Collaboration Questionnaire -- Instrumentation for FRIB

The Recoil Separator for Astrophysical Capture Reactions (SECAR)

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

The motivation to build SECAR is to enable direct measurements of astrophysical reaction rates with rare isotope beams from NSCL ReA3 and FRIB. Such measurements are needed to understand stellar explosions such as X-ray bursts and Novae, as well as other astrophysical scenarios such as late stellar evolution and explosive nucleosynthesis in supernovae. SECAR is a recoil separator optimized for capture reaction rate measurements, for which it provides the high rejection of unreacted beam particles needed to measure extremely low cross sections by counting recoils at incident beam intensities in excess of 10^7 pps.

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?

SECAR is a highly optimized device that differs from other equipment available, under consideration, or proposed for FRIB.

- It is optimized for proton capture reactions (alpha capture can also be performed), where recoil and beam mass difference are minimal and where beam rejection is therefore most challenging.
- It is optimized for measuring the smallest cross sections obtainable with the highest intensity rare isotope beams available at FRIB.
- The measurements are performed by counting the separated recoils – recoils are not merely a tag for other measurements.

Therefore, SECAR will have unique capabilities, most importantly a very high rejection of unreacted beam particles.

SECAR will be used in conjunction with a Gas target system. We envision to use a modified version of the gas jet target being developed for NSCL ReA3/FRIB. In addition, an efficient gamma-ray detection system around the gas target will be used. Such a system is available.

We intend to use SECAR already at NSCL for measurements of capture resonances with particularly high cross sections.

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?

The SECAR project is currently in the conceptual design phase. The nature of this project is such that even a rough outline of the main components requires very detailed calculations and designs.

SECAR will consist of a set of ion optical devices (magnets, electrostatic elements, others) that form several stages to achieve the desired beam rejection. The funded design process envisioned for the coming year will include an analysis of a number of alternative options to achieve the design goals. One of many possible designs is shown in the figure, inspired by the St. GEORGE recoil separator project currently underway at the University of Notre Dame.

As the conceptual design is still under development, the capabilities are not finalized. What is currently envisioned is: (a) beam rejection in excess of $1:10^{10}$ up to mass A~65 ; (b) sufficient acceptance to transmit all recoils for the reactions of interest (likely in the range of +- 20-40 msr); (c) Rigidity limit of ~0.8 Tm; and (d) Energy acceptance around +- 4%.

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

The project is currently in the conceptual design phase.

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

Project cost is currently estimated at 6.2 M. DOE Office of Nuclear Physics has selected the project for funding under FOA DE-PS02-08ER08-10 "Research Opportunities at Rare Isotope Beam Facilities".

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

Current collaborators are: Georg Berg, Notre Dame; Jeff Blackmon, LSU; Manoel Couder, Notre Dame; Uwe Greife, Colorado School of Mines; Fernando Montes, MSU; Ernst Rehm, ANL; Hendrik Schatz, MSU (spokesperson schatz@nscl.msu.edu); Michael Smith, ORNL; Michael Wiescher, Notre Dame; Al Zeller, MSU

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? web-site?)

