

Project Management Plan

for the

Cornell-BNL ERL Test Accelerator (CBETA) Project

A collaboration between

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and

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Change Log

Revision No.	Pages Affected	Effective Date
Revision 0	Entire Document	2016 / 07 / 16
Revision 1	Most of the pages	2017 / 01 / 27
Revision 2		
Revision 3		
Revision 4		
Revision 5		

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1.0 INTRODUCTION

This Project Management Plan (PMP) describes the coordination of project efforts to ensure that the Cornell-BNL ERL Test Accelerator (CBETA) project is completed on time and within budget. The PMP defines the top-level project milestones, review structure, and the organizational framework; it identifies the roles and responsibilities of participants, and it presents the top level of the Work Breakdown Structure (WBS). Planning and costing methodologies are described, but detailed cost and schedule information is found elsewhere.

The project is a collaboration of scientists and engineers in the Cornell Laboratory for Accelerator-Based Sciences and Education (CLASSE) and in the BNL Collider-Accelerator Department (C-AD). Collaborators work together as a single integrated team during design, fabrication, construction, installation and commissioning, notwithstanding the geographic separation between the two institutions. Activities and plans are established by mutual consensus wherever possible.

1.1 Project Description

The main goal of the CBETA project is to build a multi-turn Energy Recovery Linac (ERL) with a Fixed-Field Alternating Gradient (FFAG) return loop. CBETA is a small prototype version of the large eRHIC accelerator that BNL is designing, in preparation for a proposal to the Department of Energy to build an Electron-Ion Collider on Long Island.

The CBETA electron accelerator is jointly designed through a collaboration between Cornell University and Brookhaven National Laboratory, to be constructed and commissioned at Wilson Laboratory on the Cornell Campus. The accelerator will integrate equipment that already exists at Cornell with equipment newly constructed by the project team.

The electron source gun with its laser system, the Injector Cryo-Module (ICM), its merger system, and the high-power beam stop will be relocated from their previous operating locations to new locations, joining the Main-Linac Cryomodule (MLC) that is already installed in the L0E hall as the CBETA accelerating unit. This relocation includes moving infrastructure: the associated RF-power system, the cryogenic system, and the electrical controls of these components.

A single new FFAG return arc will be constructed and installed in the same hall. The arc is made capable of passing multiple turns of very different energies by including separator-and-combiner sections that connect the arc to the MLC at both ends. The main magnets in the arc will use permanent magnet material to produce the magnetic field. They are corrected by relatively weak electro-magnetic correction coils.

This configuration will be commissioned and operated for accelerator physics tests with an initial beam current of at least 1 mA. Single turn beam currents will be increased towards the expected limit of about 40 mA, for a total current of 320 mA, since four accelerating and four decelerating (energy recovery) turns pass through the common linac.

The successfully completed project will be a prototype for a future eRHIC ERL, testing and developing the concept of multi-turn energy recovery using a single FFAG loop with energy acceptance of up to a factor of four. After completion of the project, CBETA may be used at Cornell in a number of ways that

are beyond the scope of this document. It is the intention of the signing parties that all components of CBETA will remain at Cornell for future research after this collaboration period.

2.0 PROJECT SCOPE

2.1 Technical Scope

- Clean out the previously installed workspaces, vacuum lab, and the CESR east RF transmitters from Wilson laboratory's former extracted-beam hall, LOE.
- Move the existing ERL equipment into this hall: The ERL gun with its laser system, ICM, ERL merger, MLC, and the beam stop.
- Provide electrical and cryogenic infrastructure, RF sources and electrical controls for the relocated equipment.
- Design an optics and layout configuration for a 4-turn ERL that integrates a new FFAG return loop with the existing equipment.
- Design, fabricate and assemble permanent magnets for the arc, with electro-magnetic correction coils.
- Design, fabricate and assemble all magnets for the separator-and-combiner sections.
- Install the magnets and vacuum chambers on girders in the LOE hall, and equip electro-magnets with power and controls.
- Install diagnostic systems to be used to optimize the beam trajectory, optics and emittance.
- Provide controls to operate all systems.
- Design and install radiation shielding for all components.
- Design and install equipment protection systems and personnel protection systems.
- Obtain authorization to commission and operate.
- Commission and reach the Key Performance Parameters (KPPs) listed in Table 1.
- Increase performance as far as possible towards or beyond the design parameters listed in Table 1.
- Exercise other operational modes relevant to eRHIC, e.g. 10 MHz beam structure and 1 nC bunch charge.

