



Fermi
Gamma-ray Space Telescope

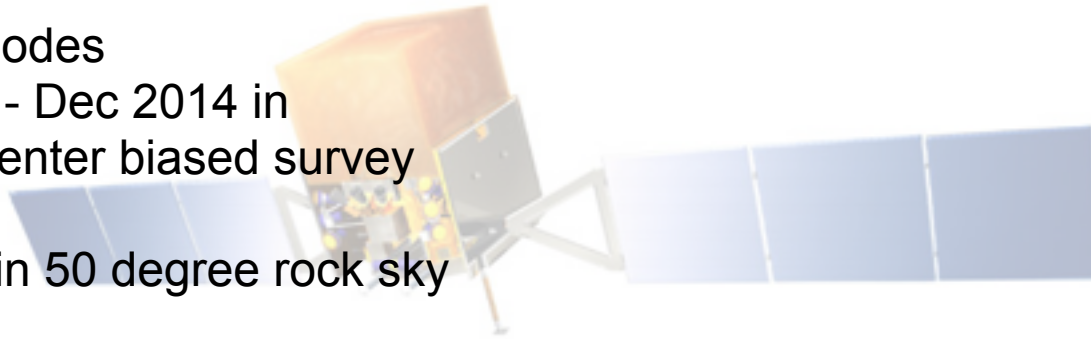
***Fermi* Mission Status and Plans for the Future**

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



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)

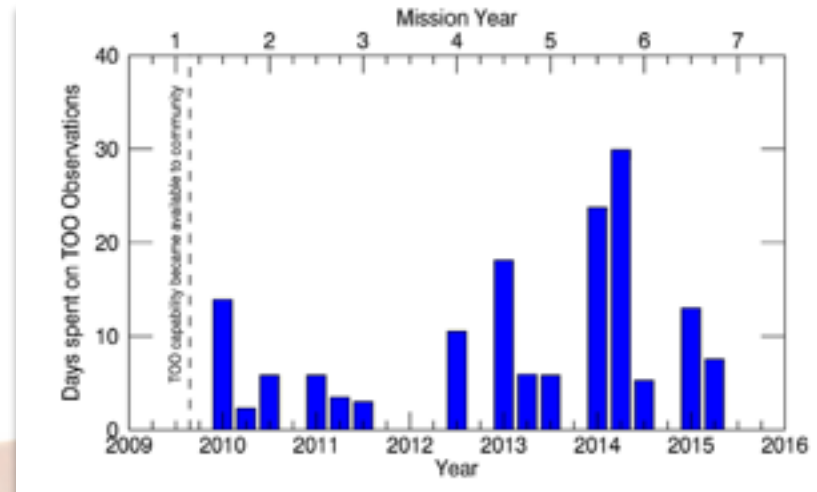


Fermi Spacecraft & Operations

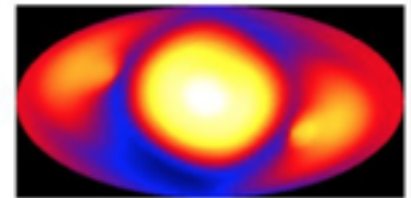
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• Observation Modes

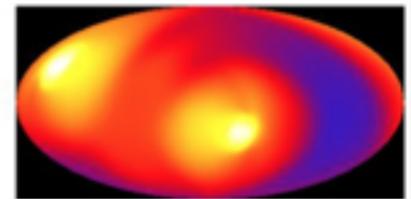
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Galactic Center Pointing



50 degree rocking survey mode



TOOs since last Symposium:

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

More information on Fermi TOOs:

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



Pass 8 improvements in:

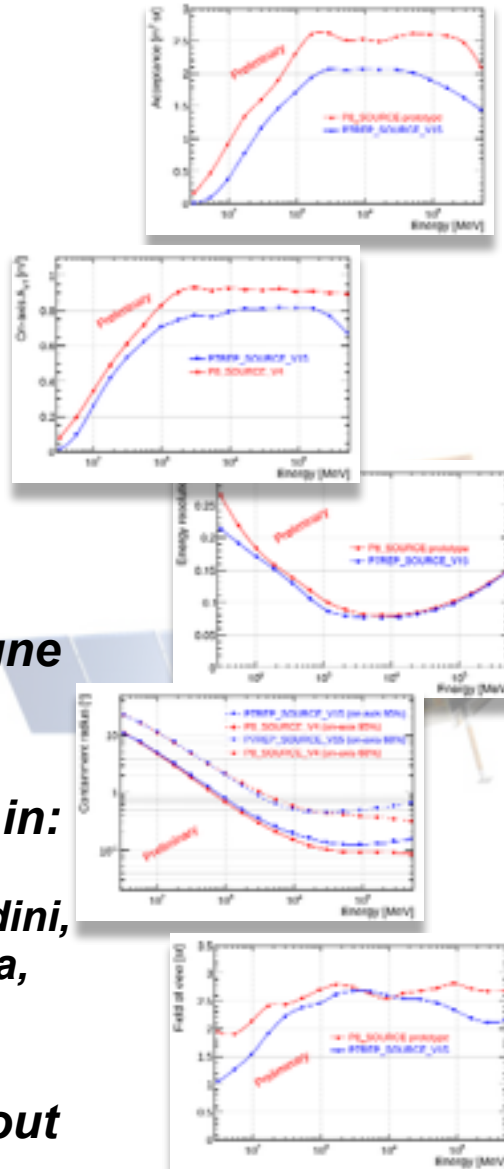
- acceptance
- effective area
- energy resolution
- PSF
- sensitivity
- field of view

P8 public release June 24, 2015

More Pass 8 details in:

