Some 20 years ago the W and Z bosons were the biggest prizes in particle physics, and Carlo Rubbia and the UA1 experiment at CERN won the race to find them

# Carlo Rubbia and the discovery of the W and the Z

Gary Taubes

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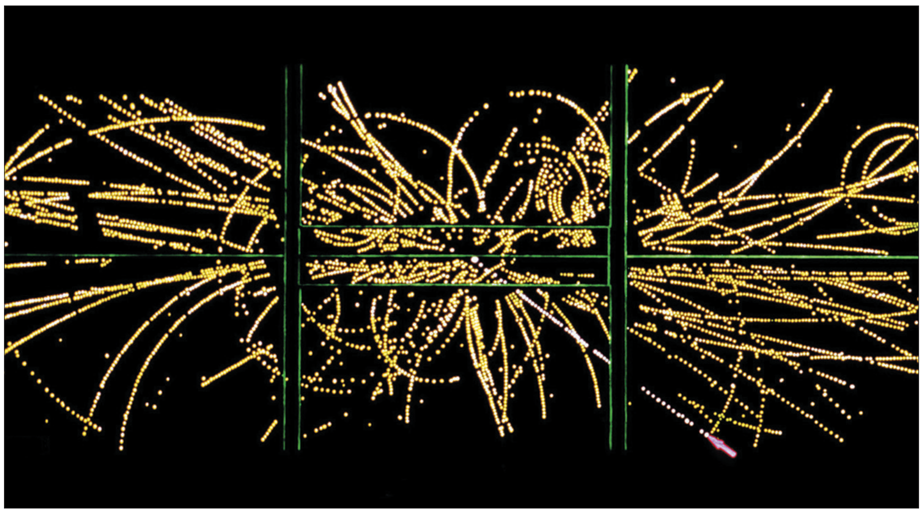

The first detection of a W boson by Carlo Rubbia and the UA1 collaboration at CERN in 1982 was rewarded with the Nobel prize in 1984. Rubbia (on the left in the photograph) shared the prize with the accelerator physicist Simon van der Meer (on the right). The signature of the W boson is an electron with high transverse energy (arrowed bottom right) produced back-to-back with a neutrino. Since neutrinos cannot be detected directly, physicists search for "missing energy" instead.

ONE summer night in 1982, about a month before the Super Proton Synchrotron (SPS) at CERN was due to start colliding beams again, the Italian particle physicist Carlo Rubbia was pacing up and down. He had a newspaper in his hand, and he was waving it around and raving at a colleague. The newspaper was French and the article that had upset him was about the forthcoming experimental run at the SPS. Not surprisingly the article described the two experiments at the collider – called UA1 and UA2 – from a French point of view.

According to the newspaper, UA2 was the French hope, while UA1 was a juggernaut belonging to CERN and Italy (even though three of the labs in the UA1 collaboration were French). The article portrayed UA2 as a small experiment, clever and cute. UA2 was David. UA1 was big, ugly and expensive – not the kind of experiment you would build if you were going to do the physics of the decade. UA1 was Goliath. And it was pretty clear which experiment this French paper expected to succeed.

At least that is how Rubbia saw it, and he was angry and seemed even a little frightened. The David and Goliath story was one of Rubbia's favourite metaphors, but hitherto he had always assumed the role of David. "What are we going to do?" he yelled. "What's it going to do to the group when they see this sort of crap? What if they're right?"

There was more to this than mere chauvinism on the part of a Parisian reporter. You could hear similar feelings expressed any day in conversations in the CERN corridors, or at the cantina where a good number of the world's physicists could be found at any time of the day or night. UA2 had good physicists who worked well together: they did not have 130-odd personalities all trying to do everything at once. Sure, UA1 had its supposedly beautiful apparatus and its state-of-the-art central detector. But the researchers would not be able to figure out what it was telling them until years after the UA2 scientists, with their simple but sensible detector, had announced that they had discovered the W boson – the particle that had been predicted to carry the weak force.

