Institute of Beam Physics Technology,
KIT, Karlsruhe, Germany

Karlsruhe Institute of Technology

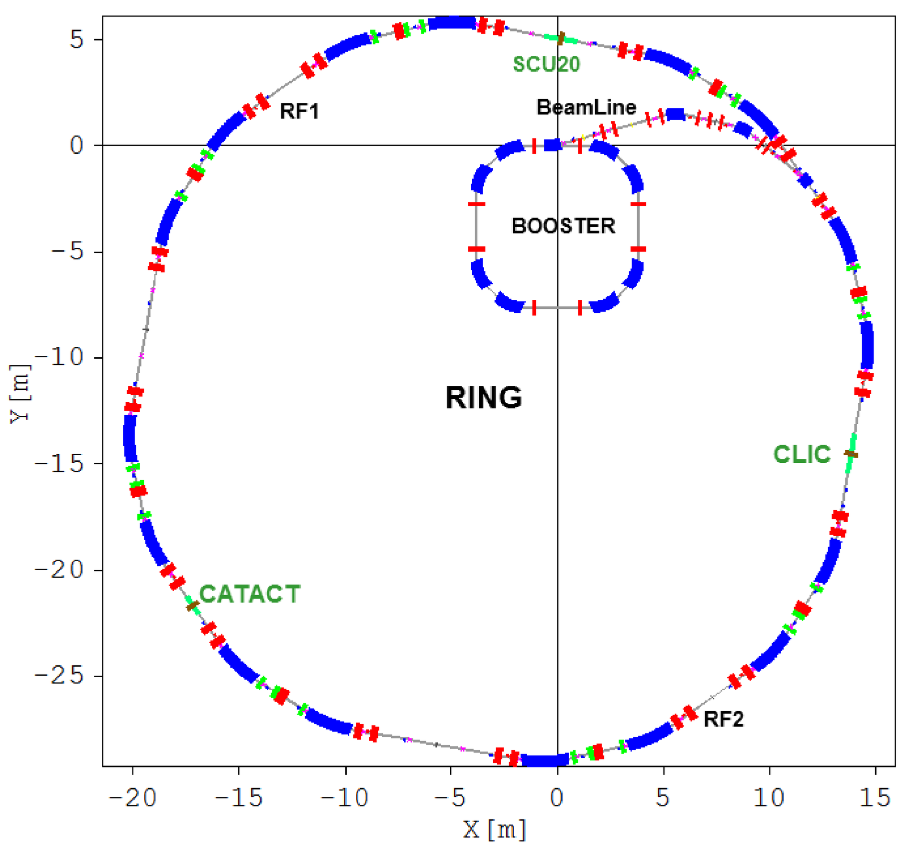
Different operation regimes at the KIT storage ring KARA (Karlsruhe Research Accelerator)

MOPAB036

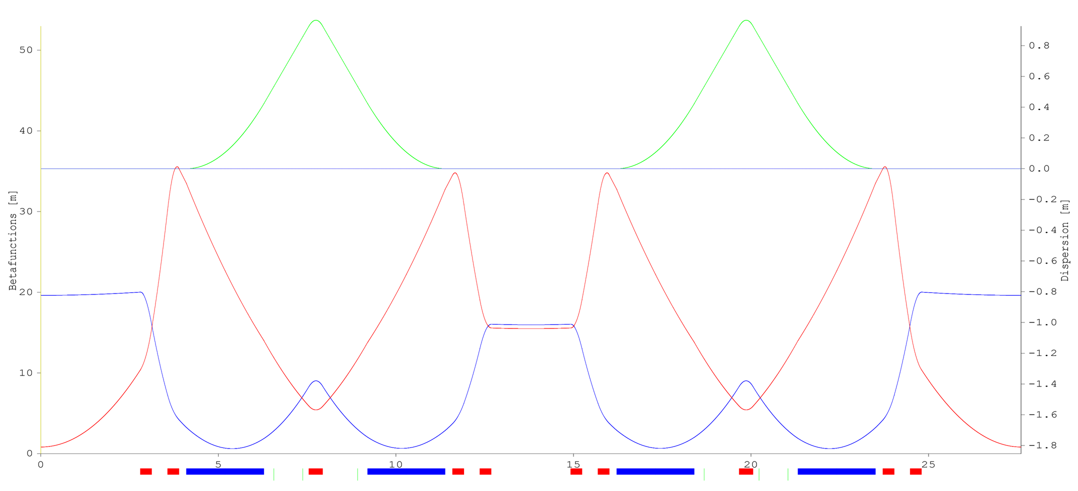
A.Papash*, P.Schreiber, M. Brosi, E. Huttel, A. Mochihashi, A.-S. Müller, R.Ruprecht, M.Schuh, N.Smale

