

# The puzzling emission of $\gamma$ -ray binaries

**Guillaume Dubus**

**with special thanks to Benoît Cerutti & Astrid Lamberts**

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Institut de Planétologie et d'Astrophysique de Grenoble

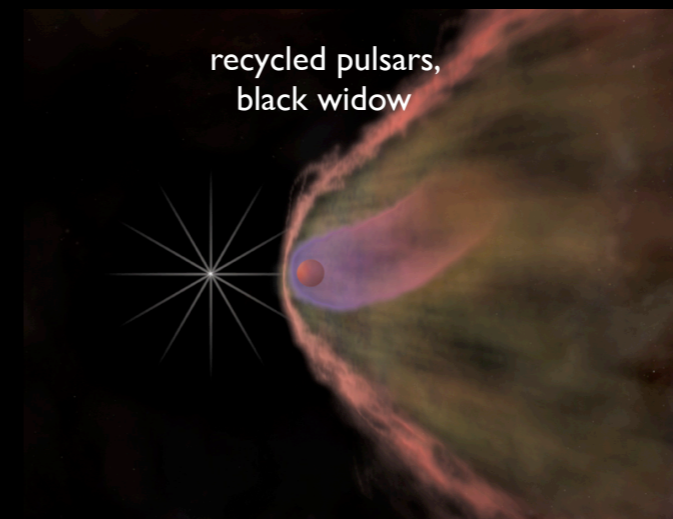
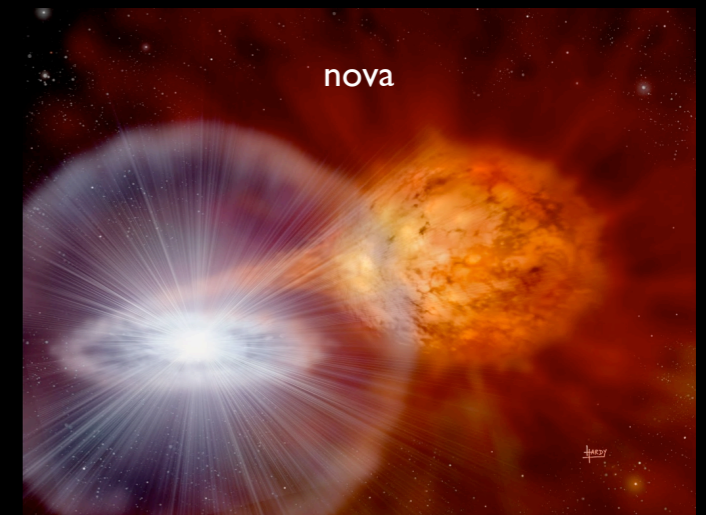
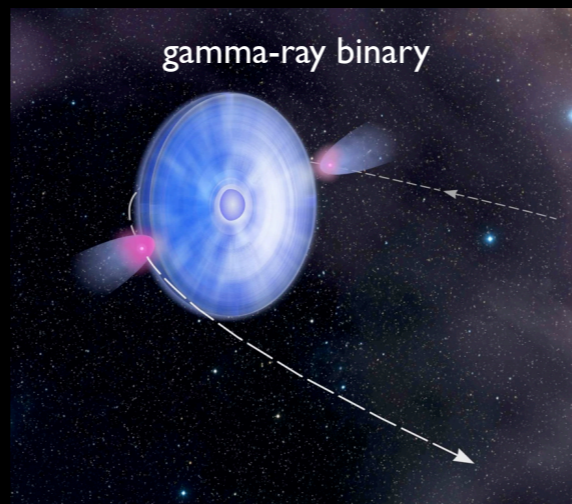
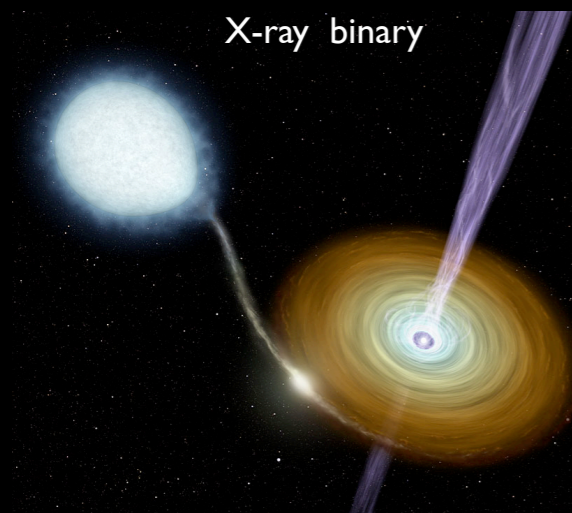
Credit: F. Reddy/NASA/GSFC





