Status of the Synchrotron Radiation Source MAX II

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Abstract.

At the MAX laboratory a third generation storage ring operating at 1.5 GeV is at the last stage of production, and first injections will take place in August this year.

The machine, which is optimised for VUV and soft X-ray, is designed to stay within rather tight limits in cost and space but without sacrificing performance.

This work presents not only the status of the project today but does also give an overview of the accelerator system from a technical point of view.

1. INTRODUCTION

In 1990 the decision to build a successor and complement to the "old" MAX I electron storage ring [1] was taken. The new ring should start first experiments on beamlines in 1995 and the performance goals were set to:

a. A large number (minimum 8) straight sections for insertion devices.
b. The design spectral region was the VUV and soft X-ray regions.
c. High brilliance experiments.
d. A beam life-time of at least 10 h.

Today (June 1994) we are close to completion of the accelerator system which has included everything from an extraction system for MAX I via a transfer line, the new storage ring with all auxiliary equipment to a new building of 3000 m^2 for offices and laboratory. First injection into MAX II are scheduled for late August. The extraction and transfer line are already tested successfully.

The "non physics parameters" economy and available space gave the following design points:

a. As injector the MAX I ring had to be utilised.
b. The existing infrastructure of MAX I, including some beamlines, should be used.
c. The new building could not exceed 3000 m^2, thus restricting the circumference to 100 m.

These points were fulfilled by taking use of a rather simple 10 period DBA lattice. The effective electron beam emittance was then lowered a factor of two by allowing a finite dispersion in the long straight sections. The ring circumference was reduced by moving the sextupole fields into the quadrupole magnets and the lengths of the straight sections were optimised.

The design from a technical point have favoured simple industrial production, which in turn has given that all magnets within a ring cell are mounted directly and fixed onto a common girder (this also reduces the sensitivity to vibrations). A total cell, including girder, magnets, vacuum system and diagnostics is then delivered from the manufacturer. The ten girders are finally interconnected with standard vacuum chambers for the insertion devices at the laboratory (see also table 1 and [3]).

2. THE LATTICE

In figure 1 the machine functions of the tenfold DBA lattice of MAX II are shown. As a deviation from a perfect DBA lattice we have allowed some dispersion in the straight sections of the machine due to the following reasons:

a. A finite dispersion at the dipole ends makes it possible to reduce the emittance.
b. The chromaticity correcting sextupoles must be placed at positions where the dispersion is non-zero. We can in this scheme get a higher periodicity of the sextupole distribution which favours the dynamic aperture size.
c. The effective emittance growth due to the non-zero dispersion is less than 10%, but at the same time we have a reduction with a factor of two. The emittance is increased when strong field insertion devices are used but the contribution from the dispersion to this emittance growth is marginal compared to the contribution from the dispersion prime. In a calculated example where the parameters of a 7.5 T three-polewiggler is used, the emittance increases from 8.8 nm to 12 nm. Of this increment, only 20 % is due to the dispersion.

The chromaticity correcting sextupoles are integrated in the quadrupole magnets. A more compact lattice is obtained in this way and the sextupole strengths are minimised which results in a larger dynamic aperture.

The chromaticity can then be adjusted in two ways. Separate sextupoles can be introduced in some of the straight sections. The multipole magnets are equipped with backleg windings which can be used for some 10% chromaticity tuning.

The most important lattice parameter values are seen below in table 1.

The actual tolerances for the sextupole settings are not that critical as long as the chromaticity is positive and not too large. A too large value will enlarge the operating area in

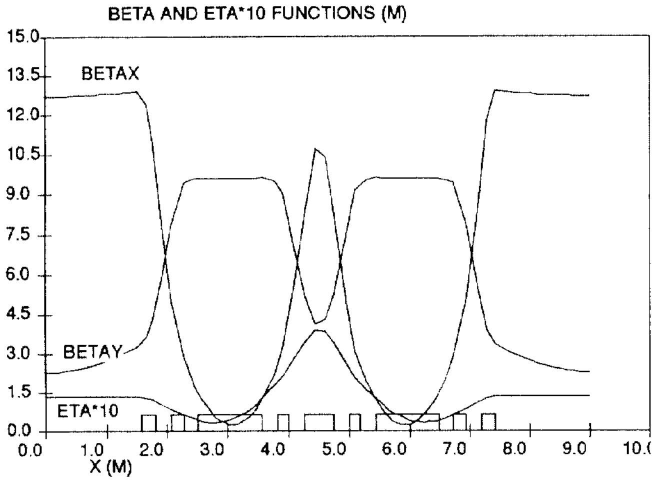

Figure 1. The machine functions.

the tune diagram and no harmful resonances should be crossed. In our case, we can allow for chromaticities between 0 and +4. The designed values for the corrected chromaticity are +2 in both directions.

