Proposal Summary

The first measurement of the charge radius of the proton from the Lamb shift in muonic hydrogen was found to be five standard deviations away from the value extracted from regular hydrogen. A similar discrepancy exists between regular and muonic deuterium. This so-called "Proton Radius Puzzle" might be an indication of new physics such as a new particle that couples to muons differently than to electrons. Around the same time, the axial radius of the nucleon was found in recent high statistics neutrino experiments to differ significantly from the value extracted from older neutrino experiments.

My *long-term goal* is to understand the effects of the strong interaction and distinguish them from effects of new physics. The *research objective* of this project is to separate nuclear, nucleon, and quark effects in neutrino-nucleus interactions and to determine nucleon structure effects in spectroscopy of hydrogen-like atoms. The former is essential for neutrino oscillation experiments and the latter is important for distinguishing proton structure effects from possible signals of new physics. I am well positioned to address these issues. I have already done theoretical work on these topics and I have extensive experience with calculations in the framework of effective field theories and their applications. In particular, I have successfully identified and addressed non-perturbative uncertainties in the extraction of fundamental parameters, such as $|V_{ub}|$. Two specific objectives will be pursued:

- **Objective 1:** Separate nuclear, nucleon, and quark effects in neutrino-nucleus interactions such as charged-current quasi-elastic scattering, and the recently discovered coherent neutrino-nucleus elastic scattering.

- **Objective 2:** Determine proton structure effects in hydrogen-like bound systems using effective field theory methods and the impact of such effects on muon-proton scattering.