

Project Management Plan

for the

Cornell-BNL ERL Test Accelerator (C-Beta) Project

A collaboration between

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and

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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 (C-Beta) 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.

1.1 Project Description

The main goal of the C-Beta project is to build a multi-turn Energy Recovery Linac (ERL) with a Fixed-Field Alternating Gradient (FFAG) return loop. C-Beta 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 C-Beta 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 CryoModule (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 C-Beta 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 are made from permanent magnet material embedded in iron poles, with fixed fields. They are corrected by relatively weak electro-magnetic correction coils. Magnets in the separator-and-combiner sections are also electro-magnets.

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, C-Beta will continue to be used at Cornell in a number of ways that are beyond the scope of this document.

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 electro-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 design parameters.

Parameter	Unit	KPP	Design
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

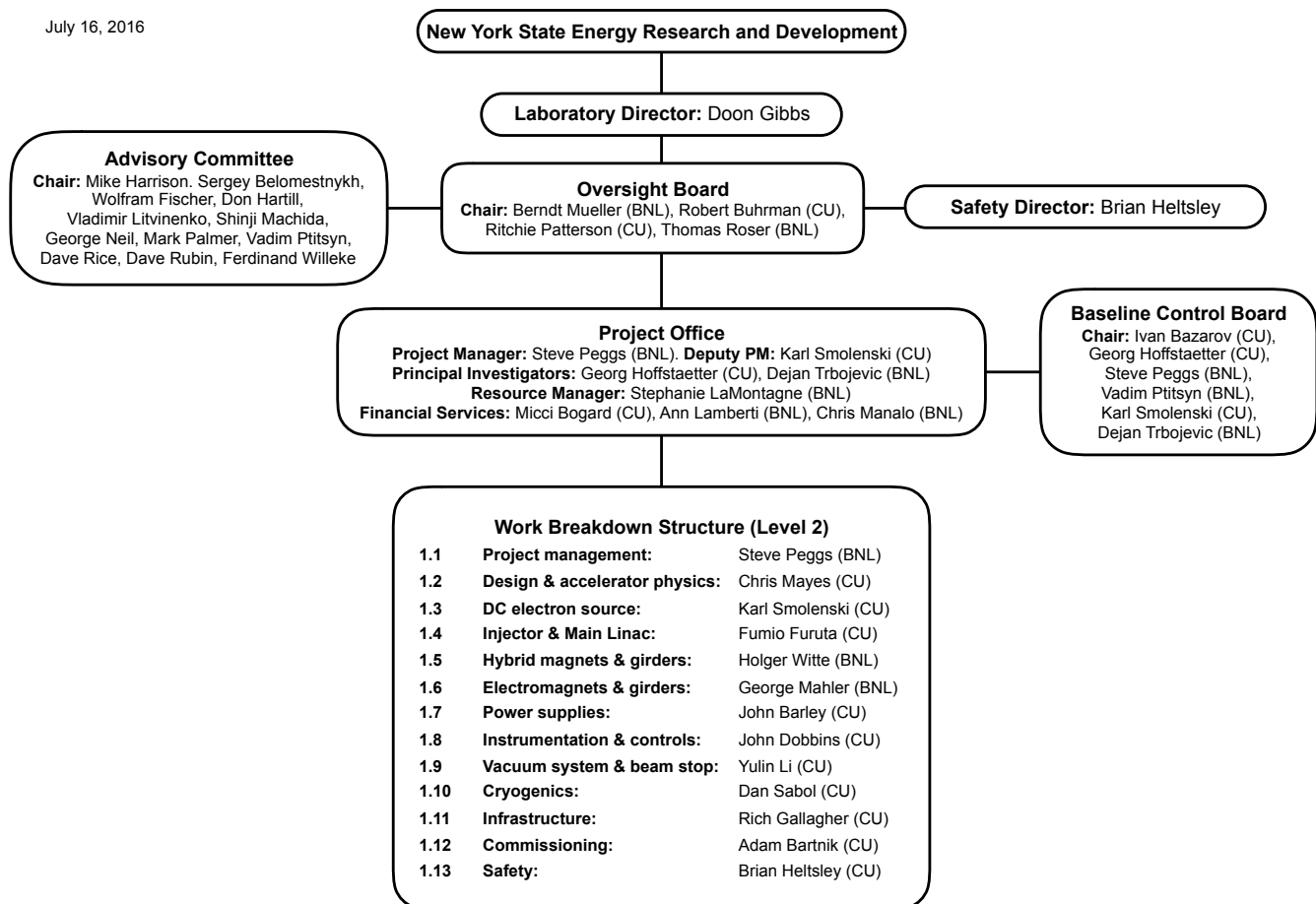
2.3 Work Breakdown Structure

The WBS is used to plan, manage and report C-Beta 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 current WBS is shown down to Level 2 in its relationship to the C-Beta management structure in Figure 1.