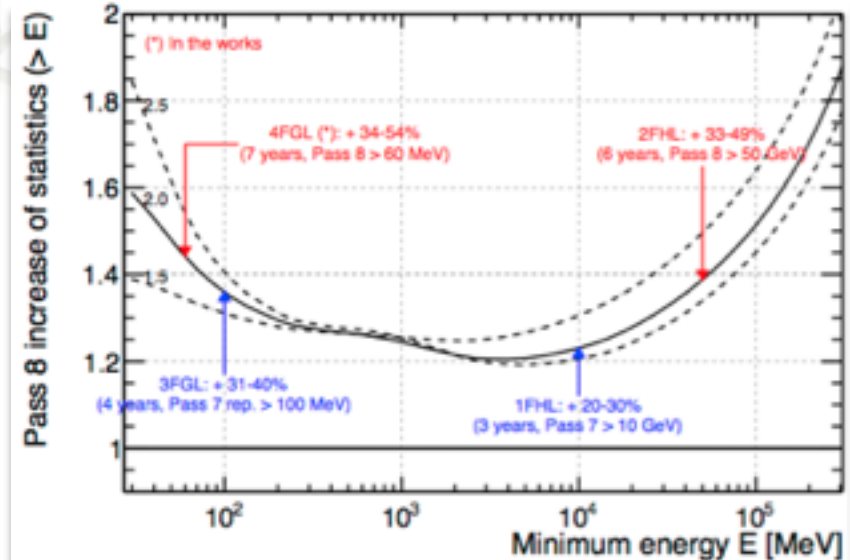
- talk by M. Wood
- posters by L. Baldini, E. Bloom, M. Testa, M. Wood

P8 Results throughout the Symposium



Large Area Telescope (LAT)

- Major analysis upgrade with Pass 8 event reconstruction pipeline
- New catalogs





