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Tuning simulations for FCC-ee using Python Accelerator Toolbox

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The development of ultra-low emittance storage rings, such as the e+/e- Future Circular Collider (FCC-ee) with a circumference of about 90 km, aims to achieve unprecedented luminosity and beam size. One significant challenge is correcting the optics, which becomes increasingly difficult as we target lower emittances. The use of stronger quadrupoles and sextupoles makes these machines particularly sensitive to misalignments, which can severely impact performance. This study investigates optics correction methods to address these challenges. We examined the impact of arc region magnet alignment errors in the baseline optics for the FCC-ee @ Z energy. To establish realistic alignment tolerances, we developed a sequence of correction steps using the Python Accelerator Toolbox (PyAT) to correct the lattice optics, achieve nominal emittance, and large Dynamic Aperture (DA). We focused initially on the Linear Optics from Closed Orbit (LOCO) method, which fits the measured Orbit Response Matrix (ORM) to the lattice model to determine optimal parameters such as quadrupole strengths. We implemented a Python-based numerical code for LOCO correction and evaluated its effectiveness for the FCC-ee. Results indicated successful optics corrections. We also compared LOCO with phase advance + η_x and coupling Resonance Driving Terms (RDTs) + η_y optics correction, finding that the latter performed better in achieving design emittance values and a large DA area for realistic alignment tolerances.

Primary authors: MUSA, Elaf (DESY); Dr AGAPOV, Ilya (DESY); Dr CHARLES, Tessa (Australian Synchrotron)

Presenter: MUSA, Elaf (DESY)

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