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Experimental Division Progress in FY 69

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EXPERIMENTAL DIVISION PROGRESS IN FY 69

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Experimental Planning and Support

The AGS is steadily used by research groups from universities throughout the United States, as well as resident Brookhaven physicists. These groups develop research proposals for high energy physics experiments using the research facilities at the AGS. After approval of their proposal, the staff of the Experimental Planning and Support Division assists the experimenter in planning his experimental set-up. This often necessitates the design of a new particle beam or an unusual magnet. When the equipment is ready, the experimental area personnel makes the necessary beam changes, and operates the magnets, separators, and targets for the experimenter. Fifteen counter experiments operated at the AGS during the past year. Most of them took data and completed experiments. Others were occupied with testing or preparing for an experiment. On the average two bubble chambers operated during the year, and a total of 3.7 million pictures were taken. Further details of the experimental program and the equipment developed are presented in the following sections.

Experimental Facilities and Program

The year saw the successful inauguration of the experimental program for counter experiments utilizing the slow extracted proton beam (SEB) from the F-10 straight section of the AGS. Matching the experiments to the increasing sophistication of the SEB system, two experiments were completed utilizing the protons directly and a third began taking data using the first secondary beam from a target in the proton beam. A BNL/Yale collaboration using the full 28.5 GeV/c proton beam on a massive uranium target set an upper limit to the cross section for the intermediate boson, $W^{\pm}$, up to a mass of 6 GeV/c^2. A Columbia University group, again utilizing a two ton uranium target and protons at 28.5 GeV/c collected data in a search for massive bosons in the 2-6 GeV mass range decaying into two muons. In addition, with the same apparatus they were able to study the annihilation of anti-protons and protons into muon pairs and to extend the cross section and mass range limits of the search for the W^{+}. In March the first secondary beam for counter experiments from the SEB was delivered to a BNL group utilizing a massive wire chamber array on-line to the PDP-6 computer to study a wide range of interactions of π and K mesons in hydrogen. This single secondary beam facility is capable of delivering particles of either sign of charge over a range $\sim$ 10-25 GeV/c.

A full program of counter experiments was also carried out from the internal target station at G-10, and an efficient mode of sharing beam on a pulse to pulse basis between G-10 and the SEB has evolved. On Beam #6, G-10 + 4.7° on the outside of the AGS ring a group from the State University of New York at Stony Brook completed a study of the associated production of K mesons and Σ hyperons involving 500 hours of running time. In the same beam a University of California group from La Jolla completed some 300 hours of running in a CP violation in K-meson decay. A third group from Cornell used optical spark chambers to study backward peaks in neutral meson production for 350 hours. Finally an MIT-Brown-Padua collaboration began running on an experiment to study various aspects of π^{-}-p interactions using optical spark chambers. This run will be concluded after the present shutdown. During the Christmas shutdown a neutral beam port was installed utilizing the front end of the G-10 + 4.7° beam and a Princeton group has begun running on a very sensitive test of CP violation in K^{o} meson decay.

At beam #5, G-10 + 10°, the enriched counter beam utlizing electrostatic separators, a series of K meson experiments was carried out during the period. In the first of these an MIT group, utilizing a BeO target which turned out to be a significant advance in target technology, collected some 560 hours of data on various aspects of K^{o} decay. A Cal Tech, BNL, University of Rochester group completed 640 hours of running on the scattering of K^{+} mesons at large angles from hydrogen. A Princeton group has studied CP violation in the τ decays of $K^{\pm}$ mesons for 400 hours using wire chambers coupled to computers. At the present time a group from Yale using a polarized proton target and a group from BNL are set up on the two branches of this beam to study the scattering and certain decay mode of K mesons respectively.

On the neutral beam on the inside of the AGS ring, Beam #7, at G-10 - 20^o, a Columbia/Harvard group completed some 1000 hours of running to study charge asymmetry in K_L^o leptonic decay. A Princeton group completed some 400 hours of running to investigate other aspects of K_L^o decays. A Cornell/Princeton experiment is being installed to utilize this beam after the shutdown.

