Joint Analysis of Fermi-LAT and HAWC Observations of SS 433

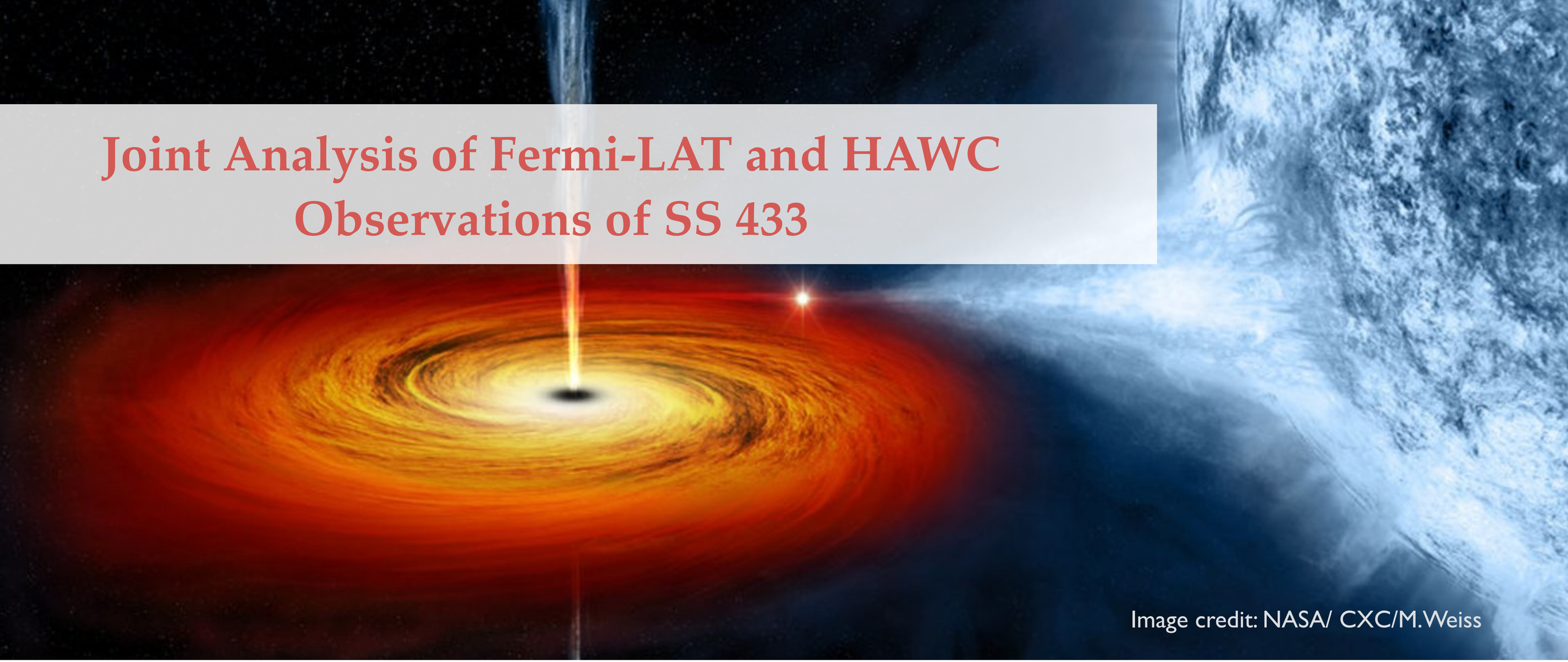

Image credit: NASA/ CXC/M.Weiss

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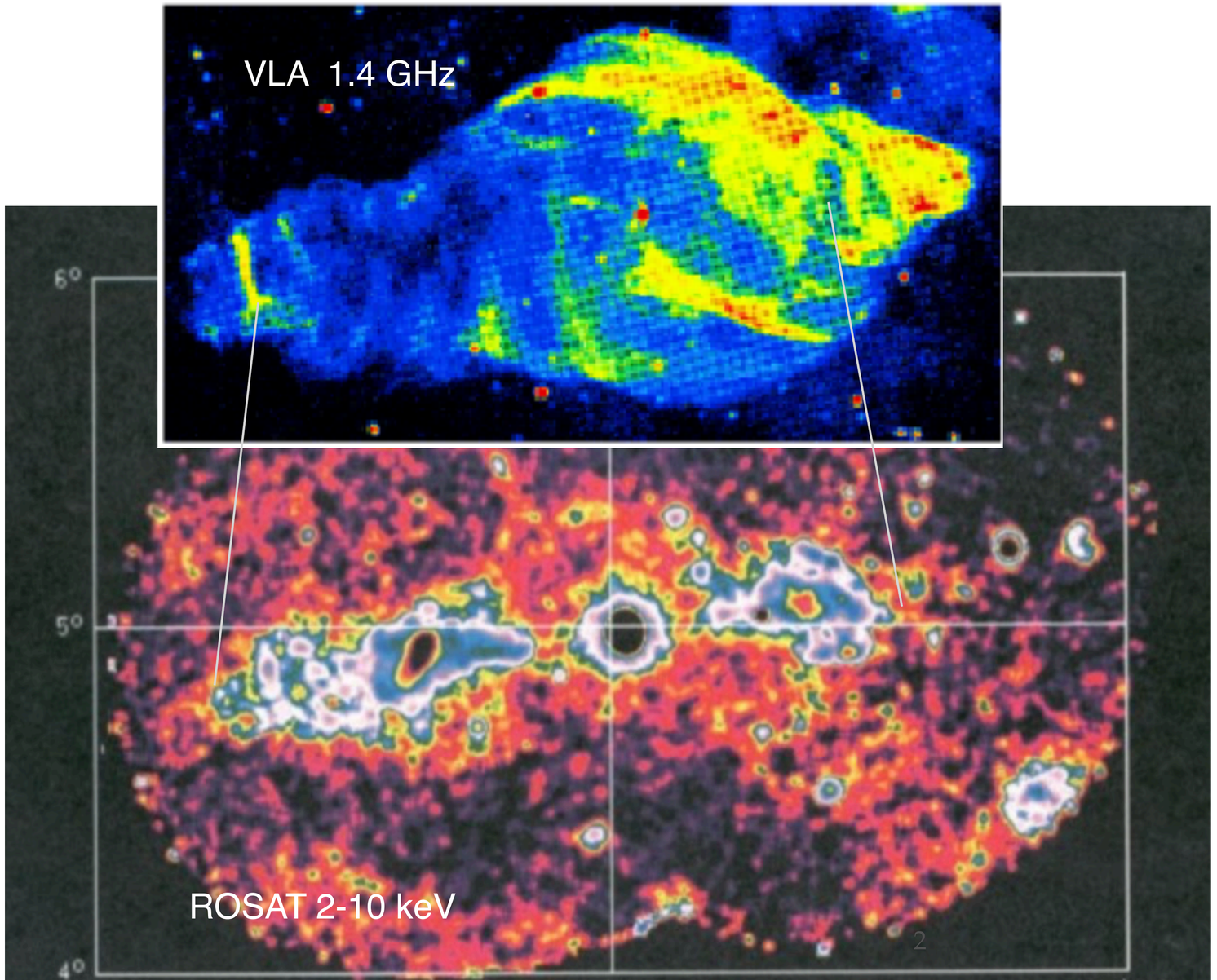
University of Wisconsin-Madison
ICRC 2021

