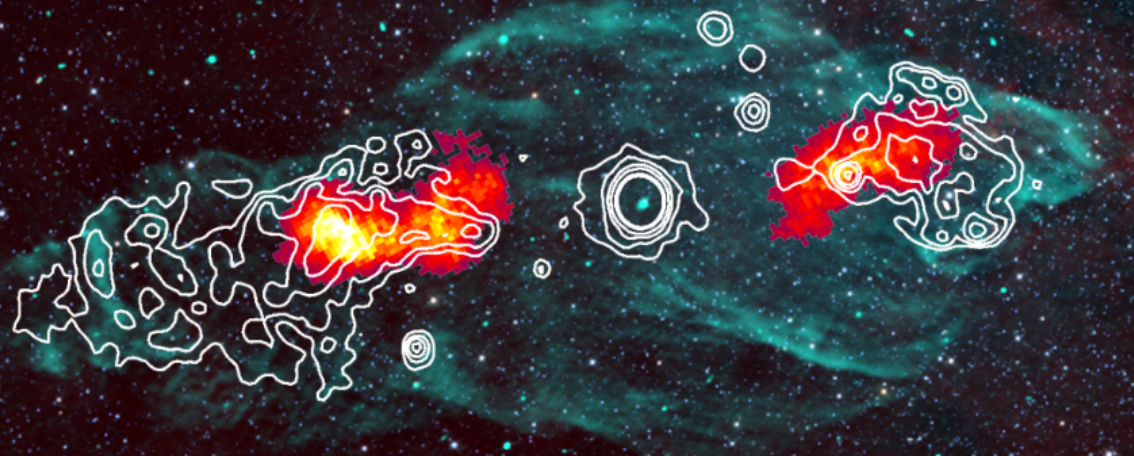




H.E.S.S. recent discoveries of gamma-ray binaries



Laura Olivera-Nieto
VGGRS - 12/04/2023



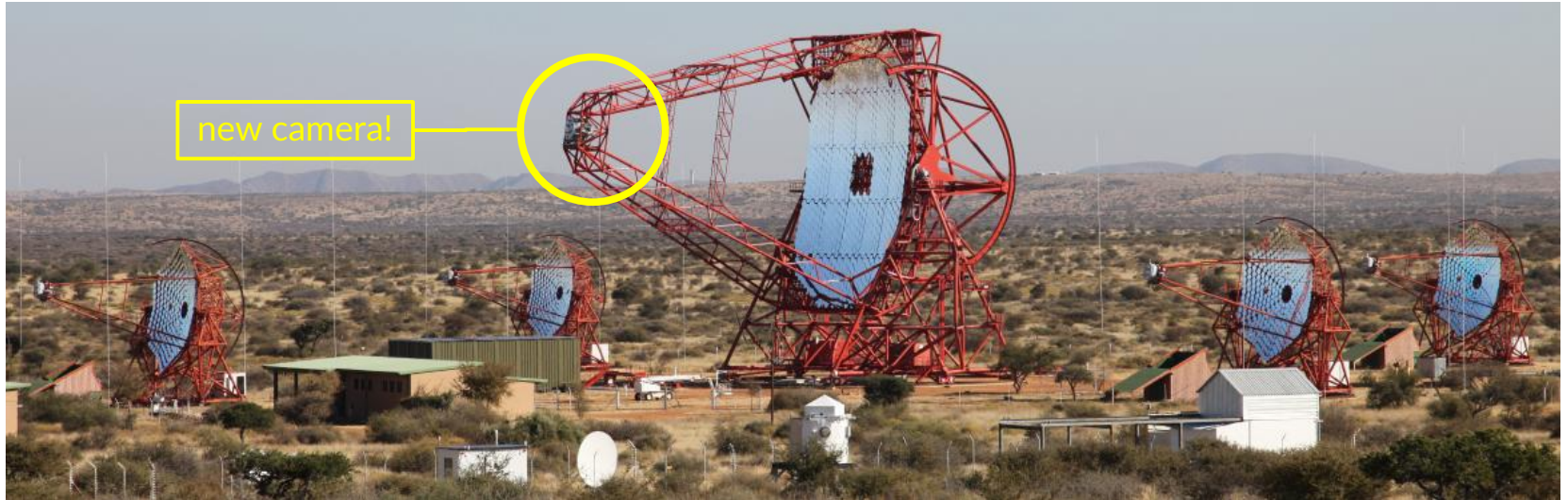
H.E.S.S.

- ▶ Array of 5 Imaging Atmospheric Cherenkov Telescopes (IACT) located in Namibia.
- ▶ Four 12m telescopes (CT1-4), one 28m telescope (CT5)
- ▶ Energy range from 10s of GeV to 10s of TeV.



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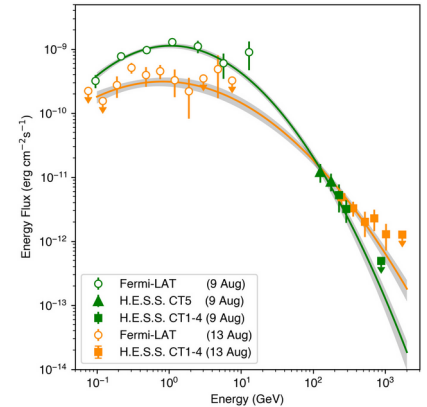