A significant development during the period is the increasing use of wire chamber arrays and large spectrometers on line to computer facilities, either the experimenter's own computer or the Laboratory's PDP-6, or a linking of the experimenter's computer to the Laboratory installation. The state-of-readiness of computer facilities will have increasing impact on the efficiency of utilization of the AGS by counter groups.

This year saw a change in the scheduled mode of operating the two smaller bubble chambers at the AGS. The 30 and 31-in. bubble chambers now alternate their running periods, reducing manpower and electric power needs as emphasis shifts to other areas of the accelerator. These two chambers are each provided with separated particle beams. K mesons, from zero up to about 900 MeV/c in momentum, may be obtained in the 30-in. chamber, while the beam to the 31-in. chamber provides K mesons from about 1.5 BeV/c to 3.0 BeV/c, with π mesons and anti-protons available to 4.0 BeV/c. In the north experimental area, the 80-in. bubble chamber is still serviced by two separated beams: No.3, which is effective to 5.0 BeV/c for K mesons or 8.0 BeV/c for anti-protons, and No. 4 an rf separated beam, which can give purified K mesons to 12.8 BeV/c, anti-protons to 18 BeV/c, and pions or protons to 28 BeV/c.

In the first of two running periods, the 30-in. bubble chamber completed 146,000 more pictures of K^+ and π^+ in liquid deuterium for Princeton University. In the winter-spring period, 288,000 more pictures of K^- and anti-protons in H_2 and D_2 have been taken. About 200,000 more K^+ pictures are expected to be done in this period, giving a total for the year of 634,000. Experimental groups have come from the Universities of Melbourne, Wisconsin, and Maryland, from Tufts, and Brandeis Universities, and from the Illinois Institute of Technology.

The program for the 31-in. chamber has also been divided into two parts. In the summer and fall, eight research groups came from Syracuse, Brandeis, Vanderbilt, Columbia, and Carnegie-Mellon Universities, and from the Universities of Kansas, Maryland, and Michigan. Beams of π^-, K^-, and anti-protons were photographed in both liquid H_2 and D_2 chamber fillings. A total of 1.072 million pictures was accumulated in this period. In the late spring, physicists from four of these same universities will return to obtain some 435,000 more exposures, to bring the year's total for this beam and chamber to 1.5 million pictures before the shutdown in early summer.

Operation in the North Experimental Area was confined this year to the use of the rf separated beam. The summer and fall was occupied by exposures in liquid H_2 totaling 940,000. These were done for experiments being carried out by the State University of New York at Stony Brook, Yale and Harvard Universities, by the Universities of Wisconsin, Notre Dame, and California at Davis, and by Brookhaven National Laboratory. A liquid D_2 filling is now in the 80-in. chamber, in which about 550,000 pictures are planned to be taken for some of the schools above as well as for groups from the Universities of Colorado, Hawaii, Tennessee, Pennsylvania, and California at Los Angeles, from Purdue University and from Oak Ridge National Laboratory. Just prior to the summer shutdown, about 120,000 more pictures in liquid H_2 will be taken for the Brookhaven group.

In the Southwest Experimental Area a new facility was constructed during the year to provide a neutrino beam and a charge particle test beam to the 7-foot cryogenic bubble chamber. This work consisted of refurbishing and supplementing the existing fast ejected beam from B-10, lengthening the concrete shielding cave by 85 feet, and relocating 10,000 tons of steel to form the new filter for the neutrino beam. It is expected that the experiments in the chamber will be run next year.

Experimental Equipment

During the year there were, on the average, 12 beams in operation or under construction in the East, West, North and Southwest Experimental Areas. Fig. 1 shows the configuration of beams in the Target and East Experimental Buildings in the Spring of 1969. The scheduling and use of these areas was such that construction of new beams could proceed without interrupting operations on other beams. Thirty-eight man years of effort were expended on new construction by members of the Experimental Division and the Laboratory's Plant Engineering and Planning Division.

A summary of the inventory and usage of major experimental service items is given below.

