

Variable galactic γ -ray sources

Guillaume Dubus

with many thanks to Fermi/LAT collaboration



Fermi Symposium 2011, Rome
Institut de Planétologie et d'Astrophysique de Grenoble

Variable galactic γ -ray sources

[pulsars]

gamma-ray binaries: spectrum of LS sources, lightcurve of PSR B1259-63

unidentified transients in the Galactic Plane

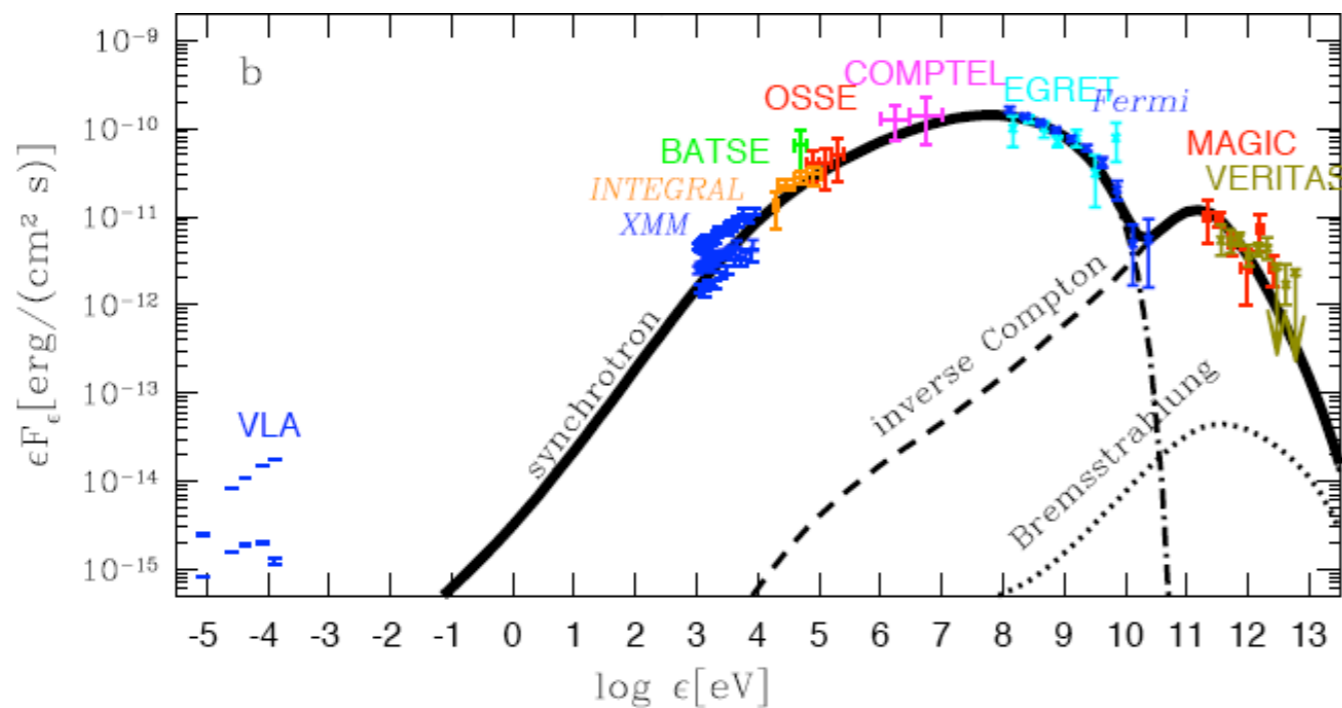
microquasars: Cygnus X-3 flares

novae: Symbiotic V407 Cyg

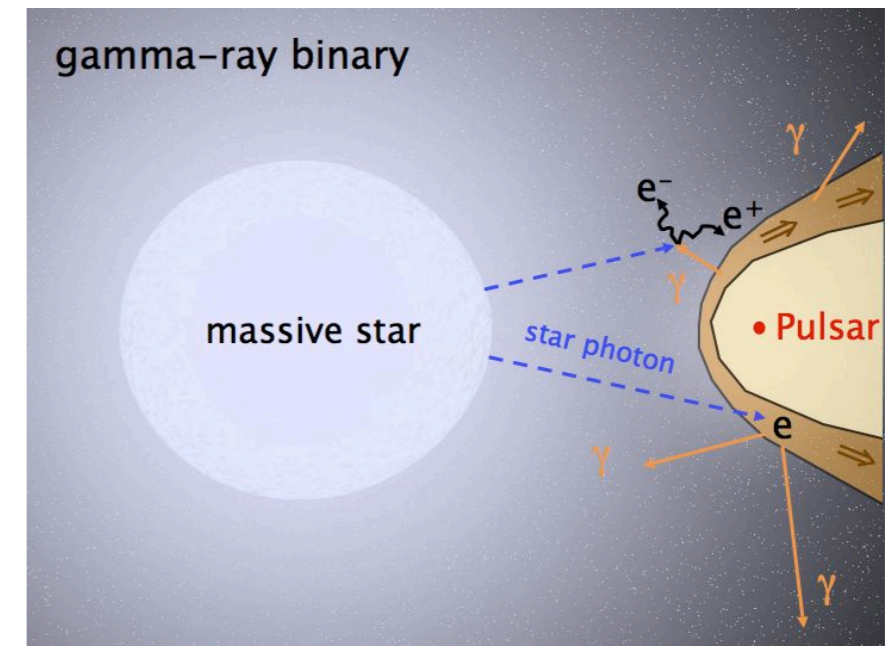
colliding wind binaries: eta Carina ?

Gamma-ray binaries

- interacting massive star + compact object
- **dominant gamma-ray emission**
- **likely pulsar winds in binaries**

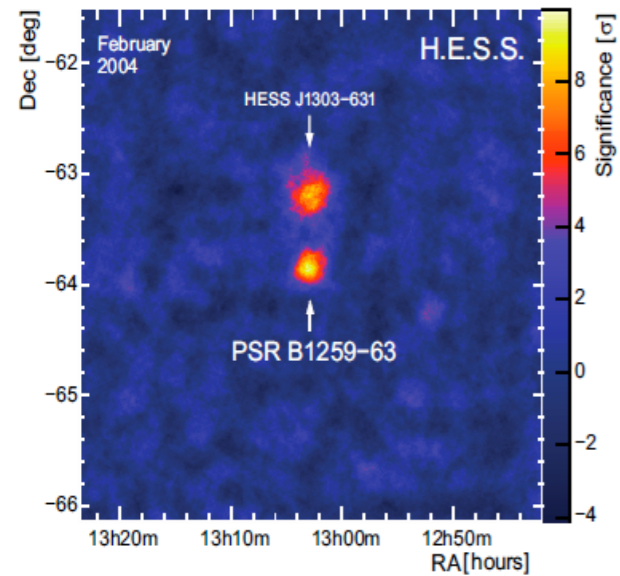


LS I +61°303 spectral energy distribution (Zdziarski et al. 2009)

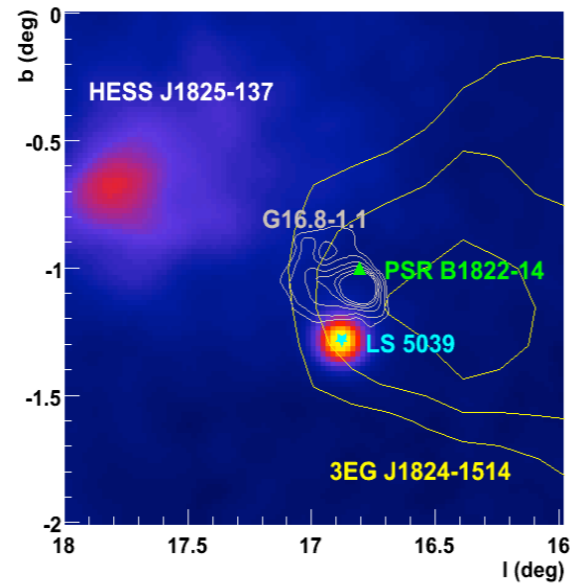


Gamma-ray binaries

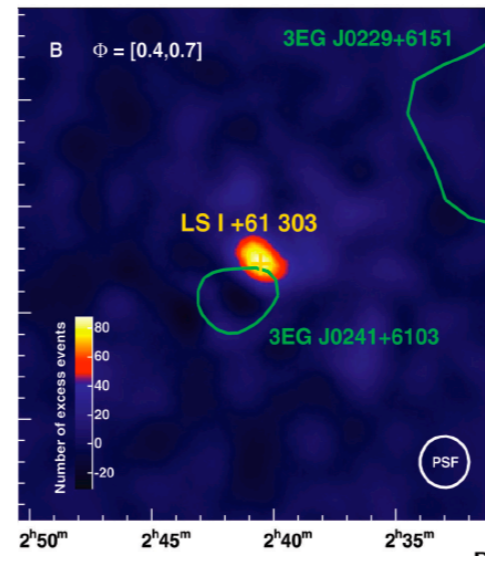
PSR B1259-63



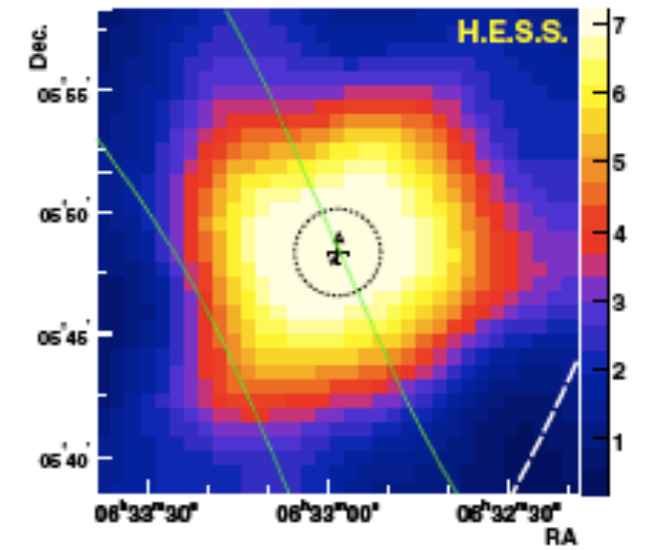
LS 5039



LS I+61 303



HESS J0632+057



PSR J1023+0038

detection at periastron

→ A. Abdo

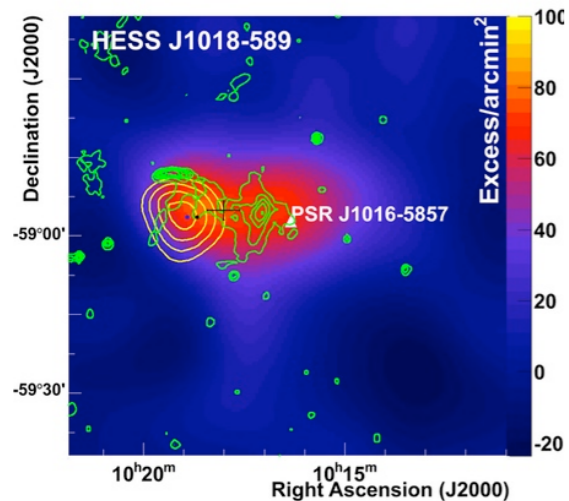
GeV modulation, spectrum, variability

→ D. Hadasch

**X-ray, TeV modulation found
no GeV reported**

Bongiorno et al. 2011 Acciari et al. 2011

1FGL J1018.6-5856

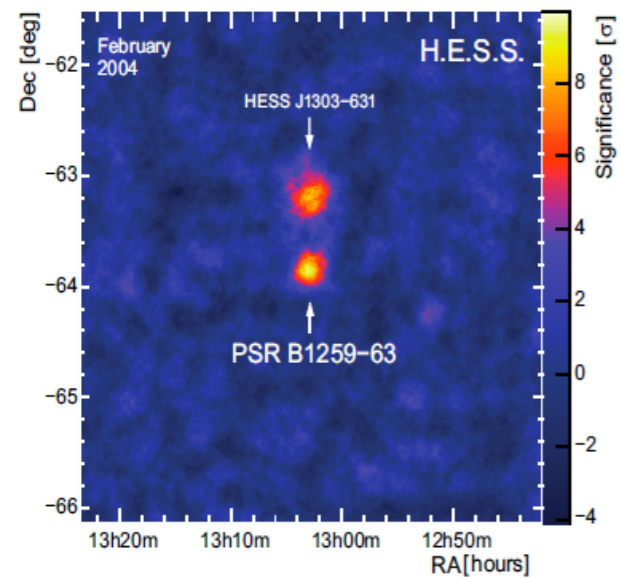


new γ -ray binary

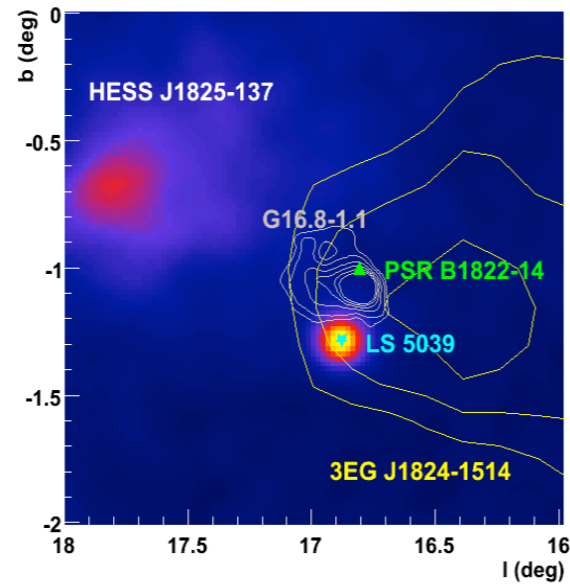
→ R. Corbet

Gamma-ray binaries

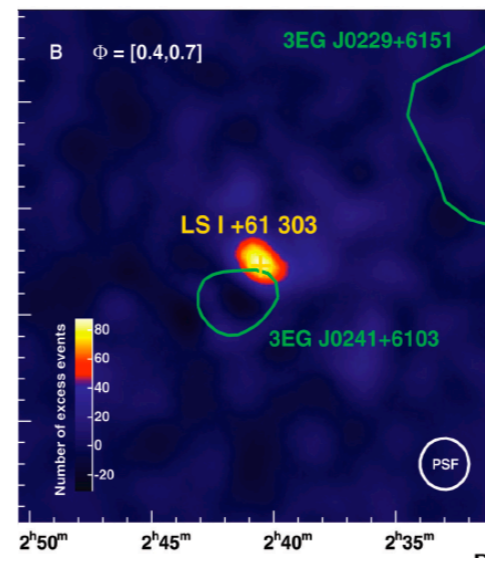
PSR B1259-63



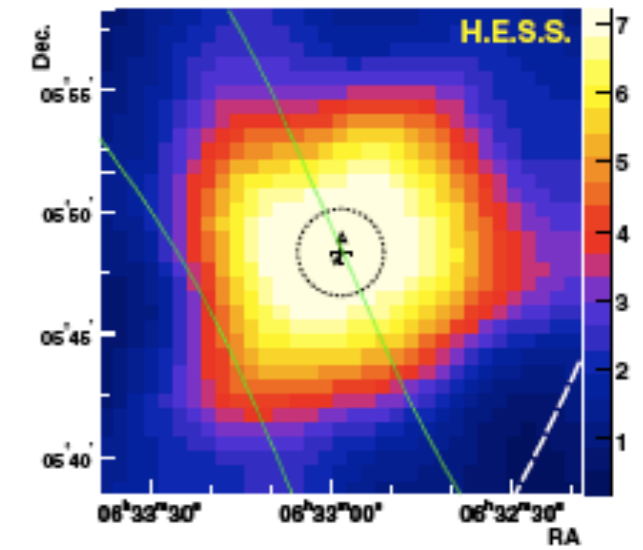
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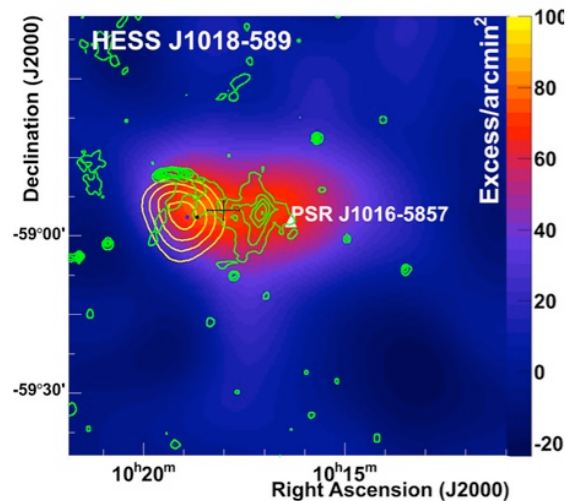
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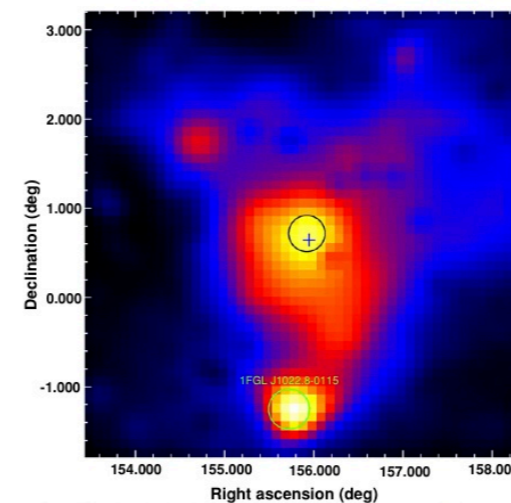
1FGL J1018.6-5856



new γ -ray binary

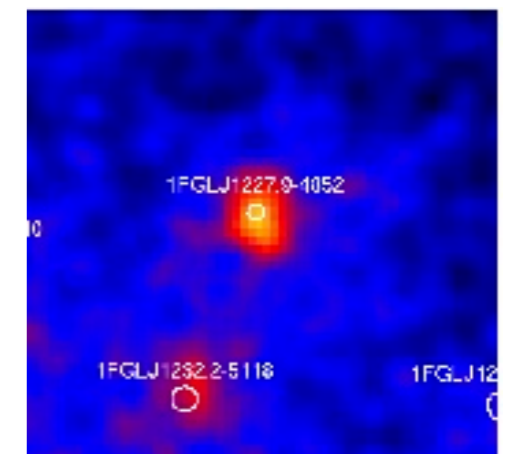
→ **R. Corbet**

PSR J1023+0038 ?