in this talk

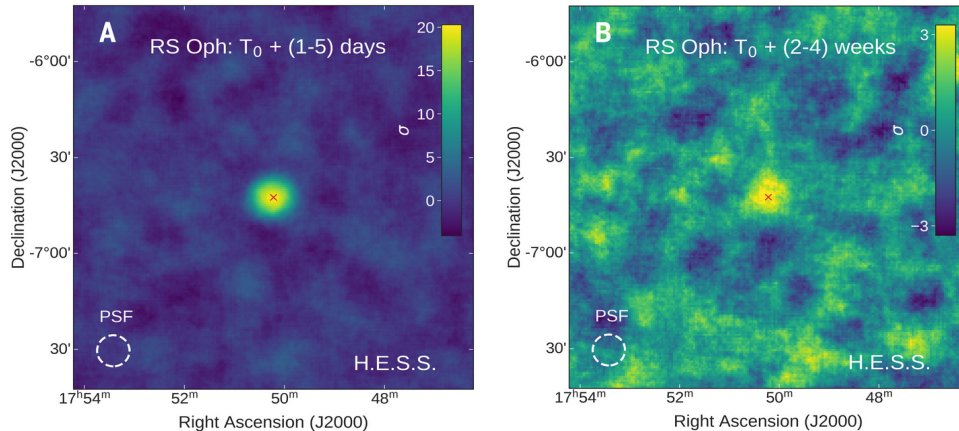
Name	Compact Object	Star	jet?	Orbital period	HE	VHE	VHE variability?
RS Oph	WD	RG	no	454 days	yes	yes	yes
HESS 0632 +057	?	Be	no	317.3 days	yes	yes	yes
LMC P3	NS?	O5 III	no	10.3 days	yes	yes	yes
Eta Carinae	LBV + O/B/WR type		no	~5.5 yr	yes	yes	yes
SS 433	BH	A7 Ib	yes	13 days	?	yes	no
V4641 Sgr	BH	B9 III	yes	2.8 days	?	yes	no
other microquasars	BH/NS	-	yes	-	some	no	?

RS Oph

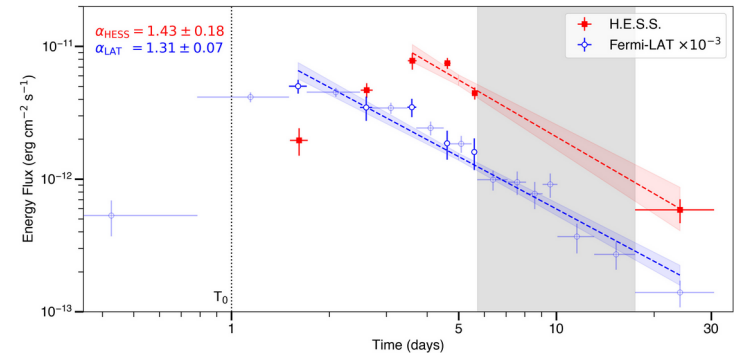
- ▶ Recurrent nova (white dwarf - red giant accreting binary system)
- ▶ Most recent eruption in August 2021 – detected by H.E.S.S. (and MAGIC and LST-1)
- ▶ Detected over several days → time-resolved emission!
- ▶ Hadronic scenario favored, very efficient acceleration



H.E.S.S. Collaboration, Science 376, 77 (2022)

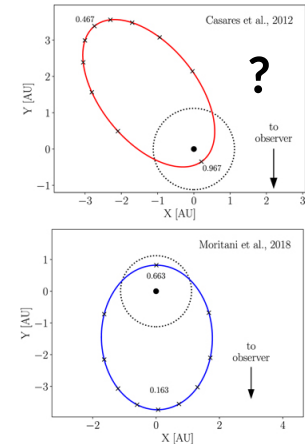


H.E.S.S. Collaboration, Science 376, 77 (2022)

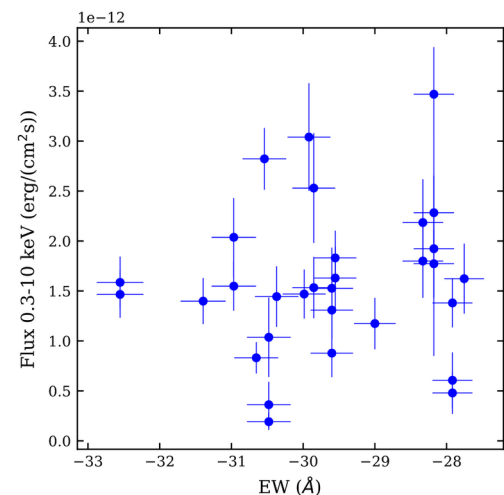
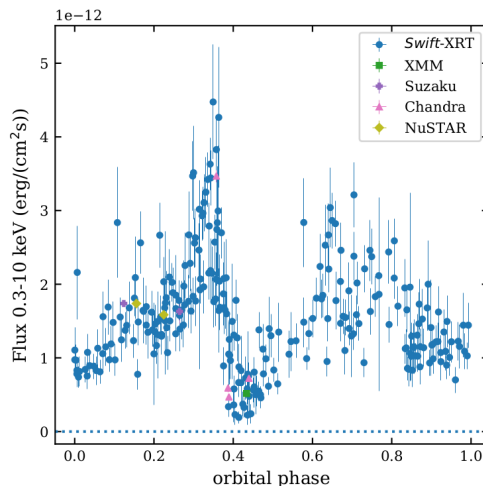
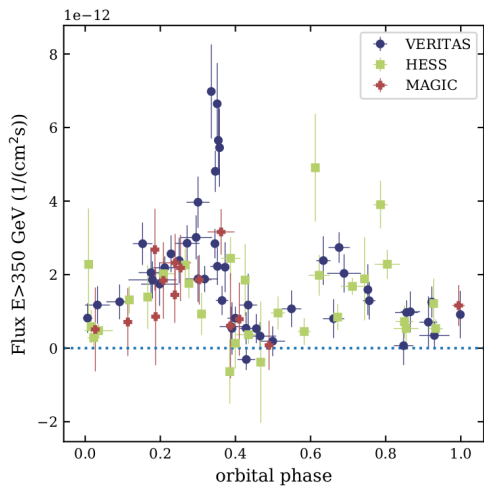


