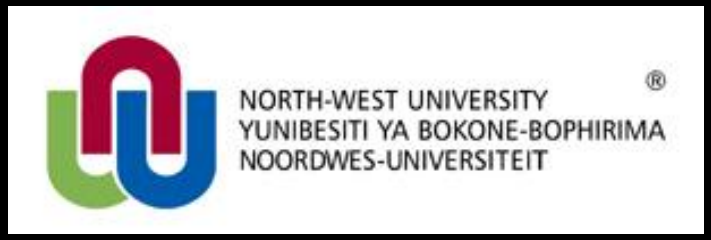


Role of the disk environment in the observed TeV light curve from PSR B1259-63/LS 2883

Iurii Sushch[1,2], Brian van Soelen[3] and Markus Böttcher[1]

[1]North-West University, South Africa

[2]Ivan Franko National University of L'viv, Ukraine

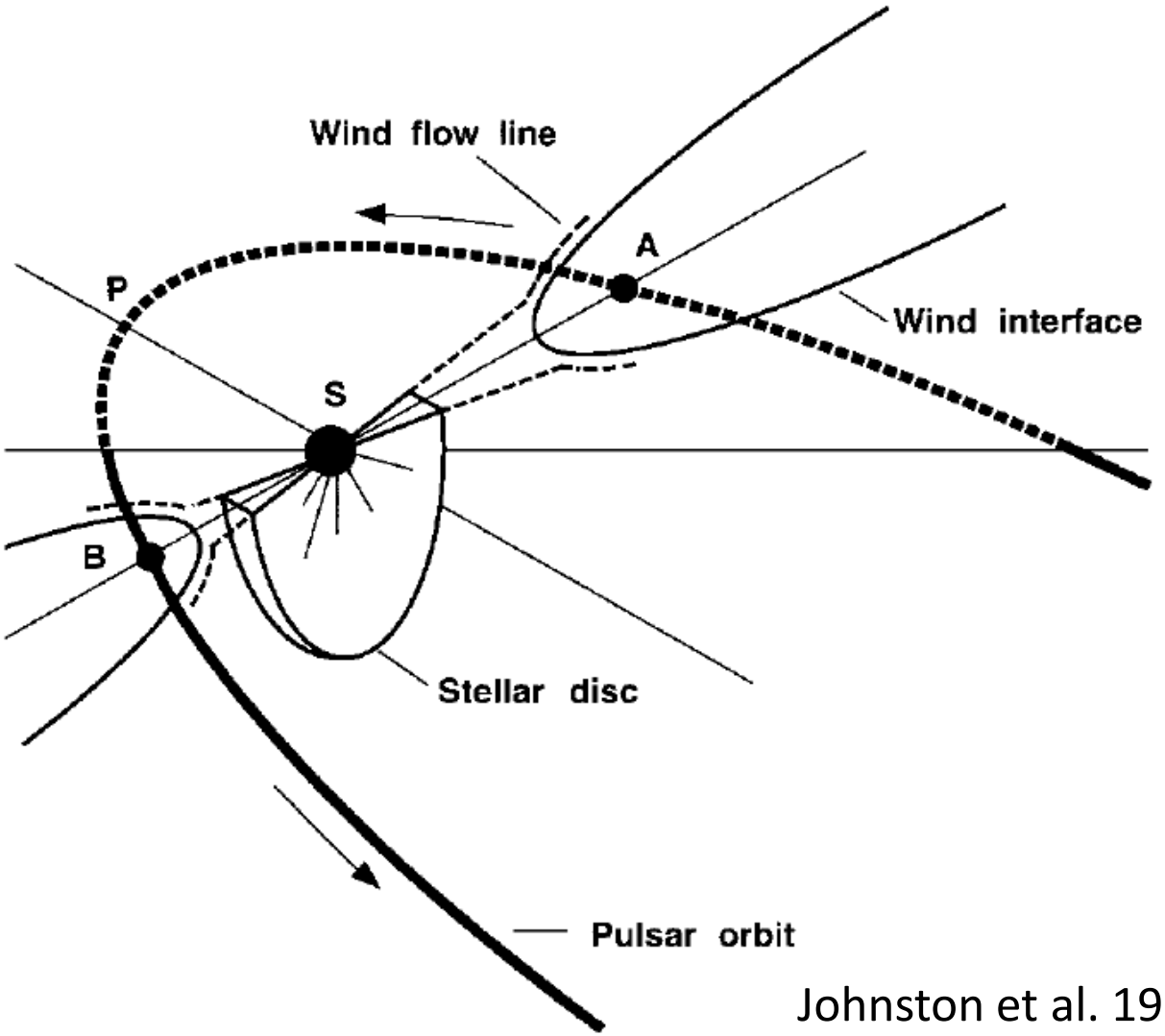
[3]University of the Free State, South Africa

HEPRO V, La Plata, Argentina, 7 Oct 2015

PSR B1259-63/LS 2883

PSR B1259−63
- P = 48 ms
- $L_{SD} = 8 \times 10^{35}$ erg/s
- $t_c = 3.3 \times 10^5$ years
- P_{orb} = 3.4 years
- Eccentricity = 0.87

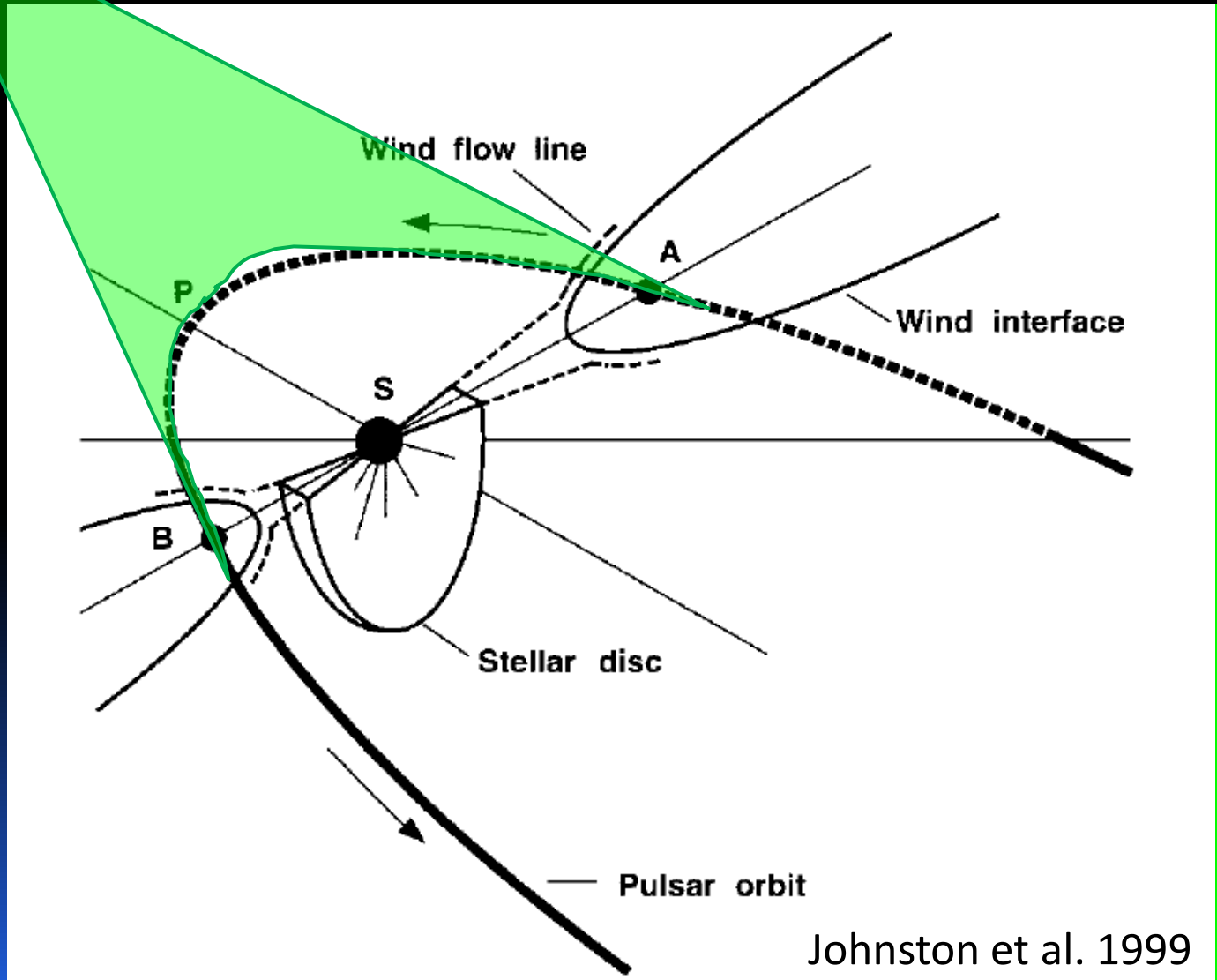
LS 2883
- Be star
- Circumstellar disk
- $L_{star} = 2.3 \times 10^{38}$ erg/s
- T = 27500 – 30000 K
- $M \approx 31\ M_{sun}$
- $R = 8.1 – 9.7\ R_{sun}$
- D = 2.3 kpc



