FIRST TESTS OF THE INDIANA SILICON SPHERE (ISiS)

K. Kwiatkowski, D.S. Bracken, J. Brzychczyk,* D. Cook,† J. Dorsett, T. Hamilton, K. Komisarcik, N. Madden,‡ K. McDonald, K.B. Morley, J. Ottarson,§ C. Powell,# E. Renshaw, N.R. Yoder, and V.E. Viola
Department of Chemistry and Indiana University Cyclotron Facility, Bloomington, Indiana 47408

Inaugural tests of the Indiana Silicon Sphere 4π detector (ISiS) have been conducted recently using the 200-MeV ^{4}He + ^{27}Al reaction to investigate the detection characteristics of the device.

The ISiS detector is based on a spherical geometry and is designed primarily for the study of light-ion-induced reactions. It consists of 162 detector telescopes – 90 in the forward hemisphere and 72 in the backward hemisphere – covering the angular ranges from 14° to 86.5° and from 93.5° to 166°. The design consists of four rings, each composed of 18 tapered trapezoidal telescope housings, in both the forward and backward hemispheres. To increase granularity for the most forward angles, the ring nearest 0° is segmented into two components. A design drawing of the detector configuration in the forward hemisphere is shown in Fig. 1. Each telescope is composed of (1) a gas-ionization chamber (GIC) operated at 30-40 torr of CH_4 or 15–20 torr of C_3F_8; (2) a 500-μm ion-implanted passivated silicon detector, Si(IP), and (3) a 28-mm thick Csi(Tl) crystal with light guide and photodiode readout. Detectors are operated in a common gas volume; vacuum isolation is provided by a thin polypropylene window supported by a cage-like structure. The telescope dynamic range permits measurement of $Z \approx 1-15$ fragments with discrete charge resolution over the dynamic range $0.6 \leq E \leq 90$ MeV. The Si(PI)/CsI(Tl) telescopes also provide particle identification for energetic H, He, Li and Be isotopes. The Si(IP) detectors constitute a critical component of ISiS in that they provide both excellent energy resolution and reliable energy calibration for the GIC and CsI(Tl) elements.

The ISiS detector solid angle/energy acceptance for light-ion-induced reactions is significantly improved compared to currently operating 4π arrays based on phoswich technology. The figure of merit here is the product of solid angle coverage and the fraction of the total fragment energy spectra that is above threshold. For ISiS, the total solid angle is 80% of 4π, as determined by simulations with the GEANT code. The major acceptance advantage of the ISiS array is its very low detector threshold ($E/A \approx 0.5$ MeV, compared to $E/A \approx 2.0$–3.5 MeV for phoswich telescopes). Due to the distortions for the fragment spectra toward low energies for light-ion-induced reactions above about 500 MeV/nucleon, the relative gain in differential cross section is substantial (greater than a factor of about three) for the ^{3}He + ^{nat}Ag system which we have been studying.

For these initial tests only the forward hemisphere was loaded, consisting of 90 individual triple telescopes. Beam currents of about 0.5 nA of ^{4}He provided an event rate with minimum dead-time problems. In Fig. 2 we show spectra corresponding to one slice of detectors covering 14° to 86.5°, as shown in Fig. 1. Isotope resolution is obtained for energetic H, He, Li and Be fragments in the silicon/CsI telescope, while good Z resolution