Abstract

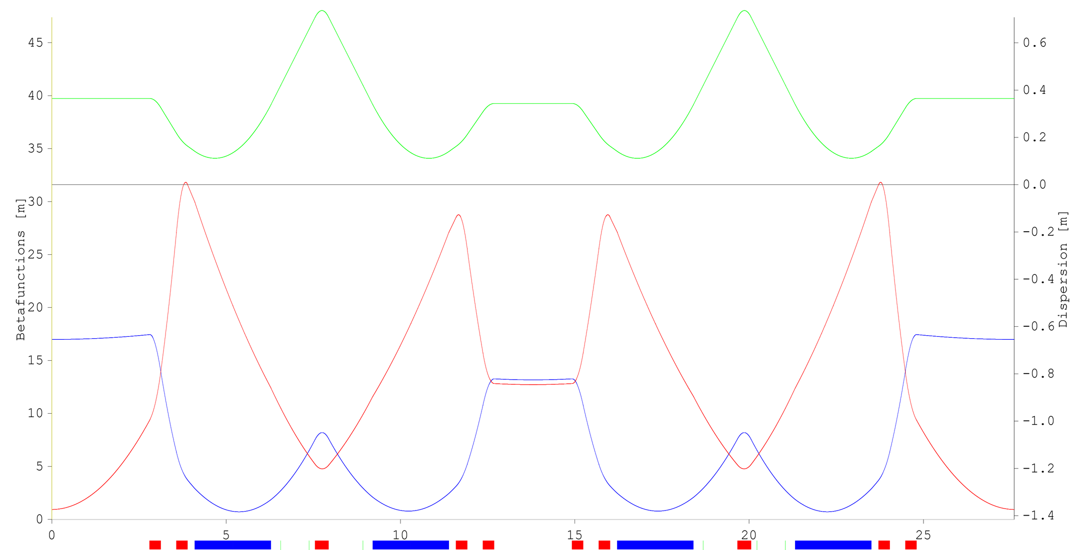
The KIT storage ring KARA operates in a wide energy range from 0.5 to 2.5 GeV. Different operation modes have been implemented at KARA, so far, the double-bend achromat (DBA) lattice with non-dispersive straight sections, the theoretical minimum emittance (TME) lattice with distributed dispersion, different versions of low-compaction factor optics with highly stretched dispersion function. Short bunches of a few ps pulse width are available at KARA. Low-alpha optics has been simulated, tested and implemented in a wide operational range of the storage ring and is now routinely used at 1.3 GeV for studies of beam bursting effects caused by coherent synchrotron radiation in the THz frequency range. Different non-linear effects, in particular residual high-order components of the magnetic field, generated in high-field superconducting wigglers have been studied and cured. Based on good agreement between computer simulations and experiments, a new operation mode at high vertical tune was implemented. The beam performance during user operation as well as at low-alpha regimes has been improved. A specific optic modes with negative compaction factor were simulated, tested and in operation.



