# AN ALIGNMENT OF J-PARC LINAC

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*Abstract*

J-PARC linear accelerator components are now being installed in the accelerator tunnel, whose total length is more than 400 m including the beam transport line to 3GeV synchrotron. A precise alignment of accelerator components is essential for high quality beam acceleration. In this paper, planned alignment schemes for the installation of linac components and watching the long term motion of the building are described. Markings are placed on the floor, which act as a reference for the initial alignment at the installation. For a straight line alignment, the wire position sensor is placed on the offset position with respect to the beam center by a target holder. The hydrostatic levering system is used for watching the floor elevation over the long period.

## INTRODUCTION

The outline of the planned alignment scheme for J-PARC linac [1] was presented in the previous paper [2]. Following the planned scheme, metrological survey and floor making of the linac building has recently been performed for the primary alignment on the installation phase. The measurement and floor marking cover the klystron gallery (on the ground floor), accelerator tunnel (13-m underground), and the "intermediate tunnel" (5.5-m underground) which locates between the accelerator tunnel and klystron gallery as a buffer region to avoid the leakage of radiated air. Prior to the floor marking, a whole-site survey on the J-PARC surveying network [3] and a preliminary survey of 3GeV synchrotron tunnel [4] have also been performed to check the consistency between linac and 3-GeV synchrotron floor markings. In this paper, the results of the floor marking and the detailed scheme for the component installation are presented.

As presented in the previous paper [2], we put the emphasis on the continuous monitoring of the alignment, mainly because our accelerator complex has been built on a sandy ground beside the ocean. We plan to use the HLS (Hydrostatic Leveling System) and WPS (Wire Position Sensor) for the continuous monitoring of the floor elevation and horizontal distortion, respectively. The recent progress on the fabrication of peripherals, which support the HLS and WPS, is also presented in this paper.

## FLOOR MARKING FOR INSTALLATION

Before marking on the floor, the displacement of the through-holes for the waveguides from the klystron gallery to the accelerator tunnel has been checked, because the holes with large displacement should be fixed to have enough clearance for waveguide installation. The linac straight line is determined to minimize the fixation, and the tilt with respect to the 3-GeV synchrotron is absorbed in the 2nd arc section of the L3BT (Linac to 3-GeV synchrotron Beam Transport). The relative position between linac and 3-GeV synchrotron has been determined utilizing three linac reference points with access holes from the ground floor. We have these points at the upstream end, the beginning of the first arc, the end of the straight line. With the linac straight line determined above, the displacements between linac and 3GeV synchrotron are found to be about 3mm in horizontal and 0.00065deg in injection angle. These displacements are compensated at the 2nd arc region adjusting the bending angle and drift length.

The beam line reference points, which are used as a reference of installation, are set from the linac reference points. These points are placed on the upstream side of the ion source, both ends of four straight sections (DTL-SDTL, ACS, L3BT scraper, and L3BT injection), and crossing points of straight lines connecting adjacent bend centers in the first arc. For a high position accuracy of this beam line reference point, a small stage was adopted as shown in Fig 1. This stage is buried in a floor to prevent the damage from the external force and the interference with a walk.

Figure 1: View of the beam line reference point. Watertight cover will be attached.

In the linac straight line, we have set up two offset lines, which locate 460mm and 2000mm passage side from the beam axis, in addition to the line under the beam axis. The 460-mm offset line is convenient for the linearity check of DTL and SDTL tanks, because they have alignment references at this location. The wire position for the WPS is also supposed to be 460 mm from the beam axis. However, the 460-mm offset line is not suited for setting up a total station on it because of the lack of clearance. The 2000-mm offset line is prepared to make up this shortcoming. A distribution of floor marking is shown in Fig 2.

