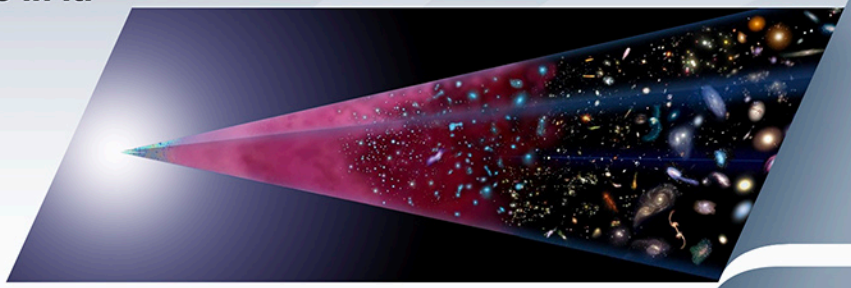
# NASA Astrophysics

## A Balanced Plan
## A Strategic Vision

# Why Astrophysics?

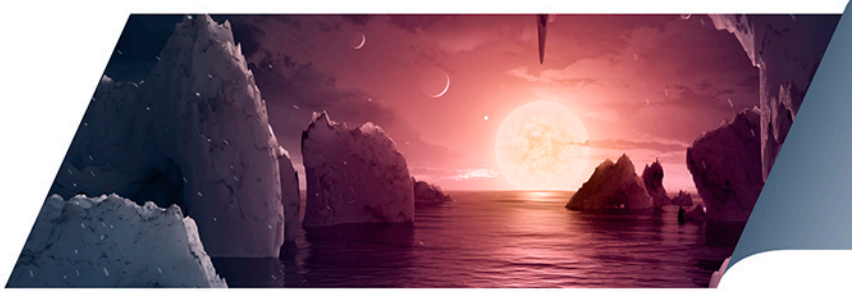
***Astrophysics is humankind's scientifice endeavor to understand the universe and our place in it.***

**How did our universe begin and evolve?**

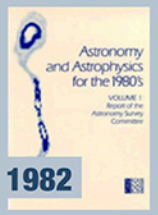


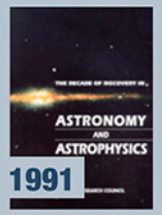
**How did galaxies, stars, and planets come to be?**

**Are we alone?**



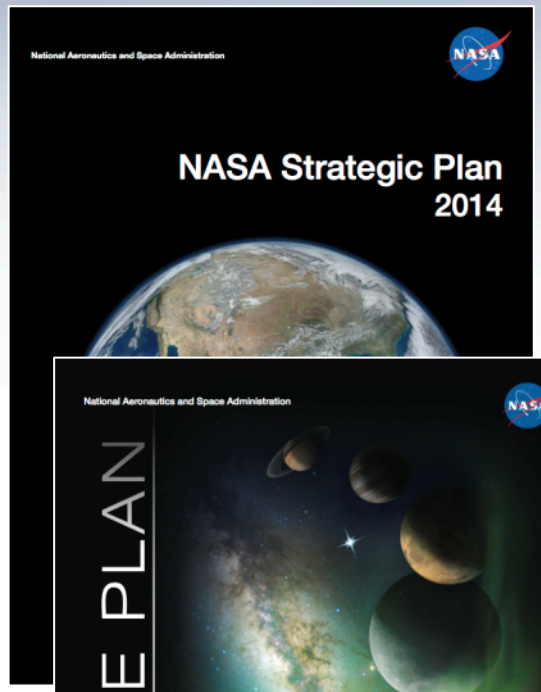
**Enduring National Strategic Drivers**

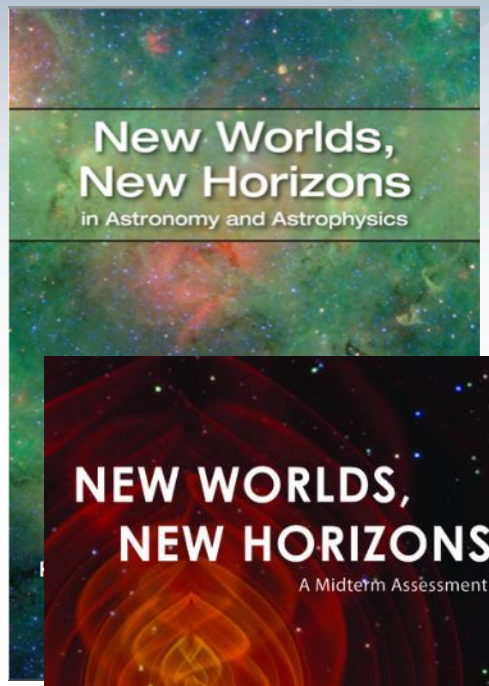


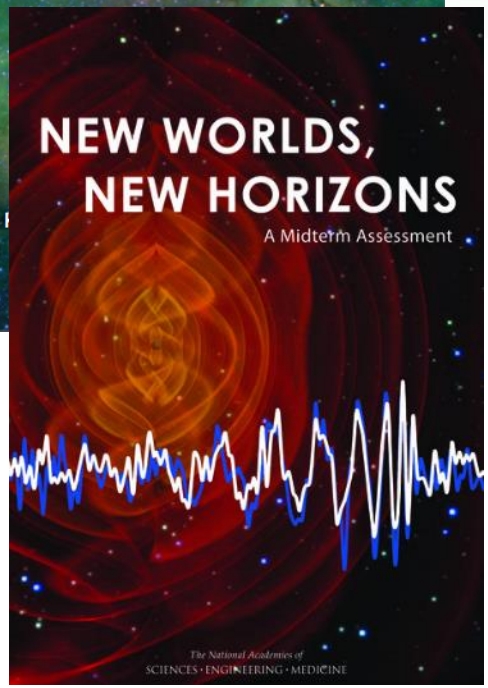
# Astrophysics Strategic Planning

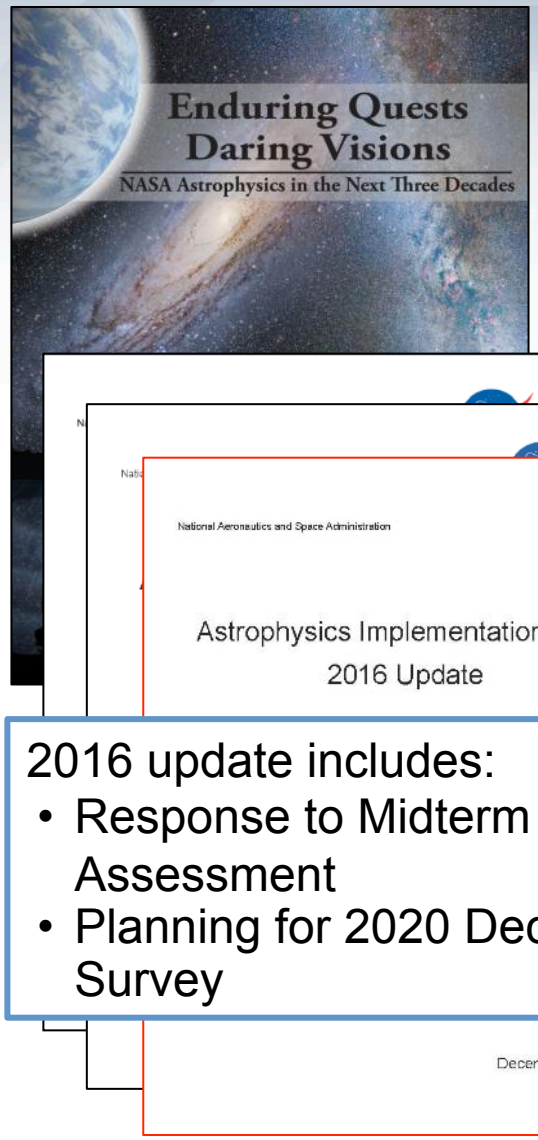




To be updated in 2018 (per GPRAMA)




2016 update includes:

- Response to Midterm Assessment
- Planning for 2020 Decadal Survey

**https://science.nasa.gov/astrophysics/documents**

# Current Program: an integrated strategic plan

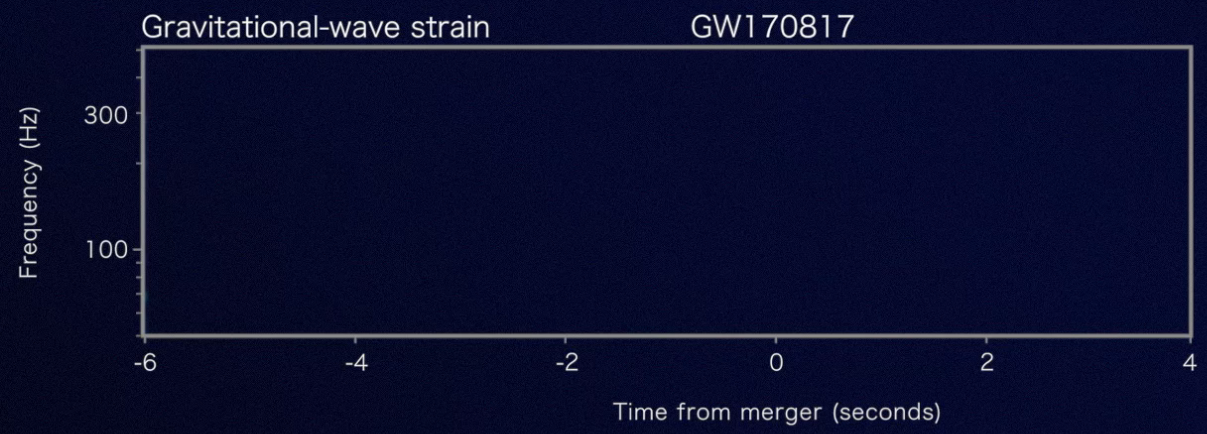
**We are executing a balanced strategic program for Astrophysics**

- Operating missions, large and small, continue to deliver paradigm changing science
  - Cosmology, Dark Energy, Exoplanets, Origin of Structure, …

