Thaxted Astronomical Society

News Features

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CERN’s New Particle Accelerator 4 Times Bigger

https://www.dailymail.co.uk/sciencetech/article-8439607/CERN-poised-new-20-BILLION-particle-accelerator.html

CERN backs new £19 BILLION particle accelerator that is four times bigger and six times more powerful than the Large Hadron Collider

Daily Mail 19th June 2020 >

- **The project would be built in phases with extra experiments added over time**
- **The Future Circle Collider will cover an area of 100km (62miles) under Europe**
- **It will become a 'Higgs factory' creating a 'great number of Higgs particles'**
- **Funding still needs to be approved by EU member states and other partners**

A new particle accelerator four times bigger than the Large Hadron Collider is a step closer after CERN agreed to back the £19 billion (€21bn) project.

The Future Circle Collider (FCC) will have a 62-mile (100km) circumference and be six times more powerful than the Large Hadron Collider (LHC).

The next-generation particle-smashing machine will allow scientists to study the Higgs boson in more detail, as well as provide new insight into dark matter.

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he Future Circle Collider will intersect with the Large Hadron Collider, expanding further out under Switzerland and France in tunnels stretching 62 miles.

Before any work can begin, a geological survey is needed under Geneva and the proposed route of the tunnel - just in case there are underground rivers that would put a stop to the proposals or require a whole new route.

The massive project doesn't have universal approval from the scientific community, with some claiming it is a 'waste of money' that would be better spent elsewhere.

Some researchers claim the money would be better spent on a radio telescope on the Moon, a gravitational wave detector in space, or more direct research funding.

Approval from CERN doesn't mean it will definitely be going ahead; it will still need to secure funding from EU members states, the UK and other agencies.

It also won't be operational until the 2040s, as work won't start on it for about a decade, and it will take just as long to complete the construction of the underground tunnels.

Officials hope for a decision by CERN's 22 member states within the next few years about the project, that would debut with an electron-positron collider at an estimated cost of €9billion (£8.16 billon)

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A second phase would involve a superconducting proton machine in the same tunnel - bringing the total cost to about €21 billion (£19 billion).

While the first machine would start operations in the 2040s, the second machine could start smashing particles sometime in the late 2050s.

The FCC's ultimate goal is to provide a 100-kilometre superconducting proton accelerator ring, with an energy of up to 100 TeV (tera-electronvolts), meaning an order of magnitude more powerful than the LHC,' said Frédérick Bordry from CERN.

'The FCC timeline foresees starting with an electron-positron machine, just as LEP (Large Electron–Positron Collider) preceded the LHC,' he said.

Expanding our understanding of the fundamental laws of nature requires the energy frontier to be pushed much further, CERN researchers said of the new collider.

'Reaching this goal within the 21st century in an economic and energy efficient way calls for a large circular collider,' they wrote.

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The first stage after approval is given and funding secured will be to conduct a geological survey to see if there are any underground lakes beneath Geneva.

If there are, it could lead the whole plan - and location of the FCC - to be reconsidered, which could delay its operational launch.

In fact, some of the technology required to smash particles at the sort of energy level being proposed doesn't even exist yet.

Research is needed into high-field superconducting magnets and other technologies before construction of the actual collider can begin.

This was one of a number of projects proposed as a replacement for the LHC when it reaches the end of its life by the start of the next decade.

Another proposal was a linear collider that could be expanded in stages - and the CERN council has urged CERN to work with Japanese scientists on this as a separate project.

However, in the end the council decided FCC was the better choice for CERN.

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Not only will the machine be larger, but it will be equipped with double-strength magnets for more powerful collisions.

This could ultimately help to solve many of the universe's unanswered mysteries, including dark matter.

'When you look into things like the movement of galaxies, we see that we can only understand and explain about 5 percent of what we observe,' Professor Michael Benedikt, leader of the FCC, told Horizon Magazine.

