M.Zerlauth

4th Meeting of the HL-LHC Parameter and Layout Committee

Participants: Amalia Ballarino, Markus Brugger, Helmut Burkhardt, Jean-Paul Burnet, Samy Chemli, Gijs De Rijk, Stephane Fartoukh, Brennan Goddard, Bernhard Holzer, Mike Lamont, Roberto Kersevan, Mikko Karpinnen, Heene Mainaud Durand, Dominique Missiaen, Herve Prin, Stefano Redaelli, Lucio Rossi, Hermann Schmickler, Andrzej Siemko, Ezio Todesco, Markus Zerlauth (Scientific Secretary)

Excused: Rama Calaga, Jorg Wenninger

The slides of all presentations can be found on the website and Indico pages of the PLC:
HL-LHC PLC homepage: https://espace.cern.ch/HiLumi/PLC/default.aspx
Indico link: https://indico.cern.ch/conferenceDisplay.py?confId=239311

O.Bruning opened the meeting by approving the minutes of the previous meeting. Following the Doodle poll the default HL-PLC slot was agreed to be on Tuesday morning. The next meeting will take place on the 2nd July (baseline).

O.Bruning reviewed the actions from last meeting as follows:
-) The full optics for the 150mm aperture is ready and can be presented during the next meeting
-) A decision on the baseline powering can normally be taken today (at least a proposal should be endorsed).
R. van Weelderen pointed out that for the CRYO plant in IR4 a real specification for the required upgrade needs to be completed for the end of 2014.
Action: CRYO should verify with RF (for 800MHz higher harmonic system) and COLL to include their needs in estimation of heat-loads
-) Follow-up of crab-cavity space requirements: This issue will be followed up in a future technical committee and should lead to a first assessment and global study before the summer. The study should focus initially on crab cavity implications and on a 2nd priority at the potential benefit for other optimizations, e.g. relocation of powering equipment into the new cavern to avoid R2E problems and sc links…
J.P.Burnet asked whether one could imagine relocating all power converters currently installed in the RRs into such a new cavern? O.Bruning replied that theoretically this would be possible, but should be addressed in detail in the mentioned TC.

O.Bruning proposed to establish a list of renovations and actions that will NOT be done in LS1 but rather during LS2/3 to be sure to plan the upcoming shutdowns accordingly. Action: I. Bejar Alonso and TC to follow-up

O.Bruning announced the upcoming CERN internal LIU review planned for October 8-9-10th (internal CERN), as well as the HL-LHC collaboration meeting in Daresbury in November.
S.Redaelli announced that the date for the collimation review has been decided to be on the 30 and 31st of May.

HL-LHC Configuration Management – (S.Chemli - slides)

S.Chemli presented a proposal addressing the configuration management for HL-LHC in perspective of merging it in the future with the system already in place for the LHC. A clear distinction has to be made between the LHC Project (prior to its installation) and the LHC machine. The LHC project was handled through configuration management to allow for a clear and common view on the state of the project (e.g. documents stored in the Hardware Baseline, parameters in equipment catalogue,..), once the machine in operation it followed the same rules, complemented by a configuration management and control of changes (through ECRs).
When handling several machines & layouts in parallel, aspects like consistent naming, parameters, layout drawings, functional positions/slots,… need to be considered. As an example, several names for the different (prototype) versions of the new inner triplet magnet have already been defined in the naming portal (MQXC/D/Fx). With the decision of the final design being taken the 'official' name should be defined.

Action: Official names for 'approved' equipment need to be defined (I. Bejar Alonso to follow-up), eventual extension to 8 characters

As for the parameters of e.g. magnets the proposal is to continue using the existing LHC equipment catalogue (as it is already fully integrated into Layout, operation, MAD generation…), however before integrating the official catalogue, parameters should follow an approval circuit through the appropriate bodies.

Layout drawings are conceptual drawings covering the Layout, electrical interconnections and cryogenics. HL-LHC drawings should be created with new names (and a restricted lifetime), which will however require the maintenance of parallel sets of drawings until the final merge during LS3. The issue of multi-branching is likely to happen for HL-LHC (to deal with multiple scenarios until a final decision is taken) and hence needs to be properly integrated (including potential dependencies) in the DB structures.

