SECTION III

ACCELERATORS AND COLLIDERS
(continued)

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PROGRESS IN THE AGS UPGRADE PROJECTS*

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Abstract The objectives of the AGS Upgrade Project are to prepare the AGS for Booster injection with an increase in the proton intensity to 6 x 10^{13} particles per pulse for a new generation of experiments on rare K decay, neutrino physics, the (g-2) value of the muon, and many other areas; to increase polarized proton intensity to 10^{12} particles per pulse for multi-target spin physics; to accelerate heavy ions up to Au for heavy ion physics; and, of course, to improve the flexibility and reliability of the AGS. High priority has been given to those projects which will reduce, at an early stage, beam losses during injection and acceleration, such as a fast electrostatic beam chopper and a high frequency dilution cavity. Other upgrade programs in progress are: a vacuum overhaul to reduce the AGS operating pressure by a factor of 100; an upgrade of the low and high field magnet correction system; automation of the Siemens main magnet power supply, etc.

The upgrade program progresses in parallel with the construction of the 1.5 GeV Booster, with a view toward completion of its major components in 1993, two years after starting Booster commissioning. The last of the major AGS improvement projects to be completed will be the new AGS radio frequency cavities.

The upgrade program started back in 1985 with the vacuum system because, at that time, the vacuum system caused a significant fraction of unscheduled machine downtime. Also, in order to minimize electron capture during heavy ion acceleration and for stable, high intensity proton beam acceleration, pressures in the 10^{-9} Torr range are required. Finally for high intensity operation, one has to aim toward a low maintenance, radiation hardened all-metal vacuum system. Upgrading the vacuum system is one of the more complex and time-consuming tasks. Basically, the program consists of a reduction in the magnitude of outgassing from the existing vacuum chambers and an increase of the

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pumping capacity. The program includes rework and/or replacement of practically all vacuum chambers, new ion pumps with higher pumping speed, all-metal valves, new vacuum clamps and seals, new R-C networks, etc. A new computerized vacuum control system was installed during the summer of 1988. In 1989, all-metal sector and roughing valves, new straight sections, and beam components chambers will be installed. The new system will be completed during a long, four-month shutdown in 1990.

In 1986, development began of a new preinjector line for the 200 MeV Linac to replace the obsolete 750 keV Cockcroft-Walton. The centerpiece of this new line is a high current Radio Frequency Quadrupole (RFQ), constructed by Lawrence Berkeley Laboratory.[1,2] The RFQ preinjector (see Figure 1) is equipped with a new rotationally symmetric magnetron source, two solenoids, fast beam diagnostics, and a 35 keV fast beam chopper[3] (see Figure 2) for programmed population of the longitudinal phase space. This electrostatic traveling wave chopper will also remove undesirable 200 MeV beam between AGS bunches that are

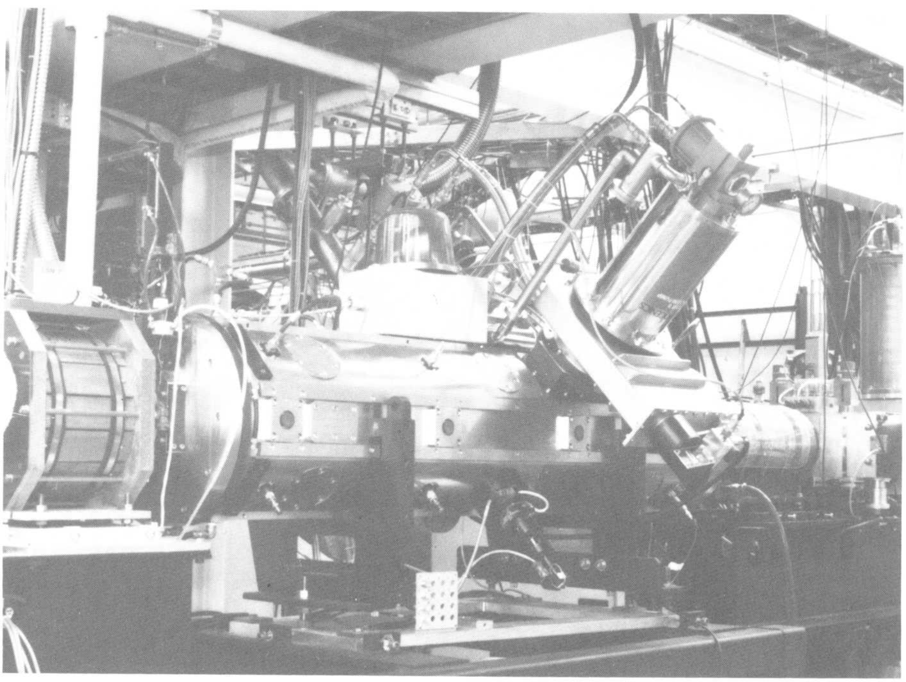

FIGURE 1 The 750 keV RFQ preinjector beam line.

