Gamma-ray emission and absorption in Cygnus X-3

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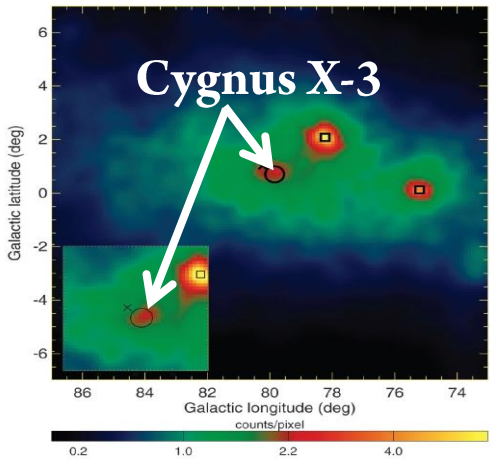
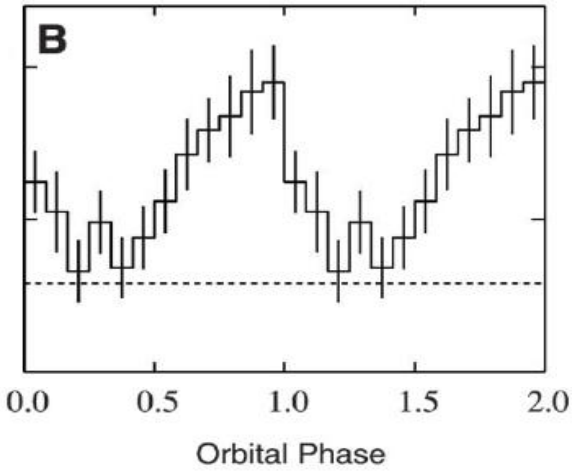
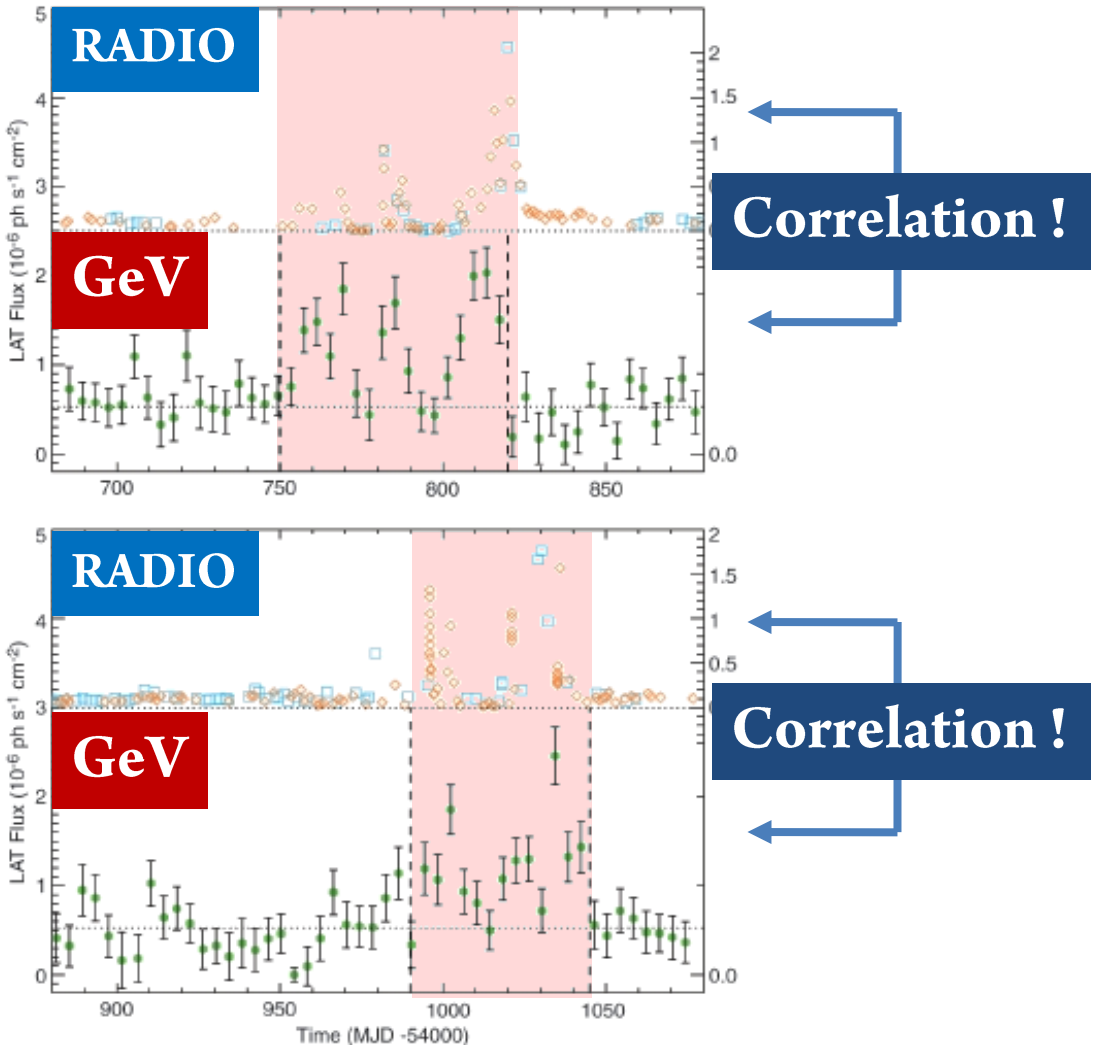
Cygnus X-3 is detected at GeV during radio flares

