EXPERIMENTAL APPARATUS

VACUUM SYSTEM OPERATING EXPERIENCE FOR THE BEAM LINE AND FOR EXPERIMENTAL CHAMBERS

R.A. Blue and R.M. Ronningen

The primary features of the beam line relevant to vacuum design are summarized as follows: Aluminum construction with indium seals, Cryopumps at the two magnet chambers with ion pumps at about ten foot intervals along beam pipes. Some viton o-ring seals are used where metal seals proved to be inconvenient. With the exception of an old beam scanner all devices having sliding shafts were eliminated in favor of bellows seals where linear actuators are required. many of the components were carried over from use with the K-50 cyclotron facility.

Between one and two years of operating experience has been acquired for most vacuum system elements. Basically the beam line vacuum systems have proved to be satisfactory both for normal operation and in recovery following a vacuum accident, even one as severe as a direct venting of a experimental chamber to atmosphere with the beam line isolation gate valve open. Although the installation of automatic protection circuits is not complete for all chambers the beam lines connecting to the cyclotron are protected. The response time is limited by the rather slow closure of ordinary pneumatically actuated gate valves.

For large capacity pumps we have depended on closed-cycle cryopumps. Two different models have been purchased. We are operating seven CTI model 7 pumps and four Varian model VK12-C. Both models are nominally 6-inch pumps with air pumping speeds of around 1000 l/sec. Several of the CTI units have passed 10,000 hrs of operation with 6,000 hrs being typical for the Varian pumps.

In general these pumps have proved to be quite trouble free. There was some initial concern about the inconvenience that could result from a 5-hour turn around time when regeneration is required. Some effort and expense was applied to testing methods for speeding up the pump warm-up. Very little time was gained so we have concluded that back filling the pump with dry nitrogen and continuing the flow during warm-up is sufficient. The rather expensive optional vent tube sold by CTI offers no real advantage. All pumps should be equipped with vent valves, however.

Under normal operation pump regeneration is required very infrequently, on a time-scale of months. However, in spite of our efforts to maintain oil-free systems, the accumulation of oil deposites on the first stage array was often the cause for deterioration of performance due to a rise in pumping array temperature.

Following oil contamination of the 80K pumping array the pumps can be restored to operating condition by the use of Freon TF to remove the oil deposite. Should the contamination be severe it is sometimes necessary to clean the charcoal absorber on the 15K array by immersing it in Freon and then vacuum baking over night. No charcoal arrays have yet been replaced.

The more difficult aspects of maintaining these pumps involve maintaining the purity of the helium gas refrigerant and the mechanical components of the cold head and compressor. Factory service on these units is expensive and slow. To deal with this problem we are developing our capability for in-house maintenance. Our experience with major failures to date for the CTI units include two cases when the cold head valve motor seized up and one cold head requiring replacement of the piston seal rings. One Varian compressor unit failed. We have also completed the required replacement (after 10,000 hours) of the charcoal absorber unit in three of the CTI compressors.

One mishap with the connecting heluim lines resulted in the loss of helium charge and subsequent air contamination of the compressor and cold head. Since the clean-up proceedure outline in the manual proved to be inadequate, apparently due to the degree of contamination, we are constructing an auxiliary adsorption unit for heluim cleaning.

The seven ion pumps operating on the beam lines have proved to be very reliable. These 60 liter per second triode ion pumps were built by Thermionics. Only one pump has required any maintenance at all. Replacement of the titanium grids and insulators was needed after sputtering had eroded away the grids in several places. This pump was located farthest from the roughing port such that it always was started under a poorer vacuum than any of the other pumps. This pump was also subjected to venting and pump down much more often than most of the pumps.

For roughing beam lines and chambers three mobile turbomolecular pump units have been shifted among various stations. These units, two Leybold and one Alcatel, have given generally satisfactory service. One Leybold pump was replaced under warranty due to bearing failure. The frequency convertor for this pump seems to be somewhat more failure prone. Two replacements have been required in less than 400 hours operating time. The Alcatel unit is no longer marketed in the U.S. and the company is not even maintaining a stock of turbo lubricating oil in this country.

The general design of the systems and the mix of pump types has met our needs. In particular the combination of ion pumps and cryopumps works very well on the beam lines. The operating pressure is generally in the low 10^{-7} Torr range for most of the beam line.

H. Van der Plicht, B. Sherrill, S. Bricker,
R. Blue, W. Benensen, L.H. Harwood, and J. Nolen

Initial tests of the K=320 spectrograph (S320) were carried out during the spring of 1983. See the 1982-83 Annual Report for a description of the spectrograph. In the first runs the spectrograph was tuned by focussing the beam spot on a scintillator in the focal plane with the spectrograph positioned at 0°. With a beam spot on target about 5 mm wide and 3 mm tall, a focal plane image about 0.7 mm wide by 10 mm tall was obtained, as shown in the photograph in figure 1, corresponding to an energy resolution $E/\Delta E \gtrsim 1000$. By moving the spectrograph left and right $\pm$ 12 mr the beam was made to scan the full horizontal angular acceptance of the spectrograph. The quadrupoles, sextupole, and octupole were tuned to obtain the same narrow focal plane image over this angular range. All magnets of the system seem to work properly, except that tests of the resolution along the full 20% energy range of the focal plane have not yet been carried out.

The S320 also doubles as a switching magnet for the neutron chamber and split-pole spectrograph. When acting as a switching magnet, the S320 is positioned at 0° and the other two beam lines are connected to its vacuum manifold. This system has been checked out and works as advertised.

