



Recent Results on SNRs and PWNe from the Fermi Large Area Telescope

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On behalf of the Fermi LAT Collaboration*

Fermi LAT Collaboration

Principal Investigator: Peter Michelson (Stanford University)

390 Scientific Members (including 96 Affiliated Scientists, plus 68 Postdocs and 105 Students)

Managed at SLAC

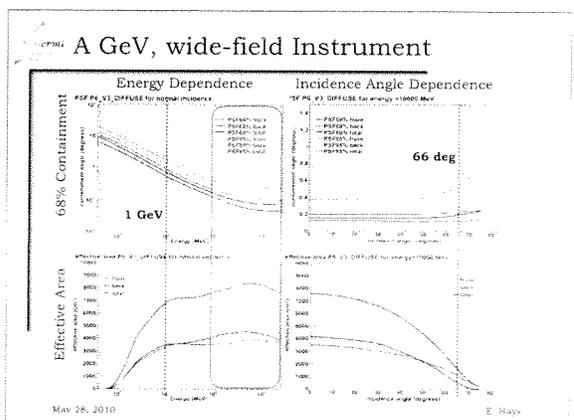
- France: IN2P3, CEA/Saclay
- Italy: INFN, ASI, INAF
- Japan: Hiroshima University, ISAS/JAXA, RIKEN, Tokyo Institute of Technology
- Sweden: Royal Institute of Technology (KTH), Stockholm University
- United States: Stanford University (SLAC and HEPL/Physics), University of California at Santa Cruz - Santa Cruz Institute for Particle Physics
- International Space Flight Center: Naval Research Laboratory, Sonoma State University, Ohio State University, University of Washington

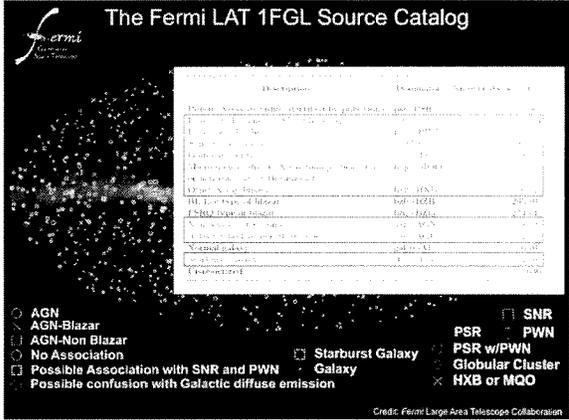
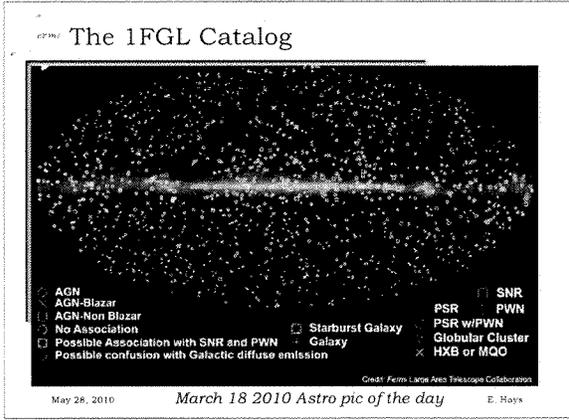
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Galactic Results from LAT

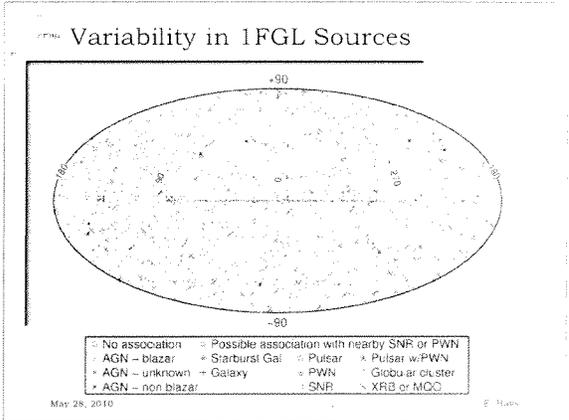
- + 1FGL Galactic populations
 - + The seen, the unseen, and the unknown
- + Selected Highlights
 - + Pulsars
 - + Pulsar Wind Nebulae
 - + Supernova Remnants
 - + Transients
- + Future Prospects

