ARGONNE NATIONAL LABORATORY

PHYSICS DIVISION

DESCRIPTION
OF THE
PROGRAMS AND FACILITIES
OF
THE PHYSICS DIVISION

OCTOBER 1992

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DESCRIPTION OF THE PROGRAMS AND FACILITIES OF THE PHYSICS DIVISION

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INTRODUCTION

The Physics Division at Argonne National Laboratory performs basic research in nuclear and atomic physics. The Division in 1992 has 106 full-time members [40 regular scientific (Ph.D. level) staff, 10 postdoctoral appointees and visitors, and 56 technical, administrative, and secretarial personnel] and an annual operating budget of about $13 million. The Division's research effort splits roughly into 85% nuclear physics and 15% atomic physics.

The ANL Physics Division traces its roots to nuclear science research at the University of Chicago around the time of the second world war. Following the move from the University of Chicago out to the present Argonne site and the formation of Argonne National Laboratory, the Physics Division has had a tradition of research into fundamental aspects of nuclear and atomic physics. Initially, the emphasis was on areas such as neutron physics, mass spectrometry, and theoretical studies of the nuclear shell model. These interests have diversified and at the present time our research addresses a wide range of current problems in nuclear and atomic physics.

The major emphasis of our experimental nuclear physics research is in Heavy-Ion Physics, centered at the recently completed ATLAS facility (Argonne Tandem-Linac Accelerator System). ATLAS is a designated National User Facility and is based on superconducting radio-frequency technology developed in the Physics Division. In addition, the Division has strong programs in Medium-Energy Physics and in Weak-Interaction Physics as well as in accelerator development. Our nuclear theory research spans a wide range of interests including nuclear dynamics with subnucleonic degrees of freedom, dynamics of many-nucleon systems, nuclear structure, and heavy-ion interactions. This research makes contact with experimental research programs in intermediate-energy and heavy-ion physics, both within the Division and on the national scale. The Atomic Physics program, the largest of which is accelerator-based, primarily uses ATLAS, a 5-MV Dynamitron accelerator and a highly stable 150-kV accelerator. A synchrotron-based atomic physics program has recently been initiated with current research with the National Synchrotron Light Source in preparation for a program at the Advanced Photon Source, (APS) at Argonne. The principal interests of the Atomic Physics program are in the interactions of fast atomic and molecular ions with solids and gases and in the laser spectroscopy of exotic species. The program is currently being expanded to take advantage of the unique research opportunities in synchrotron-based research that will present themselves when the Advanced Photon Source comes on line at Argonne.

The Physics Division has traditionally had strong connections with the nation's universities. We have many visiting faculty members and we encourage students to participate in our programs for performing thesis research.

HEAVY-ION PHYSICS

One of the major programs in the Argonne Physics Division is research at the Division's superconducting heavy-ion linac, ATLAS. At this facility, nuclear collisions are studied between complex nuclei using the full range of stable isotopes, both as target nucleus and as projectile. The interest in these studies ranges from aspects of nuclear structure and nuclear reactions under unusual conditions of excitation energy, angular momentum, and mass asymmetry to the search of possible new particles generated in the collisions between two very heavy nuclei. At low bombarding energies, near the Coulomb barrier, features which are determined by the nuclear mean-field are studied. At high incident energies, the onset of the transition from the mean-field regime to the collision-dominated regime can be investigated. The choice of neutron-rich and neutron-deficient beams and target nuclei allows the production and study of nuclei far from stability. The availability of high-energy ions over the entire mass table allows studies of the atomic physics of highly-stripped ions of many elements. The excellent properties of the ATLAS accelerator allow accelerator mass spectrometry with previously unattainable sensitivity, which opens up the possibility to study problems in a variety of new research areas.

All of these programs are carried out with the use of experimental equipment located in several target areas (see Figure 1 and Figure 4, p. 12). In particular, the new equipment in target area IV possesses features that allow unique reaction studies. The Fragment Mass Analyzer, a combination of electric and magnetic dipoles, allows us to separate exotic nuclei produced in fusion reactions between two heavy nuclei from the intense primary beam. The mass analyzer is being used to study the properties of nuclei far away from the valley of stability. APEX (ATLAS Positron Experiment) uses a large electron spectrometer to search for the e^+-e^- decay of a possible new particle produced in the high electric field of two colliding heavy nuclei. The gamma-ray facility consists of 50 detectors made from the high-density scintillation material BGO, surrounded by 12 high-resolution germanium detectors with Compton-suppression shields, also made of BGO. This device allows us to extend nuclear structure studies to higher angular momenta than previously possible, up to the limiting rotational frequencies where the nucleus fissions. A multi-purpose scattering facility is used for reaction studies with a wide variety of particle detectors, including time-of-flight systems that make use of the picosecond timing features of the sharply-pulsed beams from ATLAS. The magnetic spectrometer allows high-resolution studies in energy and mass of a multitude of reaction products from collisions between complex nuclei. Several general-purpose beam lines are available for use with experimental equipment to be brought in by users of the facility.

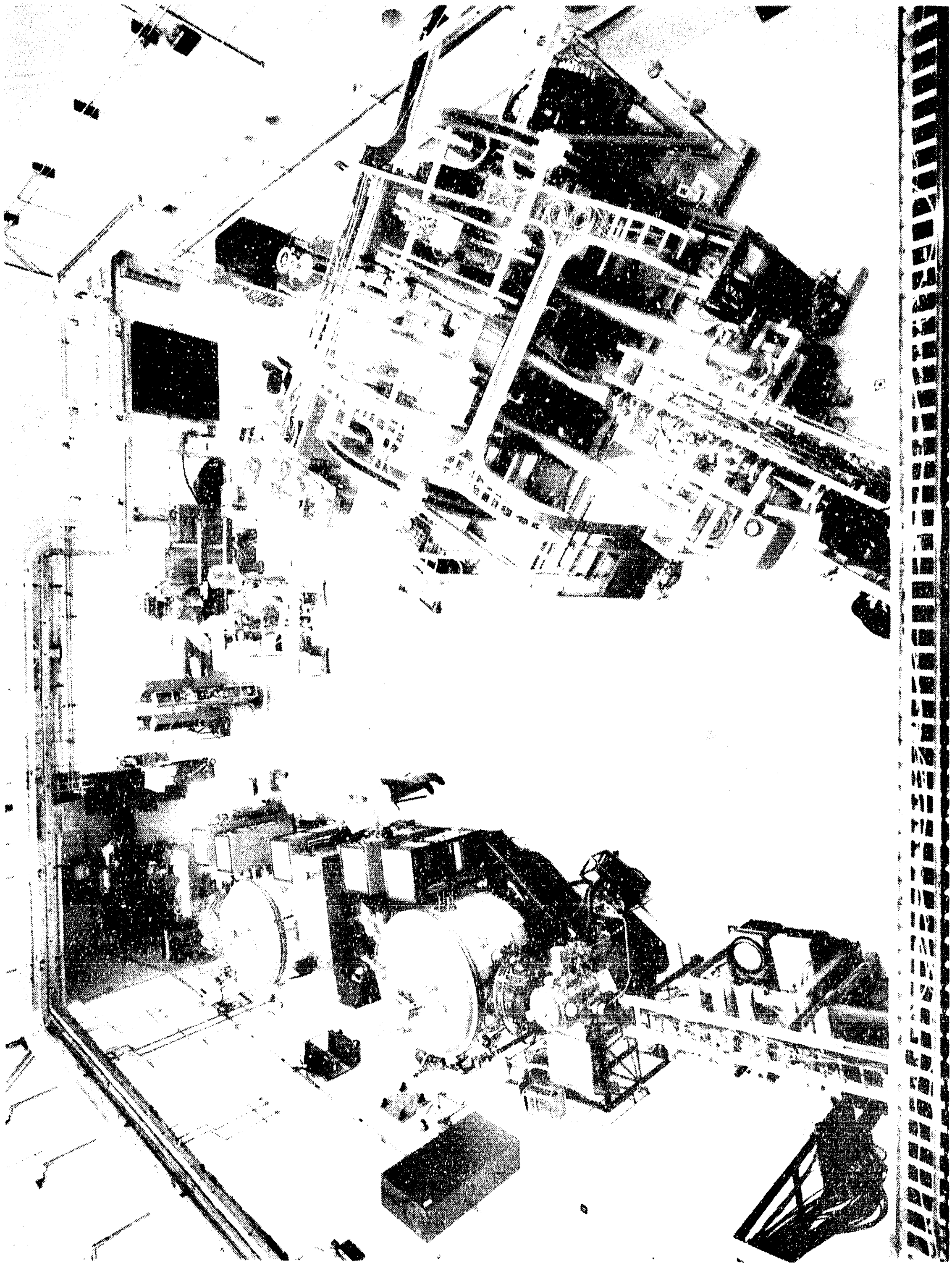


Figure 1. ATLAS experimental facilities. To the left is the FMA with APEX on the right.