# Binaries $> 100$ MeV

Many types detected in past years by Fermi, AGILE, VERITAS, HESS, MAGIC

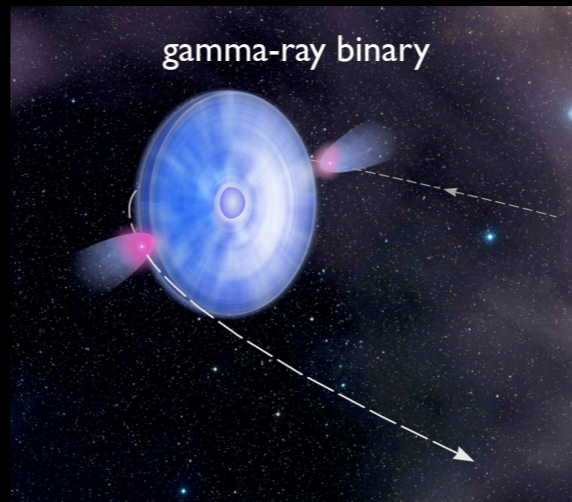


see Dubus, 2013, *Astron. Astrophys. Rev.*, 21, 64

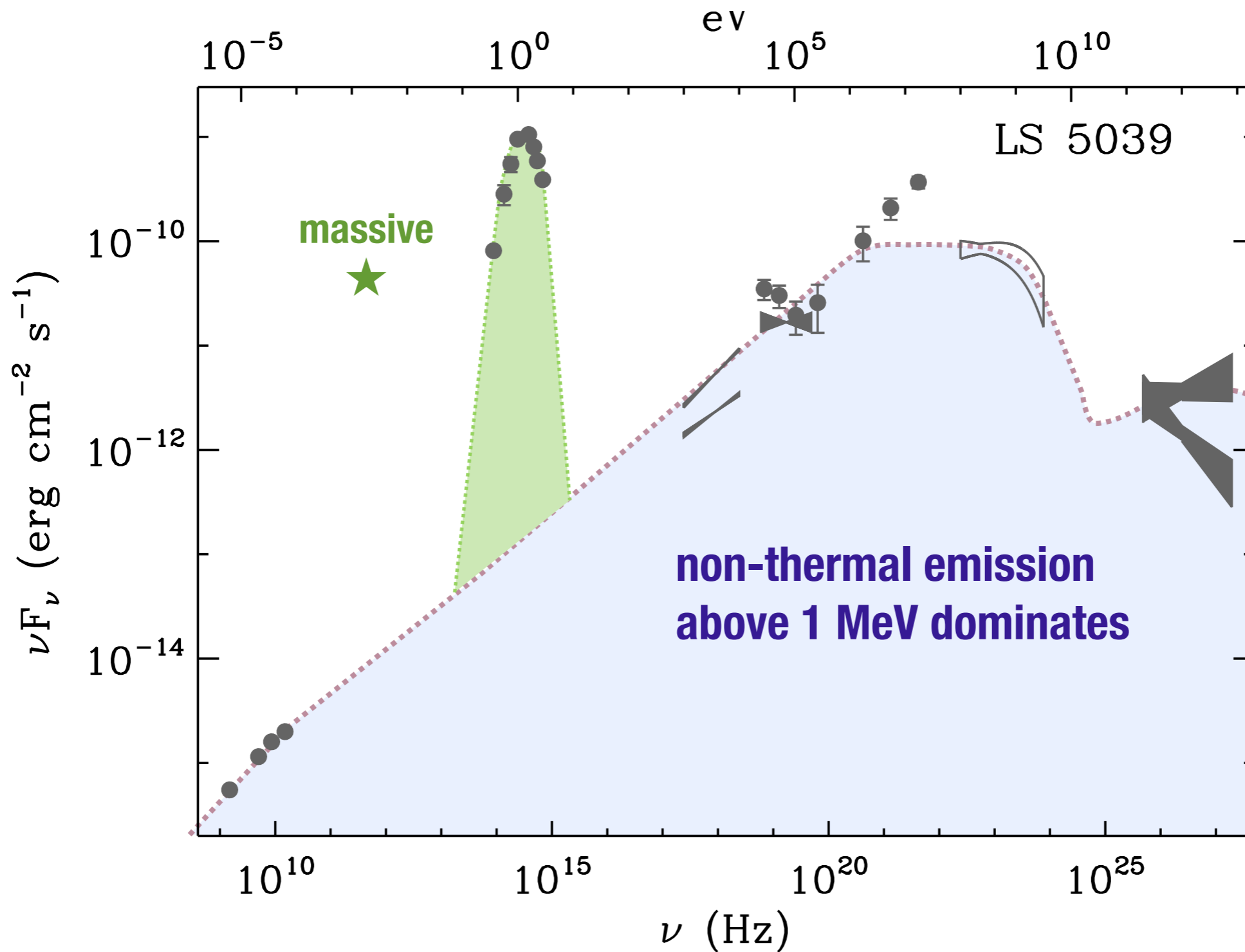
The puzzling emission of gamma-ray binaries (G. Dubus)

# Binaries $> 100$ GeV

only gamma-ray binaries in very high energy gamma-rays



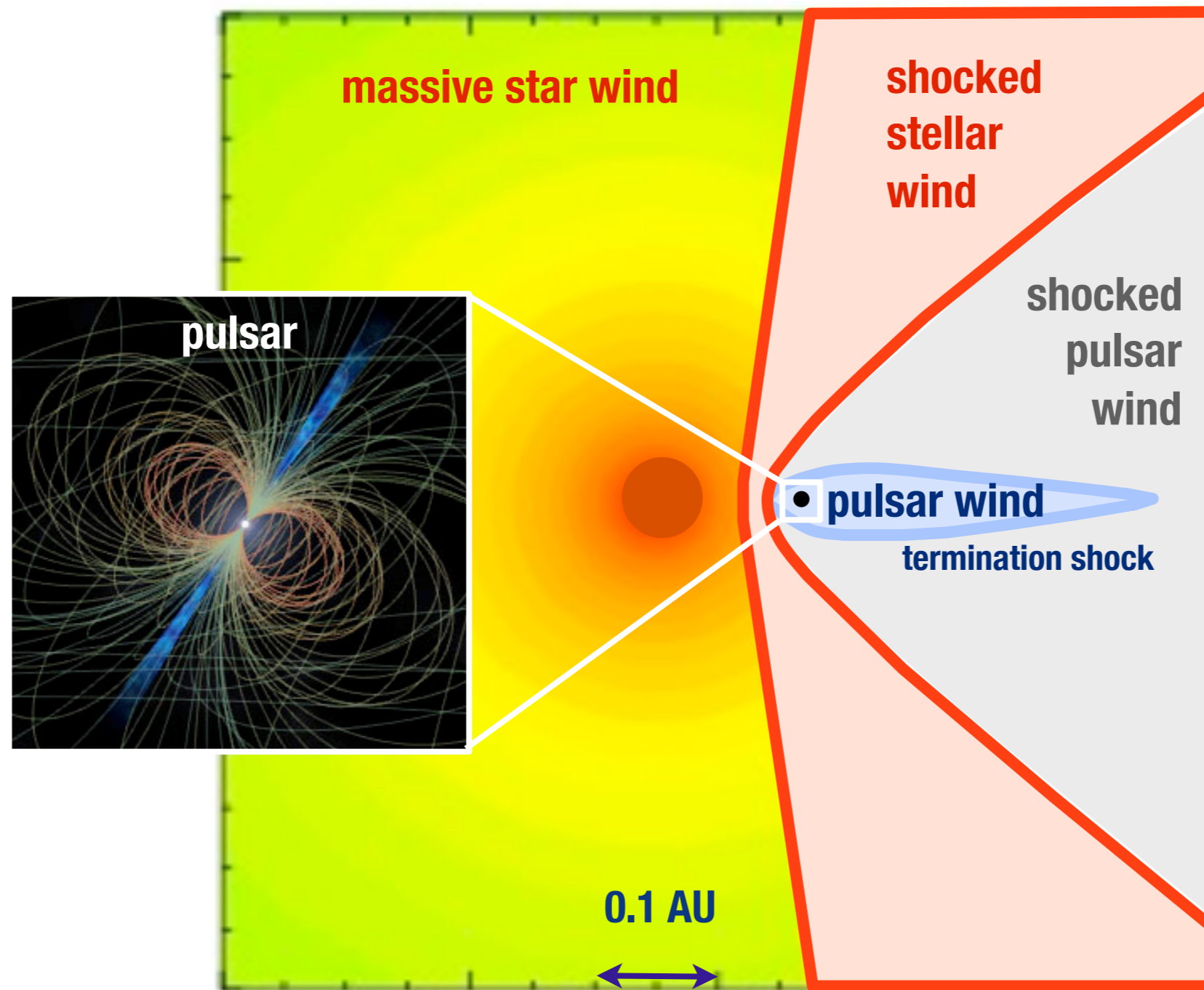
# Gamma-ray binaries



5 known systems incl. one with pulsar → all rotation-powered ?

