BBC NEWS

Success for 'Big Bang' experiment

By Paul Rincon
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Three decades after it was conceived, the world's most powerful physics experiment has sent the first beam around its 27km-long tunnel.

Engineers cheered as the proton particles completed their first circuit of the underground ring which houses the Large Hadron Collider (LHC).

The £5bn machine on the Swiss-French border is designed to smash particles together with cataclysmic force.

This will re-create conditions in the Universe moments after the Big Bang.

But it has not been plain sailing; the project has been hit by cost overruns, equipment trouble and construction problems. The switch-on itself is two years late.

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The collider is operated by the European Organization for Nuclear Research - better known by its French acronym Cern.

The vast circular tunnel - the "ring" - which runs under the French-Swiss border contains more than 1,000 cylindrical magnets arranged end-to-end.

The magnets are there to steer the beam - made up of particles called protons - around this 27km-long ring.

Eventually, two proton beams will be steered in opposite directions around the LHC at close to the speed of light, completing about 11,000 laps each second.

At allotted points around the tunnel, the beams will cross paths, smashing together near four massive "detectors" that monitor the collisions for interesting events.

Scientists are hoping that new sub-atomic particles will emerge, revealing fundamental insights into the nature of the cosmos.

Major effort

"We will be able to see deeper into matter than ever before," said Dr Tara Shears, a particle physicist at the University of Liverpool.

"We will be looking at what the Universe was made of billionths of a second after the Big Bang. That is amazing, that really is fantastic."

The LHC should answer one very simple question: What is mass?

LHC DETECTORS

ATLAS - one of two so-called general purpose detectors. Atlas will be used to look for signs of new physics, including the origins of mass and extra dimensions

CMS - the second general purpose detector will, like ATLAS, hunt for the Higgs boson and look for clues to the nature of dark matter

ALICE - will study a "liquid" form of matter called quark-gluon plasma that existed shortly after the Big Bang

LHCb - Equal amounts of matter and anti-matter were created in the Big Bang. LHCb will try to investigate what happened to the "missing" anti-matter

"We know the answer will be found at the LHC," said Jim Virdee, a particle physicist at Imperial College London.

The currently favoured model involves a particle called the Higgs boson - dubbed the "God Particle". According to the theory, particles acquire their mass through interactions with an all-pervading field carried by the Higgs.

The latest astronomical observations suggest ordinary matter - such as the galaxies, gas, stars and planets - makes up just 4% of the Universe.

The rest is dark matter (23%) and dark energy (73%). Physicists think the LHC could provide clues about the nature of this mysterious "stuff".

But Professor Virdee told BBC News: "Nature can surprise us... we have to be ready to detect anything it throws at us."

Full beam ahead

Engineers injected the first low-intensity proton beams into the LHC in August. But they did not go all the way around the ring.

On Wednesday, they sent a proton beam around the full circumference of the LHC tunnel.

Technicians had to be on the lookout for potential problems: There are on the order of 2,000 magnetic circuits in the machine. This means there are 2,000 power supplies which generate the current which flows in the coils of the magnets," he told BBC News.

If there was a fault with any of these, he said, it would have stopped the beam. They were also wary of obstacles in the beam pipe which could prevent the protons from completing their first circuit.

Mr Myers has experience of the latter problem. While working on the LHC's predecessor, a machine called the Large-Electron Positron Collider, engineers found two beer bottles wedged into the beam pipe - a deliberate, one-off act of sabotage.

The culprits - who were drinking a particular brand which advertising once claimed would "refresh the parts other beers cannot reach" - were never found.

After the the beam makes one turn, engineers are due to "close the orbit", allowing the beam to circulate continuously around the LHC.

Engineers will then try to "capture" it. The beam which circles the LHC is not continuous; it is composed of several packets - each about a metre long - containing billions of protons.

The protons would disperse if left to their own devices, so engineers use electrical forces to "grab" them, keeping the particles tightly huddled in packets.

Once the beam has been captured, the same system of electrical forces is used to give the particles an energetic kick, accelerating them to greater and greater speeds.

After Wednesday's test, engineers will need to get two beams running in opposite directions around the LHC. They can then carry out collisions by smashing them together.

Long haul

The idea of the Large Hadron Collider emerged in the early 1980s. The project was eventually approved in 1996 at a cost of SFr2.6bn.

However, Cern underestimated equipment and engineering costs when it set out its original budget, plunging the lab into a cash crisis.

Cern had to borrow hundreds of millions of euros in bank loans to get the LHC completed. The current price is nearly four times that originally envisaged.

During winter, the LHC will be shut down, allowing equipment to be fine-tuned for collisions at full energy.

"What's so exciting is that we haven't had a large new facility starting up for years," explained Dr Shears.

"Our experiments are so huge, so complex and so expensive that they don't come along very often. When they do, we get all the physics out of them that we can."

Steve Myers said engineers would break out the champagne if all went to plan. But a particular brand of beer will not be on the menu, he said.

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