STATUS OF THE BNL 200-MEV INJECTOR LINAC*

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ABSTRACT

The 200-MeV proton linac injector for the AGS is nearing completion. The pre-injector and first accelerating cavity have accelerated over 200 mA to 10.4 MeV. The current status of the linac installation is outlined.

One of the major features of the AGS Conversion Project is the installation of a new higher energy, high intensity injector for the AGS. A 200-MeV proton linac was chosen and detailed design was started in 1967. The general parameters of this linac are given for reference in Table I. Figure 1 shows an aerial view of the AGS Complex with the Linac Building on the far side of the ring. By September 1969, the building was sufficiently near completion to permit the start of component installation.

TABLE I

General Parameters of the 200-MeV Linac

Preinjector Energy	0.75 MeV
Output Energy	200.3 MeV
Peak Beam Current	100 mA
Emittance (100 mA at 200 MeV)	π cm-mrad
Beam Pulse Length (Max)	200 μsec
RF Pulse Length	400 μsec
Operating Frequency	201.25 MHz
Number of Cavities	9
Total Length of Accelerator	144.8 m
Number of Unit Cells	286
Total Peak RF Excitation Power	22 MW
Pulse Repetition Rate (Max)	10 pulses/sec

The preinjector, consisting of a Haefely Cockcroft-Walton (Fig. 2), duoplasmatron source and high gradient accelerating column (Fig. 3), was installed and operating by January 1970. The performance of the preinjector[1] has been most gratifying although some development work remains to be done. At very high currents (400 mA at the base of the column) some form of pulse shortening occurs and high current operation has been

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restricted to pulse lengths below 50 μsec. In addition, the emittance of the preaccelerator, while adequate for linac operation and AGS injection, is not as small as we believe possible. The low energy beam transport system (Fig. 4) is about 8 m long and contains eight sets of triplets, two fundamental frequency bunchers and beam analyzing equipment.[2]

The first accelerating cavity was installed in the building concurrently with the preaccelerator. The rf system, pulsed quadrupole supplies, vacuum and cooling were completed by March. A complete analysis station for the 10-MeV beam was installed in the area now occupied by Cavity No. 2 and included emittance devices and a momentum analyzing magnet.

A proton beam was first accelerated to 10 MeV on March 24, 1970. The initial run-up of the system proceeded remarkably smoothly as no serious problems were encountered. The traditional problem of multipactoring in the cavity was overcome in about one day of operation. The cavity can readily operate at fields 50% above the design value. Very little difficulty with sparking was noted; nevertheless, the low energy drift tubes show typical sparking patterns (Fig. 5), although without any damage.

From April through July, the 10-MeV beam was run regularly and a detailed study made of the operating characteristics. Table II shows the peak performance obtained. The operation of the system was extremely stable. Beams of 150 mA were accelerated for several hours at a time without any manual adjustments required. As an additional exercise, deuterons were accelerated to 5 MeV in the 2βλ mode. A peak current of 18 mA was achieved using 400 kV injection voltage.

TABLE II

Operation at 10.4 MeV

Injection Energy	780 kV
Emittance at input, Horiz.	19.5 π cm-mrad
Vert.	19.5 π cm-mrad
Emittance at 10 MeV, Horiz.	6 π cm-mrad
Vert.	7.5 π cm-mrad
Cavity synchronous phase	-32°
Current at base of column	0.400 A
Current at entrance of cavity	0.270 A
Current at 10 MeV	0.210 A
Energy	10.4 MeV
Energy Spread (FWHM)	0.5 MeV
Cavity Transmission	79%

During the period of 10 MeV testing, installation of Cavities No. 3 and on continued. Cavity No. 3 has been tested with full rf power and is ready for beam. No multipactoring difficulties were encountered nor any rf problems with the multistem arrangement. Figure 6 shows the interior of Cavity No. 3 and is typical of the multistem cavities. At the present time, all cavities are in position except for No. 9. Figure 7 shows the tunnel from the low energy end and Fig. 8 from the end of Cavity No. 7 looking toward the preinjector. Cavities No. 4 and No. 5 are under vacuum and ready for rf power, No. 6 and No. 7 have been aligned and final low level rf tuning is completed. Alignment of Cavity No. 2 is complete and rf tuning is in process. Alignment of drift tubes in Cavity No. 8 is starting and No. 9 will be moved into the building in October.

All nine of the rf amplifier stations are in place in the upper equipment bay (Fig. 9) and five of the stations have been tested. The quadrupole magnet power supplies, cavity cooling systems and rough vacuum pumps are installed in the lower equipment bay as seen in Fig. 10. Complete controls to the local control stations are being installed concurrently with the equipment. However, at present, the linac control room is in rudimentary form. The Data Acquisition and Display System, which is the heart of the overall control system, has been developed and tested and the components are now being procured.

The high energy beam transport system will carry the 200-MeV beam from the linac about 400 feet to the injection point in the AGS. Thirty feet beyond the end of the linac there will be a fast switching magnet which permits the deflection of pulses not used for injection into a spur tunnel. Here will be located a complete beam analysis system to continuously monitor the linac beam. Also provisions are incorporated for use of this beam for radiochemistry experiments and for the production of large quantities of radioisotopes by the BNL Department of Applied Science. Components for the high energy beam transport system are now being procured and installation will start shortly. A debuncher (15 feet long and developing 5 MV) is planned and the cavity ordered. However, its completion and installation will have to be delayed. Without the debuncher, it may not be possible, initially, to inject the full 100 mA into the AGS because of the large energy spread introduced by longitudinal space charge forces in the long transport line.