Some tests of the focal plane detectors for the S320 have been carried out, but these tests are not yet complete. Preliminary momentum and particle ID spectra have been recorded and are described in a separate article on the focal plane detector in this annual report. Further tests to optimize detector parameters such as gas pressure and voltages will be done in the next running period. At that time a "beam tuning plate" will be installed to permit quick verification of the beam line width at the focal plane and also to permit independent checks of the detector resolution with a narrow slit which can be inserted via remote control.

In the mean time the S320 has been used for two heavy ion experiments. An experiment on fragmentation by Harwood and Westfall was carried out in the +22° port using a solid state detector telescope. (See separate description of this experiment). An experiment on high energy light particle emission in heavy ion reactions was carried out by F. Becchetti, et al using the standard S320 detector at higher than normal pressures to detect high energy protons.

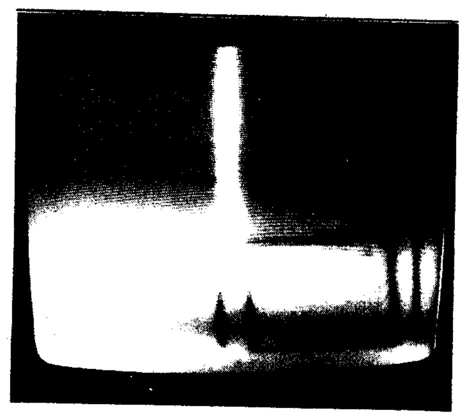


Fig. 1. Photograph of a 25 MeV/A ^{14}N beam spot at the focal plane of the S320 showing a dispersion- matched energy resolution $E/\Delta E \gtrsim 1000$, line width less than 0.7 mm.

THE DETECTION SYSTEM FOR THE S320 MAGNETIC SPECTROGRAPH

J. van der Plicht, W. Benenson, R.A. Blue, W.G. Lynch, B. Sherrill, J. Yurkon

The detection system for the S320 spectrograph consists of a stack of five detectors. A position sensitive single wire proportional counter (SWPC) is followed by an ionization chamber (IC), then another SWPC and IC [1]. They are modular units; the SWPC for instance can be replaced by a driftchamber (DC) as position sensitive detector. The detectors are 10" long (SWPC) and 6" deep (IC). All detectors operate in the same gas volume and are separated from spectrometer vacuum by a 0.001" thick Kapton window, which can hold a pressure difference of 1 atmosphere. Behind this modular detector box a 3" thick scintillator (SC) is mounted. So far the detectors were operated at a pressure of 50 torr isobutane.

The following properties can be measured with this detection system: horizontal position along the focal plane (SWPC's and DC), energy loss and time of flight (from RF cyclotron - SC). The detectors are operated in coincidence mode, typically front SWPC, one IC and SC. The raw data signals are read into a VAX 750 computer through a CAMAC ADC. The DC however is readout by the PCOS system, which connects each wire to its own amplifier and discriminator and then to CAMAC TDC's [2].

The data are analyzed by the program LOG, which writes the data to tape in buffer form (400 events/buffer). The buffers are sampled by the code DATA, which creates histograms, calculates the position spectra by means of the charge division method, and calculates the angle of incidence from front and back position signals. By observing horizontal versus vertical position, abberrations can be corrected.

The detection system has been tested extensively, both with radioactive sources and with a variety of beams from the K500 cyclotron since its operation. The position resolution of the SWPC measured with a ^{241}Am source (5.5 MeV alpha's) was better than 0.5 mm FWHM. With beams of ^{12}C and ^{14}N in the range of 15-30 MeV/A, the position resolution for the elastically scattered particles was found to be 1 mm FWHM. Improvement is this resolution is being worked on. A preliminary test for the DC yielded a position resolution of 0.4 mm [2]. The energy resolution for these heavy ions is measured to be 5% for the SC, and 4% for the IC. Excited states were observed for the transfer reactions ^{209}Bi(^{14}N,^{13}C)^{210}Po and ^{209}Bi(^{14}N,^{15}O)^{208}Pb. Fig. 1 shows for these ^{14}N induced reactions on ^{209}Bi at 15 MeV/A a two

MSU-83-498

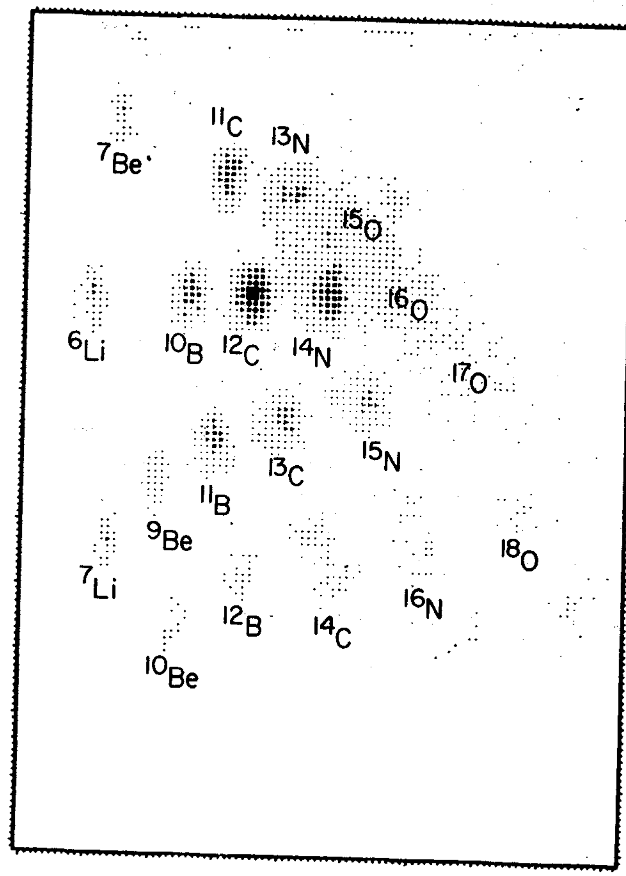


Figure 1

dimensional plot of energy loss versus time of flight, showing different isotopes ranging from Li to O. The time of flight was corrected for path length differences using the position information. The time resolution is at present limited by the RF signal from the cyclotron (around 6 ns) and can be improved considerably by means of a startdetector. Such a startdetector, a low pressure MWPC, is being constructed a present.

