Fiducialization and alignment strategy for the integrated magnets in the MAX IV rings.

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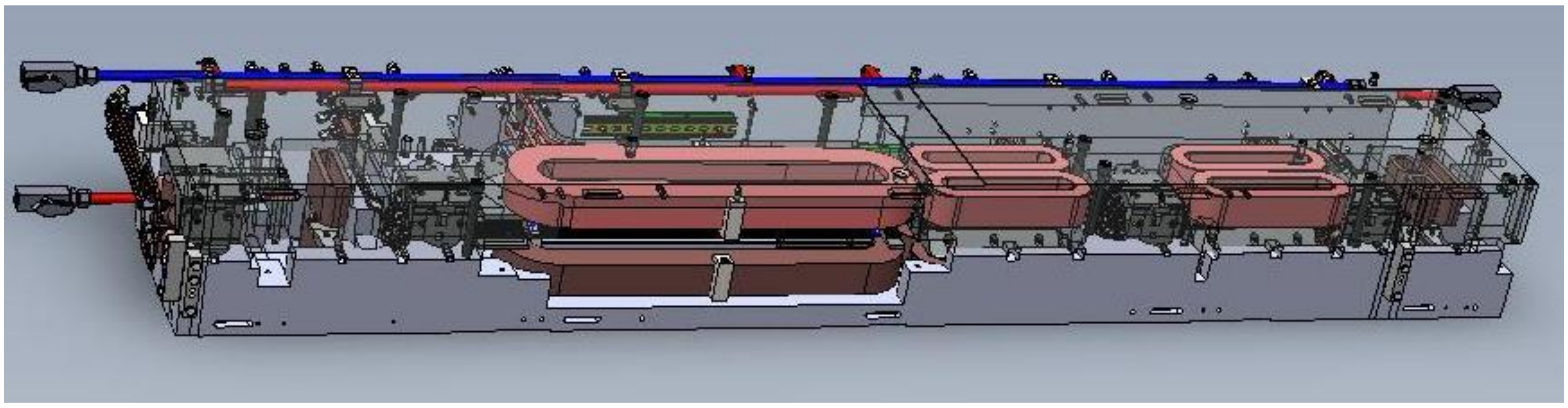
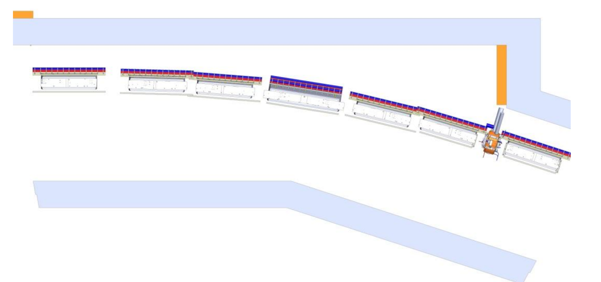


The 1.5 GeV-ring



One of the 20 achromates in the 3 GeV-ring

Task:

3GeV-ring: 140 integrated magnet blocks in 20 acromats.
Block size: 256x350x2300-3350mm.
Circumference: 528 m.
Alignment tolerance: 100 (goal 50)µ, 1 sigma
Roll: 0.2mrad, 1 sigma.

1,5GeV-ring: 12 integrated magnet blocks.
Block size: 300x400x5000mm.
Circumference: 97 m.
Alignment tolerance: 100 (50)µ, 1 sigma
Roll: 0.2mrad, 1 sigma.

Magnet block in the 3 GeV ring

Solution:

The aim when constructing the alignment mechanisms was to fulfill the usual design features like alignment precision, orthogonal motion, vibrational stiffness, stability and simplicity.

We decided for a solution with a complete separation of the adjusting mechanisms.

- Three sturdy standoffs of threaded rod type combined with spherical bearings and sliding surfaces.
- Two transversal adjustments of push-repush (spring washer) type combined with spherical bearings and sliding surfaces.
- One longitudinal adjustment like the transversal type.