Tam et al. 2010

XSS J12270-4859 ?

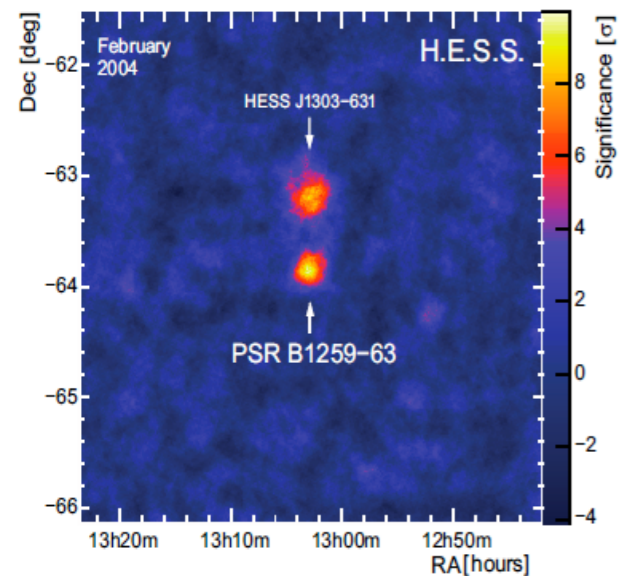


Hill et al. 2011

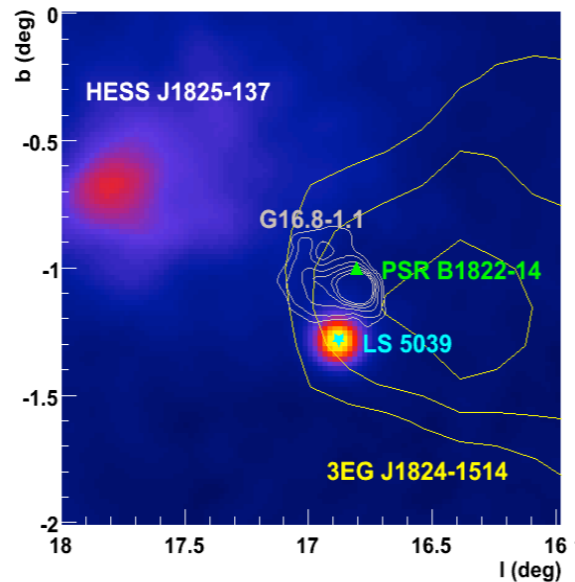
low mass γ -ray binaries ?

Gamma-ray binaries

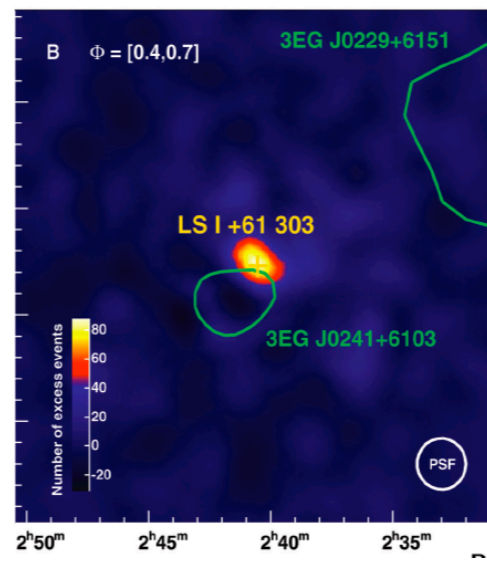
PSR B1259-63



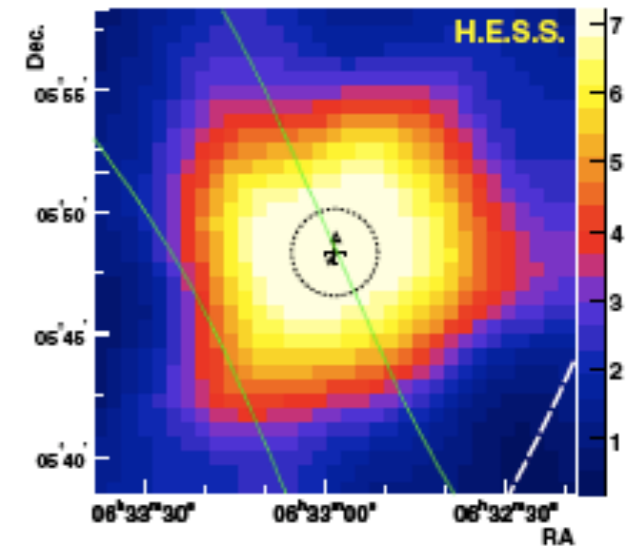
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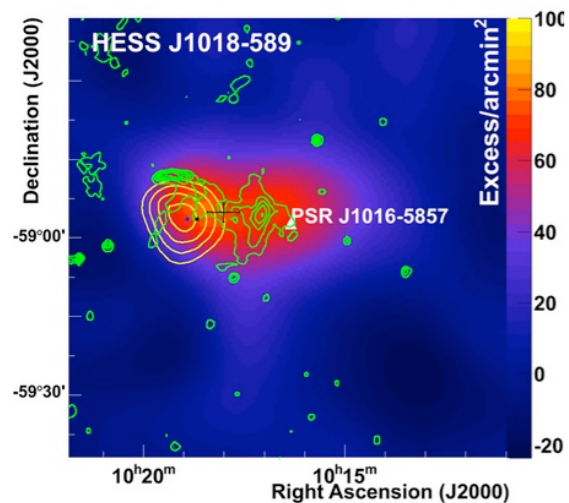
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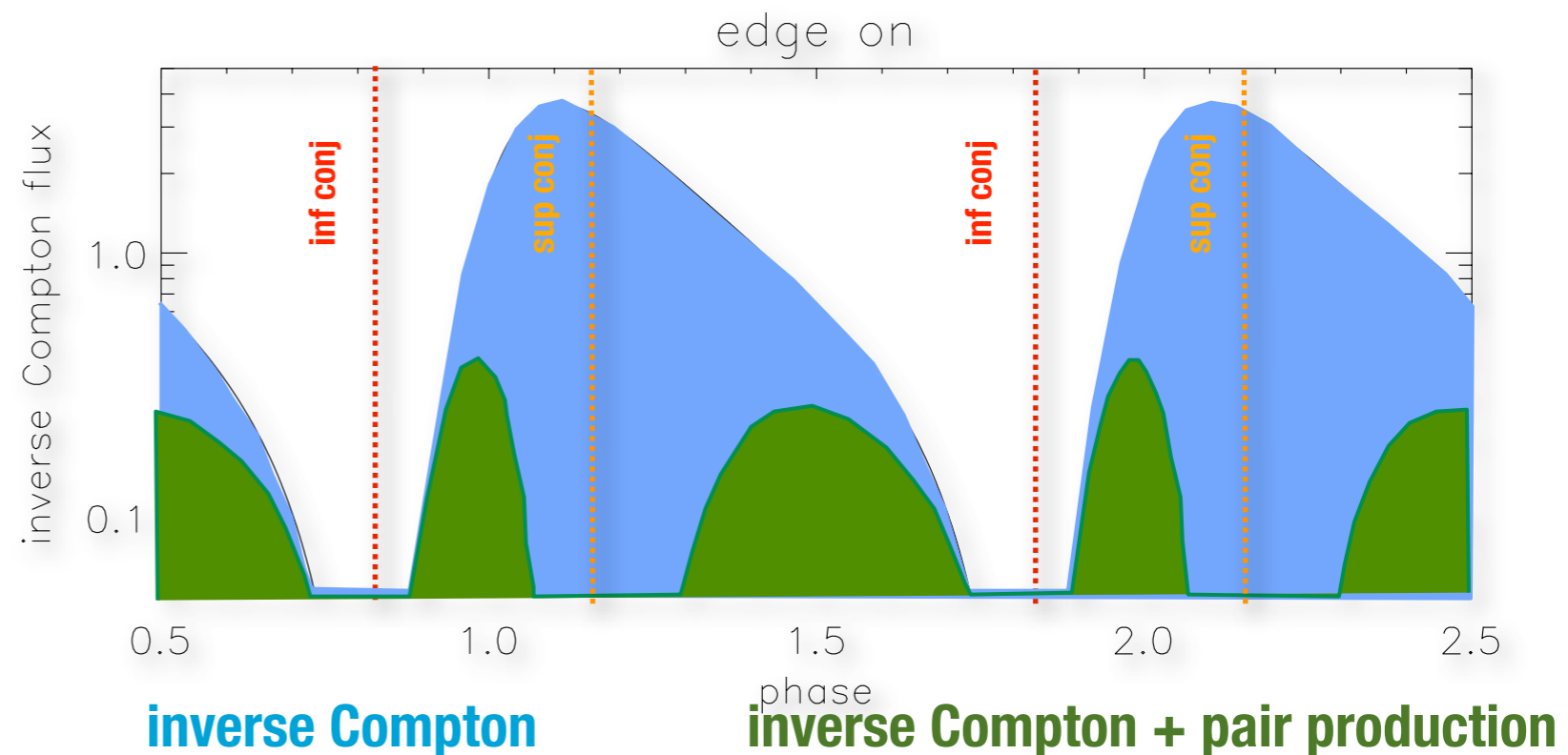
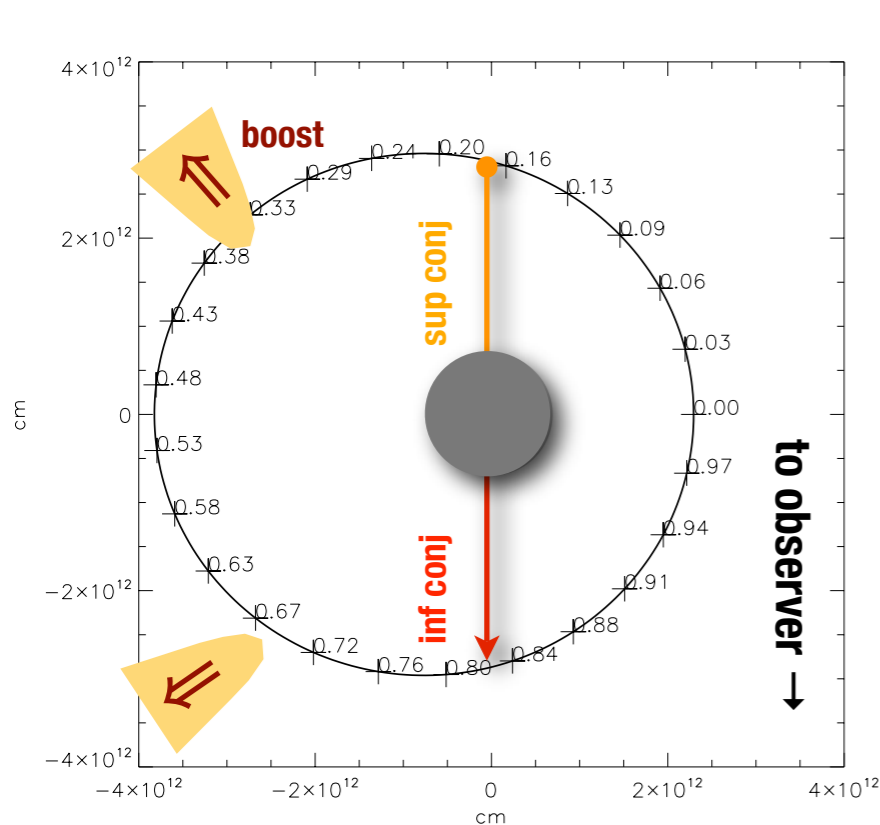
new γ -ray binary

→ R. Corbet

key: orbital modulations

Orbital modulations

- Anisotropic inverse Compton on star photons
- Pair production on star photons
- Doppler boost [if bulk relativistic motion]

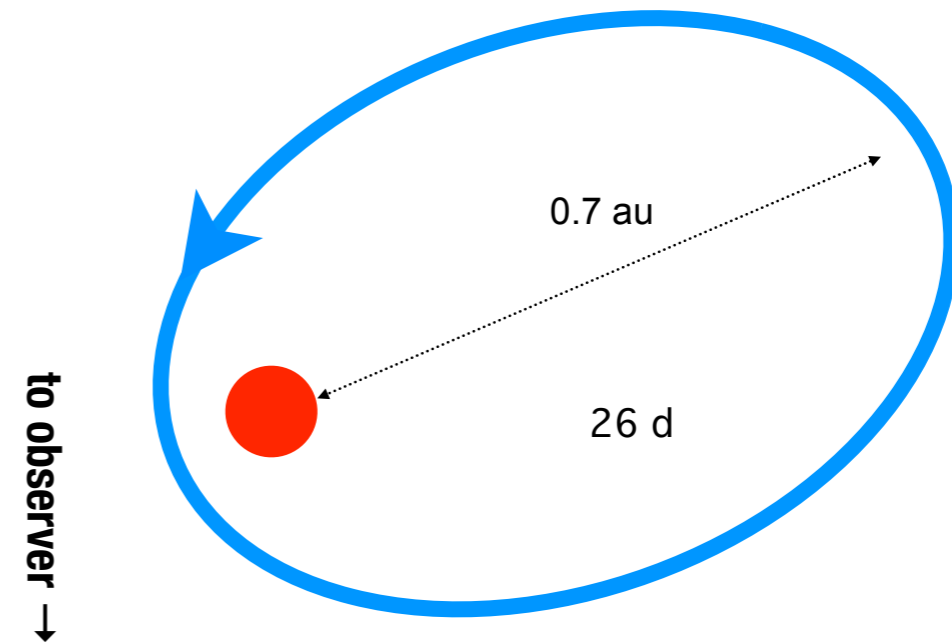
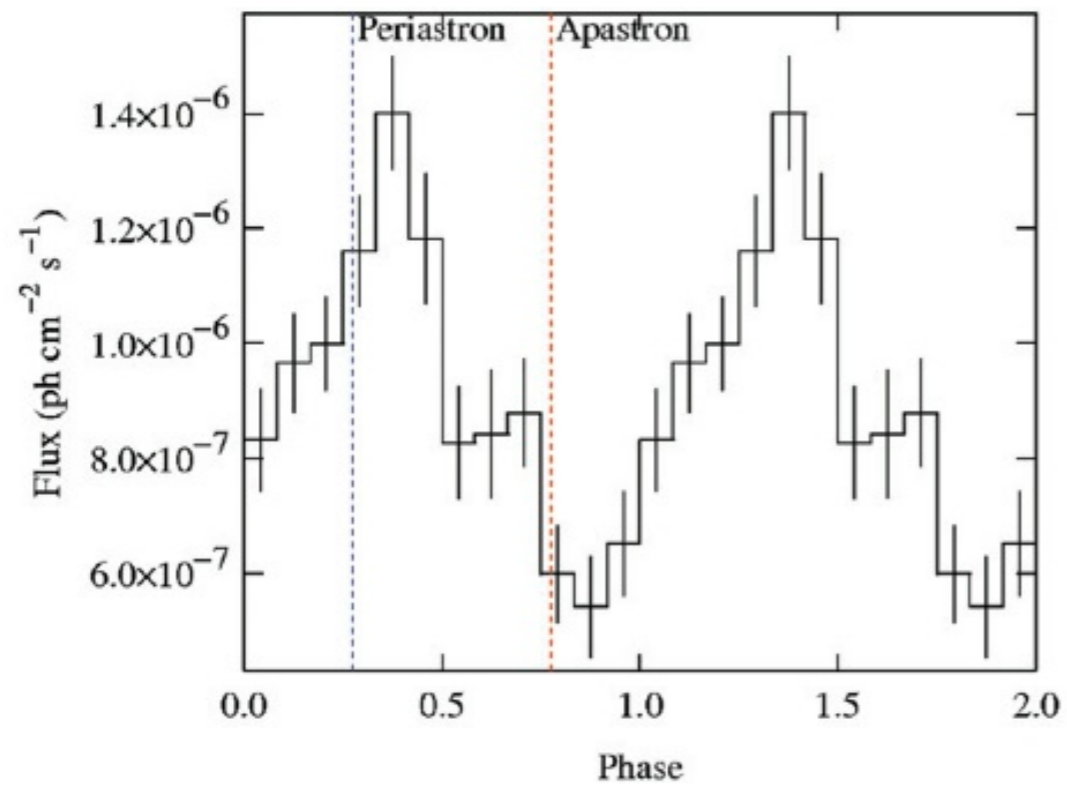


