Fermi Mission Status and Plans for the Future

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

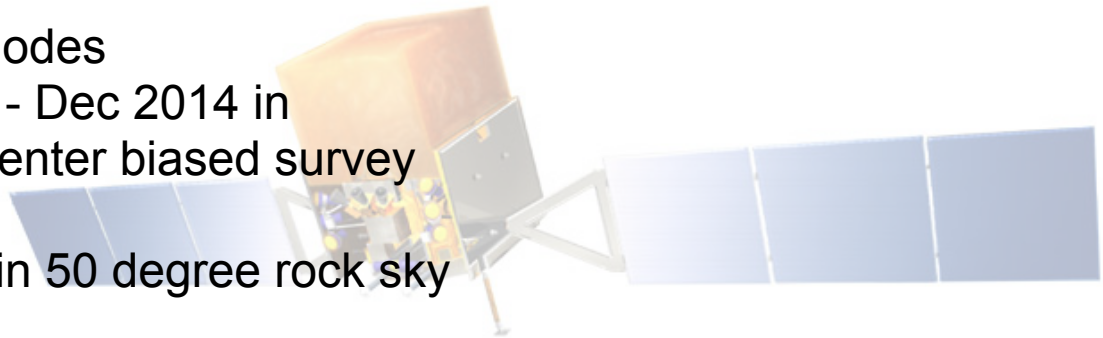
6th International Fermi Symposium - Arlington, VA - November 9-13, 2015

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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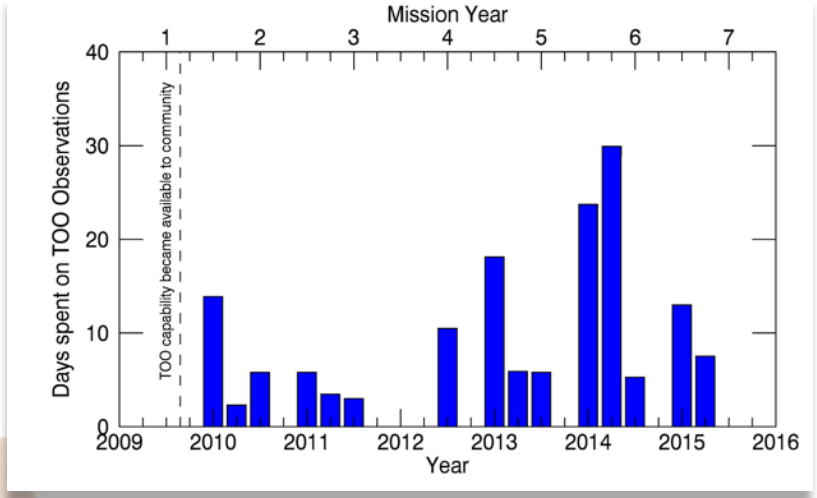
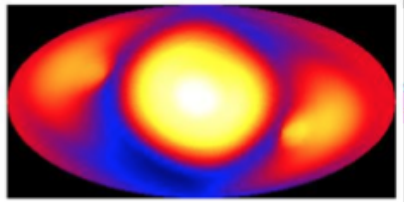


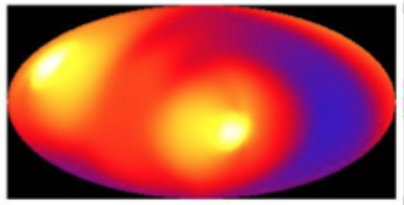
TOOs since last Symposium:

- **3C279**
- **Nova SGR 2015 No.2**
- **GRB 150201A**

Galactic Center Pointing



50 degree rocking survey mode



More information on Fermi TOOs:
http://fermi.gsfc.nasa.gov/ssc/observations/too/

Fermi Status: Large Area Telescope (LAT)

Pass 8 improvements in:

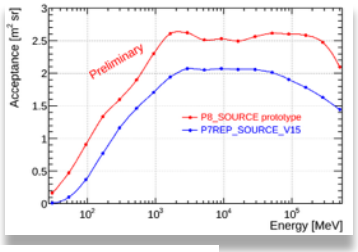
- ***acceptance***
- ***effective area***
- ***energy resolution***
- ***PSF***
- ***sensitivity***
- ***field of view***

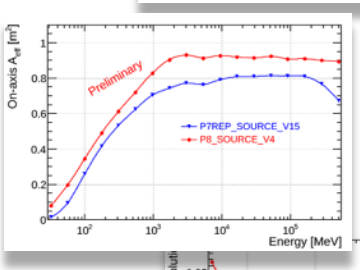
P8 public release June 24, 2015

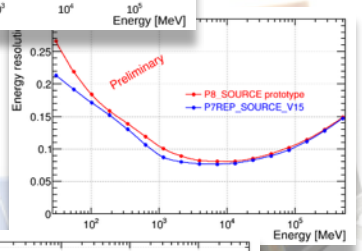
More Pass 8 details in:

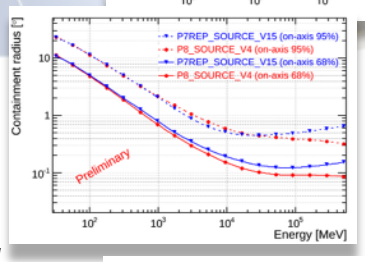
- ***talk by M. Wood***
- ***posters by L. Baldini, E. Bloom, M. Testa, M. Wood***

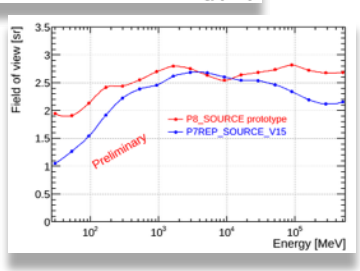
P8 Results throughout the Symposium











Large Area Telescope (LAT)

