

# TeV and X-ray emission from the 50-year period binary PSR J2032+4127/MT91 213 during periastron passage



NASA/Goddard

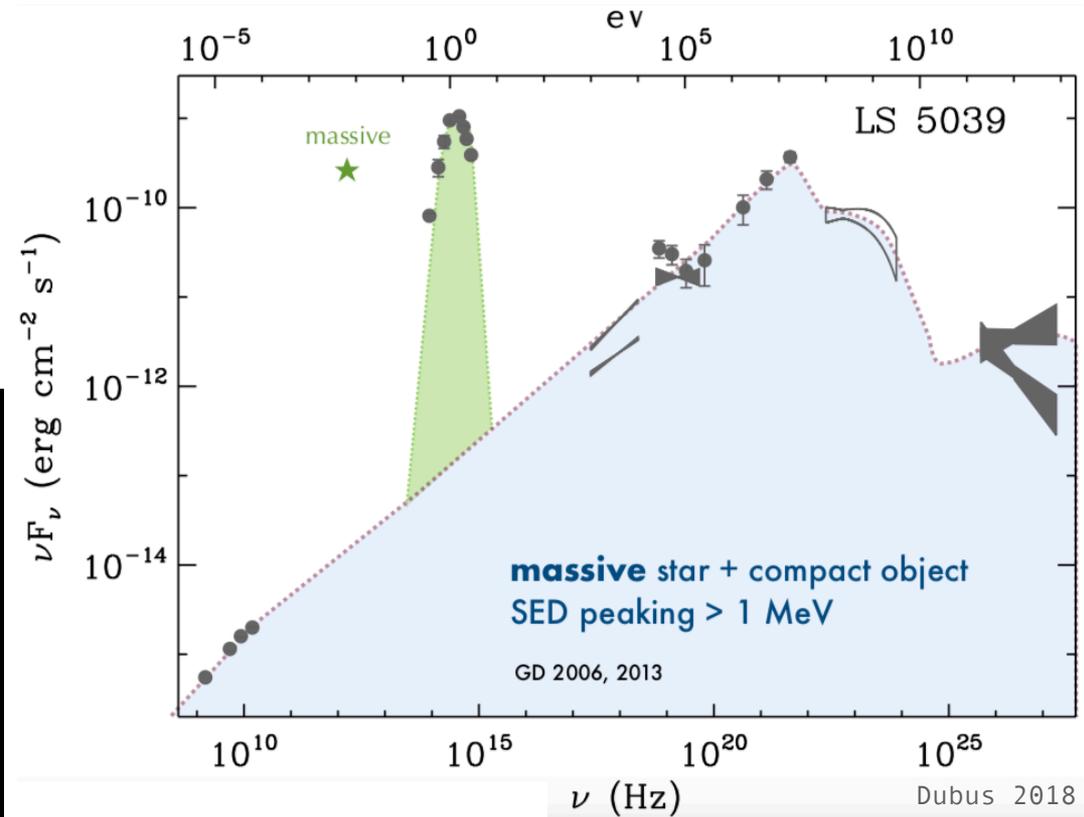
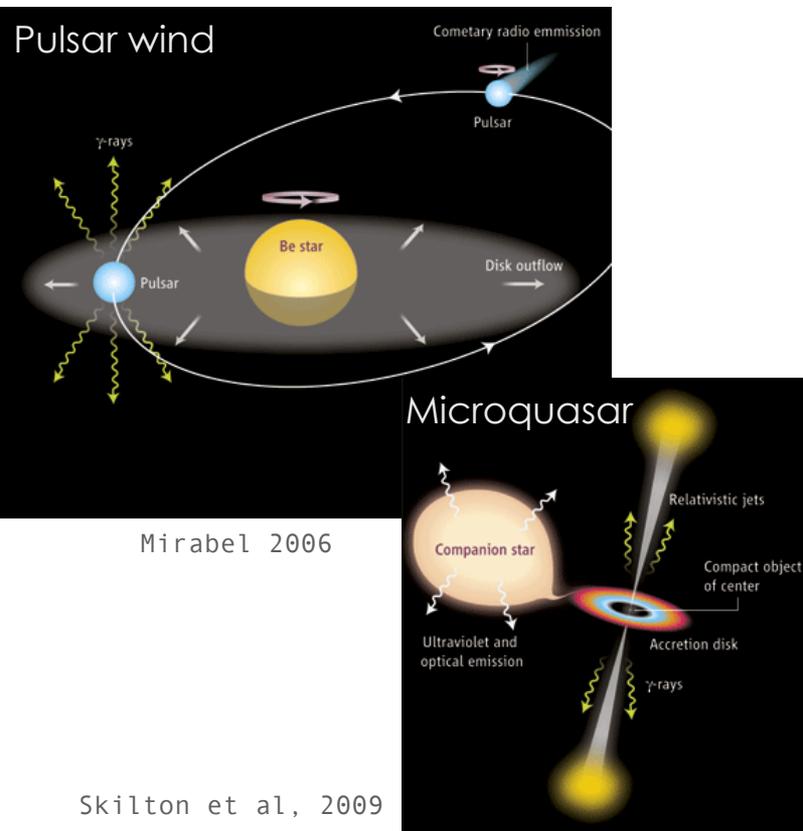
**Oscar Blanch Bigas (IFAE)**

J. Herrera, A. López-Oramas (for **the MAGIC** collaboration),  
R. Bird and T. J. Williamson (for **the VERITAS** Collaboration)

