Report from the PSI CD1 Conceptual Design Review

June 2017
CERN

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Introduction

In 2016 a memorandum of understanding and a specific addendum were negotiated between PSI and the FCC Design Study at CERN. One subject of the collaboration is to be the Canted-Cosine Theta technology and its potential application in an FCC main dipole magnet. The initial program duration is three years. An important goal of the program is the construction of a technology model magnet, proving the feasibility of some key features that a CCT magnet would have to possess in order make for a viable candidate in the FCC design study. In addition to the collaboration of PSI and CERN, the PSI program will closely coordinate their activities with the CCT program in Berkeley (LBNL).

The Committee was called to analyse the Conceptual Design of the first technological model.

General remarks

The program includes a design study for 16 T and also a modelling activity.
The Committee remarks the excellent collaboration between PSI and US laboratories: this was particularly effective for example in the establishment of the design tools and methods.
The exchange of information between the two labs on all the different aspects of the CCT magnet development is certainly essential for the success of the PSI program.

Though the activity started very recently, the material presented was well developed at the conceptual level. It is shown that the proposed concept of a "high engineering current density cosine-theta design" may have a potential of keeping the coil volume within acceptable size still providing some beneficial features of stress management.

In the following the answers to the questions to the Committee are provided.

Answers to the questions

1. *Is the PSI program well motivated in view of the FCC design requirements?*
    a. *Is the staged approach with two different sets of coils, CD1 and CD2, in a shared mechanical structure appropriate?*
    b. *Is it reasonable for PSI, at this time, to move ahead with ordering conductor for CD2, given that conductor delivery times are ~1.5 years?*

The staged approach is appropriate and represent a safe approach towards the solutions of the different questions still to be addressed in the CCT design. I particular we believe that postponing the winding with a wide cable to a second stage (CD2) is a sound strategy.

For this reason we recommend to procure the strand for the CD2 magnet only after having performed winding tests using wide Nb3Sn cable ("scrapped" strand could be used) to gain confidence on windability and coil fabrication. In addition, the cable for CD2 should not be fabricated before a successful test of CD1.

2. *Is the mechanical design of the shared structure in CD1 and CD2 configuration sound, i.e. have risks been identified and addressed in a reasonable manner?*

Yes, the support structure seems adequate and risks have been addressed (sensitivity analysis).

The «reference FCC design» has been simplified into tunable key&bladder structure to easier R&D.

3. *Is the electromagnetic and electro-thermal modelling sufficiently detailed to start the technical design and, eventually, the procurement of parts, or is there additional analysis that should be performed?*

Yes, the modelling is sufficiently complete and the engineering design can start.

The analysis have been performed in detail for CD1 with a conservative approach, neglecting the effect of eddy currents in the structure. The model magnet can be protected with an external resistor.
No sensitivity analysis has been performed on the conductor positioning in the slots, but we believe that at this stage this is not important for CD1.

4. *Have major technical risks been appropriately identified and are the foreseen tests adequate to address them?*

We believe that the main risks are the following

- Lack of experience of PSI in this technology. For this reason, winding tests with «scrapped» conductor seems extremely useful. On the other hand, starting with Nb-Ti conductor, not really representative, would not be effective.
- Possible damage of conductor and of its insulation. Additional conductor should be procured as a reserve. The proposed glass/mica system appears appropriate

5. *Are the PSI infrastructure goals and plans realistic and appropriate from a technical perspective?*

PSI plans to perform the full magnet manufacture: wind, heat-treat and impregnate the coil, assemble the magnet.

We believe that for a laboratory willing to carry a Nb3Sn program procuring a furnace is mandatory. Its characteristics have to be based on strategic view of PSI on Nb3Sn magnets.

We support the idea of «easier» tools for the rest of the assembly (including impregnation).