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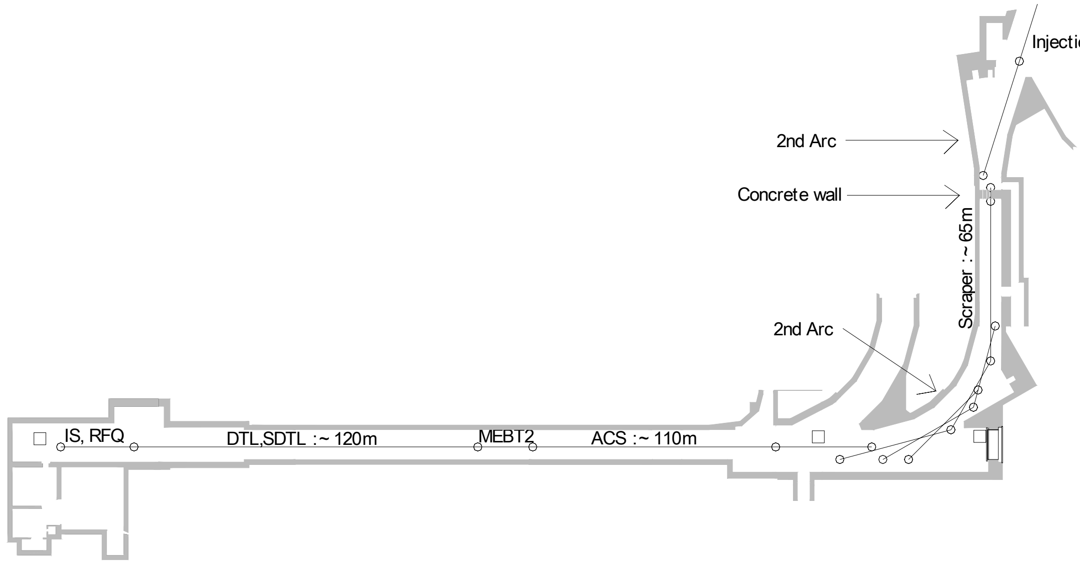


Figure 2: Distribution of the beam line reference points (open circle) and the linac reference points (open square) in the accelerator tunnel.

For efficient installation, two kinds of rough marking are also prepared on the accelerator tunnel. One is the dotted metal plate, which has been glued at the input coupler location for each cavity, for the alignment of the waveguide. The other is the punching on base plates for quick and systematic installation of the stands for cavities and magnets.

On the sidewall of the accelerator tunnel, the level marks have been taped with the interval of around 6m. The height of the level marks is different for each accelerator section. From the ion source to SDTL section, level marks are placed on the beam height, because the installation is carried out by looking at the center of the accelerator elements. At the ACS and L3BT section, the height of the level marks is adjusted to the alignment target on the reference bases of the magnets.

## REFERENCE FOR INSTALLATION

In installation of DTL and SDTL tanks, we plan to use alignment telescope to secure linearity between neighbouring tanks. Even in the installation phase, good linearity is required especially for DTL, because the clearance for the final alignment is very small due to heavy wiring for DTQ's. To set up an alignment telescope, an alignment target should be held above the beam line reference point exactly at the beam height. In order to lift a target right above a floor point with the accuracy of < 0.1mm, we have developed an alignment target mount on which an optical plummet (NL, Leica Geosystems AG) is mounted (See Fig. 3). The alignment target mount has an attach-detach system with precise position reproducibility, with which we can replace an optical plummet with an optical target for the alignment telescope. A corner cube reflector, 1.5 inch bearing, or total station can also be equipped on the alignment target mount. For the level adjustment on the beam height, scale bar stands on the 1.5inch bearing for levelling instrument (DNA03, Leica Geosystems AG).

To secure the linearity of the DTL and SDTL section, we plan to use four alignment target mounts. One of them will be kept at the SDTL exit during the installation to monitor the error accumulation. Another will be kept at the DTL exit during DTL installation to secure the DTL linearity. Remaining two will be used to set up the telescope axis moved tank by tank. It is necessary to arrange the alignment target closely due to the limitation of view length of the telescope. Therefore, the telescope axis should be extended as the installation proceeds. Error accumulation by the extensions will be checked with a total station (TDA5005, Leica Geosystems AG), which is located at the floor marker of SDTL exit.


Figure 3: Alignment target mount. A fine (0.05mm/div) elevation stage is equipped in the lower mount. Linear stages and lower mount has a through hole to see the floor marking by NL.