Functional positions, types and regions are going to change heavily during the conception phase, and an internal mechanism in the Layout DB would be desirable to verify the integrity of data at any stage. The Layout database should be used for defining the configuration of assemblies, e.g. for the LQXD at the functional position LQXDA.3R5 of the region 4R5, along with the introduction of validity dates for all

elements handled in the Layout DB. CO is targeting the end of LS1 to have said features implemented.

The HW baseline is the place to store long-term documentation (e.g. everything concerning procurement, specification, change requests,...). The proposal is to start renaming the existing nodes with a 'current machine' prefix, and in the following duplicate the nodes with the 'HL-LHC' prefix which will ease the attachment of documents to the activity structure. Only nodes which require HL-LHC modifications would be duplicated and branched.

Discussion:

H.Schmickler commented that the naming 'new'/'old' equipment is unfortunate as the terms will become obsolete with time.

O.Bruning requested that it should be possible to 'select' HL-LHC in the DB and retrieve the list of all approved modifications for the High Luminosity Upgrade representing the current baseline.

O.Bruning enquired about the timescale to produce a first set of drawings after the next HL-PLC meeting in July (which should allow completing a first baseline layout of the high-luminosity insertions 1 and 5). S.Chemli replied that it will not be very time consuming to implement the new structure of drawings, but for detailed mechanical drawings a lot of elements need to be in place and details clarified (starting with MAD input files, space for end covers…).
O.Bruning stated that the goal for a first version of the IR drawings should be the HL-LHC meeting in Daresbury in November.

H.Schmickler proposed to organize a follow-up meeting with concrete use-cases and interests in order to make an appropriate decision.

Action: S.Chemli to organize 1-2 meetings to decide on proposal for parallelism/branching.

H.Schmickler asked whether the current data in the DB is completely reflecting reality (i.e. the machine as installed)? S.Chemli replied that this is not 100% the case at this moment in time as not all ECRs planned for LS1 are yet integrated.

Action: Clean up LHC names & definitions, e.g. name of IR, which is interpreted differently by various teams and reports - offline-discussion Lucio and Stephane Fartoukh.

Layout for interaction regions in HI Lumi LHC – (E.Todesco - slides)

E. Todesco introduced the work being done so far to define the layout of the interaction regions (in conjunction with S.Fartoukh and R. de Maria) by showing the 3 layouts for the (current) LHC, Phase I and finally the HL-LHC layout proposal.

For HL-LHC the idea of a compact corrector package in a dedicated cryostat following the Q3 has been maintained. The Service Module for cryogenics is placed for HL-LHC after the D1 in order to allow for the compact design of the triplet requested by the optics team. Q1 and Q3 are each split into two 4m modules (as requested by US colleagues). The Q2 is composed of two individual magnetic elements, for modularity reasons installed in independent cryostats (each with its dipole corrector package MCBX).

The distance between cryostats has been increased wrt to Phase I to 1m, as interconnections between NbSn3 and busbars requires additional space (further optimization by 10-20 cm to be studied in 2nd iteration).

The requirements for corrector magnets were the provision of 2.5 Tm around Q2 and 4.5 Tm between Q3 and D1, which will be provided by 3 nested correctors for H/V correction with 2.1 T of peak field each. An alternative design with 2 layers (providing up to 4T in peak field) is being studied to safe further space, this would however imply dealing with a 4 times higher torque between the coils. An alternative to be further explored is the use of canted dipoles (coil wound around the tube in a way to provide dipole field and cancel solenoid field).

Following a question from A.Siemko, E.Todesco clarified the 'motor' effect issue in the current MCBX assemblies: Indeed the very first prototypes revealed a problem with the glue between the two apertures; however this should not be a problem for the correctors currently in the machine and hence no limitation is required to be applied for their operation. A.Siemko commented that ideally the magnets should be decoupled; however this clearly would impact their performance due to the larger space requirements.

For the non-linear correctors it is proposed to use super ferric (more resistant to radiation) and non-nested (due to large beta functions) elements with a maximum saturation of 20%, which will satisfy the ABP requirements with a safety factor of at least 1.5. For the time being 9 individual objects are foreseen (maintaining also components like a5, a6 which may be removed once the detailed magnetic measurements of D1 and others are known).

The separation dipole D1 requires 35 Tm, assuming one layer of MB dipole cable (to limit the fringe field) providing a peak field of 5.2 T over a length of less than 6.7 m. A second option being studied is based on two layers or reduced margins to reduce the required length by an additional 1-2 m (requires further inputs from heat load calculations which are expected in the next weeks).

