CALIBRATION OF PHOSWICH MODULES FOR USE IN EXPERIMENTS 859 AND 866 AT THE BROOKHAVEN AGS

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In August 1991, we measured the detector response of several phoswich modules to protons and deuterons of known incident energies at IUCF. These phoswich modules are currently being used in Experiments 859 and 866 at the Brookhaven National Laboratory Alternating Gradient Synchrotron for studying the production of light fragments ($Z \leq 2$) resulting from collisions of 14.6 GeV/A silicon beams and 11.3 GeV/A gold beams with targets ranging in mass from aluminum to gold.[1]

The purpose of the calibration run was to measure:

a. the amount of fast and slow light produced by protons and deuterons which stop in the large and small phoswich modules as a function of their kinetic energy.
b. the intrinsic energy resolution of the large and small phoswich modules.
c. the dependence of the fast and slow signal components on the placement of the ADC gates in time relative to the incoming particle.
d. the characteristics of the light curve for particles punching through the entire detector.
e. the dependence of the light curves on the type of phototube used.
f. the dependence of the energy resolution on the material used to wrap the modules.
g. the decay time of the slow plastic.

Although our entire run (actual data taking) spanned less than 24 hours, we were able to measure all of these quantities. In this contribution, for the sake of brevity we will only highlight our most interesting results. We refer the reader to Ref. 2 for further details.

Each of our phoswich modules is a $\Delta E/E$ telescope consisting of 5 mm of "fast" scintillator (BC412) followed by 26 cm of "slow" scintillator (BC444) read out using a single phototube. The calibration setup was designed to mimic the E859 setup as closely as possible in order to avoid systematic errors. The basic idea of the setup was to perform a coincidence measurement between a tag detector (kindly provided by Ed Stephenson) and our detector to pick out those interactions which resulted from elastic scattering of the incident proton off a target proton or off a target deuteron. In the IUCF Gamma Cave, we were able to measure elastically scattered protons and deuterons in our detector for the kinetic energy ranges of 22–173 MeV and 20–100 MeV, respectively.

The slow plastic (BC444) is quoted by Bicron as having a decay time of 180 ns. This decay time, of course, affects one's choice of ADC gate lengths. For 99.6 MeV protons, we measured a decay time of 262 ns. Previously, an ORNL group and collaborators have measured the decay time to be on the order of 304–266 ns for 8–16 MeV protons.[3] Our results along with their results suggest that the decay time is sensitive to the incoming energy of the proton, with longer decay times corresponding to lower energy protons.

To a good approximation, one finds that the light curves for protons, deuterons and tritons are related in a simple linear manner. However, one generally finds that the theoretical and experimental linear coefficients describing the relationship between these light curves differ slightly from one another. This effect is known as the pulse height defect.

From both our calibration data and our E859 data, we have measured pulse height defects on the order of 5–6% for deuterons and 8–10% for tritons. The value for deuterons is consistent with that obtained by a previous measurement at IUCF.[4]

From our calibration data set, we can also determine the intrinsic energy resolution of our phoswich detectors (including that of the electronics). In practice, however, this information is not so simple to extract because the widths of our distributions are affected by the finite aperture of the tag detector collimator, the energy loss fluctuations of the particle before it reaches our detectors and the intrinsic detector resolution. Rather than attempting to deconvolute all of the various contributions to obtain the intrinsic resolution, we simply quote the total resolution as an upper limit. We find that the total relative resolution improves as a function of increasing energy, being roughly 7% at 22 MeV and 1.6–2.3% at 173 MeV.

In summary, our calibration run was quite successful. We plan to detail our results in a paper to be soon submitted to Nucl. Instr. and Methods. We would like to acknowledge the generous help provided by Chuck Foster, Ed Stephenson and others at IUCF who made this calibration much simpler to complete. The IUCF accelerator control people (who had to reset the area each time we wanted to change our configuration) provided excellent beam. In addition, Ken Asselta of BNL did a great job in locating and shipping the equipment necessary for carrying out our task. We thank them all.

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1. "Target rapidity proton distributions for Si+A collisions at the AGS," James B. Costales, UCRL JC 108446, to appear in Nucl. Phys. A, T.C. Awes, F.E. Obenshain, F. Plasil, M.R. Strayer, and C.Y. Wong, eds., Quark Matter 91, Gatlinburg, TN 11/1991.
2. "Calibration of the E859 Phoswich Modules," J.B. Costales, T.C. Sangster, M.N. Namboodiri, unpublished informal report to the E859 Collaboration (2/1992).
3. K.M. Teh *et al.*, Nucl. Instr. and Meth. A**254**, 600 (1987).
4. Sarah Makoski (an 1991 IUCF summer student from Mt. Holyoke supervised by Ed Stephenson and Chuck Foster) measured the deuteron pulse height defect at IUCF using the setup which we used for our calibrations. She obtained a pulse-height defect result on the order of 5–7%, a value in good agreement with our result (5–6%).
5. C.A. Pruneau *et al.*, Nucl. Instr. and Meth. A**297**, 404 (1990).