Active galactic nuclei detected at TeV energies with the HAWC Gamma-Ray Observatory

Sara Coutiño de León (presenter, scoutino@icecube.wis.edu), Alberto Carramiñana, Daniel Rosa-González, Anna Lia Longinotti, Fernando Ureña-Mena

Introduction

Active galactic nuclei (AGN) are the most common type of γ-ray emission source. Very high-energy (VHE) observations are important to characterize the energetics of AGN. While the VHE sky has been well surveyed by Fermi-LAT in the 0.1-100 GeV energy range, at TeV energies most of our knowledge comes from pointed observations with Imaging Atmospheric Cherenkov Telescopes. In this work we present the results of an AGN survey in the TeV energy range with HAWC and the VHE spectra of detected AGNs.

AGN sample

In Albert et al. (2021) 138 objects from the 3FHL catalog were selected to be analyzed in a HAWC 1523-day data set, following these criteria:

- AGN identification or association,
- Redshift $z \leq 0.3$
- Declination $-21^{\circ} < \delta < +59^{\circ}$

Source Class	Number of Sources		
	Identified	Associated	Total
BL Lac objects (BLL + bll)	6	111	117
Blazars candidates of uncertain type (bcu)	⋯	8	8
Radio galaxies (RDG + rdg)	2	4	6
Flat-spectrum radio quasars (FSRQ + fsrq)	1	5	6
Starburst galaxies (SBG + sbg)	0	1	1
Total number of sources in sample	9	129	138

