THE INJECTION SCHEME FOR THE ANKA STORAGE RING

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Abstract

Calculations show that the injection into the storage ring ANKA is optimal when three kickers distributed over one quadrant are used. The maximum deflection angle is 3.0 mrad resulting in a closed orbit deviation of 19 mm at the septum. The magnetic length of the kickers is 0.25 m. The septum is an active one positioned outside the vacuum. The tracking calculations based on DIMAD show that an injection efficiency of >90% can be achieved. The energy acceptance of the injection process is larger than 1%.

1 INTRODUCTION

ANKA is a 2.5 GeV synchrotron light source under construction at the research center Karlsruhe in Germany. The storage ring has a four fold symmetry with a double DBA-structure. The injector is a 500 MeV booster synchrotron with a 53 MeV racetrack microtron as pre-accelerator. One quadrant of the 110.4 m long storage ring together with the injection elements is shown in fig. 1. A parameter list of the ring can be found in the paper "Status of ANKA" in these proceedings [1].

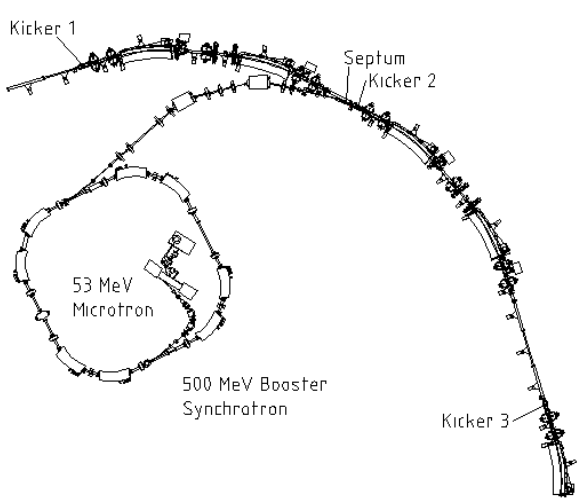

Figure 1: The injection geometry into ANKA

ANKA can operate with various optics. The calculations for the injection compare two of them, the so-called f- and h-optics [2]. The optic with the highest dynamic aperture is the f-optic and the optic with the smallest emittance is the h-optic. The optical functions for both optics are similar. The horizontal β-function at the injection point is 14.5 m for the f-optics and 19 m for the h-optics.

2 OPTIMIZATION OF THE INJECTION SCHEME

For the injection into the storage ring a compromise has to be found between the length of the orbit distortion around the injection point and the strength of the kickers. Both have to be as small as possible [3]. A short closed orbit distortion is possible with a four kicker injection scheme like in ELETTRA [4] etc. This is not favorable for ANKA. In order to keep the 4 long straight sections free for insertion devices and to reduce the number and the strength of the kickers a 3 kicker injection scheme similar to MAX II [5] has been chosen. The closed orbit distortion goes over ¼ of the storage ring and the kicker strength is moderate. The arrangement of the 3 identical kickers is shown in fig. 1 and the corresponding closed orbit distortion in fig. 2. The deflection angles for both optics are listed in table 1.

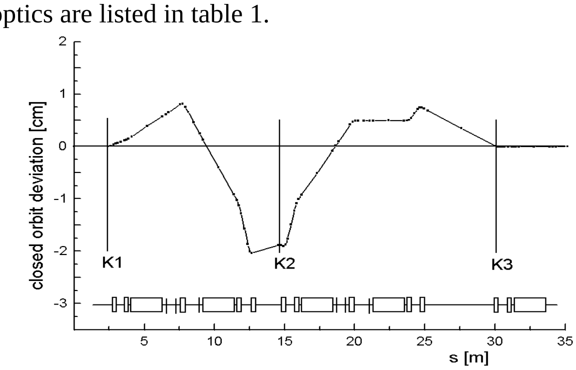

Figure 2: The injection bump with 3 kickers

Table 1: Kicker strength for f- and h- optics

	Unit	f-optics	h-optics
Kicker 1	mrad	1,26	1,27
Kicker 2	mrad	-2,06	-2,31
Kicker 3	mrad	1,4	1,53

