MAX III COMMISSIONING

M. Eriksson[#], Marlene Bergqvist, L.-J. Lindgren, M. Brandin, M. Sjöström, Sara Thorin, MAX-lab, Lund, Sweden

Abstract

Some of the features of the MAX III synchrotron radiation storage ring are presented and the commissioning of this ring is described.

MAX III MOTIVATION

The prime motivation for the MAX III ring construction is to get a larger number of insertion devices (IDs) at MAX-lab when the straight sections at MAX II are filled. Low photon energy beamlines operating in the UV spectral region perform as well in a low energy ring as one of higher electron energy. Moreover, the optimisation of the low photon energy IDs is simplified in a low energy ring.

Another motivation is to get experience from small solid iron magnets with integrated magnet functions as a preparation for the MAX IV project.

MAX III DESIGN

The electron energy in the MAX III ring was chosen to 700 MeV to get a spectral overlap with the MAX II ring and to cover the low photon energy at the normal incidence monochromators. A sufficient number of straight sections should be provided for IDs and an 8-fold magnet structure will give us a sufficient number of straight sections for this purpose. The machine functions and the design parameter values are given below.

Table 1: MAX III parameter values

Parameter	Design	Achieved
Electron energy (MeV)	700	700
Circ current (mA)	200	85
Qx	3.8	3.9
Qy	2.85	2.76
ξx	1	1.2
ξy	1	-1
Injection energy (MeV)	500	380
No of straight sections	8	8
Circumference (m)	36	36
Injection energy (MeV)	500	400
RF (MHz)	100	100
Harmonic cavity (MHz)	500	500

[#]Mikael.Eriksson@maxlab.lu.se

It should be noted, that the injection energy is defined by the MAX injector energy and lower than the operating one. This is a sad fact motivated by economical constraints.

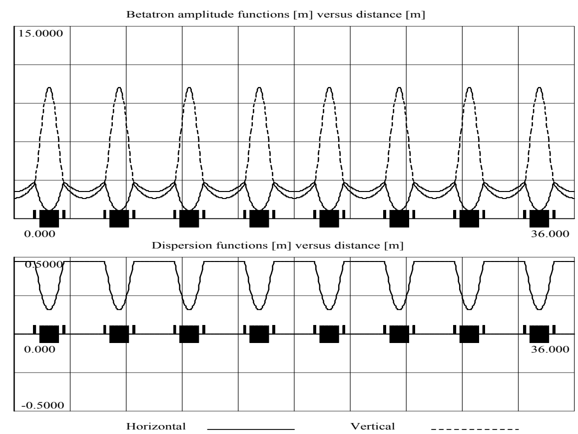

Figure 1: MAX III machine functions. The dotted graph in the upper figure indicates the vertical β-function and the solid one is the horizontal. The lower figure shows the dispersion curve with a maximum dispersion of 0.45 m

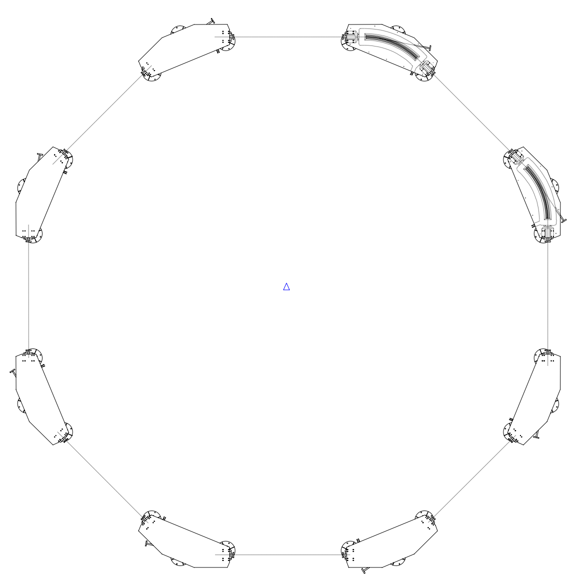

Figure 2: The MAX III ring.

The MAX III design is described in more some detail in ref [1].

Magnet Cells

One magnet cell consists of a dipole magnet containing vertically focussing gradient. Pole face windings are used for gradient and sextupole adjustments. The vertically chromaticity correcting sextupoles are contained in the dipole magnet ends, which are machined accordingly. The flanking horizontally focusing quadrupoles are machined to yield the horizontally chromaticity correcting sextupoles.

Figure 3: One MAX III cell.

The magnets in each cell were machined out from solid steel blocks. Each steel block contains all the magnets in the cell. The ring and one magnet cell are shown above.

Vacuum System

The dipole vacuum chambers designed in a conventional way with absorbers and ion pumps. This chamber is hidden in the magnet block and not accessible from outside. Baking is carried out by connecting the dipole coils to the 50 Hz net. The eddy currents in the solid iron heat up the whole cell within a few hours to baking temperature. The epoxy impregnated coils are kept cold by the cooling water system.

5 of the 8 straight sections consists of NEG-coated extruded Al chambers with an inner aperture height of 11 mm.

Commissioning Experience

Much of our efforts during the early commissioning were related to the non-conventional solution of the magnet system. After a few corrections of the magnet cells, this issue turned out to be pretty problem-free and the magnet lattice behaved as planned regarding corrector strengths, betatron wave numbers and chromaticity.

Even ramping turned out to be less crucial than expected; we had feared the eddy currents in the solid magnets should force us to very slow rampings, but a 3 minutes long ramping time is sufficiently long.

Once cycled, the magnet fields are quite reproducible. No magnet field corrections are needed from one injection to another, provided the ramp cycle stays the same.

Commissioning is on the other hand plagued by two other constraints:

The first one is a transverse instability seen at the injection energy, most probably the resistive wall (RW) effect. The small gap vacuum chambers, occupying 30 % of the circumference, provide quite significant transverse impedance.

Simulations of RW effects show growth rates in the ms region. Strong spontaneous betatron bands around the RF frequency and its harmonics is a strong indication of the RW instability.

To increase the robustness against the resistive wall instability, we changed the operating tunes to slightly above the 3rd integer. This seemed to work quite nicely with a very flat electron beam. However, the dispersion went up in the straight sections, so this optics was abonded, since no significant currents (less than 10 mA) could be stored.

The other constraint is the accessibility to the MAX III cave during the scheduled operations of the MAX I and MAX II rings. All major changes in the machine can be delayed by weeks due to the ongoing routine operation.

The 5th harmonic Landau cavity turned out to be of good help during the commissioning. One important feature of this cavity is that it stretches the bunches and thus decreases the RW effect.

At the moment, we can stack some 85 mA and are conditioning the vacuum system with this current.

To summarise, the commissioning of the MAX III ring follows the same pattern as for the MAX I and MAX II rings, which also uses the low energy injection scheme. The early conditioning of the vacuum system is hampered by the fact that the injected currents are restricted by the high vacuum pressure. Once the first rough conditioning is done and the currents increased, conditioning speeds up.

REFERENCES

[1] G. Leblanc et al. "MAX III, a 700 MeV Storage Ring for Synchrotron Radiation", EPAC2000, Vienna