Johnston et al. 1999

PSR B1259-63/LS 2883: unpulsed emission

Radio pulsed emission disappears as the pulsar goes behind the disk

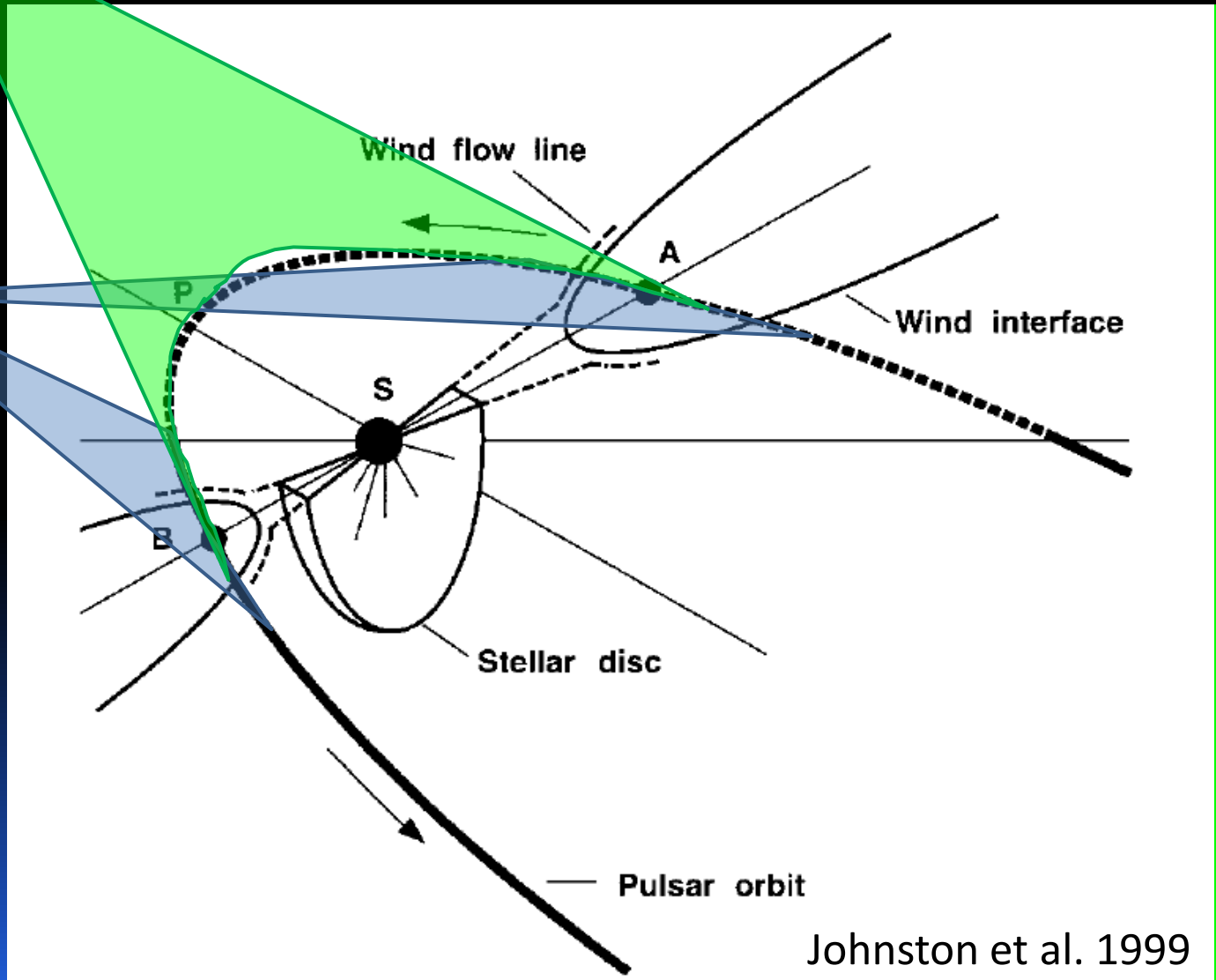


Johnston et al. 1999

PSR B1259-63/LS 2883: unpulsed emission

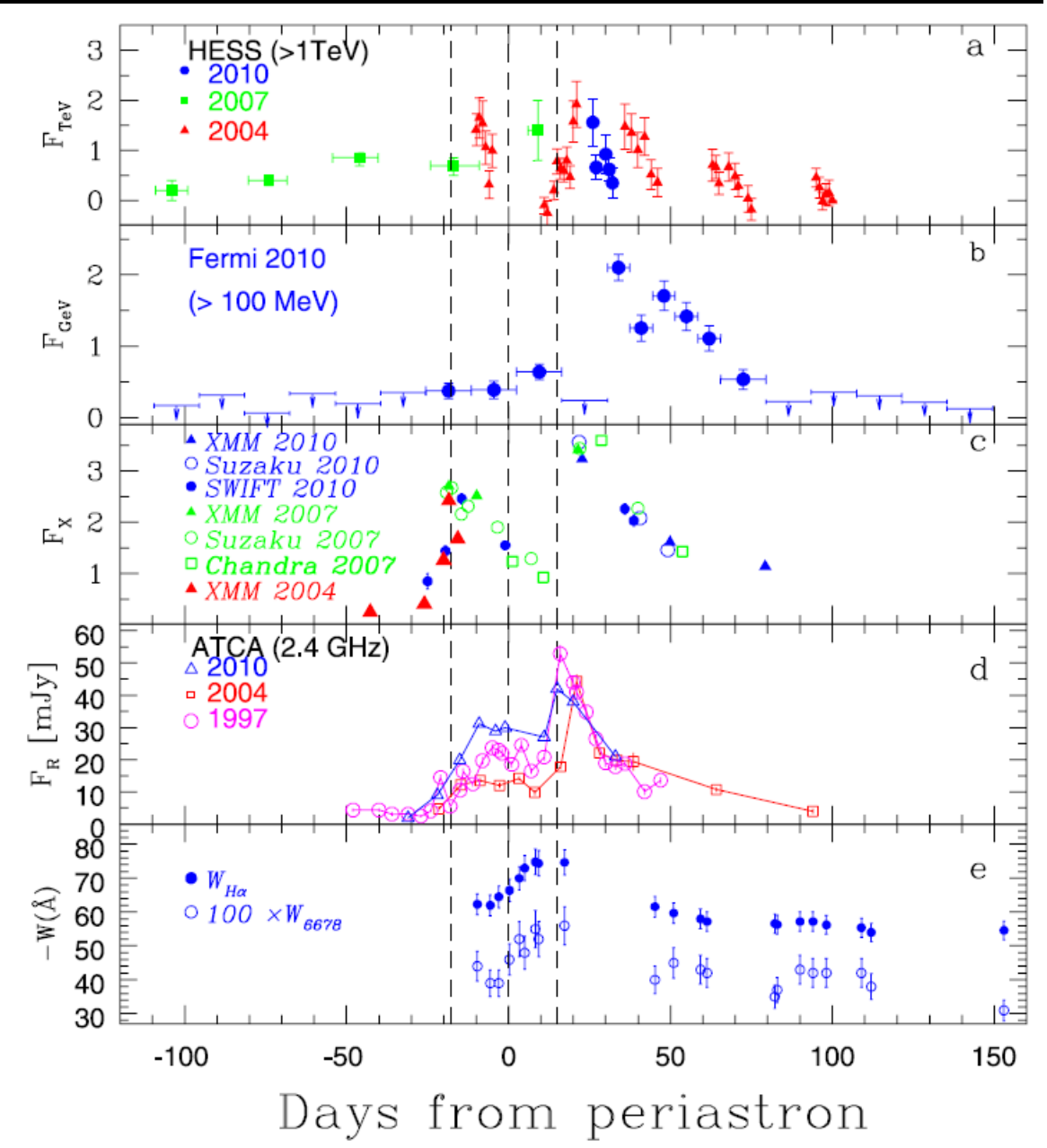
Radio pulsed emission disappears as the pulsar goes behind the disk

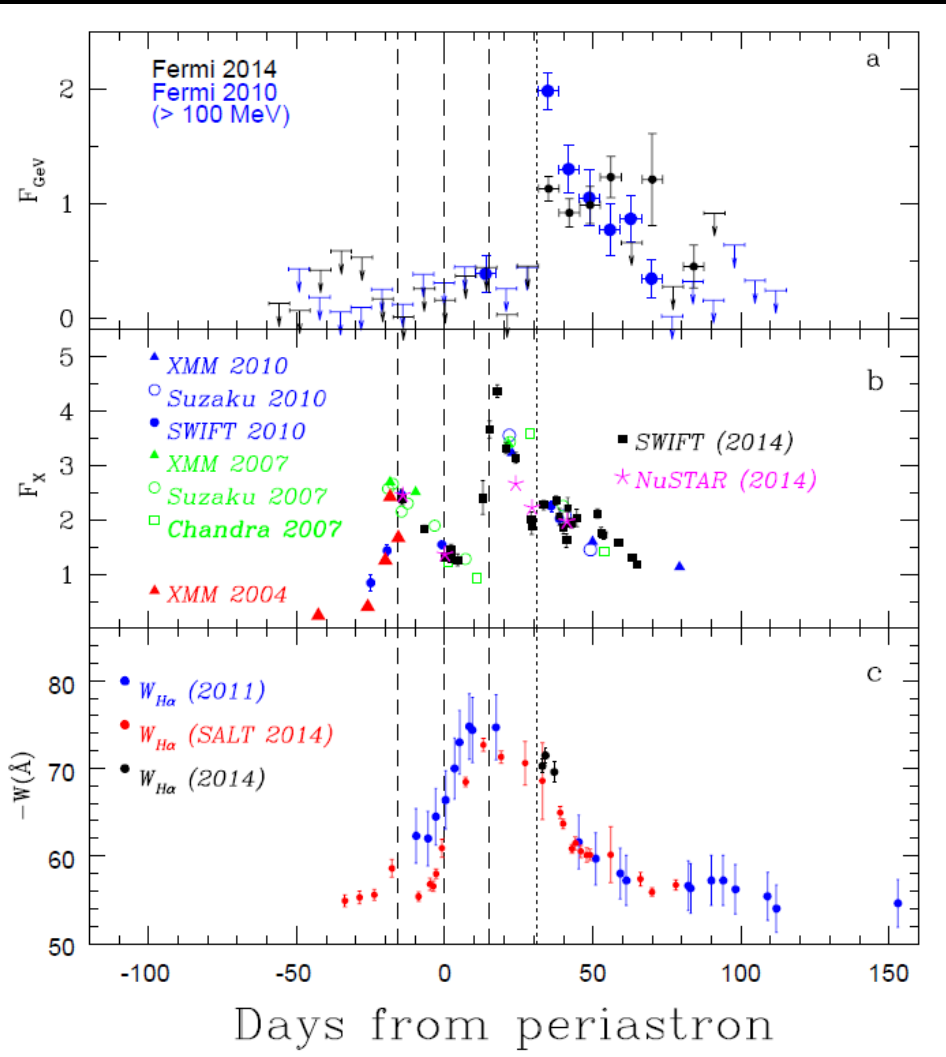
The unpulsed emission from the system is enhanced when the pulsar interacts with the circumstellar disk



