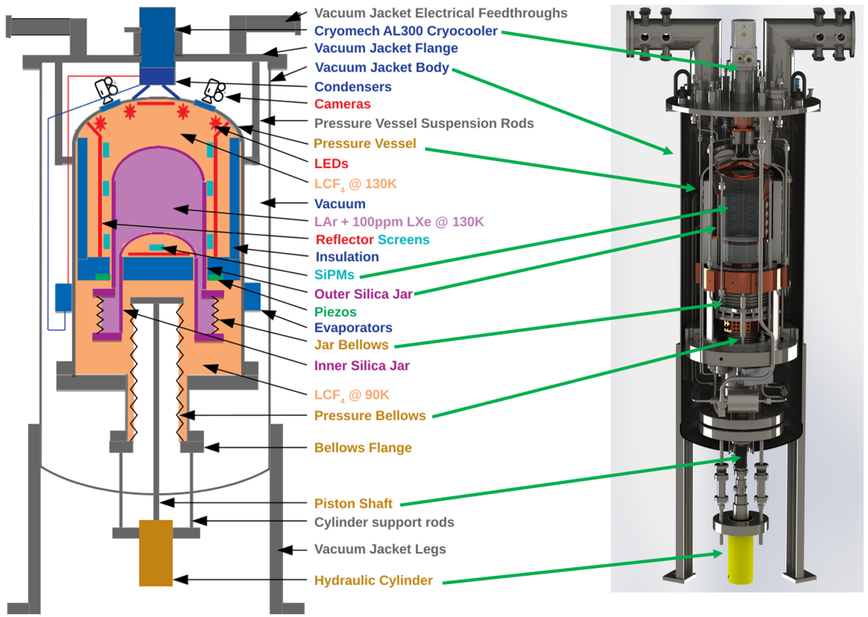
Reactor CEνNS with SBC Liquid Argon Bubble Chambers

R. Neilson on behalf of the SBC Collaboration

The Scintillating Bubble Chamber (SBC) Collaboration is constructing a 10-kg liquid argon bubble chamber with scintillation readout. The goal for this new technology is to achieve a nuclear recoil detection threshold as low as 100 eV with near complete discrimination against electron recoil events. In additional to a dark matter search, SBC is targeting a CEνNS measurement of MeV-scale neutrinos from nuclear reactors. A high-statistics, high signal-to-background detection would enable precision searches for beyond-standard-model physics.

The SBC Experiment

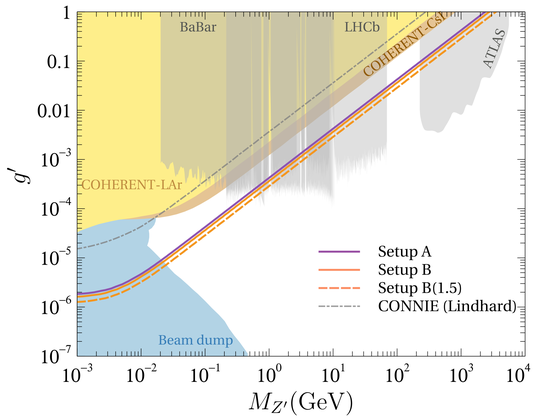
- Combines the electron recoil (ER) insensitivity of bubble chambers with the event-by-event energy resolution of scintillation detectors
  - Nuclear recoils (NR) create scintillation proportional to energy and produce bubbles; ERs do not deposit enough energy as heat in the liquid to create bubbles.
  - Cameras and LEDs to capture bubble images, SiPMs for scintillation readout, piezoelectric sensors for acoustic bubble detection.
- A 30g xenon bubble chamber has already demonstrated sub-keV NR sensitivity with superb ER rejection.
- Our first argon detector (below) is under construction at Fermilab.
  - 10kg of liquid argon in the 'warm' active region at 130K. The cold region at 90K is inactive.
  - Nuclear recoil threshold is adjustable down to 40eV by modifying the degree of superheat. Target NR threshold for dark matter and CEνNS physics is 100eV.
  - 1000ppm xenon wavelength-shifts the scintillation light to 175nm.



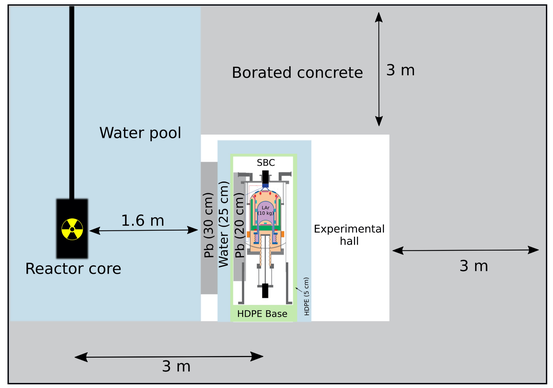
Reactor CEνNS Physics

The extremely high neutrino flux at reactors allows for multiple physics searches.

- Detection of CEνNS from reactor neutrinos. Signal rate from 8-1600 events/day depending on LAr mass and reactor power/baseline. Projected signal-to-background better than 5:1.
- Search for neutrino non-standard-interactions via CEνNS (e.g., *Z'* below).
- Weinberg angle at low energy.
- Neutrino Magnetic moment.
- Search for sterile neutrino oscillations.



Sensitivity to *Z'* (B-L) gauge boson. PRD103 L091301 (2021).
Setup A (right): 10kg target, 3m from 1MW reactor.
Setup B: 100kg target, 30m from 2GW reactor.



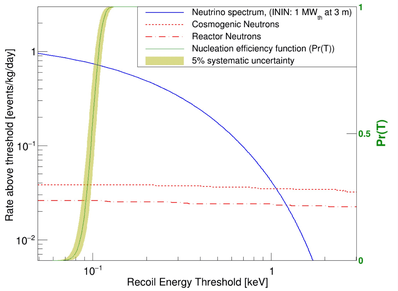
Site under consideration (ININ): 1MW TRIGA Mark-III reactor near Mexico City (Setup A)

Backgrounds

Main backgrounds:

- Cosmic neutrons.
- Reactor neutrons.
- Reactor gammas (nuclear Thomson scattering).
- ER background is negligible.

Scintillation channel provides background rejection.

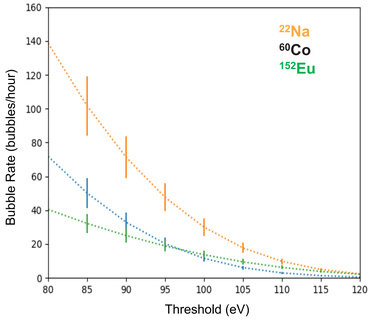


Setup A neutrino spectrum and projected backgrounds.

Calibrations

Sub-keV NR calibrations:

- Photoneutron (^{124}Sb-Be, ^{207}Bi-Be, ^{58}Co-Be).
- Nuclear Thomson scattering.
- ^{40}Ar thermal neutron capture.



Thomson scattering NR endpoint near the 100eV threshold