Collaboration Questionnaire -- Instrumentation for FRIB

Collinear resonance laser ionization spectroscopy

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

   Physics motivation: nuclear structure (shell structure, neutron/proton halo/skin), fundamental symmetries.

   Capability of the instrument: The system will enable to determine ground and isomeric states electromagnetic moments, nuclear spin, and mean-square charge radius with high detection sensitivity.

   Why is this important for FRIB science: This system can determine fundamental properties of nucleus away from b-stability line towards nucleon drip lines in the nuclear chart with high detection sensitivity.

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?

   It has high detection sensitivity (ultimately a few ions/second).

   The system will be used in conjunction with a gas filled linear quadrupole ion trap (Beam Cooler and Buncher) to bunch ion beams.

   The system can provide isomerically pure ion beams due to the high selectivity of laser ionization, which may be used by other experiments that require such a beam property.

   The system can be used at NSCL or other laboratory before FRIB.

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?

   Area and beam line layouts are illustrated in figure 1 and 2, respectively. Ion beams from gas stopping system will be bunched using the gas filled linear quadrupole ion trap and transported to the resonance laser ionization beam line. The ion beam will be first neutralized, through charge exchange reactions with alkali vapor in a charge exchange cell (CEC). The neutral atoms will then interact with laser lights (interaction region: ~1 m long). The atoms will be selectively ionized through two ~ three excitation steps and the ions will be detected as a signal. The detection sensitivity (background rate) is ultimately determined by the vacuum condition of the interaction region.

   This technique may be able to apply to the ion rate about a few ions/second.

   The design (including the laser system) has not been fixed yet and multiple options are being considered.

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

A collinear laser spectroscopy and beta NMR systems are being developed at NSCL (BECOLA: http://groups.nscl.msu.edu/becola/). Some components/techniques can be used in the collinear resonance laser ionization spectroscopy. The charge exchange cell and photon/ion detection system are being tested/developed in collaboration with groups at University of Mainz and ISAC.

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

Approximate cost: ~$1.5 million (major components: laser system ($850K), vacuum pump system for UHV ($350K), beam line ($100K), and detection system ($50K)).

Possible source of funding: will be discussed.

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

B. Barquest (MSU (GS)), G. Bollen (MSU), C. Geppert (U. Mainz/GSI), A. Klose (MSU (GS), A. Krieger (U. Mainz (GS)), P. Levy (TRIUMF), P. Mantica (MSU), K. Minamisono (MSU: contact person (minamiso@nscl.msu.edu)), P. Mueller (ANL), W. Noertershaeuser (U. Mainz/GSI), R. Ringle (MSU), S. Vinnikova (MSU (GS))

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?)

A web-site will be established for laser spectroscopy experiments at NSCL and FRIB. Meetings (annual/bi-annual) and/or circular mailings will be developed.

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

Some of the key components will be tested at an existing collinear laser spectroscopy facility in collaboration with groups at University of Mainz and ISAC to identify the best configuration for the proposed system. One of ongoing projects is a test of CEC. The CEC (ISAC design, NSCL made) will be shipped to University of Mainz and its performance will be compared with an alternative design of CEC.

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

Laser spectroscopy with bunched beam experiments at ISAC.

Laser systems for the resonance laser ionization source at ISAC and ORNL are similar setups for collinear resonance laser ionization spectroscopy.