'But with questions like the so-called problem of dark matter, which is linked to the fact that galaxies and stars are not moving as you would expect them to, the only explanation we have is that there must be matter we do not see which distorts the movement accordingly.'

CERN says the machine will be a kind of 'Higgs factory' - producing enough of the bosons - first discovered at the LHC in 2012 - to give scientists a deeper insight.

'The discovery of the Higgs boson was a milestone in the long-standing effort to complete the Standard Model of Particle Physics,' the agency wrote.

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'Yet the Standard Model cannot explain certain observations, such as: the abundance of matter over antimatter, the striking evidence for dark matter and the non-zero neutrino masses.'

It is hoped that, by producing them in greater numbers, experts will be able to understand how they decay - something not possible with the lower-powered LHC.

This is important as it would allow CERN to discover if a leading theory - that Higgs particles decay into dark matter particles - is accurate or not.

'The frontier machines envisaged by the FCC study offer a rich experimental programme spanning almost a century,' CERN said in the design report.

'The unprecedented precision and high energy reach, will extend well beyond the LHC our search for answers to the most fundamental questions.'

The science produced by the FCC puts particle physics in 'uncharted territory' according to Tara Shears from the University of Liverpool.

The Large Hadron Collider had a clear target - to look for the Higgs boson - but there isn't a similar rock-solid prediction needing to be explored by the FCC.

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'That makes knowing where and how to look for answers more challenging and higher risk,' Shears told Nature.

'We do know that the only way to find answers is by experiment and the only place to find them is where we haven't been able to look yet.'

However, Sabine Hossenfelder, a theoretical physicist at the Frankfurt Institute for Advanced Studies in Germany claims that the money needed to build the FCC could be better used for more directed research.

'There is no reason to think that there should be new physics in the energy regime that such a collider would reach,' she told Nature.

'That's the nightmare that everyone has on their mind but doesn't want to speak about.'

CERN said it was not possible to say exactly what benefits the new collider would bring to the world, but pointed out that the discovery of the electron in 1897 led to the electronics industry.

'Proton colliders have been the tool-of-choice for generations to venture new physics at the smallest scale,' said Eckhard Elsen from CERN.

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'A large proton collider would present a leap forward in this exploration and decisively extend the physics programme beyond results provided by the LHC and a possible electron-positron collider.'