First acceleration of protons to 200 MeV is scheduled for the end of December 1970 and injection into the AGS for July 1971. Based on the performance of the 10 MeV section of the linac, we expect the machine to accelerate 100 mA to 200 MeV with an emittance of about π cm-mrad without difficulty. Although 200 mA was successfully accelerated to 10 MeV, the rf systems for Cavities No. 2 through 9 were not designed with sufficient power to accelerate 200 mA on a continuous basis. Nevertheless, we hope to achieve close to 150 mA in short pulses.

References

1. V. J. Kovarik and Th. J. M. Sluyters, "Proceedings of the IV International Symposum on Discharges and Electrical Insulation in Vacuum," Waterloo, Ontario, Sept. 1970, p. 172.
2. The details of this and other systems are contained in several papers included in the Proceedings of this Conference.

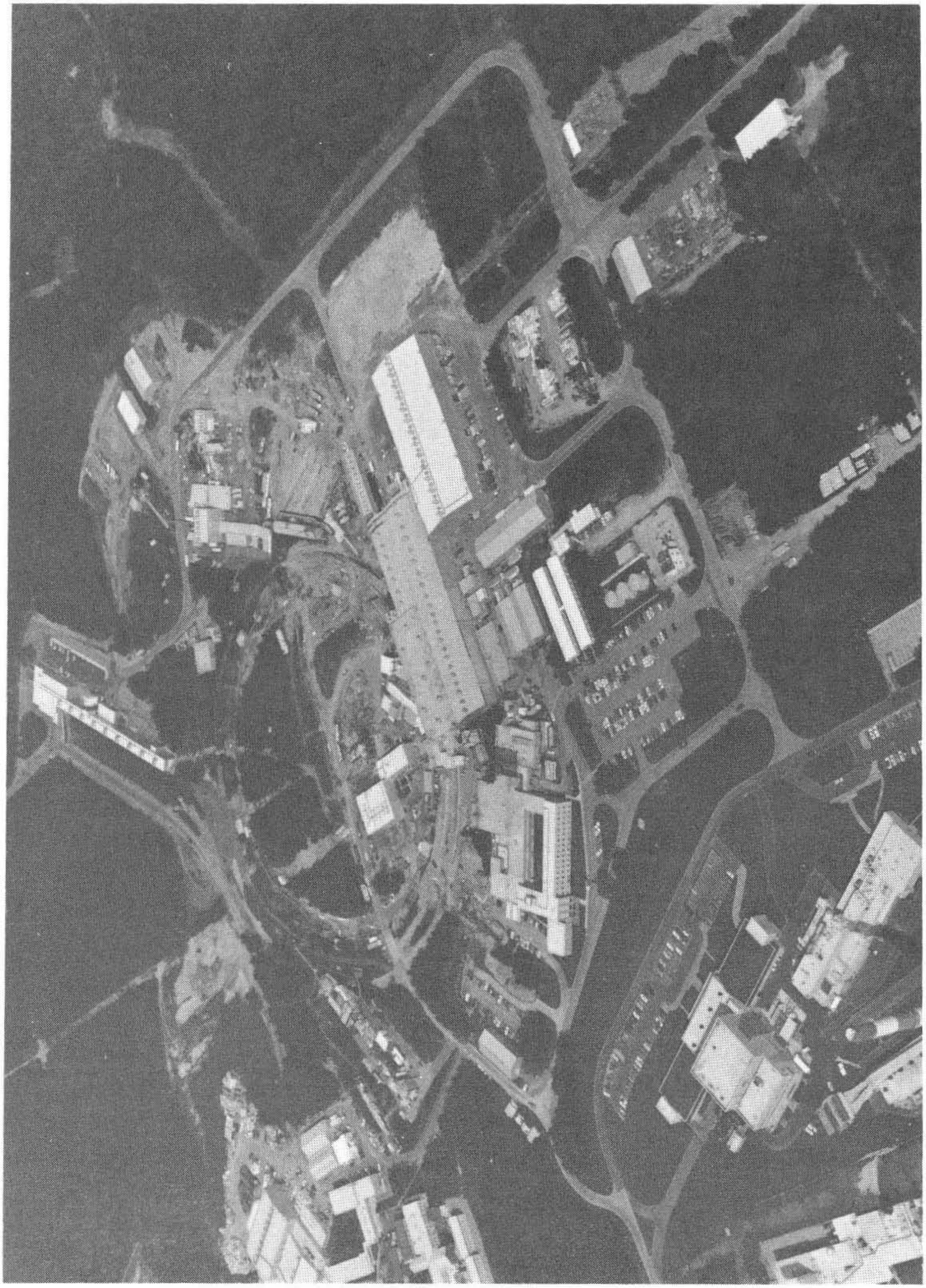

Fig. 1. Aerial view of the AGS Complex showing the Linac Complex on the far side of the ring.

