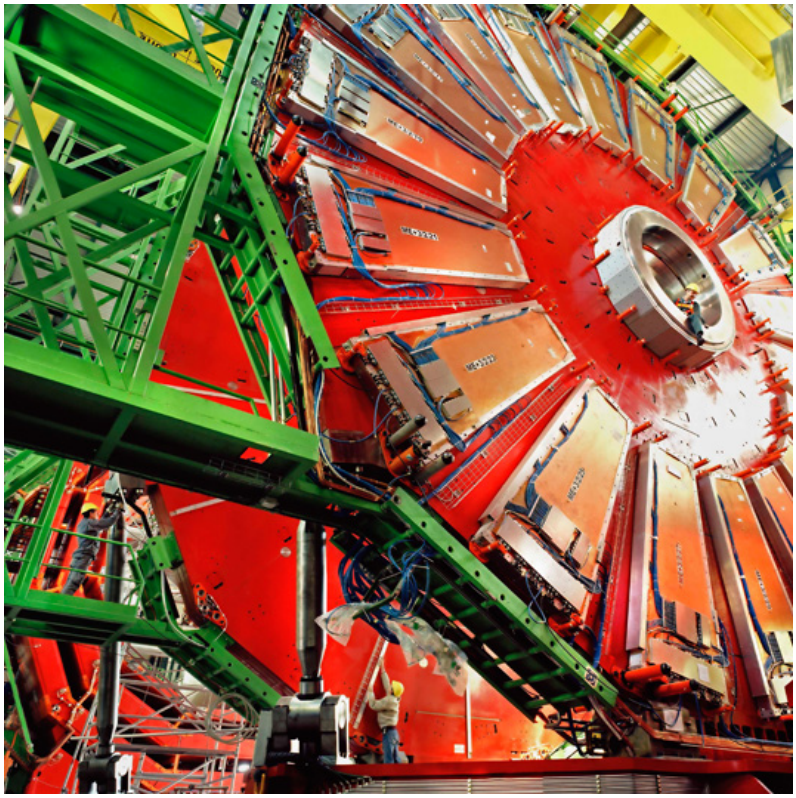
On June 18, the two experiments stopped recording data in order to get ready for Melbourne. By then they had already collected as many collisions — some 400 trillion — as they had the entire previous year.

The Atlas teams had already begun analyzing the first batch of this data a week before. Dr. Gianotti was at a conference at Fermilab when her colleague Dr. Kado sent her a plot of the new data.

The gamma rays were still there, and had grown in significance, putting the boson on the verge of reality. Dr. Gianotti scrawled a note back: "Oh, my God."

A week later, her team looked at another important decay channel, and her enthusiasm deflated. There was nothing. She spent a few days and nights with her "neurons spinning," she recalled, wondering how they could have been fooled.



Peter Ginter/Getty Images

The CMS detector helped gather data for the physicists, who were looking for a "5-sigma" discovery, meaning that the odds that it occurred by chance are less than 1 in 3.5 million.

In the next two batches of data, however, nine candidates showed up in the "zed" channel, as they called it. "It was just beautiful to see those," Dr. Gianotti said.

At 10 p.m. on June 14, small teams of CMS physicists began "opening the box" on their data. Later that night, Dr. Incandela received a plot from the so-called 4-lepton channel, showing a spike at 124 billion electron volts.

He later told the writer Ian Sample that his life changed at that moment.

That afternoon, almost 300 physicists crowded into the room to hear talks on the first results of the unblinding, and the entire collaboration learned that the Higgs was nigh. People were sitting on the floor and standing, Dr. Tonelli said. Another 307 people had linked in by videoconference.

The room was too hot, all the doors had been opened. Dr. Tonelli said, "Everybody was really feeling we were doing something important."

On June 22, Dr. Heuer announced that there would be a special symposium at CERN on the morning of July 4, the day the Melbourne meeting was to start. Scientists who had already bought tickets to Australia rushed to rebook.

At the time, it seemed like a gamble: neither experiment had yet reached the all-important 5-sigma level. But as various scientists were pointing out, CERN couldn't go on almost discovering the Higgs boson forever. Some said CERN should just shut up until the discovery was official.

"If you only have 4.9 you are not allowed to call it a discovery," Dr. Heuer said later. "But it was sure that even if being short of 5-sigma, if I see both experiments I can still call it a discovery because we are beyond 5 if we combine the two."

The members of each of the collaborations had to approve anything that was to be presented at Melbourne, which meant that their leaders had a week to mobilize an army and read a thousand pages of papers and reports.

Dr. Incandela, of CMS, said he felt "like a hunted animal."

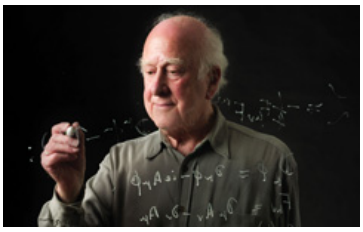
"I felt tremendous stress, obviously, because things were very tight," he recalled. "Several times per day, I would just say, 'O.K., don't panic, we're going to make this.' But my goal was to make sure we did everything right, and that the collaboration would not regret it, and that the collaboration would all feel part of it, because everyone worked on this in one way or another."

In a conference room near his office, he set up a SWAT team of a dozen of his brightest young analysts, his "kids," as he called them. "Keep your smiles to yourself," he warned them, if they happened to find themselves in the company of their rivals.

