Results on the observations of compact binaries with the MAGIC telescopes

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Compact binaries are systems composed of a star and a compact object, either a black hole (BH) or a neutron star (NS). They are possible very high energy (VHE, VHE>100 GeV) gamma-ray emitters. Despite the large number of observations devoted to the search, only five of these systems have been detected at these energies. MAGIC is actively looking for new gamma-ray binaries and studying the behavior of the already detected systems. In this contribution, the most recent results on the observations in this field addressed by MAGIC will be presented: the latest outcomes on a multi-year campaign of the gamma-ray binary LS I +61° 303 or the search of VHE emission from two candidates: MWC 656 and SS 433.

THE GAMMA-RAY BINARY LS I +61° 303

- Gamma-ray binary composed of a B0Ve star + unknown compact object, with an orbital period is 26.4960(28) days [1]
- Periodical VHE outburst is detected during the apastron passage (Φ = 0.5 - 0.75)
- Sporadic VHE emission is detected at later phases (Φ = 0.8 - 1.0)
- Super-orbital modulation of the peak flux of 1667±8 days, discovered in radio [1] and detected in several wavelenghts
- The flip-flop scenario [2], where the system changes from a propeller regime (periastron) to an ejector regimen (apastron), has been proposed to explain the VHE emission of this binary

Super-orbital modulation

- ❖ VHE flux stands yearly variability
- ❖ The super-orbital signature is compatible with the radio 4.5-year modulation at a 8% (χ 2/ndf = 27.18/18) level (Fig. 1)

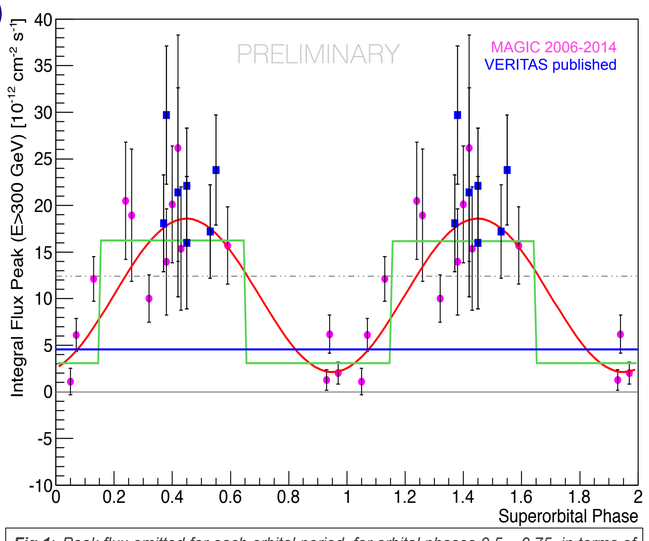

Fig.1: Peak flux emitted for each orbital period, for orbital phases 0.5 – 0.75, in terms of the super-orbital The dashed line represents 10% of the Crab Nebula flux. The grey solid line marks the zero level, just as a reference.

Spectral stability

- ❖ The VHE spectrum is compatible (at 23%) with a power-law with constant index α= 2.43 ± 0.04 (χ 2/nd f= 8.9/7)
- ❖ No super-orbital or high/low-emission dependence has been found

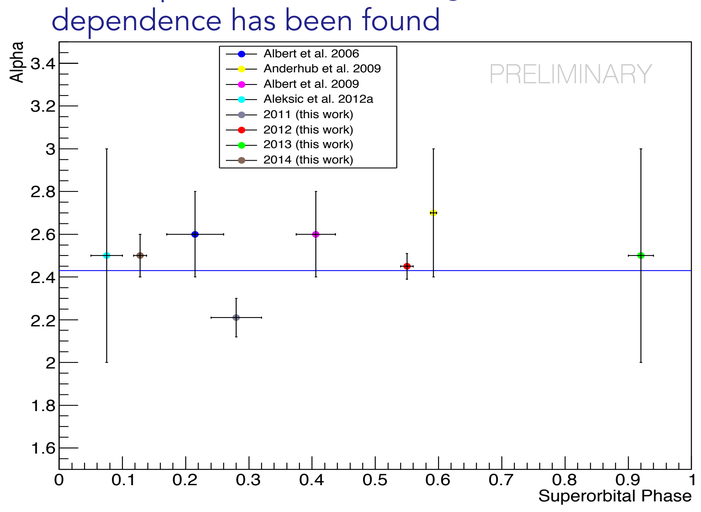

Fig.2: Super-orbital dependence of the spectral index for all MAGIC campaigns of LS I +61◦303, considering a 1667-day period. The blue line corresponds to the average value.

