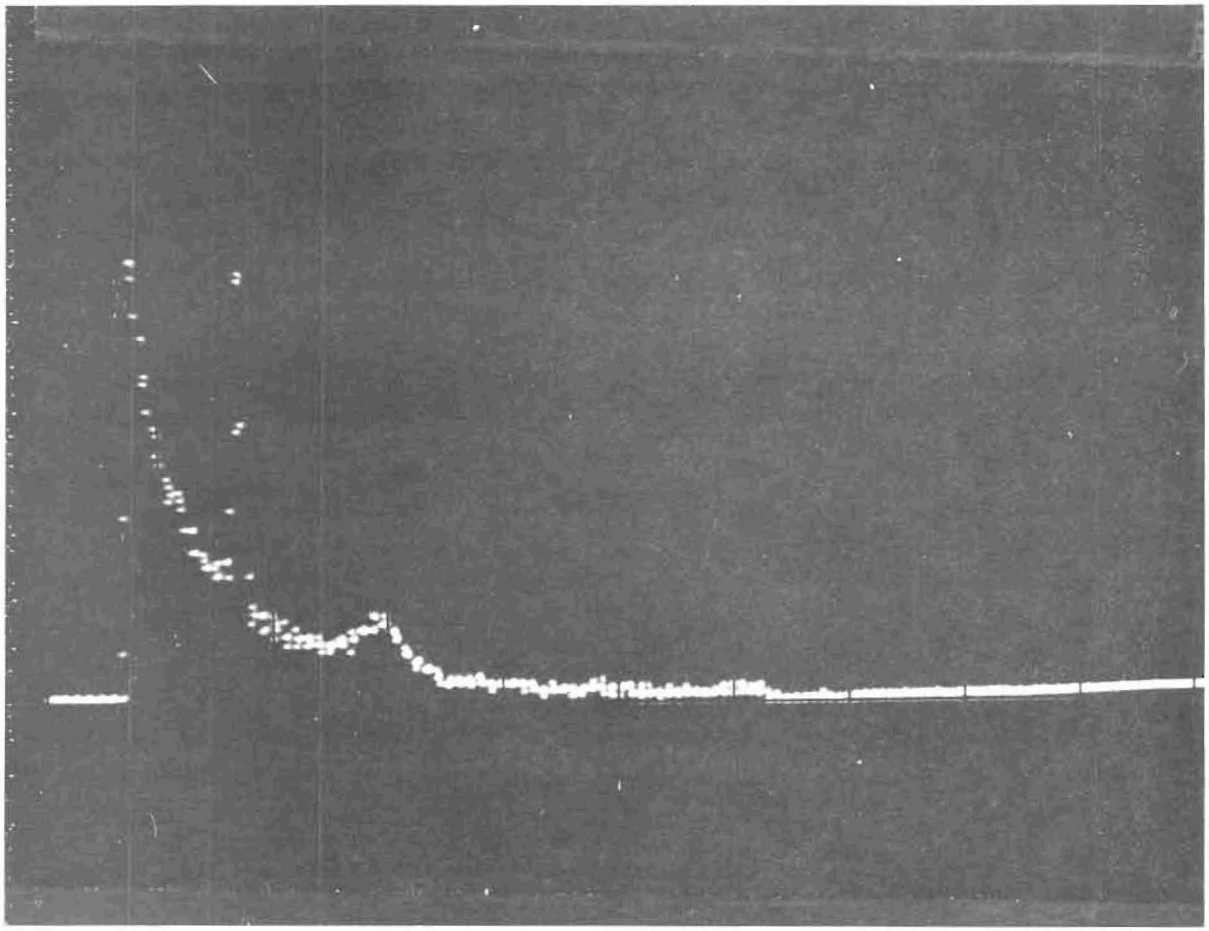
national accelerator laboratory

NAL-69
0090.01

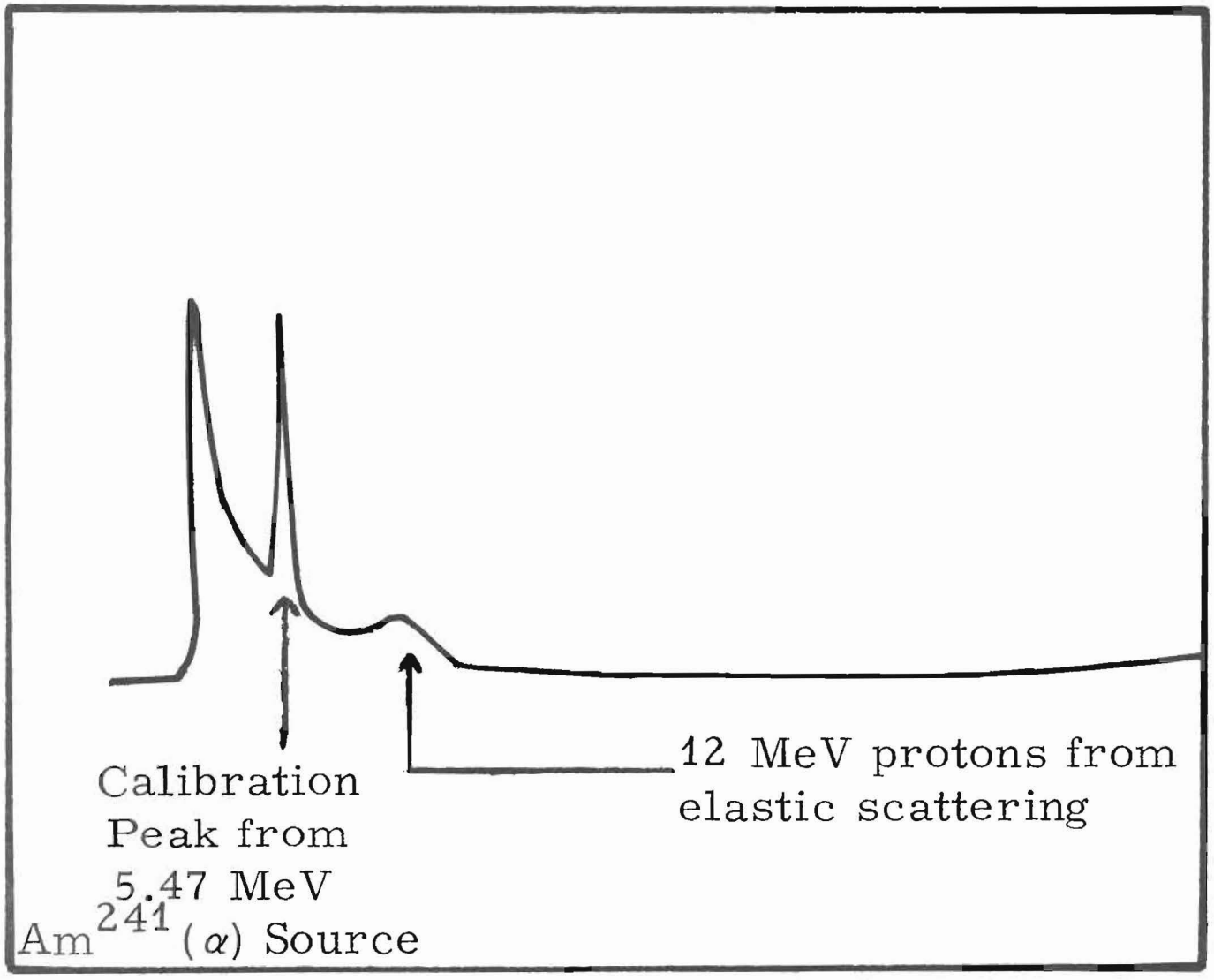
MONTHLY REPORT OF ACTIVITIES

March 31, 1972



DATA FROM FIRST HIGH-ENERGY PHYSICS EXPERIMENT AT NAL

Operated by Universities Research Association Inc. Under Contract with the United States Atomic Energy Commission



THE COVER: Indication of recoil protons from p-p elastic scattering integrated from 21-57 GeV.