---

1. J. Yurkon et all., MSU Ann. Rep. 1981/82 p. 72
2. G. Westfall et all., this Ann. Rep.

S320 DRIFT CHAMBER

G.D. Westfall, L.H. Harwood, and J. Yurkon

We are in the process of making operational a drift chamber for the focal plane of the S320 spectrometer. This device can provide position resolution down to about 0.3 mm and energy loss information over a wide range of particles and energies. The wire spacing is 1 cm with two planes using offset wires to eliminate the problem of knowing which side of the sense wire the particle passed. Chambers of this design can be made very large (several up to 2 X 2 m are in use at other laboratories). This chamber and associated electronics could be a forerunner of larger chambers for use on the S800 spectrometer, on the RPMS, and in the Multi-particle Detector Array now under construction.

The drift chamber was tested for the first time with beam in the focal plane of the S320 Spectrometer using 35 MeV/nucleon ^{14}N elasticaly scattered off gold at 4 degrees. Several different voltage and pressure combinations were tried varying from 1200 to 1500 volts and 75 to 300 torr of pressure. Preliminary results showed a position resolution of about 300 micrometers although the response was non-linear. The linearity can be improved by using ethane gas and increasing the voltage.

Further tests are planned to test more suitable gasses and to determine the optimum operating voltages.

THE ACTIVATION STATION

D.J. Morrissey, R.A. Blue

An Activation Station has been created at the zero degree port of the first bending magnet of the beam transport system. The Activation Station is placed at the closest point to the cyclotron after focusing elements. This facility then uses the first few elements of the beam transport system to deliver a well focused beam of maximum intensity for target irradiations. The Activation Station is simple in that it consists of a target ladder and a Faraday cup, but allows the experimenter to view the beam focus and position on a scintillator at the target position.

Two different outside user groups have used the Activation Station during the last year. On two occasions stacks of target and recoil collector foils were irradiated for several hours with 35 MeV/A 12-C beams at intensities that ranged up to 100 nA. The targets were removed and counted off-line for induced activities. A second group used the facility on four different occasions to bombard a Be target with 14-N in order to create 13-N (half-life = 10 min.). This isotope was used as a tracer in a set of biochemical experiments. The bombardments ranged from 15 to 30 MeV/A at intensities of up to 150 nA. The reaction products were stopped in a water Faraday cup. After the buildup of activity over about 20 minutes the water was purged through a tube and collected on the outside of the shielding wall. Some of the results from this work are presented elsewhere in this annual report.

