Roadmap to Complementarity

Key Investments in the High-Energy Space Infrastructure Environment for 2040

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Some Core Conclusions

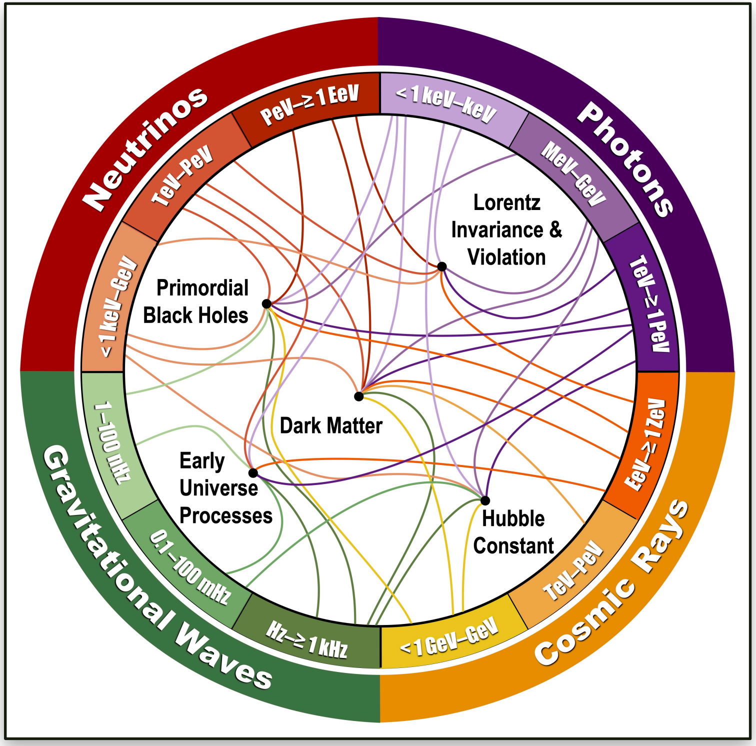
NASA, NSF and DOE have made historic investments in individual messengers, especially detector experiments for gamma-rays, cosmic rays, neutrinos, and gravitational waves.

In order to make the best use of those existing resources, it is necessary to coordinate between them and other complementary experiments and missions.

In selecting new missions, experiments and allocating funding to support projects, some attention should be paid to complementarity among the program elements and the existing and projected research environment in each era.

