The jets of SS 433 as seen by H.E.S.S.

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for the H.E.S.S. Collaboration

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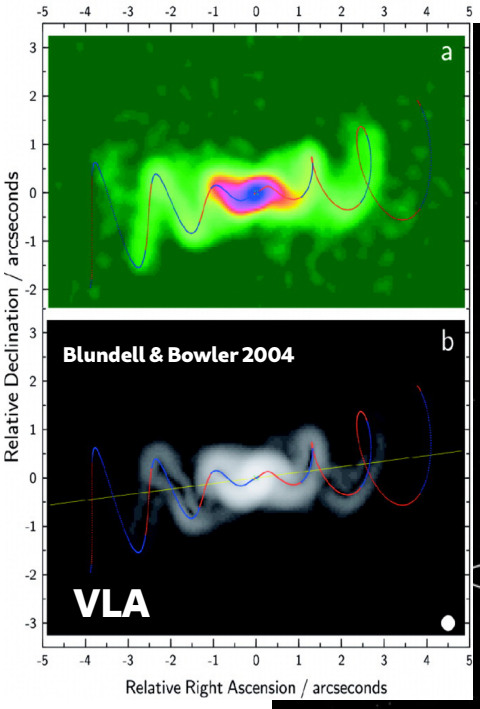
H.E.S.S.

