Meeting Minutes of the
137th FCC-ee optics design meeting and 8th FCCIS WP2.2 meeting

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When: 23.04.2021 9:00-11:00 CET

Agenda

Presenter	Title
F. Zimmermann	**Brief Report from the FCC-ee Injector and SRF Review**
R. Yang	**SuperKEKB status & near-term plans**
D. Shatilov	**Parameters for 45/45 arc lattice at W**

1 General information

F. Zimmermann opens the meeting by announcing that starting sometime mid May, the meeting slot will be moved to allow colleagues from the US to join. Most likely, future meetings will take place on Thursdays, starting at 14:30 CET. **B. Dalena** introduces **H. de Grandsaignes d'Hauterives**, a new PhD student at CEA Paris-Saclay working on the FCC-ee HEB.

2 Brief Report from the FCC-ee Injector and SRF Review

F. Zimmermann presents a quick summary of both the FCC-ee injector review and the FCC-ee SRF review, which took place on April 19th and 20th, respectively. The summary only includes slides presented there and personal impressions, with the full report from the reviewers expected in the 2nd half of May.

In the injector review particular focus was put on reviewing the pre-injector layout, linac operations mode, positron production, and pre-injector operation for the top-up injection. Compared to the CDR, the pre-injector layout was simplified, with each linac now operating only with one beam energy. In addition, the higher electron beam energy at the target allows for a higher positron yield.

A. Faus-Golfe adds that as was noted by one reviewer, coherent synchrotron radiation (CSR) for the long transport line (TL) should be checked. **F. Zimmermann** agrees and notes that CSR was studied in the past by **T. Charles** for the CDR and optimized. **T. Charles** comments that due to the long bunch length, in her opinion CSR shouldn't be too problematic. **A. Faus-Golfe** replies that while the situation at 1.5 GeV is more relaxed, the higher energy of 6 GeV may come with more problems. Additionally, emittance blow-up in the TL has to be investigated. **F. Zimmermann** agrees and adds that for the location of the damping ring (DR) there is a trade-off between positron losses between the first linac to the damping ring and the emittance blow-up between the DR and the second linac.

Further topics are the number of bunches per linac pulse and a comparison between the lifetime in the

collider and the filling time for different scenarios, which even in the worst case and for the more stringent 4IP case feature a safety margin of a factor 2. One last key topic is the use of a 20 GeV linac over the SPS PBR, as in the case of the latter, the operation as PBR would only allow for limited beam for studies of other users.

In the SRF review meeting, the choice of the RF frequency range in both the collider and the booster are reviewed, as well as technological solutions and cavity design, together with the overall R&D strategy and time scale. In the CDR baseline, the RF frequency is initially 400 MHz and doubled for the later $t\bar{t}$ operation. The frequency was chosen as it also already used in the LHC and planned for the FCC-hh. An alternative was recently proposed, using a Slotted Waveguide Elliptical (SWELL) cavity with either 600 MHz or 650 MHz, with the use of a conventional elliptical cavity with the same frequency as fallback option, which is also planned to be used in the EIC.

K. Oide asks why more cells are required when using 600 MHz instead of 400 MHz. **F. Zimmermann** replies that he does not know the exact reasons, but assumes it could be related to the reduced power per cavity.

A. Blondel asks if the change of the cavities could pose issues with polarization. **K. Oide** replies that issues with polarization at higher harmonics could occur and have to be assessed. **F. Zimmermann** remarks that with the higher harmonics, the synchrotron frequency distribution will also change and should be studied.

A. Abramov asks if with the multiple options discussed now, which option should be used in currently planned studies. **F. Zimmermann** replies that this will depend on the outcome of the review, but for the moment, the frequency and hardware design could be decoupled. Ideally, if studies show no issues with either 600 MHz or 650 MHz, the baseline could be changed in summer, otherwise the CDR solution will be kept. **A. Abramov** remarks that some tracking codes planned to be used for the collimation studies require a detailed modeling of the RF-cavities, as such this choice might impact these studies. **F. Zimmermann** adds also the proposed change of layout and optics will affect these studies. As a new baseline should be presented to the EU by Nov. 1st, the decision on these topics should come around June, ideally before the FCC-week. **G. Roy** comments that for the Project Breakdown Structure (PBS) and the optics repository, the CDR is used as reference and will be updated once more information is available.

3 SuperKEKB status & near-term plans

Following the setting of a luminosity world record at SKEKB, **R. Yang** presents an preliminary summary of the past operation period and some issues encountered. On April 15th, a peak luminosity in SKEKB of $2.83 \cdot 10^{34}\text{cm}^{-2}\text{s}^{-1}$ was achieved, and with an integrated luminosity of 1.6fb^{-1} per day. The current data taking period spans from Feb. 26th to Jul. 5th, with the currently delivered luminosity slightly behind the target. One goal of the current run is to increase the beam current from around 800 mA to 1.1 A, which would increase the peak luminosity to $3.8 \cdot 10^{34}\text{cm}^{-2}\text{s}^{-1}$. One of the issues encountered is a vertical emittance blow-up during collision which is suspected to stem from chromatic coupling and currently limits the luminosity performance.

