KIT, Germany
Budker INP, Russia
CERN, Switzerland

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Studies on beam dynamics of a superconducting damping wiggler in the ANKA storage ring in low-alpha mode

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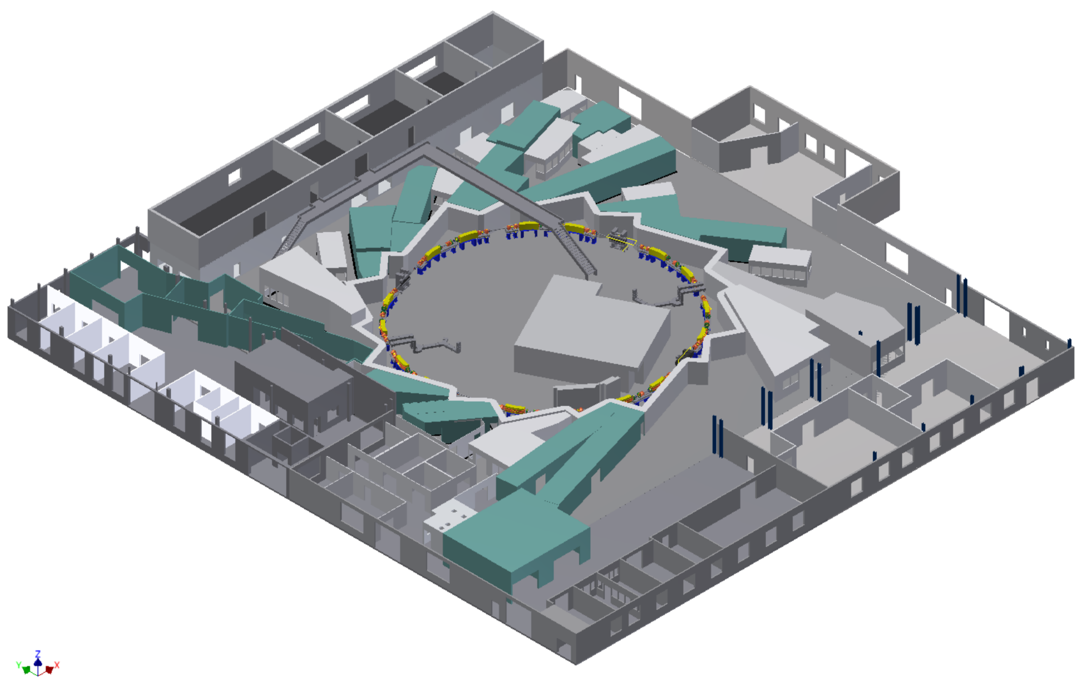
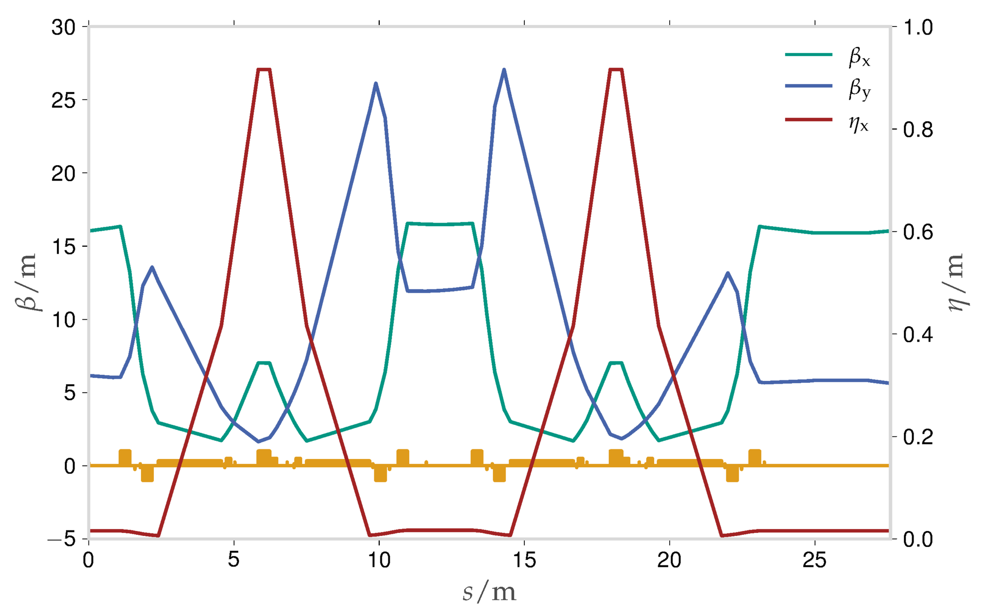
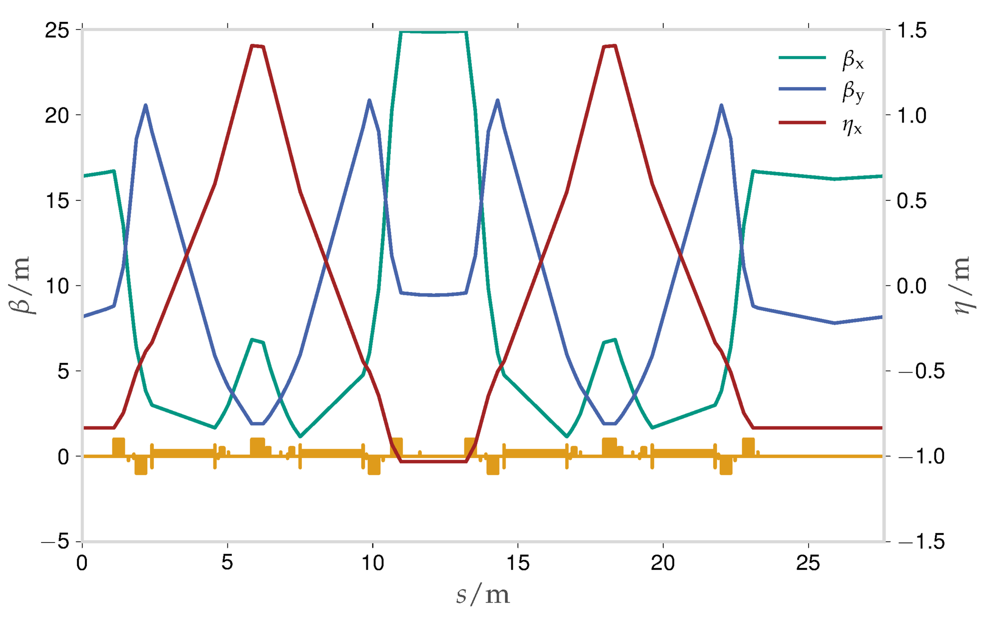
ANKA