# Gamma-ray binaries: what are they?



- Show **periodic emission**
- **Bulk of the non-thermal** emission lies in the  **$\gamma$ -ray domain** ( $E > 1 \text{ MeV}$ )
- **Only 7 display VHE** ( $E > 100 \text{ GeV}$ ) **emission**
- Massive star + compact object (2 pulsars, 5 unidentified)

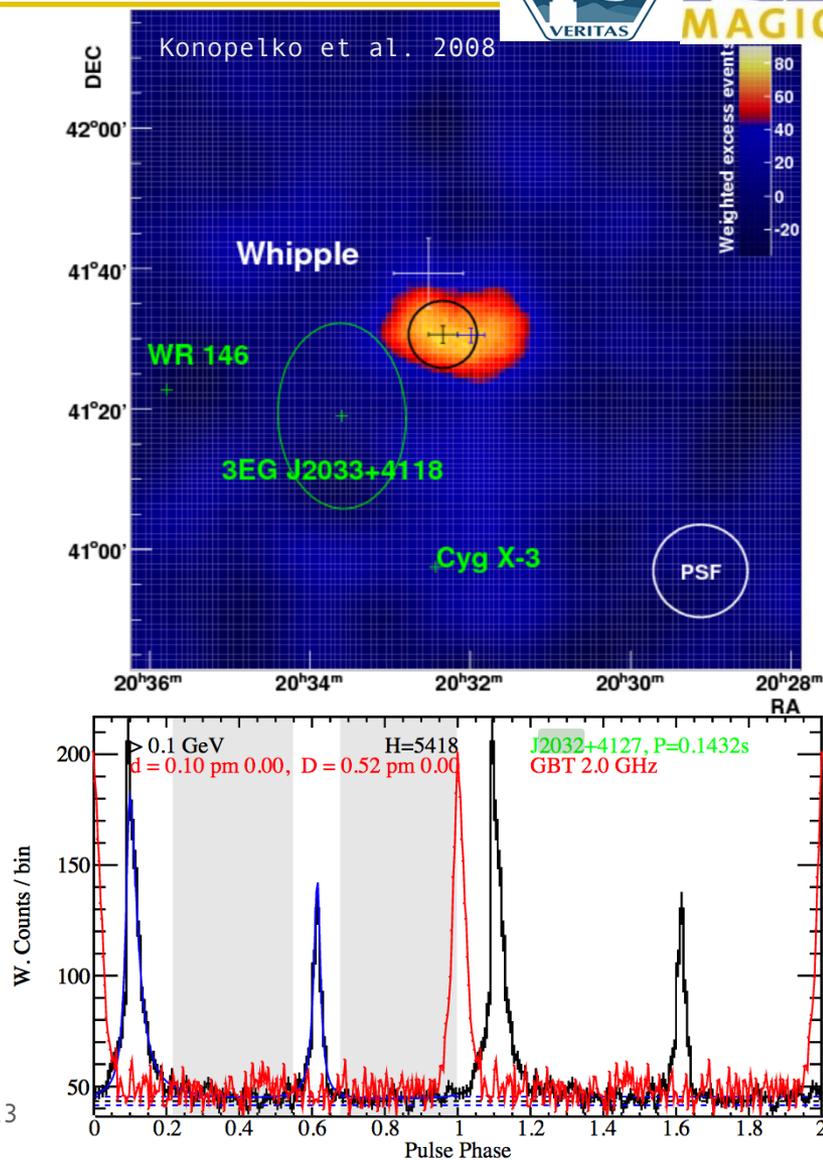


# TeV 2032+4130 & PSR J2032 +4107



- **TeV 2032+4130** : unidentified source discovered by HEGRA (HEGRA 2002, Aharonian et al. 2005) and confirmed by Whipple (Konopelko et al. 2008), MAGIC, (Albert et al. 2008)
- Hard spectrum ( $\Gamma \sim 2$ ) high energy ( HAWC,  $E > 56$  TeV ) source (Abeysekara et al. 2017)
- **Pulsar PSR J2032+4127** discovered in blind search by *Fermi*-LAT (Abdo et al. 2009). Young, high spin-down power