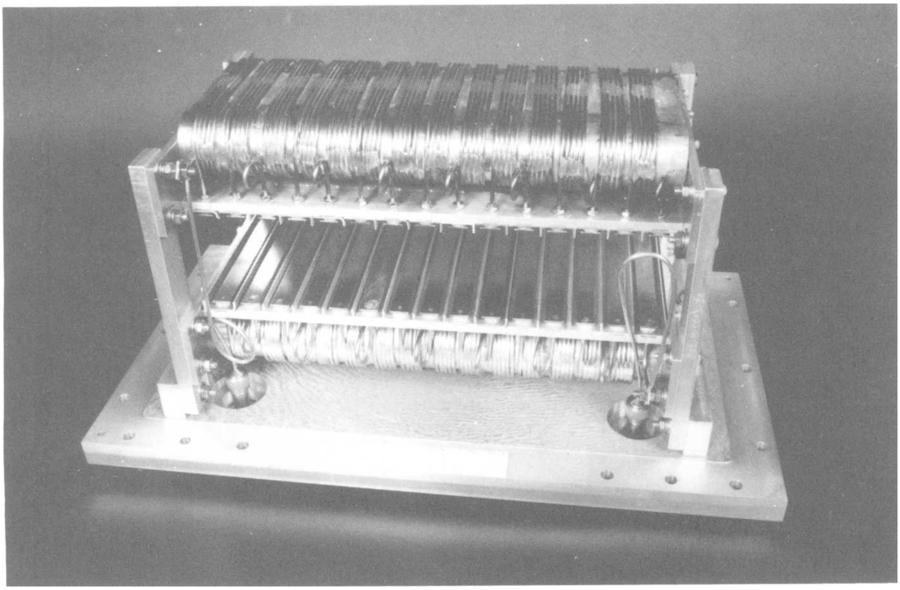

FIGURE 2 The fast pulsed electrostatic beam deflector.

up to now dumped in the AGS ring. Since January 1, 1989, the AGS/Linac has been operating with the new RFQ preinjector and the performance has been excellent. The output of the RFQ is now routinely in excess of 50 mA, with a beam emittance of 0.11 π cm.mrad normalized. The 35 keV beam chopper is being commissioned. In combination with a 750 keV chopper, the Linac is capable of delivering single 200 MeV Linac micro-bunches (< 1 ns long, every 10 μs) to the Radiation Effects Facility for neutron time-of-flight experiments.

In the AGS ring, about 5 to 10% of the beam is lost when it passes through the transition energy at 8.4 GeV. In order to eliminate these losses for present and higher beam currents, two complementary correction systems are being developed: a high frequency rf dilution cavity and a fast quadrupole jump scheme. Both projects were initiated in 1987. The 93 MHz dilution rf cavity will reduce the beam's tendency to go unstable by reducing its density in longitudinal phase space at selected times before, during, or after the AGS transition energy. This cavity was installed in the summer of 1988 and was successfully commissioned early in 1989, eliminating beam losses at gamma transition. The other correction scheme induces a quick jump of the transition energy with the help of three fast pulsed quadrupole doublets equally distributed around the ring, just as the beam passes through transition. The transition jump will decrease by a factor of one hundred the amount of time the beam spends in the unstable region. Both systems will avoid beam losses during transition up to intensities of at least 6 x 10^{13} protons per pulse. The transition jump is being installed during the present summer shutdown.

The beam loss during beam extraction is about one percent for FEB (Fast Extracted Beam) and about three to four percent for SEB (Slow Extracted Beam). Reduction of these beam losses is a difficult task. With Booster injection, the beam size is likely to increase and the present FEB equipment will have to be modified by the time the AGS g-2 experiment is scheduled. The conceptual design and construction of the new fast extraction system coupled with a more efficient internal beam dump has started.

For higher intensity operation, the present transverse damping system is inadequate. A new broadband feedback system is under construction to control the resistive wall instability, to suppress coherent oscillations arising from any beam injection error with the Booster, and to suppress possible bunch-to-bunch instabilities arising with higher intensity operation. Installation of the new damper is planned for FY 1991.

The ten existing acceleration rf cavities were built for accelerating beams of 10^{13} particles per pulse. This system operates well and has supported beam intensities as high as 1.9 x 10^{13} ppp. In order to reduce beam loading at the higher intensities expected with the Booster, the power amplifiers have to be rebuilt and located in the ring. The rf drive system has to be improved as well and the monitoring system will be updated. The new rf system will be designed during FY 1990 and will be constructed in a three-year time span from 1991-1993.

Another improvement project in progress is the Siemens Main Magnet Power Supply Upgrade consisting of new rectifiers, new timing, and computer control system. The existing excitron rectifiers will be replaced with the more efficient Silicon Controlled Rectifier (SCR) modules, because the excitrons are no longer being manufactured and the SCR modules will save the Laboratory several hundred thousand dollars per year. The new modules will be fabricated and tested by the Siemens Corporation and are to be installed in FY 1991.

Other projects in progress are: the AGS injection kicker and septum magnets; the improved low and high field tune correction system with highly accurate regulated monopolar and bipolar power supplies; shortened quadrupoles and sextupoles to provide space for additional injection, extraction, and diagnostics equipment such as the loss monitors, the jump targets and the tune meter, as well as to separate the quadrupolar correction functions for protons and polarized protons; improved internal beam dump with dump kicker; modernization of the computer controls system using Apollo workstations and new device controllers; an enlarged and modernized main control room; and, finally, a general AGS overhaul and clean up of the basic service equipment in the AGS tunnel.

The AGS Upgrade Project has already begun to benefit the operational reliability of the AGS as demonstrated in its increased averaged operating efficiency; since 1985, the operating efficiency has been improved from 67% to 77%.

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