2.2 Key Performance Parameters

Table 1: Key Performance Parameters (KPPs) and stretch goal parameters.

Parameter	Unit	KPP	Stretch
Electron beam energy	MeV		150
Electron bunch charge	pC		123
Gun current	mA	1	40
Bunch repetition rate (gun)	MHz		325
RF frequency	MHz	1300	1300
Injector energy	MeV		6
RF operation mode			CW
Number of ERL turns		1	4
Energy aperture of arc		2	4

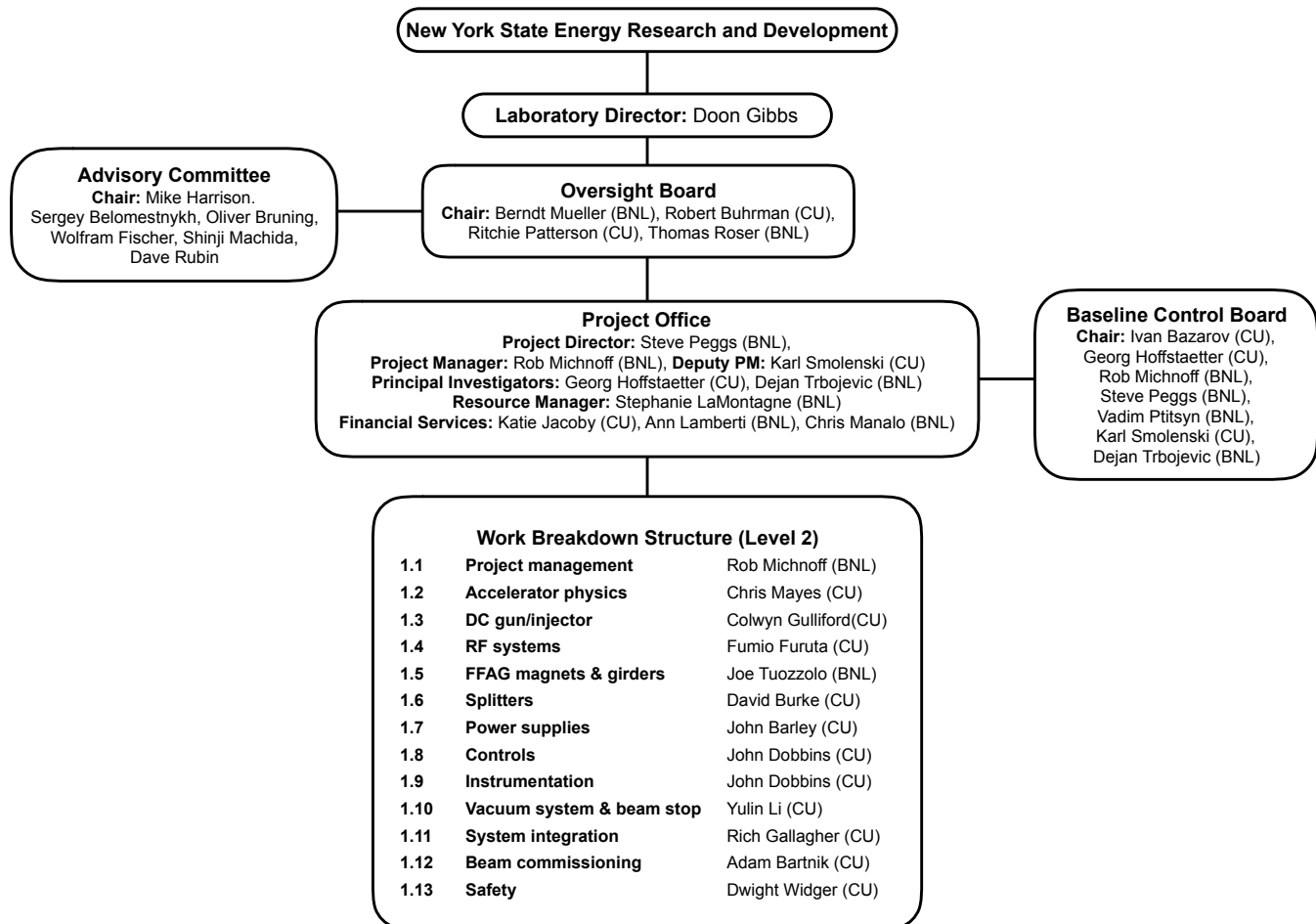
2.3 Work Breakdown Structure

The WBS is used to plan, manage and report CBETA project activities. A WBS Dictionary is being developed based on the milestone schedule and will be distributed to all signatories on this document upon its completion. The WBS is shown to Level 2 in its relationship to the CBETA management structure in Figure 1.

The total estimated project cost is \$25.0 M. Cost estimates were developed from a bottom-up analysis of each contribution to the scope of the CBETA project. More detailed and accurate cost and schedule estimates will be made in preparation of a baseline technical, cost and schedule review in February 2017, including a breakdown of which costs occur at Cornell, and which at BNL. Cost and schedule estimates will be maintained and tuned throughout the duration of the project.

Each L2 subsystem will undergo a Construction Readiness Review, where final designs, costs, and schedule estimates will be presented.

Figure 1: CBETA management structure, in relationship to Level 2 of the Work Breakdown Structure.



2.4 Schedule Milestones

The technical milestones are identified in the Statement of Work (SOW) with NYSERDA in months from funding start (October 31, 2016) and are reproduced here:

Two critical “go/no go” technical performance milestones have been incorporated into the project work scope to mitigate overall risk and allow for project termination, if necessary, before all funding has been committed.

Total project duration is 42 months and includes the following (Table 2) technical milestones:

Table 2: Technical timeline showing major milestones after funding start date

#	Technical milestone	Month	Comment
	<i>NYSERDA funding start</i>	<i>0</i>	<i>October 31, 2016</i>
<i>1</i>	<i>Engineering design documentation complete</i>	<i>3</i>	
<i>2</i>	<i>Prototype girder assembled</i>	<i>6</i>	
<i>3</i>	<i>Magnet production approved</i>	<i>8</i>	
<i>4</i>	<i>Beam through Main Linac Cryomodule</i>	<i>10</i>	<i>Go/no go 1</i>
<i>5</i>	<i>First production magnet tested</i>	<i>14</i>	
<i>6</i>	<i>Fractional Arc Test: Beam through MLC & prototype girder</i>	<i>18</i>	<i>Go/no go 2</i>
<i>7</i>	<i>Girder production run complete</i>	<i>25</i>	
<i>8</i>	<i>Final assembly and pre-beam commissioning complete</i>	<i>28</i>	
<i>9</i>	<i>Single pass beam scan</i>	<i>32</i>	
<i>10</i>	<i>Single pass beam with energy recovery</i>	<i>36</i>	<i>Key parameters achieved</i>
<i>11</i>	<i>Four pass beam with energy recovery (low current)</i>	<i>38</i>	
<i>12</i>	<i>CBETA commissioned and project complete</i>	<i>42</i>	<i>Estimated: April 2020</i>

In addition the SOW contains the following statement on the management of the project:

With each quarterly progress report the Contractor shall provide a detailed description of the activities for the upcoming quarter, including a detailed list of the equipment to be purchased, to the NYSERDA Project Manager for approval. The Contractor shall not proceed with such activities or equipment purchases without NYSERDA’s prior written approval.

Appropriate reviews and meetings will be scheduled to ensure that the project will meet the above milestones within budget and schedule:

The Advisory Committee will review the progress of the project and the performance of the management about twice per year, reporting their findings and recommendations to the Project Oversight Board. If specific technical questions require it, the Advisory Committee may recommend adding outside experts for a specific review.

