Longer Historical Context of Gamma-ray Reports:

Where we've been, where we need to go and thoughts about how to get there

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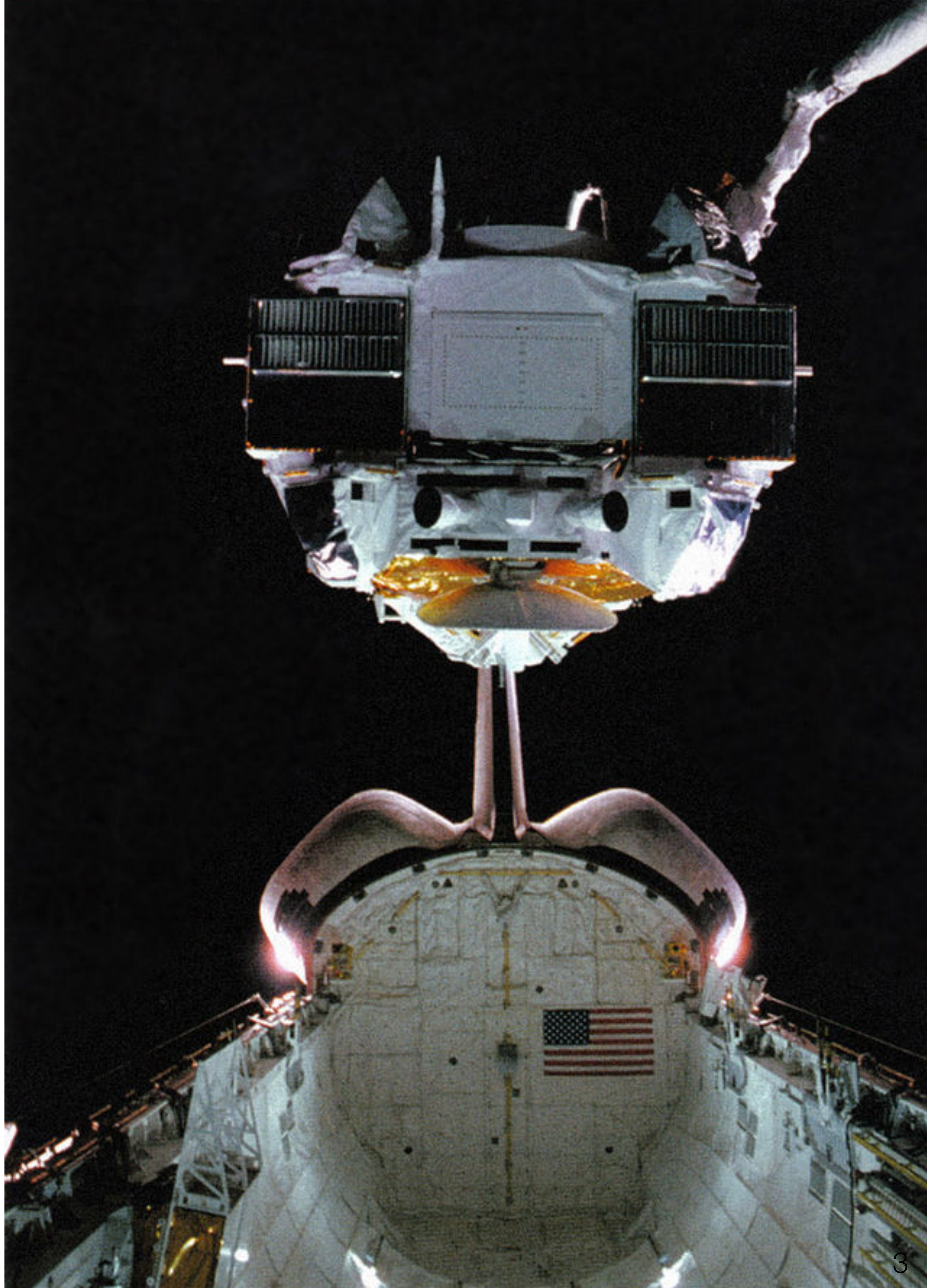
Taking from slides J. Perkins presented to GR SIG

AAS 243 GR SIG meeting
Nola
January 9, 2024

Where have we been?
Say in 1997…

Compton Gamma-ray Observatory

- One of the original **Four Great Observatories.** Launched 1991 and de-orbited in 2000
- Four Instruments:
  - The Burst Alert and Transient Source Experiment (BATSE) an all sky monitor 20 keV to 1 MeV
  - The Oriented Scintillation Spectrometer Experiment (OSSE) for the 0.05 to 10 MeV range
  - The Compton Telescope (CompTel) in the 0.8 to 30 MeV range capable of imaging 1 steradian.
  - The Energetic Gamma-Ray Experiment Telescope (EGRET) in the 30 MeV to 10 GeV range.