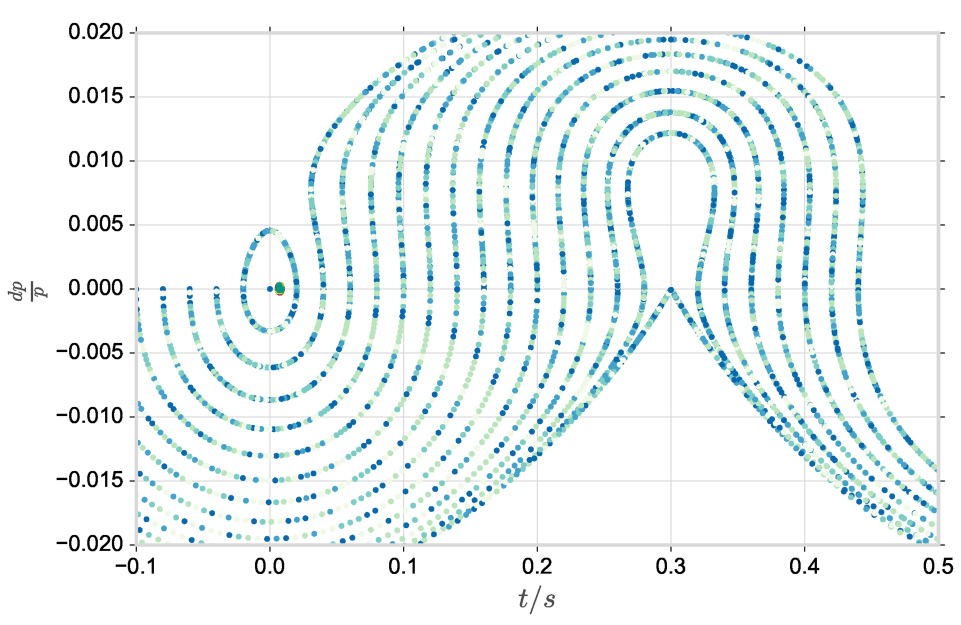
circumference (m)	110.40
bending radius (m)	5.56
normal operation energy (GeV)	2.50
low-α_c operation energy (GeV)	1.30



Optical function of one quarter of the 2.5 GeV lattice.



