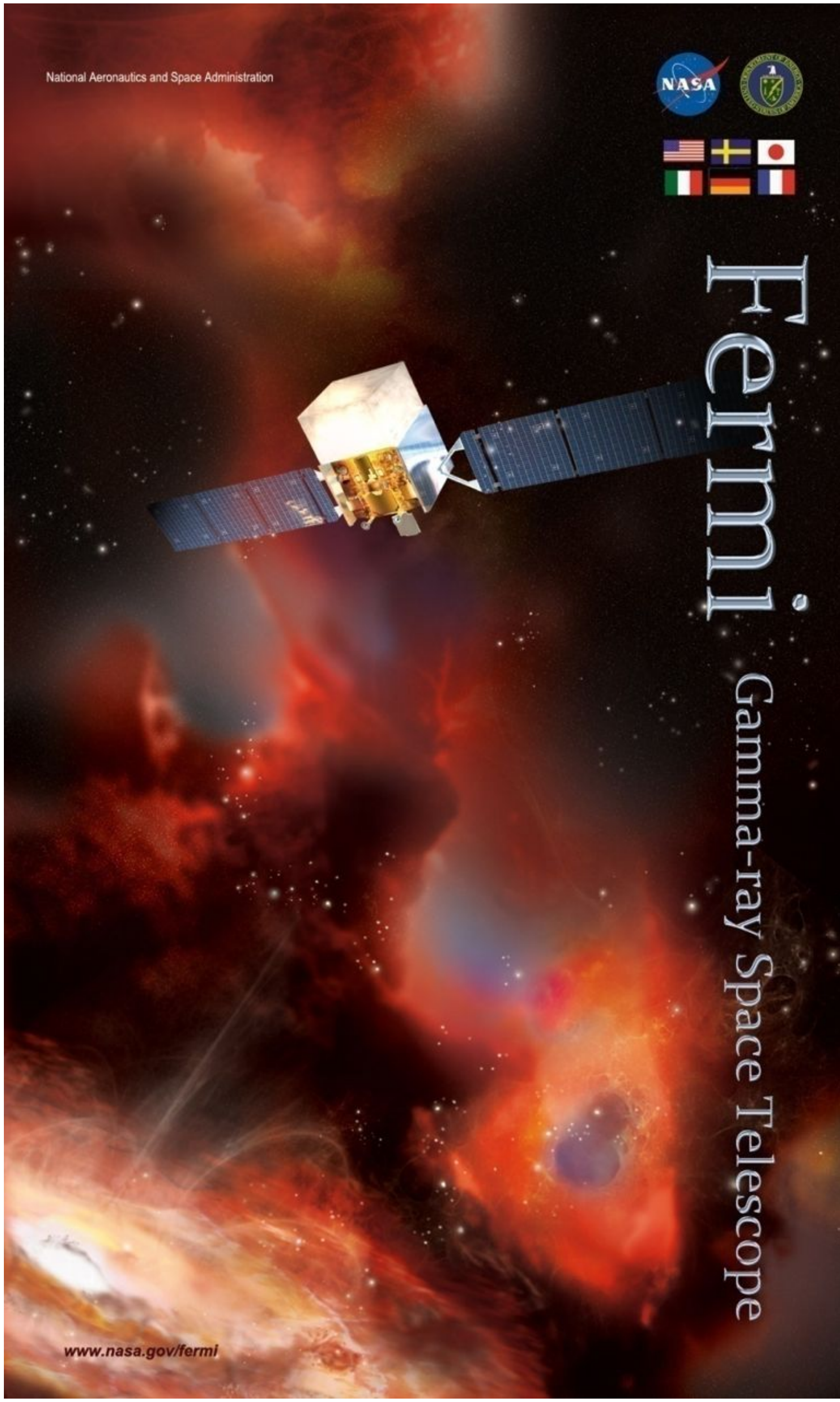

Fermi at Three

Status and Some Highlights from the Fermi Gamma-ray Space Telescope and Personal Reminiscences

JE65

S. Ritz
ritz@scipp.ucsc.edu

See http://www-glast.stanford.edu/ and links therein

Fermi Gamma-ray Space Telescope

Way Back

Nuclear Physics B304 (1988) 877–908
North-Holland, Amsterdam

DETAILED NEUTRINO SPECTRA FROM COLD DARK-MATTER ANNIHILATIONS IN THE SUN

S. RITZ[1] AND D. SECKEL[2]
CERN, Geneva, Switzerland

Received 12 October 1987

Cold dark-matter particles captured by the Sun can annihilate and may produce an observ-
ble flux of high-energy neutrinos. We discuss the effects of the solar medium upon the neutri
flux. Muons, pions, and kaons lose their energy to the medium
so that the flux is dominated by prompt neutrinos from τ, c
differential fluxes of neutrinos from annihilations via $\tau\bar{\tau}$, c
successful model for final states in e^+e^- collisions augmente
tions. Fragmentation and finite-mass effects are important fo
energetic fermions, stopping and absorption are important. We
in a form useful for estimating event rates in terrestrial experim
to the case of a superstring dark-matter candidate.

1. Introduction

Observations of the Universe at many different scal
matter which we cannot see [1]. Many candidates for
advanced, a number of which are species of massive el
these, the ones currently favoured are cold dark-mat
Whilst CDM could be composed of very light particle
models it consists of heavy particles weighing 1 GeV or
test such a hypothesis in a laboratory experiment. On
neutrinos from the annihilations of heavy CDM particle
the Sun [5–7]. This possibility is the subject of this pap
We will not discuss other signals such as gamma ray
from annihilations in the galactic halo [8]; or the man
detection of CDM via the elastic scattering of CDM
low-temperature detector.
Several papers have addressed the possibility of dete
annihilations in the Sun. Only recently has it clearly
medium plays an important role, in that muons, pions, a

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[2] Present address: University of California at Santa Cruz, Santa Cr

0550-3213/88/$03.50 © Elsevier Science Publishers B.V.

Volume 214, number 3 PHYSICS LETTERS B 24 November 1988

COSMIC RAY CONSTRAINTS ON THE ANNIHILATIONS OF RELIC PARTICLES IN THE GALACTIC HALO

John ELLIS, R.A. FLORES[1]
CERN, CH-1211 Geneva 23, Switzerland

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Department of Physics, MIT, Cambridge, MA 02138, USA

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D. SECKEL[3]
University of California, Santa Cruz, CA 95064, USA

and

Joseph SILK
University of California, Berkeley, CA 94720, USA

Received 23 August 1988

Volume 158B, number 5 PHYSICS LETTERS 29 A

LIGHT HIGGS BOSONS AND SUPERSYMMETRY

John ELLIS, K. ENQVIST, D.V. NANOPOULOS
CERN, CH 1211 Geneva 23, Switzerland

and

S. RITZ[1]
University of Wisconsin, Madison, WI 53706, USA

Received 3 May 1985

297

NEW PARTICLES

H. Baer, J. Berdugo, F. Bianchi, F. Carminati, Y. Chang, M. Chen,
C. Dionisi, J. Ellis, P. Folegati, M. Martinez, C. Matteuzzi, P. Mättig,
G. Mikenberg, S. Ritz, P. Sorba, X. Tata, W. Venus, H.G. Wu,
Sau Lan Wu, A. Yagil, G. Yekutieli and G. Zobernig

CONTENTS

Volume 198, number 3 PHYSICS LETTERS B

IMPLICATIONS FOR DARK MATTER PARTICLES OF SEARCHES FOR ENERGETIC SOLAR NEUTRINOS

John ELLIS, R.A. FLORES
CERN, CH-1211 Geneva 23, Switzerland

and

S. RITZ
Physics Department, University of Wisconsin, Madison, WI 53706, USA

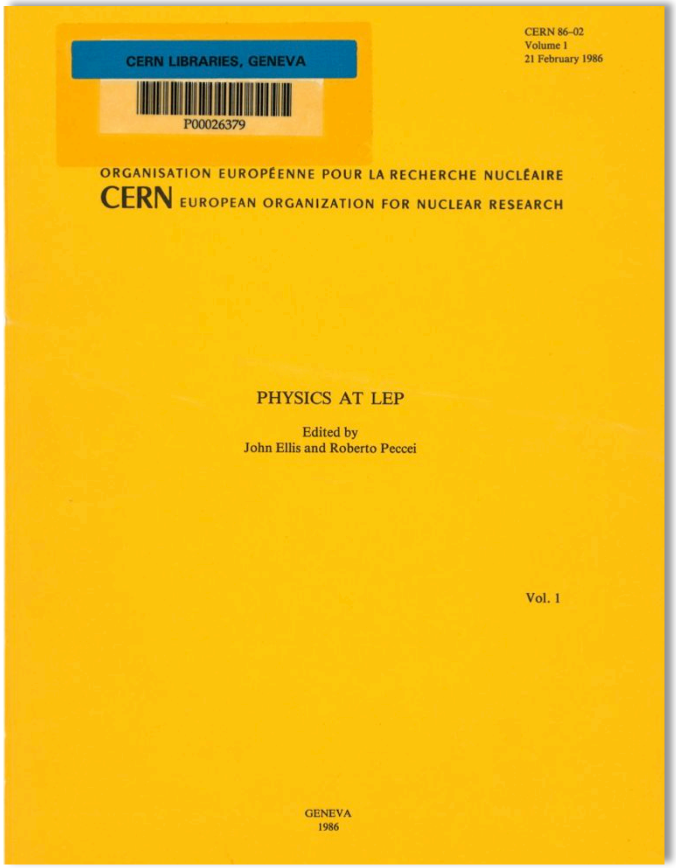
Received 28 August 1987

We investigate whether recent searches for energetic solar neutrinos give new constraints on candidate dark-matte
such as photinos $\tilde{\gamma}$ and higgsinos $\tilde{h}$, in view of the astrophysical and particle physics uncertainties. Previous quark mode
of the elastic cross sections responsible for $\tilde{\gamma}$ or $\tilde{h}$ capture in the sun can be improved using hyperon decay data, but a
into doubt by recent European Muon Collaboration data on the spin-dependent proton structure function, which
estimate of $\sigma(\tilde{\gamma}p)$ by a factor up to four. We emphasize the need to include charm and bottom quark fragmentation ef
calculating the flux of neutrinos from dark matter annihilation events, which may reduce the observable flux by a factor
the most stringent upper limits from the Fréjus experiment still allow a local $\tilde{\gamma}$ or $\tilde{h}$ density considerably above th
0.20–0.43 GeV/cm^3 favoured by astrophysics, and no range of $m_{\tilde{\gamma}}$ or $m_{\tilde{h}}$ can yet be excluded.

There is an emerging consensus that non-dissipa-
tive dark matter is prevalent in galactic halos [1].
One of the prime possibilities is that the halo dark
matter consists of some species of massive, non-re-
lativistic, neutral, weakly-interacting particle. A pos-
sible candidate for this dark-matter particle is the

lations, e.g., $\tilde{\gamma}\tilde{\gamma}\to f\bar{f}$, can produce energetic n
via the prompt decays of heavy flavours: f
This idea has been pursued extensively [11–
varying estimates given of the resulting ν fl
Data are now becoming available fron
ground detectors [16–18], most recently th

Way back



should be useful, and giving references whenever possible to the original literature where more details could be found. Some of the more complicated formulae are also available in the 'Electronic Yellow Book', under CERN IBM account T3.EYB, to which references are given in the text when appropriate.

We are excited by the physics opportunities offered by LEP, and have been impressed by the continued enthusiasm of our experimental colleagues. We would like to pay homage here to the quantity and quality of effort they have devoted to this report, despite their more immediate and time-consuming commitments to tight schedules for preparing their experiments. We would also like to put on record the very harmonious and friendly co-operation that we noticed between members of the different experimental collaborations within the various LEP physics

Way back

(H.1)

Astrophysical observations strongly suggest
that galactic haloes contain dark matter which
has not dissipated like the conventional matter
in the galactic disc, and is likely to be non-baryonic
There is no shortage of particle physics candidates
for this dark matter, with three of the most
favored being massive neutrinos, axions and relic supersymmetric
particles. Experimental physicists are now devising
strategies for detecting these different
They have been offered three pos
dark matter particles X such
supersymmetric particles. Th
off nuclei in the laborator which may
particles X trapped in the Sun
observable flux of high ene

COSMIC RAY CONSTRAINTS ON THE ANNIHILATIONS OF RELIC PARTICLES IN THE GALACTIC HALO

John ELLIS, R.A. FLORES [1]
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and

Joseph SILK
University of California, Berkeley, CA 94720, USA

Received 23 August 1988

Astrophysical observations [#1] strongly suggest that galactic haloes contain dark matter which has not dissipated like the conventional matter in the galactic disc, and is likely to be non-baryonic (see, e.g. ref. [2]). There is no shortage of particle physics candidates for this dark matter, with three of the most favoured being massive neutrinos, axions and relic supersymmetric particles [3,4]. Experimental physicists are now devising strategies for detecting these different species of relic particles. They have been offered three possible signatures of heavy dark matter particles χ such as massive neutrinos or supersymmetric particles. These are χ scattering off nuclei in the laboratory which may produce detectable nuclear recoil energy and/or inelastic nuclear excitation [5], annihilations of relic particles χ trapped in the Sun which may produce an observable flux of high energy solar neutrinos [6], and annihilations of relics χ in the halo which may produce detectable fluxes of antiprotons [7], positrons and gamma rays [7,8]. New

[1] Address after September 1st, 1988: School of Physics and Astronomy, University of Minnesota, Minneapolis, MN 55455, USA.
[2] Address after September 1st, 1988: Department of Physics, Columbia University, New York, NY 10027, USA.
[3] Address after September 1st, 1988: Bartol Research Foundation, University of Delaware, Newark, DE 19716, USA.
[#1] For a recent review, see e.g. ref. [1].

Way back

voured being massive neutrinos, axions and relic supersymmetric particles [3,4]. Experimental physicists are now devising strategies for detecting these different species of relic particles. They have been offered three possible signatures of heavy dark matter particles χ such as massive neutrinos or supersymmetric particles. These are χ scattering off nuclei in the laboratory which may produce detectable nuclear recoil energy and/or inelastic nuclear excitation [5], annihilations of relic particles χ trapped in the Sun which may produce an observable flux of high energy solar neutrinos [6], and annihilations of relics χ in the halo which may produce detectable fluxes of antiprotons [7], positrons and gamma rays [7,8]. New

Fast Forward…June 2008

The Accelerator

Launch!

- Launch from Cape Canaveral Air Station 11 June 2008 at 12:05PM EDT
- Circular orbit, 565 km altitude (96 min period), 25.6 deg inclination.

A moment later…

… and then …

… on its way!

Prior to Fairing Installation

The Observatory, Spring 2008

Large AreaTelescope (LAT)
20 MeV - >300 GeV

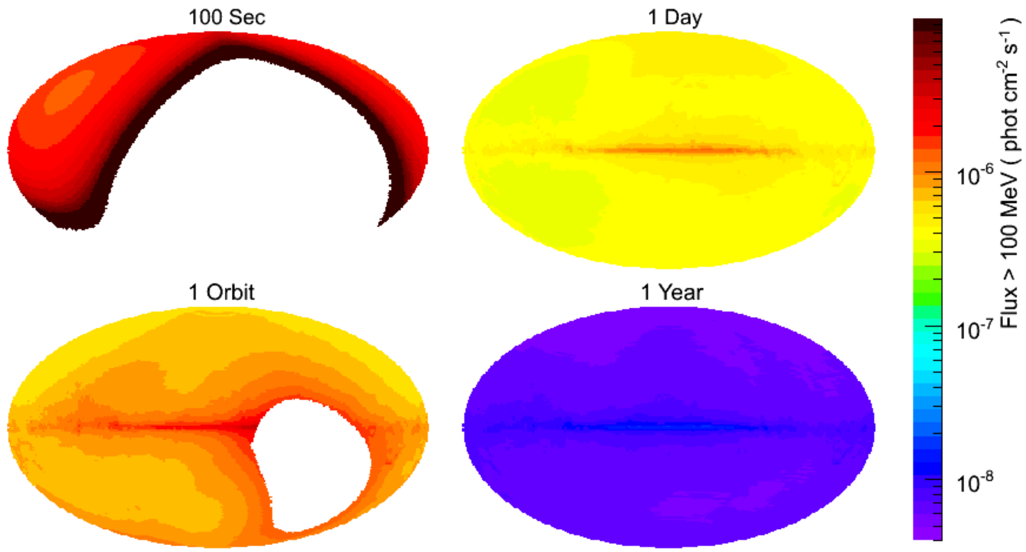
Gamma-ray Burst Monitor (GBM)
NaI and BGO Detectors
8 keV - 40 MeV

KEY FEATURES

- **Huge field of view**
  - **–LAT: 20% of the sky at any instant; in sky survey mode, expose all parts of sky for ~30 minutes every 3 hours. GBM: whole unocculted sky at any time.**
- **Huge energy range, including largely unexplored band 10 GeV - 100 GeV. Total of >7 energy decades!**
- **Large leap in all key capabilities. Great discovery potential.**

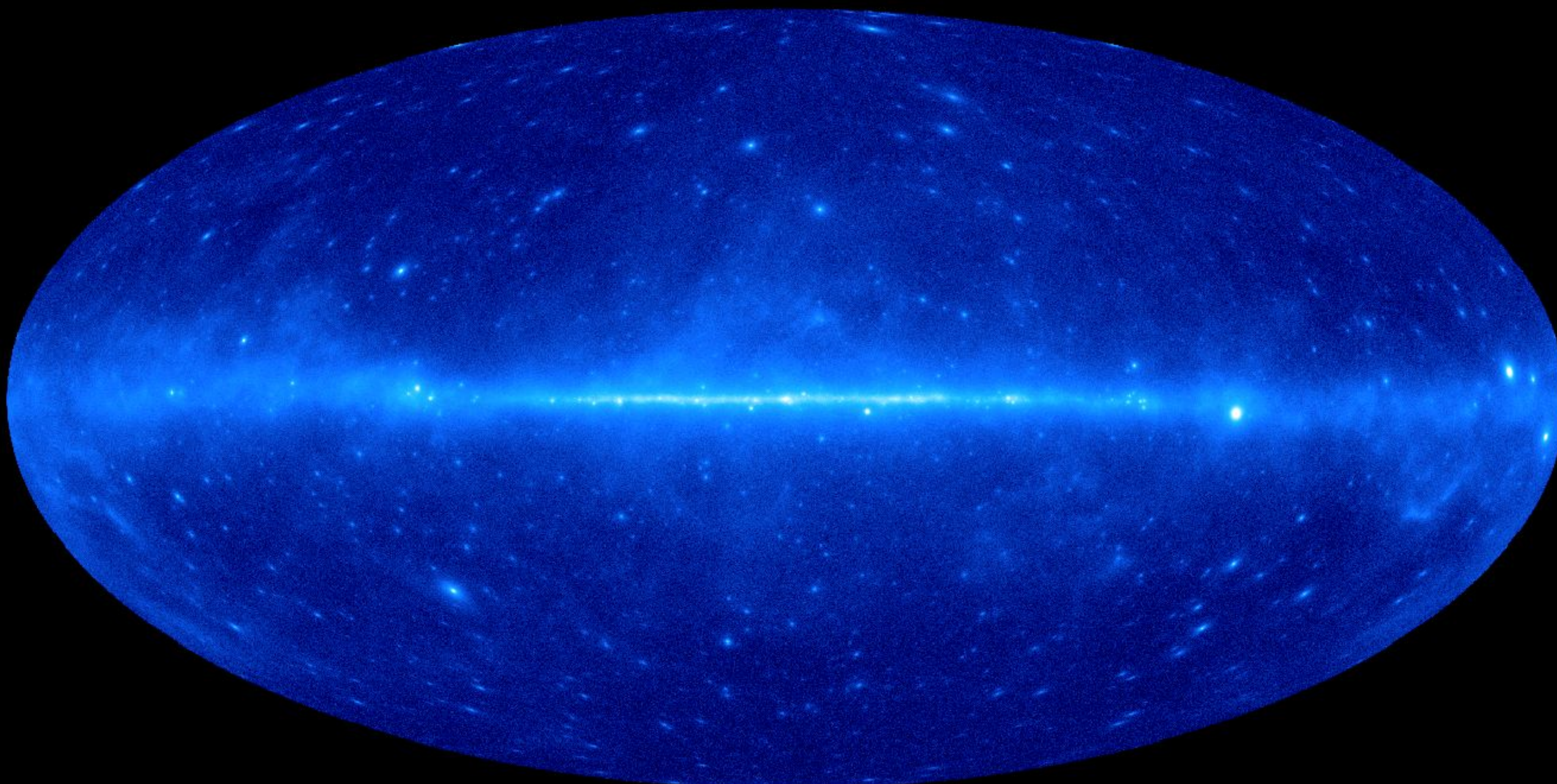
Operating modes

- Primary observing mode is Sky Survey
  - Full sky every 2 orbits (3 hours)
  - Uniform exposure, with each region viewed for ~30 minutes every 2 orbits
  - Best serves majority of science, facilitates multiwavelength observation planning
  - Exposure intervals commensurate with typical instrument integration times for sources
  - EGRET sensitivity reached in days

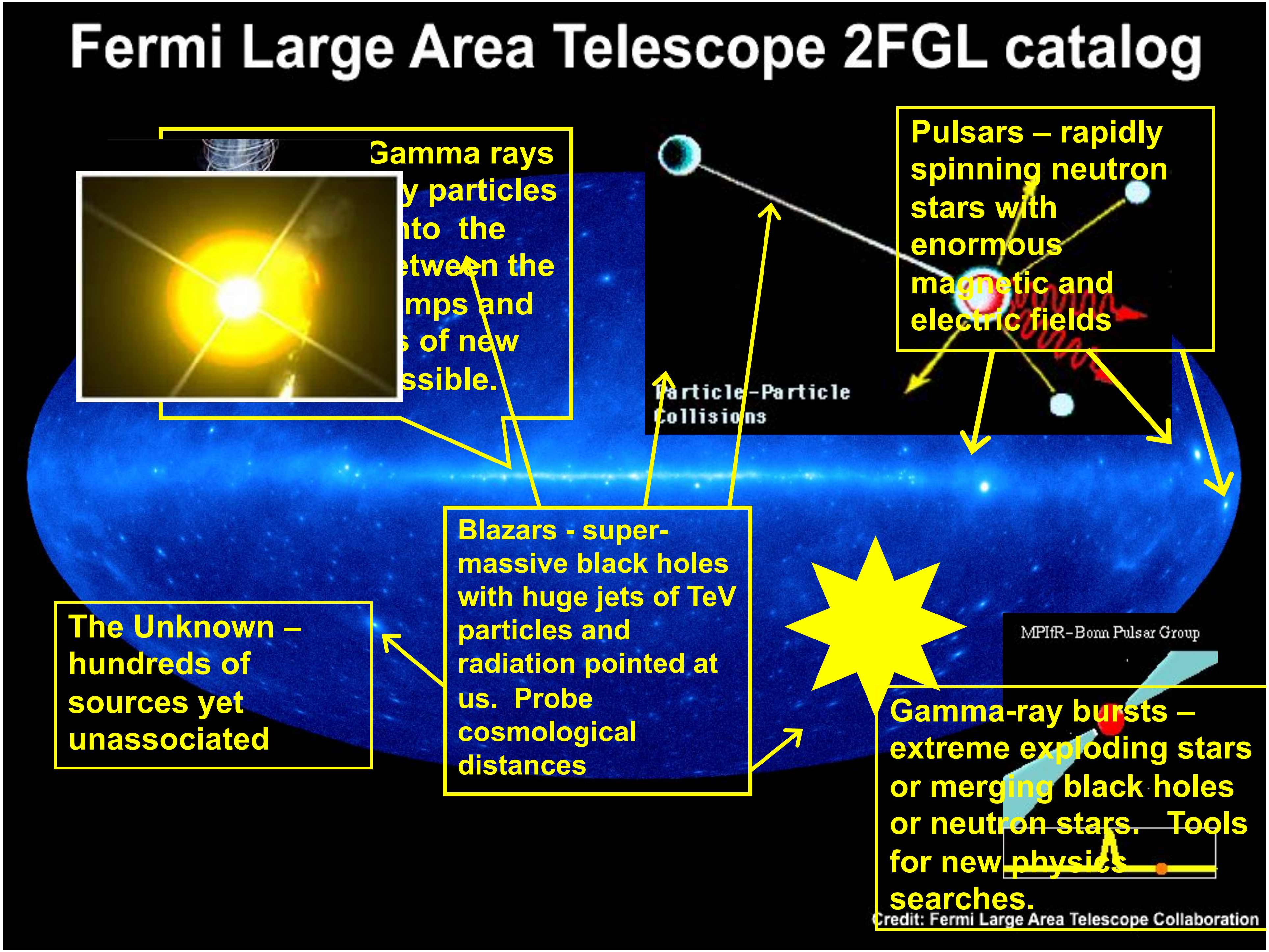


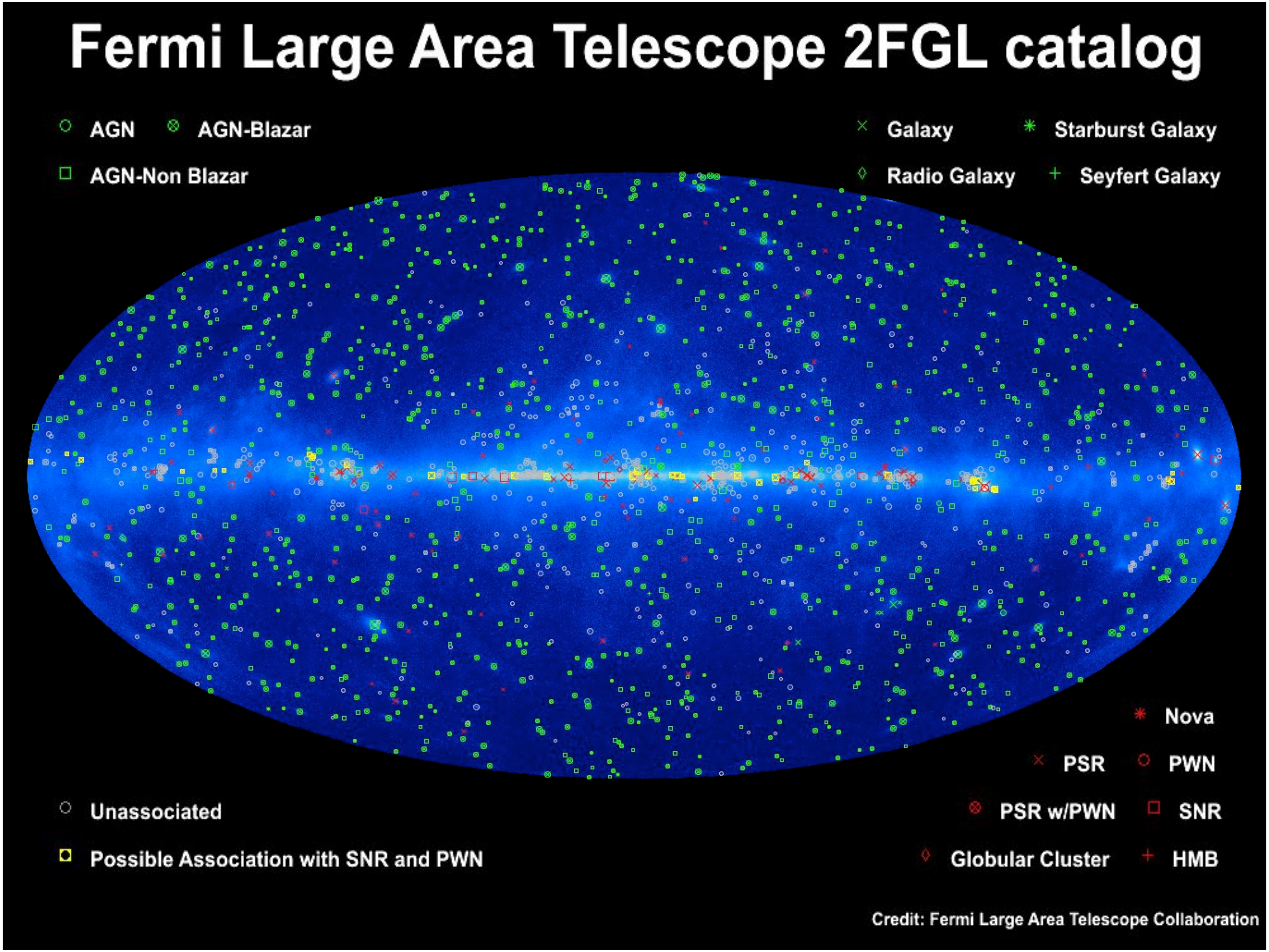
- **Pointed observations when appropriate (limited fraction, and selected by peer review) with automatic earth avoidance selectable. Target of Opportunity pointing.**
- **Autonomous repoints for onboard GRB detections in any mode.**