NAL-69
0090.01

MONTHLY REPORT OF ACTIVITIES

March 31, 1972

Abstract: This report summarizes the activities of the National Accelerator Laboratory in March, 1972.

Experiment # 36

The physics program at NAL began the night of March 6 when the elastic scattering of high-energy protons was first detected. Data-taking continued throughout the following week. This first experiment on the elastic scattering of protons at small angles, Experiment # 36, is being done in the Internal Target Area at the CO Straight Section of the Main Ring. The technique used is to measure the angle and energy of the slow recoil protons using semi-conductor detectors inside a vacuum box that is integral with the accelerator vacuum system and at angles from 90° to 79° to the beam line. Four institutions are participating: Rockefeller University, the University of Rochester, the Joint Institute for Nuclear Research at Dubna, USSR, and NAL. There are two major physics objectives: 1) a measurement of the differential cross section in the forward direction and determination of the slope of the p-p nuclear diffraction peak; 2) a measurement of the real part of the nuclear scattering amplitude by using the nuclear-Coulomb interference. The first part of the experiment was started using a target constructed at the University of Rochester consisting of a tiny rotating foil of polyethelene, 2 microns thick and with dimensions such that the accelerator beam hits it for approximately 500 microseconds out of each 16 milliseconds. The elastic

peak illustrated on the cover was obtained in six hours of running at a beam intensity of approximately 2×10^{10} protons/pulse and a 3 second repetition rate. The recoil protons in this illustration had a momentum transfer of $0.024(\mathrm{GeV}/c)^2$, 12 MeV kinetic energy, and are an integration over primary proton energies from 21 to 57 GeV.

In order to carry out the second major objective of the experiment, determination of the real part, the target must be thinner than is possible with polyethelene. During this phase of the experiment, a narrow jet of cold hydrogen gas, or possibly tiny hydrogen "ice" crystals, will be shot through the beam in a few 0.2-second pulses during the acceleration cycle. In order to maintain a good vacuum in the accelerator, it is necessary to pump the large volume of hydrogen gas involved at high speed. This is accomplished by shooting the jet into a helium cooled cryo-pump where the hydrogen is frozen. Every half hour or so the whole jet-cryo-pump assembly is raised remotely out of the accelerator and the accumulated hydrogen in the cryo-pump is sublimated away. The idea of using a thin target of relatively high density hydrogen in the circulating beam of an accelerator was proposed by the Soviet Group from Dubna. They developed the advanced technology required to accomplish this and carried out a small angle p-p experiment at the Serpukhov accelerator using this technique. The Soviet Group of seven scientists accompanied by their wives arrived in the United States on March 5 and brought with them a gas jet target constructed in the Dubna Machine Shop to fit in the main-ring tunnel at NAL. They also brought an array of solid-state detectors and associated fast electronics. Rockefeller University has furnished the PDP-11 Computer and NAL has supplied the helium liquifier and

the vacuum system that connects the target to the accelerator and to the detector array. Right now the Soviet and American scientists are working together to assemble the diverse pieces from two sides of the world into a unified system. This assembly is being done in the NAL Village and it is hoped that by the end of May final tests will be complete and the jet target will be installed in the Main Ring. Simultaneously, with this effort, data-taking will continue with the foil target.

Accelerator Section

In addition to the above, the accelerator operated for the first part of the month for various accelerator experiments. There were control difficulties with the bimodal ramp used to accelerate to 200 GeV. (The bimodal ramp has a number of 30-GeV pulses and, every 45 seconds, a ramp to 200 GeV. It was put in to circumvent the heating problems arising from the lack of water cooling.) A single ramp to 75 GeV was therefore installed and operated. A series of high-field orbit-position measurements was taken. There was some correlation with the previous low-field measurements, particularly in the relatively large excursions in Sector C. A program of moving magnets in accordance with computer simulations of these orbit deviations is being inaugurated (similar to the successful program in the booster). Commissioning work was also done on the beam-position measuring system in order to bring all the data back to the control room and avoid the present tedious trips to service buildings.

