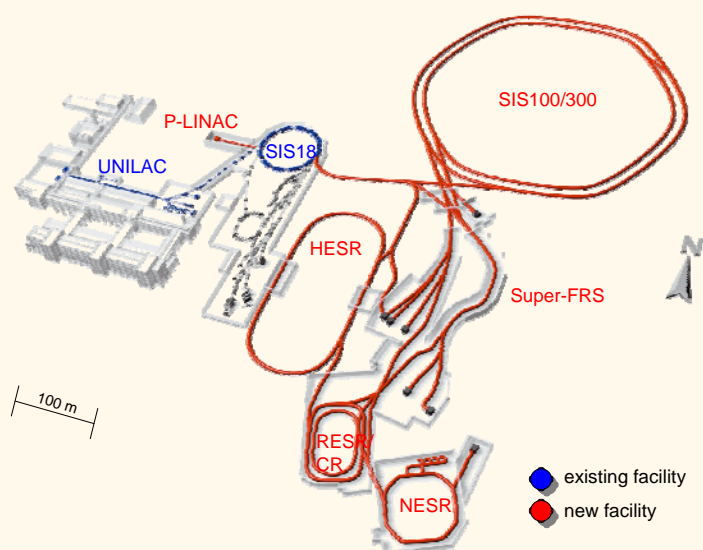


# Start of construction for the International Facility for Antiproton and Ion Research (FAIR) – Aspects of Survey and Alignment

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Layout of FAIR (red) together with the existing SIS18 and UNILAC (blue)

## FAIR NUMBERS

FAIR is one of the biggest research project and most complex accelerator center of the world ([www.fair-center.eu](http://www.fair-center.eu)).

- After final completion: 8 circular and 2 linear accelerators together with approx. 3,500 m beam lines
- 400 beam diagnostic devices, 500 superconducting magnets and composite modules, 1000 normal conducting magnets of 64 types with weights from 100 kg to 100 t
- 24 new buildings and tunnels which need roughly 600,000 m<sup>3</sup> concrete and 35,000 t steel. Walls show partly a thickness of 8 m.
- 1,500 bored piles with a diameter of 1.2 m in a depth of -60 m
- Total investment costs until 2018 for the final completion of FAIR currently estimated to 1.6 billion euro



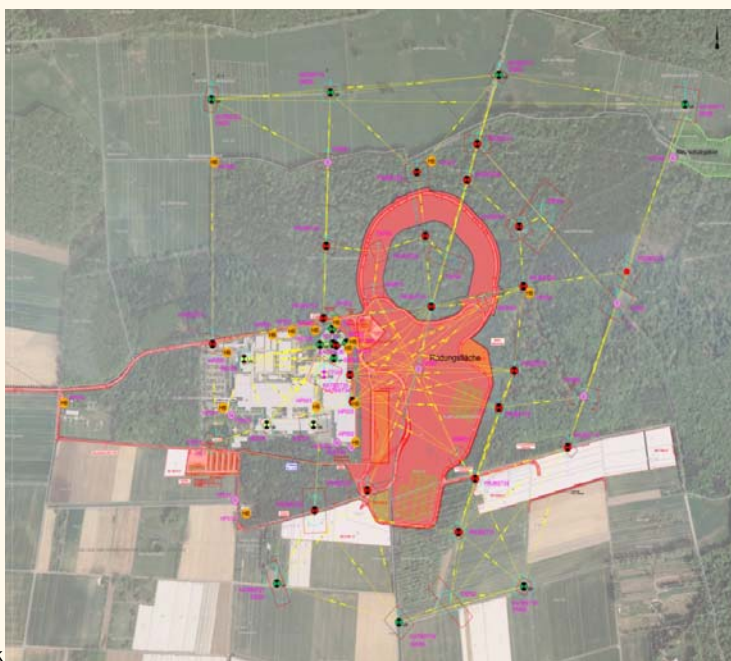
Cleared construction site next to existing GSI halls (seen from east)  
© Niko Schneider



