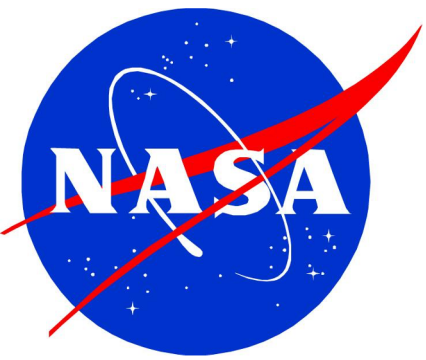


NASA's Physics of the Cosmos Program

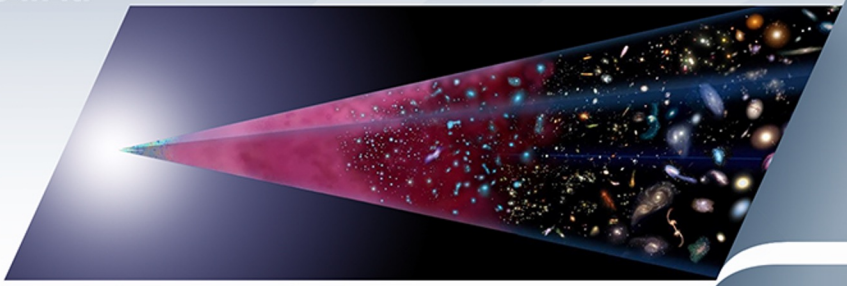
Brian Williams
Interim PCOS Chief Scientist

April APS
17 Apr 2021

Why Astrophysics?

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

How did our universe begin and evolve?



Physics of the Cosmos (PCOS)

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

Cosmic Origins (COR)

Are we alone?

Exoplanet Exploration (ExEP)

Program Office Themes

Enduring National Strategic Drivers

Physics of the Cosmos Program Office Purpose:

to explore some of the most fundamental questions regarding the physical forces and laws of the universe:

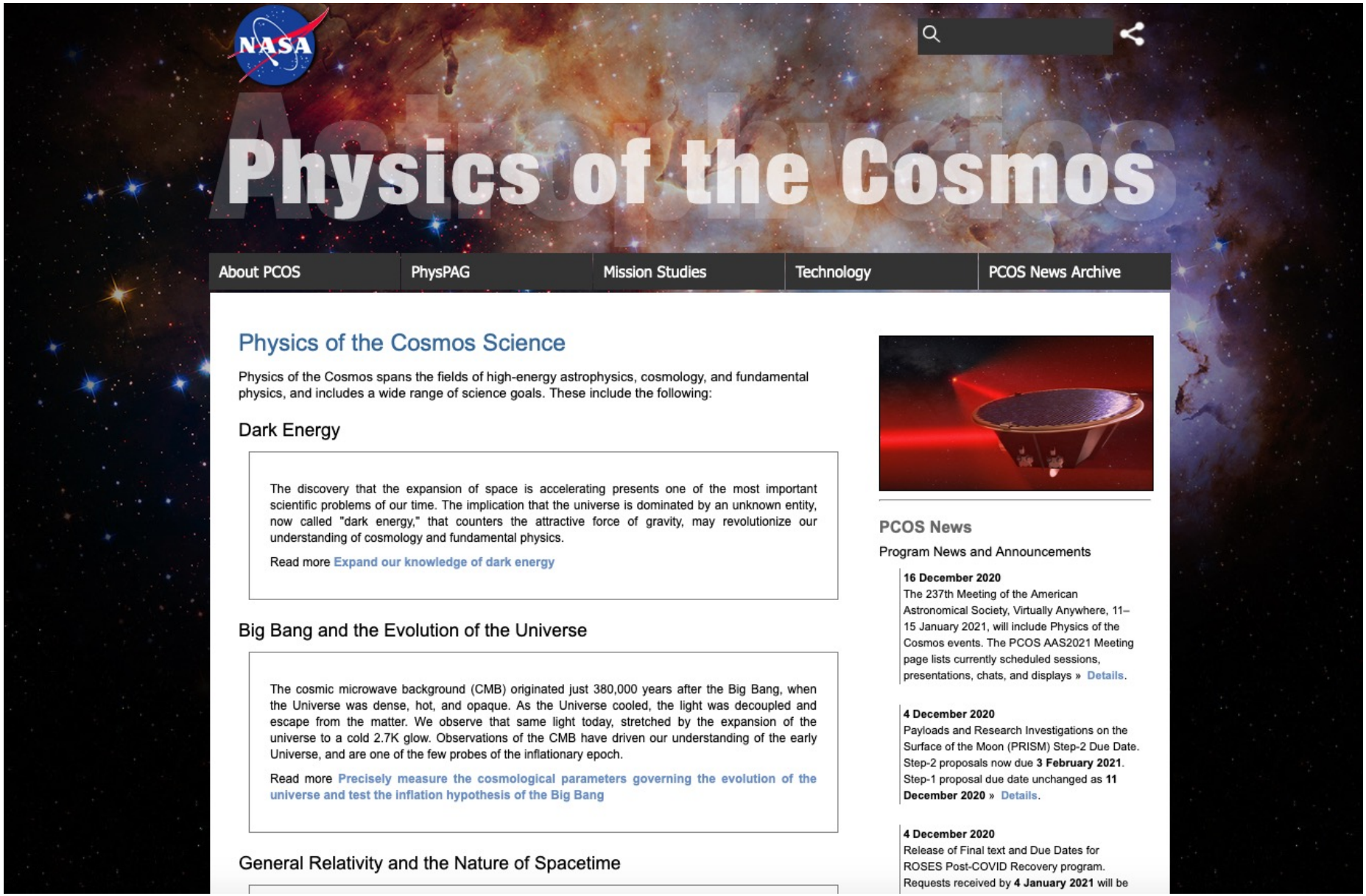
- the validity of Einstein's General Theory of Relativity and the nature of spacetime;
- the behavior of matter and energy in extreme environments;
- the cosmological parameters governing inflation and the evolution of the universe; and
- the nature of dark matter and dark energy.

