FUTURE CIRCULAR COLLIDER

3rd FCC-hh design meeting

Thursday 16th March 2023, 14:00 – 15:40

Chair:	Massimo Giovannozzi
Speakers:	Massimo Giovannozzi, Ezio Todesco, Gustavo Pérez, Andrey Abramov
Participants:	Andrey Abramov, Roderic Bruce, Sergio Calatroni, Massimo Giovannozzi, Cedric Hernalsteens, Michael Hofer, Susana Izquierdo, Patrick Krkotic, Katsunobu Oide, Gustavo Pérez, Thys Risselada, Ezio Todesco, Frank Zimmermann

AGENDA

OVERVIEW OF RECENT ACTIVITIES (MASSIMO GIOVANNOZZI)

The minutes of the previous meeting were approved without comments.

Considerations on energy swing of superconducting magnets with application to the FCC-hh injection energy determination (Ezio Todesco)

The baseline choice for FCC-hh injection beam energy is 3.3 TeV, using the LHC as injector. The main alternative is injecting at 1.3 TeV using a superconducting machine in the SPS tunnel. The baseline has an energy swing of 15. Going to 1.3 TeV would have a swing of 38 – challenging with respect to what has been done in the past in superconducting machines. An MD was proposed in 2018 to inject in the LHC at 225 GeV instead of the nominal 450 GeV.

With regards to the aperture, the FCC-hh magnets have an aperture of 50 mm. Reducing the injection anergy by a factor of 3 results in a 60% larger beam which could be adequate for injection at 1.3 TeV. However, the margin currently available could be used to get rid of issues related to high-order nonlinearities, or to use a much longer cell with a higher filling factor as well as reducing the quadrupole number and strength.

The main issue is that with Nb_3Sn magnets injection occurs below the penetration field resulting in swing during ramp but also reproducibility. A study on this problem was presented in 2018 to be presented in a future meeting by Susana.

In conclusion, 1.3 TeV injection is not currently proven as workable. Additionally, with the reduction of the FCC arc length a revision of the FCC-hh collision energy may be needed: an 80 TeV centre-of-mass all Nb_3Sn ring with main dipoles at 14+ T, and a 120 TeV centre of mass with Nb_3Sn + HTS ring with main dipoles at 20+ T.

Studies of an FCC-hh lattice with 16-dipole FODO cells (Gustavo Pérez Segurana)

From the configuration presented in the previous meeting, both PF and PH (betatron and momentum collimation insertions respectively) have been successfully matched to the V1.0 optics at the primary collimator. The necessary shortening of the insertions to 2032 m was achieved by reducing the distance between Q7 and Q6 thus leaving the optics unchanged for most of the collimators installed except for 1 TCLA in each of the insertions.

The next steps towards a complete ring V3.1 are to adapt the IP displacement scheme to match the IPs of FCC-ee and FCC-hh with the 16-dipole arc cells, finish matching dispersion suppressors for PB, and finally merge with the shortened PB (to be provided by Wolfgang).

Andrey comments it may be necessary to also include space for collimators around Q11. **Gustavo** answers that this should be a simple change with minimal effect on the geometry of the DS by redistributing the already reserved space at Q10 and Q8.

UPDATES ON THE FCC-HH COLLIMATION STUDIES (ANDREY ABRAMOV)

Collimation is one of the main challenges for the FCC-hh as the stored beam energy for the proton beams reaches 8.3 GJ. With respect to the last set of studies, the dogleg dipoles are now powered, there are dedicated optics in the injection and extraction insertions with their respective collimators, and β^*has been reduced from 55 cm to 30 cm. With these changes, optimizations of the collimation insertion settings have been investigated.

The DS collimator downstream of the betatron collimation must be adjusted. From the change from 50 cm to 30 cm β^* the inner triplets are the aperture bottlenecks at top energy, need to make sure IR aperture is protected and the tertiary collimators must be adjusted. Cold losses are above the estimated quench limit. Comparing the IR losses, for the CDR, cold losses remained around $10^{-7}\ \mathrm{m}^{-1}$, for the 2022 PA31 lattice, it reached a few $10^{-7}\ \mathrm{m}^{-1}$, for the current lattice the losses reach $10^{-5}\ \mathrm{m}^{-1}$. This is possibly an effect of the decreased β^*, but must be addressed.

Initial mitigation attempts are being performed. PD losses have been reduced to $10^{-6}\ \mathrm{m}^{-1}$ and PF losses have been reduced to $6 \times 10^{-6}\ \mathrm{m}^{-1}$ by closing PF secondary collimators, repositioning and closing TCLDs and opening TCTs.

Future work includes optimization of the locations of the TCLDs in PF to mitigate the DS loss cluster, resolve the issues with cold losses in the IRs and include the remainder of the CDR collimators in the model (injection protection collimators and physics debris absorbers).

Massimo pointed out that the nominal β^* is 30cm so it won’t be relaxed back to 55 cm. Also, with the planned swap of separation and recombination dipoles for superconducting magnets, more space will be made available to optimize collimator placement in the experimental insertions.

Minutes reported by Gustavo Pérez Segurana