Magnets for MAX IV

Martin Johansson, Advanced Low Emittance Rings Technology (ALERT)

Workshop, Valencia, Spain, May 5th-6th, 2014

MAX IV

Contents

1. the MAX IV 3 GeV ring magnet block concept
2. production status
3. alignment within magnet blocks

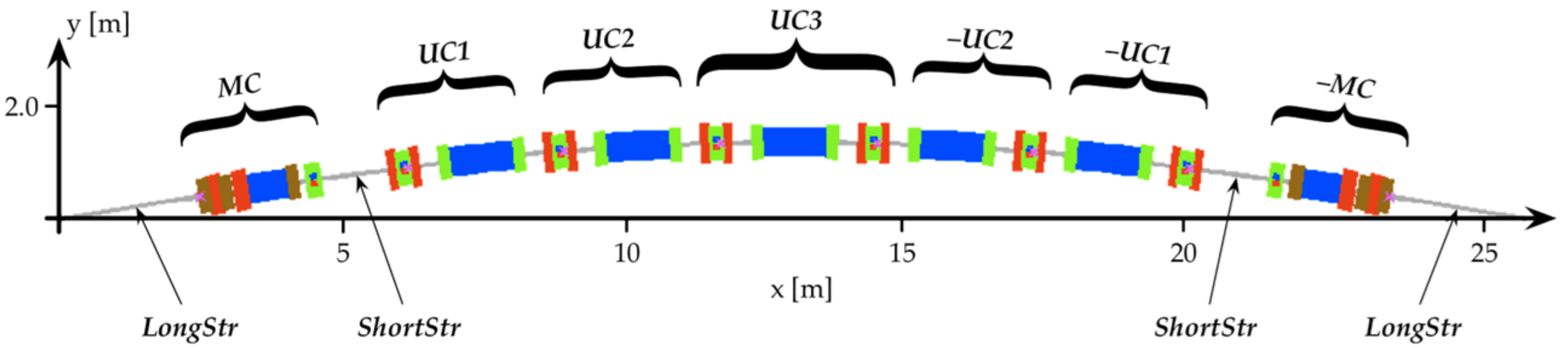
1. the MAX IV 3 GeV ring magnet block concept

The MAX IV facility

- Currently in construction in Lund, Sweden.
- 3 GeV storage ring
- 1.5 GeV storage ring
- full energy linac

March 12th, 2014 photo: Perry Nordeng

The MAX IV 3 GeV ring lattice



- 7 bend achromat consisting of five unit cells and two matching cells.
- 20 identical achromats.
- 528 m circumference.
- 0.33 nmrad bare lattice emittance.

The MAX IV 3 GeV ring magnets

Key aspects:

- magnet aperture of Ø25 mm
- magnet block concept:

