The hour timescale GeV flares of PSR B1259-63 in 2017

P. H. Thomas Tam

Sun Yet-sen University

Yudong Cui, Partha Pal, Xinbo He

China

Zhuhai

Vietnam

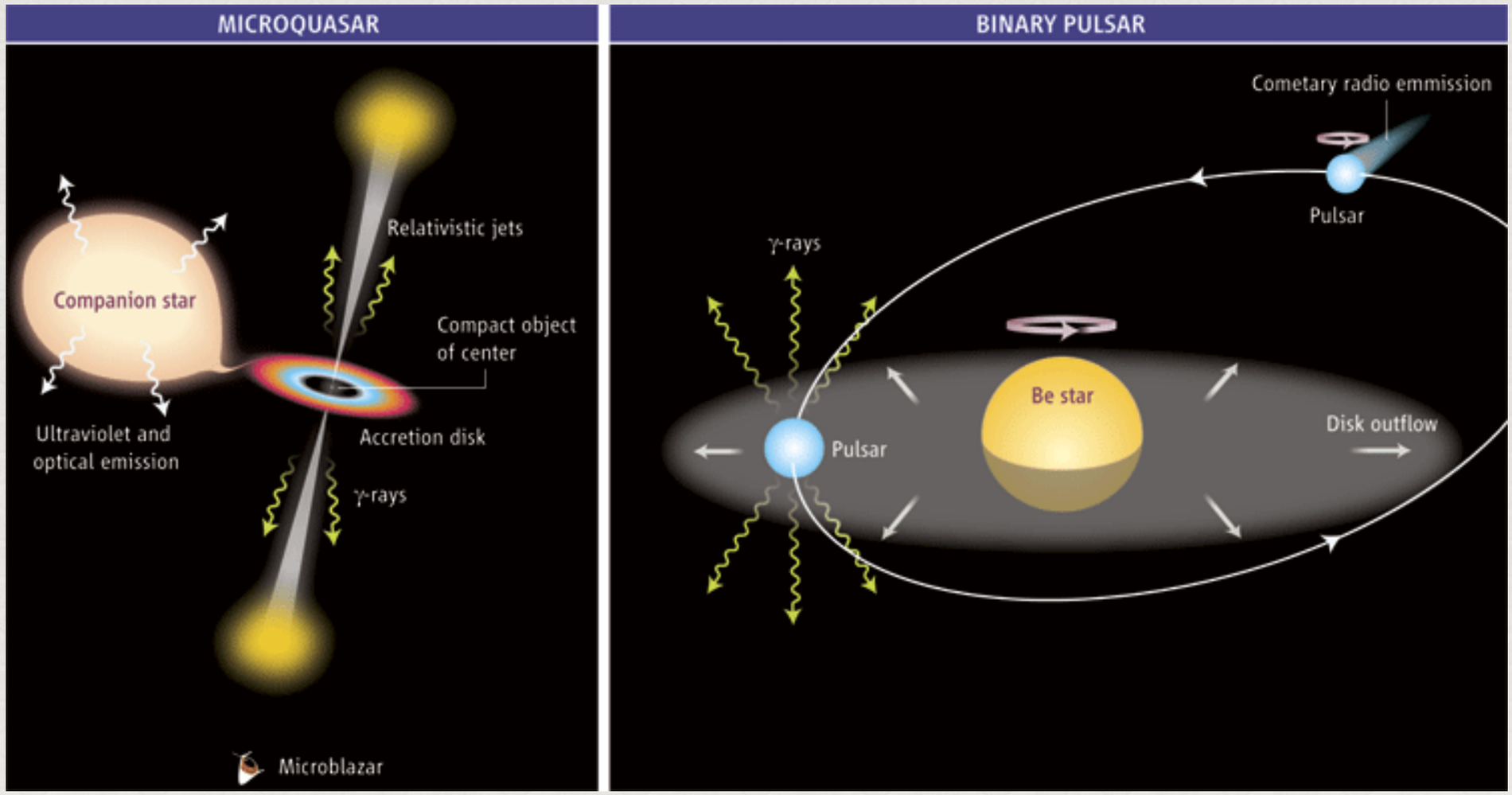
Hong Kong

Macau

where we are now

where we are now

Gamma-ray binaries



Currently known high-mass gamma-ray binaries

Dubus (2015)

name	binary components		P_{orb} (d)	HE	VHE	refs (⋆)	notes
(high-mass) gamma-ray binaries							
PSR B1259-63	pulsar	Be	1236.7	✓	✓	[12, 13]	47.7 ms
HESS J0632+057	?	Be	315		✓	[14, 15]	
LS I +61°303	?	Be	26.5	✓	✓	[16, 17]	magnetar ?
1FGL J1018.6-5856	?	O	16.6	✓	✓	[18, 19]	
LS 5039	?	O	3.9	✓	✓	[20, 21]	

Currently known high-mass gamma-ray binaries

Dubus (2015)

name	binary components		P_{orb} (d)	HE	VHE	refs (⋆)	notes
(high-mass) gamma-ray binaries							
PSR B1259-63	pulsar	Be	1236.7	✓	✓	[12, 13]	47.7 ms
HESS J0632+057	?	Be	315		✓	[14, 15]	
LS I +61°303	?	Be	26.5	✓	✓	[16, 17]	magnetar ?
1FGL J1018.6-5856	?	O	16.6	✓	✓	[18, 19]	
LS 5039	?	O	3.9	✓	✓	[20, 21]	
LMC P3	?	O	~10	✓	✓		
PSR J2032+4127	pulsar	Be	50 years			GeV pulsation	

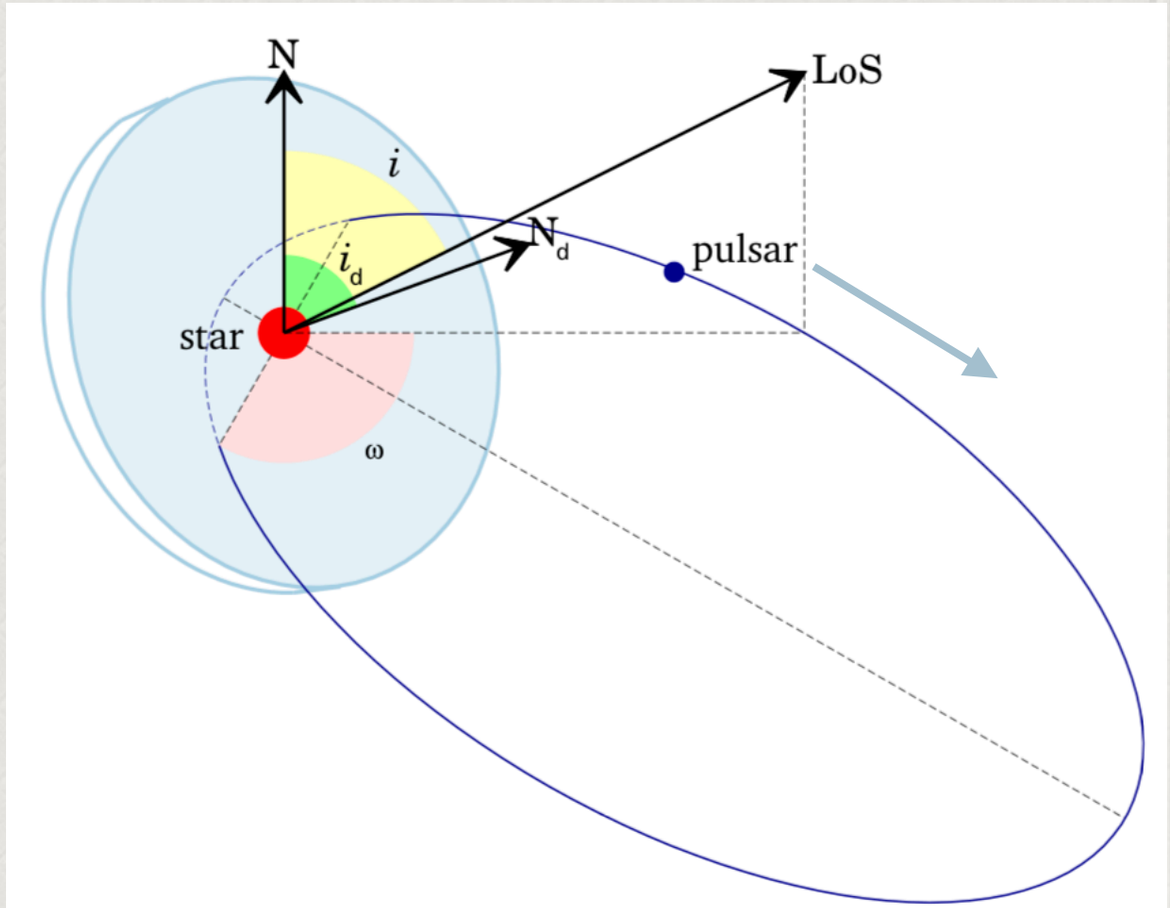
Currently known high-mass gamma-ray binaries

Dubus (2015)

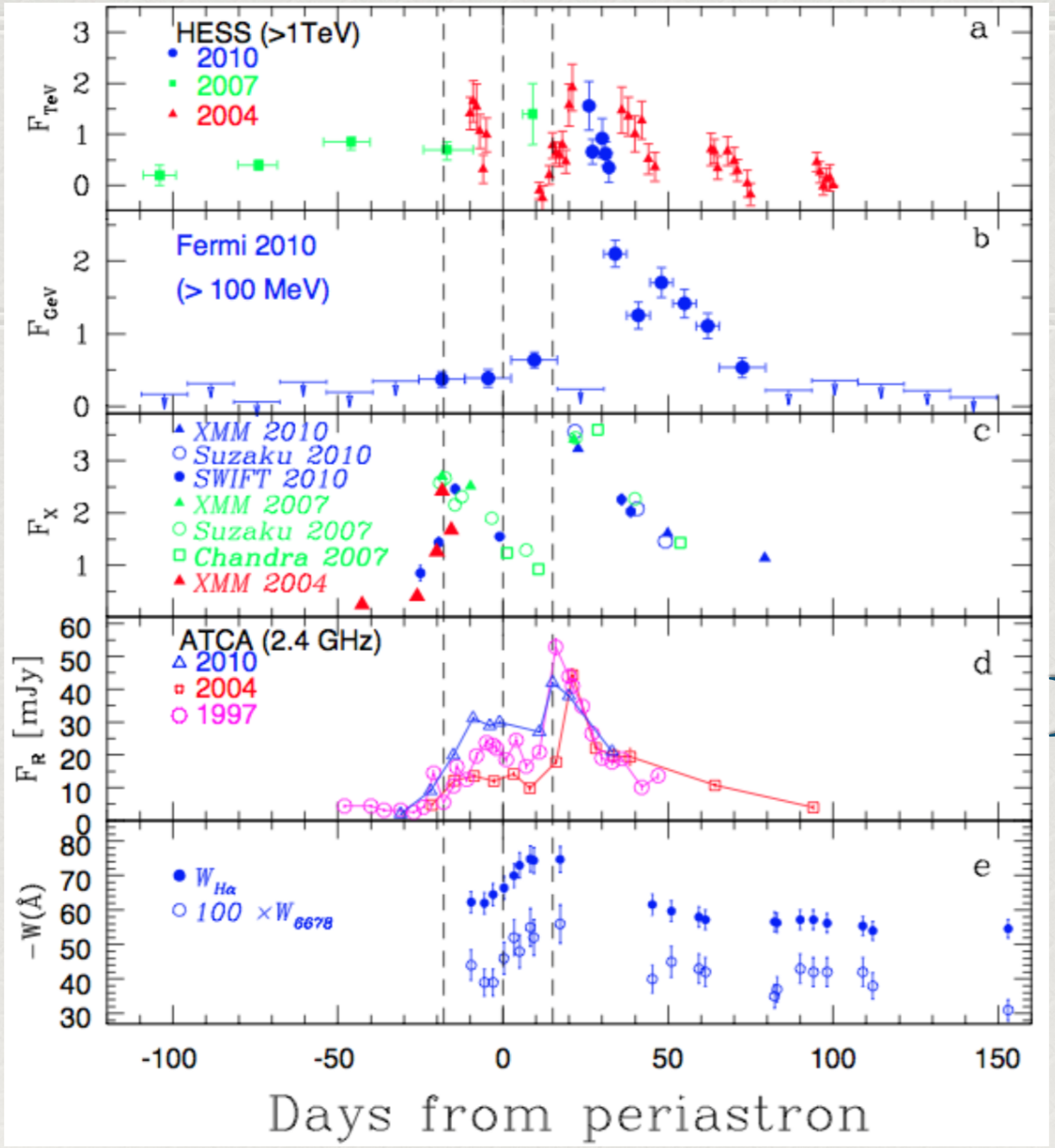
name	binary components		P_{orb} (d)	HE	VHE	refs (⋆)	notes
(high-mass) gamma-ray binaries							
PSR B1259-63	pulsar	Be	1236.7	✓	✓	[12, 13]	47.7 ms
HESS J0632+057	?	Be	315	✓	✓	[14, 15]	
LS I +61°303	?	Be	26.5	✓	✓	[16, 17]	magnetar ?
1FGL J1018.6-5856	?	O	16.6	✓	✓	[18, 19]	
LS 5039	?	O	3.9	✓	✓	[20, 21]	
LMC P3	?	O	~10	✓	✓		
PSR J2032+4127	pulsar	Be	50 years			GeV pulsation	

