Project Execution Plan
for the
Electron Beam Ion Source Project
(EBIS)

Project # 06-SC-002

at
Brookhaven National Laboratory
Upton, NY

For the U.S. Department of Energy
Office of Science
Office of Nuclear Physics (SC – 26)

July 2006

Project Execution Plan
for the
Electron Beam Ion Source Pre-Injector
(EBIS)
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1 INTRODUCTION

Brookhaven National Laboratory (BNL), located in Upton, NY, is owned by the U.S. Department of Energy (DOE) and operated by Brookhaven Science Associates (BSA) under the U.S. Department of Energy Contract No. DE-AC02-98CH10886. The flagship Nuclear Physics facility at BNL is the Relativistic Heavy Ion Collider (RHIC). Successful RHIC operations depend on an accelerator complex that accelerates ions to intermediate energies leading up to RHIC injection. This process starts in the Tandem Van de Graaff heavy ion pre-injector. BNL is fabricating a new heavy ion pre-injector for RHIC, the Electron Beam Ion Source (EBIS), which will lead to more reliable, cost-effective operations and new capabilities. This project will provide a new heavy ion pre-injector for RHIC, based on a high charge state heavy ion source, a Radio Frequency Quadrupole (RFQ) accelerator and a short Linear accelerator (Linac).

CD-0 Approve Mission Need:
Authority – Director, Office of Science
On August 2, 2004 Raymond L. Orbach approved the statement of Mission Need for the Electron Beam Ion Source Preinjector with a Total Project Cost (TPC) range of $16 million to $19.5 million. The approval also designated the Associate Director for Nuclear Physics as the Acquisition Executive for this project with authority to approve all subsequent Critical Decisions.

CD-1 Approve Preliminary Baseline Range
Authority -Associate Director for Nuclear Physics
On September 30, 2005 Dennis Kovar approved the EBIS preliminary baseline range and authorized preliminary design. The DOE TPC range at CD-1 had decreased to $12.1 million - $14.8 million, which reflected NASA's $4.5 million funding contributions and refinements to the cost and schedule.

CD-2 Approve Performance Baseline
Authority - Associate Director for Nuclear Physics.
Since CD-1, there have been no changes to the technical scope or project cost and schedule plans. The DOE TPC at CD-2 is $14.8 million. The NASA funding contribution is $4.5 million.

This Project Execution Plan (PEP) describes the coordination of efforts of the project team, including the processes and procedures used by the EBIS Contractor Project Manager (CPM) and Federal Project Director (FPD) to ensure that the project is completed on time and within budget. The PEP defines the project scope and the organizational framework, identifies roles and responsibilities of contributors, and presents the work breakdown structure (WBS) and schedule. The PEP also describes the formal change control process by which project cost, schedule, or scope may be revised in consultation with the FPD and the DOE Office of Science, Office of Nuclear Physics.

2 MISSION NEED

The mission of the Nuclear Physics (NP) program is to foster fundamental research in nuclear physics that will provide new insights and advance our knowledge on the nature of matter and energy and develop the scientific knowledge, technologies and trained manpower that are needed to underpin the DOE missions for nuclear related national security, energy and environmental quality. As part of its strategic mission, the NP program plans, constructs and operates major scientific user facilities and fabricates experimental equipment to serve researchers at universities, national laboratories and industrial laboratories. The program provides world-class, peer-reviewed research results in the scientific disciplines encompassed by the NP mission areas under the mandate provided in Public Law 95-91 that established the department.

EBIS provides research capabilities that directly support the NP mission and address the NP Program Goal 05.20.00.00 to understand the evolution and structure of nuclear matter from the smallest building blocks, quarks and gluons, to the elements in the universe created by stars. A main objective of this nuclear science field is searching for the quark-gluon plasma and other new phenomena that might occur in extremely hot, dense plasma of quarks and gluons believed to have filled the universe about a millionth of a second after the “Big Bang.” Most of the world’s current experimental effort on this question is carried out using relativistic heavy-ion collisions at RHIC, which is supported by the DOE NP program.

The present pre-injector of heavy-ions for RHIC uses Tandem Van de Graaff accelerators built around 1970. The beam is transported to the Booster accelerator via an 860-meter long line. The successful development of an EBIS prototype at BNL makes it possible to replace the present pre-injector with a reliable, low maintenance and cost effective Linac-based pre-injector. This new pre-injector would consist of an EBIS high charge state ion source, an RFQ accelerator and a short Linac. EBIS would increase the reliability and efficiency of RHIC operations, reduce the costs of RHIC operations and provide new experimental capabilities.

The pre-injector system will also provide for a major enhancement in capability for the NASA Space Radiation Laboratory (NSRL), which utilizes heavy-ion beams from the RHIC complex. EBIS would allow for the acceleration of all important ion species for the NASA radiobiology program, such as, helium, argon, and neon which are unavailable with the present Tandem injector. In addition, the new system would allow for very rapid switching of ion species for NSRL experiments, reducing delays due to the interference with RHIC injection operations, and allowing enhanced mixed radiation-field studies.

The new pre-injector offers the following advantages:

- Replacement of the two Tandems as the Booster preinjector, resulting in more stable beam intensities.
- Elimination of the need to use the 860-meter long transport line from Tandem to Booster; using instead a much simpler and economic 30-meter long line from EBIS to reduce setup time and allow fast switching between beams of different rigidities.

- Simplification of Booster injection scheme.
- Capability to provide ions not presently available for the NASA program, such as noble gas ions (major components of galactic cosmic rays), as well as more massive ions such as uranium and, with additional enhancements, polarized ^{3}He, for the RHIC program.
- Increased flexibility to handle the multiple needs of RHIC, NSRL and Alternate Gradient Synchrotron (AGS). Two Tandems are needed for fast beam switching, while the EBIS preinjector will be able to switch species on a pulse-to-pulse basis.
- Improvements in reliability, setup time and stability should lead to increased integrated luminosity in RHIC and increased productivity for NSRL.
- Reduced operating costs. The Tandem facility requires a staff of approximately 12 Full Time Equivalents (FTEs) to support maintenance and a 24-hour shift rotation during operations. The Linac-based pre-injector should be able to run unattended at most times, as with the present proton Linac, and will require only a staff of approximately 3 FTEs.

3 FUNCTIONAL REQUIREMENTS

The technical objectives of the new pre-injector need to meet requirements of both the RHIC and NASA NSRL experimental programs. The corresponding technical scope and performance specifications required at Critical Decision-4 (CD-4) are described in Table 4.1. The system parameters desired from a new pre-injector are as follows:

- **Species**: **d to U.** The EBIS will produce helium to U beams. A deuterium beam may be produced in a simple plasma source injecting directly into the RFQ. The RFQ, Linac, and transport lines must be designed to handle all species in this range. The species extracted from EBIS depend on the injected singly charged ions. With the external ion sources included in the present design, beams from typical gases and solids as required by RHIC and NSRL will be available. Production of some more exotic beams may require additional development or resources devoted to the external source of such ions for injection.

- **Intensity at injection into the Booster: up to 1.1 x 10^{11} charges/pulse with EBIS**. Species which have been run for RHIC and NSRL are shown in Table 3-1, along with intensities at Booster injection which are required in order to reproduce previously observed intensities. The EBIS pre-injector should at least match this performance in all cases.

Table 3-1 Beams and intensities at Booster input required to match past performance

Species	User	Q	Ions/pulse	Charges/pulse
Au	RHIC	32+	2.7×10^{9}	8.6×10^{10}
D	RHIC	1+	2.5×10^{11}	2.5×10^{11}
Cu	RHIC	11+	1.0×10^{10}	1.1×10^{11}
C	NSRL	5+	2×10^{10}	1×10^{11}
O	NSRL	8+	6.7×10^{9}	5.3×10^{10}
Si	NSRL	13+	5×10^{9}	6.5×10^{10}
Ti	NSRL	18+	1.3×10^{9}	2.4×10^{10}
Fe	NSRL	20+	1.7×10^{9}	3.4×10^{10}

- **Injected pulse width: variable, 10 – 40 μs.** This allows 1-4 turn injection into the Booster. This simplifies the injection, and should greatly reduce the sensitivity to small beam losses at injection, which could otherwise lead to a pressure bump resulting in further beam loss.

- **Repetition rate: 5 Hz.** This keeps overall RHIC fill times to only a few minutes.

- **Switching time between two species: 1 second**. There are presently several operating scenarios for RHIC and NSRL, depending on, among other things, whether either is running alone, or the two are running concurrently. To allow operation with the desired flexibility, the new pre-injector must be able to switch beam species and transport line rigidity in 1 second.

- **Injection energy: 2 MeV/amu.** At present, injection from the Tandems is at 0.92 MeV/amu for Au. At this energy, there is a significant beam loss due to electron capture during Booster injection. By raising the injection energy to 2 MeV/amu, the capture cross section is reduced by a factor of 20-40.

- **Q/m: 0.16 or greater.** This ratio equals that presently delivered for Au from the Tandem. For lighter ions a higher q/m is required (Si^{13+}, Fe^{20+}) in order to achieve the desired Booster output energy for NSRL, within the rigidity constraints of the Booster and extraction transport lines.

4 PROJECT OVERVIEW

The project, including DOE and NASA contributions, includes the fabrication of an Electron Beam Ion Source for the production of high charge state heavy ions, plus the procurement of an RFQ and heavy ion Linac to accelerate ions from EBIS to a final energy of at least 2 MeV/amu. A transport line is to be fabricated to transport the beam from the output of the Linac to the existing Booster heavy ion injection point, as show below in Figure 4-2. The project includes the fabrication or procurement of the dipole and quadrupole magnets, power supplies, diagnostics, vacuum components, and controls to properly operate the EBIS source, accelerators, and beam lines. The project also includes the assembly of subsystems, and the installation and testing of these subsystems in their final location in the equipment bay at the high energy end of the existing Linac building.

The EBIS project is divided in four major systems, including (a) Source & Accelerator Structures; (b) Electrical Systems; (c) Mechanical Systems; (d) Facilities & Installation Support. The sections below describe the present design for the EBIS pre-injector for both the DOE and NASA efforts.

4.1 SOURCE & ACCELERATOR STRUCTURES

The Source & Accelerator Structures form the framework of the EBIS Pre-Injector. The superconducting solenoid, trap region electrodes, electron gun and electron collector are the major hardware items for the EBIS. External ion injection sources feed singly charged ions into the EBIS trap for further ionization to the desired final charge state. The Low Energy Beam Transport (LEBT) provides matching of the beam extracted from the EBIS into the RFQ. This line includes magnetic and electrostatic focusing and steering, and appropriate diagnostics. The RFQ provides initial acceleration of the beam to an energy sufficient for injection into a single Linac cavity. The Linac, an Interdigital-H (IH) structure in the present design, then accelerates the beam to the final required energy of 2 MeV/amu. The frequency presently chosen for both the RFQ and Linac is 100.625 MHz, which matches many existing Linacs and RFQs.

A layout of the pre-injector is shown in Figure 4-1.

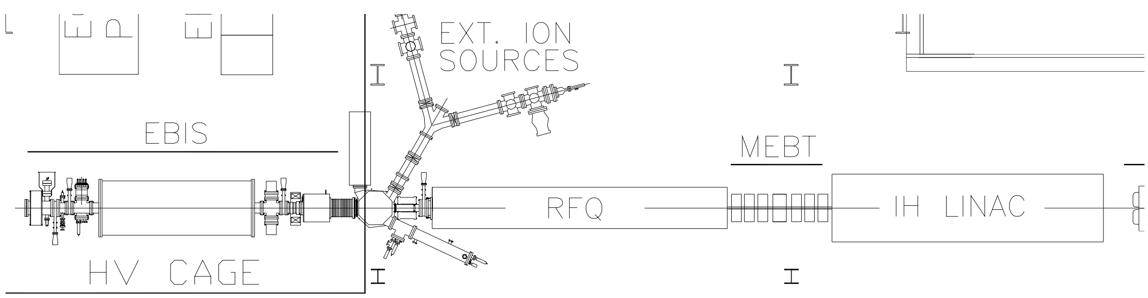


Figure 4-1 Layout of the pre-injector

4.2 ELECTRICAL SYSTEMS

The Electrical systems include all power supplies, diagnostic instrumentation, Radio Frequency (RF) systems and controls systems required for the operation of the EBIS, RFQ, Linac, and associated beam transport lines. There are five 100.625 MHz RF amplifier systems required, feeding the RFQ, IH Linac, and three buncher cavities. These systems will include amplitude and phase regulation, and cavity frequency tuning. Diagnostics include Faraday cups, current transformers, profile monitors, and time of flight spectrometers. Controls will be implemented in the same way as other recent installations such as the new polarized ion source and NSRL. All transport line diagnostics are similar to existing equipment, and applications software already exists. Vacuum equipment will be controlled via Programmable Logic Controllers (PLC's), with a PLC interface module to tie into the control system.

4.3 MECHANICAL SYSTEMS

The Mechanical Systems include both Magnet and Vacuum systems. Two 73-degree dipoles in the high energy beam transport line will bend beam into Booster. These dipoles will be able to switch field in 1 second, for fast changes in beam species. The High Energy Beam Transport (HEBT) line will use existing quadrupole and steering magnets. The vacuum systems will be sufficient to provide the required vacuum of 10^{-9} to 10^{-10} Torr in the EBIS trap region. Cryo pumping will be used on the RFQ and Linac.

4.4 FACILITIES & INSTALLATION SUPPORT

This includes facility modification, cooling systems and installation of the EBIS components. The new pre-injector will be housed in the lower equipment bay of Building 930 as shown in Figure 4-2. It will connect to the existing Tandem-to-Booster transfer line just before it enters the Booster electrostatic inflector. Cooling systems are required for the EBIS electron collector, EBIS magnets, RFQ and Linac cavities, and several power supplies.