Physics of the Cosmos spans the fields of high-energy astrophysics, cosmology, and fundamental physics, with a wide range of science goals. These include the following:

- General Relativity and the Nature of Spacetime
- Massive Black Holes and the Evolution of Galaxies
- Matter and Energy in the Most Extreme Environments
- Dark Energy
- Big Bang and the Evolution of the Universe

More resources: https://pcos.gsfc.nasa.gov

pcos.gsfc.nasa.gov



Activities supporting PCOS goals and priorities:

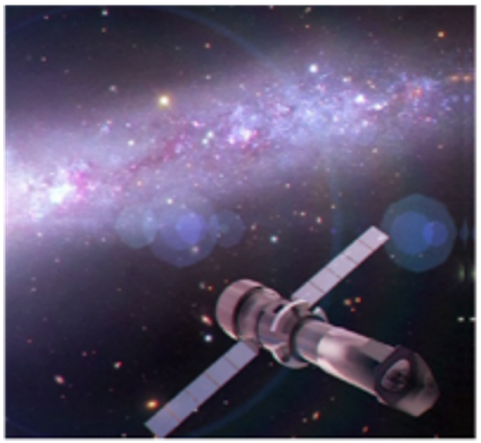
- Managed by the PCOS/COR Program Office at NASA's Goddard Space Flight Center and reported to NASA Headquarters.
- Include:
  - **Mission studies** and pre-project mission oversight, insight, and support
  - **Strategic technology** (SAT) maturation oversight, insight, and support
  - **Community engagement**, including via the Physics of the Cosmos Program Analysis Group (PhysPAG)
  - Maintaining **science cognizance** to enable more successful NASA strategic planning

The PCOS Program Office hosts
- ATHENA Study Office
- LISA Study Office

and oversees
- science and
- technology activities

for NASA's contribution to these ESA-led and other strategic missions.

Athena



Athena is an ESA flagship X-ray mission slated for launch in the early 2030s

Two instruments provided by member states:

- calorimeter (X-IFU) and
- wide-field imager (WFI)

NASA is planning hardware contributions, with options for both X-IFU and WFI, and is discussing observatory contributions.

Current status: in (ESA) Phase B

- Nov 2019: Athena passed Mission Formulation Review (MFR)!
- Mission Adoption Review scheduled for June 2022
- US Athena Study will become a Project in May 2022

NASA Athena Science Team is co-chaired by Jon Miller (Michigan) and Laura Brenneman (SAO)

For more info:

http://www.the-athena-x-ray-observatory.eu/

https://asd.gsfc.nasa.gov/athena/

LISA

LISA is an ESA-led space gravitational wave observatory.

NASA is a junior partner with possible technology contributions, including:

- Laser (GSFC, JPL)
- Telescope (GSFC, U. Florida)
- Charge management system (U. Florida)

Additional NASA contributions will include

- Science Ground System Support
- Precursor Science programs
- Guest Investigator programs

Current status: in (ESA) Extended Phase A

- Dec 2019: LISA passed ESA Mission Consolidation Review
- Mission Formulation Review in Fall 2021
- Mission Adoption currently anticipated in mid-2020s.

