COMMISSIONING AND INITIAL OPERATION OF THE ISOTOPE PRODUCTION FACILITY AT THE LOS ALAMOS NEUTRON SCIENCE CENTER (LANSCE)*

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Abstract

The recently completed 100-MeV H$^+$ Isotope Production Facility (IPF) at the LANSCE will provide radioisotopes for medical research and diagnosis, for basic research and for commercial use. A change to the LANSCE accelerator facility allowed for the installation of the IPF. Three components make up the LANSCE accelerator: an injector that accelerates the H+ beam to 750-KeV, a drift-tube linac (DTL) that increases the beam energy to 100-MeV, and a side-coupled cavity linac (SCCL) that accelerates the beam to 800-MeV. The transition region, a space between the DTL and the SCCL, was modified to permit the insertion of a kicker magnet (23^o kick angle) for the purpose of extracting a portion of the 100-MeV H$^+$ beam. A new beam line was installed to transport the extracted H+ beam to the radioisotope production target chamber. This paper will describe the commissioning and initial operating experiences of IPF.

INTRODUCTION

The radioisotope program at the Los Alamos National Laboratory (LANL) has been a successful and ongoing effort in the production and distribution of isotopes, nationally and internationally. LANSCE has been an integral part of this program for more than 20 years. Traditionally, the production of radioisotopes at LANSCE was accomplished by the irradiation of targets near the LANSCE H$^+$ 800-MeV beam stop. However, this production capability ended when the mission and experimental program of LANSCE changed. To meet the continuing demands for radioisotopes from the medical community, research organizations, industry and government institutions, IPF was designed and constructed at LANSCE [1, 2]. On December 23, 2004, IPF received its first beam. Commissioning of the facility was completed at the end of April 2004, having achieved all of the design criteria. Operation will restart in the fall of 2004 when LANSCE resumes beam operation for its user programs.

IPF BEAM LINE

The layout of the IPF beam line optics and diagnostics is shown schematically in Fig. 1. The upstream face of the 10.5 foot-thick shield wall is the demarcation between the portion of the beam line installed in the pre-existing LANSCE beam tunnel and the portion installed in the new IPF lower facility. Fig. 2 shows in more detail the layout of the IPF beam line from the transition region (shown in yellow) to the shield wall separating the old and new tunnels.

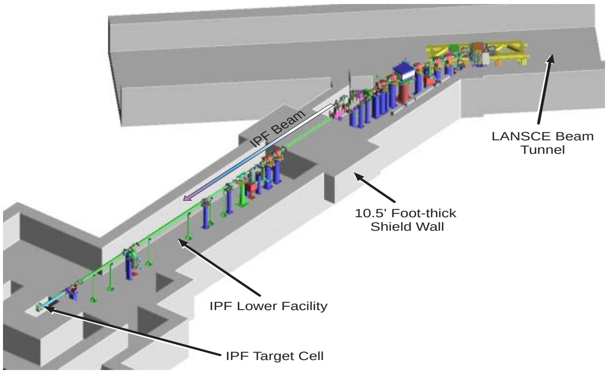

Figure 1: Layout of the IPF beam line. The LANSCE accelerator is not shown.

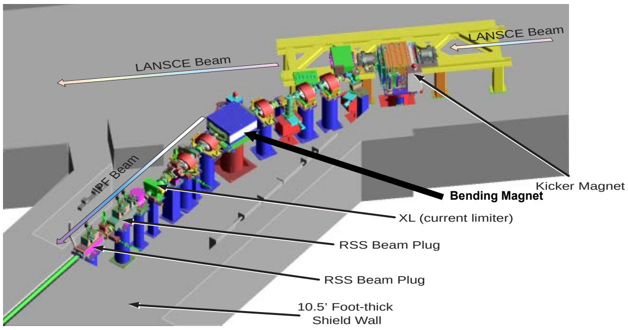

Figure 2: Layout of the IPF beam line in the LANSCE accelerator tunnel, starting with the placement of the kicker magnet in the transition region. The LANSCE accelerator is not shown.