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)



TeV

GeV

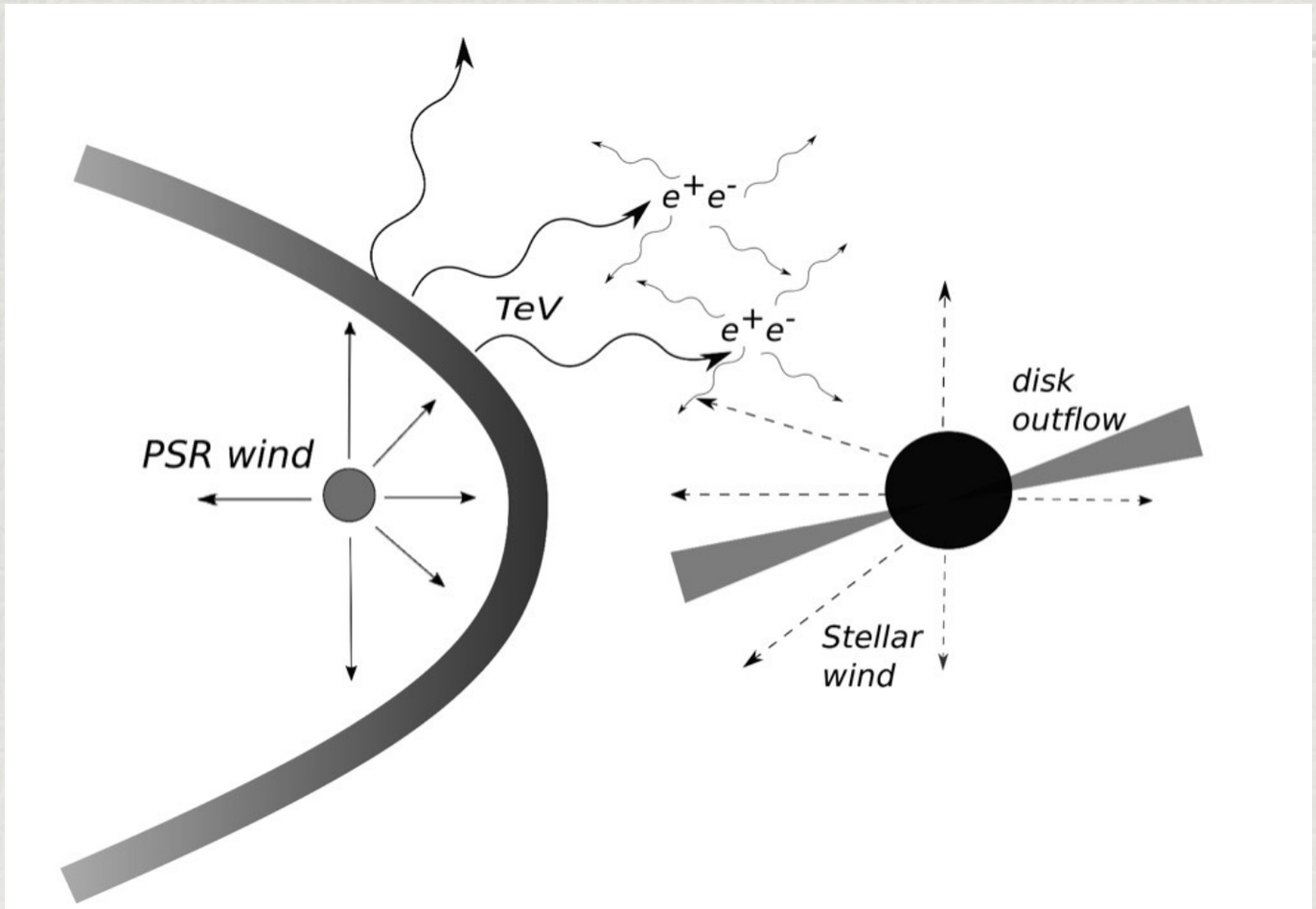
X-ray

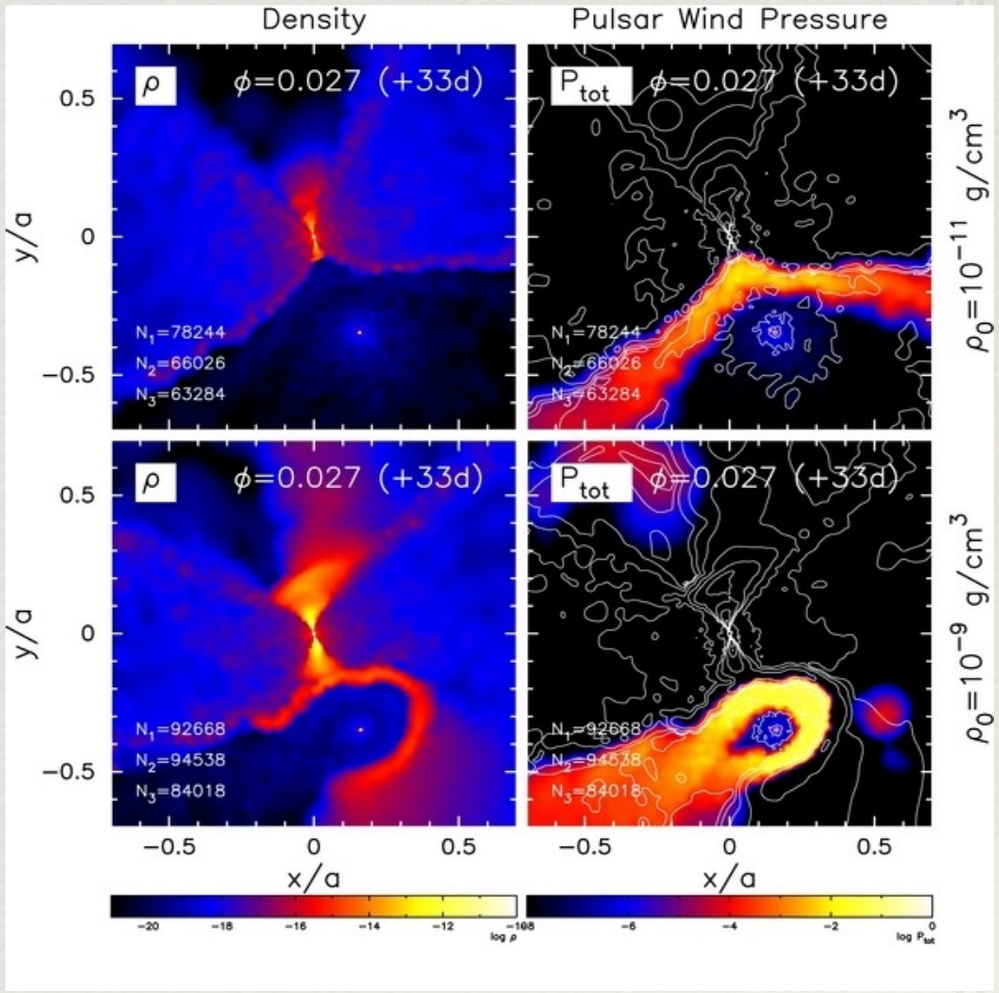
Radio

Hα

Chernyakova et al. (2014)

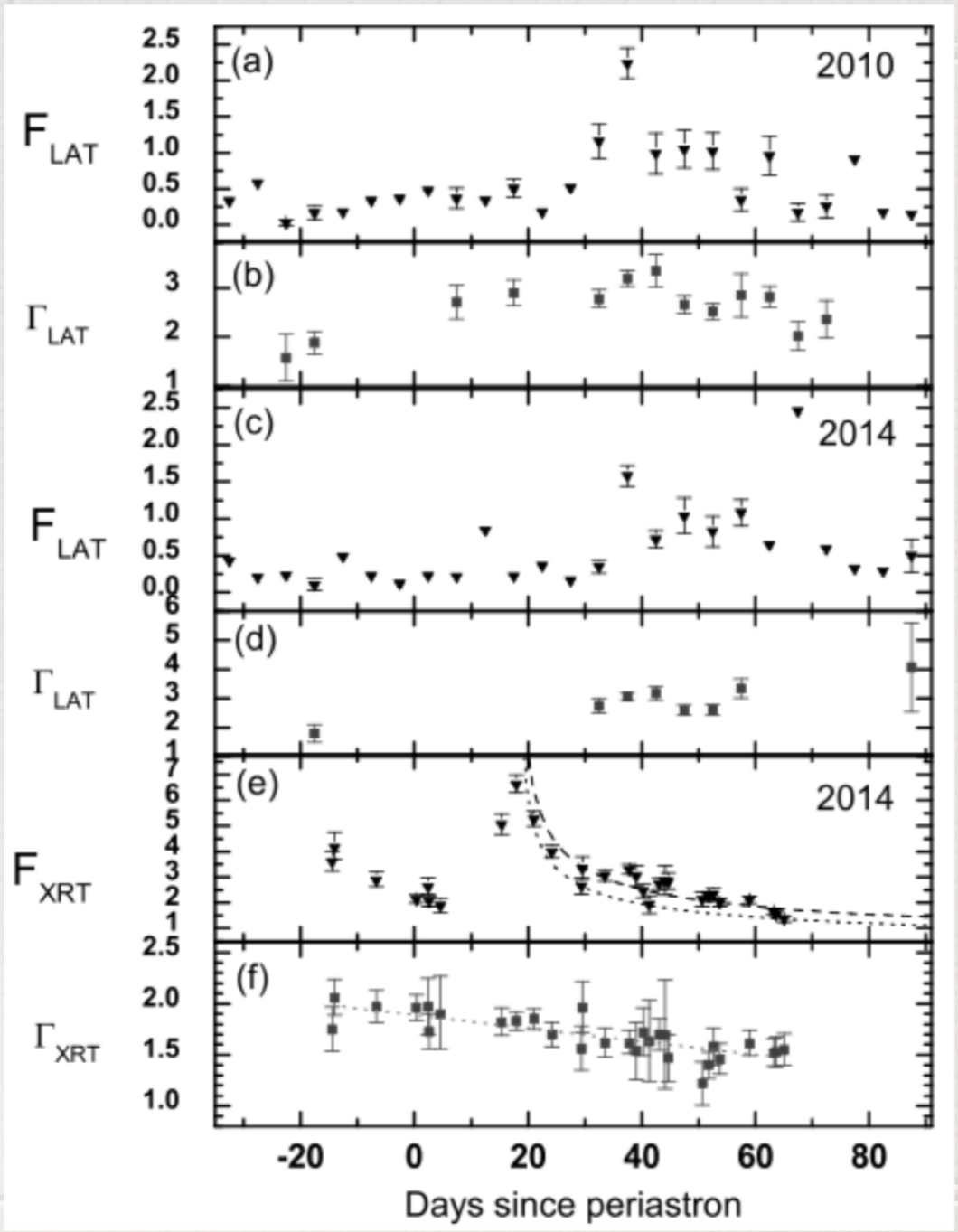
Shock acceleration can explain the X/TeV well, e.g., Takata+(2012)





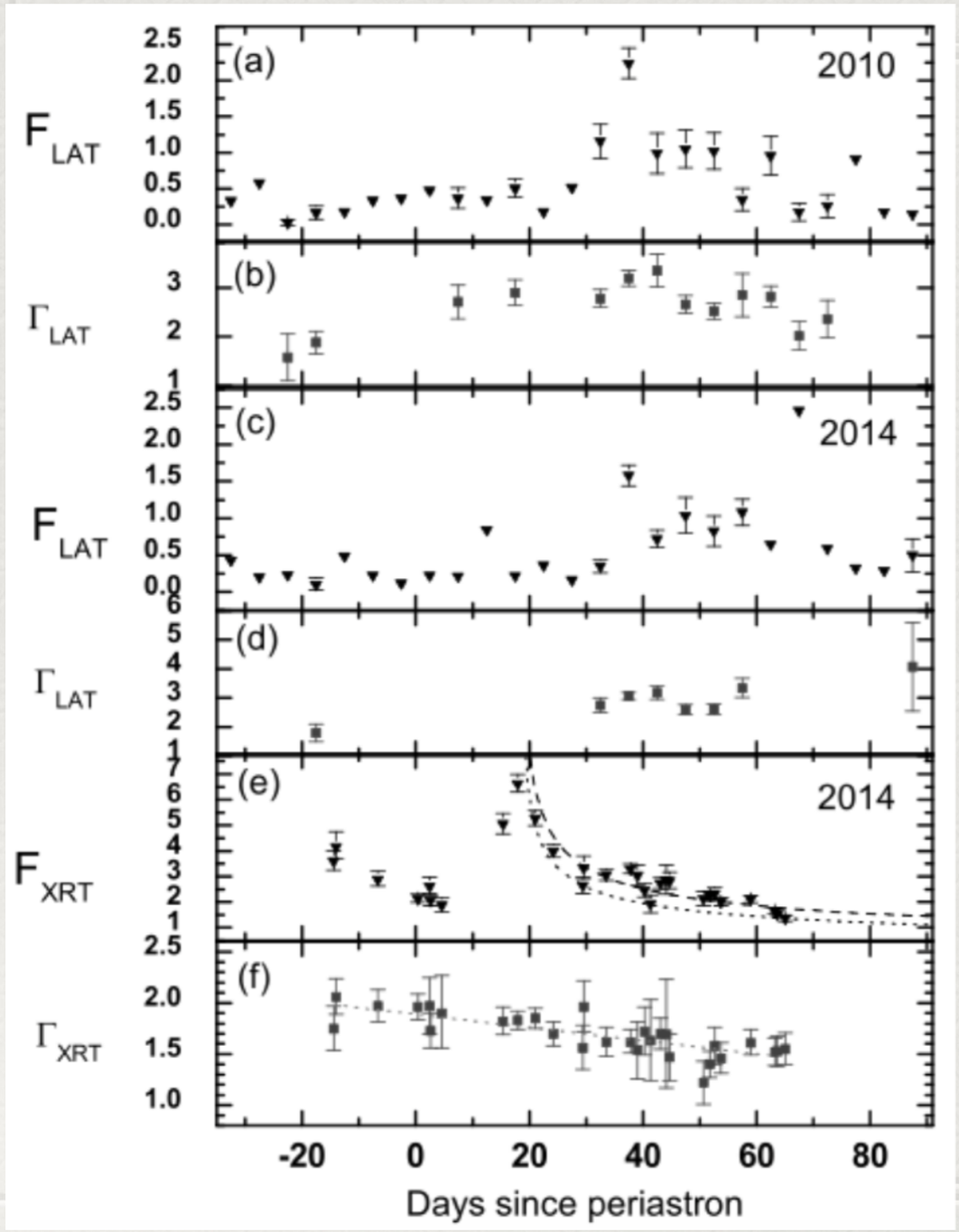
Takata +(2017)