Johnston et al. 1999

Across the spectrum



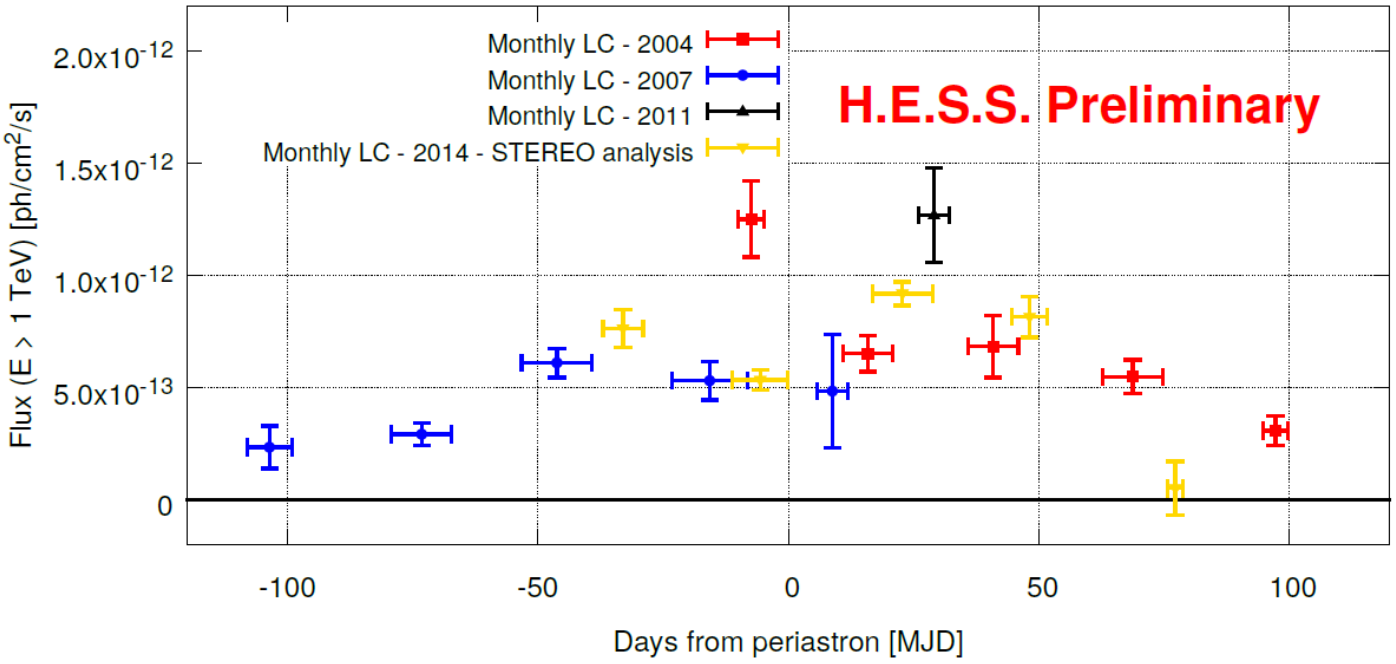


Chernyakova et al., 2015

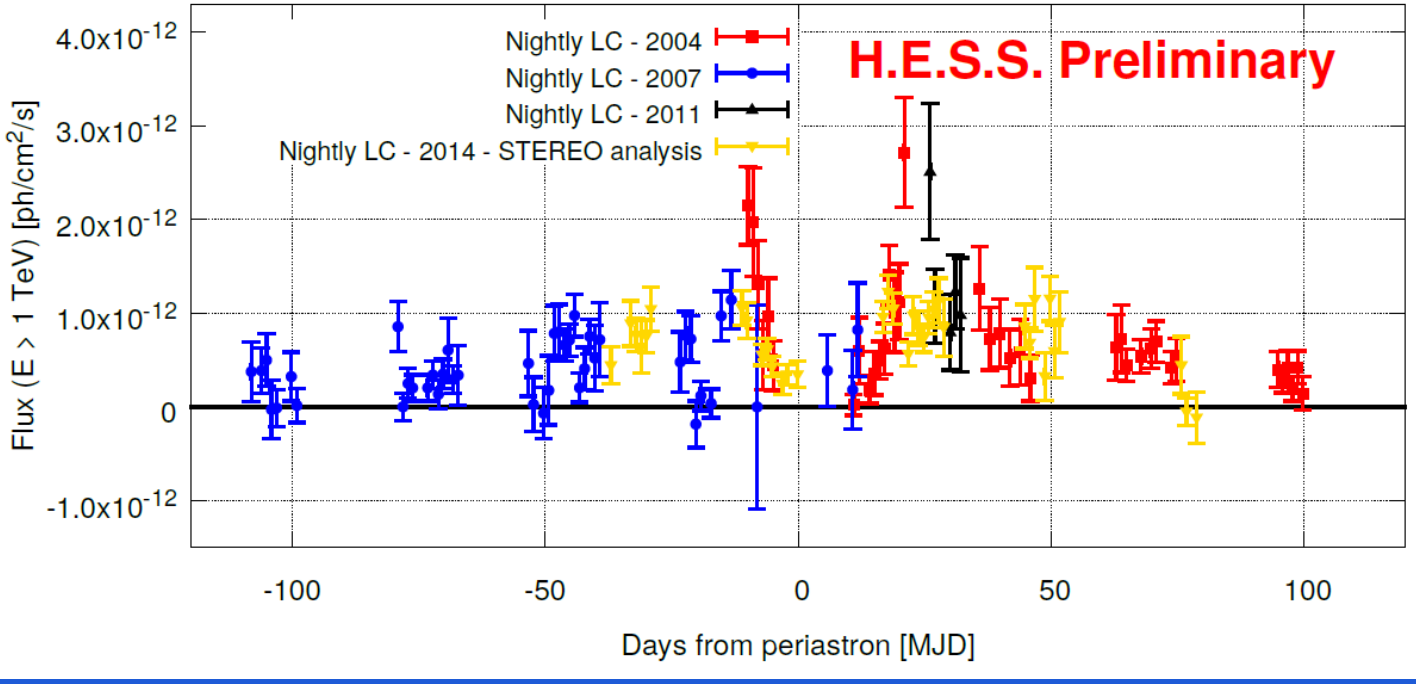
Chernyakova et al., 2014

TeV Light Curve

monthly



nightly

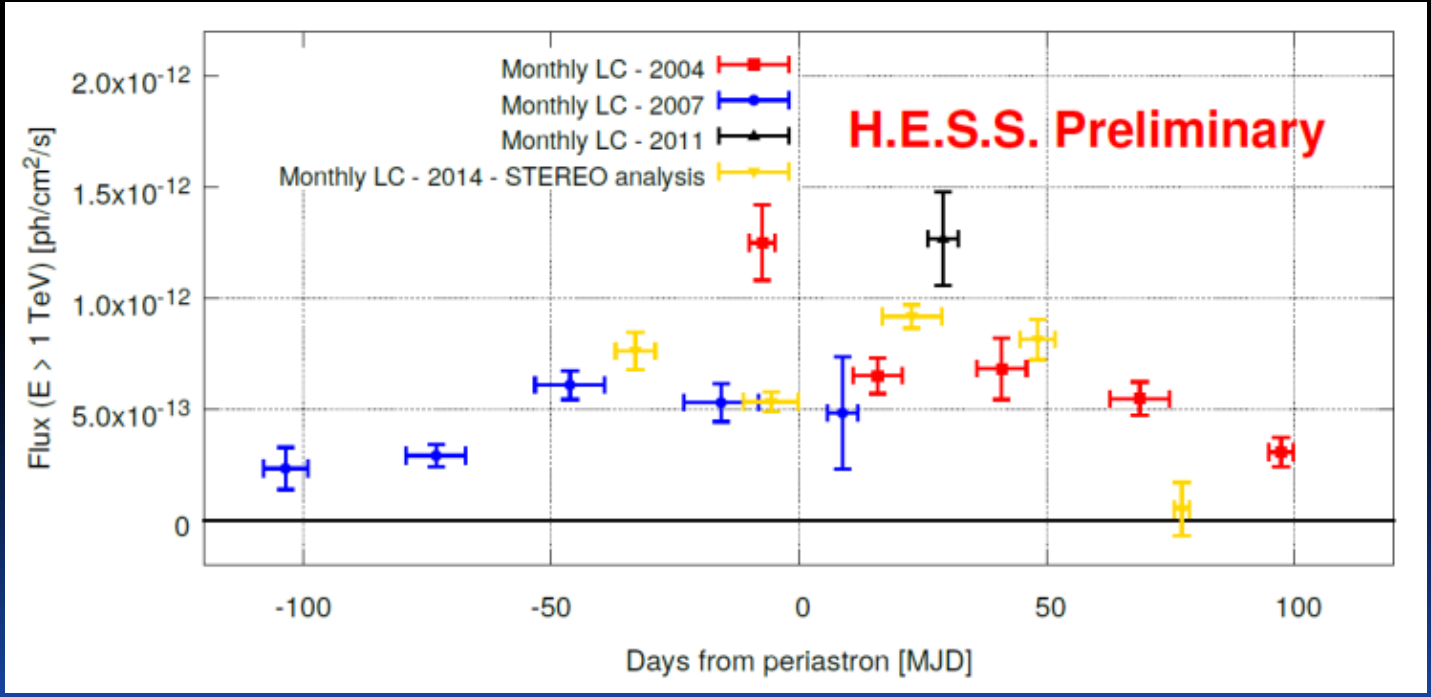


Romoli et al., 2015

Interpretation of the TeV light curve

In leptonic scenario one expects:

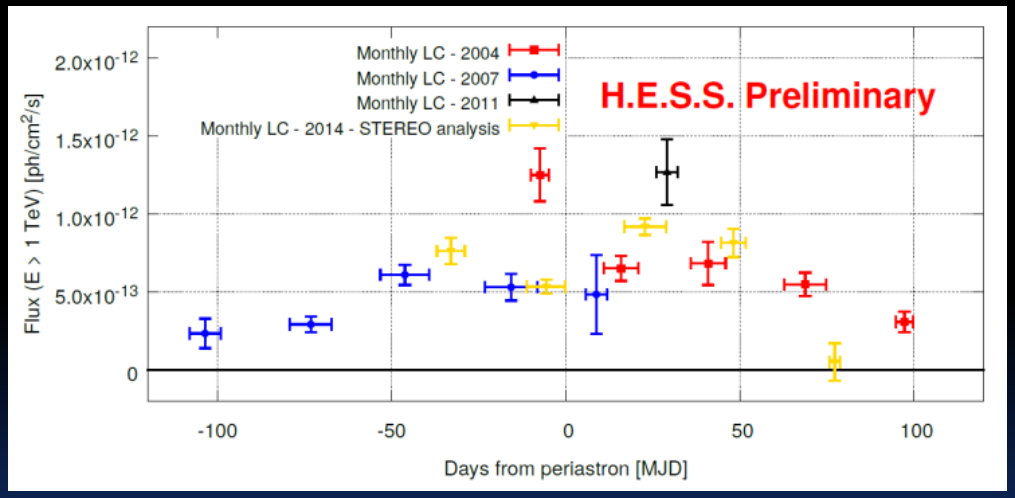
- Peak in TeV flux at periastron when the separation distance is minimal
- Smooth dependence in the case of the saturation regime

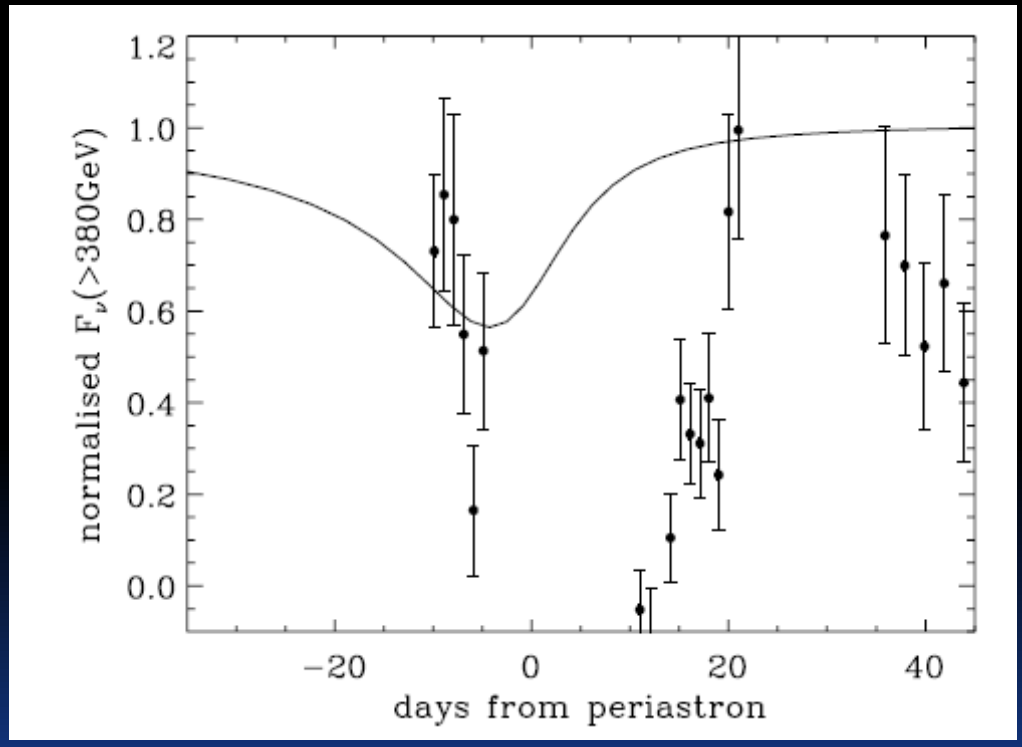


Interpretation of the TeV light curve

In leptonic scenario one expects:

- Peak in TeV flux at periastron when the separation distance is minimal
- Smooth dependence in the case of the saturation regime





Dubus, 2006

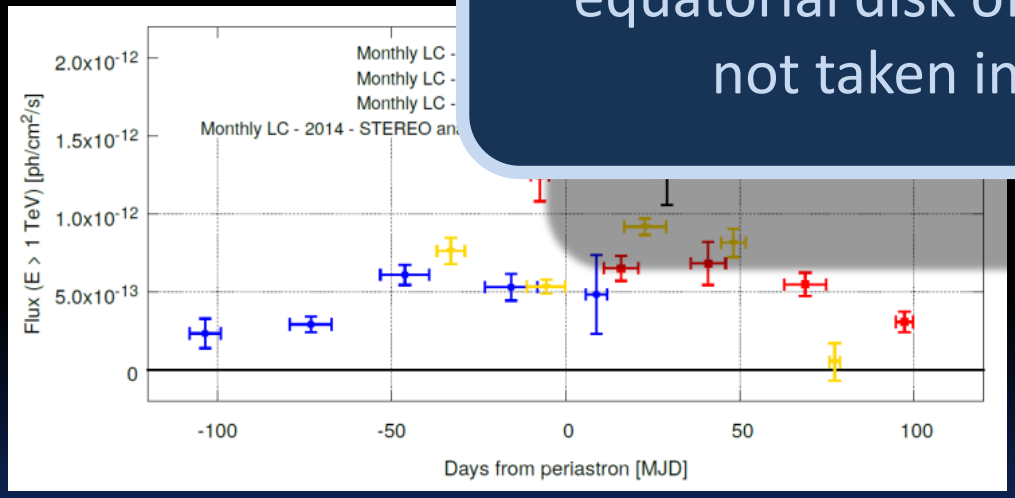
Gamma-gamma absorption of VHE gamma-rays by stellar photons?

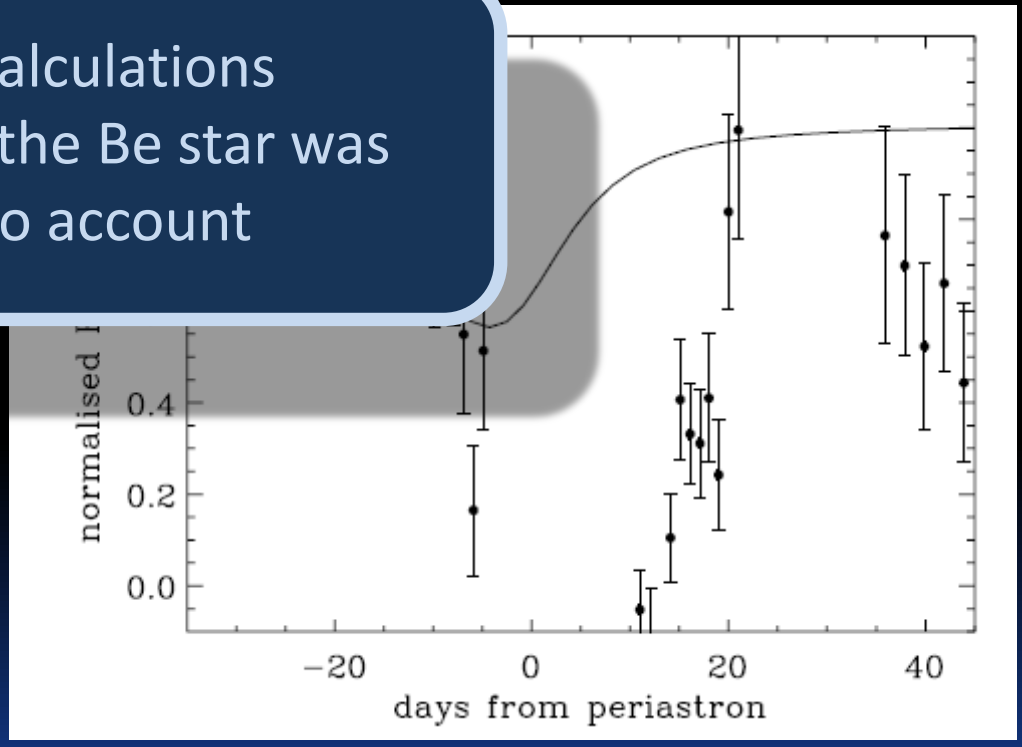
Interpretation of the TeV light curve

In leptonic scenario one expects:

- Peak in TeV flux at periastron when the separation distance is minimal
- Smooth dependence in the case of the saturatio

But in these calculations equatorial disk of the Be star was not taken into account

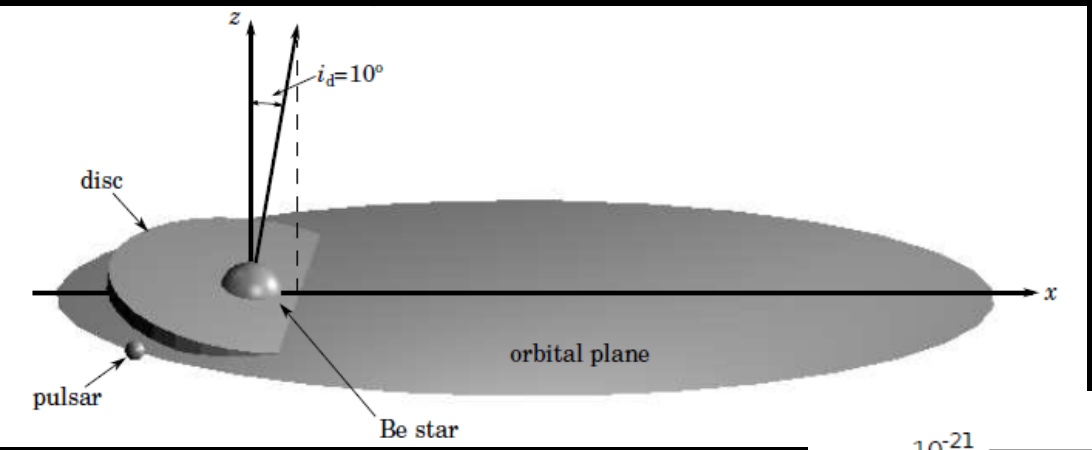




Dubus, 2006

Gamma-gamma absorption of VHE gamma-rays by stellar photons?