MAX-PLANCK-INSTITUT FÜR KERNPHYSIK

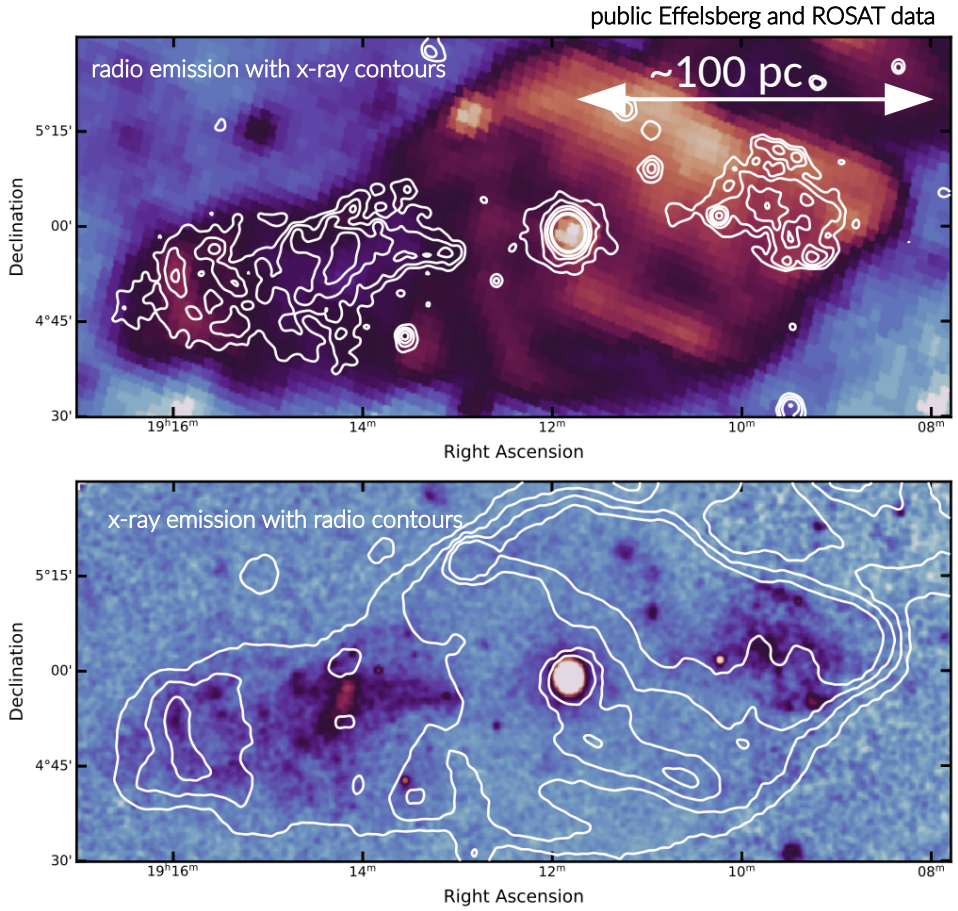


~162 days
20º
~0.26c
~13 days
COMPANION STAR
ACCRETION DISC
JET
$10^{39} - 10^{40}$ erg/s
COMPACT OBJECT
GAS STREAM
TOWARDS EARTH
The SS-433 System
ESO

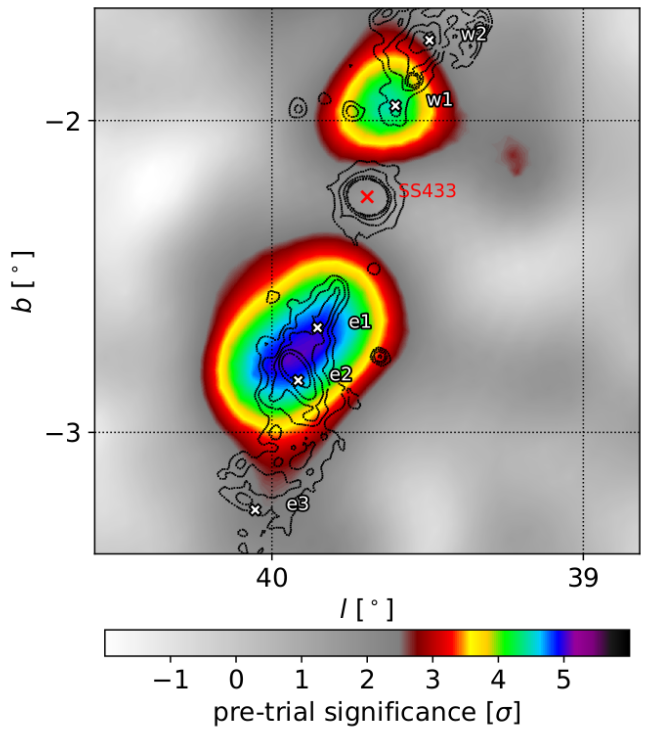
SS 433

- 5.5 kpc away (or a little closer)
- jet launches with 0.26c with a precession angle
- then disappears in the x-ray
- reappears again (why?)
- smaller opening angle
- extended x-ray jets are “lumpy”
- B amplification regions? material from W50 being hit by the jet?
- upper limit on the jet velocity at the edge of system is 0.023c
- both jets expand into different ambient densities

