25. EXPERIMENTAL AREA

25.1 INTRODUCTION

When considering the experimental area for the CMS detector, the main constraints are given by the construction and the installation of the magnet and the necessity of providing adequate and safe working conditions during the fabrication, assembly and installation periods. Great effort has been made to balance the necessity and the convenience of a large experimental hall with the overall cost and with the basic limitations set by the LHC machine elements as well as the already existing LEP installations.

The design of CMS is based on a large superconducting solenoid surrounded by an iron muon spectrometer. The 4 T field of the solenoid acts directly on the steel disks, which form the forward part of the iron yoke, thus creating a large magnetic pressure. To resist this force, only assembly based on 600 mm thick plates has been found to provide a satisfactory solution. The design of the barrel yoke consists of three layers built up of steel plates. The thickness of the inner layer is 295 mm, the middle and the outer layers being 630 mm thick each, weighing up to 40 ton per unit piece, which must be assembled to create the five rings of the muon spectrometer barrel. The coil, which will be built as a single unit weighing 250 t, has to be inserted in the horizontal position into the central barrel ring of the yoke YB0. The vacuum tank is then welded around the coil (see Chapt. 26).

Carrying out this heavy assembly work in the underground cavern is excluded for the following reasons. It would require a very large cavern with one additional large access pit and two 80 t cranes, one at each end of the cavern, since large pieces cannot be transferred over the detector unless the height of the cavern is substantially increased. Even if these requirements were met, the detector construction work would have to proceed in series, because of the limited length of the cavern along the beam line, and the fact that most of this work is not compatible with the cleanliness required for the assembly of the superconducting coil. The duration of the construction of the magnet in the underground area is estimated to take at least 45 months (compared to 34 months for assembly at the surface). Furthermore, the duration of this activity would have to be counted from the finishing date of the underground area, i.e. minimum thirty months after the scheduled stop of LEP. An additional 24 months would be required for the assembly and completion of the sub-detectors. Thus a complete assembly of the detector in the underground cavern would imply a shut-down of more than eight years between LEP and LHC, which would be unacceptable. Finally, the safety risk for personnel and equipment would inevitable be greater.

The alternative is to carry out, to the possible extent, all the detector assembly work on the surface, in parallel with LEP operation and with the construction of the underground cavern after the stop of LEP. Several sub-detectors, such as the barrel muon chambers, can be installed in the yoke at the surface, saving additional time in the underground area. In this way, the shut-down period between LEP and LHC can be reduced to less than five years. However, temporarily a larger surface hall is required temporarily, together with the hiring of heavy lifting equipment at some point in time.

25.2 SURFACE BUILDINGS

25.2.1 Building Dimensions

The surface building requirements of CMS are dominated by the need to carry out a complete assembly and test of the magnet on the surface, which requires a minimum height of 18.3 m under the crane hook. This implies a 23.5 m high building. The construction of the magnet sub-assemblies, too large to transport by road, requires a 100 m long, 23.5 m wide assembly hall (SX5), which will be linked to the main access shaft (PX56) for installation underground after testing (see Fig. 26.3). In order to allow changing the relative position of the large sub-assemblies inside the hall, two alcoves have been added, which locally increase the effective width of the hall. The hall is equipped with two 80 t overhead cranes and a heating and ventilation system, but has no general temperature stabilisation. Further more, the main assembly hall is complemented by a temporary appendix (SXL5) needed for the 'in situ' reinforcement of the conductor for the superconducting coil. Fig. 25.1 shows the general layout of surface buildings at Point 5. The proposed layout extends outside the present Point 5 border and one of the existing buildings (SU5) must be moved.

