Studying the AGN Radio and Neutrino correlation

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Neutrinos travel nearly unattenuated over cosmological distances making them an excellent messenger to study high-energy processes occurring in the universe. IceCube, the world's largest and most sensitive astrophysical neutrino detector, reported a high-energy neutrino event on 22 September 2017 which was found to be coincident with a flaring blazar, TXS 0506+056. This first multi-messenger observation hinted at blazars being sources of observed astrophysical neutrinos and raised a need for extensive correlation studies to properly understand which blazers might be neutrino sources. Here, we present a correlation analysis between 15GHz radio observations of active galactic nuclei reported in the MOJAVE XV catalog [1] and IceCube detector data and the sensitivity of this analysis to such a correlation.

Motivation:

- The Blazar PKS1502+106 was found to be possibly correlated with an IceCube alert (IC190730A). At the time of the alert, the radio observations of the FSRQ were seen reaching an all time peak flux of 4 Jy [2]
- Moreover, Radio neutrino correlation analysis will help us understand hadronic acceleration processes occurring in AGN [3].

Catalog and data description

- The MOJAVE XV dataset is used as the AGN source sample with radio observations. This sample consists of 5321 observations of 437 AGNs in the 15 GHz band, obtained between 1996 January 19 and 2016 December 26 with the VLBA in full polarization mode.
- IceCube data with full sky coverage detected between 2008 to 2017 is used. We look for spatial correlations in the directions of the ra,dec positions of the MOJAVE sources for the analysis.

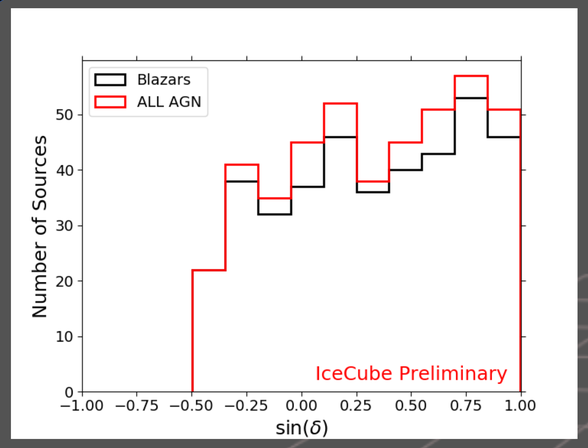

Fig 1: Distribution of the MOJAVE source sample (complete sample and only blazars)

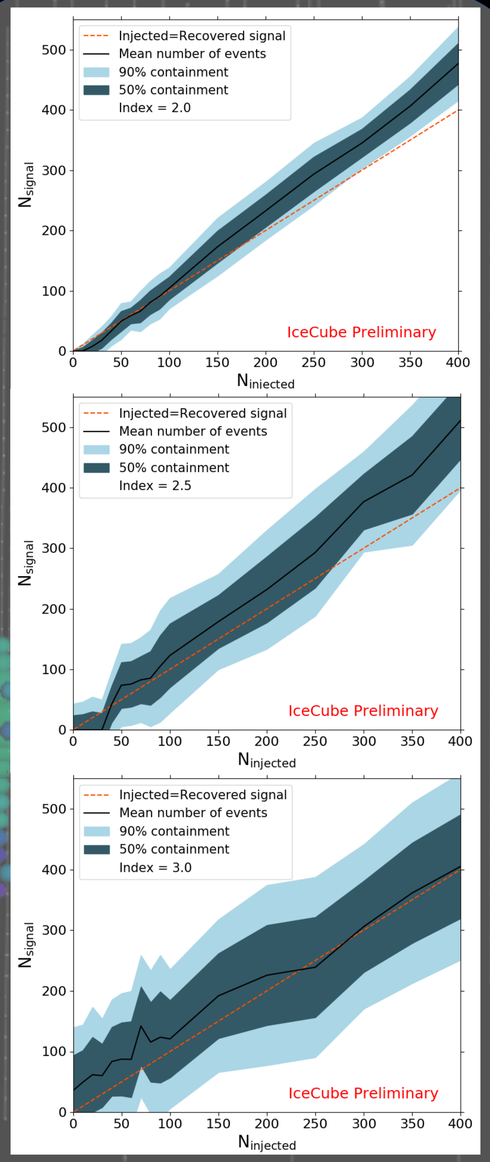

Fig 2: Ability of the analysis to reconstruct a signal from the MOJAVE AGN is shown for different spectral assumptions. X-axis denotes the number of signal events in the sample injected on top of background, while y-axis denotes the number of fit signal events for each of these spectral assumptions.

