X-ray and TeV gamma-ray emission from the 50-year period binary system PSR J2032+4127/MT91 213

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for the VERITAS and MAGIC collaborations

See: Abeysekara, A. U., et al. 2018, ApJL, 867, L19

36th ICRC
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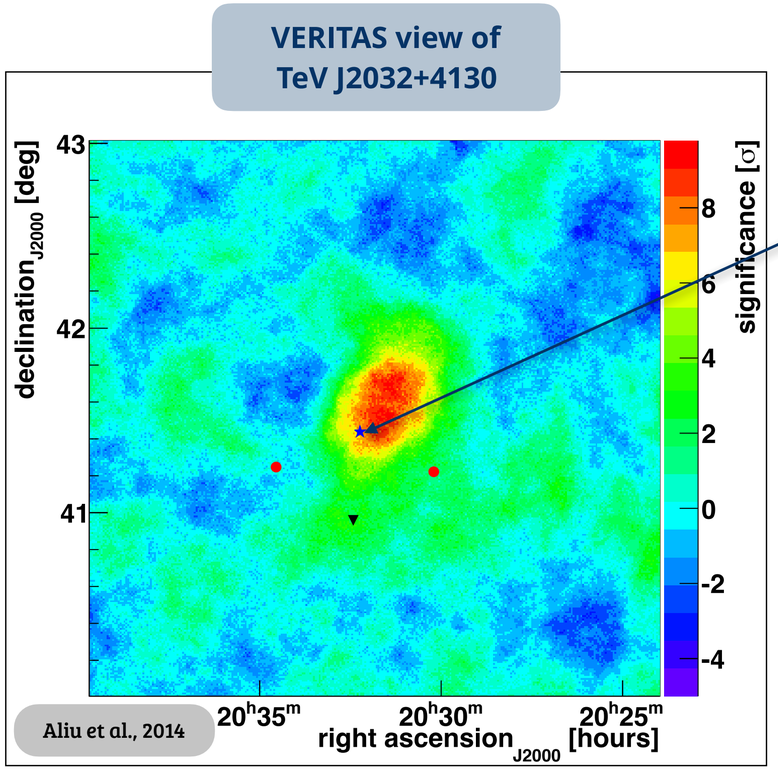
PSR J2032+4127 & TeV J2032+4130

- PSR J2032+4127: energetic radio / gamma-ray pulsar discovered by *Fermi*-LAT
- Nearby (~0.1°) in sky to unidentified extended TeV source TeV J2032+4130
  - Potentially a pulsar wind nebula (PWN) powered by PSR J2032+4127



PSR J2032+4127	
Period	143 ms
Spin-down	1.7 x 10^{35} ergs/s
Distance	1.4 - 1.7 kpc
Age	~180 kyr

PSR J2032+4127 in a binary

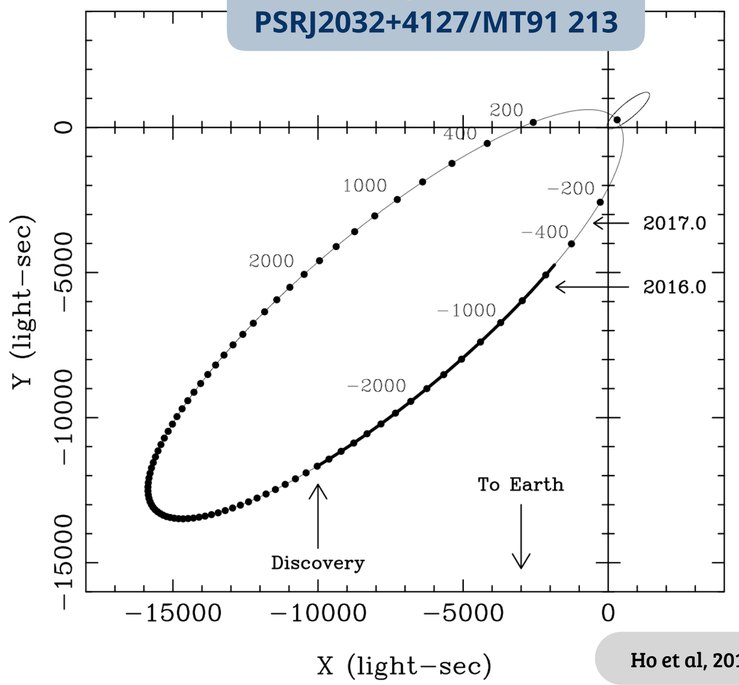
- Timing residuals suggest PSR J2032+4127 is a member of a binary[1]
- Confirmed in 2016 with observation of sharp increase in X-ray flux[2]
- Orbital companion: ~15 M⊙ Be star MT91 213