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The purpose of the IPF beam line in the LANSCE primary-beam tunnel is to extract the H+ beam from the LANSCE accelerator (total deflection due to the kicker and DC bender magnets 45°) and to prepare it for injection into the IPF lower facility through the 10.5 foot-thick shield wall. Principal beam line components include a kicker magnet (23° bend), a DC bender (22° bend), five quadrupole magnets, two X-Y steering magnets, two current monitors, four beam position monitors (BPMs), a wire scanner, seven beam loss monitors, a beam current limiter, a fast valve and three beam plugs (one for tuning and two for radiation protection). All of the beam line elements, plus associated vacuum and water systems, had to fit in the pre-existing confined space surrounding the LANSCE transition region. Figs. 2 and 3 give a sense of the space limitations that played an important role in the design of this portion of the beam line. In particular, limited space placed stringent requirements on IPF kicker magnet design and fabrication [3].

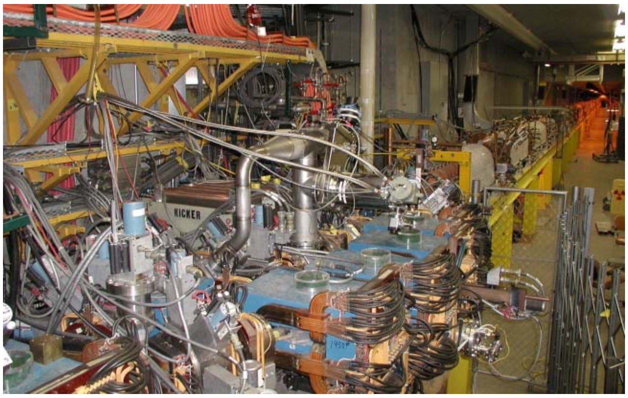

Figure 3: Downstream view of the LANSCE transition region between the DTL and SCCL accelerators. H^+ beam is extracted to the left.

Figure 4: The IPF kicker magnet as installed in the LANSCE transition region. Upstream end of the magnet is to the left.

Space limitations played no role in the new IPF lower facility which houses the balance of the IPF beam line and the target irradiation station (see Fig. 5). The function of this portion of the beam line is to raster the beam in a circular pattern and transport the resultant beam to the IPF target. Rastering the beam profile mitigates beam damage to targets by producing a more uniform beam irradiation of the target. Active beam line components include two quadrupole magnets, two rastering magnets (raster rate 5 kHz), two X-Y steering magnets, two current monitors; four beam position monitors, five beam loss monitors, a target harp, and a guard ring. In both segments of the beam line the principal diagnostics for beam tuning are the BPMs, wire scanner and target harp.

Figure 5: View of IPF lower facility looking downstream towards the target irradiation station.

IPF COMMISSIONING ACTIVITIES

IPF commissioning entailed more than commissioning the IPF beam line and target facility. It required the return to service of the H^+ injector and low energy beam transport (LEBT). Neither the injector nor LEBT had been operational for a number of years. Additionally, delivery of beam to IPF required the resumption of dual-beam operation (H^+ and H^-) for the DTL in such a way that the H^+ beam requirements of IPF were met while minimizing the impact on H^- beam quality for all other user programs at LANSCE. Once the above prerequisites were accomplished, commissioning of the IPF beam line and target began, resulting in first beam to IPF on December 23, 2004.

In commissioning the IPF beam line, four systems received special attention. All four of them are particularly important to meeting the design beam line requirements. They are the BPMs, the rastering magnets, the target harp and the guard ring. The BPMs are intended to be the primary diagnostic for setting the beam line tune and for monitoring and maintaining it. The rastering magnets are essential for distributing the beam power uniformly over the target irradiation area in order to mitigate beam damage to the target. The target harp and guard ring are necessary for precise beam profile measurements for both the rastered and unrastered beam.

Although the IPF kicker magnet and modulator system have been demonstrated to operate at their design specifications [3] in pulsed mode, this capability was not used for two reasons. First, there were no other H^+ users requiring beam and, second, DC kicker operation facilitated beam line commissioning (e.g. it allowed the use of a stainless steel magnet vacuum chamber rather than quartz one [5]).