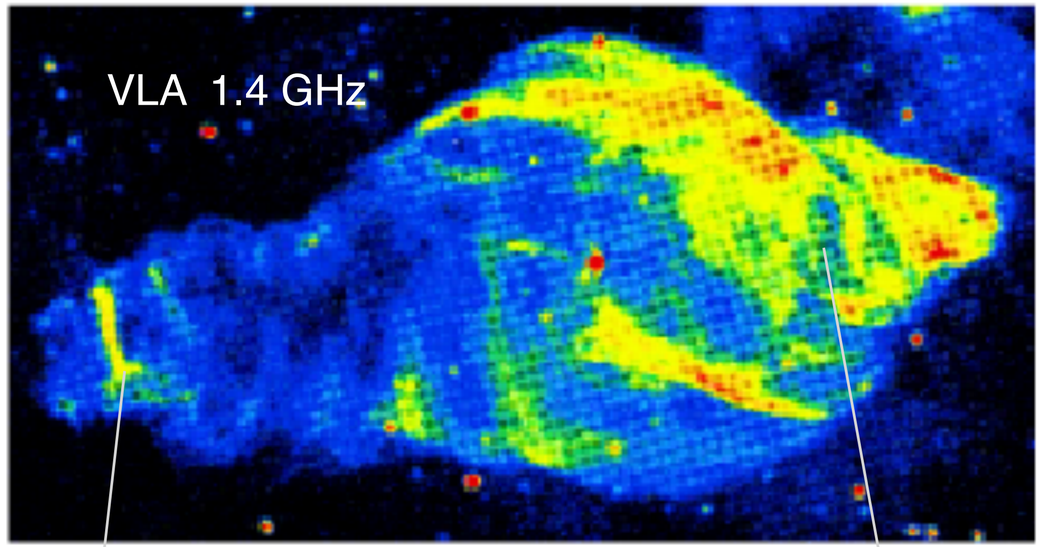
The SS 433 / W50 Complex

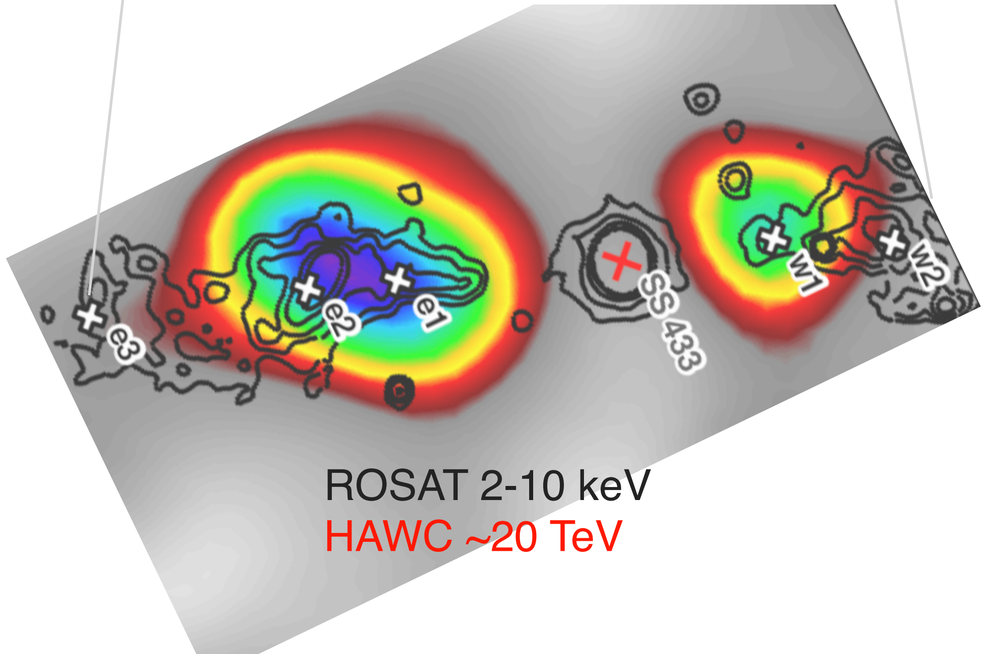


- **Microquasar inside a SNR**
  Jet speed 0.26 c
  Jet luminosity10^39 erg/s

- Up to 50 keV X-rays observed, suggesting existence of **multi-hundred TeV electrons**

