

## Fermilab Rolls for Doubles

One teravolt equals 1,000,000,000,000 ( $10^{12}$ ) volts. By American count it is a trillion, by European count a billion. It is less confusing to say "teravolt." An electron or a proton that has been accelerated through a potential difference of one teravolt has an energy of one tera-electron-volt (TeV). By spring of 1983 the main synchrotron at the Fermi National Accelerator Laboratory in Batavia, Ill., is expected to be ready to bring protons to such an energy. Testing of the last two sections of the superconducting magnets that make a teravolt possible is planned for October. If that is successful—and it is expected to be—final preparations for the running of particle beams will commence.

One teravolt represents a doubling of the maximum energy for which the accelerator was originally built. When it is reached, the Fermilab synchrotron will again be, without peer, the most energetic proton accelerator in the world.

In addition to TeV protons, the synchrotron will also provide beams of TeV antiprotons, and will be able to collide protons and antiprotons. It will thus operate in two modes, either by striking beams of accelerated particles against fixed targets, or by striking beams of accelerated protons and antiprotons against each other head on.

As of mid-September the location where proton-antiproton collisions will take place was marked by a large hole in the ground. Across the road from the hole, buffalo roam in a pasture. In the hole, when the collision point and surrounding detectors have been built, protons and antiprotons will, it is hoped, not roam, but very precisely collide with each other. In September in the main accelerator tunnel there were still gaps in the "Energy Doubler/Energy Saver," the second accelerating ring, which is laid directly under the original one, and which will take particles at half a TeV from the original ring and double their energy. The apparatus for making beams of antiprotons and preparing them for injection into the main accelerator is also still under construction. If all goes well, all these technologies will mesh together during the next few years to provide Fermilab with its multiple capabilities.

The buffalo are not a bad symbolism. These are frontier technologies. What must come together between now and 1985 are the technologies of superconducting magnets and the large-scale liquid-helium refrigeration that they require, and the new and very exotic techniques of producing and "cooling" antiprotons. The schedule now envisioned is that the last two of six sectors of magnets into which the full circle of the energy doubler is divided will be tested in October. That is,

they will be chilled to liquid-helium temperature (below 4 kelvins), and their field configurations, their stability, their durability, etc., will be observed. If these tests are successful, these magnets (the E and F sectors) will remain cold; the other four sectors (previously tested) will be refrigerated, and the ring will be ready for acceleration of a test beam of protons in the spring of 1983.

Experimentation with beams of TeV protons striking fixed targets could then begin by autumn of 1983. Several fixed target experiments could be accomplished while the antiproton accumulator and the detecting apparatus to go around the beam collision point are completed. By the end of 1985 they should be ready, and in 1986 experimentation with colliding beams of protons and antiprotons could commence.

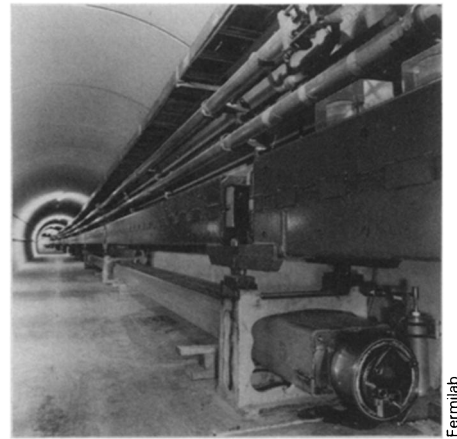
The Fermilab synchrotron was first designed for 200 GeV (0.2 TeV). During construction the maximum was changed to 400 or 500 GeV, and the accelerator was commissioned with that maximum in 1972. Before the original synchrotron was finished, plans to double the energy again were already underway. To do the doubling in the original tunnel—because of earth-moving requirements this was the only practical way—required superconducting magnets to bend and focus the beam.

That meant designing and building magnets that had never been made before. This work began almost as soon as the original accelerator was commissioned (SN: 1/4/75, p. 11). Now Fermilab has a factory for producing superconducting magnets—the doubler needed 1,000 of them—and supplies them to other installations.

To refrigerate these magnets, which are laid around a four-mile circumference, to the temperatures at which they are superconducting required the world's largest helium refrigeration system. According to Richard Andrews, one of the staff members involved, the last pieces of this system—compressors, heat exchangers, helium tanks, etc.—are being installed or are ready to go. The magnets are all in place. The gaps in the ring are places for "spool pieces," which provide fine adjustments to the particles' trajectory.

While the work to double the synchrotron's energy was in progress, the possibility of accelerating antiprotons arose. It has been vigorously pursued, particularly at the CERN laboratory in Geneva, where they now have colliding beams of protons and antiprotons at a quarter of a TeV each. Fermilab decided to add a proton-antiproton collision capability to the doubler project when CERN began its work.

The main difficulty in working with an-



In Fermilab's tunnel. Upper ring is original accelerator, lower is the doubler.

tiprotons is that they must be "cooled." Antiprotons are made with a wide range of momenta. If the antiprotons are to be accepted by the accelerator, their range of momenta must be narrowed, a process called "cooling." Two methods of cooling were pursued at first, one by Fermilab, one by CERN. CERN's method has proved successful, and so Fermilab decided to switch and redesigned its antiproton accumulator to fit.

Meanwhile, a large detector is being assembled to go around the first collision point. According to Roy Schwitters and E. Dennis Theriot Jr., two of the people involved, it represents a collaboration of several groups in the United States and Japan. It is intended to be an exploratory experiment to see what happens when TeV protons collide with TeV antiprotons.

Experimentalists are confident that there will be many important things to see in such collisions. At least one theorist believes the opposite. We shall see when we shall see.

—D.E. Thomsen

## Structure figured for colon mutagen

Colon cancer strikes more than 100,000 persons in the United States each year. Many studies have linked the disease to dietary factors, such as excess meat and inadequate fiber; however, little is known about colon cancer on the molecular scale. Now, two groups of researchers have independently determined the structure of a mutagen—a chemical capable of altering genes—that is produced by intestinal bacteria. While the bacteria are found in all humans, preliminary studies involving feces analyses suggest that only about one-third of the population has detectable amounts of the mutagen. Researchers believe that even if this chemical, which is a lipid (fat) compound, proves neither to be a carcinogen nor to play any role in colon cancer, it still might provide some clues in the disease mystery.

The structure of the chemical, which is