

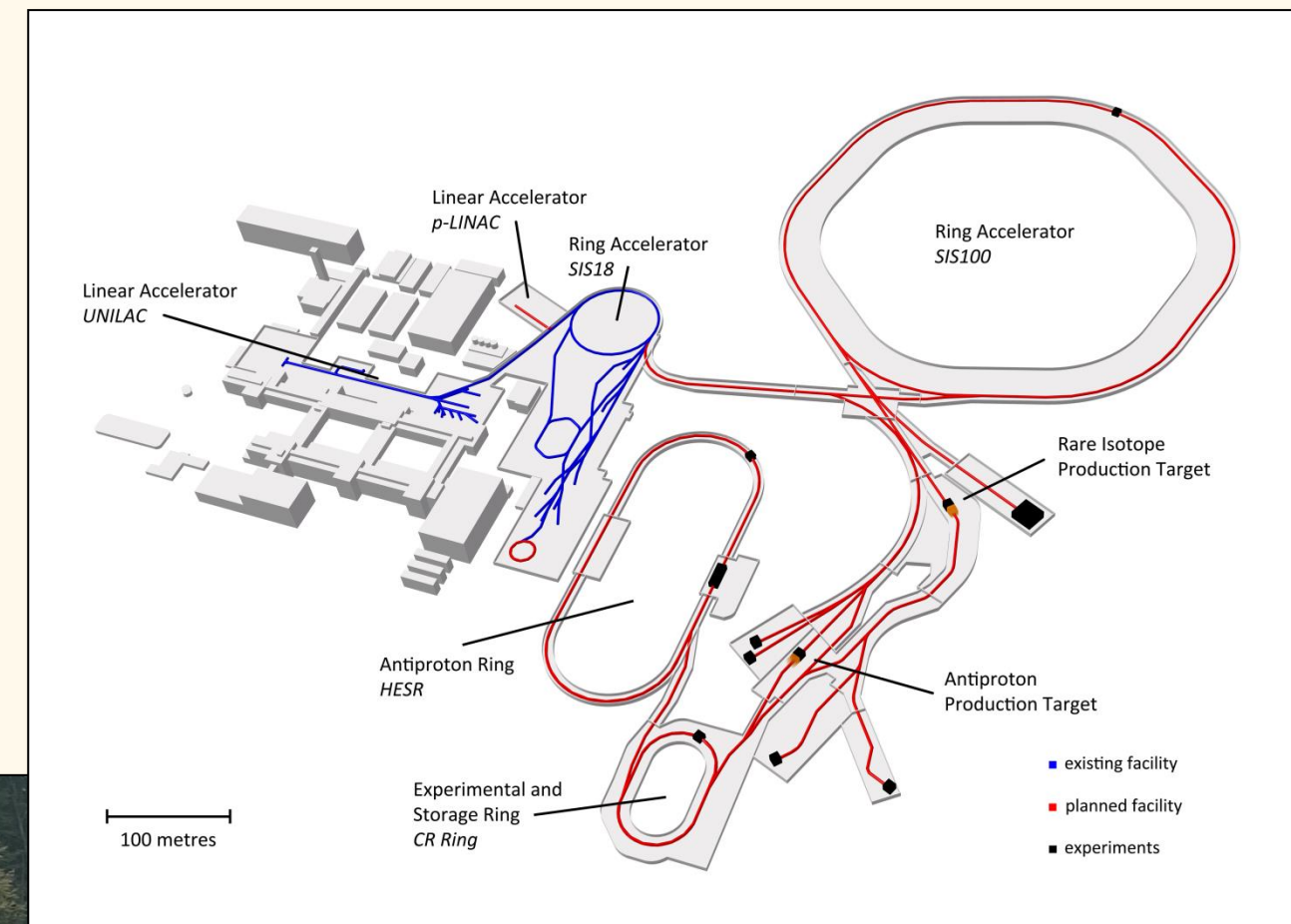
# Monitoring Measurements during the Construction Work for FAIR and Re-alignment of the GSI Machines for the Beam Time 2018