The SS 433 / W50 Complex





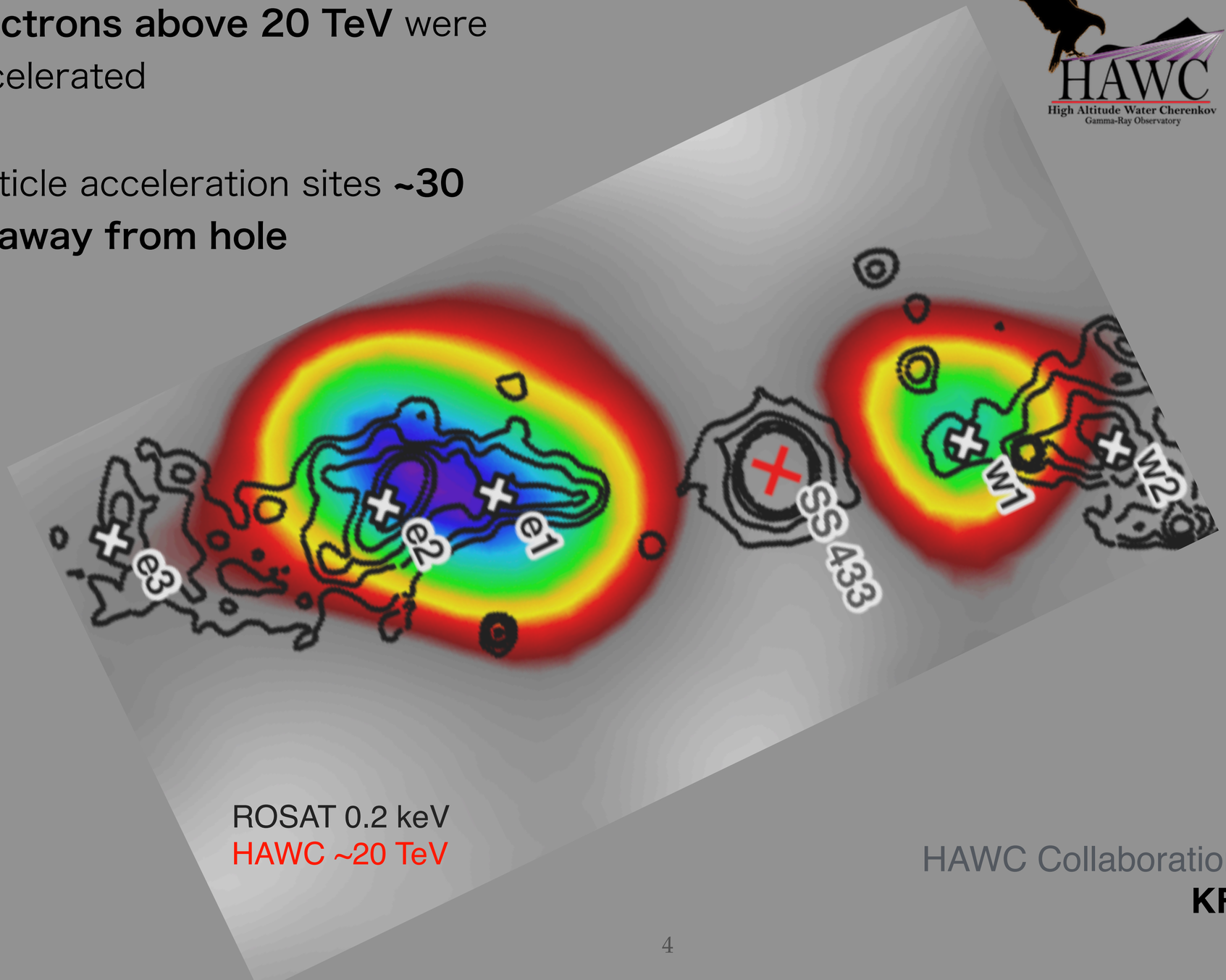
ROSAT 2-10 keV
HAWC ~20 TeV

- **Point-like TeV gamma-rays in both lobes** detected by HAWC

HAWC Collaboration, *Nature* (2018)
Main authors: BenZvi, Brenda, **KF**, Rho, Zhang, Zhou

- **Electrons above 20 TeV** were accelerated

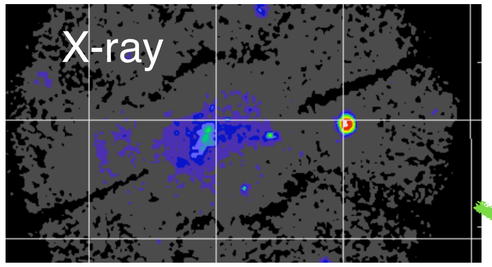
- Particle acceleration sites **~30 pc away from hole**