Construction Readiness Reviews will evaluate each critical subsystem before the construction of that subsystem is approved. These reviews may be performed by a committee convened by the Oversight Board, with advice on membership from the Project Director and the Advisory Committee chair. If

appropriate, several subsystems may be reviewed simultaneously. The Oversight Board will give approval for each construction start.

3.0 CHANGE CONTROL

Changes to the project parameters, scope, cost, and schedule will be controlled using the thresholds described in Table 3. Appropriate levels of the management structure will be alerted as soon as possible that an action needs to take place.

The Project Director (PD), Project Manager (PM) and the Deputy Project Manager (DPM) will specify contingences at least down to Level 3, in consultation with the Cost Account Managers. All contingencies are owned by the Senior Management Team (PD, PM, DPM and two Principal Investigators), and cannot be spent without its approval.

The most important system parameters, especially those that impact several subsystems, are described in a parameter data bank, including all system parameters that might be needed for accelerator performance simulations, or which might affect accelerator operations.

Table 3: Change control thresholds: actions taken on different management levels.

Level	Cost	Schedule and Risk	Technical Scope
NYSERDA PM Oversight Board	Costs needs that surpass the total project cost	Project Milestones, Review Milestones, review scopes	Changes of Key Performance Parameters and design parameters
Senior management team	Contingency allocations	L2 subsystem completion dates and risks	Baseline changes, after consultation with the Baseline Control Board
Project Manager & Deputy Project Manager	Allocations at L2 larger than \$10k, without contingency	Milestone changes that do not affect L2 completion dates or risks	Changes that do not affect the baseline
Cost Account Managers	Allocations at L3 less than \$10k, without contingency	Changes that do not affect L3 milestones	Changes that do not affect technical deliverables

4.0 MANAGEMENT STRUCTURE – ROLES AND RESPONSIBILITIES

The CBETA management structure outlined in Figure 1 has the following components, each with specific roles and responsibilities.

4.1 Project Oversight

4.1.1 Oversight Board

The Oversight Board is responsible for ensuring the success of the project, paying attention to ensure that timely funding, appropriate external scientific advice and clear decision making authority are available to the project.

- Two representatives from BNL, and two from Cornell.
- Chaired by BNL.
- Works with funders to secure timely delivery of funding.
- Receives independent advice from the Advisory Committee.
- Makes changes to the Project Office and the Advisory Committee, as needed.
- Reviews changes that impact the top level of Table 3.
- Reviews monthly financial reports and a quarterly project report from the Project Director and takes appropriate action.
- Receives and approves Project Review reports, and shares them with the Project Office.
- Approves the construction start of each WBS L2 subsystem.

4.1.2 Advisory Committee

The Advisory Committee serves as a standing, external (to the project) advisory body that may be called upon for advice by the Oversight Board.

- Chair and membership approved by the Oversight Board, in consultation with the Senior Management Team.
- Chair is from BNL, members are mostly from BNL and Cornell University.
- Invited to the CBETA site at least once annually.
- Provides written reports of its findings and recommendations to the Oversight Board.

4.2 Project Office

- The Project Office includes the PD, PM, DPM, BNL-PI, CU-PI, a resource manager from BNL, and financial services support from both BNL and Cornell.
- The PD, PM, DPM, BNL-PI and CU-PI comprise the Senior Management Team of the project.
- Scheduling and financial decisions are made by consensus whenever possible. If consensus is not possible, the Oversight Board is consulted.
- The Senior Management Team meets at least weekly, either face-to-face or by phone.
- The Senior Management Team approves the use of contingency, schedule, and scope changes as per Table 3.

4.2.1 Project Director (BNL)

- Works with the Project Manager and Deputy Project Manager to provide overall direction for the project.
- Is the primary project official and contact with NYSERDA and the Oversight Board.

- Provides a monthly financial report and a quarterly project report to the Oversight Board and quarterly reports to NYSERDA and maintains close communication with them.
- Works with PM and DPM to define the WBS structure and to establish intermediate milestones.
- Maintains the database of the project's baseline-design parameters.
- Coordinates with the Oversight Board and the PI's to organize reviews, including negotiating and communicating review scope, charge, dates, and committee membership.

