Actual survey and alignment activities at GSI for FAIR

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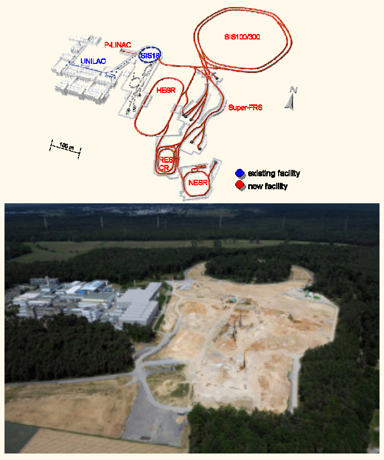
FAIR @ GSI

A highly sophisticated accelerator complex, FAIR - Facility for Antiproton and Ion Research, is being constructed next to GSI Helmholtz Center in Darmstadt, Germany, as a new international research laboratory. The about 4.000 meters long beamlines with their dedicated buildings will be built predominantly below ground, taking an area of about 20 hectares.
Starting the really first preparatory work for the construction in 2011, the erection of the building shells for the facility is scheduled for 2015. The final construction permit was handed over in May 2014, leaving behind a 2-year period of receiving about a dozen partial construction approvals stepwise.



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In the meantime an important milestone was reached with the completion of the pile-drilling work in May 2014. A total of 1.350 steel-armored concrete piles with a length up to 60 meters and a diameter of 1.20 meters have been drilled within 15 months. With five modern drilling rigs, among them the world's largest such special drilling devices, which first saw service at the FAIR construction site, it was possible to produce one drilled pile per rig and day.
The piles stabilize the subgrade so that the later buildings at the FAIR facility will settle less and more equally (predicted mean ground settlement of 35 centimeter reduced to 50%).

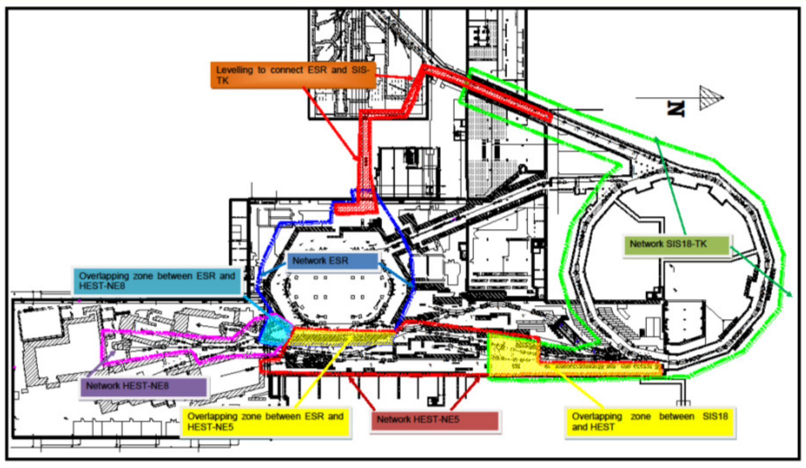
Network Surveying for Monitoring and Alignment Tasks

Regarding the future building activities for FAIR and changes in the groundwater level and thus expected ground settlements, a large 3D network campaign was performed as reference network within the existing accelerator machines (SIS18-HEST-ESR-TK) in summer/autumn 2013.

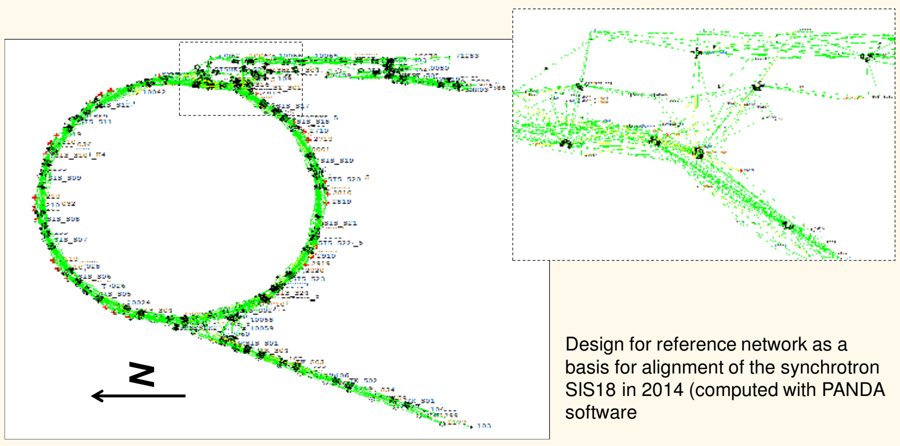
- Using Leica AT401, TDA 5005 and FARO SI.2 combined with Leica DNA03 assigned to different machines
- Point accuracies from 0.02 to 0.06 mm

