Recent Improvements to the Lattices for the MAX IV Storage Rings

Leemann, Simon

Published in:
[Host publication title missing]

2011

Link to publication

Citation for published version (APA):
Leemann, S. (2011). Recent Improvements to the Lattices for the MAX IV Storage Rings. In [Host publication title missing] (pp. 3029-3031)

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
RECENT IMPROVEMENTS TO THE LATTICES FOR THE MAX IV STORAGE RINGS

S.C. Leemann∗, MAX-lab, Lund University, SE-22100 Lund, Sweden

Abstract

Construction of the MAX IV facility started early this year. The facility will include two storage rings for the production of synchrotron radiation. The 3 GeV ring will house insertion devices for the production of x-rays while the 1.5 GeV ring will serve UV and IR users. Recently, the lattices for the storage rings in the MAX IV facility were updated. In the 3 GeV storage ring the vertical beam size in the long straights has been reduced. The lattice of the 1.5 GeV storage ring has been updated to take into account first results from detailed magnet and vacuum system designs. Additionally, a new injection method to facilitate commissioning of the storage rings has been studied. This paper summarizes the changes made in the lattices and the effect of these modifications.

INTRODUCTION

The MAX IV facility will use a 3 GeV linac and two storage rings to deliver synchrotron radiation to a broad and international user community across a wide spectral range and covering different temporal scales [1, 2]. Construction of the facility started earlier this year and is progressing swiftly [3, 4]. A facility overview is displayed in Fig. 1.

Figure 1: Overview of the MAX IV facility. The gun bunker is at the top left followed by the underground linac tunnel. The 1.5 GeV and 3 GeV storage ring buildings are indicated. The short-pulse facility (SPF) is indicated at the top right.

With facility construction ramping up quickly, detailed designs have to be completed soon so purchasing orders can be sent out on time. This paper summarizes the latest modifications to the lattices for the MAX IV storage rings. The following two sections focus on the 3 GeV and 1.5 GeV storage ring lattices. The final section introduces a new injection scheme intended to facilitate commissioning of the storage rings.

3 GeV OPTICS IMPROVEMENTS

The MAX IV 3 GeV storage ring lattice relies on a multibend achromat (MBA) to achieve ultra-low emittance (ε x < 0.3 nm rad) while retaining large dynamic aperture and momentum acceptance [5]. The detailed magnet and vacuum system designs for the 3 GeV storage ring [6] are almost complete. Feedback from these design efforts have called for a few changes to the 3 GeV storage ring lattice and optics [7]. The most important optics modification is related to insertion device (ID) compensation.

The ultra-low emittance MBA lattice requires optics to be matched to strong IDs [8]. This is accomplished in two stages: locally using quadrupole doublets installed around the IDs and globally using the main focusing quadrupole family and pole-face strips (PFSs) in the gradient dipoles. One disadvantage of using air-cooled PFSs to compensate for strong IDs is that it limits the number of strong IDs that can be compensated for to about six, whereas 19 long straights are available to users in the 3 GeV storage ring. Another disadvantage is that powering the PFSs gives rise to a considerable dipole component as has been revealed by measurements on the prototype magnet [9]. This is undesirable as dynamic ID compensation then creates varying dipole kicks around the storage ring which have to be compensated by the orbit feedback system [10].

One solution to this problem is lowering the vertical beta function in the long straights, thus reducing the amount of tune shift generated by an ID and hence, relaxing the required compensation strength. In the updated 3 GeV storage ring lattice [7] the vertical beta function at the center of the long straights has therefore been reduced from 4.8 m to 2.0 m (cf. Fig. 2). Because of the reduced amount of tune shift generated by strong IDs with this optics, both local and global optics matching can now be performed using only the quadrupole doublets at the IDs. The PFSs no longer have to be powered dynamically. This reduces the complexity of ID compensation and facilitates operation of the storage ring. The new lattice optics not only reduces the amount of tune shift generated by IDs, it also reduced the beam height in the ID by one third. At the 1 Å diffraction limit, the rms vertical beam size is now 4 μm. Note that due to the ultra-low lattice emittance, this diffraction limit corresponds to a comparably high emittance coupling of about 3%. Dedicated skew quadrupoles will allow a significant reduction of coupling so that vertical source sizes as low as 1 μm should become possible.
Both MAX IV storage rings have been designed to rely exclusively on pulsed sextupole magnet (PSM) injection...
from the start [17]. This injection scheme has several advantages over conventional injection with a closed four-kicker bump. The potential to make top-up injection entirely transparent to users is certainly the main motivation behind this decision. However, despite the great performance expected from PSM injection, commissioning a new storage ring with this injection scheme is non-trivial. During early commissioning the exact beam position is possibly not known and at least a few magnets with erroneous strengths or inverted polarity have to be assumed. Additionally, the injected bunches have to be transported from the injection septum through a fairly long magnet section successfully before reaching the PSM where they can be captured within the storage ring acceptance. If, due to unforeseeable errors, this transport is not successful, a lack of stored beam makes diagnosing and correcting the errors very difficult.

In order to facilitate early commissioning, it has therefore been decided to install a single dipole injection kicker as close as possible to the injection septum in both storage rings. This will allow injecting beam into the storage ring even before exact beam positions and optics are known and have been corrected. Although the dipole kickers cannot be installed directly at cross-over locations (which would allow for on-axis injection), the amplitude of the injected beam at the dipole kicker is sufficiently low so that an appropriate dipole kick will knock the injected particles to well within the storage ring acceptance.

For both rings, an ideal kick strength has been calculated in order to minimize the reduced invariant of the injected particles (3.5 mrad in the 3 GeV ring, 2.2 mrad in the 1.5 GeV ring). Furthermore, if this strength is reduced somewhat, injected particles are captured within the storage ring acceptance (albeit not at the minimum reduced invariant) while any particles previously stored in the machine are not kicked out of the acceptance. Operated at such a setting, the dipole kickers can be used to accumulate small amounts of beam in the storage ring. Once some beam can be stored, magnet errors can be detected, corrections to the optics can be made, and beam positions can be more accurately determined. The commissioning team is then in a much better position to commission injection with the PSM. In this way, the dipole kickers reduce the risk of relying exclusively on a novel injection scheme in both storage rings from the start.

REFERENCES

[16] Å. Andersson et al., “The 100 MHz RF System for the MAX IV Storage Rings”, MOPC051, this conference.