Table 1.
Machine parameters for MAX II

Q_x	9.22
Q_v	3.18
Operating electron energy	1.5 GeV
Horizontal emittance	$8.8\ 10^{-9}$ rad m
Ring circumference	90 m
Momentum compaction factor	0.004
Natural horizontal chromaticity	-27
Natural vertical chromaticity	-10
Natural energy spread	$0.7\ 10^{-3}$
Dispersion in straight sections	0.13 m
Periodicity	10
Straight section length	3.2 m
RF	500 MHz
Bunch length (RMS)	20 ps
Beam life time	> 10 h

3. Systems for Extraction and Injection

The MAX II storage ring will be injected from the existing MAX I ring. MAX I will accumulate 200 mA and accelerate up to 500 MeV. The beam will then be moved towards a septum magnet with two bump magnets and kicked over the septum by a fast kicker magnet which is placed 270^o in horizontal betatron phase space upstream the septum magnet [4].

At injection into MAX II three bump magnets move the closed orbit in MAX II towards the injection septum magnet. The latter magnet is pulsed with the magnet core outside the vacuum chamber which consists of a 0.15 mm thin walled stainless steel tube 10 mm in diameter.

The pulse from MAX I is 100 ns long and contains 200 mA. MAX II has a circumference of 300 ns, and thus three shots from MAX I will suffice to fill MAX II.

4. Magnets

The end fields of the *dipole magnets* give a sextupole component which changes from injection to full excitation due to saturation. This effect will be adjusted for by powering backleg windings on the quadrupoles. The field of the dipole magnets will reach 1.5 T in a 40 mm gap.

The *multipole magnets* supplies both quadru- and sextupole fields needed for the ring (table 2).

Table 2.
Quadru- and sextupole parameters

	QF	QF	QD	QD
Length (m)	0.25	0.5	0.2	0.18
Number	20	10	20	20
$B'/B\rho$ (m^{-2})	4.18	4.18	3.98	3.98
$B''/2B\rho$ (m^{-3})	9.7	10.1	18.3	18.1
Bore radius (mm)	30	30	30	30
Power (kW)	3.1	4.7	2.5	2.4

5. Vacuum System

The MAX II vacuum system is suspended freely from all magnets and built out of stainless steel. Two ion pumps per cell stands for the main pumping positioned at the bending magnets. Additional pumping is accomplished by TSPs integrated in the multipole magnets.

No in-situ baking is fore-seen as the system is baked to 250-300^o C when mounted prior delivery to MAX-lab. Still we will have to open the system when connecting the cells to the straight section chambers, which can be made pretty quickly, and thus a mild baking is needed afterwards. The magnets will be positioned onto the girder after this baking and the girder positions adjusted. In case of an accidental venting, the magnets can be lifted off and the vacuum system re-baked.

The heat absorbers are located in the vicinity of the pumps. One absorber is placed in each dipole magnet taking the main synchrotron radiation load. Two mechanisms are used to decrease the gas desorbtion: - The synchrotron radiation will hit a groove machined in the absorber. Most photo electrons will then be caught in the groove. - The absorbers are mainly positioned where we have magnet fields. The photo electrons will then return to the absorber and hit the absorber close to the point of emission. This will also reduce the areas exposed to the photo electrons.

The desorbtion constants used in the calculations are the ones empirically found at MAX I.