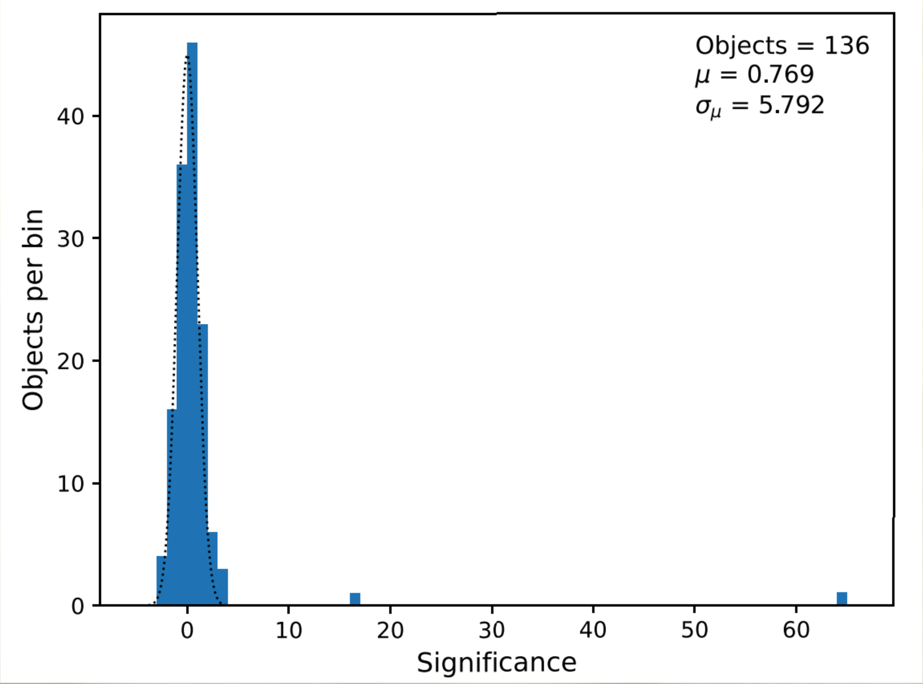
HAWC follow-up of 3FHL sample

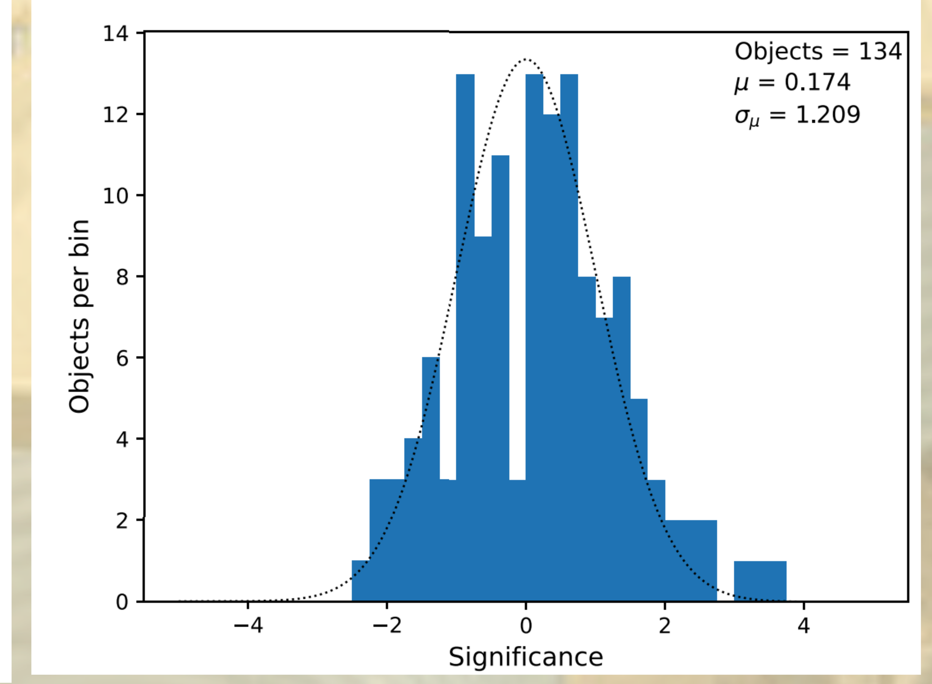
We performed a maximum likelihood test assuming a point-like source model for each source from the 3FHL sample with an intrinsic power-law differential flux spectra with index α=-2.5 attenuated by the EBL.

HAWC data analysis is based on computing the likelihood ratio of a source +background (S+B) to a background-only (B) model, given by the test statistic,

$$TS = 2\ln\left(\frac{\mathscr{L}(S+B)}{\mathscr{L}(B)}\right).$$

Given a TS value, its statistical significance can be approximated by $\sigma = \sqrt{TS}$.





