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Anxiously await new data on ‘God particle’

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High noon is approaching for the biggest manhunt in the history of physics. At 08:00 A.M. Eastern time today morning, scientists from CERN, the European Center for Nuclear Research, are scheduled to give a progress report on the search for the Higgs boson — infamously known as the “God particle” — whose discovery would vindicate the modern theory of how elementary particles get mass.

The report comes amid rumors that the two competing armies of scientists sifting debris from hundreds of trillions of proton collisions in CERN’s Large Hadron Collider, or L.H.C., outside Geneva, have both finally seen hints of what might turn out be the elusive particle when more data is gathered next year.

Alternatively, the experimentalists say that a year from now they should have enough data to rule out the existence of the most popular version of the Higgs boson, sending theorists back to their blackboards in search of another explanation of why particles have mass.
So the whole world will be watching.

Among them will be Lisa Randall, a Harvard particle theorist and author of the new book "Knocking on Heaven's Door: How Physics and Scientific Thinking Illuminate the Universe and the Modern World." In an interview with Dennis Overbye of The Times, Dr. Randall provided this guide to the action for those of us in the bleachers.

Q. What is the Higgs and why is it important?

A. The name Higgs refers to at least four things. First of all, there is a Higgs mechanism, which is ultimately responsible for elementary particles' masses. This is certainly one of the trickier aspects of particle physics to explain, but essentially something like a charge — not an electric charge — permeates the vacuum, the state with no particles.

These "charges" are associated with a Higgs field. As particles pass through this field they interact with the "charges," and this interaction makes them act as if they had mass. Heavier particles do so more, and lighter particles do so less. The Higgs mechanism is essential to the masses of elementary particles.

The Higgs particle, or Higgs boson, is the vestige of the simplest proposed model of what created the Higgs field in the first place. Contrary to popular understanding, the Higgs field gives mass — not the Higgs boson. But a discovery of the Higgs boson would tell us that the Higgs mechanism is right and help us pin down the theory that underlies both the Higgs mechanism and the Standard Model.

In the simplest implementation of the Higgs mechanism, the experimental consequence is the Higgs boson. It is the particle that the experimentalists are now searching for.

Of course, Higgs is also the name of the person, Peter Higgs, who first developed the underlying theory (along with five others who will be in contention for the Nobel Prize if and when the Higgs particle is discovered.)

Q. How will we know it when we find it?

A. In the simplest implementation of the Higgs mechanism, we know precisely what the properties of the Higgs boson should be. That's because of its connection to the Higgs mechanism, which tells us that its interactions with any particular particle are determined by that particular particle's mass.

Knowing the interactions, we can calculate how often the Higgs boson should be produced and the ways in which it should decay. It can decay only into those particles that are light enough for energy to be conserved. Roughly speaking, the Higgs boson decays into the heaviest such particles the most often, since it interacts with them the most strongly.

What we don't know, however, is the Higgs boson's mass. The Higgs boson decays differently, depending on its mass, since a heavier Higgs boson can decay in ways that a light Higgs boson can't. So when experimenters look for the Higgs boson, they look over a range of masses and employ a variety of search strategies.

Q. What do we know about it so far?

A. Experimenters have already ruled out a large range of masses. The Higgs boson, if it exists, has to be heavier than 114.4 giga-electron volts (GeV), which are the units of mass that particle physicists use. By comparison, protons, the bedrock of ordinary matter, are about 1 giga-electron volt, and an electron is only half a million electron volts.

Based on recent searches by the L.H.C., the Higgs boson is also excluded between about 140 GeV and 500 GeV. This makes the most likely region for the Higgs mass to be between about 115 and 140 GeV, which is the range Tuesday's results should focus on, although in principle heavier Higgs boson masses are in contention too.

I don't want to shatter hopes, but don't count on Tuesday's results being definitive. This is the toughest range of masses for the L.H.C., and detection is tricky for this range. I suspect they will have enough evidence not to exclude the Higgs, but too little to fully pin it down without next year's data.

Q. What difference does its mass make?

A. Actually, as far as matter's properties go, it doesn't really make a great deal of difference. As long as the Higgs mechanism is in place, elementary particles that we know about will have the masses that they do.

But no one thinks the Higgs is the final word about what underlies the Standard Model of particle physics, the theory that describes the most basic elements of matter and the forces through which they interact. Even if the Higgs boson is discovered, the question will still remain of why masses are what they are.

According to quantum field theory — the theory that combines quantum mechanics and special relativity — masses would be expected to be ten thousand trillion times bigger. Without some deeper ingredient, a fudge of that size would be required to make it all hang together. No particle physicist believes that.

We all expect a richer theory underlying the Standard Model. That's one reason the mass matters to us. Some theories only accommodate a particular range of masses. Knowing the mass will give us insight into what that deeper underlying theory is.

Q. Is the L.H.C. a flop if we don't find the Higgs boson?

A. The great irony is that not finding a Higgs boson would be spectacular from the point of view of particle physics, pointing to something more interesting than the simple Higgs model. Future investigations could reveal that the particle playing the role of the Higgs has interactions aside from the ones we know have to be there for particles to acquire mass.

The other possibility is that the answer is not the simple, fundamental particle that the Large Hadron Collider currently is looking for. It could be a more complicated object or part of a more complex sector that would take longer to find.

Q. Does this have anything to do with neutrinos — specifically, the ones that were recently reported as having traveled faster than light on a journey that originated at CERN?

A. Neutrinos have tiny masses. The Higgs mechanism is probably partially responsible for those, too. Just nothing that encourages them to go faster than light (which they most likely don't). In 1993, the U.S. Congress canceled a larger American collider, the superconducting super collider, which would have been bigger than the CERN machine.

Q. Would it have found the Higgs particle years ago?

A. Yes, if it had gone according to schedule. And it would have been able to find things that weren't a simple Higgs boson, too. The L.H.C. can do such searches as well, but with its lower energy the work is more challenging and will require more time.

(Source: The New York Times)