4.2.2 Project Manager (BNL)

- Coordinates closely with the Deputy Project Manager (DPM).
- Manages the execution of the WBS L2 subsystems for which BNL is the lead.
- Oversees engineering design, procurement, fabrication, and assembly of the subsystems on which BNL is the lead institution, in coordination with the C-AD Chief Mechanical Engineer.
- Oversees delivery of BNL equipment for installation at Cornell, in coordination with C-AD Chief Mechanical Engineer.
- Validates labor charges at BNL.
- Provides a monthly report that includes cost and schedule information, estimate at completion and milestone status to the Project Director.
- Appoints those Level 2 managers and L2 or L3 Cost-Account Managers (CAMs) that are at BNL, in consultation with the PD, DPM and BNL PI, and with consent from the C-AD chair.
- Work with the CAMs at BNL, the C-AD chief engineer and the C-AD chair to identify BNL staff for the project.
- Work with DPM, BNL and CU in maintaining the resource-loaded schedule and budget tracking.
- Ensures the preparation of drawings, specifications, procurement documents, installation and test instructions, and other documents to establish and record the project configuration, including as-built documentation, and makes them available to Cornell in mutually agreed upon formats.
- Ensures that project activities at BNL are conducted in a safe and environmentally sound manner, consistent with local DOE safety rules.
- Enforces the rules in the Project Management Plan for contingency use in cost, scope, and schedule.

4.2.3 Deputy Project Manager (Cornell)

- Coordinates closely with the Project Manager.
- Manages the execution of the WBS L2 subsystems for which Cornell is the lead, except WBS 1.2 (Design and accelerator physics).
- Oversees engineering design, procurement, fabrication, and assembly of the subsystems on which Cornell is the lead institution.
- Develops the statement of work for each funding period, in consultation with the Cornell PI.
- Works with BNL to establish Project Milestones consistent with the resource loaded schedule and BNL needs.
- Oversees equipment installation in L0E, in coordination with the CLASSE Facilities Engineer.
- Validates labor charges at Cornell.
- Appoints those Level 2 managers and L2 or L3 Cost-Account Managers (CAMs) that are at Cornell, in consultation with the rest of the Senior Management Team, and with consent from the CLASSE Director.
- Provides a monthly Estimate of Completion and milestone status to the PM
- Appoints Level 2 managers and L2 or L3 CAMs from Cornell, in consultation with the PD, PM, and CU-PI and with consent from the CLASSE Director.

- Work with the CAMs at Cornell, the CLASSE Technical Director, the CLASSE Facilities Engineer, supervisors, and the CLASSE Director to identify the staff for the project.
- Work with PM, CU and BNL in maintaining the resource-loaded schedule and budget tracking.
- Ensures the preparation of drawings, specifications, procurement documents, installation and test instructions, and other documents to establish and record the project configuration, including as-built documentation, and makes them available to BNL in mutually agreed upon formats.
- Establishes and mediates interfaces between different WBS elements.
- Ensures that project activities at Cornell are conducted in a safe and environmentally sound manner, consistent with CLASSE and Cornell safety requirements.
- Enforces the rules in the Project Management Plan for contingency use of cost, scope, and schedule.

4.2.4 Principal Investigator (Cornell)

- Serves as primary Cornell contact for the project to the outside world.
- Coordinates with PD and the BNL PI to organize reviews.
- Works with BNL to establish Key Performance Parameters, design parameters, technical scope and Project Milestones.
- Serves as primary contact with BNL on arranging contracts, with support by the CLASSE administrative director and the DPM.
- Coordinates Cornell preparation of major documents and technical reports such as Design Reports.
- Serves on the Baseline Control Board.
- Participates in hiring decisions of technical staff or research associates at Cornell who will be paid mainly by the project.
- Co-chairs the Publications and Speakers Committee