Optical function of one quarter of the 1.3 GeV low-α lattice.



Simulated longitudinal phase space: one bucket of the input distribution for the simulations. The particles used for tracking simulations (colored) stay in this bucket after radiating.

Damping wiggler

Motivation and figures

$$\frac{\varepsilon_w}{\varepsilon_0} = \frac{1+\left(\frac{\rho_0}{\rho_w}\right)^3 \frac{\langle\mathcal{H}_w\rangle}{\langle\mathcal{H}_0\rangle}}{1+\frac{L_w}{2\pi\rho_0}\left(\frac{\rho_0}{\rho_w}\right)^2},$$

with the

- bending radius of the wiggler $\rho_w = \frac{E}{eB_w}$,
- the bending radius of the dipoles ρ_0,
- length of the wiggler L_w, and
- dispersion (η) dependent function $\mathcal{H}$.

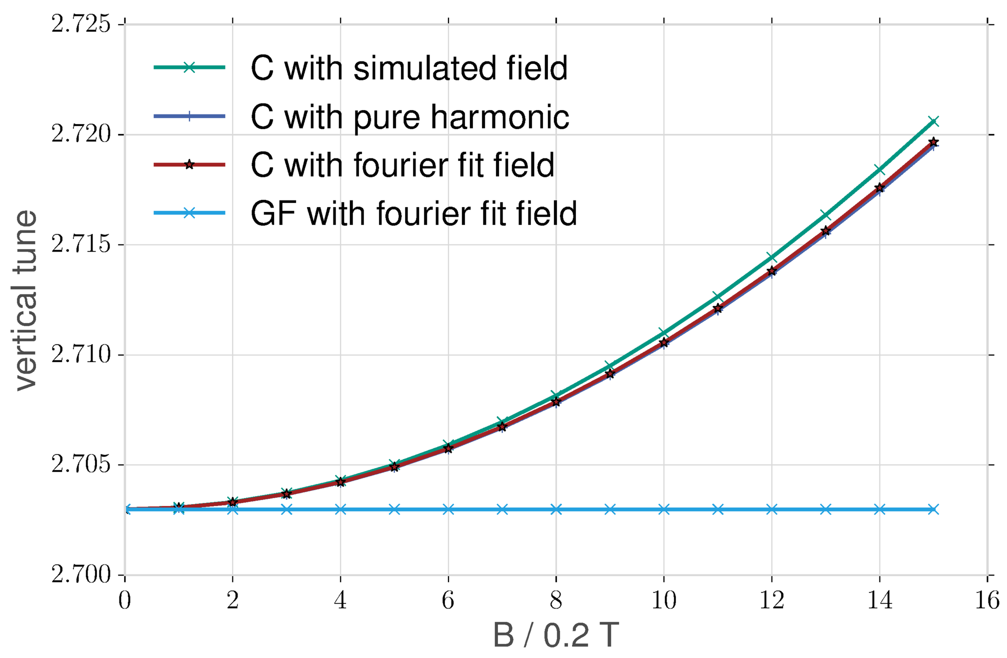
Figures of the superconducting CLIC damping wiggler prototype and the superconducting CATACT wiggler.

