National Aeronautics and
Space Administration

ASTROPHYSICS



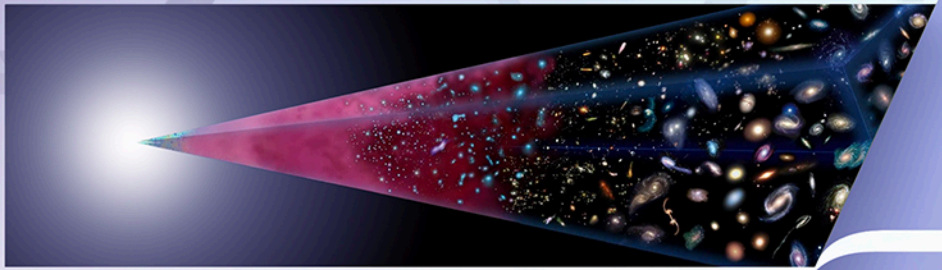

NASA Astrophysics Update

Astronomy and Astrophysics Advisory Committee
NSF Headquarters, Alexandria VA
September 20, 2018

Paul Hertz

Director, Astrophysics Division
Science Mission Directorate
@PHertzNASA

Why Astrophysics?



How did our universe begin and evolve?

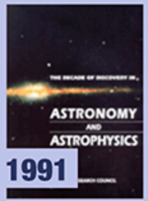
How did galaxies, stars, and planets come to be?

Are we alone?

Enduring National Strategic Drivers

1972

1982

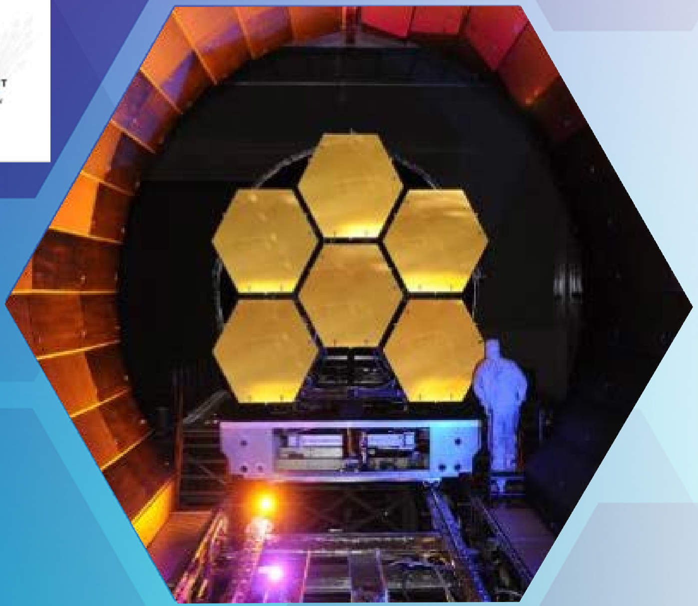


1991

2001

2010

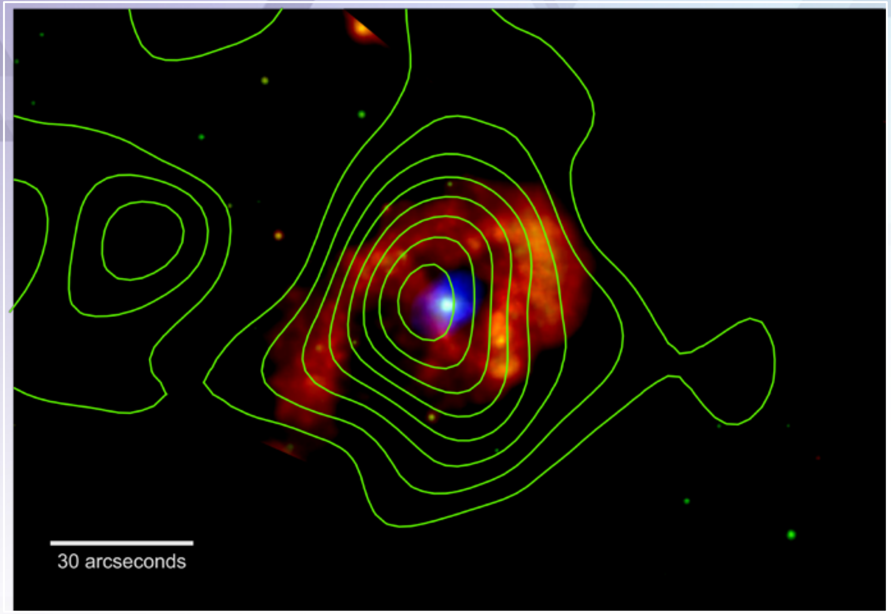
Astrophysics is humankind's scientific endeavor to understand the universe and our place in it.

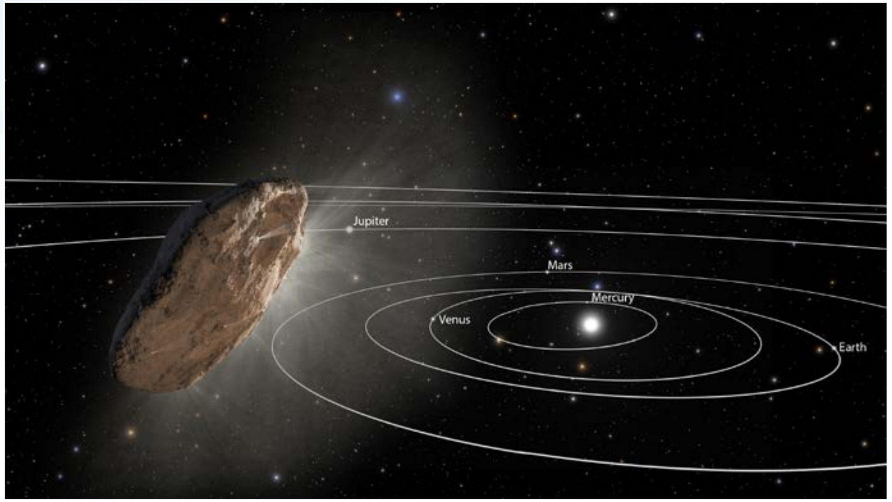


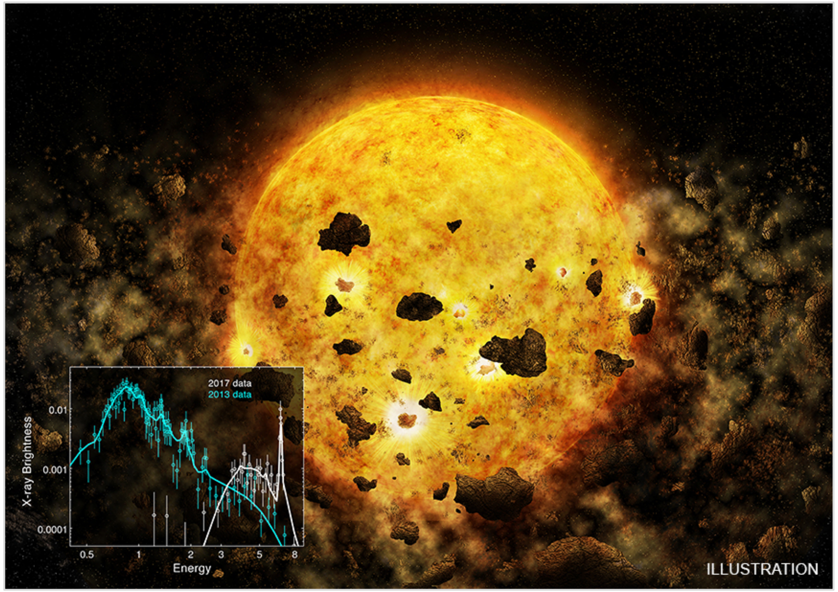
Outline

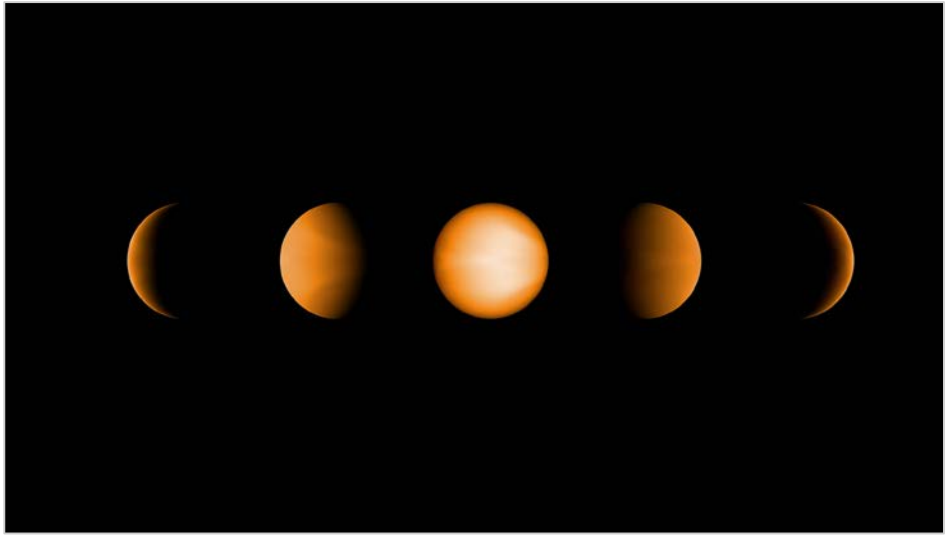
- Science Highlights
- Program and Budget Update
  - Astrophysics Program Structure
  - Major Accomplishments
  - Budget Update
- R&A Update
  - R&A Content, Budget, and Status
  - High Risk/High Reward Research
  - Code of Conduct
- Missions Update
  - TESS, Webb, WFIRST
  - Explorers, SmallSats, Athena/LISA
  - SOFIA, Senior Review
- Planning for Astro2020
  - Decadal Survey Timing
  - Decadal Survey Planning
- Response to April 2018 APAC Recommendations

Some NASA Science Stories of 2018









UL: NuSTAR Mission Proves Superstar Eta Carinae Shoots Cosmic Rays

UR: Hubble - Our Solar System’s First Known Interstellar Object Gets Unexpected Speed Boost

LL: Chandra May Have First Evidence of a Young Star Devouring a Planet

LR: Spitzer - Water is Destroyed, Then Reborn in Ultrahot Jupiters

NASA Astrophysics

Program and Budget Update

NASA's Astrophysics Program

Operating: Hubble, Chandra, XMM-Newton*,
Spitzer, Fermi, Kepler, SOFIA

Developing: Webb, XRISM*, Euclid*, WFIRST

Operating: Gehrels Swift, NuSTAR, NICER, TESS

Developing: IXPE, GUSTO

Phase A Study MIDEX: Arcus, SPHEREx

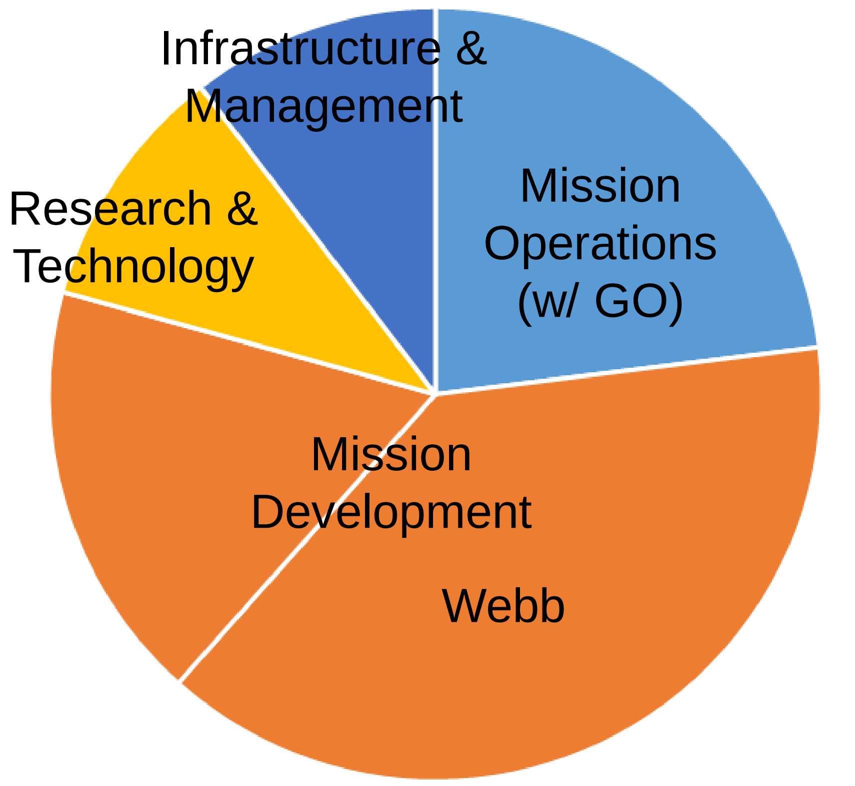
Phase A Study MO: ARIEL*, COSI-X, ISS-TAO

Pre-Phase A Study: Athena*, LISA*

Decadal Survey Study: HabEx, LUVOIR, Lynx, OST

* Contribution to Partner-led Mission

- Strategic Missions
  - Flagships and Probes led by NASA
  - Contributions to Partner-led Missions
- PI-led (competed) Missions
  - Explorers Missions (small and medium)
  - Contributions to Partner-led Missions
- Supporting Research and Technology
  - Research and Analysis
  - Technology Development
  - Suborbital Payloads (Balloons, Sounding Rockets)
  - CubeSats and ISS-attached Investigations
- Infrastructure and Management
  - Data Archives
  - Balloon Program
  - Mission Studies



FY 2018 Budget: $1.38B

NASA's Astrophysics Program

- Strategic Missions
  - Flagships and Probes led by NASA
  - Contributions to Partner-led Missions
- PI-led (competed) Missions
  - Explorers Missions (small and medium)
  - Contributions to Partner-led Missions
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- Infrastructure and Management
  - Data Archives
  - Balloon Program
  - Mission Studies

Astrophysics Program Offices (after restructuring)

Astrophysics Division

- **Flight Programs**
  - Astrophysics Strategic Missions @ HQ
    - WFIRST
    - Webb*
    - SOFIA**
  - Astrophysics Explorers @ GSFC
    - TESS
    - IXPE
    - GUSTO
    - XRISM
    - Euclid
- **Supporting Research and Technology Programs**
  - PCOS/COR @ GSFC
  - EXEP @ JPL
  - Research @ HQ

* after commissioning (CY2021)

** after PCA is cancelled (CY2018)

Major Accomplishments: April – July 2018

- Transiting Exoplanet Survey Satellite (TESS) launched April 2018
- SOFIA returned to science operations following extended maintenance period May 2018
- GUSTO completed System Requirements Review May 2018
- WFIRST passed KDP-B May 2018 and began preliminary design phase (Phase B); funds appropriated by Congress in FY18 allow WFIRST to begin Phase B
- Palestine balloon campaign flew two missions (SuperBIT, ASCOT) May-July 2018
- Sweden balloon campaign flew 3 missions (AESOP-lite, HiWIND, PMC Turbo) May-July 2018
- First NASA astrophysics CubeSat (HaloSat) launched May 2018, deployed July 2018
- IXPE completed Preliminary Design Review June 2018
- NASA submitted Webb replan cost and schedule report to Congress based on results of WIRB report June 2018
- TESS entered science operations August 2018
- Ft. Sumner balloon campaign underway August-October 2018
- Euclid sensor chip electronics (SCE) recovery plan approved September 2018