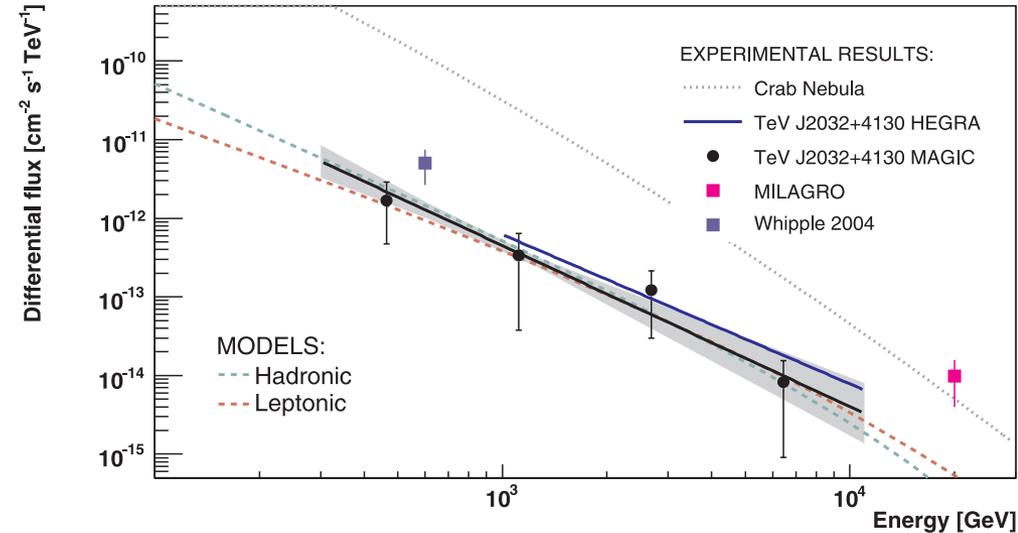
Abdo et al, 2013



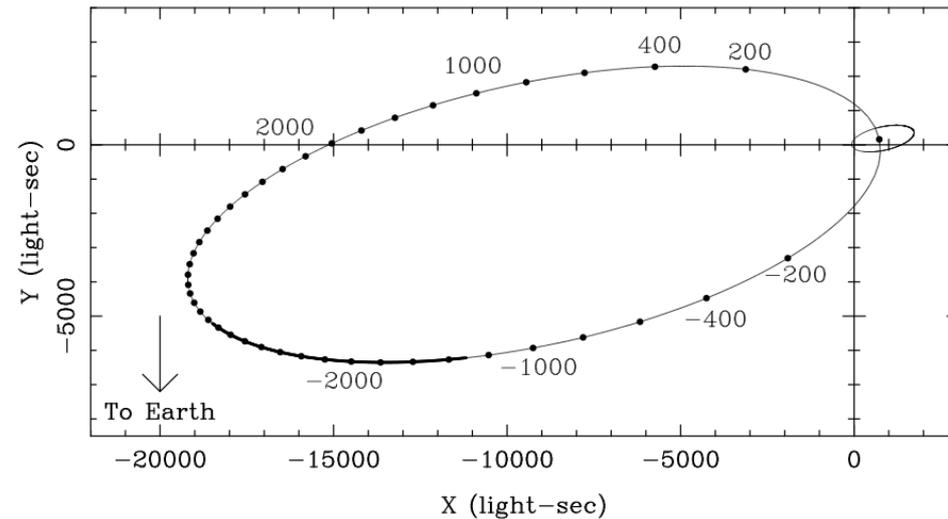
# The nature of their emission

- **TeV 2032+4130** possibly a **wind nebula** driven by the pulsar PSR J2032+4127 (Bednarek 2003, Aliu et al. 2014)
  - Extension found to be asymmetric
  - Located in a Radio void

Albert et al, 2008  
Kornpeko et al. 2008

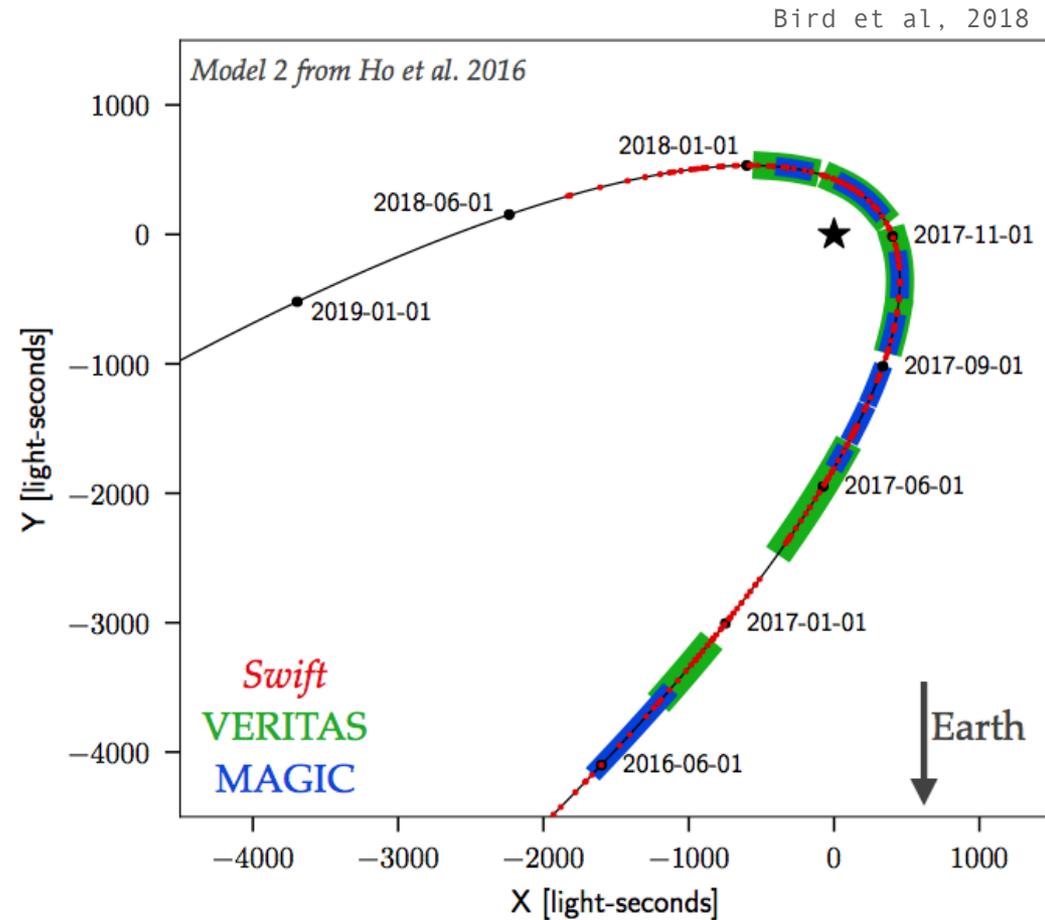


- **Binary nature:** PSR 2032+4127 associated to Be star MT91 213 (Lyne et al. 2015)
  - Orbital Period  $\sim 50$  years (Ho et al. 2017)
  - Periastron November 2017 (MJD 58070)