- identify emission mechanism
- distinguish variability in phys. conditions from var. due to observer geometry

LS I+61°303

→ D. Hadasch

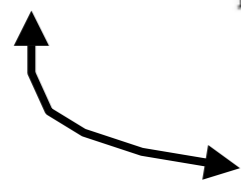
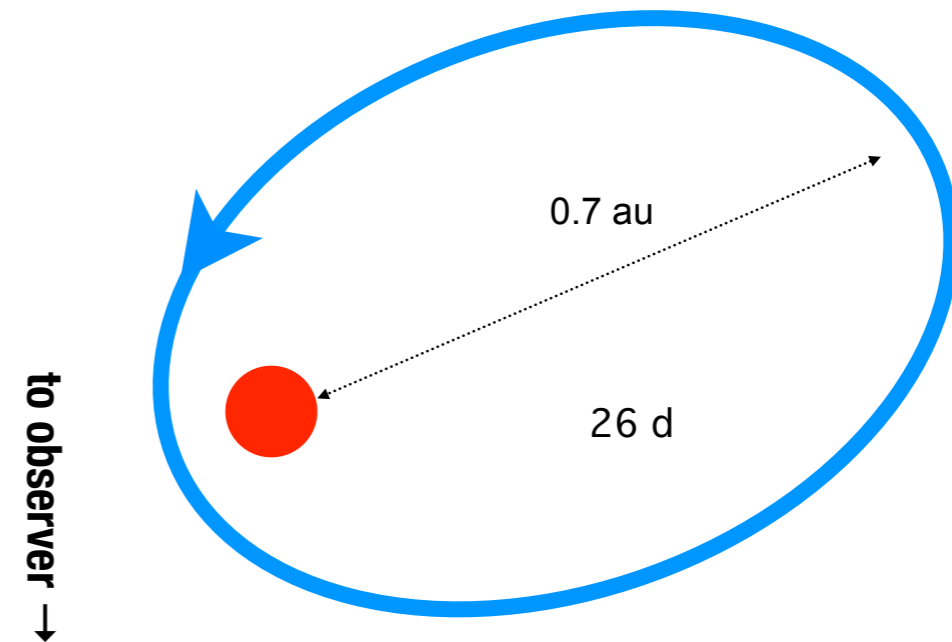
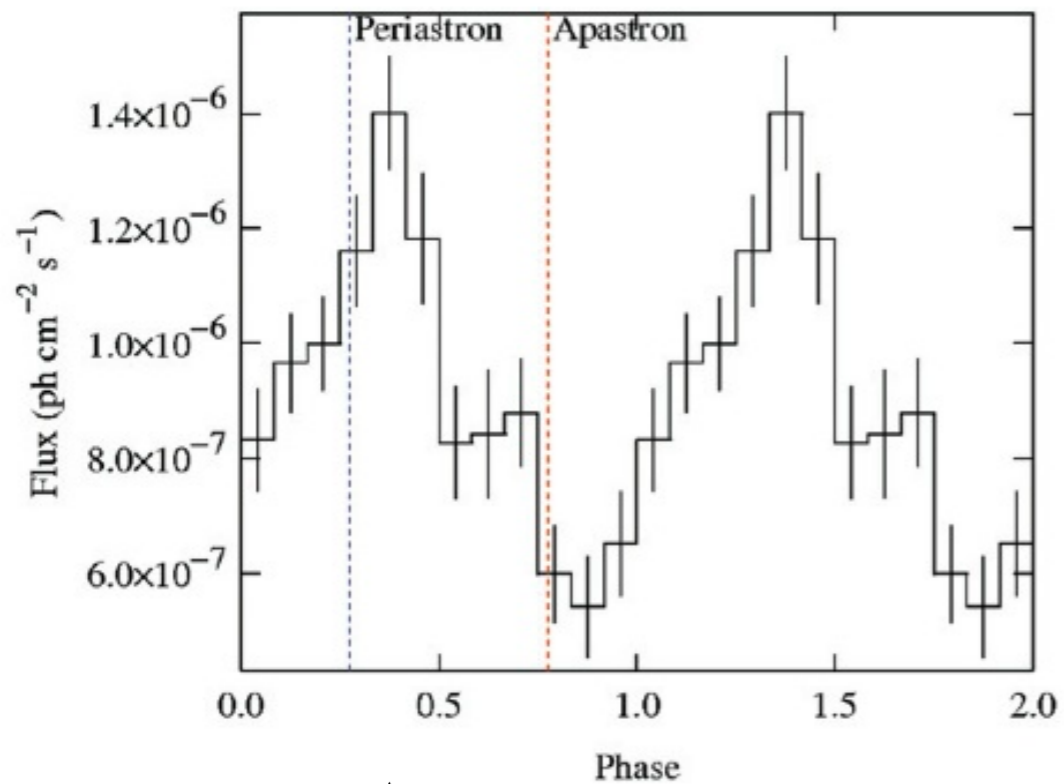
- modulations suggest inverse Compton



LS I+61°303

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- modulations suggest inverse Compton

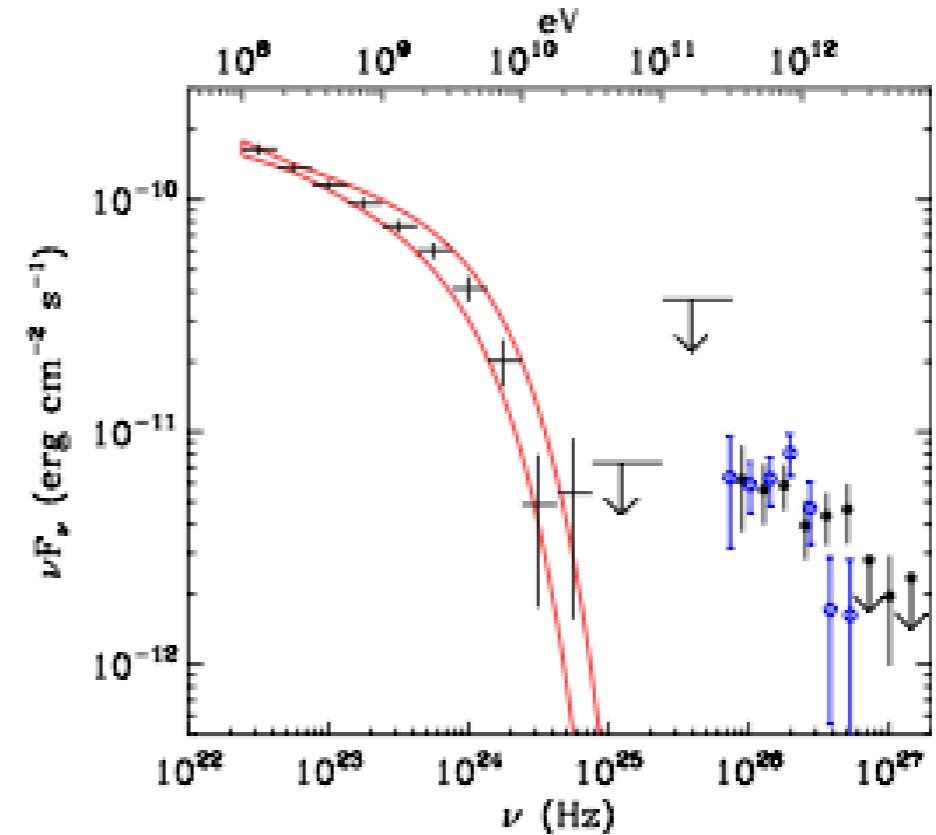
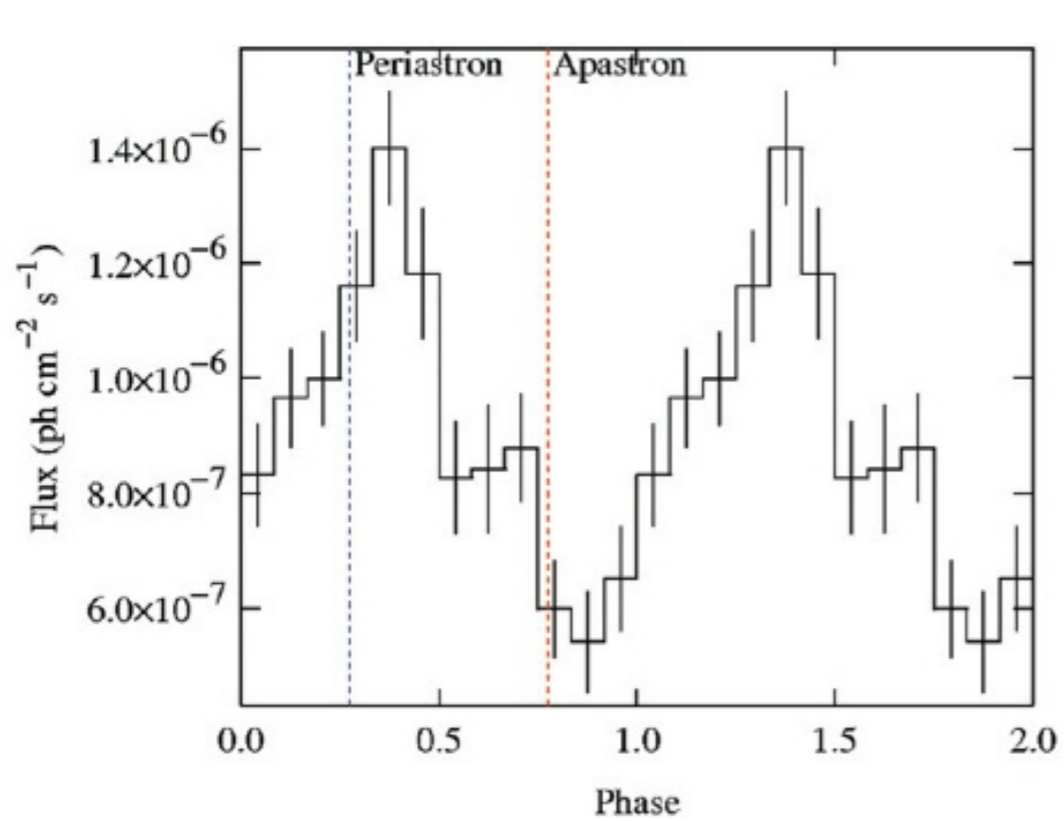


HE peak offset from IC expectations
HE modulation absent recently
VHE peak phase varies

LS I+61°303

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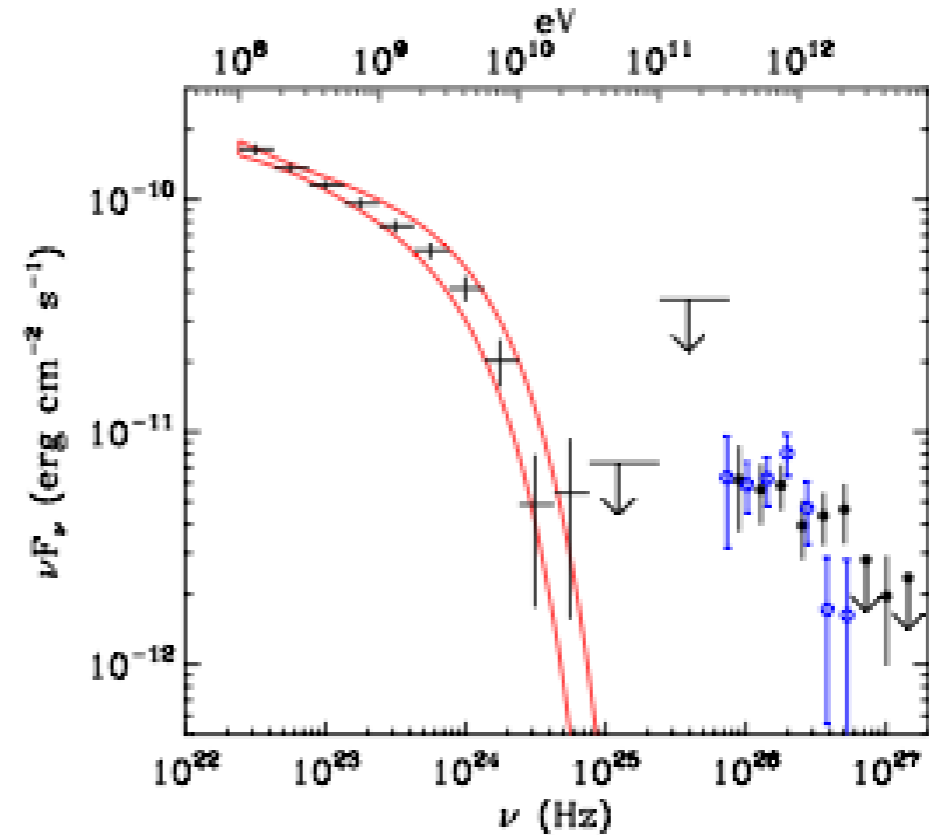
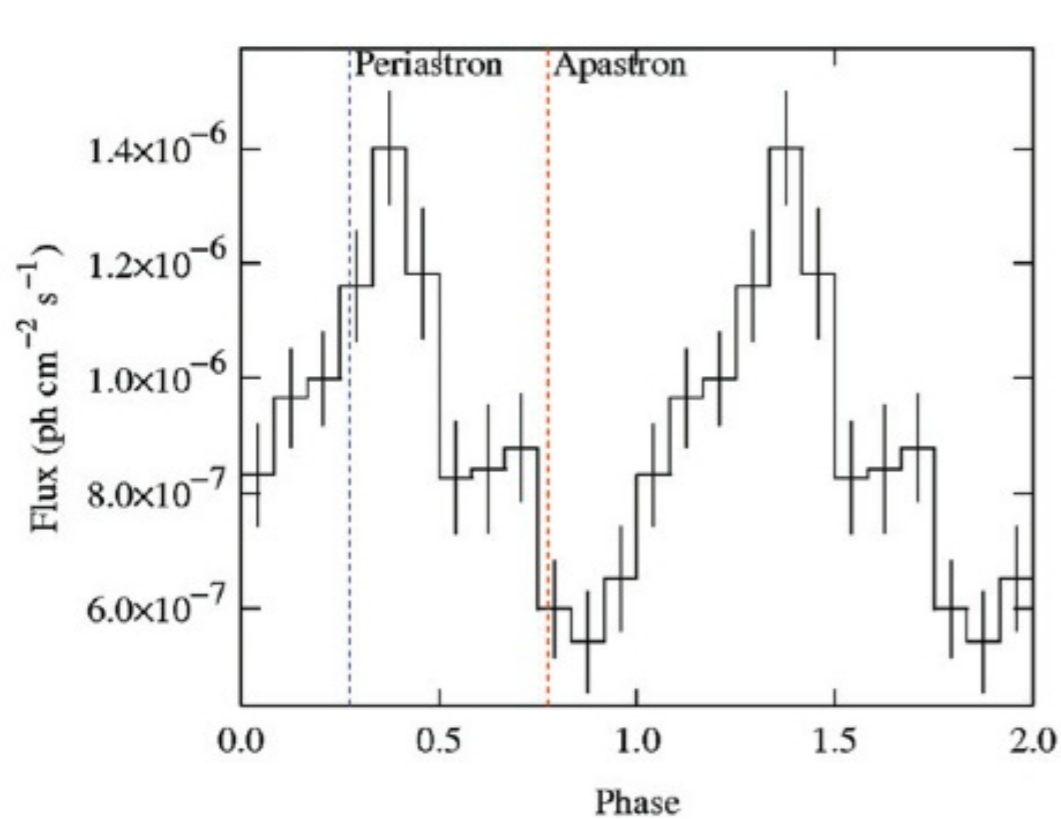
- modulations suggest inverse Compton
- spectrum suggests two populations of HE particles