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## CURRENT STATUS OF FAIR

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

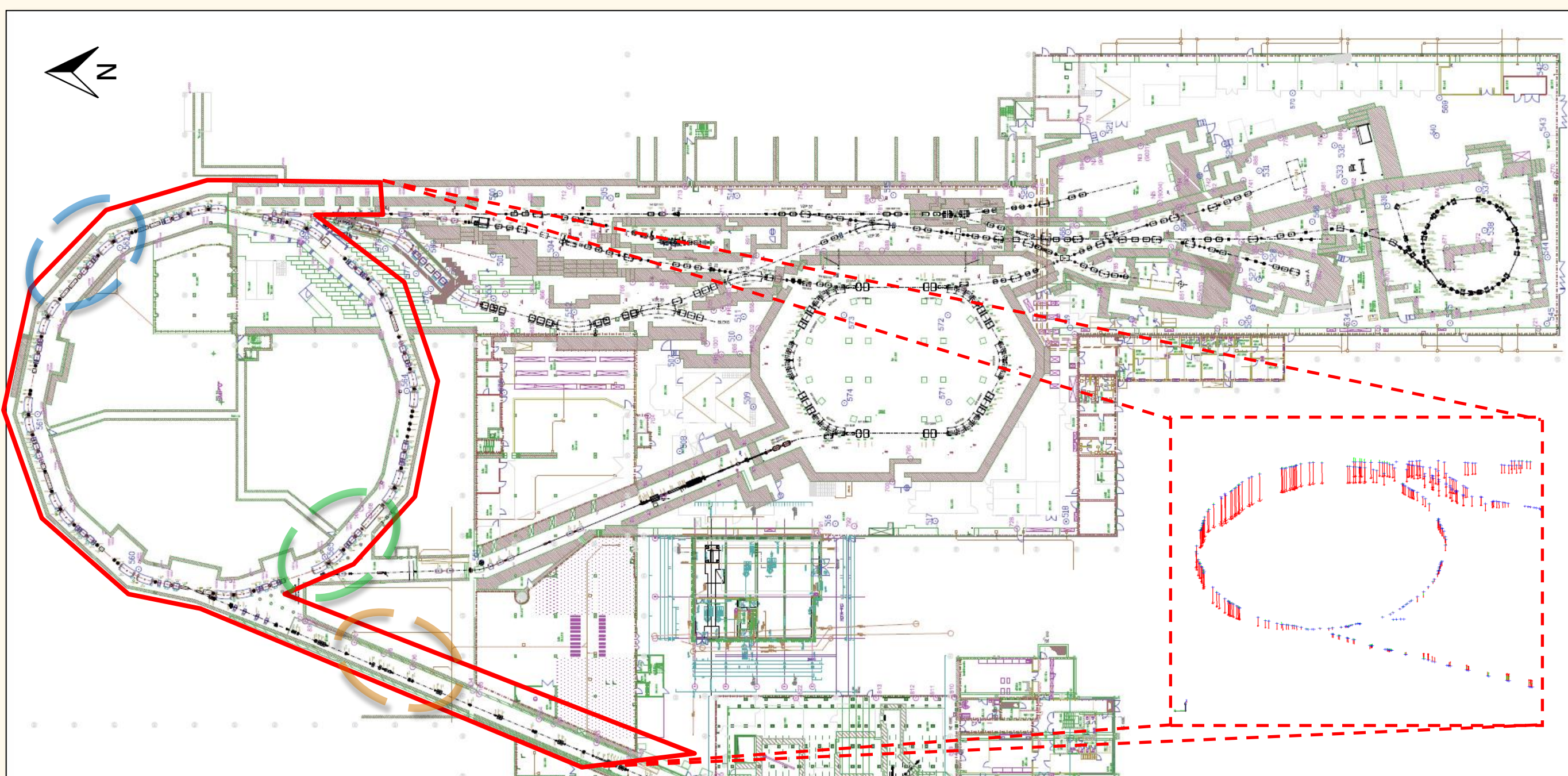
- The concrete work for preparing the tunnel of the SIS100 particle accelerator has started.
- Everything is prepared to link the existing SIS18 ring accelerator to the future SIS100 ring.
- The SIS18 particle accelerator is upgraded. It will serve as one acceleration stage for FAIR.
- Transformer station north was built.
- Groundwater lowering in construction site area is in process.
- First FAIR components at site for acceptance tests.