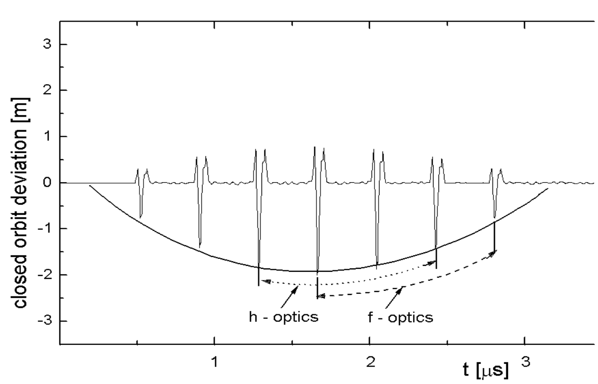

Figure 3: The time window for f- and h-optics

A kicker pulse length of 3 µs has been chosen. The time window in which the injection is possible is >1µs for both optics as shown in fig. 3.

The optimization of the injection is performed by using the tracking part of DIMAD [6]. The tracking takes the sextupoles into account. The emittance of the injected beam is 147 nmrad. The calculations are performed for 100 particles, distributed over ± 2σ.

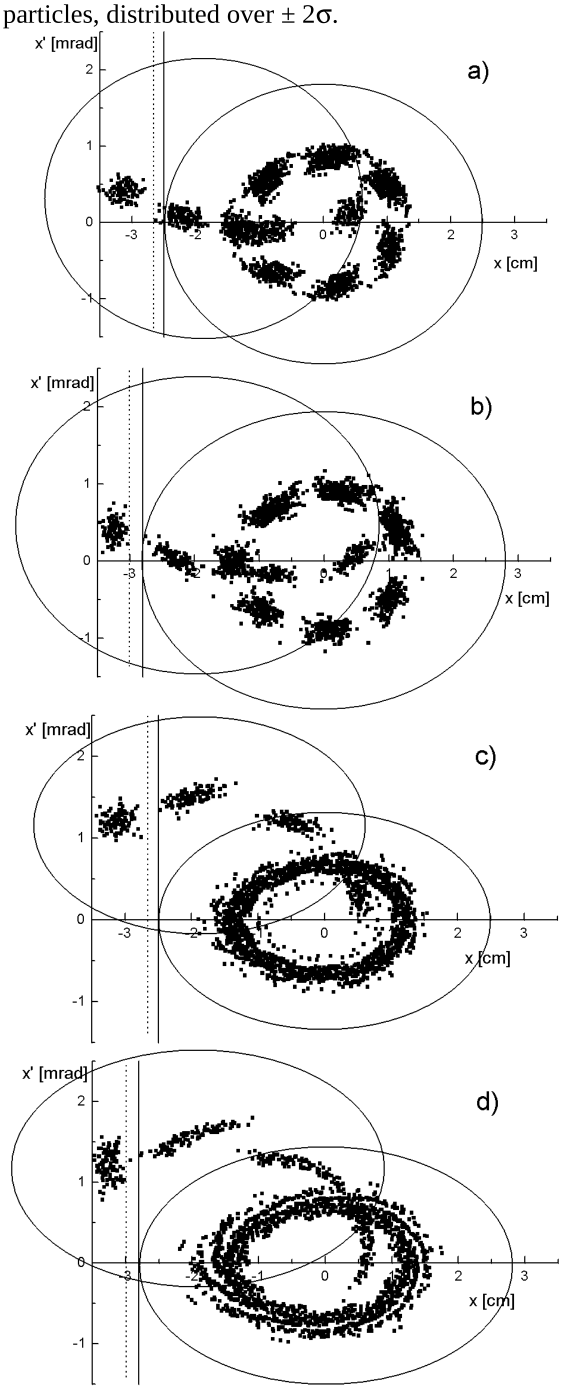

Figure 4: Injection into the storage ring ANKA for a) the f-optic in the case that the β-functions of the transfer line and the storage ring are identical = 14.5 m, b) as in a) but with a β-function of the transfer line of 7 m. c) as in a) but for the h-optic, β-functions are identical = 19 m and d) as in c) but the β-function of the transfer line is 7 m.

