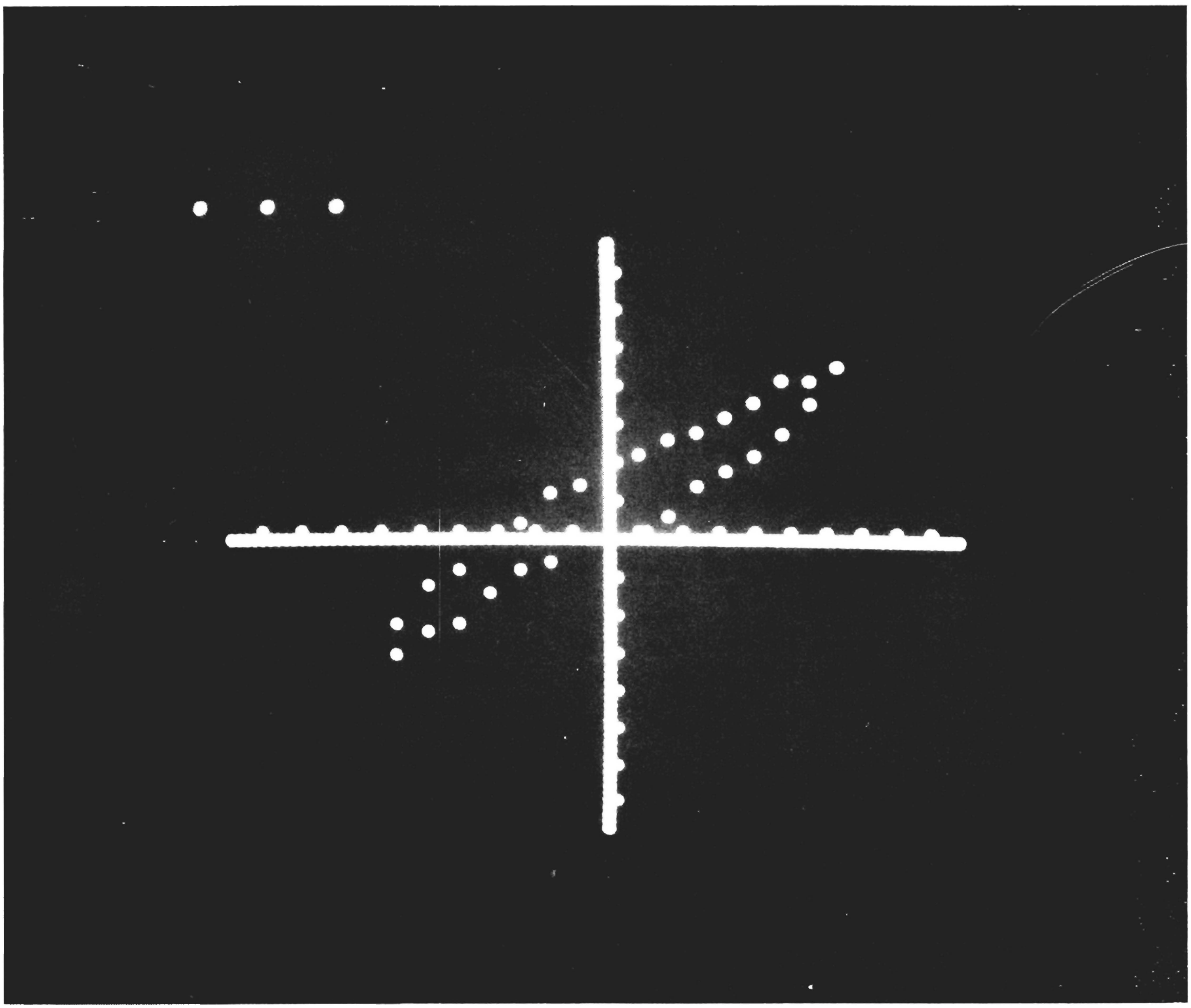
national accelerator laboratory

MONTHLY REPORT OF ACTIVITIES

April 30, 1969



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national accelerator laboratory

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MONTHLY REPORT OF ACTIVITIES

F. T. Cole

April 30, 1969

Abstract: This report covers the activities of the National Accelerator Laboratory for the month of April, 1969.

General

1. Accelerated Beam. A 600-keV proton beam was achieved in the prototype preaccelerator on April 17. Since then, the proton energy has been raised to 750 keV and the accelerated current to 70 milliamperes. This work is led by Cyril Curtis and Glenn Lee of the Linac Section.

The rapid beam-emittance measurement system developed by Michael Shea of the Booster Section is in operation and is being used with the preaccelerator. Edward Gray and Norman Lau of the Linac Section developed the software for the system. The cover photograph shows a phase plot produced by the system through the SDS computer. More phase plots and discussion of the initial operation are given under "Linac" below.

