High-chromaticity Optics for the MAX IV 3 GeV Storage Ring

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Motivation

Tavares et al., IPAC'11, p. 754

- Initial instability studies indicate threshold currents for resistive wall and TMC instabilites sufficent for design optics.
- However, only preliminary studies, instabilites during commissioning still have to be considered.
- Threshold currents increase with chromaticity.

Aim

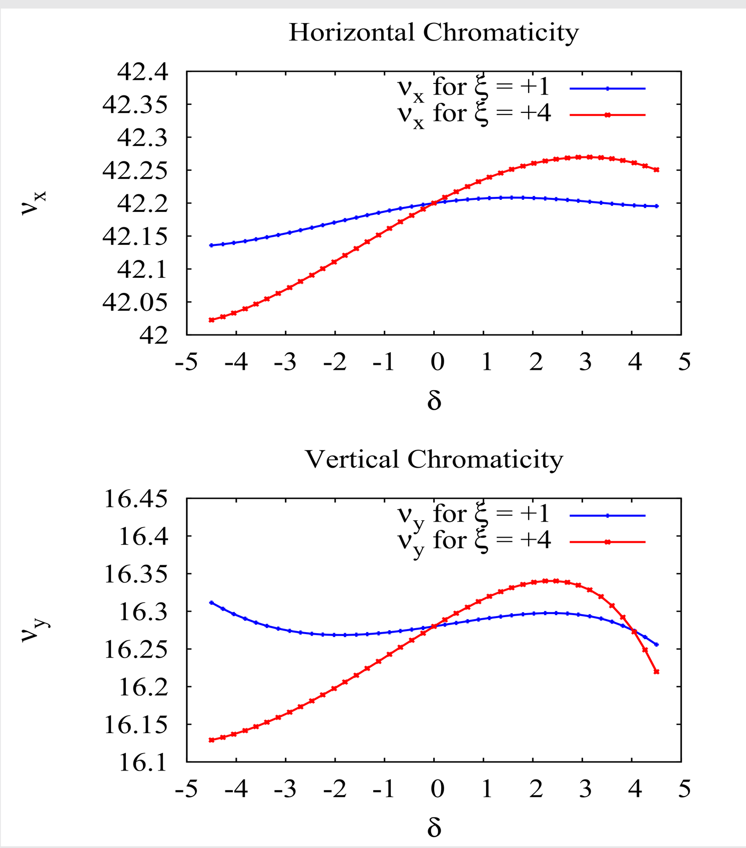
- Develop an alternate optics with linear chromaticity +4 in both planes for the MAX IV 3 GeV storage ring.
- Sufficent performance to be operated as a short-term solution if instability issues occur during commissioning.

Optimization of Nonlinear Optics

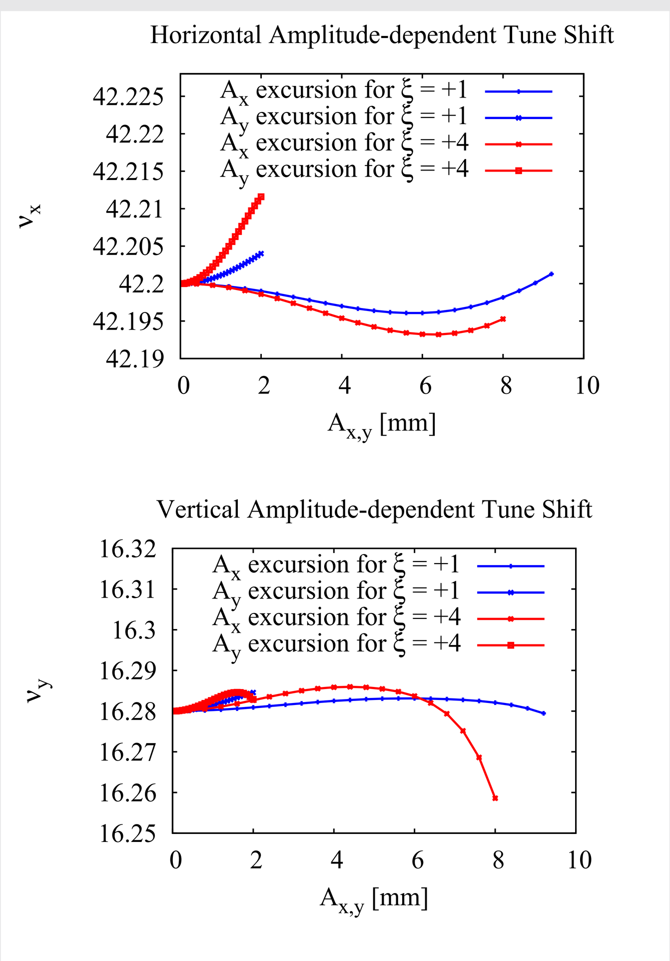
- Linear chromaticity corrected with sextupoles.
- Chromatic tune shifts and chromatic tune footprint tailored with sextupoles.
- Amplitude-dependent tune shifts minimized with octupoles.