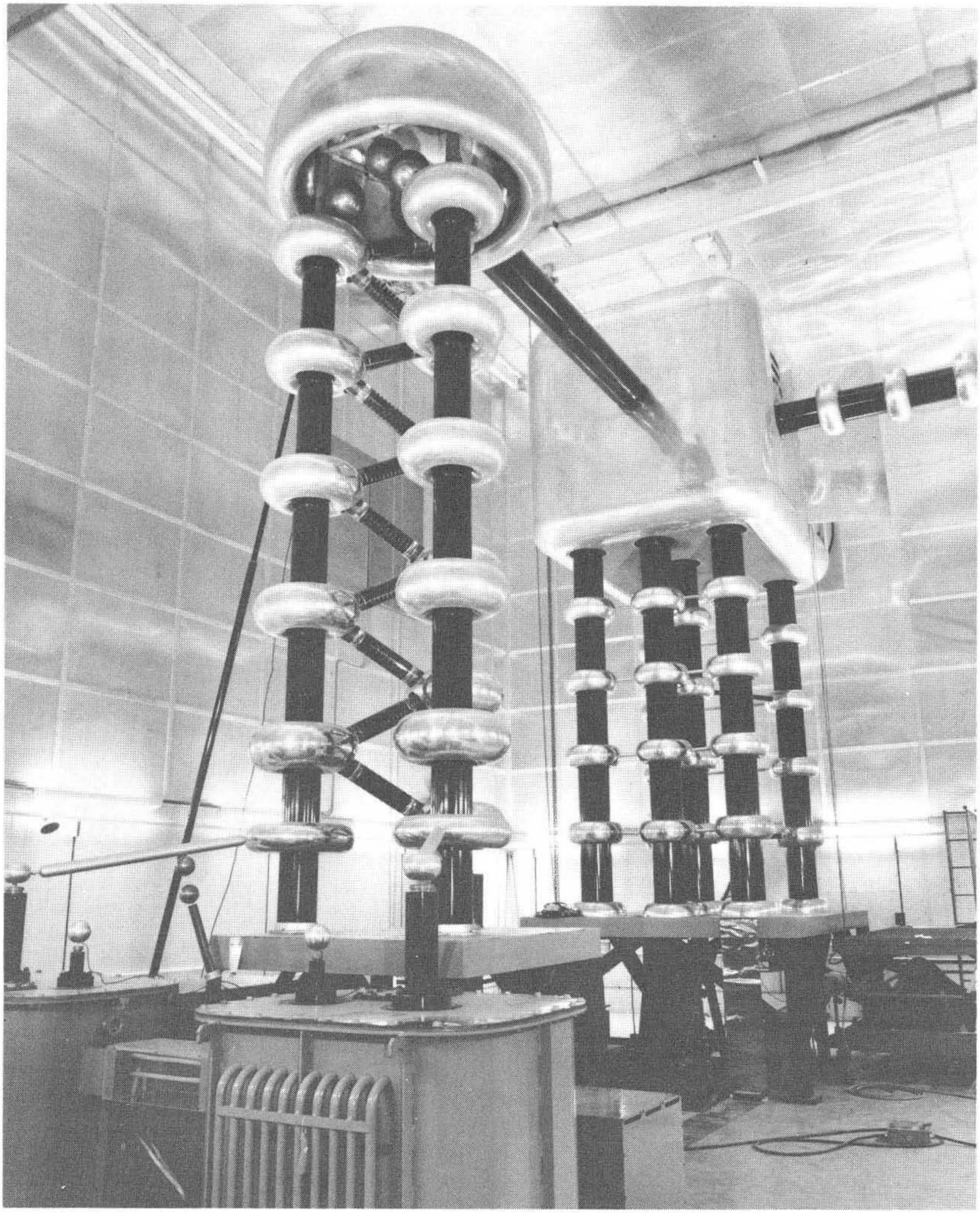

Fig. 2. The Cockcroft-Walton preinjector.

