

Investigating the region of 3C 397 in High Energy Gamma rays

By

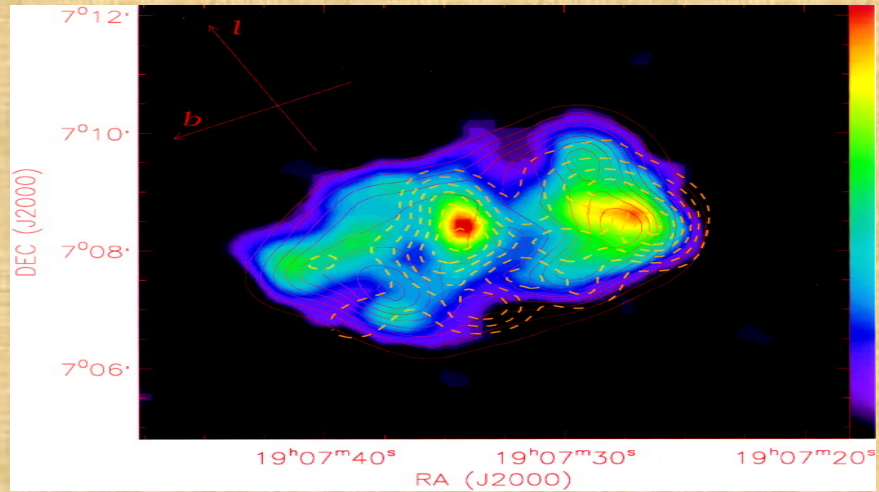
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3C 397 (G41.1-0.3)

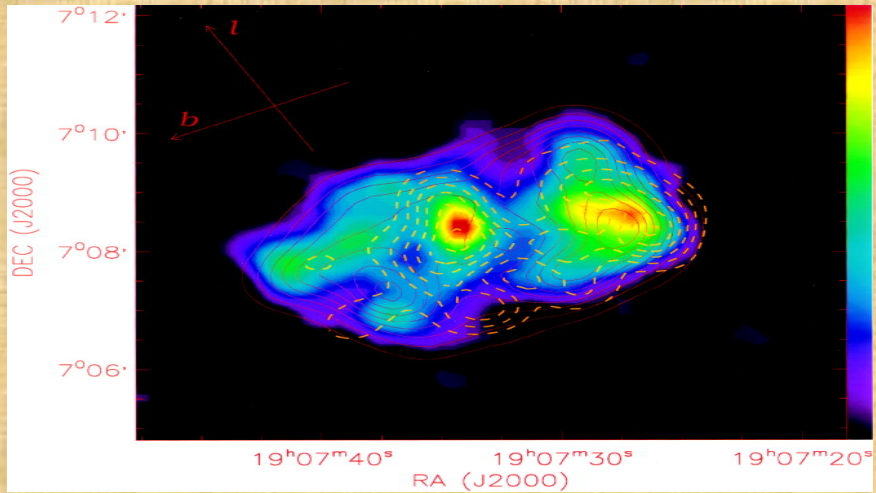
- A Type Ia Galactic supernova remnant (SNR).
- It is one of the brightest radio and X-ray extended source, used to be regarded as one of the youngest SNRs (S. Safi-Harb et al. 2000)
- It is classified as a “mixed-morphology” SNR. (S. Safi-Harb et al. 2005)



Smoothed ROSAT HRI image of 3C 397
(Y. Chen et al 1999)

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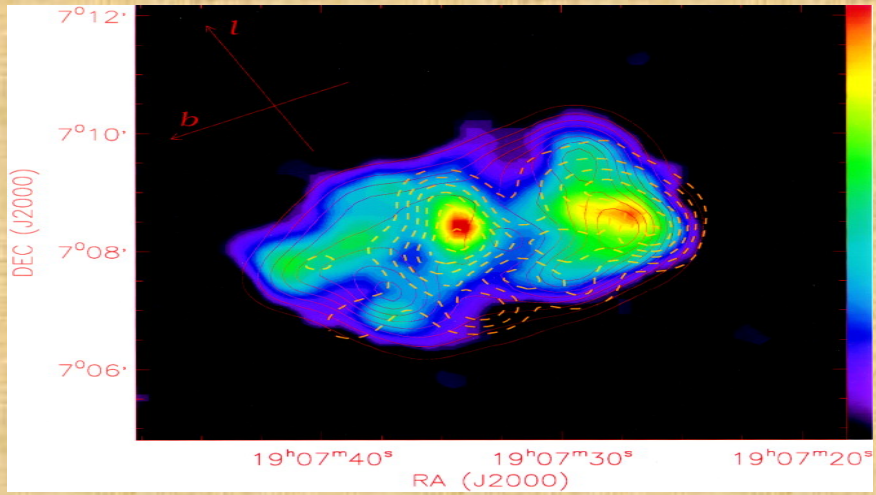
Fermi Large Area Telescope (Fermi-LAT)



The Fermi LAT is scanning and covering the whole sky every three hours in the energy range from 20 MeV to 300 GeV to survey the gamma ray emission from different astrophysical and cosmological events.