Leemann et al., PRST-AB 14 (2011)

Tune Shifts

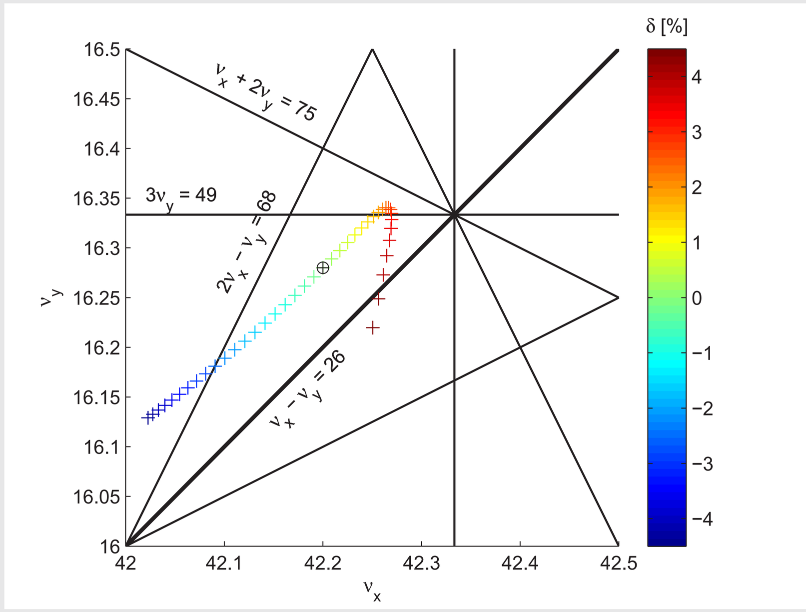


Larger chromatic tune shift for the hich-chromaticity optics ($\xi = +4$) compared to the design optics ($\xi = +1$).



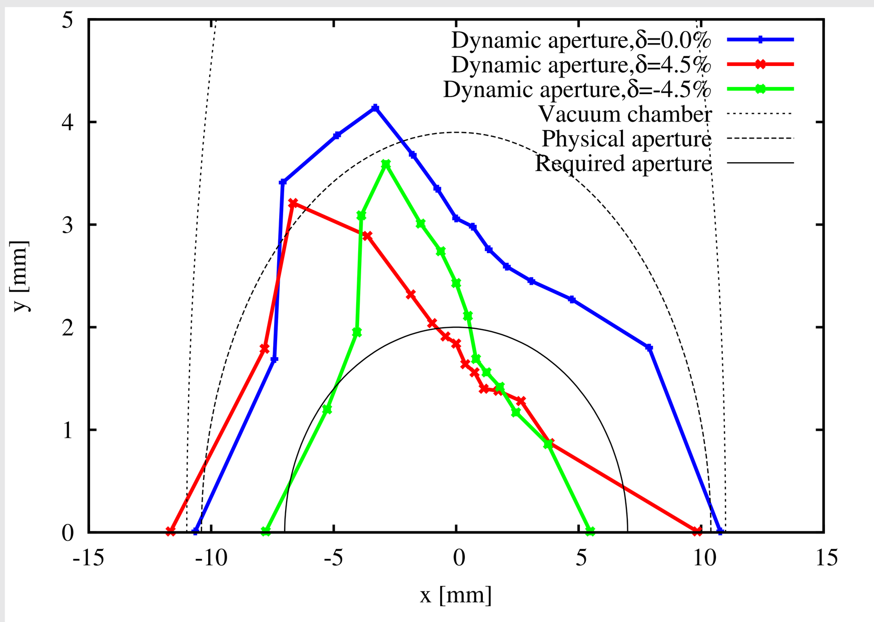
Larger amplitude-dependent tune shifts for the hich-chromaticity optics ($\xi = +4$) compared to the design optics ($\xi = +1$).