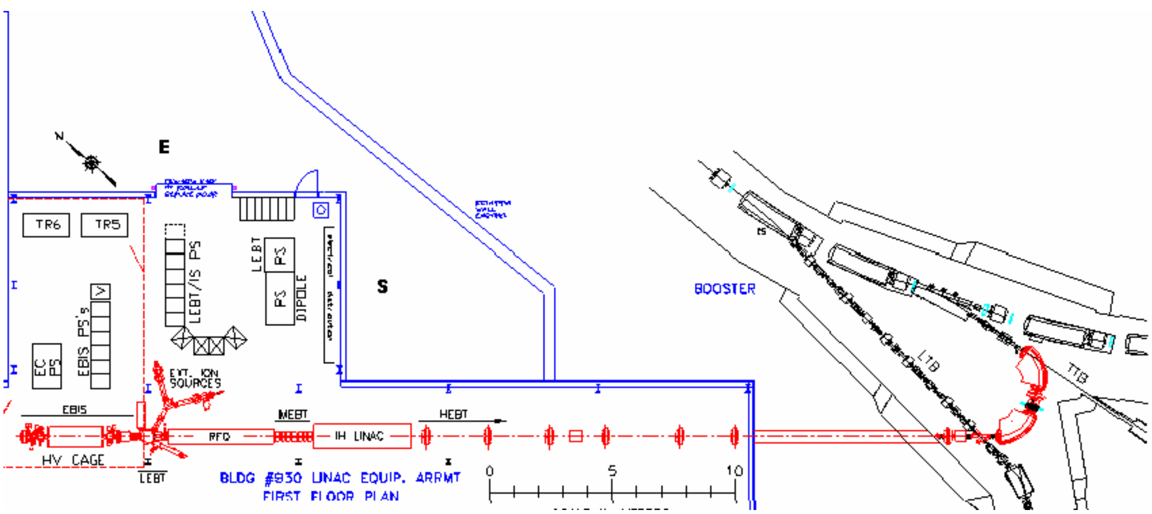


Figure 4-2 Placement of EBIS Pre-Injector in lower equipment bay of 200 MeV Linac.

4.5 TECHNICAL SCOPE AND DELIVERABLES

The DOE scope is the following activities or procurements:

- All Project Engineering and Design (PED), installation, and commissioning for the entire project
- All EBIS chambers, internal structures, and warm magnets

- The LEBT and external ion injection lines
- All controls, diagnostics, cooling water systems, and vacuum components, except for some vacuum components related to the beam port.
- All Medium Energy Beam Transport (MEBT) and HEBT beamline components, except for two HEBT dipoles
- All RF systems for operation of the RFQ, Linac, and bunchers
- All power supplies for EBIS, LEBT, and external ion sources, except for the electron collector and fast pulsing EBIS platform supplies.
- Electrical services required for the operation of the pre-injector

The NASA scope is the procurement of the following items:
- The EBIS superconducting solenoid
- The RF Quadrupole accelerator
- The Linac structure
- The buncher cavities
- The two HEBT dipole magnets and their power supplies
- The electron collector power supply
- All quadrupole magnet and steering magnet power supplies for the Linac MEBT, and HEBT
- The fast pulsing power supplies for the EBIS drift tubes and platform bias
- The beam port through the earth shielding between Linac and Booster, and some associated vacuum equipment.

The DOE deliverables are complete when all the items listed as DOE scope, above, have been procured or fabricated; the EBIS, RFQ, Linac, and beam transport lines have been installed; and the CD-4 requirements from the Table 4-1 below have been verified.

The NASA deliverables are complete when all the items listed as NASA scope, above, have been delivered to BNL, and the beam port is installed.

Table 4-1 CD-4 performance to be demonstrated at Booster input (measured on the current transformer located between the two HEBT 73 degree dipoles).

	CD-4 Performance	**Optimum Performance**
Species	Fe, Au	He to U (assuming appropriate external ion injection)
Intensity	3 x 10^8 Au^{32+} / pulse 4 x 10^8 Fe^{20+} / pulse	2.7 x 10^9 Au^{32+} / pulse 4 x 10^9 Fe^{20+} / pulse 5 x 10^{10} He^{2+} / pulse
Charge-to-mass ratio, Q/m	0.162 (Au) 0.357 (Fe)	≥ 0.16, depending on ion species
Repetition rate	Demonstration of pulsing	5 Hz
Pulse width	10-40 μs	10-40 μs
Switching time between species	Demonstration of switching	1 second
Output energy	2 MeV/amu	2 MeV/amu

4.6 ALTERNATIVE ANALYSIS

Research & Development (R&D) was carried out and the technology needed to realize an Electron Beam Ion Source meeting RHIC requirements was developed, leading to a successful demonstration of the "proof of principle". Before selecting the EBIS, alternative high charge state heavy ion sources were considered; in particular the Electron Cyclotron Resonance (ECR) source, and the Laser Ion Source (LIS). The EBIS was chosen as best meeting the requirements for a new RHIC pre-injector, based on considerations such as intensity, reliability, flexibility in the choice of species, fast switching between species, etc.

The LIS has serious reliability problems, and the species it can produce are limited to those coming from solid targets, preferably with high melting points. Pulse-to-pulse switching of species is probably not possible.

The ECR source cannot produce a sufficient intensity of high charge state heavy ions to meet the RHIC requirements. In addition, it has less flexibility than an EBIS in the choice of ion species. Maximum ECR outputs vary considerably with species (it favors gases and low melting point metals). Pulse-to-pulse switching of species would be difficult to do with maximum intensity, since there is often a "memory" effect when changing species, meaning the source has to clean up over time after a change in species to reach optimum performance. A final concern with the ECR source is the increased difficulty of transporting and matching of these high current beams into an RFQ. The required charge states tend to be in the tail of the ECR charge state distribution for heavy beams, so only a few percent of the total current would be in the desired charge state, meaning that the total extracted current is very high, leading to space-charge problems in transport.

In contrast to the alternatives, the EBIS can meet the intensity goals. With the pre-conceptual R&D prototype, a factor of 20 increase in EBIS performance compared to previous EBIS's was achieved. To meet RHIC requirements, the EBIS must be scaled in the same manner by only another factor of 2. With the EBIS the required charge states can be easily produced, and the EBIS can produce ions of any species; and with external ion injection species can be changed on a pulse-to-pulse basis. The current produced is independent of species. At least 20% of the total current out of EBIS is contained in the charge state of interest for any EBIS beam, so the total current extracted remains at a reasonable level. Finally, with an EBIS, a fixed amount of charge per pulse is extracted, and the beam pulse width can be controlled to match optimally the Booster injection requirements.

The RFQ is the only technology choice for the first acceleration stage of the EBIS beam. The Interdigital-H (IH) Linac structure was chosen as the next acceleration stage in the baseline design. This is a low-risk choice, since there are many Linacs of this type in operation. The IH Linac used at CERN for acceleration of Pb, in particular, almost exactly meets the EBIS requirements. A superconducting heavy ion Linac was considered, but suffers from higher cost and increased operational complexity.

An internal technical review of the pre-conceptual design was held on January 27-28, 2005, and the external committee of source and accelerator experts endorsed the choices made for both ion source and accelerators.

If the new Linac-based pre-injector is not built, significant upgrades to the Tandems will be required in order to ensure reliable long-term operation for RHIC and NSRL. Construction began for the Tandem Van de Graaff facility in 1966, and it was commissioned in 1970. Many of the Tandem systems date back to 1960's technology and need modernization. Without the completion of EBIS, alternative high cost (approximately $9 million, FY04 $) risk mitigation plans will have to be initiated in order to prevent unexpected failures of the Tandem from suspending RHIC operations for extended periods. Alternatively stated, the EBIS project would provide potential contingency in scheduling of the RHIC accelerator. Upgrading the Tandems will not lead to new performance capabilities that are needed for the long-term plans for the RHIC facility or NSRL.

4.7 RESEARCH AND DEVELOPMENT (R&D)

The primary purpose of the R&D is to test the ion beam extraction, acceleration, and transport line focusing system presently being considered for matching the EBIS beam into the RFQ. R&D efforts include the implementation of a test stand that will be used to test the RHIC EBIS electron collector design for thermal load handling. Finally, the test stand is be able to provide a beam at the required input energy for initial testing of the final RFQ at BNL prior to installation in the final location. These developments will serve to reduce technical and schedule risks on the project. The R&D includes the procurement of the full power electron collector, which will later be used on the RHIC EBIS. Procurement of a 100 kV isolation transformer, high voltage isolation, and some

EBIS power supply modifications will allow the EBIS to be operated from a high voltage platform, producing beams at the final energy required for injection into the RFQ. Finally, a prototype of the final LEBT design will be built and tested.

5 MANAGEMENT ORGANIZATION

5.1 GENERAL

This document provides the management organization for the EBIS as defined for the development, construction and final assembly. Agreements between DOE SC and NASA and between BNL and NASA were established and documented. (see Appendix C) Figure 5-1 outlines the management structure for EBIS.

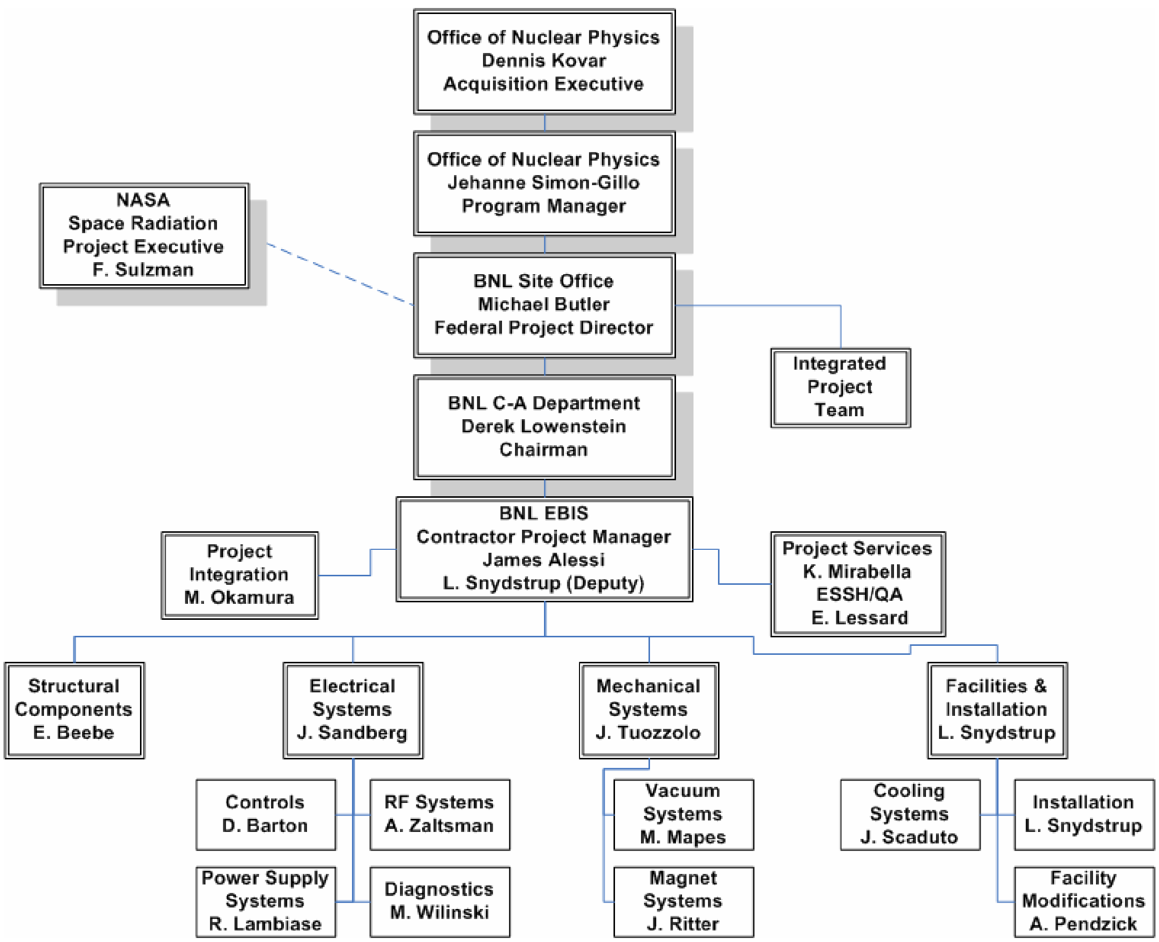


Figure 5-1 Management Organization Chart for EBIS

5.2 PROJECT MANAGEMENT RESPONSIBILITIES

5.2.1 Department of Energy

Within the DOE Office of Science (SC), the Office of Nuclear Physics (SC-26) has overall DOE responsibility for the EBIS project.

Responsibilities

The Acquisition Executive is Dennis Kovar, Associate Director of the Office of Science for Nuclear Physics (SC-26). As such, he has full responsibility for project planning and execution, and for establishing broad policies and requirements for achieving project goals. Specific responsibilities for the EBIS project include:

- Chairs the ESAAB Equivalent Board.
- Approves Critical Decisions and Level 1 baseline changes.
- Approves the Project Execution Plan.
- Delegates approval authority for Level 2 baseline changes to the Federal Project Director.
- Conducts Quarterly Project Reviews.
- Ensures independent project reviews are conducted.

The Office of Nuclear Physics (SC-26.2) is responsible for planning, constructing, and operating user facilities to provide special scientific and research capabilities to serve the needs of U.S. universities, industry, and private and Federal laboratories. Within NP, the Facilities and Project Management Division (SC-26.2) has direct responsibility for providing funding, and programmatic guidance to the EBIS project. The EBIS Program Manager, in SC-26.2, is the primary point of contact with the following responsibilities:

- Oversees development of project definition, scope and budget.
- Prepares, defends, and provides project budget with support from the field organizations.
- Reviews and provides recommendations to the AE on Level 1 baseline changes.
- Monitors Level 1 and 2 technical, cost, and schedule milestones.
- Participates in Quarterly Reviews, ESAAB Equivalent Board meetings, and project reviews.
- Ensures ES&H requirements are implemented by the project.
- Coordinates with other SC Staff offices, HQ program offices and the DOE Office of Engineering and Construction Management (OECM).