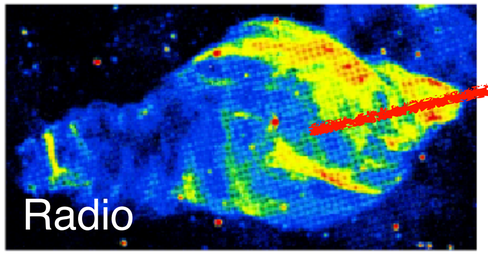


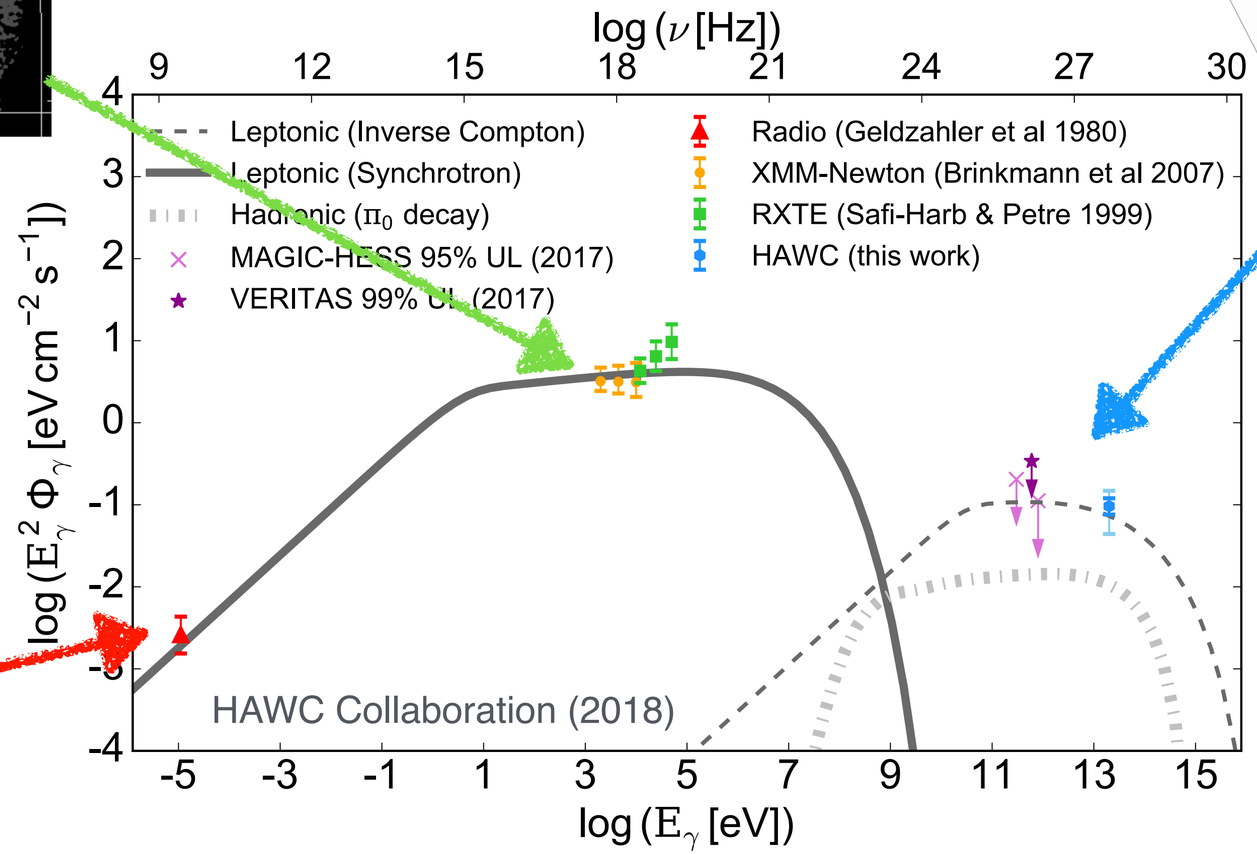
ROSAT 0.2 keV
HAWC ~20 TeV

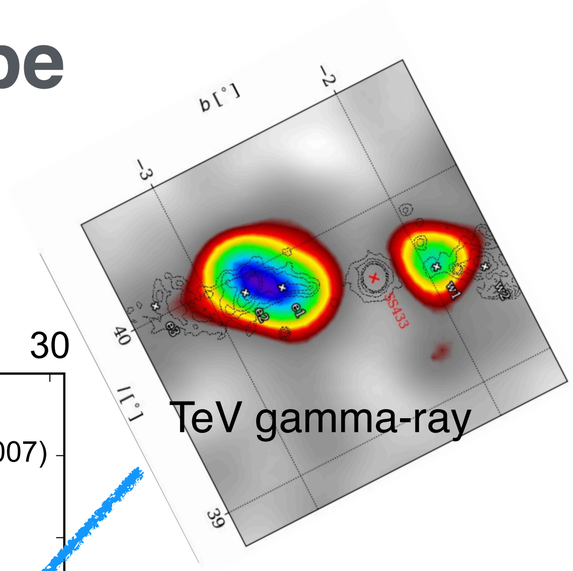
HAWC Collaboration, *Nature* (2018)
KF as main author