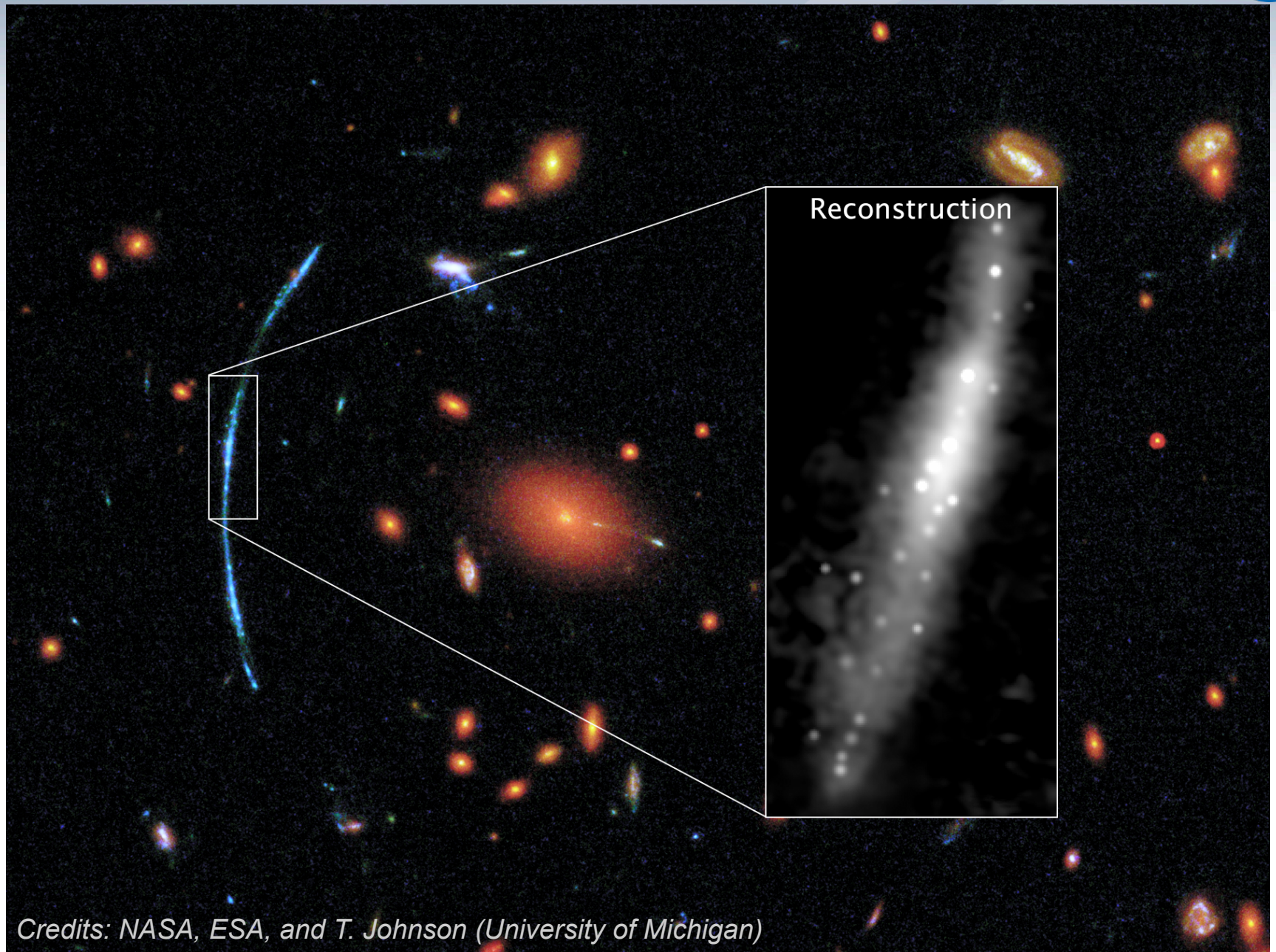
# GW170817 / GRB170817a

Fermi


LIGO



# Hubble sees Star Forming Regions at z=2.5




*Credits: NASA, ESA, and T. Johnson (University of Michigan)*

# Chandra informs 3D Model of Nova V745 Sco Outburst

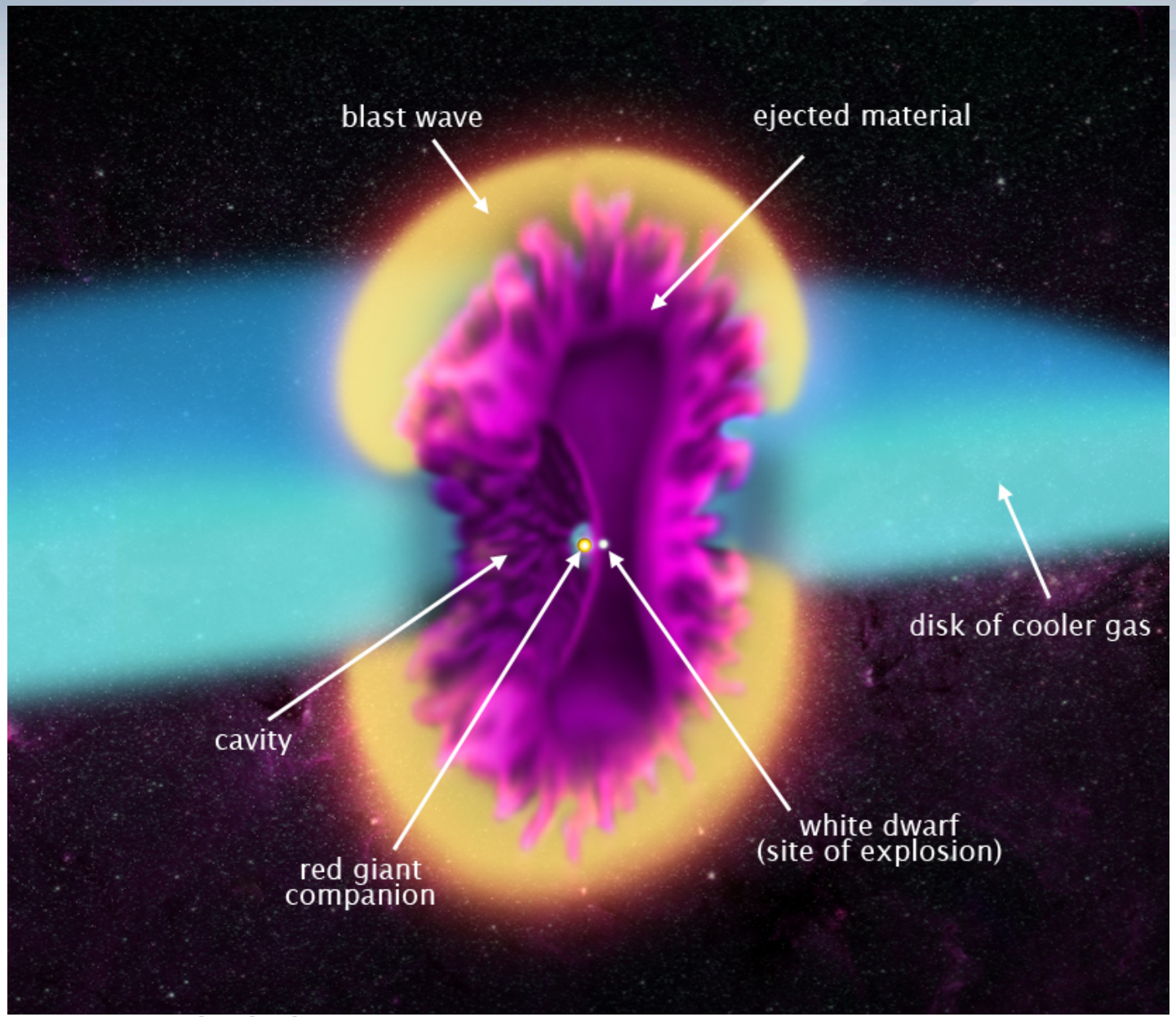



Illustration: NASA/CXC/M.Weiss)

# Hubble Observes Pitch Black Planet WASP-12b

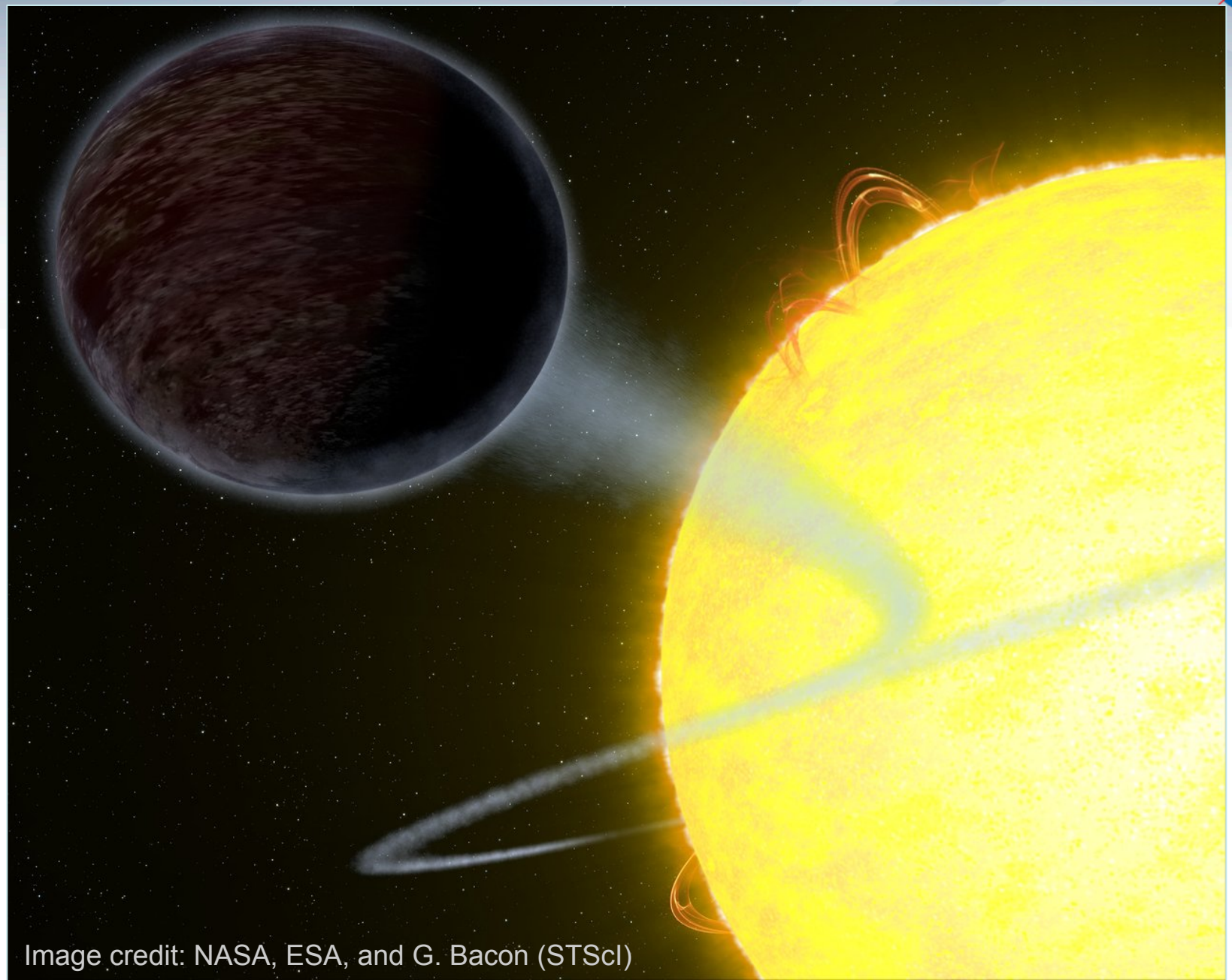
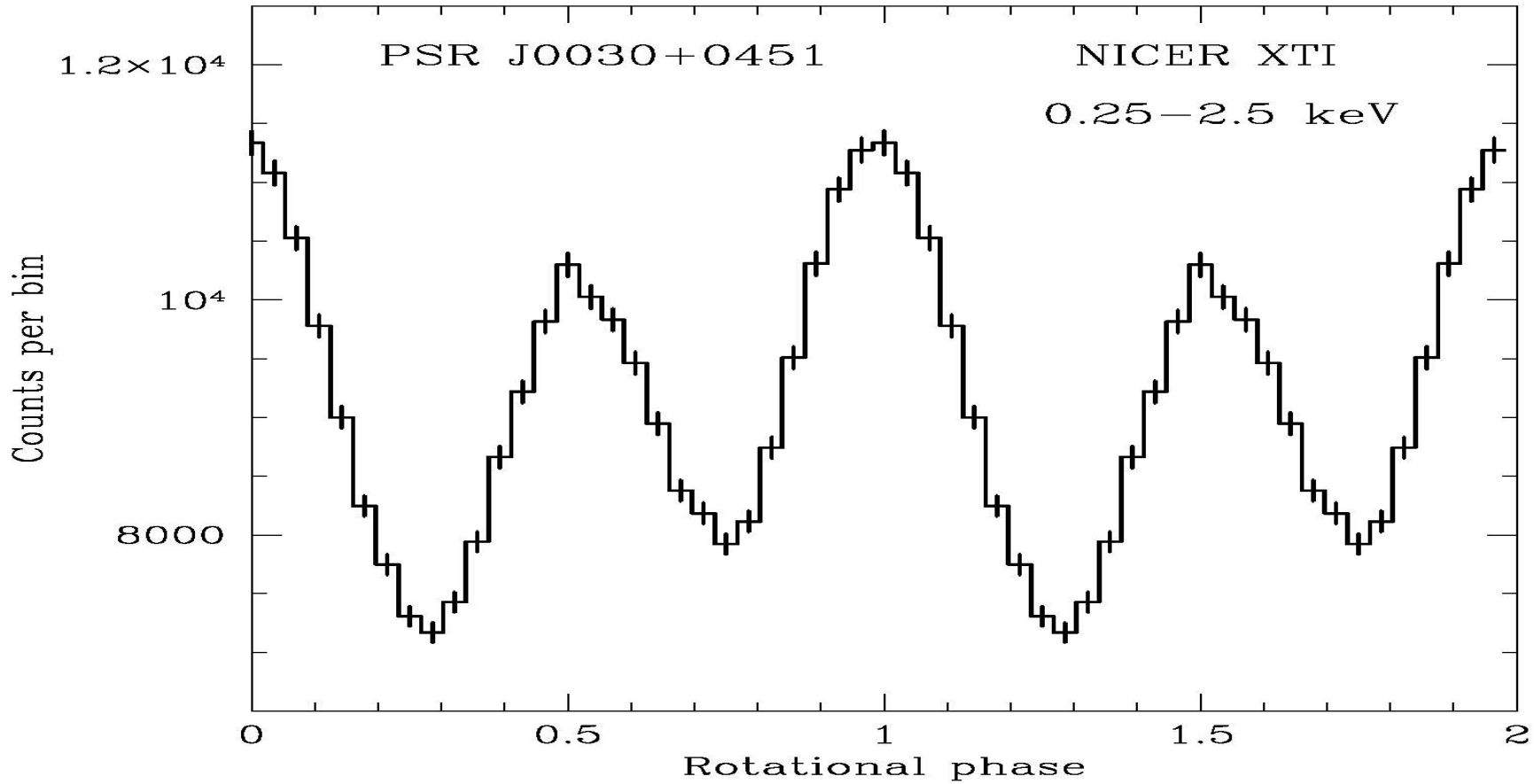
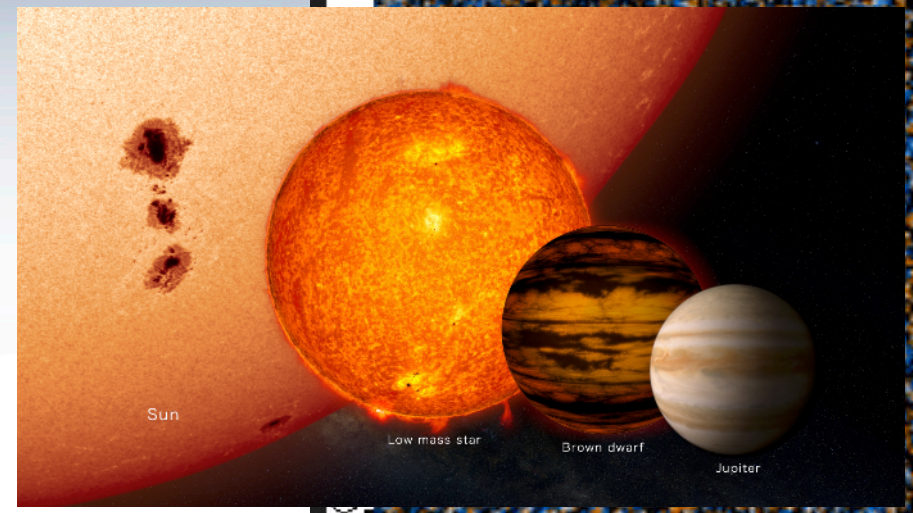