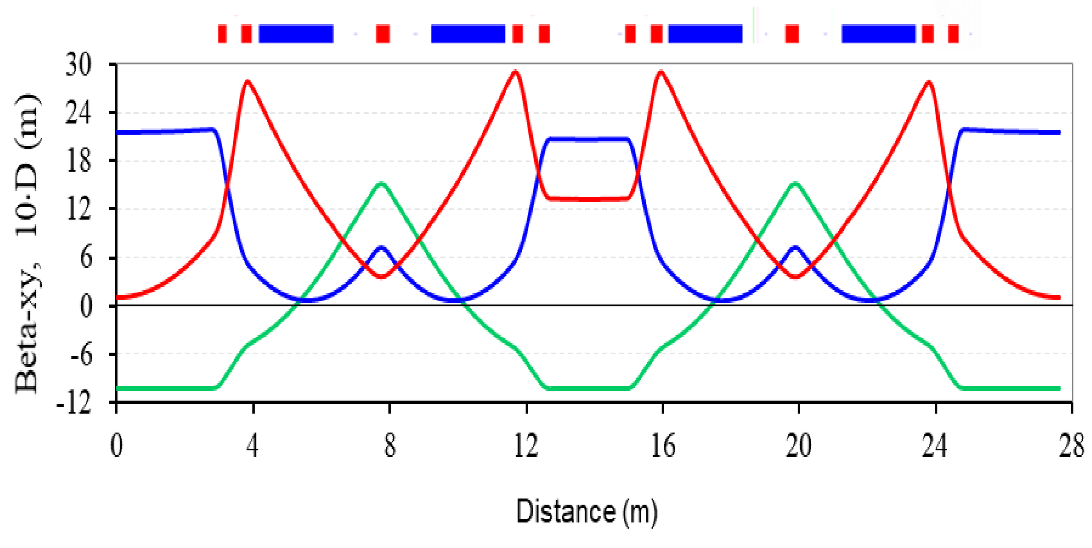
Model of the KARA ring, Booster and Beam Line [2]. **Magnets** are depicted in **blue**, **quadrupoles** in **red** and **sextupoles** are marked in **green**.



Double Bend Achromat Cell
βx – blue, **βy – red**, **D - green**



TME Cell with Distributed Dispersion



Low–α optics α=+1·E-4 *Dispersion* is stretched from +1.44 m to –1.03 m (straights)
Negative–α optics is similar. *Dispersion* is stretched from +1.6 to – 1.6 m

* alexander.papash@kit.edu

- **DBA (double bend achromat)** lattice – achromat straight sections (D=D′=0)
- **TME (theoretical minimum emittance)** distributed dispersion Qy=2.69 (**USER-1** optics)
- **Modified TME** lattice – distributed dispersion and **Qy=2.801** (**USER-2** optics)
- **low–α >** 0 E=0.5 to 2.5 GeV
- **negative–α <** 0 E=0.5, 0.9, 1.3 GeV, see [8]
- high vertical tune Qy=2.801 mode was implemented and Lifetime reduced due to residual octupole field of 2.5T SC wiggler was restored, see [2,3]
- Different options of **Low–α** optics have been simulated**,** tested and realized in a wide operational range of ring, see [7]
- Short bunches of a few **ps** pulse width are available
- A specific optics with **negative compaction factor** was simulated and implemented, see [6,8]
- to operate at negative–α, **direct injection** of 0.5 GeV beam from the booster into negative–α lattice was realized
- Regular operation and R&D studies at negative **α<0**
- feasibility of **filling** and **storing** of beam in **α-buckets** was studied, see [9]