Once it was created, if it was created, a W would exist for a billionth of a trillionth of a second and then blow apart into various combinations of subatomic debris. The characteristic decay or "signature" of the particle that the UA1 physicists were trying to spot was a subtle one. They hoped to identify it by recognizing its electron. But there were a lot of other elementary particles that might look like electrons if the central

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Carlo Rubbia (left), Simon van der Meer, Herwig Schopper, Erwin Gabathuler and Pierre Darriulat at the press conference held on 25 January 1983 to announce the discovery of the W boson at CERN.

detector was not working perfectly. And it was not, not then at least. Even if the W were to show up smack in the middle of their detector, as they all hoped, the researchers wondered if they would recognize it.

### Working day and night

The SPS run began in early October 1982. The machine was working well – colliding protons and antiprotons at a centre-of-mass energy of 540 GeV. Since the machine physicists preferred to work on repairs and timing during the day, they were not able to get the beams ready until 9 or 10 p.m. The beams would then collide until morning. Those physicists who had crucial jobs – who, for instance, had built sensitive portions of the machine, like the central detector – had to sit through the night taking data and baby-sitting the apparatus, and then catch whatever sleep they could during the day.

Rubbia rigidly controlled every aspect of the experiment. If the collider continued to run smoothly, they might see at most five to ten W bosons by the end of the year. They could not afford to miss any. As soon as the beams were ready, Rubbia wanted the detector cranked up and taking data. He did not want to see the physicists spending precious minutes dithering about getting it going. He wanted to make sure that by the end of the year they had at least had a chance to look at just about every collision that the SPS provided – all two billion of them.

Of course, even if their electronics could work fast enough to save every one of those two billion collisions on computer tape – which they could not – it would be physically impossible to look at them all. But only one out of every 1000 events would be even remotely interesting, and the rest would be junk. Physicists at the Rutherford Lab in the UK had designed and built a "trigger" system that would fire only on that one interesting event and throw out the other 999. If this trigger registered a large splash of energy in a limited area of the calorimeters, for instance, it would interpret that as a potential electron and tell the computers to save all the information from that event before going on to the next one. Rubbia had his researchers set up the detector and the computers so that within a day of an interesting collision occurring, they could scan the computerized reconstruction of the event on a machine known as a Megatek – a device that looked like an oversized computer terminal and worked like a 3D video game.

Early in the run they found what, at first glance, appeared to be a W, and Rubbia became very excited. It seemed to have a high-energy electron on one side and nothing on the other side, a possible indication that a neutrino had been emitted. Rubbia was leaving for the US shortly after it was found. He threw details of the event into his bag, figuring he would flash them at his colleagues at Harvard. But when he arrived in the US he got a call from Alan Astbury – his co-spokesperson on UA1 – telling him to keep quiet about the event. They did not think it was a W.

### Christmas comes early

A few days later the UA1 team found its first good W candidate. It was beautiful, an incredible collision that had ejected particles all over the detector. Almost certainly it contained an electron with nearly half the energy of a W particle, just as the theorists had predicted. It had only one problem. One of the vagaries of the electroweak interaction was that W bosons were supposed to "spin" in the same direction as the incoming protons. And this one did not. If the Weinberg–Salam model of the electroweak interaction was correct, there was only about a 20% chance that it was a W.

Rubbia argued that maybe W bosons had the wrong helicity. It was so damn close to being a W that it was almost inconceivable to him that it might not be one. He told Astbury that they should publish based on that one event, and claim the discovery immediately. Rubbia argued that this case was no different to that of the $\Omega^-$, which was the classic one-event discovery. In the case of the $\Omega^-$, a particle that contains three strange quarks, the theorists had predicted its existence down to the exact mass, and groups at Brookhaven in the US and CERN had raced to find it. When the Americans found one event that fitted the predicted characteristics of the $\Omega^-$ and had the perfect mass – the theory had said 1.685 GeV and the Brookhaven candidate weighed in at $1.686 \pm 0.012$ GeV – they published.