Planned Accomplishments August 2018 – June 2019

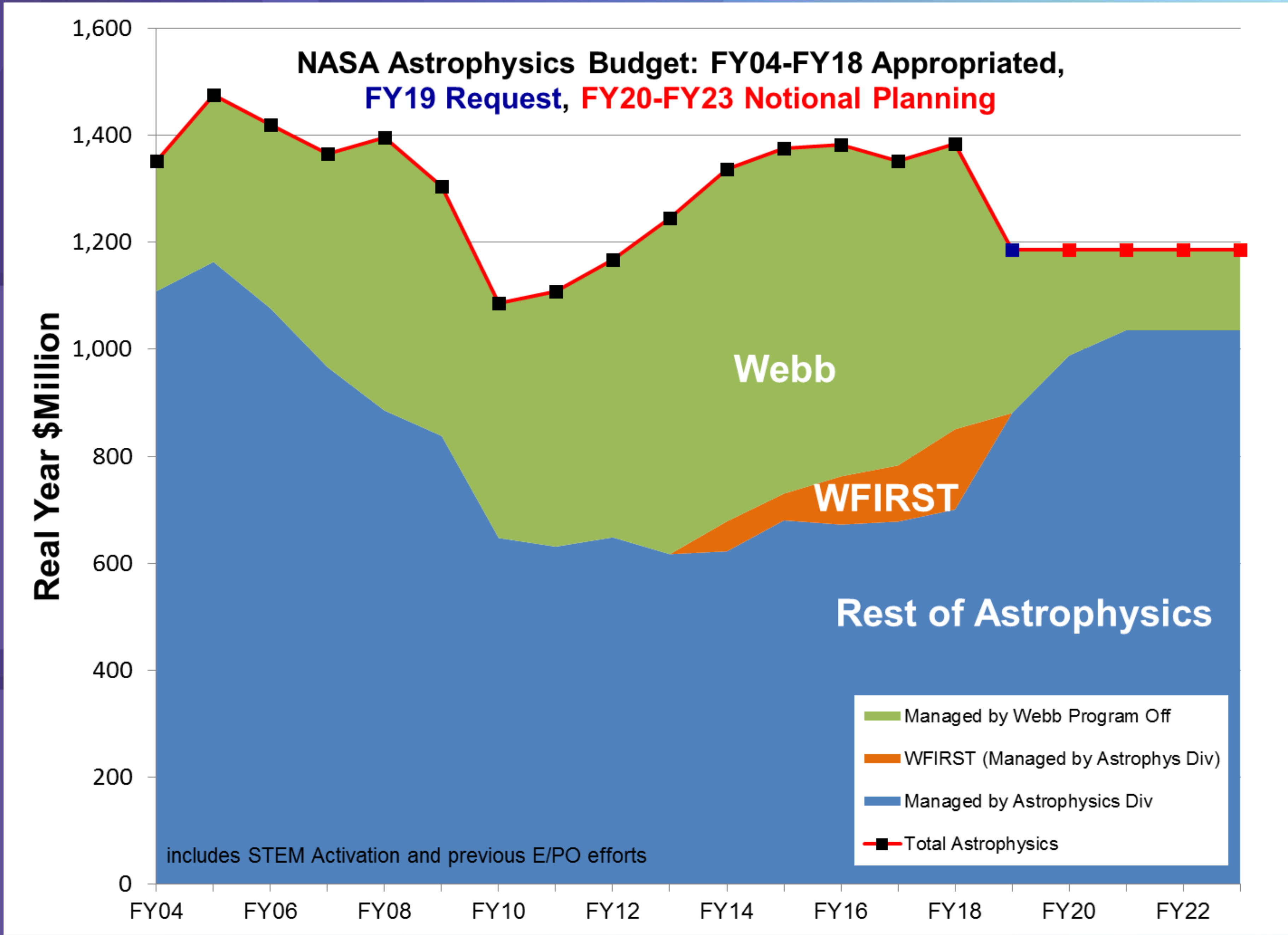
- IXPE will enter Phase C October 2018
- SOFIA Operations and Maintenance Review will be conducted in late 2018
- Kepler completes its amazing mission when the fuel is exhausted TBD 2018
- Antarctic balloon campaign will be conducted December 2018 – February 2019
- Next Astrophysics MIDEX and Mission of Opportunity will be downselected January 2019
- Astrophysics Decadal Survey will begin January 2019
- SOFIA Five Year Review will be conducted early 2019
- Astrophysics Senior Review will be conducted Spring 2019
- Next Astrophysics SMEX and Mission of Opportunity AO will be released in Spring 2019
- Large Mission Concept Studies will be submitted to Decadal Survey Summer 2019

Astrophysics Budget Overview

- The FY18 consolidated appropriation provides funding for NA[illegible]cs to continue its planned programs, missions, projects, research, and technolog[illegible]
  - Total funding provided for FY18 (Astrophysics in[illegible]1.352B in FY17 to $1.384B in FY18, an increase of ~$32M (2.4%) from[illegible]
  - NASA Astrophysics FY18 appropr[illegible]ress toward launch, WFIRST formulation into Phase B, Explorers missio[illegible]MO Phase A, increased funding for R&A, continued operating missions[illegible]beSats, technology development, and mission studies.
  - The NASA Astro[illegible]ation prohibits NASA from placing SOFIA into the Senior Review.
  - $10M (2.2%) redu[illegible]Astrophysics to accommodate directed spending increases for WFIRST, Hubble, and SOFIA[illegible]mmodated by reducing carryover for operating missions (requires FY19 payback).

DONE

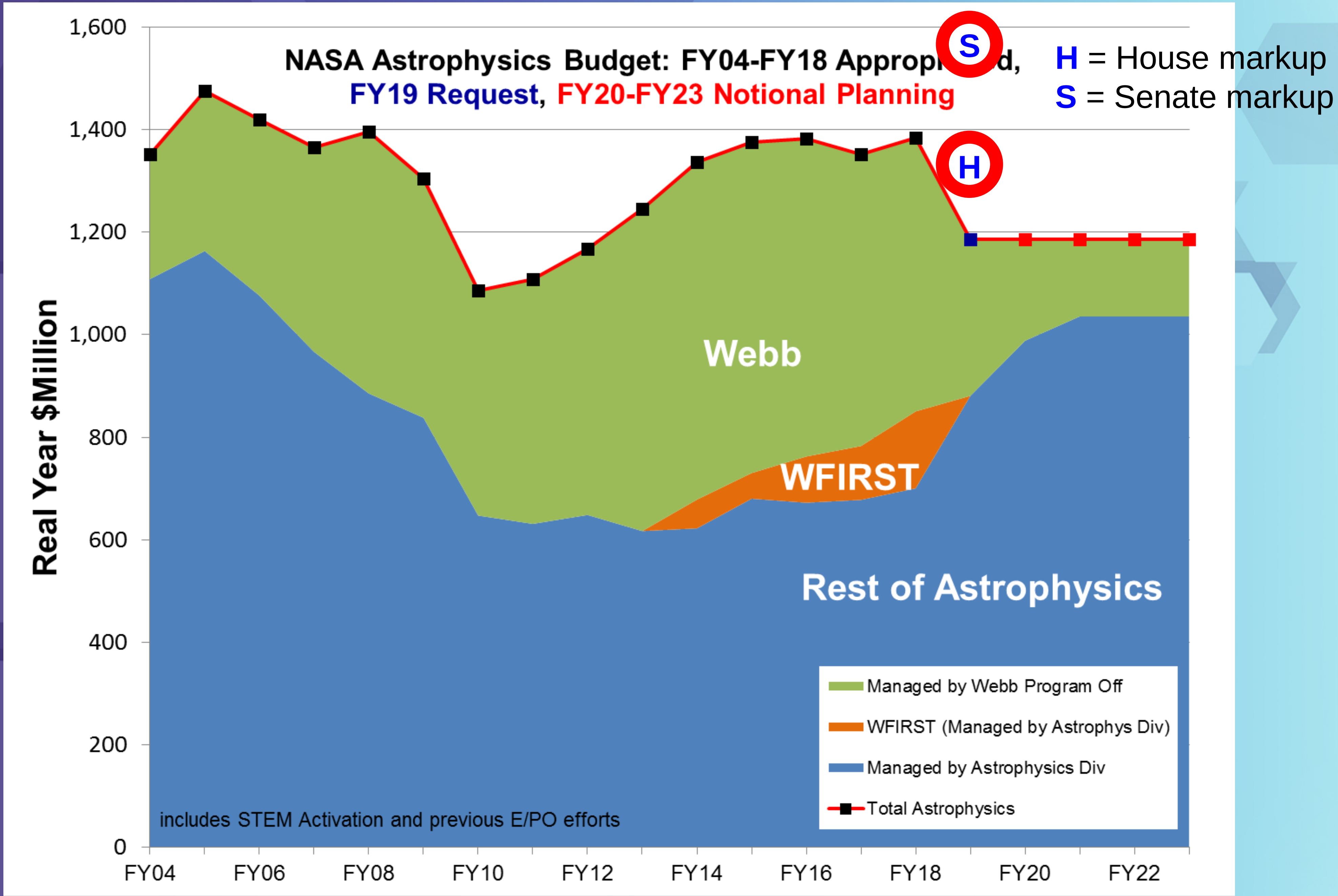
- The FY19 budget request proposes a reduced level of funding for NASA Astrophysics.
  - Total requested funding for FY19 (Astrophysics including Webb) is ~$1.185B, a reduction of $200M (14%) from FY18 appropriation.
  - Webb included as project within Astrophysics budget, integration and testing continues toward launch.
  - Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, WFIRST is terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research.



NASA Astrophysics Budget: FY04-FY18 Appropriated,
FY19 Request, FY20-FY23 Notional Planning
Real Year $Million
1,600
1,400
1,200
1,000
800
600
400
200
0
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
Webb
WFIRST
Rest of Astrophysics
Managed by Webb Program Off
WFIRST (Managed by Astrophys Div)
Managed by Astrophysics Div
Total Astrophysics
includes STEM Activation and previous E/PO efforts

Astrophysics Budget – FY19 Appropriations

($M)	Admin Request	House Markup	Senate Markup	Comments
Astrophysics (w/ Webb)	1,185.4	1,333.6	1,547.8	Senate: Start Astro2020 on time
Webb	304.6	304.6	304.6	Both: $8B cost cap
Hubble	78.3		98.3	Senate: Reject cutting costs
SOFIA	74.6	85.2		House: No Senior Review Senate: Encourage Senior Review
WFIRST	0.0	150.0	352.0	House: $20M for starshade tech Both: $3.2B cost cap
R&A	83.4	83.4		
Science Activation	44.6	44.0	45.0	
Technosignatures	0.0	10.0		
Search for Life Tech	>>15.0		15.0	
Rest of Astrophysics	678.2	656.4		-21.8 (-3.2%)
Rest of Astrophysics	757.9		747.9	-10.0 (-1.3%)



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FY19 Request, FY20-FY23 Notional Planning
S
H
H = House markup
S = Senate markup
Real Year $Million
1,600
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R&A Update

Astrophysics Research and Analysis (R&A) Elements

Supporting Research and Technology

- Astrophysics Research & Analysis (APRA)
- Strategic Astrophysics Technology (SAT)
- Astrophysics Theory Program (ATP) (not 2018)
- Theoretical and Computational Astrophysics Networks (TCAN)
- Exoplanet Research Program (XRP)
- Roman Technology Fellowships (RTF)
- SmallSat Studies

Data Analysis

- Astrophysics Data Analysis (ADAP)
- GO/GI programs in ROSES for:
  - Fermi
  - Kepler/K2
  - Swift
  - NuSTAR
  - TESS
  - NICER (coming)

Mission Science and Instrumentation

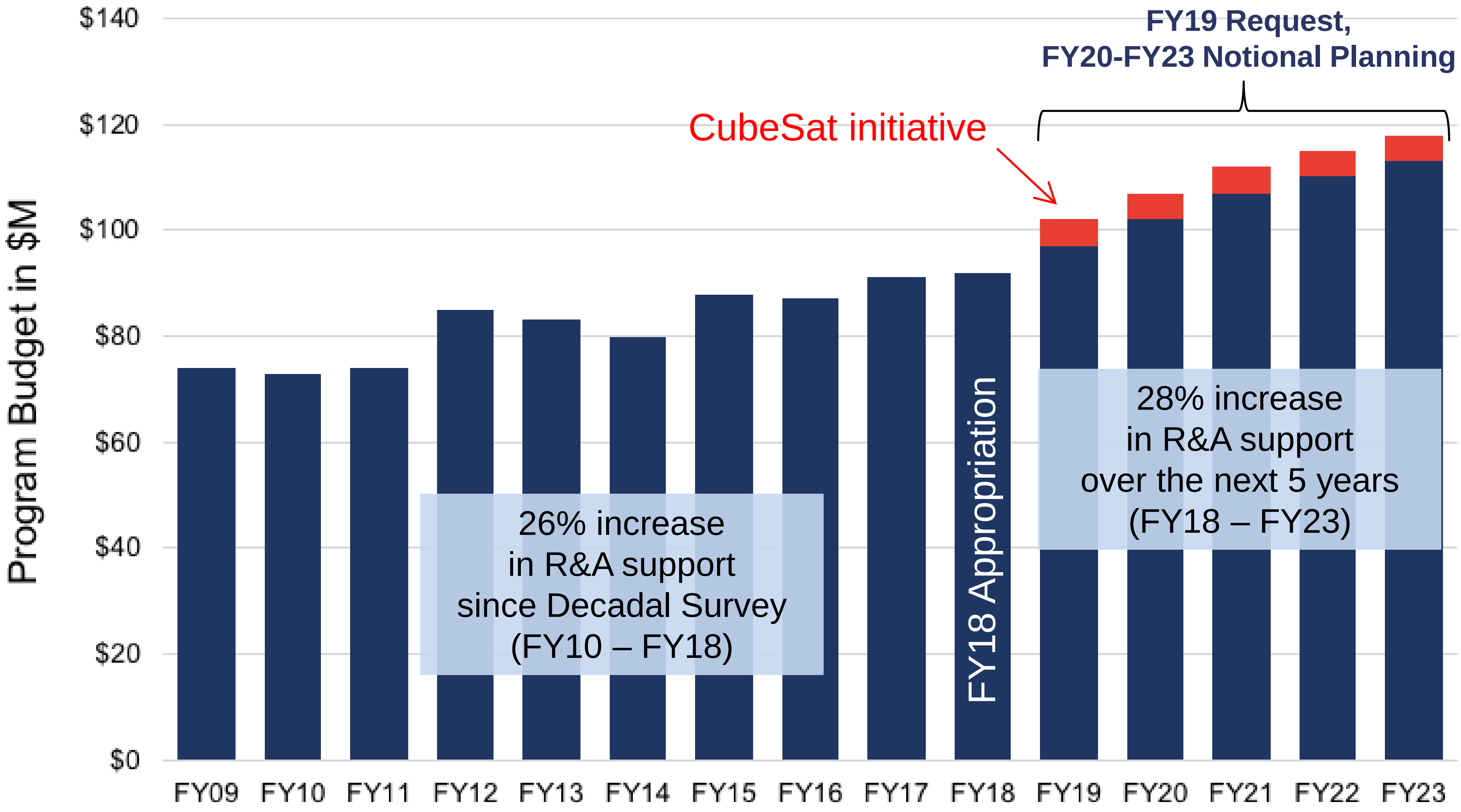
- SOFIA next-generation instrumentation
- Sounding rocket, balloon, cubesat, and ISS payloads through APRA
- XARM Participating Scientists
- LISA Preparatory Science

Separately Solicited

- GO/GI/Archive/Theory programs for:
  - Chandra
  - Hubble
  - SOFIA
  - Spitzer
  - Webb
- NASA Hubble Fellowship Program (Einstein, Hubble, and Sagan Fellows)
- Graduate Student Fellowships (NESSF)

Planned Growth in R&A Funding

Program	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
R&A	$74	$73	$74	$85	$83	$80	$88	$87	$91	$92	$97	$102	$107	$110	$113
CubeSat											$5	$5	$5	$5	$5
Total	$74	$73	$74	$85	$83	$80	$88	$87	$91	$92	$102	$107	$112	$115	$118



Theoretical and Computational Astrophysics Networks (TCAN)

- TCAN supports coordinated efforts in fundamental theory and computational techniques.
- TCAN aims to unite researchers in collaborative networks that cross institutional and geographical divides.
- Last call for proposals was in 2012. Issued a call for proposals for TCAN in ROSES-2017. $1.5M allocation.
- Proposals were due on January 25, 2018, selections made on June 19, 2018,
- 32 proposals received, 3 proposals selected, selection rate 9%.

