STATUS OF BEAM LOSS SPATIAL DISTRIBUTION MEASUREMENTS AT J-PARC LINAC*

H. Sako#, A. Miura, JAEA, Tokai, Naka-gun, Ibaraki 319-1195, Japan
T. Maruta, KEK, Tsukuba, Ibaraki 305-0801, Japan

Abstract

Beam loss in the ACS (Annular-Coupled Structure linac) section is highest in the J-PARC linac. In previous investigations, we found the loss is mainly caused by H^0 generated in electron stripping of H^- by remnant gas inside the beam duct. Since H^0 emitted outward is converted to H^+ through the beam duct, by counting the number of H^+ (namely proton), the number of H^0 produced inside the beam duct, namely the absolute amount of beam loss, could be evaluated. We developed scintillating fiber hodoscopes to measure trajectories and time-of-flight of charged particles. In this work, we show status of spatial distribution measurements of proton trajectories.

DETECTOR SYSTEM

Detailed description of the detector system is shown in Refs. [1-3]. Here we describe mainly upgrades made in the beam shutdown period of July-Sep. 2012. We developed a detector position control system shown in Fig. 1. The control system consists of an upstream mover and a downstream mover. Both of them are installed in the left side of the beam duct looking into the beam direction. They are separated in the beam direction by about 1600 mm for time-of-flight measurements. Two horizontal-position measuring fiber planes (H0 and H1), and two vertical-position measuring fiber planes (V0 and V1) are mounted in the upstream mover, and two horizontal-position measuring fiber planes (H2 and H3) and two vertical-measuring fiber planes (V2 and V3) are mounted in the downstream mover. Each plane consists of 16 of 64 long, 4 x 4 mm^2 square plastic scintillating fiber (V0-3, H2-3) and 16 of 64 mm-long, 4 mm diameter round fiber (H0-1) (shown in Fig. 2), which forms sensitive area in each plane of 64 x 64 mm^2. Each mover moves the hodoscope planes horizontally and vertically with two stepping motors. The detector positions are controlled remotely from the Klystron gallery at the ground level.

EXPERIMENT

Since Oct. 2013, we measured charged particles by varying the upstream and the downstream hodoscope positions horizontally, while keeping the vertical position at the beam axis. Due to the limited number of readout channels, we measure only 12 fibers in H0 and H1, 11 fibers in H2 and H3, 12 fibers in V0 and V1, 10 fibers in V2, and no fiber in V3.

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#hiroyuki.sako@j-parc.jp

Figure 1: Fiber scintillating hodoscopes mounted on the detector position control system.

In charged particle tracking algorithm, we reconstruct a 3-dimensional straight line in (x, t, z) for H0-H4, where x is the horizontal position, t is the signal time measured by TDC (Time-to-Digital Converter), and z is the longitudinal position along the beam axis. Similarly we reconstruct a straight line in (y, t, z), where y is the vertical position for V0-2.

Figure 2: A new scintillating fiber hodoscope.

Fig. 3 shows residuals in x and t in Planes H1 and H2, and residuals in y and t in V1. Clear peaks showing straight tracks are observed at the 3 planes.