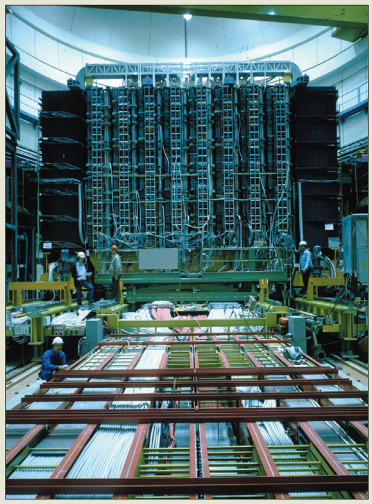
Astbury and colleagues convinced Rubbia that this was different and that the UA1 team simply did not have enough confidence in its single event to make that kind of claim. But Rubbia leaked the story to the physics community (among other things he gave a copy of the event details to a visiting Stanford physicist so that he could take it back to California) to establish his own impetuous version of a priority claim.

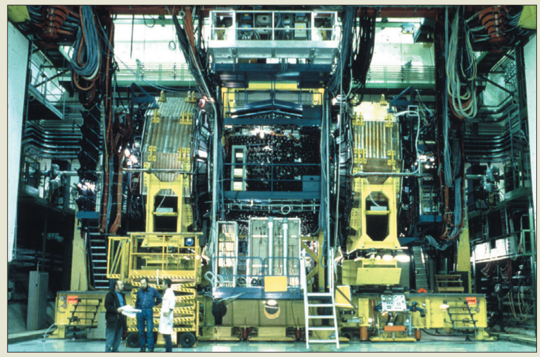
Rubbia also took the event details to the US with him. "We had a clear W signal in November," he said later, "and I had with me in my suitcase a number of events that were certainly W events, beyond the shadow of a doubt. I showed them to a few very good people like [Abdus] Salam and [Steven] Weinberg, but that was really absolute top secret." He also showed the material to Sheldon Glashow at Harvard, who then predicted at a meeting of the National Association of Science Writers a few days later that the W would be discovered in CERN by his birthday in early December. (Glashow, Salam and Weinberg had shared the 1979 Nobel Prize for Physics for their work on the unification of the weak and electromagnetic interactions.)

Rubbia and five US members of UA1 also took the details of the event to the Department of Energy (DOE) in Washington, which funds most high-energy physics in the US. The DOE's Bernie Hildebrand asked Rubbia to sign the computer-generated image of the event and then mounted it on his wall. Later, Hildebrand heard second or third hand that Burt Richter of the Stanford Linear Accelerator Center had seen the event and he did not believe it was a W. Hildebrand added a note to the picture that read "Carlo, this is not a W – Burt."

The SPS run ended on 7 December. Until then the UA1 physicists worked their insane hours, nursing the machine and the central detector while trying to figure out how to prove that what they had were W bosons. By the time the collider shut down for the year, UA1 had maybe five events, each of which might be a W, although they could not prove it.

To make sure that the physicists took a Christmas vacation, and maybe even relaxed, the CERN management turned off both the heating in the lab and also the computers. They knew that many physicists would gladly freeze to death if they thought they would be able to get time on the computers.





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The UA1 experiment (left) during assembly and the UA2 experiment (above). The UA1 collaboration won the race to detect both the W boson and the Z boson at the SPS proton–antiproton collider at CERN. The experiments were called UA1 and UA2 because they were housed in underground areas 1 and 2 at the SPS.

