



Fermi

Gamma-ray Space Telescope

UNIVERSITY OF  
Southampton

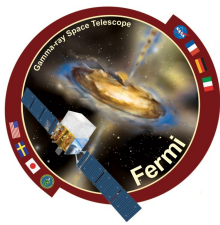
SLAC

NATIONAL ACCELERATOR LABORATORY



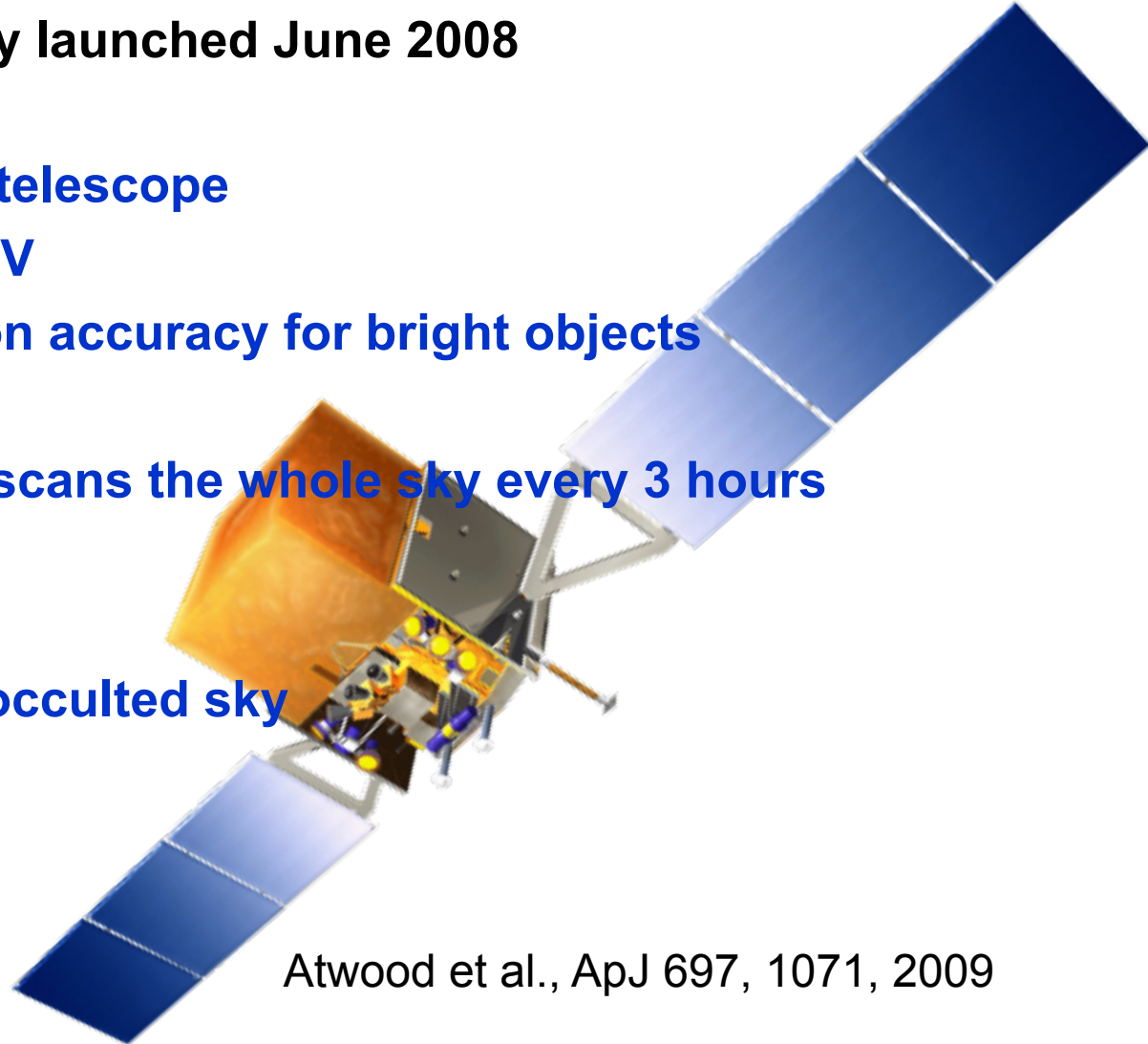
## The discovery of Galactic Gamma-ray, binary transients with Fermi

