EXPERIMENTAL FACILITIES DEVELOPMENT

Facilities in Operation

Isotope Production Area, Radiochemical and Decay Spectroscopy Laboratory

The isotope production area is presently used for a variety of high-intensity experiments such as production of sources for Mossbauer studies using 60-100 MeV protons, studies of (^{3}He,π^-) production at energies of 150-225 MeV, and ^{7}Li-induced reactions on ^{93}Nb. The target stations located along the beam line in this area include: (a) an in-air, solid-target, charged-particle irradiation facility, (b) an automatic beam degrader followed by a general-purpose station used for (c) radio iodine production, or (d) a quick-change, in-vacuum, solid-target irradiation station. The in-air irradiated targets can be transported from the isotope production room to the chemistry trailer in about 5 sec using a pneumatic rapid-transport system.

The radiochemistry trailer has been used extensively in the past year for a number of radiochemical experiments and studies. The facilities have also been used for radioactive source preparation and recoil track etching. The decay spectroscopy trailer is equipped for α-, β- or γ-ray counting using various Ge(Li) detectors, a KEVEX x-ray detector, and surface barrier detectors. Data acquisition is with either the Canberra 8180 or Nuclear Data 50/50 4096 channel analyzers. A new acquisition for the off-line facility is a vacuum detector station fitted with its own diffusion pump and Freon refrigerator.

Beam Swinger Facility

Installation of the beam swinger facility for neutron time-of-flight experiments was completed in mid-February 1979, and the first experiments were performed on schedule in late February. These experiments used a small hut housing the neutron detector and electronics located at about 70 meters from the target on the 0°-26° neutron flight line. A second hut and the 24°-50° neutron flight line were completed and used for experiments in late October. This hut is large enough to accommodate 1 meter by 1 meter neutron detectors and associated electronics. An additional large hut and the 48°-74° flight line are planned for completion by summer of 1980.

160 cm Scattering Chamber

A commercial oil-free vacuum roughing system (a Varian 2-stage "Megasorb" sorption unit) was installed in late spring of 1979. This system, which incorporates automatic valving and bakeout controls, allows relatively rapid and convenient vacuum cycling of the 2m^3 chamber volume repeatedly (up to 6 times) between bakeout of the molecular sieve.

A coaxial in-line cryotrap cooled by a 1W He refrigerator was recently installed in the entrance beam line to provide some degree of isolation between the supposedly clean (oil-free) chamber and the diffusion-pumped beam line. Evaluation of the effectiveness of this cryotrap must await a thorough cleaning of the chamber/beam dump system which has itself become contaminated through periodic use at times when the oil-free roughing and/or high-vacuum cryopumping system was out-of-order.

The microprocessor-based electronic remote-control module for the new stepping-motor drives and absolute shaft-angle encoder readouts of all chamber motions (detector arms, target position, target angle) was assembled and tested off-line in 1979. The mechanical interfacing of the new motors and encoders was designed and fabrication is underway. Installation of the new chamber control system, however, is expected to be possible only after completion of the pion spectrograph mechanical installation, sometime during the summer of 1980.

Target Laboratory

During 1979 the target lab supplied an estimated 90% of the targets used at IUCF. A new dry-settling and pressing technique was developed for very thin binder-supported targets and 2-25 mg/cm^2 thick unsupported targets. The method is material conservative and has been used to produce targets of ^{Nat}S, ^{Nat}C, $^{12\&13}C$, $^{151\&153}Eu_2O_3$, $^{148\&154}Sm_2O_3$, $^{183\&186}WO_3$, $CaHPO_4$, and Melamine. Other targets fabricated during the past year were: CD_2, $^{6\&7}Li$, ^{7}LiD, $^{7}LiCl$, ^{11}B, AlN, Al_2O_3 $^{24\&25}Mg$, ^{28}Si, ^{40}Ca, ^{54} $^{56\&57}Fe$, ^{58}Ni, ^{59}Co, ^{92}Mo, ^{107}Ag, ^{112}Sn, La, ^{141}Pr, ^{159}Tb, ^{165}Ho, ^{185}Re, ^{169}Tm, ^{171}Yb, ^{195} ^{196}Pt, $^{207\&208}Pb$, ^{209}Bi.

The most notable improvement to the lab was the modification and hook-up of a 10 kV, 500 mA DC/6V, 33A AC power supply for high-vacuum evaporations using electron beam guns.

Delivery on a two work station, double-length glovebox with a closed-loop argon purification system is expected in early March of 1980.

