PROFILE MEASUREMENT AND TRANSVERSE MATCHING IN J-PARC LINAC

H. Akikawa[#], Z. Igarashi, M. Ikegami, S. Lee, KEK, Tsukuba, Ibaraki, Japan
S. Sato, G. Shen, T. Tomisawa, A. Ueno, JAEA, Tokai, Ibaraki, Japan

Abstract

Beam commissioning of J-PARC linac has been performed since November 2006. We have developed wire scanners in order to measure beam profile and perform transverse matching. Four wire scanners are installed at each matching section. We report the result of measurement of beam profile.

INTRODUCTION

In J-PARC linac [1], 36 wire scanners are allocated in order to measure beam profile. Four wire scanners are at MEBT1 section between RFQ and DTL where the beam energy is 3MeV, other four are at SDTL section where the beam energy is 50MeV, and the rest 28 are at A0BT, L3BT, and beam dump section where the beam energy is 181MeV. Each wire scanner has two wires and they are moved by stepping motor. One wire is stretched vertically to measure horizontal profile and the other wire is stretched vertically to measure vertical profile.

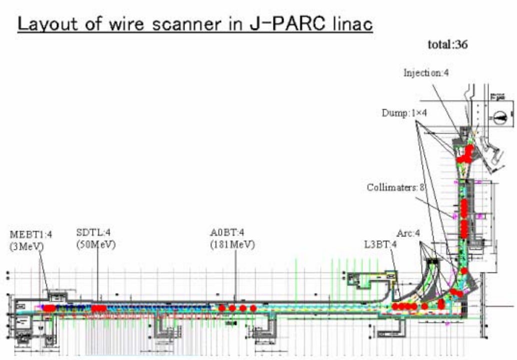

Figure 1: Layout of wire scanners.

SIGNAL GENERATED IN WIRE

Wire scanners in J-PARC linac are designed to capture electrons in H^- beam [2]. In the method of capturing electrons, larger signal is obtained than detecting secondary electrons because secondary emission yield is about 1/10 of beam current. 7 μm-diameter carbon wires are used for 3 MeV and 30 μm-diameter tungsten wires are used for 50 – 181 MeV beam, respectively. Since stopping power of tungsten is so large to stop proton in 3 MeV beam, we selected carbon wire for MEBT1. On the other hand, since 7 μm-diameter carbon wire cannot stop electrons over 40 MeV beam, tungsten wires were selected for the downstream.

[#] akikawa@post.j-parc.jp

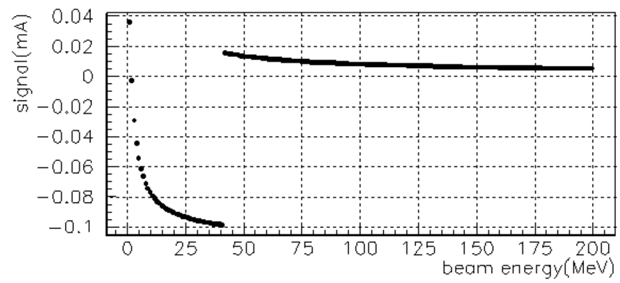

Figure 2: Signal estimation in the case of 7 μm-diameter carbon wire.

Temperature simulation of the wire has also been performed. We considered full beam condition for the simulation, 50mA current, 50Hz repetition, 500μs length, and 56% duty. Since the available limit temperature of carbon is about 3000K and the melting point of tungsten is 3680K. The wires will not be heated up to the limit temperature in the result of this simulation.

Figure 3 shows the signal efficiency which is defined as the ratio of integrated signal and beam intensity for the bias voltage of from 0V to +60V. In the voltage from +20V to +60V, the efficiencies are same for low and high intensity. On the other hand, the efficiency under +20V depend upon beam intensity, which causes distortion of measured profiles. We are measuring beam profile with the bias voltage of +20V on wire.

