Summary of the 2022 NASA's TDAMM Workshop

Suvi Gezari (STScI)

Rita Sambruna (GSFC)

The 2020 Decadal Report

ASTROPHYSICS
NASA's Science Mission Directorate

The New Messengers and New Physics theme embodies the dual revolutions brought about by the marriage of observations of light with those from gravitational waves and elementary particles (multi-messenger astrophysics) along with the expansion of measurements of the sky over time (time-domain).

Recommendation:
NASA should establish a time-domain program to realize and sustain the necessary suite of space-based electromagnetic capabilities required to study transient and time-variable phenomena, and to follow-up multi-messenger events. This program should support the ***targeted development and launch*** *of competed Explorer-scale or somewhat larger missions and missions of opportunity.*

TDAMM Workshop

https://pcos.gsfc.nasa.gov/TDAMM/

As a first step in the response to the Decadal recommendation, NASA has organized, via the Physics of the Cosmos Program Office, a workshop to gather international community input on **TDAMM science priorities** to be addressed with future space missions.

The workshop was held on August 22-24, 2022 in Annapolis, MD

350+ participants attended the hybrid presentations and discussions

Summary Part 1: Science

Source Class	Phenomena	Messengers
White Dwarfs	Type Ia SNe, WD+WD mergers, detached WD binaries, novae, accreting WD LISA sources, accretion induced collapse, WD+NS/BH binaries	low-f GWs, EM time domain
Neutron Stars and Black Holes	X-ray binaries, NS+NS mergers, NS+BH mergers, gamma-ray bursts, core-collapse SNe, common envelope events, stellar mergers, fast and blue optical transients	high-f GWs, EM time domain, neutrinos
Supermassive Black Holes	blazars, tidal disruption events, extreme-mass ratio inspirals, binaries, coalescences, and recoiling systems, compact-object mergers in AGN disks	low-f GWs, EM time domain, neutrinos, cosmic-rays
Unknowns	fast radio bursts, fast X-ray transients, pevatrons, “unknown unknowns”	EM time domain, cosmic rays
Interdisciplinary Aspects	fundamental physics, cosmology, dense matter	GWs, EM time domain, neutrinos

Workshop Agenda

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	Monday		
8:15 AM	Registration		
9:00 AM	Plenary Session Kickoff: Suvi Gezari Keynote Speaker Mark Clampin Program Scientist: Valerie Connaughton		
9:45 AM	Break		
	Jetted Transients-SMBH (blazars) Chairs: Gezari, Franckowiak Room B/C	Explosive Transients-WD (SNe Ia) Chairs: Cenko, Andrews Room A	Non-Terminal Transients-Other (supernova remnants, starburst galaxies, galaxy clusters) Chairs: Romero-Wolf, Burke-Spolaor Room F
10:00 AM	**Invited: Marcos Santander**	**Invited: Kate Maguire**	**Invited: Imre Bartos**
10:45 AM	**Contributed: Tiffany Lewis** ***Theoretical Modeling of TXS***	**Contributed: Benjamin Rose** ***A Forecast of Extragalactic Transient Light Curves for the Roman Time Domain Core Community Survey***	**Contributed: Henrike Fleischhack** ***PeVatrons – where are our Galaxy's most powerful accelerators hiding?***
11:00 AM	**Contributed: Haocheng Zhang** ***High-energy polarimetry as a probe for blazar hadronic signatures***	**Contributed: Abigail Polin** ***The Future of Type Ia SNe***	
	Explosive-Transients-NS/BH (core-collapse SNe) Chairs: Andrews, Franckowiak Room B/C	Non-Terminal Sources-WD (CVs, WD binaries) Chairs: Nelemans, Breivik Room A	Jetted Transients-Other (engine-powered SNe) Chairs: Margutti, Metzger Room F
1:30 PM	**Invited: Charlie Kilpatrick**	**Invited: Simone Scaringi**	**Invited: Anna Ho**
2:15 PM	**Contributed: Ori Fox** **Supernovae Interacting With Their Circumstellar Environments**	**Contributed: Kevin Burdge** **The future of "multi-messenger" time domain astronomy: Ultracomapct Galactic binaries**	**Contributed: Bei Zhou** **Choked-Jet Supernovae as Hidden Astrophysical Neutrino Sources**
2:30 PM	**Contributed: Chris Fryer** **Multi-Messenger/Multi-Phenomena Diagnostics of Core-Collapse**	**Contributed: RafaelMartínez-Galarza** **Towards the Seamless Discovery of High Energy Transients: New Data Representations**	
2:45 PM	**Contributed: Avishay Gal-Yam** **Early UV emission from exploding massive stars**		Merger-Driven Transients-Other II (classical and symbiotic novae) Room F Invited: Elias Aydi
3:30 PM		Break	
	Non-Terminal Sources-SMBH (SMBH binaries, AGN) Chairs:Burke-Spolaor, Gezari Room B/C	Jetted Transients-NS/BH (micro quasars, gamma-ray bursts) Chairs: Wilson-Hodge, Cenko Room A	Merger-Driven Transients-Other II (stellar mergers, common envelope systems) Chairs: Kasliwal, Metzger Room F
3:45 PM	**Invited: Tingting Liu**	**Invited: Amy Lien**	**Contributed: Navin Sridhar** **Applications of hyper-accreting X-ray sources to fast radio bursts and stellar merger transient events**
4:30 PM	**Contributed: Caitlin Witt Multi-Messenger Coordination on the Supermassive Scale**	**Contributed: Eric Burns** **How to Make Speed-of-Light Jets**	Merger-Driven Transients-WD (WD-WD, WD-NS, WD-BH) Chairs: Gijs Nelemans, Breivik
4:45 PM	**Contributed: Scott Noble Time and Wavelength Domain Predictions for Accreting Binary Black Holes**	**Contributed: Taya Govreen-Segal** **Prospects for Resolving the Hubble Tension with a Small Number of Binary Neutron Star Mergers with**	**Invited: Kyle Kremer**
5:00 PM	**Contributed: Daniel Stern Extreme Quasar Variability**	**Contributed: James Rhoads** **Looking for orphans (and their cousins) in wide fields.**	**Contributed: Yossef Zenati Transients from ONe white dwarf - neutron star/black hole mergers**