The high-voltage power supply, which is, of course, vital to this work, is on loan to us from the Argonne National Laboratory.

2. Name of the Laboratory. Dr. Glenn T. Seaborg, Chairman of the Atomic Energy Commission, announced on April 29 that the Commission will name the National Accelerator Laboratory in honor of the late Enrico Fermi.

Formal dedication and naming of the Enrico Fermi Laboratory will not take place until major construction work has been completed and the facility is in operation, probably in the fall of 1972.

Dr. Seaborg, in announcing the AEC's plans said: "It is particularly fitting that we honor Dr. Fermi in this manner, for in so doing we further acknowledge his many contributions to the progress of nuclear science, particularly his work on nuclear processes."

3. Construction Progress. Structural work has been completed on the four temporary laboratory buildings (Main Ring, Booster, Shop, Beam Transfer) in the Laboratory Village and the Sections are moving into them. Work on electric services to these buildings is under way.

Construction status of the major construction subcontracts is summarized in a table appended to this report. Figures 1 through 7 are recent photographs of aspects of the construction.

Fig. 1. A recent aerial photograph of the construction site, looking southeast. The linac building is behind the parking lot. The booster-enclosure excavation is to the right. The small white dots to the left and right of the far side of the booster excavation are main-ring survey monuments.

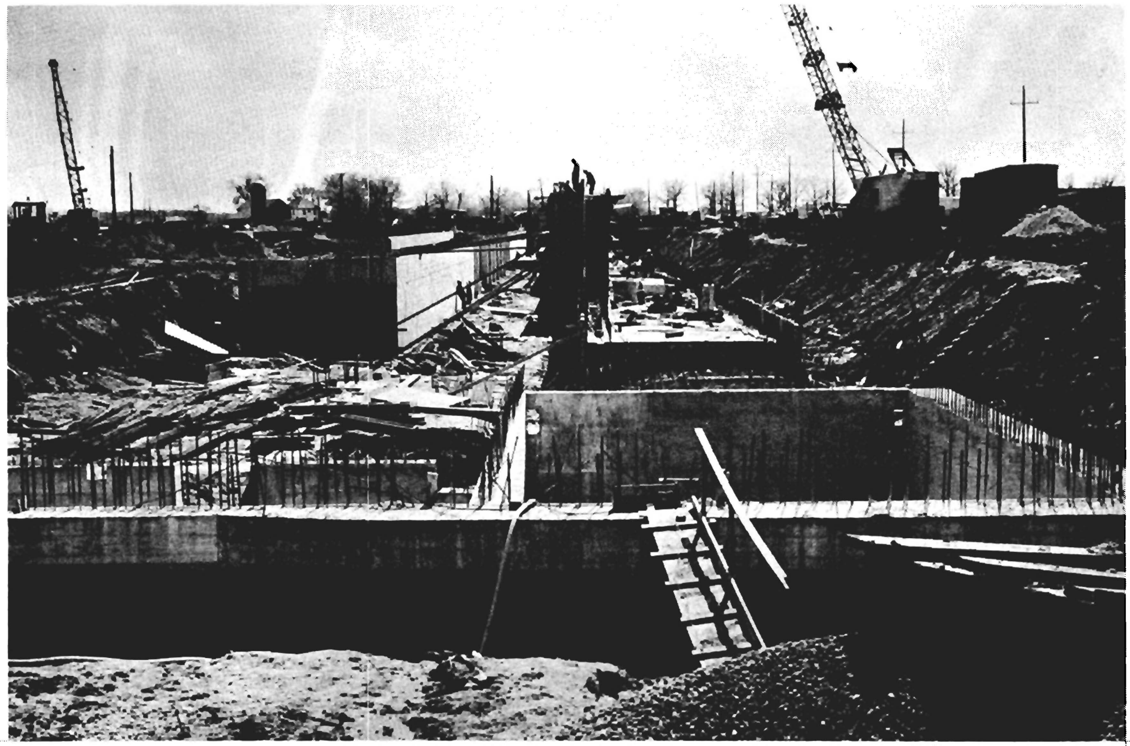


Fig. 2. The linac building. The preaccelerator pit is in the foreground, the cavity housing on the right, and the equipment gallery on the left.

Fig. 3. The booster excavation.

Fig. 4. Progress on the main road. The linac building is to the right.