Title	Nodes	Project Description
Modeling Polarized Galactic Foregrounds for Cosmic Microwave Background Missions	Univ. CA, Berkeley Princeton Univ. Univ. CA, San Diego Univ. Wisconsin	State of the art MHD simulations of the turbulent, dusty interstellar medium to model contamination of next-generation CMB observations by galactic foreground emission
Origin of the Giant Planet Dichotomy: Multi-Scale Modeling of Planetary Envelope Accretion	Univ. Colorado Univ. Arizona UNLV	3D hydrodynamical modeling of the accretion of material from a protoplanetary disk by a rock-ice core to study the formation of extrasolar mini-Neptunes and gas giants
Advancing Computational Methods to Understand the Dynamics of Ejection, Accretion, Winds and jets in Neutron Star Mergers	RIT NASA/GSFC Johns Hopkins Univ. West Virginia Univ.	Multi-code, general relativistic MHD simulations of binary neutron star mergers, from the inspiral before coalescence to the formation of a merged remnant just after

Proposal Status Update

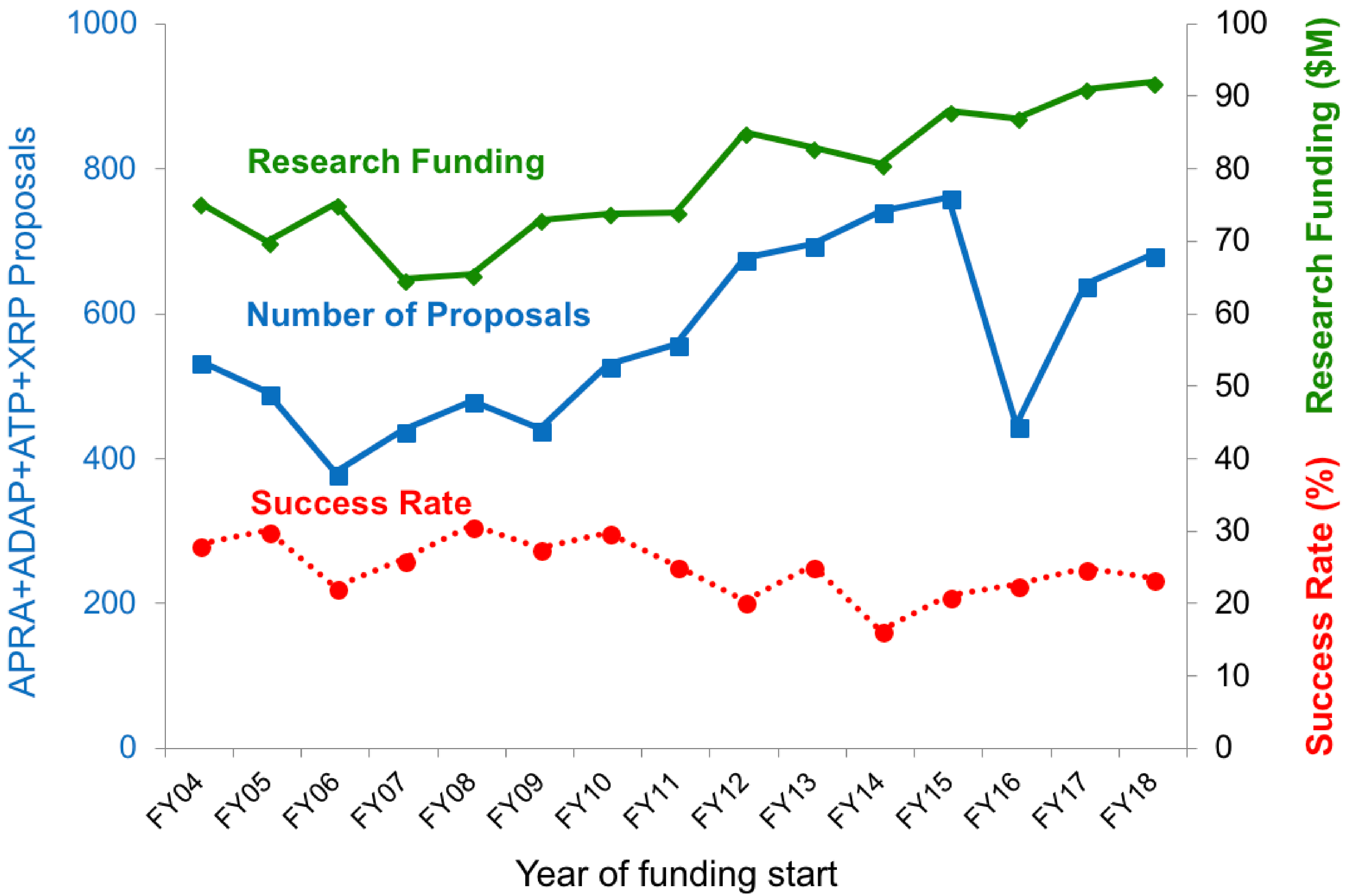
GO Selection Rate = 32%
R&A Selection Rate = 20%

Average: 106 days (44 – 148 days)
80% PIs notified: 89 days

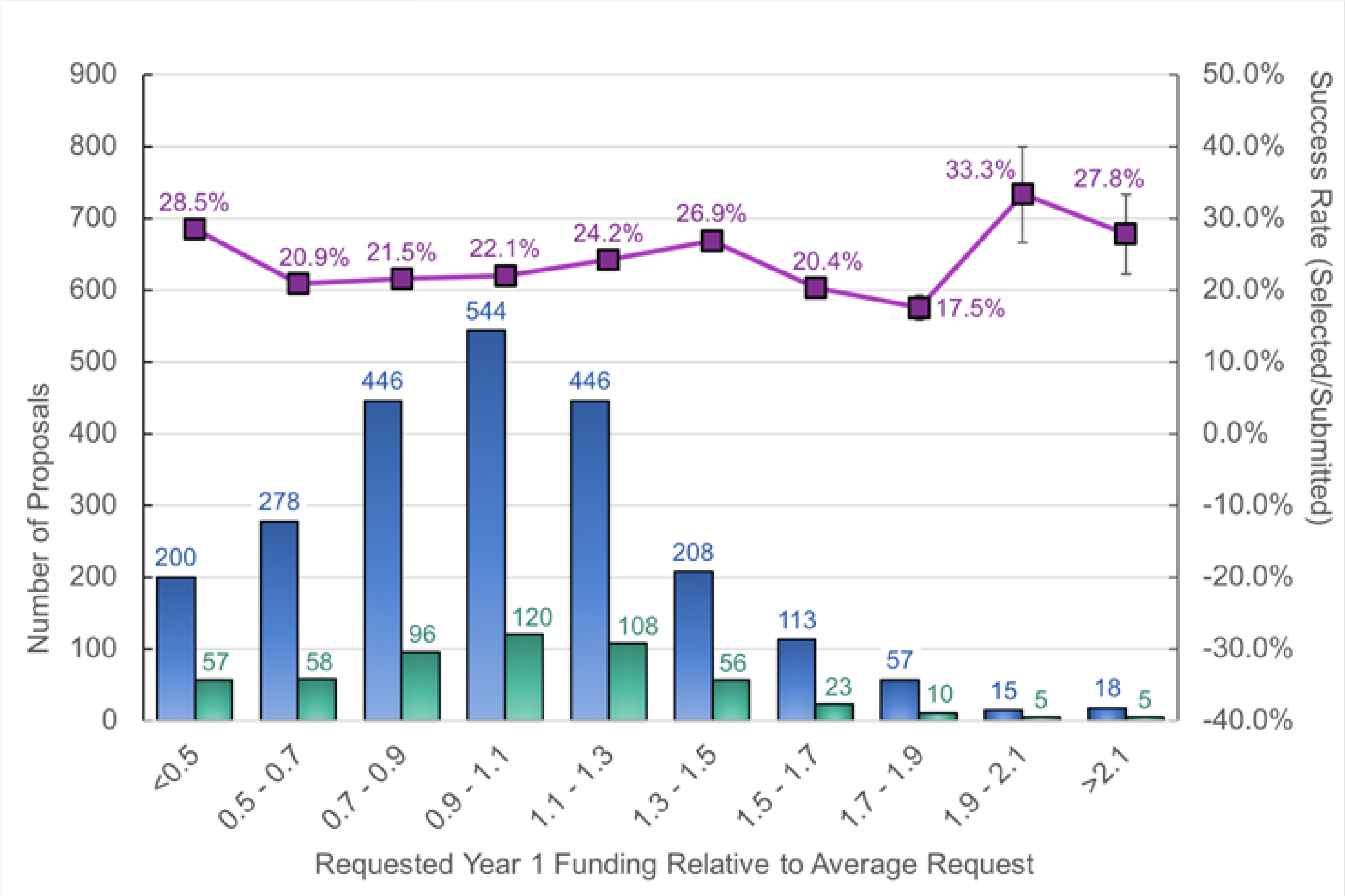
Status: Sep 18, 2018

Solicitation	Proposal Due Date	Notify Date	Days since received	Number received	Number selected	% selected
Hubble GO – Cycle 25	Apr 7, 2017	June 26, 2017	80	971	271	28%
Exoplanet Research	May 25, 2017	Oct 8, 2017	136	50	9	18%
SOFIA GI – Cycle 6	June 30, 2017	Nov 7, 2017	130	198	104	53%
Astrophysics Theory	July 27, 2017	Dec 22, 2017	148	216	53	25%
Webb Early Release Science	Aug 18, 2017	Nov 13, 2017	87	106	13	12%
Swift GI – Cycle 14	Sep 28, 2017	Jan 13, 2018	140	146	30	21%
TESS – Cycle 1	Oct 6, 2017	Feb 3, 2018	132	143	38	27%
K2 – Cycle 6 (Phase 2)	Apr 19, 2018	June 25, 2018	67	41	23	56%
NESSF-18	Feb 1, 2018	May 15, 2018	103	177	8	5%
Chandra GO – Cycle 20	Mar 16, 2018	July 16, 2018	122	526	156	24%
XARM Participating Scientist	Dec 13, 2017	Feb 21, 2018	64	39	5	13%
NuSTAR – Cycle 4	Jan 19, 2018	April 17, 2018	88	196	83	42%
TCAN	Jan 26, 2018	June 21, 2018	146	32	3	9%
Segmented Telescope Design	Feb 1, 2018	Mar 16, 2018	44	5	2	40%
Fermi GI – Cycle 11	Feb 23, 2018	May 26, 2018	92	138	42	30%
Spitzer GI – Cycle 14	Mar 23, 2018	May 29, 2018	67	116	50	43%
SAT (Technology)	Mar 19, 2018	Aug 14, 2018	148	25	8	35%
APRA (Basic Research)	Mar 19, 2018	Aug 14, 2018	148	170	35	21%
SmallSat Studies	Jul 13, 2018	Sep 10, 2018	59	38	9	24%
ADAP (Data Analysis)	May 17, 2018	Sep 18, 2018	124	242	42	17%

Proposal Pressure



Requested funding not anti-correlated with success



ADAP 2010-2018

2325 submitted proposals

538 selected proposals

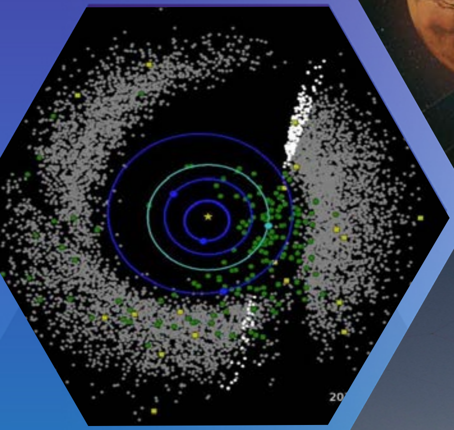
Average request in RY$ grew by 35% over this period

NAS Recommendation

- “NASA needs to investigate appropriate mechanisms to ensure that high-risk/high-payoff fundamental research and advanced technology-development activities receive appropriate consideration during the review process.” *Review of the Restructured Research and Analysis Programs of NASA’s Planetary Science Division, 2017, p. 31.*
- There is also the wide spread perception that NASA peer review, and possibly all peer review, is hostile to truly innovative, high-risk research and technology development proposals

Data on High Risk/High Impact Proposals

- For one year, SMD asked peer reviewers to answer the following questions:
- IMPACT: How large an effect on current thinking, methods, or practice would this project have, if successful?
  - Three choices: high (H), medium (M), low (L)
- RISK: To what extent would this proposal test novel and significant hypotheses, for which there is scant precedent or preliminary data or which run counter to the existing scientific consensus
  - Three choices: A great extent (G), to some extent (S), little or none (L)
- Looked at the results for 1,577 proposals submitted to ROSES-2017

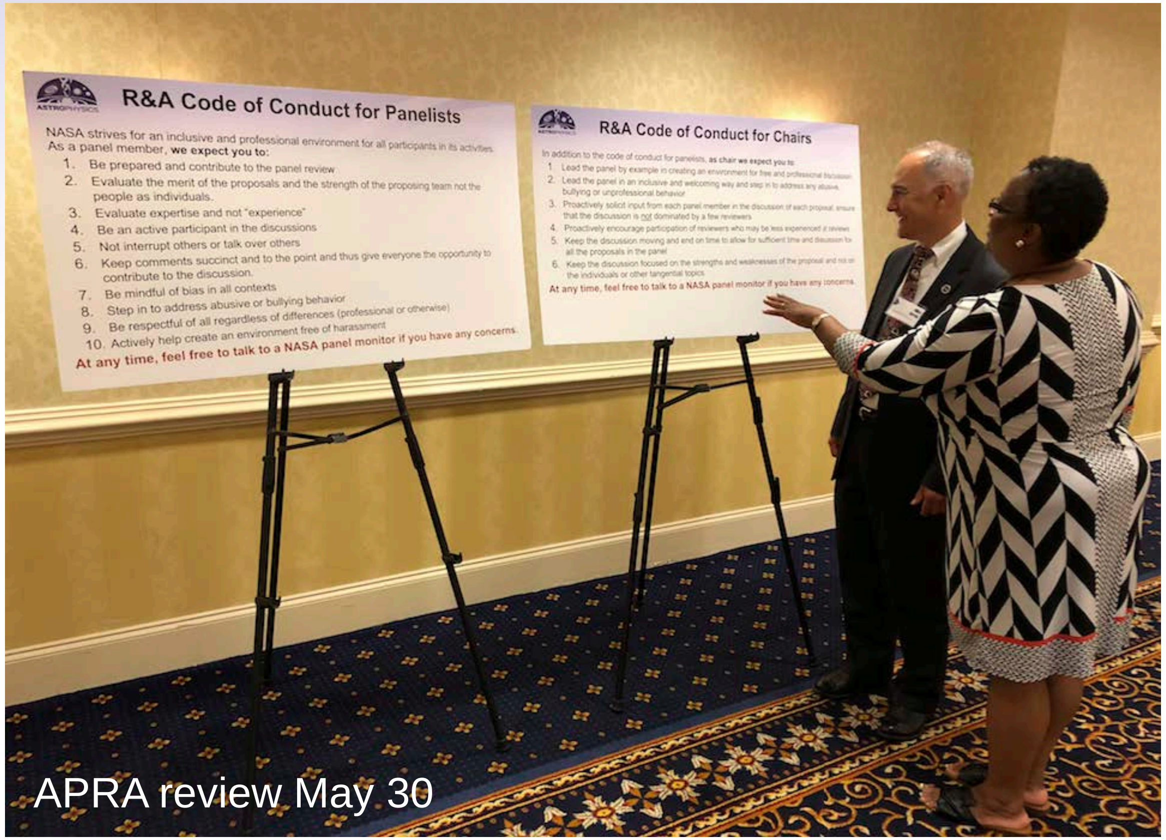


Results

- 10% of proposals in examined set were judged to be high-impact/high-risk
- 24% of all proposals (regardless of risk or impact) were selected for funding
- 35% of high-risk/high-impact proposals were selected for funding
- Merit score driven by perceived impact regardless of perceived risk
- Panel process seems agnostic to risk level for proposals judged to have high-to-moderate impact

R&A Code of Conduct

- APD has developed R&A Code of Conduct.
- Starting in May, the Code of Conduct is presented during the Opening Plenary Sessions and poster boards are prominently displayed at all peer reviews.



APRA review May 30

R&A Code of Conduct for Panelists

NASA strives for an inclusive and professional environment for all participants in its activities.
As a panel member, **we expect you to:**

1. Be prepared and contribute to the panel review
2. Evaluate the merit of the proposals and the strength of the proposing team not the people as individuals.
3. Evaluate expertise and not “experience”
4. Be an active participant in the discussions
5. Not interrupt others or talk over others
6. Keep comments succinct and to the point and thus give everyone the opportunity to contribute to the discussion.
7. Be mindful of bias in all contexts
8. Step in to address abusive or bullying behavior
9. Be respectful of all regardless of differences (professional or otherwise)
10. Actively help create an environment free of harassment

At any time, feel free to talk to a NASA panel monitor if you have any concerns.

R&A Code of Conduct for Chairs

In addition to the code of conduct for panelists, **as chair we expect you to**:

1. Lead the panel by example in creating an environment for free and professional discussion.
2. Lead the panel in an inclusive and welcoming way and step in to address any abusive, bullying or unprofessional behavior
3. Proactively solicit input from each panel member in the discussion of each proposal; ensure that the discussion is not dominated by a few reviewers
4. Proactively encourage participation of reviewers who may be less experienced at reviews
5. Keep the discussion moving and end on time to allow for sufficient time and discussion for all the proposals in the panel
6. Keep the discussion focused on the strengths and weaknesses of the proposal, and not on the individuals or other tangential topics

At any time, feel free to talk to a NASA panel monitor if you have any concerns.