public Effelsberg and ROSAT data

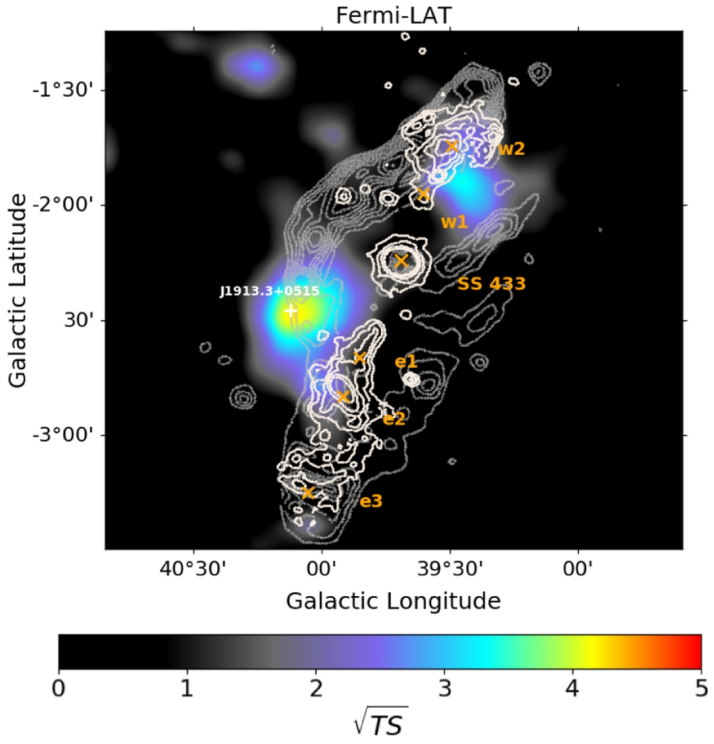


Gamma-rays from the large scale jets



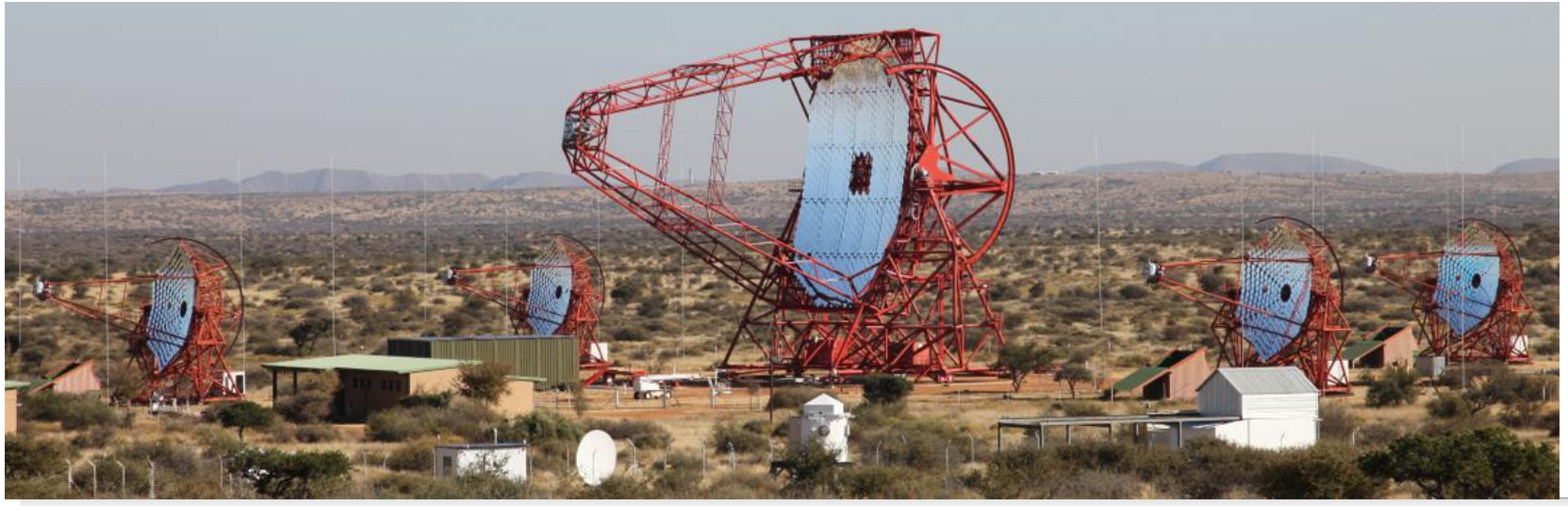
← detected by HAWC
(Abysekara et al 2018)

more complicated in Fermi →
(Fang et al 2020, Li et al 2020)