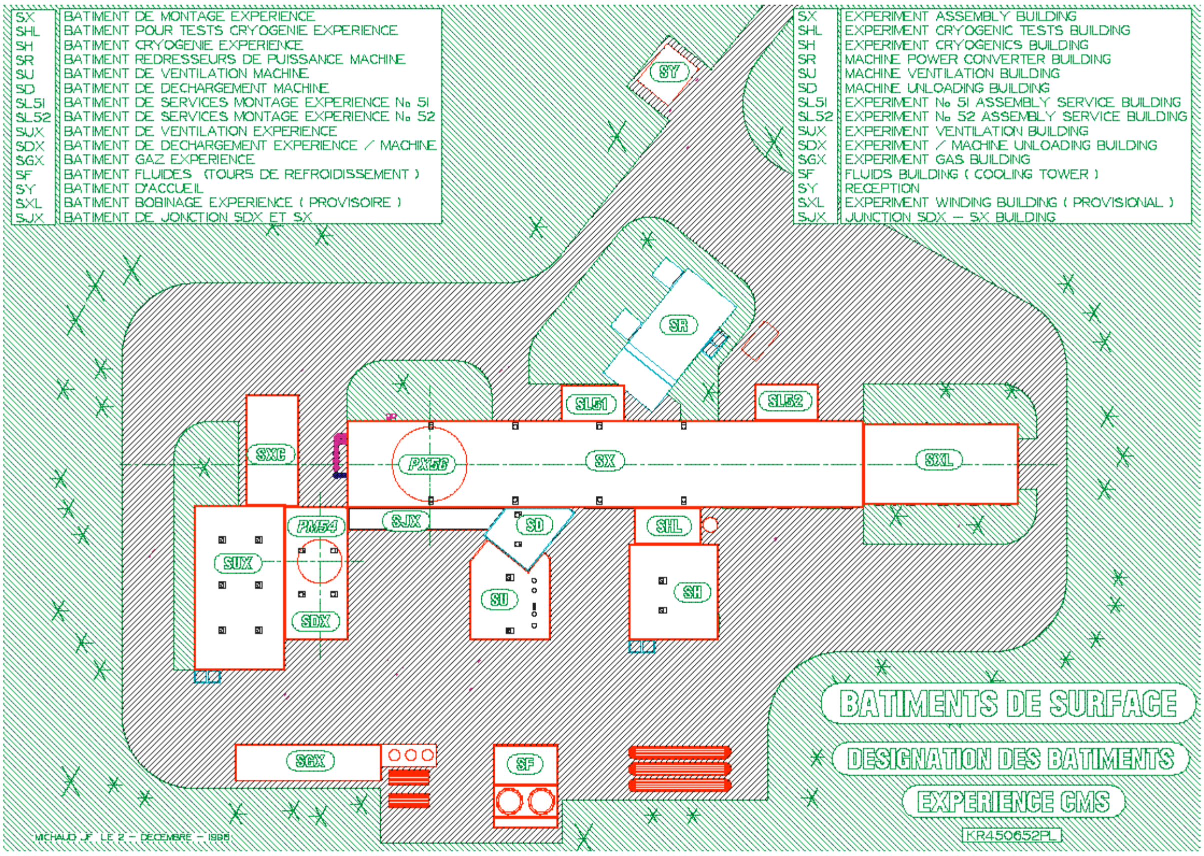

Fig. 25.1: General view of the surface building layout at Point 5

25.2.2 Environmental Impact

The CMS collaboration together with CERN are concerned about the environmental impact of the proposed assembly hall. The preparation of several of the sub-detector units could be made in existing CERN assembly halls, and if more time were to be available for the installation there would be a possibility of constructing even relatively large and heavy sub-assemblies outside the experimental area of CMS. However, road transport sets a strict limit to the size and weight of objects that can be transported. However, after the completion of the manufacturing, assembly and testing of detector components on the surface and their lowering to the cavern, the alcoves and the appendix SXL5 will be demolished, and the height and the length of the assembly hall will be reduced to 16 m and 100 m respectively from its most extended dimensions of 23.5 m and 141m.

25.3 UNDERGROUND AREAS

25.3.1 General Considerations

The basic design criteria for the integration of the CMS experimental cavern at Point 5, where the beam level is situated at a depth of 90 m, are:

- longitudinally oriented cavern (UXC5) providing space for the withdrawal of the endcap sections,
- one access shafts (PX56), centred on the beam line, permitting successive installation of the large detector pieces from one side of the cavern,
- separate cavern (USC5), placed parallel to the main cavern and integrated with the LHC machine by-pass tunnel, housing the counting room (at a radiation-safe distance, allowing shortest possible routing of the cables), and the technical services (cryogenics, gas, power supplies, cooling and ventilation),
- one personnel access shaft (PM54) serving both caverns USC5 and UXC5, thus avoiding a dead end in the latter,
- preserve and use the existing LEP installations, as far as possible.

