ANKA - OPERATION AND FUTURE PLANS

F. Perez, E. Huttel, M. Pont and R. Rossmanith
ANKA, Forschungszentrum Karlsruhe, P.O. 3640, D-76021 Karlsruhe, Germany

Abstract

ANKA, a 2.5 GeV storage ring for synchrotron radiation in Karlsruhe, delivers beam to ten bending magnet beamlines: an infrared (edge effect), three LIGA and several X-ray beamlines (absorption, diffraction, fluorescence, topography, protein crystallography and surface diffraction). Generally, there is one injection per day with a current of around 200 mA and a lifetime of more than 20 hours. Several machine improvements have been done during the last year: calibration of the BPMs by a Beam Based Alignment procedure, improvement of the orbit correction, studies of the cavity's HOM and introduction of new filling patterns. Unfortunately, an accident in one beamline has contaminated the storage ring vacuum chamber with Krypton. The system is slowly recovering, five weeks after the accident a beam current of 150 mA with a lifetime of 16 hours was stored. In the near future two insertion devices are going to be installed at ANKA: one planar undulator for soft X-rays and a wiggler for an environmental beamline A superconductor undulator is as well under development [1].

1 INTRODUCTION

ANKA is a 2.5 GeV synchrotron light source with an emittance of 90 nmrad. The beam is accumulated at 500 MeV in the storage ring and usually ramped up to 2.5 GeV. Special shifts for lithography are run at 1.3 and 1.8 GeV.

The ANKA storage ring has been running for beamline commissioning and user's runs for one year. At the same time some machine improvements have been introduced, which have led to a maximum stored current of 210 mA at 2.5 GeV with an orbit stability within ±20 µm.

2 BEAM BASED ALIGNMENT

Initially the orbit correction algorithm (SVD) was not able to correct the orbit better than 0.4 mm rms, indicating that the BPMs were not properly aligned with respect to the centre of the quadrupoles. It was then decided to calibrate the BPMs performing a Beam Based Alignment (BBA) procedure.

At ANKA, the quadrupoles are grouped in five families and each family is fed by a single power supply. For the BBA each quadrupole should be individually excited and the distortion on the beam orbit observed. This was achieved by connecting a small power supply with a floating output in parallel to a quadrupole. An array of relays allows switching between each quadrupole. The distortion on the beam orbit is minimum when the beam crosses the centre of the quadrupole.

The following procedure is used. First, each BPM is associated to a quadrupole on its vicinity. Then, a bump is performed at the position of the quadrupole. When an extra current is given to the coils, a beam crossing off-centre the quadrupole feels a kick and the orbit is distorted. The rms value of this orbit distortion is then recorded and the procedure repeated for different bumps. The rms distortion versus the bump strength given by the BPM reading is fitted to a parabola and the minimum is taken as the centre of the quadrupole in reference to the BPM, see figure 1. The process is done manually and the quadrupole positions are determined with an error of ±50µm.

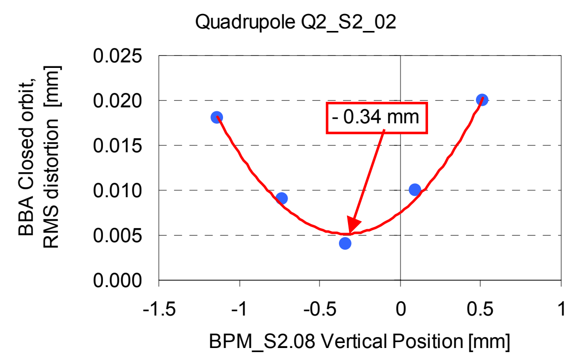

Figure 1: Determination of the centre of the quadrupole in reference to the BPM reading.

We found offsets of 1.2 mm in the vertical and 1.7 mm in the horizontal positions (0.07 and 0.15 mm rms). The results are then used in the calibration of the BPMs. With the new calibration we are able to reproduce and maintain the orbit within ±20 µm rms vertical and ±80 µm rms horizontal.

3 CLOSED ORBIT CORRECTION

Already at the first runs, we observed that the orbit was drifting as much as 150 µm over a 24 hours period as can be seen in figure 2.

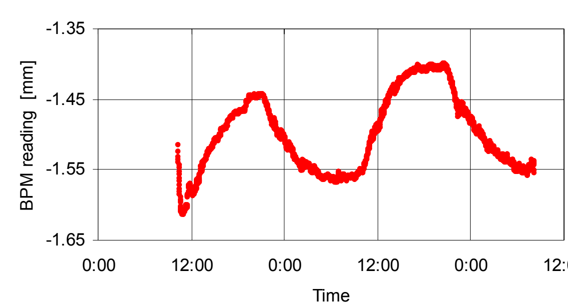

Figure 2 Drifting of the horizontal orbit over two days at BPM_S4.04

We assume it is related to some temperature drift in the hall, water or elsewhere; in any case, after the implementation of an automatic closed orbit correction program the orbit can be kept within ±20 µm.

