THE MAGNET ALIGNMENT METHOD FOR THE J-PARC MAIN RING

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Abstract

In the J-PARC site, the infrastructure for the whole site measurement is planned for the global alignment of the accelerator components. For the neutrino experiments, the J-PARC main ring must be directed to the SUPER-KAMIOKANDE exactly. The global measurements from the Kamioka site to the J-PARC site are carried out by using GPS system on the ground level. Several measurement through-holes, in order to transport the coordinates from the ground level into the accelerator floor level directly, are prepared around the J-PARC accelerator complex. The beam-line definition and the magnet alignment method for the J-PARC main ring are reported with the present alignment status.

INTRODUCTION

The J-PARC accelerator complex [1] consists of a LINAC, RCS (Rapid Cycling Synchrotron) and MR (Main Ring). In the early stage of the J-PARC project, the through holes, which transfer the coordinates of GPS measurement on the ground level into the accelerator tunnel, were proposed on the MR construction plan because the MR has to be aligned precisely to have a direction to the SUPER-KAMIOKANDE which is 300 km away from the J-PARC site. Finally, this idea is adopted all over the site because it is convenient to grasp the relative positions of accelerator components. The whole site measurements is carried out every winter including these through holes in order to check the arrangement of accelerators.

The MR is composed of three straight lines (named as: INS-A, INS-B and INS-C) and three arcs (ARC-A, ARC-B and ARC-C). A schematic view of the J-PARC MR tunnel is shown in Fig 1. Six through holes are prepared MR_01 to MR_06. The 136 level target are distributed for the floor level measurement. Moreover, L-type and washer-type targets are placed on both walls among the level targets for the beam-line definition and magnet alignment.

BEAM-LINE DEFINITION AND MAGNET INSTALLATION

In usual, the beam-line is defined based on the whole ring measurement after the completion of the construction work. Unfortunately, we had to define the beam-line even the MR tunnel was under construction. The beam-line was defined in these four periods:

- The first stage: August 2005, (all 50BTHs, MHR01 to MHR56)
- The second stage: March 2006, (MHR57 to MHR74)
- The third stage: September 2006, (MHR75 to MHR103)
- The last stage: December 2006, (MHR104 to MHR124)

The parentheses indicate the corresponding areas. The on-wall targets (L-type and washer-type) are measured by laser-tracker (LT) system in the local coordinates. The LT measures the relative positions of the on-wall targets in the area of radius of 20 m at a time. By moving its location along the MR tunnel, the on-wall targets figure out the shape of MR tunnel. Measured position data of the on-wall targets are transformed to the KEK_J-PARC coordinates using GPS global measurement. The KEK_J-PARC coordinates are the right-hand system whose origin is set to the center of RCS ring and whose x-axis is parallel to the INS-C. The beam-line and central points of the magnet bases were drawn and marked on the floor by using the on-wall target coordinates. The magnets were installed on them.

Fig. 2 shows the floor levels of the MR tunnel. The vertical displacement is about ± 10 mm except for one section. At the MHR10, the 3NBT beam line which transfers the RCS beam to the neutron experimental hall is crossing above the MR tunnel. There is a largest vertical displacement of about 40 mm. The magnets were placed on high plane of 2.1 below the sea level considering the future subsidence. The magnets in the descended area were installed with spacers under their bases as shown in Fig 3 in order to compensate the floor subsidence.

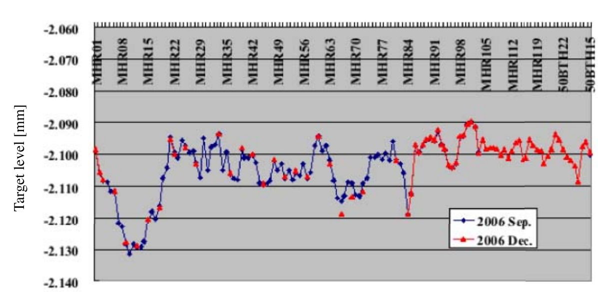

Figure 2: Measured target level of the MR tunnel from the sea level. The floor level is -13 mm from the target level. The floor level displacement is about -40 mm at the maximum.

