Recent Progress in Solar Atmospheric Neutrino Searches with IceCube

Josh Villarreal*[1], Gerrit Roellinghoff[2], and Jeffrey Lazar[1,3]

[1]Department of Physics and Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, MA 02138, USA
[2]Dept. of Physics, Sungkyunkwan University, Suwon 16419, Korea
[3]Dept. of Physics and Wisconsin IceCube Particle Astrophysics Center, University of Wisconsin–Madison, Madison, WI 53706, USA

ICRC 2021

1 Abstract

Cosmic-rays interacting with nucleons in the solar atmosphere produce a cascade of particles that give rise to a flux of high-energy neutrinos and gamma-rays. Fermi has observed this gamma-ray flux; however, the associated neutrino flux has escaped observation. In this contribution, we put forward two strategies to detect these neutrinos, which, if seen, would push forward our understanding of the solar atmosphere and provide a new testing ground of neutrino properties. First, we will extend the previous analysis, which used high-energy through-going muon events collected in the years of maximum solar activity and yielded only flux upper limits, to include data taken during the solar minima from 2018 to 2020. Extending the analysis to the solar minima is important as the gamma-ray data collected during past solar cycles indicates a possible enhancement in the high-energy neutrino flux. Second, we will incorporate sub-TeV events and include contributions from all neutrino flavors. These will improve our analysis sensitivity since the solar atmospheric spectrum is soft and, due to oscillation, contains significant contributions of all neutrino flavors. As we will present in this contribution, these complementary strategies yield a significant improvement in sensitivity, making substantial progress towards observing this flux.

2 Summary

- Solar atmospheric neutrinos (neutrinos generated in the Sun's atmosphere) are one of the few naturally-produced high energy neutrinos that have yet be detected experimentally.
- A previous solar atmospheric neutrino event selection looked for only high-energy (> 1 TeV) muon-neutrino events.
- The soft Energy spectrum of solar atmospheric neutrinos encourages us to probe lower (< 300 GeV) and medium (100 GeV - 1 TeV) energy regimes when building new event selections, as well as including events of all flavors.
- During periods of solar minima, the solar gamma ray flux is harder and higher. Since solar gamma rays share a similar production mechanism to solar atmospheric neutrinos, we think that extending analyses to include periods of solar minima (the most recent of which was from 2018-2020) may give us a better chance at detecting solar atmospheric neutrinos.
- We believe that combining the existing high-energy event selection with low- and medium-energy event selections (the medium-energy event selection is presented in this work), as well as extending the analysis period to include the most recent solar minimum, will put an affirmative solar atmospheric search closer in reach of IceCube.

*Presenter