ITEM	INVENTORY	USAGE
Magnets	216	85%
Power Supplies	211	88%
Beam Separators	12	83%
Shielding	90 000 tons	85%
Experimental Power	45 MVA	87%
Experimental Cooling Water	4 050 GPM	94%

The Power Supply Group has purchased ten 450 kW and five 120 kW dc power supplies. Incorporated in these units are three design changes which will improve reliability and usefulness. A standard low level firing circuit that is interchangeable with all power supply sizes, a remotely operated reversing or transfer switch, and a low voltage air circuit breaker. Work continues on other power supply improvements, with the major improvements this year in current regulation and remote controls which will afford a greater degree of regulation.

About 8 MVA of new experimental power was made available along the East wall of the East Experimental Area via 16 distribution boxes. This power was provided by purchasing a 3750 kVA transformer and by relocating a similar unit from the Cosmotron. The power to these transformers was provided by splicing into an existing feeder cable. An additional 9 MVA of new experimental power was made available in the East Experimental Building Addition via 36 distribution boxes. This power is supplied from the new "M" substation as part of the conversion project.

The mechanical service group continues its efforts to reduce machine downtime due to experimental magnet failure and to increase radiation resistance of all magnets in high radiation areas. This program consists of relocating the magnet coil jumper hoses from the aperture area to an area under the magnet away from the beam, fitting these jumper hoses with quick disconnects, replacing the cooling water hoses with flexible copper tubing, providing an external electrical connection used to quickly read coil voltages when coil shorts are suspected and the provision of water sensing mats under the magnets that detect leaks immediately and alarm remotely. Also, ceramic insulators have been installed on two magnets and are currently being life tested to evaluate their usefulness in radiation areas.

Four 18C72 magnets have been received and are now being assembled in the experimental area. These magnets, after initial testing, will be installed in the slow external proton beam. Purchase orders are being issued for seven additional 18D72 bending magnets and five N3Q36 quadrupole magnets for use as general beam transport magnets. All existing 18D72 Mark I magnet cores are being modified to Mark II cores in order to provide interchangeability of coils and thereby reduce the number of spare coils required. Vacuum boxes have been designed to utilize the full aperture of the 18D72 and 30D72 magnets in the slow external proton beam and are now being ordered.

A large magnet-transporting device, capable of lifting, moving, and positioning a 100-ton spectrometer magnet within the necessary alignment tolerances has been fabricated and tested. This device is scheduled to be used with a 48D48 spectrometer magnet in the BNL Double "V" Experiment.

The efforts of the Magnet Study Group have principally been devoted to the design and study of cryogenically cooled window frame dipole magnets for use in general beam transport and in synchrotrons. The group has also routinely maintained and provided precision-calibrated Hall probes for use by various experimental groups. Precision calibration curves of all beam transport magnets are available, the newest type magnet being the 18Q36 quadrupole which has replaced the rectangular quadrupoles in separated beam #3 at the AGS. Magnetic measurements on the SEPB septum and ejector magnets were made and corrective measures devised for reducing the fringing field of the ejector magnet.

An effort of appreciable significance has been that of back-leg winding improvements for the accelerator magnets. Due to the difference in magnetic reluctance between the open and closed magnets in the AGS, there has always existed a difference in magnetic gradient at low fields between the two types of magnets that has caused a shrinking of the AGS aperture at injection.

A series of backleg windings was devised to correct the gradient differences, which have resulted in a considerable gain in the intensity of the AGS. In addition to the gradient correction, the windings were designed to also provide ν-tuning at injection and correction of the 8θ and 9θ stopbands as well as any other periodic correction that may be necessary, for example, 4θ and 12θ.

A laboratory dipole magnet using cryogenically cooled coils was designed and constructed to study the highly saturated magnetic circuit. Results of these tests, which essentially agree with computer studies, indicate that one is able to achieve a field of 41 kG with modest sextupole aberrations of 2.5%. Further testing, both electric and magnetic, in LH_2 of a dipole model with a coil constructed of 99.9999% pure aluminum indicates that this type of magnet at fields greater than 40 kG is practical for a synchrotron. Tests are continuing using high purity aluminum as a stabilizer for superconducting materials.

A 2.5" diameter quadrupole magnet using a high current density cryogenically cooled coils was designed, constructed and tested. The maximum gradient was 20 kG/in. and the harmonic aberrations were as small as those of a standard AGS beam transport quadrupole. The use of high purity aluminum for beam splitter magnets is also being studied and a model is being constructed. In conjunction with the magnet testing program, properties of conductors at cryogenic temperatures as well as insulation systems for cryogenic coils and cores are being studied.