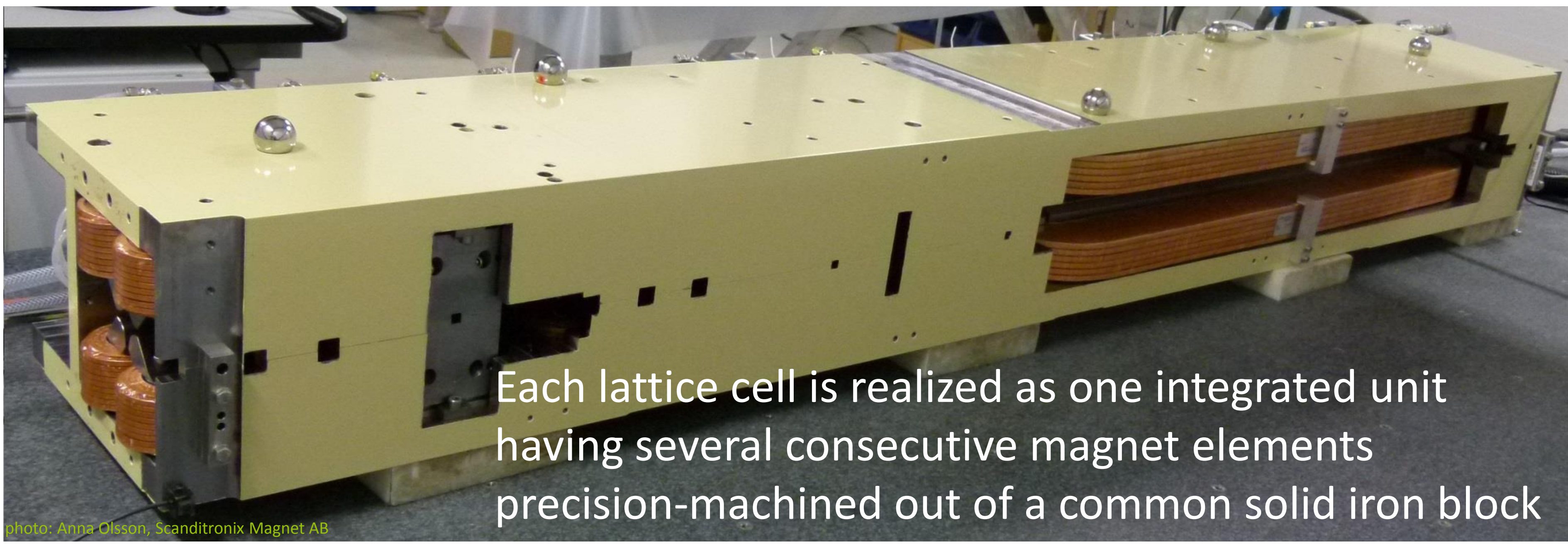


photo: Anna Olsson, Scanditronix Magnet AB

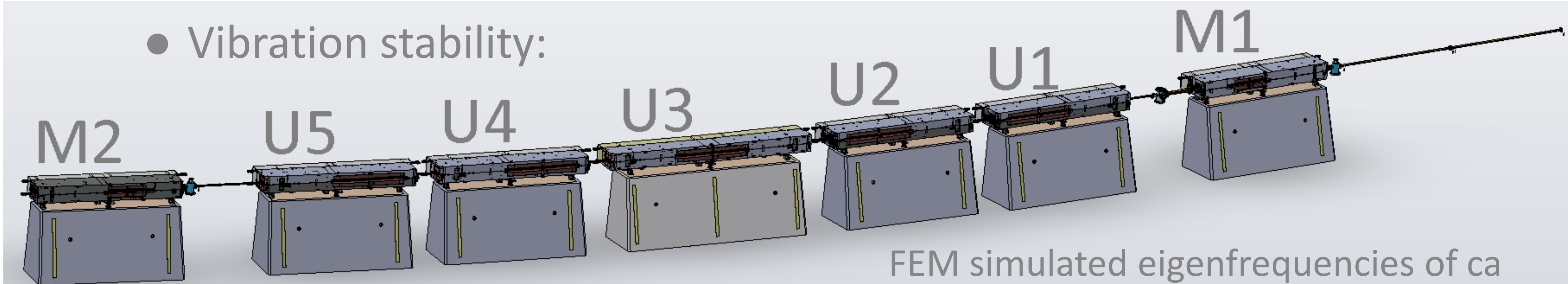
Why?

Ø25 mm pole aperture:

- Lattice compactness . Enabled by NEG-coated vac. chambers!

Magnet block:

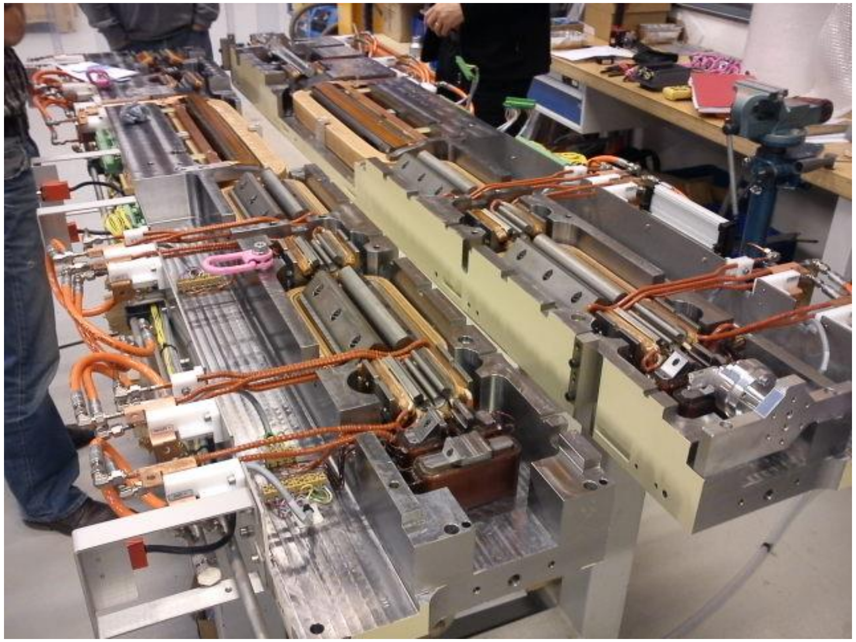
- Vibration stability:



FEM simulated eigenfrequencies of ca 100 Hz for concrete support + adjustment mechanisms + magnet block.

- Reduction of installation work.
- Alignment within each block given by yoke machining accuracy.

Magnet block features



- Dismountable at horizontal midplane.
- all yoke parts = Armco low carbon steel.
- Quad and corr pole tips mounted over the coil ends.
- 6pole and 8pole magnet halfs mounted into guiding slots in yoke block.