Broadband SED of the Eastern Lobe









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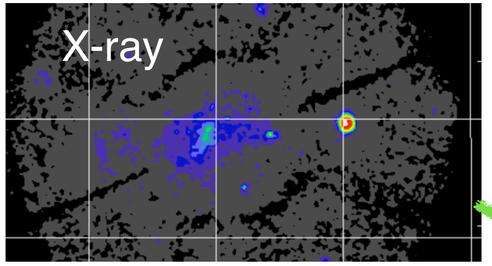
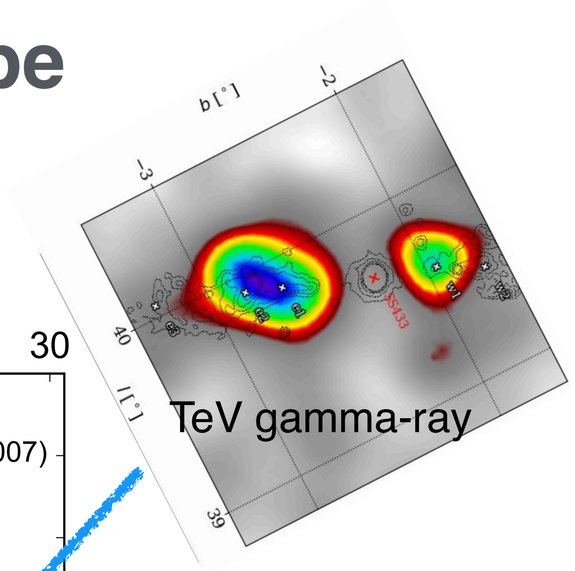
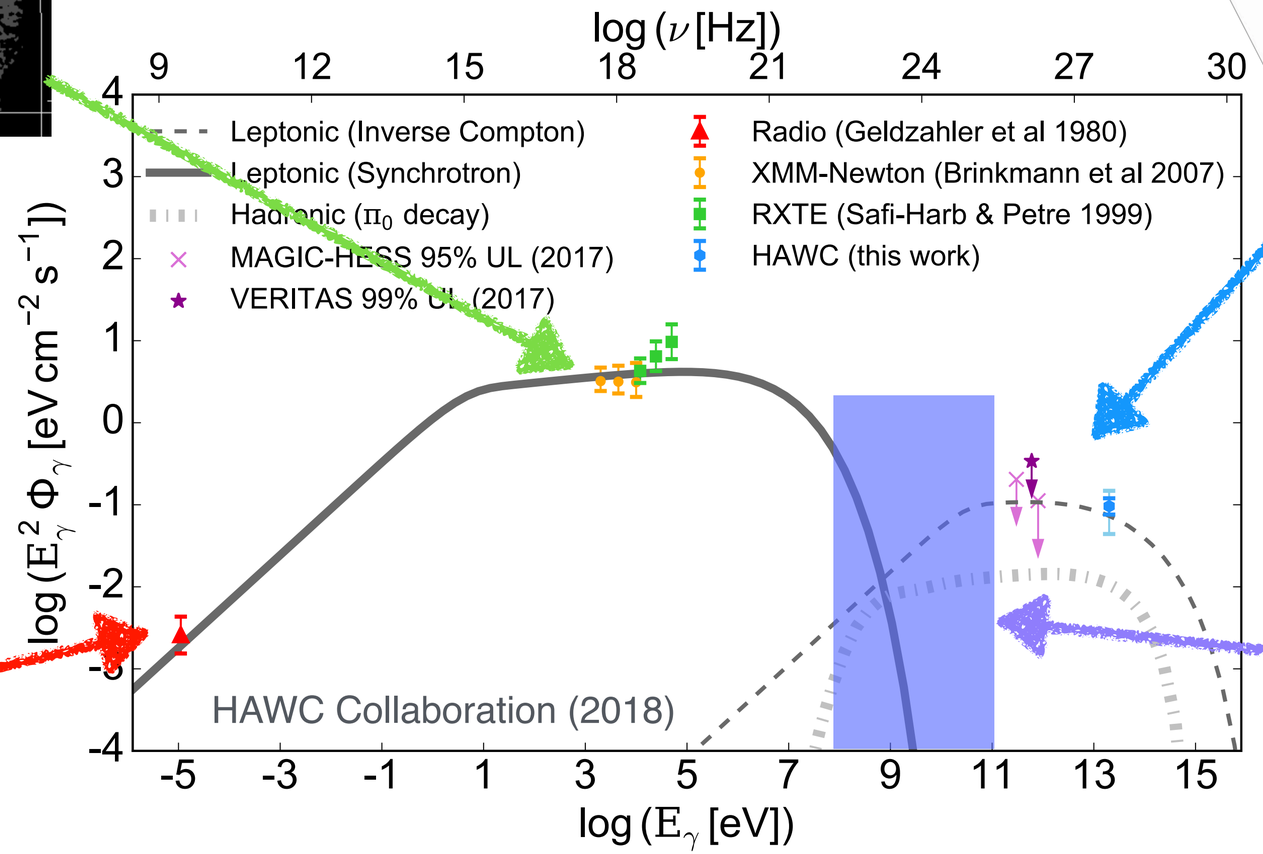
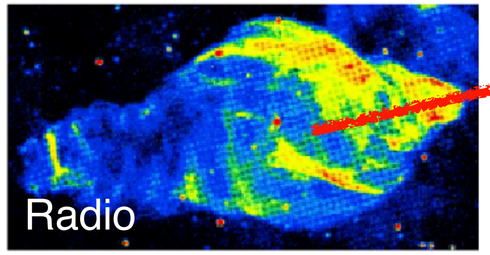
Broadband SED of the Eastern Lobe



