H.E.S.S. searches for TeV gamma-rays associated to high-energy neutrinos

the case of IceCube-170922A / TXS 0506+056

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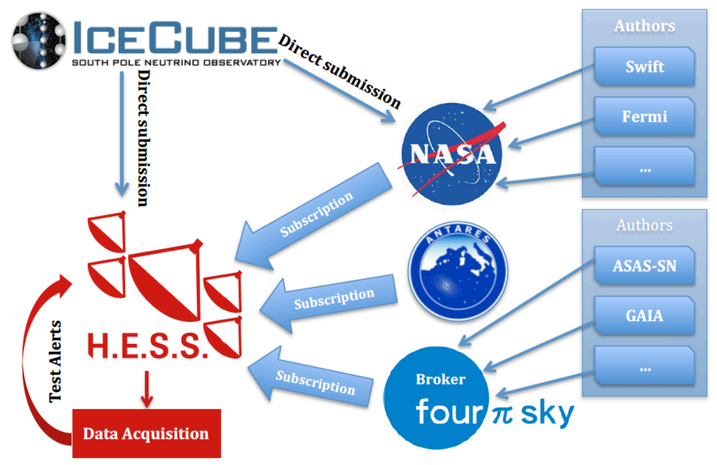
The H.E.S.S. multi-messenger program

The H.E.S.S. multi-messenger program exploits potential spatial and temporal correlations between multiple messengers from the high-energy universe. Thanks to the biggest and fastest Imaging Cherenkov telescope, HESS-II 28m opened a new window to the high-energy universe: **real-time multi-messenger astronomy at TeV energies**. Extending the various H.E.S.S. programs involving the full range of electromagnetic radiation (e.g. Fast Radio Bursts [1], Gamma Ray Bursts [2], AGNs [3], etc.) we are here searching for coincident emission of high-energy gamma rays with high-energy neutrinos and gravitational waves.



Gamma-ray emission associated to high-energy neutrinos

Correlations between high-energy neutrinos and gamma-rays indicate sites of hadronic interaction and are thus tracers of cosmic ray accelerators. These searches build the core of the H.E.S.S. multi-messenger program. Follow-up observations of alerts from high-energy neutrino telescopes have allowed over the last years to successfully extend the program towards time-dependent searches for transient emission.

Steady sources

Over the last years four H.E.S.S. observation campaigns searched for continuous emission of high-energy gamma rays from regions around neutrino events detected by IceCube, fulfilling the "High-energy Starting Event" (HESE). See black circles in Fig. 1. None of the observed regions showed significant high-energy gamma-ray emission [4].

