

Radiation Hardened Opto-Atomic Magnetometer (RHOM)

Progress Update



DOE Funding Opportunity: DE-FOA-0001770
Grant Number: DE-SC0018586
Period of Performance: 4/4/22 - 4/3/24

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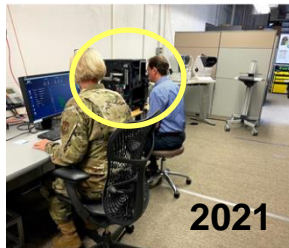


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Hedgefog Research (HFR) is a small business with an established manufacturing base and a growing number of commercial products. The company has expertise in optical metrology/sensing, atomic/molecular spectroscopy, atom-based sensors, mass spectrometry, and electrical/mechanical engineering.

- **Optical system design and metrology/sensor development**
- ISO 13485:2016 certified
- Full-cycle product development



Automated Vision Tester
- *developed for USAF*

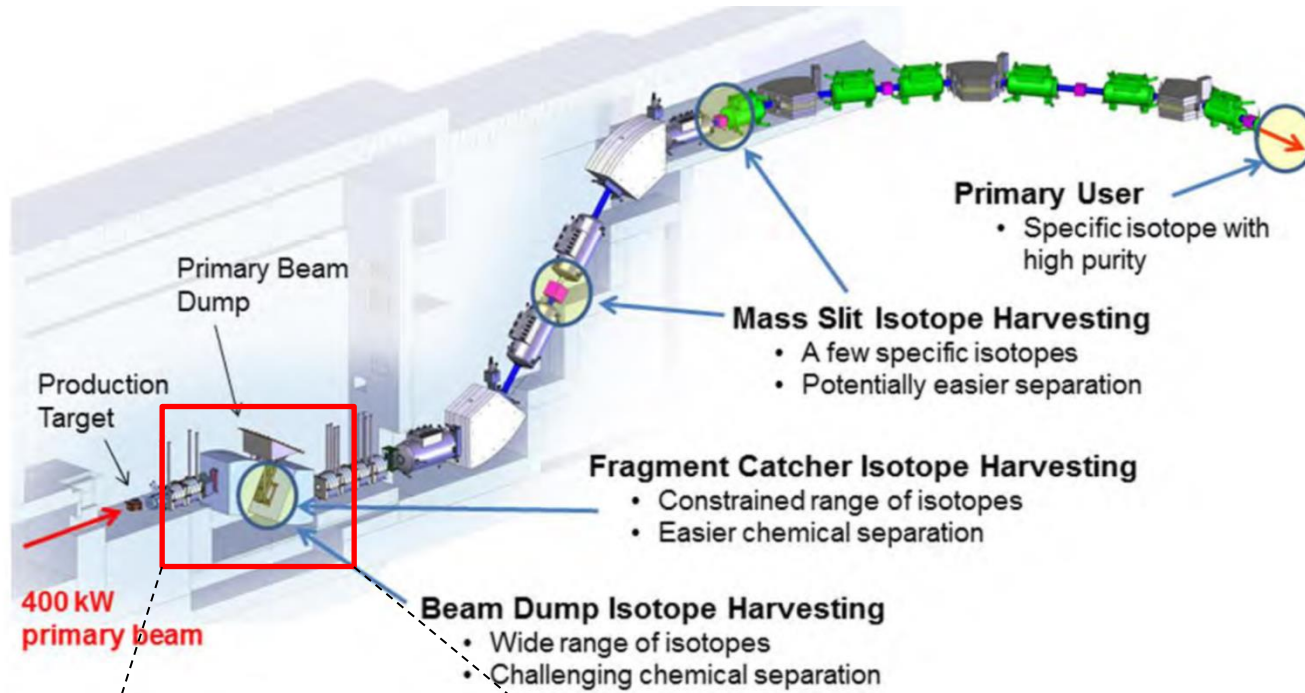


Custom-fit scleral lens
- *internally funded*

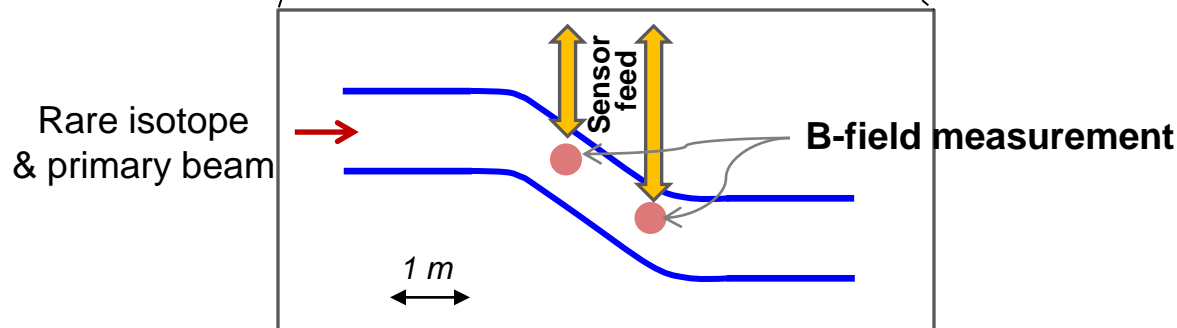
- In rare isotope beam (RIB) facilities, **production and manipulation of the reaction products**, including ionization, purification, acceleration, and transport, need to be optimized individually to achieve maximum production rate of target nuclei.
- **Precise electromagnetic manipulation of reaction products** is needed to deliver intense rare-isotope beams with good ion optical quality and desired timing/energy characteristics.
- **Magnetic-field probing** is one of the diagnostic tools routinely used in the operation of RIB facilities.
- Nuclear magnetic resonance (NMR) probes commonly used in these applications have **limited lifetime** (~ weeks) due to radiation-induced damage. This results in facility downtime and increased operation cost.

- Magnetic-field sensing in high-radiation environments (gamma ray and **neutron, 0.1 ~ 10 MGy/yr**), replacing NMR probes
- Target operation lifetime **> 1 year**
- Field range: **0.2 ~ 5 T**
- Precision ($\Delta B/B$) better than 10^{-4} , **10^{-5} desired**
- Field gradient (in one direction): 10^{-4} cm^{-1}
- Rep. rate: higher than 1 min^{-1} , **1 Hz desired**

