DETECTOR DEVELOPMENT AND CALIBRATION

ISiS: THE INDIANA SILICON SPHERE

K. Kwiatkowski, D.S. Bracken, J. Brzychczyk, K. Komisarcik, N. Madden,*
K.B. Morley, J. Ottarson,† C. Powell, E. Renshaw, and V.E. Viola
Indiana University Cyclotron Facility, Bloomington, Indiana 47408

In order to investigate fragmentation processes in intermediate energy collisions, a versatile 4π nuclear particle detector array is required. Such an array must possess the following characteristics: (1) nuclide (Z and/or A identification) of products; (2) spatial characterization of the ejectiles, with good granularity; (3) well-defined energy spectra; (4) low thresholds, and (5) easy, reliable energy calibrations. These have been the design goals for the Indiana Silicon Sphere (ISiS) which is currently being constructed at IUCF.

The ISiS detector (Fig. 1) 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 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. 2. Each telescope is composed of a gas-ionization chamber (GIC) operated at 40 torr of CF_4 or 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. Prototype telescopes and electronics modules have been successfully tested with proton and ^{4}He beams at IUCF and with heavy ions at the Argonne National Laboratory ATLAS Facility during the past year. The telescope dynamic range permits measurement of $Z \approx 1-15$ fragments with discrete charge resolution over the dynamic range $0.5 \leq E/A \leq 90$ MeV. The Si(IP)/CsI(Tl) telescopes also provide particle identification for energetic H, He, Li and Be isotopes. Recently, tests with actual ISiS telescopes and preamp/shaper units have demonstrated these characteristics. 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.

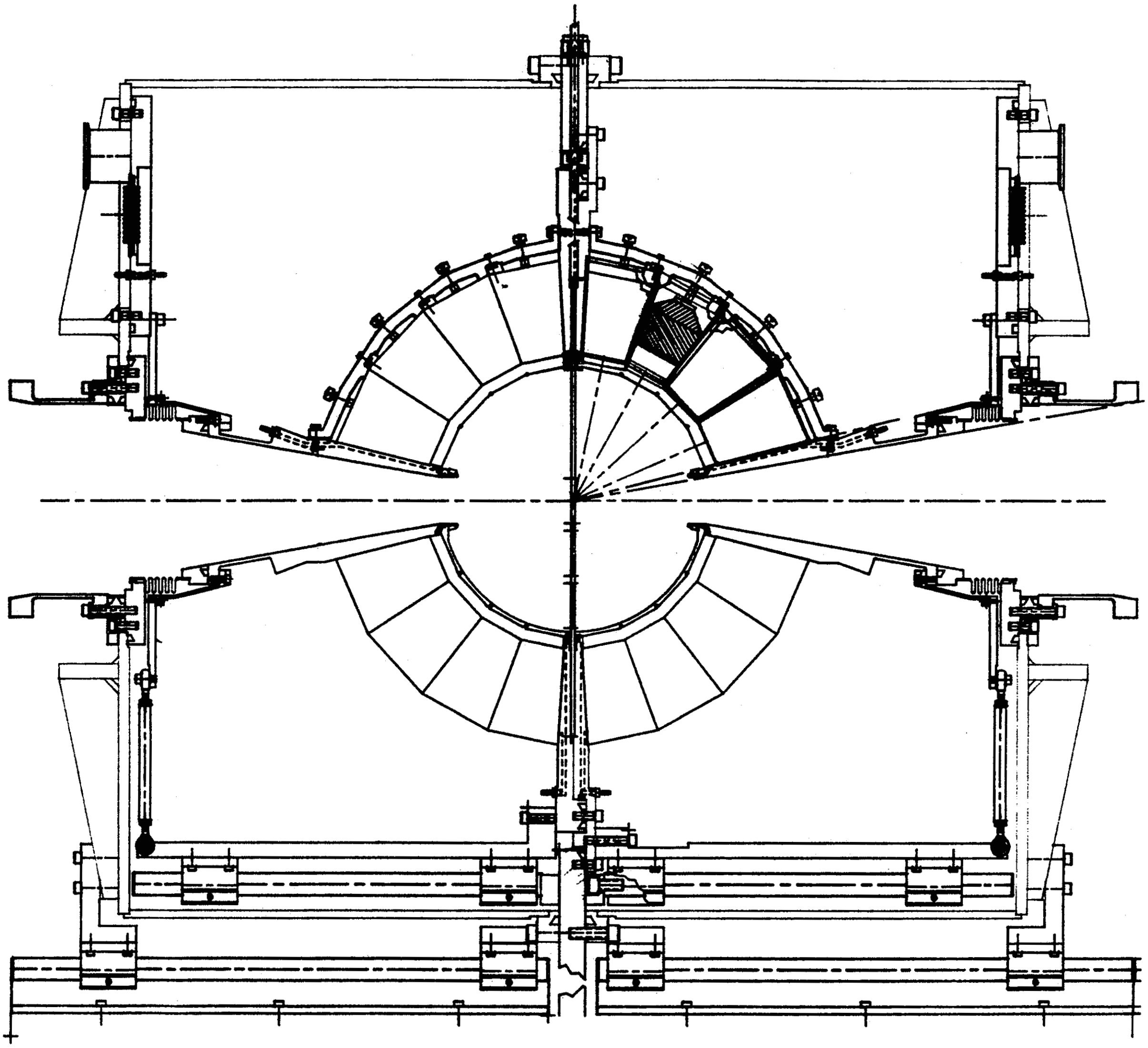

Figure 1. Engineering drawing of ISiS.