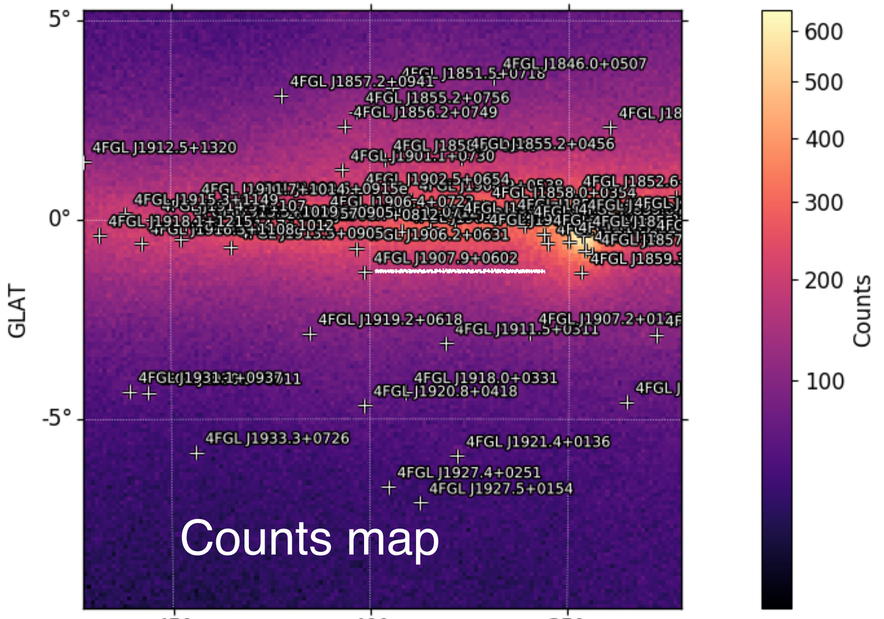


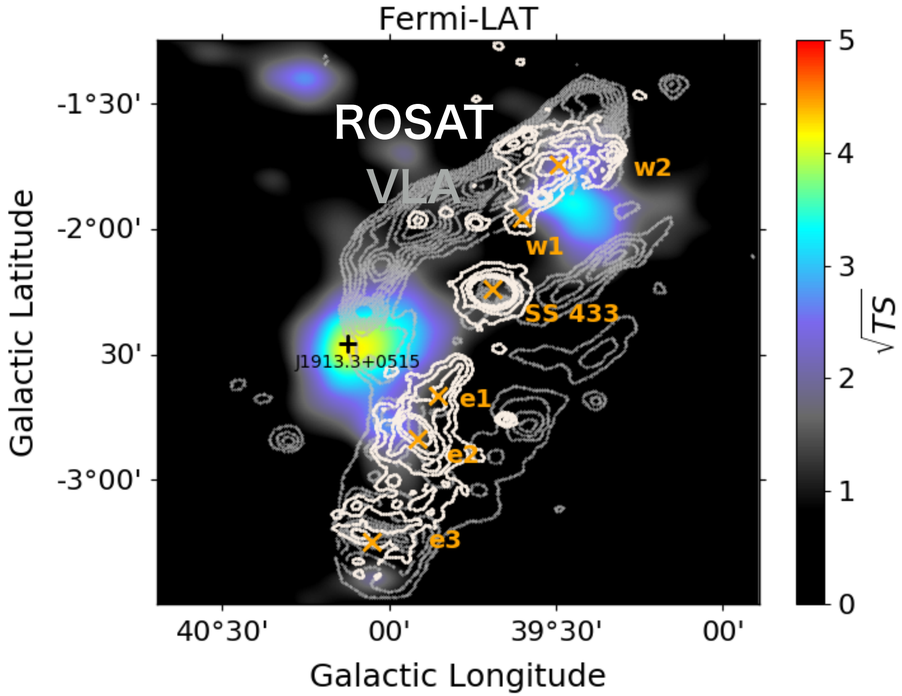




What do the lobes look like **between 100 MeV and 100 GeV?**

Fermi-only Analysis - Baseline ROI





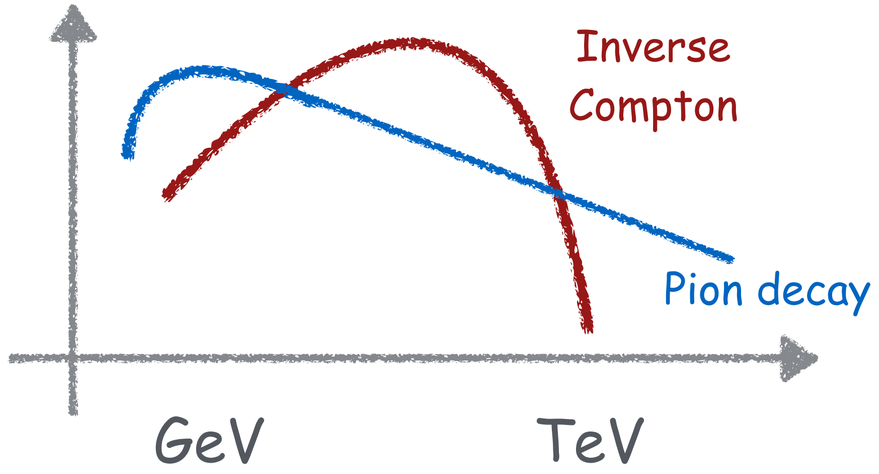
10.5-year Fermi data; 4FGL source catalog + corresponding Galactic diffuse model and isotropic diffuse model + **PSR J1907.9+0602 gated off.**

FL8Y J1913.3+0515 marginally significant; **hint of emission in the eastern lobe**

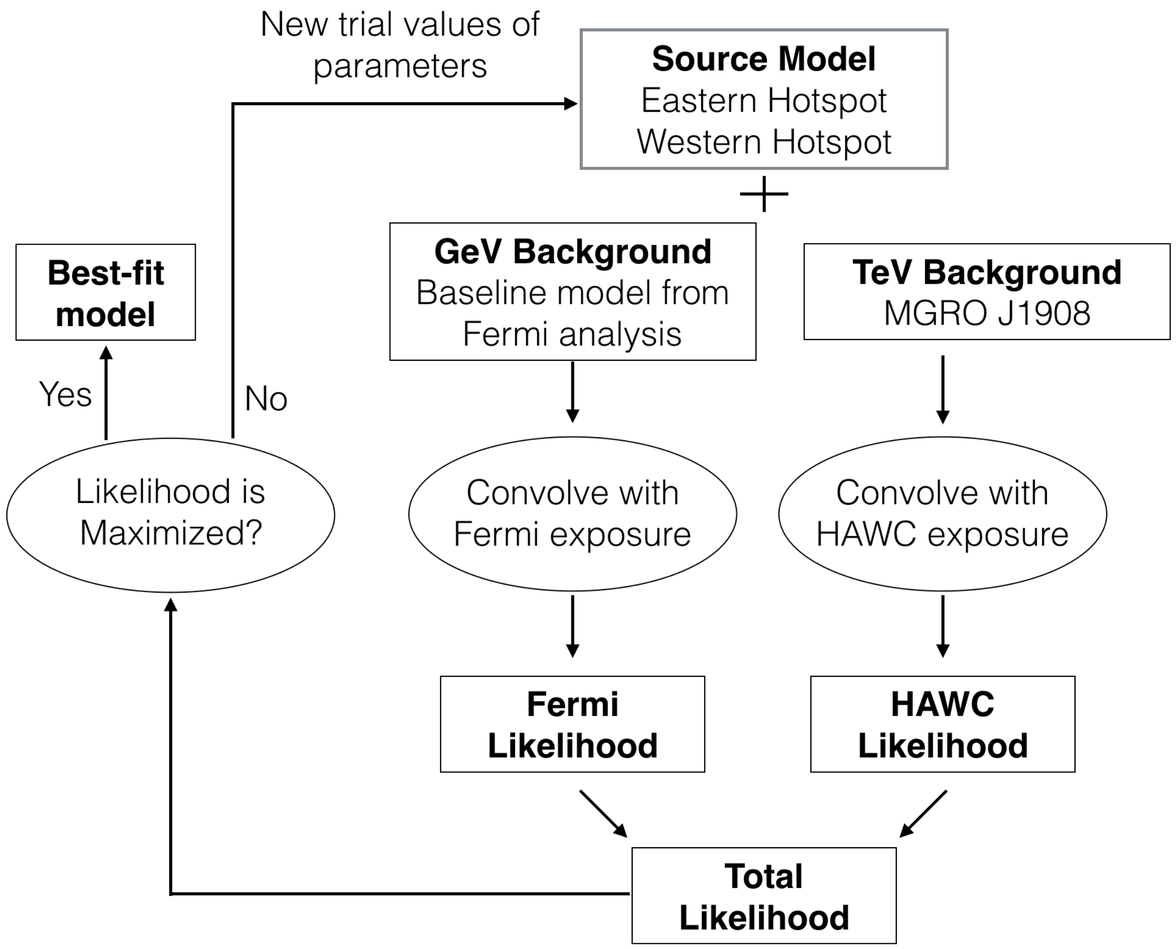
A Joint Analysis of Fermi-LAT and HAWC Data

