48th Meeting of the HL-LHC Technical Coordination Committee – 05/04/2018

Participants: C. Adorisio, A. Apollonio, V. Baglin, I. Bejar Alonso, R. Bruce, O. Brüning (chair), J.-P. Burnet, S. Claudet, P. Costa Pinto, E. Coulinge, B. Delille, A. Devred, B. Di Girolamo, M. Giovannozzi, R. Jones, H. Mainaud Durand, P. Martinez Urios, E. Metral, M. Modena, S. Pittet, M. Taborelli, Y. Thurel, E. Todesco, R. Tomas Garcia, S. Yammine, D. Wollmann.

Excused: G. Arduini, Y. Papaphilippou, M. Zerlauth.

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

S. Claudet asked about the outcome of the cost and schedule review and if the closeout summary is available online. O. Brüning explained the slides of the closeout session are available (here, it is recommended to **not disseminate this presentation** as it is a draft version and some modifications are still possible).

O. Brüning recalled the actions from the 47th HL-LHC TCC.

ACTION 1: in the ECR on the modification of the shielded beam screen design a reference to the specifications on alignment errors should be added (WP12).

ACTION 2: WP3 and WP12 should give a presentation in July on the outcomes of the short model tests and the impact on the beam screen of the CLIQ protection system.

ACTION 3: the parameter table in the TCC webpage was updated with the new parameters.

Iteration on length of high order correctors – E. Todesco – slides

E. Todesco reported on the need of reviewing the requirements of correctors' strength for the higher order correctors of the inner triplet, following inputs received from WP2. It was shown that for correctors we are at the limit (87 %) of the nominal force for orders a4 and b5. E. Todesco explained that the only possibility to change the present situation is to increase the corrector strength, as no knobs are available in the current design for improving a4 and b5.

Two options were considered to increase the strength: 1) increasing the current (50 % more current to get 30 % more strength) and 2) increasing the corrector length (30 % more length to get 50 % more strength). Option 2 seems the most promising but requires 320 mm of additional space. Optimization of the cold-mass layout allows recovering 120 mm. In addition, it is under consideration to recover the missing 200 mm by having a shorter skew quadrupole. This would imply being able to correct 35 units instead of 50. WP2 is in the process of

evaluating if this would be acceptable. Today in the LHC we correct 16 units out of the possible 39.

M. Giovannozzi agreed that the requirements for the skew quadrupole should be reviewed, this topic is going to be discussed in the WP2 meeting to be held on 10th April.

E. Todesco also pointed out that a reduction of the current does not lead to a very sharp decrease of the field. A possibility could be to work with a correction of only 25 units, but having 120 A circuits maintains the possibility of reusing 120 A converters.

O. Brüning asked what would be the implications for this change on integration. E. Todesco explained it would be transparent for integration, as the outer cold mass dimension doesn't change.

O. Brüning concluded that the proposal seems acceptable, provided the approval from WP2.

ACTION: WP2 should report on the implications of having shorter skew quadrupoles for HL-LHC.

Innovative 2-quadrant PC for the IT main circuit, introduction and project overview – S. Pittet - slides

S. Pittet recalled the requirements for an 18 kA 2-quadrant power converter design for the HL-LHC inner triplets. The goal of the design is to perform a ramp-down of the inner triplets in the shadow of the main LHC dipole magnets. Today the R&D for this design is ongoing and the progress of the project is in line with the schedule. S. Pittet outlined the scheme for the inner triplet powering, featuring a main converter plus three trim converters. The selected topology for the converter is based on the combination of a 1-quadrant converter input stage, an intermediate energy storage system and a 2-quadrant converter as the output stage. This solution allows reducing the peak power drawn from the electrical network and increases the immunity to grid perturbations, while simplifying the control of the power flow.

S. Pittet explained the choice for the technology for the energy storage system. LTO (Lithium Titianium Oxide) batteries were selected considering costs, size and expected lifetime.

S. Pittet recalled the ongoing discussions concerning the crowbar voltage, which was proposed to be increased from 10 V to 50 V. This has a strong impact on the converter design and is under evaluation.

M. Modena asked how the lifetime for the batteries is defined. S. Pittet explained that it is defined as the time to suffer a degradation of 20 % from the nominal performance.

O. Brüning asked if the only constraint from the design is to perform a discharge in the shadow of the dipoles. J.-P. Burnet explained that also the interface with the SC link should be considered, i.e. when a crowbar discharge is triggered, quenches of the SC link must be avoided.

O. Brüning asked if the local energy storage in the alcoves has an impact on accessibility of the

area. J.-P. Burnet commented that no impact is foreseen and that safety procedures for the interventions will be developed accordingly.