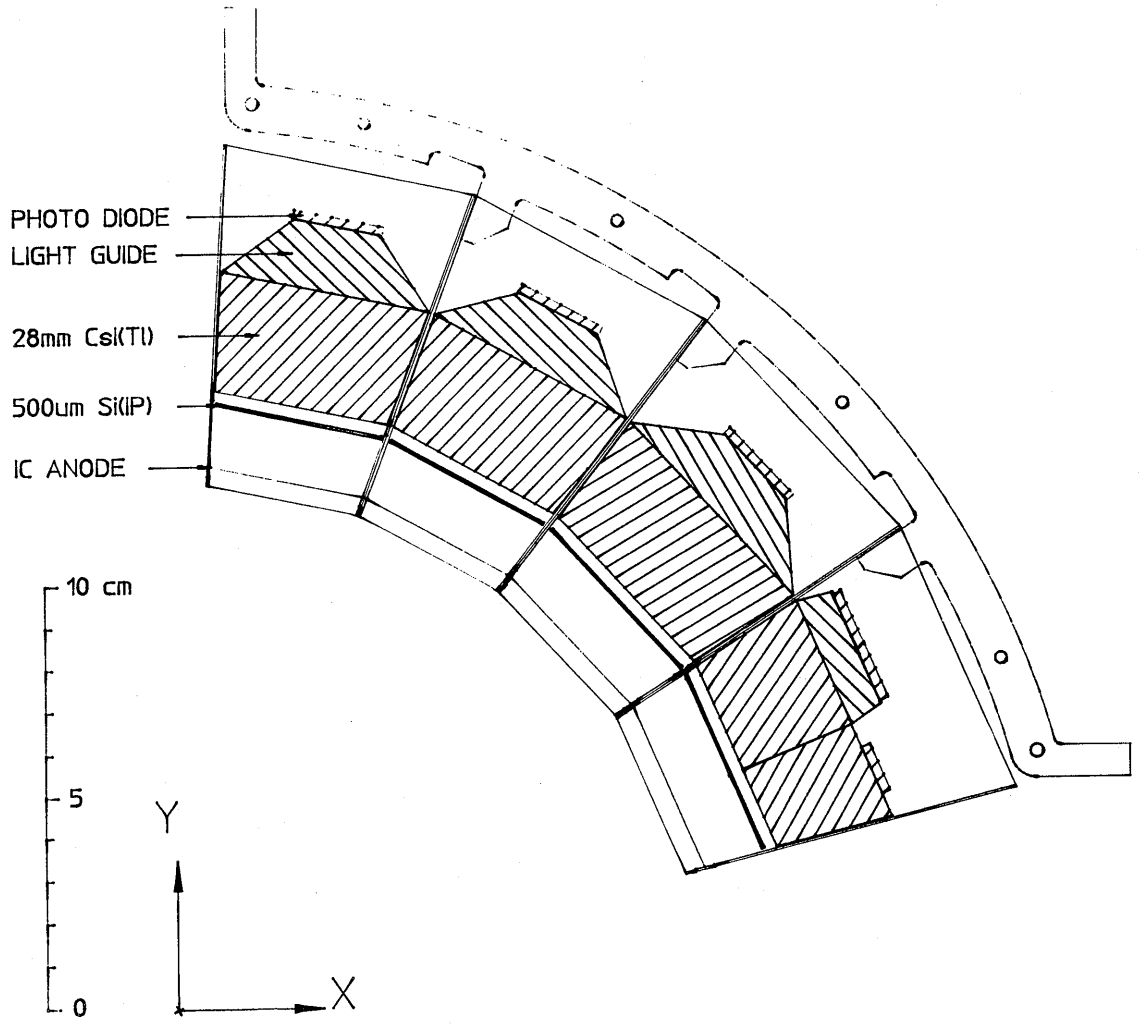

Figure 1. Telescope configuration for forward hemisphere array. Each unit is part of an 18-member ring; the forward-most element is segmented into two halves.

is obtained in Z=1−12 fragments in the ion-chamber/silicon portion of the telescopes.

*Institute of Physics, Jagellonian University, Krakow, Poland.
†REU student, Humboldt State University, Yreka, California.
‡Consultant, Livermore, California.
§Consultant, NSCL, Michigan State University, East Lansing, Michigan 48824.
#Present address: Department of Chemistry, Michigan State University, East Lansing, Michigan 48824.

