Modeling the high-energy radiation in gamma-ray binaries

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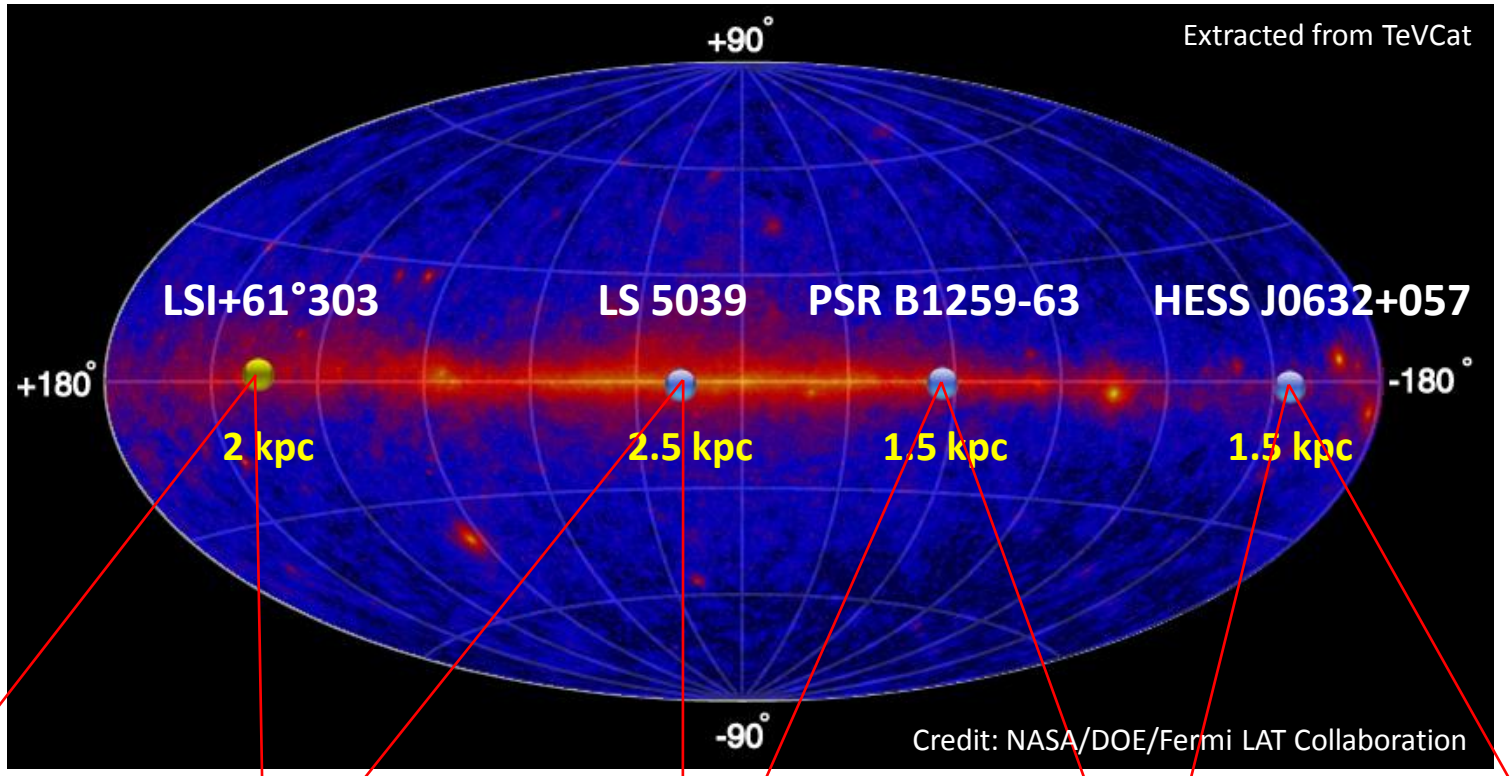
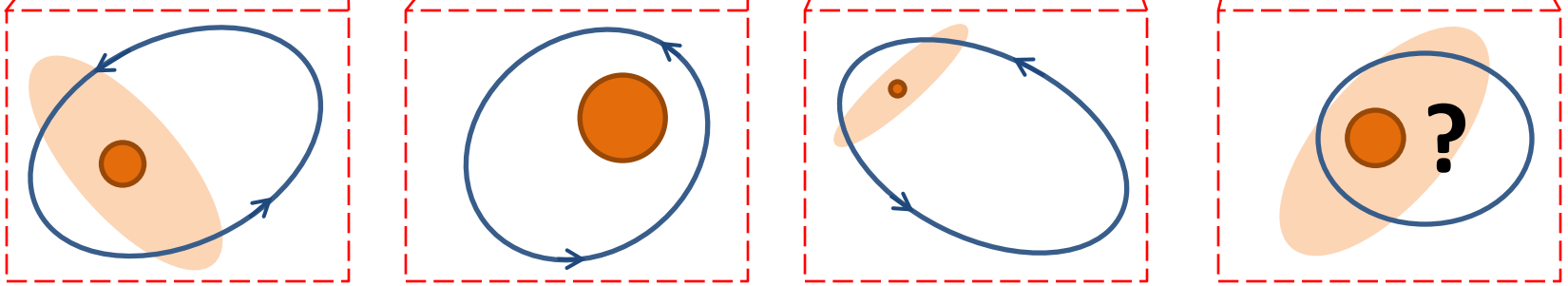
Some binaries in the gamma-ray sky



