12th Meeting of the HL-LHC Parameter and Lay-out Committee

Participants: G.Arduini, V.Baglin, I,Bejar Alonso, O.Brunig (Chair) H. Burkhardt, R.Calaga, R. de Maria, I. Efthymipopoulos, L.Esposito, P.Fessia, M. Giovanozzi, H.Prin, S.Redaelli, L.Rossi, F.Savary, E.Todesco, R.van Weelderen, M.Zerlauth

Excused: R.Jones, , Y.Uythoven, L.Bottura, D.Wollmann, F.Cerutti, S.Fartoukh

The slides of all presentations can be found on the website and Indico pages of the PLC:

HL-LHC PLC/TC homepage: https://espace.cern.ch/HiLumi/PLC/default.aspx

Indico link: https://indico.cern.ch/event/340523/

O.Bruning opened the meeting by briefly introducing today's agenda. The minutes of the previous meeting remain to be finalized and will be approved during the next meeting.

Approval of revised Layout (drawings & Layout DB) P.Fessia – slides

P.Fessia presented an update of the layout drawings (acknowledging input from all WPs, in particular WP2, WP3, WP6, WP10, WP12 and WP13) in view of providing an up-to-date reference for the upcoming annual meeting, focusing on the recent changes and the remaining steps to be taken before the official approval.

The drawings will be made available in EDMS as of tomorrow or the day thereafter (can now be found here). The drawings will be distributed in a formal way, including a table of BPM positions.

The new drawings attempt the representation of the real size of the crab-cavities and BPMs in the Layout, even if the detailed mechanical design is not yet done. The table of magnets has been updated according to input of WP2 (including the magnetic center + magnetic length).

For the MCBC/MCBY is was decided to revert the magnetic length to the initial design value (rather than the measured values after series production as they were currently present in the equipment catalogue).

Following a question of L.Rossi, R.Calaga confirmed that a pick-up for the phase measurement of crab cavities has been foreseen in the high-luminosity IRs (as there is no issue of space in this region).

A head-tail monitor (or similar to measure the non-closure of the crab-bump) should be installed in the insertion region. R.Jones confirmed by mail after the meeting that BI is in the process of finalizing a conceptual specification on this point. It appears to make more sense to install 2 BPMs with 90-degree phase advance in IR4 as the phase advance in the IR regions looks unfavorable to perform a local measurement. Nevertheless BI will probably propose to install BPMs close to the crabs in IR 1 & 5, to at least be able to measure the transverse position longitudinally for each bunch at the entry to the crabs.

A list of yet uncompleted and new issues was presented as follows:

- The distance between the Q1 and the TAS is today even shorter then in the present LHC configuration. The necessary detailed mechanical study will be performed by WP12 but started only recently.
  O.Bruning asked the reason for this modification, upon which P.Fessia clarified that this was mostly driven by the need of larger capillaries which (which required moving everything by ~ 100mm).
- Preliminary discussions on the Q5 in IR6 done have taken place and resulted in a 1st layout draft by H. Prin. When the situation is fully clarified this will be integrated into the official drawings - (see later presentation today by H.Prin).
- It still needs to be clarified whether the TCLMA is required between the TAXN and Q4. New computations indicate that it might not be necessary but the studies remain to be finalised.
- In Point 4 the cleaning of the reservation space is completed but not yet approved. The configuration management team is preparing an official document to be submitted to the LMC and HL-PLC for approval. Following this, the re-population can be started, according to available resources in the integration team.

Main issues to be solved for next release are several concurrent issues for the lay-out between Q1 to D1 e.g. the distance TAS-Q1 being too short, the distance between mechanical ends od MQFXA/B magnets and end cover probably not enough for all needed equipment and the capillary diameter vs 1st interconnection study and discussion with WP12 showing that interconnections are too short. The total length estimated for the interconnection is 883 mm, meaning we are already some 73 mm short of the needed length. Discussions will continue but we might have to increase to as much as 1000 mm. R. De Maria commented that if one would have to increase to 1000 mm in each interconnection of the inner triplet cryostat this would result in the loss of some 5Tm of the quadrupole strength (few %).

