Meeting Minutes of the
161st FCC-ee optics design meeting and 32nd FCCIS WP2.2 meeting

Indico: https://indico.cern.ch/event/1237189/
When: 19.01.2022 15:30-17:30 CET

Agenda

Presenter	Title
P. Raimondi	**Update on collider with local chromatic correction**
K. Oide	**Status of optics design**
K. André	**SR power deposition from injected beam**
F. Zimmermann	**Towards the FCC Midterm review**

1 General Information

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

He mentions that following the discussion from the last meeting, **M. Migliorati** has started to study the impact of the reduction of the beam-pip aperture on the transverse impedance. **M. Migliorati** comments that a reduction of the aperture around the ring will lead to an increase of the transverse impedance by 60 %. An aperture reduction only in the quadrupoles and sextupoles will lead to an increase due to two factors, the resistive wall contribution and the geometric contribution of the tapers, of about 25 %. It is noted that the aperture reduction will also affect the impedance of different devices, such as the BPMs. **M. Koratzinos** asks what the power loss due to resistive wall is. **M. Migliorati** replies that it is around 8 MW for a bunch length of 3.5 mm. **F. Zimmermann** notes that further discussion on the topic of a smaller beam-pipe aperture should take place.

F. Zimmermann mentions that the ICFA Beam Dynamics Newsletter will focus on "Challenges of future e^+e^- circular collider". Submission on studies on FCC-ee are encouraged, and it is noted that the deadline for submission is in one month from the time of the meeting, on Feb. 20th.

2 Update on collider with local chromatic correction

P. Raimondi presents an update on the collider design which was first presented at the FCCIS workshop the previous month. The previous cell layout, parameters and optics including the matching constraints are quickly summarized. Following iterations on the design have led to a cell with the length decreased from 480 m to 400 m, leading to an increase of the number of cells from 160 to 192. The strength of some

quadrupoles decreased to a point where they could be removed, the dipole length has been adjusted to decrease the emittance, and the position of the two quadrupoles around the symmetry point is optimized to reduce the second order chromaticity. In the previous design, the same layout for all operation modes was assumed, and next studies will look into adapting the arc cell layout to achieve a small emittance for the $t\bar{t}$ operation mode.

F. Zimmermann asks if the gradient in the dipole is required. **P. Raimondi** confirms, noting that this will impact the number of cells required to achieve a given emittance. **F. Zimmermann** mentions that this could increase the energy spread for the lower energy operation modes, thereby affect the polarization measurements. **P. Raimondi** comments that the gradient was chosen to achieve a partition number, and thereby energy spread close to the current one.

A. Bogomyakov asks if the tracking done to show the anharmonic properties is 4D or 6D. **P. Raimondi** replies that it is 4D tracking in MAD-8.

P. Raimondi recaps the conditions required from the straight sections, after which the updated design for the technical straight is shown. The final focus design has been further improved by optimizing the quadrupole layout to ease the optics matching, as well as adding octupoles to correct the 4^{th} order chromaticity.

A. Bogomyakov asks if the crab sextupoles are powered in the full tracking studies. **P. Raimondi** replies that for the time being, this is not the case.

P. Raimondi continues by showing the chromatic optics of the final focus system, noting that at the first image point, the vertical β-function increases significantly, making it a good location for a momentum collimator. A first parameter table is shown, noting that the same luminosity as in the current baseline can be achieved with a smaller current. The parameters were designed such that a beam-beam tune-shift below 0.14 is achieved. In the ensuing discussion, it is expressed that further optimization should see to increase the luminosity.

K. Oide comments that in the vertical emittance, the contribution from the solenoid should be taken into account. **D. Shatilov** adds that at the begin of the Study, it was decided to assume a minimal vertical emittance of 1 pm. This constraint should be revisited.

