THE PRECISE SURVEY AND THE ALIGNMENT RESULTS OF THE J-PARC LINAC

T. Morishita#, H. Asano, A. Ueno, K. Hasegawa, JAEA, Tokai, Ibaraki 319-1195, Japan
M. Ikegami, KEK, Tsukuba, Ibaraki 305-0801, Japan

Abstract

J-PARC linear accelerator components have been installed. Before the beam commissioning, a precise survey for alignment has been performed. The reference points were set up on the tunnel wall to built a survey network. Based on the survey results, the magnets in the straight section were re-aligned finely. Then, the results of the displacement are confirmed to be tolerable for the beam commissioning.

INTRODUCTION

J-PARC linear accelerator [1] components have been installed and the beam commissioning has been started in Nov. 2006. The length of the straight section is about 300 m which consists of the ion source, the radio frequency quadruple linac (RFQ), the drift tube linac (DTL), separated type DTL (SDTL), and the beam transport line. Precise alignment of the accelerator components is essential for high quality beam acceleration. The outline of the alignment scheme for J-PARC linac was presented in the previous paper [2]. Following the planned scheme, metrological survey and floor making of the linac building has been performed for the primary alignment on the installation phase [3], where a whole-site survey on the J-PARC surveying network [4,5] have also been performed to check the consistency between linac and 3-GeV synchrotron.

After the installation, a precise survey has been performed to measure the displacement of the cavities and magnets at the primary alignment. Then, the unacceptable misaligned components have been re-aligned to satisfy the requirement. For the horizontal survey, we have built the survey network in the accelerator tunnel, where a laser tracker (LT600, Leica Geosystems AG) is used to measure the horizontal position. For the vertical alignment, heights of the accelerator components are measured by a digital level (DNA03, Leica Geosystems AG). In this paper, the results of the precise survey and the final alignment of the straight section of the J-PARC linac are presented.

SURVEY NETWORK FOR THE HORIZONTAL MEASUREMENT

The transverse tolerance for the displacement of magnets is +/-0.1mm and that for the monotonous deflection is 0.05 mm / 10 m [2]. To obtain enough accuracy of the magnet position, the reference points were fixed on the tunnel wall with about 5m interval, and the survey network was constructed by linking the reference points with the reference bases of the accelerator components. The reference points on the tunnel wall cover the whole area of the J-PARC linac.

The position of the accelerator components and reference points are measured by a laser tracker. The corner cube reflector (CCR) nest is directly fixed on the wall as a reference point. The reference base of the accelerator component has the reference hole of 24.96 mm in diameter, which allows us to put a variety of targets or sensors by utilizing the precise attach / detach system (Hirai High-touch Set). The views of the precise attach / detach system and the reference base of the cavity is shown in Fig. 1.

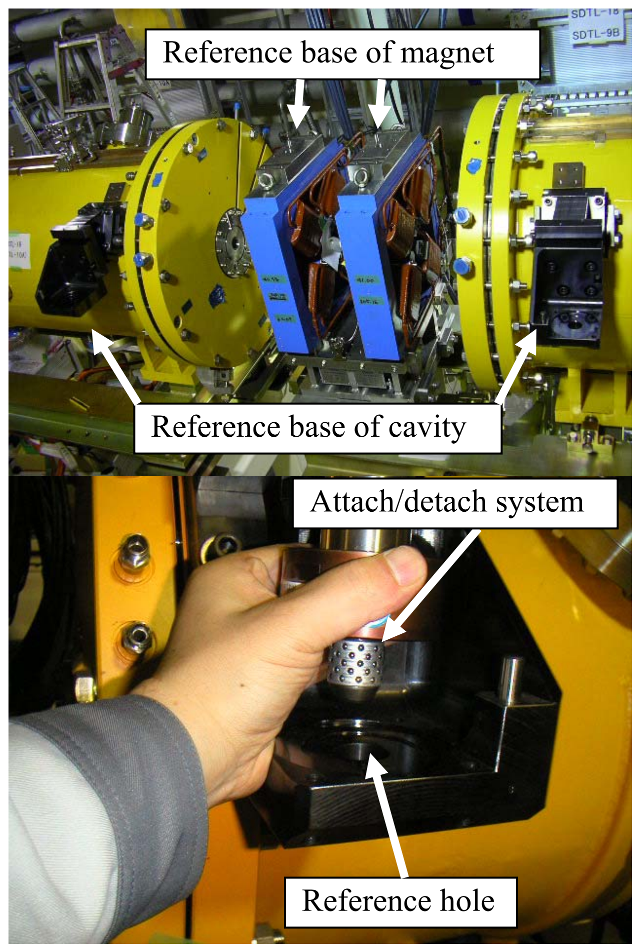

Figure 1: Reference bases of cavities and magnets, and attach / detach system for CCR holder.