The yoke bottom and top blocks

- Each magnet block consists of a yoke bottom and yoke top block.
- 2.3-3.4 m long, machined out of one solid iron block.
- dipole profile machined directly out of the iron block.
- mechanical tolerances of ±0.02 mm for critical surfaces:
  - dipole profile
  - sideways guiding slots
  - vertical mating surfaces
  - midplane and reference planes

MAX IV

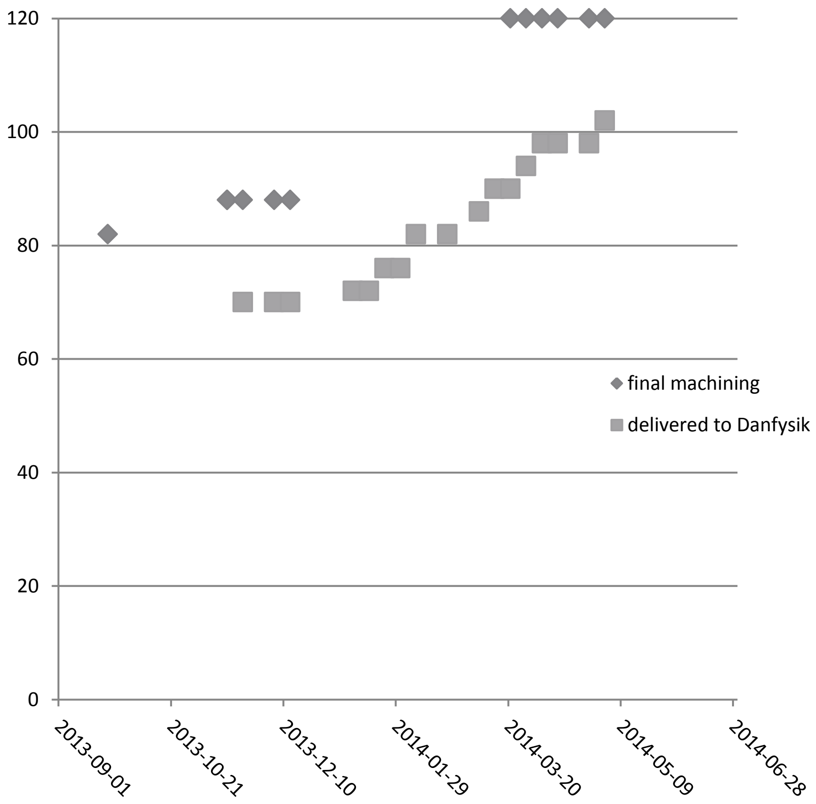
2. production status

Background - 3 GeV ring magnet contracts

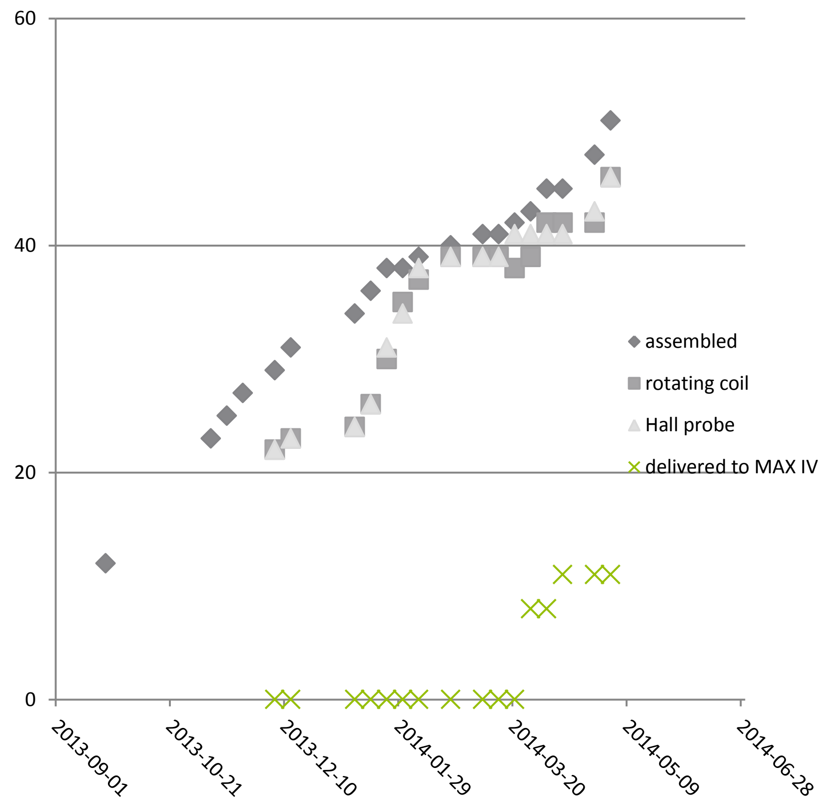
- Production sourced as build to print-contracts for fully assembled and tested magnet blocks, with MAX-lab providing technical specifications and full sets of manufacturing drawings.
- Suppliers responsible for mechanical tolerances, and performing field measurements according to MAX-lab spec.
- MAX-lab responsible for magnetic field properties!
- Contracts signed Sept 2011:
  - Danfysik A/S: M1, M2 and U3 = 60 magnet block units.
  - Scanditronix Magnet AB: U1, U2, U4 and U5 = 80 magnet block units.

