INSTALLATION OF THE LHC LONG STRAIGHT SECTIONS (LSS)

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Abstract

The LHC long straight sections (LSS) serve as experimental or utility insertions. There are two high luminosity experimental insertions located at Point 1 and 5 and two more experimental insertions at Point 2 and 8 which also contain the injection systems. The beams only cross at these four locations and are focused by superconducting low-beta triplets. Insertions 3 and 7 each contain two collimation systems. Insertion 4 contains two RF systems. Insertion 6 contains the beam dumping system. The installation of the LSS is a challenge due to the compact layout that characterise these areas and the difficulties related to the underground work mainly in zones of restricted access. Specific devices are required for handling and installing various heavy and voluminous elements. This paper reviews the installation scenarios, describes the sequences presently planned and highlights the potential problem areas. The particular case of sector 7-8 where the LSS elements will be installed in parallel with the cryogenic distribution line (QRL) is used as an example of a 'rapid' installation scheme to illustrate how resources are used. The consequences of possible shortcuts are also mentioned.

INTRODUCTION

Each LHC long straight (LSS) is approximately 528m long. The complete description of each LSS is provided in the LHC design report [1].

These LSS are all different and the precise machine layout [2] is more complex for the experimental insertions, and specially, at Points 2 and 8 where the injection lines join the main ring. For this reason, this paper will not deal with the installation issues of the insertions 3, 4, 6, and 7 which are considered as being simpler in terms of installation.

According to the LHC installation schedule [3] the first LSS to be installed will correspond to the experimental insertion at Point 8 which houses the low-beta triplets and the injection line junction. The LSS8 represents a real challenge since it will be the first time that specific transport and installation devices will be used to install the low-beta triplets and their distribution feed boxes (DFBX).

INJECTION TEST MILESTONE: INSTALLATION SCENARIO

The LHC installation schedule foresees the first injection test through the injection line TI8 and the sector 7-8 by the end of 2006. In order to achieve this, the LSS at Point 8 and the arc 7-8 have to be installed and commissioned by the end of November 2006 (see Fig.1).

LSS at Point 8 (LSS8R), Right Side

At Point 8 and contrary to the other interaction points, the machine layout is not symmetrical with respect to the centre of the experimental cavern due to the fact that the interaction point is 11,220m closer to the left side of the machine tunnel. This asymmetry implies that the compensator magnet and the Q1 are located close to the experimental cavern: a supporting structure was required and this is the reason why it has been necessary to build a new armoured concrete supporting beam.

The main part of the shielding wall that will protect the experiment LHCb [4] has to be mounted before the low-beta triplet (quadrupoles Q1, Q2, Q3) is installed in order to avoid any hazardous heavy handling close to these cryomagnets. The present schedule for the production of these shielding walls is quite short and could have a negative effect on the installation programme. The MBXWS normal conducting compensation magnet could be installed before the shielding although the latter is designed to allow the replacement of the magnet in anytime in case of damage.

The installation of the beam line components will start in August 2005 after completion of the QRL commissioning. Therefore, from the installation of the support jacks there is a period of 4 months allocated to the transport, installation and alignment of the MBXWS, low-beta triplet, separation cryodipoles D1 and D2, stand-alone cryomagnets, DFBX, collimators TCDD and TDI, kicker magnets MKI and septum magnets MSI. The interconnection work, cryogenic and vacuum activities will follow. The cool-down of the whole sector 8-1 will start by the end of June 2006.

Some difficulties such as the work in coactivity and safety restrictions have been identified and play a main role when defining the installation scenario. Thus, no coactivity will be permitted during power short circuit tests and machine cool-down. Besides, activities occurring in parallel to the QRL pressure tests and X-ray tests will not be authorized. Nevertheless, certain type of activities could be tolerated in parallel with others, as it is the case of the vacuum bake-out and NEG activation works during the commissioning powering tests.

LSS at Point 8 (LSS8L), Left Side

Due to the unexpected problems discovered during the installation of the first cryogenic distribution line (QRL) in the LHC sector 7-8, CERN management decided to take the responsibility of the QRL repair works and re-installation in this sector. The aim of CERN action is to keep the schedule for the above mentioned injection test and to complete the LHC installation by July 2007.

