Multi-wavelength emissions from PSR-Be binaries

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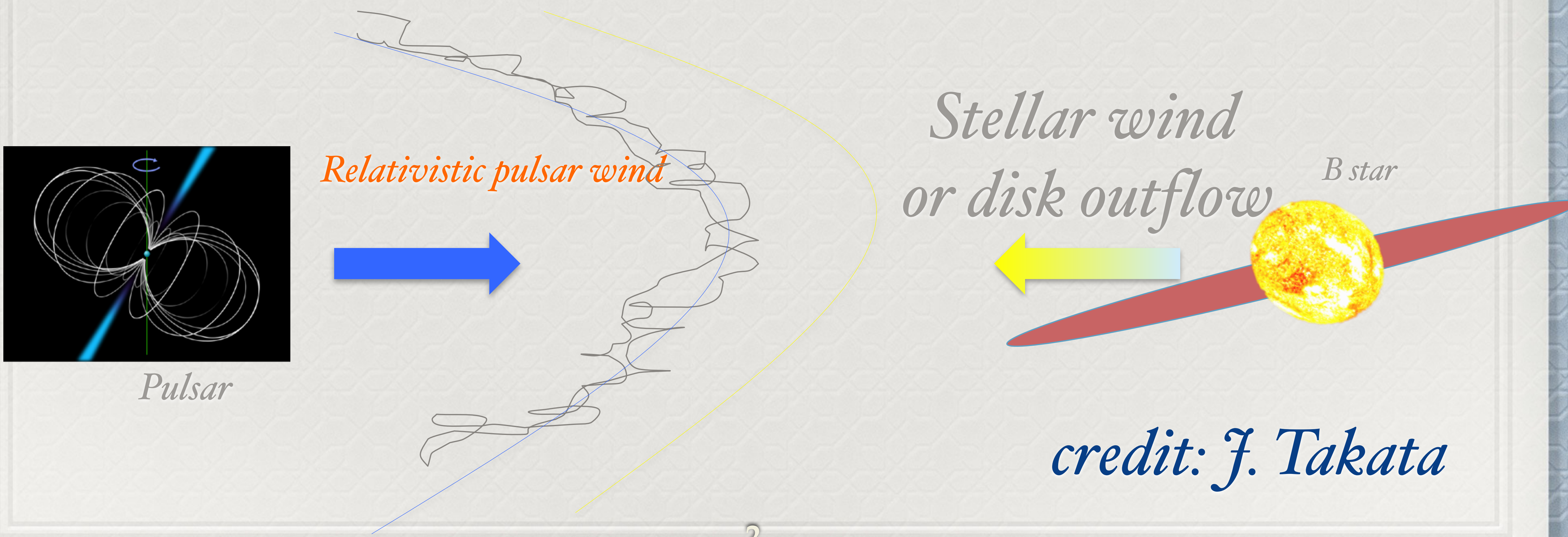
Emissions from Pulsar/Be star binary

Three emission regions normally considered in modeling

1. *Magnetosphere (<10^9cm, pulsed)*
2. *Pulsar wind region (<10^{13}cm, no synchrotron, only I.C.).*
3. *Shock accelerated pulsar wind (synchrotron & I.C.)*
4. *others (e.g., outside the binary orbit)*

Great laboratories for studying pulsar environment in AU scale

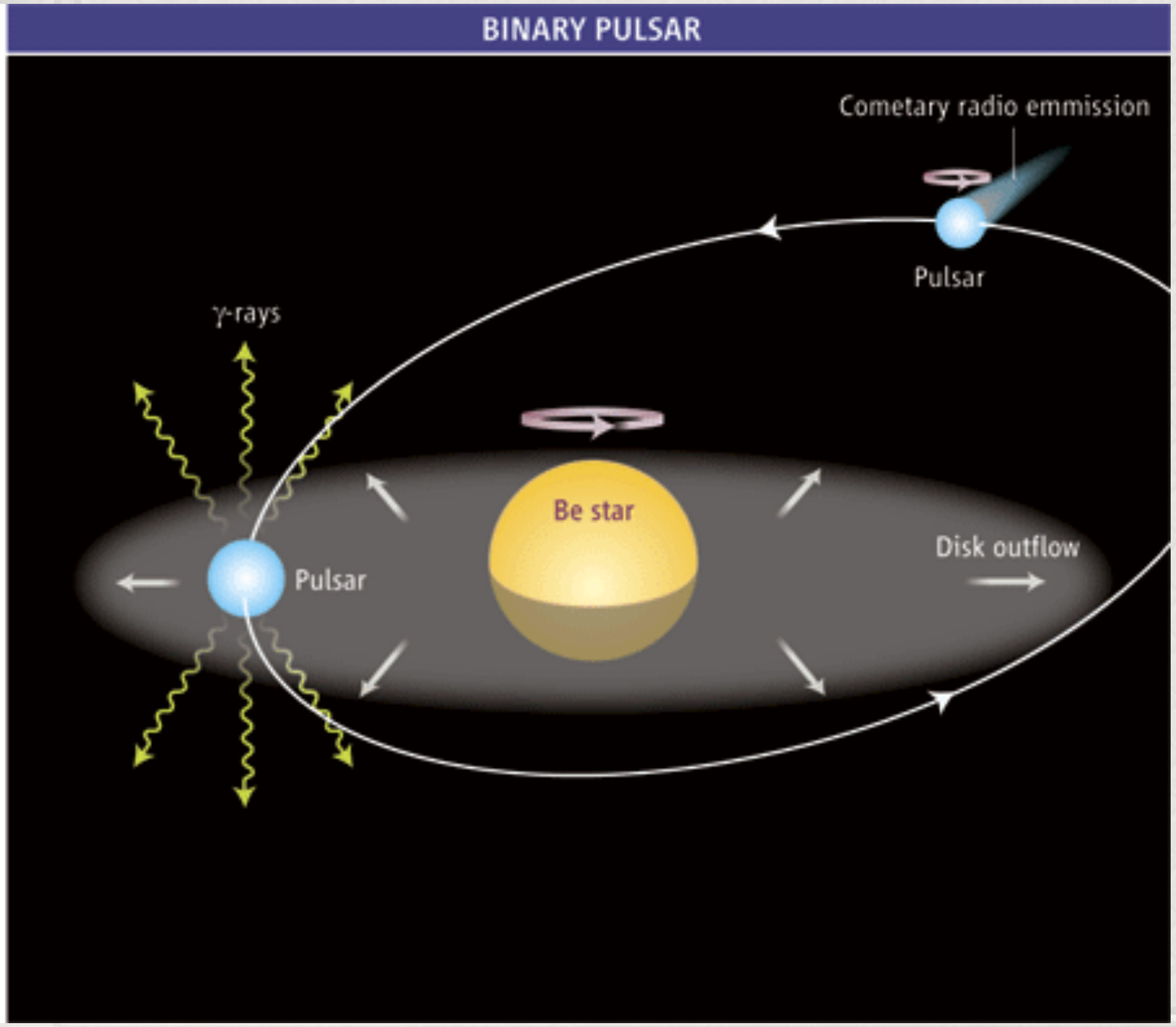


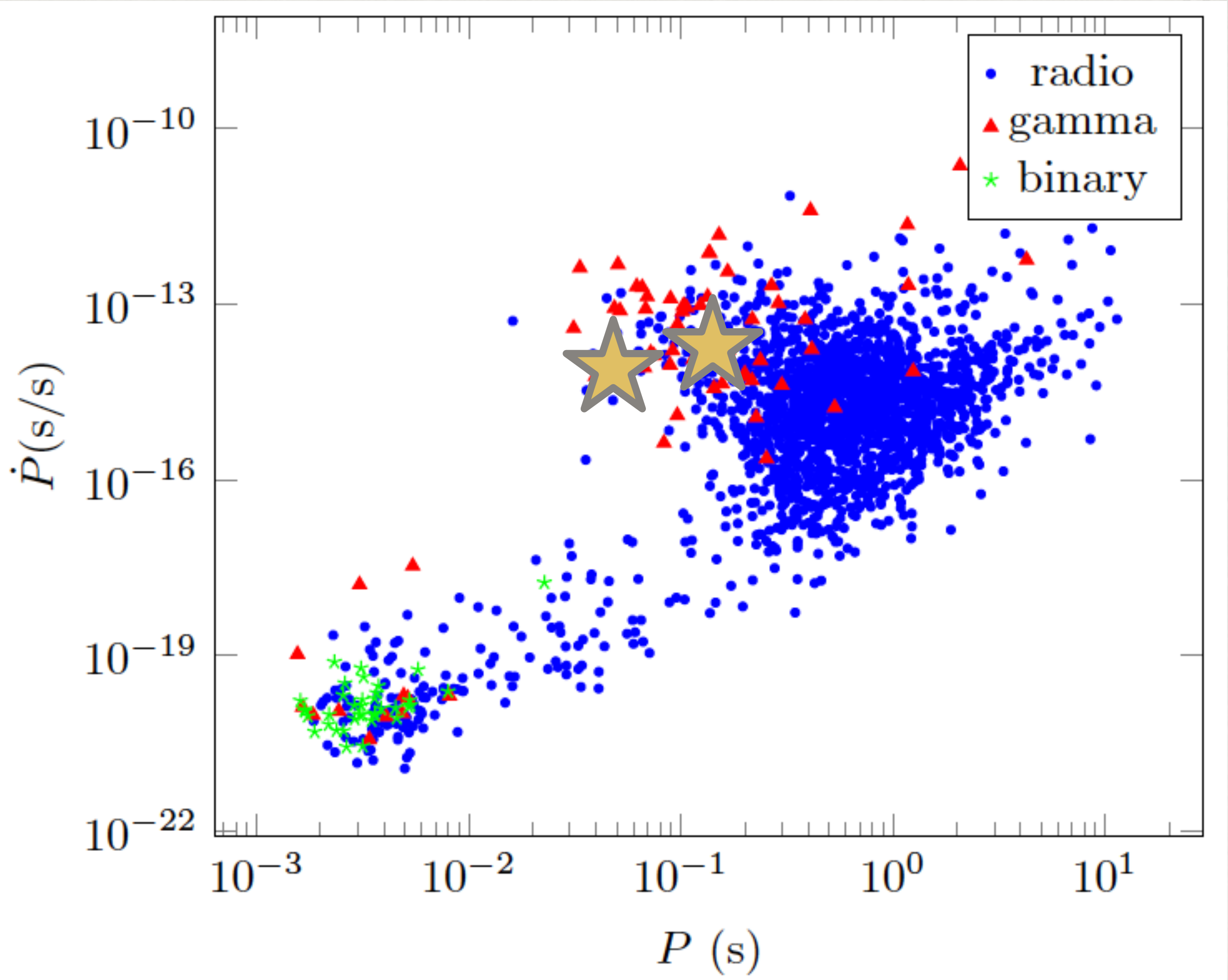
credit: J. Takata

Gamma-ray binaries with a confirmed pulsar

Two similar systems

PSR/Companion	P (s)	L_{35}	P_o (yrs)	e	a (lt-s)	T_*	R_*
J2032+4127/MT91 213	0.143	1.7	25-50	0.96	9022	30000K	$10R_\odot$
B1259-63/LS2883	0.048	8	3.4	0.83	1296	~30000K	$\sim 9R_\odot$

