4th FCC-hh design meeting

Thursday 27th April 2023, 15:30 – 16:30

Chair:	Massimo Giovannozzi
Speakers:	Massimo Giovannozzi, Susana Izquierdo Bermudez
Participants:	Roderick Bruce, Massimo Giovannozzi, Michael Hofer, Susana Izquierdo Bermudez, Patrick Krkotic, Nicolas Mounet, Gustavo Pérez, Thys Risselda, Ezio Todesco
Apologies:	Wolfgang Bartmann

AGENDA

Meeting actions 2

Overview of recent activities (Massimo Giovannozzi) 2

Persistent Currents Magnetization Effects in The 16 T Main Dipoles for the FCC-hh (Susana Izquierdo Bermudez) 2

MEETING ACTIONS

OVERVIEW OF RECENT ACTIVITIES (MASSIMO GIOVANNOZZI)

Currently preparing for the scientific advisory committee meeting, FCC week, IPAC papers, and write up of the mid-term review of the feasibility study.

PERSISTENT CURRENTS MAGNETIZATION EFFECTS IN THE 16 T MAIN DIPOLES FOR THE FCC-hh (SUSANA IZQUIERDO BERMUDEZ)

Within the EuroCirCol Program, three different magnet design options were explored. All for a 16 T operating field, but with different coil configurations: Cos-Theta at INFN, block at CEA and common-coil at CIEMAT. This included the study of the persistent currents at injection for the different coil configurations.

The field quality at injection is dominated by the persistent current effects, which depends on the sub-element diameter and critical current density. The FCC targets consist of effective strand diameter of $20\ \mu m$ and critical current density. Until now, the focus has been to increase the critical current density, while the filament size is currently $50 - 60\ \mu m$, the reduction of which would be the focus of a second stage of the development.

Different cases are considered for the study of strand magnetization. With the current filament size of $50\ \mu m$ and grain boundary pinning (being the state-of-the-art technology) and different versions with $20\ \mu m$ filament size but varying the effectiveness of the grain boundary pinning. Going from $50\ \mu m$ to $20\ \mu m$ scales the strand magnetization. At 1.9K the critical current is halfway between the HiLumi and the FCC target set 5 years ago.

Two different cases are considered for the injection energy as relevant to FCC-hh. Injection at 3.3 TeV using the LHC as injector and injection at 1.3 TeV using a superconducting SPS as injector.

When studying the sensitivity to the coil design, it is with today's strand quality of $50\ \mu m$ and FCC's target critical current. When looking at b3, block has half of the persistent current contribution than the others. For b5, block and common-coil are similar, while for b9 block looks better. Since the parameters are far from the reference spec its more significant to compare the general options. Looking at b3 at 1.3 TeV injection energy, it is >100 units and the curve in this region is very steep, so small changes result in wide swings of b3. If injecting at 3.3 TeV, the curves are flatter. This conclusion is the same when considering b5, b7, and b9.

The study of the sensitivity to the filament size focuses on the cos-theta design. Here, the reduction of the filament size from $50\ \mu m$ to $20\ \mu m$ results in a reduction of the width of the hysteresis loop and the penetration field.

When considering the sensitivity to the critical current between the two injection scenarios, again the injection at 1.3 TeV is much more sensitive to the different parameters affecting magnetization.

All these effects have been reproduced in the 11 T short-model programme. The spread of b3 at 1.3 TeV equivalent energy is of ~50 units while at 3.3 TeV equivalent, the spread is of ~15 units.

In conclusion, we can't prove today that the 1.3 TeV injection scenario is viable.

Ezio added to the conclusions that we can go to smaller filament size, but it conflicts with higher critical current density and cost optimization. **Susana** agrees, the two targets oppose each other.

Massimo asks if there is any research line towards smaller filament size, **Susana** answers that at least this is not at CERN, unaware if someone external is.

Patrick asks if it is possible to vary the temperature of magnet already at low temp to tweak the critical current. **Massimo** says it's an interesting question, but the cryogenic system is very slow and would have to be synchronized with the ramp. **Susana** remarks that in SM18 it is difficult to test magnets at temperatures other than 1.9 K or 4.5 K. The cryogenic team shall be contacted to have a further insight on the possibilities.

Minutes reported by Gustavo Pérez Segurana