Orbital Parameters

Companion	MT91 213
Period	45-50 yr
Eccentricity	~0.95
Periastron	13 November 2017

Model #2
Ho et al, 2017

Binary Orbit of PSRJ2032+4127/MT91 213

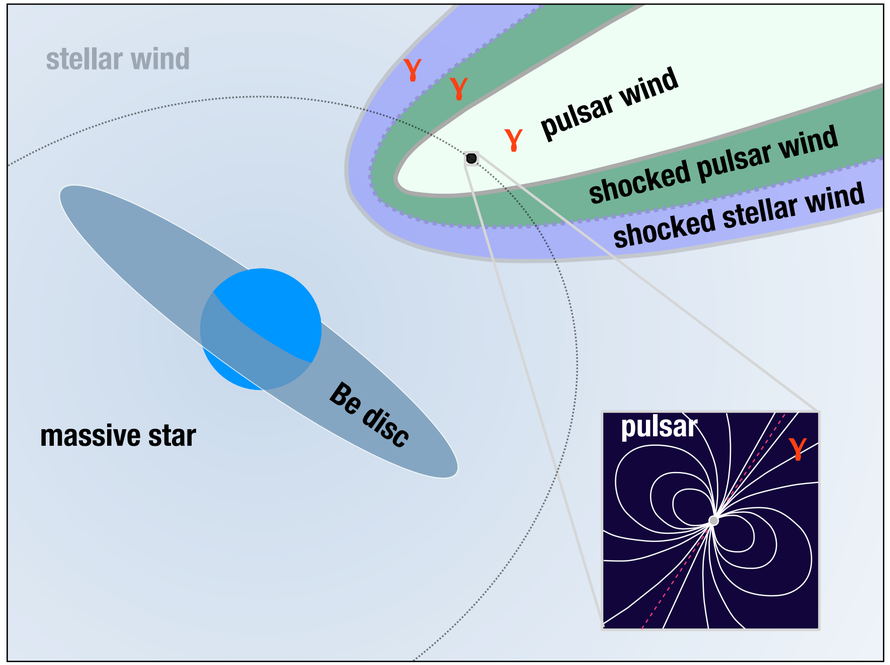


Ho et al, 2017

1) Lyne et al, 2015
2) Ho et al ,2017

Gamma-ray Binaries

- Massive O/B star with neutron star/BH companion
- Pulsar-powered γ-ray binaries:
  - Non-thermal emission from wind collision shock
    - Synchrotron + inverse Compton
  - Energy budget from pulsar spin-down
  - Variability along orbit
    - Changing distance of shock to pulsar
    - Doppler beaming
    - Inverse Compton scattering angle
    - Changing opacity to high-energy photons