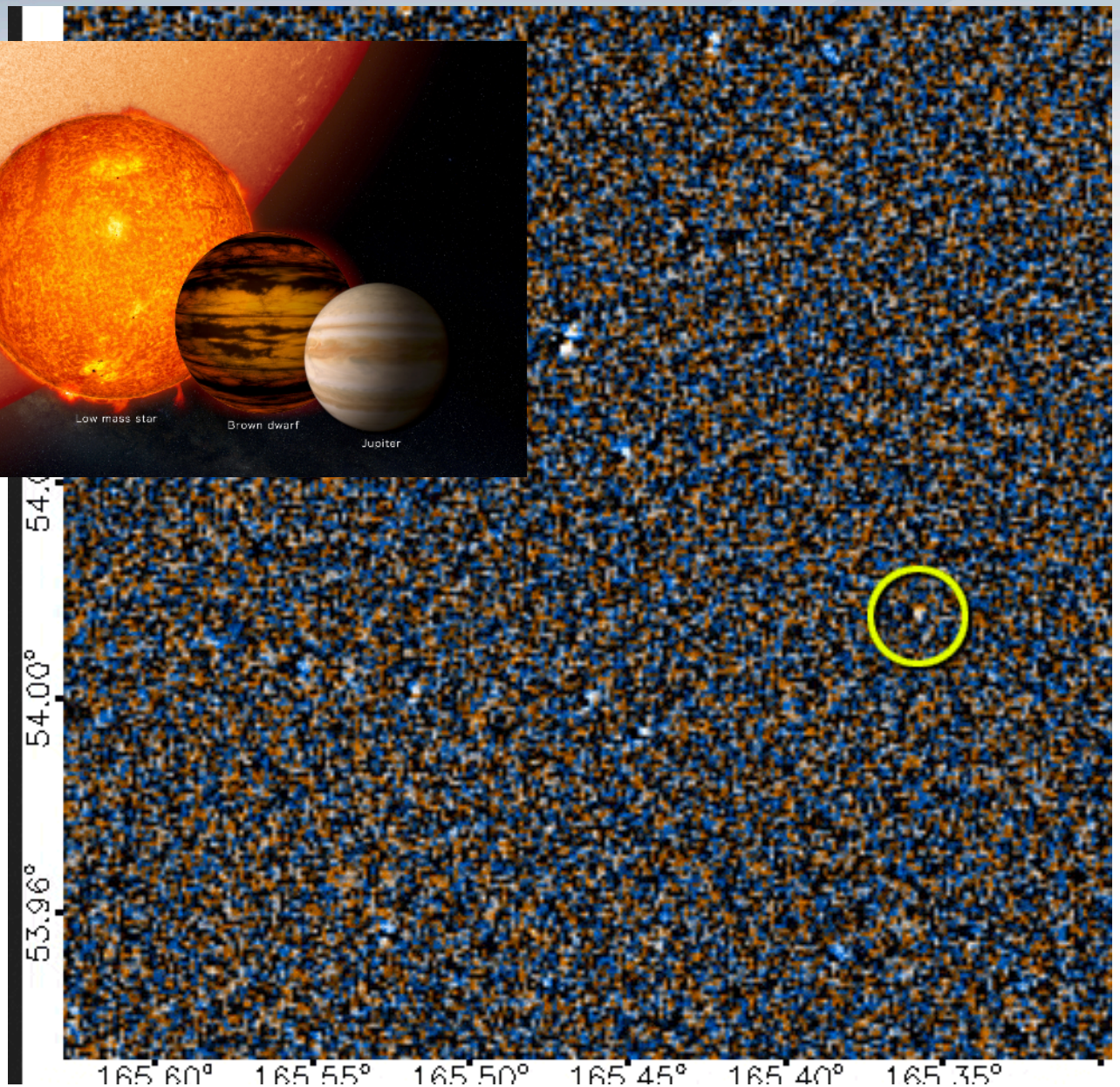
Image credit: NASA, ESA, and G. Bacon (STScI)

# NICER Measuring Neutron Star Equation of State



# NASA-funded citizen science project discovers brown dwarf in WISE data



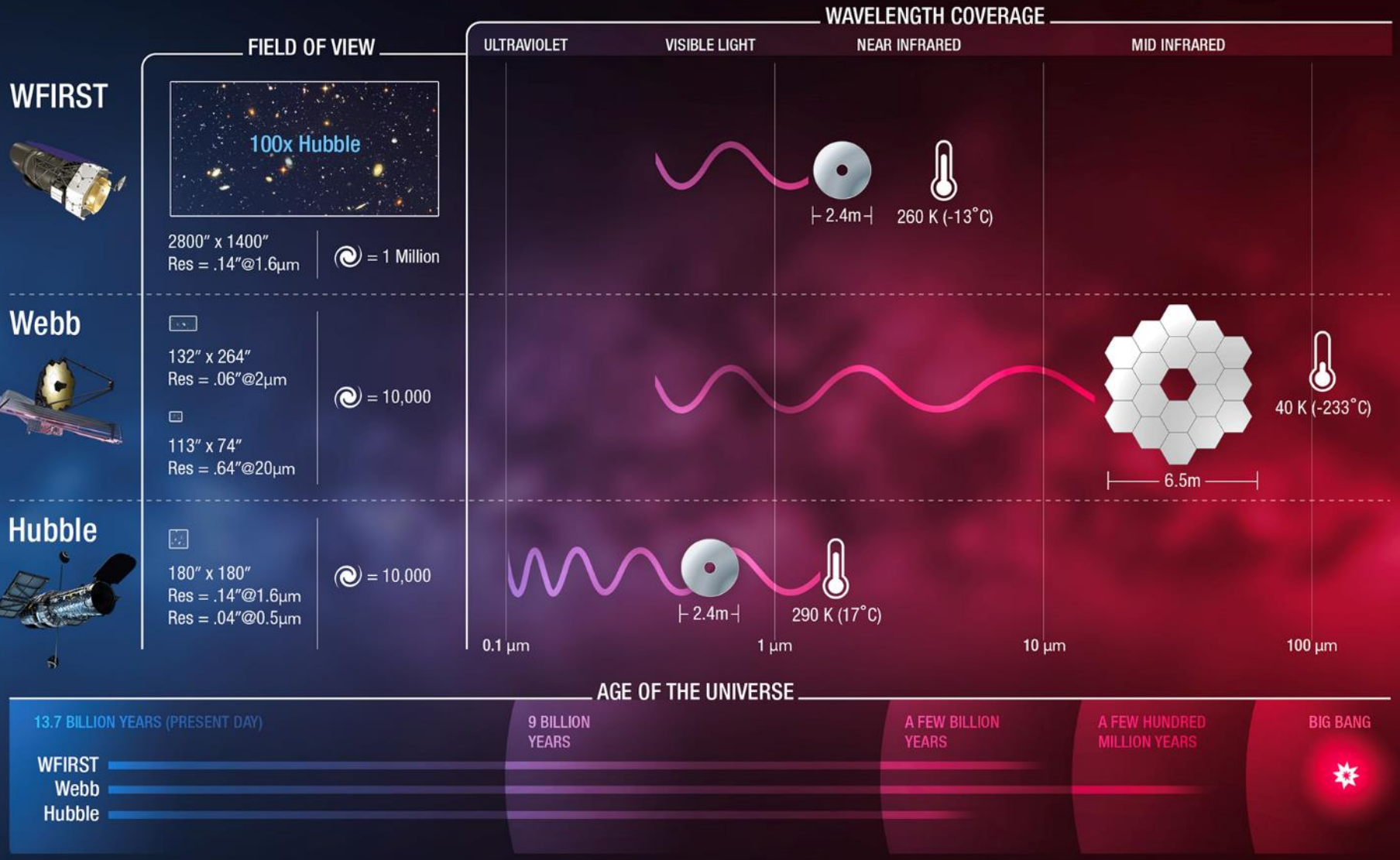
# Current Program: an integrated strategic plan

**We are executing a balanced strategic program for Astrophysics**

- Operating missions, large and small, continue to deliver paradigm changing science
  - Cosmology, Dark Energy, Exoplanets, Origin of Structure, …

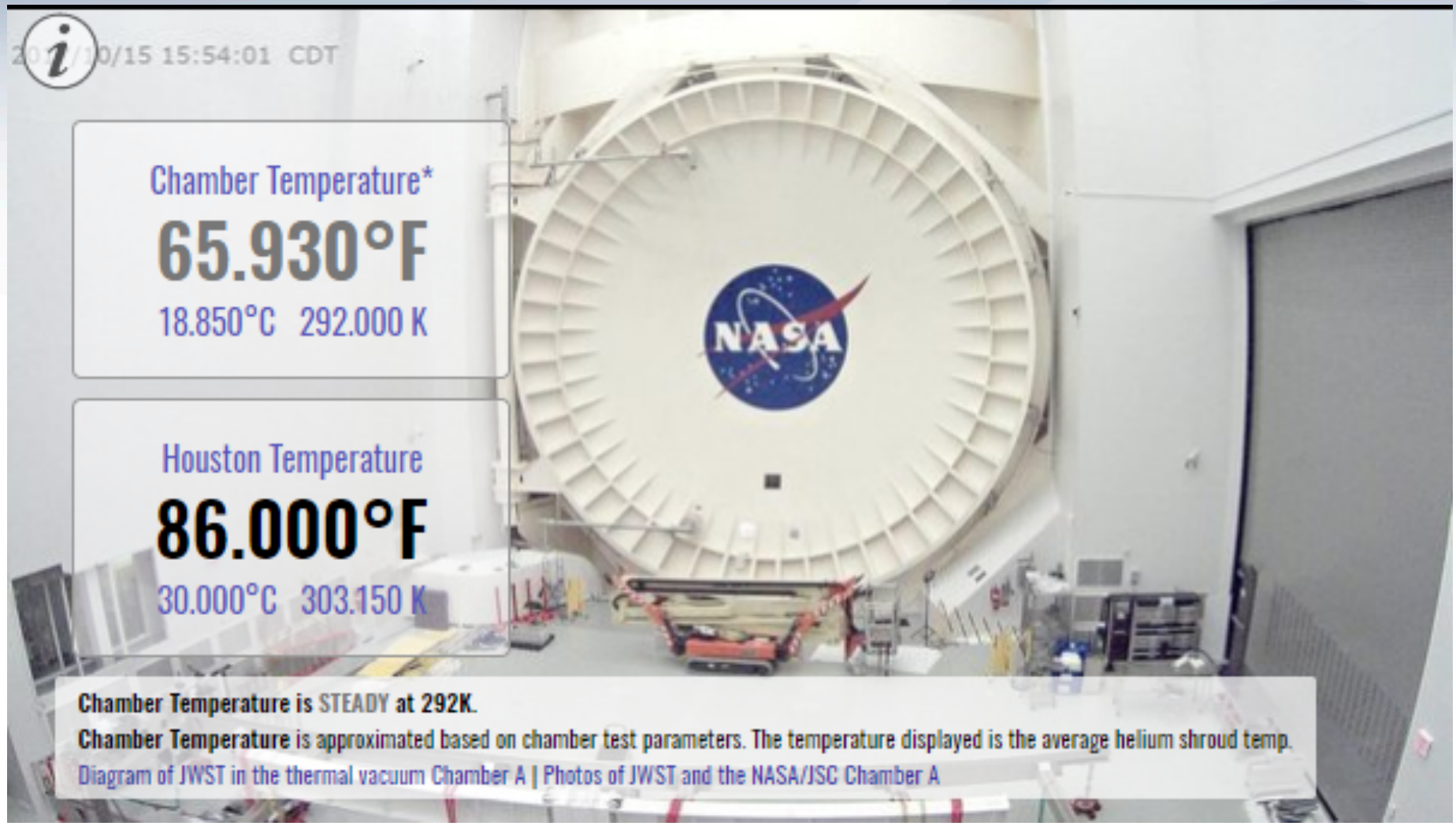
- Large strategic missions under development …
  - Are next generation great observatories
  - Will rewrite textbooks
  - Can only be done by NASA

# GREAT OBSERVATORIES



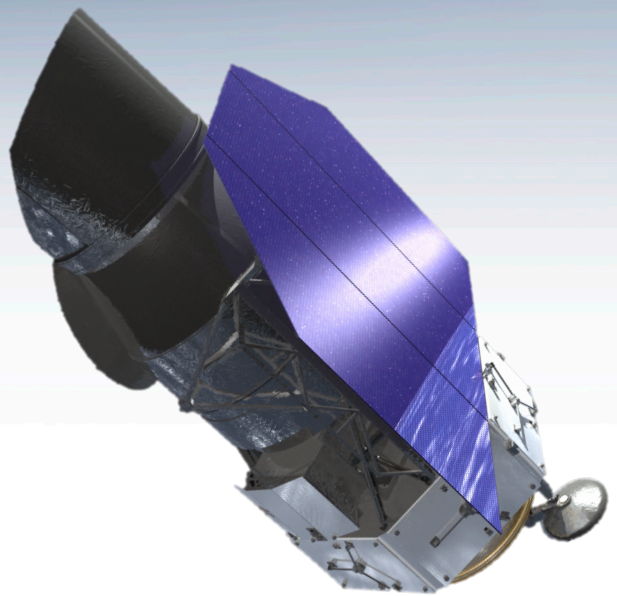
# Webb Telescope

Presentation on Webb Telescope by Eric Smith on Wednesday




October 15 Update: OTIS is in day 85 of a 93-day planned cryovacuum test and in its warm-up phase. Door opening tentatively scheduled for October 23.

# WFIRST
## Wide-Field Infrared Survey Telescope



**Wide-Field 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 L2; using existing hardware, images 0.28deg$^2$ at 0.8-2μm

**Instruments (design reference mission)**: Wide Field Instrument (camera plus IFU), Coronagraph Instrument (imaging/IFS)

**Phase:** Currently in Formulation (Phase A)

**https://wfirst.gsfc.nasa.gov/**

**CURRENT STATUS:**

- Successfully completed three-year technology demonstration activities on WFIRST's two critical mission technologies (near infrared detectors and coronagraph technologies)
- Completed industry formulation studies on Wide Field Instrument Optomechanical Assembly
- Conducting WFIRST Independent External Technical/Cost/Management Review (WIETR) in response to findings and recommendations in National Academies' Midterm Assessment
  - NASA is managing WFIRST with major emphasis on cost control
  - WFIRST will proceed to SRR/MDR and KDP-B after responding to WIETR recommendations
- WFIRST does not have a starshade; but NASA is studying a starshade for the next Decadal Survey's consideration.
  - Starshade compatibility is being studied during Phase A; mandated minimum impact on WFIRST.
  - NASA will decide by fall 2017 whether to maintain starshade compatibility.
- Jeff Kruk is new Project Scientist following loss of Neil Gehrels

# WFIRST

- NASA commissioned a WFIRST Independent External TMC Review (WIETR)
- An independent review of WFIRST before Phase B was recommended by two National Academies studies: the 2013 Harrison Report and the 2016 Midterm
- In direct response to these National Academies recommendations, the WIETR was commissioned by the SMD AA on April 27, 2017
- The WIETR Terms of Reference contain these questions:
  - Are the technical requirements understood and reasonable?
  - Are the scope and cost/schedule understood and aligned?
  - Are the management processes in place adequate for a project of this scope and complexity?
  - Are the benefits of the coronagraph to NASA objectives commensurate with the cost and cost risk of development?