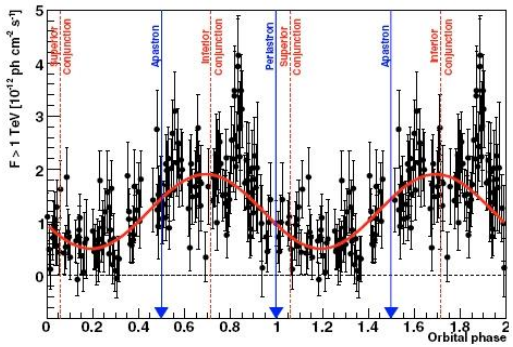


26.5 days | 3.9 days | 1240 days | ?

GeV & TeV beacons: The orbital modulation

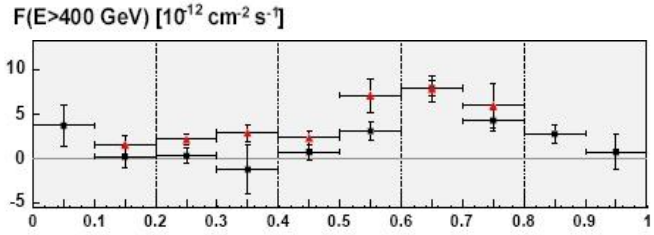
TeV

LS 5039



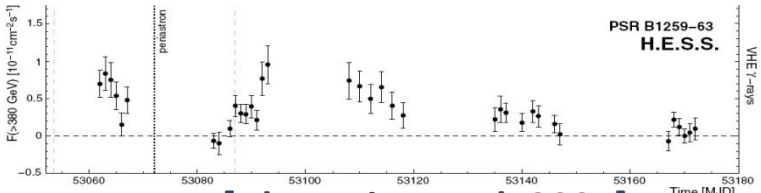
[Aharonian et al. 2006]

LSI +61°303



[Albert et al. 2008]

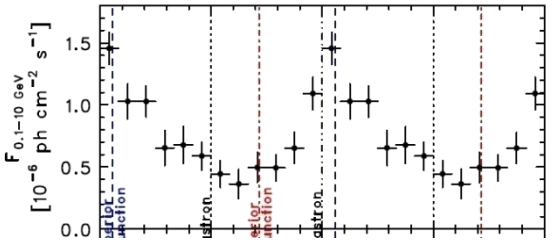
PSR B1259-63



[Aharonian et al. 2005]

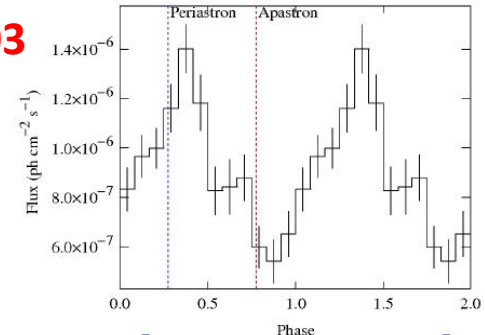
GeV

LS 5039



[Abdo et al. 2009]

