SHARAQ Project: Progress in 2009

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On March 23, 2009, the first beam was successfully transported to the final focal plane of the SHARAQ spectrometer. We investigated detector responses to heavy-ion beams and the ion optical properties of the SHARAQ spectrometer[1)] and the high-resolution beam line[2)] in the subsequent commissioning runs and found that the system as a whole worked almost as per its design. The first physics run with the spectrometer was performed in November 2009. In this article, we review the progress in the SHARAQ project in 2009.

1 Last minutes of the construction

The construction of the spectrometer and the beam line was continued until the end of February 2009. Cathode read-out drift chambers (CRDC) were installed at the focal plane of the SHARAQ spectrometer in January 2009. The vacuum chambers and pumping systems of the spectrometer were built in February.

Fig. 1. Newly constructed beam line magnets: two normal-conducting dipole magnets (DH7 and DH8) and a superconducting triplet quadrupole magnet(STQ-H15).

Two normal conducting dipole magnets with a bending angle of 30°, vacuum chambers for beam line detectors, and vacuum pumps were installed in the high-resolution beam line in February 2009[3)]. Figure 1 shows a photograph of the newly constructed beam-line magnets: two normal-conducting dipole magnets (DH7 and DH8) and a superconducting triplet quadrupole magnet(STQ-H15).

2 Commissioning runs

A primary ^{14}N beam accelerated up to 250 MeV in SRC was transported from F0 of BigRIPS to the focal plane of the SHARAQ spectrometer. This is the first time that a beam was accelerated without involving an IRC. The ion beam struck plastic scintillation counters placed downstream of the focal plane for the first time at 22:37 on March 23, 2009 (JST).

The beam-line detectors consisting of eight multi-wire drift chambers (MWDC) and the SHARAQ focal-plane CRDCs were irradiated by the ^{14}N beam and the secondary beams of ^{12}B, ^{9}Li, ^{6}He, and ^{3}H at 200A MeV. The detectors were operated at a low gas pressure of 10 kPa for the beam-line MWDCs and at 2 kPa for the CRDCs. Detection efficiencies were found to be almost 100% even for light ions with Z in the rage 1–7[6,7)]. We have also confirmed that position resolutions are high and amount to 200–300 μm FWHM, which meets the design requirements. A new data taking system was also found to function satisfactorily.

The ion-optical properties of the magnetic system were investigated by using beam trajectories determined by the tracking detectors described above. Momentum dispersions $(x|\delta)$ at the dispersive focal planes F6 and FH7 and at the focal plane of the SHARAQ spectrometer were found to be 7.8 m, 7.5 m and 5.8 m, respectively. These values are consistent with the design values.

Beam-line tuning was carried out to achieve lateral and angular dispersion matching conditions and double focus conditions at the SHARAQ target position[4)]; the tuning was performed by adjusting the excitation currents of the four quadrupoles QH18, STQH19a, b, and c. During the tuning, the correlations between particle trajectories at the dispersive focal plane FH7 and at the focal plane of the SHARAQ spectometer were used for diagnostics. The beam position at FH7, x_{FH7}, corresponds to the beam momentum, and thus, the correlation between x_{FH7} and the position in the

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focal plane of the SHARAQ spectrometer, x_{FP}, provides a good measure of $(x|\delta)$ of the whole ion-optical system. The upper panel of Fig. 2 shows the correlation between x_{FH7} and x_{FP}. The upright correlation between x_{FH7} and x_{FP} in the figure clearly shows that the beam position at the focal plane of the SHARAQ spectrometer is independent of the beam momentum, which indicates the achievement of the lateral dispersion matching condition.

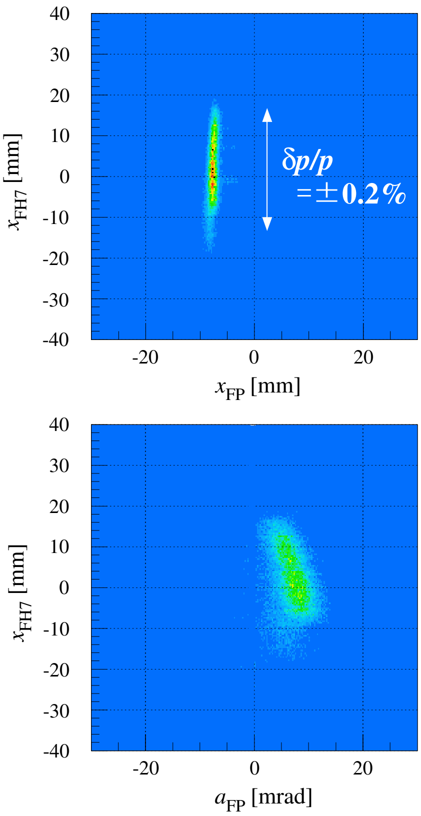

Fig. 2. Horizontal beam images at the final focal plane in the achromatic (upper panel) and the dispersion matching transport (lower panel).

Similarly, the correlation between x_{FH7} and the horizontal angle at the focal plane of the SHARAQ spectrometer, a_{FP}, that is shown in the lower panel of Fig. 2 is a good measure of the angular dispersion matching. After tuning, we succeeded in obtaining the lateral and angular dispersion matching conditions simultaneously.

Figure 3 shows the horizontal beam image at the focal plane of the SHARAQ spectrometer. Its width corresponds to the intrinsic momentum resolution of the ion-optical system. The upper panel presents the data obtained in the achromatic transport mode. In this mode, the resolution was limited by the momentum spread of the beam. After the dispersion matching condition was obtained by carrying out beam line tuning, the beam image was narrowed down considerably, as shown in the lower panel of Fig. 3.

The resulting momentum resolution $\delta p/p$ was found to be approximately 8100. Further studies to improve the momentum resolution are in progress. From the ion-optical studies, it is clearly demonstrated that tracking of the beam particles in the beam line facilitates beam line tuning that is required to obtain the dispersion matching conditions.

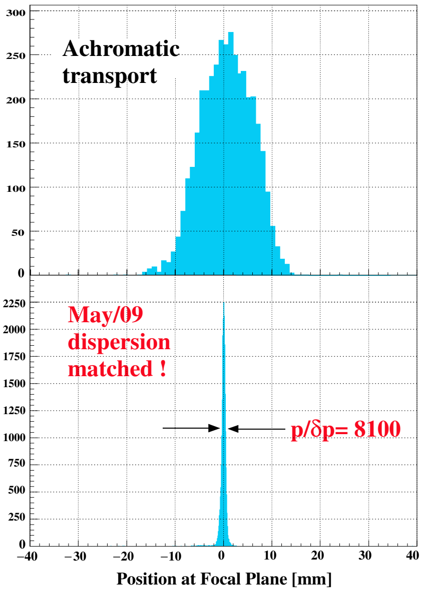

Fig. 3. Horizontal beam images at the final focal plane in the achromatic transport mode (upper panel) and in the dispersion matched transport mode (lower panel).

3 The $(t, {}^3\mathrm{He})$ Experiment

The first physics run with the SHARAQ spectrometer was performed to search for β^+-type isovector spin monopole resonances in ^{90}Zr and ^{208}Pb. The $(t, {}^3\mathrm{He})$ reaction at 300 MeV/nucleon was used to extract β^+ strengths. An intense triton beam of 10^7 s^{-1} was produced by projectile fragmentation of a primary 320-MeV/nucleon ^{4}He beam, and the scattered ^{3}He ions were momentum-analyzed by the SHARAQ spectrometer. The details of the experiment are described in Ref. 8.

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