The 1987 Accelerator Startup

John Crawford and Robert Mau

In these early stages of the 1987 Collider-mode engineering run, it is perhaps appropriate to look back over the last year and assess where we have been, where we are now, and make some guesses about where we are going.

It has been 15 months since the Accelerator was shut down for a long nine-month civil construction period (time flies when . . .); that last run ended on October 13, 1985, at 0530 with the historic news that the Collider Detector Facility (CDF) had recorded 1.6-TeV proton-antiproton collisions. The euphoria was short-lived. The realization set in that there were going to be major upheavals in the Accelerator systems, that several large construction projects were beginning just as winter was making its appearance, and that we had committed to a startup schedule that left little room for miscalculation.

First, let's consider some of the major projects undertaken during the shutdown:

1. Construction of the D0 Collider Detector building.

2. Construction of a 21-ft-high overpass to carry the Main Ring beam above the B0 detector.

3. Change the Booster controls from the old Xerox 530-based system to the VAX system that the rest of the Accelerator was running on.

4. Upgrade of the 13.8-kV feeder system throughout the Accelerator.

5. Installation of Z/n plates (microwave instability dampers) at each Main Ring magnet.

6. Installation of the Booster to Debuncher beamline (the AP-4 line).

7. Installation of several "small" collider experiments in the Main Ring tunnel at B0, C0, and E0.

8. Rebuild approximately 500 Main Ring correction magnets.

9. Installation of a completely re-designed 8-GeV line (the Booster to Main Ring transfer line).

10. Construction of an experimental area at AP-50 in the Pbar Source.

11. Dismantling the entire refrigeration system between A4 and B1 (including refrigerator buildings) and then re-assembling the system once the B0 Overpass was completed.

12. Installation of 12 new transformers for the TEVATRON power supplies, and rebuilding 286 Main Ring and TEVATRON power supplies.

In addition to these major projects, literally hundreds of smaller improvements were made, each with its own requirement for de-bugging during the startup.

So, how has the startup gone? Well, we actually began bringing systems up around January 17, 1986, when commissioning of the AP4 beamline began. By the end of January, the line was being routinely used to provide protons to the Debuncher Ring. (It is worth noting that the protons were circulated in the same direction as antiprotons would normally travel, so the polarities of most devices in the ring had to be manually reversed, then reversed again for antiproton production.) Booster and Pbar Source studies continued until May 1, when installation of the new Booster control system began.

Booster and Main Ring startup began on July 18, with 8-GeV beam achieved in the Booster by July 27th. The next step was to commission the new 8-GeV line; this began on Friday, August 1, and beam was transported to the C0 abort dump by Monday, August 4. (Due to the continuing construction work, commissioning was carried out only on weekends. Because the tunnel was still open at D0 for the collision hall construction, beam had to be stopped at C0.) By August 11, a few turns of beam had been circulated in the Main Ring, but the next three weeks provided nothing but frustration for the tuners as coasting beam could not be established. Finally, a concentrated obstacle search yielded a garbage bag and a plastic beampipe cover - coasting beam followed on September 2. Main Ring beam was accelerated to 120 GeV by September 8, and cooldown of two sectors in the TEVATRON had begun.

TEVATRON power supply testing began on September 11, but all sectors were not cooled down and ramped until October 8. TEVATRON-accelerated beam was achieved on October 14 and beam was stored at 800 GeV by October 20. Antiproton stacking had begun in the Accumulator by November 12; by November 26, antiprotons had been reverse-injected into the Main Ring and accelerated to

150 GeV. On Sunday, November 30, antiprotons were accelerated to 900 GeV, stored, squeezed, and collided with 900-GeV protons.

By now, all was ready for the CDF detector to be moved into the collision hall during the week of December 15; however, a small setback occurred on December 7 when a high-field quench in the TEVATRON ruptured the cryostat of the E27-4 dipole, requiring the eventual replacement of four magnets. Once the CDF detector was in place, much work remained to be done on the gas systems; these required frequent accesses into the collision hall until about January 7. Collider commissioning began in earnest on January 10.

Where are we now and what remains to be done? The TEVATRON is now being filled twice per day. Each fill consists of three antiproton bunches and three proton bunches. Each antiproton bunch is formed by transferring a batch of antiprotons, consisting of 10 or 12 bunches, from the Accumulator to the Main Ring where they are accelerated to 150 GeV and then coalesced into a single bunch just before transfer to the TEVATRON. Three successive supercycles are used to form the X, Y, and Z bunches. On the fourth supercycle the proton bunches are formed using a similar sequence: A batch of protons, consisting of 6 to 8 bunches, is extracted from the Booster and injected in the Main Ring. After acceleration to 150 Gev, these bunches are also coalesced into a single bunch and transferred to the TEVATRON. Three successive Main Ring cycles within the supercycle form the A, B, and C bunches. Several 10-hour stores have been achieved. While luminosity and beam quality are not quite as good as we would like, there is reason to be optimistic. The set-up time for transfers also seems to be decreasing, despite glitches. The antiproton stacking rate has reached 9- to 10-billion antiprotons per hour. While this is below the 100 billion per hour called for in the design, it already exceeds the best achieved at CERN. The size and duration of the $\bar{p}$ stack is also increasing - we have attained a maximum of 150 billion antiprotons in the stack and this particular stack was stored in the Accumulator for 14 days before it was accidentally dropped. (For reference: the longest CERN has been able to maintain a stack has been 41 days.)

What does the future hold?

For the very near term, CDF will be turning on their central tracking chamber and the Accelerator will be scheduling three $\bar{p}$ transfers per day instead of two. There are on-going efforts to improve Main Ring efficiency, $\bar{p}$ stacking rate, and transfer efficiency all through the reverse injection, store, squeeze, and cogging operations. In the slightly longer term, we would like to see the whole colliding-beams operation change from a wild adventure to a somewhat dull routine.

Of course, far off in the hazy future lies another 800-GeV fixed-target run, with its own set of problems to be overcome. Stay tuned...