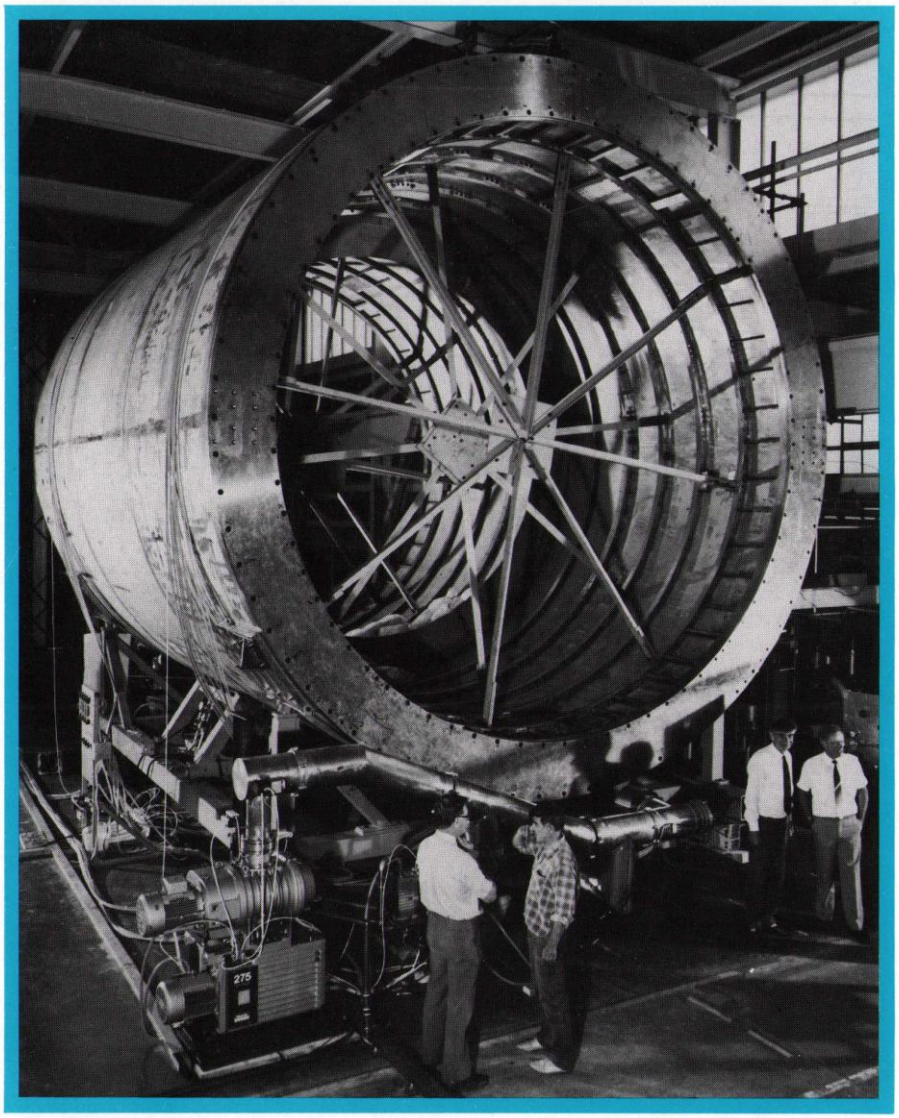
THE DELPHI SOLENOID



Rutherford Appleton Laboratory

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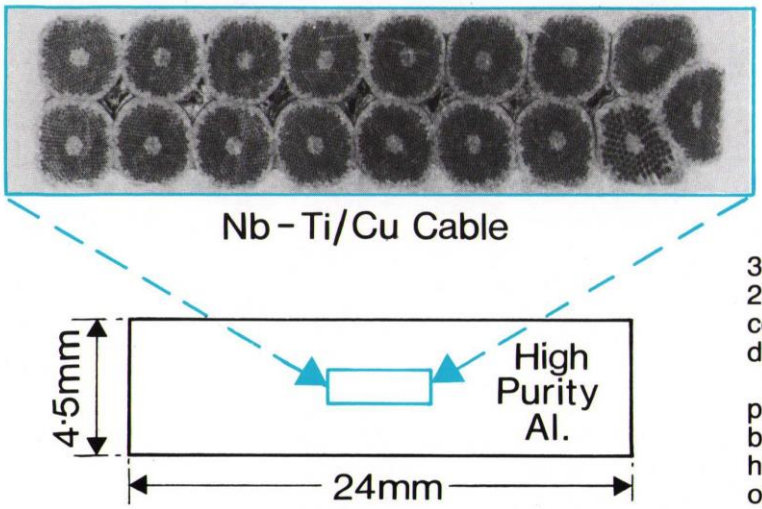
The World's Largest Superconducting Solenoid

has been designed and constructed at Rutherford Appleton Laboratory (RAL) under a joint agreement with CERN in Geneva. It forms part of the DELPHI experiment at CERN to be mounted on the Large Electron-Positron (LEP) accelerator now under construction.

Magnetic fields deflect charged particles and measuring their deflections enables their momenta