Astrophysics CubeSats

- Solicited via ROSES APRA, up to 12U allowed
- Launch free to PI, LCAS/RideShare
- Five 6U CubeSats have been selected to date, typically 3 years from start to launch, <$5M
- #5: ARTEMIS, B. Fleming, CU

HaloSat (left) and RainCube (right).

HaloSat being loaded into the dispenser on March 27.

• **HALOSAT, PI**: Phil Kaaret, U Iowa • **Energies**: soft X-rays • **Science Objectives:** HaloSat will map the distribution of hot gas in the Milky Way and determine whether it fills an extended, and thus massive halo, or whether the halo is compact, and thus does not contribute significantly to the total mass of the Milky Way. • **Launch**: **Deployed from ISS July 13, 2018, solar arrays deployed, power positive, detectors working.**	• **CUTE, PI:** Kevin France, CU • **Energies**: UV • **Science Objectives:** The Colorado Ultraviolet Transit Experiment (CUTE) will take multiple medium resolution UV spectra of hot Jupiters during transit, in order to measure the composition of the atmosphere being ablated away. Magnetic fields may be detected via the presence of tori or bow shocks. 14 targets. • **Launch**: 2020 to sun synchronous orbit
• **SPARCS, PI**: Evgenya Shkolnik, AZ State U • **Energies**: UV • **Science Objectives:** Determine rate, strength and color of bright UV flares from a select 25 M dwarfs, with an eye towards how these flares affect the habitability of planets. • **Launch**: September 2021	• **BurstCube, PI:** Jeremy Perkins (GSFC) • **Energies**: hard X-rays • **Science Objectives:** Rapid localizations for high-significance LIGO/Virgo detections coincident with short GRBs; Correlate short GRBs with LIGO/Virgo sub-threshold signals, increasing volume; Search of gamma-ray transients • **Launch**: Fall 2021

NASA Astrophysics

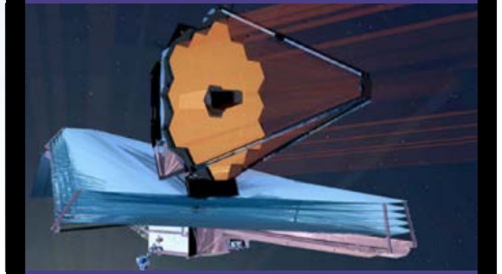
Missions Update: TESS, Webb, WFIRST, Explorers, SmallSats, Athena/LISA, SOFIA, Senior Review

Astrophysics Missions in Development

TESS 4/2018
NASA Mission

Transiting Exoplanet
Survey Satellite

Webb 2021
NASA Mission

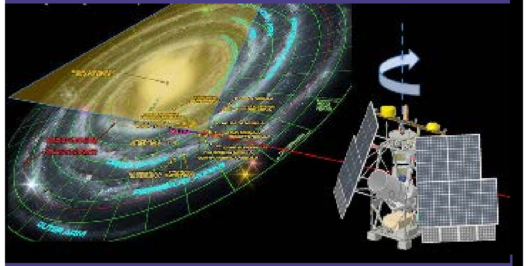


James Webb
Space Telescope

IXPE 2021
NASA Mission

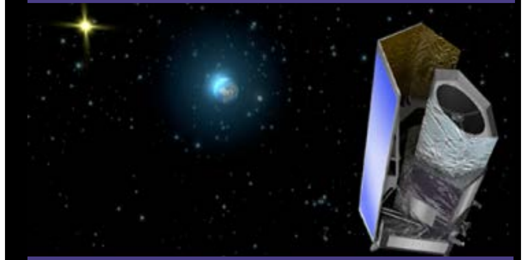
Imaging X-ray
Polarimetry Explorer

GUSTO 2021
NASA Mission



Galactic/ Extragalactic ULDB
Spectroscopic Terahertz Observatory

Euclid 2022
ESA-led Mission



NASA is supplying the NISP
Sensor Chip System (SCS)

XRISM/XARM 2022
JAXA-led Mission

NASA is supplying the SXS
Detectors, ADRs, and SXTs

MIDEX/MO 2022/
2023
NASA Mission

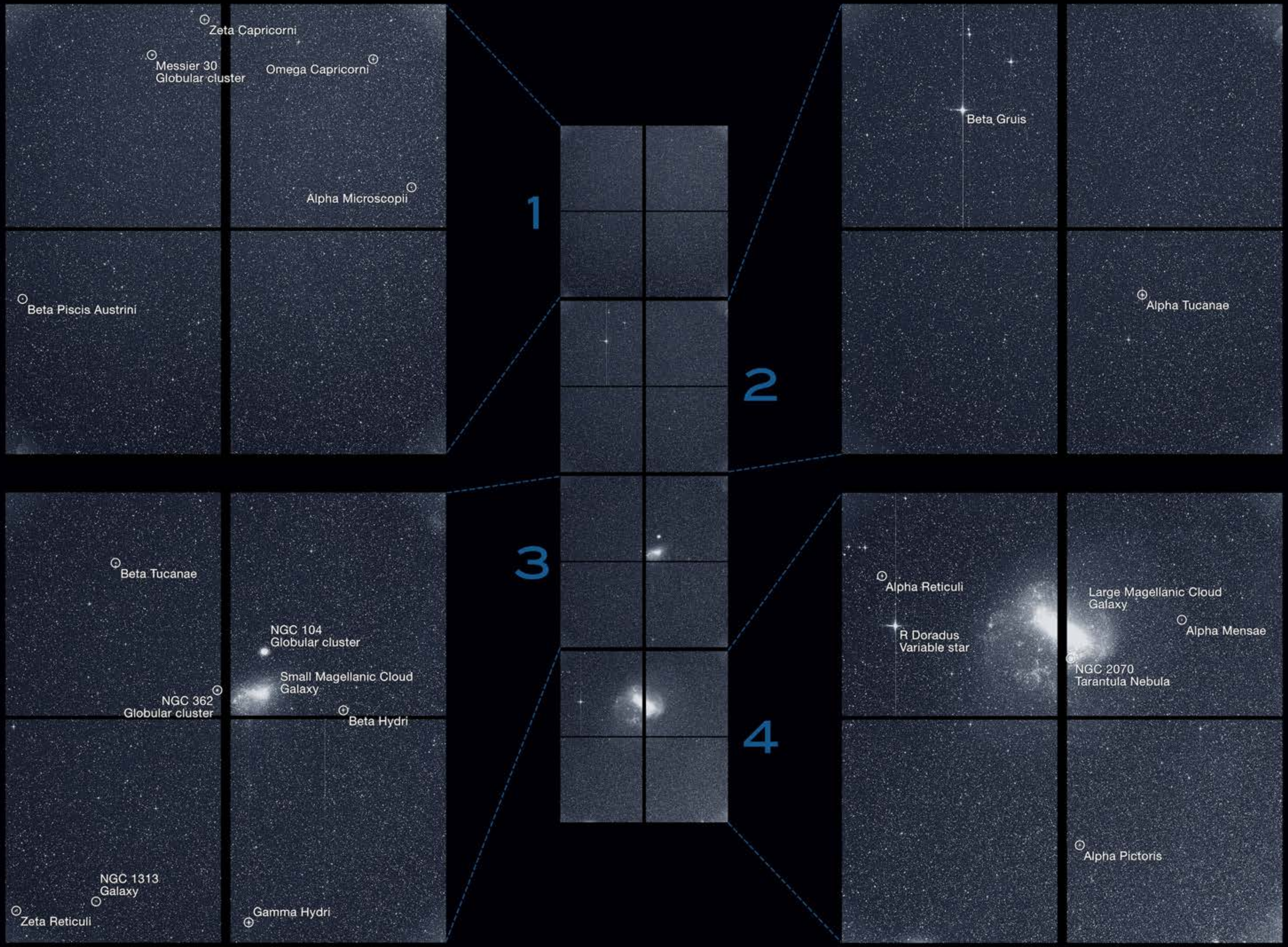
Arcus or SPHEREx
ARIEL, COSI-X, or ISS-TAO

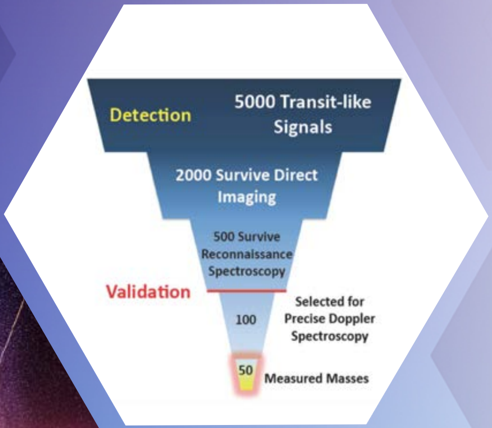
WFIRST Mid 2020s
NASA Mission

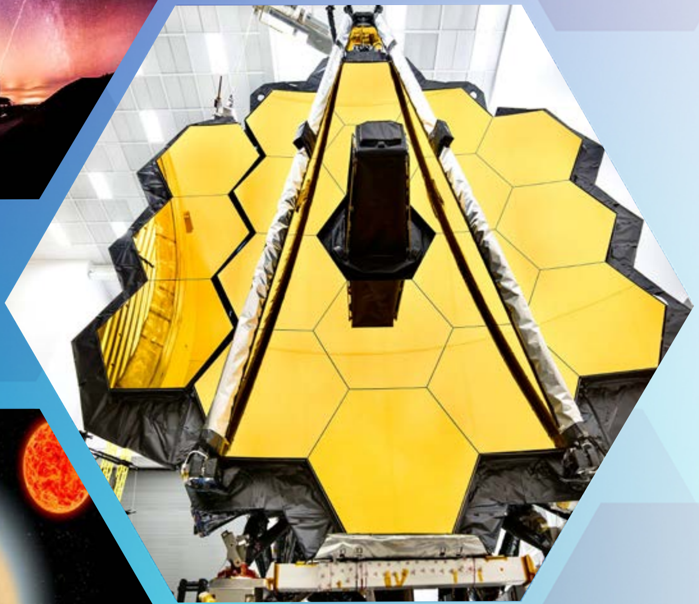
Wide-Field Infrared
Survey Telescope

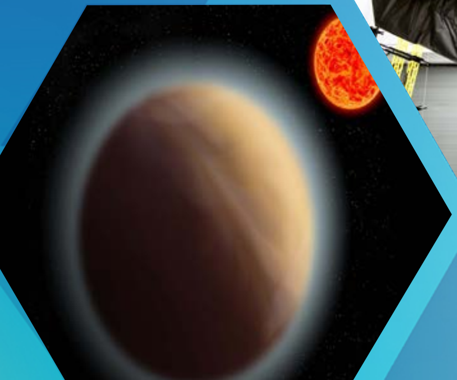
TESS First Light

September 17, 2018









TESS Follow-up Program

- Ground-based follow-up program required for
  - Confirmation of exoplanet candidates
  - False-positive identification
  - Host star characterization
  - Planet mass determination
- Space-based follow-up program required for
  - Atmosphere detection (Hubble, Spitzer)
  - Molecule detection and atmosphere characterization for planets down to super-Earth sizes (Webb)
- Extended TESS science community receiving alerts
  - Enables follow-up ground-based observations while TESS field remains in the nighttime sky

TESS Guest Investigator Program

- The TESS GI program will maximize the science return from the TESS mission, for exoplanet discovery, and many other areas of astrophysics
- TESS Cycle 1 (southern ecliptic hemisphere) GI investigations have been selected
  - Cycle 1 projects cover asteroids, stellar oscillations, flares, exoplanet studies, compact objects, blazars, and more
  - More than 140 proposals received, requesting ~100,000 targets
- There are opportunities for synergy with all of NASA's operating missions
- Cycle 2 (northern ecliptic hemisphere) proposals will be due December 2018

https://heasarc.gsfc.nasa.gov/docs/tess

Webb

The James Webb Space Telescope

March 2018, Webb prepares for additional testing at Northrop Grumman in Redondo Beach, CA

Latest Webb Update

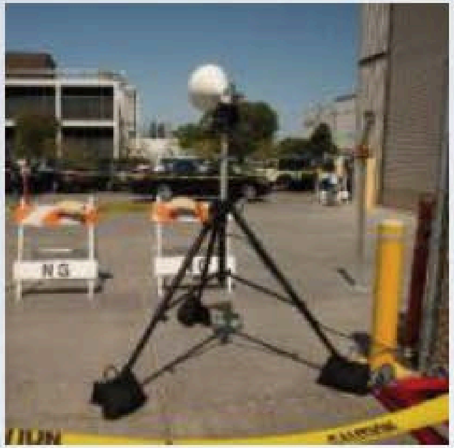
- Programmatic
  - Established a new, 80% confidence level, launch date of March 2021. Implementing Independent Review Board (IRB) recommendations. Will have the IRB assess progress this November
- Spacecraft Element (SCE)
  - Post Acoustics Test hardware repairs completed
  - Sunshield membrane covers reinstalled onto spacecraft element
  - Environmental testing to resume with acoustics test first week of November
- OTIS (Optical Telescope + Integrated Science instruments)
  - Completed warm functional tests of telescope and instruments (all nominal)
  - Completed Aft Deployable ISIM Radiator deployment test (post cryo-vac test, results nominal)
  - Final OTIS deployment test of secondary mirror will occur when SCE completes env. testing.
- Science and Operations
  - GO Call will be re-issued in late 2019/early 2020 (allowing at least 14 months to launch date)
  - Ground segment testing and operations rehearsals continuing and more added

Sunshield Membrane Covers

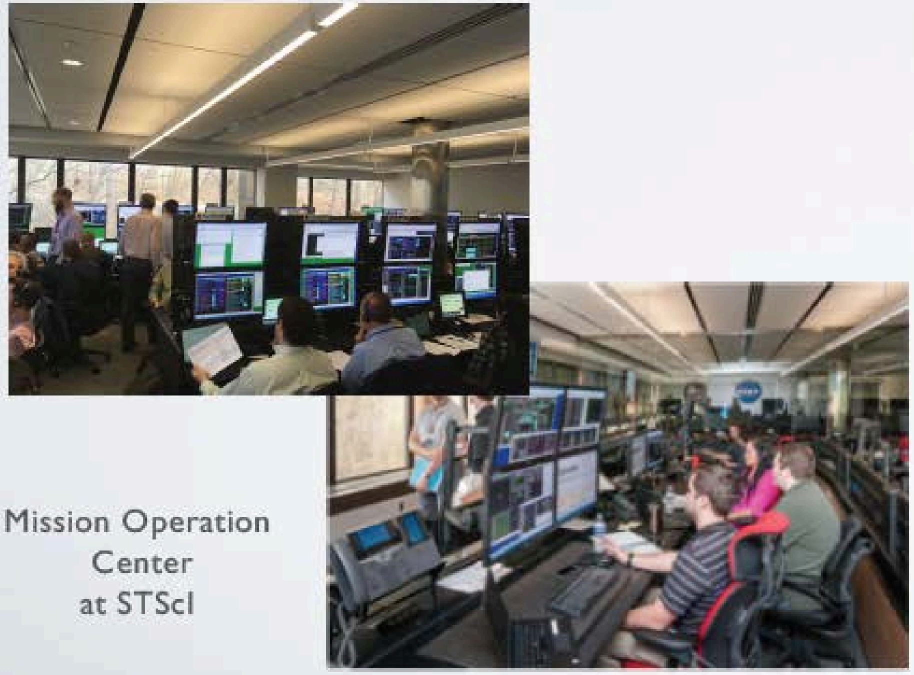
Sunshield membrane covers at Northrop Grumman prior to batten repairs

Nut Side of Batten Assembly

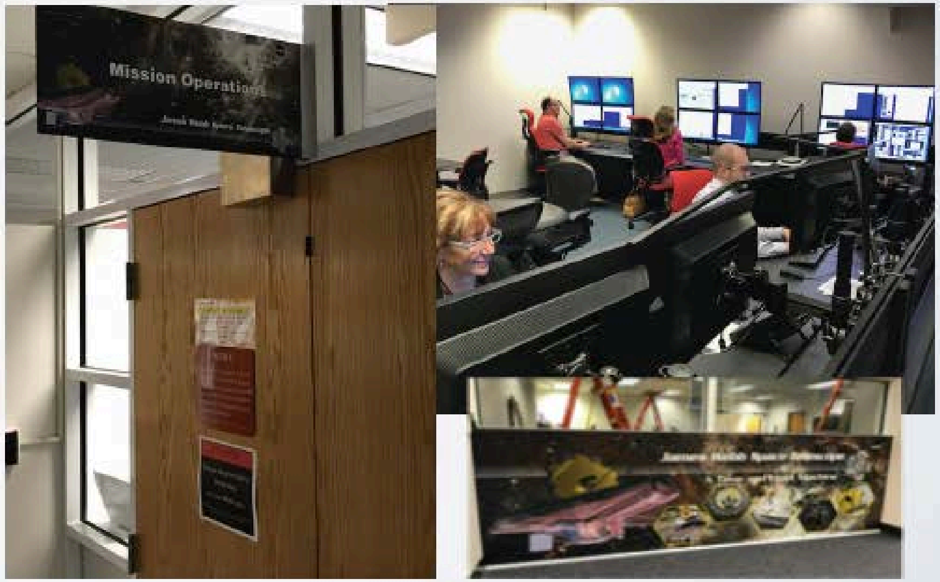
Mission Operations Activities & Facilities