USER STATION

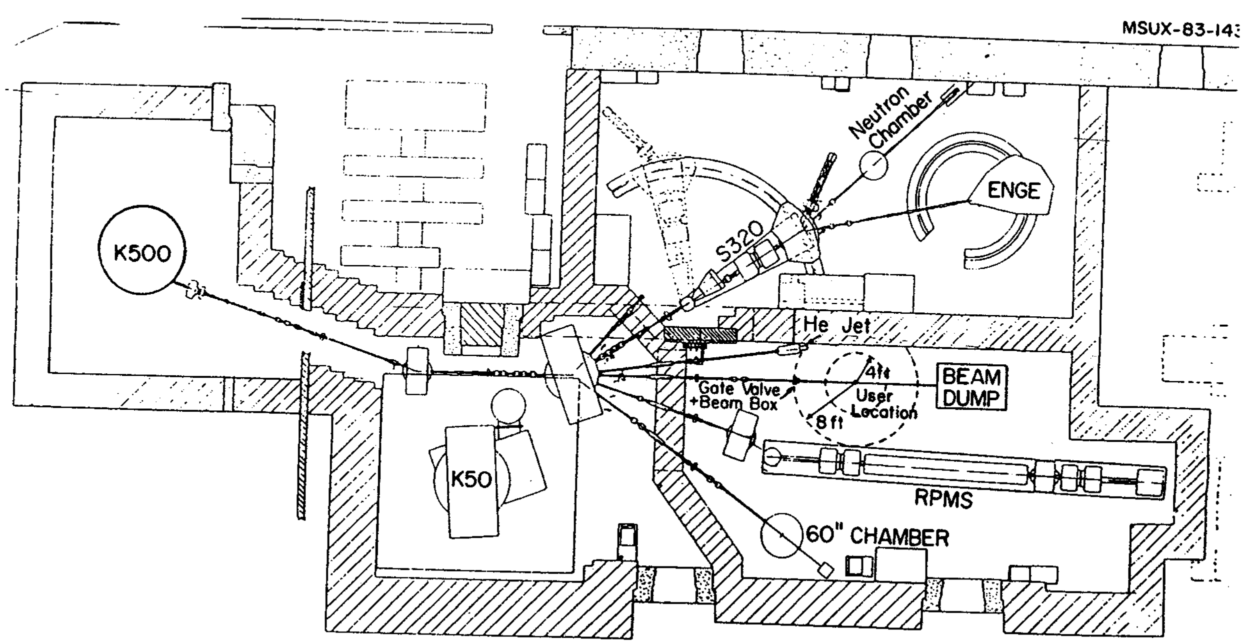
R.M. Ronningen

Although no experiments accepted by PACI chose initially to use the γ-ray line, it was used by three groups. A University of Michigan group used a $^{12}C^{4+}$ beam having 30 MeV/A to irradiate tissue. The beam was required to be rather parallel so that a broad, uniform distribution on target could be attained. Morrissey et al. (see Sec. A, "^{7}Li, a Nuclear Thermometer") used a ^{14}N beam having 35 MeV/A in a particle - γ experiment feasibility study which in fact commissioned the α-line. The beam spot was less than 5 mm in diameter on target. The Stony Brook - Oak Ridge - GSI collaboration used the same beam to study subthreshold pion production (Exp. 82011). The beam spot was larger (~10 mm dia.). The reason for this is not understood except that larger source slits were used in this latter run. In both of the ^{14}N experiments the beam was stopped about 10 ft. from the target in a graphite block within the beamline. A 55 gal. barrel of water surrounded this stop. Lead blocks provided local shielding against γ-rays from the beam dump.

Future plans for this line include turning it into a user's station, moving the target position upstream to a new position (see Fig.1). This allows an 8 ft. diameter space on the RPMS side for user set-ups. The goniometer is being adapted to support a new particle-γ coincidence chamber, currently under design and construction. The chamber will

(1) be 20 in. diameter,
(2) have a hemispherical dome of thin aluminum,
(3) have two moveable tables for particle counters,
(4) have ports at the target height every 30°.

Fig. 1. User station on the gamma-ray beam line (~0.7° bend). The site is marked "User Location".



THE NEUTRON CHAMBER AND BEAM LINE

B. Remington, G. Casky, A. Galonsky, J. Kasagi
A. Kiss and Z. Seres

In the time-of-flight method of determining neutron energy spectra, energy resolution improves with increasing neutron flight path. This necessitates locating neutron detectors outside of the target chamber, which in turn puts constraints on the chamber itself. It should be thin-walled to minimize neutron attenuation and scattering, and it should be large enough to accommodate charged particle detectors so that coincidence experiments are possible. The Rochester chamber, which served as the original scattering chamber for the K50 cyclotron, has a 1/8" steel wall and a 36" diameter, making it ideal for neutron experiments.

To bring the beam into the neutron line, the S320 Spectrograph is parked at 0°, the target in the Minnesota Chamber is withdrawn, and the S320 magnets are used to focus and steer the beam through +10°. A final degree of beam focusing is supplied by a quadrupole magnet mounted on the exit from the S320 such that it rotates with the spectrograph when the neutron line is not connected. Following the quad is a lexan insulator flange, a pump-out "T", and a bellows.

With the initial design of the experiment calling for gas detectors inside the chamber, a special target chamber extension was designed here and built in the machine shop of the University of Notre Dame. This enables the target to be mounted at the entrance of the chamber, allowing room for three gas detectors to occupy the inside of the chamber proper. A cryopump is mounted on the port at the bottom, and electronics feedthroughs and windows are accommodated by the four side ports. In order to create a flat surface on which to set detectors inside the chamber but still allow efficient pump-down a perforated aluminum plate is mounted. It has 3" of vertical adjustment. The chamber is electrically isolated from its support frame by four G10 pods and from the cryopump by a lexan insulator flange. A last minute switch from using gas detectors to the more conventional Si telescopes obviated the need for the Notre Dame target chamber; the flange on the top port of the chamber was redesigned to allow a target drive mechanism to be mounted there.

Two things happen to the beam as it passes through a target. First, since it is focused at the target, simple beam optics dictate that it must diverge upon passing through the focal point. Second, the beam ions undergo scattering with the target nuclei. The net effect is that the beam spot broadens as it heads downstream towards the beamdump. Special care has to be taken to deal with this situation, as this broadened beam could strike the downstream beam line walls creating neutrons which might find their way into detectors as unwanted background. Considering probable beams and targets, calculations were carried out showing the effect of single and multiple scattering. A reasonable solution was arrived at by enlarging the downstream beam line to 6" inner diameter instead of the standard 3.75". For example, considering a 35 MeV/n ^{14}N beam incident on a 8 mg/cm^2 ^{165}Ho target (as called for in the first experiment), 1% of the beam is scattered through an angle $\theta > 15$ mrad, whereas the Faraday cup subtends an angle at the target of 18 mrad (see Fig. 1).

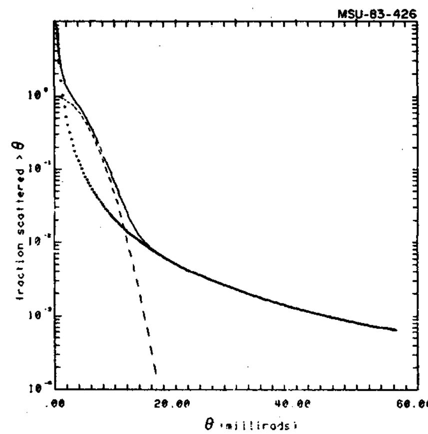


Fig. 1. This is a plot of the fraction of the beam scattered through an angle ≥θ versus θ. The dotted line is for single scattering, the dashed line for multiple scattering, and the solid line is the sum of the two, i.e., total scattering.