# WFIRST

**WIETR Panel Membership**

- **Dr. Peter Michelson**, Stanford U. (Co-Chair, Science)
- **Mr. Orlando Figueroa**, NASA (Ret.) (Co-Chair, Program)
- **Mr. Bob Bitten**, Aerospace Corp.
- **Dr. David Charbonneau**, Harvard U.
- **Dr. Daniel Eisenstein**, Harvard U.
- **Dr. Lynne Hillenbrand**, Caltech
- **Mr. Dave Kusnierkiewicz**, APL
- **Dr. Dimitri Mawet**, Caltech
- **Mr. Pete Theisinger**, JPL (Ret.)
- **Dr. Roger Brissenden**, SAO
- **Ms. Eileen Dukes**, Consultant
- **Mr. Bill Green**, JPL (Ret.)
- **Dr. Anne Kinney**, Keck Obs
- **Dr. James Lloyd**, Cornell U.
- **Mr. Mark Saunders**, NASA (Ret.)

https://www.nasa.gov/mission_pages/GLAST/team/Michelson-bio.html

*Peter Michelson*

| WIETR Schedule | |
|---|---|
| WIETR Announced | April 27, 2017 |
| Panel Members Announced | June 22, 2017 |
| Kickoff Meeting at GSFC | August 7 – 10, 2017 |
| Site Visits by Subpanels | August 14 – 31, 2017 |
| Formulation, Discussion, and Documentation of Findings | September 2017 |
| Informal Report to Center, Program, Project | Late September 2017 |
| Draft Report to SMD | Early October 2017 |
| Final Report | October 19, 2017 |

https://www.nasa.gov/mission_pages/mars/news/Figueroabio.html

*Orlando Figueroa*

# Project Approach

- Project continues to work on requirements development, technology advancement, and other Phase A activities while WIETR is underway
- System Requirements Review and Mission Definition Review (SRR/MDR) postponed from original date of July 11, 2017
- After receiving the WIETR report, NASA will formulate a plan to respond to WIETR findings and recommendations before defining milestones for the remainder of WFIRST Phase A
- Key Decision Point B (KDP-B) is provisionally planned to occur during first quarter of Calendar Year 2018, following a rescheduled SRR/MDR
- Project milestone reviews such as SRR/MDR will be conducted by a Standing Review Board (SRB), per NASA's standard practices
  - The WIETR panel is separate from the SRB
  - The WIETR panel will be disbanded after delivering its report
- WIETR process is expected to increase NASA's level of confidence in its KDP-B cost estimate for WFIRST
- NASA's official cost and schedule commitments for WFIRST will be formalized at KDP-C, currently planned for 2020

# Current Program: an integrated strategic plan

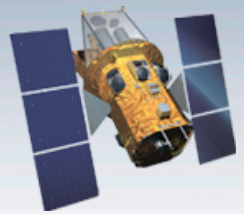
**We are executing a balanced strategic program for Astrophysics**

- Operating missions, large and small, continue to deliver paradigm changing science
  - Cosmology, Dark Energy, Exoplanets, Origin of Structure, …

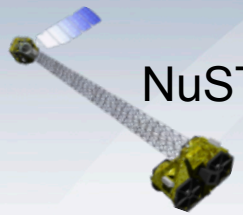
- Large strategic missions under development …
  - Are next generation great observatories
  - Will rewrite textbooks
  - Can only be done by NASA

- A high cadence of Explorers has been resumed

# Astrophysics Explorers Program

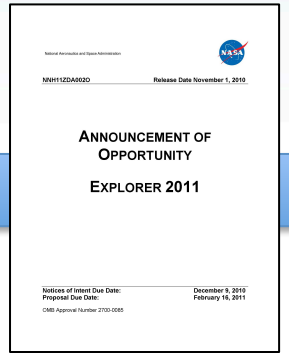


Swift



NuSTAR

NICER



National Aeronautics and Space Administration

NNH11ZDA002O — Release Date November 1, 2010

ANNOUNCEMENT OF OPPORTUNITY

EXPLORER 2011

Notices of Intent Due Date: December 9, 2010
Proposal Due Date: February 16, 2011

OMB Approval Number 2700-0085

MIDEX 2011

National Aeronautics and Space Administration

NNH14ZDA003O — Release Date September 17, 2014

Announcement of Opportunity

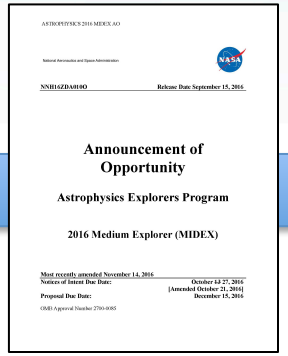
Astrophysics Explorers Program

2014 Small Explorer (SMEX)

Notices of Intent Due Date: October 15, 2014
Proposal Due Date: December 18, 2014

OMB Approval Number 2700-0085

SMEX 2014



ASTROPHYSICS 2016 MIDEX AO

National Aeronautics and Space Administration

NNH16ZDA010O — Release Date September 15, 2016

Announcement of Opportunity

Astrophysics Explorers Program

2016 Medium Explorer (MIDEX)

Most recently amended November 14, 2016

Notices of Intent Due Date: October 14 27, 2016 [Amended October 21, 2016]
Proposal Due Date: December 15, 2016

OMB Approval Number 2700-0085

MIDEX 2016

National Aeronautics and Space Administration

NNH14ZDA013O — Release Date September 17, 2014

Announcement of Opportunity

Astrophysics Explorers Program

14 Small Explorer (SMEX)

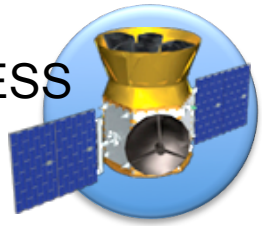
Notices of Intent Due Date: October 15, 2014
Proposal Due Date: December 18, 2014

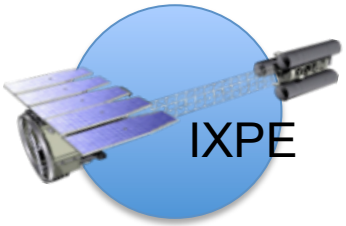
OMB Approval Number 2700-0085

SMEX 2019 (planned)

## Small and Mid-Size Missions

TESS





IXPE

Arcus
FINESSE
SPHEREx

## Missions of Opportunity

NICER

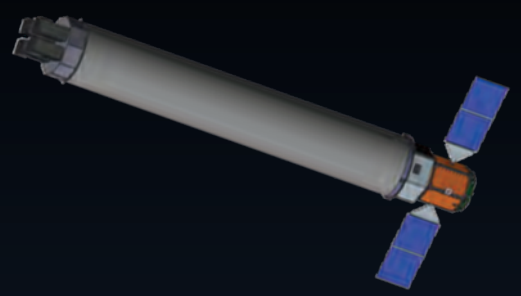
GUSTO

CASE
COSI-X
ISS-TAO

XARM

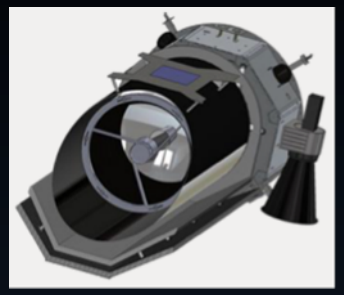
# Astrophysics Explorers in Competitive Phase A

## Arcus
PI: R. Smith/SAO



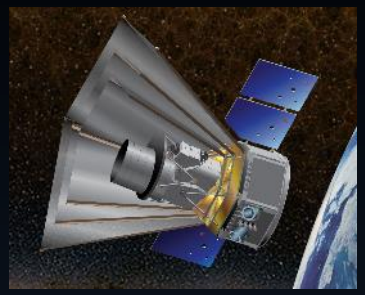
High resolution x-ray spectroscopy to explore the origin of galaxies

## FINESSE
PI: M. Swain/JPL



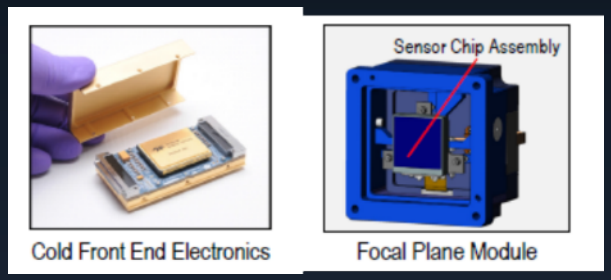
NIR transit spectroscopy to explore exoplanet atmospheres

## SPHEREx
PI: J. Bock/Caltech



NIR spectral survey addressing cosmology, galaxy evolution, and origin of ices

## CASE
PI: M. Swain/JPL

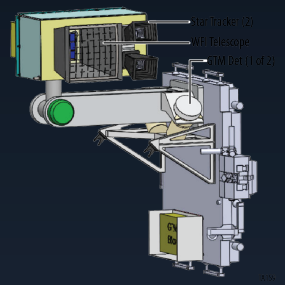



Contribution of detectors to ESA's ARIEL

## COSI-X
PI: S. Boggs/UCB

ULDB balloon mission to study origin of elements in the galaxy

## ISS-TAO
PI: J. Camp/GSFC



All-sky x-ray survey to study transients and search for GW sources

# Current Program: an integrated strategic plan

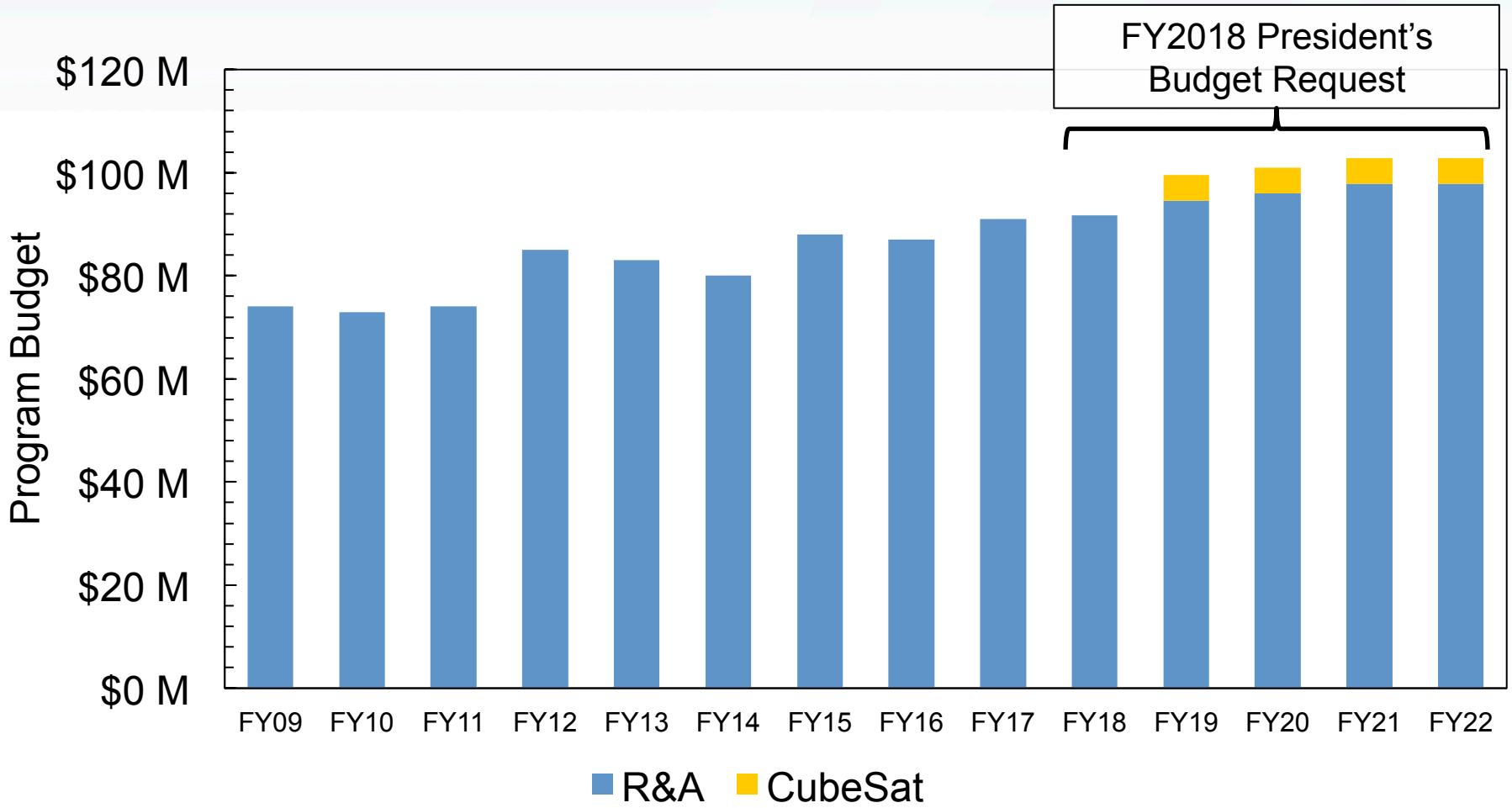
**We are executing a balanced strategic program for Astrophysics**

- Operating missions, large and small, continue to deliver paradigm changing science
  - Cosmology, Dark Energy, Exoplanets, Origin of Structure, …
- Large strategic missions under development …
  - Are next generation great observatories
  - Will rewrite textbooks
  - Can only be done by NASA
- A high cadence of Explorers has been resumed
- Investing in the community has been prioritized
  - R&A, technology development, supporting capabilities, ….