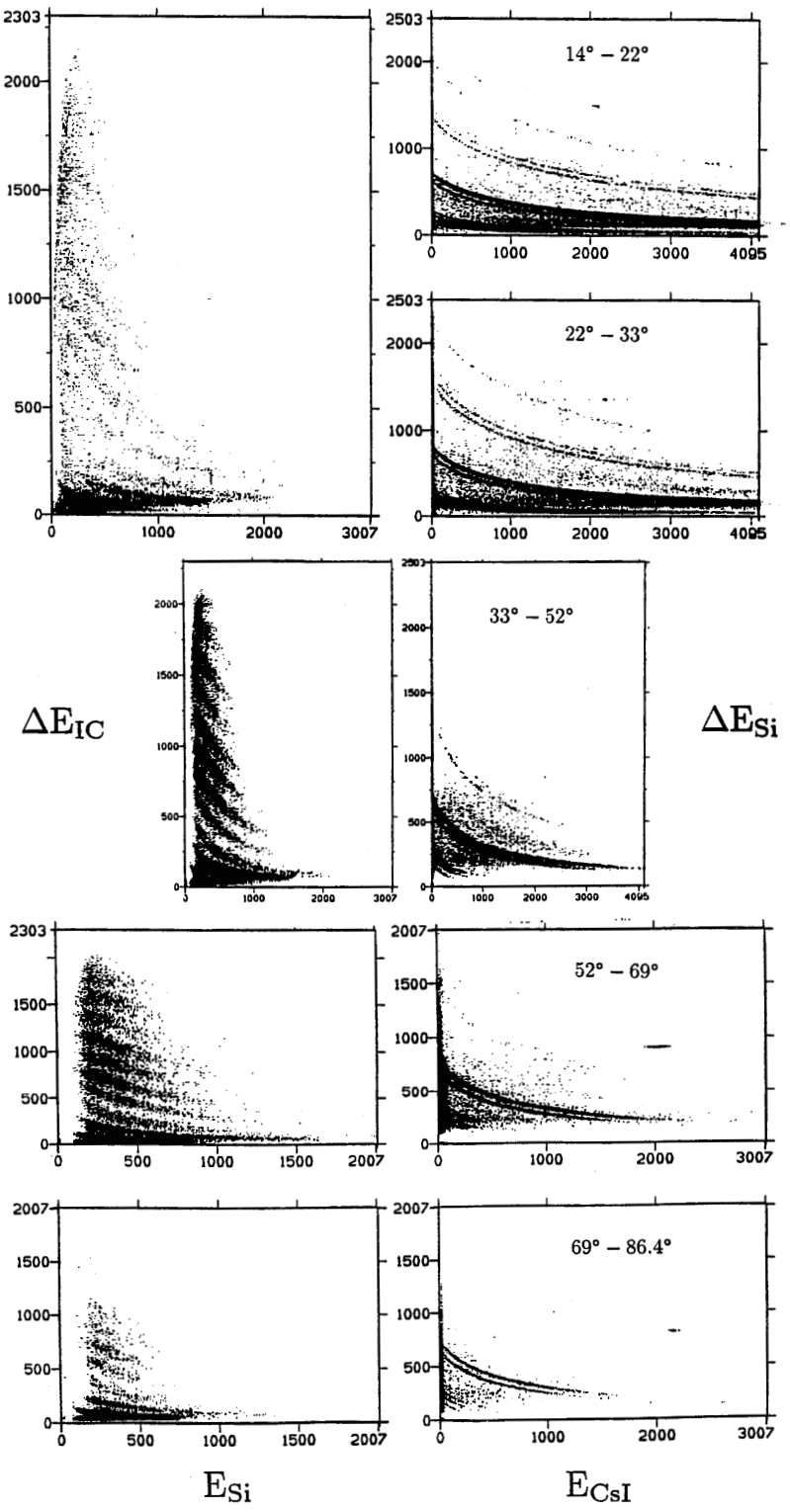

Figure 2. Spectra from one slice of ISiS array, corresponding to the schematic drawing in Fig. 1. Left column: ion-chamber/silicon response; Right column: silicon/CsI response. Angles are indicated on figure.