Neutrinos in Lake Geneva: Measuring the LHCb Forward Neutrino Flux with Large-Scale Detectors

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This work investigates the physics potential of hypothetical large-scale detectors observing the interactions of neutrinos produced in proton-proton collisions at the LHC. We focus on the LHCb interaction point, as the forward neutrino flux from this location passes through Lake Geneva before exiting the Earth's surface. This offers two interesting possibilities: (1) a long pipe-like detector deployed within Lake Geneva, and (2) a large panel-based detector deployed on the Earth's surface. The former can leverage the large active volume enabled by the lake environment to collect a large dataset of all-flavor neutrino interactions within the detector, while the latter can leverage the long range of TeV-scale muons to collect a large dataset of muon neutrino interactions in the surrounding bedrock. One could also perform a coincidence measurement of muon neutrinos interacting in the lake-based detector and producing muons that are then observed in the surface-based detector. We estimate the event rates using a custom Monte Carlo simulation and show that these detectors can pin down the charm hadron contribution to the forward neutrino flux. Such a measurement would significantly constrain existing uncertainties on the prompt atmospheric neutrino flux, which is an important and poorly understood background to astrophysical neutrino searches at current and next-generation neutrino telescopes.

First affiliation

Harvard University

Second affiliation

Gender

Male

Collaboration (if any)

Poster prize

No

Given name

Carlos

Surname

Argüelles Delgado

Institutional email

carguelles@fas.harvard.edu

Primary author: ARGÜELLES DELGADO, Carlos (Harvard University)

Co-authors: KARLE, Albrecht (University of Wisconsin-Madison); THOMAS, Jennifer (University College London); KAMP, Nicholas (Harvard University); Dr YUAN, Tianlu (University of Wisconsin-Madison)

Presenter: ARGÜELLES DELGADO, Carlos (Harvard University)

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