

I. Publishable summary

1. EXECUTIVE SUMMARY

The Large Hadron Collider (LHC) at CERN is the largest scientific instrument ever designed and built. To keep the LHC at the forefront of research in high-energy physics it will need significant upgrades to increase its luminosity capabilities by a factor of ten after 2020. As part of the High Luminosity LHC (HL-LHC) programme, the FP7 HiLumi LHC Design Study achieved all of its scientific and technical goals within its four years of activity.

This project covered six EU-funded Work Packages with contributions from 15 European laboratories and universities, and partners from United States, Russia and Japan.

The development of technologies key to the HiLumi upgrade such as beam dynamics, magnets, crab cavities, collimators, and superconducting links were the core results of this Design Study. In addition, a timeline and governance for the construction and installation of the HL-LHC was established. The main outcomes of the project are outlined below:

- Networking with the LHC Experiments community to establish a reasonable timeline for the construction and installation of the HL-LHC. This resulted in the creation of the LHC / HL-LHC Plan, which foresees the upgrade installation to begin in 2024.
- A coherent set of beam parameters were established that would achieve the increase of luminosity which is tenfold the design luminosity of the LHC.
- HiLumi contributed to new technologies for the development of the magnets required to help reduce the beam focal length at the collision points. New quadrupole aperture and cooling protocols were defined, and magnets for the insertion regions of the HL-LHC were designed.
- Further technological advances of HiLumi include the development of a new material (molybdenum-graphite) to minimise the impedance of the collimators which act as a barrier between the magnets and the beam. The use of MgB₂ wire allowed the development of a novel Superconducting Link system for the HL-LHC. Furthermore, new schemes for beam collision were designed and tested.
- Links with industry were cultivated through outreach events, consultation on best practice, and making European Industry aware of the opportunities for contracts at the level of 500 million euros, to become equipment and service providers during the construction phase. A new H2020 pre-commercial procurement project was launched to incentivize industry regarding the production of very challenging key technologies required for the LHC upgrade. The project brings together international infrastructures with aligned technical requirements in magnet development to act as a single buyer group.

- Beyond industrial influence, the HiLumi LHC Design Study has also had a number of societal impacts. More than 80 outreach talks were given by HiLumi LHC project members, and 35 PhD students and postdocs were involved in research and studies, resulting in six university dissertations based on the project to date. Additionally, some HiLumi LHC technologies have medical applications, which may lead to the production of more compact accelerators for use in medical imaging.
- By upgrading the LHC, Europe will be able to maintain its status as a world-leader in high-energy physics up to at least 2040. This ensures that the European Research Area remains attractive for researchers in a competitive global market.

In achieving all of its technical and scientific goals, the HiLumi design study has paved the way for the transition into the construction phase of the HL-LHC.