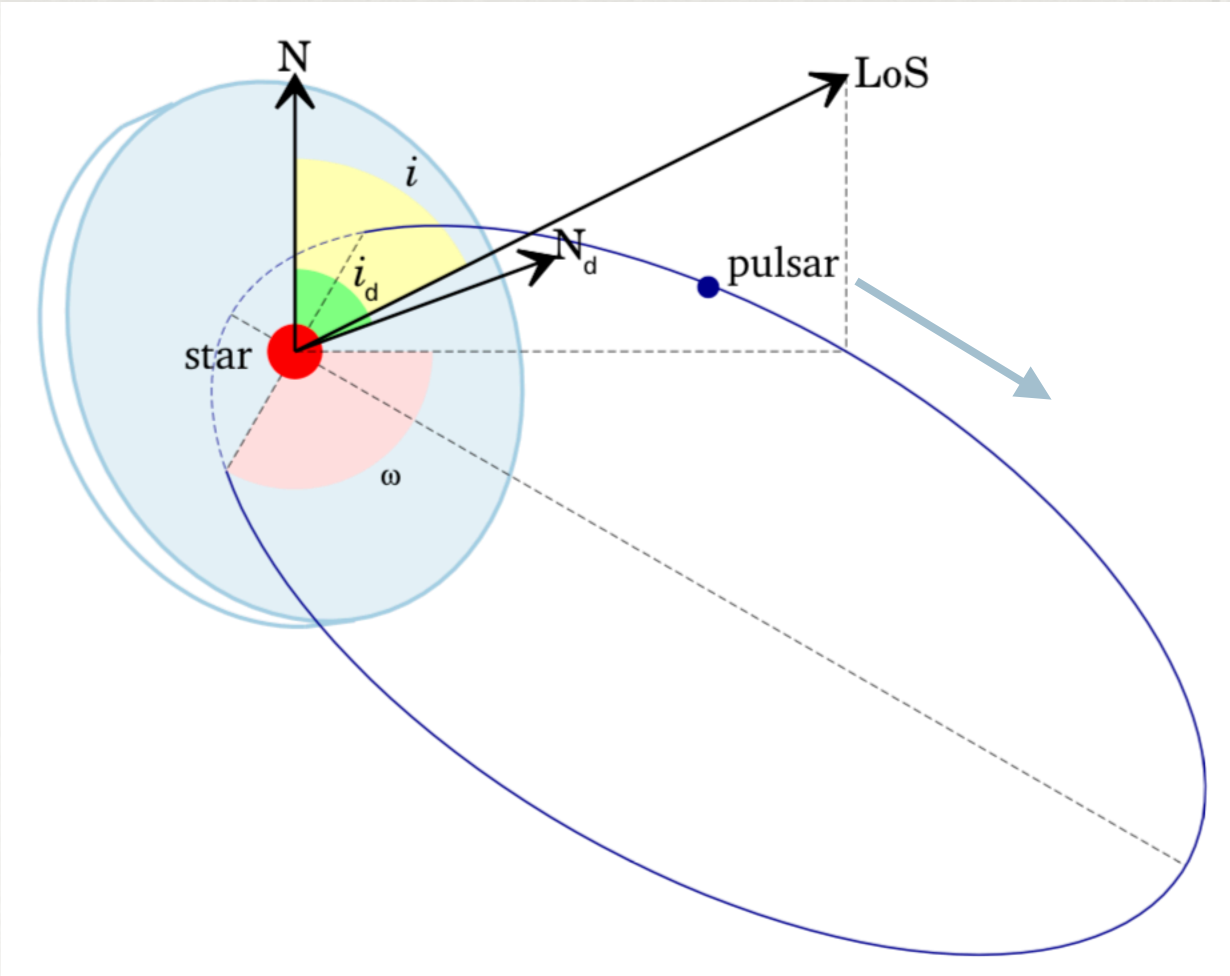




PSR B1259-63

PSR B1259-63/LS 2883

- *comprising of a pulsar and an Oe star, at d~2.3 kpc*
- *orbital period: 3.4 years*
- *Interaction between the stellar wind/disk and the pulsar wind => non-thermal radiation close to periastron*

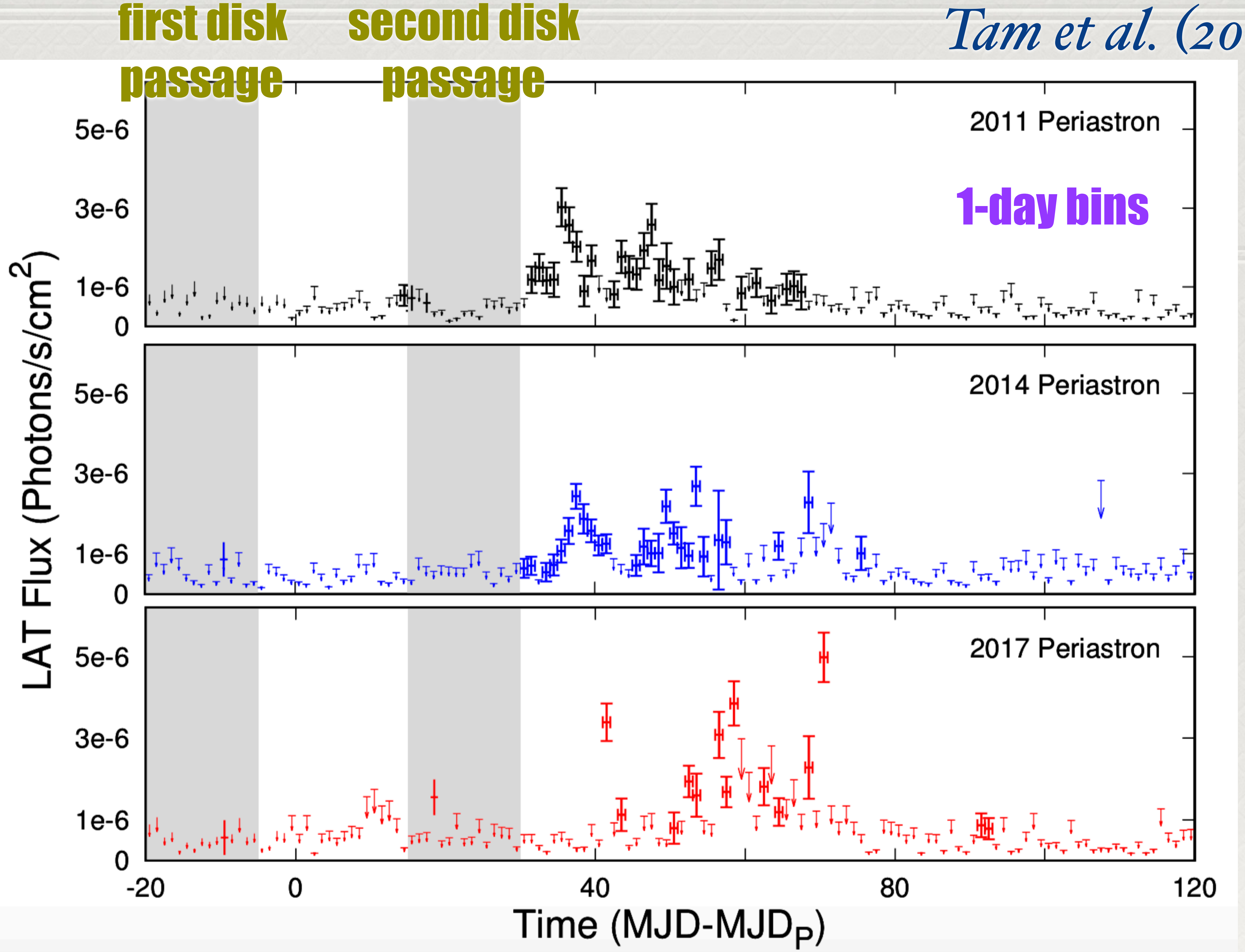


Sushch & van Soelen (2017)

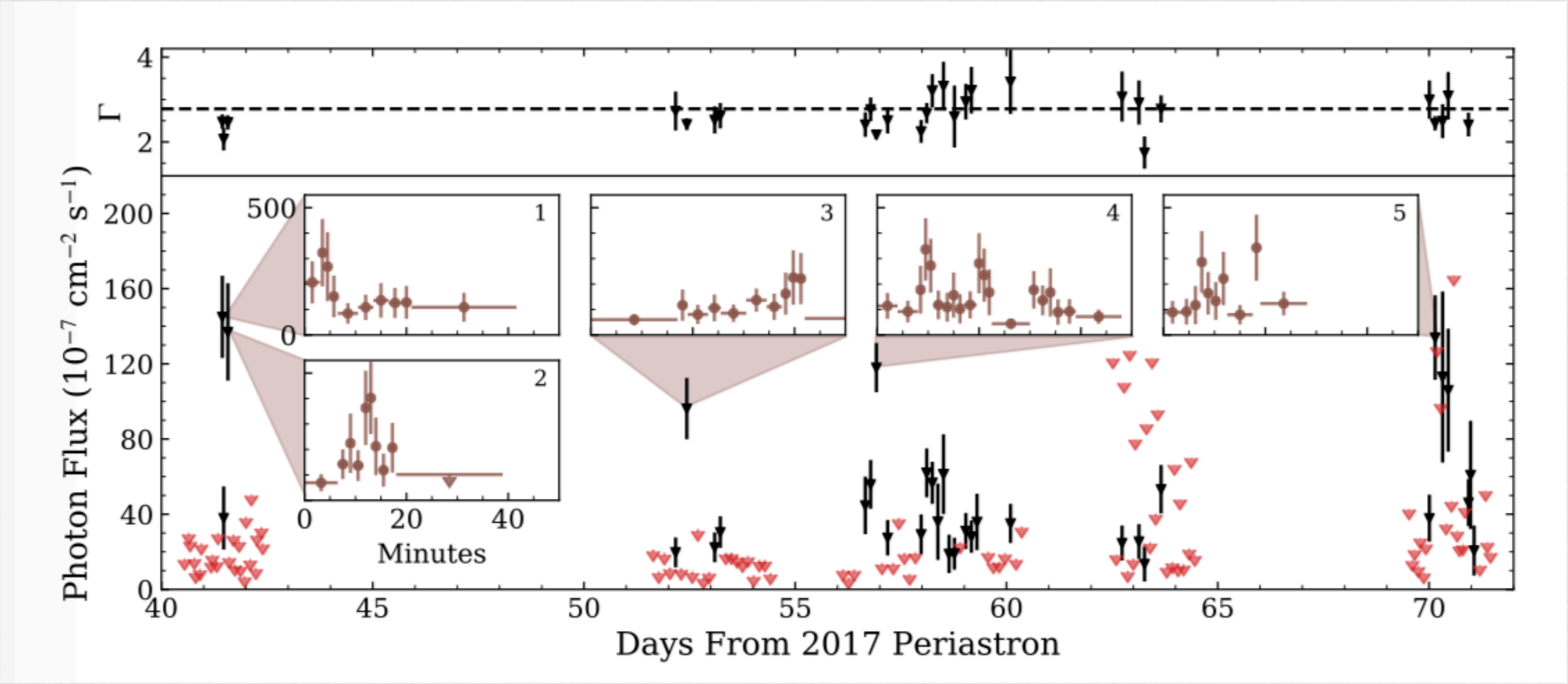
PSR B1259-63

- *Radio pulsar in a binary (Johnson et al. 1992)*
- *discovered in TeV (Aharonian et al. 2004) and in GeV (Abdo et al. 2011, Tam et al. 2011)*
- *MWL => pulsar wind-stellar wind interaction as an important model for other gamma-ray binaries as well*

