Urge to use protons bearing ergs

Ever since the 1890s, when Ernest Rutherford first used the products of natural radioactivity to probe the structure of atoms, physicists have sought higher and higher energies to probe finer and finer structures in the hope of arriving finally at the most elementary entities out of which matter is built. In the last month physicists at the Fermi National Accelerator Laboratory in Batavia, Ill., have started to experiment with the most energetic such probes ever, the 800-billion-electron-volt (800 GeV) protons from the laboratory's Tevatron.

The Tevatron is the first accelerator to qualify for the title of "ergatron"—that is, it delivers an erg of energy to each proton. In fact 800 GeV equal about 1.28 ergs. For comparison, a 5 ounce baseball flying at 100 miles per hour (the fastest pitch on record according to Guiness) carries more than a billion ergs. The protons are moving at nearly the speed of light, but the baseball's mass equals about 10^{26} protons, and that accounts for the enormously greater kinetic energy. However, the human arm cannot accelerate protons, and baseballs cannot probe subatomic structure. In a few months, when they get some downtime, the Tevatron's managers will try to jack the maximum to 925 or 935 GeV. The Tevatron's name indicates that it was designed for one TeV (1,000 GeV), but although the round number might please Guiness's editors, the experimenters feel the difference between 935 and 1,000 is not worth worrying about.

In recent years a great deal of publicity has gone to the achievements of the colliding beam installations, which collide one beam of accelerated particles against another, providing a great deal of energy for the formation of new phenomena. Striking a single beam against stationary targets, as the Tevatron now does (although it puts less energy at the disposal of new phenomena) permits the mounting of a variety of experiments designed for specific purposes, whereas the colliding beams do only one thing. Therefore, says Thomas P. Kirk, head of Tevatron II development, "Fixed target physics is not dead. It's still scientifically not only viable, it's exciting." Twenty-one experiments — six of which are now running—have been approved for Tevatron II, which is the current 800 GeV experimental program.

Four of these experiments have to do with the production of the elementary particle property called charm. Charm first appeared as an attribute of the J-psi particles discovered in 1974. At that point, says Kirk, it was barely possible to deduce the existence of charm. Second generation experiments were able to study the overall kinematic behavior of charm. This third generation experiment, 10 years after the discovery, will be able to study very subtle details of charm's behavior that are important to the theory of how matter is built.

Other experiments will seek to produce charm in different ways from the electron experiments in which it was first found. Ten years later such attempts are still in a rudimentary stage. The Fermilab experiments will use protons, neutrinos, muons and pions as energy carriers in the attempt to generate charm particles. "Fixed target physics," says Kirk, "can tell you if you produce it by protons, pions, kaons, neutrinos and muons, then you learn something you could never learn by having protons and antiprotons colliding forever."

Two of the running experiments concern asymmetries in the weak interaction, the class of forces and influences that govern most radioactive decays. Nature is generally symmetric with respect to left and right and positive and negative electric charge, but the weak interaction sometimes violates these principles. One experiment will examine violating behavior by K-zero-short particles, which are too shortlived to be practically studied at lower energies. An experiment already finished (which was actually done at 400 GeV) examined a similar deviation in the behavior of sigma particles. The same group did an earlier experiment at Argonne National Laboratory, and the experiment was so difficult at low energies that it took 10 years to analyze the data. They found the amount of deviation predicted, but didn't know whether it was positive or negative. Now they have redone the experiment, and again found the right amount, but for now they won't tell the sign, Kirk says, because they want to make a splash at a conference in Leipzig during the summer. If the sign is as expected, it will be another confirmation of the "standard model" of particle physics. If it is opposite, Kirk says, it will be a crisis.

—D. E. Thomsen

Magnetic mystery: Tracing a comet's ghost

About a year ago, a scientist reviewing past data from the Pioneer Venus spacecraft, which has been orbiting Venus since the end of 1978, noted an unusual event. On Feb. 12, 1982, the probe's magnetometer had shown a marked increase in the strength of the interplanetary magnetic field, which reached a sharp peak and returned to its original level about half a day after the episode began.

What had happened? Venus itself was certainly not at fault, Christopher Russell of the University of California at Los Angeles and a group of colleagues wrote in NATURE last October. The peak of the disturbance was in the wrong location, sunward of the "bow shock" where the planet's magnetic field holds off the solar wind, and although the event seemed to change with time, it did not appear to be controlled by anything related to the position of the planet.

Nor was the spacecraft passing through the magnetic tail of Mercury, which was too far around the sun to have made any difference even if the tail were long enough to reach Venus's orbit. Other factors virtually ruled out the sort of "magnetic cloud" sometimes produced by the clustering of interplanetary magnetic field lines, and changes caused in the solar wind by the sun did not seem a likely factor.

One possible explanation, Russell's group suggested, was that Venus — with the spacecraft in orbit around it — had passed through the wake of an active comet. Material given off by the comet (the theory goes) would be ionized by sunlight and trapped on the magnetic field lines being carried outward by the solar wind; the resulting "mass-loading" of the solar wind would cause its supersonic flow to slow down, forming a shock wave that bunched up its magnetic field lines. This would produce the detected increase in the field's strength. Yet no known comet was near Venus at the time.

The cause of that event is still a mystery. But a search through the sum of the spacecraft's data reveals 32 other episodes that are very similar, if smaller. And for some of those, a cometary culprit may have been found—unless it is not a comet at all.

It is designated as 2201 Oljato, a so-called "minor planet" — a term that is usually taken to refer to asteroids but that is believed in some cases to refer to the nuclei of comets that have only been seen too far from the sun to be showing the telltale fuzziness that would establish their identities. Oljato is also difficult to observe (discovered in 1947, it was not seen again until 1979, even though it circles the sun every 3.2 years), but there is at least one tantalizing hint that it may be more than a bare-rock asteroid. Ultraviolet spectra made last year by two observers showed only the expected results of a rocky surface, but Lucy McFadden of the NASA Goddard Space Flight Center in Maryland reported unusual wide-band reflectivities that were "much larger than expected." The case is *far* from open-and-shut, McFadden and her colleagues noted, but "the inference is obvious: Asteroid 2201 may be a comet nucleus in the final stages of outgassing."

Of the 32 events identified by Russell in the data, he says, 10 or 11 were clustered on the same side of the sun where Oljato had recently crossed Venus's orbit. If Oljato is indeed a comet nucleus, Russell reasons, the sun's heat may have caused it to give off volatile material that led to the increase in the interplanetary magnetic-field strength.

—J. Eberhart