Status – Danfysik M1, M2 and U3

yoke machining, 120 pcs

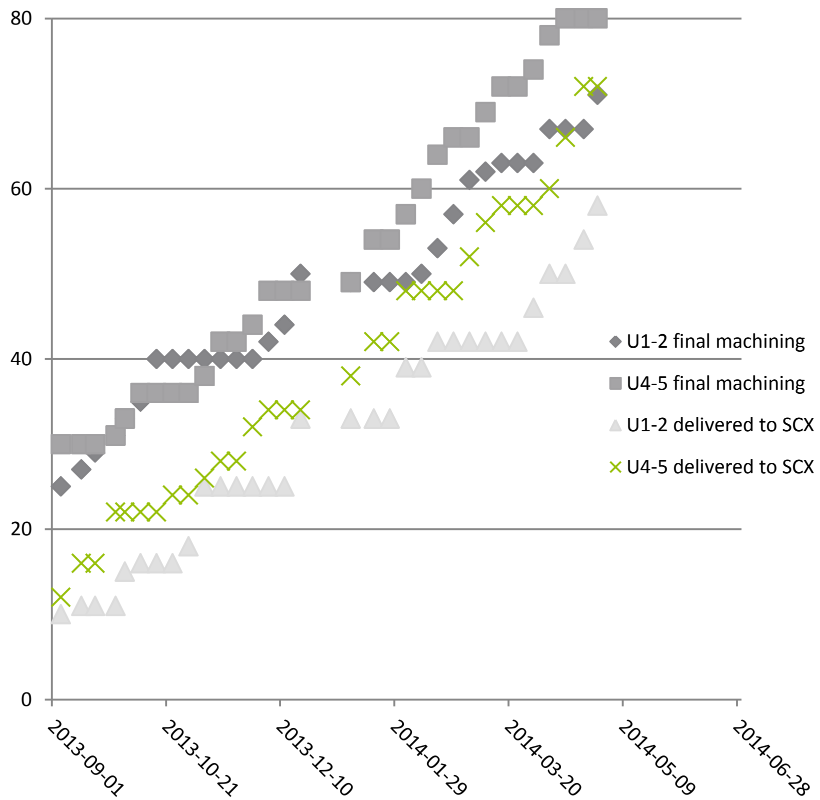


assembly and test, 60 pcs

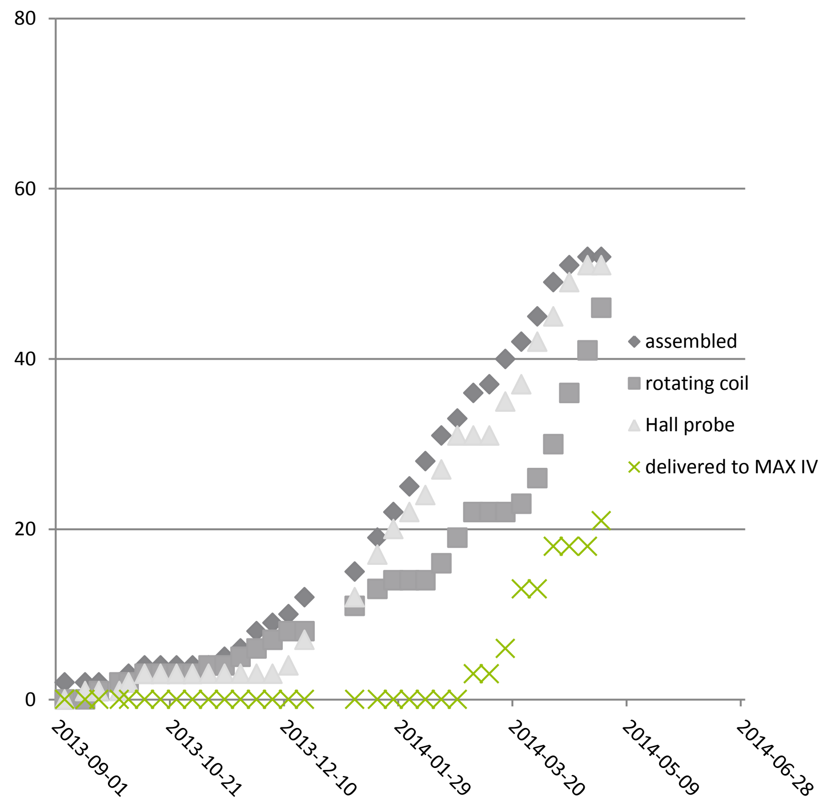


Status – Scanditronix Magnet U1,2,4,5

yoke machining, 80 + 80 pcs



assembly and test, 80 pcs

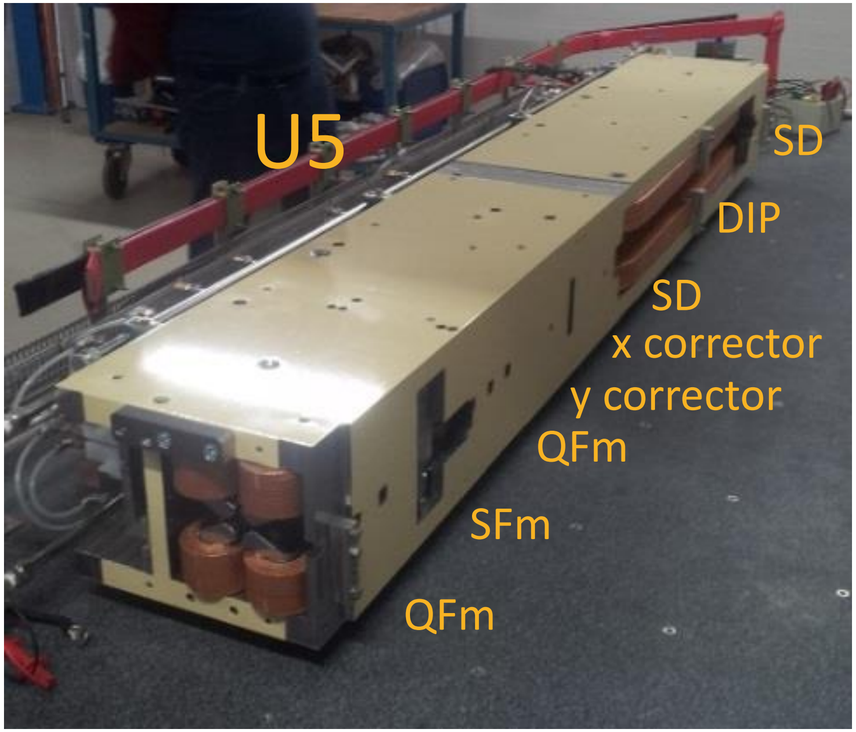


Status - summarized