The total estimated project cost is \$25.0 M, including a total contingency of \$5.7M that is close to 30%. Cost estimates were developed from a bottom-up analysis of each contribution to the scope of the C-Beta project. More detailed and accurate cost and schedule estimates will be made in 2016, 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. All L2 subsystems are assigned a contingency that will change continuously as information becomes available. However, the total contingency of \$5.7M will not be exceeded.

Figure 1 C-Beta management structure, in relationship to Level 2 of the Work Breakdown Structure.



2.4 Schedule Milestones

The high-level Project Milestones shown in Figure 2 mark the due dates for key accomplishments in the overall progress of the project. The primary Review Milestones shown in Figure 3 tentatively schedule the occasions on which achievements will be scrutinized, enabling reviewers to influence the course of the project.

The Advisory Committee will review the progress of the project and the performance of the management approximately yearly, 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.

Figure 2 Project Milestones marking due dates for key accomplishments in the overall progress of the project.

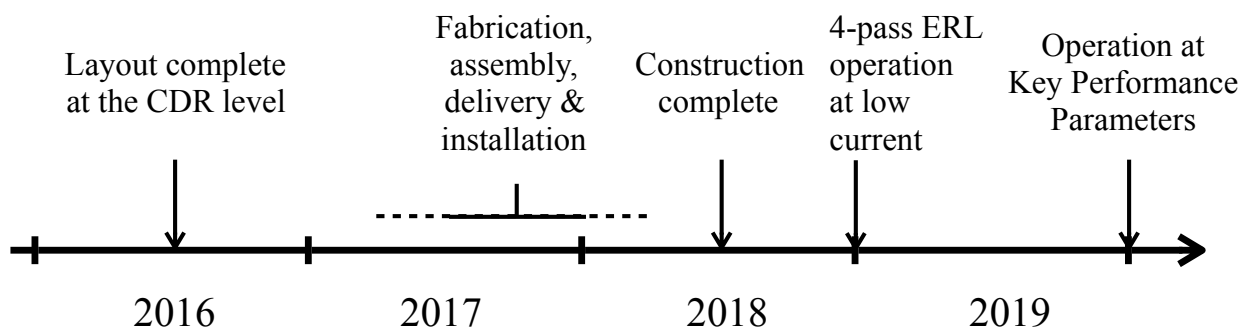
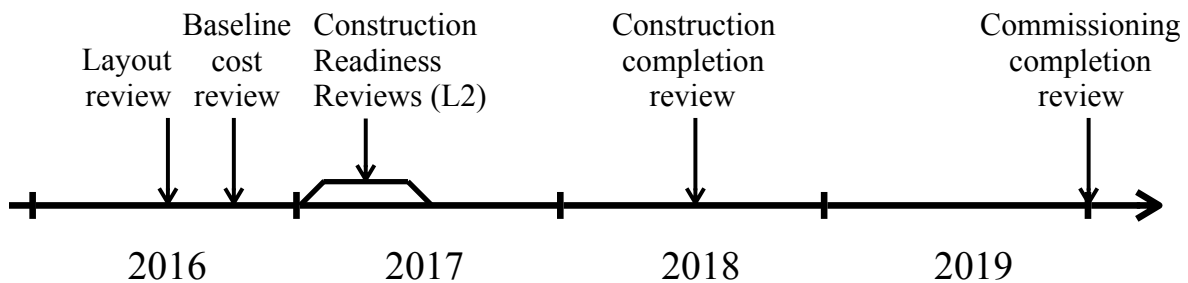


Figure 3 Primary Review Milestones, internal and external. Construction Readiness Reviews will evaluate the technical design, cost and schedule milestones of each L2 subsystem.



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 Management Board and the Advisory Committee chair. If appropriate, several subsystems may be reviewed simultaneously. The Oversight Board will give final 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 2. Appropriate levels of the management structure will be alerted as soon as possible that an action needs to take place.

The 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 Management Board (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 2: Change control thresholds: actions taken on different management levels.

Level	Cost	Schedule and Risk	Technical Scope
Oversight Board	Costs needs that surpass the total project cost	Project Milestones, Review Milestones, review scopes	Changes of Key Performance Parameters and design parameters
Management Board	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 C-Beta management structure outlined in Figure 1 has the following components, each with specific roles and responsibilities.

4.1 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 and the Safety Director.
- Makes changes to the Project Office and the Advisory Committee, as needed.
- Reviews changes that impact the top level of Table 2.
- Reviews monthly financial reports from the Management Board 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.

4.2 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, the Management Board or the Project Manager.

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

4.3 Baseline Control Board

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

4.4 Project Office

- The Project Office includes the Management Board (see below), a resource manager from BNL, and financial services support from both BNL and Cornell.
- It is accountable to the Project Manager.
- Tracks financial progress of the C-Beta Project.
- Coordinates with CLASSE and C-AD to gather appropriate financial information.
- Provides monthly financial reports.