HESS 0632 +057

- ▶ Deep combined exposure from VERITAS, MAGIC and H.E.S.S.
- ▶ Detected variability in gamma-ray flux with a period and amplitude correlated to the x-ray modulation
- ▶ No correlation with optical H α parameters of simultaneous observations

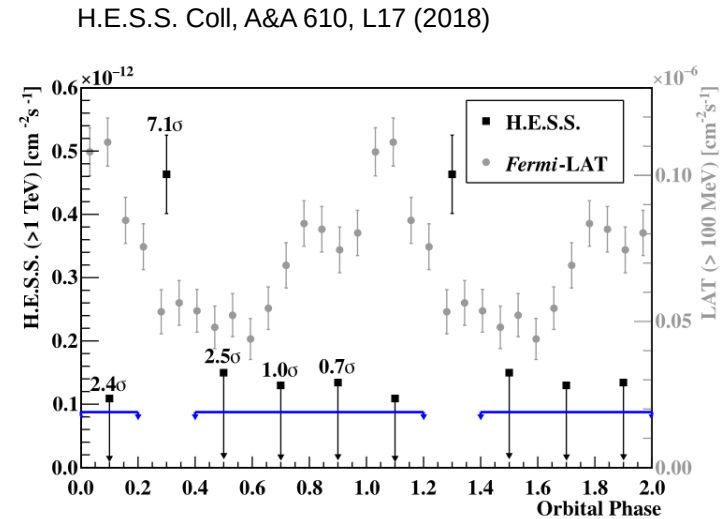


VERITAS, MAGIC, HESS et al, ApJ 943, 2021



LMC P3

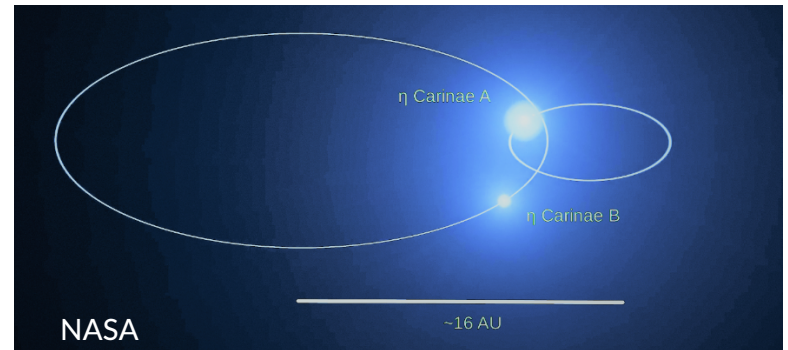
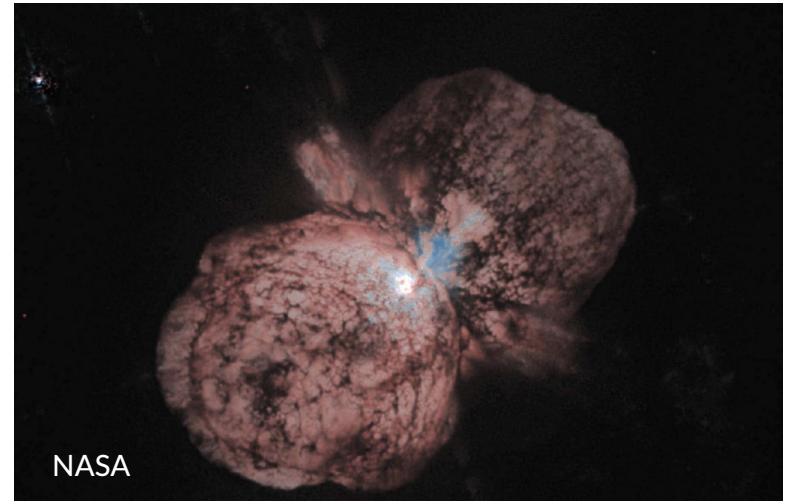
- ▶ First-ever detected extragalactic gamma-ray binary
- ▶ Detection by H.E.S.S. in 2018, period of 10.3 days
- ▶ Phase coverage of the initial observations was not great: periodicity cannot be deduced from the H.E.S.S. dataset alone.
- ▶ TeV emission near inferior conjunction
- ▶ Slightly eccentric orbit $e = 0.40 \pm 0.07$, neutron star compact object, superior and inferior conjunction at 0.98 and 0.24 respectively ([Van Soelen et al 2019](#))



- ▶ New H.E.S.S. data, better binning informed by these parameters → better sampled light curve
- ▶ Led by Lalenthra Fisher
- ▶ Will be shown at the ICRC (talk)

