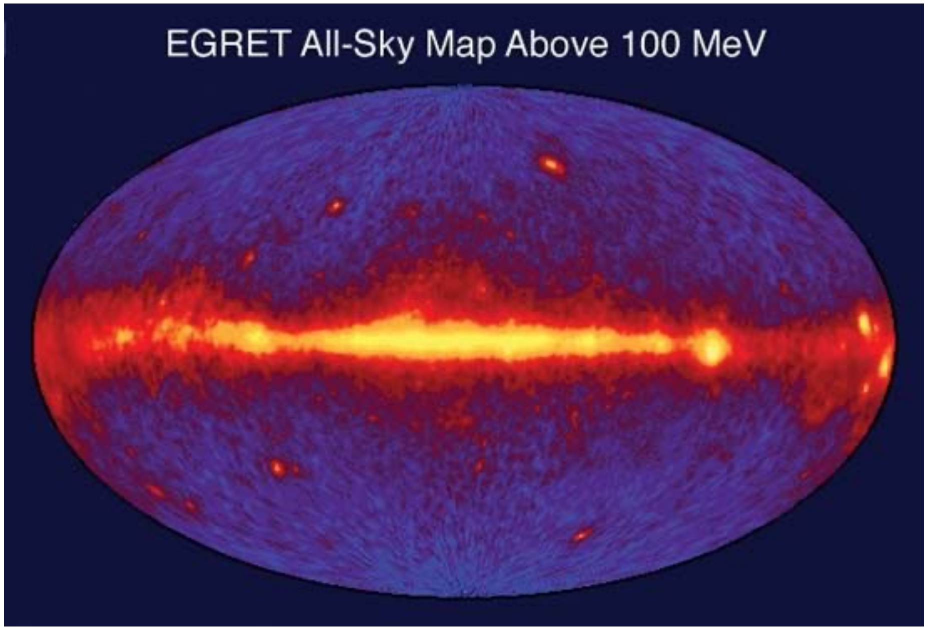
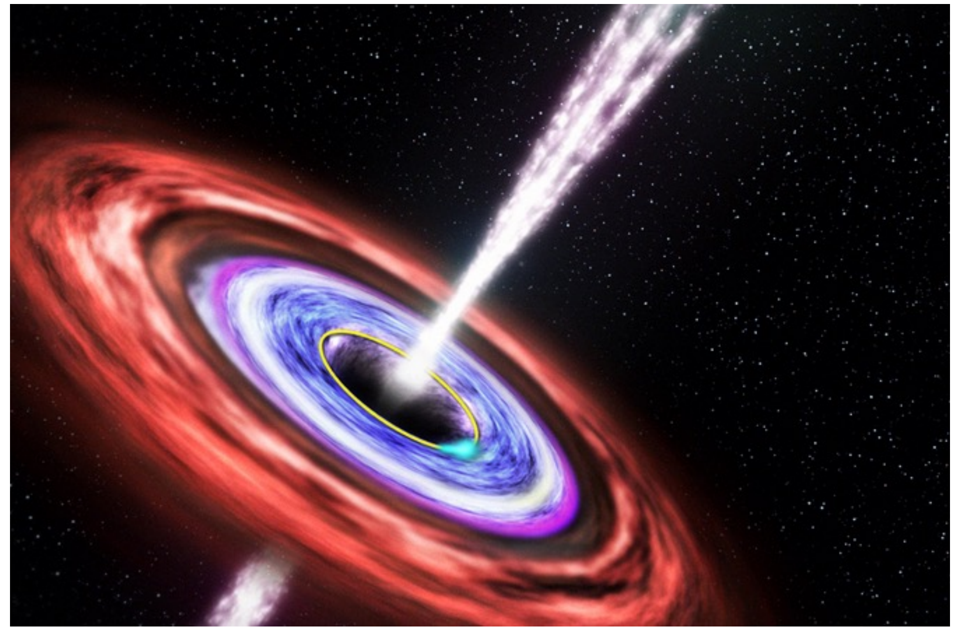
Gamma-ray Science Interest Group
Technology Gaps





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Technology Gaps Webinar

- Technology Gaps Webinar May 14 **- video and slides now available**

- **Technology Gap Process:**
- **10 year cycle: Decadal Review sets science priorities**
- **2 year cycle:**
  - astronomy community identifies gaps, submits to program (due June 3)
  - Gaps reviewed by NASA technologists, sent to PAG ECs
  - tech management board reviews/prioritizes gaps
  - Gaps released to public (Sept. 30)
- **1 year cycle:**
  - Strategic Astrophysics Technology (SAT) calls. Goal of SAT to mature tech. to point where it can be included in flight missions (TRL 6).

