61st Meeting of the HL-LHC Technical Coordination Committee – 15/11/2018

Participants: C. Adorisio, A. Apollonio, G. Arduini, V. Baglin, M. Bajko, L. Bottura, R. Bruce, O. Brüning (chair), S. Claudet, R. Corsini, D. Delikaris, R. De Maria, A. Devred, P. Fessia, M. Freitas Mendes, S. Gilardoni, N. Grada, J. Hansen, R. Jones, H. Mainaud-Durand, M. Martino, M. Modena, T. Otto, V. Parma, A. Perin, M. Pojer, D. Ramos, G. Riddone, L. Rossi, J. Serrano, L. Tavian, R. Van Weelderen, A. Verweij, S. Yammine.

Excused: M. Giovannozzi, Y. Papaphilippou, M. Zerlauth.

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

No additional comments were provided to the minutes, which were therefore approved.

O. Brüning recalled the action regarding the position of the 11 T magnet and the possibility of a shift to cell 9. A summary of all implications will be presented by the involved WPs in the TCC on 29th November. The decision should then be approved the LMC, so the discussion should be finalized as soon as possible.

Executive summary STRING review – L. Tavian - slides

L. Tavian reminded the TCC about the scope of the HL-LHC IT-STRING day, consisting in a comprehensive review of the baseline configuration and foreseen test programme, material and test resources concerning all involved WPs. The committee was also charged with identifying possible advantages/disadvantages of alternative configurations of the STRING (reduced scope, duration). The HL-LHC budget officer pointed out that savings of 1 MCHF for WP16 would be needed.

L. Tavian reported on the outcome of the review (the full report can be found here), highlighting that the IT-STRING will be performed too late to have an influence on the series production of the main components. The test programme should therefore focus on validating the collective behaviour of the new technologies (Nb3Sn magnets, MgB2 link, CLIQ protection, etc.). The outcome of the review was summarized into 10 recommendations, covering the motivation, configuration, resources, budget and schedule and project organization. Even if not formally included in the review mandate, the panel members agreed that an important milestone in 2022-23 is necessary in front of decisions to be made in 2024 about the long term European strategy at a higher level.

The panel recommended to keep the full magnet circuit configuration, but didn't find a strong added value of including beam screens and BPMs in the STRING, as these items could be

studied in dedicated mock-ups. Concerning the schedule, it was recommended to limit the test duration to the end of 2022. Finally, the panel recommended empowering the support to WP16 and keeping a close connection to the project office and the department heads.

L. Bottura asked to clarify what was meant with recommendation #8, regarding the confirmation that the magnet design is compatible with the proposed quench programme. L. Rossi explained that this comment is related to the high number of quenches (178 mentioned during the review) that should be performed in the STRING. There could be issues with magnet integrity due to this. M. Bajko explained that not all quenches would be at high current, the number should not exceed the numbers typically achieved during HWC in the machine.

D. Delikaris remarked that the costs associated to operation of the STRING, as from recommendation #6, should be covered by the department's operational budgets.

O. Brüning concluded that one of the main outcomes of the review is that the time for the STRING test should be limited to one year of operation.

First feedback on STRING review recommendations – M. Bajko – slides

M. Bajko reported on the first feedback from WP16 on the recommendations from the review panel following the STRING day.

Recommendation #1: M. Bajko commented that this is fully in line with the scope of the IT STRING.

Recommendation #2: M. Bajko reported that the magnet configuration should be fully representative, but this will be verified again with E. Todesco. For the warm powering the configuration will not be final, but this should not be a problem according to WP6b. For cold powering, A. Devred pointed out that the interface boxes will be prototypes, but the SC-link will be the first of the series production.

Recommendation #3: M. Bajko commented that the removal of the beam screen allows saving 680 kCHF (580 kCHF vacuum and 100 kCHF cryogenics).