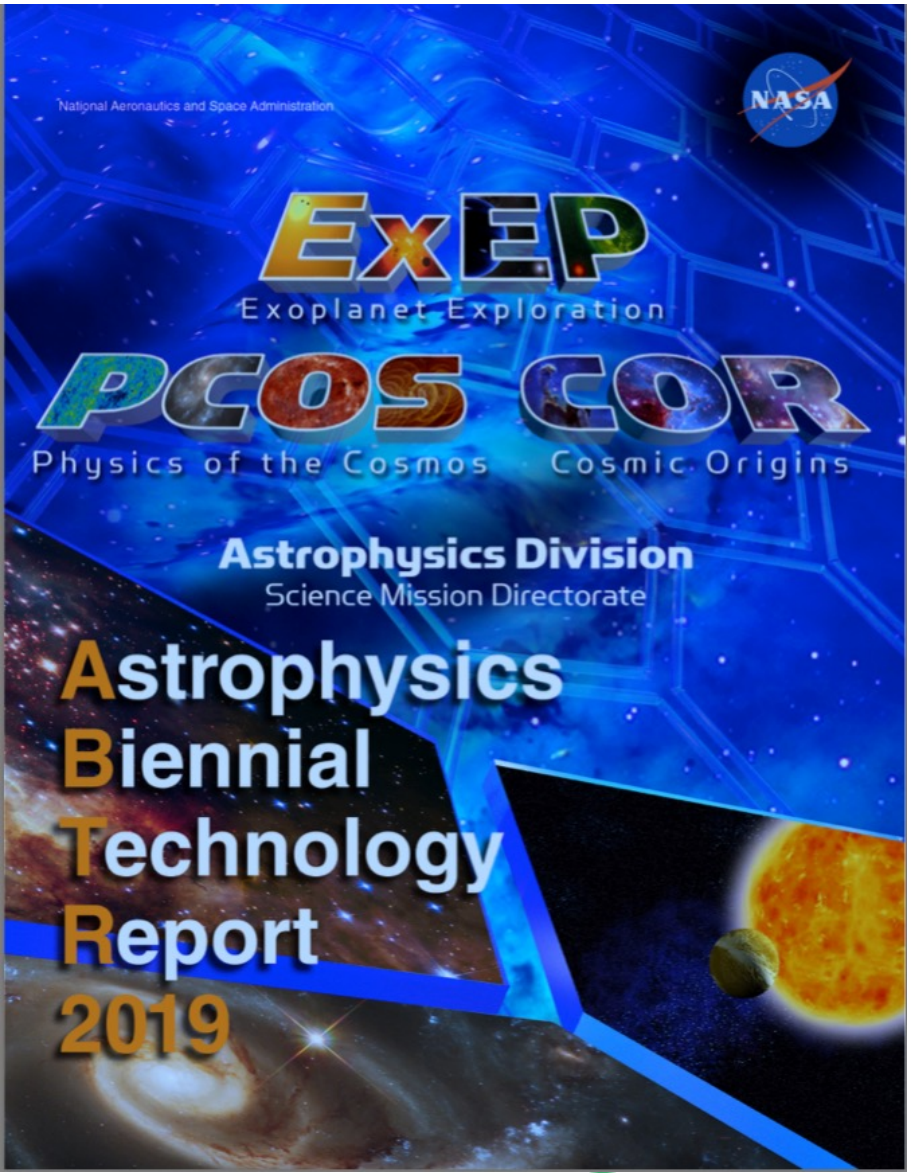
NASA LISA Study Team (Kelly Holley-Bockelmann, Chair) highlights:

