Fermi Mission Status and Plans for the Future

Judy Racusin (NASA/GSFC) on behalf of the Fermi Mission Team
Fermi Status

Fermi Spacecraft & Operations
- Continues to operate as expected
- Closely monitoring performance of all observatory subsystems, no degradation of observatory performance

- Observation Modes
  - Dec 2013 - Dec 2014 in Galactic center biased survey mode
  - Currently in 50 degree rock sky survey
  - In last year:
    - 3 Target of Opportunity (ToO) observations (~20 days)
    - 25 Autonomous Repoint Requests (~2.6 days)

Large Area Telescope (LAT)
- Major analysis upgrade with Pass 8 event reconstruction pipeline
- New catalogs

Gamma-ray Burst Monitor (GBM)
- New localization contours
- Ongoing work to improve automation (RoboBA)
Fermi Status: Observations

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More information on Fermi TOOs: http://fermi.gsfc.nasa.gov/ssc/observations/too/
Fermi Status: Large Area Telescope (LAT)

Pass 8 improvements in:
- acceptance
- effective area
- energy resolution
- PSF
- sensitivity
- field of view

P8 public release June 24, 2015

More Pass 8 details in:
- talk by M. Wood
- posters by L. Baldini, E. Bloom, M. Testa, M. Wood

P8 Results throughout the Symposium

Large Area Telescope (LAT)
- Major analysis upgrade with Pass 8 event reconstruction pipeline
- New catalogs
Fermi Catalogs

- LAT
  - FGL (General)
  - FHL (High-energy)
  - LAC (AGN)
  - PC (Pulsars)
  - LGRB (GRBs)
  - FAVA (Flaring sources)
  - SNR (supernova remnants)
  - Solar flares (upcoming)

- GBM
  - GGRB (GRBs)
  - Mag (Magnetar bursts)
  - TGF

See talks by M. Ajello, D. Kocevski
See posters by G. Vianello, T. Brandt, G. Fitzpatrick, A. Allafort, D. Yu
New Localization contours
- include statistical and asymmetric systematic errors (Connaughton et al. 2015)
- Automatically generated and distributed via GCN
- Useful for follow-up with wide-FoV optical telescopes (e.g. iPTF, MASTER)
- Especially important for LIGO/Virgo
- RoboBA (coming soon)
  - Ground automated positions to ~4.5° radius + contours ~1 minute after trigger ends

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**Fermi Science Menu**

**Galactic**
- Dark Matter searches
- Novae
- SNRs & PWN
- Globular Clusters
- γ-ray Binaries
- Sun: flares & CR interactions
- Terrestrial γ-ray Flashes
- Unidentified Sources

**Extragalactic**
- GRBs
- Blazars
- Radio Galaxies
- Starburst Galaxies
- LMC & SMC
- Fermi Bubbles
- e⁺e⁻ spectrum

Unidentified Sources
Science Highlights: Time Variable Sources

Blazar 3C279
- Most dynamic blazar flare ever seen (x10 in 1 day) in June 2015
- *Fermi* Target of Opportunity Observation allowed measure of short-timescale variability
- Triggered multiwavelength campaign

See talk by M. Hayashida

Galactic Binary V404 Cyg
- First outburst of this low mass X-ray binary since 1989
- 169 GBM triggers June 15-27
- Also detected by MAXI, *Swift*, INTEGRAL, & many others in multiwavelength campaign

See talks by D. Huppenkothen & P. Jenke
Science Highlights: Dark Matter

**dSph galaxies limits**
- DES discovered 8 new dSph galaxies (DES collab, arXiv:1508.03622)
- LAT limits are most constraining yet (Drlica-Wagner et al. 2015)

**Galactic Center Excess**
- 1-10 GeV excess within 10° of Galactic center
  - ~40 GeV DM annihilation?
  - or unresolved astrophysical sources?