[Fermi LAT coll., 2009]



GeV light curve

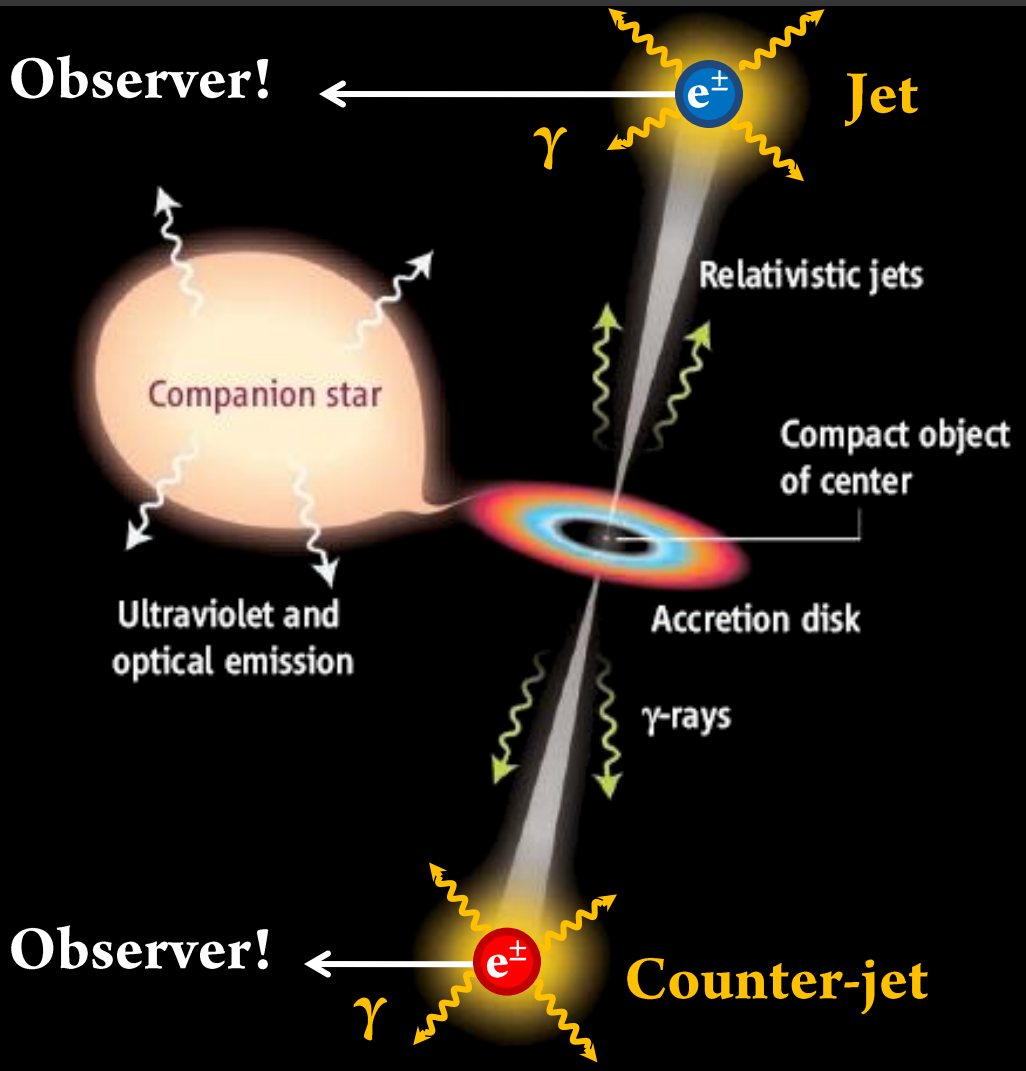




Orbital modulation (4.8 h)!

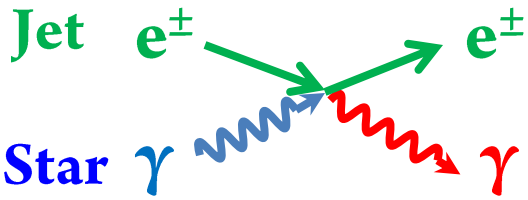
Gamma rays originates from the jet ?

Gamma rays are emitted by energetic pairs injected in an inclined and relativistic jet



