Whitepaper on the IsoDAR experiment

The DAEδALUS Collaboration, January 26, 2013

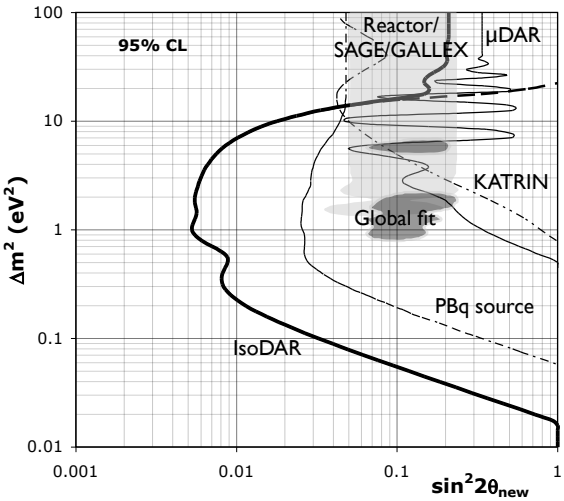

Figure 1: *The sensitivity of the IsoDAR experiment [1] to $\bar{\nu}_e$ disappearance in a five-year run. The sensitivities for both rate+energy shape (solid line) and shape-only (dashed line) are shown. Other curves from Refs. [4, 5, 6, 7].*

IsoDAR is a novel isotope decay-at-rest source of $\bar{\nu}_e$ for Beyond Standard Model searches. The source [1] consists of an accelerator producing 60 MeV protons [2] that impinge on a ^{9}Be target, producing neutrons. These enter a 99.99% isotopically pure ^{7}Li sleeve, where neutron capture results in ^{8}Li; this suffers β decay at rest to produce an isotropic $\bar{\nu}_e$ flux with an average energy of ∼6.5 MeV and an endpoint of ∼13 MeV. The $\bar{\nu}_e$ will interact in a scintillator detector via inverse beta decay (IBD), $\bar{\nu}_e + p \rightarrow e^+ + n$, which is easily tagged through prompt-light–neutron-capture coincidence. When paired with KamLAND [3], the experiment can observe 8.2×10^5 reconstructed IBD events in five years. With this data set, IsoDAR will decisively test sterile neutrino oscillation models, allow precision measurement of $\bar{\nu}_e$-e scattering, and search for production and decay of exotic particles.

The sterile neutrino search uses electron flavor disappearance, interpreted within models with three active and one (3+1) or more sterile neutrino flavors [8, 9, 10, 11]. These models result from fits to combined appearance (muon-to-electron flavor [12, 13, 14]) and disappearance (muon flavor [15, 16, 17] and electron flavor [4, 5, 18]) data. Fig. 1 presents the oscillation landscape at 95% confidence level for electron flavor disappearance in a 3+1 model. IsoDAR covers the global fit allowed region for $\bar{\nu}_e$ disappearance [8] (dark grey) at 5σ in four months. The high statistics of the five-year run distinguish models with one or more sterile neutrinos, as shown in Fig. 2. The impressive capability of IsoDAR led to its choice as a Physical Review Letters highlight [19].

The timescale for this experiment is ∼2016 and cost is ∼ $30M. Our accelerator is comparable in cost to those in a recent DOE study on cyclotrons [20]. Application to medical isotope production [21] has led to interest from cyclotron companies in supporting development of our accelerator [22, 23, 24]. For a comparison of cost-effectiveness to other technologies, see Ref. [25].

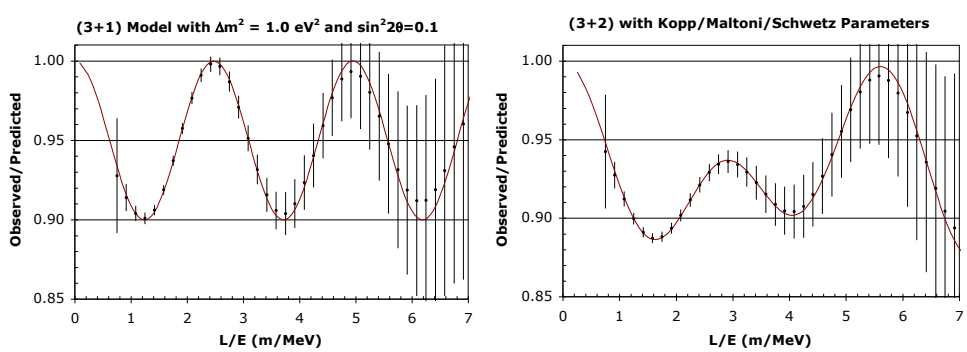

Figure 2: *The L/E dependence of two example oscillation signatures after five years of IsoDAR running [1]. The solid curve is the oscillation probability with no smearing in the reconstructed position and energy. The 3+2 example (right) represents oscillations with the global best fit 3+2 parameters from Ref. [9].*

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