REALIGNMENT OF GANTRY 1

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The Gantry 1 for proton therapy has been surveyed by the PSI alignment group during construction works in the adjacent PROSCAN area. The installed inclination sensors showed significant irreversible deformation of the foundations and a change in position of the Gantry 1. The new position was measured and realignment was done according to the last known reference coordinates.

INTRODUCTION

Most of the components and experiments at PSI require accurate positioning in order to work correctly. During shut-down 2003, heavy construction works were planned in the PROSCAN area. The existing facility for proton therapy, Gantry 1, is located in the same hall. This made it necessary to monitor the position of this facility during this period. Significant movements were detected, so that the Gantry 1 had to be realigned to its original position.

SURVEY

Two highly sensitive 2-axis-inclination sensors NIVEL 20 were used to continuously register tilt-like movements of the Gantry 1 support construction (see Fig. 1 and Fig. 2). Additional measurements were performed at the PROSCAN shielding walls using our high accuracy WILD N3 level instrument.

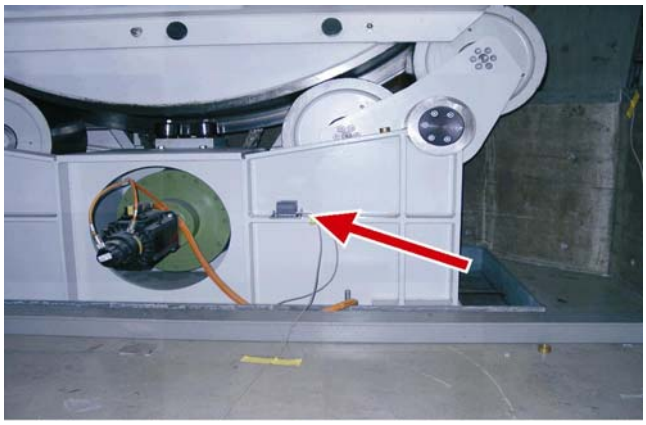

Fig. 1: The picture shows the support frame of Gantry 1. The arrow indicates the location of the inclination sensor N2.

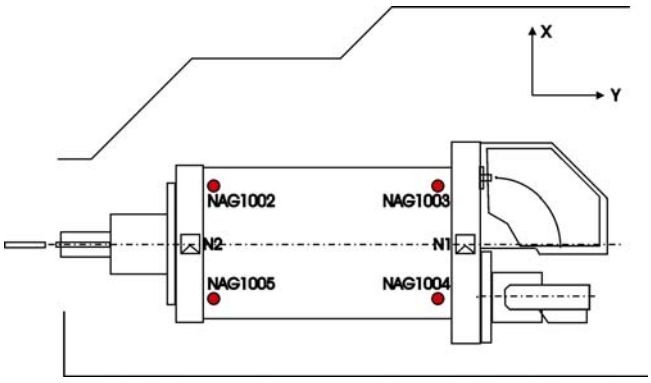

Fig. 2: The layout shows the location of the reference points on top of the Gantry 1 and the two inclination sensors attached to the support system.

During the preparation of the nearby foundation, serious changes in tilt and level of the Gantry 1 were detected, in parallel to an irreversible deformation of the floor and a misalignment of the Gantry 1. Fig. 3 shows the recorded deviations. The graph of sensor N1 indicates the inclination close to the area where the foundation work took place. Ni_rot_ΔY represents the tilt angle around the beam axis. Curve Ni_rot_ΔX shows the tilt angle perpendicular to the beam axis.

