FCC International Advisory Committee

Report on the Review held in June 2017 with COMMENTS

7. SCRF R&D

Comments:

C7.1. An installation and staging plan for the RF system from FCC-ee to FCC-hh exists.

C7.2. Currently three cavity designs are being considered, including one at 800 MHz.

C7.3. While the Z-pole and FCC-hh are high-current machines (ranging from 1.4 A to 0.5 A), the H and t-pole are high-voltage machines (ranging from 2.6 to 9.5 GV).

C7.4. Since high current favours low frequency and low number of cells, single-cell 400 MHz cavities have been selected for FCC-hh and FCC-ee Z.
Since high voltage and low current favour high gradient and larger number of cells, 4-cell 400 MHz and 800 MHz have been selected for high energy FCC-ee.

C7.5. The tracking code BlonD is used to estimate the microwave instability and coupled-bunch instability; since these instabilities could result in a severe performance limitation, especially for the FCC-ee Z, it would be wise to benchmark with other well-known tracking codes that have been developed at SLAC or for synchrotron light sources (mbtrack, …).

C7.6. Feedback is seen as a key-component to cope with the longitudinal coupled bunch instabilities; specifications of the feedback systems should be assessed.

C7.7. HOM power and damping: calculations have been made for a bare cavity and those for different layouts are ongoing; while coaxial HOMP couplers could be used on both sides of the cavities, warm absorbers might be anyhow needed outside the cryostats for the high-frequency propagating modes.

C7.8. Fundamental power coupler: the coupler, which must be capable of transferring 0.735 MW and 1 MW in CW mode to the beam of the FCC-ee Z and W, respectively, doesn't exist on the shelf and thus requires intensive R&D.

C7.9. Cavity R&D plan: aggressive R&D programs are planned for both Nb/Cu for which a decrease of surface resistance by a factor 2 to 3 is targeted (by means of a promising tool, such as the electron cyclotron resonance -ECR- plasma metal ion source) and A15 compounds which could offer even more cryogenic cost savings, but require a longer way to go.

C7.10. High-efficiency klystron: given the very high beam power (2 x 50 MW for the FCC-ee Z) the development of an overall high-efficiency klystron, including the power-efficient solenoid magnets, should be actively pursued (HEIKA program).

Recommendations:

R7.1. 800 MHz versus 400 MHz for the high-energy FCC-ee: as the high-frequency choice requires an operating temperature of 2K instead of 4.5K and has a strong impact on the cryogenics, the study should clearly show the advantages and drawbacks in terms of cost and complexity of both options.
→ detailed study of the overall performance/cost/risk for a pure 400 MHz design vs hybrid 400/800 design is ongoing.

R7.2. Strong arguments shall be delivered for the large variety of cavity designs (freq. choices). In particular, it should be considered that eliminating the 800 MHz option should have important impact on the cryo system (eg. no need for a 2K cryo system).
→ Indeed. See R7.1.

R7.3. Microwave and coupled-bunch instability: it would be wise to benchmark with several tracking codes.
→ Microwave instability threshold was also calculated by M. Magliorati using different code, the results agree. Coupled-bunch instabilities were analysed using analytical approach due to difficulty in simulations of many bunches

R7.4. HOM power and damping: calculations should be made not only for a bare cavity but for a full cryomodule including beam pipes and tapers.
→ Beam pipes and tapers are included now.

R7.5. Specifications for the feedback systems should be defined.
→ The work for FB on fundamental cavity impedance has not started yet

R7.6. R&D programs: an aggressive R&D program on Nb coating and A15 compounds should be highlighted and detailed, as well as for the fundamental power coupler. Overall, high-efficiency klystrons including solenoids should be developed for the FCC to be efficient in terms of energy balance.
→ R&D programs have started for both technologies. They should be further strengthened to improve the chances of success.