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EXPERIENCE WITH THE COMMISSIONING OF THE U15-UNDULATOR FOR SWISSFEL-ARAMIS BEAMLINE AND NEW DEVELOPMENTS FOR THE ATHOS BEAMLINE

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Abstract

The development of the U15 undulator was presented at the Medsi conference 2012 in Shanghai. Meanwhile the undulatorline is finished. The presentation will explain the experience with the production, the assembling and the commissioning of the undulators. We succeeded to implement a robotic system, that did the final adjustment of all the magnets automatically. Therefore, we were able to reduce the time for the adjustment of the magnets dramatically. A whole loop with measuring, adjustment of the columns and final adjustment with the robotic system for the magnets takes 3 days. The presentation will explain these steps.

For the next beamline, we will profit from the experience of the U15 undulator development, but there are new requirements, because it will be a polarized undulator with a period of 38mm. We are developing a new arrangement of the drives, a further development of the magnet keepers and a vacuum pipe with only 0.20mm of wall thickness.

SWISSFEL PROJECT OVERVIEW

SwissFEL with electron energies of 5.8 GeV will have two undulator lines for hard- and soft X-rays. The first beamline is Aramis that will produce hard X-ray (7 – 1) Å The second beamline will be Athos for soft X-rays.

ARAMIS UNDULATOR U15

Overview

Figure 3 shows the overview with the following main parts:

- Main frame in mineral cast
- Outer beam
- Wedge drive system
- Cam shaft mover
- Vacuum chamber
- I-beam with block keeper, magnets and poles
- Gap measuring system
- Columns
- Power and controls

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Main Parameters of U15 Undulator

- Magnetic length 3990mm
- Period 15mm
- Gap workspace 3 to 20mm
- K-values 1.0 to 1.8
- Vertical forces max. 27.4kN
- Magnet material Nd2Fe14Br + Diffused Dy

Changes

After the design, manufacturing and measuring the pre-prototype we had to change and add several things:

- Design and thickness of magnets/poles considering existing block-keeper design (Figure 1)
- Design of columns (Figure 2)
- Monitoring system of wedge drive
- Motor cooling
- Temperature stabilised assembling area
- FEM based column adjustment

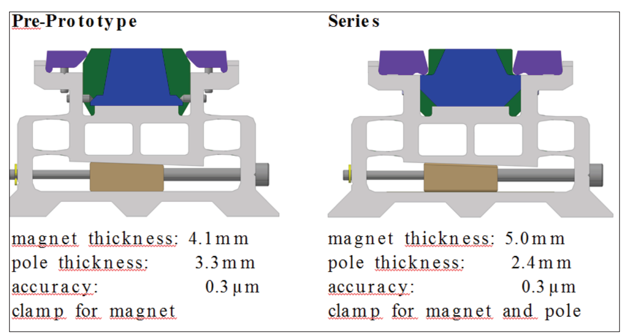

Figure 1: Keeper design changes.

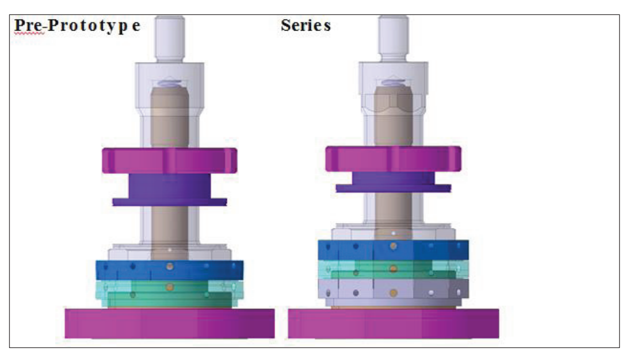

Figure 2: 2nd lock nut to stabilize the fix position. Adjustable range: ± 0.5mm. Accuracy: 1µm

