STUDY OF J-PARC LINAC BEAM POSITION MONITOR AS PHASE MONITOR

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Abstract

In J-PARC LINAC [1], about a hundred of beam position monitors (BPM's) with stripline electrodes are being operated [2]. Signals from striplines would be useful also for beam phase measurement [3], for which we are currently using fact current transformer monitors (FCT's) [2, 4], and then we are taking a study for such usages. In this paper, current situation of our studies both with the test bench and with the negative H beam are presented.

BPM IN J-PARC LINAC

In J-PARC LINAC, there are about a hundred of BPM's, and each BPM has 4 stripline electrodes (up, down, right, and left sides). As diameters of beam pipe are different depending on the location along accelerator, inner diameter of the BPM was designed to follow them.

Table 1: Diameter of BPM's.

BPM location	BPM diameter [mm]	Size (in azimuth) of stripline	Shape (in azimuth) of stripline
MEBT	23.9, 29.4	7.2 mm	Flat
SDTL	37.7	7.2 mm	Flat
A0BT (for ACS)	37.7, 40	7.2 mm	Flat
L3BT	70	32.6 deg	Round along duct
	85	36.4 deg	Round along duct
	120	39.6 deg	Round along duct

Table 1 shows the diameters. From upstream, MEBT section contains 23.9 and 29.4 mm of BPM's, SDTL with 37.7 mm, A0BT (currently no acceleration cavity; ACS-type [1] of cavities are planned to be installed in the J-PARC LINAC energy upgrade) with 37.7 mm and 40.0 mm. In L3BT transporting section, there are three diameters; 70.0 mm for matching section from ACS (in the future), 85.0 mm in arc section of LINAC, and 120.0 mm in the following scraper section, the RCS injection line, and four dump lines (0 degree dump, 30 degree dump, 90 degree dump, and 100 degree dump). In order to have impedance matching with output signal cable (50 ohm) toward readout electronics (324 MHz of logarithmic amplifier, located in the 1st floor), size (in azimuth) of strip line are designed [2] with the POISSON codes.

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RAW SIGNAL IN TEST BENCH

We have some spare BPM's other than installed BPM's in the accelerator beam line. The installed BPM's have been under operation all the time during the J-PARC user runs and the beam commissioning runs, therefore they are unable to be taken out so far.

Test Bench Setup

To test the spare BPM's (for the A0BT section), we use adapters from N-connector to beam pipe diameter, which are originally designed for the FCT phase calibration. Figure 1 shows the setup. The input signal from a pulse generator is entering from top (relating to upstream of beam) of BPM, and exiting toward the bottom (relating to downstream of beam) side of BPM, through the adapter on each side. Output signal is observed from upstream of one of the four striplines, while the other (downstream) side of each stripline is terminated with 50-ohm.

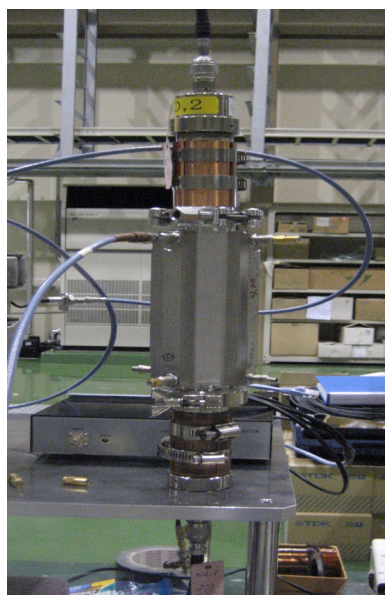

Figure 1: Test bench setup.

Raw Signal

Figure 2 shows raw signal from one of stripline electrode in BPM-spare (diameter 37.7mm) through the center conductor of calibration set up. Top profile (ch1) is for input, and the bottom profile (ch2) is for output. The horizontal axis is 5ns per division (10 divisions). The vertical axis is 1 V and 10 mV (ch1 and ch2), per division (8 divisions). About 30mV output from one of the stripline is seen (for 1V input on center conductor). The first output signal (which is from time when the input pulse is entering at upstream of the stripline) is in the same charge polarity with input signal (positive). And then the second output signal (which is from time when the input pulse is exiting at downstream of the stripline) is in the opposite polarity (negative) output.

