RADIATION DOSE RELATED TO ANKA OPERATION MODE

I.Birkel, M.Hagelstein, E.Huttel, A.-S.Mueller, P.Wesolowski
Forschungszentrum Karlsruhe GmbH, Institute for Synchrotron Radiation, Hermann-von-Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany

Abstract

Radiation doses in the ANKA hall are measured by area monitoring and personal dosimeters. In August 2004 the ANKA machine optics was replaced by a new optics with reduced emittance and higher brightness. Measurements of the beam lifetime and the related radiation doses show a strong correlation between operation mode of the machine and dose distribution in the hall.

ANKA MACHINE PARAMETERS

The ANKA storage ring is a ramped storage ring operated at energies between 500 MeV and 2.5 GeV. Electrons are injected from a 500 MeV booster synchrotron with 1 Hz injection rate. They are usually ramped to 2.5 GeV for spectroscopy or to 1.3 GeV for special user operation for X-ray lithography.

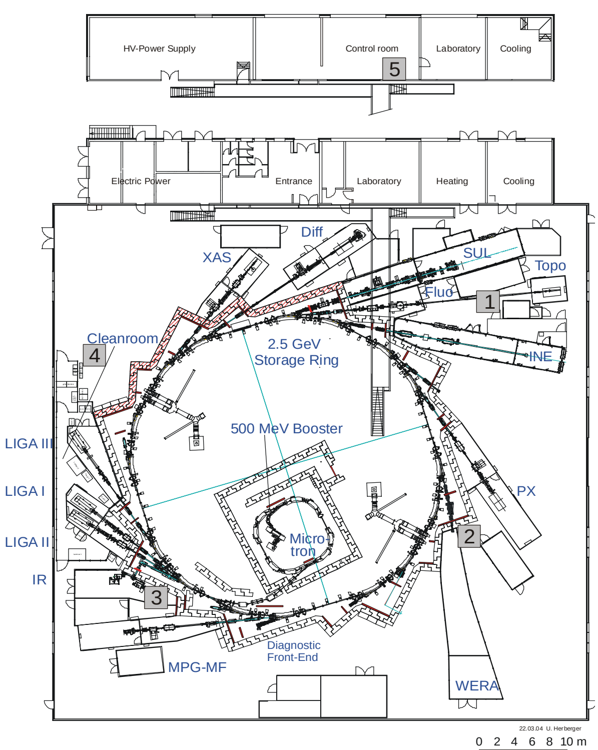

Figure 1: ANKA Facility with Radiation Detector Stations 1-5

SHIELDING

Booster synchrotron and storage ring are shielded with a 3 m high and 80 cm thick wall of ordinary concrete. Next to the control room in the first floor, the shielding wall is 4.5 m high. Booster synchrotron and storage ring injection septum are covered with a 35 cm thick concrete roof. Inner sides of ratchet walls are reinforced by a 15 cm thick and 60 cm high belt of lead bricks at beam level.

X-ray beam lines are shielded with metal hutches and an additional shadow wall of 15 cm lead bricks next to the source point in the storage ring. The metal hutches have a steel lead sandwich structure with varying lead layers of 1.5 to 6 mm depending on beam optics, energy and intensity used at the beam line. At the Infra Red beam line, next to the injection septum, the ratchet wall is doubled, i.e. 160 cm concrete and 30 cm lead.

Table 1: ANKA Machine Parameters

Storage Ring		
max. Energy	2.5	GeV
max. Current	400	mA
Circumference	110.4	m
Structure	8	DBA
Booster Synchrotron		
max. Energy	500	MeV
max. Current	10	mA
Circumference	26.4	m
Stgructure	4	FODO
Race Track Microtron		
max. Energy	50	MeV
max. Current	10	mA

AREA MONITORING AND RADIATION DETECTORS

Control room, stairs to the control room and experimental floor up to the height of the shielding wall are free accessible. The annual personal dose there is less than 1 mSv/y. At machine operation the area inside the shielding wall and the hall above 3 m are prohibited areas. Beam line hutches with open radiation shutters are prohibited areas at machine operation. Prohibited areas are controlled by an interlock system. Trials to access prohibited areas at machine operation cause beam dumps.

Gamma and neutron radiation in the ANKA hall are measured with several detector systems. The area dose is measured by an online system with a central computer and monitor stations in the forward direction of the straight sections and in the control room. Each station consists of an ion chamber for the detection of gamma radiation and a BF3 proportional counter in a polypropylene cylinder for neutrons.

Personal doses of users and most members of the ANKA staff are controlled with TLDs and neutron balls distributed all over the hall and in the beam line control cabins. They are exchanged and read out every 6 months by the safety department of the research centre.

ANKA machine staff members, radiation safety officers and some members of the technical group wear Albedo dosimeters. They are exchanged and read out every month by the safety department. Since the begin of the storage ring operation one Albedo dosimeter showed a dose higher than the detection limit. The measured dose was 70 µSv.

Portable gamma and neutron detectors are used for measurements around beam lines and in the hall.

