Meeting Minutes of the
183rd FCC-ee optics design meeting and 54th FCCIS WP2.2 meeting

Indico: `https://indico.cern.ch/event/1404486/`
When: 11.04.2024 15:00-16:30 GVA time

Agenda

Presenter	Title
F. Zimmermann	**Update on booster vacuum system, operation mode and polarisation time estimate in the damping ring**
K. André	**Dynamic aperture studies with Xsuite**
V. Gawas	**Luminosity optimization and tuning**

1 General information

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

F. Zimmermann informs that discussions have taken place between **X. Buffat** and **K. Ohmi** regarding the **K. Ohmi**'s newly developed PIC code. It appears feasible to use it on CERN cluster/GPU, and it will be possible to benchmark against Xsuite once the beam-beam PIC module will be ready.

H. Damerau updates on the ongoing discussions regarding he modification of the FCC circumference, considering technical and optics design point of views. There are concerns about changing the RF frequency for the whole injector complex, but over a timescale of 70+ years, adjustments/refurbishment would likely be needed anyways. **H. Damerau** argues that we should not exclude using LHC for FCC in the future as a consequence it is easier to change the FCC RF frequency than its circumference.

There's a concern raised about the impact of modifying the RF frequency on the FCC-ee injector S-band linac R&D (cavities and klystrons). However, **M. Boland** remarks that such changes have been manageable in their experience, citing an example of RF frequency change from 2.8 GHz to 3.0 GHz without significant impact on R&D.

The FCC-ee Accelerator Technical Design Committee (ATDC) will alternate with the Optics Design Meeting, which will now be called Accelerator Design Meeting (ADM), held every other week. **J. Wenninger** will co-chair the ADM.

The participants list for the FCC week 2024 is mostly finalized, along with the program.

2 Update on booster vacuum system, operation mode and polarisation time estimate in the damping ring

F. Zimmermann proposes, based on FCC-ee "booster day", using a copper vacuum chamber with a thickness of 1 to 1.5 mm and an inner radius of 30 mm without NEG coating nor in-situ bake-out. Additionally, he proposes reducing the number of bunches per cycle to 1120, resulting in 10 cycles for full injection, which would take about 35 s. This would allow reducing the pressure tolerance in the booster to 30 nTorr in contrast to the current 1 nToor estimate with a single cycle injecting 11200 bunches. Still it is not clear if 30 nTorr is feasible without NEG coating nor in-situ bake-out.

F. Carra raises concern about whether a 1 to 1.5 mm beam pipe would mechanically resist the pressure. **C. Carli** asks if eddy currents and impedance have been considered. **F. Zimmermann** answers that it needs to be investigated.

A. Lechner adds that 10 injections might take too long considering the total booster cycling time for top-up injection in the collider. 5 injections might be the maximum, pending confirmation from **A. Chancé**.

Pre-polarized beams in the damping ring could potentially save 1 to 2 hours each time the collider is filled from scratch after an abort. He estimates the polarization time using the alternative injector layout with a 427 m circumference damping ring, at 2.86 GeV, and additional parameters for the wigglers, resulting in about 4 minutes.

K. Oide comments that the polarization time is too long and would require two damping rings if one needs to top-up one beam every 30 s. **F. Zimmermann** suggests adapting the wigglers to reduce the polarization time to a fraction of a minute.

3 Dynamic aperture studies with Xsuite

K. André presents Dynamic Aperture (DA) studies performed with Xsuite employing a bisection method to reduce the number of macroparticles tracked thus accelerating the computation to determine the DA limit or chaotic region.

The objective was to replicate **K. Oide**'s DA studies (performed with SAD) without tracking a grid of tens of thousands of macroparticles, which is computationally intensive. By increasing the number of macroparticles tracked at the DA limit, more data points across multiple phases can be averaged.

The bisection method enables faster DA computation, facilitating large parameter search optimization and allowing for DA tests on the GitLab repository when lattice changes are made.