Tam et al. (2018)



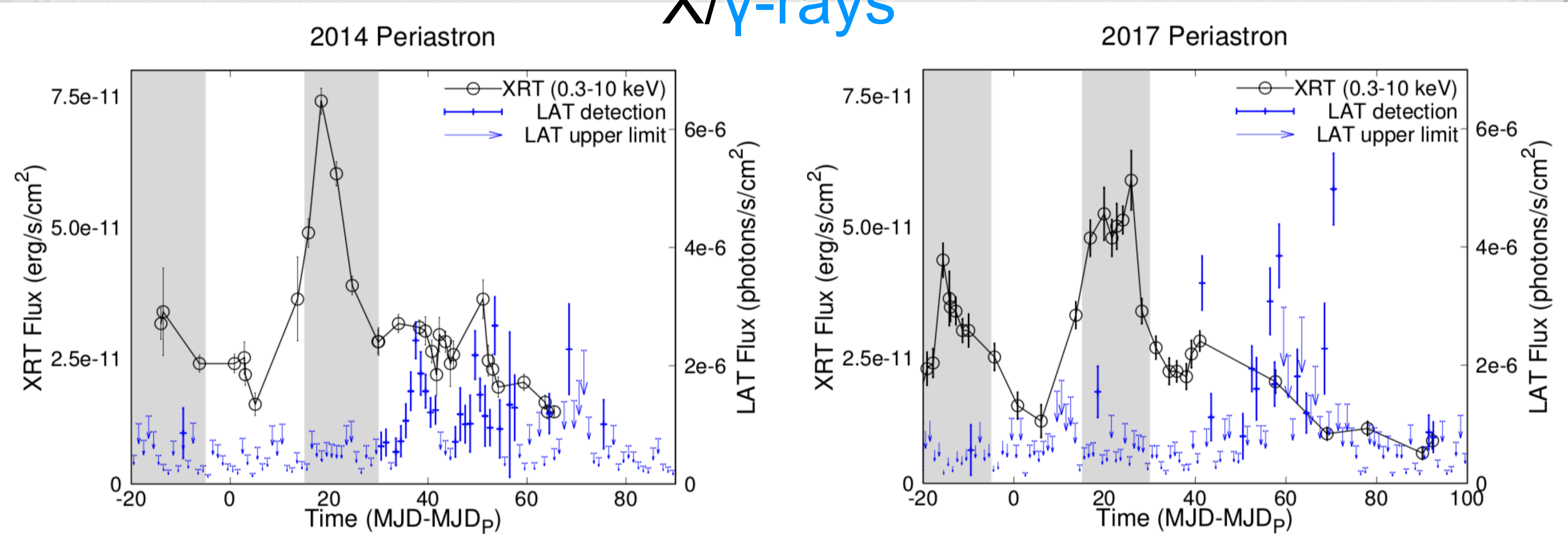
- **clearly occurs at different orbital phase**



Johnson et al. (2018)

Is the GeV flare orphan? counterpart searches

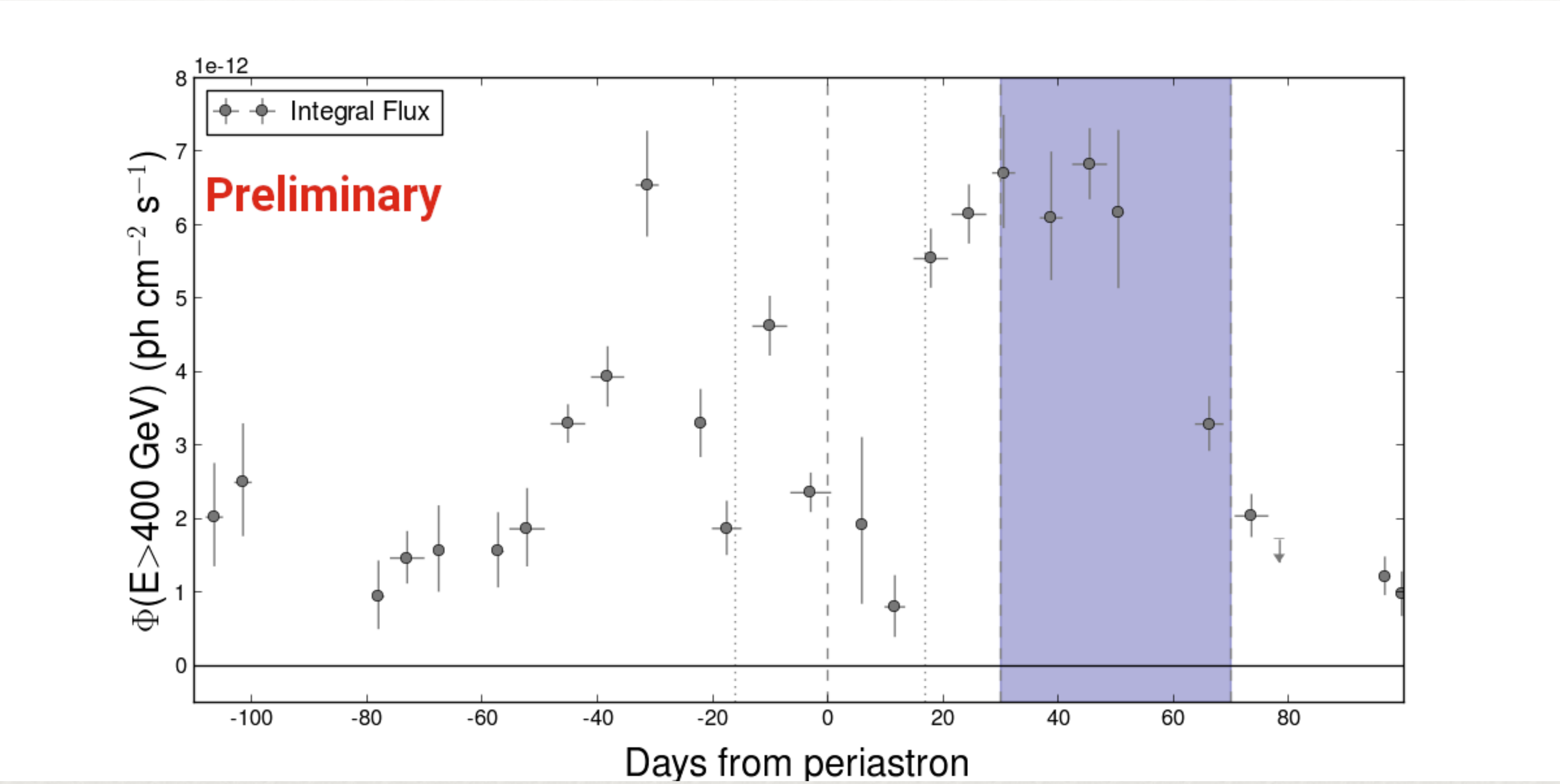
X/γ-rays



correlated X/γ activities in 2014 (Tam+ 2015)

No obvious correlated X/γ activities in 2017

but insufficient data coverage..

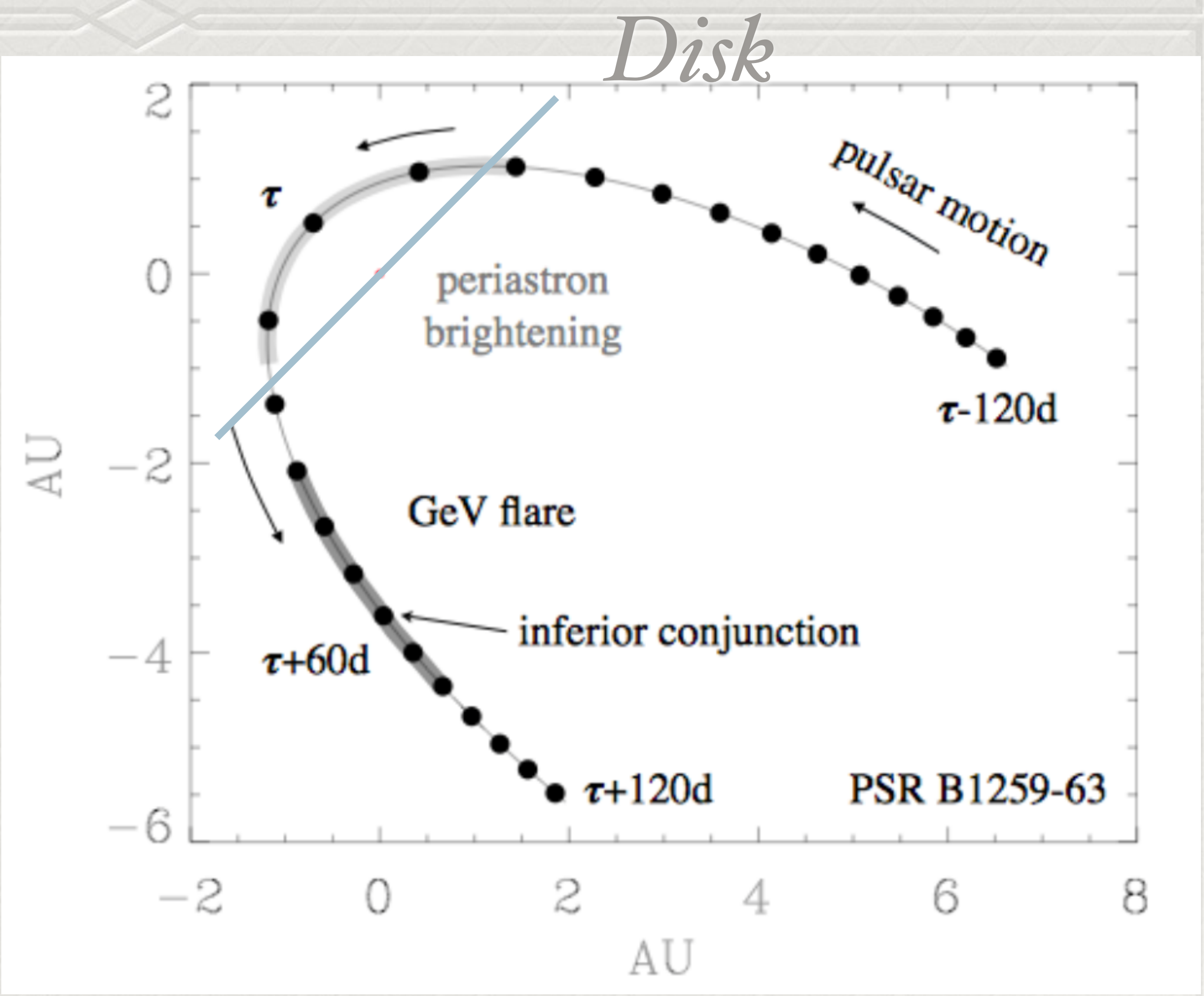


TeV counterpart of GeV flare?

