*The First Template: 13 Mar. 2019*
*Final version: 2 April 2019.*

# International Review on D1 and D2 Superconducting Magnets for HL-LHC

# -- Review Panel Report --

*Review Panel Members*

*Peter Wanderer (BNL, chair), Hélène Felice (CEA), Massimo Sorbi (INFN), Jim Strait (FNAL), Akira Yamamoto (KEK-CERN)*

*Link Person: Ezio Todesco (CERN)*

Dates: 11-13 March 2019

## Introduction --- Objectives of the Review

HL-LHC is in the final stage of design and prototyping: all technologies for the hardware upgrade must be fully proven by 2020. This review covers two important superconducting magnets for HL-LHC sharing the same basic technology, namely the use of Nb-Ti Rutherford cable. These magnets are designed and manufactured as in-kind contribution for HL-LHC by two different Institutes in collaboration with CERN that will complete integration in a cryo-assembly:

MBXF (D1) single aperture dipole magnet and cold mass and vertical test at 1.9 K: KEK (Tsukuba, Japan); cryostat by CERN;

MBRD (D2) double aperture dipole magnet: INFN (Genova, Italy): cold mass and cryostat by CERN;

CERN will carry out all cryogenic and power test in the final configuration.

Both types of magnets are in the stage of model size testing and in the process of preparing the prototype and series production. The D1 model has been designed, produced and tested by KEK (Tsukuba, Japan), which will take care also of the procurement of the prototype and series. The D2 has been designed by INFN-Genova, the model built by industry under INFN responsibility and tested by CERN. Prototype and series will be procured by INFN-Genova.

# Mandate:

The scope of the review was to examine:

1. Magnet requirements and final design status including conductor choice, mechanical structure, field quality, quench protection, cold mass with its interfaces (cryostats, electrical, hydraulic, mechanical, vacuum), integration issues, safety aspects and planning requirements;
2. Strategy for in-kind procurements;
3. Results of model magnets and status of prototype magnets;
4. Strategy for magnet construction and/or procurement and overall production/delivery schedule;
5. Status of production tooling, finalization of design, status and maturity of production procedure definition and QA, tracking and production documentation and information exchange with CERN;
6. Components procurement and preparation status and plans (including superconducting cable);
7. QA/QC and status of documentation;
8. Test plan and acceptance criteria.

A copy of the full mandate for the review is attached.

# Executive Summary

Finding and Comments:

- International Review on D1 and D2 Superconducting Magnets for HL-LHC was held at CERN on 11 - 13 Mar. 2019, with two major topics: dipole D1, dipole D2.
- The Committee has received 12 reports in open sessions and 4 specific reports, in the closed sessions.
- The Committee congratulates the D1 and D2 teams on significant progress in the magnet design and model work, with international collaborations with KEK in Japan

for D1 dipole and with INFN-Genova in Italy for the D2 dipole, based on their bilateral agreements with CERN.

- The committee members appreciated the vigorous and open discussions on critical technical issues that took place during the review.
- Both magnets are medium field (~5T) dipoles made with NbTi Rutherford cable (leftover from LHC), about 7-8 m long. The requirements for both are challenging.

SUMMARY FOR D1

- The design uses collars that are relatively thin radially, to take maximum advantage of the iron yoke.
- The large aperture of the D1 (150 mm) requires a large number of turns in the coil. This creates challenges in the coil straight section (coil size and prestress) and in the coil ends (coil end forces are radially inward).
- Short models S1, S1b, and S2 have been built and tested. S1b reached the ultimate current. S2 reached the ultimate current and, after a thermal cycle, reached the nominal current in one quench. Short model S3, now under construction, will be a reproducibility test.
- Cold field quality results from S2 are good except for b3 (16-18 units), the cause of which is under investigation. It is important to correct this before the start of series production.
- Displacements of up to 3.4 mm after powering have been observed in the coil end blocks of the model magnets. The strategy for securing the coil ends by adding epoxy and increasing preload is appropriate.
- Bids for construction of the prototype in industry will be opened in April. The magnet is part of the string test. There is no float in the prototype schedule. Results from S3 will be fed into construction of the prototype when possible.
- KEK will deliver magnets (cold mass in helium containment vessel) to CERN. The construction schedule, one to two per year, is set by the schedule of funding from the government. Six magnets will be delivered: four to install, two as spares.