LSI +61°303



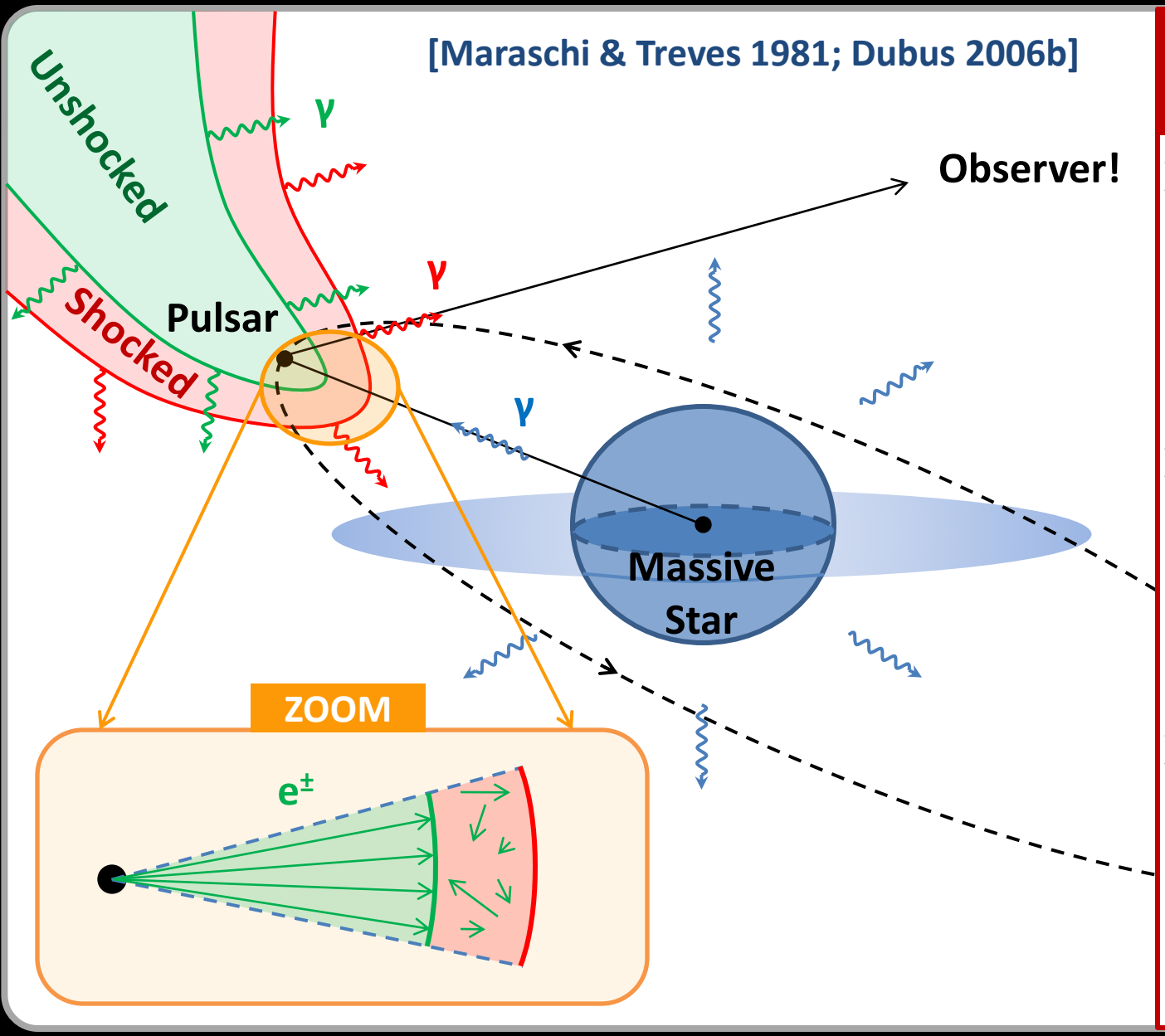
[Abdo et al. 2009]

➔ **Richard Dubois' Talk!!**

- Orbital modulation **GeV** and **TeV**
- Stable modulation

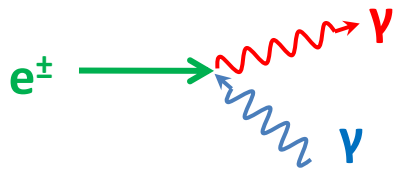
➔ **Orbital effect**

The pulsar wind nebula scenario: The big picture!

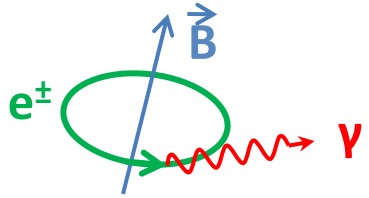


High-energy processes:

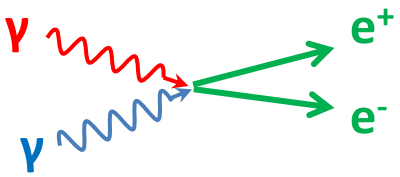
- Inverse Compton



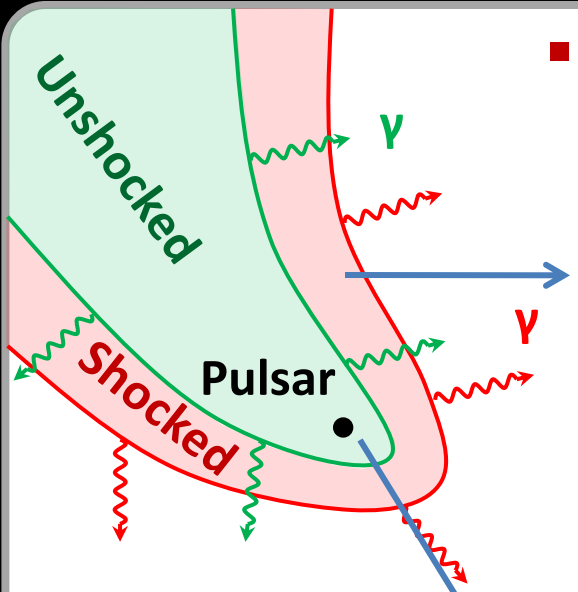
- Synchrotron radiation



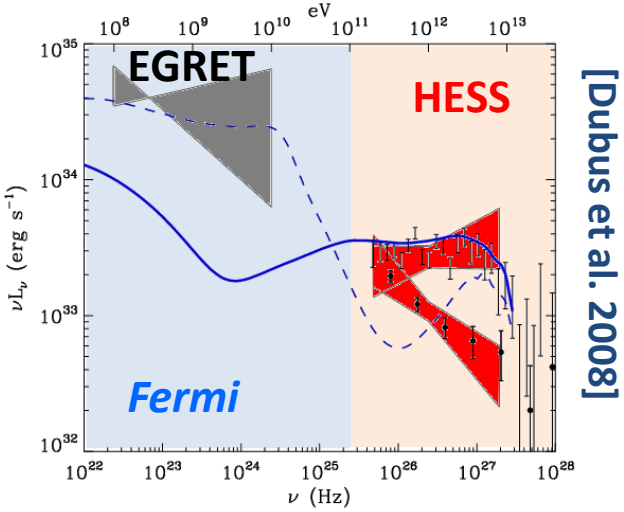
- Pair production



Modeling the high-energy radiation in LS 5039



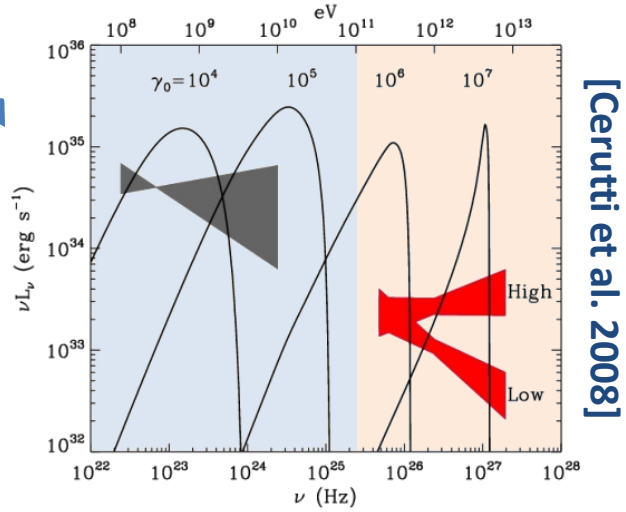
- **Emission shocked wind**



[Dubus et al. 2008]

- Pulsar spin-down power
  $L_p=10^{36}$ erg/s
- Magnetic field at the shock
  B=0.8 ± 0.2 G
- Injected electron index
  p=2 ± 0.3

- **Emission unshocked wind**



[Cerutti et al. 2008]

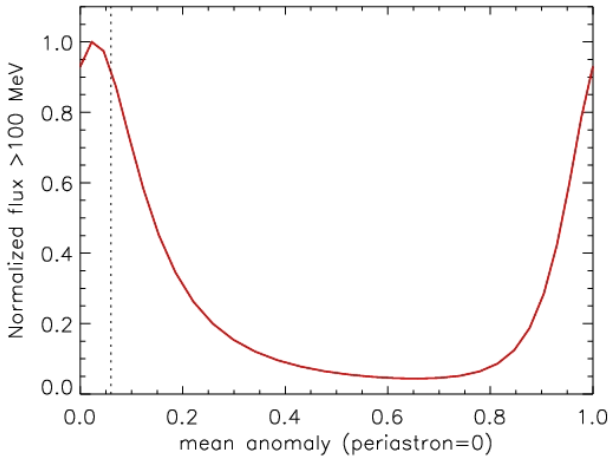
- **Strong** spectral signature!
- **Low** Lorentz factor or **highly magnetized** wind?
- **Dominant** contribution

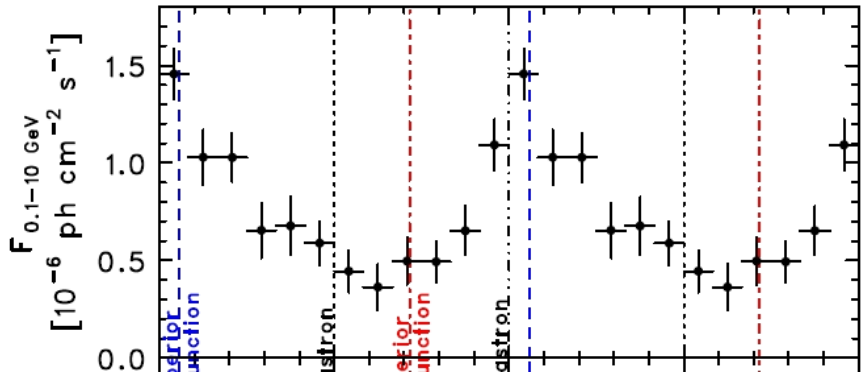
[Sierpowska-Bartosik & Torres 2008]

Theoretical GeV & TeV modulation in LS 5039…

+ Cascades!