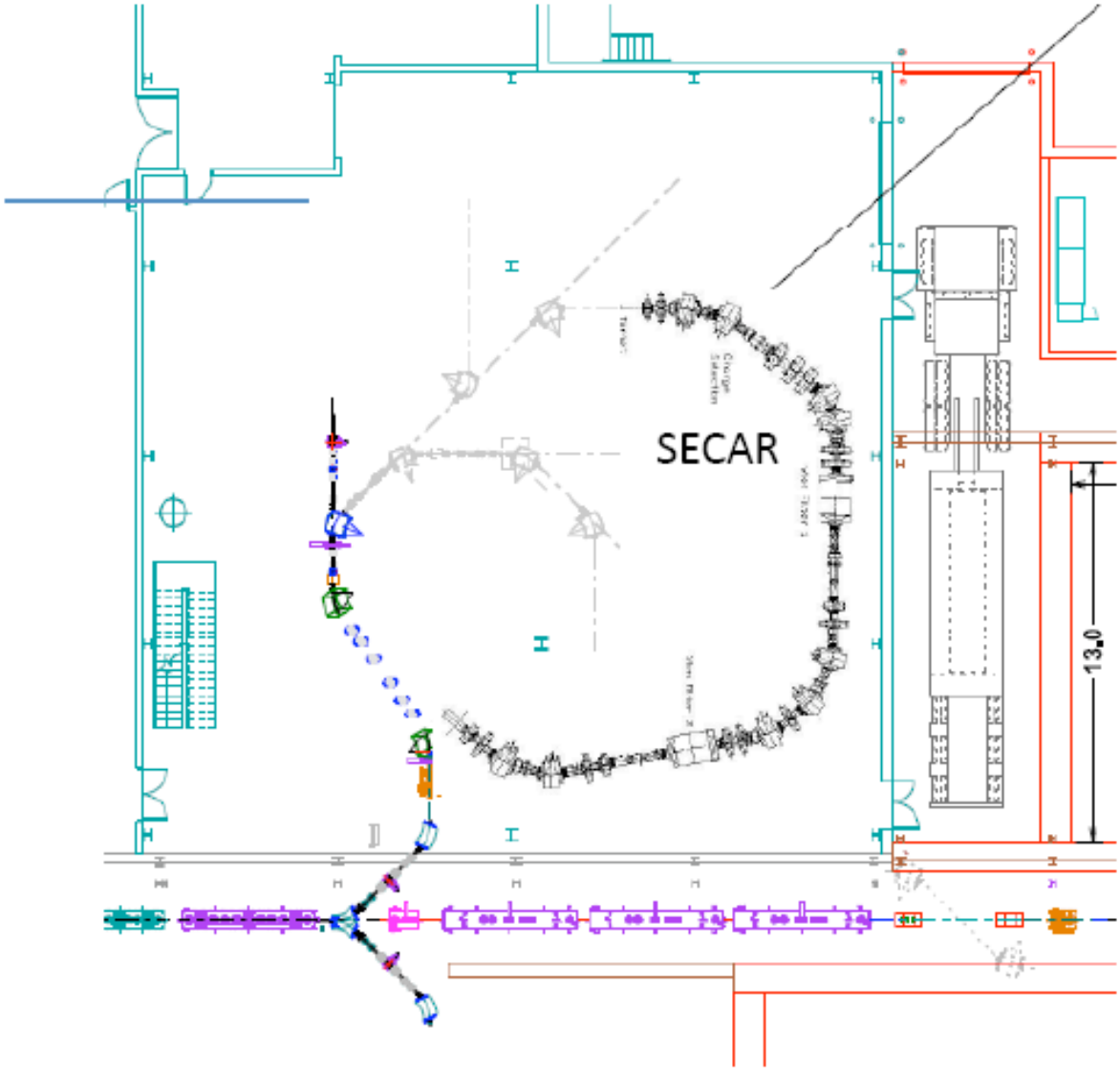
The collaboration is a subset of the FRIB nuclear astrophysics group (**fribastro.org**). Within fribastro.org, the project has been discussed at several FRIB and NSCL users meetings. This group then decided to submit a proposal to DOE for the funding of SECAR and to take advantage of the recoil separator design expertise currently available in the US at the University of Notre Dame, where the St George recoil separator is currently under construction. The collaboration is open and anybody interested to work on this project is welcome to join. Fernando Montes and Uwe Greife have joined since the submission of the proposal. There is a website at http://www.fribastro.org/5_EQUIPMENT/SECAR/SECAR.html

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

Alternative designs are currently being considered as part of the conceptual design process. We have not yet arrived at a final design.

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

Inherently, a recoil separator is difficult to move and to share among different facilities. The Daresbury recoil separator at ORNL has similar goals and characteristics but reduced performance.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