D1 Recommendations

- Understand the origin of the higher order harmonic, b3, in order to meet the requirement and improve the field quality of the prototype and series magnets.
- Investigate experimental options, including possible construction of a 4$^{th}$ model magnet, for confirming reduction of b3 before start of series magnets.
- Investigate the possibility of reoptimizing the start of series production, to allow time, if required, to definitively solve the b3 problem.

SUMMARY FOR D2

- The D2 is a twin aperture magnet with both fields pointing in the same direction.
- The INFN team has designed coils which are left-right asymmetric to overcome the left-right asymmetry in the flux return. Preload is applied via stainless steel collars. In the model magnet, the "nose" (which aligns the coil and the collar) is a separate piece. The two collared coils are installed in an aluminium sleeve, which is then installed in an elliptical iron yoke.
- The cold test of the first D2 model magnet was recently completed at CERN. The quench performance of the magnet during the first cooldown was limited by one coil (1/2 an aperture). The CERN team responded quickly by warming the magnet, disconnecting the limiting aperture, and then resuming the cold test. The remaining aperture reached the ultimate (for a single aperture magnet) current in two additional quenches. The INFN team plans to replace the bad coil and retest the magnet.
- Due to a scheduled cryogenic maintenance period, no cold field quality measurements were made.
- Warm field quality measurements were made at the magnet's manufacturer, ASG. Three of the low-order harmonics were out of tolerance (b2, b3, and b5). Due to schedule pressures, the coils were wound with out-of-tolerance copper wedges. A calculation that incorporated the out-of-tolerance dimensions indicated that the wedges are the cause of the large b3 and b5. The source of the b2 is under investigation. It is important to correct the field quality before the start of series production.
- Meeting the field quality specifications is much more important at the nominal field than at lower field, but measurements at 4.5 T have not yet been made.
- When the coils were collared, the force of the press used to complete the collaring was much larger than estimated. Various problems affected the strain gauge measurements, so additional work is needed to obtain a firm conclusion. A particular focus will be the pole gauges that record the azimuthal load.
- The contract for the prototype began on 15 March. The INFN team will feed results of the test of the repaired model magnet into the prototype design when possible. The prototype will not have the "nose" separate from the collar. The prototype test is scheduled for the end of 2020. D2 is not included in the string test.
- The yoke-containment vessel interface is more complex than in most other magnets (e.g., D1). Since the tests of the model magnet did not include the stainless steel shell, the performance of this interface has not yet been verified.
- INFN will deliver cold masses to CERN; CERN will install the helium containment vessel. Six magnets will be delivered: four to install, two as spares.
- It is possible that the series schedule can be shortened to allow for a delay in the production start for input from the prototype, for example regarding field quality or the yoke-shell interface.

D2 Recommendations

- Perform additional computer simulation and measurements of a short mechanical model, including the temperature dependence, to examine/confirm the interface between the yoke and outer-shell.
- Demonstrate the field quality with cold measurements at nominal current with one more short model aperture (two new coils), with improved wedge size control. If possible, the same one-piece collars planned for the prototype and series magnets should be used.
- Pursue ANSYS modelling and strain gauge hardware verification to investigate the discrepancy between strain gauge readings and targeted values.

## Response to the Mandate – D1:

**Charge #1: Examine magnet requirements and final design status including conductor choice, mechanical structure, field quality, quench protection, cold mass with its interfaces (cryostats, electrical, hydraulic, mechanical, vacuum), integration issues, safety aspects and planning requirements.**

D1 Findings

- The basic D1 magnet cold mass design with its interfaces has been well optimized, to meet the requirement featuring a large aperture dipole magnet. (Fine tuning will be required to achieve the required tolerance on b3 and to secure the coil ends.)

D1 Comment:

- Good design concept for assembling the D1 together with Q1-Q3 in in a common cryostat.