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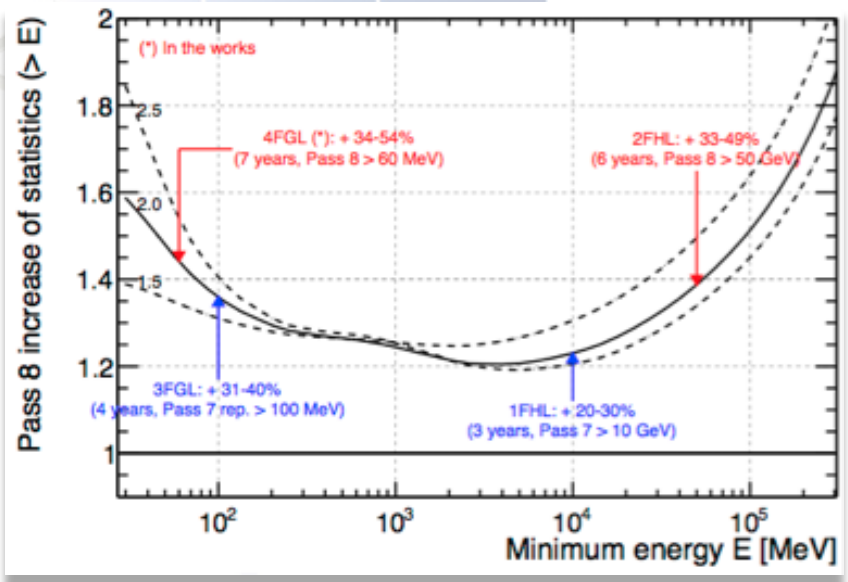
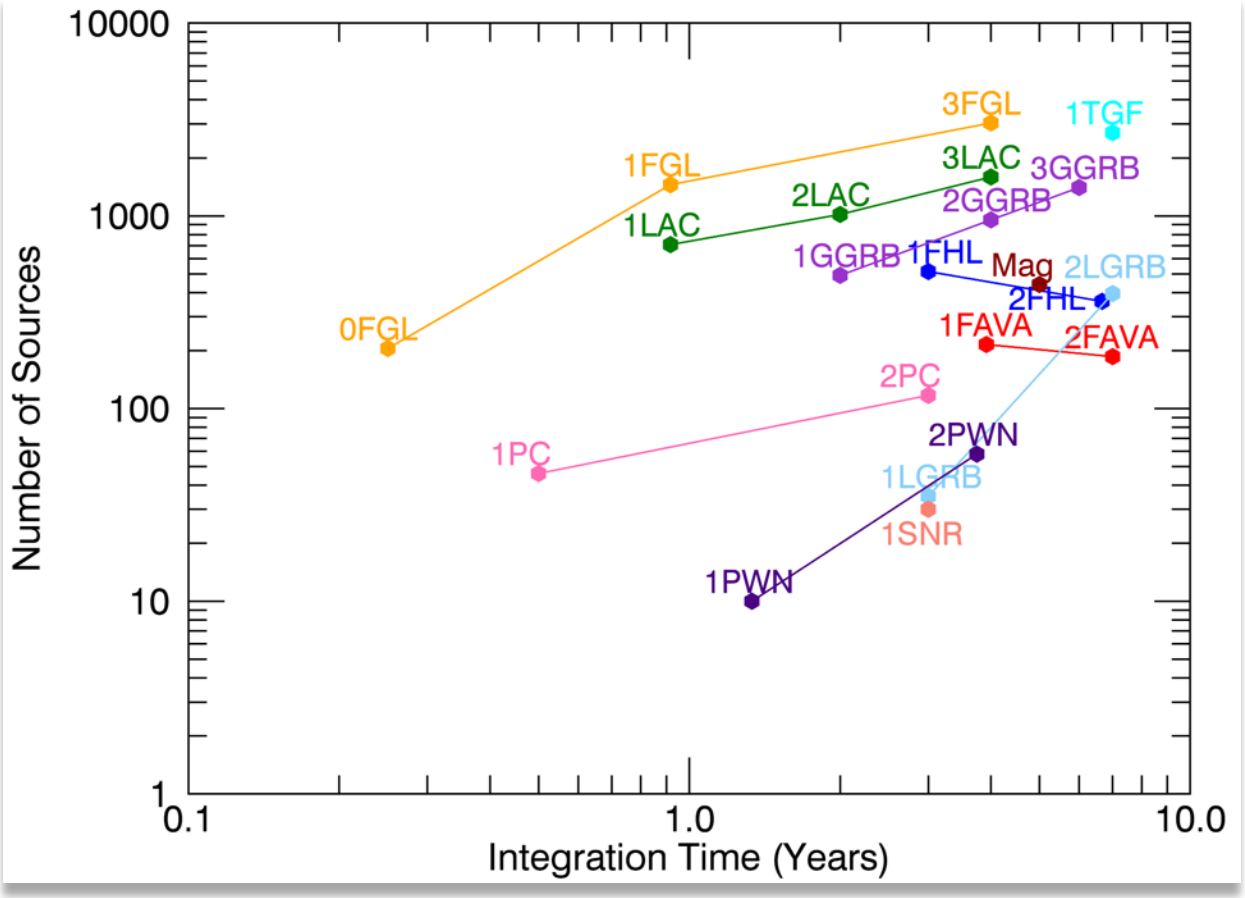
- **New catalogs**



Fermi Status: Catalogs

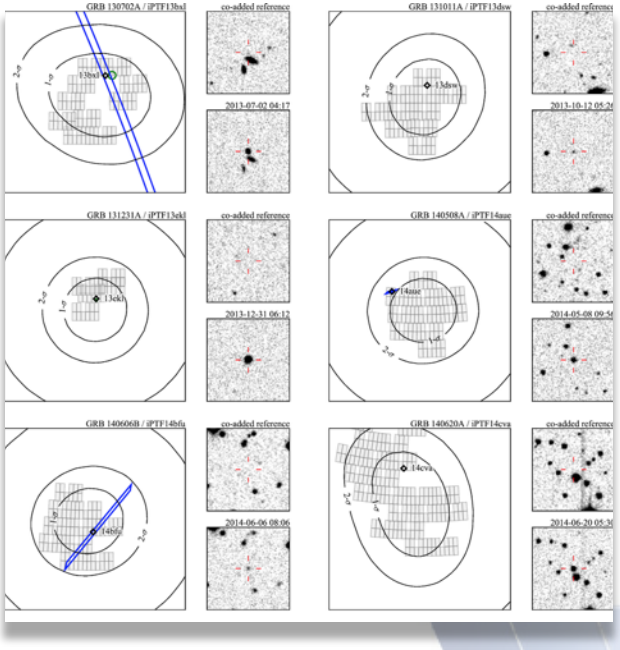
Fermi Catalogs

- 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

Fermi Status: Gamma-ray Burst Monitor (GBM)



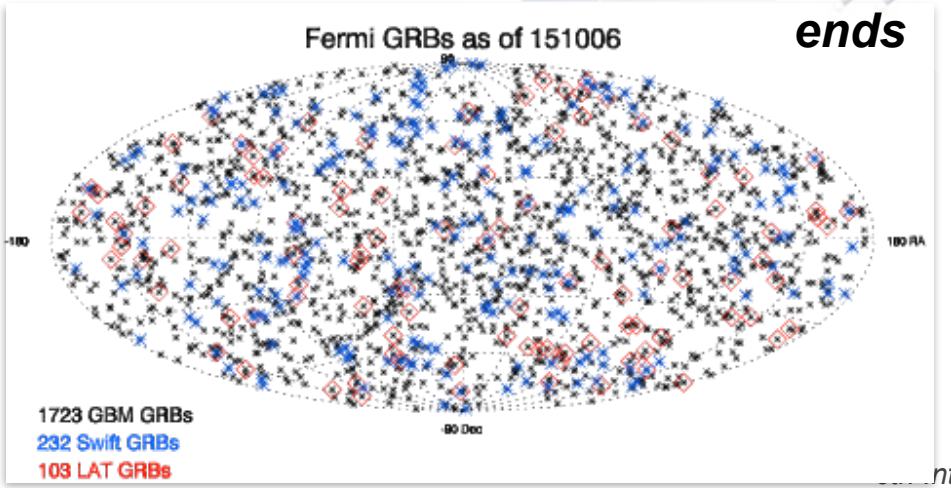
Singer et al. (2015)