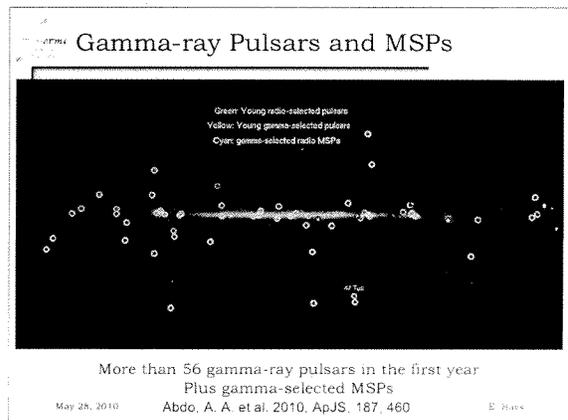
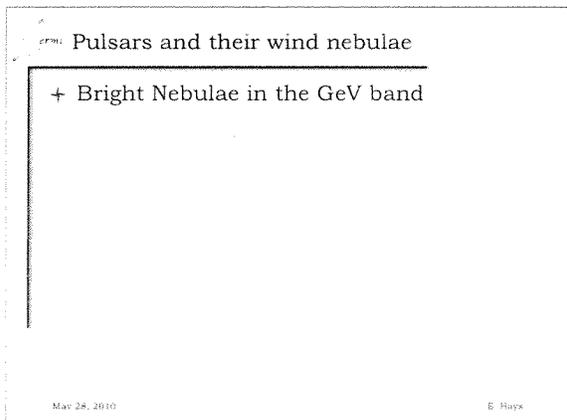
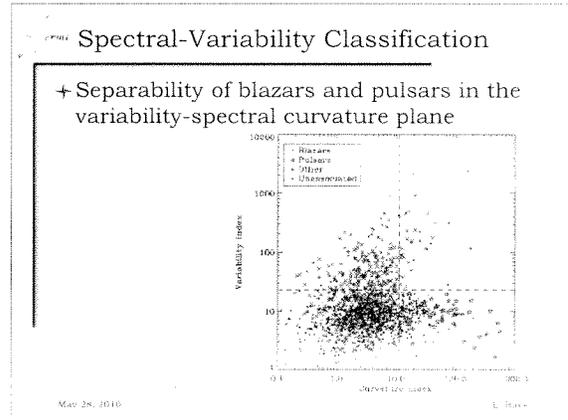
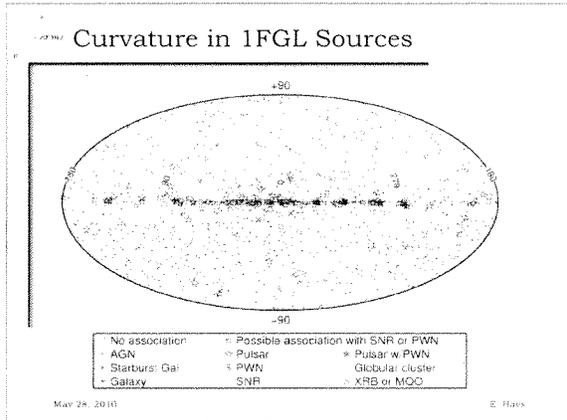
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- ### Unidentified Gamma-ray Sources
- + Previous MeV-GeV energy gamma-ray missions left a legacy of "unidentified" sources (~2/3 of 3EG catalog)
 - + Unidentified meant multiple possible candidates OR no plausible candidates (unassociated)
 - + LAT first catalog <50% unassociated
 - + LAT associations greatly aided by
 - + Dramatically improved gamma-ray localization
 - + Dedicated catalogs of potential gamma-ray counterparts
 - + Multiwavelength searches
 - + LAT identifications from
 - + Periodicity
 - + Spatial morphology
 - + Correlated variability with other observations
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GeV PWN Search

