STATUS OF THE BNL 200 MeV LINAC*

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ABSTRACT:

The BNL 200 MeV Linac normally accelerates H^- ions during its operating schedule. During selected periods, typically of six to ten weeks duration, polarized H^- ions are accelerated. Since Linac H^- commissioning, longer 7835 tube lives have been recorded and after initial operating bugs were eliminated, preinjector reliability has improved. Hardware components in the Preinjector, rf system, and ion source have been replaced or upgraded, and plans are being implemented for future system improvements. BLIP operations were initially curtailed during polarized beam running and a pulsed magnet has been installed in LEBT to restore BLIP running time to original levels.

INTRODUCTION:

The BNL 200 MeV Linear[1] Accelerator (LINAC) was converted to H^- acceleration in the Fall of 1982 and polarized H^- operating periods were first scheduled during fiscal year 1984 (FY84).[2] The polarized H^- beam is accelerated to 750 keV by an RFQ Linac operating 201.25 MHz.

Typical H^- beam current at 200 MeV is 25-30 mA peak with a maximum width of 470 microseconds at a pulse rate of 5 Hz. The ion source current at the preinjector terminal is typically 50mA. Polarized H^- beam current at 200 MeV is typically between 7 and 14 μA and the width is 500 μs at 0.5 Hz.

The polarized source current delivered to the RFQ had peak values near 20 μA. The measured polarization at 200 MeV was greater than 60%. During FY86, polarized beam operations were scheduled for 1600 hours out of approximately 6000 Linac operating hours.

A new beam line has been constructed in the Brookhaven Linac Isotope Production facility (BLIP) tunnel to supply 200 MeV H^- beam to the DOD Radiation Effects Facility and the planned Neutral Particle Beam Facility[3].

These new installations will use a small percentage of the beam pulses that normally go to the BLIP facility.

OPERATIONAL PERFORMANCE:

Figure 1 summarizes the Linac performance for the past five fiscal years. The best year was FY82 (96.2%) and the worst was FY83 (93.2%).

Since its original commissioning in 1971, the Linac reliability improved from 86% to 95% in FY76 when the repetition rate was reduced from 10 to 5 Hz[4].

The dip in reliability in FY83 is due to the early operating experience of the H^- source and its ancillary equipment.

The Preinjection failure rate was 0.49% in FY82 and 2.9% in FY83. The Preinjector data for FY85 includes polarized H^- operations.

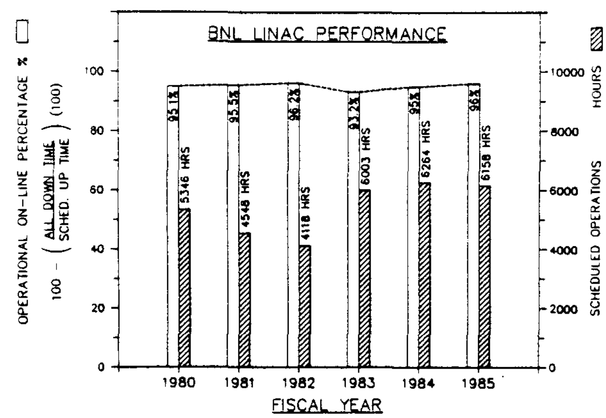

Figure 1 LINAC Reliability

Figure 2 plots the down time for the major contributors to Linac failures. Improvements have been implemented in most Linac systems over the years with recent and planned efforts being focused on the RF and the Preinjectors.

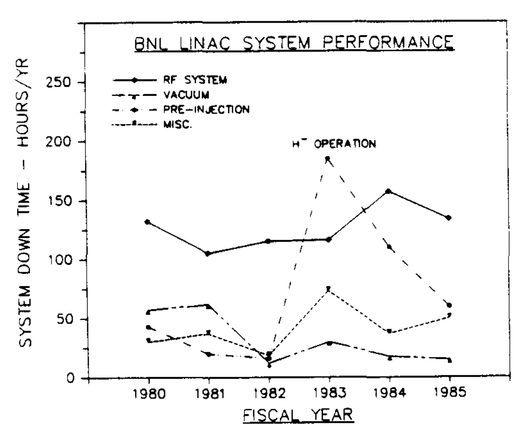

Figure 2 LINAC Major Systems Performance

PREINJECTOR:

The original pulsed quadrupole doublet located adjacent to the H^- ion source in the vacuum space of the 750 kV accelerating column failed several times since H^- commissioning. These magnets were constructed from laminated copper strips that were soldered at their connecting points.

