COMMISSIONING OF THE ANKA STORAGE RING

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Abstract

ANKA is a 2.5 GeV synchrotron radiation facility built at the Forschungszentrum Karlsruhe that was approved in 1996 and it is now under commissioning. ANKA consists of a 500 MeV injector and a 2.5 GeV storage ring. The commissioning of the 2.5 GeV storage ring began in December 1999. Before the end of the year more than 10000 turns were observed at 500 MeV in the storage ring. After a shut down period of one month the first beam was accumulated in February 2000 and in March the energy was ramped up to 2.5 GeV. In April 100 mA were injected in the machine for the first time. Since then, the storage ring has been brought close to the design parameters, and routine operation in June means ramping 50-70 mA up to 2.5 GeV with a lifetime of 2-3 hours.

1 INTRODUCTION

The Synchrotron Radiation Source ANKA is a light source of second and half generation. It consists of a 500 MeV injector [1] and a 2.5 GeV storage ring [2]. The storage ring has a four fold symmetry, with eight double bends, four long (5.6 m) straight sections for insertion devices and four short straight sections (2.2 m). Of these one houses the injection and two others the RF cavities. The main parameters of the storage ring are given in table 1. The layout of the machine has been presented elsewhere [3].

The complete injector, consisting of a racetrack microtron and a booster synchrotron, was built and commissioned by DANFYSIK. The 53 MeV racetrack microtron was commissioned during winter 1998-99 at the factory; the 500 MeV booster synchrotron was commissioned during summer-autumn 1999 in ANKA. In December 1999 a beam of 8 to 10 mA was extracted from the booster at an energy of 500 MeV fulfilling the specifications. The repetition rate of the injection process is 1 Hz. The main problem to achieve the booster specifications was the heavy beam loading effect at injection that was underestimated in the design phase and that reduced considerably the amount of current that would be accelerated to 500 MeV. The implementation of a fast feedback loop [4] solved the problem.

Table 1: Parameters of ANKA at 2.5 GeV

Parameter		**Unit**
Energy	0.5-2.5	GeV
Circumference	110.4	m
Number of dipoles	16	
Dipole field	1.5	T
Number of quadrupoles	40	
Maximum gradient	18	T/m
Number of sextupoles	24	
Maximum gradient	520	T/m^2
Number of correctors, h/v	28/16	
Maximum kick strength, h/v	1/1	mrad
Momentum compaction factor	0.008	
Natural Chromaticity	-17/-8	
Energy spread	0.001	
Emittance	40-70	nm rad
Max. overvoltage factor	3.6	
Energy lost per turn	622	keV
Maximum RF voltage/cavity	560	kV
Photon critical energy	6	keV

2 COMMISSIONING OF THE STORAGE RING

Commissioning of the storage ring started the 7th of December of 1999. Because the beam lines were still being built and the work inside the ring was not yet completed the initial steps of commissioning took place in the evenings as well as during weekends. In addition the complete diagnostics were not yet available. The current monitor work in late February and the systems for measuring the tune and the BPM's in May 2000.

2.1 Injection into the Storage Ring

The beam extracted from the Booster is transferred to the storage ring via a 20 m long transfer line. The beam is horizontally injected into the storage ring from the inner side. Two bending magnets, 9 quadrupoles and 6 horizontal and vertical correctors take care of the matching of the beam between the booster and the storage ring.

A septum magnet bends the beam 25 mm away from the central orbit. Three kicker magnets create a closed orbit bump closed to the septum sheet. The bump is extended over two achromats, in this way the strength of the kickers is reduced considerably but the quadrupoles have a non negligible influence during injection.

2.2 First turns

To obtain the first turn 6 fluorescent screens were available. Also useful was a portable radiation dosimeter with which it was possible to determine were the beam was lost and adjust the magnets around this point.

On 13th of December tens of turns were observed in a photo multiplier that has been installed in one of the two diagnostic beamlines [2]. Before Christmas more than 10000 turns were recorded. The RF frequency at that time was 499.9 MHz instead of the nominal one 499.65 MHz. This could have made difficult to store a beam.

The storage ring was started again the 7th of February, after a shut down to complete some of the pending work. The same day, 10000 turns were again recorded, and on the 10th of February a beam of around 1 mA was stored for some hours, with the sextupoles off. Next step was to switch the sextupoles on. Then the stored beam was increased up to 20 mA at 500 MeV. The highest current that has been accumulated at 500 MeV until now is 100 mA.

2.3 Ramping

The 17th of March the beam was ramped to full energy. Due to the vacuum increase as the energy increases, only few mA were ramped in order to avoid a vacuum interlock at the RF cavities, set to 1 10^{-7} mbar.

After 10 Ah of accumulated dose 70 mA have been ramped and accumulated at 2.5 GeV, with a lifetime of approx. 3 hours.

During the first attempts of ramping the quadrupoles were adjusted in order to keep the beam stable as seen on a synchrotron light monitor. After the setting into operation of the tune measurement system, the quadrupoles were adjusted to keep a constant working point. No losses of the beam are observed during ramping.

Also the first attempts of correcting the closed orbit while ramping were performed very roughly and manually. The corrector settings at 500 MeV were directly scaled at the different energies. Still now we use the same procedure.

3 FIRST RESULTS

3.1 Tunes

The design values for the tunes are 6.85 and 3.25 for the horizontal and vertical tune respectively.

The tunes are measured by exciting the beam with a spectrum analyser with a tracking generator through a stripline and picking up the beam response in a dedicated BPM.

The working diagram during ramping is shown in figure 1. The tunes at injection have been selected as those that maximised the injection rate.