# Interacting pulsar wind

Termination shock very close to pulsar: down to scale  $\sim 10^4 R_{LC}$



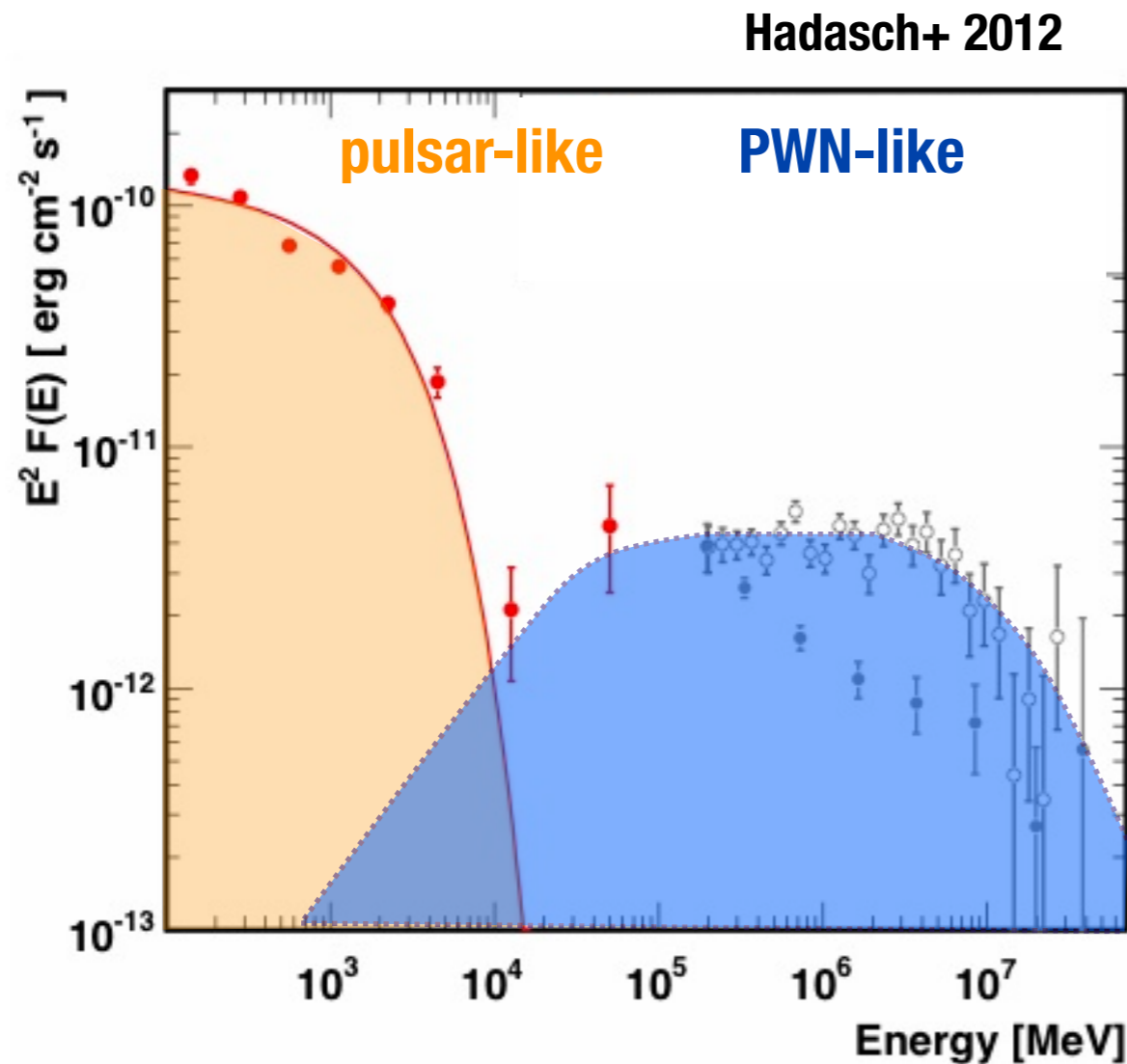
adapted from  
Lamberts et al. 2013

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# Gamma-ray emission

two components : pulsar & pulsar wind nebula (PWN) ?