The absence of existing major underground structures at Point 5 gives a certain freedom in the design of the overall layout of the experimental cavern. However, the unfavourable underground geological rock structure (compared to Point 1) and the location of the deep underground water layers have been carefully examined prior to the final design. In particular, this has resulted in a 7 m thick separation wall between the two caverns (as compared to the minimum 3 m required for the radiation shielding), hence, the service cavern will be permanently accessible.

Additional reduction of radiation doses will be provided by the intrinsic shielding offered by heavy objects such as the calorimeters and the magnet yoke and the use of mobile shielding around the beam line. The main access shaft is centred on the LHC beam line and must, therefore, have a mobile shielding plug of 2 m thick concrete, which will be situated at the surface level flush with the floor of the assembly hall. A 3 m thick shielding door will separate the access from the bottom the shaft PM54 to the floor of the main cavern.

It is essential that the design of the experimental area also includes facilities to provide for safe and efficient working conditions during the installation and maintenance. The proposed scheme in which all detector units and the magnet are fully assembled and tested on the surface and brought down into the experimental cavern with a minimum of further assembly work, has resulted in reduced dimensions of the underground cavern. An additional demountable platform to separate ventilation systems and to provide mechanical protection from falling objects is incorporated in the main access shaft at the level of the ceiling of the cavern. A three level gangway system fixed to the cavern walls provides for unobstructed circulation and easy access to the two independent exits from the underground caverns.

25.3.2 Layout of the Underground Caverns

Following the general constraints and the installation scenario for the magnet and the detector units, indicated above (see also Chapt. 26), the overall layout of the underground structures for the CMS experiment has been defined for Point 5 (see Fig. 25.2 and 25.3). The existing underground structures at Point 5, the access shaft PM56 and the junction UJ57 serving the LHC machine proper, do not have to be modified, since they are placed outside the boundaries of the new structures.

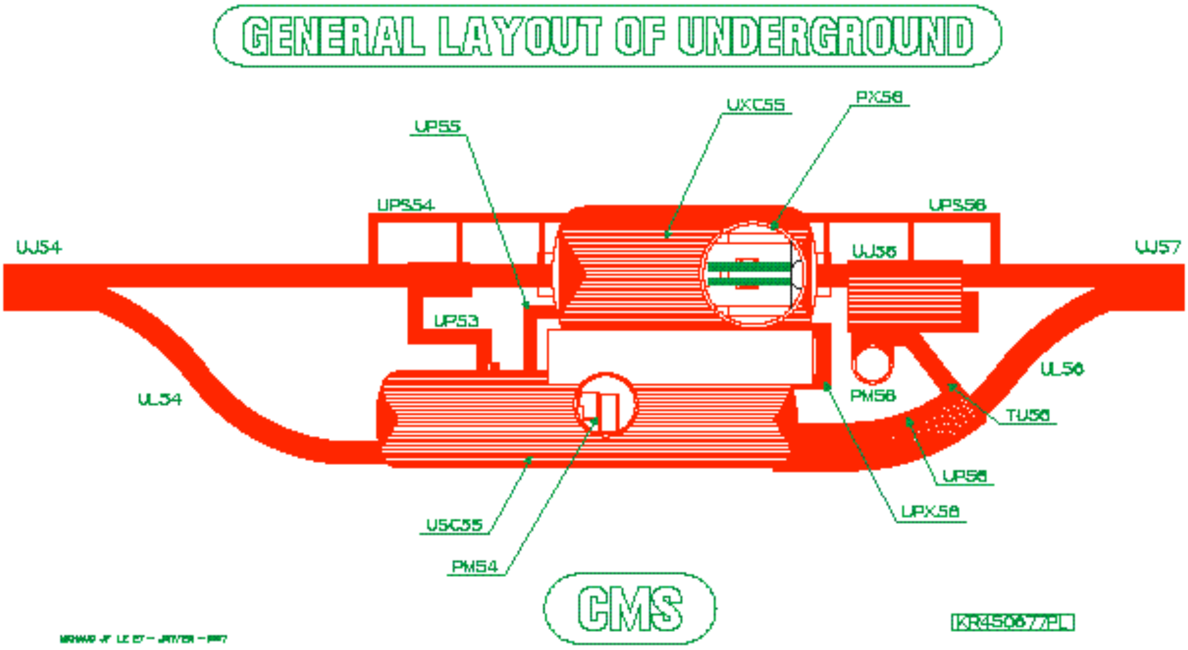

Fig. 25.2: General layout of underground structures at Point 5.