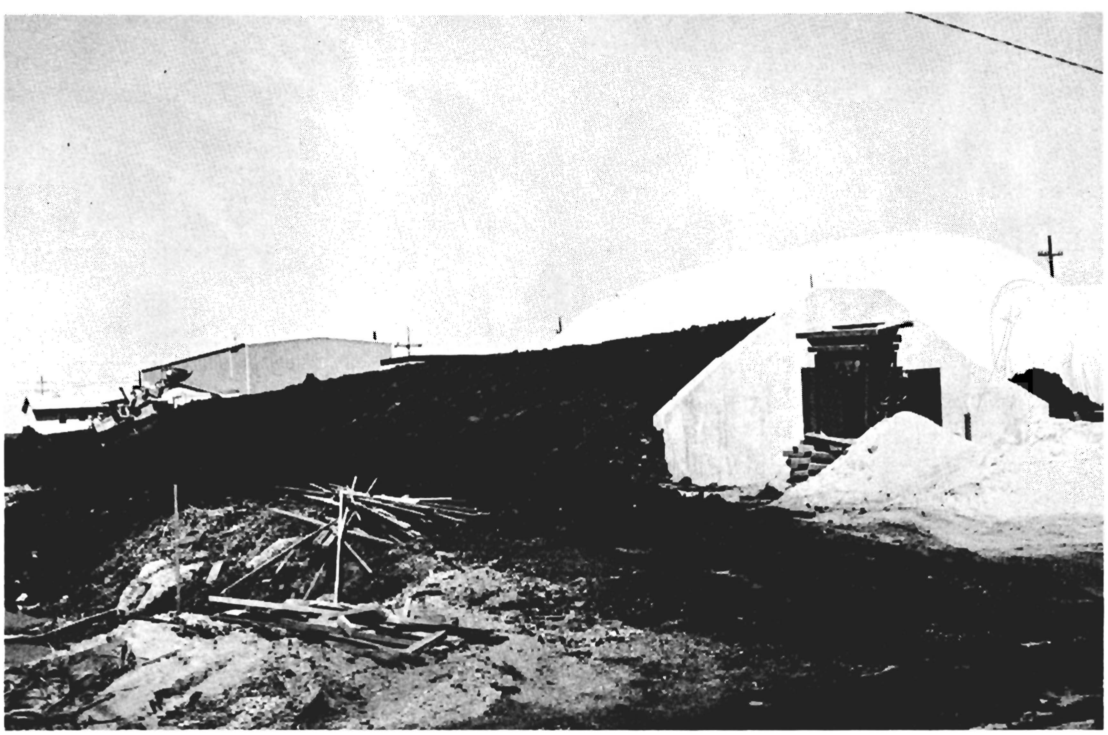


Fig. 5. The main-ring enclosure prototype.

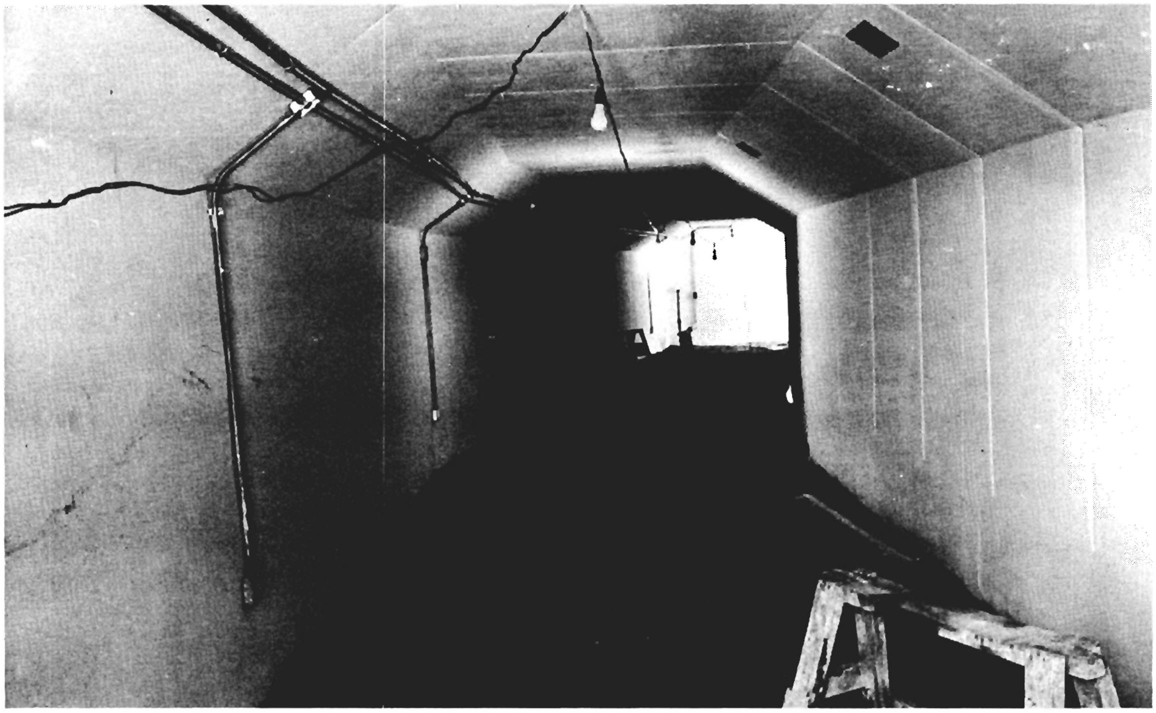


Fig. 6. Interior of the booster-enclosure prototype.