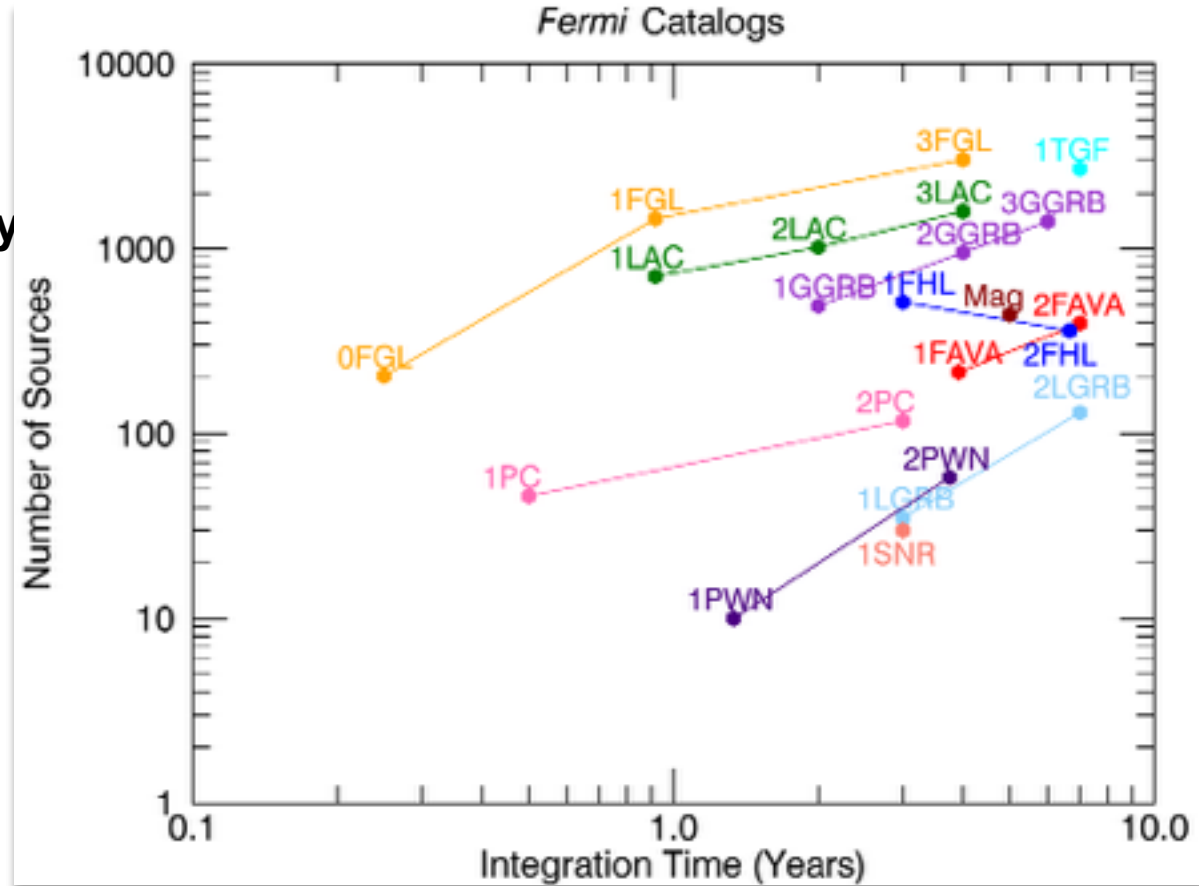
Fermi Catalogs

• LAT

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

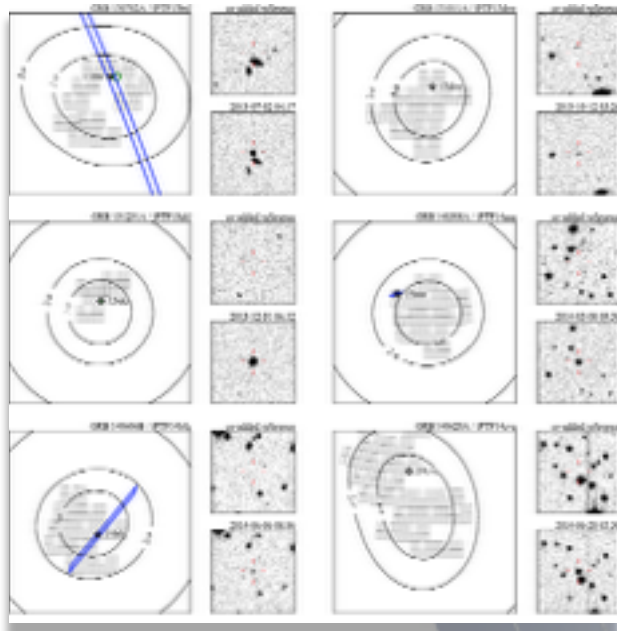
• GBM

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



See talks by M. Ajello, D. Kocevski

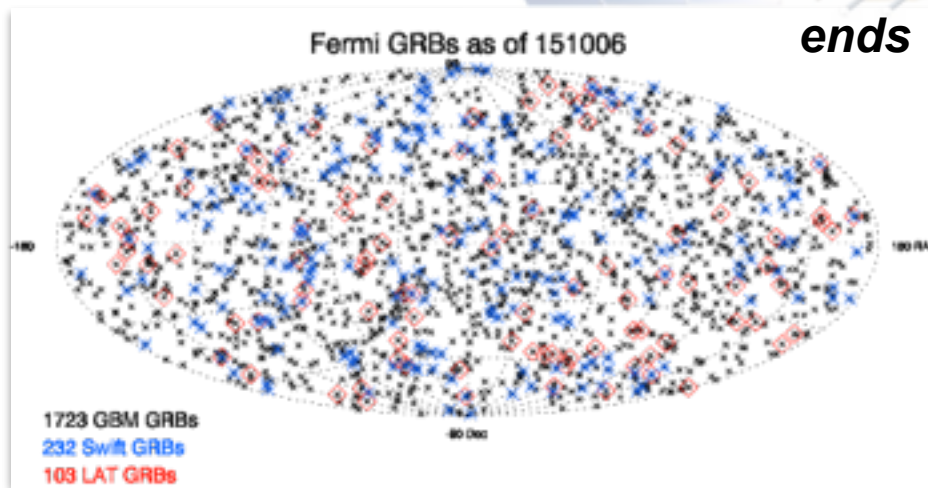
See posters by G. Vianello, T. Brandt, G. Fitzpatrick, A. Allafort, D. Yu



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 $\sim 4.5^\circ$ radius + contours ~ 1 minute after trigger ends***



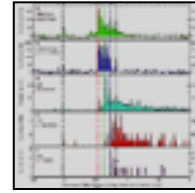
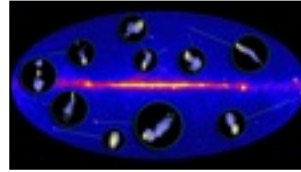
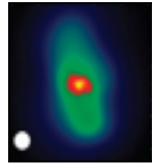
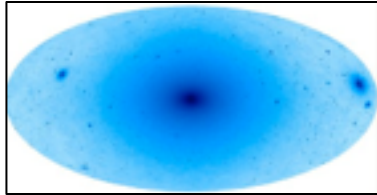
Gamma-ray Burst Monitor (GBM)

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

Fermi Science Menu



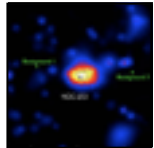
Dark Matter searches



GRBs

Blazars

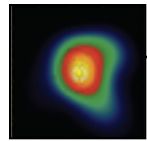
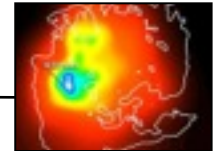
Radio Galaxies



Starburst Galaxies

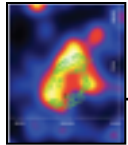
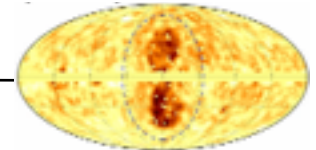
Extragalactic

LMC & SMC

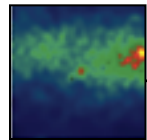


Globular Clusters

Fermi Bubbles

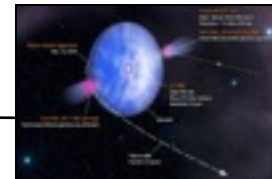


SNRs & PWN



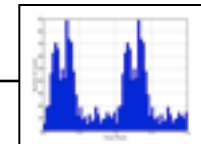
Novae

γ -ray Binaries

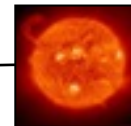


Galactic

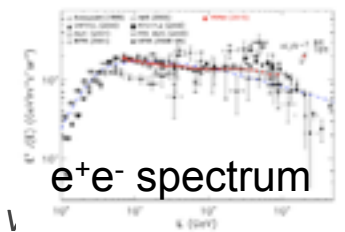
Pulsars: isolated, binaries, & MSPs



Sun: flares & CR interactions



Terrestrial γ -ray Flashes



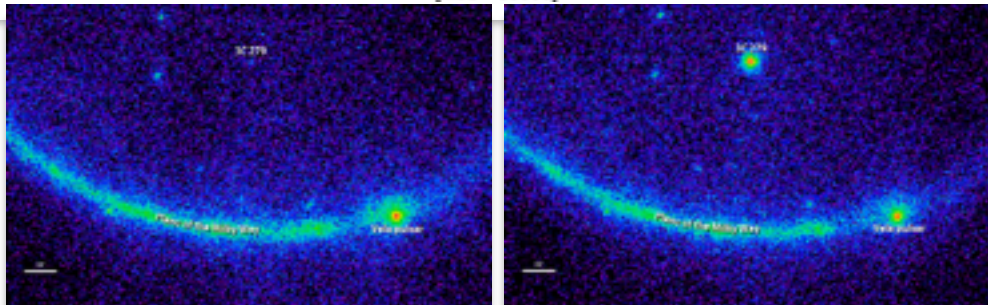
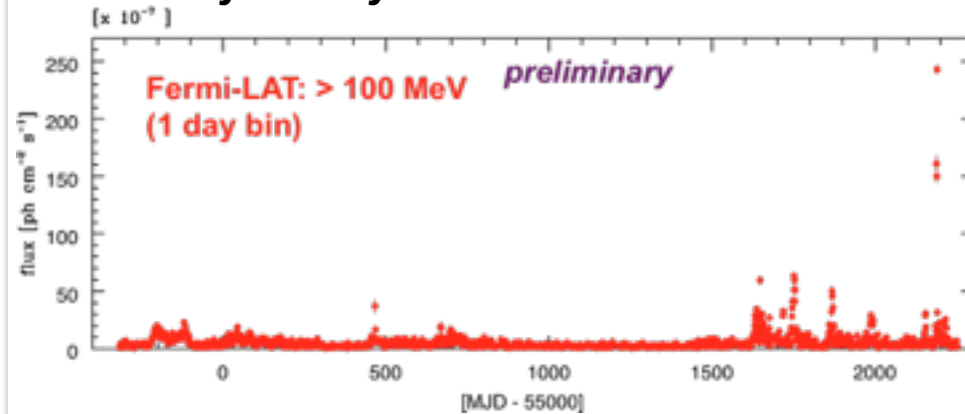
Unidentified Sources