2011 GeV flares repeat in 2014 in similar orbital phase

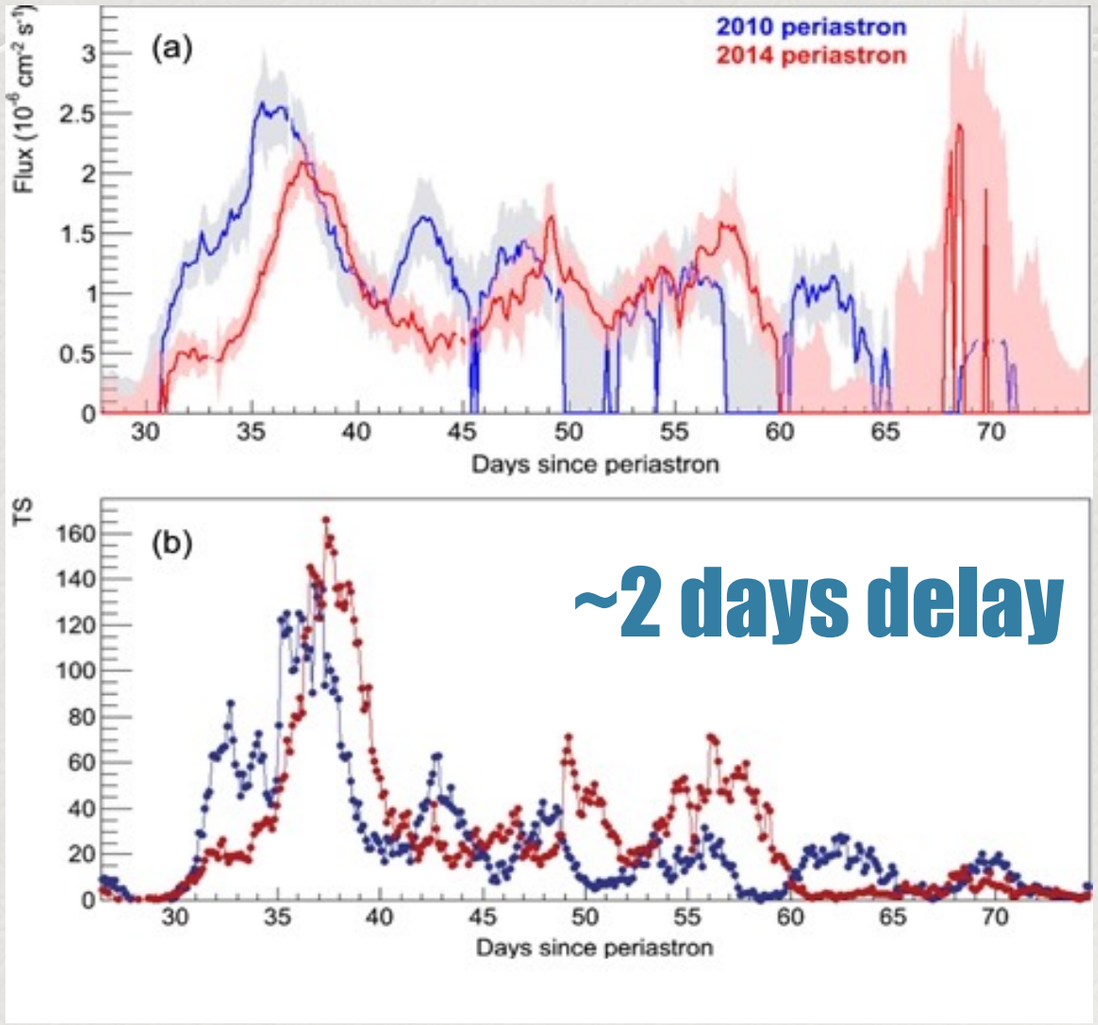


Tam et al. (2011, 2015)

2011 GeV flares repeat in 2014 in similar orbital phase

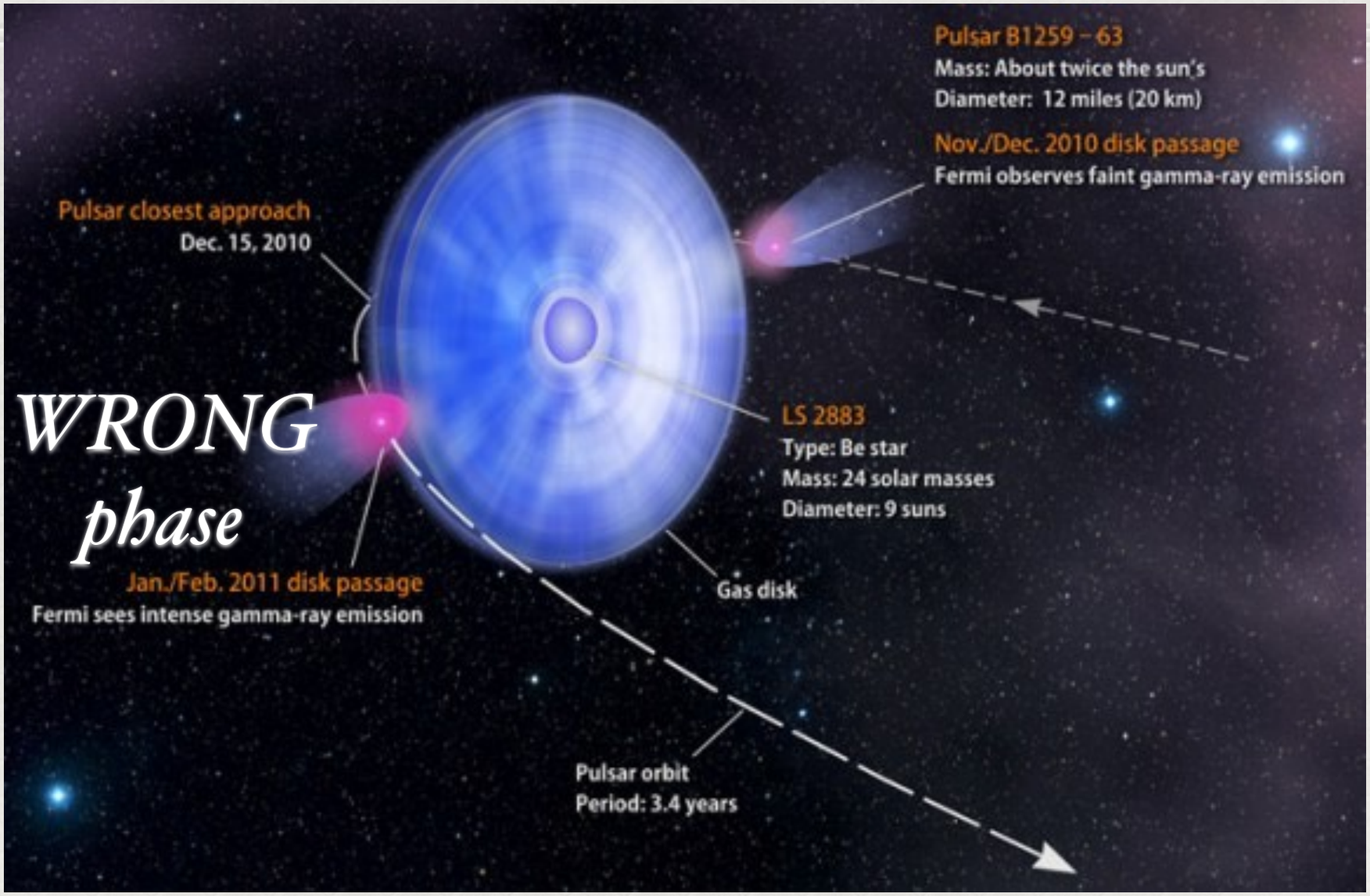


Tam et al. (2011, 2015)



Caliandro+ (2015)

The orbital phase where GeV emission occurs

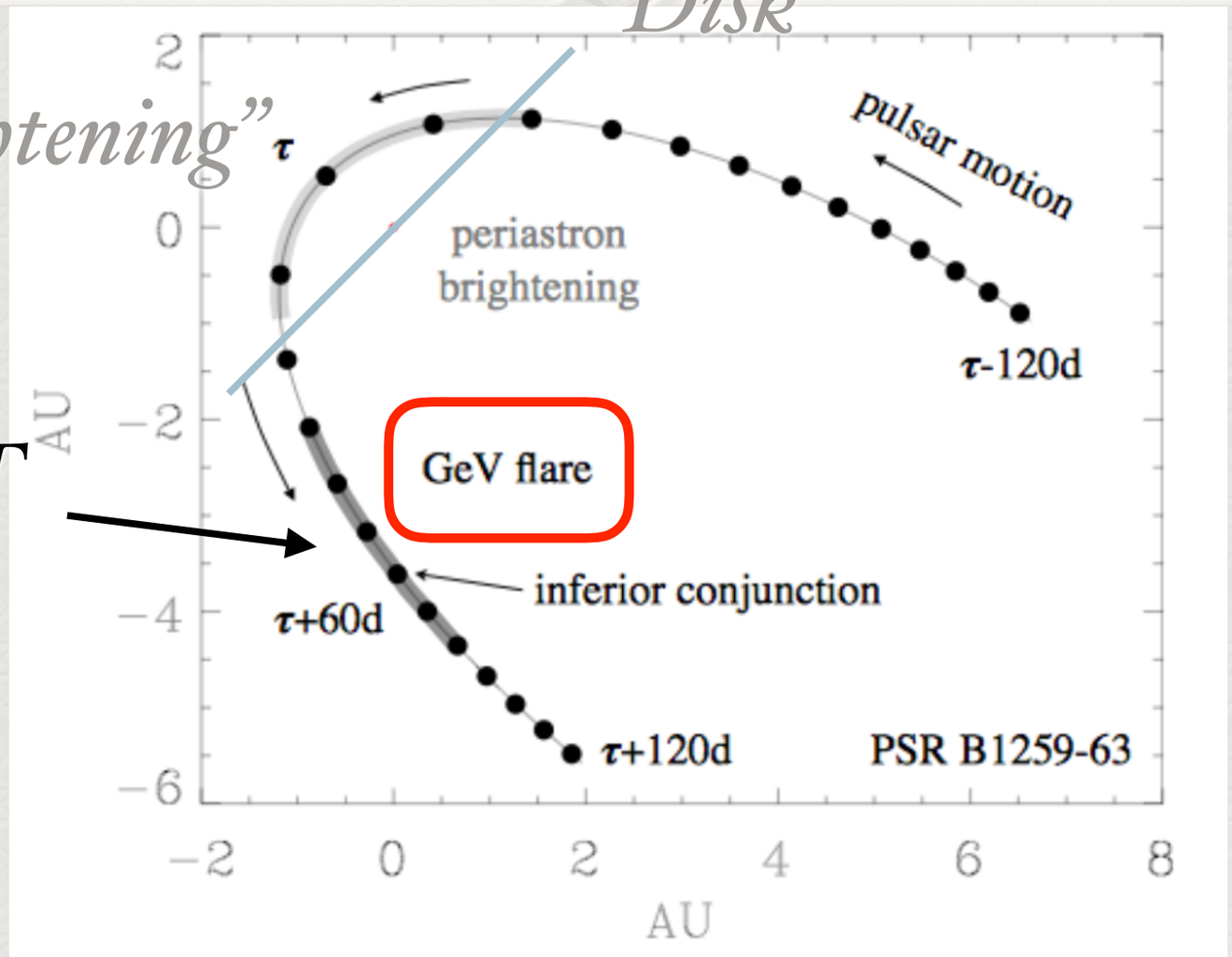


The orbital phase where GeV emission occurs

Disk

"Brightening"