# Observations Campaign

- Available **archival data** from MAGIC & VERITAS
- Preparation for periastron passage: **extensive observation campaign.**
  - **Swift XRT:** 134.6 hour (186 observations)
  - **VERITAS:** 181.3 hours
  - **MAGIC:** 87.9 hours
- Long and coordinated campaign allows for detailed study of passages through periastron



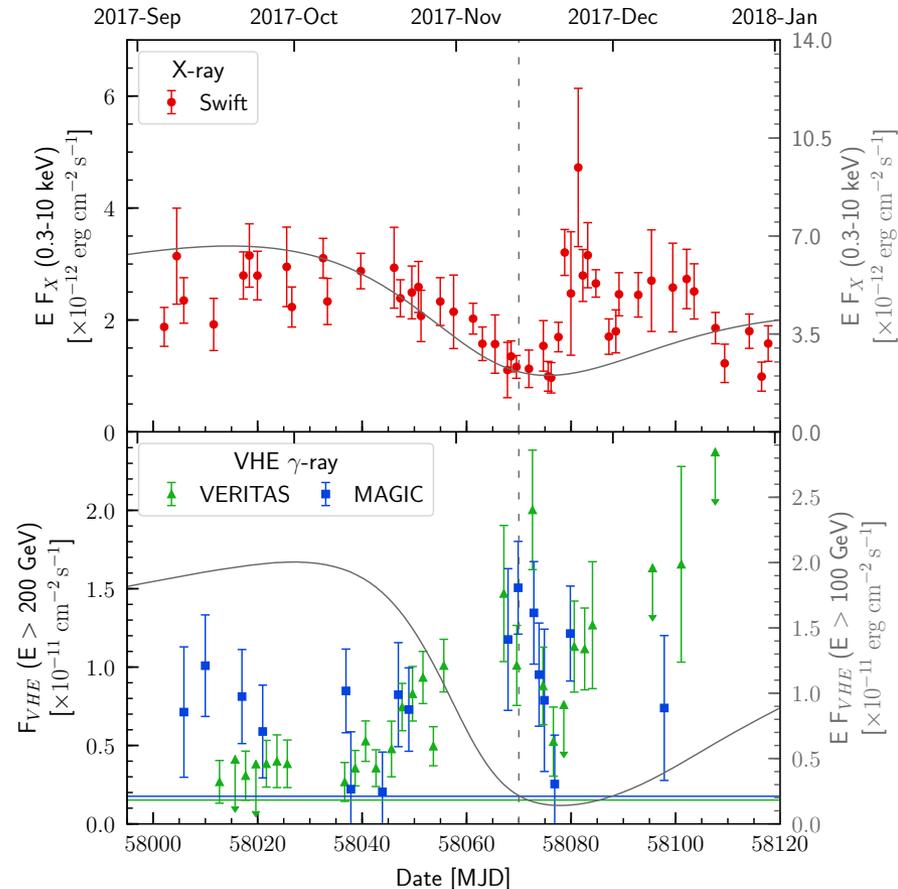
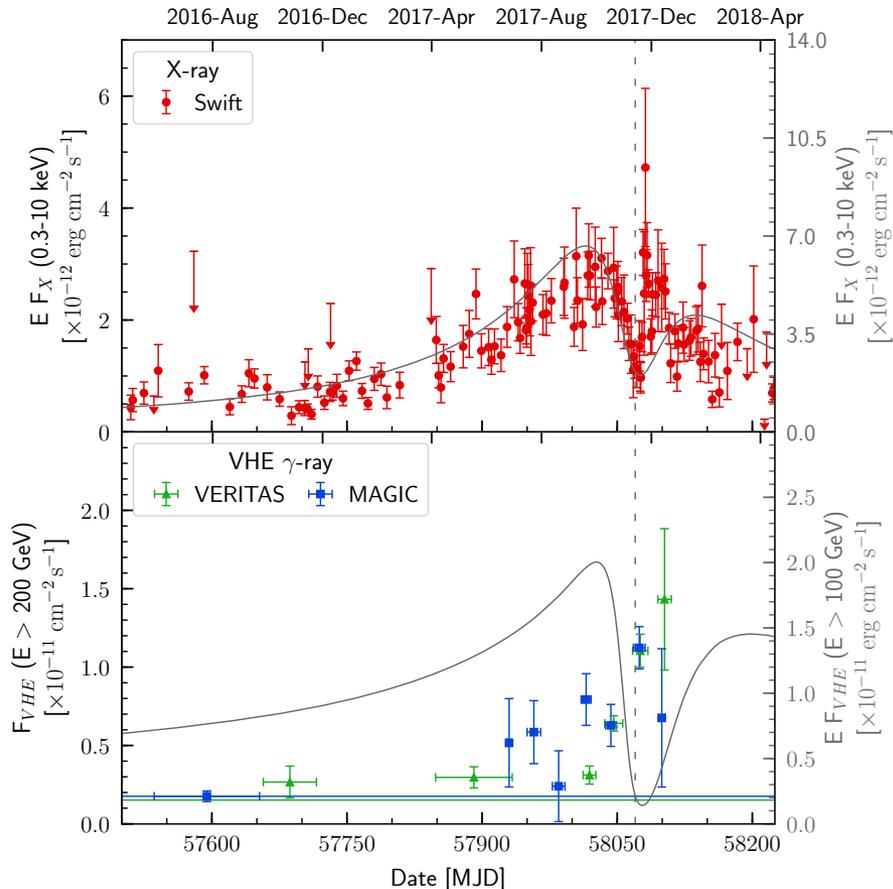


