CERN-ACC-2014-0315

HiLumi LHC

FP7 High Luminosity Large Hadron Collider Design Study

Milestone Report

Study of the Minimal Distance Between Two Coils in a Cold-Mass

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04 December 2014

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

This work is part of HiLumi LHC Work Package **3: Magnets for Insertion Regions**.

CERN-ACC-2014-0315

Grant Agreement No: 284404

HILUMI LHC

FP7 High Luminosity Large Hadron Collider Design Study

Seventh Framework Programme, Capacities Specific Programme, Research Infrastructures, Collaborative Project, Design Study

MILESTONE REPORT

STUDY OF THE MINIMAL DISTANCE BETWEEN TWO COILS IN A COLD-MASS

MILESTONE: MS39

Document identifier:	HILUMILHC-Mil-MS39
Due date of deliverable:	End of Month 36 (October 2014)
Report release date:	04/12/2014
Work package:	WP3: Magnets
Lead beneficiary:	CERN
Document status:	Final

Abstract:

In this report we present the results.

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404. HiLumi LHC began in November 2011 and will run for 4 years.

Delivery Slip

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Authored by	G. Ambrosio H. Felice P. Ferracin	FNAL LBNL CERN	17/10/2014
Edited by	C. Noels	CERN	27/10/2014
Reviewed by	E. Todesco, WP leader G.L. Sabbi, Deputy WP leader L. Rossi, Project coordinator	CERN LBNL CERN	16/11/2014
Approved by	Steering Committee		17/11/2014

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Executive summary

In this report we present the minimum distance between magnets in the cold-masses of the inner triplet. At this stage, we will focus only on the Q1 assemblies assuming that the Q1 and Q3 cryo-assemblies are identical. The minimum distance is 440 mm, which is close to the initial guess of 500 mm.

1. INTRODUCTION

Each of the Q1 and Q3 quadrupoles of the interaction region triplet will be made out of two magnets assembled in the same cold mass. Here, we focus only on the Q1 cold mass and magnets assuming that the Q1 and Q3 assemblies are identical. The distance between the two magnets inside the cold mass is critical for the accelerator layout and performance, and for the magnet to magnet splices design. We will summarize here the key longitudinal dimensions and giving justification to the decision to have the minimum distance between the two magnets in the Q1 cold mass, presently set to 500 mm (magnetic length to magnetic length, see Fig. 1) [1].

2. Q1 AND Q3 DESCRIPTION

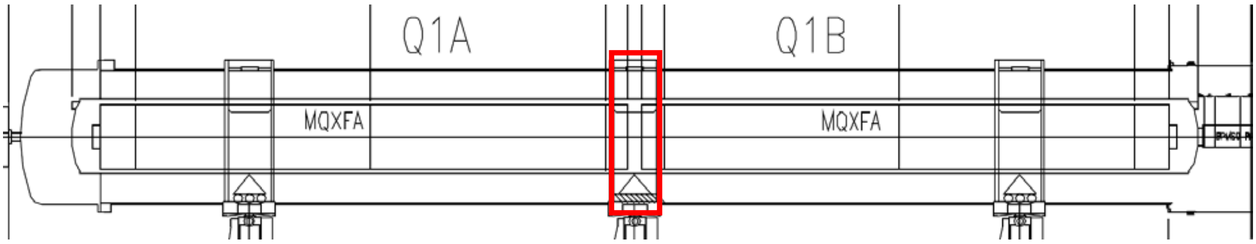

Fig. 1 Overview of the Q1 cryostat including the Q1 cold mass composed of the two magnets MQXFA. The area of interest for this study is captured in the red box and corresponds to the distance between the two magnetic lengths.

The MQXFA magnet is a 150 mm aperture Nb_3Sn quadrupole using a shell-based support structure. Fig. 2 shows a cross-section of the MQXF short prototype [2]. MQXFA cross-section is expected to be very similar to the one of the short prototype. In this report, this cross-section will be taken as a reference.

The magnetic length is 4000 mm at 1.9 K for each magnet in the Q1 and Q3 cryo-assemblies [1]. At the stage of the design, the support structure is a scale up of the MQXF short prototype. Based on that, Fig. 3 summarizes the main longitudinal dimensions of the MQXFA magnet.

