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**CERN-TS-2004-010 (IC)****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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# 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.

## INTRODUCTION

The Low-Beta quadrupoles (Inner Triplets made of Q1, Q2 and Q3) provide the final focusing of the proton beams before collision at four locations in the LHC machine: the high luminosity interaction regions located at IR1 and IR5, and the low luminosity interaction regions located at IR 2 and IR8. The main hardware difference is the use of conventional separating D1 magnets due to the high level of energy deposition at the high luminosity interaction regions and superconducting D1 magnets at the low luminosity interaction regions [1].

The LHC-US collaboration provides the Low-Beta quadrupoles, Separation Dipoles, Distribution Feed Boxes (DFBX) and Neutral Beam Absorbers (TAN) for the LHC experimental insertions. The installation of these elements in the LHC tunnel is under CERN responsibility.

A special transport vehicle has been studied for the transport of the Long Straight Section cryo-magnets (Low-Beta quadrupoles, Separation dipoles, Matching quadrupole triplet and Dispersion Suppressor quadrupoles). After leaving this transport vehicle, the transfer tables allow the transfer and installation of the cryo-magnet onto the support jacks [2]. Unfortunately, this procedure is not applicable for the installation of all the Inner Triplet cryo-magnets due to the difficulty of access in the areas concerned.

## LOW-BETA QUADRUPOLES INSTALLATION CONSTRAINTS

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

### *Point 1 Insertion (IR1)*

The quadrupoles Q1, situated on each side of the ATLAS experiment, straddle between the tunnel and the ATLAS experimental forward shielding fixed tube of diameter 2570mm. In order to guarantee the stability of the cryo-magnet it has been decided to fix the two front support jacks of Q1 to the concrete floor underneath the tube. Thus, two holes have been made through the tube to reach the concrete floor that will serve as the support. Since the transport vehicle will not be able to go through the tube, the direct transfer on the support jacks using the transfer tables will not be possible.

### *Point 2 Insertion (IR2): Left side*

Q1 and part of Q2 will be installed on a new supporting structure made out of concrete and situated in the ALICE experimental cavern. A shielding plug made of steel (on the machine side) and concrete (on the experiment side) will be situated in front of the resistive compensator magnet. This structure will be built in the experimental cavern as a continuation of the tunnel section (slope included) to enclose all these elements and the compensator magnet. Therefore, the transport and installation of Q1 and Q2 will be possible using the transport vehicle and the transfer tables. Another structure has been foreseen for supporting the compensator magnet situated closer to the ALICE experiment.

### *Point 2 Insertion (IR2): Right side*

The concrete/steel shielding plug required by the ALICE experiment will be installed around Q2, in the tunnel. Since the overall 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 required close to these cryo-magnets once they are installed. The drawback is that neither Q1 nor Q2 can be installed using the transport vehicle and transfer tables. A chicane will allow the access to the compensator magnet situated in front of Q1.

### *Point 5 Insertion (IR5)*

The quadrupoles Q1, situated on each side of CMS, straddle between the tunnel and the Cubical Frame (part of the CMS forward shielding). The three support jacks of the Q1 are in this confined zone of cross-section 2x2 (m<sup>2</sup>). Similarly to Point 1, the transport vehicle will have to stop before this zone, and consequently, the transfer on the support jacks using the transfer tables will not be possible.

### Point 8 Insertion (IR8): Left side

As for the insertion IR2, the left and right sides of IR8 are different regarding installation. The machine layout is not symmetrical with respect to centre of the experimental cavern (MP8) due to the fact that the interaction point (IP8) is 11,220m closer to the left side of the machine tunnel.

The installation of the Low-Beta quadrupoles in the left side of the experimental insertion IR8 does not present difficulties in terms of access to the zone. Two shielding plugs are required by the LHCb experiment. The compensator magnet will be situated between these shielding plugs. For security reasons, the first shielding plug, situated 2.2m from the IP8, will be installed before the compensator magnet. The later will be transported and installed with the transportation system already developed for the LHC resistive magnets. The transport and installation of the Low-Beta quadrupoles can be done using the transport vehicle and the transfer tables. The second shielding will be mounted only once these quadrupoles are installed.

