Meeting Minutes of the
139th FCC-ee optics design meeting and 10th FCCIS WP2.2 meeting

Indico: `https://indico.cern.ch/event/1033215/`
When: 20.05.2021 14:30-16:00 CET

Agenda

Presenter	Title
E. Carideo	**Collective Effects for single-beam in FCC-ee**
J. Keintzel	**Impact of bunch currents on optics measurements in SuperKEKB**

1 General information

Note that the first presentation and discussion thereafter was part of an ABP-CEI section meeting. The second presentation was then presented as part of the regular FCC-ee optics design meeting.
F. Zimmermann announces that **Y. Dutheil** is joining the FCC-ee project and working on the injection into the collider ring.

2 Collective Effects for single-beam in FCC-ee

E. Carideo presents studies on longitudinal and transverse single beam instabilities in FCC-ee. First, the FCC-ee project and the parameters for the different operational scenarios are described. Studies focus on the lowest energy scenario with a beam energy of 45.6 GeV, which due to the largest beam current and number of bunches is considered the most critical case. Two configuration are looked into, one where energy spread and bunch length taking into account only synchrotron radiation and one where also the effect of beamstrahlung are considered. Given the large circumference of the ring, the resistive wall (RW) impedance is the main source of wakefields in the FCC-ee. A 100 nm thick NEG coating is assumed for the copper beam pipe. The power loss for a 12.1 mm long bunch is mainly dominated by the RW component and the bellows, with the next largest component already a factor 3 lower. Wake potentials of various components are compared for different codes and good agreement between the software tools is observed. In simulations using the presented impedance model, a distortion of the longitudinal bunch distribution from the original Gaussian shape is observed. Bunch length and RMS energy spread for a bunch population up to $6 \cdot 10^{11}$ are presented, for the case with and without beamstrahlung, noting that the effect helps mitigating the microwave instability. It is observed that the effect of the transverse impedance on either bunch length and RMS energy spread is negligible. For the transverse mode coupling instabilities (TMCI), two approaches are compared, one using the tracking code PyHEADTAIL and the other using the Vlasov solver DELPHI. Both agree well with each other and showing the merging of mode 0 and -1 at a bunch intensity of around $3 \cdot 10^{11}$. Including the longitudinal RW component lowers the threshold to around $2 \cdot 10^{11}$.

R. Kersevan notes that a 100 nm thick NEG coating may not be realistic and rather a thickness between $150 - 200$ nm should be used instead. **E. Carideo** points to studies by **E. Belli** which show that the impact of 200 nm thick coating is noticeable but not critical. **M. Migliorati** adds that the impedance model is still work in progress and that the focus currently is to establish the tools which can take all effects into account, then followed by discussion with the hardware groups and a refinement of model. **M. Zobov** comments that already with 200 nm thick coating, the threshold is close to the nominal intensity.

G. Rumolo asks if the bellows will be shielded. **R. Kersevan** replies that design may follow the one from SKEKB, and will be optimised in terms of impedance. **M. Migliorati** adds that the SKEKB bellows design is used in the model, however winglets are not taken into account.

G. Rumolo asks if slicing of the bunch in PyHEADTAIL is comparable to the 0.4 mm used to obtain the wake potential, which is then convoluted with the nominal bunch length. **E. Carideo** replies that 500 or more slices are used, which taking into account 6 σ_z is of the same order as the 0.4 mm.

D. Shatilov asks if for the studies on TMCI, the change of the bunch length with increasing bunch population is taken into account. **M. Migliorati** replies that these PyHEADTAIL studies should be self consistent studies and for the case of both transverse and longitudinal wakes, this should be accounted for. **D. Shatilov** inquires if this also takes into account beamstrahlung. **M. Migliorati** replies that this is not the case.

3 Impact of bunch currents on optics measurements in SuperKEKB

In **J. Keintzel**'s presentation, the impact of varying bunch currents on optics measurements in SuperKEKB are discussed. Measurements were taken in the low energy ring during one shift in February, exciting the beam horizontally using the injection kicker and with bunch currents in a range from 0.2 mA to 1.2 mA. In the following, the kick factors for the collimators from the model are summarised, which together with the charge give the kick strength of these elements. It is found that the damping time is shorter than expected and it is assumed that there is additional damping from a head-tail effect. The BPM resolution is presented for different bunch currents and the best resolution of 200 μm is found at the highest bunch current of 1.25 mA. The dipolar and quadrupolar contributions from the collimators give rise to an intensity dependant tune, with the measurements showing good agreement with the model in both planes. Using the change of the phase advances with bunch current and a response matrix, two strong impedance sources are identified.

F. Zimmermann notes that the optics may not be stable due to e.g. temperature changes with the different bunch currents. He asks if the two collimators found are expected to be the largest impedance sources. Looking at the model values, **J. Keintzel** concludes that this is indeed the case.

M. Zobov asks if there are also tune measurements for different multi bunch currents available. **J. Keintzel** replies that this is not the case. **M. Zobov** further inquires if lattice nonlinearities are accounted for in the decoherence time. **K. Oide** replies that these should be negligible.

T. Lefevre notes that the quoted BPM resolution of 200 μm appears quite poor. **J. Keintzel** explains that these values are obtained by taking the BPM data, using SVD, the 20 strongest modes are identified and subtracted from the raw signal and the RMS of the residual is then presented. **T. Lefevre** notes that this then may also include other effects. For the case of the LHC, in TbT mode a resolution of 50 μm is expected. **F. Zimmermann** replies that this then should be seen as the noise in the BPM readings rather than the resolution, including also effects coming from the beam and not just the BPM hardware. **J. Keintzel** adds that in the available literature, only the resolution in the averaging mode is given and not the TbT resolution.

K. Oide notes that the noise on the measurements seems to saturate at around 200 μm.

After the meeting, **R. Wanzenberg** points out that there is an IPAC paper from 2011 on similar studies done in PETRA III.

Follow-up items

TASK
Update impedance model to use 200 nm thick NEG coating
Compare BPM resolution/noise on the readings for different machines

31 Participants:
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