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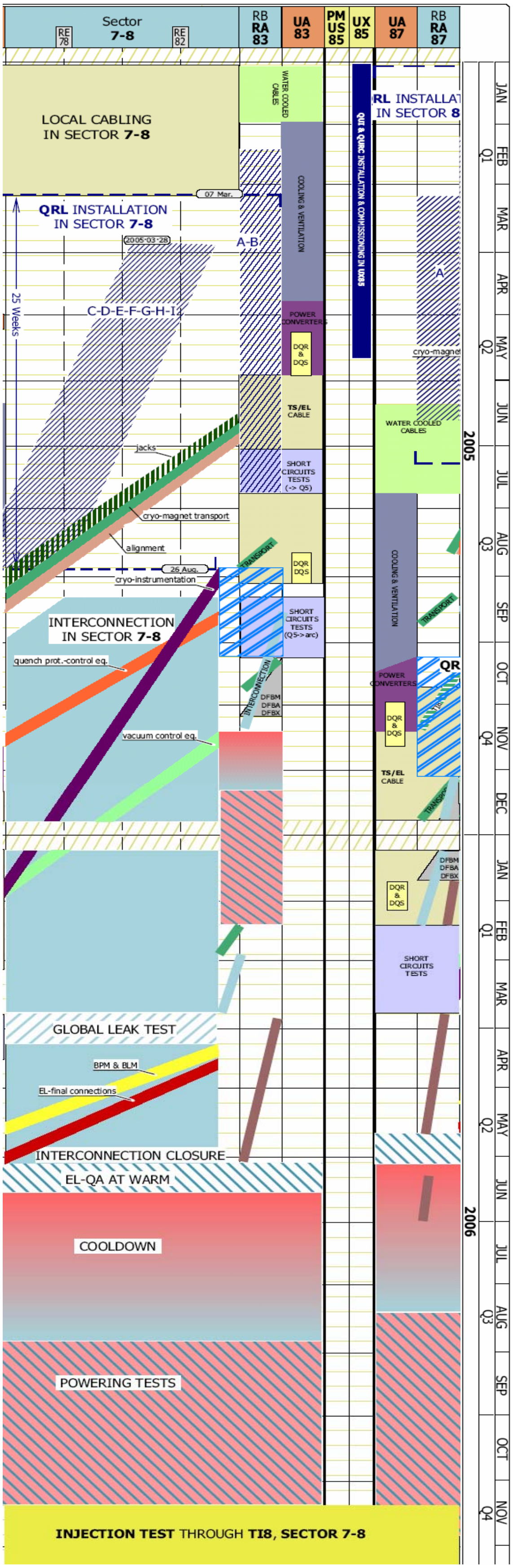

Figure 1: Extract of LHC Coordination Schedule

With a view to gather the maximum experience on the installation and to be able to propose an optimized and reliable scenario for the other sectors, the following sequence of activities has been proposed for LSS8L:

- Installation of two QRL sub-sectors in about 600m.
- Cool-down and tests of these QRL sub-sectors.
- Installation of the compensation magnets (MBXWH and MBXWS), low-beta triplet and stand-alone magnets (D2-Q4, Q5) while the remaining of the QRL will continue to be installed in the sector 7-8.
- Global cool down tests and power tests of LSS8L.

Handling and Transportation

In the right side of the insertion IR8, the shielding plug required by the LHCb experiment will be installed around Q1. Standard transportation equipment available at CERN is not adequate for handling and installing Q1 due to the position of the shielding. Therefore, the technical solution that has been adopted consists in installing Gantry type rails in this dead-end of the tunnel and transferring longitudinally the quadrupole Q1 along the beam axis using a set of two motorised bogies [5]. This solution ensures a safe longitudinal transfer and installation and/or a quick removal in case of failure. The motorised bogies are being manufactured and reception tests will be carried out in June 2005.

A common spreader beam has been studied for handling the low-beta quadrupoles and separation dipoles and another specific spreader beam has been ordered for the DFBX handling.

The underground transport of the DFBX will be done using a system of wheels fixed directly to it and the final transfer onto the beam line is under study. The main transport constrain of the DFBX is given by its height (2.4m). In order to reach the locations at Point 8 the DFBXs have to be lowered down the Point 8 shaft.

In general, any particular transportation material will be load tested in industry and further validation and acceptance tests will be performed at CERN beginning of summer 2005.

SPECIFIC INSTALLATION OF THE EXPERIMENTAL INSERTIONS IR1, 2, 5

The four experimental insertions have several differences in terms of layout and accessibility that determine their specific logistics. Therefore, the low-beta triplets are installed in very confined areas, through the tunnel radiation shielding walls in IR2 and IR8 and inside the forward experimental radiation shielding in ATLAS and CMS experiments.