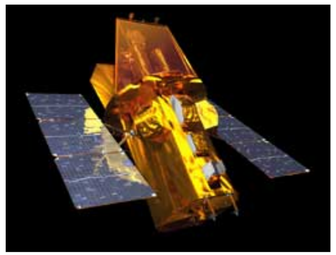


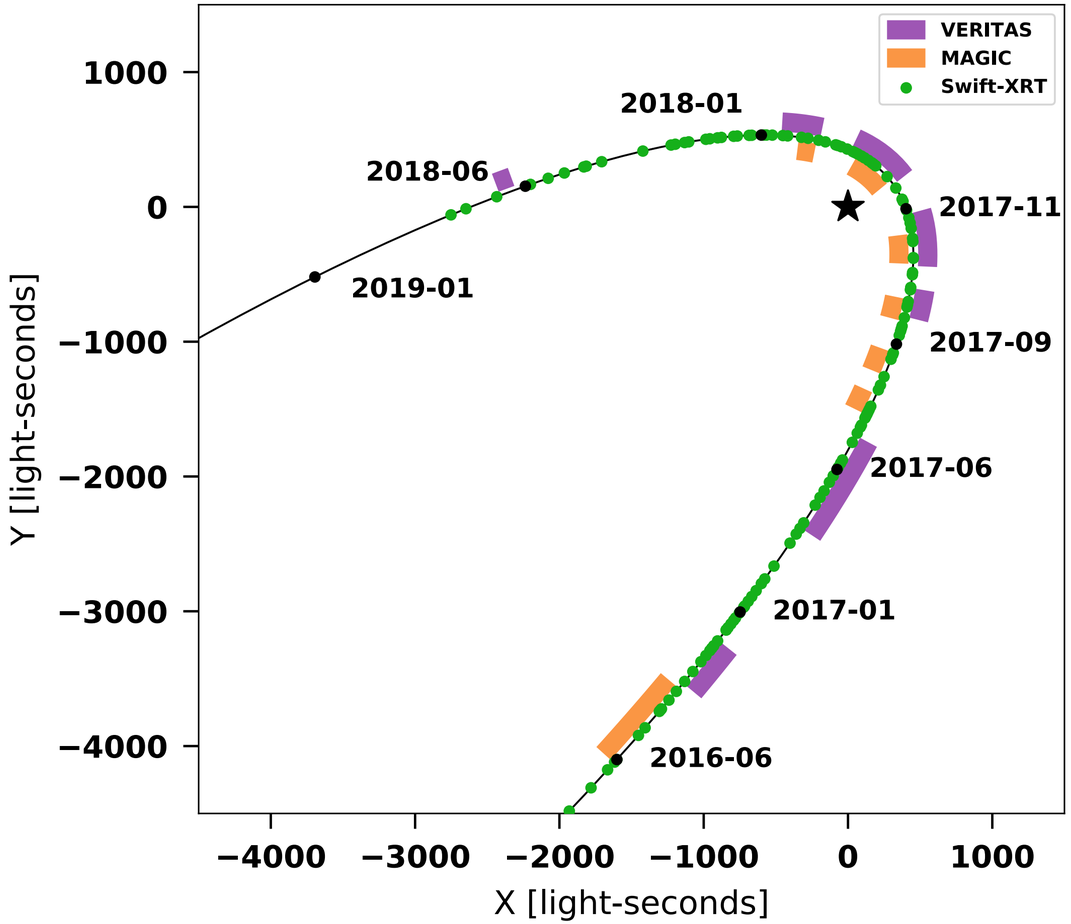
Dubus, 2013

Observations

2016 - 2018 Exposures

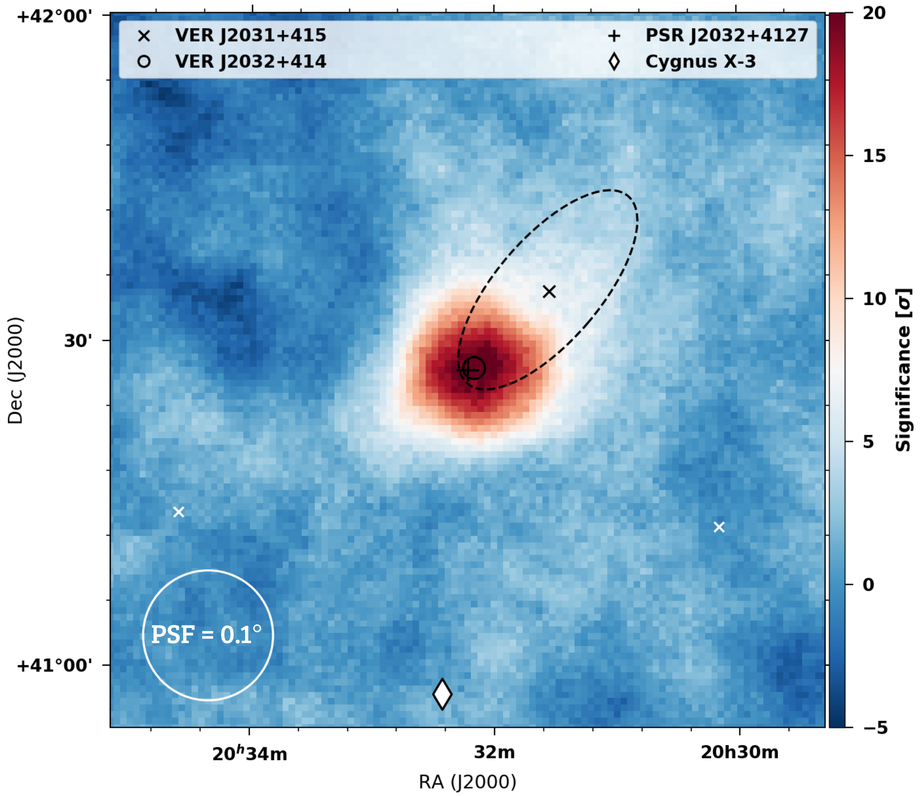
- VERITAS: 140 hours
- MAGIC: 88 hours
- *Swift*-XRT: 409 ks