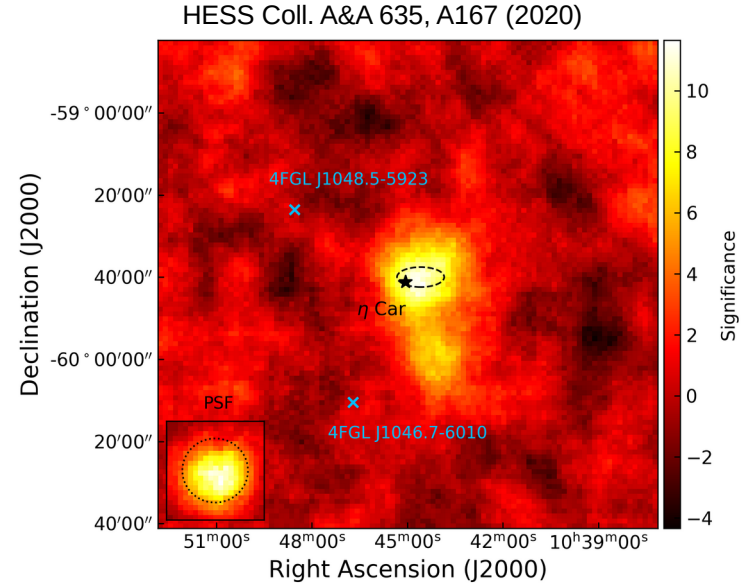
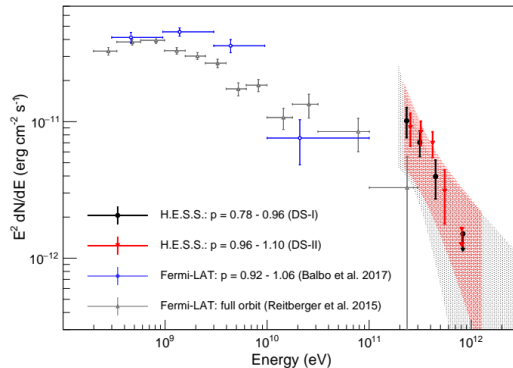
Eta Carinae

- ▶ One of only two colliding wind binaries known to be gamma-ray emitters
- ▶ Two massive stars in a highly eccentric orbit
- ▶ Eta Car A: Luminous Blue Variable, $M \sim 100M_{\odot}$
- ▶ Eta Car B: Wolf-Rayet or O-type, $M \sim 30M_{\odot}$
- ▶ Period ~ 5.5 yr, last periastron passage in February 2020, previously in 2014



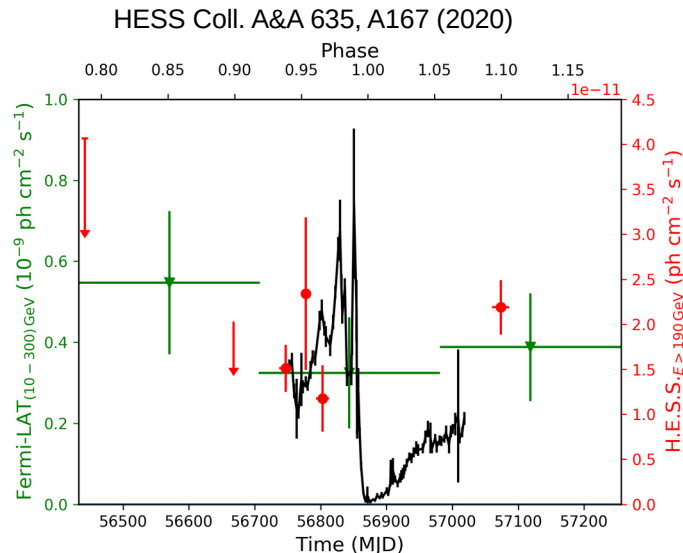
Eta Carinae

- ▶ Detected by H.E.S.S. before and after the 2014 periastron passage.
- ▶ Very difficult field, high systematic uncertainties
- ▶ E.g. hotspot below the position of Eta Car
- ▶ origin of the emission likely hadronic



Eta Carinae

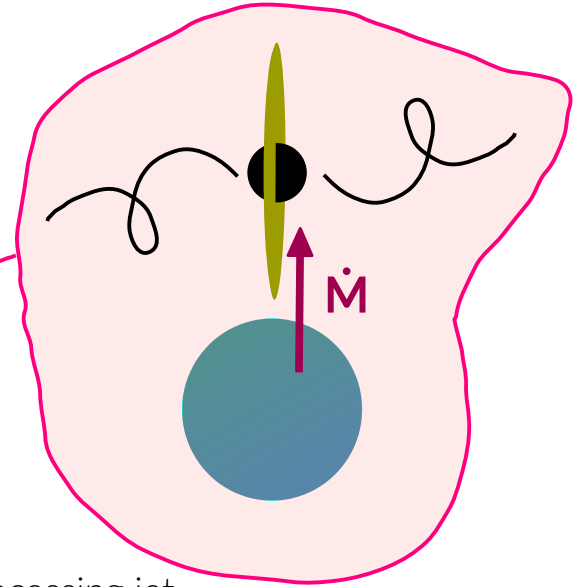
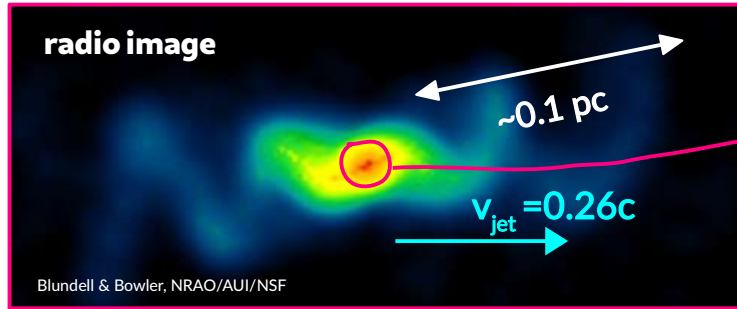
- ▶ 2014 periastron was not directly observed
- ▶ NEW: The 2020 periastron passage was observed fully.
- ▶ Data now exists for a full orbit
- ▶ New analysis, better treatment of noise, more confidence on spectral measurement.