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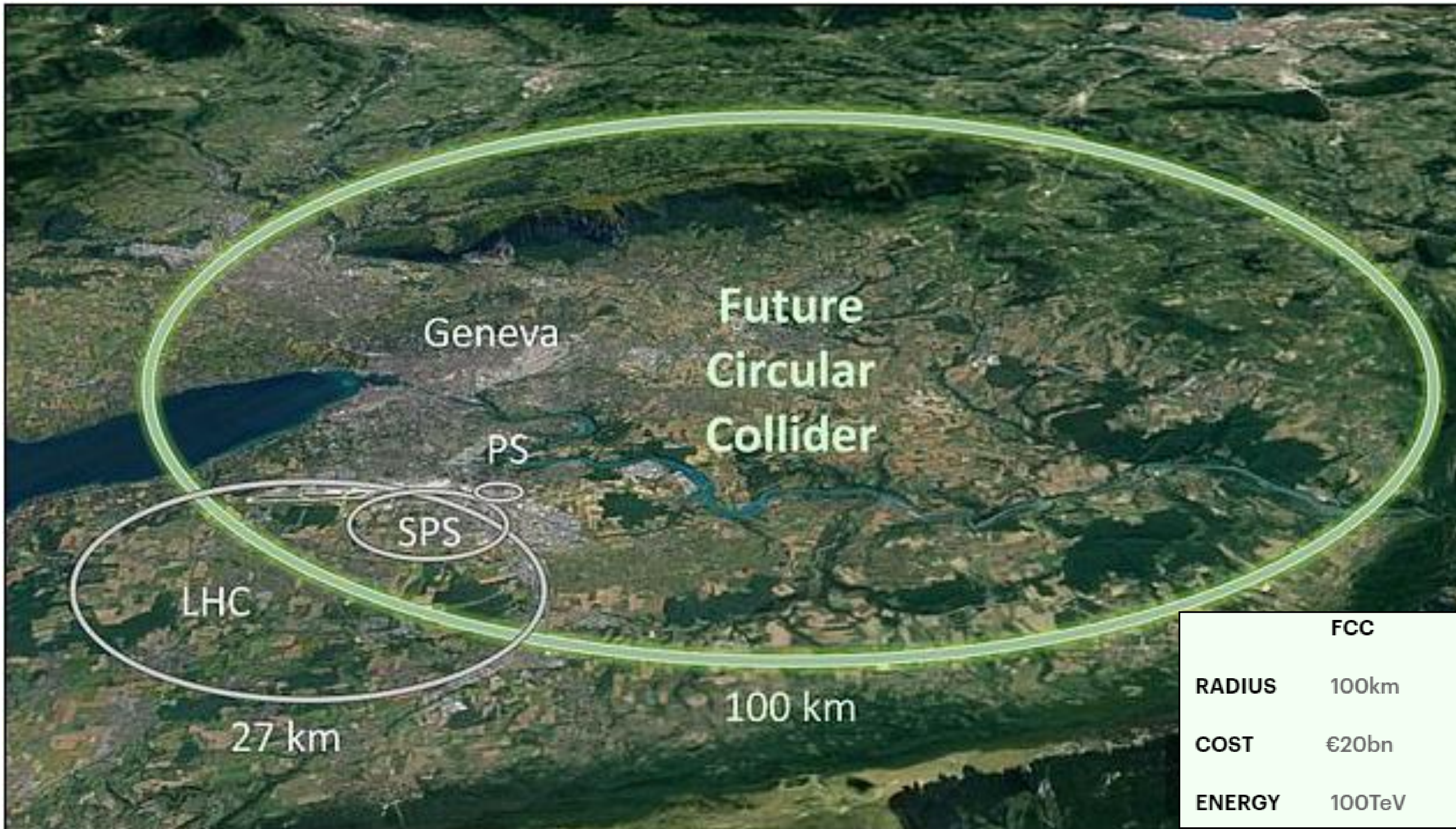