# Light Curve at VHE and X-Rays



Abeyssekara et al., 2018

Takata et al., 2017, Lie et 2018

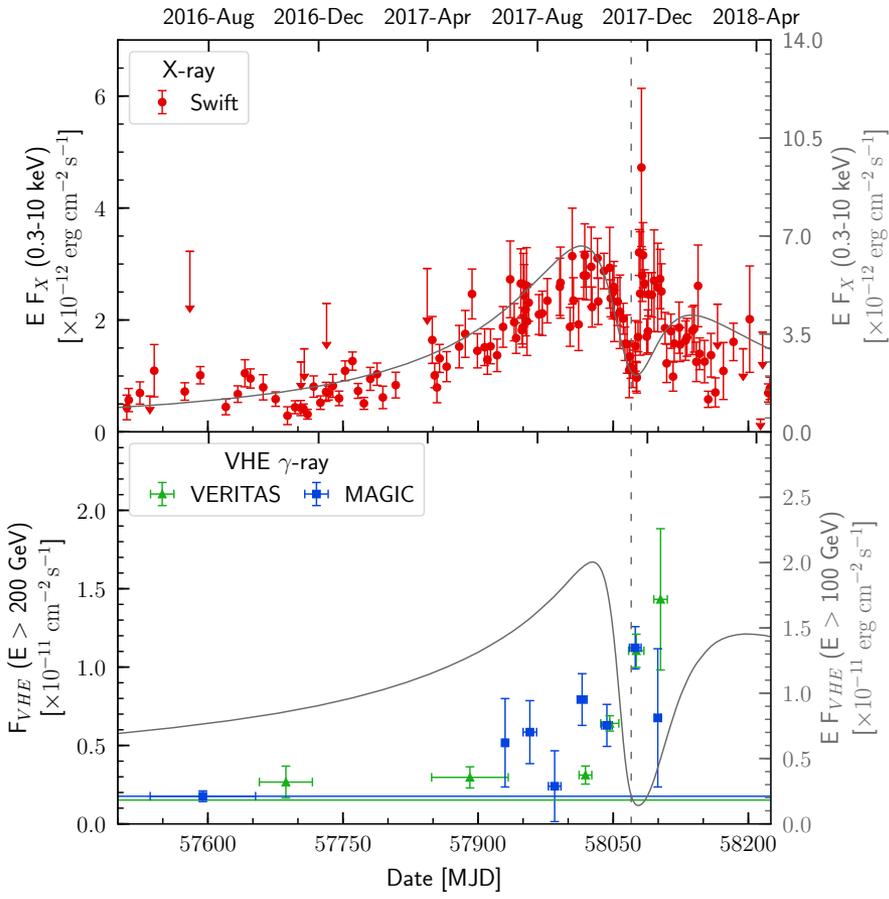


- **VHE ( $E > 200$  GeV) peaks at periastron** while for X-Ray peaks  $\sim 30$  days before
- X-Ray deep at periastron and recovery shortly after
- Deep 1 week after periastron at VHE, may be  $\gamma$ - $\gamma$  absorption