Recommendation #4: M. Bajko asked what configurations should be studied in more detail and suggested defining a number of cases to focus on. O. Brüning explained that the recommendation aims at discovering the benefit/effort of alternative configurations to the full string baseline (e.g. with a reduced number of magnets), highlighting possible savings and the corresponding scope reduction on the number and type of tests that could be performed. L. Rossi suggested studying the 80 K option, plus a configuration without the D1 magnet and possibly without half of the triplet magnets (i.e. only Q1 and Q2a) A. Devred commented that the reduction in the number of magnets would prevent validating the collective behavior in terms of protection. M. Pojer pointed out that there could be additional costs associated to designing reduced configurations, so these should also be considered. M. Bajko commented that at this stage the full STRING configuration seems to be the optimal also from a cost point of view.

Recommendation #5: M. Bajko suggested that the analysis of the cost reduction for other WPs should be done by the project office. L. Rossi confirmed this should be done by WP16, which will be involved in relevant PSMs.

Recommendation #6: M. Bajko stated that the involvement of BE groups in the STRING is required.

Recommendation #7: M. Bajko reported that the proposal to limit the duration of the STRING to end of 2022 is already in line with the presented schedule, as a period for tests in 2022 was already foreseen.

Recommendation #8: M. Bajko commented that the total cited number of quenches (178) can be reduced, due to the fact that the triplet magnets are in the same circuit and more over when one is quenched the others are also . Between 50 and 80 quenches less can be expected, having a direct impact on the planning. L. Bottura asked what is the acceptance criterion for magnets with respect to the number of quenches they should withstand. S. Claudet recalled that the number should be 50 quenches.

Recommendation #9: M. Bajko and the program steering committee for the IT-STRING should report regularly to the TCC.

Recommendation #10: M. Bajko commented that this should be worked out with the management.

S. Gilardoni asked if monitoring of the interconnections will be possible in the IT-STRING. M. Bajko explained that all joints will be equipped with voltage taps, so a detailed monitoring is possible.

G. Arduini asked if there is already a plan for individual tests for those items that will not be tested in the STRING, e.g. a beam screen vibration test on a long magnet. It has to be checked whether this test is necessary.

ACTION: WP2, WP3 and WP12 should assess whether a beam screen vibration test on a long magnet should be performed outside the STRING.

Remote alignment options and solutions – P. Fessia – slides

P. Fessia provided an update on the responsibilities for cabling requests during LS3, reported by M. Modena in the 60th TCC. A summary of responsibilities and request management by equipment type can be found here.

P. Fessia reported on the status of the MS optimization process, already including some updates with respect to the HL-LHC annual meeting. Slide 5 shows the details of the items potentially involved in the fully remote alignment process (up to the Q6 magnet excluded).

Adopting the fully remote alignment option requires a revision of the vacuum layout, and a summary of the possible changes envisaged by WP12 was presented.

Several possibilities to perform the remote alignment can be considered. The reference case

is the remote alignment during operation (or during a technical stop) for maximum strokes of ±2.5 mm, requiring 30 minutes without accessing the tunnel. A summary of all options, including the dose for the teams involved in the interventions, is shown in slide 7.

The identified maximum stroke is justified by observations of ATLAS (2 mm upwards) and CMS (1.5 mm downwards) movements with respect to the reference of the cavern. These values were translated to the corresponding machine movements. The computed values amount to a movement of 0.3 mm /year and 0.2 mm/year in IP1 and IP5, respectively. In addition a safety margin for remote alignment was assumed in order not to require any human intervention, yielding the 2.5 mm maximum stroke. In case the fully remote alignment would not be used for this operation, the same correction would take several weeks.

P. Fessia mentioned that machine protection aspects of the fully remote alignment option were discussed in the MPP meeting on 9/11/2018. It is clear that such system will need to be interlocked, a key-type interlock should be envisaged in order to operate the motors only under safe beam conditions.

P. Fessia summarized the gain in corrector strength allowed by the use of the fully remote alignment system. In particular, a significant aperture gain is expected for the Q4 and Q5 magnets.

The total cost for the fully remote alignment amounts to 5.343 MCHF and would open the door for further optimizations of the MS.