- + Known high-energy PWNe
 - + From X-ray and TeV observations
 - + Crab, Vela X, MSH 15-52 nebulae...
- + Off-peak searches of gamma-ray pulsars
 - + Catalog from LAT team underway
- + Young, energetic radio pulsars
- + TeV nebula candidates

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Crab Pulsar and Nebula

Pulsar 100 MeV to 20 GeV

Hyper-exponential cutoff excluded at ~ 5 sigma.
Consistent with emission well above the neutron star surface

Nebula from MeV to TeV

Inverse Compton emission consistent with mean magnetic field in nebula $100 \mu\text{G} < B < 200 \mu\text{G}$

Abdo, A. A. et al. 2010, ApJ, 708, 1254 E. Hays

Vela X: Nebula of the Vela Pulsar

Excess map

Excess counts $E > 800$ MeV

Profile

Data compared with a simulated point source at position of Vela Pulsar

Abdo, A. A. et al. 2010, ApJ, 713, 146 E. Hays

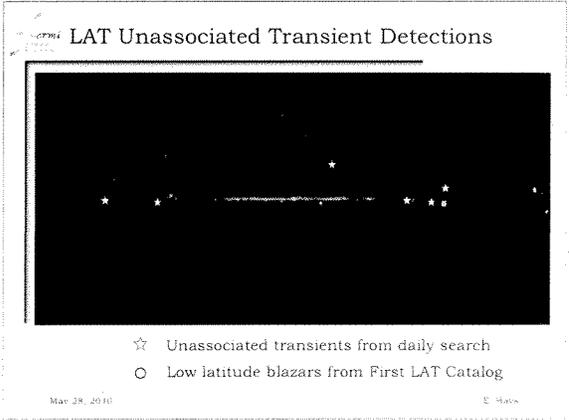
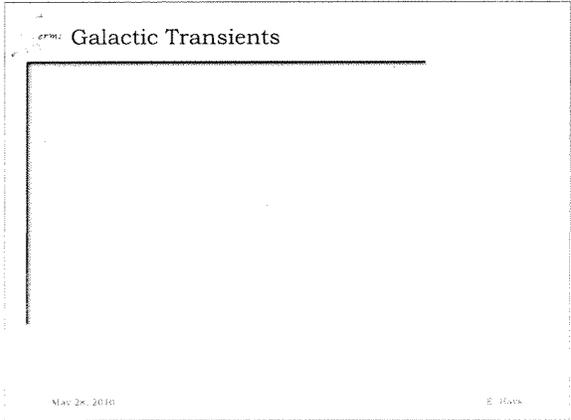
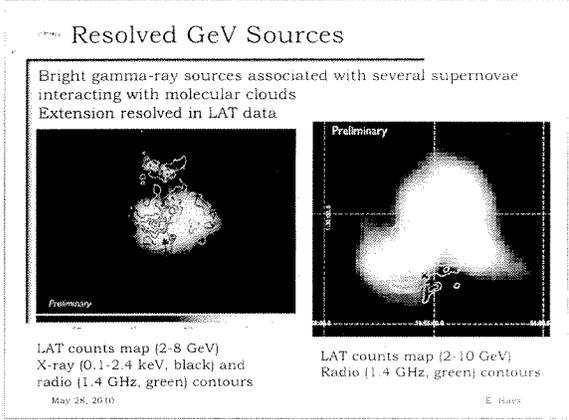
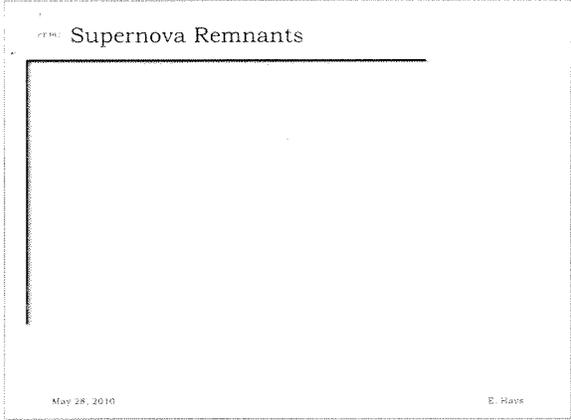
MSH 15-52

$E > 1 \text{ GeV}$

$E > 10 \text{ GeV}$

Legend: \bullet Pulsar, \circ Synchrotron, \square on CRAB, \triangle on IS, \diamond on Starlight, \times on IS

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Gamma rays from a Nova

- + Fermi J2102+4542
- + Located in the direction of the Cygnus region
- + Bright, high confidence, detected over several days by automated processing
- + No likely blazars in error circle...

