LOW BETA STRUCTURE FOR THE ANKA STORAGE RING

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Abstract

The ANKA storage ring has a fourfold symmetry with a double DBA structure. Four (~1.7 m) straight sections are used for the RF and the injection. Four sections (~ 4.5 m) are used for insertion devices (three installed). The beta functions in these sections are 14 in horizontal and 7 m in vertical. This is not ideal for small gap (7 mm) insertion devices. Reducing the vertical beta function to 2 m is possible with the present magnet configuration and is done for special user operation. Reducing both the horizontal and vertical beta function is favoured for one foreseen beamline. This will afford a change of the present magnet configuration. Different options have been calculated and will be discussed.

INDRODUCTION

At the ANKA Synchrotron Radiation Source presently 13 beam lines are in operation, 12 of them at bending magnets; one with a wiggler source has an 11 mm NEG coated aluminium vacuum chamber. The foreseen ANKA upgrade will include two beam lines equipped with in-vacuum insertion devices with 7 mm gap, which will need a low vertical beta. Furthermore a low horizontal beta is in discussion for one of these beam line. An optics with a low vertical beta can be achieved with the present magnet configuration and it is in use for test of the installed in-vacuum superconducting undulator [1]. Having both a vertical and a horizontal beta can only be achieved with a new magnet configuration. Different options have been investigated: having a low beta in one, two or four sections. The linear optics have been calculated with BAD [2], the non linear optics with OPA [3]. The dynamic apertures were calculated with the vacuum chamber given as limits: In general +/-15 mm in the vertical, +/-35 mm in the horizontal and +/- 3 mm in the vertical for a 2 m long part for the low beta section. The chromaticities have been set to 1 in the horizontal and 3 in vertical. For better comparison the dynamic apertures given in the Figures are normalized to 10 m beta function both for the horizontal and vertical plane.

STANDARD OPTICS

The ANKA storage ring has a fourfold symmetry with a double DBA structure. Each DBA cell is build by two quadrupole doublets, two bends, two defocusing sextupoles one focusing quad and one focusing sextupole. The now used standard optics has distributed dispersion and is in use since 2004. The beta functions are shown in Fig.1 the main parameters are given in Table 1.

Table 1: Main parameters of the standard optics

Emittance	54 nm rad	
Tune h/v	6.72	2.69
Nat.chromaticity	-11.8	-7.8
Betas straight h/v	13.4 m	8.6 m

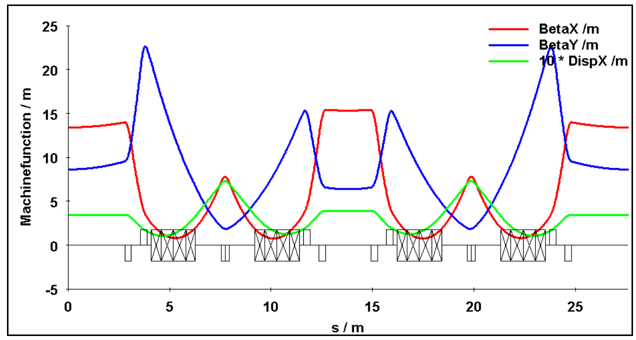

Figure 1: Beta function of the standard optics.

The dynamic aperture is shown in Fig.2, it differs from published data [4] due to the limitation of the vacuum chamber and the normalization to 10 m beta function.

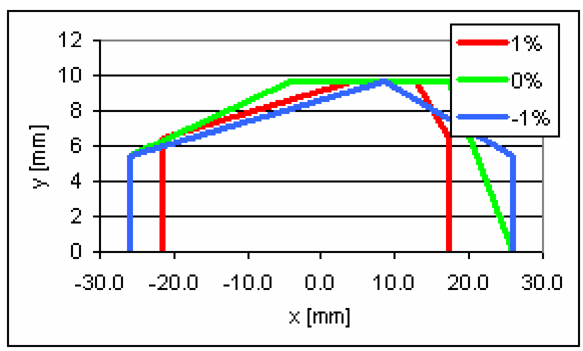

Figure 2: Dynamic aperture of the standard optics for different momentum deviations.

