Astrophysics Explorers Update

Astrophysics Advisory Committee | March 30, 2023

Pat Knezek, Linda Sparke
Astrophysics Division
Science Mission Directorate

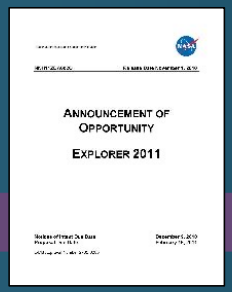
Astrophysics Explorers Program

Selected before 2011

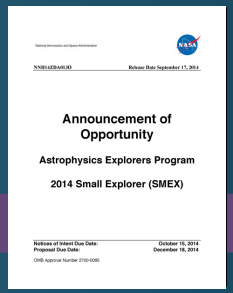
Gehrels
Swift

NuSTAR

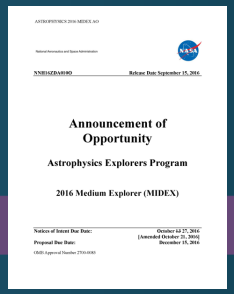
4 AOs per decade



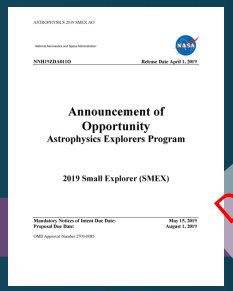
MIDEX 2011



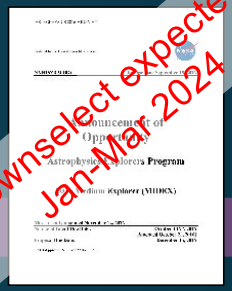
SMEX 2014



MIDEX 2016



SMEX 2019



MIDEX 2021

Downselect expected Jan-Mar 2024

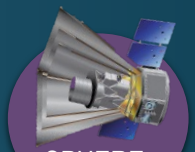
PROBE 2023

SMEX ~~2024~~ 2025

Small and Mid-Size Missions

TESS

IXPE

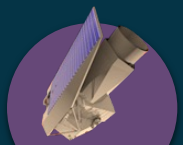


SPHEREx

COSI

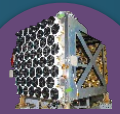
STAR-X
UVEX

Directed 2013



Euclid

Missions of Opportunity



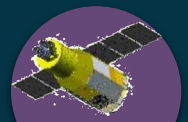
NICER

GUSTO

ARIEL

LEAP
MoonBEAM

Directed 2017



XRISM

Compton Spectrometer and Imager (COSI)

PI: John Tomsick, University of California, Berkeley

COSI is Compton imaging spectrometer with cryogenic Ge detectors for 0.1-5 MeV gamma-rays

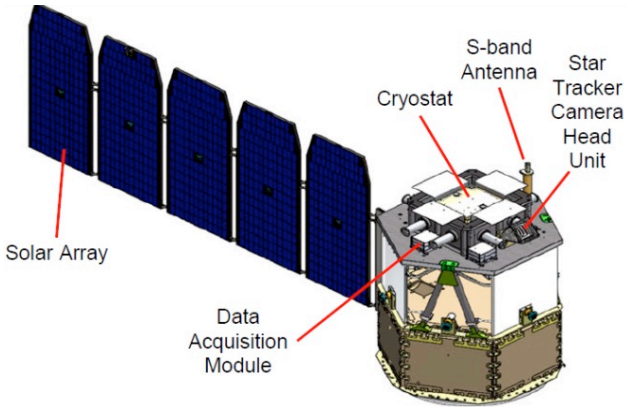
COSI will provide an understanding of the positron excess; map ^{26}Al (half-life 60yr) to study element formation; make the first map of ^{60}Fe (half-life 2.6Myr, only source is core-collapsed SN) to trace past core collapse supernovae; and discover new young supernovae in ^{44}Ti (half-life 0.7Myr).

