Measurement of Second-Order Beam Optical Matrix Elements of the FRS Spectrometer

W. Schott, M. Knülle, H. Gilg, A. Gillitzer, J. Homolka, P. Kienle, R.S. Hayano [a], K. Itahashi [a], T. Yamazaki [a], T. Baumann [b], H. Geissel [b], G. Münzenberg [b], A. Schröter [b], H. Irnich [c], and N. Iwasa [d]

[a] University of Tokyo [b] GSI Darmstadt [c] Universität Gießen [d] Rikkyo University, Japan

In order to improve the momentum resolution in the chosen focal plane S2, 28.15 cm downstream of the FRS half path length, for measuring the ^{3}He recoils of the ^{208}Pb (d,^{3}He)^{207}Pb $\otimes$ π^- reaction [1], the second order beam optical matrix elements $(x, aa) = d^2x_2/da^2$ and $(x, ap) = d^2x_2/dad\delta$ were measured and adjusted to be small by means of four sextupole magnets between the target T and S2 in test experiments. The sextupoles are positioned at the front and rear end of each dipole. x_2 means the transverse coordinate at S2 in the horizontal plane, a the angle at T in the horizontal plane and $\delta = dp/p_o$ the relative momentum deviation. $(x, aa) = -(a, a)^2 d^2x_2/da_2^2$ is obtained by the curvature of the measured points in the $x_2(a_2)$ plane and the angle magnification $(a, a) = da_2/da$, where a_2 means the angle in this plane at S2. $(x, ap) = (a, a) \cdot \frac{(dx_2/da_2)_{p_o} - (dx_2/da_2)_p}{(-dp/p_o)}$ results from the difference in slope of the measured points in the $x_2(a_2)$ plane taken at $a_2 = 0$ for particles with momentum p_o and some smaller momentum p, respectively.

In November 1995 a test running time was made at GSI using 300 MeV/u ^{12}C projectiles. A hole target of 140 mg/cm^2 Al and 1 mm hole diameter and a stripe target of 270 mg/cm^2 Al and 1 mm gap width have been used. Thus, the ^{12}C beam contained 300 MeV/u particles passing through the hole or the gap and particles with a somewhat smaller energy corresponding to a momentum deviation $-dp/dp_o$ of $2.23 \cdot 10^{-3}$ and $4.31 \cdot 10^{-3}$ passing through the aluminium of the hole and stripe target, respectively. By means of the two dipole magnets of the beam line between the extraction point of the accelerator (SIS) and the FRS target T, rays with different angles a at T (0, $\pm$6 mrad, $\pm$10 mrad) were produced. At S2 the angles in both planes were measured by means of two MWPC's. Using the measured and computed (program GICO) (x, aa) and (x, ap) values for sextupoles switched off, a sextupole setting with strongly reduced (x, aa) and (x, ap) was found and applied at the main running time. Before the main experiment the reduction of (x, aa) and (x, ap) using the sextupole $\neq 0$ setting was confirmed by single rays ($a = 0$, $\pm$4 mrad, $\pm$8 mrad) of 300 MeV/u deuterons using a 3 mm thick Al target with a 1 mm hole (for d passing through the aluminium $-dp/p_o$ is $2 \cdot 10^{-3}$). x_2 and a_2 were measured by means of four fast drift chambers. Fig. 2 shows the measured points in the $a_2(x_2)$ plane with a parabola fit to the points. From the curvature of the parabola and the slope of the tangent to the parabola at $a_2 = 0$ $(x, aa) = 157.17$ m/rad^2 and $(x, ap) = -11.16$ m/rad result with absolute values being smaller than $(x, aa) = -362.85$ m/rad^2 and $(x, ap) = -137.69$ m/rad with switched off sextupoles (cf. fig. 3). $(a, a) = 0.821$ from GICO calculation was used. Correspondingly, for the sextupole $\neq 0$ setting the emittances of the rays through the hole are clearly separated from the $-dp/p_o \neq 0$ rays, thus, improving the momentum resolution at S2 especially for the $a_2 = -3... + 10$ mrad range, in contrast to the sextupole $= 0$ setting as shown in fig. 4 and 5, respectively. Since the slope of the tangent in fig. 2 is only little shifted from vertical to a positive value, the real focal plane is only $r_{12} \cdot x_2/a_2 \approx 0.2$ m upstream from S2 as shown in fig. 1, where the single rays are plotted in the $z - x_2$ plane. r_{12} means the beam matrix element describing the emittance inclination.

The authors would like to thank Dr. G. Hinderer for helpful discussions.

References

[1] H. Gilg et al., this report p. 101

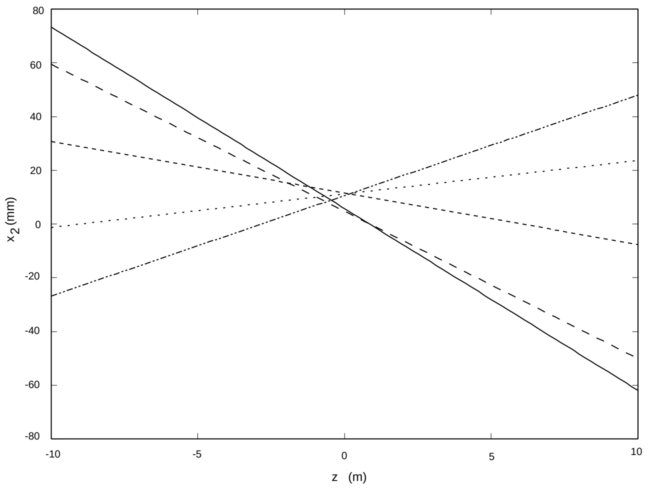

Fig. 1: x_2 *vs* z plot of d rays passing through the hole of T; else like fig. 2. $z = 0$ means the S2 position.