Key Science Areas for Future High-Energy Multimessenger Work

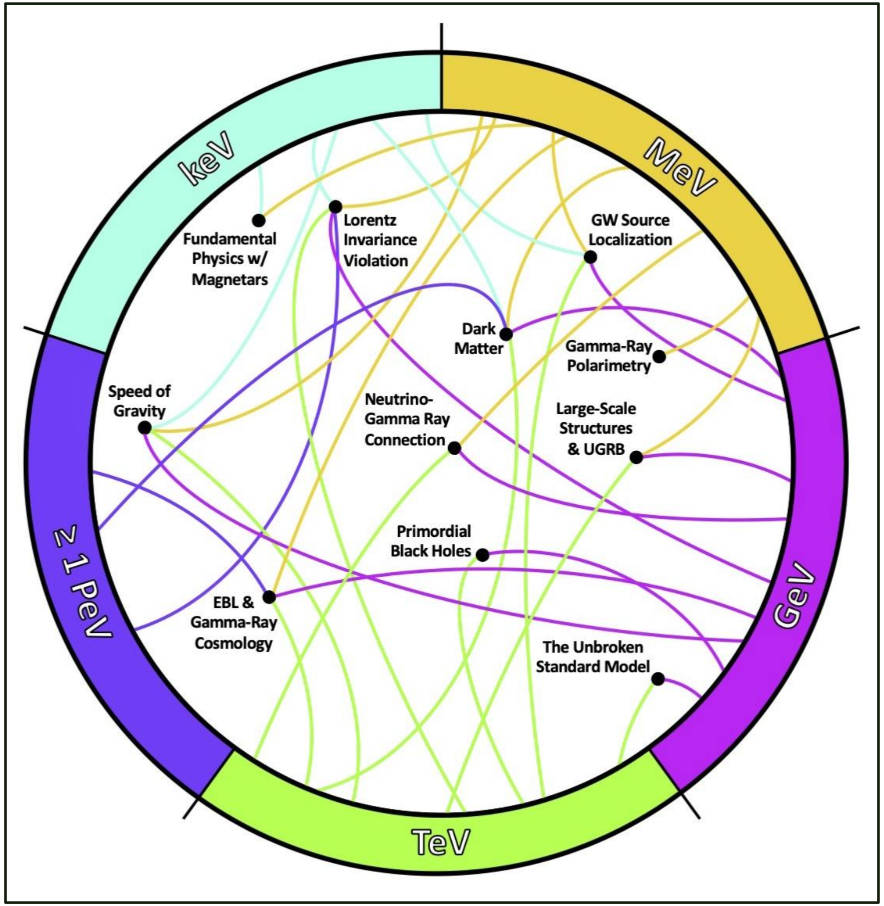
- Extreme gravity environments
- Neutron Star Equation of State
- Nuclear and Atomic Astrophysics
- Jet formation
- Neutrino origination
- Cosmic Ray origination
- Particle acceleration
- Plasma Physics
- Dark Matter
- Hubble Tension



Credit: Tiffany Lewis; Multimessenger WP

Key Gamma-Ray Science

- Gamma rays provide a unique view of extreme environments
  - Magnetars, Active Galaxies, Cosmology, etc
- Crucial to Multimessenger Studies
  - GRB 170817 GeV with GW
  - TXS 0506+056 GeV with neutrinos
- To probe fundamental physics beyond earth, we have to understand the Universe’s laboratories through Astrophysics.



Credit: Kristi Engel; Gamma Ray WP

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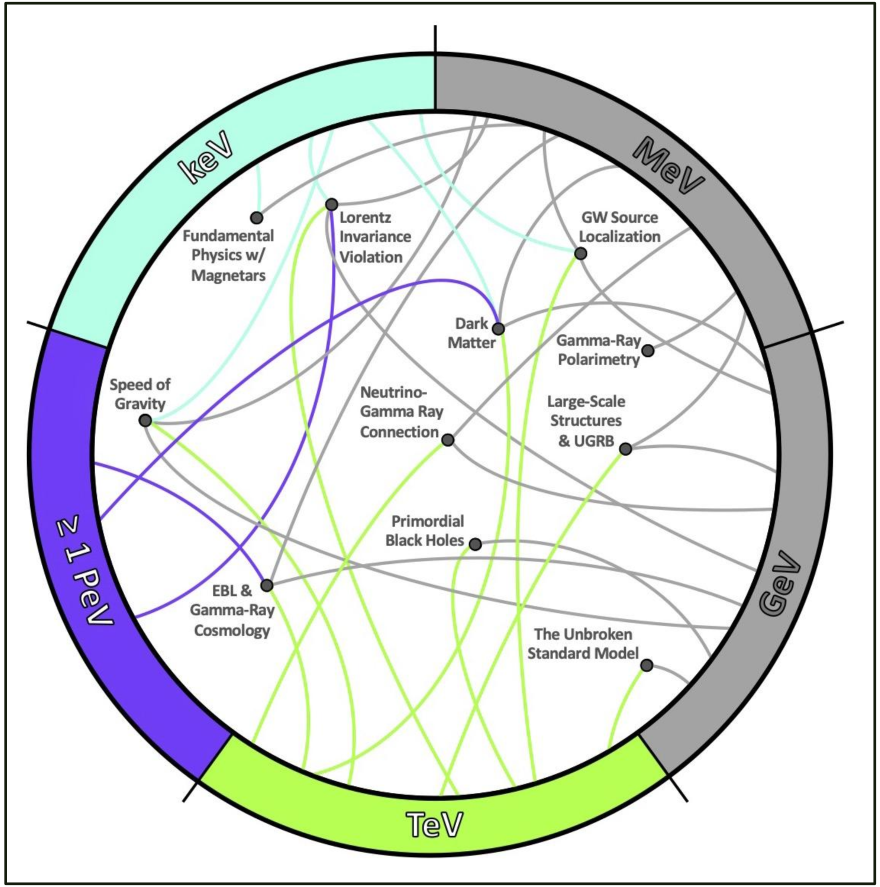