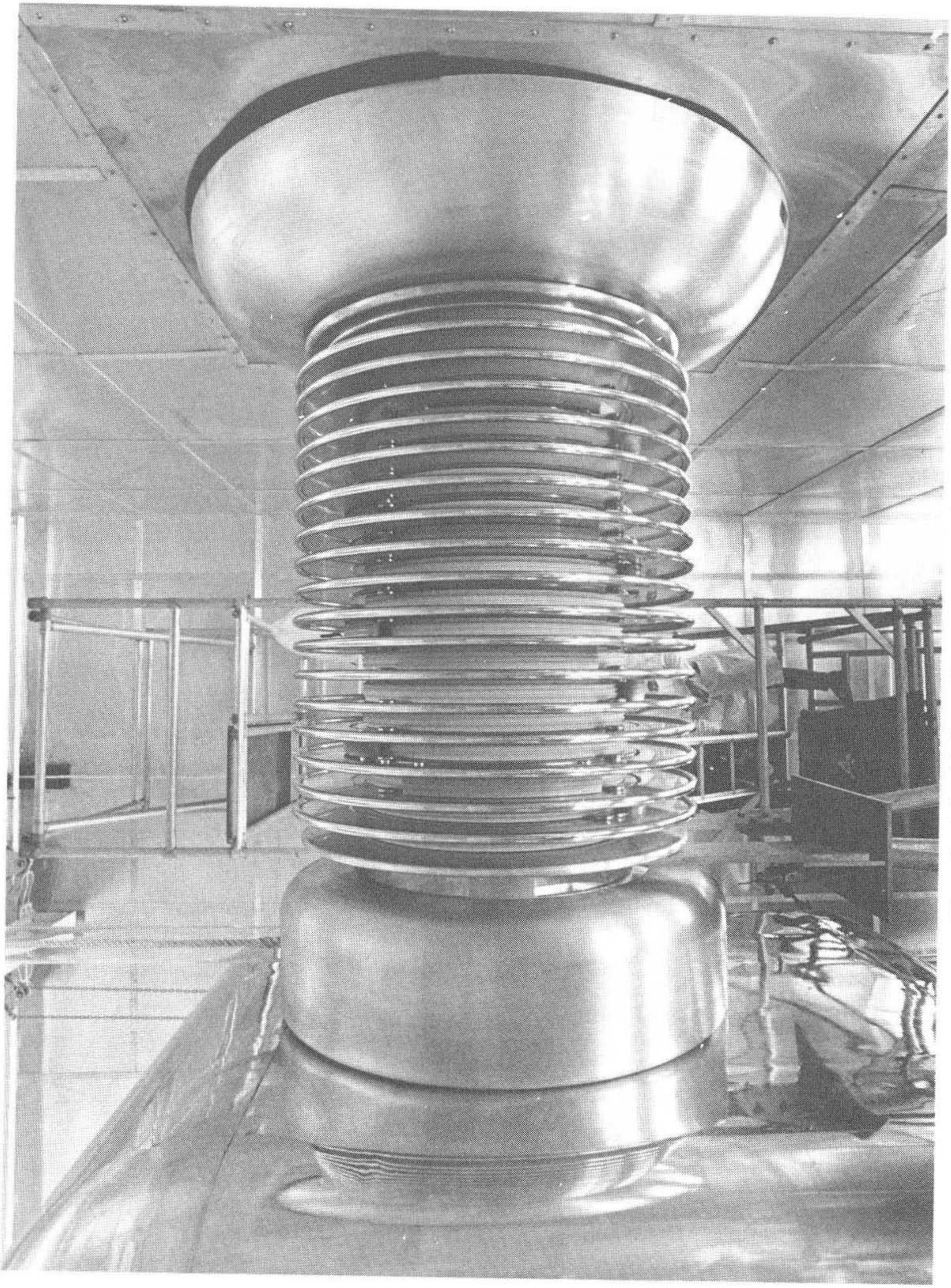

Fig. 3. The high gradient accelerating column.

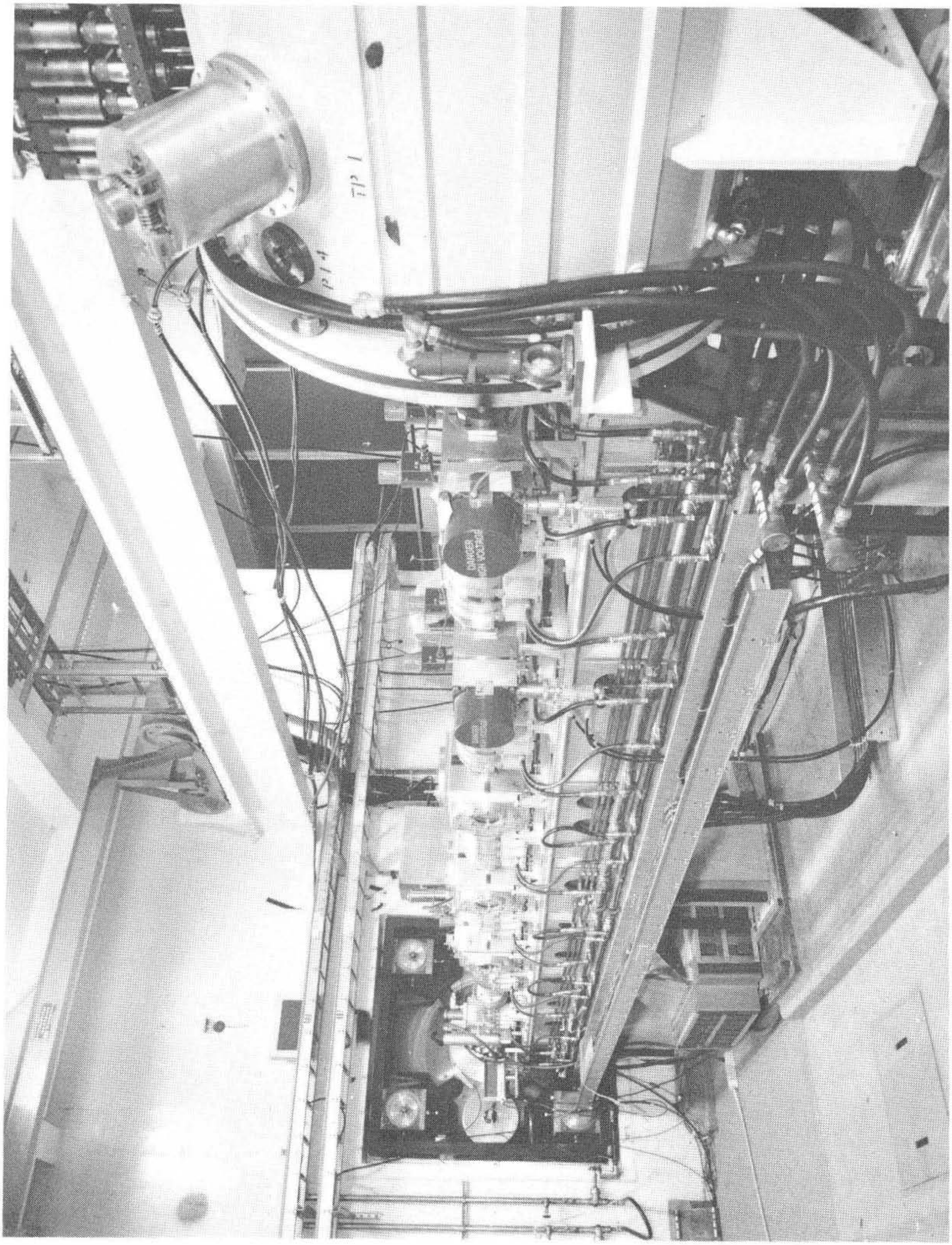

Fig. 4. The low-energy beam-transport system.

