



THE FERMI LARGE AREA TELESCOPE

Principe Giacomo*^{1,2,3}

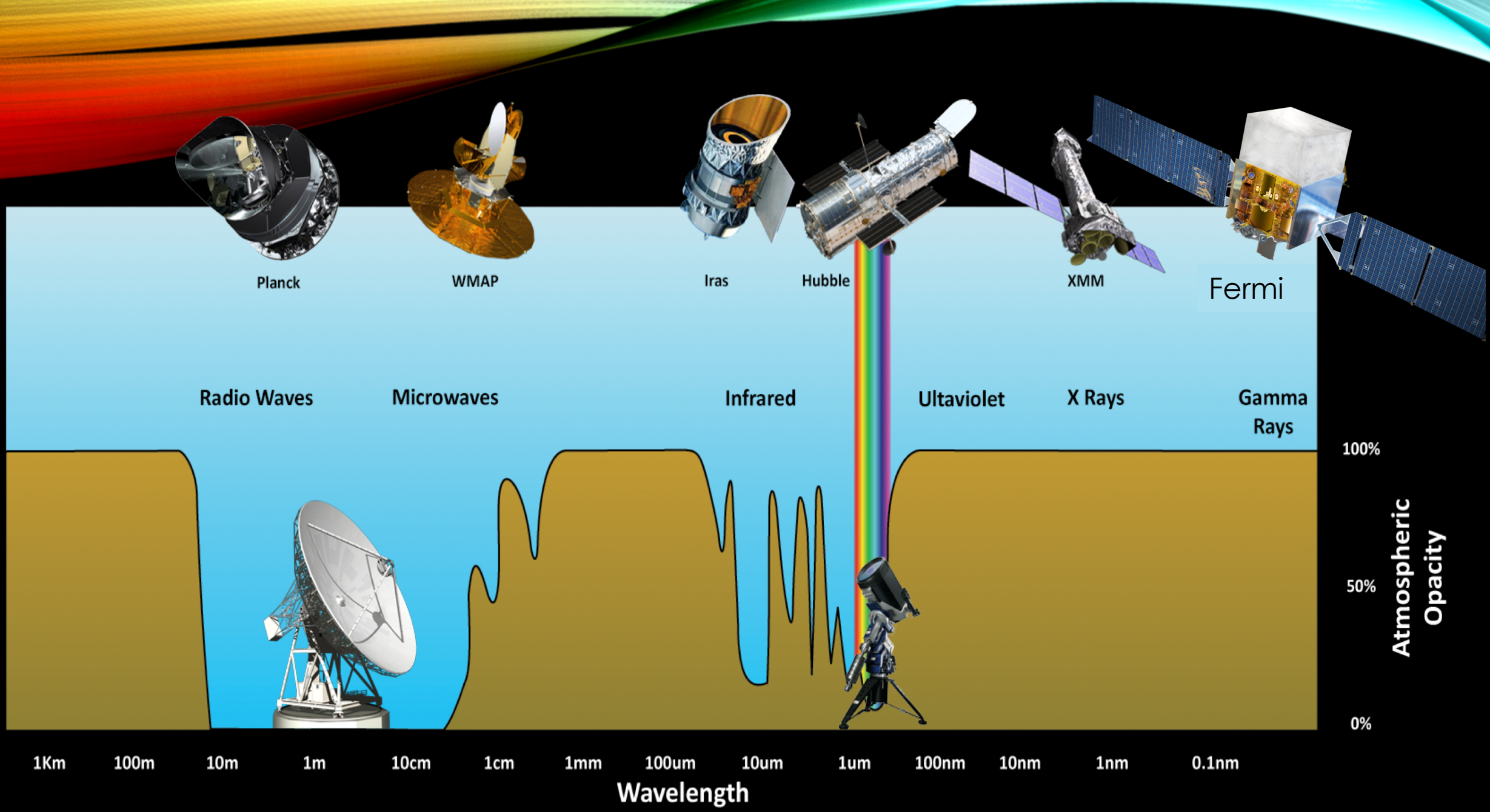
¹Dipartimento di Fisica, Università di Trieste, Trieste, Italy

²Istituto Nazionale di Fisica Nucleare, Trieste, Italy

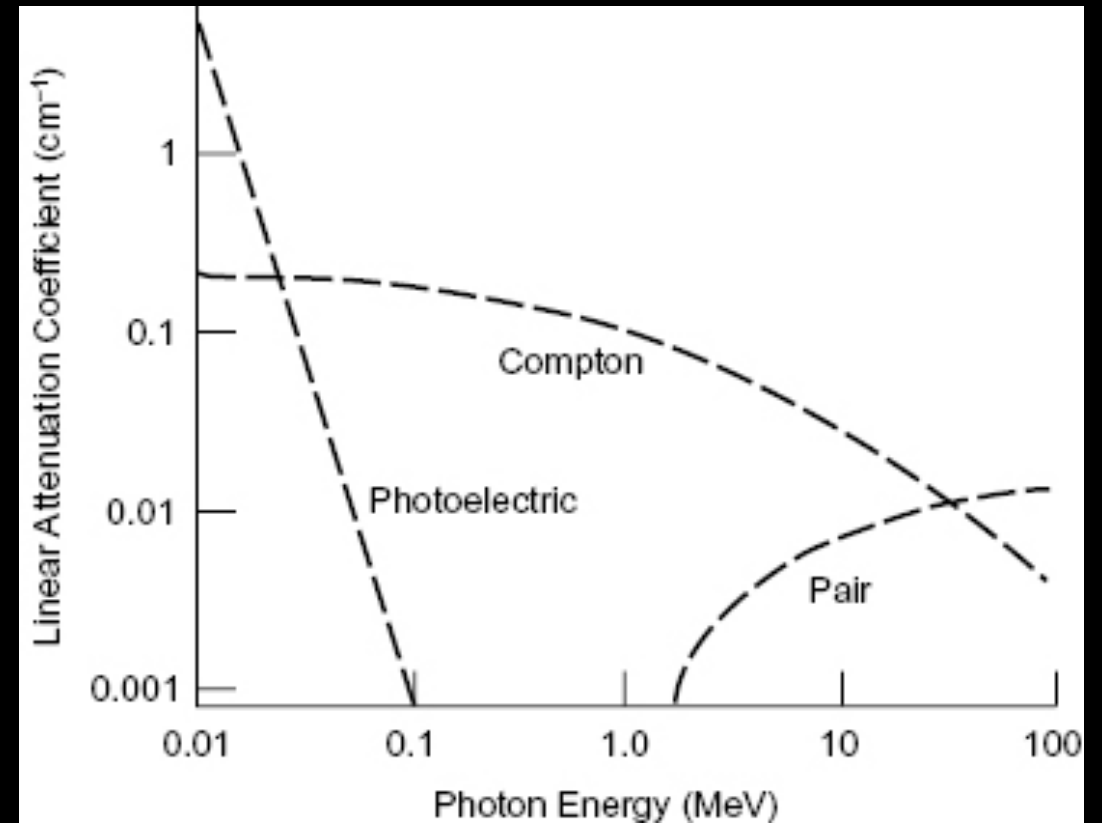
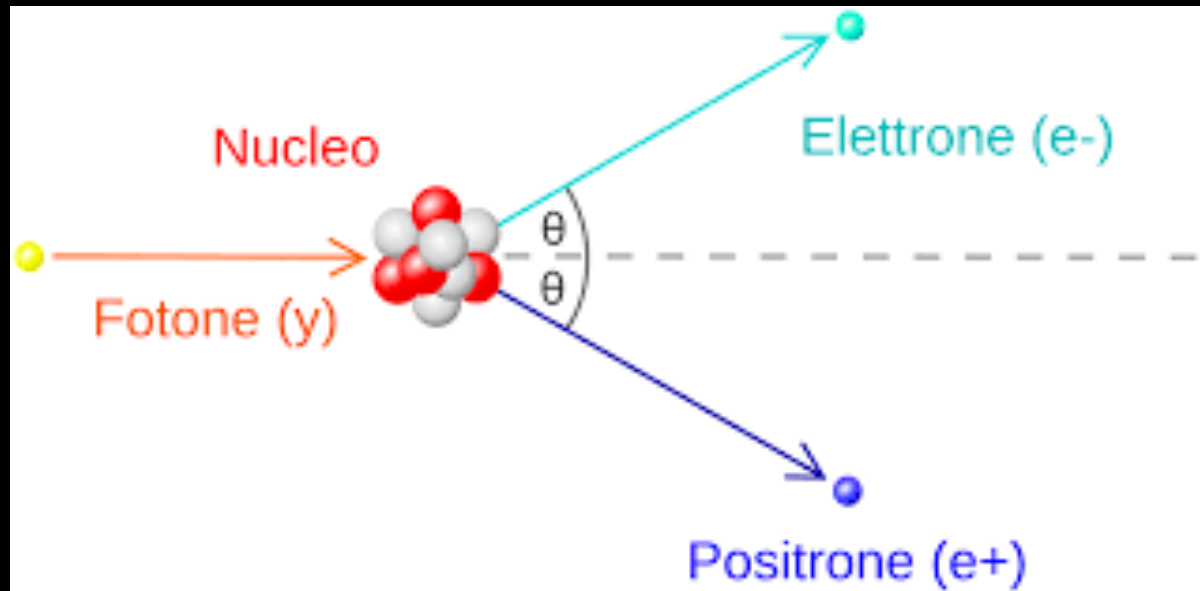
³INAF - Istituto di Radioastronomia, Bologna, Italy

How can we observe gamma rays?





