

PIP-II MEBT Kicker Final Design Review Charge

Document number: ED0007959

Document Approval

Name: Matt Slabaugh Org: AD/ENG/MSD/PROC Contact: slabaugh@fnal.gov Role: Committee Member	Date:
Name: Ed Cullerton Org: AD/ENG/RF/LLRF Contact: ecullert@fnal.gov Role: Committee Member	
Name: Chris Jensen Org: AD/ENG/EESD Contact: ccjensen@fnal.gov Role: Committee Chair	
Name: Org: Contact: Role:	
Name: Org: Contact: Role:	

Approvals managed via Fermilab Teamcenter Workflows.

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Revision History

Revision	Date Release	Originator: Role:	Description of Change
-		L. Prost WFE Manager	Initial release

Revision control is managed via Fermilab Teamcenter Workflows.

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1. Introduction

The Medium Energy Beam Transport (MEBT) chopping system is a key part of the MEBT. It provides the capability to arbitrarily select which bunches will be further accelerated within the 162.5 MHz train delivered by the RFQ. The chopping system is composed of two deflecting structures (a.k.a. kickers) working synchronously and a high-power beam absorber. The focus of this review is on the kickers.

Due to stringent requirements [1], the kicker was considered beyond state-of-the-art. Two designs were proposed and developed in parallel. One prototype of each kicker type was fabricated and eventually installed in the PIP-II Injector Test (PIP2IT) beamline for testing with beam. The two designs are denominated according to their structure's impedance, namely 50-Ohm and 200-Ohm.

Prior to CD-1, the 200-Ohm kicker design was chosen to be the baseline kicker design for the PIP-II MEBT chopping system. In part, the rationale for this choice was:

- The 200-Ohm system demonstrated (proof-of-principle) that it could provide the appropriate kicking pattern for bucket-to-bucket injection into the Booster
- That same proof-of-principle for the 50-Ohm system would require the purchase of expensive power amplifiers not compatible with the project's budget profile
- The 200-Ohm kicker driver is being developed at Fermilab (and was partly supported with a LDRD in its early stage)
 - Negligible up-front capital costs

The next step in the development program of the MEBT chopping system is the fabrication of two identical 'production' kickers that will replace the 50-Ohm and 200-Ohm kicker prototypes currently in the beam line at PIP2IT. Then, final testing of the chopping system (including the high-power beam absorber) will take place.

The expected outcome of the MEBT Kicker Final Design Review is the recommendation to proceed with the fabrication of two kickers (mechanical structure) and kicker drivers. It is foreseen that these kicker systems will eventually be used in the PIP-II WFE with minimal to no modifications.

2. Review Agenda

MEBT Kicker Final Design Review Agenda

Date: Thursday, August 2, 2018

Time: 13:00-17:00

Indico Site: <https://indico.fnal.gov/event/17313/>

Participants:

Lionel Prost lprost@fnal.gov	AD/PIP-II DPT	Role: Coordinator, Presenter
Chris Jensen ccjensen@fnal.gov	AD/ENG/EESD	Role: Chair
Matt Slabaugh slabaugh@fnal.gov	AD/ENG/MSD/PROC	Role: Reviewer
Ed Cullerton ecullert@fnal.gov	AD/ENG/RF/LLRF	Role: Reviewer
Alex Chen alexchen@fnal.gov	AD/ENG/MSD/PROJENG	Role: Presenter
Greg Saewert saewert@fnal.gov	AD/ENG/EESD	Role: Presenter
Ding Sun ding@fnal.gov	AD/ENG/RF/HLRF_SRF	Role: Presenter
Alexander Shemyakin shemyakin@fnal.gov	AD/PIP-II DPT	Role: Presenter
Tim Hamerla hamerla@fnal.gov	AD/ENG/MSD/CAD	Role: CAD Support

Agenda details:

- I. Introduction (*Lionel Prost*) 20'
 - a. Charge and Scope of the review
 - i. *Agenda for the review*
 - b. Organizational structure and team
 - c. Quick recap of the kickers development history
 - d. MEBT kickers requirements
 - i. *Recent scope reduction*
 - II. 50-Ohm kicker design (*Ding Sun*) 30'
 - a. Specifications
 - b. Fabrication of prototype
 - c. Test results
 - i. *Low power (RF) tests*
 - ii. *High power tests (thermal/vacuum)*
 - III. 200-Ohm kicker electromagnetic design (*Greg Saewert*) 45'
 - a. Requirements and approach overview
 - b. Electromagnetic (RF) design
 - i. *Test results*
 - c. Issues to be addressed
 - IV. 200-Ohm kicker mechanical design (*Alex Chen*) 45'
 - a. Specification & requirement
 - b. Mechanical design overview
 - c. Analyses & tests with the prototype
 - V. Interfaces (*Lionel Prost*) 10'
 - VI. Kickers characterization with beam at PIP2IT (*Sasha Shemyakin*) 20'
 - a. Requirement, setup and measurements procedures
 - b. 50-Ohm kicker performance measurements
 - c. 200-Ohm kicker performance measurements
 - VII. Wrap-up (*Lionel Prost*) 10'
 - a. 200-Ohm kicker as the baseline for the PIP-II chopping system
 - b. Cost & Schedule
 - VIII. Closeout (*Chris Jensen – Review Chair*)
 - a. Preliminary Findings, Comments & Recommendations
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3. Review Charge Statement

For the Final Design Review of the MEBT Kicker, we would like the committee to comment on the robustness of the 200-Ohm kicker design for PIP-II taking into account the fact that the initial requirements, arbitrary bunch pattern generation with CW beam delivered by the RFQ, have been reduced in scope – bucket-to-bucket Booster injection pattern with 1.1% beam duty factor upstream.

More specifically, we would like the committee to consider the following questions:

1. Are the designs mature and technically sound to satisfy design specifications?
 - a. The mechanical structure (e.g.: vacuum chamber, helices) and the driver electronics may be addressed separately
2. Do the measurements appropriately show that the 200-Ohm kicker and kicker driver meet the basic performance requirements?
 - a. RF, thermal, vacuum, Machine Protection, beam
 - b. Are the mechanical and RF designs sound for providing long-term operation?
3. Have installation issues been adequately addressed?
 - a. Was maintenance/servicing of the units taken into account appropriately?
4. Have all the major interfaces been identified and incorporated into the design?
5. Are all necessary design specifications, requirements and interface documents complete or near completion?
 - a. Have the critical documents (e.g. FRS, some key drawings) reviewed, approved and released?
6. Is the design team organized and staffed to successfully complete the project?
 - a. Has a succession plan been identified?
7. Have all of the major risks been identified and managed?
8. Are procurements appropriately planned?
9. Is the development of associated drawing packages or schematics (electrical) sufficiently mature? What % of the total number of drawings/schematics to be generated is approved and released?
10. Is the cost and schedule reasonable to achieve the planned scope?
 - a. This is a 'reasonableness' assessment by technical experts, not a detailed cost/schedule review
11. Are all related ES&H aspects being properly addressed?
12. If applicable, have all the previous design review action items/comments been addressed?
13. Have lessons learned been addressed?
14. Are there any other issues that have been identified and need to be addressed?
 - a. Where shortcomings of the prototype are identified by the presenter, is the correction/upgrade path likely to succeed within the timeframe of 6 months to a year?
15. Is the design sufficiently mature so as to allow Final Design Review approval?

From this review, we seek from the Review Committee the recommendation to proceed with the fabrication of two 200-Ohm kicker systems.

The Review Committee is kindly asked to submit a Final Design Review Report no later than 4 weeks after the conclusion of the review. A Review Report template will be provided.

4. Acronyms

CD-1	DOE's Office of Science "Critical Decision point 1"
DOE	Department of Energy
FRS	Functional Requirement Specification
MEBT	Medium Energy Beam Transport
PIP-II	Proton Improvement Plan-II
PIP2IT	PIP-II Injector Test
RF	Radio Frequency
TC	Teamcenter
WFE	Warm Front End

5. Reference Documents

Below is a list of documents that serve as references for the review. Additional documents may be added to this list up to 1 week prior to the date of the review.

Note that TC 'Documents' are in fact TC "Items", which may contain more than one document. In particular, the material shown during the review (e.g.: slides), some supporting documentation and the Review Report are all located within the Final Design Review Teamcenter Item # ED0007959 [0].

