

Fermi LAT Collaboration

New results from Fermi

Luca Latronico INFN-Torino <u>luca.latronico@to.infn.it</u>

on behalf of the Fermi-LAT collaboration

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Outline

- Fermi and astroparticle physics
- Science results
 - Recent Highlights
 - Prospects



Brief History of Detectors Pre-Fermi



- Image: 1967-1968, OSO-3 detected Milky Way as an extended γray source, 621 γ-rays
- 1972-1973, SAS-2, ~8,000 celestial γ-rays

sermi

Gamma-ray Space Telescope

- 1975-1982, COS-B, orbit resulted in a large and variable background of charged particles, ~200,000 γ-rays.
- 1991-2000, EGRET, large effective area, good PSF, long mission life, excellent background rejection, and >1.4 × 10⁶ γ-rays
- 2007-, AGILE, like 1/16-th LAT, with small calorimeter, sensitivity ~EGRET



Pair Conversion telescope concept

Large Area Telescope key design elements







- solid state detectors
 - Iarge FOV
 - no consumables
- onboard processing
 - soft trigger
- detectors segmentation
 - optimal performance







The Fermi Observatory

Large Area Telescope (LAT) - pair conversion telescope
20 MeV - > 300 GeV

Huge field of view (2.4sr)

- 20% sky any instant
- All sky for 30' every 3h

Huge energy range

- Including 10-100 GeV
 Public data
- ~400 collaboration papers
- ~2400 total nb of papers

Gamma Burst Monitor (GBM) - counters

• 8 keV - 40 MeV

launch from KSC 11-6-2008

Mission timeline

Gamma-ray nace Telescope



Extend operations through NASA Senior Reviews (SR) Spring 2016 SR to confirm operations through 2018 and recommend through 2020 - <u>http://science.nasa.gov/astrophysics/documents</u>

The Fermi y-ray sky



Point source catalogs



4 years 3FGL catalog - 3000+ sources 2015, ApJS, 218, 23

Gamma-ray pace Telescope

basis for most LAT analyses

Diffuse emission: the case of the Inner Galaxy



- Independent analyses report a spatially extended excess
- Spherically symmetric, spectrum consistent with DM

Segmentate with potential astrophysical contributions (diffuse from CR inhomogeneities, MSP)

Isotropic Gamma Ray spectrum



systematics from Galactic foreground are largest uncertainty

- probes cosmological propagation of photons
 - constrains models of Extragalactic Background Light (EBL)

Gamma-ray Space Telescope Dark Matter search in dwarfs



- Dwarfs are DM dominated systems with no gamma-rays expected from astrophysics
- No observation of gamma-rays constrains WIMP properties
 - current limit for 100% BR in bb excludes masses < ~130GeV</p>

Many more highlights not covered here:

Solar Flares, 2015, ApJL, 805, L15

Novae, 2014, Science, 345, 554

DM lines, 2015, Phys. Rev. D, D91, 122002

Gamma-ray anisotropies and cross-correlations, PRL 114, 241301 (2015)



gamma-ray emission in PSR away from surface, e.g. 2013, ApJS, 208, 17 rejection of simplest single-zone emission in blazars, e.g. 2015, ApJ, 810, 14 Crab flares, e.g. 2011, Science, 331, 739 challenges to standard GRB afterglow model, e.g. 2014, Science, 343, 42 complete 400+ publications at <u>https://www-glast.stanford.edu/cgi-bin/pubpub</u>



Science Highlights - summary

- Fermi is the reference gamma-ray observatory
 - ~1G photons, thousands sources, public database
- Fermi data enrich many diverse science areas
 - HEP, cosmology, astrophysics
- Ideal instrument for time domain astrophysics
 - full-sky, realtime coverage
 - Iong term stable operations

Prospects - Upgraded performance



Pass8 performance and data publicly released June 2015



Prospects - SNR



* potential to resolve morphologies and separate spectral components

Resolving complex regions



Ist extra-galactic pulsar in the 30Doradus region in the LMC

Resolving complex regions



LMC view in 2010 (slide from XXIV La Thuile, J. Knodlseder)



Prospects - Hard sources



HESS Galactic Plane Survey arxiv. 1307.4690



- ✤ ~1500 sources above 10 GeV
 - connects GeV and TeV (IACT) observations
 - Potential to isolate HE component in SNR, ideal probe for EBL



Prospects - IGRB



- Iow detection threshold crucial for modeling numerous, faint populations
- high-energy measurements drive critical spectral contribution
- Constrains Cosmological Dark Matter



Prospects - CRE physics



- CRE spectrum now probing ~TeV cutoff
 - compatible but not requiring local component
- Potential for CR astronomy through CRE anisotropy
 - Prediction uncertainties get smaller if model fit combines AMS positrons



Prospects - DM searches



optical surveys are significantly increasing number of dwarfs

In the next 4 how may be a server of the server of the

GW150914 Fermi observations



the GW era started on our dark side of the sky

Solution of the second seco

Gamma-ray Dace Telescope **Prospects - GW followups**



- LAT short baseline search around t_{GW} + [4442–4867] s
- Flux upper limits 100MeV-1GeV, independent on GRB model
- Largest excess (TS~18) likely contamination or from Earth limb

Prospects - GW followups Dermi pace Telescope

Gamma-ray



LAT long baseline search in t_{GW} +/- 1 month

Largest excesses (4 with TS>20 pre-trial) less frequent than simulated background fluctuations (9)

Gamma-ray pace Telescope Prospects - GW followups



- LAT covers entire sky in 3 hours
- LAT localization ~ 0.1-1 degrees
- LAT sensitive to transients from ms to years timescales

Pulsar Timing Array





- GW search window at very low frequency (5-500 nHz) through pulsar timing (nanoGRAV)
- ♦ Fermi Pulsar Search Consortium discovered 70 MSPs in LAT unassociated sources (40% of the MSP discoveries since 2008 and about ¹/₃ of all known Galactic MSPs)



Science prospects - summary

 Fermi will keep addressing critical astroparticle questions thanks to improved
 performance and multi-messenger synergies

- CR origin, particle acceleration and propagation
- Dark Matter Identification
- EM counterparts to Gravitational Waves