11th Meeting of the HL-LHC Technical Coordination Committee

Participants: M.Alcaide Leon, A.Apollonio, G.Arduini, C.Arregui, M.Bajko, A.Ballarino, S.Bertolasi, L.Bottura, C.Bracco, R.Bruce, J.-P.Burnet, O.Capatina, O.Capatina, S.Chemli, S.Claudet, R.DeMaria, D.Delikaris, B.Delille, J.Gascon, T.Lefevre, H.Mainaud Durand, V.Mertens, Y.Papaphilippou, L.Rossi, F.Rodriguez Mateos, F.Sanchez Galan, L.Tavian, J.-P.Tock, E.Todesco, R.Tomas, D.Wollmann, R.Van Weelderen, A.Vervej, S.Yammine, M.Zerlauth (Chair), I.Zurbano.

Excused: I.Bejar Alonso, F.Bertinelli, O.Brüning, F.Cerutti, M.Giovannozzi, R.Jones, J.Jowett, M.Lamont.

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

M.Zerlauth opened the meeting by reviewing the actions of the previous meeting. One action was related to the need for mitigations of failure cases for protection elements in IR6 after conclusions from the thermos-mechanical analysis. A 2nd action concerned the presentation as an AOB on the need for shielding in the connection cryostat. Finally, the decision on mid-circuit/coil voltage taps for all HL-LHC magnets should be followed up in the HL-LHC magnet circuit forum (with WP3 and WP7) and become part of the circuit documentation (part also of today's TCC meeting).

He proceeded with the introduction of the agenda.

Update on Magnet Circuits' Configuration, F.Rodriguez Mateos – slides

F.Rodriguez Mateos presented an update of the magnet circuit configuration, including the main recommendations from the Magnet Circuits' Review in March 2016, the main aspects of the re-baselining in June 2016, the follow-up to the given recommendations and the Magnet Circuits' Forum.

The review report was provided on the 23rd of March and presented on the TCC of the 31st of March 2016 by A.Yamamoto (see slides). The recommendations were classified per circuit type and status. Most of the actions are for "Mr. Circuit", but there are also actions to be addressed by various WPs. There is a set of recommendations for specific elements and activities (ElQA, HDS) but also general ones applying to all circuits, as for the STRING or issues on planning, schedule and documentation. There is a total of 27 recommendations. After the review, an ECR was prepared compiling all the changes but it is not yet distributed. At the

same time, another ECR is necessary for the re-baselining. It would be desirable that these two ECRs are combined to a single one.

F.Rodriguez Mateos proceeds in outlining the outcome of re-baselining in June 2016 and the impact on the circuits, summarised in an updated table by D.Wollmann with new currents for Q4-Q5-Q6. If a combination of ECRs is finally decided, this table should be approved, as well. L.Rossi asks if the maximum voltage in case of quench is included in this table. F.Rodriguez Mateos answers that in the present table only the current is presented but he will come back on this. G.Arduini points out that it would be interesting to have the circuit voltage present in the table, as it impacts the ramp rate and F.Rodriguez Mateos agrees. A.Ballarino comments that it would be interesting to provide a full circuit layout, with the individual components visible, including the diode and leads. She adds that it is difficult to approve the circuit parameters without viewing the global circuit operation. F.Rodriguez Mateos answers that this is indeed a good point and proposes to have these layouts appearing in the ECR, as, up to now, they only appear on slides. R.de Maria reminds that, in the recent past, it was discussed between the WP2 and J.-P.Burnet the possibility for increasing the ramp down rates of Q4 and Q5, adding diodes to the circuits. This proposal has not been further discussed. He wonders if this should be included in the same scope. J.-P.Burnet adds that this issue is indeed apparent and problematic for the present LHC squeeze. The idea is to connect diodes in series with the power convertors and then apply a negative voltage during the ramp down (when asking for zero voltage), thereby increasing the negative DI/DT. This is cheaper and more efficient that adding cables, although there is some increase on power consumption, as mentioned by L.Rossi. A test set-up is under development to validate the principle. If the test results, expected by end of the year, are positive, this solution could be proposed to improve the squeeze time. M.Zerlauth mentions that this is something to be discussed in the 'Circuits forum'. He adds that the circuit drawing should be at least updated in a conceptual way. E.Todesco points out that for some magnets there are no circuits yet. F.Rodriguez Mateos answers that EN/EL will give a hand for the update and production of any missing drawings. M.Zerlauth adds that indeed a contact person from EN/EL exists. L.Bottura stresses that in some cases, for the corrector circuits, there are magnets connected in series and this should be addressed as well.

