

DESIGN OF LARGER BPM IN J-PARC LINAC

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Abstract

In J-PARC LINAC section, several different diameters (from 37.7mm to 180 mm) of beam position monitors (BPMs) are used. Especially after the arc section of the L3BT beam transport section, larger BPMs are used. In this paper, scheme of design of those larger BPMs are described.

J-PARC LINAC の大口径 BPM の設計

BEAM POSITION MONITORS IN J-PARC LINAC

In the J-PARC LINAC [1], we have been installing BPMs in MEBT, SDTL, A0BT and L3BT section [2, 3]. From arc section of L3BT the diameter is getting larger and at the scraper section, diameter is 120mm[4]. Just before injection to RCS synchrotron, the diameter becomes 180mm. For all the BPM in the LINAC, electrode type is commonly as a strip line. And the installation is done directly on the quadrupole magnet so that position accuracy is well achieved. Those BPMs are calibrated before installation, using a scanning wire simulating beam [5].

ALLOCATION OF LARGER BPM

Upto A0BT, duct diameter is 40mm or less. In L3BT, diameter begins with 70 mm, and at the entrance of arc-section is 85 mm. Between a scraper section and a section just before RCS injection, BPM with 120mm diameter are used. Also at the beam dumps, namely 0-degree dump, 30-degree dump, 90-degree dump, and 100-degree dump, BPMs with 120 mm in diameter are used. And the last BPM in LINAC has 180mm diameter. For the reference, in RCS section the first BPM has 240mm diameter [6]. Those larger BPM has a role to monitor the quality of injecting beam to RCS synchrotron. For beam painting into RCS, those larger diameters are required.

MECHANICAL DESIGN

As the large volume of mechanical structure is made of stainless steel, handling of heavy monitor needs to be considered. Figure 1 shows cross section (upper picture) and top view (lower picture). Hinges for crane handling are attached, and mechanical positioning structures onto the magnet yokes are minimized in volume (namely, are limited only around the center of the magnet yoke length in z-direction). To adjust fine positioning, bellows are welded on the both side of BPM.

There are 5 points where the mirror ball for survey is positioned (see top view in figure 1). Relative positions of each of these five need to be surveyed, because position of the middle one is the only known points with respect to pickups, while other four points are not known because those four are welded to the central parts (namely relative positioning is poorer). This internal survey among the five needs to be done before the housing magnet is closed, because the middle one is hidden behind the magnet (from surveyor). Then, survey of BPM with respect to the general coordinate of J-PARC is done with other four points.

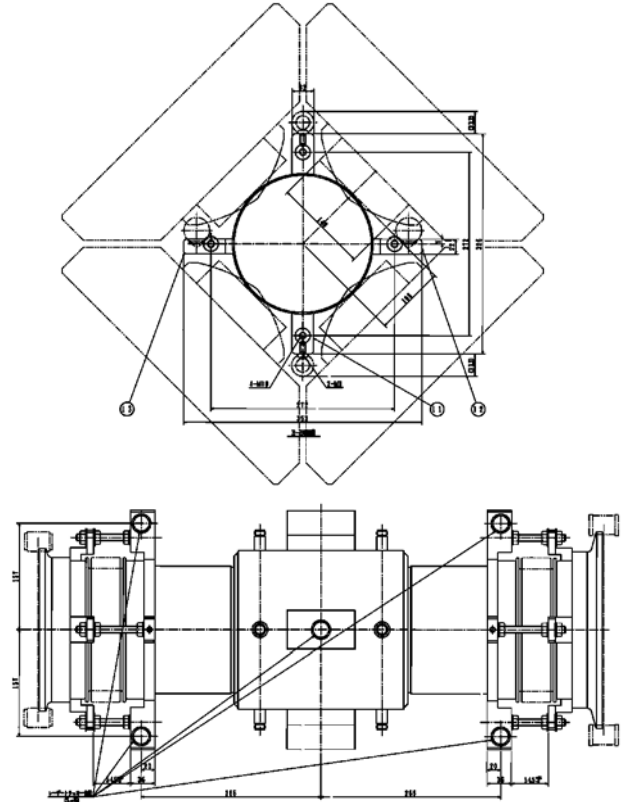


Fig. 1: Mechanical design of larger BPM (ϕ 180mm). Upper picture shows cross section, hinges for the lifting are shown. And the lower shows top view. There are 5 points where the mirror ball for survey is positioned.

