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P2MAC Summary

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PIP-II Tuesday Meeting

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Charge

The P2MAC is asked to review the plans for PIP-II including R&D activities and development of the conceptual design. Advice and/or recommendations are sought relative to the challenges of the current design concept, the evaluation of alternatives, and the appropriateness of the accompanying R&D program. In particular we would like specific advice, recommendations, and/or commentary on:

1. **Conceptual Design Development:** a) Are the plans for developing the PIP-II conceptual design, with the Reference Design as a starting point, likely to yield a design meeting the enumerated performance goals? b) What alternatives to the approach outlined in the Reference Design might be considered?

2. **R&D Program:** a) Is the R&D plan properly directed at addressing the primary technical and cost risks in an effective manner? b) Are the risks appropriately prioritized and will the completion of the R&D plan provide a basis for proceeding to the construction phase with confidence that performance goals can be met? c) Is the R&D program proceeding satisfactorily toward a construction start near the end of the current decade?

3. **India Collaboration:** Is the program, and division of responsibilities, outlined in the Joint R&D Project document well aligned with the needs of PIP-II, and will it support a construction start encompassing both U.S. and Indian deliverables?

The P2MAC is not limited by these specific charge areas and may delve into other related areas, and offer advice, comment, or recommendations, as it deems appropriate under the general guidance of this charge.

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1. **Conceptual Design Development:** a) Are the plans for developing the PIP-II conceptual design, with the Reference Design as a starting point, likely to yield a design meeting the enumerated performance goals?

The plans for preparing PIP-II linac construction phase are well-motivated and cover essential subjects for the linac to reach the required beam characteristic. However, the efforts required for demonstrating that the existing machines can reach the required performance shall not be underestimated. Pace of progress for the Booster, Recycler and Main Injector is slow because of resources limitations (e.g. design of the booster injection girder, construction of the collimators in the recycler, early test of power amplifiers, etc.).

b) What alternatives to the approach outlined in the Reference Design might be considered?

The main alternative to the proposed version of PIP-II is to limit the future linac to pulsed operation. Renouncing to CW would bring-in significant benefits during construction and exploitation: heat dissipation in the amplifiers would be much lower, reducing construction and maintenance cost, electrical consumption would be drastically lower (cryogenics, RF, magnets), chopping would be simpler… If the instantaneous beam current is increased, resonance control becomes less challenging and the duration of injection in the booster can be reduced. Upgrading to a higher pulsing rate could significantly increase the physics reach of the Mu2e experiment.*

*Note: This is a misinterpretation of the needs of Mu2e. We will correct during review of the report.

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2. **R&D Program:** a) Is the R&D plan properly directed at addressing the primary technical and cost risks in an effective manner?

YES. The R&D plan covers all critical items, but the rate of funding is a clear limitation that necessitates prioritization. The potential need for CW operation in the long term complicates today's R&D program and is a drain of resources (e.g. for amplifiers, chopper*..).

b) Are the risks appropriately prioritized and will the completion of the R&D plan provide a basis for proceeding to the construction phase with confidence that performance goals can be met?

Prioritization is not fully clear to the Committee. Some R&D tasks clearly deserve more attention, e.g.:

For the linac, resonance control is a crucial subject which benefits from LCLS-II developments but still deserves additional efforts for PIP-II. Allocating more time for testing with cold cavities is highly recommended.

For the rings, the design of the injection girder in the booster is a difficult issue which deserves being addressed as soon as possible. This is also the case of the construction of the collimators for the Recycler which is necessary to reach the PIP goal of 700 kW beam power, but is also a mandatory step towards demonstrating the potential of the Recycler to attain PIP-II performance goals.

c) Is the R&D program proceeding satisfactorily toward a construction start near the end of the current decade?

At the current level of financing it is not obvious that the R&D program will converge on time to minimize risks. Many items in the PIP-II R&D are on the critical path for starting construction in 2019 (e.g. PXIE). The SRF R&D and prototyping efforts are well past CD-0 in many areas but, due to various reasons, some delays are noticed wrt plans presented during the previous PIP-II MAC.

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3. **India Collaboration:** Is the program, and division of responsibilities, outlined in the Joint R&D Project document well aligned with the needs of PIP-II, and will it support a construction start encompassing both U.S. and Indian deliverables?

The Indian partners have an important role in the Joint R&D project which depends critically on their contributions being delivered on time and meeting specifications. The same will be true during the construction phase. The Committee is confident in the will and competence of the Indian laboratories, but considers that their contributions should be monitored and reviewed like those from other partners. That will be even more important during the construction phase, where similar project management and system engineering practice have to be applied throughout the project (Progress report, Quality Assurance, Engineering documentation validation and storage…).

Recommendations

R1: Investigate/estimate the uncontrolled variations of the linac beam energy.
Implementation of an additional system for energy stabilization during the pulse should only be considered as a last resort corrective measure.

R2: For the alternative solution of an sc linac operating only in pulsed mode, optimize the pulse current and pulse structure.

R3: Prioritize the design of the Booster injection girder and the whole injection scheme to demonstrate the feasibility of the long injection time needed with a 2mA linac beam.

R4: Pursue simulation and code development for RF gymnastics in the rings in collaboration with other laboratories.

R5: Continue to address the identified R&D areas but further prioritize in case of resource challenges.
One possibility would be to decrease the priority given to the CW requirements.

R6: Identify the risk of single source dependencies and develop mitigation plans where appropriate.

R7: Project management and system engineering practice have to be standardized throughout the PIP-II project (Progress report, Quality Assurance, Engineering documentation validation and storage…). All contributions should be monitored in a similar fashion by the various review and advisory committees.

R8: Resonance control of the SRF cavities is a crucial subject which deserves additional efforts. Allocating more time for testing with cold cavities is highly recommended.

R9: For the solid state amplifiers, place order early to reach nominal performance in time.
Don't underestimate the amount of spares parts necessary to commission and maintain operational equipment. **The Committee remarks that most troubles encountered are linked to CW operation of the amplifiers.**