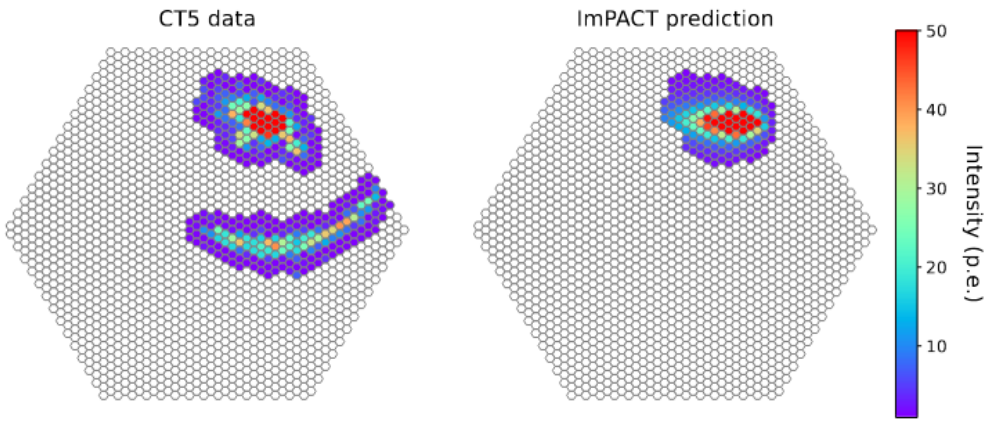
H.E.S.S. observations

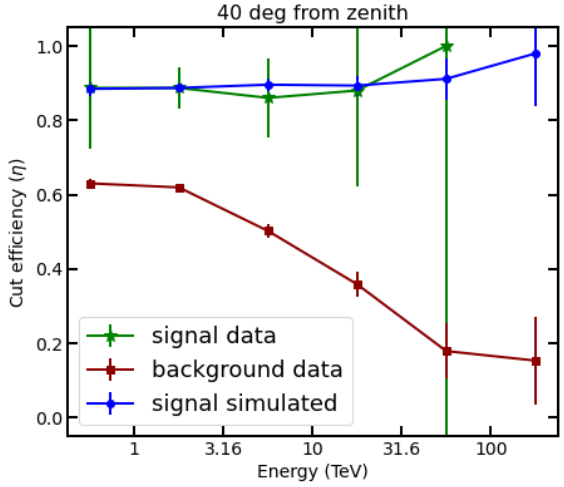
- Array of four 12m + one 28m diameter Cherenkov telescopes located in Namibia
- Dedicated observations of the SS 433 system in 2019, 2020, 2021 + archival data
- Total of ~300 hours, spread around the large field of view
- Majority of new observations taken with full array