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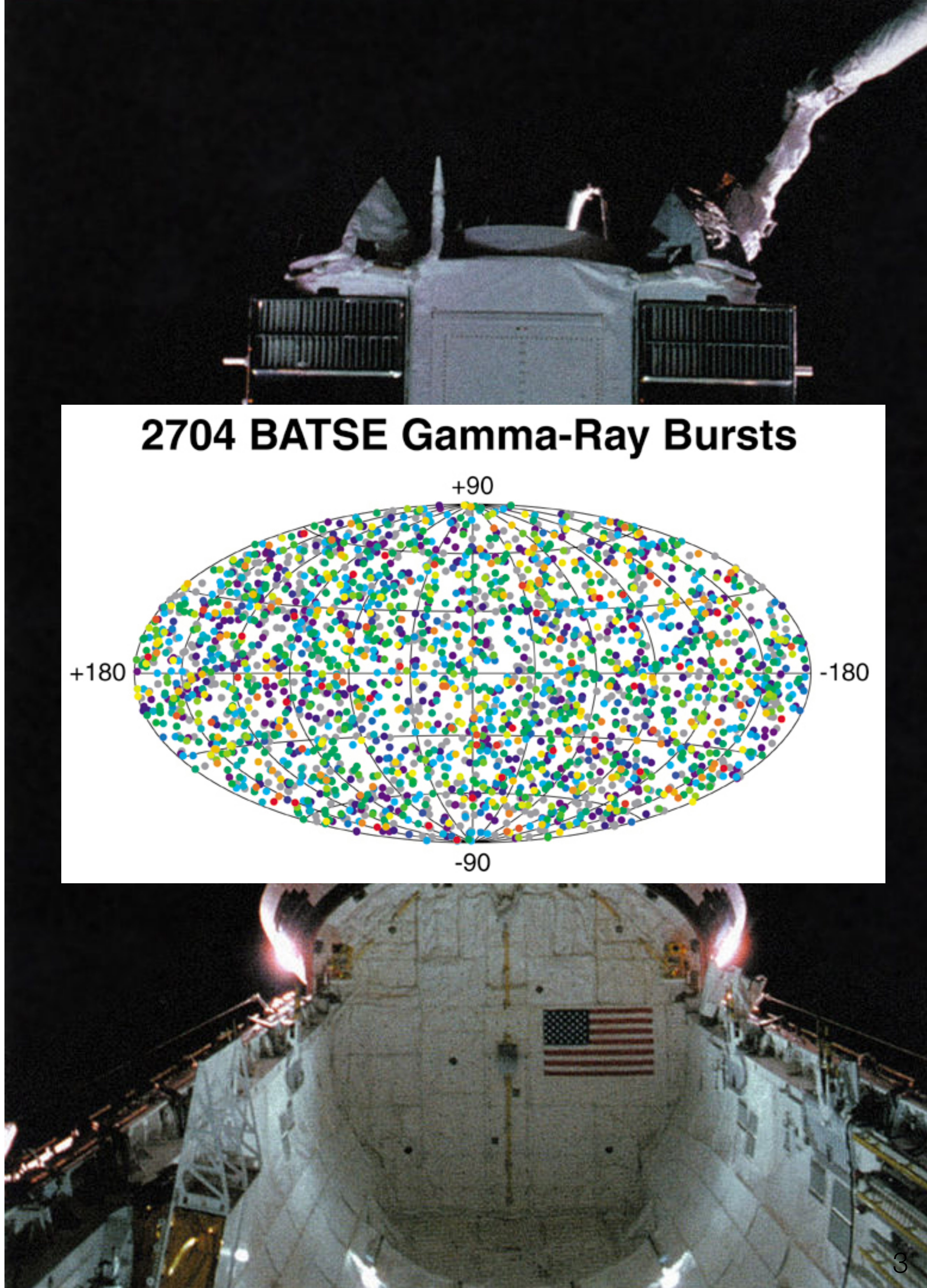

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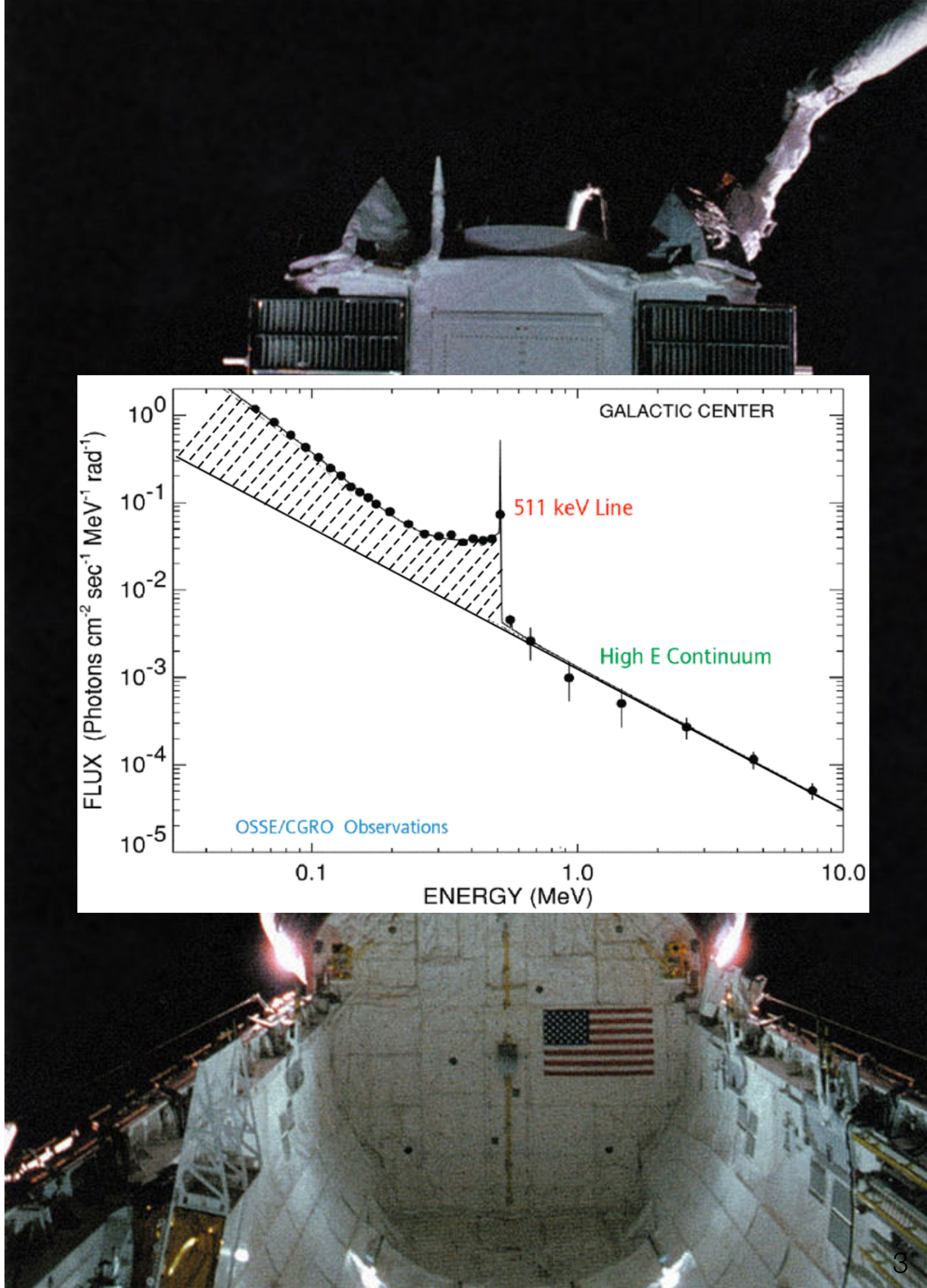

