26. ASSEMBLY AND PLANNING

26.1 EXPERIMENTAL AREA REQUIREMENTS

The assembly of CMS is a demanding task because of the very large size and mass of the various elements. This assembly cannot be done directly in the underground area (UXC5), which has been designed to the minimum size to minimise cost. As explained in Chapt. 25.1, if the assembly was done underground then the required size of the underground area would have to be at least 90 m long with a large cross section allowing for the installation of two 80 tonne travelling cranes.

26.1.1 Requirement for Surface Buildings

Point 5, which has been allocated to CMS is too far from the main site of CERN to allow a meaningful use of existing halls, and, in addition, the transport of large pieces (say more than 15 m in diameter and more than 1000 tonne in weight) is not possible in the region. Thus CMS requires, during the assembly period, a large assembly hall on the surface (SX5), the required occupancy date for the first phase of SX5 being 1/10/1999.

This hall cannot be positioned directly over the main shaft because this area has to be left free for the civil engineering to complete USC5 and UXC5 after the stop of LEP, and then to allow UXC5 to be equipped, (Fig. 26.1).

The cross section of the surface hall SX5, during the assembly period, is determined by the size of the experiment and allows for the installation of two 80 tonne travelling cranes. This determines the outside dimensions of the building as 23.5 m wide and 23.5 m high, (Fig. 26.2).

The assembly of the solenoid which is a 13 m long heavy object inside a 13 m long cryostat, can only be done horizontally. As this operation has to take place when all other large pieces are already present, it is in fact this operation which determines the length of the surface building for the assembly period, (Fig. 26.3). The required length is 92 m.

The decision to wind on site requires only a small additional building (SXL5) to complete and reinforce the conductor and spool it on site, as spools of reinforced conductor are not transportable. This additional building is considered a part of the magnet project and its cost has been taken into account inside the magnet budget.

After the surface test of the magnet, the assembly building will be connected to the part of the SX5 building covering the main shaft, which will have been completed in the mean time, allowing for the transfer of the heavy pieces to the underground area.

After the transfer of the CMS magnet to the underground area has been completed, the surface building SX5 will be reduced in height to 16 m, and in length to 100 m, a size sufficient for the normal running of CMS and which also satisfies environmental requirements, (Fig. 26.4).

26.1.2 Requirement for Underground Area

The main cavern (UXC5), 26.5 m in diameter and 53 m long at a depth of 97 m ground to ground, is very similar in shape, size and volume to the present LEP cavern at point 2, and the CMS detector fills it nearly completely (Fig 26.5). The service cavern (USC5) has a diameter of 18 m and a length of 85 m, and is aligned parallel to the main cavern, but offset to provide a minimum distance of 7 m between them, (Fig. 26.6), for structural but also shielding reasons as explained in Chapt. 25.3.

The main access shaft to UXC5 is PX56 which has a 20.4 m diameter, providing a 14 m x 19.5 m free opening for the installation of the magnet. A second shaft, PM54, 12 m diameter provides access to USC5, and at the same time gives access to the other end of the detector (from the main access shaft) through a short transfer tunnel TX54, as explained in Chapt. 25.

The part of the service cavern directly facing the experiment is used to house the counting rooms. The other part of the service cavern, farther away behind PM54, is used to house all services, (Fig 26.7). In particular the services for the magnet, mainly the cold box and the power supply will be installed in USC5. In order to maintain the shielding efficiency of the wall between USC5 and UXC5, the transfer lines and the bus bars will pass through the shielding wall at an angle, (Fig 26.8). It is presently planned to installed the dump resistor in the lowest portion of the main shaft PX56, above the demountable platform closing the main shaft.

26.2 ASSEMBLY ON THE SURFACE

The assembly of the magnet in the surface hall SX5 will start with the assembly of the first End-Cap, as described in Chapt. 8. In parallel, the welding of the two end sections of the outer vacuum tank will be finished to form complete shells, and these will be stored inside the side alcove destined to receive, at a later stage, the cold box for the surface test of the magnet, (Fig 26.9, phase 4).

Then assembly of the barrel iron rings will proceed using a Ferris-Wheel arrangement, as described in Chapt. 7. The two rings YB-2 and YB-1 will first be assembled, in this order, using a dedicated jig (Fig. 26.13-A), then the central iron ring YB0 will be assembled using the central shell of the outer vacuum tank, properly reinforced, as the assembly jig (Fig. 26.13-B). The assembly of the two rings YB2 and YB1 can then proceed, in this order, using the same assembly jig as the first two rings (Fig. 26.9, phase 10).