SIS100 tunnel – construction site (Aug. 2018)

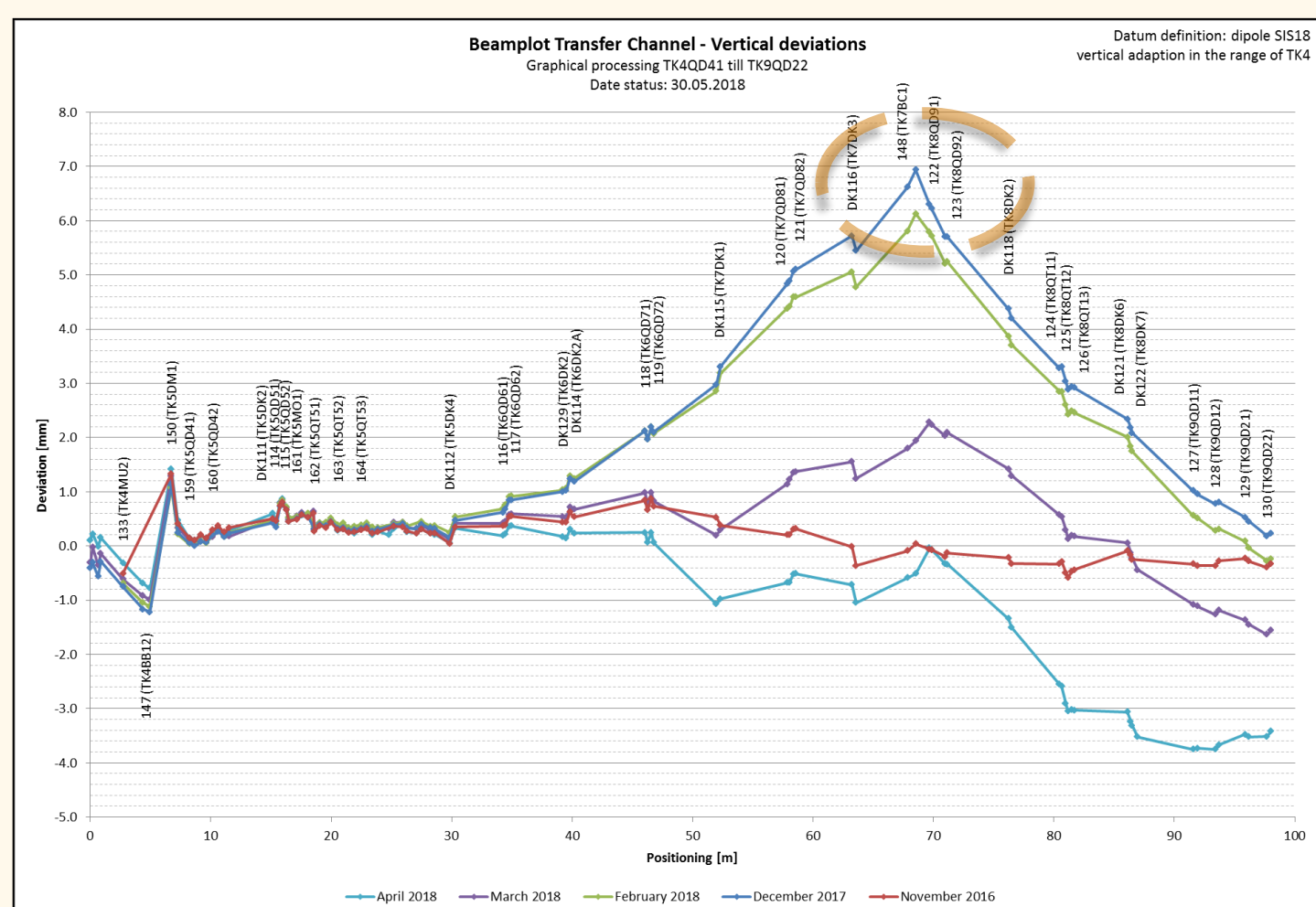
## MONITORING MEASUREMENTS DURING THE CONSTRUCTION WORK FOR FAIR

- Due to the current construction work for FAIR, significant deformations in the area of the existing GSI synchrotron (SIS18) and adjacent beamlines occurred in 2017/2018.
- High-precision 3D-network measurements were carried out at different epochs to monitor the magnitude of ground settlement. (Dec. 2017 – Apr. 2018)
- Using leveled Leica AT402 (no additionally leveling by Leica DNA03)
- Evaluation by the software PANDA (4 parameters – Leica AT402 as tachymeter) and vertical adaptation at the area transfer channel 4 (TK4)
- Point accuracies from 0.02 to 0.06 mm