**Adam Hill**  
on behalf of the Fermi-LAT  
collaboration



**Fermi was successfully launched June 2008**

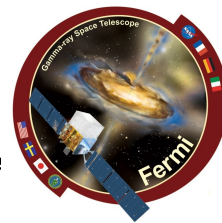
- **LAT:**
  - **Pair-production telescope**
  - **20 MeV – 300 GeV**
  - **1' source location accuracy for bright objects**
  - **~2.5 str FOV**
  - **In survey mode scans the whole sky every 3 hours**
- **GBM:**
  - **8 keV- 30 MeV**
  - **Views whole unoccluded sky**



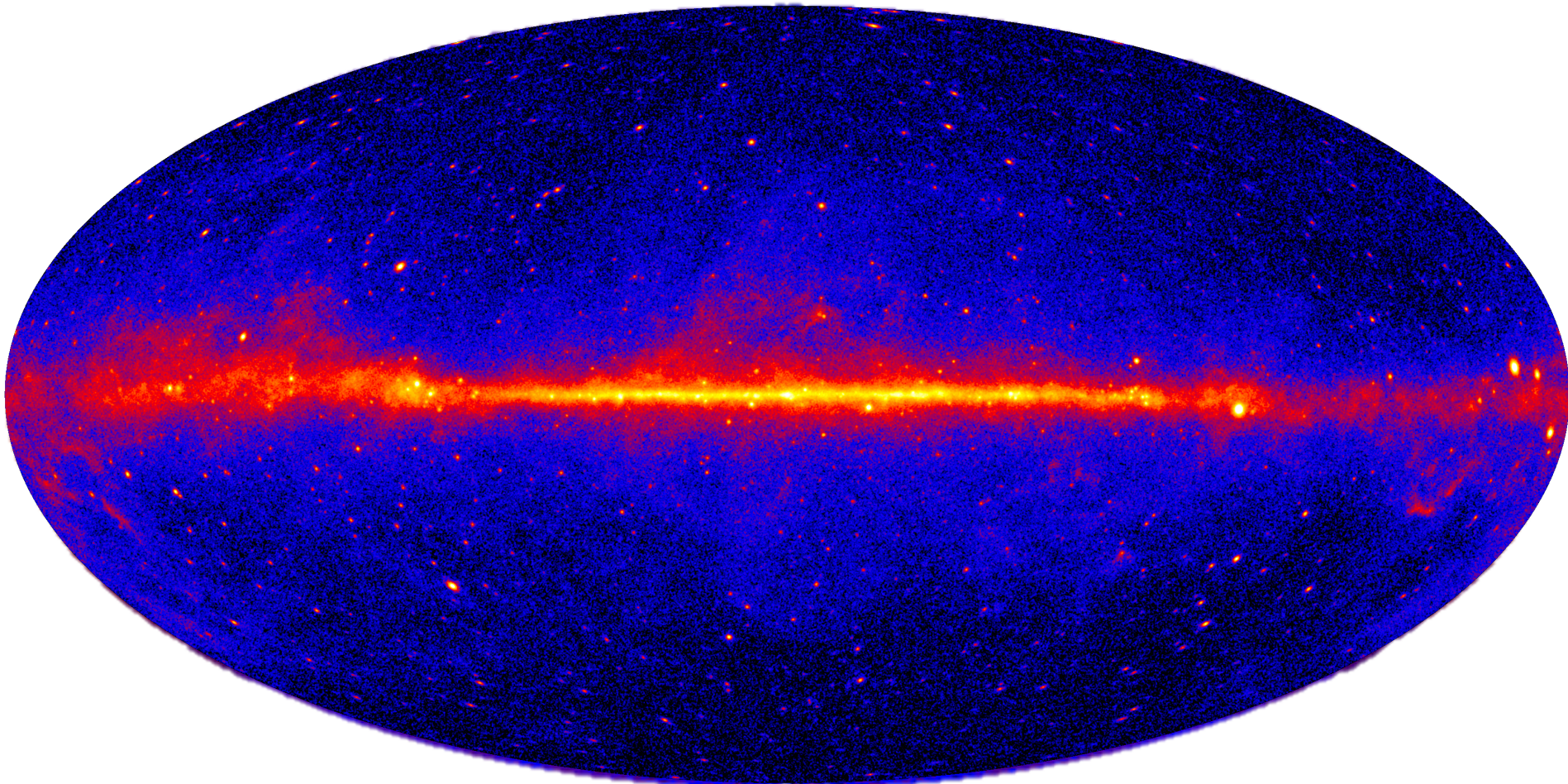
Atwood et al., ApJ 697, 1071, 2009



# The GeV sky



3 year LAT  $>1$  GeV map map



2FGL catalogue 1873 sources; Nolan et al., 2012, ApJS, 199, 31, arXiv:1108.1435



- Team of 'Flare Advocates'
- Daily analyse LAT data in 6hr and 24hr segments
- All sources flaring above  $1 \times 10^{-6}$  ph cm<sup>-2</sup> s<sup>-1</sup> are monitored and light curves released publicly; 89 sources at present