The main cavern UXC5, 26.5 m in diameter and 53 m long, is comparable in size and volume to the present LEP cavern at Point 2. The auxiliary cavern housing the counting room and the technical services as well as the LHC machine by-pass tunnel has an overall diameter of 18 m and a total length of 85 m. It is aligned parallel with the main cavern and separated by a 7 m thick wall. The thickness is primarily dictated by the required civil engineering structures and it largely offers appropriate radiation shielding. Two access tunnels, one from the auxiliary cavern (UP56) and one from the bottom of the shaft PM54 (UP55), join the main cavern at different levels. In addition, at the height of the beam, two smaller survey galleries interconnect the main cavern with the machine tunnel.

The more detailed features of the CMS experimental cavern are shown in Fig. 25.4. The main access shaft PX56, 20.4 m in diameter, provides a net 14 m ´ 19.5 m opening for the installation of the magnet and the detector units. A second access shaft PM54, 9 m in diameter, provides lateral installation access at the floor level to the other end of the detector. This is necessary, since the limited crane clearance over the detector does not allow large objects to be transported between the two endcap regions. Metal plates are embedded in the concrete floor inclined by 1.23% and thus running parallel to the slope of the beam line. In the central part of the cavern the floor level is lowered by 3 m in order to provide access under the detector for services. This volume is also connected to the counting room in the auxiliary cavern via 3 labyrinth tunnels to run cables and services.

The low b quadrupoles, which penetrate into the experimental hall, are placed on a solid concrete platform (see Fig. 25.4) in order to provide a stable foundation for the intersection elements. This concrete structure also serves as a radiation shielded alcove for the HF detectors, when the main endcap sections are withdrawn for access.

