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INSTALLATION OF THE LHC EXPERIMENTAL INSERTIONS

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Abstract

The installation of the LHC experimental insertions, and particularly the installation of the low-beta quadrupoles, raises many technical challenges due to the stringent alignment specifications and to the difficulty of access in very confined areas. The compact layout with many lattice elements, vacuum components, beam control instrumentation and the presence of shielding does not allow for any improvisation in the installation procedure. This paper reviews all the constraints that need to be taken into account when installing the experimental insertions. It describes the chronological sequence of installation and discusses the technical solutions that have been adopted.

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1 INTRODUCTION

The complex layout of the LHC experimental insertions, the difficult accessibility and the stringent alignment specifications require a specific installation procedure to be thought out and implemented.

A special low bed trailer has been studied for the transport of the Long Straight Section cryomagnets. After leaving this trailer, the Transfer Equipment Sets (TES) allow the transfer and installation of the cryomagnet onto the jacks. Unfortunately, this procedure is not applicable for the installation of all the Inner Triplet cryomagnets due to the difficulty of access in the areas concerned.

The Inner Triplet quadrupoles require continuous alignment by means of motorized jacks which will be supplied by the India collaboration (Centre for Advanced Technology-CAT). It has been decided that the motorization study of the jacks will also be carried out by CAT.

2 LOW-BETA QUADRUPOLES INSTALLATION CONSTRAINTS

The Low-Beta quadrupoles (Inner Triplets) are installed in very confined areas (dead-end tunnels), through the tunnel radiation shielding walls and inside the forward experimental radiation shielding. The constraints that have been identified in each installation area are detailed next.

2.1 Point 1 Insertion (IR1)

The quadrupoles Q1, situated on each side of ATLAS, straddle between the tunnel and ATLAS experimental forward shielding fixed tube (TX1ST) of diameter 2570 mm. Therefore, the two front jacks (E, T) of the Q1 are in this tube. In order to guarantee the stability of the cryomagnet it has been decided to fix the jacks to the concrete floor; therefore, two holes have been made through the tube in order to reach the concrete floor underneath which will serve as the support. Moreover, the LSS trailer that will transport the Q1 will not be able to go through the TX1ST, so it will have to stop before it, in RB14 and RB16; hence, the direct transfer on the jacks using the TES is not possible.

2.2 Point 2 Insertion (IR2)

The Low-Beta quadrupoles installation is different on the left and on the right sides of the IP2:

2.2.1 Left side (PX24-RB24-UJ24)

Q1 and part of Q2 will be installed in PX24, on a new supporting structure made out of concrete. This structure will support as well the resistive corrector magnet MBXWT. Another supporting structure has been foreseen for the corrector magnet MBWMD that is closer to ALICE experiment. A shielding plug made of steel (on the machine side) and concrete (on the experiment side) will be situated in front of the MBXWT magnet. A tunnel section will be built as a continuation of the tunnel RB24 (slope included); therefore, the transport and installation of the Q1 and Q2 will be possible using the LSS trailer and the TES.

2.2.2 Right side (RB26-UJ26)

The Low-Beta quadrupoles will be installed in RB26 and UJ26. The concrete/steel shielding plug required by ALICE experiment will be installed in RB26, around Q2 quadrupole. Since the overall calculated weight of the shielding is about 90 tons, it has been decided, for security reasons, to mount the main part of the shielding before the quadrupoles installation. Therefore, no heavy handling will be carried out close to these cryomagnets once they are installed. The drawback is that neither Q1 nor Q2 can be installed using the LSS trailer and TES. The access to the magnet MBXWT that is situated in front of Q1 will be possible through a chicane.

2.3 Point 5 Insertion (IR5)

The quadrupoles Q1, situated on each side of CMS, straddle between the tunnel and the CMS forward shielding (Cubical Frame). The three jacks (E, S, T) of the Q1 magnets are in this confined area of 2x2 (m²) section. Similarly to Point 1, the LSS trailer will have to stop before this area, in UJ56 and R542, and consequently, the transfer on the jacks using the TES is not possible.

2.4 Point 8 Insertion (IR8)

As for the insertion at Point 2, the left and right parts of the insertion are different in terms of installation. This is due to the fact that the IP8 (interaction point) is 11.220 m closer to RB84 than the MP8 (center of the experimental cavern); hence, the machine layout is not symmetrical with respect to the IP8. The installation differences are the following:

2.4.1 Left side (RB84-UJ84-RA83)

The Low-Beta quadrupoles will be installed in areas of good accessibility. The shielding plug required by LHCb experiment will be installed in RB86, before UX85, in front of the corrector magnet MBXW. Their transport and installation can be done using the LSS trailer and the TES. For security reasons, the shielding plug will be installed before these cryomagnets if the shielding blocks have to be transported through the tunnel.

2.4.2 Right side (RB86)

In this case, the shielding plug will be installed in RB86 around Q1. Due to the position of the foreseen shielding and the chicane, the transport of Q1 and Q2 is not possible using the LSS trailer and the TES. As for Point 2 right, the main parts of the shielding have to be installed before the quadrupoles in order to avoid dangerous heavy handling close to these cryomagnets. The shielding chicane will allow the access to the MBXWS corrector magnet and to the front end of Q1 and permit the transport of this corrector magnet in case of damage or replacement.

