A PROPOSAL FOR AN ADDITIONAL BEAMLINE TO THE TRIUMF ISAC FACILITY

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Abstract

The present ISAC facility at TRIUMF is fed by one beamline, beamline 2A, that can direct beam to one of two target locations. One of these targets has been in use since ISAC was commissioned; the second is currently being commissioned. The number of proposals for experiments at ISAC are such that we feel the need to deliver more simultaneous radioactive ion beams. A proposal has been made for an another beamline to ISAC so as to make additional beams available. Through partial extraction by H^- stripping, this proposed line would extract a 450-500 MeV beam from extraction port 4 of the TRIUMF cyclotron. A fast switching system would be used to feed an additional two target stations, each equipped with its own mass-separator system. These new target stations will allow target and ion-source development, and also at least three simultaneous experiments at ISAC. In addition to these two target stations, provision for a 200 μA beam dump has been made.

INTRODUCTION

ISAC at TRIUMF is a radioactive ion beam facility that uses the isotope separation on line (ISOL) technique to produce radioactive ion beams (RIB). The ISOL system consists of a primary production beam, a target/ion source, a mass separator, and a separated-beam transport system. These systems together act as the source of radioactive ion beams to be provided to the accelerator or the low-energy experimental areas. We utilize the 500 MeV - 100 μA primary proton beam extracted from the H^- cyclotron[1]. A new beamline has been built to transport this beam to one of the two target stations followed immediately by a residual proton beam dump.

Before discussing the proposed new beamline we present an overview of the beamlines that are presently in operation at TRIUMF. Figure 1 shows a layout of the TRIUMF cyclotron and the existing beamlines. Beamline 1A (BL1A), running to the east of the cyclotron, is the high-current beamline that feeds experiments in the meson experimental hall. Although capable of extracting beams in the energy range from 180 to 500 MeV at a maximum intensity of 170 μA, it is normally run at 500 MeV at a beam current of ~ 150 μA. Beamline 2C is used for proton therapy (PT) and for isotope production. The latter accepts beam in the energy range of 70 to 110 MeV with a typical beam current of 50μA (maximum 80 μA). To the west of the cyclotron, beamline 4 (BL4) feeds beams to experimenters in the proton experimental hall. The energy range of this beamline is 180 to 500 MeV at a maximum intensity of 10 μA.

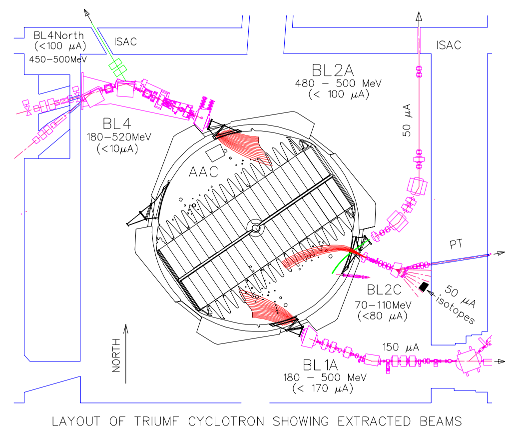

Figure 1: Beamlines in the cyclotron vault.

The TRIUMF ISAC facility is now fed by one beamline, beamline 2A, that delivers extracted beam in a northerly direction. This beamline is designed for extraction energies between 480 and 500 MeV and an intensity of 100 μA. Currently, the typical operating intensity of 50 μA is limited by the targets. The primary proton beam can be directed to one of two targets: the west target that has been in operation since ISAC was commissioned, and the east target to which the proton beam has been delivered just recently. Because of the demand for experimental beam, provision of additional beamlines to ISAC is considered imperative.

THE PROPOSED BEAMLINE 4N

Historically, extraction port 4 of the TRIUMF cyclotron has been used for beam delivery to the TRIUMF proton experimental hall. There the demand for beam time for experiments has been declining. Consequently, it is proposed to install another beamline from this extraction port such that this new beamline could be used to provide the additional lines to the ISAC facility. The vault portion of this beamline is seen in the upper left corner of figure 1. An overview of the proposed facility is shown in figure 2.

This new beamline, called beamline 4N (N for North), more-or-less parallels BL2A and runs north to deliver beam to another set of targets and mass analyzing systems. Thus, in principle, three beams of radioactive ions—one from beamline 2A and two from beamline 4N—could be delivered to ISAC.