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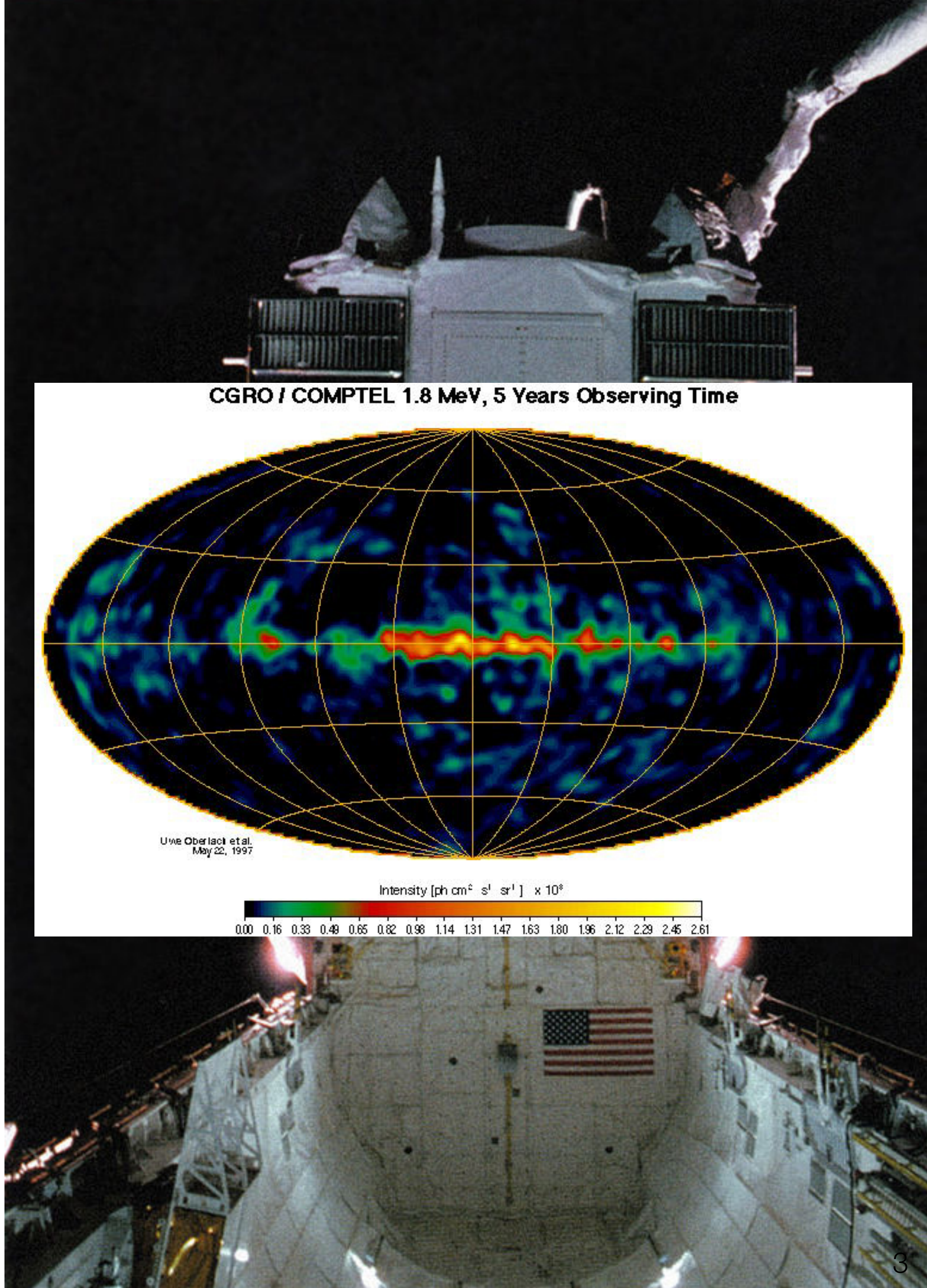

