ANKA-STATUS OF THE 2.5 GeV SYNCHROTRON LIGHT SOURCE AT FORSCHUNGSZENTRUM KARLSRUHE

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Abstract

ANKA, a 2.5 GeV synchrotron light source will be built within the next three years at the Research Centre Karlsruhe, Germany. This source is dedicated to the fabrication of microstructures (LIGA-technique) and X-ray analysis. With four double-DBA structures, a magnetic field of 1.5 T and a circumference of 110.4 m, an emittance of 39 $nm \cdot rad$ can be reached. ANKA has four long (6 m) straight sections for the installation of insertion devices. Additional four short (2.2 m) straight sections host the injection scheme, four ELETTRA-type cavities (two cavities per section) and one short insertion device. The RF power will be provided by two 250 kW klystron. The pre-acceleration will be done with a 22-50 MeV linac or microtron. As injector a 500 MeV booster synchrotron with a repetion rate of 3 to 10 Hz is foreseen. The ramping from 0.5 GeV to 2.5 GeV will be done in around one minute.Eleven out of thirty-two available bending magnet radiation ports will be equipped with beam lines in the first phase.

1 INTRODUCTION

Fabrication of microstructures by X-ray deep lithography (XRDL), galvanoforming, and plastic molding (German acronym LIGA) has made its way from Forschungszentrum Karlsruhe to many labs throughout the world. ANKA is designed to satisfy the needs of XRDL as well as of X-ray analysis, in particular, of microstructures. Industrial demand of service in both fields will play a major role for ANKA [1]. After the approval of ANKA in March 1996 a redesign of the storage ring has been done and the design of the main components has been finished. At present, a call for tender for the main components (injector, magnets, power supplies, vacuum-system, and rf-system) is under way and it is assumed that the first contracts for the production of some components can be placed in June 1997. According to the time schedule the first beam should be stored at the end of 1999.

2 LATTICE OF THE ANKA STORAGE RING

As mentioned in earlier papers [2],[3], the lattice of ANKA is a double DBA-structure with a fourfold symmetry. The leading design principles were to build a light source which

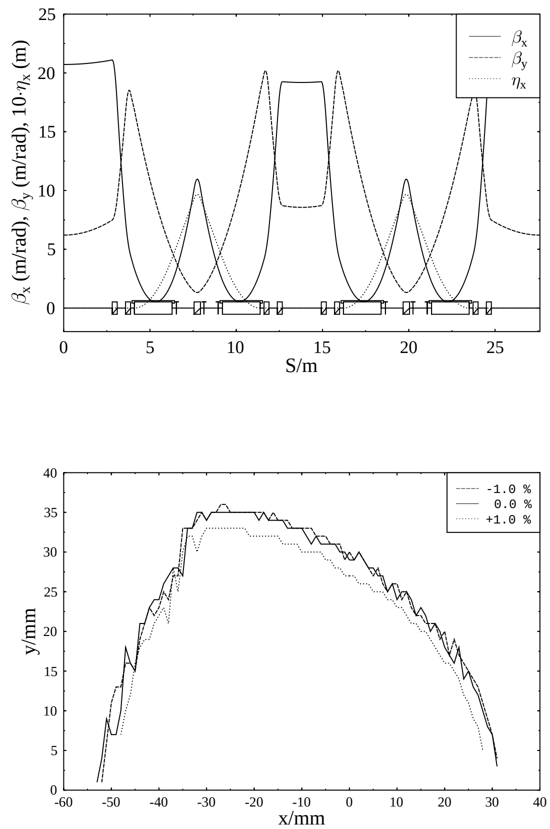

Figure 1: Behaviour of the machine functions within one quadrant of the ANKA storage ring: a) Upper figure: optics A with achromatic arcs, b) Lower figure: dynamical aperture of the ring.

is relatively small and has a low emittance; two conditions which are usually in contradiction. The original design contained only four straight sections of 5.6 m length each, one of which was used up for injection. To get more space for insertion devices, a redesign was made, increasing the circumference to 110.4 m. ANKA now has four long straight sections (6 m) and four short straight sections (2.2m). The layout of the storage ring is presented in fig. 2. The long straight sections are foreseen for insertion devices with the possibility to insert some more quadrupoles for getting a mini-beta section [4] in a later stage. The short straight sections will be used for the injection, for the in-

Table 1: Main parameters of ANKA for both optics. * Upgrading at a later time.