The 6" beam line is followed by a 6" bellows, pump-out "T", viewing "box", and plunger (for extending a scintillator into the beam). Then come the beam dump and shielding. Without extensive shielding around the beam dump the signals from the target would be completely washed out by those from the background neutrons emanating from the beam dump. At least as a 1st order approximation, the effectiveness of a given thickness of material as a neutron shield varies as

$$\text{effectiveness } \rho/A^{1/3}$$

where ρ=density and A=mass number. This indicates that steel is an effective shielding material, hence we incorporated two 21,000 lb steel slabs as the main parts of our dump, filling in from below and above with concrete blocks. In the thirties and forties, these steel slabs were part of the yoke of the famous University of Michigan 40" cyclotron. At the entrance into the beam dump, we included three layers of lead bricks as gamma ray shielding. The neutron flux should be maximal around the Faraday cup at the back of the dump. We poured and stacked parafin around it to serve as moderating material, the idea being that a moderated neutron scattering 180° back towards our detectors would be of a low enough energy as to not add significantly to the background. Provision was made for air or water cooling of the Faraday cup, but at the beam energies and intensities currently available, this was not a necessary feature. The completed neutron line is shown in Fig. 2, though at this point it is disconnected from the S320.

After the completion of the first two experiments on the neutron line, a few refinements seem in order. The main problem to be dealt with is one of alignment. The centers of diametrically opposite ports of the chamber are misaligned by up to 1/2", a problem of the original chamber construction many years ago. The result is that if the beam is centered in both the incoming and outgoing beam lines, then it basically misses a

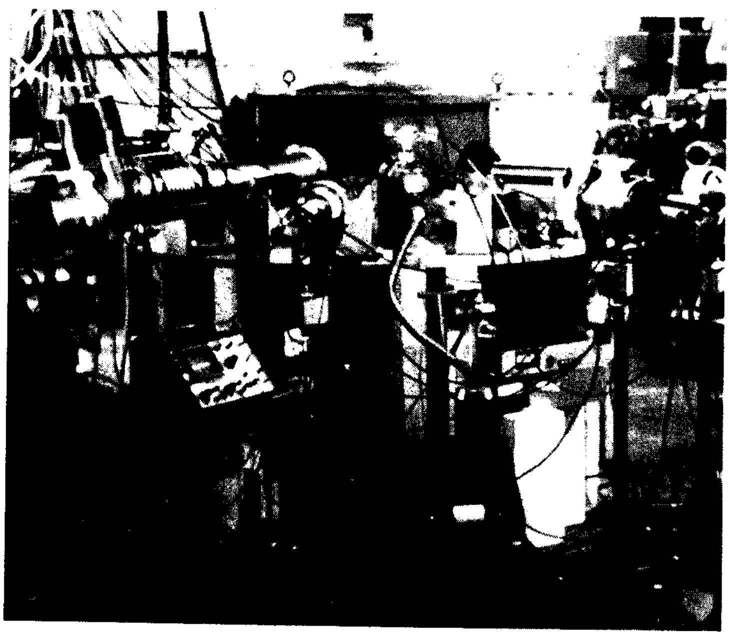


Fig. 2. This shows the neutron chamber as seen from the door opening into the north vault. Here the chamber is disconnected from the S320.

target driven from the center of the top port. The beam was steered through the center of the target and to the center of the beam dump by running it slightly off center in both the entrance and exit ports. The "center of the chamber", as defined by where the beam strikes the target, will be marked on the perforated aluminum table, along with the beam direction and angles moving out from it. The target drive mechanism will be modified to allow readout of target position and orientation. A roughing pumpout port will be added to the bottom of the chamber, and a lid-lifting mechanism will be installed above the chamber.

SIXTY-INCH SCATTERING CHAMBER

R.A. Blue and B.E. Hasselquist

The majority of the experiments completed in the first operating period of K-500 cyclotron were carried out in the sixty-inch scattering chamber. This chamber was constructed by adding an aluminum extension to the base of the forty-inch chamber that had been used with the K-50 cyclotron facility. The remote positioning drives for target, turntable, and an additional detector mounting arm, all part of the original chamber, were preserved in the chamber modification.

The enlarged chamber is constructed in three pieces. The bottom, which is attached to the base, has 15-inch side walls containing 8 ports which provide for beam entrance and exit and the experimental requirements for signal leads, gas lines, target viewing, etc. The chamber top has a convex shape beginning with a vertical rise of about four inches before curving into the center two feet above beam height. An additional ring is available to add 9 1/2 inches to the side wall. A plate for mounting out-of-plane detectors at fixed positions can be installed in the chamber. This plate in the form of a half ring can be pivoted about the beam axis to any position in the upper hemisphere.

The vacuum system for the chamber provides for rapid pump down although the preservation of fragile targets and detector windows often precludes use of the available pumping speed. The initial roughing of the chamber is handled by a roots blower/mechanical pump system, capable of reducing the pressure to the 0.1 Torr range within 10 minutes. Continued pumping is handled by a turbomolecular pump and finally a cryopump. The cryopump is rated at about 1000 l/s for air and 4000 l/s for water vapor. With the chamber in a clean condition this pump can bring the pressure into the 10^{-7} Torr range! Added gas loads from gas detectors and other devices installed for experiments make pressures in the low 10^{-6} Torr range more typical during actual runs.

The beam transport to the chamber provided a satisfactory beam spot for most experiments but some difficulty was experienced with a "halo" which was dependent on beam tuning. The origin of this problem is not yet understood but can be avoided if the experiment provides for monitoring the halo so that the beam tuning can be used to minimize the effect. After exiting from the chamber the beam is stopped about 10 feet away in a well-shielded faraday cup.