RIGHT phase

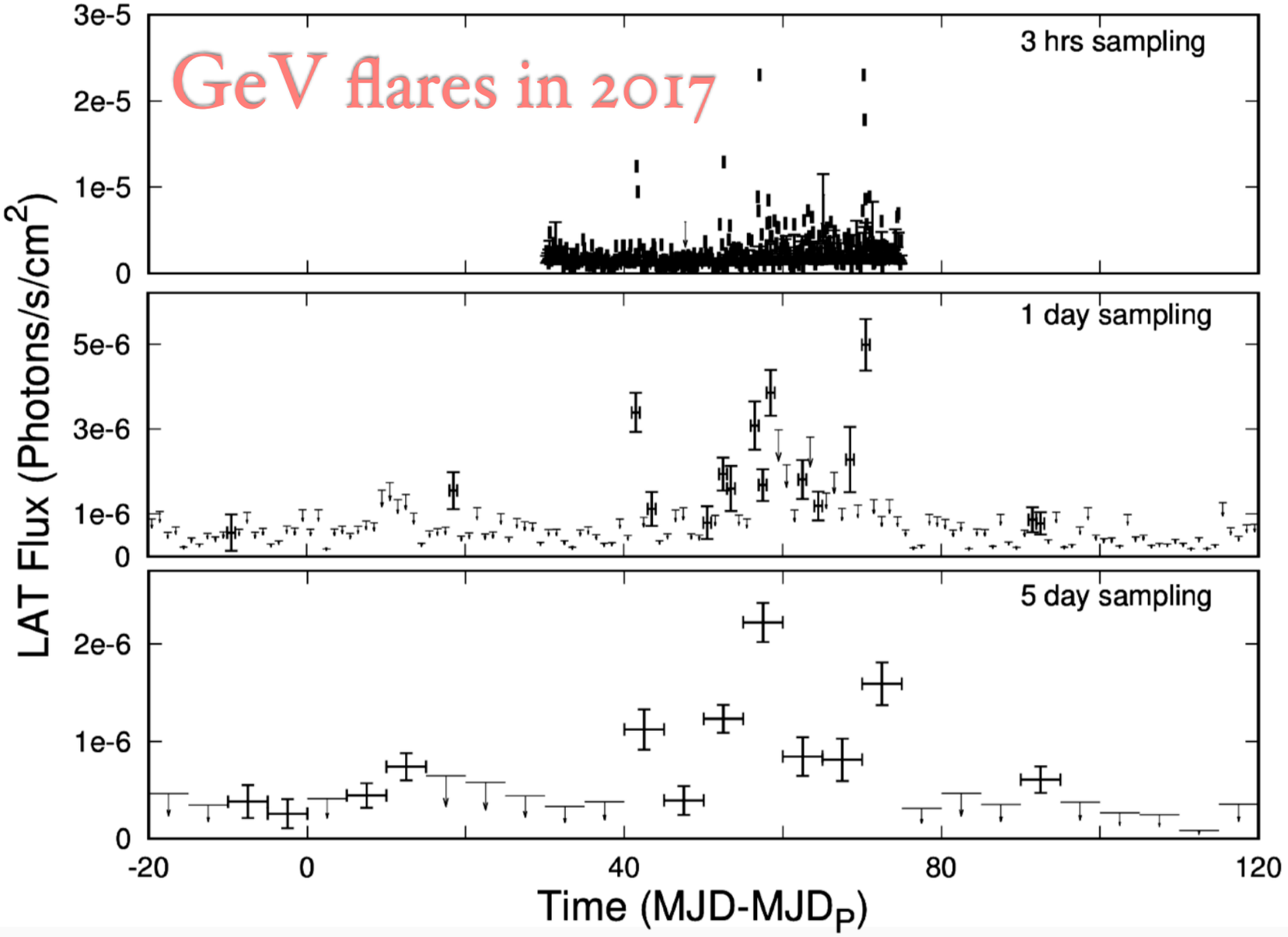


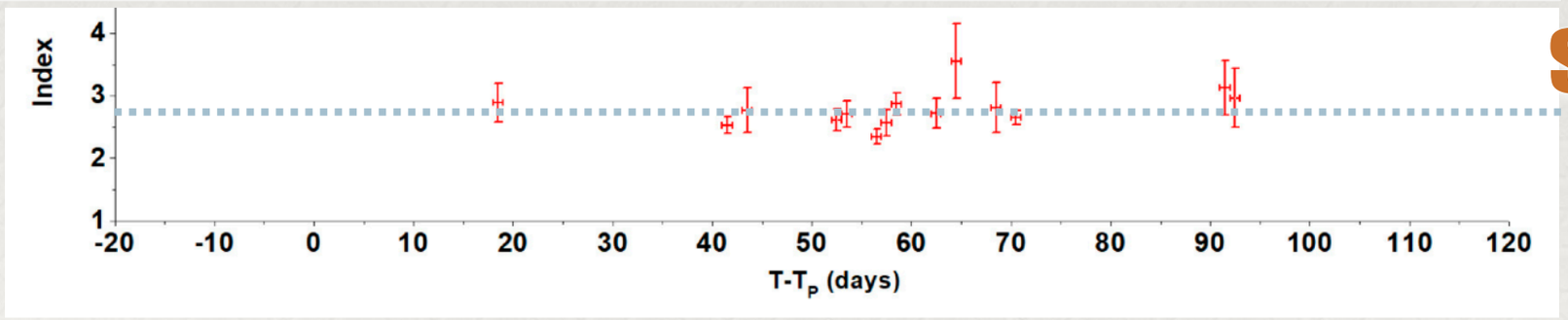
Dubus (2013)

News from 2017 periastron

(Tam et al., ApJ, 2018)

GeV flares in 2017



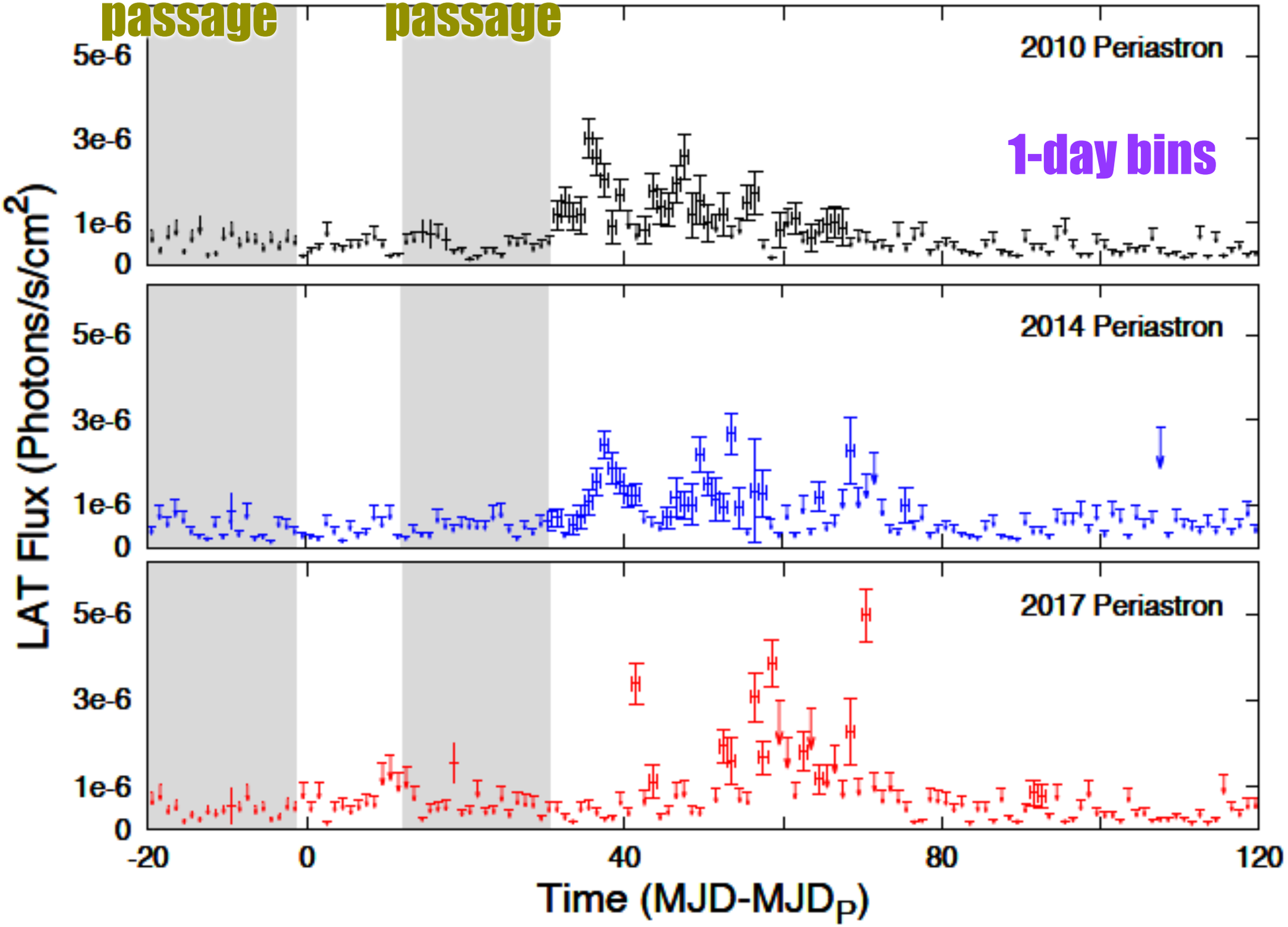


2.8

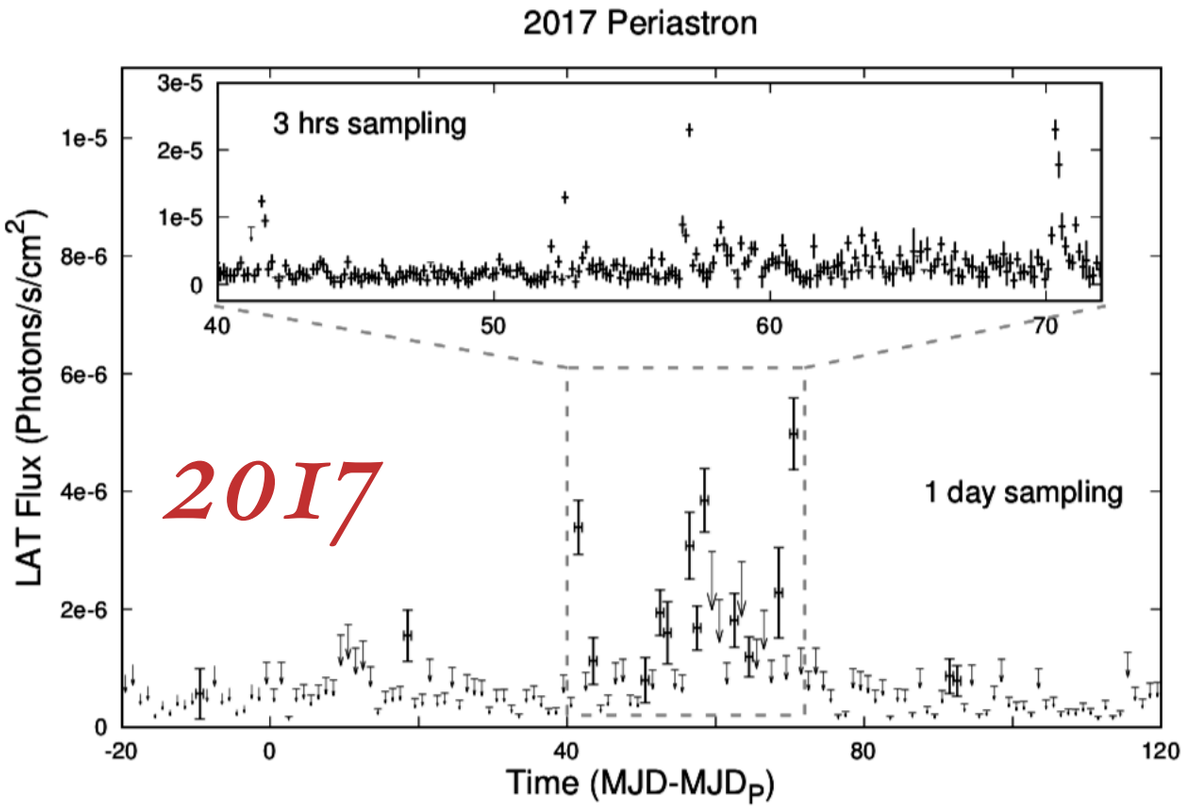
spectrum does not change!