Successful GSEG-1 utilized SN antenna (left), DSN test trailer and dedicated personnel (right)



Mission Operation Center at STScI



Backup Mission Operation Center (bMOC) in GSFC Building 32

Blue font indicates “first time” activities

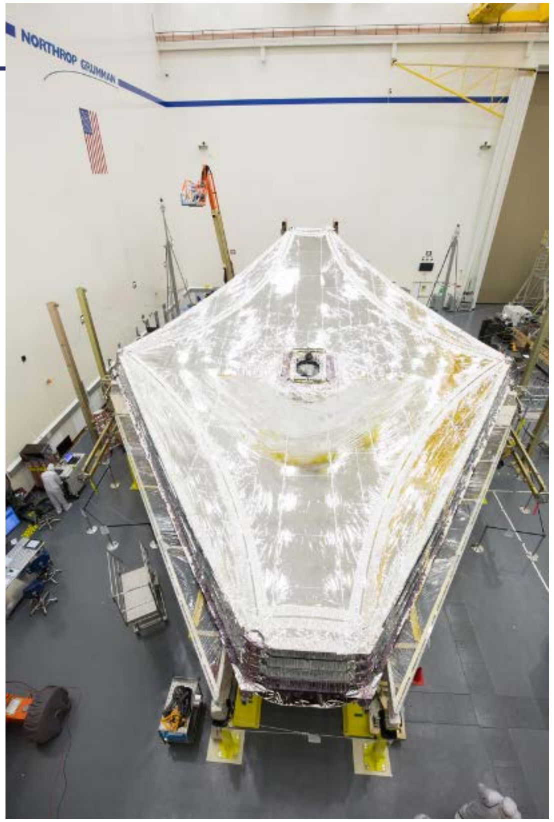
Remaining I&T Activities

Science Payload

- OTIS Deployments at NGAS (secondary mirror support structure)

Spacecraft Element

- *Acoustics (with repaired hardware), vibe, and thermal vacuum tests*
- Post-Environment deployment



Observatory Integration

- Pre-environmental Observatory deployment
- Observatory fold and stow
- *Observatory system (electrical) test*
- Observatory vibration, acoustics tests
- *Observatory deployment*
- Observatory fold and stow for launch
- Observatory final system test

Summary of IRB Report and Response

- NASA received report from the Standing Review Board (SRB) and the Independent Review Board (IRB).
- Webb science is world class and compelling.
- Mission success is the driving consideration going forward.
- Technical complexities have greatly impacted the development schedule.
  - First of a kind developments.
  - Avoidable technical errors, especially human errors and embedded problems.
- NASA focused on schedule and recommendations for mission success.
- NASA accepts the IRB recommendations.
- NASA & NGAS have initiated process controls and corrective actions to address the IRB recommendations.
- Revised schedule and cost reflect a 80% confidence level; consistent with SRB/IRB.
  - Conservative in accounting for unplanned inefficiencies.
  - UFE may be applied to unknown-unknown issues.
- Proposed total lifecycle budget is within IRB estimation of $1B additional cost.
- The congressionally mandated $8B development cost cap is exceeded by $803M.

Webb Baseline Cost Commitment

- Independent Review Board (IRB) estimates ~$1B additional cost to complete development
  - This is an estimate using a 29-month launch delay at the current burn rate of ~$35M per month through launch and commissioning
  - A detailed estimate by the project agrees with the IRB estimate; the project estimate includes planned work efforts at NGAS/STScI/GSFC, funded unliened schedule reserve, enhancements for mission success, and conservative cost reserves at all levels (NGAS, GSFC/project, HQ/program)
  - Approximately $200M of unexpended reserves offsets this requirement, so additional budget needed to complete Webb development is ~$800M
  - The new baseline cost commitment includes an inflationary adjustment for operations (Phase E) over the 5-year prime mission lifetime

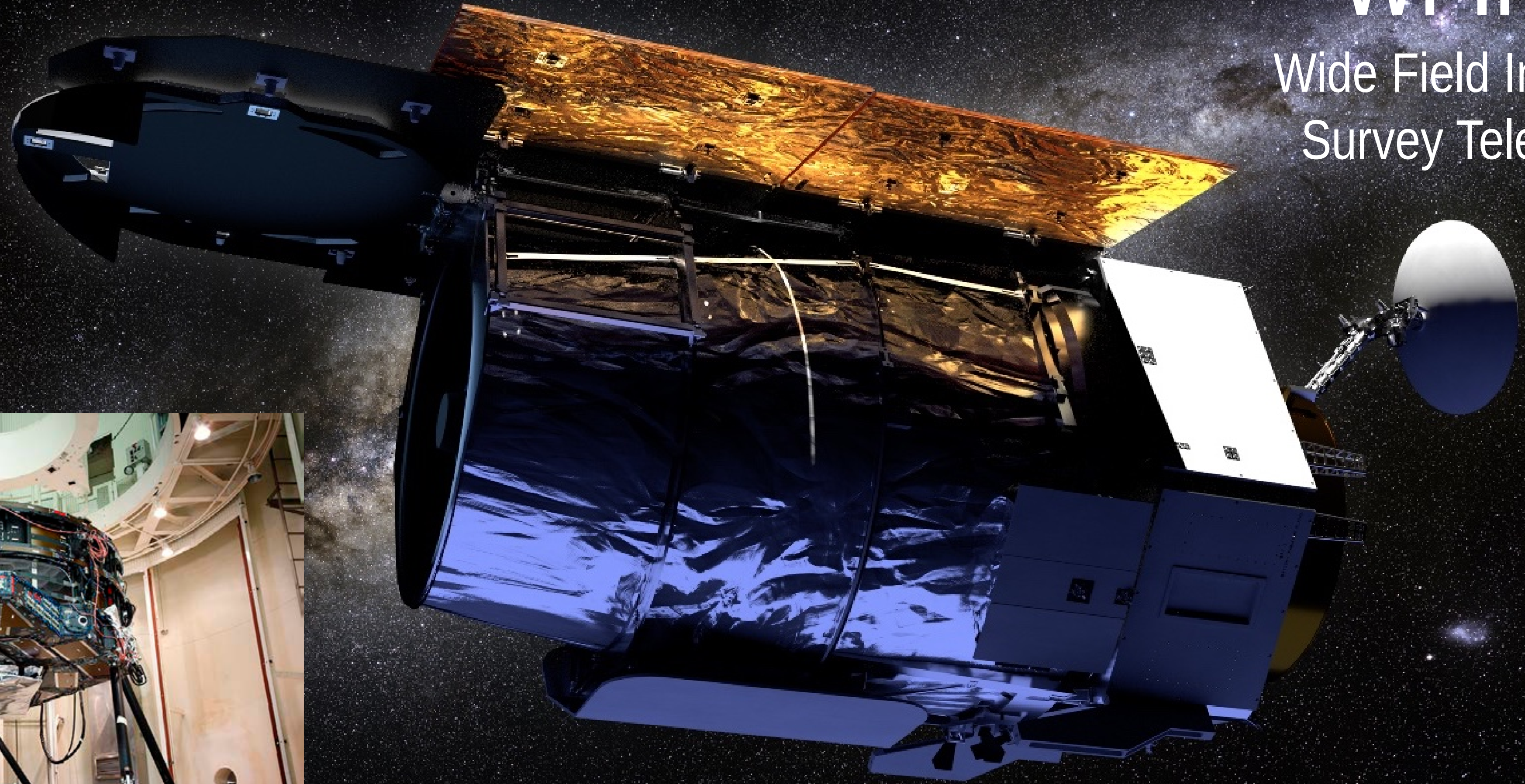
	Prior Baseline	New Baseline	Change
Development	$7.998 B	$8.803 B	+ $805 M
Total Life Cycle Cost	$8.825 B	$9.663 B	+ $837 M
Launch Date	October 2018	March 2021	+ 29 months

Webb Replan Cost

- The new launch date is March 30, 2021 and the new development cost is $8.803B
  - The increased in development cost is $805M through commissioning (September 30, 2021)
  - Existing ops budget through FY21 is ~$310M, so need ~$490M additional funding in FY20-FY21
- Principles
  - NASA understands the Decadal Survey priorities
  - NASA will protect the Explorer and R&A Programs
- NASA believes that the anticipated cost growth on Webb is likely to impact other science missions

WFIRST

Wide Field Infrared
Survey Telescope



Primary mirror assembly / Harris Corporation

WFIRST Update

- WFIRST passed SRR/MDR, approved in May 2018 to enter Phase B (preliminary design phase)
- Phase B baseline incorporates recommendations of WFIRST Independent External Technical/Management/Cost Review (WIETR) and maintains project cost management agreement of $3.2B (Phases A – E)
- NASA selected Ball Aerospace to develop Wide Field Optomechanical Assembly (WOMA) and perform instrument-level integration at Ball facility
- Completed System Requirements Reviews for all primary mission elements (Wide Field Instrument, Coronagraph, Optical Telescope Assembly, Spacecraft, Ground System, Instrument Carrier)

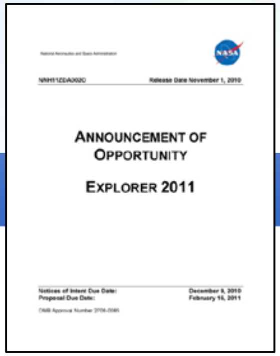
WFIRST Update (2)

- Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, the President’s FY19 Budget Request proposes that WFIRST be terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research
- Funds appropriated by Congress in FY18 allow WFIRST to begin Phase B in May 2018
- If Congress adopts the Administration’s request to terminate WFIRST, the funds made available would enable a competed mission AO in FY19
- National Academies’ Exoplanet Science Strategy Report recommends that NASA launch WFIRST “to conduct its microlensing survey of distant planets and to demonstrate the technique of coronagraphic spectroscopy on exoplanet targets”

Astrophysics Explorers Program

Gehrels-Swift

NuSTAR



Announcement of Opportunity

Explorer 2011

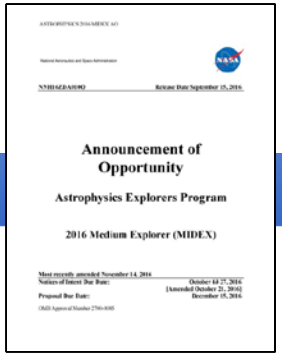
MIDEX 2011

Announcement of Opportunity

Astrophysics Explorers Program

2014 Small Explorer (SMEX)

SMEX 2014



Announcement of Opportunity

Astrophysics Explorers Program

2016 Medium Explorer (MIDEX)

MIDEX 2016

Announcement of Opportunity

Astrophysics Explorers Program

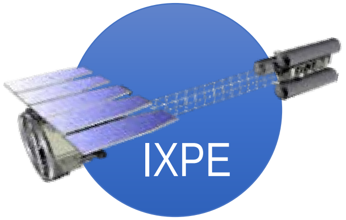
2019

2014 Small Explorer (SMEX)

SMEX 2019 (planned)

Small and Mid-Size Missions

TESS



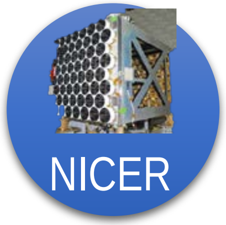
IXPE

Arcus
SPHEREx

Directed 2012

Euclid

Missions of Opportunity



NICER

GUSTO

ARIEL
COSI-X
ISS-TAO

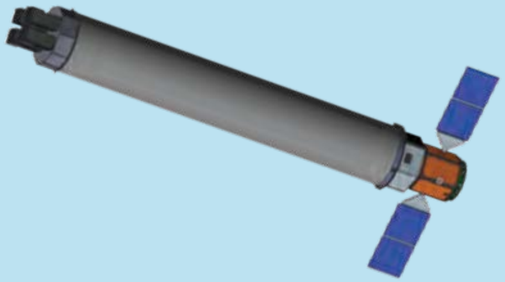
Directed 2017

(formerly XARM)

XRISM

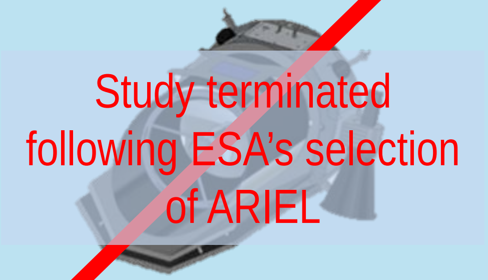
Astrophysics Explorers in Competitive Phase A

Arcus
PI: R. Smith/SAO



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

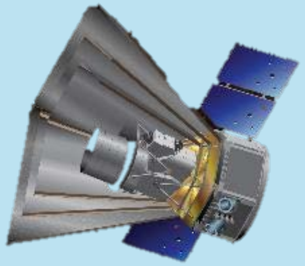
FINESSE
PI: M. Swain/JPL



Study terminated following ESA's selection of ARIEL

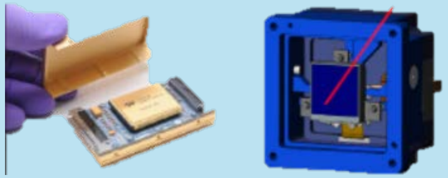
NIR transit spectroscopy to explore exoplanet atmospheres

SPHEREx
PI: J. Bock/Caltech



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

ARIEL
PI: M. Swain/JPL

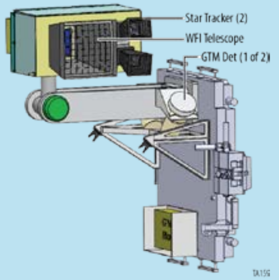


Contribution of detectors to ESA's ARIEL

COSI-X
PI: S. Boggs/UCB

ULDB balloon mission to study origin of elements in the galaxy

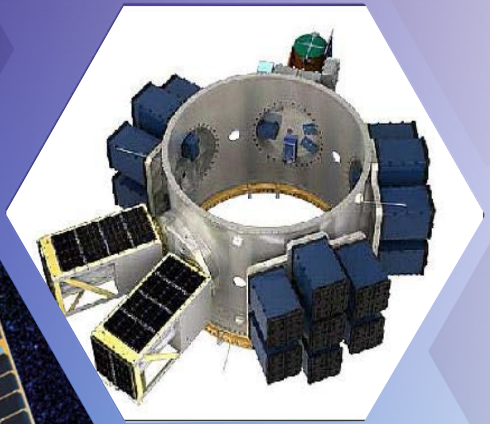
ISS-TAO
PI: J. Camp/GSFC

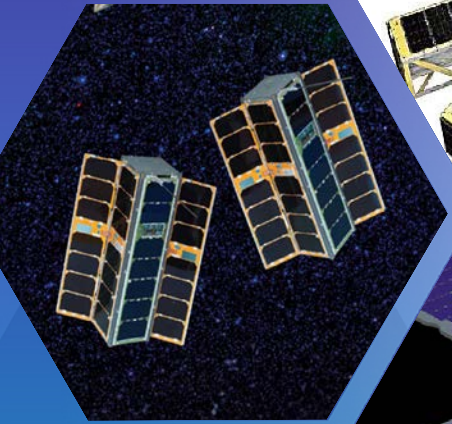


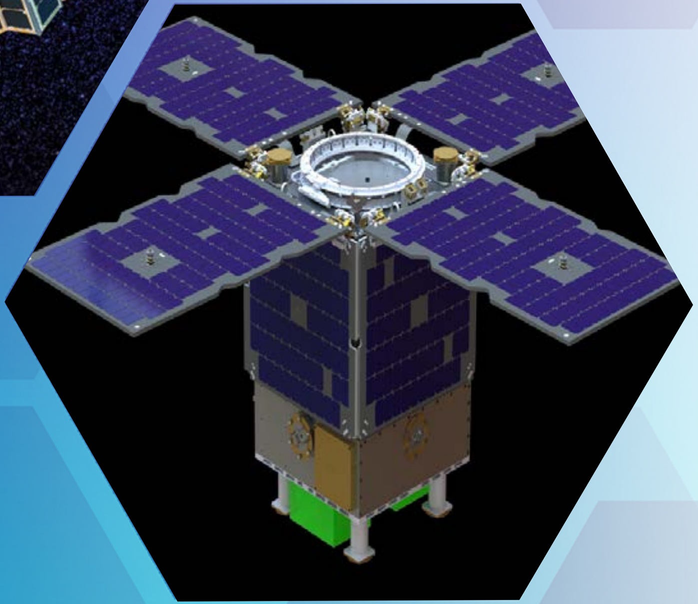
All-sky x-ray survey to study transients and search for GW sources

2019 Explorers AOs: SMEX and Missions of Opportunity

- Next Astrophysics Explorers AOs will be issued in Spring 2019
- Small Explorers (SMEX) missions
  - PI-managed Cost Cap: $195M (FY20$) including launch
  - NASA-provided launch (ELV or ISS) for $50M charge
  - PI-provided alternative access to space permitted
- Missions of Opportunity
  - PI-managed Cost Cap: $75M (FY20$) for: Partner MOs, Small Complete Mission MOs
  - PI-managed Cost Cap: $35M for: Suborbital-class MOs, SmallSat MOs
- Community Announcement issued in June 2018
- Draft AOs planned for late 2018







Astrophysics SmallSats

Step 0: Request for Information (RFI)

- Sought ideas to do high priority Astrophysics science projects at a price point between typical R&A and Explorer MOO projects ($10M-$35M).
- 55 replies responsive to Astrophysics science and/or technology.