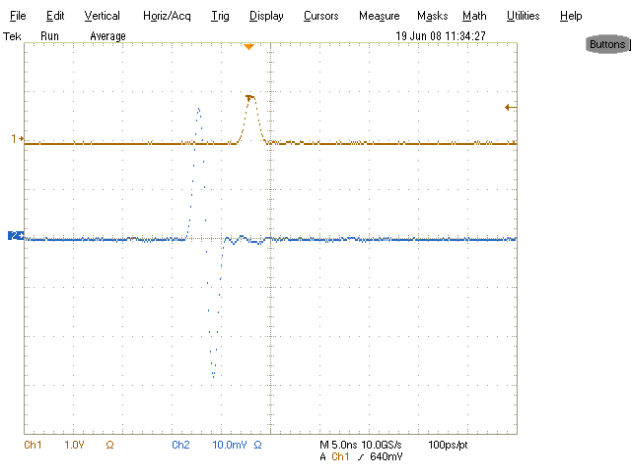

Figure 2: Signal from upstream side of stripline electrode. [top : ch1]input signal, [bottom: ch2] output signal.

On the other hand, when signal from downstream side of stripline, situation is different (in this case, upstream side of electrode is terminated with 50-ohm, in order to simulate the original signal cable), as shown in Figure 3. Top profile (ch1) is for input, and the bottom profile (ch2) is for output. The horizontal axis is 5ns per division (10 divisions). The vertical axis is 1 V and 10 mV (ch1 and ch2), per division (8 divisions). Except some mV of reflection signal (probably due to small mismatch), no signal is seen as expected [5], for input signal close to the light velocity ($\beta \sim 1$). To get stable signal during tuning of acceleration cavity (during which the beam velocity, β, is changing), it would be better to take signal from the upstream side of stripline electrode, by sharing the signal with beam position monitoring. Note that the time relations in the Fig. 2 and 3 between the input and the output, are shifted due to some delay in the bench test setup.

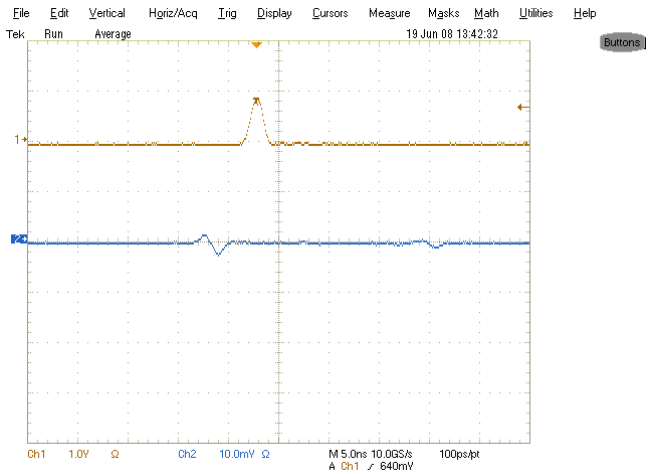

Figure 3: Signal from downstream side of stripline electrode. [top: ch1] input signal, [bottom:ch2] output signal.

RAW SIGNAL WITH BEAM

In the L3BT section (where beam energy stays 181MeV so far (before ACS upgrade of A0BT section)), the sum of 4 electrodes outputs are taken in the accelerator tunnel (2nd-base floor), and transmitted through about 100 m of RF cable (about 8dB attenuation in 324MHz. Andrew LDF2RN-50) from tunnel to electronics floor (grand floor). Figure 4 shows the BPM locations in J-PARC LINAC.

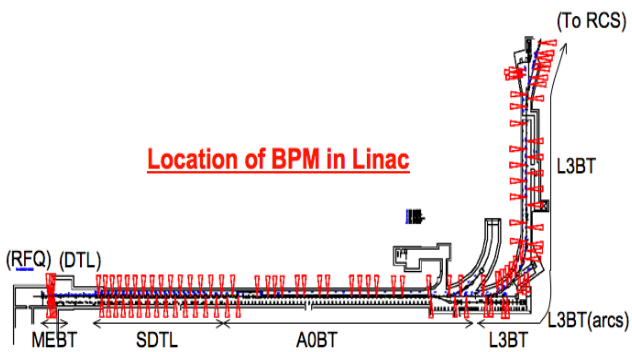

Figure 4: Location of J-PARC BPM's. (Note that, for easiness of reading, the red arrows show locations only in z-direction (beam axis direction), but not in x- or in y-direction).