Absorption in the disk



$E_{ph} = 0.5\ (E_{\gamma,\ TeV})^{-1}$ eV

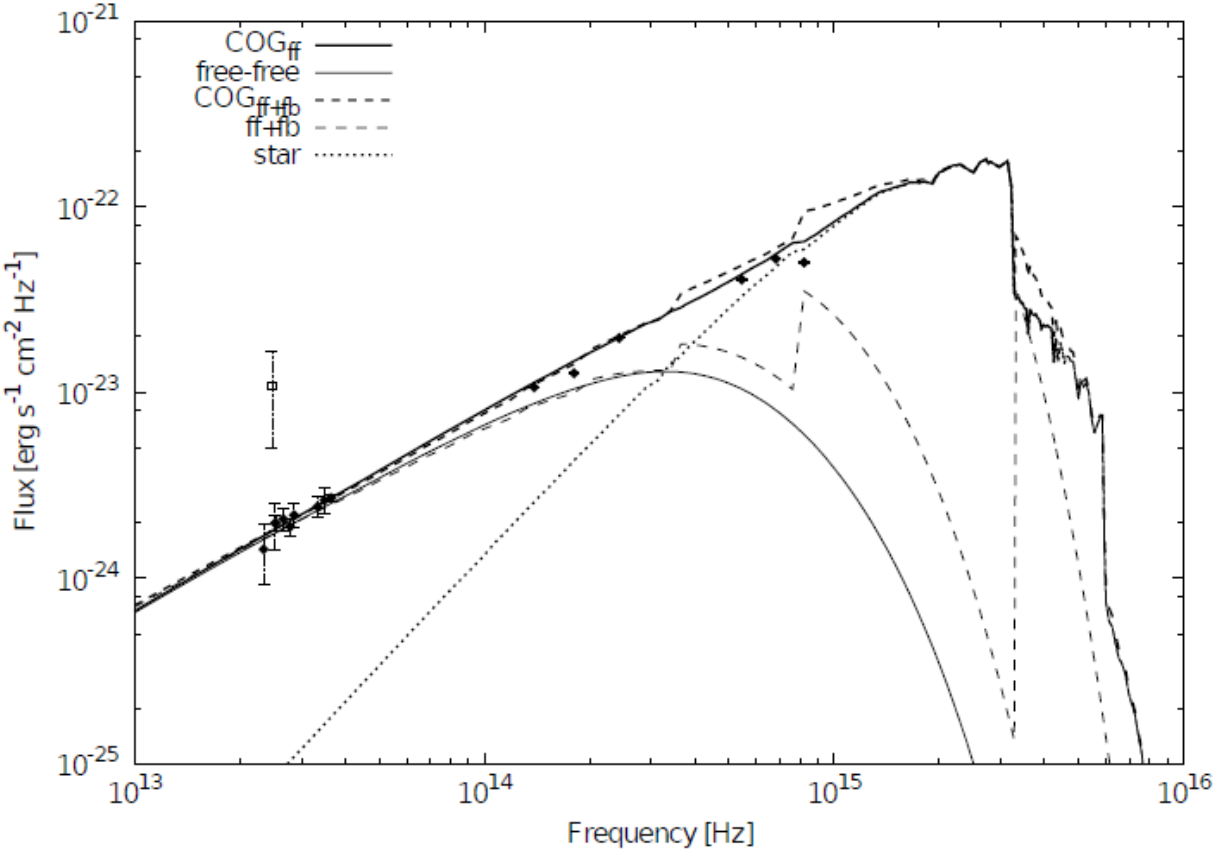
$\nu_{ph} = 1.25e{+}14\ (E_{\gamma,\ TeV})^{-1}$ Hz

$T_{star} = 33000$ K

$R_{disk} = 50\ R_{star}$

$T_{disk} = 19800$ K

$\theta = 1°$



van Soelen et al., 2012

Geometry of the disk

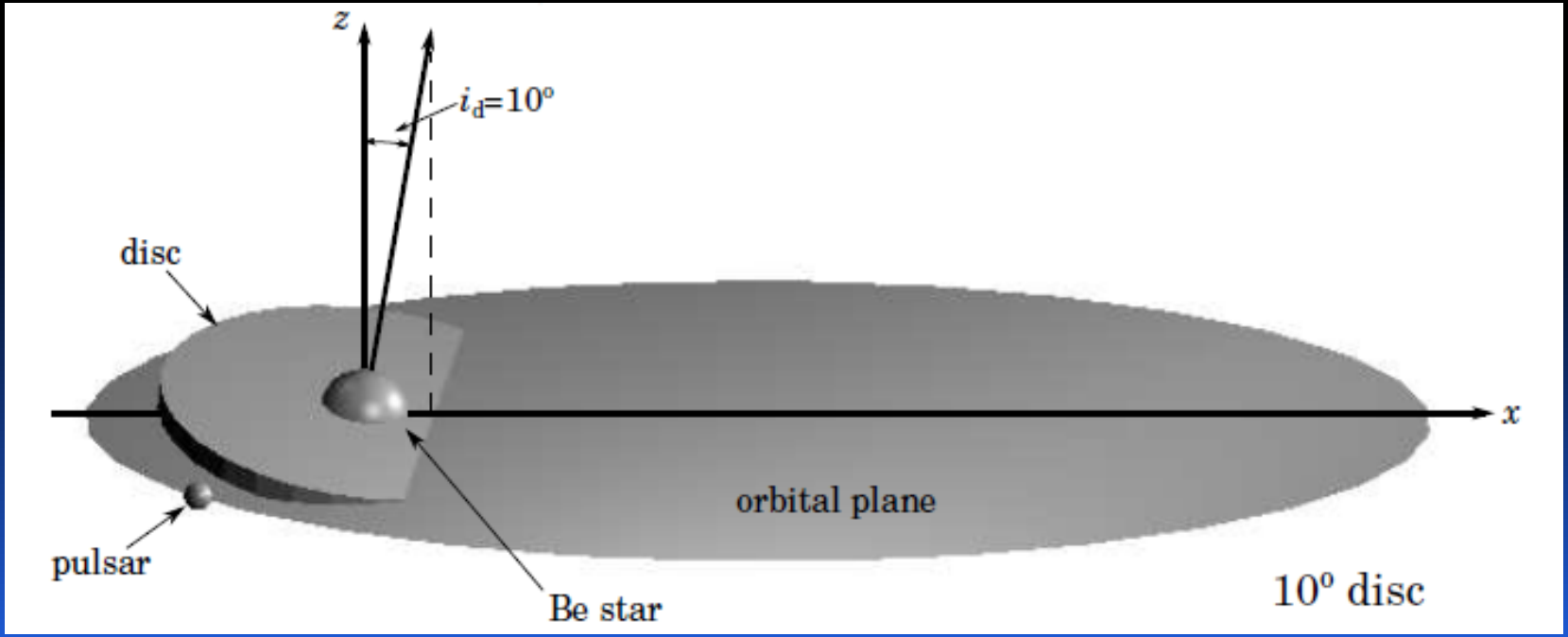
i = 35° - inclination angle of the orbit