Hyper-Pure Germanium Detector Telescope System

Development of the hyper-pure germanium detectors has continued with the objective of measuring their properties and improving their reliability and resolution in our environment. The mechanical modifications to the cryostats described in last year's annual report, including the ability to mount silicon surface-barrier ΔE detectors internally, were tested and used in several experiments. Further improvements were made to the individual detector holders by the replacement of the usual indium electrical contacts with copper foils, held in place by a gold plated, spring loaded compression assembly. This new detector holder, designed by the detector group headed by Dr. R. Pehl at the Lawrence Berkeley Laboratory at our request, has allowed us to anneal the detectors at temperatures greater than 120^{o}C without fear of softening or melting the electrical contacts. In addition, a dedicated portable vacuum system, consisting of a sorption pump for roughing and a 6" cryopump and ion pump for high vacuum, was constructed and used to provide a cryostat vacuum in the low microtorr range during experiments. In all, 8 intrinsic germanium detectors ranging in thickness from 1 to 15 mm (each of 450 mm^2 area) were used in 10 experiments during the last year. The results of some of these experiments are discussed in the scientific section of this report.

Detector reliability and lifetime were considerably improved by storing and handling them in an argon gas atmosphere. As reported last year, the most common failure mode for the detectors is the development of high leakage currents (> 5 nA) as bias is applied, resulting in poor detector resolution. When this happens, the normal procedure has been to warm the detector to 100^{o}C for about an hour, after which the leakage current returns to normal (< 0.2 nA). If this procedure fails, the detector is returned to Dr. Pehl for repair. Tests were conducted in this laboratory to determine the effect of storing the detectors in various gases. A detector was initially heated until its V-I characteristics were acceptable, as shown in curve 1 of Fig. 2. The detector was then warmed to room temperature, the cryostat backfilled

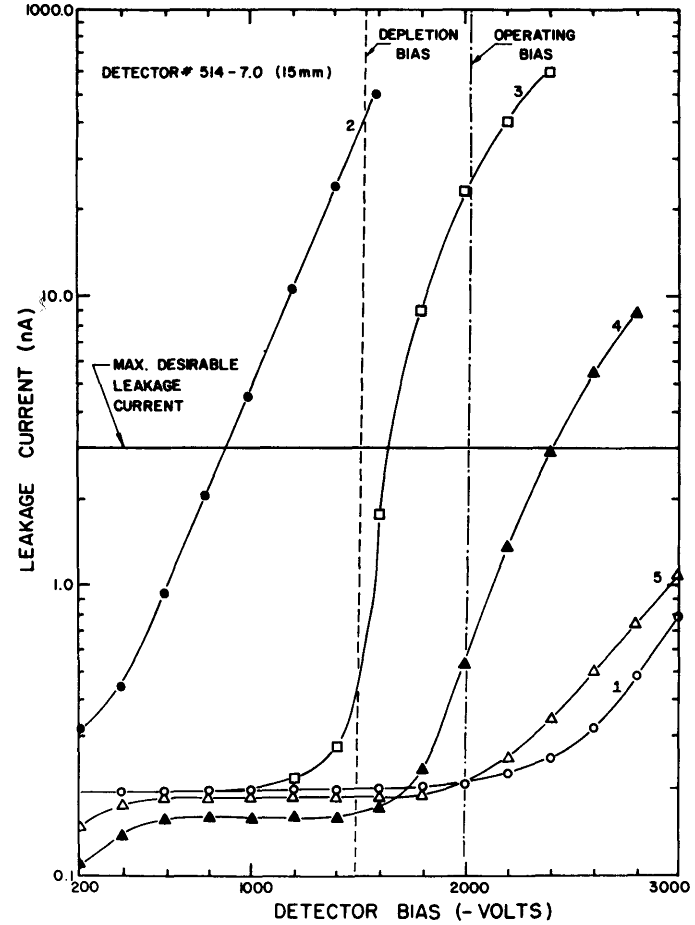

Figure 2. Germanium detector leakage current as function of bias voltage (V-I characteristic) after baking at 100°C for clean-up (curve 1), and after backfilling of cryostat with room air (curve 2), nitrogen (curve 3), helium (curve 4) and argon (curve 5).

with the test gas, and then repumped (without heating) and cooled to LN temperatures. The resulting V-I curves after backfilling the cryostats with room air or nitrogen, helium and argon gases (all research grade purity) are given as curves 2, 3, 4 and 5, respectively, in Fig. 2. In each case, the V-I curve prior to backfilling with the test gas was made to look similar to curve 1 by reheating the detectors. The results, duplicated for two different detectors, show that the only environment which left the V-I characteristic unchanged was the argon gas. Since we have been handling these detectors in argon gas, they have gone through the year (and 10 experiments) with no detector failures other than those caused by cryostat vacuum failures.