Pair production



Fermi precursors

1967: Vela - Discovery of the 1st Gamma Ray Burst

1968: OSO-3 - Discovery of > 100 MeV γ -ray emission from the Milky Way

1972: SAS-2 - First high-energy γ -ray images; discovery of Geminga pulsar

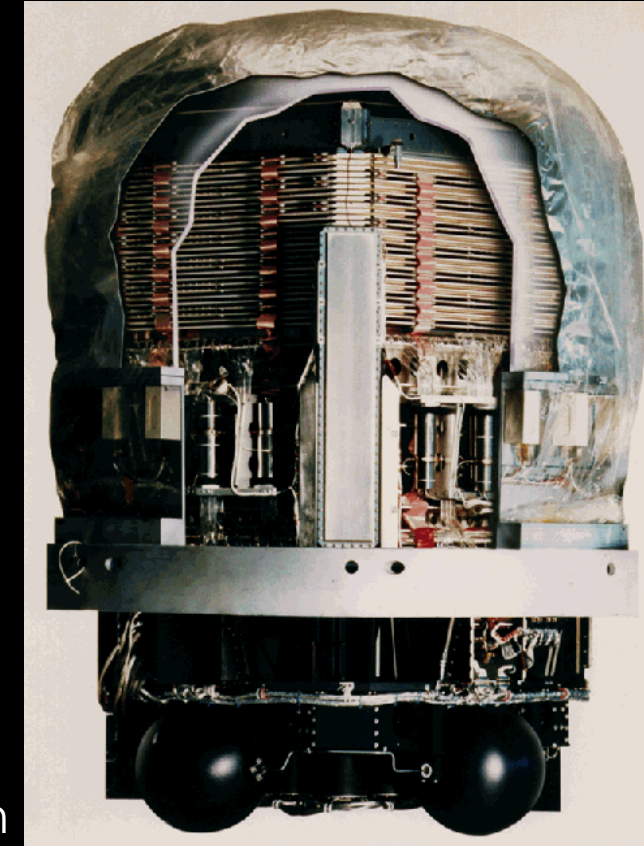
1975: Cos-B - First detailed γ -ray map of the Milky Way with 24 point sources

1991: CGRO (EGRET) - First all-sky survey of the γ -ray sky; major discoveries

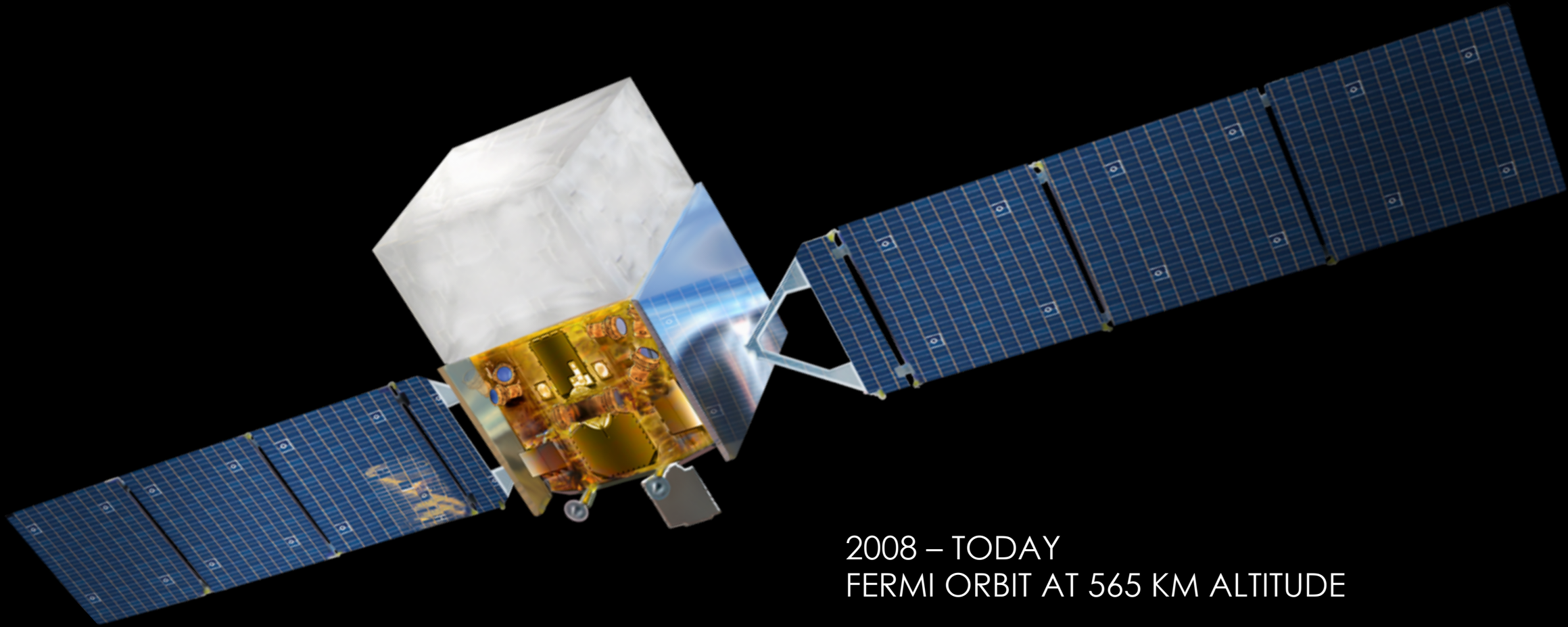
2007: AGILE – First detection of variability of Crab Nebula, terrestrial γ -ray Flash



AGILE



EGRET



2008 – TODAY
FERMI ORBIT AT 565 KM ALTITUDE



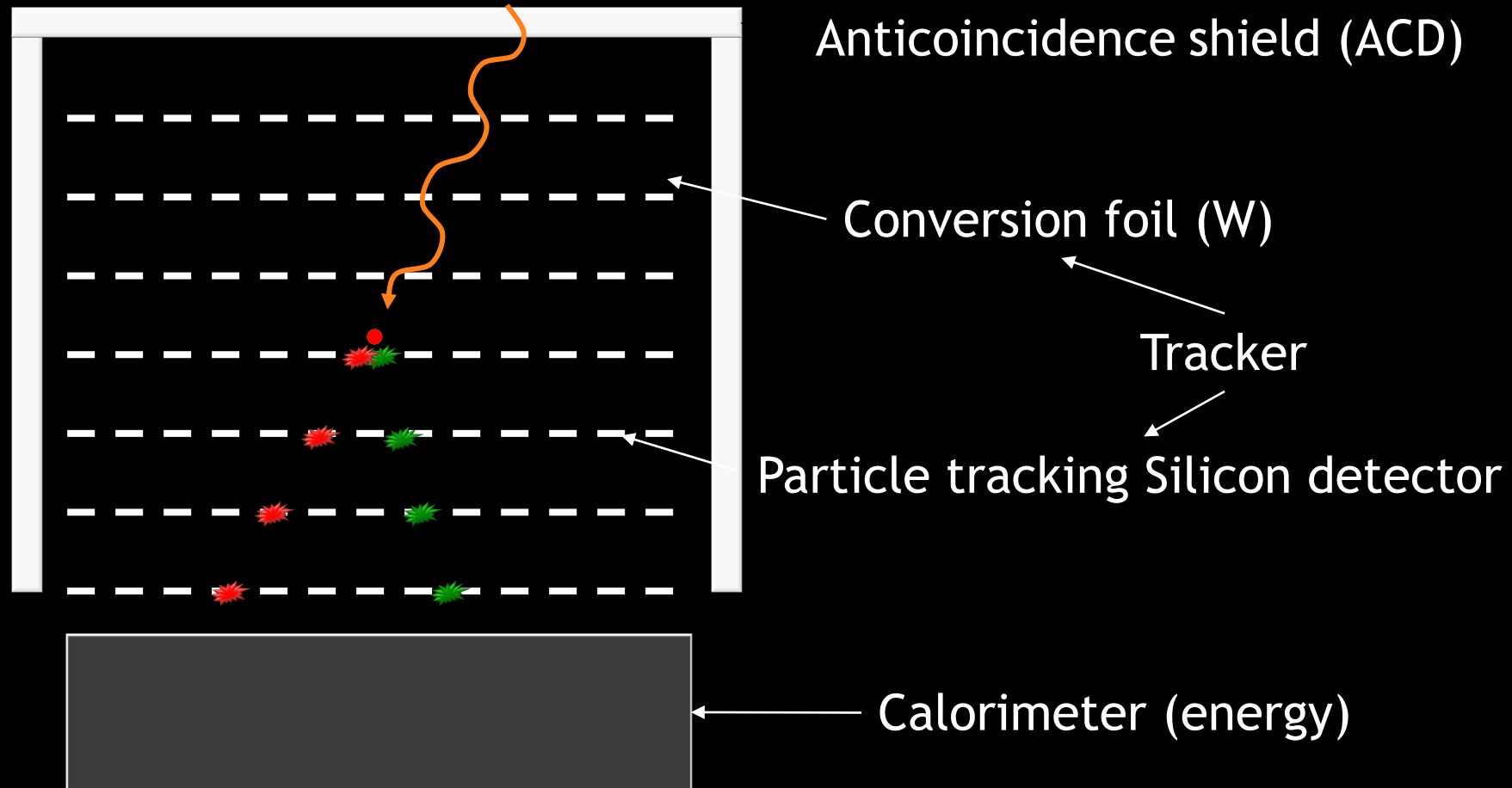
Large Area Telescope (LAT)

Observes more than 20% of the sky at any instant,
views entire sky every 3 hrs 20 MeV - >300 GeV.

Gamma-ray Burst Monitor (GBM)

