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Interpretation of the coincident observation of a high energy neutrino and a bright flare of blazar TXS0506+056

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On September 22nd 2017, the IceCube Neutrino Observatory reported a muon track from a neutrino with a very good positional accuracy. The alert triggered a number of astronomical follow-up campaigns, and the Fermi gamma-ray telescope found as counterpart an object named TXS0506+056 in a very bright, flaring state; this observation may be the first direct evidence for an extragalactic source of very high-energy cosmic rays. While this and subsequent observations provide the observational picture across the electromagnetic spectrum, answering where in the spectrum signatures of cosmic rays arise and what the source properties must be, given the observational constraints, requires a self-consistent description of the processes at work. Here we perform a detailed time-dependent modeling of these relevant processes and present a self-consistent model for the source. We find a slow but over-proportional response of the neutrino flux during the flare compared to the production enhancement of energetic cosmic rays. We also demonstrate that energetic cosmic-ray ions, which produce the neutrinos, provide emission in the hard X-ray band and, to a lesser degree, in TeV gamma rays, whereas optical photons and GeV-scale gamma rays are predominantly radiated by electrons. Our results indicate that especially future X-ray and TeV-scale gamma-ray observations of nearby objects can be used to identify more such events.

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