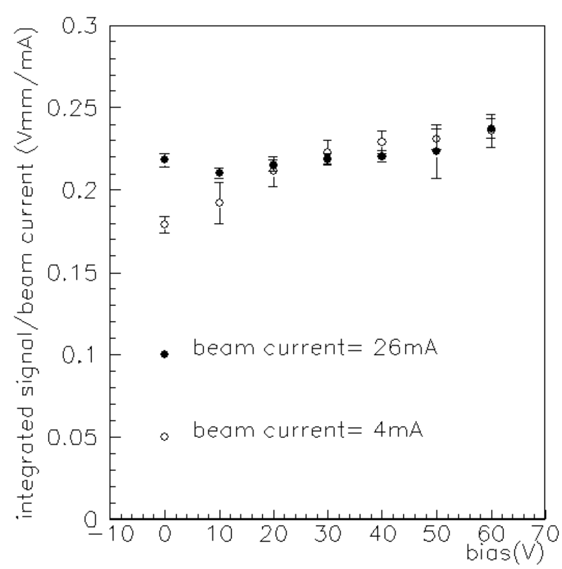

Figure 3: Dependence of signal efficiency on beam intensity for 3 MeV beam.

 1-4244-0917-9/07/$25.00

BEAM LOSS DETECTION METHOD

In SDTL, A0BT, and L3BT section, we have also tested the method of detecting beam loss caused by scattering of beam at a wire. Figure 4 shows layout of wire scanners and beam loss monitors in SDTL section. The beam loss monitors are Ar + CO_2 gas filled proportional counters, which detect γ-ray, neutron and charged particles induced by lost particle [3]. We added bias voltage of +20V on wires and operated beam loss monitors in +2000V voltage.

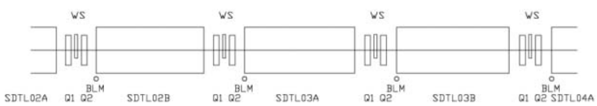

Figure 4: Layout of wire scanners (WS) and beam loss monitors (BLM) in SDTL section.

Figure 5 shows typical wave forms for current detection in a wire and for beam loss detection obtained at same time. The wave form for current detection has flat top however the wave form for beam loss detection is not flat and signal decreases in a beam pulse period. It is possible for bias voltage of beam loss monitor to drop in generating signal. Figure 6 shows the profiles measured by current detection in a wire and by beam loss detection. The obtained profiles differ especially near the center of beam and the profile for beam loss detection is broader than for current detection.

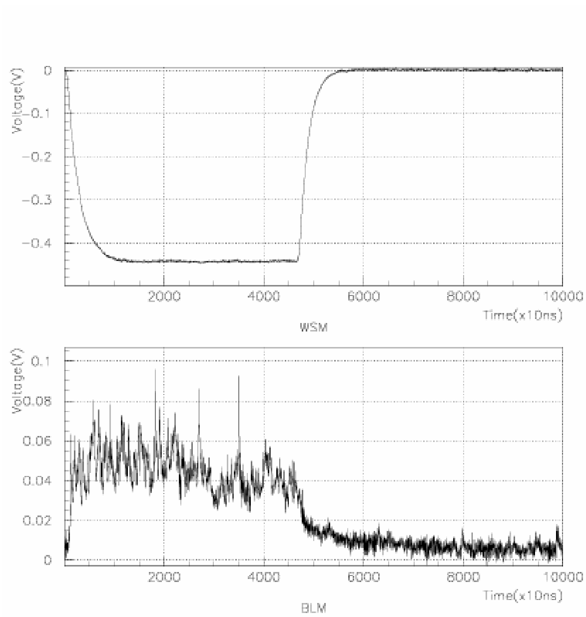

Figure 5: Typical wave forms in wire scanning obtained by current detection and by beam loss detection.

