2nd Meeting of the HL-LHC Parameter and Layout Committee

Participants: Austin Ball, Amalia Ballarino, Luca Bottura, Francesco Brogg, Oliver Bruning (Chair), Helmut Burkhardt, Francesco Cerutti, Stephane Fartoukh, Erk Jensen, Mark Antony Gallilee, Stephen Gibson, Bernhard Holzer, Roberto Kersevan, Daniel Lacarrere, Herve Prin, Mirko Pojer, Lucio Rossi, Burkhard Schmidt, Rob Van Weelderen, Kaan Vatansever, Markus Zerlauth (Scientific Secretary).

Excused: H.Schmickler

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=201229

O.Bruning opened the meeting by approving the minutes of the previous meeting and recalling the agreed actions.
-) The controls group has been contacted to define a representative to the PLC meetings, the answer is still pending.
-) An update of the Technical Committee mandate has been postponed to next meeting due to H.Schmickler being excused for todays meeting.
-) The presentation for the inner triplet beam screen is on today's agenda.

1 HL-LHC insertion layout – (B. Holzer - slides)

B.Holzer reviewed the 4 baseline optics for the experimental insertions IR1 and IR5, all of which for the time being are still being based on the assumption of a 120mm, respectively 140mm triplet aperture. The values will have to be updated following the recent decision of a triplet aperture of 150mm.
The choice of technology and achievable gradients for the triplet magnets will have an influence on the possible optics conditions in the long straight sections, in particular for the Q4 region which is the intended installation region of the crab cavities. As an example, a triplet gradient of 170T/m and an aperture of 120mm will allow for a beta function around 1km, which is well below the expectation of the RF team.
Additional quadrupoles (or increased strength) of the Q5, Q6 and Q7 would not result in a considerable gain for the 60cm optics, a quasi-triplet configuration of the Q4-Q6 magnets + an additional Q7 would however allow for much larger beta values at the crab cavity location (up to 1.8km in both planes compared to 1.2km). This would require a doubling of the strength of the Q7, of which the feasibility remains

to be addressed. In addition, like for the other schemes studied, an additional strong orbit corrector at the location of the D2 is needed to compensate for the beam offset (needed for crossing angle, luminosity leveling and separation) otherwise induced at the crab cavities. This would imply to move the D2 by some 15 meters.

Action: B.Holzer to verify the impact of such a change on the aperture of the D2 magnet.

E.Jensen commented that it is favorable to go from 700m to 1200m or 1800m, still RF was assuming a beta function of 4km which already required 3 crab cavities and a total voltage of 10MV (with a current estimate of 3.3-3.5 MV/cavity, the detailed value will only be confirmed after completion of the R&D).

S.Fartoukh added that considering the crossing angle a total voltage of 12.2MV will be needed; 10MV per beam per side is the bare minimum to allow full crabbing with a standard matching section layout with 15cm of β*.

Action: Clarify the numbers before upcoming meeting with R.Calaga

Fringe field effects of large aperture triplet quadrupoles have shown in first simulations to be bigger than expected, and will hence be included in next iteration.
Optics transitions are also being looked at to assure an (ideally) monotonic change of currents during the cycle.
Concerning the optic tolerances it was defined that a single error must not change the beta function by more than 10%, resulting in an allowable strength change of 2E-4 as the worst case in a single triplet magnet (Q3 in L5 and R5).

The new working hypothesis is by now the 150mm Triplet, however a few more weeks will be needed to finalize the according layout, in which (in addition to the Q2) also Q1 and Q3 will be composed of 2 magnets each.

Next steps will include finishing the new triplet layout for IR1 and iR5, combined with Lattice Optimisation for Crab Cavities (Q4/5/6 & additional Q7), including in the overall Lattice / Optics the new phase advance in IR2 & IR8, the Fringe Field Re-Match and the new Triplet Layout in Optics Transition Match.

Discussion:

L.Bottura questioned why we need in the new triplet design 2.1m between the magnetic elements Q2a/b. H.Prin explained that this is mainly required to perform the interconnection (the only other element present in this space are the BPMs which however do not require much space).
In reply S. Fartoukh commented that a decrease of the distance would be preferable for the β* (which is very sensitive to the positioning of the two elements).

R.Van Weelderen added that CRYO requests would have to be taken into considerations for such changes, e.g. in case the D1 has to become a cold magnet at 1.8K.

L.Bottura enquired whether there is sufficient space for an additional Q7. Requirements for the problem of fringe fields have to be specified as they can be taken into account to some extent in the magnet design.

Action: B.Holzer and MSC to study the impact of an additional Q7 to allow for an increase of its strength by 50%.