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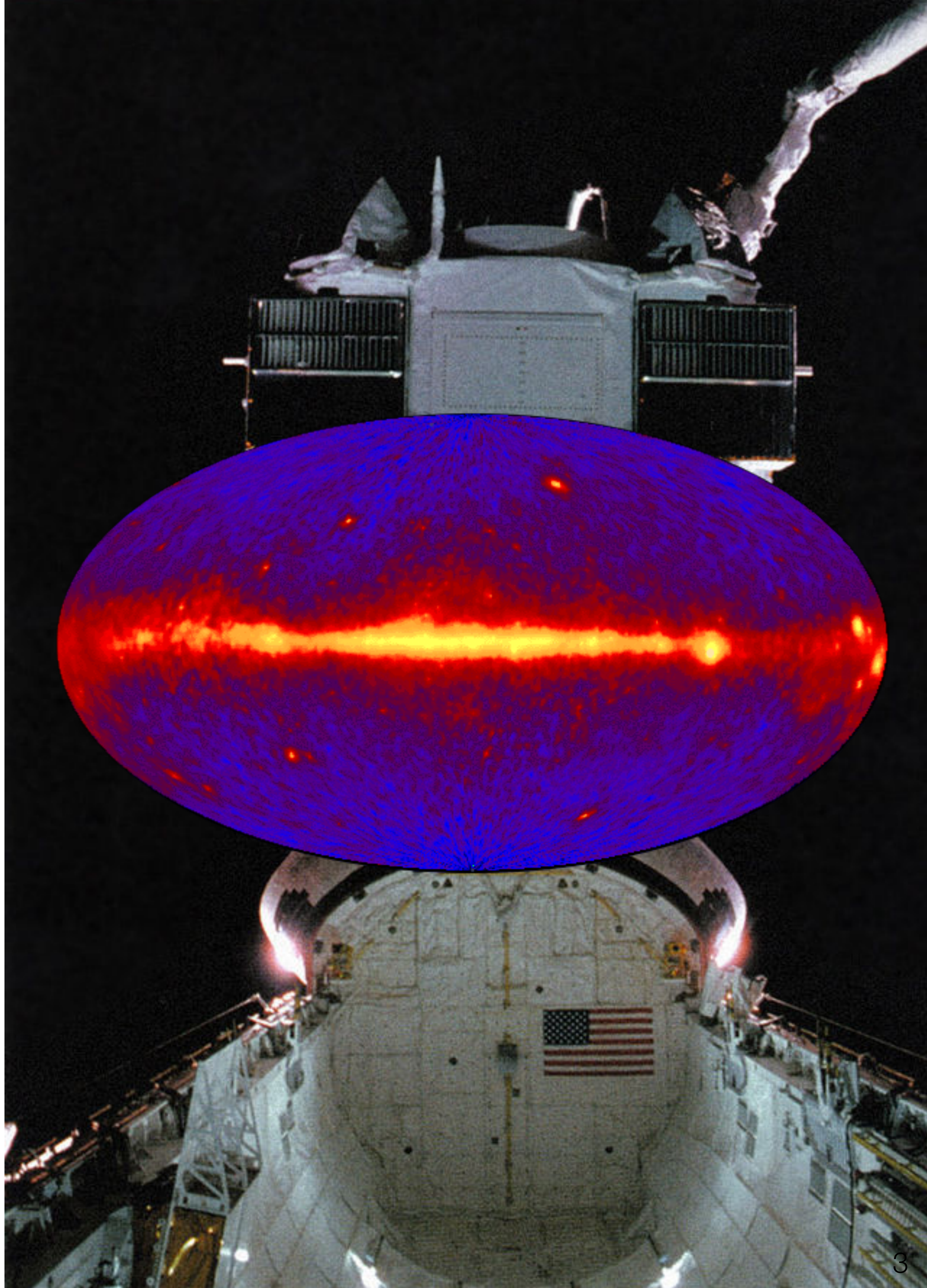
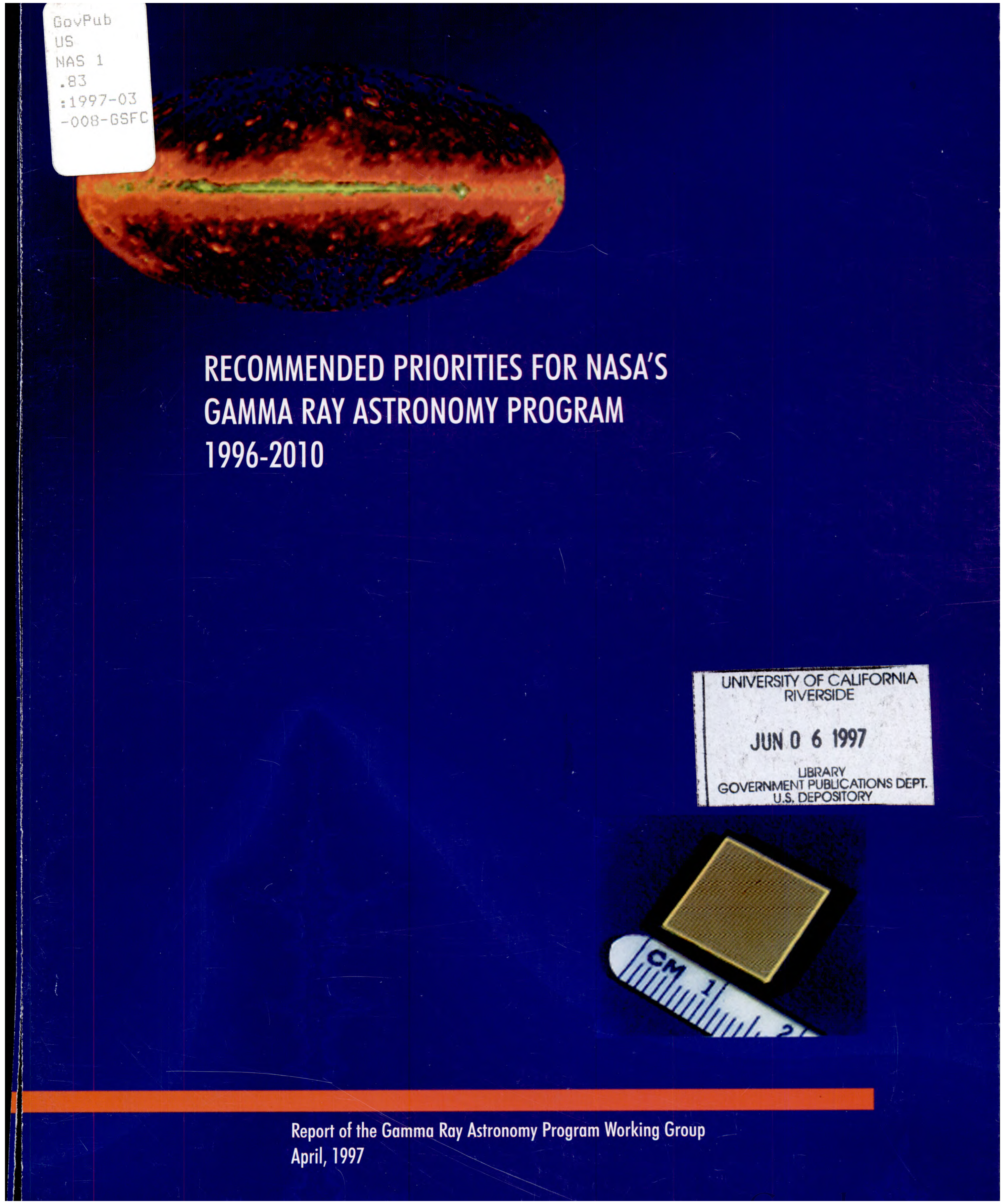


