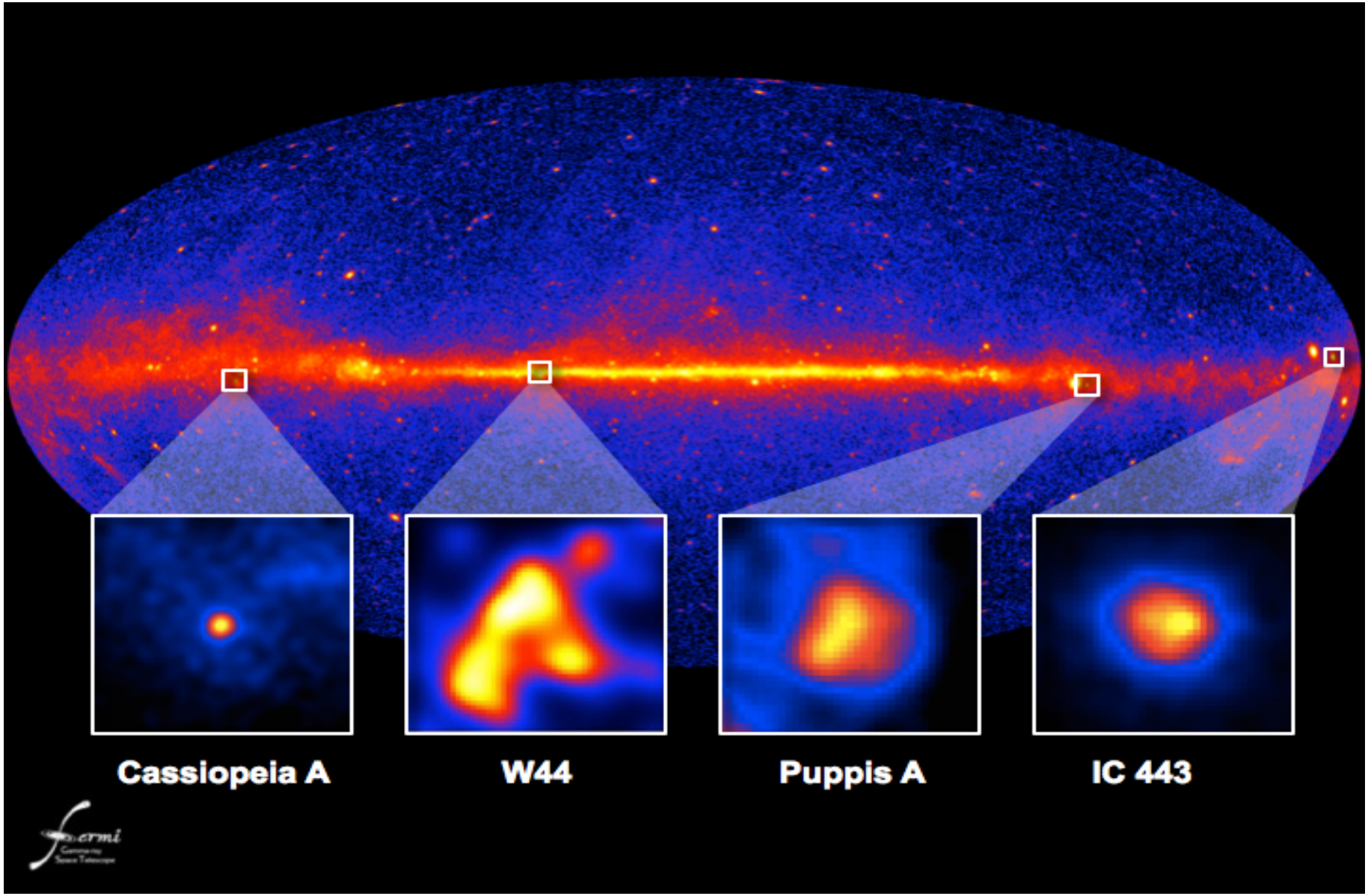
Supernova Remnants



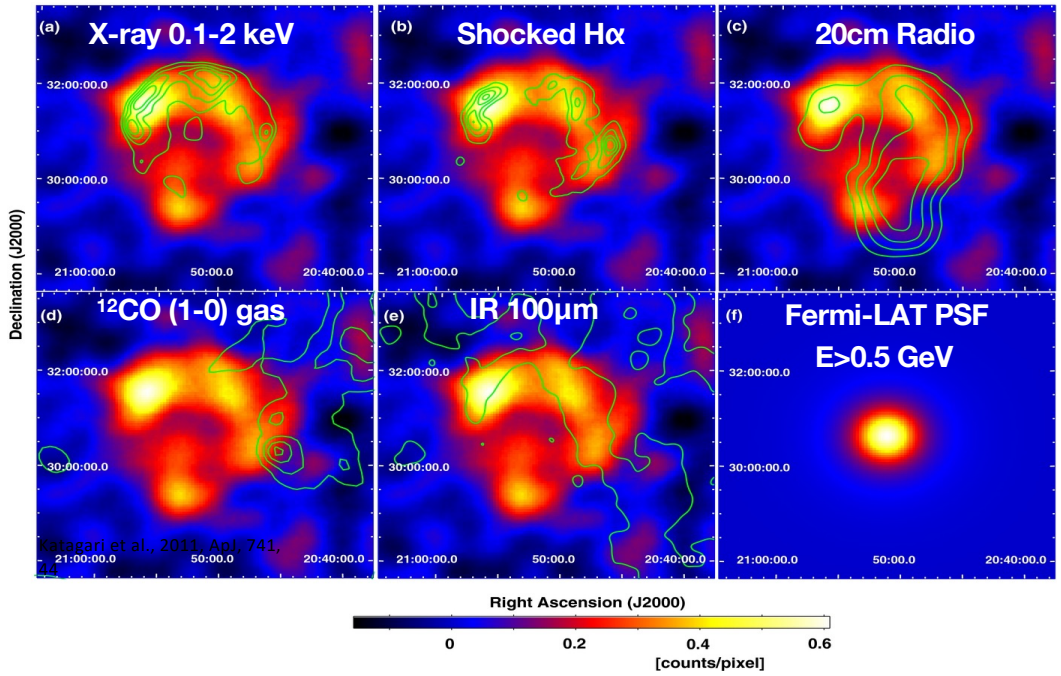
Credit: NASA / DOE /
Fermi LAT Collaboration