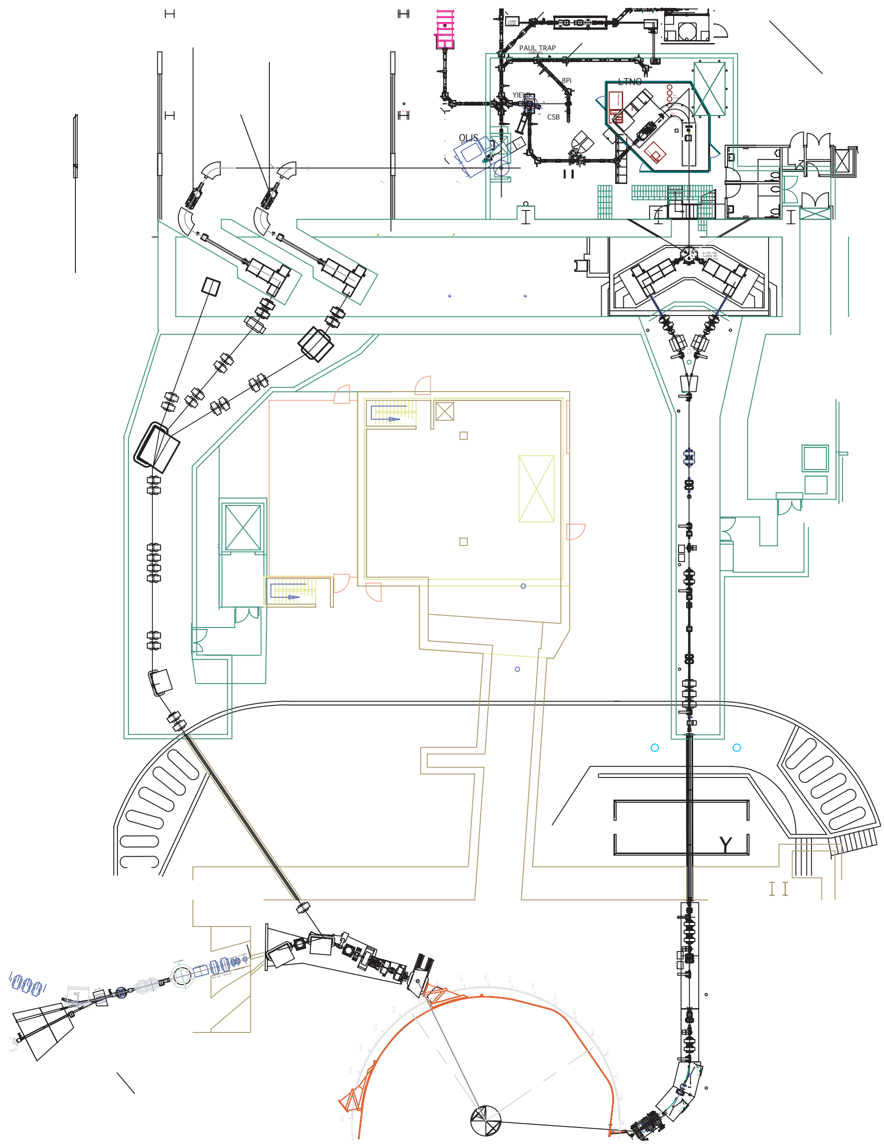

Figure 2: Beamlines to the ISAC facility: existing BL2A (right) and proposed BL4N (left).

Optics of the beamline

The vault section of BL4N utilizes the first three quadrupoles of BL4. Because we wish to leave the beamlines to the proton experimental hall intact, the existing 40° dipole is replaced with a switching magnet that bends 40° left and 32.6° right with respect to the direction of the extracted beam. A quadrupole doublet is also added in this vault section. There follows a long 16 m drift through the (existing) shielding berm of the cyclotron to the tunnel that encloses the remaining portion of the beamline. In the tunnel a quadrupole doublet, another 32.6° dipole, and another quadrupole doublet are the first transport elements encountered by the beam. These elements are used to produce a dispersed double waist at the midpoint of the long drift through the berm and a doubly-achromatic double waist downstream of the last dipole.

A four-quadrupole matching section follows to produce another double waist with a beam size of ± 2 mm in each of the horizontal and vertical directions.