  - [http://fermi.gsfc.nasa.gov/ssc/data/access/lat/msl\\_lc/](http://fermi.gsfc.nasa.gov/ssc/data/access/lat/msl_lc/)

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- 186 ATels sent to date

## Fermi LAT Detection of a New Gamma-ray Transient in the Galactic Plane J0902-4624

ATel #3972; *[R. Ojha \(NASA/GSFC\)](#), [E. Hays \(NASA/GSFC\)](#), [C. C. Cheung \(NRC/NRL\)](#), [M. Dutka \(Catholic U.\)](#); on behalf of the *Fermi Large Area Telescope Collaboration*  
on 16 Mar 2012; 22:03 UT*

Distributed as an Instant Email Notice Transients  
Credential Certification: *Roopesh Ojha (Roopesh.Ojha@gmail.com)*

Subjects: Gamma Ray, >GeV, Request for Observations, Transient

Referred to by ATel #: [3973](#)

- Keep up to date with the Fermi Blog
  - <http://fermisky.blogspot.com/>



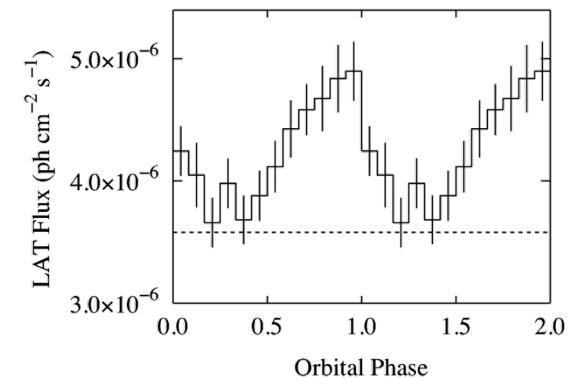
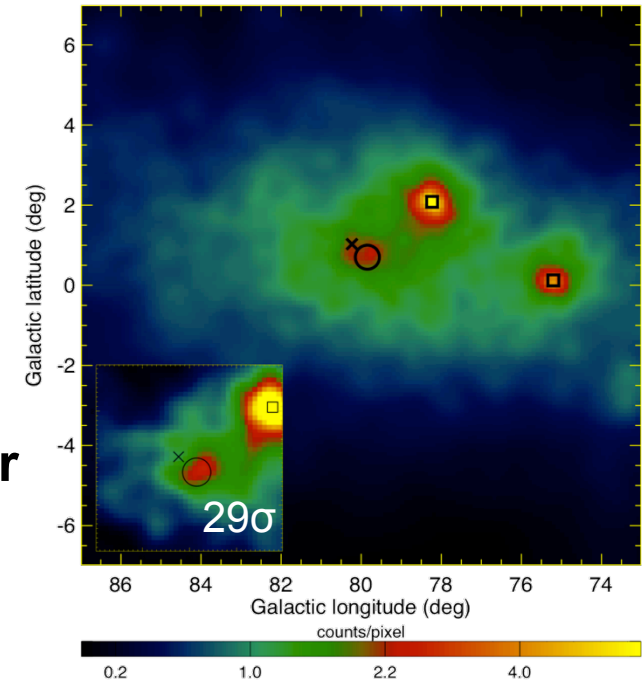
# Cyg X-3: a gamma-ray microquasar



