Wire Test of Large Type BPM for P2DT in RAON

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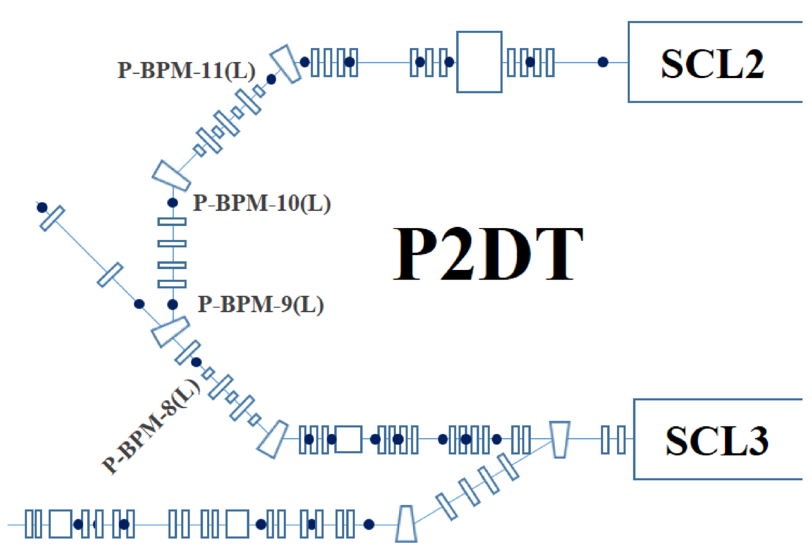
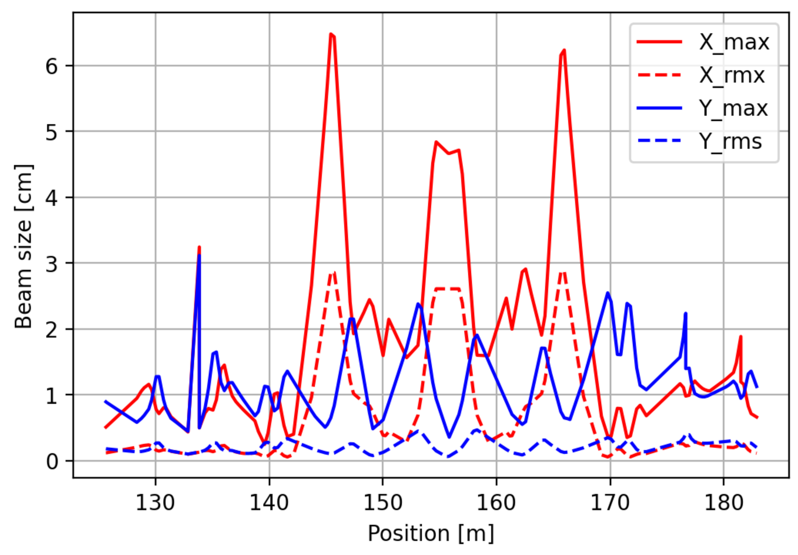
RAON (Rare isotope accelerator complex for On-line experiments) is accelerator to accelerate heavy ion such as uranium, oxygen, and proton. P2DT(Post to Driver linac Transport line) where is between SCL3 and SCL2 make more efficiency beam with stripper to accelerate in SCL2 section. To correct beam trajectory, we have to measure transverse beam position with 100 um transverse position resolution. In bending area in P2DT, BPM should accept a beam that has large size (~10 cm) horizontally. We simulated Large type BPM with CST particle studio. Fabricated LBPM was tested on the developed wire test bench that could move BPM for ±10 cm width, ±4 cm height with manual steering knob.

