Contribution ID: **132** Type: **not specified**

Input to the European Strategy for Particle Physics – KATRIN collaboration

Direct kinematic neutrino-mass measurement is essential for determining the absolute neutrino mass scale, a key unknown in particle physics with deep implications for cosmology and for theories beyond the Standard Model. Unlike neutrino oscillation experiments, which probe mass differences, kinematic methods directly measure absolute neutrino masses. Precision spectroscopy of weak decays, such as beta decay and electron capture, complements cosmological and neutrinoless double beta decay constraints while providing the only model-independent approach.

Tritium beta decay leads these efforts, with KATRIN currently setting the most stringent upper limit and aiming for sub-300 meV sensitivity with its final dataset. Future advancements, including atomic tritium and improved detection techniques, target sub-50 meV sensitivity to ultimately probe the full mass range presently allowed by oscillation bounds.

Beyond neutrino mass, high-precision beta-decay spectroscopy enables searches for exotic weak interactions, sterile neutrinos across various mass scales, and tests of fundamental symmetries, offering a powerful probe of physics beyond the Standard Model.

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