List of PIP-II – related abstracts submitted to IPAC’18

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1. Test results of PIP2IT MEBT chopping system components*

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The PIP-II project is a program of upgrades proposed for the Fermilab injection complex. A unique feature of PIP-II is the capability to form a flexible bunch structure by removing a pre-programmed set of bunches from a long-pulse or CW 162.5 MHz train at 5 mA. This bunch selection is made in the 2.1-MeV Medium Energy Beam Transport (MEBT) section by a dedicated chopping system, which consists of two fast kickers working in sync followed by a dedicated beam
absorber. The prototype components of the chopping system, two versions of the kicker and a 1/4-size absorber, are installed in the PIP-II Injector Test (PIP2IT) accelerator and have been successfully tested with a beam. The report presents the results of these tests.

2. **PIP-II Injector Test Warm Front End: Commissioning Update**


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The Warm Front End (WFE) of the Proton Improvement Plan II Injector Test (PIP2IT) at Fermilab has been constructed to its full length. It includes a 15-mA DC, 30-keV H⁺ ion source, a 2 m-long Low Energy Beam Transport (LEBT) with a switching dipole magnet, a 2.1 MeV CW RFQ, followed by a Medium Energy Beam Transport (MEBT) with various diagnostics and a dump. This report presents the commissioning status, focusing on beam measurements in the MEBT. In particular, a beam with the parameters required for injection into the Booster (5 mA, 0.55 ms macro-pulse at 20 Hz) was transported through the WFE.

3. **Fast Faraday Cup Measurements at the PIP-II Injector Test Facility**

J.P. Carneiro#, B. Hanna, L. Prost, A. Saini, A. Shemyakin, D. Sun, Fermilab, Batavia, IL 60510, USA

A Fast Faraday Cup has been installed in the Medium Energy Beam Transport of the PIP-II Injector Test Facility at Fermilab. This paper presents a description of the diagnostic and the bunch length measurements performed with it for a beam current ranging from 0.5 mA to 10 mA. We also discuss what we consider to be the limitation of our Fast Faraday Cup and we give an estimate of the longitudinal emittance as a function of the beam current.

4. **Beam Optics Measurements in Medium Energy Beam Transport at PIP-II Injector Test Facility**

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The Proton Improvement Plan-II Injector Test (PIP2IT) is an accelerator test facility under construction at Fermilab that will provide a platform to demonstrate critical technologies and concept of the front-end of the PIP-II linear accelerator (linac). The PIP2IT comprises H⁻ ion source capable to deliver 10mA, 30 keV DC beam, low energy beam transport (LEBT), a 162.5 MHz, CW radio frequency quadrupole (RFQ) that will accelerate the beam from 30keV to 2.1 MeV, medium energy beam transport (MEBT), one cryomodule of each, half wave resonator and single spoke resonator, family of superconducting resonators and, high energy beam transport (HEBT). Presently, beamline up to MEBT has been commissioned and in operation routinely at the PIP2IT facility. In this paper we presents beam characterization performed at MEBT using differential trajectory measurement, transverse emittance measurement and, envelope measurements.
5. Design of PIP-II Medium Energy Beam Transport
   A. Saini, C. Baffes, V. Lebedev, L. Prost, A. Shemyakin

The Proton Improvement Plan-II (PIP-II) is the proposed upgrade for the accelerator complex at Fermilab. The central piece of PIP-II is a SRF 800 MeV linac capable of operating in both CW and pulse regimes. The PIP-II warm front end comprises an H- ion source capable to deliver 15 mA, 30 keV DC or pulse beam, Low Energy Beam Transport (LEBT), a 162.5 MHz, CW Radio Frequency Quadrupole (RFQ) accelerating the ions to 2.1 MeV, and a 14-m Medium Energy Beam Transport (MEBT) that prepares the beam for injection into the SRF part of PIP-II. The unique feature of the MEBT, a bunch-by-bunch chopping system, defines many features of the MEBT, e.g. its length. This paper discusses factors driving specific choices and presents the concept of the PIP-II MEBT, including its beam optics.

6. Beam Characterization using Scraping System at Proton Improvement Plan-II Injector Test Facility
   A. Saini, A. Shemyakin

Medium energy beam transport (MEBT) of the Proton Improvement Plan-II Injector Test (PIP2IT) consists of an elaborated beam scraping system. The system consists of four assemblies spread along the MEBT, with each assembly composed of four radiation-cooled, electrically isolated plates that can be moved into the vacuum chamber in horizontal or vertical direction. Primary objective of the PIP2IT scraping system is to limit the maximum action of particles injected into SRF part of the linac and therefore, to protect the SRF component from beam irradiation. This paper presents beam measurements performed at the MEBT to characterize the scraping system in terms of minimization of largest beam action after the scraping system.

7. First performance results of the PIP2IT 200 Ohm MEBT chopper

The PIP2IT project is a program to upgrade the Fermilab linac injection complex. The PIP2IT machine includes a 2.1 MeV Medium Energy Beam Transport (MEBT) section that is to include a unique chopping system to perform arbitrary, bunch-by-bunch removal of 162.5 MHz structured beam. The arbitrary chopping pattern is required for the PIP2IT linac to deliver beam to the existing Booster machine operating with an asynchronous clock. The MEBT chopper system will consist of two identical kickers working together and a beam absorber. The choppers must cleanly kick individual bunches during 600 microsecond pulse trains of 162.5 MHz beam at 20 Hz intervals. This paper reports on the first performance results of the 200 Ohm chopper version successfully tested at the PIP2IT injector test facility at Fermilab. The chopper driver is a high-speed switch delivering 550 Volt pulses to a 200 Ohm characteristic impedance helical traveling-wave kicker. The one complete chopper tested consists of two drivers of opposite polarity and two helical kickers.