Then the second end-cap will be assembled, as described in Chapt. 8, and the outer shell of the vacuum tank completed by welding the two end sections, previously stored inside the side alcove, to the central part of the vacuum tank, (Fig 26.9, phase 12).

The reinforcement of the conductor on site by Electron Beam welding will proceed in the hall SXL and the conductor for the first layer will be spooled inside SX5, (Fig 26.10, phase 13). The winding machine will then be installed and winding of the first layer may proceed, (Fig 26.10, phase 15).

Winding of the following layers of the coil, and curing, will proceed in parallel with the preparation of the conductor length for the subsequent layers, (Fig 26.10, phase 17) as it is explained in Chapt. 19.

When the coil is finished (see Chapt. 19), including the quench-back cylinder, the outer cold screen and associated superinsulation layers, it will be rotated to the horizontal position, (Fig 26.11, phase 22). To ease the passage of the centre of gravity, from one side to the other of the rotation axis, a removable water counterweight is integrated in the device. The water tank is first filled with water. Then, using a rented gantry crane, the solenoid is tilted to bring the projection of the centre of gravity close to the rotation axis. The system is secured in this position. Then the water is drained out, and the centre of gravity will slowly change side with respect to the rotation axis. From this point, the securing system will be slowly elongated, bringing the coil axis to the horizontal position. The central barrel ring will then be slid over the coil assembly, (Fig 26.11, phase 23 and Fig. 26.14) using high pressure air pads.

The shell of the inner vacuum tank will be prepared on the same turning system previously used to rotate the coil to the horizontal position. In parallel the cold mass will be completed, (Fig 26.11, phase 25), in particular the layer to layer connections. Then the inner shell of the vacuum tank, equipped with its cold screen and associated superinsulation layers, will be rotated to the horizontal position, and the central barrel ring (now including the coil) will be slid over it, (Fig 26.12, phase 26), using high pressure air pads.

The vacuum tank will then be completed by welding the end flanges, as explained in Chapt. 9. In parallel all connections from the coil to the outside world through the chimneys will be completed.

Cooling down of the coil may then proceed, (Fig 26.12, phase 28). The two halves of the Hadronic Calorimeter will be inserted inside the inner vacuum tank to stress the vacuum tank to its definitive shape in order to have the final position of the coil during the magnetic test at the surface.

The yoke will be closed to allow the magnetic test at full current, (Fig 26.12, phase 32). This test will proceed in steps. The decentering forces will be measured and the position of the coil will be adjusted, acting on the suspension system, to minimise the forces due to decentering and misalignment, as explained in Chapt. 9 and 18. After the magnetic test, the two HB will be removed from the vacuum tank and the magnet will be ready for installation in the underground area.

Then, when the underground hall will be available towards end of October 2003, all heavy elements will be slid over the floor of the surface assembly hall using high pressure air pads, on top of the shielding plug. This plug (2 m thick for protection against radiation) has been designed to support the 2000 tonne weight of the central section of the magnet, (Fig 26.15).

A rented gantry crane (of 2500 tonnes capacity) will be erected over the building SX5 to lift and transfer the heavy pieces to the underground area, (Fig 26.16).

26.3 PLANNING

The general planning of the experiment (version 23) has been reviewed taking into account all known facts:

i) Surface building SX5 first phase ready by 1/10/99,
ii) Reinforcement of conductor on site in SXL5,
iii) Winding of the coil on site (see coil planning in Chapt. 19),
iv) All known activities in SX5,
v) The target date for the start up of the LHC Machine of 1/07/05.

Activities in SX5 provide in fact the backbone of CMS master planning, defining when sub-detectors are needed.

This planning (Fig. 26.17) shows the completion of the surface test of the magnet to be the end of October 2003. This is just compatible with the occupancy date of UXC5 given by the present Civil Engineering planning. The critical path starts from the authorisation to break ground at point 5, then goes through the time needed for the construction of the first phase of the surface building SX5, assembly of the first end cap, assembly of the barrel rings, conductor reinforcement, assembly of the second end cap, coil winding and final assembly of the coil leading to the test of the magnet on the surface.