- **HMXB; Wolf-Rayet companion; orbital period 4.8 hours**
- **Microquasar undergoing frequent radio outbursts associated with resolved relativistic jets**
- **Controversial HE past: claims of MeV-PeV emission in 70's & 80's; not confirmed later**
- **Fermi and AGILE report  $\gamma$ -ray emission concurrent with radio flares from Cyg X-3**
- **LAT detects modulation of the  $\gamma$ -ray flux on the 4.6 hour orbital period  $\rightarrow$  definitive ID**

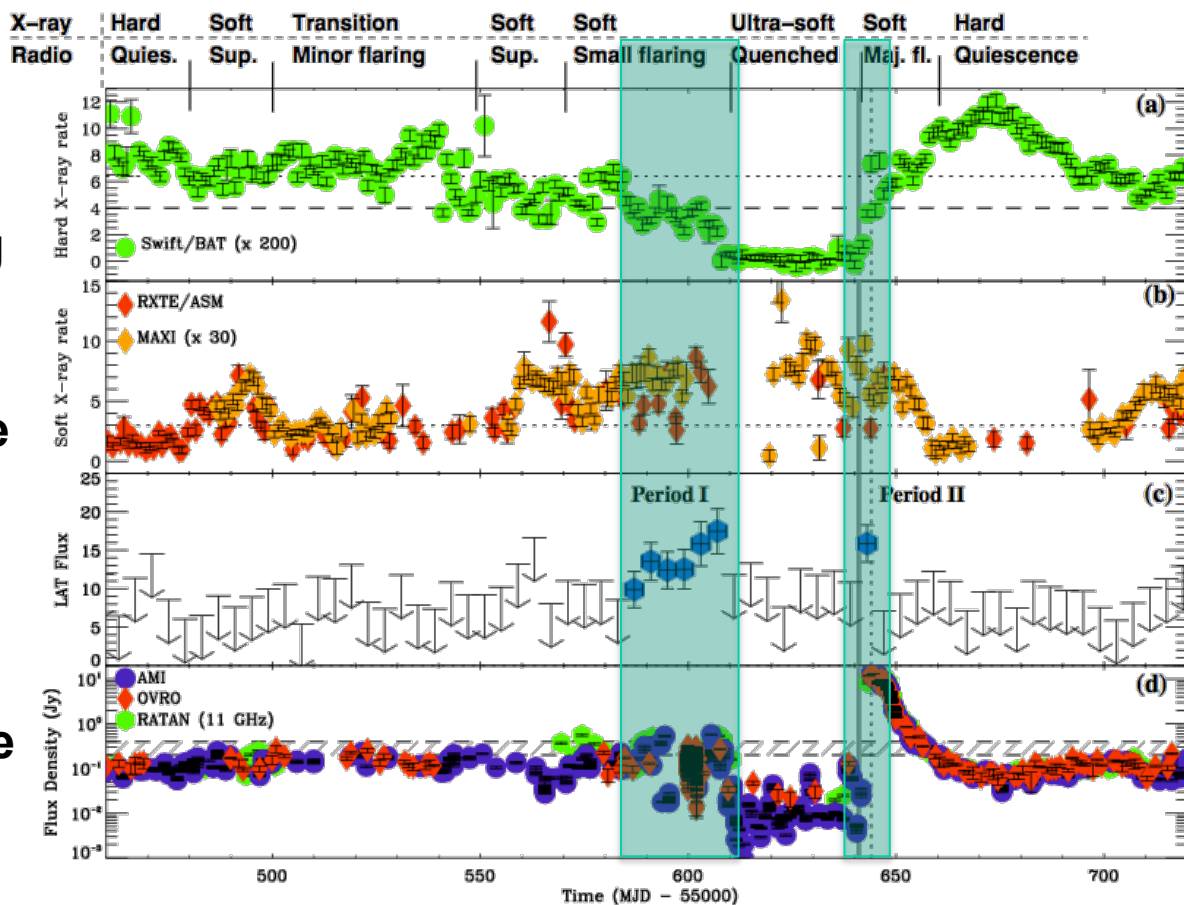
Fermi-LAT collaboration et al., 2009, *Science*, 326, 1512