### Point 8 Insertion (IR8): Right side

In the right side of the insertion IR8, the shielding plug required by the LHCb experiment will be installed around Q1. The transport of Q1 is not possible using the transport vehicle and the transfer tables due to the position of the shielding and of the chicane (see Fig. 1). As for IR2 right, the main parts of the shielding have to be installed before the quadrupoles in order to avoid dangerous heavy handling close to these cryo-magnets. The chicane will allow the access to the front end of Q1 and to the compensator magnet and will permit the replacement of this magnet in case of damage.

## TECHNICAL SOLUTIONS FOR LOW-BETA QUADRUPOLES INSTALLATION

The complete installation of the Q1, and sometimes Q2, using the transport vehicle and the transfer tables is not possible in the insertion regions IR1, IR2 right, IR5 and IR8 right. The technical solution that has been adopted

consists in installing Gantry type rails in the areas concerned and transferring longitudinally the quadrupoles (Q1 and/or Q2) using a set of two motorised bogies (see Fig. 2). Thus far, the rails required in the right side of the insertion IR8 are already installed [3].

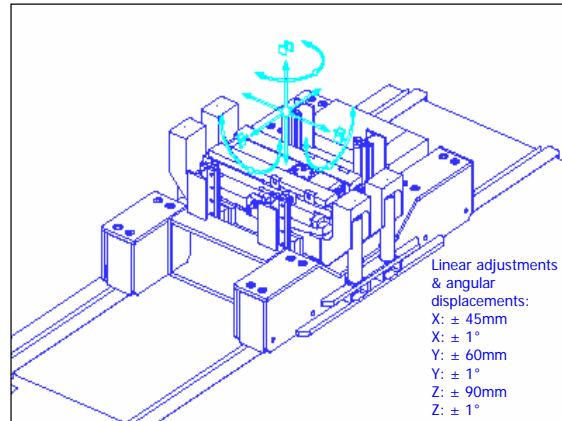


Fig. 2: Bogies concept design.

This solution ensures a safe longitudinal transfer and installation and/or a quick removal in case of failure. The bogies are equipped with motorised translation units 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 axis levels (950 mm at IR5 and 1100 mm elsewhere) and compact enough to pass through the shielding plugs.

During the transport and installation phase, the Low-Beta quadrupole will be transported on the transport vehicle as close as possible to its final position. From the trailer it will be unloaded onto the transfer tables.

In order to be able to use the transfer tables the tunnel floor surface has to be levelled out; therefore, the rails have to be embedded in the floor. The type Gantry rails, size A55, has been selected.

As the next step in the process, the quadrupole will be transferred using the transfer tables onto the motorised bogies that will be ready on the rails (see Fig. 3). The

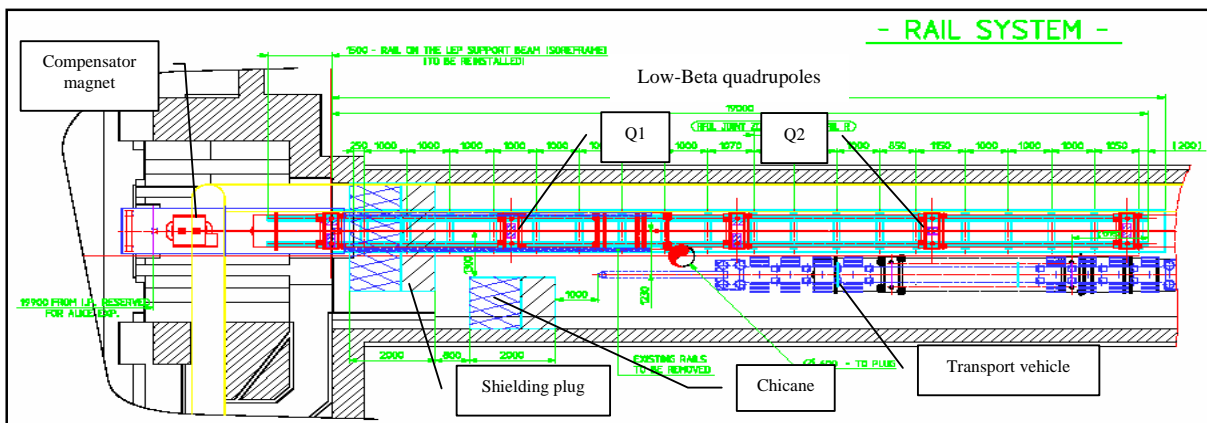


Fig. 1: Installation in IR8 right side.

bogies will allow to transport the cryo-magnet and to lay it down onto the support jacks. Then, the bogies will be able to be removed from underneath the quadrupole.