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

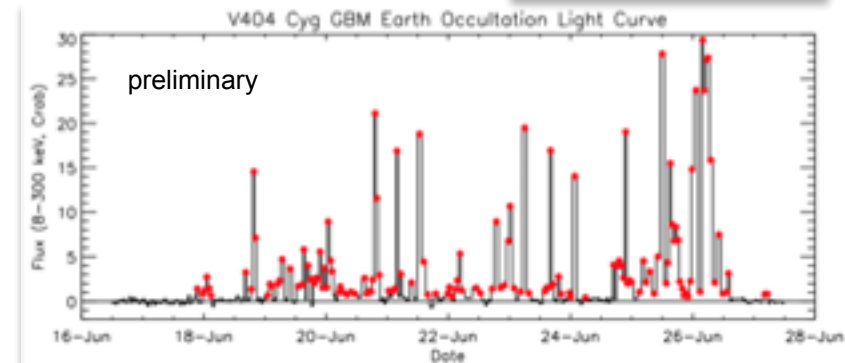
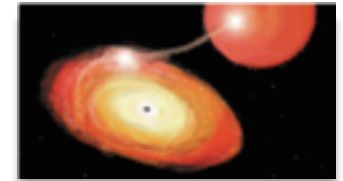
See talk by M. Hayashida



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

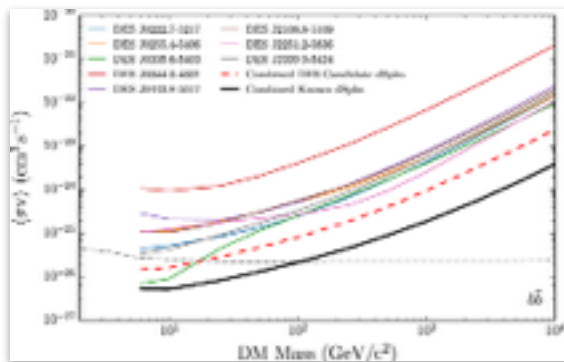




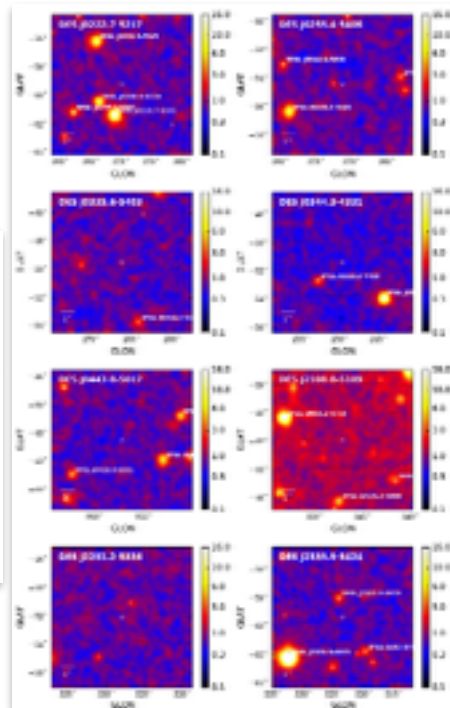
dSph galaxies limits

- 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



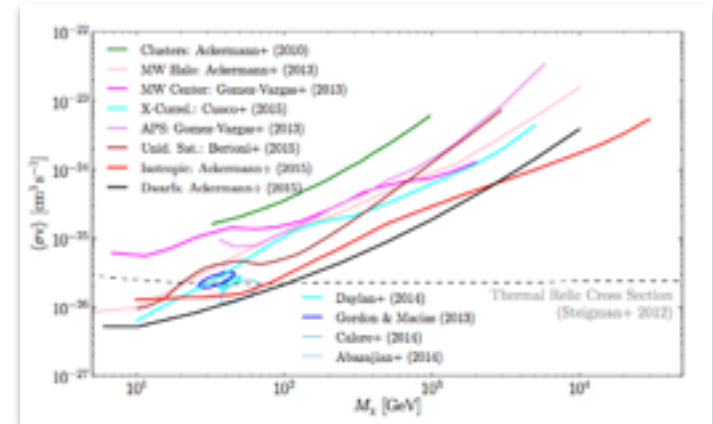
Drlica-Wagner et al. (2015)



Galactic Center Excess

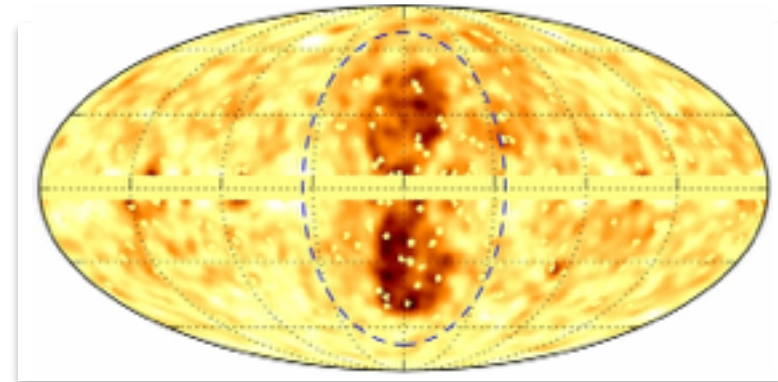
- 1-10 GeV excess within 10° of Galactic center
- ~40 GeV DM annihilation?
- or unresolved astrophysical sources?