LOW VERTICAL BETA

The beta function for the 'low vertical beta' is shown in Fig. 3, the dynamic aperture in Fig.4, the main parameters in Table 2. As expected the dynamic aperture is reduced due to the 3 mm aperture. The higher value is due to the normalization from 2 to 10 m beta function.

Table 2: Main parameters of the low vertical beta optics

Emittance	53 nm rad	
Tune h/v	6.79	2.78
Nat.chromaticity	-12.6	-9.8
Beta straight	14.7 m	1.9 m

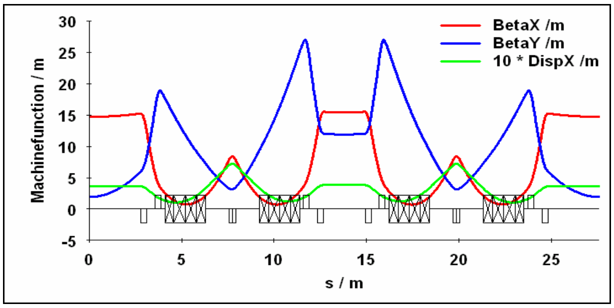

Figure 3: Beta function of the low vertical beta optics.

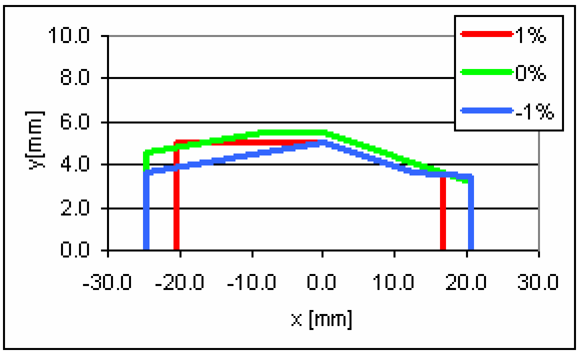

Figure 4: Dynamic aperture of the low vertical beta optics.

LOW BETA IN FOUR SECTIONS

The beta functions for horizontal and vertical low beta in four sections is shown in Fig. 5. The quadrupole doublet has been replaced by a triplet. Technically the magnets of the former doublets could be used for the outer magnets of the triplet. The dynamic aperture turned out to be unacceptable small, as can be seen from Fig. 6. The same is true for the momentum acceptance, as can be seen from Fig. 7. Working points with less focussing give a slightly better acceptance but at the expense of a larger emittance. The introduction of additional sextupoles in the long straight section also gave no considerable improvement. This option was limited due to the fact that the space for these magnets is only available in four sections. A solution with stronger quadrupole doublets had been investigated some time ago by G.K.Sahoo [5]. With a doublet the beta functions could not be adjusted independently; the achieved vertical beta was about 2 m, the horizontal at 0.3 m. Furthermore this option needed the exchange of the complete quadrupole doublets and the vacuum chambers in the straight section, including four chambers for the bend.

Table 3: Main parameters of the optics with four low betas

Emittance	63 nm rad	
Tune h/v	8.28	3.23
Nat.chromaticity	-18.6	-11.4
Beta straight h/v	0.8 m	0.8 m

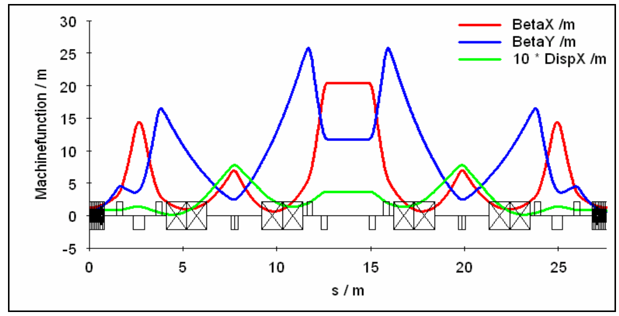

Figure 5: Beta function of the optics with four low betas.