- Science Support Taskforce Report: Maximizing US Participation in LISA Science

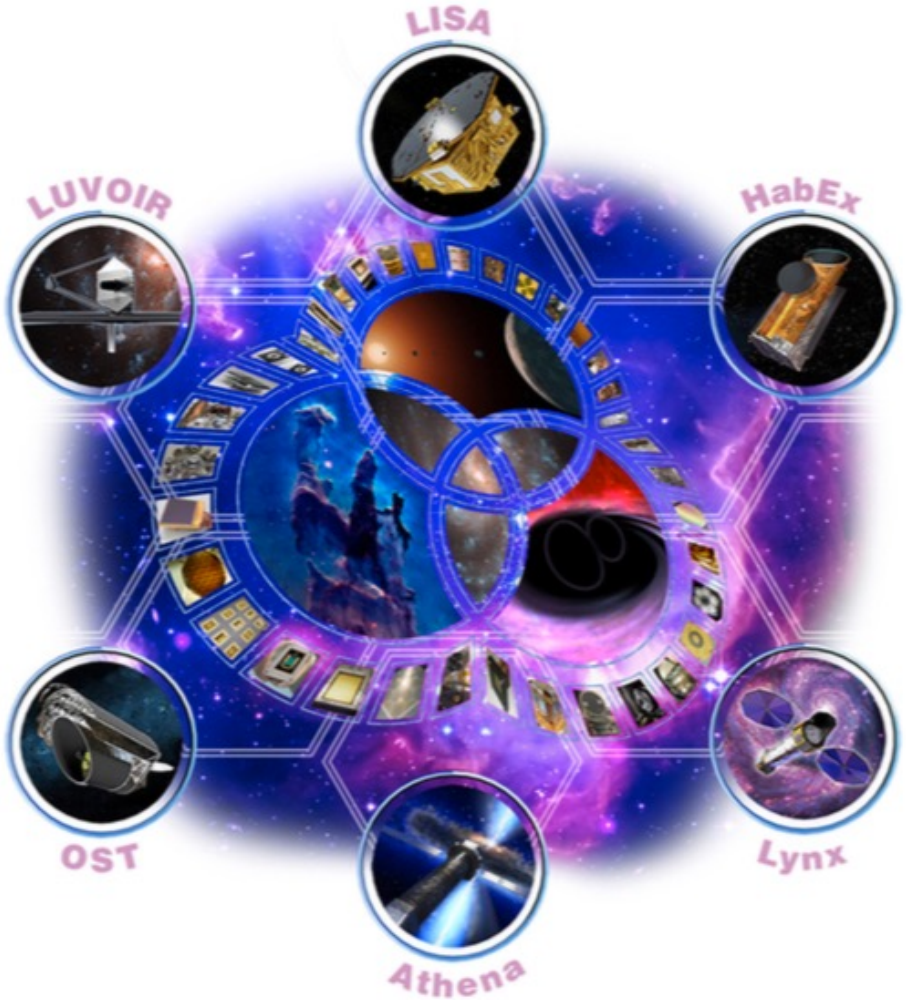
For more info:

https://sci.esa.int/web/lisa/ and https://lisa.nasa.gov/

First Astrophysics Biennial Technology Report



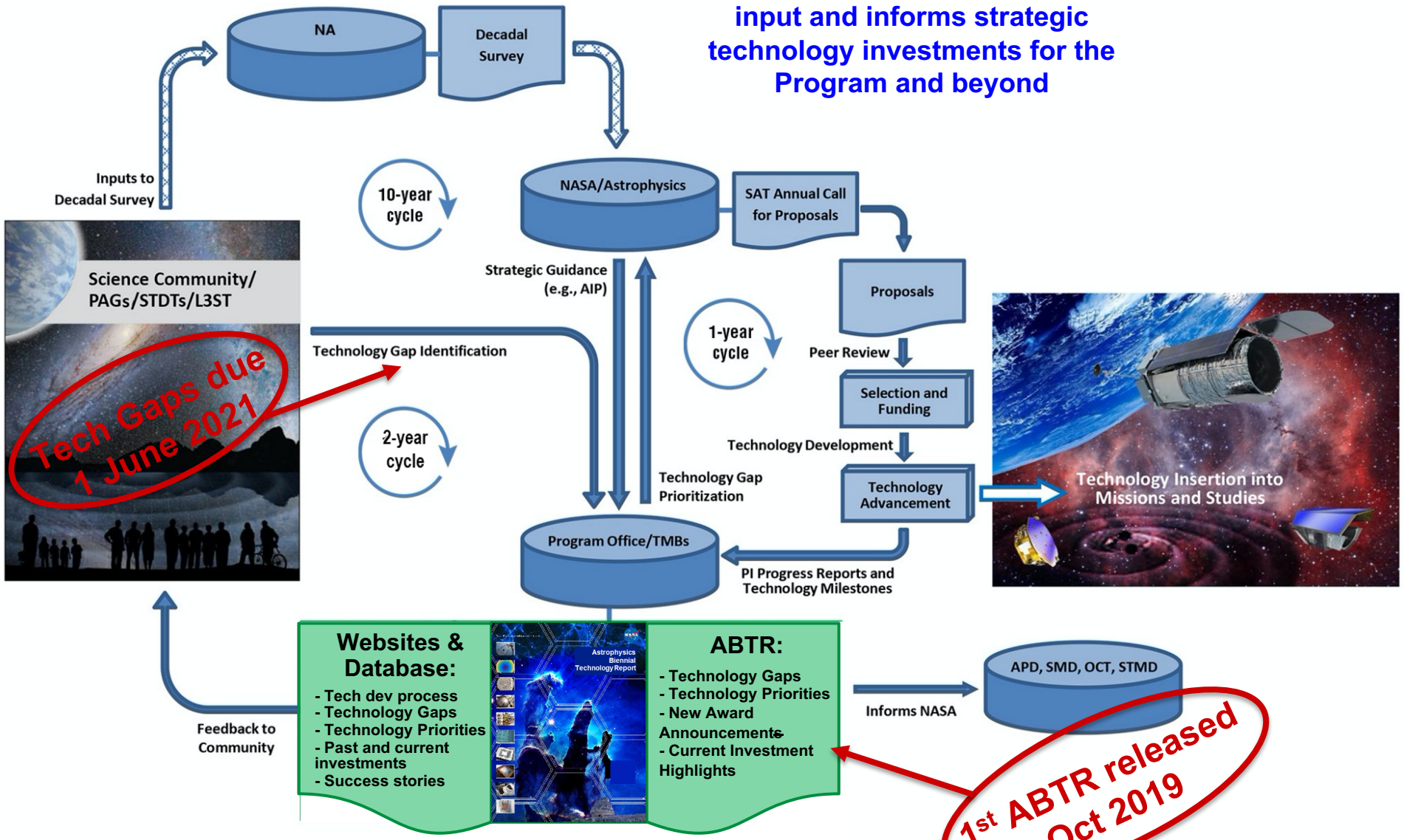
Process is responsive to community input and informs strategic technology investments for the Program and beyond