The quadrupoles in both Preaccelerators have been replaced with a conventional doublet shown in Figure 3. The magnet parameters are:

Operating Current (Pulsed)	40 Amps
Resistance	0.130 Ohms
Inductance	2.5 mH
Gradient at Operating Current	400 G/cm

The pole profile for these magnets has been adapted from the LESB II 12Q12 quadrupoles (an AGS beam transport quadrupole) and from Brookhaven "narrow quadrupole" studies[5]. The coil slot dimension has been chosen such that the integral effect of the first harmonic of the quadrupole ($6\theta/2\theta$) is negligibly small. Field harmonics have been measured at 75% of the pole tip radius and are <0.1% except for the $10\theta/2\theta$ term which is 0.6% and agrees with the scaling prediction.

Significant down time has occurred because of support rope failures at the HV end of the 750 kV accelerating column. This Dacron rope has been replaced with a "Hi Lite" insulator string manufactured by Ohio Brass[6]. The installed insulator is shown in Figure 4. Its BIL rating is 1520 kV and the rms 60 Hz wet flashover is 780 kV.

A fire in preinjector #1, caused by a defective oil filled selenium rectifier, destroyed 20 rectifiers, several capacitors, and blackened the Preinjector enclosure before it was put out by the CO_2 extinguishing system. An extensive repair and clean-up effort over several weeks was required before the Preinjector was operational. Fortunately, Preinjector #2 was brought on line within a shift and overall laboratory operations were minimally affected.

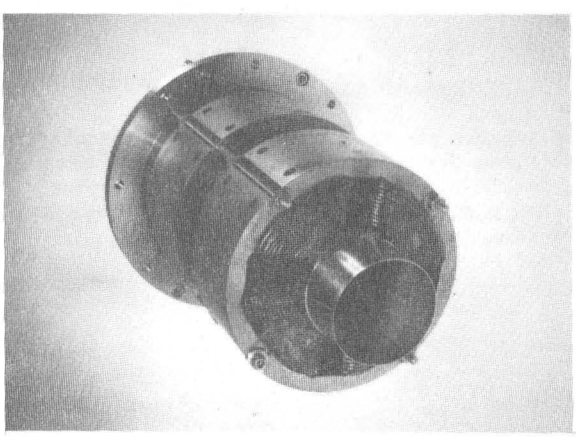

Figure 3 Quadrupole Doublet Assembly

In order to reduce the risk of fire, we are in the process of replacing the selenium rectifiers with controlled avalanche silicon rectifiers imbedded in a cast epoxy assembly. The rectifier used here was first tried at Fermi National Laboratory's Preinjectors with excellent results.

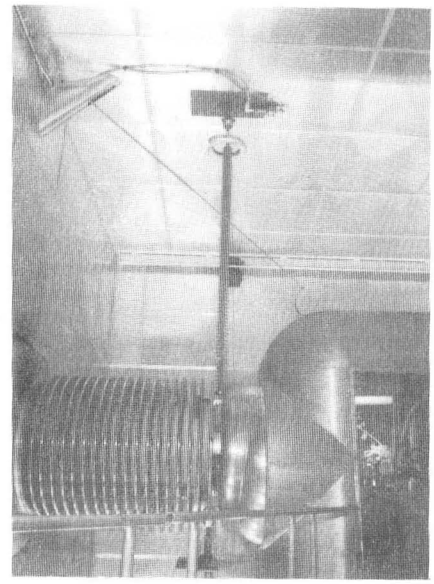

Figure 4 "Hi Lite" Installation

RF SYSTEM:

One of the beneficial effects expected from H^- operation was longer power amplifier tube life because of the reduced filament operating currents permitted with the lower beam power requirements, (typically 3.7 MW peak compared to 5.3 MW peak)[4]. The following is a summary of the tube life records to date (emission failures only).