Tavani et al., 2009, *Nature*, 462, 620





- 2008/9  $\gamma$ -ray emission coincident with 'soft' X-ray state & radio flares
- 2011 a giant radio flare was observed, following a quenched radio state
- $\gamma$  rays detected during onset of giant radio flare **AND** preceding the quenched state
- Connection between  $\gamma$ -ray and radio implies the emission is associated with the relativistic jet



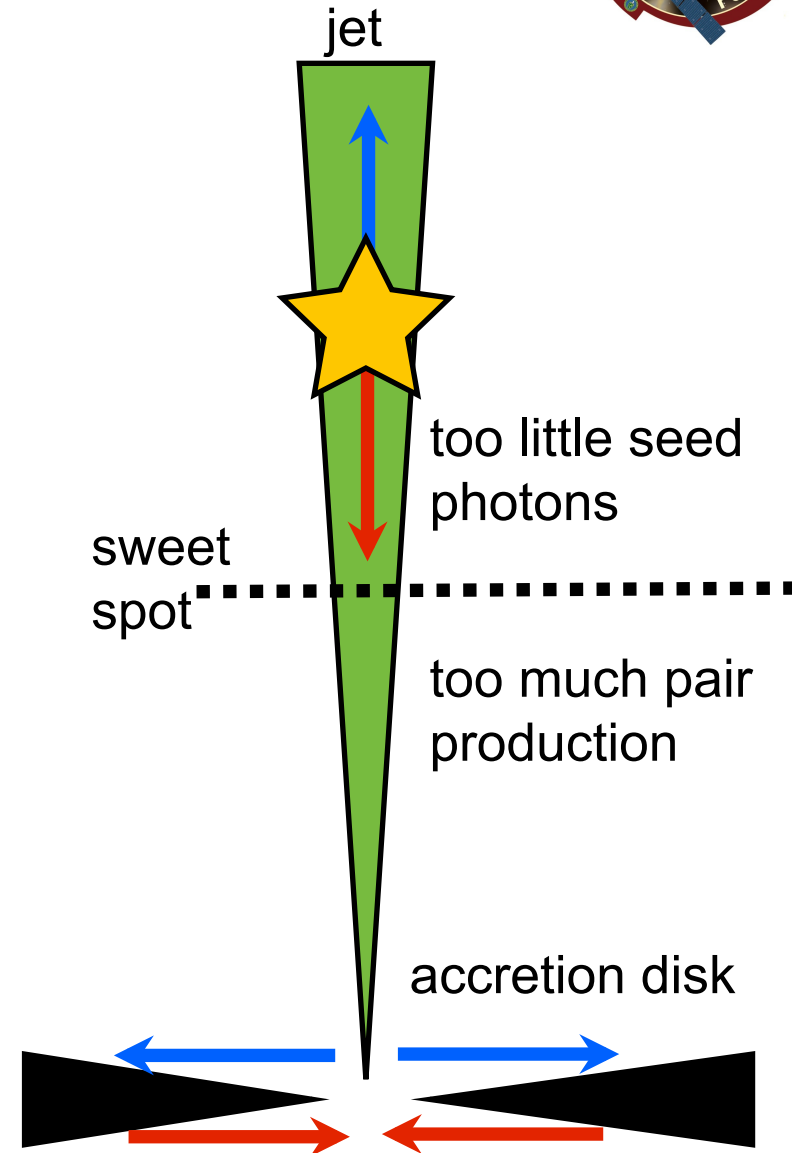
Corbel et al., 2012, MNRAS, *in press*  
arXiv:1201.3356