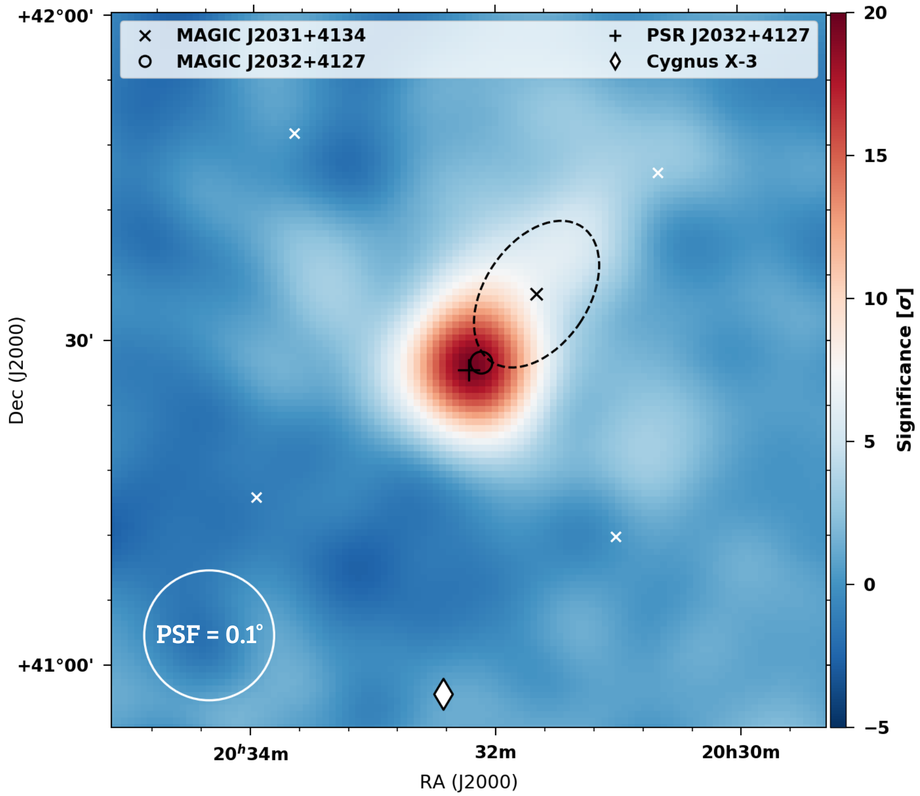


Detection

VERITAS



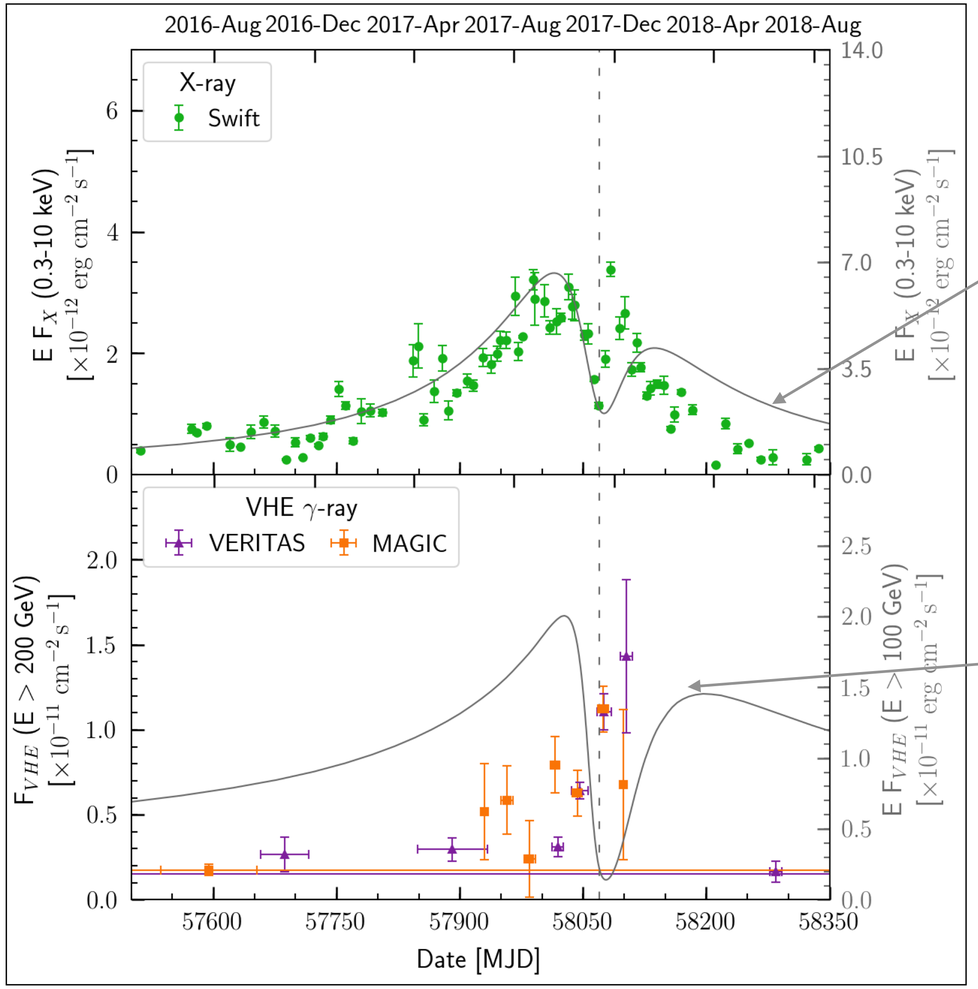
MAGIC



A significant, **point-like**, **time-variable** excess from the binary was detected early in the in the Fall 2017 campaign; the total dataset for this period is detected at over **20 σ**

Variability

- Steadily increasing X-ray flux as pulsar moves closer to Be star