Jehanne Simon-Gillo is the Federal EBIS Program Manager.

Michael A. Butler at the Brookhaven Site Office (BHSO) is assigned as the Federal Project Director. The Federal Project Director responsibilities include:

- Overall responsibility for planning, implementing, and completing EBIS.
- Provides overall project management oversight.

- Issues key work authorization.
- Provides necessary funds via approved financial plans.
- Manages and allocates the contingency funds according to the procedure defined in the Baseline Change Control (Section 7).
- Submits key project documents and critical decisions to DOE and reports project progress.
- Ensures that the project complies with applicable ES&H requirements (e.g., National Environmental Policy Act [NEPA] requirements).
- Approves Level 2 Baseline changes.

5.2.2 NASA

Frank M. Sulzman, Space Radiation Project Executive, NASA – Johnson Space Center, is the NASA representative to the EBIS Project.

Responsibilities

- Functions as NASA point of contact for project matters.
- Reviews relevant project documentation
- Participates in monthly and quarterly Project teleconferences, as well as key Project reviews (Preliminary Design Review, Critical Design Review, Operational Readiness Review, etc.)

5.2.3 Brookhaven National Laboratory

Chairman for the Collider-Accelerator Department at BNL

Funding for this project will be directed through BNL's Collider-Accelerator Department (C-AD). Fiscal and management responsibility for the fabrication of EBIS will reside with the Chairman, Derek Lowenstein. The Chairman is the designated Principal Investigator for the NASA Space Radiation Laboratory Facility.

Responsibilities

The Chairman for the Collider-Accelerator Department at BNL shall be administratively and fiscally responsible for the entire project. In particular he must do the following:

- Provides overall management oversight for all aspects of the project.
- Appoints the Contractor Project Manager.
- Approves key personnel appointments made by the Contractor Project Manager.
- Approves major subcontracts recommended by the Contractor Project Manager.
- Ensures that adequate staff and resources are available to complete EBIS in a timely and cost effective manner (within constraints of the budget provided by DOE).

- Ensures that EBIS has demonstrated that it meets the functional requirements.
- Provides documentation and access to information necessary for operation of EBIS at other sites.
- Ensures the work is performed safely and in compliance with the ISM rules.
- Reports to the Associate Laboratory Director for Nuclear and Particle Physics regarding the operations of the Collider-Accelerator Department.
- Reports to Frank Sulzman, NASA, regarding NSRL operations.

5.2.4 Contractor Project Manager

The Chairman for the Collider-Accelerator Department, Derek Lowenstein, has appointed James Alessi the EBIS Contractor Project Manager.

Responsibilities

The Contractor Project Manager shall report directly to the Chairman for the Collider Accelerator Department and will be in charge of the overall management of EBIS. The CPM shall appoint the key staff needed for the project with the approval of the Chairman for the Collider-Accelerator Department. The CPM also will have the following responsibilities:

- Responsible and accountable for the successful execution of contractor's project scope of EBIS.
- Supports FPD in implementing DOE project management process.
- Provides input on project documentation.
- Implements contractor performance measurement system.
- Delivers project deliverables as defined in this PEP.
- Identifies and ensures timely resolution of critical issues within contractor's control.
- Allocates the contingency funds according to the procedure defined in the Baseline Change Control (Section 7).
- Acts as the spokesperson for the project to the DOE and the scientific community.
- Collaborates with the Associate Lab Director for Nuclear and Particle Physics and the Chairman for the Collider-Accelerator Department to assemble the staff and resources needed to complete the project.
- Keeps the scientific community informed on the progress of the project.
- Appoints the Quality Assurance Manager (QAM).
- Appoints the Deputy Project Manager (DPM)
- Provides monthly input to the Federal Project Director to be used in report to DOE.
- Submits quarterly status reports to BHSO Federal Project Director.
- Ensures the work is performed safely and in compliance with the Integrated Safety Management (ISM) rules.
- Produces necessary Environment Safety and Health (ES&H) documentation (e.g., NEPA).

- Approves baseline changes up to and including Level 3.
- Responsible for all Milestones, level 0 through 3.

5.2.5 Deputy Project Manager

The Deputy Project Manager is appointed by, and reports directly to, the Contractor Project Manager. He functions as the Lead Engineer for the Project and acts as the CPM when the CPM is absent/unavailable. He has the following responsibilities:

Responsibilities

- Maintains the same Project-specific signature authority as the CPM
- Responsible for all non-Physics parameters.
- Sets priorities for EBIS drawings
- Responsible for Design Reviews
- Monitors all major procurements and Central Shops orders to assure timely placement of orders
- Liaison to Admin Group, ensuring timely payment of invoices
- Responsible for all Milestones, level 0 through 3.

5.2.6 Project Integrator

The Project Integrator is responsible for coordinating data produced by the rest of the EBIS team and confirming that the output from the various systems and scientists aligns with the Project scope. While not responsible for creating the information, the Integrator maintains an overview of all scope requirements, including parameters, energy, power; footprints, quantities and planned locations of equipment; and is responsible for calling meetings as required whenever data from one area appears to be in conflict with expected outcomes and/or Project scope and direction.

Responsibilities

- Reviews all parameters
- Maintains parameter list

5.2.7 Subsystem Managers

The EBIS Project contains four major systems: Structural Components Electrical Systems, Facilities and Installation Support, and Mechanical Systems. The EBIS Contractor Project Manager has appointed managers to be responsible for the subsystems, which comprise the major systems. They are: Edward Beebe for Structural Components, Bob Lambiase for Power Supply Systems, Michelle Wilinski for Diagnostic Instrumentation, Donald Barton for Controls, Alexander Zaltsman for RF Systems, John Ritter for Magnet Systems, Mike Mapes for Vacuum Systems, Alexander Pendzick for Facility Modifications, Joseph Scaduto for Cooling Systems, and Louis Snydstrup for Installation. They will be responsible for the design, construction, installation, and testing of their subsystem, in accordance with the performance requirements, schedule, and budget.

Responsibilities

- Collaborate with the CPM to assemble the staff and resources needed to complete the subsystem.
- Communicate the system design requirements to the staff.
- Ensure that subsystems meet the EBIS system design requirements, including interfaces.
- Responsible for carrying out the design, construction and assembly of the subsystem in accordance with the scope, schedule and budget, assuming funding and resources as described in the PEP.
- Provide regular reports on the status of the subsystem to the Contractor Project Manager.
- Ensure the work is performed safely and in compliance with the ISM rules.

5.2.8 Quality Assurance Manager

David Passarello has been assigned as the QAM.

Responsibilities

- Collaborates with the CPM and Deputy Contractor Project Manager to ensure the quality of EBIS.
- Ensures that the quality system is established, implemented, and maintained in accordance with the EBIS Quality Assurance Plan.
- Provides oversight and support to the partner labs and institutions to ensure a consistent quality program.

5.3 INTEGRATED PROJECT TEAM

The composition of the EBIS Integrated Project Team (IPT) is given in Table 5-1. Its responsibilities are described in the DOE directive. The team meets at least quarterly, or more frequently if necessary. The DOE Federal Project Director chairs the IPT.

Table 5-1. EBIS Integrated Project Team

DOE Federal Project Director (Chair)	Michael A. Butler
DOE Site Contracting Officer	Michael D. Holland
DOE Program Manager for EBIS	Jehanne Simon-Gillo
DOE Science Program Manager	Gulshan Rai
NASA Space Radiation Program Manager	Frank Sulzman
BNL Project Manager for EBIS	James Alessi

BNL Procurement Operations Manager	David E. Dale
BNL ESSH Lead	Ed Lessard
C-AD Assistant Chair for Administration	Stephanie LaMontagne

5.4 OPERATION PHASE

The EBIS will operate as the ion source and first stage injector to the RHIC facility. The ion source, RFQ and Linac form an injector chain for ion injection into the Booster synchrotron. This facility will be a permanent installation that is dedicated to providing ions to the Collider-Accelerator Department accelerator complex. RHIC will have first priority for these beams. In addition, when RHIC does not require its use, the EBIS injector chain can provide beams for the NASA Space Radiation Laboratory (NSRL) at the Booster or for beams to be used at the AGS. The EBIS injector system operation will be totally integrated into the C-AD Pre-injector Group.

The cost of operation of the EBIS pre-injector will be lower than that of the Tandem. The Tandem facility requires a staff of approximately 12 FTE's to support maintenance and 24 hour shift rotation during operations. The EBIS pre-injector will require a staff of ~3 FTE's for operation and maintenance, since it should be able to run unattended at most times, and will be monitored by C-AD Main Control Room personnel. Operating cost savings have been estimated at $1.46 million per year ('06 $), with approximately 100 k$ going to NASA, and the remainder going to DOE NP.

5.5 LIFE CYCLE COSTS

Construction costs as described in this document, are estimated to be $19.3 million.

It is expected that ~ 3 FTE's will be required to operate and maintain the EBIS pre-injector. Included is a core scientific, engineering, technical support from within the C-AD Preinjector Group, plus additional support at a smaller scale from other groups within C-AD (Controls, Diagnostics, Vacuum, Power Supply, Cooling Systems, RF, Drafting, etc.). Costs for electrical power and materials are estimated at < 1 M$ for 32 weeks of operations per year, which is slightly less than required for Tandem operation.

The EBIS pre-injector will be fully integrated with the rest of the C-AD complex, and has already been incorporated in the current Safety Assessment Document for the Department. Decommissioning and decontamination will be included as a part of the D&D of the RHIC facility. With the low final energy from the pre-injector for any ion species, there will be no activation of components, so D&D activities would involve either the disposal or reuse of standard scientific equipment.

6 SCHEDULE AND COST SCOPE

EBIS has been organized into a Work Breakdown Structure (WBS) for purposes of planning, managing and reporting project activities. Work elements are defined to be consistent with discrete increments of project work. EBIS has thirteen major WBS Level 2 components: Structural Components, Controls Systems, Diagnostic/Instrumentation, Magnet Systems, Power Supply Systems, RF Systems, Vacuum Systems, Cooling Systems, Facility Modifications, Installation, Project Services, Commissioning and R&D.

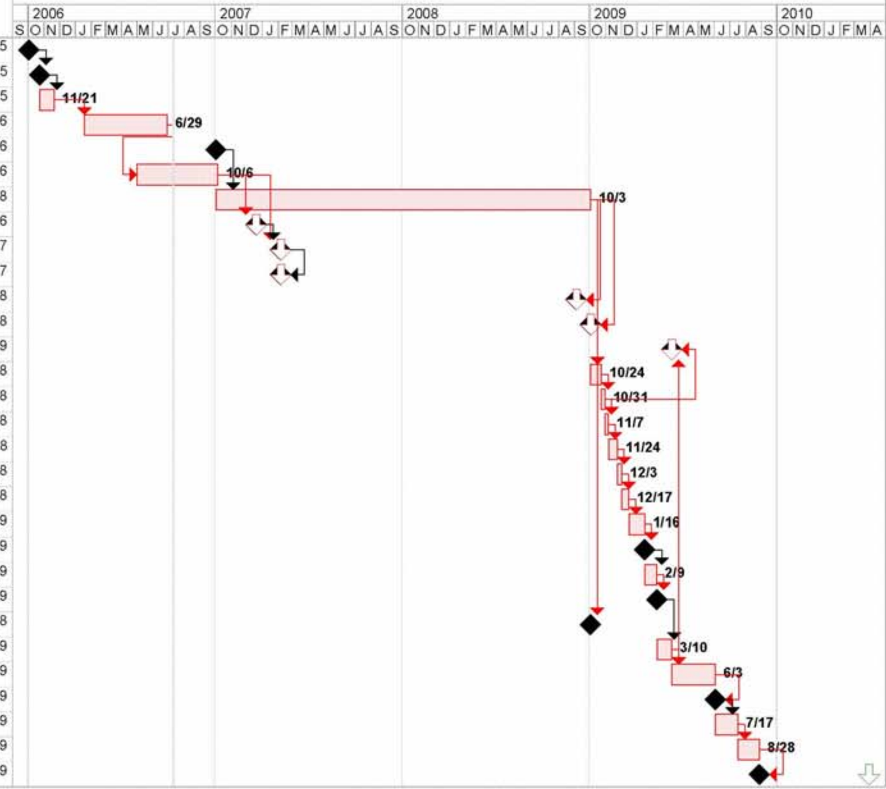
The cost and schedule for the EBIS project scope have been developed based on the following assumptions:

1. DOE Approval of CD-2 no later than September 2006
2. DOE Approval of CD-3 no later than October 2006
3. Receipt of DOE Construction funding no later than November 1st, 2006
4. Receipt of FY07 NASA funding no later than October 1, 2006
5. Receipt of planned FY08 funds no later than 1st qtr FY08
6. No resource limitations other than noted funding are anticipated
7. Beneficial occupancy of the New York State funded building addition no later than September 30, 2007
8. RHIC operations to be shutdown in summer FY07 and summer FY08 to allow time for installation of EBIS equipment in the Booster tunnel.

6.1 SCHEDULE

The Gantt chart view in Figure 6-1shows the current critical path to the Early Finish (EF) dates. The schedule is fully integrated to include both the DOE and NASA efforts.
With an official CD-4 date of 2QFY10 and a planned early finish date of 3QFY09 for the final construction task (HEBT test with Beam Complete), 12 weeks have been allocated for Performance Validation and Document development, Project Closeout, Lessons Learned; with CD-4 approval as the final task in 4QFY09. This allows approximately 30 weeks of float after the end of the early finish schedule.
Using the EF CD-4 date, and looking for all tasks with float of 5 days or less, the critical path method calculates the Linac as the longest path through the EF schedule. The Linac is a purchased item, and the delivery date used is an estimate based on discussions with the most likely vendor.