R.Van Weelderen commented that CRG is currently looing into a possibility for saving electrical power (and hence operating cost) by operating the capillaries at 25 bar rather then 20 bar. He enquired whether the higher pressure in the capillaries would affect any equipment? P.Fessia and H.Prin replied that they do at first sight not see a big issue, but the higher pressure might require exchanging the thickness of the capillaries. For CRG the main problem lies with the connectivity due to flexible connections…

P.Fessia also highlighted that there might be a need to allocate more space to the correctors in D2, Q4 (which are currently under design).

The proposal is to collect the input from all stakeholders in order to prepare a coherent mechanical proposal to be provided to WP2 as starting point for any new iteration.

P.Fessia concluded by commenting on the approval process for the new layout version/drawings. As the present layout has minor changes only, the modified layout will be put in approval in the coming days together with the LHC-LHC excel file of the optics V1.1.

Discussion:

G.Arduini commented that once a better estimate of the needed length for the corrector packages of Q4 is available WP2 can better assess the situation and try optimising on either side.

O.Bruning commented that 160 mm seem a lot for the diameter of the capillaries? P.Fessia and R.Van Weelderen replied that we need to extract 1kW, hence we need to increase from 2 thin capillaries to 4x16mm.

Action: G.Arduini/WP2 to verify the impact on aperture loss and beta* in case the length of interconnections in the inner triplet has to be increased to ~ 1000 mm and present an update in an upcoming committee.

Decision: Maintain the additional Q5 in IR6 and the MS at Q10 in the baseline, while continuing to study further options.

Movable TAN Roadmap - I.Efthymiopoulos – slides

I.Efthymiopoulos introduced the TAXN, being the neutral beam absorber that will capture the outgoing flux of neutral particles produced at the high-luminosity regions IP1/IP5 and hence protects the downstream twin aperture magnet (D2 +) from quenching by localizing the induced activation to this massive absorber. In addition the TA(X)N assures the transition from single to double beam pipes and houses slots forward physics experiments and eventual additional beam instrumentation (luminosity monitors).

The TAXN for HL-LHC has to be water cooled to be able to absorb the 1-2kW of deposited energy (for ultimate beam parameters of 7.5E34 of inst. luminosity) and will be designed to be installed/disassembled in-situ in presence of other equipment.

The option of a truly movable TAN was studied but finally considered too challenging. The movable TAXN could instead become a special collimator (redesigned and reinforced by a downstream TCL). The fixed part would absorb all radiation for vertical crossing and most of the radiation for horizontal one, while a second TAN with movable jaws in the H plane (+- 10 mm) would provide against remaining showers in the horizontal plane. The jaws of the 2nd movable TAN would also need to be of considerable jaw size (unlike the TCL), however it would not need to move with the beam as e.g. dump protection elements. Designing a movable jaw TAXN in this way would be a rather similar effort as that of a special collimator and could remove some of the layout issues in the TAXN-D2 region.

Present simulation studies suggest to a diameter of 40mm, 3.5m long separated pipes, 149/159 mm IP/non-IP beam separation and a position that is 4m closer to the IP then the current TAN. First estimates in this configuration yield a total absorbed power of 1150W at 5E34 and a peak does of 4.5 GGy @ 3000 fb^{-1} which can be linearly scaled to ultimate performance at 7.5E34/4000 fb^{-1}

The plan is to update the simulations studies for energy deposition and coverage for the annual meeting. In the following the set of design parameters for the TAXN, including apertures, length use of W inserts, slots for instrumentation/experiments will have to be defined in order to freeze the design by the middle of 2018 to allow for procurement, design and installation at the beginning of LS3.

I.Efthymiopoulos concluded by pointing out that the TAXN in point 8 also has to be designed and should in fact already be installed during LS2!

Discussion:

S.Redaelli clarified that the additional movable collimator would not be an additional element but would be one of the 3 collimators that are already foreseen in this region for HL-LHC (see as well the issue mentioned in the previous layout presentation whether the fixed mask is needed or not).