MEDIUM-ENERGY PHYSICS

Medium-energy physics research at Argonne explores nuclei, nuclear matter, and fundamental nuclear interactions between the constituents of nucleons and the manner in which they are modified in nuclei. The Argonne program emphasizes studies in which the quark-gluon structure of nucleons affects the basic physics involved in nuclear forces and nuclei. In order to identify these phenomena, it is often necessary that probes have the high spatial resolution obtained at high energies, although other features may be elucidated in tests of the low-energy properties of the weak interaction. To achieve these goals, staff members lead and collaborate in research projects at a variety of major national and international research facilities and also design, develop, and construct innovative targets and detector systems to facilitate research.

In recent years, the medium-energy group has been involved in studies of muon scattering by nuclei at the Muon Laboratory at Fermilab, and in electron scattering at both the NPAS facility at SLAC and the VEPP-3 storage ring in Novosibirsk, Siberia. The interactions of relativistic heavy-ions with nuclei were studied at the AGS at BNL while neutrino oscillations were investigated at LAMPF. An extensive series of measurements at CEBAF has been approved and is in preparation, while design studies are in progress for a major experiment at the HERA ring in Hamburg, Germany. An advanced design polarized deuterium target is being developed for use at VEPP-3 and at HERA. The SOS spectrometer system, to be used in conjunction with the HMS spectrometer for coincidence studies, is currently being constructed and will be available for use at CEBAF in the initial round of experiments.

Deep-inelastic scattering of muons by nuclei, by providing convincing evidence that the quark structure of nucleons is modified within the nuclear medium, has led to an extensive re-examination of nuclear structure within the framework of Quantum Chromodynamics (QCD). FNAL experiment E665 has yielded considerable new information by studying deep-inelastic scattering of 500-GeV muons coincident with leading hadrons from a variety of nuclei. The production of two forward-going jets is sensitive to gluon distributions in nuclei, while the excellent particle identification allows study of the flavor dependence of the fragmentation properties of nucleons and the propagation of quarks through nuclei. The ongoing analysis of data holds promise of providing important new insights into the effects of the nuclear medium upon the constituents of nuclei and the role of quark structure in nuclear physics.

At SLAC, a study of photodisintegration of the deuteron has now been extended up to an energy of 4.2 GeV in a test of constituent counting rules. Preliminary analysis indicates that, at angles near 90 degrees, the energy dependence of the cross section is consistent with a quark-parton description of the system, but, at forward and backward angles, deviations are observed that suggest the need for additional physics input. In a companion experiment, the momentum transfer, q^2, dependence of the (e,e'p) reaction has been extended to extremely high values for targets ranging from carbon to gold. A striking prediction of QCD is that at sufficiently high values of q^2, the final-state interactions of the recoil proton will decrease with increasing energy, i.e., the nuclear medium will become more transparent to the recoil proton. This effect, termed "color transparency", coupled with previous studies at lower energies provides a means for examining the transition from a description of nuclei in terms of nucleons and mesons to one involving quarks and gluons. Another way to investigate the transition from a nucleon-meson to a quark-gluon description is to measure tensor polarization with the scattering of electrons by polarized deuterium. An Argonne-Novosibirsk collaboration has studied these interactions at moderate momentum transfers with electrons stored in the VEPP-3 ring, but extending these measurements to higher momentum transfers requires an improved target. Figure 2 is a schematic drawing of the target being developed at Argonne to generate both tensor- and vector polarized deuterium as well as polarized hydrogen for use in these experiments. The polarized source for this target has already exceeded the best figure-of-merit previously available. In addition to providing significant new information, the ANL program at Novosibirsk serves as a proof-of-principle for an investigation of the internal spin structure of the nucleon that is planned for the HERA ring. These experiments involve polarization of both the circulating 30-GeV electron beam and the target nuclei.

Within the next few years, the CEBAF electron accelerator will begin operation with beam in Hall C. Among the earliest research to be performed will be an

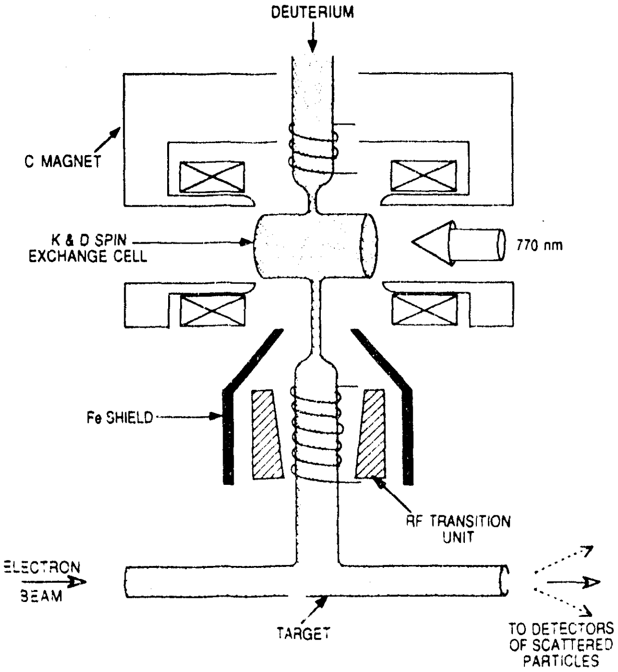


Figure 2. Schematic drawing of the polarized target. Deuterium molecules are dissociated and the neutral atoms enter the spin-exchange cell where circularly polarized laser light aligns the spins of the electrons in the alkali vapor. The electron polarization is transferred to the D atoms during spin-exchange collisions between deuterium and alkali atoms in the strong magnetic field. The emergent deuterium atoms enter a weak magnetic field where RF transitions flip the electron spins to polarize the deuterium nuclei via hyperfine interactions and then into the target cell where interactions with the circulating electron beam occur.

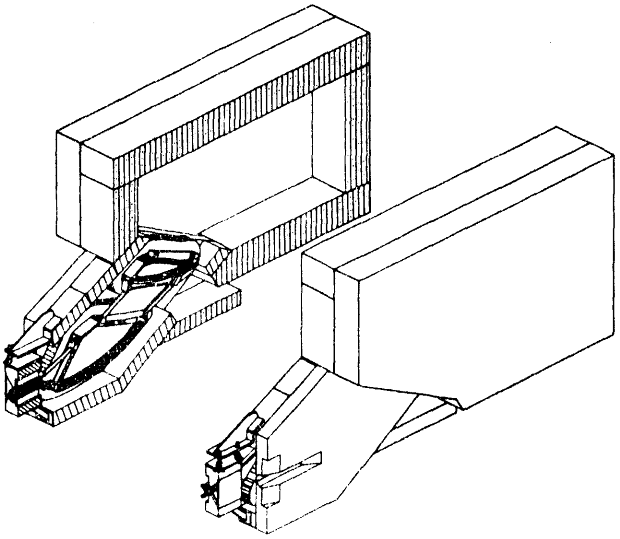


Figure 3. Exploded section of the SOS spectrometer and detector hut. The magnetic elements of the spectrometer, a quadrupole and two dipoles, (QDD), are visible in the left-hand section as are the magnetic return yokes and the concrete hut that will shield the particle detectors from ambient radiation. The SOS will be mounted upon a support structure to allow both the HMS and SOS spectrometers to pivot about a common center.

extensive series of experiments proposed by the Argonne Medium Energy Group to examine problems that range from nucleon propagation within the nuclear medium to determination of the influence of quark degrees of freedom and studies of the electroproduction of pions, strange mesons, and hypernuclei. The mass dependence of (e,e'p) reactions will be studied over a range of energies such that nucleon-meson descriptions should evolve into models that involve quarks and gluons. Binary photo-disintegration of the deuteron, including measurements of the polarization of the protons, and photo-production of neutral pions will be investigated in detail. Sub-nucleon degrees of freedom will be probed by determining the momentum dependence for the longitudinal electroproduction of charged pions on targets of D, ^{3}He, and ^{4}He. The same targets will be utilized in the first studies of the electroproduction of strange mesons and light hypernuclei. Almost every proposal for Hall C involves coincident detection of particles in two magnetic spectrometers, namely the High Momentum Spectrometer, (HMS), and the Short Orbit Spectrometer, (SOS); the Argonne MEP group has assumed responsibility for construction of the SOS.