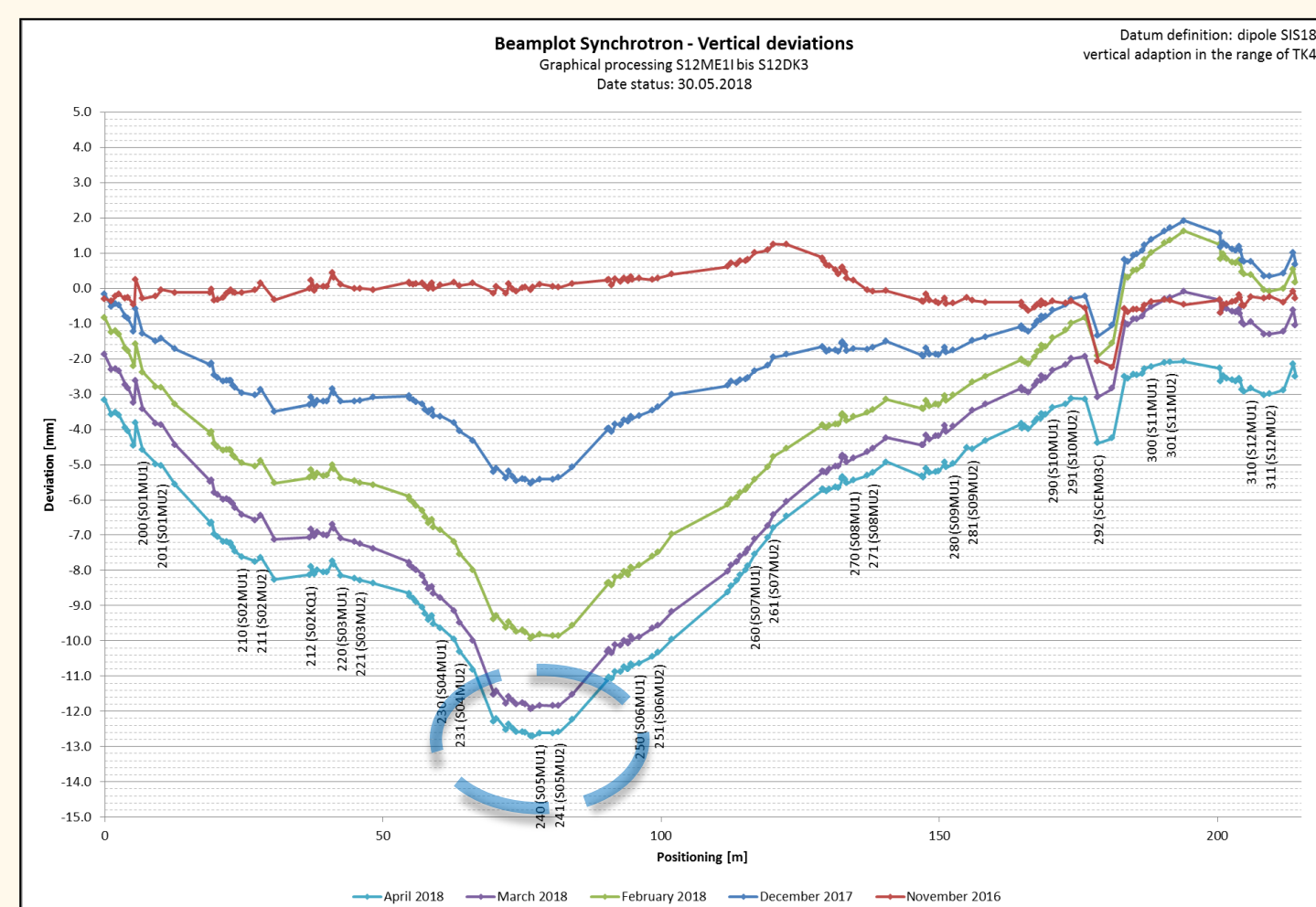


Monitoring area of the existing facility (red)

