Advancing the Landscape of Multimessenger Science

Tiffany R. Lewis

NASA Postdoctoral Fellow at Goddard Space Flight Center

Co-Editors: Kristi Engel, Tonia Venters, Marco Muzio

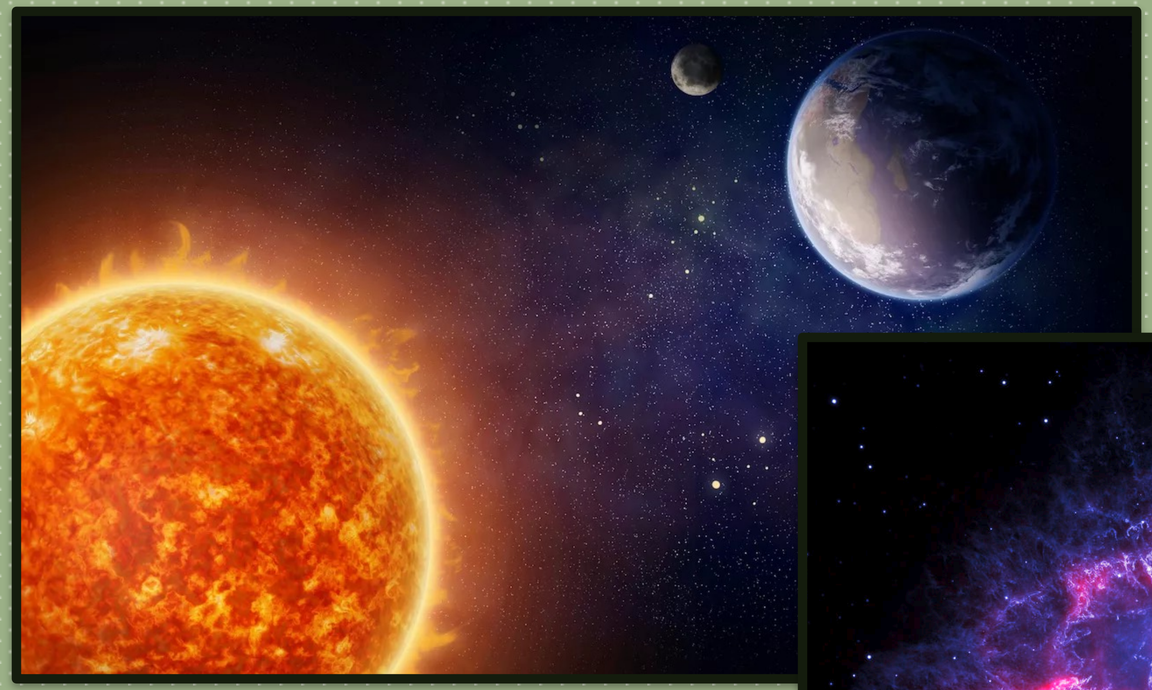
Snowmass Community Summer Study - HE & UHE Neutrinos

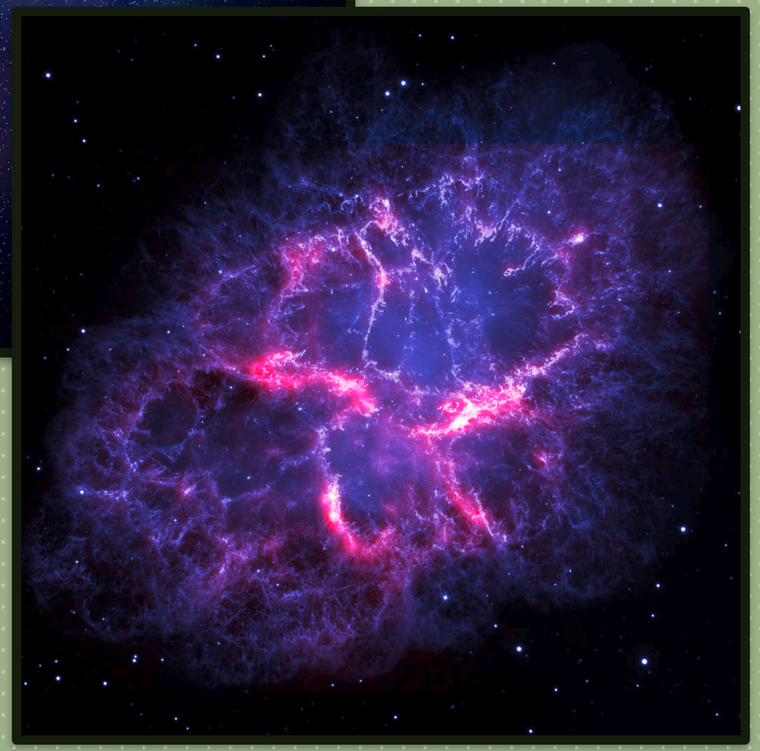
24 July 2022

tiffanylewisphd@gmail.com

Dawn of the Multimessenger Era

Combined measurements are more constraining than an abundance of measurements from an individual messenger.