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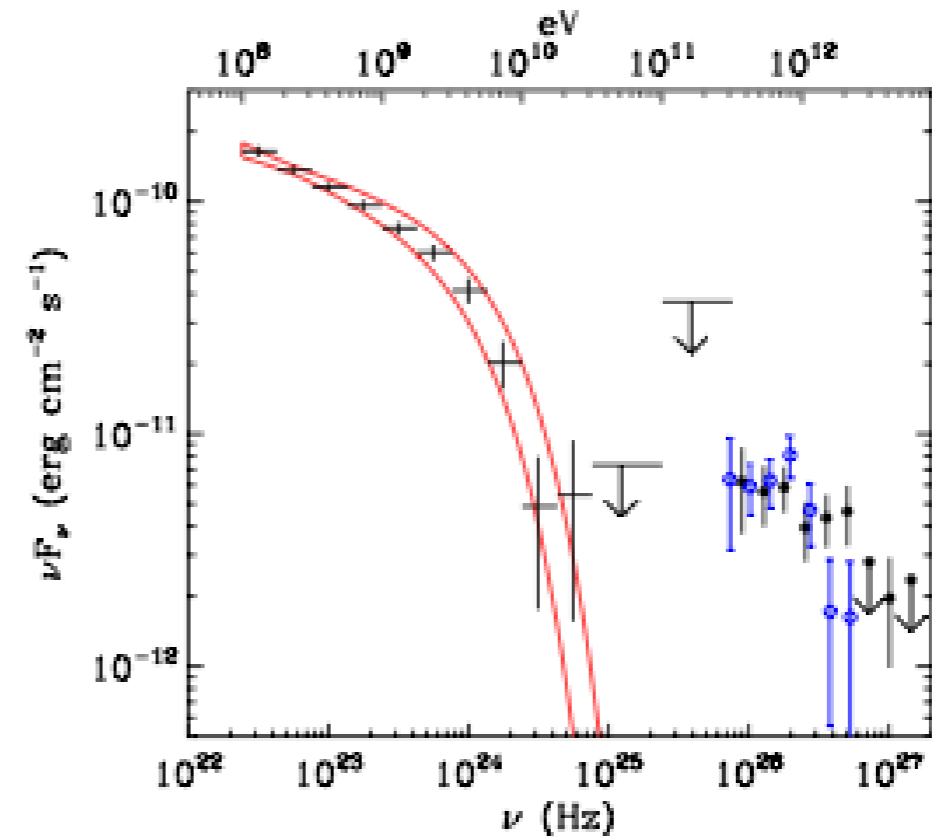
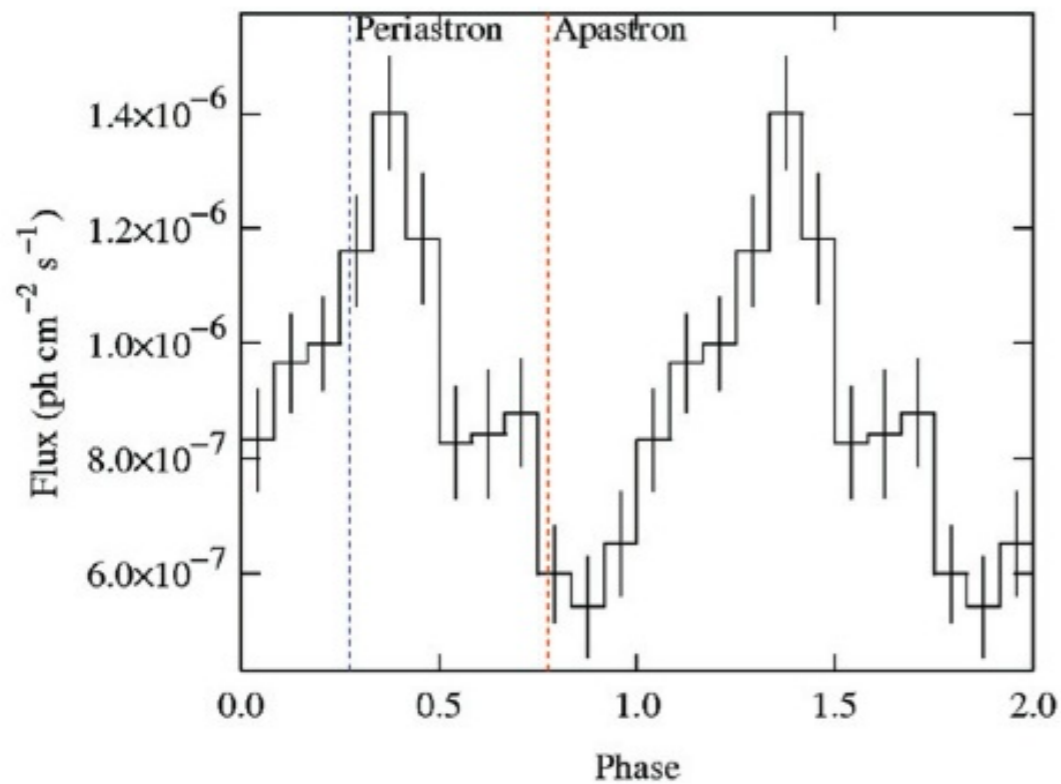
pulsar magnetospheric emission pulsar wind nebula

(but modulation, variability ??)

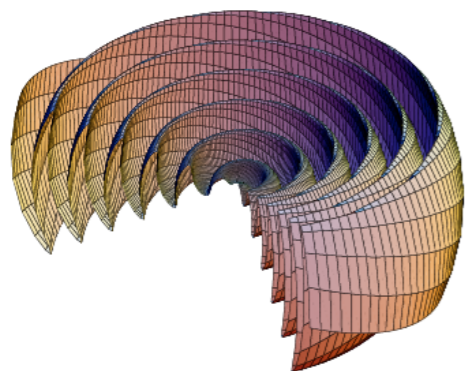
LS I+61°303

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- modulations suggest inverse Compton
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LS I+61 303 (Abdo et al. 2009)



striped pulsar wind emission ?

(Pétri & GD 2011)

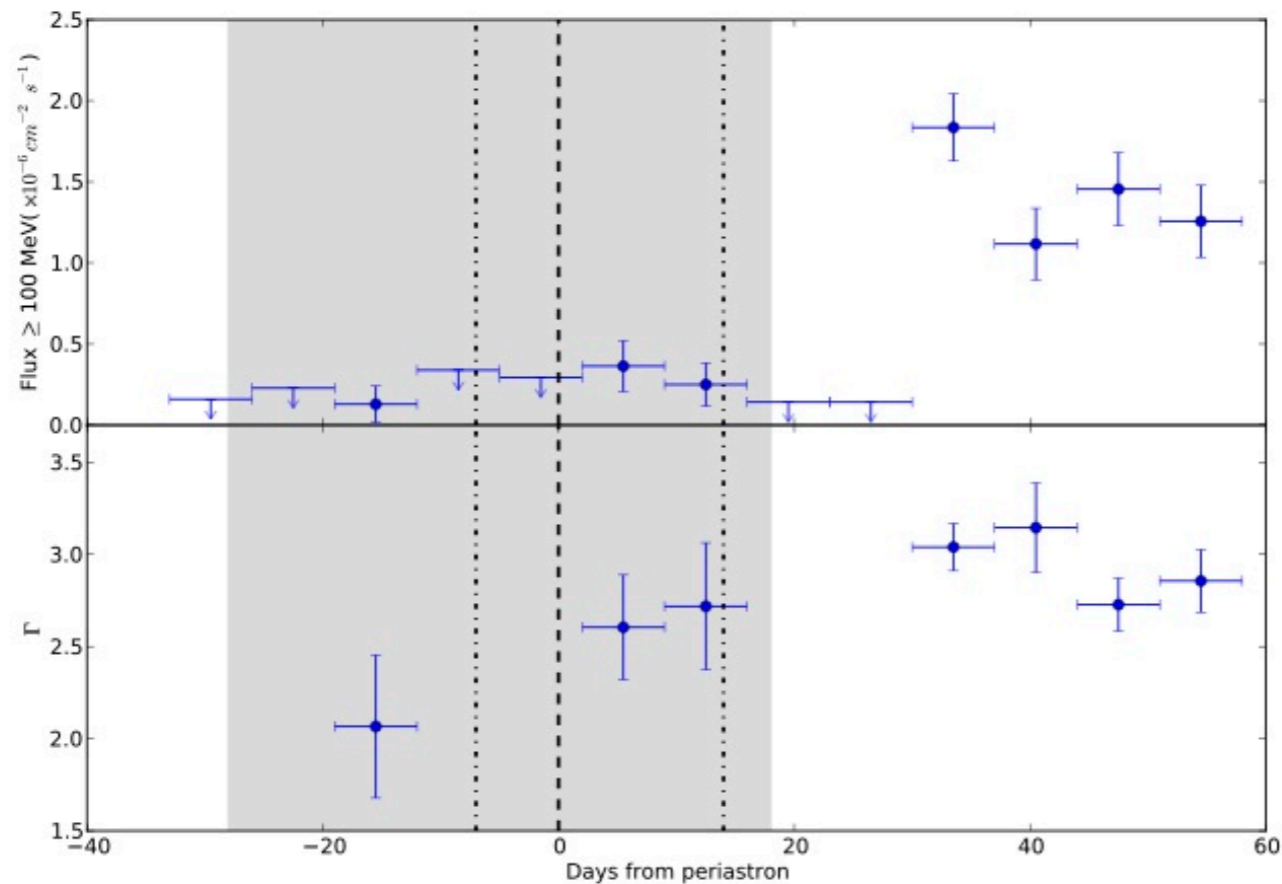
pulsar magnetospheric emission ?? **pulsar wind nebula**

Fig: Kirk et al.

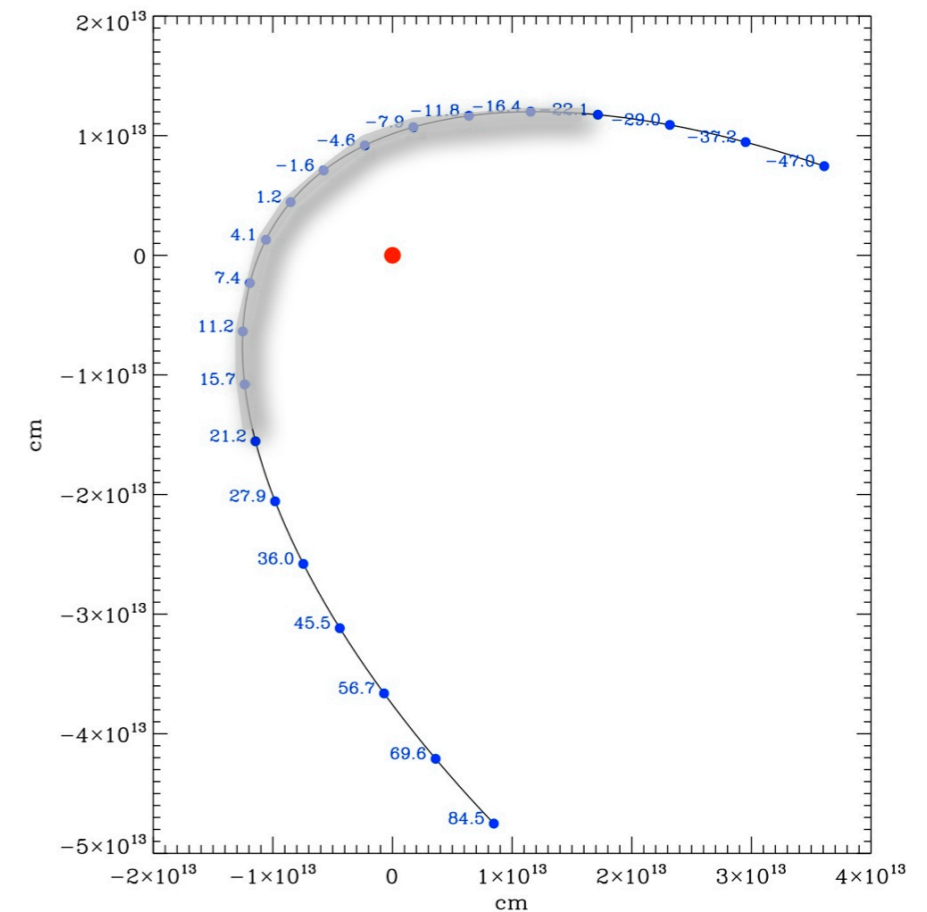
PSR B1259-63

→ A. Abdo

Fermi/LAT lightcurve (Abdo et al. 2011)



orbit close to periastron

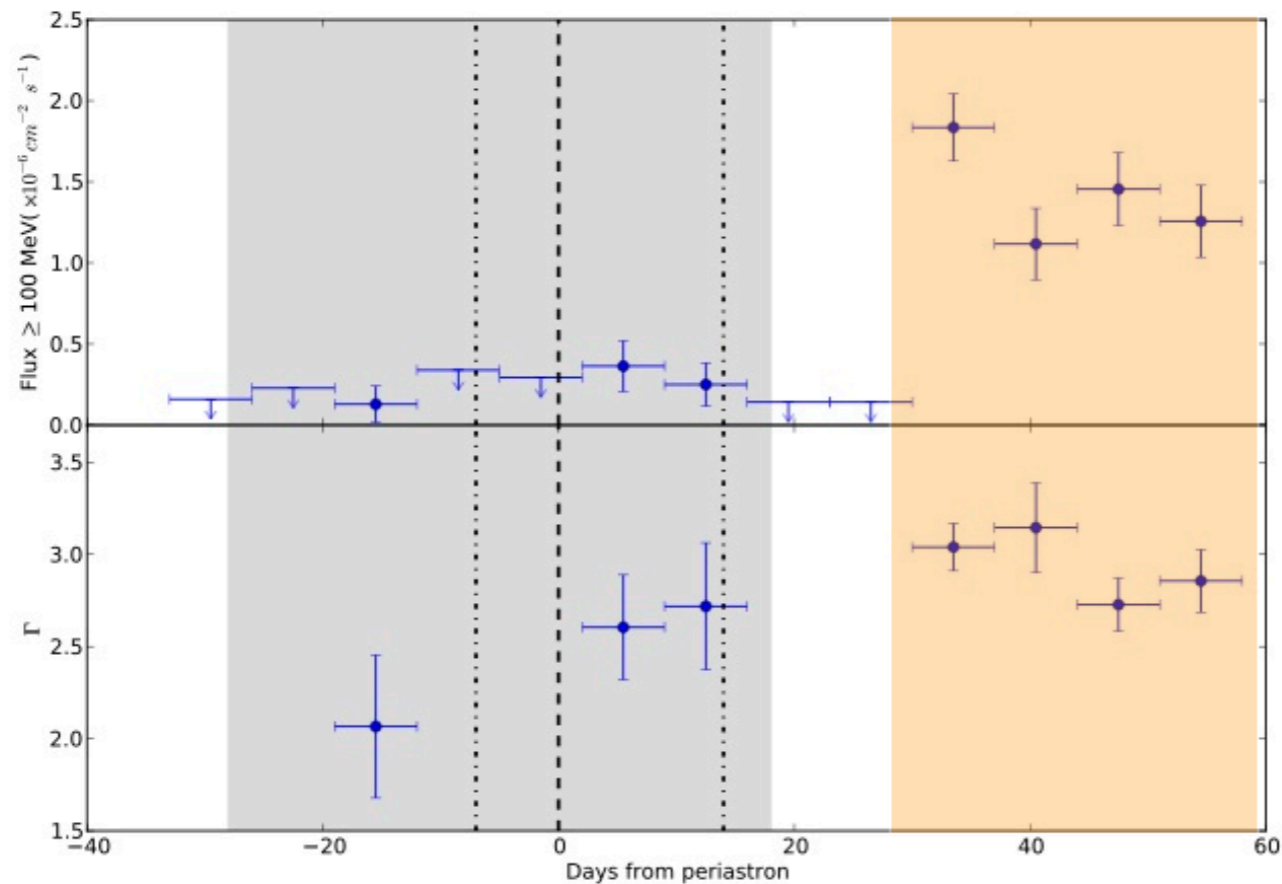


- 10^{36} erg/s spindown pulsar in 3.5 year orbit around Be star
- Fermi/LAT detection at periastron mid-December 2010

