14th Meeting of the HL-LHC Parameter and Layout Committee

Participants: G. Appollinari, G.Arduini, V.Baglin, O.Bruning (chair), R.Calaga, R.de Maria, I.Efthymiopoulos, P.Fessia, R.Garcia Tomas, C.Garion, S.Gilardoni, H.Prin, L.Rossi, S.Redaelli, F.Savary, E.Todesco, J.Uythoven, R. Van Weelderen, M.Zerlauth

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/378400/

The minutes of the previous PLC meeting have been distributed, and so far no comments or corrections have been received. Hence the minutes are considered approved.

G.Arduini asked whether the new RF finger design, which has been proposed for the inner triplet, was measured for its contribution to the impedance? C.Garion confirmed that this is the case, but that the design in question was foreseen for the 11T dipole area and seems not the best solution for the inner triplet.

Action: The involved teams (VSC and ABP) should come back to a TC meeting at a later stage with an updated proposal.

Stefano announced that he will make a short comment on the length of the collimator for the in 11T dipole after the presentation of F.Savary.

Review of HL-LHC triplet layout (R.de Maria - slides)

R. de Maria presented results of a new iteration on the triplet lengths, taking into account the new constraints provided by WP2, namely a magnetic length of <=4.2m (magnetic length including thermal contraction) for Q1/Q3 and an allowed excess of the nominal triplet gradient of 130Tm by 1-2%. With these constraints, optics solutions have been found with triplet gradients of 132.6Tm and L* of 23m, respectively 24m. Including the updated interconnection length this results in a detrimental effect on the beta* reach of ~5-10% and ~1-2% in integrated luminosity. L.Rossi stated that all simulations/figures should be done for 2.2E11 bunch population rather than 1.9E11p. Out of the two L*=23m and 24m solutions found, the L*=23m is more favorable for BPM positioning and their distance from the long-range encounters (with most emphasis given on the BPM1, 2 and 3 as the ones installed closest to the experiments). R.de Maria commented that the issue of BPM1 (which in L*=23m will be placed in a sub-optimal position) still remains to be addressed.

E.Todesco commented that he endorses these new figures, as they will provide significant additional margins for the magnet design.

Decision: The new triple magnet length is approved, however an iteration is required within the different WPs to identify the optimal solutions between L*=24m and L*=23m). It was agreed to come back in a future PLC meeting with a final decision on this issue, following an iteration with the BI colleagues.

80 bunch scheme plus comments on BCMS and 8b+4e (S.Gilardoni - slides)

S.Gilardoni recalled the generation of the standard scheme in the PS, using an injection of 6 bunches on h=7, splitting them into 3*2*2=72 bunch trains.

80b trains are generated by using 7 bunches in 7 buckets, and then triple splitting them into 21b each. One bunch needs to be eliminated for reasons of the kicker gap before applying twice a double splitting to achieve 20*2*2=80b.

An 82b scheme was done in the past, but the 2 additional bunches already end up on the kicker rise-time and are hence not cleanly extracted. Also a 76b scheme is possible, thanks to the new transverse damper that allows selective blow off of bunches. Further MDs are already planned which will allow, thanks to the new transverse damper firmware, a precise tagging of the bunch to be blown away.

The plans for 2015 include

- Validate the elimination of a single bunch out of a train when tagging firmware is ready
- Losses localization: Try to concentrate losses in PS well shielded regions like close to the internal beam dumps or to the dummy septum (non-active element used to shield extraction septum during extraction)
- Check for ghost and badly-injected bunches in the SPS
    - Validate the bunch extinction efficiency
    - Check kicker rise times and synchronisation
- Assess impact on e-cloud and longitudinal stability in PS and SPS
- Injection of 1-2 80b trains into LHC
    - Check effect of kicker ripple, e-cloud (function of train length), ghost bunches, damper, BI, losses

In addition, other possible limitations need to be further quantified (protection devices which could see the full beam like TPSG in SPS, TCDIs in TI2/TI8 TLs, TDI in LHC…; SPS RF total power; impedance heating in SPS and LHC;….).