	CLIC dw	CATACT
period length λ_w (mm)	51.40	48
periods	36	20
length (mm)	1850.40	960
maximal B field (T)	2.90	2.50
bending radius ρ (m)	1.50/2.87	1.73/3.34
Undulator parameter K	13.92	11.20

- inherent nonlinear
- relatively small effects for one wiggler (ANKA), but
- 52 per damping ring foreseen for CLIC

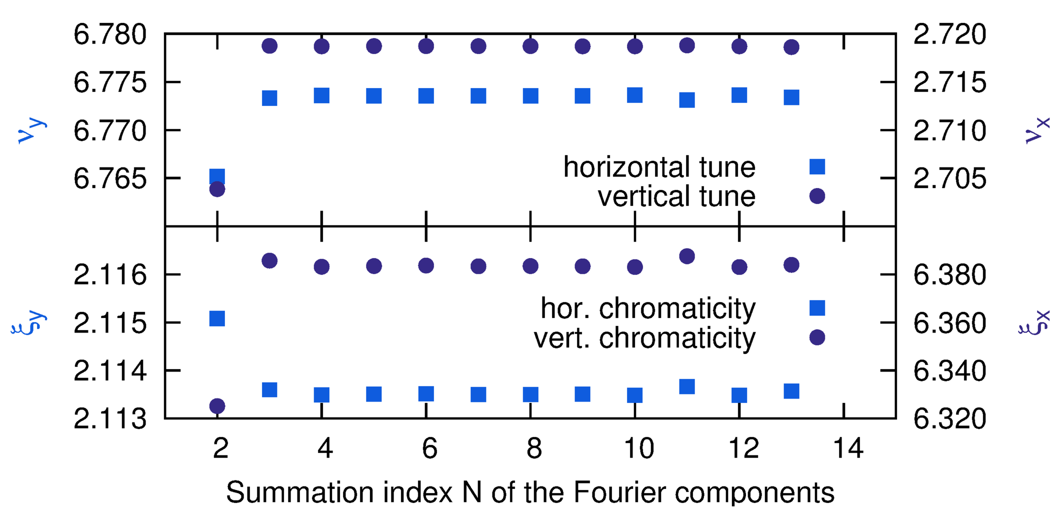
Model building

The simulation software ELEGANT supports wiggler simulations with different models that can use “real” field data. In our case the field data comes from FEM-simulations and measurements from Budker INP.



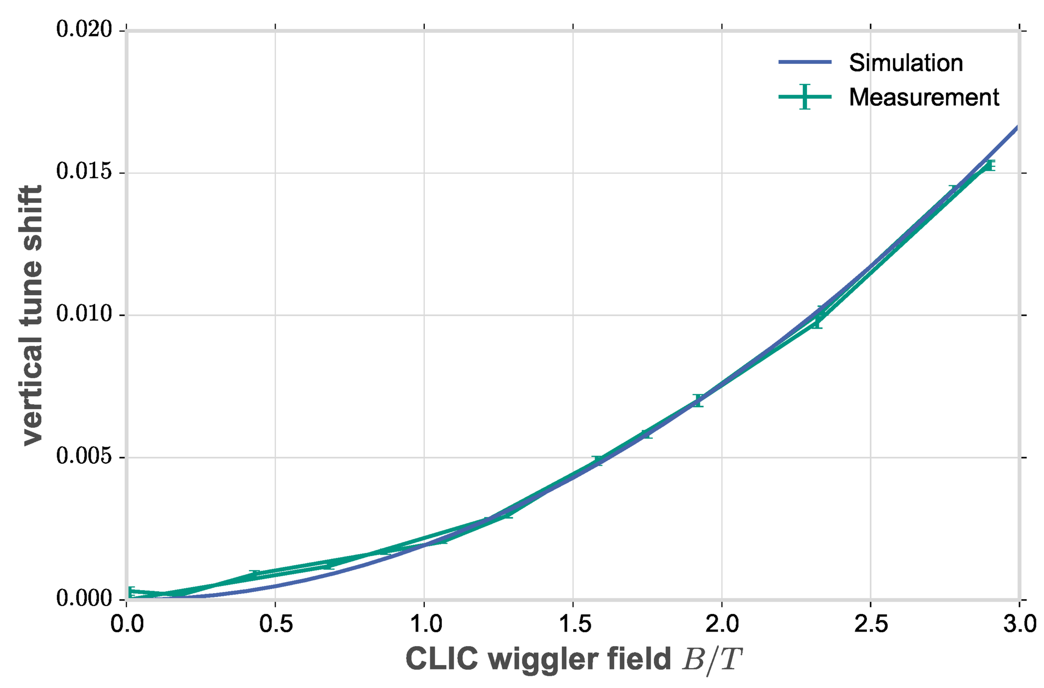
- different wiggler implementations show different behaviours
- Fourier components need to be extracted from B-field measurements

$$B_y = \sum_{m,n} C_{mn} \cos(k_{x,m}x)\cos(nk_z z)\cosh(k_{y,mn}y),$$



Limits for fit of Fourier components: tunes and chromaticities for different orders of Fourier summands. $N = 4$ is sufficient for a fit to FEM-modelled field data to converge in the tune and chromaticities.