4.5 Management Board

- The Management Board has four members: a Principal Investigator from both Cornell and BNL, a Project Manager from BNL, and a Deputy Project Manager from Cornell.
- All Management Board members are also members of the Baseline Control Board.
- Resolves resource conflicts within the project.
- Approves the use of contingency, schedule, and scope changes as per Table 2.
- Prepares a Monthly Report containing cost and schedule information, mainly for internal use, based on financial and schedule information from the Project Office.
- Provides a Quarterly Report to the Oversight Board.
- Presents the status of the project in meetings of the Advisory Committee.
- Meets at least weekly, either face-to-face or by phone.
- Maintains the parameter data bank of important design parameters.
- Technical decisions are made by consensus whenever possible. If consensus is not possible, the Advisory Committee may be consulted, through the Oversight Board.
- Scheduling and financial decisions are made by consensus whenever possible. If consensus is not possible, the Oversight Board is consulted.

4.6 Principal Investigator (Cornell)

- Serves as primary Cornell contact for the project to the outside world.
- Coordinates with BNL to organize reviews, including negotiating review scope, charge, dates, and committee membership.
- Works with BNL to establish Key Performance Parameters, design parameters and technical scope.
- Works with BNL to establish Project Milestones consistent with the resource loaded schedule and BNL needs.
- Serves as primary contact with BNL on arranging finances and contracts.
- Coordinates Cornell preparation of major documents such as Design Reports.
- Co-chairs the Management Board.
- Serves on the Baseline Control Board.
- Participates in hiring decisions of technical staff or research associates at Cornell who will be paid by the project.
- Resolves resource conflicts within the project.

4.7 Principal Investigator (BNL)

- Serves as primary BNL contact for the project to the outside world.
- Coordinates with Cornell 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 establish Project Milestones consistent with the resource loaded schedule and BNL needs.
- Coordinates BNL preparation of major documents such as Design Reports.
- Co-chairs the Management Board.
- Serves on the Baseline Control Board.
- Participates in hiring decisions of BNL staff who will be paid by the project.

4.8 Project Manager (BNL)

- Coordinates closely with the Deputy Project Manager (DPM).
- Manages the execution of the L2 subsystems for which BNL is the lead, especially WBS 1.1 (Project management).
- 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 Quarterly Report to the Oversight Board, and maintains close communication with them.
- Appoints Level 2 managers and L2 or L3 Cost-Account Managers (CAMs), in consultation with the rest of the Management Board, and with consent from the C-AD chair.
- Works with CAMs to define the WBS structure and to establish intermediate milestones.
- Work with the CAMs, the C-AD chief engineer and the C-AD chair to identify staff for the project.
- Supports the DPM and BNL staff 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.
- 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 and scope and schedule.
- Presents the status of the project in meetings of the Advisory Committee.
- Maintains the database of the project's baseline-design parameters.

4.9 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 1.1 (Project management) and WBS 1.2 (Design and accelerator physics).
- Oversees engineering design, procurement, fabrication, and assembly of the subsystems on which Cornell is the lead institution.
- Oversees equipment installation in L0E, in coordination with the CLASSE Facilities Engineer.
- Validates labor charges at Cornell.
- Provides a monthly Estimate at Completion and milestone status to the Management Board.
- Appoints Level 2 managers and L2 or L3 CAMs, in consultation with the CU-PI, the PM, and (when appropriate) the BNL-PI, and with consent from the CLASSE Director.
- Works with CAMs to define the WBS structure and to establish intermediate milestones.
- Work with the CAMs, the CLASSE Technical Director, the CLASSE Facilities Engineer, supervisors, and the CLASSE Director to identify the staff for the project.
- Maintains 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.
- Establishes and mediates interfaces between control accounts.
- 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 and scope and schedule.

5.0 PROJECT MANAGEMENT AND OVERSIGHT

5.1 Risk and Contingency Management

C-Beta 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, at about the 30% level. These funds are held by the Management Board and specified at least down to WBS L3.

5.2 Project Reporting and Communication

Project reporting consists of:

- Weekly meetings of the Management Board.
- 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.

All scientific and technical meetings related to C-Beta are open to all participants. A Publications and Speakers Committee will organize papers and their authorship, and will assign talks.

5.3 Environment, Safety and Health

The C-Beta activities at Cornell will abide by the CLASSE safety procedures, underlying Cornell's safety oversight. BNL will abide by its local safety procedures.

6.0 GLOSSARY

BNL	Brookhaven National Laboratory
C-AD	Collider-Accelerator Department
CAM	Coat Account Manager
C-Beta	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 C-Beta will be sited
MLC	Main-Linac Cryomodule
PI	Principal Investigator
PM	Project Manager
PMP	Project Management Plan
RF	Radio Frequency
WBS	Work Breakdown Structure