COSI will use polarization to gain insight into extreme environments, such as accreting black holes (AGN and Galactic) and γ-ray bursts (GRBs).

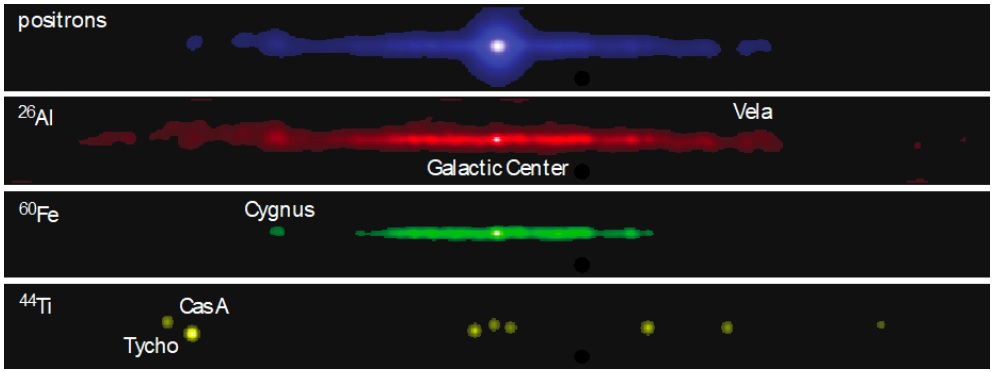
COSI will localize the γ-ray counterparts to GW events (short GRBs) and detect high-energy neutrino counterparts.

System Requirements Review January 2023; Preliminary Design Review February 2023

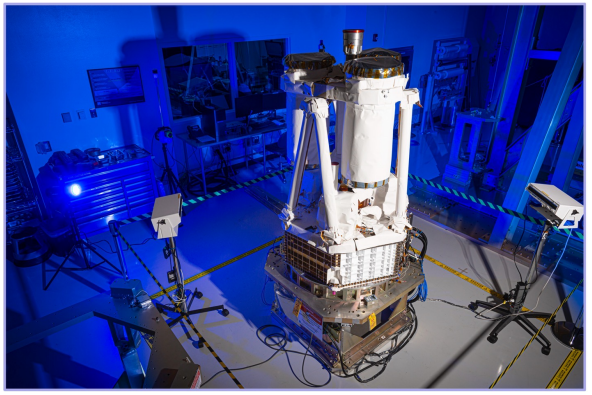
Launch Readiness Date: 2027



Simulated Radioactive Milky Way



IXPE shows that many high-energy sources are polarized

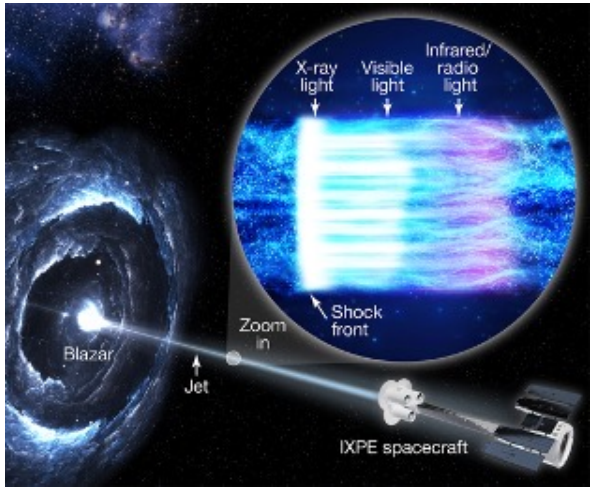


IXPE (Imaging X-ray Polarimetry Explorer, a collaboration between NASA and the Italian Space Agency) launched on December 9, 2021 – it is NASA's first mission to study the polarization of X-rays.

Mission operations began on January 11, 2022. IXPE is now in the second year of its two-year baseline mission.

As of January 11, 2023, 39 sources were observed; 20 of these have secure detections of X-ray polarization:
e.g.