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	Tuesday		
	Small group meetings, self organized		
9:45 AM	Break		
	Jetted Transients-SMBH II (Tidal Disruption Events) Chairs: Gezari, Franckowiak Room A	Merger-Driven Transients-NS/BH (NS-NS, NS-BH, BH-BH) Chairs: Kasliwal, Nissanke Room B/C	Explosive Transients- Other (FRBs, FXTs) Chairs: Burke-Spolaor, Margutti Room F
10:45 AM	**Invited: Sjoert van Velzen**	**Invited: Alessandra Corsi**	**Invited: Shami Chatterjee**
11:00 AM	**Contributed: Yvette Cendes New Discoveries in Late-Time Emission from Tidal Disruption Events**	**Contributed: Samuele Ronchini Perspectives for multi-messenger astronomy with the next generation of gravitational-wave detectors and high-energy satellites**	**Contributed: W. Niel BrandtFuture Investigations of the New Extragalactic Population of Faint, Fast X-ray Transients**
11:15 AM	**Contributed: Robert Stein Identifying Transient Neutrino Sources with the Zwicky Transient Facility**	**Contributed: Eran Ofek Gravitational Waves in the UV**	**Contributed: Walid Majid Multi-wavelength characterization of FRBs**
12:00 PM	Discussion	Discussion	Discussion
12:00 PM	Lunch (On your own)		
	Merger-Driven Transients- SMBH (SMBH binaries, EMRIs) Chairs: Burke-Spolaor, Slutsky Room A	Merger-Driven Transients-Other I (common envelope systems) Chairs: Kasliwal, Metzger Room B/C	Non-Terminal Sources-NS/BH (XRBs, magnetars, pulars) Ramirez-Ruiz, Wilson-Hodge Room F
1:30 PM	**Invited: Elena Rossi**	**Invited: Kishalay De**	**Invited: Erin Kara**
2:15 PM	**Contributed: Jeremy Schnittman Supermassive Black Hole Mergers**	**Contributed: Yadira Gaibor Constraining occurrence rates of short-period post-common envelope binaries**	**Contributed: Maria Drout Stripped Star plus Compact Object Binaries: Identifying the Progenitors of Neutron Star Mergers**
2:30 PM	**Contributed: Krista Lynne Smith The Physics of Accretion Disks and Binary AGN with Very High-Cadence Band-filtered Optical/UV**	Discussion	**Contributed: Thomas Maccarone X-ray Binaries as Time Domain Sources**
3:45 PM	**End of Daily Sessions**		
4:30 PM		Editing of System Reports by Session Chairs	
	Wednesday		
9:00 AM	Infrastructure Panel		
	Short individual introductions GCN - Judy Racusin HEASARC - Alan Smale NOIRLab - Tom Matheson DSN - Joe Lazio Near Space Network (NSN) - Chris Roberts IPAC - George Helou		
	Discussion		
11:00 AM	Break		
11:15 AM	**Non-Terminal Sources Reports** **WD: Nelemans** **SMBH: Burke-Spolaor** **NSBH: Ramirez-Ruiz** **Other: Romero-Wolf**		
12:00 PM	Lunch		