However, many UA1 physicists continued to work at their home institutions, and by the end of December Michel Spiro and Daniel Denegri of Saclay had finally figured out how to prove the existence of the neutrino in the W decay, and therefore prove if an event was really a W or just looked like one. Spiro and Denegri had written a computer program that could add up the energy deposited throughout the nearly hermetically sealed detector and calculate if there was an imbalance. Simple Newtonian physics dictates that the energy deposited from the collision on one side of the detector has to balance that deposited on the other side. If it did not, something must have escaped detection, and the only thing that could escape would be a neutrino. If this "missing energy" plus the electron energy added up to give the expected mass of the W, then the probability that the event was a W became overwhelmingly great.

The UA1 detector had been designed to completely surround the collision point for just this reason. Now the researchers really could prove that they had W bosons – real particles that even Richter would believe in. They had only five of them, but they sure as hell appeared to be real. Denegri called Rubbia with the news before he left to spend Christmas with his family "looking at the pyramids and sailing the Nile". It was Rubbia's longest vacation in a decade, and the first time he had spent as much time with his family in probably twice that long.

## When in Rome

On 12 January 1983 Rubbia, together with Pierre Darriulat of the UA2 collaboration, was scheduled to speak about the results of the autumn run at a conference in Rome. The week leading up to the conference was madness and two UA1 physicists – Bernard Sadoulet and Alan Norton – were working night and day on the background analysis. There was the ever-present fear that UA2 might have beaten them to the W. Or, even worse, UA2 might come out and say that there was no W!

Sadoulet and Norton were trying to estimate what other possible, uninteresting factors might be responsible for what they thought were the bosons. What kind of junk might conspire to look like the particles, possessing both the electron and, more importantly, the missing energy from the neutrino? The answer came out as close to nothing as they could wish. "Carlo left on a Tuesday for Rome," Sadoulet said. "I remember we went to bed at four that morning. At seven I was making the final computations of the background plots that Carlo took at one-thirty when he went to the airport."

Rubbia's talk in Rome was on jets (which are caused by the decay of quarks), the missing energy, and what he labelled "etcetera", and he told the conference that he would concentrate on the etcetera. In an hour-long talk he never actually said that the W had been discovered, but he talked all around it, and he showed the events that were most likely the bosons, and that the background in them was infinitesimal. His message was clear, despite his caveat that the evidence was preliminary.

Darriulat followed. He, too, showed events that appeared to be W bosons – in fact the results from UA2 were almost identical to Rubbia's – but his conclusion was less certain. "The need for more statistics is evident," he said. However, Rubbia had seen all he needed to see. UA2 would not deny the existence of the W. The events that Darriulat had shown confirmed to Rubbia that he was right.

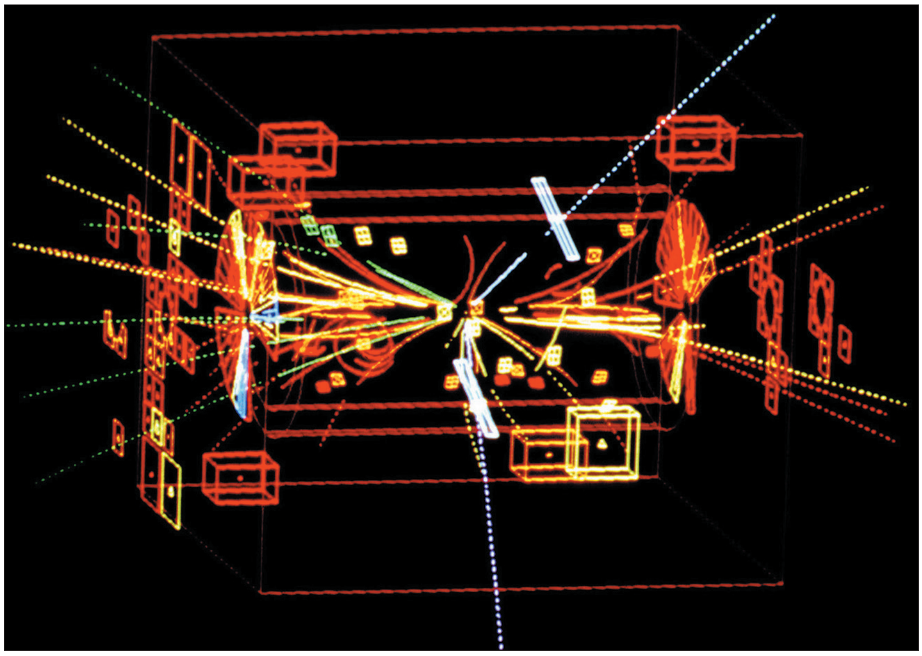
Leon Lederman of Fermilab gave the plenary talk at Rome. His first point was: "The speed with which the data was analysed and physics presented are truly astonishing, considering the complexity of the collisions, the sophistication of the detectors, and the hordes of experimental physicists." Lederman also added a comment about the competition between UA1 and UA2. It reminded him, he said, of a story about two physicists, whom he called Carlino and Spierre, who were confronted by a huge bear while walking in the woods. "One of them (which one?)," Lederman related, "said to his colleague, 'A bear! Let's run!' The other responded, somewhat pedantically, 'You can't run faster than a bear.' To which the first physicist replied, 'I don't have to run faster than the bear. I have to run faster than you.' "

