THE ACCELERATOR: JANUARY 1976 TO JULY 1976

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Introduction

The 18-month period covered by this report may be characterized as a time in which operation for high-energy physics experimentation was consolidated into a stable routine. There have been spectacular one-shot achievements, but there has also been a steady growth in average performance and improved reliability. At the same time, the flexibility of the accelerator has been extended. The accelerator has operated at energies from 200 to 500 GeV; an energy of 400 GeV became standard in July 1975 and the flattop at this energy has been as long as 2 seconds.

The intensity of the accelerator has increased steadily during this period. A new intensity record of 2×10^{13} protons per pulse was achieved in January 1976. The average intensity per pulse is now more than 10^{13} protons (including pulses on which acceleration was not even attempted) for periods of a month or more. We have operated with many different spill modes, mixing fast and slow spill to support the variegated program of the Laboratory.

There have also been a number of very significant improvements in various systems of the accelerator. In this report, we shall discuss these activities in more detail.

Accelerator Energy

In July 1975, a decision was made to operate the accelerator at a standard energy of 400 GeV. The higher energy had previously been used for particular experiments, but it was desired to utilize it on a broader scale to provide more intense secondary beams and to provide an opportunity to solve the operational problems that had beset the occasional 400-GeV operation. These hopes have been realized; 400-GeV operation is providing higher-intensity beams for experiments with reliability equal to that of lower energies.

A long series of power-supply developments and improvements continued through this time. A principal development has been the capacitor tree in the Laboratory substation. It is a system designed to match the impedances of the main-ring pulsed-power system and the Commonwealth Edison distribution system. The technical problems of protecting this system against the effects of ferro-resonances developing in the main-ring distribution system have been extremely challenging. Our ability to run at higher energies with good intensity has been directly related to the solution of these problems.

All these developments culminated in reaching 500 GeV on May 14. We have always regarded 500 GeV as the ultimate energy attainable with the present main-ring magnets and it was gratifying not only to reach it, but to sustain it for some hours. I expect that we will operate at 500 GeV for long high-energy physics runs within a year or so.

Accelerator Intensity

The new intensity records and higher average intensity has come from the combined efforts of many groups. A new larger-aperture column in the preaccelerator has made it possible to accelerate larger intensities in the linac--up to 235 mA, more than twice the design intensity. The higher linac intensity has made it possible to use single-turn injection into the booster, with a concomitant improvement in early losses. At the same time, a new control program for the main-ring magnet power supply was developed and the individual power supplies were modified and improved. Mode dampers for suppressing parasitic modes in the accelerating cavities that had been inducing beam instabilities were also developed. Dampers have now been installed in both booster and main-ring systems. Two new accelerating stations have also been constructed and installed in each accelerator to increase the accelerating voltage available to the beam.

Accelerator Reliability

Not incidental to the accomplishment of all of the programs of the division has been a continuous effort at improvement of reliability of all of the various systems. One of the most productive of the improvement programs has been the development of techniques for predicting magnet deterioration within the Main Ring. This program has resulted in a marked decrease in the number of magnet failures that occur during operation. In the past year, an average of less than one magnet per month has failed during operation. Another important improvement program has been the replacement of all the original ceramic insulators in the main-ring rf system

and many associated improvements in the cavities and electronic equipment. Booster rf equipment has also shown steady improvement in reliability over this period of time. The two additional rf stations for both the booster and the Main Ring have increased redundancy, as well as increasing the ability of the systems to accelerate larger beam currents. The improvement program of main ring power supplies that has been important in increased energy has also improved reliability. This program is still in progress and it will not be completed for another few months.

Beam-Utilization Work

The flexibility of beam spills has increased in this period. The accelerator has operated with a 2-second flattop at 400 GeV, made possible by the capacitor tree. The accelerator has also operated with a front porch of 1 second at 200 GeV and a flattop of 2 seconds at 300 GeV, giving a spill duty factor of 35%.

There have also been many different spill modes, some delivering large beam current in fast spills for neutrino experiments and simultaneous slow spill to different areas for counter experiments. There have also been multiple fast spills to the bubble chambers during a long spill for counters.

Another important development within the division has been the completion of the Internal Target Area expansion program, which provides increased floor space for spectrometer systems to experiments using the internal beam. This expansion allows a wider scope of experiments to be performed in this area and provides facilities for more precise measurements.

Also completed during this period was the triple-split arrangement, which allows beam to be delivered to each of the three Proton Laboratories concurrently. This arrangement has completed the provision for servicing a total of six external beam-production targets concurrently, with beam also being supplied to as many as two targets in the Internal Target Area on each accelerator pulse.

Cancer Therapy Facility

The Cancer Therapy Facility has progressed through the phase of initial investigation development of a basic shielding arrangement for the facility, initial dosimetry, and radiobiology measurements and has now been upgraded to allow operation of the facility with the objective of beginning patient treatment in the very near future.

Energy Doubler

Meanwhile, the work in the Superconductor Group has resulted in the production of magnets that have now raised our enthusiasm and enabled us to look forward to a new generation of superconducting accelerators for Fermilab that will increase the available energy and again test the abilities of the accelerator operators and the experimenters to utilize spills at much higher energies and with much longer spill lengths than have ever been available before. These activities present enormous challenges to the entire division and to the Laboratory for the future.

In looking back at this period, it is apparent that the achievements are due to the long-term effort of many people. These efforts realize in accelerator performance months and even years after the inception of the

programs. This, I am confident, is the way it will be in the future. Those programs designed to produce improvements in intensity for high-energy physics use such as higher peak linac intensity, larger booster, etc., will have their results on the time scale of a year or more. The efforts must be supported by the dedication of consistent periods of time for accelerator studies as well as manpower and dollars. With this support the outlook is very bright.

It has been a privilege and pleasure to act as the leader of the Accelerator Division in this past year. I should like to take this opportunity to thank all of those in the entire Laboratory as well as the division for their efforts in this period and wish that everyone will have as much success under the new division leadership.