Isotope Harvesting at FRIB

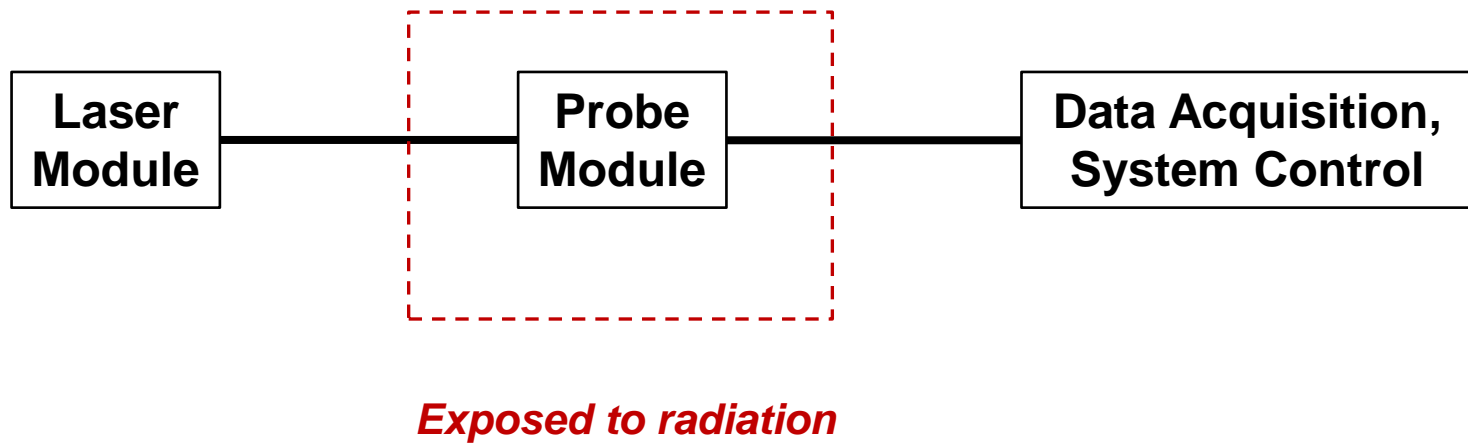


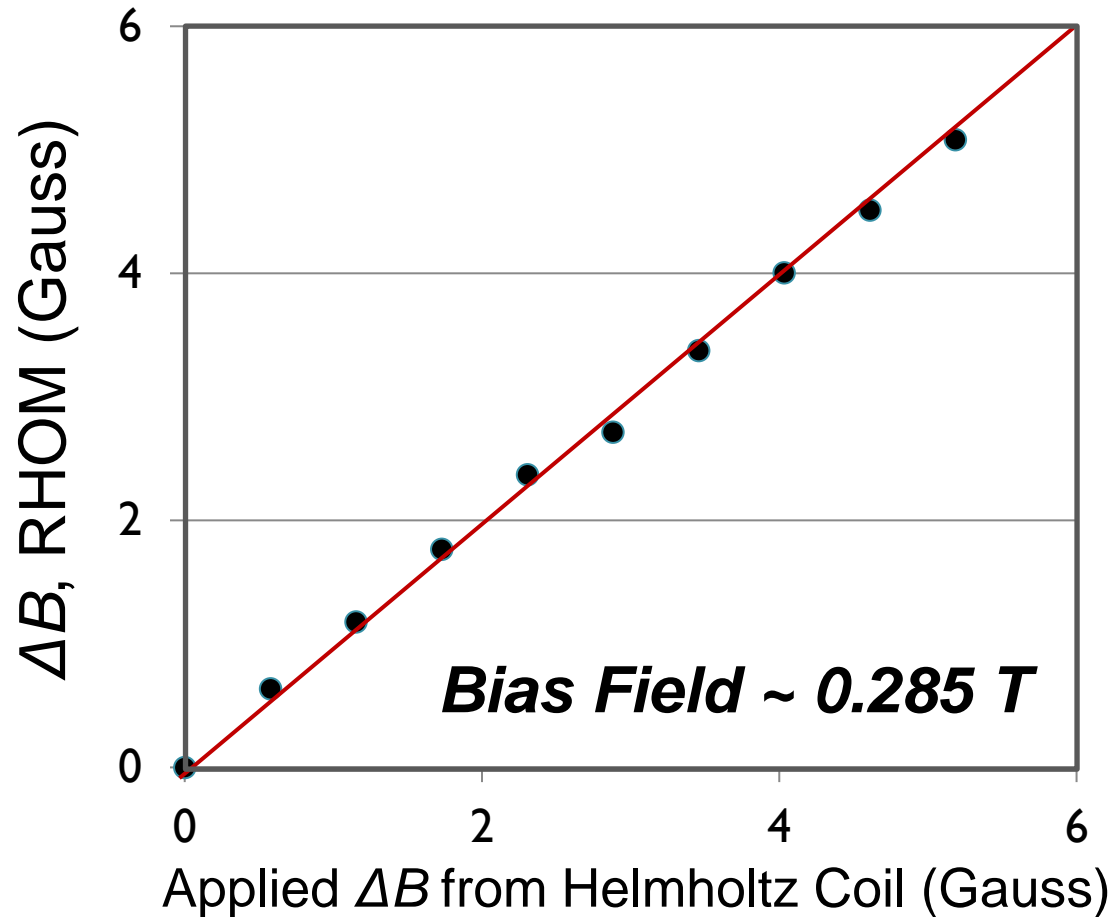
** FRIB: Opening New Frontiers in Nuclear Science
August 2012*



Radiation Hardened Opto-Atomic Magnetometer

- Contains **minimal number of radiation-hard components** exposed to radiation (glass cell, metallic mirror, optical fiber, mechanical housing)
- RHOM accuracy guaranteed by quantum mechanics; **no need for device calibration**
- Sensitivity better than **10^{-5} T**
- Relative precision (**$\Delta B/B$**) better than **10^{-5} at 1 T** (~ 1 Hz sampling rate)





Calibration-free determination of magnetic field

- Developed a new probe module design (1.5 in. × 1.3 in. × 1.5 in.)
- Devised and successfully tested a new optical system scheme
- Developed data acquisition and signal processing software, which, combined together, will provide a fully automated real-time magnetic-field sensing.
- Finished down-selection of system components
- Currently building a fully packaged RHOM prototype that provides a real-time measurement of a local magnetic field. This prototype will be sent to end user for testing and validation.
- HFR is experiencing a slight delay (~ 2 months) in deliveries of a few system components

- System packaging
 - RHOM system to be delivered to DOE will contain
 - two 19-in. rack-mountable modules (Controller & Laser)
 - one RHOM probe
 - optical fiber (connecting the Probe and Laser module)
 - user interface
- Radiation hardness of the RHOM probe to be performed in 2023/2024

Thank you!