All eyes will turn. Next week, physicists will reveal the latest results in the hunt for the Higgs boson in a seminar like this one at CERN.

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PARTICLE PHYSICS

First Solid Signs of the Higgs Boson Could Be Announced Next Week

It's just about time to put up or shut up for the most sought-after elementary particle, the famed Higgs boson. Next week, physicists working with the world's biggest atom smasher—the Large Hadron Collider (LHC) at the European particle physics laboratory, CERN, near Geneva, Switzerland—will report the latest results of searches for the Higgs, the key to physicists' explanation of how all particles get their mass. Nobody expects a definitive claim of discovery, but given the amount of data the LHC has produced in 2 years of running, some physicists say that—if it's there—the Higgs should begin to emerge from "background" particle collisions like a sapling rising above the grass.

"You should start to see something," says Dmitri Denisov, an experimenter at Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois. In fact, if no sign of the Higgs appears, then its existence may come into question, says Michael Peskin, a theorist at SLAC National Accelerator Laboratory in Menlo Park, California. "If the Higgs is really not there, that could certainly be discovered with the current data set," he says.

The LHC feeds two enormous particle detectors, called ATLAS and CMS, that are designed to detect the Higgs as it pops out of collisions of high-energy protons and quickly decays into familiar particles. The mass of the Higgs remains to be determined, although previous searches have restricted it to above 114 giga–electron volts (GeV), or about 122 times the mass of a proton, and ruled out a small range of higher masses. This summer, the ATLAS and CMS teams reported data that, taken together, show that the Higgs does not exist in the range from 141 GeV to an untenably high 476 GeV. That paints the Higgs into a corner from 114 to 141 GeV.

Researchers now have twice as much data. In the units physicists use, each experiment now has 5 inverse femtobarns of data. That's still not enough to make an incontrovertible discovery. Physicists measure the strength of a signal, such as the number of candidate Higgs decays, in multiples of the uncertainty in the measurement, denoted sigma. That yardstick reveals the chances that random backgrounds could create a fake signal as big. For example, the chances of spotting a spurious three-sigma signal are 0.14%. The standard for a discovery is five sigma, as the chances that background processes will produce such a large signal are 1 in 3.5 million. To achieve such sensitivity, ATLAS and CMS would need 10 to 15 inverse femtobarns of data each.

Still, as a data set grows, a signal "shouldn't go from nothing to five sigma in one shot," Denisov says. So with the data they have now, ATLAS and CMS should start seeing signs of the Higgs, if it's there. The two teams will report their latest results at a special seminar at CERN on 13 December.

If both experiments report excesses of Higgs candidates in the same mass range, many physicists will take that result as evidence of Higgs. And rightly so, says Gordon Kane, a theorist at the University of Michigan, Ann Arbor. "All the knowledgeable theorists will immediately believe it is [there] if there are coincident 2-sigma signals," he says.

Others are more cautious. "We have seen lots of 3-sigma signals [of other things] that have gone away," says Marcela Carena, a theorist at the University of Chicago in Illinois. In fact, in July both ATLAS and CMS reported small excesses of Higgs candidates in the same low-mass region. By August, with more data, those excesses had weakened.

Alternatively, both ATLAS and CMS could see no sign of an excess. That outcome would undermine the case for the Higgs, at least as it is described by physicists' standard model. That would be "incredibly important," Peskin says. However, other versions of the Higgs could still exist, he says.

The standard model assumes that empty space is filled with a Higgs field, akin to an electric field, that drags on particles to give them inertia, the essence of mass. That field is made up of Higgs bosons much as an electric field consists of photons. The standard model also assumes that there is only one type of Higgs and that it's the only particle waiting to be discovered. If other new particles exist, then they could interact with the Higgs and alter its decays to make it harder to detect, Peskin says. So killing off the standard-model Higgs would not ax the entire Higgs "mechanism" for giving particles mass. Physicists might have to look for years to find a nonstandard-model Higgs, however.

More ambiguous results are possible: CMS could see something and ATLAS not, or vice versa. The least-revealing result may be the most likely, says Jacobo Konigsberg of the University of Florida, Gainesville, who works on the CMS experiment. With 5 inverse femtobarns of data, neither CMS nor ATLAS may be able to rule out the Higgs in the mass range between 114 and about 130 GeV, he says, leaving a window in which it might or might not exist. Indirect evidence suggests that the Higgs should have a relatively low mass, so "the room that's left is where it's likely to be," Konigsberg says.

Given the rate at which the LHC has been cranking out data, physicists say they will surely discover or rule out the standard-model Higgs within a year. "2012 will be the year of the Higgs," says Rob Roser, an experimenter at Fermilab. But that prospect won't stop people from jumping to conclusions based on the data presented next week. "It's going to be overinterpreted within 24 hours," Peskin predicts. The chances that he's wrong are 1 in 3.5 million.

–ADRIAN CHO

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