Led by Simon Steinmassl

- ▶ Will be shown at the ICRC (talk)

SS 433



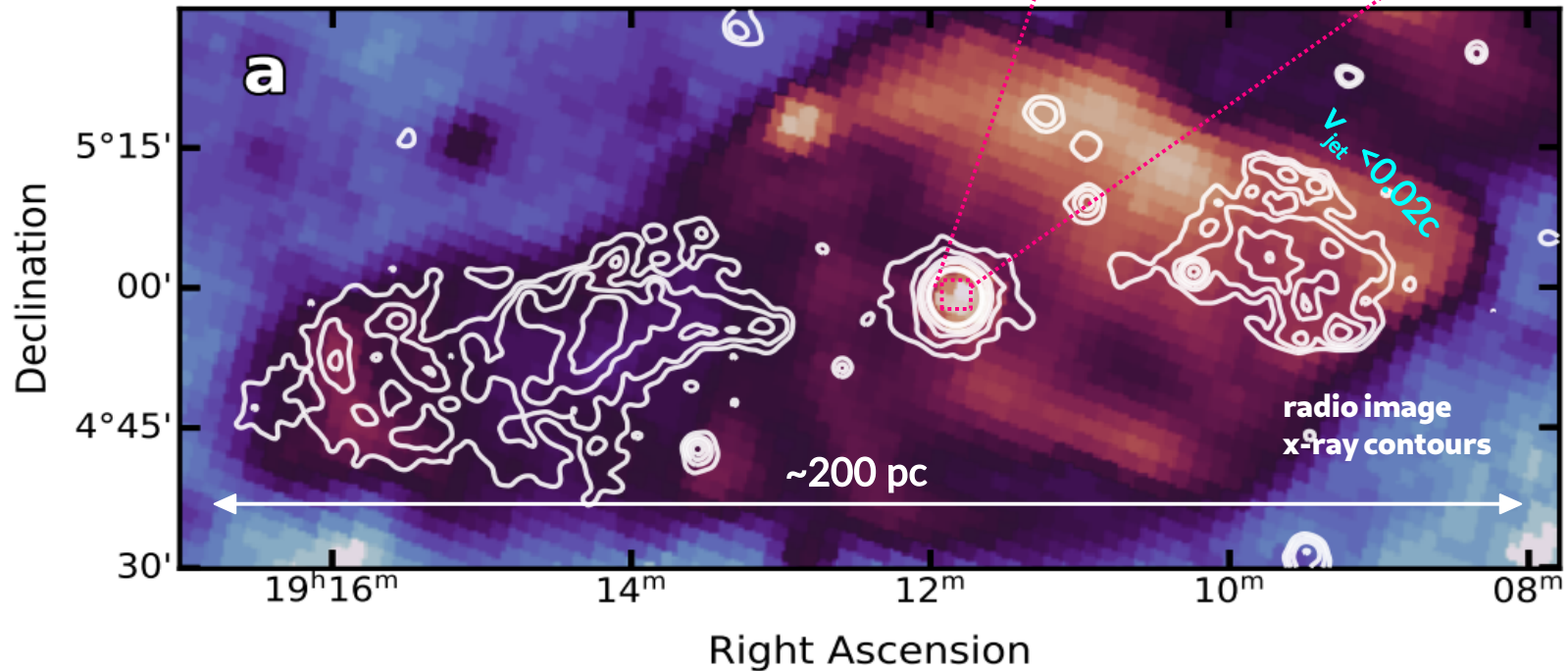
- ▶ very high accretion rate, 10^{-4} - $10^{-3} M_{\odot}$
- ▶ other microquasars have $< 10^{-8} M_{\odot}$
- ▶ continuously in super-Eddington regime
- ▶ (for ~ 50 years)

- ▶ precessing jet
- ▶ half-opening angle of 20°
- ▶ 162 days period
- ▶ distance $\sim 5.5 \text{ kpc}$

SS 433

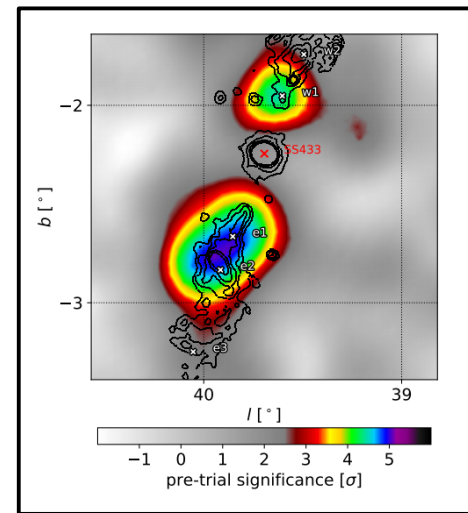
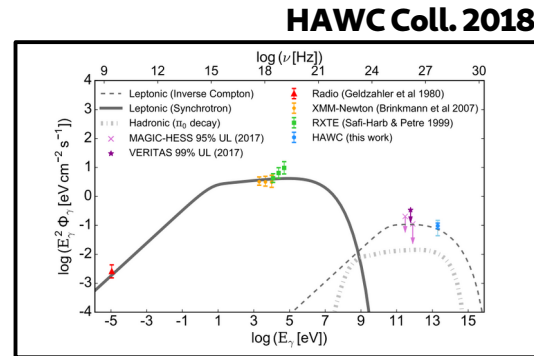
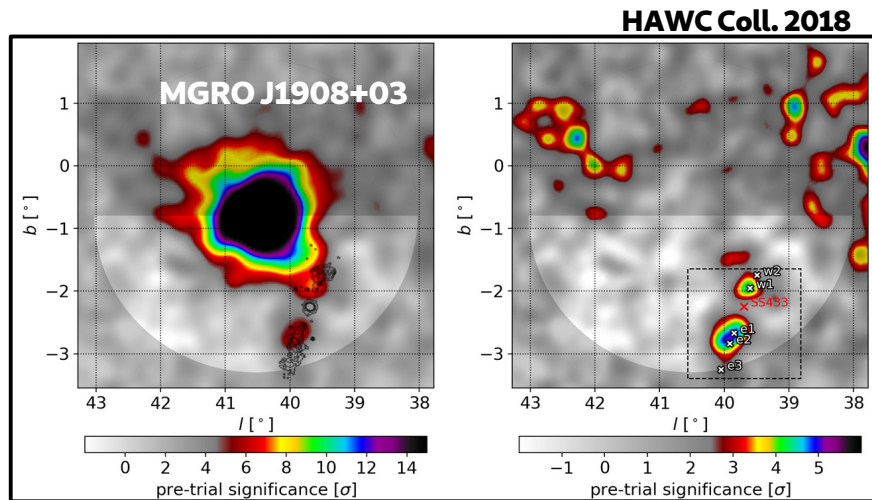
“east”

