

PIP-II 650 MHz $\beta=0.61$ Jacketed Cavity Prototype Final Design Review & Procurement Readiness Review Charges

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Document Approval

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Revision History

Revision	Date Release	Originator: Role:	Description of Change
-	28 Oct 2019	S. Chandrasekaran L3 Manager for 650 MHz Review Coordinator	Initial Release

Revision control is managed via Fermilab Teamcenter Workflows.

Table of Contents

1. Introduction.....	3
2. Review Agenda	4
3. Review Charge Statement.....	5
4. Acronyms.....	6
5. Reference Documents.....	6

1. Introduction

The PIP-II Project's superconducting linear accelerator (Linac) will fuel the next generation of intensity frontier experiments at Fermilab. Benefitting from the high efficiencies of superconducting radio-frequency (SRF) technology, the linac shall consist of five types of superconducting cavities and cryomodules. They will accelerate H⁻ ions to 833 MeV for injection into the Booster Complex of Fermilab. Upgrades to the existing Booster, Main Injector, and Recycler Rings will enable them to operate at a 20 Hz repetition rate and provide a 1.2 MW proton beam for the Deep Underground Neutrino Experiment (DUNE) at the Long Baseline Neutrino Facility (LBNF). The superconducting Linac shall operate at harmonic frequencies of 162.5 MHz, 325 MHz, 650 MHz, with energy ranging from 2.1 MeV to 833 MeV. The relativistic β for the H⁻ ions goes from 0.07 to 0.854 over this energy range.

The PIP-II Linac shall consist of one half wave resonator (HWR) cryomodule, two single spoke resonator of type 1 (SSR1) cryomodules, seven single spoke resonator of type 2 (SSR2) cryomodules, nine low beta elliptical cavity cryomodules (LB650), and four high beta elliptical cavity cryomodules (HB650). The LB650 cryomodules contain four 5-cell cavities each, with geometric beta of 0.61 and operating at 650 MHz.

The PIP-II linac is to operate with continuous wave (CW) RF, and a pulsed beam. Having pulsed compatibility is encouraged, to lower operations costs. In both regimes cryomodule shall support peak currents of 10 mA chopped with arbitrary patterns to yield an average beam current of 2 mA.

PIP-II is the first US Department of Energy particle accelerator project with significant international in-kind contributions from France, India, Italy, and the United Kingdom. The LB650 section of the linac has contributions from CEA in France for the cryomodule design and hardware, VECC in India for the cavity design and hardware, and INFN in Italy for the bare cavity design and jacketed cavity hardware. Fermilab owns the end groups for the cavities and the helium vessel design, as well as the interfaces for the cavity with the coupler, tuner, and cryomodule.

Due to the complex design of the cryomodules as well as the international partnerships, PIP-II requires a significant design coordination and integration oversight. As part of the oversight strategy, a design review plan specific to PIP-II has been developed [3]. The primary goal of the Project design reviews is to ensure optimized and safe design by identifying potential or actual design problems as early as possible to minimize the cost, schedule, and performance impact.

This review comprises of the Final Design Review for the prototype LB650 cavity (bare and jacketed) and the Niobium Procurement Readiness Review to fabricate these prototype cavities. Per the PIP-II Design Review Plan,

1. Final Design Reviews (FDRs) are technical and programmatic reviews to provide assurance that the completed design of the selected configuration meets all functional and performance specifications as well as interface agreements. The technical areas addressed during the review include the design configuration and integrity of the selected design; verification planning, requirements, and compliance; operations planning; support equipment; and systems compatibility.
2. Procurement (or Production) Readiness Reviews (PRRs) are held prior to the start of manufacturing and testing of major sub-system assemblies. PRRs are largely technical reviews, but include assessment of the planned cost, schedule, and personnel needs to complete the manufacturing processes that are covered.

2. Review Agenda

Location: Hermitage Conference Room, ICB 2nd floor East, & on Zoom

Date: 7 & 8 November 2019

Indico Site: <https://indico.fnal.gov/event/22161/>

Zoom: <https://fnal.zoom.us/s/703251375>

Reviewers: Leonardo Ristori, Fermilab (Chair)

Michael Kelly, ANL

Joel Fuerst, SLAC

3. Review Charge Statement

The review committee is charged to evaluate the design and programmatic readiness of the PIP-II 650 MHz $\beta=0.61$ prototype jacketed cavities to approve fabrication, processing, jacketing, and validation activities. The jacketed cavity is defined as the niobium and niobium titanium of the bare cavity, the titanium helium vessel with chimney, including the tee connection to the 2-phase pipe, and necessary safety restraints (e.g. the helium vessel bellows safety bracket). The review committee is urged to evaluate by responding to the following questions:

1. Technical Scope
 - a. Are all design & performance specifications and requirements approved and released?
 - b. Are the designs mature and technically sound to satisfy design & performance specifications?
 - c. Have all the major interfaces been identified and incorporated into the design?
 - d. Are the cavity fabrication, processing, and validation steps appropriately mature for prototype final design stage?
 - e. Is the development of associated drawing packages sufficiently mature for final design stage?

2. Design Management
 - a. Is the design team organized and staffed to successfully complete the project?
 - b. Have all the major risks been identified and managed?
 - c. Are procurements appropriately planned?
 - d. Are all related ES&H aspects being properly addressed?
 - e. Are appropriate QA and QC steps being implemented?

3. Overall Readiness
 - a. Is the design sufficiently mature to allow *Prototype* Final Design Review approval?
 - b. Is the procurement package ready to allow for procurement of bare and/or jacketed cavities from industry?

4. Acronyms

HB650	High Beta 650 MHz
LB650	Low Beta 650 MHz
B90	$\beta=0.90$ HB650
B92	$\beta=0.92$ HB650
PDR	Preliminary Design Review
FDR	Final Design Review
PRR	Procurement Readiness Review

5. Relevant Documents

ED0008163	PIP-II Project Review Plan
ED0010864	650 MHz $\beta=0.61$ Jacketed Cavity Prototype Final Design Review
ED0010863	650 MHz $\beta=0.61$ Jacketed Cavity Prototype FDR Charge
ED0010865	650 MHz $\beta=0.61$ Jacketed Cavity Prototype FDR Report
ED0001830	650 MHz $\beta=0.61$ Cryomodule functional requirements specifications
ED0009658	650 MHz $\beta=0.61$ Cryomodule technical requirements specifications
F10128651	650 MHz $\beta=0.61$ Dressed/Jacketed cavity assembly
F10128653	650 MHz $\beta=0.61$ Bare cavity assembly
ED0011075	650 MHz $\beta=0.61$ dressed cavity engineering note (4.0 mm thick Nb raw material)
ED0011076	650 MHz $\beta=0.61$ dressed cavity engineering note (4.4 mm thick Nb raw material)
ED0007567	L3 Interface control document
ED0011092	Interface control document
ED0011092	Interface specification document
ED0009602	Safety by Design table: 650 MHz jacketed cavity
ED0009601	Failure Modes and Effects Analysis: 650 MHz jacketed cavity
ED0005527	650 MHz $\beta=0.92$ dressed cavity engineering note
ED0005130	650 MHz $\beta=0.90$ & $\beta=0.92$ cavity helium vessel engineering note (design report)