Step 1: Funded mission concept studies

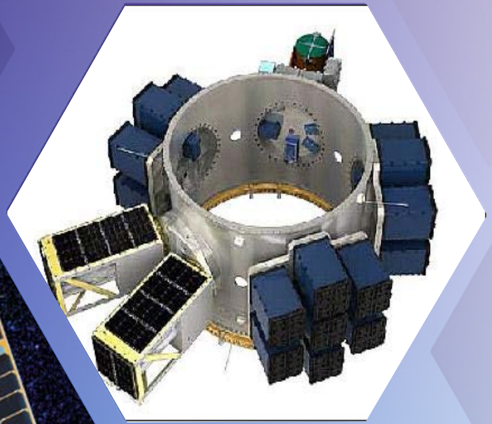
- NASA will fund SmallSat mission concept studies (via ROSES) in advance of the 2019 SMEX/MO AO
- 38 Proposals received, 9 proposals selected

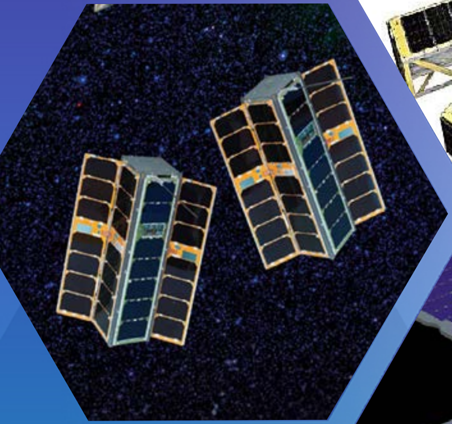
Step 2: NASA will include SmallSats in the 2019 Explorer Mission of Opportunity PEA (Program Element Appendix) of the SALMON-3 AO

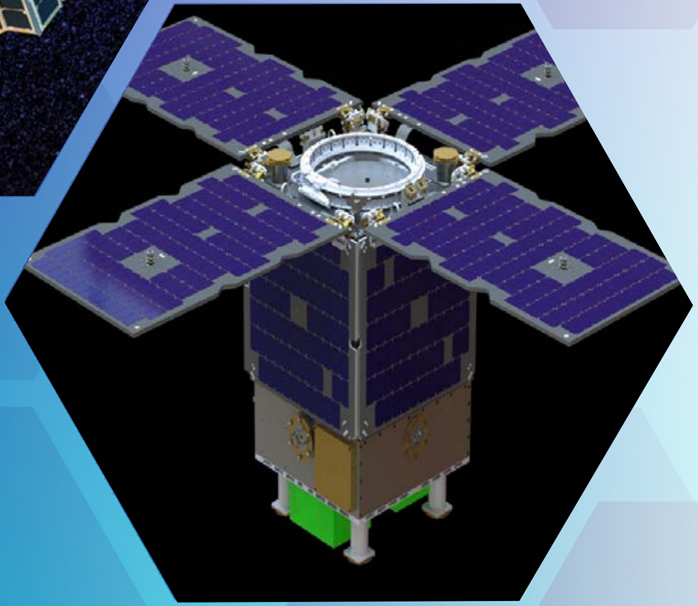
- Potential new class of MO: SmallSats ($35M cost cap)
- NASA will find launch for standard CubeSat and ESPA*-ring forms

* EELV Secondary Payload Adapter

Astrophysics SmallSats







Selected Mission Concept Studies

- X-ray Quantum Calorimeter Satellite (XQSat), Philip Kaaret at University of Iowa in Iowa City
- Dark Ages Polarimetry Pathfinder (DAPPER), Jack Burns at University of Colorado in Boulder
- Gravitational-wave Ultraviolet Counterpart Imagers (GUCI++), Stephen Cenko at NASA Goddard Space Flight Center in Greenbelt, Maryland
- Miniature Distributed Occulter Telescope (mDOT), Bruce Macintosh at Stanford University in California
- MicroArcsecond Small Satellite (MASS), Michael Shao at the NASA Jet Propulsion Lab in Pasadena, California
- Smallsat Exploration of the Exospheres of Nearby Hot Jupiters (SEEJ), Scott Wolk at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts
- Virtual Telescope for X-ray Observations (VTXO), John Krizmanic at the University of Maryland, Baltimore County
- HREXI SmallSat Pathfinder (HSP), Jonathan Grindlay at Harvard College in Cambridge, Massachusetts
- Infrared SmallSat for Cluster Evolution Astrophysics (ISCEA), Yun Wang at the California Institute of Technology in Pasadena, California

https://www.nasa.gov/feature/nasa-astrophysics-eyes-big-science-with-small-satellites

ESA Large Mission Updates

- Athena
  - NASA planning for a hardware contribution, plus a U.S. GO program and a U.S. data center.
  - NASA will contribute to both the X-IFU and the WFI instruments.
  - NASA and U.S. community participating in Athena Science Study Team (including its Science Working Groups) and Instrument Teams.
  - Transitioning to a NASA project in 2018/2019.
- LISA
  - NASA has established a LISA Study Office at GSFC.
  - NASA is funding five US-based technologies with the aim of reaching TRL 5/6 by Adoption.
  - NASA and U.S. community participating in LISA Science Study Team and the LISA Consortium.
  - NASA established a NASA LISA Study Team to interface with NASA LISA Study Office, LISA Consortium, and Decadal Survey.
  - NASA issued call for LISA Preparatory Science proposals in ROSES.
  - Transitioning to a NASA project in 2018/2019.

Prospects and Challenges for Athena and LISA

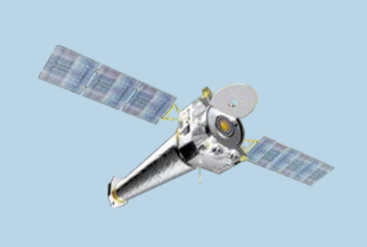
- NASA is proceeding toward Athena and LISA in close partnership with ESA
- ESA has announced intent to accelerate adoption of both missions, and request budget sufficient to have both operating together
- However, NASA's progress is budget limited
  - The planning budget for NASA Astrophysics is down by 14% due to the proposed termination of WFIRST
  - The replan of the James Webb Space Telescope requires additional funding, and this is likely to have an impact on NASA's astrophysics portfolio
  - Accelerating NASA-funded technology maturation for LISA may require prioritization among the five U.S. technology development efforts

Astrophysics Missions in Operation

Hubble 4/90
NASA Strategic Mission

Hubble Space Telescope

Chandra 7/99
NASA Strategic Mission



Chandra X-ray Observatory

XMM-Newton 12/99
ESA-led Mission

X-ray Multi Mirror - Newton

Spitzer 8/03
NASA Strategic Mission

Spitzer Space Telescope

Gehrels-Swift 11/04
NASA MIDEX Mission

Swift Gamma-ray Burst Explorer

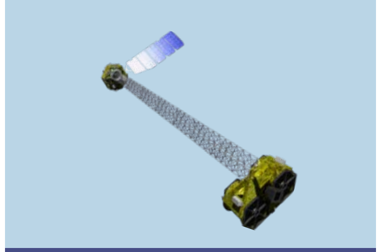
Fermi 6/08
NASA Strategic Mission

Fermi Gamma-ray Space Telescope

Kepler 3/09
NASA Discovery Mission

Kepler Space Telescope

NuSTAR 6/12
NASA SMEX Mission



Nuclear Spectroscopic Telescope Array

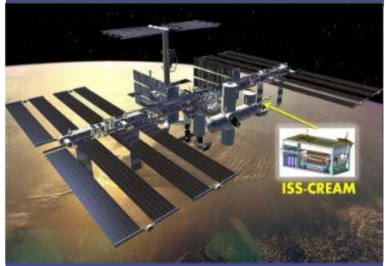
SOFIA 5/14
NASA Strategic Mission

Stratospheric Observatory for Infrared Astronomy

ISS-NICER 6/17
NASA Explorers Miss. of Oppty

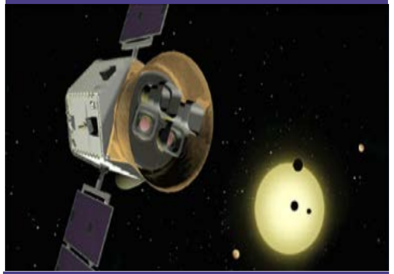
Neutron Star Interior Composition Explorer

ISS-CREAM 8/17
NASA Research Mission

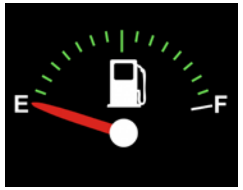


Cosmic Ray Energetics And Mass

TESS 4/18
NASA MIDEX Mission



Transiting Exoplanet Survey Satellite



SOFIA

Stratospheric Observatory for Infrared Astronomy

- SOFIA's initially agreed upon 5-year prime mission will be completed at the end of FY19
- At the end of a prime mission, NASA usually assesses the science performance, management of a program and proposed future science to decide on an extension of the program through a Senior Review Process, as required by the 2005 NASA Authorization Act.
- The 2018 Consolidated Appropriations Act, however forbade NASA from placing SOFIA in the 2019 Senior Review.
- Given that the program has finished 5 years of operations, the time is appropriate to review 2 aspects of the SOFIA Project:
  - A review of SOFIA's science progress and science prospects to assure that SOFIA is and will remain scientifically productive and relevant (early 2019)
  - A review of SOFIA's operational paradigm to assure that SOFIA is optimally efficient and effective in planning and executing the science program (late 2018)
  - The reviews will not consider closeout or cancellation of SOFIA.

Senior Review 2019

Astrophysics Advisory Committee

Senior Review Subcommittee

- Hubble Panel
- Chandra Panel
- Rest-of-Missions Panel

- Chandra X-ray Observatory (Chandra)
- Fermi Gamma-ray Space Telescope (Fermi)
- Hubble Space Telescope (Hubble)
- Neutron star Interior Composition ExploreR (NICER)
- Nuclear Spectroscopic Telescope Array (NuSTAR)
- Neil Gehrels Swift Observatory (Swift)
- Transiting Exoplanet Survey Satellite (TESS)
- X-ray Multi-mirror Mission-Newton (XMM-Newton)

Not in Senior Review: Kepler, SOFIA, Spitzer

Senior Review 2019 Schedule

2018:

- ✓ APAC approves Terms of Reference for the Senior Review Subcommittee
- ✓ Draft call for proposals issued
- Establish Senior Review Subcommittee, including appointment of subcommittee members compliant with FACA
- Final call for proposals issued

2019:

- Senior Review proposals due
- Rest-of-missions, Chandra, and Hubble panels meet
- Reports from Rest-of-missions, Chandra, and Hubble panels due to Senior Review Subcommittee
- Senior Review Subcommittee meets
- Senior Review Subcommittee reports to APAC
- APAC delivers formal recommendations to NASA
- NASA responds to Senior Review and provides direction to projects

NASA Astrophysics

Planning for Astro2020

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

CAA report on NASA's preparations for the 2020 DS

- Early in 2018, NASA tasked the CAA to provide an independent assessment of NASA's preparations for the 2020 Decadal Survey, and suggest improvements.
- The CAA released a short report in July 2018 (https://www.nap.edu/catalog/25212/report-series-committee-on-astronomy-and-astrophysics-mission-concept-studies) where it commended NASA for "*its sustained and well-considered efforts to prepare the needed project information for the next decadal survey*."
- The report listed 7 findings aimed at improving the value of the studies to the 2020 Decadal.

Decadal Survey Planning

- NASA's highest aspiration for the 2020 Decadal Survey is that it be ambitious.
  - The important science questions require new and ambitious capabilities.
  - Ambitious missions prioritized by previous Decadal Surveys have always led to paradigm shifting discoveries about the universe.

- There are two areas where NASA has recently worked to ensure an ambitious Decadal Survey:
  - The timing of the Decadal Survey.
  - The scope of the large mission studies.

Decadal Survey Timing

- NASA AA for Science Thomas Zurbuchen expressed concern about whether an ambitious and forward-looking Decadal Survey could take place during a period of uncertainty regarding Webb and WFIRST
  - He charged the community with considering whether there was any alternative to delaying the Decadal Survey
- National Academies Astro2020 consultation group and leadership of CAA, SSB, and BPA discussed the issue.
  - Considered input from the community survey conducted by NASA's Program Analysis Groups https://cor.gsfc.nasa.gov/copag/rfi/copag-rfi.php
- Academies group recommended that the start of the Astro2020 Decadal Survey not be delayed
- On May 24, Zurbuchen accepted the recommendation
  - Zurbuchen explained in blog entry at https://blogs.nasa.gov/drthomasz/

Decadal Survey Planning
Large Mission Concept Studies

- All four STDTs have submitted interim reports to NASA
  - The Interim Reports have been reviewed by an independent review team.
  - Feedback was provided to the STDTs to allow them to improve their final reports
- The interim reports contain each STDT's Architecture A
- NASA has directed the STDTs to develop a less costly Architecture B during the next year
  - This will provide the Decadal Survey with ranges of scientific scope for their missions, as well as a range of science goals at different budget levels
  - This was recommended by the NAS study "Powering Science" (2017)
  - All were already considering a less costly Architecture B
- NASA anticipates that all of the architectures will be submitted to the Decadal Survey for consideration

2020 Decadal Survey Planning

- NASA has initiated studies for large (Flagship) and medium (Probe) size mission concepts to inform the 2020 Decadal Survey Committee in an organized and coherent way
  - Main purpose is to provide the Decadal Survey Committee with several well-defined mission concepts to facilitate their deliberations
- Specifically, NASA is:
  - Sponsoring 4 community-based Science and Technology Definition Teams (STDTs) to partner with a NASA Center-based engineering team and study large (strategic) mission concept studies selected from the NASA Astrophysics 30-year Visionary Roadmap, a community-based report, and the 2010 Decadal Survey
  - Supporting 10 PI-led Study Teams for Probe-size mission concept studies, selected competitively
  - Supporting several other planning activities / studies / white papers including: Balloon Program Roadmap; Evolution of NASA Data Centers; SmallSats; In-Space Servicing/In-Space Assembly.
  - Investing in next-generation technologies, including ultrastable telescope technology, starshades, coronagraphs, x-ray mirrors, detectors, etc.
- Material related to NASA's 2020 Decadal Survey planning activities are posted at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

NASA Astrophysics

NASA Response to AAAC July 2018 Recommendations

Response to Recommendations - 1

Recommendation: The three agencies should coordinate, and where possible standardize, the guidelines and expectations for the releases of data sets, data products, data access tools, and related software used to produce future surveys, astrophysical simulations, and missions.

- *Our thrust here was that a good job was being done in the public releasing of data, both by NASA missions and NSF/DOE surveys, but more could be done to release the software used to generate the released data and to create the derived data products. We did not want to put too many details into the recommendation, as we do not want to over-constrain possible responses by the agencies. We were envisioning some kind of incentivizing of an open source model.*

  In the case of future surveys, we anticipate that making early versions of mission/survey software available during the development of the mission/survey would enable the community to plan/optimize their own use of the data products that would be forthcoming. Having the software available helps everyone understand what was done and has near and long-term scientific benefits. There will likely be effort, i.e. costs, incurred in order to make the software available. Our intent is that reasonable costs be supported (funded) and that some effort be made among the agencies to make it possible for tools to be shared. Coordination between the agencies is expected to be beneficial. For example, we might avoid developing conflicting requirements (between agencies) for software and data releases.