All reference points and accelerator components in the area of about 20 m are measured with a laser tracker, then, it was moved to the next position about 5 m away, and the

takatoshi.morishita@j-parc.jp

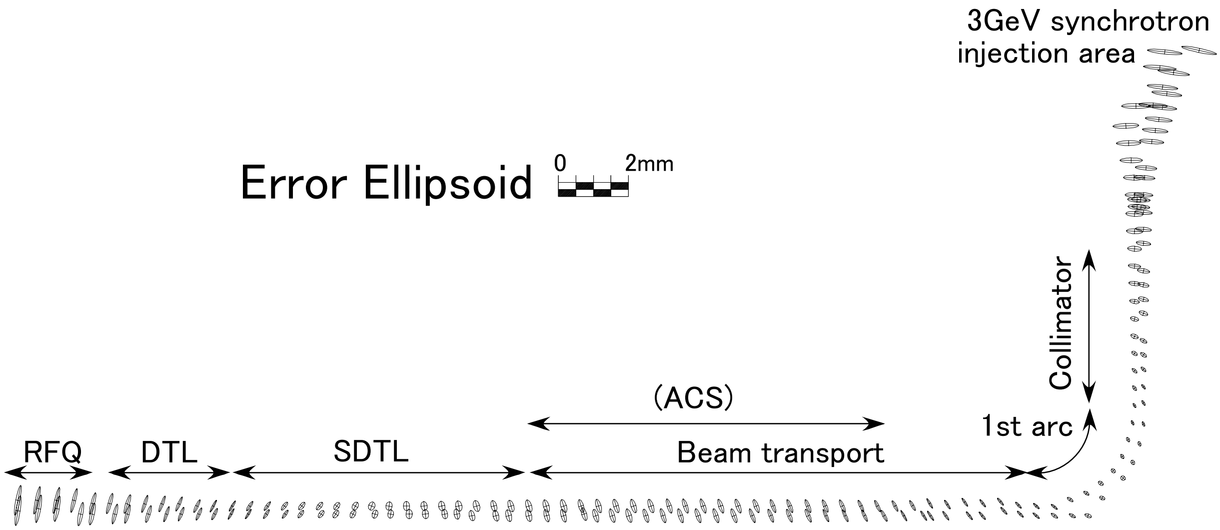

Figure 2: The error ellipsoid of the whole are of the J-PARC linac

measurement repeated. Detailed procedure is described in Ref. [2]. The error ellipsoid of the whole site of the J-PARC linac, estimated by this survey network [5], is shown in Fig. 2. Because the linac tunnel is long (more than 400 m) and narrow, the error becomes about 0.9 mm and 1 mm at the upstream end and the downstream end of the linac, respectively. However, the accuracy in the narrow region (about 20 m) is better than 0.1 mm. Then, the displacement in the neighbouring area can be kept below the tolerable limit.

ALIGNMENT RESULTS: HORIZONTAL DIRECTION

Figure 3 shows the result of the transverse and horizontal displacement of the quadruple magnets in the straight section of the J-PARC linac. The vertical axis is the relative displacement of the magnets from the ideal straight line. We found that the displacement of +/- 2 mm from the ideal straight line. This displacement might be occurred by the error from the floor marker setting or the deformation of the building.

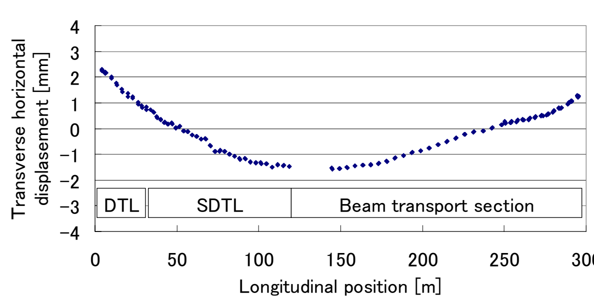

Figure 3: Horizontal position of the cavities and magnets in the straight section of the J-PARC linac.

However, the magnitude of this monotonous deflection is tolerable because the requirement is 0.05mm/10m, which corresponds to 11mm/150m. Then, we don't dare to correct all the displacements from the ideal straight line. Instead, we try to mitigate local bumps in the alignment, so that we can make the alignment fall onto a smooth curve.

Firstly, to evaluate the smoothness, the measured data were fitted by polynomial in the DTL/SDTL section and the beam transport line. Figure 4 shows the displacement from this polynomial. Figure 4 indicates that the most part magnets are aligned properly at the installation.

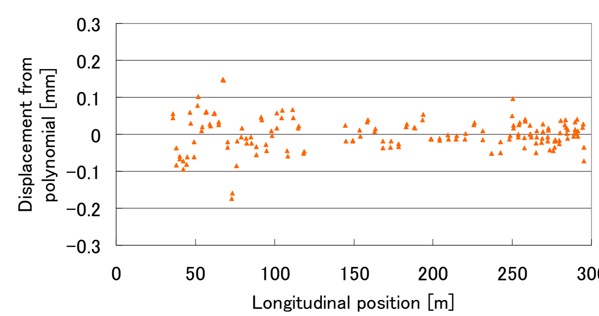

Figure 4: Transverse and horizontal displacement from the polynomial after the installation.

