ELECTRON BEAM ION SOURCE

MONTHLY REPORT

January 1-31, 2009

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| Performing Organization: | Brookhaven Science Associates |
| Location: | Brookhaven National Laboratory<br>Upton, New York 11973-5000 |
| Contract Period of Performance: | FY2005 – FY2010 |

BROOKHAVEN NATIONAL LABORATORY

**Brookhaven National Laboratory**
**EBIS MONTHLY PROGRESS REPORT**
**January 2009**

## I. Contractor Project Manager's Assessment

Technical Progress and Accomplishments

The highlights for this reporting period were the successful completion of the factory tests of the superconducting solenoid, and the acceleration of beam from the Test EBIS in the RFQ. Also, the request for quotation for the last major power supply order (MEBT and Linac quadrupoles) was dispatched. The annual DOE review of the EBIS Project occurred near the end of the month.

Issues and Concerns

A minor concern continues to be the availability of adequate staffing for installation activities. It is expected that this shortfall will improve as RHIC starts operations and resources can move from maintenance and machine improvements to EBIS construction.

## II. Detailed Status by WBS

### WBS 1.1 – Structural components

### EBIS Hardware

Superconducting Solenoid

L. Snydstrup of Brookhaven went to ACCEL from January 3-15, 2009 for the factory test of the EBIS solenoid magnet system. Initially, the system had problems in cooling down due to a blockage that prevented liquid helium filling. This was the same type problem that had occurred in December. Since the system was warmed up to 100K, the blockage was assumed to be water ice, instead of frozen nitrogen. The system was warmed up to above 273K and pumped down to remove any free water. When the LN2 cool-down was started, the fill was still blocked. Inspection with a borescope showed that the guide tube for the fill line was dislodged. The magnet turret was disassembled, the guide tube repositioned, and the turret reassembled. This delay resulted in an extended Brookhaven presence at ACCEL. The system was cooled down normally, and it was finally powered to full field on Monday, January 12. The testing was completed on Wednesday, January 14. The magnet system was ramped up and down to a full field of 5 Tesla several times without quenching and operated at 10% over the nominal field without any problems. The system was operated in persistent mode and the current leads retracted and reinserted successfully. The magnetic field was measured, and the results forwarded to Brookhaven subsequent to the testing. The measurement of magnetic field axis position was acceptable. The helium evaporation rate was measured to be within specification. Brookhaven subsequently accepted the test results, marking the completion of the factory testing, which had been attempted for the first time in July 2007. Shipment of the magnet is expected soon.

The purchase contract for the spare superconducting solenoid was placed with Cryomagnetics on January 27, 2009. The magnet system is expected to be delivered in October 2009.

Electron Collector

The beryllium copper electron collector was vacuum leak checked at Brookhaven and found to be acceptable. The unit was shipped back for the final machining and soldering of the water side parts. The delivery date is estimated to be early March. Brookhaven has manufactured the water manifold and chamber extension for this unit. The iron shield is also being fabricated at BNL.

Central Drift Tube

For convenience, the final drift tube assembly process has been moved to a new location, near the EBIS high bay assembly area in Building 930. The complete drift tube structure was assembled in its cradle except for the slanted mirror tube. (After processing at high temperature, the stainless steel slanted mirror tube was still found to be magnetic to an unacceptable degree; therefore, it was decided to remanufacture the tube from a better non-magnetic stock material). Several improvements were made to the assembly: 1) Holes in the support cradle, which were a potential source of high voltage corona, have been covered with a single stainless steel foil which spans the entire length of the cradle. 2) The drift mounting and adjustment system was modified to use coiled springs instead of Belville spring washers, which were found to be too rigid. In addition, cradle holes were expanded to slots to allow for the lateral motion necessary during drift tube height adjustment.

LEBT and External Ion Injection

The final designs of the deflectors for the switchyard chamber location are in process. The design of the cylindrical deflectors downstream of the ion sources is completed.

## RF Structures

IH-Linac

The Linac cavity is in the final stages of machining. Except for the face flanges of the upper and lower cavity, all machining features will soon be finished. RF testing is expected in February, and then these results will enable final machining of the face flanges. Copper plating of the finished cavity by GSI is planned for March 2009.

RFQ

The RFQ was successfully tested with beam, as described in the Test-EBIS section below.

Buncher Cavities

Manufacture of rebuncher cavity (C-1) continues.