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



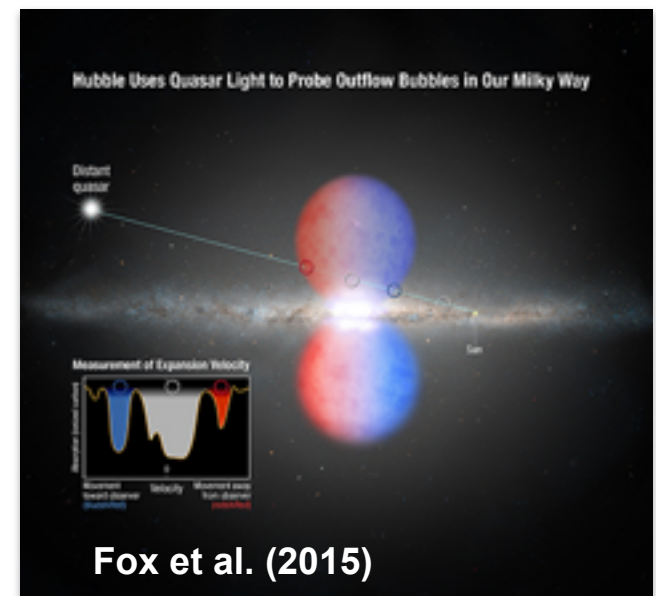
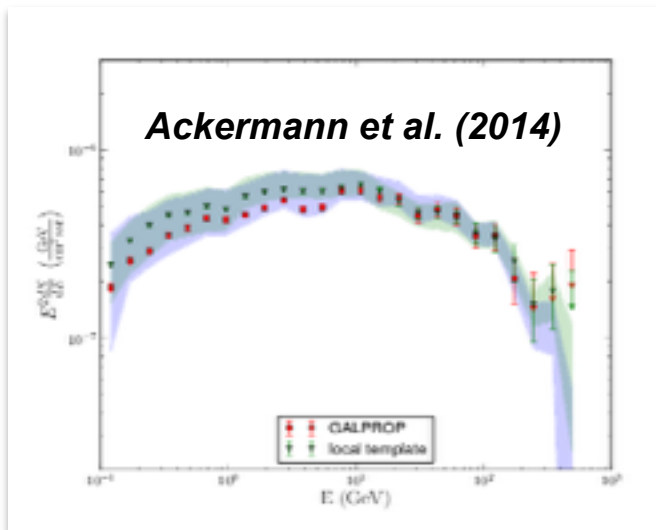


- High-energy cutoff at ~ 100 GeV
- Significant enhancement in south-eastern region
- Evidence >900 km s $^{-1}$ wind via HST UV spectroscopy of quasar behind bubbles indicating Galactic Center activity in last ~ 2.5 -4 Myr



Ackermann et al. (2014)

See talks by M. Su & V. Dogiel





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

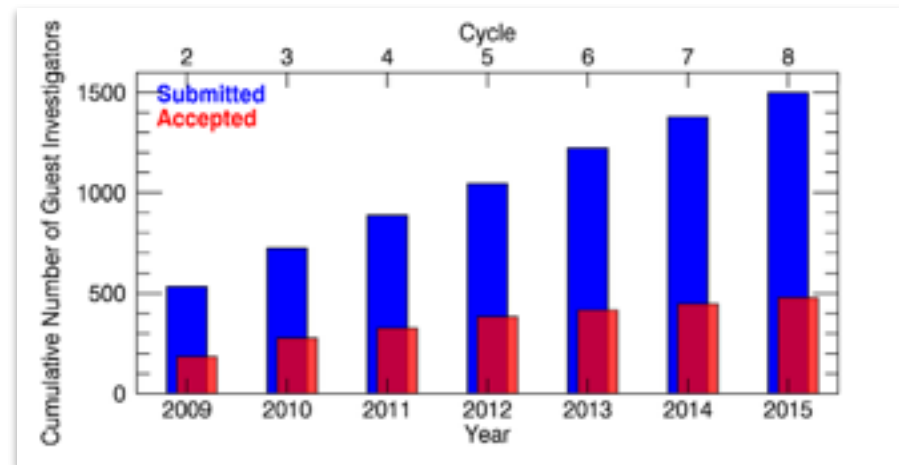
Funds are dispersed to GIs as soon
as they are available

<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





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**

Improvements to Observations of Short and Medium Timescale Transients



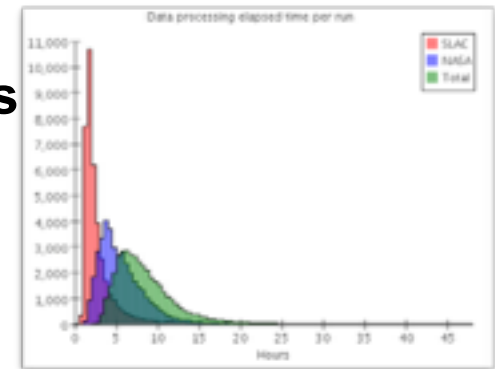
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All data go public immediately

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**

Improvements to Observations of Short and Medium Timescale Transients



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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](#)



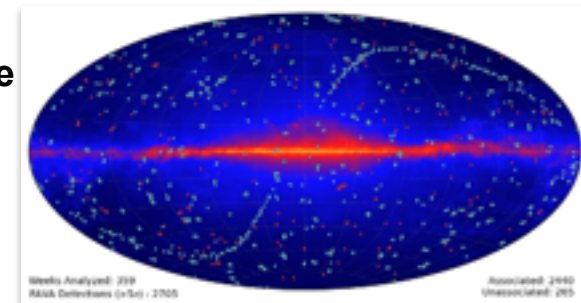
- Reduce data latency
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Fermi All Sky Variability Analysis (FAVA)

1 week search timescale (+3 day)

aperture photometry technique

See talk by D. Kocevski



Improvements to Observations of Short and Medium Timescale Transients



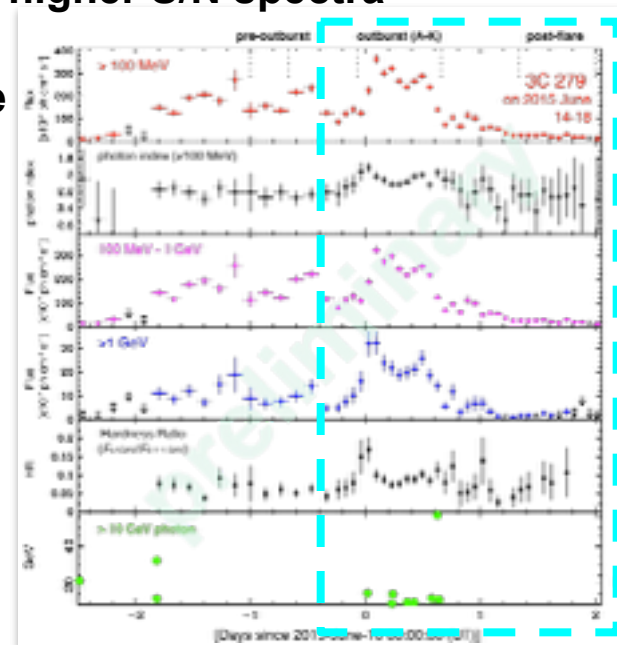
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Short-term (days-weeks) pointed observations

