Contribution ID: **246** Type: **Parallel Contributed Talk**

Physics opportunities at nuSTORM

Thursday, 25 February 2021 18:10 (20 minutes)

The intense beam of muon and electron neutrinos with precisely known energy distributions provided by the stored-muon facility (nuSTORM) shall allow for a rich physics program with considerable impact in our understanding of fundamental properties of neutrinos and their interactions. In particular, the precision goals of the oscillation program can only be achieved with a realistic modeling of neutrino-nucleus scattering dynamics. nuSTORM can critically contribute to this effort by providing the ultimate experimental program of neutrino-nucleus scattering measurements.

Especially appealing are the prospects for new precise direct or indirect measurement of neutrino scattering cross sections on single nucleons. They represent a priceless input for event generators and provide valuable information about hadron structure in the axial sector. Precise data in the kinematic region beyond the excitation of the Delta(1232) baryonic resonance will illuminate the poorly understood transition from resonant to deep-inelastic scattering, which is critical for the DUNE program.

The cross section for the scattering of neutrinos on complex nuclei arises as a non-trival interplay between lepton kinematic factors and response functions, which is very sensitive to the energy and momentum transferred to the target. The availability of charged-current interaction data with both muons and electrons in the final state under the same conditions can provide stringent tests of electroweak nuclear response theory. In particular, it is critical to pursue a better understanding of two-nucleon contributions to the cross section and the discrepancies with theory found by MINERvA and NOvA. No less relevant is the detailed description of various exclusive final states (including nucleon knockout, single and multiple pion and strangeness production) with direct implications for calorimetric neutrino-energy reconstruction at oscillation experiments.

Sensitivity to physics beyond the Standard Model (BSM) is provided by unique features of the nuSTORM design: the precisely known flavor composition and neutrino-energy spectrum. This allows exquisitely sensitive searches for short-baseline flavor transitions, covering topics such as light sterile neutrinos, nonstandard interactions, and non-unitarity of the neutrino mixing matrix.

In synergy with the goals of the neutrino-scattering program, new physics searches would also profit from measurements of exclusive final states. This would allow BSM neutrino interactions to be probed by means of precise measurements of neutrino-electron scattering, as well by searching for exotic final states, such as dileptons or single-photon signatures.

Collaboration name

nuSTORM

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Session Classification: New Facilities