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The unparalleled experiment

The coldest place in the universe and the world's largest particle accelerator are to be found north-west of Geneva. We visit a parallel world – the European Organization for Nuclear Research, CERN. By Joel Frei

A hundred meters below the earth, narrow passageways lead through a maze of pipes, cables and tubes. Physicist Niko Neufeld grins mischievously: "It's a bit like a Harry Potter film here - you never really know where these winding paths will end." Neufeld is one of 7,000 scientists at CERN, the world's largest particle physics research centre. Answers to the big questions are sought here - Where do we come from? Why this world and not another one? How did the universe develop? This "global laboratory", where researchers from more than 80 countries work, is the size of a small town.

The labyrinth

The streets in CERN are named after famous physicists such as Heisenberg, Curie and Einstein. This town of physicists has its own post office, a bank, a travel agency and a theatre. CERN's energy requirements are also on a par with those of a town; the research facilities consume a tenth of the canton of Geneva's electricity. The giant laboratory's budget stands at around one billion Swiss francs. By way of comparison, CERN's budget is larger than the GDP of the Central African state of Burundi.

Neufeld heads further into the labyrinth and goes down a passageway that passes through giant reinforced concrete blocks. "We're now coming to what we call the dark side", he reveals. What sounds like a Hollywood-style struggle between good and evil is actually part of the matter-of-fact world of science. The concrete blocks protect people and electronic equipment located on the "good" side against the radiation of stray particles. The passageway through these concrete blocks eventually leads to a giant, surreal-looking machine. It is one of the six detectors in the ring of the world's largest particle accelerator, which is known as the LHCb. This piece of equipment aims to shed light on one of the last mysteries of antimatter: when the big bang occurred, why was all matter that came into contact with antimatter not destroyed? Why was there a small residual amount of matter which would form our universe?

The particle accelerator

The new, more powerful LHC (Large Hadron Collider) particle accelerator was built in the old accelerator's ring-shaped tunnel. This underground storage ring has an impressive 27-kilometre circumference and extends far into neighbouring France. In the LHC, protons are accelerated to almost the speed of light and fired in both directions in the circle. They inevitably collide with one another and new particles emerge from these collisions. The detectors in the particle accelerator's ring record these collisions and generate a mass of data for physicists to evaluate. Countless extremely powerful magnets hold the protons in their path. These are cooled to -271° Celsius - nowhere in the universe is as cold - to fully exploit their capacity. In their experiments the researchers reconstruct the original physical state of the universe, when the world was a billionth of a second old. To see the enthusiasm and delight on the physicists' faces, you would think they themselves were going on a journey back in time with their detector time machine.

A huge metal device hangs in a cavern that can only be reached through a narrow entrance. The ATLAS detector is the largest of the six detectors in the ring and constitutes the main component of the new particle accelerator. The workers clambering over it look like dwarfs by comparison. Next year, the protons will collide with one another in the centre of this machine. Physicists hope the ATLAS detector will provide evidence of the Higgs particle, which currently only exists in theory and which they believe will explain why particles have a mass.

The physicists

A large part of the research centre complex is located on French soil. The border runs through the research site. At lunchtime, physicists whose offices are in France eat at the restaurant on the Swiss side. The physicists, who come from all over the world to carry out research at CERN, can sometimes forget which country they are in. The cliché of the absent-minded professor is alive and kicking in the land of CERN. A physicist who was overly enthusiastic about his work is said to have fallen ill with scurvy because he spent too much time thinking about his experiments and not enough on eating healthily. Tour guide Sophie Tesauri leads the way into a hall on French territory. Sheep graze peacefully on a nearby meadow. The hall is in poor condition and the shabby toilets are part of an outside annex. "The money is used for research - my office doesn't even have double glazing", says Tesauri with a smile.

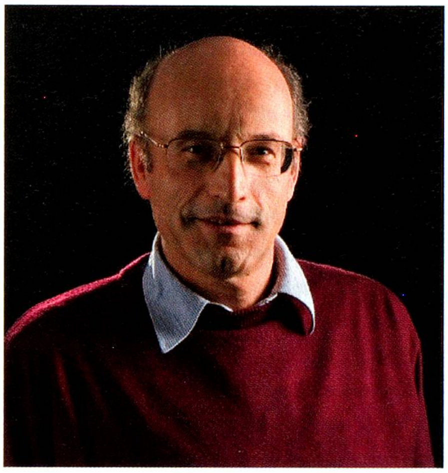
The boundaries of science

Inside the hall, physicist Michael Doser demonstrates an antimatter experiment that he conducted research on several years ago. The research team succeeded in artificially producing an anti-hydrogen atom. The discussion with Doser drifts into the obscure world of metaphysics. When asked whether physics will ever be able to explain what preceded the big bang, he replies that asking the question was futile based on the current level of scientific knowledge: "Time first emerged with the big bang and we still don't know what time means." Doser does not believe that the current generation of physicists will succeed in solving the mysteries of gravity and time. Researchers are unable to explain why we stick to the earth, and time remains an abstract concept. However, he has faith in the future generation of physicists: "I believe in mankind's ingenuity. New tools will be found to answer new questions." As in science fiction movies, he believes that mankind will one day be able to artificially extend its intelligence, enabling him to discover what preceded the big bang. "The aim of physics is to show how everything fits together and that the universe could not have been any different", says Doser.