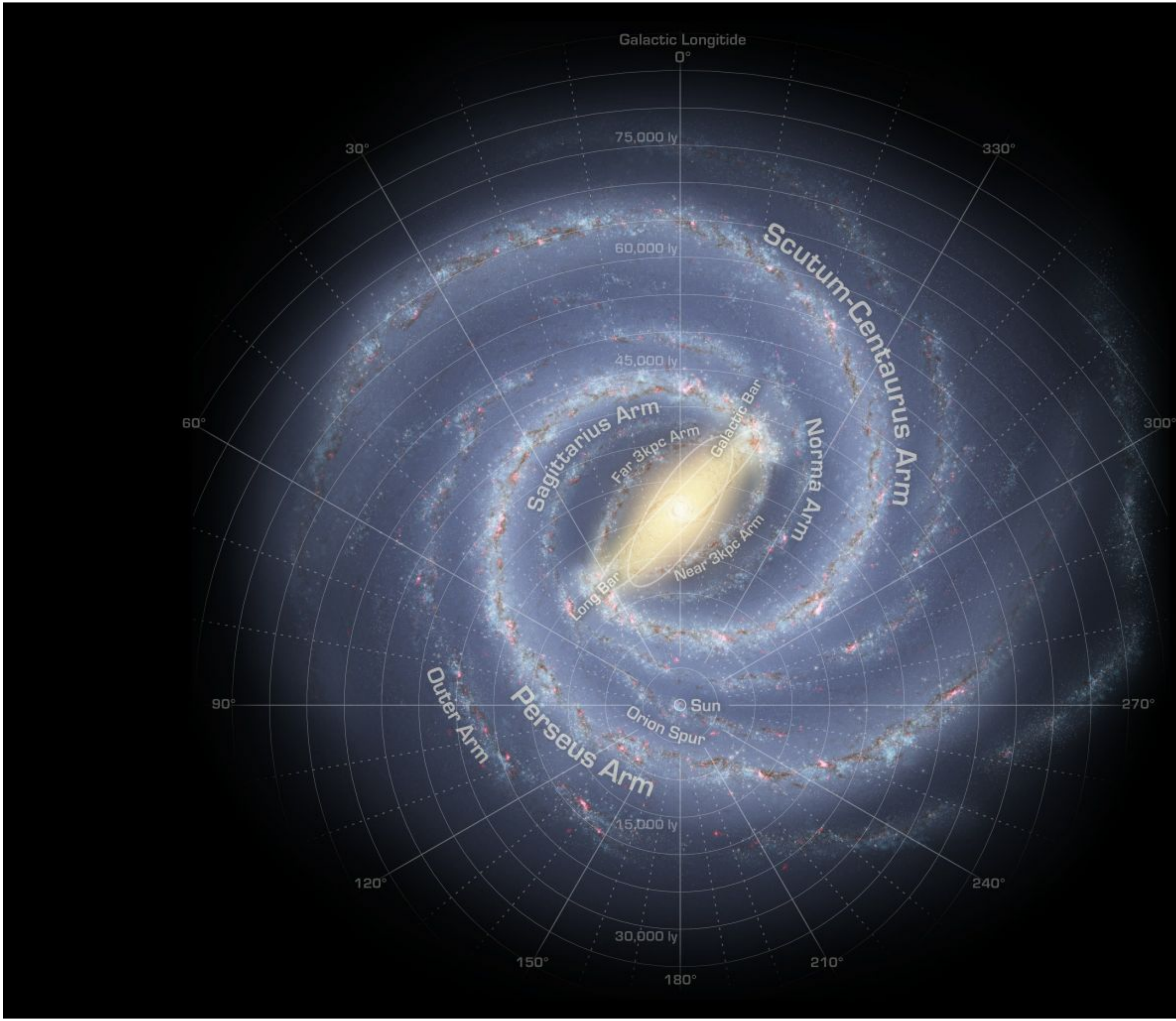
Fermi Large Area Telescope 2FGL catalog



Credit: Fermi Large Area Telescope Collaboration


Fermi Large Area Telescope 2FGL catalog
Gamma rays
y particles
nto the
etween the
mps and
s of new
ssible.
Particle–Particle
Collisions
Pulsars – rapidly spinning neutron stars with enormous magnetic and electric fields
Blazars - super-massive black holes with huge jets of TeV particles and radiation pointed at us. Probe cosmological distances
The Unknown – hundreds of sources yet unassociated
MPIfR–Bonn Pulsar Group
Gamma-ray bursts – extreme exploding stars or merging black holes or neutron stars. Tools for new physics searches.
Credit: Fermi Large Area Telescope Collaboration


Fermi Large Area Telescope 2FGL catalog
AGN
AGN-Blazar
AGN-Non Blazar
Galaxy
Starburst Galaxy
Radio Galaxy
Seyfert Galaxy
Nova
PSR
PWN
PSR w/PWN
SNR
Globular Cluster
HMB
Unassociated
Possible Association with SNR and PWN
Credit: Fermi Large Area Telescope Collaboration



Credit: R. Hurt

Including some highlights from…

2011 Fermi Symposium

9-12 May 2011
Rome, Italy

Overview

The 2011 Fermi Symposium is dedicated to results and prospects for scientific exploration of the Universe with the Fermi Gamma-ray Space Telescope and related studies. Topics include: blazars and other active galactic nuclei, pulsars, gamma-ray bursts, supernova remnants, diffuse gamma radiation, unidentified gamma-ray sources, and searches for dark matter. Multi-wavelength/multi-messenger contributions to these topics are welcome. The meeting will be held in Rome, Italy.

Program

TBD

Hotel & Local Information

- Hotel Details and List
- Local Information

Important Dates:

TBD

Registration Information

TBD

Proceedings

TBD

Organizing Committees

- Local Organizing Committee
- International Science Organizing

Talk references highlighted

Non-trivial “Trivia” (circa mid-2011)

- ~170 billion LAT event triggers
- GBM Triggers: 1194 (654 GRB, 141 TGF, 174 SGR, 56 solar flare)
- # Autonomous Repoint Requests (ARR): 58
- Highest-z LAT GRB: 4.35
- Highest-energy photon from a GRB: 33 GeV (at 82s, z=1.82)
- Highest-z LAT AGN: 3.1
- Highest-energy photon candidate event: 4 TeV
- # Gamma-ray pulsars: >88
  - # Millisecond Pulsars (MSPs): 31
  - # Gamma-ray-selected (radio-blind) pulsars: >24
  - # new radio MSPs due to LAT data: 35
- Public data access: >8TB

Some Fermi Highlights

- Discovery and study of >88 gamma-ray pulsars, >24 of which are seen to pulse only in gamma rays. 31 are ms pulsars.
  - 35 new ms radio pulsars discovered thanks to LAT data!
- Remarkable high-energy emission from gamma-ray bursts
  - Starting to see what was missing
  - Also provides interesting limits on photon velocity dispersion
- Very high statistics measurement of the cosmic e+e- flux to 1 TeV
- Nailing down the diffuse galactic GeV emission
- First Fermi determination of the isotropic diffuse flux
- Early searches for Dark Matter signatures in different kinds of sources
- Many new results on supermassive black hole systems (AGN), including sources never seen in the GeV range
- More cosmic accelerators: Galactic X-ray binaries and supernova remnants. Probing the cosmic-ray distributions in other galaxies; LMC and SMC.
- Extragalactic Background Light constraints
- New limits on large extra dimensions
- Crab short *flares*
- 2^{nd} catalog: 1873 sources

>100 LAT papers out…

Fermi LAT Publications 5/10/10 2:22 PM

Publications

Exploring the Extreme Universe

Home | Mission | Instrument | Collaboration | Institutions | Publications | NASA | Pictures | Internal

Fermi LAT collaboration publications

Select a topic: All

Links:

- How we classify papers by collaboration members
- Independent publications by LAT collaboration members (Category III)
- Ph. D. dissertations
- Rapid publications: ATel and GCN
- Proceedings of the 2009 Fermi Symposium
- Pre-launch publications

2010

Gamma-ray Spectral Evolution of NGC 1275 Observed with Fermi LAT
Kataoka, J. et al. 2010, ApJ, 715, 554 doi: 10.1088/0004-637X/715/1/554
arXiv: 1004.2352
ADS: 2010ApJ...715..554K BibTeX Citations
SPIRES

The First Catalog of Active Galactic Nuclei Detected by the Fermi Large Area Telescope
Abdo, A. A. et al. 2010, ApJ, 715, 429 doi: 10.1088/0004-637X/715/1/429
arXiv: 1002.0150
ADS: 2010ApJ...715..429A BibTeX Citations
SPIRES

Detection of the energetic pulsar PSR B1509-58 and its pulsar wind nebula in MSH 15-52 using the Fermi Large Area Telescope
Abdo, A. A. et al. 2010, ApJ, 714, 927 doi: 10.1088/0004-637X/714/1/927
arXiv: 1003.3833
ADS: 2010ApJ...714..927A BibTeX Citations
SPIRES

The discovery of gamma-ray emission from the blazar RGB J0710+591

http://www-glast.stanford.edu/cgi-bin/pubpub Page 1 of 14

Fermi LAT Publications 5/10/10 2:22 PM

Abdo, A. A. et al. 2010, Phys. Rev. Lett., 104, 101101 doi: 10.1103/PhysRevLett.104.101101
arXiv: 1002.3603
ADS: 2010PhRvL.104j1101A BibTeX Citations
SPIRES

ADS: 2010ApJS..187..460A BibTeX Citations
SPIRES

Constraints on Cosmological Dark Matter Annihilation from the Fermi-LAT Isotropic Diffuse

Acciari, V. A. et al. 2010, ApJL, 715, L49 doi: 10.1088/2041-8205/715/1/49
arXiv: 1005.0041
ADS: 2010ApJ...715L..49A BibTeX Citations
SPIRES

Fermi-Large Area Telescope Observations of the Exceptional Gamma-Ray Outbursts of 3C 273 in 2009 September
Abdo, A. A. et al. 2010, ApJL, 714, L73 doi: 10.1088/2041-8205/714/1/L73
ADS: 2010ApJ...714L..73A BibTeX Citations

Fermi Gamma-ray Imaging of a Radio Galaxy
Abdo, A. A. et al. 2010, Science, 328, 725 doi: 10.1126/science.1184656
ADS: 2010Sci...328..725A BibTeX Citations
Public: Abstract Full text

The Vela Pulsar: Results from the First Year of Fermi LAT Observations
Abdo, A. A. et al. 2010, ApJ, 713, 154 doi: 10.1088/0004-637X/713/1/154
arXiv: 1002.4050
ADS: 2010ApJ...713..154A BibTeX Citations
SPIRES

Fermi-LAT Observations of the Vela X Pulsar Wind Nebula
Abdo, A. A. et al. 2010, ApJ, 713, 146 doi: 10.1088/0004-637X/713/1/146
arXiv: 1002.4383
ADS: 2010ApJ...713..146A BibTeX Citations
SPIRES

Fermi Large Area Telescope observations of PSR J1836+5925
Abdo, A. A. et al. 2010, ApJ, 712, 1209 doi: 10.1088/0004-637X/712/2/1209
arXiv: 1002.2977
ADS: 2010ApJ...712.1209A BibTeX Citations
SPIRES

Discovery of Pulsed Gamma-rays from PSR J0034-0534 with the Fermi LAT: A Case for Co-located Radio and Gamma-ray Emission Regions
Abdo, A. A. et al. 2010, ApJ, 712, 957 doi: 10.1088/0004-637X/712/2/957
arXiv: 1002.2607
ADS: 2010ApJ...712..957A BibTeX Citations
SPIRES

The First Fermi Large Area Telescope Catalog of Gamma-ray Pulsars
Abdo, A. A. et al. 2010, ApJS, 187, 460 doi: 10.1088/0067-0049/187/2/460
arXiv: 0910.1608

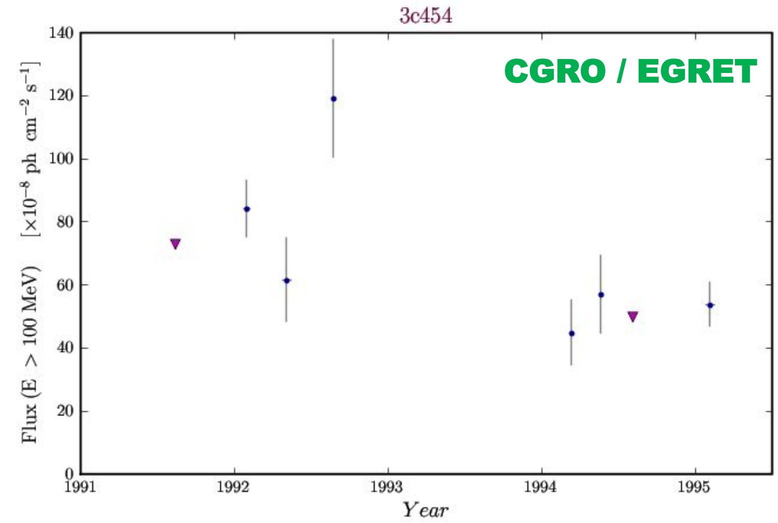
http://www-glast.stanford.edu/cgi-bin/pubpub Page 2 of 14

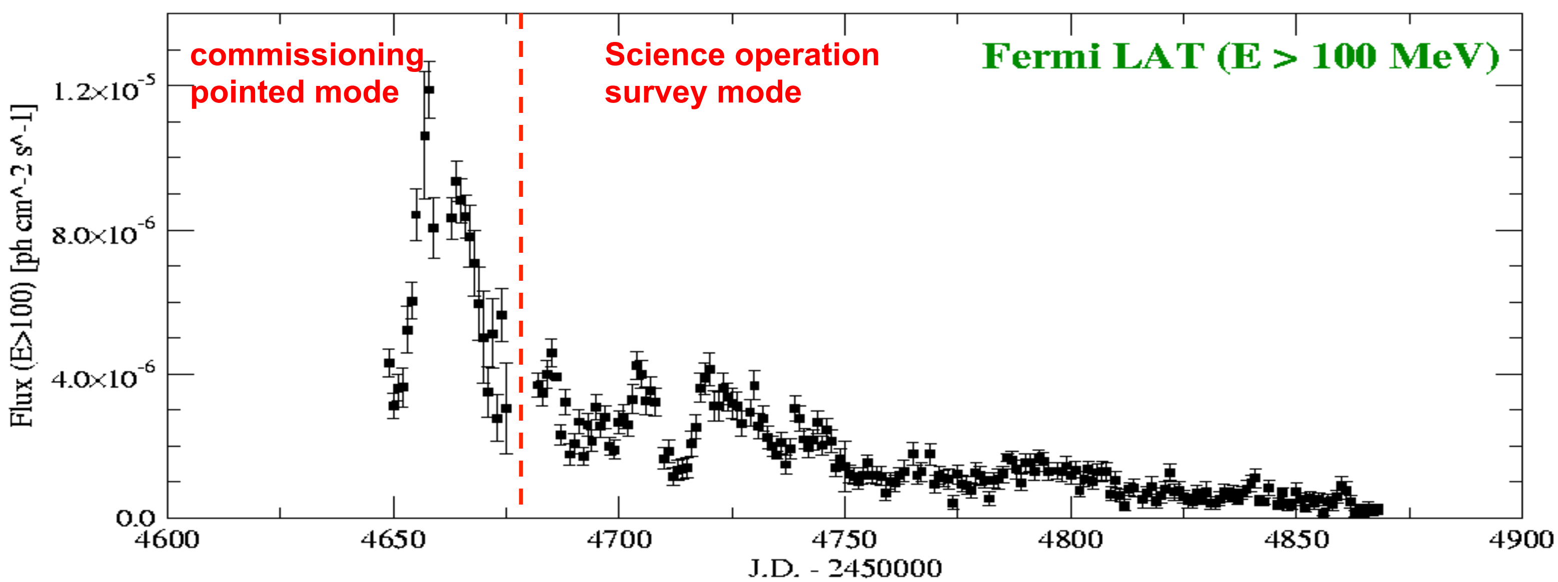
…with many more in the pipeline… plus GBM papers..plus many more still using the public data!

http://www-glast.stanford.edu/cgi-bin/pubpub

Example of all-sky payoff: 3C454.3

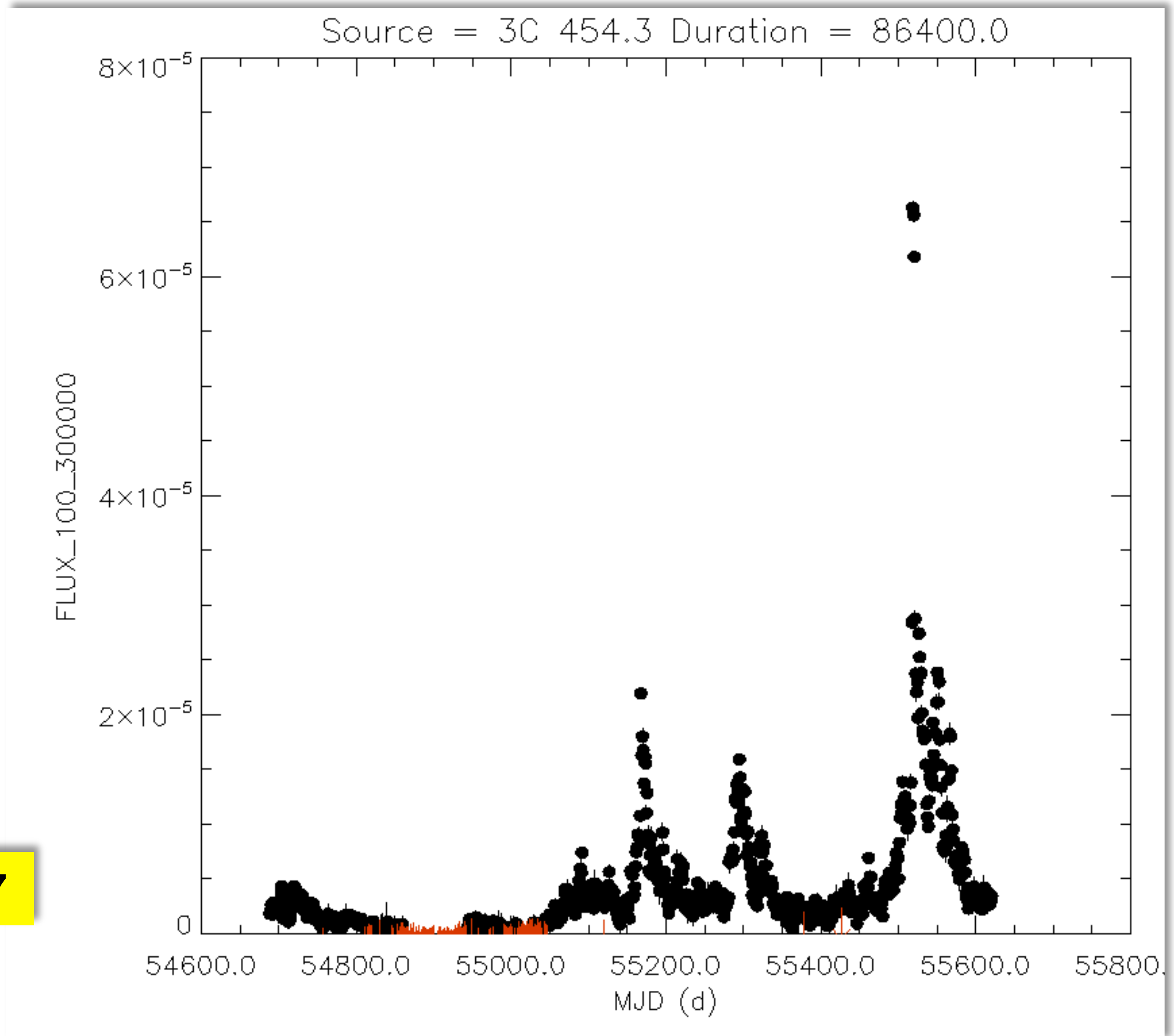
- **Well-known radio source at z = 0.859; also detected by EGRET, AGILE**





3C454.3

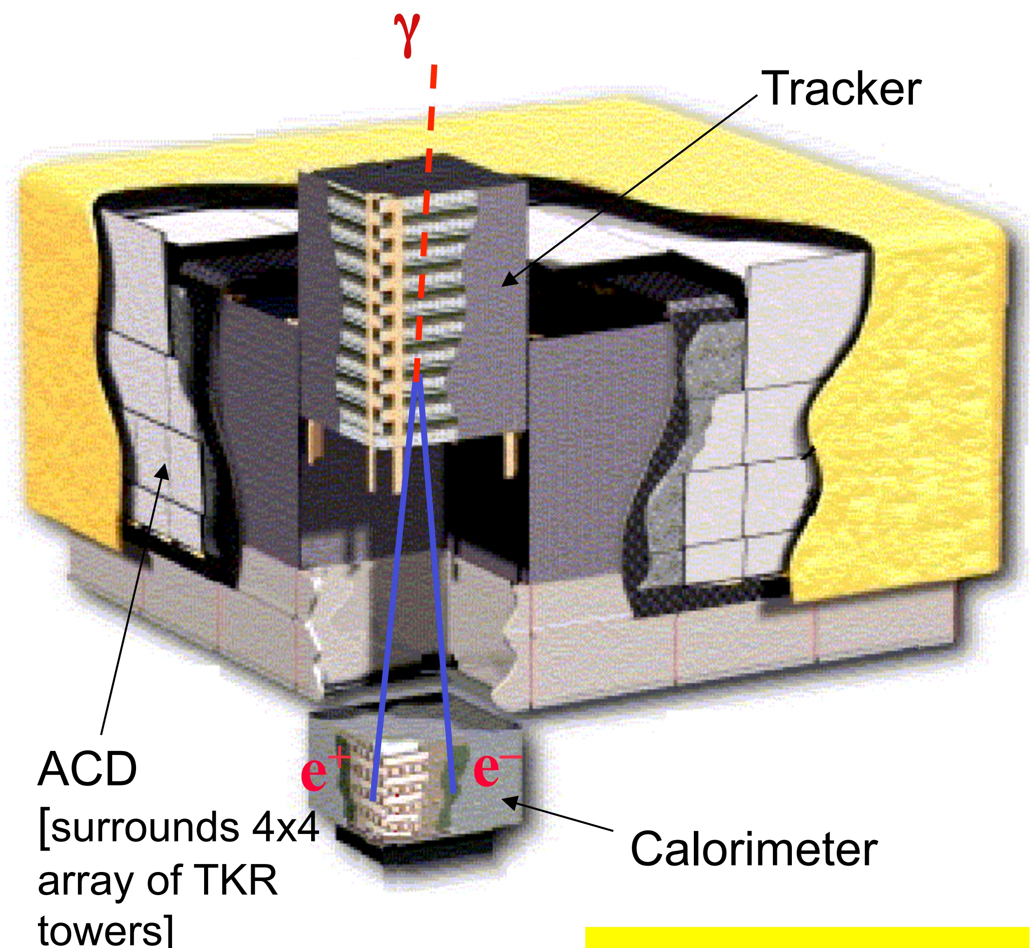
http://fermi.gsfc.nasa.gov/ssc/data/access/lat/msl_lc/



Also see **arXiv:1102.0277**

LAT Overview

- Precision Si-strip Tracker (TKR) Measure the photon direction; gamma ID.
- Hodoscopic CsI Calorimeter (CAL) Measure the photon energy; image the shower.
- Segmented Anticoincidence Detector (ACD) Reject background of charged cosmic rays; segmentation removes self-veto effects at high energy.
- Electronics System Includes flexible, robust hardware trigger and software filters.



Atwood et al, ApJ

Systems work together to identify and measure the flux of cosmic gamma rays with energy 20 MeV - >300 GeV.

