Studies of Fragment Separator at the Cyclotron Institute

G.J. Kim, G.J. Derrig, G.A. Souliotis and D.H. Youngblood

In order to provide some radioactive beams to the MDM spectrometer and also to the NIMROD detector, we have looked into using the Beam Analysis System (BAS) line as a particle fragment separator. See Fig. 1. The BAS line is normally used to produce highly resolved beams for MDM experiments. BAS utilizes seven dipoles with a total bend of 175 degrees to obtain an energy resolution of _E/E = 1/2500. However, the line normally uses the first part of BAS with an 88-degree bend (through BM01 to BMA04) to obtain an energy resolution of _E/E = 1/1250 (at S02), and then the second half of BAS with an 87-degree bend (from BMA05 to BMA07) and the one-to-one magnification from S02 to S03 is used to further clean the beam.

A projectile fragment separator requires a production target followed by two dispersive sections with a degrader between the two sections for the _E particle separation. Therefore to use BAS as a separator, a production target would be placed at S01, a _E-separation degrader would be located at S02 (the intermediate focus point in BAS), and the final achromatic focus would be at S03. A few modifications to the current BAS line would be necessary, such as an addition of a quadrupole doublet just downstream of BMA04 and a small shift in the S02 location.

We found a number of problems using BAS as a fragment separator. First and foremost, all the existing vacuum pipes are 4 inches in diameter (quadrupoles have 4 inch aperture), and the pole gaps for the dipoles are narrow, ranging from 1.25" to 2.75"; the BM02 has the smallest gap and it would certainly need to be widened for the separator applications. Secondly, because BAS was designed for small emittance beams (about 5_ mm-mrad), the drift spaces between quadrupoles are long and together with large bend angles through dipoles limit the emittance and the momentum acceptances to small values. The lack of floor space for additional quadrupoles in the BAS line reduces the possible acceptance; for example a quadrupole triplet after the production target would improve the particle collection efficiency, but presently there is no space in front of BM01 to do this. In conclusion, the use of BAS would result in a small acceptance, at most about 7_ mm-mrad with _p/p = _0.3%; this is only 1/20 of A1200 at MSU [1] and it will be difficult perform useful experiments with such small yields.

We turned next to the idea of completely rearranging the beam lines to include a fragment separator, which would then be coupled into BM04 (in the 88 inch vault) for beam delivery to the MDM and the NIMROD caves. A possible design is shown in Fig. 2. In order to provide enough space and the proper angle for the separator line, some changes to the beam line between BM01 to BM03 would be needed. The fragment separator would include a production target, two 6-inch gap, 35 degree bending dipoles, and ten 8 inch-aperture quadrupoles and four sextupoles. An achromatic degrader assembly will be positioned halfway between the two dipoles. At the first focus point (at the degrader position), the quadrupole-triplet—dipole—quadrupole-doublet configuration would provide M_x = _1.2 and M_y = _2.5, and dispersion of 1.6 cm/%, giving _p/p = 1/1250 with an 1 mm beam spot at the target. The second half of the separator system would mirror the first half, and with the inner quadrupoles properly adjusted, the separator would give an achromatic focus at the second focus point just upstream of BM04. The compact 16 m-long separator would have a solid angle of 1.6 msr (40 mr _ 40 mr) and momentum acceptance of 6%, thus giving about 4 times the acceptance of A1200 of MSU. The production estimates for some rare beams are given in the contribution following this by G.A. Souliotis.

References

[1] B. M. Sherrill, D. J. Morrissey, J. A. Nolen, and J. A. Winger, Nucl. Instr. and Meth. **B56**/**57**, 1106 (1991).