## PERIPHERALS FABRICATION FOR CONTINUOUS MONITORING

### *WPS Holder*

WPS is planned to be used for the continuous monitoring of the horizontal linearity of the cavities and Q-magnets. The reference base on the Q-magnets locates right above a beam line. A target holder arm is developed for the Q-magnet in order that the reference points of cavities and Q-magnets are aligned linearly from DTL to ACS line. Figure 4 shows the WPS holder for SDTL Q-magnet. WPS is fixed on the linear stage to adjust the vertical position to the sagged wire.

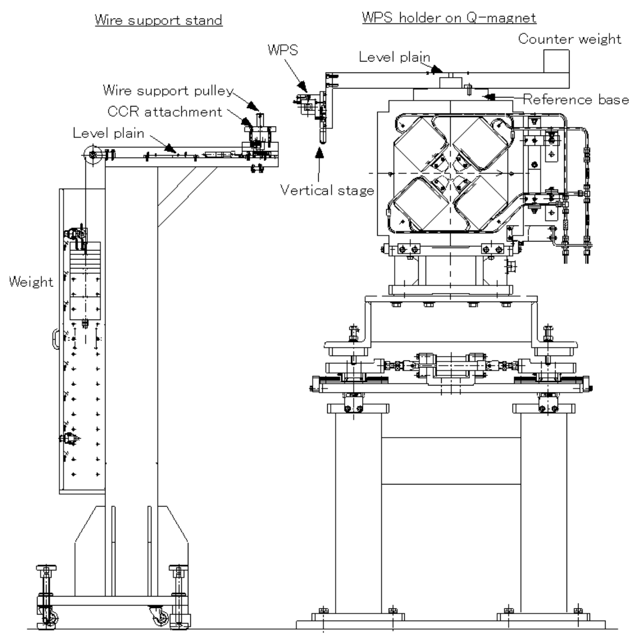


Figure 4: Wire support stand and WPS holder on Q-magnet.

The wire support stand has been prepared to stretch wire at 460mm offset position as shown in Fig. 4. To avoid the interference to cavities, magnets and their stands, a column support locates at a passage side. A corner cube reflector can be attached near the wire support pulley to measure the position of wire.

### *HLS*

To measure a ground motion of the accelerator tunnel, a HLS is arranged over the accelerator tunnel with about 50m interval. To set the HLS vessel at the same level plane initially, the height of sensors will be adjusted by DNA03 and stuff on HLS sensor top. The decrease in the water level due to the infiltration evaporation of the water pipe or connector halts a continuous watching. A maintenance system has been developed as shown in Fig. 5. This system can regulate a water level by elevating the water vessel (about five liter in capacity), where an elevation resolution is enough to adjust the water level within the HLS sensor measurement range (5mm). An elevation of water vessel can operated remotely. A pump for forced circulation is connected in the piping loop for initial water feeding and removing of the air bubble. A filter and an ion-exchange resin are incorporated for scheduled purification of water.

A total pipe length becomes more than 800 m. To shorten dumping time of the water level by disturbance, a large inner diameter pipe of 18mm or more will be used [5]. Water pipe between HLS sensors will be fixed on the same level with HLS vessel to avoid the error caused by the water temperature distribution[6].

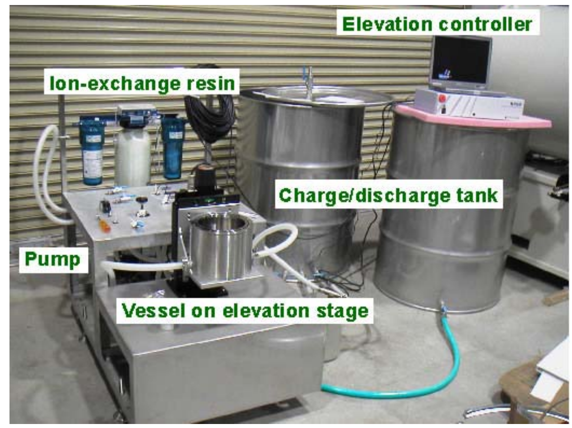


Figure 5: Maintenance system of HLS.

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