D1 Recommendation:

- None

**Charge #2: Examine strategy for in-kind procurements.**

D1 Findings:

- The in-kind contribution has progressed through three phases: 1) three short models, 2) one prototype and 3) six production magnets.
- The prototype procurement process is in progress and will be followed by the series production with a multi-year contract financially supported by MEXT and KEK

D1 Comment:

- The strategy is appropriate.

D1 Recommendation:

- None

**Charge #3: Examine results of model magnets and status of prototype magnets.**

D1 finding:

- Good results except for b3 and motion of coil ends.
- The cause of the large b3 is not fully understood. The conjecture that it is caused by an oval deformation does not fully account for the observed value. The plan is to make a correction in either the coil or yoke to introduce a b3 of the opposite sign. This will first be done in the full-length prototype.
- Up to 3.4 mm displacement of coil end turns after powering has been observed in the model magnets. The strategy to correct this involves wet winding of the coil ends and eposy-resin filling injection and increased azimuthal and longitudinal prestress. The displacement has been reduced to ≤ 1 mm in MBXFS2, but breakage of cable insulation occurred.
- The prototype procurement in progress. Construction of the prototype will start at the same time as the tests of MBXFS3.

D1 Comments:

- The origin of the excessive b3 should be understood. It may be worthwhile to further study ovalization by precise measurements of the short model.
- Construction of the third model magnet as a reproducibility check is encouraged.
- The plan to modify the prototype coil or yoke to cancel the observed b3 seems likely to work. However, since the cause is not understood, there is risk that the problem will not be fully corrected. For example, the b3 in S3 may not reproduce that in S2 or the correction applied in the prototype may not fix the problem or may introduce other effects. The current schedule does not have time to make further corrections between the prototype and series production.
- The risk that the b3 problems may not be definitively solved before the start of production of the series magnets could be mitigated in at least two ways: by constructing a 4th model magnets (S4) in parallel with S3 and prototype to test the b3 cancellation; and by providing time, if needed, between the prototype and series production to allow further experimental investigation about the cause(s) of the b3 anomaly and ways to fix it.
- The strategy for securing the coil ends by adding epoxy in the models and, in parallel, developing a radiation-hard version of this epoxy is appropriate. However, the breakage of the insulation observed in S2 is a concern, particularly since the installed magnets will undergo many more excitation cycles than in the model tests, resulting in greater risk of cumulative damage. It would be desirable, therefore, to consider if additional measures, for example an internal support, could be employed to limit the displacement.

D1 Recommendation:

- Understand the origin of the higher order harmonic, b3, in order to meet the requirement and improve the field quality of the prototype and series magnets.
- Investigate experimental options, including possible construction of a 4$^{th}$ model magnet, for confirming reduction of b3 before start of series magnets.

**Charge #4: Examine strategy for magnet construction and/or procurement and overall production/delivery schedule**

D1 Findings/Comments:

- The schedule is tight for delivery of the prototype to CERN, in order to be included in the IR string test at SM18.
- The 3rd short model is under development to demonstrate/examine the fabrication/performance reproducibility.
- The committee supports the options being considered to reduce b3 in the prototype.
- The prototype/production magnet schedule is reasonable.
- Testing of the prototype is planned to be completed 1 month before the start of series production, which does not leave sufficient time to correct any problems with the prototype, particularly regarding the correction of b3, before starting series production.

D1 Recommendation:

- Investigate the possibility of reoptimizing the start of series production, to allow time, if required, to definitively solve the b3 problem.

**Charge #5: Examine status of production tooling, finalization of design, status and maturity of production procedure definition and QA, tracking and production documentation and information exchange with CERN.**

D1 Finding/Comment:

- Good

D1 Recommendation:

- None

**Charge #6: Examine components procurement and preparation status and plans (including superconducting cable).**

D1 Finding/Comments:

- Good.
- Bids for industrial production will be opened in April.
- The distribution of components supplied by CERN and by KEK/industry seems to be well-defined.

D1 Recommendation:

- None

**Charge #7: Examine QA/QC and status of documentation.**

D1 Findings/Comments:

- Appropriate
- CERN and KEK's efforts for QA/QC are well-organized.