# Cyg X-3: Potential scenario



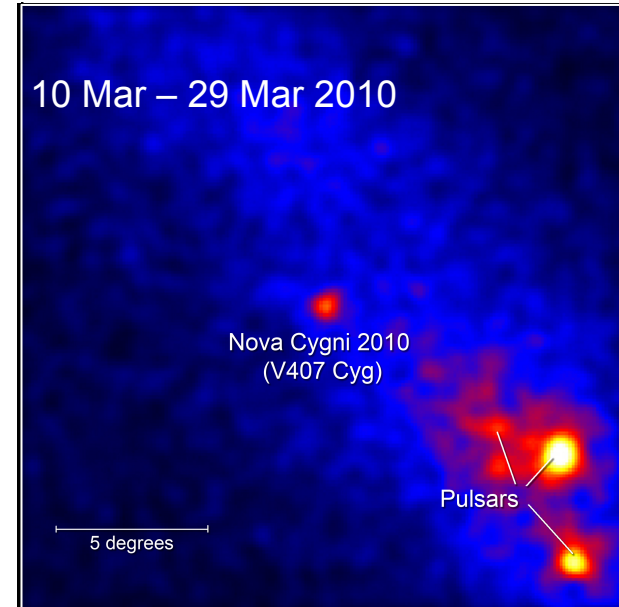
- Shock forms at various distances along the jet (e.g. Miller-Jones et al. 2009)
- Transition **IN/OUT** of the ultrasoft X-ray state coincident with **decrease/increase** in jet efficiency with non-thermal region moving **CLOSER/FURTHER** from the compact object
- $\gamma$ -ray emission is most efficient at “sweet spot” bounded by strong pair production on thermal X-rays and decreasing seed photon density for IC (Cerutti et al. 2011; Sitarek & Bednarek 2011)
- Detections before and after quenched state occur when shock moves through this region





- Flare advocates notice a new source in Cygnus region March 13-14; Atel #2487
- New 6-8 $\sigma$   $\gamma$ -ray source consistent with symbiotic binary V407 Cyg
- An optical nova from V407 Cyg had been discovered on March 10 by Nishiyama & Kabashima, IAUC 2199 (2010)
- Looking back LAT detected emission at onset of optical outburst at 5.7 $\sigma$
- >100 MeV emission detectable for 2 weeks with a peak flux of  $9 \times 10^{-7}$  ph  $\text{cm}^{-2} \text{s}^{-1}$

