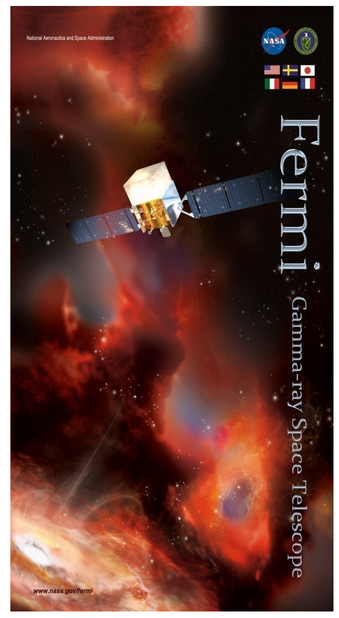
The discovery of γ-ray emission from Nova Sco 2012

An analysis using reprocessed Pass7 LAT data

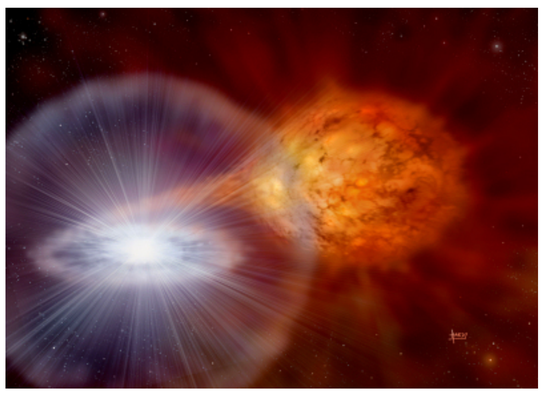
A.B. Hill (SLAC & University of Southampton), C.C. Cheung (NRC/NRL) & P. Jean (IRAP-UPS) on behalf of the Fermi Large Area Telescope Collaboration

SLAC NATIONAL ACCELERATOR LABORATORY UNIVERSITY OF Southampton



ABSTRACT

In March 2010 the Large Area Telescope on-board the Fermi Gamma-ray Space Telescope discovered for the first time >100 MeV γ-ray emission from a nova within our galaxy, V407 Cyg. The high-energy spectrum and light curve was explained as a consequence of shock acceleration in the nova shell as it interacts with the local ambient medium. It was suspected that the necessary conditions for high-energy emission from novae would be rare. In June 2012 the LAT detected a new flaring source, Fermi J1750-3243, which is spatially coincident and contemporaneous with a new nova, Nova Sco 2012. We report on the exciting discovery of this new, 'γ-ray' nova and present a detailed analysis of its high-energy properties.

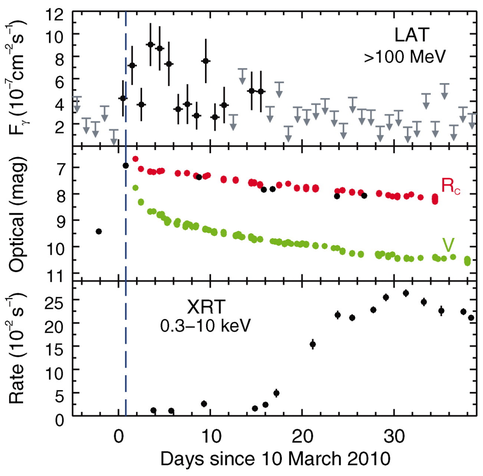


An artist impression impression of a nova eruption within a symbiotic binary. Image credit: David A. Hardy & PPARC

V407 Cyg: The first γ-ray nova

On 11 March 2010 Japanese amateur astronomers reported the discovery of a new 8th magnitude nova in the Cygnus constellation [1]. The nova was identified as originating from the known symbiotic binary, V407 Cyg. Symbiotic binaries are systems comprised of red giant star and a hot white dwarf which is typically accreting material from the red giant via its stellar wind or Roche-lobe overflow. In the case of V407 Cyg it hosts a Mira-type variable red giant and so the white dwarf is embedded in a particularly dusty environment.

The discovery of a classical nova like event in this system was completely unexpected. A further unexpected discovery came when the Fermi LAT announced a detection of γ-ray emission above 100 MeV from the nova [2,3]. The γ rays were detectable for approximately two weeks after the optical nova onset with a peak flux above 100 MeV of 9 x 10^{-7} ph cm^{-2} s^{-1}.