Also in '97

"The mandate of the working group is to recommend a road map to the future for use as an input to the next NASA strategic plan..."



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GAMMA-RAY ASTRONOMY PROGRAM WORKING GROUP MEMBERS:

Elena Aprile (Columbia)
Alan Bunner (NASA) [Ex-Officio (NASA Headquarters)]
Neil Gehrels (GSFC) [Co-Chair]
Jonathan Grindlay (Harvard)
Gerald Fishman (MSFC)
W. Neil Johnson (NRL)
Kevin Hurley (UCB/SSL)
Steve Kahn (Columbia)
Richard Lingenfelter (UCSD)
Peter Michelson (Stanford)
Thomas Prince (Caltech) [Co-Chair]
Roger Romani (Stanford)
James Ryan (UNH)
Bonnard Teegarden (GSFC)
David Thompson (GSFC)
Trevor Weekes (Harvard/Smithsonian)
Stanford Woosley (UCSC)

’97 Report Checklist

✓ Intermediate Missions: We got Fermi and NuSTAR

✓ MIDEX and SMEX: We got Swift but not EXIST (although you could count NICER)

✓ Technology: We have had a robust technology development program that supported Fermi and Swift and continues to build technology.

✓ Balloons: We got long duration balloons and I would say this directly led to the success of COSI and LEAP.

✓ Data Analysis & Theory: This was mainly supported through GI programs like those of Fermi and Swift.

✓ TeV Astronomy: We got VERITAS, HESS, HAWC, and MAGIC.

Updated June 2022

Credit: NASA's Goddard Space Flight Center

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Learn from Past Success

- Large-scale missions should be a foregone conclusion
    - There's no reason gamma rays shouldn't be considered in the mix; however, we didn't (or weren't invited) to submit a Flagship proposal for Astro2020 and we aren't a part Future Great Observatories SAG

Learn from Past Success

- advocacy, Advocacy, ADVOCACY
  - Stakeholder institutions (IPAC, SSL, STScI, WIPAC…)
  - NASA Center Management (MSFC, JPL, GSFC, Ames…)
  - Government agencies (NRL, NSF, DOE…) and other govt. agencies (ASI, JAXA… etc)
  - Universities (previous roadmap: Harvard, Stanford, Columbia, UCB/SSL, UCSD, UNH etc… plus LIGO/IceCube/CTA affiliated institutions)
  - Industry
- The way you get these institutions excited is to… Think big (they don't care about explorers and smaller per se)

A Success oriented Roadmap

- Science is the foundation, but focus on capabilities and actionable items that can be given to HQ and shared with our partners and stakeholders
  - i.e.: this is what the community needs to be served in the next 10-15 years; use the white papers, white books, etc that have been written already
  - From APAC perspective: a ~15 page report with a executive summary that contains actionable items clearly listed
- Think BIG!
  - Shoot for a prioritized probe call in the next decadal

Backups

Intermediate Missions

The HIGHEST PRIORITY recommendation is:

A next generation 10 MeV to 100 GeV gamma-ray mission such as GLAST. 1 to 2 orders of mag improvement in sensitivity compared to EGRET.