See talk by A. Drlica-Wagner, R. Caputo
See posters by A. Geringer-Sameth, M. Mazziotta

See talks by A. Albert, D. Nieto, F. Donato, C. Weniger, B. Safdi, D. Malyshev, A. Viana
See poster by T. Linden
Science Highlights: The *Fermi* Bubbles

- High-energy cutoff at \(~100\) GeV
- Significant enhancement in south-eastern region
- Evidence \(>900\) km s\(^{-1}\) wind via HST UV spectroscopy of quasar behind bubbles indicating Galactic Center activity in last \(\sim2.5-4\) Myr

See talks by M. Su & V. Dogiel

\[\text{Ackermann et al. (2014)}\]

\[\text{Fox et al. (2015)}\]
Cycle 9 deadline: Jan 22, 2016

GI Program Details:
- Funding for analysis of *Fermi* LAT and/or GBM data and/or correlative observations
- Funding for theoretical studies related to *Fermi*
- Pointed mode or ToO observations
- NRAO, NOAO, Arecibo, VERITAS, INTEGRAL observations related to *Fermi* science
- Funds are dispersed to GIs as soon as they are available

GI program continuing to expand to new users
Average award has decreased to reconcile shrinking budget
Oversubscription rate 5:1 highest in astrophysics division

http://fermi.gsfc.nasa.gov/ssc/proposals/
Fermi Analysis Tools

With Pass 8 data release, FSSC/LAT team released a major revision to the LAT Science Tools, documentation, and analysis threads (revised >300 individual files)
• changes/additions to event classes + Instrument Response Functions (quality, front/back, PSF, EDISP)
• new P8 diffuse models

New User Contributed Software
• GBM orbital background subtraction tool
• LAT XML manipulation tools
• http://fermi.gsfc.nasa.gov/ssc/data/analysis/user/
Improvements to Observations of Short and Medium Timescale Transients

Goal: Utilize the full potential of Pass 8 and experience of 7 years of Fermi operations to efficiently search for short (<hours) and medium (~days) timescale transients

- Reduce data latency
- Transient search pipelines
- Streamline Target of Opportunity (ToO) process
- Expedite follow-up observations
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All data go public immediately

Data Latency Steps
- spacecraft - TDRSS
- ground network - MOC
- MOC - Instrument Processing Centers - FSSC

Improvements
- FOT already implementing greater frequency of shorter TDRSS passes and new algorithm to chose passes
- reorder data subsets downlink order
- faster transfer from ground network to MOC

See poster by D. Thompson
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Automatic Science Processing (ASP)

- 6 hr & 1 day search timescales
- Used by Fermi Flare Advocates for many transient detections (Fermi Sky Blog, ATels)

Fermi All Sky Variability Analysis (FAVA)

- 1 week search timescale (+3 day)
- aperture photometry technique

See talk by D. Kocevski
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Short-term (days-weeks) pointed observations
- increase exposure ~x2 above survey mode
- better quality data to measure short timescale variability and higher S/N spectra
- at expense of even exposure on the rest of sky

See talk by M. Hayashida for more on 3C279

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Fermi mission will promptly update community via Fermi-news, ATel, GCN, direct communication with observers, etc. with ToO details to encourage multiwavelength coordination and follow-up

... Science!

Fermi mailing lists: http://fermi.gsfc.nasa.gov/ssc/library/newsletter/
Fermi MW coordination: http://fermi.gsfc.nasa.gov/ssc/observations/multi/

see also Multiwavelength workshop on Friday
Optimizing the High Energy End of the LAT Energy Range

Goal: Utilize the full potential of Pass 8 and maximize the science return from the high energy end of the LAT

Sensitivity increases
• faster at high energies (~t, photon limited)
• relative to low energies (~t^{1/2}, background limited)

Diffuse emission model
• needed for all medium/long timescale analyses
• built from surveys of interstellar gas, Fermi data
• especially difficult at high energies where no templates exist and unique features (e.g. Fermi bubbles)

Updated catalogs
• needed for source populations at high energies (e.g. 2FHL)

