Meeting Minutes of the
193^{rd} FCC-ee Accelerator Design Meeting and 64^{th} FCCIS WP2.2 Meeting

Indico: `https://indico.cern.ch/event/1461702/`
When: 09.10.2024 11:00-12:00 GVA time

Agenda

Presenter	Title
X. Buffat	**Update on scenario with 2-cell cavities at Z-pole**
K. Oide	**Optics with finite chromaticities**

1 General information

K. André opens the meeting. The minutes of the previous meeting are approved without any further comments.

F. Zimmermann asks about the effect of a higher synchrotron tune on the DA. **K. Oide** did not observe an impact on the DA/MA.

2 Update on scenario with 2-cell cavities at Z-pole

X. Buffat presents a new scenario for operation at the Z-pole, including 2-cell RF cavities and an increased RF voltage to 200 MV. Two solutions are proposed:

- **Proposal 1:** Increase the number of bunches (17200 vs. 11200) to maintain the beam-beam parameter around 0.1, similar to the nominal scenario.
- **Proposal 2:** Conserve the same number of bunches but allow a higher beam-beam parameter ($\xi_y =$ 0.122 vs. 0.098).

Both scenario results in a higher luminosity +5% and +18% respectively compared to the nominal scenario.

Discussion of proposal 1:

While proposal 1 increases the number of bunches, concerns arise regarding the electron cloud formation. Previous studies considering 15 ns bunch spacing have shown significant electron cloud build-up and multipacting in the quadrupoles, leading to potential instabilities. Specifically, this occurs at Secondary Electron Yield (SEY) of 1.

Regarding Transverse Mode Coupling Instabilities (TMCI) there are no noticeable differences in the vertical plane. The tune shift driven by the impedance is larger due to the shorter bunch length, but the synchrotron tune is larger too leading to TMCI occuring at the same intensity. In the horizontal plane, no TMCI are observed with the higher RF voltage scenario.

Discussion of proposal 2:

The second proposal, maintaining the bunch population and allowing larger beam-beam parameter seems more promising, although it would give rise to some microwave instability when considering 2.16e11 ppb and a higher RF voltage slightly affecting the energy spread without major issue noted.

Considering a higher RF voltage **X. Buffat** confirms **K. Oide**'s observations of a vertical blow-up because of a stronger beam-beam parameter. Strong-strong beam-beam simulations result in a horizontal tune space limited to 0.012, similar to the other options, which is compatible with **I. Karpov**'s findings of a synchrotron tune spread of 0.0025 in Reverse Phase Operation (RPO). Additional synchrotron tune spread and odd synchro-betatron resonance with longitudinal impedance still need further investigation. If more horizontal tune space is required, an increase of β_x^* could be beneficial.

Weak-strong beam-beam studies showed that area of good tunes (Q_x, Q_y) reduces with the larger beam-beam parameter. A potential mitigation could be to increase the vertical emittance by 25%, which would result in a similar luminosity and beam-beam parameter compared to the nominal "80 MV" configuration.

Regarding polarisation, the beneficial impact of the larger Q_s is partly compensated by the increase in momentum spread, the figure of merit $\nu_s \sigma_\delta / Q_s \approx 1.15$ instead of 1.3-1.4 in the current "80 MV" scenario.

K. Oide questions whether the electron cloud multipacting in the quadrupoles is indeed an issue, asking how severe it is and if it has been observed in operating lepton machine because as far as he knows no instabilities have been observed at SuperKEKB. **L. Sabato** responds that the stability threshold is inversely proportional to the length of the elements, and because the total length of quadrupoles is relatively short compared to the circumference, explaining why multipacting in the quadrupoles would lead to instabilities.

F. Zimmermann the second option featuring a higher RF voltage seems better, combined with a higher vertical emittance to alleviate some of the challenge posed by a higher beam-beam parameter. **X. Buffat** comments that the interplay between longitudinal impedance and beam-beam effects should be examined. He adds that an intermediate abort gap reduction could also help finding a compromised solution.

M. Zobov comments that the bunch population is another degree of freedom and could be reduced to manage the beam-beam tune shift, and other related parameters.

I. Karpov wonders if a shorter kicker rise time is feasible.

3 Optics with finite chromaticities

K. Oide presents an update of the GHC lattice with finite positive chromaticity $Q_x', Q_y' = [+5, +3]$ as a requested from the previous meeting to help mitigate collective effects. He used chromatic constraints to minimise the impact of the momentum spread on β^*, α^* and the phase advance during the sextupole optimization.

The Momentum Acceptance (MA) appears unchanged from previous optics configurations, but a larger vertical emittance blow-up and a shorter beam lifetime are observed. The cause of the reduced lifetime is unclear, perhaps due to the increased chromaticity, or other changes changes in the lattice.

The MA of the 200 MV configuration is slightly decreased. There is also a significant vertical emittance even assuming a larger vertical emittance at collision (2.9 pm.rad instead of 1.9 pm.rad) to preserve the nominal beam-beam parameter ($\xi_y \approx 0.1$). This poor beam-beam performance could be attributed to a larger energy spread (0.150% vs. 0.111%) as highlighted by **M. Zobov**. **K. Oide** suggests that fine-tuning of the working point might improve the situation but warns that a shorter abort gap might also be necessary for RPO.

He introduces a common optics design, at the Z and W operation modes, for the RF, collimation and injection/extraction straight sections that preserves the super-periodicity of the lattice. The horizontal separation of the two beams is modified to 70 cm instead of 35 cm. He requests that the optics for the injection.extraction and collimation should be examined to subsequently fine tune the optics design.

G. Roy asks if section-specific optimization could be beneficial. **K. Oide** answers that dedicated optics could be implemented, but this would require re-optimizing the sextupoles to recover the DA/MA. This common lattice optics design preserves the super-periodicity and does not require to re-optimize the sextupoles.

G.Broggi notes that the optics is similar to the current collimation optics, though the momentum collimation needs maximum dispersion with a small beta function to decouple betatron and momentum collimations.

I. Karpov questions the RF implementation in this common lattice/optics, noting that it only works with separated beam pipes. **K. Oide** confirms that this proposal is specifically designed for the Z and W operation modes. For the Zh operation mode, the lattice and optics will be modified, and the beam crossing at the center will be removed.

K. André asks about the choice of a 50% crab waist. **K. Oide** answers that it was previously optimized for maximum lifetime but might not be the optimal choice for this specific lattice.

The lattice and optics design are also adapted to accommodate the non-local solenoid compensation scheme (compensation solenoid and vertical dipoles). The downstream space following QC2R is extended to 15 m, and most quadrupoles except in the LSS are shortened from 2.9 m to 2.7 m.

35 Participants:
K. André, M. Boscolo, G. Broggi, Q. Bruant, O. Brunner, X. Buffat, H. Burkhardt, K. Cantun, B. Dalena, H. Damerau, L. Deniau, A. Djurdjevic, A. Frasca, C. Garcia, A. Ghribi, C. Goffing, S. Gorgi Zadeh, S. Jagabathuni, P. Janot, I. Karpov, J. Keintzel, R. Kieffer, M. Koratzinos, A. Korsun, M. Migliorati, K. Oide, F. Peauger, G. Roy, L. Sabato, J. Salvesen, K. Skoufaris, L. van Riesen-Haupt, C. Zannini, F. Zimmermann, and M. Zobov