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***

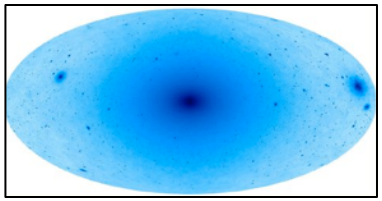


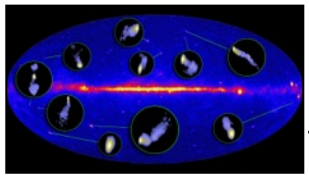
Gamma-ray Burst Monitor (GBM)

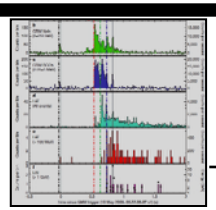
- **New localization contours**
- **Ongoing work to improve automation (RoboBA)**

Fermi Science Menu

Dark Matter searches

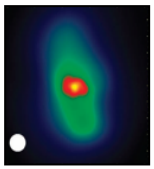




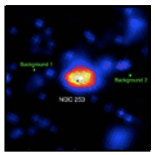


GRBs

Blazars

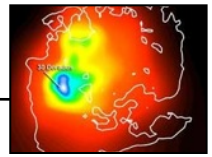


Radio Galaxies

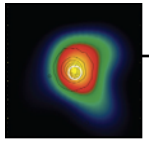


Starburst Galaxies

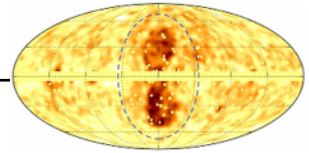
Extragalactic



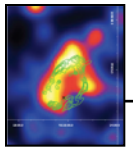
LMC & SMC



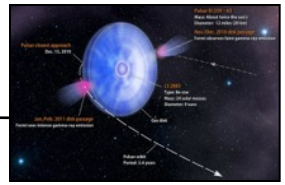
Globular Clusters



Fermi Bubbles

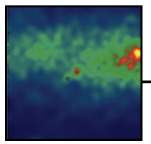


SNRs & PWN

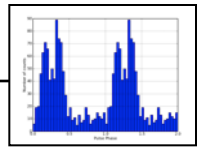


γ-ray Binaries

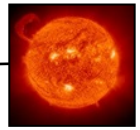
Galactic



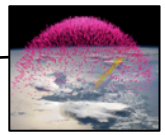
Novae



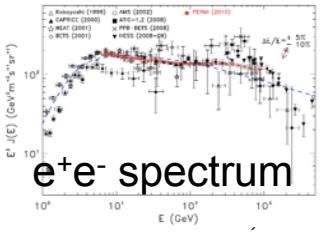
Pulsars: isolated, binaries, & MSPs



Sun: flares & CR interactions



Terrestrial γ-ray Flashes



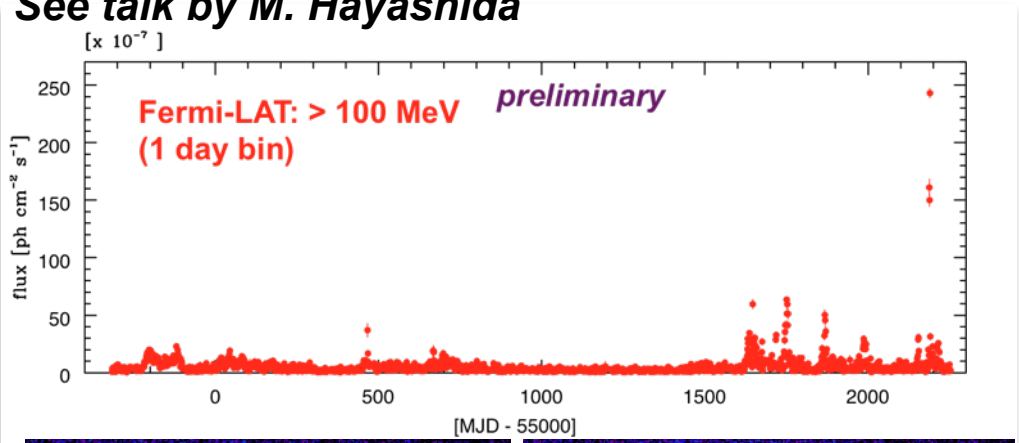
Unidentified Sources

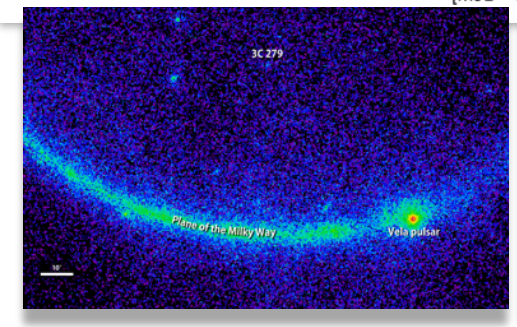
Science Highlights: Time Variable Sources