Adapted from © F. Mirabel

Inverse Compton scattering



+

Relativistic Doppler effects

+

Anisotropic effects

+

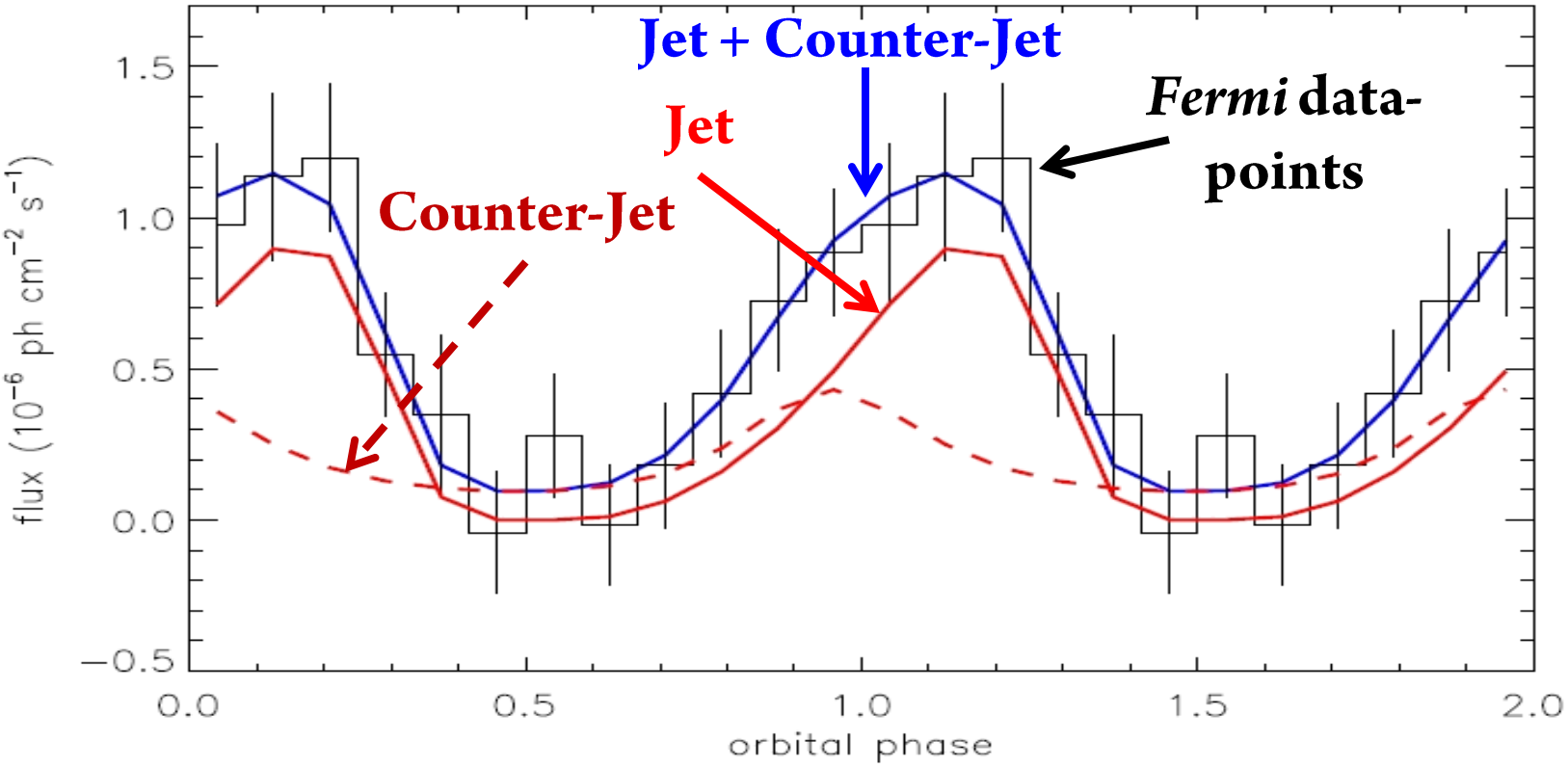
5 Free parameters

$H \quad \beta_{jet} \quad \phi_{jet} \quad \theta_{jet} \quad P_e$

➔ χ^2 minimization

The Doppler-boosted IC explains the GeV modulation

Example of a good fit solution



[Dubus, Cerutti, & Henri, MNRAS 2010]

$H \sim 3$ d $\quad \beta_{jet} \sim 0.45 \quad \phi_{jet} \sim 12° \quad \theta_{jet} \sim 106° \quad P_e \sim 10^{38}$ erg/s