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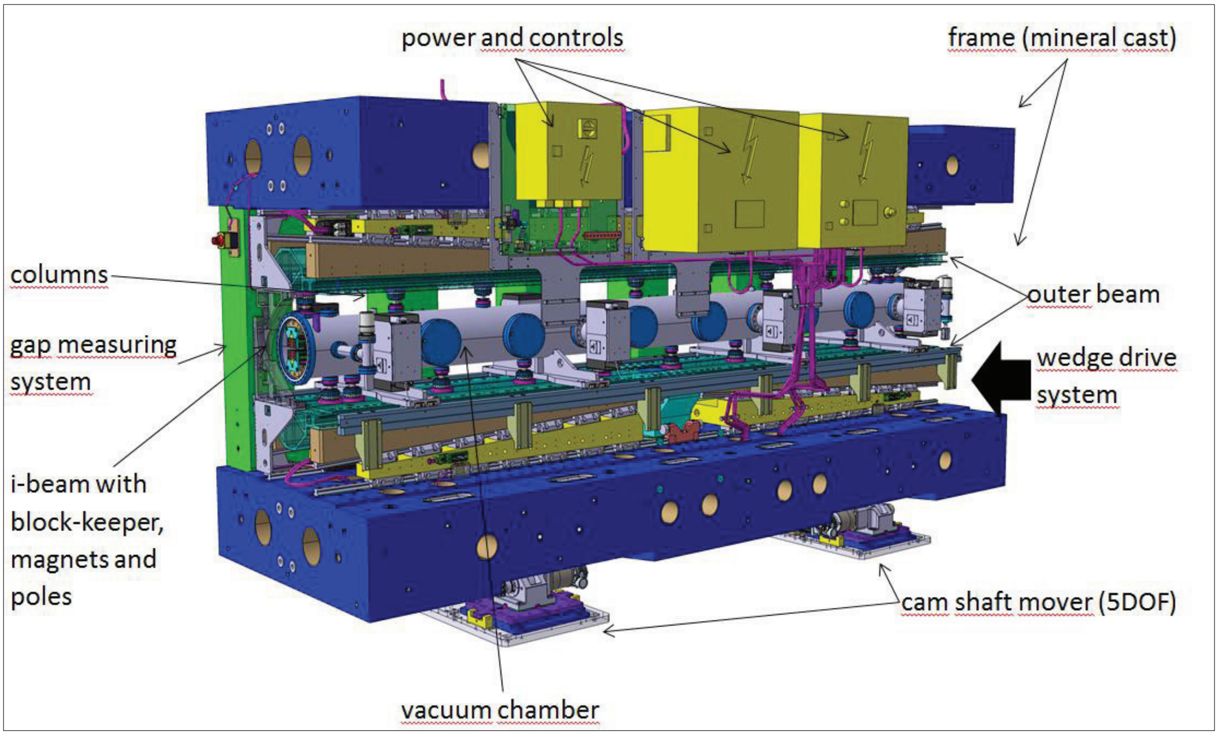

Figure 3: Overview of U15.

Measurements Benches

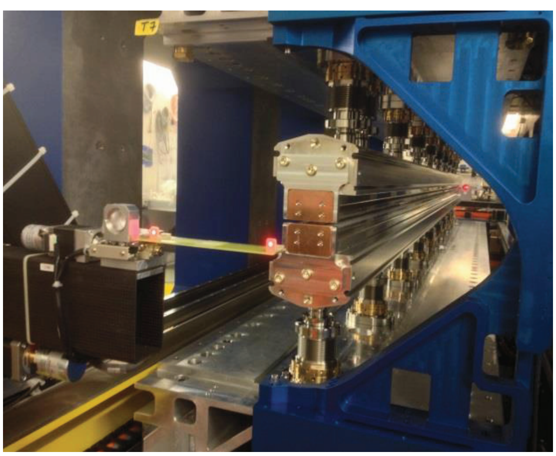

Figure 4: Measurement without vacuum tank.

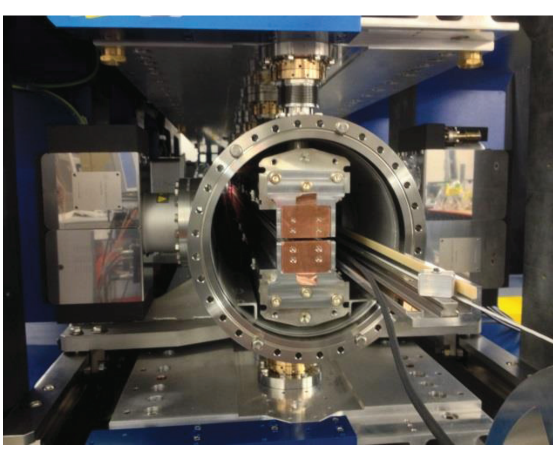

Figure 5: Measurement inside the vacuum tank.

The magnetic fields are measured with hall probes. They are driven from a linear motor and stabilized with a laser based control system. Trajectory and phase are measured and optimized without vacuum chamber (Figure 4). With a second system, that measures inside the vacuum tank, phase and calibration field are checked with different gaps (Figure 5).

Column Adjustment

FEM calculations are made for every column with the influence to the I-beam. These results were included in the algorithm for the optimization. The first step in the optimization adjustment of the columns (Figure 6 -8)

Figure 6: Adjustment of the columns.