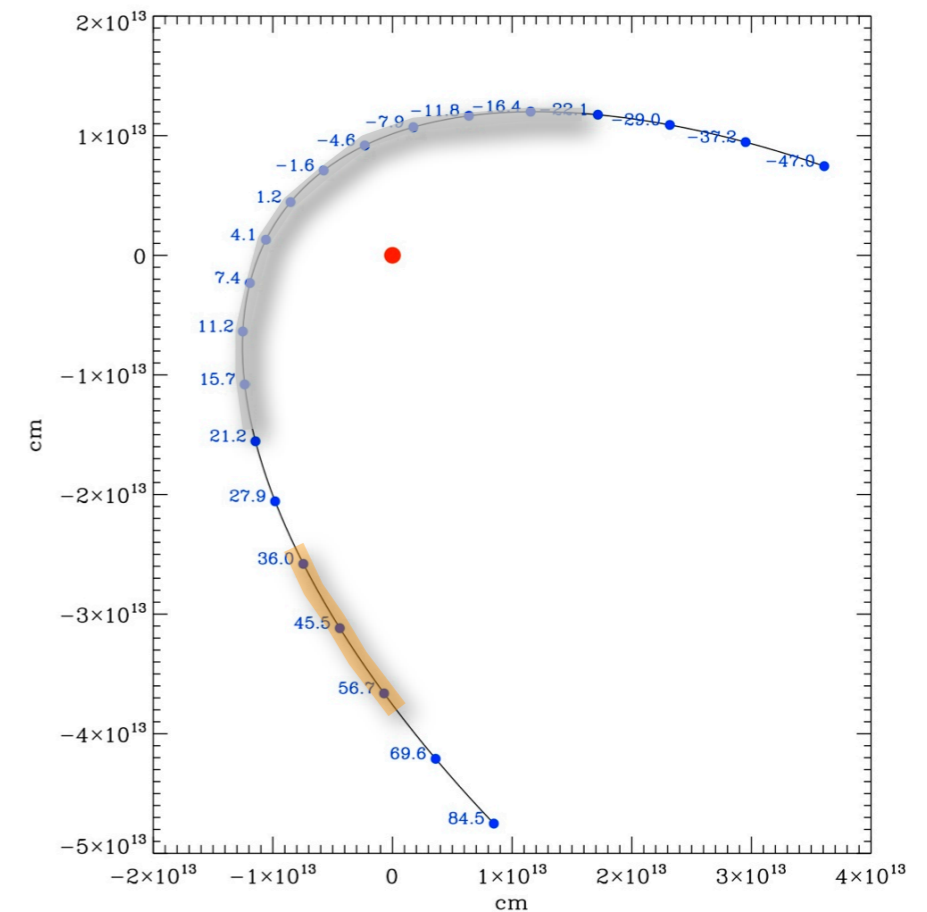
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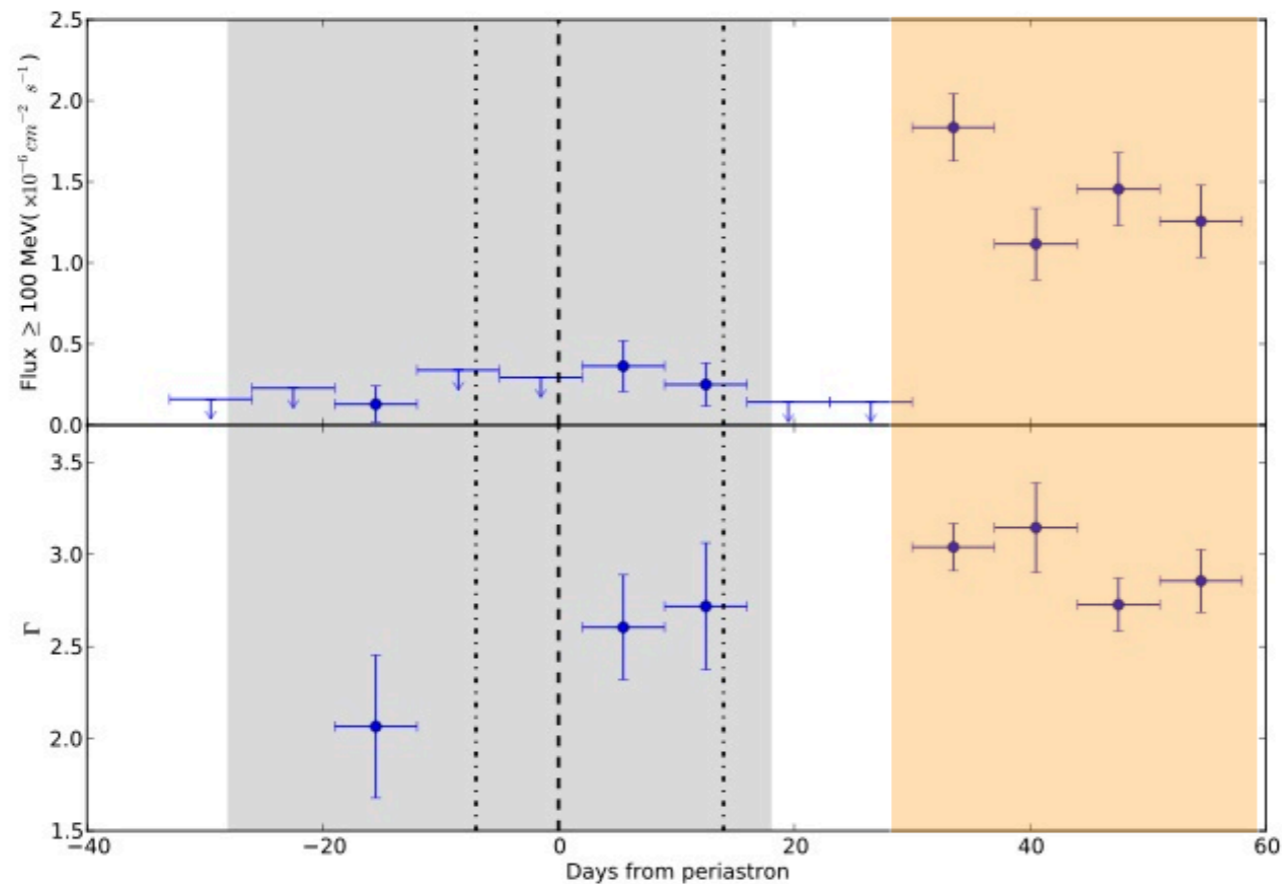


- 10^{36} erg/s spindown pulsar in 3.5 year orbit around Be star
- Fermi/LAT detection at periastron mid-December 2010
- brighter in February (near inf. conjunction)

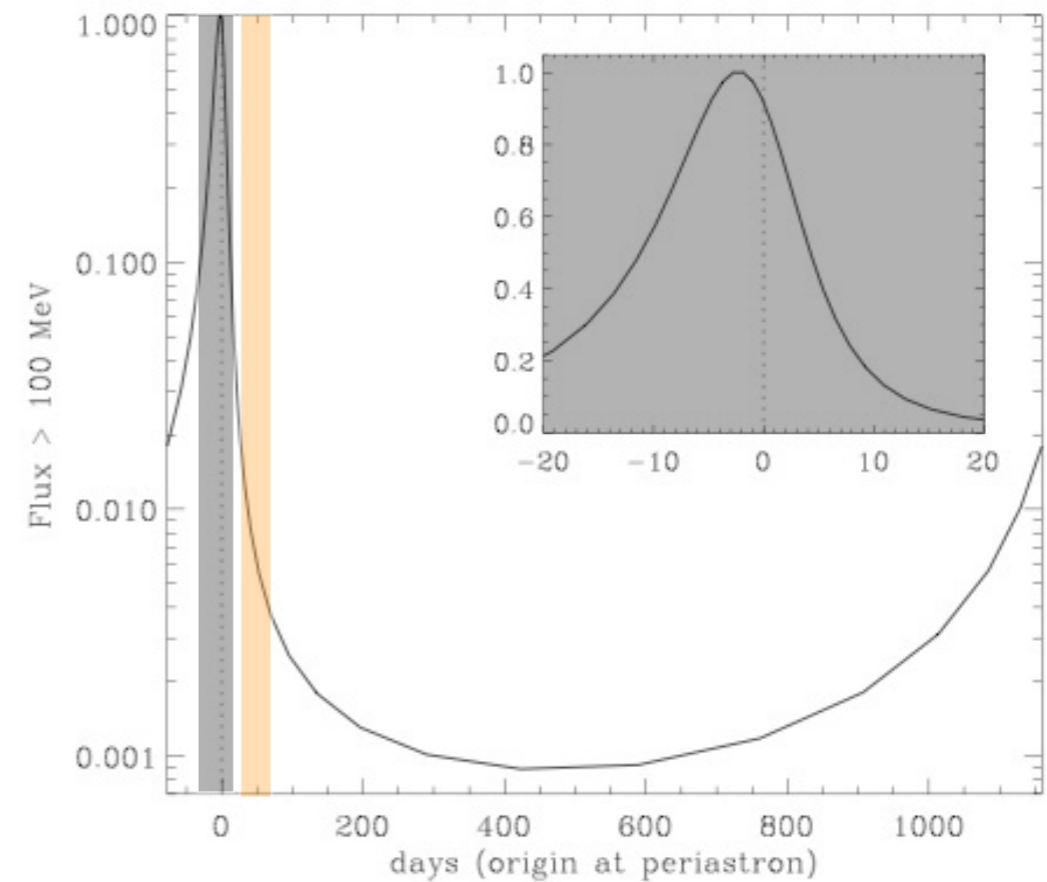
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IC striped pulsar wind (Pétri & GD 2011)

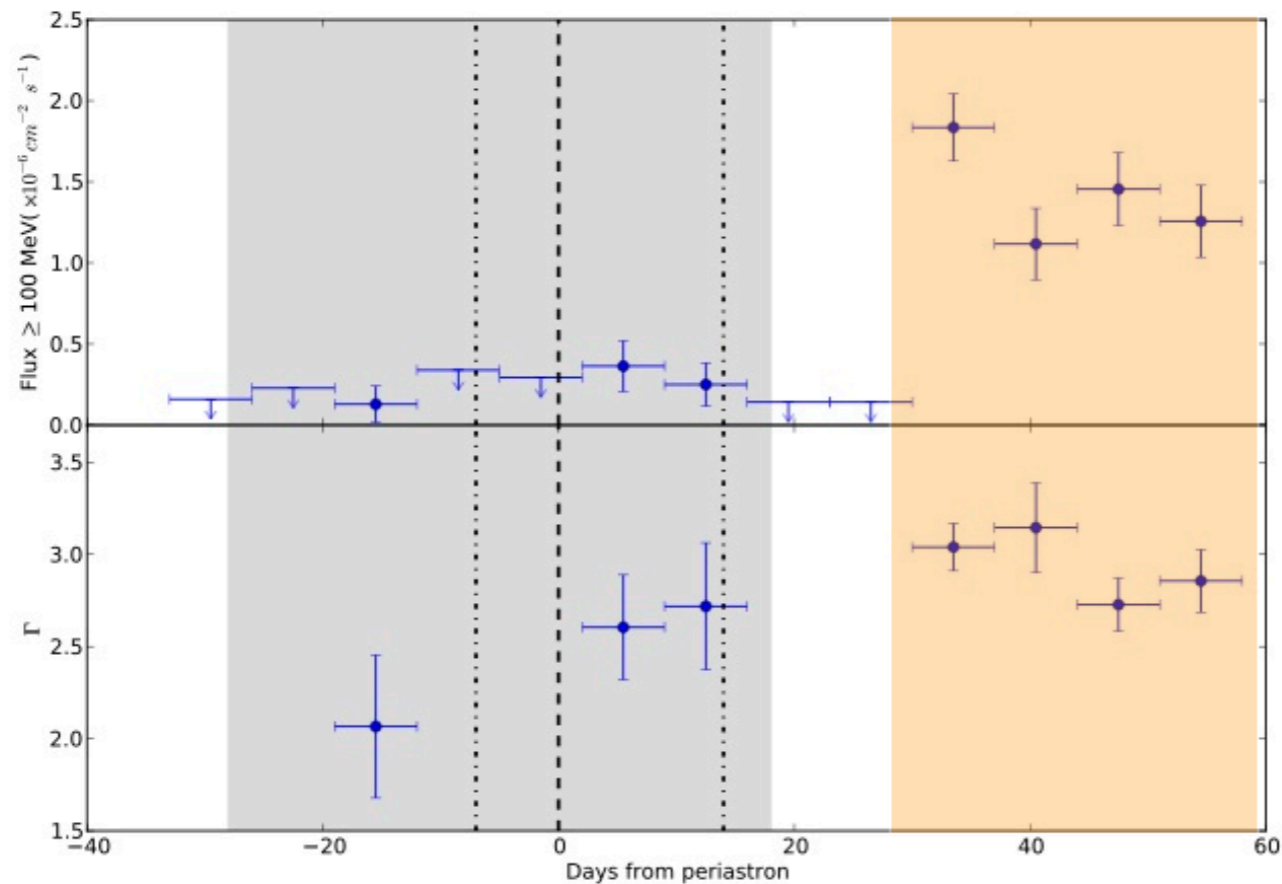


- **inv. Compton on Be star photons works only near periastron**

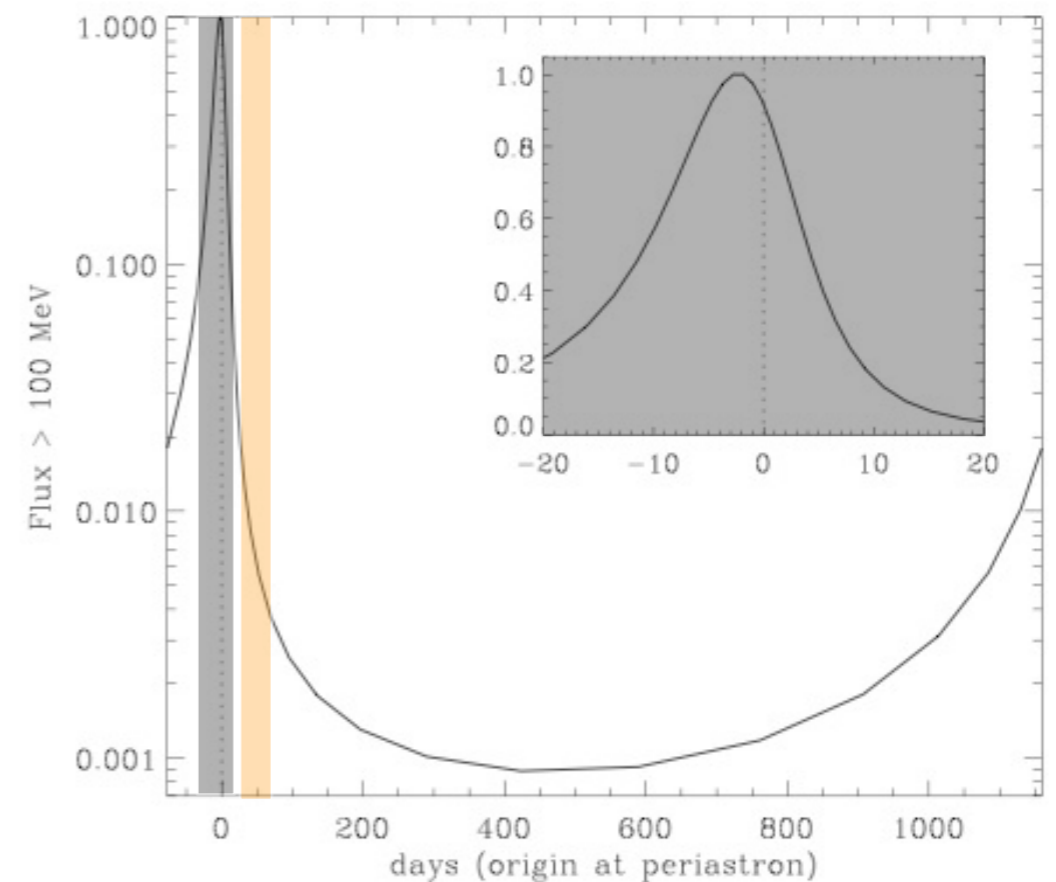
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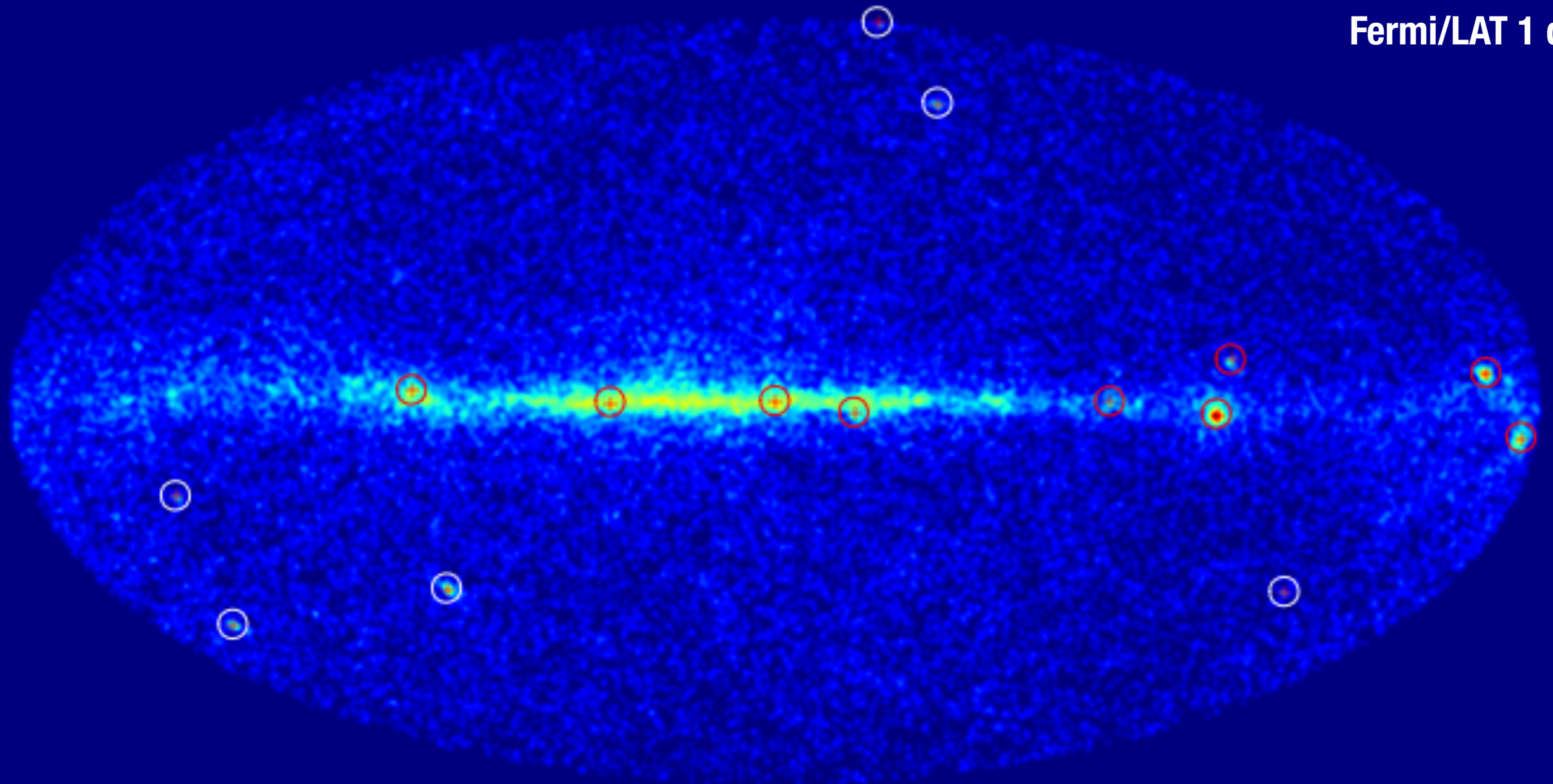
- **inv. Compton on Be star photons works only near periastron**
 - Be disk (π_0 , free-free...) ? HE sync ? Doppler boost ? IC on other fields ?...
- **Nearly all spindown power radiated away in γ -rays at peak**

