Letter of Interest: **Progress with the IsoDAR Cyclotron**

Primary Frontier: Accelerator / Accelerators for Neutrinos **AF2**
Additional Frontier: Neutrino Physics / Artificial Neutrino Sources **NF09**

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The IsoDAR experiment [1,2] will provide a highly sensitive search for sterile neutrinos, by placing a powerful source of electron antineutrinos in close proximity to a kiloton-scale liquid scintillator detector such as KamLAND. A compact cyclotron produces a 10 mA beam of 60 MeV protons that strike a neutron-producing target. These neutrons are captured in a sleeve surrounding the target, consisting of a mixture of beryllium and highly-enriched (>99.99%) ^{7}Li. The ^{8}Li neutron-capture product decays within 1 second yielding a high endpoint-energy nu-e-bar that is detected via inverse-beta decay (IBD) in the detector. For the most-favored parameters for sterile neutrinos, the nu-e-bar oscillation pattern has maxima and minima within the volume of the detector, providing exquisite sensitivity for discovery of one or more sterile neutrinos through shape analysis.

REQUIREMENTS:
The current requirement is a factor of 5 in output intensity over any existing compact cyclotron, and has raised questions as to the feasibility of reaching this level of performance. Table 1 lists our strategies for overcoming the limitations of existing cyclotron designs.

Issue	Strategy
Increasing injected/accelerated current	Good DC ion source RFQ Buncher provides >80% capture efficiency
Manage space-charge forces	Accelerate H_2^+ instead of H^- or protons
Control beam loss during acceleration (minimize activation)	Thorough understanding of beam behavior Utilize vortex effect [7] Effective placement of collimators
Efficient extraction (also minimizes activation)	Resonance-enhanced septum extraction Establish good turn separation Narrow stripper to protect septum

In the time since the last Snowmass process, substantial progress has been made on all these points, leading us to the conclusion that there are no showstoppers along the path to building and operating this cyclotron at the required specifications.

PROGRESS:
- H_2^+ ion source: As a result of earlier experimental work [3], a filament-driven multi-cusp source has been built at MIT with NSF funding [4]. This source has

demonstrated excellent selectivity for H_2^+, over 80%, and is being commissioned now to increase the total current output.

- RFQ Buncher/Injector [5,6]: Contract for construction of a split-coaxial RFQ, operating at the cyclotron frequency of 32.8 MHz, has been awarded to Bevatech, GmbH (Frankfurt). It will provide the required bunching and transmission efficiencies for inflection into the central region of the cyclotron. An external technical review has been conducted with extremely helpful results and construction of the RFQ will commence in fall 2020. This work is funded via an NSF MRI Grant.

- Full Start-To-End simulation: This effort is nearing completion. The following elements have been completed:

- Source matching to RFQ, and effective LEBT design complete
- RFQ beam dynamics completed and reviewed
- Preliminary spiral inflector and central-region design complete
- Capture and bunch formation modeled with OPAL [7] code [8]
- Vortex effect integrated: space-charge mitigated bunch compression [8]
- Halo control via collimators placed at low energy (< 2MeV/amu) orbits [8]
- Extraction and turn separation modeled (Power loss on septum <150 W) [8]

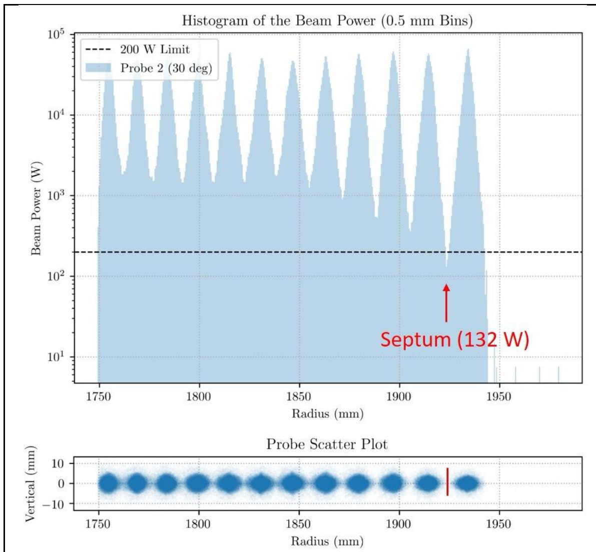

Fig.1: Beam profile for last turns in cyclotron. Turn separation at location of septum is such that beam loss on septum is about 130 watts, comfortably below the maintenance-level activation limit

CONCLUSIONS: Excellent progress has been made on the cyclotron design. We are convinced it can be built and will operate at required specifications. We are now seeking funding for the engineering design and construction of the cyclotron itself. Furthermore, we are convinced that the developments pioneered for this project will establish new performance milestones for high-current cyclotrons that will have far-reaching applications.

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