# The Future of High-Energy Astrophysical Neutrino Flavor Measurements

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The flavor composition of high astrophysical neutrinos, has long been regarded as a versatile tool to learn about high-energy astrophysics and test fundamental physics. We show realistic projections of how the determination of how the uncertainty in the predicted flavor composition at Earth of the isotropic flux of high-energy neutrinos and its measurement will evolve over the next two decades. We find that, by 2040, improved measurements of $\theta_{12}$ by JUNO and of $\theta_{23}$ by DUNE and Hyper-Kamiokandewill reduce the size of the allowed flavor regions at Earth predicted by standard oscillations by a factor of 5–10 compared to today, and the combined measurements from Baikal-GVD, KM3NeT/ARCA, P-ONE and IceCube-Gen2are expected to reduce the uncertainty in flavor composition by a factor of 2 from 2020 to 2040. Moreover, if high-energy neutrinos are produced by a variety of production mechanisms, each yielding a different flavor composition, we will be able to identify the dominant and sub-dominant mechanisms. To illustrate the improvement that we will achieve in testing beyond-the-Standard-Model neutrino physics using the flavor composition, we explore neutrino decay into invisible products. We have shown that future observations will be able to constrain the lifetime of the heavier neutrinos to nearly $\sim 10^5(\mathrm{eV}/m)$ s if only $\nu_1$ is stable. We also find that the next generation of neutrino telescopes can probe microscopic black holes with a Planck scale up to 6 TeV assuming large extra dimensions.