

Minutes from the 3rd FCC-ee Optics design of the 19th of June 2015

Participants: Sandra Aumon, Michael Benedikt, Helmut Burkhardt, Anton Bogomyagkov, Andreas Doblhammer, Bastian Haerer, Bernhard Holzer, Evgeni Levichev, Roman Martin, Ivan Koop, Katsunobu Oide, Dmitry Shatilov, Marco Alan Valdivia Garcia.

Summary of the crab waist interaction region for FCC-ee and the arc, presented by Anton Bogomyagkov (BINP)

Anton Bogomyagkov presented a summary of the BINP mini-review which took place the 12th of June. The beam parameters for the crab waist scheme are presented for the different energies: the crossing angle is 30 mrad and the beta function at the IPs is 0.5m in the horizontal and 1 mm in the vertical plane.

Anton Bogomyagkov showed as well the optics functions in the interaction regions composed by a Final Focus Telescope (control of the tune and 2nd order chromaticity), Chromaticity correction schemes in horizontal and vertical planes (CSSY+CSSX+CCT are as well a transition section to adjust the dispersion function), the crab section which allows to get the proper phase advance to the IP. Chromaticity correction still works with 2mm beta* in the vertical plane, at contrary to 3mm. The energy loss the IR is about 0.1 GeV. A distance 0.72m in the horizontal plane between the two beams trajectories after the crab sextupoles. Katsunobu Oide asked from where does it come from. Anton replied that LEP was using as well two apertures and they used the same idea. The tunnel should be straight in order to accommodate the IR from the FCC-pp.

Anton continues with the synchrotron radiation fans for 175 GeV in the IR, which the dipoles are not longer than those in the arcs. The people from the physics said that concrete shielding can be built against the radiation from MB3 MB4 for example, but MB0 and MB1 are very dangerous for the detectors. Helmut and Manuela are working on the background and they might do again simulation about the scattering in this area. In particular, the production of neutron can make the machine very radioactive. Bernhard Holzer reminds that even if similar phenomena happens in LHC, it is nevertheless a very clean machine and everything has been done to avoid quench in the magnet due to the background (particles shower).

Anton presented the rematching of one quarter of FCC-ee in order to fulfill the requirement of Pavel (tracking and DA studies): get a tune integer multiple of 2π through the interaction region between the last quadrupole of the arc and the first quadrupole of the next arc. Katsunobu Oide objected that changing the strength of the arc quadrupoles will change the beta-function and the emittance, that is not favorable. Anton replied that the tunes are not changing much. Katsunobu

said that those quadrupoles should not be touch, since emittance tuning will be performed and Bernhard added that small tuning quadrupoles could be additionally installed.

Anton summarized the new results from Pavel about energy acceptance, which is now -2.5% and 2% over one quarter of FCC-ee. A summary of the different component of the chromaticity are showed with their respective induced tune shift at a dp/p of 0.02. Third order chromaticities are significant. The simulations were done without damping.

Anton showed some beam parameters at 175GeV and pointed out that the momentum compaction of $6.96e-6$ is a very important parameter for beam-beam simulations.

New results about two variant of coupling compensation from the solenoids in the IR were presented. Anton mentioned that anti-solenoids are a strong option to compensate coupling in this region. At 45GeV, an orbit distortion in the vertical plane appears between the main solenoid and the anti-solenoid. Its fringe field provokes a blow up in vertical emittance. At 175 GeV, extra skew quadrupoles were added to correct the vertical dispersion, which goes down to max 4.2mm.

As summary, the target vertical emittance of 1pm at 45GeV is not fulfilled with proposed coupling compensation, however making the solenoid elliptical can reduce the vertical emittance to 1pm. The ratio between axis and semi axis has to be optimized. The design luminosity would be as well reached.

Concerning beam-beam simulations, Anton summarized results of simulation done at 175, 120 and low energies. The vertical β^* could be relaxed to 2mm for 120 and 175 GeV. The beam distributions are significantly different between Head-on/11mrad Crossing angle and the crab waist scenario for 120 GeV. At lower energies, the vertical β^* should stay to 1mm and the 2 mm case does not give better results due beam-beam tune shift. Katsunobu commented that beam-beam is a huge problem in Super-KEKb, and crab waist were used to relax the situation.

As summary,

- the vertical β^* can be relax at high energies from 1 to 2 mm.
- The horizontal β^* should be as well increased from 0.5 to 1 m.
- The performances of the baseline and the crab waist scheme are similar at 175 GeV.
- The on-momentum DA is correct, at contrario to the off-momentum DA.

Bernhard and Evgeni rose the question about the number of IPs, because the crab waist scenario is based on 4 IPs, whereas efforts started on scenarii with 2 IPs (more relax situations concerning chromaticity correction). Katsunobu said that 2 IPs/4 IPs are assumptions and Michael Benedikt said that it has to converged with the hadron part. Bernhard suggested to work with 2 IPs which should be easier for chromaticity correction and therefore DA and compare with 4 IPs. Anton added that the DA of off-momentum particles is limited by sextupoles. Coherent beam-beam instability could be as well a problem while there is coupling with all the bunches, and maybe a feedback could help. Katsunobu suggested to adjust the path length from IP to IP.

Updated optics with two tunnels around the IR, presented by Katsunobu Oide

Katsunobu Oide presented an optics update for the racetrack hadron based layout. Katsunobu showed a layout with 2 IPs and 2 RF sections used also to cross over. Using the crossing angle of 30 mrad, the distance between the two tunnels at the IP is about 24 m. Bernhard mentioned the proton people did not yet provide their survey, the length of the FCC-hh is not known yet.

Katsunobu presented the optics function of such lattice. Bernhard asked why the beta function on the right of the IR are changed. Katsunobu replied that he changed the cell length. The synchrotron radiation loss and therefore the RF voltage are reduced. He used local chromaticity correction and crab waist in the IR, 30mrad crossing angle. The question arised about the transformation between the peak in beta function on the both sides of the IP: between the two peaks, there is -I and I between the IP and the first maximum in beta after the IP.

Katsunobu showed that the some of the dipole fields are very weak around the IR (critical energy for the photons of about 100keV), more additional tunnel is need, since the diverged. Compensation of the solenoid was as well presented.

Preliminary results were also presented about the common RF sections. Since the SR is reduced, the RF power was as well lowered (4.6GV/section). 50m long electrostatic beam separators would be needed, however the SR coming from the last dipole can hit the electrostatic separator. Results in DA were as well presented. The computations take into account crab waist, solenoid, radiation damping. A momentum acceptance of +/- 2% can be achieved (SR damping included) for 175 GeV. Lower the beta functions at the IP helps a lot. In this lattice, the tunnels near the IPs are separated along 5-6km, which can be also used for the booster.

FCC-ee design questions by Evgeni Levichev

Evgeni Levichev presented a list of question/answer concerning the optics design of FCC-ee.

Lattice development will be continued on crab waist , non crab waist etc., until one of the option converges to an acceptable scenario. The lattice of the BINP team has 4 IPs and the one of Katsunobu Oide has 2 (more relax conditions). 30mrad will be conserved and the BINP design with 1mm beta* will continue to complete the study. Concerning the injector of the FCC-ee, more news about should come from Yannis.