DESIGN OF LARGER BPM PICKUPS

Design scheme is kept common with those for the smaller BPMs. Electrostatic simulation code, POISSON [7], is used to optimize the impedance of pickup so that matching with signal transport line (50 ohm) is acquired. Figure 2 shows example of field calculation. Note that, in order to manage mechanical constraint with the housing magnet yoke, depth of concave around pickup is limited, therefore the width is relatively smaller than those for smaller diameter of BPMs. The pickup is mounted on the ceramic insulator, and N-type RF connector is used for cable connection. Downstream side of the connectors are terminated with 50 ohm, as is the same scheme with smaller BPMs.

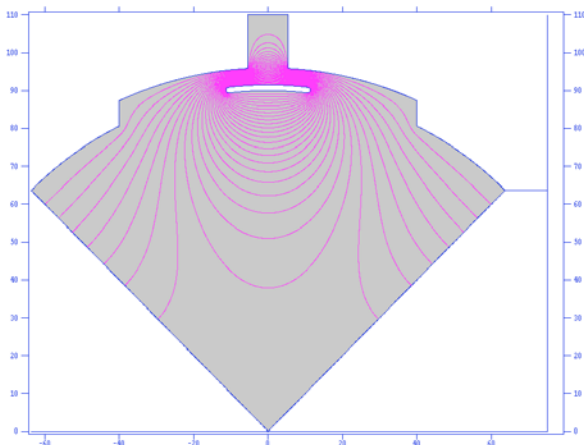


Fig. 2: Electrostatic calculation of Larger BPM (with 180mm diameter). Note that, in order to manage mechanical constraint with the housing magnet yoke, depth of concave around pickup is limited, therefore the width is relatively smaller than those for smaller diameter of BPMs.

PRODUCTION OF BPM

Larger BPM has difficulty in accuracy of production. We set accuracy of production of positioning structure from -50 to -150 micro-meter in design, where the magnet yoke has -30 to +30 micro-meter accuracy in design. After making duct (with concave behind pickups) and pickups, impedance measurements are taken for fine adjustment of impedance, before welding bellows and other mechanical structures. To finalize the size of pickup, several size close to the design value is produced, and impedance are measured with network analyzer with 324MHz. Then interpolation or extrapolation scheme is used to determine final size.

After production of the larger BPM, calibration with scanning wire is planned. As the bench setup for the smaller BPMs cannot be used for the BPM with 180mm diameter (x-, and y- scanning stage has too small dynamic range). Therefore, we are planning to use calibration setup for RCS-BPMs. The setup has designed for different signal frequency range, but by using multi

channel (>5ch) network analyzer this different condition can be optimized.

READOUT ELECTRONICS OF BPM

Logarithmic amplifier is used to cover wide dynamic range of the signal (for example, in 180mm BPM, a few centi-meter of beam position discrepancy from duct center corresponds to several dB's of change on pickups)

To minimize sinusoidal-like wave shape of output (with respect to input power) from logarithmic amplifier, compensation circuit is implemented. The circuit takes sum with 6dB-attenuated signal (because wave structure is about every 6 dB), and residual fluctuation reduced to the level less than $\pm 0.8\text{dB}$. Figure 3 shows the compensation scheme of logarithmic amplifier (For each channel, one module contains 4 channels). Note that SG means signal generator, which in real case, output from each pickup of BPM.