## Vertical deviations

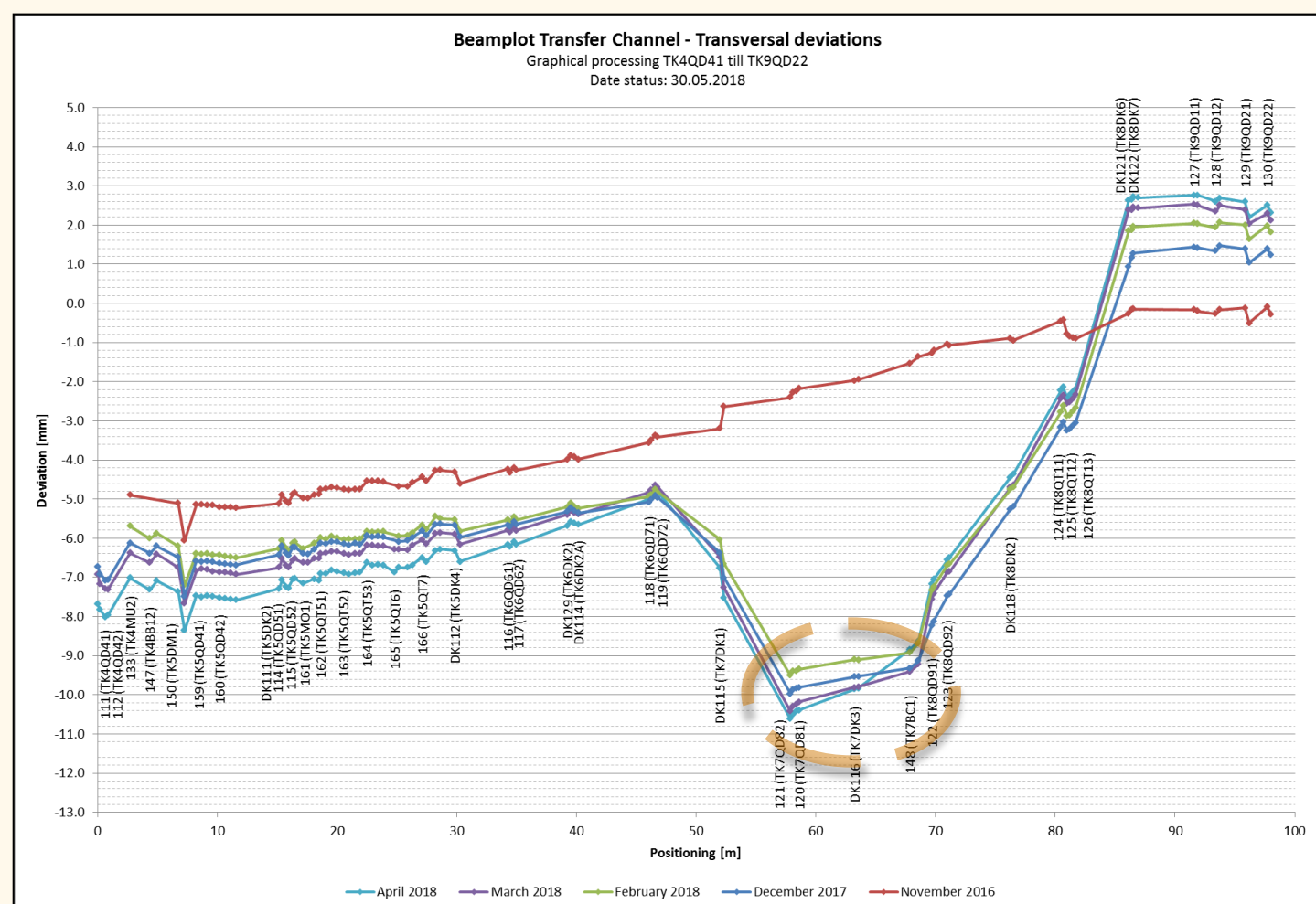


Beamplot – Transfer channel (vertical deviations)