Fermi

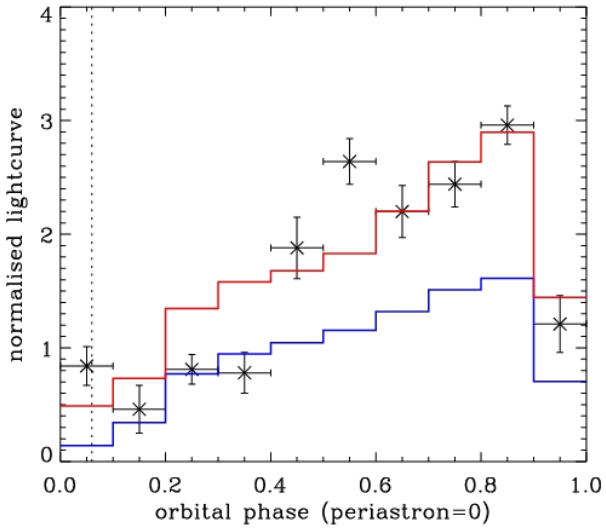




[Abdo et al. 2009]

Anti-correlation!

HESS

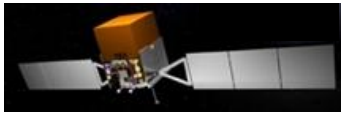


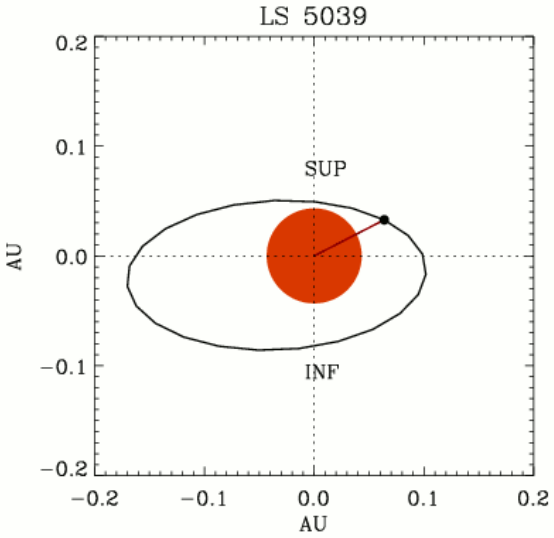
[Cerutti et al. In preparation]

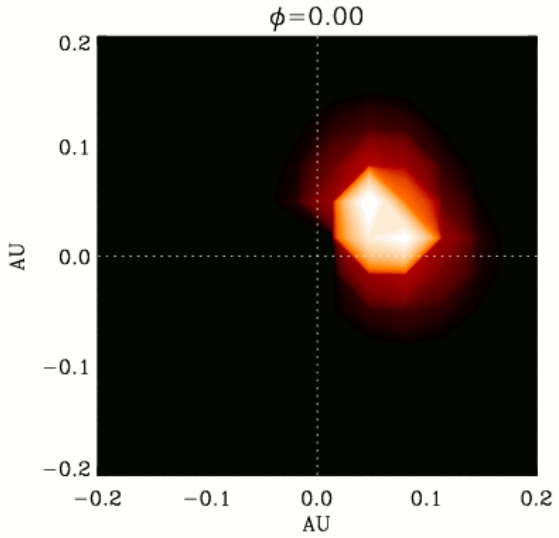
- GeV-TeV **anti-correlation** due to **pair production** [Dubus 2006a]
- Computation of **3D pair cascade radiation** with a Monte Carlo code, constraints:
  - **Inclination**: **40°**
  - Max ambient **magnetic field**: **5 G**
  - TeV emitter **close** to the pulsar

… as one would observe in the gamma-ray sky!