4.2.5 Principal Investigator (BNL)

- Serves as primary BNL contact for the project to the outside world.
- Coordinates with PD and the Cornell PI to organize reviews, including negotiating review scope, charge, dates, and committee membership.
- Works with Cornell to establish Key Performance Parameters, design parameters and technical scope.
- Work with Cornell to achieve Project Milestones consistent with the resource loaded schedule and BNL needs.
- Coordinates BNL preparation of major documents and technical reports such as Design Reports.
- Serves on the Baseline Control Board.
- Participates in hiring decisions of BNL staff that will be paid mainly by the project.
- Co-chairs the Publications and Speakers Committee

4.3 BASELINE CONTROL BOARD

- Is consulted when changes to major parameters are requested.
- Chair is from Cornell, from outside the Project Office.
- Membership includes all members of the senior management team, plus an additional representative from BNL.
- Decisions are made by consensus whenever possible.
- If necessary, the Advisory Committee may be consulted.

5.0 PROJECT MANAGEMENT AND REPORTING

5.1 Risk and Contingency Management

CBETA risks are managed by the ongoing maintenance of a Risk Register, including an evaluation of the likelihood of each risk, its consequences, and mitigation strategies. Contingency funds are set aside to enable mitigation. These funds are held by the Senior Management Team and specified at least down to WBS L3.

5.2 Project Reporting and Communication

Reporting by the Project Director to NYSERDA

Quarterly Reporting: The Contractor shall prepare reports quarterly. These progress reports shall be in a letter format and shall cover the following areas, with appropriate explanation and discussion:

- a) Title of project*
- b) Agreement number*
- c) Period of this report*
- d) Progress of this report*
- e) Planned progress in the future*
- f) Identification of problems*
- g) Planned Solutions*
- h) Ability to meet schedule, reasons for slippage in schedule*
- i) Schedule - percentage completed and projected percentage of completion*
- j) Analysis of actual cost incurred in relation to budget*
- k) Deliverables completed during the reporting period (these should be clearly identified with the subtask number.)*
- l) Detailed description of activities and equipment list for upcoming quarter*

Copies of the quarterly progress reports shall be submitted to NYSERDA's Project Manager by the 15th of the month following the period of work that was performed. The Contractor shall submit deliverables and itemize all milestones achieved during the quarter along with the quarterly report. The Contractor shall also submit details about expected spend on the labor and material for the next quarter.

Internal Reporting

- Weekly meetings of the Senior Management Team.
- Monthly Reports of cost and schedule information, mainly for internal use.
- Quarterly Reports for the Oversight Board, consisting of:
 - An overall project summary.
 - A Project Milestone status.
 - A financial summary.
 - A log of any approved changes to scope/cost/schedule.
 - An estimate of the completion date and scope.
 - Major issues and risks.

Publications and presentations

All scientific and technical meetings related to CBETA are open to all participants. A Publications and Speakers Committee, chaired by the Principal Investigators, will organize papers and their authorship, and will assign talks.

5.3 Environment, Safety and Health

The CBETA activities at Cornell will abide by the CLASSE ES&H procedures, underlying Cornell's safety oversight. BNL will abide by its local ES&H procedures.

6.0 GLOSSARY

BNL	Brookhaven National Laboratory
C-AD	Collider-Accelerator Department
CAM	Coat Account Manager
CBETA	Cornell-BNL ERL Test Accelerator
CESR	Cornell Electron Storage Ring
CLASSE	Cornell Laboratory for Accelerator-based Sciences and Education
CW	Continuous Waveform
DOE	Department of Energy
DPM	Deputy Project Manager
ERL	Energy-Recovery Linac
ES&H	Environmental, Safety and Health
EVMS	Earned Value Management System
FFAG	Fixed-Field Alternating Gradient
ICM	Injector Cryo-Module
KPP	Key Performance Parameters
L2, L3	Level 2 or 3 of the Work Breakdown Structure
LLRF	Low-Level RF
L0E	An experimental hall at Wilson Laboratory, where CBETA will be sited
MLC	Main-Linac Cryomodule
PD	Project Director
PI	Principal Investigator
PM	Project Manager
PMP	Project Management Plan
RF	Radio Frequency
WBS	Work Breakdown Structure