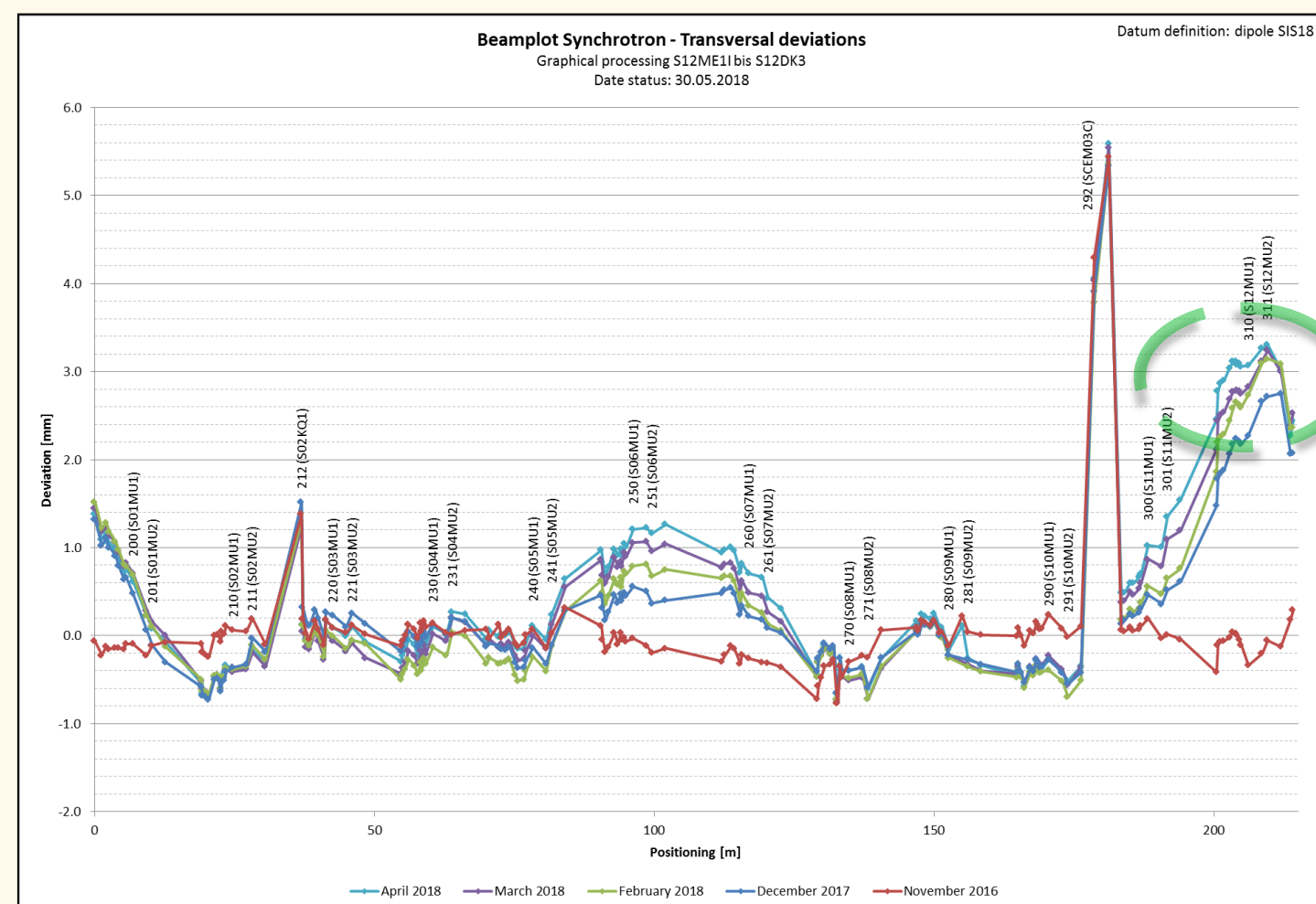


Beamplot – Synchrotron SIS18 (vertical deviations)

## Transversal deviations



Beamplot – Transfer channel (transversal deviations)



Beamplot – Synchrotron SIS18 (transversal deviations)