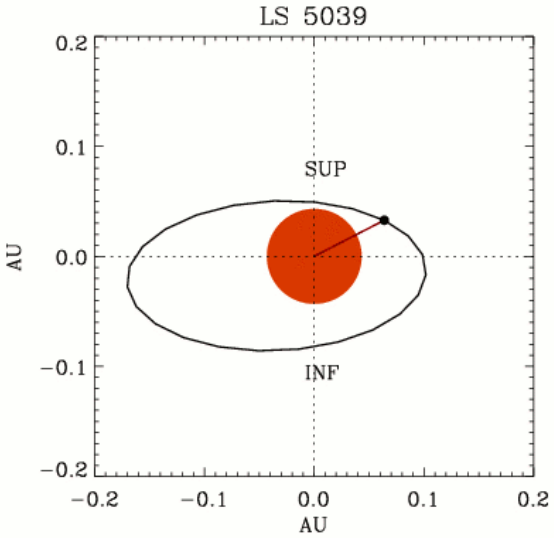
Fermi

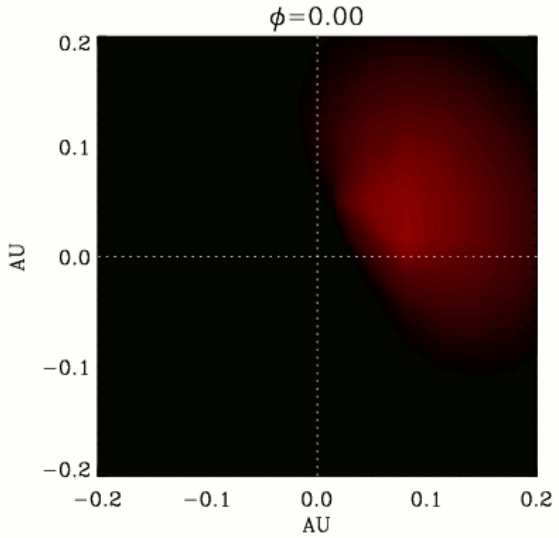




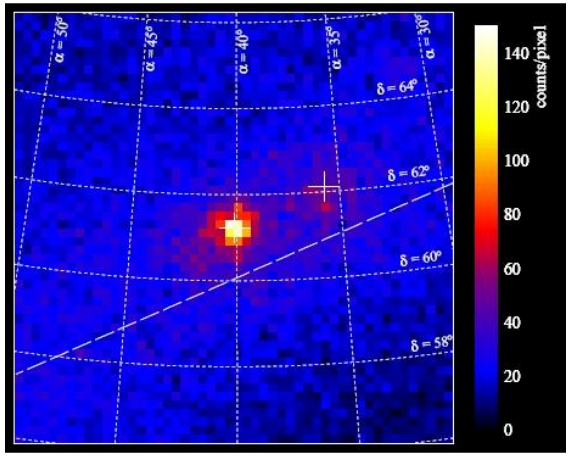


HESS

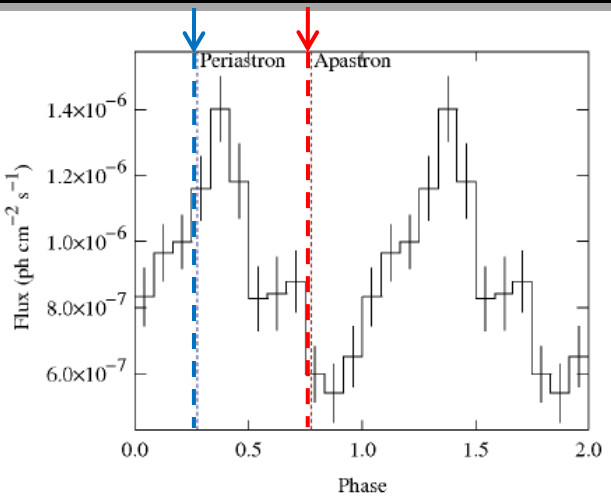


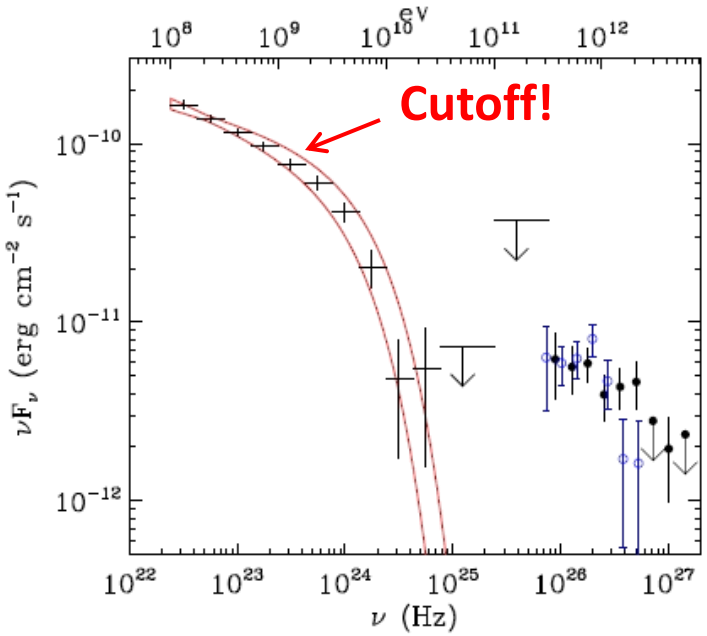


New modeling challenges: LSI +61°303 seen by *Fermi*



[Abdo et al. 2009]