As already described for IR8, the installation of the Q1, using a special LSS transport vehicle and the transfer tables is not possible in the IR1, IR2 right side and IR5. It will be installed with the special pair of motorised bogies guided by Gantry type rails. These will be also valid for the installation of Q2 in IR2 right side and IR5.

Insertion IR1

In order to guarantee the stability of the Q1 it has been decided to fix the two front support jacks to the concrete floor underneath the ATLAS experimental forward shielding fixed tube. Moreover, two steel-welded platforms for personnel access will be mounted in these tubes. The rails that will allow the longitudinal transfer of Q1 will have a continuation in these tubes.

The Hydrostatic Levelling System (HLS) and Wire Positioning System (WPS) survey equipment that is required for surveying the low-beta quadrupoles is installed in two phases, i.e. the material belonging to the civil engineering galleries which already partially installed, and the equipment installed on the quadrupoles themselves. The latter will be installed in the tunnel, at the last moment, due to its fragility.

The TAN absorbers that are installed at each side of Point 1 will be transported from Point 2 which means an underground journey of 3.5km. The main transport constrain of the TAN is its weight. TAN absorbers will be assembled on the surface and transported in the tunnel using a pair of motorized hydraulic trolleys of 35 tons full capacity which manufacture is on-going in the European industry.

Extra-shielding for protection of equipment will be installed between D1 and Q6 [6].

Insertion IR2

A new concrete blockhouse that will support and enclose the machine is under construction in the experimental cavern in LSS2L. This structure will be a continuity of the tunnel section (slope 1.39% included) and will be situated underneath the experiment shaft. The shielding wall made of steel and concrete is also required in front of the compensation magnet.

Special cryoassemblies with high jumpers will be lowered down the above mentioned experiment shaft and loaded directly on the transport vehicle which will start its journey from that place.

In the case of LSS2R, the rails necessary for the installation of Q1 and Q2 are already installed. Then the concrete/steel shielding wall required by the ALICE experiment will be mounted. The compensation magnet (MBXWT) situated in front of Q1 could be installed before the shielding but also afterwards as it could be transported through the shielding window foreseen.

Insertion IR5

The survey equipment required for the HLS and WPS set-up will follow the same installation procedure as for Point 1.

The rails which will allow the longitudinal transfer of Q1 and Q2 through the tunnel and the Cubical Frame (part of the CMS forward shielding) are partially installed. Due to the heavy armoured tunnel floor at those places, the installation of the rails became costly and time-consuming and has required of alternative solutions.

In order to reach the locations at Point 5 the DFBXs and the TANs have to be lowered down the Point 6 shaft which means also an underground journey of 3.5km.

As for insertion 1, extra-shielding for protection of equipment will be installed between D1 and Q6.

SUMMARY OF INSTALLATION DATES

The installation dates of the LSS are shown bellow:

LSS8L	⇒ Aug 2005	LSS6R	⇒ May 2006
LSS8R	⇒ Sept 2005	LSS5R	⇒ May 2006
LSS1L	⇒ Dec 2005	LSS7L	⇒ Jun 2006
LSS5L	⇒ Feb 2006	LSS7R	⇒ Jul 2006
LSS3R	⇒ Feb 2006	LSS2R	⇒ Aug 2006
LSS4R	⇒ Feb 2006	LSS3L	⇒ Sep 2006
LSS4L	⇒ Mar 2006	LSS1R	⇒ Oct 2006
LSS6L	⇒ Mar 2006	LSS2L	⇒ Nov 2006

CONCLUSION

Each LSS is a particular case of installation due to the different configuration of the areas and the safety constraints to be applied such as the restrictions on coactivity work, on logistics, on access during pressure, cool-down and other various tests. Consequently, the chronological sequence will have to be optimized for each LSS in order to be consistent with the installation particularities of the components and the areas.

The cryogenic quadrupoles of the matching sections and the separation dipoles will be transported on the LSS vehicle and transferred onto the beam line using the pair of transfer tables already developed for the main arc cryomagnets.

A special vehicle with several possibilities of configurations, already designed for the transport and installation of the injection lines magnets, will also be used for the installation of the normal conducting magnets in the LSS. This vehicle is also required for other installations at CERN and its use has to be carefully planned.

Certain LSS components such as collimators, RF supra-conducting cavities, Roman Pots and calorimeters ZN and ZP, which are less heavy and/or difficult to handle, will be transported and installed using devices either already existing at CERN or under design.

REFERENCES

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