Meeting Minutes of the
186th FCC-ee accelerator design meeting
and 57th FCCIS WP2.2 meeting

Indico: https://indico.cern.ch/event/1416849/
When: 29.05.2024 16:00-17:30 GVA time

Agenda

Presenter	Title
L. Sabato	**Status of electron cloud studies**
K. Oide	**Update on GHC lattice**

1 General information

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

F. Zimmermann reports on the FCC week registration status with a big turnouts from the US. He comments on the program, the chairpersons and the posters.

2 Status of electron cloud studies

L. Sabato presents the status of the electron cloud studies at the Z energy (highest number of bunches & smallest bunch spacing) featuring the midterm report parameters.

He presents two potential filling schemes:

- 20 ns bunch spacing and 40 trains of 280 bunches
- 25 ns bunch spacing and 20 trains of 560 bunches

The latter scheme highlights the largest Secondary Electron Yield (SEY) multipacting thresholds. Quadrupoles and sextupoles are identified as the most critical elements from the electron cloud perspective. Additionally, bunch intensities of 1×011 and 1.5×10^{11} (subnominal) have the lowest SEY multipacting thresholds.

Electron cloud studies are ongoing including nested magnets, High Temperature Superconductor (HTS) in short straight section, and combined function magnets providing and alternative optics and lattice designs.

The heat load from electron cloud is estimated to range from 5 to 7% of the synchrotron radiation power per beam for filling schemes 1 and 2 respectively considering multipacting, with dipoles being the main contributors. Without multipacting, the total heat load is negligible (<200 W).

He then discusses the electron cloud instability threshold, in drift sections an electron density higher than $1.0 \times 10^{11}\,\mathrm{e^-/m^3}$ results in an unstable transverse motion. The central electron density is higher than the instability threshold above the SEY multipacting threshold, leading to beam instabilities.

In dipoles, instability threshold arises beyond $5.0 \times 10^{10}\,\mathrm{e^-/m^3}$ which is again exceeded above the SEY multipacting threshold for all bunch intensities and both filling schemes. The same conclusion applies to the quadrupoles. In sextupoles, the central electron cloud density before the bunch passage is smaller than the electron cloud instability threshold even with multipacting most likely due to the element length dependence.

Photoemission from the vacuum chamber due to the synchrotron radiation emitted by the beam is also considered, which can lead to higher central electron cloud density and quicker saturation. The central electron cloud density before the bunch passage could exceed the instability threshold even below the SEY multipacting threshold, setting an upper limit for the number of photoelectrons generated per beam particle ($<1 \times 10^{-4}\,\mathrm{cm^{-1}}$). Based on results from **R. Kersevan** a photon flux ranging from 1×10^{13} to $1 \times 10^{14}\,\mathrm{photons/cm^2s}$ is expected. To comply with the upper limit of photoelectrons generated per beam particle, the photoelectron yield should be 3×10^{-3}.

In conclusion there are extremely tight material constraints to avoid multipacting with the baseline beam parameters. Bunch intensities in the range of 1/10th of the nominal intensity to the nominal intensity are the most critical from the SEY threshold. SEY multipacting thresholds are better considering larger bunch spacing, and electron cloud avalanche multiplication could lead to additional heat loads in the order of some percent of synchrotron radiation power. Electron cloud could lead to transverse beam instabilities and the beam would be unstable in all the studied elements, except sextupoles, above the SEY multipacting thresholds. Furthermore considering the additional contribution of the photoemission on the electron cloud formation process, the beam could be unstable even below the SEY multipacting threshold. Methods to mitigate electron cloud instabilities (increase the bunch spacing, feedback systems, chromaticity) should be investigated.

F. Zimmermann comments that a saw-tooth pattern on the beam pipe is under study to mitigate photoemission.

M. Zobov asks is coupled multi bunch instabilities in addition to single bunch instabilities are expected. **L. Sabato** replies that the constraints are already very tight with single bunch instabilities. 50is ok if TMCI is ok to be confirmed. **F. Zimmermann** adds that **C. Carli** suggests an alternative filling scheme to be looked at. **K. Oide** comments that for higher bunch intensity the beam lifetime drops to about 1 min.

X. Buffat comments that the results depend on the electron cloud model used. **L. Sabato** answers that he could compare both models and choose the most conservative. **F. Yaman** comments that he oberseved thaty the Furman-Pivi model is the most pessimistic.

X. Buffat wonders if change the RF frequency to change the synchrotron tune is a possibility, one should aim to run without multipacting and a positive chromaticity should also be investigated.

3 Update on GHC lattice

K. Oide presents the status of the GHC lattice. The sextupole length has reverted to 1.3 m with a maximum strength of $860\,\mathrm{T\,m^{-2}}$ at $t\bar{t}$ energy.

The momentum acceptance at Z is larger than 1%, approximately 1.05%, which is limited by the RF voltage, meeting the requirement for top-up injection. Although some progress on DA/MA is expected, the beam lifetime is already satisfactory.

F. Zimmermann asks about the status of the beam lifetime discrepancy between SAD and Xsuite. **X. Buf-**

fat answers that it has been narrowed down to the quantum lifetime (synchrotron radiation + lattice) in Xsuite and is not due to beam-beam interactions or beamstrahlung. The issue may originate from the wigglers used to create the vertical emittance or from the arcs. **H. Burkhardt** adds that analytical formula should be accurate for comparison with simulations and anticipates more significant discrepancies at higher energy. **C. Carli** asks about the accuracy of the equilibrium emittance and damping times. **X. Buffat** explains that there is a mismatch between matrix and tracking in Xsuite, suggesting an issue in the matrix definition. A test on a simple FODO ring is planned. **F. Zimmermann** suggests checking the synchrotron radiation photon spectrum in Xsuite.

K. Oide mentions that RF transparency with only one RF station has been checked, and the objective is to add the other insertions as soon as possible.

The lattices in SAD and MADX formats have been uploaded to the indico page.

47 Participants:
K. André, A. Apyan, A. Asif, M. Boland, R. Bruce, Q. Bruant, X. Buffat, H. Burkhardt, C. Carli, F. Carlier, A. Ciarma, B. Dalena, L. Deniau, C. Eriksson, K. Furukawa, V. Gawas, C. Goffing, E. Howling, B. Humann, S. Jagabathuni, P. Janot, I. Karpov, J. Keintzel, R. Kersevan, P. Kicsiny, R. Kieffer, M. Koratzinos, A. Lechner, C. Li, S. Liuzzo, L. Mether, M. Migliorati, K. Oide, F. Peauger, T. Pieloni, G. Roy, L. Sabato, B. Salvachua Ferrando, G. Simon, R. Tomás, A. Vanel, L. von Freeden, F. Yaman, S. Yue, Z. Zhang, F. Zimmermann, and M. Zobov