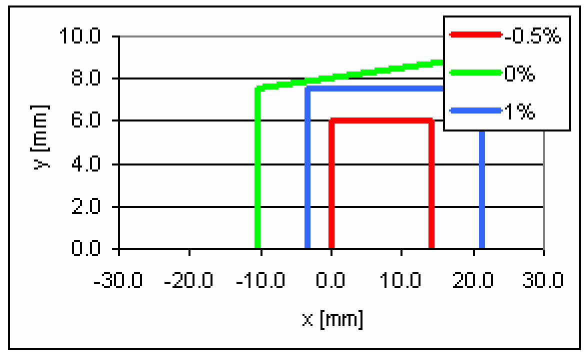

Figure 6: Dynamic aperture of the optics with low beta-functions in four sections.

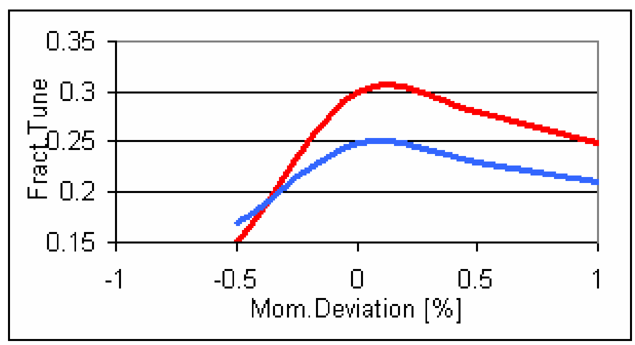

Figure 7: Momentum dependence of the tune for the optics with low beta in four sections.

LOW BETA IN TWO SECTIONS

The beta functions for horizontal and vertical low beta in two sections is shown in Fig. 8., the main parameters are given in Table 4. The dynamic aperture is still small compared with the standard optics but larger compared to the version with four low beta sections.

Table 4: Main parameters of the optics with two low betas

Emittance	63 nm rad	
Tune h/v	7.31	3.20
Nat.chromaticity	-13.7	-9.5
Beta straight h/v	1 m	1 m

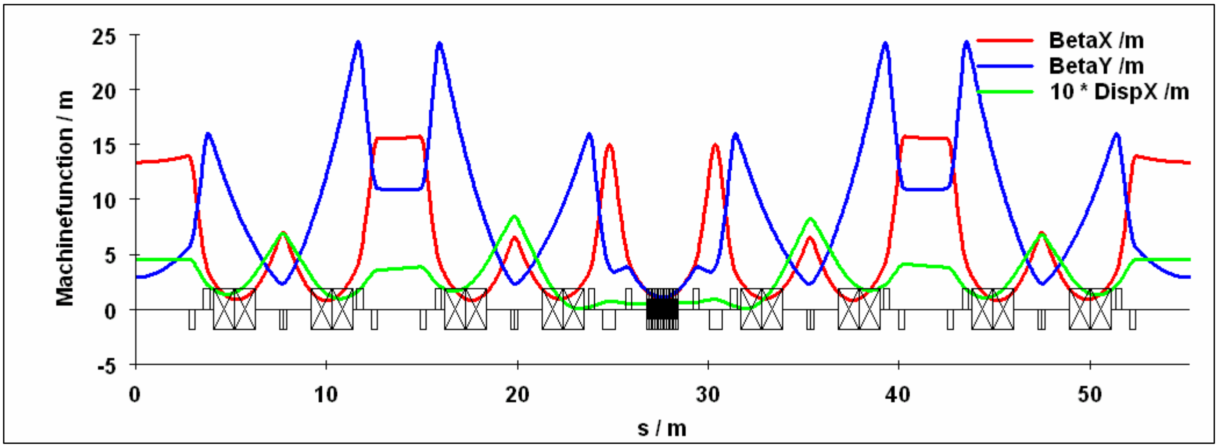

Figure 8: Beta functions of the optics with vertical and horizontal beta-functions in two sections.