https://apd440.gsfc.nasa.gov/technology.html)

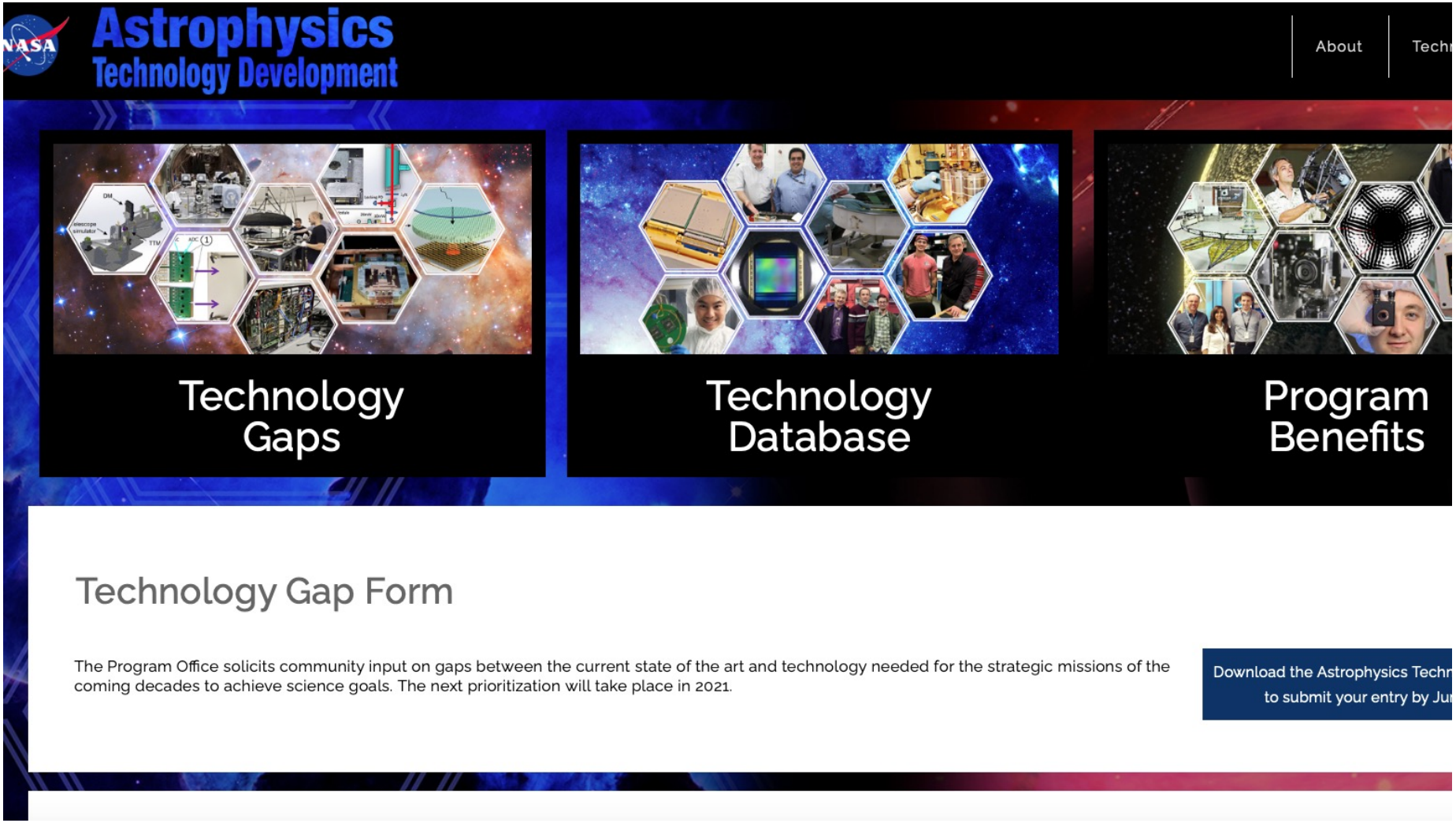
Strategic Technology Development Process