New monument nearby cleared construction site

## SURFACE POINT NETWORK

- 36 monuments distributed over an area of 1.3 km x 1.3 km
- Simulation computations for a combined 1D+2D network, based on the use of total station and digital level, result into mean standard deviations of 0.7 mm ( $\sigma_H$ ) and 1.4 mm ( $\sigma_V$ ); a pure 1D network, e.g. for monitoring tasks, is predicted to achieve a standard deviation of 0.3 mm

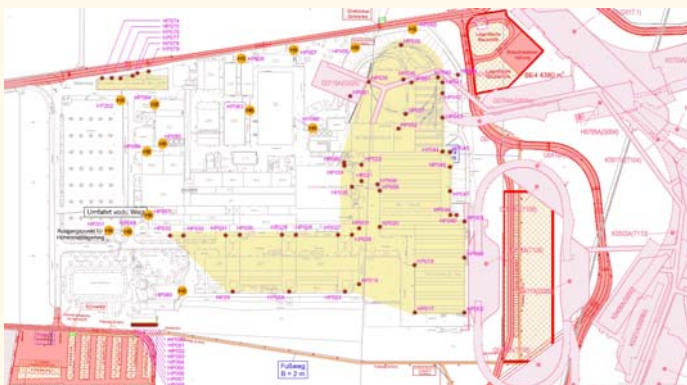


Basic primary network

## STRUCTURAL MONITORING

Operation of the existing GSI accelerators shall initially be continued during construction of FAIR buildings. Strong lowering of the groundwater is supposed to lead to ground settlements which will appear at existing GSI buildings and tunnels and thus on the accelerator machines, too.

- First precise leveling campaign before starting the development measures for the construction site: mean standard deviation of 0.2 mm ( $\sigma$ ) was reached
- Measurements serve as preservation of evidence and clarification of reasons for possibly occurring structural damages caused by the construction activities
- No online monitoring system for existing accelerators is foreseen due to operation time until start of upgrading in 2015

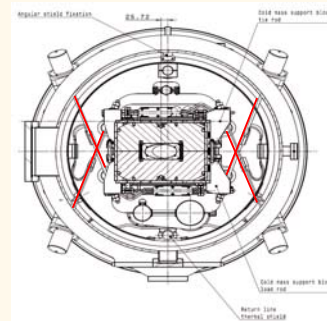


Point distribution for deformation monitoring at existing GSI buildings (pink labeled)

## TESTS ON SUPERCONDUCTING DIPOLE MODULES: DISPLACEMENT AND DEFORMATION

Prototype of the superconducting dipole module for synchrotron SIS100:

- Behavior of the dipole yoke with respect to its surrounding cryostat during pumping processes, thermal cycles, after quenches and after transport
- Stability of the cryostat in the zones next to suspension and fiducial points



Cross-section of the dipole module suspension rods (red)



Prototype of a superconducting dipole module with for SIS100 on the test bench

## MAGNET MOVEMENT AND YOKE DEFORMATION

Determination of shrinking and displacement values of the non-accessible magnet in cold condition (4 K) versus warm condition (297 K) and in between

- Measuring concept based on existing KERN E2 theodolite, FARO SI.2 laser tracker and suitable tools for lighting and sighting as well as a modified vacuum vessel and fit bores in the yoke
- Defined precision of  $\pm 0.1$  mm was confirmed by a large number of measurement runs



