Alignment Procedures for the MAX-II Storage Ring

G. LeBlanc, W. Stiefler, MAX-lab, Lund, Sweden

Abstract

The techniques and equipment used for alignment of the MAX-II[1] storage ring are described and evaluated. This includes the initial placement of reference points relative the MAX-I ring which is used as an injector. The magnetic elements of the MAX-II ring are placed on machined supports on girders which are aligned relative each other and a central pillar. Consequently, there is no possibility of individual alignment of the separate magnets. Some of the implications of this as well as practical experiences from the alignment procedure will be presented.

1 The Initial Positioning

1.1 The Layout of the Storage Rings

Figure 1 shows the layout of the two storage rings, MAX-I and MAX-II. The strategy for the alignment of MAX-II was decided upon based on this figure. The first part of the transport line from MAX-I to MAX-II is in line with one of the straight sections in MAX-I. This was therefore chosen as the baseline for all further measurements.

1.2 The Baseline Definition

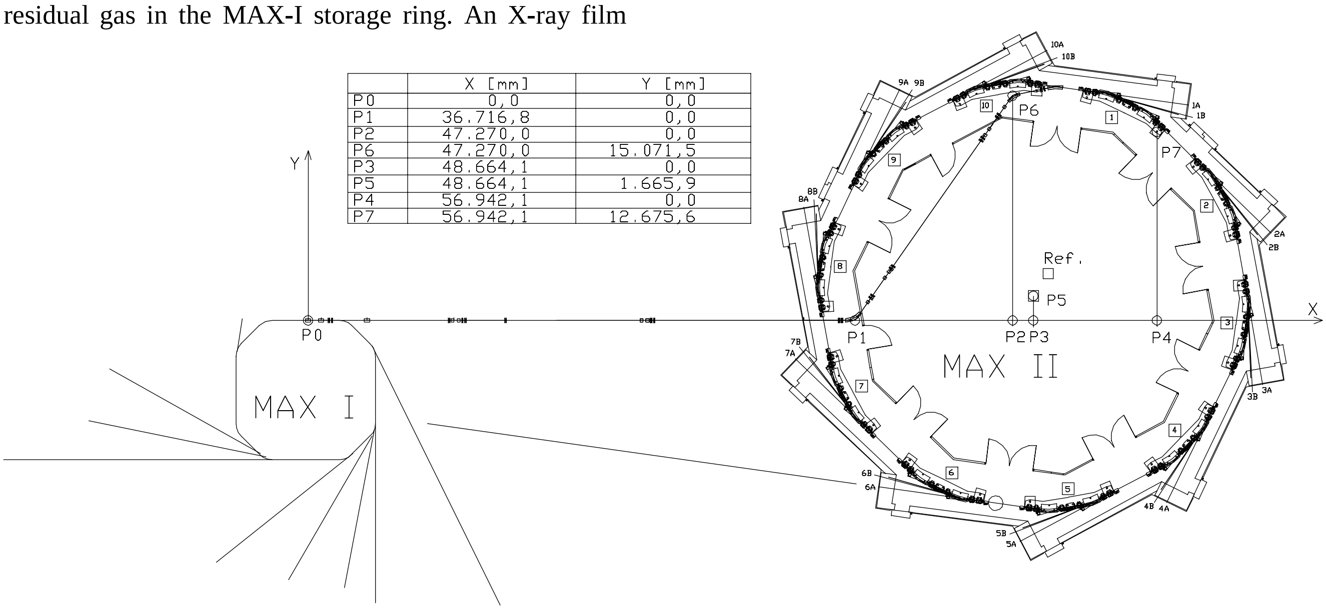
This baseline was determined by using a beam of Bremsstrahlung from the electron collisions with the residual gas in the MAX-I storage ring. An X-ray film was placed behind a lead plate which was used as an intensifier[2]. A number of exposures were made at various distances from the MAX-I ring, the greatest of which was approximately 30 m. The accuracy of this method is better than 0.1 mrad.

1.3 The Determination of the Fixed Points

In order to align the entire system, four points were needed.

- Points P1 and P6: The positions of two of the bending magnets of the transport line.
- Point P5: The center of the MAX-II storage ring.
- Point P7: An alignment pillar on the first girder.

Point P1 was determined by measuring the distance along the baseline to the point P0, which is the center of the straight section in MAX-I. In order to determine the points P5, P6, and P7, the positions of points P2, P3, and P4 on the base line were calculated so that the angles between the lines (P2-P6), (P3-P5), and (P4-P7) were all 90 degrees. The actual positions of points P5, P6, and P7 were then found using an autolevel, a pentagon prism, and a measuring tape. The fine adjustment of the triangle (P3, P4, P5) was accomplished with the help of Distinvar wires[3]. This finally defined the center of the storage ring and the reference pillars were put in place. An additional pillar was mounted near the center pillar for use as a reference during vertical positioning with a hydrostatic leveling system[4].