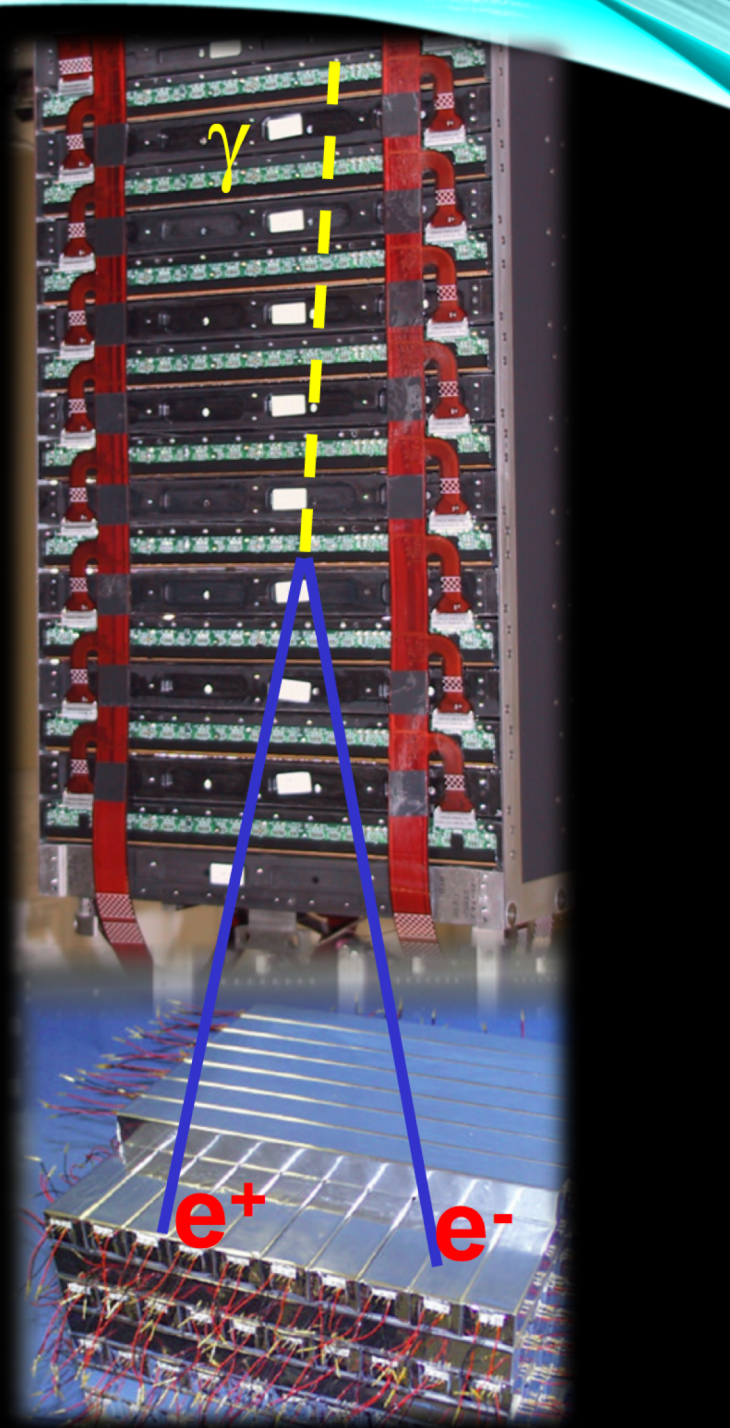
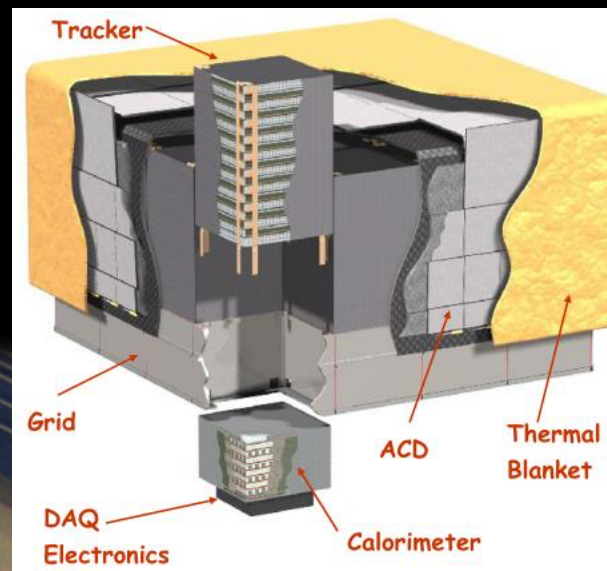
Observes entire unocculted sky.
Detects transients from 8 keV - 40 MeV

HOW TO CATCH GAMMA-RAY: PAIR CONVERSION TELESCOPE



Gamma rays interact by pair production, the conversion of the gamma-ray energy into two particles - an electron and a positron (really an antiparticle)

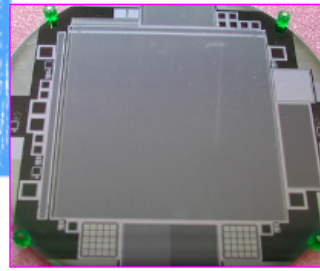
How does the LAT look like?



Module Structure Components
SLAC: Ti parts, thermal straps, fasteners.
Italy (Plyform): Sidewalls

SSD Procurement, Testing
SLAC, Japan, Italy (HPK)

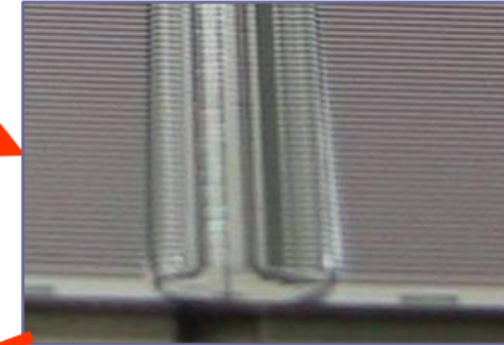
9.5 cm, 380 strip



10,368

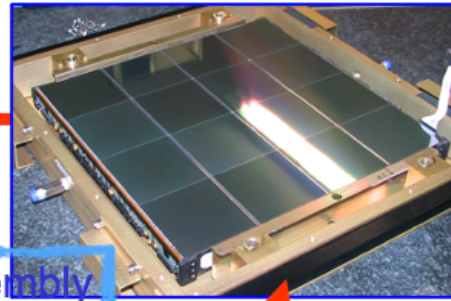
SSD Ladder Assembly
Italy (G&A, Mipot)

μm connections



2592

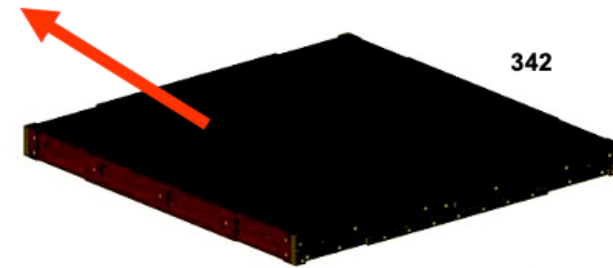
342 inter-ladder // 100 μm



Tray Assembly and Test
Italy (G&A)

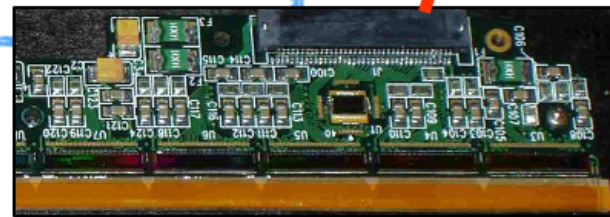
648

Tracker Module Assembly and Test
Italy (INFN, Alenia Spazio)

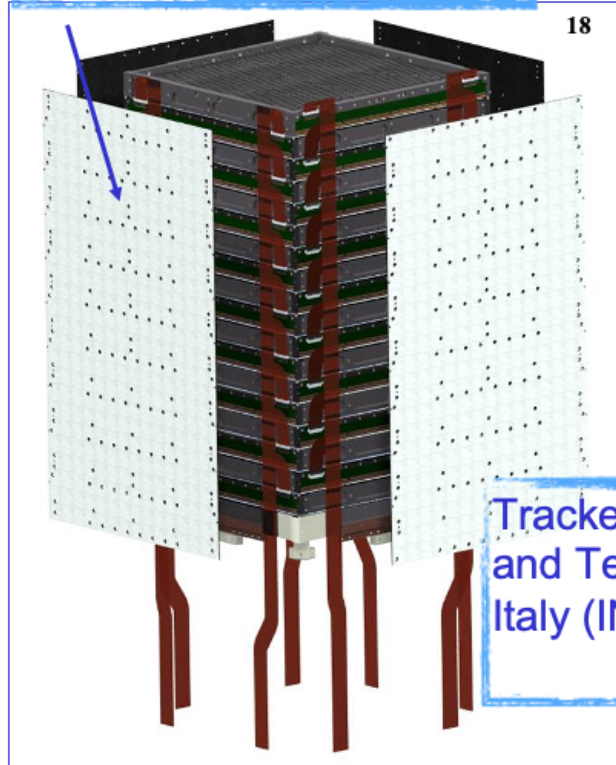


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Composite Panel, Converters, and Bias Circuits
Italy (Plyform): fabrication
SLAC: CC, bias circuits, thick W, Al cores



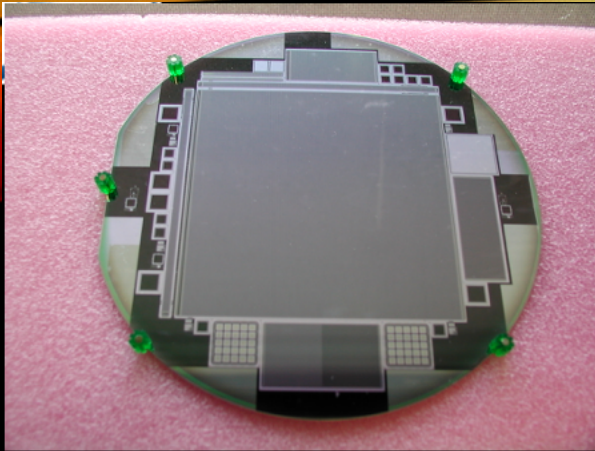
Electronics Fabrication, burn-in, & Test
UCSC, SLAC (Teledyne)



18

inter-tower stay-clear 2mm

Readout Cables
UCSC, SLAC
(Parlex)

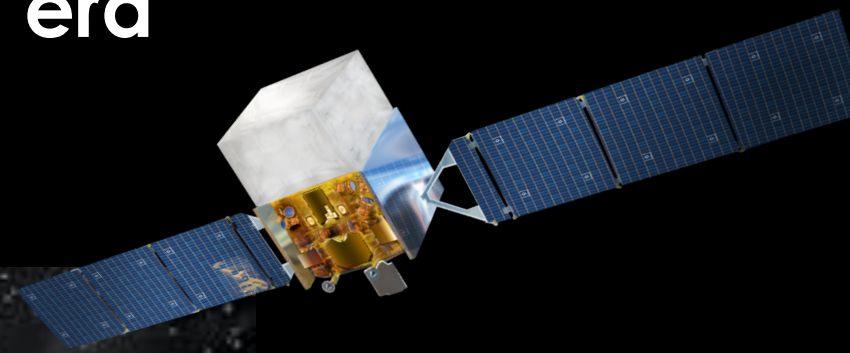


**LAT Tracker: 12500 SSD, 100 m² of Si, 30 M single channel tests
@ INFN - 2001-2005 - 60 people (physicist, engineers, technicians)**