MACHINE OPERATION IN 2004

Figure 2 shows current and lifetime at 2.5 GeV in 2004. Usually 180 to 200 mA are injected and ramped to 2.5 GeV. Values below 170 mA are related to either partial beam losses during ramping or poor vacuum after interventions at storage ring components.

Until end of August the machine was filled with three bunch trains with 35 bunches per train, every bunch 2 nsec long. Since end of August the machine optics is changed to an optics with higher brightness due to a lower emittance. This new optics accepts until now 200 mA in two trains. The higher electron density per bunch results in additional Touchek losses at high currents after ramping and a shortening of the beam lifetime.

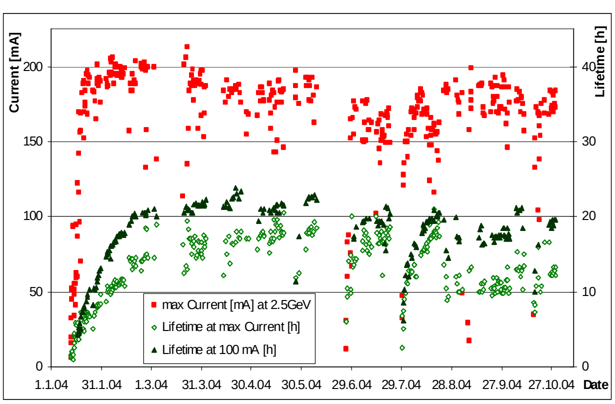

Figure 2: Machine Operation in 2004.

CHANGE OF THE MACHINE OPTICS

Until August 2004 the emittance of the ANKA storage ring was about 100 nmrad. The optics was optimized for zero dispersion in the straight sections. In August 2004 the machine optics has been changed to an emittance of 50 nmrad and nonzero dispersion all over the storage ring for higher brilliance and future developments of the facility like inserting a superconducting undulator [1] with a gap size of 8 mm or smaller in the south straight section.

Table 2: Machine functions

Emittance 0	**106 nmrad**	**49.7 nmrad**
Coupling	1 %	1 %
Emittance x	105 nmrad	49.2 nmrad
Emittance y	1.05 nmrad	0.49 nmrad
Energy	2.477 GeV	2.477 GeV
Circumference	110.4 m	110.4 m

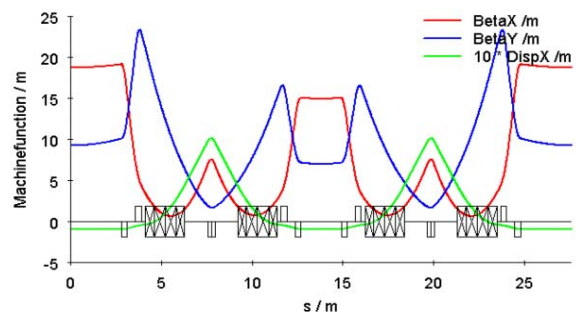

Figure 3: Machine functions for 100 nmrad emittance

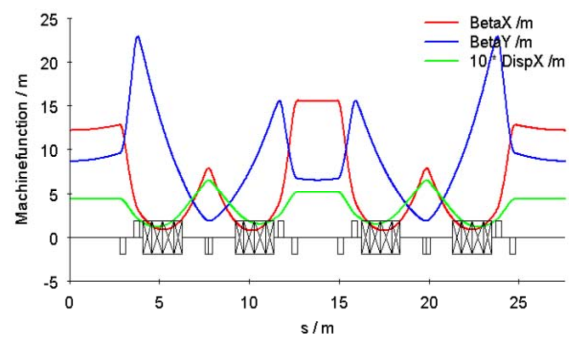

Figure 4: Machine functions for 50 nmrad emittance

DOSE PER DAY RELATED TO THE OPERATION MODE

Figure 5 shows total doses of gamma and neutron radiation per day from March to October 2004 measured

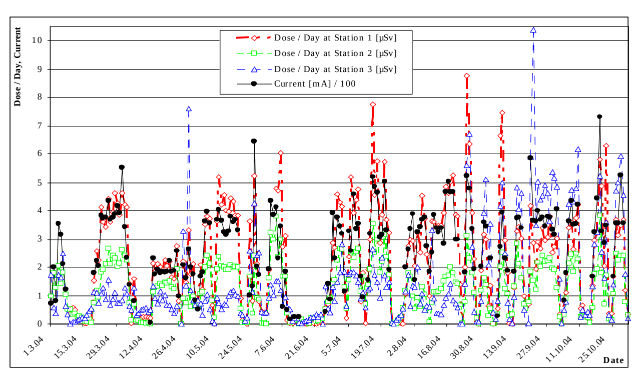

Figure 5: Current and total dose per day measured at three stations

at stations 1 - 3 on the experimental floor. Values of station 4 are not included because the station has been moved in September. Dose values per day are connected by dashed lines for better readability.

The black line with filled dots in figure 5 shows the total current injected at one day. The mean value is about 350 mA per day. At the beginning of the year the machine was operated with one injection of about 200 mA per day due to a stable beam with lifetimes of about 22 h at 100 mA. After the change of the machine optics at the end of August the dose values measured at station 2 remain at about the same level, whereas the doses measured at station 1 go slightly down and the values at station 3 are significantly higher. Single high values are related to beam losses and following reinjections caused by beam dumps, machine physics studies and repairs or exchanges of storage ring components with intervention in the vacuum system.