10 months after this campaign the synchrotron SIS18 (circumference 216m with a total amount of 95 components to be aligned) was unscheduled observed during a two-week-ongoing network measurement as a preparation for a complete alignment.

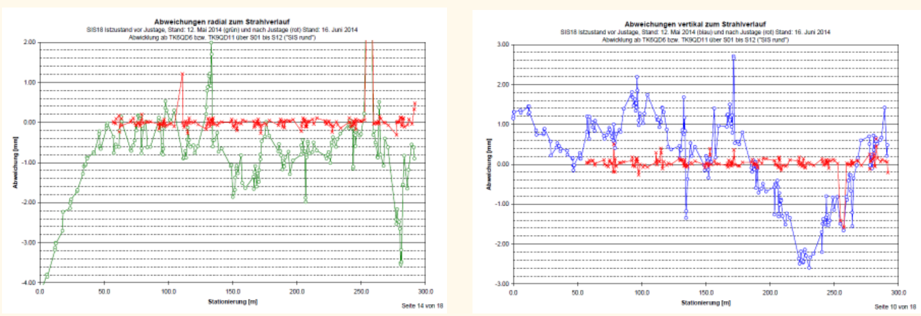
- Using FARO SI.2 and Leica DNA03
- Evaluation by the software PANDA
- Comparison of both networks 2013 vs. 2014: deviations in the western injection area of ca. +0.25 mm and the southeast region of ca. -0.75 mm
- Alignment of all components during a four-week-campaign with an accuracy better than 0.1mm



Network campaign 2013: measuring areas @GSI



Design for reference network as a basis for alignment of the synchrotron SIS18 in 2014 (computed with PANDA software

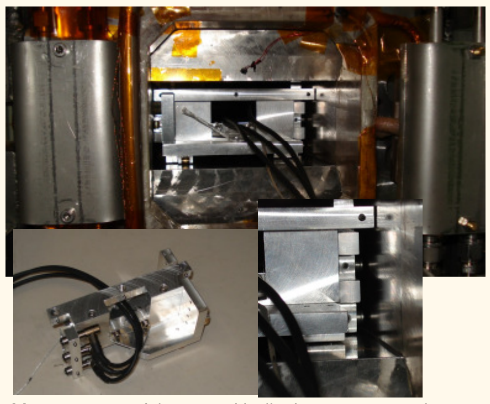


Beam plot for synchrotron SIS18: lateral (green) and vertical (blue) deviation before and after alignment (red)

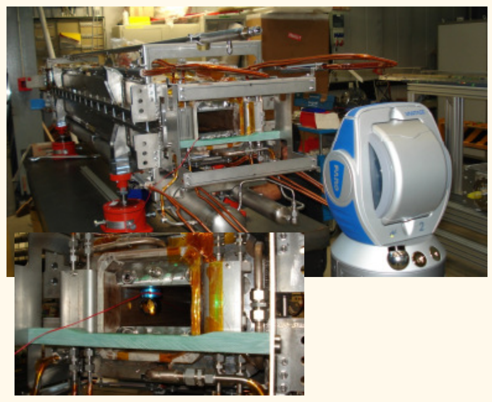
Quality Assurance

The validation of manufacturing tolerances during the process of magnet design is an emerging field of interest. An example is given by the FAIR synchrotron SIS100 superconducting dipole magnet.