## Test EBIS

16-pole deflector/lens: Installation of power supplies and HV cables for the 16-pole wide aperture deflector and adapter lens was completed at Test EBIS. The present configuration only allows one set of deflection settings, which can be optimized for either ion injection into the TestEBIS from the external source, or ion extraction from the TestEBIS following internal gas injection. Work is under way on new software and hardware multiplexer which will allow independent optimization of injection and extraction which is necessary for ion injection followed by extraction to the RFQ. The entire deflector and electronics has been installed on an isolated platform so that it can be biased to + /-10kV for use as an “adapter” lens, with independent settings during the ion injection and extraction periods.

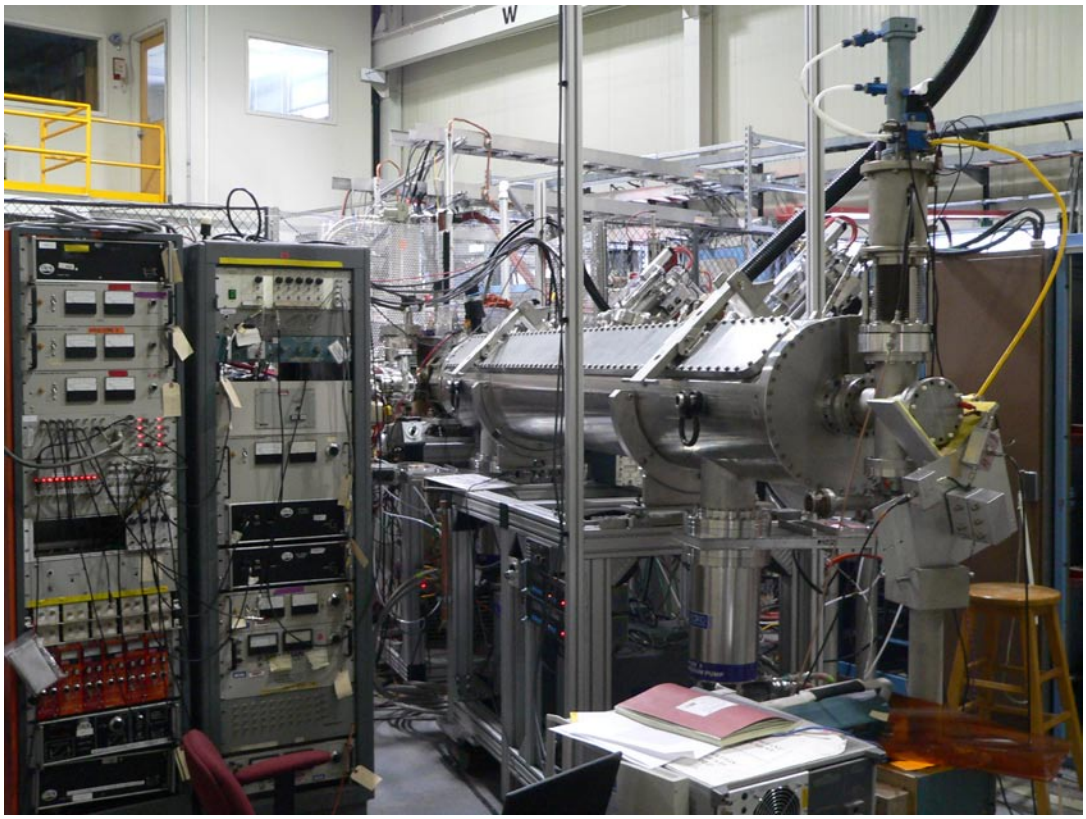
HV internal Lens: A -60 kV dc power supply was installed on the EBIS platform to provide voltage to the internal lens. The dc supply has to be either optimized for extracted beam during gas injection trials, or optimized for ion injection during ion injection tests from the external source. To accommodate independent lens settings during injection and extraction, a fast, bipolar 60 kV supply is under development. It uses three + /-20kV Trek supplies in series, and allows us to test the configuration planned for use in the RHIC EBIS facility. Power supply interface (PSI) control has been incorporated, with an additional 4 channels of V233 function generator supplied by the CAD Controls Group. New software control was added to EBIS voltage controller and timing program to accommodate analog pulse control using the PSIs, similar to the electron gun anode control implemented previously. Analog pulsing of the + /-60kV supply was tested, and achieved the full + /-60kV. Some corona problems were found and the solution will be applied to similar configurations being installed at the RHIC EBIS installation.

