

WBS	WBS Name	Institution	WBS Manager
A1.01	<b>PROJECT MANAGEMENT</b>	BNL/Cornell	Michnoff
A1.01.01	<b>Milestones</b> This scope is a placeholder for all project high level milestones for NYSERDA. There is no cost or labor related to this WBS element.	BNL/Cornell	Michnoff
A1.01.02	<b>Project Management</b> This scope primarily supports labor for two principle investigators, the project director, the Brookhaven Lab project manager and the Cornell University project manager. Responsibilities include cost analysis and control, project schedule activities and monitoring, and high level scientific and engineering review of activities.	BNL/Cornell	Michnoff
A1.01.03	<b>Meetings &amp; Reviews</b> This scope includes time for staff to participate in review meetings and at scientific conferences, including preparation work. The estimate is based on one review per year.	BNL/Cornell	Michnoff
WBS	Task Name	Institution	WBS Manager
A1.02	<b>ACCELERATOR DESIGN</b>	Cornell	Mayes
A1.02.01	<b>Baseline Splitter Lattice Design</b> This scope includes the magnetic steering and focusing design and simulation for the Splitter sections (SX, RX), mechanisms for path length adjustment, and error correction analysis.	Cornell	Mayes
A1.02.02	<b>Fractional Arc Lattice Design</b> This scope includes design and simulation for the beam lines from the MLC through the first girder of FFAG magnets.	Cornell	Mayes
A1.02.03	<b>Single Pass Lattice Design</b> This scope includes designing and simulating the one-pass energy recovery mode lattice. It also includes accelerator physics analysis and simulations for this machine, such as error and their correction, beam halo, beam breakup instability, and coherent synchrotron radiation.	Cornell	Mayes
A1.02.04	<b>Four Pass Lattice Design</b> This scope includes the same studies as the single pass design, but for the full four-pass machine.	Cornell	Mayes
WBS	WBS Name	Institution	WBS Manager
A1.03	<b>DC GUN/INJECTOR</b>	Cornell	Gulliford
A1.03.01	<b>DC Gun/ Injector Line Preparation</b> This scope includes all labor and minor purchases required to get the DC electron source (gun) and beamline components up to the Injector Cryomodule (ICM) operational. It includes maintenance and repairs to the existing DC electron source (gun) and buncher cavity.	Cornell	Smolenski
A1.03.02	<b>Laser Modifications/Upgrade</b> This scope includes all labor and purchases required to implement modifications to the existing laser system in order to provide laser beam to the cathodes for bunch frequency / patterns required for CBETA operations, which differ from past implementations. A new laser room will be build immediately next to the gun for ease of laser transport.. Excludes procurement and installment of the physical laser room which is covered in WBS 1.11 in System Integration.	Cornell	Bartnik
A1.03.03	<b>Cathode Development</b> This scope includes all labor and purchases required produce photocathodes required by CBETA.	Cornell	Cultera
A1.03.04	<b>B1: Merger Modification</b> This scope includes all labor and purchases required for the design, fabrication, and installation of the B1: Merger section of the CBETA machine. This includes the magnets, girders, instrumentation, and vacuum system for the B1: Merger which injects beam into the CBETA recirculator.	Cornell	Moore
A1.03.05	<b>B2: Diagnostic Line</b> This scope includes all labor and purchases required for the design, fabrication, and installation of the B2: Diagnostic section of the CBETA machine. This includes the magnets, girders, instrumentation, and vacuum	Cornell	Moore
WBS	WBS Name	Institution	WBS Manager
A1.04	<b>RF SYSTEMS</b>	Cornell	Furuta
A1.04.01	<b>Main Linac Cryomodule (MLC) Preparation</b> This scope includes the work required to warm and move the MLC into final position for CBETA operation, including all modifications to the instrumentation.	Cornell	Quigley
A1.04.02	<b>LLRF</b> This scope includes the design, installation, and testing of the low level RF control system. This includes the relevant testing for pre-beam commissioning.	Cornell	Quigley
A1.04.03	<b>RF Power Sources</b> This scope includes the design, procurement, assembly, installation, and testing of the solid state amplifiers (SSAs) which power the MLC cavities and the related waveguides and cabling. This also includes installation of the RF deflector cavity for the diagnostics beamline and its related RF hardware.	Cornell	Quigley
A1.04.04	<b>Cryogenics</b> This scope includes the design, procurement, assembly, installation, and testing of the cryogenic infrastructure to support the operation of the ICM and MLC. This includes the additional pump skids, transfer lines, and heat exchangers for the cryo system. Construction of a helium purifier and routine maintenance of the refrigerators is included.	Cornell	Sabol
