Meeting Minutes of the
159th FCC-ee optics design meeting and 30th FCCIS WP2.2 meeting

Indico: `https://indico.cern.ch/event/1205924/`
When: 10.11.2022 15:00-18:00 CET

Agenda

Presenter	Title
L. Sabato	**E-cloud studies in the FCC-ee**
F. Yaman	**Updates on the Electron Cloud Build-up Results for the FCC-ee**
L. Baudin	**Possible booster/collider arc configuration and support at different operation modes**

1 General Information

F. Zimmermann opens the meeting. The minutes from the last meeting are approved with no further comments. **F. Zimmermann** briefly summarizes the upcoming workshops. He also presents some quick updates from the RF-group. Compared to the previous parameter tables, the RF voltage of the 400 MHz cavities at the $t\bar{t}$ operation mode was adjusted.

D. Shatilov asks if the presented voltage is per beam or for both beams. **F. Zimmermann** replies that the numbers for H and $t\bar{t}$ mode are for both beams.

After further discussions, the number of cryomodules has been increased by 10 % to provide some operational margin. It was recently proposed to put all RF-cavities in one straight section also in the $t\bar{t}$ operation mode, with the booster RF in another straight section. First integration studies indicate that this solution seems feasible, however some iterations on the placement of the booster RF are required.

There has been a request to further shorten the circumference of the tunnel by a few 100 m to allow for a better placement of the surface sites. Based on the constraint that both SPS and LHC could be used as injector for the FCC-hh, the RF-group has found three solutions with a shorter circumference, the preferred one with a tunnel length of 90.83 km. Further validation are required before a new tunnel baseline will be put forward.

O. Etisken introduces **S. Ozdemir**, a new master student working on e-cloud studies for the pre-booster ring.

2 E-cloud studies in the FCC-ee

L. Sabato presents studies on the impact of different parameters on the e-cloud formation. This will later be used as input to studies on the beam stability in the presence of e-cloud formation, which due to their significant computational load can only be performed with a limited number of variables. All studies have been performed for the Z-operation mode. A brief overview of how e-cloud build-up occurs in an accelerator and main variables is presented. In the following, the impact of varying one of these parameters on the electron density after reaching a steady state is presented. It is found that the electron density in the defocusing quadrupoles is similar to the one in the focusing quadrupole, and similar so, the density in the dipoles does not depend on their location in the FODO-cell. The height of the antechamber is also shown to have also a negligible effect. As expected, it is found that increasing the bunch spacing reduces the electron density significantly, with the impact larger in the drift space and the dipoles. It is also found in simulation that in the electron ring, the density is much lower than in the positron ring.

K. Oide asks which energy spread has been used. **L. Sabato** replies that both the bunch length and energy spread including beamstrahlung have been used.

D. Shatilov asks why in the dipoles the electron density decreases with increasing bunch intensity. **L. Sabato** replies that this due to the intensity affecting the acceleration of the electrons, the multipacting is affected, as seen also in the LHC.

P. Raimondi notes that due to the bootstrapping, the range of studied bunch intensities should go from one tenth up to the full bunch intensity.

F. Zimmermann asks what happens if the winglet depth is reduced. **M. Koratzinos** adds that the vacuum group now considers a total width of 115 mm, down from the previous 120 mm. **L. Sabato** replies that this can be checked.

P. Raimondi asks how much power is lost by the beam as this might impact on the energy calibration studies. **L. Sabato** replies that this number can be checked.