First measurements



Measured and simulated vertical tune shifts for the different wiggler fields show good agreement. The CLIC wiggler is being operated with since the beginning of 2016.

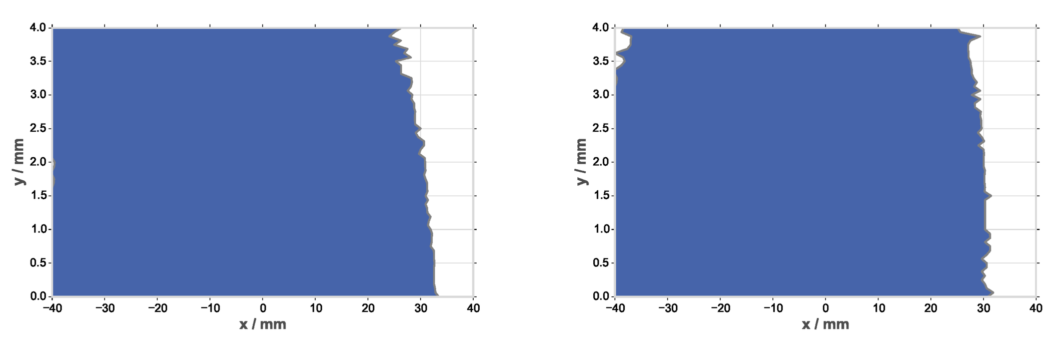
Octupole components

Since we suffered from lifetime decrease from ≈ 13 h to ≈ 10 h when turning on the first superconducting wiggler (CATACT), we try to figure out where this comes from.

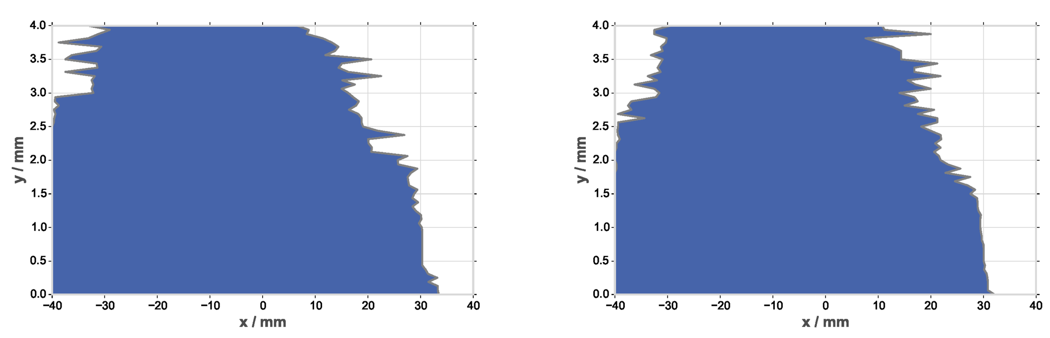
An octupole component of the CATACT wiggler may cause a dynamic aperture decrease leading to a shorter lifetime:

$$K_n L = \left(\frac{\partial^n B_y}{\partial x^n}\right)_{x=y=0} \frac{L}{B\rho} \approx 15\,\mathrm{m}^3$$

with the rigidity $B\rho$, the wiggler length L and the vertical wiggler field B_y. Values from the CATACT wiggler.



Dynamic aperture for the ring with the CATACT wiggler, and with an additional octupole inside the wiggler.



Calculations done for the CLIC wiggler with the estimated octupole component of the CATACT wiggler.
Higher order effects of the CATATC wiggler may cause the lifetime decrease and thus need to be investigated in more detail, also for the CLIC wiggler.

References

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[3] H. Wiedemann. *Particle Accelerator Physics*. Springer Berlin Heidelberg, 3 edn. (2007).

[4] K. Zolotarev. CLIC damping wiggler prototype field data personal communication