Process is responsive to community input and informs strategic technology investments for the Program and beyond



https://apd440.gsfc.nasa.gov/technology.html

Technology Gap Solicitation



Due on June 1st OR 3 weeks after the release of the Astro2020 Decadal Survey, whichever is *LATER*

ABTR: Tech Gaps

Tier 1 Technology Gaps
Angular Resolution (UV/Vis/NIR)
Coronagraph Contrast
Coronagraph Contrast Stability
Cryogenic Readouts for Large-Format Far-IR Detectors
Fast, Low-Noise, Megapixel X-Ray Imaging Arrays with Moderate Spectral Resolution
High-Efficiency X-Ray Grating Arrays for High-Resolution Spectroscopy
High-Resolution, Large-Area, Lightweight X-Ray Optics
Large-Format, High-Resolution, UV/Vis Focal Plane Arrays
Large-Format, High-Spectral-Resolution, Small-Pixel X-Ray Focal-Plane Arrays
Large-Format, Low-Noise and Ultralow-Noise Far-IR Direct Detectors
Large-Format, Low-Noise, High-QE Far-UV Detectors
Next-Generation, Large-Format, Object Selection Technology for Multi-Object Spectrometers for LUVOIR
Vis/NIR Detection Sensitivity

ABTR: Tech Gaps

Tier 1 Technology Gaps
Angular Resolution (UV/Vis/NIR)
Coronagraph
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Fast, Low-Noi
Spectral Reso
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Large-Format,
Large-Format,
Large-Format,
Large-Format,
Next-Generati
Spectrometers
Vis/NIR Detec

Tier 2 Technology Gaps
Advanced Millimeter-Wave Focal-Plane Arrays for CMB Polarimetry
Detection Stability in Mid-IR
Heterodyne FIR Detector Arrays and Related Technologies
High-Efficiency Object Selection Technology for UV Multi-Object Spectrometers
High-Performance Spectral Dispersion Component/Device
High-Reflectivity Broadband FUV-to-NIR Mirror Coatings
High-Throughput Bandpass Selection for UV/Vis
Large-Format Object Selection Technology for Multi-Object Spectrometers for HabEx
Starshade Deployment and Shape Stability
Starshade Starlight Suppression and Model Validation
Stellar Reflex Motion Sensitivity – Astrometry
Stellar Reflex Motion Sensitivity – Extreme Precision Radial Velocity