ID	Task Name	Start	Finish
2	PED Funds Available Structional Components	Mon 10/3/05	Mon 10/3/05
145	Start of RFQ Procurement Process	Mon 10/24/05	Mon 10/24/05
146	RFQ Physics Calculations	Mon 10/24/05	Mon 11/21/05
147	RFQ Specification and Award	Thu 1/19/06	Thu 6/29/06
163	NASA Linac Funding	Tue 10/3/06	Tue 10/3/06
165	Linac Specification and Award	Mon 5/1/06	Fri 10/6/06
166	Linac Procurement	Tue 10/3/06	Fri 10/3/08
167	Linac Preliminary Design Review	Wed 12/20/06	Wed 12/20/06
168	Linac Final Manufacturing Dwg & Specifications	Tue 2/6/07	Tue 2/6/07
169	Linac Final Design Review 30% of Cost	Tue 2/6/07	Tue 2/6/07
170	Linac Pre-Shipment Test	Fri 9/5/08	Fri 9/5/08
171	Linac Delivery to BNL 50% of Cost	Fri 10/3/08	Fri 10/3/08
172	Linac Acceptance Test 20% of Cost	Tue 3/10/09	Tue 3/10/09
174	Linac Shipping to BNL	Fri 10/3/08	Fri 10/24/08
175	Linac Incoming Inspection	Fri 10/24/08	Fri 10/31/08
180	Linac Mount on Stand	Fri 10/31/08	Fri 11/7/08
181	Linac Assist Vacuum and Leak Checking	Fri 11/7/08	Mon 11/24/08
182	Linac Assist Water Connections	Mon 11/24/08	Wed 12/3/08
183	Linac Assist RF Hookup	Wed 12/3/08	Wed 12/17/08
184	Linac Low/High Power Tests	Wed 12/17/08	Fri 1/16/09
185	Linac Ready for Beam	Fri 1/16/09	Fri 1/16/09
775	Linac Mech Install	Fri 1/16/09	Mon 2/9/09
951	LINAC Install Complete	Mon 2/9/09	Mon 2/9/09
995	Linac Procurement Placed	Fri 10/3/08	Fri 10/3/08
1042	Linac Test with Beam	Mon 2/9/09	Tue 3/10/09
1045	HEBT Test with Beam	Tue 3/10/09	Wed 6/3/09
1047	HEBT Test with Beam Complete	Wed 6/3/09	Wed 6/3/09
1048	Performance Validation & Document Development	Wed 6/3/09	Fri 7/17/09
1049	CD4 Presentation & Approval	Fri 7/17/09	Fri 8/28/09
1050	CD4 Complete	Fri 8/28/09	Fri 8/28/09



Project: Project Summary
Date: Mon 7/10/06

Task | Critical Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Critical Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary | Deadline

Figure 6-1 Early Finish schedule showing Critical Path

6.1.1 Milestones

Milestones will be used as schedule events to mark the due date for accomplishment of a specified effort or objective. A milestone may mark the start, an interim step, or the end of one or more activities as needed to provide insight into the Project's progress. Milestones are assigned to different levels (Table 6-1) depending on their importance and criticality to other milestones and the overall Project schedule.

Table 6-1 EBIS Milestone levels

Milestone Level	Description
0	Critical Decision milestones
1	Start and/or Completion of Major Project Phases
2	Milestones that support the accomplishment of the Level 0 and level 1 milestones
3	Milestones to monitor and assure progress

Table 6-2 shows the high level project performance milestones. These, and all lower level milestones are maintained in the EBIS Microsoft Project cost and schedule database.

Table 6-2 Level 0, 1, and 2 Project Milestones

Project Milestones Level 0	
Critical Decision 0 (CD-0)	Q4, 04 (A)
Critical Decision 1 (CD-1)	Q4, 05 (A)
Critical Decision 2 (CD-2)	Q4, 06
Critical Decision 3 (CD-3)	Q1, 07
Critical Decision 4 (CD-4)	Q2, 10
Project Milestones Level 1	
RFQ Procurement Placed	Q4, 06 (A)
Linac Procurement Placed	Q2. 07
Beam Port Complete	Q4, 07
SC Solenoid Factory / Acceptance Test	Q1, 08
Building Addition Approved for Occupancy	Q3, 08
EBIS Safety Assessment Document Complete	Q4, 08
CASE for EBIS Approved by DOE	Q4, 08
BHSO Letter Approving Commissioning	Q3, 09
Beam Out of EBIS	Q3, 09
HEBT Dipole Installation Complete	Q4, 09
Beam Out of RFQ	Q4, 09
Beam Out of Linac	Q1, 10
Beam Through HEBT	Q2, 10

Project Milestones Level 2	
R&D EBIS Installed on HV Platform	Q1, 06 (A)
Electron Collector Procurement Placed	Q1, 06 (A)
Superconducting Solenoid Procurement Placed	Q2, 06 (A)
R&D High Voltage Beam Tests Begin	Q3, 07
Electron Collector Pressure / Vacuum Tested	Q1, 08
EBIS Drift Tube Structure Complete	Q3, 08
EBIS Preassembly Complete	Q4, 08
Electron Collector PS Acceptance Tested	Q2, 09
ARR Review Team for EBIS Appointed	Q2, 09
RF Amplifiers Acceptance Tested	Q2, 09
Accelerator Readiness Review	Q3, 09
EBIS Install Complete	Q3, 09
RFQ Tested to Full Power	Q3, 09
RFQ Installation Complete	Q4, 09
Linac Tested to Full Power	Q1, 10
Linac Installation Complete	Q1, 10
HEBT Beamline Installation Complete	Q1, 10
HEBT Dipole PS Acceptance Tested	Q1, 10

6.2 COST SCOPE

Table 6-3 shows the estimated DOE TPC cost summary for the EBIS. The following standard DOE escalation factors were used - 2.8% (2006) and 2.6% (2007-2009).

Table 6-3 Cost Baseline for EBIS project.

WBS	Title	M$
1.1	Structural components	1.5
1.2	Controls Systems	0.8
1.3	Diagnostics	0.7
1.4	Magnet Systems	0.3
1.5	Power Supply Systems	1.0
1.6	RF Systems	2.8
1.7	Vacuum systems	1.4
1.8	Cooling Systems	0.3
1.9	Facility Modifications	0.5
1.10	Installation	1.4
1.11	Project Services	1.0
1.12	Commissioning	0.2
1.13	R&D / CDR	0.7
subtotal		12.6
	Contingency	2.2
Total		14.8

6.2.1 Funding

The EBIS project is being funded by DOE-NP and NASA. With refinements during the project engineering design phase, the estimate for the DOE TPC at CD-2 is $14.8 million. The DOE funding profile at CD-2 is shown in Table 6-4. (See Appendix B for NASA information.)

Table 6-4 EBIS Project Funding Profile

$M

	FY 05	FY 06	FY 07	FY 08	Total
R&D	0.5	0.1			0.6
CDR	0.2				0.2
PED/EDIA		2.0	0.1		2.1
Cons			7.4	4.2	11.6
Pre-Ops				0.3	0.3
TEC		2.0	7.5	4.2	13.7
TPC	0.7	2.1	7.5	4.5	14.8

6.2.2 Contingency

The FPD manages the contingency funds according to the DOE Order 413.3 procedure defined in the Baseline Change Control section and as specified in the Change Control table in Table 7-1. Table 6-5 shows the estimated average contingency rate by subsystem, utilized to develop the overall project contingency.

Table 6-5 Average Contingency on DOE Scope

WBS	Title	%
1.1	Structural components	17.5
1.2	Controls Systems	16.4
1.3	Diagnostics	15.8
1.4	Magnet Systems	23.3
1.5	Power Supply Systems	25.5
1.6	RF Systems	14.4
1.7	Vacuum systems	13.5
1.8	Cooling Systems	20.0
1.9	Facility Modifications	25.2
1.10	Installation	20.5
1.11	Project Services	20.0
1.12	Commissioning	20.0
1.13	R&D / CDR	18.4
average		17.9

The contingency percentages were derived by evaluating every task for cost, technical, schedule and design risks, and applying a weighting factor. The contingency rates are determined by considering the development status of the items, and the uncertainties plus risks in completing the construction and testing. The guidelines used to establish the contingency percentages are listed in Table 6-6.

Table 6-6 Contingency risk and weighting factors

TECHNICAL, COST, SCHEDULE and DESIGN RISK FACTORS

Risk Factor	Technical	Cost	Schedule	Design
0	Not used	Not used	Not used	Detail design > 50% done
1	Existing design and off the shelf H/W	Off the shelf or catalog item	Not used	Not used
2	Minor modifications to an existing design.	Vendor quote from established drawings.	No schedule impact on any other item	Not used
3	Extensive modifications to an existing design	Vendor quote with some design sketches	Not used	Not used
4	New design; nothing exotic	In-house estimate based on previous similar experience	Delays completion of non-critical subsystem item	Preliminary design >50% done; some analysis done
6	New design; different from established designs or existing technology	In-house estimate for item with minimal experience but related to existing capabilities	Not used	Not used
8	New design; requires some R&D but does not advance the state-of-the-art	In-house estimate for item with minimal experience and minimal in-house capability	Delays completion of critical path subsystem item	Conceptual design phase; some drawings; many sketches
10	New design of new technology; advances state-of-the-art	Top-down estimate from analogous programs	Not used	Not used
15	New design; well beyond current state-of-the-art	Engineering judgment	Not used	Concept only

TECHNICAL, COST, SCHEDULE and DESIGN WEIGHTING FACTORS

	Condition	Weighting Factor
Technical	Design OR Manufacturing	2
	Design AND Manufacturing	4
Cost	Material Cost OR Labor Rate	1
	Material Cost AND Labor Rate	2
Schedule	Same for all	1
Design	Same for all	1

7 CHANGE CONTROL

Changes to the technical, cost and schedule baselines will be controlled using the thresholds described in Table 7-1.

All changes that include or exceed Level 3 approval thresholds (as defined in Table 7-1) should first be submitted to the CPM using a Project Change Request (PCR). For changes exceeding Level 3, the CPM will endorse the request (i.e., recommend approval) to higher authority or reject the request. If endorsed, the CPM will then transmit the PCR to the FPD with recommendations. If the request exceeds Level 2, the BHSO Baseline Change Control Board (BCCB) will submit the PCR to the FPD in DOE Headquarters for approval. All Level 2 PCRs will be reviewed and approved by the BHSO BCCB and all Level 3 PCRs will be reviewed and approved by the CPM.

The BHSO BCCB will consist of the EBIS FPD (chair), the BHSO Director, the Associate Director for Nuclear & Particle Physics at BNL (or designee), the Chairman of the Collider-Accelerator Department, the CPM, and others as directed by the FPD. Technical advisors will be included as needed in the BHSO BCCB. The chair has the final responsibility to endorse the PCR. For Level 3 changes and requests for higher-level changes the CPM will consult with the Project Engineer.

If the change is approved, the copy of the approved PCR, together with any qualifications or further analysis or documentation generated in considering the request is returned to the requestor, and copies are sent to the official at the next higher control level and to EBIS for filing. If approval is denied, a copy of the PCR, together with the reasons for denial, is returned to the requestor, and a copy is filed. The official at the next higher control level may review the granted change to ensure proper application of the procedure and consistency of the change with the goals and boundary conditions of the project.

Table 7-1. Summary of Baseline Change Control Thresholds

Change Level	**Cost** (Table 6-3)	**Schedule** (Table 6.2)	**Technical Scope** (Table 4-1)
DOE-SAE	> 25% cumulative increase to TPC	6 or more months increase (cumulative) to project completion date	Any change affecting conformance to mission need requirement
DOE-SC-26 Program (Level 1)	Any increase in the TPC or cumulative allocation of more than $500k contingency	3-month or more delay of a Level 0 or 1 milestone date	Any change in CD-4 deliverable that affects mission need requirement
DOE-BHSO Federal Project Director (Level 2)	A cumulative increase of more than $250k in WBS Level 2 or cumulative allocation of more than $250k contingency	> 1-month delay of a Level 0 or 1 milestone date or > 3-month delay of a Level 2 milestone date	Any deviation from technical deliverables that does not affect expected performance specifications
EBIS Contractor Project Manager (Level 3)	Any increase of >$50k in the WBS Level 2	> 1-month delay of a Level 2 milestone date or any change greater than 3 months to a level 3 milestone	Any significant change in the System Requirements document.

8 ANALYSES, ASSESSMENTS AND PLANS

8.1 ENVIRONMENT, SAFETY AND HEALTH

8.1.1 Purpose of the ESSH Chapter

The purpose of this chapter is to briefly describe the rigorous environmental protection, safety, security, health and quality (ESSH) activities associated with the EBIS Project that will be completed prior to commencement of construction, commissioning and operations.

8.1.2 Review of ESSH Issues Associated with the EBIS Design

The shielding policy for this facility is the same as that for the rest of the Collider-Accelerator facilities since the new pre-injector and beam line are to be the responsibility of the Department. Specifically, the Collider-Accelerator Department's Radiation Safety Committee will review facility-shielding configurations to assure that the shielding has been designed to:

- Prevent contamination of the ground water.
- Limit annual site-boundary dose equivalent to less than 5 mrem.
- Limit annual on-site dose equivalent to inadvertently exposed people in non-Collider-Accelerator Department facilities to less than 25 mrem.
- Limit dose equivalent to any area where access is not controlled to less than 20 mrem during a fault event.
- Limit the dose equivalent rate to radiation-workers in continuously occupied locations to ALARA but in no case would it be greater than 0.5 mrem in one hour or 20 mrem in one week.
- Limit the annual dose equivalent to radiation workers where occupancy is not continuous to ALARA, but in no case would it exceed 1000 mrem.

In addition to review and approval by the Radiation Safety Committee, the Radiation Safety Committee Chair or the ESHQ Associate Chair must approve final shield drawings. Shield drawings are verified by comparing the drawing to the actual configuration. Radiation surveys and fault studies are conducted after the shield has been constructed in order to verify the adequacy of the shield configuration. The fault study methodology that is used to verify the adequacy of shielding is described and controlled by Collider-Accelerator Department procedures.