A visit to CERN, near Geneva, is like entering a parallel world. What is reality and what is metaphysics? At the end of this tour through the world of basic research, many questions remain unanswered. The main one is: What are 7,000 scientists actually doing in this labyrinth of grey buildings, detector caverns and tunnels?

"There's definitely nothing dangerous going on"

What is the research being carried out at CERN at a cost of billions actually aiming to achieve? What do the physicists in Geneva hope to discover through their work? Joel Frei interviews Peter Jenni, a physicist from Berne who has worked at CERN since 1980, about his work.

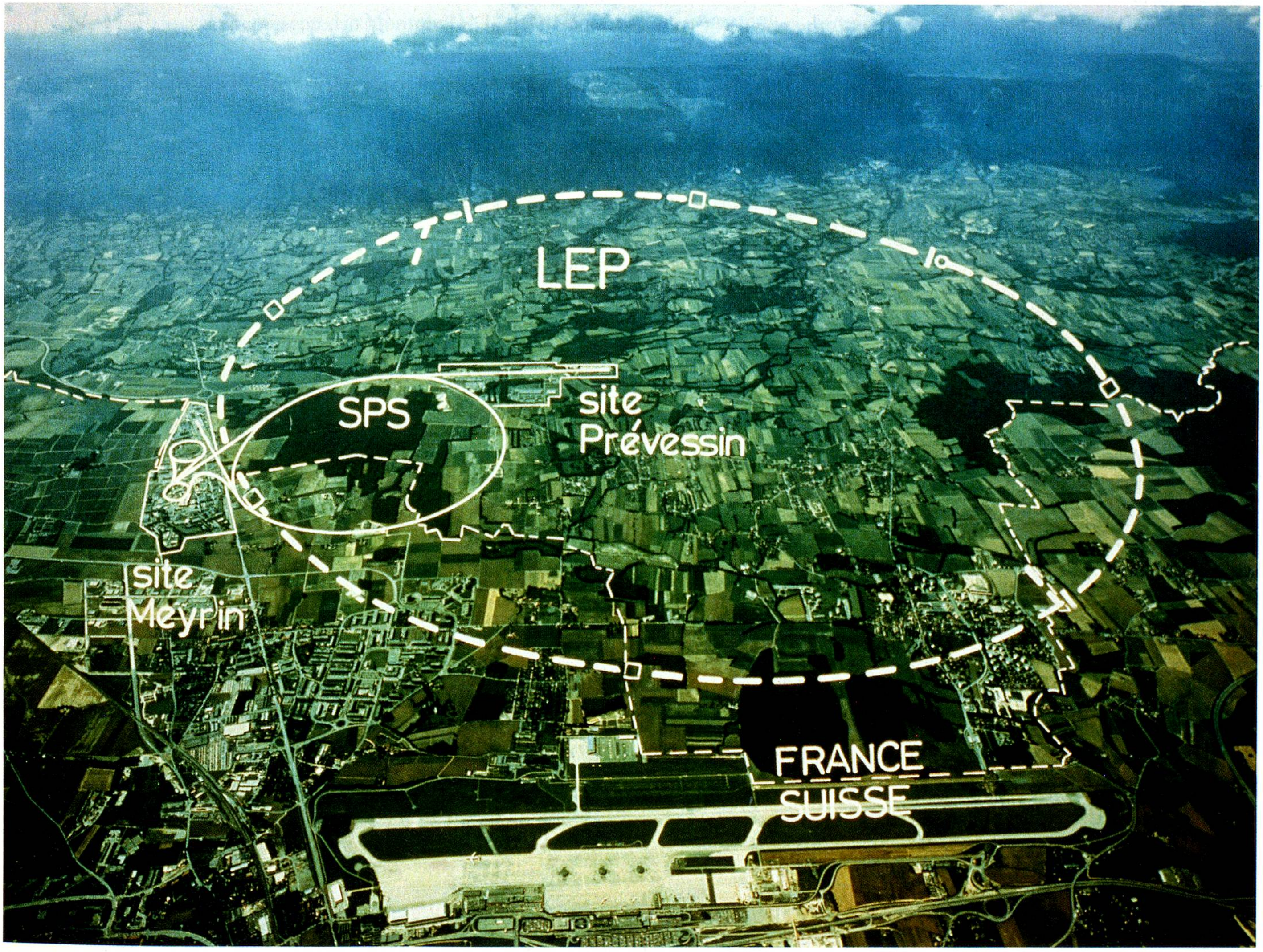


Peter Jenni has worked as a physicist at CERN since 1980.