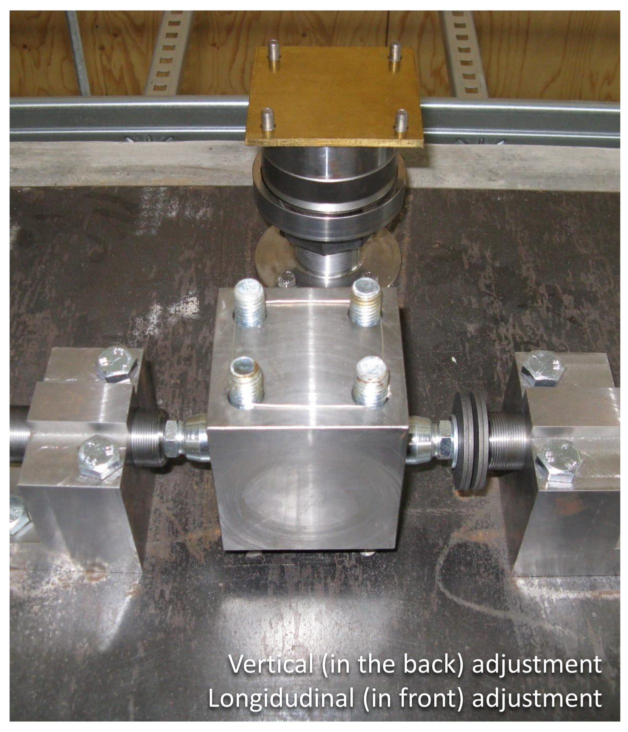
Stability gain.

When calculating the Eigen frequency of the bigger and heavier magnet blocks for the 1.5 GeV-ring the constructors was worried by the low Eigen frequency of 46Hz (goal> 55Hz). Realizing that with our alignment solution there is no "locked" position of the mechanisms as long as the sliding surfaces are parallel and the movement follows the axis, we let all the positions free to be optimized with respect to bending and vibrating. The constructors were then able to raise the Eigen frequency to 55 Hz. Problem solved!

Fiducialization.

In order to reduce the time needed for alignment we have arranged the fiducialization of the magnet blocks so that the time required for aligning each block is minimized. We decided to try to minimize the "alignment backlash" in order to get as few iterations as possible. This was achieved by placing the target holders right over each rotation axis.

Analyzing the system, one finds that the minimum number of target holders on the rotation axis follows the formula **x = n-1** In this case it is 2 for vertical, one for transversal and none for longitudinal motions. The "free" target holders can be placed is such a way that one will get a free line of sight from the preferred instrument position or positions.



Vertical (in the back) adjustment
Longidudinal (in front) adjustment

Error budget over one accromate, 1 sigma.

Our Leica AT401 over 10.5 m	39 µm
Tolerance at manufacturing	20 µm
Control measuring	3 µm
(Network estimated	30 µm)
Sum	44 (53) µm

Result:

	Vert1	Vert2	Vert3	Trans1	Trans2+long
Start	X: 1643.608 Y: 147.004 Z: 0.189	X: 1015.062 Y: -120.992 Z: 0.038	X: 386.526 Y: 147.003 Z: 0.197	X: 2030.136 Y: 0.007 Z: 0.007	X: 0.018 Y:-0.005 Z: 0.031

Moving all axis ±~0.5 mm

Δpos after each adj.	Z1: 0.004	Z2: -0.004	Z3:-0.005	Y1: -0.002	Y2: -0.002 X1: -0.002
Pos. after 1:st round	X: 1643.606 Y: 147.038 Z: 0.213	X: 1015.058 Y: -120.972 Z: 0.069	X: 386.524 Y: 147.010 Z: 0.204	X: 2030.136 Y: 0.046 Z: 0.059	X: 0.018 Y: -0.004 Z: 0.035
Δ	X: 0.002 Y: 0.034 Z: 0.024	X: 0.004 Y: 0.020 Z: 0.031	X: 0.002 Y: 0.007 Z: 0.007	X: 0.000 Y: 0.039 Z: 0.052	X: 0.000 Y: 0.001 Z: 0.004

Wanted accuracy: Better than 100µm Error envelope: 44µm Time for alignment: 8.42 minutes

Time for alignment: 8min 42sec.
A second adjustment of vertical and transversal position could be needed.

Alignment mechanisms

Integrated target holders

The MAX IV Laboratory

The MAX IV Laboratory opened for operation in 1987 (under the name MAX-lab) and is a national laboratory operated jointly by the Swedish Research Council and Lund University. The laboratory supports three distinct research areas: Accelerator Physics, Research based on the use of Synchrotron Radiation, and Nuclear Physics using high energy electrons.

At present three synchrotron storage rings are in operation MAX I-III and each year close to 1000 researchers visit the laboratory to perform experiments. The MAX IV laboratory is also responsible for the build up of the MAX IV facility situated in the Brunnshög area just outside of Lund and approximately 2 km from the present facility.