Optical/TeV observations

- ❖ Search for optical/VHE (LIVERPOOL/MAGIC) correlation to to test conection between size of the disk and TeV emission
- ❖ No intra-day correlation connecting the two frequencies (Table 1)

Simultaneity	Parameters	*r*	Prob
Nightly	TeV - EW	-0.23	0.84
Nightly	TeV - FWHM	-0.14	0.72
Nightly	TeV - vel	-0.44	0.97
3 hours	TeV - EW	-0.32	0.80
3 hours	TeV - FWHM	-0.24	0.74
3 hours	TeV - vel	-0.45	0.90

***Table 1**: Correlations and probabilities.*

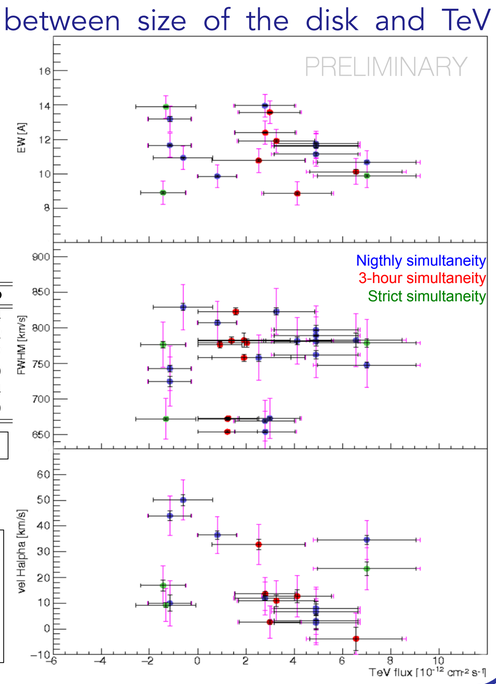

***Fig.3**: Correlation between the TeV and the Hα parameters (EW, FWHM qnd centroid of the velocity) at orbital phases 0.75 - 1.0. Each data point represents a 10-minute observation in the optical and a variable integration in theVHE regime.*

THE Be/BH BINARY MWC 656

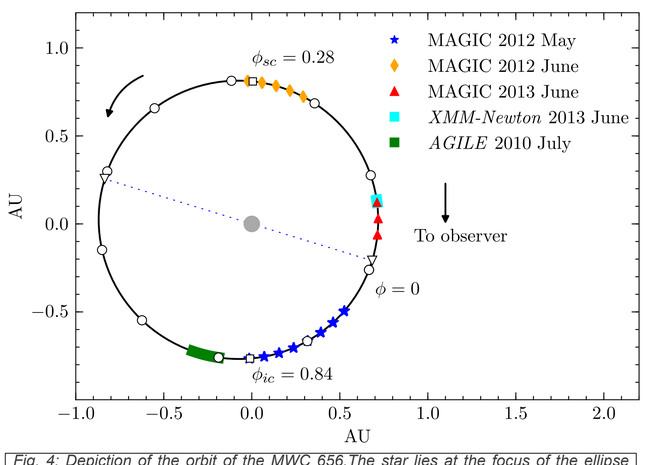

Fig. 4: Depiction of the orbit of the MWC 656.The star lies at the focus of the ellipse while the BH follows the elliptical orbit. Empty circles represent steps of 0.1 orbital phases, while triangles mark the periastron and apastron phases, which are linked by a dotted line. The inferior and superior conjunctions are marked as squares.