Particular features of the SOS, shown in Figure 3, are: large dynamic range, 0.2-2.0 GeV/c; large solid angle, ~9 msr; 40% momentum acceptance; ~10^{-3} momentum resolution; and a relatively short distance from target to detectors, optical length 7.4 m. This last feature is critical for the detection of unstable particles, such as pions and kaons, in order to minimize decay losses. The rigid structural design of the SOS spectrometer, coupled with a compact detector package, will also permit out-of-plane measurements when the SOS system comes into operation in 1994.

Another fundamental study involves an experimental search for a 17-keV neutrino reportedly emitted in beta decay. The experiment employs a superconducting solenoidal beta spectrometer to make precise measurements of the energy spectrum from beta-decay of ^{35}S and a novel technique for reducing the effect of backscattering and other sources of background. While the Standard Model does not preclude the existence of such a massive neutrino, it is unexpected and, if confirmed, would require significant modification of the present theory. The Argonne search was recently completed and sees no evidence of the 17-keV neutrino with much better limits than the previous reports.

THEORETICAL PHYSICS

The theory group of the Physics Division consists of 8 staff members and typically a few postdocs or faculty visitors. The principal areas of investigation are intermediate- and high-energy nuclear physics, heavy-ion reactions, and nuclear many-body problems. The group has large collaborations with other research institutes in the United States and throughout the world.

The research in intermediate- and high-energy nuclear physics is aimed at investigating nuclear dynamics which are dominated by the excitations of non-nucleonic degrees of freedom and relativistic effects. We are developing a nuclear theory for investigating electromagnetic and hadronic production of mesons and nucleon resonances from nuclei. The model is being used to examine under which conditions the meson-baryon picture of the two-nucleon system breaks down and the quark-gluon degrees of freedom become explicit. A light-front formulation has been developed to investigate electromagnetic interactions with relativistic two- and three-particle systems. A general relativistic formulation of interacting many-particle systems is also the focus of our research. We are developing hadron models starting from Schwinger-Dyson equations of quantum chromodynamics.

The focus of our heavy-ion research is the collision dynamics accessible to the ATLAS accelerator at Argonne. We have developed a unified coupled-channel approach which can describe simultaneously elastic scattering, inelastic scattering, particle transfer and fusion processes. By systematically analyzing extensive data from ATLAS and other heavy-ion facilities, the approach will lead to theoretical understanding of some fundamental parameters which characterize the heavy-ion collisions at energies of about a few MeV per nucleon. We are also carrying out theoretical calculations of the superdeformed nuclear states observed in heavy-ion collisions.

Our research in the area of many-body problems is to develop a consistent description of nuclear dynamics starting from realistic two-nucleon and three-nucleon potentials. Extensive calculations have been performed to obtain satisfactory descriptions of the properties of three- and four-nucleon systems. The equation of state predicted from a nuclear matter calculation is an important input to the study of neutron stars. A cluster-expansion variational Monte Carlo method has been developed for calculating massive nuclei such as ^{16}O and ^{40}Ca. The objective is to calculate momentum distributions and structure functions for a fundamental understanding of extensive electron scattering data.

ATOMIC PHYSICS

The atomic physics effort in the Physics Division includes both experimental and theoretical programs. Most of the experimental work is accelerator based, utlizing the 5-MV Dynamitron accelerator, the superconducting heavy-ion linac ATLAS, and a low-energy accelerator (BLASE), for laser/fast-beam measurements.

The Dynamitron accelerator is used for molecular-ion structure measurements using the Coulomb-explosion technique, in which fast molecular ions are dissociated in a thin foil. The ion fragments are captured on a novel multi-particle position- and time-sensitive detector. The recorded momenta yield the structures of the initial ions.

The ATLAS-based measurements are aimed at developing our understanding of relativistic atomic structure, especially in highly-stripped ions with more than one electron. These many-body problems are attacked by precision beam-foil spectroscopy and time-of-flight decay measurements in ions with a few electrons. In addition, the new ECR injector ion source for ATLAS is used for atomic structure and collision studies in slow, but highly-charged ions. These measurements include both electron and optical spectroscopy following excitation in gas targets.

The beam-foil-laser group has focused its attention in the past on studying the effects of Quantum Electrodynamics in light atomic ions and hyperfine structure in heavy ions. The effort includes collinear laser-ion-beam spectroscopy with its narrow line width and Doppler tunability. This technique is being applied to both atomic and molecular ions.

The effort in atomic theory is on a smaller scale, and its direction varies with the interests of the people involved. Recent studies have included the calculation of atomic structure, such as multiconfiguration Dirac-Fock studies of rare-earth hfs, and the interpretation of experiments involving small molecules and their ions.

THE ATLAS FACILITY

The ATLAS facility is a heavy-ion accelerator system designed for precision studies in nuclear physics and other areas of science. As shown in Figure 4, the accelerator consists of several major components: two injectors, a positive-ion injector (PII), and an alternate tandem electrostatic accelerator, which serve as sources of low-energy ions followed by two stages of superconducting heavy-ion linear accelerator (linac), the BOOSTER section, and the ATLAS addition. A small part of the linac was first operated in 1978, the world's first ion accelerator based on the phenomenon of superconductivity. Since then the linac has been used steadily for research and has been gradually increased in size, capability, and reliability to its present status as a major facility capable of accelerating nuclei throughout the entire periodic table to energies above the Coulomb barrier for nuclear reactions.

The newest addition to the ATLAS facility is the positive-ion injector, completed in early 1992. It consists of an electron-cyclotron resonance (ECR) ion source and a superconducting injector linac (Figure 4) optimized for low-velocity ions. Highly-charged ions produced in the ECR source are analyzed, bunched and then fed into the superconducting linac for further acceleration. The ECR source and injector linac are now complete, providing an injector accelerating voltage of 12 Megavolt. PII increases beam intensities by 100 fold over those achieved with the tandem injector and, in addition, allows the acceleration of ions of all elements up to and including uranium to energies sufficient to overcome the Coulomb barrier between the heaviest nuclei.

ATLAS is a National Collaborative Research Facility and is used by scientists from many institutions in the United States and some from abroad. Running time for proposed experiments is allocated by a Program Advisory Committee. The experimental areas of ATLAS contain many state-of-the-art instruments which include a multiple-detector gamma-ray facility, two scattering chambers, two magnetic spectrographs, an electron spectrometer, and beam lines for atomic physics experiments and for general-purpose use. Two new large experimental facilities, a Fragment Mass Analyzer (FMA) and the Argonne Positron Experiment (APEX) have been constructed recently. The FMA is essentially a mass separator which separates nuclei produced in reactions between complex nuclei into different mass fractions. This equipment, in conjunction with the already existing Argonne-Notre Dame gamma-ray facility, provides an exceptionally sensitive tool for the investigation of nuclear structure and reaction mechanisms. APEX will be used to study positrons and electrons produced in the very large Coulomb fields which occur during collisions of heaviest beams and targets, such as uranium on uranium. The instrument consists of a solenoid which transports the electrons and positrons generated during a nuclear collision to an array of high-resolution silicon detectors. By measuring coincidence spectra between electrons and positrons, scientists expect to measure and understand effects of these large Coulomb fields. Both instruments were constructed by Argonne Physics Division staff in collaboration with scientists from other institutions.

