STATUS OF THE 2.5 GeV LIGHT SOURCE ANKA

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Abstract

The construction of the 2.5 GeV synchrotron light source ANKA is now completed. The injector, a 53 MeV racetrack microtron and a 500 MeV booster synchrotron made by Danfysik was installed in spring 1999, commissioning started in June and the specifications, 10 mA at 500 MeV, were achieved in December 1999 [1]. The magnets for the storage ring (16 dipoles, 40 quadrupoles, 24 sextupoles and 44 correctors) were measured and installed by May. The vacuum system (circumference 110.4 m, 95 ion pumps) was closed in August 1999. The two RF plants (one 250 kW klystron and two 500 MHz cavities, each) were delivered in April and August respectively. All power supplies were delivered by the end of August. The commissioning of the storage ring began in December 1999. Before Christmas more than 10000 turns were observed at 500 MeV. In June 2000 between 50 and 70 mA are routinely accelerated to 2.5 GeV. Ten front-ends have been installed and 8 complete beamlines should start to be commissioned by September 2000.

1 INJECTOR

The synchrotron light source ANKA has a 500 MeV injector delivered as a turnkey system by DANFYSIK [1]. The electrons are produced by a 70 keV electron gun. These electrons are accelerated by a 53 MeV racetrack microtron equipped with a 3 GHz linac. The pulse from the microtron has a length around 1-2 µsec and a current ranging from 6 to 10 mA. Repetition rate is 1 Hz.

The electrons are then transferred to the booster synchrotron using a septum magnet and a kicker. The booster consists of eight 45° dipole magnets. Four straight sections house the injection, the extraction elements as well as the RF cavity. Eight quadrupoles focus the beam in the horizontal direction. Vertical focusing is done by the edges of the dipole. There is one RF cavity, delivered by ELETTRA, which only requires 200 W of power. At the beginning of the booster commissioning 80 % of the beam was lost after injection. The reason was the high beam loading caused by the injected beam into the cavity. A fast feedback loop was installed which compensates for this beam loading effect and enables now the acceleration of up to 10 mA [2].

2 INJECTION into the STORAGE RING

Injection into the storage ring takes place at 500 MeV. The septa magnets for injection into the booster, extraction out of the booster and injection into the storage ring are of the same design. The magnet is in air with one turn coil around the vacuum chamber (active septum). The vacuum chamber is a thin tube with a cross section of 10x10 mm. For injection into the storage ring three kickers are used making a local bump extended over two achromats. These kickers consist of one coil with a ferrite window frame yoke in air and a ceramic vacuum tube. The parameters of the pulsed magnets are given in table 1.

Table 1: Pulsed Magnets Parameters

Parameter	Number	Unit
Septum		
B field	0.8	T
Current	7000	A
Gap	11	mm
Radius	2	m
Deflection angle	15	degrees
Half sine length	200	µsec
Kickers		
B field, max	0.025	T
Current, max	900	A
Gap	46	mm
Length	200	mm
Half sine length	3	µsec

3 MAGNETS

The ANKA storage ring has 16 C-type dipole magnets made by TESLA with a gap of 41 mm. The deviation of the integrated field is up to 5 10^{-3}, larger than specified, therefore some shunts will be implemented in the near future. Table 2 presents the main parameters for the magnets.

Table 2: Magnets Parameters at 2.5 GeV

Parameter	**Number**	**Unit**
Dipoles		
Field strength	1.5	T
Current	660	A
Bend angle	22.5	degrees
Gap	41	mm
Radius	5.559	m
Windings/coil	40	
Quadrupoles		
Gradient	18	T/m
Current	300/340	A
Iron length	355/285	mm
Bore diameter	70	mm
Windings/coil	26/30	
Sextupoles		
2nd Gradient	350	T/mm^2
Current	120	A
Iron length	120	mm
Bore	75	mm
Windings/coil	20/18	

Thirty two quadrupoles with an iron length of 285 mm are arranged as doublets and 8 quadrupoles with an iron length of 355 mm length are used in the achromats The layout of ANKA has been presented elsewhere [4].

The chromaticity is corrected with 16 vertical and 8 horizontal focussing sextupoles.

The quadrupoles and sextupoles were made by SIGMAPHI and had been delivered by the end of 1998. They had been measured at ANKA in spring of 1999 with a rotating coil [3] and found to be within specifications.

The quadrupole doublet is placed on one girder and the quadrupole of the achromat together with the sextupoles on another. The magnets are aligned on the girder by a machined V groove and an additional bar. A screw can adjust the tilting of the quadrupoles. The girders can be aligned horizontally by 3 struts (left, right thread) and vertically by three screws.

The main parameters of the power supplies are given in Table 3.

Table 3: Maximum power supply parameters

Parameter	**Current [A]**	**Voltage[V]**
Dipole	800	500
Quadrupoles	400	65/115
Sextupoles	230	65/115
Correctors, H	1	20
Correctors, V	2	55
Klystron	9	52000

4 RF SYSTEM

The RF system of ANKA consists of two plants, each one with two cavities. At each plant the power of a 250 kW klystron made by EEV is split into two by a magic tee. A circulator between the magic tee and the klystron protects the latter. 125 kW of RF power can be delivered into each cavity by a coupling loop. The cavity system [5] together with the complete low level electronic has been delivered by ELETTRA. After some conditioning, the specified cavity voltage of 600 kV could be obtained. The main parameters of the RF system are given in table 4.