The parameters of the jet are constrained by the model

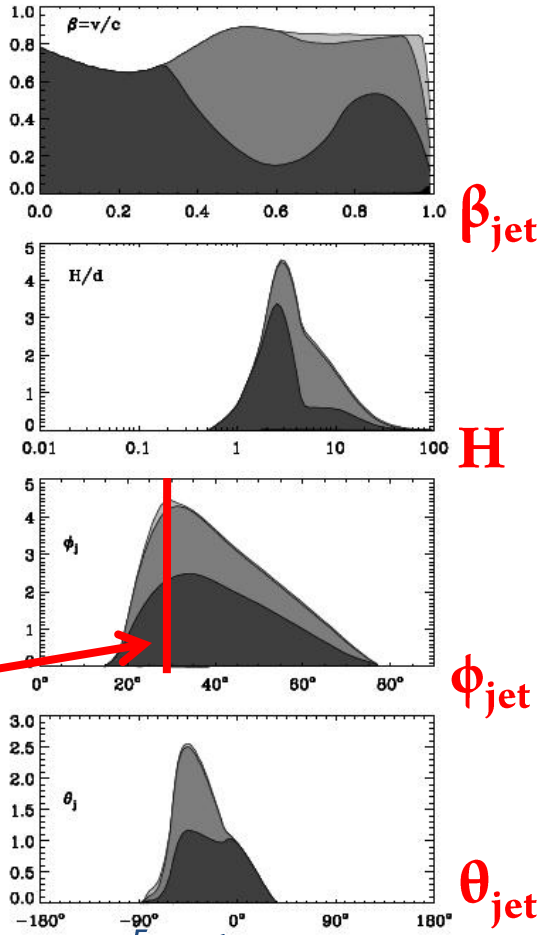
Legend

- $P_e < L_{edd}$
- $P_e < 0.1\ L_{edd}$
- $P_e < 0.01\ L_{edd}$

≈Line of sight

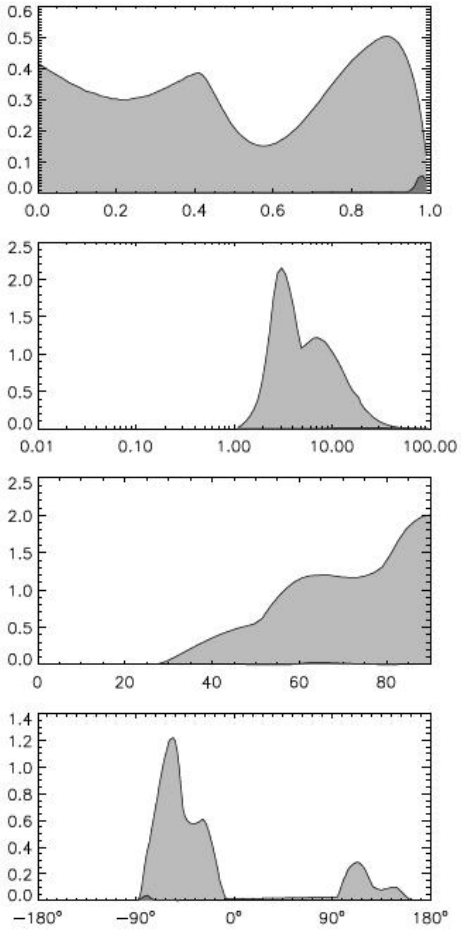
➔ *Microblazar!*

Black hole solution



β_{jet} H ϕ_{jet} θ_{jet}

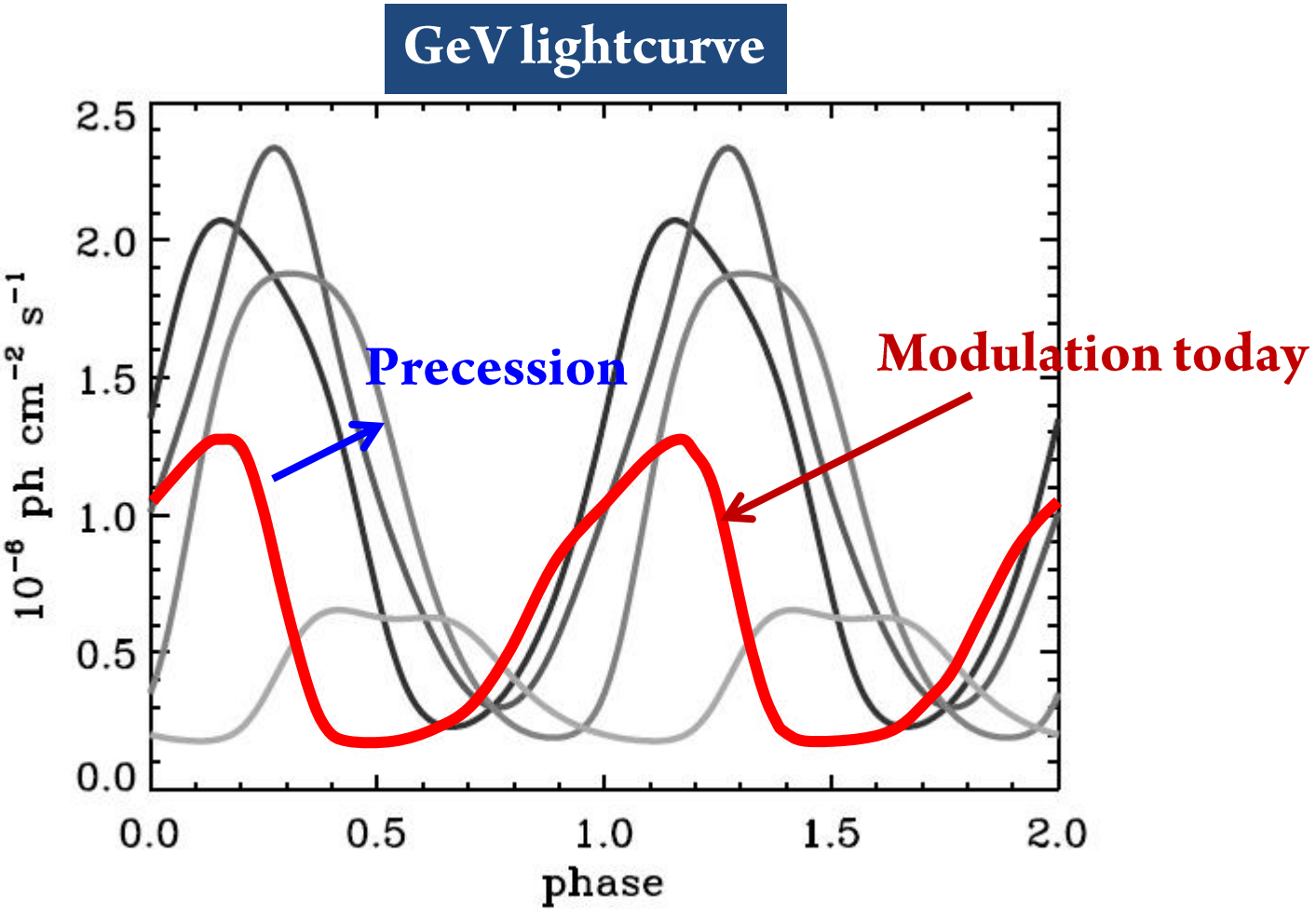
Neutron star solution



[Dubus, Cerutti, & Henri, MNRAS 2010]