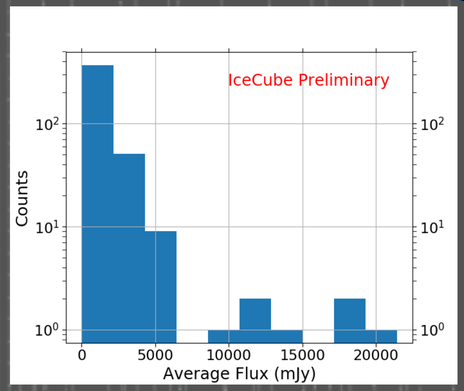

Fig 3: AGN Average flux observed at 15 GHz used as the weights for the stacking analysis

Likelihood stacking description:

- A time independent stacking analysis is used to test the hypothesis where the neutrino flux is proportional to the radio flux $F_\nu \propto F_R$
- We make use of the average radio flux of each source as the weight to be used in stacking; $w_i = F_{Ri}$ (see Figure.3)
- The muon neutrino flux obtained from the stacking with 90% C.L. (Confidence Limit) gives us the sensitivity of the correlation hypothesis test.

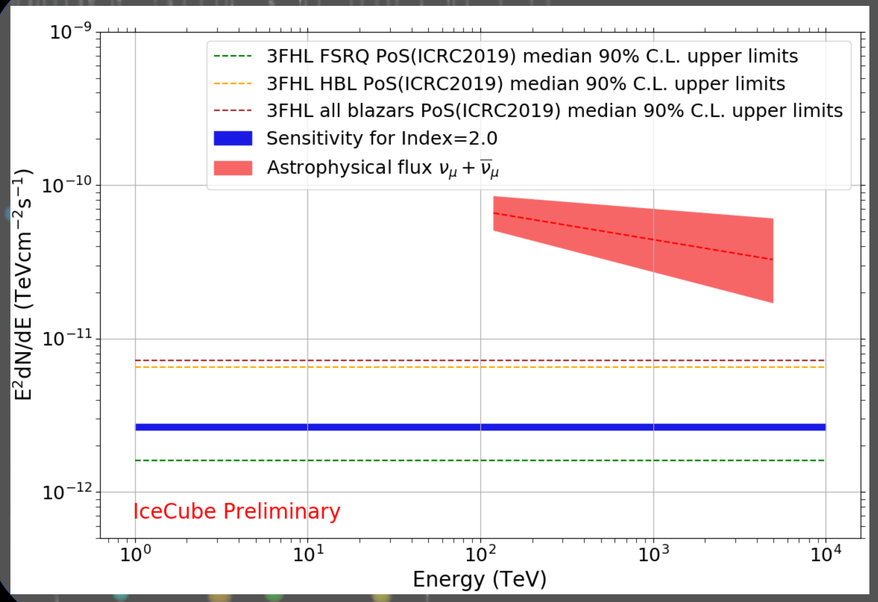

Fig 4: The preliminary sensitivity results for a spectral index of 2 for this work is shown as the blue line. The upper limits (at 90% C.L.) from a separate analysis testing the correlation between IceCube events and the 3FHL sample [4] are shown in dashed lines for comparison. The red shaded region shows the measured diffuse astrophysical neutrino flux from [5].

References:

[1] Lister, M.L. et.al, 2018ApJS..234...12L

[2] S. Kiehlmann et.al. ATel. 12996, 1 (2019)

[3] Plavin, A.V. et.al. arXiv:2001.00930

[4] IceCube Collaboration, PoS ICRC2019 (2020) 916

[5] IceCube Collaboration, , PoS(ICRC2017)1005

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