Introduction: IceCube neutrinos at PeV energies

The IceCube Collaboration’s announcement of the detection of a neutrino flux in excess of the atmospheric background is a watershed in multimessenger astronomy. Due to the steeply falling atmospheric background spectrum, events at PeV energies most likely have an extraterrestrial origin (Aartsen et al. 2014, see Fig 1), and there are many such sources for which these neutrinos originated is ongoing (Anchordoqui et al. 2014; Dermer et al. 2014; Mannheim, 1993). We can estimate the maximum expected neutrino fluence for the twelve brightest γ-ray sources (in the two fields) from the Fermi-LAT catalog (Norian et al., 2012), and these sources can be used as tests of our understanding of the multiwavelength properties of AGN from the TANAMI sample that are positionally coincident with the PeV neutrino events.

Possible astrophysical sources

- Isotopic distribution of all IceCube events → extragalactic origin likely
- Gamma-ray Burst (GRB) origin unlikely, no GRBs found at position and time consistent with PeV events.

AGN/Blazars: Particle acceleration in jets

Assuming that protons are accelerated in the jet, pions are created by interactions with UV photons, neutrinos, and other particles (Mannheim, 1993). We can estimate the maximum neutrino fluence by using the integrated flux of the high-energy hump $F_\nu = F_{\nu, hump}$, where the symbols have their usual meanings. In other words:

$$F_\nu = F_{\nu, hump}$$

AGN/Blazars are the most likely extragalactic candidate sources (Mannheim, 1993; Halzen, 2005).

Results I: VLBI images

Six TANAMI sources are located in the first median positional uncertainty region for the two PeV events; three in each of the fields (see Table 1). Of the twelve brightest γ-ray sources (in the two fields) from the Fermi-LAT catalog (Nolan et al., 2012), only these six sources have correlated VLBI flux densities at 8.4 GHz above 600 mJy.

The neutrino fluence can be calculated directly from the integrated flux of the high-energy hump.

Results II: Broadband spectra

We obtain values for the maximum expected neutrino fluence for each of the sources (see Table 2), by adopting $F_\nu = 1$ PeV as the production peak energy, an energy distribution of $\Delta E = 600$ days, an effective area of $A_{\text{eff}} = 10^{0.04} \text{ cm}^2$ for contained PeV events, and the integrated TeV to GeV flux. The sum of these values for the six blazars in 1 day is $1.9 \pm 0.4$. This is surprisingly close to the actual number of observed events. Assuming a more realistic neutrino spectrum lowers this number, but leaves room for the additional contributions from a large number of remote, faint blazars not included in the TANAMI sample.

Conclusion & Outlook

Bright AGN are able to calorimetrically explain the observed IceCube events at PeV energies.

- The assumptions leave room for contributions from unidentified, resolved sources.
- The publication of the third IceCube event (Aartsen et al. 2014) includes six TANAMI sources in the field of view, including Centaurus A (Kadler et al., in prep).

References

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