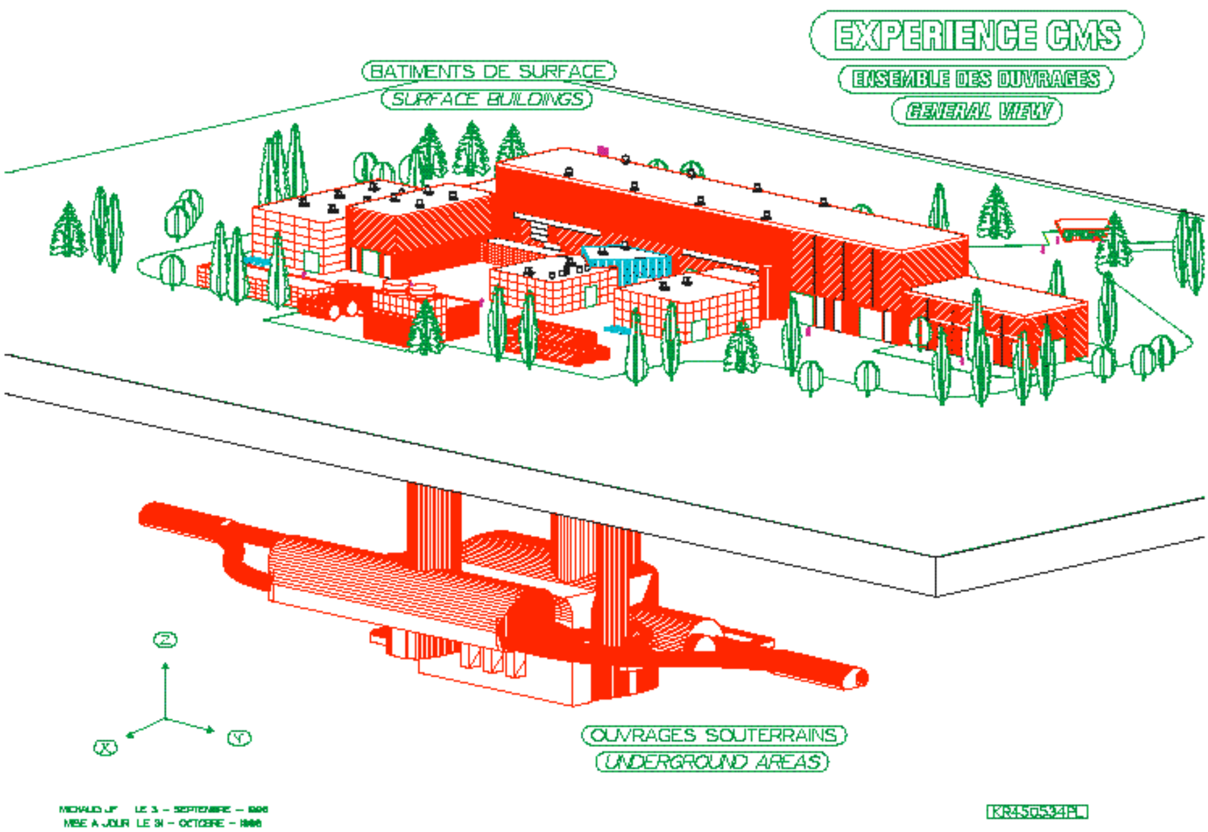

Fig. 25.3: General design of the CMS experimental area.

25.3.3 Main Cavern Infrastructure

Although the bulk of the heat load produced by the detector units will be removed by dedicated cooling arrangements, the environment in the experimental hall will play an important role in the long term stability of the detector. The ambient air in the cavern must be kept at a low humidity level (dew point 9 °C ± 1) and with a high degree of temperature stability (18 °C ± 1). In order to achieve this, a system of distributed ducts for the injection of air into the cavern has been designed to fit the walls behind the gangways.

The gangways are arranged on three levels and aligned with the rack platforms attached to the detector. A series of stairs makes it possible to access the protection platform in the main shaft PX54, (see Fig. 25.5).

The cavern is equipped with a 20 t crane having an effective hook-span of 17 m.

25.3.4 Auxiliary Cavern

The auxiliary cavern USC5, which is horizontal (hence, not aligned with the slope of the main cavern), is essentially divided into two sections, one for the counting room and the gas distribution system, and one for the general detector services. In addition, the latter section will house the power supplies for the low ß LHC machine quadrupoles. The two sections, which are nearly identical in size, will be separated by the common access shaft

PM54 and the personnel safe room.

