

ACROSS

Enabling Time Domain and Multi-Messenger Astrophysics

Artist's rendering of a supermassive black hole powering an active galactic nucleus (AGN). Credit: NASA/JPL-Caltech

The goal of the Astrophysics Cross-Observatory Science Support (ACROSS) initiative is to incentivize and enable community-validated science cases that exceed the capabilities of a single observatory or science team. We partner with observers and science teams to provide services and infrastructure, transforming our fleet of observatories into a cohesive observing system to realize the full potential of time domain and multi-messenger science.

RAPIDLY COORDINATED OBSERVATIONS of transient or variable sources are challenging for many reasons, including that all observatories have unique capabilities and constraints, observation planning cycles for different science teams vary greatly, and ground and space-based observatories have differing dependencies on infrastructure.

IN RESPONSE TO THE ASTRO2020 decadal's recommendation that time-domain and multi-messenger astrophysics (TDAMM) is the highest-priority sustaining activity in space, the NASA Astrophysics Division directed the Physics of the Cosmos program office to study implementation options for a general observer facility focused on enabling TDAMM science in October 2022. The first year of the study focused on NASA's space-based assets. A two-year pilot phase (2024-25) was approved to begin development of cross-observatory science-support tools, operations concepts, and infrastructure to facilitate space-based follow-up observations, as well as development of a TDAMM-focused research solicitation. In parallel with the pilot, the study will examine opportunities to engage and coordinate with ground-based assets in the U.S. as well as ground- and space-based assets globally.

WITHIN THE CONTEXT OF TDAMM science cases, we seek to partner with observatories and observers to identify

capability gaps, to highlight best practices, and to develop processes and tools that streamline, standardize, or automate coordinated science planning and execution workflows. Our goals are to improve access to information, lower barriers to entry to the field for all, reduce the workload required of observers and operations teams, and create efficiencies that maximize whole-of-fleet science return. To keep the scope of the pilot activities tractable, we will focus initially on a limited number of missions. These missions include the pointed X-ray missions Swift, NICER, NuSTAR, and IXPE (together providing a good mix of complementary and overlapping capabilities), the wide-field gamma-ray telescopes aboard the Fermi Gamma-ray Space Telescope, and the Keck Observatory as an opportunity to prototype interfaces with ground-based facilities. The scope of the pilot will expand to include other missions as availability of resources and their interest allow.

As a resource for the community, we will provide a help desk staffed by scientists with expertise in TDAMM-relevant missions and science who can assist users in coordinating "ACROSS" multiple observatories. Additionally, we plan to host tutorials and training sessions for ACROSS services and tools at the next NASA-sponsored TDAMM Workshop, anticipated Fall 2024.

Long Gamma-Ray Burst with particle jets
Credit: NASA's Goddard Space Flight Center Conceptual Image Lab

ACROSS TDAMM Research Announcement

A TDAMM Research Announcement (RA) is in development, targeting an initial call in 2026. Several funded research areas are being studied, including development of tools or observing modes to enable new science cases; funded Director’s Discretionary Time (DDT) observations made by multiple smaller missions (analogous to the flagships’ DDT funding opportunities); and an overarching TDAMM science call for proposals designed to streamline or fill the gaps between existing joint observing calls, remove the risk of double jeopardy, and explicitly support observing programs which require coordination between two or more observatories.

We invite further discussion with the astrophysics community, including both scientists and mission representatives, to better understand their needs and concerns as ACROSS begins its pilot phase.

Artist’s rendering of a gamma-ray burst and kilonova produced by the merger of two neutron stars. Credit: NASA’s Goddard Space Flight Center/CI Lab

Components of several of the major tool- and resource-development activities planned for the ACROSS pilot

Science Feasibility Tools:	Fleet state & status information streams
Pointed instruments	<ul style="list-style-type: none"> • Target visibility / observability • Mission target histories • Long- and short-term observing plans • Constraints on planning / scheduling feasibility
Wide-field instruments	<ul style="list-style-type: none"> • Whether event of interest was coincidentally detected • When it was last within FoV • When it will next be within FoV
ToO Toolkit:	Target of Opportunity pages for new missions
	<ul style="list-style-type: none"> • A tailorable software toolkit to assist observation planning and execution • Enables streamlined, standardized, and automated ToO workflows • Incorporates cross-observatory science feasibility information streams and follow-up decision support tools
Web Portal:	Curated information for TDAMM general observers
	<ul style="list-style-type: none"> • Capability summaries for TDAMM-relevant observatories • Links to ACROSS and community-developed tools • Links to ToO submission pages for all missions • Links to funding opportunities, conferences, and workshops • Current TDAMM events of interest page