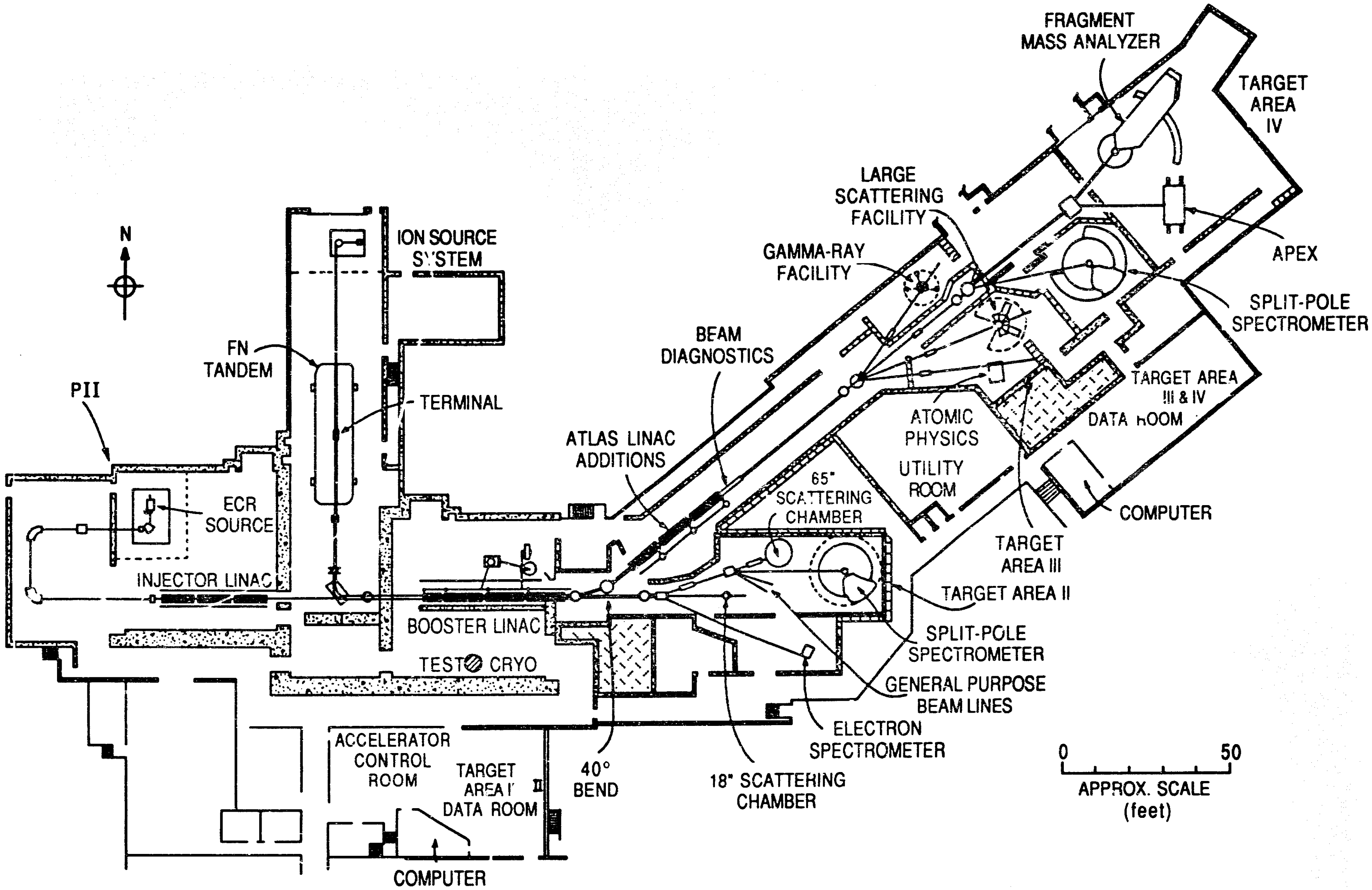


Figure 4. The ATLAS facility.

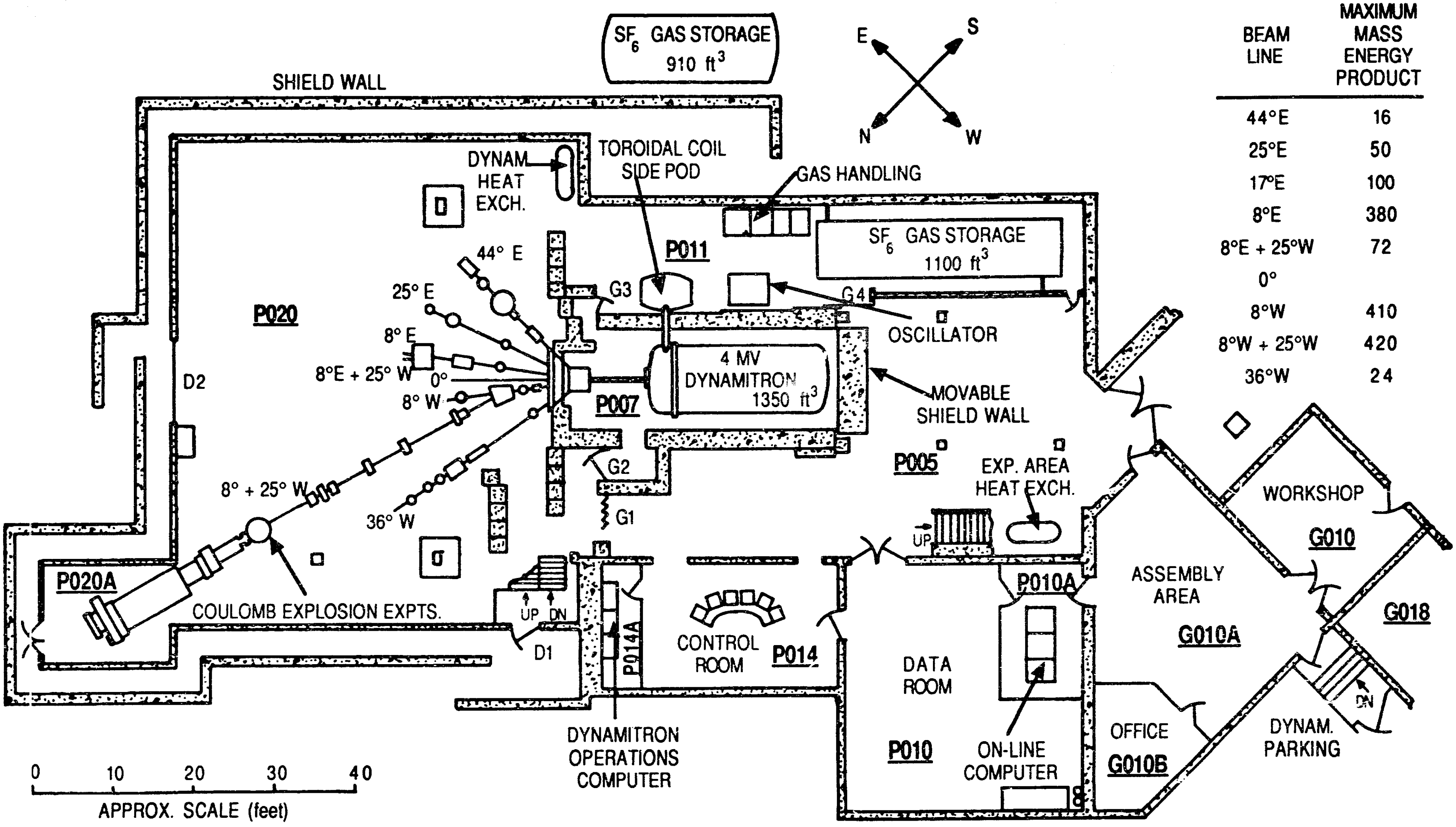
THE DYNAMITRON ACCELERATOR

The Dynamitron accelerator located in the Physics Division provides intense and highly collimated beams of fast atomic or molecular ionic projectiles for use in experiments in atomic and nuclear physics, and in the irradiation of materials. Part of the beam time is made available to outside users from the academic community. During the past 15 years approximately 30 Ph.D. students have obtained their degrees based on work performed at the Dynamitron.