The operation was suspended on March 11 for work on reconnection of the cooling-water system. By the end of the month, the cooling system was in operation and regular acceleration to 200 GeV will be started soon.

The magnets were also high-potted at 2 kV several times during the month. In this exercise, 9 bending magnets and 5 quadrupoles with shorts to ground were detected. One quadrupole was repaired in place and the other magnets were replaced.

Proton Switchyard

The proton switchyard is the complex of tunnels and magnets that guide the extracted proton beam to the experimental areas. The beam line is complete for the Neutrino Area (the central beam line), the installation for the Meson Area is 90% complete, and the first part of the beam line for the Proton Area has been installed so that construction and installation may continue further downstream during operation of the first two laboratory areas.

In the first week of March, 1972, there was some success in extracting the beam from the Main Ring. Two one-meter-long dipoles were pulsed to bump the beam into an electrostatic septum, which by a combination of Coulomb scattering and electric field bending, diverts the beam into the magnetic septum and extraction channel. A few percent of the 75-GeV beam was extracted and detected in the Transfer Hall. See Figs. 1 and 2.

The beam lines are basically composed of a doublet focusing system of quadrupoles ten feet long, with the doublets spaced at about 400-500 foot intervals. Tunnel areas are connected by 8 or 12-in. pipelines, but the basic apertures are the quad apertures (3-in. diameter) and the dipole apertures (1-1/2 in.×3 in.). The first "switch" in the beam line is three dipoles (also 10 ft in length) which will switch the beam into the Proton Area transport line. At the beginning of the next tunnel, two dipoles act as the switch to the Meson Area. The switching dipoles will be replaced by splitting stations consisting