(*https://www.mpi-hd.mpg.de/hfm/HESS/pages/home/som/2018/10/*)

Mysterious GeV flares

- *Delayed compared to X-ray/TeV peak*
- *Most recent periastron passage at 2017-09-22*



Dubus (2013)

origin of GeV flares

- *Models predicting IC/synchrotron at GeV cannot explain the GeV flares delayed compared to X-rays (e.g., Tam+ 2015)*
- *Models based on geometrical effects (Doppler boost, e.g., Kong+2012)*
- *Models predicting smooth(1-5 day) GeV emission*
- *Accretion-disk model (Yi & Cheng 2017)*

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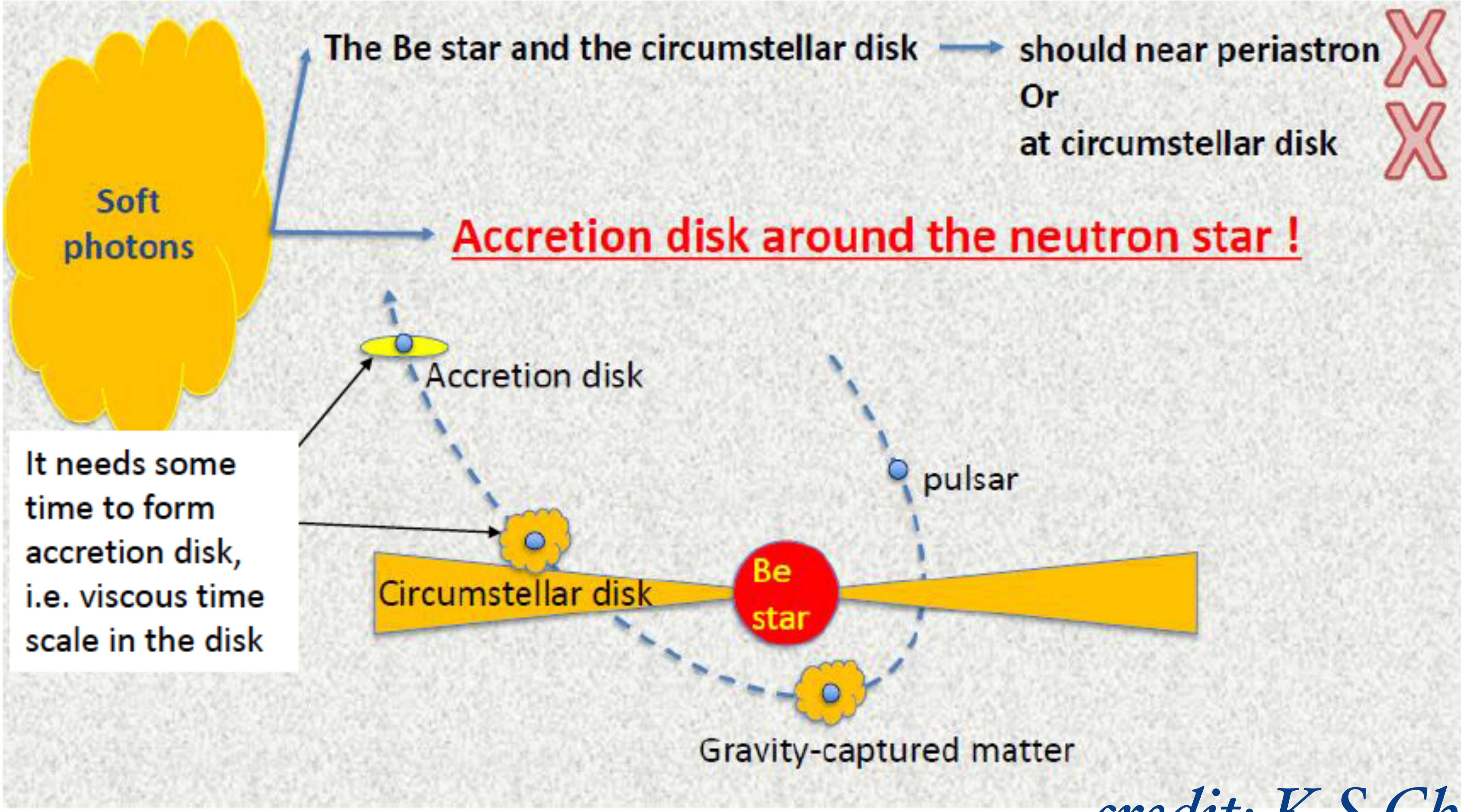
- *~~Models predicting smooth(1-5 day) GeV emission~~*
- *Accretion-disk model (Yi & Cheng 2017), no evidence for pulsar timing change due to disk torque (Yi & Cheng 2018)*

Model for GeV-flare from PSR B1259-63/LS2883 (Yi & Cheng 2017)



credit: K S Cheng

PSR J2032+4127

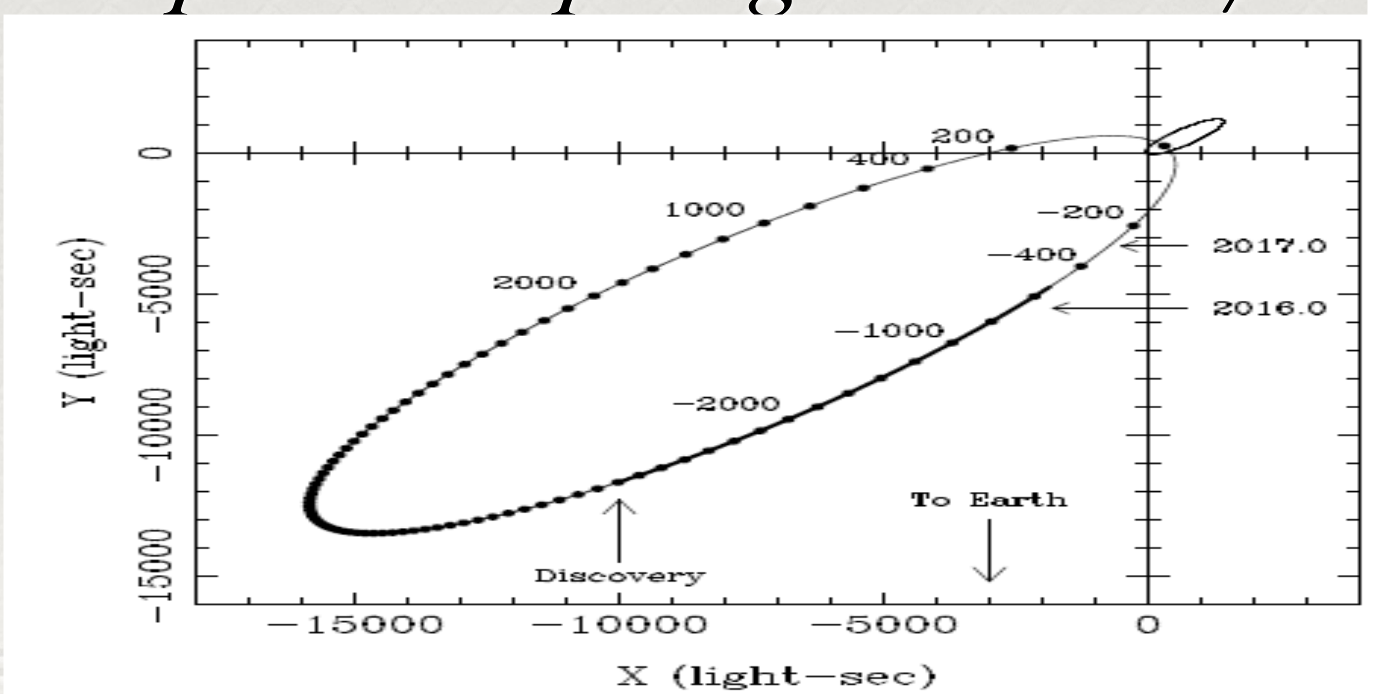
PSR J2032+4127/MT91 213

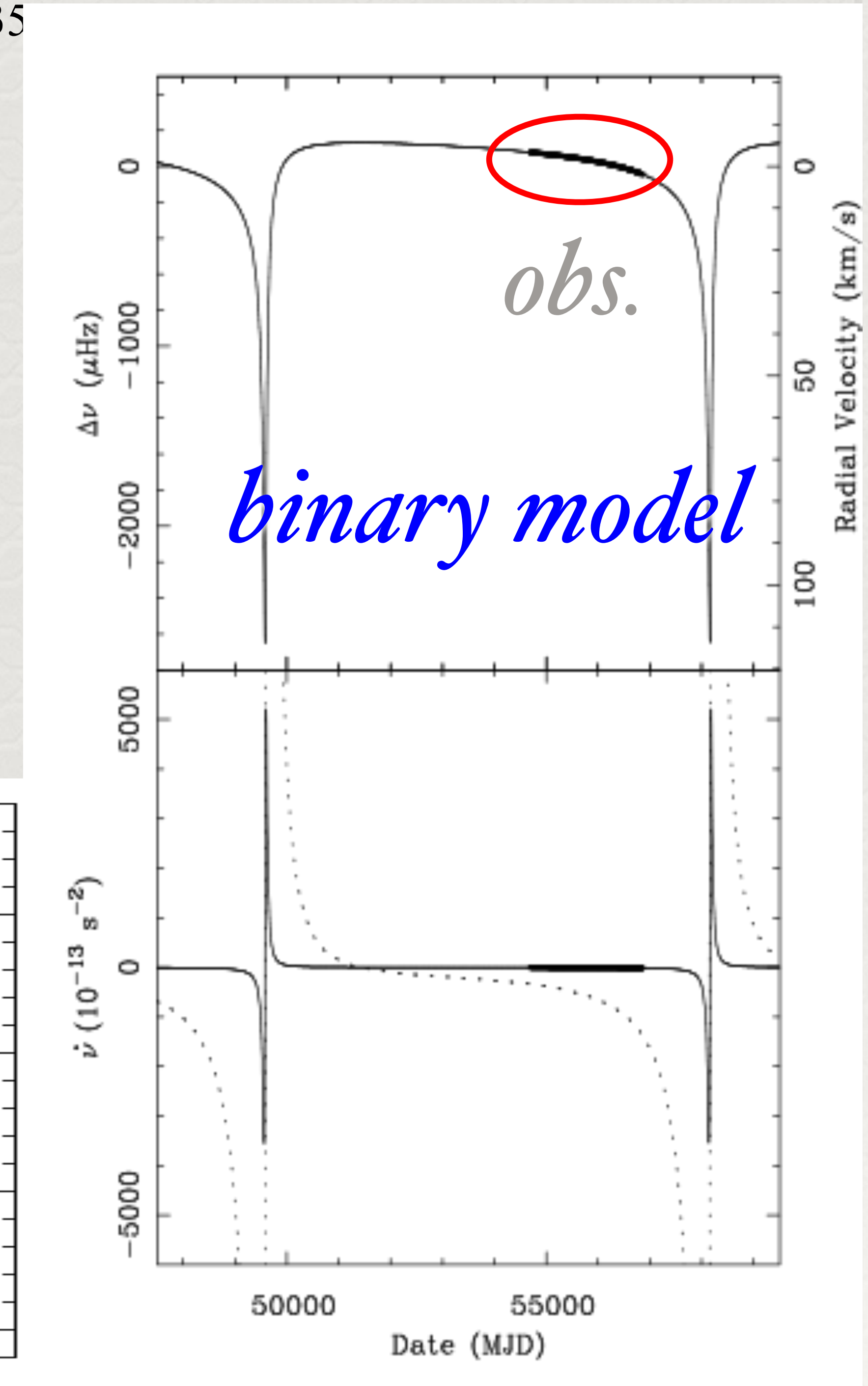
- *A gamma-ray pulsar (Camilo et al.2009)*