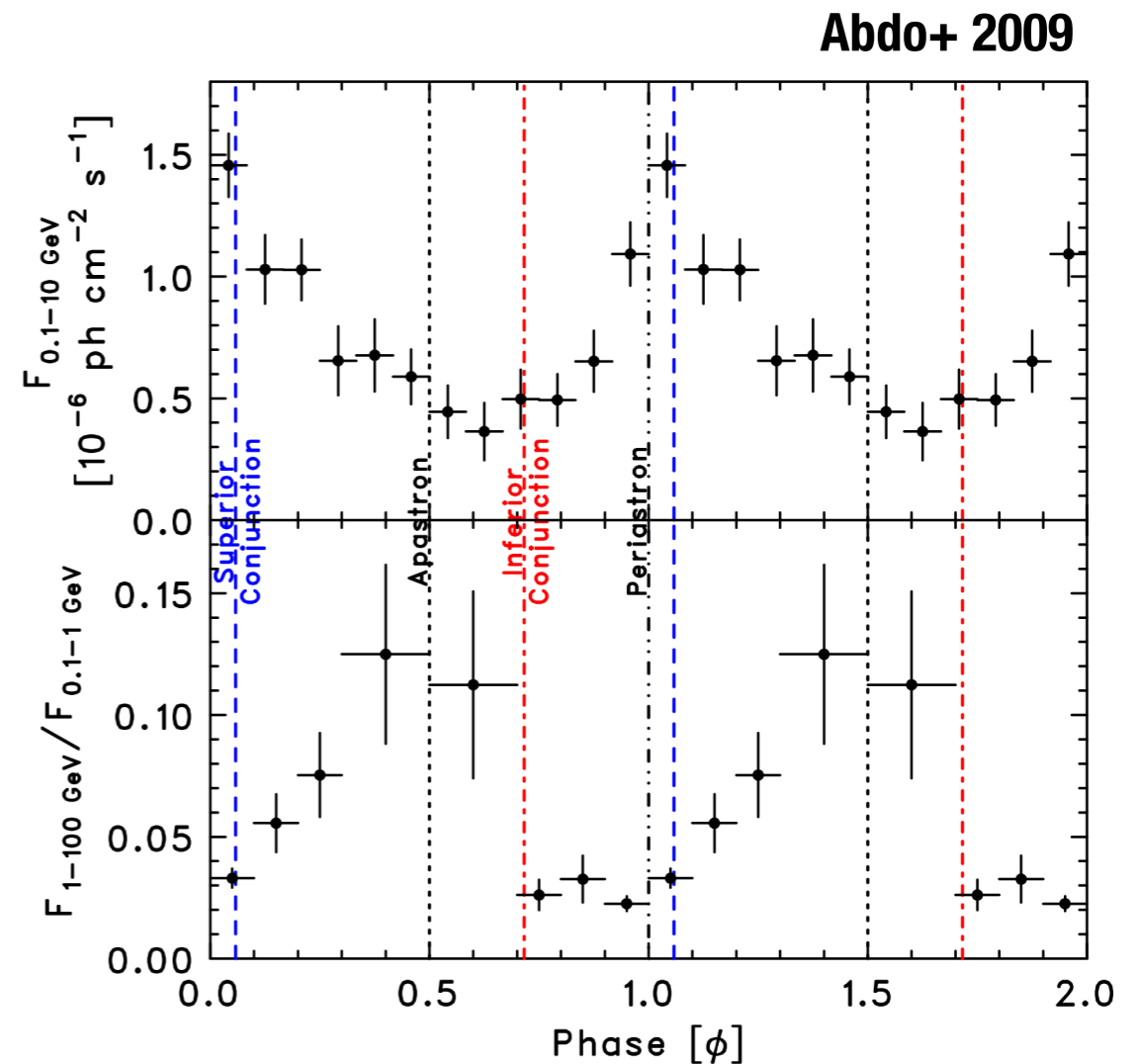
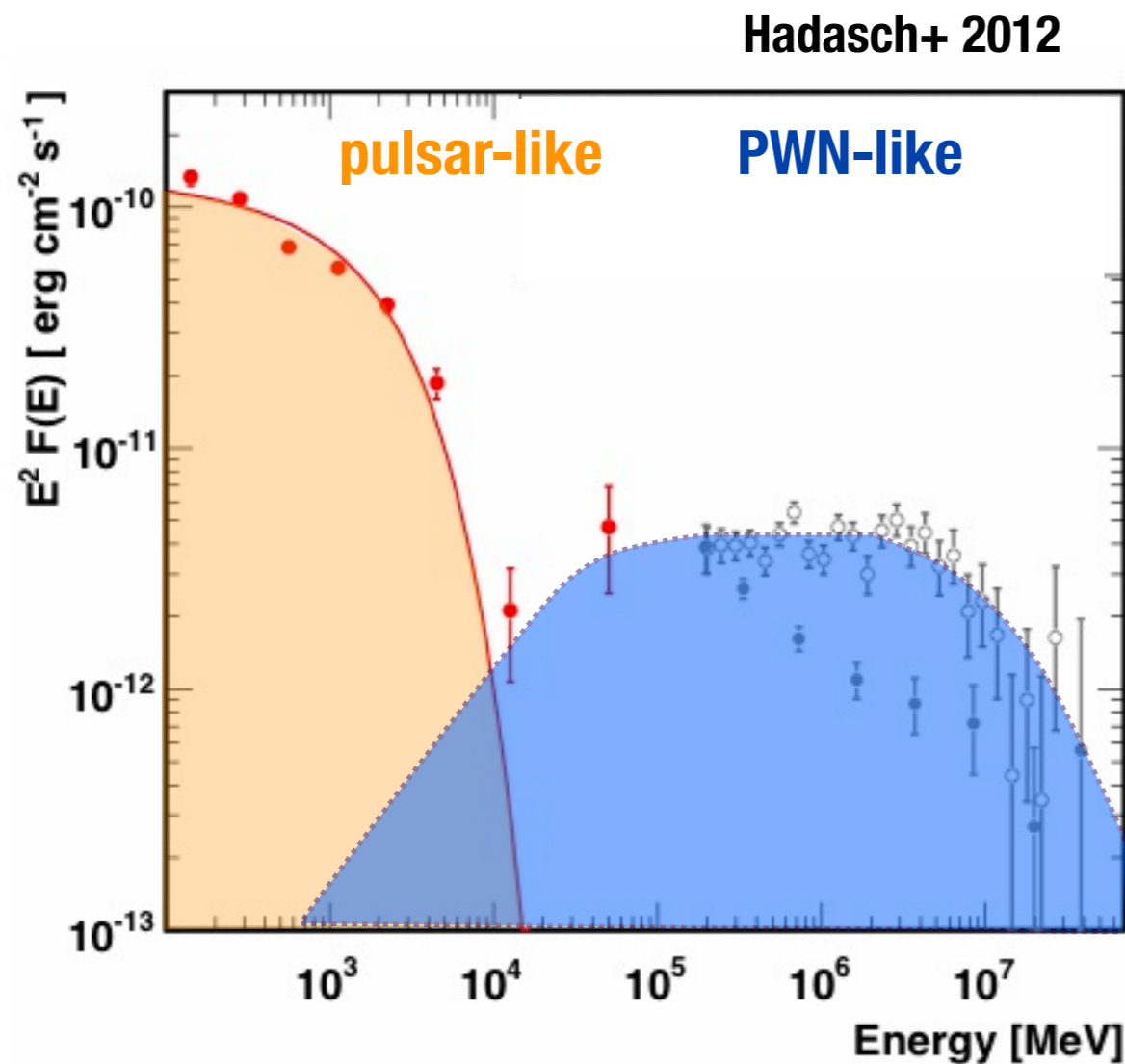