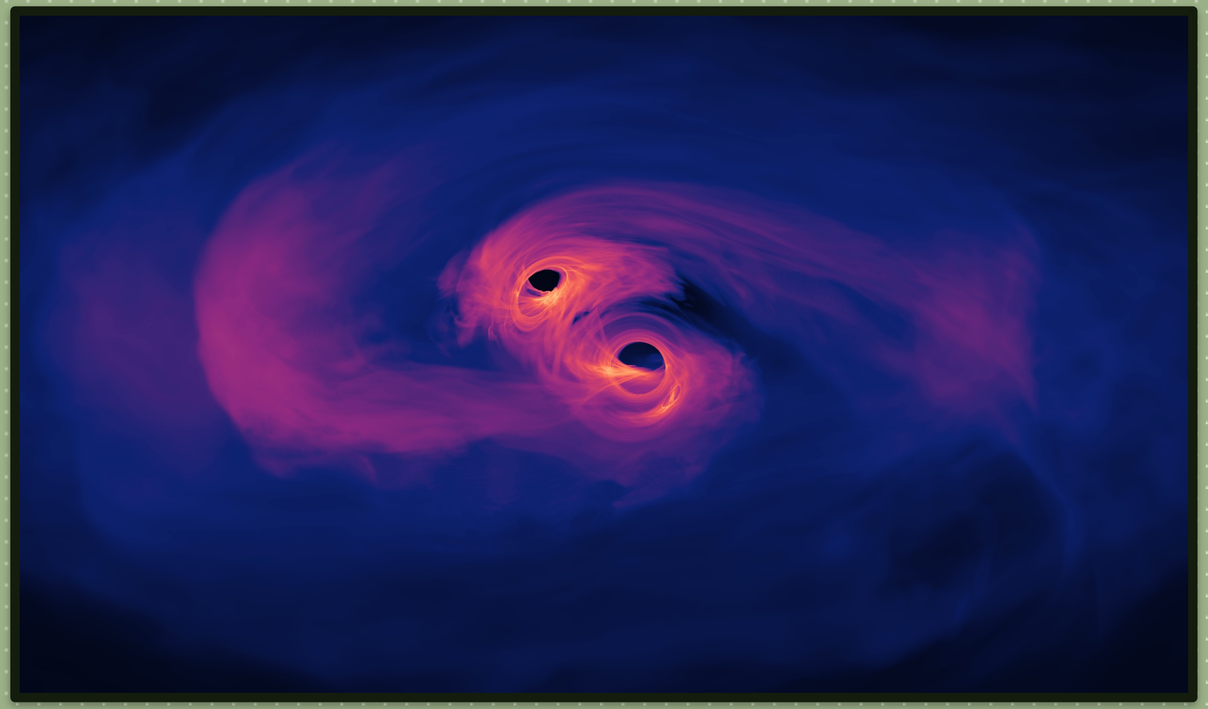




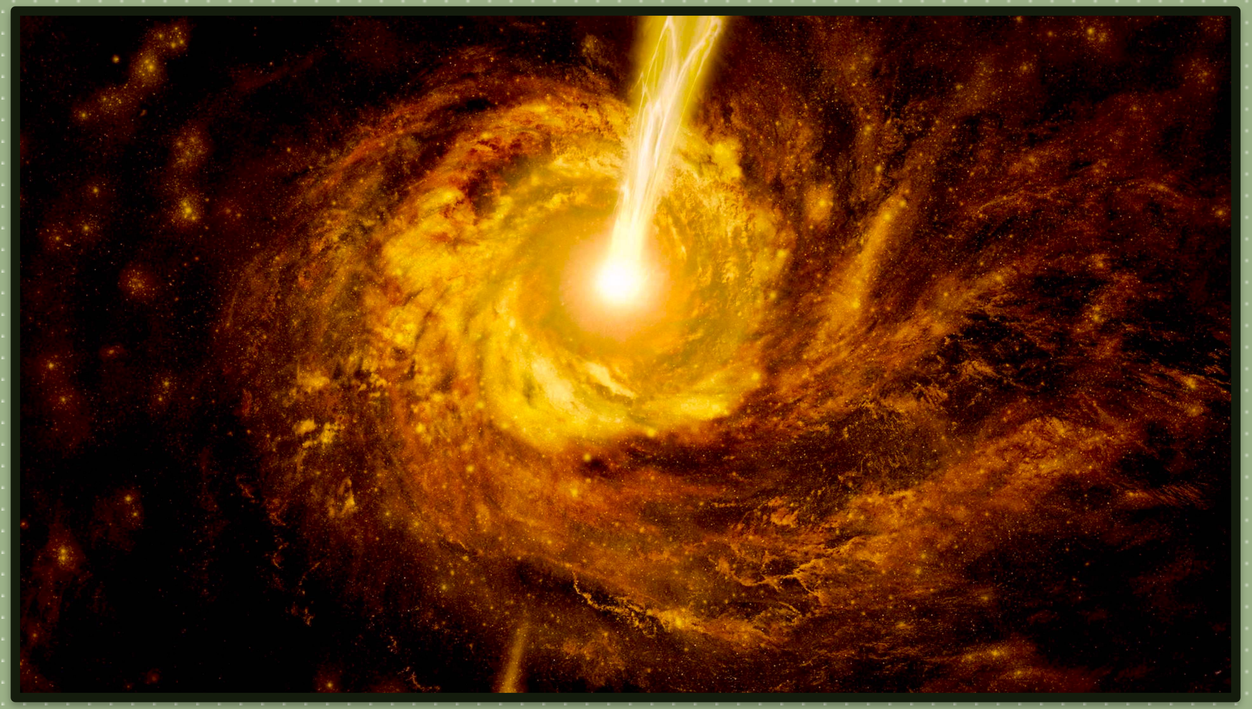
- The Davis Experiment observed the Sun in neutrinos and discovered neutrino oscillations.
- Neutrinos and photons from SN 1987A confirmed the paradigm of core-collapse supernovae and placed upper limits on neutrino mass.

Image Credit: Getty Images, ESA/Herschel/PACS/MESS Key Programme Supernova Remnant Team; NASA, ESA and Allison Loll/Jeff Hester (Arizona State University)

Current Multimessenger Landscape



GW 170817



TXS 0506+056