- Yoke machining is near completion.
- Magnet block assembly and test is roughly halfway through.
- We have started accepting magnet block deliveries.
- Projected end dates are within this summer.

3. alignment within magnet blocks

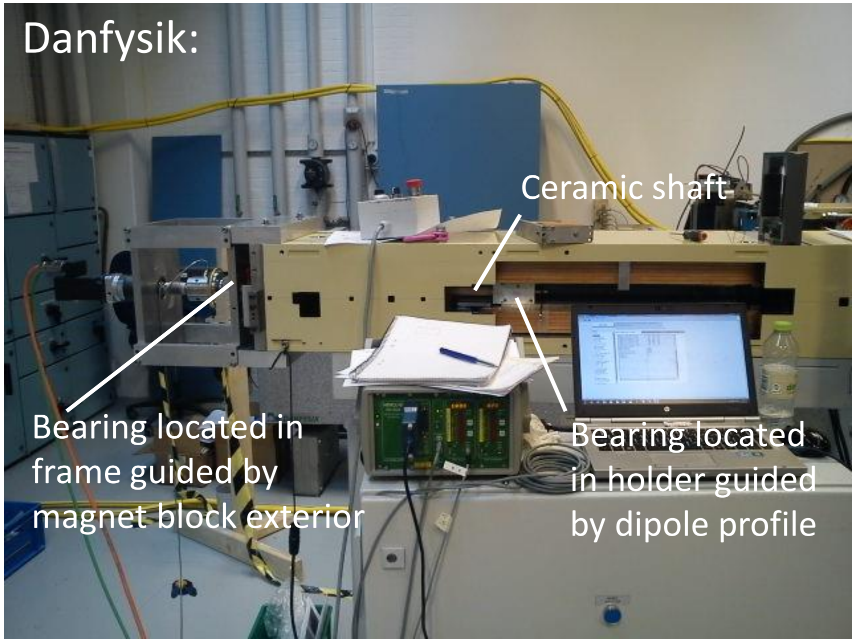
Background – specification for rotating coil measurements