GeV spectra like that of the 100+ Fermi/LAT pulsars

TeV (X-ray) emission similar to pulsar wind nebulae

# Puzzle: pulsar-like component

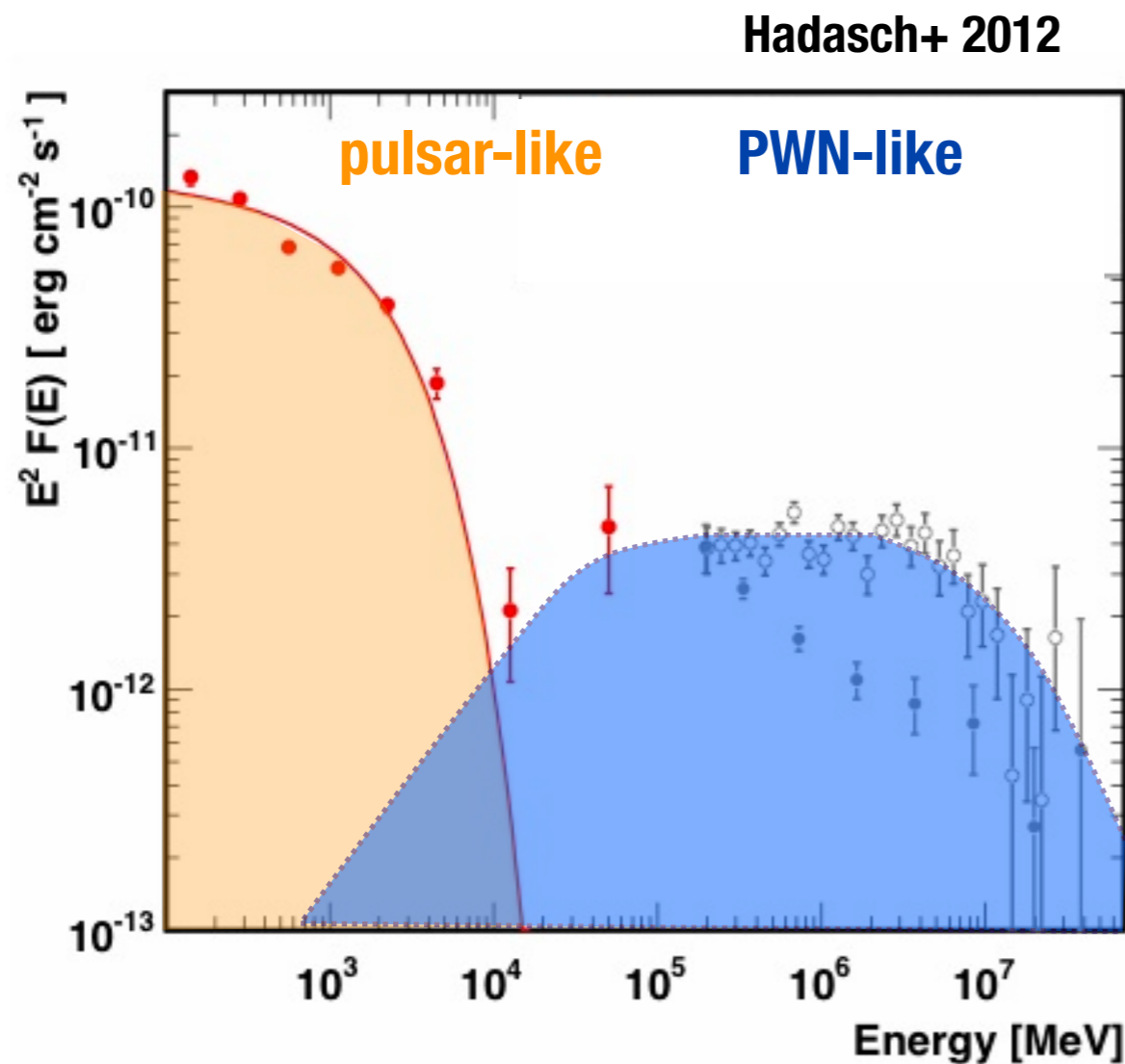
orbital modulation unexpected for pulsar emission within light cylinder



modulation best understood as inv. Compton on stellar light

# Puzzle: pulsar-like component

orbital modulation unexpected for pulsar emission within light cylinder



origin of pulsar-like component

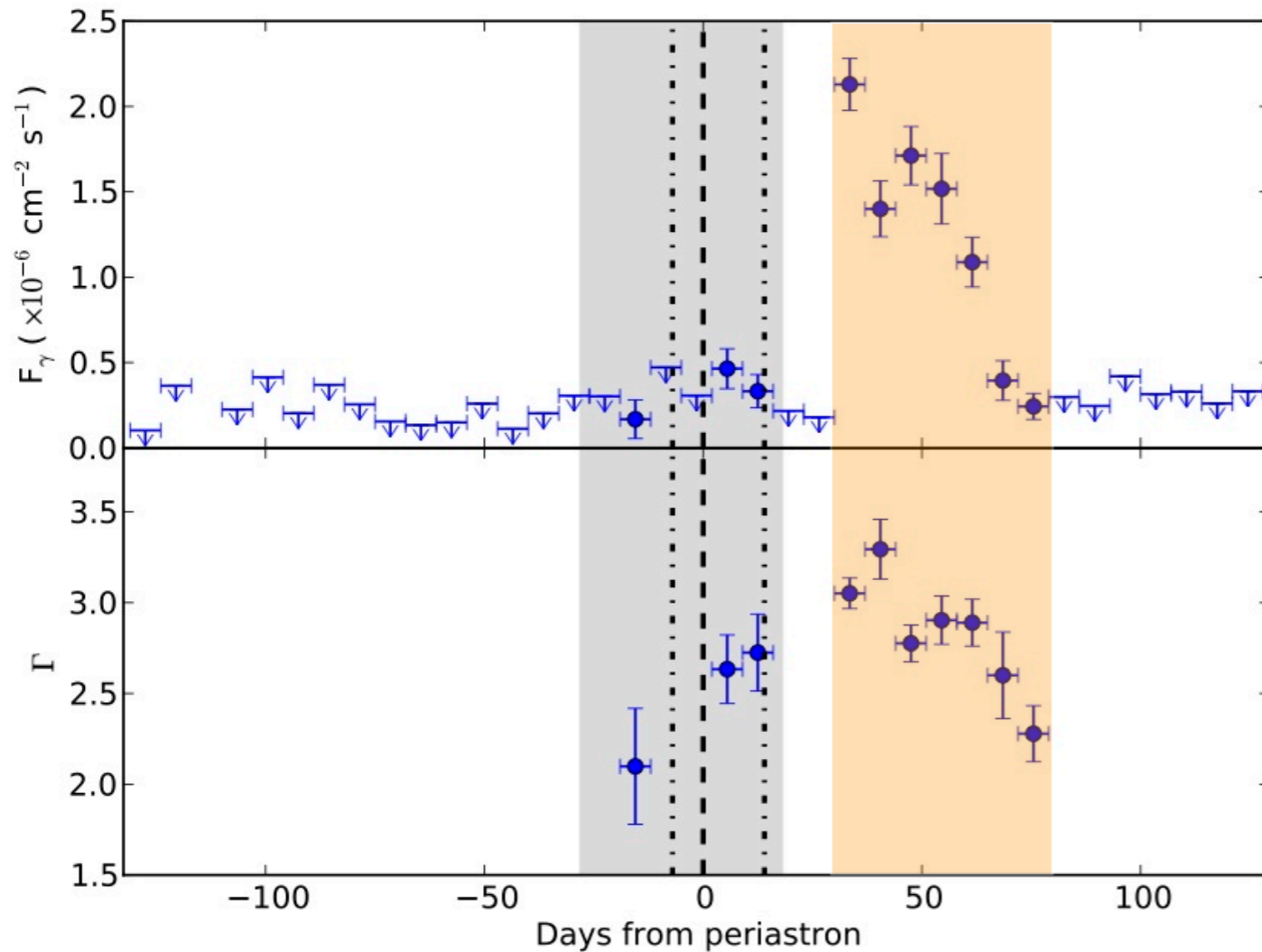
- striped wind (Pétri & GD 2011)
- cold wind (à la Khangulyan+ 2012)
- thermalized particles at shock (Zabalza+ 2013, GD & Cerutti 2013)
- shocked stellar wind (Bednarek 2011)

a clue to pulsar emission process ?