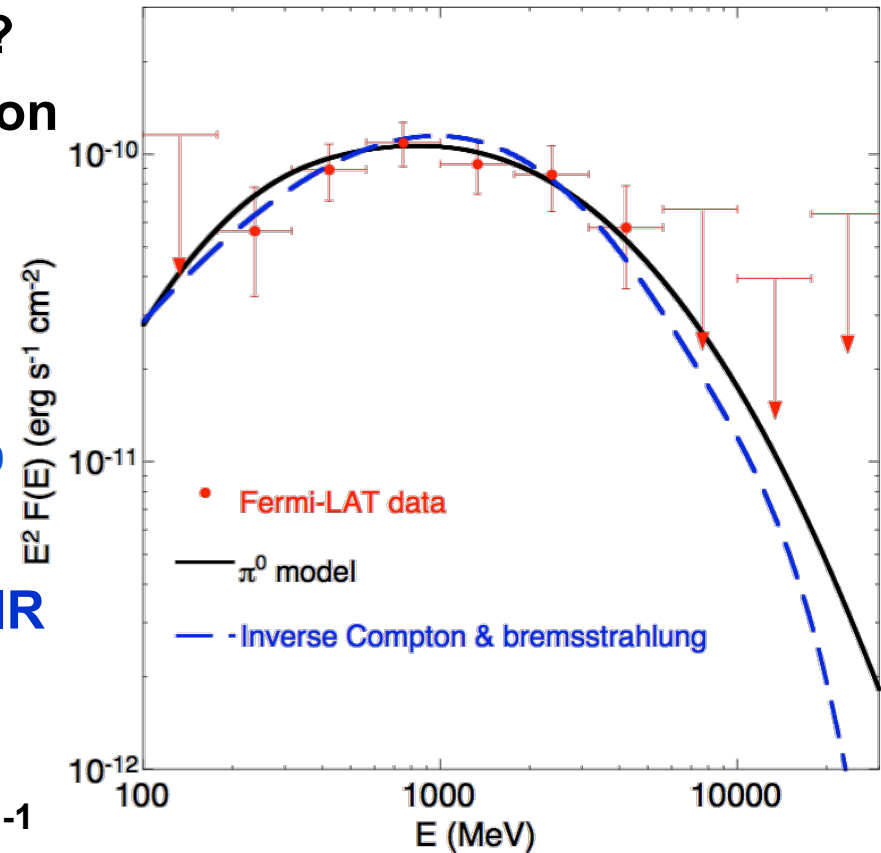
Abdo et al. 2010, Science, 329, 817  
arXiv:1008.3912