## Rubbia gets a standing ovation

The CERN management had scheduled two seminars to present the new results. The UA1 lecture was scheduled for Thursday 20 January, and that from UA2 was booked for the following day. It was at this seminar that Rubbia officially announced the discovery of the W. In so doing, Rubbia had to present his evidence to the physicists of CERN; he also had to deal with his persona, and the memory of too many mistakes in the post – on the basis of which physicists were perfectly willing to disbelieve whatever he had to say. He had to summarize in one hour the culmination of almost a decade of working and hustling, leading and believing.

The main auditorium at CERN, which seats 500 people, had maybe twice that many in it. Physicists shared chairs. Many could not take notes because they had nowhere to place a notebook and write. The doors were left open and people stood outside and looked over the heads of the people standing in the doorways. They sat on the grand piano in the corner of the auditorium, and even under the piano.

Rubbia was nervous. He sipped at his water, he pulled on his tie, he ran his hand through his hair and fiddled with his 100 or so transparencies. He had been asked by the CERN management not to announce the W discovery in Rome, partly because they wanted it announced at CERN and partly because they did not yet trust it.



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The first Z boson seen by the UA1 detector on 30 April 1983. The signature of the Z boson is a high-energy electron and a positron flying off in opposite directions (the white tracks).

Instead, Rubbia sold CERN the W with the passion that he had sold them the idea of a proton–antiproton collider eight years earlier. He demonstrated how the researchers understood the UA1 detector, how they knew that it worked, how the central detector worked, how good was its precision, what its faults were. He anticipated every question, every criticism. When he was done with the apparatus, he told them about the physics, the evidence for the W, and why they believed in it. This is what we have done, he said, this is what we have seen, and this is why we must be right.

When he was finished, they gave him a standing ovation. Physicists who had made fun of Rubbia and predicted, even hoped, that his project would fail and take half the lab with it, physicists who had fought with Rubbia and swore never to work with him again, all clapped for five minutes. CERN was happy. It was beautiful physics, and they acknowledged it. It was their discovery, their vindication. They had waited nearly three decades for it. It was their Nobel prize. They were euphoric. And the applause was for Rubbia because for perhaps the first time in his career he had justified himself.

When, less than two years later, the Nobel prize did in fact come, the physicists would all say: "Yeah, we know. Big deal. But it can't touch the W talk itself." After that day in the CERN auditorium, the Nobel was only a formality. Everyone knew then that Rubbia had pulled it off.

### UA1 beats UA2 into print

The following day, Luigi DiLella presented the evidence from UA2 – in the same auditorium, to a slightly smaller crowd. The physics was virtually the same, but what would have been a *tour de force* in its own right was now simply confirmation physics.

