CONSTRUCTION OF A GAS STOPPING STATION AT THE NSCL

P.A. Lofy, D.J. Morrissey, M.M. Baird, G. Bollen, J.H. Ottarson,
R.J. Ringle, S. Schwarz, V.L. Varentsov[a]

Measurements on nuclei far from stability can and will continue to provide the most stringent tests of nuclear theories. Detailed measurements of masses, half-lives, and decay processes will be possible with thermalized beams of ions from the NSCL s Coupled Cyclotron. Even the most exotic nuclei can be studied if the thermalization and subsequent extraction are rapid (~10 ms).

For example, the measurement of masses with high precision is best accomplished using low energy ion beams. Therefore, in order to meet the emerging requirement for thermal energy beams and to study the intricacies associated with stopping and collecting ions from projectile fragment separators, the gas stopping project was initiated as part of the larger LEBIT (Low Energy Beam and Ion Trapping) Project, described elsewhere in the NSCL 2000 Annual Report. The focus of this report is the stopping of the fast radioactive beams in a gas stopping station.

The Gas Stopping Station will function as a high pressure, gas-filled radioactive ion source. Beams of exotic nuclei will be produced in the A1900 fragment separator and transported to the N4 vault. The ions will be dispersed on a shaped degrader and refocused onto the entrance window of a gas cell. The Gas Stopping Cell is the key element that is under development. The cell will use approximately one bar of high purity helium gas to stop the intermediate energy ions as they straggle through the entrance window. These exotic nuclei will be thermalized in the helium and extracted from the cell with electric potentials and gas flow through a supersonic nozzle. The ions will be captured in an rf multipole rod structure in a differentially pumped expansion chamber. Then, the ions will be transported at low potential to one of the low-energy beams lines in the N4 vault extension.

The group has two goals in the forefront. First, the design and construction will be optimized to perform the stopping and extraction of ions with a high efficiency. Second, in order to conduct interesting physics experiments, the extraction of ions from the gas cell must be completed quickly in order make mass measurements on nuclei that have half-lives on the order of ~10 ms.

Until recently, similar efforts involving gas stopping cells were characterized by a clear separation of nuclear physics from the gas stopping or atomic physics. The origin of these efforts can be traced back to the IGISOL work in Jyv skyl [1]. The NSCL s initiative is among several new attempts to stop and collect very energetic ions in relatively high pressure gases. Other gas stopping projects currently underway include:

	Gas	Cell Size	Pressure	E (MeV/A)
Argonne [2]	He	~ 20 cm	100 mbar	~ 3
SHIPTRAP [3]	He or Ar	15-20 cm	150-200 mbar	~ 5
RIKEN [4]	He	200 cm	150 mbar	~ 50
NSCL Gas Cell	**He**	**~ 50 cm**	**1 bar**	**~ 100**

The projects listed above cover a wide range of incoming beam energies. The NSCL s attempt to bring the highest energy beams to rest is a challenge indeed. The stopping of intermediate energy ions in this gas cell is a bridge to performing gas stopping at the Rare Isotope Accelerator (RIA), where beam energies may be as great as 400 MeV/A.

The gas stopping program at the NSCL began to take shape in the later part of 2000. Vacuum equipment arrived in the fall and was assembled soon thereafter. Figures 1 and 2 below depict the basic layout of the Gas Stopping Station. The principle hardware consists of three 13.25" ConFlat (250 mm tube) six-way crosses with the required vacuum pumps needed to support this differentially pumped system.

Figure 1: Gas Stopping Station photograph

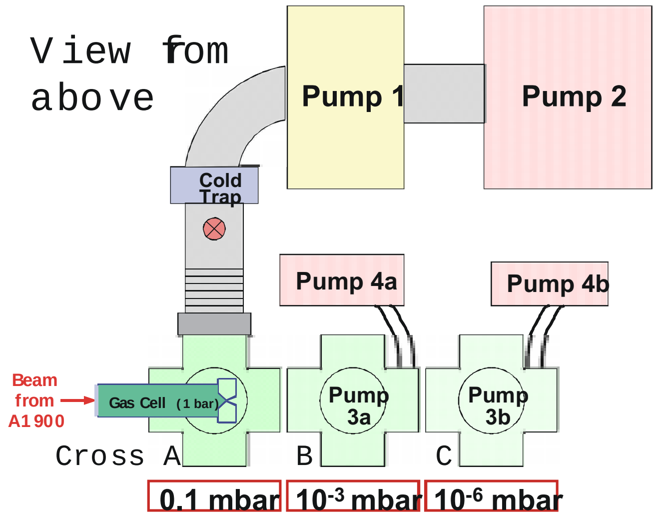

Figure 2: Block diagram accenting pumps and pressures

	Pump	Manufacturer	Model	Type	Pumping Speed	Cooling
1	Booster	Varian	VB-5400	Roots Blower	2550 L/s 5400 cfm	Oil
2	Backing (Booster)	Varian (for Tuthill Corp.)	KT-1350	Mechanical Piston	368 L/s 779 cfm	City water
3a, 3b	Turbo Pumps	Varian	2000HT MacroTorr	Turbo-molecular	2000 L/s	City Water
4a 4b	Turbo backing pumps	Varian	DS1602 DS1002	2-stage Rotary Vane	23 L/s, 49 cfm 15 L/s, 31 cfm	Oil

The underlying design is straightforward. The radioactive ions of the beam will enter the first cross (Cross A) from the left, where it will come to rest in the high pressure helium of a reentrant gas stopping cell contained within the cross. Through a combination of electric potentials and gas flow, the ions will be extracted through a supersonic nozzle and guided downstream by an rf quadrupole also contained in Cross A. The ions will exit Cross A through a skimmer, with most of the helium pumped away by the large Roots Blower (Pump 1) and its backing mechanical pump (Pump 2). These two large pumps will be able to handle the huge gas load coming from the high pressure helium cell.

In Crosses B and C, the ions will encounter another rf multipole and finally a Quadrupole Mass Spectrometer (for beam diagnostics) before leaving the Gas Stopping Station and being transported to the low energy beam lines. Design and construction of components within Crosses B and C are still underway.

Calculations and initial measurements of the gas flow from two nozzles have been completed and are presented elsewhere in this Report. The transport of ions in the LEBIT system has been studied and construction is beginning as also described in this Report.

This work was supported by the National Science Foundation under grant PHY-95-2844 and by the Department of Energy under grant DE-FG02-00ER41144.

a. V.G. Khlopin Radium Institute, St. Petersburg 194021, Russia

References

[1] P. Dendooven, Nucl. Instr. And Meth. B 126 (1997) 182-189.
[2] G. Savard, et al., Argonne National Laboratory Physics Division 1999 Annual Report, p. 104.
[3] J. Dilling et al., Hyperfine Interactions 127(1/4) 491-496, 2000.
The SHIPTRAP Project at GSI, http://www-aix.gsi.de/~shiptrap.
[4] M. Wada, et al., RIKEN Review No. 31, p. 56.