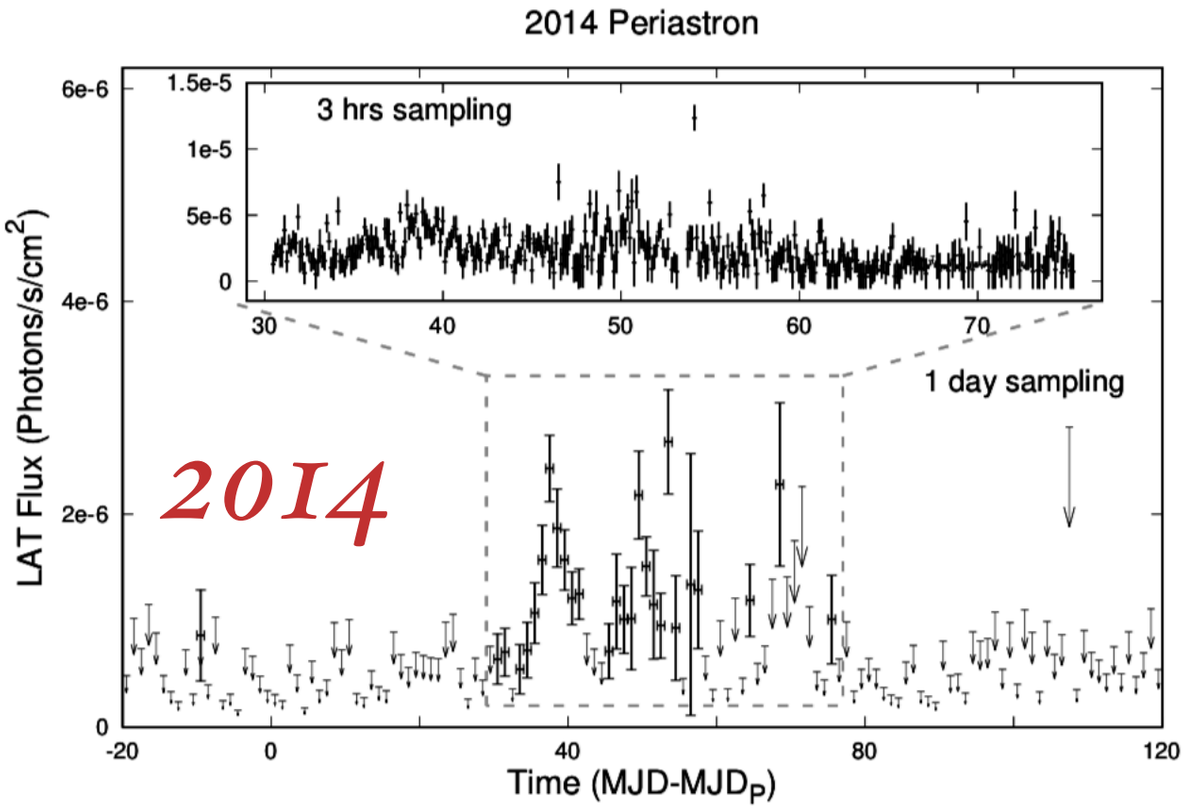
first disk passage

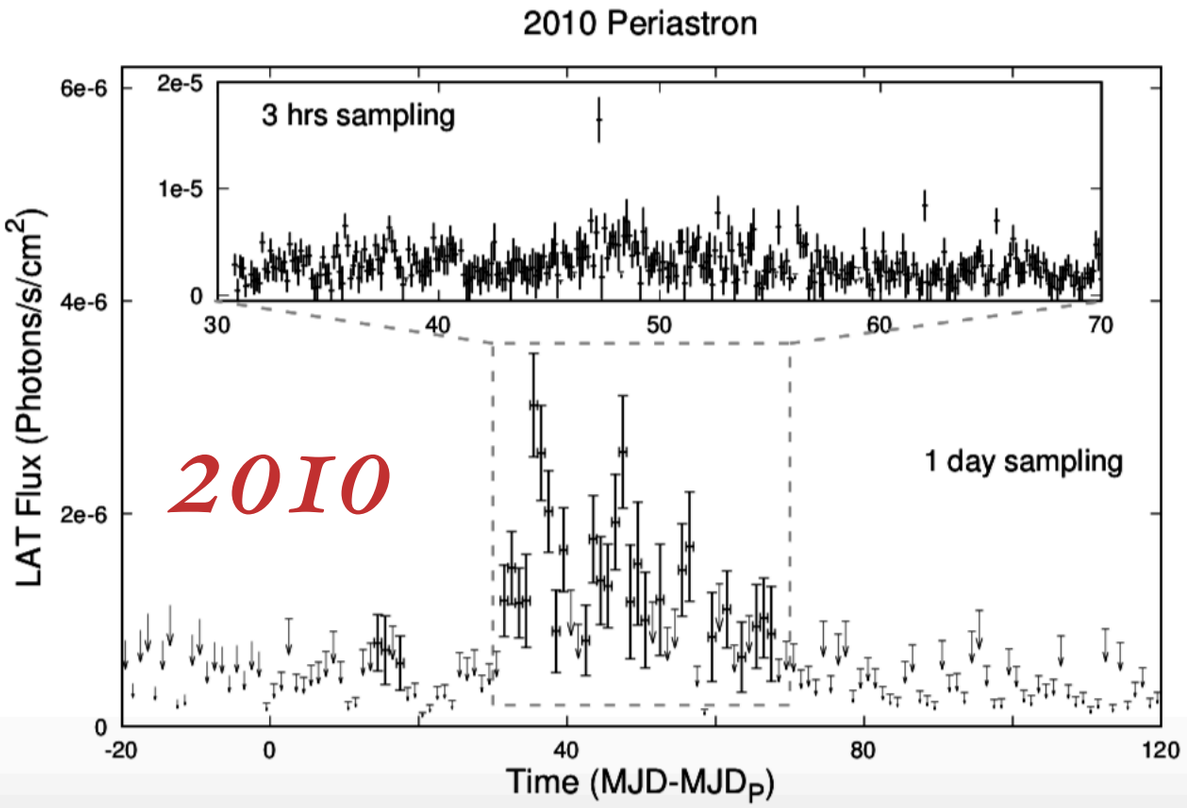
second disk passage

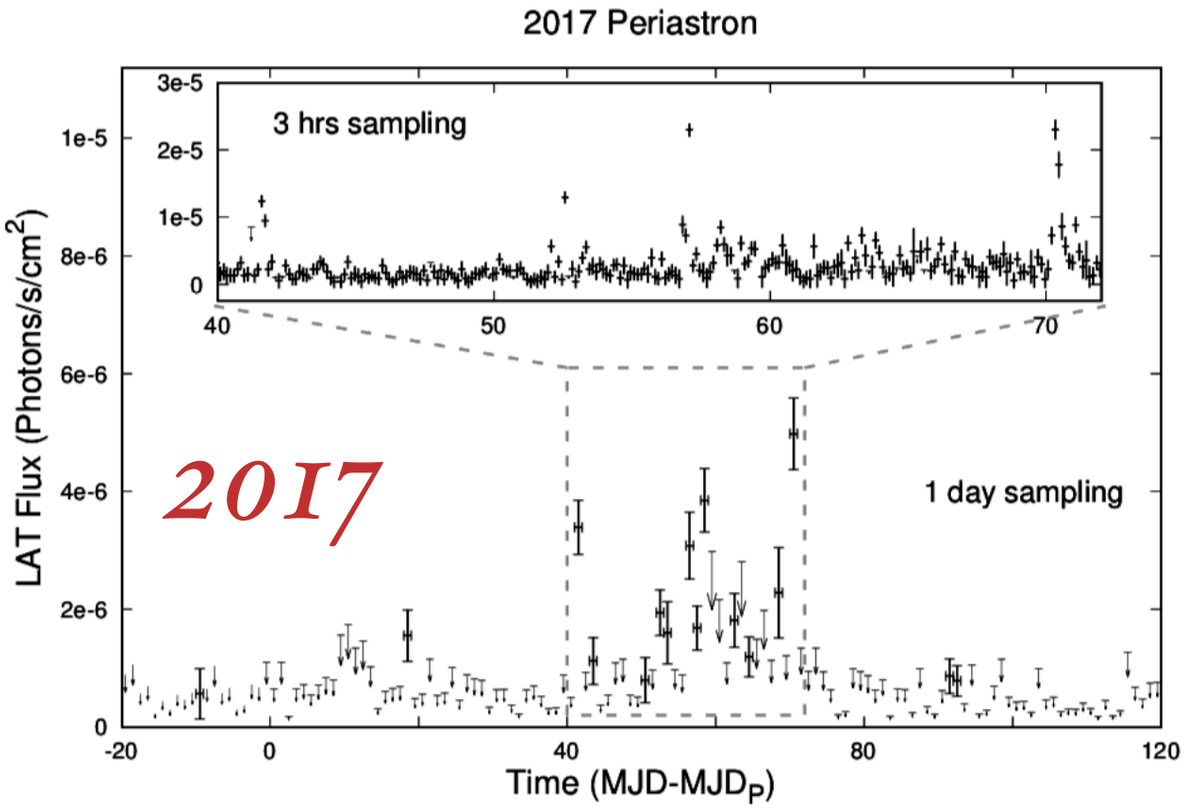


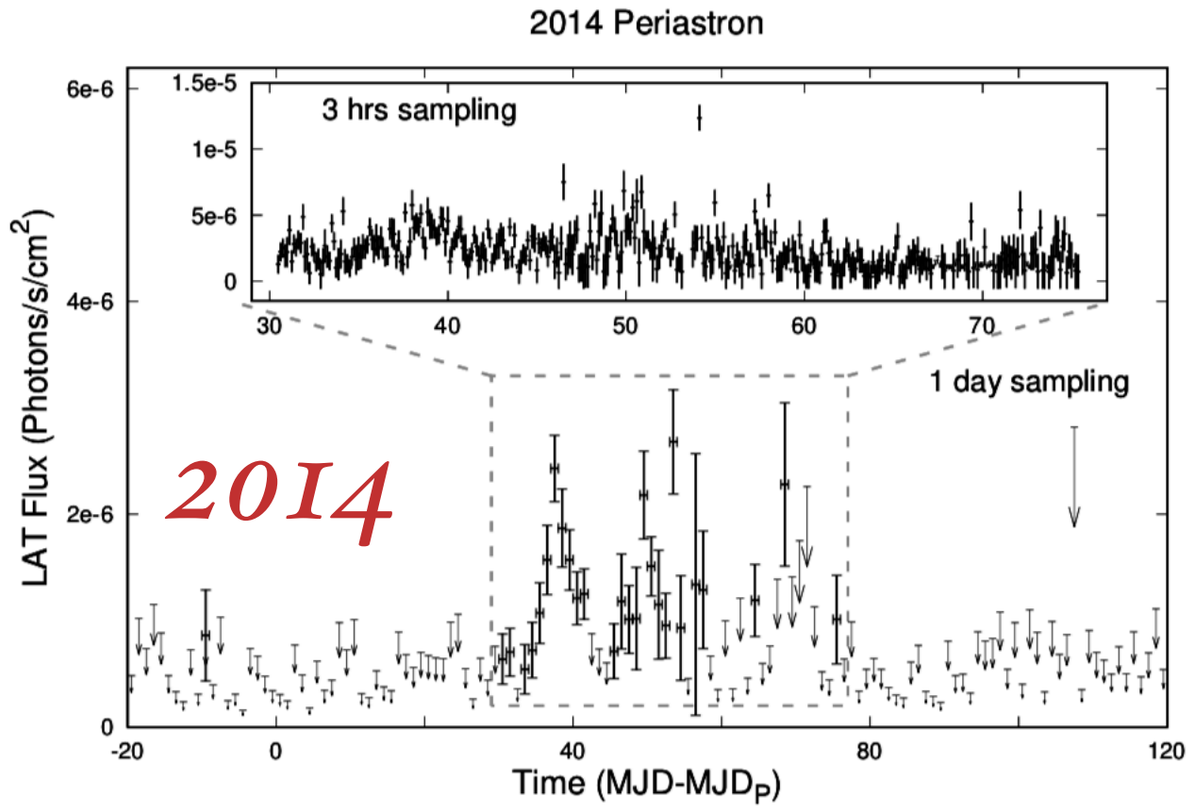
- clearly occurs at different orbital phase