A. Bogomyakov comments that a similar design has been studied in the past, and is summarised in this paper.

P. Raimondi concludes by stating the next studies, among which are the reduction of the critical energy of the SR photons from the last dipoles upstream of the IP.

3 Status of optics design

K. Oide presents a status update of the baseline collider layout. The new layout has a slightly shorter circumference of 90.657 km, achieved by shortening the long straight sections. Other changes include a larger inter-beam distance, more space between the quadrupoles in the RF-section, and space for a polarimeter upstream of every IP. Future modifications include a vertical separation scheme in the crossing region of the technical straight section, and installing small dipoles in the gaps, which are present in lattices for Z and W. As presented in a previous meeting, the arc sextupoles are adjusted to optimize the lifetime. At the moment, the dynamic aperture does not meet the requirements. An updated parameter table for the new layout is presented, noting a slight decrease in the number of bunches, decreasing the luminosity.

D. Shatilov notes that the energy spread at Z with Beamstrahlung is currently larger than the energy acceptance of the machine, which should result in a small lifetime. **K. Oide** comments that currently it is 6×10^6 s for an acceptance of $\pm 0.9\%$. **P. Raimondi** also notes that the working point should be revisited given the large beam-beam tune spread.

M. Koratzinos comments that the current length of the crabsextupoles does not pose an issue, but the increased length is preferred to allow using simpler technology.

4 SR power deposition from injected beam

K. André presents an update on the SR background due to off-axis top-up injection. The design and location of the different SR masks around the IP is shown. An overview of the injection scheme and the chosen parameter is shown, noting that the injected bunch only carries a tenth of the charge of the stored beam. The location in phase space of the injected bunch centroid at a final focus quadrupole over 100 turns is shown, demonstrating that at the Z operation mode with a damping time of around 2400 turns, the whole space is covered. The linear SR power deposition from the injected bunch is shown for different transverse offsets. It is noted that at the maximum transverse offset of about 8.5 mm, the SR hits either the central beam pipe or the mask close to the last final focus quadrupole. In this case, the linear power deposition is around 4 kW/m at the mask. It is shown that a maximum orbit offset of 6.5 mm, corresponding to settings of 4 $\sigma_{x,stored}$ and 3 $\sigma_{x,injected}$, leads to a negligible linear power deposition in the mask. The case for $t\bar{t}$ is quickly shown, where due to the different optics, the offset is smaller, which together with a faster damping time of 45 turns presents a less problematic situation.

5 Towards the FCC Midterm review

F. Zimmermann presents the goals of the FCC midterm review and required next steps. Proposed by the CERN management and confirmed by the CERN Council, a mid term review, coupled with a cost review, will take place mid 2023. A second review will take place in 2025. A number of deliverables is outlined, including a consolidated layout, a comparative study between the SPS as a prebooster compared to a 20 GeV linac, and different operation schedules. The timeline and important milestones is given, noting the presentation of major parts of the deliverables at the FCC-Week in June, and the delivery of the documents by mid September 2023.

Follow-up items

TASK
Estimate deposited SR energy for injected beam

45 Participants:
A. Abramov, K. André, J. Bauche, M. Behtouei, A. Bogomyagkov, M. Boland, M. Boscolo, H. Burkhardt, P. Burrows, E. Carideo, A. Chancé, B. Dalena, Y. Dutheil, C. Eriksson, O. Etisken, A. Faus-Golfe, C. Garcia, A. Ghribi, B. Härer, M. Hofer, X. Huang, P. Janot, I. Karpov, R. Kersevan, A. Lechner, M. Migliorati, E. Montbarbon, A. Novokhatski, K. Oide, S. Ozdemir, P. Raimondi, A. Rajabi, R. Ramjiawan, M. Reissig, U. van Rienen, L. van Riesen-Haupt, L. von Freeden, L. Sabato, D. Shatilov, M. Sullivan, R. Tomás, R. Wanzenberg, F. Yaman, Z. Zhang, and F. Zimmermann