Activity report of the FCCee Lumi CHART project since May 2022

Design of collider beam optics:

Since the 2019 CDR, the following key revisions were made on the FCC-ee layout and beam optics:

- 4 IP, 8 shafts.
- Adopted the new tunnel layout of PA-31 series, from 1.0 to 3.0 (newest), characterized by SLSS = 1400 m, LLSS = 2032 m, Circ = 90657.4 m, Δ_{IP} = 10.201 m.
- Changed the separation of e+e- from 30 to 35 cm.
- Designed the Long-long straight section (LLSS) for inside-outside beam exchange and the RF in one of them.
- Designed the RF section for Zh/tt with shared RF.
- Designed the Short-long straight section (SLSS) including the IP.
- Each SLSS incorporates sections for polarimeters and polarization wigglers.

https://indico.cern.ch/event/1237189/contributions/5222868/attachments/2578585/4446935/Optics_Oide_230119.pdf
https://indico.cern.ch/event/1186798/contributions/5062582/

Optimization of the beam lifetime

Noticed that the legacy way of optimization of the dynamic aperture (DA) was not sufficient to ensure the beam lifetime given by the lattice nonlinearity. The "legacy way" means to optimize the survival of particles in the phase space starting at a particular location in the ring. This is probably due to the situation that the initial phase and amplitude must cover the entire phase space, requiring much large number of test particles. Due to computing limitations, it is difficult to perform, esp. in the optimization process, which needs thousands of samples. This situation is more severe at Z with large momentum spread enhanced by the beamstrahlung under relatively long radiation damping time. At W, there is another issue due to the high synchrotron tune required by the polarization measurement, causing strong synchrotron side bands around the half integer betatron tunes.
Thus, a robust and efficient method to evaluate the beam lifetime is required, and this will be one of the subjects of research for the next period.
https://indico.cern.ch/event/1178975/contributions/4952198/attachments/2488857/4273897/ZLifetime_220804_Oide.pdf

Evaluation of beam vibration and required precision of beam position monitors and feedback

As the small beam spot size at the IP ($\sigma_y^* \approx 35$ nm), the estimation of the beam vibration is crucial. As the first step, the beam vibration caused by the coherent and random ground motions has been estimated. As the result, it was found that a beam feedback based on the detection of beam-beam deflection is necessary up to 10 Hz. The requirements on the beam position monitors (BPMs) are within reachable range of performance by currently available technology, at a glance.
https://indico.cern.ch/event/1186798/contributions/5062667/
https://indico.cern.ch/event/1209598/contributions/5092252/

Evaluation of center-of-mass energy at each IP under machine errors

The determination of the center-of-mass energy is a crucial point for the physics of FCC-ee. Various machine errors such as misalignments of magnets deviates the beam energy along the beam orbit. An estimation was done by a simulation with possible misalignment of magnets. The resulting deviation of the CM energy is about 0.5 ppm.
https://indico.cern.ch/event/1181966/contributions/5041336/attachments/2510397/4314893/WP2_220919_Oide.pdf

Construction of IP tuning knobs

The primary tools crucial for precise adjustments of optics at the interaction regions in the event of mismatches caused by machine errors are tuning knobs. These knobs, namely beta-star (both horizontal and vertical planes), waist (both horizontal and vertical planes), vertical dispersion (with an ongoing study on the horizontal dispersion knob), linear coupling (F1001, F1010 driving terms), and orbit (both horizontal and vertical planes), have been developed thus far. To address further complexities expected during real machine operation, magnet misalignments were introduced in the lattice, leading to orbit distortion. The resulting distortions and feed-down terms pose challenges for the knobs to function as intended. Therefore, orbit correction becomes imperative, particularly in the proximity of the tuning magnets, for the knobs to exhibit a robust performance.

More information can be found here:
https://indico.cern.ch/event/1351567/contributions/5709592/attachments/2773337/4832733/SATYA_SAI_JAGABATHUNI%20FCC-ee%20IR%20Tuning%20Knobs.pdf

Assessment of luminosity-related signals

Luminosity optimization relies on measuring the realistic signals from Bhabha scattering, beamstrahlung and/or radiative Bhabha photons. The initial assessment looks at the change in luminosity and beamstrahlung signals with respect to waist-shifts, vertical dispersion, and skew coupling introduced in the beam. These studies, which are currently in progress, could be utilized to determine signals in the energy spectrum of the beamstrahlung photons to be used for measuring the transverse beam sizes, while shifts in the angular distributions are linked to the IP beam-beam steering.