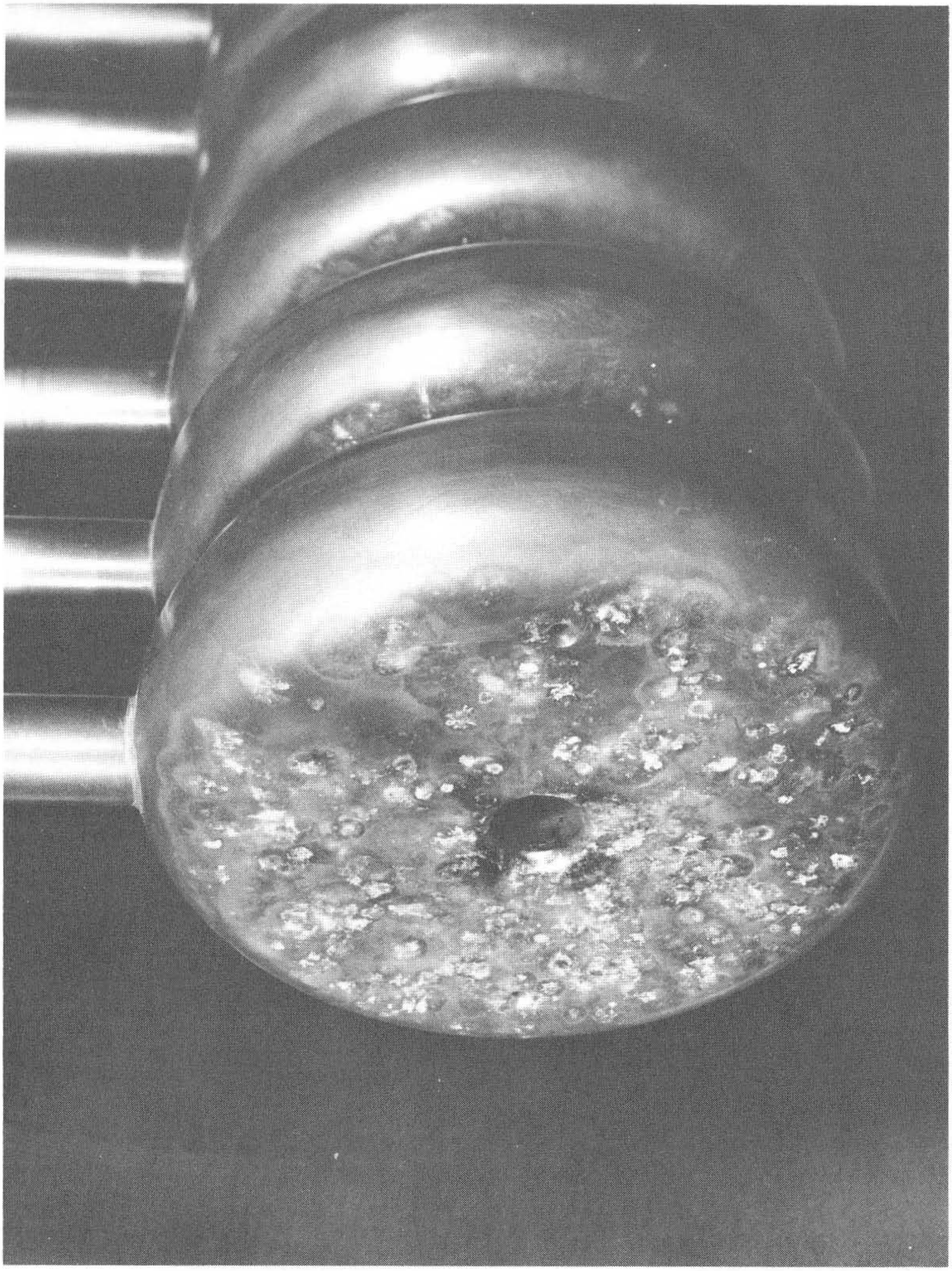

Fig. 5. The first drift tube of Cavity No. 1, showing sparking patterns.