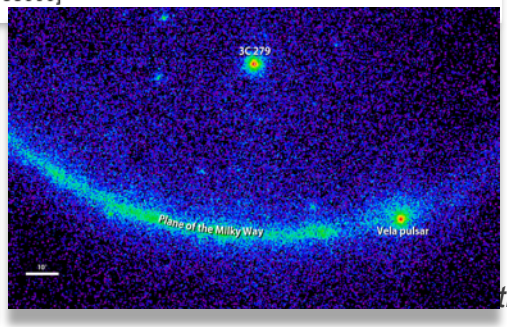
Blazar 3C279

- 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



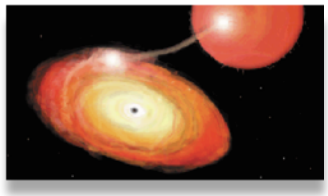


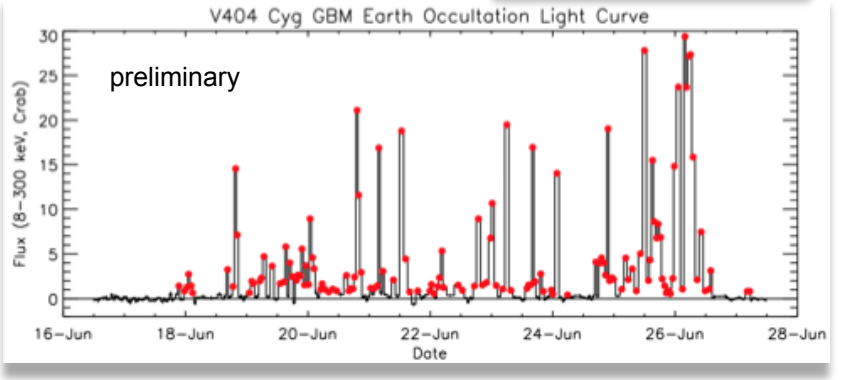


Galactic Binary V404 Cyg

- 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



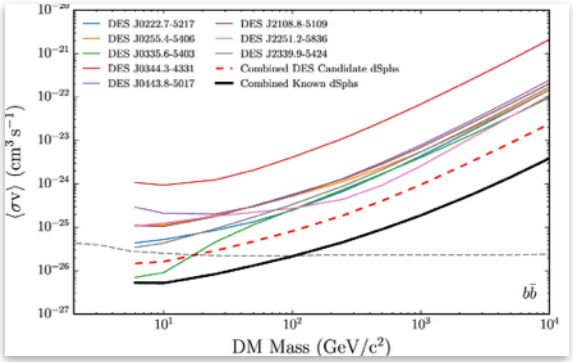


Science Highlights: Dark Matter

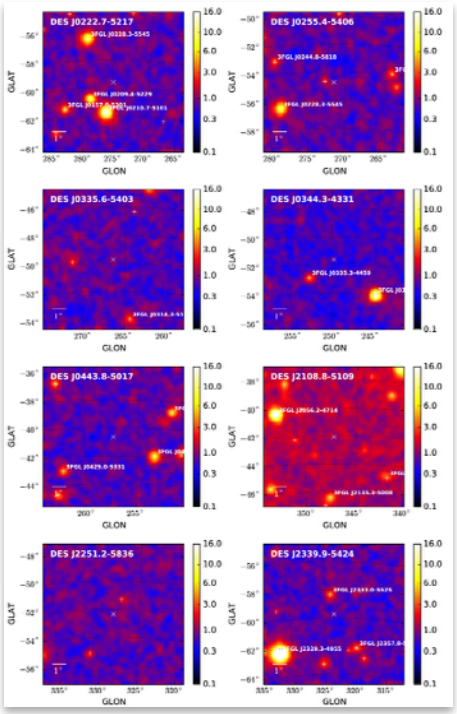
dSph galaxies limits

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

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



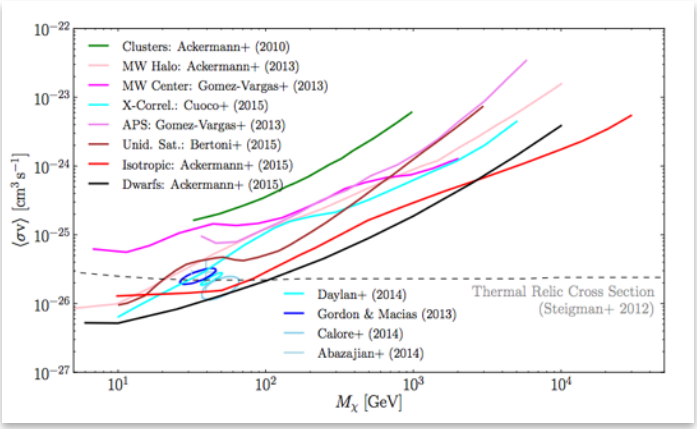
Drlica-Wagner et al. (2015)



Galactic Center Excess

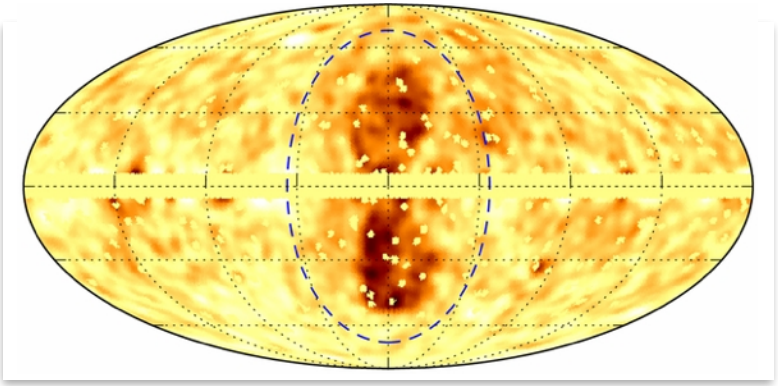
- 1-10 GeV excess within 10° of Galactic center
  - ~40 GeV DM annihilation?
  - or unresolved astrophysical sources?

See talks by A. Albert, D. Nieto, F. Donato, C. Weniger, B. Safdi, D. Malyshev, A. Viana
See poster by T. Linden



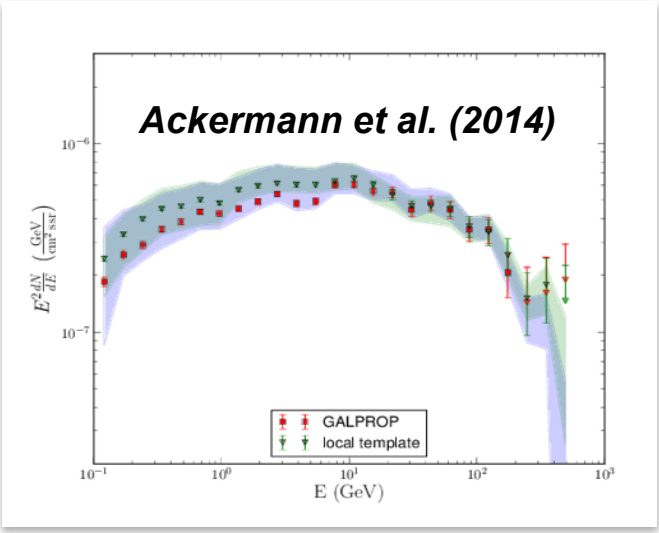
Science Highlights: The *Fermi* Bubbles

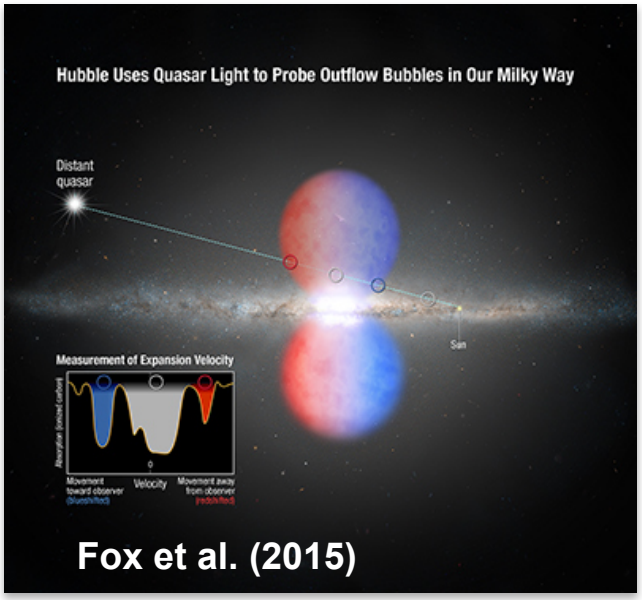
- **High-energy cutoff at ~100 GeV**
- **Significant enhancement in south-eastern region**
- **Evidence >900 km s^{-1} wind via HST UV spectroscopy of quasar behind bubbles indicating Galactic Center activity in last ~2.5-4 Myr**



Ackermann et al. (2014)