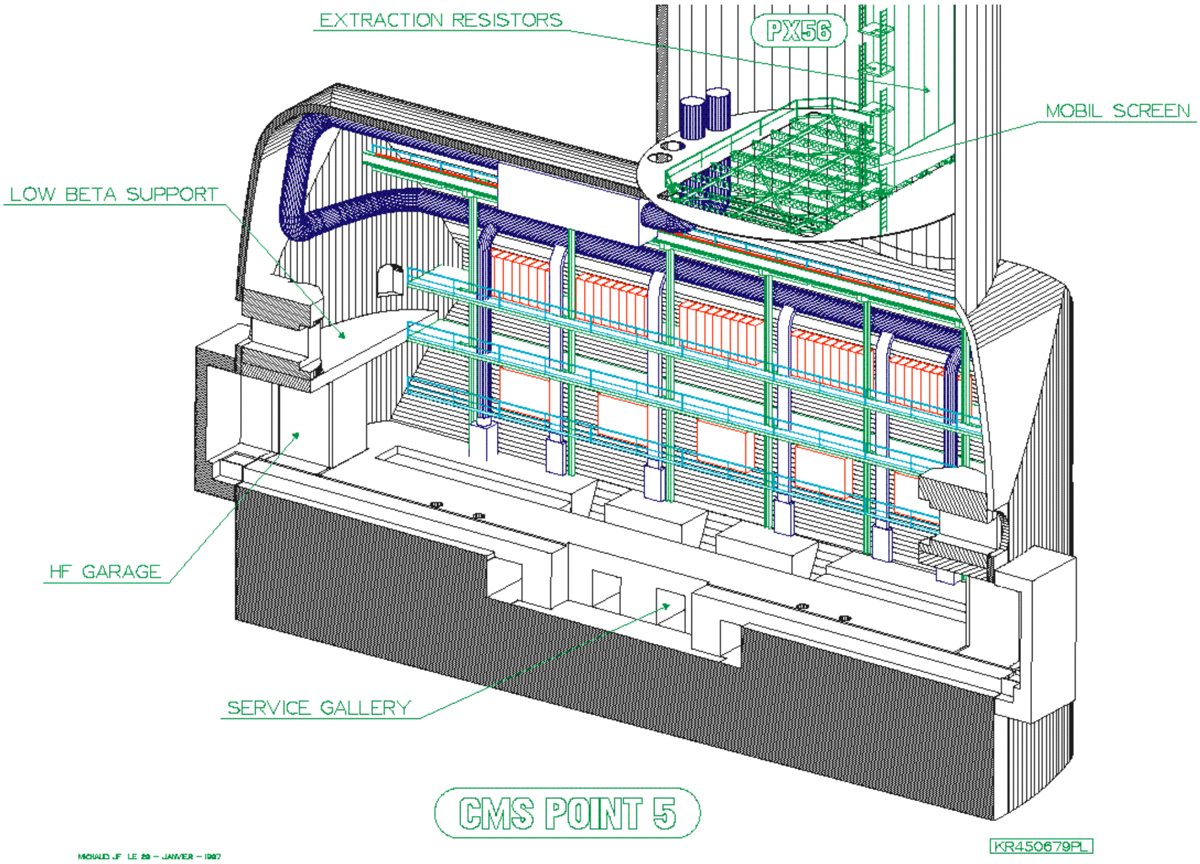

Fig. 25.4: Detailed view of experiment cavern showing the protection platform in the access shaft, the low b concrete platform and the 'garage' for the HF detectors.

The counting room, which is longitudinally centred with respect to the detector in the main cavern, has been designed to house approximately 250 electronics racks installed on a two-floor structure with separation walls. This cavern section also houses the gas distribution system. The 9 m diameter shaft (PM54) will give access to the two floors of the counting room, as well as to the floor level of the main cavern via a dedicated large shielding door in the separation wall. The access shaft will be equipped with a fire protected 3 t lift and staircase system, which will ease the installation of all counting room equipment and provide direct installation access to the main cavern floor level. The limited size of the access shaft will not allow installation of large prefabricated counting room modules. This is, however, not regarded as necessary since the cavern itself will constitute the 'housing structure' and will also allow the centralisation of the cooling, ventilation and power arrangements (see Fig. 26.7).

The other half of the auxiliary cavern will house the power supply and the cryogenic system for the magnet, part of the magnet quench protection system, the cooling and ventilation distribution systems as well as a few racks for the low ß LHC machine power supplies.

25.4 construction planning

The construction planning for the civil engineering work at Point 5, is summarised in Fig. 25.6 [3]. CMS activities could start in the assembly hall SX5 and its appendix SXL5 during the last quarter of 1999. Installation in the underground areas could start as from the middle of 2003. The control building SCX5 would be delivered ready for installation by the middle of 2004.

25.5 safety

The design of experimental area has incorporated several specific safety aspects in addition to those described in Chapt. 28, such as:

- fixed gangways and staircases for easy access at all levels in the underground caverns,
- emergency escape routes at each end of the main cavern,
- smoke extraction, in case of fire,
- fixed and mobile radiation shielding surrounding the low b quadrupoles and absorbers,
- hard cover (demountable platform), providing protection beneath the main access shaft.

