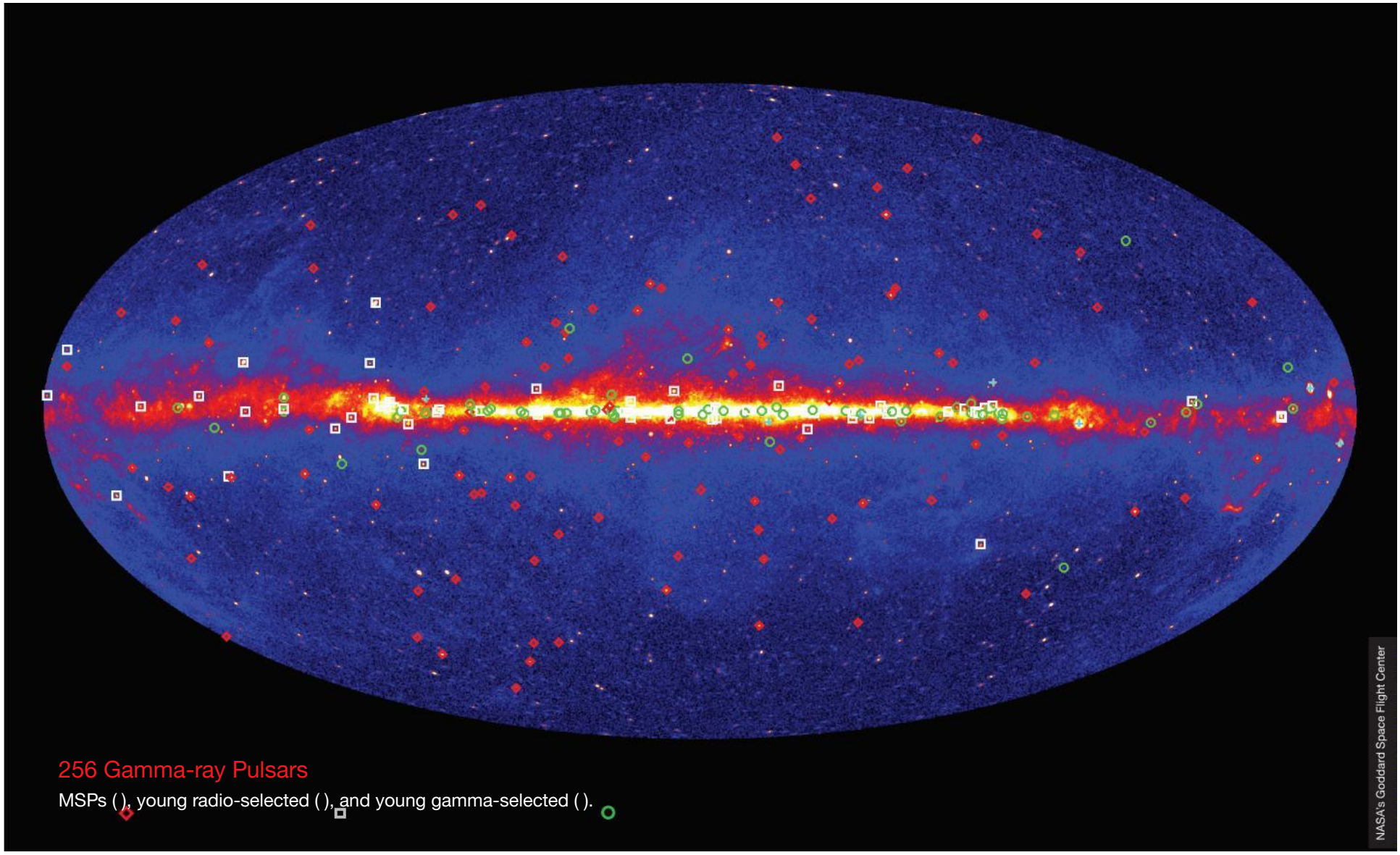
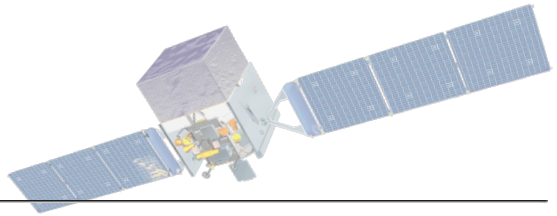
National Aeronautics and Space Administration



Shown above are the gamma-ray pulsars detected with the L AT. For more information visit http://fermi.gsfc.nasa.gov/

Pulsars



New Insights into Pulsar Physics from Fermi

Pulsars are rotating neutron stars created when massive stars explode as supernovae. They slow down continually due to electromagnetic dipole torques, losing most of their energy to magnetized particle winds. A smaller part of their energy loss appears as radiation across the electromagnetic spectrum, with most of the power concentrated in the gamma-ray band.

