37th Meeting of the HL-LHC Technical Coordination Committee – 21/09/2017

Participants: C. Adorisio, A. Apollonio, G. Arduini, V. Baglin, I. Bejar Alonso, F. Bordry, O. Brüning (chair), H. Burkhardt, R. Calaga, F. Cerutti, P. Chiggiato, S. Claudet, P. Cruikshank, D. Delikaris, R. De Maria, B. Delille, B. Di Girolamo, P. Fessia, S. Gilardoni, R. Grada, J-M. Jimenez, R. Jones, T. Lefevre, H. Mainaud Durand, P. Martinez Urios, R. Martins, M. Modena, V. Parma, Y. Papaphilippou, S. Redaelli, M. Taborelli, L. Tavian, R. Tomas Garcia, R. Veness, R. Van Weelderen, M. Zerlauth.

Excused: M. Brugger, L. Rossi.

The slides of all presentations can be found on the website and Indico pages of the TCC.

O. Brüning opened the meeting by reviewing the agenda and the minutes of the 36th HL-LHC TCC. Concerning the estimates of the cooling capacity in IR4 for HL-LHC, O. Brüning asked if the possible installation of the hollow e-lens would have a significant impact. S. Claudet replied that the contribution of the hollow e-lens is estimated to be in the order of 10 W, which is negligible compared to the available capacity of 1 kW in IR4.

As a follow-up of the actions, R. Calaga will present the revised schedule for the cold testing in SM18 and installation of the crab cavities in the SPS on 5th October.

O. Brüning recalled the decision regarding the modification and displacement of the TCLIA in IP2. S. Redaelli mentioned that a final aperture validation for ALICE is still ongoing by R. Bruce, who can report in an upcoming HL-LHC TCC.

ACTION: R. Bruce should report on the impact of the TCLIA displacement on the IR2 aperture.

AOB: Change of the position of the UL galleries, P. Fessia- slides

P. Fessia reminded the TCC about the procedure for proposal of Space Modification Requests (SMR). The SMRs summarize the list and reasons of the proposed changes, describing the impact on cost and planning. P. Fessia recalled the status of the 11 created SMRs, which can be found following this link.

P. Fessia explained the proposal to move the UL cores by 4 m towards the LHC arc. This has implications on civil engineering, cabling and the QXL path. In addition, the UL on the left side is moved by an additional 2 m (i.e. a total of 6m), to achieve full symmetry of the installation of the QXL with respect to the IP. V. Parma confirmed the need for this change and stated that this will cover all present and future needs identified by WP6a. P. Fessia asked the endorsement of the TCC to proceed with the discussions with the civil engineering

consultants. No detailed cost estimates are available at the moment. The SMR will then be modified into ECR and will go through the normal approval procedure.

DECISION: O. Brüning stated that the TCC approves the SMR and agreed with starting the preparation of the ECR.

AOB: ECR for HL collimation activities during YETS 2017/18, S. Redaelli - slides

S. Redaelli reported on the proposed replacement of one crystal primary collimator (TCPC) in IR7 during the upcoming YETS 2017/18. The candidate crystal to be replaced will be confirmed by the ongoing analysis of recent MD measurements and of new measurements planned for MD3. The ECR leaves the option open to change any of the four presently installed primary crystal collimators, but otherwise specifies in detail the impact, which should be minor as only one crystal goniometer assembly needs to be replaced with an equivalent one.

O. Brüning commented that crystal primary collimators are anyway only used for studies for HL, so the change should be transparent for operation. S. Redaelli confirmed this and showed the TCPC drawing. The goniometer where the crystal is mounted is hidden by a replacement chamber during standard operation.

M. Zerlauth asked if there are already defined plans for MDs in 2018, because the deployed interlock logic might need to be modified accordingly (the current implementation allows the movement of the crystals only if the total intensity in the ring is below 3E11p). S. Redaelli explained that it is planned to update the controls to make the setup compatible with higher intensities in 2018. He thinks that the detailed scenario for 2018 should be discussed in the dedicated machine committees (Machine Protection Panel and Collimation Working Group)

S. Redaelli explained that the ultimate goal of crystal collimators is to operate them for ion operation, but that the major part of the MDs is carried out with protons.

DECISION: O. Brüning stated that the TCC approves the ECR, which should now go through the normal approval procedure via the LMC.

Extension of a-C coating beyond the Triplet area, P. Costa Pinto - slides

P. Costa Pinto reminded that aC coating of all triplet magnets is the baseline for HL-LHC. IP1 and IP5 triplets feature new designs and the coating will be deployed in the laboratory. Triplets for IP2 and 8 will require coating in situ. The technology for in-situ coating has been developed by the VSC group and is ready to be applied. P. Costa Pinto presented on behalf of the VSC group the proposal to coat the Q5R2 magnet during the YETS 2017/18, highlighting that this would be the last opportunity to validate this technology and confirm the expected beneficial impact on the heat-load in the LHC environment before LS2. This magnet was identified in collaboration with colleagues from the CRG group as a suitable candidate, as there's confidence that a significant heat load reduction should be observed, disentangling the

different contributors to the heat load and validating the e-cloud suppression by the aC coating.