The large capital investment and the unique nature of the CMS detector do imply that a first class fire fighting system must be installed in the CMS experimental area. The global fire prevention of the experimental area has not yet been decided on, but in discussions with CERN/TIS experts, general foam generators or more locally placed water fog systems have been considered

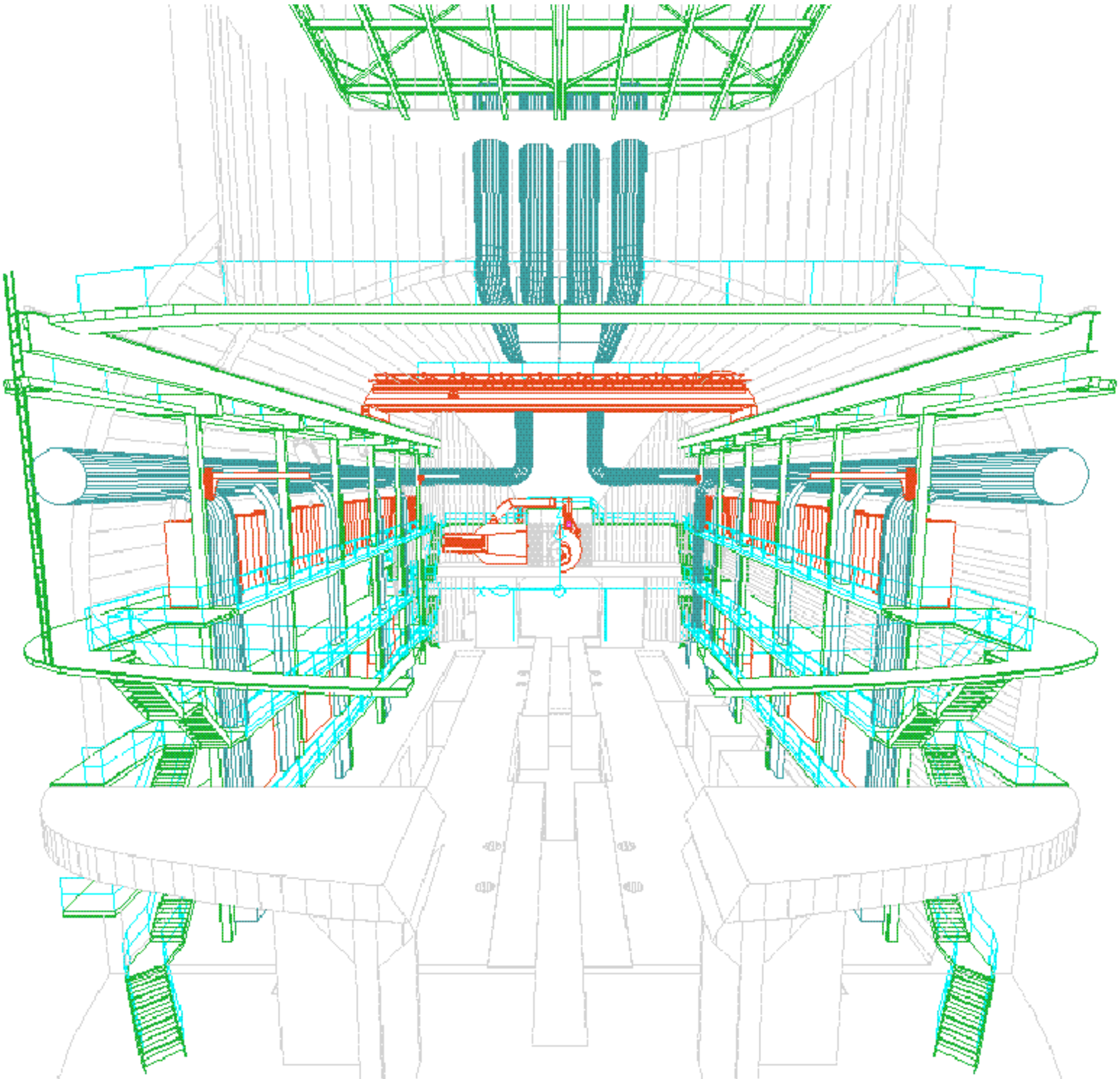

Fig. 25.5: General view of cavern infrastructure.