3 TECHNICAL SOLUTIONS FOR LOW-BETA QUADRUPOLES INSTALLATION

As above-mentioned, in the insertion regions IR1, IR2 right, IR5 and IR8 right the complete installation of the Q1, and sometimes Q2, using the LSS trailer and the TES is not possible. The technical solution that has been adopted consists in installing rails in the areas concerned and transferring longitudinally the quadrupoles (Q1 and/or Q2) using a set of two motorized bogies. This solution ensures a safe longitudinal transfer and installation and/or a quick removal in case of failure [1]. The bogies are equipped with motorised translation units (DEMAG) and are adjustable in height and in the horizontal plane (x-y) and also permit some angular adjustment with respect to the x and y axis. They have to be compatible with the two beam axes levels (950 mm and 1100 mm) and compact enough to pass through the shielding plugs.

The quadrupole concerned is transported on the LSS trailer as close as possible to the final position. From the trailer it is downloaded onto the TES. In between both manoeuvres the cryomagnet is supported on the special temporary downloading equipment. In order to be able to use the TES the tunnel floor surface has to be levelled out; therefore, the rails have to be built in the floor. The type Gantry rails, size A55, has been selected.

As the next step in the process, the quadrupole is transferred using the TES onto the motorised bogies that are already on the rails. The bogies are used to transport the cryomagnet and to lay it down onto the jacks. Then, the bogies can be removed from underneath the quadrupole.

The above-mentioned bogies, at the present design state, are shown in Fig. 1. The position of the two bogies under the Q1 or Q2 is shown in Fig. 2:

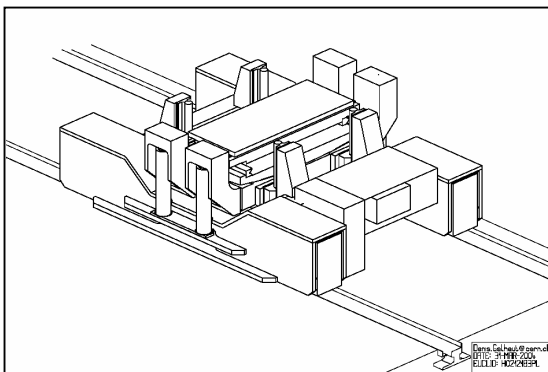


Fig. 1: Bogies concept design on Gantry rails.

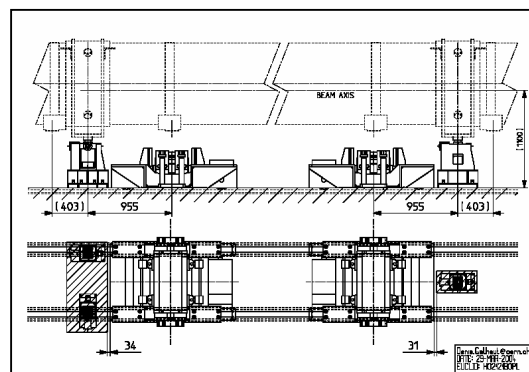


Fig. 2: Bogies before transfer, under Q1 or Q2.

Fig. 3 illustrates the above-mentioned rails system, the shielding plug and the LSS trailer in RB86.

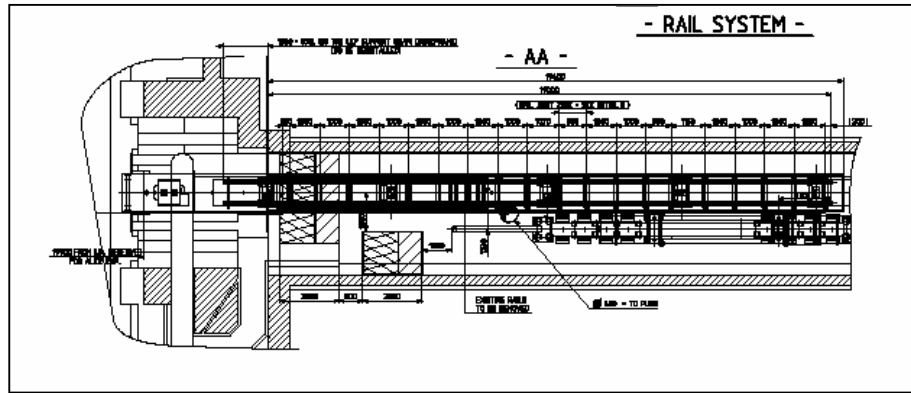


Fig. 3: Q1 installation in RB86 (from drawing LHCLQX_H0005)

At Point 1, a supporting metallic structure is required for continuing the rails inside the TX1ST steel shielding tube. This structure will be used to build an access gangway inside this tube.

At point 5, the free space around Q1 in the CMS forward shielding and the end of the LHC tunnel is small. Thus, in order to remove the bogie from underneath the cryomagnet the design has included the possibility of taking it apart.

Concerning the alignment systems (Hydrostatic Levelling System and Stretched Wire) required by TS/SU group, the components that are attached to the cryostats will be installed in the tunnel.