D1 Recommendation:

- None

**Charge #8: Test plan and acceptance criteria.**

D1 Finding/Comment:

- There was no mention of acceptance criteria for magnets shipped from industry to KEK. In particular, no information was presented regarding the responsibilities of industry, KEK, and CERN for magnet acceptance

D1 Recommendation:

- None

**"Charge #9" (from the body of the document): The committee is invited to comment on the level of integration of the teams and on the collaboration interface and information and documentation exchange.**

D1 Comments:

- The collaboration is very well integrated
- The KEK team has found regular visits by a CERN staff member to be of great value and very important in maintaining tight communication with CERN.
- The interfaces are relatively simple because KEK is delivering a complete cold mass.

# Response to the Mandate – D2:

**Charge #1: Examine magnet requirements and final design status including conductor choice, mechanical structure, field quality, quench protection, cold mass with its interfaces (cryostats, electrical, hydraulic, mechanical, vacuum), integration issues, safety aspects and planning requirements.**

D2 Findings/Comments

- The magnet design relies on INFN's past experience on the SIS 300 magnet. The support structure is composed of SS collars that provide prestress to the coils surrounded by an aluminium sleeve that counteracts the repulsive force between the two apertures. This assembly is embedded in an elliptical iron yoke. The iron yoke does not contribution to the coil preload. The coil pole and collars are separate parts in the short model. The pole and collars will be merged in a single "collar with nose" part for the prototype.
- A novel electromagnetic design with an elliptical iron yoke, to optimize the field quality and the excitation dependence. On the other hand, the design requires an additional filler-component inserted between yoke and outer shell. The mechanical design should be further examined, with a focus on the cold mass and containment vessel interfacing behaviour.
- From a safety design viewpoint (a pressure equipment directive--PED) there is still room for improving the overall magnet design to further harmonize the electromagnetic design (the responsibility of INFN) with the design of the interface to the outer-shell (CERN's responsibility).

D2 Recommendation:

- Perform computer simulation and measurements of a short mechanical model, including the temperature dependence, to examine/confirm the interface between the yoke and outer-shell.

**Charge #2: Examine strategy for in-kind procurements.**

D2 Findings/comments:

- Well organized with INFN with having good industrial candidates
- CERN is supplying specialized components and components for the series

D2 Recommendation:

- None

**Charge #3: Examine results of model magnets and status of prototype magnets.**

D2 Findings/Comments:

- The preliminary measure of field quality at room temperature, in particular for b2, b3 and b5 in the short model, is a concern, and one of the causes is considered to be insufficient wedge size control. The whole problem should be understood, and the field quality should be improved, using possible short models and the prototype work in this process.
- The committee is concerned that the field quality, in particular the out-of-tolerance value of b2, is not understood and that there are no plans to make a new model magnet(s) to demonstrate that the field errors would be corrected by the use of in-tolerance wedges.
- The field quality at 4.5 T, where it really matters, has not been measured, and therefore the shifts due to iron saturation have not been verified.
- Measurements of the prototype at full field will not be made until late 2020. If the field quality is found to be not good enough at the point, a substantial schedule delay could result.
- The risk of a delay would be mitigated by building a second model magnet combining the one operational aperture with a second one made with two new coils made with fully compliant components, possibly with the final collars as in the prototype. This could be built and tested while the prototype is under construction yielding valuable information for the series magnet production. If field quality problems are identified with this model, there would still be time to react before starting the series production.
- Despite the positive quench results of the second aperture, given the strain gauge data, it can be suspected that the preload is not applied as expected in the windings. A bending effect could play a major role and explain the discrepancy between modelling and measurements. The fact that the amount of force used to collar and "uncollar" the aperture is the same could indicate that the force in the system is there but not distributed as planned. Possible causes could be a mismatch between coil pole pieces and collars, or between coil pole turn and pole piece angle.

D2 Recommendation:

- Demonstrate the field quality with cold measurements at nominal current with one more short model aperture (two new coils), with improved wedge size control. If possible, the same one-piece collars planned for the prototype and series magnets should be used.
- Pursue ANSYS modelling and strain gauge hardware verification to investigate the discrepancy between strain gauge readings and targeted values.