“west”



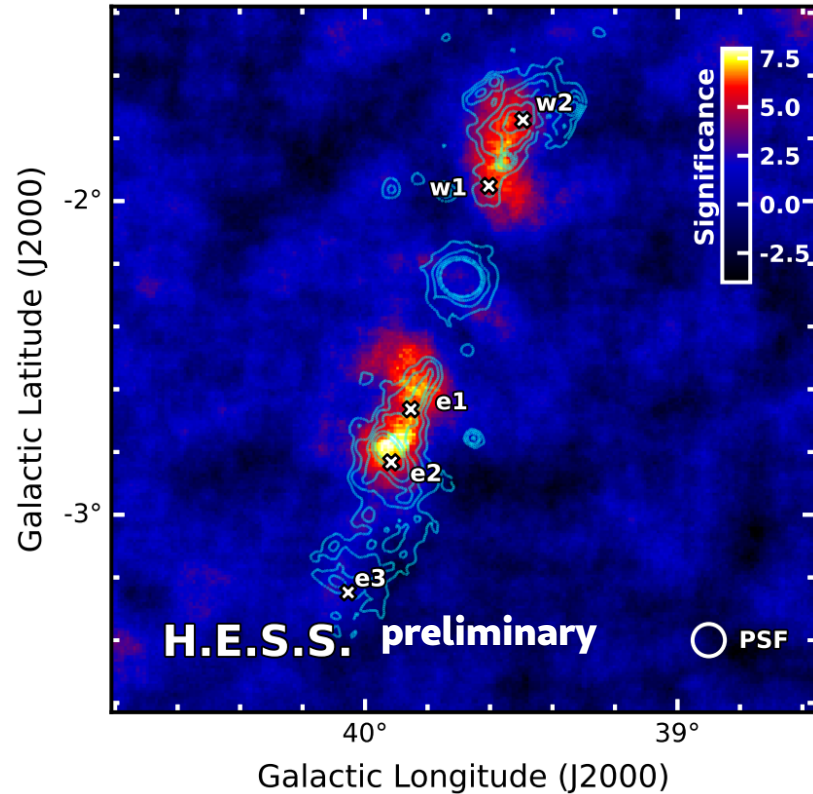
SS 433

- ▶ detected by HAWC in 2018
- ▶ two hotspots consistent with the jets of SS 433
- ▶ both consistent with a point source description
- ▶ flux at 20 TeV reported (for both jets)



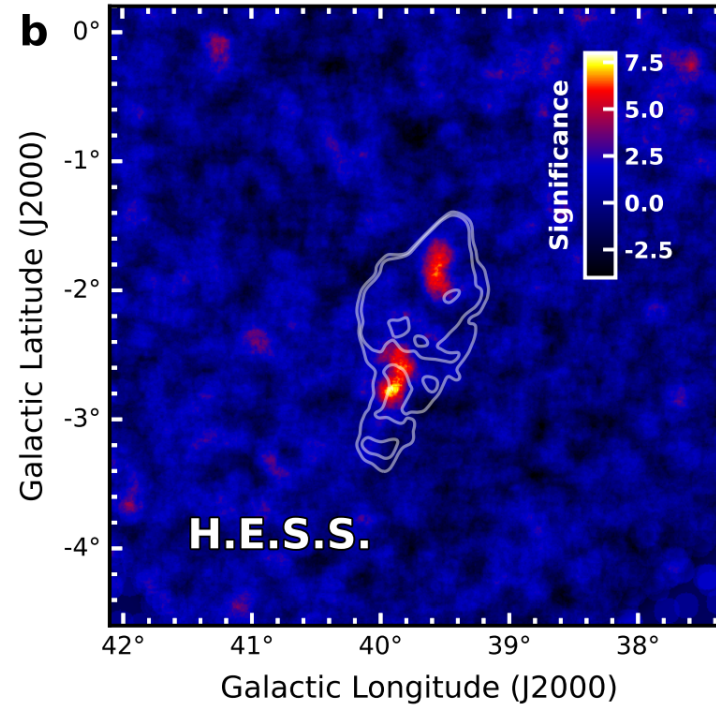
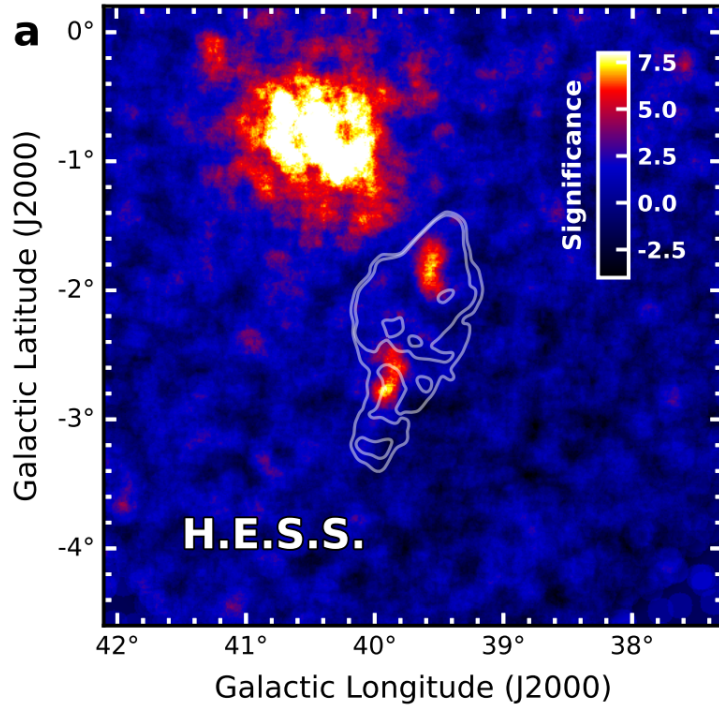
SS 433

