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Spinning particles and spin-offs

More than half a century after CERN was set up to smash and measure the building blocks of the Universe, it's discovered several new particles, won some Nobel prizes – and invented the world wide web.

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No sooner than scientists at CERN – the French acronym for the European Organization for Nuclear Research – announced that they had likely detected something that seemed like the Higgs boson last year, some more hard work began: trying to describe it. The most popular media nickname was 'the God particle': it was the last to be discovered of the 17 particles in the so-called Standard Model of elementary particles.

Physicists didn't like this. It had nothing to do with God, and giving too much glory to the Higgs did not reflect its proper role. If the Standard Model was 'a gorgeous and elegantly crafted mansion', wrote Nobel Prize-winning physicist Sheldon Glashow in 1989, then the Higgs boson was its 'flush toilet' – 'a rather ugly thing, but it works and no one has come up with a plausible alternative.'

CERN theoretical physicist Gian Giudice, who took an active part in the first TEDx event organised at CERN on 3 May 2013, agreed: 'Although indispensable for the functioning of the house, it isn't something that you proudly show to your guests.'

So, if it's so hard for normal people to understand what has even been discovered, how can we make sense of it all? Some might say that CERN is one of the world's priciest science projects, and diverts thousands of top brains that could be trying to cure disease or prevent global warming - instead, they send tiny particles zooming round a circular tube under the countryside near Geneva and watch what happens when they smash into each other.

New knowledge

The key motivation, of course, is new knowledge, and the reality is that CERN has notched up a number of big discoveries. Though we don't yet know how the new discoveries might be used, a lot of progress in technology has been linked to science. CERN, more perhaps than any other big science facility, has built up another strong argument: the spin-offs. Its quest needed the processing of vast quantities of data that could not be managed by conventional means. Marshalling such computer power from different countries led it to develop the first website, and then make the world wide web available for free in 1993. CERN is currently developing a technique called grid computing, which allows arrays of computers in different locations to work together.

The web is, for sure, one the best known spin-offs from CERN's R&D. But the physicist developing huge experiments for the particle accelerator also invented new technologies that are now used in other domains, like hadron therapy in medicine.

As early as the 1940s, hadrons - subatomic particles such as neutrons and protons - had been identified as appropriate particles for the radiotherapy of deep-seated tumours. In contrast with radiation treatment by electron or photon beams obtained from radioisotopes like cobalt, hadrons deposit most of their energy near the end of their path. By carefully controlling the energy of a proton beam, most of its energy can be deposited in a cancerous deep-seated tumour and not in the healthy tissue around it. Pioneering studies were carried out at CERN in the late 1960s.

As far as medical imaging is concerned, CERN also played an important pioneering role. Many detectors developed at CERN can be used in medical applications, particularly if combined with well-established imaging techniques such as Positron Emission Tomography (PET) or Computer Tomography (CT), themselves spin-offs of fundamental research in particle physics.

CERN also developed crucial new techniques to produce an ultra-high vacuum, which is used to coat the tubes where the particles used in experiments are accelerated. These techniques can now be used to improve solar panels, domestic appliances such as fridges, and heat insulation in windows and walls.

Frontier research

'What we are doing is certainly a very abstract science, but the tools that we need to get there are often what is useful for society,' says Giudice. 'All the technology that was developed... satisfies a need of a group of people that works at the frontier.'

CERN's most spectacular piece of equipment is the Large Hadron Collider (LHC), a 27-kilometre circumference tube buried an average of 100 metres underground – and it didn't come cheap. The LHC took about a decade and CHF 4.6 billion (EUR 2.9 billion) to construct, and its experiments cost CHF 1.1 billion (EUR 880 million) a year to run – though this is just a fifth of the full cost of experiments, the rest coming from collaborating institutions round the world. It is powered by 120 megawatts of electricity, enough for the half-million homes in the surrounding Canton of Geneva. That makes it one of the world's biggest, most expensive science projects – though it's a bargain compared to the International Space Station, whose cost from 1985 to 2015 has been put at USD 150 billion (EUR 115 billion).

Money well spent

CERN has delivered results for this money, in particular related to the Standard Model. In 1984, CERN scientists Carlo Rubbia and Simon van der Meer were awarded the Nobel Prize for work they did leading to the discoveries of the W and Z bosons, two other particles in the 17.

The Higgs discovery was a confirmation of something scientists had believed for the past half-century. But there are still plenty of mysteries out there, and CERN thinks the LHC, which started operating in 2008, could help unravel these. In particular, it's currently hard to reconcile the force of gravity with the Standard Model. One theory that could help is called supersymmetry, and suggests the existence of particles beyond those we currently know – possibly detectable in the LHC.

Gian Giudice is a theoretical physicist at CERN. © CERN
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Secondly, astronomers think that visible matter accounts for only 4 % of the Universe, and they call the rest dark matter (23 %) and dark energy (73 %). If supersymmetric particles are responsible for the dark stuff – as some physicists believe – it might be possible to find some at the LHC.

CERN physicist Giudice says this is in a sense harder than the Apollo moon landings, as the astronauts knew, basically, where they were going and what they would find. They 'didn’t expect to be welcomed by strange creatures with green skin and long antennae,' he pointed out. Particle physicists, as they investigate ever-smaller phenomena, are more like Venetian traveller Marco Polo, who had only a vague idea of the 'fabulous cities and strange beasts' he would meet.

More info

More about the TEDx conference at CERN

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