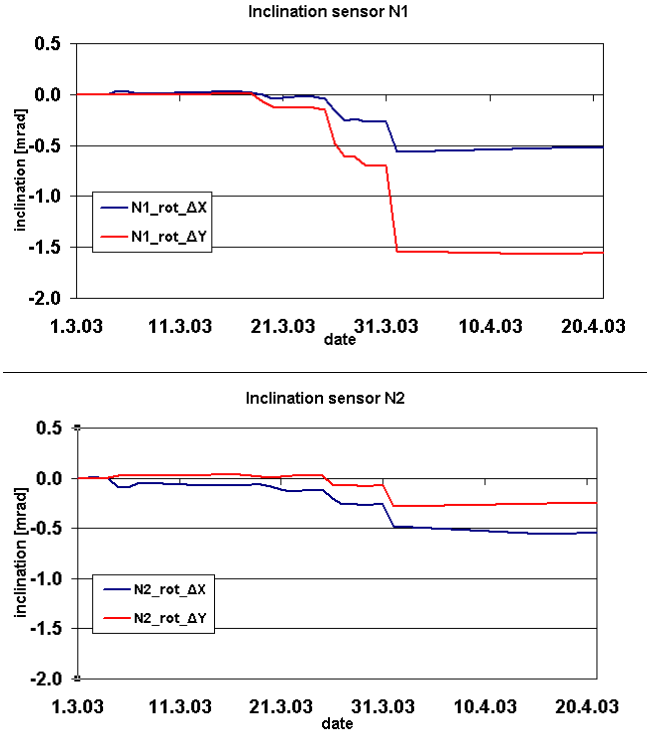

Fig. 3: Inclination values of sensors 1 and 2, during the period from March 1st 2003 to April 20th 2003.

MEASUREMENTS

Some reference points of the alignment network were located in the area of the deformation. Before measuring Gantry 1, a complete measurement of the alignment network and a recalculation of all reference points had to be done. After the foundation works were finished, we could start the measurements and the recalculation. The alignment net was based on the reference points in the stable part of the WNAA hall. Afterwards, the deviations from the Gantry's original position (last measured in November 1998) could be derived. Using our WILD N3 levelling instrument (Fig. 4) and our Totalstation LEICA TDA5005, we could reach an accuracy of 0.03 mm RMS for the

height (H) and 0.2 mm RMS for the position (X, Y) of the points in the network, including the points of the alignment network and the object reference points.

Fig. 4: Measurement of the height of the object reference marks on top of the Gantry 1, using our WILD N3 precision level instrument.

RESULTS

The maximum deviations of the four object reference points on top of the Gantry 1 NAG1002 to NAG1005 were 4.1 mm for the height (H) and about 5.7 mm for the displacement of the position perpendicular to the beam axis (X) (Fig. 5).

	Differences		
	ΔX[mm]	ΔY[mm]	ΔH[mm]
NAG1002	-1.2	0.1	-1.5
NAG1003	-5.7	0.5	-4.1
NAG1004	-5.7	-1.5	-2.2
NAG1005	-1.6	-1.5	0.0

Fig. 5: The table shows the measured displacement values of the reference marks before realignment.

ALIGNMENT

Based on the measured deviations, it was decided to perform a realignment of the Gantry 1. The main goal was a precise positioning (ΔH and $\Delta X < 0.5$ mm) of the Gantry 1 according to the values measured in November 1998. The position in the beam direction (Y) is not adjustable but this is not critical for the reliable operation of the Gantry 1.

The Gantry 1 has a weight of 120 tons, so the challenging alignment procedure was done in close collaboration with the PSI Hallendienst and the Gantry 1 manufacturer Schaer Engineering/Switzerland. The vertical adjustment was done by using the designated wedge mechanism of the support system; the horizontal movements were done using a hydraulic press. It was possible to adjust the Gantry's position with sufficient precision. The final position was reached after three iterations. The remaining deviations for the height were about 0.2 mm. For the horizontal position, we could reach residuals less than 0.3 mm (Fig. 6).

	Differences		
	ΔX[mm]	ΔY[mm]	ΔH[mm]
NAG1002	0.0	0.5	-0.2
NAG1003	-0.1	1.0	0.0
NAG1004	-0.3	0.8	0.0
NAG1005	-0.3	0.7	-0.2

Fig. 6: The table shows the deviations of the reference marks after successful realignment.

CONCLUSION

The displacement of the Gantry 1 has been successfully detected by permanent monitoring with inclination sensors. It was also necessary to measure the actual position by using high accuracy surveying instruments. After precise measurement of the vertical and horizontal deviations, the position of the Gantry 1 could be re-established within sufficient accuracy.