Secondly, we abstracted the displaced magnets to be re-aligned by the following criteria.

- More than 0.07 mm displacement from polynomial.
- More than 0.1 mm displacement from adjacent magnet.

Based on the above scheme, 18 magnets have been re-aligned by a laser tracker.

Figure 5 shows the result of the transverse and horizontal displacement from the polynomial after the re-alignment. As a result, we have obtained a smooth alignment of the straight section of the J-PARC linac.

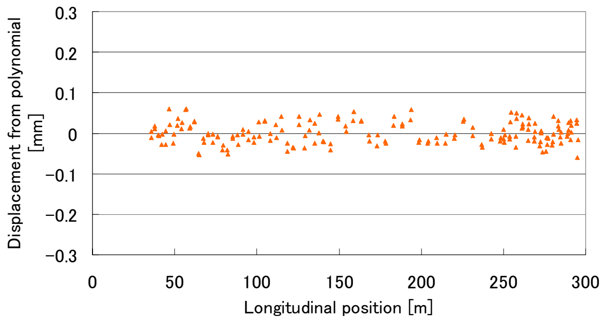

Figure 5: Transverse and horizontal displacement from the polynomial after the re-alignment.

ALIGNMENT RESULTS: VERTICAL DIRECTION

The height change of the accelerator tunnel has been periodically watched by measuring the vertical marker height located in a lateral groove of the tunnel floor with the intervals of about 20 m. Figure 6 shows the height change of the accelerator tunnel since Feb. 2005. The horizontal axis is the distance from the upstream end of the linac. The vertical axis is the relative height form the reference point, which is used for the whole J-PARC site.

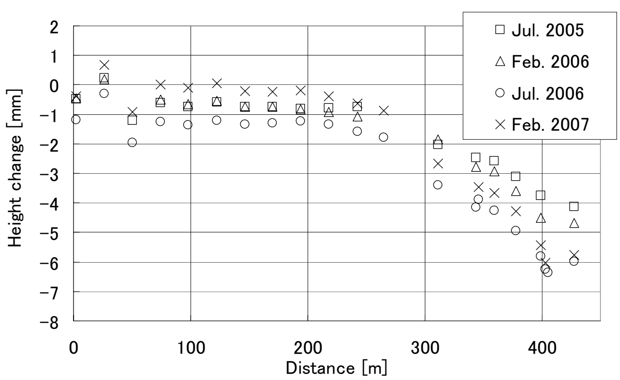

Figure 6: Height change of the accelerator tunnel since Feb. 2005

Since Feb. 2005, we have observed about 6 mm settlement at the downstream end of the J-PARC linac (injection area to 3GeV synchrotron). However, the straight section (less than 300 m) seems to be more stable, then, the components in the straight section has been aligned the same level with the earth curvature compensation as described in [6]. The height change at the downstream end from Jul. 2006 to Feb. 2007 seems to have been stabilized than before. Then, to adjust the height from the linac to the 3GeV synchrotron, we have decided to tolerate a slight correction for the vertical beam angle with the steering magnets at the exit of the first arc, avoiding a large-scale re-alignment of the upstream section. Then, the magnets after the first arc are aligned along the height marker on the tunnel wall, which has been marked based on the height measured at Feb. 2005. We plan to align the beam transport line from the end of the straight section to the injection area in summer 2007, where the height of the magnets have be adjusted finely.

SUMMARY

The precise survey has been done by a laser tracker with a fine-grained survey network. The re-alignment of the straight section of the J-PARC linac has been completed, where we have emphasised on attaining the smoothness between adjacent magnets. The results of the displacement are sufficient for the beam commissioning. Excellent beam transmission has been obtained in the early stages of the beam commissioning[7].

ACKNOWLEDGEMENT

Authors would like to thank Dr. K. Mishima, Mr. N. Abe of PASCO Corp. for the design of the survey network and its evaluation.

REFERENCES

[1] Y. Yamazaki (eds), “Accelerator Technical Design Report for J-PARC”JAERI-Tech 2003-044; KEK-Report 2002-13.

[2] M. Ikegami *et al.*, Proc. of LINAC2004. , August 2004, p474.

[3] T. Morishita *et al.*, Procs. of 2005 Particle Accelerator Conference, Knoxville, Tennessee, USA, p. 2851.

[4] K. Mishima and N. Tani, “Geodetic Survey Work of High Intensity Proton Accelerator Facility”, Proc. of IWAA2004, CERN, Geneva, 4-7 October 2004.

[5] K. Mishima and N. Abe, private communication.

[6] T. Morishita *et al.*, ‘THE DTL/SDTL ALIGNMENT OF THE J-PARC LINAC’, in these proceedings.

[7] K. Hasegawa, ‘COMMISSIONING OF THE J-PARC LINAC’, in these proceedings.