ABTR: Tech Gaps

Tier 1 Technology Gaps
Angular Resolution (UV/Vis/NIR)
Coronagraph
Coronagraph
Cryogenic Rea
Fast, Low-Noi Spectral Reso
High-Efficienc
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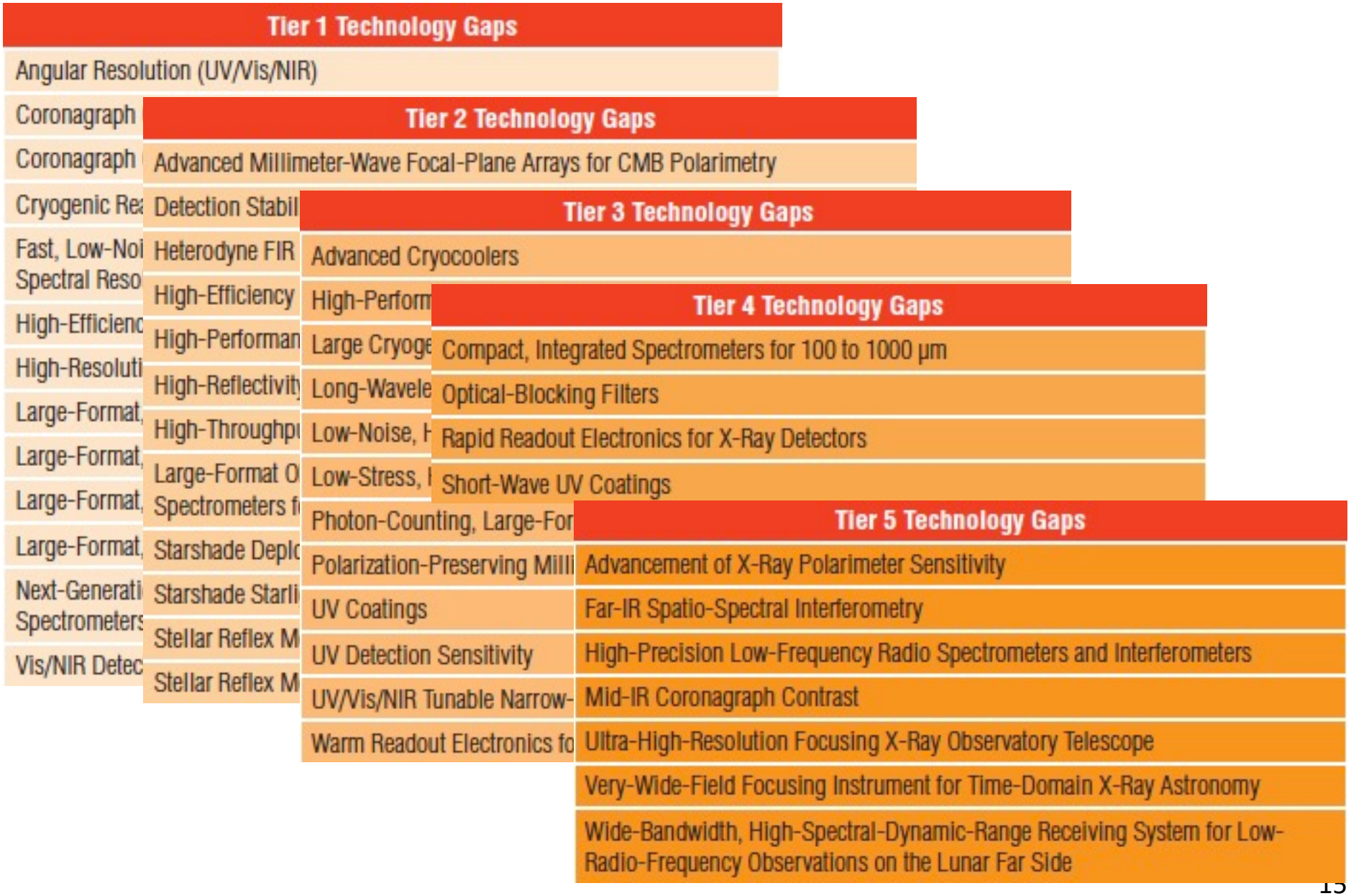
Next-Generati Spectrometers
Vis/NIR Detec

Tier 2 Technology Gaps
Advanced Millimeter-Wave Focal-Plane Arrays for CMB Polarimetry
Detection Stabil
Heterodyne FIR
High-Efficiency
High-Performan
High-Reflectivity
High-Throughpu
Large-Format O Spectrometers f
Starshade Deplo
Starshade Starli
Stellar Reflex M
Stellar Reflex M

Tier 3 Technology Gaps
Advanced Cryocoolers
High-Performance, Sub-Kelvin Coolers
Large Cryogenic Optics for the Mid-IR to Far-IR
Long-Wavelength-Blocking Filters for X-Ray Micro-Calorimeters
Low-Noise, High-QE UV Detectors
Low-Stress, Highly Stable X-Ray Reflective Coatings
Photon-Counting, Large-Format UV Detectors
Polarization-Preserving Millimeter-Wave Optical Elements
UV Coatings
UV Detection Sensitivity
UV/Vis/NIR Tunable Narrow-Band Imaging Capability
Warm Readout Electronics for Large-Format Far-IR Detectors

ABTR: Tech Gaps



PCOS Chief Scientist enables ground-breaking science from space by working at the interfaces between missions and studies, technology, the community, and NASA HQ.

Current PCOS Science Goals and Priorities:

- Ensure a more successful **Decadal survey** by supporting community preparations and HQ activities, spanning the range of inputs: from science to missions, technology, and state of the profession, which all impact our ability to do ground-breaking science
- Ensure more **successful missions** by
  - supporting ongoing mission studies and pre-projects, e.g., LISA, Lynx, Athena
  - through technology efforts, e.g., SAT;
  - by coordinating with current missions; and
  - by preparing for studies for mission recommended by the Astro2020 Decadal
- **Engage the community** to support a successful APD portfolio.