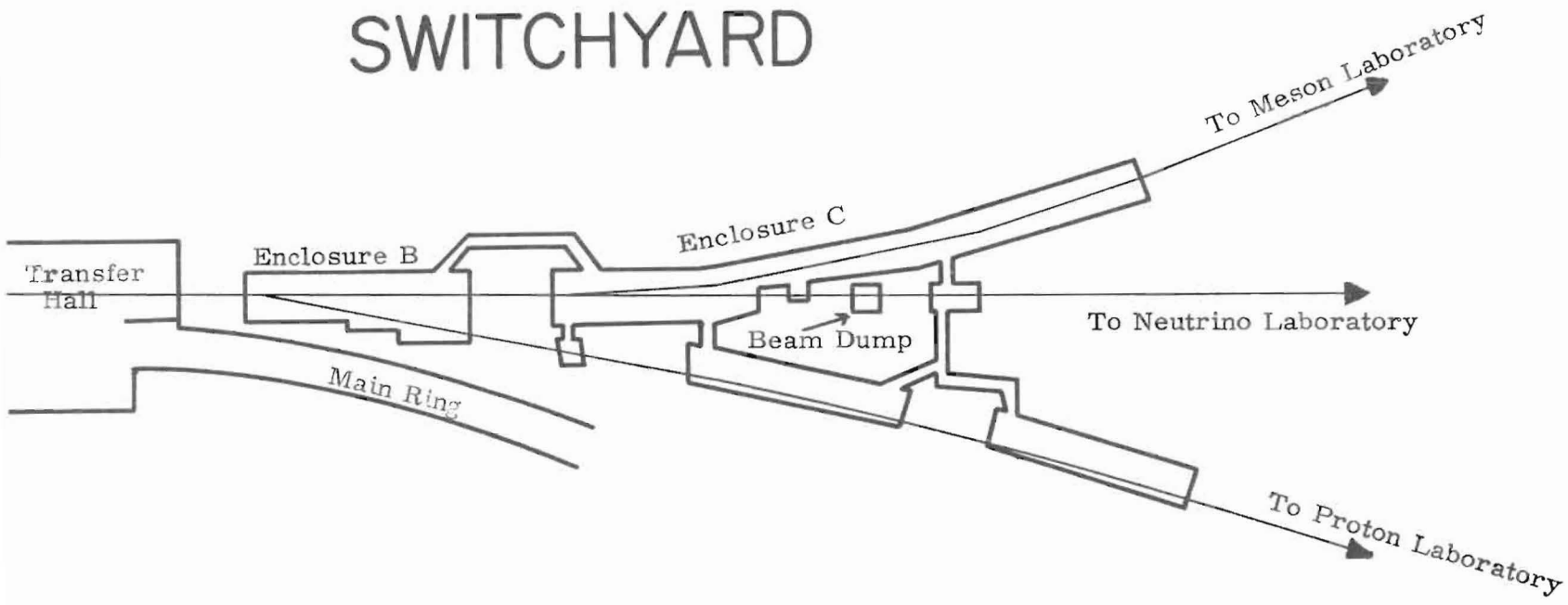


Fig. 1. Schematic of Switchyard (not to scale).