LAT Collaboration

- France
  - CNRS/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, Santa Cruz - Santa Cruz Institute for Particle Physics
  - Goddard Space Flight Center
  - Naval Research Laboratory
  - Sonoma State University
  - The Ohio State University
  - University of Washington

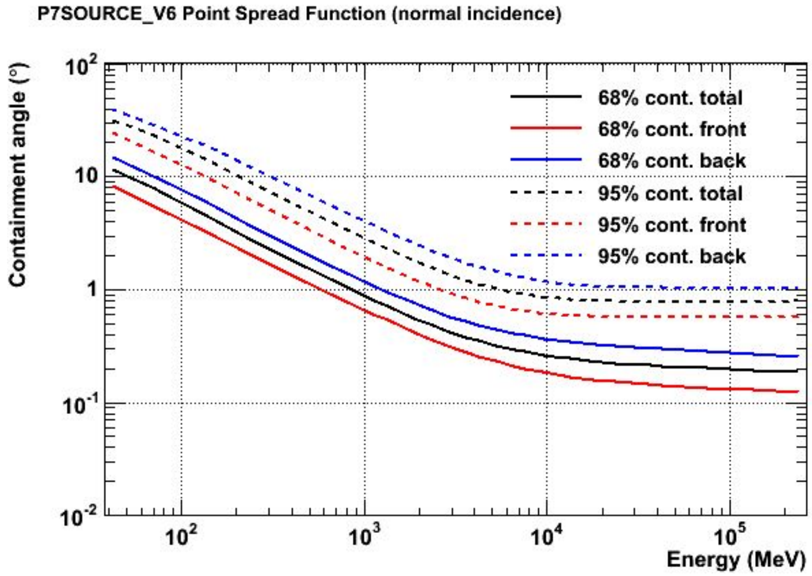
PI: Peter Michelson
(Stanford)
~400 Scientific Members (including 97 Affiliated Scientists, plus 71 Postdocs and 123 Students)

Cooperation between NASA and DOE, with key international contributions from France, Italy, Japan and Sweden.

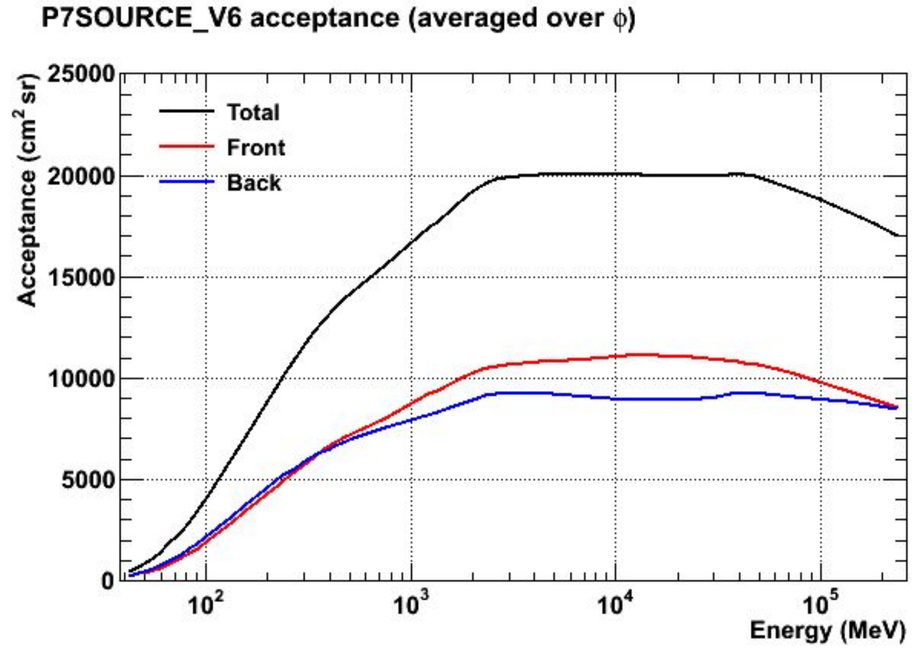
Project managed at SLAC.

LAT Performance

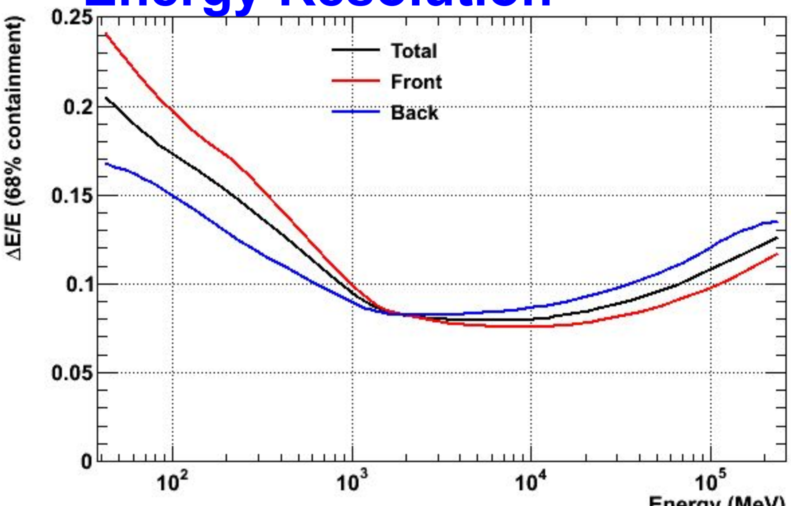
PSF 68% Cont. Radius

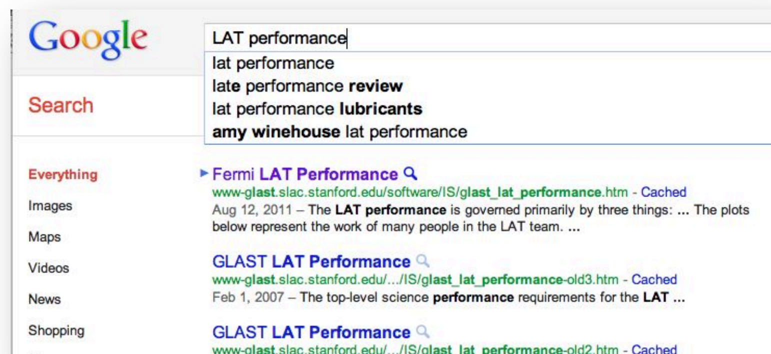


Acceptance



Energy Resolution

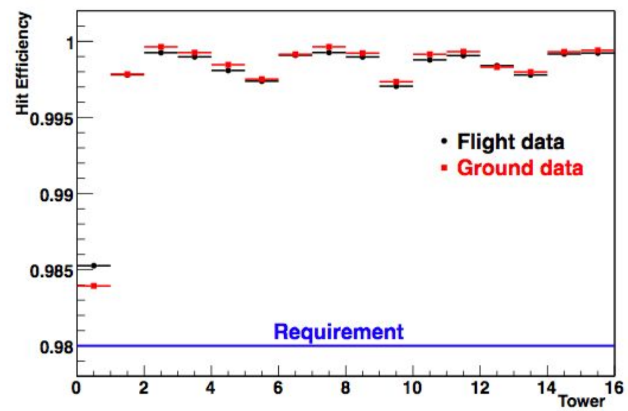




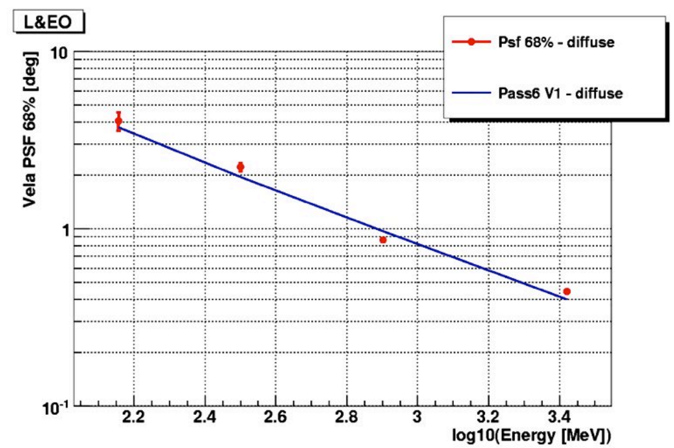
Different event classes trade background rejection and PSF against effective area

LAT Working Very Well On Orbit!

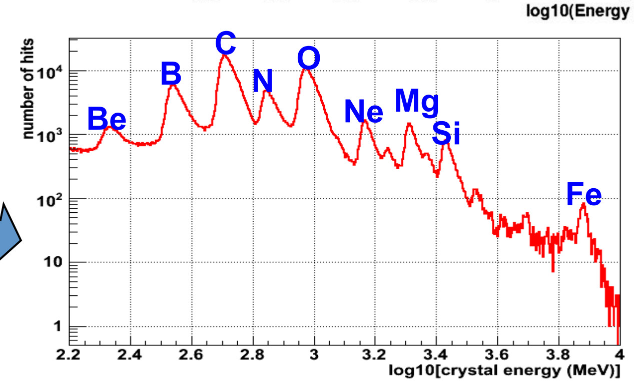
- Total background rates very close to expectation (non-trivial!)
- Spectacular charged-particle hit efficiency:



- PSF on-orbit as expected (note intrinsic energy dependence => localization is source-dependent)
  - verify using on-pulse photons from Vela, compare with detailed MC simulation:



- On-orbit calorimeter calibration stable
  - use cosmic ray heavy ions:

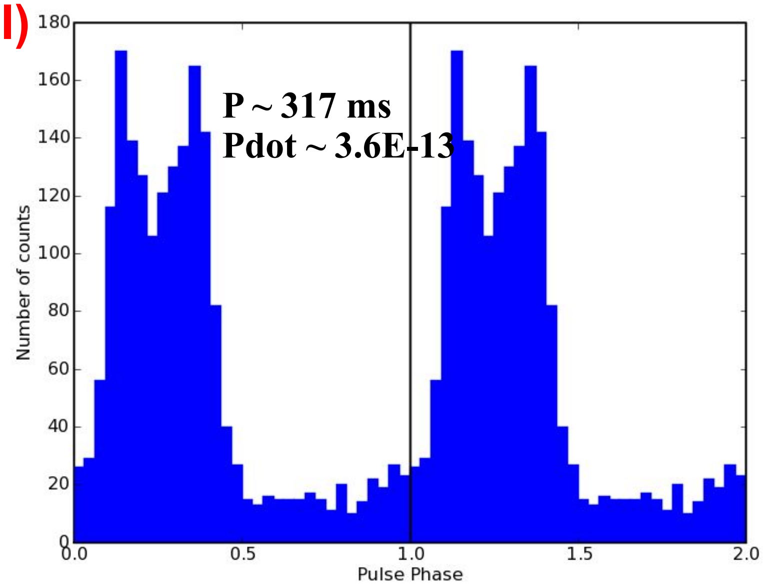


Discovery of First Gamma-ray only Pulsar

A radio-quiet, gamma-ray only pulsar, in Supernova Remnant CTA1

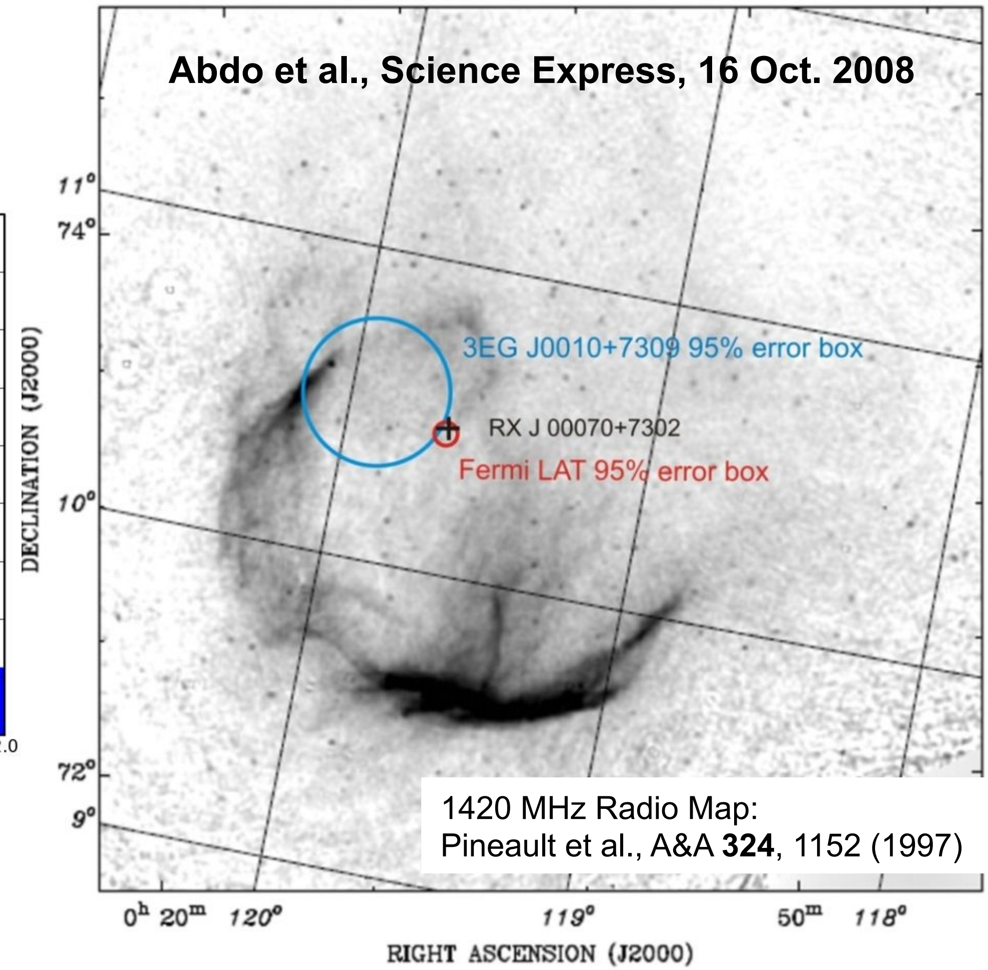
Quick discovery enabled by

- **large leap in key capabilities**
- **new analysis technique (Atwood et al)**



- Spin-down luminosity ~10^{36} erg s^{-1}, sufficient to supply the PWN with magnetic fields and energetic electrons.

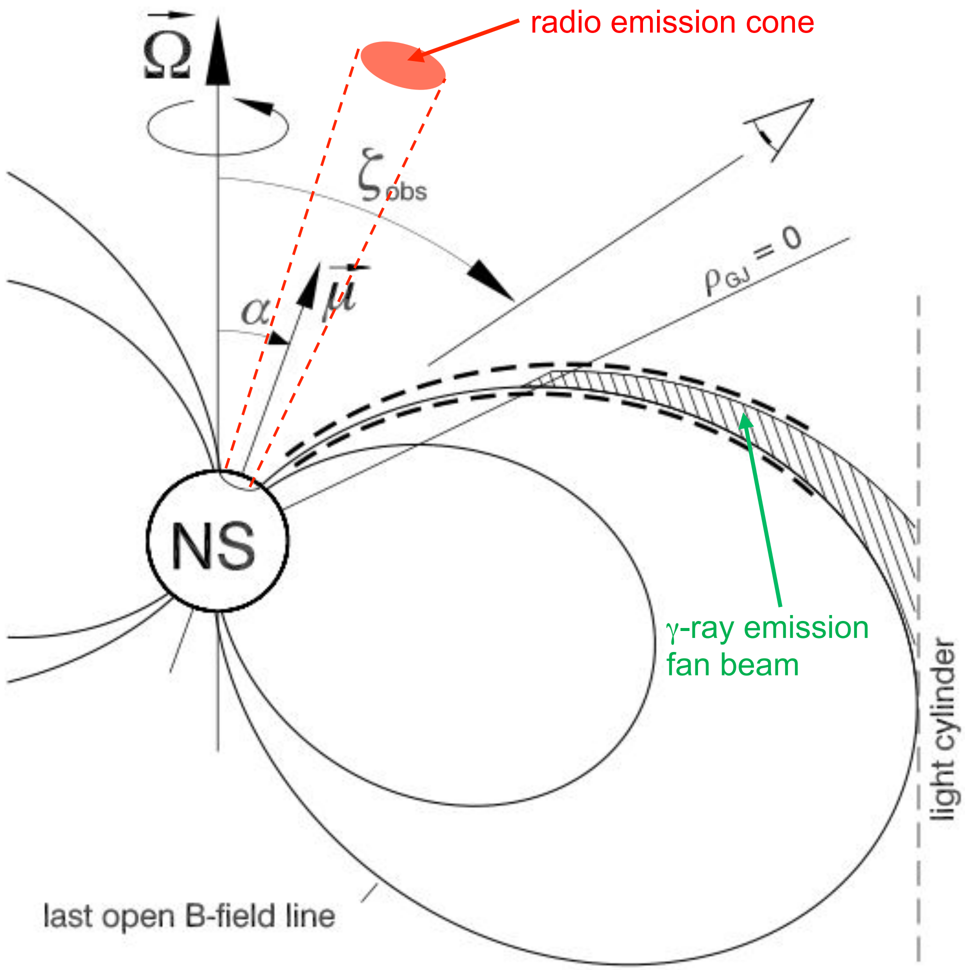
- The γ-ray flux from the CTA 1 pulsar corresponds to about 1-10% of E_{rot} (depending on beam geometry)



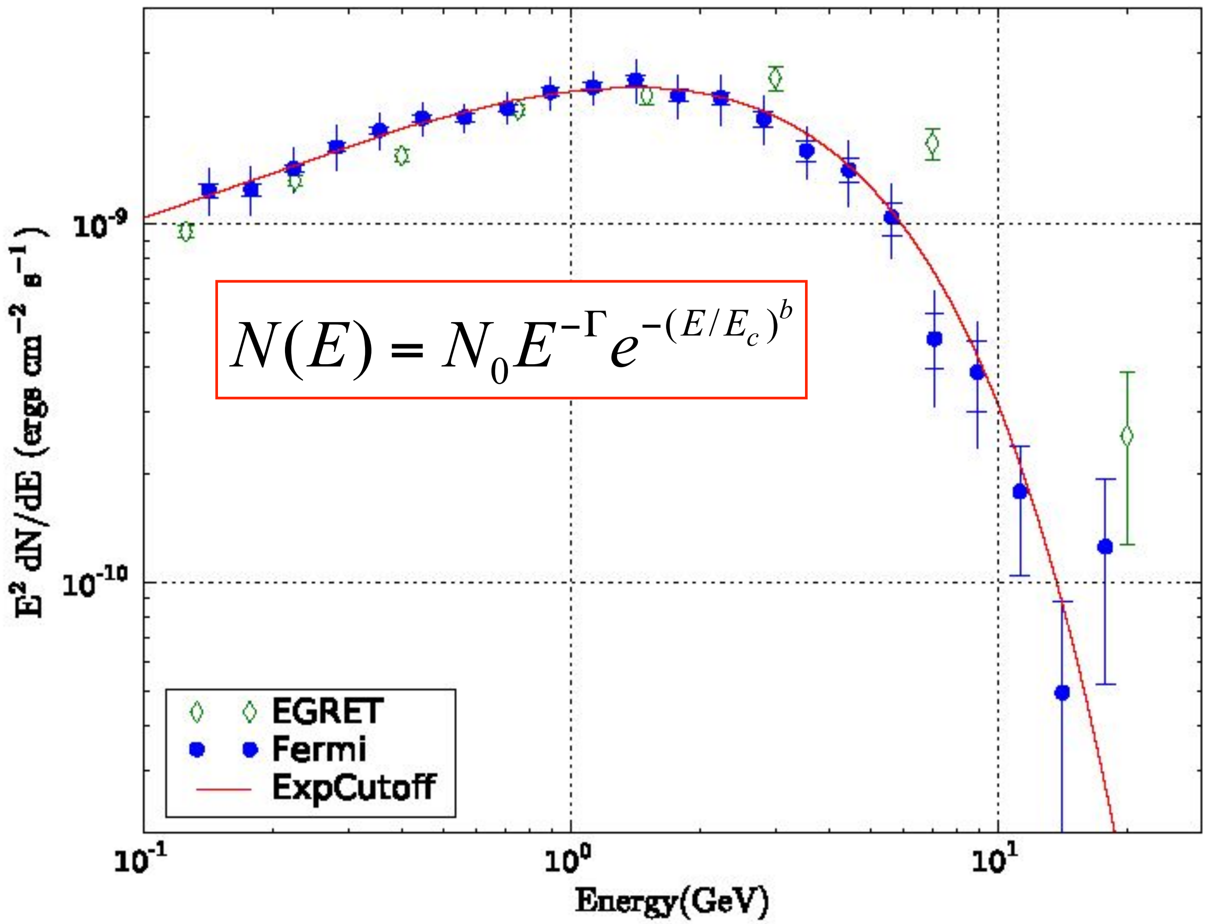
1420 MHz Radio Map:
Pineault et al., A&A **324**, 1152 (1997)

Age ~(0.5 – 1)x10^4 years
Distance ~ 1.4 kpc
Diameter ~ 1.5°

Pulsar Field Geometry Simplified



Vela: phase-averaged spectrum (SED)



$$N(E) = N_0 E^{-\Gamma} e^{-(E/E_c)^b}$$

Consistent with b=1 (simple exponential)

$$\Gamma = 1.51^{+0.05}_{-0.04}$$

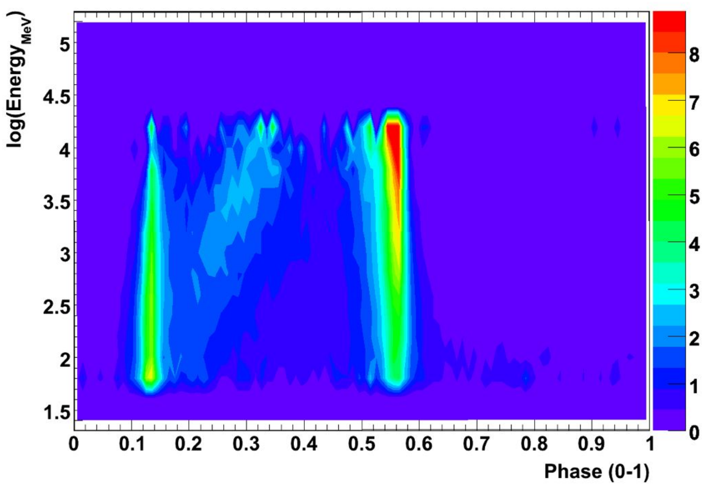
$$E_c = 2.9 \pm 0.1 \text{ GeV}$$

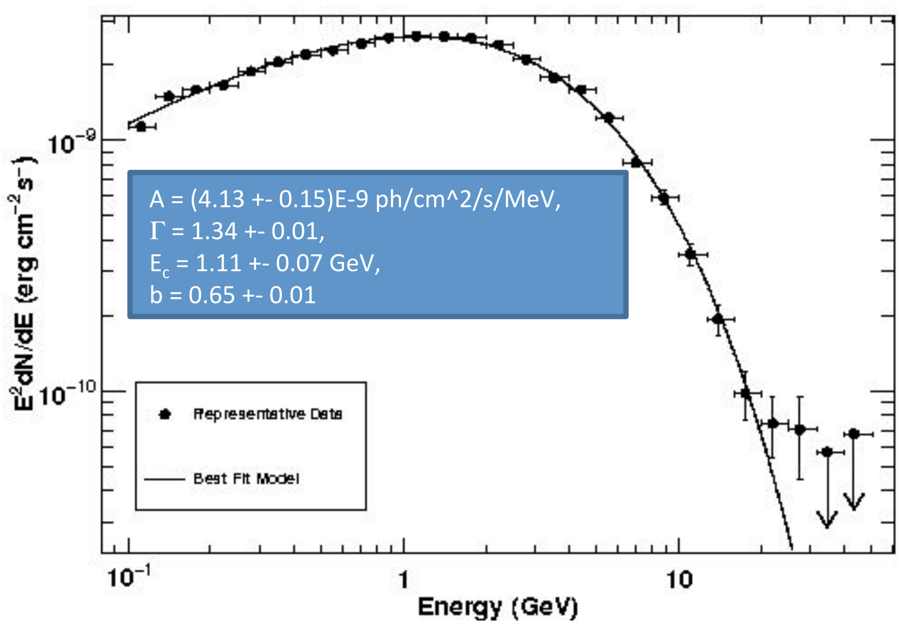
b=2 (super-exponential) rejected at 16σ

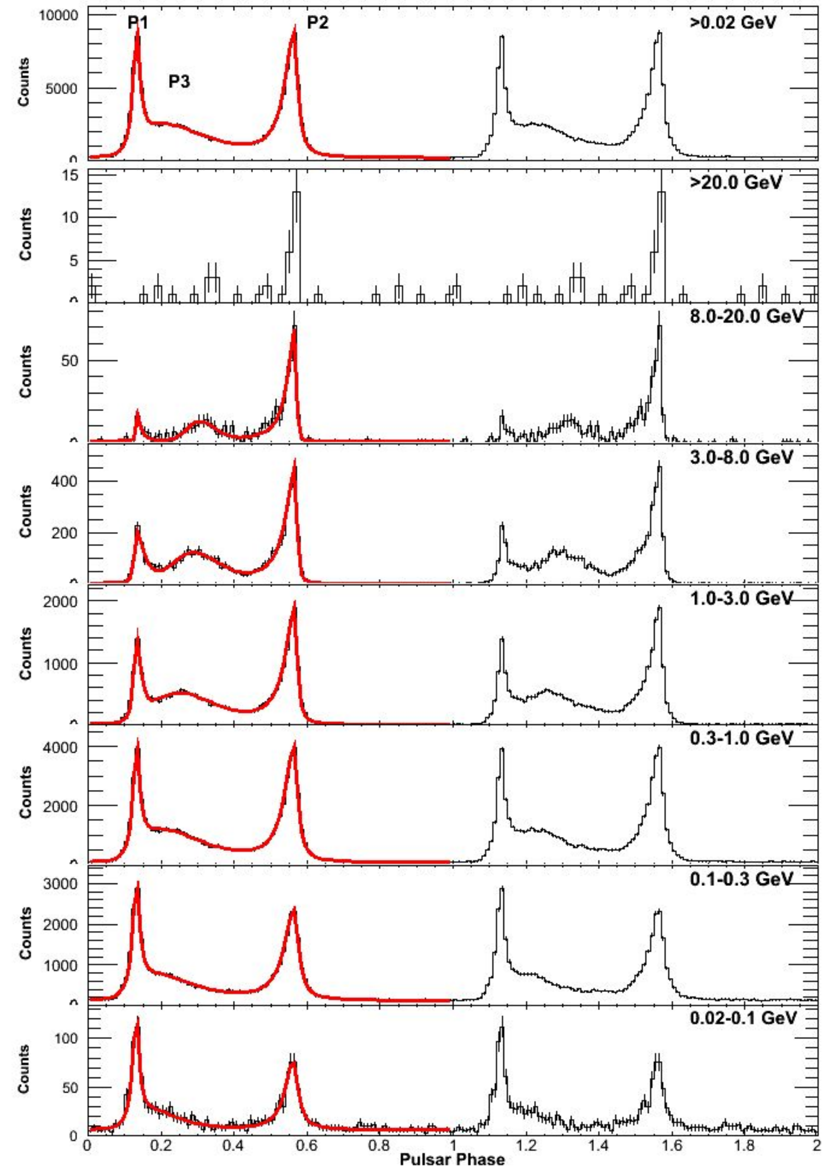
No evidence for magnetic pair attenuation:
Near-surface emission ruled out