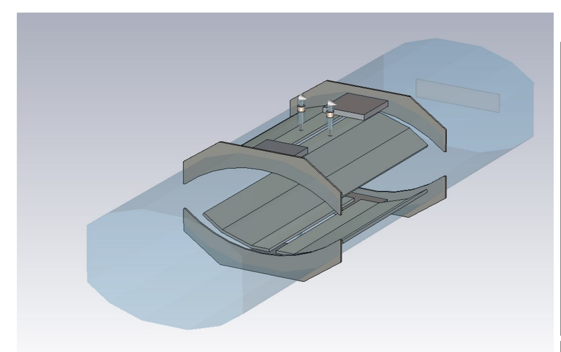
RAON accelerator & P2DT section

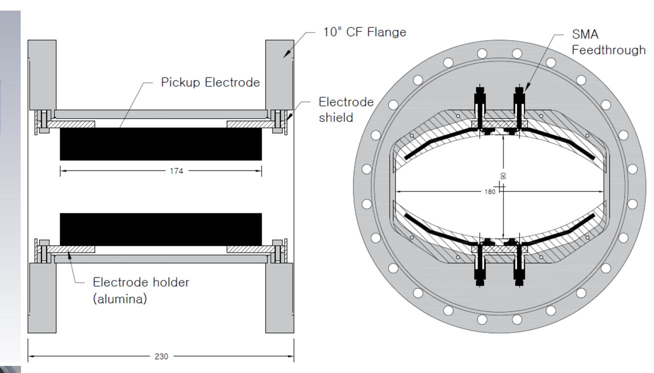


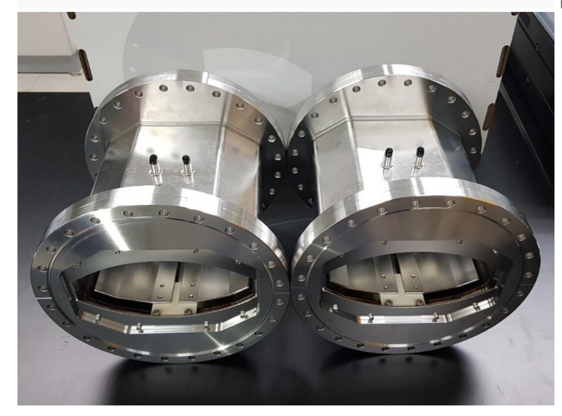


In P2DT, the charge state of the beam is changed to a higher charge state by the charge stripper, and the charge state selected by the charge selector is transferred to the experimental area through SCL2. In the P2DT section, the energy, and bunch length of a uranium beam are 18.5 MeV/u and 0.3 ns rms, respectively. The designed input beam pulse current of P2DT is 340uA, and the output beam current is 660uA. In the case of a uranium beam, the maximum beam size along the horizontal direction is greater than 6 cm after passing the first dipole magnet. The BPMs are required to accept large-size beams for measuring the positions and phases of the beams. The required transverse position resolution is 150 μm at 81.25 MHz, that is the fundamental RF frequency and bunch repetition rate of the RAON. The formula of Δ/Σ will be used to calculate the position on the basis of the signal strength of BPM. We prepared an electronic system to calculate the signal strength and phase of all electrodes using the IQ method of 81.25 MHz.