○ GeV modulation :

Max/Min close to **periastron**/**apastron**

○ Spectrum:

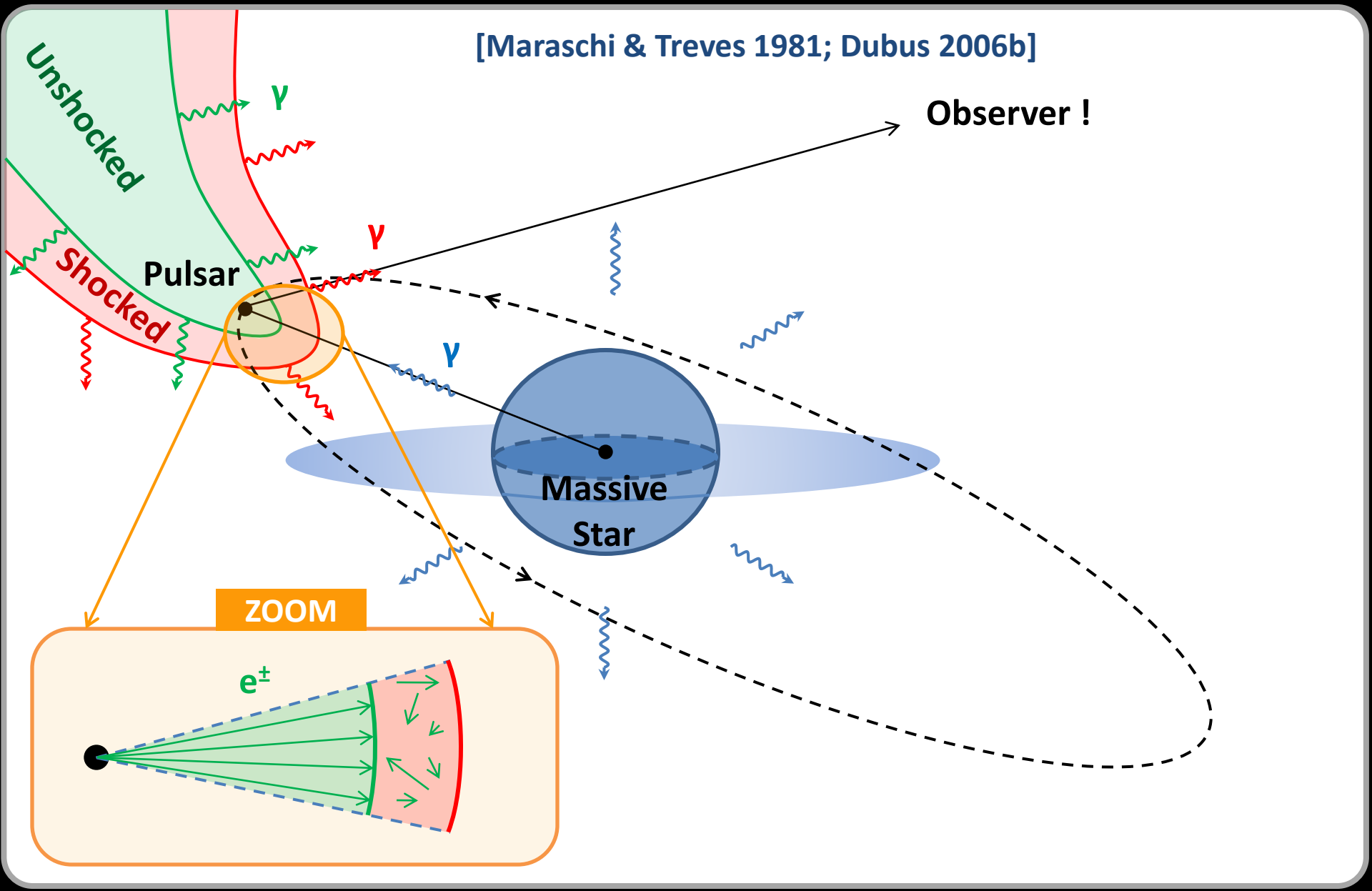
Power-law + **exponential cutoff** at 6 GeV !

- **Incompatible** with γγ-absorption
- **Magnetospheric** pulsar emission?
- Signature **unshocked pulsar wind**?

...

