PIP-II 650 MHz Low Beta Cryomodule Prototype Preliminary Design Review Charge

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1 INTRODUCTION

The PIP-II Project's superconducting linear accelerator (Linac) will fuel the next generation of intensity frontier experiments at Fermilab, USA. 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, hardware, assembly, test and transportation (frame), from INFN in Italy for the cavities, from Fermilab in the US for the power couplers an some small hardware for the cryomodule.

The LB650 cryomodule is being designed by CEA with inputs from Fermilab engineers.

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. 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 Preliminary Design Review for the LB650 cryomodule (design .maturity ~30-50%). Per the PIP-II Design Review Plan:

- Preliminary Design Reviews (PDRs) are technical and programmatic reviews intended to assure the chosen design approach meets the technical requirements. Detailed designs are not expected at this time, but preliminary design and analyses are required to demonstrate compliance with requirements. A presentation of the design and interfaces by means of block diagrams, signal flow diagrams, schematics, logic diagrams, configuration and layout sketches, analyses, modeling and any early results is required. Supporting data and analyses for mechanical, power, thermal, and reliability assessments should be shown.

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2 REVIEW AGENDA

Location : Virtual Meeting

Date : 8-10 March 2021

Indico Site : https://indico.fnal.gov/event/47833/

Reviewers : Ed Daly, JLAB
Vittorio Parma, CERN
Kay Jensch, DESY
Paolo Pierini, ESS

Agenda :

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Day 1

Time	Duration	Title	Presenter	Institute	Presentation ID
1:30 PM	0:15	Reviewers executive meeting			
		Introduction Session			
1:45 PM	0:10	Welcome	O. Napoly	CEA	PDR-LB650-D1-01
1:55 PM	0:20	The PIP-II project (including status on cavities and couplers)		FNAL	PDR-LB650-D1-02
2:15 PM	0:20	CEA contribution to PIP-II	O. Napoly	CEA	PDR-LB650-D1-03
2:35 PM	0:20	LB650 cryomodule: Functional Requirements Specification (FRS) & Technical Requirements Specification (TRS)	C. Simon	CEA	PDR-LB650-D1-04
2:55 PM	0:15	Coffee Break			
		Cryomodule Design Session			
3:10 PM	0:30	Cryomodule LB650 overview: design principles (including design handbook), common parts with HB650, PED, interfaces	N. Bazin	CEA	PDR-LB650-D1-05
3:40 PM	0:30	Vacuum Vessel	R. Cubizolles	CEA	PDR-LB650-D1-06
4:10 PM	0:30	Strongback: mechanical design	R. Cubizolles	CEA	PDR-LB650-D1-07
4:40 PM	0:20	Strongback: thermal study	N. Bazin	CEA	PDR-LB650-D1-08
5:00 PM	0:30	Thermal shield: thermal studies + mechanical design	R. Cubizolles	CEA	PDR-LB650-D1-09
5:30 PM	0:30	Discussion			

Day 2

Time	Duration	Title	Presenter	Institute	
		Cryomodule Session - continued			
1:30 PM	0:15	Magnetic shield	J. Plouin?	CEA	PDR-LB650-D2-01
1:45 PM	0:20	Alignment and cavity posts	R. Cubizolles	CEA	PDR-LB650-D2-02
2:05 PM	0:30	Cryogenic circuits (including heat loads)	N. Bazin	CEA	PDR-LB650-D2-03
2:35 PM	0:15	Instrumentation: pre-series cryomodule and series cryomodules	C. Simon	CEA	PDR-LB650-D2-04
2:50 PM	0:15	Transportation plan	R.Cubizolles	CEA	PDR-LB650-D2-05
3:05 PM	0:30	Transport studies	R.Cubizolles	CEA	PDR-LB650-D2-06
3:35 PM	0:15	Test plan (SAR2) and acceptance criteria	H. Jenhani / S. Arsenyev	CEA	PDR-LB650-D2-07
3:50 PM	0:15	Coffee Break			
		Cryomodule Project Management Session			
4:05 PM	0:15	Procurement Plan	S. Ladegaillerie	CEA	PDR-LB650-D2-08
4:20 PM	0:15	QA / QC	C. Cloué	CEA	PDR-LB650-D2-09
		Cryomodule CAD			
4:35 PM	0:30	Live CAD model review - discussion	R. Cubizolles	CEA	PDR-LB650-D2-10
5:05 PM	0:30	Discussion			

Day 3

Time	Duration	Title	Presenter	Institute	
		Cryomodule Assembly Session			
1:30 PM	0:30	Assembly of the cryomodules: overall organisation	O. Napoly	CEA	PDR-LB650-D3-01
2:00 PM	0:30	Assembly of the cryomodules: post clean room operations + SAR1, including QA/QC during assembly	TBD	CEA	PDR-LB650-D3-02
2:30 PM	0:15	Coffee Break			
2:45 PM	0:45	Assembly of the cryomodules: string assembly in clean room, including QA/QC during assembly	S. Berry	CEA	PDR-LB650-D3-03
3:30 PM	0:30	Discussion			
4:00 PM	1:00	Executive Session			
5:00 PM	0:30	Close Out preparation			
5:30 PM	0:30	Close Out			

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3 REVIEW CHARGE STATEMENT

The review committee is charged to evaluate the design and programmatic maturity of the PIP-II 650 MHz lowbeta prototype cryomodule design, to allow for final design of the cryomodule to proceed. The review committee is urged to evaluate by responding to the following questions:

1. Technical Scope
   a) Are all design and performance specifications and requirements reviewed, and at the level of maturity commensurate with a Preliminary Design Review?
   b) Have all the major interfaces (internal - between components supplied by different Institutes - and external - with the other systems of the accelerator) have been identified and incorporated into the design?
   c) Are the development of the CAD sufficiently mature for the preliminary design stage?
   d) Are there any unmanaged items that could affect safety, quality, cost, schedule, or performance?

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 appropriate ESH (Environmental, Safety and Health), QA (Quality Assurance), and QC (Quality Control) steps being implemented?
   d) Is the schedule reasonable to achieve the planned scope?

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