On the Saturday morning, Rubbia joined his UA1 colleague David Cline for a cup of coffee in the CERN cantina. There they met DiLella, Allan Clark and Peter Jenni, all UA2 physicists. Rubbia looked unusually serious. He proceeded to tell the UA2 physicists that although he was convinced that both collaborations had discovered what appeared to be W bosons, they should think twice before publishing. If it was not the W, Rubbia said, it would be the end of their careers. "And so," as DiLella explained later, "Carlo said that he had decided that he would not publish."

In fact, Rubbia had decided nothing of the sort. The previous day he had delivered the first draft of a paper to Klaus Winter, a CERN physicist and editor of *Physics Letters*. He had told Winter that the final draft would be quickly forthcoming, and that he would appreciate immediate publication. Then, saying that he had already alerted the journal, he convinced his group leaders to allow him to hasten the writing of the paper. But his physicists fought against rushing. Sadoulet argued that this was an important paper in the world of physics, and that they should not just churn it out. It should be checked and thought over carefully.

"But it was important," Rubbia said later. "We were close. Had we waited three weeks, our priority claim would have gone to hell."

By Sunday the final draft was written. On Monday morning Rubbia gave the draft to Winter, and later that night he sent the paper by courier service to Amsterdam to be hand-delivered to the offices of *Physics Letters*. Probably no more than a handful of the 135 physicists working on UA1 read the final draft. "People were shown a draft on Friday afternoon," said Eric Eisenhandler of Queen Mary College in London, "and told that they had until Monday to comment on it. And when they turned up on Monday, they found that the paper had already gone out."

The UA2 physicists, on the other hand, wrote their paper in the conventional way and circulated it to all 60 physicists on the collaboration, who had two weeks to read it and make comments. It was published one month after the UA1 paper. Rubbia had established his priority, along with page one of *The New York Times*.

The episode in the cantina clinched the Nobel prize for Rubbia, or at least according to Dave Cline. "We didn't know whether UA2 would try to send the paper in simultaneously," he said, "but they didn't operate like that. It's not that they're

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This Z event has been colour-treated to show the electron and positron in yellow.

super-honest, they just didn't know how to move fast. They didn't think we would move so fast. It was a mistake, of course, because Carlo always moves fast."

Rubbia had not been alone in wanting to clinch an unambivalent priority claim. Herwig Schopper, the lab's director general, wanted to assure the Nobel prize for CERN as well. Schopper had been director of the DESY laboratory in Germany when the gluon had been discovered at about the same time by four different experiments at the PETRA collider. However, the discovery was not handled well and neither DESY nor the collaboration that discovered the gluon first received the credit they were due (see *Physics World* September 1995 p5).

Schopper had been vacationing in Japan during the Rome workshop and the UA1 and UA2 seminars. He returned the following Sunday and immediately set about establishing priorities. In the interim, research director Erwin Gabathuler, one of Rubbia's old rivals, had been in charge. Before Rubbia's W seminar, CERN had held a press conference, issuing a release that announced rather vaguely that experiments at CERN "begin to reveal the expected signature of a long-sought particle of matter: the 'W intermediate vector boson.'". No names were mentioned.

Schopper was much more direct, however. When he returned, he sent a telex to his fellow lab directors around the world announcing that they had seen events at the collider: "Most straightforward interpretation is decay of W into electron plus neutrino." Then he went on to say that "UA1 has submitted paper and Rubbia is to present results at American Physical Society Meeting New York, this week".

Schopper called another press conference for Tuesday. The reporters who had been at CERN one week before were now told that the W had definitely been discovered. This time the press release announced "A Major Step Forward in Physics: The Discovery of the W Vector Boson". It went on to say that since the last press release, three new developments had come to light: that UA1 team had written a paper and sent it off; that the paper "confirms the discovery of the W intermediate vector boson"; and that "the discovery will be announced tomorrow...in New York, by the UA1 Collaboration Leader, Prof. Carlo Rubbia".