arXiv:0812.2960

Vela 11 months



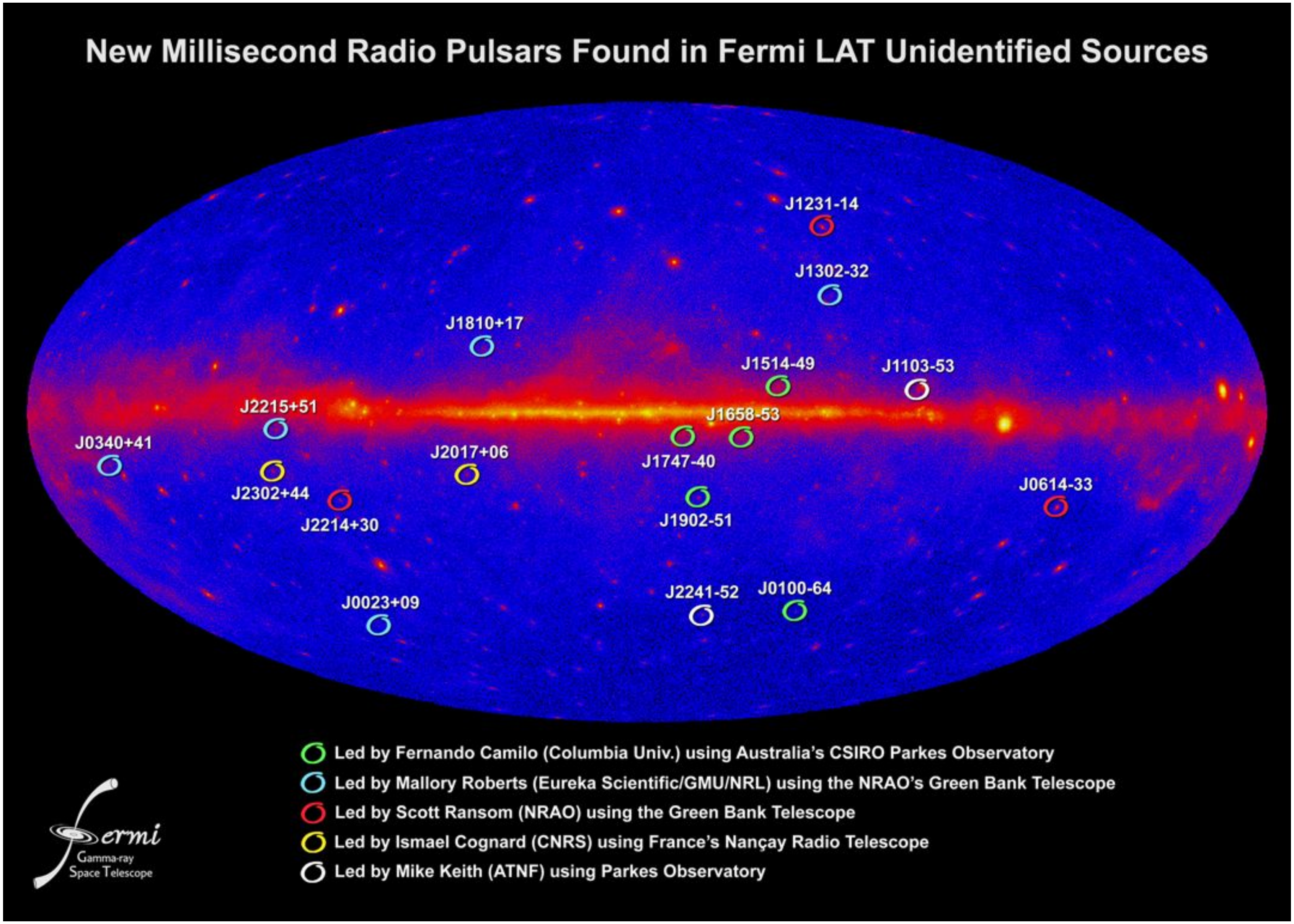


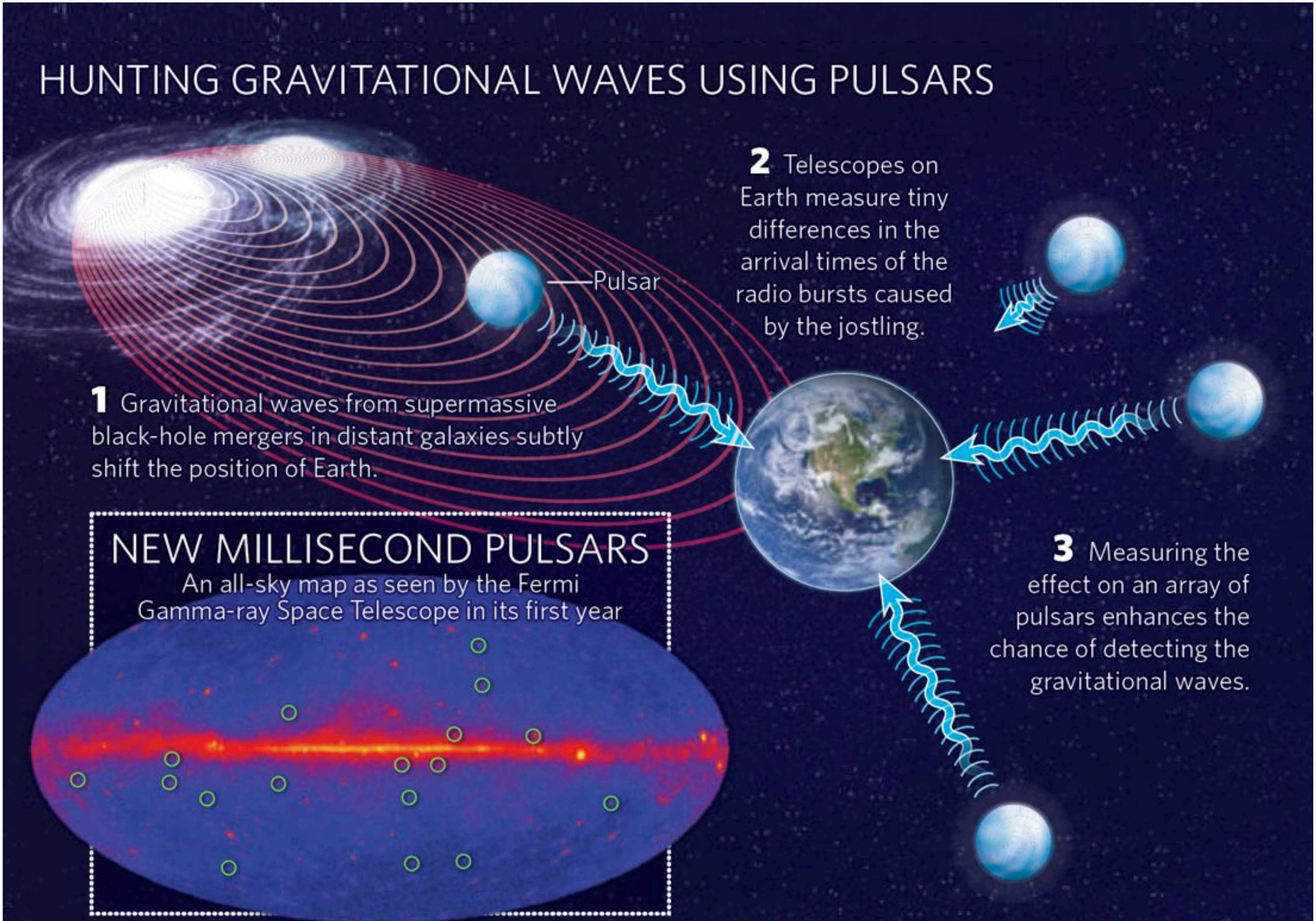


arXiv:1002.4050

events time stamped to <1 microsec

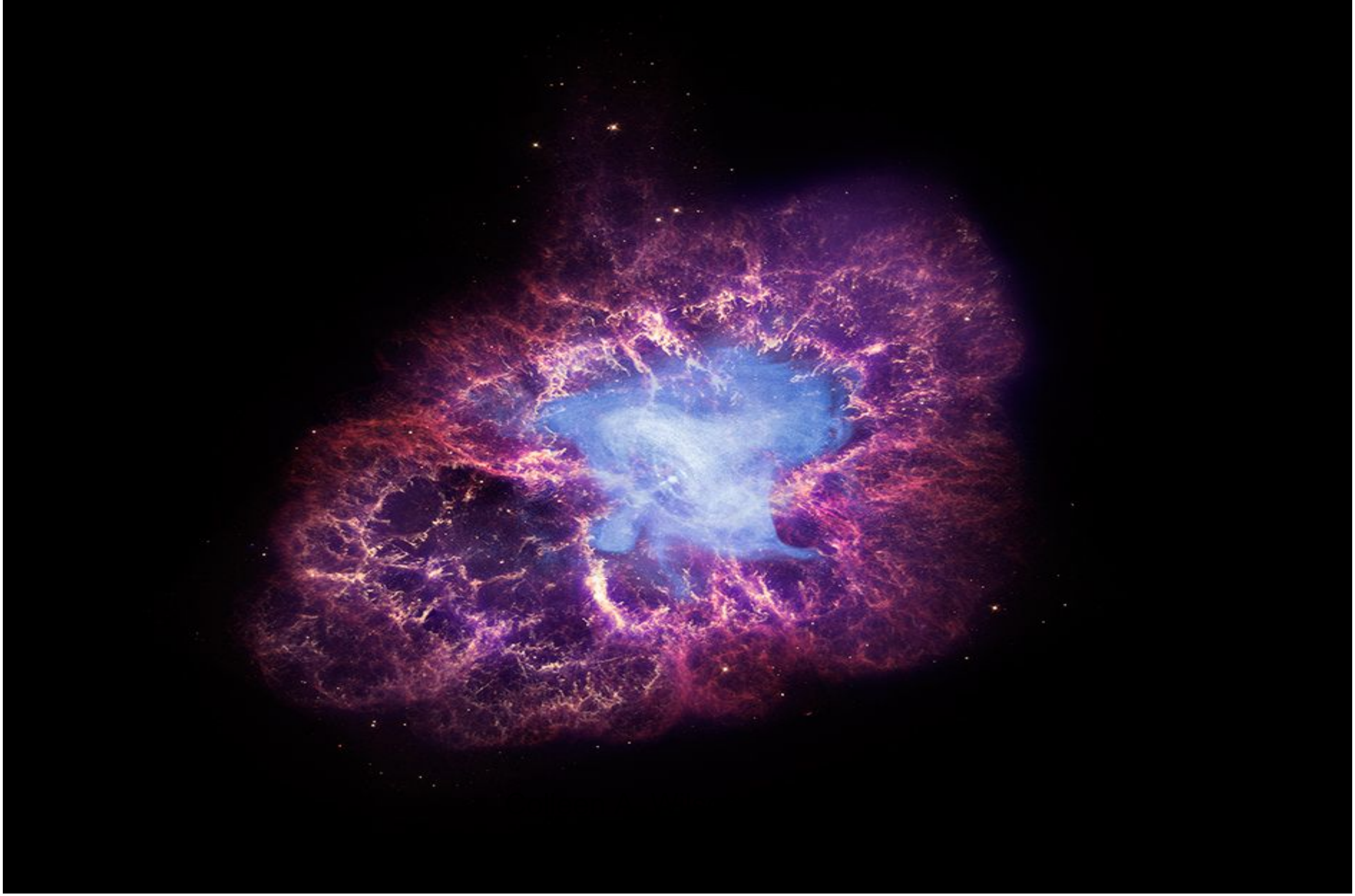
Millisecond pulsars and Fermi





See http://nanograv.org

A Variable Standard



High Energy Activity from the Crab

AGILE detection of enhanced gamma-ray emission from the Crab Nebula region

ATel #2855; M. Tavani (INAF/IASF Roma), E. Striani (Univ. Tor Vergata), A. Bulgarelli (INAF/IASF Bologna), F. Gianotti, M. Trifoglio (INAF/IASF Bologna), C. Pittori, F. Verrecchia (ASDC), A. Argan, A. Trois, G. De Paris, V. Vittorini, F. D'Ammando, S. Sabatini, G. Piano, E. Costa, I. Donnarumma, M. Feroci, L. Pacciani, E. Del Monte, F. Lazzarotto, P. Soffitta, Y. Evangelista, I. Lapshov (INAF-IASF-Rm), A. Chen, A. Giuliani(INAF-IASF-Milano), M. Marisaldi, G. Di Cocco, C. Labanti, F. Fuschino,M. Galli (INAF/IASF Bologna), P. Caraveo, S. Mereghetti, F. Perotti (INAF/IASF Milano), G. Pucella, M. Rapisarda (ENEA-Roma), S. Vercellone (IASF-Pa), A. Pellizzoni, M. Pilia (INAF/OA-Cagliari), G. Barbiellini, F. Longo (INFN Trieste), P. Picozza, A. Morselli (INFN and Univ. Tor Vergata), M. Prest (Universita` dell'Insubria), P. Lipari, D. Zanello (INFN Roma-1), P.W. Cattaneo, A. Rappoldi (INFN Pavia), P. Giommi, P. Santolamazza, F. Lucarelli, S. Colafrancesco (ASDC), L. Salotti (ASI)

*on **22 Sep 2010; 14:45 UT***

Distributed as an Instant Email Notice (Transients)

Password Certification: Marco Tavani (tavani@iasf-roma.inaf.it)

Subjects: Pulsars

Referred to by ATel #: 2856, 2858, 2861, 2866, 2867, 2868, 2872

AGILE is detecting an increased gamma-ray flux from a source positionally consistent with the Crab Nebula.

Integrating during the period 2010-09-19 00:10 UT to 2010-09-21 00:10 UT the AGILE-GRID detected enhanced gamma-ray emission above 100 MeV from a source at Galactic coordinates (l,b) = (184.6, -6.0) +/- 0.4 (stat.) +/- 0.1 (syst.) deg, and flux F > 500 e-8 ph/cm2/sec above 100 MeV, corresponding to an excess with significance above 4.4 sigma with respect to the average flux from the Crab nebula (F = (220 +/- 15)e-8 ph/cm^2/sec, Pittori et al., 2009, A&A, 506, 1563).

We strongly encourage multifrequency observations of the Crab Nebula region.

No corresponding flare in X-rays with INTEGRAL (Atel # 2856), Swift (Atel # 2858, 2866), or RXTE (Atel # 2872) or NIR (Atel #2867). No evidence for active AGN near Crab (Swift, Atel # 2868).

Fermi LAT confirmation of enhanced gamma-ray emission from the Crab Nebula region

ATel #2861; R. Buehler (SLAC/KIPAC), F. D'Ammando (INAF-IASF Palermo), E. Hays (NASA/GSFC) on behalf of the Fermi Large Area Telescope Collaboration

*on **23 Sep 2010; 17:34 UT***

Distributed as an Instant Email Notice (Transients)

Password Certification: Rolf Buehler (buehler@slac.stanford.edu)

Subjects: >GeV, Pulsars

Referred to by ATel #: 2866, 2867, 2868, 2872

Following the detection by AGILE of increasing gamma-ray activity from a source positionally consistent with the Crab Nebula occurred from September 19 to 21 (ATel #2855), we report on the analysis of the >100 MeV emission from this region with the Large Area Telescope (LAT), one of the two instruments on the Fermi Gamma-ray Space Telescope.

Preliminary LAT analysis indicates that the gamma-ray emission (E >100 MeV) observed during this time period at the location of the Crab Nebula is (606 +/- 43) x10^-8 ph/cm2/sec, corresponding to an excess with significance >9 sigma with respect to the average flux from the Crab nebula of (286 +/- 2) x10^-8 ph/cm2/sec, estimated over all the Fermi operation period (only statistical errors are given). Ongoing Fermi observations indicate that the flare is continuing.

The flaring component has a spectral index of 2.49 +/- 0.14. Its position, Ra: 83.59 Dec: 22.05 with a 68% error radius of 0.06 deg, is coincident with the Crab Nebula.

Fermi will interrupt its all-sky scanning mode between 2010-09-23 15:49:00 UT and 2010-09-30 15:49:00 UT to observe the Crab Nebula. Afterwards regular gamma-ray monitoring of this source will continue. We strongly encourage further multifrequency observations of that region.

For this source the Fermi LAT contact person is Rolf Buehler (buehler@stanford.edu).

The Fermi LAT is a pair conversion telescope designed to cover the energy band from 20 MeV to greater than 300 GeV. It is the product of an international collaboration between NASA and DOE in the U.S. and many scientific institutions across France, Italy, Japan and Sweden.

Fermi Gamma-ray Space Telescope

A Variable Standard

arXiv:1011.3855v1

Science, 331, 739

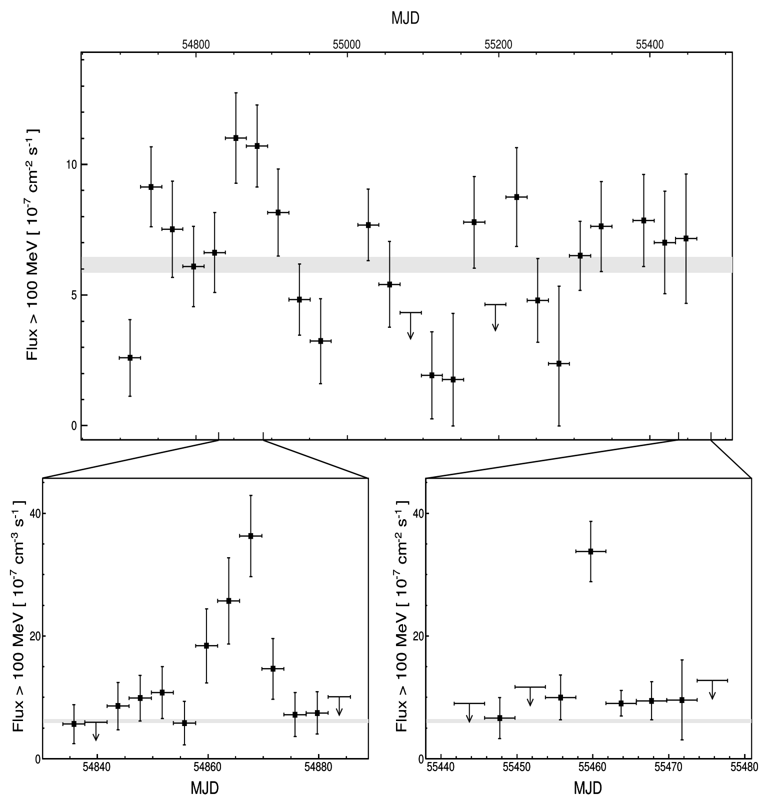
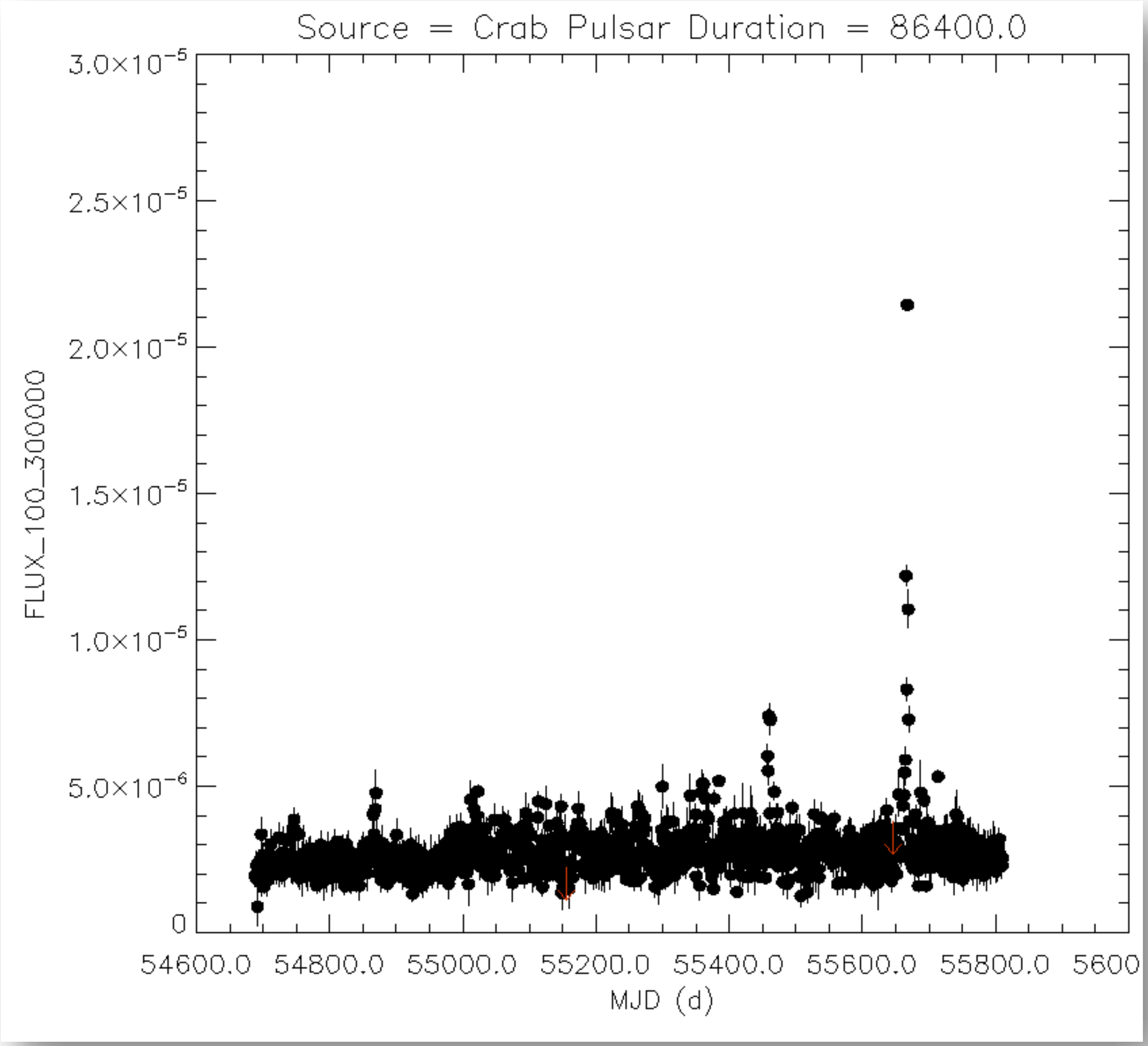


Figure 2: Gamma-ray flux above 100 MeV as a function of time of the synchrotron component of the Crab Nebula. The upper panel shows the flux in four-week intervals for the first 25 month of observations. Data for times when the sun was within 15° of the Crab Nebula have been omitted. The gray band indicates the average flux measured over the entire period. The lower panel shows the flux as a function of time in four-day time bins during the flaring periods in February 2009 and September 2010. Arrows indicate 95% confidence flux limits.