The DOE ESHQ requirements applicable to the new pre-injector are listed in Table 8-1. All hazards, including radiological hazards, associated with DOE accelerator facilities are addressed comprehensively in DOE Order 420.2A, Safety of Accelerator Facilities. Appropriate and adequate protection of workers, the public, and the environment from ionizing radiation is also covered under 10CFR1035, "Occupational Radiation Protection," which applies to all DOE facilities regardless of the source and type of ionizing radiation. The C-A Department implements the DOE requirements indicated in Table 8-1 using procedures and training. At the BNL level, the Standards Based Management System (SBMS) is used to keep DOE requirements current and to flow requirements down to the Department level. At the C-A Department level, SBMS requirements are flowed down into routine operations procedures. All ESHQ requirements and hazard controls are documented in detail in the C-A Operational Procedures (OPM).

In order to meet the requirements in DOE Order 420.2A, Safety of Accelerator Facilities, C-AD has incorporated a description and safety assessment of the new pre-injector into the current Safety Assessment Document for C-AD. At the appropriate time, the C-A Department will obtain an approved Accelerator Safety Envelope for the new pre-injector from DOE and perform an Accelerator Readiness Review in accord with Order 420.2A prior to commissioning and operations.

Table 8-1 Current DOE ESHQ Requirements for BNL Accelerators

Topic	DOE Requirements Document
Authorization Basis Documents	DOE O 420.2B, Safety of Accelerator Facilities DOE O 420.1A, Facility Safety (Natural Phenomenon and Fire Protection Sections)
Conduct of Operations	DOE O 54100.19 Chg 2, Conduct of Operations Requirements for DOE Facilities
Quality Assurance	DOE O 414.1B, Quality Assurance
Maintenance Management	DOE O 430.1B, Real Property Asset Management DOE O 430.2A, Departmental Energy And Utilities Management
Training and Qualification Programs	DOE O 54100.20A Chg 1, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities
Radiation Protection	Title 10, Code of Federal Regulations, Part 1035, Occupational Radiation Protection
Transportation and Packaging	DOE O 460.2 Chg 1, Departmental Materials Transportation and Packaging Management DOE O 460.1B, Packaging and Transportation Safety
Worker Protection	DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees
Environmental Protection	DOE O 450.1, Environmental Protection Program DOE O 451.1B Chg 1, National Environmental Policy Act Compliance Program - Change 1
ESH Reporting	DOE O 231.1A, Environment, Safety, and Health Reporting
ESH Standards	DOE O 54100.4 Chg 4, Environmental Protection, Safety, and Health Protection Standards
Accident Investigation	DOE O 225.1A, Accident Investigations
Radioactive Waste Management	DOE O 435.1 Chg 1, Radioactive Waste Management

The C-A Department conforms to the requirements of ISO 14001, Environmental Management System, and OHSAS 18001, Occupational Safety and Health Management System, and achieves third-party registration for these internationally recognized management systems. Thus, in addition to DOE requirements, documentation of environmental protection and occupational safety and health programs for new pre-injector facilities will be prepared and audited by independent parties. This documentation will include:

- Environmental Process Evaluations for all processes with significant environmental aspects.
- Facility Risk Assessments for all facilities and areas.
- Job Risk Assessments for all jobs.

DOE O 420.1A, Facility Safety, has two sections that are applicable to accelerator facilities: Natural Phenomenon and Fire Protection Sections. DOE STD-1020-2002, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities, describes the Performance Criteria (PC) to be used for evaluating building design for earthquake, wind and flood phenomena. DOE-STD-1020-2002 employs the graded approach in assigning PC categories to DOE buildings. The graded approach enables cost-benefit studies to be used to address categorization. It is noted that the radioactivity entrained within the new pre-injector components would not have a significant off-site impact as a result of an earthquake, high winds or flood. Based on the small amounts of hazardous materials that will be present at the new pre-injector facilities, the PC1 category is applicable. That is, BNL will use model building codes for the new pre-injector facilities that include earthquake, wind, and flood considerations. BNL is currently using PC1 for all other C-AD facilities for life safety issues.

Significant environmental aspects of the new pre-injector project include:

- Excavation
- Chemical Storage/Use
- Liquid Effluent
- Hazardous Waste
- Radioactive Waste
- Radiation Exposures
- New or Modified Federal/State Permits

Based on the disposition of cooling tower discharge, the existing New York State Pollutant Discharge Elimination System (SPDES) permit would be revised as necessary. The cooling system would be a closed loop deionized water system using ion exchange beds that would be removed for regeneration or disposal by a contractor off site. In no case would the ion beam strike the water directly. At the proposed beam current and ion-beam energy, no induced activity would be expected. Discharge of contaminants to the ground or to the sanitary system would be neither planned nor expected from the cooling system. The closed loop cooling system would be connected to the cooling tower via a heat exchanger. Cooling-tower water would be treated either with ozone or with biocides and rust inhibitors, and would meet all SPDES effluent limits.

8.1.3 ESSH Plans for Construction

All requests for goods or services will be processed through a formal and well-documented system of review to incorporate any special ESSH requirements of the contractor or vendor. BNL will review the proposed contract scope of work using Work Planning and Control for Experiments and Operations Subject Area. The building modification and utility drawings for the new pre-injector will be sent to the BNL's Safety and Health Services Division for review by the appropriate Environment, Safety and Health (ES&H) disciplines.

C-AD will define the scope of work with sufficient detail to provide reviewers and support personnel with a clear understanding of what is needed, expected, and required. This will include the type of work to be performed, location of work, defined contract limits, allowed access routes, and any sensitive or vulnerable laboratory operations or infrastructure that may be impacted by this work. The C-AD will ensure that facility hazards are characterized and inventoried specific to the expected construction location and activities.

The C-AD will ensure that minimum ESSH competency requirements for contractors are detailed and provided to the Procurement & Property Management Division (PPM). PPM will include those requirements in the bid and contract documents to qualify contractors for award. Competency requirements will be consistent with the project, facility and job to be performed.

8.1.4 ESSH Plans for Commissioning, Operations and Decommissioning

The Collider-Accelerator Department has already identified hazards and associated on-site and off-site impacts to the workers, the public and the environment from the C-AD accelerator facilities, including the new EBIS based pre-injector, for both normal operations and credible accidents. Sufficient detail was provided to DOE in the current C-AD Safety Assessment Document (SAD) to ensure that C-AD has performed a comprehensive hazard and risk analysis. The amount of descriptive material and analysis in the SAD related to both the complexity of the facility and the nature and magnitude of the hazards. In addition, the SAD provides an understanding of radiation risks to the workers, the public and the environment.

The risk analysis in the SAD addresses the hazards of the entire system of pre-injectors and accelerators. It also addresses hazards, controls and risks for all facilities such as pre-injectors, injectors, accelerators, experimental halls, experiments and their associated targets and detectors. The C-AD SAD follows the generally accepted principles identified in DOE Order 420.2B.

8.2 PROJECT QUALITY ASSURANCE PROGRAM

8.2.1 Program

The project, through the Collider-Accelerator (C-A) Department, shall adopt in its entirety the BNL Quality Assurance (QA) Program. This QA Program describes how the various BNL management system processes and functions provide a management approach which conforms to the basic requirements defined in DOE Order 414.1B, Quality Assurance.

The quality program embodies the concept of the “graded approach” i.e., the selection and application of appropriate technical and administrative controls to work activities, equipment and items commensurate with the associated environment, safety and health risks and programmatic impact. The graded approach does not allow internal or external requirements to be ignored or waived, but does allow the degree of controls, verification, and documentation to be varied in meeting requirements based on environment, safety and health risks and programmatic issues.

The BNL QA Program shall be implemented within the Project using C-A QA implementing procedures. These procedures supplement the BNL Standards Based Management System (SBMS) documents for those QA processes that are unique to the C-A Department. C-A QA procedures are developed by C-A QA and maintained in the C-A Operations Procedures Manual, Chapter 13.

The C-A QA philosophy of adopting the BNL Quality Program and developing departmental procedures for the implementation of quality processes within C-A ensures that complying with requirements will be an integral part of the design, procurement, fabrication, construction and operational phases of the Electron Beam Ion Source Project.

A Quality Representative has been assigned to serve as a focal point to assist C-A management in implementing QA program requirements. The Quality Representative has the authority, unlimited access, both organizational and facility, as personnel safety and training allows, and the organizational freedom to: assist line managers in identifying potential and actual problems that could degrade the quality of a process/item or work performance, recommend corrective actions, and verify implementation of approved solutions. All C-A personnel have access to the Quality Representative for consultation and guidance in matters related to quality.

8.2.2 Personnel Training and Qualifications

The BNL Training and Qualification Management System within the Standards Based Management System (SBMS) supports C-A management's efforts to ensure that personnel working on EBIS are trained and qualified to carry out their assigned responsibilities. The BNL Training and Qualification Management System is implemented within the C-A Department with the C-A Training and Qualification Plan of Agreement.[1]

8.2.3 Documents and Records

The BNL Records Management System and controlled document Subject Areas within SBMS, supplemented by C-A procedures, provide the requirements and guidance for the development, review, approval, control and maintenance of documents and records.

C-A documents encompass technical information or instructions that address important work tasks, and describe complex or hazardous operations. They include plans, and procedures, instructions, drawings, specifications, standards and reports.

[1] http://www.agshome.bnl.gov/AGS/Accel/SND/Training/trainplan.pdf C-A Department Training and Qualifications Plan

8.2.4 Work Process

Work is performed employing processes deployed through the BNL SBMS. SBMS Subject Areas are used to implement BNL-wide practices for work performed. Subject Areas are developed in a manner that provides sufficient operating instructions for most activities. However, C-A management has determined that it is appropriate to develop internal procedures to supplement the SBMS Subject Areas. These C-A procedures are bounded by the requirements established by the BNL Subject Areas.

Group leaders and technical supervisors are responsible for ensuring that employees under their supervision have appropriate job knowledge, skills, equipment and resources necessary to accomplish their tasks. Where applicable, contractors and vendors are held to the same practices.

8.2.5 Design

Design planning shall establish the milestones at which design criteria, standards, specifications, drawings and other design documents will be prepared, reviewed, approved and released. The design criteria shall define the performance objectives, operating conditions, and requirements for safety, reliability, maintainability and availability, as well as the requirements for materials, fabrication, construction, and testing. Appropriate codes, standards and practices for materials, fabrication, construction, testing, and processes shall be defined in the design documentation. Where feasible, nationally recognized codes, standards and practices shall be used. When those are either overly restrictive, or fall short of defining the requirements, they shall be modified, supplemented, or replaced by BNL specifications.

Specifications, drawings and other design documents present verifiable engineering delineations in pictorial and/or descriptive language representations of parts, components or assemblies for EBIS. These documents shall be prepared, reviewed, approved and released in accordance with C-A procedures. Changes to these documents shall be processed in accordance with the C-A configuration management program.

8.2.6 Procurement

Personnel responsible for the design or performance of items or services to be purchased shall ensure that the procurement requirements of the purchase request are clear and complete. Using the graded approach, potential suppliers of critical, complex, or costly items or services shall be evaluated in accordance with predetermined criteria to ascertain that they have the capability to provide items or services which conform with the technical and quality requirements of the procurement. The evaluation shall include a review of the supplier's history with BNL or other DOE facilities, or a pre-award survey of the supplier's facility. C-A personnel shall ensure that the goods or services provided by the suppliers are acceptable for intended use.

8.2.7 Inspection and Acceptance Testing

The BNL Quality Management System within the SBMS, supplemented by C-A procedures, provides processes for the inspection and acceptance testing of an item, service or process against established criteria and provides a means of determining acceptability. Based on the graded approach, the need and/or degree of inspection and acceptance testing shall be determined during the activity/item design stage. Inspection/test planning has as an objective the prompt detection of nonconformances that could adversely affect performance, safety, reliability, schedule or cost.

8.3 RISK ASSESSMENT

This section contains a high level overview of risks in the EBIS Project. Procedures for assessing and tracking risk in a more formal way is documented in the EBIS Risk Management Plan, and a Tracking List for identified risks is maintained and updated as needed.

Risk of not proceeding with the EBIS project:

If the new Linac-based pre-injector is not built, significant upgrades to the tandems will be required in order to ensure reliable long-term operation for RHIC. This has been discussed in Section 4.6.

Technical, Cost and Schedule Risks:

The technical risks of the EBIS design are low. The successful EBIS ion source R&D program at BNL has greatly decreased any risk related to a source of this type reaching the planned performance requirements. A prototype EBIS has operated with the full required electron beam current of 10 A, which is a factor of 20 improvement over previous EBIS sources. Since EBIS scaling laws are very well understood, the scaling of the source output by a factor of 2 from the prototype is achieved by a straightforward doubling of the EBIS trap length, that is, by doubling the length of the superconducting solenoid. The development described in Section 4.6 helps minimize technical and schedule risk related to the LEBT design.

The RFQ and the Linac accelerators are both mature technologies, with very similar devices operating successfully at BNL as well as at other accelerator laboratories. The present plan is to procure these devices from laboratories where several similar units have been built previously. Therefore, technical risk on these devices is low. There is a perceived higher than normal schedule risk on these devices, however, because it is likely that these items will procured either from, or with the assistance of, University laboratories in Europe. There is a risk of schedule delays due to conflicts with other commitments that may arise at these laboratories. This risk will be minimized by early procurement of both the RFQ and Linac, and frequent communication with these collaborators. The RFQ order was placed in June 2006. (NASA funded construction)

Currency exchange risk – it is probable that the EBIS project will include foreign procurements. Due to the cost risk associated with an unfavorable dollar vs. Euro exchange rate change, an average contingency rate of 35% has been applied to several key items. In addition, risk will be reduced by placing early procurements of some of these key items.