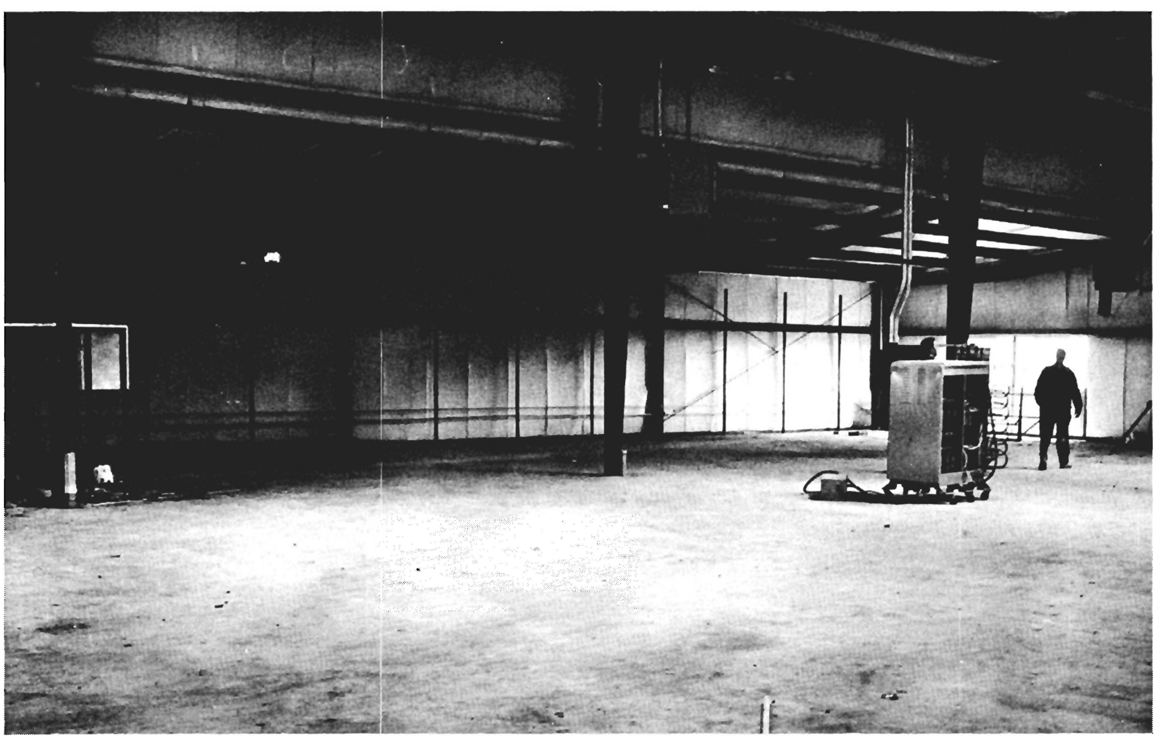


Fig. 7. The booster laboratory. The prototype equipment gallery is in the background.

4. Appointments. Frank Shoemaker will return to Princeton, from which he has been on leave. We all regret that he is returning to Princeton, but we are grateful to him for his outstanding contributions to the design of the main ring.

Accelerator Theory

High-β Modification and Main-Ring Aperture. The possibility of a modification to increase the orbit amplitude function β_x in the extraction straight section, mentioned in last month's report, led to a re-examination of the main-ring aperture. The vertical aperture in the main ring is fixed by space-charge limits and it has been decided that this aperture should be kept at its present value to keep the ultimate intensity capability of the accelerator larger than 10^{14} protons per pulse.

The horizontal aperture is now determined by requirements for beam extraction. Use of a high-β modification would reduce the requirements, but any significant reduction in horizontal aperture would mean that closed-orbit errors would have to be eliminated and that there would be no space for any orbit errors arising from injection or the passage through transition energy.

It has therefore been decided to keep the main-ring apertures at their present values, 5 by 1.5 inches in B1 magnets and 4 by 2 inches in B2 magnets. Were we at a somewhat more primitive design stage, it would be interesting to consider methods of reducing these errors that eat up aperture, but many design decisions have already been made.

Linac

1. Prototype Preaccelerator Operation. Figure 8 is an oscilloscope trace of the accelerated beam taken during the first few hours of operation. The current has since been increased to 70 mA.