Now added to monitored source list

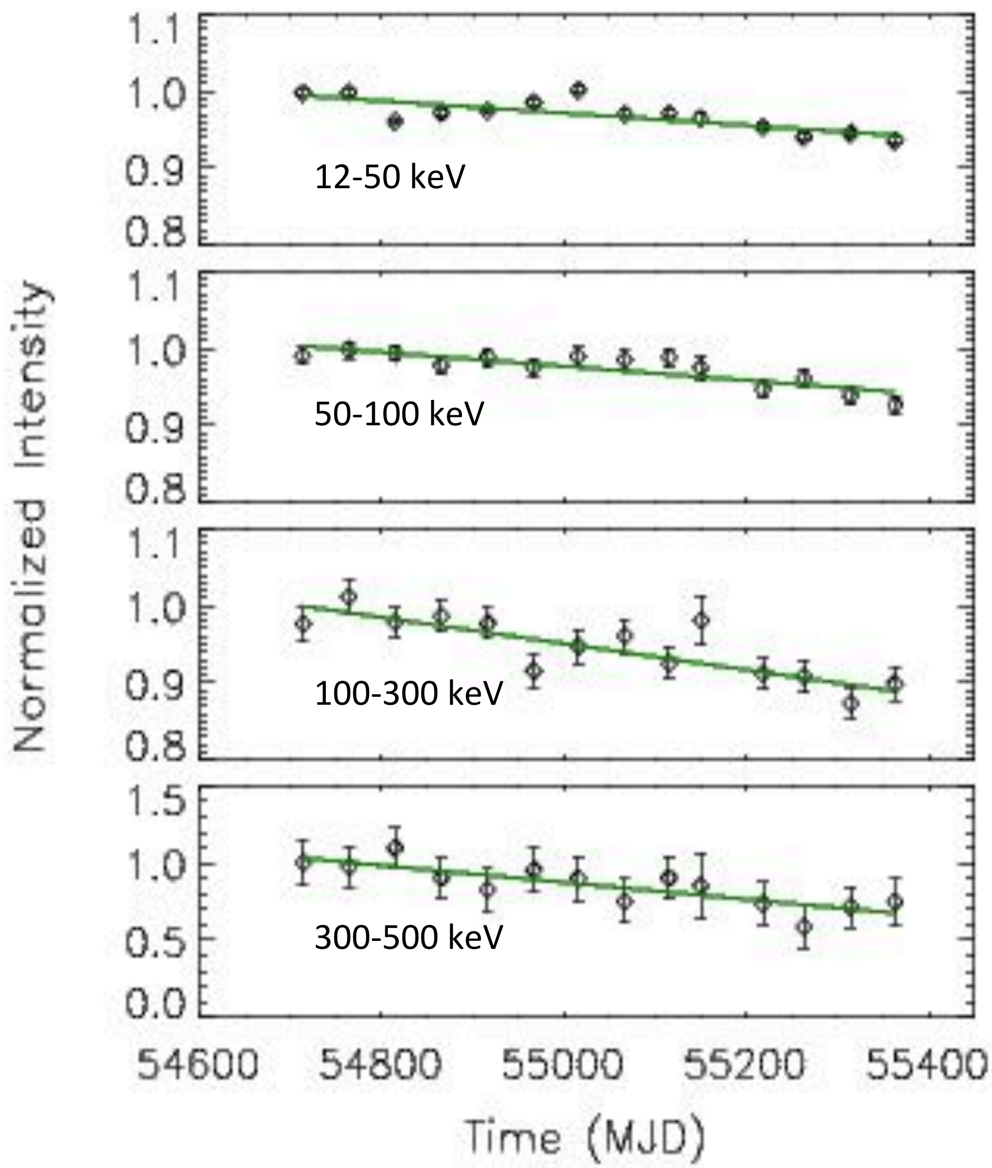
…also see **arXiv:1010.2679**

http://fermi.gsfc.nasa.gov/ssc/data/access/lat/msl_lc/



GBM Observations of the Crab Nebula

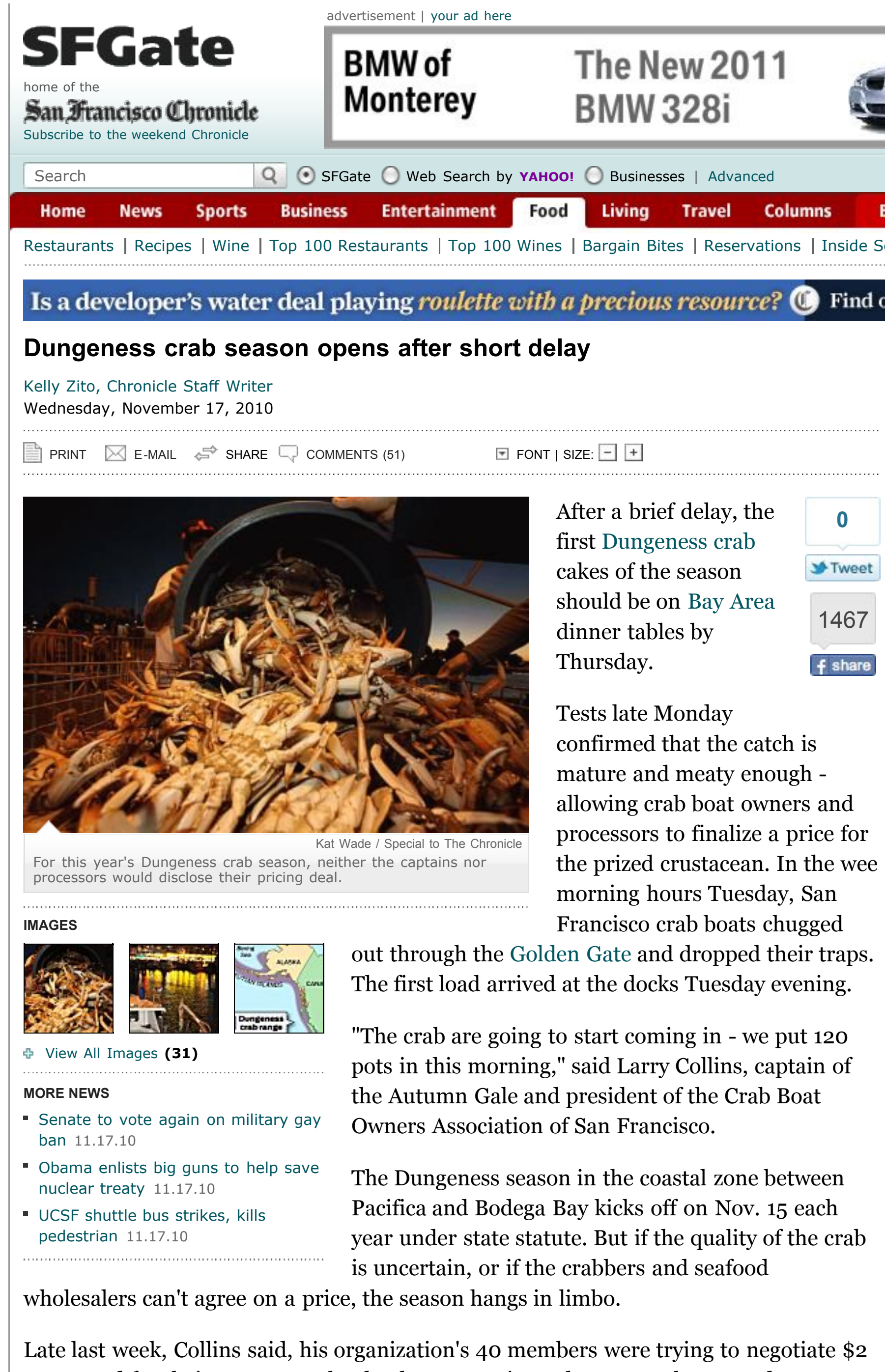
- **Normalized to long-term average in each band**
- **Decline in Crab flux (MJD 54690-55390)**
- **No changes in GBM response or calibration**



Wilson-Hodge et al 2010

arXiv:1010.2679

“But if the quality of the crab is uncertain…the season hangs in limbo.”



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Is a developer's water deal playing *roulette with a precious resource?* Find ou

Dungeness crab season opens after short delay

Kelly Zito, Chronicle Staff Writer

Wednesday, November 17, 2010

PRINT E-MAIL SHARE COMMENTS (51) FONT | SIZE: – +

Kat Wade / Special to The Chronicle

For this year's Dungeness crab season, neither the captains nor processors would disclose their pricing deal.

0 Tweet 1467 share

After a brief delay, the first Dungeness crab cakes of the season should be on Bay Area dinner tables by Thursday.

Tests late Monday confirmed that the catch is mature and meaty enough - allowing crab boat owners and processors to finalize a price for the prized crustacean. In the wee morning hours Tuesday, San Francisco crab boats chugged out through the Golden Gate and dropped their traps. The first load arrived at the docks Tuesday evening.

"The crab are going to start coming in - we put 120 pots in this morning," said Larry Collins, captain of the Autumn Gale and president of the Crab Boat Owners Association of San Francisco.

The Dungeness season in the coastal zone between Pacifica and Bodega Bay kicks off on Nov. 15 each year under state statute. But if the quality of the crab is uncertain, or if the crabbers and seafood wholesalers can't agree on a price, the season hangs in limbo.

Late last week, Collins said, his organization's 40 members were trying to negotiate $2

IMAGES

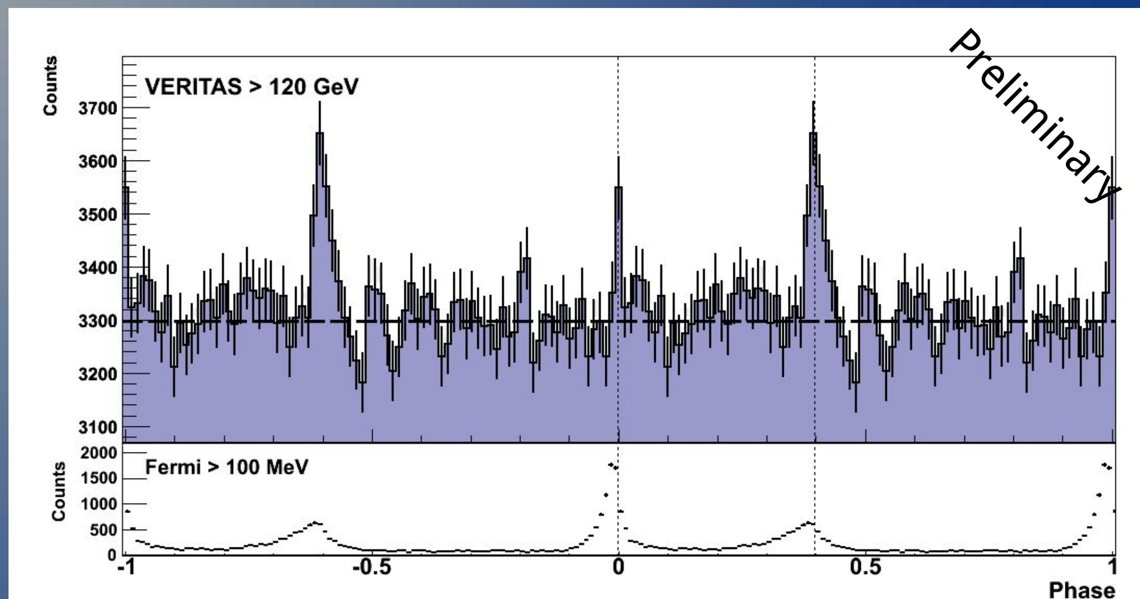
View All Images (31)

MORE NEWS

- Senate to vote again on military gay ban 11.17.10
- Obama enlists big guns to help save nuclear treaty 11.17.10
- UCSF shuttle bus strikes, kills pedestrian 11.17.10

VERITAS WOW!

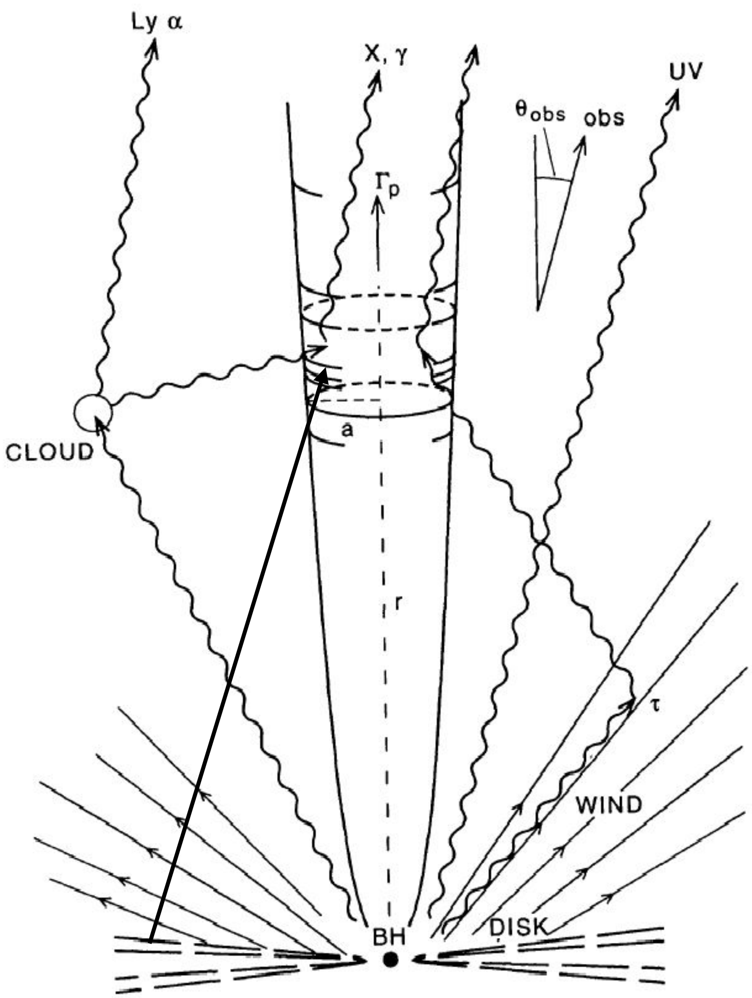
Pulsed Signal



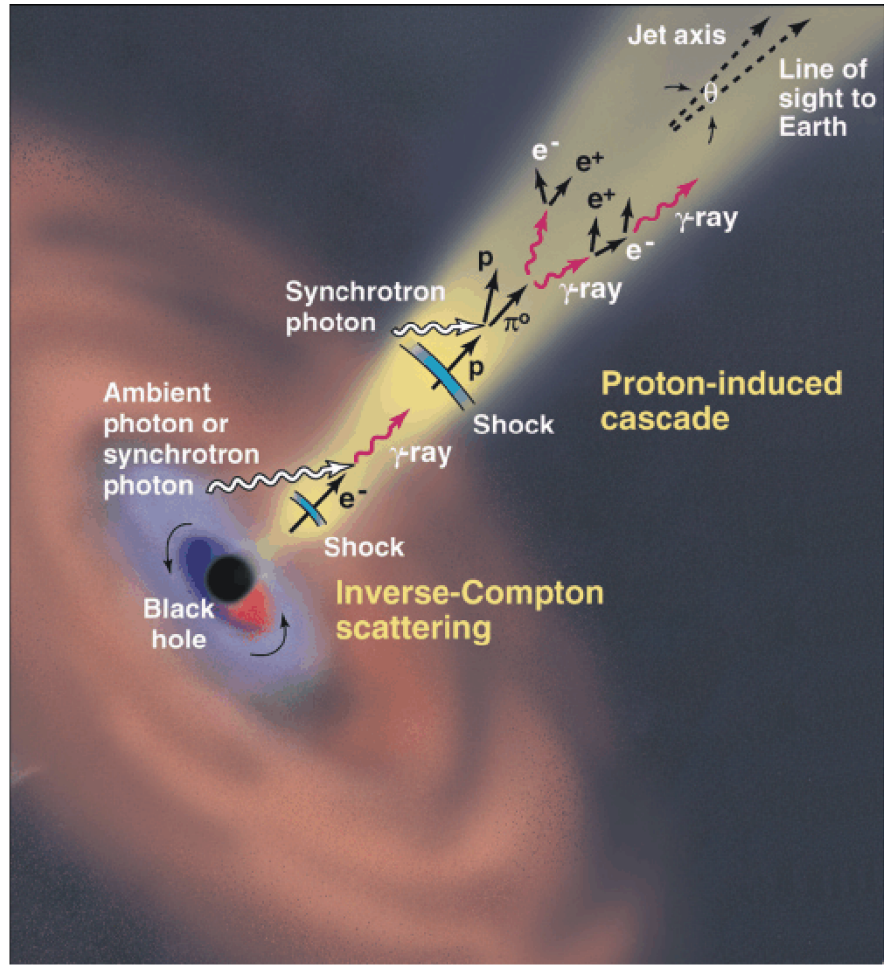
- Event time barycentering with tempo2 and custom codes
- Phase folding using Jodrell Bank ephemerides

Statistical significance of pulsed signal:
H-Test: 50, i.e. 6 σ

Models of Blazar Gamma-ray Production



(from Sikora, Begelman, and Rees (1994))



(credit:J. Buckley)

Variability and MW keys

LAT Continuous Source Releases

The LAT team continuously releases flux & spectra as a function of time for all sources in a pre-defined list + flaring sources during flares.

- Modified data release after ~6 months:
  - Lowered flux threshold to release information on flaring sources by factor of 2.
  - Provided information continuously (not just during flares).
  - started with 23 sources, now have >50, with contact people assigned.

•http://fermisky.blogspot.com

Contact Information for Individual Sources - GLAST LAT Multiwavelength Coordinating Group - SLAC Confluence 5/10/10 2:34 PM

Contact Information for Individual Sources

Added by David J. Thompson, last edited by C. C. Teddy Cheung on May 05, 2010

Please note: This is a public page (for multifrequency purposes).

List of Contacts for Individual Sources

LAT Monitored Source List Light Curves are available for most of these sources

Fermi-LAT Weekly Sky blog and Daily Sky blog

For reference, see all Astronomer's Telegrams from the Fermi-LAT collaboration

Extragalactic sources from ATels, in order of (the First) ATel number, starting with earliest

Source Name(s)	Friend(s) of the Source	ATEL number(s)
3C 454.3	Greg Madejski (madejski at stanford.edu)	1628, 2200, 2328, 2534
PKS 1502+106	Stefano Ciprini (stefano.ciprini at pg.infn.it)	1650, 1905
PKS 1454-354	??	1701
3C273	Jim Chiang (jchiang at slac.stanford.edu), Werner Collmar (wec at mpe.mpg.de)	1707, 2168, 2200
1510-089	Andrea Tramacere (tramacer at slac.stanford.edu)	1743, 1897, 2033
AO 0235+164	Luis C. Reyes (lreyes at kicp.uchicago.edu)	1744, 1784
3C 66A	Luis C. Reyes (lreyes at kicp.uchicago.edu)	1759
PKS 0208-512	Werner Collmar (wec at mpe.mpg.de)	1759
PKS 0537-441	Gino Tosti (tosti at pg.infn.it)	1759, 2124, 2591
3C279	Greg Madejski (madejski at slac.stanford.edu), Werner Collmar (wec at mpe.mpg.de)	1864, 2154
B0133+47	Hiromitsu Takahashi (hirotaka at hep01.hepl.hiroshima-u.ac.jp), Gino Tosti (tosti at pg.infn.it)	1877
J123939+044409	Andrea Tramacere (tramacer at slac.stanford.edu), Nanda Rea (N.Rea at uva.nl)	1888
PKS 1244-255	Andrea Tramacere (tramacer at slac.stanford.edu), Nanda Rea (N.Rea at uva.nl)	1894
PKS 0454-234	Dario Gasparrini (dario.gasparrini at asdc.asi.it)	1898
0917+449	William McConville (wmcconvi at umd.edu)	1902

https://confluence.slac.stanford.edu/display/GLAMCOG/Contact+Information+for+Individual+Sources Page 1 of 4

Rapid Publications from the Fermi LAT Collaboration: GCN and ATEL

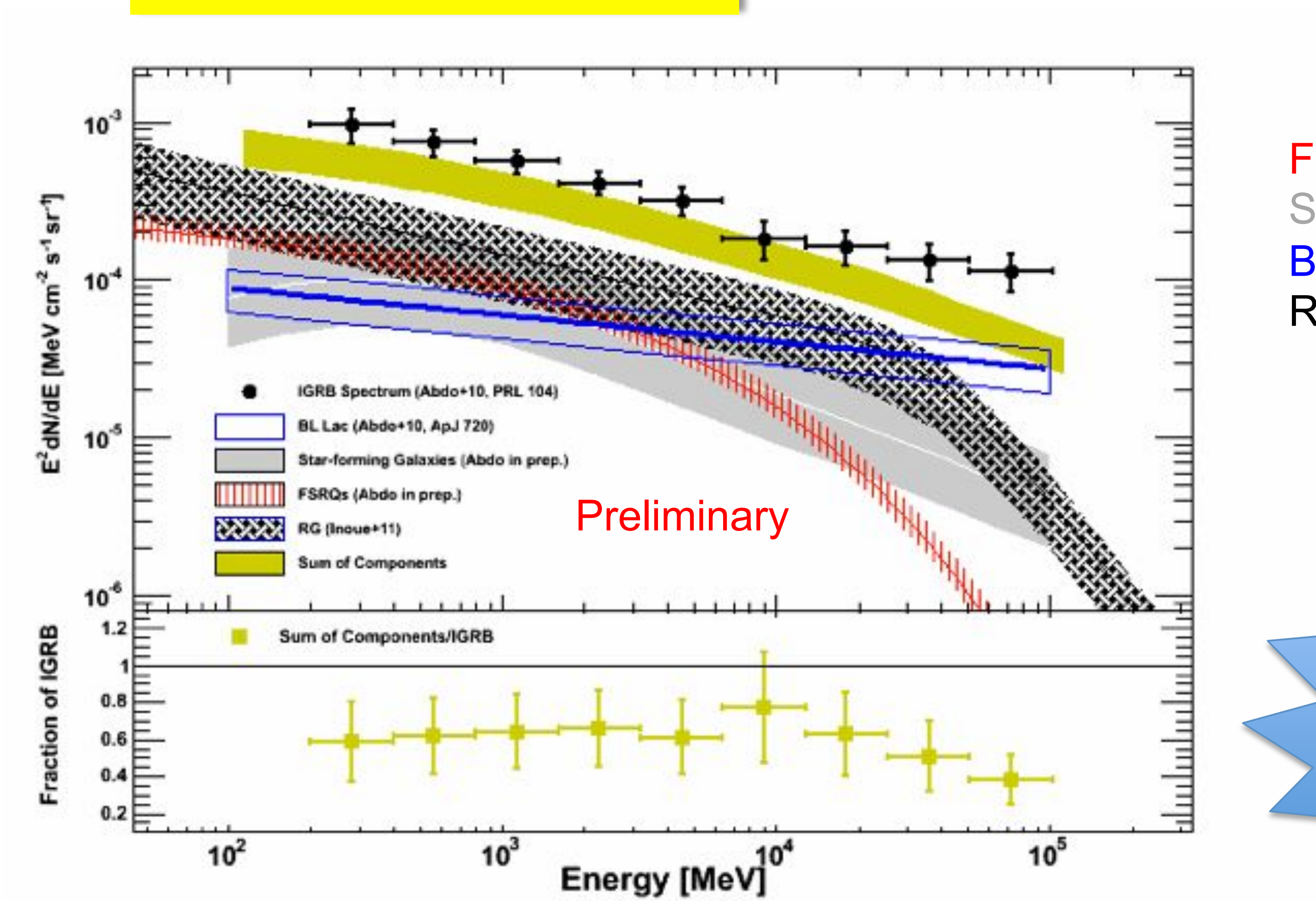
Astronomer's Telegrams (ATEL):

date	number	title
2010-Nov-11	3026	Fermi LAT detection of increasing gamma-ray activity from the FSRQ B3 1708+433
2010-Nov-08	3014	GeV emission from SHBL J001355.9-185406
2010-Nov-03	3002	Fermi LAT detection of increasing gamma-ray activity from the FSRQ PKS 1730-13
2010-Oct-30	2986	Swift follow-up confirms the high flaring state of the blazar PMN J2345-1555
2010-Oct-26	2972	Detection of a simultaneous optical and gamma-ray flare from blazar PMN J2345-1555
2010-Oct-22	2966	Fermi LAT detection of a possible new gamma-ray blazar PMN J1913-3630
2010-Oct-21	2963	Swift follow-up confirms the high activity state of CGRaBS J1848+3219
2010-Oct-19	2954	Fermi LAT detection of a GeV flare from CGRaBS J1848+3219
2010-Oct-15	2944	Fermi LAT observations of enhanced gamma-ray activity of blazar PKS 2155-304
2010-Oct-15	2943	Fermi LAT detection of an intense GeV flare from the high-redshift and gravitationally lensed blazar PKS 1830-211
2010-Oct-05	2907	Fermi-LAT detection of GeV gamma-ray emission from CRATES J0531-4827
2010-Oct-03	2901	Swift follow-up of the gamma-ray flaring blazar PKS 0727-11
2010-Sep-29	2886	Fermi LAT observations of increasing gamma-ray activity of blazar 3C279
2010-Sep-28	2879	Crab flux no longer elevated in Fermi-LAT band
2010-Sep-23	2861	Fermi LAT confirmation of enhanced gamma-ray emission from the Crab Nebula region
2010-Sep-23	2860	Fermi LAT detection of a GeV flare from the FSRQ PKS 0727-11
2010-Sep-18	2848	Flaring blazar B2 0619+33: Swift X-ray and UV/optical observations
2010-Sep-09	2837	PKS 1329-049 revived: new gamma-ray activity observed by Fermi LAT

Also see http://fermisky.blogspot.com/

What Produces the Isotropic Flux?

earlier work: arXiv:1002.3603



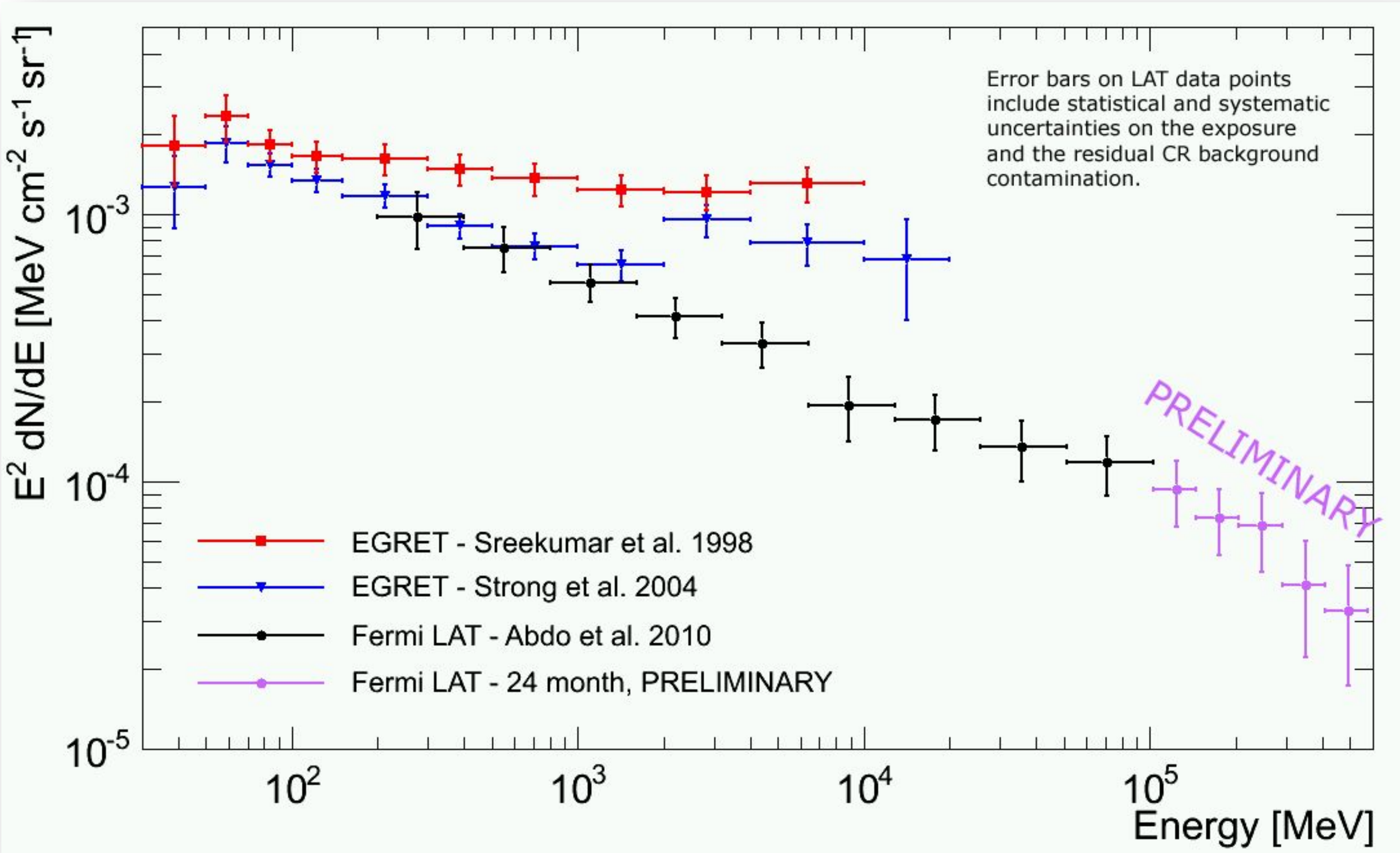
updated

FSRQ
Star-forming Gal.
BL Lac
Radio Galaxies

more to explore!