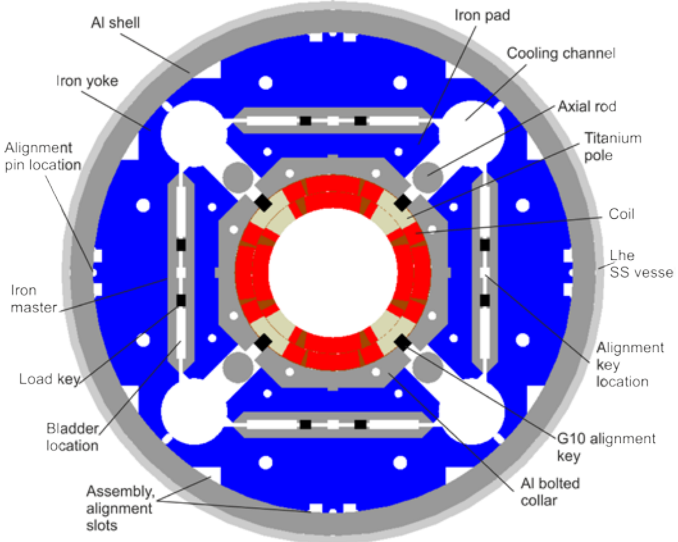

Fig. 2 Cross-section of the MQXF magnet [2].

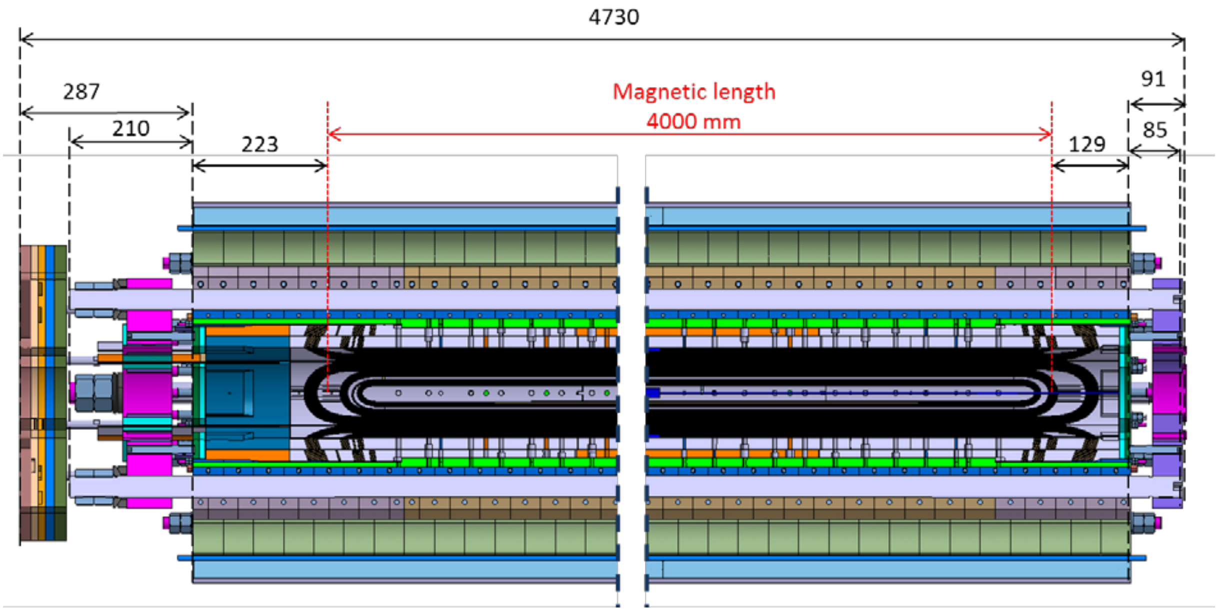

Fig. 3 Longitudinal cross section of the MQXFA magnet (150 mm aperture)- The magnetic length is not in scale with the model. Ends only are shown.

From left to right (connection (or lead end) side to non-connection (or return end) side), we can see:

- the splice box (77 mm),

- the lead-end axial endplate nested between the support structure and the splice box (210 mm),

- the distance between the end of the magnetic iron yoke on the connection side and the magnetic length (223 mm);

- the total length of the magnetic iron yoke (4352 mm) includes the 4322-mm-long coils.

- the distance between the magnetic length and the end of the magnetic iron yoke on the non-connection side (129 mm);

-the return-end axial endplate (91 mm or 85 mm).

These lengths give a minimal distance magnet to magnet (between magnetic lengths) of 440 mm, which with a 60 mm physical gap between the magnets gives the 500 mm used for the present baseline layout.

3. ANALYSIS OF DIFFERENT COMPONENTS

The driving components of return end are (see Fig. 4):

- The coil end and coil end-shoe length,
- The G10 and stainless steel pushers ,
- The return end axial endplate thickness,
- The axial spacing between the end of the yoke and the endplate.