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PSR J1906+0722

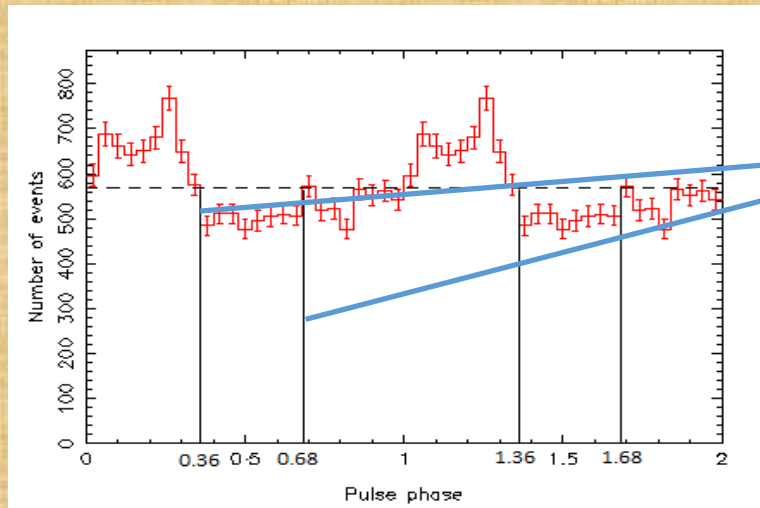
- PSR J1906+0722 is a newly discovered gamma-ray pulsar.
- It was detected as a part of blind survey by the computing system, Einstein@Home.
- It is lying within 1° from the radio location of 3C 397.
- PSR J1906+0722 is a young, energetic, isolated pulsar with a spin frequency of 8.9 Hz, a characteristic age of 49 kyr and spin down power 1.0×10^{36} erg sec^{-1} .

Gamma-ray Analysis



Here we have selected nearly six years (04/08/2008 to 01/10/2014) of Pass 8 source class LAT events from energy range 100 MeV to 300 GeV with radius of interest (ROI) of 10^0 around PSR J1906+0722 and have used the gll iem v06.fits and iso P8R2 SOURCE V6 v06.text to model the galactic and extragalactic diffuse background respectively and the point sources from the Fermi-LAT 3FGL catalog. We have used gtselect to select photons with energies > 100 MeV and a zenith angle cut of 90 to remove contamination from the Earth's limb.

As PSR J1906+0722 has already been detected as a part of a blind search survey of the undefined Fermi-LAT sources, we have an updated ephemeris for this pulsar (C. J. Clark et al. 2015). To eliminate the possible contamination due to strong emission from PSR J1906+0722 itself, we have applied the pulsar gating technique. We have then performed the binned likelihood analysis for its off-pulse phase interval data. For each of the cases, the normalization parameters of both the components of the diffuse background radiation were left free.



The off-pulse phase interval of PSR J1906+0722 between the phases 0.36 and 0.68 .