Data analysis

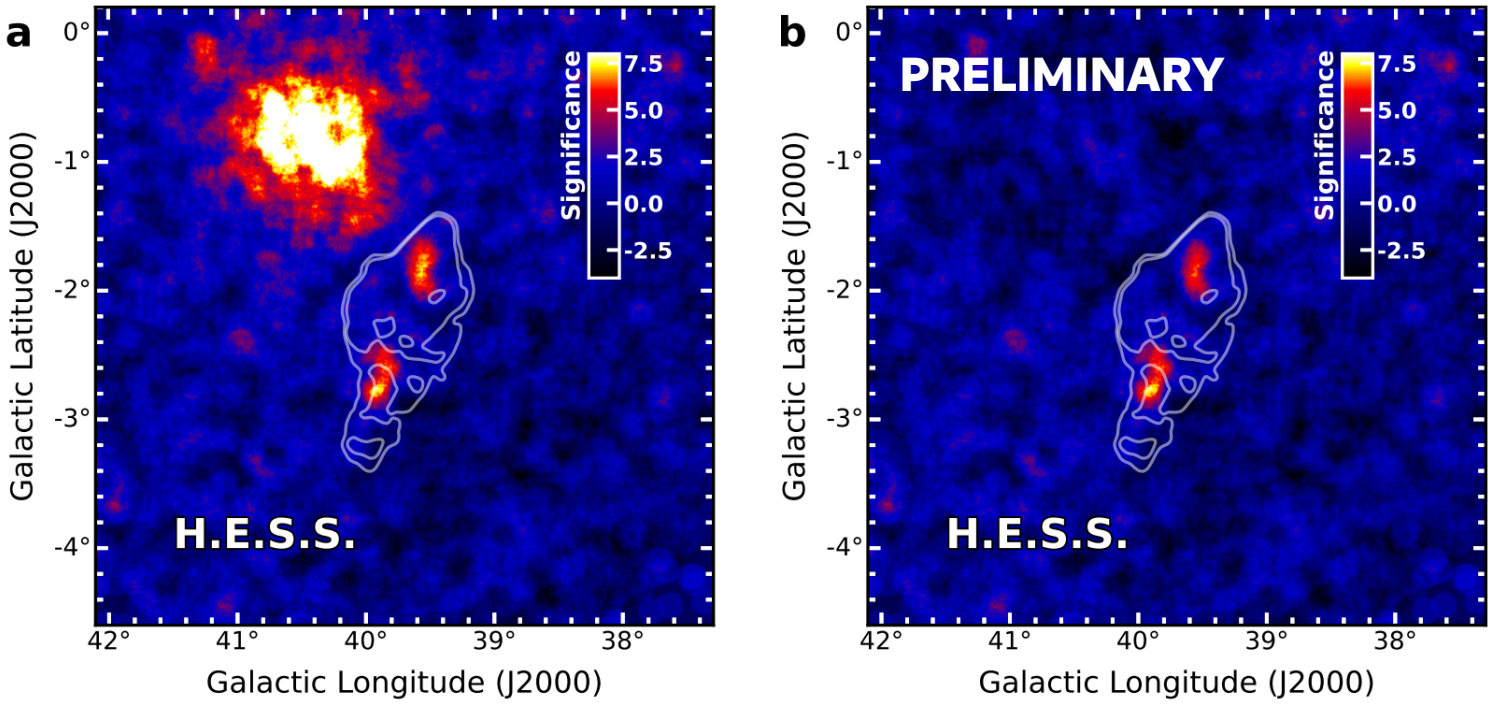
- Standard 4-tel HESS analysis using a *super hard* config optimized for hard, faint sources
- CT5 data as an extra step of background rejection (ABRIR) → **see poster by Helena Ren!**
- High level analysis done in Gammapy → **see talk on Thursday by Atreyee Sinha!**