i_d = 10° - inclination of the disk

ω = 138.7° - periastron longitude

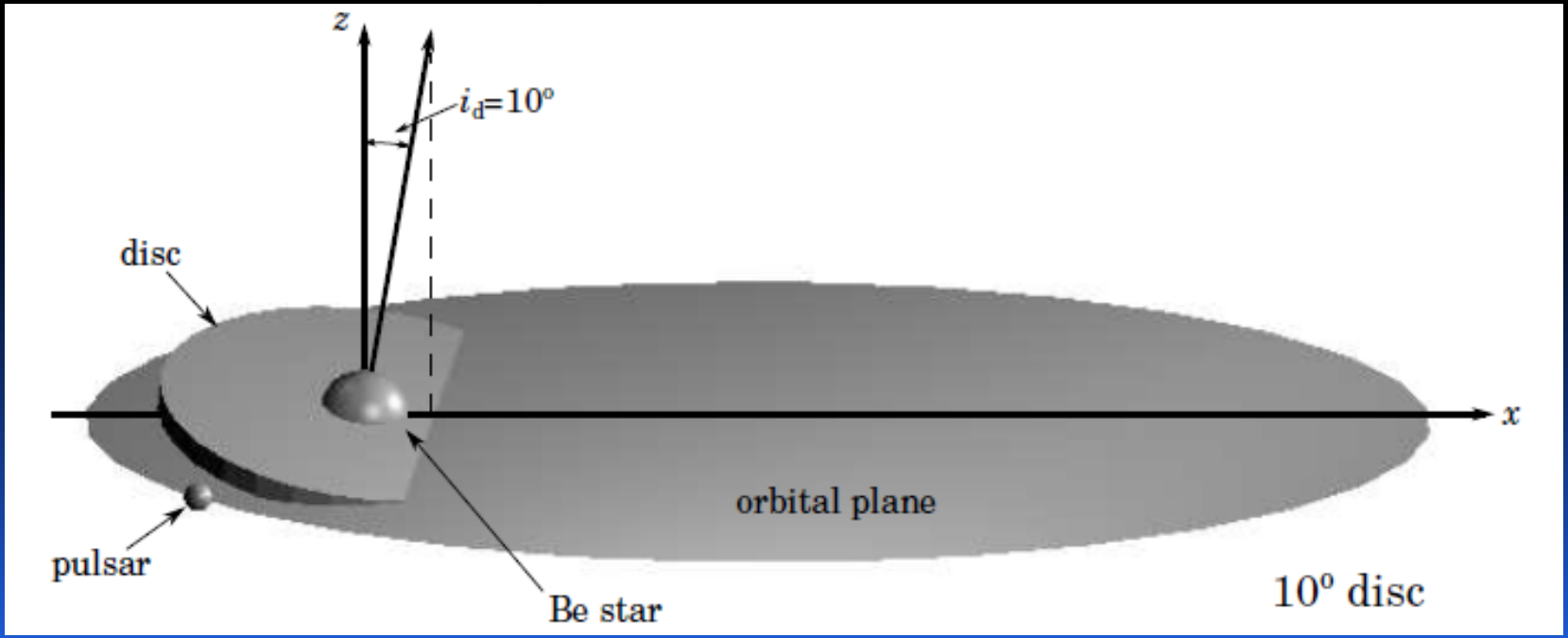
θ = 1° - half-opening angle

Disk plane perpendicular to the orbit plane major axis

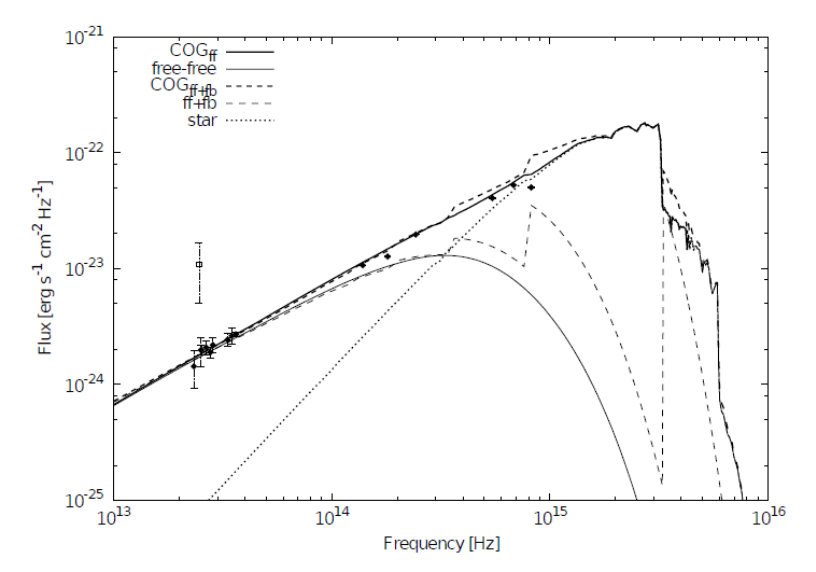


Model assumptions

- Gamma-ray emission from the pulsar is assumed point-like
- TeV emission is assumed to be generated in the saturation regime
- Only disk is considered. Stellar photons are not taken into account

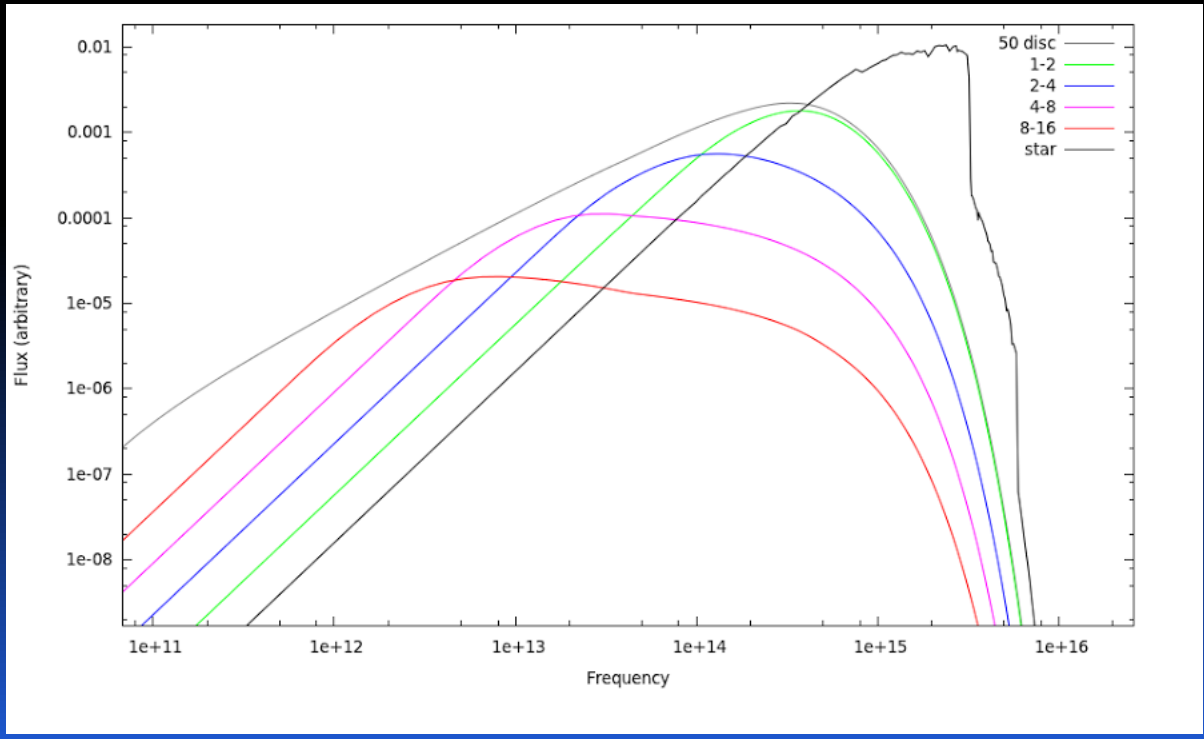


Photon density in the disk



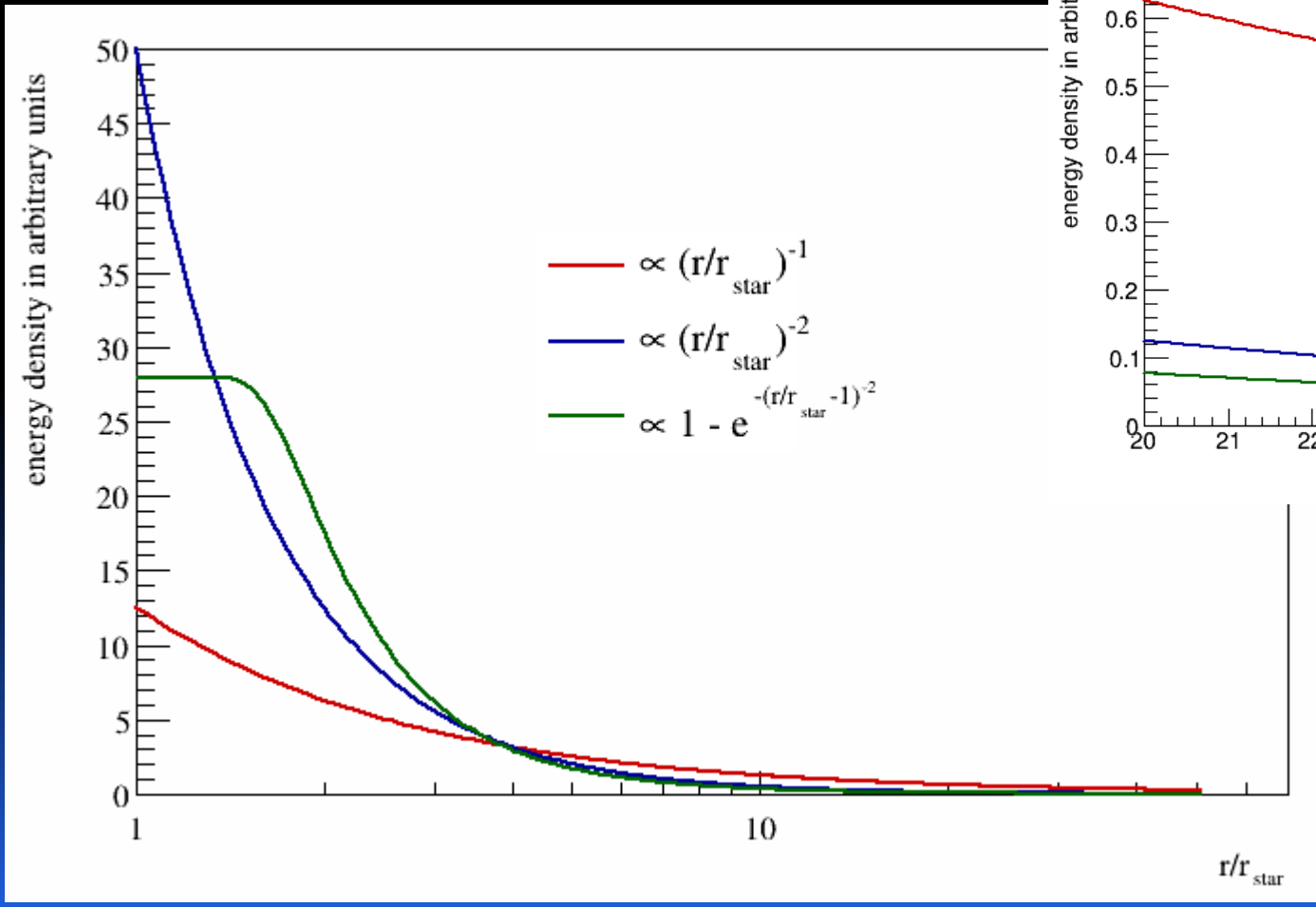
The model of the free-free emission fit to the observational data yields an average energy density of 0.18 erg/cm^3