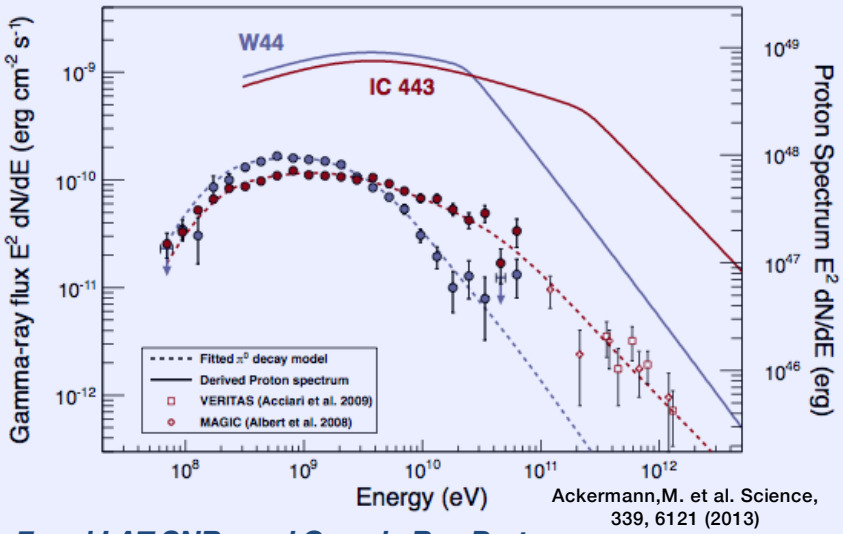
New Insights into SNRs From Fermi

Supernova remnants (SNRs) are structures formed by the explosive death of stars: either at the end of a massive star's life or as the result of a white dwarf accreting material from its companion star. Among the most energetic particle accelerators, SNRs are widely thought to supply the Galaxy with cosmic rays.

Fermi LAT gamma-ray observations of SNRs **reveal the underlying emission mechanisms**, tracing the populations of relativistic particles, the physics of acceleration and the surrounding environment. To date, observations have **associated more than 23 SNRs, with around 50 additional candidate associations listed in the third Fermi LAT source catalog**. A key result from the Fermi LAT study of SNRs has been to unambiguously show that SNRs accelerate cosmic-ray protons to the high energies needed to explain the Galactic cosmic ray spectrum.

The Cygnus Loop SNR is resolved as a shall (D~3°) by Fermi LAT. Correlation with emission at X-ray, Radio and Halpha wavelengths (green contours) suggests that gamma rays originate in interactions with the gas adjacent to the shock. Interactions between accelerated hadrons and interstellar gas provide a reasonable explanation for the gamma-ray spectrum. Leptonic models are disfavored, as they require a lower gas density , lower magnetic field and higher radiation field than is observed.





Ackermann,M. et al. Science, 339, 6121 (2013)

Fermi LAT SNRs and Cosmic Ray Protons

A definitive detection of a pion decay bump near 67.5 MeV (characteristic of interactions between relativistic protons and gas) in the spectra of two interacting SNRs (W44 and IC 443) has been made by Fermi LAT. This detection, for the first time, directly identifies SNRs as sites of cosmic ray proton acceleration.

SNR Science with the LAT

- Fermi's unprecedented spatial resolution provides unambiguous SNR identification and allows the GeV morphology to be correlated with other wavelengths.
- The LAT energy range covers more than 3 decades in energy, allowing spectral curvature to be identified. Spectral curvature is commonly observed for SNRs interacting with a dense environment.
- Older SNRs (e.g. W44) in dense environments tend to have bright GeV emission, indicative of interactions between the SNR and nearby molecular clouds.
- Young TeV-bright SNRs (e.g. RX J1713.7) often show GeV emission rising to a peak in the TeV. However, the historical SNR Cas A has a much softer spectral index and a lower-energy cutoff. These contrasting results indicate either different emission mechanisms, environments, or changes in the accelerated particle distribution with time.
- **In the first Fermi LAT SNR Catalog we have systematically characterized GeV emission in regions containing the known radio SNRs, challenging simple, but previously sufficient, SNR emission models.**

For more information, visit http://fermi.gsfc.nasa.gov/

NASA's Fermi mission is an astrophysics and particle physics partnership managed by NASA's Goddard Space Flight Center in Greenbelt, Md., and developed in collaboration with the U.S. Department of Energy, with important contributions from academic institutions and partners in France, Germany, Italy, Japan, Sweden and the United States.