STATUS OF THE 2.5 GeV STORAGE RING ANKA

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Abstract

ANKA (Ångström Source Karlsruhe) is a 2.5 GeV synchrotron light source under construction at the Research Center Karlsruhe (FZK), Germany [1]. This source is dedicated to the fabrication of microstructures (LIGA-technique) and X-ray analysis. It has a circumference of 110.4 m and a variable emittance of minimum 50 nm rad. ANKA has four long (6 m) and four short (2.2 m) straight sections. One short section is used for the injection and two are used for the RF cavities. One short section and the four long sections can be used for the installation of insertion devices. The injector is a 53 MeV microtron and a 500 MeV booster synchrotron with a repetition rate of 1 Hz.

Keywords: storage ring,, booster synchrotron, magnets, vacuum, radio frequency, control system

1. INTRODUCTION

ANKA is a light source tailored to the fabrication of microstructures by lithography, a technique which made its way from the Research Center Karlsruhe to many laboratories throughout the world. ANKA was approved in March 1996. Since that time all components of the accelerator were prototyped and after acceptance ordered. According to the time schedule the first beam should be stored at the end of 1999.

The main parameters of the storage ring are summarized in table 1. ANKA has a four fold double DBA structure, shown in figure 1. One possible optics for one quarter of the ring is shown in figure 2. The machine can be operated with zero dispersion in the long straight sections (horizontal emittance about 80 nm mrad) or a dispersion of 0.5 m in the long straight sections (horizontal emittance about 50 nm mrad). During the first operation period the machine will operate without insertion devices.

Table 1: Parameter List of the ANKA Storage Ring

Parameters	Unit	Value
Circumference	m	110,4
RF-frequency	MHz	500
Harmonic number		184
Injection energy of particles	MeV	500
End energy of particles	GeV	2,5
Electron beam current	mA	400
Relative energy spread		$0{,}91 \cdot 10^{-3}$
Horizontal emittance ($D_x^* = 0$)	nmrad	76
Horizontal emittance ($D_x^* = 0{,}5$)	nmrad	46
Horizontal tune		7,15
Vertical tune		3,15
Horizontal chromaticity		-17
Vertical chromaticity		-8
Momentum compaction factor		$0{,}8 \cdot 10^{-2}$
Horizontal damping time	μs	2,9
Vertical damping time	μs	3,0
Longitudinal damping time	μs	1,5