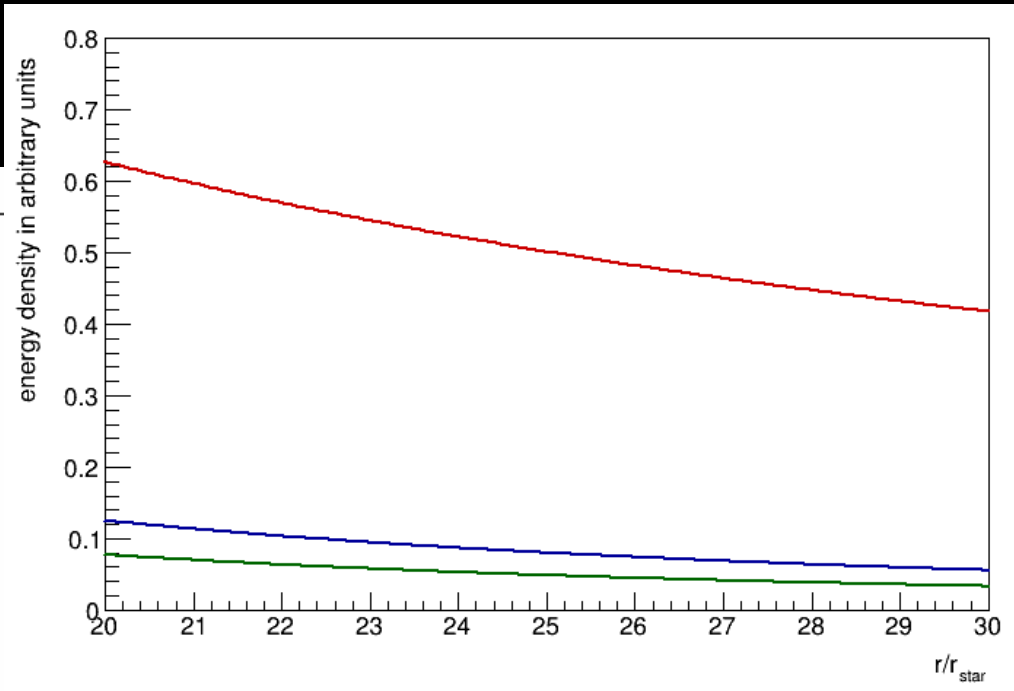
Flux from the disk at different distances from the star



First step: approximation with the BB

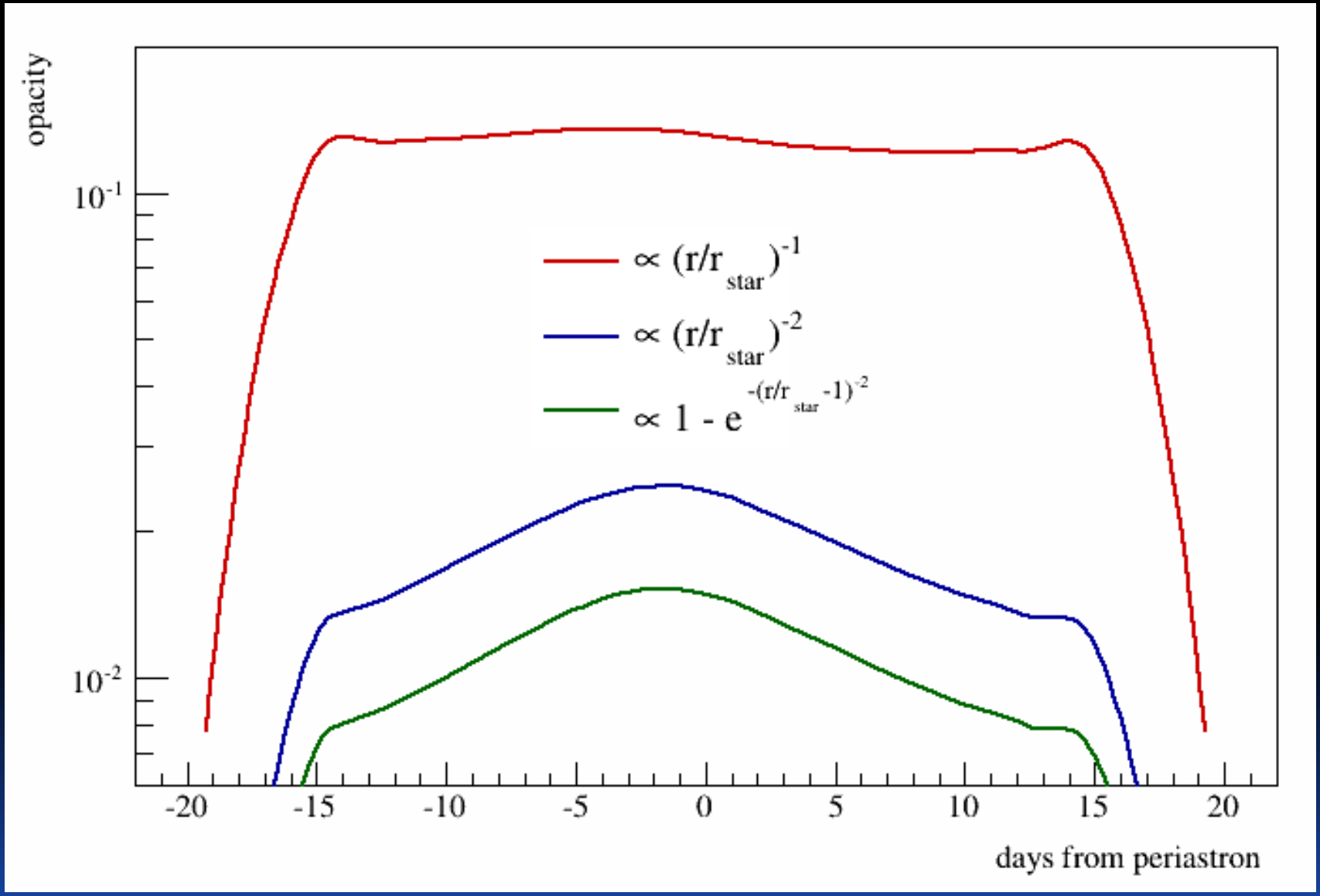
- Black body with T = 3000 K (to get the peak at the same frequency)
- Assumed functional dependence on the distance from the star in a way that the average energy density agrees with observations



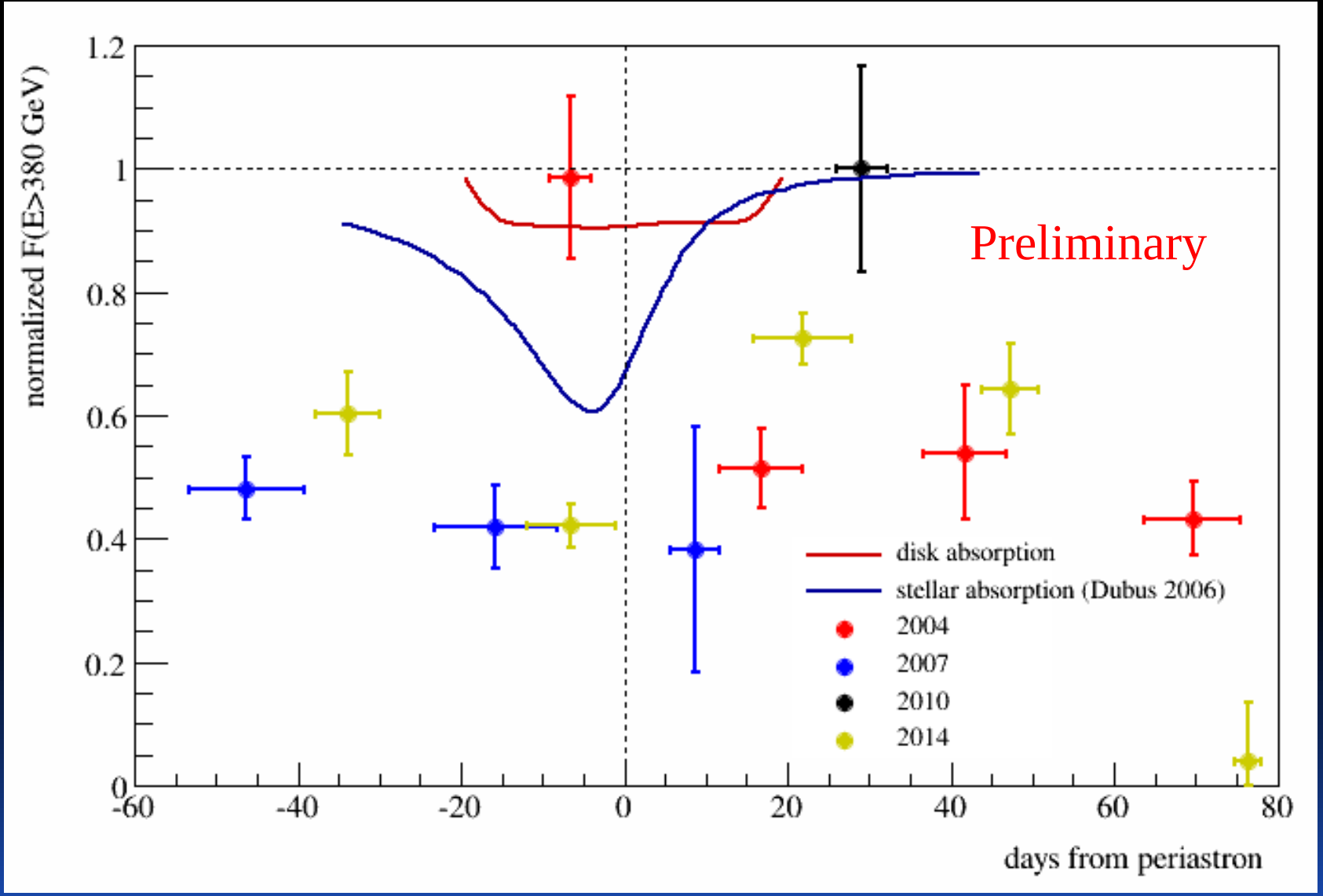


Closest distance at which the incoming gamma-ray interacts with the disk is about 20 R_{star}

