The IsoDAR Sterile Neutrino Search

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for the *IsoDAR* collaboration

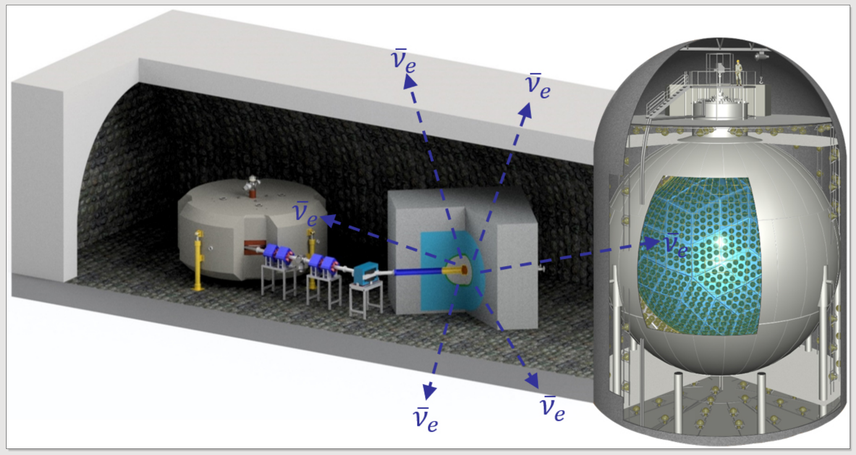
The IsoDAR Experiment Setup

IsoDAR is designed as an eV-scale sterile neutrino search. The major components are:

- H_2^+ cyclotron delivering 10 mA of 60 MeV protons on target
- ^{9}Be target surrounded by ^{7}Li sleeve for $\overline{\nu}_e$ production via ^{8}Li **Iso**tope **D**ecay-**A**t-**R**est
- Close proximity to kton scale detector such as KamLAND or the proposed Yemilab Neutrino Telescope

Positioning the IsoDAR $\overline{\nu}_e$ source 16 m from the center of KamLAND would result cover the range:

$$0.8 \leq \frac{L}{E} \leq 7 \left(\frac{\text{m}}{\text{MeV}}\right)$$

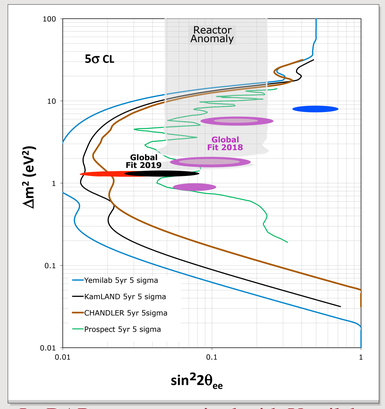


Experimental setup for IsoDAR@KamLAND. Detector image credit: K. Inoue

Motivation for eV-scale ν_s search

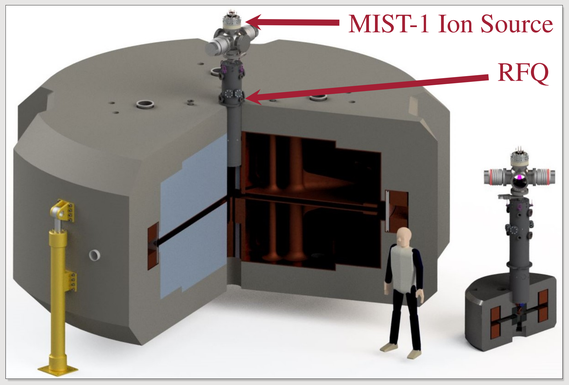
Short Baseline Oscillation Experiments

- Anomalies observed by MiniBooNE, LSND, and others
- KARMEN, PROSPECT, and others consistent with Standard Model predictions for 3 ν flavors
- Global data fits limit allowed oscillation parameter space
- IsoDAR can definitively cover global best fits in 5 years runtime
- IsoDAR capable of distinguishing between ν_s models



IsoDAR coverage paired with Yemilab, KamLAND, and CHANDLER. Prospect is shown for comparison.

Novel Cyclotron Design



IsoDAR cyclotron & RFQ-DIP prototype cyclotron.