Action: BI and E.Todesco to make an iteration concerning the BPM positions (Q1-Q2-Q3 interconnections look OK; it's more tricky however between the corrector package and D1 and before the Q1, the latter of which is particularly important).

The tentative allocation of contributions was shown as follows: CERN will produce the two Q2 magnets, Japan the D1 and the American colleagues the Q1 and Q3. The corrector package will be under the responsibility of Spain and Italy. O.Bruning commented that the American contribution is limited to the cold mass, while the cryostating + heat exchangers are CERN responsibility.

To build the Q5 one could envisage using spare MQYs, their use needs however to be assessed in light of their activation and the remaining spare magnets.
Action: E.Todesco to report back in next meeting concerning MQM/MQY (spare) situation.

The option of doubling the Q7 in force (supporting the crab cavities) is followed on a low priority, currently best solution would be to displace the DFBA and use 4 additional MQM magnets.
Action E. Jensen to report after the first crab cavity measurements on the needs from RF.

In conclusion a baseline has been established from the IP up to (and including) D1, which will now be followed by a detailed estimation of the heat load on correctors and the D1 as well as dimensioning of cryogenics, and iron holes to possibly feedback on the aperture.
A review of the layout is foreseen for the end of the year, including details on the magnet heads and interconnections. Until June 2013 the full model will be extended up to Q4.

Discussion:

S.Chemli commented that if the Q1 remains at the same position, a TAS upgrade might be envisaged to include considerations for additional BPM locations. E.Todesco replied that this is indeed one of the options being explored.

S.Farthouk enquired about the status of the D2 recombination dipole. E.Todesco replied that BNL is conducting a study using one layer of BNL or LHC dipole cable. The magnet is considered working between 4-5 T with a length of 8-10 m. The Americans will however not be responsible for the D2; potentially the Russian colleagues are interested.

Magnet Powering for HL-LHC (A.Ballarino - Slides)

A.Ballarino presented a baseline proposal for magnet powering of HL-LHC in the HI-Lumi insertion regions, with a focus on the powering of the triplet. The current LHC triplet is powered through a DFBX installed in between the Q1/2/3 and D1 cryostats, while the standalone quadrupoles and dipoles D2 to Q6 are powered by an

independent DFBL before the regular arc commences with the DFBA. The inner triplet powering is hereby realized with 3 nested power supplies, allowing savings on powering equipment (converters, leads, busbars….) while increasing complexity, regulation and protection of the circuit/magnets.
The baseline assumed for the future Hi-Lumi triplets is as follows:

-) DFBX moved to the surface
-) DFB and power converters in surface building
-) SC link transferring the current from the surface to the tunnel
-) Cooling DB and SC link using new refrigerators

O.Bruning enquired whether the mentioned surface buildings already exist? A.Ballarino replied that a preliminary integration study has been done, e.g. whether existing shafts can be used for links, etc… Detailed space requirements and location of buildings remain however to be defined.

Two possible powering layouts were presented in the following. Proposal 1 corresponds to the original baseline and foresees a series connection of the Q1, Q2 and Q3 magnets with three additional trim converters (similar to current LHC configuration). This option was however not retained as it requires bypass diodes due to the series powering of quads + a very complicated regulation and protection system. J.P Burnet commented that a lot of engineering time had to be spent on the current triplet configuration to obtain the required performance, hence EPC would much prefer to avoid a similar solution for HL-LHC at the cost of purchasing additional powering equipment (as equipment costs are considered negligible in the global consideration).

Proposal 2 foresees an independent powering of the Q1/Q3 and Q2 assemblies in combination with according trims on Q3 and Q2b, allowing for full flexibility for the optics and reducing the constraints for magnet protection at the expense of an additional power converter and 2 additional 17kA busbars in the cryo-links.

R. van Weelderen asked whether there is a difference in terms of magnet protection between the two proposals. E.Todesco replied that both variants are roughly equivalent in this respect.

Compared to current DFBx (where 40kA are transported), the HI-LHC DFB and sc link would have to carry up to 150kA, assuming the proposal 2 as the new baseline.

With operating currents currently being defined for the magnets in the matching section, a decision for the powering of these magnets needs to be made soon (i.e. whether the DFBL will be retained and whether an increase in current will impact the current design - currently 7.5kA leads are integrated into the DFBL).

