Minutes from the 4th FCC-ee Optics Design meeting of the 3rd of July 2015

Participants: Sandra Aumon, Anton Bogomyagkov, Andreas Doblhammer, Bastian Haerer, Bernhard Holzer, Roman Martin, Ivan Koop, Katsunobu Oide, Pavel Piminov, Dmitry Shatilov, Sergey Sinyatkin, Marco Alan Valdivia Garcia.

Beam-beam simulations for FCC-ee(tt) - Preliminary results, Demin Zhou

Demin Zhou presented preliminary results for beam-beam simulations in FCC-ee with the lattice with crab waist provided by Katsunobu Oide (FCCee_t_25_4_cw_DZ.sad). The motivation is to look at the beam-beam issues in terms of dynamical aperture with and without crab waist and with/without beamstrahlung.

Demin Zhou presented a list of beam parameters and it was noted that this list is slightly out-to-date. In particular the presented crossing angle is about 60mrad whereas an option is 30mrad.

Dmitry Shatilov noted that the working point should be above the linear coupling resonance line. Demin Zhou will change the beam parameters in his simulations. Dynamical aperture studies were performed with SAD without beamstrahlung and with CW, bare lattice and with/without beam-beam, and no significant loss of DA was observed. Demin Zhou added that the beamstrahlung is not self-consistent in SAD, whereas it is a very strong effect for FCC-ee.

Some simulations at 175 GeV were done with BBWS developed by K. Ohmi in which the beamstrahlung is included. Demin Zhou computed the luminosity performances for different beam-beam simulations w/wo CW, w/wo beamstrahlung. For a crossing angle of 60 mrad, the best performance in terms of luminosity was obtained with crab waist without beamstrahlung. The case with CW and beamstrahlung (BS) is worse due to an increase of the beam size and therefore the luminosity goes down. Dmitry Shatilov made the remark that for FCC-ee, the beamstrahlung is very strong, so the simulation should include everything.

Demin Zhou presented the beam sizes and the bunch length as a function of the intensity of the bunch. In the simulations with BS, he showed a coupling between transverse and longitudinal planes, in which the bunch length increases with intensity.

Working point scans were as well performed for different scenarios (w/wo CW,w/wo BS). The working point could be chosen according to these considerations. With a large crossing angle, beam-beam resonances are excited. Tune diagram without CW and with BS, resonances appear on the bunch length due the coupling transverse, longitudinal plane with beamstrahlung. Since the bunch length is larger, beam-beam effects are more relax and therefore less resonance.

The case with CW, no BS does not show resonances on the bunch length, due to CW. By adding the BS, an interplay between longitudinal and transverse plane occurs. However, the situation will relaxed with a smaller crossing angle (30 mrad instead of 60).

Demin Zhou performed particle tracking simulations with SAD with a a quarter of FCC-ee lattice (IP to IP), however he observed the beam becomes unstable even without beam beam effects. Demin Zhou observes a large blow up of the beam size within 500 turns. He will investigate the cause of the loss of DA. Katsunobu suggested to not start from the IP.

The large highlight of the presentation is the interplay between longitudinal and transverse plane to be understood. Demin Zhou will also perform simulations with strong-strong interactions for beam-beam instability.

Dmitry Shatilov asked about the BS life-time and whether Demin Zhou took into account the particles go above the energy acceptance. He suggested to include everything into the simulations.

Katsunobu Oide asked whether the blow up observed on the beam size depends on the CW in SAD simulations. Demin Zhou said he could not test without CW so far because the DA has to be re-optimized.

Performance comparison of interleaved sextupole schemes + New racetrack lattice - Bastian Haerer

Bastian presented a follow-up and new results of his chromaticity correction scheme for FCC-ee. He reminded that he is using a lattice without local chromaticity correction, 12 folds, 90/60 degree phase advance per FODO cell. He will compare the 2 and the 4 IPs cases. In the 4 IP case he also slightly changed the working point to 0.249 instead of 0.25.

The matching of the Montague functions between two IPs is done with sextupoles on both sides of the quadrupoles. In his last presentation already, Bastian noticed that the horizontal chromaticity was disturbing the vertical W function.

Bastian presented a new strategy: instead of matching the horizontal and the vertical W-function separately, they are now matched at the same time. The phase advance between FD and the arc is also optimized. Both Wx,y are matched to small values at the end of the first arc, then arc 2 is used to match the first order chromaticity and finally, in Arc3 the W-functions increase gradually to be matched to zero at the IP.

In the case of the 4 IPs, the Wx-function is oscillating a lot in the Arc2. The momentum acceptance calculated by MADX reaches from -0.22 % to 0.06 %, but I crosses both an integer and an half-integer resonance. So the interval not crossing any resonance is [-0.08 % , 0.06]. The momentum acceptance is dominated by third order chromaticity. Bastian repeated the same exercise for 2 IPs, where the momentum acceptance crosses the half integer resonance at -0.15% and reaches up to 0.06 %. Again it is dominated by third order chromaticity. In general, there is an improvement in momentum acceptance by going from 4 IPs to 2 IPs: using the same matching method the second and third order chromaticities can be decreased to half of their value before.

In order to correct this 3rd order chromaticity, Bastian presented a formula derived by Anton Bogomyagkov, in which the 3rd order chromaticity depends on the W^2, but also on octupoles (K3) and on a parameter b2 (second order derivative of the beta-function with respect to momentum spread). An idea would be to install a sextupole where b2 is large. He hesitates to install octupoles, since they are non-linear elements and could disturb the dynamic aperture.

Bastian then matched the arc cell to a slightly different tune. Instead of 90/60 deg, the phase advance per cell would be 0.249/0.166. In the case of 4 IPs the momentum acceptance is [-0.24 %, 0.22 %] and is dominated by second order chromaticity.

Bastian proposed to Luis to start DA studies, when he is finished with the calculations for the Racetrack layout. As future work, Bastian will implement a method to get the 3rd order chromaticity under control (octupoles, sextupole according to the derivative of the beta-function).

Bastian presented the new racetrack baseline layout (version 17), without the TSSes between the two long arcs. The short arc plus its dispersion suppressors (DS-SARC-DS) were increased by 400 m in total compared to the official baseline layout to fulfill the requirements for the sextupole families. Bernhard Holzer said that he was waiting for the people from CEA to compare the geometry of the two lattices. However, giving up the TSSes will increase the sawtooth effect. Andreas Doblhammer will investigate tapering options for the dipole strength to counteract this increase.

Anton made the remark that the IR goes straight and he asked whether it is a requirement by the hadron machine, and if there were 2 beam lines, how far they can be from each other.