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V 407 Cygni - a symbiotic nova

- + Position and timing consistent with V 407 Cygni, a recurrent nova detected in outburst ~2 days before the Fermi report

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V407 Cygni: a variable star

Symbiotic binary:
White dwarf star and red giant star orbiting each other

Near Deneb in Cygnus

Variability from

- Mira variable star
- White dwarf accretion
- Binary interaction

A complex and fascinating system!

V407 Cyg ~ 6000 light years away

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March 11 - A Nova!

Hydrogen accreting on to the surface of the white dwarf ignites a nuclear explosion (30-60 of these per year in Milky Way)

Candidate nova discovered by amateur astronomers, Nishiyama and Kobashima

Fermi detects a new gamma-ray source in the same field on March 13 (ATEL #2487)

Usually below here

Spectrum does not look typical - a symbiotic recurrent nova?
Very few systems explode on decade timescales (RS Ophiuchi ~20 yr period)

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Symbiotic Nova

- + Symbiotic Binary System: White dwarf + red giant system
- + Nova: White dwarf builds up mass envelope to the point of thermonuclear fusion
 - + Dramatic increase in visual magnitude
- + Recurrent Nova?
 - + Hints but no strong confirmation of previous nova
- + Pre-nova activity
 - + White dwarf shows ongoing variability at level of several in magnitude
 - + V407 Cyg companion is a Mira star showing variability at level of several in magnitude
 - + Dusty environment with stellar wind
- + Origin of the gamma rays?
 - + Strong shock propagating into dense medium around giant star (and stellar wind)
- + Pion decay or electron processes? (brehmstrahlung)

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Summary

<http://fermi.gsfc.nasa.gov>

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Extras

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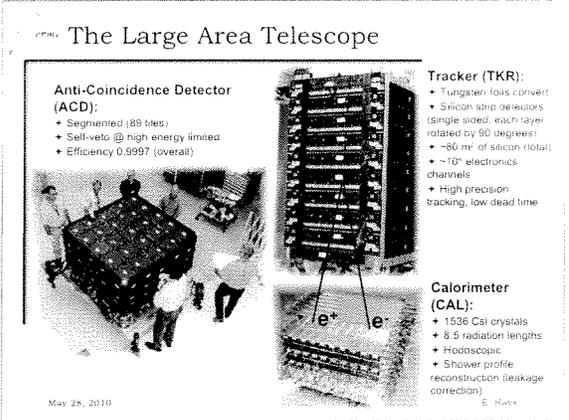
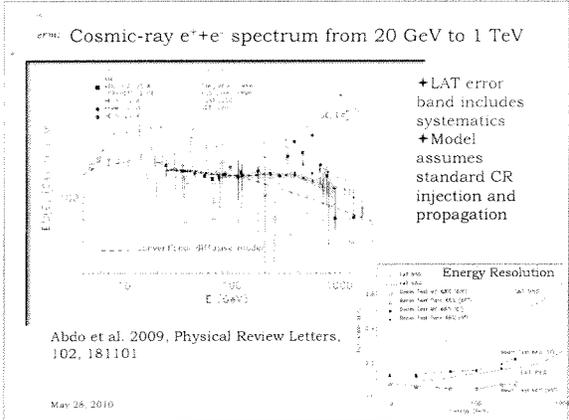
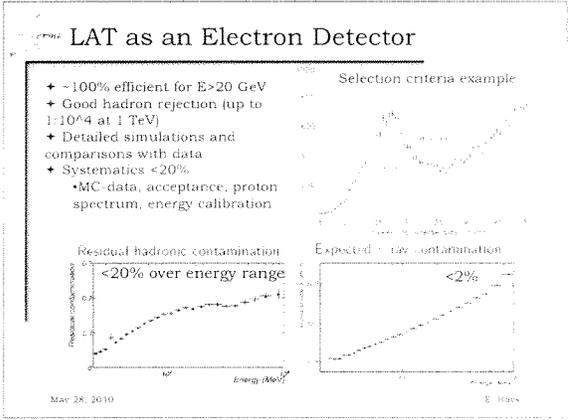
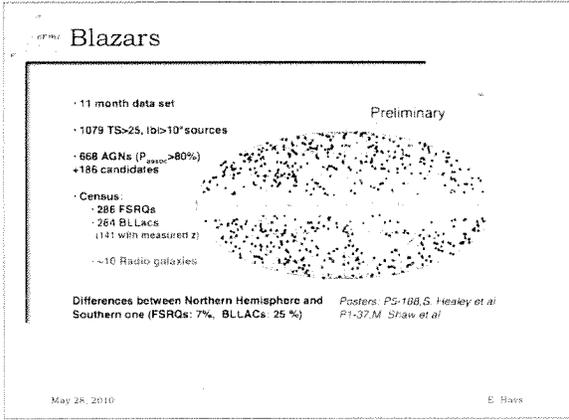
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Pulsars everywhere...