June 11, 2008; 6:05 PM CEST

The begin of the Fermi-LAT era



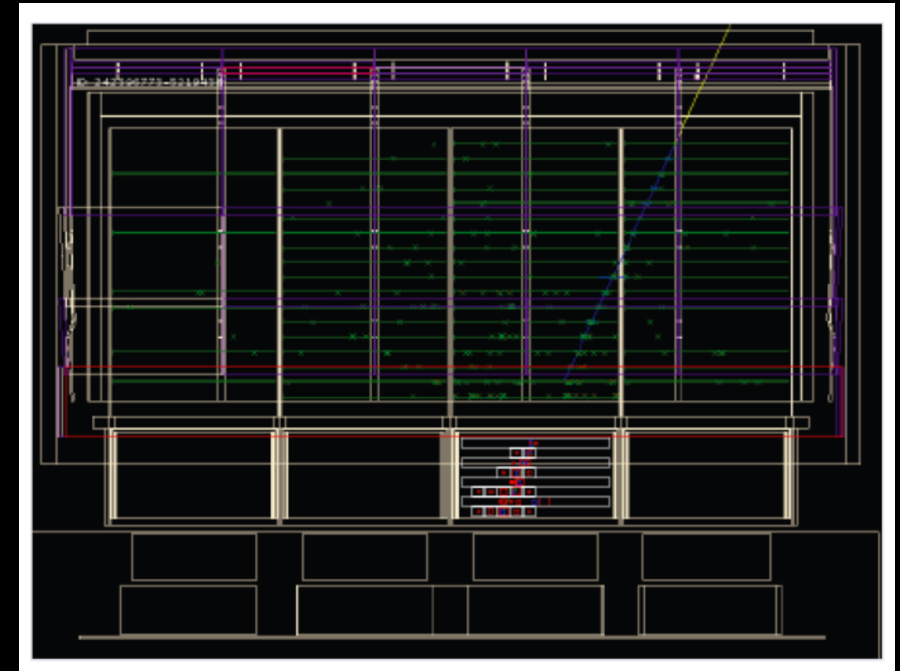
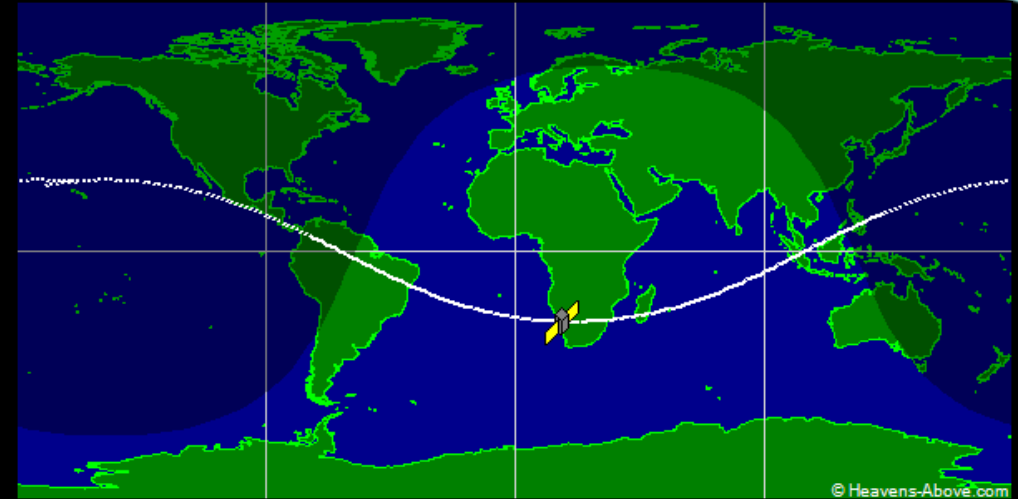
*A long time ago,
in a galaxy far,
far away.....*

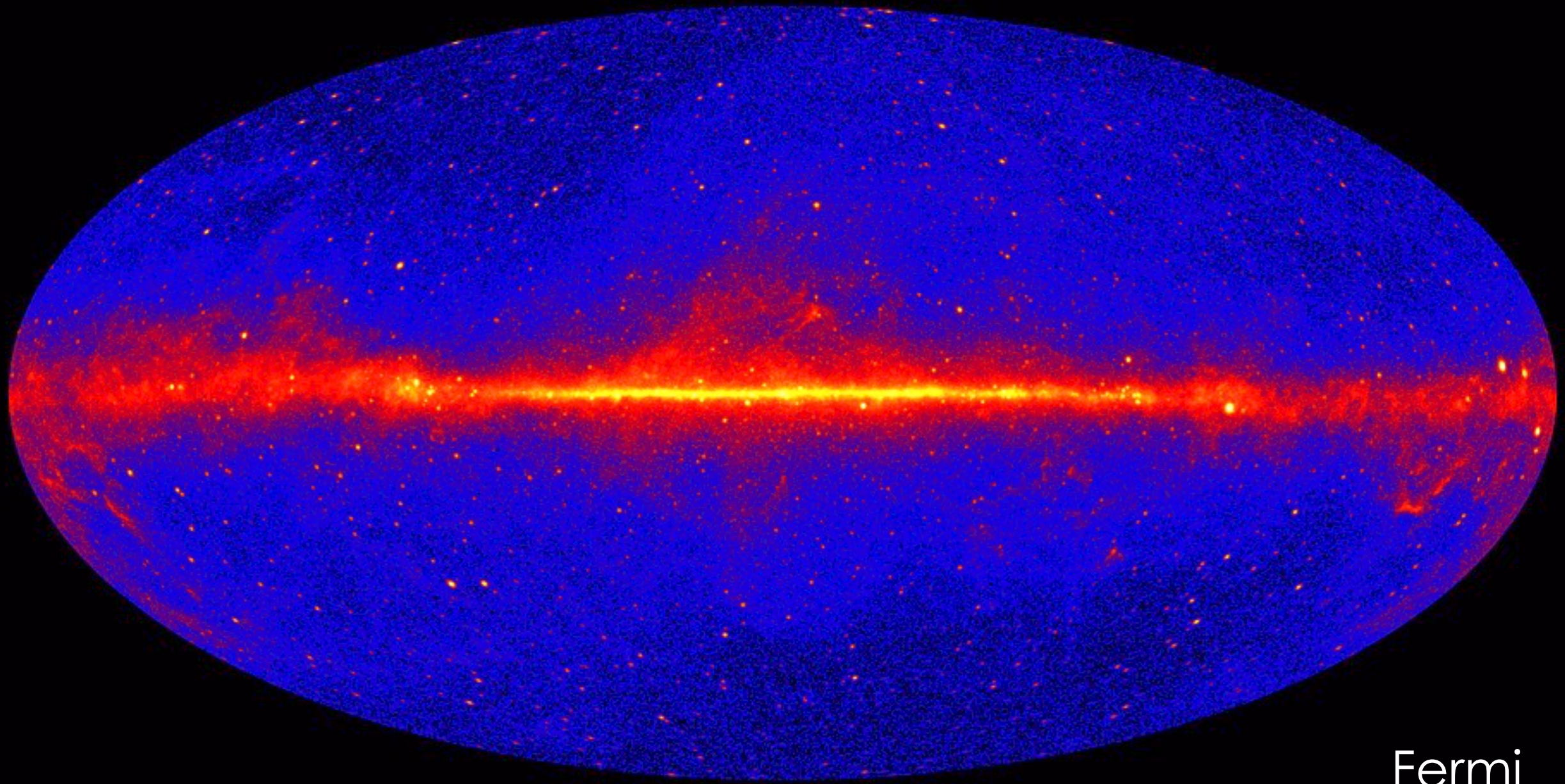
Fermi in DATA (up today, Dec. 16, 2021)

- 74690 orbits since launch
- 4872 days of science mission (2008 Aug. 4)
- LAT has 98.7% uptime for the science mission

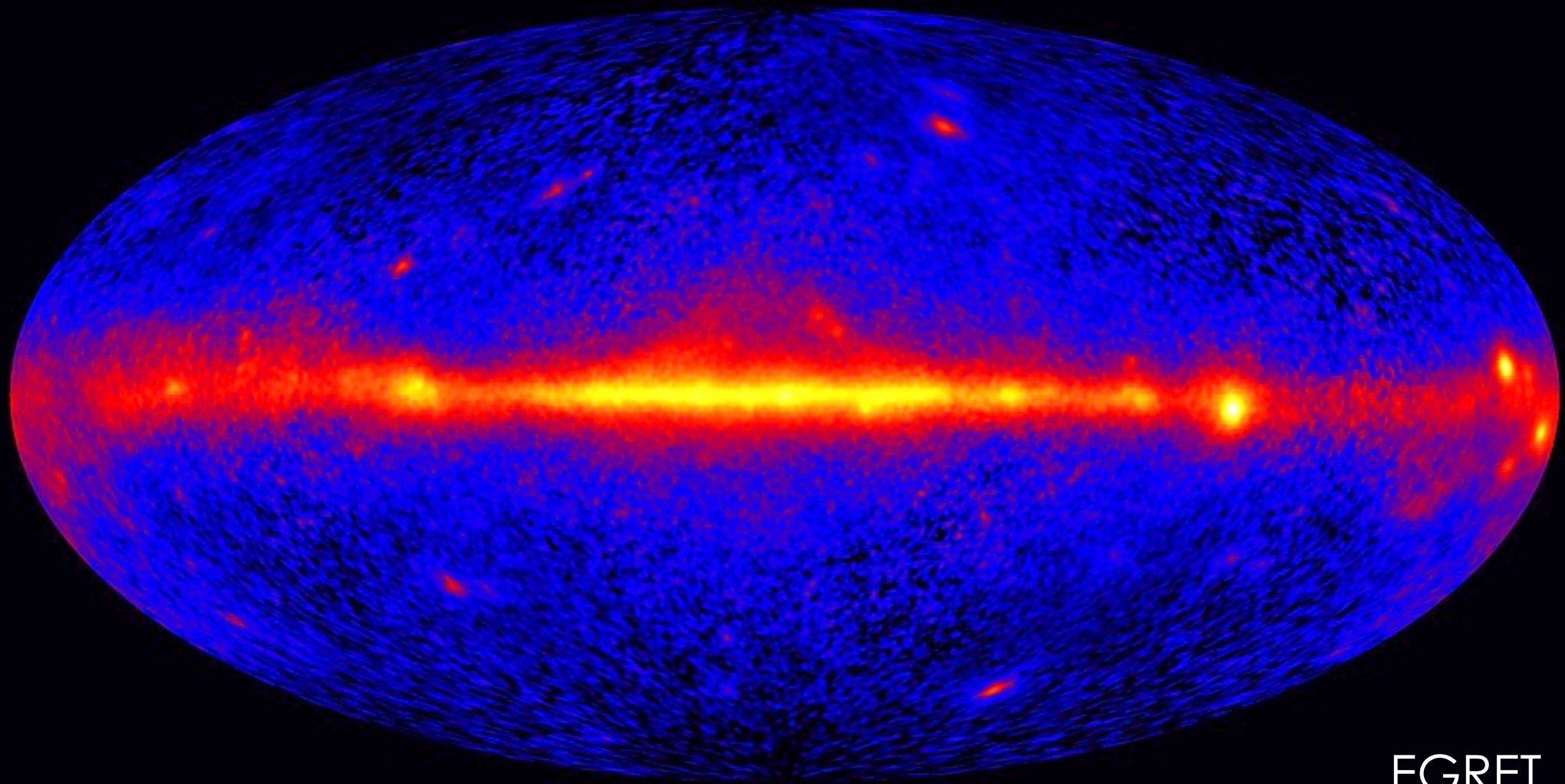
Event counts:

- 790 billion triggers on the LAT
- 158 billion events downlinked
- 3.82 billion LAT events available at the FSSC (2.4%)
- 4 photons/second (including Earth limb)