F. Zimmermann asks why currently a β^* of 1 mm compared to the lower $\beta^* = 0.8$ mm achieved in the previous run is used and if this is linked either to the background in the detectors or the injection efficiency. **R. Yang** replies that this is mostly linked to the higher background in the experiments and the decision was taken to ensure safe operation. **K. Oide** adds that due to the loss in lifetime, there is no gain in integrated luminosity.

F. Zimmermann asks if he understood correctly that TMCI is not a limitation after the recent collimator change. **K. Oide** and **R. Yang** correct that it is a performance limitation.

F. Zimmermann asks what the target bunch current is for this run. **K. Oide** replies that the threshold is 1.6 A, but highly dependent on the tune, which oscillates, likely due to feed-down of the sextupoles. He adds that crosstalk between beam-beam and TMCI could also be factor in choosing a lower bunch current.

A. Faus-Golfe asks what are the reasons for investigating nonlinear collimation. **R. Yang** replies that this should reduce the impact of the collimators and help with the TMCI threshold. **K. Oide** adds that the optics design for this scheme is still ongoing, as not many locations are available for housing the skew sextupoles.

F. Zimmermann notes that the emittance blow-up is quite concerning. **K. Oide** adds that even without collision, the design beamsize is not reached.

4 Parameters for 45/45 arc lattice at W

As a follow-up to the presentation of a lattice with a larger momentum compaction factor at Z in the 133rd FCC-ee Optics Design Meeting & 4th FCCIS WP2.2 Meeting, **D. Shatilov** presents the impact of using the same cell phase advance of $45^\circ/45^\circ$ also during operation at W. Using this arc cell option would allow to keep only two designs ($45^\circ/45^\circ$ at Z and W, $90^\circ/90^\circ$ for ZH and $t\bar{t}$), reducing the complexity. Numbers presented are based on scaling as a such a lattice is not yet available and are presented both for the case of an RF-frequency of 400 MHz and 650 MHz. Going to the lower cell phase advance increase both horizontal and vertical emittance by a factor 2. To partly compensate the loss in luminosity, the number of particles per bunch is increased by more than a factor 2. In this new scenario, the luminosity per IP is reduced by roughly 12%.

K. Oide notes that he has not started working on these lattices, but that with the lower phase advance, the difference between the β-functions in the quadrupoles will decrease, which will have an impact on the chromaticity correction. The need for stronger sextupoles could then have an adverse effect on the dynamic aperture. **D. Shatilov** adds that in this design, the horizontal dispersion should be larger, partly offsetting this issue. **K. Oide** asks if the proposal from **B. Härer** in a previous meeting of creating a longer arc cell with a phase advance of $90^\circ/90^\circ$ by shunting one quadrupole could help. **D. Shatilov** comments that for W, a lattice with an arc cell phase advance of $90^\circ/90^\circ$ has been tested in the past. Due to a strong beam-beam coherent instability, the $60^\circ/60^\circ$ option was chosen. He adds that the solution with the longer cell could work, potentially also for Z.

F. Zimmermann asks if in this longer cell scheme, an arrangement could be found where sextupoles location is fixed. **K. Oide** says that this will not be possible.

F. Zimmermann comments that from this presentation, it appears that operation with 600 MHz looks feasible. **D. Shatilov** agrees and adds that this is also the case for Z.

M. Zobov notes that here scaling for turbulent mode coupling should also be accounted for.

Follow-up items

TASK
Discussion with RF-group on the requirements of the 600 MHz SWELL cavities and impact on beam dynamics (increase of broadband impedance, polarization)
Evaluate feasibility of 90°/90° lattice with longer arc cells for Z and W

46 Participants:
A. Abramov, I. Agapov, J. Bauche, M. Benedikt, A. Blondel, A. Bogomyagkov, M. Boscolo, H. Burkhardt, P. Burrows, E. Carideo, F. Carlier, T. Charles, B. Dalena, S. Doebert, O. Etisken, A. Faus-Golfe, K. Furukawa, M. Giovannozzi, H. de Grandsaignes d'Hauterives, B. Härer, M. Hofer, B. Humann, P. Janot, J. Keintzel, R. Kersevan, A. Krainer, M. Koratzinos, R. Losito, M. Migliorati, C. Milardi, N. Mirian, E. Montbarbon, N. Nikolopoulus, K. Oide, T. Pieloni, F. Poirier, L. van Riesen-Haupt, L. Rivkin, G. Roy, D. Shatilov, R. Wanzenberg, F. Yaman, R. Yang, Y. Zhang, F. Zimmermann, and M. Zobov