Transients in the Galactic Plane

Fermi/LAT all-sky survey mode. Automated search runs every 6 hours, 1 day, 1 week.

weekly report <http://fermisky.blogspot.com>

list of binaries specifically monitored → poster Glanzman & Dubois



Fermi/LAT 1 day

Variable galactic γ -ray sources ATels

| Atel source | date | l | b | err | note |
|----------------|------------------------------|--------|-------|------|------------------------------------|
| J0903-3531 | 10/2008 | 259.59 | 7.7 | 0.08 | AGN ? |
| J0910-5041 | 10/2008 | 271.62 | -1.8 | 0.07 | AGN ? |
| J0109+6134 | 02/2010 | 125.12 | -1.23 | 0.09 | AGN |
| J1018-5856 | 03/2011 | 284.32 | -1.70 | 0.02 | gamma-ray binary |
| Cyg X-3 | 05/2010, 03/2011 | 79.85 | 0.79 | - | microquasar |
| V407 Cyg | 03/2010 | 86.96 | -0.55 | 0.12 | nova |
| Crab | 09/2010, 04/2011 | 184.43 | -5.79 | 0.06 | Crab flare |
| PSR B1259-63 | 12/2010, 01/2011 | 304.18 | -0.99 | | gamma-ray binary |
| J1057-6027 | 06/2009 | 289.3 | -0.64 | 0.07 | |
| GC region | 02/2011 | 0.09 | -0.23 | 0.36 | 20s |
| J0109+6134 | 02/2010 | 125.18 | -1.21 | 0.6 | AGN |
| J1037-5708 | 10/2010 | 285.5 | 1.1 | 0.5 | |
| J2206+6203 | 01/2010 | 104.9 | 5.1 | 0.4 | |
| J1410-6147 | 02/2008 | 312.2 | -0.3 | 0.5 | |
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| PSR B1259-63 ? | 08/2010 | 304.7 | -0.8 | 0.6 | no Fermi at that time |
| Cygnus region | 11/2007 | 75.0 | -0.4 | 1 | |
| J2022+4032 | 04-05-06-10/2008 | 78.2 | 2.1 | 0.5 | ? PSR J2021+4026. Chen et al. 2011 |
| Cyg X-1 ? | 10/2009, 03./2010 | 70.3 | 2.5 | 1.2 | no Fermi. Sabatini et al. 2010 |
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Fermi/LAT

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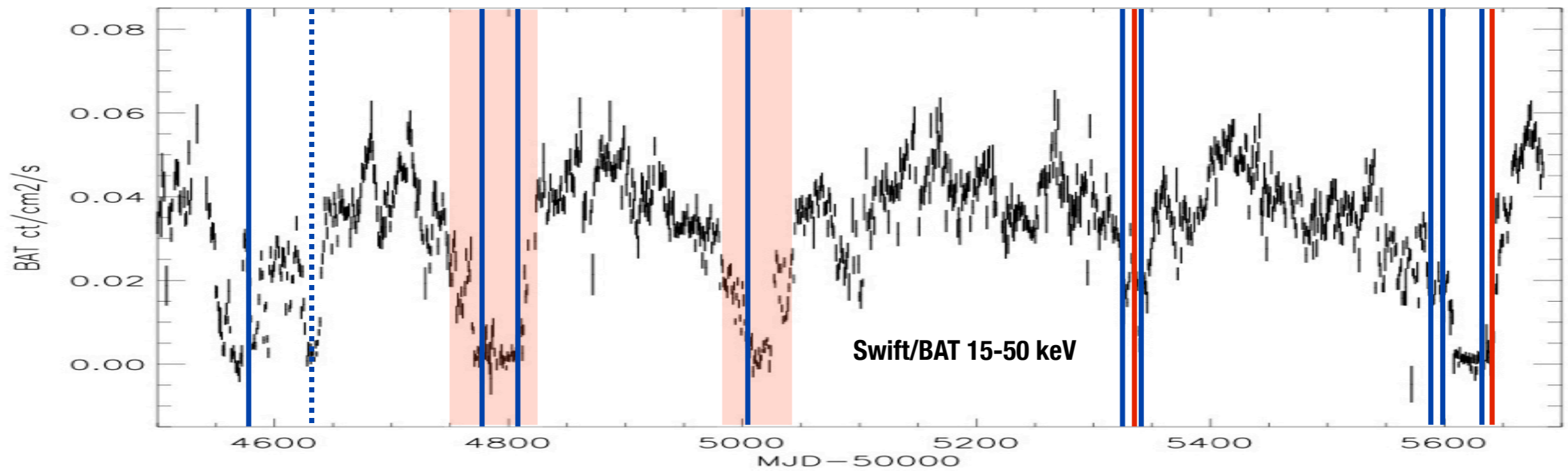
Fermi/LAT

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Cygnus X-3 flares

AGILE & Fermi/LAT detections

Tavani et al. 2009, Abdo et al. 2009, Williams et al. 2011, + *ATeIs*

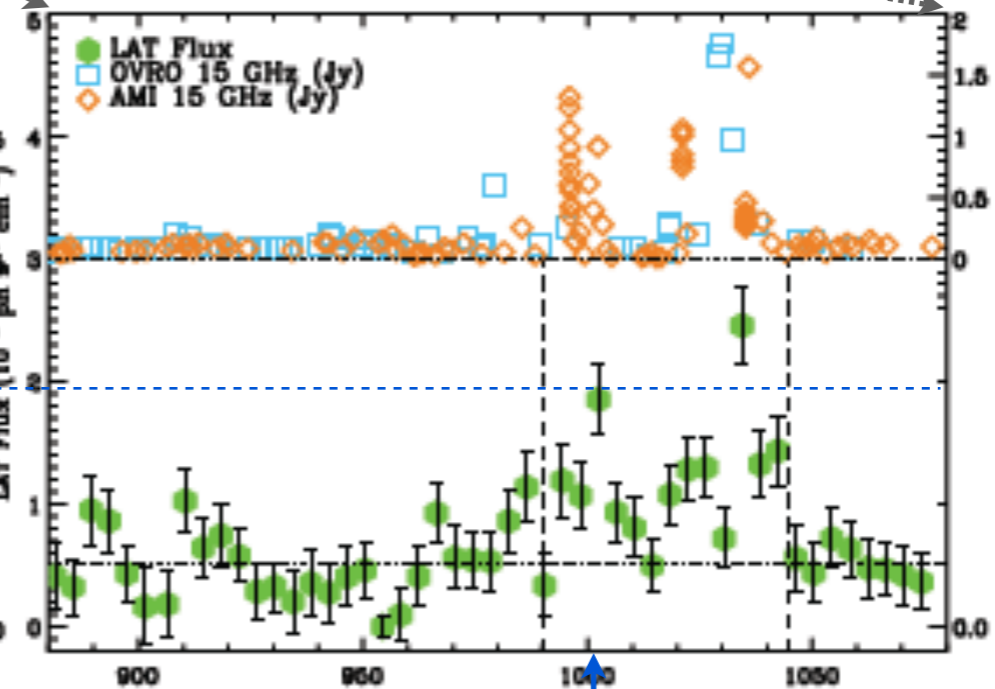
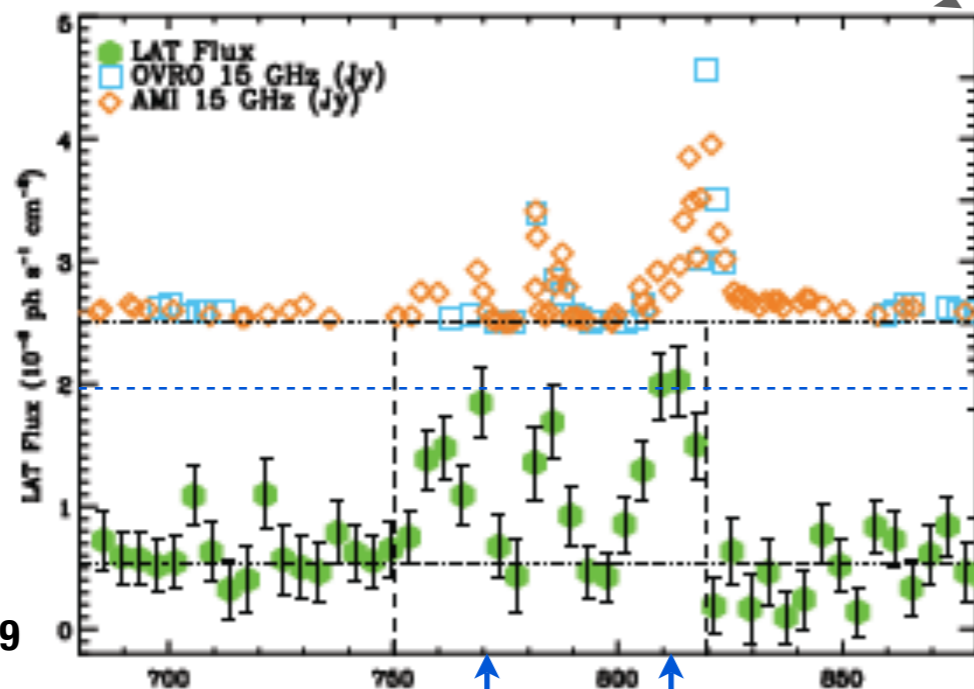
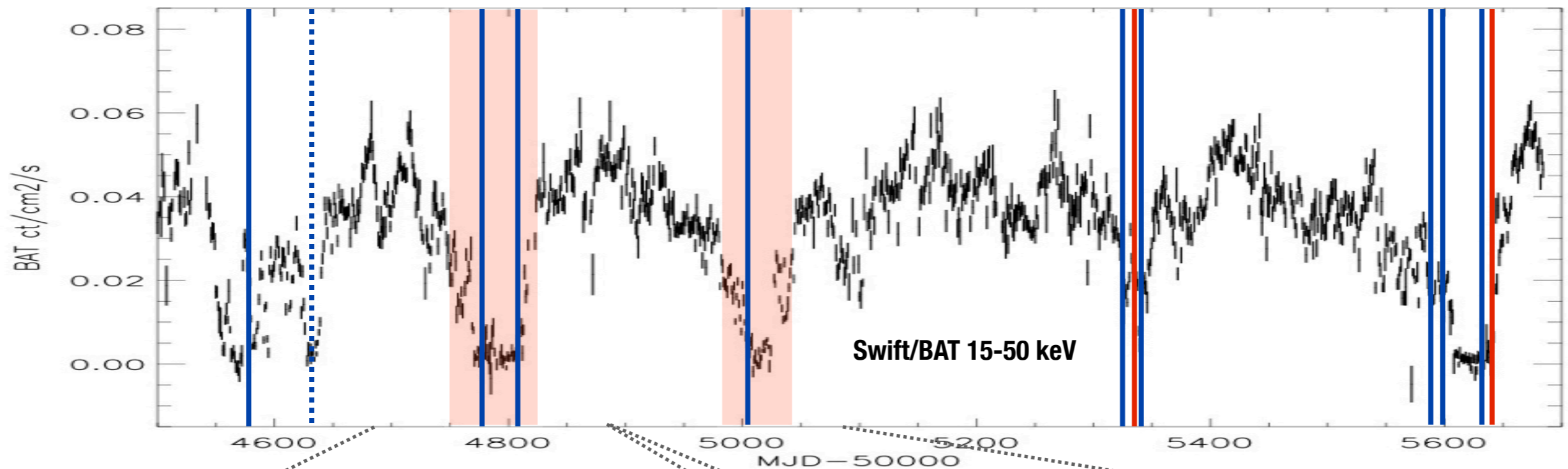