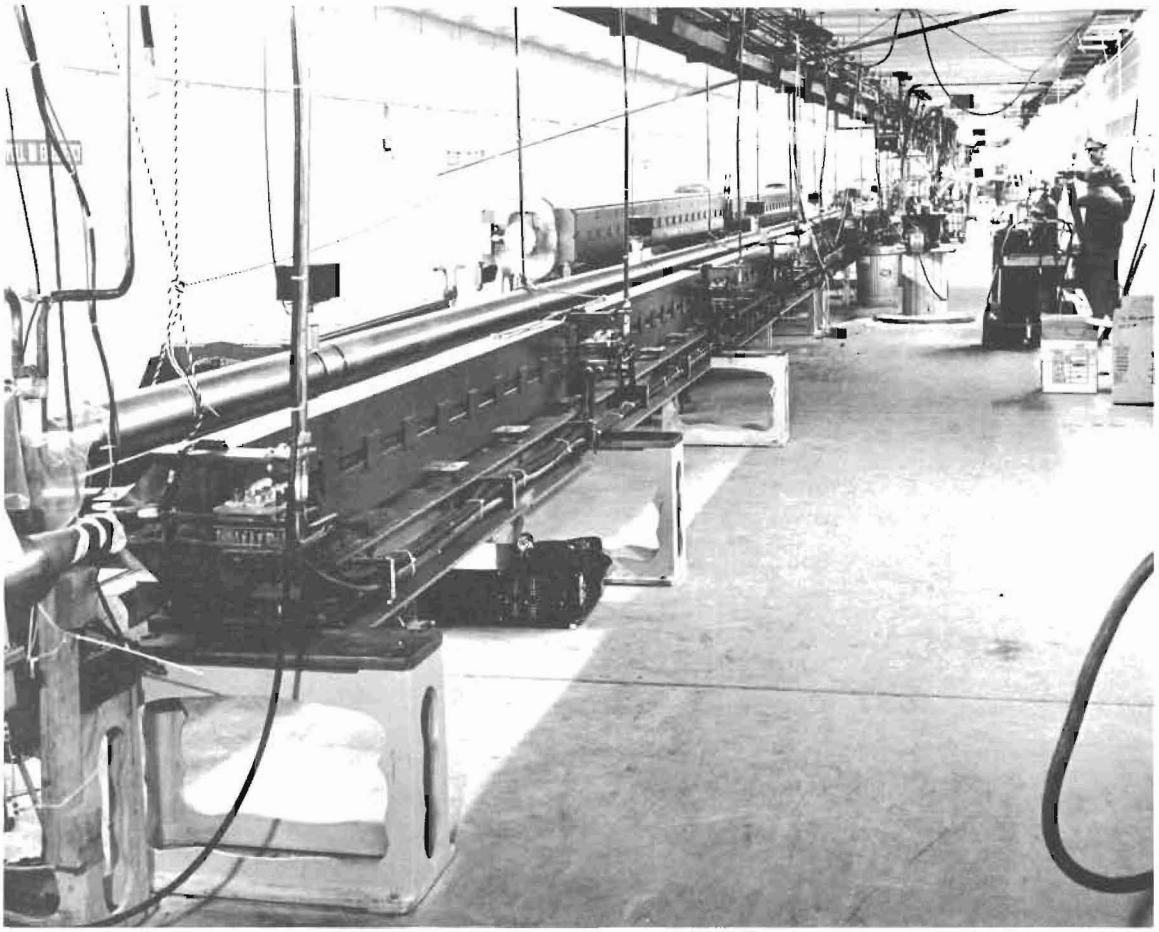


Fig. 2. The last set of horizontally bending dipoles in the extraction channel. This is a view looking upstream from outside of the Main Ring in the Transfer Hall. The extraction magnets are shaped to clear the pipe in the Main Ring straight section. Do not be confused by a number of stand-by Main Ring magnets that can be seen in the background.

of electrostatic splitter and magnetic channels. This is to allow simultaneous operation of laboratory areas. See Figs. 3 and 4.

Fig. 3. Looking upstream in the first transport tunnel, Tunnel B. The dipoles on the left bend the beam toward the Proton Lab, and the straight ahead line shows a quadrupole pair providing focusing for the beam to the Meson and Neutrino Areas.

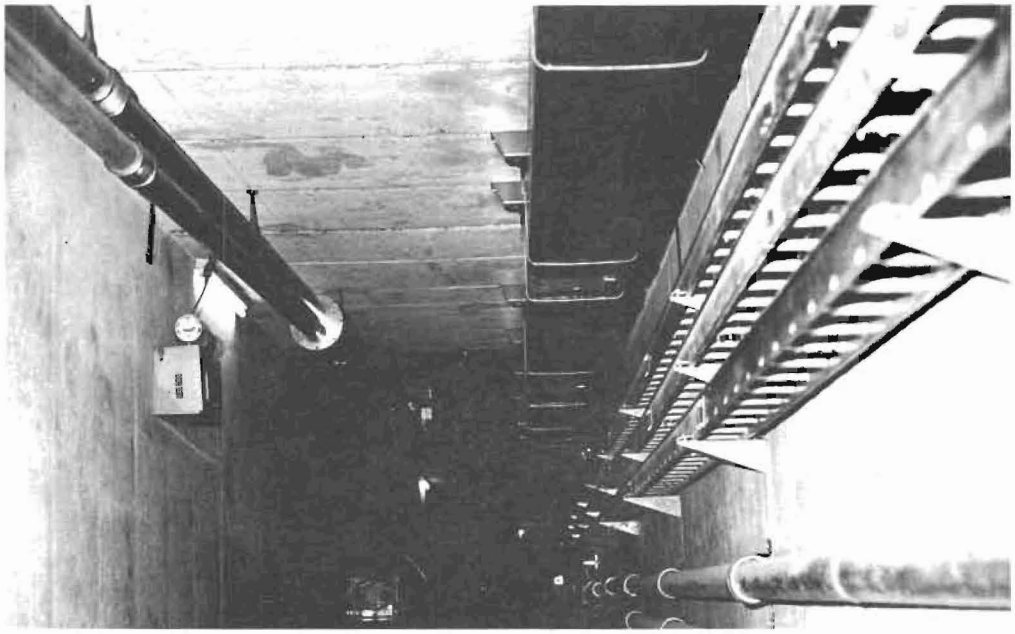


Fig. 4. Looking upstream showing three beam lines. The dipoles on the right bend toward the Meson Area, and the two beam pipes on the left are for the beam dump and the Neutrino Area.

When the switching magnets are off, the beam continues down the Neutrino Beam Line, where it is finally switched up at a 10-mrad angle to reach the elevation of the Neutrino Target Area. If these dipoles are off, the beam continues at Main Ring beam elevation for about 300 ft to the dump. See Fig. 5. The dump has the capacity for dissipation of the full design beam power. It is composed of a rectangular aluminum core 1-1/2 × 1-1/2 × 6 ft, surrounded by steel billets in a watertight 12 × 12 × 16-ft box, with piping for water cooling if needed. The box is filled with water. See Figs. 6 and 7.