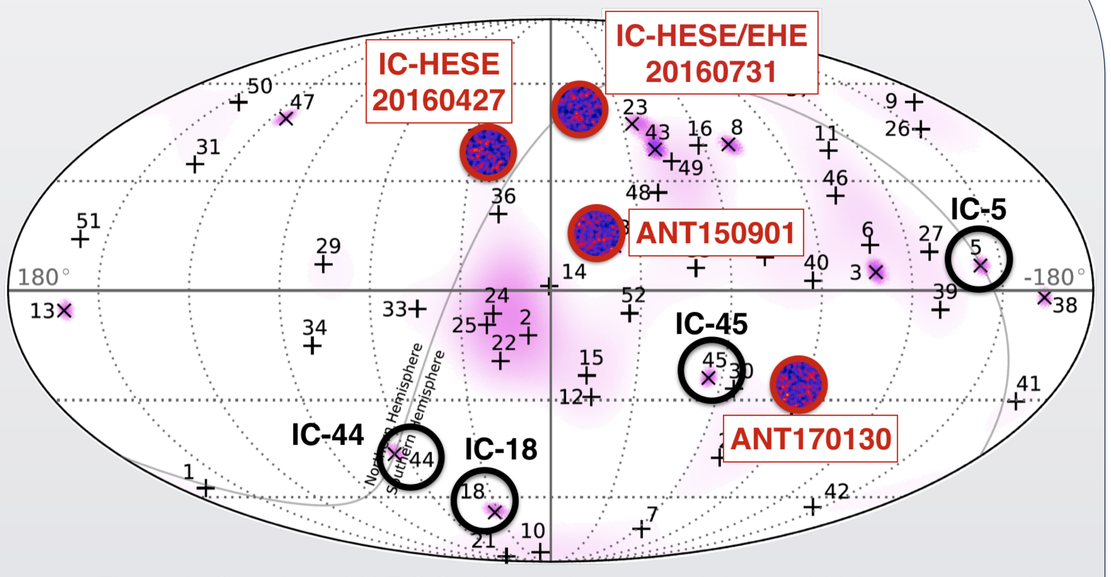


Figure 1: Overview of H.E.S.S. observations around detected high-energy neutrinos until summer 2017. Black circles denote archival observations searching for steady sources, red circles denote searches for transient sources. From [4]

Transient sources

Both spatial and temporal coincidences are necessary to derive significant correlations between neutrino and gamma-ray signals. Searches for coincident gamma-ray emission with high-energy neutrinos detected by the IceCube and ANTARES neutrino telescopes cover different timescales ranging from days (IC-HESE-160427), down to hours (IceCube-170922) and tens of seconds (ANT170130). See [4] for details on the individual observations.

Alert	Delay	Duration
IceCube-160427A	2d15h	2h
IceCube-160731A	16h	2h
IceCube-161103A	12h	2h

IceCube-170922 / TXS 0506+056

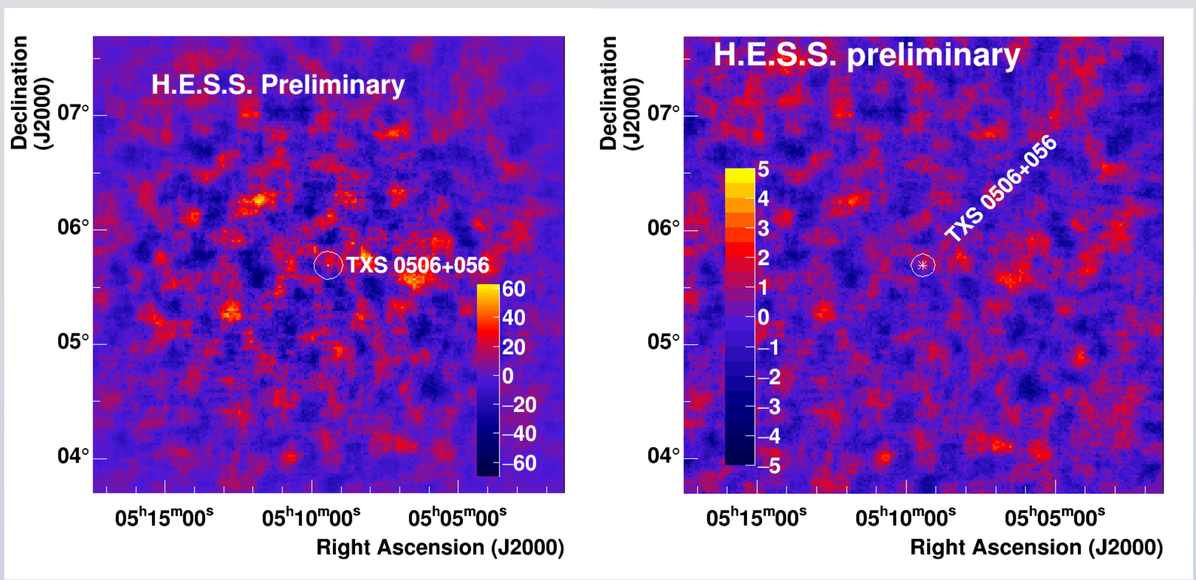


Figure 2: H.E.S.S. observations of the IceCube alert IC-EHE-170922 starting about 4h of the alert and continuing over a period of several weeks. Here a monoscopic analysis of data taken with the 28m H.E.S.S.-II telescope is presented. Left: Map of gamma-ray excess counts. Right: Map of Li&Ma significances.