The Beam Separator Group operated 10 electrostatic separators in four beams and the rf separated beam. The two rf deflectors were opened during the fall because of organic contamination, and sections of the internal structures cleaned. The program initiated last year to replace all organic seals in the deflector vacuum system with metallic seals was accomplished except for those in the pneumatic valves. As soon as suitable bellows-sealed valves can be obtained, the changeover to metallic seals will be completed.

In October, as a result of a series of tests reported last year on the test separator, the two separators in the 30-in. bubble chamber beam were removed from the beam and modified with grounded shields. After their return to operation the separators showed the same improvements as demonstrated by the test separator. Also in October a new separator control area for the 10^{o} beam at G-10 was put into operation.

The testing program on the test separator was continued in this past year. A series of tests utilizing all-metal electrode systems and glass-metal electrode systems were conducted on gaps of 5 and 10 centimeters.

The voltage gradients obtained are shown on the table below:

GAP VOLTAGES PER CENTIMETER WITH
CROSSED MAGNETIC FIELD

	All-Metal		Glass-Metal	
	5 CM	10CM	5 CM	10 CM
Operational Results	70	50	100	50
Laboratory Test Results	80	60	120	60

The test separator is limited to 600 kV total gap voltage by the present means of electrode support and the feedthrough insulators. Of the various gases used during the tests, helium appears to give the best overall operation. Further testing is planned using improved corona treatment of the glass electrodes and the feedthrough surfaces.

New rf deflectors have been ordered for eventual use as a third deflector and a spare. A test facility is being constructed in order to operate these deflectors at high power levels for the acceptance tests. Also during the past year many modifications have been made in the modulator units to improve the accessibility and the reliability of the electronic components.

The Cryogenic Group's major efforts have been directed towards the design, fabrication, and operation of liquid hydrogen or liquid deuterium targets. Five targets were designed and operated at the AGS. These targets consist of a mylar flask surrounded by super-insulation and a vacuum container. Supporting equipment includes a liquid reservoir, two liquid level detectors, vapor vent lines, vacuum electronics, and an electrical power control chassis. Cryogenic liquid transfer lines were constructed for a number of experimental set-ups.

A system was developed to fill LH_2 targets automatically. The system consists of pressurizing H_2 gas supply, a 175 liter liquid hydrogen dewar, a vacuum jacketed transfer line and cold valve, a LH_2 reservoir and target system, and a main electrical control chassis. The main control chassis includes all the control relays, air control valves, timer, and other controllers required to sequence the valves and controls that start and stop LH_2 transfer to the LH_2 target system. The main control panel front face includes an annunciator panel and a complete piping schematic.

A cryogenic purification system was designed for use with wire chambers. The purifier is designed to purify 200 cubic feet per hour of a 90% neon-10% helium gas mixture. The impurities removed are water vapor, sulfur dioxide, alcohol, argon, oxygen, and nitrogen. These contaminants are removed by absorption at ambient temperature, condensing at CO_2 temperature, and condensing and absorption at liquid nitrogen temperature. The purifier system also includes a pressure controlled make up system for argon, SO_2, and alcohol to mix with the 90% neon-10% helium gas mixture.

The Beam Instrumentation Group's major efforts have been to improve the instrumentation and operation of beam No. 1A and beam No. 2. The shutter magnet in beam No. 1A was improved and modified for multi-pulse operation. Time-of-flight instrumentation for monitoring beam purity was provided in beam No. 2. Preliminary design and preparation is now being done to further improve the quality of instrumentation and efficiency of operation in these beams, using a small special purpose digital computer.

The High Energy Electronic Equipment Pool (HEEP) has an inventory of some 2500 components, which they loan, maintain and repair, for use at the Laboratory. The counter experiments at AGS employed a major portion of this equipment, with each piece being used in 2 to 3 experiments during the year. Equipment utilization was about 85%.

