Minutes of the 106th WP2 Meeting held on 3/10/2017

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General Information (G. Arduini)

Minutes of 105th have not been circulated, yet.

Last TCC covered the proposal of the coating of a standalone magnet (Q5R2) supported by vacuum, cryogenics and beam dynamics to study the expected reduction of the heat load. The TCC supported the request, provided a risk analysis on the intervention for the LHC or no intervention for the HL-LHC. Vacuum then dropped the proposal.

Update on beam-induced heat load (G. Iadarola)

Gianni presented an update on the beam-induced head load. The heat load on the insertion magnets with two apertures have already been documented in a note.

Simulations of the electron cloud build-up have been performed and the expected heat load for the triplet corrector package elements is expected to be similar to that in a drift.

A full table of the triplet area in Point 1/5, updated with bunch length of 9 cm, has been presented. The table assumes coating (excluding the drift) but a table without coating is also present in a document in preparation. Gianluigi commented that the contribution of drifts is large and deserve an analysis of the impact on heat load if these parts are not coated. Serge commented that the cost of coating has to compare also on the running cost of power consumption. Gianni replied that the impact of the drift if not coated is also included in the note and will be clearly spelled out in the presentation to the HL-TCC.

Experience with 8b4e in LHC follows the expectations. A more detailed model has been developed taking into account a refined model of the photon spectrum, photoelectron yield. The model has a set of parameter given in a range (conservative or optimistic) that needs to be fitted with experience.

The effect of photoelectrons is strong in the drift or vertical correctors. A small effect is present in the dipole, which is important given the fraction of the dipoles in the machine. On the quadrupoles there is no effect, because the multipacting is very high.

The conservative option is tested with measurements. The low load sectors show a SEY of 1.15, while the high load has 1.4 in average. Some cells have been scrubbed, while other cells show no conditioning.

A scan for the HL-LHC has been performed. SEY of 1.15 gives the limit of operation for HL-LHC implying that the good sectors are compatible with HL-LHC. The high load sectors are not compatible with HL-LHC. A similar exercise with the optimistic scenario, is going to be performed but it is not expected to change largely the picture.

In conclusion the priority is to identify and suppress source of large heat loads in S12, S23, S78, S81 and

preserve the performance in the other arcs since there is no much margin available.

Rogelio asked if 8b4e is a safe scenario. Gianni replied that he cannot conclude before knowing the effect with the large intensity.

Update of cooling capacity and limitations (D. Zamora)

Daniel reported on the local cooling limitations and estimates for Run III and HL-LHC. The sector 23 and 78 will be the weakest even after the HL-LHC new installations.

With HL-LHC the expected increase of heat load can be managed by treating the surface or increase the cooling capacity. For the latter, one could increase the temperature gap on specific points or increase the mass flow (acting on the control valve). The increase of mass flow needs to be compensated by the cryo-plant that could become a limitation.

The valve could open fully, losing control. Change the valve seat can increase by few factors the cooling capacity for the standalone but not much for the arc. Another valve gives additional factors in the standalone, but no longer in the arcs due to the length of the circuits.

Examples of estimates using scaling are given. Gianluigi asked to use the latest impedance and synchrotron radiation estimates provided for the LHC.
Serge mentioned that in certain case static losses are higher compared to what it is expected, excluding beam induced ones. Gianni proposed to use Q6R1 (for instance) as a possible test for coating in the view of HL-LHC (Q6 will not be replaced). **Action: Serge and Gianni to see offline the options.**

In conclusion more analysis are needed for understating the source of heat load (including static), the beam screen capillary is not a limitation, carbon coating restores the cooling capacity. Coating L2/R8 in addition to the triplets in Point 2 and Point 8 is needed given the limited cooling capacity in Sector 23 and 78 in particular. Gianni commented that coating the other side would provide some additional margin.

Gianluigi asked whether one still needs coating for Q4/Q5 in Point 1 and 5 in the hypothesis that those magnets are kept as the nominal LHC.

Stability with e-cloud (A. Romano)

Annalisa presented the analysis of the results of the simulation carried out combining PyECLOUD and PyHEADTAIL. The simulations are computationally very demanding and work has been carried out to optimize the code to reduce the time taken from 46 days to 3 day for 1000 turns. The simulations are performed in the INFN-CNAF cluster.

In the LHC, the onset of instability development in dipoles depends on the electron density seen by the beam and it is not expected in dipoles. However the situation changes significantly when the bunch intensity decreases w.r.t. the nominal parameters. The scenario for the LHC uses a SEY of 1.4. The e-cloud in the quadrupole is expected to drive instability at injection as observed.

Simulations for HL-LHC have been carried out separately for quadrupole and dipoles using the pre-squeeze optics. The EC pinch dynamics in the quadrupoles can be very sensitive to the initial phase space distribution again due to the trapping effects, therefore one needs self-consistent simulations using the build-up simulation

as initial conditions.

Due to the non-monotonic e-cloud density with bunch intensity, also the instability threshold follow a non-monotonic variation showing that at low bunch population the threshold for the onset of the instability is lower consistently with what observed in the LHC (pop-corn instability). For the HL-LHC, the bunch population is large enough not to generate instabilities.

Stabilizing mechanisms have been studied showing mild effect from the octupoles and transverse feedback. The most effective mechanisms come from the chromaticity.

At 7 TeV few unstable cases around LHC-like intensities can be observed only in the vertical plane, developing after 10k simulated turns, but without including stabilization mechanisms. Gianluigi asked to study the end-of-fill scenario with LHC-like bunch intensity and to study the required values of chromaticity to stabilize it. **Action: Gianni.**

A first look at the dipoles hints that no instability is expected. Gianluigi expect that dipoles can be involved in coupled bunch instabilities. Gianni observed that to study coupled bunch instabilities few years of development are needed. Gianluigi agreed and noted that it will be important to start the development of the relevant simulation codes.

Gianluigi asked what the sensitivity to offsets in the quadrupoles is as this should reduce the density of electrons seen by the beam.

Field quality of the 11T dipoles (P. Hermes)

Pascal presented an update on the study of dynamic aperture and beta-beating with field quality of the 11T Dipoles with new field error estimates (5/2/2017). The baseline is a replacement of one dipole in 8L7/8R7. Possible extension includes one dipole in cell 10.

A comparison with between the 3 scenarios (including the one without 11T dipoles) has been carried out at injection and collision, showing similar DA when including the MBH together with the nominal scenarios.

During the ramp the field quality is very different in particular b3. To study this effect, a simulation at injection using the worst case field quality has been carried out comparing the different sources. The biggest effect comes from b3, up to a degradation of 0.6 sigma B1 or 0.9 sigma for B2 but not affecting the minimum DA.

The beta-beating coming from the b2 of MBH is calculated alone and together with the expect effect from the MB. At injection the effect is negligible. At collision the impact is sizeable in particular for the vertical plane. A possible mitigation strategy is to use Q8 to compensate for the beta beating. Gianluigi asked if a dedicate b3 spool could be used to mitigate the b3 component. Massimo replied that the impact on the dynamic aperture is limited and therefore it is not justified.

Gianluigi asked what DA is expected for the LHC since the magnet is to be installed in Run III, Massimo will estimate that. **Action: Massimo.**

Rogelio asked about the current needed in Q8 since it could be sizeable. Massimo replied that it has to be evaluated but he considers that it should be small. **Action: Massimo.**

Reported by Dario, Gianluigi, Riccardo and Rogelio.