- ❖ Only Be star + BH binary system ever detected [3].
- ❖ *AGILE* detected emission at E>100 MeV [4]. Not detection at high energies by *Fermi*-LAT [5] neither in radio [6].
- ❖ Simultaneous MAGIC, X-ray (*XMM-Newton*) and optical (STELLA) observations performed (Fig. 4).
- ❖ No significant gamma-ray emission detected [7]. VHE ULs were set (see Fig. 5)

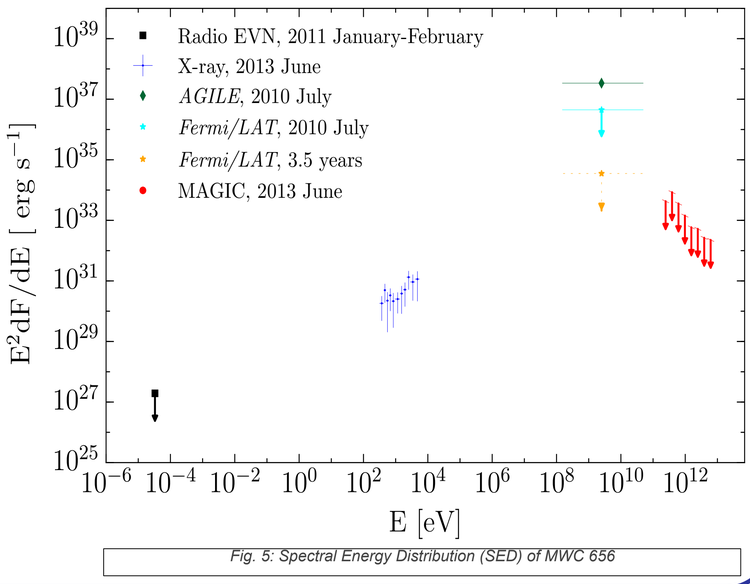

Fig. 5: Spectral Energy Distribution (SED) of MWC 656

- ❖ The low X-ray flux [8] and optical measurements are consistent with the source being in a quiescent state.
- ❖ A VHE flux based on the extrapolation of the emission from the AGILE detection is excluded.
- ❖ Detectability: CTA + flaring states.

THE MICROQUASAR SS 433

- ❖ Composed of a A3-A8 star + BH, lying inside W50 nebula
- ❖ Only super-critical accretor in the Milky Way
- ❖ Two relativistic jets, with a precessional period of 162.3 days, interact with the nebula
- ❖ Gamma rays absorption expected along 80% of the orbit [9]
- ❖ No significant VHE signal, neither from the SS 433, nor from the western/eastern interaction regions (Fig. 6) [10]

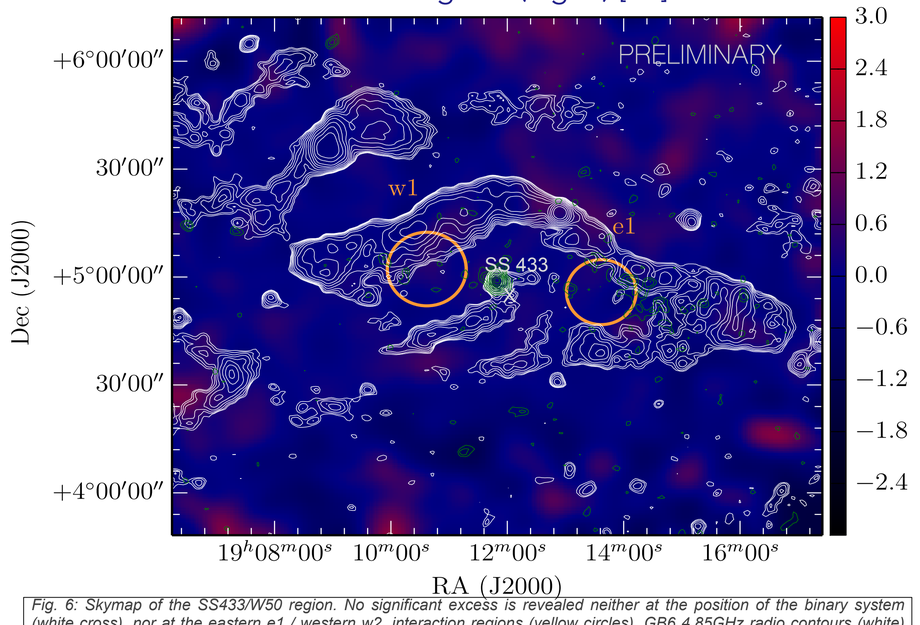

Fig. 6: Skymap of the SS433/W50 region. No significant excess is revealed neither at the position of the binary system (white cross), nor at the eastern e1 / western w2, interaction regions (yellow circles). GB6 4.85GHz radio contours (white) and ROSAT broadband X-ray contours (green) are over-plotted.

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