A new electronic chassis washing facility has improved the cleaning techniques and allows a faster turn-around for the equipment. Also, the original Brookhaven logic (Nanocards) have been retired and are being replaced with 200 MHz logic modules in an effort to provide the best and most reliable equipment for general use.

Distr: Admin. Group
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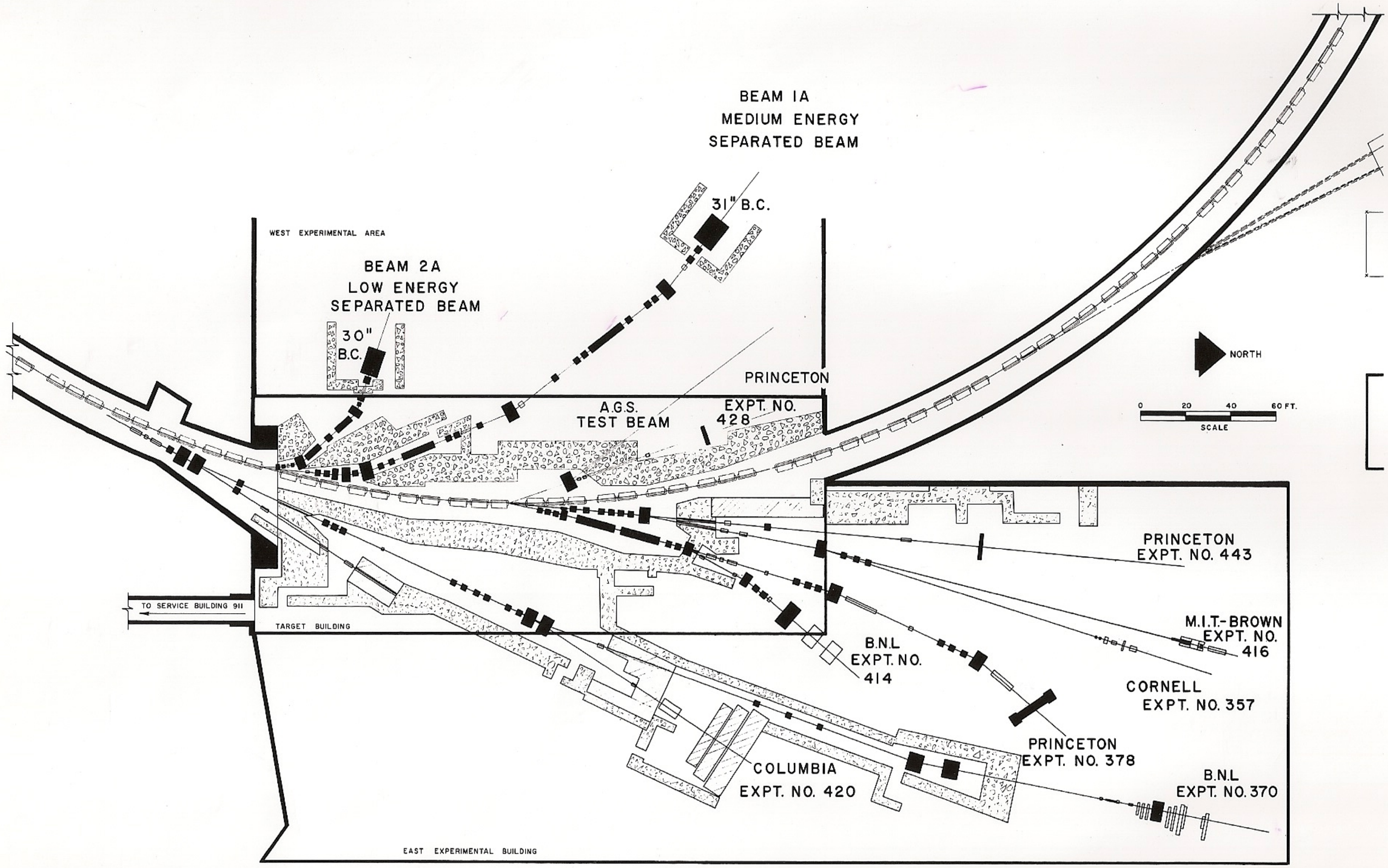

Fig. 1 Configuration of Beams in the Target and East Experimental Buildings - Spring 1969