	X [mm]	Y [mm]
P0	0,0	0,0
P1	36.716,8	0,0
P2	47.270,0	0,0
P6	47.270,0	15.071,5
P3	48.664,1	0,0
P5	48.664,1	1.665,9
P4	56.942,1	0,0
P7	56.942,1	12.675,6

Figure: 1 The layout of the MAX storage rings.

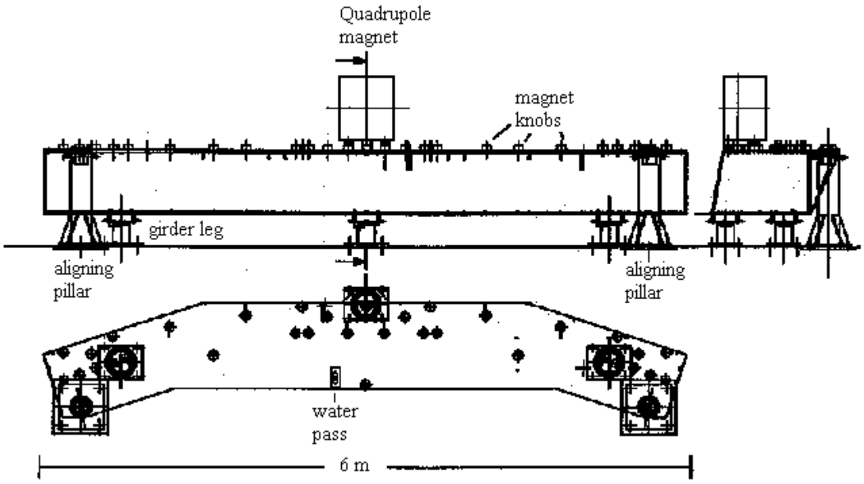


Figure 2: MAX-II magnet girder

2 Alignment Procedure for the Magnet Girders

The MAX-II storage ring is built with a tenfold symmetry. The ten sections are built on girders with machined knobs as magnet supports. Figure 2 shows one such girder. Once the magnets are placed on the girders , there is no further alignment of the individual magnets. The girders as a whole are aligned relative a center pillar. Due to the production techniques used for the magnet poles, it is possible to determine the magnet centers accurately using the magnet surface as the reference. In this way the alignment tolerances can be relaxed for the individual magnets and the alignment scheme for the ring is simplified[1].

2.1 Vertical Alignment

The alignment pillars for the girders can be separated from the girders themselves and were initially positioned relative to point P7 with a measuring tape and a theodolite. The girders were then placed on the pillars and the magnets placed on the girders.

The vertical alignment of the girders is performed with the help of a hydrostatic leveling system designed at MAX lab. Two vessels are connected with a hose and filled with water. A laser displacement sensor is mounted on each vessel and measures the height of the water. The two units are first calibrated while placed on a reference pillar in the middle of the storage ring. One of the units is then moved to the reference points on the girders and the alignment is made. The precision of the measurements is .01 mm.

Initially, the quadrupole in the center of each girder was left off. This was due to the fact that three points were needed in order to align the girders vertically. One of the magnet supports was used as a third point and then a water level was mounted on the girder and zeroed when the hydrostatic leveling system showed that the girder was level.

2.2 Horizontal Alignment

The girders are aligned using distinvar wires. There are two reference points on the girders which are used to set the distance to the center pillar and the distance between the individual girders. The precision of the measurements is .03 mm.

3 Practical Experiences

3.1 Settling of the Girders

The first year after completion of the ring, it was settling with approximately .02 mm per month, making periodic measurements and corrections necessary. A total alignment with measurements and corrections could be performed by two people in less than a week.

3.2 Ring Expansion

When the ring was complete except for the RF system and the commissioning process was well under way, the first injections of a coasting electron beam were made. Measurements of these first turns were made and indicated that the circumference of the ring was slightly off as defined by the energy of the electrons. A calculation of the corrected circumference was made and it was found that the circumference should be increased by approximately 10 mm. Using the Distinvar system, the change was made, taking two people only two days.

3.3 The Continued Efforts

In the future, the electron beam will be used as a probe to determine the quality of the alignment of the storage ring, and experience shows that the system of fixed magnets on adjustable girders makes for a relatively simple and quick alignment procedure. It is planned to make measurements and, if necessary, adjustments during the periodic nuclear physics experiment weeks when the injector for MAX-II is used as a pulse stretcher.

REFERENCES

[1] 'Design Report for the MAX-II Ring', Å. Andersson et al. MAX Publications: ISSN 0284-1285 ISRN LUNTDX/NTMX--7019--SE

[2] 'Sendero Luminoso', W, Stiefler, MAX-LAB Activity Report 1991.

[3] Baechler et Fils, Geneva, Switzerland.

[4] 'Hydrostatic Leveling System with Laser Sensors' P. Röjsel and W. Stiefler. These proceedings.