See talks by M. Su & V. Dogiel





Guest Investigator Program

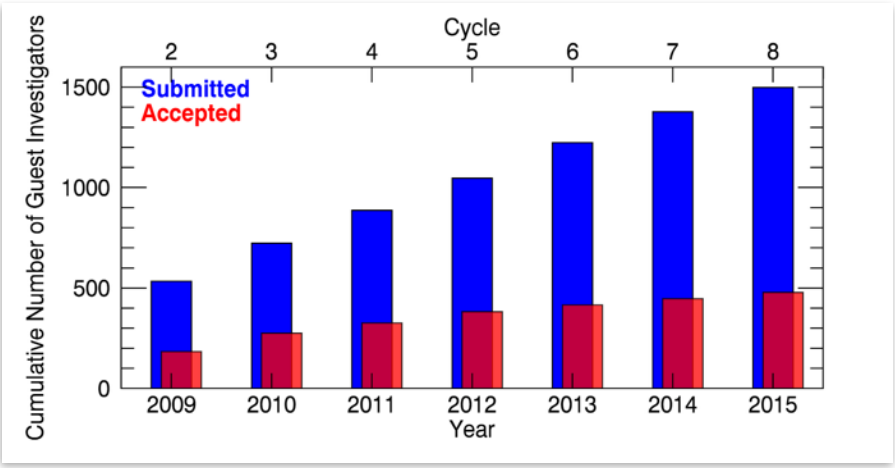
Cycle 9 deadline: Jan 22, 2016

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

http://fermi.gsfc.nasa.gov/ssc/proposals/

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



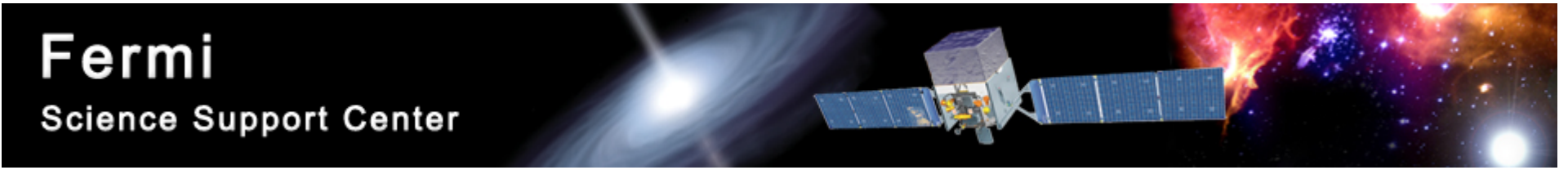
Fermi Analysis Tools

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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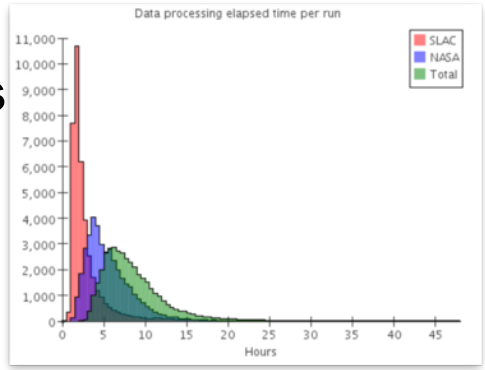
All data go public immediately

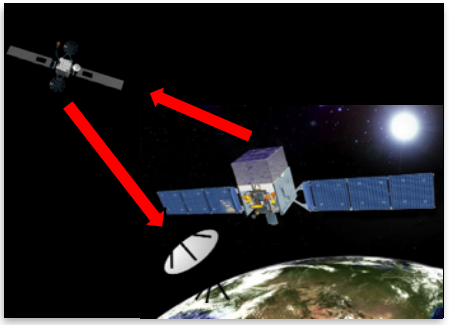
Data Latency Steps

- 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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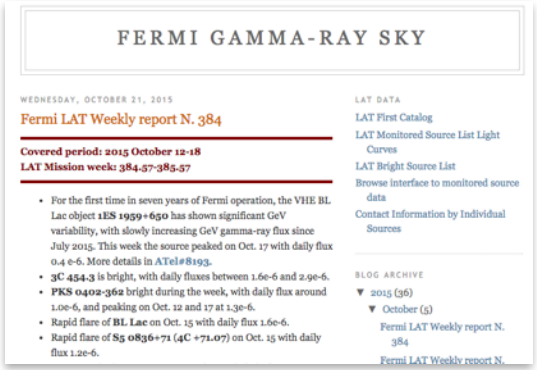
Automatic Science Processing (ASP)

6 hr & 1 day search timescales

Used by *Fermi* Flare Advocates for many transient detections (*Fermi* Sky Blog, ATels)

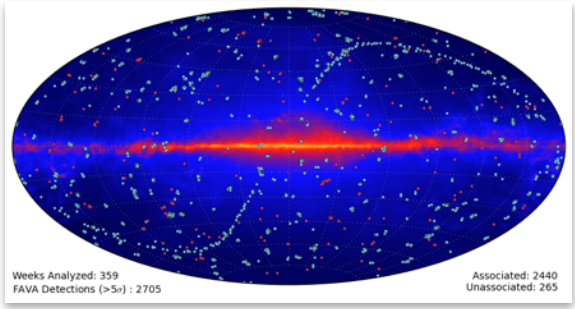
The Astronomer's Telegram



***Fermi* All Sky Variability Analysis (FAVA)**

1 week search timescale (+3 day)

aperture photometry technique



See talk by D. Kocevski

Improvements to Observations of Short and Medium Timescale Transients

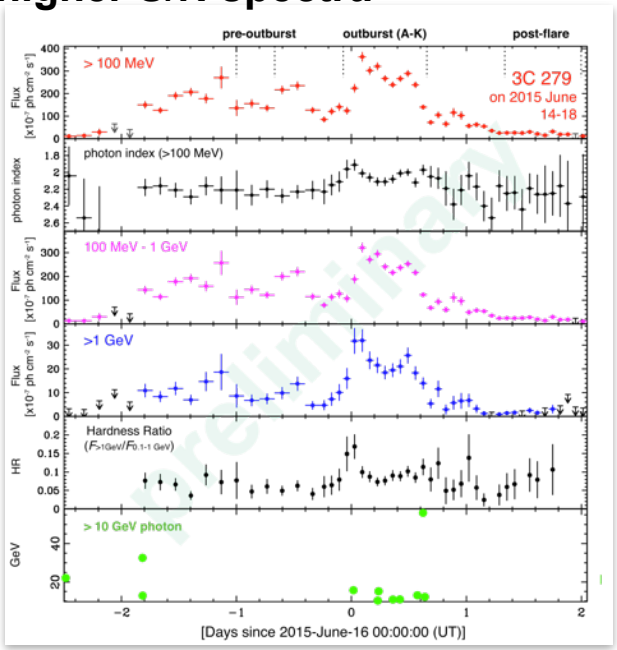
Goal: Utilize the full potential of Pass 8 and experience of 7 years of Fermi operations to efficiently search for short (<hours) and medium (~days) timescale transients

- Reduce data latency
- Transient search pipelines
- **Streamline Target of Opportunity (ToO) process**
- Expedite follow-up observations