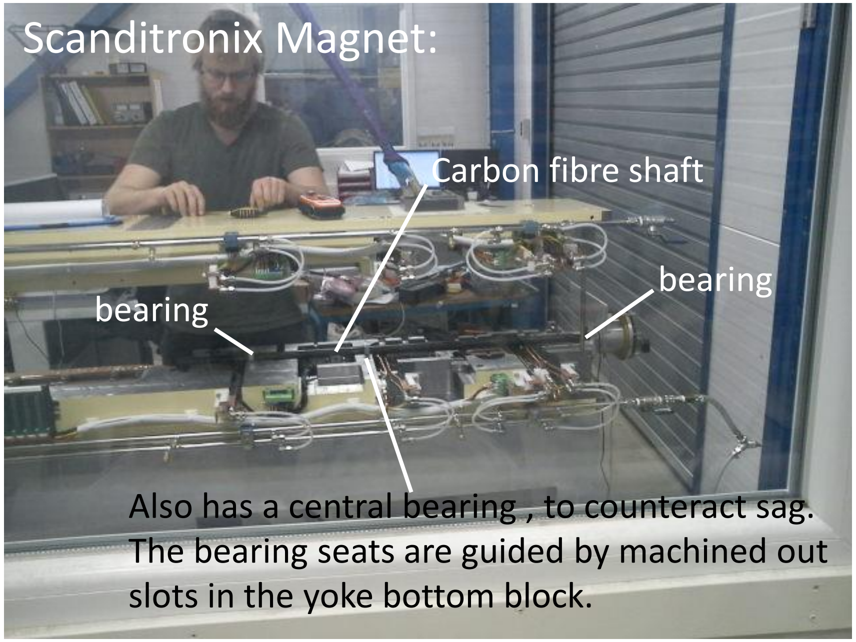


- The technical specification lists rotating coil measurements to be performed for all magnet elements except DIP/DIPm.
- Does not indicate how to access magnet elements for rotating coil measurements.
- Requires rotating axis to be aligned within ±0.1 mm to magnet block ref. surfaces. Which is rather relaxed. We do not attempt to fiducialize to field measured magnetic center locations.
- Based on principle decision that we believe magnetic centers are given by mechanical locations of pole profiles.
- The technical specification was not written so as to provide any verification of this.
- However, with the field measurement data that has been obtained, we have tried to draw some conclusions...

Rotating coil measurement setup.

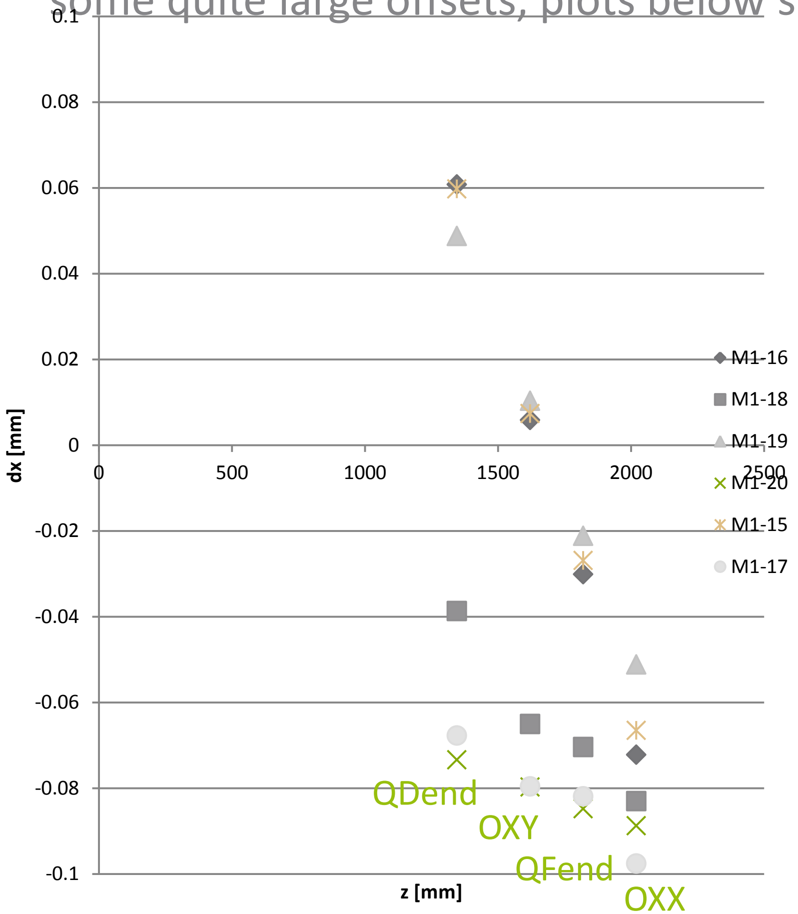
- Both magnet suppliers chose solutions with a long rotating shaft containing several measurement coils, located at each magnet element:

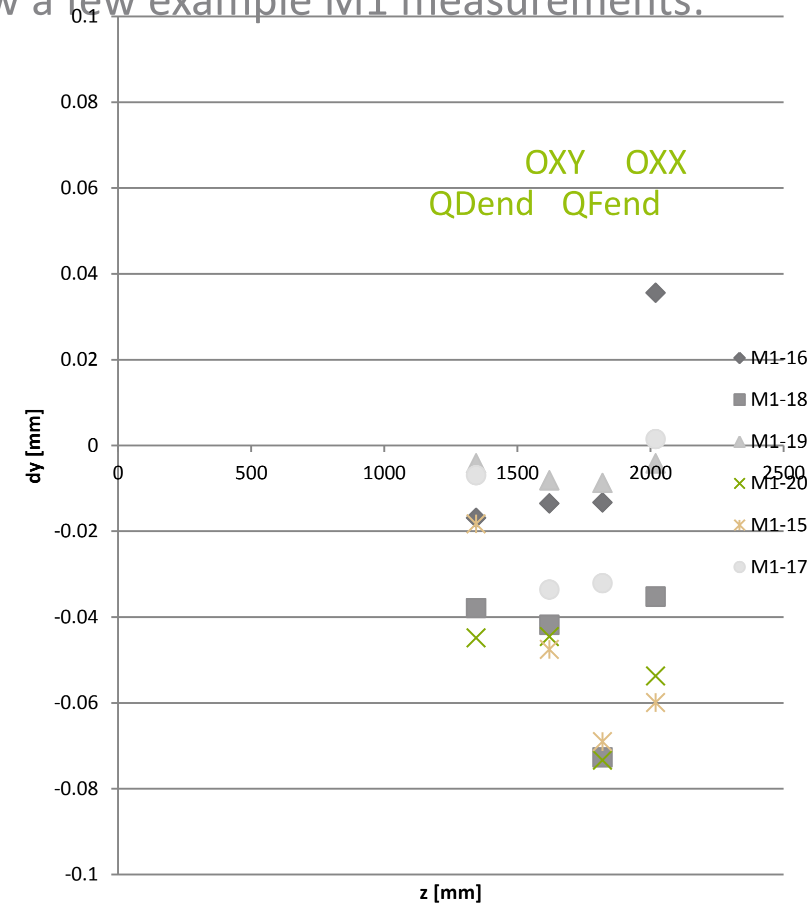




Example rotating coil results – offsets calcualted from feed-down.

- Looking at measured magnetic centre location relative to rotating axis, we have some quite large offsets, plots below show a few example M1 measurements:



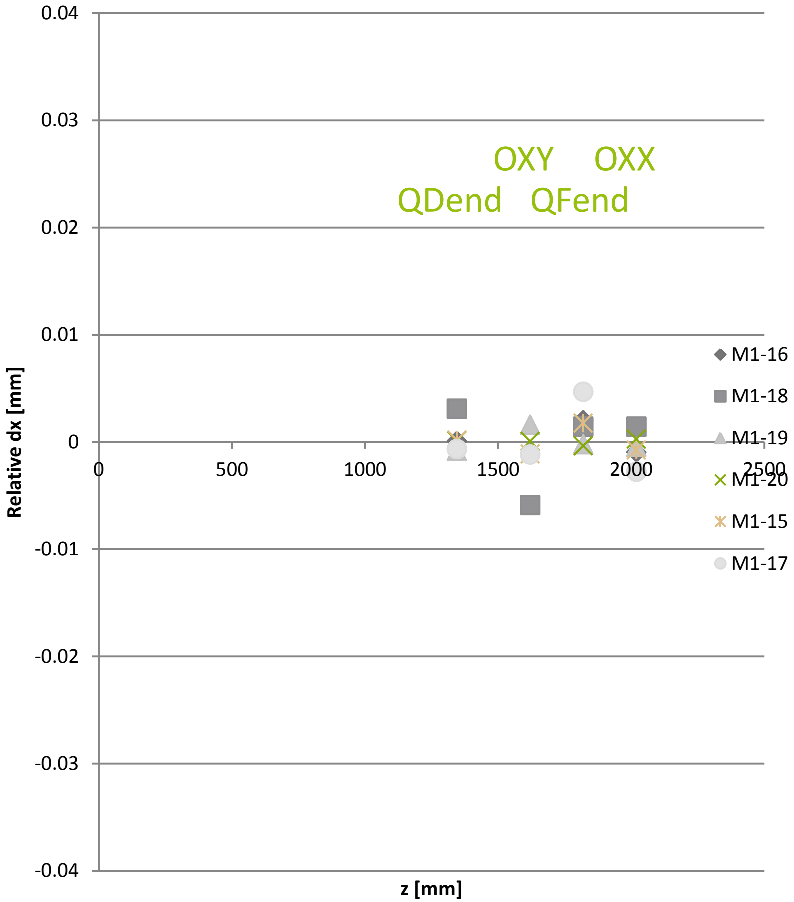


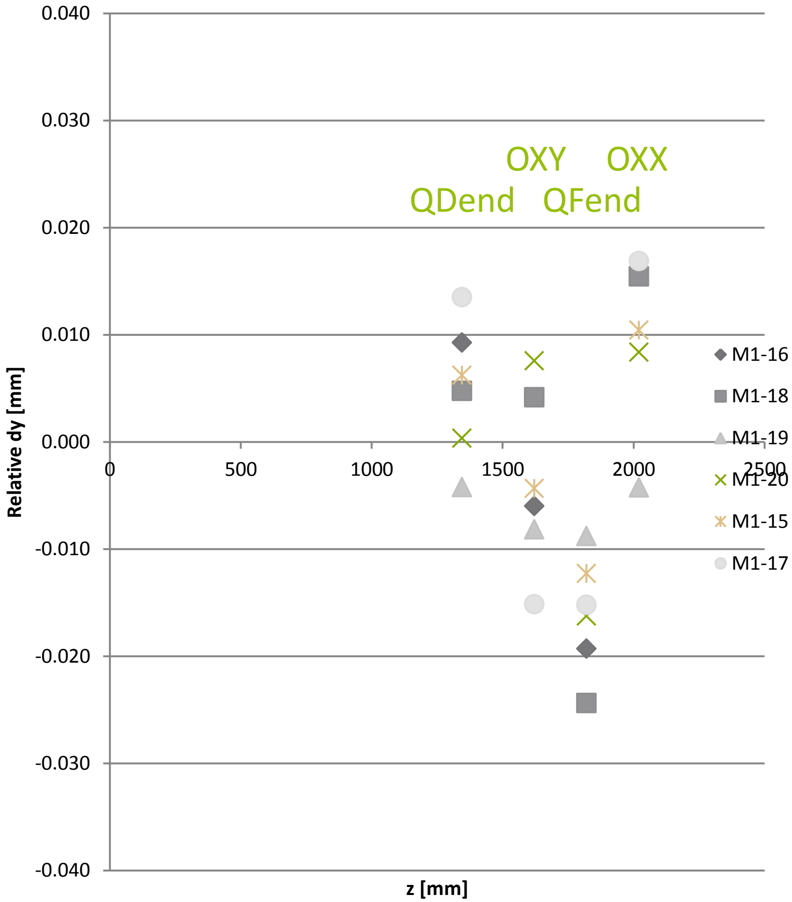
- But relative alignment within each measurement looks a lot better, especially in the horizontal direction.

MAX IV

Relative alignment within magnet blocks.

- subtracting a linear fit we see relative alignment:

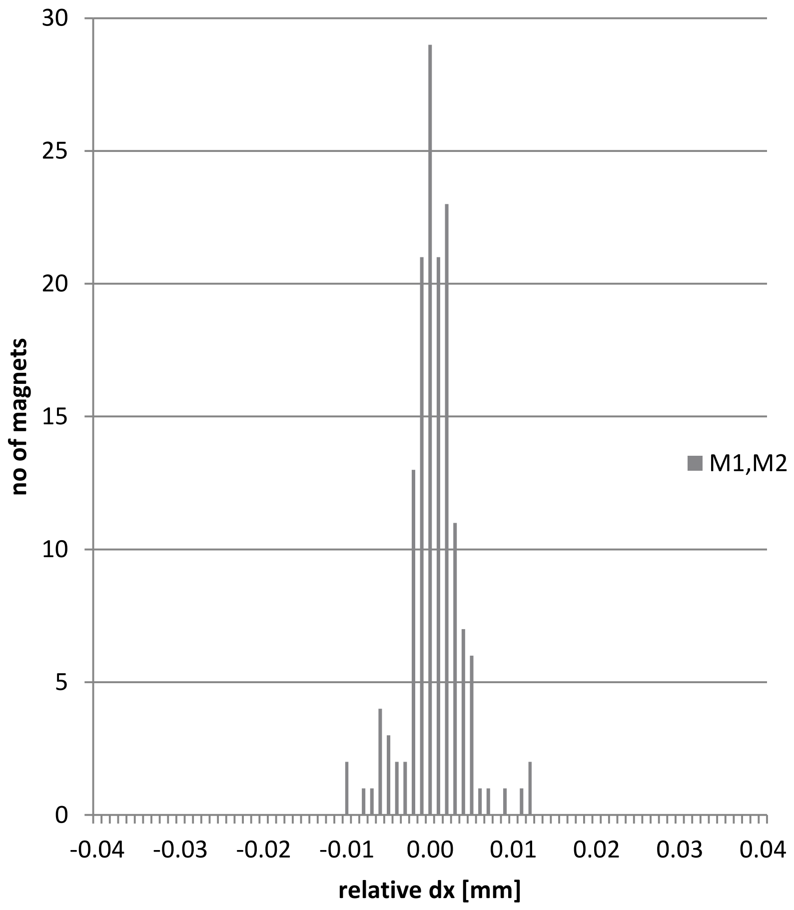




- Horizontal alignment is better than a priori estimate from mechanical tolerances, vertical is closer to estimate, but includes rotating axis sag.

Relative alignment within magnet blocks

- Statistics for 38 pcs M1,2 and 34 pcs U1,2,4,5:



- M1/M2 relative dx (plot to the left): RMS = 0.003 mm, max/min < +0.012/-0.010 mm.
- M1/M2 relative dy: RMS = 0.009 mm, max/min < +0.020/-0.027 mm.
- U… (3 consecutive magnets over 400 mm) relative dx: RMS = 0.004 mm, max/min < +0.012/-0.011 mm.
- U… relative dy: RMS = 0.006 mm, max/min < +0.009/-0.018 mm.
- Our conclusion: rotating coil measurements indicate that MAX IV magnet block alignment concept works!

MAX IV

Questions?