4 HANDLING AND UNDERGROUND TRANSPORTATION

Since the LHC-US equipment is supplied without any handling or underground transport device, lifting devices and transportation units have to be studied and provided by CERN.

4.1 Underground transportation

As mentioned above, the study of the bogies for transferring Q1 and/or Q2 is well-advanced.

The underground transport of other main elements such as the Neutral Beam Absorbers (TAN) and the Distribution Feed-Boxes (DFBX) is under study and no definitive decision has been taken yet.

The TAN is a heavy element (33 tons) and the overall length is 4.9 m. It will become very radioactive with time; hence, handling time should be minimised. Although it can be dismantled in parts of maximum weight 5 tons, the fact of assembling it in the tunnel would require special preparation of the area and in case of removal, the time required would probably exceed the acceptable limits. Ideally, the TAN should be lowered down the pit and transported in the tunnel already assembled. Since it can be considered as a “self-supporting” unit it could be equipped directly with a heavy rollers system and be pulled with a tractor (or equivalent solution).

The DFBX weighs about 6 tons and the length is about 2.5 m. The transport constraint is determined by its height: 2.4 m. Nowadays, it is considered that the DFBX should be pre-equipped (as the others DFB) on the surface with all boxes containing instrumentation wires, transformers for heaters, etc. Especially, mounting the instrumentation rack, the cryogenic valve box and the cable tray and cabling should be preferably done on the surface. However, the expected radiation level in these areas could impose another solution. To reach the locations at Point 5, the DFBXE and DFBXF have to be lowered down the shafts at Point 4 and 6 and then be transported through the R tunnel (3800 mm diameter). It implies that no much extra equipment can be

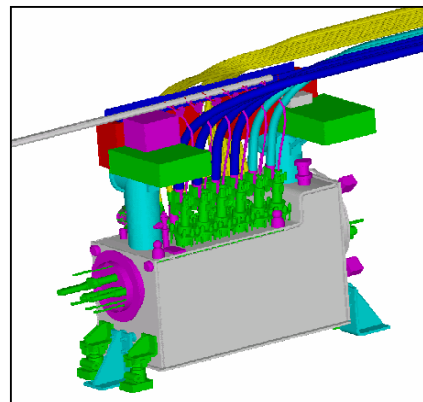


Fig. 4: DFBXG (IR8, left) integration draft study.

mounted on the surface. The present integration studies (Fig. 4) have shown that the DFBX fully equipped could not be transported through an R tunnel. In principle, the DFBX can be also considered “self-supporting” and the solution of fitting appropriate wheels is being analyzed. As a matter of fact, the final decision on whether equipping it or not (even partially) on the surface will determine the final transport choice (wheels, special frame,...).

4.2 Lifting devices

As far as the cryomagnets are concerned, i.e. Inner Triplets quadrupoles, Separation Dipoles, Q4, Q5, Q6 and Q7, hitherto, no spreader beams have been supplied and/or studied. With the aim of minimising the number of different types of spreader beams, it has been proposed to consider all these cryomagnets together and perform a global study.

A lifting fixture for the DFBX is already known [2].

For lifting purposes, the TAN are equipped with hoist rings that will allow removing them easily when they become radioactive. Thus no special spreader beam has to be developed.

5 CHRONOLOGICAL SEQUENCE OF INSTALLATION

The chronological sequence that has been considered for preparing the installation planning for the first LHC Insertion (IR8 left) to be installed is as follows:

Prior to the LSS installation, the following tasks have to be completed:		<ul style="list-style-type: none"> - General services - QRL installation - DC liaisons installation and test (depending on the zones) - Signal and control cabling installation - Rails for transfer of Q1 and/or Q2 (when required) - Mounting of shielding plugs (main components) - Marking on the floor of the machine elements (if required) - Partial installation of the HLS and WLS (in points 1 and 5)
T0 (time 0)	Supports installation (jacks and vacuum):	<ul style="list-style-type: none"> - Drilling, positioning, aligning, fixation. - Special case for Q1, Q2, TAN and collimators
Installation (transport and positioning) of magnetic elements:		<ul style="list-style-type: none"> - Resistive magnets (on the experiment side) - Low-Beta triplets - Stand-alone cryomagnets - Other resistive components
Beam instrumentation installation		
Alignment of beam elements		
Installation and connection of jumpers		
Interconnecting work		
Installation and connection of vacuum equipment		
Finalize installation of Hydrostatic Leveling System (HLS) and Wire Leveling System (WLS)		
Hydraulic connections		
Signal and control connections		
DC connections (resistive elements)		
Vacuum and leak detection tests		

As described previously, the rest of the Insertion Regions is essentially more complicated in terms of installation due to the transfer rails, shielding walls, confined areas, etc. Nevertheless, the general pattern used for IR8 left is going to be the base for composing the planning of other Insertions including the adaptation, each time, of the variations and the particularities.

6 ACKNOWLEDGEMENTS

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7 REFERENCES

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 [2] ‘Stress analysis of LHC DFBX lifting fixture’-LBNL Engineering Note, code: LH2001 M8046.