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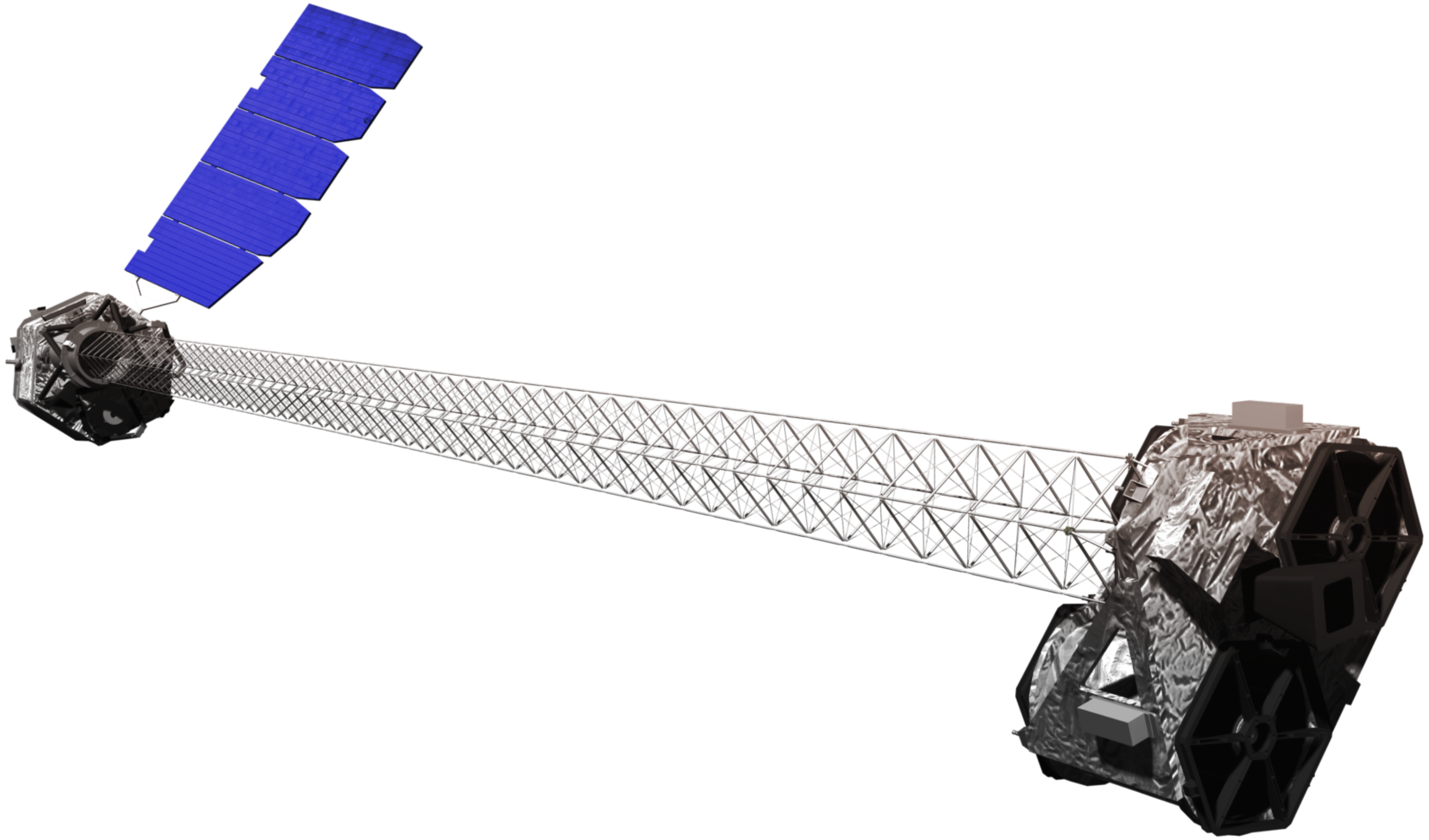
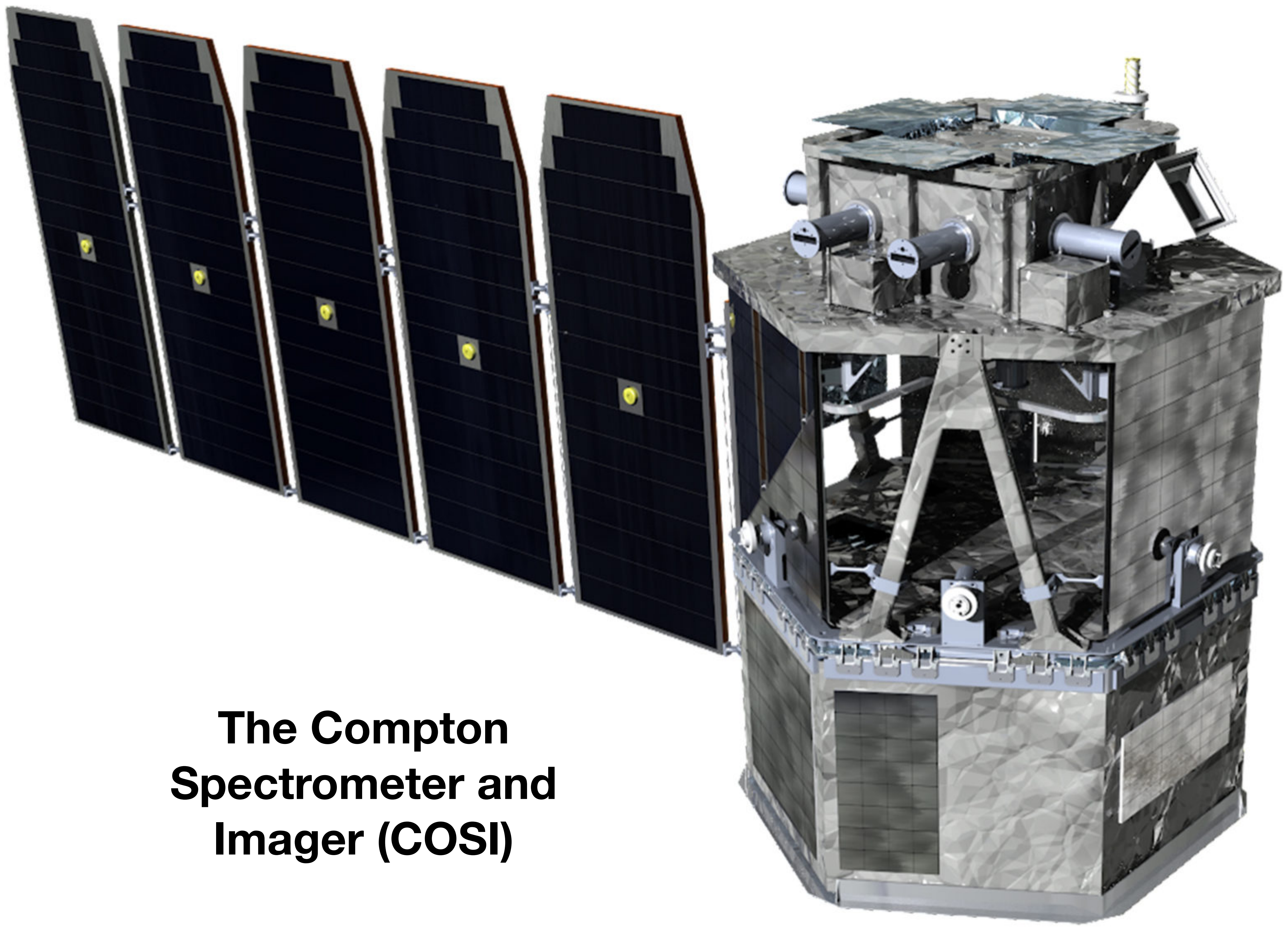


