Searching for rare processes in short-baseline neutrino experiments with liquid argon time projection chambers

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Liquid Argon Time Projection Chamber

Liquid argon time projection chamber (LArTPC)\(^1\) detector offers:
- Unprecedented spatial and calorimetric resolution
- Scalability and high cost-efficiency

The readout of LArTPC can be viewed as a 2D time-space image

Ecological foot-print

The Short-Baseline Neutrino Program\(^2\)

Comprises three LArTPC detectors: SBND (near detector), MicroBooNE and ICARUS (far detector)
- Main Physics goal:
  - Search for light sterile neutrino oscillations
  - Measure neutrino-argon cross-sections
  - Beyond-Standard Model (BSM) physics searches

Searches for SM-predicted, rare neutrino scattering processes

**Neutrino Current \(\Delta\) radiative decay search in MicroBooNE\(^3\)**

MicroBooNE investigated hypothesis of enhanced neutral current (NC) \(\Delta \rightarrow N + \gamma\) as source of LEE seen by MiniBooNE\(^4\)
- Never before measured process
- 3.18 enhancement could account for the \(\gamma\) source of LEE seen by MiniBooNE

**NC coherent single photon search in MicroBooNE\(^5\)**

Neutrino-induced NC coherent 1\(\gamma\) production is a rare, never before measured but SM predicted process \(^6\)
- O(10) events expected in MicroBooNE for first three runs
- No hadrons exiting the nucleus in the final state but only one photon

**Challenges**

Very rare signal - 125 events expected for first three run periods

**5 tailored boosted decision trees (BDT’s) to remove cosmic, charged current and NC \(\pi^0\) background**

Dedicated high-statistics NC \(\pi^0\) sample to constrain NC \(\pi^0\) rate in-situ

**Searches for BSM single-photon-like processes**

Ongoing searches in MicroBooNE and SBND that look for single-photon-like activity:
- Exotic e\(e^\pm\) production through light dark photon mediated neutrino scattering \(^7\)
- Single photon production from heavy neutrino due to transition magnetic moment \(^8\)
- Both searches are made possible by the DarkNews event generator\(^9\)

Predicted e\(e^\pm\) signal for MicroBooNE\(^8\) corresponding to e\(e^\pm\) model parameters which best fits MiniBooNE reconstructed visible energy: \(m_\nu = 1.25\, GeV, m_\psi = 107.5\, MeV, m_\chi = 72\, MeV, \varepsilon = 0.01\)

**MicroBooNE and LAr1-ND and ICARUS-WA104 Collaborations, arXiv:1503.01520**

**Current efforts are ongoing to evaluate the sensitivity of MicroBooNE and SBND to these models**

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**[6] A. Abdullahi, Neutrino 2022 poster**