P. Costa Pinto reminded the TCC about the successful tests carried out in the SPS (coated e-cloud detector installed since 2008 and tests in COLDEX for the assessment of the aC coating performance at low temperature). About 300 m of the SPS are already coated (half in the laboratory and half in situ).

Laboratory tests confirm that the SEY remains below 1.1 along 10 m of coated beam screen. Tests also highlight a reduction of the average SEY with a mild bake-out, which would be possible for triplets but not for standalone magnets. P. Fessia asked what was the temperature reached during the bake-out, as this could have an impact on the Nb3Sn coils. P. Costa Pinto explained this was around 100°C, but further studies are needed to verify the compatibility of the bake-out with the magnet integrity.

In all cases that were tested, the adhesion strength remained above 10 MPa, no peel-off was observed even after 10 thermal cycles done (as a simulation of magnet quenches).

P. Costa Pinto presented the requirements in terms of schedule and resources for coating the Q5R2 magnet. About 11 weeks would be necessary (68 days + 9 days contingency). Concerning involved resources and manpower, both the CRG and VSC groups agreed it could be feasible.

P. Costa Pinto mentioned that even in case of bad SEY (> 1.2), the coating will condition faster than the copper surface, so no issues are expected. In order to cope with the remaining unknown related to the deployment of the coating on a magnet which was already exposed to beam, the VSC group will test this procedure on one of the dipoles removed from the LHC during LS1 (MB1007) in October 2017. No concerns are expected with RF fingers.

O. Brüning asked if the coated surfaces have been tested under proton irradiation, e.g. in HiRadMat. P. Costa Pinto presented the results of a test on SPS-like coating (without an additional titanium layer which is now part of the baseline and should improve adhesion) for different doses, according to the dose estimates provided for HL-LHC (worst case 1 GGy for triplets in IP1 and 5). In the worst case, the adhesion strength after irradiation went down to 5 MPa, no issues are therefore expected for the application in the HL-LHC. M. Taborelli added that the dose was collected from low energy beams, so the resulting energy deposition represents a pessimistic case with respect to the real conditions in the LHC.

F. Bordry asked more details about the presented risk assessment, both in terms of schedule/resources and potential downtime in case of accidents or non-conformities arising during the warm-up and cool-down of the magnet. He stressed that this point needs to be clarified before taking a decision. In addition, the gain of performing such a test before LS2 should be clearly highlighted and compared to the estimated risk.

S. Claudet commented that for CRG the schedule seems feasible, but this should be checked with the YETS coordination team (M. Bernardini). D. Delikaris agreed that mechanical risks for the magnet should be taken into account in the risk assessment.

S. Claudet pointed out that the motivation to select Q5R2 is that a significant heat load is

measured on this magnet, therefore an accurate measure of the heat load reduction is possible with a few Watts of accuracy.

V. Baglin added that tests in the machine will allow measuring the impact of photons (which is not possible in SPS with COLDEX).

G. Arduini added that this would be a good opportunity to assess the performance of aC coating before LIU beams. Limitations to the total intensity injected in the LHC could be discovered in case of problems with aC coating.

J. M. Jimenez commented that on one hand it's true that this tests will allow for additional measurements of the efficiency of aC coating, but on the other hand if limitations are identified, there's no back-up option available for LS2, when in-situ coating is scheduled to be used. In addition, the behaviour of the coating has not been tested so far with two beams, which has implications on the formation of the e-cloud. No spares are available for the concerned magnet, so the risk in case of damage is a stop of 6-9 months. He concluded that if F. Bordry agrees to go on with the coating of the triplets in LS2 even without the test, then the test is not mandatory.

D. Delikaris suggested looking for a magnet to be coated in the matching section of sector 1-2, which will anyway be warmed-up. P. Chiggiato mentioned that a suitable candidate should be identified to have a measurable reduction of the heat load. He added that the test would gain the required confidence to deploy this technology during LS2, as in case the LS2 deadline is missed, the development of a new technology (e.g. LESS) will imply a delay of few years, i.e. up to LS3.

O. Brüning underlined that one should keep in mind the different roles of the LMC and TCC committees. The main purpose of the discussion at the TCC was to discuss the benefits and interest of performing the coating from the HL-LHC point of view. A final decision will have to be taken at the LMC and for that a proper risk assessment and a more detailed discussion of the risk-benefits should be prepared.

O. Brüning concluded that from the HL-LHC project point of view, it would clearly be interesting to have a proof of concept for aC coating in the machine and a demonstration of the e-cloud suppression through heat load measurements in the machine.