The next several photographs show the operation of the beam-emittance measuring system. The beam passes through a narrow (0.003 in.) slit whose position can be remotely adjusted by a motor-drive probe drive. The slit defines a narrow vertical slice in the horizontal phase space. The beam then drifts approximately 4 inches to the segmented detector shown in Fig. 9, where the current is monitored from 20 segments (plus two end guards).

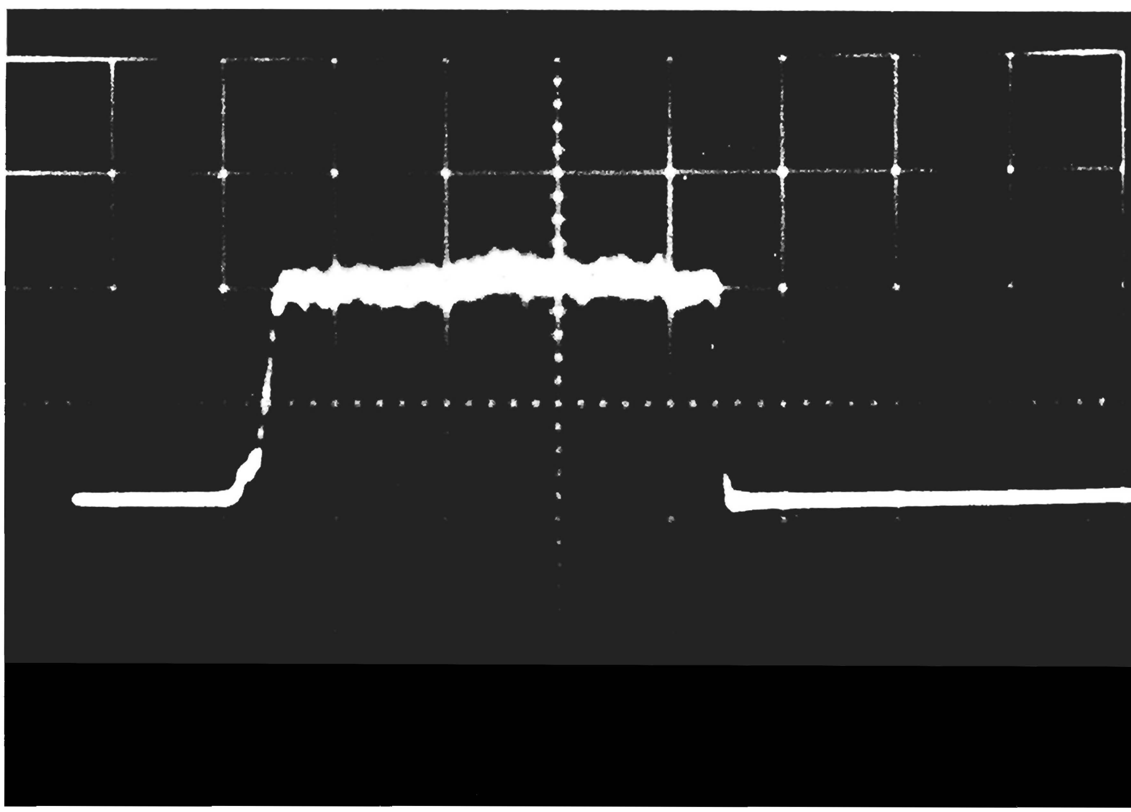


Fig. 8. Oscilloscope trace of preaccelerator beam (using a toroid current pickup developed by the RF Section). The ordinate is current, with 10 mA/cm. The abscissa is time, with 20 microseconds/cm.

