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Multi-objective Genetic based Algorithms and experimental beam lifetime studies for the SOLEIL storage ring

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The aim of this project is to optimize the nonlinear beam dynamics of the Synchrotron SOLEIL storage ring using Multi-objective Genetic Algorithm (MOGA). MOGA uses ELEGANT as a tracking code to compute the on- and off-momentum acceptances as optimization objectives and the quadrupole and sextupole setting magnets as optimization variables. The off- and on-momentum acceptances are strongly related to two important parameters impacting the accelerator performance: the injection efficiency and the beam lifetime, respectively.

A model of the current SOLEIL storage ring lattice with the physical limitations and the multipole field components is optimized with MOGA. Two optimized solutions have been selected after 1 month of computation in the SOLEIL computer cluster. After crosscheck and in-depth characterization with the Tracy3 code, they were tested experimentally in the control room of SOLEIL using beam-based experiments. The experimental results confirm the significant improvement of the beam lifetime obtained in the simulations: 40 % and 50 % with respect to the nominal lattice. The optimization scheme has been validated with a good predictive model.

In addition, a detailed study of the behavior of the beam lifetime was performed with important parameters during the machine operation as scraper dimensions, coupling, RF-voltage and current among others. The results allow understanding the relation between the beam, the Touschek and the gas lifetimes. There is a good agreement between the simulated and experimental Touschek lifetimes, especially for the internal scraper. However there is a discrepancy between the calculated and the experimental values of gas lifetime due to the difficulty to determine the effective atomic number and the mean pressure of the residual gas in the SOLEIL storage ring. Results will be presented in details.

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