Chromatic Tune Footprint



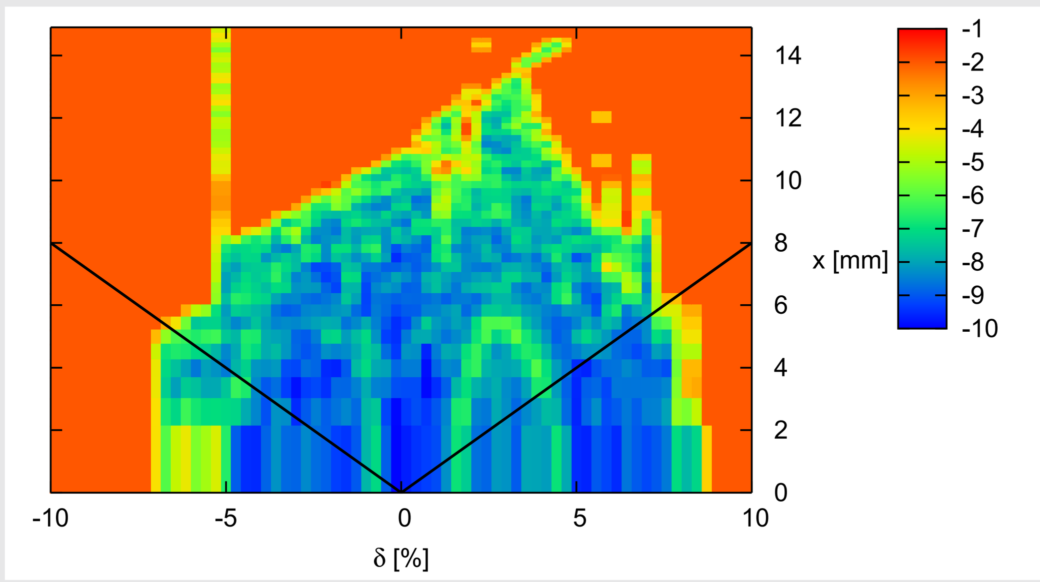
- Larger chromatic tune footprint for the high-chromaticity optics compared to the design optics.
- Chromatic tune footprint tailored to avoid low-order normal resonances. Less emphasis during design process on avoiding skew resonances.

Dynamic Aperture



- The dynamic aperture is reduced compared to the design optics.
- Reduction is more significant for negative than positive momentum deviations.
- Error studies show reduction of dynamic aperture most dramatic for negative momentum deviatons.

Momentum Acceptance



- Several areas of somewhat elevated diffusion within the desired momentum acceptance ±4.5%.
- Encountered resonances expected to be weakly driven.
- Error studies indicate reduced momentum acceptance (roughly ±3.5%).

Touschek Lifetime

- Touschek lifetime reduced by roughly 5 hours compared to design optics.
- Further reduction caused by errors, however most likely sufficent for commissioning.

Challenges for a High-chromaticity Optics

- Enlarged chromatic tune footprint caused by increased linear chromaticity calls for strong sextupoles. Strong sextupoles → increased amplitude-dependent tune shifts → strong octupoles.
- When octupole gradients considerably enlarged they affect the chromatic tune shifts through second order dispersion → complex design process calls for several iterations.
- Technical limitations, e.g. maximum available magnet gradients.

MAX IV Project → http://www.maxlab.lu.se/maxiv

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