Purchased in 1968 for studies in nuclear physics, the Dynamitron is now used primarily for research in atomic physics. A steady program of improvements to the accelerator has led to a powerful, versatile, and smoothly operating facility that includes computer systems for control and data-acquisition purposes. A valuable feature is the broad range of positive-ion projectile species that can be accelerated and magnetically analyzed. (Four different types of ion sources are available for use.) There are six fully instrumented beam lines. These include a station for experiments requiring extremely high angular resolution (e.g. experiments on molecular-ion dissociation and ion channeling). Another beam line is equipped for the study of interactions of collinear laser and fast-ion beams. In the experimental area there are several high-resolution detectors and spectrometers available for measurements on γ–rays, x-rays, optical photons, electrons, beta-decay spectra, and positive ions (see Figure 5). Present atomic physics applications of the accelerator include studies on the interactions of fast molecular ions with matter, the determination of molecular-ion structures, particle-induced desorption of biomolecules, beam-foil spectroscopy, laser/ion-beam interactions, and ion channeling in crystals. Nuclear research includes weak-interaction studies, quark searches, polarized target production, and measurements of the cross sections for reactions between light nuclei (of importance in the fusion energy program and in astrophysics).

The accelerator voltage can be varied smoothly between 0.5 and 4.8 million volts. Monatomic positive-ion beams of most of the elements are readily produced. Molecular-ion beams ranging from the simplest (e.g. H^{2+}) to complex projectiles such as C^6H^{6+} are also obtained easily. Most of these beams are available with currents of a microampere, and in some cases (e.g. for hydrogen and deuterium beams) of several hundred microamps. Energy instabilities and ripple in these magnetically analyzed beams have been reduced to less than 3 parts in 10,000. For applications requiring a pulsed beam, there exists a post-acceleration chopper system giving beam pulses variable in duration down to a few nanoseconds and at repetition rates variable up to 4 MHz. For measurements needing high angular resolution, beam divergences variable down to 1.5×10^{-4} radian are readily obtainable.

Extensive improvements to the accelerator are almost completed that will result in higher voltage (5 MV) capability, improved energy stability, faster turn-around time, and greater intensities for beams of multi-charged heavy ions.



BEAM LINE	MAXIMUM MASS ENERGY PRODUCT
44°E	16
25°E	50
17°E	100
8°E	380
8°E + 25°W	72
0°	
8°W	410
8°W + 25°W	420
36°W	24

Fig. 5. The Dynamitron.

COMPUTING FACILITIES

Computing facilities in the Physics Division are designed to meet the needs of data acquisition, data analysis, experiment control, word processing, electronic mail, and networking. The hub of the computer systems within the Physics Division is a pair of VAX 3300 computers with shared disks which support a VAX cluster of five VAXstation 3000 class computers and two smaller VAX's. A smaller VAX cluster consisting of a VAX-750, three VAXstation 3000 class computers, and a MicroVAX-II supports the Weak Interactions and Medium Energy Physics groups.

The Medium Energy group also has a Silicon Graphics Iris workstation. A number of other groups have purchased UNIX workstations. These include the Theory group with an IBM RS/6000 and seven X terminals, the Atomic and Molecular Physics group with a Sun IPC, and a Sun IPC for general use. Macintosh and IBM/PC (or compatibles) are in common use throughout the Division. Among their uses are text processing, electronic mail, data analysis, terminal emulation and network access, data-base management, data acquisition, and experiment control. Other VAX computers in the Division include two VAX-750 and two Micro-VAX II computers used primarily for data acquisition with Daphne, a data-acquisition program developed by the Physics Division. With the site-wide ethernet, access is available to many computer resources on the site and to many networks off-site. On-site resources include the computers and graphic output devices of the Computers and Telecommunications Division (CTD), graphics output devices at the Media Services Division, and the Advanced Computing Research Facility (ACRF). The sitewide ethernet will be upgraded to FDDI during 1992/93, offering a factor-of-ten improvement in bandwidth. Off-site networks include a T3 link (44 Mbits/sec) to the NSF internet, BITnet, the High Energy Physics DECnet (HEPNET), and Tymnet.

Argonne is part of CICnet, a mid-western consortium of laboratories and universities connected by a T1 (1.5 Mbit) which supports both TCP/IP and DECnet protocols. Large-scale computer projects can be investigated at facilities available from the Computing and Telecommunications Division (CTD) and on a proposal basis at the Advanced Computing Research Facility (ACRF) and the Magnetic Fusion Energy (MFE) Research Center Cray-XMP at Lawrence Livermore Laboratory. The CTD Division manages a Cray XMP/14, an IBM 3084QX9, and a VAX cluster which includes a VAX/VMS 8700 and a VAX/VMS 6000-410. The ACRF specializes in multi-processor algorithms. ACRF computers include T1 access to a 576 processor Intel Touchstone Delta, a Connection Machine CM-2, a BBN TC2000, an Active Memory Technology DAP with 1024 processors, and several machines with a smaller number of processors. The ACRF facilities include several computers optimized for visualization work with equipment to make video tapes.