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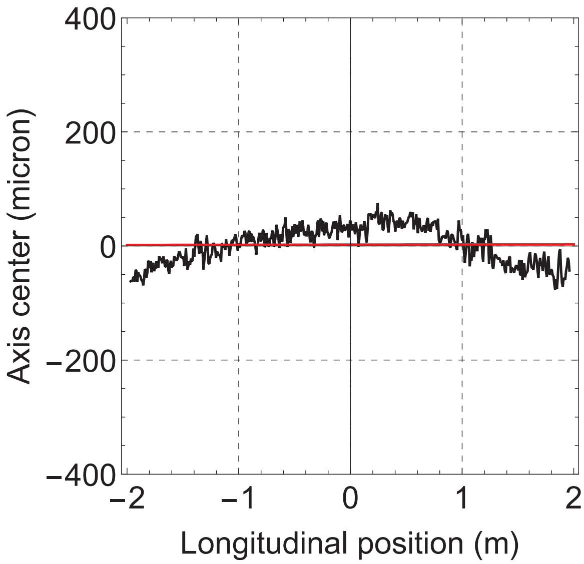

Figure 7: Magnetic field before the optimization.

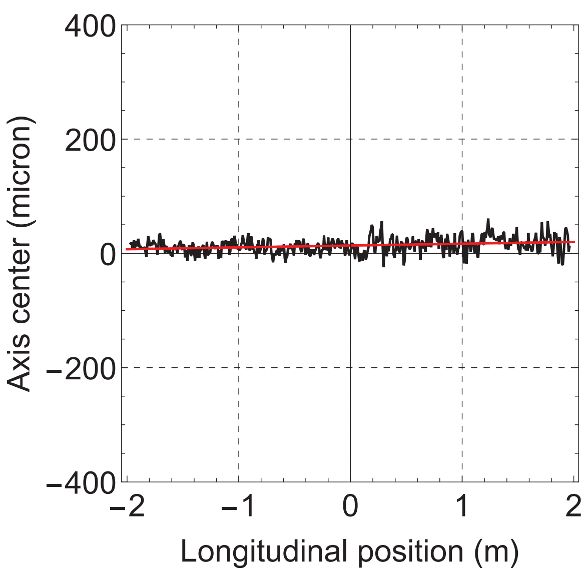

Figure 8: Magnetic field after the first optimization.

Automated Pole Height Adjustment

The pole heights are optimized with a robot system. With that system a complete optimization run takes between one and two hours.

It is a stepper motor that works as a screw driver. It sits on a pneumatic drive. With the pneumatic drive, the system checks when the screwdriver fits the screw.

With that system, every individual height of the magnets is adjusted (Figure 9).

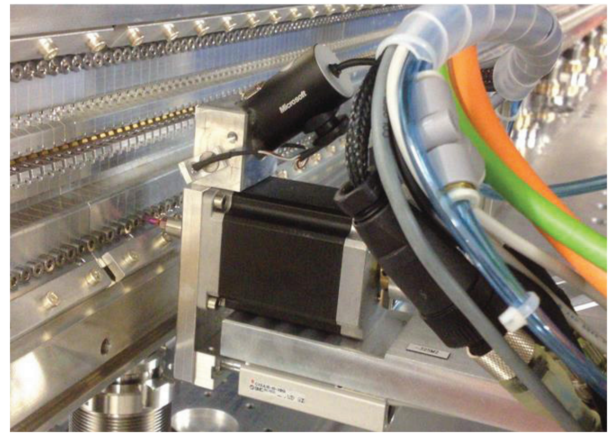
Figure 9: Robot system for adjustment.

Optimization

The whole optimization is done in 3 steps without the vacuum chamber.

1. Optimization of the columns to straighten the axis (Figure 11: After first step)
2. First automated pole height adjustment (Figure 12 after 2nd step)
3. Second automated pole height adjustment (Figure 13 after 3rd step)

These steps are done in 3 days, instead of 1 or 2 month, which we needed in the past.

The phase error is different for different gaps. We optimize at a gap of 4mm (Figure 10)

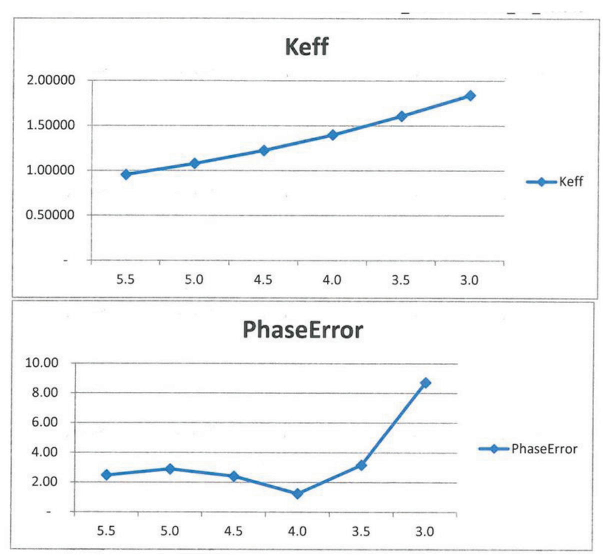

Figure 10: Keff and PhaseError for different gaps.