Another very-high priority:

A Focusing Hard X-ray Telescope.

Intermediate Missions



The Compton Spectrometer and Imager (COSI)

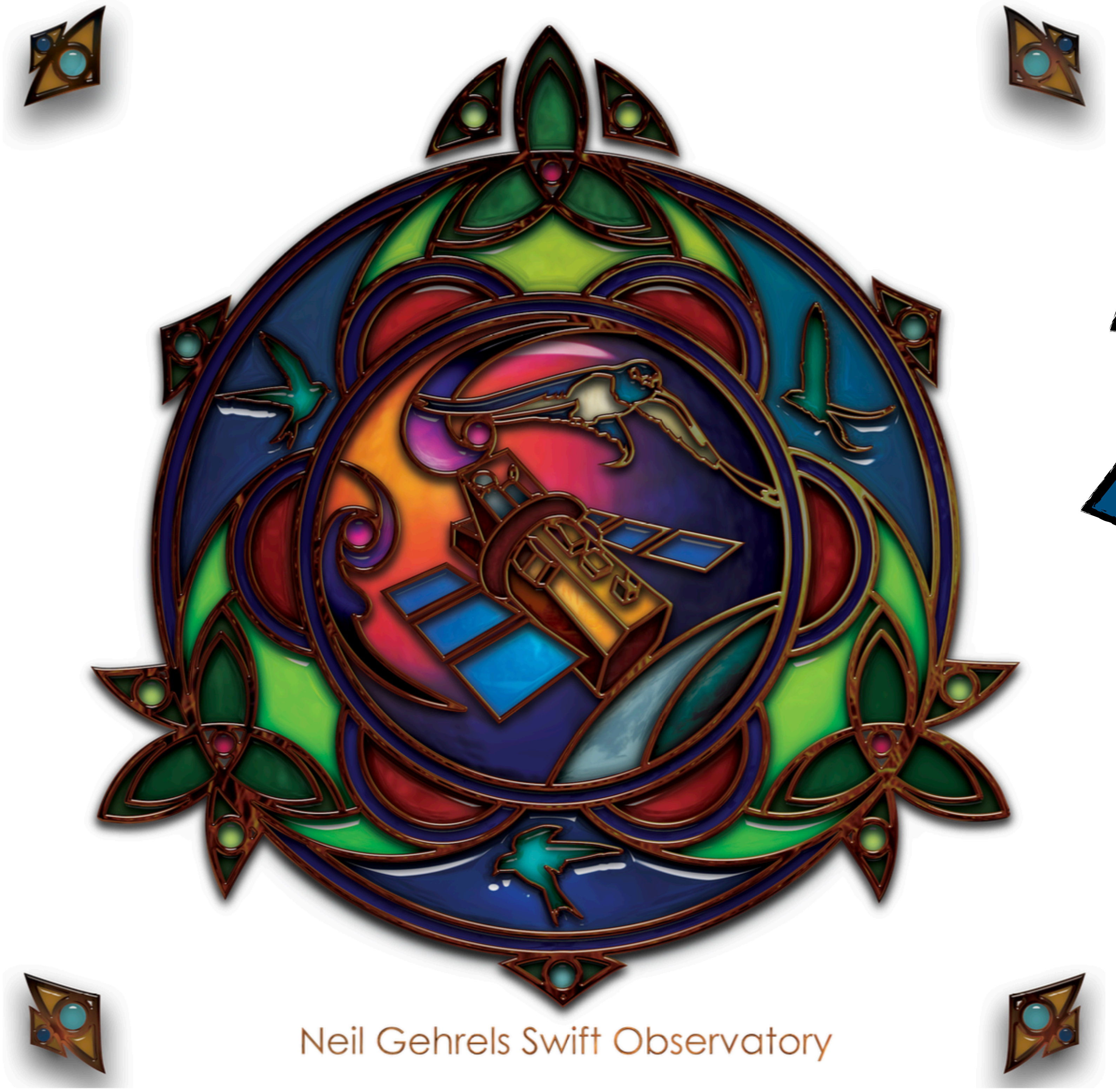
The second very-high priority:

A next-generation nuclear line and MeV continuum mission. A major step forward compared to INTEGRAL in both sensitivity and energy range.

MidEx and SMEX Missions

A gamma-ray burst localization mission. Such a mission would address the origin of gamma-ray bursts. Missions with coding apertures or an array of small telescopes would fill this need.