- ▶ Detected by H.E.S.S.
- ▶ Statistical significance of 7.8 and 6.8σ for east and west, respectively.
- ▶ Emission is clearly extended
- ▶ Can do detailed study of morphology and spectra
- ▶ Paper about to be submitted!



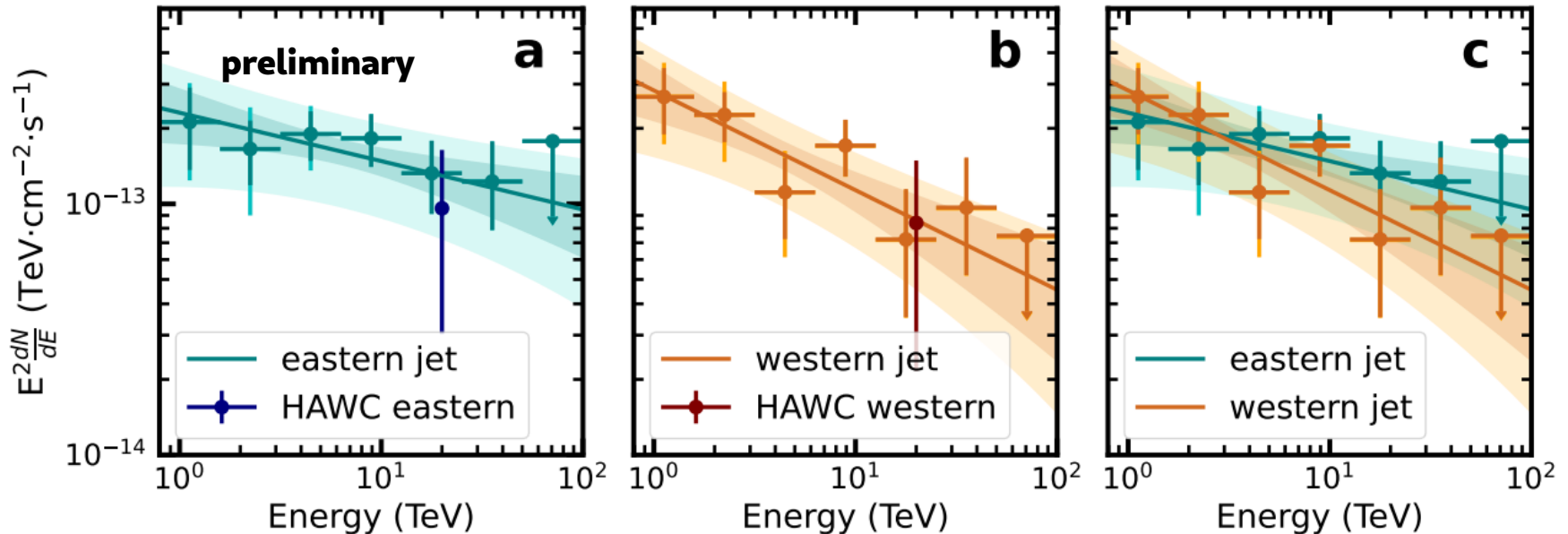
SS 433

- ▶ MGRO J1908+06 is less of a problem for H.E.S.S.