### The discovery of the Z boson

Luigi DiLella of UA2 was one of the most likeable characters in particle physics, but he was not above trying to get revenge once his team had conceded the discovery of the W. The next challenge was to nail down the neutral Z or "Z-zero" boson, which had also been predicted by the electroweak theory. Most physicists thought that this would have to wait until the spring run, when the SPS would be tuned to produce five times as many collisions as in the autumn.

Surprisingly, however, the UA2 experiment had actually seen one Z event in the autumn. The Z was supposed to decay into, among other combinations, two high-energy electrons with a mass that added up to about 92 GeV. The UA2 team had spied an event with one good electron, and a second that had hit a coil in part of the detector and shattered into debris, so that all they could see was the aftermath. The mass was well within the range of a Z. Darriulat flashed up a transparency of this event at Rome, but did not dare at that stage to call it a Z.

DiLella talked to Jack Steinberger about it. Steinberger had been Rubbia's adviser at Columbia and had worked with him for several years at CERN, but they were no longer on speaking terms. Steinberger was also considered one of the best experimental physicists in the world (and went on to share the Nobel prize in 1988 for the discovery of the muon neutrino).

"I told Jack about this famous event", said DiLella, "in which one electron was good and the other appeared to have showered. And he said, publish it immediately. That is enough. If it is only one isolated event, if it has a mass of 94 – even if one leg is sick – you should claim it is a Z-zero." DiLella relayed this opinion to his colleagues, and suggested they publish, but they refused. They wanted at least one perfect Z.

Early in February, two months before the spring run was due to start, DiLella decided that the only way to beat Rubbia was to jump the gun, so he wrote a draft paper claiming discovery of the Z, leaving blanks for the characteristics of the events he hoped the team would find. As DiLella saw it, they would not need more than one day from the time the Z appeared to the time they filled in the blanks and sent the paper off to *Physics Letters*. Not even Rubbia could move that fast.

The spring run began on 12 April. At 5 a.m. on 4 May, UA2 got its first Z, but, like the earlier one, it had problems. Although the mass was about what it should be, this time both the electrons were disappearing into cracks in the calorimeters and could not be measured accurately. "The paper had been written", said DiLella, "as though we really had gotten a golden Z-zero. So we said, let's wait for the next Z-zero, perhaps it will be golden."

By the time the UA2 physicists had decided not to publish, they had lost again. At 3 a.m. that same morning, Marie-Noelle Minard of UA1 was working late at her office in Annecy in France, which was an hour's drive from CERN. Minard had a printout of collisions from a few days before that had not yet been scanned. One event, according to the printout, had two high-energy electrons. She eyed the numbers for about a minute before deciding it was a Z-zero. Minard asked a friend, who was also working late that night, to drive her to CERN. They climbed into his old BMW and took off through the French countryside.

They arrived at CERN at 5 a.m. Minard put the event on the Megatek and saw two beautiful electrons. She called Jim Rohlf, who was working a late shift at the control room, and asked him to take a look. "Sure enough," Rohlf recalled, "we had really discovered it." About 7 a.m. Rohlf called Rubbia – who lived half an hour from the lab – and he was in the scanning room within 40 minutes. "We looked at the event for about two seconds," said Rohlf, "and he said, 'That's a Z-zero.' He knew. It was obvious compared with the shit we'd been looking at that it came the closest so far."

That event is now referred to as the famous Z-zero. Not just the first one, but the famous one. And it was beginning a long and distinguished career in the physics literature. However, like the events seen by UA2, it was not gold-plated. One electron was perfect, the other was not.

From the scanning room, Rubbia went to the cantina, where he flashed the pictures of the new Z to a few of his British physicists over coffee, and then called Schopper – who was at a conference in San Remo, Italy – to break the news. By 9.30 a.m. that morning, on the strength of a phone call, Schopper had announced that the Z had been discovered.

