

Fermi

Status and requests to INFN for 2016

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Pisa, July 10, 2015

OVERVIEW

- Status of the observatory
- Status of Pass 8 now in production
- Recent science highlights
- Publications and collaboration status
- Requests for 2016

Gamma-ray Space Telescope

FERMI STATUS AND TIMELINE



Baseline: operate through FY 2018 (i.e., 10 years) TBR in 2016. Full SR reports @ http://science.nasa.gov/astrophysics/documents/

FERMI SCIENCE TOPICS IN A NUTSHELL A REMARKABLY WIDE DYNAMIC RANGE



PASS 8 NOW RELEASED

A 540 GeV simulated gamma ray



▶ Pass 8 is a comprehensive revision of the entire LAT event-level analysis

- Simulation, reconstruction, background rejection, analysis methods
- The Pisa Fermi group gave a major contribution
 - Rewriting of reconstruction algorithms
 - Design and implementation of event classes
 - Management of Pass 8 validation and transition
- The goals are to extend the energy reach, maximize the S/N, reduce the systematic uncertainties
- Data processing pipeline switched to Pass 8 on 24 June 2015
 - FSSC now serving Pass 8 data

IMPROVEMENTS WITH NEW EVENT-LEVEL ANALYSIS http://www.slac.stanford.edu/exp/glast/groups/canda/lat_Performance.htm



▶ New set of IRF (P8R2_V6) are available

- ► Larger acceptance at all energies (×2 at 100 MeV, ×1.25 at 1–100 GeV)
 - Increased statistics and broader energy range
 - Better sensitivity
 - Improvement in time-domain high-energy astronomy
- Larger field-of-view (more off-axis effective area)
- Narrower PSF at moderate-to-high energies, with reduced tails
 - Improvements in high-energy source analysis

THE LAT 4-YEAR POINT SOURCE CATALOG (3FGL)



► The 3FGL has been released this year

- ~ 3000 sources, mostly blazars and pulsars
- About 1/3 of the sources are not associated
- The successor will use Pass 8 and more than 6 years of data
- Catalogs are among the most important collaboration products
 - And among the most-cited papers in all of astronomy
- Broad, long-term projects, with huge scientific content
 - Population studies, logN-logS, luminosity functions
 - Searches for new classes of objects among the unassociated sources
 - Contribution of unresolved sources to the diffuse γ -ray emission
- Other catalogs in preparations
 - Both "general" and for specific source classes
 - ► Hard sources, Active Galactic Nuclei, variable sources, GRBs, etc.

THE SECOND CATALOG OF HARD SOURCES (2FHL)



- Pass 8 data at > 50 GeV
 - Improved acceptance
 - Excellent angular resolution (0.1°)
 - Position accuracy of 2 arcmin
 - Good source separation



- Counterpart of the H.E.S.S. Galactic plane survey
- \blacktriangleright Seed for CTA and other IACT observation (e.g. \sim 250 sources not in TeVCat)
- Complement HAWC survey



- Detailed study of source properties
 - Association, spectra, population, etc.
- Study of the extra-galactic background light (EBL)

LINE SEARCH WITH PASS 8 http://arxiv.org/abs/1506.00013 accepted in PRD



- Lines are expected from Dark Matter annihilation or decay (via $\gamma\gamma$ and Z γ)
- Several searches have been already performed
 - A claim of a 133 GeV line from the Galactic Center triggered a huge interest
- Results updated using Pass 8 and 5.8 years of data
- Pass 8 improvements relevant for line search:
 - Improved energy reconstruction
 - Increased effective area with equivalent energy resolution
 - Energy dispersion event type included in event selection
- No significant spectral lines was found

LINE-LIKE FEATURE NEAR 133 GEV



- Adding ~ 2 years of data (from the 3.7 of previous result) Pass 7 local significance decreased from 3.3σ to 2σ
- \blacktriangleright Moving to Pass 8 data, the local significance is further reduced to $<1\sigma$

DARK MATTER CONSTRAINTS FROM DSPH http://arxiv.org/abs/1503.02641 submitted to PRL



- Dwarf Spheroidal Galaxies among the cleanest targets for indirect DM searches:
 - Largely DM-dominated objects
 - Do not expect significant conventional γ-ray emission
- Improvements with Pass 8:
 - Better angular resolution
 - Using the 4 PSF event types
 - 3FGL to model point-like background sources
 - 6 years of data
- These are among the best limits currently available

NEWLY DISCOVERED DSPH CANDIDATES http://arxiv.org/abs/1503.02632 submitted to ApJL