- **Experimental perspective:** The source is not significant in GeV (TS ~ 10) and marginally significant in TeV (5 sigma).

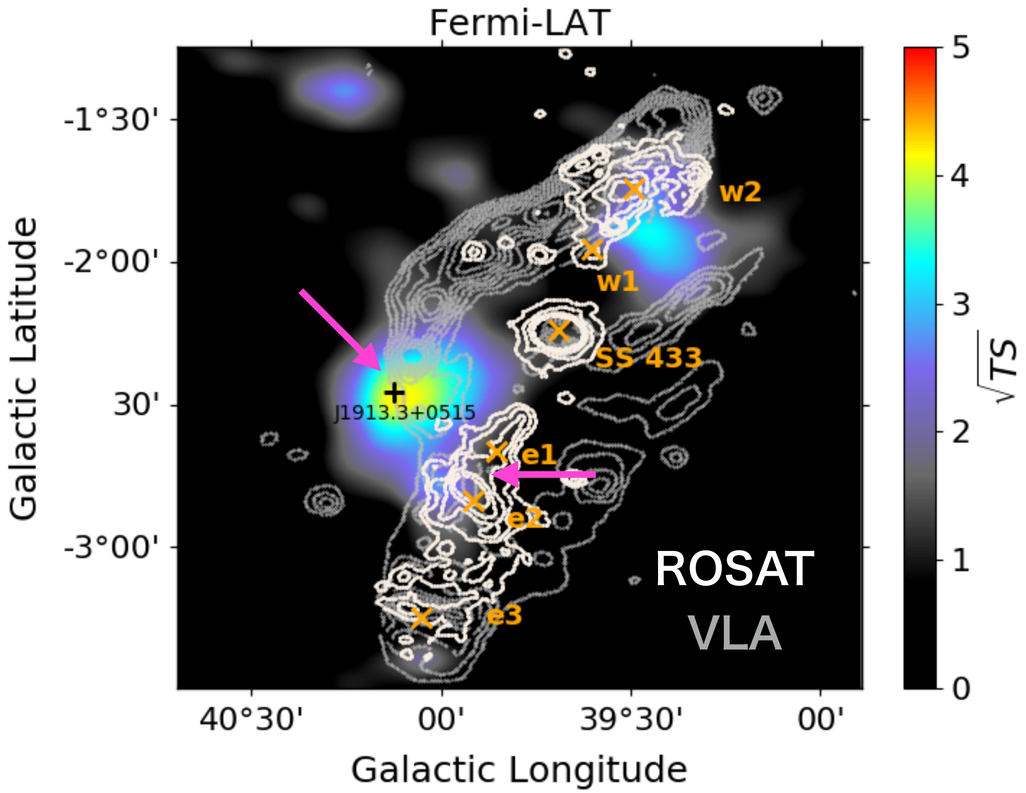
- **Theoretical perspective:** A GeV to TeV spectrum helps to reveal the origin of high-energy photons