K. Oide comments that also the region around the interaction point could be checked, in particular the heat-load.

3 Updates on the Electron Cloud Build-up Results for the FCC-ee

F. Yaman presents an update on the e-cloud build-up studies. As was the case also for the previous presentation, results are presented for the Z operation mode. In these studies, both the ECLOUD and Furman-Pivi model are compared, together with different SEY rates, photo-electron generation rates, different bunch spacing and beam pipe radii. Both models show similar behaviour in the dipole and drift region for both $SEY = 0$ and $SEY = 1.1$. For both models, results are then presented for SEY between 1.1 and 1.4 and for a beam pipe radius of 30 mm and 35 mm. The average electron density between the passing bunches is then presented as a function of the SEY and for a photo-electron generation rate of either 10^{-3} or 10^{-4}. A discrepancy between the two models is observed. It is also noted that for the higher photo-electron generation rate, the Furman-Pivi yields electron densities above the critical threshold. For photo-electron generation rates of 10^{-4} or below, both the ECLOUD and Furman-Pivi model find electron densities below the critical one in both dipoles and drifts. Next steps include simulations with measured SEY data and wake & impedance calculations due to e-cloud.

D. Shatilov asks if the dependence on the bunch length has been studied. **F. Yaman** replies that no noticeable change has been observed when changing the bunch length. **M. Zobov** notes that at DAFNE, in simulation no significant change has been observed either. However, the heat-load increases when using shorter bunch, resulting in more outgassing and worse vacuum conditions. He asks if the 25 ns bunch spacing is fixed. **F. Zimmermann** that for the time being, a range from 15 ns to 35 ns is considered, with 25 ns being the baseline.

4 Possible booster/collider arc configuration and support at different operation modes

L. Baudin presents on different installation configurations for the FCC-ee and booster in the tunnel. The current schemes for the arcs of the booster and collider is presented, noting the installation of additional quadrupoles and sextupoles in the collider after the W operation mode. It is proposed that in the collider, rather than using three different dipoles lengths, only one dipole length is used, and where necessary, additional mini dipoles will be installed on the same girder as the quadrupoles. This allows to keep the bending as is in the current design while simplifying the production. Moreover, different ways of supporting the booster ring over the collider are shown. The preferred solution is installing the booster on a t-shaped support, requiring a radial offset to the collider of about 40 - 50 cm. Similar so, it is considered to lower the booster ring and therefore the minimum vertical separation between the booster and collider has to be considered. Last, the question is raised if the booster quadrupoles and collider dipoles have to be on top of each other or if an azimuthal shift can be tolerated.

B. Dalena comments that the request to have the collider and booster quadrupoles on top of each other came from integration studies, in order to simplify cabling. It is also for this reason that the booster and collider use the same cell length. **F. Carra** comments that a small azimuthal shift should not complicate cabling too much. **F. Zimmermann** notes that from the optics point, the azimuthal shift should be ok, but might need cross checks with the integration group.

F. Zimmermann comments that the radial shift of the booster will affect the circumference. **B. Dalena** replies that this could be recouped by the experimental bypass. **F. Zimmermann** replies that then the radial shift should cause no issues. A difference in circumference could complicate the synchronization between the booster and collier and should be avoided if possible.

M. Koratzinos asks if the radial shift will complicate the access for installation and maintenance. **L. Baudin** replies that the booster could be accessed from the other side, but benefits and downsides of each solution will have to be checked with all groups. At this point, discussion mainly focuses on identifying the limitation.

Follow-up items

TASK
Check electron densities for bunch intensities ranging from one tenth to the full bunch intensity

39 Participants:
A. Abramov, I. Agapov, K. André, L. Baudin, M. Boscolo, K. Cantun, F. Carra, Y.-C. Chae, A. Chancé, A. Ciarma, B. Dalena, F. Francesini, K. Hanke, M. Hofer, P. Hunchak, J. Keintzel, R. Kersevan, M. Koratzinos, A. Krainer, C. Li, L. Mether, M. Migliorati, K. Oide, S. Ozdemir, T. Pieloni, P. Raimondi, A. Rajabi, R. Ramjiawan, T. Raubenheimer, M. Reissig, U. van Rienen, L. van Riesen-Haupt, G. Schiwietz, D. Shatilov, G. Simon, A. Vanel, F. Yaman, F. Zimmermann, and M. Zobov