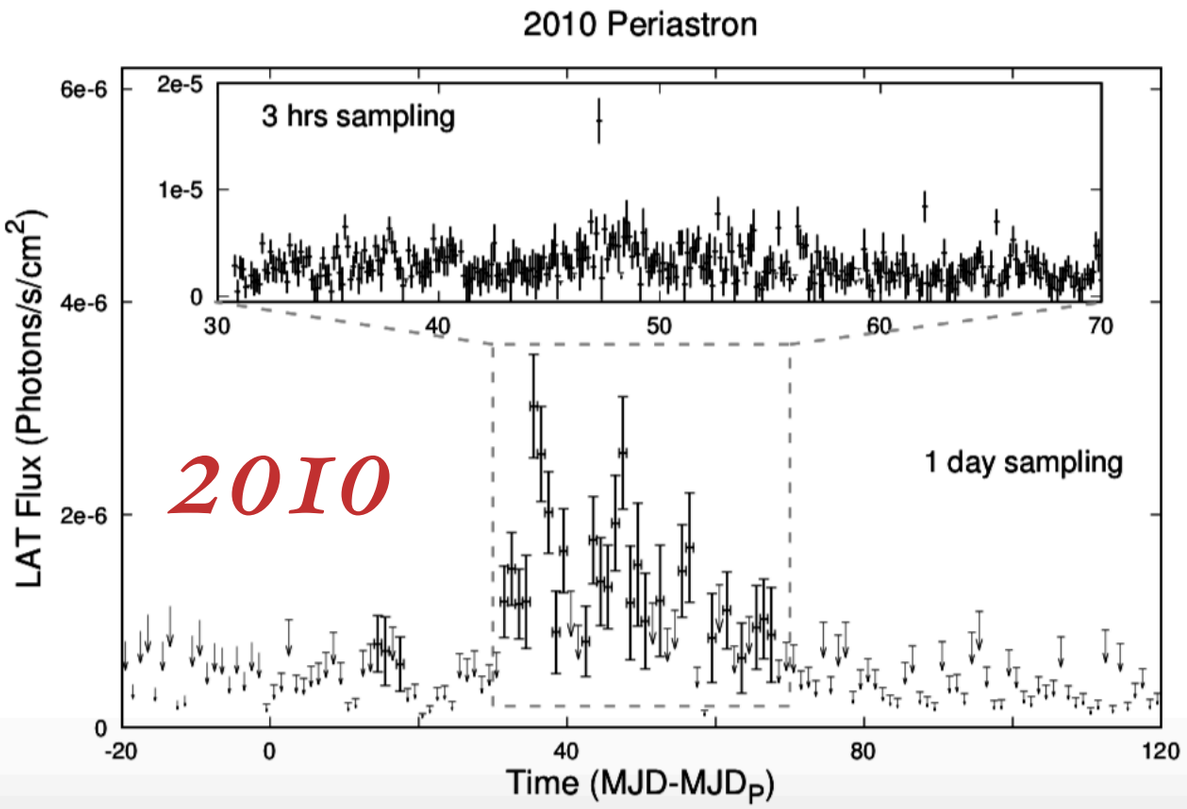

2017 Periastron
3 hrs sampling
1 day sampling
2017
LAT Flux (Photons/s/cm^2)
Time (MJD-MJD$_P$)


2014 Periastron
3 hrs sampling
1 day sampling
2014
LAT Flux (Photons/s/cm^2)
Time (MJD-MJD$_P$)


2010 Periastron
3 hrs sampling
1 day sampling
2010
LAT Flux (Photons/s/cm^2)
Time (MJD-MJD$_P$)

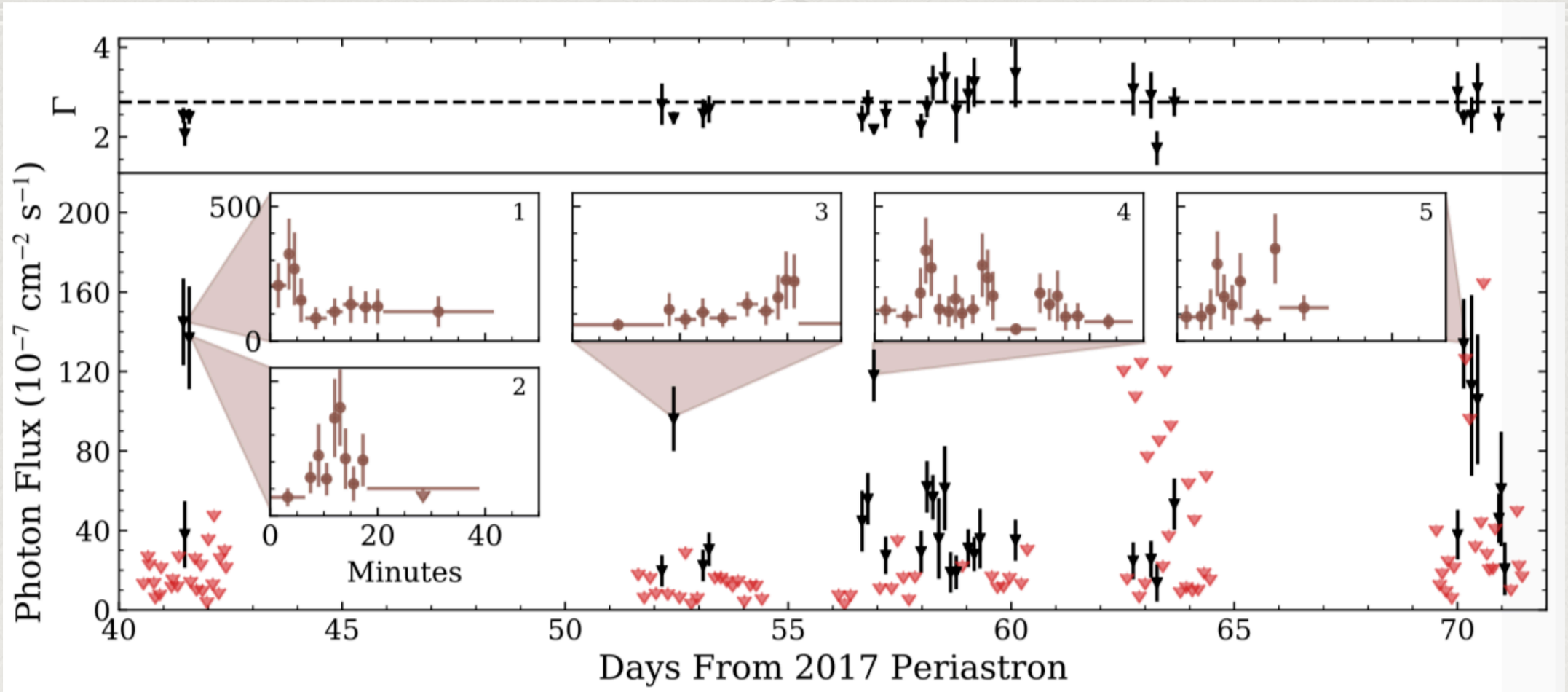




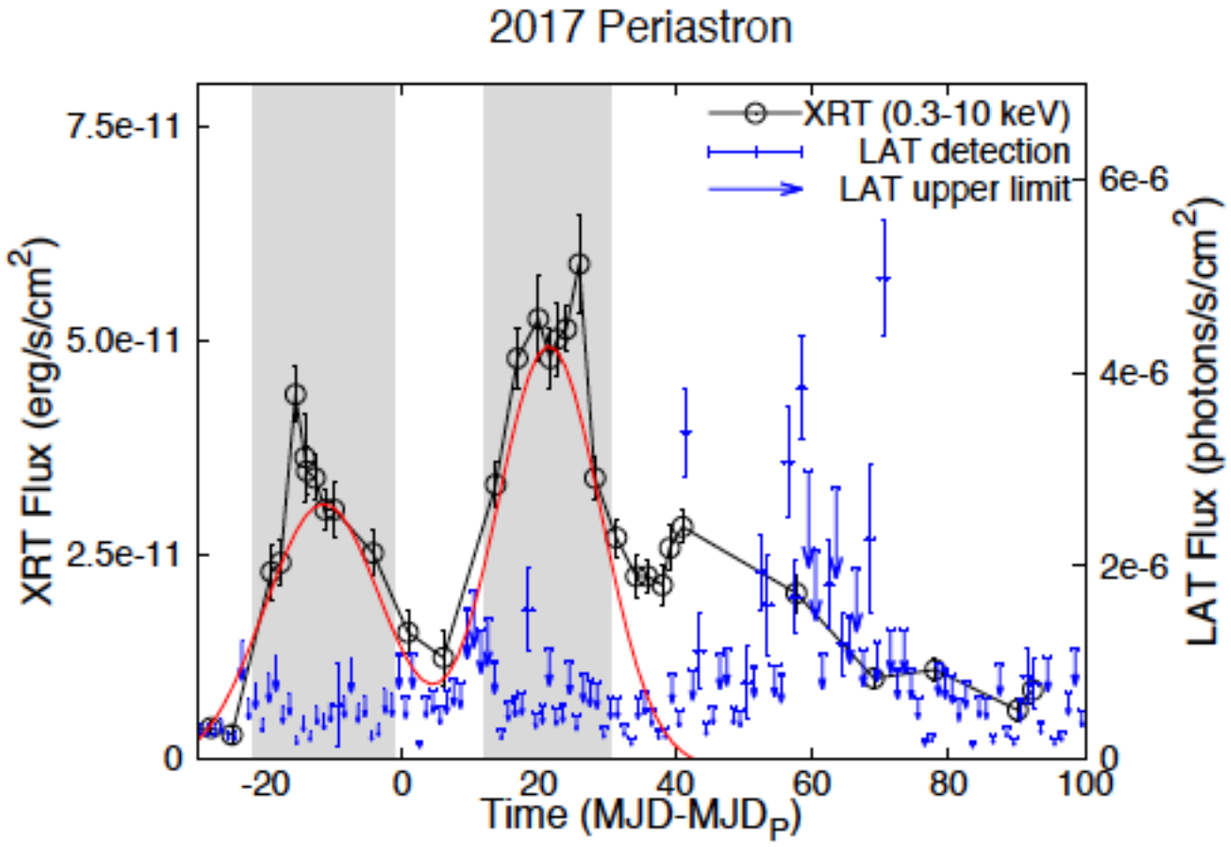


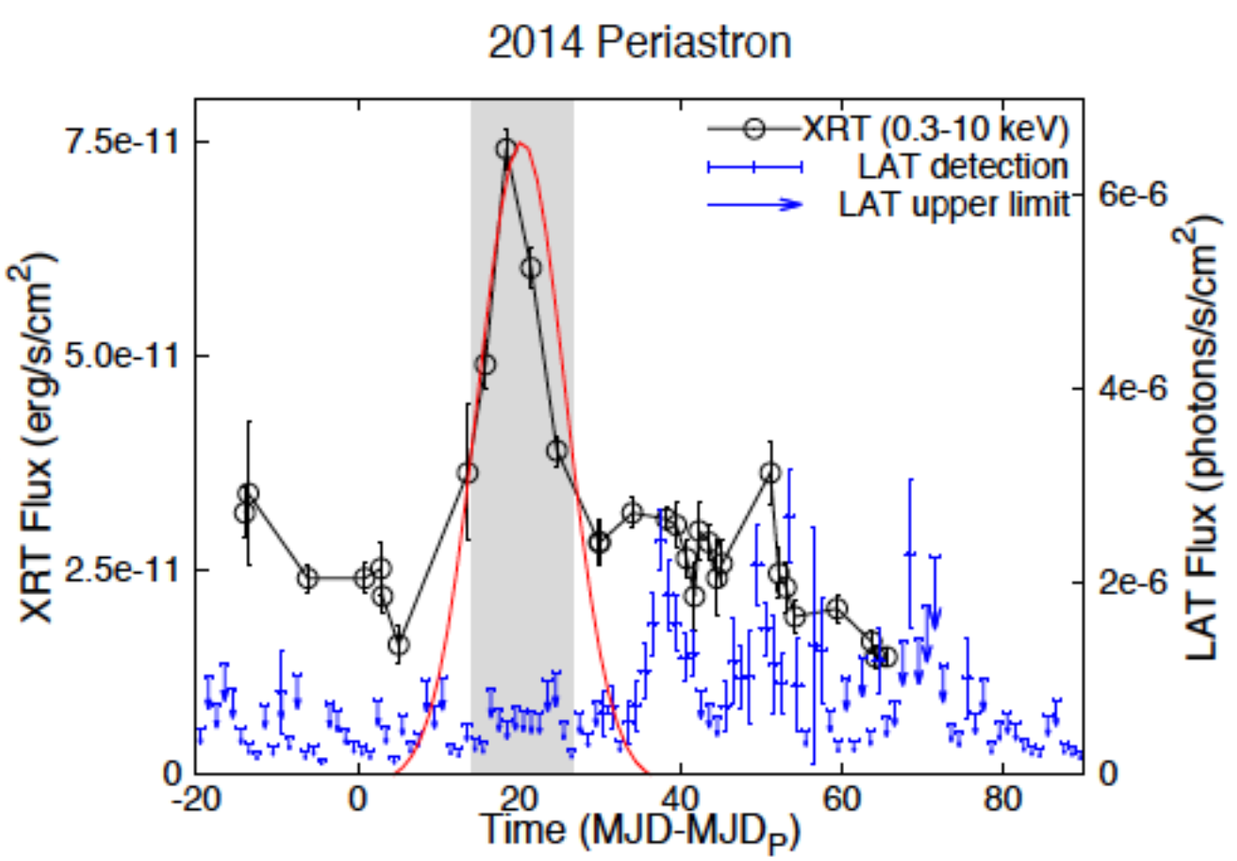
- **2017 flares are different:**
- **orbital phase different than 2011/14**
- **duration of flares ~3-12 hr, shorter than 2011/14**
- **previous works only show 0.5-7 day bins for 2010 & 2014**

Some flares may be even as short as a few minutes!