On the night of June 24, the graduate students and postdocs in Atlas were tiptoeing toward the 5-sigma finish line. Among them was Sven Kreiss, a New York University graduate student who got a preliminary glimpse of the answer alone in his office late that night when, as part of a crosscheck, he combined the data from two signatures of the Higgs decay and found the result breached 5-sigma. The next day he sent a plot to his adviser Kyle Cranmer, whose birthday it was, saying he had a present for him.

Dr. Cranmer shot back a joyful expletive worthy of the discovery of a sacred particle.

The job of ultimately confirming the boson's discovery had been entrusted to another pair of graduate students, Haoshuang Ji, a Wisconsin student, and Aaron Armbruster of the University of Michigan — who had sent the plot that Dr. Gross had woken up to in November. They were each working to combine all the Higgs data from all the myriad ways it could fall apart and leave a trace in the detectors. This calculation would make or break the Higgs, because the boson had to behave properly in all its guises.



The long road to find the Higgs boson is littered with subatomic particle discoveries and canceled colliders, but it ends with a discovery and a theory validated nearly 50 years after the idea was born.

American scientists are wondering what role, if any, they will play in the future in high-energy physics — the search for the fundamental particles and forces of nature — a field they once dominated.

Definitions of some important physics terms, from atoms to Z bosons.

Some recommended reading, with comments from Dennis Overbye.

It could take years of measurements before physicists have the cold numbers that clinch the case that the new particle

announced last July is in fact the long-lost Higgs boson.

On the afternoon of June 25, Mr. Ji announced he had gotten a result of 5.08 sigma, causing cheers to go ringing down the corridor outside Dr. Wu's office; everybody ran to sign the printout. The next day, Mr. Armbruster arrived at the same result.

Atlas was at 5-sigma.

The scorecard, as later enumerated by Dr. Wu:

1,000 trillion proton-proton collisions

240,000 Higgs bosons

350 pairs of gamma rays

8 sets of lightweight particles from the lepton channel.

From this trickle of a trickle of atomic pitter-pat, 6,000 physicists had finally started to put a face on the ghost of the vacuum, the secret controller of cosmic destiny.

Filling in that face could take years. Not knowing yet how closely the new particle matched the predictions of the Standard Model, the physicists took to calling it a "Higgs-like boson." Or as Dr. Cranmer put it, "Not a God particle but a God-like particle."

"We don't know what nature has prepared for us," Dr. Gianotti said.

She added, "Clearly if we had not discovered the Higgs boson it would have been much more intriguing from a physics point of view. But it is so nice to find a new particle."

On the eve of the scheduled announcement, Dr. Incandela rehearsed his talk and found that his team was still nervous. Were they ready to go public? It was too late, he told them. They were at 5-sigma. The train had left the station. "We have to stand by our data," he said.

Later, he said it was what they needed to hear.

Dr. Natalia Panikashvili

On July 4, 2012, members of CERN celebrated the discovery of a Higgs-like particle. Over its life, the project involved more than 6,000 physicists and cost over $10 billion.

CERN officials locked their auditorium three days before the special symposium to prevent people from camping out in it. Still, the night before, students and scientists began sleeping on the steps. Dr. Higgs and the other founders of the Higgs theory, Dr. Englert, Dr. Hagen and Dr. Guralnikwalked into the auditorium on the morning of July 4 to a standing ovation.

Dr. Incandela finished writing his talk at 8:42 that morning. The seminar started at 9. When he walked in, he recalled, "I was just so happy that everything came together — I really enjoyed giving the talk."

At one point, he noticed that the hand holding a laser pointer was shaking. "It was just the adrenaline," he said. "My heart was pounding."

At the end, he flashed a plot of CMS's final data analysis, showing the big new bump. The room exploded in applause.

He thanked CERN and the world. "These results are global," he said, "and now shared with all of mankind."

Dr. Gianotti, of Atlas, now had to follow Dr. Incandela, having gone first in December. After the news from CMS, she wondered if anyone would even be interested in what she had to say. "I'm saying to myself, 'Well, even if our results were essential, in some sense they will be nothing new compared to what they've seen already.'"

If nothing else, she thought, her talk would be a valentine to the passion and competence of the 3,000 Atlas scientists.

"Every slide was a reward to the work of many, many people," she said. "So I was feeling so proud."

"And I think I got the energy from the eyes of some of my Atlas colleagues who were sitting here in the auditorium," she added. "The fact that they were looking at me with such intensity and attention was giving me really the strength to go on."

When she showed the Atlas 5-sigma result, the audience exploded again. The applause seemed to go on forever. It had been left to Dr. Heuer to declare officially that a new particle had been discovered.

"I think we have it," he said. The cheers began again. Dr. Higgs was seen wiping away tears.

The morning dissolved into pandemonium and Champagne, in the CERN auditorium and in labs, classrooms, conference rooms and living rooms in every time zone in which humans wondered about their universe. Dr. Wu waded through the crowd. She hugged Dr. Higgs.

"I've been looking for you my whole life," she said.

"Well," he replied, "now you have found me."

PREVIOUS PART

This article has been revised to reflect the following correction:

Correction: March 5, 2013

Because of an editing error, an earlier version of a photo caption with this article misstated the temperature of the cooling system around the accelerator ring at CERN. It is –456 degrees Fahrenheit, not –520 degrees.

This article has been revised to reflect the following correction:

Correction: March 8, 2013

An article on Tuesday about the search for the Higgs boson misidentified, at one point, the group for which a physicist, Vivek Sharma, works. As the article correctly noted elsewhere, Dr. Sharma works for CMS, not for Atlas.

A version of this article appeared in print on March 5, 2013, on page D1 of the New York edition with the headline: Chasing the Higgs.

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