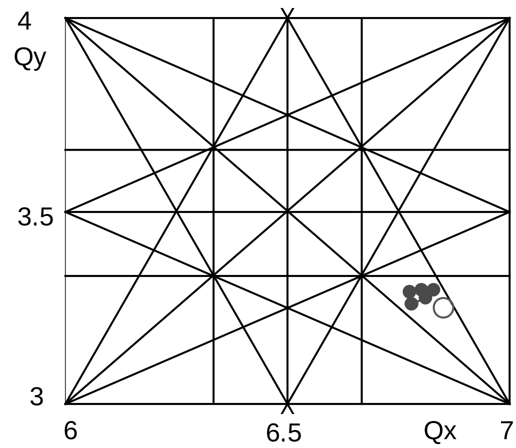

Figure 1: Working diagram during ramping

The chromaticitiy as a function of sextupole strength has also been investigated and found to agree with the expected values.

3.2 Linear Optics

Figure 2 shows the horizontal dispersion function along the storage ring for the storage ring in comparison with the calculated one. The agreement is very good. It was measured by changing the RF frequency and recording the closed orbit.

3.3 Closed orbit correction

Closed orbit correction relies on 32 BPM stations, 28 horizontal correctors and 16 vertical correctors.

The maximum kick available is ± 1 mrad in both directions.

The software for the closed orbit correction uses either a calculated or a measured response matrix for setting the correctors. Until now is not correctly working, thus the orbit is till now adjusted manually up to ± 1-2 mm. See figure 3.

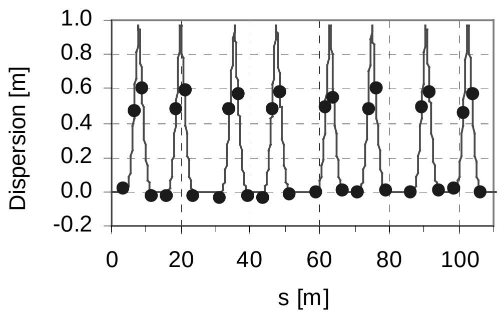

Figure 2: Dispersion function at ANKA

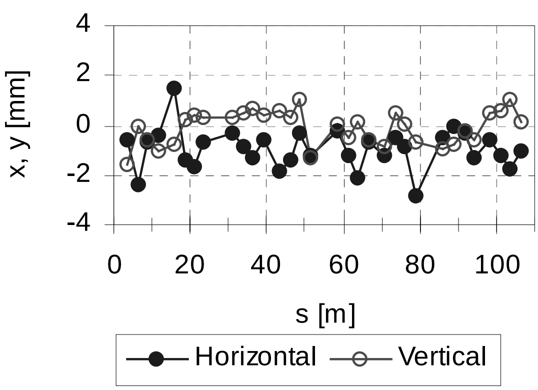

Figure 3: Closed orbit as measured by BPM’s

3.4 Vacuum and lifetime

In order to see if the glow discharge process was helpful in order to reduce the pressure as has been claimed at Brookhaven [5] two long sections of the vacuum chamber were glow discharged, while the rest were not.

When the first beam was stored (about 10 mA at 500 MeV) the pressure increased from $2\ 10^{-9}$ mbar to $5\ 10^{-8}$ mbar. This corresponds to a desorption coefficient of about $2\ 10^{-3}$ molecules/photon. Comparing the sections which had been glow discharged with those that have been not, no difference in pressure and gas composition could be observed. After a dose of 2 Ah (at 500 MeV) the water content was significantly reduced and the desorption rate decreased by a factor of two.

Since December 1999 the accumulated dose is 10 Ah, 5 Ah already accumulated at 2.5 GeV The mean pressure without beam is $1\ 10^{-9}$ mbar. At 2.5 GeV and with a current of around 50 mA the pressure increases up to $5\ 10^{-8}$ mbar.

A typical lifetime for the above beam is around 2-3 hours. Figure 4 shows the beam current decay.

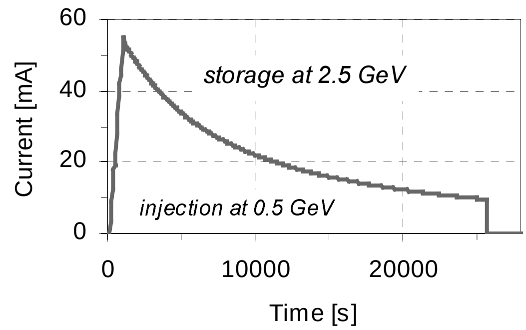

Figure 4: Stored beam intensity versus time

3.5 Current limitations

The maximum injected current has been around 100 mA. The limit is believed to be due to the presence of ions on the machine or to multibunch instabilities. Studies are being conducted in order to identify the source of problems, and a gap filling structure will be installed in the near future.

4 CONCLUSIONS

After 700 hours of effective commissioning the storage ring shows the expected behaviour. Next steps will include to start looking at the stability of the beam, as well as proceed with the commissioning of the beamlines.

During the present runs up to 50-70 mA are injected at 500 MeV and ramped to 2.5 GeV. Lifetime is typically 3 hours.

ACKNOWLEDGEMENTS

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REFERENCES

[1] L.Praestegaard et al., this conference, *Commissioning of the ANKA injector*

[2] D.Einfeld et al., this conference, *Status of the 2.5 GeV Light Source ANKA*

[3] D.Einfeld et al, EPAC’98, Stockholm, page 635

[4] F.Pérez et al., this conference, *Fast Phase Loop for beam loading compensation in the ANKA Booster*

[5] C.L.Foerster, Synchrotron Radiation News, 11 [1998] page 20