Minutes of the 98th WP2 Meeting held on 29/06/2017

Participants: S. Antipov, G. Arduini, D. Berkowitz, S. Claudet, P. Hermes, G. Iadarola, D. Kaltchev, N. Karastathis, R. De Maria, E. Metral, Y. Papaphilippou, D. Pellegrini, A. Perin, G. Skripka, G. Sterbini, A. Tsinganis.

Excused: M. Giovannozzi, R. Tomas.

Summary of heat load after the statements emerged from the vacuum review (G. Iadarola)

The heat load estimates are performed by WP2 and WP9, Gianni reports good communication between the groups which resulted in standardised file formats.

At the moment the cryogenics system is dimensioned by WP9 taking into account only on the estimates of SR and impedance as the data. E-cloud estimates are produced by WP2 for comparison with the available margins.

Different heat loads between the different sectors are pointed out, the origin is not understood. This is a concern when moving to the HL-LHC beam intensity where the loads from SR and impedance will be higher, leaving a smaller budget for the e-cloud.

Recommendations for the coating of the interaction regions with low SEY materials (e.g. aC) were made, in particular it was requested to coat the beams screens in the matching sections L8 and R2 in addition to the triplet and D1 areas in IR2 and 8 for where the same cryoplants are shared by the IR and the arc. It is intended that the new HL-LHC elements (triplet, D1, D2 and correctors

The heat load in the triplet section of IR1 and IR5 is shown, the simulation of the multipoles has been completed and the corrector package is being added in the estimations. Gianni expresses concerns for the e-cloud density in some multipoles, which looks high near the pumping holes of the octagonal beam screen, **further checks will be performed. Action: Giovanni to complete the verifications and contact Vincent in case of issues.**

An SEY of 1.1 for the coated regions is assumed as upper limit, to be reviewed after the input from Vincent providing the SEY profile as agreed in the previous meeting. Discussion is on-going concerning the requirements for a statistical analysis.

Riccardo asks if the total kick received from the e-cloud has been quantified and compared to the triplet imperfections. Gianni replies that this could be look into although it is non-trivial as the e-cloud density evolves very quickly along the bunch profile. Yannis adds that Elena Benedetto and Giuliano Franchetti performed some studies with a frozen model, seeing excitation of resonances.

The latest results for IR1 and IR5 are shown. With respect to the previous ones (see 89th WP2 meeting), the DFX is no longer considered an uncoated drift and the integration algorithm has been updated. This resulted in a new estimate of 373.5 W of total heat load, including the uncoated warm drifts. The value raises to about 400 W per IP side when adding the contribution of resistive wall impedance side, which appears to be in the shadow.

It is stressed that the uncoated drifts are the main contributors to the heat load, giving about 250 W. Gianluigi express the need to balance the difficulties between coating and heat load on cryogenics.

Gianni shows that there are still uncertainties on the design of the interconnections, in simulation they are assumed to be 1m long uncoated drifts, although they may be shorter.

Gianluigi asks if the BPMs could be coated, Gianni replies that this was not done in the SPS but there should be no difficulties in doing that.

Antonio points out that the high heating in the warm parts looks bearable with proper dimensioning; but he is worried about very localised heating, leading to high temperature and potentially causing out-gassing.

Gianluigi noted that we should add the heat load due to image currents on the BPMs.

Gianni asks if the heat load from the debris is considered in the cooling requirements, Daniel replies in the positive.

In IR2 and IR8 there is more margin: the total heat load is ~80 W per IP side, assuming a screen temperature of 20K which is confirmed both by vacuum and cryogenics teams. However, since the cryoplant is shared with the arc, it was recommended to coat all the screens up to the matching sections.

Gianni presents the progress for the estimates of the heat load in the arcs. Preliminary plots show show that:

- the multipoles behave very similarly to quadrupoles,
- there is a relevant contribution from the drifts,
- the heat load grows rapidly for SEY above 1.3, especially in the dipoles.