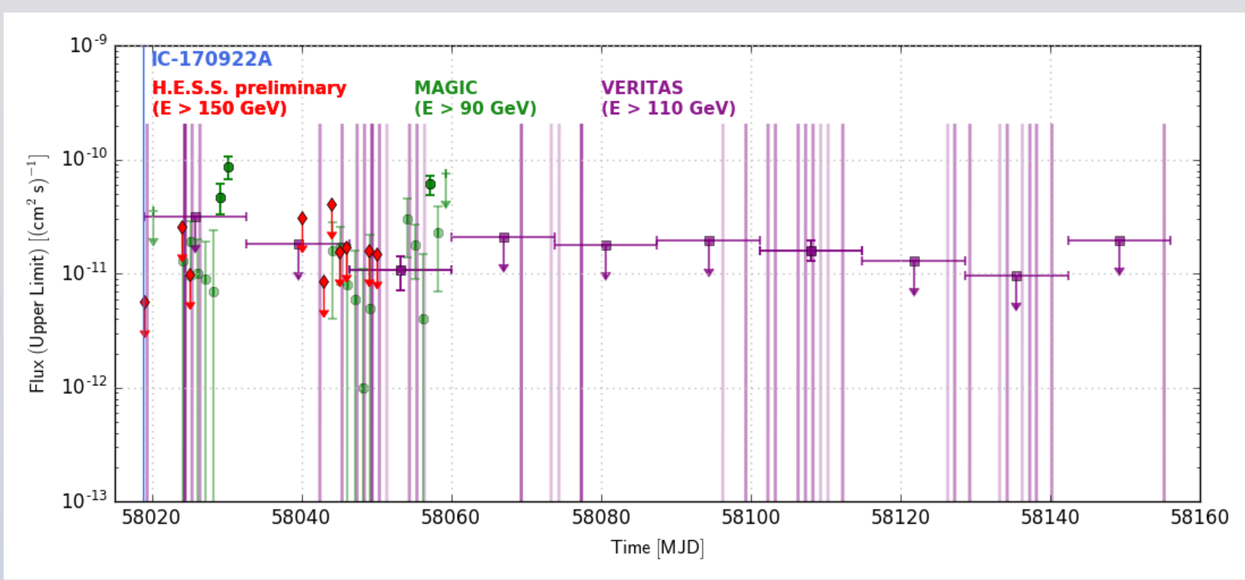


Figure 3: High-energy gamma-ray lightcurve obtained during IACT follow-up observations of the IceCube alert IC-EHE-170922. All data points show integral upper limits (or detected fluxes). H.E.S.S. data points have the been derived assuming a $E^{-3.9}$ energy spectrum (as indicated by the MAGIC collaboration, green markers [5]) and are given above an energy threshold of E_{thr}=150 GeV. The extensive VERITAS observations [6] are given in purple.

We here focus on the H.E.S.S. follow-up observations of IceCube-170922. Observations of the region comprising the flaring blazar TXS 0506+056 started about 4h after the IceCube alert and continued over several weeks. The total dataset presented here comprises 13h of data taken with the 28m H.E.S.S.-II telescope. In a monoscopic analysis no gamma-ray emission has been observed above E_{thr}=150GeV.
As illustrated in Fig. 3 our observation windows don't overlap with the detection times reported by MAGIC [5] and VERITAS [6] and provide thus further evidence for the rapid variability of TXS 0506+056.

Outlook: The observations presented here are part of a world-wide, multi-messenger effort searching for gamma-ray counterparts to high-energy neutrinos combining data from all current IACTs (FACT, H.E.S.S., MAGIC and VERITAS). An overview is available at [7].

These searches are also part of the Transient Key Science Project of the next generation observatory, the Cherenkov Telescope Array [8].

Acknowledgements

[1] F. Schüssler et al. (H.E.S.S.) Gamma 2016 + A&A 597 (2017) A115
[2] C. Hoischen et al. (H.E.S.S.), 35th ICRC, 2017
[3] M. Seglar-Arroyo, F. Schüssler et al. (H.E.S.S.), 35th ICRC, 2017
[4] F. Schüssler et al. (H.E.S.S.), 35th ICRC, 2017
[5] S. Ansoldi et al. (MAGIC), ApJL 863 (2018) 1
[6] A.U. Abeysekara et al. (VERITAS), ApJL 861 (2018) 2
[7] M. Santander et al. (FACT, H.E.S.S., MAGIC, VERITAS, IceCube), 35th ICRC, 2017
[8] F. Schüssler et al. (CTA consortium), TeVPA 2018