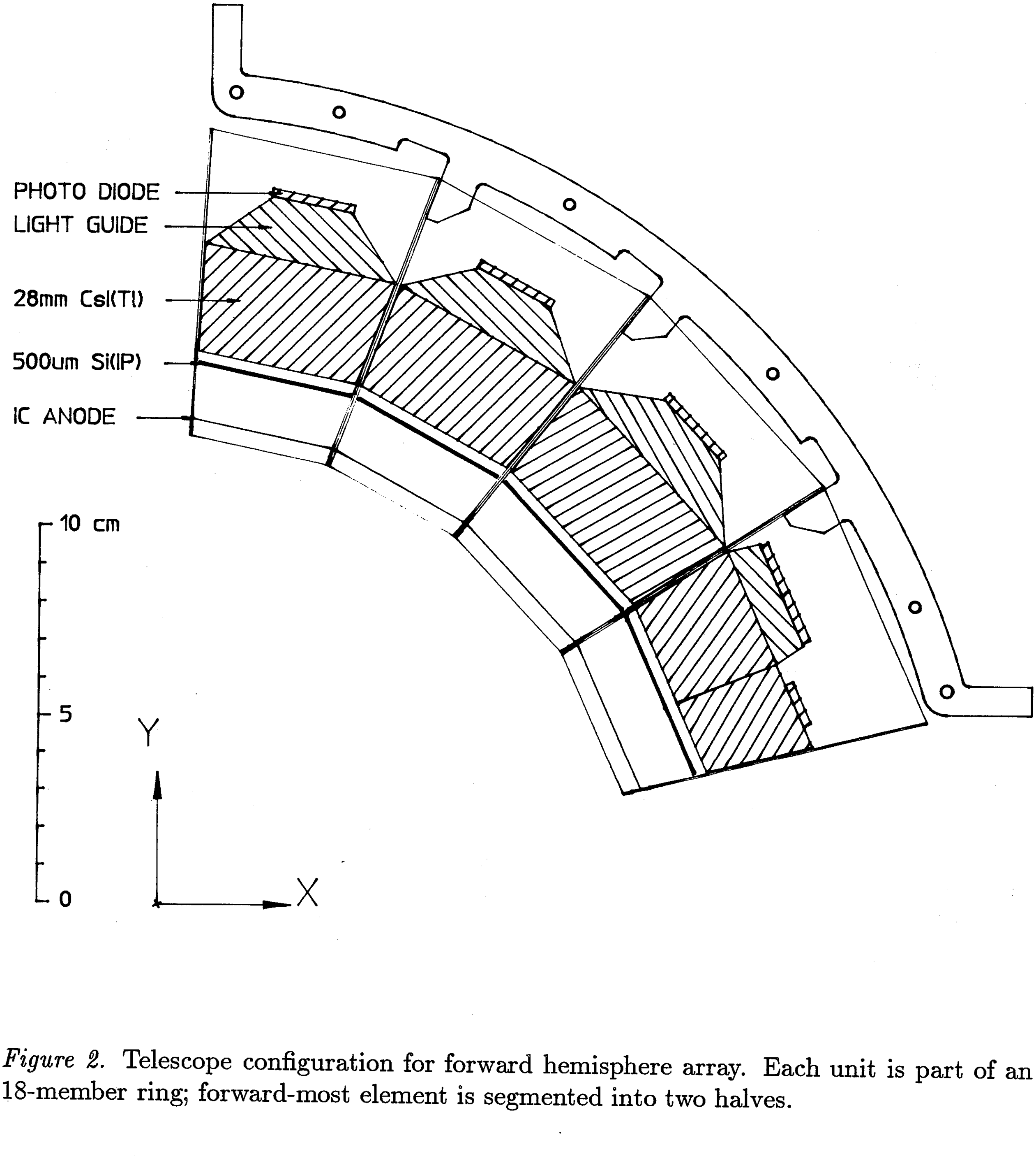

Figure 2. Telescope configuration for forward hemisphere array. Each unit is part of an 18-member ring; forward-most element is segmented into two halves.

The ISiS detector solid angle/energy acceptance 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 thresholds ($E/A \approx 0.5$ MeV compared to $E/A \approx 2.0$-3.5 MeV for phoswich telescopes). Due to the distortions of 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 ($\sim$ a factor of three) for the ^{3}He + ^{nat}Ag system which we have been studying.

The present status of the detector is summarized briefly as follows:

(1) Mechanical components – These are complete and assembled.

(2) Detector components – Ion chamber housings are complete with anode wire installation in progress; 95% of the silicon detectors have been delivered, with all devices mounted in frames and electrical leads attached; all CsI crystals have been machined, polished and attached to light guides; 25% of the photodiodes have been delivered.

(3) Electronics – preamplifier/shaper design is complete and production of all modules will begin shortly. Constant fraction discriminators of the APEX design are beginning to arrive; peak-sensing ADCs are on order, and TDCs have been delivered.

(4) Computer – As a starting configuration, we will use CAMAC/VME for data acquisition, using XSYS and/or PAW software.

---

* Consultant, Livermore, California

† Consultant: NSCL, Michigan State University, East Lansing, Michigan 48824

IDENTIFICATION AND ENERGY MEASUREMENTS OF LIGHT PARTICLES WITH A CsI(Tl)–PHOTODIODE COMBINATION

R. Bent, H. Nann, M. Saber, and C. Sun
Indiana University Cyclotron Facility, Bloomington, Indiana 47408

F.-J. Chen
Northwestern University, Evanston, Illinois 60208

G. Hardie
Western Michigan University, Kalamazoo, Michigan 49008

Recently with the availability of large-area silicon photodiodes, the use of CsI(Tl) scintillator detectors has enjoyed a renaissance. CsI(Tl) scintillator material has several advantages over NaI(Tl). It is less hydroscopic, has a shorter radiation length and the photon yield per energy loss is higher.[1] Moreover, the relatively long wavelength emission of