Probe and SMEX Missions



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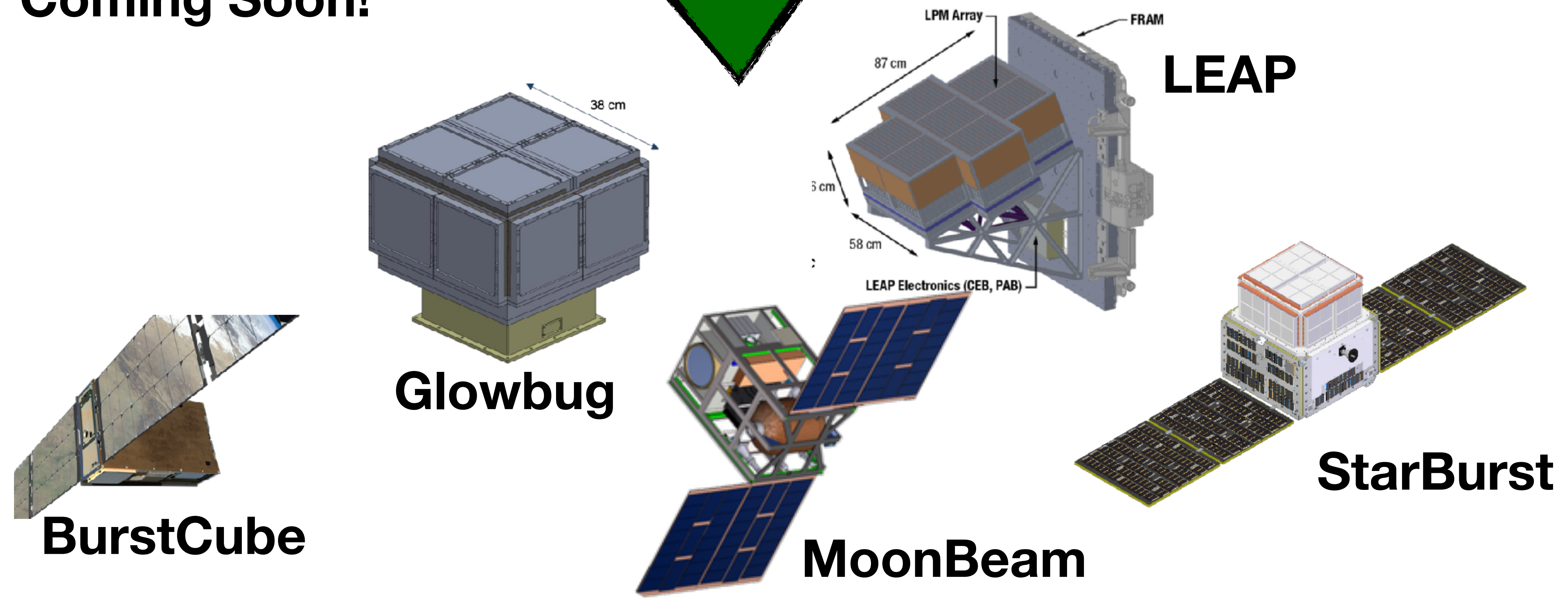
Coming Soon!



KEY QUESTIONS IN GAMMA-RAY ASTRONOMY FROM 1997

- **What is the origin and nature of gamma-ray bursts?**
- **What are the physical conditions and processes near accreting black holes and neutron stars?**
- **How does matter behave in extreme conditions like those in neutron stars, supernova expulsions and active galactic nuclei?**
- **How do astrophysical accretion processes work and what are their instabilities, periodicities and modes?**
- **What is the nature of the jets emanating from galactic black holes and AGN and how are the particles accelerated?**
- **What is the origin of the diffuse gamma-ray background?**
- **What is the nature of the unidentified high energy gamma-ray sources?**
- **What are the sites of nucleosynthesis?**
- **How do supernovae work? What are the progenitors and explosion mechanisms? What has bene the rate in the last several hundred years?**
- **What and where are the sites of cosmic ray acceleration?**

Why did they recommend these missions?

- They developed a series of **Key Science Questions** that pointed to the need for this diverse set of missions.
  - Lesson: Lead with the Science
  - Lesson: Don't shy away from the big problems
  - Lesson: Make strong/bold recommendations
- Many of these questions are still open but we have made significant progress.

Fermi/Swift capabilities are an Astro2020 Decadal priority

Sustaining Programs (Space)

Time-Domain Program (highest priority)

- A program of competed missions and missions of opportunity to realize and sustain the suite of capabilities required to study transient phenomena and follow-up multi-messenger events.
- Notional cost: $500 million–$800 million over the decade

Probe Line

- Competed line of cost-capped probe missions to bridge the gap between Explorers and strategic missions; focused on gaps in science and wavelength capabilities– this decade Far-IR and an X-ray complement to Athena
- $1.5 billion/mission, cadence of approx. one/decade

Programs that Sustain and Balance the Science

Turning to medium-scale missions and projects, the scientific richness of a broader set of themes—exploring *New Messengers and New Physics*, understanding *Cosmic Ecosystems*, and placing *Worlds and Suns in Context*—as well as the need to capitalize on major existing investments and those coming online in the next decades drive the essential sustaining projects (Tables S.5 and S.6). In space, the highest-priority sustaining activity is a **space-based time-domain and multi-messenger program** of small and medium-scale missions. In addition, the survey recommends a new line of probe missions to be competed in broad areas identified as important to accomplish the survey's scientific goals. For the coming decade, a far-IR mission, or an X-ray mission designed to complement the European Space Agency (ESA's) Athena mission, would provide powerful capabilities not possible at the Explorer scale. With science objectives that are more focused compared to a large strategic mission, and a cost cap of $1.5 billion, a cadence of one probe mission per decade is realistic. The selection of a probe mission in either area would not replace the need for a future large, strategic mission. For ground-based projects, the highest-priority sustaining activity is **a significant augmentation and expansion of mid-scale programs**, including the addition of strategic calls to support key survey priorities. The survey also strongly endorses investments in **technology development for advanced gravitational wave interferometers**, both to upgrade NSF's Laser Interferometer Gravitational-Wave Observatory (LIGO), and to prepare for the next large facility.[5]