Uncertainties in the Booster operation schedule (for RHIC or NSRL) may impact the EBIS project schedule. This risk will be minimized by careful management of the project, since the majority of work can proceed in parallel with Booster operations. The HEBT dipoles, which can only be installed during a Booster shutdown, will be procured early to allow large schedule float. The beam port through the shielding wall between the Linac and Booster must also be done during a Booster shutdown period. This NASA-funded effort was planned for early installation during summer of 2006 in order to minimize schedule risk, and is complete.

Delays in project funding due to a Congressional Continuing Resolution could delay the placement of several key long-lead procurements. This is perceived to be a high risk, so BNL will work closely with DOE and NASA to insure that adequate funds are available for key procurements, and there will be an attempt to avoid scheduling large procurements for the first quarter of a fiscal year.

9 PROJECT CONTROLS AND REPORTING SYSTEMS

The EBIS project has been entered into the Project Assessment and Reporting System (PARS) and is updated on a monthly basis by the FPD.

The CPM leads monthly cost and schedule reviews and reports the result to the FPD. In addition, he leads quarterly overall cost, schedule and technical performance reviews and reports the results to the BHSO-DOE office. The FPD reports progress to the DOE Program Manager on a quarterly basis. The FPD and CPM participate in monthly teleconference calls with the DOE Office of Nuclear Physics. The Office of Nuclear Physics conducts annual progress reviews with a panel of experts.

The standard BNL accounting system is the basis for collecting cost data, and the Control Account structure for EBIS separates costs according to funding source (DOE or NASA), funded phase (R&D, PED, Construction, Pre-Ops), and WBS. A direct one-to-one relationship has been established between each WBS element of Level 2 or lower and a separate control account in the BNL accounting system.

Technical performance is monitored throughout the project to insure conformance to approved functional requirements. Design reviews and performance testing of the completed systems are used to ensure that the equipment meets the functional requirements.

APPENDIX A: WBS DICTIONARY

This dictionary gives a succinct definition of some of the most important tasks included in the WBS and describes both DOE and NASA activities.

1.1 Structural Components

1.1.1 EBIS Hardware

The mechanical components which comprise the EBIS source.

1.1.1.1 SC Solenoid

The superconducting solenoid is a major element of EBIS and its function is to focus the electron beam generated in the electron gun and maintain its diameter in a region of the ion trap. No shielding is planned for the solenoid in order to enable use of its magnet field "tails" for the electron beam transmission in areas where use of other coils is difficult. The required magnetic field in the center of solenoid is determined by the combination of parameters (cathode emission current density, ion confinement time, tolerated level of impurities, ability of the electron collector to dissipate certain power). The solenoid is located on the EBIS platform and should require minimum maintenance for refilling of cryogens. (A portion of this WBS is funded by NASA)

1.1.1.2 Electron Gun

The EBIS electron gun generates the electron beam used for the ionization and confinement of ions in a trap. Since the electron beam propagates through the areas with very low potentials and with different magnetic fields the requirements on the laminarity of the electron beam are high. For this reason the magnetic field on the cathode is high enough to determine formation of the electron beam in a cathode-anode gap. The cathode material (IrCe) provides high emission current density with a lifetime of several thousand hours. The electron gun chamber is separated from the rest of the EBIS by two gate valves, which in a case of gun failure allows replacement of whole gun unit by a new one without venting the gun chamber and venting only small buffer volume between gate valves.

1.1.1.3 Drift Tube & Chamber Structures

Drift tubes are installed along the EBIS axis to control ion trap operation and propagation of the electron beam. Drift tubes are electrically isolated from the ground and connected to the external power supplies via electrical feedthroughs in a vacuum jacket. Vacuum chambers form a vacuum envelope around the EBIS with the pressure of residual gas in the range of $1x10^{-10}$ Torr. Three gate valves separate different parts of the EBIS for the purpose of maintaining high vacuum in parts that are not vented during modification or repair.

1.1.1.4 Stands, Platform Hardware

This includes the mechanical support structures for the EBIS, the electron gun, the LEBT line, and the external ion sources. It also include the 100 kV insulating platform for the EBIS source and its associated power supplies, as well as the electrical system required to put a ramp on the EBIS trap electrodes for fast ion extraction.

1.1.2 LEBT and External Ion Injection

The beamlines between the EBIS output and RFQ input.

1.1.2.1 LEBT

The LEBT is a transitional portion of the pre-injector and is used for:

- transmission and forming for the injection into RFQ of the ion beam extracted from the EBIS,
- transmission of the ion beam from the external ion injector into the EBIS,
- diagnostic measurements of the ion beams (total ion current measurements, ion beam content measurements),
- vacuum pumping of the electron collector.

The LEBT consists of two vacuum chambers separated by a gate valve; it contains optical electrostatic elements (deflectors, lenses), magnetic lenses for focusing the ion beam into the RFQ and diagnostic elements.

1.1.2.2 External Ion Injection

A set of two or more ion sources generating low charge state ions for injection into EBIS. This also includes ion optics, a switching station for electronically selecting the desired ion species for ion injection, ion current monitors, vacuum system and power supplies.

1.1.3 RF Structures

Resonant cavities used to accelerate or decelerate (for bunching) the ion beam. When radiofrequency power is fed into these resonant cavities, the appropriate electric fields for acceleration or deceleration are produced.

1.1.3.1 RFQ

The Radio Frequency Quadrupole (RFQ) is a resonant structure in which four long, continuous vanes or rods, machined with precise modulations and configured in a quadrupole geometry, provide bunching, focusing, and acceleration of the injected ion beam. This type of structure is able to provide efficient rf acceleration at the low energies ion beams have when initially extracted from an ion source. A 4-rod RFQ operating at 100.625 MHz is planned. (A portion of this WBS element is funded by NASA)

1.1.3.2 Linac

The Linac is a resonant structure, which generates time dependent axial electric fields to accelerate ions. When the rf field direction is reversed, the ion bunches are shielded from the decelerating fields by internal drift tubes. An "Interdigital-H" - type Linac operating at 100.625 MHz is planned. (A portion of this WBS element is funded by NASA)

1.1.3.3 Buncher Cavities

A resonant cavity in which the time dependent field in a gap is adjusted to decelerate the front of a beam bunch arriving at the gap, and accelerate the back of the bunch, so that all particles in the bunch arrive at a downstream point more closely spaced in time. By changing the phase of the cavity by 180 degrees relative to the bunch, it can be used to remove energy spread in the beam ("debuncher") instead. (A portion of this WBS element is funded by NASA)

1.2 Controls

Networked, front-end interfaces will be connected via Ethernet to control console workstations and central C-AD servers. Full pulse-to-pulse modulation functionality will be provided. Custom application software will be provided as needed, but extensive re-use will be made of existing software designs with EBIS database additions.

1.2.1 Timing & Infrastructure

C-AD fiber optic infrastructure will be extended to the EBIS equipment area and a standard network switch and timing chassis will be provided. Workstations and monitor screens will be provided for console-level control access, along with supporting software and database configuration.

1.2.2 EBIS

Waveform generation and data acquisition for EBIS will be provided using the fiber-optically isolated PSI interface and VME function generator. The fiber link interface of these standard C-AD modules will be modified to operate at 50 to 100 kHz for this application. Additional fiber optic links will carry pulsed trigger signals to the high voltage platforms. Standard VME chassis will be provided. Minor modifications will be required to existing front-end software for the function generator. A custom console application program will be developed for power supply waveform control.

1.2.3 Accelerators & Beam Transport

Commercial and C-AD standard VME modules will be used to control magnet power supplies and beam-line instrumentation. Standard VME chassis assembly and timing modules will be provided for these systems and also for RF system interfaces. Front-end software effort will be mainly configuration and database setup. Existing console programs for beam line diagnostics will be modified to include the EBIS transport lines.

1.3 Diagnostics/Instrumentation

1.3.1 Faraday Cup

A fully destructive measurement is made when a detector head is plunged into the beam path to collect the entire ion beam. The captured charge is measured as a current in the processing electronics. Several types of detector heads can be employed depending on the characteristics of the desired measurement. Channeltrons or multichannel plates are used for fast high bandwidth response.

1.3.2 Current Transformers

A ferrite toroid wound with many turns of signal wire is positioned around a ceramic break in the beam transport, all enclosed in a protective shroud. This is used as a non-destructive technique to measure the ion beam current characteristics with respect to time. A separate set of wire turns on the toroid is used for injecting a calibration signal.

1.3.3 Profile Monitors

Transverse beam profiles are measured by plunging an array of thin wires into the beam path. Each of the wires collects the charge from the small portion of the ion beam it intercepts; this charge is detected as a current in the processing electronics.

1.4 Magnet Systems

1.4.1 EBIS Warm Solenoids

The EBIS warm solenoids consist of three solenoid magnets. The electron gun solenoid is designed with water-cooled hollow conductors, pancake-style coils and no iron return. The electron gun coil provides the necessary field for proper electron beam launching and transport. The electron collector solenoid is similar in design to the electron gun solenoid. The electron collector solenoid focuses the beam to allow for proper electron collector operation. The remaining magnet, the LEBT solenoid, is a pulsed solenoid located directly in front of the RFQ. The LEBT solenoid focuses the EBIS beam into the RFQ. The design of the LEBT solenoid uses pancake coils with a laminated iron return similar in design to the BNL Optically Pumped Polarized Ion Source (OPPIS) LEBT solenoid.

1.4.2 MEBT Quadrupoles

The EBIS MEBT quadrupole magnets are used to provide the necessary focusing for beam transport between the RFQ output and the Linac input.

1.4.3 HEBT Dipoles

The HEBT dipoles are two similar 73° bending dipoles. The basic design of the dipoles is a C style with the open end facing the outer curve to allow the chamber to have a port for the Tandem-to-Booster (TTB) line into the Booster. The magnets will be constructed of laminations of different sizes which when assembled will produce the required bend shape. The magnet coils will be made of water-cooled hollow copper conductor. (A portion of this WBS element is funded by NASA)

1.4.4 HEBT Quadrupole Magnets

The HEBT quadrupoles will be air-cooled Danfysik magnets. Originally used for other projects at BNL, these magnets are available for the EBIS beam line. These magnets will allow switching of values in ~ 1 second for running of different magnetic rigidity beams.

1.5 Power Supply Systems

1.5.1 EBIS

Power supplies to support EBIS itself:

- Solenoid, cathode, cathode heater, collector and grid supplies.
- Platform bias supplies and the transformers to isolate them.
- Drift tube supplies, Behlke switches, and transverse magnetic supplies.
  (A portion of this WBS element is funded by NASA)

1.5.2 External Ion Injectors and LEBT

Power supplies to support two external ion sources, the transport from the ion sources to the LEBT, and the LEBT itself:

- Heater, arc pulser and extractor power grid supplies.
- Platform bias supplies and the transformers to isolate them.
- Supplies for electrostatic and electromagnetic steering elements and lenses.
- Mass analyzer and focusing solenoid power supplies.

1.5.3 MEBT, IH LINAC, and HEBT

Power supplies for the MEBT, IH LINAC, and HEBT:

- Pulsed quadrupole magnets and steering magnet power supplies.
- Linac drift tube quadrupole magnet power supplies.

- Pulsed bending magnet power supplies.
  (A portion of this WBS element is funded by NASA)

1.6 RF Systems

1.6.1 High Level RF

The final rf amplifier stages powering the RFQ, Linac, and three bunchers. This also includes the coaxial transmission line connecting the amplifier outputs to the rf cavities.

1.6.2 Low Level RF

The low power rf systems which provide the phase and amplitude controls for the high level rf systems, and frequency control for the resonant cavities.

1.7 Vacuum Systems

(A portion of this WBS is funded by NASA)

1.7.1 Beampipes, Chambers, Pumps, and Valves

The pipes or chambers that have vacuum pressure inside and provide a path for the ion to be transported, as well as provide a housing for special components inside the vacuum system. The pumps used to evacuate or pump down a vacuum chamber from atmospheric pressure to the desired high vacuum or ultra-high vacuum range. Manual or pneumatically operated valves used to isolate vacuum pumps and/or a section of the beam line from another section or vacuum chamber.

1.7.2 Vacuum Instrumentation & Control

A PLC-based control system used to monitor and control the vacuum system and components such as gauges, pumps and valves.

1.7.3 Beam Port Vacuum Components

The beampipe, chamber, and other associated vacuum equipment required as part of the beam port section.

1.8 Cooling Systems

The cooling system will use the excess capacity of the NSRL deionized water system to supply 325 gpm to the preinjector facility equipment. A high pressure flow loop will branch from this supply, consisting of a boost pump and heat exchanger, for two high pressure applications: the electron collector and the Linac quadrupoles. The present Linac chilled water system, which dissipates heat into the existing Linac cooling tower, will be extended for the air conditioning in the new building addition. Low flow chillers for tight temperature range control and special water conditioning will be used for the RF equipment, as necessary. The active on-line deionized water controls will maintain the required resistivity. The RF Linac chilled water loop will have a 4109 iron corrosion inhibitor control system.

1.9 Facility Modifications

1.9.1 Beam Access Port

A new access port for the EBIS beam line will be installed through the earth shielding from Linac to the Booster. (A portion of this WBS is funded by NASA)

1.9.2 Power modification

Provides for the relocation of existing power & tray in the Linac area where the EBIS beam line will be installed.

1.10 Installation

The major systems and components of the EBIS are installed at the facility site in building 930, including structural components, control systems, diagnostic and instrumentation systems, magnets, power supplies, RF systems, vacuum systems, and cooling systems. The installation effort also includes any minor additions or changes to the building and facility necessary to accommodate these systems and components.

1.10.1 Structural Components

The major structural components installed in the facility include the Electron Beam Ion Source (EBIS), RFQ, and Linac. Other components will include smaller devices located in the LEBT, MEBT, and HEBT beam transport regions, such as auxiliary ion sources (LEBT), bunchers, electrostatic beam transport devices, and beam monitoring devices.

1.10.2 Controls

Installation of controls for the entire project.

1.10.3 Diagnostics/Instrumentation

Installation and checkout of all diagnostics in the beamlines.