Period	Average Time to Failure	Number of Failures
From 1971	14,043	35
Since 4/82	20,998	8

7835 Tube Failures Due to Low Emission

If the trend indicated by the data is real, a significant cost savings can be realized since our present 7835 rebuild cost is averaging over $75,000 per tube.

For the 78 failures that have occurred since 1971 the average time to failure for all causes is 11,500 hours and low emission accounts for 55% of the failures.

Development work has been completed on an SCR primary control regulator for the 7835 power amplifier anode supply. This modification will eliminate the series pass tube used to charge the 40 µF capacitor bank and save 1,507 MW hours per year for 5 Hz operation.

BLIP/POLARIZED H⁻ OPERATION:

During scheduled polarized H^- operation, the BLIP facility is unable to operate because of low beam intensity. A switching magnet (Figure 5) and pulsing supply have been built and tested in the LEBT transport system to permit injection of H^- beam pulses from Preinjector #1 between polarized H^- beam pulses. The power supply uses resonant discharge techniques, to produce a 5ms magnet current flat top with a stability of ± .05 per cent. A possible safety hazard in the AGS experimental area has to be resolved before this system can be used. If several failures occur simultaneously it might be possible to have a high intensity beam in a personnel area.

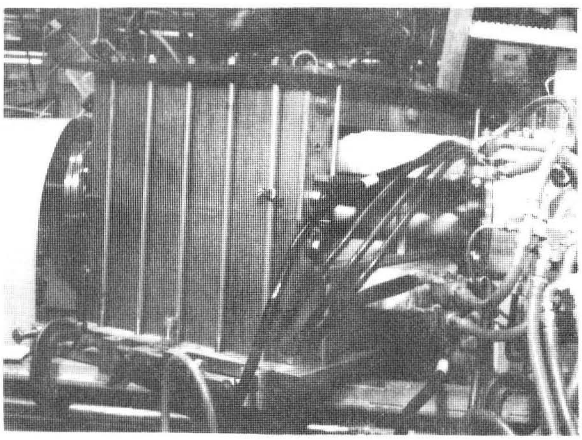

Figure 5 Low Energy Beam Transport Pulsed Magnet

RFQ:

Polarized H^- ions are acceleratd from 20 keV to 750 KeV by an RFQ Linac[7], operating at 201.25 MHz, before injection into the 200 MeV linac. Three 201.25 MHz bunching cavities are located along the 5.8 meter transport line between the RFQ and the Linac to preserve the bunch structure, assuring that all the beam captured by the RFQ is injected within the longitudinal acceptance of the Linac. Measurements before and after the Linac indicate that at least 90% of the injected beam is accelerated to full energy.

RF drive power of approximately 120 kW peak is provided by a power amplifier which uses an RCA 4616 tetrode in the final stage. This unit is identical to driver stages for the Linac 7835 power amplifiers.

Power is coupled to the RFQ via a one-into-eight coaxial manifold system[8] that distributes the power into two ports in each quadrant. The advantages of this drive method are: 1) the intrinsic field flatness of the quadrupolar symmetric structure is preserved; 2) the unwanted TE111 modes are suppressed by more than 25 dB below the operating TE211 mode; 3) the peak power at each input drive loop is only 15 KW.

Total accumulated running time of the RFQ is now over 3200 hours, comprised almost entirely of two polarized H^- runs in 1984 and 1985. The next anticipated running period is early 1987. In the interim, off-line studies are planned to investigate the effects of beam loading and determine the maximum beam current usable with this structure.

An amplitude control system[9] using the RCA 4616 screen modulator has been developed to regulate the accelerating gradient in the RFQ. The system regulates to better than .05%.

FUTURE PLANS:

A new RFQ, to be designed and built by the Lawrence Berkeley Laboratory will be installed to replace the existing Preaccelerators. A new symmetrical source is under development at BNL to enhance the capabilities of the RFQ and improve LINAC reliability[10,11].

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