Gas curtain monitor installation in the LHC, R. Veness - slides

O. Brüning reminded the TCC about the discussions of having a gas curtain monitor (BGC) installed as a diagnostic system for the hollow e-lens. R. Veness presented the working principle of the monitor, which allows for a 2-D reconstruction of the profile of the concentric electron and proton beams. R. Veness showed a preliminary integration drawing in LSS4 in the LHC, featuring the current laboratory prototype (not meant to be installed in the machine). He then highlighted the potential for the use of the BGC for HL-LHC. This is a minimally invasive instrument, which is independent of local magnetic fields, but requires a given integration time to reconstruct the profile. It is under development in collaboration with the Cockcroft institute, GSI and Wroclow University of Science and Technology. The developed

Experimental system is promising, but it is limited by the achievable intensity of the electron beam.

R. Veness explained the proposal and schedule for the LHC experimental programme. In order to make preliminary measurements of the florescence it is proposed to make an installation (ECR in progress) in the YETS 2017/18, using the infrastructure from the BGI. It is then proposed towards the end of LS2 to install a BGC prototype (phased installation), in order to validate simulation results and gain operational experience.

L. Tavian pointed out that in the integration drawings the gas curtain monitor looks to be very close to a standalone magnet and asked if the risk of gas leaks to the cold bore has been quantified. R. Veness explained that the gas is forced into a 30 μm aperture, so the possible leak should be small. In addition, gate valves are foreseen to decouple the monitor from the rest of the sector. He mentioned that this could be simulated and the risk will be better quantified. P. Chiggiato mentioned that in UHV systems normally one tries to avoid having turbo-molecular pumps, the risk related to this should also be considered. R. Veness commented that other types of pumps could also be adopted if necessary. O. Brüning asked to highlight what is the added value of having this tool in combination with the e-lens. R. Jones explained that this would be an advanced diagnostics tool for optimization of the performance of the e-lens, similarly to what has been done for collimators with the integration of BPMs, which nowadays allow for a much faster alignment. S. Redaelli pointed out that if the monitor works with protons this could also be used to measure the emittance during the ramp. R. Jones mentioned that the problem is the integration time, a bunch-by-bunch measurement is difficult, but an average measurement could be possible.

F. Bordry asked about the possibility to test this monitor in another machine before the LHC (e.g. RHIC where e-lenses are routinely used). R. Jones explained that the problem is the required integration time, the principle does not work on fast cycling machines, ideal conditions are found in the LHC. In addition, the interest is to get data at high energy. Oliver Brüning commented that one might explore the possibility of testing the device also at RHIC.

O. Brüning recommended to closely follow-up the development of this monitor with the vacuum group to make sure it is conform to LHC standards, as this is coming from an external collaboration.

In summary, O. Brüning expressed the HL-LHC project interest and support for testing this new type of gas monitor. Such a test would provide valuable feedback for the finalization of the hollow e-lens designs. However, the installation in the LHC during LS2 needs to be approved by the LMC and he encouraged the BI group to develop in collaboration with the VSC and CRG groups a detailed risk assessment for the presentation at the LMC.

AOB: Update on thermal simulations for the HL-LHC IR stripline BPM, T. Lefevre - slides

T. Lefevre recalled the different contributions to the heat load for the BPM: 1) static heat load for the BPM cables (58 mW), 2) dynamic heat load (50 mW/cable), 3) heat load from collision

debris (2 W on the BPM body, 100 mW on striplines). The BPM requires active cooling, but its contribution to the overall heat load is small compared to other sources.

T. Lefevre reminded the TCC about the new BPM design and gave an update on the studies for the cooling circuitry, which features cooling capillaries, as inspired by the design for the beam screen cooling.

T. Lefevre presented the results from the structural and thermal simulations. The conclusions from the analysis are that the maximum predicted deformation is acceptable (60 µm) and that the highest temperature is reached in the cables, but no issues are expected. It is crucial to achieve a very good contact of electrical feedthroughs with the stripline, so the mechanical design will be further refined for this.

It is under consideration to apply aC coating for the BPM, as there's a considerable difference in the heat load with and without coating. This is under evaluation with colleagues from ABP and VSC. O. Brüning asked if coating of the BPM would have an impact on its performance. T. Lefevre commented that no impact was observed with NEG coating in the past, this has to be evaluated for aC coating. R. Jones added that LESS treatment could also be possible for the stripline.

S. Claudet commented that the optimal solution for the cooling should be studied. He suggested considering the global picture of the interconnect, balancing the gain of the cooling with capillaries and the complexity of the solution. T. Lefevre agreed and added that simulations for this can be done. It could potentially be possible to remove the capillaries if the cooling can be done through thermal contact with the cold bore.

AOB: HL aspects and input for upcoming R2E cost & schedule review, S. Claudet - slides

S. Claudet announced that he will represent the HL-LHC project at the R2E cost and schedule review, which will be held on 12-13th October 2017. He therefore asked to all WP leaders and group leaders to inform him about possible messages to be passed. R. Garcia Alia added that a preparation meeting will be held before the workshop for possible discussions.

AOB

O. Brüning announced the agenda of the next HL-LHC TCC meeting on 5th October. V. Baglin will present the results from the COLDEX tests of LESS. M. Bajko will report on the preparation of SM18 for the string test, with focus on the measures to reproduce the tunnel slope. R. Calaga will give an update on the schedule and preparation for the SPS crab cavity tests.