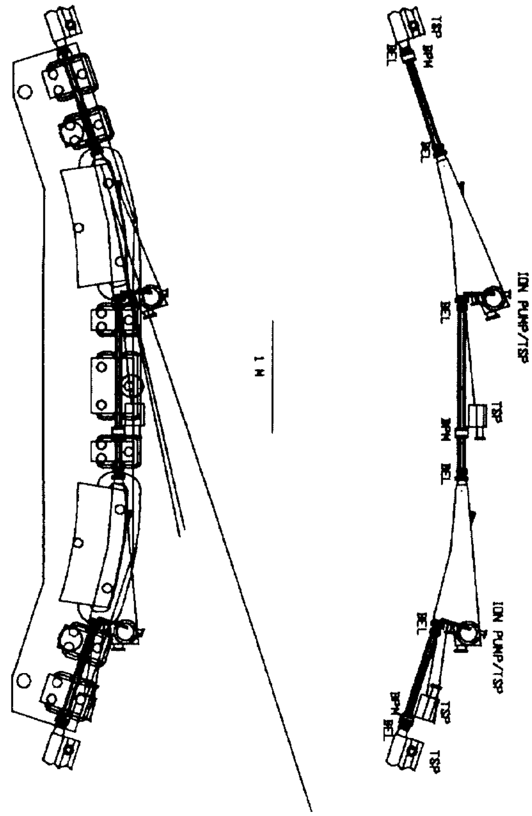

Figure 2. The vacuum system and cell layout.

6. ALIGNMENT, LIFETIME AND APERTURE

Each magnet is suspended on three carefully machined knobs giving well-defined surfaces for the magnet positioning. A stamped groove in the magnet lamina fits into an axis which fits into the girder knobs. The magnets can thus be aligned relative each other within a RMS deviation of 15 µm. Other knobs on the girders serve as reference points for the girder alignment relative a centre pillar.

The closed orbit deviation is mainly sensitive to misalignment of the individual magnets and not the girders. Some care has been taken to minimise the influence of vibrations on the closed orbit position. The dimensioning of the girders though is more an answer to the need to push up the eigenfreuquency spectrum of the girders than the static load bending. The lowest harmful vibration mode of a loaded girder is pushed up to about 60 Hz.

The beam life-time is in our case defined by the vacuum and Touschek effects. Assuming a dynamic aperture of 22.5 mm mrad in both transverse directions and an energy acceptance of 2 % the beam lifetime goes from 8 to 17 h (500 - 1500 MeV). At higher energies, the beam life-time is dominated by the Touschek effect. At lower energies, the Touschek lifetime is increased due to multiple scattering and the elastic scattering becomes dominant.

The dynamic aperture (discussed in more detail in [5]) is large enough for injection into an uncorrected machine and the energy acceptance is larger than 3%.

Finally the calculated flux and brilliance of the MAX rings from dipole and a standard set of insertion devices are given in fig 3.

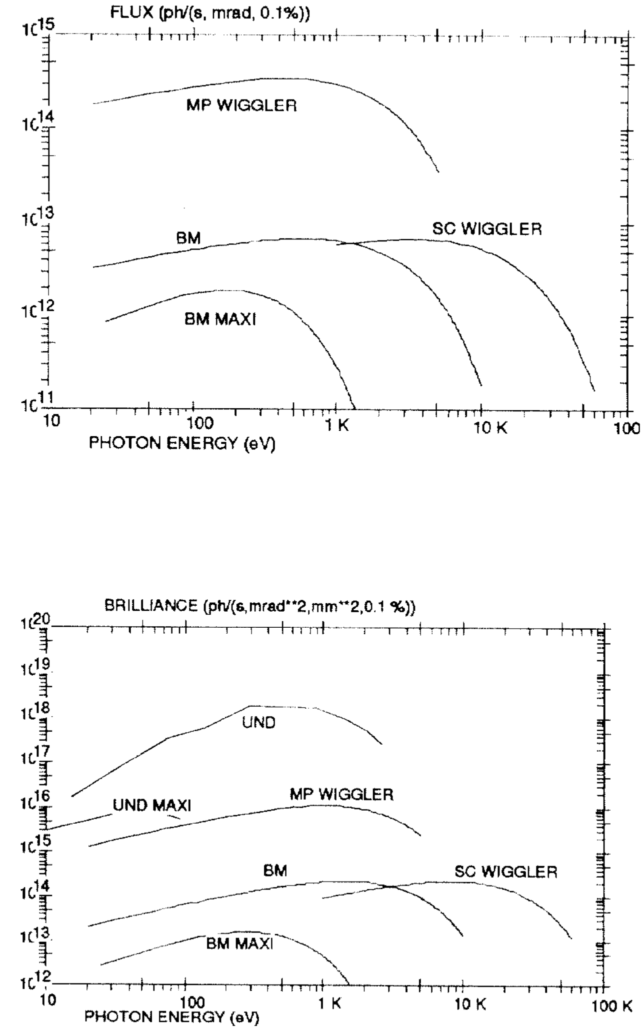

Figure 3. Flux and brilliance from MAX II.

References:

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2. MAX-lab ad hoc committee report, 1989
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5. S. Werin, Dynamic aperture of the MAX II storage ring, these proceedings.