There is a good agreement between DA results with Xsuite and SAD tracking codes for the LCC lattice and crab waist at 0% (turned off), for Z and $t\bar{t}$ energy modes.

K. Oide mentions having only synchrotron radiation damping implemented when performing DA studies on a single seed. **K.André** agrees to do the same and remove the quantum fluctuation.

C. Carli and **F.Zimmermann** comment on the incorrect definition of the action. **K.André** answers he will look into it.

Regarding DA results for the LCC lattice, including crab waist, SAD provides lower on- and off-energy DA than Xsuite. The discrepancy could be due to improper setting of parameters/variables in SAD (*e.g.* "cs_comp" for correcting the DA deterioration of the crab sextupoles).

Considering the GHC lattice, only DA studies with crab sextupoles turned on have been compared, showing good agreement. However, Xsuite shows a smaller transverse acceptance compared to SAD across the range of energy deviation, possibly due to the quantum fluctuation included in the model.

A next step will be to compare the DA and Momentum Aperture (MA) computed with Xsuite with the results from pyAT.

4 Luminosity optimization and tuning

V. Gawas presents evaluations of the beamstrahlung signal for luminosity optimization and tuning.

She discusses various tolerances impacting the IP spot size, such as vertical waist shift and vertical dispersion, utilizing GUINEA-PIG for her studies.

Initially, she compares the impact of vertical waist shifts for the Z and $t\bar{t}$ energy modes, observing a non-monotonic behavior of the beamstrahlung energy spectrum and angular distribution as well as the luminosity at the Z energy. However, at the $t\bar{t}$ energy, the three observables seem to be monotonic with the evolution of the vertical waist shift.

F. Zimmermann suggests investigating both positive and negative waist shifts and confirming the direction of the shift.

M. Koratzinos suggests looking for the inflexion point of this non-monotonic behavior.

Similar conclusions apply for a vertical dispersion applied on the electron beam, with the Z energy exhibiting a non-monotonic behavior and the $t\bar{t}$ energy, showing a monotonic influence of the vertical dispersion on the three observables, with smaller variations in luminosity.

The impact of vertical waist shifts on beamstrahlung power is also compared, showing significant changes at Z energy but much less variation at $t\bar{t}$ energy. Modifying the vertical dispersion has little effect on the beamstrahlung power at both Z and $t\bar{t}$ energies.

In conclusion, beamstrahlung signals (power, energy spectrum, and angular distribution) have been studied at Z and $t\bar{t}$ energies, including vertical waist shift or vertical dispersion at the IP. The impact on luminosity has also been investigated. Future work will involve additional effects such as skew coupling and combining these effects. The long-term objective is to develop a Machine Learning framework combining these signals.

A. Lechner notes that the beamstrahlung power was higher in presentations from last year, *c.f.* **A. Ciarma**'s presentation. **V. Gawas** confirms that using the mid-term beam parameters resulted in a decrease in beamstrahlung power.

47 Participants:
K. André, A. Apyan, H. Bartosik, M. Boland, R. Bruce, Q. Bruant, X. Buffat, P. Burrows, R. Calaga, C. Carli, F. Carlier, F. Carra, A. Chancé, A. Ciarma, B. Dalena, H. Damerau, V. Gawas, A. Ghribi, K. Hanke, C. Hernalsteens, B. Humann, S. Jagabathuni, I. Karpov, R. Kieffer, M. Koratzinos, T. Lefevre, A. Lechner, R. Losito, N. Mirian, A. Novokhatski, K. Ohmi, K. Oide, A. Piccini, L. Rivkin, L. Sabato, F. Saeidi, J. Salvesen, G. Simon, A. Thabuis, A. Vanel, U. van Rienen, R. Wanzenberg, F. Yaman, S. Yue, Z. Zhang, F. Zimmermann, and M. Zobov