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



http://fermi.gsfc.nasa.gov/ssc/observations/too/

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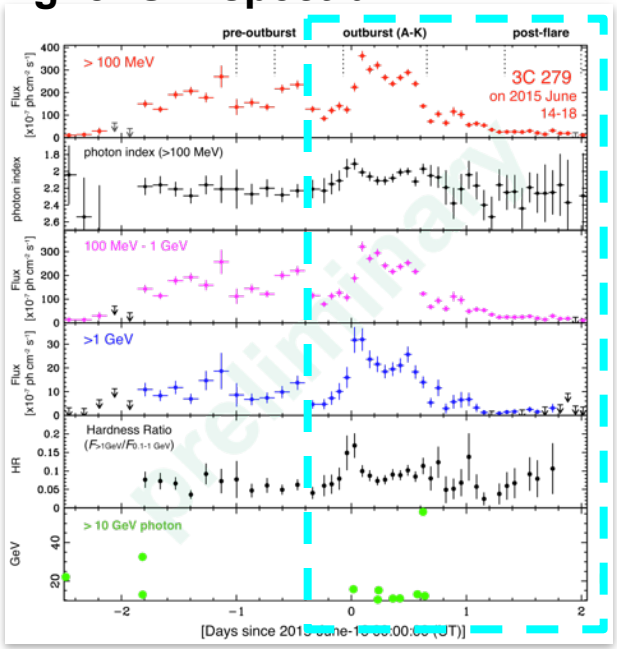

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Fermi mission will promptly update community via Fermi-news, ATel, GCN, direct communication with observers, etc. with ToO details to encourage multiwavelength coordination and follow-up

… Science!

see also Multiwavelength workshop on Friday

Fermi mailing lists: http://fermi.gsfc.nasa.gov/ssc/library/newsletter/

Fermi MW coordination: http://fermi.gsfc.nasa.gov/ssc/observations/multi/

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

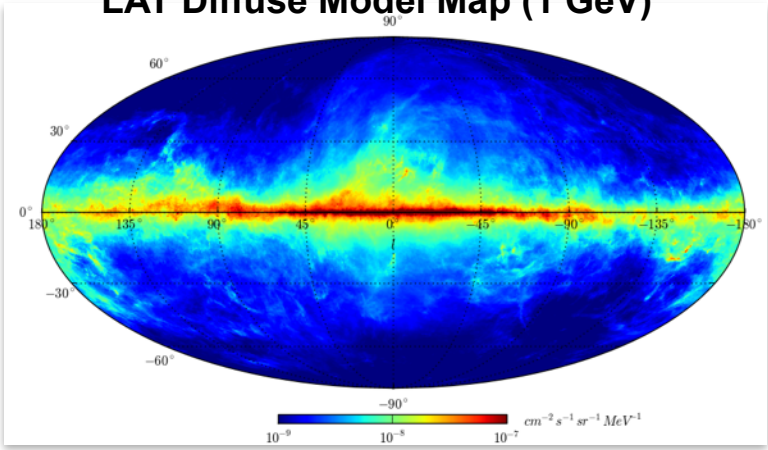
- **needed for all medium/long timescale analyses**
- **built from surveys of interstellar gas, *Fermi* data**
- **especially difficult at high energies where no templates exist and unique features (e. g. *Fermi* bubbles)**

Updated catalogs

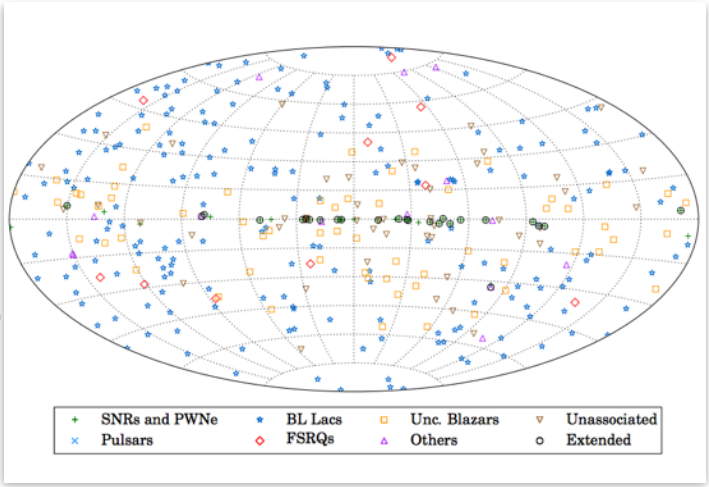
- **needed for source populations at high energies (e.g. 2FHL)**

See talks by J. Perkins, M. Ajello
See poster by S. Bonnefoy

LAT Diffuse Model Map (1 GeV)



2FHL Catalog, Ackermann et al. 2015, arXiv: 1508.04449



Maximizing the Scientific Potential of Long Baseline Observations

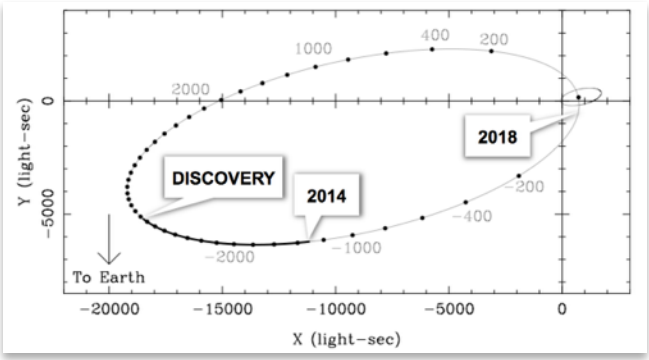
Fermi's unique ability to monitor the whole sky over the last 7 years has yielded rich datasets of variable sources

- 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)

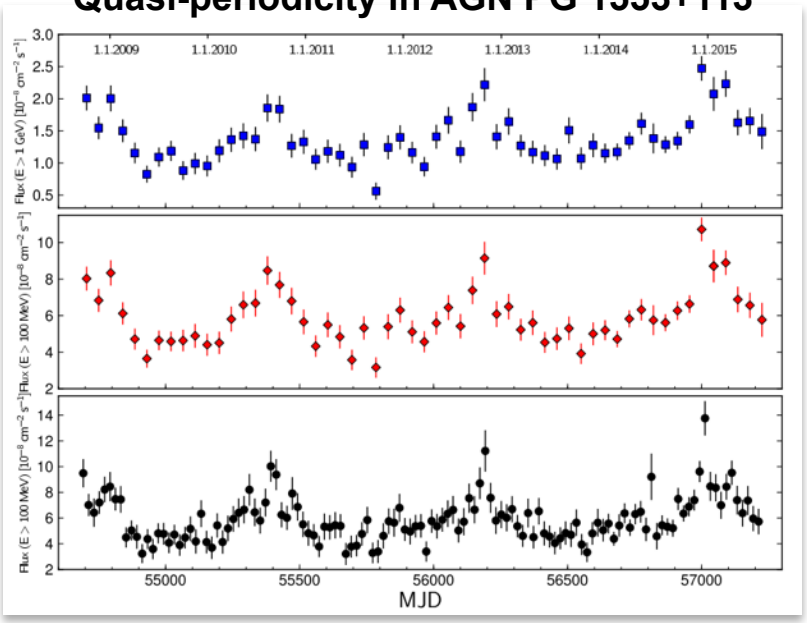
Deep stares require updated diffuse & sources catalogs