8. Preliminary Beam-Machine Interactions Calculations for PIP-II

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PIP-II is Fermilab's flagship project for providing powerful, high-intensity proton beams to the laboratory's experiments. The heart of PIP-II is a 800-MeV superconducting linac accelerator. It will be located in a new tunnel with new service buildings and connected to the present buster through a new transfer line. To support the conceptual design of civil engineering, both operational beam loss and the worst-case beam accident scenarios are considered. Detailed calculations with the FLUKA and MARS15 codes follow. They are on-going at Fermilab and preliminary results will be presented in this paper.

9. Final Design of SSR1 Cavity Cryomodule for PIP-II Project at Fermilab
Vincent Roger, Sergey Cheban, Thomas H. Nicol, Yuriy M Orlov, Mattia Parise, Donato Passarelli, Paolo Vecchiolla, Fermilab

This paper reports the final design of the Single Spoke Resonator 1 (SSR1) cryomodule developed in the framework of PIP-II project at Fermilab. The most recent results of finite element analyses and calculations performed to optimize the thermal shields, the current leads, the piping system, and the vacuum vessel are presented. Finally, the strategy to assemble the cryomodule and meet the requirements will be described step by step.

10. Testing of SSR1 Production Tuner for PIP-II
Jeremiah Paul Holzbauer, Donato Passarelli, Yuriy Pischalnikov, Derek Plant (Fermilab, Batavia, Illinois)

The PIP-II project at Fermilab is a proton driver linac calling for the use of five different, novel cavity geometries. Prototyping at Fermilab is in the advanced stages for the low-beta single-spoke resonator (SSR1) and associated technologies. A production tuner design has been fabricated and tested, both warm and cold in the Spoke Test Cryostat (STC). This paper will present the detailed studies on this tuner, including slow motor/piezoelectric tuner range and hysteresis as well as dynamic mechanical system characterization.

11. Preparation and Qualification of Dressed SSR1 Cavities for String Assembly at Fermilab
D. Passarelli et al.

The qualification of dressed Single Spoke Resonators type-1 (SSR1) to meet technical requirements is an important milestone in the development of the SSR1 cryomodule for PIP-II project at Fermilab. This paper reports the procedures and lessons learned in processing and preparing those cavities for horizontal cold testing prior their integration into cavity string assembly.

12. Tooling Systems for the Assembly and Integration of the Coldmass in the SSR1 Cryomodule for PIP-II Project at Fermilab
D. Passarelli et al.

In this paper we present the plan and tooling designed for the assembly of the cavity coldmass and its final integration into the vacuum vessel. Several challenging aspects were considered in
order to minimize undesired stresses on critical components and to preserve the alignment of cavities and solenoids within the technical requirements of the PIP-II project at Fermilab.

13. Tuner for SRF 650 MHz 5-Cell Elliptical Cavity

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The PIP-II project at Fermilab is a proton driver linac calling for the use of five different cavity geometries, including 650 MHz 5-cell elliptical cavities, that will operate in RF-pulse mode. Detuning of these cavities by Lorentz Forces will be large and strongly depend of the stiffness of the cavity’s tuner. Significant effort has been invested into ANSYS simulation of the different designs of the tuner to optimize stiffness of the dressed cavity-helium vessel-tuner system. Two compact tuner prototypes were designed, built, and tested (warm). The major design features include: double lever mechanism, highly reliable active components (electromechanical actuators and piezo-actuators), and the ability to replace tuner active components through designated ports in the cryomodule vacuum vessel. Results of tuner prototypes testing (warm) will also be presented.

14. Neural Network Modeling and Control for the PIP-II Radio Frequency Quadrupole

Auralee Edelen (CSU, Fort Collins, Colorado), Daniel Bowring, Brian Edward Chase, Jim Steimel (Fermilab, Batavia, Illinois), Jonathan Edelen (RadiaSoft LLC, Boulder, Colorado), Sandra Biedron (University of New Mexico, Albuquerque)

Resonant frequency control is of substantial importance for the PIP-II Injector Test RFQ, which operates in both pulsed and continuous wave (CW) RF modes for a wide range of duty factors. The resonant frequency is controlled entirely via a water cooling system with two sub-circuits for the vanes and walls, which enables differential tuning. The difficulty of the control task is exacerbated by long-term time dependencies in the system, the dynamic response of the resonant frequency to thermal expansion and contraction of the RFQ vanes and walls, and nonlinearities/coupling in the cooling system itself. PID control over the resonant frequency has been shown to be insufficient for meeting all of the desired performance goals, particularly with regard to trip recovery*. Building on initial work at Fermilab for a different system**,***, we have been developing two kinds of neural network controllers to address this problem****. Here we describe the control algorithms, the training process, and simulated/experimental results.


**Edelen, A., et al., IPAC15, MOPWI028.


****Edelen, A., et al., IPAC16, THPOY020
15.INFN-LASA Design and Prototyping Activity for PIP-II

Andrea Bignami, Michele Bertucci, Angelo Bosotti, Jinfang Chen, Paolo Michelato, Laura Monaco, Carlo Pagani, Rocco Paparella, Daniele Sertore (INFN/LASA, Segrate (MI)), Saeid Pirani (ESS, Lund)

The design of the PIP-II medium-\(\beta\), 5-cell, 650 MHz SRF elliptical cavity and the first steps of its prototyping activity are here presented. A design based on a three dies fabrication model has been chosen and fully characterized in terms of electromagnetic and mechanical parameters. Goal of the optimization has been to realize a high performant cavity for CW operation with reasonably good performances when pulsed. A prototyping phase started with the production of three single-cell cavities used to validate the LASA model and to develop an optimal recipe for RF surface treatment according to the state-of-the-art of the high-Q frontier.