4 CAVITY'S HOM CHARACTERISATION

In order to have a good control of the beam stability, the dependence of the HOMs of the cavities as a function of the cavity's temperature and their influence on the beam was investigated.

A 100 mA at 2.5 GeV beam was stored, the temperature of a cavity changed and the beam stability observed with a spectrum analyser attached to a strip line

In figure 3, we can see the spectrum of a stable beam and the one of a beam excited by a longitudinal instability. We could not observe any transversal mode in the temperature range investigated.

After sweeping the temperature on the four cavities of the ANKA storage ring we have found a frame, which allows us to set the cavities to a "stable" or "unstable" temperature, see figure 4.

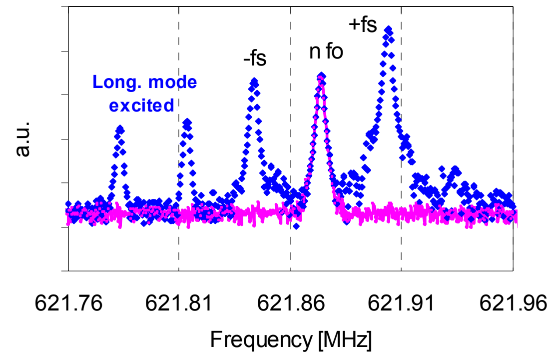

Figure 3: Stable beam (pink line) versus longitudinally excited beam (blue dots).

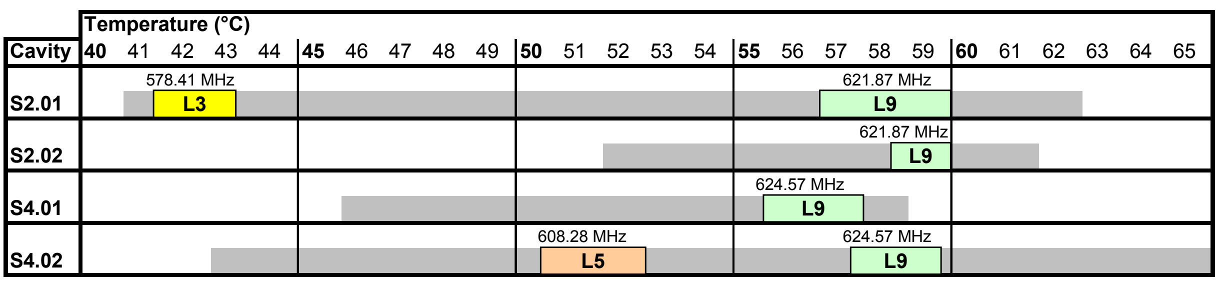

Figure 4: Beam stability windows (grey) of the temperature cavity settings at 2.5 GeV. Also shown are the temperature intervals with excited modes L3, L5 and L9.

5 BEAM STABILITY INVESTIGATION

The maximum current at injection was limited in the past to 170 mA with the onset of vertical oscillations, which generally severed the tail of the bunch train. A train of 25 bunches (184 bunches correspond to a completely filled ring) is coming from the booster. In the past, three connected trains were filled, leaving a gap of around 2/3 of the ring. It turned out that the accumulated current could be increased to over 220 mA when a small (10 ns) gap was introduced between the three trains.

It should be mentioned that most of the transversal stabilisation is achieved by exciting a longitudinal mode in one of the cavities.

The change of emittance and energy spread during injection has been obtained using two synchrotron light monitors in the visible range, one on a zero dispersion point and another on a dispersion one. The beam profiles on both monitors were analysed and the energy dispersion and emittance extracted. For that the measurement of the beta and dispersion functions is needed.

We measured the beta functions at the position of each quadrupole by exciting each of them individually with the same PS used in the BBA, see figure 5. The dispersion was measured at the BPMs position by changing the frequency [2]. A fit of the machine functions was done and the values at the SLM points were used.

Figure 6 shows the emittance and energy spread as a function of bunch current during injection. The linear increase of the emittance is due to the intrabeam scattering. The behaviour of the energy spread is more complicated due to the present of both, the microwave instability and the HOM longitudinal instability that at such low energy cannot be totally damped.

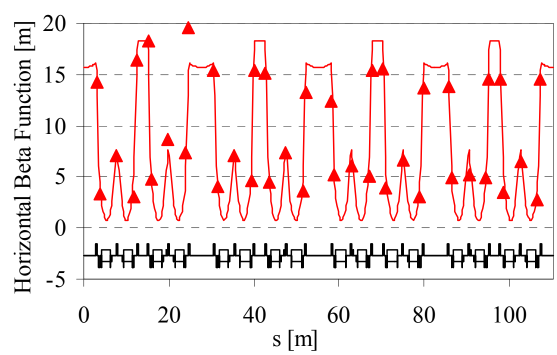

Figure 5: Horizontal beta function measured at each quadrupole and their fitting.

One should notice that the energy spread at 5 mA/bunch is 15 times the natural one. That means that the beam is highly unstable in the longitudinal plane during injection.