→ poster Piano for AGILE

Cygnus X-3 flares

AGILE & Fermi/LAT detections

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Fermi
Abdo et al. 2009

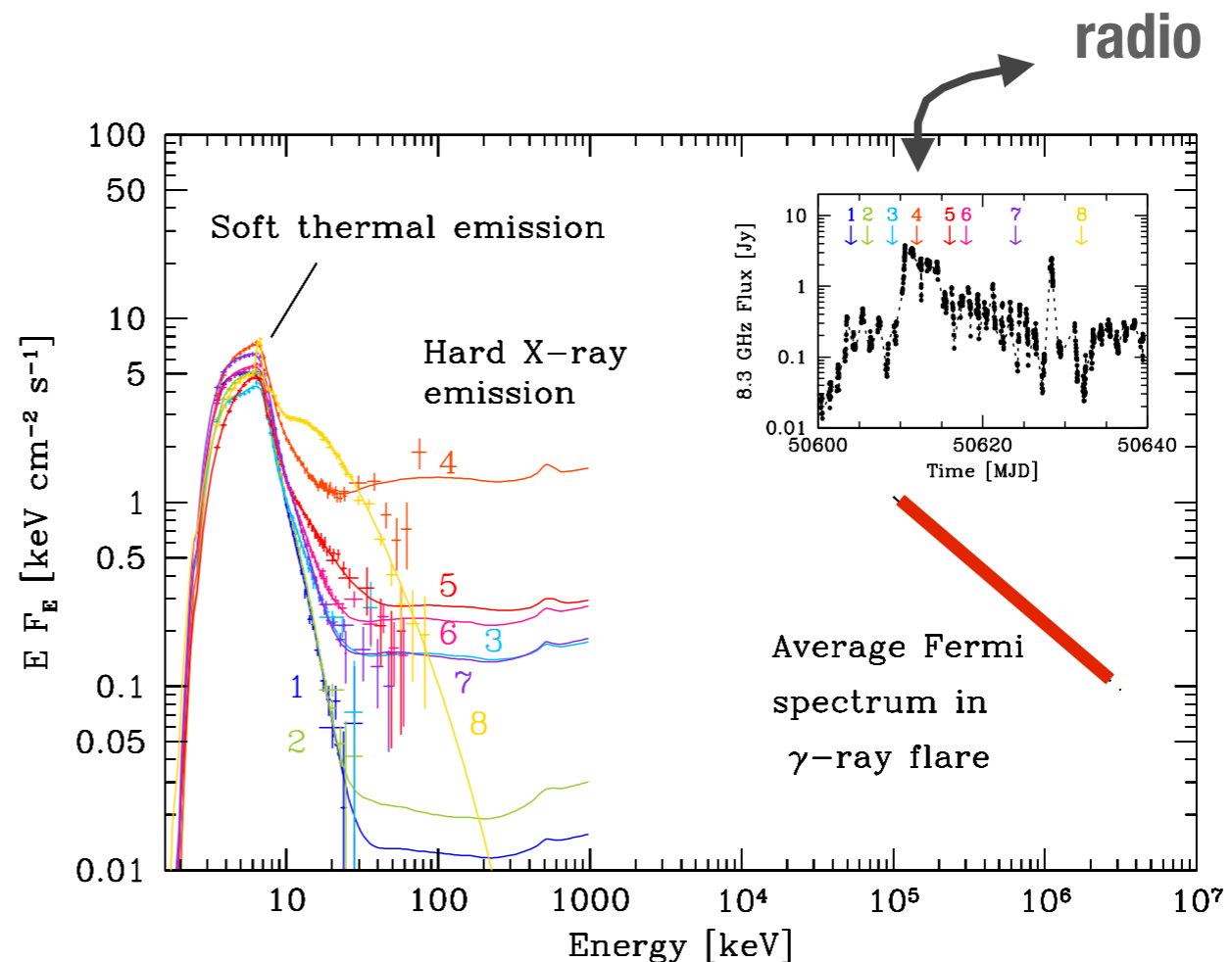
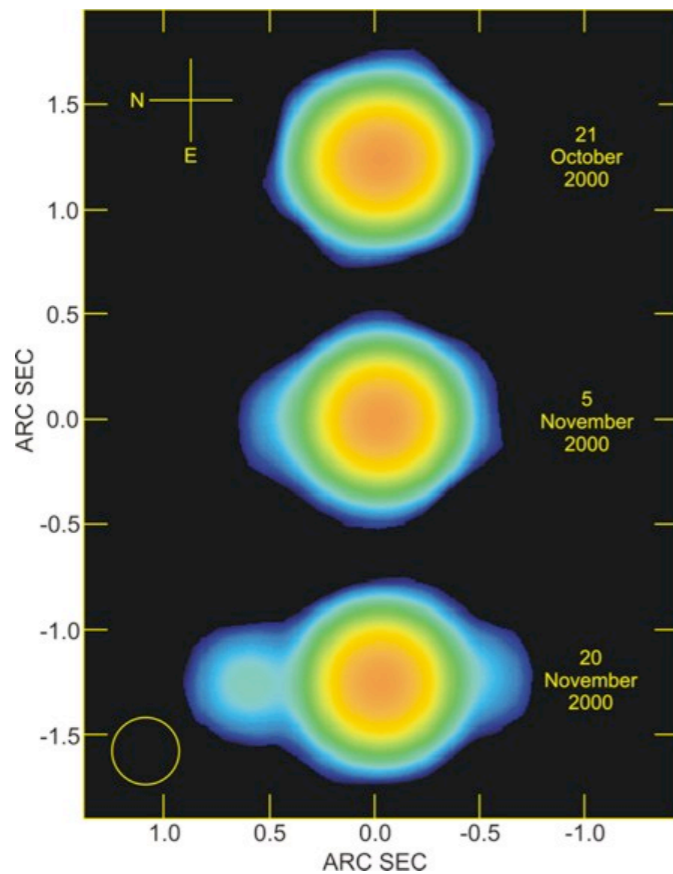
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HE γ -rays from a microquasar

- Relations between X-rays, radio, γ -ray
- Link between non-thermal proc. and jet formation ?
- Only confirmed detection from a microquasar

Radio jet Cyg X-3 (Martí et al. 2001)

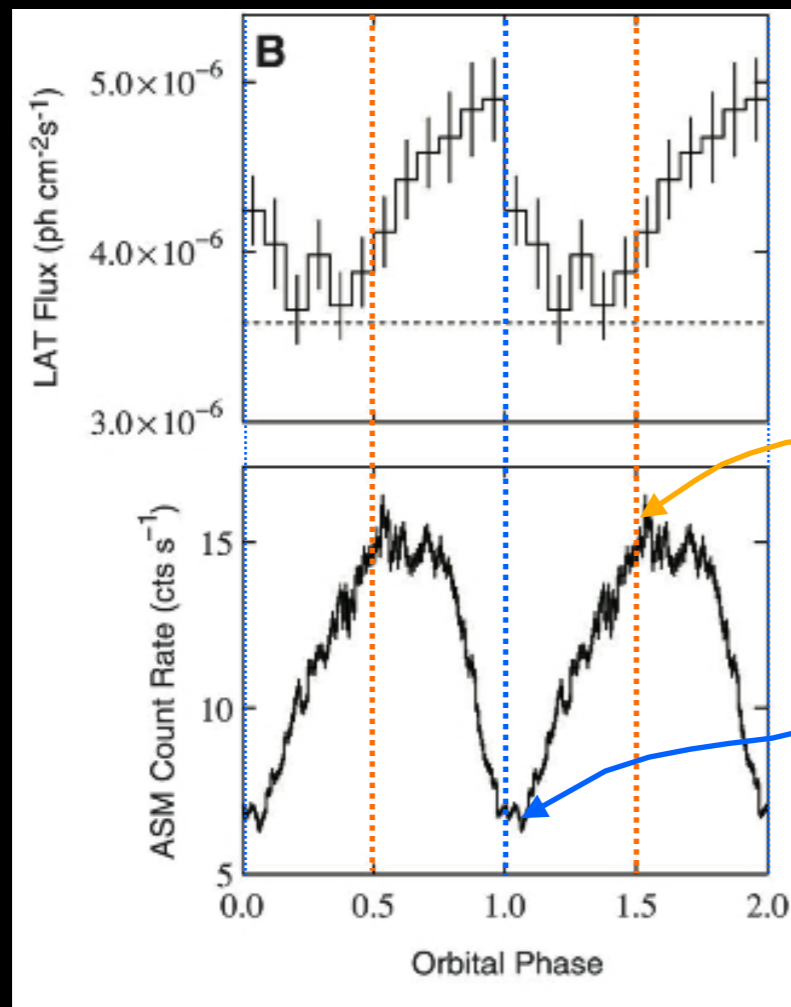


adapted from Szostek et al. 2008

γ -rays <10% X-rays

γ -ray and X-ray modulation

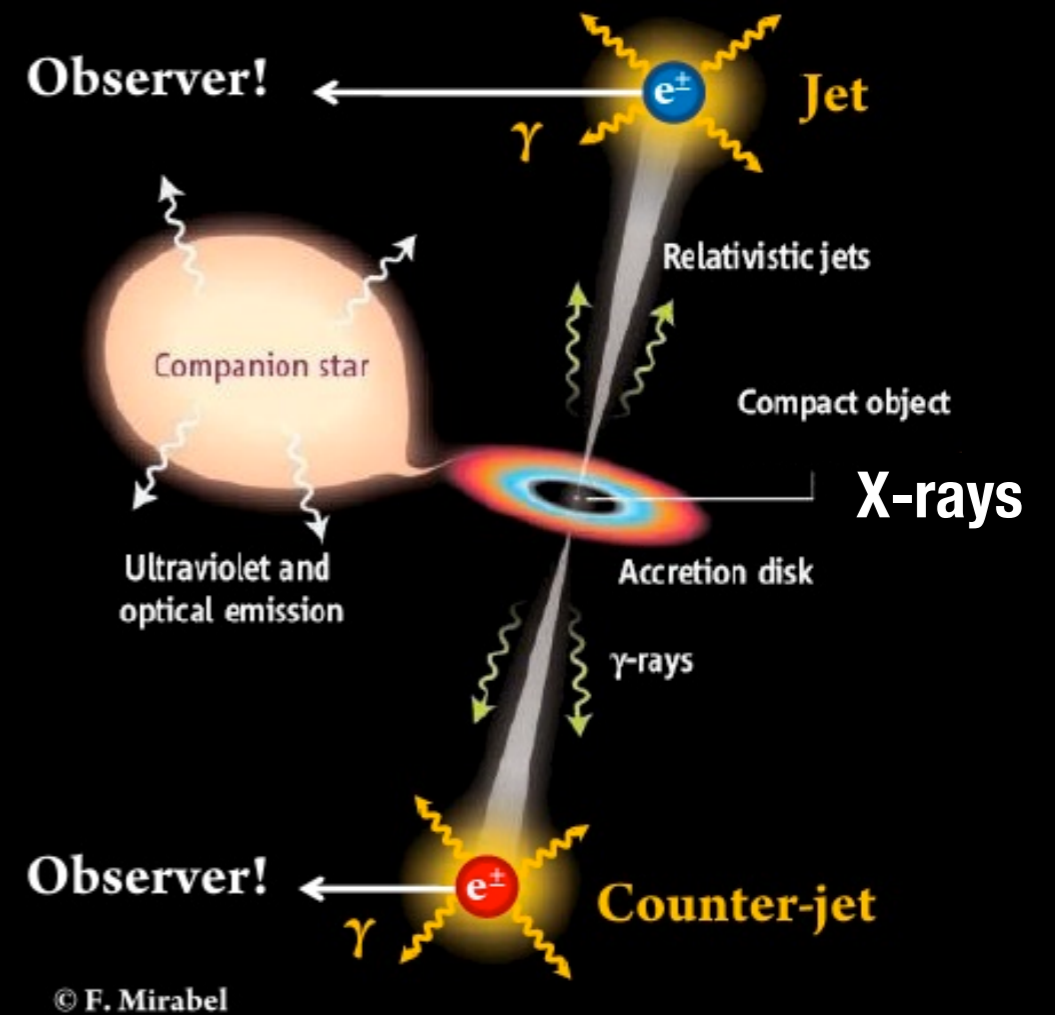
- X-ray modulation from Thomson scattering in Wolf-Rayet wind



X-ray max
inf. conj.
~ γ -ray min

X-ray min
sup. conj.
~ γ -ray max

Abdo et al. 2009

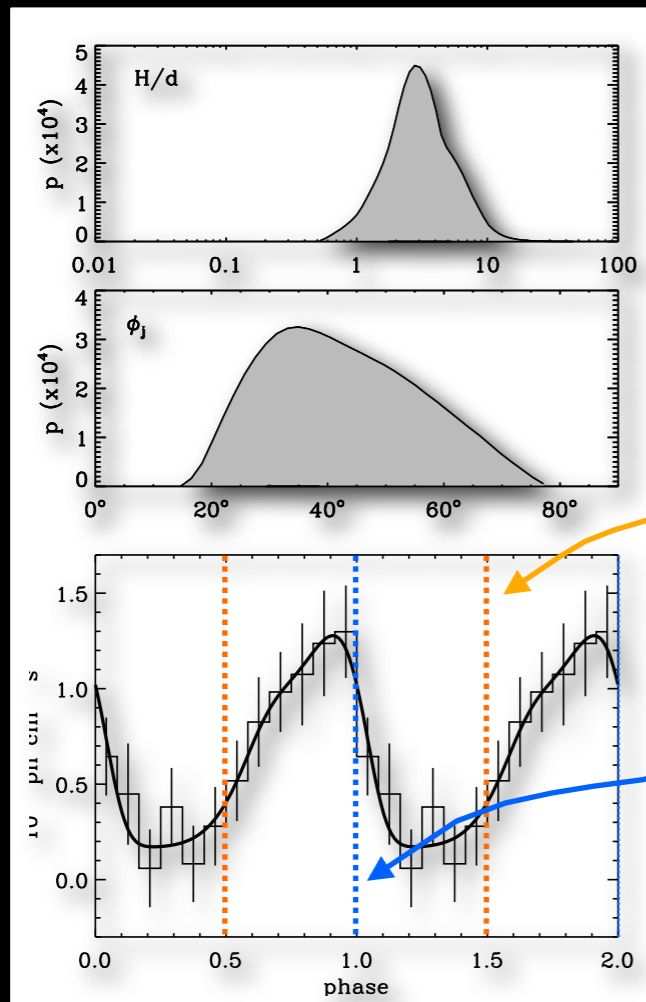


- γ -ray modulation due to inv. Compton on Wolf-Rayet photons ?

γ -ray and X-ray modulation

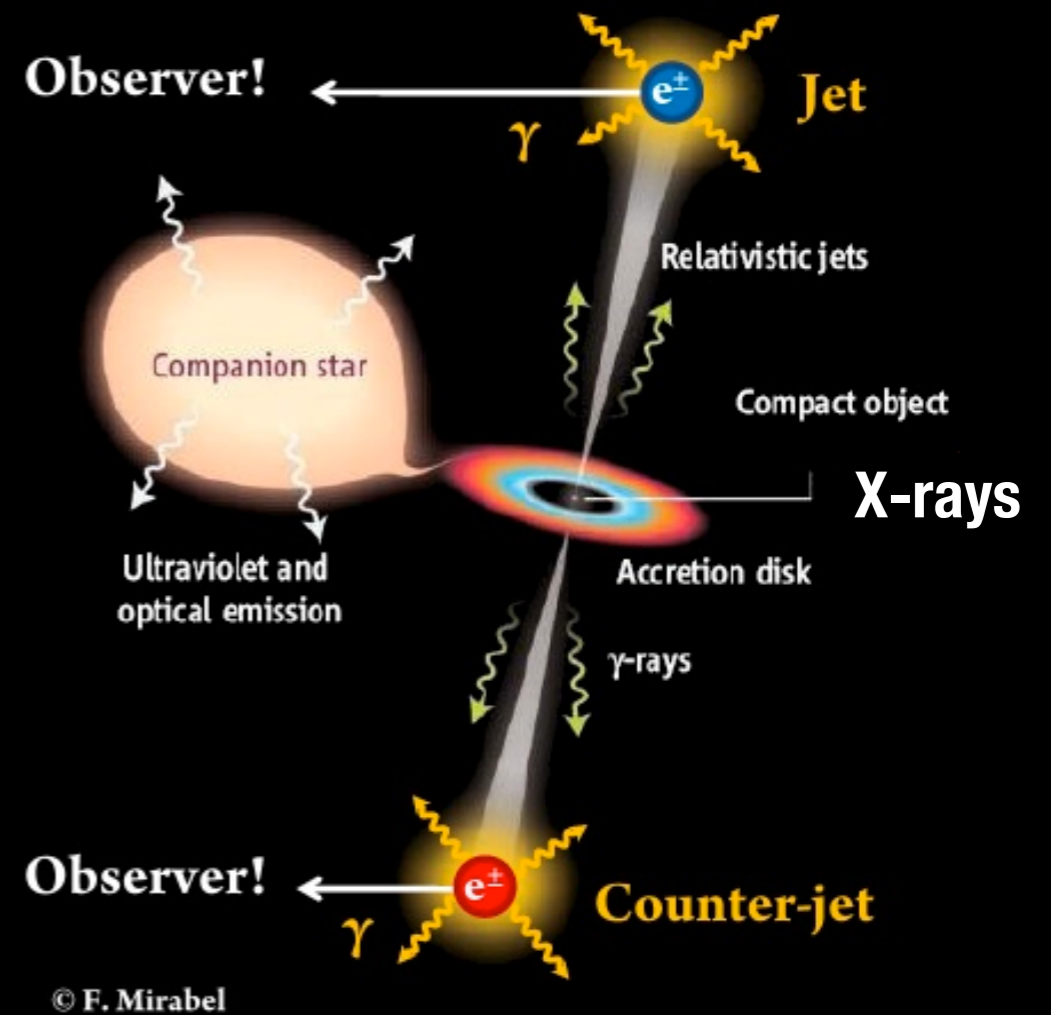
- γ -ray modulation due to inv. Compton on Wolf-Rayet photons

GD et al. 2010, Cerutti et al. 2011



X-ray max
inf. conj.
~ γ -ray min

X-ray min
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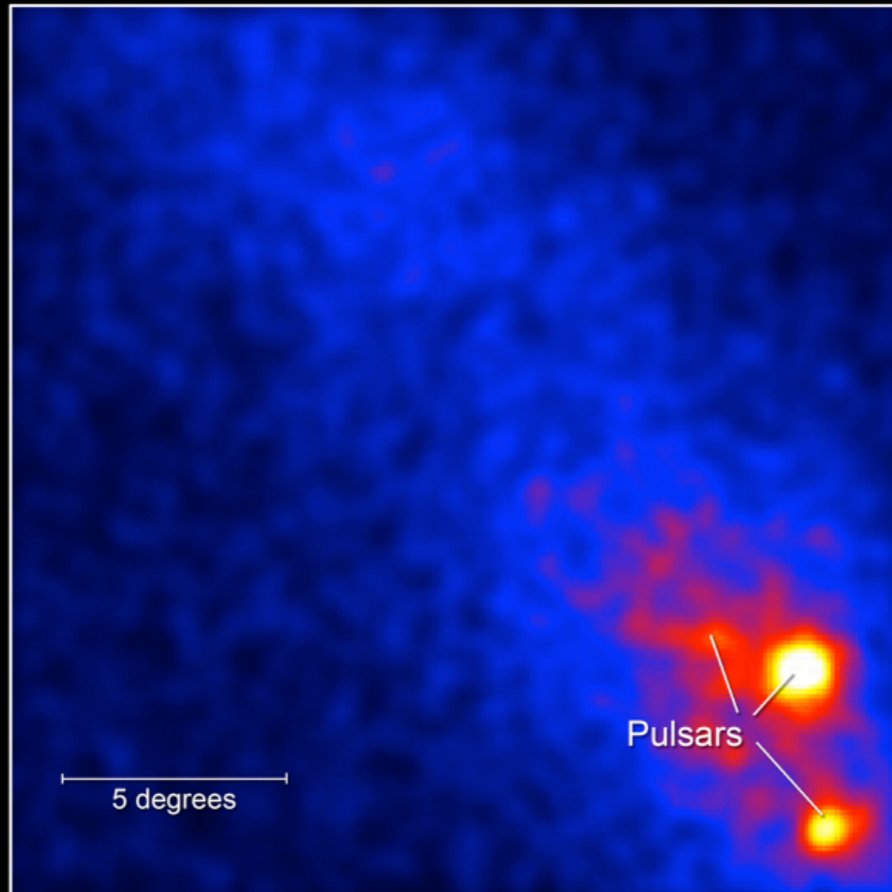
- not too close, not too far : recollimation shock ?
- matter, radiation density : is Cyg X-3 unique ?

