6 May 2022

Why a future collider at CERN? An elevator pitch for decision-makers
v.7

[Physics]
After sixty years of collider[1] research, we know what are the fundamental building blocks that make up visible matter (stars, planets, galaxies, people), and the forces that keep them together. However, our current knowledge does not cover some of the most obvious properties of the Universe: it cannot explain what makes up 95% of the mass and energy of the Universe around us, or why matter (including us!) exists at all, for example.
A future collider will open the door to unravelling some of these mysteries: it is the best way to measure the properties of the Higgs boson, discovered at CERN in 2012, and the key to understanding many of the outstanding questions; a future collider will also allow a new realm of energies to be explored – up to 10 times higher than the current Large Hadron Collider (LHC) – thus bringing greater discovery potential.
A future collider at CERN will [enable world-leading collider research] / [be a world-leading physics facility] for the next 60 years, well into the 21st century.

[200 words; 1min]

[Benefits to society]
The development, construction and operation of a future collider at CERN will be a platform for the development of advanced technologies in many domains (including superconductivity, imaging and detection, quantum computing, robotics, artificial intelligence) and will feed the innovation cycle for decades. It will spill over into areas beyond particle physics (including health and the environment), and potentially help confront global societal challenges. Such a facility will also provide immense industrial opportunities through contracts for high-tech products and services, and produce a stream of highly-skilled professionals to supply a wide range of fields, including engineering, finance, computing and data analysis.
Planning, building and operating a future collider will bring people together across geographical, cultural and scientific borders, and inspire much-needed future careers in STEM.

[124 words; 37s]

[1] Colliders are research tools used in particle physics to accelerate particles in opposite directions and make them collide at specific points. By studying these collisions, physicists are able to probe the world of the infinitely small.

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In more detail

[Physics]
Sixty years of research at CERN and other particle physics laboratories around the world have provided many answers to questions that have fascinated philosophers and scientists for centuries: What are we made of? Where do we come from? Where are we going? Colliding particles at almost the speed of light gives us insight into the early Universe – just a millionth of a millionth of a second after the Big Bang – and how it has evolved since then.

Our understanding of the visible Universe is encapsulated in the Standard Model of particle physics – a triumph of 20th century science. The discovery of the Higgs boson – in 2012, at CERN - completed the Standard Model, yet many questions remain unanswered, including new questions about the fundamental nature of the universe arising from the discovery of the Higgs boson:

- Visible matter (stars, planets, galaxies, people) accounts for only 5% of the Universe; we do not know what makes up the remaining 95%! Understanding the remaining 95% would allow us to better understand how galaxies are held together (possibly by dark matter).
- Another longstanding mystery is why matter exists in the first place. According to what we know today, the Big Bang should have created matter and anti-matter in equal amounts, which should have annihilated one another, producing pure energy. However, today we are surrounded vastly by matter, which makes up everything we see in the Universe, including ourselves. Most of the anti-matter produced in the early universe disappeared, and we don't know why.
- The Higgs boson played a role in the early universe: without the Higgs boson, fundamental particles would not have acquired mass, hence atoms would not exist and we would not be here. Yet we do not understand how its pervasive presence throughout the universe was established a tenth of a billionth of a second after the Big Bang.

Indeed, the Higgs boson is the key to understanding many of the outstanding questions about the Universe: it could be a portal to the dark sector of the Universe; it might have played a role in the creation of the matter/anti-matter asymmetry and in the exponential expansion of space in the very early universe (immediately after the Big Bang).

- **A future collider will allow us to produce formidable amounts of Higgs bosons and measure the properties of this special particle with unparalleled precision, which will give us insight into how it may have shaped the Universe we know today.**

We know much more today about the building blocks of the Universe and their interactions than we did when the LHC (Large Hadron Collider) started at CERN, 11 years ago. Yet to further explore the open mysteries of the Universe, collisions at greatly larger energies than those achieved by the LHC are needed.

- **Through the exploration of the new realm of energies offered by a future collider, discoveries will be made and answers to the existing mysteries, such as the nature of dark matter, may be found.**

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[Benefits to society]

Sixty years of building and carrying out research with particle colliders[2] have transformed the world (e.g. the World Wide Web, 50 000 accelerators in hospitals for medical imaging and treatment, microelectronics). A future collider brings immense opportunities for further societal benefits over the next 60 years.

The scale and demands of the advanced technologies needed for a future collider (including superconductivity, imaging and detection, quantum computing, robotics, artificial intelligence) will feed the cycle of innovation and knowledge-based job creation for decades.

- The technologies developed for the construction and operation of a future collider will find applications beyond particle physics, in crucial areas such as healthcare, environment and sustainability, and information technology, potentially helping to address global societal challenges.
- A future collider will require intense and large-scale industrial participation, thus providing significant business opportunities for a wide range of industries/businesses in your country/region.
- A future collider will increase the technological value of companies. Studies have shown that each CHF spent by CERN in procurement for the LHC generated three CHF worth of additional value to the suppliers of high-tech equipment[3].
- Designing, planning, building and operating a future collider will provide unique learning and training opportunities for professionals in a diversity of roles (including but not restricted to highly skilled technicians, physicists, and engineers) [4]
- This stream of highly-skilled professionals will supply a wide range of fields, including engineering, finance, computing and data analysis.

[For a science minister]
A future collider at CERN will give your scientific community access to unique, state-of-the art facilities and allow it to be part of a global, excellence-driven research endeavor, reflected in high-impact publications, successful grant applications and high-scoring research performance assessments.

The development, construction and operation of a future collider will provide unique platforms to inspire young people in your region/country to pursue careers in science, technology, engineering and mathematics (STEM) and prepare them to address global societal challenges.

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[2] Colliders accelerate particles in opposite directions and make them collide at specific points. By studying these collisions, physicists are able to probe the world of the infinitely small.

[3] The economic impact of technological procurement for large-scale research infrastructures: Evidence from the Large Hadron Collider at CERN, P.Castelnovo, M. Florio, S. Forte, L. Rossi, E. Sirtori, 2018

[4] A 2018 study on the value of human capital formation at CERN confirmed both quantitatively and qualitatively that the impact for Early Career Researchers of training in a CERN's LHC and HL-LHC accelerator project is a 5% to 13% salary premium (depending on the level of higher education and technology field). Social Cost-Benefit Analysis of HL-LHC, A. Bastianin, 2018