Credit: Kristi Engel; Gamma Ray WP

Categories of Technology Gaps

- Future of Space Comms (see TDAMM Comm SAG)
- Theoretical Models for key science questions
- Computational Models for key science questions
- Optics
- Detectors
- Detector Simulations & event reconstruction
- Readout electronics

Resource Gaps

- Coordination
- Theory
- Computation
- Software Support
- DEIA
- Outreach

Key Investments following aging Excellence

- TDRSS is being phased out - opportunity for purpose-built space communications array with specifications for higher data rates and lower latency alerts.
- CGRO was a Great Observatory and the first major gamma-ray mission. We've learned and grown as a field more than we could have imagined since those first gamma-rays, through Fermi and Swift, but these are now aging too. As the next generation of Great Observatories takes shape, there is a need for a next-gen Gamma-ray Great Observatory
- Multi-mission Coordination Support - It is currently difficult to take advantage of the full fleet of NASA missions even though they often have complementary capabilities. As we build complementarity into the future fleet of ground and space-based observation facilities, we also want scientists to be able to take advantage of those complementarities.

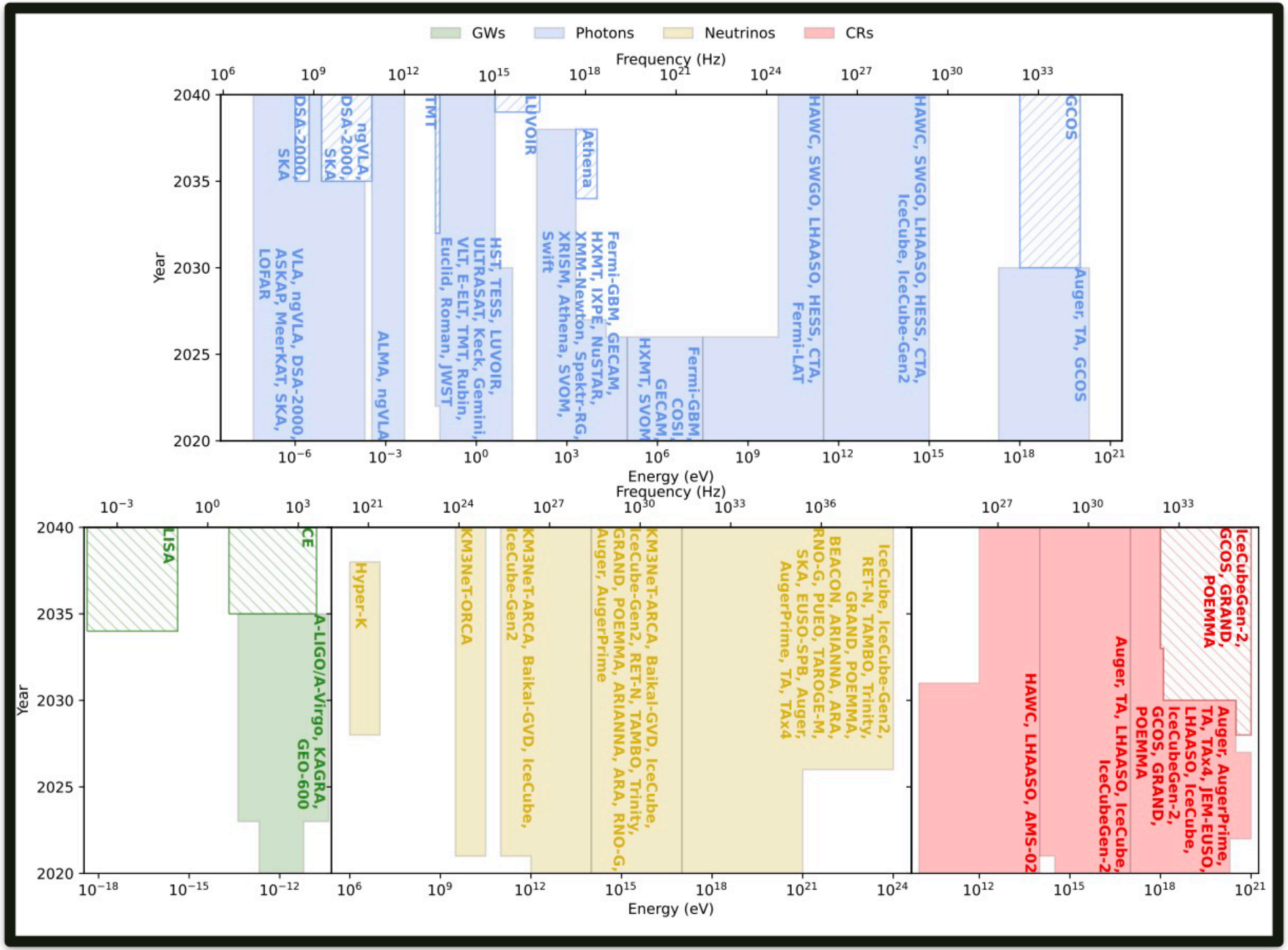
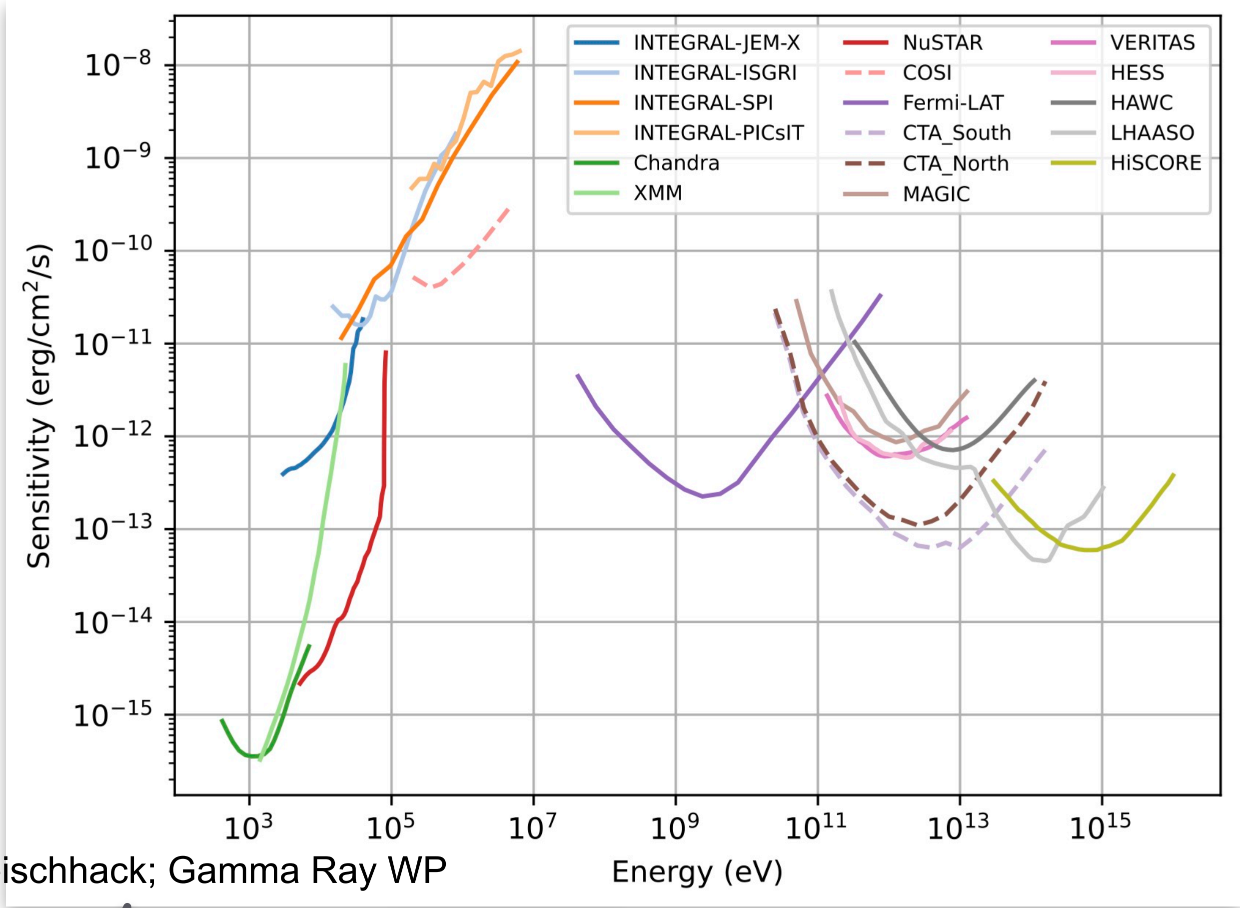
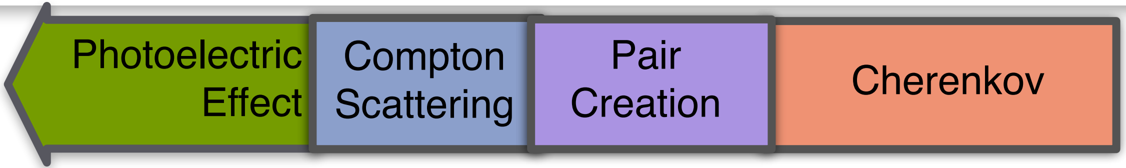