Long baseline variability requires regular calibration & understanding of the instrument stability

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

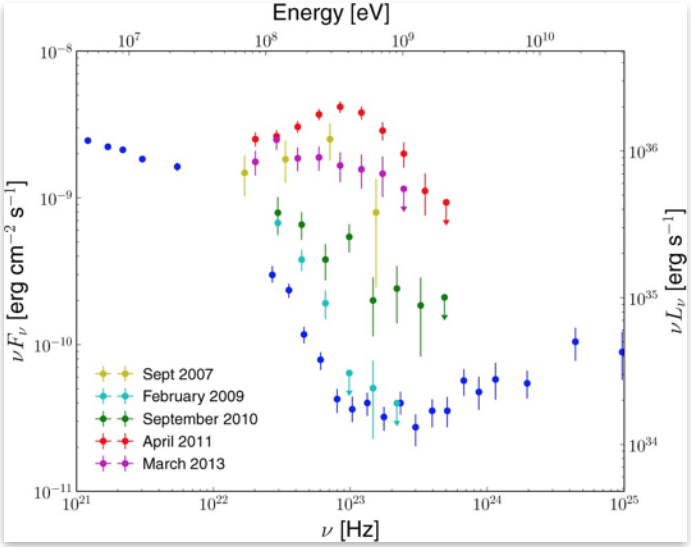


Ackermann et al. 2015, arXiv:1509.02063

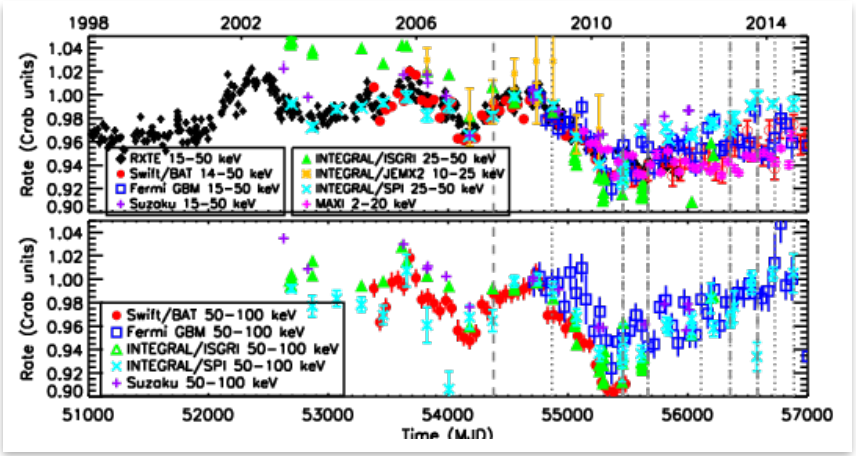
More on long baseline observations in talk by D. Thompson

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



Buehler & Blandford (2014)

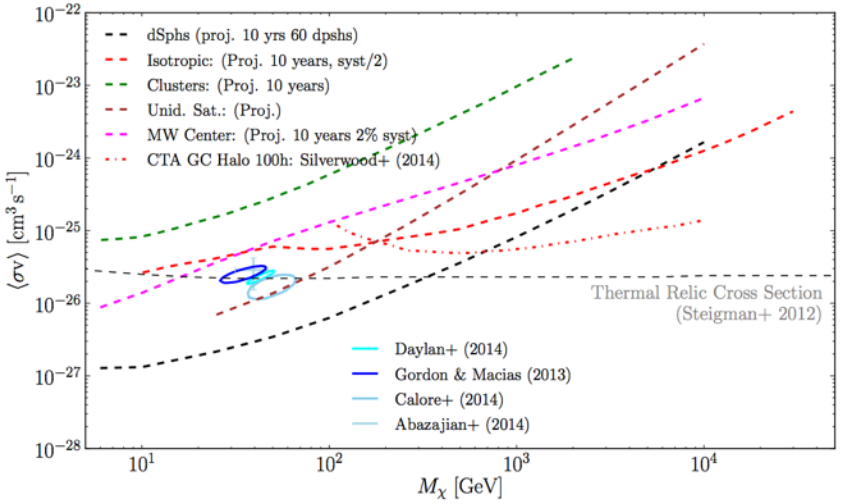


C. Wilson-Hodge

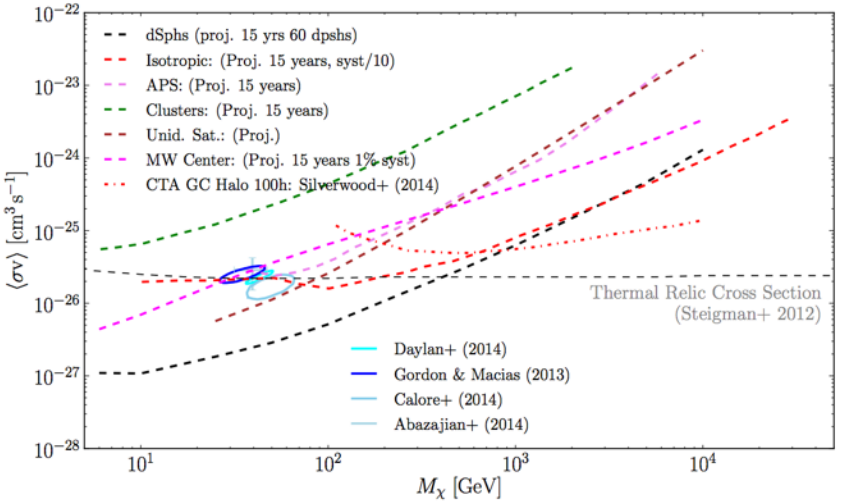
The Future: Dark Matter

- **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**

10 Years of LAT Data



15 Years of LAT Data



The Future: Multimessenger Synergies

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
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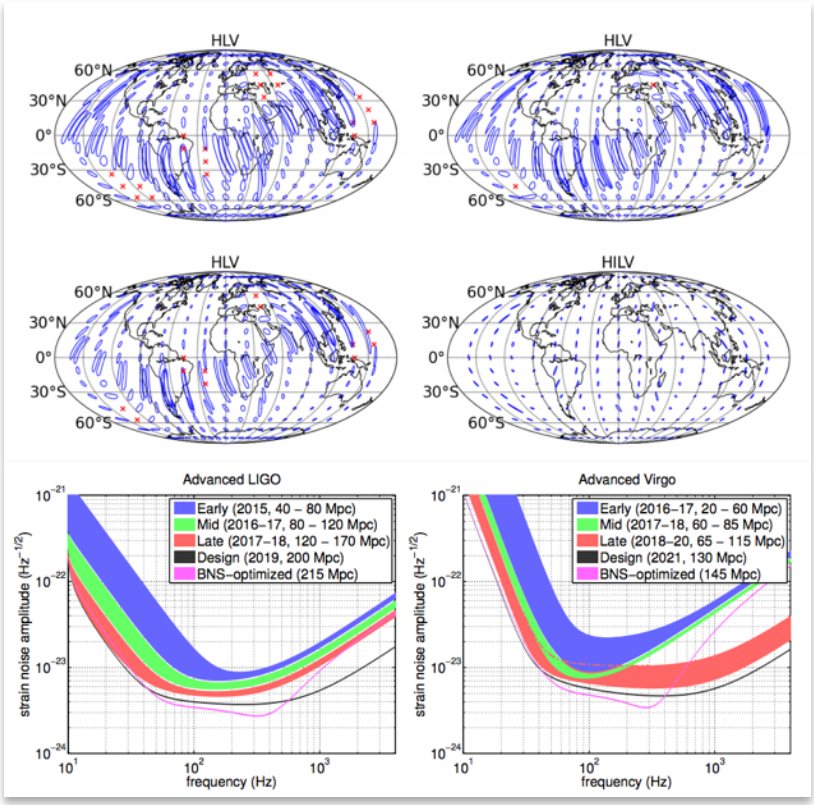
GBM localizations will drastically reduce follow-up area, and will help to identify the host galaxy, redshift, environment, etc.