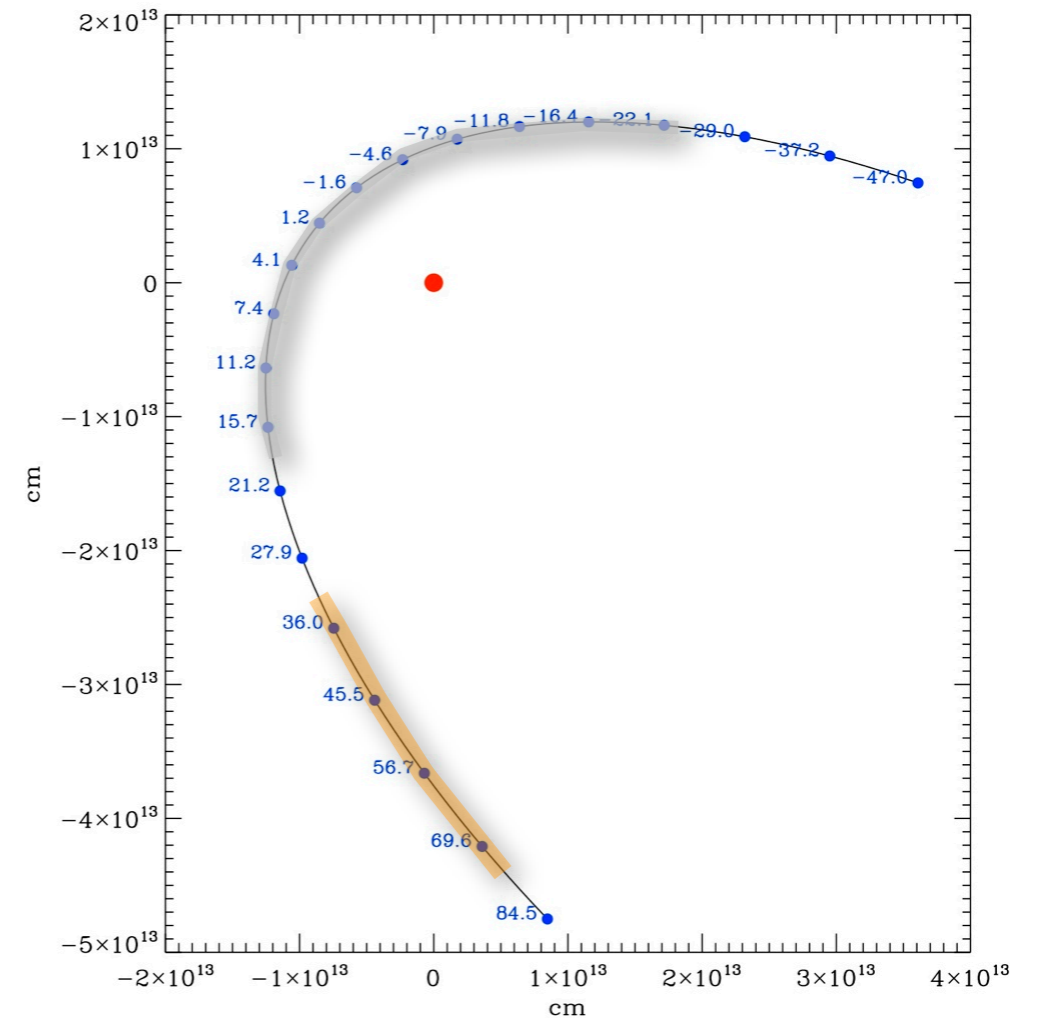


# Puzzle: GeV flare of PSR B1259-63

Fermi/LAT lightcurve (Abdo et al. 2011)