➔ **Energetically favored!**

The precession of the jet changes the modulation

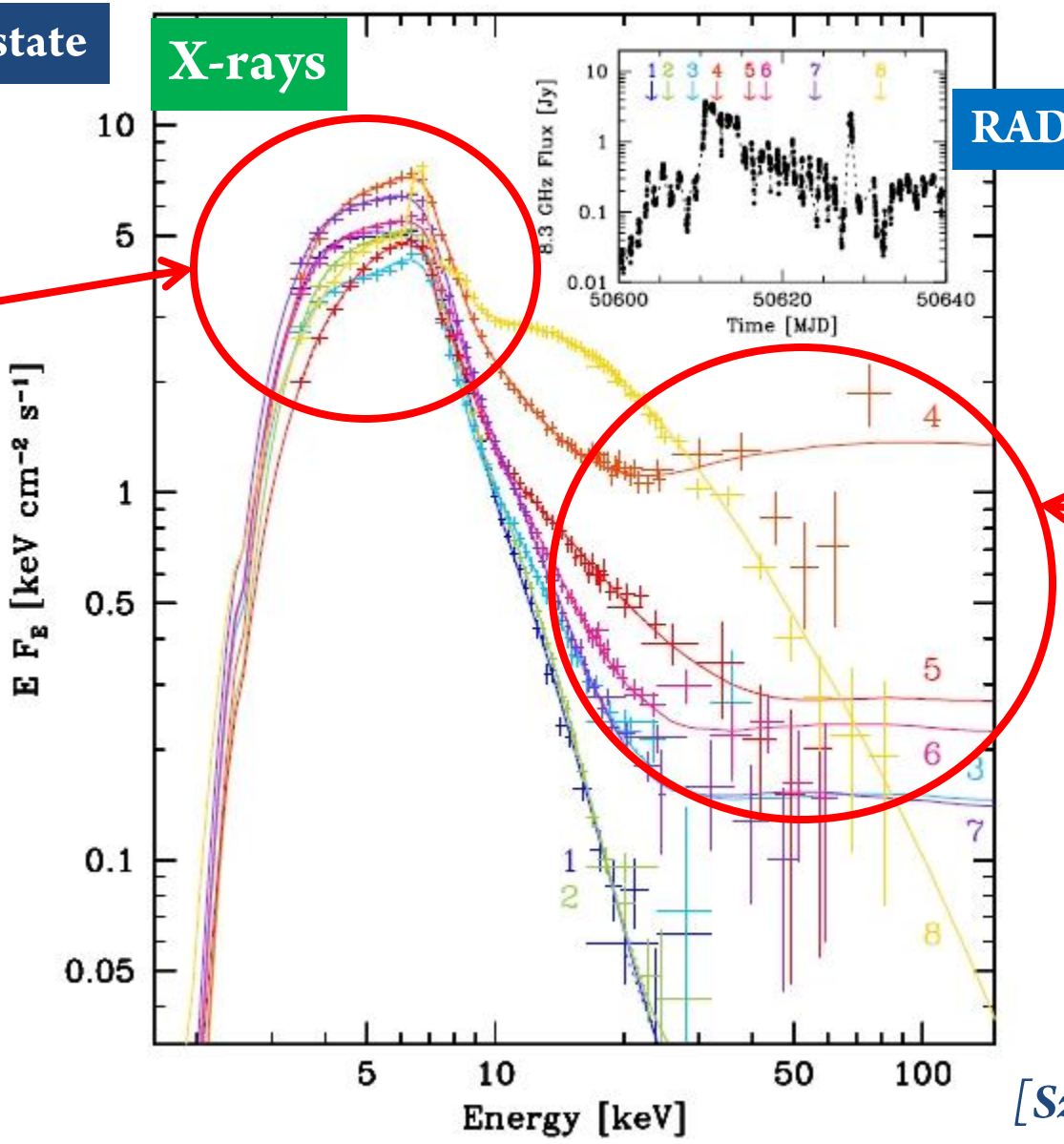


[Dubus, Cerutti, & Henri, MNRAS 2010]