- ▶ 8 new dSph candidates were discovered using the first year of data from the Dark Energy Survey (DES)
 - Only 15 sources used in previous study
 - Source properties need to be fully studied (including if they are really dSph)
- No significant gamma-ray emission was observed
 - Upper limits on DM cross-section
 - J-factors estimated assuming these are similar to the other dSph
- DES and other optical surveys will increase the number of DM search target in the following years
 - We expect a large sensitivity improvement
 - Second year of data will be released soon



COSMIC RAY ELECTRON ANALYSIS



- The goal is to extend the spectrum in the range 1-3 TeV
- New event selection based on Pass 8
- Preliminary results already available
 - With conservative error bars
- Currently working on classification optimization and validation
- Search for anisotropies will follow the spectrum
 - Exploiting \sim 6 years of data

Collaboration publications



Summary of Fermi LAT science publications

3 July 2015 Category Land II papers in refereed journals

Journal	Published	In press	Total
Advances in Space Research	0+1=1	•	1
Astronomy and Astrophysics	6+44=50	0+2=2	52
Astroparticle Physics	2+6=8		8
Astrophysical Journal	84+67=151	2+5=7	158
Astrophysical Journal Letters	23+27=50		50
Astrophysical Journal Supplement	9+3=12	•	12
Astrophysics and Space Science	0+1=1		1
Journal of Cosmology and Astroparticle Physics	3+5=8	•	8
Journal of Geophysical Reserch	0+1=1		1
Monthly Notices of the RAS	0+32=32	0+3=3	35
Nature	2+1=3		3
Nature Physics	0+1=1		1
Nuclear Instruments and Methods	0+1=1	•	1
Physical Review D	8+4=12	1+0=1	13
Physical Review Letters	7+0=7		7
Publications of the ASJ	0+1=1	•	1
Science	19+0=19		19
Total	163+195=358	3+10=13	371

List of papers

Papers submitted to journals: 27 Near submission: 4 Published category III papers: 177

Rapid publications:

Astronomers' telegrams: 331 GCN circulars: 111



For the record: this was 35 in 2012, 43 in 2013, 50 in 2014

FERMI LAT PAPERS AND CITATIONS DATA FROM http://inspirehep.net

- 1. [1280] The Large Area Telescope on the Fermi Gamma-ray Space Telescope Mission, ApJ 697, 2009 (1071–1102)
- 2. [802] Measurement of the Cosmic Ray $e^+ + e^-$ spectrum from 20 GeV to 1 TeV with the Fermi Large Area Telescope, PRL **102**, 2009 (181101)
- 3. [560] Fermi Large Area Telescope First Source Catalog, ApJS 188, 2010 (405-436)
- 4. [410] Constraining Dark Matter Models from a Combined Analysis of Milky Way Satellites with the Fermi Large Area Telescope, PRL **107**, 2011 (241302)
- 5. [404] The Spectrum of the Isotropic Diffuse Gamma-Ray Emission Derived From First-Year Fermi Large Area Telescope Data, PRL **104**, 2010 (101101)
- [354] Fermi Observations of High-Energy Gamma-Ray Emission from GRB 080916C, Science 323, 2009 (1688–1693)
- 7. [340] The First Fermi LAT Catalog of Gamma-ray Pulsars, ApJS 187, 2010 (460-494)
- 8. [330] Fermi Large Area Telescope Bright Gamma-ray Source List, ApJS 183, 2009 (46–66)
- 9. [295] Bright AGN Source List from the First Three Months of the Fermi Large Area Telescope All-Sky Survey, ApJ **700**, 2009 (597–622)
- 10. [293] A limit on the variation of the speed of light arising from quantum gravity effects, Nature **462**, 2009 (331–334)
- [286] Measurement of separate cosmic-ray electron and positron spectra with the Fermi Large Area Telescope , PRL 108, 2012 (011103)
- 12. [253] Fermi LAT observations of cosmic-ray electrons from 7 GeV to 1 TeV , PRD 82, 2010 (092004)
- 13. [243] On possible interpretations of the high energy electron-positron spectrum measured by the Fermi Large Area Telescope, Astropart.Phys. **32**, 2009 (140–151)

COLLABORATION SCIENCE GROUP LEADS Last rotations in March 2015 (INFN in red)

Analysis Coordinator (Deputy): Luca Baldini (Jeremy Perkins)