Table 4: RF Parameters at 2.5 GeV

Parameter	**Number**	**Unit**
Frequency	499.65	MHz
Impedance	3.3	MΩ
Q-Factor:	40000	
Cavity voltage	4 x 560	V
Cavity power	4 x 50	kW
Beam power	4 x 62	kW
Bunch length	1	cm
Synchrotron frequency	42	kHz
Energy loss/ turn	622	kV

5 VACUUM SYSTEM

The vacuum system of ANKA [6] is made from stainless steel 316LN. The vacuum chambers in the region of the dipole and the adjacent quadrupole chamber have ante-chambers. Large ion pumps (16 x (500+300) l/s)) are installed in the ante-chambers to help the crotch absorbers to absorb 90% of the SR [7]. The remaining 10% of the SR is absorbed at the cooled outer side of the vacuum tubes of the straight section, which are pumped by 63 small ion pumps. There had been some worries that the high gas load due to SR induced desorption is too high to prevent an initial storing of the electron beam. Thus the 75 l/s ion pumps in the straight sections were upgraded to 150 l/s. By this the effective pumping speed at $2\ 10^{-9}$ mbar is increased from 40 to 60 l/s.

The vacuum chambers made by FMB had been baked, leak tested and the desorption rate and gas spectra had been measured at the factory. The desorption rate was found to be less than 10^{-12} mbar/(l sec cm^2). A system for in-situ baking has not been installed.

The vacuum system of the storage ring was pre-evacuated with turbo pumps up to a pressure of about $2\ 10^{-8}$ mbar. After starting the ion pumps a pressure of $2\ 10^{-9}$ mbar could be achieved within one month.

Eight Penning Gauges (Balzer) measure the vacuum pressure. In addition the current of each of the 95 ion pumps can be measured independently. The current of each pump is measured at high voltage and transmitted to ground by a current to frequency converter.

The vacuum of the storage ring can be separated into four sectors plus two RF sections using 6 gate valves delivered by PHITEC.

6 DIAGNOSTICS

For the diagnostic of the electron beam several components are installed:

- 6 fluorescent screens used to look for the first turn
- 1 current monitor from Bergoz
- 32 beam position monitors.
- 1 diagnostic beamline equipped with a CCD camera
- 1 diagnostic beamline equipped with a photo multiplier.
- 1 stripline (4 x 150 mm long electrodes)
- 1 scrapper to determine the physical vertical acceptance
- 1 annular electrode

The BPM's produced by METACERAM have a diameter of 10 mm. They are horizontally separated 20 mm (width of the vacuum chamber 70 mm, height 32 mm). They are welded into the vacuum chamber and are fixed to the girders of the quadrupoles. The electronics for the BPM had been designed at FZ Jülich and produced in co-operation with the Bonn University [8]. The four signals of one BPM are brought to a station nearby for multiplexing, filtering, demodulating, amplifying and digitalizing. Four BPM's are connected to a master station, which communicates with the control system.

The two diagnostic beamlines have a cooled 45° polished copper mirror 3 m from the source point followed by a vacuum window. At one beam line a photo multiplier is directly positioned on the window. In this way each turn of the electron beam can be observed separately, which was of great help at the beginning of the commissioning. At the second front-end a 300 mm lens images the electron beam to an intersection picture which is then magnified by a camera.

For the tune measurements two electrodes of the stripline connected in series and terminated by 50 Ω, are excited by 1-2 MHz from a spectrum analyser with tracking generator, amplified up to 10 W power. The response is measured with a dedicated BPM, placed one quarter of the storage ring away, the signal of which is amplified, filtered by 500 MHz and demodulated with a PIN diode before returned to the spectrum analyser.

7 BEAMLINES

Up to now only beam lines emerging from bending magnets are foreseen. Ten front ends have been installed, and eight beam lines will be completed within this year. Table 5 gives the main parameters for the beamlines.

Table 5 Main parameters of the beamlines

Beamline	Energy range [keV]
Lithography I	1 – 4
Lithography II	3 – 8
Lithography III	4 – 30
Diffraction	5 – 30
Protein crystallography	5 – 20
Fluorescence + Topography	1 – 30
Infrared	4 – 10000 cm^{-1}
Absorption spectroscopy	2.4 - 30

In addition the Max Planck institute from Stuttgart is installing a beamline for surface diffraction.

FMB delivered the front ends. OXFORD delivered all the beam lines except for the infrared beam line, which has been installed by BESTEC.

8 COMMISSIONING

Commissioning of the Storage Ring started in December 1999. At present we are routinely injecting between 50 and 70 mA at 500 MeV and ramping them to 2.5 GeV with a lifetime of around 3 hours. More details about the first results of the commissioning are given in reference [9]. The commissioning of the beamlines will start after summer.

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