Fermi Gamma-ray Space Telescope: Looking Towards the Future

Julie McEnery (NASA/GSFC)
on behalf of the Fermi Mission Teams

The Fermi Gamma-ray Space Telescope has been surveying the high-energy gamma-ray sky for the past three and a half years. As observations continue, we open new phase space in the energy, temporal and sensitivity domains. Analysis and operational updates enhance Fermi's science capabilities beyond that expected from additional observation time alone. New observatories and facilities provide new power to uncover the physics of the dynamic sources seen with Fermi. In this poster we describe some of the opportunities the Fermi user community can expect as observations continue.

Extending Observations to Higher energies

Fermi-LAT is photon-starved at high energies, thus increased integration time extends observations to higher energies. Allowing with Continued observations:

• Study of source populations above 50 GeV
• Measurement of expected spectral features in the extragalactic diffuse.
• Either reveal dark matter signatures or severely constrain popular WIMP models of dark matter.

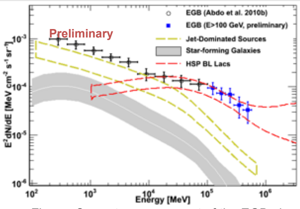


Figure: Current measurement of the EGB along with contributions (and associated uncertainties from star forming galaxies and jet sources.

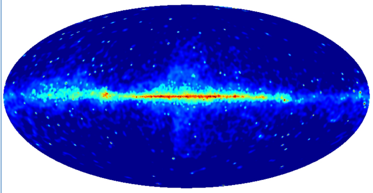


Figure: Adaptively smoothed image >10 GeV, based on 36 months of data.

Observations at higher energies will provide a new view of the gamma-ray sky - just like having a new instrument!

With the limited statistics currently available at >10 GeV, Fermi is starting to reveal large-scale regions of excess high-energy emission not predicted by interstellar emission models. Extended observations will provide unique skymaps at higher energy

Synergies with other Observatories and Missions

Fermi's instruments huge fields of view, scanning observation mode, And sensitivity to changes in the gamma-ray sky on timescales from A fraction of a second for GRB to years for AGN are highly complementary with studies at other wavebands

Observational facilities are coming online that will provide new power to uncover the physics of the dynamic sources seen with Fermi. For example, since GBM is the most prolific detector of short bursts (45/year)within 1–2 years of commissioning, ALIGO will either detect gravitational waves in coincidence with GBM detections of short GRBs, or neutron star-black hole mergers will be ruled out as the progenitors of these events.

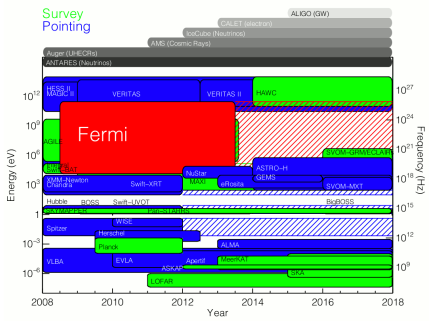


Figure: Fermi will be the only mission covering its broad energy band in the coming years. The growing number of survey and non-photon astronomy programs (green, grey) as well as pointed mode telescopes (blue) will be relying on Fermi's flexible observing capabilities for synergy.

Benefits of increased Sensitivity

Additional observations will deepen the exposure across the entire sky.

This will **increase the number of known sources** of gamma-rays allowing us to:
• Reveal the radio and gamma-ray emission geometry of pulsars by sampling a large population at different lines of sight.
• Search for pulsars in new regions such as the Galactic center, the LMC and massive star binary systems.
• Test unified models of AGN with larger samples of off-axis objects.
• Provide a detailed characterization of the contribution of unresolved point sources to the EGB by detecting over 1000 new blazars and other extragalactic sources to fainter fluxes.
• Study high energy gamma-ray emission from solar flares over a full solar cycle.
•And much more…

Improved sensitivity will allow Fermi to **spatially resolve more extended objects** and **greatly improve localizations** for the nearly 600 unidentified gamma-ray sources, thereby enhancing the opportunity to **discover new classes of gamma-ray emitters** such as clusters of galaxies.

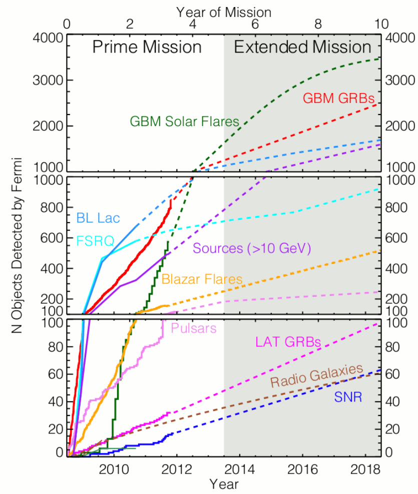
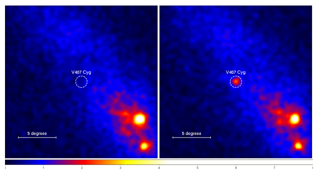


Figure: Fermi has increased the number of known gamma-ray sources by nearly an order of magnitude compared with previous experiments. Predictions of future detections exhibit varying rates for different source classes.

Monitoring the High-Energy Sky

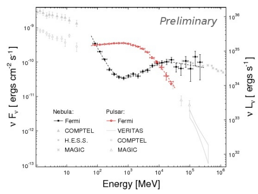
In survey mode, the default observing mode for Fermi, the LAT views the entire sky every 3 hours. Continued survey mode observations will provide:
• **A longer baseline for temporal studies** - enabling searches for long period galactic binaries and the general exploration of gamma-ray variability of timescales of years

Figure: Gamma-ray skymaps before and during the remarkable gamma-ray outburst from nova V407 Cygnii. (remarkable because Novae were not expected to exhibit the particle acceleration required to produce gamma-rays



•**Additional unexpected gamma-ray transient discoveries** rivaling the scientific return from the discovery of gamma rays from the nova V407 Cyg and dramatic flares from the Crab that have been seen so far.

Figure: The Crab pulsar has a power-law tail and has been detected at VHE energies by VERITAS and MAGIC. Leading to the obvious question of how many more VHE pulsars are there? Also shown in the pulsar wind nebula (black), which flares dramatically, but strongly peaked in the 0.1 - 1 GeV range, only accessibly to instruments like Fermi-LAT



• **Timing solutions for gamma-ray pulsars,** this is especially important for radio-quiet pulsars, where the LAT is the only instrument able to provide the timing solutions needed to direct VHE searches.

Analysis and operations initiatives

• The large amount of information recorded for each LAT event offers **extensive scope for improvements in analysis**, both by improving the low level event reconstruction and by tuning selection parameters for specific scientific goals. Due to analysis updates, the science performance of the LAT has improved several times since launch. However, the most significant improvements are yet to come and are described in detail in other presentations at this meeting.
• A new **high temporal resolution data-taking mode will be implemented for GBM**, by transitioning to continuous time-tagged event mode - a photon counting datatype. This will allow offline searches for very short duration transients to be performed with much greater sensitivity. We estimate that this will result in the detection of >900 Terrestrial Gamma-ray flashes, exceeding in just one year the number of TGFs that the previous most sensitive instrument, RHESSI, detected in 6 years.

http://fermi.gsfc.nasa.gov/ssc/library/austinaas2012.html