Image Credit: NASA/GSFC

High-Energy & Particle Astrophysics

Multimessenger Sources:

- Neutron Star Mergers
- Supernovae
- Magnetars
- Black Holes
- Active Galactic Nuclei
- Blazars
- Diffuse Backgrounds

In order to differentiate BSM physics, we must first understand in detail how each source works in the same way an experimentalist must understand their experimental systematics to accurately express their results.

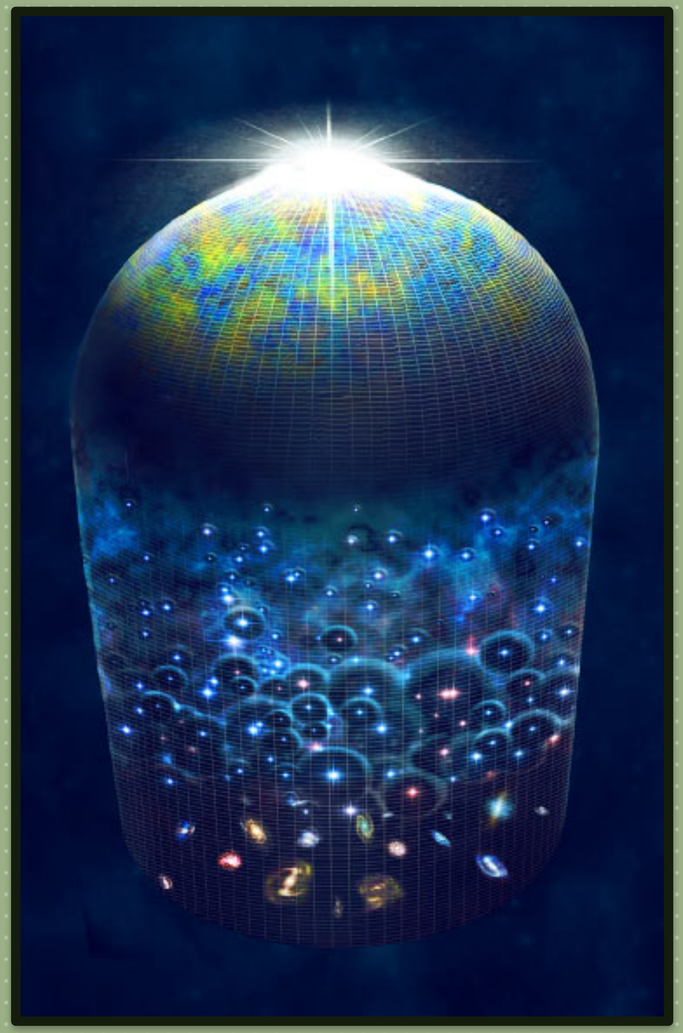


Image Credit: M. Weiss / Harvard-Smithsonian Center for Astrophysics.