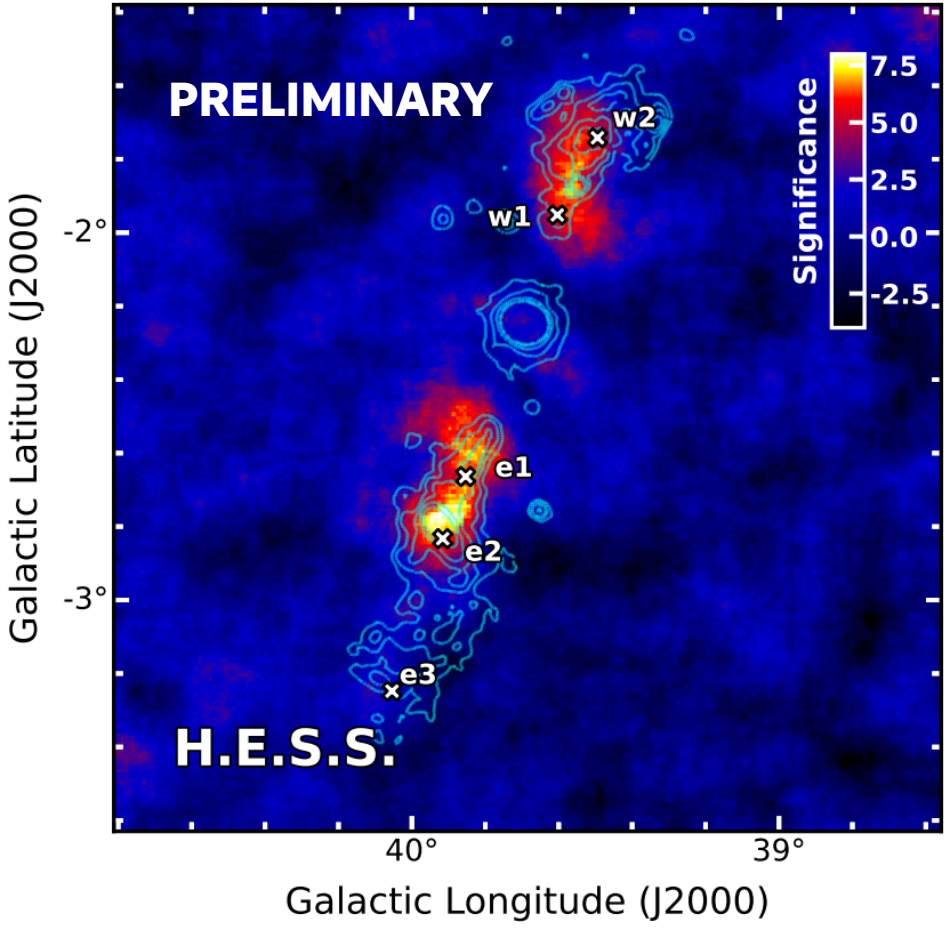
Full field of view

- Some contamination from HESS J1908+063 expected in western jet
- Model it using a combined Gaussian spatial + LogParabola spectral model



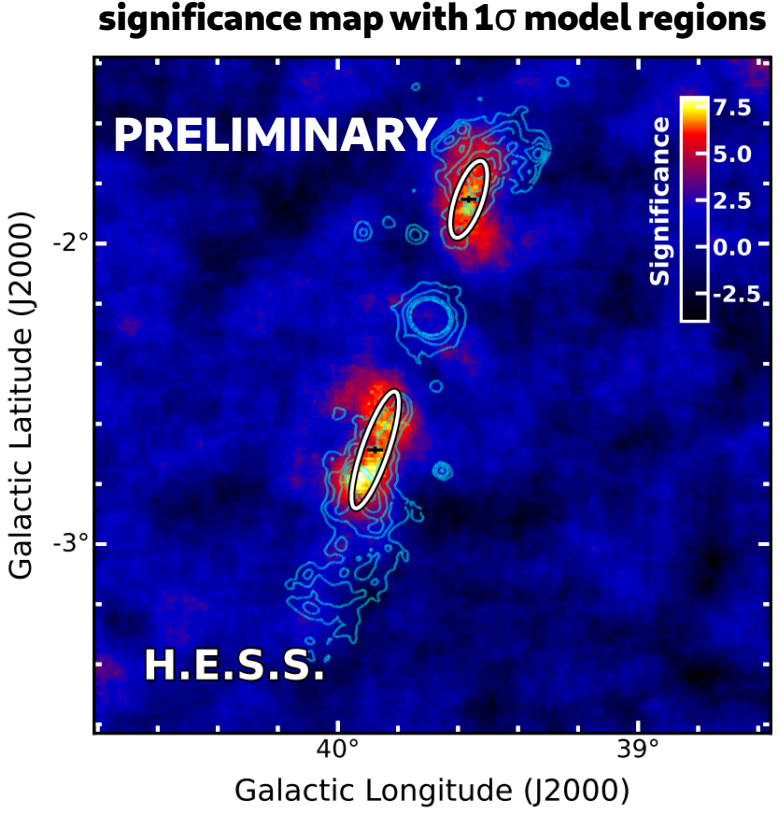
Zoom in to SS 433

- Two separate TeV excess consistent with each of the jets
- Western and eastern jet detected with 6.8σ and 7.8σ respectively
- No detectable emission from the central binary
- No detectable emission past the e2 region in eastern jet



Spatial model of the jets

- Emission from the jets best described by two elongated Gaussians
- Extended description preferred by $7.7\sigma_{east}$ and $4.7\sigma_{west}$
- Ellongated description preferred by 5.8σ and 3.5σ
- Angle consistent with that of the jets
- Eastern component:
  - major axis (1σ) → 0.21±0.04°
  - minor axis (1σ) → 0.04±0.02°
- Western component:
  - major axis (1σ) → 0.13±0.03°
  - minor axis (1σ) → 0.05±0.02°