# Light Curve at VHE and X-Rays - Models



Abeyssekara et al., 2018

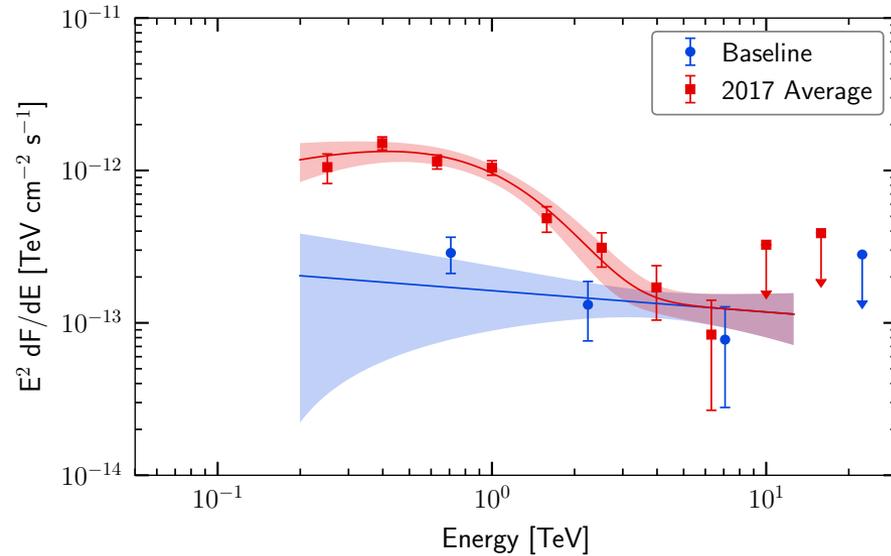


(a) Full Dataset

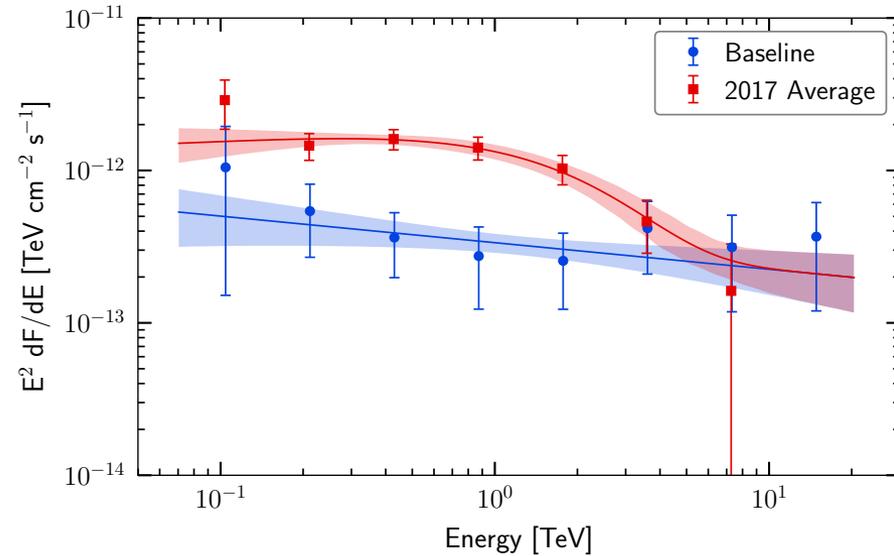
- **Increasing X-ray flux** due to radial dependence of the **pulsar wind magnetisation** (Takata et al 2017 & Lie et al 2018)
- **VHE flux level** at periastron absorption of primary gamma-rays + **Inverse Compton** (Bednarek et al 2018)
- **X-ray brightening** at superior conjunction: interaction with **circumstellar disk** Be or geometrical effect orientation **stellar disk** (Petropoulou, 2018)
- **VHE deep** at superior conjunction: similar to PSRB1259-63/LS2883 attributed to  $\gamma$ - $\gamma$  **absorption** (Sushch & van Soelen, 2017)

# VHE spectra at periastron passage

Abeysekara et al., 2018



(a) VERITAS 2017 fall average



(b) MAGIC 2017 fall average

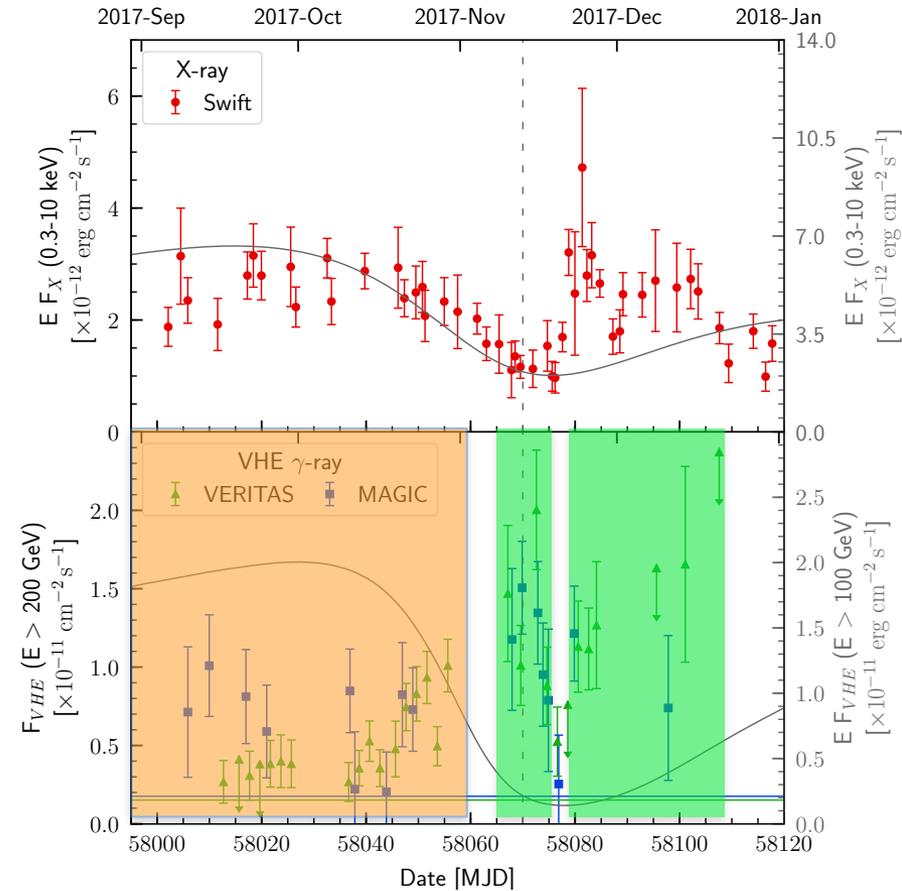
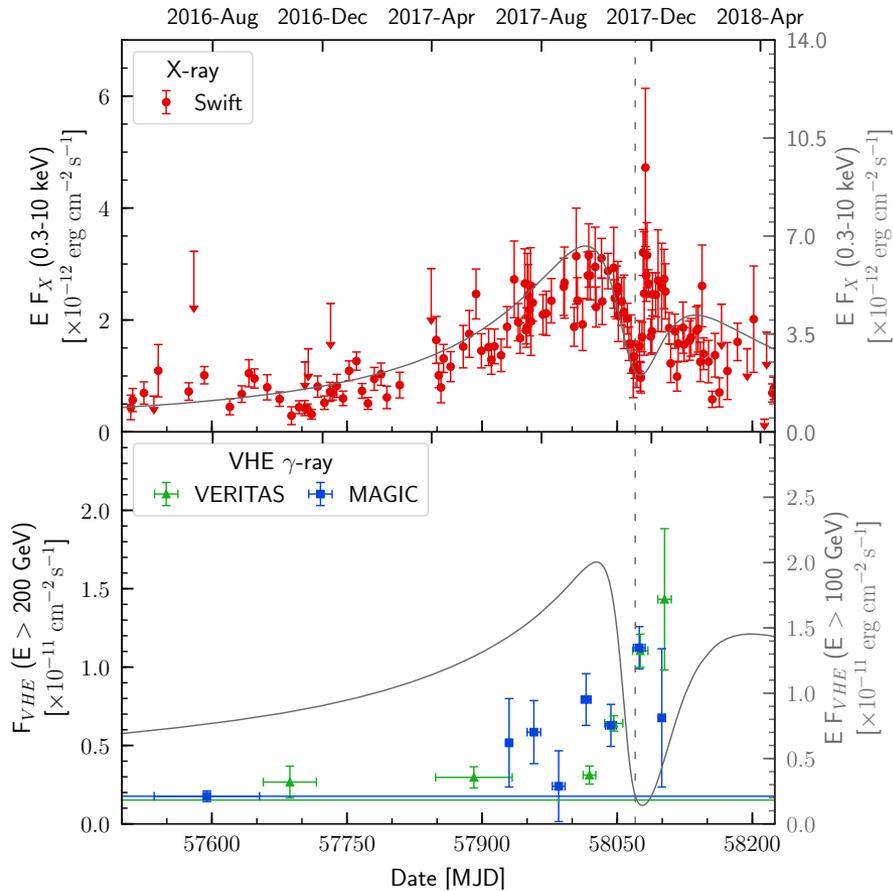
- Spectra reconstructed considering baseline emission
- Use full dataset (baseline & autumn 2017) and conduct simultaneous fits to different components.
- Statistically significant cut-off detected by both experiments.