$$P \simeq 143\,\mathrm{ms} \quad L_{\mathrm{sd}} \simeq 1.7 \times 10^{35}$$

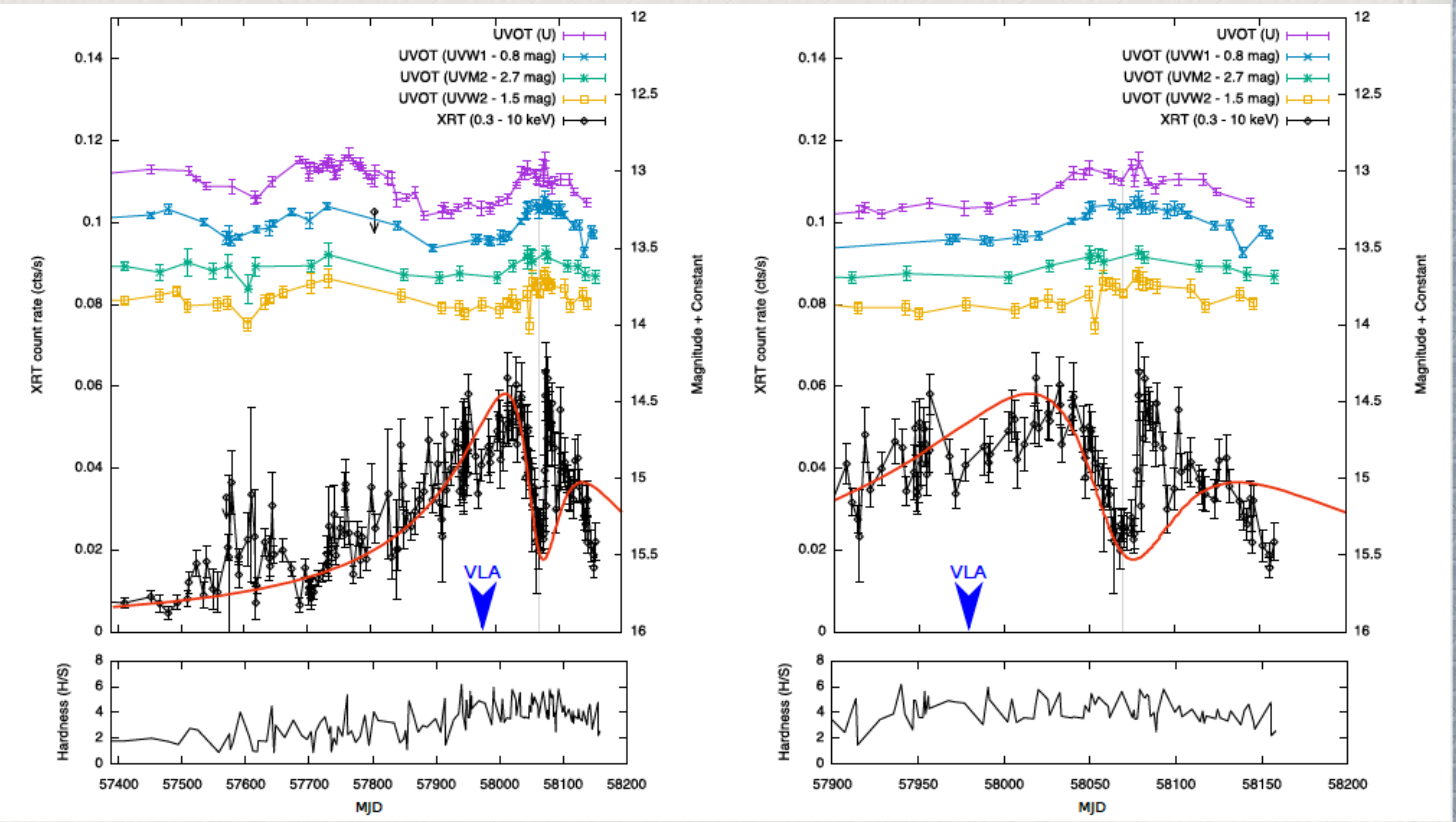
- *Radio pulsation unveiled*
- *Very long orbit binary: P~50 years.*

  (Lyne+ 2015, Ho+ 2016)
- *Last periastron passage in late 2017.*

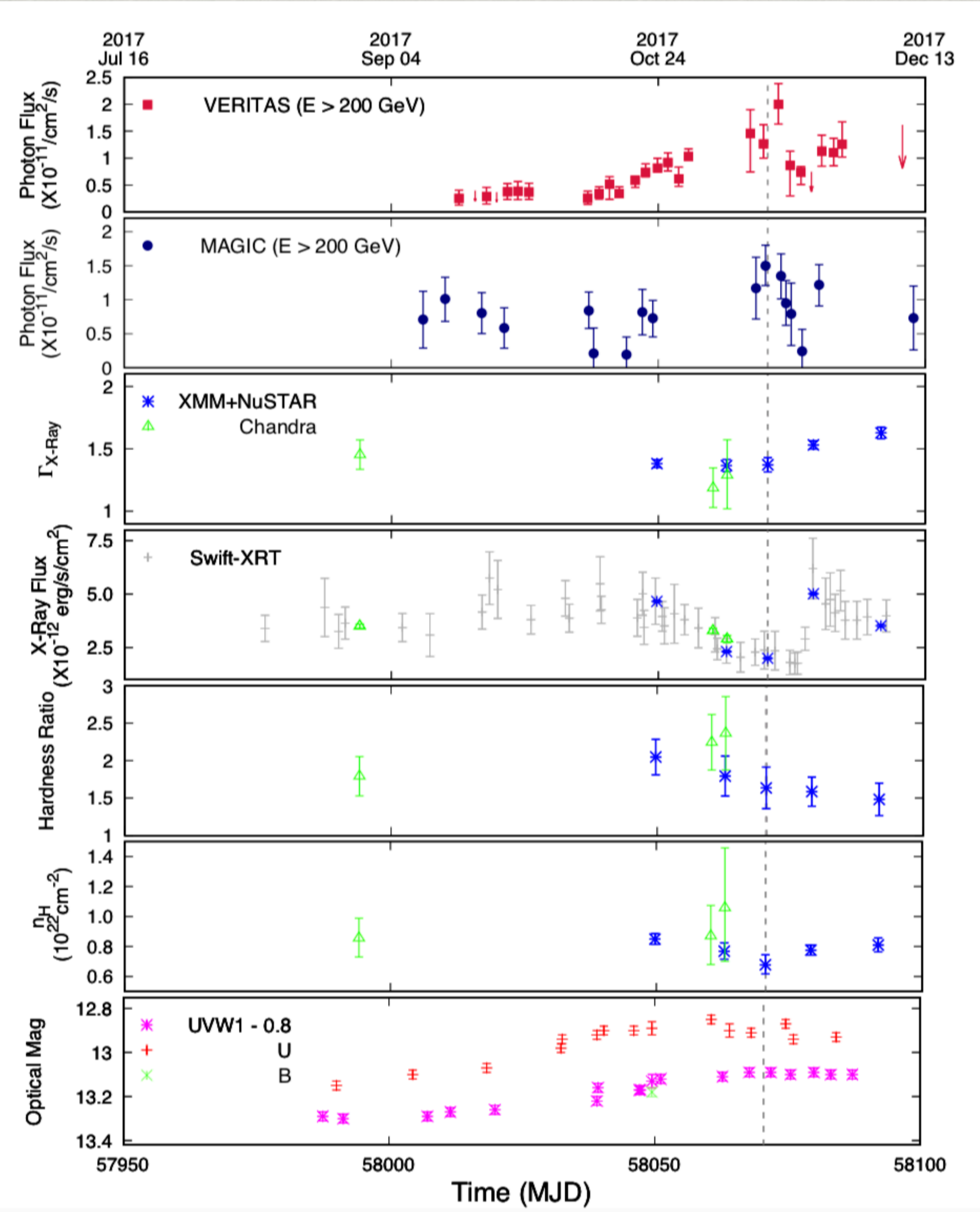




Full X-ray light curve



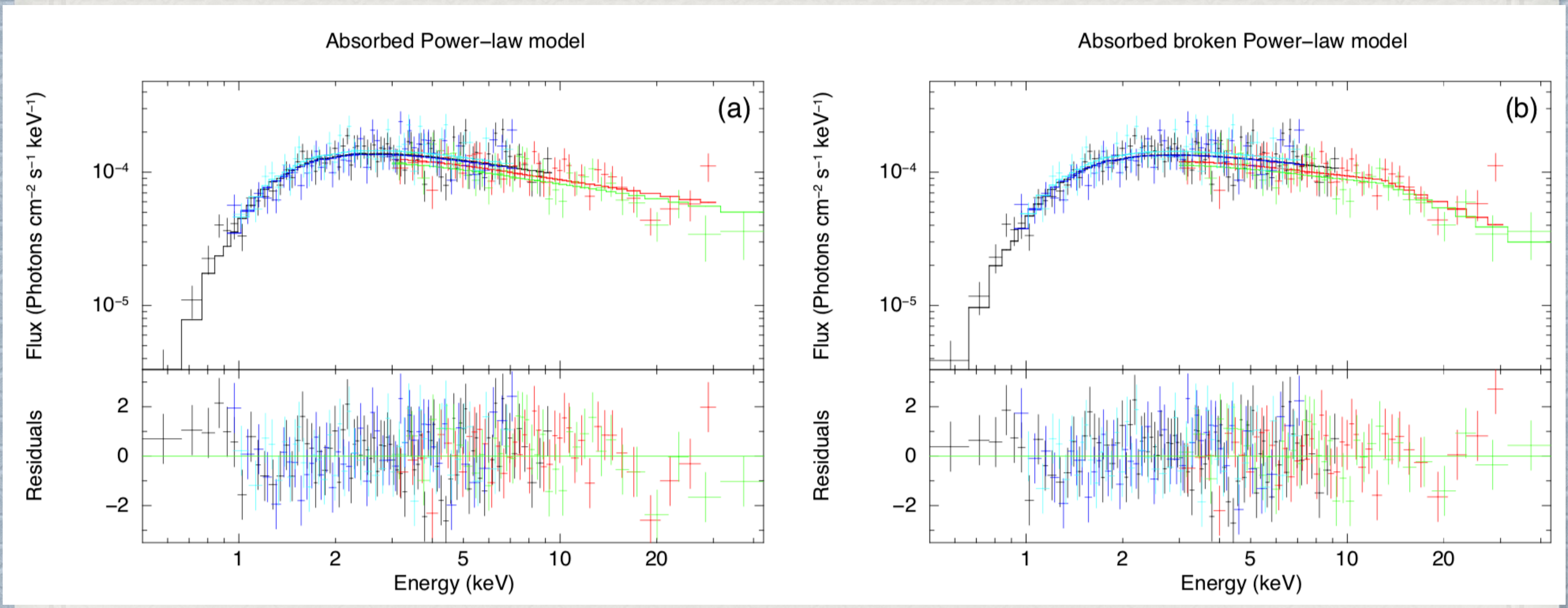
Li et al. (2018)