H_2^+ Cyclotron

- IsoDAR requires 10 mA of 60 MeV protons
- Compact cyclotron best for underground
- Spacecharge effects limit cyclotron currents
- Using H_2^+ halves spacecharge effects
- Strip electron after extraction for 10 mA H^+

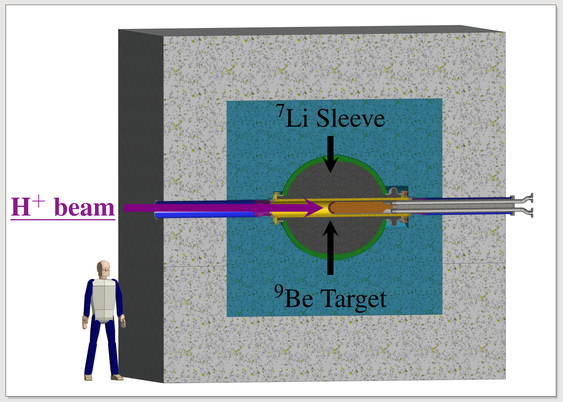
RFQ – Direct Injection Project

- MIST-1 ion source provides DC H_2^+ beam
- Radio frequency quadrupole used for bunching and axially injection into cyclotron
- RFQ matched to cyclotron frequency for increased injection efficiency

Neutrino Production

Isotropic $\overline{\nu}_e$ source

- Proton beam on ^{9}Be target produces neutrons
- Neutrons are captured by surrounding sleeve of highly purified ^{7}Li yielding ^{8}Li
- ^{8}Li undergoes β-decay at rest and emits $\overline{\nu}_e$
- $\overline{\nu}_e$ emitted isotropically with known energy distribution from localized source



IsoDAR target, sleeve, and neutron shielding design

Neutrino Detection

Artist rendition of IsoDAR $\overline{\nu}_e$ source near KamLAND

- IsoDAR $\overline{\nu}_e$ source must be positioned as close as possible to detector for maximum statistics
- $\overline{\nu}_e$ detectable in 2 channels in liquid scintillator

Inverse Beta Decay

- Prompt e$^+$ signal
- Delayed neutron capture signal
- Low-background

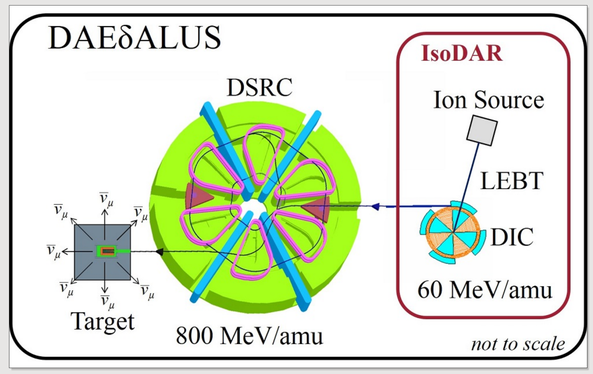
Electron Scattering

- >2,600 events
- Purely leptonic interaction
- Precision $sin^2\theta_W$ measurement

Cyclotron Applications

The IsoDAR cyclotron may additionally:

- Greatly enhance global production capabilities of hard to produce medical isotopes such as ^{225}Ac
- Provide beams to accelerator-driven reactors
- Serve as injector cyclotron for DAEδALUS
  - IsoDAR cyclotron feeds 800 MeV/amu cyclotron
  - 800 MeV beam drives π-DAR ν_μ source
  - 3 ν_μ sources located at 3 different baselines from $>$ 20 kton ν detector
  - Measurement of δ_{CP} in neutrino sector



Conceptual layout for DAEδALUS ν_μ production

Status and Outlook

- The MIST-1 ion source has produced record breaking H_2^+ DC-beam currents during early commissioning and is being optimized to meet IsoDAR design goals.
- The RFQ and IsoDAR cyclotron are in the advanced design stages and RFQ manufacturing is expected to begin later this year.
- Target, sleeve, and shielding simulations have demonstrated that IsoDAR's physics goals and engineering challenges can be simultaneously met.
- In addition to being a definitive eV-scale ν_s search and precision measurement of $sin^2\theta_W$, the IsoDAR cyclotron has numerous additional applications.

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