- Blazars Mrk 421 and Mrk 501 are 10%-15% polarized in X-rays, 2-5x more than in visible light: X-rays likely from a magnetized shock (lower picture)
- Accreting stellar-mass black hole Cyg X-3 shows 25% polarization: X-rays likely reflected from a thick dusty torus.



If IXPE passes review at the end of its two-year mission, a general observer program will begin in February 2024.

2021 MIDEX Competitive Phase A Studies

- **STAR-X: Survey and Time-domain Astrophysical Research Explorer:** Sensitive widefield X-ray telescope in 0.2-6 keV; below 2 keV, STAR-X effective area > Chandra. Images < 5 arcsec over 1 degree field in X-ray, and co-aligned UV imager with 2 filters.
- STAR-X can respond within 2 hours to point its X-ray and UV telescopes at transient cosmic sources. With TDRSS, STAR-X sends alerts within 5 minutes of observation. STAR-X Principal investigator: William Zhang (GSFC)

- **UVEX: UltraViolet EXplorer:** Wide-field (12 sq deg) UV imager to survey the whole sky simultaneously in two bands to 50-100 x depth of GALEX, with images <3 arcsec.
- R~1000 spectroscopy in 150-250 nm and targeted deep imaging will give insights into galaxy evolution and the lifecycle of stars.
- UVEX slews rapidly to follow up alerts within 3 hours. UVEX will distribute alerts for transient sources within 1 hour of data receipt (4 downlinks/day). UVEX Principal investigator: Fiona Harrison (Caltech)

2021 MO Competitive Phase A Studies

- MO: LargE Area burst Polarimeter (LEAP): Mounted on the ISS, LEAP uses Compton scattering to study gamma-ray bursts from the energetic jets launched during the formation of a black hole after the explosive death of a massive star, or in the merger of compact objects.
- LEAP's polarization measurements will probe magnetic fields, energy dissipation and emission mechanisms in those ultra-relativistic jets. MO Principal investigator: Mark McConnell (University of New Hampshire)

- MO: Moon Burst Energetics All-sky Monitor (MoonBEAM): From its lunar-resonant orbit, MoonBEAM's soft gamma-ray detector (< 5 MeV) sees almost the whole sky at any time, providing 13+ days of un-interrupted livetime.
- Triangulation with observations from Earth or LEO can localize sources to within 2 degrees.
- Alerts for gamma-ray bursts from distant cosmic explosions can be downlinked within 5 minutes. MoonBEAM Principal investigator: Chuimun Michelle Hui (MSFC).

Astrophysics Probe

On August 16, 2022 NASA issued a draft AO for a PI-led Astrophysics Probe for comment.

- The PI cost cap is $1B; AO requires a General Observer/Guest Investigator (GO/GI) Program during the 5-year prime mission. For a pointed observatory, 70% of observing time is allocated for GO. A survey observatory will make data available as soon as practicable.
- The target date for the final Probe AO remains July 2023
- This is a two-step AO: because the Probes are more complex than previous Explorers, and this is the first one, the competitive Phase A studies will last 12 months
- In response to the recommendation of Astro2020, Astrophysics will accept proposals for:
  - A far-infrared imaging and/or spectroscopy mission
  - An X-ray probe
- Proposing teams should check the Q&As frequently at https://explorers.larc.nasa.gov/2023APPROBE/

Release of final AO:	**July 2023 (target)**
Proposals due:	NET mid-November 2023

Astrophysics Explorers: future AOs

Since the release of the Astro2010 report, Astrophysics has been able to maintain a cadence of 4 Explorers opportunities per decade, each offering a Mission and a Mission of Opportunity.

The FY24 budget request does not allow the release of the next SMEX/MO AO in Spring 2024; instead, it is deferred by a year to Spring 2025.

At this point there is no change to the timing of the 2026 MIDEX/MO.