A search for spectral hardening in HAWC sources above 56 TeV

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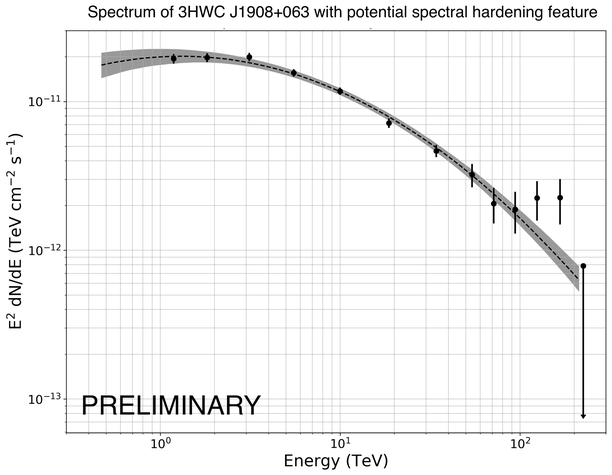
Abstract

The ultra-high-energy gamma-ray source 3HWC J1908+063 may exhibit a hardening of the spectral index at the highest energies. A second population of particles is needed to satisfactorily explain the highest energy (above 50 TeV) emission. This component could be hadronic in origin, which would imply acceleration of particles up to the cosmic-ray knee. In this poster, we search through the 3HWC catalog to see if any other particles exhibit this spectral hardening feature. If this feature is widespread among gamma-ray sources, they could be the source of Galactic PeVatrons.

Motivation



The spectrum of 3HWC J1908+063, one of the brightest and highest-energy HAWC sources, appears to show hints of spectral hardening above ~75 TeV [1] – the flux points appear flat in E^2dN/dE space, deviating from the best-fit spectrum (a log-parabola). This is roughly a two sigma effect.

This is interesting if it is widespread among other sources, as it indicates that there may be multiple populations of particles contributing to the TeV gamma-ray emission. This shape is difficult to fit with single-population hypotheses for the emission origins.

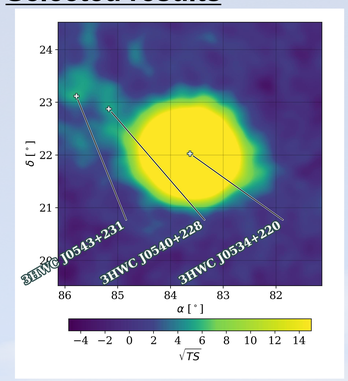
Method

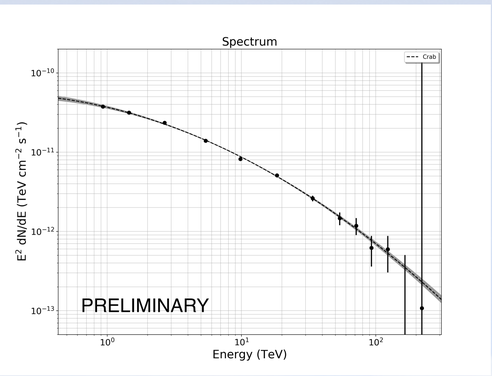
We search through sources in the 3HWC catalog [2] to look for this feature. Sources must have high enough significance that spectral points can be obtained (TS > 50) and they should have an energy range that extends past 56 TeV. There are 19 sources fitting these criteria.

The sources are then fit using a likelihood method [3]. 3HWC sources within 2.5 degrees of the source of interest are included in the model to reduce contamination from nearby sources. Several different spectral shapes are considered for each source, and the best one is determined. The highest-energy bins are half the width of a normal HAWC energy bin (see proceeding for details). The allows for better characterization of the high-energy tail.

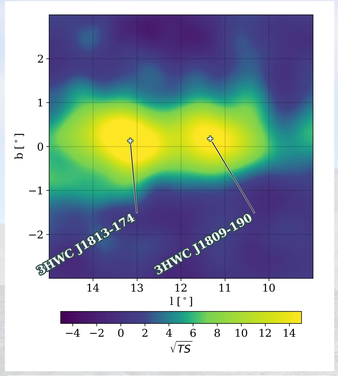
Selected results are shown in the right-hand panel.

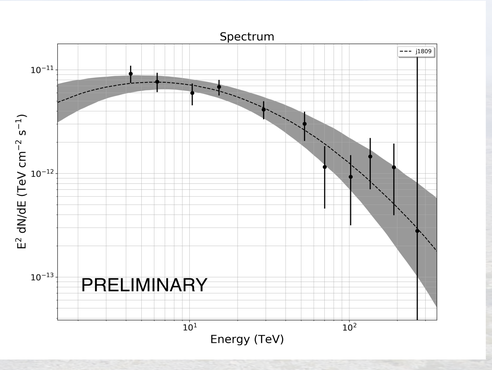
Selected results



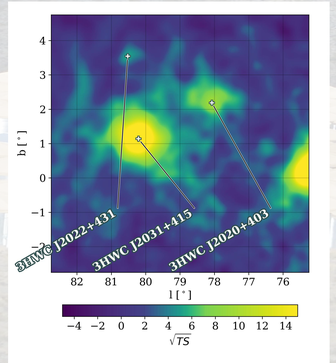


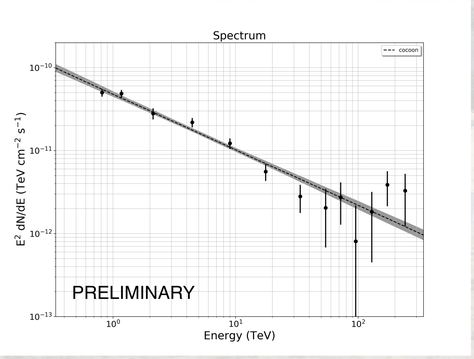
We first study the Crab Nebula. This source is a standard candle and its spectrum is very well-known over several decades in energy. No spectral hardening is observed, which shows that the feature observed in 3HWC J1908+063 is not an instrumental effect related to mis-modeling of the HAWC detector at the highest energies.





The middle figure is the 3HWC J1809-190 spectrum. The last two high significance (TS > 4.0) points are both ~1 sigma deviations from the best-fit line, although the uncertainties are large.





The bottom figure is the spectrum of the Cygnus Cocoon, a large superbubble surrounding a region of massive star formation. There is one point that is 1.4 sigma away from the best-fit line.

As these two sources are much weaker than 3HWC J1908+063, this highlights the need for more sensitivity at the highest energies. HAWC is currently analyzing a new pass through our data, which should provide this sensitivity.

References

[1] See https://indico.desy.de/event/27991/contributions/101982/, this conference

[2] A. Albert et al 2020, ApJ 905 76

[3] See https://indico.desy.de/event/27991/contributions/102018/, this conference