That was it for the UA2 team. By the time the researchers got to CERN for their morning coffee, their yet-to-be published Z-zero paper was redundant.

On 27 May Rubbia officially announced the discovery of the Z in a seminar at CERN. By then UA1 had one more Z, which was indisputable. On 1 June Rubbia mailed off the paper to *Physics Letters* and CERN distributed its official press release. Since the preliminary announcement had already been covered in *The New York Times*, the new press release was seen as confirmation of an earlier discovery. "Physicists Confirm Discovery of Z-Zero," said the *Times* headline. By now UA2 was irrelevant.

On 7 July Darriulat announced that UA2 had also seen the Z. However, when the lab's management announced the confirmation in a press release, they did not ask UA2 to propose the wording – as was the tradition. The CERN press release was unequivocal: Z-zero discovery confirmed. Results in excellent agreement with the published UA1 results...

### The Nobel prize

Schopper was not about to make the same mistake with the W and the Z that he had made with the gluon discovery at DESY. He had begun to sell Simon van der Meer – the Dutch accelerator expert whose work on the stochastic cooling of antiproton beams had made the experiments possible in the first place – and Rubbia to the Nobel committee. The Nobel prize can be awarded to at most three people. One of the problems with the gluon discovery was that too many people had been involved.


Carlo Rubbia (second from the left) and Herwig Schopper (to Rubbia's left) watch LEP start up at CERN on 14 July 1989.

The same was true for the discovery of neutral currents at the Gargamelle experiment at CERN a decade earlier. Nobody could decide who should get credit, and the press releases announcing the breakthrough mentioned no names at all. It was a faceless discovery.

This time around, every press release also came with a supplement that explained how this was all made possible by stochastic cooling, courtesy of van der Meer; and no press release, even the one announcing UA2's confirmation of the Z, was without Rubbia's name.

Schopper also wanted to secure the future of the large electron positron (LEP) collider at CERN. Although he had persuaded the governments of CERN's member states to pay for the machine, he would still have to fight every year to keep the money coming in against a grim economic background in Europe. LEP was a $500m project and Schopper needed international prestige for the project. The Nobel prize would provide that prestige.

At Rubbia's press conference announcing the Z discovery, a month before the spring run ended, Schopper told reporters that the discoveries were the most important in physics since the invention of the transistor 25 years earlier, and they would surely merit a Nobel Prize for Physics. It was one of the few occasions in the history of science that a lab director had told the press to inform the Nobel Foundation where his vote lay – before the experiment was even finished.

In 1984, less than two years later, Rubbia and van der Meer shared the Nobel Prize for Physics for "their decisive contributions to the large project, which led to the discovery of the field particles W and Z, communicators of weak interaction".

Rubbia's experiment did more than discover the W and the Z – it also changed the balance of power in particle physics. Rubbia has done more than prove that the W and the Z existed and that the Standard Model was correct. Perhaps most important, he had proved that Europeans could do physics as well as or better than the Americans. Six days after the Z-zero press conference, *The New York Times* published an editorial on particle physics with a classic headline: "Europe 3, U.S. Not Even Z-Zero."

The editorial suggested revenge, and only a week later particle physicists in the US voted to cancel construction of the Isabelle accelerator at Brookhaven and go full speed ahead with the Superconducting Super Collider (SSC). This massive machine would have an energy 100 times greater than anything at CERN.

The SSC – which was cancelled a decade later – was as much a reaction to Rubbia's success as anything else. It was an unprecedented decision. No one would deny that the SSC would be a machine that could do great physics, but the idea reeked of revenge. For the first time since the Second World War, US physicists were number two in high-energy physics, and they did not like it.

**Gary Taubes** is a writer and journalist based in New York City, email taubes@nyc.rr.com. This article is a shortened version of chapter 7 of his book *Nobel Dreams: Power, Deceit and the Ultimate Experiment* (1986 Random House), which was based on an extended stay at CERN between August 1984 and April 1985