The total sum looks compatible with the heat load in the “good” arc cells although the results are to be confirmed. Gianni points out the presence of other materials such as Rhodium and copper-berilium, he also reports uncertainties with respect to the modelling of the ends of the beam screen.

The heat load scaling vs SEY in the TAXS has been simulated. Gianluigi asks if the heat load due to luminosity debris in the TAXS is dominant with respect to the beam induced heating, it is confirmed that the former is ~600W while the latter is ~20W. NEG coating is excluded due to the fact that backing-out is not possible, a-C is being considered.

Serge points out that in the slides only the beam induced heat load is considered, the quoted margin has also to include other losses such as the static ones, indeed today we are already running very close to the limit.

Summary of cooling capacity and limitations for the HL-LHC (D. Berkowitz)

Daniel presents the cryo configuration explaining the foreseen upgrades. The total heat load for the existing cryoplant is estimated starting from raw data which take into account both the calculations for the HL-LHC (SR, impedance) provided by WP2 and extrapolations from the LHC experience. The e-cloud heating is not included.

Gianni points out that the paper on the twin bore magnets in the interaction regions (CERN-ACC-2016-0112) reports the heat loads for all the magnets. He suggests to check if the values presented there are compatible and do not show bottlenecks. Serge agrees on the interest of looking at these local limitations, once the global estimates are completed. Gianluigi stresses that it is important to check if specific magnets have a large impact. **Action: Serge and Daniel**

The factors contributing to the heat load estimates are collected in a table. It is clarified that the resistive heating refers to the magnet coils, while impedance effects are called image current. The scaling factors from LHC to HL-LHC for SR and impedance are shown. The agreement with respect to the WP2 estimations is excellent for the SR, while the discrepancy for the impedance is justified by different assumptions. Mesurements were performed (see WP2-WP9 Joint meeting, 16 September 2016) and were consistent with the WP2 estimates.

Some cryogenics power is lost in the distribution. The given limit always quotes the value available at the beam screen. In 2017 the entire cooling capacity is expected to be used. Serge clarifies that the estimates of the heat load has some margin at 1.8K, but this is not true for the 4.5K circuit. Given the higher intensity for HL-LHC the heat load on the cold mass at 1.9 K due to losses from beam gas interactions will increase (approximately double) and for that reason the margin for HL-LHC will be smaller than that presently available for LHC.

The loads of the diverse temperature circuits are shown, pointing out the current margins and the ones expected for the HL-LHC. The largest increase of load will be on the 4.6-20 K circuit for the beam screen.

Gianluigi comments that, in view of the reducing uncertainties, it will be important to make a statement on whether the heating will fit or not.

Gianluigi asks if a typical fill can fit in the cooling capacity, taking into account the decay of the SR and impedance loads. Serge points out that currently we are transferring some cooling capacity from the 1.8K circuit to the 4.5K, but in the HL-LHC there will be no margin to do this.

Serge adds that measurements pointed out discrepancies between the cooling capacity measured in the tunnel and the one available from the cryoplant, highlighting inefficiencies in the transfer which need to be understood and potentially improved.

Serge reports the results of the measurements performed in the instrumented arc cells. Quadrupoles behave as expected, but dipoles show different behaviours. One may extract the e-cloud contribution and decouple the unknown extra source of heating, although this might be a surface difference which falls back to e-cloud. Gianluigi points out that we do not know how this extra source scales and without knowing the origin, the uncertainty will not change. Serge replies that it would be good anyway to add into the estimates the data for the sectors with lower heat load.

Gianluigi asks about a possible strategy for the annual meeting update. It is proposed to come back to WP2 early October and have a possible contribution to the TCC possibly on the 19th October in view of the annual meeting in which the available power for the e-cloud should be presented. It is also important to understand the origin of higher loads in the bad dipoles.

Priority should be given to the finalisation of the work for the arcs, as the estimations for the IRs are considered detailed enough for the time being.

Reported by Dario, Gianluigi, Riccardo.