The pulsar population divides into two categories: young pulsars, with rotation periods of ~0.01-1 seconds and surface magnetic fields around 1012 G, and those with millisecond periods that have much lower surface fields. The millisecond pulsars (MSPs) are thought to be recycled from the main pulsar population through spin-up by accretion from a binary companion.

Pulsar Science with the LAT

The Fermi Large Area Telescope (LAT) has revolutionized pulsar science by detecting and studying the gamma-ray properties of 294, including young (both radio-loud and radio-quiet) and recycled pulsars (both in the Galactic field and globular clusters).

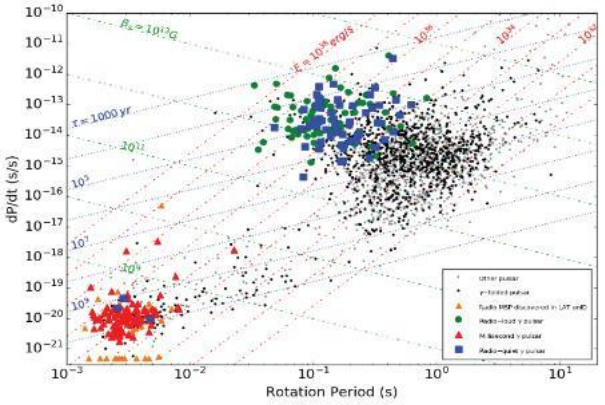
Emission above 100 MeV implies that electrons are accelerated to energies of at least 10 TeV. LAT observations established that the acceleration and gamma-ray emission take place far above the neutron star surface.

The LAT is the first instrument to discover pulsars through their gamma-ray pulsations alone. Because many of these pulsars are radio-quiet, the LAT is uncovering a previously hidden population, providing a more unbiased survey of core-collapse supernovae in our Galaxy.

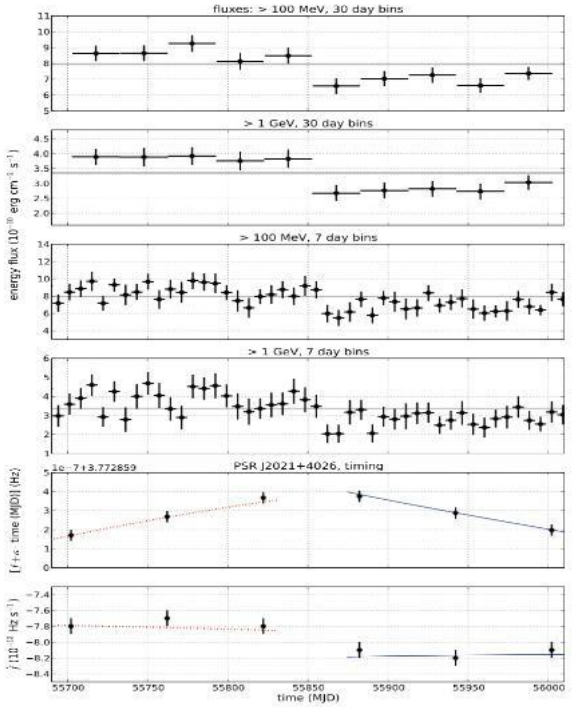
Advances in Pulsar Physics

Before Fermi's launch, pulsar flux >100 MeV was thought to be non-variable. However, Fermi LAT detection of a significant drop in flux, paired with an increase in slowdown rate, of PSR J2021+4026 (see bottom figure) showed that the axiom of pulsar high-energy stability is not true. This variability may be evidence of global changes in the pulsar magnetosphere. Several MSPs have also recently been observed to transition between rotation-powered pulsars and low-mass X-ray binaries and in two cases the transitions were accompanied by significant changes in the observed gamma-ray flux.

Curvature radiation from particles accelerated along magnetic field lines is thought to be the primary mechanism for pulsar emission >100 MeV, but a cutoff is expected near a few GeV. Recent detections by TeV telescopes of pulsed emission from the Crab and Vela pulsars >100 GeV suggest either an extra component becomes dominant at these energies or a new mechanism is needed. The Fermi LAT catalog of sources >10 GeV includes significant pulsed detections of 20 pulsars above >10 GeV. As LAT continues to collect data, these statistics will improve, helping better characterize this emission.



TOP RIGHT: Periods and period derivatives of known pulsars with LAT. Gamma-ray pulsars are indicated in color.



RIGHT: The Fermi LAT light curve (top 4 panels) of PSR J2021+4026 centered on its drop in flux and change in period and spin-down rate (bottom 2 panels)

FS-2023-11-181-GSFC