

# A mixed origin of neutrinos from TXS 0506+056

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The blazar TXS 0506+056 was recently identified as a tentative source of very high energy neutrinos. In 2017, the IceCube Observatory recorded a track-like event initiated by a neutrino with the primary energy  $E$  between 200 TeV and 7.5 PeV (90 % CL) accompanied with a bright “flare” across the electromagnetic (EM) spectrum, in particular, in the high energy (HE,  $E > 100$  MeV) domain [1]. Additionally, in 2014-2015 the same instrument detected a “cluster” of track-like events from the same source; most of these are compatible with  $\sim 100$  TeV neutrinos with a  $E^{-2}$  power-law spectrum [2]. The 2014-2015 neutrino events were not accompanied by a bright EM flare, but the HE gamma-ray spectrum during the “neutrino cluster” episode was probably harder than during the “gamma-ray flare” [3].

Given the different behaviours of neutrino and photon emissions recorded during the above-mentioned two episodes, it is natural and tempting to presume the different emission mechanisms during the “flare” and “cluster” episodes. In the present work, profiting by the recent re-classification of TXS 0506+056 as a flat-spectrum radio quasar (FSRQ) [4] (that probably has a broad line region (BLR), narrow line region (NLR), and a dusty torus), we propose a model where the “flare” is explained by the photohadronic (proton-gamma or nucleus-gamma) mechanism, while the “neutrino cluster” and the associated EM emission are due to hadronuclear (proton-proton or nucleus-nucleus) interactions with subsequent development of EM cascade in the dusty torus/NLR photon field.

We show that such a “mixed” model reasonably well describes the observations. This model predicts an “ankle” in the diffuse neutrino spectrum, where the low-energy neutrinos are predominantly due to the hadronuclear mechanism, while the high-energy neutrinos are mostly of the photohadronic origin. We discuss the signatures in the high energy and very high energy ( $E > 100$  GeV) gamma-ray ranges that could be used to test our model.

#### References

1. IceCube Collaboration et al., *Science*, 361, eaat1378 (2018)
2. IceCube Collaboration et al., *Science*, 361, 147 (2018)
3. P. Padovani et al., *MNRAS*, 480, 192 (2018)
4. P. Padovani et al., *MNRAS*, 484, L104 (2019)

**Primary authors:** DZHATDOEV, Timur; Mr PODLESNYI, Egor (Moscow State University)

**Presenters:** DZHATDOEV, Timur; Mr PODLESNYI, Egor (Moscow State University)

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