Technology Gaps by Tier

- Technology Gaps by Tier
- **Tier 1 (highest priority) through Tier 5 (lowest priority)**
- **Tier 1-4 gaps**
  - Strategic
  - do not need to be resubmitted
  - inform SAT calls
- **Tier 5 gaps**
  - not strategic.
  - They don’t inform SAT calls
  - will not be retained–will need to be resubmitted each cycle
  - Tier 5 gaps seem to be “back-up” in case NASA priorities change.

Technology Gaps by Tier

Tier 1 Technology Gaps

- Advanced Cryocoolers
- Coronagraph Contrast and Efficiency
- Coronagraph Stability
- Cryogenic Readouts for Large-Format Far-IR Detectors
- Heterodyne Far-IR Detector Systems
- High-Performance, Sub-Kelvin Coolers
- High-Reflectivity Broadband Far-UV-to-Near-IR Mirror Coatings
- High-Resolution, Large-Area, Lightweight X-ray Optics
- High-Throughput Bandpass Selection for UV/VIS
- High-Throughput, Large-Format Object Selection Technologies for Multi-Object and Integral Field Spectroscopy
- Large Cryogenic Optics for the Mid IR to Far IR
- Large-Format, High-Resolution Focal Plane Arrays
- Large-Format, Low-Darkrate, High-Efficiency, Photon-Counting, Solar-blind, Far- and Near-UV Detectors
- Large-Format, Low-Noise and Ultralow-Noise Far-IR Direct Detectors
- Long-Wavelength-Blocking Filters for X-ray Micro-Calorimeters
- Low-Stress, High-Stability, X-ray Reflective Coatings
- Mirror Technologies for High Angular Resolution (UV/Vis/Near IR)
- Stellar Reflex Motion Sensitivity – Astrometry
- Stellar Reflex Motion Sensitivity – Extreme Precision Radial Velocity
- Vis/Near-IR Detection Sensitivity

Tier 4 Technology Gaps

- Advanced Millimeter-Wave Focal-Plane Arrays for CMB Polarimetry
- Improving the Photometric and Spectro-Photometric Precision of Time-Domain and Time-Series Measurements
- UV/Opt/Near-IR Tunable Narrow-Band Imaging Capability
- Very-Wide-Field Focusing Instrument for Time-Domain X-ray Astronomy

Tier 5 Technology Gaps

- Complex Ultra-Stable Structures for Future Gravitational-Wave Missions
- Disturbance Reduction for Gravitational-Wave Missions
- Gravitational Reference Sensor
- High-Performance Spectral Dispersion Component/Device
- High-Power, High-Stability Laser for Gravitational-Wave Missions
- Laser Phase Measurement Chain for a Decihertz Gravitational-Wave Mission
- Micro-Newton Thrusters for Gravitational Wave-Missions
- Stable Telescopes for Gravitational Wave-Missions

Submitting Technology Gaps

- Current Tech Gaps
- Technology Gaps form – due June 3
- Tech Gaps: TRL <= 5. SAT funds 3 <= TRL <=5.
- State where in Astro2020 gap is mentioned

Astrophysics Strategic Technology Gap Input Form	
Technology Capability Gap Name:	Date Submitted:
Submitter Name:	Organization:
Telephone:	Email Address:
Prioritization Information (see accompanying instructions)	
Identify Strategic Missions Enhanced or Enabled by Closing this Technology Gap: ☐ **HWO** ☐ **Far-IR Flagship** ☐ **X-ray Flagship** ☐ **CMB Probe** ☐ **Far-IR Probe** ☐ **X-ray Probe** ☐ **Other (write in below the mission name and reference where it is mentioned in Astro2020):**	
Brief Description of the Technology Capability Needed (100 – 150 words):	

Submitting Technology Gaps

- No need to resubmit gaps already included if Tier 1-4 *unless* you want to suggest a change.
- Submit gaps between current state-of-the-art and what is needed to achieve science/mission objective
- Don’t endorse or advertise any organization, mission, or person
- Don’t include proprietary or ITAR sensitive information

Strategic Activities

- **Gaps related to future *strategic* missions – Great Observatories, X-ray/IR Probes**

- **Gaps related to "Strategic, non-mission activities"**
- **includes TDAMM.**
  - Astro2020, pages S-3, S-8, 1-17, 7-18, 7-19, J-17
  - "In space, the highest-priority sustaining activity is a space-based time-domain and multi-messenger program of small and medium scale missions"
- **Includes gamma-rays, cosmic rays, etc.**
  - Gamma-rays: Astro2020 page B-18, C-8, J-2, J-17, J-20, L-2, L-5 thru L-20
- **Strategic non-mission activities will be ranked lower tier (lower priority) but *will not* be ranked Tier 5**

Questions/Comments?

