Meeting Minutes of the
197th FCC-ee Accelerator Design Meeting
and 68th FCCIS WP2.2 Meeting

Indico: `https://indico.cern.ch/event/1476963/`
When: 12.11.2024 16:00-17:30 GVA time

Agenda

Presenter	Title
R. Soos	**Vertical Instability Study for FCC-ee (Z) Due to Beam-Beam in Presence of Transverse Wakefields**
K. André	**Review of Tapering for FCC-ee**

1 General information

F. Zimmermann opens the meeting. The minutes of the previous meeting are approved without further comments.

X. Buffat shares an update from simulations performed by him and **Y. Zhang**. Despite using identical configurations, differences were observed when including only longitudinal wakefields. He suspects they have started with different initial vertical emittance, it needs to be confirmed. Independently of the X-Z instabilities, he emphasizes the need to defined an equilibrium vertical emittance caused by machine errors and misalignments, rather than relying solely on “dynamic emittance" influenced by the placement of the vertical wigglers (creating the vertical lattice emittance).

X. Buffat questions what is the limit in finite positive chromaticity achievable with the GHC & LCC lattices. **K. Oide** answers that +5 chromaticity in both planes did not appear to be a limit, suggesting it could be pushed to +10. **K. André** reports that he has achieved +15 chromaticity in both plane with the LCC lattice at Z energy without degradation of Dynamic Aperture (DA) and Momentum Aperture (MA).

K. Oide proposes to implement nonlinear collimator(s) on the outgoing side of each IR as the possibility to enhance the collimation efficiency.

F. Zimmermann gives the objective of a first draft of the accelerator chapter of the FCC Feasibility Study Report (FSR) by the end of the year 2024. Details regarding the FSR outline and assignment of coordinators of section and subsection are discussed to streamline the drafting process.

2 Vertical Instability Study for FCC-ee (Z) Due to Beam-Beam in Presence of Transverse Wakefields

R. Soos presents beam-beam interactions studies with particle tracking and the Circulant Matrix Model (CMM) applied to FCC-ee at Z energy operation mode.

Discussions on virtual drift to implement the difference between beam-beam interactions at the Interaction Point (IP) or at the Collision Point (CP). A two particles model is used to understand the effects of the phase advance during beam-beam interactions, considering virtual drift, hourglass and crossing angle.

Virtual drifts and the hourglass have a significant effect on the stability in machines with high hourglass factor such as FCC-ee, CEPC and SuperKEKB (low beta design).

The circulant matrix model is able to reproduce results obtained with different models, showing it can reliably consider beam-beam effects with transverse impedance for FCC-ee. These results were confirmed with Xsuite. She highlights that the Crab sextupoles have an additional tune shift effect on top of the phase advance. The total tune shift is different, but the instability remains the same.

She presents ongoing chromaticity studies with CMM and Xsuite results. Chromaticity scans, including transverse wakefields, show a zero growth rate for chromaticity beyond +5 over 8000 turns.

Further studies will examine parameters like beam size and vertical tunes may be studied for FCC-ee at Z energy after extensive studies considering the virtual drifts and the hourglass effect.

R. Soos notes that the CMM neglects all nonlinearities, *e.g.* of beam-beam interactions and crab sextupoles, making direct comparison between CMM and particle tracking difficult but feasible.

F. Zimmermann asks if there are ideas to test at DAFNE. **X. Buffat** asks for beam parameters to explore possible studies.

M. Zobov asks if longitudinal wakefields were included. **R. Soos** answers that they were not included. **M. Zobov** adds that he was in contact with **Y. Zhang**, and instabilities persisted with $Q'_{x,y}$ =+5, suggesting exploration of higher chromaticities.

W. Hölfe questions whether detuning from the transverse feedback system has been considered to move the tune shift from beam-beam interactions in the opposite direction. **X. Buffat** answers that it has not yet been considered.

3 Review of Tapering for FCC-ee

K. André presents an overview of past tapering studies for FCC-ee, revisiting methods and findings from prior investigations.

- 2016 studies: based on a 100 km racetrack lattice with two RF sections and 175 GeV beam energy, tapering was averaged per arcs (divigind the lattice into 12 arcs). The maximum orbit excursion was about 300μm, and the beta and dispersion beating were re-adjusted to below 10% using free quadrupoles in dispersion suppressors and matching sections.
- 2021 studies: based on 120 GeV beam energy and conducted with pyAT, considering group of dipoles that were tapered differently:
  - **B1** (main arc dipoles at sextupole-free sections)
  - **B1L** (main arc dipoles at long sextupole sections)
  - **B1S** (main arc dipoles at short sextupole sections)
  - the other dipoles received individual tapering.

  Averaged tapering configurations tested with 50μm, 100μm and 200μm orbit tolerance. Results showed up to 15% beta beating and 30 cm dispersion error, but no optics re-matching was performed.
- **Tapering tools:** Implementations of tapering in MAD-X, SAD, and Xsuite perform individual scaling of the magnet strengths based on the local particle momentum on the closed orbit.

- **Trim coil proposal:** A solution from the FCC week 2021 featured trim coils for dipole tapering.

K. Oide emphasized the importance of the reference momentum setting, for multiple RF sections because several solutions exist. In case of a single RF section, defining the tapering relative to the center of the RF section ensure the optimal solution.

T. Raubenheimer suggests using small shunts as a potentially robust, albeit complex, alternative. **G. Roy** notes that shunts should be tuned for each energy mode. **K. Oide** wonders if this solution is feasible with twin aperture dipoles. **T. Raubenheimer** is unsure. **C. Carli** highlights similar challenges with trim power supplies.

C. Hernalsteens and **D. Domange** will look into the implementation of group tapering in Xsuite.

J. Gao mentions that the solution for CepC is based on two RF sections and trim coils implemented in dipole groups.

43 Participants:
K. André, A. Apyan, M. Bai, G. Broggi, X. Buffat, H. Burkhardt, P. Burrows, C. Carli, A. Chancé, A. Ciarma, B. Dalena, L. Deniau, D. Domange, J. Gao, C. Garcia, D. Gibellieri, C. Goffing, C. Hernalsteens, W. Hölfe, I. Karpov, J. Keintzel, P. Kicsiny, R. Kieffer, M. Koratzinos, E. Macchia, L. Mether, G. Nigrelli, A. Novokhatski, K. Oide, F. Peauger, T. Raubenheimer, L. Sabato, J. Salvesen, K. Skoufaris, R. Soos, R. Tomás, L. van Riesen-Haupt, R. Wanzenberg, J. Wenninger, S. Yue, C. Zannini, F. Zimmermann, and M. Zobov