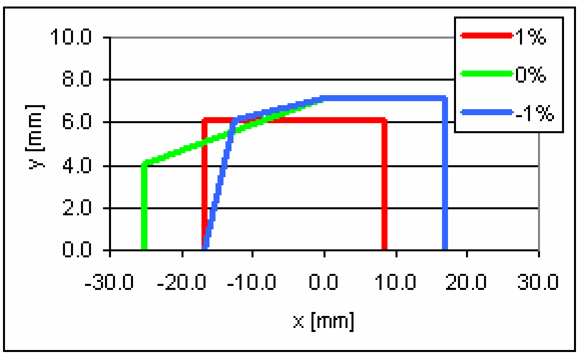

Figure 9: Dynamic aperture of the optics with low beta-functions in two sections.

LOW BETA IN ONE SECTIONS

The beta functions for horizontal and vertical low beta in one section look similar as the ones with low beta in two sections. The dynamic aperture is acceptable, as can be seen from Fig. 10; the same is the case for the momentum acceptance, shown in Fig.11.

Table 5: Main parameters of the optics with one low betas

Emittance	63 nm rad	
Tune h/v	7.31	3.20
Nat.chromaticity	-13.7	-9.5
Beta straight	1 m	1 m

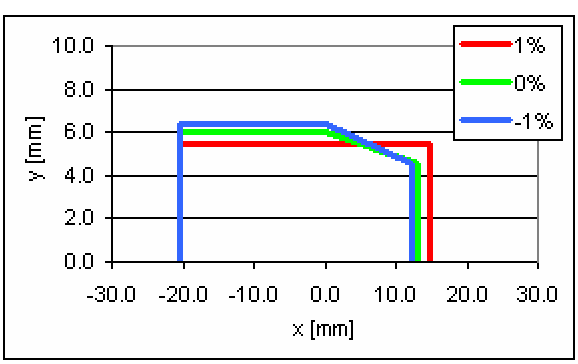

Figure 10: Momentum dependence of the tune for the optics with low beta-functions in one section.

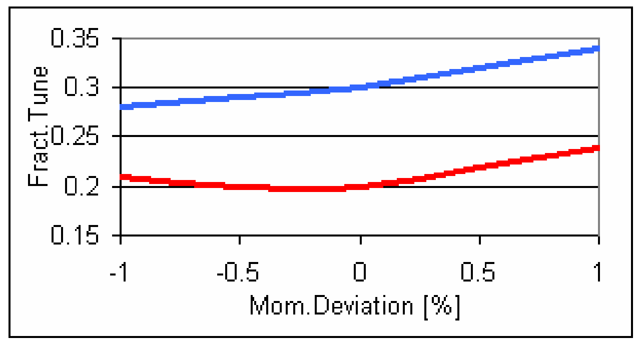

Figure 11: Momentum dependence of the tune for the optics with low betas-functions in one section.

INJECTION PROCESS

The injection process has also been investigated. At ANKA the orbit bump for the injection is extending over two achromats and is done with three small kickers. At least one section foreseen for a low horizontal beta is involved. Since a kicker in such a section is not practical, this kicker has been shifted within the triplet magnets. For the closed orbit a 20 mm bump at the septum position was calculated. An incoming beam with 1 mm rad horizontal and 0.2 mm rad vertical emittance was tracked. The incoming particles see the field of kicker 2 and 3 and are then oscillating within a given phase space before being damped by the synchrotron radiation. The present optics, the low vertical beta optics and the two fold low horizontal and vertical beta show only small losses at the septum, the four fold optics showed a severe reduction in intensity.

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