A1.04.05	<b>Cryomodule Instrumentation and Controls</b> This scope includes the design and procurement of instrumentation and sensors needed for MLC operations and related installation and testing.	Cornell	Sabol

WBS	WBS Name	Institution	WBS Manager
A1.05	<b>FFAG MAGNETS &amp; GIRDERS</b>	BNL	Tuozzolo
A1.05.01	Halbach Magnets This scope includes the design, procurement, & testing of the QF & QD Halbach magnets, with support/alignment hardware and cooling.	BNL	Mahler
A1.05.02	Halbach Corrector Magnets This scope includes the design, procurement, and testing of the dipole and quadrupole corrector magnet assemblies.	BNL	Trabocchi
A1.05.03	Magnet Characterization & Measurement This scope includes the activities, including labor and hardware, related to magnet characterization, QA, and Multipole tuning.	BNL	Brooks
A1.05.04	FFAG Girders This scope includes the design, procurement, and inspection of arc and straight girders.	BNL	Mahler
A1.05.05	FFAG Magnet/Girders Assembly This scope includes the installation of magnets, vacuum chambers, and support components on girders and shipment to Cornell for final installation.	BNL/Cornell	Mahler
WBS	WBS Name	Institution	WBS Manager
A1.06	<b>SPLITTER</b>	Cornell	Burke
A1.06.01	Electromagnets This scope includes the design, procurement, & testing of 144 magnets consisting of 64 quadrupoles, 36 dipoles, 8 septa, 4 commons and 32 vertical correctors. This includes supporting/alignment hardware.	Cornell	Burke
A1.06.02	Extraction Line Magnets This scope includes the design, procurement, & testing of 6 magnets consisting of 4 quadrupoles and 2 dipoles and any supporting/alignment hardware. The remaining components to the beam stop preexist.	Cornell	Burke
A1.06.03	Tables This scope includes the design, procurement, & testing of four tables to which the magnets are mounted. The tables will provide a stable platform capable of multiple configurations. Other components to facilitate electrical, cooling, vacuum and signal requirements are also in this scope.	Cornell	Burke
A1.06.04	Table Assembly This scope includes the assembly and surveying of the magnets onto the table and connecting the electrical, cooling and signal interconnects. Providing mounting interfaces to the vacuum is also in this scope.	Cornell	Burke
A1.06.05	General Support This scope includes travel to magnet and table suppliers, general material and supplies, and software.	Cornell	Burke
WBS	WBS Name	Institution	WBS Manager
A1.07	<b>POWER SUPPLIES</b>	Cornell	Barley**
A1.07.01	Splitter: Dipole Power Supplies This scope includes the procurement, assembly, and installation of power supplies as well as related cabling and racks for the Splitter Dipole magnets.	Cornell	
A1.07.02	Splitter: Quadrupole Power Supplies This scope includes the procurement, assembly, and installation of power supplies as well as related cabling and racks for the Splitter Quadrupole magnets.	Cornell	
A1.07.03	Splitter: Corrector Power Supplies This scope includes the procurement, assembly, and installation of power supplies as well as related cabling and racks for the Splitter Corrector magnets.	Cornell	
A1.07.04	FFAG Corrector Power Supplies This scope includes the procurement, assembly, and installation of power supplies as well as related cabling and racks for the FFAG arc Halbach magnet window frame correctors. This includes both vertical and horizontal correctors. Quadrupole corrector power supplies are not included.	Cornell	
WBS	WBS Name	Institution	WBS Manager
A1.08	<b>CONTROLS</b>	Cornell	Dobbins
A1.08.01	Network Infrastructure This scope includes the design, procurement, installation, and testing of network infrastructure devices such as network switches, serial device servers, and cables.	Cornell	Dobbins
A1.08.02	Computer Hardware This scope includes the design, procurement, installation, and testing of computer hardware devices such as the EPICS IOC computers, operator consoles etc.	Cornell	Dobbins
A1.08.03	Network Services This scope includes the design, procurement, installation, and testing of network services such as file servers.	Cornell	Dobbins
A1.08.04	EPICS Services This scope includes the design, development, and testing of EPICS Services such as the archiver, alarm handler, database configuration, save/restore features, etc.	Cornell	Dobbins
A1.08.05	EPICS Device Support This scope includes the design, development, and testing of EPICS device supports, including BPMs, BAMs, and magnet power supplies.	Cornell	Dobbins

A1.08	<b>CONTROLS (cont'd)</b>	Cornell	Dobbins
A1.08.06	<b>EPICS IOCs</b> This scope includes the design, development, and testing of EPICS IOCs, for magnet power supplies, vacuum, RF power, low level RF, BPMs, Cryogenics, personnel protection, machine protection, dump, BLM, gun, view screens, beam stops and BAMS. (Some RF IOC software will be provided as part of the RF WBS section A1.04.)	Cornell	Dobbins