to be determined. Powering the giant solenoid will create an immense uniform magnetic field in which these precise measurements can be made. Using a superconducting solenoid, the electrical power consumption will be only 0.5 MW. A conventional system for the same field would have required 50 MW.

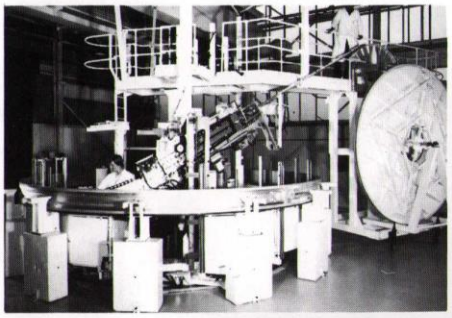
Superconductor

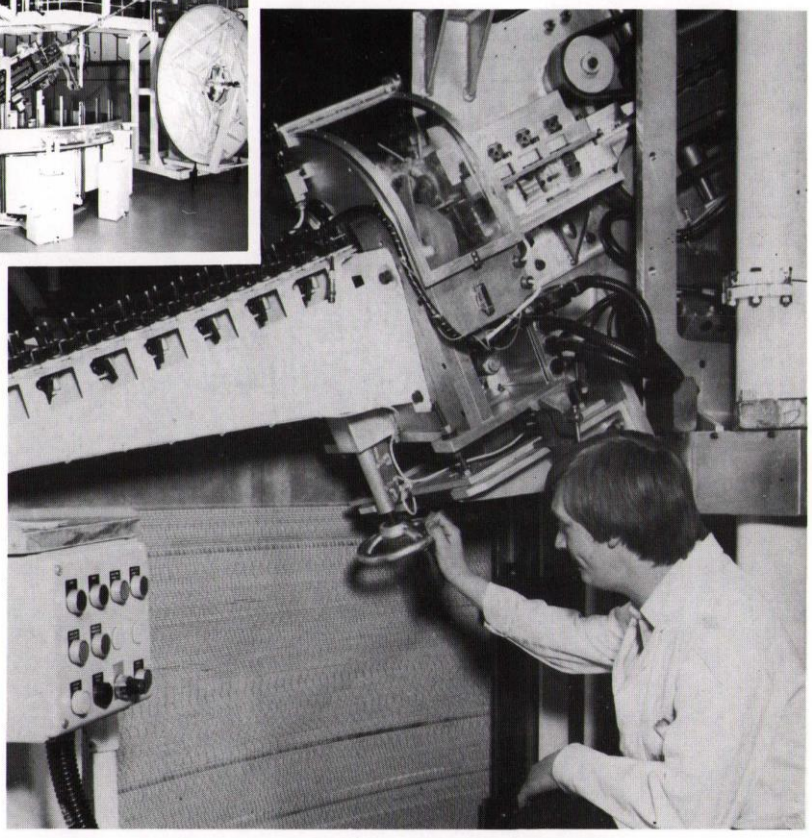


300 niobium-titanium superconducting filaments 25 microns in diameter, embedded in a matrix of copper, make up a wire. 17 wires 700 microns in diameter are twisted to form a cable.