SS 433

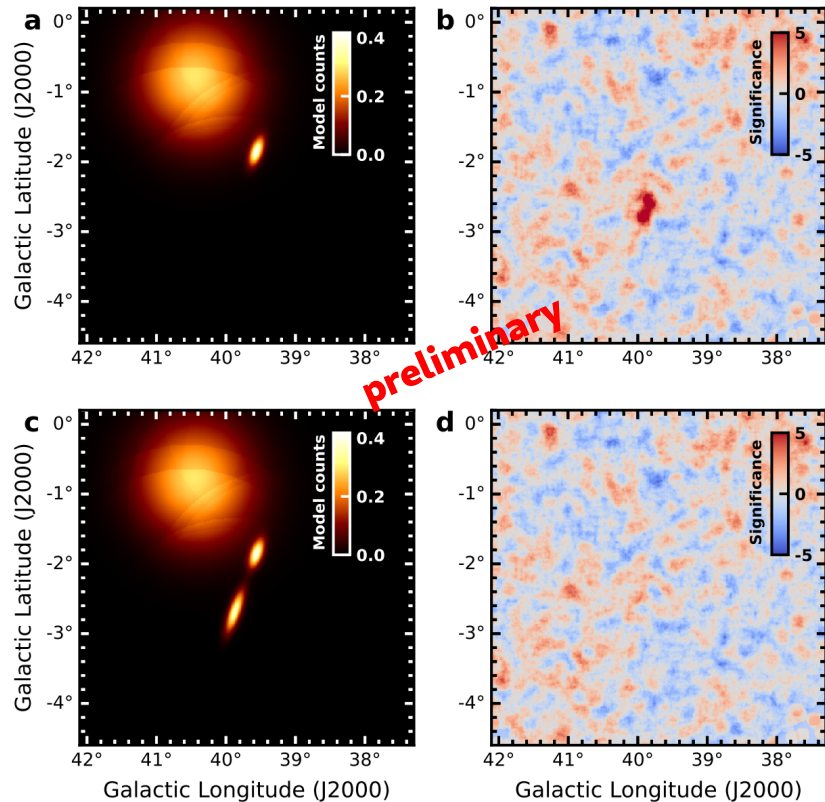
- ▶ Spectral shape consistent with a power law, no evidence for curvature or cutoff
- ▶ Flux level consistent with the HAWC measurement at 20 TeV



SS 433

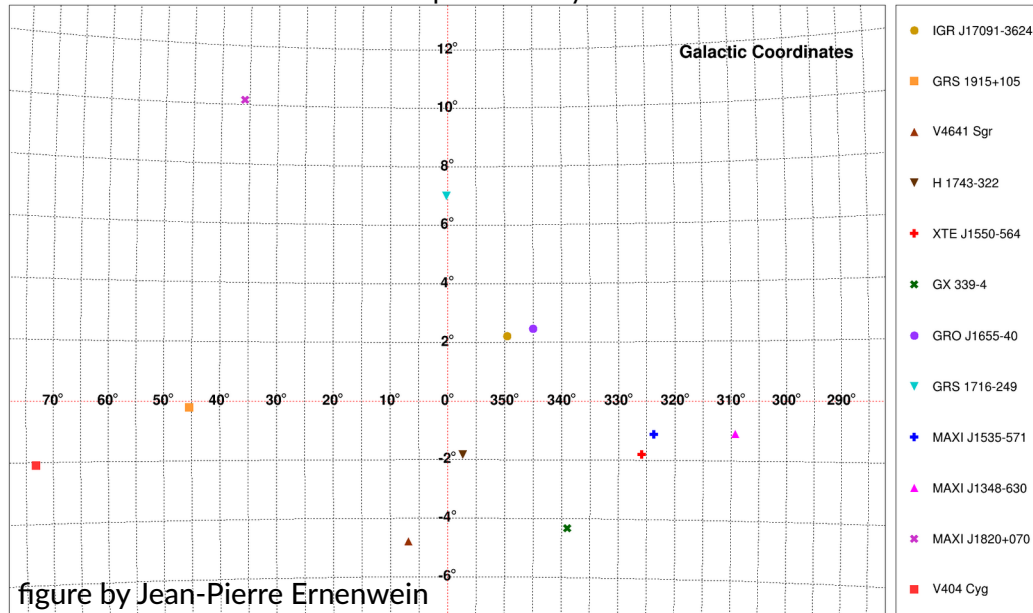
- ▶ Emission is significantly (7.8 and 4.7σ for east and west, respectively) extended
- ▶ Ellipticity is preferred by 5.8 and 3.5σ for east and west respectively when angle is fixed to the jets
- ▶ Eastern excess is ~ 40 pc across
- ▶ Western excess is ~ 25 pc across

	l (deg)	b (deg)	σ_{maj} (deg) (pc)	σ_{min} (deg) (pc)	θ (deg)
east	$39.88 \pm 0.02_{\text{stat}}$	$-2.69 \pm 0.03_{\text{stat}}$	$0.21 \pm 0.04_{\text{stat}}$ $20.1 \pm 3.8_{\text{stat}}$	$0.04 \pm 0.02_{\text{stat}}$ $3.8 \pm 1.9_{\text{stat}}$	-19
west	$39.56 \pm 0.01_{\text{stat}}$	$-1.85 \pm 0.03_{\text{stat}}$	$0.13 \pm 0.03_{\text{stat}}$ $12.5 \pm 2.9_{\text{stat}}$	$0.05 \pm 0.02_{\text{stat}}$ $4.8 \pm 1.9_{\text{stat}}$	-19



Other microquasars

source list for archival data of microquasars study



- ▶ Long-time running target-of-opportunity observation program + some dedicated observations have resulted on decently-sized datasets for a number of microquasars.
- ▶ Study of this data to provide upper limits on the TeV emission, both integrated and during flares.

- ▶ Led by Sébastien Le Stum
- ▶ Will be shown at the ICRC (poster)

Summary

- ▶ H.E.S.S. is able to provide detailed morphological, temporal and spectral studies of a number of gamma-ray binaries
- ▶ Not shown here: MAXI J1820+070 (dedicated talk), LS 5039 (ongoing effort)
- ▶ Lots of new results will be shown at upcoming ICRC
- ▶ SS 433 paper about to be submitted (with more results than shown here!)
- ▶ Stay tuned!