Tests of Fundamental Physics

- Hubble Tension
  - Photons & Gravitational Waves
- Primordial Black Holes
  - Photons, Neutrinos & Gravitational Waves
- Dark Matter
  - Photons, Neutrinos & Cosmic Rays
- Lorentz Invariance Violation
  - Photons & Gravitational Waves

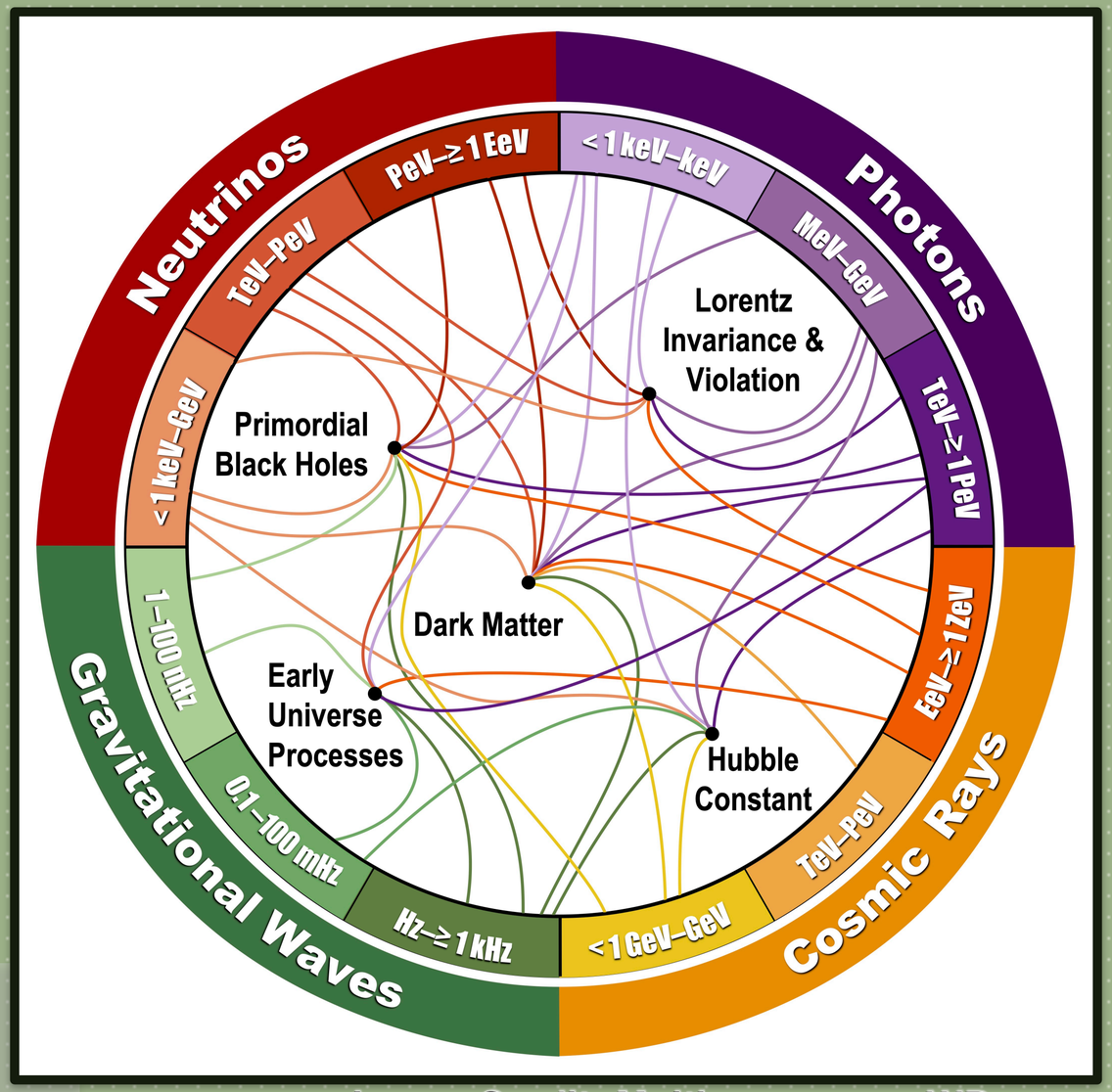
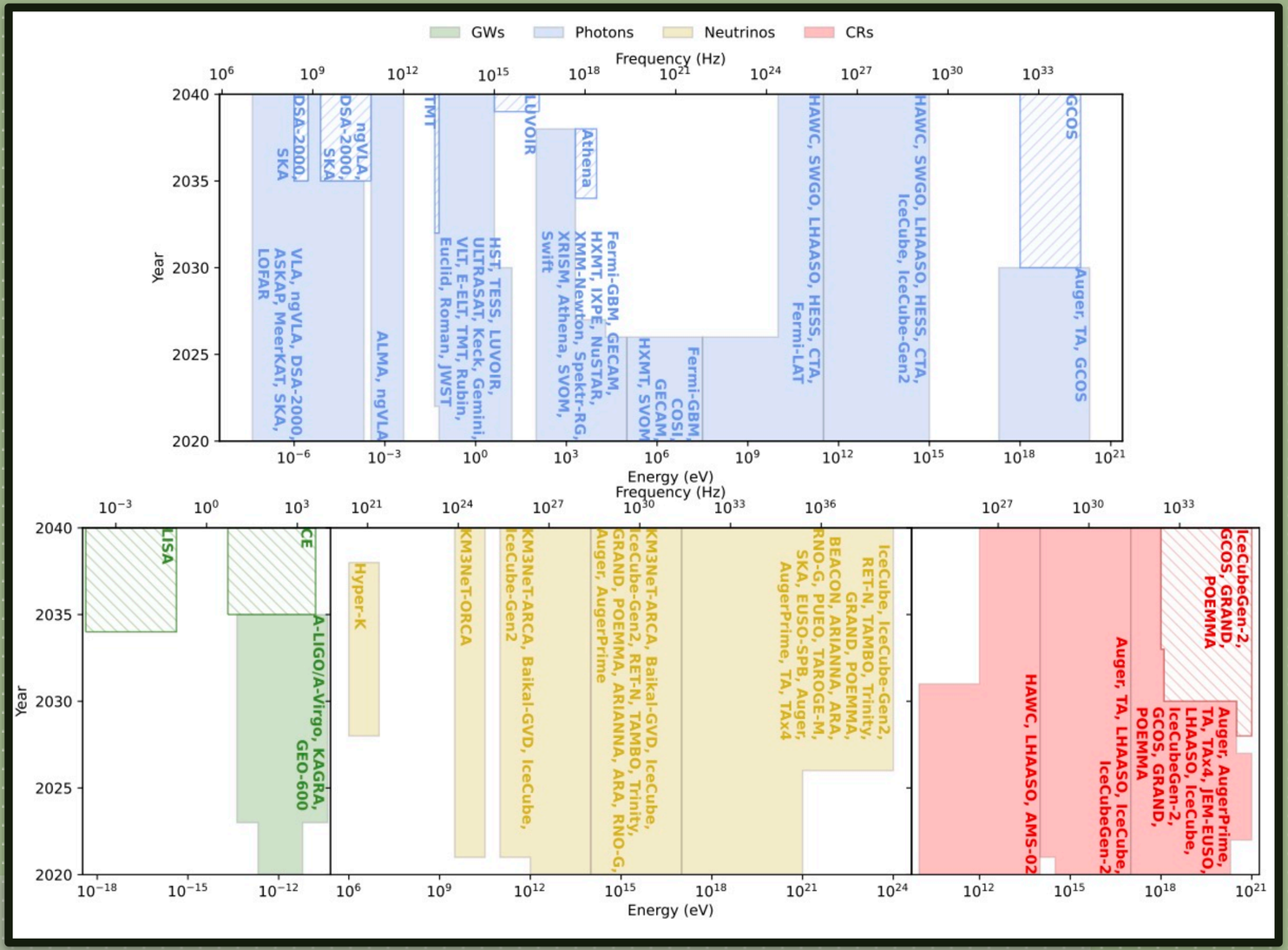