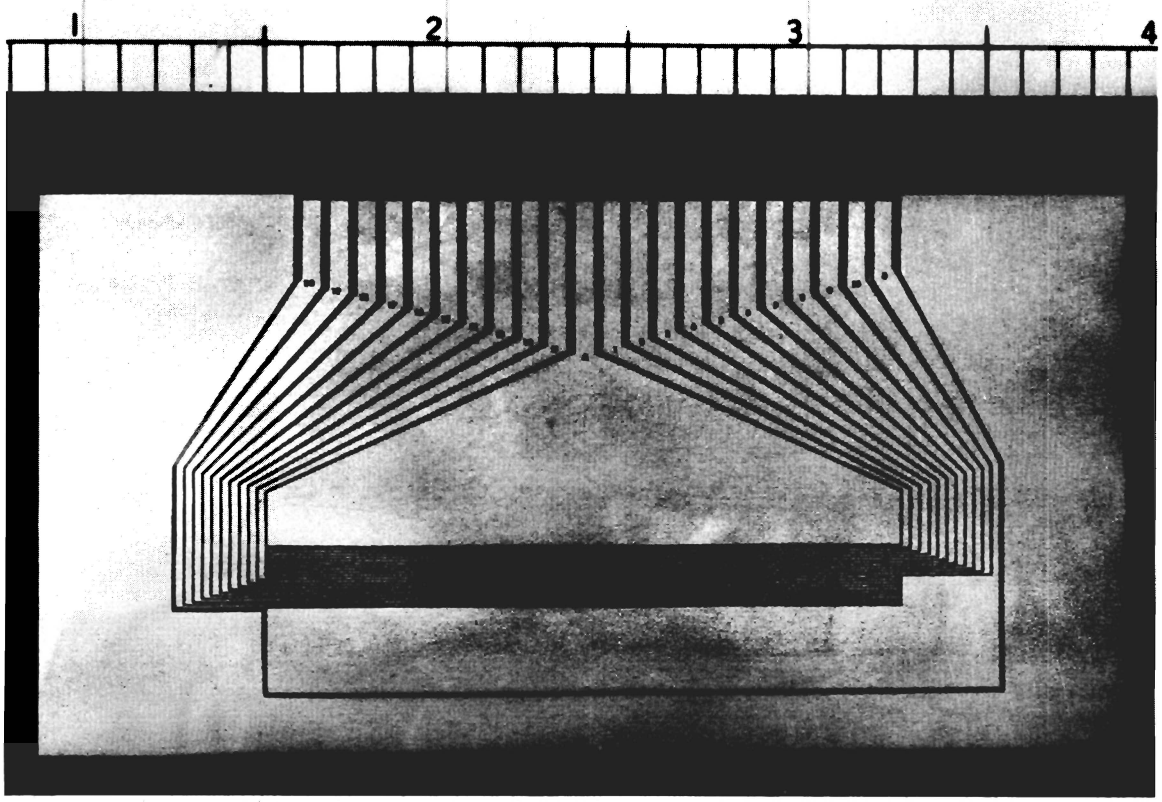
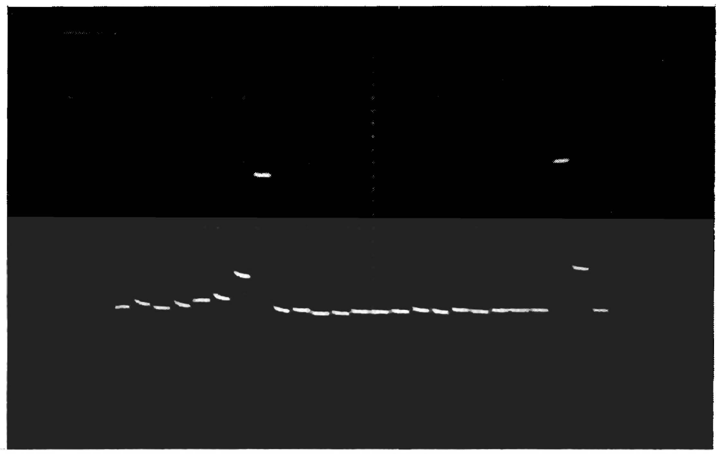


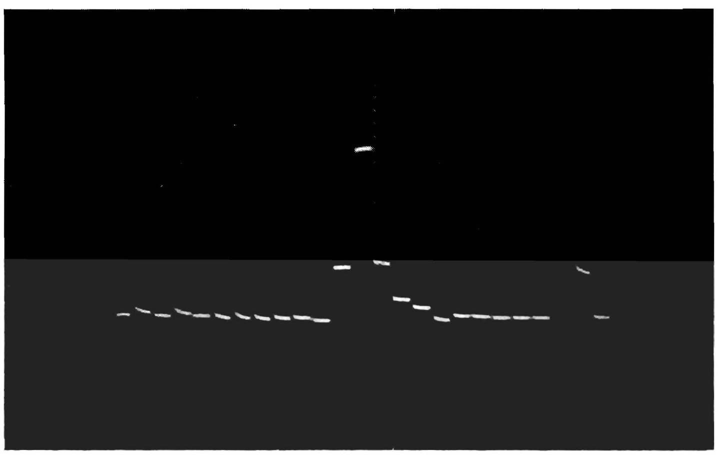
Fig. 9. The detector of the rapid beam-emittance measurement system.

Two examples of the raw data from the detector are shown in Fig. 10, with different slit positions x. The computer controls a sequence of measurements, stepping the slit position. An example of the alphanumeric control display is shown in Fig. 11. The operator can choose the sequence of steps and the threshold levels (as fractions of the density of the central portion of the beam). Figure 12 shows three such phase plots (not for the same case as Fig. 11). Each phase plot is generated in approximately 5 seconds.

The beam is extremely stable from pulse to pulse and it is therefore possible to get meaningful data on the changes in emittance during a pulse by sampling a number of pulses. Figure 13 gives examples of the emittances at different times during the pulse.



x = -2 cm



x = + 0.5 cm

Fig. 10. Data from the detector at two different slit positions.