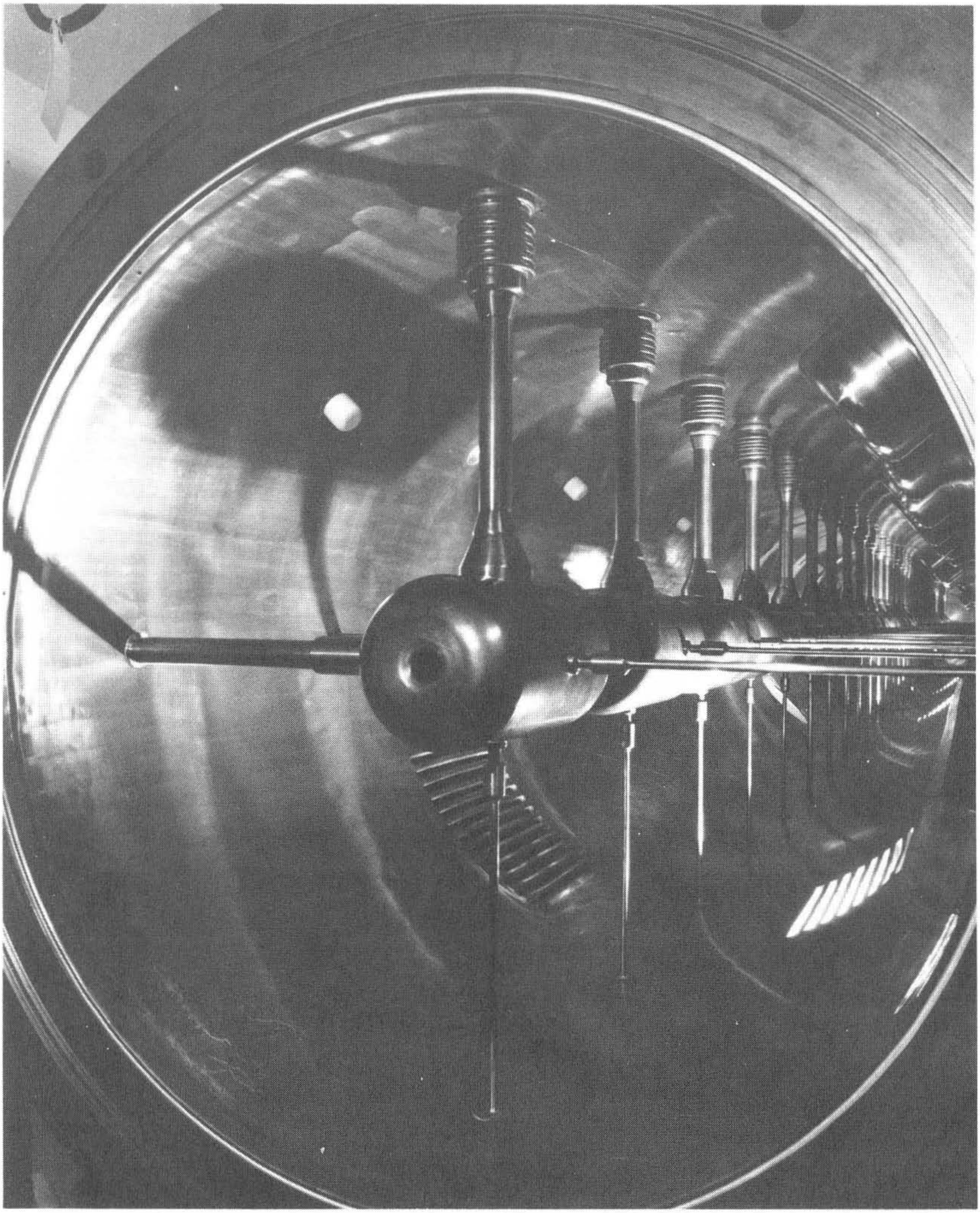

Fig. 6. The interior of Cavity No. 3 from the low-energy end, showing the multi-stem arrangement, tuning bar and slugs, vacuum ports and rf probes.