The cable is clad in high purity aluminium to protect the superconductor if a fault occurs and it becomes resistive. The conductor is designed to have a safety factor of two on the required operating current.

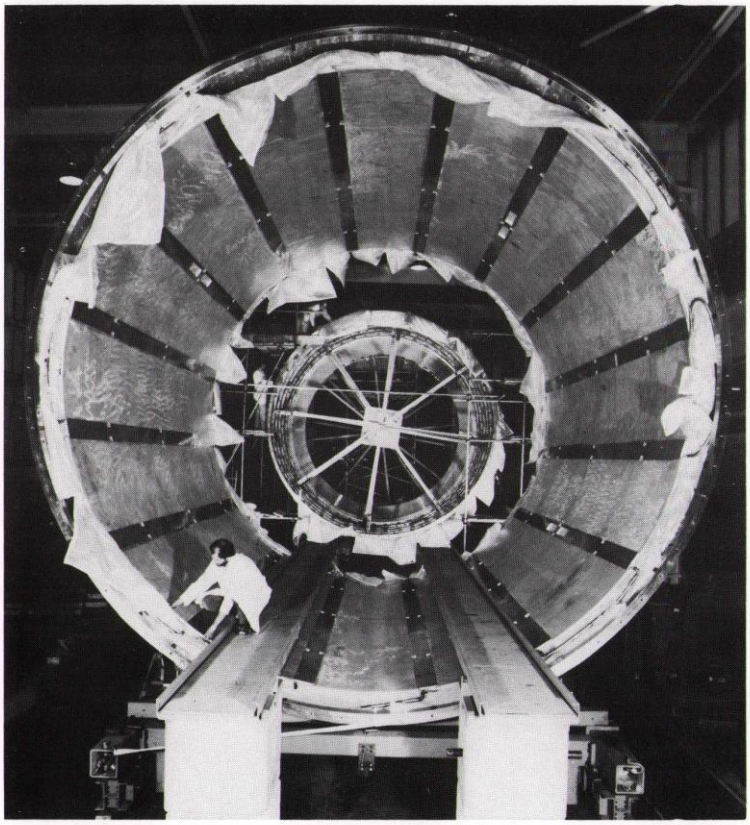
Coil winding





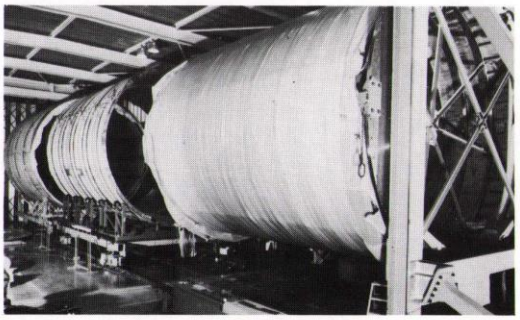
RAL developed the novel technique of winding the coil on the inside of a cylinder rather than the usual commercial practice of winding it on the outside. This allows the cylinder rather than the coil to hold the magnetic pressure. The pressure also ensures good thermal contact between the coil and the cylinder. Liquid helium is pumped through tubes on the outer surface of the cylinder to cool the conductor to 4.5 K where it becomes superconducting. Winding the coil involved forcing the conductor, which was first double half-lapped with glass tape impregnated with epoxy resin, down a ramp on to the inner surface of the cylinder. After winding, the conductor was compacted and pressed on to the cylinder wall and the resin was cured by baking. The complete coil was built in four 1.5 m long sections, plus two 0.35 m long end sections that were double layer-wound to make the field more uniform. The six sections were bolted together and the conductors were joined by edge welds.