Achromatic structure		DDBA	
Number of unit cells	4		
Nominal energy (GeV)	E	2.5	
Circumference (m)	C	110.4	
Beam current (mA)	I	200 (400*)	
Coupling factor	c	0.02	
Betatron tunes	(Q_x/Q_y)	7.10/3.15	
Nat. energy spread	dE/E	$9.1 \cdot 10^{-4}$	
Version		η=0.0	$\eta \neq$0.0
Emit. $(nm \cdot rad)$	$\varepsilon_x/\varepsilon_y$	73/1.5	39/0.8
Nat. chromaticity	ξ_x/ξ_y	-17.3/-7.7	-16.7/-7.6
Mom. com. factor	α	$0.81 \cdot 10^{-3}$	$0.91 \cdot 10^{-3}$
Beta func. (m/rad)			
– straight sections	β_x/β_y	20.0/7.00	18.0/7.00
– bending magnets	β_x/β_y	0.56/12.4	0.55/10.6
– Maximum value	β_x/β_y	20.4/19.6	18.5/19.8
Disp. funct. (m)			
– straight section	η_{ss}	0.00	0.50
– bending magnet	η_{bm}	0.11	0.12
Source Size (mm)			
– straight section	σ_x/σ_y	1.2/0.10	0.95/0.07
– bending magnet	σ_x/σ_y	0.23/0.13	0.18/0.09

stallation of the four rf-cavities (two cavities in one section) and a short insertion device.

The machine functions within one quadrant are presented in fig.1. At the working point $Q_x = 7.10/Q_y = 3.15$ the conventional DBA-lattice (optics A - fig. 1a) results in an emittance of 73.4 $nm \cdot rad$. By decreasing the strength of the quadrupole within the dispersive section one gets an optics with a distributed dispersion function (optics B). The minimum of the dispersion is now in the bending magnets, which leads to an emittance of 39 $nm \cdot rad$. The lattice can be shifted from one optics to another by keeping the working point constant. Because the dynamic aperture is larger for optics A (presented in fig 1b) than for optics B, it is planned to accumulate the beam and ramp the energy from 500 MeV to 2.5 GeV with optics A and switch to optics B at nominal energy. The main parameters for both structures are given in table 1.

3 COMPONENTS OF THE STORAGE RING ANKA

3.1 Magnets

The first design of the ANKA magnets has been presented at the EPAC 96 [5]. During the redesign of the bending magnets the pole profile has been changed in order to get to higher fields. Now it should be possible to run the magnets with a maximum field of 1.65 T. The nominal field is 1.5 T. For the quadrupoles and the sextupoles only the pole shape has been changed in order to have parallel coils, which should be cheaper for the production.

3.2 Vacuum System

The vacuum chamber with a height of 32 mm and a width of 70 mm will be made of stainless steel. An in situ bake out is not foreseen. Most of the synchrotron radiation will be absorbed by discrete absorbers (two per bending magnet) in ante chambers. Here 500 l/s and 300 l/s diode pumps will be installed. The pumping will be done with a total nominal pumping speed of 18800 l/s and 13000 l/s, respectively, at 10^{-9} mbar. Pressure profile calculations show that the foreseen pumping speed should be sufficient to obtain a pressure of $3 \cdot 10^{-9}$ mbar, necessary to get a lifetime of more than 12 h. More details of the vacuum system are presented in a seperated paper of this conference [6].