A1.08.07	<b>Operator Interface</b> This scope includes the design, development, and testing of the Operator Interface for magnet power supplies, vacuum, RF power, low level RF, BPMs, Cryogenics, personnel protection, machine protection, dump, BPM, gun, view screens, beam stops and BAMS.	Cornell	Dobbins
A1.08.08	<b>Control Applications</b> This scope includes the design, development, and testing of Control applications. The only known and required application at this time is for orbit correction.	Cornell	Dobbins
A1.08.09	<b>Timing System</b> This scope includes the design, development, and testing of the timing system.	Cornell	Dobbins
A1.08.10	<b>Machine Protection System</b> This scope includes the design, development, and testing of the machine protection system.	Cornell	Dobbins
<b>WBS</b>	<b>WBS Name</b>	<b>Institution</b>	<b>WBS Manager</b>
A1.09	<b>INSTRUMENTATION</b>	Cornell	Dobbins
A1.09.01	<b>Injector and Mirror Merger</b> This scope includes support for the re-configuration, installation, testing, and commissioning of existing diagnostics for the B1: Merger and B2: Diagnostic Lines	Cornell	Dobbins
A1.09.02	<b>Beam Arrival Monitors</b> his scope includes the design, procurement, assembly, installation, and testing of Beam Arrival Monitors (BAMs) to measure beam time of flight of the different energy beams in the Injection Line and Splitters. This includes all required cables and electronics. Equipment racks are expected to be available from Cornell's existing inventory. Dedicated Beam Position Monitor (BPM) button signals will be used for the BAMs. The BPM buttons are provided under the Vacuum system, WBS 1.10.	BNL/Cornell	Michnoff/Dobbins
A1.09.03	<b>Beam Current Monitors</b> This scope includes the design, procurement, assembly, installation, and testing of the Beam Current Monitor devices. Two beam current monitors are anticipated - one in the injection line and one in the dump line. This WBS section includes all beam-line hardware, cables and electronics. Equipment racks are expected to be available from Cornell's existing inventory.	Cornell	Dobbins
A1.09.04	<b>Beam Loss Monitors</b> This scope includes the design, procurement, assembly, installation, and testing of the Beam Loss Monitor (BLM) system. In addition to providing beam loss measurements for monitoring, the BLM system will provide digital outputs to the Machine Protection System (MPS) to inhibit beam when beam losses exceed a programmable threshold value. This WBS section includes the loss monitor devices themselves, related high voltage power supplies, cables and electronics. Equipment racks are expected to be available from Cornell's existing inventory.	Cornell	Dobbins
A1.09.05	<b>Beam Position Monitors</b> This scope includes the design, procurement, assembly, installation, and testing of the Beam Position Monitor (BPM) system. This includes all required cables and electronics. Equipment racks are expected to be available from Cornell's existing inventory. The BPM buttons are provided under the Vacuum system, WBS 1.10.	BNL	Michnoff
A1.09.06	<b>View Screens</b> This scope includes the design, procurement, assembly, installation, and testing of the view screens system. This includes all required cameras, actuators, cables and electronics. Equipment racks are expected to be available from Cornell's existing inventory. The vacuum chamber devices are provided under the Vacuum section, WBS 1.10.	Cornell	Dobbins
A1.09.07	<b>Beam Stops</b> This scope includes the design, procurement, assembly, installation, and testing of the insertable beam stops. This includes all required beam stop material, actuators, cables and electronics. Equipment racks are expected to be available from Cornell's existing inventory. The vacuum chamber devices are provided under the Vacuum section, WBS 1.10.	Cornell	Dobbins

WBS	WBS Name	Institution	WBS Manager
A1.10	<b>VACUUM SYSTEM &amp; BEAM STOP</b>	Cornell	Li
A1.10.01	<b>Arc Vacuum Chamber Assemblies</b> This scope includes the design, procurement/fabrication, assembly and testing of vacuum chambers in the FFAG arcs (FA, TA, TB and FB sections) for the CBETA project. This also includes the includes the beam pipe, bellows, flanges, welds between beam pipe sections, beam position monitor chambers and buttons, flanged beam pipe sections for view screens, and view screen assemblies.	Cornell	Li
A1.10.02	<b>Beam Splitter Chamber Assemblies</b> This scope includes the design, procurement/fabrication, assembly and testing of vacuum chambers in the splitters (SX and RX sections) for the CBETA project. This includes the includes the beam pipe, bellows, flanges, welds between beam pipe sections, beam position monitor chambers and buttons, flanged beam pipe sections for view screens, and view screen assemblies.	Cornell	Burke