Example: Radiation-hardened Silicon Photomultipliers (Manel)

Gap Name:

Radiation hardened silicon photomultipliers

Description:

Technologies that will enable the use of silicon photomultipliers in future astrophysics missions without seeing a significant performance degradation due to on-orbit radiation damage. Solutions could consist on the development of radiation-hard devices, shielding, or in-situ annealing, among others.

Current State-of-the-Art:

Current short-duration missions such as BurstCube, Glowbug, EIRSAT-1, or GAGG use or plan to use silicon photomultipliers for light readout of scintillator crystals. The NRL-led SIRI-1 mission reported a dark current increase from ~10 to 529 muA after one year of operation in sun-synchronous orbit. This increase in dark current is attributed to radiation damage, and would degrade the instrument signal-to-noise ratio and raise the power consumption in timescales shorter than the desired duration of future small and mid-scale missions.

TRL:
4

Example: Radiation-hardened Silicon Photomultipliers (Manel)

Performance Goals and Objectives:

Development of technologies that will enable the use of silicon photomultipliers in future astrophysics missions without seeing a significant performance degradation due to the radiation environment at low-earth orbit in mission-relevant timescales. This could be accomplished via the development of radiation-hard silicon photomultipliers, in-situ annealing solutions that allow for the recovery of the degraded performance, instrument designs that provide sufficient device shielding, or other solutions.

Scientific, Engineering and/or Programmatic Benefits:

Allow light readout in particle trackers and calorimeters using crystal or fiber optics scintillators with high photon collection efficiency, low mass, low power consumption, and low voltage operation.

Applications and Potential Relevant Astro. Missions:

Future gamma-ray mission concepts such as APT or AMEGO depend on the availability of silicon photomultipliers with reliable on-orbit performance.

Urgency:

TRL 6 needed prior to mission PDF for any mission that would use this. Silicon photomultipliers have the potential to enable time-domain astrophysics missions with competitive sensitivity in a mid-scale mission budget.

Example: Event Reconstruction (Jeremy)

Astrophysics Strategic Technology Gap Input Form

Technology Capability Gap Name: High Performance Computing for Event Reconstruction	Date Submitted: 5/17/2024
Submitter Name: Jeremy S. Perkins	Organization: NASA/GSFC
Telephone: 301 286 3463	Email Address: jeremy.s.perkins@nasa.gov

Prioritization Information (see accompanying instructions)

Identify Strategic Missions Enhanced or Enabled by Closing this Technology Gap:

☐ **HWO** ☐ **Far-IR Flagship** ☒ **X-ray Flagship** ☐ **CMB Probe** ☐ **Far-IR Probe** ☒ **X-ray Probe** ☒ **Other (write in below the mission name and reference where it is mentioned in Astro2020):** TDAMM, S-3, S-8, 1-17, 7-18, 7-19, J17. Gamma-rays B-18, C-8, J-2, J-17, J-20, L-2, L-5 thru L-20.

Brief Description of the Technology Capability Needed (100 – 150 words):

On-board reconstruction of particle events in detectors using high-performance computing such as GPUs, FPGAs and other highly parallel methods.

Technical Goals and Objectives (Key Performance Parameters) to Fill the Capability Gap (150-300 words):

Current missions (Fermi-LAT) and upcoming missions (COSI) use simple on board filters to discriminate photon events from particle events for event discrimination, triggering, and event classification. These are usually based on simple FPGA logic or low-power, low-performance computing

Assessment of the current TRL of full solution addressing all the above key performance parameters and requirements and references (integer between 1 and 9 per NPR 7123.1D, Appendix E): 4

Example: Event Reconstruction (Jeremy)

References justifying the above TRL (if any): The hardware exists and has been demonstrated on a lab bench at several institutions.
Scientific, Engineering and/or Programmatic Benefits (100 – 150 words): Full on-board reconstructions of both Compton and Pair events in a particle tracking detector. Allow for reconstruction of photon parameters like photon energy and direction. Remain at a low power level (baseline is the performance of current CPUs). Be able to keep up with expected events rates of tracking detectors in low earth orbit. Survive the radiation environment of a low earth orbit. Allow for on-board triggering and localization of transient events. More efficient background rejections (and thus sensitivity improvements). More efficient triggering and classification of events. Allows for mor complicated event filtering.
Applications and Potential Relevant Missions for Astrophysics Division (100-200 words): Many gamma-ray, cosmic-ray, and x-ray missions (particularly polarimeters) utilize particle tracking technology. These missions are highly relavant for the astrophysics division, particularly for TDAMM applications.
Urgency: Years to estimated launch or other schedule driver: 2028 Level of complexity (single tech, system of techs, or system of tech systems): single tech Level of difficulty (straightforward, stretch, or major stretch): straighforward