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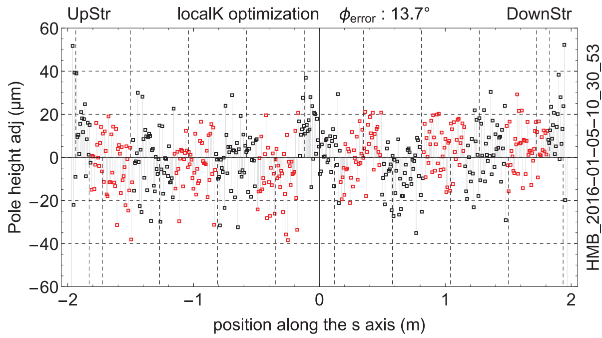

Figure 11: Measurement after first optimization.

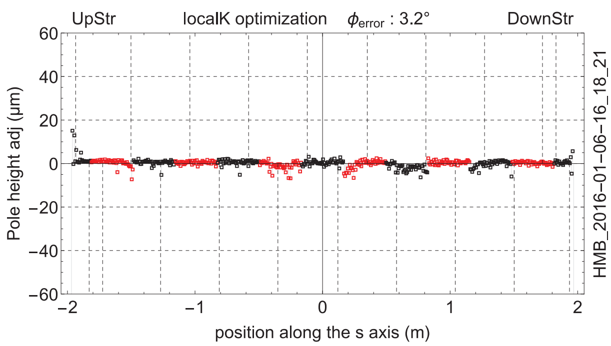

Figure 12: Measurement after second optimization.

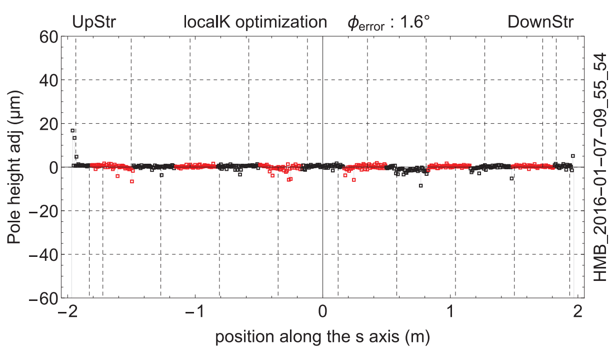

Figure 13: Measurement after third optimization.

Summary of Time Schedule

- Design from October 2008 – April 2014
- Pre-prototype from November 2010 – October 2013
- Series from July 2013 – September 2015
- Optimisation in the ID-laboratory from September 2015 - September 2016
- Installation in the tunnel starts in January 2016

ATHOS UNDULATOR UE38

The undulator for the Athos beamline will have e period of 38mm and an APPLE-X configuration (Figure 14)

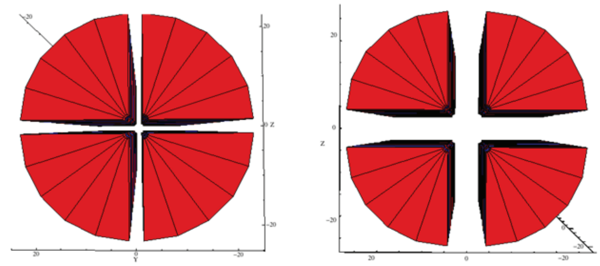

Figure 14: APPLE-X configuration.

Each of the 4 Magnetic bars has its individual drive. This gives the highest flexibility for different modes (Figure 15)

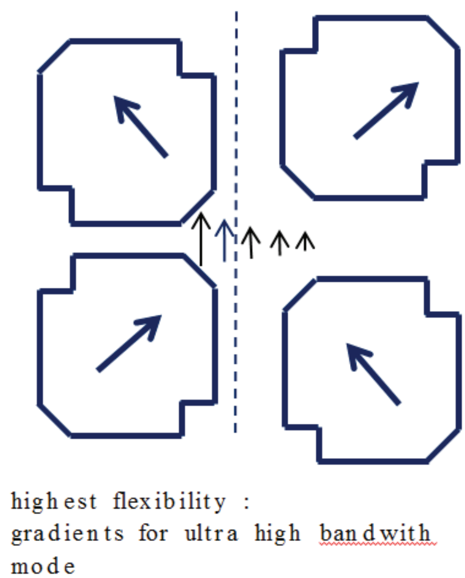

Figure 15: Highest flexibility.