**Charge #4: Examine strategy for magnet construction and/or procurement and overall production/delivery schedule**

D2 Finding/Comment:

- The committee considers that the production schedule may be shortened, based on a more detailed production schedule optimization. (For example, a schedule of one-coil/two-weeks results in shortening the series production interval to two months instead of three.) This would allow more time for short-model and prototype fabrication.

D2 Recommendation:

- None

**Charge #5: Examine status of production tooling, finalization of design, status and maturity of production procedure definition and QA, tracking and production documentation and information exchange with CERN.**

D2 Finding/Comment:

- There is excellent collaboration between INFN and CERN with appropriate work sharing.

D2 Recommendation:

- None

**Charge #6: Examine components procurement and preparation status and plans (including superconducting cable).**

D2 Finding/Comment:

- Good.

D2 Recommendation:

- None

**Charge #7: Examine QA/QC and status of documentation.**

D2 Findings/Comments:

- Appropriate.
- CERN and INFN's efforts for QA/QC are well-organized.

D2 Recommendation:

- None

**Charge #8: Test plan and acceptance criteria.**

D2 Finding/Comment:

- There was no mention of acceptance criteria for magnets from industry to INFN. In particular, no information was presented regarding the responsibilities of ASG, INFN, and CERN regarding magnet acceptance

D2 Recommendation:

- None

**"Charge #9" (from the body of the document): The committee is invited to comment on the level of integration of the teams and on the collaboration interface and information and documentation exchange.**

D2: Comments:

- Excellent collaboration between INFN and CERN.
- The Committee encourages closer communication regarding mechanical measurements and modelling aspects.
- There is still room for improving the collaboration between INFN and CERN in coming to a fully integrated design that harmonizes the electromagnetic design, for which INFN is responsible, with the mechanical design of the yoke-shell interface, for which CERN is responsible.

**International review on D1 and D2 superconducting magnets for HL-LHC - 11 Mar 2019-13 Mar 2019, CERN.**
**Daily Programme: Monday 11 March 2019**

**Contribution:** **Closed session**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(11 Mar 2019-11 Mar 2019)**

**Contribution:** **Review scope**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(11 Mar 2019-11 Mar 2019)**
**Presenter: :** **Lucio Rossi**

**Contribution:** **D2 requirements and conceptual design choices**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(11 Mar 2019-11 Mar 2019)**
**Presenter: :** **Ezio Todesco**

**Contribution:** **D2 design, short model manufacturing and test**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(11 Mar 2019-11 Mar 2019)**
**Presenter: :** **Stefania Farinon**

**Contribution:** **Integration in the cold mass**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(11 Mar 2019-11 Mar 2019)**
**Presenter: :** **Arnaud Pascal Foussat**

**Contribution:** **Documentation and QA/QC**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(11 Mar 2019-11 Mar 2019)**
**Presenter: :** **Arnaud Pascal Foussat**

**Break:** **Coffee break**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(11 Mar 2019-11 Mar 2019)**

**Contribution:** **From short model to prototype and series**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(11 Mar 2019-11 Mar 2019)**
**Presenter: :** **Pasquale Fabbricatore**

**Contribution:** **Closed session**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(11 Mar 2019-11 Mar 2019)**

**International review on D1 and D2 superconducting magnets for HL-LHC - 11 Mar 2019-13 Mar 2019, CERN.**
**Daily Programme: Tuesday 12 March 2019**

**Contribution:** Closed session
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)

**Contribution:** D1 requirements and conceptual design choices
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenter: :** Ezio Todesco

**Contribution:** D1 design, short models manufacturing and tests
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenter: :** Michinaka Sugano

**Break:** Group picture and Coffee break
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)

**Contribution:** D1 cold mass design and plans for the series
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenter: :** Tatsushi Nakamoto

**Contribution:** Documentation and QA/QC
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenter: :** Andrea Musso

**Contribution:** D1 Integration in the cryostat
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenter: :** Delio Duarte Ramos

**Contribution:** D2 cryostat design and interface with cold mass
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenter: :** Arnaud Vande Craen

**Break:** Lunch
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)

**Contribution:** Focus on D2 elliptical shape of iron
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenters: :** Pasquale Fabbricatore; Stefania Farinon

**Contribution:** Focus on mechanical measurements in D2 short model
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenters: :** Andrea Bersani; Michael Guinchard