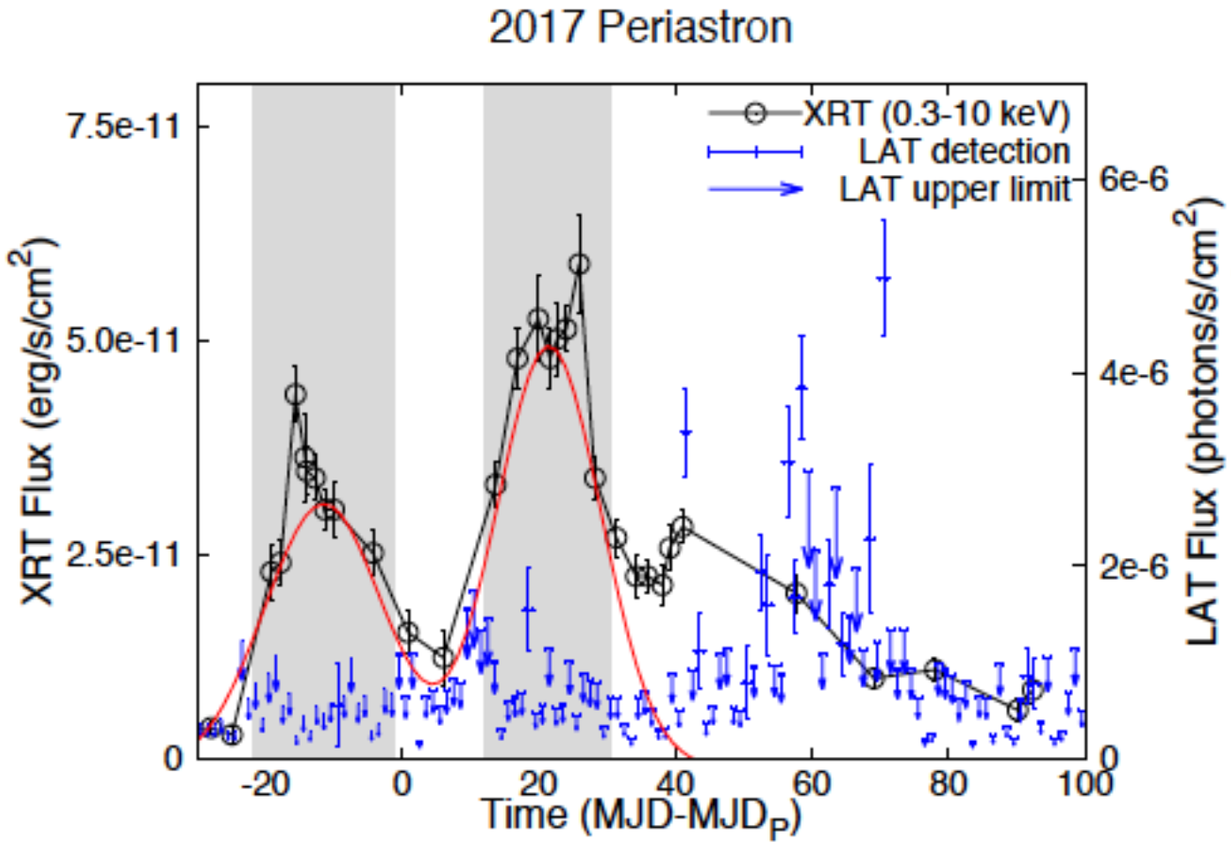
Johnson et al. (2018)