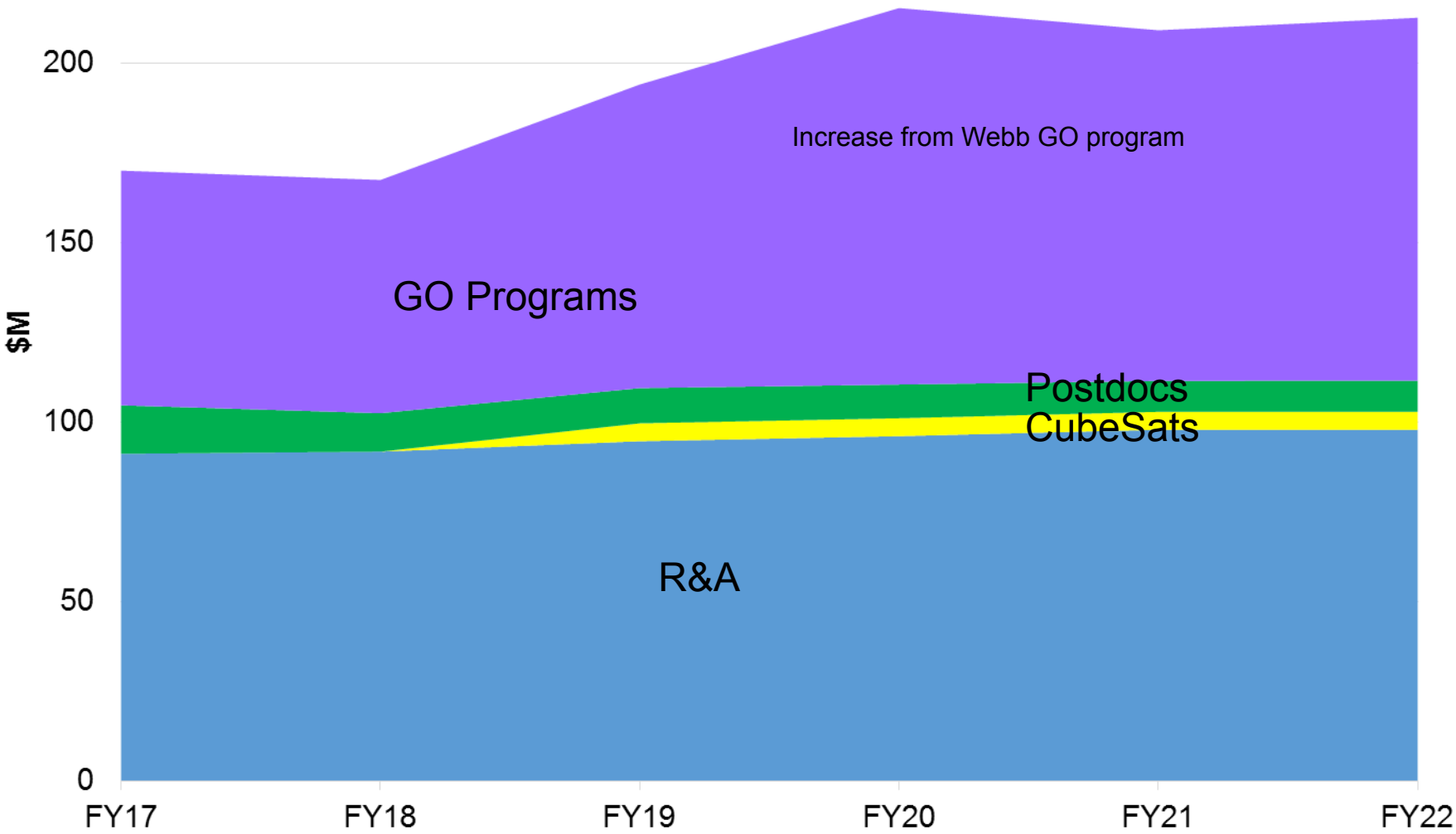
# Growth in R&A Support

Presentation on R&A by Dan Evans on Thursday

| Program | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 | FY16 | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R&A | $74 M | $73 M | $74 M | $85 M | $83 M | $80 M | $88 M | $87 M | $91 M | $92 M | $95 M | $96 M | $98 M | $98 M |
| CubeSat | | | | | | | | | | | $5 M | $5 M | $5 M | $5 M |
| **Total** | **$74 M** | **$73 M** | **$74 M** | **$85 M** | **$83 M** | **$80 M** | **$88 M** | **$87 M** | **$91 M** | **$92 M** | **$100 M** | **$101 M** | **$103 M** | **$103 M** |



# Growth in Total Community Support




GO programs funded from Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, SOFIA, Spitzer, Swift, TESS, Webb, XARM, XMM; does not include possible extensions following the 2019 Senior Review.

# Update on SAT Program

- NASA will not solicit proposals for new Strategic Astrophysics Technology (SAT) investigations in ROSES-2017.

- In order to rapidly advance key technologies for future large strategic missions ahead of the next decadal survey, NASA selected a large set of SAT-2016 proposals.

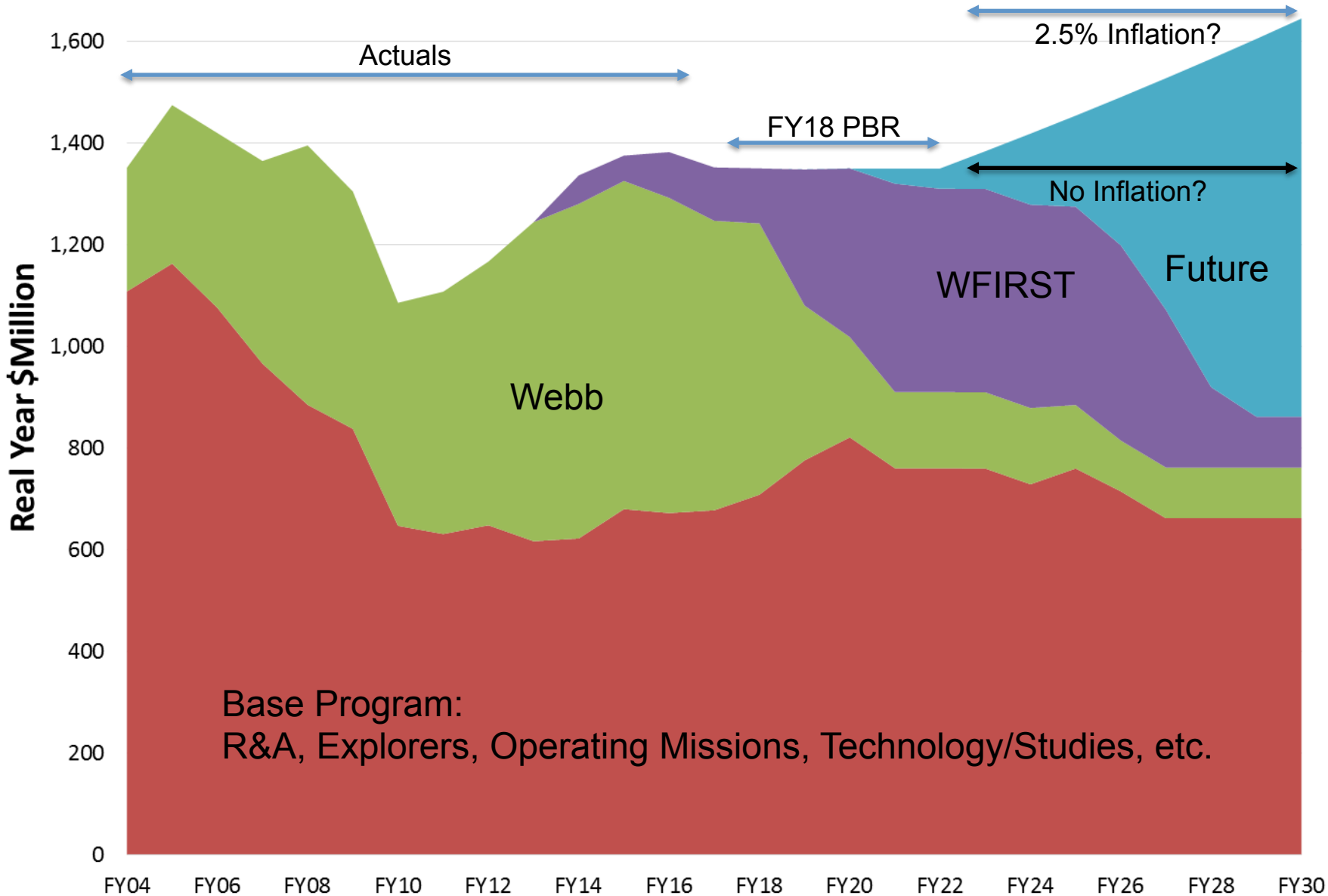
- Following an assessment of technology needs and other programmatic and budgetary considerations, NASA will decide whether or not to solicit SAT proposals in ROSES-2018.

# Current Program: an integrated strategic plan

**We are executing a balanced strategic program for Astrophysics**

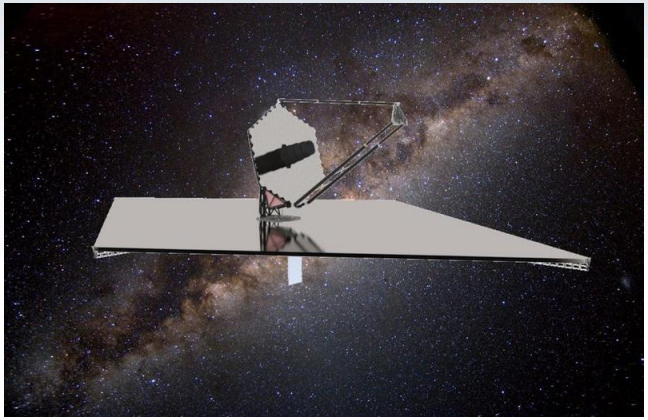
- Operating missions, large and small, continue to deliver paradigm changing science
  - Cosmology, Dark Energy, Exoplanets, Origin of Structure, …
- Large strategic missions under development …
  - Are next generation great observatories
  - Will rewrite textbooks
  - Can only be done by NASA
- A high cadence of Explorers has been resumed
- Investing in the community has been prioritized
  - R&A, technology development, supporting capabilities, ….
- Planning for the future is underway

# Planning for the Future



# Planning for the Future

- Large Mission Concept Studies

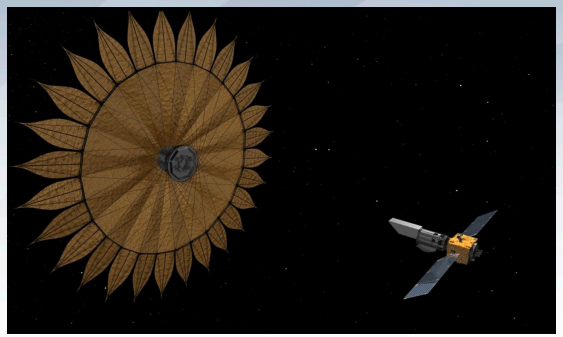


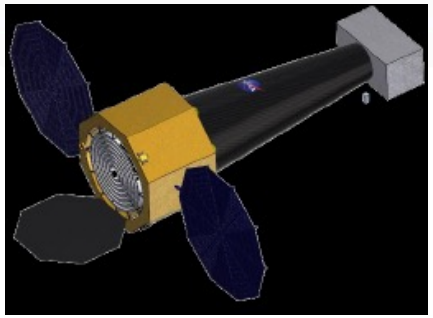
HabEx

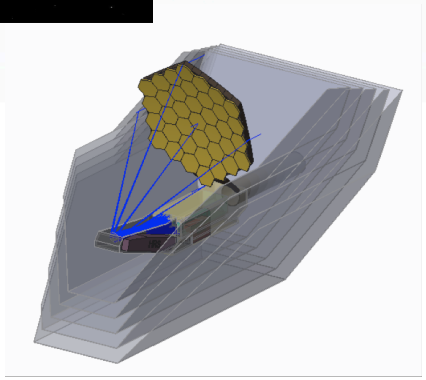
LUVOIR

Lynx

OST







- Medium (Probe) Concept Studies
  - Cosmic Dawn Intensity Mapper (A. Cooray)
  - Cosmic Evolution through UV Spectroscopy Probe (W. Danchi)
  - Galaxy Evolution Probe (J. Glenn)
  - High Spatial Resolution X-ray Probe (R. Mushotzky)
  - Inflation Probe (S. Hanany)
  - Multi-Messenger Astrophysics Probe (A. Olinto)
  - Precise Radial Velocity Observatory (P. Plavchan)
  - Starshade Rendezvous Mission (S. Seager)
  - Transient Astrophysics Probe (J. Camp)
  - X-ray Timing and Spectroscopy Probe (P. Ray)

# Planning for the Future

Presentation on Technology by Thai Pham and Brendan Crill on Thursday

| Mission Concept | TRL 2 Gaps | TRL 3 Gaps | TRL 4+ Gaps | Total # Gaps | Gaps Being Addressed |
|---|---|---|---|---|---|
| HabEx | 0 | 6 | 6 | 12 | 12 |
| LUVOIR | 1 | 4 | 4 | 9 | 7 |
| Lynx | 1 | 3 | 1 | 5 | 4 |
| OST | 1 | 1 | 3 | 5 | 2 |

- **HabEx Gaps:** mirror coatings, starshade starlight suppression, starshade controlling scattered sunlight, starshade lateral formation sensing, starshade petal position accuracy, starshade petal shape and stability, *telescope vibration control*, deformable mirrors, **visible detectors**, *large aperture primary mirror*, **wavefront sensing and control**, ***coronagraph optics and architecture***
- **LUVOIR Gaps:** closed-loop segment phasing, *vibration isolation*, ***wavefront sensing and control***, *mirror segments*, ***high-contrast segmented-aperture coronagraphy***, deformable mirrors, near Infrared detectors, **visible detectors**, mirror coatings
- **Lynx Gaps:** high-resolution lightweight X-ray optics, non-deforming X-ray reflecting coatings, megapixel X-ray imaging detectors, **large-format, high resolution X-ray detectors**, X-ray grating arrays
- **OST Gaps:** far-IR (FIR) detectors, cryogenic readouts for large-format FIR detectors, warm readout electronics for large-format FIR detectors, sub-K Coolers, cryogenic FIR mirror segments

- Green: technologies being advanced through SAT or directed development,
- **Bold**: technologies being advanced by WFIRST or ATHENA
- *Italics*: technologies being worked on through the STDT's design studies