Image Credit: Multimessenger WP

Programatic Balance



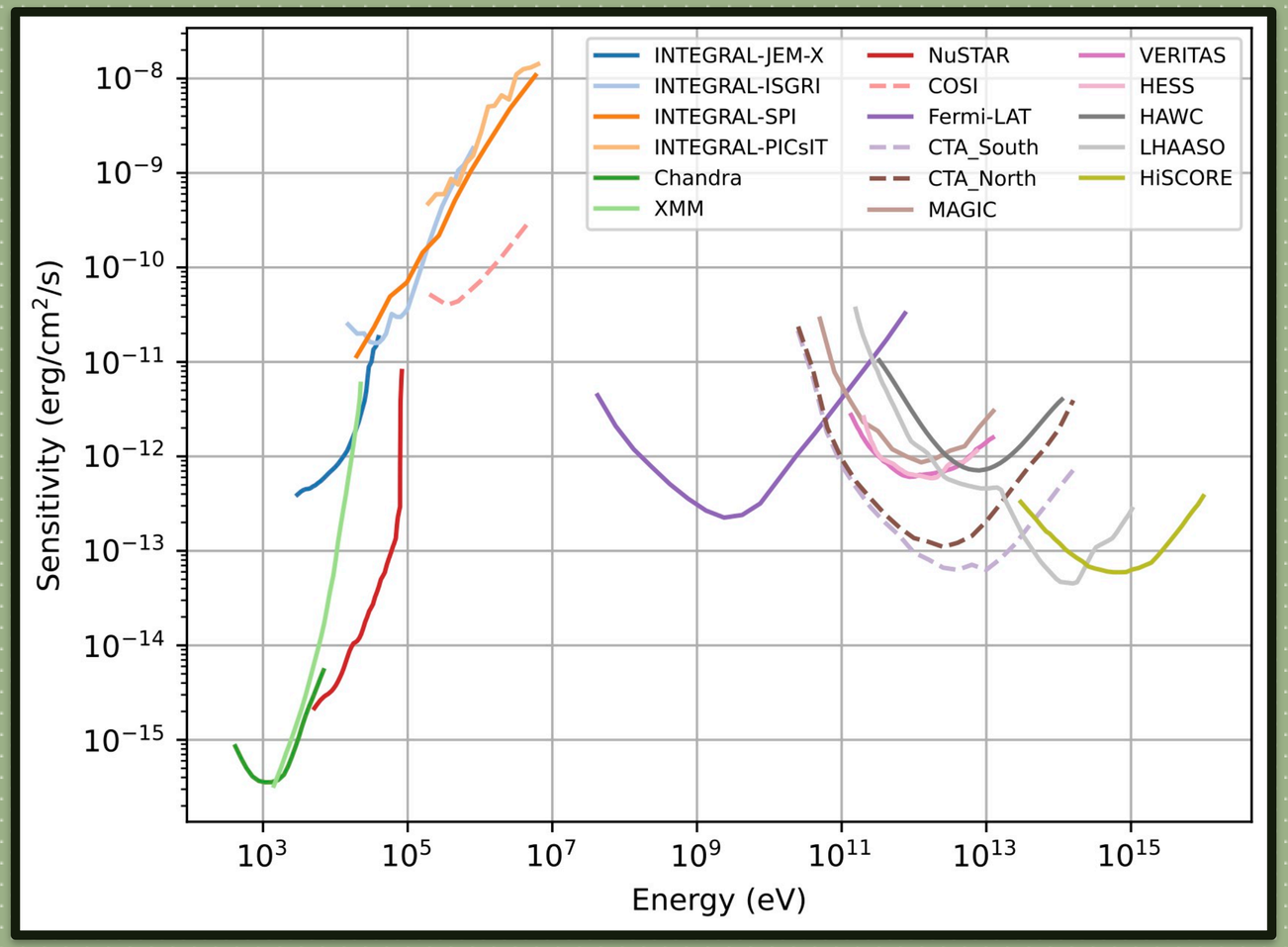
Spectral Timeline for current and planned facilities across all energies and messengers.

Most energies are set to either maintain or increase their coverage over the next 2 decades

- with the notable exception of MeV-GeV gamma-rays, which are historically central to multimessenger discoveries.

Image Credit: Multimessenger WP

Key Gamma Ray Investments



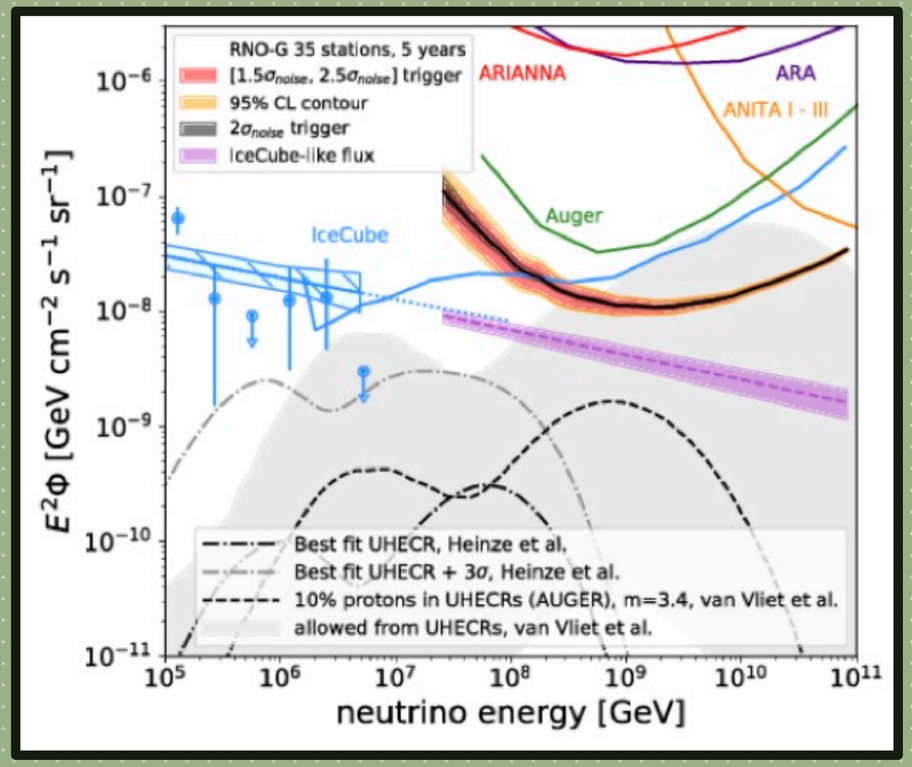
A key opportunity in the next decade is in MeV gamma ray detector development