Modification shape & amplitude

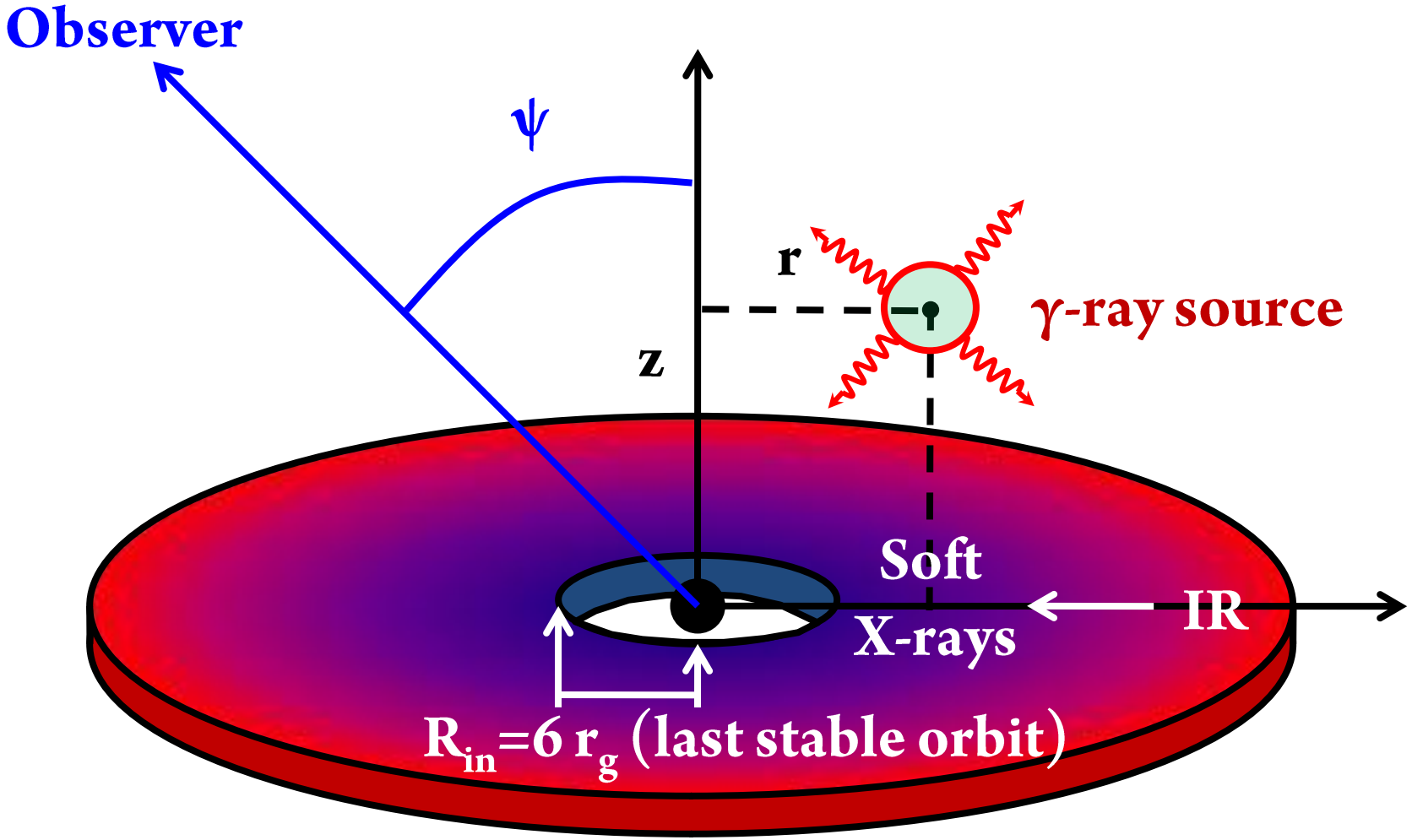
GeV γ-rays can be absorbed by the ambient X-rays

Cyg X-3 Soft state



[Szostek et al. 2008]

The accretion disk is the dominant source of X-rays



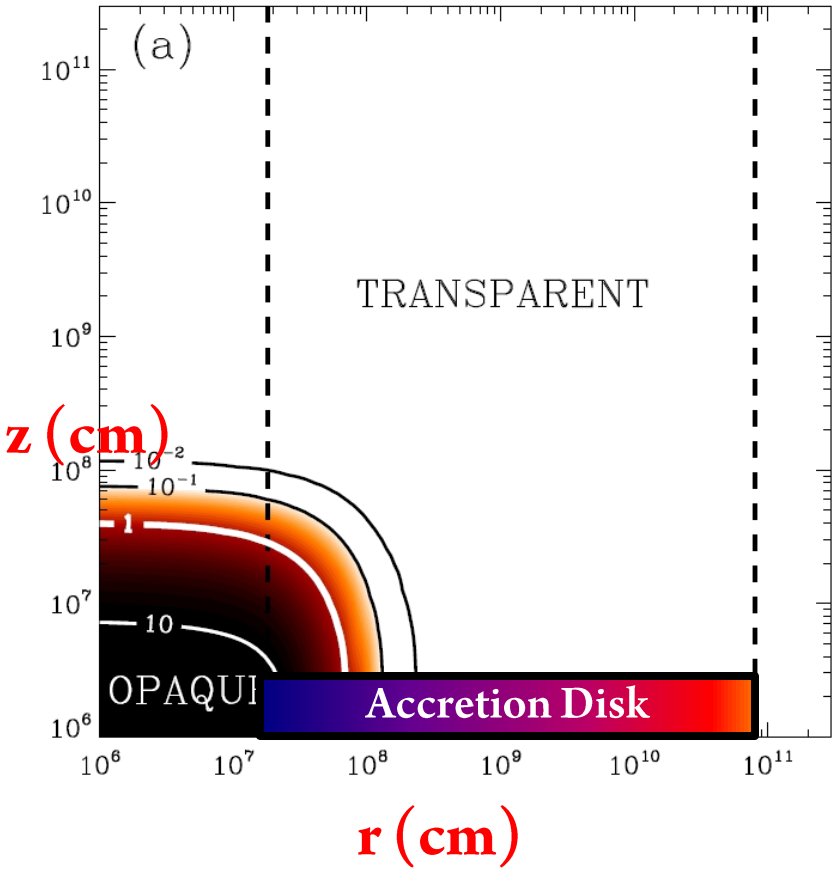
Standard accretion disk

(optically thick, geometrically thin)