The multi-wavelength light curve of the nova eruption in V407 Cyg in March 2010 [3].

Reprocessed Pass7 data

Data reprocessing results in:

- An improved PSF above 3 GeV.
- Change in background contamination of event classes.
- Stabilized energy scale.

For further details see [8] and posters at this meeting.

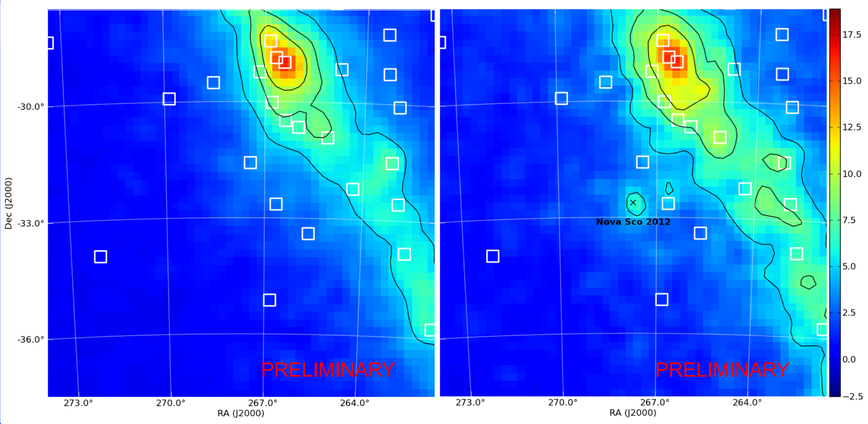
Data selection:

- June 15.0 – July 3.0 2012
- Energy range: 0.06 – 300 GeV
- IRFs: P7_V6MC
- Old Galactic and isotropic diffuse templates used (may underestimate the flux by ~20%)

A new Galactic transient: Fermi J1750-3243

In June 2012 the RSP pipeline reported a potential week long flare from a monitored X-ray binary. A detailed follow-up analysis identified a new γ-ray source, Fermi J1750-3243, which was not consistent with any of the known 2FGL catalog sources [5]. The new source was localized to RA = 267.727°, Dec = -32.720° with a 95% error radius of 0.122° [4]. The source was not consistent with the location of any of the known 2FGL catalog sources [5] or the location of the monitored X-ray binary, it was something totally new.

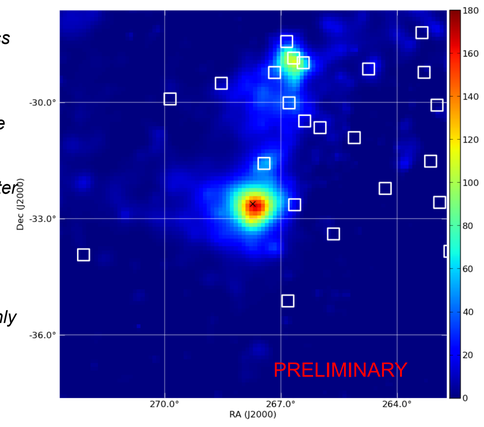
Consistent with the new LAT source location was a newly discovered optical nova, MOA 2012 BLG-320 (Nova Sco 2012) which had entered into optical outburst between June 1.77-2.15 when it brightened dramatically in the I band from 17th magnitude to 11th magnitude [6]. Subsequent IR spectral observations on June 17.879 indicated that that it was an Fe-II nova event with an ejecta velocity of ~2,200 km s^{-1}[7].



White squares indicate the location of 2FGL catalog sources and the black cross the known position of Nova Sco 2012.

Top: Smoothed LAT counts maps of the region around Fermi J1750-3243. On the left is shown the month from mid-May 2012, preceding the γ-ray flare. On the right is the same region for two weeks after the onset of γ-ray activity. Contours indicate regions of 5, 7.5 & 10 counts. N.B. the counts have been rescaled as if both maps had equal exposure.