Fig. 4a) shows the tracking results for the f-optic when the horizontal β-function of the transfer line and the storage ring are identical. Fig. 4b) shows the tracking results when the β-function of the transfer line is 7 m. Fig. 4c) and 4d) shows the same calculations for the h-optics [7][8].

In order to have some kind of flexibility it is foreseen to make the septum moveable in horizontal direction by bellows on each end of the septum. For a β-function of 7 m for the transfer line the position of the septum sheet can be moved from 25 mm to 28 mm distance from the closed orbit. The injection acceptance for energy and angle was investigated. The results are summarized in table 2. The asymmetric motion in phase space of the incoming beam is due to the sextupoles (specially visible in fig. 5).

Table 2: Injection parameters and angle and energy acceptance for injection.

Machine optics	f		h	
β-function of the incoming beam [m]	14.5	7	19	7
Septum position [mm]	25	28	25	28
Particle start position [mm]	31	32.5	31	32.5
Kicker pulse length	Angle acceptance [mrad]			
2.2 µs	± 0.5	± 0.65	± 0.4	± 0.52
3.0 µs	± 0.45	± 0.6	± 0.35	± 0.45
3.7 µs	± 0.4	± 0.55	± 0.3	± 0.4
Energy acceptance	> ± 1% at 500 MeV			

An example of the calculations for the angle acceptance of the f-optics is shown in fig. 5. By increasing the injection angle the position of the beam after the first turn moves in the direction of the septum sheet and determinates the angle acceptance. With smaller angles the beam will blow up after injection. For an angle acceptance of ± 0.5 mrad the stability of the septum pulser must be better than $4 \cdot 10^{-3}$.

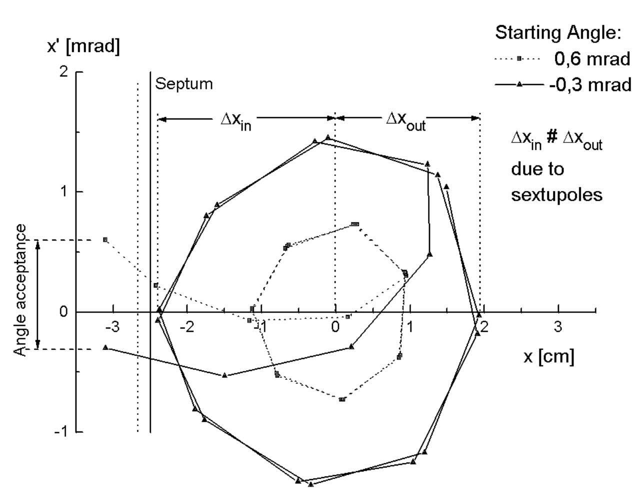

Figure 5: The angle acceptance of the injection

The energy acceptance of the injection scheme is larger as ±1% as shown in fig. 6. For an incoming beam with $\Delta E/E = 0.1\%$ this is sufficient.