A1.10.03	<b>Injection BL and Dump BL Dipole Chamber Assemblies</b> This scope includes the design, procurement/fabrication, assembly and testing of dipole chambers to integrate existing accelerator components in the IN/DI/LA/DL sections for the CBETA project. This includes the includes the beam pipe, bellows, flanges, welds between beam pipe sections, beam position monitor chambers and buttons, flanged beam pipe sections for view screens, and view screen assemblies.	Cornell	Li
A1.10.04	<b>Straight Vacuum Chamber Assemblies</b> This scope includes the design, procurement/fabrication, assembly and testing of vacuum chambers in the FFAG straight (ZA and ZB sections) for the CBETA project. This includes the includes the beam pipe, bellows, flanges, welds between beam pipe sections, beam position monitor chambers and buttons, flanged beam pipe sections for view screens, and view screen assemblies.	Cornell	Li
A1.10.05	<b>Vacuum System - Pumps and Gauges</b> This scope includes specification of requirements, procurement and testing of vacuum pumps, gauges and valves for the CBETA project.	Cornell	Li
A1.10.06	<b>Global Vacuum System - Supplies &amp; Support</b> This scope includes the procurement and maintenance of general vacuum supplies (gaskets, bakeout consumables, etc.) and general vacuum supports (leak checking, bakeout setup, etc.) for the CBETA project.	Cornell	Johnson
WBS	WBS Name	Institution	WBS Manager
A1.11	<b>SYSTEM INTEGRATION</b>	Cornell	Gallagher
A1.11.01	<b>Global Infrastructure</b> This scope includes the labor, materials and service needed to relocate systems, equipment and components that currently occupy space required for the CBETA project, and to reconfigure the facility to permit installation of the CBETA.	Cornell	Gallagher
A1.11.02	<b>Beamline System Integration (Installation)</b> This scope includes the labor and materials used for the installation and assembly of the ten distinct accelerator loop and beam-stop sections that comprise the CBETA.	Cornell	Gallagher
WBS	WBS Name	Institution	WBS Manager
A1.12	<b>BEAM COMMISSIONING</b>	Cornell	Bartnik
A1.12.01	<b>Gun, Injector Cryomodule (ICM), and Beam Stop (Complete)</b> This scope includes commissioning activities such as machine operation and minor maintenance to recover basic operation of the gun, injector, and beam dump subsystems, and test at KPP current.	Cornell	Bartnik
A1.12.02	<b>Diagnostics Line (Existing but Relocated)</b> This scope includes commissioning activities such as machine operation and minor maintenance to determine the injector operating point, and optimize bunch properties.	Cornell	Bartnik
A1.12.03	<b>Main Linac Cryomodule (MLC)</b> This scope includes commissioning activities such as machine operation and minor maintenance to verify that required MLC operating points can be reached with beam.	Cornell	Bartnik
A1.12.04	<b>Fractional Arc</b> This scope includes commissioning activities such as machine operation and minor maintenance to verify FFAG magnets with beam, and any required splitter adjustment.	Cornell	Bartnik
A1.12.05	<b>Single Pass, Energy Scan</b> This scope includes commissioning activities such as machine operation and minor maintenance to verify full arc beam optics and FFAG energy acceptance.	Cornell	Bartnik
A1.12.06	<b>Single Pass, Energy Recovery</b> This scope includes commissioning activities such as machine operation and minor maintenance to reach KPP goals	Cornell	Bartnik
A1.12.07	<b>Four Pass Energy Recovery</b> This scope includes commissioning activities such as machine operation and minor maintenance to push for UPP goals.	Cornell	Bartnik

WBS	WBS Name	Institution	WBS Manager
A1.13	SAFETY	Cornell	Widger
A1.13.01	<p>Documentation &amp; Reviews</p> <p>This scope includes the analysis and preparation of safety related documentation, permits, and participation in laboratory and campus safety reviews.</p>	Cornell	Heltsley
A1.13.02	<p>Personnel Safety Systems</p> <p>This scope includes the design, construction, and installation of personnel safety systems including access control interlocks, signage, warning beacons, etc.</p>	Cornell	Ray
A1.13.03	<p>Radiation Monitor Safety</p> <p>This scope includes the labor and materials for radiation monitor heads, readouts, and related electronics to trip the operation of CBETA</p>	Cornell	Widger
A1.13.04	<p>Radiation Maintenance</p> <p>This scope includes labor and materials for the calibration and testing of monitors in A1.13.03, Radiation Safety. It also includes area and personnel badges as required for the project. The calibration and testing is continuous throughout the project.</p>	Cornell	Widger