POSITIONING THE 100MEV LINAC AND MAGNETS WITH TWO LASER TRACKERS*

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Abstract

Proton Engineering Frontier Project(PEFP) [1] is developing a 100MeV high-duty-factor proton linac and 10 beam lines. The linac length is 93m from ion source to beam dump and the beam line length is 23m from linac center to target room. The reference points were set up on the wall of the tunnel in the 1st floor, the klystron gallery in the 2nd floor and the modulator gallery in the 3rd floor to build a survey network. Before the beam commissioning, the accelerator components and beam line magnets have been positioned within the tolerance limit by using two laser tracker systems. In this paper, the schemes for the alignment and the network survey are presented together with the results.

INTRODUCTION

A 100MeV proton linac is developing which can supply 20MeV proton beam and 100MeV proton beam to 10 beam lines [2-3]. Figure 1 shows the layout of the accelerator, beam lines and the accelerator building. The linac consists with a 50keV microwave proton source, a LEBT(low energy beam transport), a 3MeV RFQ, 20MeV DTLs, 100MeV DTLs and a 1kW beam dump which are located in the accelerator tunnel. 5 beam lines for 20MeV proton beam and 5 beam lines for 100MeV beam lines are linked to the linac. The klystrons, RCCSs and power supply racks will be installed in the klystron gallery. The bended wave guide was embedded in the concrete between the tunnel and klystron gallery to supply the high power RF. The conduit pipes were also embedded to install cooling pipes and power lines. The modulators will be installed in the modulator gallery.

ALIGN NETWORK

Coordinate System

The first step of the accelerator installation is making an alignment network in the accelerator tunnel and beam experimental halls [4]. The length of the tunnel is 135 m and the space for the 100-MeV linac was 93 m of the length. The number of the alignment targets is 42 in the tunnel with the interval of 10 m on one side where the RF components will be installed and 5 m on the wall in the other side. There are 14 target holder in the 20-MeV beam line hall and 3 network points in each target room. Figure 2 shows the accelerator tunnel before installing the 100-MeV proton linac, and the target holders for alignment. The holder was designed for the 1.5” reflector of the laser tracker.

The global coordinate system was setup. The –Y axis was setup by the gravity direction measured with the NIVEL(Leica co.). The Z axis and the origin were determined by using two permanent references as shown in Figure 3. These references are linked to the construction coordinate system. For each floor, the coordinate system is linked by the 5 see-through holes which are penetrated from the 1st floor to the 3rd floor.

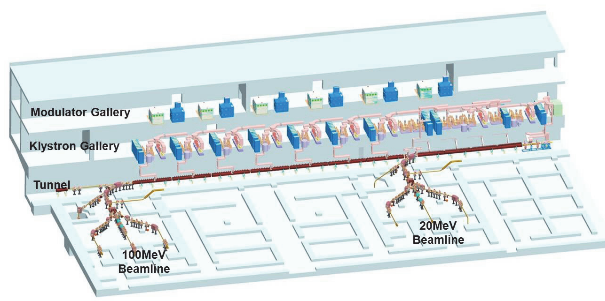

Figure 1: The layout of the linac, beam lines and the accelerator building.

Figure 2: The accelerator tunnel before installing the 100-MeV linac and the alignment networks.

*Work supported by the Ministry of Education, Science and Technology of the Korean Government
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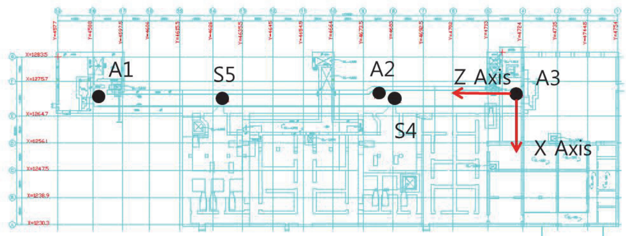

Figure 3: Coordinate system of the 100MeV proton linac. A3 is the origin and the Z axis was setup by using the coordinate of A1. The coordinates of A1 and A3 are linked with the coordinate system used for the construction.

Fiducialization

We got the fiducialization results of 107 quadrupole magnets and 14 dipole magnets.

For the quadrupole magnets, a mandrel and a pair of sleeves were adopted for the fiducialization. 3 magnets have been fiducialized 5 times and compared with results which were already measured by the supplier. For the magnet origin, the position difference is within ±50 μm for x, y and z coordinates. And the tilt angle of the z-axis is less than 0.02 degree. The deviation of coordinate and the tilt angle for 5 time-measurements are about 20 μm and 0.0005 degree, respectively.

