Summary of DOE review & AUP Roadmap for 2020

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Global CC Coordination – 1/24/20

U.S. DEPARTMENT OF ENERGY

OFFICE OF SCIENCE

Closeout Report on the DOE/SC Status Review of the

High Luminosity LHC Accelerator Upgrade Project (HL-LHC AUP)

Fermi National Accelerator Laboratory

January 14-16, 2020

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http://www.science.doe.gov/opa/

Main Comments Received

- We commend the AUP team for its notable accomplishments since the last DOE review.
- Successful testing of LARP RFD1 cavity at FNAL after bulk and light rotational BCP is very encouraging.
- The successful test of the LARP RFD2 cavity with HOMs at JLAB achieved transverse deflecting voltage of 5.1 MV with Q0=6.5E9 is a notable milestone for RFD cavity design and performance validation.
- Continue to utilize LARP prototype to evaluate and validate the design, processing and performance as needed.
- It is essential for the planned reviews to take place as scheduled prior to fabrication.
- Timely coordination with CERN on RFD scope is critical.
- The dressed cavity FDR should be executed once all dressed cavity designs are frozen, otherwise a delta review will be required.
- The schedule for final CERN design input for the dressed RFD cavity is too late to support the planned CD-3c review.

Main Comments Received (cont.)

- Consider using the 2 prototype cavities for the machine if some of the pre-series and series cavities do not meet requirements. There may be things to be done now to make this possible later.
- Agree on the data format that will be transmitted from the vendors to FNAL and on to CERN prior to pre-series fabrication.
- Simulation and measurements of the beam induced voltage on the Double Quarter Wave (DQW) crab cavity rf pick-up probe during beam operations should be further studied to make sure the proposed changes to the RFD pick-up probe will solve the problem.
- A detailed analysis of the thermal properties of the production feedthroughs should be carried out before any vertical testing is done in case the ceramics cannot withstand a large temperature change.
- Implement a solution to avoid potential cracking of feedthrough ceramic exposed to liquid Helium.

Recommendations

1. Finalize the required documentations needed for Final Design Review and Procurement Readiness Review with CERN to minimize schedule risk for pre-series and series RFD cavities fabrication by May 2020.

   (See roadmap in later slide)

2. Provide response and/or close out open recommendations before CD-3c.

   (Input from CERN required)

3. Hold a final design review of RF ancillary components before launching the series fabrication.

   (Possibly combine with cavity FDR in May 2020)

Considerations on Design Maturity

- Bare cavity design is Final:
  - RF design finalized ~1yr ago
  - CERN Drawings released in EDMS
  - CERN Eng. Spec understood, revision imminent
  - Technology validated by LARP prototypes
  - Cold tests at FNAL (Spring-Summer 2020) will validate Zanon fabrication process
- Dressed cavity design “almost Final”
  - Mech. Design by CERN is completed
  - CERN Drawings in final stages of completion
  - Technology validated on CERN DQW experience

Considerations on Design Maturity (cont.)

- RF Ancillaries design is rapidly advancing
  - Tremendous progress in last 12 months of interactions between AUP-CERN.
  - RF design completed and studied in detail by SLAC.
  - Mech drawings produced by CERN for prototypes, adopted by Jlab.
  - Fabrication to be validated at Jlab in Summer 2020.
  - Performance to be validated towards end of 2020.
  - AUP Ancillaries pre-series to be launched in 2021.
  - CERN is ahead, possible validations before FDR end of May?
  - Could the design be finalized by Apr. 2020?
  - Small changes for fabrication aspects certainly allowed after final design review.

Planning of Final Design Review

- At Fermilab, May 18-19th 2020.
  - Invitation and Charges not yet distributed.
- Scope of review to cover all AUP contribution
  - Solid ground for pre-series
  - Avoid additional review in 2021
  - HOM Dampers
- Participation of CERN is fundamental to defend mechanical design of cavity and ancillaries.

Open Recommendations

- D-CD2/3b-4: Finalize requirements associated with magnetic shielding in advance of the RFD final design review. Define the required ambient field level at the RF cavity surface with a justification based on the cavity Q_0 specification.
  - IN THE PLAN - Revision of FRS includes magnetic shielding requirements. Advanced draft in discussion between AUP/CERN. Approval Jan-Feb 2020?

Open Recommendations (cont.)

- CD2/3b-5: Before CD-3c (before Aug 2020) complete the following:
  a) Hold a Final Design Review of dressed RFD Crab Cavities.
     - Planned May 18-19th 2020 at Fermilab
  b) Revisit/Reevaluate thermal analysis of FPC and HOM couplers to ensure that the heat leakage does not exceed the total cryogenic limit.
     - Ongoing at CERN (estimated Spring 2020?)
  c) Develop a detailed heat load table for the fully dressed cavity and ancillary.
     - Ongoing at CERN (estimated Spring 2020?)
  d) Clearly define the acceptance criteria for the dressed cavities with CERN. This should include any performance validation testing after shipping from FNAL to CERN/TRIUMF.
     - AUP updated, and will share with WP4, version of Acceptance Criteria to align with CERN Engineering Spec.
     - Performance validation document for tests at TRIUMF does not yet exist, who will write this?
     - Convergence needed in early 2020 certainly before Final Design Review

Roadmap to CD-3c

AUP:

- Update: Fabr. Spec, Fabr. DWGs & MIP → Zanon
- Test 1st Zanon prototype
- Procurement Readiness Review (Including CERN)
- Develop drawing of RFD "as delivered" → Key interface

CERN:

- Approval of Revision of FRS document (EDMS 1806220)
- Revision of CERN engineering spec (EDMS 1389669)
- Approval of Acceptance Criteria (EDMS?)
- Approval of Interface Control Document (EDMS?)
- Complete Thermal Analyses, Heat Load estimates
- Finalize design of Dressed Cavity + RF Ancillaries

deadline: Apr 2020

External Reviews:

- **Final Design Review** — **18th May 2020**
- Director's CD-3c — Jun 2020
- DOE CD-3c — Aug 2020
- ESAAB (approval for construction of series) — Oct 2020