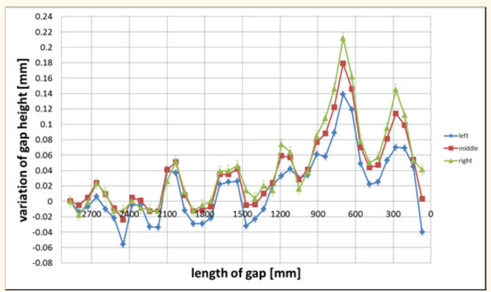
- The gap height variation, sagging of yoke and parallelism of pole shoes should be determined with a required accuracy of 0.05 mm
- With a FARO Vantage Laser Tracker, by pulling a prism through the gap, an absolute accuracy of 0.02 mm is achieved.
- Independent (relative) measurement is done by pulling a self-constructed wagon equipped with displacement transducers through the gap with a repeatability of 0.025 mm (executed by SC magnets & testing).



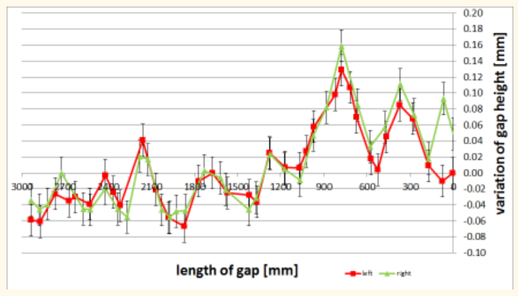
Measurement of the gap with displacement transducers



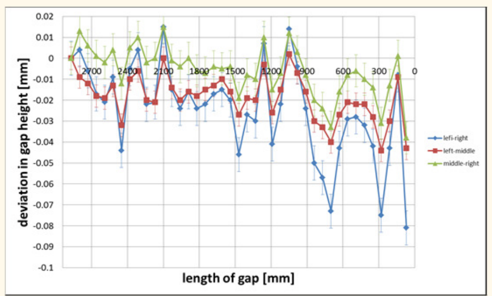
Measurement with laser tracker



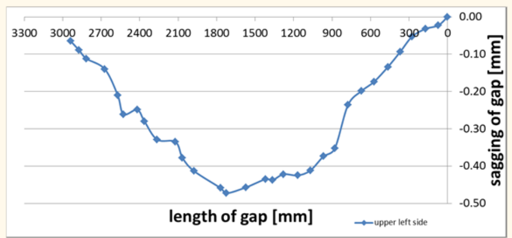
Variation of gap height measured with displacement transducers



Variation of gap height measured with laser tracker



Parallelism of pole shoes (results of displacement transducers)



Sagging of the upper left side of the gap (only measurable by laser tracker)

Examination of the Reproducibility of Super FRS-Dipole Assembly

The reproducibility of the magnet has utmost importance because once the magnet is moved to its final operating position no further inspections are possible due to the installation situation and a very tight shielding, which already exists during installation.

- The magnet is divided in to six smaller parts to facilitate the transportation. The total weight of the magnet is 90 tons, the length is about 2.5 meters.
- To find out if the assembly of the magnet is reproducible, a truck crane was used to dismantle the upper part from the lower part of the magnet.
- Measurements were carried out before and after the dismantling of the magnet into two parts.
- A FARO Vantage Laser Tracker was used for the measurement to reach the required accuracy of the reproducibility to less than 0.1 mm
- A maximum displacement of 1mm and a lateral inclination of 0.13 mrad were detected between the upper and the lower part of the magnet when dismantled and reassembled. More analyses and refinement of the process are necessary.

Dismantling the Super-FRS Magnet

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45 tons are put down carefully

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The magnet is one of three of its kind which will form a part of the Super-Fragment-Separator (Super-FRS).
The giant magnets will sort out interesting particles to be examined in experiments trying to reveal the origin of the elements.
The magnet's construction is unique because it completely avoids organic components such as epoxy resin adhesives. Any organic components would be destroyed in short time by particles flying through it. The avoidance of organic components allow for a long life of the magnet, while, at the same time, new technical developments like a novel indirect cooling system are required.

Extensive design work was necessary to develop appropriate adjusting devices that will be arranged 4 meters above the magnet and must be used without direct visual contact due to horizontal shielding.

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