See talks by J. Perkins, M. Ajello
See poster by S. Bonnefoy
Maximizing the Scientific Potential of Long Baseline Observations

Fermi’s unique ability to monitor the whole sky over the last 7 years has yielded rich datasets of variable sources

- Periodic
  - Binaries with periods of years
  - Solar flares
- Variable
  - AGN variability to correlate with multiwavelength studies
- Rare Events
  - Pulsar state transitions
  - Outbursts (e.g. Crab)

Deep stares require updated diffuse & sources catalogs
Long baseline variability requires regular calibration & understanding of the instrument stability

Quasi-periodicity in AGN PG 1553+113

More on long baseline observations in talk by D. Thompson

Pulsar/Be-star binary systems: PSR B1259-63 periastron outburst in 2011/2014, J2032+4127 may show similar in 2018

Quasi-periodicity in AGN PG 1553+113

Ackermann et al. 2015, arXiv:1509.02063
The Future: The Crab

- Gamma-ray pulsations up to ~400 GeV (MAGIC Collab., arXiv: 1510.07048)
- Nebula has shown bright flares in high-energy gamma-rays lasting ~days with short-timescale variability (LAT, AGILE)
- Long-term Variability in hard X-ray “standard candle” (GBM)
- Emission regions and acceleration mechanisms not well understood
- Rapid response to flares from Crab or discovery of similar phenomena in other PWNe will be important to initiate multiwavelength follow-up
Additional dwarf spheroidal galaxies will likely be discovered by large-scale optical surveys (e.g. DES)

Mass range excluded by LAT will reach ~350 GeV over next 4 years
Advanced LIGO/Virgo
- GBM is most likely instrument to detect and localize an electromagnetic counterpart to a binary neutron star merger (on axis)
- LAT all sky monitoring could also provide coincident transient source
- Talks by P. Shawhan & V. Connaughton

IceCube PeV Neutrinos
- GRB and/or Blazar origin?
- Talks by E. Waxman, M. Kadler & M. Santander

Pulsar Timing Arrays
- Fermi continues to provide additional pulsars, and putative gravitational wave sources like possible SMBH binary PG 1553+113
- Talk by S. Ciprini & P. Shawhan
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GBM localizations will drastically reduce follow-up area, and will help to identify the host galaxy, redshift, environment, etc.
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Fermi’s wide sky coverage provides unique capability to search for contemporaneous flaring in photon data and neutrinos
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*binary periods of ~years are in frequency range of PTAs*
*evenly sampled all-sky data is ideal for searching for these periodicities*

Acknowledgements

Ackermann et al. 2015, arXiv:1509.02063
• Every 2 years all operating missions in their extended phase compete for funding to continue operations
  – Missions in 2016 Senior Review: Fermi, Kepler (K2), NuSTAR, Spitzer, Swift, XMM
  – Chandra & Hubble separate process
• 2014 Panel Report
  – “The Fermi Observatory … is a unique asset to the NASA portfolio”
  – “The Fermi GI program has been very successful, and has directly led to several important science discoveries.”
  – “The SRP recommends continuation of the Fermi extended mission through FY18”

http://science.nasa.gov/astrophysics/2014-senior-review-operating-missions/
Conclusions

• 2016 Astrophysics Senior Review Proposal
  – Propose to extend the *Fermi* mission through to 2020
  – The *Fermi* Mission welcomes input from the community, especially throughout the *Fermi* Symposium

• Please continue to think of new and innovative ways to use the *Fermi* instruments and data

• Looking forward to many interesting results this week!
Tooning the Extreme Cosmos

Free tickets still available!
http://fermi.gsfc.nasa.gov/science/mtgs/tooning/

Take a wander into DC for a special mixture of Fermi and Art

Next Huntsville GRB Workshop

October 24-28, 2016 in Huntsville, Alabama

Organizers: Valerie Connaughton, Neil Gehrels, Adam Goldstein

Details soon!