The same gymnastics is not possible for BCMS beams, as already 8 bunches are played on the h9 optics. Hence there is no room for the additional 2 RF buckets. In the case of the 8b+4e scheme an improvement is possible though, yielding the production of batches with 56 instead of 48 bunches. The advantage of this scheme is that no bunch needs to be blown away in the PS (beneficial for integrated doses in the PS), as the required gaps are already present. The 8b+4e scheme with 3x48b was already used for the SPS scrubbing run.

In conclusion, S.Gilardoni summarized the 80b scheme as an interesting option due to a potential gain of 5% in luminosity with the same # of events/crossing. It offers an enhanced scrubbing beam potential and could be a possible mitigation in case the SPS is limited by total intensity. The MD plans to validate the production schemes are well established, but the remaining potential limitations require careful evaluation.

Decision: The PLC endorses the continuation of the MD studies, with the main aim to continue probing the possibility of the 80b scheme as a fallback production scheme and as enhanced scrubbing beam.

Replying to a question of G.Arduini, S.Gilardoni replied that a verification of the emittance of bunches on the train edges is already planned. S.Gilardoni clarified that in the BCMS scheme one cannot add a bunch as the bunch compression is already performed at 2.5GeV.

80 bunch scheme option in the LHC (R.Tomas Garcia - slides)

R.Tomas Garcia presented the potential performance estimates of the 80b scheme in the LHC. The basis for all calculations is the latest turnaround time prediction (183 minutes, following the suggested increase of the SPS ramp time).

The baseline assumption for the abort gap length is 3us (120 buckets). Using an 80b production scheme, one could fill the LHC with up to 2880b, requiring at the same time a reduction of the non-colliding bunches to 3 (instead of the current 12). The 72+ option is not preferred due to a big discrepancy for the number of collisions in LHCb. It was shown that the 80+ scheme yields the most gain for the main experiments (+5.2% in ideal conditions).

No major changes are expected for the long-range beam beam effects wrt to the standard schemes, however the SPS-LHC transfer and protection devices would have to deal with 4x80=320b instead of the nominal 288b. An additional 10% larger head load due to the e-cloud also has to be taken into account.

A pushed 8b+4e scheme would result in a lower number of long range encounters. This would allow for a smaller X-ing angle and smaller beta*, while eventually only loosing 22% in integrated luminosity.

In conclusion, the 80b scheme was found promising in terms of performance and flexibility, with an up to 5.2% increase in luminosity. The scheme is however experimentally not yet demonstrated and the increased protection risks have to be assessed. For a finalization of the production scheme, the minimum number of non-colliding bunches, the abort gap margin and the figure of merit for luminosities in the IPs need to be agreed upon.

Action: G.Arduini and S.Gilardoni should come back to a future PLC meeting with the definition of a consistent parameter set for the 8b4e bunch scheme from an LIU point of view.

J.Uythoven commented that he would verify as well the protection constraints in the TLs and LHC injection for the 80b scheme. He added that the MKI kick length will not be modified now, but this will only be done for/during the corresponding MD.

L.Rossi added that the 80b scheme is also interesting for the pile-up, as one can decrease the pile-up for the same integrated luminosity wrt the nominal scheme.

New baseline for 11T dipole (F.Savary - slides)

F.Savary introduced the current status and new baseline for the 11T dipole development. The 11T dipole magnet is intended for installation in dispersion suppressor regions (exposed to higher losses in the HL-LHC era) to allow for the installation of an additional collimator, capturing off-momentum particles.

The project is now arranged in two main phases: Provide two units in IR2 for installation during LS2 and 4+4+1 during LS3. After these years, a Cost & Schedule review, 4 additional assemblies foreseen for installation in IR1/5 have become an HL-LHC option.

L.Rossi asked whether the units foreseen for IR1/5 might be required for a peak luminosity of 7.5E34 (knowing that the 11T magnets cannot be built as easily). S.Redaelli replied that based on todays experience it is not very likely that we need them in IR1/5. Still, experience with beams close to 7 TeV is required before being able to give a definitive answer. He asked whether this decision could be altered based on experience that would soon be gained during Run2 and in case of eventual problems. L.Rossi confirmed that this is the case.