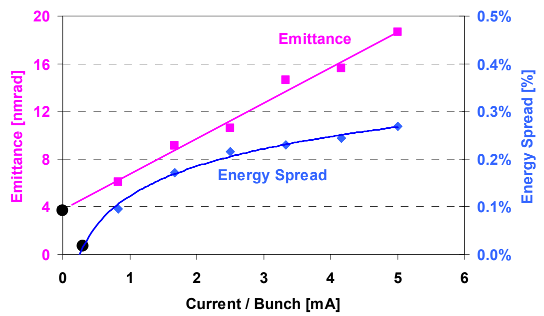

Figure 6: Emittance and energy spread vs. bunch current at 500 MeV. The black dots are the natural values.

On the other hand, at 2.5 GeV, the beam is completely stable when a proper cavity's temperature is chosen. In fact, we excite the beam longitudinally on purpose, increasing the energy spread to around 2 times the natural value, to increase the lifetime by a 20%.

6 INJECTION EFFICIENCY

One of the big drawbacks of ANKA is the low injection efficiency of about 10 %. Neither a different setting of the injection line nor an individual timing of the kickers could improve the situation. When a diaphragm was installed in the injection line, which allowed only the nominal beam (according to the emittance of the booster) to pass through, it turned out that this part of the beam could be injected with 70 % efficiency.

We believe that the emittance of the beam from the booster is diluted by the extraction process. For the extraction process the beam is slowly bumped towards the septum, but due to the large stray field of this septum the bump must be so small that the fast kicker is not strong enough to kick the beam out at once; instead, the kicker is passed at least twice [3]. Further investigations are needed in order to eliminate the problem.

7 KRYPTON CONTAMINATION

Last 23rd of April, a lamp in the infrared beamline, used to heat up the mirror during the baking of the front end, exploded. The lamp was filled with Krypton, which spread over the whole machine.

The diode pumps were switched off and all available turbo pumps installed. Purging the most severe sector with dry Nitrogen showed not improvement of the Krypton partial pressure. The Krypton is now loosely bond in the diode pumps and steadily released and pumped in equilibrium. A baking at 150°C during some days while pumping with turbo pumps improved the situation.

Now the most severe contaminated sector of the machine has been partially clean, and after three weeks, we started the operation of the machine albeit with a reduced current and lifetime.

In the forthcoming shut down, all diode pumps will be baked. We are rather confident to get good lifetime in some weeks again.

Analysing the data at the time of the accident we found that surprisingly the storage ring performed as a delay line: 100 l volumes (dipole chamber) connected by small conductance (straight sections, 1 l/s). So, the travelling time of the Krypton to reach the other side of the machine was about 100 seconds. This can be seen on figure 7, showing the pressure in the diffraction beamline, which is situated 40 m downwards from the infrared beamline. There is a pressure decrease due to the loss of the beam because of a vacuum interlock in the cavity (RF off) close to the accident location. Then the pressure is stable for about 100 s before the wave of Krypton arrives, afterwards the shutter closed and the vacuum recovered.

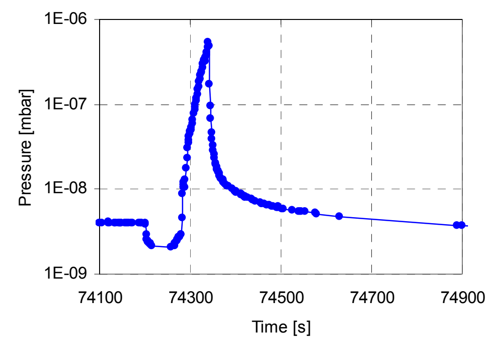

Figure 7: Pressure at the diffraction front end, showing the slow spread of the Krypton contamination.

8 NEXT PROJECTS AT ANKA

Three new beamlines are going to be installed during next year at ANKA.

One environmental beamline (SUL), which will include in-situ diffraction, fluorescence and absorption measurements. It will use initially a normal conducting wiggler (λ=7.4 cm), which will be replaced, on due time, by a superconductive mini-undulator that is actually under development at ANKA [1].

A soft XR beamline (WERA) will be used for classical as well as for advanced electron spectroscopy in the photon energy range between 80 and 1400 eV. A planar undulator (λ=10 cm) borrowed from SRRC (Taiwan) will be installed at the beginning of 2003.

Finally, an X-ray spectroscopy beamline dedicated to actinide research at ANKA will be installed at one bending magnet.

9 ACKNOLEDGMENTS

We thank Michele Svandrlik and Peter Kuske for their advice.

10 REFERENCES

[1] R.Rossmanith et al. “Superconductive 14 mm Period Undulators for Single Pass Accelerators (FELs) and Storage Rings”. These proceedings.
[2] D.Einfeld et al.. “Commissioning results at ANKA” p.2683, PAC 2001, Chicago.
[3] Lars Praestergard, PhD Thesis, “Investigations of the ANKA injector”