Joint Analysis - Framework setup



FL8Y J1913.3+0515 and TeV excess

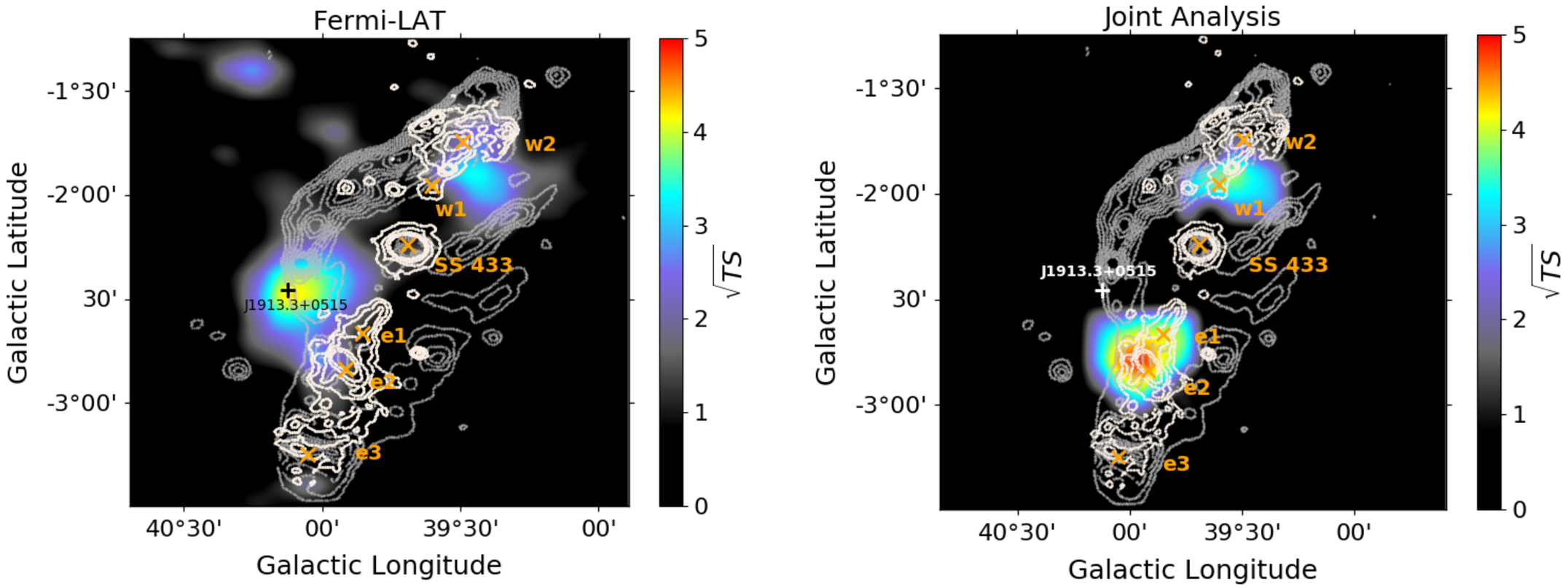


TS = 32 for one common source at middle point (5 sigma)

TS = 54 for two separate sources at their best-fit locations (6.4 sigma)

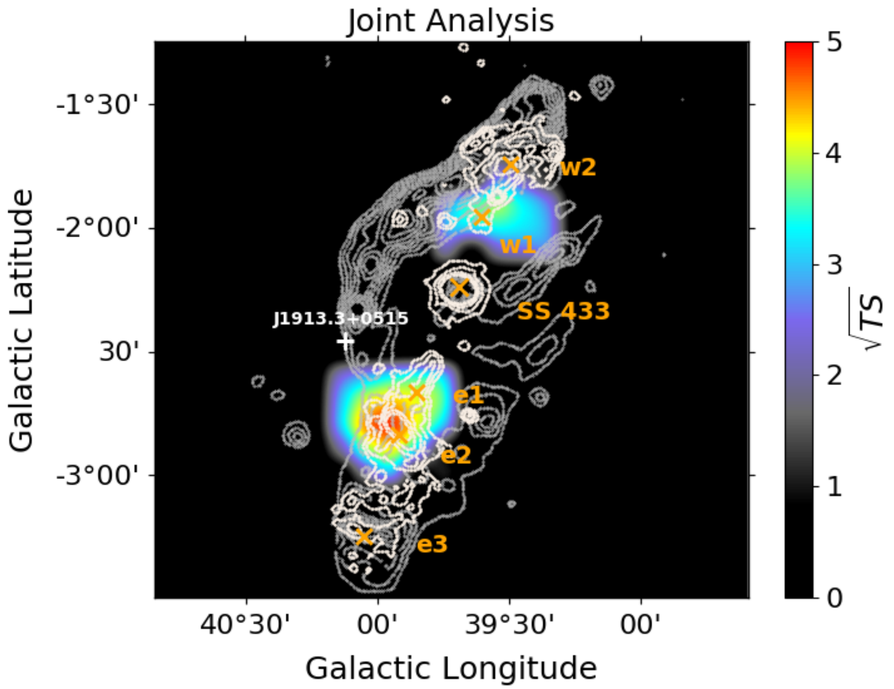
ROI w. two sources is much more significant (d TS ~ 22), suggesting that the two don't share the same origin

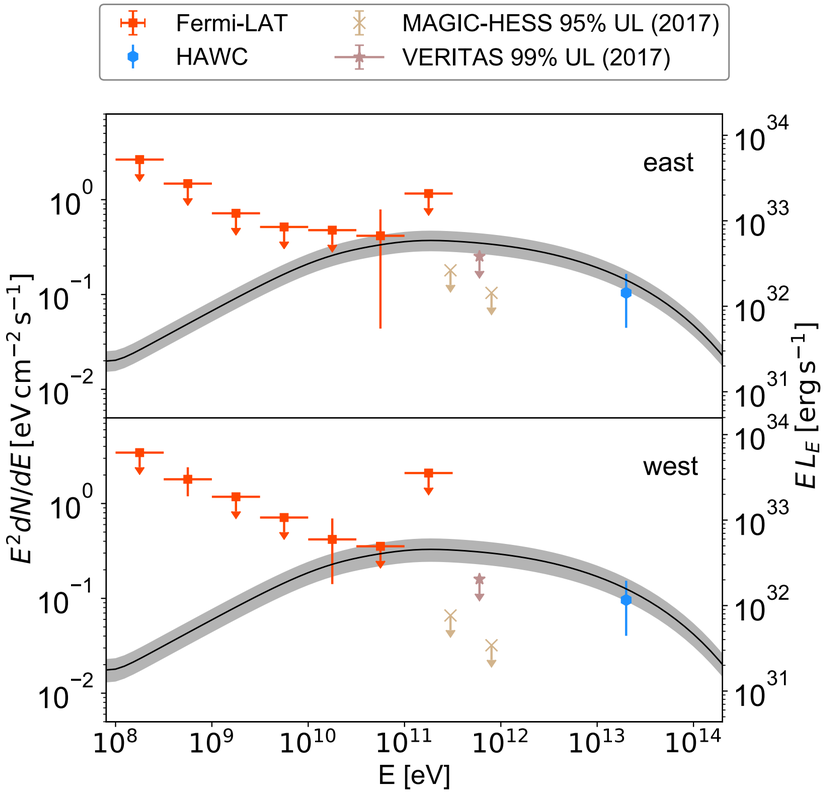
Joint Analysis - TS Map



When modeling J1913.3+0515 as a separate source, we obtain **a best-fit location inside the eastern lobe**.

Joint Analysis - Spectral Energy Distribution





SED consistent with inverse Compton emission by a population of hundreds TeV electrons that cool efficiently.

Conclusions

- **Common emission sites of GeV to TeV** gamma-rays inside the SS 433 lobes are identified. The emission is consistent with inverse Compton emission of cooled **electrons**

- This is the first joint ROI analysis across gamma-ray facilities. **The approach can be applied to other regions** measured by Fermi-LAT and HAWC.

- Implications for bigger brothers - **Jets provide plausible sites for acceleration of PeV and higher-energy particles**