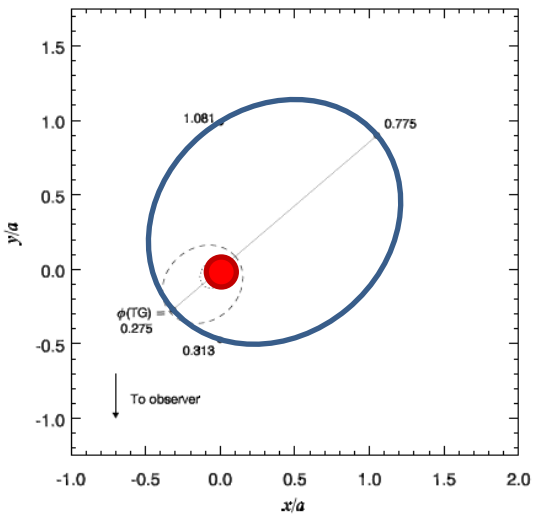
GeV-TeV link non trivial!!

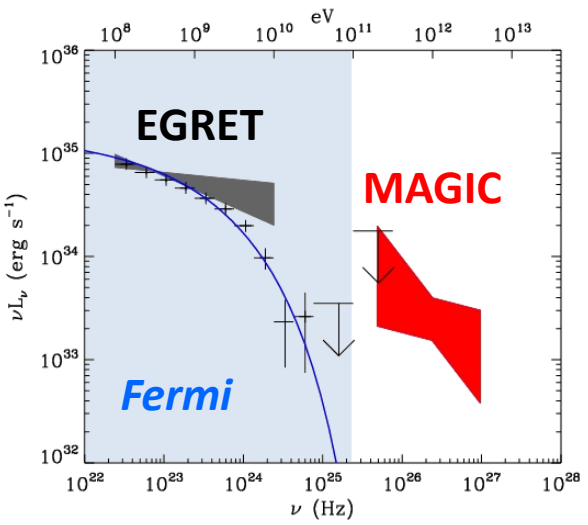
The pulsar wind nebula scenario: The big picture!



GeV excess: Signature of the unshocked pulsar wind?

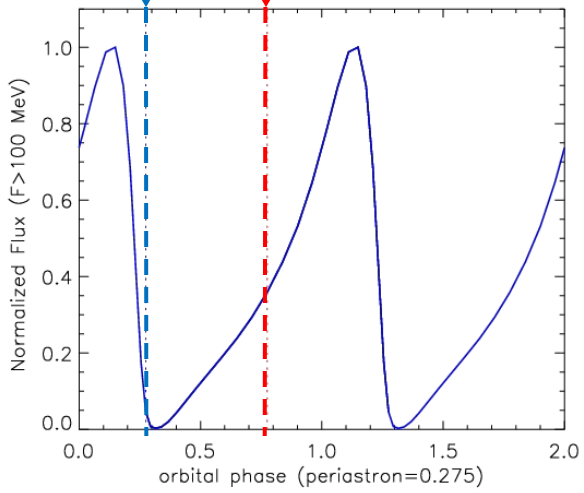
[Aragona et al. 2009]



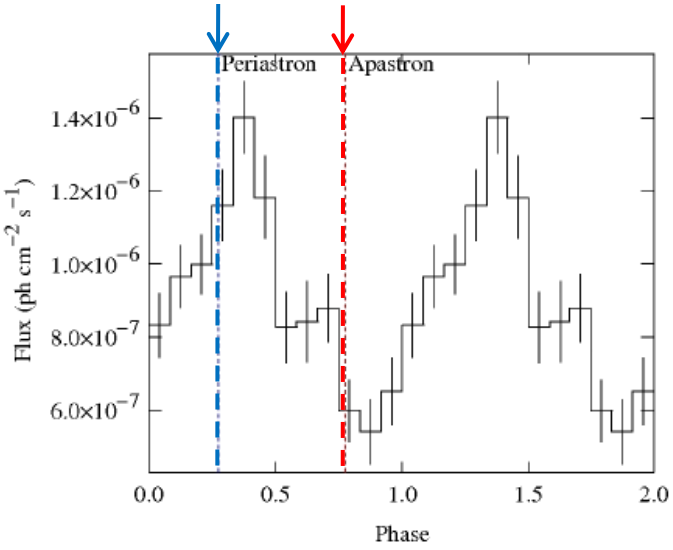


- Pulsar spin-down power
  $L_P > 10^{37}$ erg/s
- Electrons energy
  $10^3 < \gamma < 5\times10^4$
- Injected electron index
  p=3.1

Periastron **Apastron**



Shift in phase!?
+ 0.25 ??



[Abdo et al. 2009]

Conclusions

- **Leptonic model** can explain the general features but **complex interplay** between high-energy processes for:
  - **Shocked**/**unshocked** wind components
  - **Anisotropic** effects
  - **Cascades**
- ***Fermi*** observations of **LSI +61°303**:
  - ➔ **Modulation** and **cutoff** spectrum challenge models
  - ➔ Are there **2 different components** at HE and VHE?
  - ➔ Signature from an **unshocked pulsar wind**?

Acknowledgements to A.B. Hill, A. Lamberts & A. Szostek