- increase exposure $\sim x2$ 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/>

Improvements to Observations of Short and Medium Timescale Transients



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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 ($\sim t$, photon limited)
- relative to low energies ($\sim t^{1/2}$, background limited)

Diffuse emission model

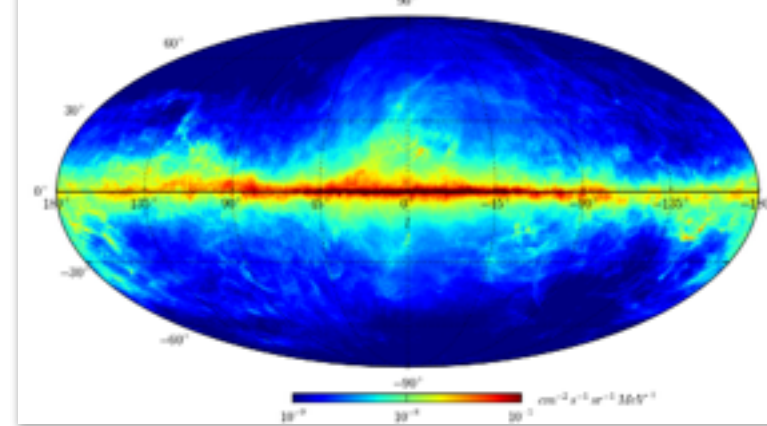
- needed for all medium/long timescale analyses
- built from surveys of interstellar gas, *Fermi* data
- especially difficult at high energies where no templates exist and unique features (e. g. *Fermi* bubbles)

Updated catalogs

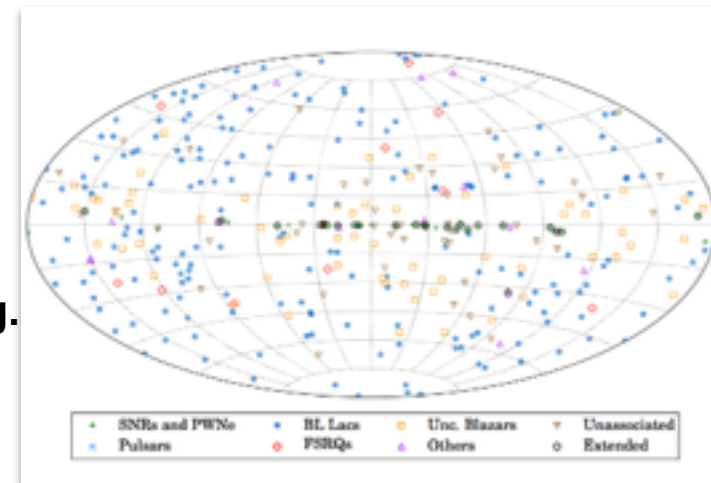
- needed for source populations at high energies (e.g. 2FHL)

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

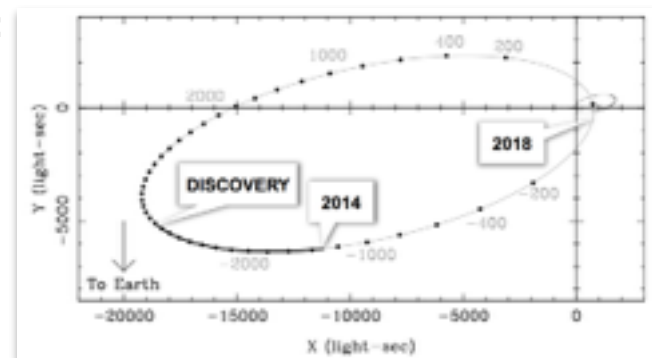
- Periodic
 - Binaries with periods of years
 - Solar flares
- Variable
 - AGN variability to correlate with multiwavelength studies
- Rare Events
 - Pulsar state transitions
 - Outbursts (e.g. Crab)

Deep stares require updated diffuse & sources catalogs

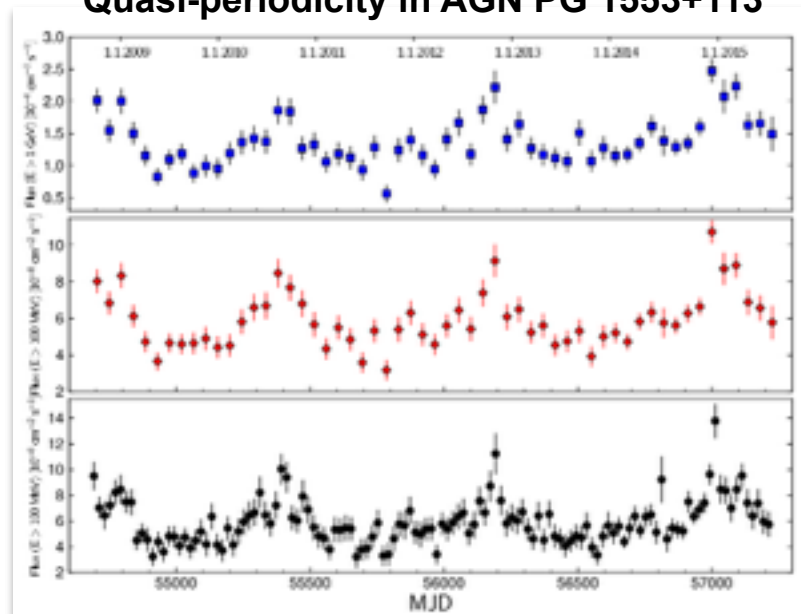
Long baseline variability requires regular calibration & understanding of the instrument stability