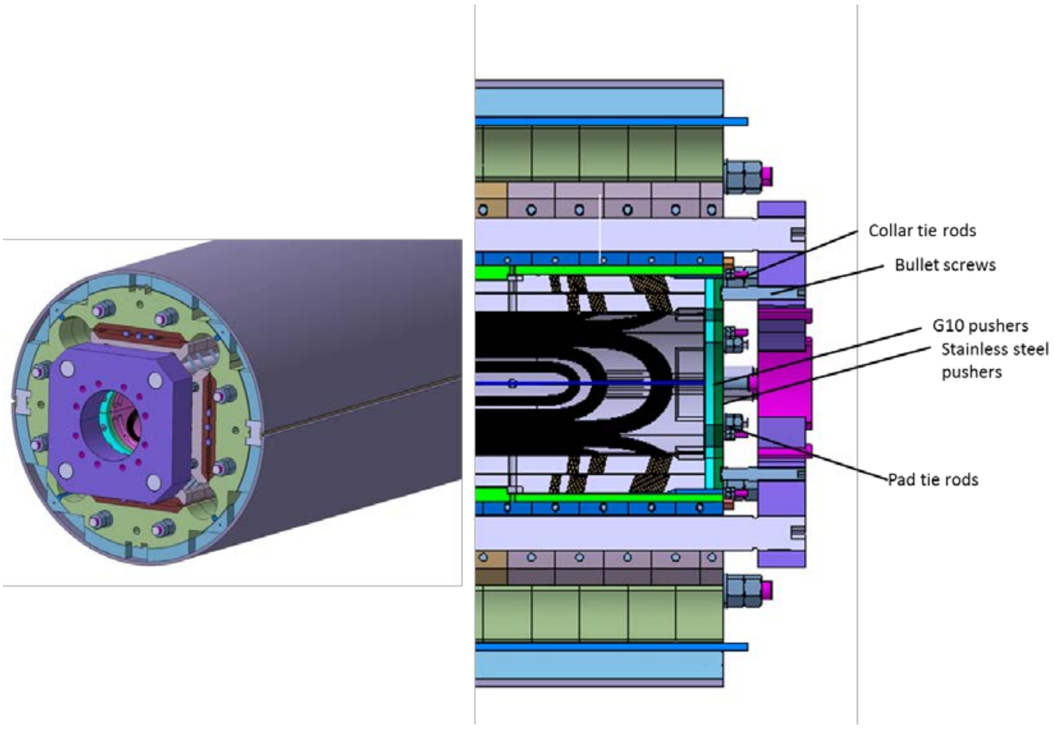

Fig. 4 Components and cross-section of the non-connection end.

As seen in Fig. 2, the magnetic length ends approximately at the second block of the inner layer on the return end. From there to the edge of the last end spacer 109 mm are used for the optimization of the coil ends (minimization of the field error and of the peak field in the end region [3]) and for the last end spacer (mechanical robustness and protection heater soldering pads). At the extremity of the end-shoes, some pushers are attached for ground plane insulation (G10) and axial preload (stainless steel). Both pusher thicknesses add-up to 20 mm. The optimized resulting distance between the end of the magnetic length on the return end and of the end of the yoke (outer edge of the pushers) is 129 mm.

The return endplate has been optimized for compactness and is 50 mm thick. The axial tied rods are directly bolted into the plate to avoid any bolts to protrude beyond the plate. An addition 6 mm is presently attributed to the instrumentation cover which is attached to the outer face of the endplate.

The total axial build-up beyond the magnetic length on the return side adds up to 220 mm (with the instrumentation cover) or to 214 mm without.

In the present layout of the Q1/Q3, the distance between the magnetic lengths of the two magnets is 500 mm. Given the present design, this leaves 60 mm between the components of the two magnets.

4. CONCLUSIONS

At the beginning of the design study, we assumed a 500 mm distance between the magnetic length of the magnets in the Q1 and Q3 cold masses. This value has been used to build the layout of the interaction region. After the design of the magnet, we can now have a more precise estimate of this distance. In the report we show the minimal distance is 440 mm, in the hypothesis of contact between the magnets. Therefore the 500 mm estimate is correct, and a further substantial reduction does not seem viable.

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ANNEX: GLOSSARY

Acronym	Definition
LHC	Large Hadron Collider
HL-LHC	High Luminosity LHC
QXF	Generic name for triplet magnet
MQXFA	Q1 and Q3