Following a question of O.Bruning, R.Calaga confirmed that FLUKA studies show that energy deposition in the crab cavities due to neutrons is an order of magnitude lower than the one that already induced by the RF itself. He added that the effect of high fluency on the crab cavities over time however is not known (as the I cavities will still see dose rates as high as 3MGy @ 3000fb-1).

Action: L.Rossi suggest that this being addressed in more detail by the RF/magnet teams. P.Fessia confirms that this is already being done.

Action: O.Bruning suggested to re-iterate this topic early 2015 once we have started converging on the open points. I.Efthymiopoulos agrees to this and will come back in the 1st/2nd PLC early next year.

Do we need an additional Q5 in IR6 and an additional sextupole corrector at Q10? R. de Maria - slides

R.de Maria briefly recalled the ATS scheme that has been adopted as the baseline optics for HL-LHC. The ATS can only be fully exploited in the LHC by an additional lattice sextupole in Q10 (MS10) of IR1/IR5 and a stronger Q5 in IR6 in order to maintain a balanced β* reach in ATLAS and CMS.

Action: We have to agree on a coherent naming/definition of the dispersion suppressor region. PLC team to distribute the official LHC definition (from LHC design report).

The additional sextupole is required to reach a beta* of the pre-squeezed optics to 44cm at 7TeV instead of 48cm (already taking into account the lattice sextupole at 600A) and the compensation of the geometric aberrations on the MS14 that are enhanced by the blow-up in the arc.

The absence of the sextupole in contrary would result in a reduction of the DA of about 2 sigma (to be kept in mind that this is still an optimistic assumptions as it does not take into account the new triplet, D2...).

R.Calaga asked whether one should not also consider the resulting changes in the tune diagram for ATS? Massimo confirmed that these tune scans have only been looked at for specific cases, however once the tolerances on field quality are known this will be the next step (adding as well beam-beam).

It would be possible to bypass the MS14 at the cost of increasing β* of the pre-squeeze to 52 cm, thus increasing the ATS factor to reach the same β* and about the same DA as the baseline. The increase of the ATS factor however has implications on the IR6 optics, collimation performance and machine protection that are yet to be quantified.

Other ideas of mitigation strategies are under consideration with semi-local compensation, requiring a smaller increase of the ATS factor but they could be evaluated when more information and experiments on lifetimes will be available. Hence ABP would strongly recommend the installation of the additional MS at Q10 as the best option according to today's knowledge. R.de Maria reminded that it always has been part of the baseline (i.e. the optics files) since the V1.0.

For ATS, different squeeze sequences are needed depending on the final β* for CMS. The IR6 optics is very rigid due to position of the quadrupoles/dump elements and internal phase advances. Basic needs like the septum phase advance and the bam size at dumps could be taken into account, however optics and squeeze are not fully validated as e.g. the beta functions at collimators do vary during the squeeze and the phase advance between the MKD and TCT are not yet optimized.

R.de Maria concluded that adding an MQY in Q5 would solve most issues and not changing the present Q5 is not an option unless downgrading β*. Powering the existing Q5 at 200T/m at 1.9K like in IR1/5 fulfills the β* reach for CMS for the present optics (without margins for the most pushed flat optics however).

This solution on the contrary still limits the β* reach in CMS with respect to ATLAS and does not leave much margins in case new optics in IR6 are required after all validations are concluded.

A gradient of 200 T/m at 1.9 K is a viable option in case the optics is frozen; otherwise doubling MQY is the best solution in terms of potential.

Discussion:

P.Fessia commented that the budget to provide, install and connect the 4 needed new cryostats and sextupoles is currently not foreseen. O.Bruning reminded that this is not a trivial intervention, hence we should profit from Run 2 to test as many things as possible, e.g. looking at DA and the requirements from experiments for the VdM scan in addition to studying the various issues with simulations. G.Arduini commented that he is not certain that one can make a realistic test.

E.Todesco agrees that if a bypass of an existing sextupole has a comparable effect, the disadvantages in terms of DA, machine protection… should be assessed.