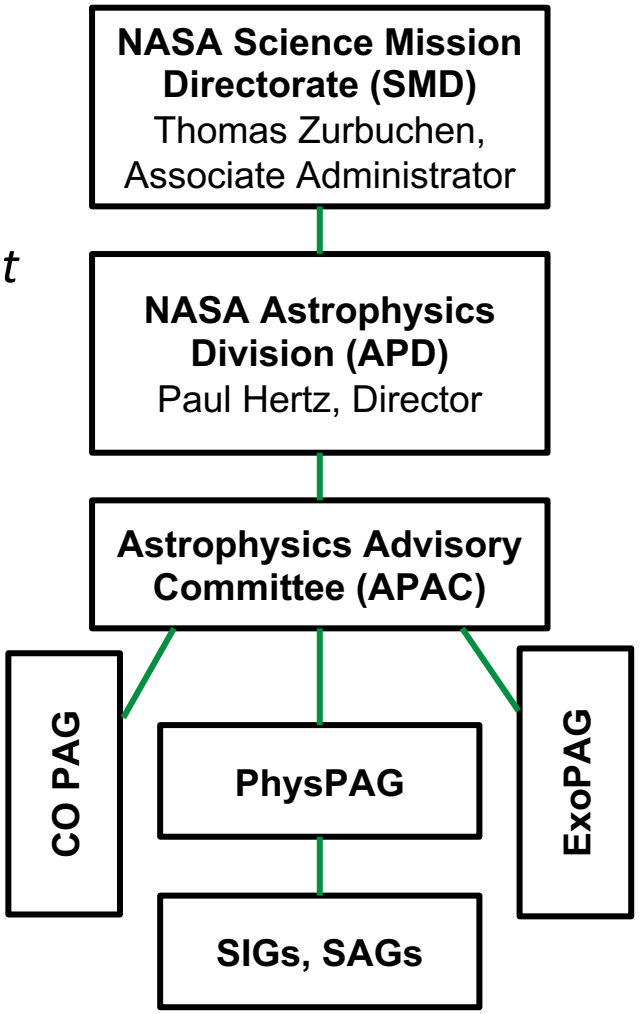
PhysPAG

Physics of the Cosmos Program Analysis Group

- **Purpose:**
  - provide input to NASA relevant to PCOS
  - help NASA inform interested parties about PCOS doings
- **Membership:** ***You!***

  Anyone interested in providing input to NASA relevant to its Physics of the Cosmos Program
- **Leadership:**
  - **Executive Committee** (EC):
    - Chair Emeritus: Graça Rocha
    - Chair: Ryan Hickox
    - Vice Chair: Grant Tremblay
  - 11 EC members chair 6 Science Interest Groups (**SIGs**): longer-standing discipline-specific
  - support formation of Science Analysis Groups (**SAGs**): group created to analyze a specific science question
  - facilitate **info flow** between NASA and community

Communication Network:



For more info: https://pcos.gsfc.nasa.gov/physpag/physpag-ec.php

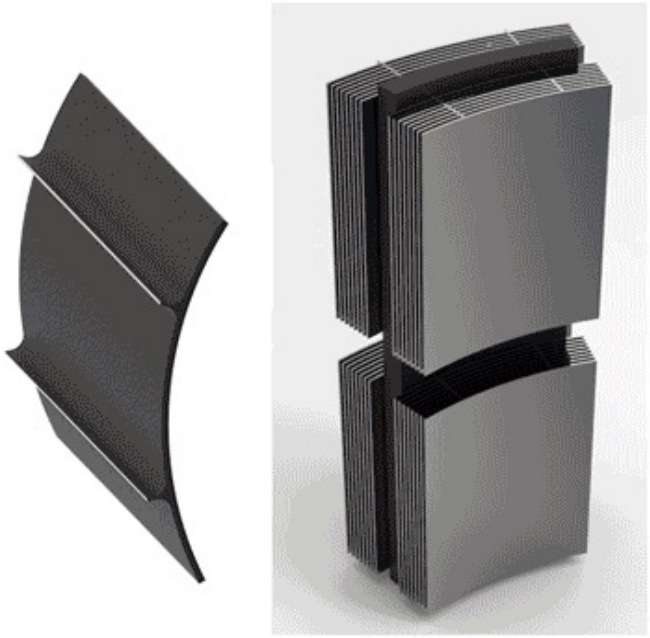
Let's Chat!

Sparks

- What have you found useful?
  - SIGs? SAGs?
  - professional exchange of ideas?
  - white paper preparations?
  - Strategic Astrophysics Technology (SAT) program?
  - ?
- What would you like to see more of ? or less of ?
  - more community leadership?
  - ?
- What do you need from NASA?
- What are you concerned about?

Conclusions

- PCOS will continue to work with the other program offices (COR, ExEP) to ensure that NASA is fully prepared for any recommendations made by the Astro2020 Decadal Survey
- PCOS will continue to provide insight and support for mission studies in development
- PCOS will continue to oversee the development of strategic technologies necessary for astrophysics in the coming years and decades
- PCOS, via the PhysPAG, will continue to offer scientific insight to NASA on various topics



Single mirror segment plus stacked segments with support panel
PI: Zhang, William (GSFC)

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https://pcos.gsfc.nasa.gov/pcosnews-mailing-list.php