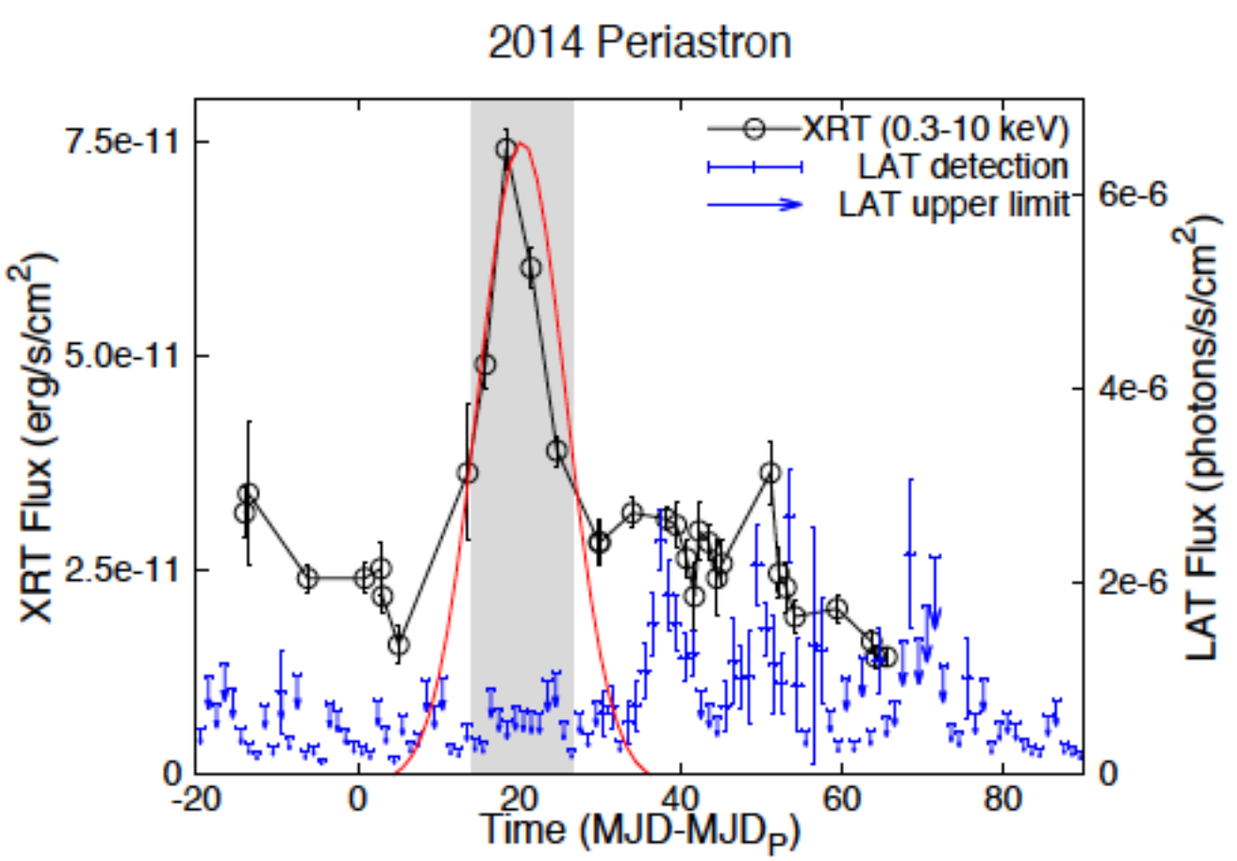




No obvious correlated X/γ activities in 2017

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

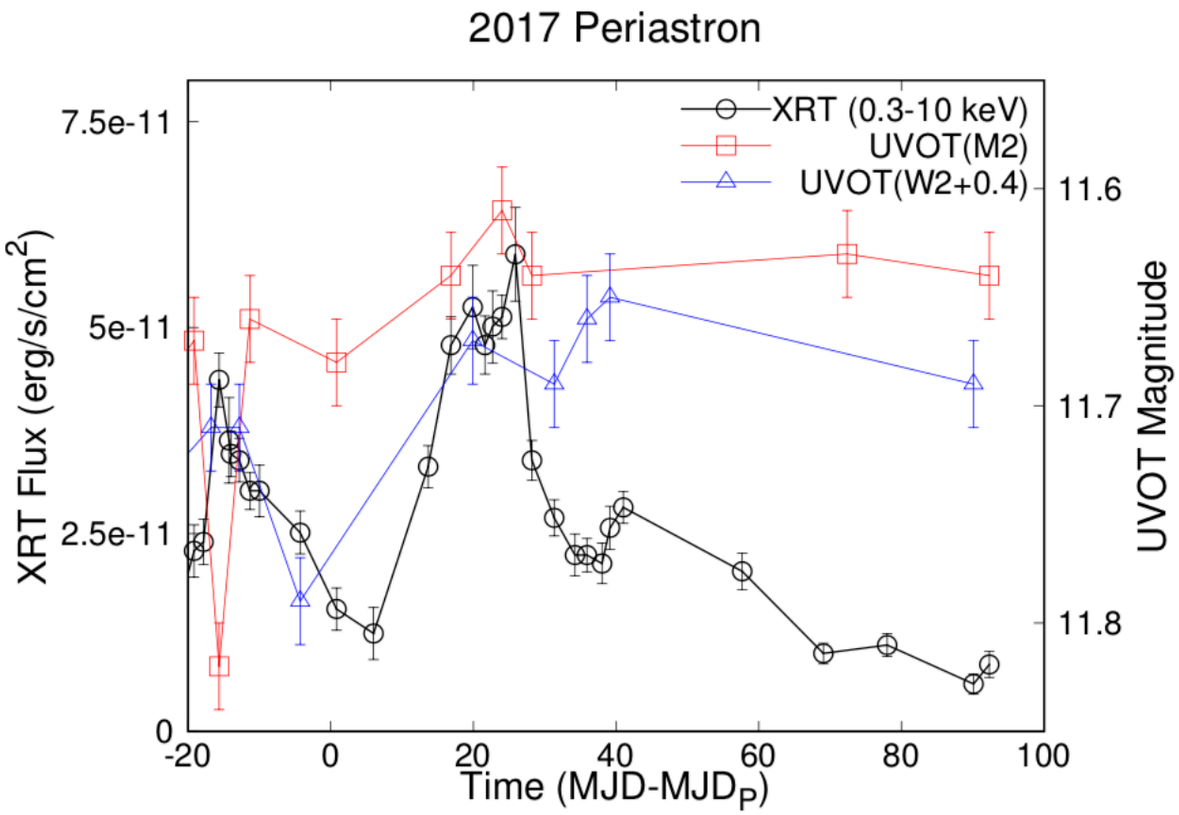


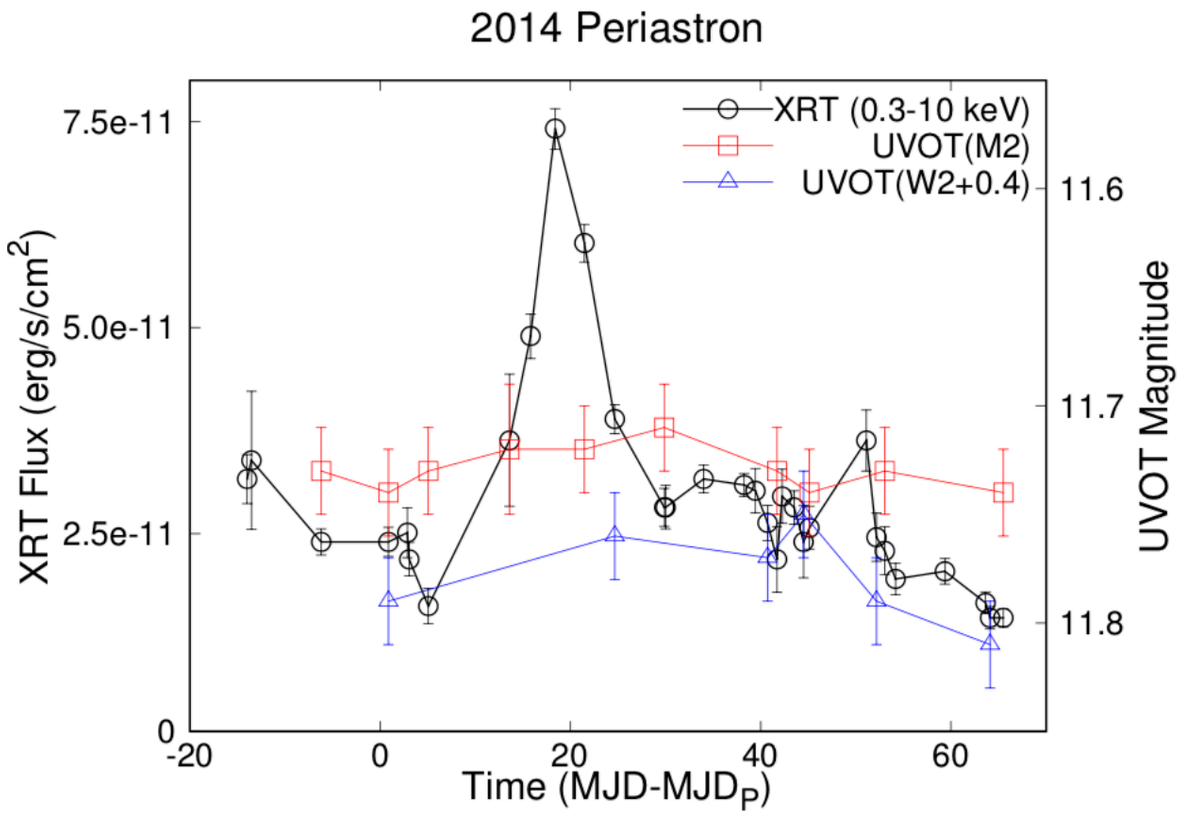


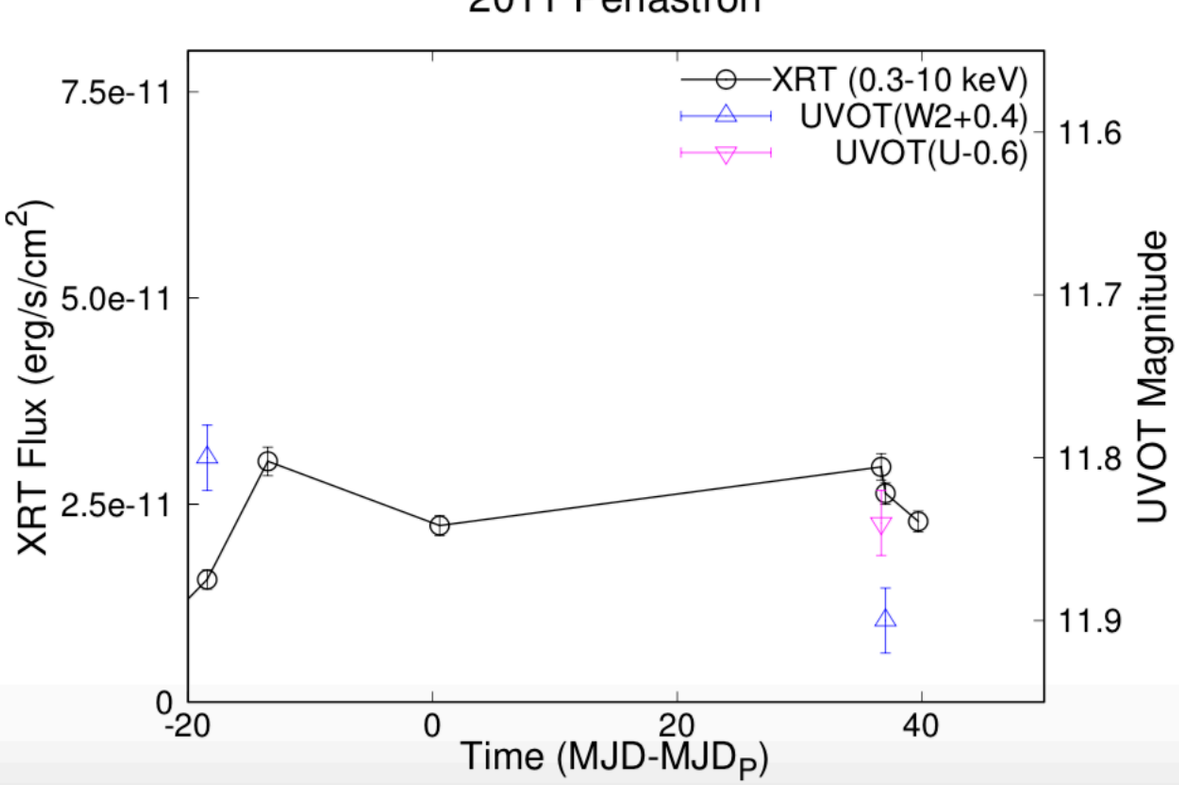
No obvious correlated X/γ activities in 2017

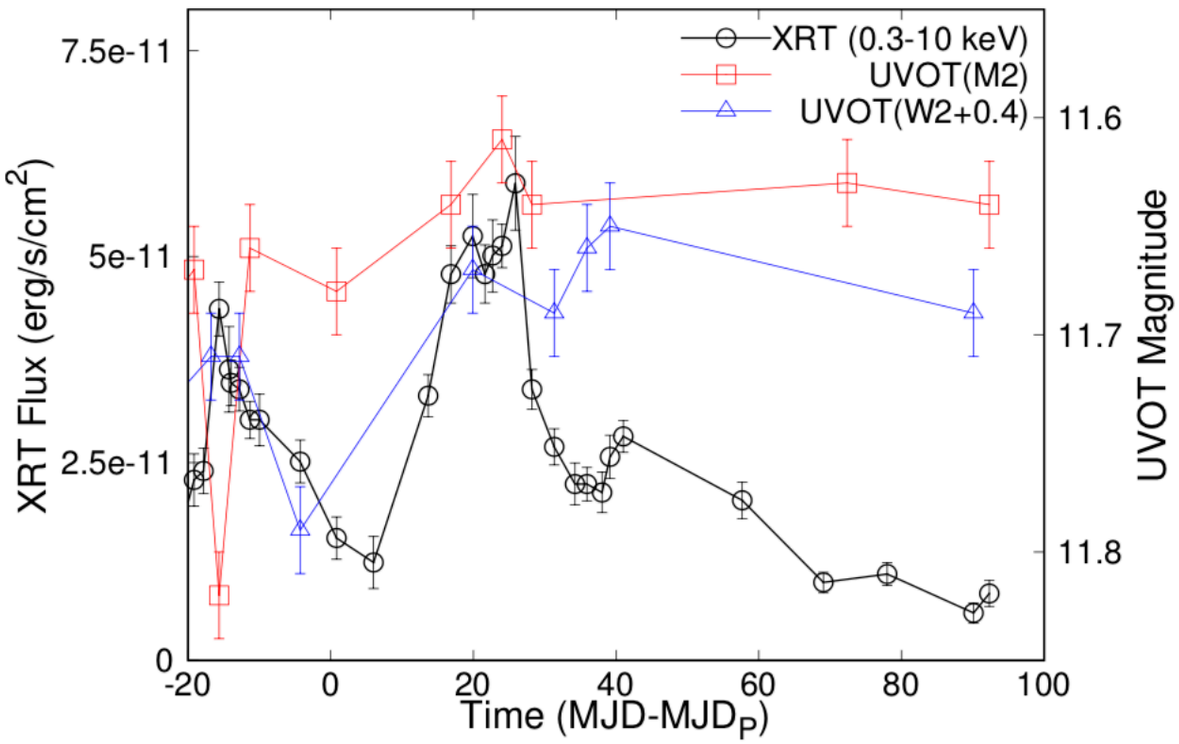
but bad data coverage..

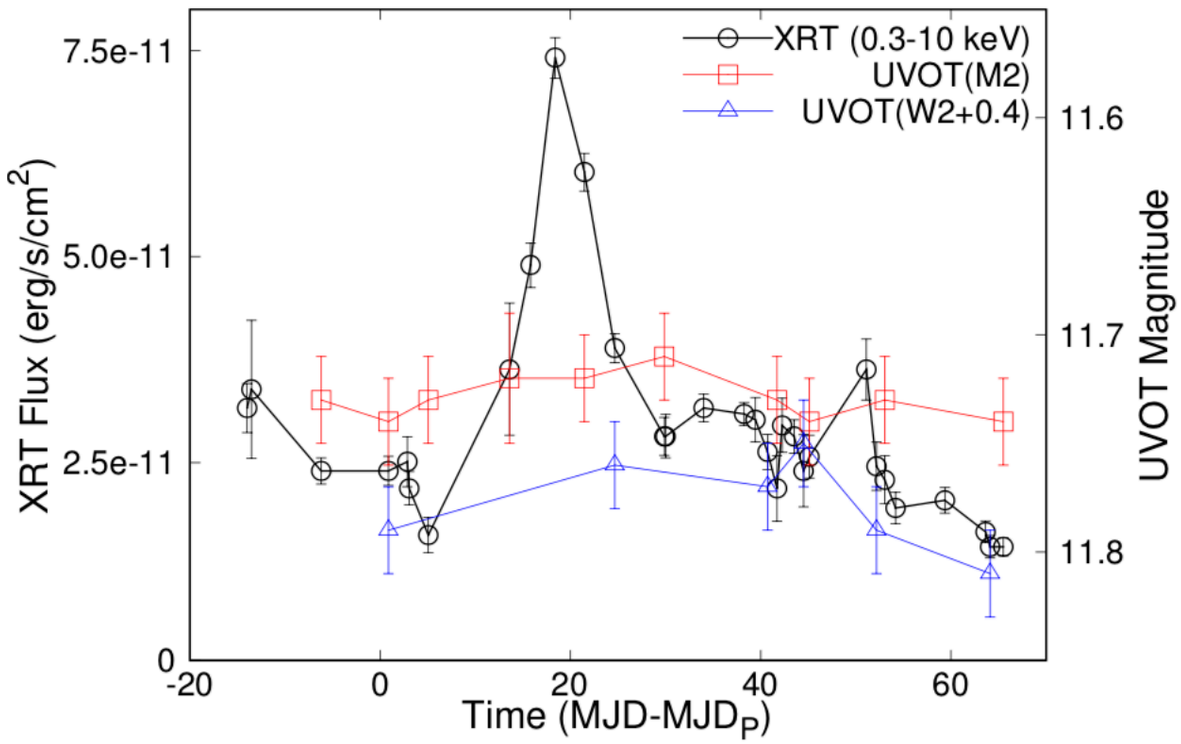
correlated X/γ activities in 2014 (Tam+ 2015)

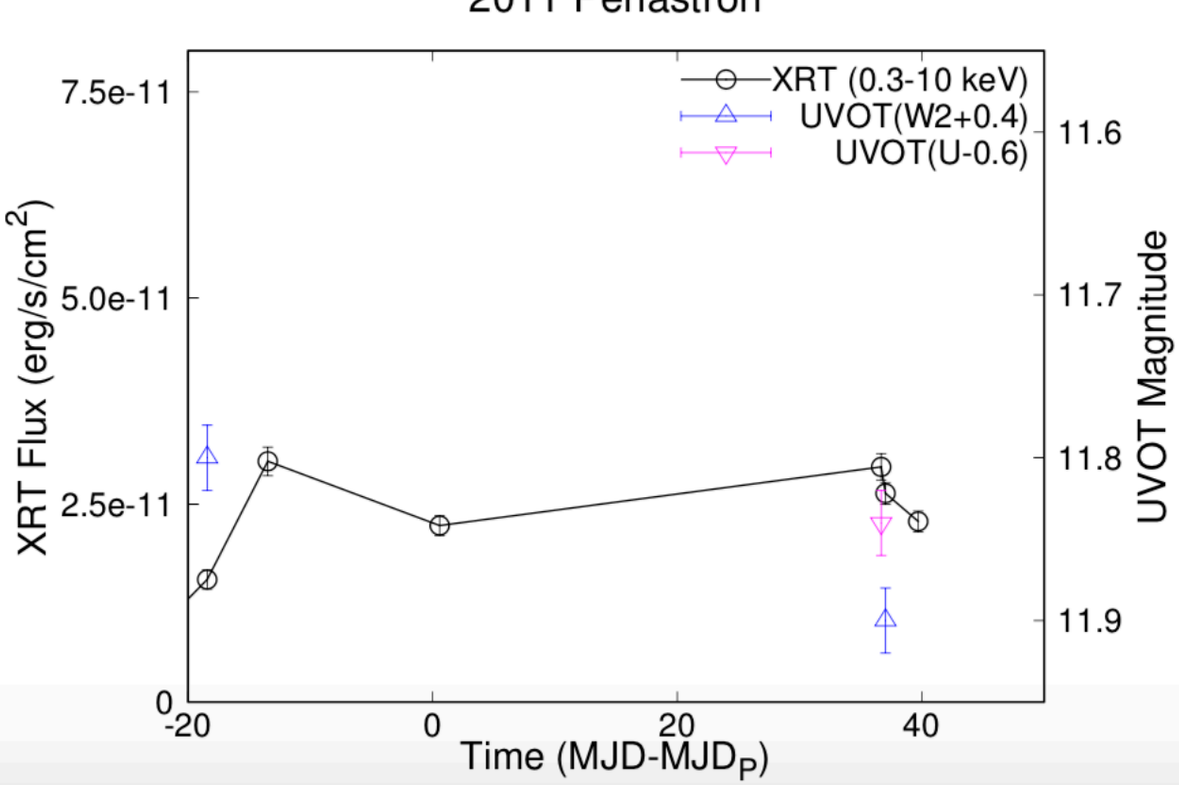

2017 Periastron
XRT (0.3-10 keV)
UVOT(M2)
UVOT(W2+0.4)
XRT Flux (erg/s/cm^2)
UVOT Magnitude
Time (MJD-MJD$_P$)
7.5e-11
5e-11
2.5e-11
0
11.6
11.7
11.8
-20
0
20
40
60
80
100


2014 Periastron
XRT (0.3-10 keV)
UVOT(M2)
UVOT(W2+0.4)
XRT Flux (erg/s/cm^2)
UVOT Magnitude
Time (MJD-MJD$_P$)
7.5e-11
5.0e-11
2.5e-11
0
11.6
11.7
11.8
-20
0
20
40
60


2011 Periastron
XRT (0.3-10 keV)
UVOT(W2+0.4)
UVOT(U-0.6)
XRT Flux (erg/s/cm^2)
UVOT Magnitude
Time (MJD-MJD$_P$)
7.5e-11
5.0e-11
2.5e-11
0
11.6
11.7
11.8
11.9
-20
0
20
40







correlated X/UV activities in 2017 ?

What causes it?

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)*

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)*

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)*

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)*

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), no evidence for pulsar timing change due to disk torque (Yi & Cheng 2018)*

Models to explore

- Accretion disk IS an effective way to produce short flares (e.g., AGN, GRBs), but how to see the disk?

- Magnetic reconnection: is there any connection with the Crab flares?

- "it may be that the underlying nature of flares in both cases [those of the Crab nebula and PSR B1259] is the synchrotron radiation associated with reconnection in the magnetized relativistic plasma." Kargaltsev et al. (2015)

Summary

- The GeV flares from PSR B1259-63 are a major unresolved phenomenon in gamma-ray binary studies (Dubus, 2013)
- Every time after periastron passage, Fermi/LAT sees GeV flares since launch, in 2011, 2014 & 2017
- The flares are clearly delayed compared to other wavelengths
- The 2017 flaring period consists of short-lived but powerful GeV flares on time scales of down to hours/minutes
- What can we expect next?