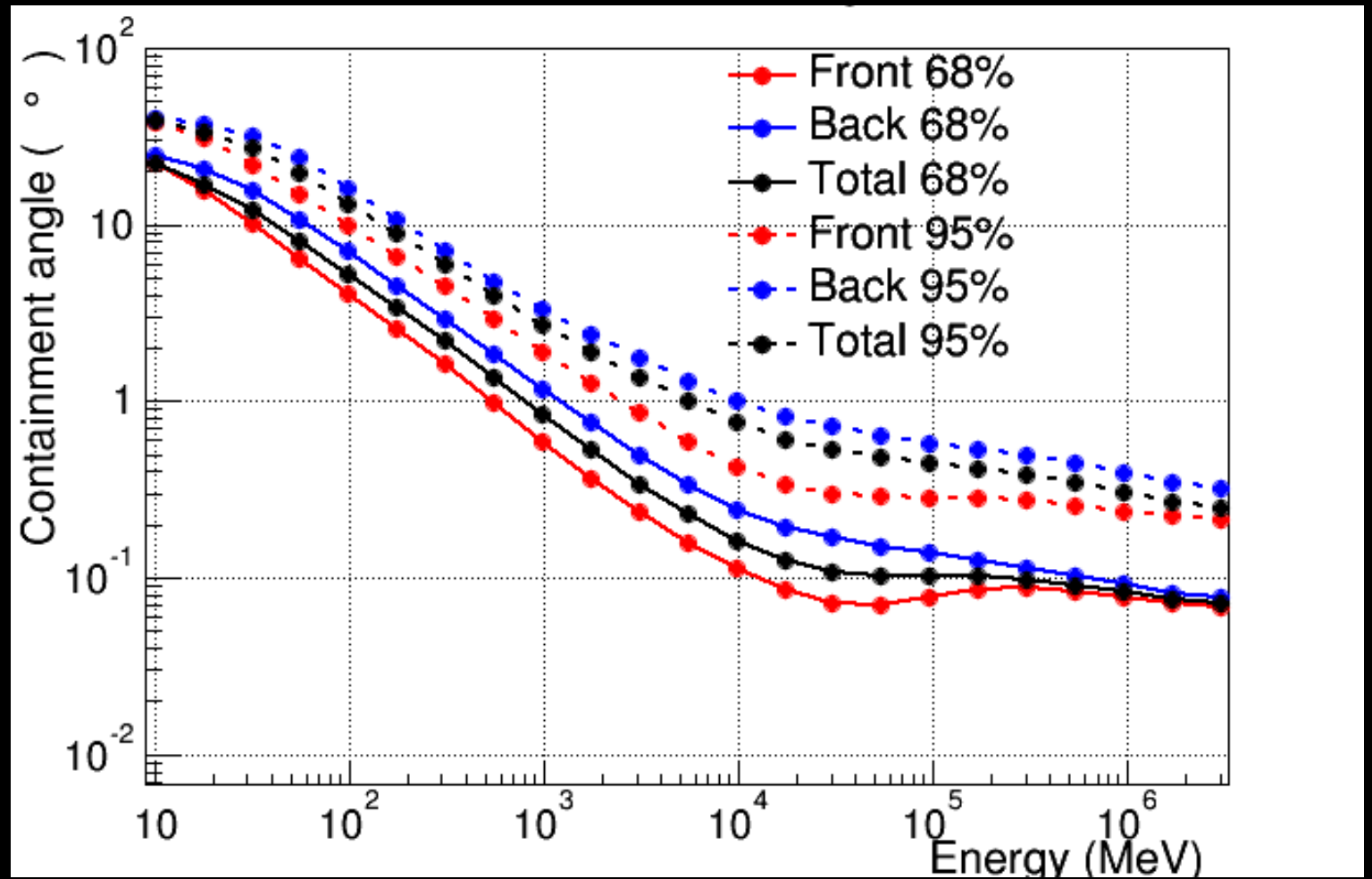
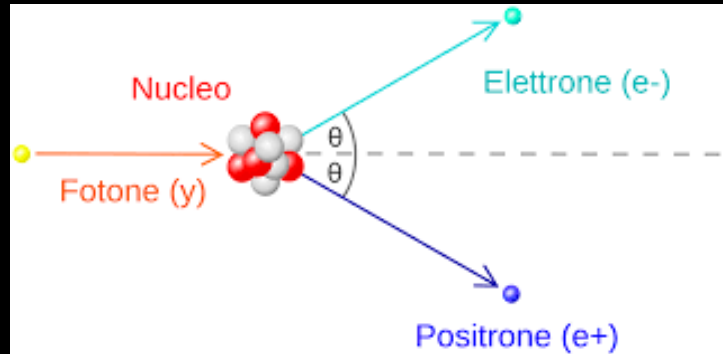


