High-chromaticity Optics for the MAX IV 1.5 GeV Storage Ring

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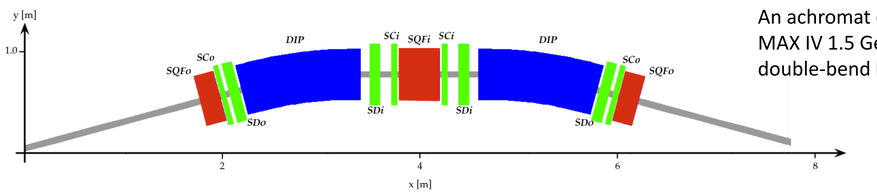
Introduction

- In case of instability issues during commissioning might need to operate the MAX IV 1.5 GeV storage ring at higher chromaticity.
- Performance of optics with linear chromaticity +4 in both planes has been studied.
- The possibility to operate this optics in the real machine has been evaluated.

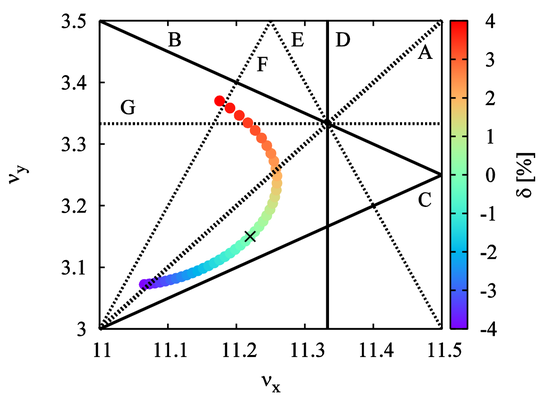
The MAX IV 1.5 GeV Storage Ring



An achromat of the MAX IV 1.5 GeV storage ring double-bend lattice.

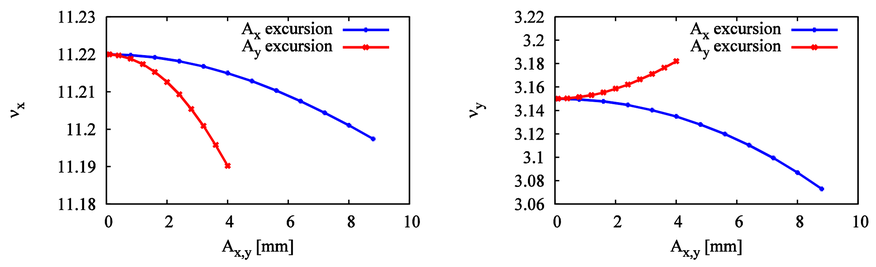
- Focusing sextupoles have been integrated into the focusing quadrupoles, whereas defocusing sextupoles are dedicated magnets.
- Small correction sextupoles inserted into the lattice to allow adjustment of the chromaticity.
- Built-in sextupole gradients designed to correct linear chromaticity to +2 in both planes.
- Design optics has corrected linear chromaticity of +1 in both planes.

Tune Shifts



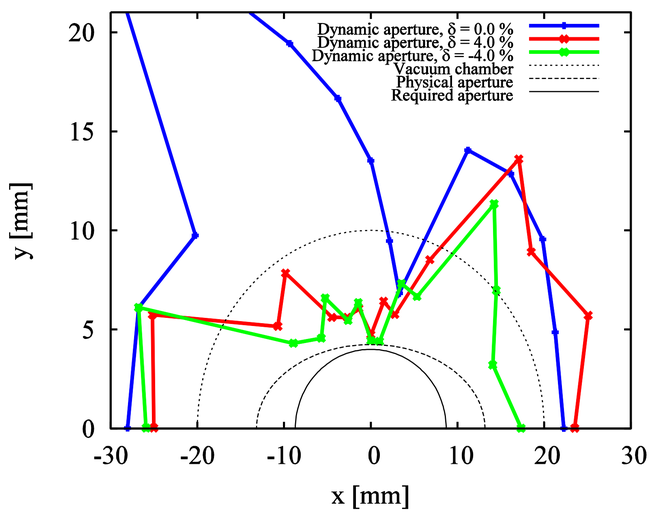
Chromatic tune footprint calculated with Tracy-3. The resonaces up to third order are displayed. A: $\nu_x - \nu_y = 8$, B: $\nu_x + 2\nu_y = 18$, C: $\nu_x - 2\nu_y = 5$, D: $3\nu_x = 34$, E: $2\nu_x + \nu_y = 26$, F: $2\nu_x - \nu_y = 19$, and G: $3\nu_y = 10$. The working point is marked with a black cross.

- Optimization focused on avoiding the resonances assumed to be most dangerous.
- To study the performance of an optics with only brief optimization no further tailoring of the ADTSs was performed.



Amplitude-dependent tune shifts calculated with Tracy-3.

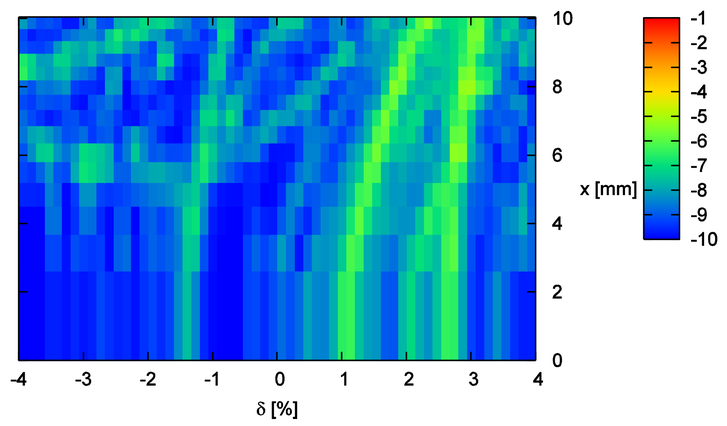
Dynamic Aperture



Dynamic aperture in the centre of the straight sections calculated with Tracy-3. The physical aperture in the horizontal plane is limited by the septum magnet used for injection and in the vertical plane by the aperture of the vacuum chamber.

- Ideal DA larger than required both on and off-momentum.
- FMA reveals low diffusion inside required aperture.
- DA reduction caused by imperfections: on-momentum → beyond physical aperture; off-momentum → not considered severe.

Momentum Acceptance



Diffusion map over the desired momentum acceptance ±4% calculated with Tracy-3.

- Area with elevated diffusion around $\delta = 1 - 3\% \rightarrow 4\nu_x = 45$.
- Area with elevated diffusion around $\delta = -1.5\% \rightarrow 6\nu_x = 67$.

Touschek lifetime (Initial Studies)

- Ideal Touschek lifetime is reduced roughly 2% compared to design optics.
- Reduction of Touschek lifetime caused by imperfections is roughly 7%.

Performance of Sextupole Magnets

- Gradients lower than technical specification of sextupole magnets for all but one magnet family.
- Gradients for this family are on the limit of what can be achieved with present power supplies.
- Further studies, including measurement data, have to be undertaken to reach final conclusion.

Conclusions

- Performance of high-chromaticity optics considered satisfactory. No problems expected for the injection process and only a small reduction of Touschek lifetime compared to the design optics.
- Performance of sextupole magnets remains to be studied in detail, but expected to be able to produce the required gradients, possibly with an exchange of power supplies.