Neutrino Science Opportunities at the High Flux Isotope Reactor

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for the Workshop Organizers (https://indico.phy.ornl.gov/event/433)

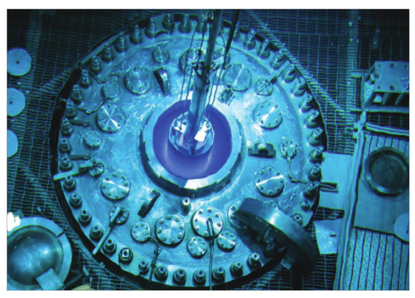
Abstract: In April 2024, Oak Ridge National Laboratory hosted the Workshop on Neutrino Science and Applications at HFIR to explore opportunities provided by the unique High Flux Isotope Reactor (HFIR) facility to host a world-leading neutrino science experimental program over the next two decades that matches the spirit and utility of its sister laboratory at the Spallation Neutron Source (SNS) at ORNL, Neutrino Alley. HFIR recently hosted the PROSPECT experiment which, while carrying out its physics program, quantified HFIR background conditions, demonstrated technology for on-surface rare event searches, and established the ability of HFIR facilities to support fundamental neutrino science. Furthermore, many physics topics including CEvNS that are accessible at a short distance from an intense and well quantified source of MeV-scale electron antineutrinos like HFIR were described in the Snowmass 2021 report and supporting white papers. This workshop focused on identifying fundamental science topics that could be pursued at HFIR in the near-term with the current facility configuration and identifying facility upgrades, e.g. to shielding and overburden, that could unlock additional scientific opportunities in the medium-to-long term.

The Workshop on Neutrino Science Opportunities at the High Flux Isotope Reactor was hosted at Oak Ridge National Laboratory with support from the High Energy Physics Intensity Frontier Program in the U.S. Department of Energy, Office of Science.

Scientific Organizers: N. Bowden, Marcel Demarteau, Bryce Littlejohn, Pieter Mumm, Jason Newby, Ohana Benevides Rodrigues, Diego Venegas Vargas, Xianyi Zhang.

48 Registered participants, 45 In-person
23 Institutions Represented

High Flux Isotope Reactor



Powerful Compact Core.

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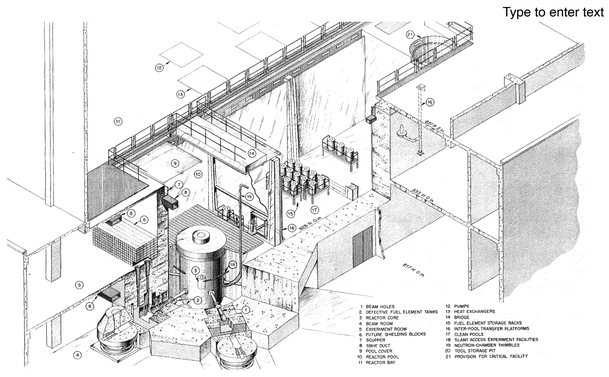


Fig. 3.1.1. Isometric of Pools and Experimental Facilities.

HFIR is a unique and power US-based science facility at ORNL
- Flux: Power (85 MWth) - baseline (~6.5m minimum) contrast with many US research reactors. Frequent On-Off for backgrounds at 5-6 cycles per year.
- Accessibility: Data and personnel access facilitated through DOE User Program in contrast with US commercial reactors

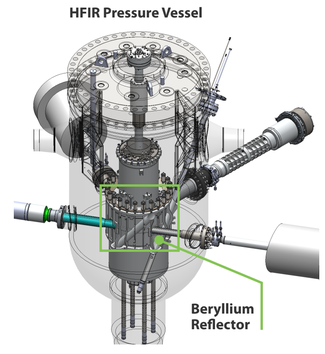
PROSPECT Experiment at HFIR
- HFIR Operations and Neutrino scientists have established a productive partnership in particle physics

Upgrades for a century of operations

High Flux Isotope Reactor Beryllium Reflector Replacement (HBRR)

Beryllium Reflector: Helps drive neutron production by reflecting neutrons back into the fuel core.

SCOPE:
- Redesign and replace the reflector and some vessel components
- Remove and replace 4 beam tubes
- Disassemble and reinstall Beam Room instruments
- Replace the cold neutron guide network
- Make opportunistic infrastructure and instrument enhancements
- Extend the Cold Guide Hall, plus reconfigure and optimize cold neutron instruments to improve performance and make room for future new instruments and capabilities



Reactor Beryllium Reflector Replacement
- Reactor Beryllium Reflector currently at historic operational lifetime of 279 GWd
- Replacement of permanent Be reflector during planned outage to begin in 2029

Pressure Vessel Replacement will sustain operations through turn of the century
- Permits operating at 100 MW by addressing embrittlement issues
- Additional neutron scattering instrumentation, enhanced isotope production, and additional guide hall.

Potential for Broad Science Program

Reactor Neutrino Flux
- HFIR has unique advantages (HEU, low thermal power uncertainty, on-off cycles) for reactor neutrino flux and spectrum measurements

Short Baseline Oscillations
- eV-scale Sterile Neutrino Searches

Reactor CEvNS Studies
- HFIR complements the SNS (energy, total flux, coherency, flavor) neutrino program at ORNL and the global CEvNS effort

Inelastic Neutrino Nucleus Scattering Measurements
- Sensitive to neutrinos below the hydrogen IBD threshold (1.8 MeV)
- Detector concepts for charge current and neutral interactions

Reactor Monitoring Applications
- Demonstration of mobile, surface operated technologies

Opportunities
- Research reactor allows rapid deployment of many compact detector technologies.

Challenges
- Most science topics extremely sensitive to cosmic backgrounds
- Surface location at HFIR requires optimized experimental shielding
- Technical and Facility engineerings studies required to establish feasibility of each concept

HFIR Neutrino Organizing Community

HFIR Neutrino Steering Committee
- Volunteers from workshop participants are organizing the community effort through regular meetings of the steering committee and HFIR points-of-contact.

HFIR Neutrino Mailing List
- Regular meetings with community are underway to communicate HFIR facility developments and assist with followup regarding HFIR facility requirements for neutrino experiments

HFIR Neutrino Experiment Survey
- Steering committee coordinating with HFIR to provide an experiment questionnaire to inform technical planning and interface with HFIR user facility for grant letters of support.

HFIR and ORNL Physics Division Committed to support the U.S. and international neutrino community in a broad physics program
- HFIR operations and scientific staff are meeting regularly with ORNL staff to assess resource requirements and coordinate communication with funding agencies.

You are invited!
- If HFIR presents a unique or complementary opportunity for your science, please contact us. Jason Newby (newbyrj@ornl.gov), Bryce Littlejohn (blittlej@iit.edu)

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