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



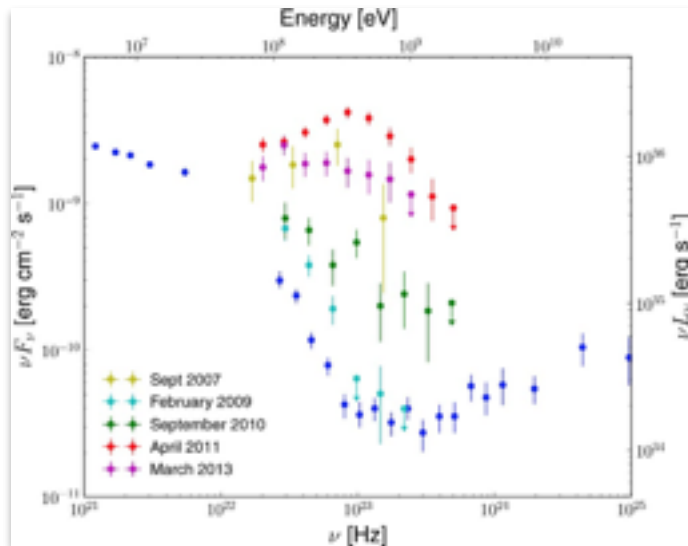
Quasi-periodicity in AGN PG 1553+113



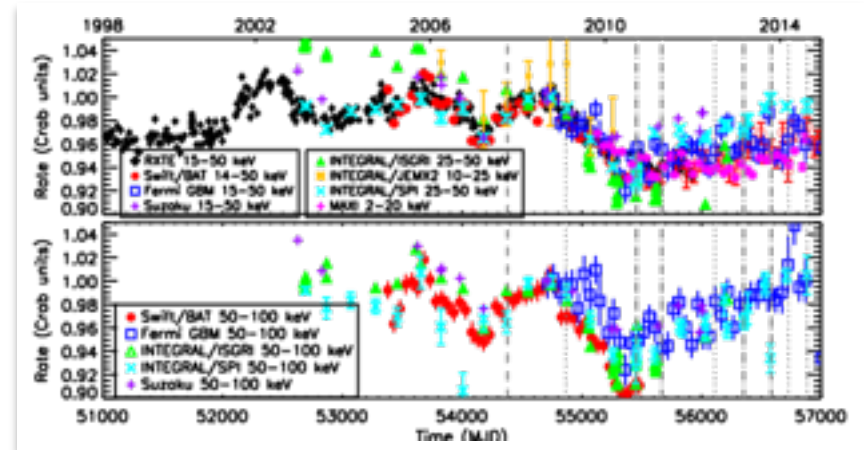
Ackermann et al. 2015, arXiv:1509.02063



- Gamma-ray pulsations up to ~ 1.5 TeV (MAGIC Collab., arXiv: 1510.07048)
- Nebula has shown bright flares in high-energy gamma-rays lasting \sim 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)

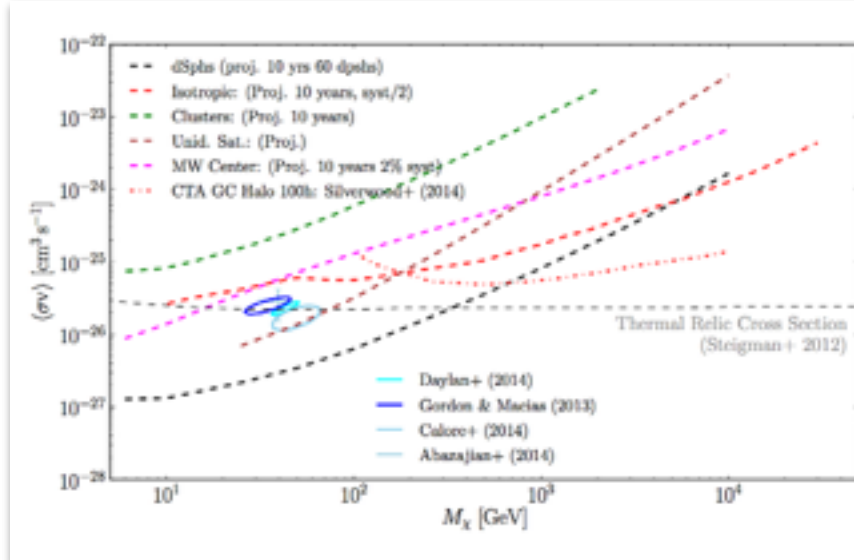


C. Wilson-Hodge

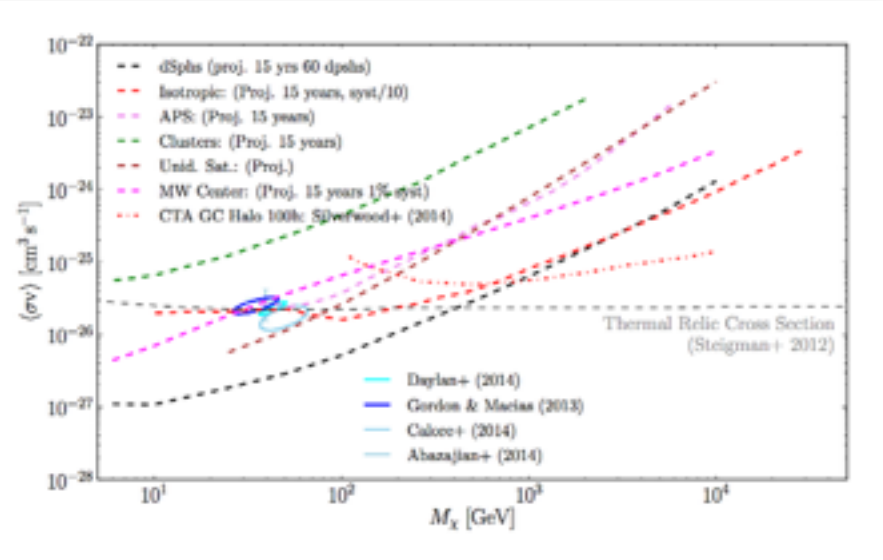


- Additional dwarf spheroidal galaxies will likely be discovered by large-scale optical surveys (e.g. DES)
- Mass range excluded by LAT will reach ~ 350 GeV over next 4 years