Spectra of the jets

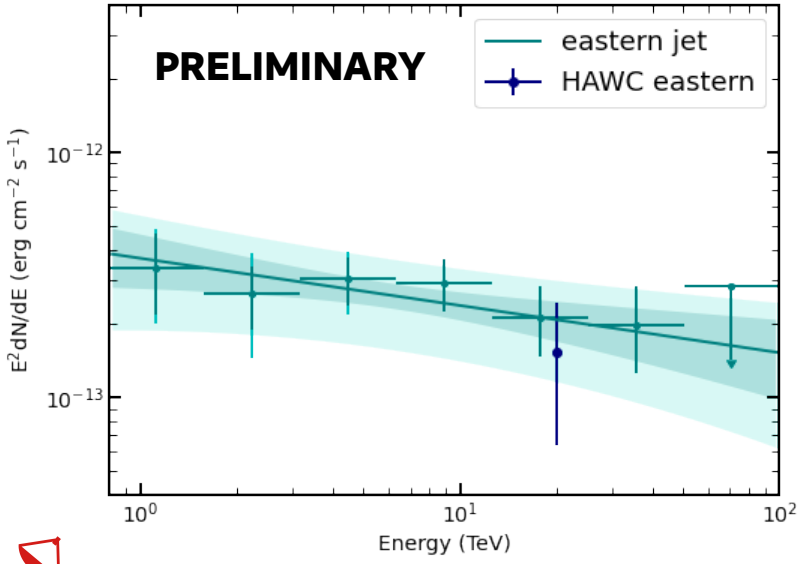
- Best described by simple power-law model
- Consistent with flux measured by HAWC in both cases
- Systematic errors included as light shaded band
- Eastern jet is slightly harder but both jets are mostly compatible

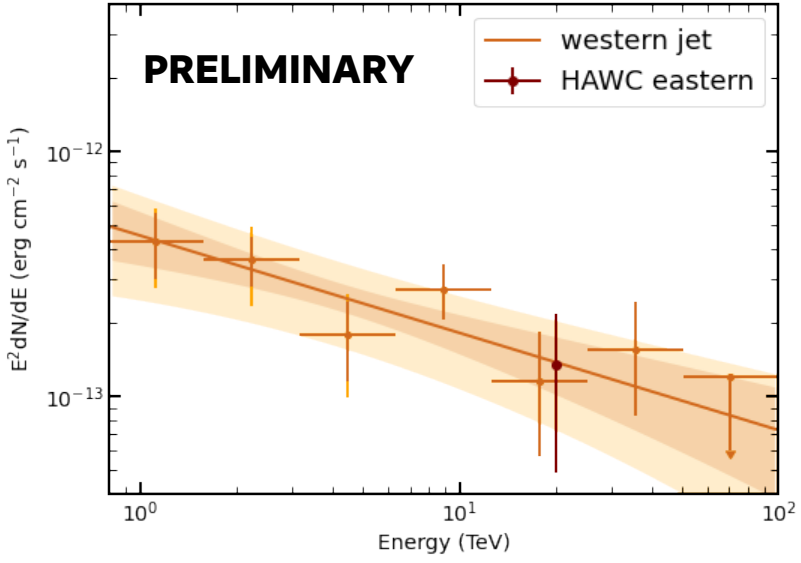
east (includes systematics)

name	value	unit	error
index	2.1928e+00		1.576e-01
amplitude	4.2955e-15	cm-2 s-1 TeV-1	1.728e-15
reference	6.1527e+00	TeV	0.000e+00

name	value	unit	error
index	2.3973e+00		1.774e-01
amplitude	9.1453e-15	cm-2 s-1 TeV-1	3.490e-15
reference	4.1868e+00	TeV	0.000e+00