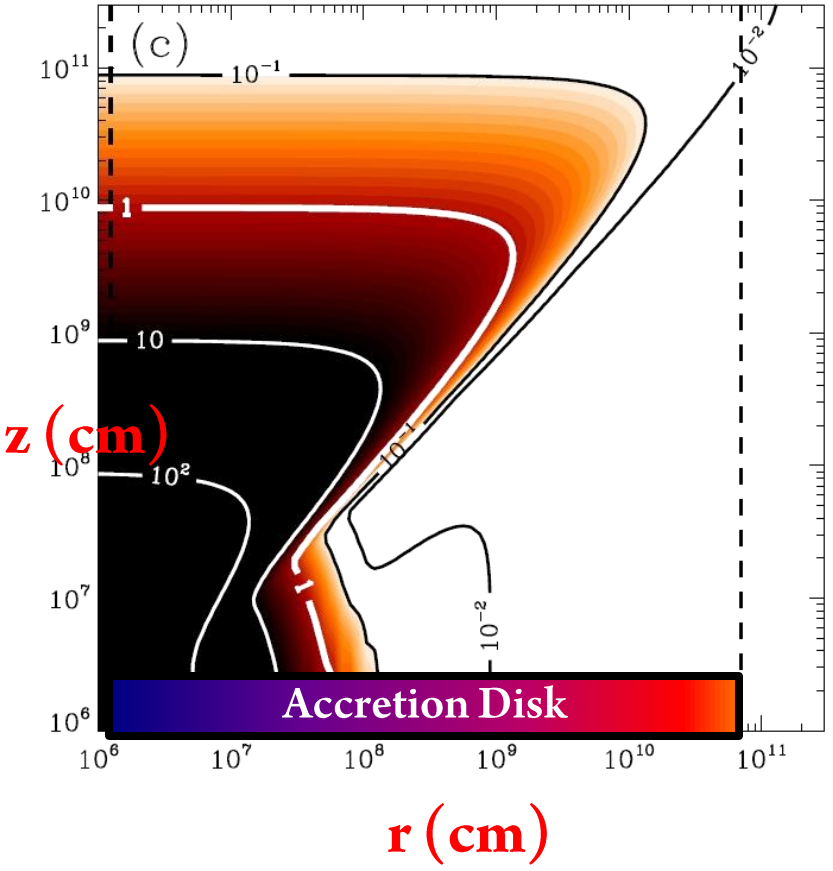
HE pairs should not be too close to the base of the jet

γ-ray opacity map above the disk

Black hole (ψ=30°)



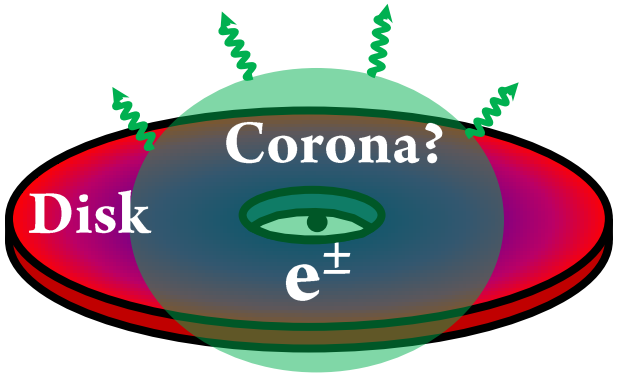
Neutron star (ψ=70°)

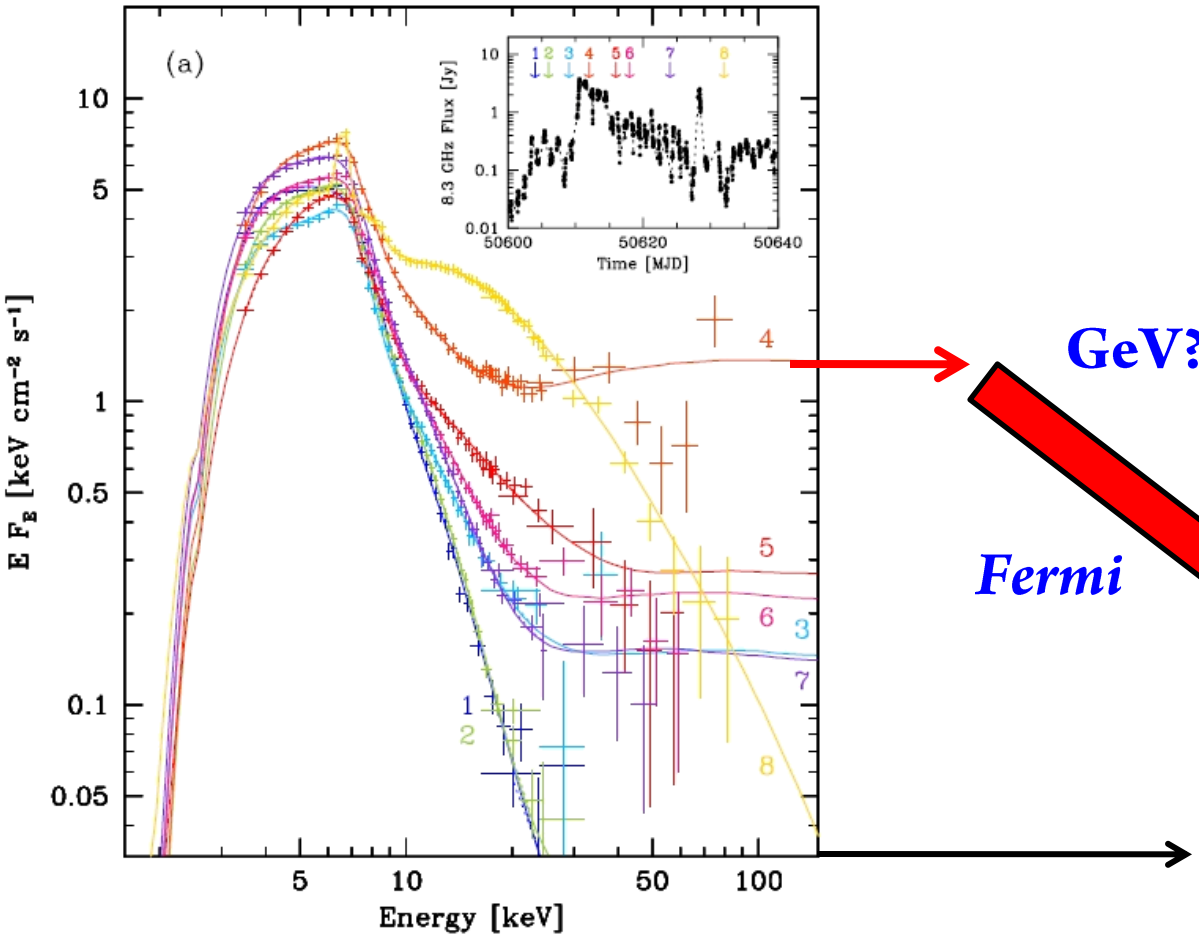


➔ H > 10^8 – 10^{10} cm

Do gamma rays originate from the corona in Cyg X-3?