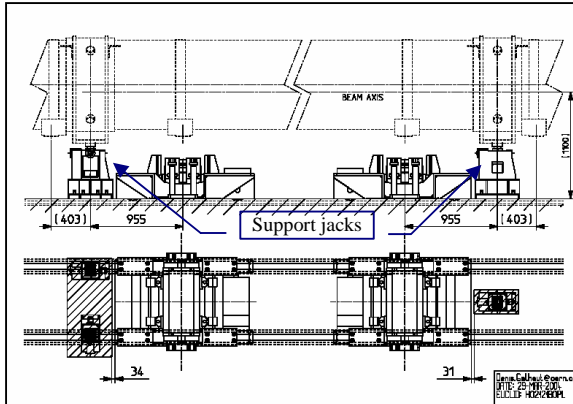


Fig. 3: Bogies after transferring and unloading Q1 or Q2.

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

At points 1 and 5, the free space around Q1 is small. Thus, the motorised bogies will have to be dismantled in several parts in order to be removed from underneath Q1.

## HANDLING AND UNDERGROUND TRANSPORTATION

The lifting devices and the transportation units corresponding to the LHC-US collaboration equipment are being studied and will be provided by CERN.

### *Underground transportation*

The design studies of the two motorised bogies for transferring Q1 and/or Q2 is well-advanced. The manufacture drawings will be ready in September 2004.

The underground transport of other main elements such as the Distribution Feed-Boxes (DFBX) and the Neutral Beam Absorbers (TAN) is being analyzed and no definitive decision has been taken yet regarding the equipment to be used.

The DFBX weighs about 6 tons and its length is about 2.5 m. The main transport constraint is given by its height: 2.4 m. For instance, to reach the locations at Point 5, the DFBXs have to be lowered down the shafts at Point 4 and 6 and then be transported through the standard tunnel (3.8 m of diameter) along approximately 3 km. The present integration studies have shown that the DFBX fully equipped can not be transported through the standard tunnel. However, it is possible to transport it partially pre-equipped on the surface with the instrumentation rack, the cryogenic valve box and the cable tray. Further cabling and fitting the boxes containing instrumentation wires, transformers for heaters, etc. will have to be done *in situ*. In principle, the DFBX can be considered “self-supporting” and fitting appropriate wheels and/or building a special transport

frame for handling and transportation purposes is being analyzed.

The TAN is a heavy element (33 tons) of total length 4.9 m. It will become very radioactive with time; hence, handling time in the LHC tunnel should be minimised. Although it can be dismantled in parts of maximum weight 5 tons, the fact of assembling them in the tunnel would require special preparation of the area and in case of removal, the time required would probably exceed the acceptable limits. Therefore, 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). At the moment, a commercial solution consisting in two motorized hydraulic trolleys with radio remote control and a full load capacity of 35 tons is being considered for the transportation of the TAN in the LHC tunnel. Tests of this system are foreseen before the end of 2004. The transfer of the TAN onto the support jacks using the transfer tables or this hydraulic trolleys system is also under study.

### *Lifting devices*

As far as the cryo-magnets are concerned, i.e. Low-Beta 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 perform a global study for all these cryo-magnets.

A lifting fixture for the handling of the DFBX is already known [4].

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

## ACKNOWLEDGEMENTS

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## REFERENCES

- [1] ‘Inner Triplet Systems at IR1, 2, 5 and 8’, Functional Specification, EDMS Id: 108981.
- [2] ‘Technical Specification for the Supply of the Jacks for the LHC cryo-magnets’, EDMS Id: 113503.
- [3] ECR ‘Hardware for the installation of LHC-US collaboration’, EDMS Id: 458030.
- [4] ‘Stress analysis of LHC DFBX lifting fixture’-LBNL Engineering Note, code: LH2001 M8046.