Accurate n_H and X-ray spectral measurements around periastron

Pal et al. (2019), see also Chernyakova's, LÓPEZ's talks

PL   Broken PL



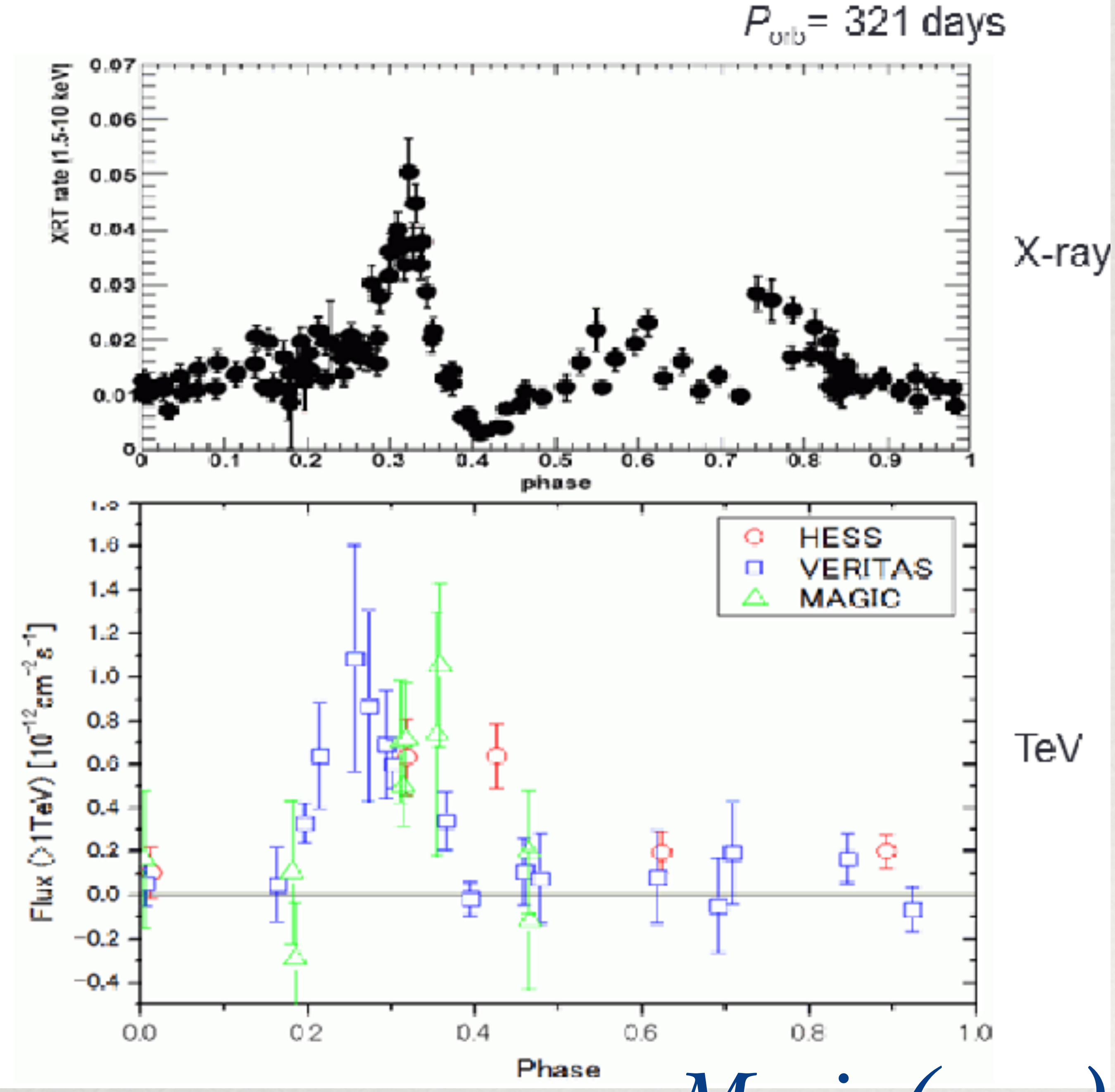
If fitting with a broken PL, the break is at 5-12 keV

Pal et al. (2019)

HESS J0632+057

HESS J0632+057

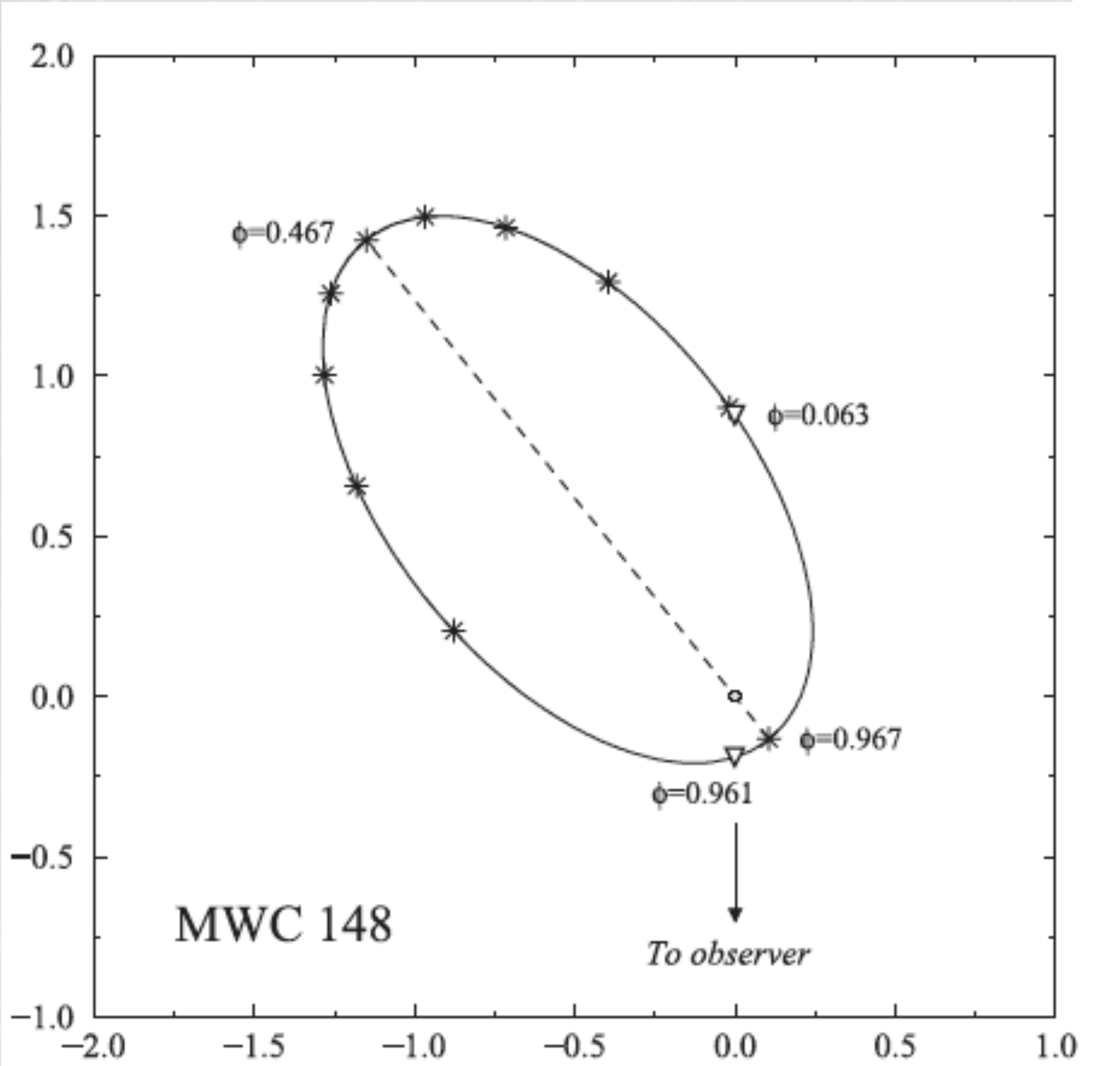
- *315 day binary period (identified in X-rays, Bongiorno et al. 2011)*
- *TeV light curve similar to in X-rays (Aliu et al. 2014, also see HADASCH's, PRADO's talk).*

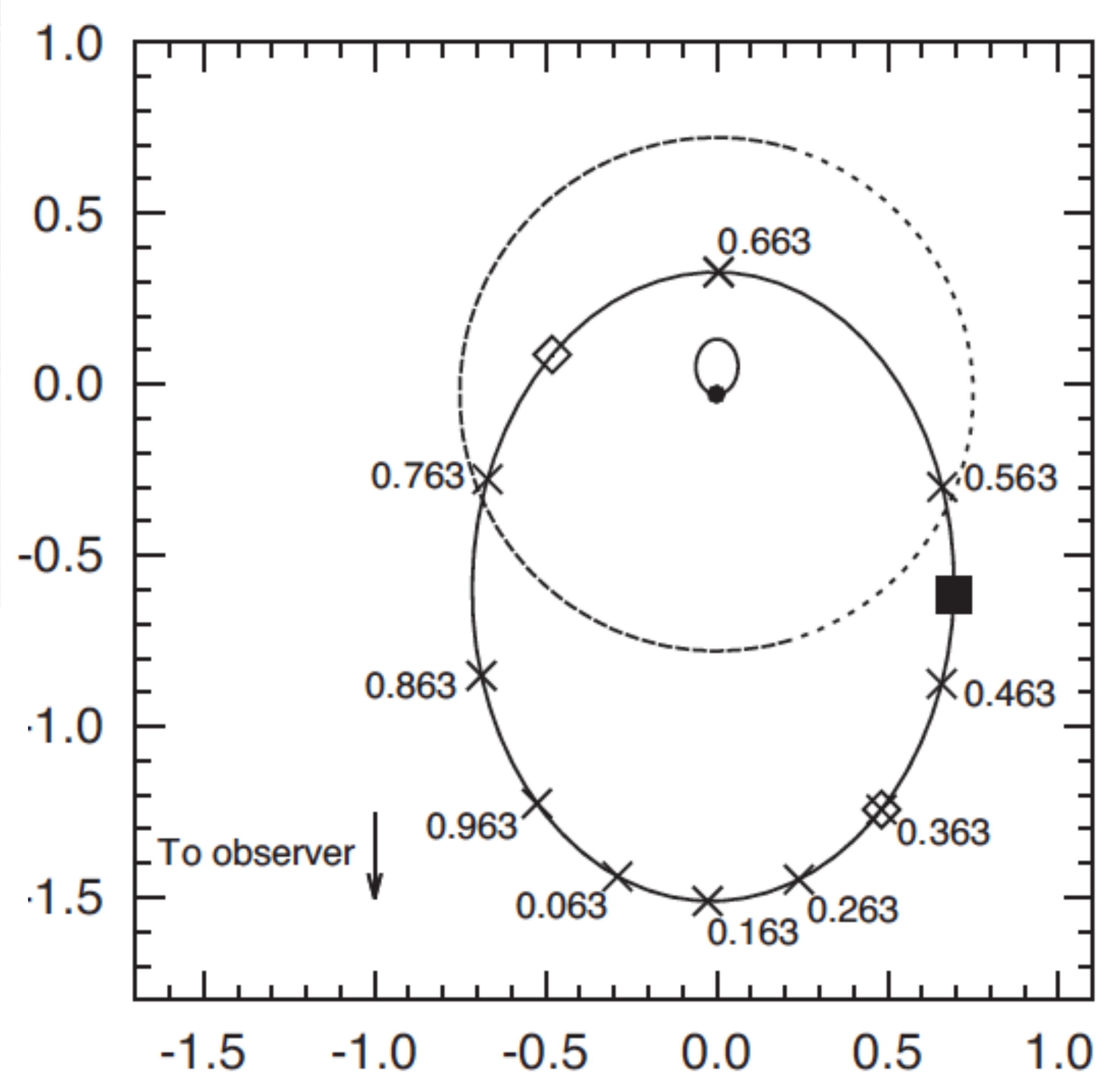


Mori+ (2013)