- + >50 gamma-ray pulsars so far
 - + >40 young, energetic pulsars
 - + 9 old, recycled millisecond pulsars
- + Identifying EGRET unidentifieds and LAT unidentifieds
- + Gamma-ray beam is bigger than radio beam
- + Pulsar spectra have exponential cutoffs in the GeV band
- + Gamma rays from outer magnetosphere preferred
- + Bonus: LAT unidentifieds also turning up new radio millisecond pulsars



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The Fermi Observatory

Large Area Telescope (LAT)

- Large field of view (>2.4 sr)
- Entire sky every 3 hrs (every 2 orbits)
- Broad energy range (20 MeV - >300 GeV)

Gamma-ray Burst Monitor (GBM)

- Views entire unocculted sky
- NaI:** 8 keV - 1 MeV
- BGO:** 150 keV - 40 MeV

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Large Area Telescope (LAT)

ACD scintillator
89 tiles

Tracker
Si strip detectors
Tungsten foil converters
pitch = 228 μm
 8.8×10^5 channels
18 planes

Calorimeter
CsI crystals
hodoscopic array
 6.1×10^3 channels
8 layers

4x4 detector array

Large Field of View >2.4 sr
Broad Energy Range 20 MeV - >300 GeV

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LAT Sensitivity with Time

Transient Science: Flares, bursts, multiwavelength campaigns, unidentified transients
Accumulated Science: New source types, populations, long-term monitoring, spatially extended and diffuse studies
 Deepest and most uniform survey of the sky at these energies

All-sky coverage in ~3 hrs (2 orbits)