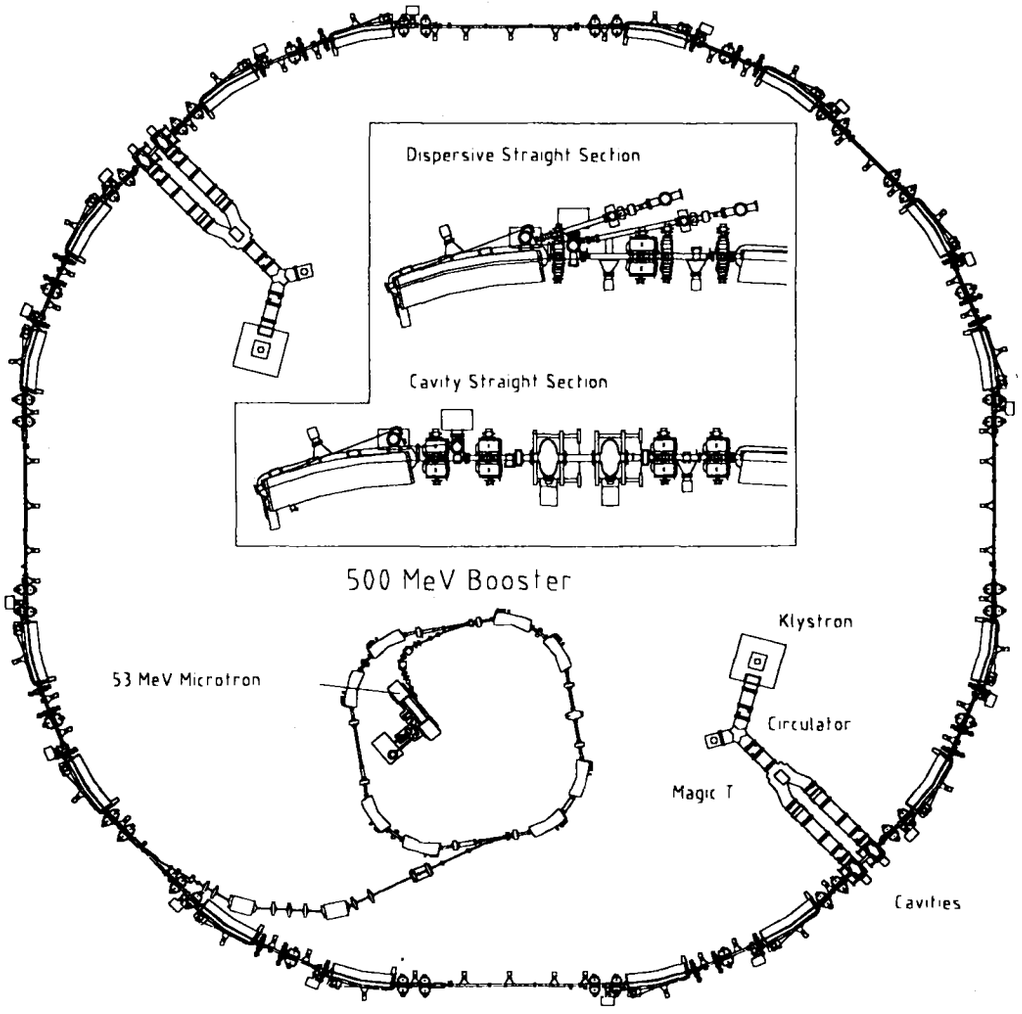

Figure 1: Layout of the ANKA storage ring

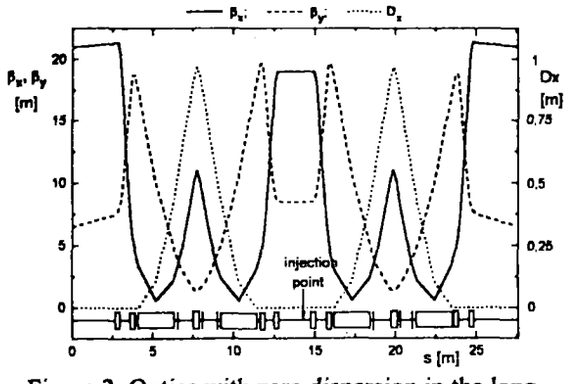

Figure 2: Optics with zero dispersion in the long straight section

2. INJECTION

The injector consists of a 53 MeV racetrack microtron and a 500 MeV booster synchrotron (repetition rate 1 Hz). [2].

Table 2: Parameters of the booster synchrotron

Parameters	Unit	Value
Horizontal tune		1.87
Vertical tune		1.29
Horizontal beta function	m	0.8-6.0
Vertical beta function	m	1.7-9.3
Horizontal dispersion	m	0.9-1.8
Momentum compaction		0.27
Horizontal emittance	mm mrad	0.15

A family of quadrupoles is focusing horizontally and vertical focusing is provided by the pole faces of the dipole magnets. The maximum stored beam is 15

mA. The acceleration is done with a 500 MHz RF cavity fed by a 200 W solid state amplifier.

3. MAGNETS

The magnetic lattice of the ANKA storage ring consists of 16 dipoles, 40 quadrupoles divided in five families, 24 sextupoles divided in two families, with a maximum second order differential of 600 T/m^2, and 44 correctors with a maximum kick strength of 0.8 mrad. Table 3 shows the main parameters for the magnets [3].

Table 3: Main parameters for the magnets of the storage ring

Parameter of the Dipoles	Units	Dipole	
Number of magnets		16	
Bend angle	Degree	22.5	
Bending radius	m	5.559	
Magnetic flux density	T	1.5	
Effective magnetic length	mm	2183	
Gap height	mm	41.0	
Nominal current	A	680	
Nominal power	W	18000	
Parameter of the Quadrupoles	Units	Q320	Q390
Number of magnets		32	8
Nom. Magnetic strength	m^{-2}	2.17	2.14
Nom. Field gradient	T/m	18.10	17.85
Effective magnetic length	mm	320	390
Nom. Integrated gradient	T	5.79	6.96
Aperture radius	mm	35	35
Nominal current	A	362	300
Nominal power	W	2725	2367

4. VACUUM

The design of the vacuum chamber of ANKA follows the ante chamber concept of recently built SR sources [4]. The e-beam chamber is 70 mm wide and 32 mm high. The vacuum chambers are made of stainless steel 316 LN with a wall thickness of 3 mm. The chamber has supporting ribs in order to reduce the deformation to less than 0.5 mm, when evacuated. The deposited power of 40 W/mm leads to a maximum wall temperature of the absorbers of 250°C.

After 1000 Ah operation time a pressure of 3 10^{-9} mbar can be achieved. The resulting lifetime which is mainly determined by the scattering of the electrons by the residual gas is more than 12 h.

5. RF SYSTEM

The RF system has been designed for a beam current of 400 mA. The parameters of the RF system are listed in Table 4 [5].

Table 4: Parameters of the RF System

Parameters	Symbol / Unit	Value
Frequency	f_{RF} [MHz]	499,652
Energy loss per turn	ΔE [keV]	670
Cavity voltage	U_{cav} [kV]	600
Synchrotron frequency	f_s [kHz]	41,8
Synchronous phase	Φ_s [°]	164
Energy acceptance	$(\Delta E/E)_{max}$ [%]	1,5
Bunch length	σ_ε [mm]	9,8
Over voltage factor	q	3,6
Number of cavities	N_{cav}	4
Shunt impedance	R_S [MΩ]	3,4
Cavity quality factor	Q_0	≥ 40.000
Coupling factor	β	3,5
Power per cavity	P_{cav} [kW]	53

6. THE CONTROL SYSTEM FOR THE ACCELERATOR

The control system [6] is designed to use existing intranet/internet infrastructure and web technologies on the three-tier standard model architecture.

The LonWorks field bus network is used with ring intelligent nodes and standard I/O modules to connect the individual devices directly to PCs that run device servers under Windows NT.

7. TIME SCHEDULE

October 1998 : Building for ANKA completed
January 1999 : Infrastructure completed
June 1999 : Begin commissioning of the injector system
October 1999 : Begin commissioning of the storage ring
January 2000 : First stored beam in the storage ring
August 2000 : Start of first experiments with synchrotron radiation

8. REFERENCES

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