Tevatron 120 – Life after Run II?

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At present, the Fixed Target program from the Main Injector (Switchyard 120) reflects a small impact on other operations, mainly generated by interruptions in the facility time line for special 120 GeV Main Injector ramps for this purpose. On the other hand, one could say that beam time to the SY120 program has been limited due to the fact that it interrupts the other higher-priority programs at the lab, namely the production of antiprotons and the delivery of high intensity proton beams to the NuMI operation. The present amount of beam delivery is small, providing $\sim 1 \times 10^{12}$ protons (1 Tp) over a 4 sec. flat-top, every 2 min., for an average rate of 33 Gp/sec. But the demand for test beams may be greater than this current level, especially in light of the needs for NOνA, MINERνA, and particularly increasing interest in test beams for the International Linear Collider effort. Additionally, there may be other experimental applications with high energy fixed target beams, where Fermilab offers essentially the only alternative.

Once the Run II program ends, the Tevatron will still be one of only four high-energy superconducting accelerators in the world. Of those four it is the only one that was designed with rapid cycling capability. However, resurrecting a high energy (800 GeV) fixed target program would be expensive, with much of the infrastructure for this operation having been removed prior to the start of Run II. Power supplies and septa would need to be reinstalled and re-commissioned, as well as a beam abort system, and so on. It is conceivable, however to use the Tevatron as a "stretcher ring" for 120 GeV Fixed Target operation to the existing Fermilab Switchyard. Ignoring the operational expense for the moment, one could imagine extracting beam from the Main Injector on two pulses separated by ~1.5 sec, and during the next several minutes performing resonant extraction from the Tevatron at 120 GeV to the Switchyard. The Tevatron would be re-tuned to operate DC at this lower energy. To achieve the same average spill rate as in the previous paragraph, consider filling the Tevatron with 40 Tp from the Main Injector every 25 min. This could provide an average spill rate of 30 Gp/sec to the Switchyard with a 99.9% duty factor and essentially no impact on the neutrino program. Additionally, there would be extra flexibility in the test beam program. A fraction of the beam circulating in the Tevatron can be extracted "on demand" for short durations, at variable instantaneous spill rates, for example. It may even be possible to decelerate slightly in the Tevatron to vary the primary beam energy to the Switchyard.

Note that the Main Injector could provide at least twice the above intensity to the Tevatron, but 40 Tp is already more than the Tevatron has ever handled during 800 GeV Fixed Target operation. (The record intensity was $\sim$ 30 Tp.) However, during those days the intensity was mainly limited by beam instabilities at high energy. At 120 GeV, the intensity presented here may be realistic. Also note that the existing internal abort system should be able to handle the 120 GeV conditions, to the extent that we equate 40 Tp @ 120 GeV with 5 Tp @ 980 GeV, while today's Tevatron Run II conditions are 10 Tp @ 980 GeV. (Naturally, fault conditions, *etc.*, would need to be verified.)

It is interesting to point out that beam transfered to SY120 from the Main Injector passes through the Tevatron Injection Lambertson Magnet. For today's SY120 operation, this magnet is left off, and the beam passes straight through and up into the SY120 beam line. In order to extract beam from the Tevatron this magnet needs to be turned on with reversed polarity. This is the process that was used during the final 800 GeV Fixed Target Run ending in 2000. An electrostatic septum would kick the resonant particles into the field region of this same magnetic septum and direct them up toward the SY120 beam line. The natural place for the electrostatic septum, assuming half-integer resonant extraction, would be the C0 straight section, which currently consists mostly of free space. The other piece of hardware required is the resurrection of the slow-spill feedback system, referred to as "QXR," which consists of fast air-core quadrupoles and associated power supplies and electronics.

Since there will be no ramping of the Tevatron, then effects such as "snap-back," tune and chromaticity drift, *etc.*, will be of little consequence, and the quench margin will be much higher. The main drawback of this scenario which immediately comes to anyone's mind is the operating cost of the cryogenic system and of the supporting infrastructure for the four-mile ring to support a 120 GeV fixed target program. Unfortunately, the fact that the power use of the Tevatron cryogenics system is dominated by the heat leak inherent of the magnets and the fact that the two-phase helium system cannot function above about 5°K prevent any savings from operating at a higher temperature with the present cryo equipment.

However, it should be noted that the 120 GeV fixed target program could be asked to not run year-round operations. The cost of running the Tevatron today is approximately $33M/year. If a 120 GeV fixed target Tevatron program ran 3-4 months per year, with some overhead kept in for maintenance costs and end effects, for example, then a $10M/year program may not be out of the question. With 40 Tp fills from the Main Injector every 2.5 minutes, the SY120 program could easily operate with an average spill rate of 270 Gp/sec with a 99% duty factor, with a 2% hit on the NuMI program (assuming a 1.5 sec cycle time). While some may interpret the costs of running a 120 GeV Tevatron program to be high, it is important to point out the capability of the synchrotron should the user community find it worth pursuing.