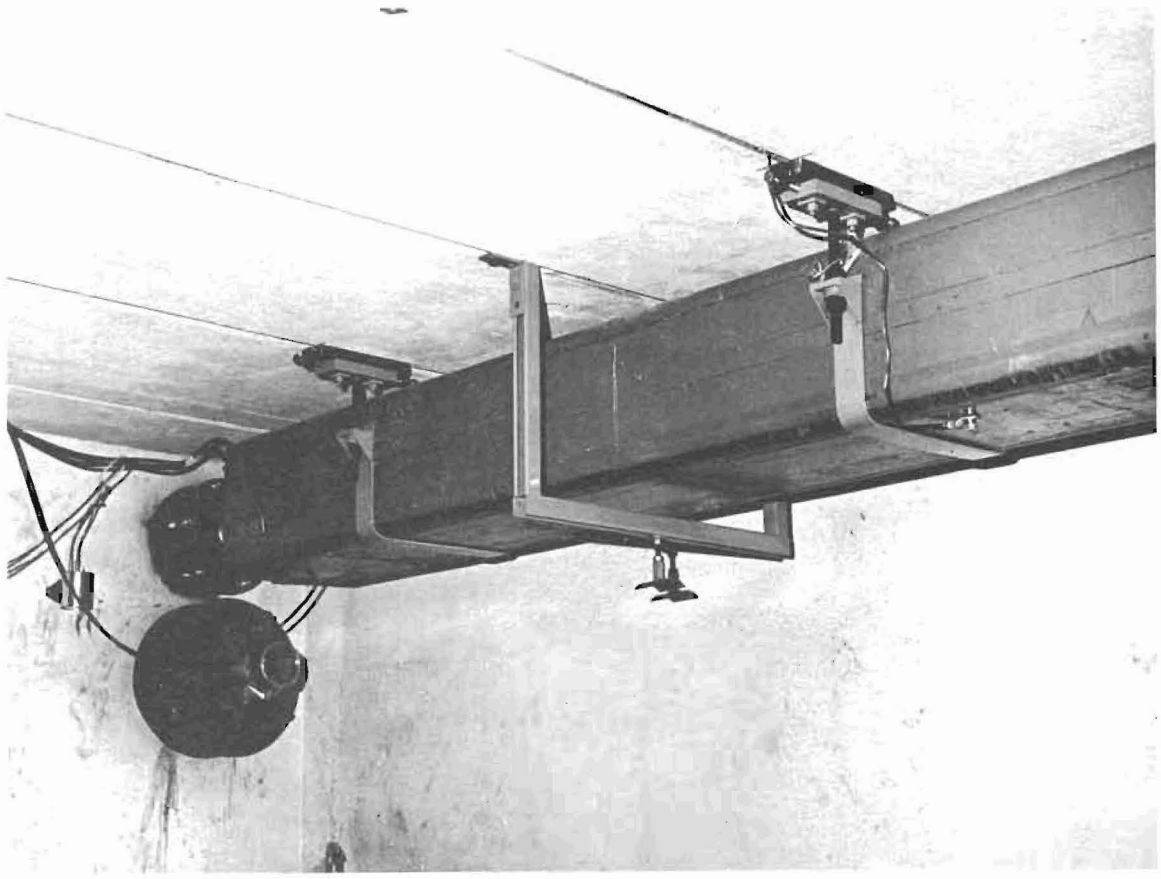


Fig. 5. The last tunnel section before a 12" pipe leading to the dump (below), and an 8" pipe leading to the first of three "manholes" in the Neutrino line. Each manhole has two quads of the type shown here.

