K600 SMALL ANGLE OPERATION

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At present, the most forward scattering angle which may be used with the beam going into the external Faraday cup is 14°. Using the internal cup inside the 24″ scattering chamber, the most forward possible angle is 6°. No coincidence detectors are practical in this latter mode. Development of the K600 spectrometer to allow small angle measurements in the range from 0° to 14° using external beam dumps is ongoing. This angular range is important for studies of L=0 transitions, e.g. unnatural parity M1 states and giant resonances excited in (^{3}He,t)-reactions and inelastic proton scattering. The goal is to maintain the good resolution of about 20 keV while minimizing the background. There are several possible ways to realize small angle operation of the K600 spectrometer as listed below.

0° Mode

Scattering angles very close to 0° can be observed if the beam is guided into the spectrometer and is stopped in a Faraday cup positioned either in the dipoles or behind the focal plane, depending on the ratio of the magnetic rigidities $R(B\rho) = (B\rho)_{beam}/(B\rho)_{react}$ of beam and reaction products. This mode has been developed for the (^{3}He,t)-reaction where $R(B\rho) = 0.5$, and the beam can be stopped conveniently on the low momentum side of dipole 1 without causing excessive background. The 4° horizontal acceptance of the K600 allows coverage of the angular range from about 0°−3° scattering angle.

For inelastic proton scattering where $R(B\rho) \geq 1$, the beam is guided through the spectrometer to the high momentum end of the focal plane. It is stopped in a well-shielded dump behind the focal plane. With a momentum dispersion of 13.3 cm/%, the inelastic proton spectrum with excitation energies $E_x > 10$ MeV at 200 MeV incident energy can be observed with the present focal plane detector.

This mode has been shown to work in a preliminary arrangement and is very useful for the identification of sources of low momentum background in the beam itself when the target is removed. The diagnostic value of this mode has been proven. Such background has been partially eliminated by appropriate beam line tunes or by modification of certain beam line elements. Despite the fact that we were able to see the 15.11 MeV excited state in ^{12}C(p,p′)^{12}C at 200 MeV, backgrounds from sources in the beam line are still too high to use this mode for nuclear physics measurements. Further studies are in progress.

4° Mode

This mode, which was suggested in the original K600 design, uses an electromagnetic septum magnet. It allows measurements with a reduced solid angle of 1 msr at angles as small as 4° ± 1°. In this mode, the beam is sent through a specially designed beam line to the external Faraday cup. Scattered particles pass through a special port in the K600 entrance quadrupole, which makes use of the declining quadrupole field branch in order to get as close as possible to the central ray of the beam.

A study has been conducted to determine if a permanent magnet septum[1] can be used to achieve smaller angles. A SINGLE RING of permanent magnets that give dipole field strengths of 7 kG and a drop to 0.2 kG within a distance D equal to the inner ring radius R are feasible. The disadvantage is that the septum gap D is filled with magnet material, a possible source of background. A DOUBLE RING with the overlapping material removed eliminates the material in the septum gap. Field transitions from -5.5 kG to $+5.5$ kG within $D = 2R$ is feasible. This septum magnet bends the beam and the reaction products of same charge in opposite directions, adding to the separation considerably. Several reasons do not favor the use of a pure permanent magnet septum, including a fixed magnetic field, an unfavorable ratio of usable dipole field width and dipole field separation, radiation sensitivity, and mechanical assembly problems.

At present, a hybrid magnet, consisting of an electromagnet boosted by permanent magnet material, seems to be the optimum configuration for angles smaller than 5° while maintaining the field flexibility of an electromagnet in a certain field range. A study of the magnetic field in the 5° port is being conducted to provide base data for tailoring the hexapole component in this field as required by ion optics. The K300 quadrupole, which is of the same type as the K600 quadrupole, is being mapped in conjunction with POISSON calculations in order to predict the dimensions of any shims needed for correction.

Beam Line Development

As previous tests have shown, there are several undesirable beam components present which produce high instrumental background count rates. These result from various sources in the beam line and spectrometer. Depending on the nature of this background different procedures can be adopted to reduce background in the spectrum. If the count rate of the background is smaller than the maximum tolerable count rate of about 400 Hz, software cuts in angle and plastic detector pulse height can clean up the spectra. The usefulness of this powerful method can be improved by increasing the speed of data taking and by making use of the fast CAMAC clear using bit pattern rejection.

A major effort will be necessary, however, to modify beam line hardware and to define favorable beam line settings to prevent creation of beam halos in the first place. A very thorough discussion of this subject was given by Brandenburg.[2] In the case of the beam transport system to the K600, several potential background sources have to be eliminated.

1. L. Knox, IUCF Summer Undergraduate Research Program, May–August 1989, IUCF Internal Report 89-3.
2. S. Brandenburg, Intl. Symp. on Heavy Ion Research with Magnetic Spectrographs at MSU, Jan. 5-7, 1989, Internal Report.