The Large Hadron Collider
A marvel of technology

10th Anniversary of the discovery of the Higgs boson, 4th July 2022

Lyn Evans
In December 1993, a plan was presented to the CERN Council to build the machine over a ten-year period by reducing the other experimental program of CERN to the absolute minimum, with the exception of the full exploitation of the LEP collider. An external expert panel chaired by Robert Aymar endorsed the design.
Although the plan was generally well received, it became clear that two of the largest contributors, Germany and the United Kingdom, were very unlikely to agree to the budget increase required. They also managed to get Council voting procedures changed from a simple majority to a double majority, where much more weight was given to the large contributors so that they could keep control.
The 10 metre long prototype bending magnet for LHC, which has reached a field of 8.73 Tesla on 14 April 1994.
Message de J.-P. Gomber et R. Perin

t à L. Evans

- on a atteint 8,73 Tesla
  200 quench
Japan becomes an Observer of CERN and announces a financial contribution to the LHC. The Japanese Minister for Education, Sciences and Culture offers a Daruma doll to CERN’s Director-General. According to Japanese tradition, an eye is painted on the doll to mark the beginning of the LHC project and the second eye must be drawn at the time of its completion. Japan makes two other major financial contributions to the LHC project in 1996 and 1998.
March

➢ India makes a financial contribution to the construction of the LHC.

➢ And in June, Russia announces a financial contribution to the project.

December

➢ Canada announces a financial contribution for the LHC, while a protocol of co-operation is defined for participation of the United States.

➢ In December 1997, the US declares a contribution.
QRL crisis June 2004
Magnet rows
Magnet rows
Aerial view of Point 5
Gallo-roman vestiges 1998
Roman coins found during archeological excavations at Point 5
Inner triplet crisis Feb 2005
The crisis of the PIM’s
Arc plug-in module with damaged fingers
Transmitter ball
The CERN Large Hadron Collider in Geneva, Switzerland, which will be the world's largest particle accelerator when it enters full operation in 2008.
Cross-section of LHC cryodipole
LHC beam screen
For roughly 3 km of the 27 km circumference, mainly in the long straight sections, the vacuum chambers are at room temperature, requiring a low residual pressure without the benefit of the distributed cryopumping. As a spin-off of the development of sputtering technology for superconducting cavities a new getter material (TiZrV) has been developed which can be sputtered on the internal surface of the copper vacuum chambers and can be activated at the very low temperature of 200 degrees (conventional getters require activation at 600 degrees).

When activated, the chamber wall itself becomes a distributed pump, producing very low residual pressure and at the same time a very low secondary emission yield, preventing the buildup of an electron cloud.

All warm chambers, including those inside the detectors, are treated in this way.
Critical current density of technical superconductors

![Graph showing critical current density (Jc) vs. magnetic field (B) for different superconductors and cables.](image-url)
Cross-section of LHC cryodipole
7000 km of superconducting cable Nb-Ti
Cable insulation by double polyimide wrap
### Specific Heat of LHe and Cu

<table>
<thead>
<tr>
<th>Temperature [K]</th>
<th>Specific Heat [J/g.K]</th>
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<tr>
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**Graph:**

- **Red Line:** LHe
- **Blue Line:** Cu

The graph shows the specific heat of LHe and Cu as a function of temperature. The specific heat of LHe increases significantly at around 2 K, while that of Cu increases linearly with temperature.
equivalent thermal conductivity of He II

\[ K(T, \dot{q}) = \dot{q}^{-2.4} \cdot Y(T) \]
\[ \frac{dT}{dX} = \frac{\dot{q}^{3.4}}{Y(T)} \]
\( \dot{q} \) in W/cm²

T in K
X in cm

OFHC copper

Helium II
Cryogenic operation of LHC sector

Sector temperature profile at 19 Feb 14:28

Temperature [K]

Point 4

RF cavities
Arc magnets
LSS magnets

Mid Arc

Point 5

Saturated Vapour Temperature: 1.79K

3.3 km