What has been the most exciting moment in your career as a physicist?

There are three moments that have been very special for me. In the early 1980s, when we carried out the proton-antiproton accelerator experiments and discovered the W and Z bosons (mediators of weak interaction), that was CERN's greatest discovery. The approval of the ATLAS project in 1995 was also a great moment. And, of course, the

Picture below:
CERN in Geneva is the size of a small town and is the workplace of research scientists from 80 different countries.



first collisions in the LHC on 23 November 2009 were a very special moment after 20 years of development work.

Has the new LHC particle accelerator already produced concrete findings?

Yes, there are already many publications on the standard model in physics. This is the first time it has been tested at such high energy levels. We are observing that this model is generally behaving as we expected. And we have also broken new ground. For example, some hypothetical particles can already be ruled out. Thanks to the high energy levels we are working with, we are able to acquire more knowledge than our competitors at the Tevatron accelerator in Chicago. We haven't discovered anything earth-shattering yet, but we are making more progress than before. Naturally we hope that the LHC will help produce many new discoveries over the coming decades.

String theory, which is also being researched at CERN, is one of the symmetry theories. Is it likely to help us discover the "theory of everything" soon?

(Laughs). That's still a long way off. String theory makes no clear statements about things that might be observed in the LHC. However, there are follow-up theories to string theory, such as supersymmetry theory, that suggest the existence of new hypothetical particles. This is a very exciting theory because the LHC can help and could enable research results to be obtained in the search for the mysterious dark matter. Back in the 1930s, Swiss physicist Fritz Zwicky observed that visible matter alone cannot explain what holds galaxies together. Another kind of matter must exist with a fundamentally different structure. We cannot see any stars made of dark matter, but there are certainly lots of them – many more than those composed of visible matter. Dark matter is one of the biggest mysteries in physics and cosmology.

How would you respond to criticism that basic research at CERN costs too much money, with an annual budget of one billion Swiss francs, and consumes too much energy, 10% of the canton of Geneva's electricity?

Basic research is vital to mankind's technological advancement. We all depend on technological achievements. When research was carried out into electricity and magnetism, nobody could foresee how important this work would become. Basic research is the engine of progress. One of mankind's most basic attributes is a desire to understand the laws of nature. This is what differentiates us from animals. Another aspect is that there are many positive applications for the technologies developed at CERN. The World Wide Web was developed at CERN, and discoveries have also been made in the field of medicine. But perhaps even more important is that many young people are trained in leading-edge technologies, and quite simply the fact that our work here is based on international cooperation. We are well aware that cutting-edge research is expensive and understand the importance of keeping energy consumption under control and managing quality.

What would you say to people who fear that the LHC will create a black hole?

What happens in the LHC has been occurring naturally for many billions of years. Much more powerful particle collisions also occur in the universe. Yet we're all still here. There is no real risk and any fears are unjustified. CERN has taken such warnings seriously and commissioned expert reports which have given the all-clear based on probability calculations. This issue has often been raised, but since the LHC has been in operation such concerns have subsided because nothing has happened.

GLOSSARY

Standard model
This model of elementary particle physics is a physical theory that describes known elementary particles and their interaction. The model describes three different types of interaction: strong interaction, weak interaction and electromagnetic interaction.

Higgs particle
Named after the Scottish physicist Peter Higgs, this particle, which still only exists in theory, is important for explaining particle mass. It is predicted in the standard model of elementary particle physics.

Dark matter
A hypothetical form of matter that cannot be seen as it neither emits nor reflects light. Dark matter is in gravitational interaction with visible matter.

Antimatter
Matter composed of antiparticles that is the counterpart of the matter of which "our" world consists. Antimatter has a very short lifespan here because, when a particle-antiparticle pair collides, both are destroyed. Massive quantities of matter and antimatter were destroyed in this way during the big bang, leaving behind a small residual amount of matter, which is our world today.

String theory
Hypothetical physical models that attempt to provide a uniform explanation of all fundamental physical forces observed to date. In particular, this theory tries to combine gravitational theories with quantum theories. It goes beyond the standard model, but has never been tested in practice.

The theory of everything
This physical and mathematical theory attempts to integrally explain and link all known physical phenomena. A single model aims to explain all of nature's fundamental interactions.

Black hole
An astronomical phenomenon whose gravitational pull is so great that it even sucks in light. It distorts space/time so severely that nothing can escape from inside the hole.