Non-destructive beam measurement: The Bergoz toroid for measuring injected and extracted beams from EBIS was tested on the bench. The toroid and associated amplifier worked as specified, with capability of monitoring pulsed currents in the range of ~10µA to 20mA with pulse width down to 2-3µs. It was observed during the tests that the toroid is very sensitive to varying stray magnetic fields. The Bergoz toroid was installed following the HV acceleration break and was used to measure the EBIS injected and extracted beams.

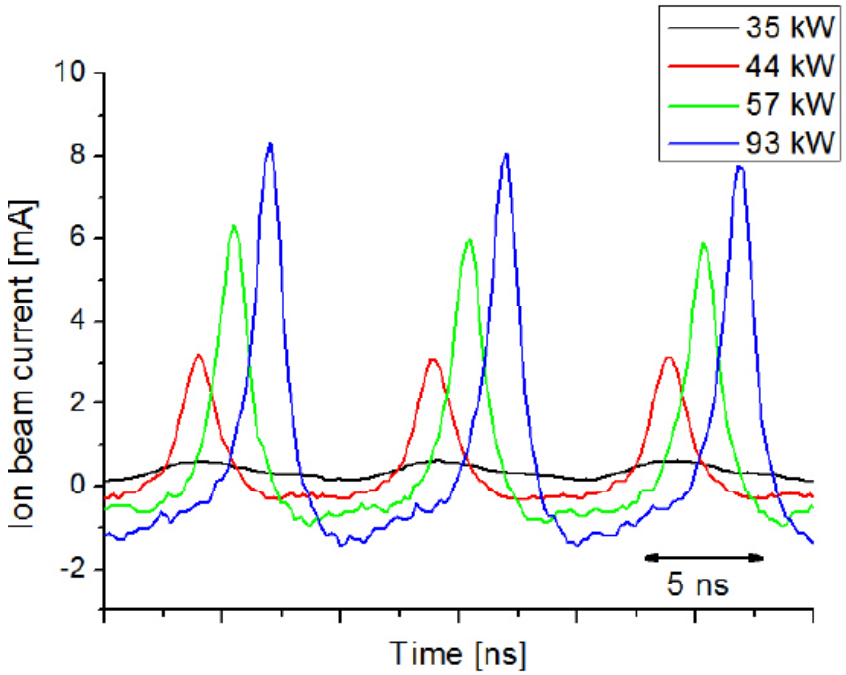
Tests of LEBT solenoid: The LEBT solenoid was operated for EBIS beam measurements on the pepperpot emittance device just after the LEBT solenoid (RFQ entrance position), as well as for beam propagation tests through the RFQ. The RHIC EBIS prototype LEBT solenoid and power supply operated successfully up to 1700A, which is above the expected maximum operating value.

Pepperpot emittance measurements: Helium was introduced into the EBIS via pulsed internal gas injection and a He1+ beam was extracted to the pepperpot emittance head located after the LEBT solenoid. The EBIS platform was pulsed to as high as 80kV during the tests, with the nominal measurement made with a beam energy of 68 keV. Ion optic settings were obtained and recorded which gave a small spot size and high convergent angle at the RFQ entrance location. These pepperpot measurements were important, since there is no room for the pepperpot when the RFQ is installed.

RFQ: After pepperpot emittance measurements were made at what would be the RFQ entrance location, the RFQ was attached and aligned to the TestEBIS beam line just after the LEBT solenoid. A toroid was mounted at the entrance of the RFQ. A fast Faraday cup and an electrically isolated end flange provided beam measurement points after the RFQ. During the first measurements, 0.8 mA He1+ was transmitted through the RFQ with 43% of the total beam charge transmitted from the entrance to exit of the RFQ. Characterization of the accelerated beam was made by measuring the bunch structure versus RF power using fast Faraday cup. Subsequent time-of-flight (TOF) measurements with the same EBIS settings showed that the beam was predominantly He+ with some H+ and $He^{2+}$ contamination. More complete studies of the RFQ performance will be made in February.



RFQ on Test EBIS




Helium beam bunches on the fast Faraday cup at RFQ output vs. rf power (average current out was 0.8 mA)

Ion Injection: Copper ion injection from the hollow cathode ion source was made for the first time since the new (RHIC EBIS) collector and collector optics have been installed at TestEBIS. About 10 nC of Cu ions were extracted, just 2.5 ms after injection into a 2.5 A electron beam. These results indicated a very good ion injection efficiency. RFQ testing with Cu10+ ions are expected during February.

## WBS 1.2 – Controls

The VME chassis assemblies for the EBIS and LEBT/Ion Injection portion of the project were completed and ready for installation.