# NASA Astrophysics

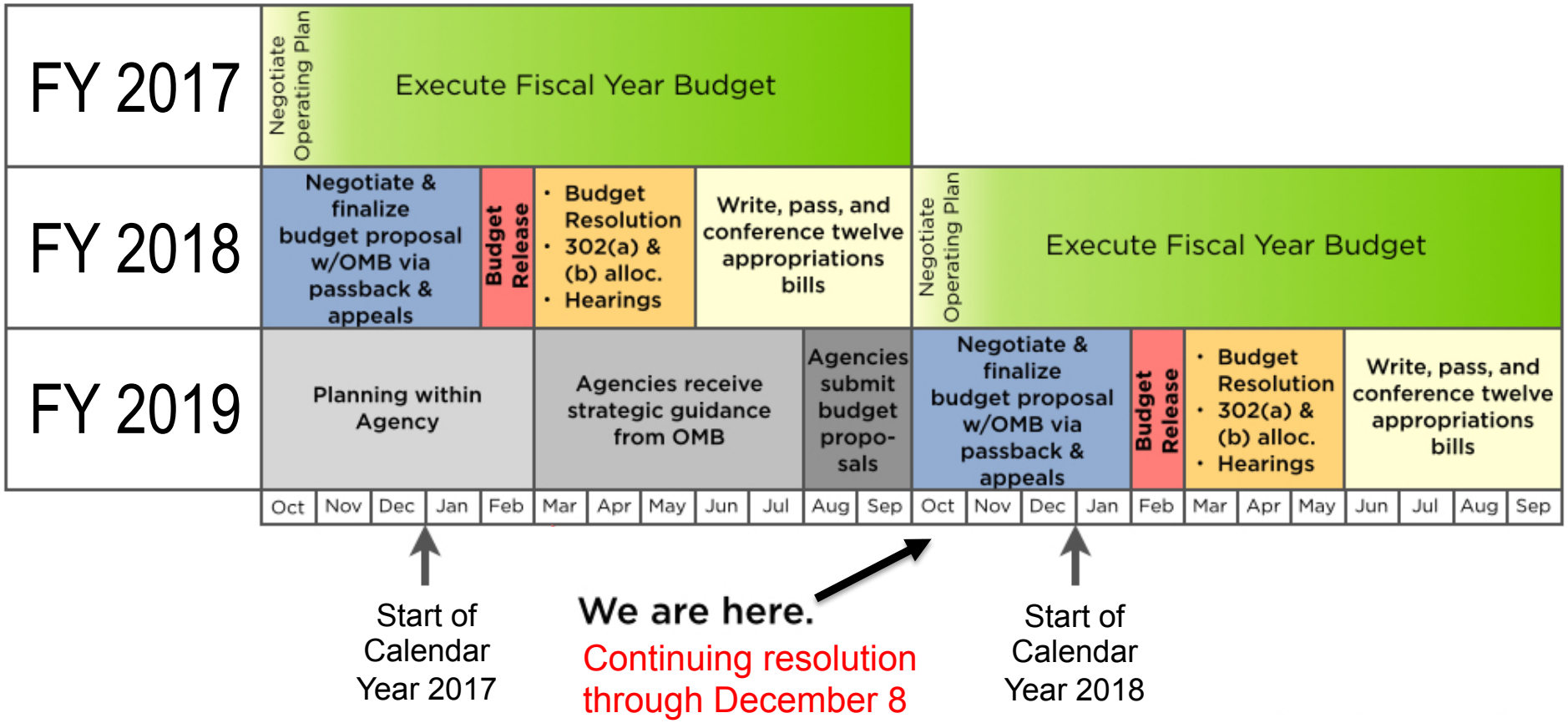
# Budget Update

# Implementing the Decadal Survey and the Midterm Assessment

| Prioritized Recommendation | NASA plans |
|---|---|
| LARGE ACTIVITIES | |
| WFIRST | In Phase A, launch in mid-2020s; independent review |
| Explorers | Planning 4 AOs per decade: SMEX 2014, MIDEX 2016, SMEX 2019, MIDEX 2021; maintain cadence |
| LISA | Partnering on ESA's LISA gravitational wave observatory; increased US role |
| IXO | Partnering on ESA's Athena x-ray observatory; no increase to US role |
| MEDIUM ACTIVITIES | |
| Exoplanet technology | WFIRST coronagraph, Starshade and coronagraph technology development; lower priority than LISA technology |
| Inflation Probe technology | Balloon-borne technology experiments, detector investments |
| SMALL ACTIVITIES | |
| R&A augmentations | R&A increased by reducing Fellowships |
| Mid-TRL technology | Initiated SAT program, includes competed & directed technologies |
| Suborbital missions | Initiated ultra long duration balloon capability |

"Despite a challenging budget environment, NASA-APD has maintained a balanced portfolio through the first half of the decade and, with the assumption of successful completion of an ambitious Explorer schedule, will do so during the second half of the decade as well. ..." NAS Midterm Assessment, Finding 4-14

# Federal Budget Cycle




Adapted by Kevin Marvel (AAS)
https://aas.org/files/budgetprocess_adaptedfromaaas.jpg
from budget presentation by Matt Hourihan (AAAS)
http://www.aaas.org/page/presentations

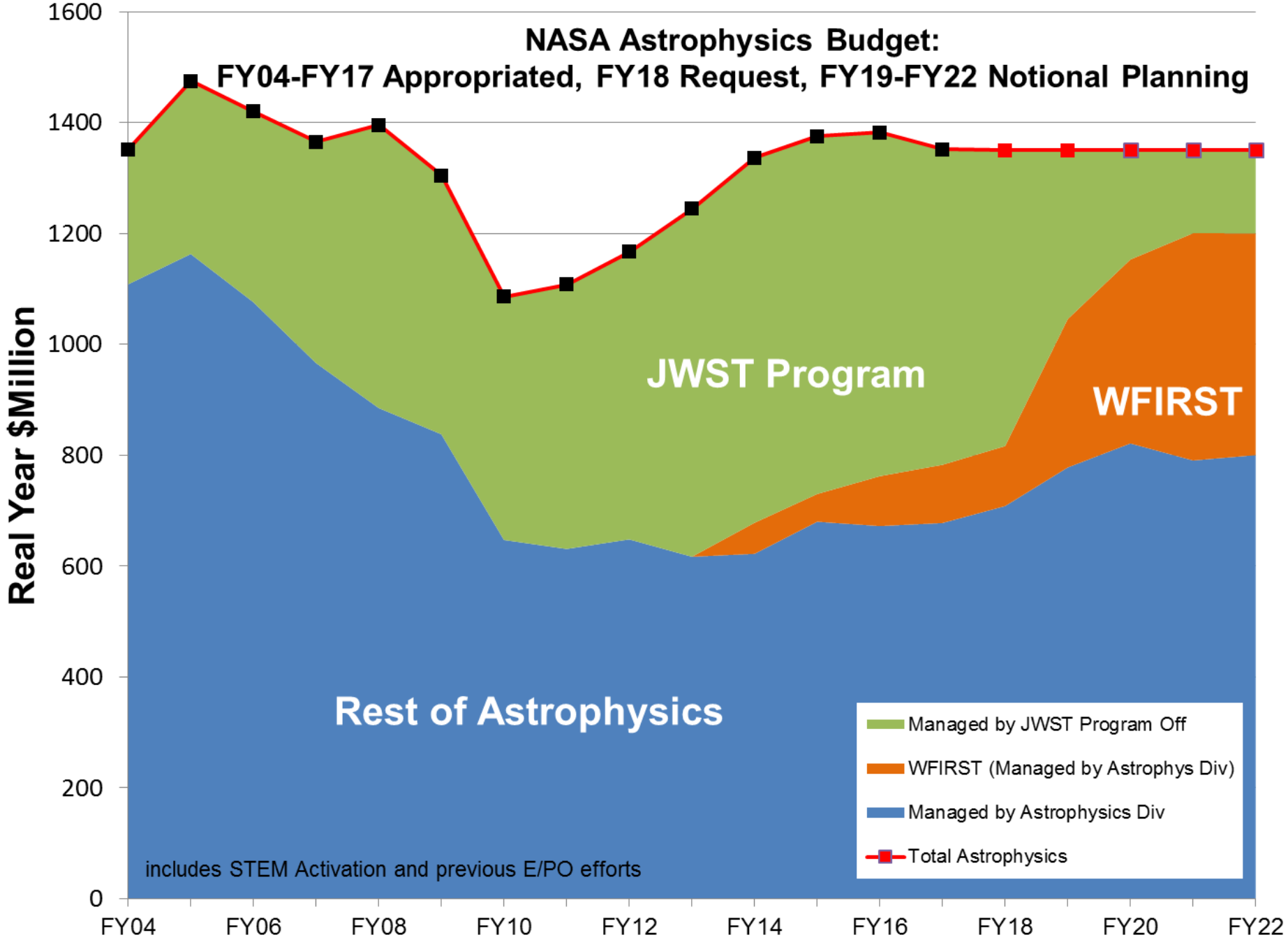
# FY17 Final Budget

| $M | FY17 Request | FY17 Actual | Delta | |
|---|---|---|---|---|
| Total | 1,350.9 | 1,352.3 | +1.4 | Reduction of $31.5M in total offset by cost sharing of STEM Activation |
| Webb | 569.4 | 569.4 | --- | Set by Appropriation |
| WFIRST | 90.0 | 105.0 | +15.0 | Set by Appropriation; Appropriation caps WFIRST LCC at $3.5B through prime mission |
| SOFIA | 83.8 | 85.2 | +1.4 | Set by Appropriation |
| Hubble | 97.3 | 97.3 | --- | |
| STEM Activation | 25.0 | 37.0 | +12.0 | Set by Appropriation but costs shared across Divisions |
| TESS | 89.0 | 74.0 | -15.0 | Deferred launch vehicle payment until FY18; reduction in HQ-held reserves in FY18 to accommodate |
| Balloon Project | 37.0 | 34.0 | -3.0 | Defer upgrades in Antarctica for efficient three payload operations |
| Rest of Astrophysics | | | -9.0 | Rephasing and reduction in many programs and projects |

# FY18 President's Budget Request

| $M | FY16 Actual | FY17 Actual | FY18 Request | Change from FY16 | Change from FY17 |
|---|---|---|---|---|---|
| NASA | 19,285 | 19,653 | 19,092 | -1.0 % | -2.9% |
| SMD | 5,584 | 5,765 | 5,712 | +2.3 % | -0.9 % |
| Earth Science | 1,927 | 1,908 | 1,754 | -9.0 % | -8.1 % |
| Heliophysics | 647 | 675 | 678 | +4.8 % | +0.4 % |
| Planetary Science | 1,628 | 1,828 | 1,930 | +18.6 % | +5.6 % |
| Astrophysics (including Webb) | 1,382 | 1,352 | 1,350 | -2.3% | -0.1 % |

- Supports an SMD-wide CubeSat/SmallSat initiative that uses smaller, less expensive satellites to advance science in a cost-effective manner.
- Reflects more efficient operations of the Hubble Space Telescope, without impact to science.
- Reflects efficiencies realized by the SOFIA in the past few years. SOFIA will participate in the 2019 Astrophysics Senior Review.
- Does not include WFIRST review recommendations.


NASA Astrophysics Budget:
FY04-FY17 Appropriated, FY18 Request, FY19-FY22 Notional Planning
Real Year $Million
1600
1400
1200
1000
800
600
400
200
0
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
JWST Program
WFIRST
Rest of Astrophysics
Managed by JWST Program Off
WFIRST (Managed by Astrophys Div)
Managed by Astrophysics Div
Total Astrophysics
includes STEM Activation and previous E/PO efforts

# FY18 Appropriation Markups

- Both Markups
  - Follow the Decadal Survey
  - Webb must be $533.7M (= requested) but do not overrun
  - STEM Activation must be $44.0M (= request); other language
- House Markup
  - Core R&A must be $74.1M (= request)
  - SOFIA must be $85.2M (+$5.3M over request, = FY17 level); other language
  - WFIRST must be $126.6M (= request) but spend $20M on starshade technology
  - Language on high energy observatories, astrophysics probes, finding target(s) for interstellar probe
- Senate Markup
  - WFIRST must be $150.0M (+23.4M over request); review; data w/ Hubble, Webb
  - Hubble must be $98.3M (+$15M over request)
  - At least $10M on “life detection technology”; consistent with request (maybe)

| | FY18 PBR | FY18 Markups | |
|---|---|---|---|
| Total Astrophysics | $ 1,350.5 M | $ 1,350.5 M | |
| Line Item Projects | $ 941.6 M | $ 995.3 M | Webb, WFIRST, Hubble, SOFIA, R&A, STEM, Starshade ($10M) * |
| Rest of Astrophysics | $ 408.9 M | $ 365.2 M | $43.7M (13%) reduction |

* Combined House and Senate markups

# NASA Astrophysics

# Selected Mission Updates

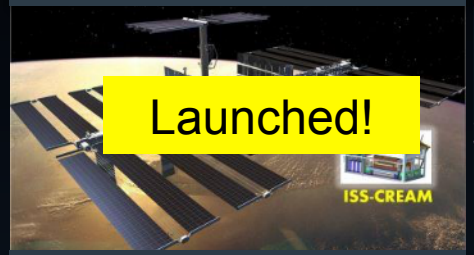
# Seeking Private Sponsor for Spitzer Operations

- SMD released a Request for Information (RFI) on October 12, 2017, seeking information to inform decisions regarding Astrophysics SmallSats.
- NASA is seeking information from parties who are interested in operating the Spitzer Space Telescope using non-NASA funding, including defining and executing a Spitzer science program, beyond the timeframe of the NASA-funded mission.
- The Astrophysics Division of SMD has committed support for Spitzer operations through March 2019. If no engineering impediments arise we expect that current Spitzer operations could continue through September 2019 and operations beyond September 2020 should be possible for the lowest data volume observing modes.
- The FY18 cost of Spitzer operations, without direct science data analysis funding for the Guest Observer (GO) program and Deep Space Network (DSN) support, is $14 million.
- Responses due December 1, 2017

- RFI is posted in Fed Biz Opportunities at https://www.fbo.gov/notices/9bbeab044b505ed30c080b98a46ff622

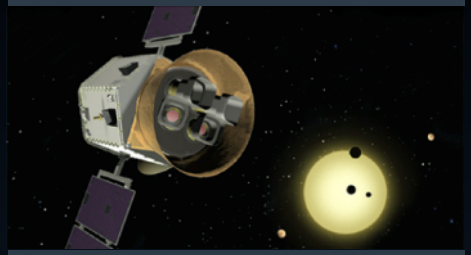
# Astrophysics Missions in Development

## ISS-CREAM
8/2017
NASA Mission



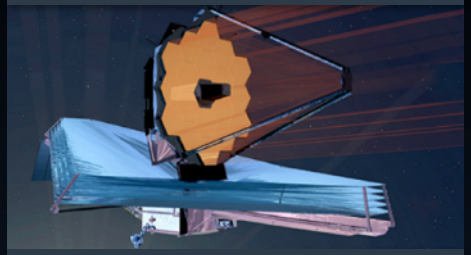

Cosmic Ray Energetics
And Mass

## TESS
3/2018
NASA Mission



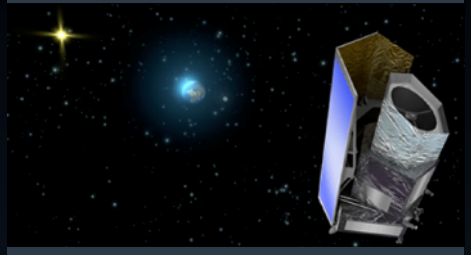
Transiting Exoplanet
Survey Satellite

## Webb
2019
NASA Mission



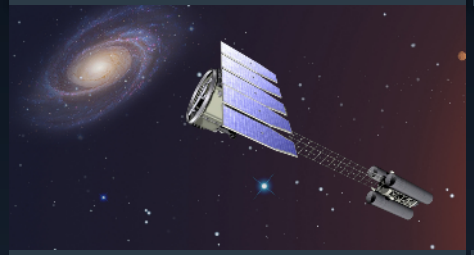
James Webb
Space Telescope

## Euclid
2020
ESA-led Mission



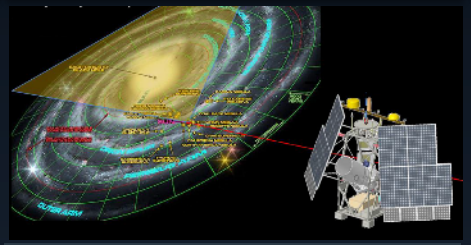
NASA is supplying the NISP
Sensor Chip System (SCS)