Innovative 2-quadrant PC for the IT main circuit, technical aspects – E. Coulinge - slides

E. Coulinge illustrated the new concept for the HL-LHC inner triplet powering, featuring the SC link, and compared it to the current LHC solution. He stressed the importance of a modular design, allowing to achieve a high level of redundancy for reaching the nominal current of 18 kA. The selected modulation is 2-quadrant with synchronous rectification. Ongoing activities are focusing on the characterization of the MOSFET that will be in use for the selected option.

O. Brüning asked if the reliability of the MOSFET components is a worry in light of the implied large number of MOSFETS to be used. S. Pittet and Y. Thurel commented that from experience the failure rate of these components is very low. Furthermore a high level of redundancy is present, so no problems are expected. E. Coulinge added that the components will be working well below the rated specifications to limit the failure rate.

ECRs for collimation system – R. Bruce - slides

R. Bruce gave an overview of the ECRs describing the collimation activities in LS2. A draft of the ECRs is available here, soon they will be distributed for approval in EDMS.

Several important upgrades are planned both in the framework of the HL-LHC and consolidation project. Five ECRs are in preparation for the following items:

- Eight new low-impedance secondary collimators in IR7 (HL-LHC project)
- Four new primary collimators in IR7 – (consolidation project, jaw material covered by HL-LHC project)
- New dispersion suppressor collimators around IR2/7, without and with 11T dipoles (HL-LHC project)
- Possibility to adapt/improve crystal collimator assemblies (TCPC) in IR7 (HL-LHC project)
- New passive absorber in IR7 (consolidation project)

O. Brüning reiterates a question that was raised at an earlier TCC and asked for a clarification on the procedure for bake-out the jaws of the 11 T dipoles in case of intervention. Can the bake-out be done in situ and can it be done without warm-up of the magnets?

ACTION: R. Bruce/S. Redaelli should report on the procedure for bake-out the jaws of the 11 T dipoles in case of intervention.

D. Wollmann asked about the replacement of the crystal collimators in LS2, for which a decision will be taken following the 2018 run, and about the plans for operation after LS2. R. Bruce explained that certainly they will not be operated with high-intensity proton beams. But an intensity ramp-up could be evaluated for ions. D. Wollmann added that from the

interlocking point of view discussions are ongoing for having a redundant measurement of the angle, this should be finalized if one wants to operate with them consistently.

Distribution list of ECRs and responsibilities of the TCC members – I. Bejar Alonso - slides

I. Bejar Alonso reminded the TCC about the motivations for releasing an ECR for HL-LHC. An ECR should be issued whenever there's a change with respect to what is described in the HL-LHC TDR. In case an ECR describes a change of the current LHC in view of HL-LHC or if an ECR has an impact on HL-LHC it must be presented at the TCC.

I. Bejar Alonso reminded the TCC members about the procedure for the review of the changes, depending if the change only affects the concerned WP or if it has an impact on other WPs.

O. Brüning highlighted to the TCC members their responsibility for the information transmission to their groups and highlighted that group representatives attending the TCC should report relevant information back to the group for discussion, once ECRs are presented in the TCC and before the ECR approval process is closed.

ECR for in situ aC coating in LS2 – P. Costa Pinto - slides

P. Costa Pinto recalled the motivation for having in the HL-LHC baseline aC coating in the region of the inner triplet magnets. Based on observations obtained during LHC Run 2, it is know that the heat load for HL-LHC will exceed the cooling capabilities of the cryogenic system.

At present, the capabilities of performing aC coating of 10 m of beam screen have been demonstrated. In order to validate the in-situ coating process in the LHC, in the last LHC Performance Workshop in 2018 it was proposed to coat selected standalone magnets (Q5R2, Q6R2, Q5L8, Q6L8) already during LS2. This will allow estimating the reduction of the heat load with LIU beams in Run 3 and validating the in-situ coating procedure while minimizing the risk (which is considerably higher when coating for example the inner triplets due to the non-availability of spares).

P. Costa Pinto described the coating process, based on the deposition of 150 nm of titanium, followed by the deposition of 50 nm of carbon. The beam screen will be fully coated, with the exception of the first 30 cm of the cold/warm transitions, due to geometric reasons.

While no major impact on the existing infrastructure is foreseen in R2, the coating of Q6L8 will require cutting the helium recovery line, this aspect was checked and accepted.

R. Jones asked if coating the BPMs will have an impact on their performance. P. Costa Pinto replied that this was also checked and no impact is expected for the button-type BPMs (while for stripline BPMs the situation is different).

M. Taborelli pointed out that a camera setup is available to check the beam screen status,

using the same support that allows performing the coating. The camera inspection will only be done before the coating to make sure there are no issues, its use after the coating has to be evaluated.

O. Brüning announced the next HL-LHC TCC meeting, which will be held on 19th April.