Trace-back method for dispersion matching conditions of primary beams at RIBF

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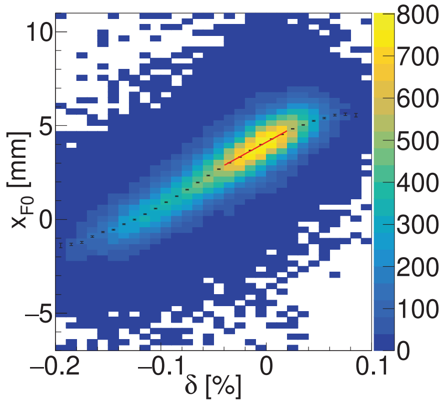
We are preparing for an experiment to search for double Gamow-Teller giant resonance (RIBF-141R1, DGTGR) at RIBF. We use a part of BigRIPS, F0-F5, as a spectrometer;[1)] this is a common setup for spectroscopic experiments at the pionic Atom Factory (RIBF-135R1, piAF).

In these experiments, the energy spread of the primary beam has the largest contribution to the energy resolution. To remedy this situation, we are developing dispersion-matching optics, where the energy spread is canceled out under the condition that the dispersion at the target position F0 $(x|\delta)_{\mathrm{F0}}$ is 34.1 mm/% for DGTGR and 44.6 mm/% for piAF.

In order to satisfy these conditions with sufficient precision, we need to develop diagnostic methods of the phase distributions at F0 based on tracking information and the tuning method by using the optical elements in the upper stream. Owing to severe radiation conditions, detectors in the upstream sections require radiation hardening, and the information obtained in the section is limited. Here, we employ the trace-back method to obtain the phase distributions from distributions measured by tracking detectors at the F3, F5, and F7 planes. In this method, a set of the horizontal position x, angle a, and relative momentum deviation from the reference particle δ $(= \delta p/p)$ at F3 is converted to one at a certain plane by multiplying with a transfer matrix. The x and a at F3 are instantly obtained by measuring the trajectory of the beam using the tracking detectors. The δ is deduced from the horizontal positions x at F5 and F7, which are dispersive and achromatic focal planes, respectively.

We attempted to apply the method by analyzing data taken in June 2018 for study of the superconducting ring cyclotron-BigRIPS (SRC-BigRIPS) optical system. A primary beam of $^{18}\mathrm{O}^{8+}$ with an energy of 230 MeV/nucleon was transported to F7. The beam trajectory was measured by parallel-plate avalanche counters (PPACs) at F3, F5, and F7 for different settings of optics between SRC and F0.

We obtained reconstructed phase distributions at F0 by using the trace-back method. Figure 1 shows the distributions at F0 for two different settings of optics, which are $(x|\delta)_{\mathrm{F0}} = 34.1$ mm/% for the upper panel and 44.6 mm/% for the lower panel. Each slope corresponds to the dispersion at F0, and the deduced values



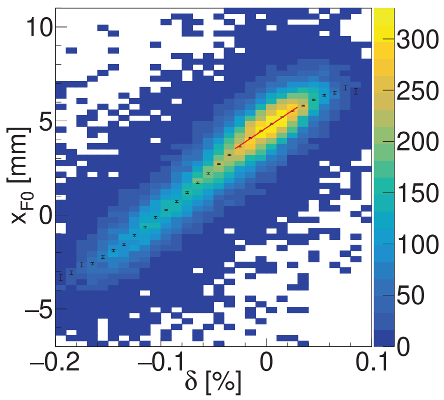


Fig. 1. Correlation between the deduced x and δ at F0 for two different settings: $(x|\delta)_{\mathrm{F0}} = 34.1$ mm/% (upper panel) and $(x|\delta)_{\mathrm{F0}} = 44.6$ mm/% (lower panel). Fitting results obtained using linear functions are shown with red lines. Each slope corresponds to the deduced dispersion.

are 30.8 mm/% and 37.3 mm/%, respectively. The fit region corresponds to the momentum spread for the well-tuned beam ($\sigma \sim 0.03\%$).[2)] The precision of determination of the dispersion at F0 is approximately 3 mm/%, which is sufficient as the experimental resolution. The absolute values of dispersion in this measurement were slightly different from the ideal values. By referring to the reconstructed distribution, we can tune the optics so as to cancel the difference. We are now refining the tuning method to provide an online feedback based on the diagnosis.

In summary, we have developed the trace-back method for tuning the dispersion at F0 so as to fulfill the matching condition. We are now working on an optimization of the tuning method for the beam time.

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