In particular for the magnet system there's the possibility to re-use the LHC Q5 units with minor modifications. For LHC Q4 units a second jumper should be added to recover the D2 jumper functionality and minimize interventions. For the cryogenic system the present QRL can be modified in order to cryogenically feed the Q4 and Q5 in their new optical positions. The return module between the QRL and QXL can be integrated in a new positon thanks to the suppression of the options for the second batch of crab cavities. The junction module still requires further optimization. The cryogenic plant power should be adapted to the new configuration. The cryogenic capacity for sector 4-5 needs to be re-evaluated if needed. Concerning warm powering, as corrector circuits are suppressed, the corresponding power converters are not necessary any more. For cold powering, the DSL modification can be significantly reduced and keeping the distance between Q4 and Q5 fixed from LHC to HL-LHC would allow to rigidly translate those segments of the system.

Combining the savings coming from the MS optimization process and the additional cost for the fully remote alignment system, a net saving of 5 MCHF can be achieved.

L. Bottura asked if the budget for the change of the DSL was already discussed. P. Fessia mentioned that 1 MCHF is already allocated for this in WP6A. In addition, the possible cost saving of staff could be quantified by GLs.

O. Brüning concluded that the proposal is endorsed by TCC, but it should be checked what implications it has on manpower. S. Gilardoni commented that despite this solution being more complex for collimation, it leads to an overall simplification of the IP and is therefore acceptable. L. Rossi thanked P. Fessia and S. Claudet and all involved people for the work on

the MS optimization.

Upon a question on the baseline for Q4 and Q5, V. Baglin explained that both magnets will be aC-coated, so there should be no additional beam screen heat load. S. Claudet pointed out that Q4 and Q5 will be removed, allowing to coat them on the surface, whereas Q6 should be coated in situ.

AOB: outcome of internal BPM review – R. Jones – slides

R. Jones reported on the outcomes of the internal BPM review for the HL-LHC triplet, held on 17th May 2018. The review involved several aspects of the design, including BPM functionality, integration, engineering and planning. One of the main challenges for this device is integration in a very dense area.

The outcome and recommendations of the reviewers are summarized in slide 7. In particular it was recommended to qualify the full BPM/beam screen assembly and alignment. As since the review took place it was decided not to include the beam screens in the IT STRING, this aspect should be covered in a dedicated mock-up. It was recommended to maintain the octagonal design for Q1 BPM to maintain the same electromagnetic design for all cold, directional BPMs. In addition, the same materials and if possible procurement contracts should be used for the common beam screen and BPM components (e.g. tungsten blocks & cooling tubes). Finally, concerning the planning, it was recommended to split the series production planning to keep enough contingency to react in case of input from prototype test.

Upon a question concerning the possible aC coating of the BPMs, R. Jones and V. Baglin confirmed they will be coated, but it still has to be decided if the stripline will also be included.

R. Jones asked the endorsement of the TCC for the following proposal:

- The overall responsibility for the following shall be given to WP12 (TE-VSC) for all cold BPMs:
  - Design and testing of the welding machines
  - Production of necessary welding procedures
  - Welding of the BPM
- The overall responsibility for the following shall be given to WP3 (TE-MSC):
  - Integration of the welding and cutting machines on the drawings
  - Integration of the BPM cabling in the interconnect
  - Supply of an interconnect mock-up

ACTION: WP3 and WP12 should confirm if the proposed split in responsibilities concerning the BPM is accepted.

AOB: Update on work for cryogenic safety of the cold powering – N. Grada – slides

N. Grada provided an update on the safety analysis carried out to identify potential failure modes leading to a cryogenic incident in the HL-LHC UR. A Failure Mode and Effects Analysis (FMEA) was done to systematically identify all possible sources of failures and the associated mitigation measures. Details on the outcomes of the analysis are available in slides 6-7.

D. Delikaris recommended involving the CRG Safety Officer in the discussions on this subject, also sharing experience from the Helium Spill Committee. S. Claudet asked if the scope of the study will also be extended to existing LHC equipment. T. Otto explained that the study focuses on the UR, which in the HL era should be accessible during operation.

O. Brüning announced the next HL-LHC TCC meeting on 29/11/2018, in which a summary of the discussions on 11 T magnet and TCLD will be provided.