Fit bore in dipole yoke



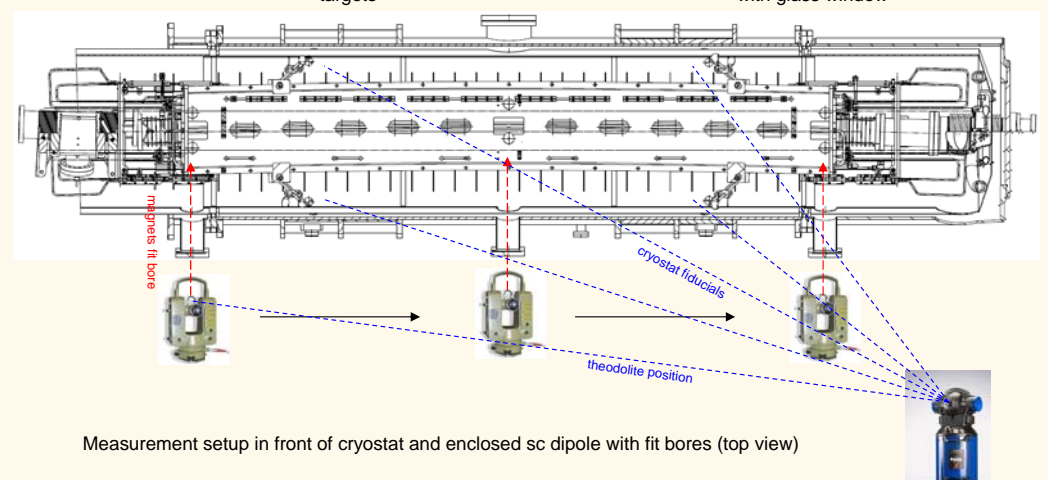
Customized targets



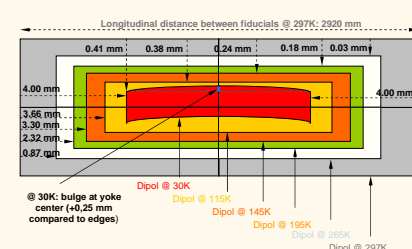
View into cryostat



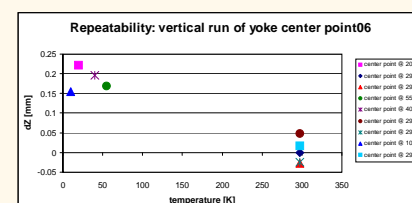
Lighting device at flange with glass window



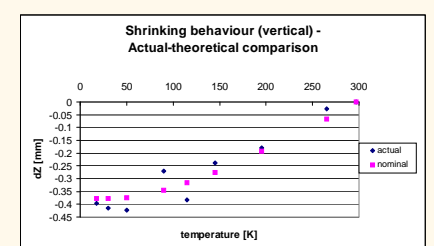
Measurement setup in front of cryostat and enclosed sc dipole with fit bores (top view)



Schematic view of the shrinking values of the upper magnet yoke in longitudinal and vertical direction, determined at fit bores at decreasing temperatures (side view)



Repeatability of measured fit bores at the center in warm and cold condition



Comparison of averaged, uncorrected, measured shrinking values of the dipole half yoke at different temperatures and correspondent nominal data for vertical (Z) direction

## CRYOSTAT DEFORMATION

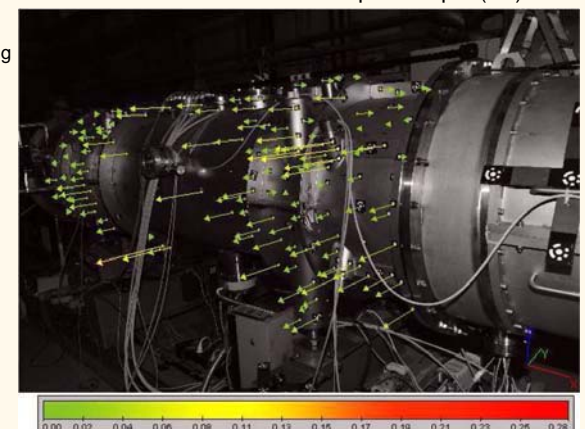
Stability of cryostat fiducials that serve for survey and alignment of the dipole module in the tunnel and cryostat shape in different conditions need to be verified

- Comparison of distances between four fiducial points after ten independent laser tracker measurements at variable magnet condition: weighted standard deviation of 20  $\mu$ m ( $\sigma$ ) was reached
- Shape of vessel under different internal pressure was studied by photogrammetry: using AICON DPA Pro with NIKON D3X results to mean deformations of 55  $\mu$ m  $\pm$  15  $\mu$ m (3D)

Exemplary vector presentation of cryostat deformations due to pumping



Fiducial on cryostat



For detailed information see paper with identical title in IWAA2012 proceedings.