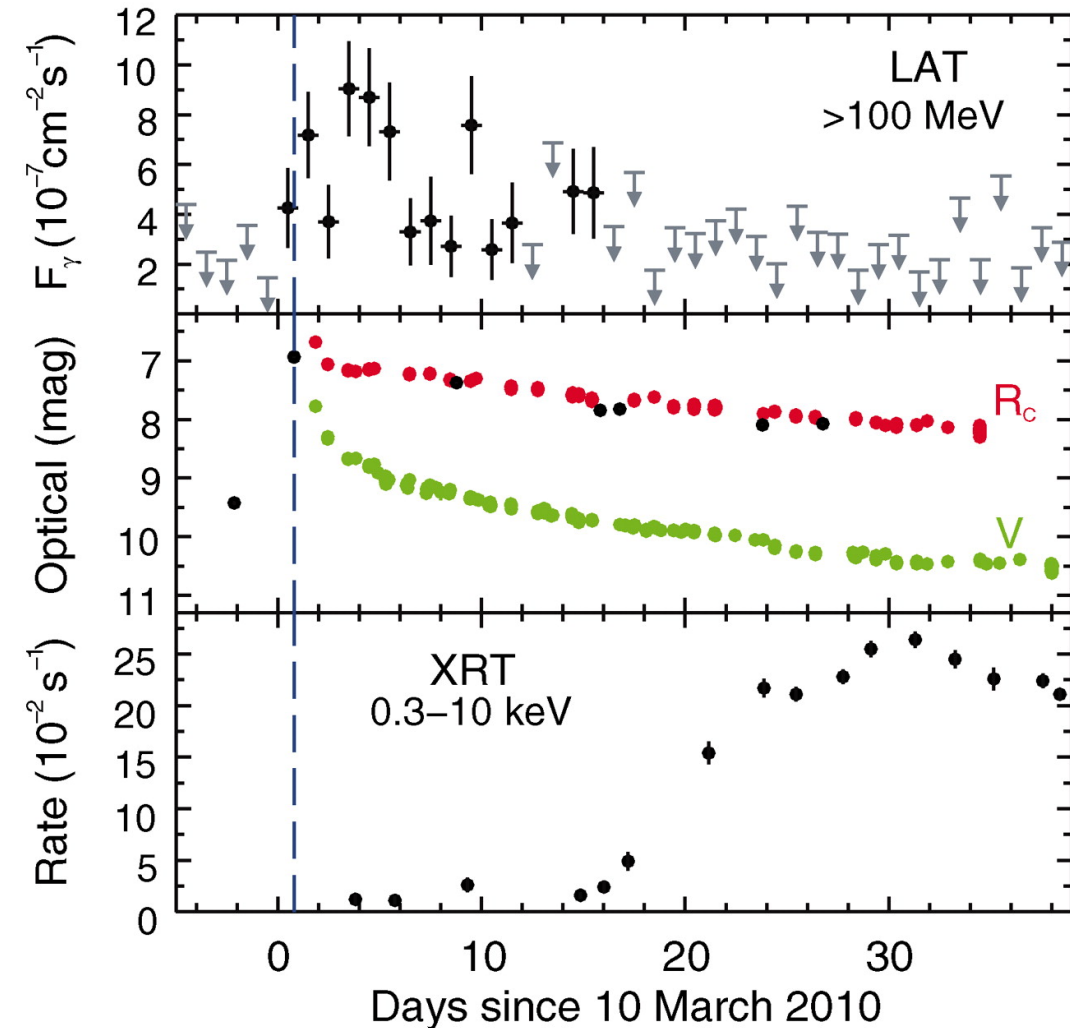




- How does a nova produce  $\gamma$ -rays?
- Novae line and continuum emission at  $<1\text{MeV}$  can't explain it.
- Shock acceleration in the nova shell would be expected.
- Two production channels:
  - Pions:  $p$  collisions produce  $\pi^0$  which decay producing  $\gamma$
  - Inverse compton:  $e$  upscatter IR photons from red giant
- KE of shell  $\sim 10^{44}$  erg  $s^{-1}$
- Total energy in  $\gamma$ -rays,  $\sim 10^{41}$  erg  $s^{-1}$
- Total energy of protons(electrons) gone into producing  $\gamma$ -rays is  $\sim 9\%$  ( $\sim 0.4\%$ ) of KE

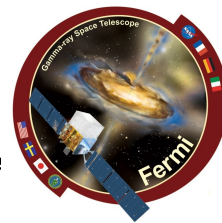


# V407 Cyg: Multi-wavelength monitoring



- First see the optical emission peak from a steep rise.
- **Thermonuclear blast produces prompt optical emission**
- **$\gamma$ -rays detected coincident with optical emission, peaking 3-4 days later**
- **Nova shell decelerates quickly in direction of RG;  $\gamma$ -rays peak early when IC and  $\pi^0$  favoured**
- **X-rays peak 30 days after onset**
- **Prompt X-ray emission produced by shocked gas; rising flux produced by ejecta reaching the base of RG photosphere (Nelson et al. 2012)**
- **MW behaviour explained by system geometry**





- **Transient activity is being detected from Galactic sources**
- **Two new GeV source classes have been identified:**
  - **Microquasars;  $\gamma$ -rays from jet emission**
  - **Novae;  $\gamma$ -rays from Fermi acceleration in nova shell**
- **Local sites of particle acceleration**
  
- **Where are all the other microquasars? Is Cyg X-3 a special case?**
- **Is the V407 Cyg emission dominated by hadronic or leptonic processes?**
- **Similar symbiotic binaries known, but do they have the right environment to produce  $\gamma$ -rays?**
- **What else is out there?**

**Keep watching the skies!**