Action PLC chair + secretary: Foresee presentation on CRYO issues/upgrades, picking up on the issues mentioned

2 LEB summary on upgrades and changes to experimental beam pipes – (M. A. Gallilee - slides)

M.A.Gallilee outlined the work of the LEB, being mandated to define, set priorities and follow-up the activities for the consolidation and upgrades of the experimental vacuum sectors in the LHC. The standard approval route of a new beam pipe design will start with the definition of an aperture for the n1 value, taking into account considerations of machine protection, Inject & dump optics, collimation and the relevant tolerances for positioning, mechanics and stability. Once the aperture defined the calculations of background, impedance/heating, e-cloud and vacuum will be performed before reporting to the LMC for approval.

The following changes are currently foreseen for the different experiments:

ALICE: Replacement of their central beryllium beam pipe from LS2 onwards (with reduced diameter).
LHCb: Would like to reduce their aperture as well, to have closer detectors for UX851
ATLAS: Apart from some ALARA related redesign, the 4.5-5m long stainless steel pipe is still considered the best option for the upgrade. A.Ball comments that in terms of cost/yield stainless steel is still the best option.
CMS: Will replace the central chamber with a smaller diameter – A.Ball added that new detector designs are already ongoing and that the limitations of the inner diameter should be clarified soon.

As a general comment, all chambers will – wherever possible – be NEG coated to reduce the secondary electron yield.

In summary, all work packages and LEB studies have been outlined with respect to HL-LHC upgrade while the main experimental requests are to accommodate HL-LHC from ALARA and aperture. Smaller apertures are requested by ALICE and LHCb for LS2, ATLAS and CMS will install smaller central chambers in LS1.

Discussion:

L.Rossi commented that so far for the Hamburg beam pipes only space reservations have been approved, while the detailed design still remains to be worked out.

O.Bruning questioned whether impedance and collective effects are already part of the studies? M.Gallilee confirmed that this is already the case.

L.Rossi enquired whether CMS has already issued the ECR for the changes + space requests? A.Ball replied that an additional collimator in front of the Q6 (second absorber for lumi debris) will complicate the installation of the experiments. The complication of this installation + falling into TOTEM territory has delayed the definition of the ECR. A re-configuration of the RPs might allow for the same physics to be done, the Hamburg beam pipes on the contrary might not be of large benefit for physics.

Action B.Holzer and M.Giovannozzi to iterate on the minimum aperture needed, after which CMS can give their feedback.

According to A.Ball a change in aperture of the beam pipes will also have an impact on the forward shielding, which therefore needs to be treated coherently.

Action: Identify the numbers for peak luminosity, which are assumed for the calculation of the radiation evolution and it's scaling. L.Rossi suggested including a talk on this subject in a future PLC meeting.

S.Fartoukh recalled that the main issue with machine protection of such changes is not necessarily with aperture. The aperture of the new TAS should be 60mm (not very much different), with an experimental beam pipe of 45mm. The TAS is normally chosen to protect the quad, but the possible failure cases have to be addressed in detail to be sure that the beam cannot hit the pipe.

3 Prediction of experimental cavern movements (A. Behrens - Slides)

A.Behrens presented recent measurements of the movement of the 4 experimental caverns of the LHC. Measurements for CMS are done by comparing deep references against reference points anchored in the ground of the cavern. While during the first years of operation in 2008 and 2009 the floor has still moved downwards by around 0.5mm, the last year did not show any change in the floor position wrt to the year 2011.

In the ATLAS cavern a Hydrostatic Leveling System (HLS) is being used, containing 2 reference points compared with 6 measurement stations placed on bedplates to generate capacitive readings. Not taking into account measurement excursions, which happened due to human activity during the 2010/11 and 2011/12 technical stops, a maximum upward movement of around 0.6mm was observed during the last 2 years of operation, which is a factor of 2 less than predicted.

Although no detailed surveys are being done for the ALICE and LHCb caverns, no serious deformation is expected nor detected in these caverns.

4 Beam screen design of the triplet magnets (R.Kersevan - Slides)

The current status of the beam screen design for the new triplet magnets was present by R.Kersevan. A similar presentation has recently been given in the respective work package meeting; today's presentation includes already a few updated numbers.
The vacuum requirements and layout of the new triplet region were recalled, which along with the current 2D cross-section of the cold-bore have been translated into a conceptual 3D model of the beam screen design, adding the required pumping slots and shields (still based on the 140mm aperture version for the triplet magnet).
The conceptual design is based on four 4mm tick tungsten inserts fixed on the outside face of an octagonal, a 2 mm thick beam screen (either made of copper coated stainless steel of co-laminated Cu/SS) and 4 GHe cooling tubes and rows of 16 pumping slots. This design is similar to the LHC arc dipoles, features however a 50% increase of the specific pumping speed to ~ 670l/s/m compared to 420 l/s/m for the LHC arc dipole beam screen.
The proposed beam pipe accounts for a weight of approximately 27kg/m, including the 4 cooling tubes for the transport of gaseous helium.