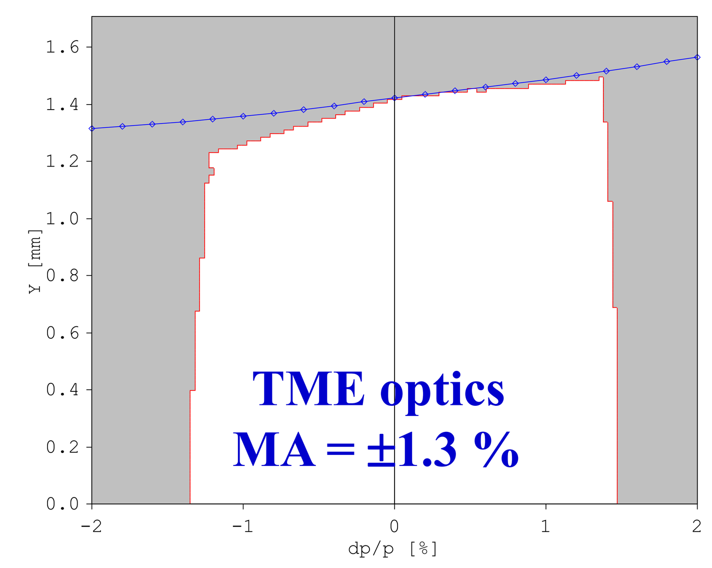
Parameters of KARA ring

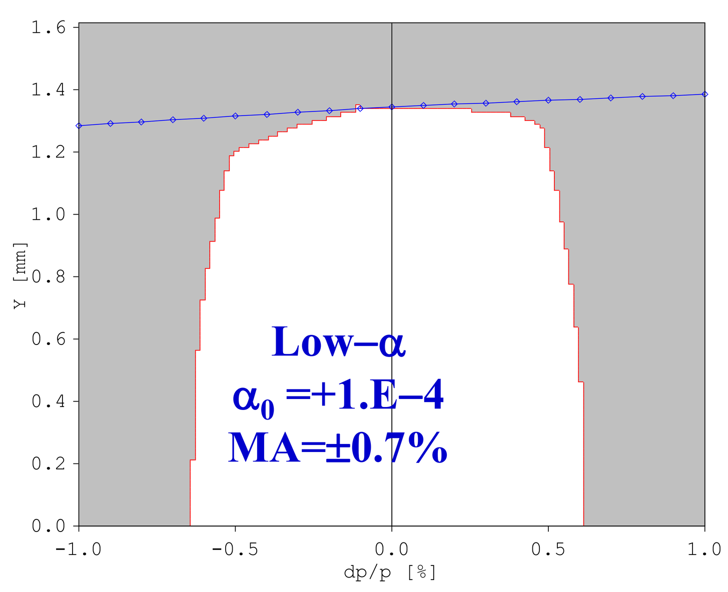
Parameter	KARA	
Energy	0,5÷2.5 GeV	
Circumference, m	110.4	
Chromaticity ξ_X / ξ_Y	+1 / +1	
Hor/vertical tunes Q_X / Q_Y	6.761 / 2.802	
RF frequency (MHz)/RF harmonic	500 / 184	
Vacuum, tor / Gas	10^{-10} / H_2	
Number of bunches	100	
Current/charge per bunch, mA/nC	(0,1÷1) / (0,037÷0,37)	
Damping time (hor/vert/long), ms	0,5 GeV	380/370/180
	2,5 GeV	3/3/1,5
SR Energy loss, keV/turn	1 (0,5) / 622 (2,5GeV)	
Natural energy spread 0,5/2,5 GeV	$1{,}8\cdot10^{-4}$ / $9\cdot10^{-4}$	
Injected beam energy spread	$4\cdot10^{-4}$	
Injected beam emittance	150÷180 nm·r	

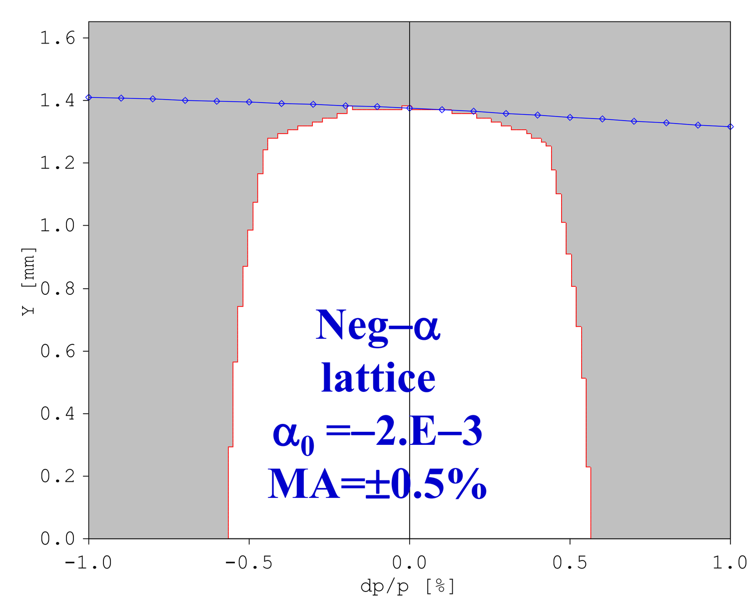
Operation modes at different compaction factors