## IXPE
2021
NASA Mission



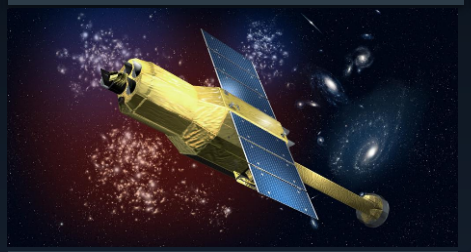
Imaging X-ray
Polarimetry Explorer

## GUSTO
2021
NASA Mission



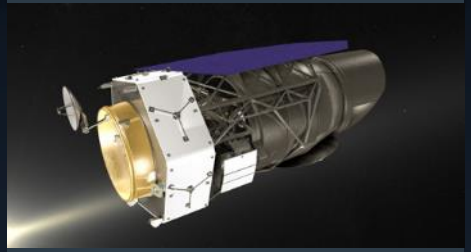
Galactic/ Extragalactic ULDB
Spectroscopic Terahertz Observatory

## XARM
2021
JAXA-led Mission



NASA is supplying the SXS
Detectors, ADRs, and SXTs

## WFIRST
Mid 2020s
NASA Mission

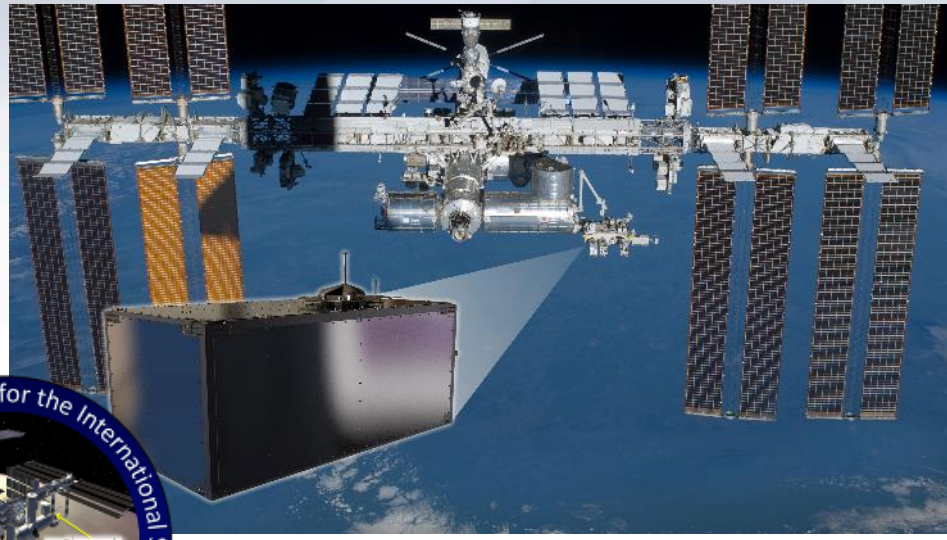


Wide-Field Infrared
Survey Telescope

# ISS-CREAM

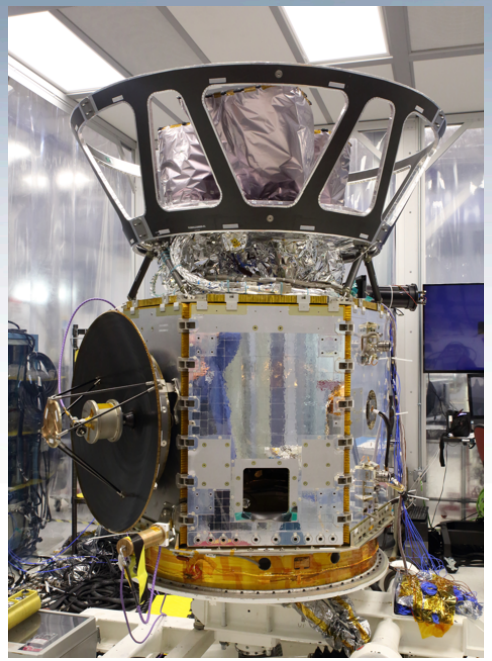
## Cosmic Ray Energy and Mass

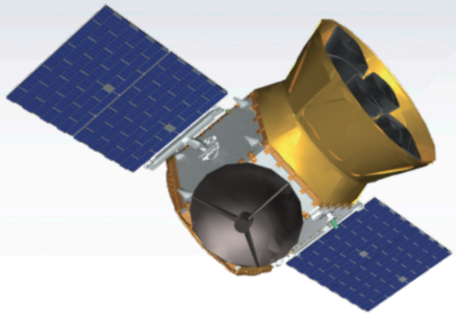
**http://cosmicray.umd.edu/iss-cream/**


# TESS

## Transiting Exoplanet Survey Satellite





**Medium Explorer (MIDEX) 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**: NLT June 2018 launch with a 3-year prime mission including 2 years of spacecraft operations and an additional 1 year ground-based observations and analysis. High-Earth elliptical orbit (17 x 58.7 Earth radii).

**CURRENT STATUS:**

- Both instrument and spacecraft bus completed and integrated.
- Observatory environmental testing started in Sept. 2017.
- Spare camera long-duration testing has shown no unexpected focus drift anomalies to date.

**SCHEDULE:**

- ✓ July 2017 – SIR
- ✓ August 2017 – KDP-D
- ✓ Sept 2017 - PER
- October - Vibration testing
- November - TVAC testing
- Late Jan 2018 - Observatory I&T complete
- Early Feb 2018 – Delivery to KSC payload processing facility
- March 2018 – Launch readiness date from Cape Canaveral FL

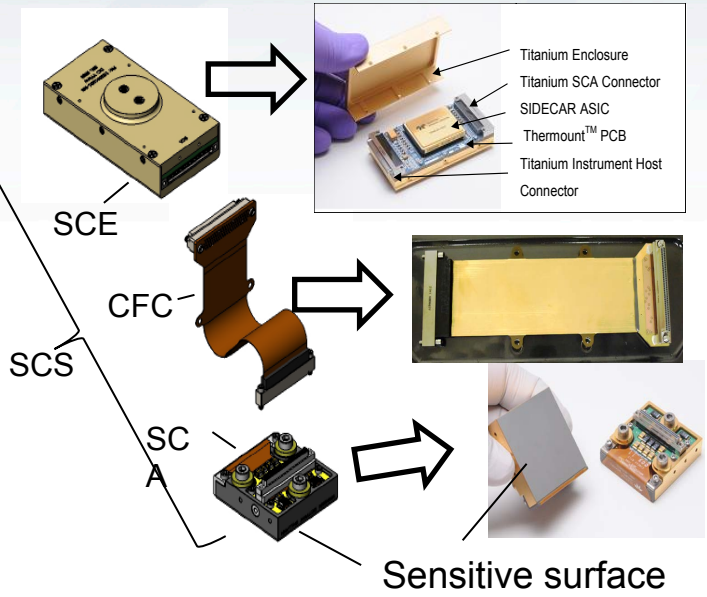
**https://tess.gsfc.nasa.gov/**

# Euclid

http://sci.esa.int/euclid/

## UPDATE:

- Problems were encountered in the sensor chip electronics (SCE).
- SCE Tiger Team initiated and report received in September.
- ESA has proposed relaxing the operating and qualification testing temperatures to reduce thermal stresses in SCEs.
- Two proposed paths forward with 12-18 month impact.
  - Option A (warm): Redesign of the enclosure and qualification for a higher Euclid operating temperature.
  - Option B: Total redesign of enclosure, PCB interface, ASIC mounting technique and design qualification.
- JPL conducting Option A testing in parallel with option B. Plan to test two additional SCEs at 115K.
  - Convening an independent panel to review the results to help to determine if Option A qualification is needed.

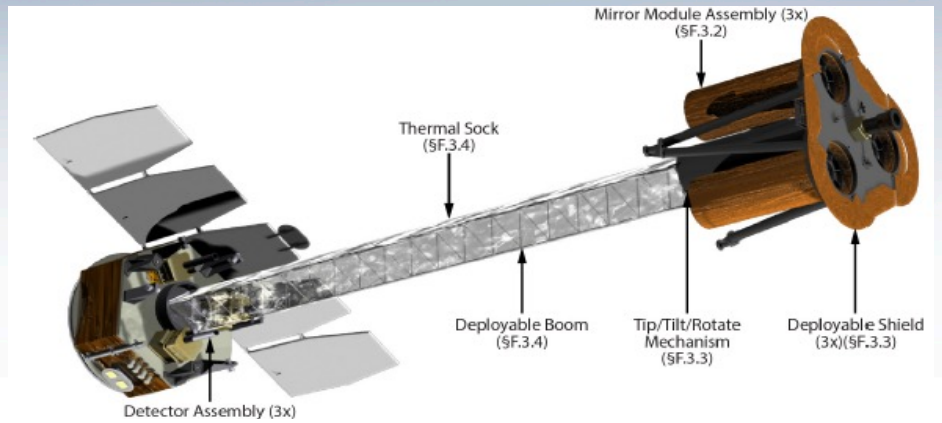



- Sensor Chip System (SCS)
- Sensor Chip Assembly (SCA)
- Cryo-Flex Cable (CFC)
- Sensor Chip Electronics (SCE)

## UPCOMING EVENTS:

- Report on status to ESA to support November meeting of ESA's Science Programme Council.
- Decision point for proceeding with Option A (warm) expected in November.
- Detailed plan for Option B due in December followed by decision point.

# Imaging X-ray Polarimetry Explorer (IXPE)



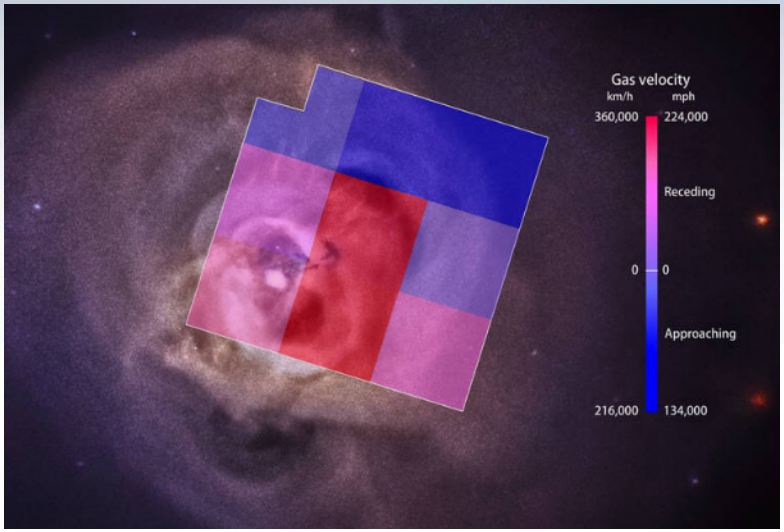

- Next Astrophysics SMEX: IXPE, PI: Martin Weisskopf, MSFC (announced January 2017)
- IXPE has a 2-8 keV energy range, proportional counter energy resolution, 11´ FOV, and ≤ 30" angular resolution
- IXPE targets AGNs and microquasars, pulsars and pulsar wind nebulae, magnetars, accreting X-ray binaries, supernova remnants, the Galactic center.
- Addresses fundamental questions about:
  - the geometries of the flows, emission regions, and magnetic fields
  - physical processes leading to particle acceleration and X-ray emission
  - physical effects of gravitational, electric, & magnetic fields at their extreme limits

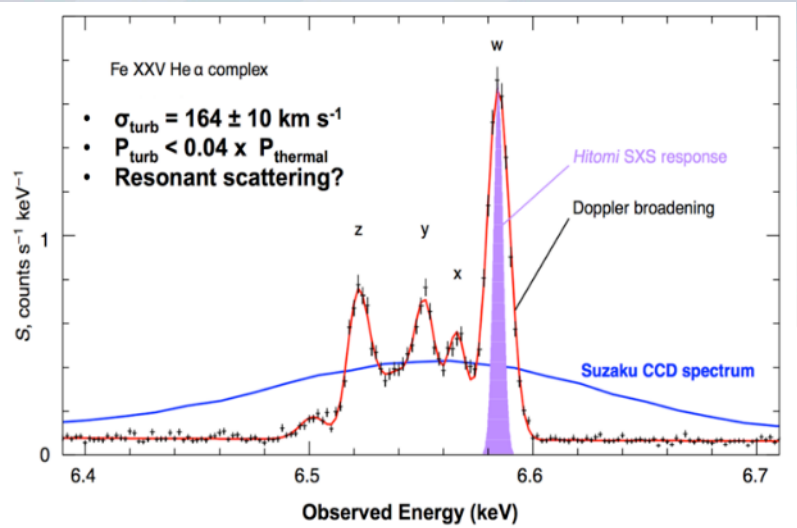
**UPDATE:**

- IXPE rephasing activity ongoing at MSFC due to reduction in their FY18 planning budget.
- IXPE replan schedule would result in a launch date slip from Nov 2020 to Apr. 2021.
- SRR completed in Sept 2017.

**https://wwwastro.msfc.nasa.gov/ixpe/**

# X-ray Astronomy Recovery Mission




- XARM is the successor to Hitomi.
- Designed to provide breakthrough advances in our knowledge of winds, outflows, clusters, and dark matter.
- Mission will include an X-ray microcalorimeter and an X-ray imager.
- XARM now in Phase A. PDR/CDR mid-November, KDP B/C in January.
- U.S. Community Involvement
  - The U.S. science community should expect a high level of involvement in the planning and execution of the XARM science mission.
  - ROSES element for XARM Science Team members (aka Participating Scientists) released. Mandatory Step-1 deadline October 24; Step-2 deadline December 13.