3.3 RF System

The rf system consists of four cavities and two 250 kW klystrons. With an installation of a rf power of 500 kW it is possible to accelerate a beam of 400 mA with an overall cavity voltage of 3.2 MV. This leads to an overvoltage factor of q = 5 with an energy acceptance of 2 $\%$ for the klystrons. A power supply with 50 kV and a current of 16 A is needed. Within this scheme the input has to stand a power of 120 kW. The intention is to use the cavities and the input couplers designed at ELETTRA[7]. A test performed recently at DESY showed that the ELETTRA input coupler can withstand a power of more than 130 kW.

3.4 Injector

The injector at ANKA consists of a 20 - 50 MeV preaccelerator, a 500 MeV booster synchrotron and the two transfer lines. As preaccelerator a microtron or linac can be used. For the booster synchrotron we investigated both a weak focusing and a strong focusing machine. Both types have some advantage and disadvantages. They are discussed in a separated paper [8] at this conference. For the ANKA project it is foreseen to buy the whole injector as a turn key machine from industry.

3.5 Control System

The design of the ANKA control system [9] is based on standard industry components. A minimum number of different hardware interfaces will be allowed. PCs are used as consoles and servers. The operating system is Windows NT. Graphical applications will be implemented in Java in order to fully benefit from Internet and WWW products and technologies. Communications, run-time databases and objects will be supported by the control system platform TACO [10] that has been developed by the ESRF. Currently, several field buses, which will connect PCs to controlled equipment, are being investigated. As of now, preference is given to LonWorks. Both TACO and LonWorks have been evaluated and proven to meet the needs of ANKA.

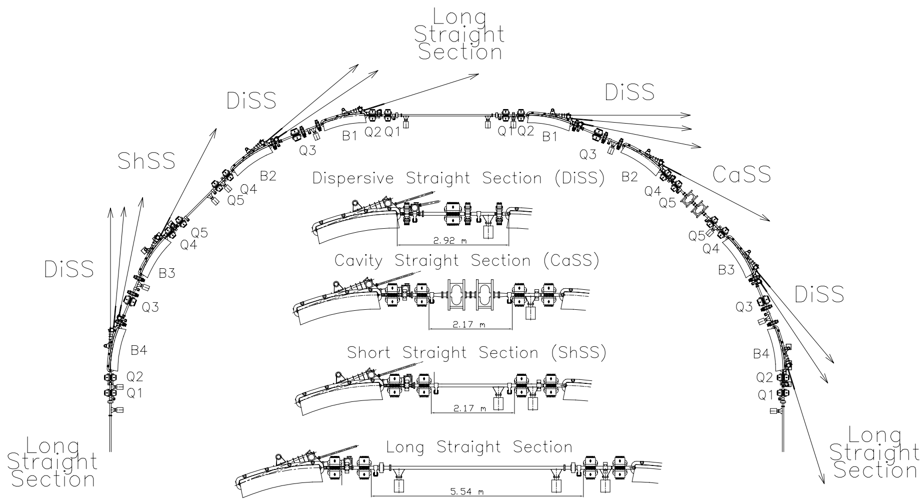

Figure 2: Layout of half of the storage ring ANKA.

Table 2: The beamlines to be built in first phase of ANKA

	Method	Industrial application
1-3	X-ray deep lithography	Microfabrication
4	Absorption, diffraction	Catalysts, chemical analysis, electrochemistry
5	Diffraction	Macromolecular crystallography, powder & single crystal diffraction
6	XUV spectromicroscopy	Mesoscale microscopy, absorption spectroscopy of light elements
7	(F)IR spectro- & micro-scopy	Chemical analysis
8	Fluorescence	Trace analysis (wafer)
9	Topography	Crystal quality (wafer)
10	SAXS, Tomography	Polymers, morphology of irregular structures
11	Roentgenography	Stress & strain, morphology, texture

3.6 Beamlines

11 beamlines, as presented in table 2, are planned to be built in the first phase. They cover X-ray deep lithography in the framework of LIGA technology and related methods in microfabrication, and include important analytical methods.

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