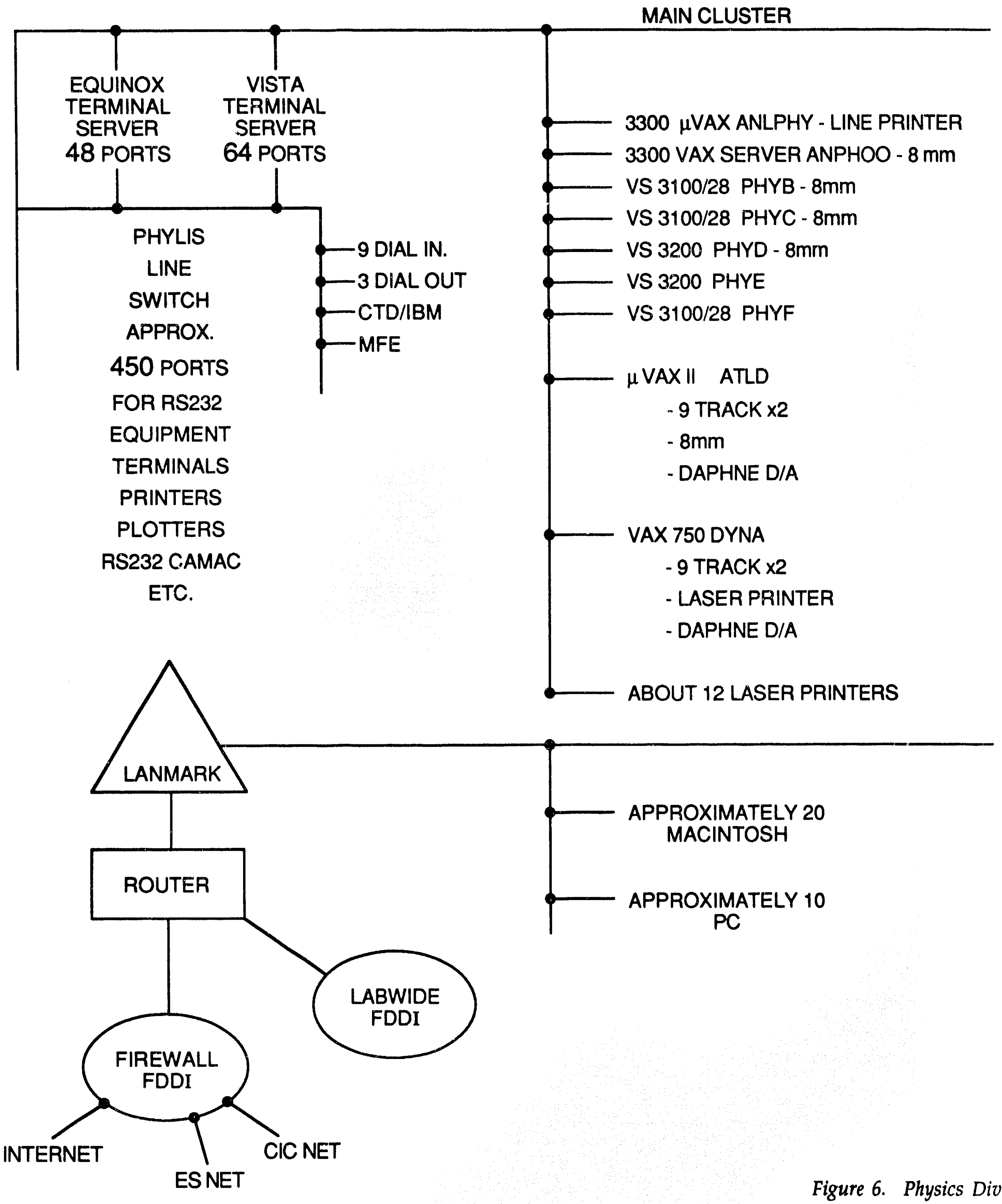
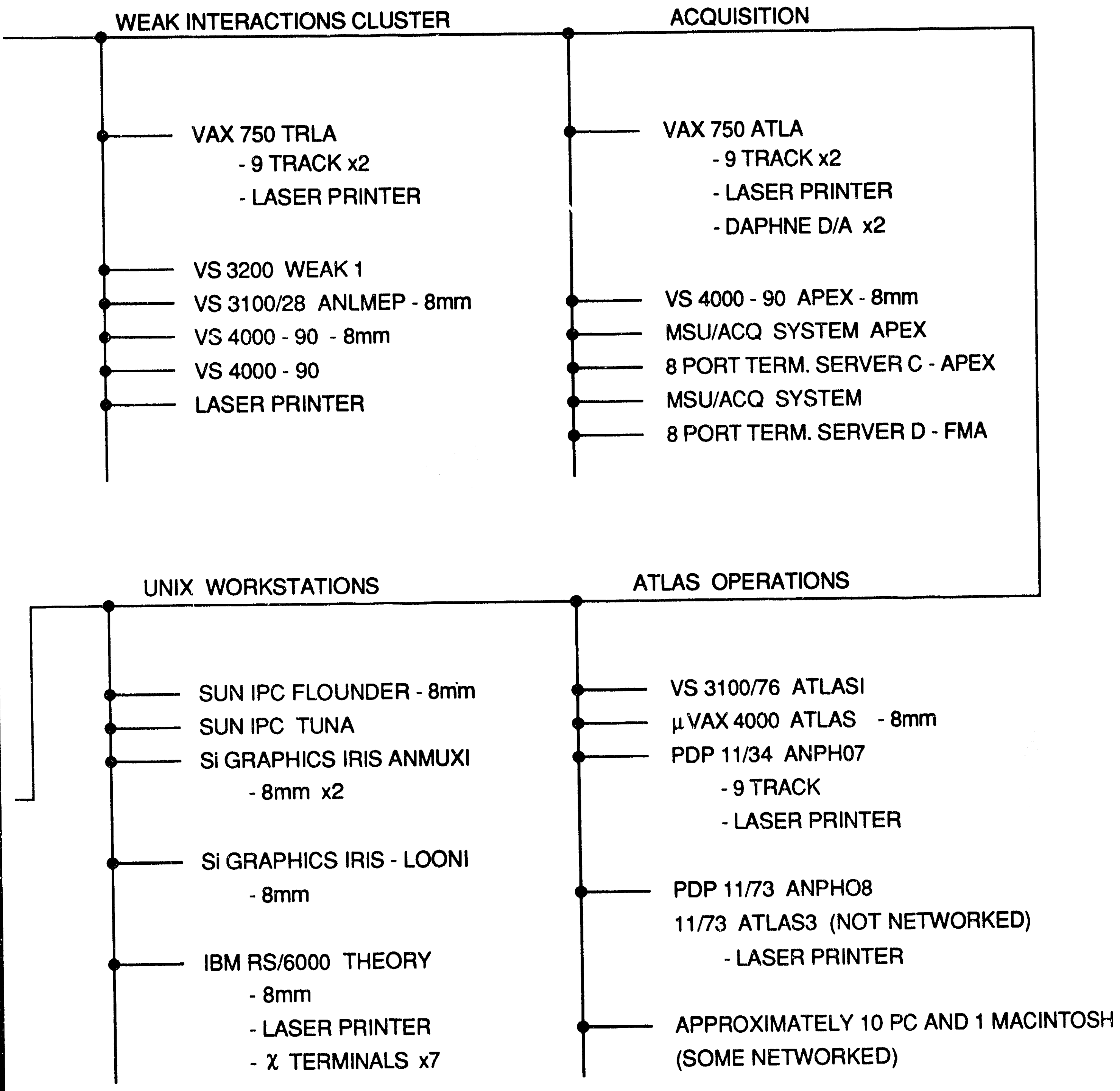


Figure 6. Physics Divisio



omputer Network

TARGET DEVELOPMENT LABORATORY

The Physics Division operates a target development laboratory that produces very thin targets for experiments performed at the ATLAS and Dynamitron accelerators. Targets are made not only for the Physics Division but also for other divisions at the Laboratory and occasionally for other laboratories and universities. This facility produces targets of various thicknesses and substrates depending on the experimental requirements. Advance notice is desired in order to procure the necessary materials and to develop the techniques involved. The targets are produced from both naturally occurring materials and stable isotopes which are supplied either in pure, elemental form or as stable compounds. The target development laboratory includes state-of-the-art equipment used for thin-film fabrication. The available techniques consist of multiple resistive heating, focused ion-beam sputtering, electron beam and electron bombardment evaporation, and mechanical rolling. The evaporators are maintained under high vacuum and each vessel contains a quartz-crystal film-thickness monitor with deposition rate indicators. Also included are movable shutters, quartz-lamp substrate heaters and thermocouple temperature sensors. This allows for complete process monitoring during target deposition. Other auxiliary equipment used for target development includes a turbo-pumped glow discharge apparatus for plasma deposition, a small rolling mill, an alpha particle thickness gauge, inert atmosphere glove box, laminar flow clean bench, a reduction furnace, and a variety of precision balances.

A target storage facility is in operation for maintaining, under high vacuum, those targets which can readily oxidize in air. This system utilizes a turbo pump and employs computer-controlled circuitry to prevent targets from exposure to atmosphere during power interruptions. A second, additional turbo-pumped chamber is now in routine use for target storage. This system uses electronically controlled valves for preserving the targets under high vacuum. There also exists a bank of vacuum dessicators connected to a mechanically-pumped manifold for use by individual experimenters.

An IBM PC-XT laboratory computer is extensively used for a number of purposes. File archives maintained on this system include all targets produced, dating back to 1978. Computer listings can be generated for inventories of all stable isotopes and chemicals maintained by the target lab. An ADC board with software allows for acquisition and analysis of alpha particle film thickness measurements. A communications port attached to a PHYLIS line connects the computer to the Physics Division VAX, or by using KERMIT, to Argonne's central computing facilities. Electronic mail may be sent to "TARGETS@ANLPHY". Due to the need for various low-level radioactive sources and targets, a laboratory at a separate location was assembled, dedicated to the production of these foils. The ability to produce these foils in-house is an important capability for the Physics Division. A second, much smaller, evaporator system was constructed for close-proximity evaporation of higher activity materials, used not only as targets, but for radioactive source development as well. The size of this system allows for minimal contamination and is presently installed within a hood. Future plans include the construction and installation of a rotating wheel within an evaporator for the production of targets to be used with the FMA. We continue to expand our ability to produce carbon films so as to meet increased demands for stripper foils and backings. We continue development of the skills required for rolling thin metal foils. Other areas of long-range development include laser beam evaporation of metals, and especially oxides of metals by ablation techniques.

TECHNICAL SUPPORT GROUP

The Physics Division Technical Support Group is a group of technicians, designers, and engineers dedicated to the technical support of the experimental program in the division. The disciplines are basically electrical and mechanical with recent emphasis on the new possibilities of interfacing the two, by making use of the hardware and software capabilities of micro-computers. Its functions range from novel and unique design and engineering, to construction, start-up, operation, and future expansion of equipment.

The electronics section of the Technical Support Group consists of two engineers and a technician whose responsibilities cover two areas. One area is electronic design and construction. Interfacing micro-computers to experimental equipment and designing chassis for data taking is typical of the work done in this area. Larger, more time-consuming projects may require the construction phase to be completed by Electronics Division. The electronics section maintains a wealth of information on circuits, vendors, techniques, and industry trends.

The second of these areas covers electronic service and maintenance. Any on-line data-taking computers, which are not under DEC maintenance contracts, require highest-priority attention when hardware failures occur. Peripherals to the computers such as terminals and magnetic tape units are also repaired and maintained.

The mechanical section of the Technical Support Group consists of one design engineer and one engineering assistant.

Proper execution of experiments on all levels requires efficient and reliable equipment, much of which does not exist in the normal market place. It is the purpose of the mechanical section of this group to find appropriate equipment if it exists, or design it if it does not. Once designed, members of the group are responsible for the fabrication, installation, start-up, and operation throughout the equipment's life cycle.