FIRST OPERATION OF THE RPMS

S. Bricker, M.C. Curtin, L.H. Harwood,
J.A. Nolen and W.E. Ormand

Beam was put into RPMS for the first time in early summer. This run was quite exciting as it was our first test of the many subsystems. The systems which worked as expected were: the inflector magnet, the target chamber, the Wien filter (with both high voltage and magnet), and the angle-changing carriage. The optics were quite impressive; we were able to get line widths of much less than 1mm when focussing the primary beam onto the focal plane. Because the moveable vacuum box for the Cornell dipole was not completed, we were limited to a straight-through path in the final magnet and thus could not investigate the mass dispersion characteristics of the system. The calculated optics were quite accurate at predicting the settings for the first quadrupole doublet; they were in disagreement with the settings for the last doublet that gave the smallest line at the focal plane. This disparity is presently under investigation.

The RMPS presently has several areas of effort. First is the construction and installation of the moveable vacuum box for the Cornell dipole; bids have been received for this item and it should be ordered soon. During the past year the 400 kVDC supply we obtained on surplus from U. Md. had a catastrophic failure for which we did not have sufficient documentation to repair. We therefore replaced the unit with a 250 kV unit from the Glassman High Voltage Corp. This unit was delivered and has had open-air tests. Like the 400 kV Spellman HV Corp. supply installed last year, this unit will be mounted "directly" to the HV feedthrough. Others items include making remote as many of the controls as possible, motorizing the carriage drive, adding more ports and stands to the target chamber, and reorganizing the vacuum system. With the cyclotron shutdown underway, it will be possible to have continuous access to the vault; this was a major hindrance to progress during the spring and early summer. The improvements should be completed by the end of the shutdown, and the RPMS will be ready for the first nuclear physics experiment in the next running perio.

STATUS REPORT OF MEHRACS

J.X. Saladin*, C. Baktash**, I.Y. Lee**, R.A. Blue, R.M. Ronningen, and R.A. Sorensen+

In last year's Annual Report we described the design studies of a Multi-Element High-Resolution Anti-Compton Shielded detector array (MEHRACS). During this past year the anti-Compton shield design was modified after consultations with vendors to incorporate the most efficient usage of the largest BGO boules currently commercially available. This design is shown in Fig. 1 and 2 and consists of seven optically interfaced segments of BGO which form a hexagon with a center plug. Although shown with seven small photomultiplier tubes we will also investigate the option of using one large P.M.T. The new design results in somewhat smaller shields, being 6 in. long and 6.21 in. point-to-point on the hexagon, compared to an 8 in. length and a 6 in. diameter in the original cylindrical design. However, the present cost is about one-half the original estimate and the design is flexible so that the length can be extended if found necessary.

Funds from NSF became available in PHY 83 and two prototype shields were ordered, along with one hyper-pure Ge detector. Using an existing HP Ge detector, testing of both shields should begin this Fall.

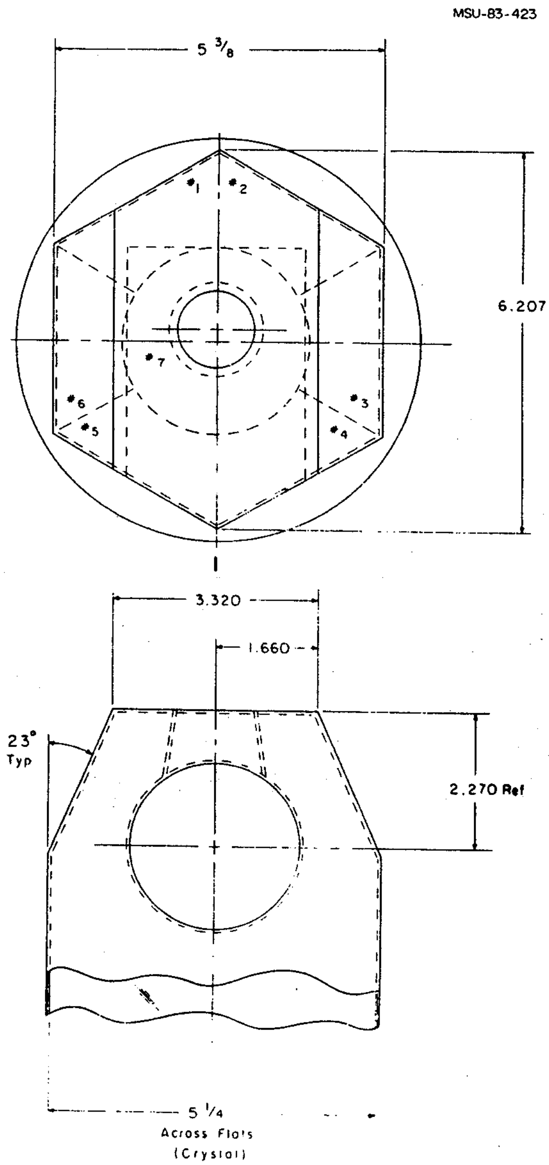


Fig. 2. Front (top panel) and bottom (bottom panel) views of an anti-Compton shield for MEHRACS. The dimensions are in inches.