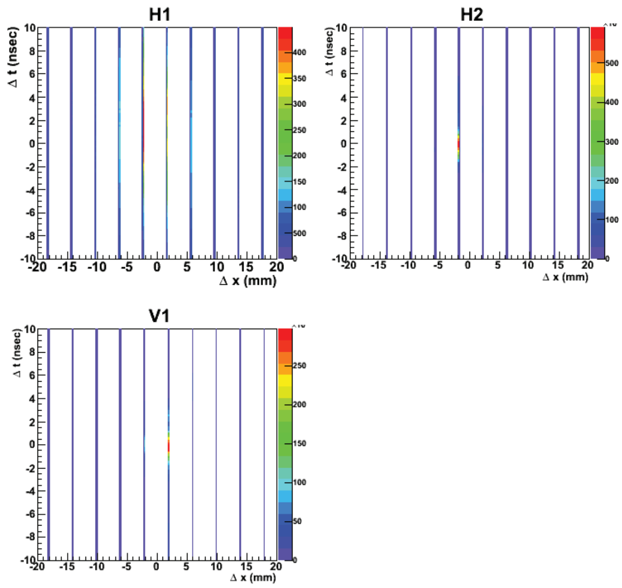

Figure 3: Residuals of particle hit positions in (x,t) for H1 (top left) and H2 (top right), and in (y, t) for V1 (bottom left) with respect to tracks.

Fig. 4 shows amplitude of particle energy loss in the scintillating fiber as a function of time-of-flight between H0 and H1 (nsec). A clear proton peak around time-of-flight of ~ 13 nsec is seen.

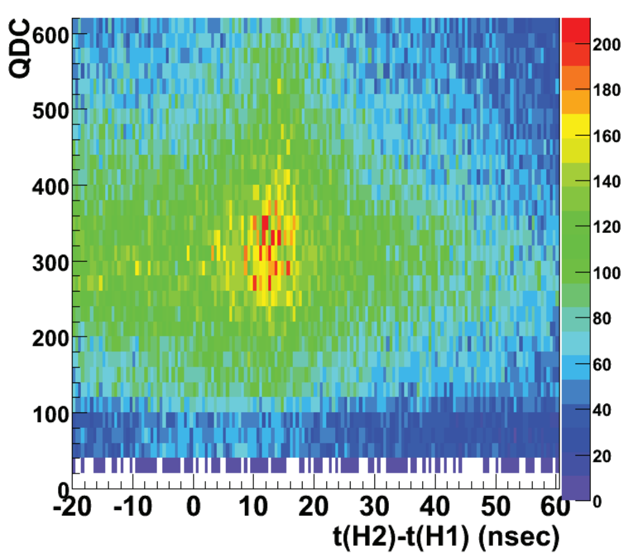

Figure 4: Amplitude of particle energy loss in the scintillating fiber as a function of time-of-flight between H1 and H2 (nsec).

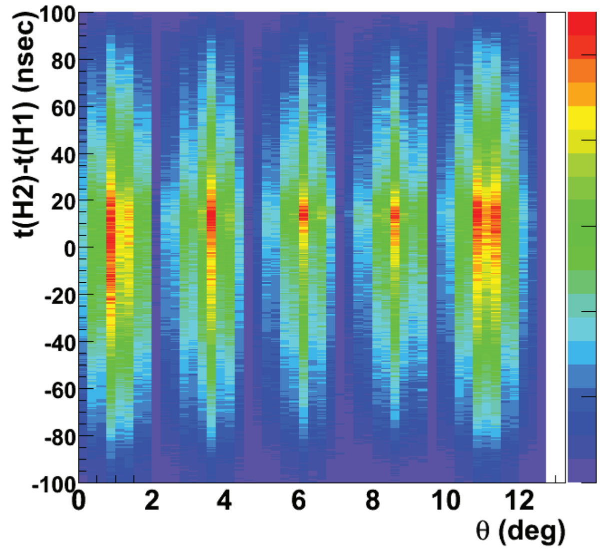

Figure 5: Time-of-flight between H1 and H2 (nsec) as a function of the horizontal track angle with respect to the beam axis (deg).

Fig. 5 shows time-of-flight between H1 and H2 as a function of the horizontal track angle with respect to the beam axis with 5 different hodoscope geometry configurations. Time-of-flight peaks in 10-15 nsec, which corresponds to β=0.35-0.53 and energy of 65-168 MeV assuming proton mass.

RESULTS

We measured proton tracks in wide range of horizontal angles. We clearly observed horizontal and vertical straight charged trajectories through 8 hodoscope planes. The velocity measured with time-of-flight is consistent with protons from H^0. Further corrections to estimate proton rates are underway.

REFERENCES

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