The detectors on hand at IUCF are all transmission mounted, although not all detectors are truly transmission-type detectors with ion-implanted contact surfaces. Several detectors with the usual lithium contact are on hand and used as stopping detectors. There was some concern over the rate of lithium drift and the resultant increase in depth of the lithium layer in these detectors, particularly in view of the habit of storing them at room temperature and annealing them at temperatures of 140°C for recovery from radiation damage or for surface clean-up. One such 10 mm detector had been used for three years and had been annealed many times. More recently, two 15 mm deep lithium-backed detectors were delivered to IUCF. The depth of the lithium contact surface of these three detectors was measured by an X-ray attenuation technique using a ^{153}Gd source, initially when the new detectors arrived and again after the new detector had accumulated 250 hours of annealing time at about 120°C. The three-year old detector had a lithium surface depth of 1.1 mm. The new detectors arrived with a lithium surface depth of about 0.6 mm, which increased to about 1.0 mm after the 250 hours of annealing. Hence, it appears that the lithium contact surface drifts rapidly to a depth of about 1 mm, and then slows down considerably so that after several years of use, the depth is still about 1 mm. These results are preliminary, and the continued drifting of these contact surfaces will be monitored as a function of accumulated annealing time. The ion-implanted boron and phosphorous contact surfaces of the transmission detectors were, as expected, found to be unaffected by the annealing process.

In-beam tests were conducted using both single (15 mm) germanium detectors and two-element detector telescopes (2 mm silicon ΔE detector and a 15 mm germanium E detector) to determine the factors limiting the charged-particle energy resolution. 60 MeV protons incident on thin carbon and gold (2.3 mg/cm^2) targets were used to measure the detector calibrations and energy resolution, respectively. The observed spectrum resolution of 58 keV FWHM for elastically scattering protons from gold detected in a single germanium detector corresponds to a detector resolution of less than 10 keV. However, the best spectrum resolution for the same target and beam for the two-element telescope was about 81 keV FWHM, which corresponds to a detector telescope resolution of about 40 keV. The reason for this unexpectedly worse resolution for the telescopes is not known. With this telescope arrangement we also found that the energy calibration was different for different reaction products from the source target and in a direction opposite to that which would be caused by a dead layer in either detector. Speculation for the cause of this effect is a possible energy or penetration-depth dependent charge collection efficiency of the silicon or germanium detectors resulting from crystal impurities. This effect was observed and reported[1] for silicon detector telescopes at lower energies, and will be the subject of continuing study here. In general, the energy resolution of germanium telescopes at IUCF is about 0.1% of the beam energy.

The current inventory of intrinsic Ge detectors at IUCF now consists of one 1 mm, two 10 mm and two 15 mm deep transmission detectors, and one 10 mm and two 15 mm deep lithium-backed detectors. These detectors are available for use by any IUCF user group. However, advance notification of their intended use must be given before they will be released to the user(s).

1) Comparative Pulse-height Anomaly for Protons and Alpha-particles in Silicon Surface Barrier Detectors, K.W. Kemper and J.D. Fox, NIM 105, 333 (1972).

Future Facilities

Pion Spectrograph System

Engineering design work on the QQSP pion spectrograph[1] and its support system was completed during 1979, and significant progress was made on the fabrication of these components. The support system will be delivered to IUCF in early February 1980 and factory acceptance tests of the spectrograph magnet system are scheduled for mid-March 1980.

It was necessary to rework the original mechanical design of the entrance quadrupole magnet extensively to permit the use of an external beam dump at relatively forward angles. In the latest design the beam can be transported to an external dump for scattering angles greater than 22°. The system has been designed to permit extraction of the beam through an aperture in the yoke of the dipole with the system positioned to allow measurements between 0° and 10°. It is also possible to make measurements at scattering angles between 170° and 180°.

Substantial progress has been made in constructing the beam line branch and beam dump for the spectrograph. It is anticipated that the entire system will be ready for initial use in experiments in early summer, 1980.

1) IUCF Techn. and Scient. Report 1977, p. 23 and 1978, p. 158.

Drift and Multiwire Proportional Chamber Development

As described in the 1978 IUCF Techn. and Scient. Report, the development of vertical wire drift chambers (VWDC) began in late 1977. Design and construction of the VWDC were completed in 1978. Initial