02-198N -- DETERMINATION AND OPTIMIZATION OF BEAM PROPERTIES AT ENTRANCE AND EXIT OF GAS CELL SYSTEMS

Principal Investigators: G. Savard, Physics
J. A. Nolen, Physics
C.-L. Jiang, Physics
C. Davids, Physics

Funding Profile:

FY 2000	$0K
FY 2001	$0K
FY 2002	$146K
FY 2003	$0K
FY 2004	$0K

Purpose: Since the early 1990's in the field of low energy nuclear science there has been worldwide interest in an advanced facility capable of producing energetic, high-quality beams of radionuclides. The scientific case for such a facility led to its recommendation in the 2002 Nuclear Science Long Range Plan as the highest priority for new construction in nuclear physics. An evaluation of various possible technical approaches to the implementation of such a facility was carried out and a facility based on the ANL concept of a multi-beam (heavy ion) driver was recommended. The purpose of this LDRD project is to develop design concepts for a major component of this larger facility, namely a large acceptance fragment separator to select reaction products and minimize their energy spread before injection into a large gas cell. This is a key component of the new paradigm combining fragmentation and ISOL technique to obtain low-energy radioactive beams of high quality from all chemical elements. It is also a critical component in that it will accept a large quantity of radioactive isotopes that must best be contained to specific designated areas of the facility.

Approach: The novel concept of stopping fragmentation products in a large gas cell before reacceleration requires a very high performance from the fragment separator feeding the ions into the gas cell. This separator must also be able to accept the very high power beam and radioactive contaminant also produced in the primary target. We have studied, in collaboration with experts from the GSI laboratory in Germany, the basic energy loss process in this energy range and the ion optics constraints, selectivity and final fragment beam monochromaticity that can be obtained with conventional design. We have looked at the main locations where radioactive contaminants can be dumped and identified a source of contamination that for high-power primary beams will limit the selectivity standard designs provide for weak isotopes. Requirements for a more advanced design for the fragment separation that removes these limitations have been identified and a possible ion optical solution has been laid out.

Technical Progress and Results: The task of the fragment separator feeding the gas cell is to collect the largest fraction possible of the reaction products, provide selectivity against contaminants and finally minimize the momentum spread of the wanted isotopes before injection into the gas cell. The ambitious parameters that have been discussed for the fragment separator are a momentum acceptance of ± 9%, an angular acceptance of ± 50mrad and a resolution sufficient to achromatize the outgoing recoil beam to $\Delta E/E$ = 0.2%. The standard fragment separator design utilizes a wedged degrader between two achromatic sections to obtain the required selectivity. While this approach works well at the current facilities, simulations indicate that for the much larger primary beam intensities that will be available at RIA the production of secondary contaminants by the intense reaction products at the intermediate degrader will not be removed by such an approach and will contaminate the weakest reaction channels. In addition, it has been determined that in some cases the contaminant beams are intense enough that the location where they will be implanted has to be within a non-reactor category 3 DOE nuclear facility. Clearly they must therefore be restricted to a well-defined region of the fragment separator. The power in these beams and the primary beam must also be handled properly.

A novel design for a fragment separator capable of properly handling the high beam intensities while removing the limitations recognized above has been identified. The main modification required is the addition of a preseparator section before the fragment separator. The preseparator is essentially a shortened fragment separator that provides a coarse selection of the isotopes of interest via energy loss in a solid. The unwanted high-intensity contaminants are removed by slits at the entrance of the main fragment separator. This provides numerous advantages: 1) only a much reduced intensity of contaminants reaches the wedged degrader of the main fragment separator so that production of secondary contamination becomes negligible, 2) the primary beam and main contaminants are confined to a well defined region which can be enclosed in the category 3 section of the facility, 3) these strong contaminants are focused to well defined points in this area so that they can easily be handled by high power beam dumps or collected if needed for other applications with minimal interference to the isotopes of interest , and 4) this additional section introduces minimal resolution loss to the full system.

Two types of fragment separators are actually needed for RIA, a high-resolution separator to provide beams to high-energy experiment and a very high acceptance device to provide ions to a gas catcher system, and both will require this modification. In the case of the separator feeding the gas cell system this will probably also lead to a reduction in cost since the preseparator coupled to the achromatization section that was required after the standard fragment separator will most likely be sufficient to meet the requirements for the system without the fragment separator.

A more detailed understanding of this new approach is now required to maximize resolution and identify the best location for beam dumps. Simulations using the new version of the code LISE, LISE++ have been set up, and a number of representative cases involving fragmentation and in-flight fission reactions will need to be computed, under a continuation of part of this work that will be funded by DOE RIA R&D funds, to determine these parameters. Fundamental work on the ion stopping at high energy, critical to a proper understanding of the modifications of the beam properties when traversing the solid degraders, has been performed in collaboration with colleagues at GSI and the gained understanding will be added to the LISE ++ simulations.

Specific Accomplishments: Preliminary results on the experiments performed on ion stopping were reported at the EMIS-14 international conference and will appear in the EMIS-14 proceedings.

C. Scheidenberger, et al., “Energy and Range Focusing of In-Flight Separated Exotic Nuclei,” accepted for publication in *Nucl. Instru. And Methods in Phys. Res. B*.