F.Savary briefly introduced the current design ideas, pointing out the issue of sector values. As they require a lot of space they had to be shifted longitudinally due to the required shielding and their design. Iterations took place with the VSC colleagues, which allowed improving the integration while maintaining the original collimator length of 650mm.

S.Redaelli confirms that a uniform solution of down to 60cm of collimator length was agreed for both ions and protons operation in the 51st ColUSM (https://indico.cern.ch/event/366694/). The design was iterated to tolerate a collimator length of 60 to 65cm. As the decision had to be taken urgently the collimation team originally agreed to a jaw length of 60cm, however this can easily be extended if an integration solution can be found for a jaw length of 65cm.

Action: As soon as the engineering solution is mature. MSC will provide the feedback on the definitive length to the collimation team.

The latest news on magnet side is that the assembly and collaring of the magnet model MBHSP102 is ongoing, while testing will start in April/May 2015. All necessary tooling will be ready soon.

E.Todesco enquired whether first plots of the training behavior of the magnet model already exist. F.Savary replied that the tests should be finished by now but that the final data (analysis) is not yet available. Clearly, 36 quenches below nominal current would be worrying for the new magnet model.

Action: MSC to come back with feedback after June on the test of the single aperture model.

TAXN baseline and open issues (E.Efthymiopoulos – slides)

E.Efthymiopoulos reported the outcome of recent discussion wrt to the TAXN design and layout in IR1 and IR5. As a reminder: the standard TAXN cannot – due to the

required apertures - provide sufficient protection for D2 for all considered beam optics. Hence a variable TAXN aperture was investigated. Instead of a complicated 'variable' design, a standard (fixed apertures) TAXN and a new TCLX collimator have been also considered.

The TCLX collimator is hereby a new design (derivative of an existing collimator), replacing the current mask in front of D2 (gain of ~500mm). The potential issue with its transverse dimensions need to be clarified.

To further reduce the layout constraints in the TAXN-D2 region, the option of a shorter TAXN with a W-core is proposed. This would be a more challenging design but judged still possible. The use of a BRAN or other detector (if required) should be reduced to the minimum length to avoid additional leakage.

As next steps, the configuration of the TAXN/TCLX configuration (physics) will take place today or tomorrow. A verification of the transverse space for the TCLX collimator (collimation vs. vacuum) needs to be performed, including the finalization of integration and the update of the technical specifications.

A change form copper to Tungsten would allow shortening the effective length of 1.5m. BI proposed a BRAN as an option, but this would need to be expressed through an official request if deemed necessary. The baseline for HL-LHC does not foresee the installation of a BRAN.

Decision: The PLC endorses the use of tungsten for the TCLX.

For point 8, a mini-TAN with 60cm of Tungsten would be sufficient. Nevertheless, a mask in front of D2 would still be required (as one still expects 1.2-1.5kW of deposited power that requires to be evacuated). The mask would hereby cover the coil region from 80-100mm.

Further work on this issue will be followed up in WP8 and in related integration meetings, discussions can be found here: https://indico.cern.ch/event/375475/

AOB

O.Bruning stated that currently no consistent reference for the integrated luminosity is being used. L_{int} will be added to the HL-LHC glossary as baseline denomination.

The ultimate luminosity is to be understood as potentially steady-state luminosity of 7.5E34 in case experiments can accept this. G.Arduini clarified that this should be then understood as ultimate leveled luminosity. L.Rossi confirmed that no safety margins must be applied on this ultimate value of 7.5E34 anymore. The margin is only to be applied to the nominal scenario that remains 5E34.

L.Rossi proposed the introduction of the denominator ITR, which is defined as the region including the TAS, inner triplet + the D1 magnet. Alternative proposals are very welcome.

L.Rossi summarized the recent C&S review, thanking everyone for the involvement and exceptional preparation work. The review was well received, yielding good comments overall. The current momentum should now be used to complete planning and proceed with the ordering (especially big quantities are a long-term issue).

The main message is that one now needs to look for the possibilities of cost-savings. Extra cost must be integrated into the CERN budget in 1-2 years (the current HL-LHC budget is 15% over preliminary estimations). The review endorsed the total project. Each WP should now follow-up the recommendations which will be made public in due time.