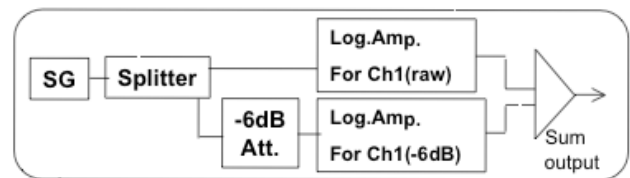


Fig. 3 Compensation scheme of logarithmic amplifier used for BPM readout.

COMPARISON WITH OTHER BPM

In J-PARC RCS section, the first BPM has larger diameter of 240mm, while this uses an independent support structure due to positioning constraint around the beam line. The difference in the positioning scheme (namely not mounting directly on the magnet quadrupole yoke) requires large attention in design for the support and position calibration.

COMMISSIONING PLAN WITH THE LARGER BPM

From this December, till 2007 June, we are planning the beam commissioning up to 30 degree dump on the L3BT arc section. This will contain tuning of debuncher 1, checking of achromat of 1/3 of arc, and checking of different operation modes. Then from 2007 September, commissioning of whole L3BT will start, including tuning of debuncher 2, and injection to RCS synchrotron. At this stage, larger BPMs need to be fully operational. Figure 4 shows location of BPMs in L3BT section. From the section of scraper, ϕ 120mm BPM are assigned. Also at the beam dump, ϕ 120mm BPM are used. And the last BPM in LINAC section is ϕ 180mm BPM.

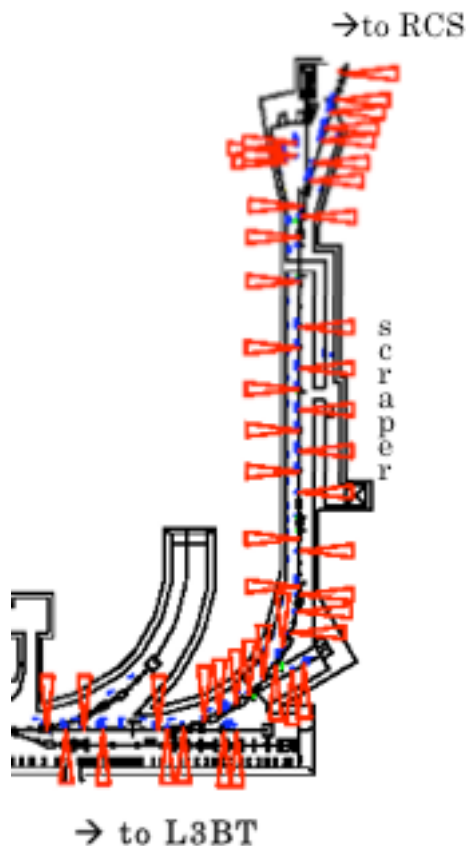


Fig4: Location of BPMs in L3BT (red arrow shows location). From the section of scraper, ϕ 120mm BPM are assigned, and the last BPM in LINAC section is ϕ 180mm BPM.

For the commissioning of the scraper section, about 0.1 mm of displacement of beam (or of beam scraper) resulting in about 10 % of increase for scraped beam [8]. Therefore comparable accuracy is preferred for the beam position monitoring.

For the commissioning of the injection to RCS, other monitors e.g. seven MWPMs (multi wire profile monitors), or thermo couplers around the beam dump (at RCS injection) are used as well [6]. Those monitors in RCS are for “after-injection” information, and the larger BPM in LINAC are providing for “before-injection” beam condition.

SUMMARY

In J-PARC LINAC, especially in the latter section, larger BPMs are needed, e.g. 120mm and 180mm in diameter.

- To get positioning accuracy, BPM is set directly on the yoke of quadrupole magnet.
- Readout electronics (logarithmic amplifier) contains correction circuit using -6dB attenuator.
- Using larger BPM, commissioning with beam is planned from December this year.

REFERENCES

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