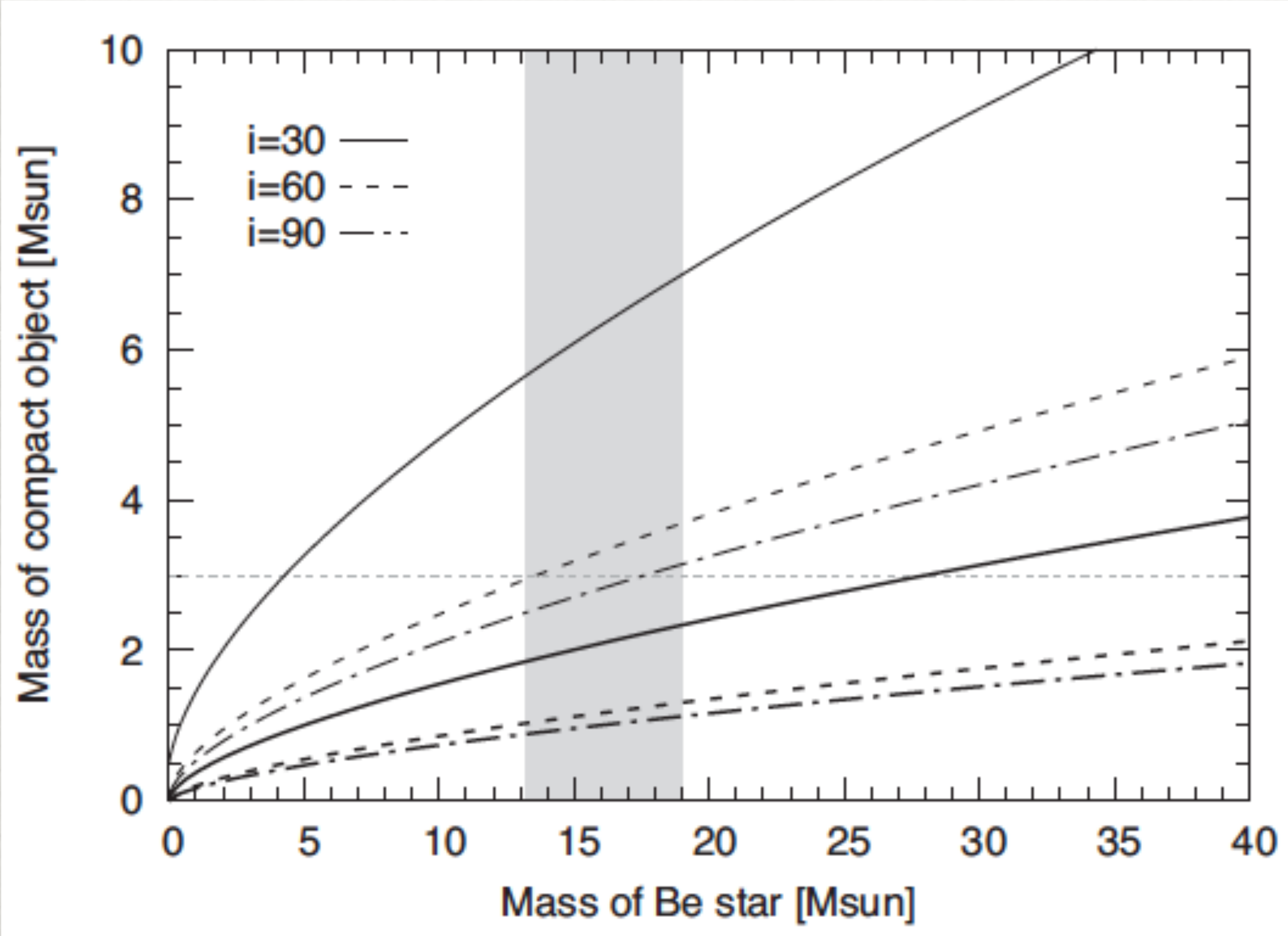
The orbit

Casares+ (2012)





Moritani+ (2018)



Thin line (Casares)

Thick line (Moritani)

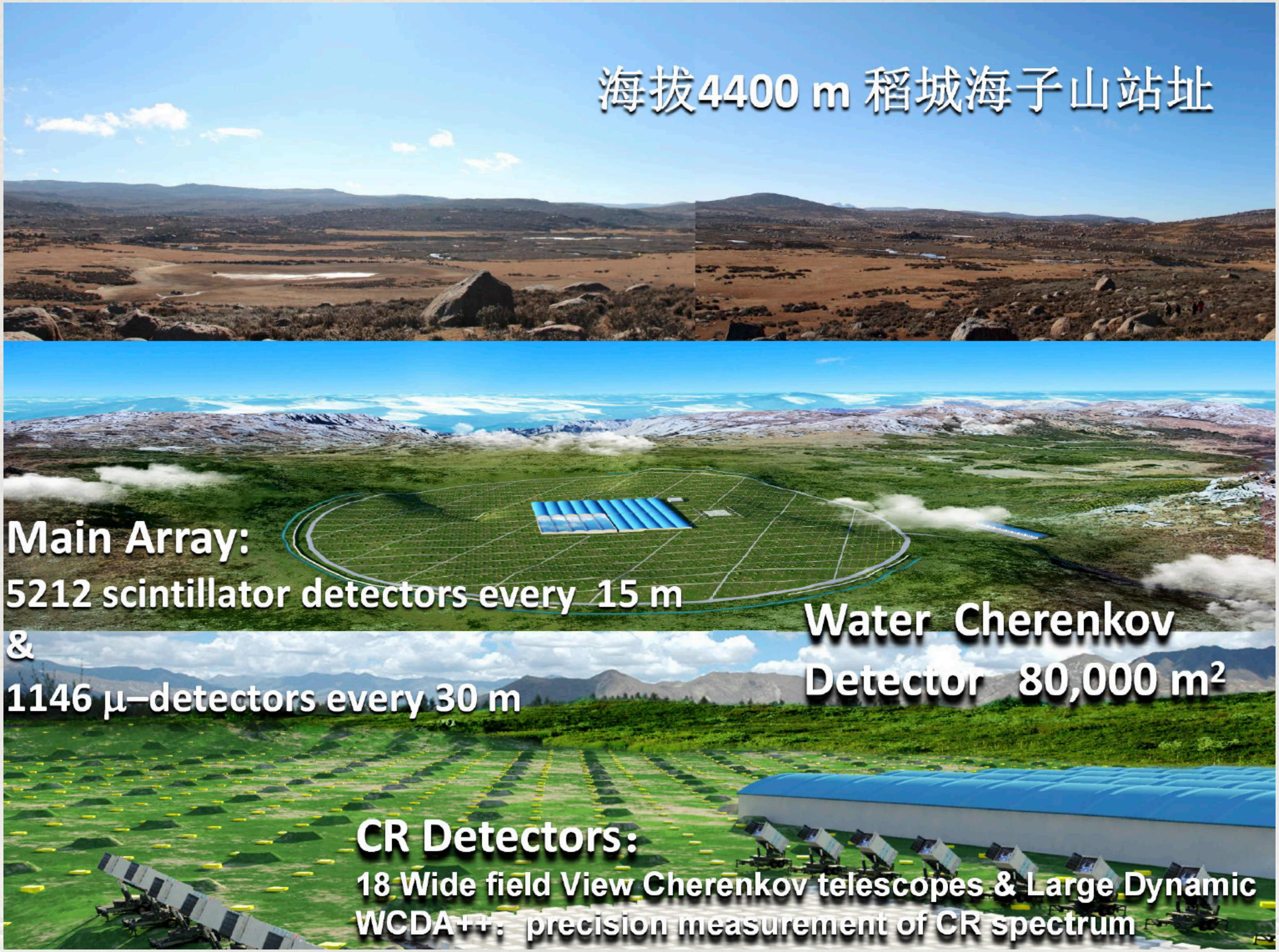
- *The mass of the compact object is constrained to be <2.5 solar mass (Moritani et al. 2018). These suggest that the compact object is a pulsar.*
- *Searching for pulsar seems to be a right thing to do*