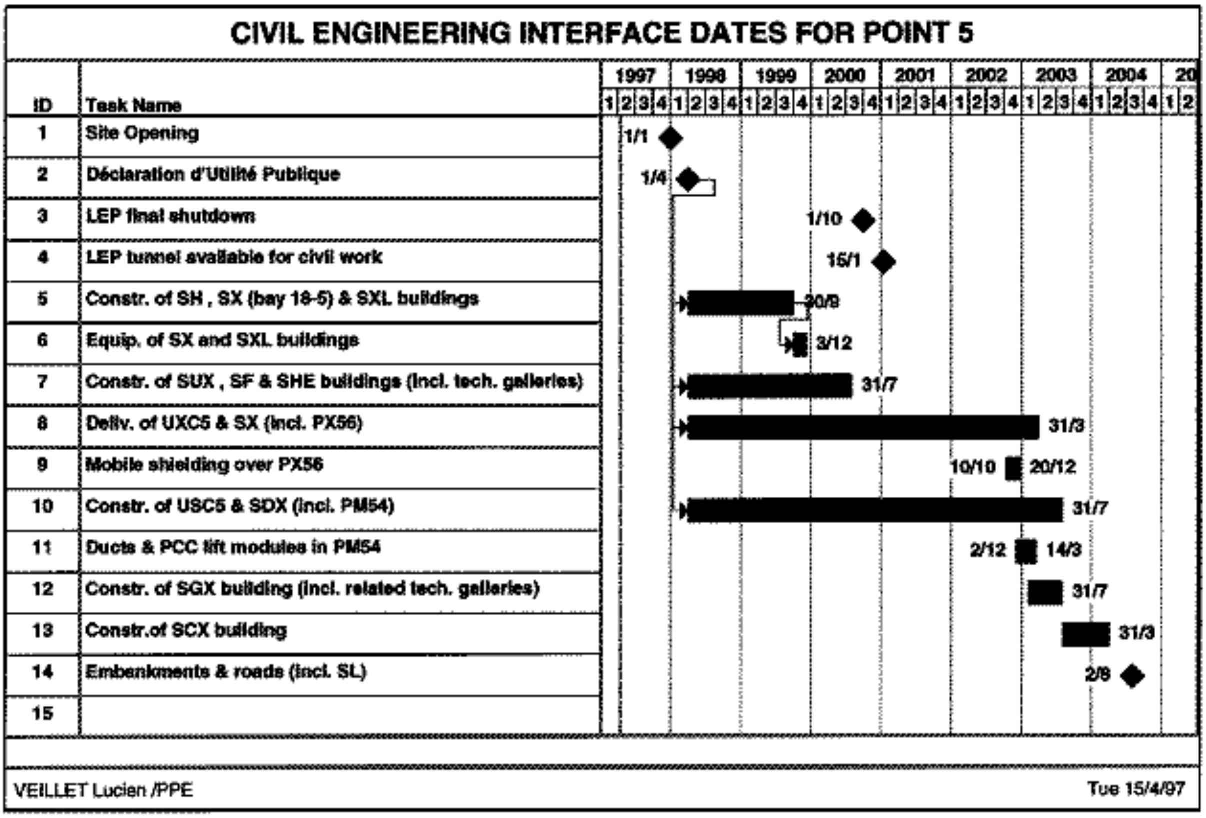

Fig. 25.6: Construction planning for the experimental hall.

25.6 Other surface facilities

During the construction phase of the magnet, and during the assembly phase in the surface hall, other hall surfaces will be required, on a temporary basis elsewhere on the CERN site, for the storage, preassembly, and testing of the sub-detectors. Some of these sub-detectors will require clean (e.g. ECAL and HF) or very clean areas (e.g. central tracker). Table 26.1 summarises the needs, as they are understood today.

25.7 CONCLUSIONS

The design of the experimental area for CMS can be integrated in the LHC machine layout in Point 5 without perturbing the latter. The construction of this experimental area does not present any major difficulty and the experience gained from the construction of the LEP experimental areas can be fully exploited. A large assembly hall, situated at the head of the main access shaft PX 56, will be needed during the construction and assembly phase of the magnet, as well as temporary hall space for the storage and assembly of the sub-detectors.

Table 25.1
Other surface facilities required on a temporary basis.

Sub-detector	Crane capacity [t]	Area [m^2]
Central Tracker;		
- Si and pixels	1	500
- MSGCs	1	1500
ECAL (EB and EF);		
- regional centre	2.5	200
- supermodul assembly	20	1000
- storage area	20	1000
HCAL (HB, HF, VF)	60	600
Muons;		
- barrel	5	1500
- endcap	2	1000
RPOs	1	700
Alignment System	5	740
Integration	10	1000