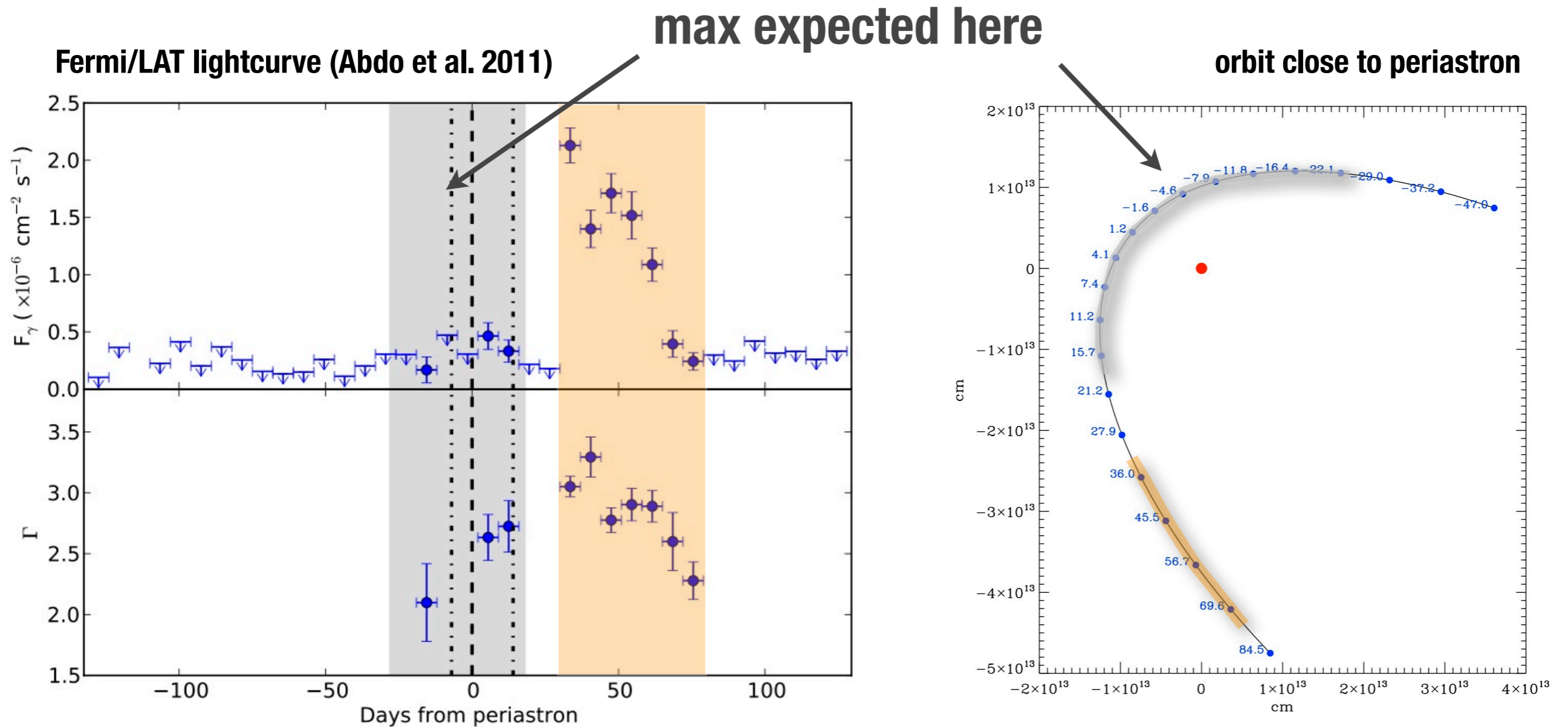


orbit close to periastron



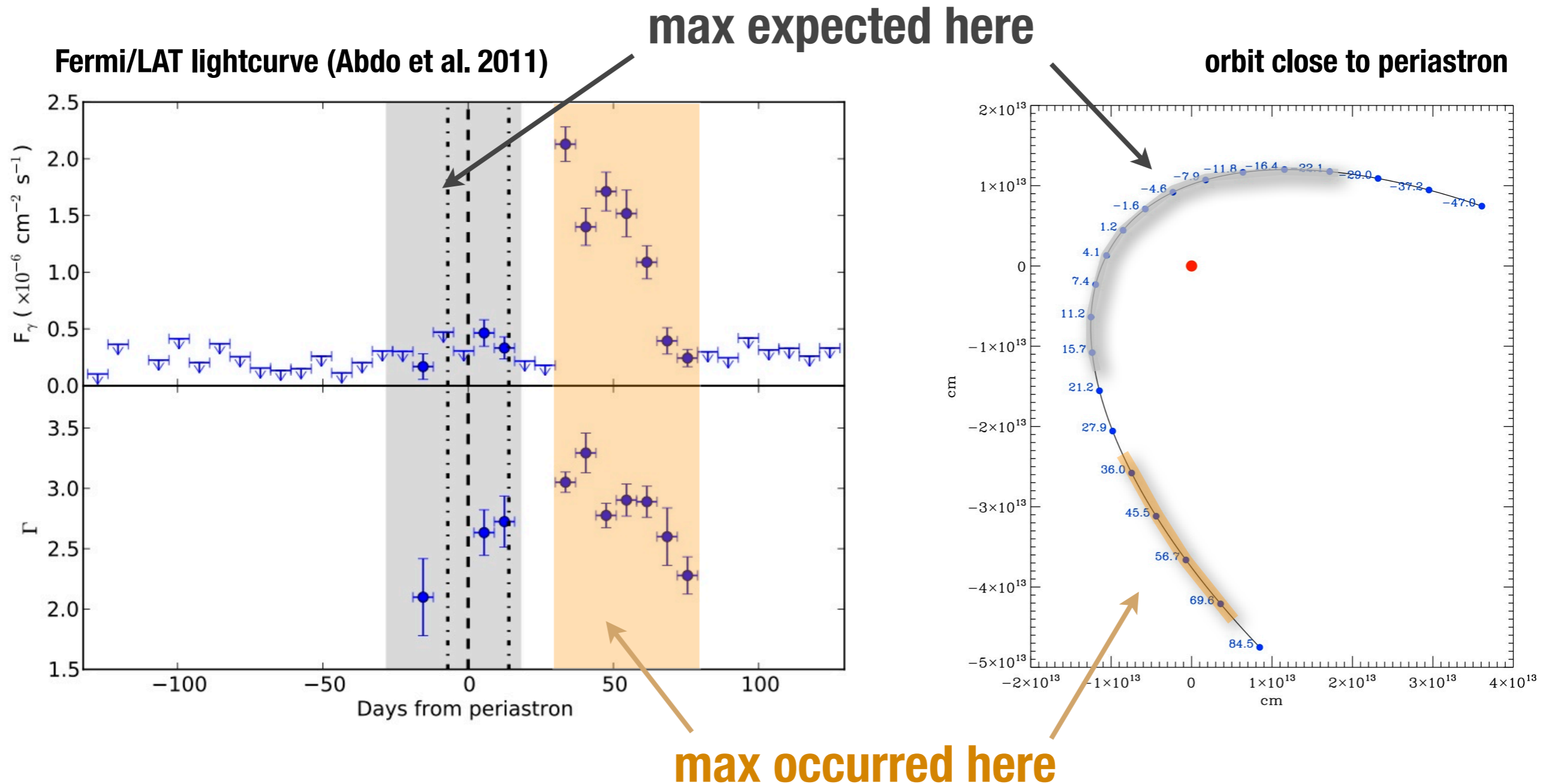
orbital phasing unexpected for inverse Compton scattering of stellar photons

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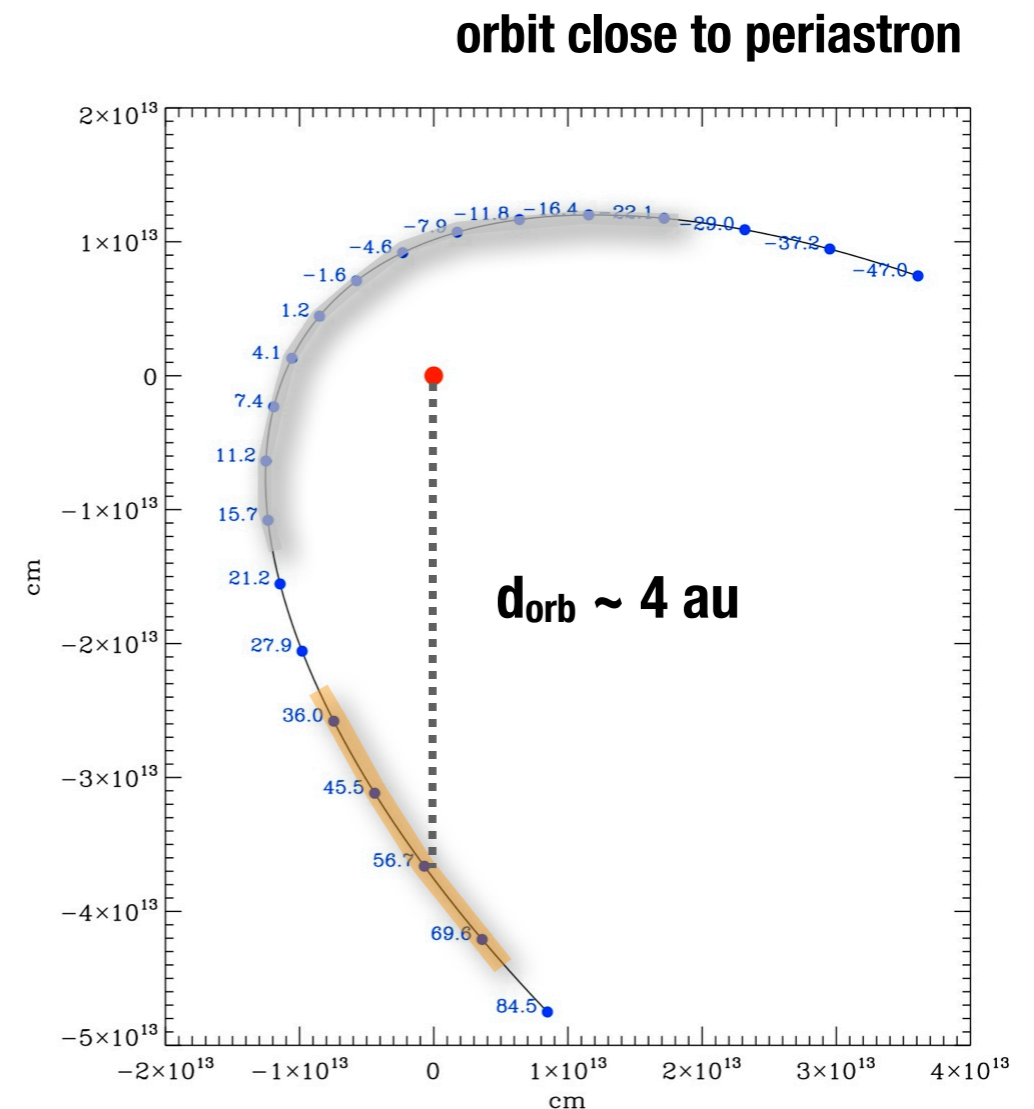
orbital phasing unexpected for inverse Compton scattering of stellar photons