west





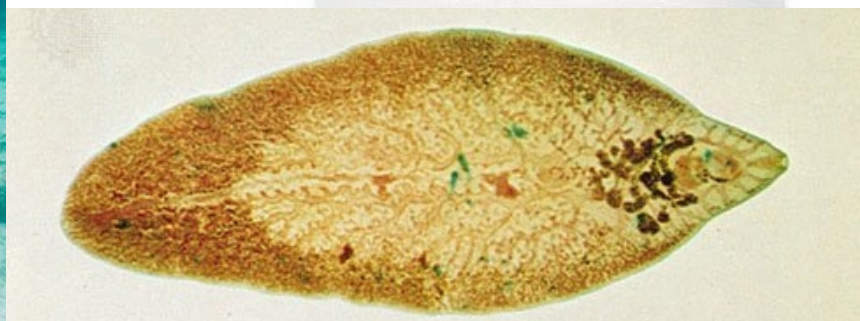
Outlook and conclusions

- Confirmation of TeV emission from the jets of SS 433 following HAWC discovery
- First detection by an IACT array
- Better energy and spatial resolution → more detailed characterization!
- Measured spectra between 0.8 TeV and 50 TeV, with upper limit in 50-100 TeV range
- TeV spectra from both jets remarkably consistent
- Spatial properties consistent with the extended x-ray jets

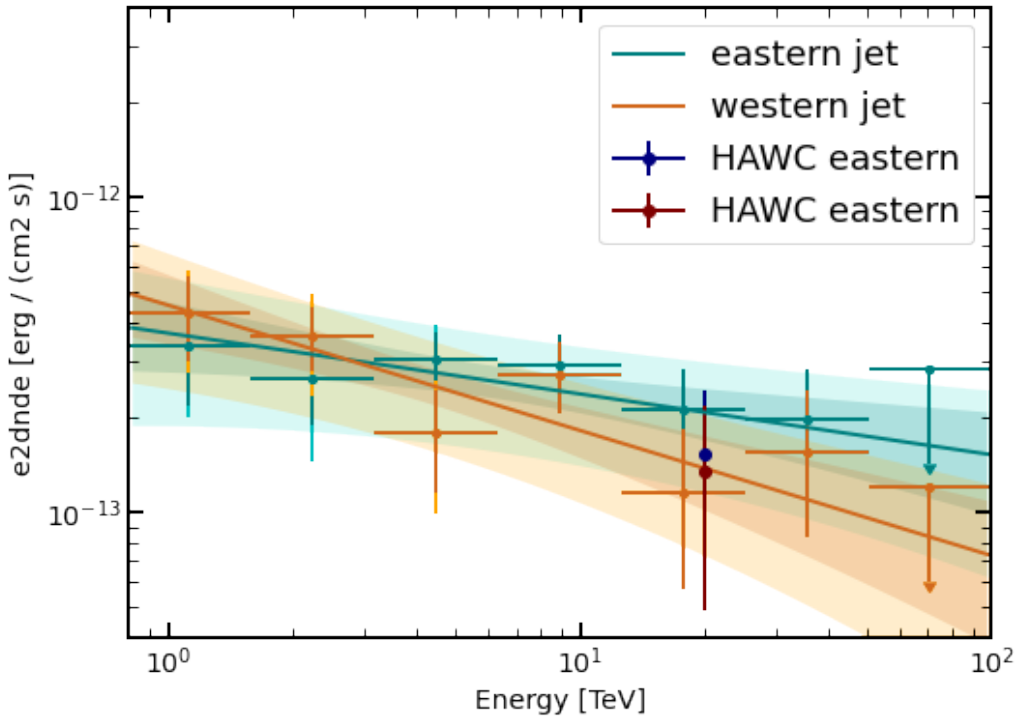
stay tuned for more ;-)

H.E.S.S.

Backup slides



Spectra of the jets in the same plot



The x-ray picture beyond ROSAT