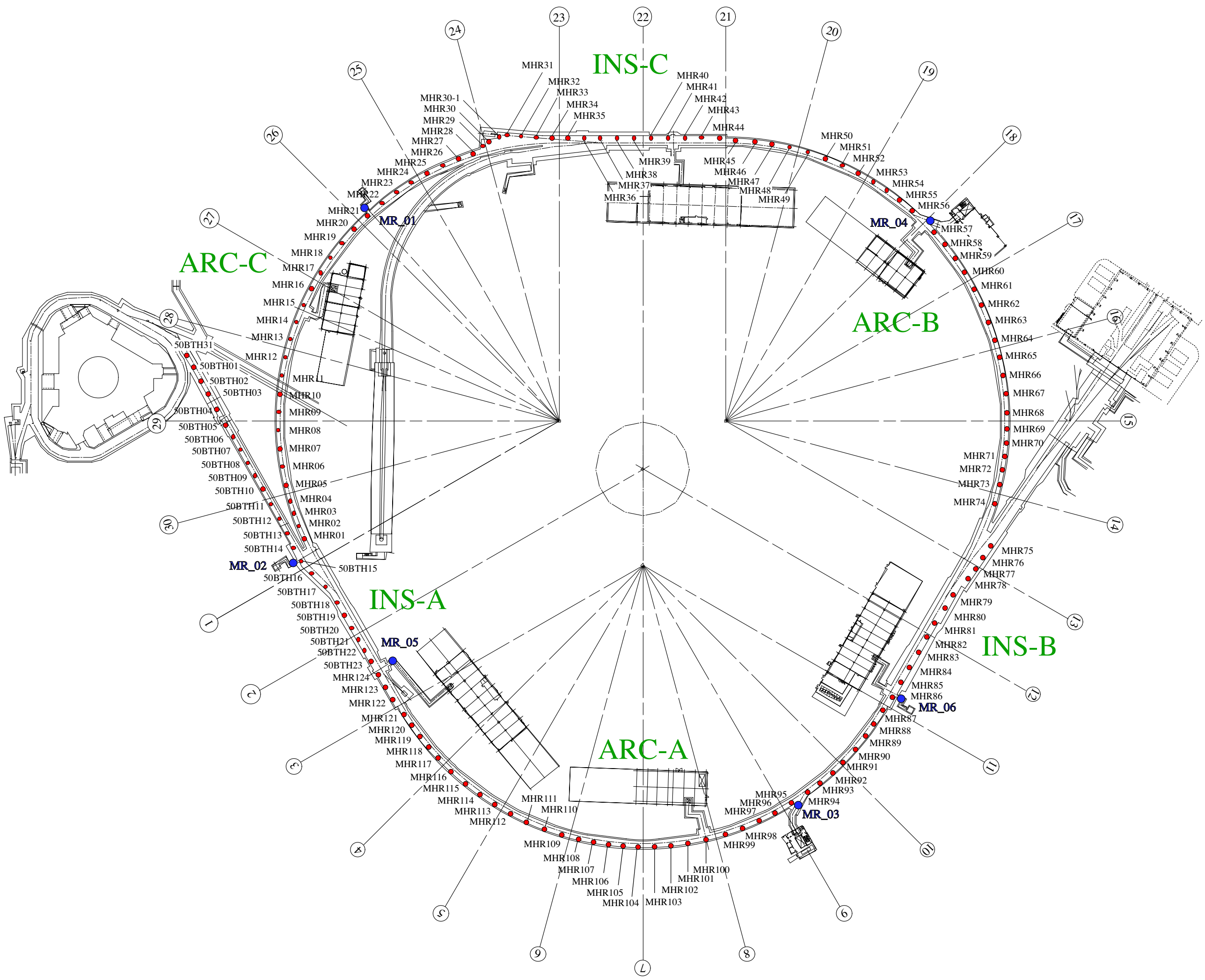

Figure 1: Distribution of the measurement targets for the floor level.

Figure 3: Magnet base spacer made of steel is installed to compensate the floor subsidence.

ALIGNMENT METHOD

The L-type and washer type targets are distributed on the walls in order to the horizontal position definition. As these targets have their own location data in the KEK_J-PARC coordinate system by the previous global measurements, the LT system represents the KEK_J-PARC coordinate by measuring four to six on-wall targets and fitting the results at any place. The magnets have the base plates with a target hole for their alignment. The bending magnet has three plates and the quadrupole and sextupole magnets have two plates. The position is measured by LT system and the rotation is measured by digital level. The required goal is less than 0.3 mm for the transverse displacement, and less than 1 mm for the longitudinal displacement as 1σ. The rotations have to be 0.3 mm/m for any direction also as 1σ. The maximum error has to be suppressed within 2σ.