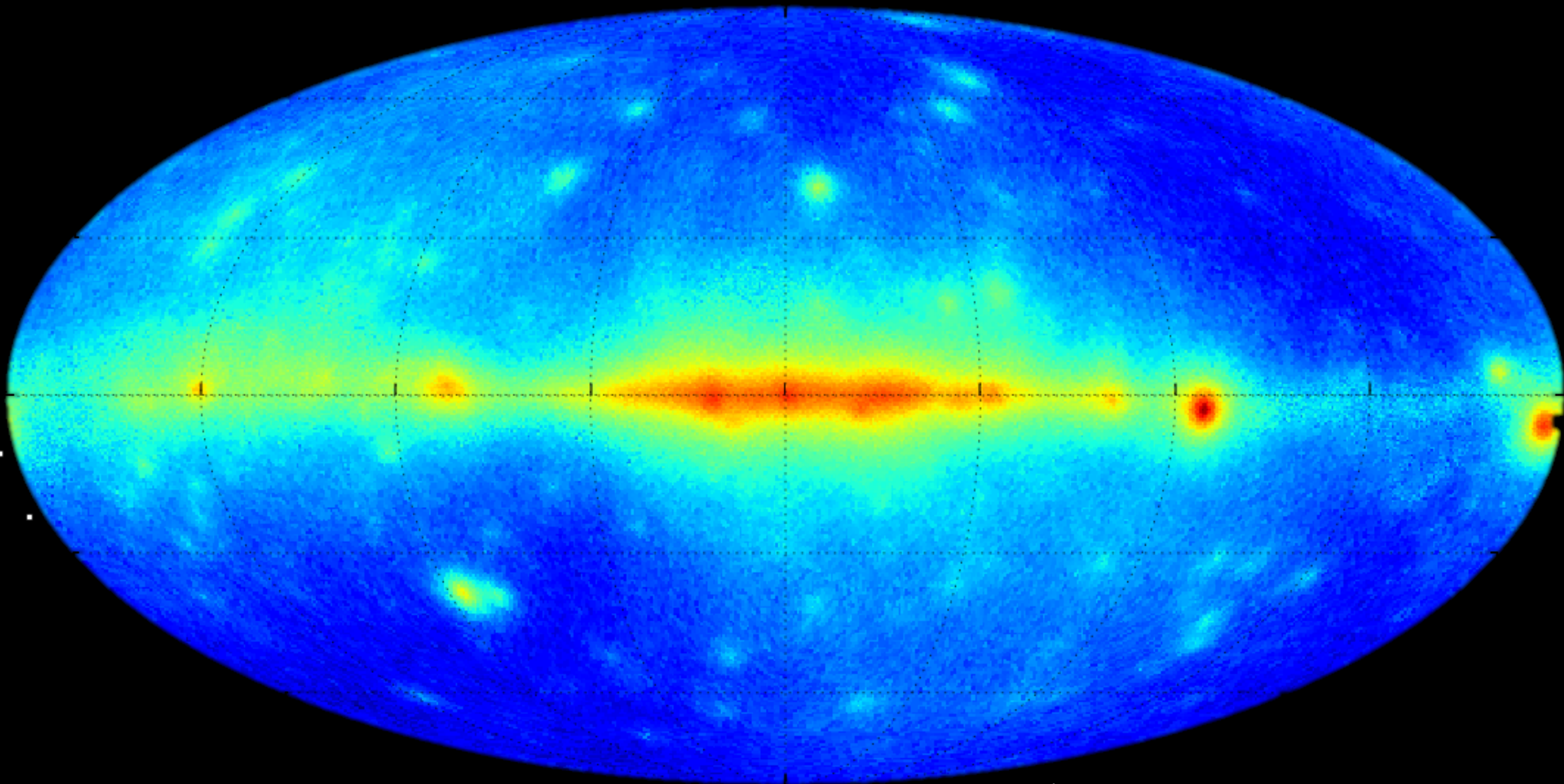
Fermi



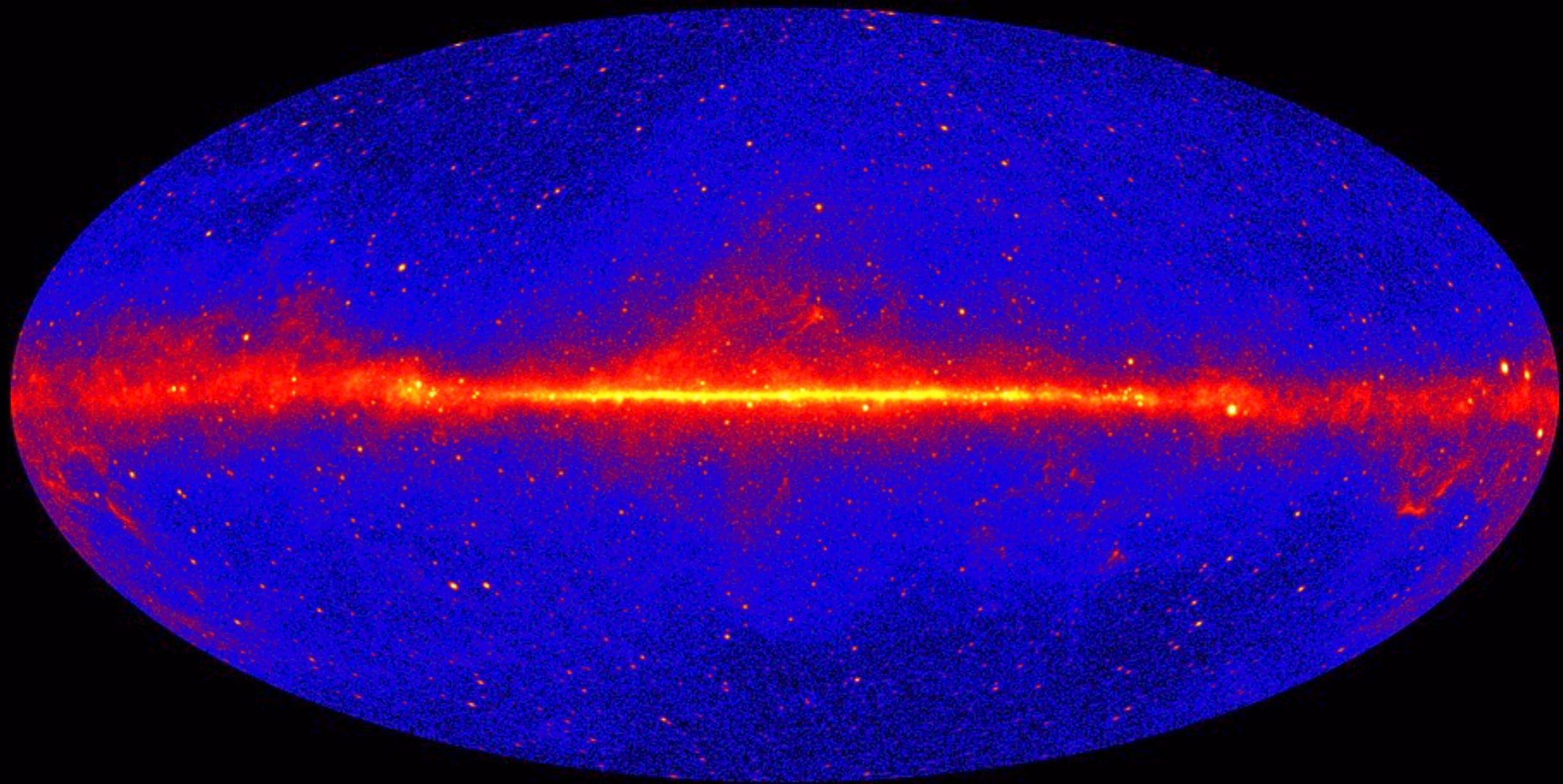
EGRET

Fermi-LAT Performances



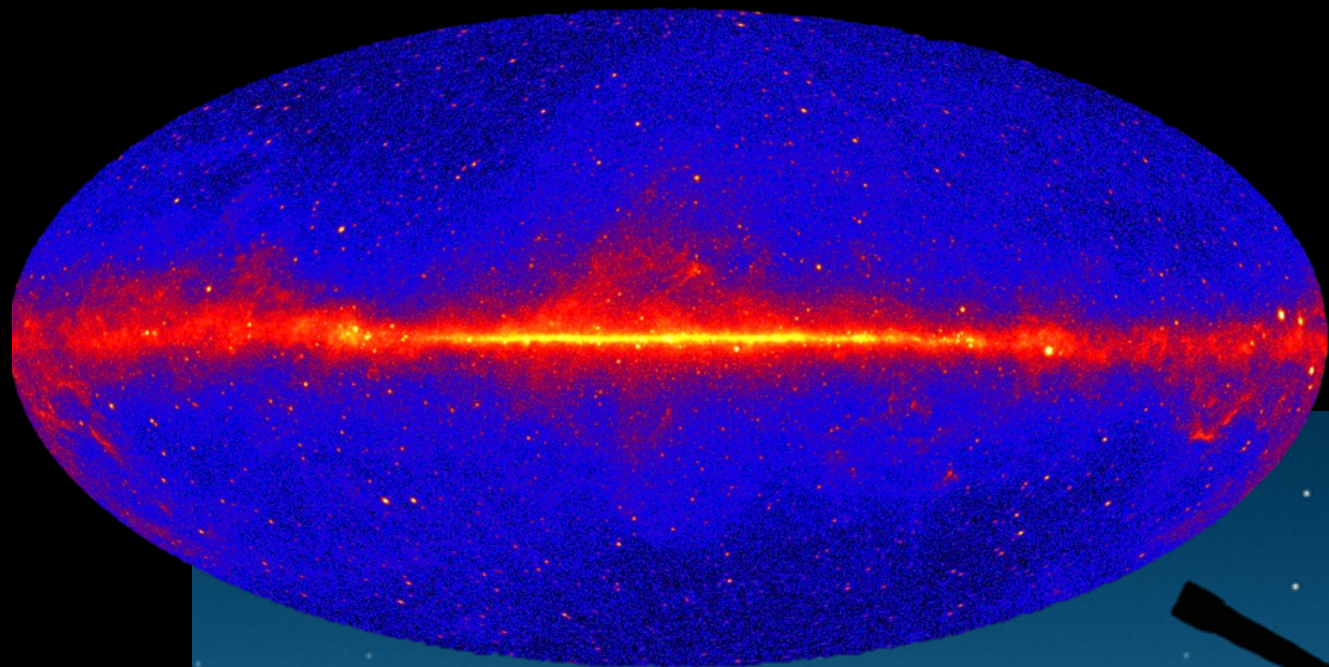


Fermi, $30 \text{ MeV} < E < 100 \text{ MeV}$



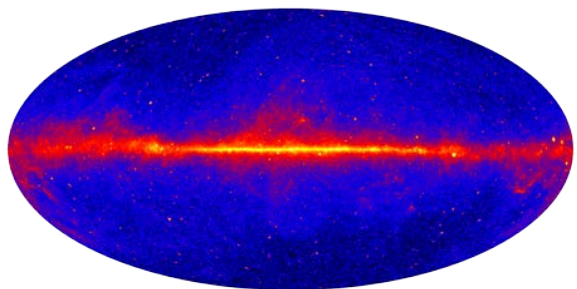
Fermi, $E > 1$ GeV

How can we extract information from Fermi-LAT data?



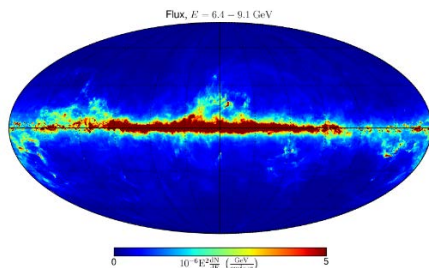
Galactic diffuse emission

Data



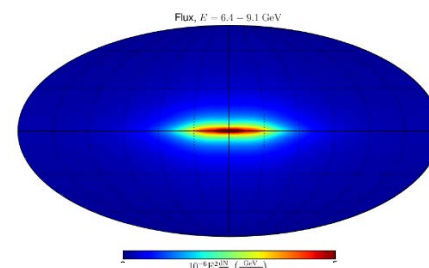
=

π^0 and bremsstrahlung

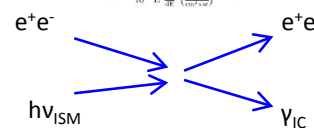
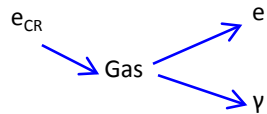
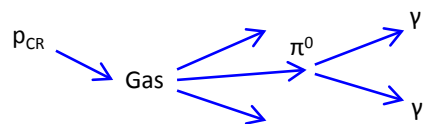


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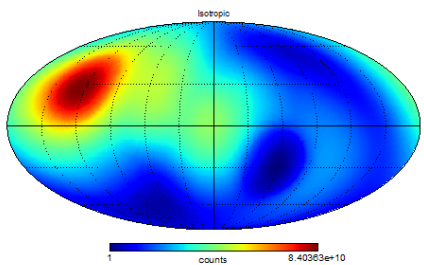
Inverse Compton



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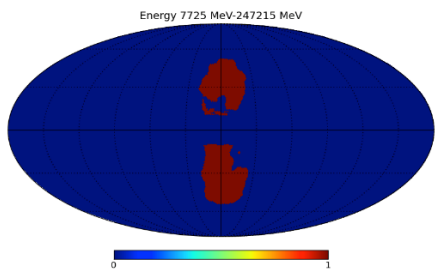


Isotropic



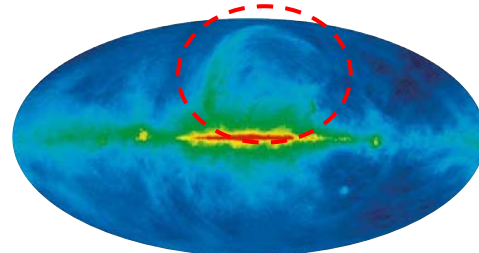
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Bubbles



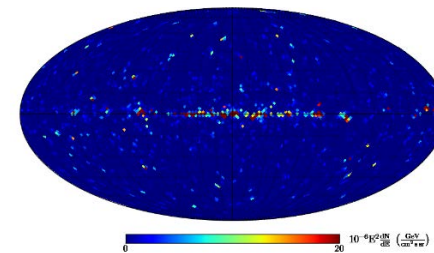
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Loop I



+

Point sources



Extragalactic + residual CR background

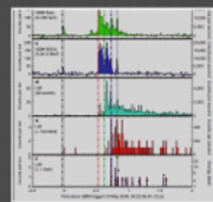
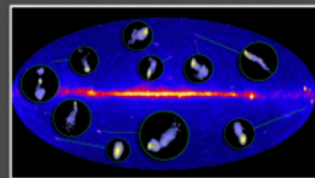
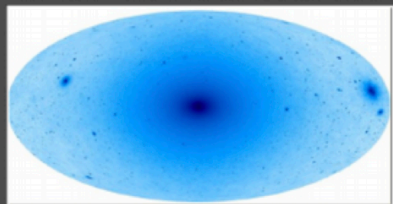
Ackerman et al (Fermi LAT)
ApJ 793 (2014)

Gold et al (WMAP)
ApJS 192 (2011)

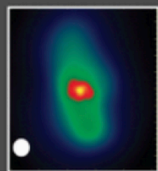
Fermi catalogs

Fermi-LAT sources

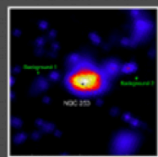
Dark Matter searches



GRBs



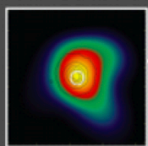
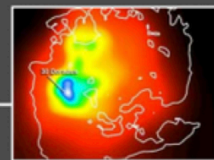
Radio Galaxies



Starburst Galaxies

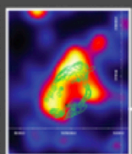
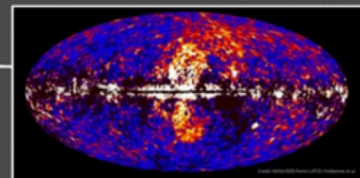
Extragalactic

LMC & SMC



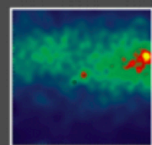
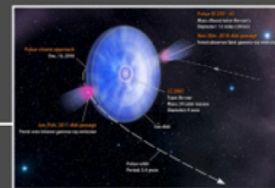
Globular Clusters