- Short time-scale variability possibly caused by clumps in stellar wind[1]
- Sharp increase in TeV flux approaching periastron
- Dip in both light-curves near periastron passage



Model from Li et al, 2018

Model from Takata et al, 2017 with parameters from Li et al 2018

1) Li et al ,2017
2) Takata et al, 2017
3) Li et al, 2018

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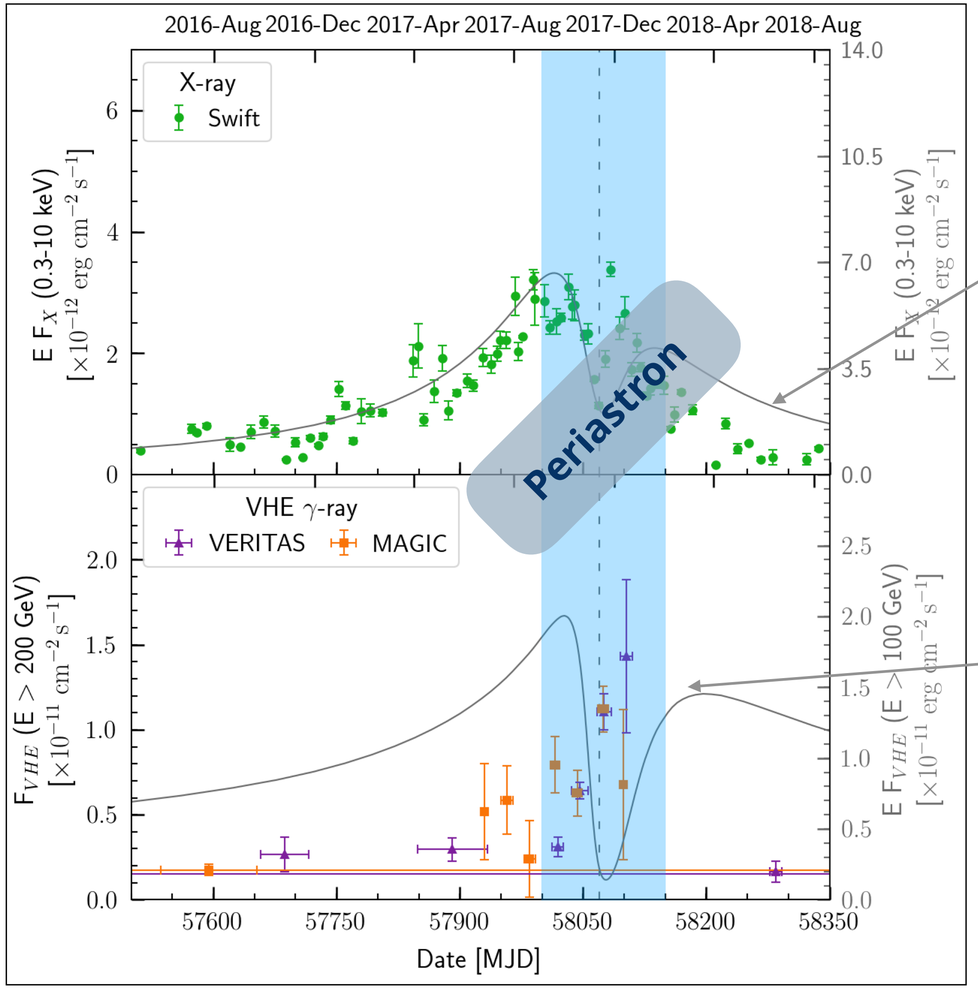