10 Years of LAT Data



15 Years of LAT Data





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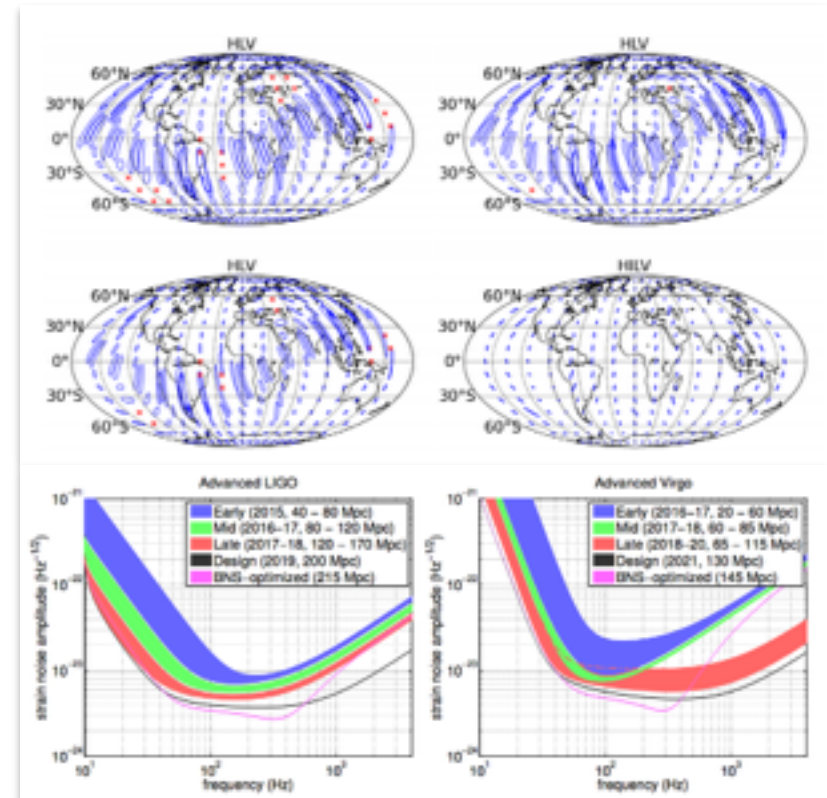
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GBM localizations will drastically reduce follow-up area, and will help to identify the host galaxy, redshift, environment, etc.



LIGO/Virgo Collaboration (2013)



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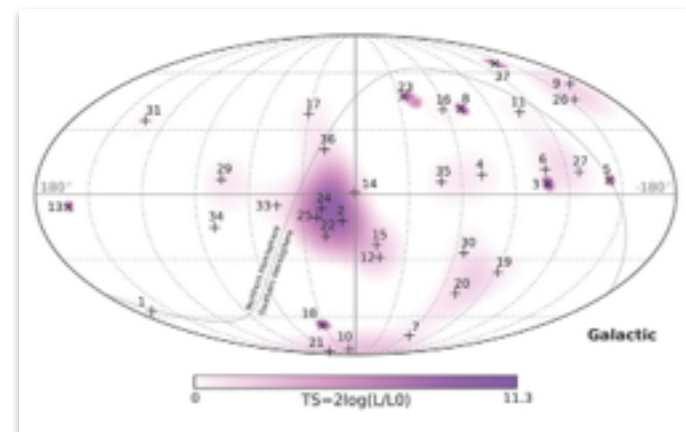
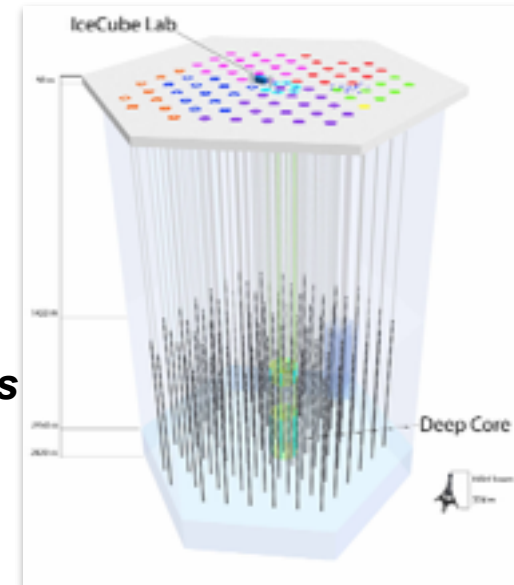
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Fermi's wide sky coverage provides unique capability to search for contemporaneous flaring in photon data and neutrinos



IceCube Collaboration (2013)



Advanced LIGO/Virgo

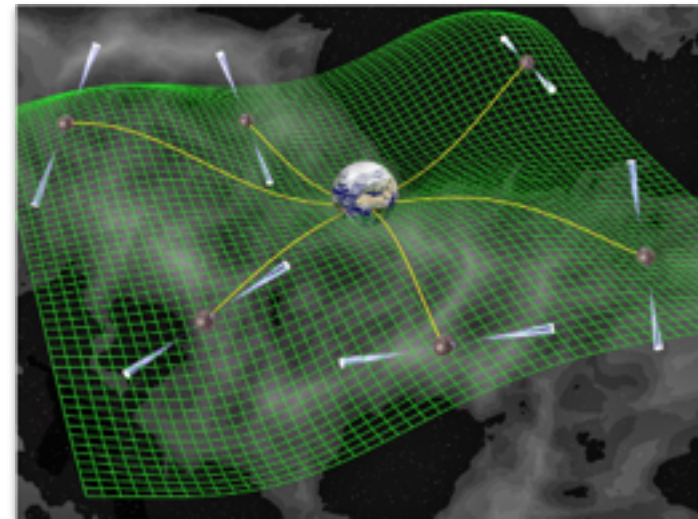
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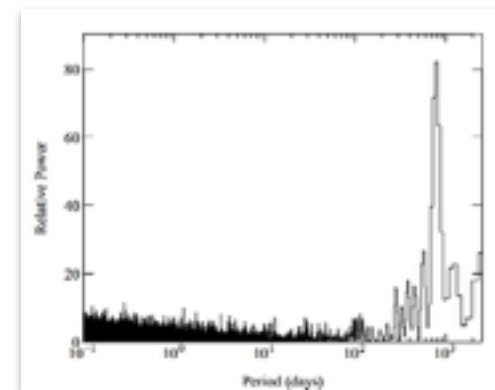
Pulsar Timing Arrays

- **Fermi** continues to provide additional pulsars, and putative gravitational wave sources like possible SMBH binary PG 1553+113
- *talk by S. Ciprini & P. Shawhan*



*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



- **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/>



- **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!**



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!