Isotopes and Applications Working Group: Report for the 20-22 Feb. 2010 FRIB Equipment Workshop

1) *What is the primary physics motivation and experimental capability of the proposed instrument and why is this important for FRIB science?*

The standard mode of operation at FRIB will be to produce a rare isotope beam for a primary user, for example ^{60}Ca from a ^{82}Se beam. At the same time, the fragmentation or fission of the production beam will produce up to 1000 other isotopes that could be collected (harvested) and used for other experiments or applications. The potential applications of these harvested isotopes range from the determination of neutron cross sections for homeland security to kinetic studies of radionuclide uptake in biological processes. Longer-lived samples of the unused isotopes could be collected and used in an ion source for accelerated beam experiments at ReA3, ReA12 or other accelerator facilities outside FRIB.

Given these possibilities, the harvesting working group addresses two general areas:

- The potential uses of rare isotopes at FRIB that fall outside of basic research in nuclear physics, astrophysics, and particle physics
- The collection of selected isotopes that could be used to prepare radioactive targets or samples for experiments and allow a limited multi-user capability at FRIB.

A high-level overview of possible applications for isotopes produced at FRIB is given in the report *Scientific Opportunities with a Rare-Isotope Facility in the United States* written by the Rare Isotope Science Assessment Committee, National Research Council (National Academies Press, 2007) and in the RIA (now FRIB) Applications Workshop – see http://www.lanl.gov/orgs/t/workshop/homepage.htm

The general areas of interest fall into 6 broad categories:

- Nuclear power (nuclear data is needed to optimize reactor design, safeguards applications, and for studies related to reprocessing or disposal of nuclear waste)
- Homeland security (nuclear data is needed for modeling of nuclear reactions, detection of nuclear material and other threats, and development and calibration of threat detection technologies)
- Stockpile stewardship (nuclear data is needed for modeling of nuclear reaction networks, similar to astrophysics studies, such as (n,2n), (n,γ), (n,p), and (n,f))
- Medical diagnostics (development of new imaging and treatment technologies, kinetic studies of material uptake in the body, and the possible production of biomedical radioisotopes for diagnostics and therapy)
- Nanoprobes for materials science using radioisotopes (for example the use of polarized ^{8}Li)
- Industrial and environmental tracers (for example ^{7}Be, ^{210}Pb, ^{137}Cs, etc.)

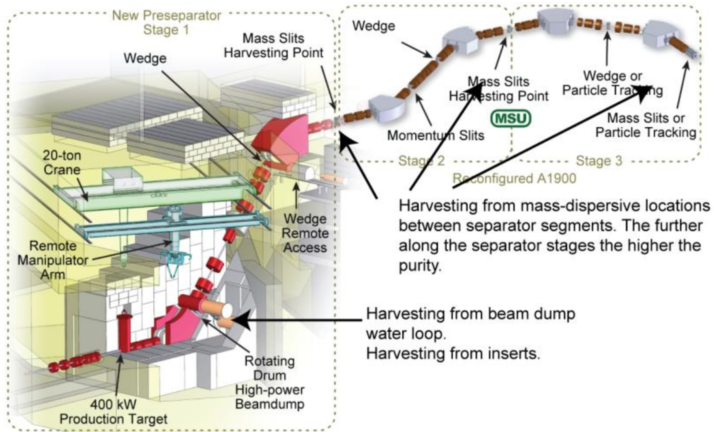
2) *What are the unique capabilities of this device that are not available in existing equipment? Is this instrument stand alone or is it to be used (solely or partially) in conjunction with other instruments. Could it be used at NSCL or other laboratories before FRIB?*

Currently no equivalent harvesting facilities exist at in-flight facilities. However, many rare isotope facilities have applied programs. For example, ISOLDE has traditionally had more than 25% of the program devoted to uses outside nuclear physics. TRIUMF has developed a capability for ^{8}Li implantation to study magnetic fields in nanomaterials, and GANIL has an associated applied division.

3) *Describe the instrument in some detail – how does it meet the scientific requirements and what are the (estimated) performance specifications? Be brief but as detailed as you can. Is the design fixed or are multiple options still being discussed and encouraged?*

Harvesting of isotopes could take place at various stages in the fragment separator, shown below.

Figure 1: Layout of the FRIB fragment separator area illustrating possible locations of isotope harvesting.



4) *What is the current stage of development of your project?*

The project is in the discussion stage. Planning and design of harvesting stations will have to be incorporated into the FRIB fragment separator designs. Some programs could start using the current NSCL facilities and harvesting techniques studied. For example, limited quantities of interesting isotopes could be supplied to potential users in order to develop the radiochemical and other techniques that would be employed with FRIB, when larger quantities of isotopes might be available. The ability to collect mass-enriched samples is of high interest in many applications.

5) *What is the approximate cost of the project: discuss possible sources of funding.*

Hardware and design costs for harvesting capabilities would be approximately $1M. Continuous, active harvesting that would allow shorter-lived beams to be collected and rapidly transported to ReA3 and ReA12 would cost 3 - 5M$.

The necessary radiochemical facilities to chemically purify harvested samples will cost approximately 1M$, provided hot cells planned for the FRIB production area and appropriate other hot-cell space on the MSU campus for processing of materials could be used.

6) *Please provide a brief list of collaborators and institutions. Spokesperson(s) provide contact info.*

A broad spectrum of individuals from national laboratories, universities and private industry are collaborating. Researchers from LLNL and LANL are developing plans for how to use the isotopes at FRIB for homeland security and stockpile stewardship applications. Other groups are now forming in the areas of medicine and nuclear energy. Activity is needed in the areas of tracer applications (i.e. ^{7}Be wear studies, geotracers) and materials science (i.e. using probes such as polarized ^{8}Li).

The contact person is Mark Stoyer, LLNL; stoyer1@llnl.gov

7) *Please can you outline how your collaboration has been developing your project and how you are growing your collaboration (How many meetings? Participants? Circular mailings? Have you a web-site?)*

We plan to hold a workshop in the near future and write a white paper on the opportunities of harvested isotopes and applications at FRIB.

8) *Did you consider alternative designs? What alternatives were considered? How did you arrive at a final design?*

A 2-stage ISOL target/ion source may be placed in close proximity the primary production target to produce ISOL beams where mass-separated isotopes could be collected and transported by a rabbit system to the radiochemistry laboratory. Hot cells and radiochemical fume hoods would be needed to prepare the ISOL targets and process the collected material.

Isotopes may also be produced directly using the high-intensity primary beam. The primary beam may be extracted in the stripper region of the accelerator and sent to an isotope production facility utilizing heavy ion reactions. This set-up would require a well-shielded irradiation cave and potentially extensive infrastructure.

What existing equipment exists in the US Community that has similar goals and characteristics, even if inferior in performance?

There is no existing equipment that can be used for this purpose.

Draft Collaboration:

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