L.Rossi and O.Bruning concluded that we keep the MS@Q10 in the baseline for the time being, but that work should continue to evaluate the disadvantages of not having it and/or if it is only installed during LS4. This topic should be itrated at a PLC by Feb next year.

S.Redaelli enquired whether the proposed changes are transparent for the beam dumping system? R.de Maria confirmed that this is not completely the case, as the beta functions would change as the optics of the dump regions changes. However the goal was to maintain the phase advance between the MKD and Septum at 90 degrees.

R.VanWeelderen commented that at point 6 the existing QRL is not equipped for cooling of standalone magnets at 1.9K, hence some investment would be needed for cooling at this temperature. Currently no work is foreseen for the QRL in IR6. While adding a new Q5 would be the preferred solution for ABP and CRYO, there spare situation would have to be carefully investigated (see as well later talk of H.Prin).

M.Giovanozzi confirmed following a question by O. Bruning that the maximum beta* currently considered is 30m in IR1 and IR5 for VdM scans as a-priori no high beta* runs are foreseen in the LHC after LS3. Values for IR2 and IR8 might be even smaller (but remains to be checked).

AOB: Cold mass configuration option for Q5 in IR6 based on existing LHC magnets - H. Prin - slides

H.Prin presented a first study into options for a stronger/additional Q5 magnet in IR6, taking into account the known constraints, standardization and environmental constraints.

Today's configuration features one MQY magnet with a MCBY corrector package, while the upgrade proposal would consists of 2 MQY magnets with a MCBY corrector package, based on the Q7 arrangement in the experimental insertions. The affected area of the IR6 insertion is already very dense, with the MKD, dump lines, jumpers and DFBM close by.

When doubling the MQY the current magnetic center cannot be kept, as the available space is limited on one side by MKDs. For this scenario the jumper connection in between the Q5L6 and the QRL will have to be adapted. The drawback of this proposal is a reduction of the current spare magnets from 7 to 5. This work remains feasible and could be done for LS2.

Using the Q5 at 1.9K would be interesting, as we do not have to use any spare components, however a vigilant integration study needs to be performed, as these 1.9K jumpers for standalone magnets do not yet exist as pointed out by R.van Weelderen. He added that one would have to cut out a part of the QRL, produce new valve boxes and verify the slope @ point 6.

Action: O.Bruning recommended to perform a more detailed study of the option including the additional Q5, both from a technical and panning point of view.

H.Prin also commented on the integration of an additional MS into the Q10, pointing out that the current Q10 is composed of an MQML + an MCBC corrector package. The corrector package with an additional sextupole is 20mm longer and hence might not fit into the existing cold-mass. This point was clarified after the meeting in an e-mail exchange between H.Prin and members of WP2, and a more in-depth study seems to indicate that integration would be possible, although difficult due to very little margins.

AOB: Ultimate Parameters for HL-LHC - P. Fessia - slides

P.Fessia presented a proposal for the ultimate parameters of the HL-LHC design system as already shown in Chamonix 2014. The shown numbers are the outcome of some first preliminary discussions, assuming an ultimate levelled luminosity of 7.5E34. The ultimate parameters for the luminosity production are in fact identical to those of the nominal HL-LHC configuration albeit with a smaller beta* value and a higher levelled luminosity. The 'ultimate' beam parameters for injection are for the moment a worst case estimate assuming that one uses BCMS type beams for the injection into the LHC in order to generate margins for emittance dilution during the injection, ramp and squeeze process in the LHC (due to the IBS growth rates the LHC cannot digest higher than the nominal HL-LHC beam brightness during luminosity production). However, the BCMS beam parameters are likely too bright for several SPS systems and the LHC injection and extraction devices (damage potential) and more accurate limits for the maximum acceptable beam brightness in the LHC still need to be developed over the coming months, depending on the details of the various equipment limits. The final brightness limits should then be communicated to other equipment groups as the maximum beam brightness for the LHC operation and as interlock values for the beam extraction from the SPS.

Action: The most relevant parameters should be included in the HL-LHC parameter table.