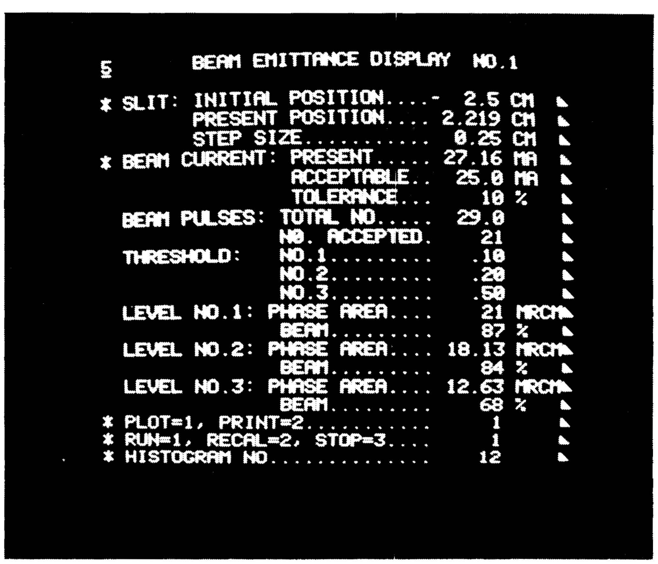
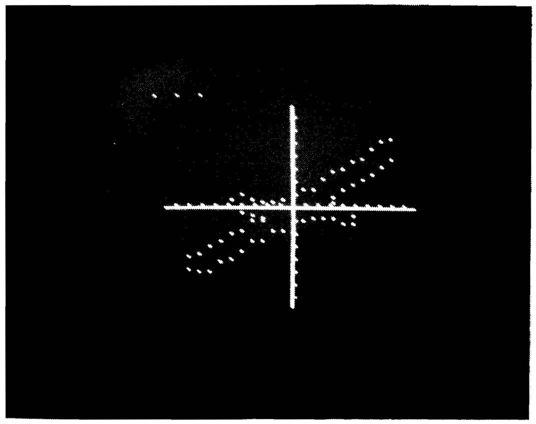
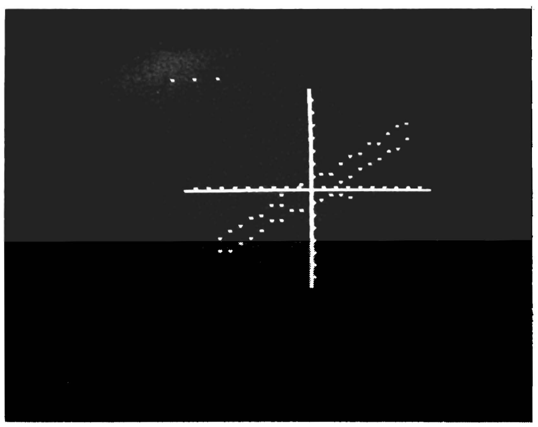


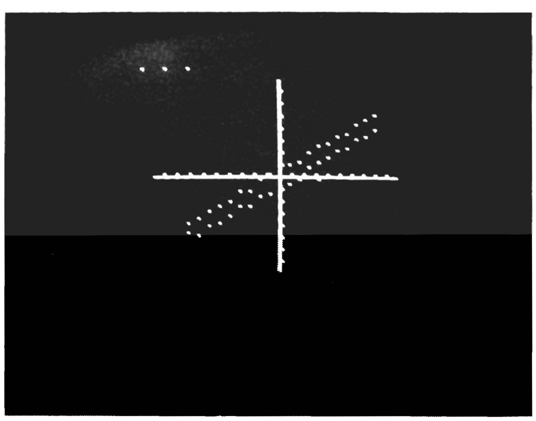
Fig. 11. The control display of the emittance measurements.