Minor asymmetry due to passages through South Atlantic Anomaly

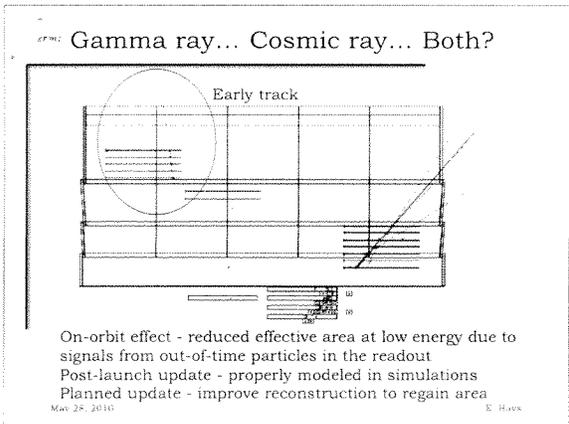
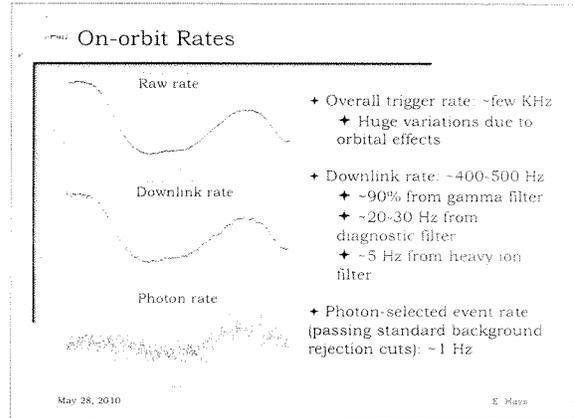
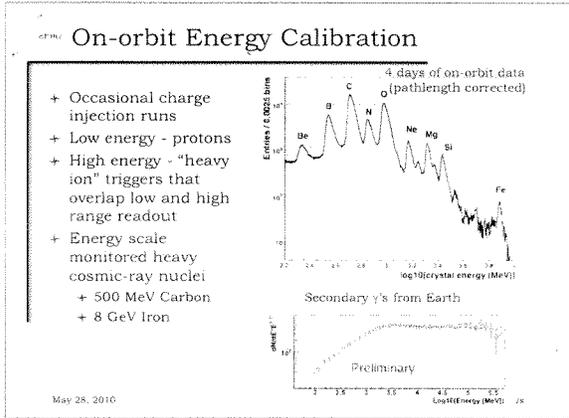
Energy (GeV) per day
100 10 1 0.1 0.01 0.001 0.0001 0.00001

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Candidate Gamma-ray Events

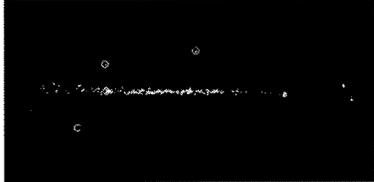
Green crosses -> detected positions of the charged particles
Blue lines -> reconstructed track trajectories
Yellow line -> estimated direction of candidate gamma ray
Red crosses -> detected energy depositions in the calorimeter

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LAT Automated Science Processing

Automatic transient monitoring
 All-sky search runs every 6 hours, 1 day, 1 week



Typical count map for 6 hours (E > 100 MeV)

LAT flare advocates monitor results and trigger multiwavelength follow-up.
 Reports at <http://fermisky.blogspot.com/>

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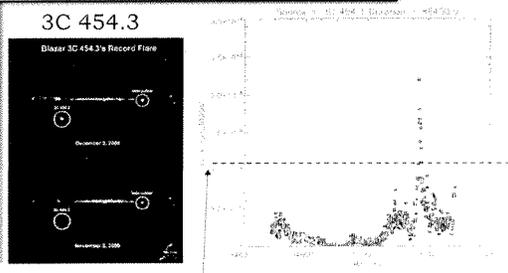
Reported GeV Flares

- + Astronomers Telegrams
 - + >70 since July 2008
 - + Associated blazars plus 6 initially unidentified transients
- + Fermi Gamma-ray Sky Blog
 - + notes on daily and weekly source activity
 - + <http://fermisky.blogspot.com>

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Early Activity and Spectacular Flare

3C 454.3
 Blazar 3C 454.3's Record Flare

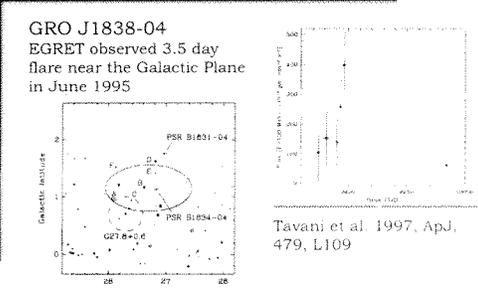


Photon flux of brightest persistent GeV source, Vela Pulsar (~1 γ every 2 min)

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Gamma-ray Transients near the Galactic Plane

GRO J1838-04
 EGRET observed 3.5 day flare near the Galactic Plane in June 1995



Tavani et al. 1997, ApJ, 479, L109

No blazar candidates found

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