Response: NASA concurs. As stated at July 2018 meeting, a final report on the two-year joint Agency detailed study to assess the benefits, approach, and cost of implementing joint processing, is expected in 2019.

Response to Recommendations - 2

Recommendation: *NASA and NSF should enhance their collaboration with each other and with other groups, including international agencies and commercial interests, to protect the accessibility of essential astronomical wavelengths to researchers.*

See response to next recommendation.

Recommendation: *Efforts, ideally coordinated with all three agencies, should be made to increase awareness of spectrum management issues among astronomers, the general public, and government agencies. Possible agents for meeting this recommendation might include the NSF-funded national facilities for operations at radio and optical wavelengths.*

> *The two above are obviously linked. Prior to the discussion during our meetings, many of our members were only loosely aware of the issues behind spectrum management. The committee ended our discussion with the consensus view that the astronomical community should be more about how the electromagnetic spectrum access is managed and that there is a role for the agencies to play in not only playing a role in spectrum management at the federal level, but also in educating the community so that the community will be a more informed advocate for protection of access. We did not have a specific plan of action to recommend.*

Response: NSF has the lead on spectrum management for radio astronomy. NASA will work with NSF.

Response to Recommendations - 3

Recommendation: NSF and NASA should continue to carry out and evaluate their strategies for reducing proposal pressure, reporting to the community for feedback on their evaluation strategies and the results.

> *We want to encourage both NASA and NSF to continue to build upon their past experiments with requests, review, and awarding of proposals in order to reduce the work load (by the community preparing/submitting proposals, the agencies in managing reviews of the proposals, and the effort of the community to participate in reviews) and increase success rates. We had in mind the examples the Agencies presented to us.*
>
> *These included the NSF going to rolling proposals (no deadlines) for the Solar and Planetary grants and the NASA ATP (theory) grants moving to every other year proposal cycle. In both cases, we questioned the agencies about their intentions to evaluate the impacts of these experiments. We are expecting continued evaluation of the outcomes, including not only whether success rates go up and workloads decrease, but also whether the demographics and other characteristics of supported programs change and in what ways.*

Response: NASA concurs and will keep the AAAC informed.

Response to Recommendations - 4

Recommendation: All current and planned surveys should publicly release their data with suitable access tools and documentation. This is consistent with the AAAC Principles of Access recommended by the AAAC in their 2013 - 2014 annual report. In addition, the surveys should release the source code used to create the data products. Surveys supported in part or entirely by the federal government through its agencies should work to include funding enabling adequate public access to the data, software, and data products produced through these surveys.

> *The consensus of the AAAC is that that in addition to surveys making their data (and software) publicly available, they should also provide (fund) tools to access these data, documentation, and software. This recommendation is in some ways a bit redundant with the earlier recommendation above.*

Response: NASA concurs. In both PI-led and Flagship missions, the Projects deliver data to the archives, who ensure they are easily available to the research community. Flagship missions have significantly larger scope, with more complex data thus necessitating more tools, documentation and user support. Flagships have their own science centers with public-facing websites, so they usually serve tools and documents directly. Data, however, flow through the archives, and tools and documents move to the archives after the end of operations.

Revised
July 18, 2018
Consistent with FY18 Appropriation

NASA Astrophysics

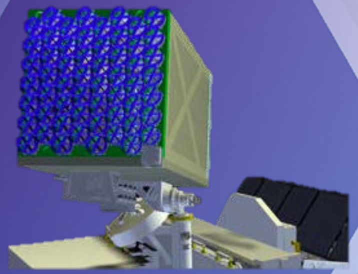
Backup

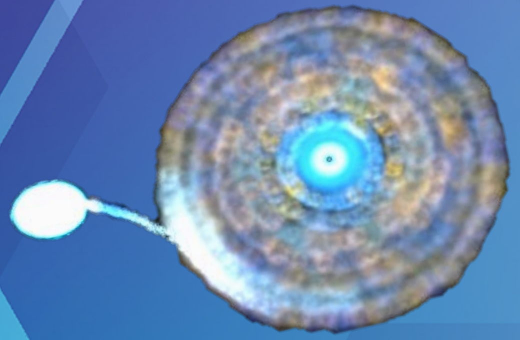
CAA report on NASA’s preparations for the 2020 DS

1. It would be helpful if each of the concept reports clearly shows the key mission requirements, which is derived from the science drivers and how they affected the design. This could include, for example, a science traceability matrix.
2. Astro2010 did not request information on possible descopes. The lack of this information hindered discussions. For Astro2020, mission concept studies could include possible descope and upgrade options and the science impact of such changes. Estimates of cost changes could be included. Implicit in this suggestion is the related suggestion that mission capabilities be prioritized.
3. Enumeration and evaluation of the risks are essential inputs to the decadal survey. These design and costing exercises present opportunities for mission concept teams to learn how to communicate risks effectively to the decadal survey.
4. NASA’s process of reviewing mission concept study reports before submission to the decadal survey will avoid problems associated with study reports providing dissimilar levels of detail and would help ensure a clear basis of comparison by the decadal survey. The prescribed format for the probe final reports could be adapted for the large missions as well.
5. The probe and large mission studies are being done somewhat differently, with the large missions having more time, resources, and possibly more opportunities to optimize the design. Based on experience in the previous decadal survey, it will be important to check that the probes have optimized the design and the presentation of the information, to the extent practical, given available resources.
6. Mission concept teams that did not participate in this preparatory process may still submit their concepts to the decadal survey. Substantial changes from the open submission policies followed by Astro2010 are not anticipated.
7. Probes have clear guidance about cost caps. Large mission studies are less constrained and have been instructed by NASA to give a range of performance and cost points. This guidance to the large missions about affordability and further guidance about NASA’s anticipated budgets will help align the results to the needs of the survey, which will also be given information from NASA about its anticipated budgets.

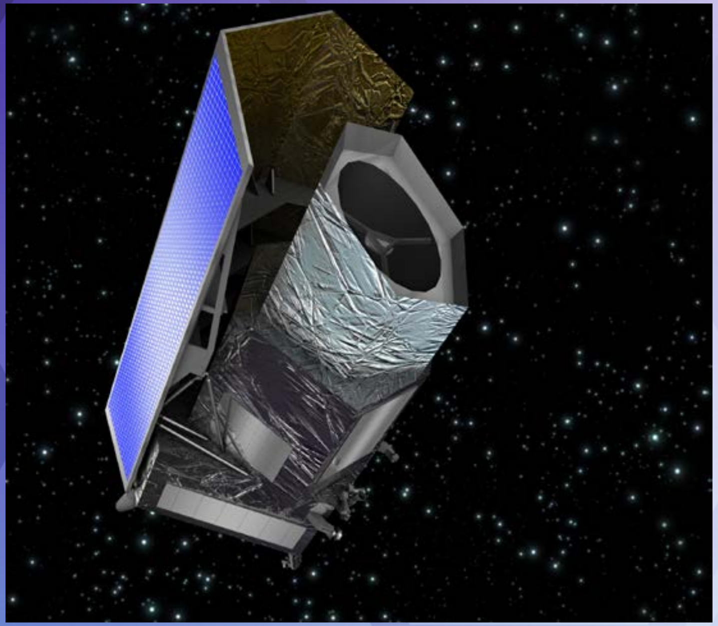
ISS-NICER

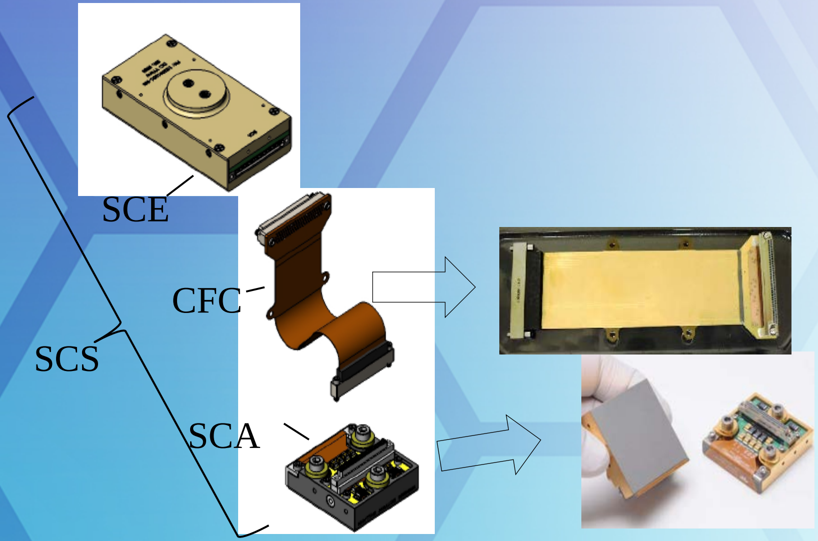
Neutron star Interior Composition Explorer





- Launched in June 2017 with a mission lifetime of 18 months
  - The instrument is working flawlessly and has already led to numerous discoveries (e.g., binary with the shortest period).
  - The NICER data are public as of February 2018 and can be accessed through the HEASARC.
  - As of now, 9 peer review papers have been published on NICER data by the Science Team in peer-reviewed journals. One PhD Thesis using NICER data was completed.
- NICER is now past mid-point. NASA is holding an independent review of the Mission Progress towards fulfilling the Level 1 science and technical requirements.
  - Contingent on results of review, NICER will be approved for a short mission extension (~6 months) until the Senior Review

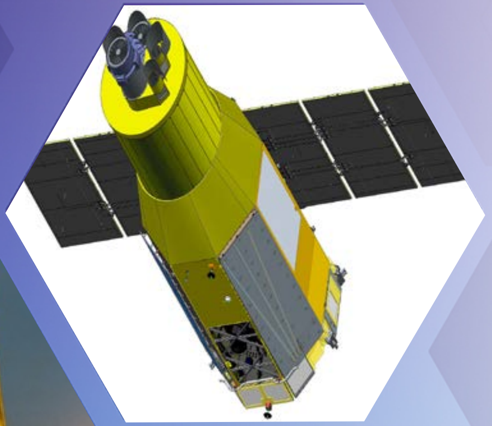




Sensor Chip Assembly (SCA)
Cryo-Flexi Cable (CFC)
Sensor Chip Electronics (SCE)

Euclid

- ESA led dark energy mission with NASA contributions
  - Launch date 2022
- NASA providing
  - 20 Characterized NIR Sensor Chip Systems
  - ~70 U.S. members of Euclid Consortium
  - Euclid NASA Science Center at IPAC
- NASA delivered 20 detectors and cryo-flex cables to ESA
  - Detectors presently under characterization testing in Europe
- NASA is now manufacturing and testing the redesigned sensor chip electronics (readout boards)
  - Engineering models currently in thermal testing
  - 20 SCEs will be delivered to ESA by March 2020



X-ray Imaging and Spectroscopy Mission (XRISM) – formerly XARM

- Name change at JAXA Project Initiation July 2018
- NASA contributing Resolve microcalorimeter and X-ray Mirror Assembly – in Phase C since January 2018
- Canadian Space Agency (CSA) joined NASA team in April 2018 – contributing calibration light source
- Science Team kickoff in Japan May 2018 including NASA Participating Scientists – 5 selected February 2018
- Resolve delivery October 2019 – GSFC team half-way through hardware build
- Launch Readiness Date January 2022
- U.S. Community Involvement
  - U.S. Scientists on Guaranteed Time Observing (GTO) Target Teams: to be selected approx. 1 year before launch
  - General Observing (GO) Program: Open to U.S. scientists starting 6-9 months after launch

Comparison of Webb and WFIRST Development Risk at KDP-B

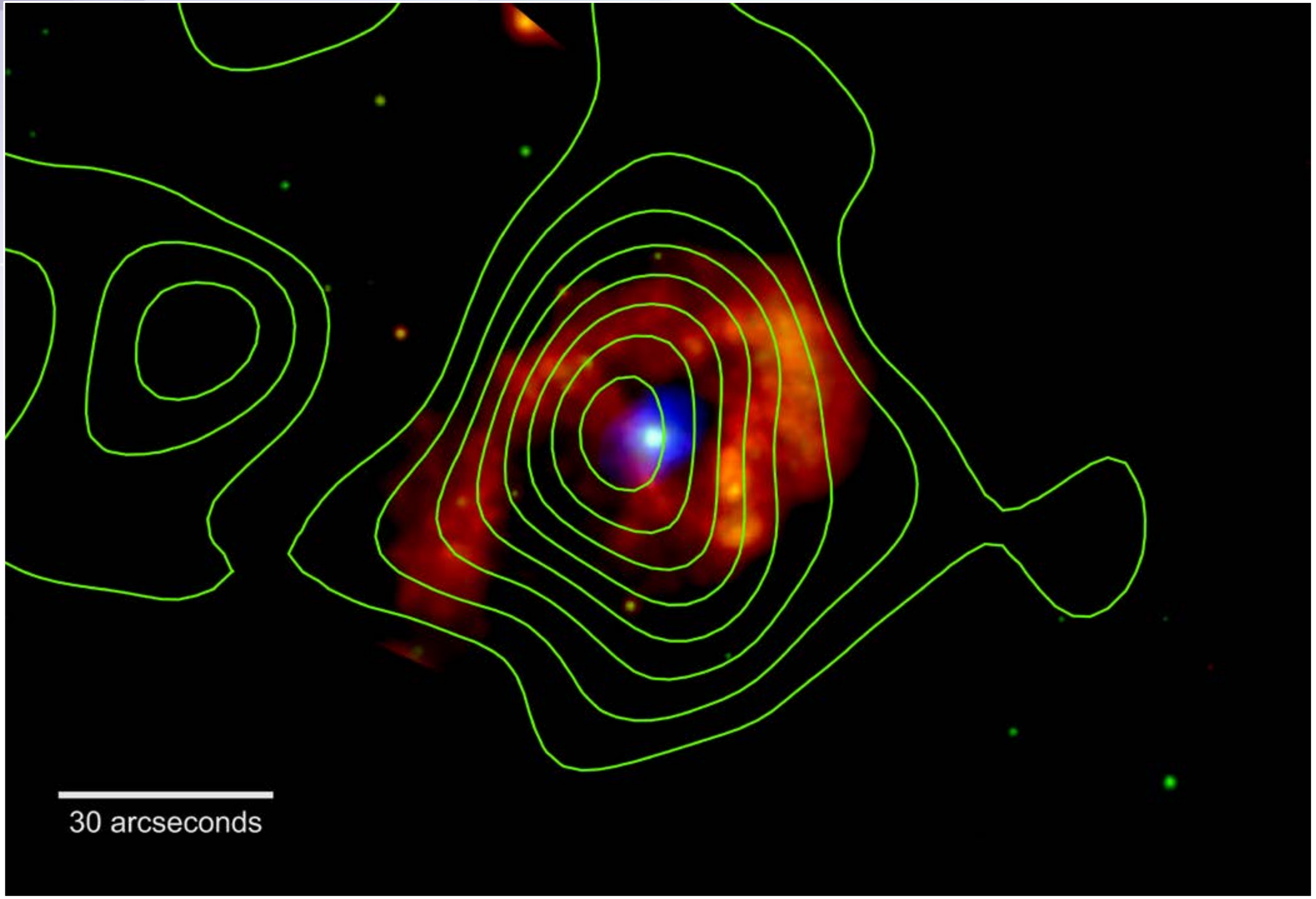
Webb @ KDP-B	WFIRST @ KDP-B
Novel, complex segmented Be mirror development	Existing 2.4m monolithic ULE mirror
Numerous technology developments	High TRL: basis of Decadal selection, recent investments
Complex cryo-cooler	Passive Al radiator
ISIM structure materials development (30 K)	Reuse of Webb design in instrument carrier (190K)
IR detector manufacturing problem uncovered after KDP-C	IR detectors presently at TRL-6, flight growth initiated at start of Phase B; Greater maturity and understanding of Webb-derived detector technologies reduces risk of encountering problems late in the WFIRST program
Four highly configurable instruments (inherent complexity), major international roles, separate guider	Single primary instrument + tech demo, no separate guider
Many complex deployments	Standard deployments

WFIRST risks are lower than those retired on Webb, and typical of high TRL missions. Incorporated numerous Webb lessons learned.

