IMPROVEMENTS AT THE BNL 200 MeV LINAC*

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Abstract

After reconfiguration of the low energy (35 keV) and the medium energy (750 keV) transport lines in 2009-10, the Brookhaven linac delivered the highest intensity beam since it was built in 1970 (~120 µA average current of H^- to the Brookhaven Linac Isotope Producer). It also delivered lower emittance polarized H- ion beam for the polarized program at RHIC. To increase the intensity further, the match into the RFQ was improved by reducing the distance from the final focusing solenoid to the RFQ and replacing the buncher in the 750 keV line with one with higher Q value, to allow operation at higher power. The transmission efficiencies and beam quality will be discussed in the paper.

INTRODUCTION

The Brookhaven National Laboratory (BNL) 200 MeV drift tube linac (DTL) provides H^- beam at 6.67 Hz, 200 MeV for the polarized proton program for Relativistic Heavy Ion Collider (RHIC) and 66-200 MeV for Brookhaven Linac Isotope Production (BLIP). The RHIC program needs 2 pulses every AGS cycle (~4 sec), one for injection into Booster and other for polarization measurement at the 200 MeV polarimeter located in the High Energy Beam Transport line (HEBT). The rest of the pulses are delivered to BLIP. The requirements for

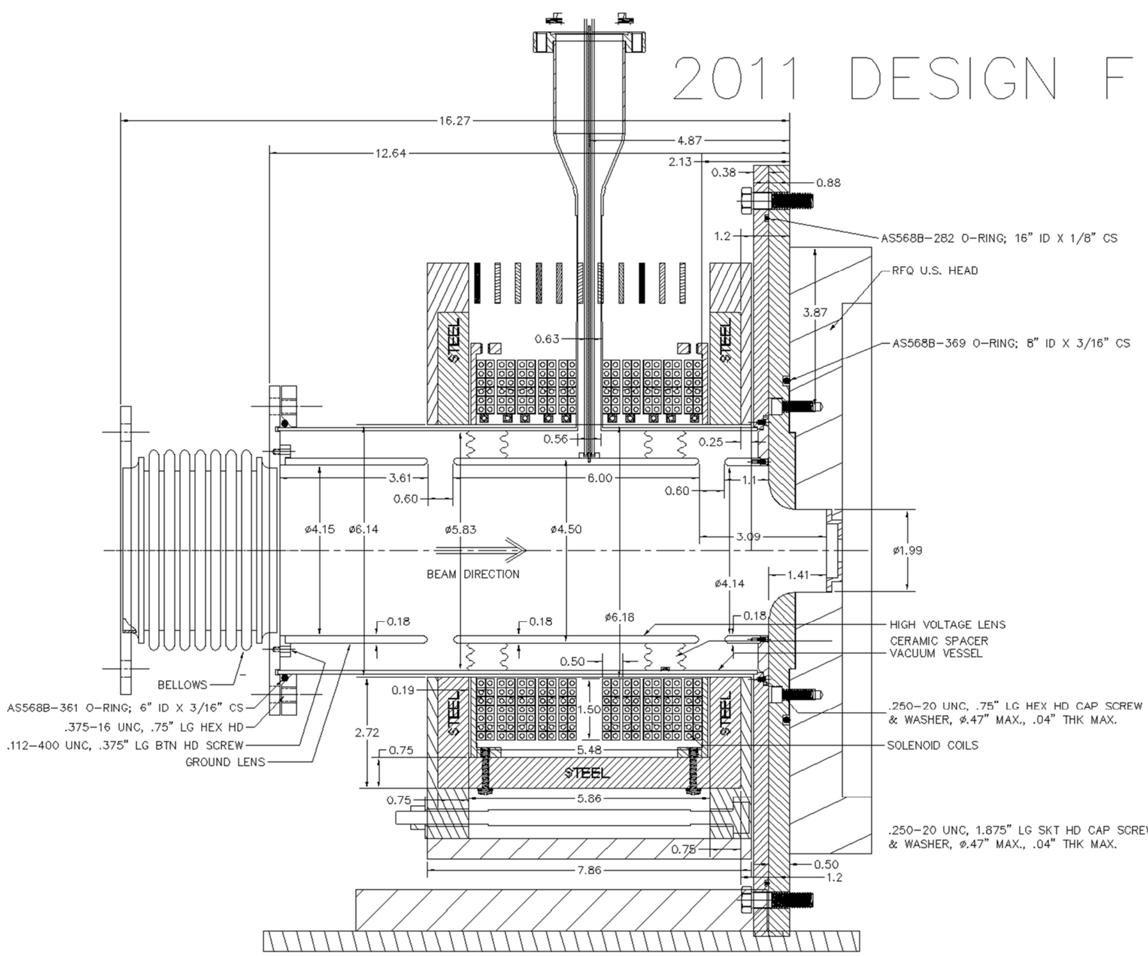

Figure 1: Design of the New Solenoid- and Einzel lens system for the front of the RFQ. The Distance between RFQ and solenoid was decrease by 1.08 inches.

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these programs are quite different and are the following. (1) RHIC: 200 MeV, 300 μA beam current, up 400 μs pulse length, polarization as high as possible and emittance as low as possible, (2) BLIP: 66-200 MeV, 450 μs pulse length, current as high as possible (~45 mA), uniform beam distribution at the target, and beam losses as low as possible. Prior to the upgrade in 2009, Linac transmission efficiencies from source to tank 9 were about 35% for the high current and 50% for the polarized beams and emittance growth several folds for the both beams. The emittance is one of the most fundamental parameters for any accelerator and in particular for the colliders. To reduce the emittance growth in the linac, low energy and medium energy beam transport lines were reconfigured as proposed in 2004 [1] in 2009 and results were reported in PAC2009, LINAC 2010 and PAC2011 [2,3,4].

