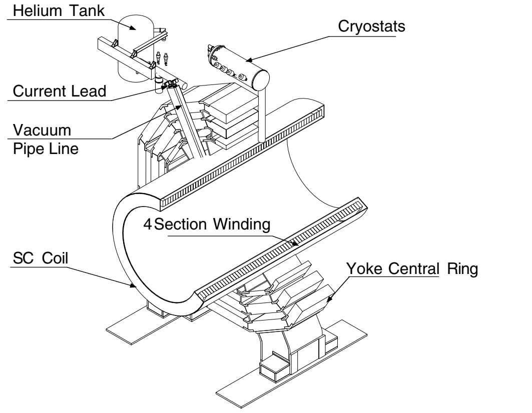
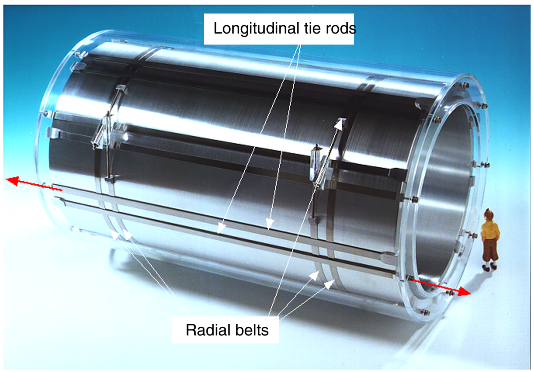
# Magnet system

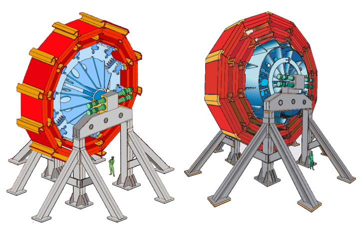



Open view of the superconducting coil inside its vacuum tank

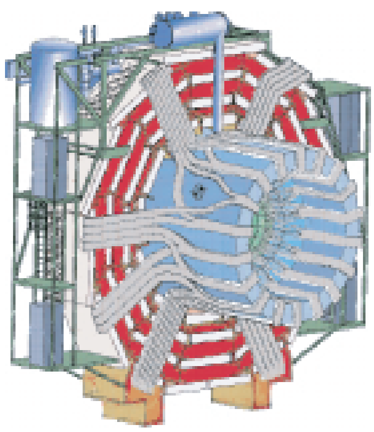



The magnetic yoke contains the muon chambers while the barrel part of the hadron calorimeter, HB, of the electromagnetic calorimeter, EB, and the tracker are situated inside, and supported from the inner shell of the vacuum tank

The CMS magnet system consists of a superconducting coil, the magnet yoke (barrel and endcap), a vacuum tank and ancillaries such as cryogenics, power supplies and process controls. The main parameters are a uniform axial magnetic field of 4 Tesla, a yoke diameter of 14 m across flats, an axial yoke length including endcaps of 21.6 m and a total weight of about 12000 tons. It will be the largest superconducting magnet system in the world: the energy stored into it, if liberated, will be large enough to melt 18 T of gold



Ferris-Wheel with assembly jig for central barrel yoke



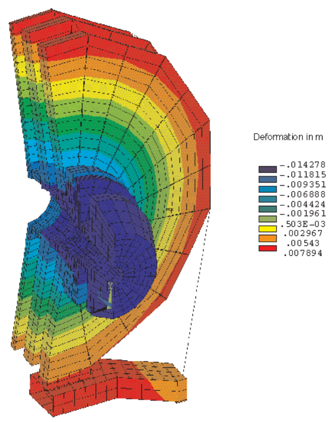
Central barrel yoke, coil, and cables

The magnetic flux generated by the superconducting coil is returned via a 1.5 m thick saturated iron yoke. This yoke is a 12-sided cylindrical structure, divided into endcap and barrel regions. The barrel yoke is divided in 5 rings, is 13.2 m long and has a mass of about 7000 T. Each barrel ring is made up of three iron layers. Connecting brackets join together the steel plates forming the three layers and provide the required structural rigidity. The central barrel ring is the only stationary part around the interaction point and it is used to support the vacuum tank and the superconducting coil. The other four barrel rings and the endcap disks slide on common floor rails, running in the beam direction, to allow insertion and maintenance of the muon stations . Each endcap is built from three independent disks which can be separated to provide access to the forward muon stations. Due to the axial magnetic field the two inner disks must withstand an attraction force of about 85 MN and resist the large bending moments induced. Therefore these two disks are 600 mm thick whereas the outer disk is only 250 mm thick. Each endcap weighs 2300 tons. The vacuum tank is made of stainless steel and houses the superconducting coil. The outer shell of the vacuum tank is attached to the inner part of the central barrel ring and the coil is symmetrically supported from it. All the barrel sub-detectors, HB, EB and tracker are supported by the inner shell of the vacuum tank via a system of horizontal rails.

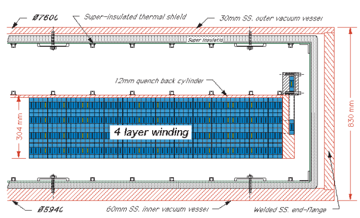
The superconducting coil system consists of the coil and the ancillary subsystems required for its operation and the protection system. The structure of the superconducting coil is self-supporting , whereby magnetic forces are resisted where they are produced. The reinforced conductor of the four layer CMS coil can sustain by itself all the induced magnetic forces. As the forces induced in the conductor by the magnetic and thermal loads go beyond the yield stress of the pure aluminum a metallurgically bonded mechanical reinforcement is needed. The best way is to have this reinforcement acting axially and tangentially to the coil thus minimizing the conductor construction and winding operation. Ancillaries for the superconducting coil are:

- the external cryogenic system from the flanges of the outer cryostats,
- the power supply from the current breakers,
- the vacuum system from the flange on the pumping line,
- the process control and the interface to the Slow Control system of the experiment.

The external cryogenic sub-system consists of the compressors, the cold box, the vessels containing the 200 $m^3$ of pressurized helium gas, the 5000 l LHe container and the cryogenic lines. The cold box and LHe container will be installed near the magnet whereas the compressors and pressure vessel will be at the surface level. The complete system will be installed temporarily on the surface for refrigerator commissioning and coil tests.




CMS Endcap
Magnetic and gravity loads along the beam direction




Cross-section through the end of the solenoid