tually outnumber the others, thereby raising the average productivity of the plot.

The mathematical results suggest that a single species could be as productive as a multispecies group only in conditions not likely to be found in nature—when only a single resource is limiting. The modeling further suggests that as the total number of species rises, variation in productivity drops, so that a diverse ecosystem will be more predictable than a simple one.

These models suggest that what happens in the experimental plots should also be true for other ecosystems, says Tilman. He thinks the work holds a lesson for those managing forests or grasslands: Grow a mix of species rather than single-species stands in order to maximize productivity and get a more consistent yield.

But the modeling and grassland experiments haven't convinced everyone that a diverse system is always the best and quickest route to high productivity in managed ecosystems. "The jury's still out," says Vitousek, noting that the low-diversity plots at Cedar Creek haven't yet filled in and covered the ground. He and others will be watching for future results from Cedar Creek to see whether the high-diversity plots do indeed win the productivity race in the long run.

–Elizabeth Culotta

PHYSICS

Getting Familiar With the Top Quark

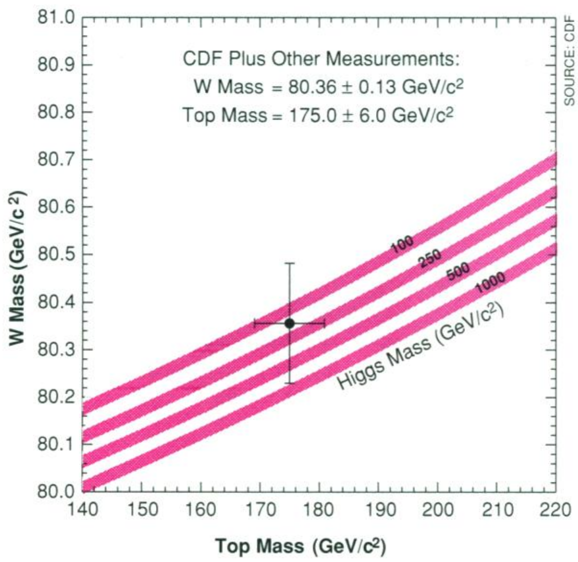
MINNEAPOLIS—Until early last year, physics textbooks were still printed with a conspicuous blank in their tables of fundamental particles. That blank finally got filled in when two collaborations at the Fermi National Accelerator Laboratory in Illinois glimpsed a massive building block of nature called the top quark. Now last year's epiphany is becoming routine. At a meeting of the American Physical Society's division of particles and fields held here last week, one group of researchers responsible for the discovery—the Collider Detector at Fermilab, or CDF—announced that they have identified roughly 100 top quarks, allowing them to nail down the mass of the now-familiar particle to within a few percent.

Physicists need that precision—greater than has been achieved for any other quark—to help them in the hunt for even bigger prey. Along with other improved particle measurements, the refined top mass provides a guidepost to the still-unseen Higgs boson, a particle that would help explain one of the major unsolved mysteries of particle physics: the array of different masses seen in other elementary particles. The top's mass implies that the Higgs could be within reach of existing accelerators. But even if it eludes them, says William Carithers, co-spokesperson for CDF, "I find it personally rather remarkable" that the top quark has yielded to close scrutiny so soon after its existence was settled. "Now it's a precision measurement."

The march toward that precision, says CDF collaborator Brian Winer of Ohio State University, came about as "we added more running time and massaged the data in a different way." The new data set covers runs of Fermilab's Tevatron collider right up until it was shut down for an upgrade early this year. The Tevatron, the world's most powerful accelerator, smashes together protons and their antimatter counterparts, antiprotons, with 1.8 trillion electron volts of energy. Over the 3 years covered by the data, the 5 trillion collisions within the house-sized CDF detector should have produced 500 or so detectable top quarks paired with their antimatter counterparts.

The top quarks themselves are too short-lived to register on any instrument, but CDF is designed to detect them indirectly, by picking up their decay products. According to the Standard Model (particle physics' current theoretical framework), virtually all top quarks decay first to a bottom quark, the next-heaviest quark, and a W particle—the carrier of the so-called weak force. Quarks can't exist alone, so the bottom quarks "cloak" themselves in other particles, producing distinctive jets of particles that trigger CDF's instruments. Altogether, the CDF researchers picked out this top quark signature in roughly 100 collisions.

To weigh the particle, the group had to take into account the top's other primary decay product, the W, which in turn decays into various leptons or quark jets. The top mass emerges when experimenters add up the energy in all of the decay products, averaged over many events. To wring extra precision from the data, the CDF group divided the events into several bins, depending on how unambiguously CDF had identified the bottom jets. This procedure, Winer says, kept "background events in 'dirty' samples from washing out good signals." Only after the data in the bins had been crunched separately were the results folded together.



Targeting the Higgs. Masses of the W particle and top quark point to mass range of the missing particle.

CDF's bottom line on the mass of the top is 176.8 billion electron volts (GeV) ± 6.5 GeV. "I thought we were going to have to wait another 5 years to know it that well," says Chris Quigg, a Fermilab theorist. Theorists have good reason to be appreciative, says Michael Barnett of Lawrence Berkeley National Laboratory: "If you believe the Standard Model, then once you know the mass of the top, you get a much better idea of what the Higgs mass should be."

That would provide clues on where to look for the particle that, theory says, is a sort of "footprint" recording how the other particles picked up mass in the first instants of the big bang. The link between the mass of the top and that of the Higgs depends on the W, for which experimenters are also getting a more precise mass: 80.37 ± 0.15 GeV, according to results announced at the meeting by Fermilab's D0 collaboration. What connects all these measurements, says Quigg, is that in an abstruse, quantum-mechanical sense, particles like the W spend part of their lives as various combinations of top quarks, Higgs bosons, and other particles, so that the values of their masses are intertwined.

But Quigg warns that the dependence of the Higgs mass on those of the other particles is "gentle," so that even with the new refinements, the range of possible masses is still fairly wide. Still, says Quigg, "it's natural for everybody to hope that the Higgs is just around the corner"—and it just might be if its mass lies in the lower part of the range suggested by the new measurements of the top and the W. In that case, the particle could be seen at CERN in Geneva, where the upgraded LEP-II collider began taking data only a few weeks ago. If the mass is larger, a glimpse of the Higgs will have to wait for a possible future upgrade of the Tevatron or for CERN's Large Hadron Collider, due to start taking data in 2006.

Meanwhile, devotees of the top. the W, and other particles will be honing their numbers still further in hopes of predicting just what the Higgs will be like when—or if—it finally fills in yet another blank in the textbooks.

–James Glanz