COMMISSIONING RESULTS

The H^+ Cockcroft-Walton injector was thoroughly tested and conditioned to provide reliable beam injection into the LEBT. Refurbished vacuum pumps, magnets, diagnostics, and other hardware repairs allowed the LEBT to be restored to service. Dedicated beam time for accelerator development allow for the resumption of routine dual-beam operation (H^+ and H^-) to the transition region. Beam was successfully transport through the modified transition region and the IPF beam line, resulting in first beam to IPF on December 23, 2004. Subsequent commissioning activities allowed for the gradual increase in average beam current from ~2 μA up to the design value of 250 μA.

The diagnostic systems performed as expected, resulting in minimal beam losses in beam transmission to target. The raster magnet system performed as designed to evenly distribute the beam over the target irradiation area. Transverse profiles of unrastered and rastered beam were monitored by the target harp as shown in Fig. 6. Commissioning of prototype target stacks followed the commissioning of the beam line. Starting at low beam currents (20 μA), the target stack was irradiated for two hours and then inspected. In increments of 20 μA or more, the pattern was repeated, culminating in an extended 96-hr 100-μA irradiation (see Fig. 7). Following this test, the irradiation duration time was decreased to two hours and the average beam current was raised in increments until the design current of 250 μA was reached and sustained (see Fig.8).

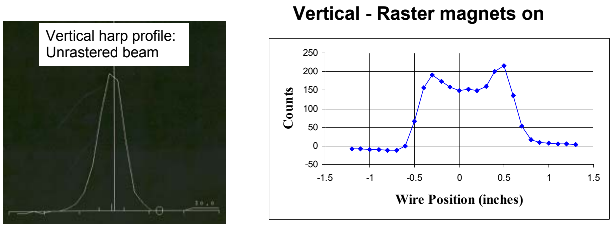

Figure 6: Vertical beam profile without and with rastering.

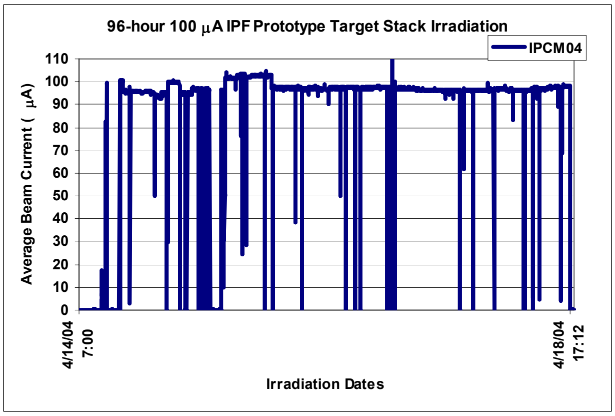

Figure 7: Average beam current data taken during a 96-hr 100-μA irradiation of an IPF prototype target stack.

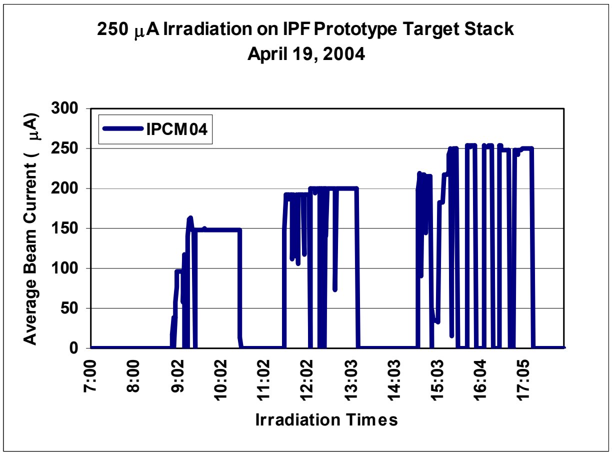

Figure 8: Data showing the increase in average beam current (100 μA to 250 μA) during the irradiation of an IPF prototype target stack.

SUMMARY AND CONCLUSIONS

Commissioning of the IPF beam line and target has been successfully completed. All beam line systems (e.g. the rastering magnets and the BPMs) met their design requirements. Beam losses are well within the expected operations envelope. The design average beam current of 250 μA has been achieved. Lastly, prototype target stacks have been irradiated at different beam currents and durations.

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