As the weight of the bending magnets is about 35 ton, it is difficult to move it by the push-bolt mechanism. The alignment stage is prepared for the bending magnets which is the special tool consisting of the x-y slide stages and oil-jacks. Under the bending magnet, there are two large spaces for the air pallet system, Two alignment stages are inserted these area and handle the bending magnet as shown in Fig 4. The magnet position is monitored in realtime by using the LT measurement system. People can adjust the magnet position directly watching the values. The

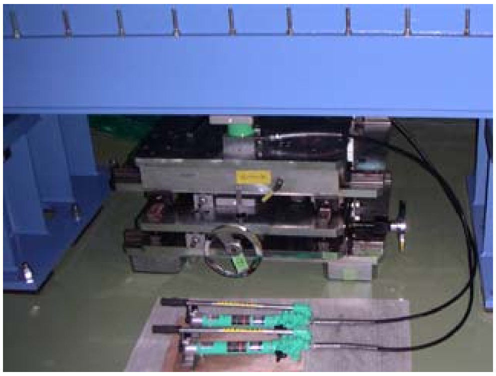

Figure 4: Alignment stage for the bending magnets consists of the two x-y stages and oil-jacks.

quadrupole magnets are adjusted by pull-bolt mechanisms for the horizontal alignment. Oil-jacks are used to assist the vertical alignment as shown in Fig 5. The sextupole mag-

Figure 5: Vertical alignment is assisted by oil-jacks for the quadrupole magnets.

nets are adjusted just using push-bolt system because they are light less than 1 ton. It was not difficult suppress the magnet displacement within 0.1 mm which was six times better than the alignment goal. On the other hand, the correction of rotations remained as the level of 0.2 mm/m due to the twist of magnets. As the bending magnets are long, they tend to be twisted around the beam-line and radial direction of the ring. The alignment efficiency which is defined as the average time needed for each magnet is about 60 minutes for the bending magnets, about 30 minutes for the quadrupole and sextupole magnets. The magnets in ARC-B and ARC-C sections have finished to be aligned.

FLOOR LEVEL FLUCTUATION OF THE TUNNEL

The short term subsidence of the floor level is shown in Fig 6 from target MHR01 to MHR103. Around MHR70, a fast subsidence of -1.8 mm/month is observed. The magnets involved in the corresponding area must be re-aligned. Generally, the fitting error of on-wall targets is large in the area with vertically large displacement. This indicates the horizontal displacement of the MR tunnel in some areas. The horizontal error at the closing point was found to be 11 mm by summing up the errors of traverse measurements along the ring tunnel, which spent more than one year. A round-trip measurement is necessary to figure out the present shape of the MR in this summer, and the continuous floor level observation is important.

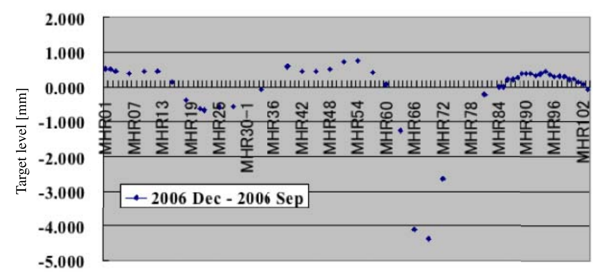

Figure 6: Observed subsidence of the MR tunnel during September to December in 2006.

SUMMARY

The magnet alignment of the J-PARC main ring carried out in 2006 is summarized as follows:

- Alignment procedure using LT system based on distributed on-wall targets is very effective.
- The floor level subsidence which requires the magnet re-alignment is still going on around the upstream of ARC-B.
- In the horizontal plane, it was found the shape of the ring is slightly distorted.
- A round-trip measurement of the MR shape is needed in this summer.
- Continuous floor level observation is necessary.

The magnet re-alignment work will be held before this December with the minimum modification case.

REFERENCES

[1] Acc. Group JAERI/KEK, "ACCELERATOR TECHNICAL DESIGN REPORT FOR J-PARC", KEK Report 2002-13, JAERI-Tech 2003-044, J-PARC 03-01, March 2003