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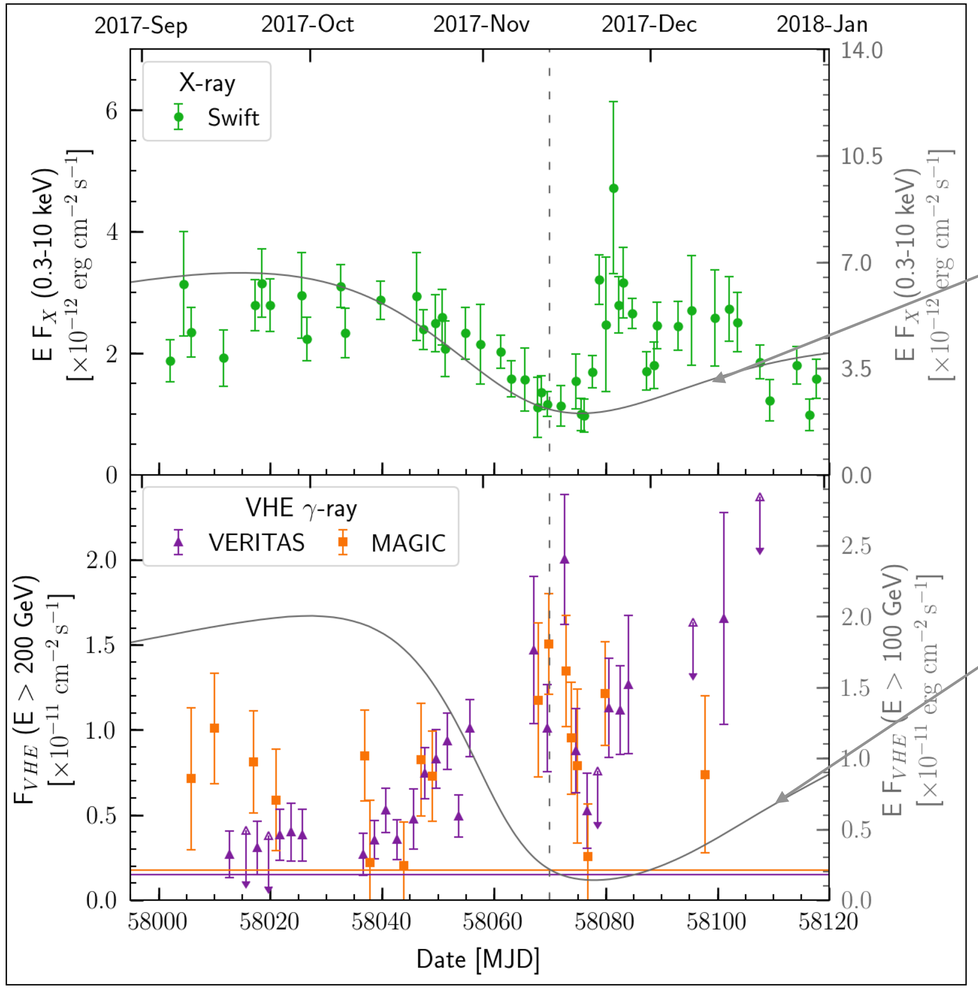
Variability

- X-ray flux begins dropping ~30 days before periastron
  - Possibly shadowed by Be disk[1]
- Post-periastron flare could be evidence for disk interaction
- Sharp post-periastron dip in TeV flux possibly due to gamma-gamma absorption during superior conjunction