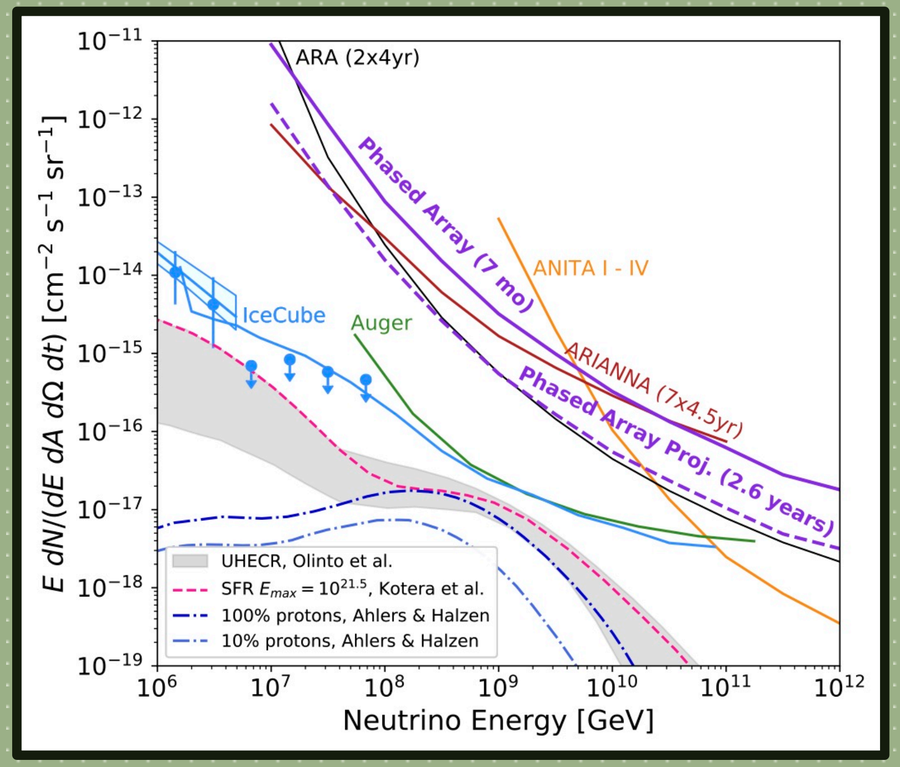
- Unprobed astrophysics - DM, diffuse, AGN, pulsars, etc
- Key space for Multimessenger
- Relevant to collider detector development

Also important to establish/maintain support for GeV and UHE gamma ray survey facilities.

Image Credit: Henrike Fleischhack

Neutrino & Cosmic Ray Facilities





Sensitivity plots for a range of cosmic ray and neutrino experiments

Image Credit: Multimessenger WP

Collaborative Infrastructure

- Collaborative partnerships
- Open access to data with previews and search-ability
- Accessibility of standardized and documented pipelines for data reduction, and modeling
- Automated transient alert networks
- Archiving for raw and processed data products and analysis codes
- Cultural shift to standardized software citations