1.10.4 Magnet Systems

The magnet systems installed in the beam transport line include dipole, quadrupole, and solenoidal magnets, and steerers. Also includes survey of elements.

1.10.5 Power supply Systems

Installation of all power supplies in their final locations, the connection of power from breaker boxes to the supplies, and the connections from the power supplies to the elements.

1.10.6 RF Systems

Installation of the rf power supplies, as well as the connection of the coaxial transmission line between the rf amplifiers and the rf cavities.

1.10.7 Vacuum Systems

Installation of beampipes, chambers, pumps, and valves. Also includes the leak checking and bakeout of systems.

1.10.8 Cooling Systems

Installation of all cooling systems.

1.11 Project Services

Level of effort tasks associated with the daily management, oversight, and assessment of the project.

1.11.1 Project Management & Support

This WBS contains the effort associated with the Project Office at BNL for the EBIS. The effort includes: the CPM, Project Controls, ESH&Q, installation and conventional facilities coordination, financial oversight, documentation and reporting, and the Project Office secretary.

1.12 Commissioning

System integration with beam. This includes beam tuning and characterization from the EBIS, through the LEBT, RFQ, MEBT, Linac, and HEBT. Activities will include the measurements of beam currents, profiles, emittances, verification of beam energy and energy spread, and measurement of charge state distributions for several ion species. Commissioning ends when the performance required for CD4 has been demonstrated.

1.13 R&D

A development program which uses the existing Test EBIS to verify the validity of several key design choices related to the extraction, acceleration, and initial transport of the ion beam from the EBIS. The R&D also includes testing the EBIS electron collector design for thermal load handling. These developments will serve to reduce technical and schedule risks on the project. The R&D includes the procurement of the full power electron collector, which will later be used on the RHIC EBIS. Procurement of a 100 kV isolation transformer, high voltage isolation, and some EBIS power supply modifications will allow the EBIS to be operated from a high voltage platform, producing beams at the final energy required for injection into the RFQ. Finally, a prototype of the final LEBT design will be built and tested. (A portion of this WBS element is funded by NASA)

APPENDIX B: NASA ITEMS

Per the Statement of Work between BNL and NASA, NASA will contribute $4.5M (AY $) to the project costs. These funds allow the schedule to be accelerated to approximately four years. Within the overall EBIS project, items have been identified for acquisition with these funds. The NASA scope includes the Radio Frequency Quadrupole, the Linac and bunchers, the EBIS superconducting solenoid, the HEBT dipole magnets, a beam access port, and various power supplies. A detailed list follows the funding tables.

NASA Funding: the planned levels of funding per fiscal year are as follows:

$M					
	FY 05	**FY 06**	**FY 07**	**FY 08**	**Total**
R&D		0.6			0.6
CDR					-
PED/EDIA					-
Cons	0.5	0.9	1.5	1.0	3.9
Pre-Ops					-
TEC	0.5	0.9	1.5	1.0	3.9
TPC	0.5	1.5	1.5	1.0	4.5

Application of NASA funds:

WBS	Title	M$
1.1	Structural components	1.7
1.2	Controls Systems	0.0
1.3	Diagnostics	0.0
1.4	Magnet Systems	0.3
1.5	Power Supply Systems	1.1
1.6	RF Systems	0.0
1.7	Vacuum systems	0.1
1.8	Cooling Systems	0.0
1.9	Facility Modifications	0.1
1.10	Installation	0.0
1.11	Project Services	0.0
1.12	Commissioning	0.0
1.13	R&D / CDR	0.5
subtotal		3.7
	Contingency	0.8
Total		4.5

Planned use of NASA funds					
1.1	**Structural Components**				
		SC Solenoid			
			Procure solenoid & ps		
			Procurement/Vendor interface		
			Vendor site inspection (2)		
			Incoming inspection		
			Onsite installation service		
		RFQ			
			Procurement		
			Travel to vendor		
			Shipping		
			Incoming inspection		
		Linac			
			Procurement		
			Travel to vendor		
			Shipping		
			Incoming inspection		
		Bunchers			
			Procurement		
			Shipping		
			Incoming inspection		
1.4	**Magnet Systems**				
		HEBT dipoles			
		Procurements			
			Laminations		
			Coils		
			Magnet stands		
			Jacks		
			Bus terminations		
			Water manifolds		
		Vendor visits (2)			
		Procurement/Vendor interface			
		Incoming inspection			
1.5	**Power Supplies**				
		Alternate anode PS			
		Electron Collector PS			
		Ion extractor PS			
		Supressor PS			
		Drift tube PS			
		Platform bias PS			
		Lens PS			
		MEBT Materials			
			Quad PS		
			Steerer PS		
			Racks		
		IH LINAC Materials			
			Quad PS		
		HEBT Materials			
			Big bend dipole PS		
			Quad PS		
			Steerer PS		
			Racks		
			Travel		
1.7	**Vacuum systems**				
		Beam Access Port			
			Beam Port efforts & Procurements		
1.9	**Facility Modifications**				
		Beam Access Port			
			Disc/reconnect LTB equipment		
			Remove/install equipment		
			contract supervision		
			port installation contract		
			as-builts & design changes		

Appendix C: Agreements

Department of Energy
Washington, DC 20585

January 11, 2006

MEMORANDUM FOR RAYMOND L. ORBACH
DIRECTOR
OFFICE OF SCIENCE

FROM: DENNIS KOVAR
ASSOCIATE DIRECTOR OF THE OFFICE OF SCIENCE
FOR NUCLEAR PHYSICS

SUBJECT: ACTION: Sign the Implementing Agreement between the Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA) which establishes the roles and responsibilities with respect to the construction of the Electron Beam Ion Source (EBIS) at Brookhaven National Laboratory (BNL).

ISSUE: The DOE Office of Nuclear Physics initiated the EBIS project with conceptual design efforts in FY 2005. NASA plans to contribute funding of $4,500,000 to the EBIS project over three years in order to accelerate the project completion, reducing the DOE estimated Total Project Cost to $14,800,000. DOE Office of Science shall be solely responsible for managing the construction, commissioning and decommissioning of the EBIS project.

BACKGROUND: The EBIS project will deliver a new pre-injector for the Relativistic Heavy Ion Collider (RHIC) facility at BNL, replacing the aging and high-maintenance Tandem van de Graaff accelerators currently being used. This new linac-based pre-injector will lead to increased integrated luminosity and is a critical component for successfully implementing the RHIC II upgrade and eRHIC.

The proposed pre-injector will also provide a major enhancement in capability for the NASA Space Radiation Laboratory (NSRL), which utilizes heavy-ion beams from the RHIC complex. EBIS would make it possible to deliver to the NASA radiobiology program accelerated beams of important ion species such as helium, argon, neon and calcium that are unavailable with the present pre-injector. The new system would additionally allow for rapid switching of ion species for NSRL experiments, providing for enhanced mixed radiation field studies and reducing delays due to the interference with RHIC injection operations and thereby improving the effectiveness of the NSRL program.

Since this agreement was drafted, NASA provided $500,000 in FY 2005. They plan to contribute the balance of the $4,500,000 on a yearly basis through FY 2008.

SENSITIVITIES: None

POLICY IMPACT: None

RECOMMENDATION: Sign the attached Implementing Agreement.

Attachment:
Implementing Agreement signed by NASA on 12/12/2005

IMPLEMENTING AGREEMENT

BETWEEN

THE DEPARTMENT OF ENERGY

AND

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

REGARDING THE

ELECTRON BEAM ION SOURCE

AT

BROOKHAVEN NATIONAL LABORATORY

1.0 INTRODUCTION

The purpose of this Implementing Agreement is to establish the roles and responsibilities of the National Aeronautics and Space Administration (NASA) and the Department of Energy (DOE) with respect to the construction of the Electron Beam Ion Source (EBIS). The EBIS project is a joint DOE and NASA project, which will be managed by DOE. NASA has a vested interest in contributing to the construction because of the enhanced capabilities EBIS will provide to the NASA Space Radiation Laboratory (NSRL) situated at the Brookhaven National Laboratory (BNL).

This agreement is complementary to the policy established in the Memorandum of Understanding regarding Energy-Related Civil Space Activities between the NASA and DOE dated July 9, 1992, and to the Memorandum of Agreement between NASA and BNL dated April 8, 1994. This Implementing Agreement does not alter the terms established under the Implementing Arrangement between DOE and NASA regarding the NSRL (formerly the Booster Applications Facility) dated October 29, 1997.

2.0 SCOPE OF ACTIVITY

The EBIS project to be executed by DOE and NASA within the framework of this agreement shall consist of inter-agency cooperation, exchange of information and funding contributions. Management and control of the EBIS project shall be vested in the DOE, Office of Science.

3.0 AGENCY AUTHORITIES

3.1 The NASA is acting pursuant to authorities conferred under the National Aeronautics and Space Act of 1958, Public Law No. 85-568, As Amended.

3.2 The DOE is acting pursuant to authorities conferred in the Department of Energy Organization Act, 42 U.S.C. §7101, et seq., (42 U.S.C. § 7151), the Atomic Energy Act of 1954, 42 U.S.C. §2011 et seq., including, but not limited to, 42 U.S.C. §2051.

3.3 These authorizations for the two agencies, together with the internal policies and procedures of each agency, define the authority of the two agencies to establish and manage their respective programs.

3.4 The authorities that the two agencies bring to the execution and integration of EBIS into the BNL program are those which they have independently as program offices within their respective agencies.

3.5 In the implementation of the agencies' decisions and resultant actions, each will follow the policies and procedures of their respective agencies.

4.0 PROJECT DESCRIPTION

The EBIS project will deliver a new pre-injector for the Relativistic Heavy Ion Collider (RHIC) facility, replacing the aging and high-maintenance Tandem van de Graaff accelerators currently being used. This new linac-based pre-injector will lead to increased integrated luminosity and is a critical component for successfully implementing the RHIC II upgrade and eRHIC. These two proposed projects are identified in the 2003 Office of Science's *Facilities for the Future of Science: A Twenty Year Outlook*

The proposed pre-injector will also provide a major enhancement in capability for the NASA Space Radiation Laboratory (NSRL), which utilizes heavy-ion beams from the RHIC complex. EBIS would make it possible to deliver to the NASA radiobiology program accelerated beams of important ion species such as helium, argon, neon and calcium that are unavailable with the present pre-injector.

The new system would additionally allow for rapid switching of ion species for NSRL experiments, providing for enhanced mixed radiation field studies and reducing delays due to the interference with RHIC injection operations and thereby improving the effectiveness of the NSRL program.

5.0 AGENCY ROLES AND RESPONSIBILITIES

5.1 The DOE Office of Science shall have executive management responsibility for the EBIS project.

5.2 The DOE Office of Science shall be responsible for the oversight of the management, construction and commissioning of the EBIS project, as described in the EBIS Project Execution Plan following its approval.

5.3 The DOE Office of Science shall retain title to the equipment procured within the scope of work referenced under the EBIS project.

5.4 NASA shall be responsible for providing the agreed level of funding under article 6.2 in a timely manner to enable the acceleration of the project profile in order to shorten the completion time of the project.

5.5 The NASA Exploration Systems Mission Directorate shall be responsible for oversight of NASA participation in the EBIS project.

5.6 DOE and NASA shall each designate an official point of contact representing each agency for this project. For DOE that person shall be the Federal Project Director. For NASA that person shall be the Human Research Program Executive.

6.0 FINANCIAL RESPONSIBILITIES

6.1 DOE and NASA shall be responsible for the costs they respectively incur in their own interest related to the support of this Implementing Agreement.

6.2 NASA shall partially fund the EBIS project in order to accelerate the project completion. For this purpose, NASA is requesting support from its budget as early as FY 2005, for this project. The proposed support is $1,500,000 per year for three years, for a total of $4,500,000.

6.3 The DOE Office of Science shall be responsible for the construction, commissioning, decommissioning, and environmental cleanup for the EBIS project, including funding except that provided by NASA for the level and purpose as stated in article 6.2 above.

6.4 The DOE is responsible for compliance with the National Environmental Policy Act (NEPA) requirements for the EBIS project.

6.5 The DOE shall pay the costs incurred by the Brookhaven Site Office to fulfill its management responsibilities.

6.6 Implementation of this agreement by DOE and NASA is subject to the requirements of the Anti-Deficiency Act, 31 U.S.C. Sec. 1512, et seq., and the availability of appropriated funds. Any requirement for the payment or obligation of funds by NASA or DOE established by the terms of this Implementing Agreement shall be subject to the availability of appropriated funds. Both Parties acknowledge that they will not be required under this Implementing Agreement to expend appropriated funds unless and until an authorized officer of that agency acts to commit to such expenditures as evidenced in writing. This agreement does not transfer funds.

7.0 OVERSIGHT AND COORDINATION

7.1 The DOE Office of Science shall perform reviews of the EBIS project to assess project performance.

7.2 NASA shall be informed of the parameters of any relevant DOE review and be invited to attend.

7.3 The Office of Nuclear Physics within the DOE Office of Science shall be informed of the parameters of any relevant NASA review and be invited to attend.

8.0 MISCELLANEOUS

8.1 The NASA and DOE agree that any requests for information received under the Freedom of Information Act (FOIA) shall be processed in accordance with the receiving agency's FOIA regulations; however, the receiving agency agrees to consult the other agency prior to the release or denial of any information requested under the FOIA. The NASA and DOE also agree that prior to the release of any significant information regarding this Implementing Agreement, or EBIS experiments conducted by or at DOE laboratories or facilities, such as a statement to the press, they shall consult together regarding the content of such a release.

9.0 AMENDMENTS, DISPUTES, APPROVALS, DURATION AND TERMINATION

9.1 This Implementing Agreement becomes effective on the date of the last signature and remains effective for a period of ten (10) years unless renewed by the Approval signatories or their successors.