20%

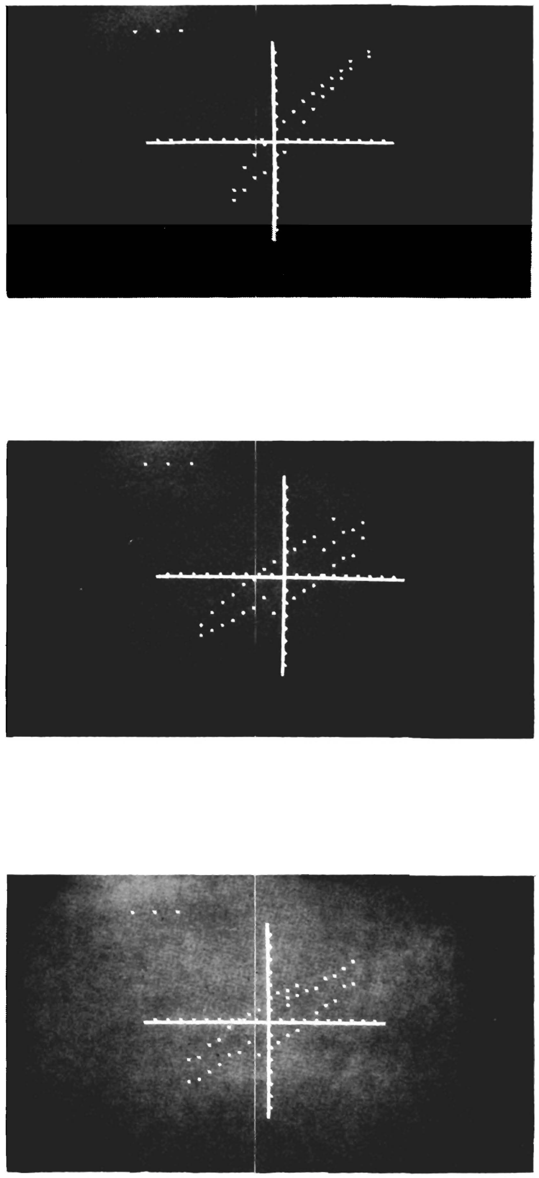


40%



60%

Fig. 12. Horizontal phase area of the preaccelerator beam for different fractions of the central density.



T + 5μsec

T + 20μsec

T + 90μsec

Fig. 13. Horizontal phase area at different times during the pulse.

Now that the equipment is in operation, a systematic study of the effects of source parameters on emittance will be undertaken. A similar system to measure vertical emittance is under construction, as is a system to measure emittances at the entrance to the first linac cavity.

2. RF System. Assembly and installation of the 5-MW prototype rf system have been completed and the system has been operated into a dummy load. Further system tests and tuning are continuing.

3. 10-MeV Cavity. Electrical measurements on the empty cavity have been completed. A quality-factor (Q) value of 90,000 (86% of the theoretical value) was measured. This gratifyingly high value is believed to be a result of the extensive work in preparing and cleaning the copper cavity surfaces.

Main Ring

1. Model-Quadrupole Measurements. Magnetic measurements generally confirm the computer design of the quadrupole. More detailed measurements are in progress. The second set of coils has been delivered and installed; they are much more satisfactory than the first set (discussed in last month's report).

2. Quadrupole Design. The main-ring aperture studies discussed above gave impetus to a re-examination of the quadrupole-coil design. It is now realized that a better, lower-cost magnet can be built with a 12-turn coil rather than a 17-turn coil. The increase in power-supply cost arising from the larger current is very small because a limited number of thyristor sizes are readily available, and the 17-turn coil therefore was forced to use a thyristor somewhat larger than necessary.

Radiation Physics

1. Booster Enclosure. Our estimates of gamma-ray exposure in the booster have been calculated independently by R. G. Alsmiller of Oak Ridge National Laboratory. There is excellent agreement between the calculations, which supports our decision to limit the sodium content of the enclosure-wall concrete.

2. Main-Ring Enclosure. As part of the Design Specification (Title I) review of the main-ring enclosure, we held discussions of the radiation-physics design with the Advisory Panel on Accelerator Radiation Safety (APARS) at a meeting here on April 23 and 24. There appeared to be no substantial disagreement on our conclusions, but we are awaiting their report.

Beam Transfer

Electrostatic Septum. The septum model has been installed in the Brookhaven AGS. It operated at electric fields approximately twice the design value, with no difficulties (such as electric breakdown) occurring when the proton beam bombarded either the septum or the cathode. Tests will continue throughout May. It is a pleasure to acknowledge the hard work and contributions of our Brookhaven colleagues to this work.

Experimental Facilities

1. 25-Foot Bubble Chamber. The first Brookhaven-NAL coordination meeting on the chamber was held at Brookhaven. It was decided as a design basis to fix the magnetic field at 40 kG, with a coil separation of 5 feet.
2. Model Superconducting Bending Magnet. The winding of the coil has been completed. The coil has been tested to 950 A, the current required for 20 kG in the final configuration.
3. Superconducting Solenoid. The twisted-strand coil has been rewound with additional insulation, which removed the turn-to-turn shorts described here last month. The coil has been tested; the critical current is independent of the charge rate over the range tested. The fastest charging rate

gave 10 kG in 0.3 sec, limited by the power supply. A new coil, with better insulation has been wound and is being tested.

APPENDIX

Construction Subcontract Status

Subcontract	Percent Complete
Site Grading and Rough Roads	53
Booster Prototype	97**
Main-Ring Prototype	76*
Linac Building	17
Booster Enclosure	1
Survey Monuments	100
Survey House	1

All as of March 31, except as noted.

*As of April 11.

**As of April 15.

Fig. 14. Tree planting on Arbor Day. Jerry Jones supervises Carolyn Noble and Rene Tracy (all of Planning and Scheduling) and Miguel Awschalom of Radiation Physics.