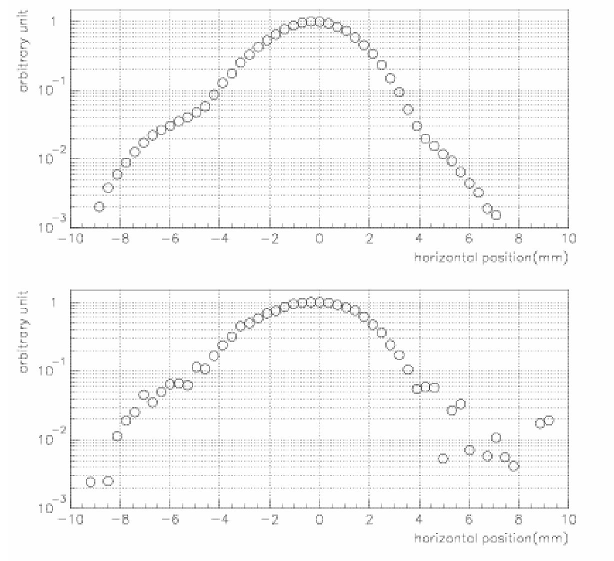

Figure 6: Typical measured profiles for current detection and for beam loss detection. In this case, root mean square for current detection is 1.98 mm and for beam loss detection is 2.35 mm.

TRANSVERSE MATCHING

We have an array of four wire scanners at each matching section to perform transverse matching [4]. Matching was performed to decrease mismatch factor, or difference of beam widths. Mismatch factor is defined as $(\sigma_{max} - \sigma_{min})/ (\sigma_{max} + \sigma_{min})$, where σ_{max} and σ_{min} are the beam widths of the most and the least broad profile in four measuring positions. Figure 7 shows the profiles measured by current detection in SDTL section, before matching and after matching. In this case, mismatch factor decrease from 0.159 to 0.050.

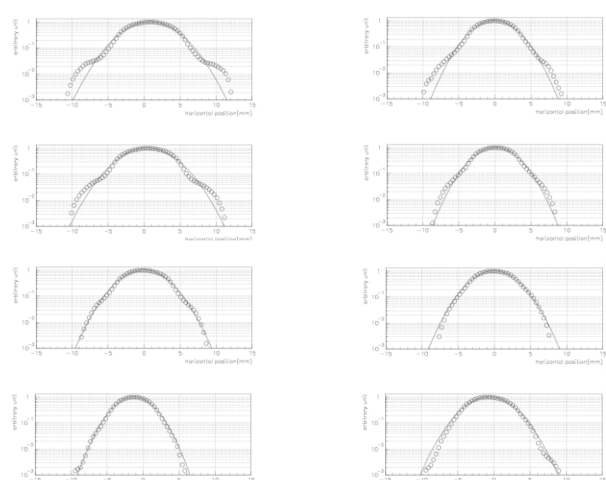

Figure 7: Measured profiles in SDTL before matching (left) and after matching (right).

1-4244-0917-9/07/$25.00

SUMMARY

We have developed wire scanners in order to measured beam profile in J-PARC linac. 7μm-diameter carbon wire was selected for 3 MeV beam and 30μm-diameter tungsten wire was selected for 50 - 181 MeV for catching electrons in H- beam. We have also tested the method of detecting beam loss caused by scattering of beam at a wire using propotional counters. We performed measurement of beam profile and transverse matching.

REFERENCES

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

[2] H. Akikawa, et al, "Wire Profile Monitors in J-PARC linac", Proceedings of LINAC2006.

[3] S. Lee, et al, "The Beam Loss Monitor System of the J-PARC Linac 3GeV RCS and 50GeV MR", Proc. of the 9th European Particle Accelerator Conference (EPAC 2004), Lucerne, Switzerland, 5-9 Jul 2004.

[4] M. Ikegami, et al, "Transverse Tuning Scheme for J-PARC Linac", Proceedings of PAC05.

1-4244-0917-9/07/$25.00