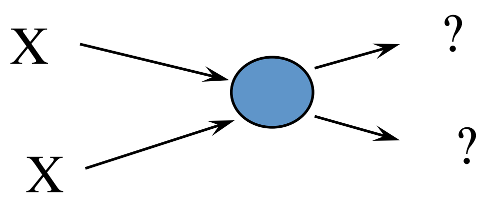
See other studies by: Stecker&Salomon+96, Pavlidou&Fields+02, Narumoto&Totani06,Dermer07, Bhattacharya+09, Inoue&Totani09, Fields+10, Makiya+10, Inoue+11,Abazajian+10, Ghirlanda+11,Stecker&Venters11,Malyshev&Hogg11

Recent Update to 600 GeV



Dark Matter

Some important models in particle physics could also solve the dark matter problem in astrophysics. If correct, these new particle interactions could produce an anomalous flux of cosmic particles ("indirect detection").



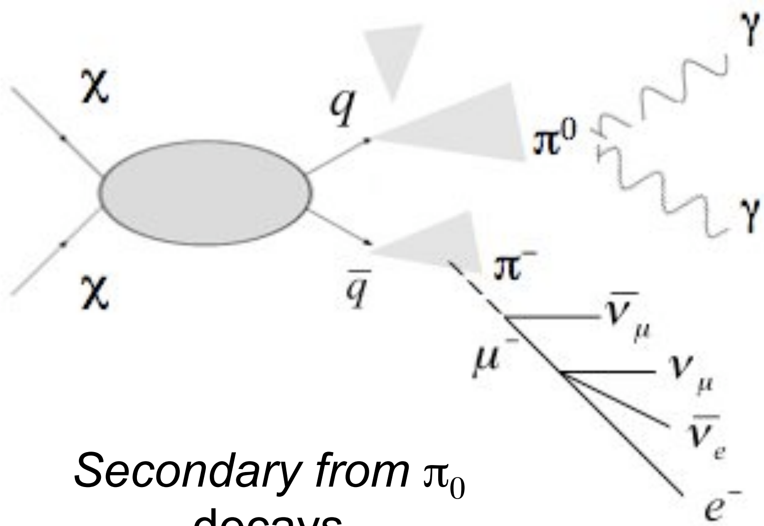
Anomalous gamma ray spectra and/or $\gamma\gamma$ or $Z\gamma$ "lines" and/or anomalous charged cosmic rays and/or neutrinos?

- If particles are stable: rate ~ (DM density)^2
- If particles unstable: rate ~ (DM density)

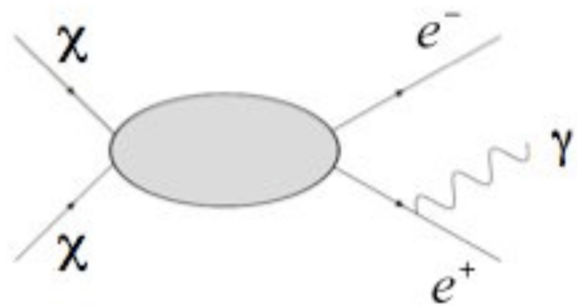
- Key interplay of techniques:
  - colliders (TeVatron, LHC)
  - direct detection experiments underground
  - indirect detection (most straightforward: gamma rays and neutrinos)
    - Full sky coverage look for clumping throughout galactic halo, including off the galactic plane (if found, point the way for ground-based facilities)
    - Intensity highly model-dependent
    - **Challenge is to separate signals from astrophysical backgrounds**

Just an example of what might be waiting for us to find!

Gamma rays from Dark Matter annihilation



Secondary from π_0
decays



Prompt lepton
pair production

$$\Phi_{WIMP}(E,\Psi) = J(\Psi) \times \Phi^{PP}(E)$$

Astrophysical factor

$$J(\Psi) = \int_{l.o.s} dl(\Psi)\,\rho^2(l)$$

Particle physics factor

$$\Phi^{PP}(E) = \frac{1}{2}\frac{\langle \sigma v \rangle}{m^2_{WIMP}} \sum_f \frac{dN_f}{dE} B_f$$

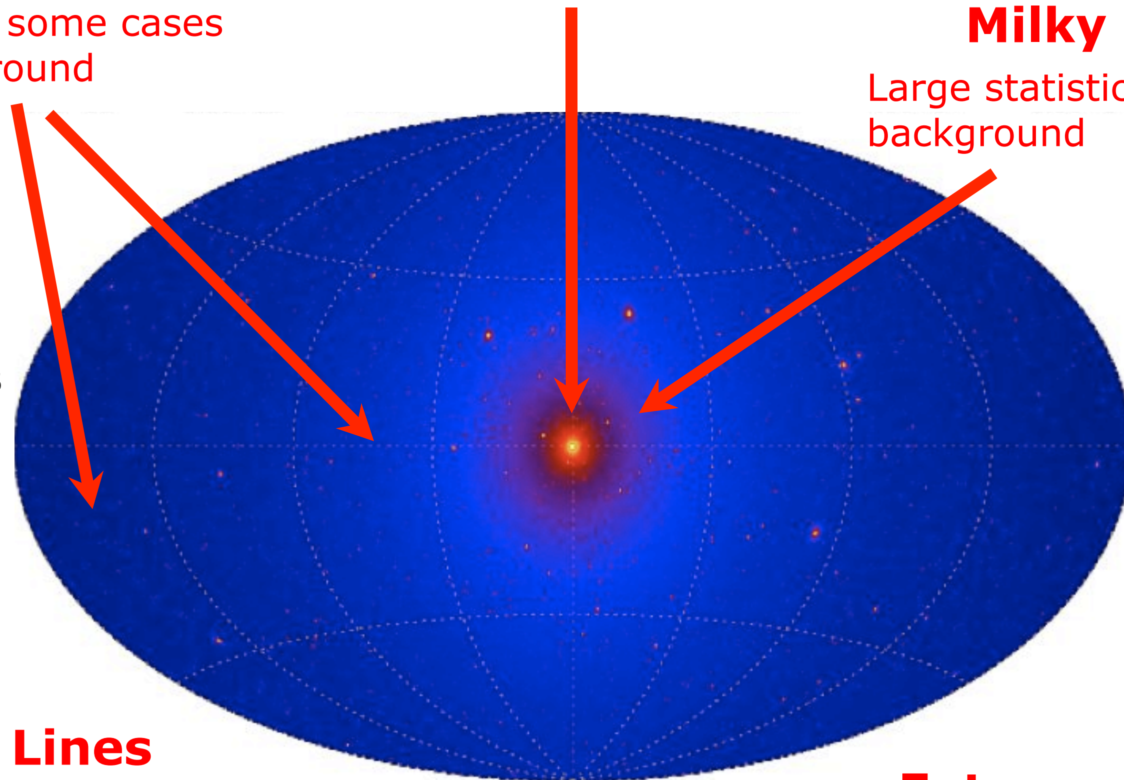
Dark Matter: Many Places to Look!

Galactic Center
Good Statistics but source confusion/diffuse background

Satellites
Low background and good source id, but low statistics, in some cases astrophysical background

Milky Way Halo
Large statistics but diffuse background

All-sky map of gamma rays from DM annihilation arXiv:0908.0195 (based on Via Lactea II simulation)



And anomalous charged cosmic rays (little/no directional information, trapping times, etc.)

Spectral Lines
No astrophysical uncertainties, good source id, but low sensitivity because of expected small BR

Extra-galactic
Large statistics, but astrophysics, galactic diffuse background

Galaxy Clusters
Low background, but low statistics

They Play Together!

Direct Detection
Relic scattering RIGHT HERE at low energy. Push to larger target mass, lower backgrounds, directional sensitivity?

Accelerators
Direct production. Push to higher energy

Observations
Push toward finding and studying galactic halo objects and large scale structure.

Indirect Detection
Relic interactions (annihilations, decays) Understand the astrophysical backgrounds in signal-rich regions. Reveal the detailed astrophysical distribution of dark matter.

Simulations
Large scale structure formation. Push toward larger simulations, finer details.

They Play Together!

Recent JE papers

arXiv:1106.2529

arXiv:1011.0077

Direct Detection

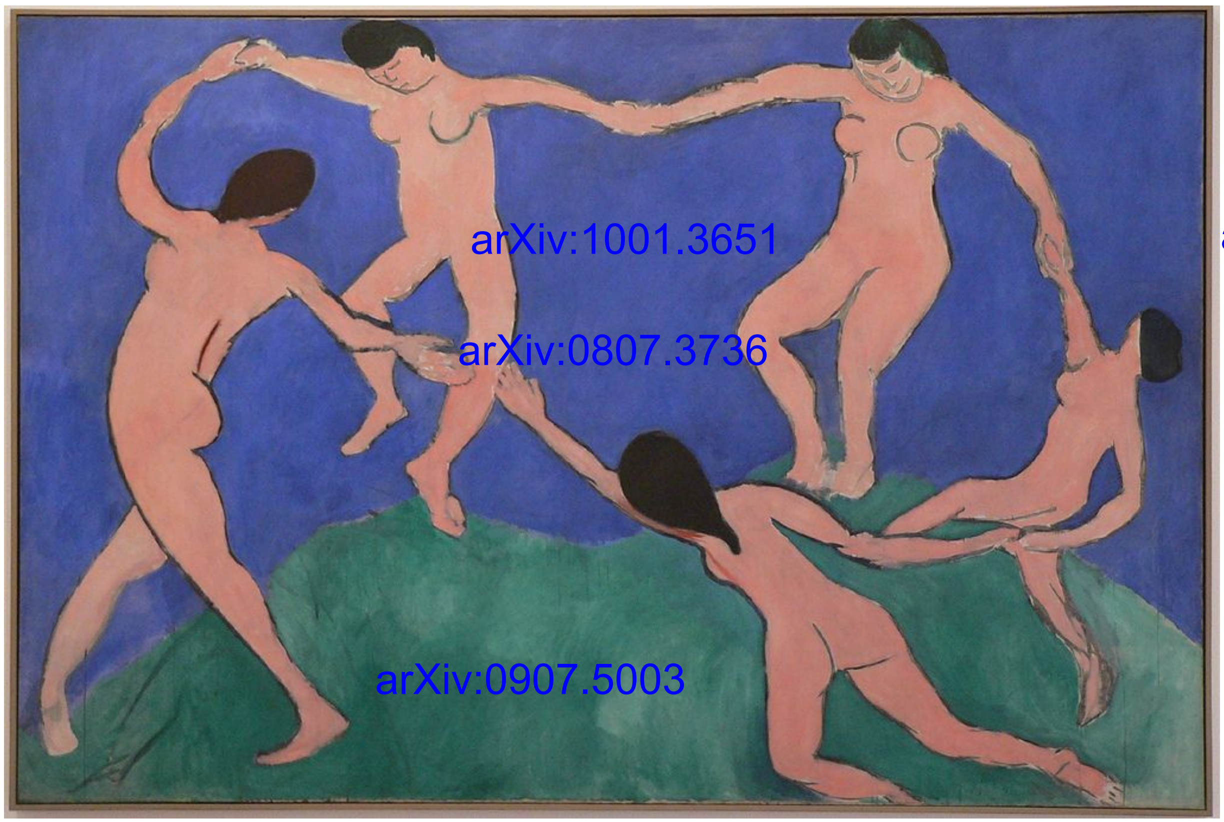
Relic scattering RIGHT HERE at low energy. Push to larger target mass, lower backgrounds, directional sensitivity?

Accelerators

Direct production. Push to higher energy

arXiv:0905.0107

arXiv:0801.3656



arXiv:0303043

Observations

Push toward finding and studying galactic halo objects and large scale structure.

arXiv:1106.0768

Indirect Detection

Relic interactions (annihilations, decays) Understand the astrophysical backgrounds in signal-rich regions. Reveal the detailed astrophysical distribution of dark matter.

Simulations

Large scale structure formation. Push toward larger simulations, finer details.

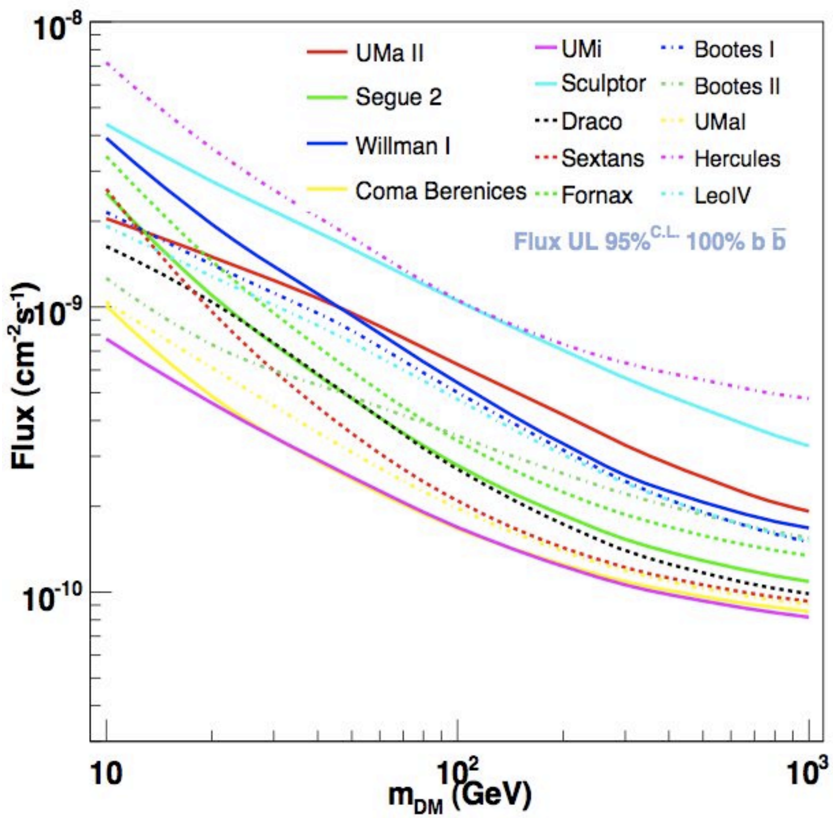
Dwarf Spheriodal (dSph) Galaxies

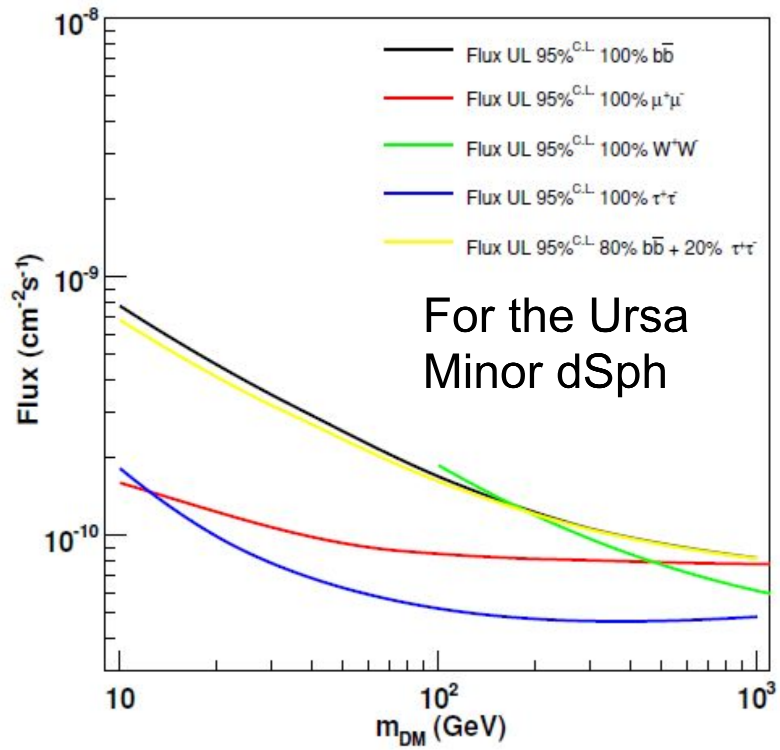
- Largest galactic substructures predicted (in ΛCDM)
- DM-dominated: mass-to-light ratios O(100-1000)
- Very low astrophysical backgrounds
  - no detected gas, low recent star formation activity
- SDSS discovery of many more ultrafaint Milkyway satellites
  - more are welcome!
- Great opportunity for indirect DM signal searches!

Search for DM in dSph

A.A. Abdo et al., ApJ 712 (2010) 147.

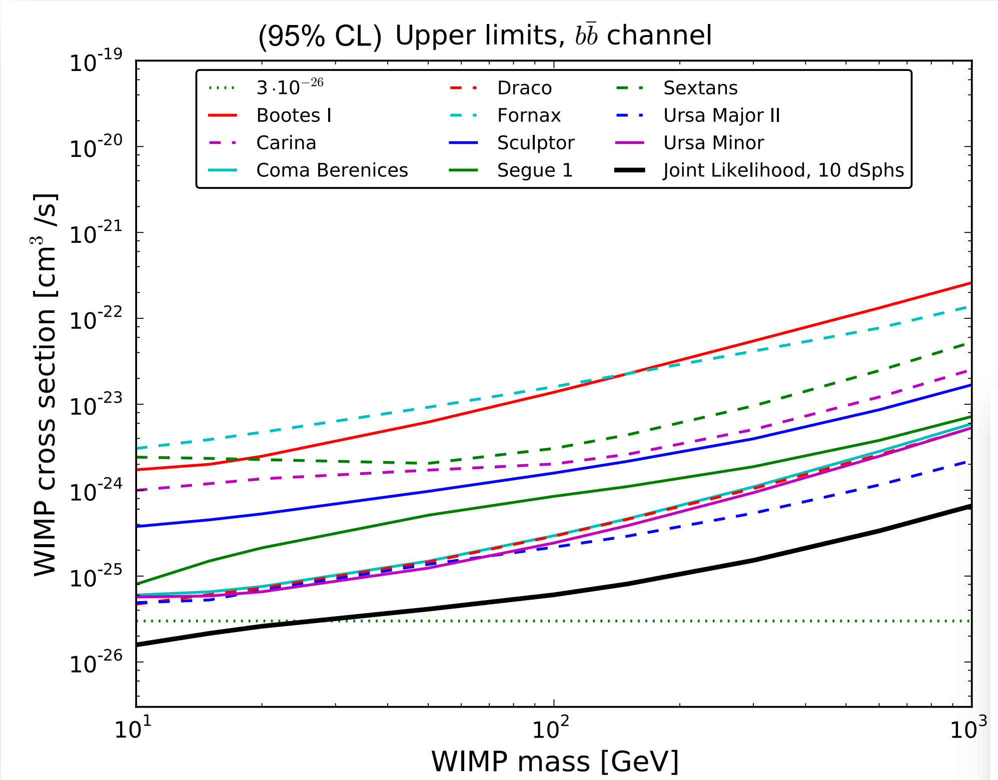
No detection by Fermi (100 MeV – 50 GeV) with 11 months of data. 95% flux upper limits are placed for several possible annihilation final states.

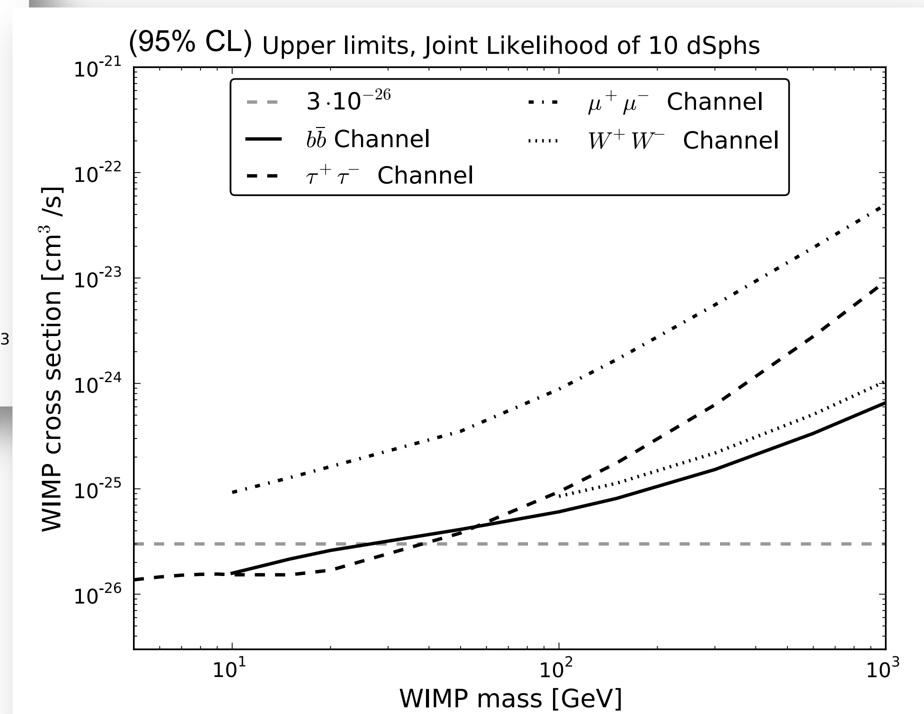




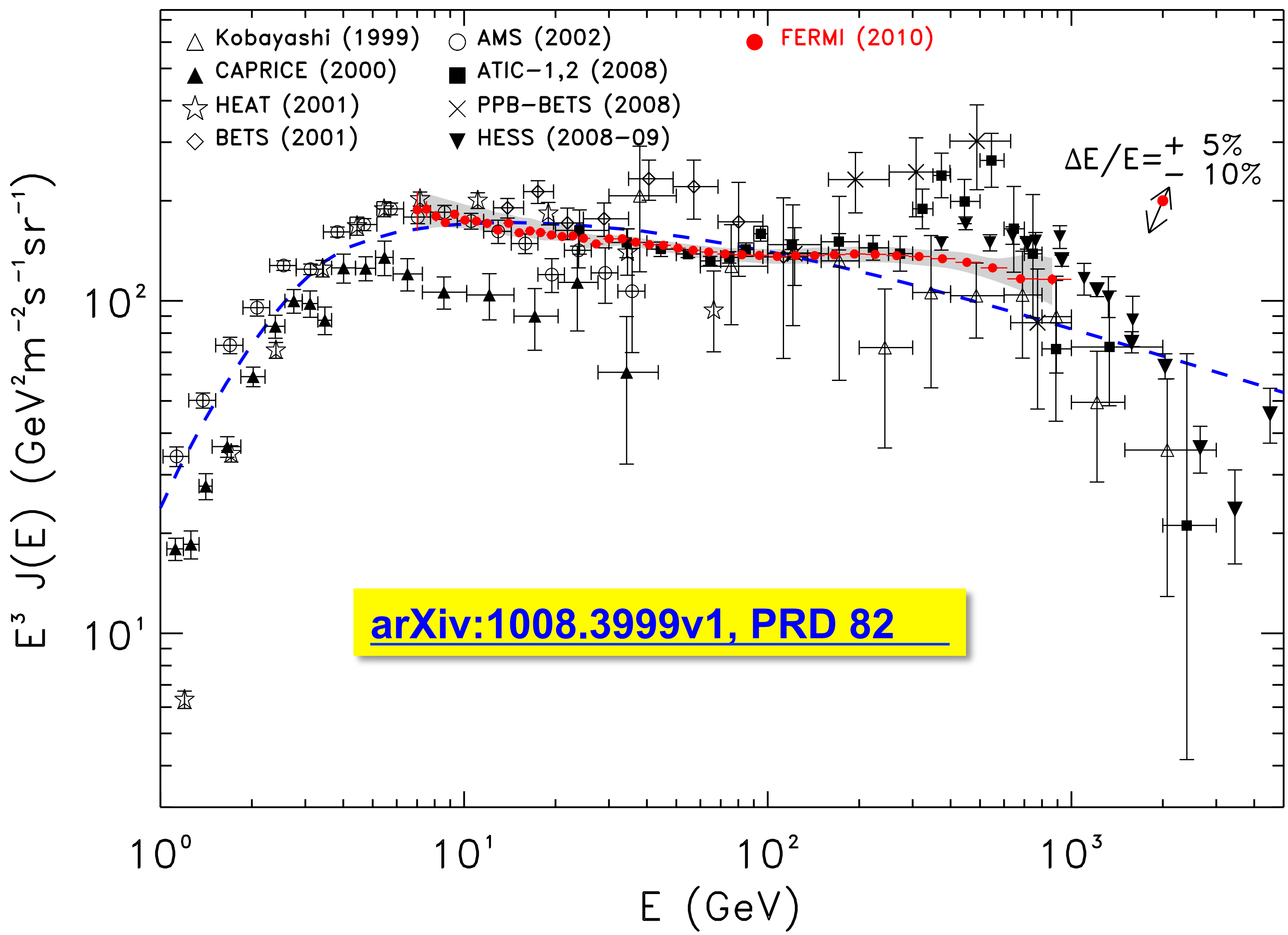
Combining dSph Limits

arXiv:1108.3546v2





LAT e+e- Spectrum Update



7 GeV – 1 TeV, double statistics (8M events)

Data/MC Comparisons

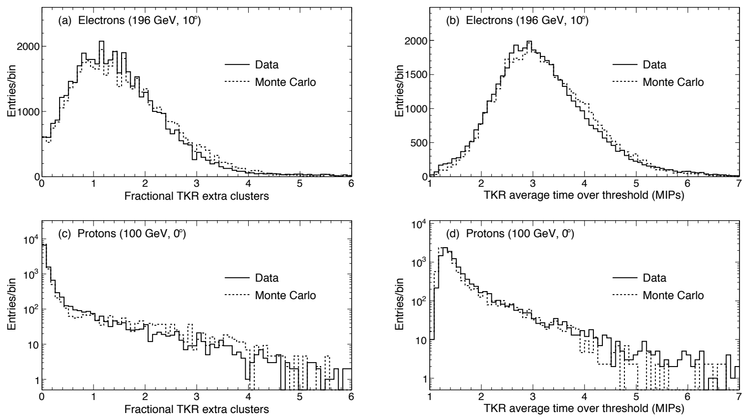


FIG. 1: Comparison of beam test data (solid line) and MC simulations (dashed line) for two fundamental tracker variables used in the electron selection: the number of clusters in a cone of 10 mm radius around the main track (left panels) and the average time over threshold (right panels). Both variables are shown for an electron and a proton beam.