# Light Curve at VHE and X-Rays



Abeyssekara et al., 2018

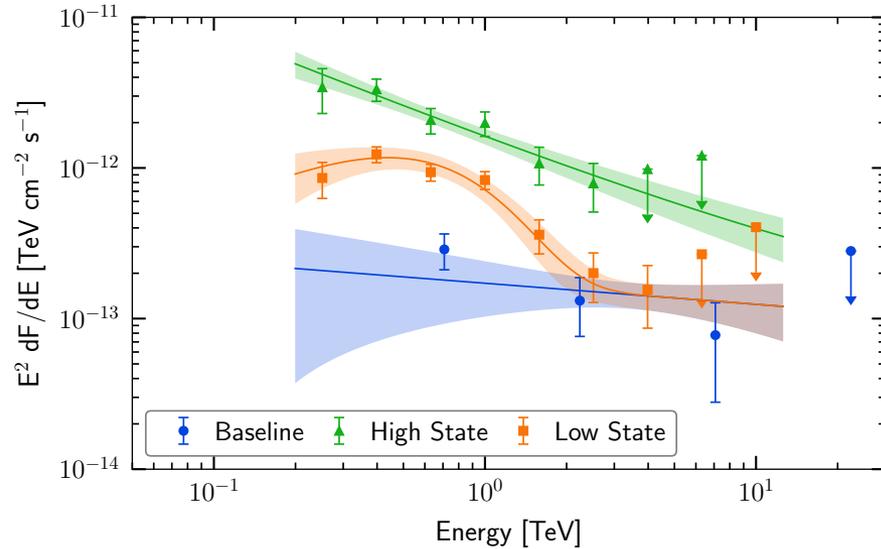
Takata et al., 2017, Lie et 2018



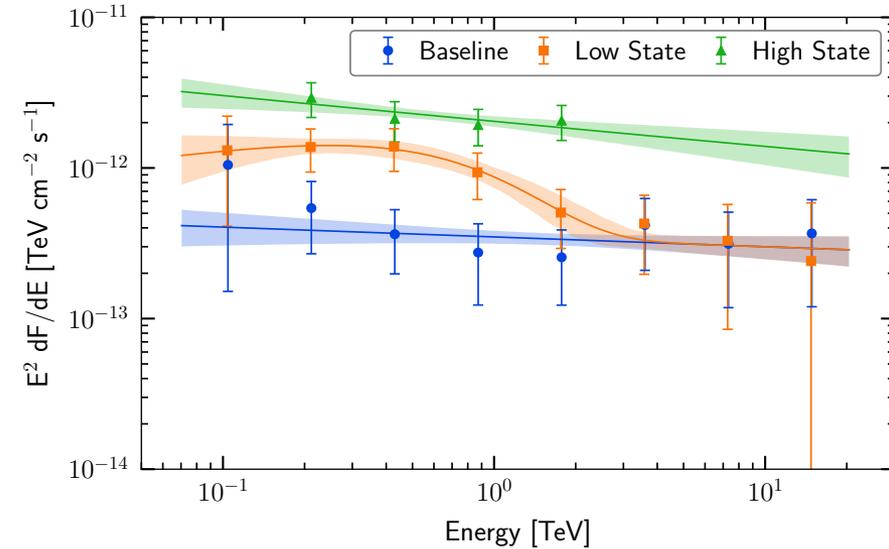
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# Low and High state spectra

Abeysekara et al., 2018



(c) VERITAS high & low states



(d) MAGIC high & low states

- Divide dataset into two periods.
  - Low State: MJD 57928-58056 (flux  $< 1 \times 10^{-11} \text{ cm}^{-2} \text{ s}^{-1}$ )
  - High State: MJD 58057-58074 and 58080-58110 (flux  $> 1 \times 10^{-11} \text{ cm}^{-2} \text{ s}^{-1}$ )
- Joint fit conducted to all 3 datasets (baseline, low & high state).
- Cut-off in low state for both experiments. No evidence for cut-off in high state.