The requirement of a copper coating or SS/CU co-lamination has been derived from conductance calculations. In addition, calculations to determine the static pressure / longitudinal pressure profile and to estimate the impact of synchrotron radiation (mostly originating in the D1 magnet) have been performed to confirm the design choices.

From SR calculations it appears that only the Q1 might actually require a beam-screen (which is the magnet where one worries the least about aperture). There might be other (thermodynamic) reasons however for putting a beam screen throughout the complete triplet region.

Roberto concluded the presentation by highlighting three fabrication/engineering issues that have been identified (compatibility with the cold mass designs, inclusion of appropriate tolerances, insertion of stiff and heavy beam screen along the cold bores) which could affect not only the design of the beam screen, but also the design of the lattice, and of the Triplet and D1 magnets coils.

Discussion:

S.Fartoukh commented that all tolerances have to be added to the calculation of the available mechanical aperture. He would hope for a mechanical aperture in the order of 65mm assuming the recently approved 150mm triplet aperture, as we would otherwise 'loose' the same 20% as is presently the case in the LHC.

Action: The BI requirements in terms of beam screen size (for proximity of beam instrumentation) have to be clarified with R.Jones, as the reduction of the beam screen at the interconnection might not be required (which in such case would also be beneficial for pressure and debris)

L. Rossi commented it was agreed with the vacuum team to test a new coating, promising a very low secondary electron yield.

Action: R.Kersevan to verify this possibility

As concluding on this design is important, L.Rossi suggested to iterate the detailed technical discussion in an upcoming Technical Committee before finalizing the parameters.

5 LHCb VELO upgrade (M.Ferro-Luzzi - slides)

The motivation to revisit the VELO aperture in light of the LHCb upgrade was recalled by M.Ferro-Luzzi. A smaller radius translates directly into a drastic improvement of the impact parameter resolution in the VELO.
In the current implementation, the inner radius of the foil in STABLE BEAMS is 5.5mm, which is the closest distance of LHCb material to the beam. The actual detectors/sensors are currently located around 8mm from the beam in their active position. The aim of LHCb is to approach the active electronics to around 5.1mm, which would require a foil at less than 3.8mm.
It was shown that the minimum required radius for the RF foil (with main contributors being the operational luminosity, maximum bunch charge, crossing angle, velo length, beam separation, hour glass effect and mechanical tolerances) is calculated to be in the order of 2mm, hence 3.5mm is considered to be a conservative estimate.

LHCb needs the go-ahead before mid of November to settle on an RF foil to be at least at 3.5mm. Such decision would decouple the development of the detector and the RF foil. It is not excluded that the final distance will be below this limit of 3.5mm. The upper limit has to be respected however as otherwise it would interfere with the detector design.
This request will be finalized by the next LEB meeting to be held on 8th of October, after which it will require the approval of the LMC and/or the HL-LHC steering committee.

Discussion:

B.Holzer raised the question whether there are any new results concerning the impedance effects of the proposal. M.Ferro-Luzzi replied that B.Salvant will work on this once LHCb has provided a step file of the model.

H.Burkhardt reported that the background study group has performed a detailed study, showing that LHCb has quite some margins for background. Final numbers are still to be published but this is expected not to be a major issue.

Nominal parameters should be used for the calculations of beam sizes used for the calculations; B.Holzer confirmed that a meeting with ABP this afternoon should clarify all of these issues.

6 AOB (all)

O.Bruning announced that the PLC is working in collaboration with the experiments on an update/extension of the Glossary and Definitions along with the parameters for the HL-LHC, which will be made available on the PLC website.

C.Noels presented the new Website of the Parameter and Layout Committee. Everyone is encouraged to send feedback and suggestions directly to Cecile, requests concerning the inclusion of parameters and definitions should be sent to the PLC team.

The next PLC meeting will be scheduled in December/January following the High Lumi meeting in Frascati. The tentative agenda will be as follows:

-) Current limitations and plans for CRYO system (arc and insertions)
-) BI aspects in the HL insertions
-) IR layout with Crab Cavities

L.Rossi announced that the 30th of November has been identified as a potential date for a 1 day workshop for WP 8 (collider experiment interface) to address the technical interface between the machine + experiments (TAS,…). A summary of this workshop should ideally be presented to the PLC.