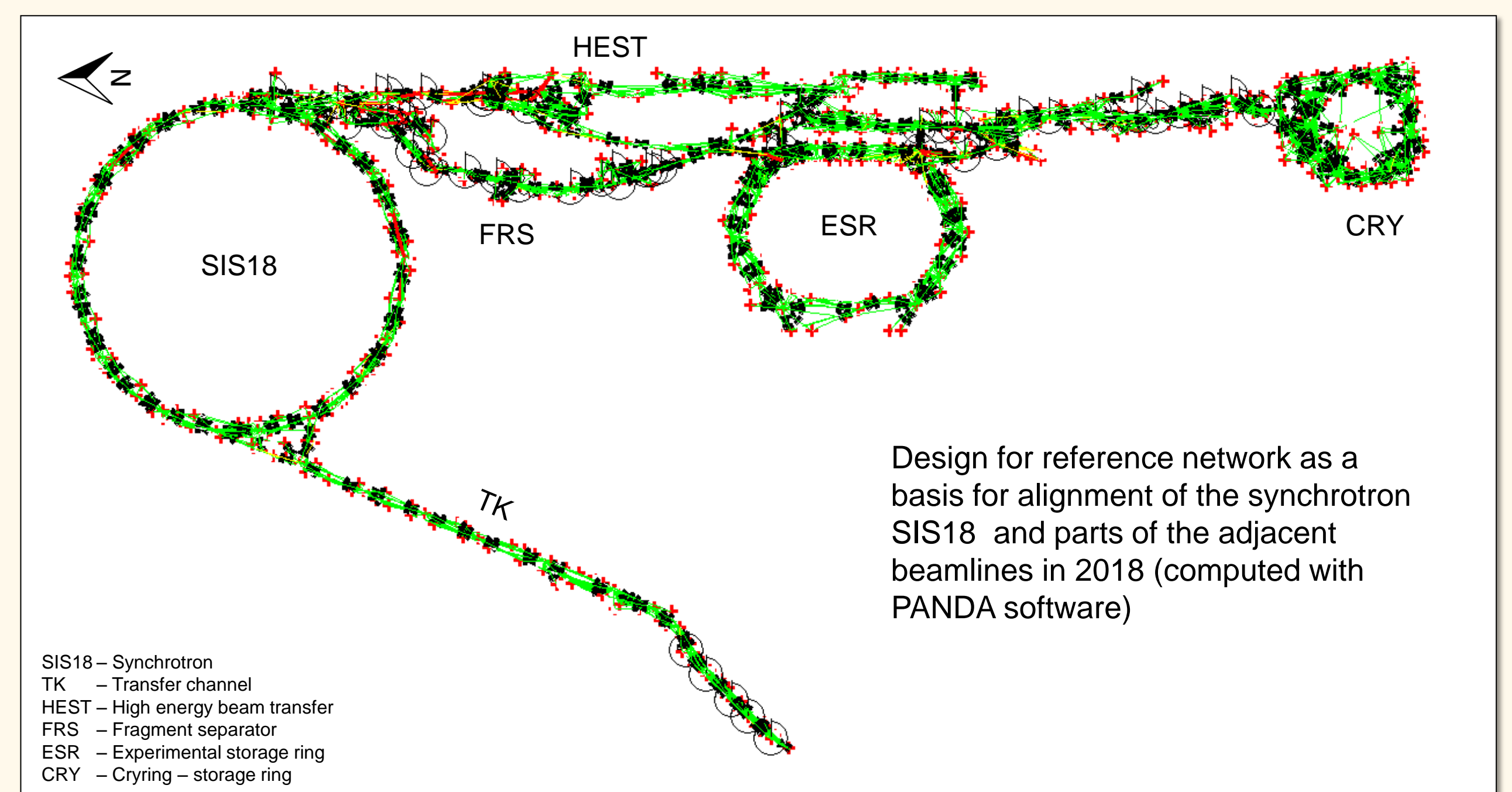
## RESULTS OF MONITORING MEASUREMENTS

- Vertical and transversal movements up to 12 mm were detected!
- Re-alignment for beam time was necessary!
- Further deformations are not out of question!

**➔ Due to the time limit period regarding the re-alignment an intensive discussion was performed.**

## RE-ALIGNMENT STRATEGY

- In addition to the monitoring measurements of SIS18, all other machine areas were successively measured from Jan. to Apr. 2018 (FARO Vantage + Leica DNA03 / Leica AT402).
- In order to be able to realize the beam time 2018, a new alignment strategy was developed based on these measurements and with the aim of minimizing the alignment values.
- For this purpose the complete synchrotron, parts of the transfer channel and the high-energy beamline (HEST) were aligned intentionally on an inclined plane instead of the usual horizontal plane for the first time.



Design for reference network as a basis for alignment of the synchrotron SIS18 and parts of the adjacent beamlines in 2018 (computed with PANDA software)

## REALIZATION

- Basis: Measurements of the GSI machine (Jan. – Apr. 2018) and evaluation in PANDA
- Datum definition V1 - dipoles SIS18 (PANDA)
- Datum definition V2 - HEST east side measurement of 2015 (SpatialAnalyzer)
- V1 was used for calculation of the current rotated nominal points  
→ SIS18 on inclined plane → only vertical adaptation
- Vertical difference between the datum definitions V1 and V2 was -4.264 mm
- One level was used for the alignment (datum definition V2)

### Transfer channel (TK)

- 3 parameter transformation (translation X / Y and rotation Z) of the datum definition V2 to GSI-NN nominals – vertical difference between TK (actual) and GSI-NN (nominals) 2.664 mm
- vertical adaptation of the TK GSI-NN nominal points of 2.664 mm
- Alignment from component 118 – relating to GSI-NN horizontal nominal points (Z +2.664 mm)
- Alignment from component DK118 - relating to rotated nominal points (inclined plane)

### Synchrotron (SIS18)

- Datum definition V1 was used to minimize radial alignment values
- vertical adaptation of the rotated nominal points (inclined plane) by -4.264 mm
- Alignment of all components in SIS18 on the inclined plane

### High energy beam line (HEST)

- Datum definition V2 was used
- vertical adaptation of the rotated nominal points (inclined plane) by -4.264 mm