Typical responsibilities include such diverse assignments as accelerator beam-transport-system design, commercial component testing and evaluation, high-vacuum chamber and pumping-system design, detector development, experimental area utility interfacing, structural support and mechanical mechanism design, and plant layout.

EDUCATIONAL PROGRAMS AND STUDENT APPOINTMENTS

The Physics Division offers college/university faculty and students opportunities to participate in ongoing research projects. The various research participation programs are administered by Argonne's Division of Educational Programs.

There are two research programs available for faculty. The Faculty Research Participation (FRP) Program is typically for 10-12 week periods normally during the summer, but may be at any time. Participation in this program usually takes the form of individual collaborations with an ANL staff member on an ongoing ANL project of interest to the faculty participant. Faculty Research Leave Appointments (FRLA) are normally for nine to twelve month periods whereby faculty members spend their sabbatical leave at Argonne.

Student research programs are designed to provide the opportunity to study and participate in research. Participation takes the form of individual collaboration with a staff member in some part of an ongoing project of interest to the student participant. There are a variety of programs for both graduate students and undergraduate students. The Laboratory-Graduate Participant Appointments support graduate students from U. S. universities carrying out their Ph.D. thesis or Master thesis research at Argonne under the joint sponsorship of an Argonne staff member and a professor at the student's university. Thesis Parts Appointments support graduate students from U. S. universities making brief visits to Argonne to make use of special Argonne facilities or to confer with Argonne staff members in the course of their thesis research.

There are two programs available for students who have completed their sophomore year of college and not as yet completed their first year of graduate school. The Science and Engineering Research Semester (SERS) is part of a new Department of Energy initiative offering challenging opportunities for students selected nationally for participation in energy-related research during the academic year The Summer Research Participation Program (SRP) extends for an 11-week period which begins in early June and runs through mid-August. In addition to research activities, a seminar series with energy issues and energy-related research being conducted at Argonne will be provided. The principal purpose of the seminars is to broaden the student's scientific perspectives.

Pre-college programs are offered for academically talented students from the Chicago area who have just graduated from High School and will attend a college or university in the Fall. This program is similar in form to the Summer Research Participation Program, except it is for an 8-week period during the summer months.

In addition to research participation opportunities, the Physics Division offers temporary employment appointments to college/university students. These appointments, made primarily during the summer months, are designed to provide Physics Division scientific and engineering staff with technical assistance. On a longer term basis, there is the Cooperative Education

Program. There are two types of Co-op programs: alternating (full- time work followed by full-time school) and parallel (part-time work concurrent with full-time school). Students employed in the Co-op program are expected to work a minimum of one year as a parallel Co-op or three semesters as an alternating Co-op.

Specific information on individual programs should be obtained from the Division of Educational Programs. Call or write the Physics Division for information on research done here and how it may relate to specific programs.

POSTDOCTORAL AND VISITING SCIENTIST APPOINTMENTS

Postdoctoral appointments are available in all research programs of the Physics Division. The appointments are for a one-year period but may be extended up to three years.

Visiting Scientist Appointments are available to individuals on leave from their parent institutions who will return on completion of their Argonne assignment. Interested applicants may inquire themselves or be recommended by Division staff. These appointments are available for up to one year.

APPENDIX A: LIST OF PRESENT SCIENTIFIC STAFF MEMBERS

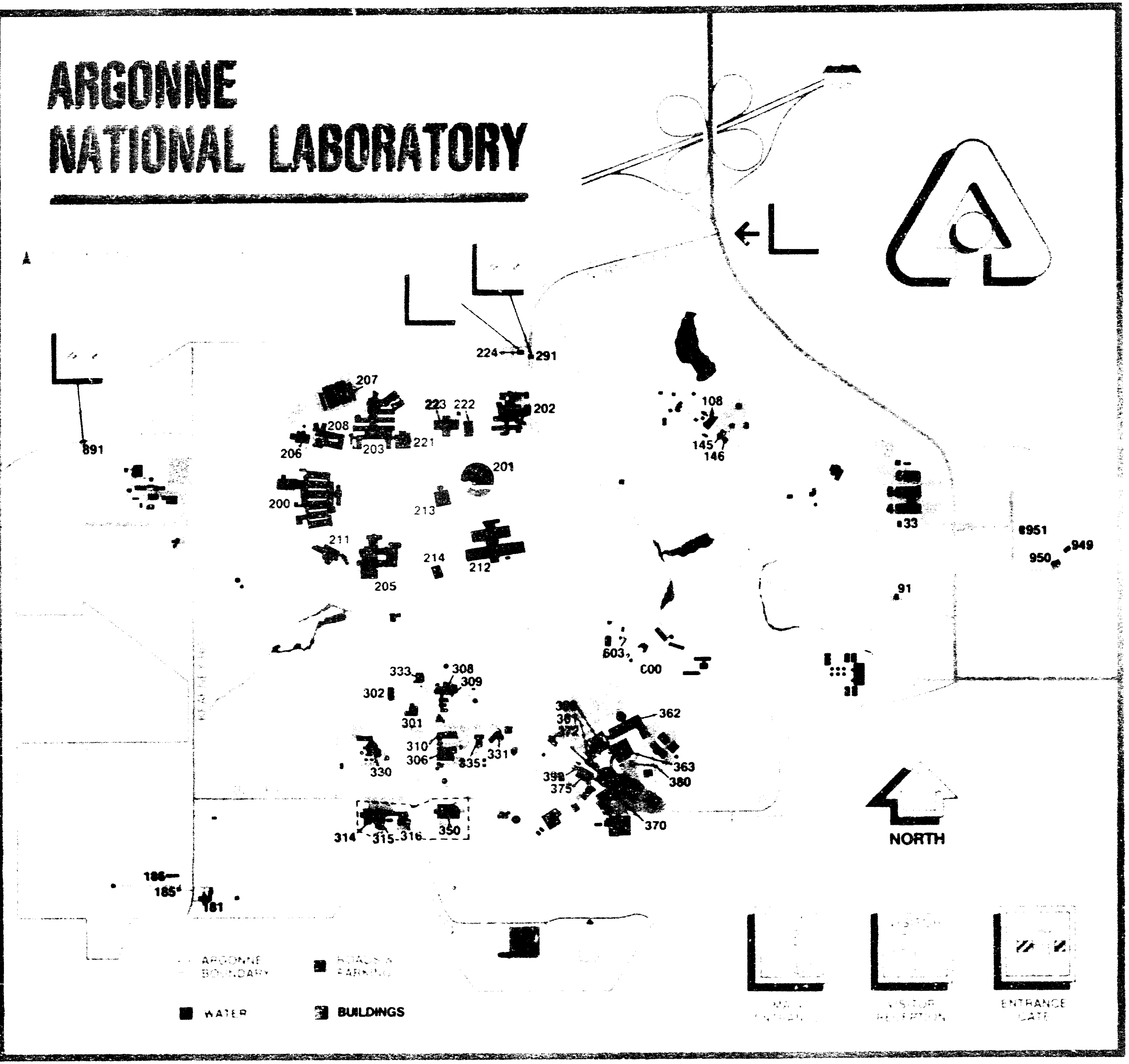
Staff Member	Year Joined Regular Staff
Irshad Ahmad	1985
Birger B. Back	1985
H. Gordon Berry	1975
R. Russell Betts	1985
Arnold Bodmer	1965
Lowell M. Bollinger	1951
Michael P. Carpenter	1991
Richard R. Chasman	1985
William J. Childs	1956
Fritz Coester	1963
Paul L. Cowan	1991
Cary N. Davids	1974
Robert W. Dunford	1986
Henning Esbensen	1985
Melvin S. Freedman	1982
Stuart J. Freedman	1981
Donald F. Geesaman	1978
Donald S. Gemmell	1962
Bruce Glagola	1985
Walter F. Henning, **Division Director**	1991
Roy J. Holt	1974
Harold E. Jackson, Jr.	1959
Robert V. F. Janssens	1981
Elliot P. Kanter	1980
Sheldon B. Kaufman	1985
Teng Lek Khoo	1977
Dieter Kurath	1951
Walter Kutschera	1978
Stephen Landowne	1985
Alexander J. Langsdorf, Jr.	1943
Tsung-shung Harry Lee	1977
Frank J. Lynch	1985
Thomas Moog	1984
Jerry A. Nolen	1992
Vijay Pandharipande	1983
Richard C. Pardo	1979
Gilbert J. Perlow	1953