# Summary



- **TeV emission** from [PSR J2032+4127/MT92 213](#) during periastron passage detected by VERITAS & MAGIC.
  - 7th gamma ray binary detected
  - 2nd where we know the nature of the compact object
- TeV J2032+4130 might be pulsar wind nebula of PSR J2032+4127
  - [PSR J2032+412](#) is a plausible candidate to be the power source
  - Is an extended TeV nebula also present around other TeV binaries?
- Both X-ray and VHE  $\gamma$ - ray show flux increase around periastron, though not at the same time
- Break in VHE spectrum for low state during periastron passage, but not at high state or baseline
- Models did not predict X-ray brightening after periastron and VHE gamma-rays emission.

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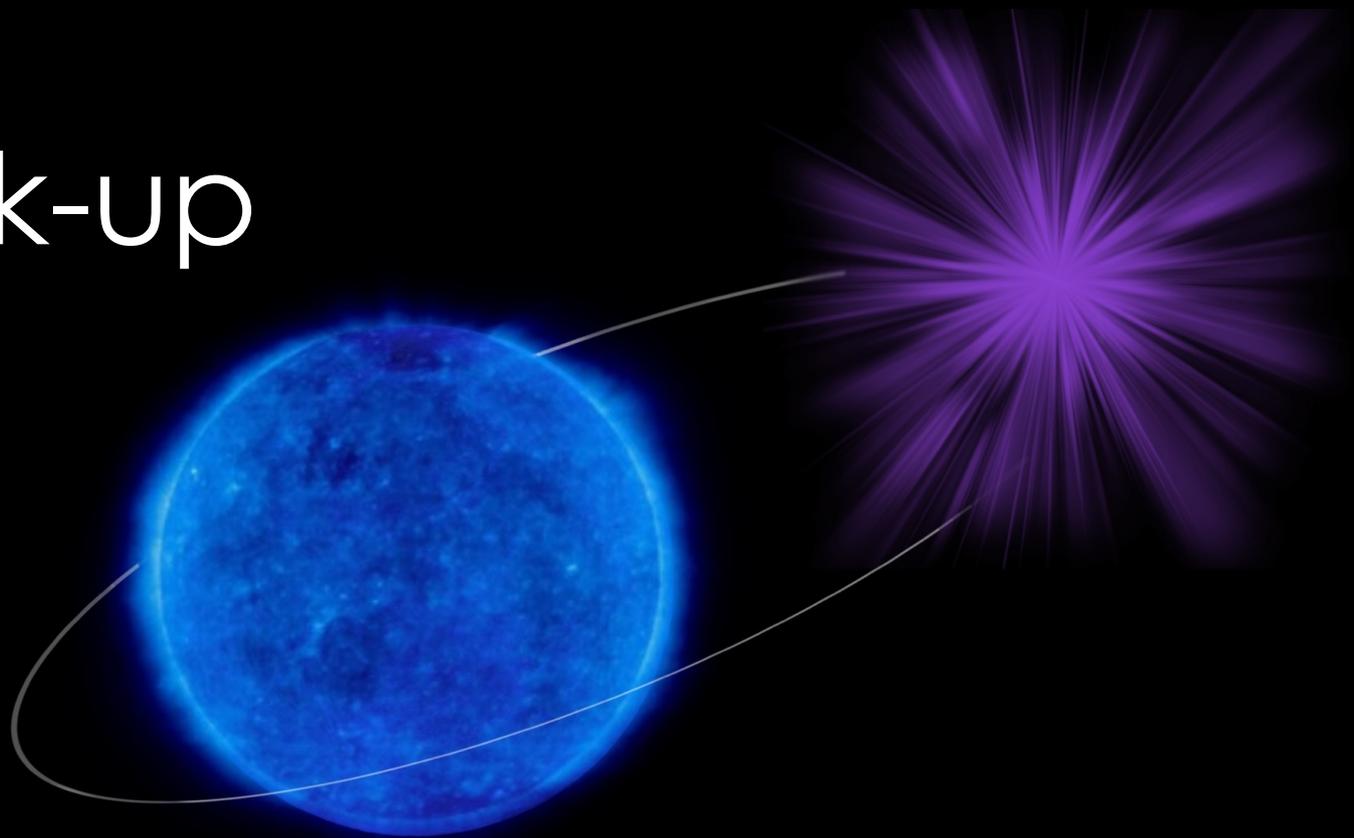
Thanks for your attention

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# Back-up





# Gamma-ray binaries: state-of-the-art



System	Star spectral type	Compact object	Porb [days]	HE emission	VHE emission
PSR B1259-53	Be	48ms pulsar	1236.72	yes	yes
LS 5039	O	-	3.91	yes	yes
LS I +61 303	Be	-	26.49	yes	yes
HESS J0632+057	Be	-	315.50	yes	yes
FGL J1018.6-5856	O	-	16.58	yes	yes
LMC P-3	O	-	10.2	yes	yes
PSR J2032+4127	Be	143 ms pulsar	50 years	yes	yes

extragalactic

new binary