Solenoid assembly



The solenoid consists of five concentric cylinders: the inner and outer shells of the vacuum tank, the coil cylinder itself and the inner and outer radiation shields (made of 16 panels supported from the vacuum tank shells). Between the cylinders are blankets of superinsulation made from multiple layers of aluminised mylar.

The cylinders were assembled horizontally on support trolleys. The inner vacuum shells were cantilevered from one end. The outer cylinders were slid on, one by one, to build up the complete solenoid. Every unit was vacuum pressure tested during assembly. The complete solenoid was vacuum tested and the radiation shields and coil were test cooled to 77 K before shipping to CERN.



Data

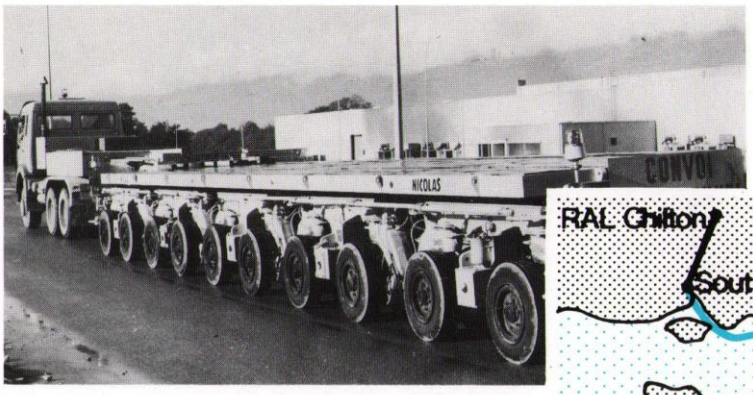
Parameters

Central Magnetic Field	1.2 Tesla
Volume of Useful Field	145 m^3
Stored Energy	110 MJ
Operating Current	5 kA
Size:	
External Diameter	6.2 m
Internal Diameter	5.2 m
Length	7.4 m
Weight	84 tonnes
Length of Conductor Used	20 km
Operating Temperature	4.5 K
Magnetic Hoop Pressure	6 atmospheres

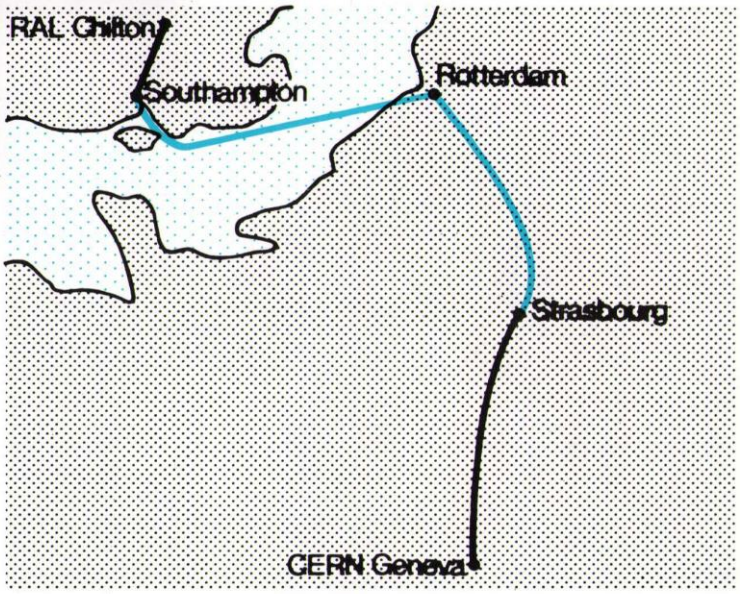
Milestones

NOVEMBER 1983	Main parameters for solenoid agreed
MAY 1984	Design proposal completed
AUGUST 1984	Main components ordered
SEPTEMBER 1985	Vacuum vessel assembly started
FEBRUARY 1986	Coil support cylinders delivered, winding tests started
MARCH 1986	Coil winding started
DECEMBER 1986	Coil winding completed
FEBRUARY 1987	Coil and vacuum vessel assembly completed
SEPTEMBER 1987	Cooling tests at 77 K
OCTOBER 1987	Ship to CERN