Fermi Bubbles



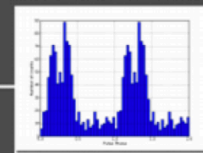
SNRs & PWN

γ -ray Binaries

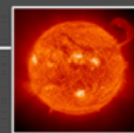


Novae

Pulsars: isolated, binaries, & MSPs



Sun: flares & CR interactions

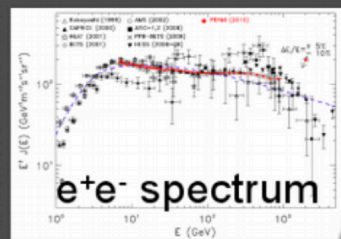


Terrestrial γ -ray Flashes

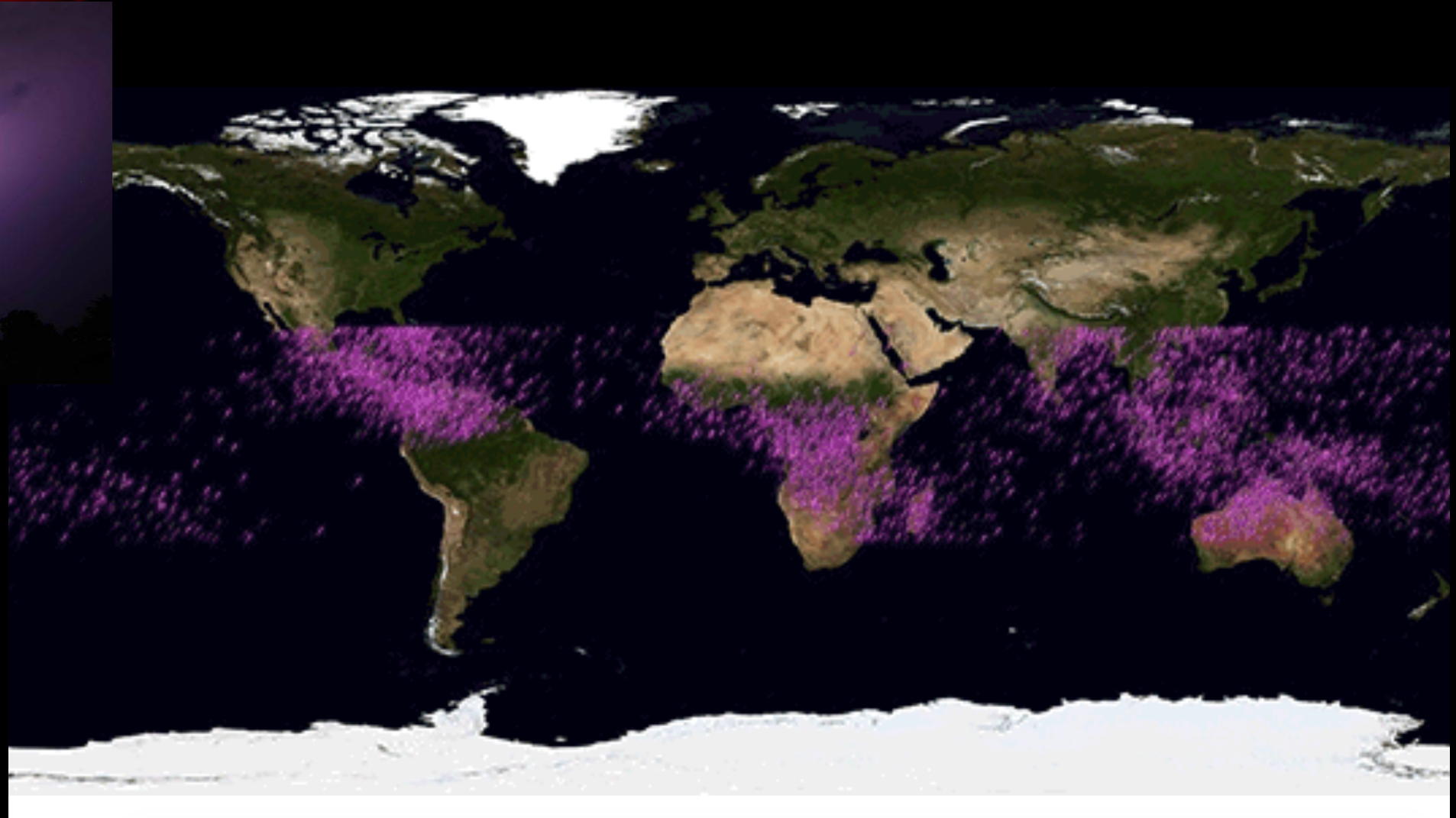


Unidentified Sources

Galactic



The most powerful natural particle accelerators on Earth!

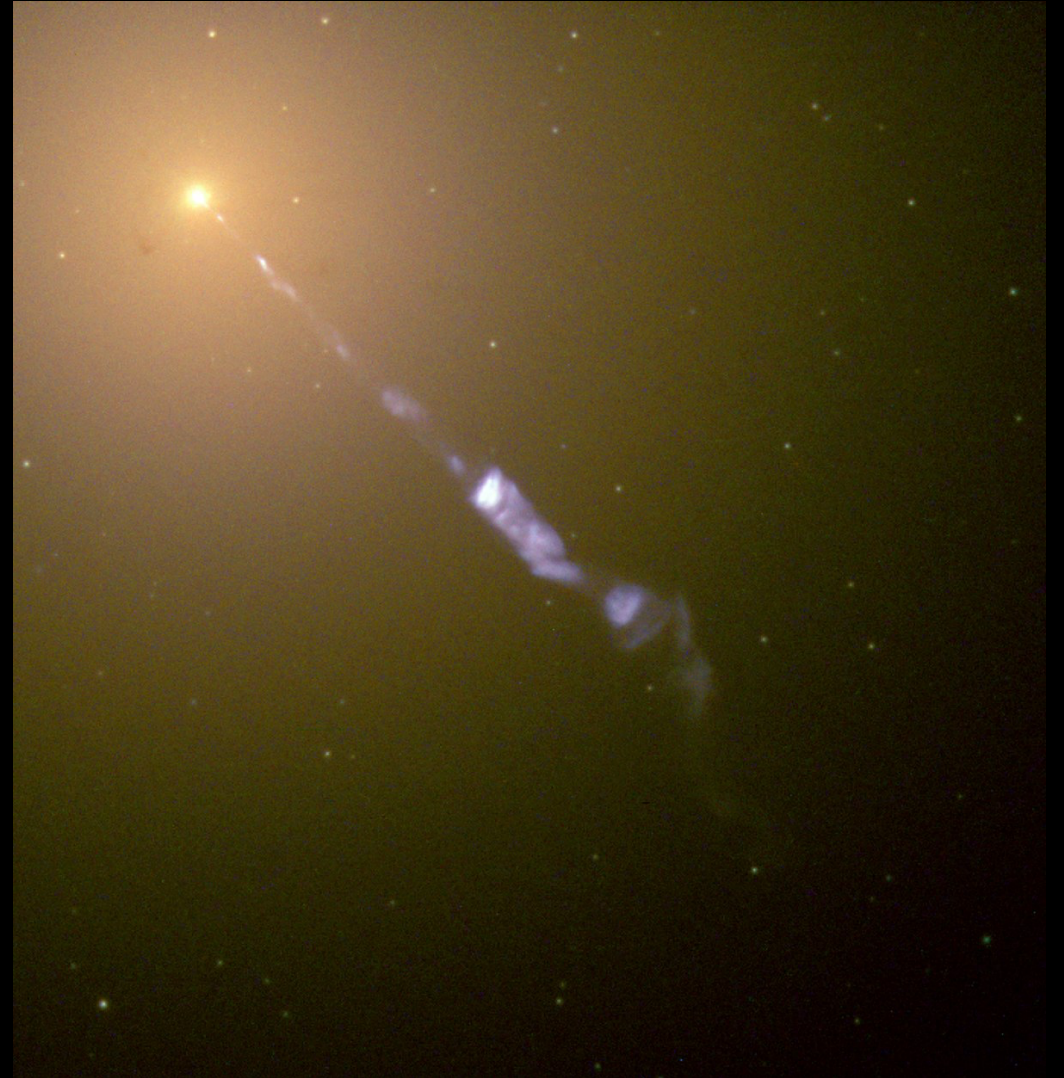


5000 gamma-ray terrestrial flashes seen (GBM, \sim MeV)

Earth and cosmic particle accelerators



CERN Large Hadron Collider
13 Teraelectronvolt (10^{13} eV)
p = mosquito flying at 3 km/h

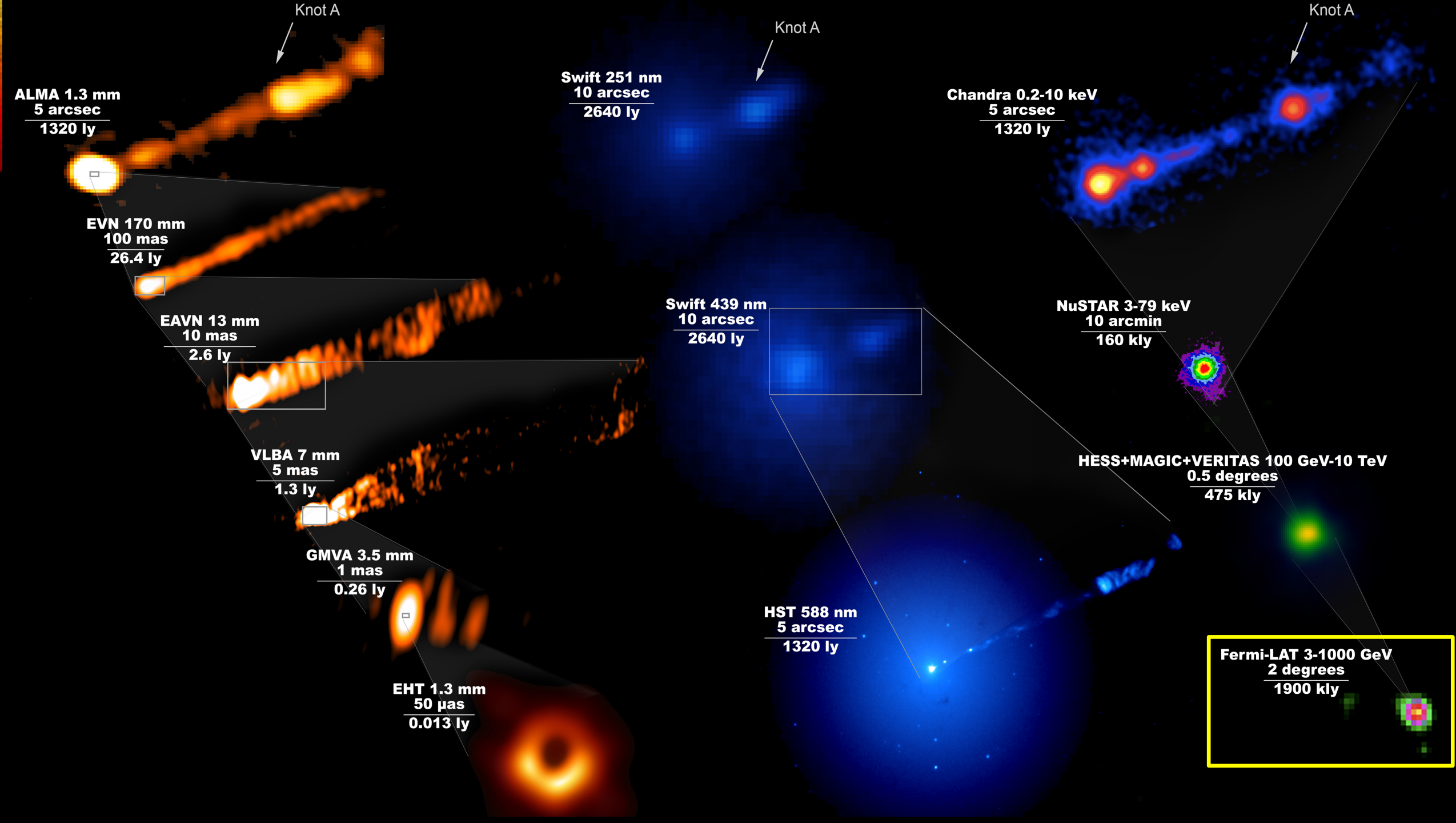


M87 radio galaxy
up to 100 Exaelectronvolt (10^{20} eV)
p = tennis ball at 100 km/h