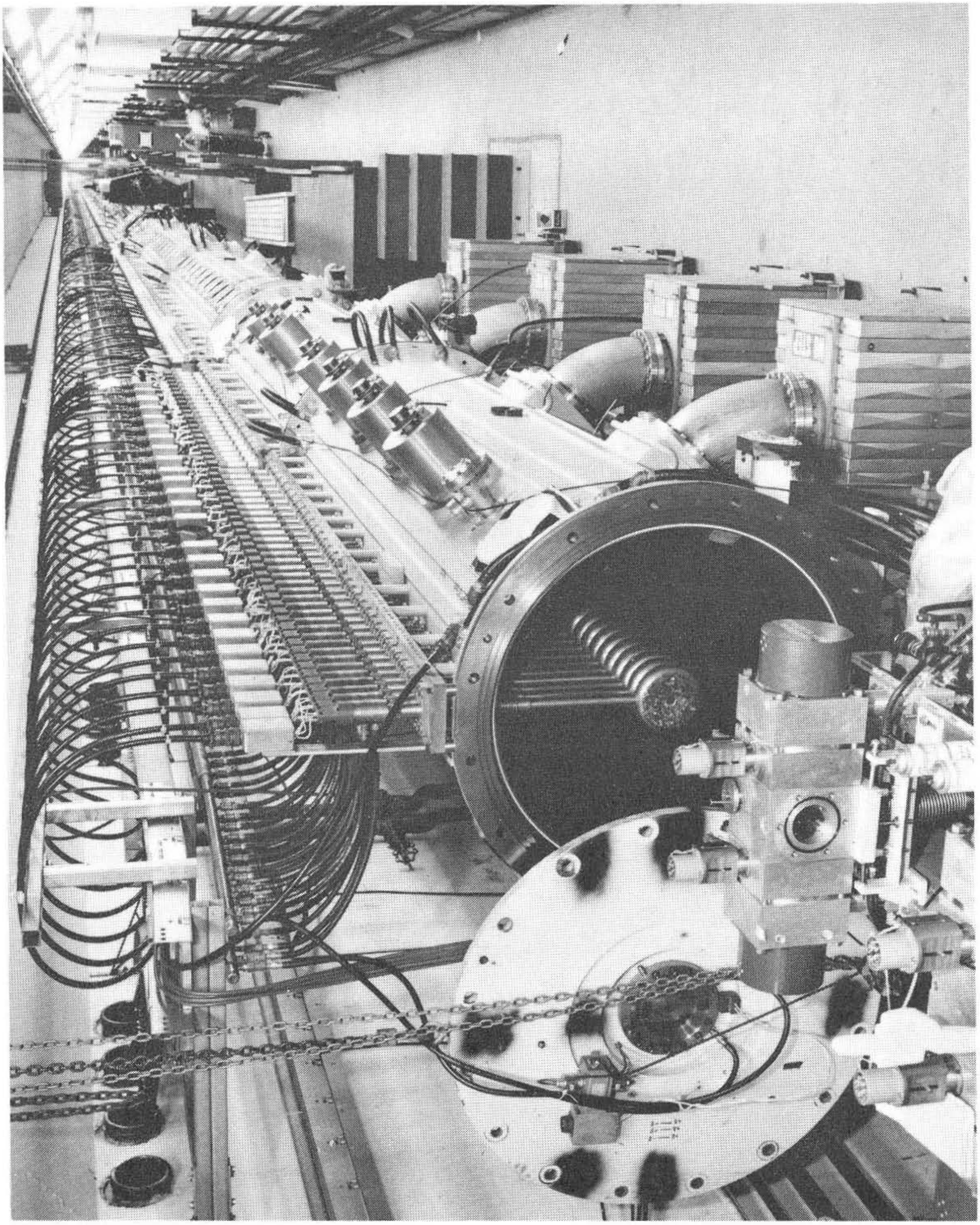

Fig. 7. The linac tunnel from the low-energy end.

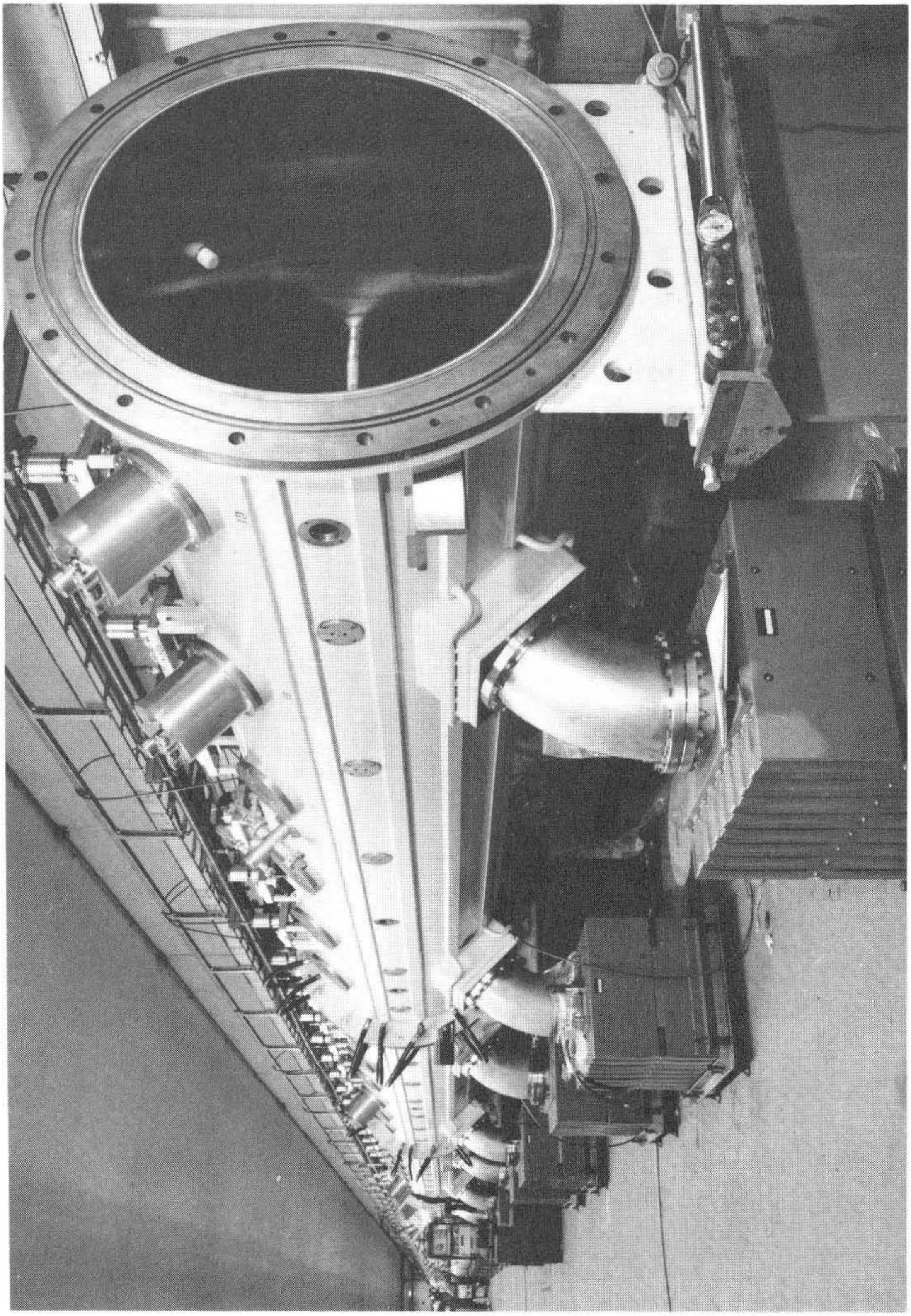

Fig. 8. The linac tunnel from Cavity No. 7 toward the preinjector.