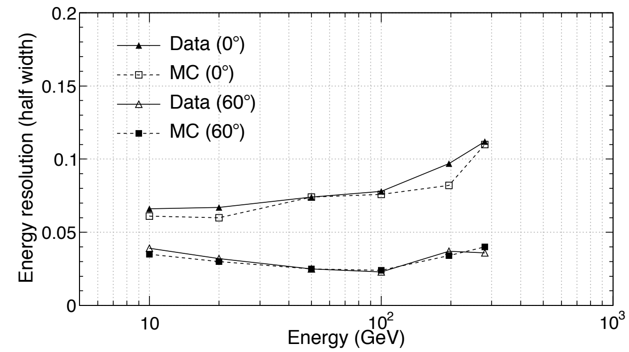


FIG. 3: Comparison of beam test data (triangles) and Monte Carlo simulations (squares) for the energy resolution for electron beams entering the CU at 0° and 60° and energies from 10 to 282 GeV. Lines are to guide an eye.

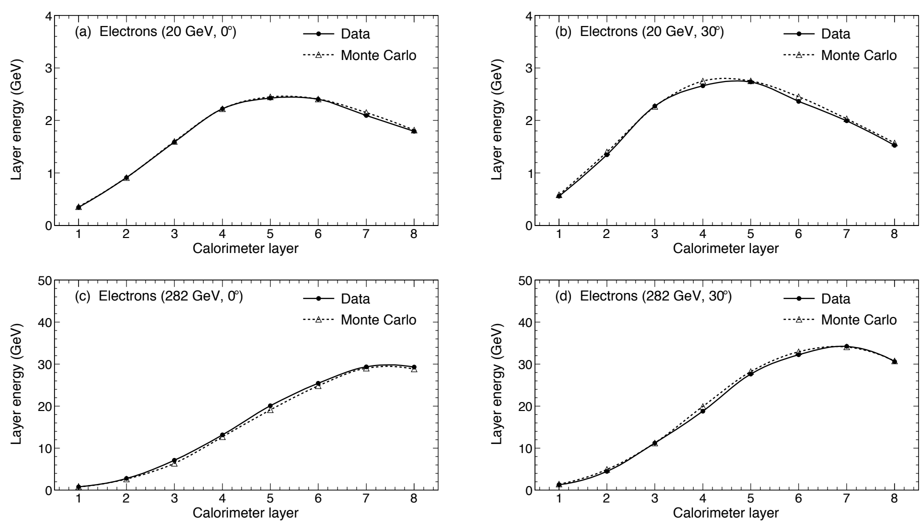
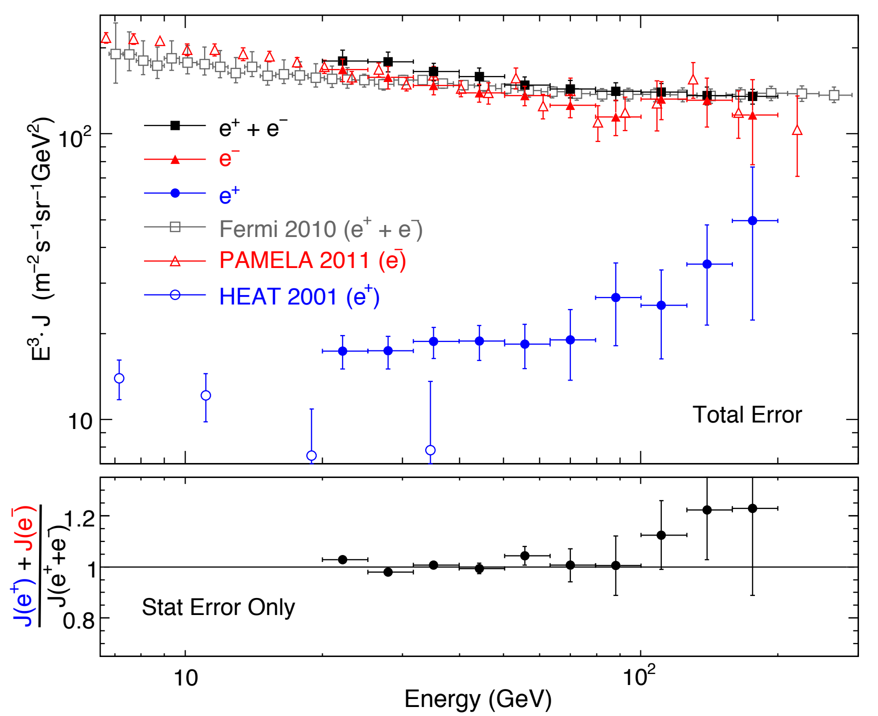


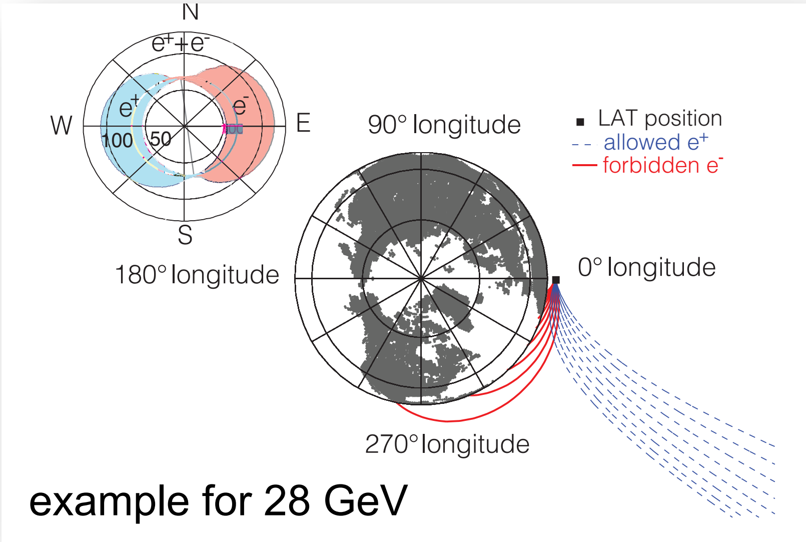
FIG. 4: Comparison of Beam test data and Monte Carlo simulations for the longitudinal shower profiles for electron beams entering the CU at 0° and 30° and energies of 20 and 282 GeV.

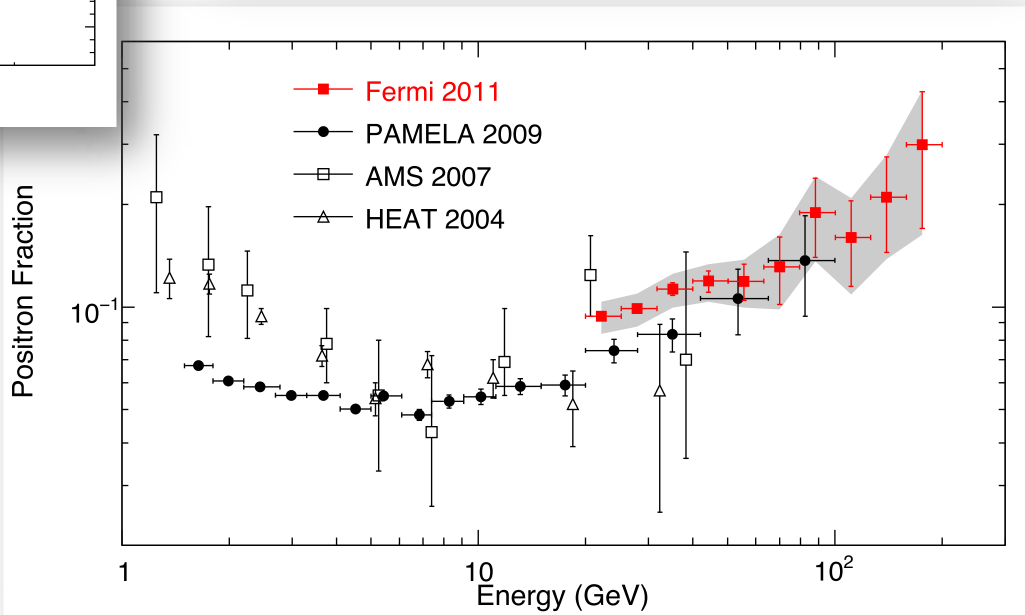
Many thanks to CERN!!

arXiv:1008.3999v1, PRD 82

LAT e+ and e- Measurement







arXiv:1109.0521

…and AMS-02 is flying!

Anomalies in e± spectra?

"*Before jumping to an interpretation involving the annihilations of dark matter particles, one should first consider more prosaic interpretations, taking into account uncertainties in cosmic-ray production and propagation through the galaxy, as well as possible contributions from nearby sources. These may render unnecessary an explanation in terms of dark matter annihilations, which would in any case require a rather special supersymmetric model.*"

- JE **arXiv:1106.2923v1**

No Significant e+e- Excess or Deficit from the Sun

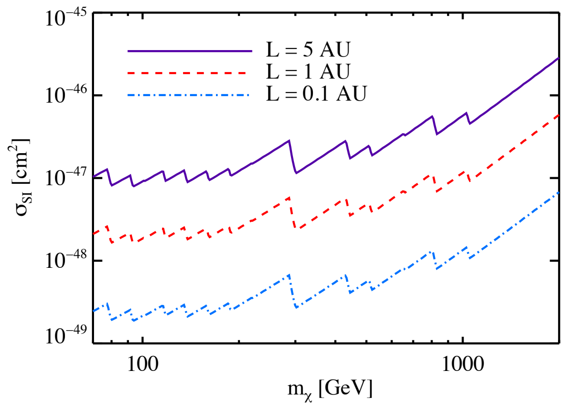


FIG. 6: Constraints on DM annihilation to e^+e^- via an intermediate state, from solar CRE flux upper limits. Solar capture of DM is assumed to take place via spin-independent scattering. The constraints obtained for three values of the decay length L of the intermediate state are shown. Models above the curves exceed the solar CRE flux upper limit at 95% CL for a 30° ROI centered on the Sun.

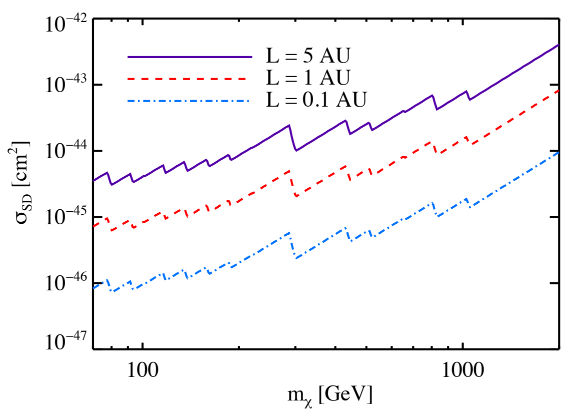
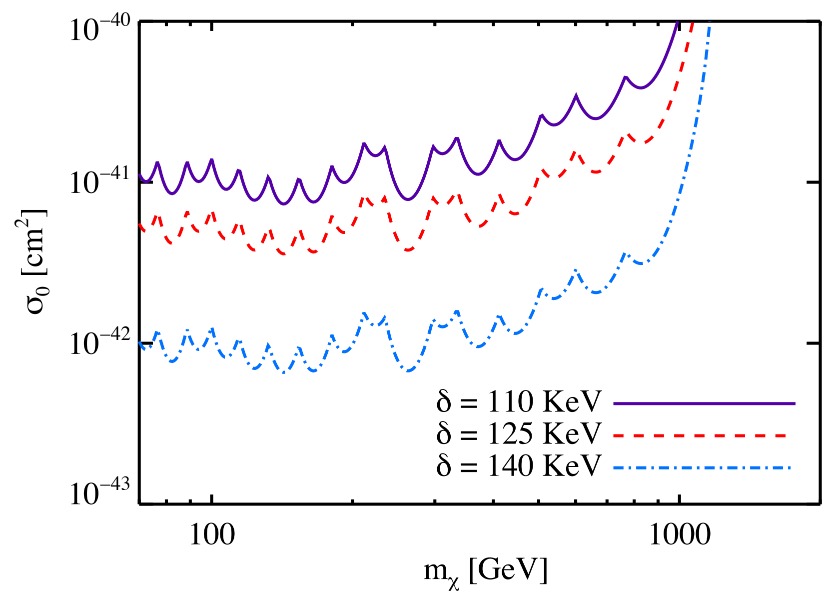


FIG. 7: Constraints on DM parameters for annihilation to e^+e^- via an intermediate state as in Fig. 6, except assuming solar capture by spin-dependent scattering.

arXiv:1107.4272

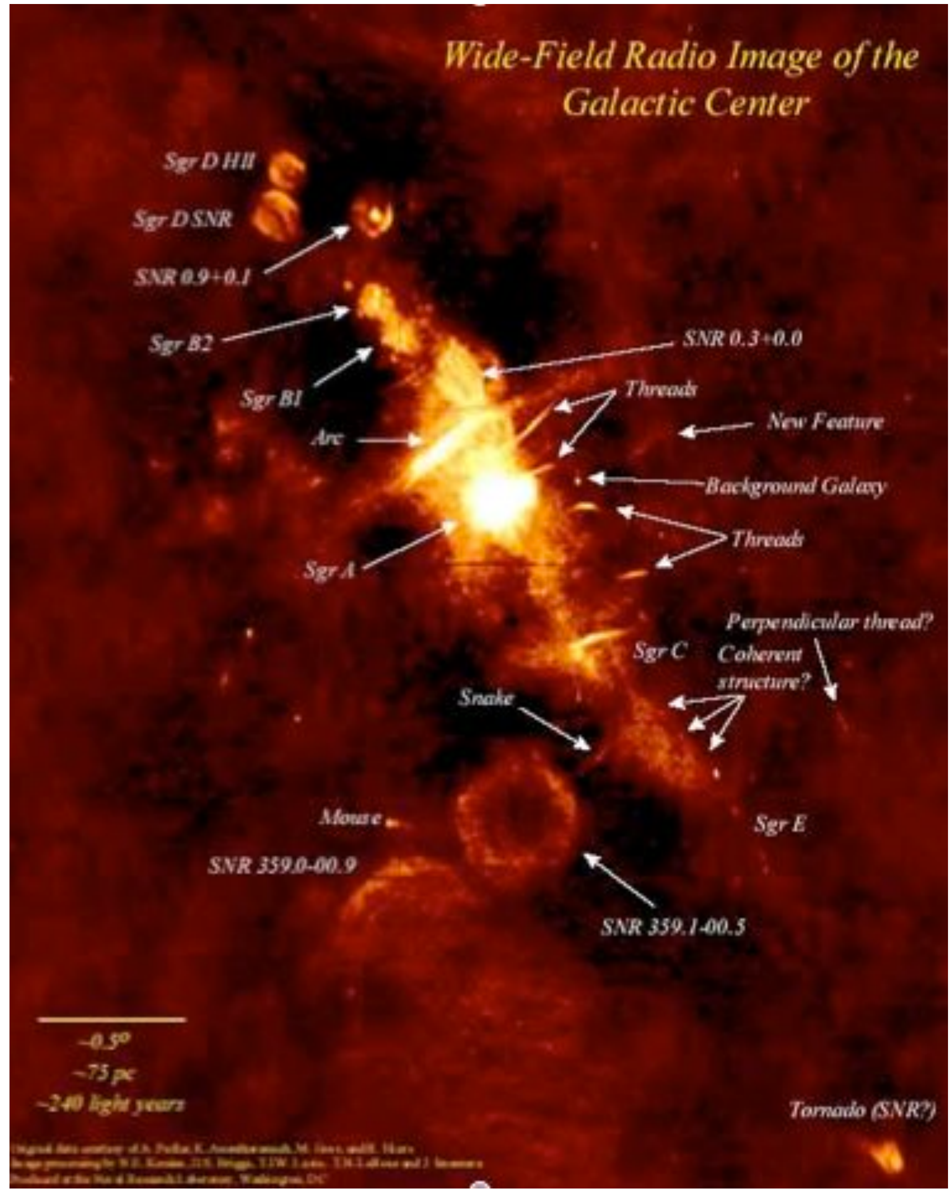


strongly excludes iDM explanation for DAMA/LIBRA – CDMS inconsistency for m>70 GeV and annihilation to e+e-

Intermediate state → e+e- constraints

Inner Galaxy

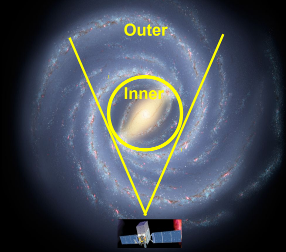
- "*Lasciate ogne speranza, voi ch'intrate*" – Dante Alighieri
- *"If you're going through hell, KEEP GOING!" - Winston Churchill* (emphasis added)



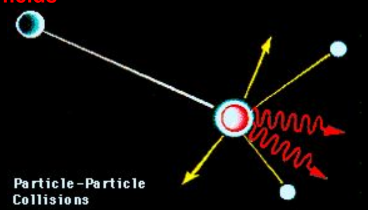
Inner Galaxy

Disentangling the Many Sources of Gamma-Ray Emission is Challenging ...

The emission from the inner Galaxy consists of a number of components:
- Outer Galaxy
- True inner Galaxy
- Point sources
- Unresolved sources



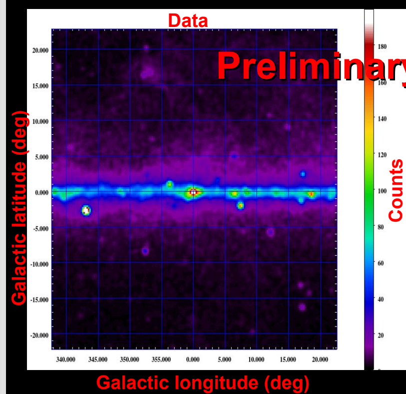
Diffuse gamma rays produced by cosmic rays interacting with the interstellar gas and radiation fields



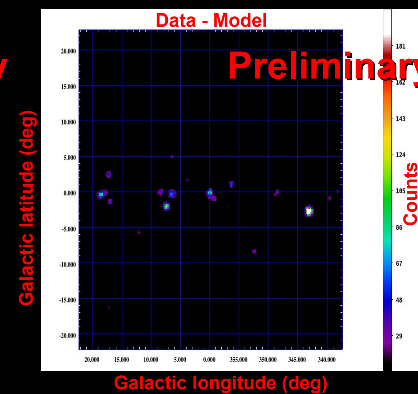
Use galprop cosmic ray propagation/diffuse emission code

http://galprop.stanford.edu

Subtraction of the Diffuse Emission



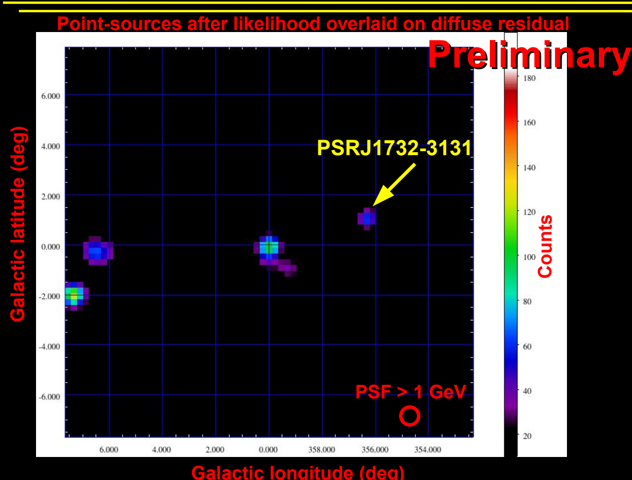
Data > 1 GeV for 45°x45° region about GC



Data - Model > 1 GeV for 45°x45° region about GC

32 Months Data (Front)

Residual Emission for 15°x15° about GC



Bright excesses remain after model subtraction

Summary

- The majority of the diffuse emission is removed using a physically-motivated model based on GALPROP
- Peaks in residual emission consistent with known sources
- Work in progress to characterise the low-level residual structures and point sources
- Forthcoming paper(s) will describe the method and results in detail

Data are Public

CERN-PH-TH/2011-130, KCL-PH-TH/2011-13, LCTS/2011-02

UMN–TH–3004/11, FTPI–MINN–11/14

Galactic-Centre Gamma Rays in CMSSM Dark Matter Scenarios

John Ellis[1,2], **Keith A. Olive**[3] and **Vassilis C. Spanos**[4]

axXiv:1106.0768v1

In order to evaluate the possible constraints imposed on the CMSSM parameter space by the latest Fermi-LAT data [12], we estimate the background using the Fermi-LAT Science Tools [57]. In our analysis, we use data collected by Fermi-LAT between Aug 4, 2008 and April 29, 2011, making a selection based on the recommendations of the collaboration. We focus our analysis in the energy range 300 MeV to 300 GeV, dividing it in 25 bins spaced evenly on a logarithmic scale. We have studied various windows around the GC in the range 1–10 degrees, but we choose as the basic region-of-interest (ROI) of our analysis the 7-degree window centred at the position of the brightest source in the GC: RA $= 266.46^0$, Dec $= -28.97^0$, as in [15]. Note however, that our conclusions are not overly sensitive to this choice of window size.

Fig. 6 displays the various background components obtained using the Science Tools [57], along with the data collected during the aforementioned period. The error bars attached to the data represent the purely statistical errors. We have performed a binned likelihood analysis using the `gtlike` tool, including in the background model file used in the fit 1) the galactic diffuse model, 2) the isotropic spectral template, and 3) the point sources, all as provided by the collaboration. Concerning the point sources, we have included additional RPS from the vicinity of the ROI, that possibly can contribute to the observed counts.

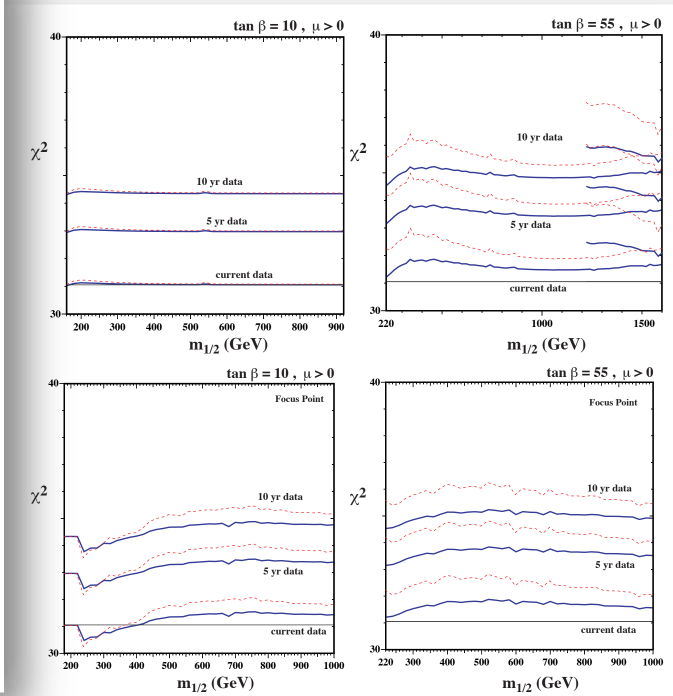


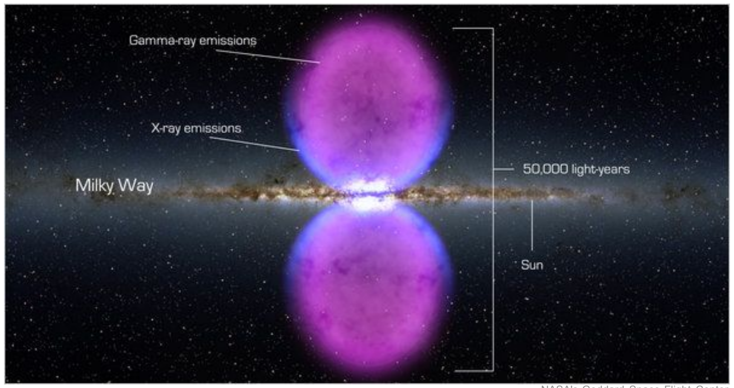
Figure 10: *The χ^2 functions along the CMSSM WMAP strips as functions of $m_{1/2}$ for $\tan\beta = 10$ (left panels) and $\tan\beta = 55$ (right panels), in the coannihilation and funnel regions (upper panels) and in the focus-point region (lower panels). In each panel, we display the χ^2 function for the background alone, a horizontal line at $\chi^2 = 31.1$, and the χ^2 function obtained by adding the calculated $\chi - \chi$ annihilation signal in the current (approximately 2 1/2 year) Fermi data sample and in projected 5- and 10-year data sets. Solid (blue) curves are based on an NFW profile, while dashed (red) curves are based on an Einasto profile.*

Fermi Gamma-ray Space Telescope

The New York Times

Space & Cosmos

Bubbles of Energy Are Found in Galaxy



NASA's Goddard Space Flight Center

From end to end, the newly discovered gamma-ray bubbles extend 50,000 light-years, or about half of the Milky Way's diameter, as shown in this illustration.

By DENNIS OVERBYE
Published: November 9, 2010

Something big is going on at the center of the galaxy, and astronomers are happy to say they don't know what it is.

A group of scientists working with data from NASA's Fermi Gamma-Ray Space Telescope said Tuesday that they had discovered two bubbles of energy erupting from the center of the Milky Way galaxy. The bubbles, they said at a news conference and in a paper to be published Wednesday in The Astrophysical Journal, extend 25,000 light years up and down from each side of the galaxy and contain the energy equivalent to 100,000 supernova explosions.

"They're big," said Doug Finkbeiner of the Harvard-Smithsonian Center for Astrophysics, leader of the team that discovered them.

The source of the bubbles is a mystery. One possibility is that they are fueled by a wave of star births and deaths at the center of the galaxy. Another option is a gigantic belch from the black hole known to reside, like Jabba the Hutt, at the center of the Milky Way. What it is apparently not is dark matter, the mysterious something that astronomers say makes up a quarter of the universe and holds galaxies together.

"Wow," said David Spergel, an astrophysicist at Princeton who was not involved in the work.

"And we think we know a lot about our own galaxy," Dr. Spergel added, noting that the bubbles were almost as big as the galaxy and yet unsuspected until now.