	FCC	LHC
RADIUS	100km	27km
COST	€20bn	€4.2bn
ENERGY	100TeV	14TeV

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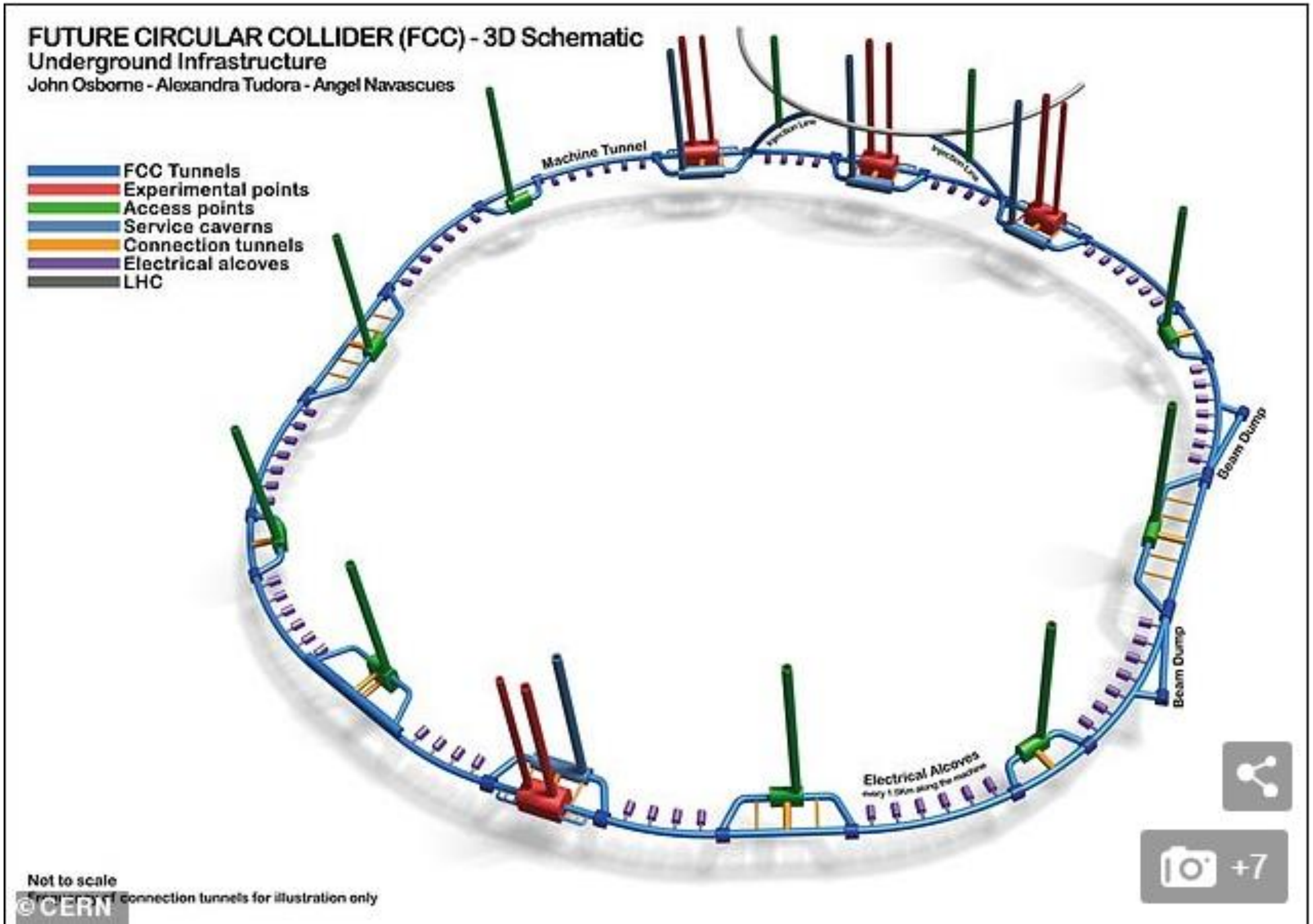
An illustration of the layout of the FCC including locations of tunnels and experiments



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THE HIGGS BOSON CARRIES MASS AND IS A FUNDAMENTAL PART OF THE STANDARD MODEL OF PARTICLE PHYSICS

The Higgs boson is an elementary particle - one of the building blocks of the universe according to the Standard Model of particle physics.

It was named after physicist Peter Higgs as part of a mechanism that explains why particles have mass.

According to the Standard Model our universe is made of 12 matter particles - including six quarks and six leptons.

It also has four forces - gravity, electromagnetism, strong and weak. Each force has a corresponding carrier particle known as a boson that acts on the matter.

The theory went that the Higgs boson was responsible for transferring mass.

It was first proposed in 1964 and wasn't discovered until 2012 - during a run of the Large Hadron Collider.

The discovery was significant as if it had been shown not to exist then it would have meant tearing up the Standard Model and going back to the drawing board.

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WHAT IS THE LARGE HADRON COLLIDER?

The LHC started colliding particles in 2010. Inside the 27-km LHC ring, bunches of protons travel at almost the speed of light and collide at four interaction points.

These collisions generate new particles, which are measured by detectors surrounding the interaction points.

By analyzing these collisions, physicists from all over the world are deepening our understanding of the laws of nature.

While the LHC is able to produce up to 1 billion proton-proton collisions per second, the HL-LHC will increase this number, referred to by physicists as 'luminosity', by a factor of between five and seven, allowing about 10 times more data to be accumulated between 2026 and 2036.

This means that physicists will be able to investigate rare phenomena and make more accurate measurements.

For example, the LHC allowed physicists to unearth the Higgs boson in 2012, thereby making great progress in understanding how particles acquire their mass.