Detected AGNs

Markarian 421 —> $\sqrt{TS} = 64.5$

Markarian 501 —> $\sqrt{TS} = 16.6$

Marginal detections

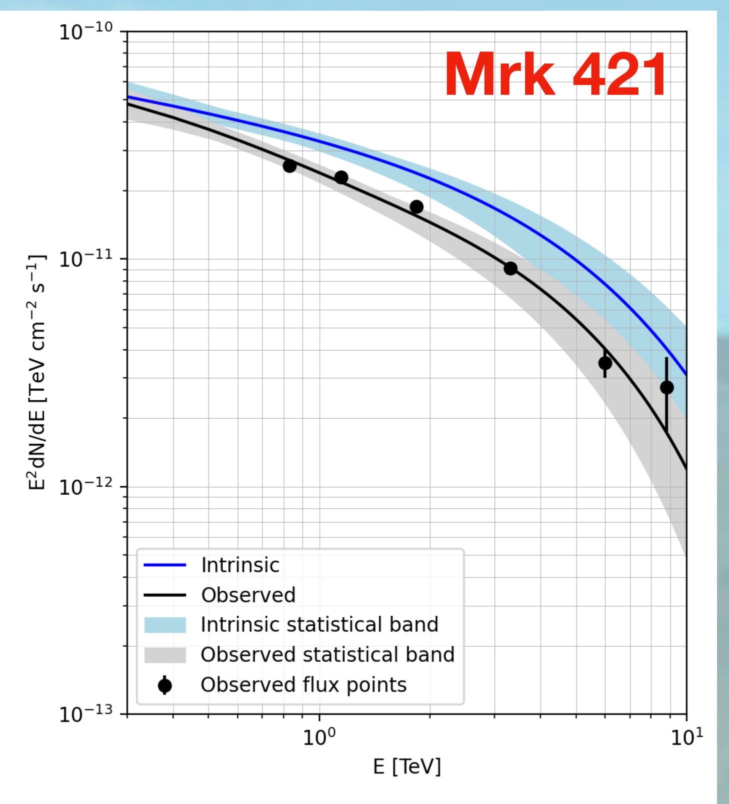
M87 —> $\sqrt{TS} = 3.6$

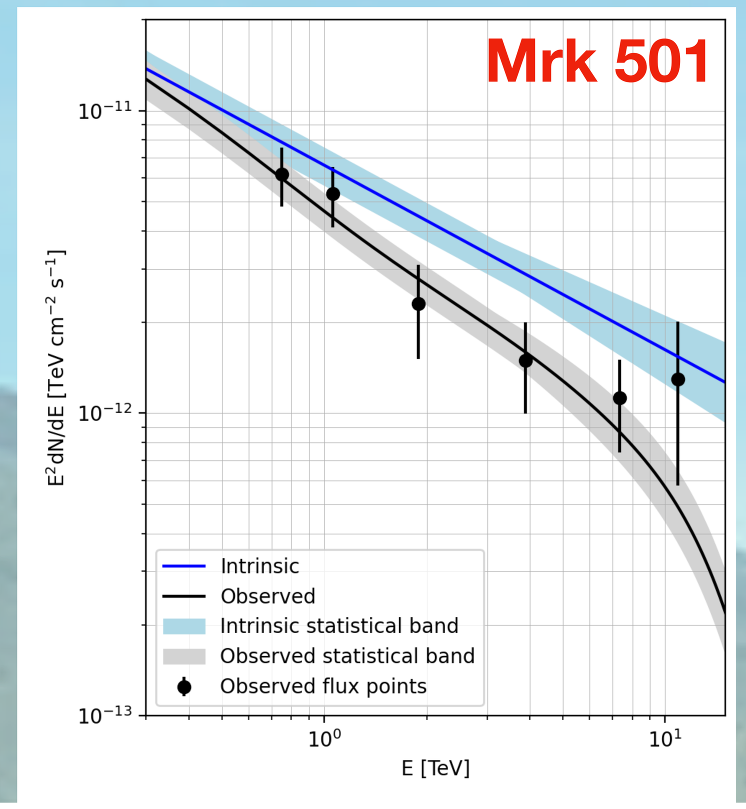
VER J0521+211 —> $\sqrt{TS} = 3$

1ES 1215+303 —> $\sqrt{TS} = 3.4$

Mrk 421 & Mrk 501

Albert et al. (2022)—> 1038 day of live data

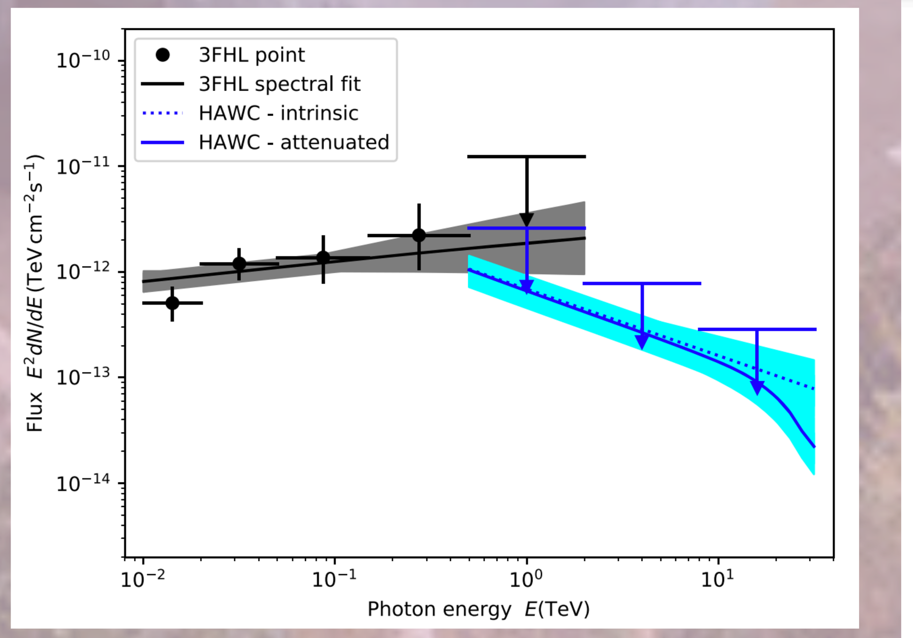


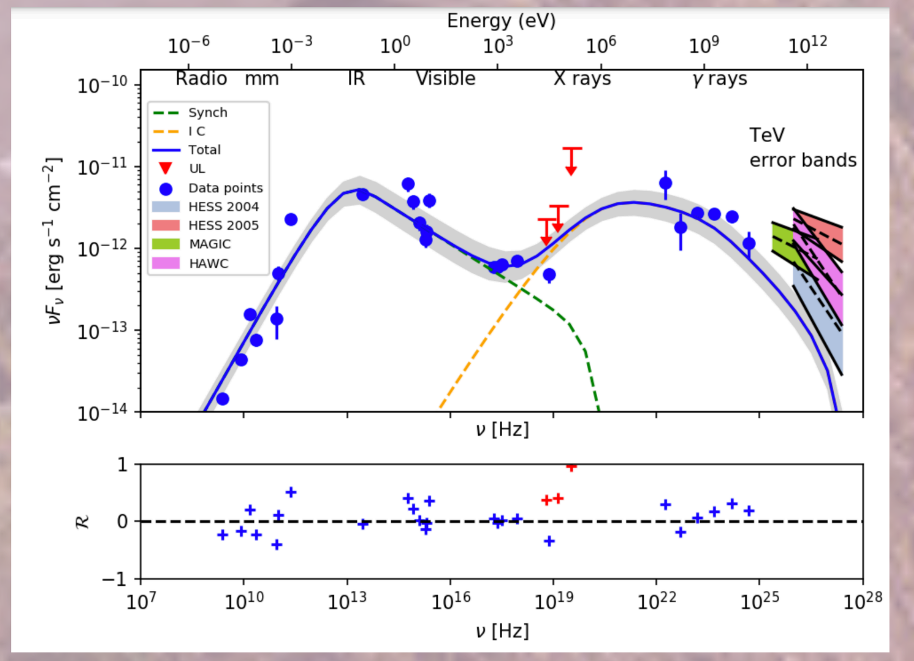


	Mrk 421	Mrk 501
$\sqrt{TS}$	48	12
N_0 [$\mathrm{TeV^{-1}cm^{-2}s^{-1}}$]	$[4.0 \pm (0.3)_{stat}(^{+0.9}_{-0.2})_{sys}] \times 10^{-11}$	$[6.6 \pm (0.9)_{stat}(^{+0.9}_{-0.6})_{sys}] \times 10^{-12}$
α	$2.26 \pm (0.12)_{stat}(^{+0.17}_{-0.39})_{sys}$	$2.61 \pm (0.11)_{stat}(^{+0.01}_{-0.07})_{sys}$
E_c [TeV]	$5.1 \pm (1.6)_{stat}(^{+1.4}_{-2.5})_{sys}$	∞
E_{max} [TeV]	9	12

M87

Alfaro et al. (2022) —> 1543 days of live data





The estimated neutrino flux in this work lies below the IceCube upper limits set in Aartsen et al. (2020).