Hard X-rays – GeV?



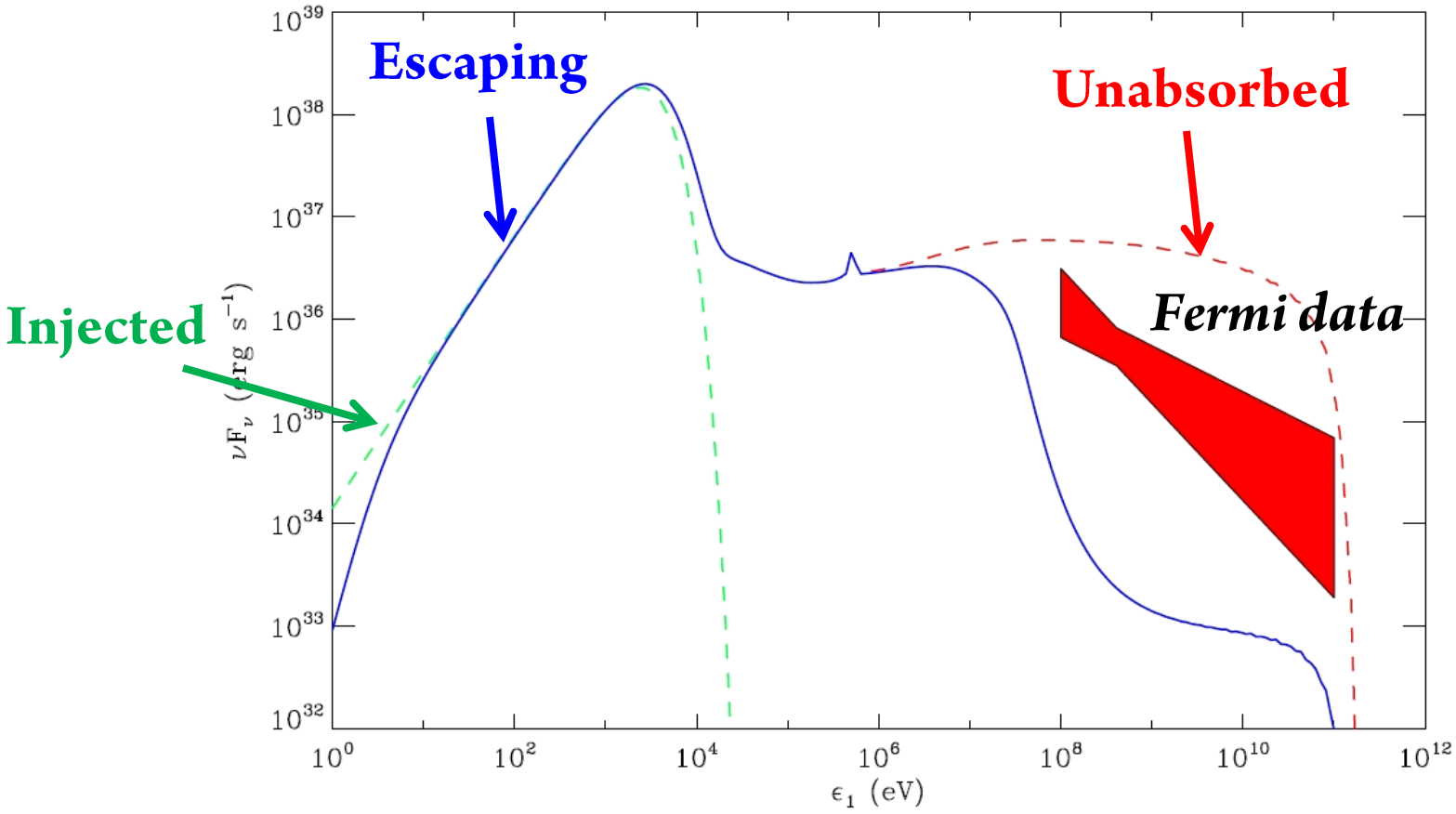


[Szostek et al. 2008]

GeV photons from the corona suffer from absorption

Escaping radiation from corona ($R=10^8$ cm)

Using ***Belm*** code
[Belmont et al., 2008]



Summary

γ-ray emission in Cyg X-3

- The jet should be **inclined**, close to the line of sight, **mildly** relativistic (**$\beta<0.9$**)
- Particles accelerated **far** from the compact object (**$H>10^{11}$ - 10^{13} cm**)
- Black-hole **favored**
- **Precession** of the jet changes significantly the γ-ray modulation

γ-ray absorption in Cyg X-3

- The γ-ray source **cannot be too close** to the compact object (**$H<10^{8}$ - 10^{10} cm**)
- Gamma-rays emitted by the corona would **suffer from internal absorption** ➔ **Extended corona?** (**$R_{corona}>10^{9}$ – 10^{10} cm**)