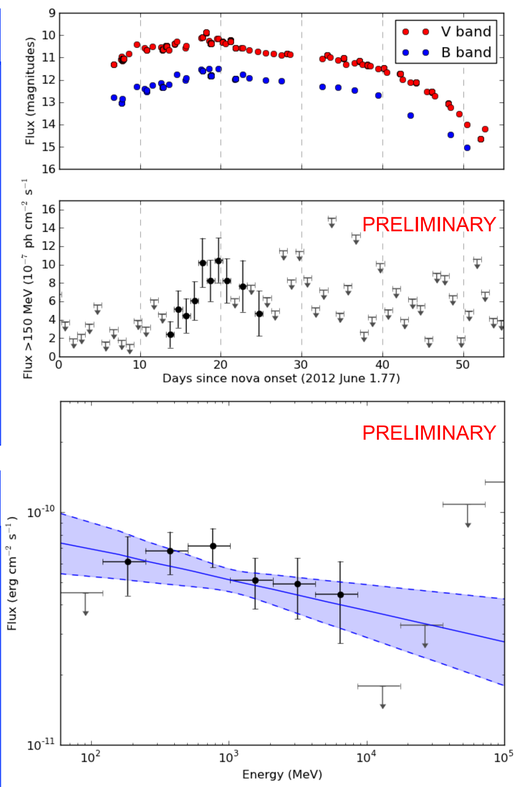
Right: The TS map of the region when only modeling the diffuse background components. An additional source at a location inconsistent with any 2FGL catalog source is clearly evident.



Preliminary LAT analysis results

Having identified a new Galactic transient consistent with a new classical nova, Nova Sco 2012, we preceded to analyze the source behaviour with the newly reprocessed Pass7 data; see above for details on event selection etc.

The source is detected clearly with a significance of >12σ (TS = 181). The spectral shape is best characterized by a simple power law model with an index of 2.13 ± 0.04. Significant emission is seen from ~0.1-10 GeV and there is no detection of spectral variability over the duration of the flare. Fixing the spectral shape parameters the flux is calculated in daily bins to generate a light curve for the source.



Top: Evolution of the nova outburst in the optical (taken from AAVSO) and the γ-ray (>100 MeV). LAT flux points are shown in black with their 1σ errors, grey arrows indicate 95% flux upper limits.
Bottom: The best-fit power law spectrum from the LAT data. The shaded blue region indicates the 2σ boundary inferred from the fitting errors.

Multi-wavelength results & summary

From the optical data from AAVSO it is clear that Nova Sco 2012 behaves very differently to V407 Cyg, in that it very gradually reaches its peak ~14 days after the initial rapid brightening. The decay time of the optical light curve is 4-5 times slower indicating a less massive WD. Using the MMRD relation suggests that the source may be 4-5 kpc away. Radio emission has also been reported from Nova Sco 2012 however X-ray observations with Swift-XRT have to date not detected anything.

We have discovered a new 'γ-ray' nova. It has many similar γ-ray properties to the first LAT detected nova, V407 Cyg: spectral shape, duration, peak flux. Conversely, the optical properties are in stark contrast showing a much slower nova, potentially ~1.6 times more distant and with an unidentified optical companion. The potential appears to exist for novae, in general, to be capable of producing γ-rays, however, the mechanism behind this emission is still to be understood and has the potential to be different within the novae sub-classes.

System	Nova Sco 2012	V407 Cyg
Optical companion	???	Mira type red giant
Distance	~4-5? kpc (from MMRD)	2.7 kpc
Nova spectral class	Fe-II	He/N
Speed class	Fast/moderately fast; t_2 ~ 25 days	Very fast; t_2 = 5.9 days
γ-ray spectrum	Power law	Cutoff power-law
γ-ray duration	~12 days	~16 days
Optical/γ-ray delay	~14 days	<3 days
Average γ-ray flux	9.6 x 10^{-7} ph. cm^{-2} s^{-1}	4.4 x 10^{-7} ph cm^{-2} s^{-1}

PRELIMINARY

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http://bit.ly/TkP9ht

[1] K. Nishiyama, F. Kabashima, 2010, IAU CBAT, reported by H. Maehara, No. 2199

[2] Cheung et al., 2010, ATel #2487

[3] Abdo et al. 2010, Science, 329, 817

[4] Cheung, Glanzman & Hill, 2012, ATel #4284

[5] Nolan et al., 2012, ApJS, 199, 31

[6] Wagner et al., 2012, ATel #4157

[7] Ashish, Ashok & Banerjee, 2012, ATel #4211

[8] Ackerman, M., et al. 2012, ApJS, 203, 4