Design & fabrication of Large type of BPM



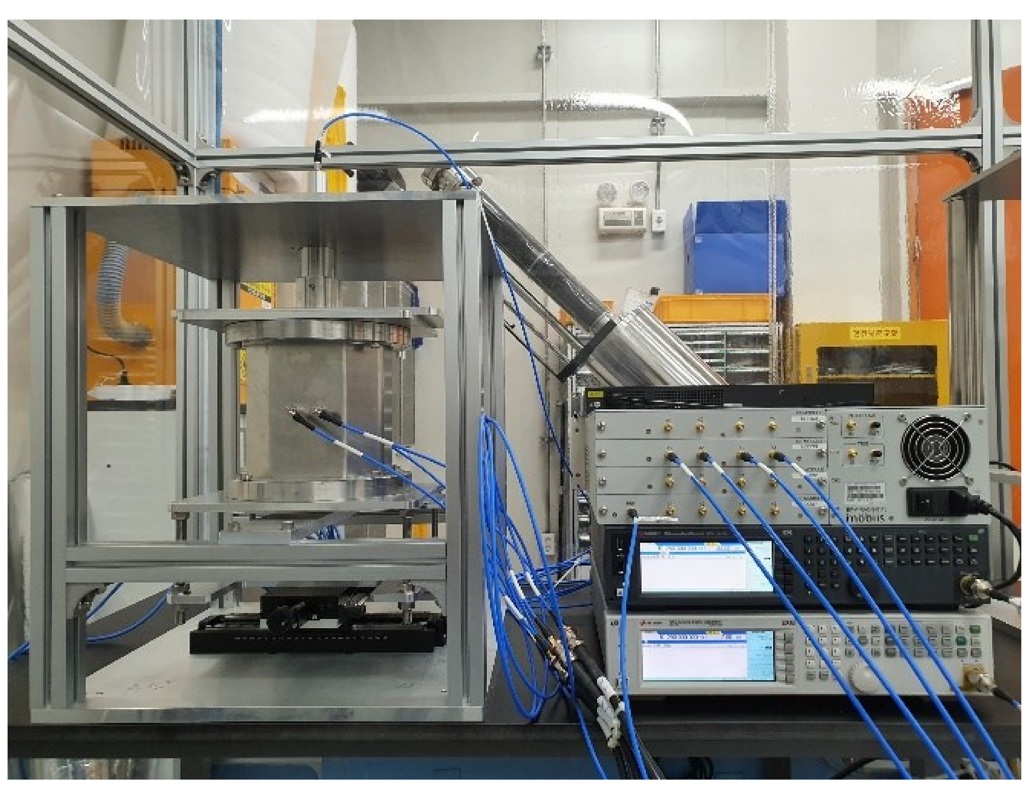


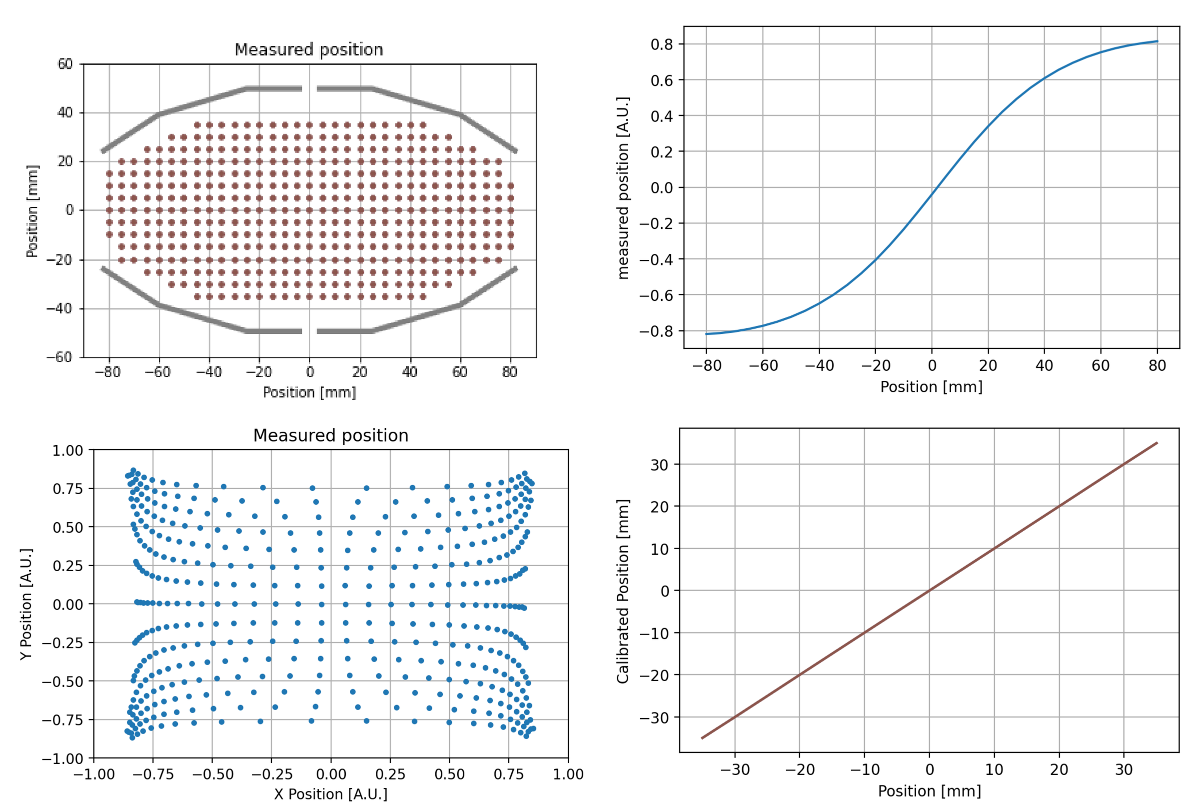


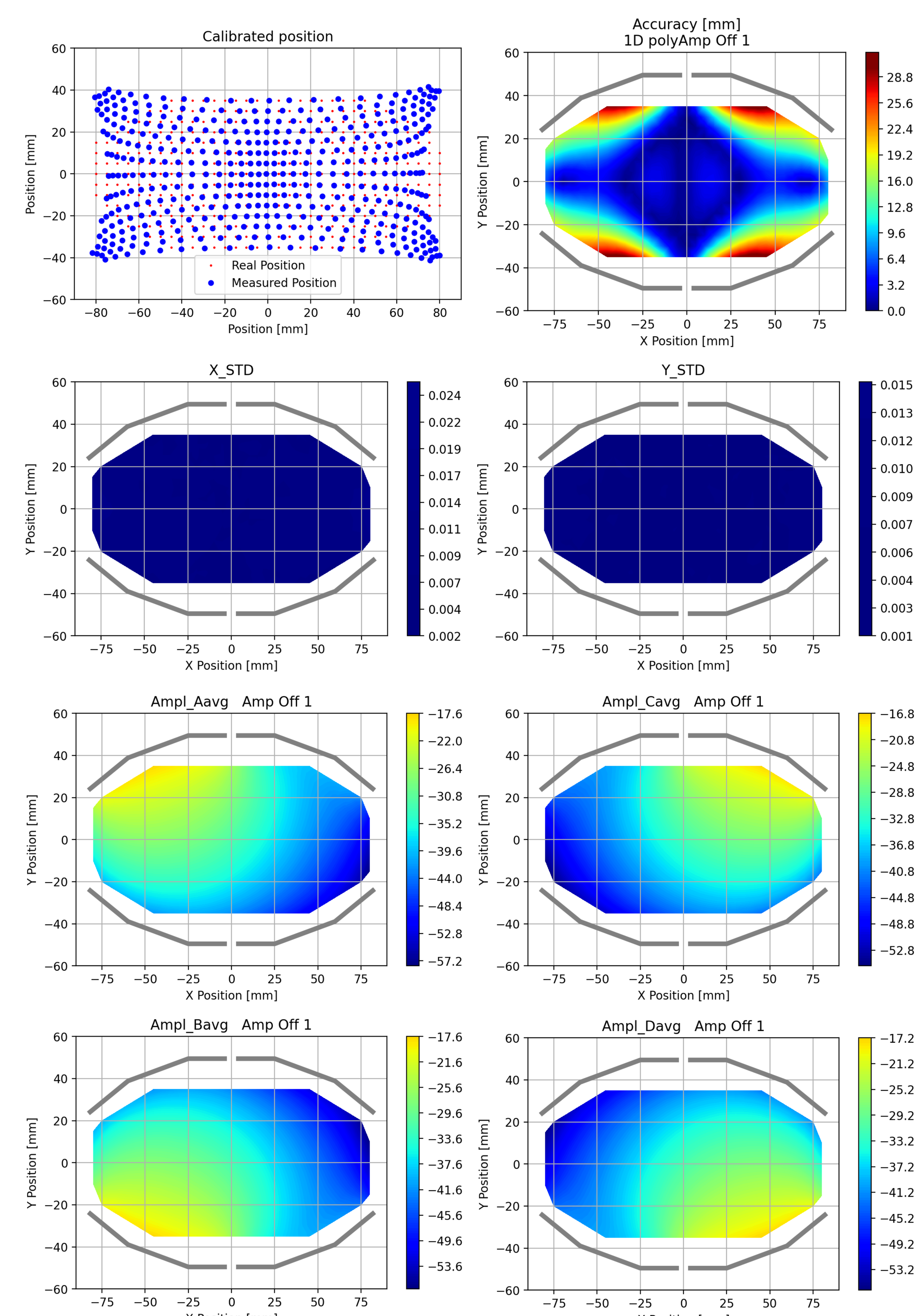
Parameter	Value
Length of pickup	178 mm
Position of feed through from center	15 mm
Gap between pickup	6 mm
Width	162 mm
Height	92 mm