WFIRST Surveys and Community Access

- Unlike all prior flagship missions, WFIRST is a survey telescope; the core surveys encompass a large amount of time and will be broadly useful to the wider community.
- NASA working with WFIRST FSWG to explore mechanisms to solicit and facilitate community engagement. Current status quo:
  - All WFIRST data will be immediately public (no propriety period).
  - There will be a call for new WFIRST Science Teams around September 2021.
  - Mission capabilities are being designed to enable notional surveys addressing three key science pillars (Dark Energy, Exoplanets, Great Observatory Astrophysics).
  - Final allocation of WFIRST observing time will be decided through open-access, nonproprietary, peer-reviewed competition of programs addressing scientific imperatives.
  - Observing time will be allocated as close to the mission time as is reasonable (balancing the evolving scientific landscape with the need to plan large surveys in advance).
- Ideas being discussed for facilitating community input:
  - Investigate alternate ways of gathering and incorporating community input to the primary survey teams.
  - Create community science working groups for ancillary survey science beyond the three pillars.
  - Establish openly-competed “Early Release Demonstration Programs” performed at start of operations to inform the time allocation process during the prime mission.

Some NASA Science Stories of 2018



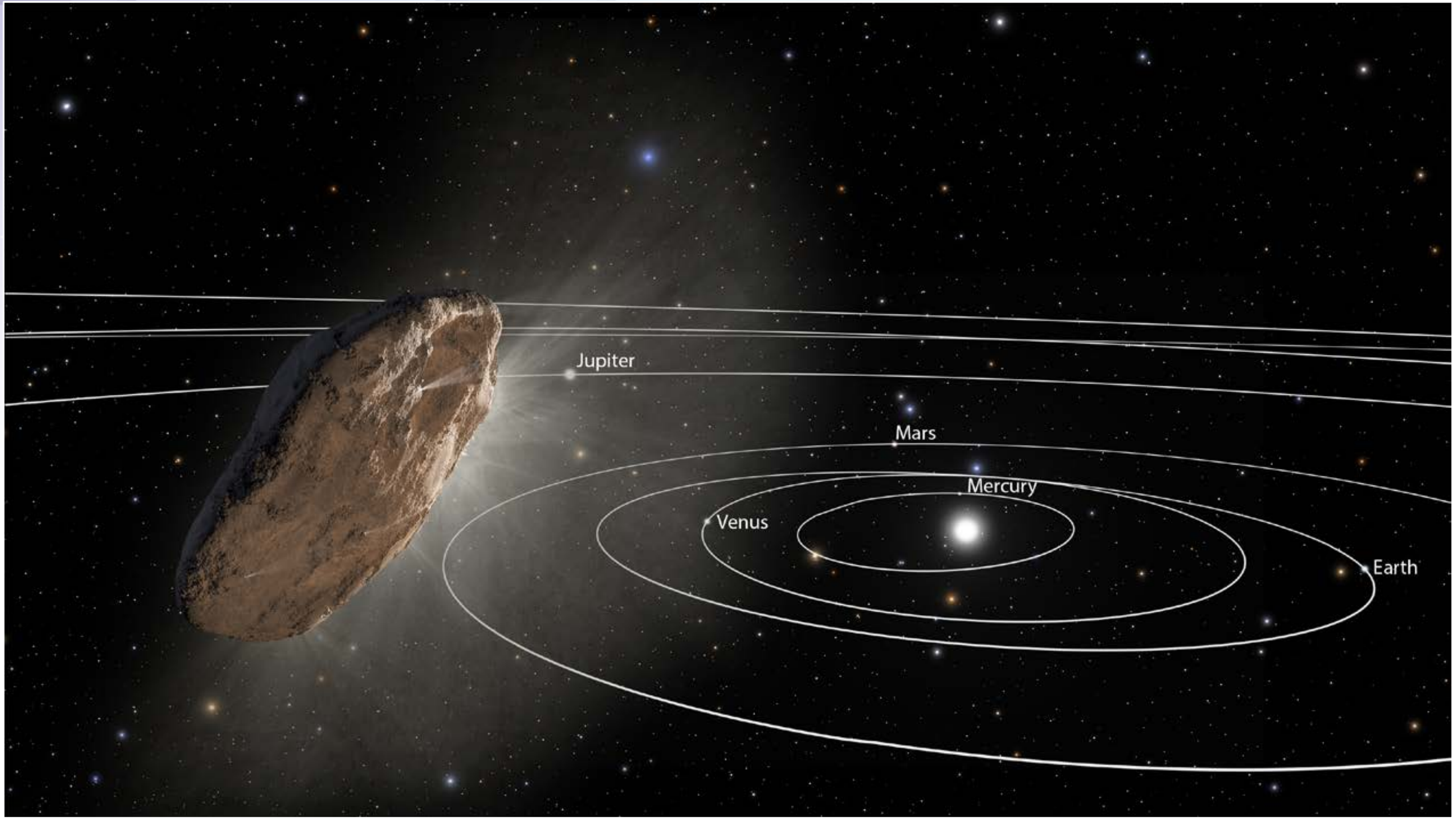
NASA's NuSTAR Mission Proves Superstar Eta Carinae Shoots Cosmic Rays

Eta Carinae shines in X-rays in this image from NASA's Chandra X-ray Observatory. The colors indicate different energies. Red spans 300 to 1,000 electron volts (eV), green ranges from 1,000 to 3,000 eV and blue covers 3,000 to 10,000 eV. For comparison, the energy of visible light is about 2 to 3 eV. NuSTAR observations (green contours) reveal a source of X-rays with energies some three times higher than Chandra detects. X-rays seen from the central point source arise from the binary's stellar wind collision. The NuSTAR detection shows that shock waves in the wind collision zone accelerate charged particles like electrons and protons to near the speed of light. Some of these may reach Earth, where they will be detected as cosmic ray particles. X-rays scattered by debris ejected in Eta Carinae's famous 1840 eruption may produce the broader red emission.

Credits: NASA/CXC and NASA/JPL-Caltech

https://www.nasa.gov/feature/goddard/2018/nasas-nustar-mission-proves-superstar-eta-carinae-shoots-cosmic-rays

Some NASA Science Stories of 2018



http://hubblesite.org/news_release/news/2018-25

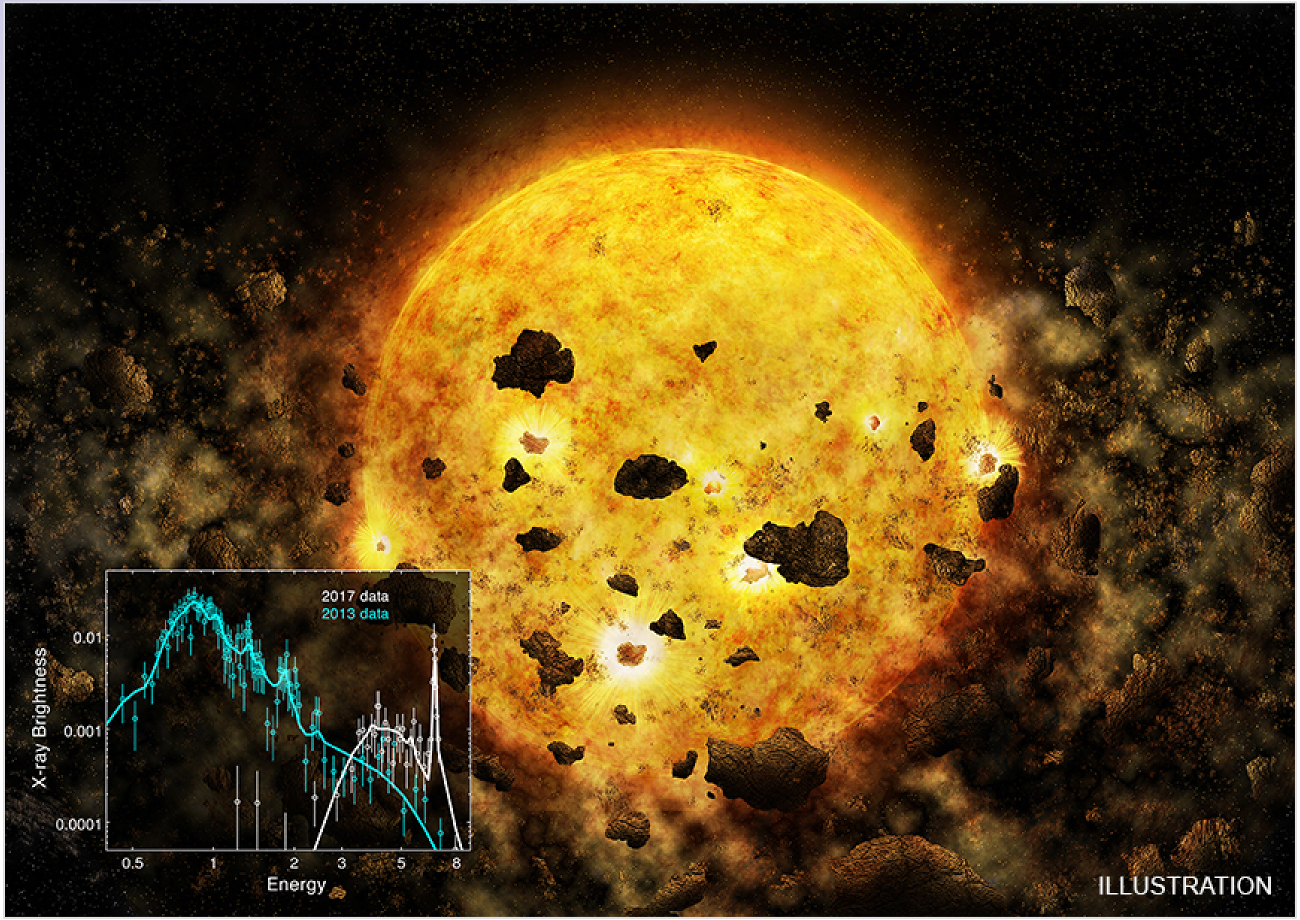
Our Solar System's First Known Interstellar Object Gets Unexpected Speed Boost

Using observations from NASA's Hubble Space Telescope and ground-based observatories, an international team of scientists have confirmed `Oumuamua the first known interstellar object to travel through our solar system, got an unexpected boost in speed and shift in trajectory as it passed through the inner solar system last year.

Artwork: NASA, ESA, and J. Olmsted and F. Summers (STScI)

Science: NASA, ESA, and M. Micheli (ESA/SSA-NEO Coordination Centre) and K. Meech (University of Hawaii Institute for Astronomy)

Some NASA Science Stories of 2018



http://chandra.harvard.edu/photo/2018/rwaur/

Chandra May Have First Evidence of a Young Star Devouring a Planet

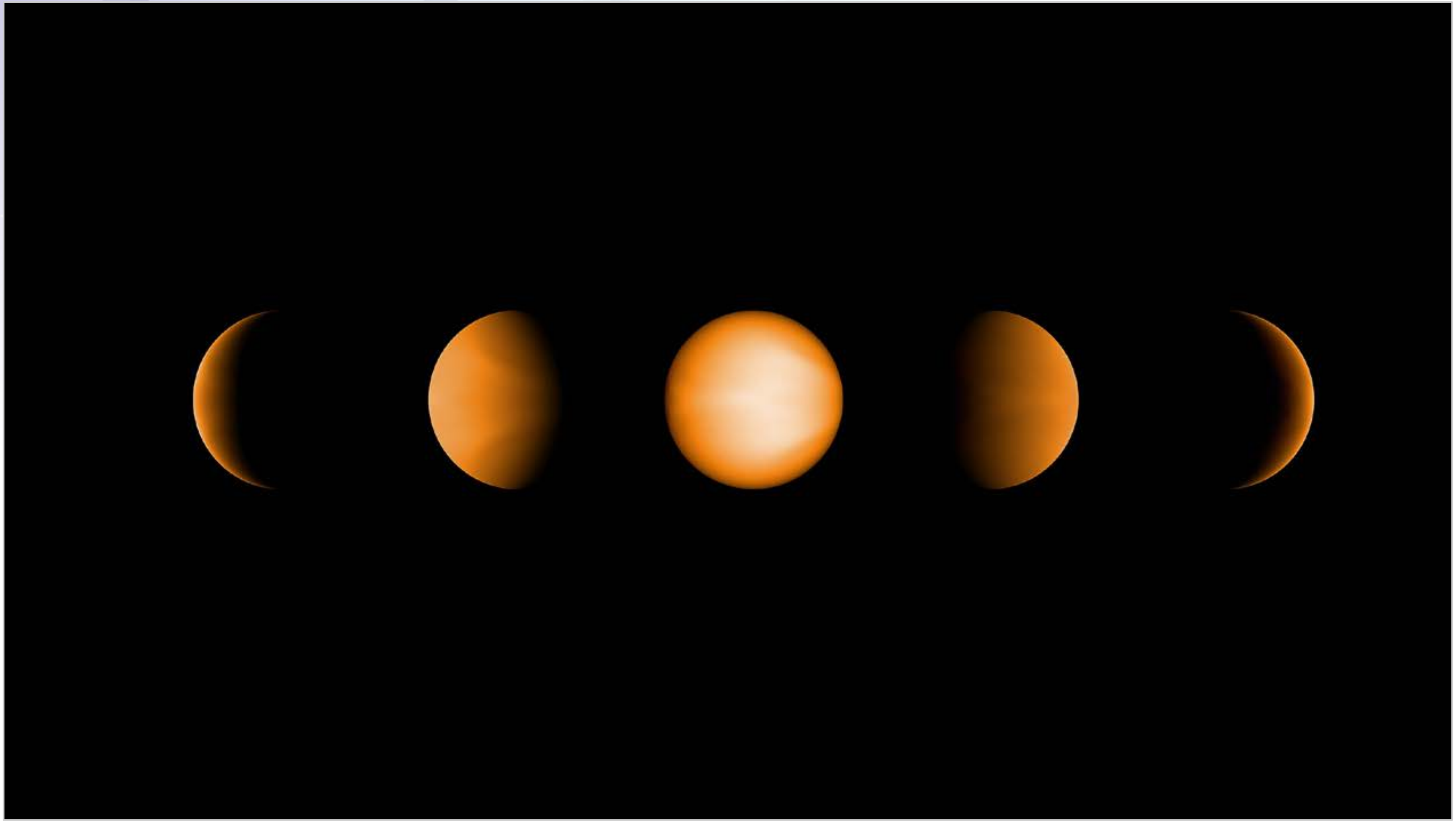
Chandra data indicates that a young star has likely destroyed and consumed an infant planet. If confirmed, this would be the first time that astronomers have witnessed such an event. The star, known as RW Aur A, is a few million years old and is located about 450 light years from Earth. Studying this may help astronomers gain insight into the processes affecting the early stages of planet development.

This artist's illustration depicts the destruction of a young planet or planets, which scientists may have witnessed for the first time using data from NASA's Chandra X-ray Observatory, as described in our latest press release. If this discovery is confirmed, it would give insight into the processes affecting the survival of infant planets.

The Chandra spectra from the 2013 and 2017 observations are shown in an inset in the graphic. The sharp peak on the right of the 2017 spectrum is a signature of a large amount of iron.

Illustration: NASA/CXC/M.Weiss; X-ray spectrum: NASA/CXC/MIT/H.M.Günther

Some NASA Science Stories of 2018



Water Is Destroyed, Then Reborn in Ultrahot Jupiters

What has puzzled scientists is why water vapor appears to be missing from the toasty worlds' atmospheres, when it is abundant in similar but slightly cooler planets. Observations of ultrahot Jupiters by NASA's Spitzer and Hubble space telescopes, combined with computer simulations, have served as a springboard for a new theoretical study that may have solved this mystery.

According to the new study, ultrahot Jupiters do in fact possess the ingredients for water (hydrogen and oxygen atoms). Due to strong irradiation on the planet's daysides, temperatures there get so intense that water molecules are completely torn apart.

http://www.spitzer.caltech.edu/news/2061-ssc2018-10-Water-Is-Destroyed-Then-Reborn-in-Ultrahot-Jupiters

NASA and Multi-Messenger Astrophysics

- NASA is enabling Multi-Messenger Astrophysics:
  - Fermi and Swift are always in survey mode to detect transients
  - Every mission accepts TOO proposals, including Hubble, Chandra, Spitzer, Swift, NuSTAR
  - GSFC is working on an alert network that extends GCN
  - Large investment of Chandra (750 ks) and Hubble (~40 orbits) time were allocated through the TOO process to follow-up the GW170817 neutron star merger
  - The Astrophysics Theory Program (ATP) supports theoretical investigations of the EM counterparts of GW sources
- A NASA-chartered community science interest group (SIG) is providing analysis of ways in which MMA can be optimized with current and future NASA observatories; the MMA SIG reports to the PhysPAG