Workshop Agenda

1:30 PM	**Merger-Driven Transients Reports** **SMBH: Slutsky** **NSBH: Kasliwal** **Other: Kasliwal** **WD: Breivik** **Jetted Transients Reports** **Other: Metzger** **SMBH: Franckowiak** **NSBH: Wilson-Hodge** **Explosive Transients Reports** **WD: Cenko** **NSBH: Andrews** **Other: Margutti**
3:30 PM	Next steps, report outline, writing assignments.
4:00 PM	Close Out

Each session had a scribe to take notes. The SOC presented summary reports for each source category:

Non-terminal sources (WD, NS/BH, SMBH, Other)

Merger-driven transients (WD, NS/BH, SMBH, Other)

Jetted-transients (NS/BH, SMBH, Other)

Explosive transients (WD, NS/BH, Other)

The SOC drafted the science findings in the TDAMM report based on the workshop **presentations**, scribe **notes**, and workshop summary **reports**.

Workshop Deliverable

- The final deliverable is a written report, available at:
- https://pcos.gsfc.nasa.gov/TDAMM/docs/TDAMM_Report.pdf

Summary Part 2: Programmatics

While focused on science, on the last day of the workshop an interactive session on TDAMM infrastructure was held

A panel of NASA and NSF experts addressed:

* GCN alerts
* Space Communications (DSN, NSN)
* Ground infrastructure (NOIRLab)
* Archives (HEASARC, IPAC)