# Puzzle: GeV flare of PSR B1259-63

Extremely efficient radiation with  $L_\gamma \sim$  spindown power !

If inverse Compton, need very high radiation density to allow electrons to cool on a scale  $\sim d_{\text{orb}}$

- Be disc photons ? (Khangulyan+ 2012)
- SSC on PWN emission ? (GD & Cerutti 2013)





# Puzzle: GeV flare of PSR B1259-63

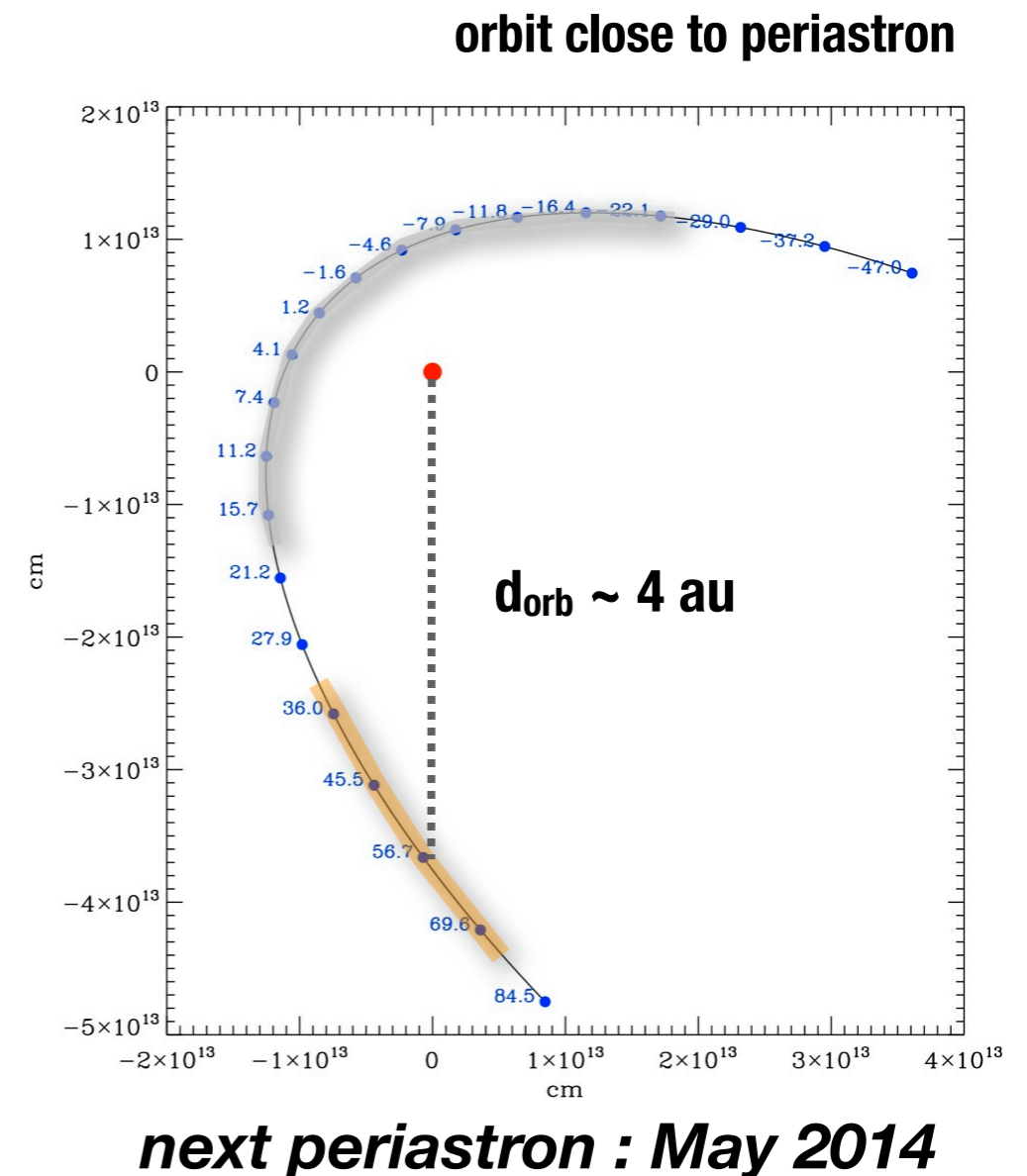
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## Alternatives to IC

- Doppler boosting (GD+ 2010, Kong+ 2012)
- conversion to EM wave (Mochol & Kirk 2013)
- Crab-like reconnection unrelated to orbit ?



# The puzzling $\gamma$ -ray binaries

- **Gamma-ray binaries powered by pulsar spindown, energy dissipated in shock with stellar wind → new probes of pulsar physics**
- **Puzzle: the GeV spectral component**

Is the similarity with emission from other pulsars telling us something about pulsar physics or ... a red herring ?
- **Puzzle: the gamma-ray flare of PSR B1259-63**

Is it due to complex inverse Compton geometry (need simulations of interaction region see A. Lamberts, MHD // tomorrow) or is it evidence for alternate emission mechanisms ?