**Contribution:** Focus on D2 field quality
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenters: :** Pasquale Fabbricatore; Stefania Farinon

**Contribution:** Focus on D1 field quality
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)
**Presenters: :** Michinaka Sugano; Tatsushi Nakamoto

**Contribution:** Q&A closed session
**Time and Place:** 30-7-018 - Kjell Johnsen Auditorium(12 Mar 2019-12 Mar 2019)

**International review on D1 and D2 superconducting magnets for HL-LHC - 11 Mar 2019-13 Mar 2019, CERN.**
**Daily Programme: Wednesday 13 March 2019**

**Contribution:** **Writing (closed session)**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(13 Mar 2019-13 Mar 2019)**

**Contribution:** **Close out**
**Time and Place:** **30-7-018 - Kjell Johnsen Auditorium(13 Mar 2019-13 Mar 2019)**

EDMS: 2060044

# International Review on D1 and D2 superconducting magnets for HL-LHC

**Objectives of the Review:**

HL-LHC is in the final stage of design and prototyping: all technologies for the hardware upgrade must be fully proven by 2020. This review covers three important superconducting magnets for HL-LHC sharing the same basic technology, namely the use of Nb-Ti Rutherford cable. These magnets are designed and manufactured as in-kind contribution for HL-LHC by two different Institutes in collaboration with CERN that will complete integration in a cryo-assembly:

- MBXF (D1) single aperture dipole cold mass and vertical test at 1.9 K: KEK (Tsukuba, Japan); cryostat by CERN;
- MBRD (D2) double aperture dipole magnet: INFN (Genova, Italy): cold mass and cryostat by CERN;

CERN will carry out all cryogenic and power test in the final configuration.

The scope of this review is to examine:

- Magnet requirements and final design status including conductor choice, mechanical structure, field quality, quench protection, cold mass with its interfaces (cryostats, electrical, hydraulic, mechanical, vacuum), integration issues, safety aspects and planning requirements;
- Strategy for in-kind procurements;
- Results of model magnets and status of prototype magnets;
- Strategy for magnet construction and/or procurement and overall production/delivery schedule;
- Status of production tooling, finalization of design, status and maturity of production procedure definition and QA, tracking and production documentation and information exchange with CERN;
- Components procurement and preparation status and plans (including superconducting cable);
- QA/QC and status of documentation;
- Test plan and acceptance criteria.

EDMS: 2060044

**Mandate:**

The review committee is invited to assess the soundness of the design and technical choices, the readiness of the various components and of the construction plan and the documentation, the QA/QC plan and its implementation, the test plan and the acceptance criteria, the status of the integration with special attention to interfaces (e.g. magnet to cold-mass, and cold-mass to cryostat). A detailed resources analysis is beyond the scope of the review, however comments on the credibility of the plan, also with respect to the available resources that will be mentioned in the review, are welcome.

As mentioned above, these magnets are in joint venture between CERN and various Institutes (KEK, INFN). The committee is invited to comment on the level of integration of the teams and on the collaboration interface and information and documentation exchange.

Following the close-out by the review chair, the committee is required to compile a short report with findings, comments and recommendations within one month. The report will be delivered to L. Rossi, HL-LHC Project Leader. The chair (or a member of the panel in case of unavailability of the chair) will report the result to the HL-TCC.

**Members of the Review Panel:**

Peter Wanderer (BNL, part time, chair)
Hélène Felice (CEA)
Massimo Sorbi (INFN)
Jim Strait (FNAL)
Akira Yamamoto (KEK-CERN)

**Dates and Place:**

11 March afternoon, 12 March and 13 March morning (2019) at CERN in room 30-7-018

**Program:**

The program is on 3 days, organized as follows

Day 1: Afternoon
- MBRD (D2)

Day 2: Morning
- MBXF (D1)

Day 2: Afternoon:
- Closed Session: discussion, further materials/talks as required, writing close out;

EDMS: 2060044

Day 3: morning

- Closed session: writing report and close out;
- Close out

End by noon of 13 March.

Ezio Todesco will be the link-person to propose and finalize the detailed program
Andrea Musso will be the scientific secretary
Elodie Kurzen will be the review assistant