# X-ray Astronomy Recovery Mission (XARM)

- US Community Participation in XARM
  - Participating Scientists: JAXA and NASA will each appoint a small number of Participating Scientists to the XARM Science Team; NASA has an open solicitation in 2017. The Science Team consists of the researchers who directly contribute to the development, operation, and management of the project. As members of the XARM Science Team, Participating Scientists will have full access to Performance Verification (PV) phase data.
    - Solicitation released September 12 as ROSES-17 Appendix D.14: Mandatory Step-1 deadline October 24; Step-2 deadline December 13.
  - PV Phase Target Team Participation: JAXA and NASA will enable broad scientific participation in the early operation of XARM. Approximately one year before launch the Agencies will openly solicit additional community members to participate in the analysis of targets observed in the PV phase of the mission that are led by the XARM Science Team. Each PV Target Team member will become a member of an object-specific team, and will receive access to the PV data for that object.
  - General Observer Program: Following the conclusion of the PV phase of the mission approximately six to nine months after launch, XARM observing time will be dedicated to General Observations allocated through an open solicitation process.

# Astrophysics Missions in Pre-Formulation

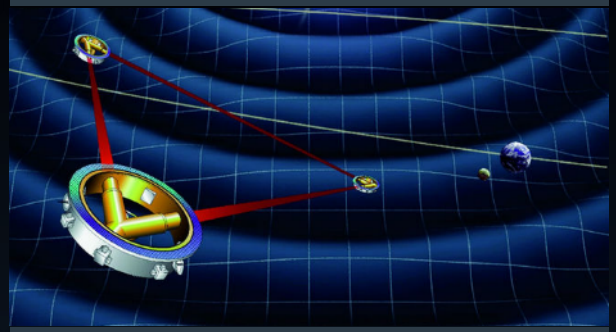
## Athena
Late 2020s

ESA-led Mission

NASA is supplying elements for both instruments

## LISA
Mid 2030s

ESA-led Mission



NASA is developing technology for both the payload and the mission

# Large Interferometer Space Antenna (LISA)

- The ESA SPC selected LISA as the Large 3 observatory of its Cosmic Vision Programme and has started Phase 0 (June – December 2017) with a series of technical meetings to study the payload trades. Phase A will start January 2018.
- NASA has established a LISA Study Office at GSFC. The LISA Study Office serves as a liaison with the ESA LISA project. The LISA Study Office is attending ESA Phase 0 design runs and will attend the final report.
- NASA and ESA discussions for US contributions to LISA are advanced. NASA is funding five US-based technologies with the aim of reaching TRL 5/6 by Adoption (nominally 2022). The candidate technologies are managed by the LISA Study Office.
- ESA formed the LISA Study Science Team (SST) and asked NASA to nominate 3 members of the US astrophysics community. The first meeting of the ESA LISA SST was held September 21-22. The NASA Program and Study Scientists attended.
- The NASA L3 Study team (L3ST) had its final face-to-face meeting on July 12 in Pasadena. The L3ST was then disbanded.
- In August, NASA issued a call for nominations for the US LISA Study Team (ST) and for NASA-nominated members of the ESA LISA SST. The NASA LISA ST will
  - Prepare a report to the 2020 Decadal Survey re-stating the science case for US participation in LISA;
  - Provide a NASA-endorsed interface with the European-led LISA Consortium;
  - Support the NASA LISA Study Office with analysis on scientific and technical issues.
- 60 applications were received by NASA, including a significant number from non-gravitational wave astrophysicists. Selections announced October 2017.

# NASA LISA Study Team Membership

| **Study Team:** | | | * US reps to ESA Science Study Team |
|---|---|---|---|
| Jillian Bellovary | CUNY-Queensborough | Brittany Kamai | Caltech |
| Peter Bender | Univ. of Colorado | Joey Key | U. Washington, Bothel |
| Emanuele Berti | Univ. of Mississippi | Shane Larson | Northwestern |
| Warren Brown | SAO | Sean McWilliams | West Virginia Univ. |
| Robert Caldwell | Dartmouth | Guido Mueller | Univ. of Florida |
| Neil Cornish | Montana State U. | Priyamvada Natarajan | Yale |
| Mike Eracleous | Pennsylvania State U. | David Shoemaker* | MIT |
| Craig Hogan | Fermilab | Deirdre Shoemaker | Georgia Tech |
| Kelly Holley-Bockelman* (Chair) | Vanderbilt Univ. | Robin (Tuck) Stebbins* | Univ. of Colorado |
| **Core Team:** | | | |
| John Baker | NASA GSFC | Tyson Littenberg | NASA MSFC |
| Jordan Camp | NASA GSFC | Jeff Livas | NASA GSFC |
| John Conklin | Univ. of Florida | Kirk McKenzie | NASA JPL |
| Curtis Cutler | NASA JPL | Michele Vallisneri | NASA JPL |
| Ryan DeRosa | NASA GSFC | John Ziemer | NASA JPL |
| William Klipstein | NASA JPL | | |
| **Pre-Formulation Office (Ex Officio):** | | | |
| Ira Thorpe | NASA GSFC | Ann Hornschemeier | NASA GSFC |

# Preparing for the 2020 Decadal Survey

- Large Mission Concept Studies
  - Habitable Exoplanet Imaging Mission
  - Large UV/O/IR Surveyor
  - Lynx (X-ray Surveyor)
  - Origins Space Telescope (Far Infrared Surveyor)
- Astrophysics Probes / Medium Mission Concepts
  - Cosmic Dawn Intensity Mapper (A. Cooray)
  - Cosmic Evolution through UV Spectroscopy Probe (W. Danchi)
  - Galaxy Evolution Probe (J. Glenn)
  - High Spatial Resolution X-ray Probe (R. Mushotzky)
  - Inflation Probe (S. Hanany)
  - Multi-Messenger Astrophysics Probe (A. Olinto)
  - Precise Radial Velocity Observatory* (P. Plavchan)
  - Starshade Rendezvous Mission* (S. Seager)
  - Transient Astrophysics Probe (J. Camp)
  - X-ray Timing and Spectroscopy Probe (P. Ray)

* Partial selection

What else should the community be studying? What else should NASA be supporting?

Decadal Survey Committee begins meeting in early 2019


Revised
October 1, 2017

# NASA Astrophysics

# Backup

# Astrophysics Division, NASA Science Mission Directorate

***Resource Management***
Omana Cawthon+
Clemencia Gallegos-Kelly+
Debra Mcneill+

***Director***
Paul Hertz

***Deputy Director***
Andrea Razzaghi

*Lead Secretary:* Kelly Johnson
*Secretary:* Kyle Nero
*Program Support Specialist:* Jackie Mackall

## Cross Cutting

*Technology Lead:* Nasser Barghouty*
*Education POC:* Hashima Hasan (Lead Comm Team)
*Public Affairs Lead:* Kartik Sheth
*Information Manager:* Lisa Wainio*
*Strategic Planning*: Rita Sambruna

## Astrophysics Research

***Program Manager*: Dan Evans**
Program Support: Ingrid Farrell*
Astrophysics Data Analysis: Doug Hudgins
Astrophysics Theory: Keith MacGregor*
Exoplanet Research: Martin Still*
APRA lead: Michael Garcia*
Cosmic Ray, Fund Physics: Thomas Hams*, Vernon Jones, Keith MacGregor*, Rita Sambruna
Gamma Ray/X-ray: Dan Evans, Michael Garcia*, Stefan Immler*, Rita Sambruna
Optical/Ultraviolet: Michael Garcia*, Hashima Hasan, Mario Perez*, Martin Still*
IR/Submillimeter/Radio: Dominic Benford*, Doug Hudgins, Kartik Sheth, Eric Tollestrup*
Lab Astro: Doug Hudgins
Theory & Comp Astro Net: Keith MacGregor*
Roman Tech Fellows: Michael Garcia
Data Archives: Hashima Hasan
Astrophysics Sounding Rockets: Thomas Hams*
Balloons Program: Vernon Jones(PS), Mark Sistilli (PE)
CREAM: Vernon Jones(PS), Jeff Hayes (PE)

## **Programs** / Missions & Projects

| | *Program Scientist* | *Program Executive* |
|---|---|---|
| **Exoplanet Exploration (EXEP)** | | |
| **Program** | **Doug Hudgins** | **John Gagosian** |
| Keck | Hashima Hasan | Mario Perez* |
| Kepler/K2 | Mario Perez* | Jeff Hayes |
| LBTI | Doug Hudgins | Mario Perez* |
| NN-EXPLORE | Doug Hudgins | Mario Perez* |
| WFIRST | Dominic Benford* | John Gagosian |
| **Cosmic Origins (COR)** | | |
| **Program** | **Mario Perez*** | **Shahid Habib** |
| Herschel | Dominic Benford* | Jeff Hayes |
| Hubble | Michael Garcia* | Jeff Hayes |
| SOFIA | Kartik Sheth | Lucien Cox* |
| Spitzer | Kartik Sheth | Jeff Hayes |
| Webb^ | Hashima Hasan | N/A |
| **Physics of the Cosmos (PCOS)** | | |
| **Program** | **Rita Sambruna** | **Shahid Habib** |
| Athena | Michael Garcia* | Shahib Habib |
| Chandra | Stefan Immler* | Jeff Hayes |
| Euclid | Eric Tollestrup* | Shahid Habib |
| Fermi | Stefan Immler* | Jeff Hayes |
| LISA | Rita Sambruna | Shahid Habib |
| Planck | Rita Sambruna | Jeff Hayes |
| ST-7/LPF | Rita Sambruna | Jeff Hayes |
| XMM-Newton | Stefan Immler* | Jeff Hayes |
| **Astrophysics Explorers (APEX)** | | |
| **Program** | **Linda Sparke** | **Mark Sistilli** |
| GUSTO | Thomas Hams* | Lucien Cox* |
| IXPE | Eric Tollestrup* | Mark Sistilli |
| NICER | Rita Sambruna | Jeff Hayes |
| NuSTAR | Stefan Immler* | Jeff Hayes |
| Swift | Martin Still* | Jeff Hayes |
| TESS | Martin Still* | Mark Sistilli |
| XARM | Dan Evans | Shahid Habib |

\+ *Member of the Resources Management Division*
* *Detailee, IPA, or contractor*
^ *Webb is part of the JWST Program Office.*

Oct 10, 2017

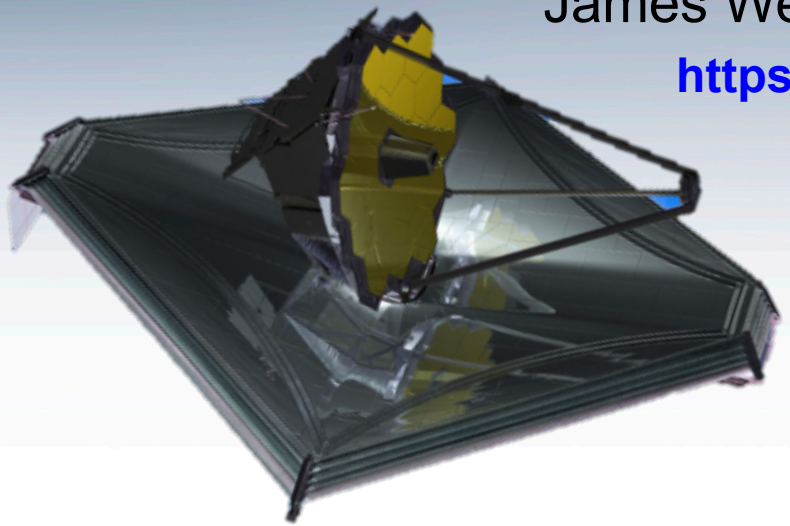
# Current and Future Explorer AOs

- NASA is maintaining a cadence of 4 Astrophysics Explorers AOs per decade, as recommended by Decadal Survey and validated by Midterm Assessment.
  - Midterm Assessment Recommendation 4-3: "NASA's Astrophysics Division should execute its current plan, as presented to the committee, of at least four Explorer Announcements of Opportunity during the 2012-2021 decade, each with a Mission of Opportunity call, and each followed by mission selection."
- Most recent Astrophysics Explorers Program AO, released in September 2016, was for a MIDEX and Mission of Opportunity (MO).
  - Three MIDEX mission proposals and three Mission of Opportunity proposals selected in August 2017 for 9-month competitive Phase A studies
  - Down-selection: Early 2019 (target)
  - MIDEX launch readiness date no later than December 2023
  - MO launch readiness date no later than December 2022, except for Partner MOs whose launch date is set by the host mission.
- Next Astrophysics Explorers Program AO will be for a SMEX and MO and is targeted for release in early 2019.
- Subsequent Astrophysics Explorers Program AO is for a MIDEX and MO and is targeted for release in late summer 2021.

# Webb

## James Webb Space Telescope

https://jwst.nasa.gov/



**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**: 2019 launch for a 5-year prime mission

**Partners:** ESA, CSA

**RECENT ACCOMPLISHMENTS:**

- Completed spacecraft bus integration with sunshield forming the spacecraft element (SCE)
- Conducted first deployment test of SCE
- Started cryovacuum testing of the science payload (~80% done)
- Received 106 proposals for Early Release Science programs

**2017- early 2018 Plans:**

- Complete cryovacuum test of science payload and ship to Northrop-Grumman
- Environmental testing of SCE
- Integration of SCE and science payload
- Observatory level deployment and environmental testing

# SOFIA

- Observing Cycle 5 Flights
  - The FORCAST instrument planned eleven (11) flights during September 12- 27, 2017; three (3) were successful
  - The Triton Occultation took place successfully October 5, 2017, from Daytona FL utilizing the FLIPO instrument
- Instrument Status
  - 535 observing hours awarded for Cycle 5
  - High Resolution Mid Infrared Spectrometer (HIRMES) completed its CDR August 30, 2017, and is continuing development activities
  - High-resolution Airborne Wideband Camera-plus (HAWC+) pre-flight readiness activities continued in support of the mid-October science flight series
  - Next Generation instrument solicitation draft in work
- Programmatic
  - Building 703 deluge repair RFAs distribution approval has been granted to repair the Science Instrument labs and personnel offices


**https://www.sofia.usra.edu/**

Astrophysics Division
Science Mission Directorate
National Aeronautics and Space Administration