Optical depth



TeV Light Curve



Summary

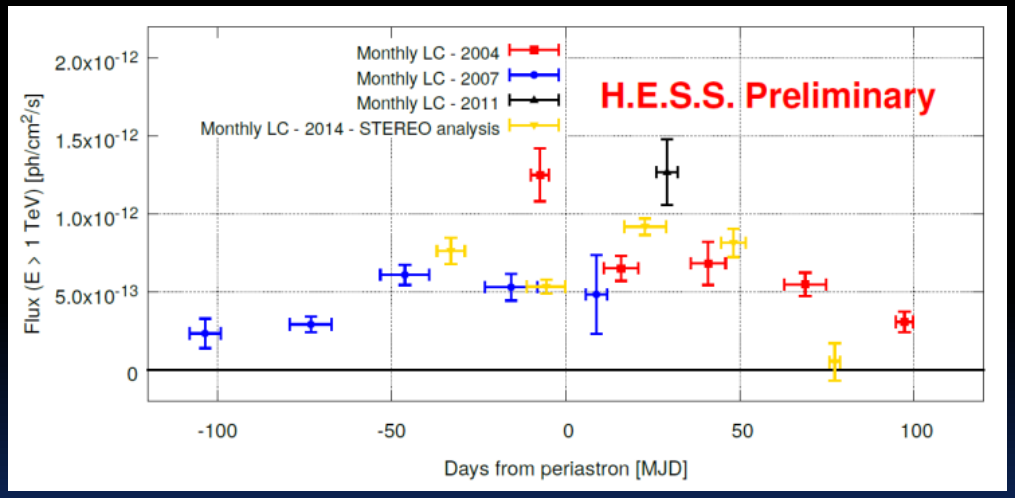
- Gamma-gamma absorption in the disk might significantly impact the TeV light curve
- Work in progress:
  - Correctly account for the photon distribution in the disk as a function of distance from the star – might strengthen the effect of the absorption in the disk
  - Include stellar photons into the model and calculate the total absorption

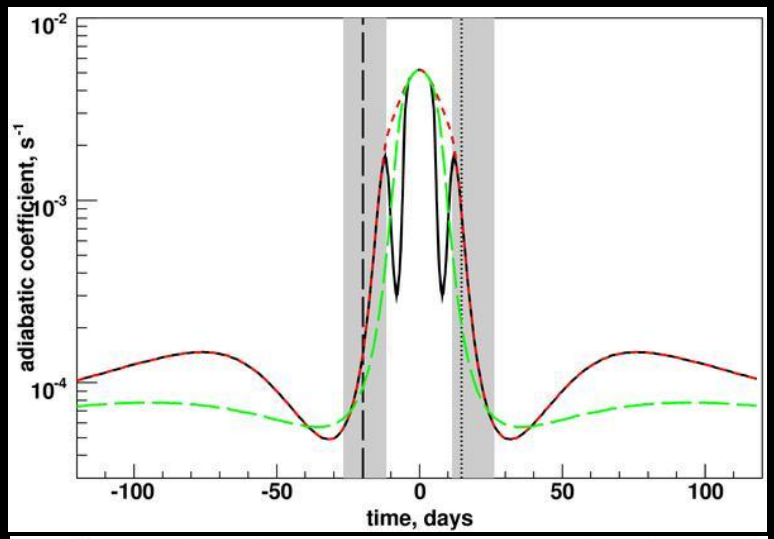
Backup slides

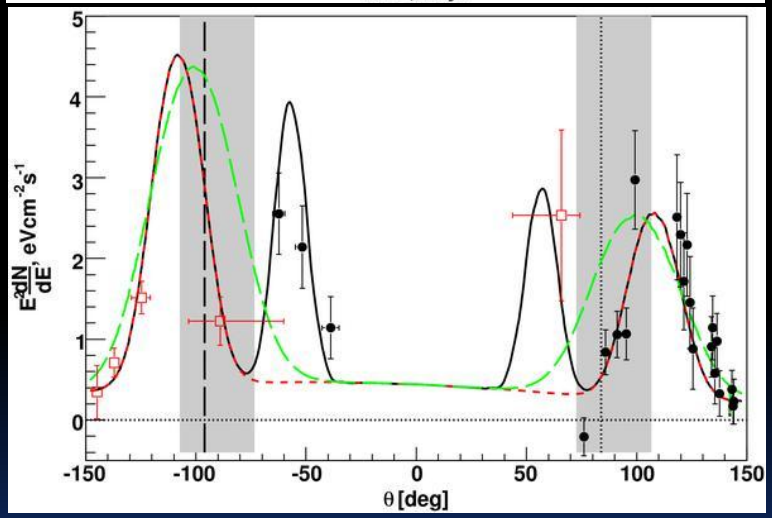
Interpretation of the TeV light curve

In leptonic scenario one expects:

- Peak in TeV flux at periastron when the separation distance is minimal
- Smooth dependence in the case of the saturation regime







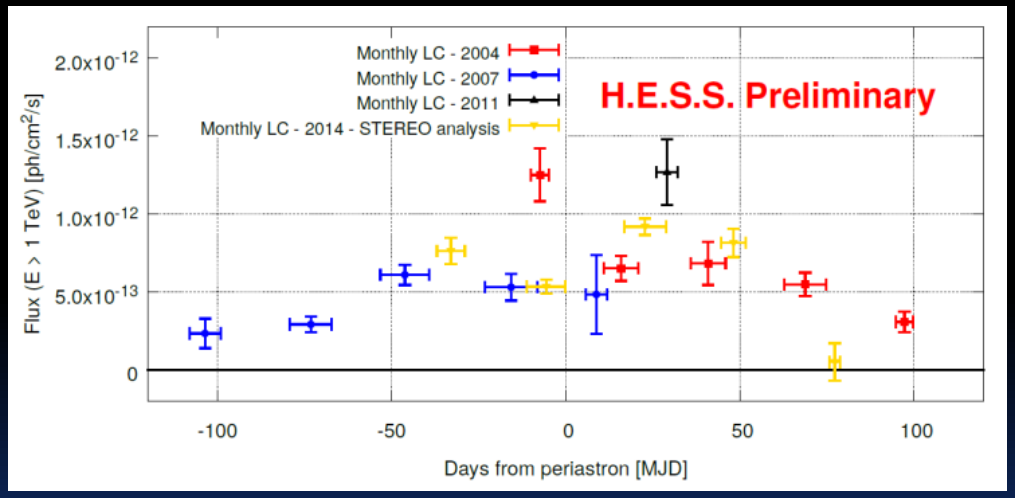
Kerschhaggl, 2011

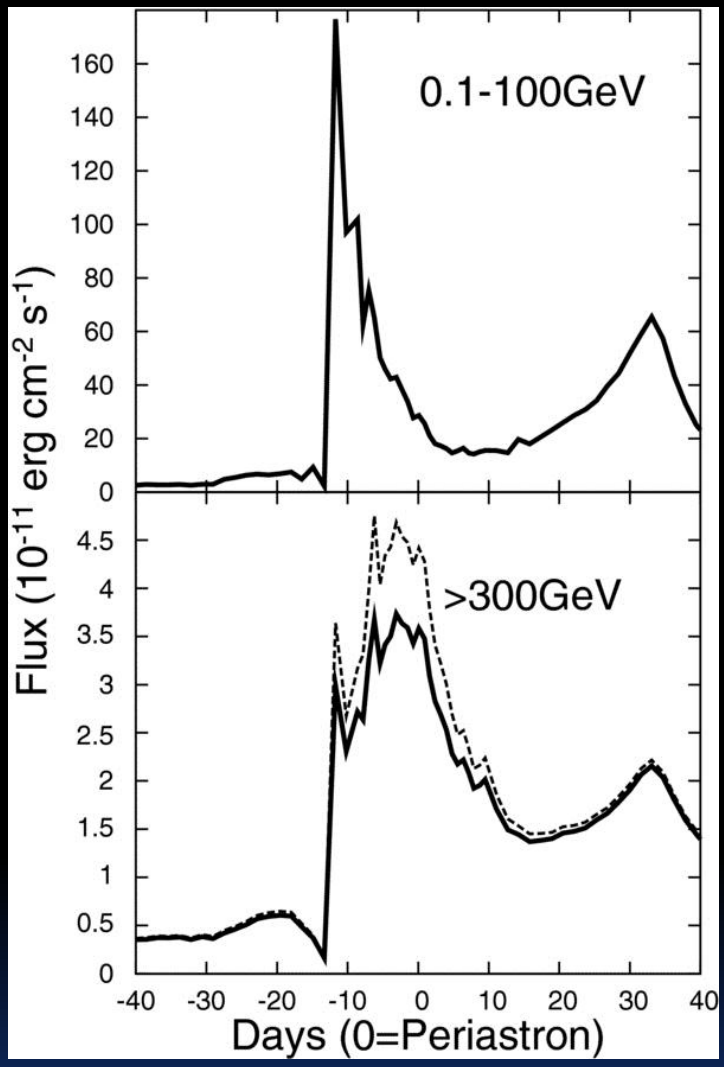
Orbital dependent adiabatic losses?

Interpretation of the TeV light curve

In leptonic scenario one expects:

- Peak in TeV flux at periastron when the separation distance is minimal
- Smooth dependence in the case of the saturation regime





Takata et al., 2012

Higher conversion efficiency in the disk? SPH 3D simulations