The length of each module is 2m. The mechanism is mounted in a closed frame, which is made from cast iron. It is designed for maximum stiffness in all directions.

The drives for gap and shift are arranged orthogonal. This gives the advantage, that no combined movements of drives are needed. Also the measurement systems for gap and shift can measure directly the relevant movement. Figure 16 shows the general arrangement.

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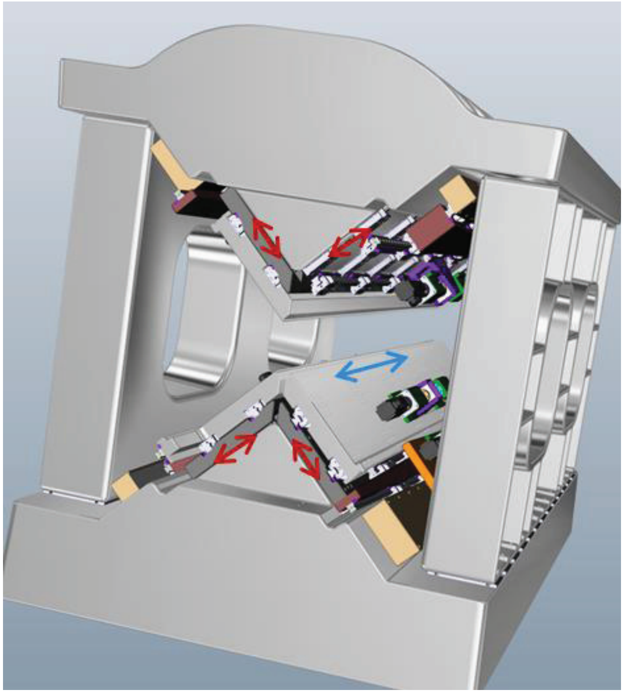

Figure 16: Frame and arrangement of the drives.

The keeper design is a flexor system like in the U15 with the following optimizations (Figure 17):

- The flexors are drawn to the wedge with a spring
- The fine adjustment is done with a differential screw

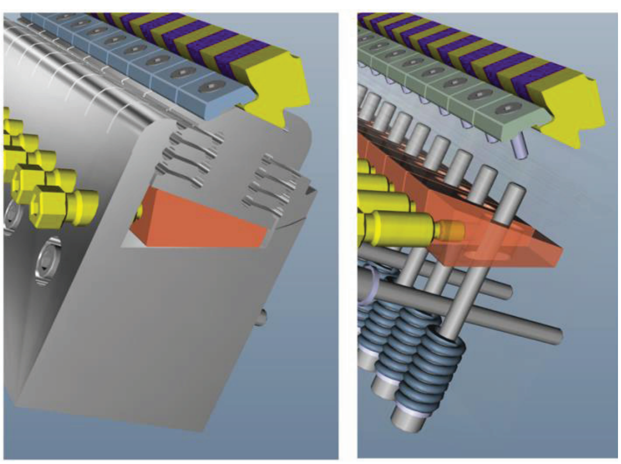

Figure 17: Keeper design.

For the vacuum chamber, we will use a tube made of copper with a very thin wall of 0.2mm (Figure 18)

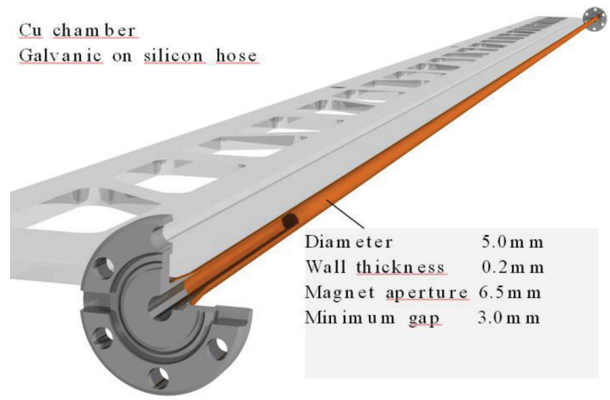

Figure 18: Vacuum Chamber.

CONCLUSION

With the new keeper system of the U15 Undulator, we can adjust the 2000 Magnets of a 4m long module with an automated robot system within 3 days.

For the new Athos beamline, we will develop a new arrangement of the magnets (APPLE-X) with orthogonal movements and a vacuum chamber in copper with a wall thickness of only 0.2mm.

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