Gamma-rays from a nova

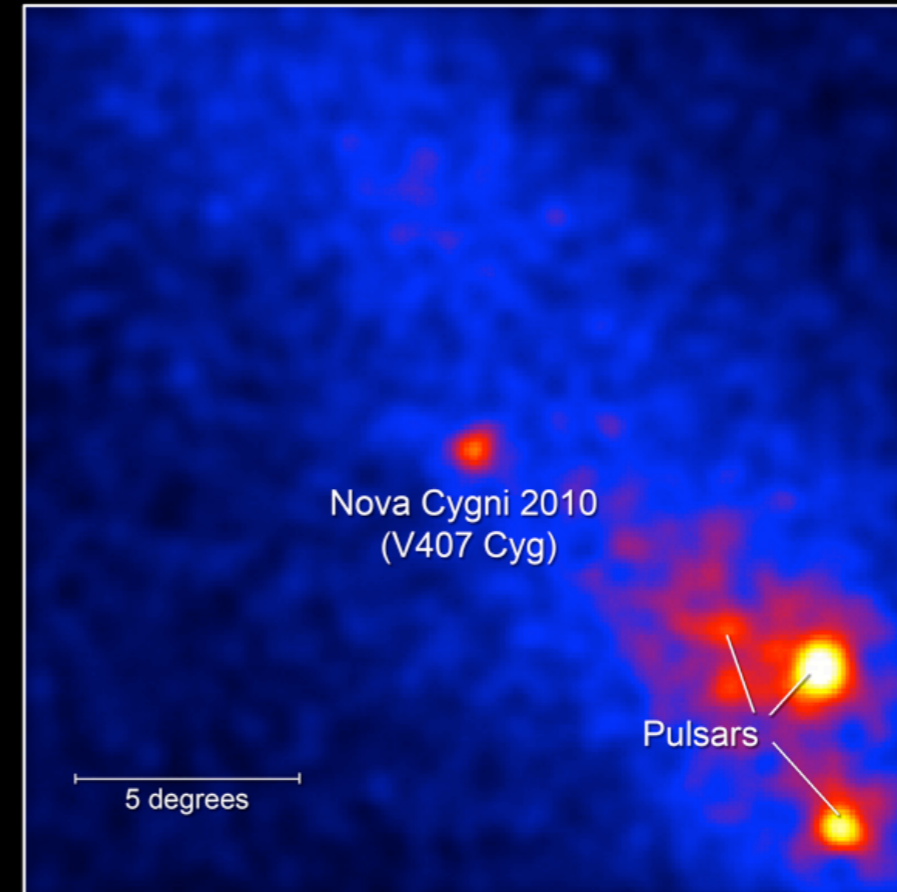
→ poster T. Cheung



Fermi Detects Gamma Rays from Nova Cygni 2010

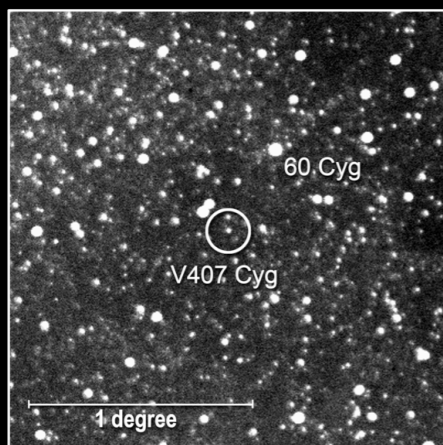


Feb. 19 to March 9, 2010

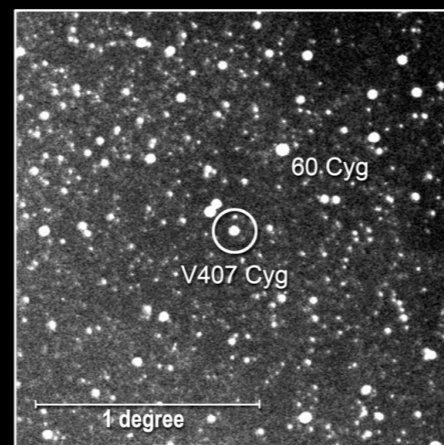


March 10 to 29, 2010

Nova Cygni 2010 in Visible Light



March 7, 20:36 UT



March 10, 19:08 UT

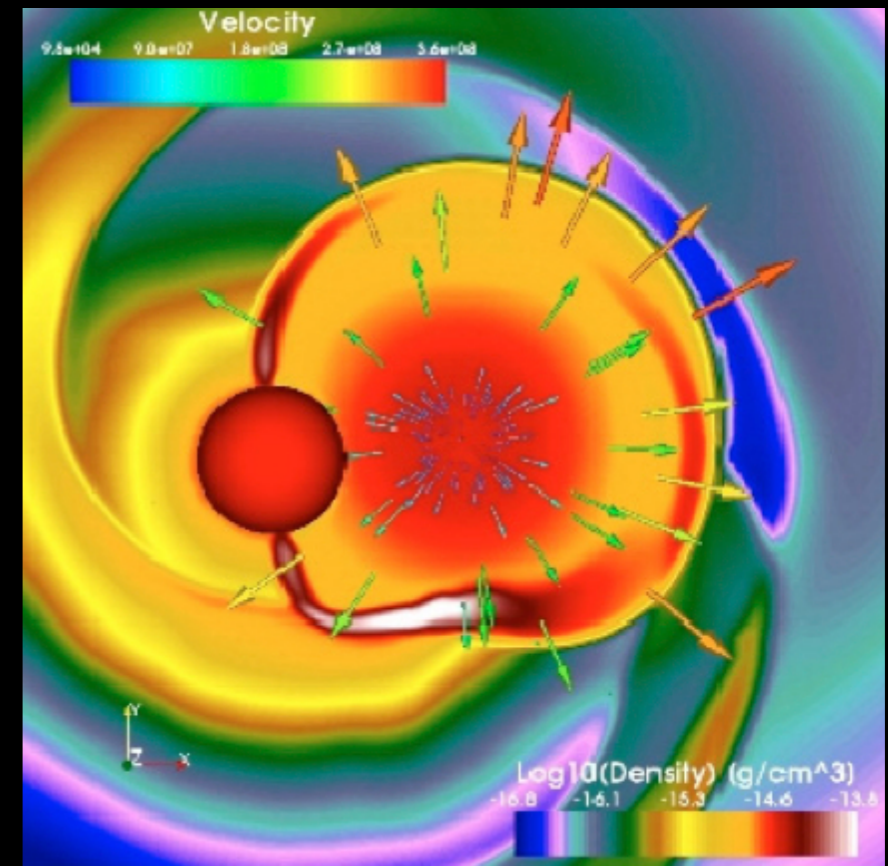
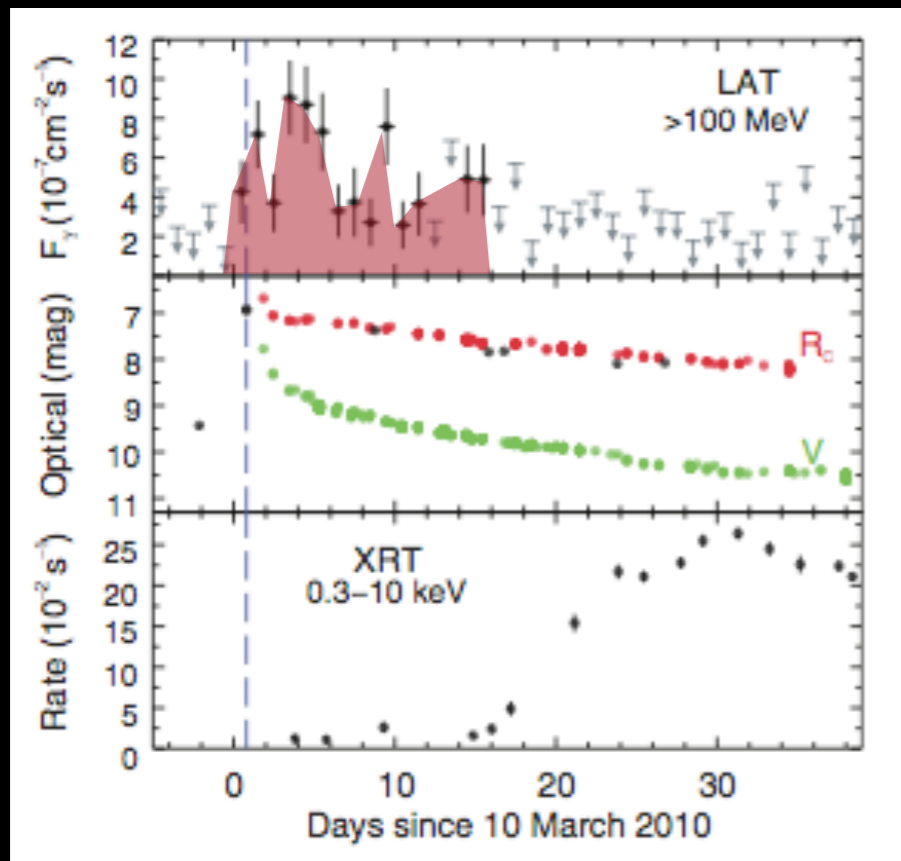
**optical nova
outburst
discovered by
amateur
astronomers
Nishiyama &
Kabashima**



Gamma-rays from a nova

→ poster T. Cheung

- thermonuclear runaway WD ejects $10^{-6} M_{\odot}$ at ~ 3000 km/s
- symbiotic system: lots of matter & radiation



- Mini-supernova, 10^{44} erg, π_0 from high energy p^+ or IC on e^-
- one every few years ? (Yungelson et al. 1995)

Summary

Identified variable galactic γ -ray sources tend to be binaries

gamma-ray binaries

spectrum of LS sources, lightcurve of PSR B1259-63 challenge models

variability gives new insights into pulsar winds

microquasars

Cyg X-3 could be unique object to link jet formation with non-thermal processes

symbiotic novae

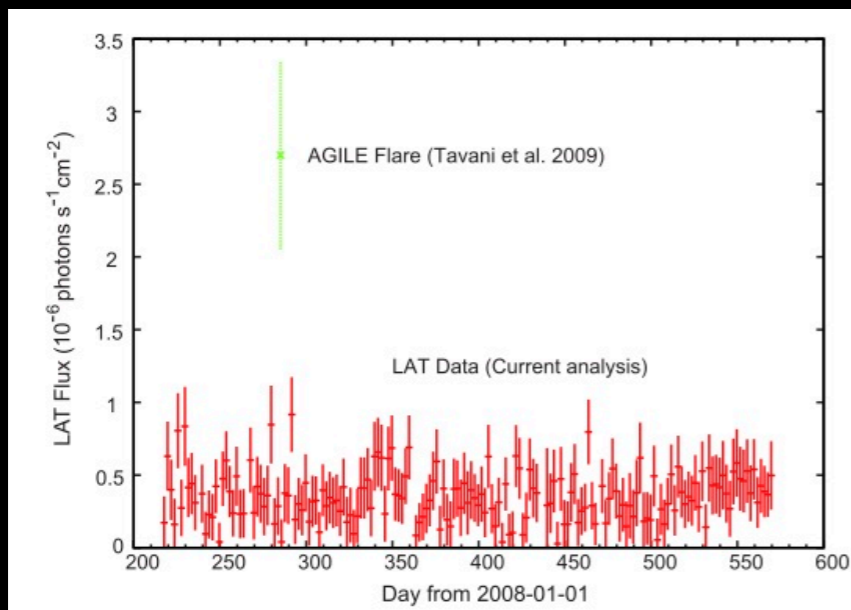
particle acceleration in a mini supernova

colliding wind binaries tbc

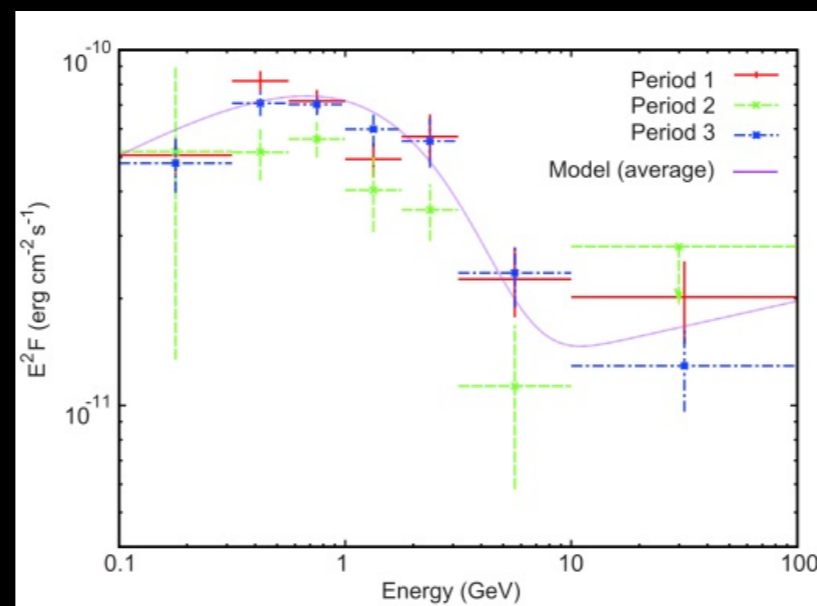
unidentified transients in the Galactic Plane more fun to come !

Colliding wind binaries

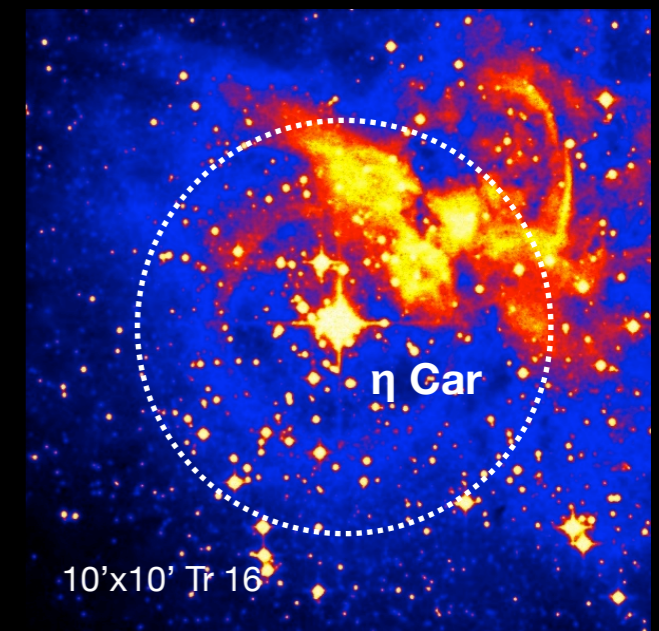
- Gamma-ray emission from Eta Carinae ?
- Large kinetic energy in winds $\sim 10^{37}$ erg/s, 5.5 yr orbit
- AGILE flare near periastron but no variability in Fermi/LAT



Abdo et al. 2010



Fermi/LAT spectrum : pulsar wind nebula in Tr 16 cluster ?



- No conclusive evidence for colliding wind binaries yet.