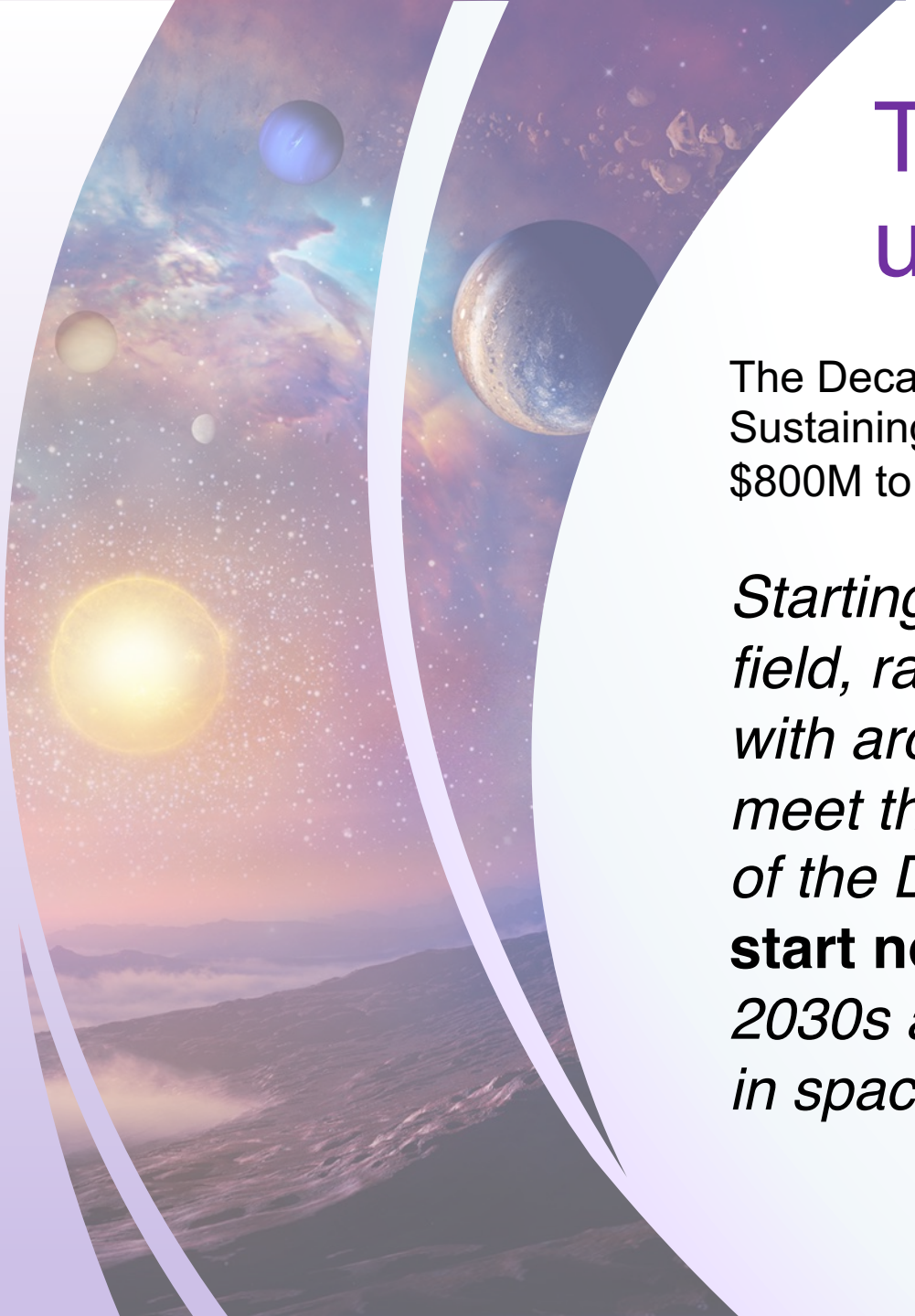
A vigorous discussion community ensued, identifying key issues

Key Issues: 1

- Real-Time Cyberinfrastructure
  - Real-time transient detections
  - Sfw to do joint data analysis
  - Archive coordination
- Theory Funding
  - Specific urgent topics (Part 1)
  - Interdisciplinary aspects w/ physics, lab Astro, cosmology
  - Precursor/preparatory science
  - High Computing simulations
- TDAMM General Observer Facility
  - To streamline transient followup with NASA facilities
  - Reduce coordination burden from observers
  - Provide scheduling options
  - Assist with proposals preparation and submission
  - Manage funding

Key Issues: 2

- NASA-NSF-international coordination
  - Optimize observing schedules
  - Archives and alerts standardization
  - Joint proposals opportunities
- Continuity of capabilities across the EM spectrum
  - Timely replace aging telescopes
- Training a diverse workforce
  - Capitalize on the TDAMM science to inspire STEM
  - Build on core value of Inclusion from the start
  - Ensure diversity of PIs
- Crediting hidden figures
  - Data scientists, sw/Hw developers, managers
  - Ensure appropriate rewards and recognition are in place



TDAMM investments are urgent

The Decadal recommended TDAMM as the top priority of the Sustaining Program, ahead of the Probes, with an augmentation of $800M to the Explorers' line

*Starting investments in the next generation of wide-field, rapid response **X-ray and gamma-ray missions** with arcmin scale position is imperative if we want to meet the challenges of this rapidly expanding field and of the Decadal's objectives. This effort should* **start now**, *in order to launch these missions by the 2030s and overlap with the many observatories, in space and on the ground, becoming available then.*

Final Remarks

The New Messengers and New Physics theme embodies the dual revolutions brought about by the marriage of observations of light with those from gravitational waves and elementary particles (multi-messenger astrophysics) along with the expansion of measurements of the sky over time (time-domain).

- Realizing the promise of the “dual revolution” requires significant and sustained investment in science, facilities, and infrastructure by NASA and the funding Agencies
- This investment must start **NOW** to leverage existing and planned capabilities of the 2030s both in space and on the ground

Acknowledgements:
NASA is grateful to the many participants of the workshop who significantly contributed to its success, and who reviewed the first draft of the summary report improving its content.