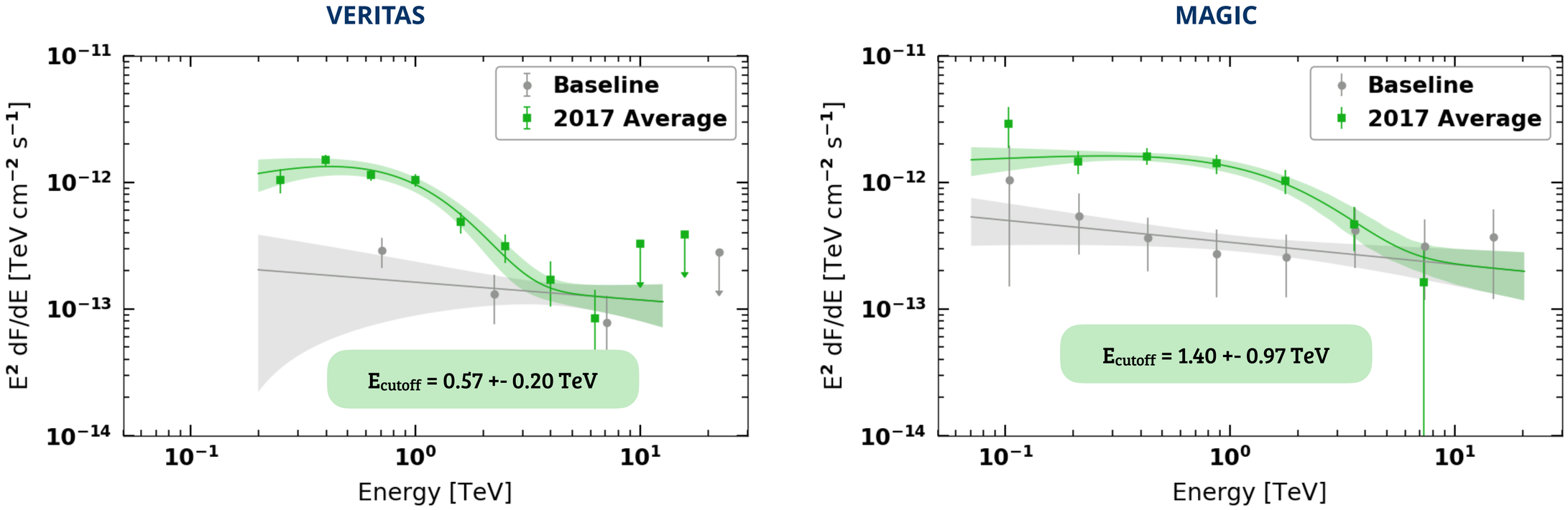


Model from Li et al, 2018

Model from Takata et al, 2017 with parameters from Li et al 2018

1) Coe et al ,2019
2) Li et al, 2018

Spectrum



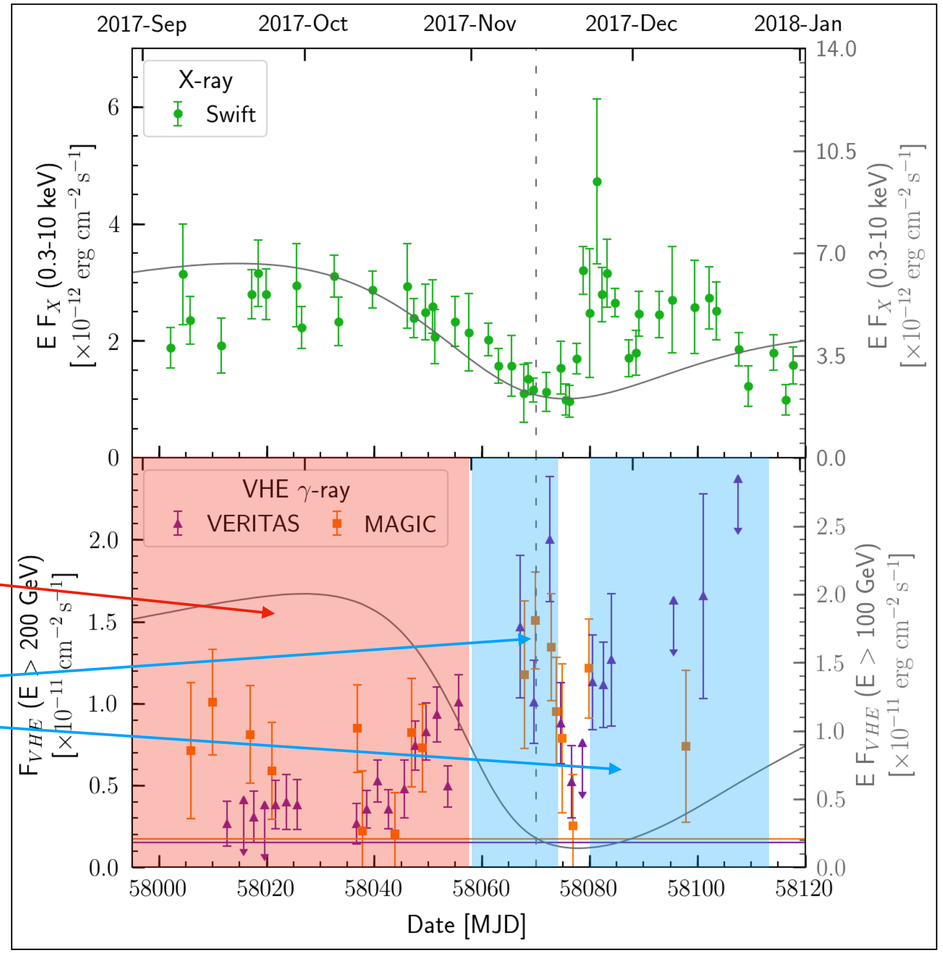
- Spectral cutoff at ~< 1 TeV
- Not seen in other γ-ray binaries, except LS 5039 (8.7 +- 2.0 TeV)
- Possible result of cascade emission, Klein-Nishina effects, synchrotron cooling