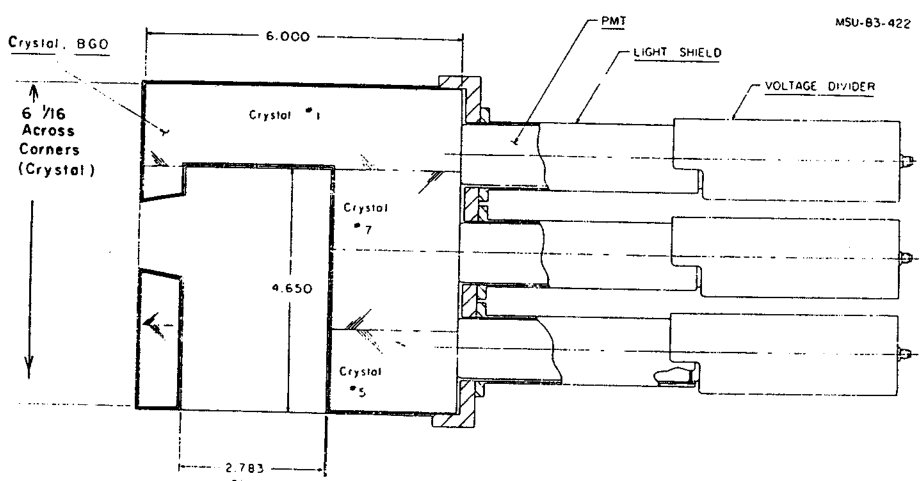


Fig. 1. Side view of an anti-Compton shield for MEHRACS. The dimensions are in inches.

* University of Pittsburgh
** Oak Ridge National Laboratory
+ Carnegie-Mellon University

S 800 PROGRESS REPORT

J.A. Nolen, A.F. Zeller, and H. Hilbert

Considerable progress on the S800 spectrograph system has been made in the past year. The dipoles have been manufactured by Japan Steel Works from forgings of low carbon ($\leq$ 0.03%) steel. Figure 1 shows one of the dipoles at the factory during drilling of the dowel holes. Machining is now complete and the dipoles are being prepared for shipment.

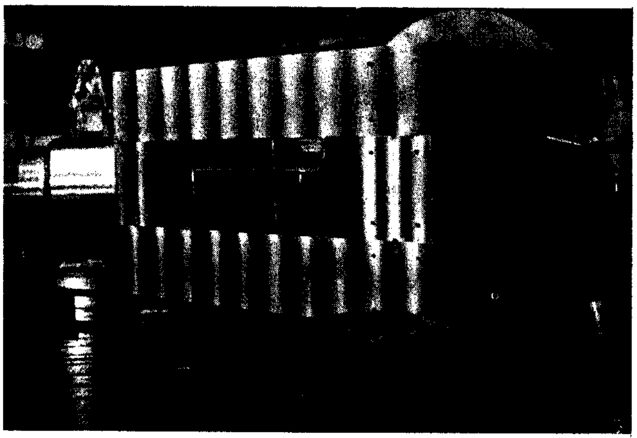


Fig. 1. S800 dipole during machining. Note that the pole tips and two stainless steel walls form a welded assembly which fixes the gap and also forms the vacuum box. The tapered gaps behind each pole tip are also visible.

The superconducting wire for the dipoles has been ordered and is presently being manufactured. Specifications and characteristics of the conductor and the coil are listed in Table 1. The coil is cryostable with approximately 50% of the perimeter in contact with liquid helium. Quench calculations show that the coil should be able to survive a quench if the magnet is dumped within a few seconds after a normal zone appears.

G10 insulating sheets, into which the wire will be laid, have been machined. They are presently in house.

The stainless steel (316) bobbin has been ordered and is being machined.

Several methods of supporting the spectrograph and carriage have been studied: 1) Air pads, which use air bags to provide safety in case of compression failure. 2) Hinges, which use a support suspended from the roof blocks, and a central pivot, and 3) Wheels and rail. The wheel-rail system has been chosen and the design is in progress.

Table I
S800 Conductor and Coil Specifications

Conductor:

Type NbTi-Cu

Copper to Superconductor ratio 15:1

Size 0.078" x 0.128"

I_{crit} @ 2T 1000 A

I_{oper} @ 1.6T central Field 467 A

Coil:

No. turns (per coil) 364

Weight (per coil) 250 kg

Inductance (per dipole) 10 h

Stored Energy (per dipole) 1.1 x 10^6 J

STATUS REPORT ON THE MULTI-PARTICLE DETECTOR ARRAY

G.D. Westfall, Z.M. Koenig, R.S. Tickle, J. Van der Plicht, J. Yurkon, G.M. Crawley, B. Hasselquist, and D. Horn

In recent years experiments have established the importance of measuring gamma rays, pions, neutrons, protons, light nuclear fragments ($A \leq 5$), medium mass nuclear fragments ($A \leq 40$), fission fragments, and projectile-like fragments resulting from the collisions of high energy nuclei. In addition it has been shown that experiments measuring one particle from each reaction suffer from integration over the unseen particles. At NSCL energies it is important to study not only light particles and projectile-like fragments, but intermediate rapidity medium mass fragments, fission fragments, and neutrons. Therefore we are constructing a device that is capable of simultaneously detecting most of the particles emerging from nuclear collisions occurring at energies available from the Phase II NSCL facility. The basic component of this device is the "logarithmic" detector. Its response is designed to increase logarithmically in stopping power with the range of penetration of the observed fragment. Thus fission fragments will be detected in thin front elements and highly energetic light particles will be observed using using thick range energy telescopes. This array of counters will have sufficient granularity to handle light particle multiplicities up to 50 with reasonable efficiency and slow, highly ionizing particles such as fission fragments with somewhat lower multiplicities of approximately 5.