FAST

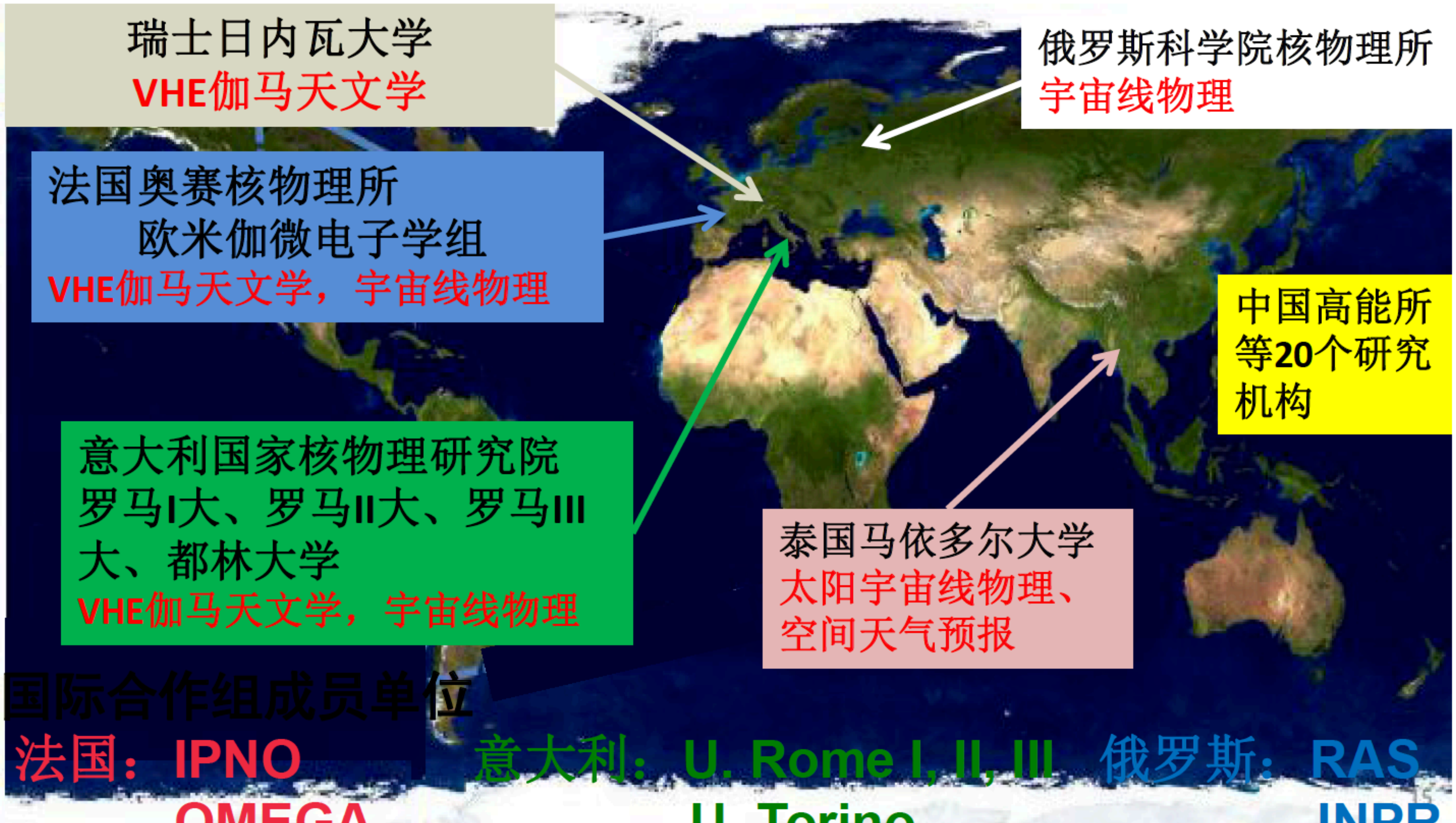
The FAST data

- *Observed for an hour each on April 23 and June 8 (away from X-ray flares/disk)*
- *RMS~20-30μJy*
- *Single pulse and periodic pulsation were searched*
- *No signal found*
- *Asking for more observational time*

LHAASO (early 2019-)
Commissioning , taking data, useful for VHE astrophysics



LHAASO国际合作团队



国际合作组成员单位

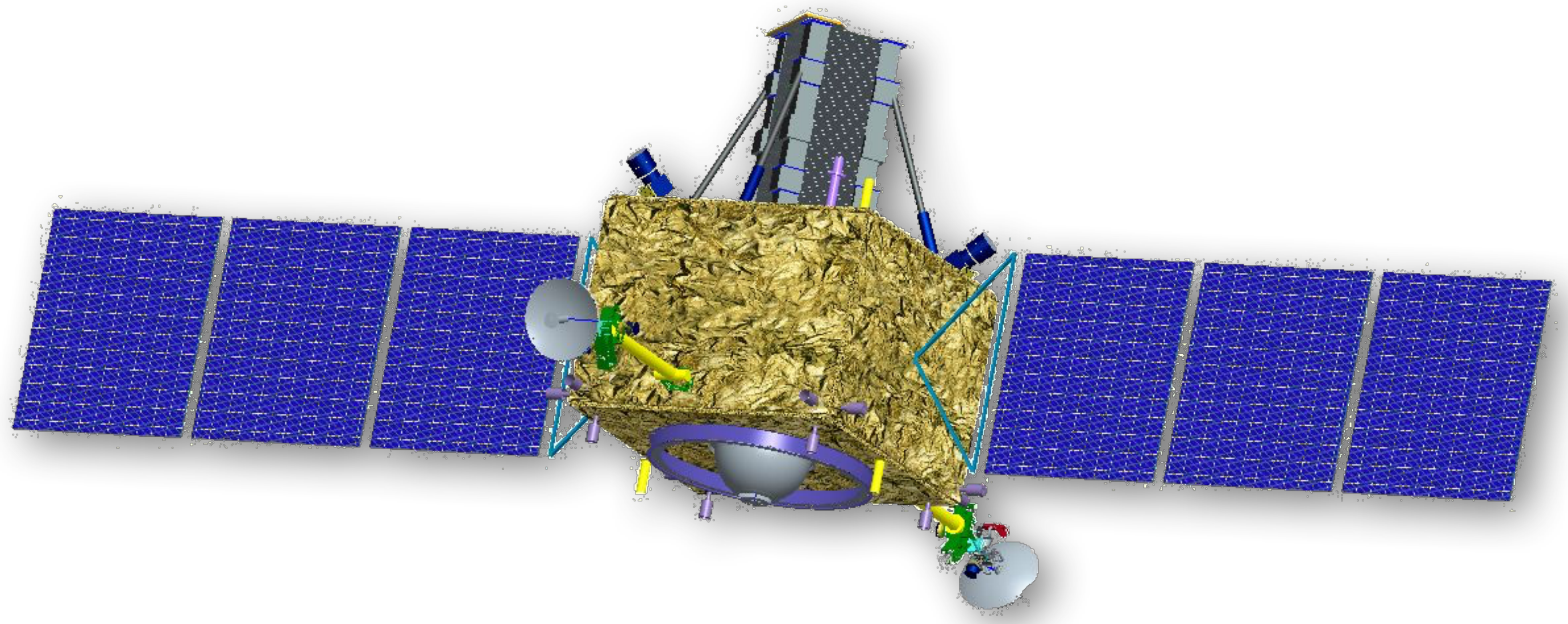
法国：IPNO
OMEGA
U. Montpellier

意大利：U. Rome I, II, III
U. Torino
U. Naples

俄罗斯：RAS
INPR

泰国：Mahidol U.

PANGU
盘古



A High Resolution Gamma-Ray Space Telescope

Meng Su[1], Pak Hin TAM (Thomas)[2] and growing…

[1]University of Hong Kong

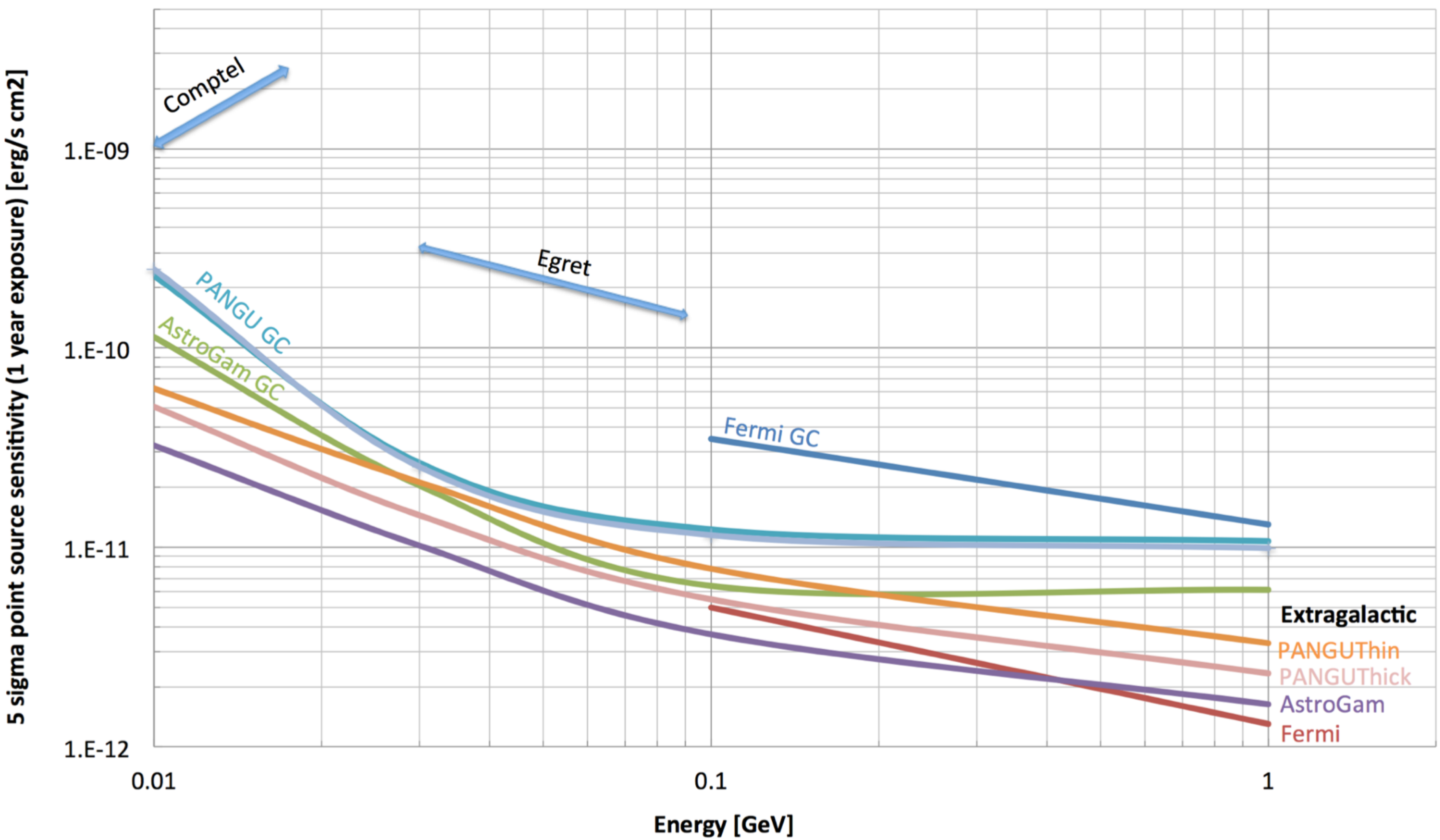
[2]Sun Yat-sen University

10 MeV - 10 GeV

*Bridging COMPTEL,
AGILE
and Fermi energies*

4th September 2019

Sensitivity curves of PANGU, compared to Fermi-LAT & AstroGAM



Mission parameter	Requirement
Energy band	10 MeV-10GeV
Field of view with nominal effective area	1 steradian (45° opening) Design: π steradian (60° opening)
Maximum field of view	2π steradian
Point source sensitivity (Galactic centre)	10^{-11} erg/s cm^2 (>100 MeV, 1 year eff. exposure) 10^{-10} erg/s cm^2 (10 MeV, 1 year eff. exposure)
Angular resolution (normal incidence)	1 degree (100 MeV) 0.2 degree (1 GeV)
Polarisation sensitivity	Amplitude: 20% for 10^4 events Direction: 45 degrees for 10^4 events
Absolute event reconstructed time tagging accuracy	10 micro-seconds
Energy resolution	30-50%
Detector alignment calibration	< 10 micro-meters
Attitude reconstruction accuracy	< 1 arcmin (X – optical - axis) < 0.5 arcmin (Y/Z axis)
Replanning capability (TOO)	< 1 working day
Mission duration	3.5 years, extendable to 10 years
Scientific telemetry	10 Mbit/s

Thank you!