Action: Study for removal/upgrade of DFBL and DFBA should be conducted (to allow for relocation of converters to surface) -> this discussion should be included in the assessment of underground space for CC in upcoming Technical Committee.

A.Ballarino concluded that the proposed baseline scenario meets the requirements from optics, magnet and powering systems and will allow the WP6 to start the detailed design of the SC-links. In parallel a round MgB2 superconducting wire is being developed, of which a first short length sample has been tested at up to 10kA @4.2 K. It will in the following be integrated into a 20m long sc link cryostat in SM18 to measure its operation in He gas at variable temperatures.
Concerning the DFBL and DFBA it has to be kept in mid that major changes of operating currents of matching section magnets will have strong implications on the powering system.

Discussion:

M.Lamont requested EPC to look into the deployment of 2Q power converters for the individually powered quads as they have been at the source of several limitations for LHC operation.

Decision/Action: PLC endorses the powering proposal #2, but requests that stability requirements of power supplies (expected in the 1ppm range) need to be verified (Action: S.Farthoukh in collaboration with the Task 2.2 and WP2). L.Rossi commented that this baseline should be iterated once the full complexity and cost of each solution is clarified.

H.Schmickler added that a decision on additional caverns could be expected for the end of the year, which may change significantly the considerations of powering (DFBA/DFBL). It was agreed that this timescale is sufficient for the different WPs.

Survey needs for high lumi insertions (H.Mainaud Durand - Slides)

H.Mainaud Durand summarized the survey aspects in the HL-insertions by introducing the current alignment procedure and achievements for the LHC. Alignment is currently done in 3 steps, 1st with fiducialisation, the initial alignment to the absolute position and finally the smoothing (followed by a continuous monitoring of the relative position during beam operation).
The determination of the magnetic axis/geometric axis is hereby done with respect to the external fiducials. With this methodology the achieved alignment of the triplet was better than 10µm.

An additional challenge is the alignment of the two triplets across an insertion, which so far was done with a common stretched wire. The accuracy could further be improved if e.g. controllable through a direct line of sight (e.g. through the vacuum pipe)
Several possible improvements have already been identified, ranging from an extension of the wire up to Q5, extending the HLS system into a safe area and to develop remote methods for transferring the position of the quadrupoles to the geodetic network.

During beam operation a surprising movement of 2 sensors in the triplet right of IR1 has been observed (while all other triplets remained very stable), exceeding 0.4mm over 3 years. This movement could not fully be explained so far (despite a known dependency on temperature and pressure in the triplet) nor confirmed by beam measurements.
Considering the alignment experience of the LHC and in view of other constraints, survey needs to be integrated ASAP in the design of all types of components (from the TAS to Q5), and be informed about the alignment tolerances that are required to:

- Define an error budget
- Define a strategy of fiducialisation and alignment
- Chose the fiducials and their location
- Chose/develop the remote adjustment system
- Reserve space allocated for the alignment /adjustment systems

While first lines of sight need to be integrated into the overall design asap, additional R & D starting this year is required to develop a:

- Longitudinal position monitoring system
- Cold mass monitoring system
- Link between alignment references of both sides of tunnel through the survey galleries
- Remote maintenance

Discussion:

D.Missiaen commented that a few tasks are already being performed remotely, e.g. adding water to the surveillance system and displacing the wire to verify the diagnostics chain. The remote handling requires however the monorail which currently cannot access the area beyond the Q3 magnet.
He added that tolerances for alignments inside magnets, between sides of an IP, etc…. must be defined asap.

H.Prin suggested easing the alignment and try intercepting forces on the VAC chambers as close as possible to the IP (ideally in front of Q1). This should be considered for the cryostat design.

Action Survey/RF: Define space reservations, especially in the area of the crab cavities (i.e. up to Q5). Reinforce discussions with different work-packages to define accuracies, space requirements. Topic will be iterated in future PLC meeting.

AOB (all)

The tentative agenda of the 5th PLC meeting on the 2nd of July will be as follows:
-) IR1 & IR5 wrap-up
Optics (R.de Maria)
Powering (A.Ballarino et al)

M.Zerlauth

RF requirements for crab-cavities (E.Jensen/R.Calaga)
Beam Instrumentation – BPM location, BBLR, etc... (R.Jones)
Report of HL-LHC confirguation management (S.Chemli et al)
Survey needs in IR1 and IR5 (H.Mainaud)
Vacuum considerations (R.Kersevan)

-) Summary COLL review