Two major design issues were considered while design-ing the BPM. First, the side regions were removed to avoid electrode damage due to machine failure. Second, the electrode plate was configured to have as high signal strength as possible. A bent electrode shape was chosen to solve the design issues. Ceramic parts are required to support the large plate to avoid overloading in the feed-through. The rectangular bent electrode is bolted to special parts that were welded with Kyocera SMA-R feedthrough. The housing, electrode, collimator, and flange were fabricated using 316L stainless steel, which is a non-magnetic material. Alumina ceramic components were assembled to insulate and hold the electrodes.

Wire test result of Large Type of BPM







The wire test bench has 2 movable stage for X and Y axis and it could move BPM for width of ±80 mm, height of ±40 mm with manual steering knob. The input signal on the wire is set to measure the signal strength at the feedthrough of the BPM, which corresponds to a current of 300 μA. The case of a beam passing through the center of the beam pipe was simulated using the CST particle studio, and the component of 81.25 MHz was calculated as a value of -32 dBm.

Since the large type BPM has a symmetrical structure, the distribution of the measured signal strength measured on the electrode plate has a symmetrical shape. As the wire test results showed that the distorted area was close to the electrode plate, the strength measured near the electrode plate did not differ significantly as the position was changed. In addition, since the electrode has a diagonal direction to represent the X-Y plane, nonlinear measurement results are obtained.

$$X_0 = \frac{Rights - Lefts}{Rights + Lefts}$$

$$Y_0 = \frac{Ups - Downs}{Ups + Downs}$$

$$X_{measured} = K_1 X_0^{\,3} + K_2 X_0^{\,2} + K_3 X_0^{\,1} + K_4 X_0^{\,0}$$

$$Y_{measured} = L_1 Y_0^{\,3} + L_2 Y_0^{\,2} + L_3 Y_0^{\,1} + L_4 Y_0^{\,0}$$

Conclusion

The BPM was designed to cover as much as possible and was fabricated using bent electrode plates of optimal length. We developed a wire test bench with two movable stages for large type BPM. Fabricated large type BPM was performed at the wire test. Accuracy and signal strength were obtained at each measurement location considering calibration factors.

Although large BPM was tested at wire test bench, it can explain in case of very narrow beam. The beam size, current, and charge state vary in the P2DT section during beam operation. There is charge stripper to strip electron from heavy-ion particle. At that time various stripped particle ion is produced and transport to SCL2 through large type BPM. To select charge state of particle beam, the beam size would be increased for X axis. Because BPM measures the center of charge, the measured position may change as the stripping efficiency changes. Of course, the calibrated position including calibration factor and real position measurement is differ depending various beam size.

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