## WBS 1.3 – Diagnostic Systems

There was no activity during this reporting period.

## WBS 1.4 – Magnet Systems

MEBT Quadrupoles

The conductor for the lower inductance design MEBT quadrupoles has been delivered to BNL. The coil winding fixture has been designed and manufactured. Test coils will be wound to verify the necessary clearance in the laminations. After the coil clearance has been reviewed, the lamination drawings will be finalized and the vendors will be solicited for pricing quotations for lamination stacks.

Warm Solenoids

Manufacture continues on the second electron gun and the electron collector solenoids. The collector solenoid coils are being epoxy-potted to minimize motion and possible coil shorts. The electron gun coils are scheduled to be wound in early March.

### WBS 1.5 – Power Supply Systems

The fast pulsed quadrupole power supply procurement solicitation was dispatched by the Procurement Division. A three week response time for submission of bids was requested to expedite the procurement cycle. Parts have been procured for the LEBT solenoid power supply.

### WBS 1.6 – RF Systems

A review of the tasks required for commissioning the RFQ and Linac RF power amplifiers was completed. As a result, several changes were made to the RF cooling water distribution system supports and cable tray layout. The control systems for rebuncher/debuncher power amplifiers, manufactured by Armstrong Transmitters, were finalized.

### WBS 1.7 – Vacuum Systems

The bakeout blanket manufacturer has agreed to put redundant circuits in one blanket and orders have been placed for the remaining blankets and ion pumps. Support was provided to monitor and log bakeout temperature and gauge readings for EBIS structural component processing.

### WBS 1.8 – Cooling Systems

Installation of manifold, back pressure regulating valves, piping and hoses for the RFQ and Linac RF amplifiers continued.

### WBS 1.9 – Facility Modifications

No activity scheduled for this reporting period.

### WBS 1.10 – Installation

The assembly of the high voltage platforms and the collector power supply HV cage was completed. The installation of the ac distribution system continues.

### WBS 1.11 – Project Services

Much of the month was spent finishing up presentations for the DOE Annual Review of the EBIS Project, which took place on January 21-22. We continue to work on a "what if" file of the schedule, incorporating new dates from the group leaders. The major change is expected in installation. The monthly telecon with the Office of Science took place on January 8$^{th}$. Planned C-AD labor for EBIS for January was 2084 hours, or 14.2 FTEs. Actual labor was 12% lower at 1822 hours, or 12.4 FTEs.

### WBS 1.12 – Commissioning

No activity scheduled.

## SAFETY

The draft Unreviewed Safety Issue (USI) document for the EBIS Preinjector remains at 90% complete.

## PHYSICS

Simulations of beam transmission from EBIS to the RFQ with the updated geometry were performed for He 1+ ions. In addition, electron beam power dissipation inside the new electron collector was simulated assuming errors in the positions of the conical electrodes in the collector.

**Financial Status**

| EBIS Project | | Burdened k$ | | | | | |
|---|---|---|---|---|---|---|---|
| WBS | Title | January Actuals | FY09 to date | Project to date (PTD) costs* | Commit-ments | | Budget at Comple-tion |
| 1.1 | Structural components | 71 | 204 | 3146 | 553 | | 3252 |
| 1.2 | Controls | 0 | 91 | 707 | 80 | | 756 |
| 1.3 | Diagnostics/instrumentation | 0 | 72 | 382 | 0 | | 696 |
| 1.4 | Magnet Systems | 2 | 11 | 485 | 0 | | 863 |
| 1.5 | Power Supply Systems | 143 | 279 | 1753 | 454 | | 2331 |
| 1.6 | RF Systems | 11 | 110 | 2188 | 102 | | 2761 |
| 1.7 | Vacuum systems | 39 | 131 | 1561 | 37 | | 1609 |
| 1.8 | Cooling Systems | | 24 | 216 | 0 | | 259 |
| 1.9 | Facility Modifications | 2 | 7 | 494 | 11 | | 550 |
| 1.10 | Installation | 101 | 375 | 920 | 62 | | 2018 |
| 1.11 | Project Services | 32 | 112 | 986 | 0 | | 1044 |
| 1.12 | Commissioning | | 0 | 0 | 0 | | 178 |
| 1.13 | R&D/CDR | | -71 | 1327 | 73 | | 1400 |
| | Contingency | | | | | | 1583 |
| | Total | 401 | 1343 | 14164 | 1372 | | 19300 |
| * costs through Jan 2009 | | | | | | | |