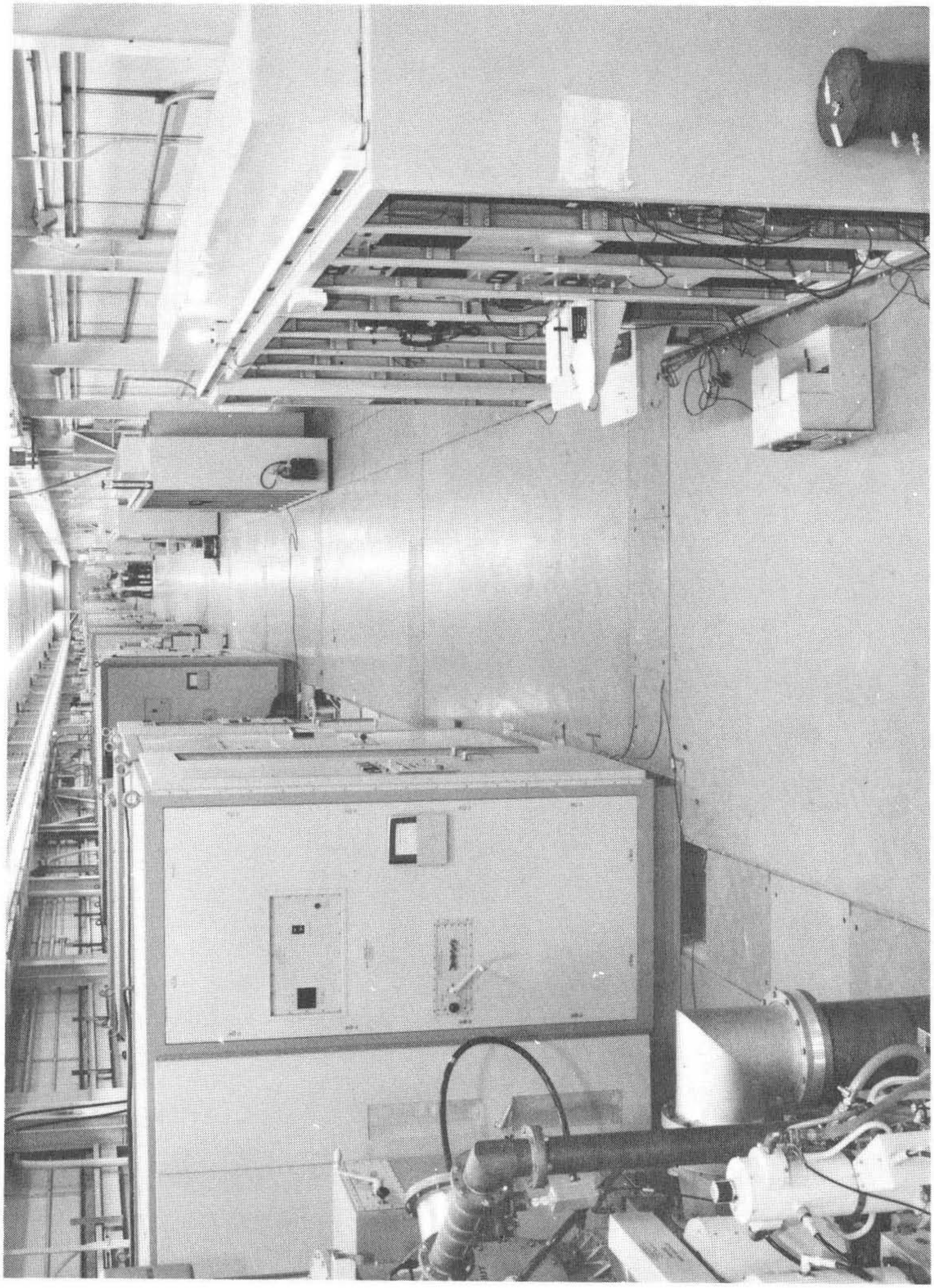

Fig. 9. The upper equipment bay showing the r f power equipment and local control stations.

Fig. 10. The lower equipment bay.

DISCUSSION

J. J. Livingood (ANL): To what do you attribute your lack of multipactoring?

G. W. Wheeler (BNL): Clean vacuum is the most important thing. We have done a great deal of cleaning and polishing and have taken care to keep the insides of the tanks clean. But the lack of oil in the pumping system is the most important factor. The rapid rate of rise of the field is also a help.

E. Regenstreif (Rennes): You said the emittance figure at the input of Tank 1 was larger than expected. Is this due to space charge?

T. J. M. Sluyters (BNL): There is about 30% increase in emittance between the pre-injector and the first tank, a distance of five meters. We can not explicitly say that this is due to space charge. We need to make more measurements to investigate this.

C. D. Curtis (NAL): What percent of the beam is in the phase-space areas you quoted? It is well known that the area changes greatly for a small percentage change in the high percentage tail of the emittance curve.

G. W. Wheeler (BNL): About 90% of the beam is inside the areas given in the paper.