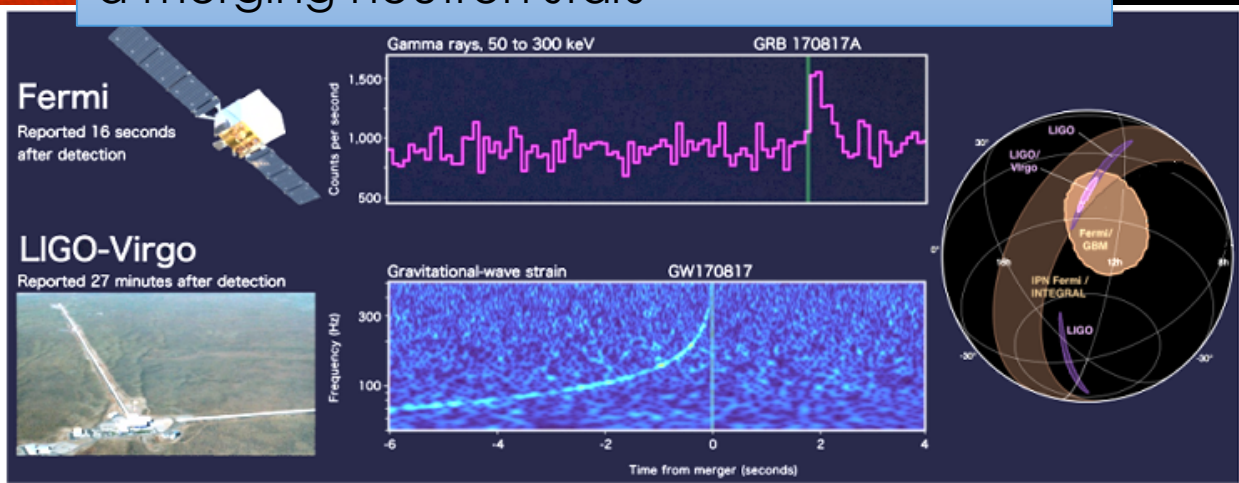


The origin of the gamma-ray emission

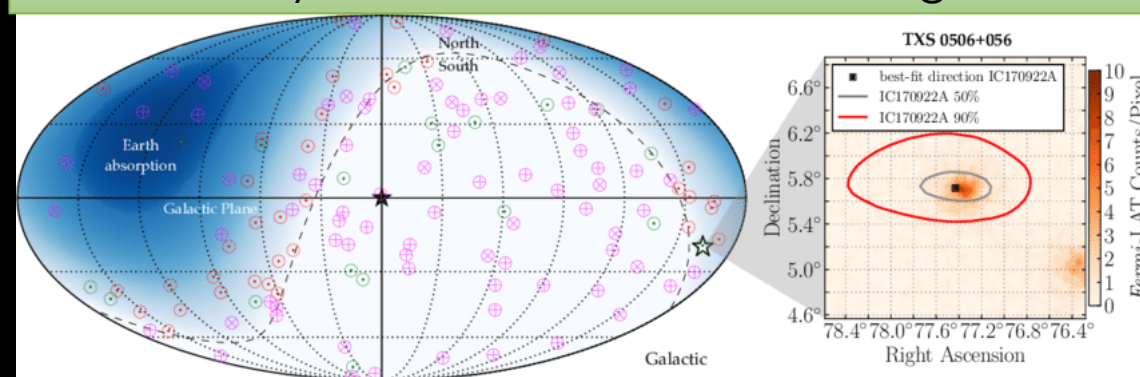
A necessary synergy with multi-wavelength and multi-messenger observatories



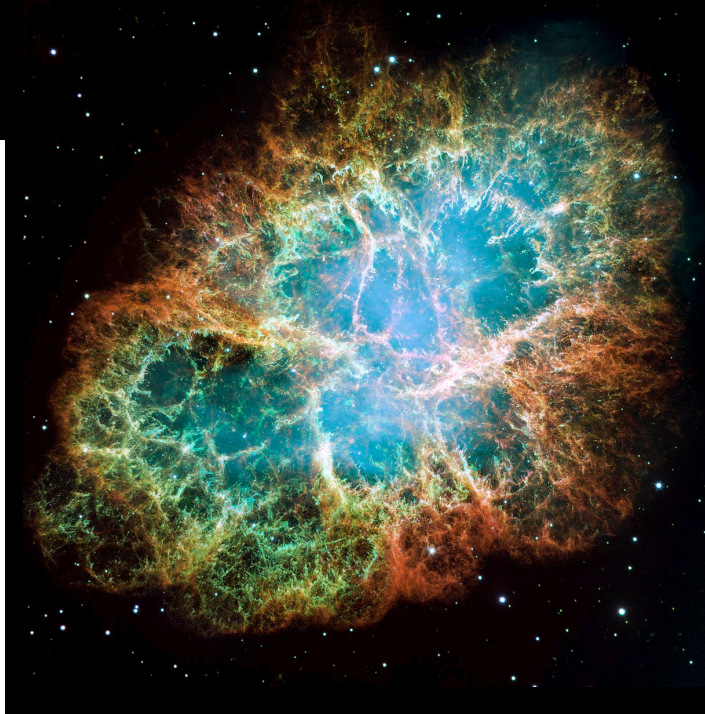
Gamma-ray and gravitational waves from a merging neutron stars



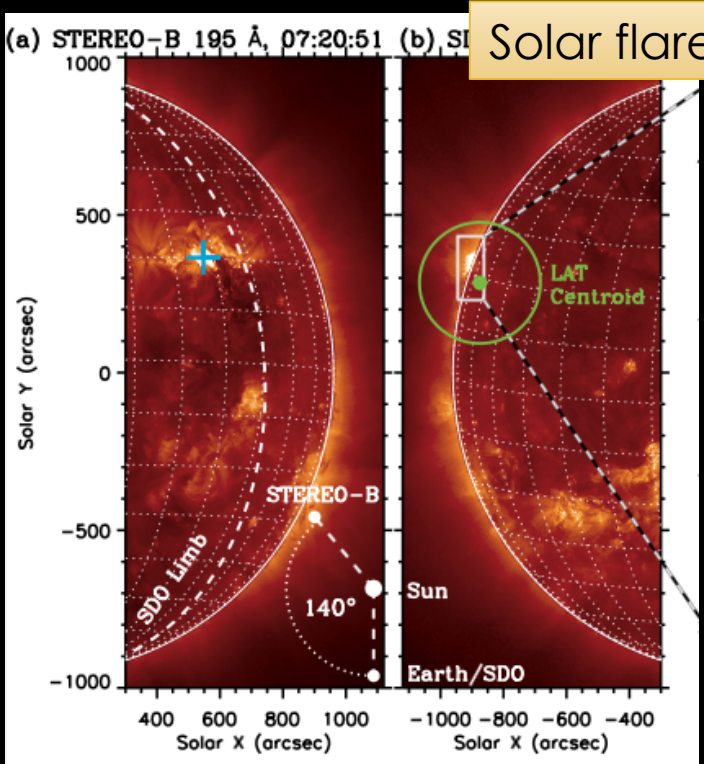
Gamma-ray and neutrino from a flaring blazar



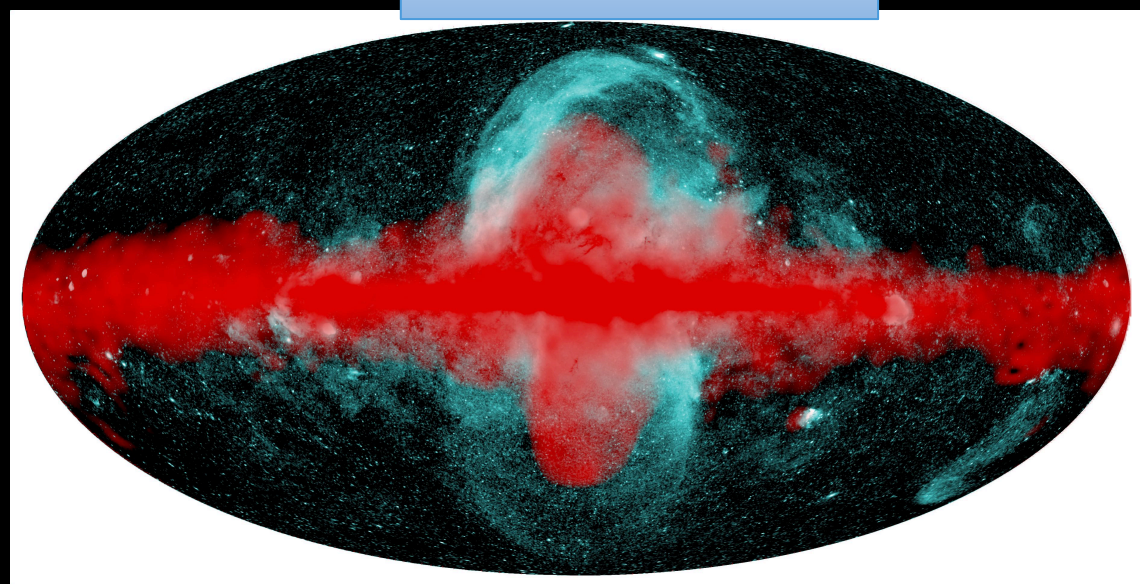
Crab nebula flares



Solar flare



Fermi-LAT bubble



FOR **THE** NEXT **FERMI** DISCOVERY



WE WANT YOU!