A quadrupole doublet and a switching magnet follow. The switching magnet directs beam to the two targets. The east target is reached through a bend (relative to the beam direction at the entrance of the switching magnet) of 60° to the right followed by one of 30° to the left. Similarly, the west target is reached by a bend of 40° to the right followed by one of 10° to the left. Beam size at each target is designed to be a double waist of dimensions ± 2 mm in each of the horizontal and vertical directions. Because any targets will be relatively thick, double achromaticity at a target is not required. However, the beamline is designed to be spatially achromatic ($R_{16} = 0$ in TRANSPORT notation) only at a target.

Figure 3 shows the beam half-widths along the beamline leading to the east target. Note that the vertical half-width is plotted as negative.

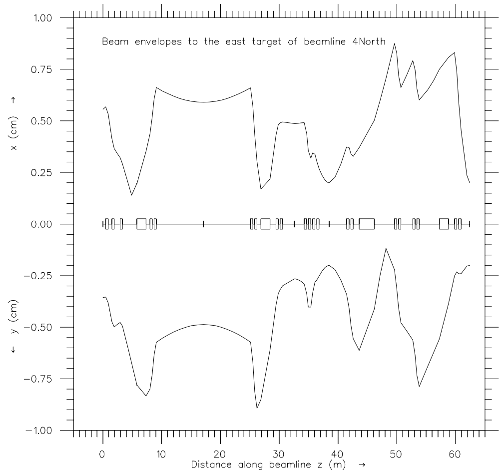

Figure 3: Beam envelopes along the beamline leading to the east target.

With all beamlines operating at their full intensities (BL1A at 150 μA, BL2C at 50 μA, BL2A at 100 μA, and BL4N at 100 μA), a beam-dump capacity of 400 μA will be required in order that the cyclotron be tuned for extraction of that amount of beam. Consequently, another beamline bending 20° degrees to the right (relative to the beam direction at the entrance of the switching magnet) is proposed to direct beam to a 200 μA beam dump. This, in conjunction with the BL1A beam dump, provide the required beam-dump capacity.

NEW TARGET STATIONS FOR THE ISAC FACILITY

The ISAC target stations are located in a sealed building serviced by an overhead crane. The target maintenance facility includes a hot cell, warm cell, decontamination facilities, and a radioactive storage area. The target area is sufficiently shielded so that the building is accessible during operation at the maximum proton beam current.

Beamline elements near the target are installed inside a large T-shaped vacuum chamber surrounded by close-packed iron shield. This general design eliminates the air activation problem associated with high-current target areas by removing all the air from the surrounding area. The design breaks naturally into modules; an entrance module containing the primary beam diagnostics, an entrance collimator and a pump port; a beam dump module containing a water cooled copper beam dump; a target module containing the target/ion source, extraction electrodes and first steering component and heavy ion diagnostics; and two exit modules containing the optics and the associated diagnostics for the transport of heavy ion beams.

The actual ISAC facility comprises two target stations. They share the same proton beam and the same mass separator. We can swap from one to the other by reversing the magnetic field in the Y-magnet in beam line 2A. This mode of operation does not permit target and new ion beam development and simultaneous delivery of RIB to experiments.

Development of new RIB is crucial because each element can take up to 2 years before it can be delivered to experiments. On the other hand, ion-source development in the harsh environment of the target is even more crucial.

In order to allow target and ion source developments for the future program at ISAC we are planning to build new target stations on the new beam line 4N. The actual target hall will be expanded to the west to include room for the two new target stations. The idea is to use as much of the actual infrastructure that we have developed over the last 10 years for the remote handling, nuclear ventilation, waste storage, etc. Furthermore, the new target station will use the same technology we have successfully developed for our actual RIB operation. Figure 2 shows a layout of the actual and proposed target stations. Each of the new stations will have its own mass separator in order to be able to switch from development work to RIB delivery in a very short time.

Eventually, we will be able to deliver more beams by the addition of a new switch-yard in the diagnostic box like the ISOLDE GPS design [2]. This design allows the selection of three ion beams within the mass range of ±15% from the central ray. This setup will eventually allow us to serve three experiments at the same time.

ACKNOWLEDGEMENT

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REFERENCES

[1] P. G. Bricault, M. Dombsky, P. W. Schmor, and G. Stanford, Radioactive ion beams facility at TRIUMF, Nuclear Instruments and Methods, B126 (1997) p. 213.

[2] E. Kugler et al. NIM B70 (1992) 41.