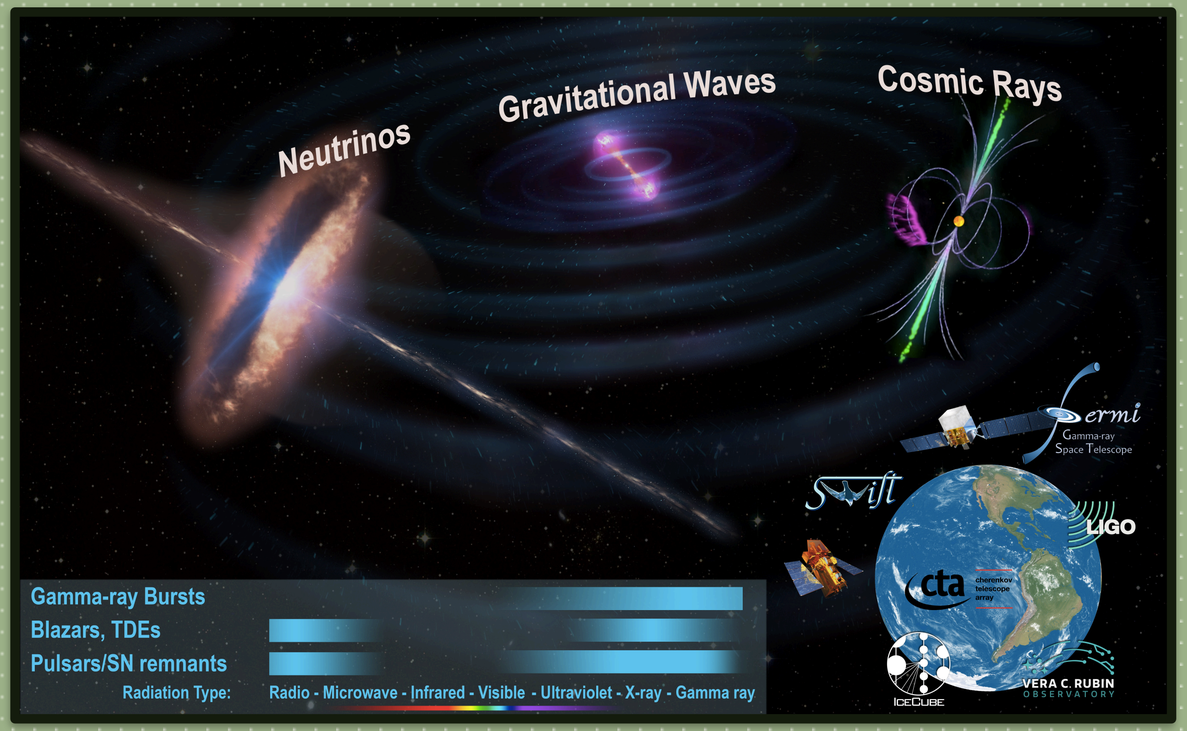


Image Credit: Multimessenger WP

Engagement & Inclusion

DEIA support - providing educational and career development opportunities

Examining our decisions about admissions, hiring, teaching and mentoring to support excellence through individual achievement of full potential.

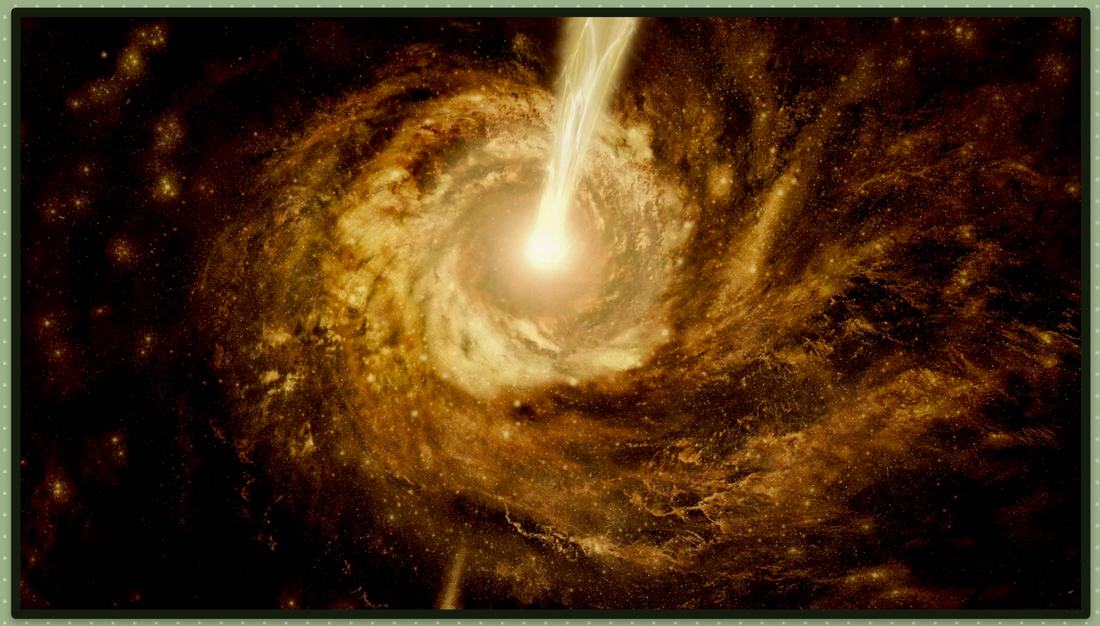
Track demographic information

Consider DEIA service in science positions

Engagement with the general public is a key pillar of support for science in general and funding for astrophysics in particular.

Astronomy that is invisible and physics that is inaccessible poses specific challenges to communication with the public - we have to do it anyway, and a lot.

Set aside expert time and funding to produce accessible explanations of key topics and distribute them broadly.



Thanks!