Spectrum

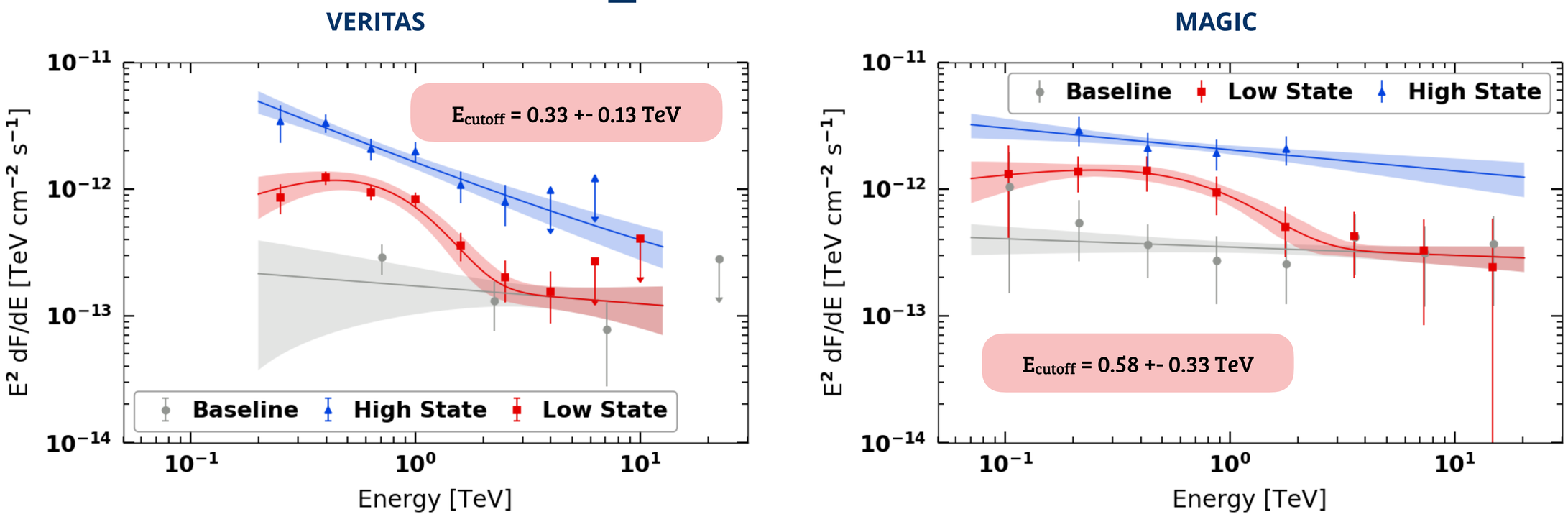
- To search for spectral variability, split data set by flux state

"Low" flux state

"High" flux state



Spectrum



- Clear cutoff in the low state
- Cutoff not obvious in the high state, but cannot be excluded

Summary

- Detection of a new γ-ray binary by VERITAS and MAGIC
  - Only periastron observations of this system until ~2067
- Only the second such system with a pulsar confirmed as the compact object
- X-ray and TeV light curves exhibit different behavior
- Dramatic variability on short time scales is not well modeled
- See: Abeysekara, A. U., et al. 2018, ApJL, 867, L19