Image Credit: “Advancing the Landscape of Multimessenger Science in the Next Decade”arXiv:2203.10074; submitting to JHEAp



Credit: Henrike Fleischhack; Gamma Ray WP



The 2040 Goal (or maybe 2050)

A balanced comprehensive multimessenger program:

- Missions/experiments covering all accessible energies and messengers - GWs, neutrinos, CRs, and photons)
- Ability to coordinate observations within (speed of computation & light) seconds between photons and other messengers
- Infrastructure allowing observations and data analysis coordination without wasting resources on massively duplicated observing

In order to discover and characterize extreme astrophysical environments.

The 2035 or 2040 checkpoint

Missions and experiments should be under construction, specifically the gamma-ray observatory

Solutions to near Earth and deep space communications that facilitate fast alerts and high data volume transfers should be implemented.

Observers and theorists are already using several advanced tools for planning observations, analyze and interpret data from all messengers

Building the technology environment for future success - 2030

Space communications program (satellite to satellite and space to ground)

Technology development funded -

Results of GOF being implemented

More efficient Human communication infrastructure

Data management plans in place, physical infrastructure for data management in place for existing missions and experiments - something generalizable

New GCN is already well underway

HEASARC is looking at improvements.

Messaging and Asks for 2025

Messaging: the 2040 goal and possible science in that environment

Asks for 2025 fiscal year: ‘the policy changes we need in order to get there’

‘The funds needed to accomplish the 2030 goals’

References

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Decadal Inputs…. Any directly relevant?