Staff Member	Year Joined Regular Staff
Murray Peshkin	1959
Steven C. Pieper	1974
Karl Ernst Rehm	1981
G. Roy Ringo	1948
Craig T. Roberts	1991
John P. Schiffer, Associate Division Director	1956
Kenneth W. Shepard	1975
George E. Thomas, Jr.	1943
Zeev Vager	1984
Robert B. Wiringa	1983
Alan Wuosmaa	1992
Jan L. Yntema	1955
Linda Young	1983
Benjamin Zeidman	1957

Buildings

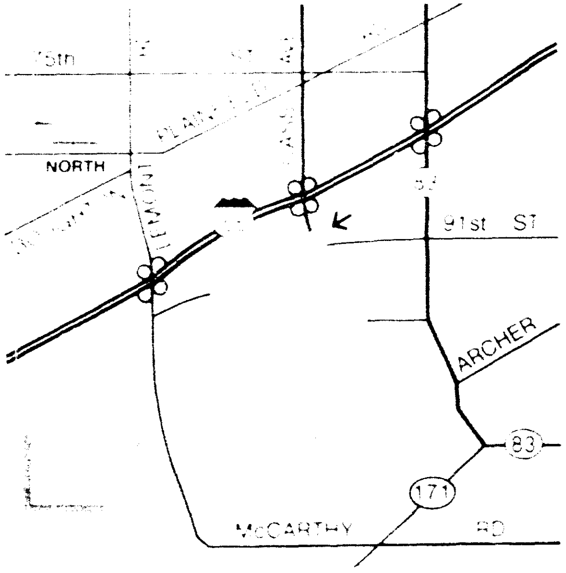
4	Receiving/Shipping
5	Warehouse
6	Storage Building
33	Credit Union
91	Guard Post
108	Central Boiler House
145	Ampel Facility
146	Fossil Energy Users Laboratory
181	Meteorology and Ecology
185	Ecology Storage and Greenhouse
186	Microcosm Facility
200	Chemistry
201	Administration ANL-DOE/CH
202	Biological and Medical Research
203	Physics and Environmental Research
205	Chemical Technology/ Fusion Power Program
206	Reactor Analysis and Safety
207	Applied Physics Engineering
208	Reactor Analysis and Safety Applied Physics
211	Cyclotron
212	Materials Science Materials and Components Technology
213	Cafeteria
214	Plant Facilities & Services
221	Computing Services Mathematics and Computer Science
222	Electronics Graphic Arts Film and Video
223	Materials Science Educational Programs
224	Visitors Reception Center
291	Guard Post
301	Laboratory Office and Storage
302	Security
306	Plant Systems – Reclamation
308 & 309	Materials and Components Technology
310	EBR-II
314	Fast Neutron Generator
315 & 316	Applied Physics Technical Information Services
331	Special Materials – Division Office
333	Central Fire Station
335	Materials and Components Technology
350	New Brunswick Laboratory
360	Intense Pulsed Neutron Source/7 GeV Advanced Photon Source Project
361 & 375	Intense Pulsed Neutron Source
362	High Energy Physics Auditorium Energy and Environmental Systems
363	Central Shops
370	OTEC EMT and Storage
372	International Energy Development Program
375	PNS – Experimental Area
380	SSD-HP Office
399	PNS Users Support Facility
600	Lodging Facility Office
603	Swimming Pool
891	Guard Post
949	Concession Stand – Recreation Area
950	Pavilion – Recreation Area
951	Argonne Recreation Center

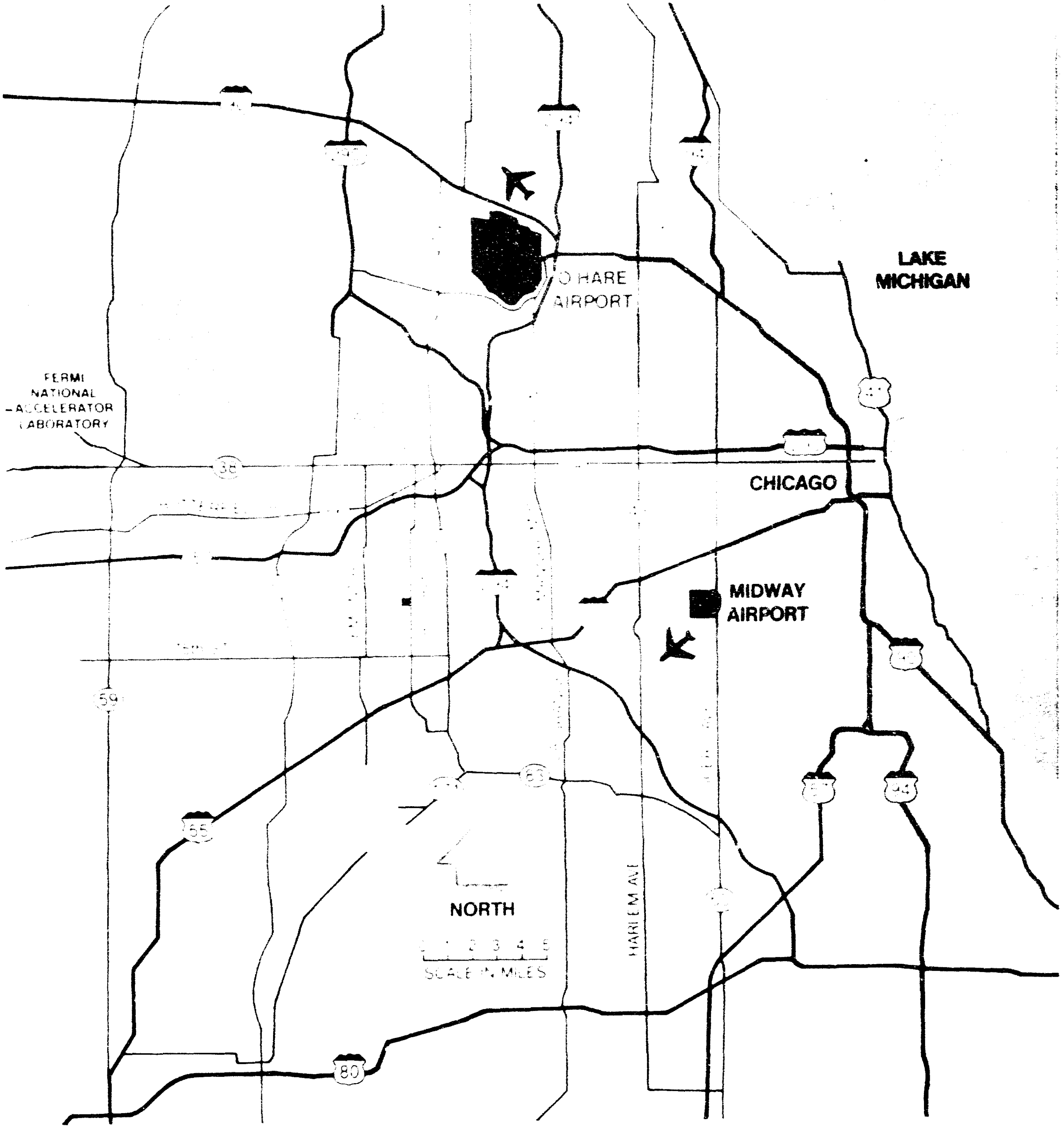
ARGONNE NATIONAL LABORATORY



ARGONNE NATIONAL LABORATORY

Served by 2 major airports (O'Hare and Midway), Argonne National Laboratory is located 25 miles southwest of Chicago, just south of Interstate 55 (Stevenson Expressway) at Cass Avenue. Visitors should take the southbound Cass Avenue exit off I-55, then turn right on Northgate Road. This will take them to the Main Gate and the Visitor's Reception Center. A gate pass, necessary for entrance to Argonne, will be issued from the Visitor's Reception Center. Access after hours is obtained when an ANL contact leaves the name of the visitor on the access list at the Main Gate. Accommodations, both short- and long-term, are easily arranged both by the visitor and/or ANL contacts. The ANL Newcomer's Assistance Office is available to help visitors settling in the Argonne area. More information may be obtained by calling (312) 972-8647.





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