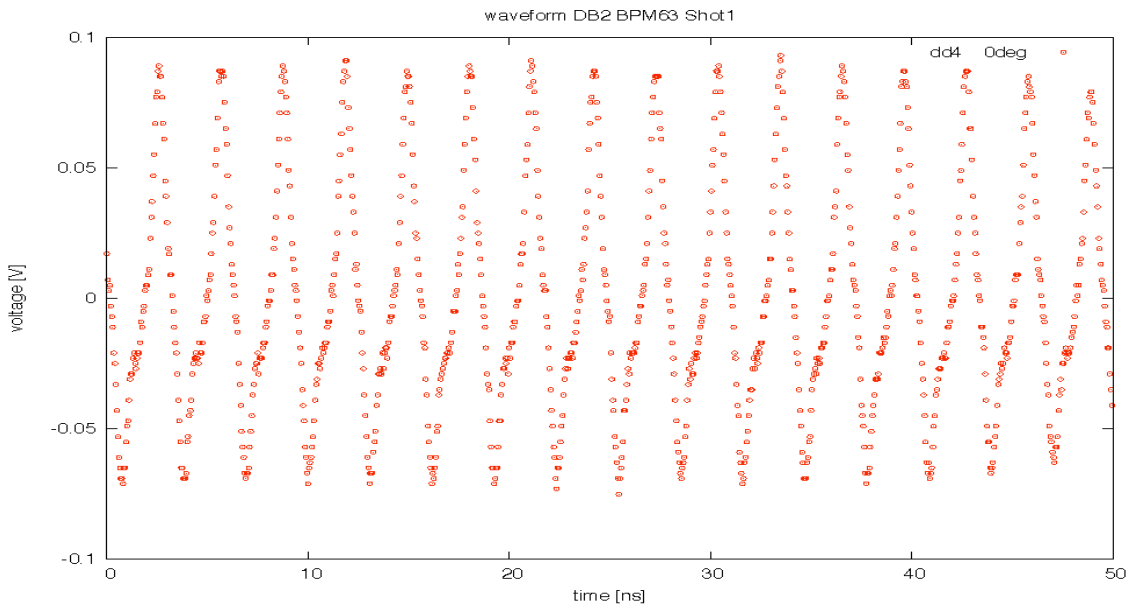

Figure 5: Raw signal from BPM. Horizontal axis is 50ns (full), vertical axis is from -0.1 V to 0.1V (full).

We have observed signals in oscilloscope (20GS/s, 4GHz band width, Tektronix TDS7404). Figure 5 shows clear raw signal from BPM-L3BT63 (diameter 120mm). The horizontal axis is 50 ns (full) and the vertical axis is from -0.1 V to 0.1 V (full). It would be useful for upgrade stage of J-PARC LINAC monitoring system. Note that charge polarity of the beam is negative (negative H beam), the first output signal (which is from time when the input pulse is entering at upstream of the stripline) is negative (the same charge polarity with input signal). And then the second output signal (which is from time when the input pulse is exiting at downstream of the stripline) is in the opposite polarity (positive) output. Non-symmetric structure would be influenced by longitudinal profile of the beam, which might be well monitored by using a bunch shape monitor [6] in the J-PARC energy upgrade stage [7].

SUMMARY

We are studying J-PARC BPM with stripline electrodes as a phase detector, with the test bench and with the real negative H beam. Signal from upstream side of stripline would be better by sharing with beam position monitoring. Sum signal of four stripline electrodes for the real beam has been observed, and it would be useful in the upgrade stage of J-PARC LINAC monitoring system.

REFERENCES

[1] J-PARC Design Report (JAERI-Tech 2003-2004, KEK Report 2002-13).

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[3] In SNS for example, C. Deibele, S. Kurennoy, Proc. of PAC-2005, pp2607 - 2609, “Matching BPM stripline electrode to cable and electronics”.

[4] S. Sato et al., “Beam Energy Measurement at J-PARC LINAC”, Proc. of the 5th annual meeting of particle accelerator society and the 33rd linear accelerator meeting [in Japanese], 2008 Aug. Higashi-Hiroshima, pp 500 - 502.

[5] For example, T. Ieiri, OHO-1991, VIII7 -8.

[6] A. V. Feschenko et al., “Bunch shape monitor for the DESY H− LINAC” pp2078 - 2080, and the references therein.

[7] H. Sako et al., “Configuration of beam profile monitors at energy upgraded J-PARC LINAC”, in this proceedings of PAC-2009.