LIGO/Virgo Collaboration (2013)

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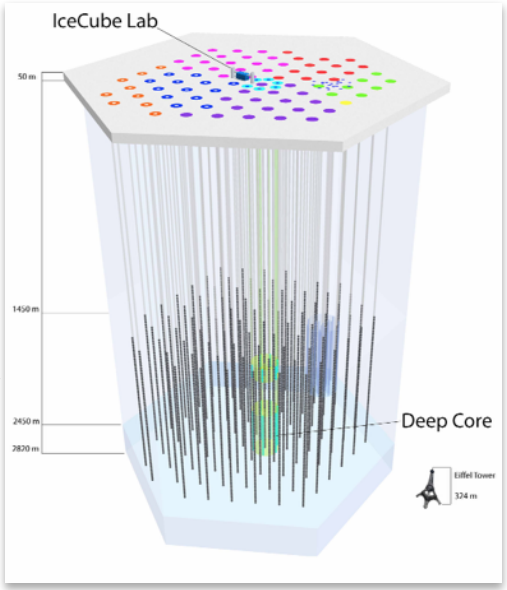
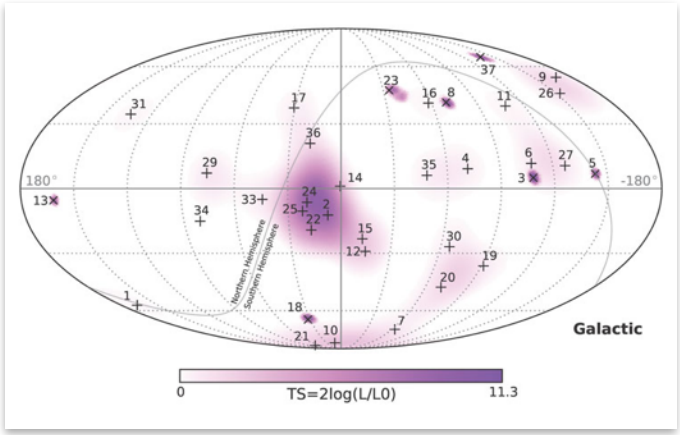
Fermi's wide sky coverage provides unique capability to search for contemporaneous flaring in photon data and neutrinos





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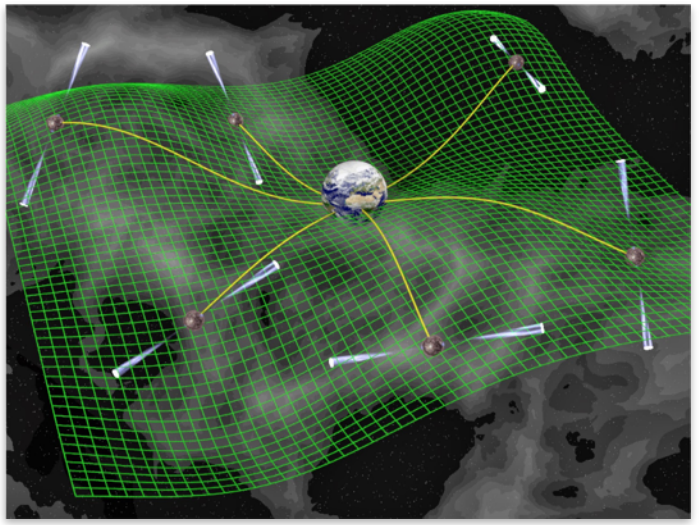
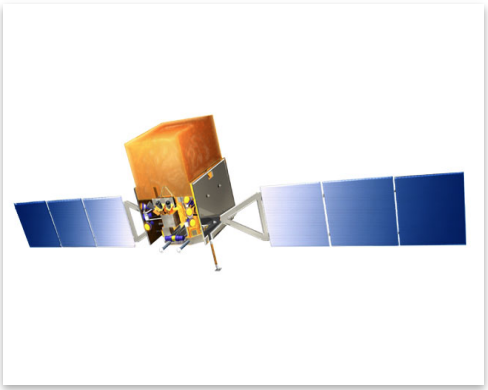


binary periods of ~years are in frequency range of PTAs

evenly sampled all-sky data is ideal for searching for these periodicities



Ackermann et al. 2015, arXiv:1509.02063

NASA Astrophysics Senior Review

- **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

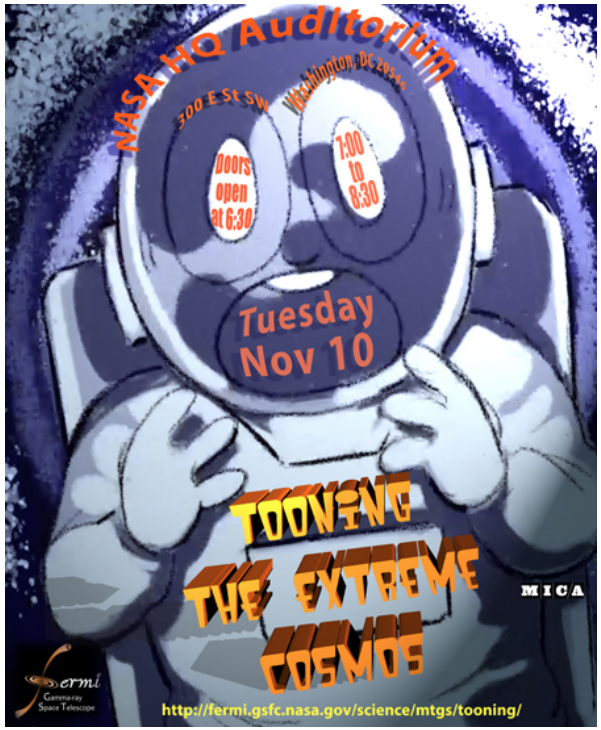
- **2016 Astrophysics Senior Review Proposal**
  - **Propose to extend the *Fermi* mission through to 2020**
  - **Draft proposal in preparation - due Jan 22, 2016**
  - **The *Fermi* Mission welcomes input from the community, especially throughout the *Fermi* Symposium**
- **Please continue to think of new and innovative ways to use the *Fermi* instruments and data**
- **Looking forward to many interesting results this week!**

Advertisements

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!