Jon Morse, head of astrophysics at NASA headquarters, said, "This shows again that the

Lobes: The Path Forward

Fermi Bubble

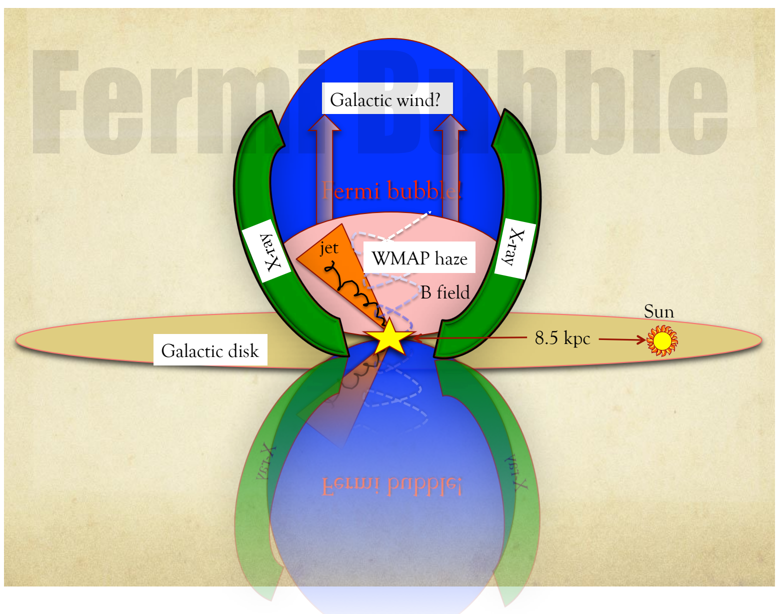
So far: there appear to be a pair of giant (50 degree high) gamma-ray bubbles at 1-5 GeV, and probably up to at least 50 GeV.

What are they?

Black hole "burp"

Superwind bubble?

Dark matter? (Dobler et al arXiv:1102.5095)

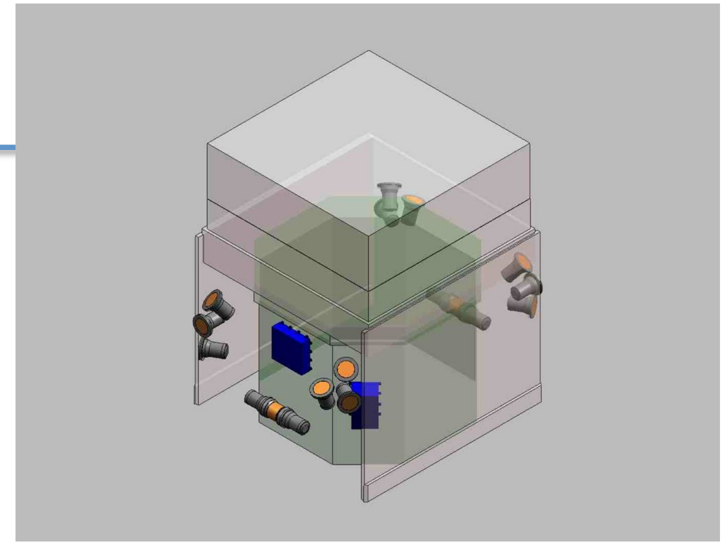


Fermi Bubble

- *Continue observation of Fermi*
- *XMM-Newton data coming soon*
- *The eROSITA and Planck experiments will provide improved measurements of the X-rays and microwaves, respectively, associated with the Fermi bubbles*
- *Magnetic field structure of the bubbles*
- *Study of the origin and evolution of the bubbles also has the potential to improve our understanding of recent energetic events in the inner Galaxy and the high-latitude cosmic ray population.*

Meng Su talk

GBM Collaboration



National Space Science & Technology Center

University of Alabama
in Huntsville

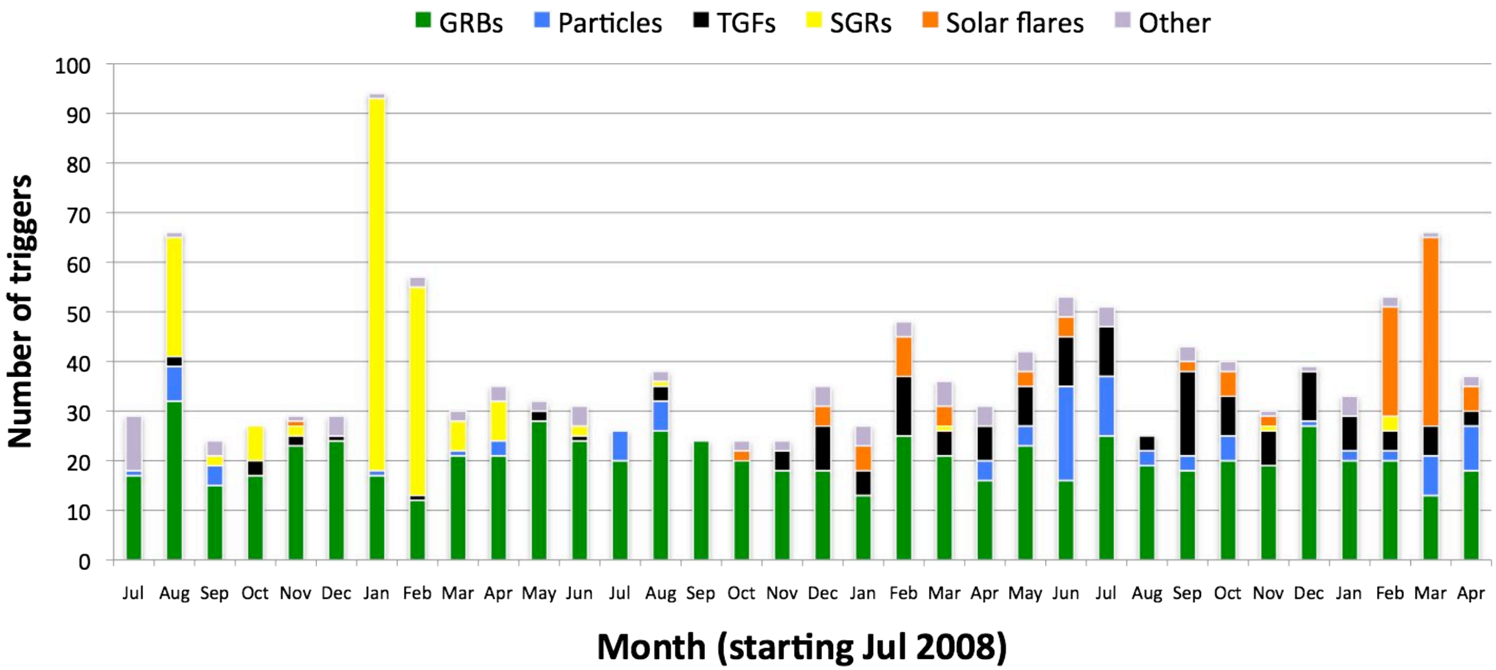
NASA
Marshall Space Flight Center

Max-Planck-Institut für
extraterrestrische Physik

Los Alamos National Laboratory

Bill Paciesas (PI)
Jochen Greiner (Co-PI)

GBM Triggers/Month



- Nov 9, 2009 - add new TGF trigger
  - TGF trigger rate increased by factor of ~10 to 1 per 3.7 days (see talk by S. Foley)
- Feb/Mar 2011 - solar activity (see talk by Y. Tanaka)

GRB: what do we see?

Summary Table & Highest Energy Events compatible with the GRB position

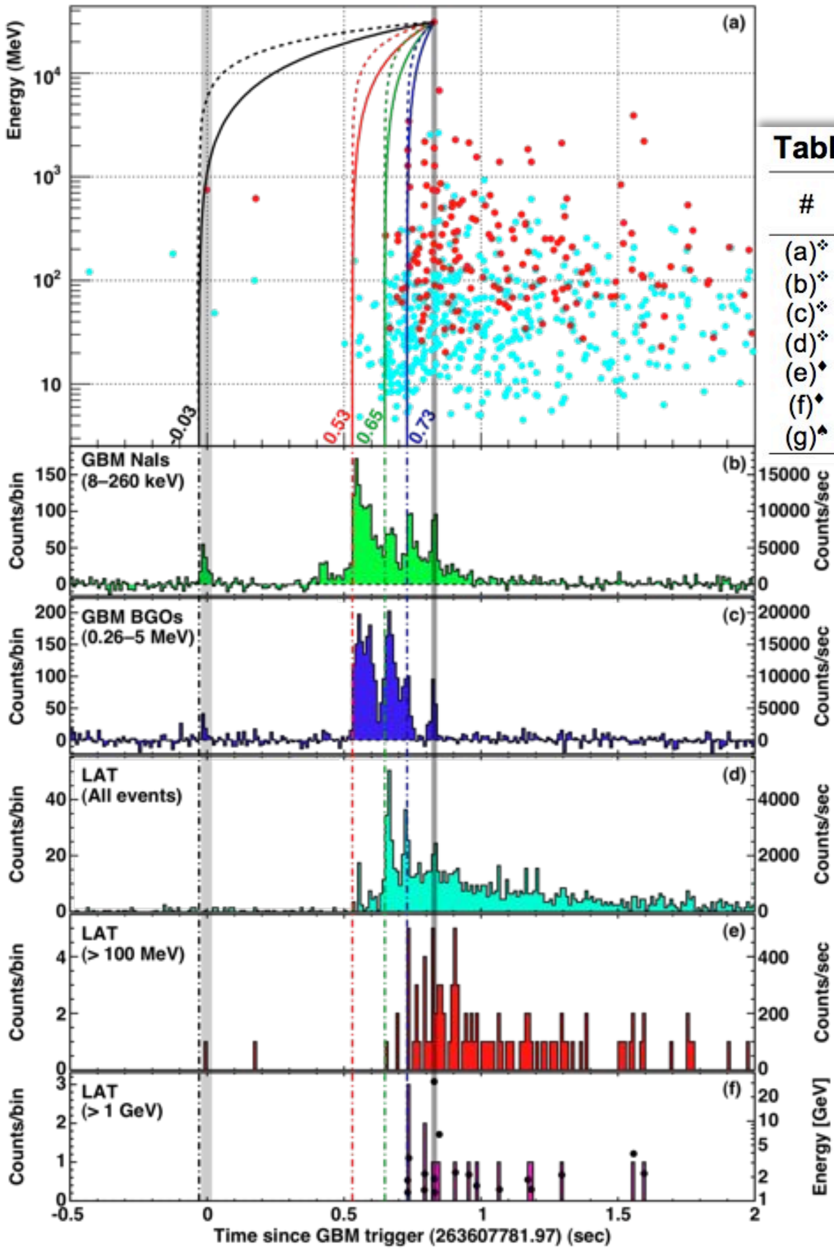
GRB Name	Likelihood Detection >100 MeV	LLE Detection	LAT off axis angle at T_0 (degrees)	GBM T_{90}	N Pred. Events (>100MeV, Trans.)	HE Delayed Onset?	Long Lived HE Emission?	Maximum Energy (GeV) meas. during the LAT detection	Arrival time of the highest events (seconds since trigger)	Redshift
GRB080825C	√	√	60.3	21	10	√	√	0.6	28.3	-
GRB080916C	√	√	48.8	63	211	√	√	13.2	16.5	4.35
GRB081006	√	x	10.7	6.4	13	-	√	0.6	1.8	-
GRB081024B	√	√	18.6	0.6	11	√	√	3.1	0.6	-
GRB081215	x	√	97.1	5.6	-	-	-	-	-	-
GRB081224	x	√	17	16.4	-	√	√	-	-	-
GRB090217	√	√	34.5	33.3	17	√	√	0.9	14.8	-
GRB090227B	√	√	70.1	1.3	3	-	-	-	-	-
GRB090323	√	√	57.2	135.2	39	√	√	7.5	195.4	3.57
GRB090328	√	√	64.6	61.7	58	√	√	5.3	698.3	0.736
GRB090510	√	√	13.6	1	183	√	√	31.3	0.8	0.903
GRB090531B	x	√	21.9	0.8	-	-	-	-	-	-
GRB090626	√	√	18.2	48.9	30	√	√	2.1	111.6	-
GRB090902B	√	√	50.8	19.3	323	√	√	33.4	81.7	1.822
GRB090926	√	√	48.1	13.8	252	√	√	19.6	24.8	2.106
GRB091003	√	√	12.3	20.2	33	√	√	2.8	6.5	0.897
GRB091031	√	√	23.8	33.9	16	√	√	1.2	79.7	-
GRB100116A	√	√	26.6	102.5	21	-	√	2.2	105.7	-
GRB100225A	x	√	54.9	13	-	-	-	-	-	-
GRB100325A	√	x	7.4	7.1	5	-	√	0.8	0.4	-
GRB100414A	√	√	69	26.5	28	√	√	4.3	39.3	1.368
GRB100707A	x	√	90.3	81.8	-	-	-	-	-	-
GRB100724B	√	√	48.8	87	24	-	-	0.1	15.4	-
GRB100728A	√	x	59.9	162.9	17	-	√	1.7	709	-
GRB101014A	x	√	54.1	450.9	-	-	-	-	-	-
GRB101123A	x	√	84.2	~160	-	-	-	-	-	-
GRB110120A	√	x	13.7	~20	9	-	√	1.8	72.5	-

Last bright GRB: Sept 2009!

PRELIMINARY

See http://fermi.gsfc.nasa.gov/ssc/resources/observations/grbs/grb_table/

QG-Related Limits from GRB 090510



Published in Nature, vol 462, p331 (plus comment on p291)

Table 2 | Limits on Lorentz Invariance Violation

#	$t_{start} - T_0$ (ms)	Limit on $\|\Delta t\|$ (ms)	Reasoning for choice of t_{start} or limit on Δt or $\|\Delta t/\Delta E\|$	E_l † (MeV)	Valid for s_n*	Lower limit on $M_{QG,1}/M_{Planck}$
(a)✧	−30	< 859	start of any < 1 MeV emission	0.1	1	> 1.19
(b)✧	530	< 299	start of main < 1 MeV emission	0.1	1	> 3.42
(c)✧	*648*	< 181	start of main > 0.1 GeV emission	100	1	> 5.63
(d)✧	730	< 99	start of > 1 GeV emission	1000	1	> 10.0
(e)♦	—	< 10	association with < 1 MeV spike	0.1	±1	> 102
(f)♦	—	< 19	If 0.75 GeV‡ γ-ray from 1st spike	0.1	−1	> 1.33
(g)♠	$\|\Delta t/\Delta E\| < 30$ ms/GeV		lag analysis of > 1 GeV spikes	—	±1	> 1.22

…with the assumption that the HE photons are not emitted *before* the LE photons.

also see, e.g., Ellis, Mavromatos, and Nanopoulos **arXiv:0901.4052** / **Phys.Lett. B674 (2009) 83-86** and Amelino-Camelia, Ellis, Mavromatos, Nanopoulos and Sarkar, **Nature 393, 763 (1998)**.

EBL Constraints

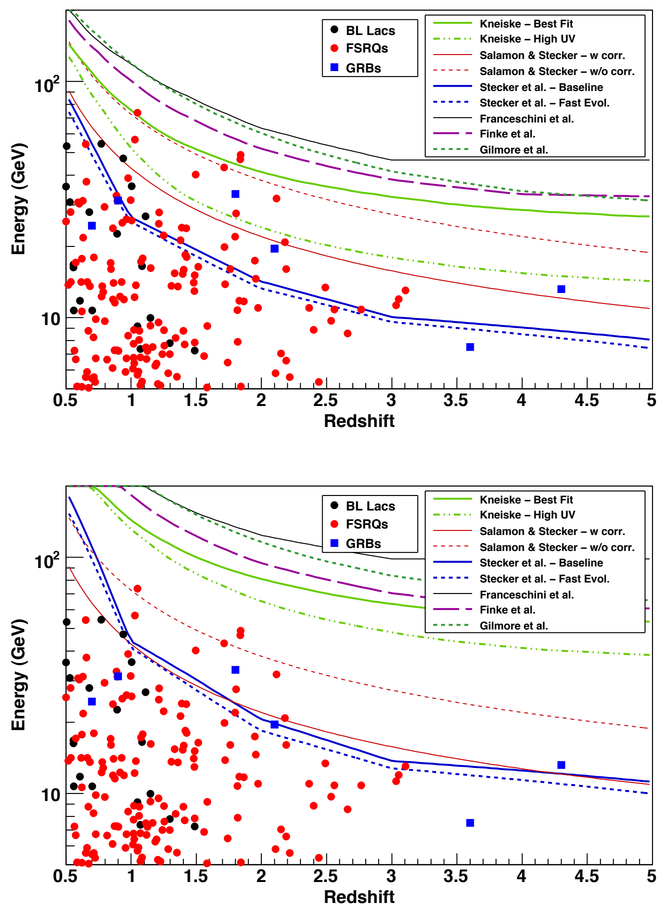


Fig. 2.— Highest-energy photons from blazars and GRBs from different redshifts. Predictions of $\gamma\gamma$ opacity $\tau_{\gamma\gamma} = 1$ (top panel) and $\tau_{\gamma\gamma} = 3$ (bottom panel) from various EBL models are indicated by lines. Photons above model predictions in this figure traverse an EBL medium with a high γ-ray opacity. The likelihood of detecting such photon considering the spectral characteristics of the source are considered in the method presented in section 3.2.1.

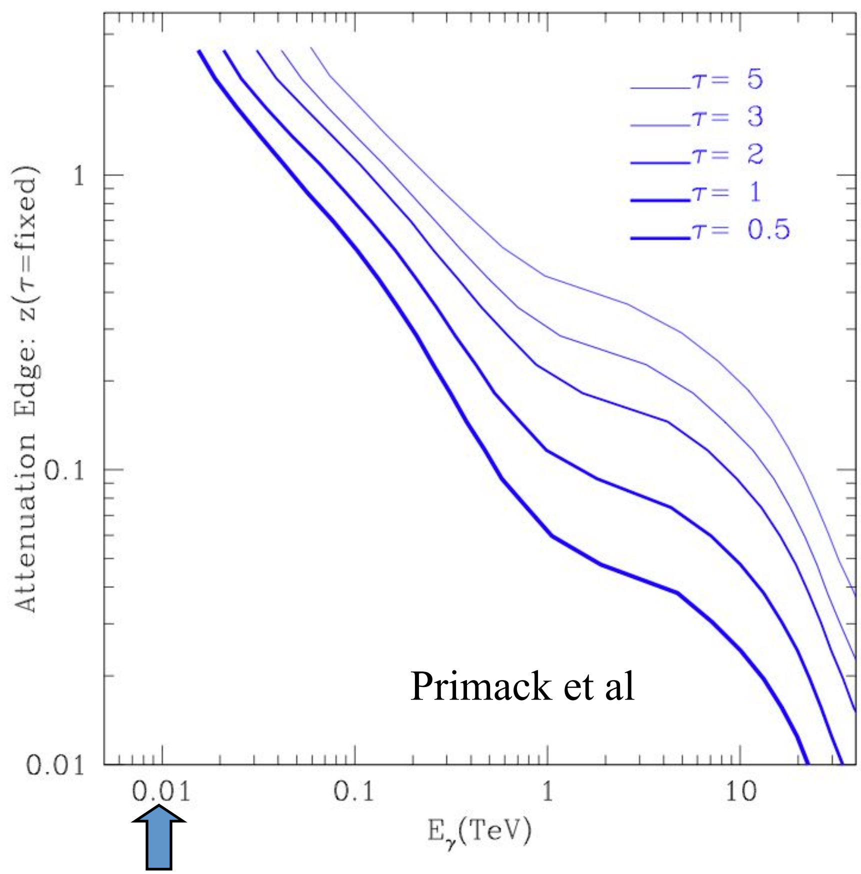
Source	z	Energy (GeV)	P_{bkg}	HEP method applied to Stecker 06		HEP Rejection Significance
				P_{HEP}	$P_{rejection}$	
J1147-3812	1.05	73.7	7.0×10^{-4}	1.2×10^{-4}	8.1×10^{-4}	3.2 σ
J1504+1029	1.84	48.9	5.6×10^{-3}	6.7×10^{-5}	5.7×10^{-3}	
		35.1	9.8×10^{-3}	6.8×10^{-3}	1.7×10^{-2}	
		23.2	5.6×10^{-3}	1.8×10^{-1}	1.9×10^{-1}	
				Combined $P_{rej} = 1.7 \times 10^{-5}$		4.1 σ
J0808-0751	1.84	46.8	1.5×10^{-3}	1.9×10^{-4}	1.7×10^{-3}	
		33.1	2.7×10^{-3}	3.7×10^{-3}	6.4×10^{-3}	
		20.6	6.9×10^{-3}	2.5×10^{-1}	2.6×10^{-1}	
				Combined $P_{rej} = 2.8 \times 10^{-6}$		4.5 σ
J1016+0513	1.71	43.3	1.1×10^{-3}	5.4×10^{-4}	1.6×10^{-3}	
		16.8	8.2×10^{-3}	4.9×10^{-1}	4.9×10^{-1}	
		16.1	8.2×10^{-3}	6.5×10^{-1}	6.5×10^{-1}	
				Combined $P_{rej} = 5.3 \times 10^{-4}$		3.3 σ
J0229-3643	2.11	31.9	1.7×10^{-3}	8.9×10^{-5}	1.8×10^{-3}	2.9 σ
GRB 090902B	1.82	33.4	2×10^{-6}	2.0×10^{-4}	2.0×10^{-4}	3.7 σ
GRB 080916C	4.24	13.2	8×10^{-8}	6.5×10^{-4}	6.5×10^{-4}	3.4 σ

Table 4: Listed are the significance of rejecting the "baseline" model (Stecker et al. (2006)), calculated using the HEP method as described in Section 3.2.1. For completeness, we also report individually the probability of the HEP to be a background event (P_{bkg}) and the probability for this HEP not to be absorbed by the EBL if it were emitted by the source (P_{HEP}). As explained in the text: $P_{rejection} = P_{bkg} + P_{HEP} \times (1 - P_{bkg})$. For those sources with more than one constraining photon, the individual and combined $P_{rejection}$ are calculated. The "fast evolution" model by Stecker et al. (2006) is more opaque and leads to an even higher significance of rejection. Applying this method to less opaque models leads to no hints of rejection since the probability P_{HEP} is large in those cases (e.g. $\gtrsim 0.1$ for the Franceschini et al. (2008) EBL model). Note that a log parabola model was used as the intrinsic model for source J1504+1029 since evidence of curvature is observed here even below 10 GeV (see Table 2).

arXiv:1005.0996

An Important Energy Band

Photons with E>10 GeV are attenuated by the diffuse field of UV-Optical-IR extragalactic background light (EBL)



No significant attenuation below ~10 GeV.

only $e^{-\tau}$ of the original source flux reaches us

EBL over cosmological distances is probed by gammas in the 10-100 GeV range.

In contrast, the TeV-IR attenuation results in a flux that may be limited to more local (or much brighter) sources.

A dominant factor in EBL models is the star formation rate -- <u>attenuation measurements can help distinguish models</u>.

The Sun is Waking Up!

SUMMARY

The M2-class solar flare, SOL2010-06-12T00:57, was modest in many respects yet exhibited remarkable acceleration of energetic particles.

The flare produced an ~50 s impulsive burst of hard X-and gamma-ray emission up to at least 400 MeV.

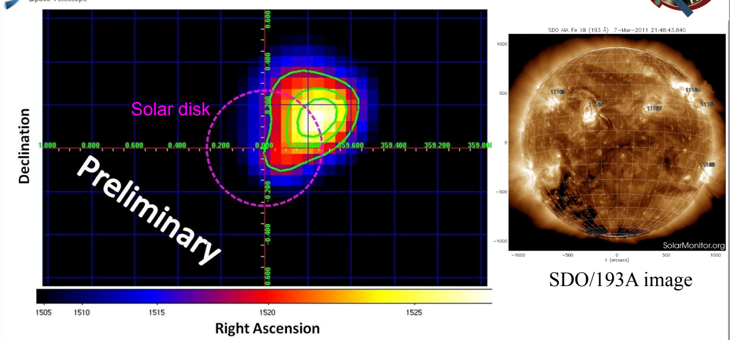
The gamma-ray line fluence from this flare was about ten times higher than that typically observed from this modest class of X-ray flare.

Analysis of the combined nuclear line and high-energy gamma-ray emissions suggests that the accelerated proton spectrum at the Sun softened from a power-law index of ~-3.2 between ~5-50 MeV, to ~-4.5 between ~50-300 MeV, to one softer than ~-4.5 >300 MeV (Preliminary).

G. Share talk

Also see J. Ryan overview talk

Gamma-ray emission region



- Sigificance map (so-called TS map) was produced for the LAT data accumulated during the whole duration
- Green lines show the 1sigma, 2sigma, 3sigma contours
- The LAT HE photons came from the North-western part of the Sun, from where M3.7 flare was emitted (active region 11164)

10

Summary

- Fermi-LAT detected the longest HE emission from the Sun following the 2011 March 7 flare. The duration was ~12 hours.
- The LAT emission came from the North-West part of the Sun, from where the M3.7 flare is emitted
- The LAT spectrum showed clear turnover around 200 MeV, suggesting that pion decay is promising
- The March 7 flare is associated with a fast CME of 2200 km/s
- We considered three possible scenarios which might explain the long-lived LAT emission
- Further quantitative discussion is ongoing, and paper is now being prepared

15

Y. Tanaka talk

Looking Ahead

http://fermi.gsfc.nasa.gov/ssc/data/analysis/LAT_caveats.html

- Many further improvements in instrument performance in progress
  - Event reconstruction and choices of event selection "knobs" all determine instrument performance. For stability, standard event class definitions established with IRFs.
  - Data were released with Pass6.
    - Some known issues, described in Caveats on FSSC site and in LAT papers, addressed with patch to IRFs.
    - Longer-term: Pass7 and Pass8 to address the remaining issues.
  - Pass7 released
      - » Improved standard photon classes
      - » Event analysis taking into account "ghost" events
    - Working closely with FSSC on ease of use for user community.
  - Exciting progress on Pass8, expected to be the ultimate version.

Final Thoughts

- *Fermi* would not have been possible without great international and multicultural cooperation!
- Cultural differences among communities are not necessarily impediments, but rather reinforcing capabilities enabling important new opportunities. We're lucky to have each other!
- Great leaps in capabilities have broad impacts, *e.g.*,
  - Sloan Dwarf Spheroidal galaxies discoveries opening new opportunities for DM signal searches.
  - Fermi all-sky sensitivity => millisecond pulsars for use by Nanograv for gravitational wave searches
  - …
- Great leaps in measurement capabilities demand new analysis approaches <u>*and*</u> new theory.
- What a wonderful time – so much great data and new results!

Fermi Gamma-ray Space Telescope

Thank you, John!

Summary

- Fermi is off to a great start!
  - The gamma-ray sky is keeping its promise. Great cooperation across the whole international team.
- Already addressing many important questions from EGRET era and moving beyond
  - new analysis techniques and approaches are essential -- new topics! **The look ahead.**
  - the challenge of great discovery potential
  - the transformational all-sky capability is paying off!
- Multiwavelength observations are key to many science topics for Fermi.
  - LAT collaboration has numerous MOUs and other cooperative agreements with other observatories.
  - For campaigners' information and coordination, see http://fermi.gsfc.nasa.gov/science/multi
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