Teamcenter Documents

0	PIP-II MEBT Kicker Final Design Review, TC# ED0007959 <ul style="list-style-type: none"> • Review charge • Slides of presentations • Alternative Analysis • List of drawings and procedures for the kicker driver • List of drawings (tree) for the kicker mechanical structure • Pressure Test form of the prototype • Selection of drawings for the review (pdf) • Drafts of 3 testing & tuning procedures for the kicker driver
1	PIP-II MEBT Kicker System Functional Requirement Specification, TC# ED0001305
	PIP-II MEBT Kicker Engineering Process Document Management, TC# ED0001271
	PIP-II MEBT 200-Ohm Kicker Engineering Process Document Management, TC# ED0002198
	PIP-II MEBT 200-Ohm Kicker Driver Engineering Process Document Management, TC# ED0006650

	PIP-II MEBT Kicker Risk Analysis, TC# ED0008143
	PIP-II MEBT 200-Ohm Kicker Driver Risk Analysis, TC# ED0006652
	PIP2IT MEBT 200-Ohm Chopper Assembly Safety Analysis Report, TC# ED0006653
	PIP-II MEBT Kicker Assembly Technical Requirements Specification, TC# ED0008094
	PIP-II MEBT Kicker Mechanical Structure Technical Requirement Specification, TC# ED0002305
	PXIE MEBT 200-Ohm Kicker Driver Preliminary Design Review, TC# ED0006651
	MEBT GIRDER 3 BUILDOUT, TC# F10063757
	MEBT 200 OHM KICKER STAND ASSEMBLY, TC# F10053899
	MEBT 200 OHM CHOPPER ASSY, MARK2, TC# F10045400

Project X and PIP-II DocDB Documents

Technical meeting presentations

	Measurements of bunch-by-bunch kicking with 200-Ohm kicker, PIP-II DocDB #1007-v1
	Update on beam measurements with 200-Ohm kicker, PIP-II DocDB #1203-v1
	Update on 200-Ohm kicker driver performance, PIP-II DocDB #1206-v1
	High Power (CW) Test of 50-Ohm fast kicker, PIP-II DocDB #1320-v2
	50-Ohm kicker deflection characterization, PIP-II DocDB #1347-v1
	Requirements for the PXIE MEBT chopper, Project X DocDB#935-v2
	RF Modeling of the Helical Kicker for Project X, Project X DocDB #1137-v1

Reviews material

	Materials of Review of PXIE 50-Ohm bunch-by-bunch kicker, Project X DocDB #1140-v2
	PXIE MEBT 200-Ohm Kicker Mechanical Design, Project X DocDB #1270-v1

6. Additional Documentation

The table below lists a variety of documents (mostly status reports) related to the development of the MEBT chopping system over the years. These documents do not support directly the purpose of this review but might be of some interest to the reviewers.

Project X and PIP-II DocDB Documents

Technical meeting presentations

	Transient Electromagnetic Analysis of MEBT Kicker for PXIE, PIP-II DocDb #38-v4
	200-Ohm Chopper Driver Progress, PIP-II DocDB #78-v1
	200-Ohm Chopper PIP2IT Assembly, PIP-II DocDB #131-v3
	200-Ohm Chopper Progress Update (chopping beam), PIP-II DocDB #1013-v3

	ICD-2 chopper requirements, Project X DocDB #318-v1
	Bench Test Results of a Helical Microstrip Line Chopper [200-Ohm], Project X DocDB #624-v2
	Chopper R&D Update, Project X DocDB #627-v1
	Test Results of 1 st Prototype Kicker [50-Ohm], Project X DocDB #873-v1
	Bandwidth Considerations for the Project X Fast Kicker, Project X DocDB #874-v1
	Power test of a short 50-Ohm kicker prototype, Project X DocDB #1165-v1
	PXIE 50-Ohm Fast Kicker: Measurement and Power Test Results of First Half Prototype, Project X DocDB #1379-v1
	200-Ohm MEBT Chopper Development Progress, Project X DocDB #1380-v2

Project X Collaboration/Retreat meetings presentations

	Chopping and limitations to MEBT; Injection to Recycler, Project X DocDB #771-v1
	Status of the Kicker R&D for a Broadband Chopper, Project X DocDB #863-v1
	Bunch-by-bunch Kicker and its Driver: 50-Ohm choice, Project X DocDB #1023-v1

Stand-alone papers

	A 500V Fast Switch for Project X 200-Ohm Chopper, Project X DocDB #1058-v1
	Project X MEBT Fast Chopper Power Supply Proposal, Project X DocDB #1146-v1