Interventions in the vacuum system of the storage ring cause temporarily poor local vacuum with additional scattering of the electrons with residual gas atoms leading to higher local dose rates. Such local dose rates are measured with portable detectors. Areas with dose rates higher than 0.5 µSv/h are closed until the local dose rate reaches values below 0.5 µSv/h.

Figures 6 - 9 show gamma and neutron doses per day measured at the stations 1 and 3 in May and October for both machine optics. Station 1 measures the radiation after a normal conducting wiggler [2] with 7.4 cm period length and 16 mm gap inserted in the north straight section. Station 3 measures the radiation at the lateral wall of the cabin of the Infra Red beam line next to the injection septum.

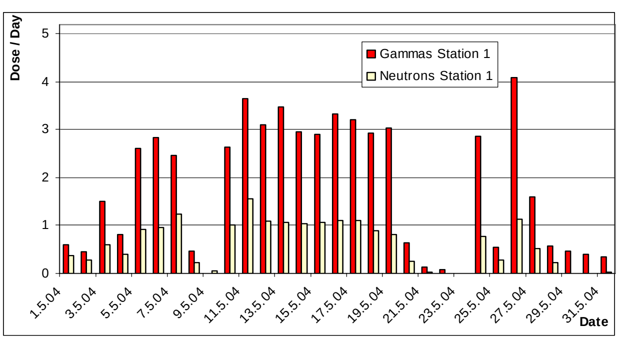

Figure 6: Gamma and neutron dose per day in [µSv] at station 1 in May 2004

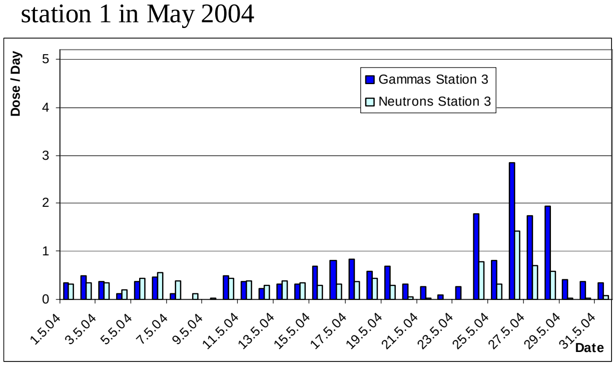

Figure 7: Gamma and neutron dose per day in [µSv] at station 3 in May 2004

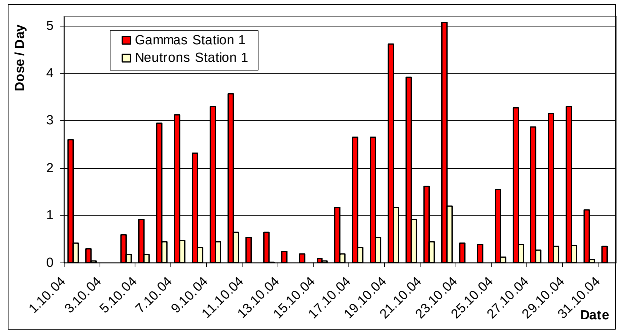

Figure 8: Gamma and neutron dose per day in [µSv] at station 1 in October 2004

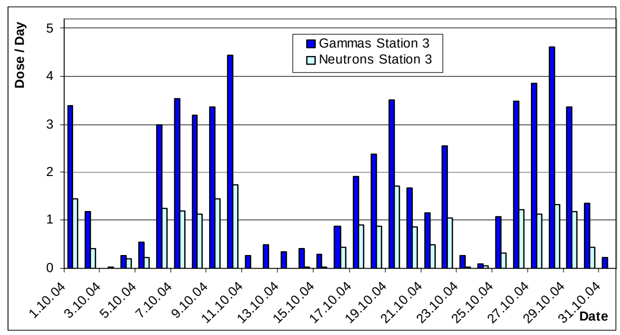

Figure 9: Gamma and neutron dose per day in [µSv] at station 3 in October 2004

In May the dose measured by station 1 was higher than anywhere else in the hall. About 70 % of the dose measured after the wiggler were due to gamma radiation and 30 % to neutrons. The radiation was mostly caused by injections and beam dumps. At station 3 the dose level was much lower and up to 50 % of the dose was caused by neutrons detected during injection.

In October station 1 and station 3 measured almost equal radiation levels with about the same ratio of gamma and neutron dose. The neutron dose after the wiggler is decreased due to the smaller beam size. Beam dumps cause higher gamma and neutron doses near the injection septum due to the nonzero dispersion in the short straight section. Readings of all dosimeters in the hall show an almost equal distribution of the radiation on the experimental floor.

REFERENCES

[1] R. Rossmanith et al., Proceedings of PAC 2003, Portland, Oregon, 899

[2] F. Perez et al., Proceedings of EPAC 2002, Paris, France, 730