Science group	Coordinators
AGN and Blazars	Dario Gasparrini
	Roopesh Ojha
Calibration and analysis	Tyrel Johnson
	Matthew Wood
Catalogs	Elisabetta Cavazzuti
	Isabelle Grenier
Dark matter and new Physics	Andrea Albert
	Miguel A. Sànchez-Conde
Diffuse emission	Anna Franckowiak
	Gudlaugur Johannesson
Galactic sources	Massimiliano Razzano
	Jack Hewitt
GRBs	Nicola Omodei
	Magnus Axelsson
Sources in the solar system	Francesco Longo
	Francesco Loparco

Attività a Pisa per il 2015/2016

Collaboration management:

- Senior Scientist Advisory Committee
- Analysis coordinator
- Publication Board
- Cosmic rays:
 - Extended CRE energy spectrum with Pass 8
 - Search for anisotropy in CRE
- Sources in the Solar System:
 - High-energy gamma-ray emission from solar flares
 - First catalog
- Galactic sources:
 - Blind searches (including binary systems and extension to ms pulsars)
 - Study of high-energy emission in gamma-ray pulsars
 - Analysis pipeline for periodic sources (pulsars and binary systems)
 - Multimessenger observations (GWs)
- Burst advocate shifts
- Instrument operations:
 - Data monitoring coordination and shifts
 - Data monitoring update to Pass 8
 - L1 pipeline operations

Gruppo Fermi INFN-Pisa

Nome	Affiliazione	%
Baldini L.	Università di Pisa	100%
Bellazzini R.	INFN	100%
Brez A.	INFN	100%
Kuss M.	INFN	70%
Massai M. M.	Università di Pisa	100%
Pesce Rollins M.	Ricercatore TD INFN	100%
Pian E.	SISSA (on leave at SNS)	50%
Pivato G.	Assegnista Università di Pisa	100%
Razzano M.	Ricercatore TD Università di Pisa	60%
Sgrò C.	Ricercatore TD INFN	100%
Shore S.	Università di Pisa	50%
Spada F.	Assegnista INFN	100%
Spandre G.	INFN	100%
Manfreda A.	Dottorando	100%
	Totale FTE	12.3
Ceccanti M.	Tecnico alte tecnologie	
Minuti M.	Tecnico elettronico	
Pinchera M.	Ingegnere meccanico	

RICHIESTE FINANZIARIE ANNO 2016

Capitolo	Voci specifiche	Subtotale [k€]	Totale [k€]
Materiale inventariabile	Storage, espansioni memoria, licenze software	10	
	Worker nodes farm Pisa	10	
	Server analisi di gruppo	3	23
Consumo	Metabolismo e maintainance strumentazione e cam- era pulita	30	30
Missioni estero	4 workshop per SWG (analisi, coordinamento, simu- lazioni) 5 persone, 1 settimana	50	
	2 collaboration meeting per 8 persone, 1 settimana	40	
	5 mu a SLAC per turni ISOC	25	
	Presentazioni a conferenze internazionali	30	145
Missioni Italia	1 riunioni collaborazione Italiana, 8 persone 4 giorni	7	
	4 riunioni di lavoro per analisi e coordinamento, 8 persone 4 giorni	22	29
		Totale	227

Descrizione	Attività	Lavoro
Centro di calcolo	Setup e manutenzione macchine per simu-	5% farm
lazione/ricostruzione (5 WN grid)		

Gamma-ray Space Telescope

SPARE SLIDES

Gamma-ray Space Telescope

STATUS OF THE LAT



- LAT is healthy and continuously collecting data
 - More than 99% up-time collecting science data (out of the SAA)
- Primary mode is sky survey
 - Scan entire sky every 3 hours
 - 1 orbit rock north, 1 orbit rock south
 - LAT boresight stays away from the Earth _____
- More time in pointed mode from ~ 2014
 - Autonomous Repoint Request and Target of Opportunity
 - To favor specific science targets (e.g. Galactic Center)

CAVEATS AND SYSTEMATIC UNCERTAINTIES http://fermi.gsfc.nasa.gov/ssc/data/analysis/LAT_caveats.html



- Several checks of the consistency and precision of the instrument simulation and the instrument response representation provided by the IRFs
- The effect of energy dispersion is particularly large below 100 MeV
 - Taking into account energy dispersion improves the data-MC agreement
- Using data below 30 MeV or above 1 TeV is strongly discouraged
- Systematics on the PSF are quantified in terms of the fractional uncertainty on the 68% containment radius

NEW EVENT TYPES



PSF and Energy resolution can be improved by tightening event selections

- Based on event-by-event quality estimator
- Pass 8 provides 4 equal-acceptance, sub-sample of events with progressively better PSF or Energy dispersion are
 - Selection can be optimized for specific cases
 - Removing the worst case(s)
 - Combining pdf in the likelihood fit