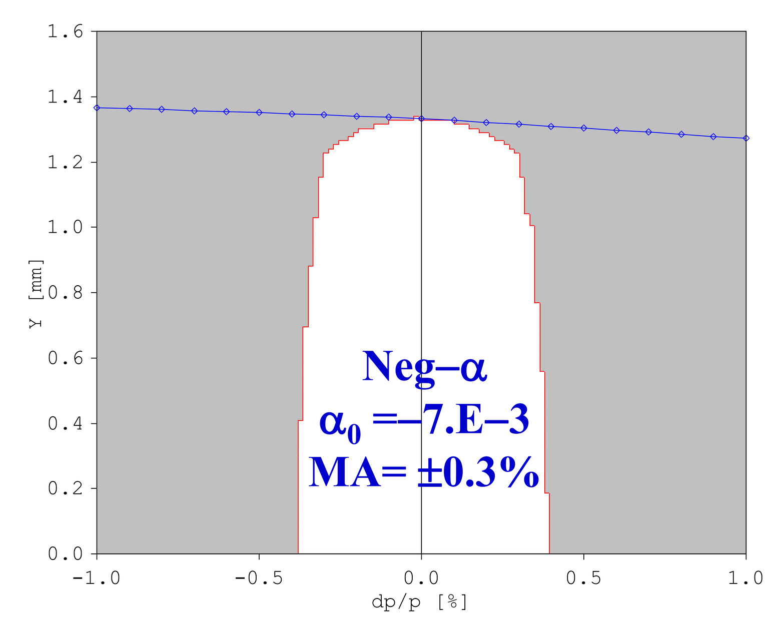
Parameter	User TME	Low–α	Negative–α
Comp.factor	$\alpha = +9\cdot10^{-3}$	$\alpha = +1\cdot10^{-4}$	$\alpha = -7\cdot10^{-3}$
Nat.emittance 0,5 GeV	2,4 nm·r	11,4 nm·r	18 nm·r
Nat.emittance 2,5GeV	58 nm·r	300 nm·r	460 nm·r
Dispersion	+0,1…0,7 m	–1…+1,4 m	±1,6 m
Natural width 0,5 GeV(rms)	σ_x=0,2 mm β_x=17 m	σ_x=0,5 mm β_x=22 m	σ_x=0,7 mm β_x=26 m
Inj.beam σ_x 0,5 GeV(rms)	σ_x=1,76 mm β_x=17 m	σ_x=2,03 mm β_x=22 m	σ_x=**2,3 mm** β_x=26 m
Natural width 2,5 GeV(rms)	σ_x=1,05 mm β_x=17 m	σ_x=2,7 mm β_x=22 m	σ_x=3,5 mm β_x=26 m

Momentum Acceptance at different operation modes









CONCLUSION

Ring performance, life time, beam current are essentially improved. Operation at negative compaction factor has been established and physical experiments are in progress [8]

REFERENCES

[1] E.Huttel et al. *Proc.PAC'05*, USA. (2005).
[2] A.Papash et al. "High Order Magnetic Field Components and Non-Linear Optics at the ANKA Storage Ring". *Proc. IPAC'17*, Copenhagen, Denmark, p.2586-2588 (2017)
[3] A.Papash et al. "Non-linear optics and low alpha operation at the storage ring KARA at KIT", *Proc. IPAC'18*, Vancouver, Canada, p. 4235-4238. (2018)
[4] A.Streun. "OPA–3.39". PSI User Guide (2012).
[5] D.Einfeld et al. *Proc. EPAC'98*, Stockholm, Sweden, p.2135-2137. (1998).
[6] P.Schreiber et al. "Status of operation with negative compaction factor at KARA". Proc. IPAC'19, p.878-881 (2019)
[7] A. Papash et al. Proc. IPAC'19, p.1422-1425 (2019)
[8] P. Schreiber et al, at this Conference
[9] A. Papash et al, at this Conference