Delivery & Route

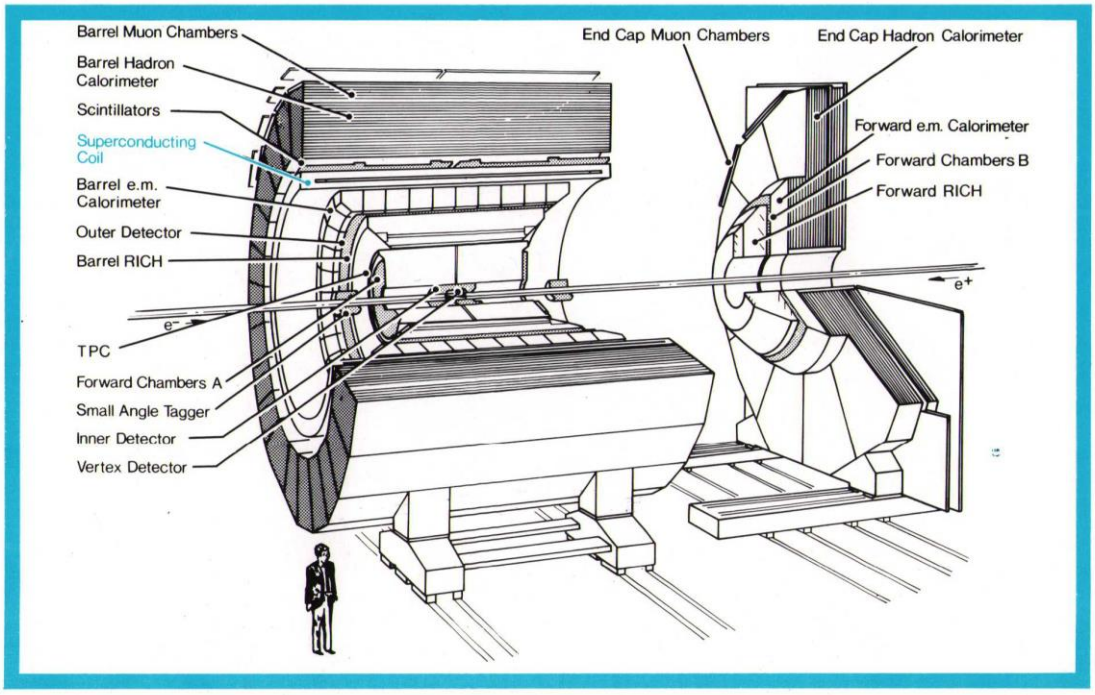


A special trailer was obtained by CERN to transport the solenoid from RAL to CERN. It has 20 pairs of wheels which are all steerable and can be raised or lowered hydraulically. The solenoid will remain attached to the trailer throughout the journey.



The solenoid travels 110 km from RAL to Southampton by road, then 480 km by ship to Rotterdam. It is then transferred to a barge to travel 650 km up the Rhine to Strasbourg. The remaining 350 km of the journey to CERN is by road. A major item in the cost of transport is for raising overhead cables and removing and replacing street furniture.

The DELPHI experiment



The 47 GeV electrons and positrons in LEP will collide head-on in the middle of DELPHI to produce millions of almost stationary Z^0 bosons each year. Z^0s promptly decay. Studying so many decays in detail may answer some of our fundamental questions about the deep structure of matter.

Does the top quark exist? Are there just three generations of quarks and leptons? Have quarks and leptons no sub-structure? Is super-symmetry realised in nature? Is the Higgs boson really the main source of mass in the Universe? Or is reality stranger than we think?