- Components to be aligned were defined by the machine coordinators

- 106 components were aligned by using Leica AT402/ FARO Vantage and Lucas Schaevitz Inclinomater

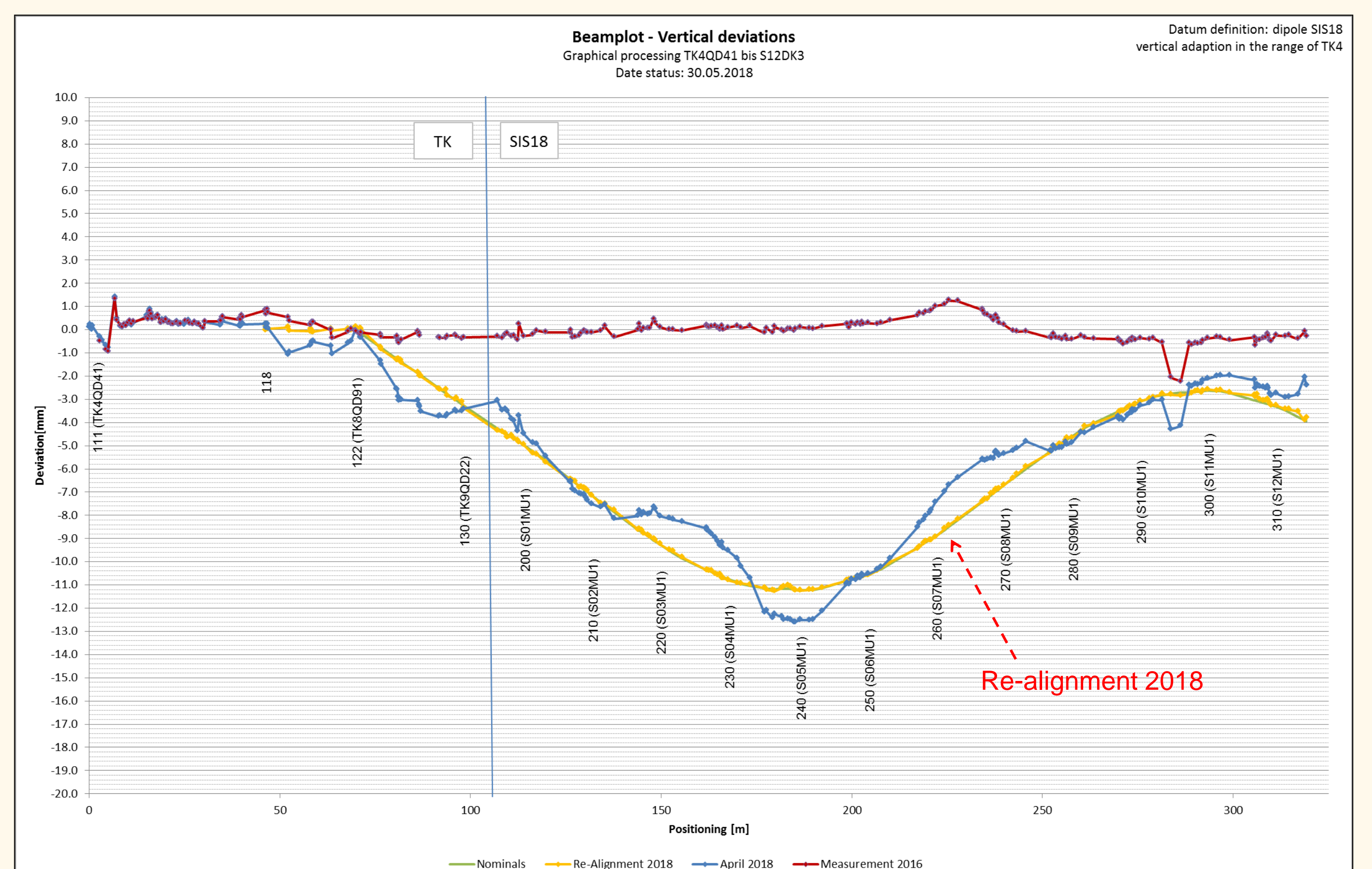


Measuring conditions during 3D-network measurements

## RESULTS

- Largest alignment range (5-6 mm transversal / 3 mm vertical) in the area of SIS18 injection
- Alignment period May 2018 (25 working days)
- Reached residual deviations after alignment ≤ 0.1 mm

**👍 The basic functionality of the machine SIS18 could be established without any closed orbit correction.**



Vertical beamplot – after re-alignment (yellow line)