Dipole magnets have been fiducialized 5 times. For the magnet origin, the position difference is within ±50 μm for x, y and z coordinate.

There are 4 fiducial points in each end side of DTLs. Each tank has individual coordinate system according to the tank geometry. The fiducialization of DTLs was accomplished during the drift tube installation process.

Anchor Installation

We measured the floor levels of the accelerator tunnel, and the 20-MeV and 100-MeV experimental halls. Figure 4 and 5 show the results. We found that the variations of the floor level are about 30 mm and 20 mm in the accelerator tunnel and the experimental halls. In order to compensate the variation, we used iron plates with different thickness at each position of the supporting structures as shown in Figure 6.

The temperature of the tunnel was 7°C in the winter because the utility was not operated. The difference in temperature is 20°C compared to the operation condition. So, the thermal expansion rate, 1.2×10^{-5}/°C-m for the concrete, was considered to determine the anchor bolt of Z axis direction.

According to the blue line survey, there were position error between the designed beam path and the centre of penetration holes which is located in the target room wall. We changed the magnet position to align the beam path and penetration holes.

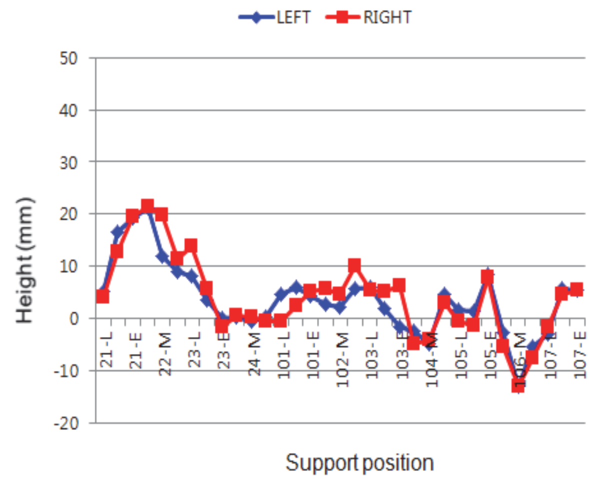

Figure 4: The floor level of the accelerator tunnel.

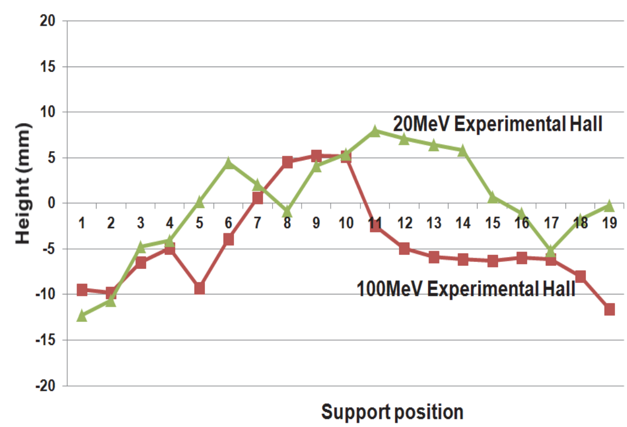

Figure 5: The floor level of the 20-MeV and 100-MeV experimental halls.

Figure 6: The linac supporting structure installed in the accelerator tunnel.

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ISBN 978-3-95450-115-1

POSITIONING OF THE 100MEV LINAC AND BEAM LINE

Because there is no crane in the accelerator tunnel and experimental hall, the accelerating structure and magnets were transported from the assembly area to the installation position by using the moving carts which were also used to place them on the supporting structures. The alignment of the accelerators and beam lines will be performed after the temperature and humidity controls are prepared. Figure 7 and 8 show the installed linac and 20-MeV beam line magnets, respectively.

Figure 7: The installed 100-MeV linac in the accelerator tunnel at Gyeongju project site.

Figure 8: The installed 20-MeV beam line magnets in the 20-MeV beam line hall at Gyeongju project site.

For the linac, 11 sets of the RF systems are required. Klystrons, RCCSs, circulators and modulators were fabricated and got ready to install.

To transmit RF power, 15 high-power RF transmission lines were installed. These waveguide penetrating into the linac tunnel was designed with the bending structure for radiation shielding. We checked the waveguide position in the tunnel during the blue line survey.

CONCLUSIONS

The installation of the 100MeV linac is underway. All of accelerator components were positioned through the blue line survey work. Beamlines and RF systems are also being installed. The beam commissioning will start in November 2012.

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