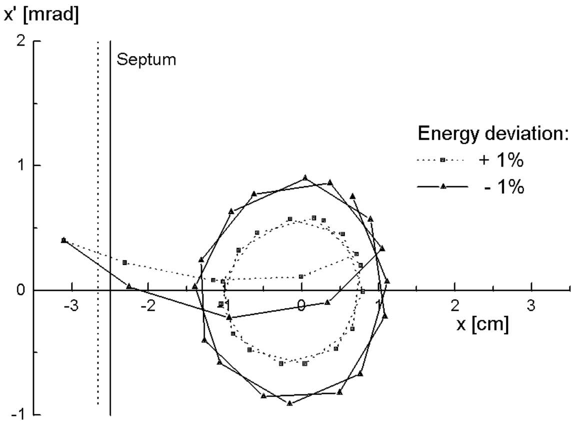

Fig. 6: The calculated energy acceptance for injection

3 DESIGN OF THE INJECTION ELEMENTS

The kickers for ANKA are window frame types with 15mm ferrite and a Ti coated ceramic vacuum chamber. The layout of a kicker is shown in fig. 7 and the main parameters are summarized in table 3.

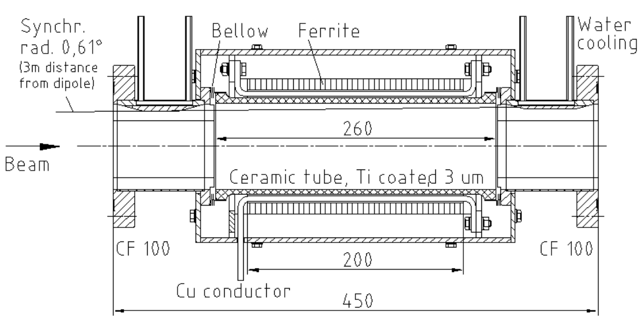

Fig. 7: Layout of the kickers

The septum is a directly driven (active septum) with a C-shaped magnet in air. The tube for the incoming beam and the stored beam join in a common flange. The technical layout of the septum is shown in fig. 8. The main parameters are listed in table 3.

Table 3: Parameter for kicker and septum

Parameters	Unit	Kicker	Septum
Deflection angle	mrad/ °	3 mrad	15 °
Max. magn. Field	mT	25	830
Magn. Length	mm	245	522
Magn. aperture	mm²	106x45	11x25
Pulse length	µs	3	250
Pulse		half sine wave	
Current	kA	0,9	7,3
Inductivity	µH	1	1,5
Capacity	µF	1	1500
Voltage	kV	1,2	0,2

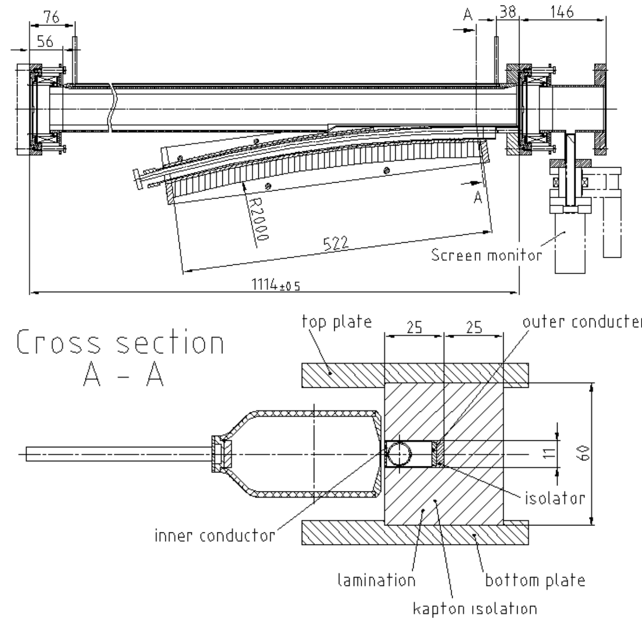

Fig. 8: Layout of the septum

4 CONCLUSIONS

With the foreseen injection scheme it should be possible to obtain an injection efficiency >90%. The energy acceptance as well as the timing window are sufficiently large. The most critical point is the angle acceptance of ±0.5 mrad. To obtain stable injection the septum pulser must have a stability of $4 \cdot 10^{-3}$. Similar to the results published by Tazzari [8] a miss match of the horizontal β-function of the transfer line and the storage ring improves the injection into ANKA.

ACKNOWLEDGMENTS

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