CHANGES FOR 2012 RUN

Changes in the Low Energy Beam Transport

As reported in PAC11, the transmission through RFQ was down about 10% due to the increase distance of 1.5 inches between RFQ and solenoid to accommodate high voltage feed through for the Einzel lens. A solenoid and Einzel lens combo was redesign. In this design, solenoid the winding was split in two parts to accommodate the high voltage feed through and system was placed 1.08 inches closer to RFQ than last year. Figure 1 show the new solenoid-Einzel lens system.

The length of the system was reduced by 6 cm compare to 2010 design [4]. The magnetic field components at 5 cm are shown in figure 2.

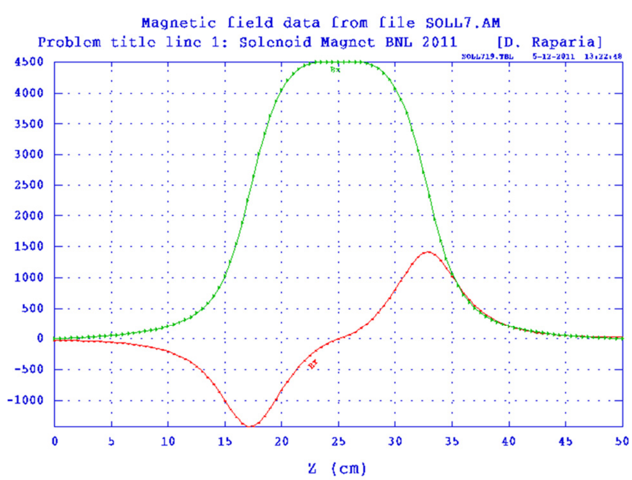

Figure 2: Magnetic field component Br and Bz along the length of the solenoid at 5 cm radius.

There is no depression in the axial magnetic field at 50 mm radius even though there are no winding in the middle due to high voltage feed through. By mistake it had only 120 turn instead of 140. It operated higher current than deign current but performed well and transmission through RFQ was increased by 10% as predicted by the calculations.

We use xenon gas in the low energy beam transport to compensate space charge for high intensity beam. We keep the line pressure about 3.6 x 10^{-6} torr. There is about 5% per meter loss due to stripping of H^- at this pressure. To reduce the pressure in the polarized beam line, we have install aperture in the line just before it meets the high intensity part of the beam line. We were able to keep lower pressure 2x 10^{-7} torr.

Changes in the Medium Energy Beam Transport

As reported in PAC 2011 that buncher performance in the MEBT is limited by the available power even thought the Q value was 10 time higher than the old buncher. For Run 12 we install still new buncher made out of copper instead of aluminium to increase the Q value by 75%. Table 1 shows buncher performance over the years.

Table 1: Buncher performance over the years

Parameters	1970	2009	2011	2012
Loaded Q	300	300	2000	3500
Power (kW)	5	10	5	5
Voltage (kV)	25	35	65	85
Trans. (%)	58	68	80	85

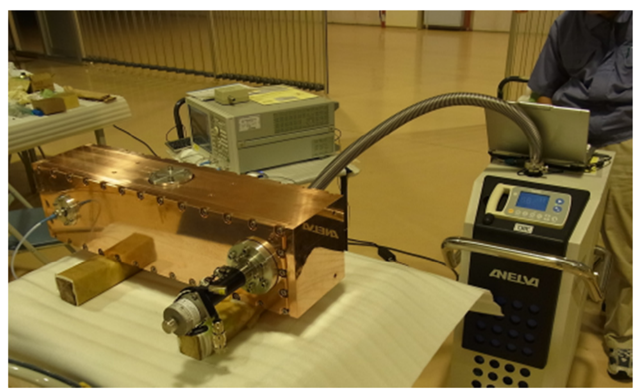

Figure 3: New 201.25 MHz copper buncher for the MEBT with Q (loaded) 3500.

RESULTS

Polarized H^-

For polarized H-, transmission from RFQ to Tank 9 was little better about 73% from 65% and polarization remain same although source current was increased by factor of two. Table 2 show the improvement of linac performance for polarized H- over the years.

Table 2: Linac performance for polarized H^-

RUN	ε_x (N,95%) π mm mrad	ε_y (N,95%) π mm mrad	Trans. (%)
2008	10.7	15.9	50
2010	4.5	5.5	65
2012	3.5	4.0	73

High Intensity H^-

The average intensity for the BLIP increased to 48 mA. The modification in the LEBT improved RFQ transmission by 10% and rest of the gain come from the new buncher in the MEBT. Table 3 show the comparison for the transmission for last three years

Table 3: Linac performance for high intensity

Intensity	2010	2011	2012
LEBT(mA)	70	70	70
MEBT (mA)	57	50	56
BLIP Target(mA)	39	41	48
Ave Cur.(μA)	120	125	130

Buncher did not perform as expected, after 3.5 kW, transmission is flat. We are planning to open the buncher and inspect this summer.

Run 12 for the polarized proton was very successful. Ion source (OPPIS) could produce higher current and linac transmission efficiencies are little better than the last year. Due to higher voltage in the buncher emittance for the polarized proton was about 25% better than the last year. In process of optimizing momentum spread out of linac, we discovered that Tank 7 was running about 1 MW lower power than the design.

This year average current delivered to the BLIP was lower than the last year in spite of higher beam current was available for the delivery. BLIP-targets had the problem of survivability.

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