



Contribution ID: 12

Type: **not specified**

Invisible jets from composite neutrinos

Wednesday 12 November 2025 16:15 (13 minutes)

The origin of Majorana neutrino masses suggests the existence of a sterile neutrino sector, which may be either too heavy or too weakly coupled to the Standard Model (SM) to be detected in the near future. The inverse seesaw mechanism provides a testable framework where the coupling between the sterile sector and the SM is large enough to allow direct experimental probes. In this context, it is crucial to explore whether the sterile sector is a weakly or strongly coupled theory and to identify methods to distinguish between these possibilities.

We propose a novel experimental probe for neutrino coupling with a strongly coupled sterile sector, based on the distinctive signature of neutrino disintegration into “dark jets” in high-energy neutrino scattering with electrons and nucleons. We investigate scenarios where the disintegration rate is dominated by events in which the dark jet invariant mass is well above the confinement scale, and we compute production rates within the conformal window. In this regime, we derive a new bound from NuTeV neutral current measurements and assess the expected sensitivity of upcoming experiments, such as DUNE and SHiP. We compare these bounds with the more standard searches of sterile state in meson and EW gauge boson decays (see Figure attached).

The unique signals discussed here offer a new experimental signature for future neutrino experiments, presenting both challenges in optimizing signal-to-background discrimination and a promising avenue for identifying composite neutrino interactions.

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Session Classification: Young Scientific Forum