This device will be composed of 30 heavy fragment detectors each comprised of a Parallel Plate Avalanche Counter (PPAC) and a Bragg Curve Counter (BCC) and 200 calcium fluoride-plastic scintillator telescopes covering 92% of the total solid angle. The heavy fragment detectors will be shaped as two concentric truncated icosahedrons having 20 (with two removed) regular hexagons and 12 regular pentagons as faces. The light particle telescopes will consist of triangular sections with six telescopes behind the hexagonal faces and five detectors backing the pentagonal faces forming 30 subarrays. Each light particle telescope will contain a 2 mm thick calcium fluoride delta-E detector backed by a 30 cm plastic scintillator E detector. Because the two scintillators have very different time constants, both can be read out with a single photo-multiplier tube. The entire system will be housed in a large vacuum vessel. One of the 30 sub-arrays is shown in Fig. 1. A schematic diagram of the assembled system is shown in Fig. 2.

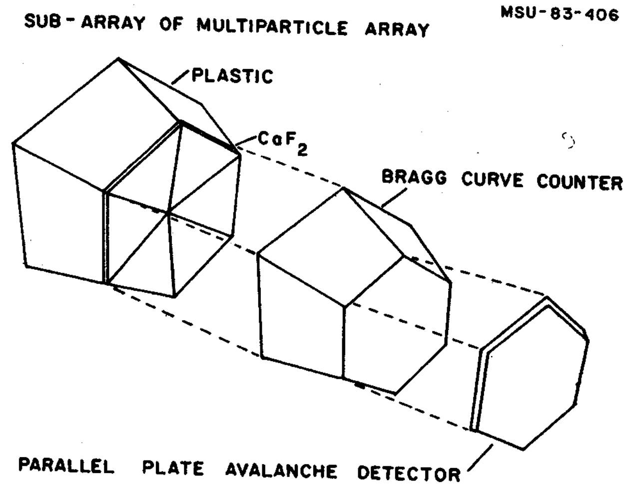


Fig. 1. Schematic representation of one of the 30 sub-arrays that will make up the Multi-Particle Detector. The sub-array consists of six CaF_2-plastic telescopes, one Bragg Curve Counter, and a Parallel Plate Avalanche Counter.

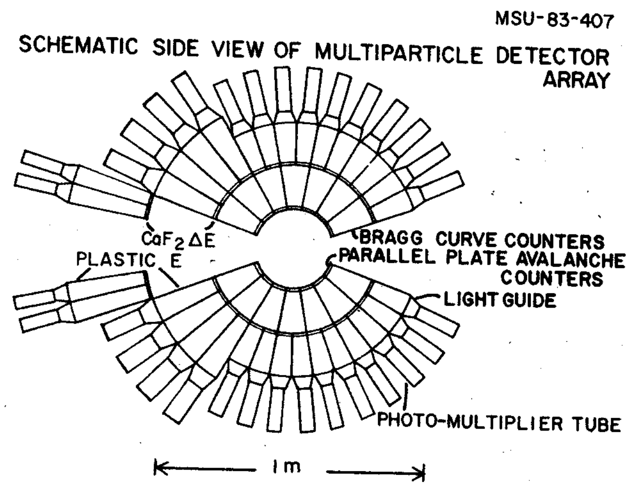


Fig. 2. Schematic side view of the assembled Multi-Particle Detector Array.

The BCC operates on the principle that stopping particles will have an increasing specific energy loss with increasing range until the equilibrium charge of the fragment begins to decrease causing the specific energy loss to reach a maximum at a value proportional to the atomic number of the fragment. The counter is designed such that the electric field is parallel to the direction of the fragment. The resulting charge is digitized using a flash encoder that integrates the charge in 30-100 nsec bins. The peak of this distribution can be related directly to the Z of the stopping fragment, the integral of the curve is the total fragment energy, and the range and plateau region provide information concerning the fragment mass number. If the fragment punches through the detector, the device functions as a simple ion chamber. The flash encoder system has been completed and a digitized pulser signal is shown in Fig. 3.

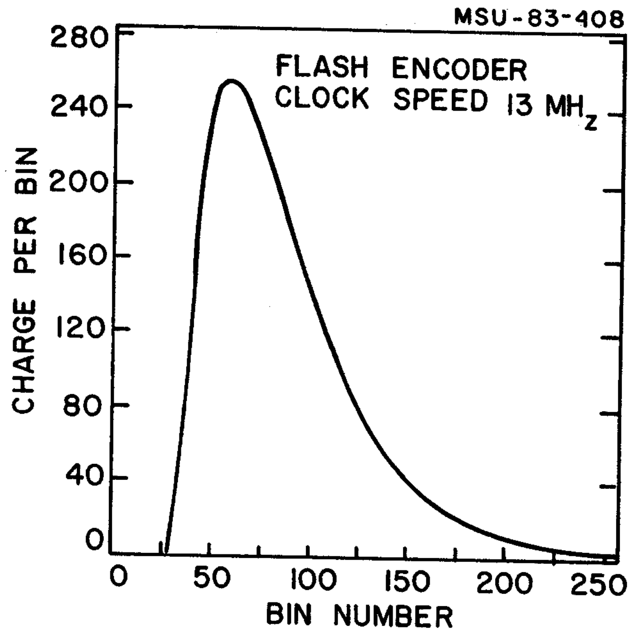


Fig. 3. Digitized output of a pulser signal using the flash encoder system designed to read out the Bragg Curve Counters. The flash encoder digitized the observed charge in 76 nsec bins with 8 bit accuracy.

One subarray as described above and shown Fig. 1 is nearly complete. This system will be tested under experimental conditions before finalizing the design of the detectors. Parameters that must be determined include window lifetimes and reliability and the dynamic range of the response of the CaF_2-plastic telescopes to medium mass fragments. The design of the mechanical supports and vacuum vessel is underway.