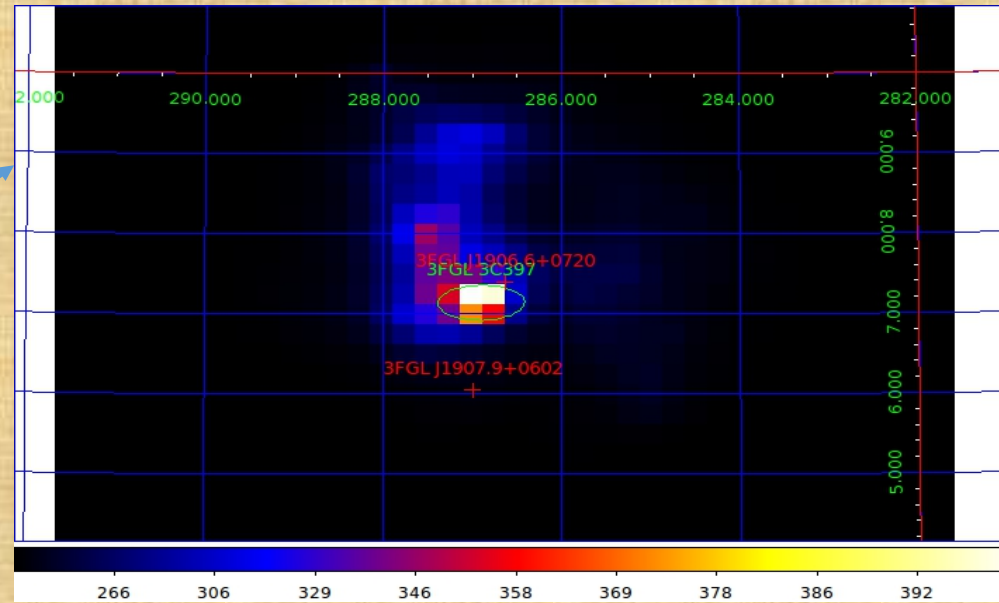
gamma-ray phasogram of PSR J1906+0722

Gamma-ray Analysis



Here we have selected nearly six years of Pass 8 source class LAT events from energy range 100 MeV to 300 GeV with an ROI of 10 degree around PSR J1906+0722.

To eliminate the possible contamination due to strong emission from this pulsar, PSR J1906+0722, applied pulsar gating technique and run likelihood for its off-pulse phase interval data.



$5^\circ \times 5^\circ$ residual TS map of PSR J1906+0722 in which the horizontal and the vertical scales represent the RA and the DEC of the region. The horizontal scale underneath the figure indicates the color values.

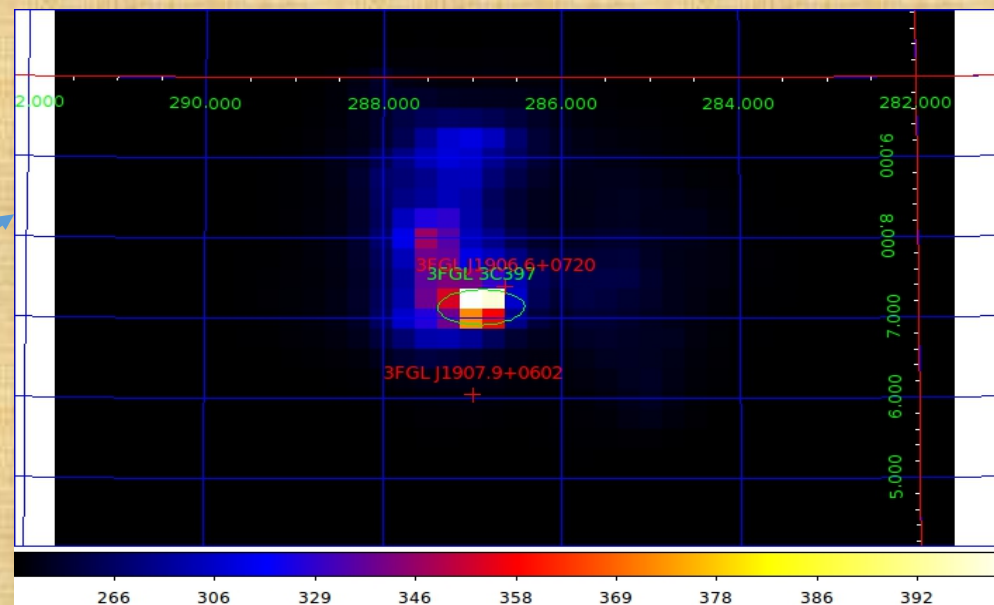
This excess gamma-ray energy emission location is exactly matching with the radio location of the SNR, 3C 397.

Gamma-ray Analysis



Here we have selected nearly seven years of Pass 8 source class LAT events from energy range 100 MeV to 300 GeV with an ROI of 10 degree around PSR J1906+0722.

To eliminate the possible contamination due to strong emission from this pulsar, PSR J1906+0722, applied pulsar gating technique and run likelihood for its off-pulse phase interval data.



$5^\circ \times 5^\circ$ residual TS map of PSR J1906+0722 in which the horizontal and the vertical scales represent the RA and the DEC of the region. The horizontal scale underneath the figure indicates the color values.

This excess gamma-ray energy emission location is exactly matching with the radio location of the SNR, 3C 397.



We have added this source to background model and modeled it with power-law spectra.

- **The integrated flux of this excess emission region is $10^{-8} \text{ cm}^{-2} \text{ sec}^{-1}$ and significance is 10σ .**

Conclusion

- We investigated the region of 3C 397 in high energy gamma rays using the Fermi-LAT data.
- As 3C 397 is a type Ia SNR, from a Chandrasekhar mass progenitor it is very unlikely to be the birthplace of a pulsar (Yamaguchi et. al. 2015). But our preliminary analysis shows that the young pulsar PSR J1906+0722 may be associated with the SNR.
- The obtained excess gamma-ray emission has been found to coincide with the radio location of 3C 397 which suggests the possibility of its association with the pulsar, PSR J1906+0722.
- In future, we plan to investigate the source spectra and we would also model the spectral energy distribution which can give us valuable clues to the emission mechanisms of the source.

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