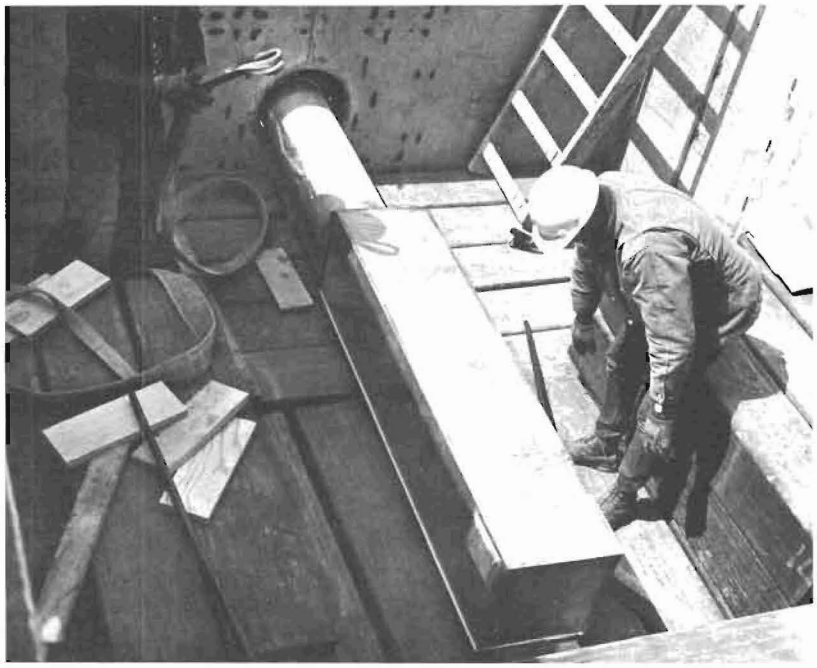


Fig. 6. The beam dump, showing the aluminum core sheathed in stainless steel.

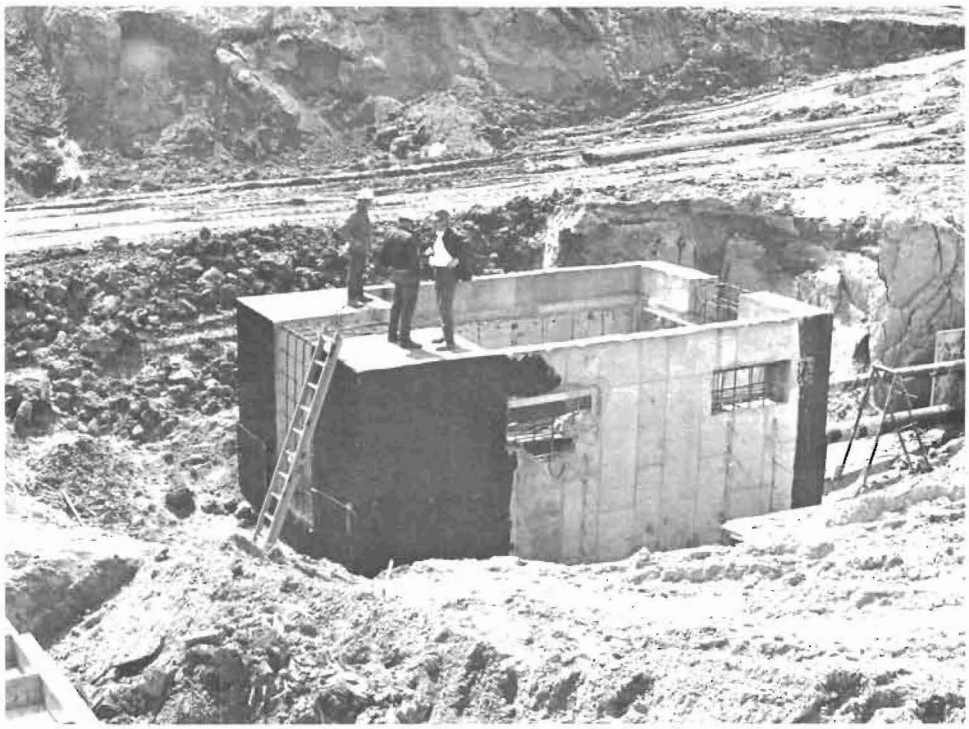


Fig. 7. The beam dump showing the pipes to the dump core and to the Neutrino Laboratory.