9.2 The Approval signatories or their successors in office shall resolve all disputes or unresolved items or issues covered by this Implementing Agreement at the participant level within their respective agencies, using Federal law and regulation as necessary. If an informal resolution is not possible at the participant level, the Approval Signatories to this Implementing Agreement, or their successors in office, shall be so advised and they shall take the appropriate actions to resolve the inconsistency or conflict.

9.3 This Implementing Agreement between NASA and DOE Offices of Science, as specified above, is made by the signatories below and can be modified as required by the mutual consent of the same signatories or their successors. Either the Director of the Office of Science at DOE or the Associate Administrator for the Exploration Systems Mission Directorate at NASA may terminate this Implementing Agreement upon presentation of ninety (90) days written advance notice to the other, or by the agreement in writing of both Parties.

Signatories
Approved by:

Scott J. Horowitz
Associate Administrator
Exploration Systems Mission Directorate
NASA

12/12/2005
Date

Raymond L. Orbach
Director
Office of Science
DOE

Feb. 2, 2006
Date

Statement of Work

Construction of a New Pre-injector for the NASA Space Radiation Laboratory at Brookhaven National Laboratory

Overview

The NASA Space Radiation Laboratory, NSRL, at BNL supplies ion and proton beams to support experiments that are designed to understand the effects of cosmic radiation to humans in space and to develop countermeasures. This statement of work covers the NASA support of a joint modification project with the Department of Energy, during the period of October 1, 2005 to September 30, 2008. The details are provided in the attached conceptual design report that is entitled; Electron Beam Ion Source Preinjector Project (EBIS). The project will provide for enhanced capabilities of the NSRL facility. Both the DOE and NASA have a joint need to replace the present Tandem accelerator injectors that provide particle beams for NSRL and the Relativistic Heavy Ion Collider (RHIC) scientific programs. The two Tandem accelerators inject ion beams into the Booster synchrotron, which accelerates these ions to higher energy. The ions are subsequently extracted to the NSRL experimental station or to the Alternating Gradient Synchrotron (AGS) for further acceleration subsequent to injection to the two RHIC synchrotron / storage rings. The joint project will replace the two Tandem accelerators with an Electron Beam Ion Source (EBIS), followed by a Radio Frequency Quadrupole (RFQ) accelerator, and a short Linac.

Benefits for NASA

The highly successful development of an EBIS at BNL now makes it possible to replace the present Tandem accelerators, with a reliable, low maintenance Linac-based pre-injector. The advantages for the NASA program are the following:

I. **Full coverage of space radiation elements:** Tandem beams are limited to ions that are produced with negative charge states, while the EBIS can produce all ions. Tandems can not accelerate ions with low electron affinity. Some of these ions, including He, Ne, Mg, Ar, and Ca, are major components of galactic cosmic rays (GCR), and significant components of the dose equivalent. This is illustrated in Table I.

Table I. GCR charge group contributions to dose equivalent (5 g/cm^2 Al).

GCR Charge, Z	% Dose Equivalent	GCR Charge, Z	% Dose Equivalent
0	0.57	15	0.61
1	16.97	16	2.48
2	15.88	17	0.82
3	0.07	18	1.39
4	0.10	19	1.11
5	0.51	20	2.46
6	3.05	21	0.74
7	1.30	22	2.36
8	8.15	23	1.27
9	0.33	24	2.43
10	2.81	25	1.91
11	0.97	26	14.73
12	6.53	27	0.07
13	1.64	28	0.77
14	7.95	Total-All Charge	100.00

Total Not accessible to Tandem 29.10%

- The Van de Graaff limitations restrict the science accessible to the research program in the following ways
  i) For radiobiology research a detailed understanding of the radiobiology of helium ions cannot be obtained. Helium ions are a major component of GCR, as seen above, and have distinct particle track structures at the cellular and tissue level that cannot be simulated with other particles, and requires their direct use and studies with these other ions would be preferred.
  ii) For physics and shielding research, detailed data bases can not be completed without direct use of these beams (He, Ne, Mg, Ar, etc.). Table II shows in the beams and energies for which the Space Radiation Initiative (SRI) has a commitment to provide shielding data The full circles indicate points where data are required; the crosses show where some data are available. The particles that cannot currently be obtained have particularly stable nuclear configurations, so that their nuclear interaction properties cannot be accurately inferred from interpolation of data between neighboring species on the periodic table.

Table II. Points for Physics Data Base

ε_P (GeV/ u)	**PARTICLE SPECIES**										
	H	He	C	N	O	Ne	Si	Ar	Ca	Mn	Fe
0.1		●	●		●		●				●
0.2	●	●	●X	X	●X		●X	X			●X
0.4			●		●		●	●			●
0.6		●			●	X	●X				●X
0.8							●	●			●
1.0	●										●X
1.5		●	●		●		●	●	●	●	●
2.0	●										●
5.0	●	●			●		●				●

iii) Studies with nearby charge groups are a reasonable substitute for radiobiology of the primary particles, but not as a means of understanding the biological characteristics of the radiation environment inside a shielded enclosure or behind shielding materials, because the physical environment cannot be predicted accurately in the absence of physics data.

iv) Mixed-field exposures: The tandem limits NSRL simulations to two ion species in one experiment, with the possibility of a third species if the BNL Linac is used to accelerate protons. EBIS-based injection would allow for the rapid switching of many ion types such that a full GCR simulation becomes possible.

II. **Improved Operations:** Overhead rates for beam setups and switching at NSRL currently occur at a rate of 30-40 % percent of the total operation hours. The addition of the EBIS pre-injector has the potential to reduce operations costs through reduction of overhead hours and FTE support for the EBIS versus Tandem injector to the Booster synchrotron.

- The EBIS will switch ion species very quickly, for fast switching between concurrent RHIC and NSRL operations, and fast switching of ion species for NSRL experiments, a feature that is not presently available. This will allow for enhanced mixed-field studies at NSRL. This optimizes the productivity for both NSRL and RHIC scientific programs.

- The new pre-injector system will require substantially fewer personnel to operate and maintain. The Tandem components are increasingly becoming obsolete and are at or beyond their expected lifetime. This will reduce the overall costs to run the pre-injector system.

- The EBIS based pre-injector will allow for a much simpler system to tune for optimum beam performance. This will increase the productivity of NSRL operations.

RISK OF CURRENT CONFIGURATION TO NASA

I) The tandem van de Graaff injectors are no longer manufactured and availability of spare parts is limited. BNL operates two tandems, one of which is required by the RHIC science program. If one of the van de Graaff injectors breaks down, the other one would have to become the RHIC injector. In that case, the beams available for NSRL would be significantly limited by the need to assure availability of RHIC beam species. The impact to NASA would be:
   a) Inability to complete the research program if use of NSRL is restricted to operating while RHIC is on.
   b) Significantly increased costs if NSRL is operated without RHIC, because NSRL operation is no longer incremental.
   c) Possible loss of access to NSRL capabilities if a single remaining van de Graaff injector is required to provide only RHIC particles and may no longer stand by to deliver NSRL beams (there is no overlap between the beam species required by the two facilities).

II) The capabilities provided by the proposed EBIS system are essential for the health of the long-term BNL heavy ion research program. For example, EBIS would enable RHIC to obtain uranium beams for high-energy nuclear physics studies. In turn, the lifetime of the BNL nuclear physics research program is essential for continued availability of NSRL. NASA requires that NSRL remain available for the next 10-15 years; this is not assured absent the EBIS modernization project.

Project Management

DOE and the BNL are proposing to replace the two Tandem accelerators, that provide beam to the Booster and then subsequently to the NSRL, with an Electron Beam Ion Source (EBIS), a Radio Frequency Quadrupole (RFQ) accelerator, and a short Linac to the Booster. The replacement of the Tandems is proposed as a joint project between the DOE and NASA. DOE and BNL will execute this joint project under the existing Memorandum of Agreement between NASA and the DOE, dated February 2002. BNL will manage the project under the prevailing DOE regulations (DOE 413.3).

In addition to the delivery of the operational EBIS, DOE will provide to NASA the EBIS Project Execution Plan, which will be jointly signed by NASA and the DOE, Project cost and schedule documents, and DOE quarterly reports. NASA is invited to participate in monthly and quarterly teleconferences to monitor the progress of the project, as well as key Project reviews (PDR, CDR, ORR, etc).

Project Cost

The EBIS Project has been estimated at a Total Project Cost of $19.3M. This total cost will be shared between NASA (4.5M$) and DOE (14.8M$) over the period FY05-08, see tables below. Project costs are provided in FY05$ and @Yr$, and the NASA and DOE funding in @Yr$.

Estimated Costs in FY 05M$

	FY 05	FY 06	FY 07	FY 08	FY 09	Total
Pre-R&D						-
R&D	0.5	0.7				1.2
CDR	0.2					0.2
PED/EDIA		1.9	0.5			2.4
Cons		0.8	5.7	7.6		14.1
Pre-Ops				0.3		0.3
TEC	-	2.7	6.2	7.6	-	16.5
TPC	0.7	3.4	6.2	7.9	-	18.2

Estimated Costs in @YrM$

		FY 05	FY 06	FY 07	FY 08	FY 09	Total
Escalation	Annual		2.800	2.600	2.600	2.600	
	Cumulative		1.028	1.055	1.082	1.110	
Pre-R&D		-	-	-	-	-	-
R&D		0.5	0.7	-	-	-	1.2
CDR		0.2	-	-	-	-	0.2
PED/EDIA		-	2.0	0.5	-	-	2.5
Cons		-	0.8	6.0	8.2		15.1
Pre-Ops		-	-	-	0.3		0.3
TEC		-	2.8	6.5	8.2	-	17.6
TPC		0.7	3.5	6.5	8.5	-	19.3

DOE FUNDING IN @YRM$

	FY 05	FY 06	FY 07	FY 08	FY 09	Total
Pre-R&D						-
R&D	0.5	0.1				0.6
CDR	0.2					0.2
PED/EDIA		2.0	0.5			2.5
Cons			4.5	6.7		11.2

Pre-Ops				0.3		0.3
TEC	-	2.0	5.0	6.7	-	13.7
TPC	0.7	2.1	5.0	7.0	-	14.8

NASA FUNDING IN @YRM$

Pre-R&D						-
R&D		0.6				0.6
CDR						-
PED/EDIA						-
Cons		0.9	1.5	1.5		3.9
Pre-Ops						-
TEC	-	0.9	1.5	1.5	-	3.9
TPC	-	1.5	1.5	1.5	-	4.5

NASA Funding

NASA will provide a total of $4.5M, at $1.5M per year (FY06-08). It is expected that the first DOE funding that will permit purchase of materials will be available in FY07, and that FY06 NASA funds will be available for the purchase of the long-lead items that are on the critical path for project completion. The FY06 NASA funds are expected to be obligated towards the following major purchases amongst other items:

- RFQ $400K
- Superconducting solenoid $500K

The FY07 and FY08 NASA funds will be used to produce those items that will provide new capabilities for NSRL operations. The NASA funds will be combined with the DOE funding to complete the construction effort and institute commissioning in FY09. BNL will report monthly to both NASA and DOE the progress of construction, including costs, obligations and schedule variations.

Attachment

GLOSSARY

AE	Acquisition Executive
AGS	Alternating Gradient Synchrotron
ALARA	As Low As Reasonably Achievable
BCCB	Baseline Change Control Board
BHSO	Brookhaven Site Office
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates
CAA	Clean Air Act
C-A	Collider-Accelerator
C-AD	Collider-Accelerator Department
CD-0	Critical Decision - 0
CD-1	Critical Decision – 1
CD-2	Critical Decision - 2
CD-3	Critical Decision – 3
CD-4	Critical Decision - 4
CDR	Conceptual Design Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERN	Conseil European pour la Recherché Nucleaire (European Laboratory for Particle Physics)
CFR	Code of Federal Regulations
CGC	Color Glass Condensate
CPM	Contractor Project Manager
DART	Days Away or Restricted Time
DOE-HQ	U.S. Department of Energy – Headquarters
EBIS	Electron Beam Ion Source
ECR	Electron Cyclotron Resonance
EF	Early Finish
EMR	Experience Modification Rates
EMS	Environmental Management System
EPA	Environmental Protection Agency
ES&H	Environment, Safety and Health
ESHQ	Environment, Safety, Health and Quality Assurance
ESSH	Environmental Protection, Safety, Security, Health and Quality
FPD	Federal Project Director
FTE	Full Time equivalent
FY	Fiscal Year
HEBT	High Energy Beam Transport
HEDP	High Energy Density Physics
IH	Inter-Digital H Structure
IPT	Integrated Project Team
ISM	Integrated Safety Management
ISO	International Organization for Standardization

LEBT	Low Energy Beam Transport
LINAC	Linear Accelerator
LIS	Laser Ion Source
LOTO	Lock-Out/Tag-Out
LTB	Linac to Booster
MEBT	Medium Energy Beam Transport
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NP	Nuclear Physics
NSRL	NASA Space Radiation Laboratory
NYSDEC	New York State Department of Environmental Conservation
OBS	Organization Breakdown Structure
OECM	Office of Engineering and Construction Management
OPM	Operational Procedures Manual
OPPIS	Optically Pumped Polarized Ion Source
OSHA	Occupational Safety and Health Act
PARS	Project Assessment and Reporting System
PC	Performance Criteria
PCR	Project Change Request
PED	Project Engineering and Design
PEP	Project Execution Plan
PLC	Programmable Logic Controller
PPM	Procurement & Property Management Division
QA	Quality Assurance
QAM	Quality Assurance Manager
R&D	Research & Development
RCRA	Resource Conservation Recovery Act
RFQ	Radio Frequency Quadrupole
RHIC	Relativistic Heavy Ion Collider
SA	Self-Assessment Program
SAD	Safety-Assessment Document
SBMS	Standards Based Management System
SC	Office of Science
SDWA	Safe Drinking Water Act
SPDES	State Pollutant Discharge Elimination System
STD	Standard
TEC	Total Estimated Cost
TPC	Total Project Cost
QAP	Quality Assurance Program
WBS	Work Breakdown Structure