F.Rodriguez Mateos continued by providing the follow up given to the Review's recommendations. A lot of work has been done regarding the analysis of CLIQ. Yet, the impact on bus-bars and links has not been finalised, and they will be discussed in one of the near future circuits' forum meetings. There was a reconsideration of the strategies for high voltage withstand levels, based on LHC experience, and an agreement was reached with WP3 and US colleagues. Coming back to L.Rossi's questions of max voltage for quench protection, he mentions that this table contains the worst case for quench voltages and the corresponding failure scenarios. L.Rossi stresses that the scenarios that have impact on HW are indeed very important to be detailed. F.Rodriguez Mateos emphasised that the development of quench detectors is advancing well and that a detailed model for CLIQ failure analysis has been developed and is giving first results, while gaining as much experience with CLIQ as possible (recent commissioning of two units at FNAL). He highlights two presentations on CLIQ and from WP7 on machine protection and availability, with a first agreement reached for QXF magnets.

The Magnet circuit's forum was organised following a recommendation of the review. A mandate was drafted and should be approved by the project leader. The WP representatives have been identified and the first meeting will be organized for July 12th, followed by the second for July 26th.

Discussion

L.Rossi encourages WPs to participate actively in the forum, where the grand majority of circuit work should be discussed. He stresses that this is the point of the project where irreversible decisions may be taken. M.Zerlauth adds that indeed the detailed work should be done in the Forum and then approved in the TCC. R.De Maria asks if the agendas are available. F.Rodriguez Mateos answers that the 1st one is indeed fixed. A list of subjects with priority is being also set-up and will be announced ASAP. L.Bottura questions if the strategy about the hi-pot voltages is the one followed in the LHC (e.g. 5kV for coils, etc). F.Rodriguez Mateos replies positively and adds that what is missing is a specification document. He further points out that the strategy is indeed the same but not the levels. For example, as can be seen in slide 16 of his presentation, the worst case voltage is set by applying a factor of two plus 500 V. Sometimes the safety factor of two is reduced. So indeed, it is basically the same as for the LHC but there is some modulation for every magnet. L.Bottura stresses that this should be indeed documented. There is a general agreement that the ECR should contain also an updated table with voltage values. L.Rossi will discuss with I.Bejar Alonso about when this updated ECR could be presented in the TCC.

Regarding documentation, L.Rossi would like also to pre-announce a recent change of strategy. Initially, every change related to the baseline changes due to the budget restriction was supposed to be documented in an ECR, supported by small documents for every affected WP. It was finally decided that, in view of the next C&S review, instead of a series of small documents, to collect everything in a TDR v0.2, reflecting (and evidencing) all changes. This will be also discussed in detail in the next TCC.

SM18 update and summary of Superconducting Magnet Test Facility Workshop, M.Bajko – slides

M.Bajko reviewed the status of the SM18 upgrade, summarising of what has been achieved so far and focusing on the work left for the test stands at CERN. She also reported on a collaboration activity which started with a 1st workshop uniting different test stands from around the world.

She shows first the SM18 layout, with its central part occupied by the SCM test stand, containing 10 horizontal benches and 3 vertical cryostats. The vertical cryostats zone, called Cluster G of about 400 m^2 is under upgrade with an extra space called Cluster D of 150 m^2 to accommodate the test of larger diameter magnets with higher operating current for HL-LHC. The Cluster G is limited by the current but nevertheless it allows by its dimensions to accommodate and test magnets with priority. The cluster G is under major upgrade, allowing

to test the FRESCA2 magnet. The cryostat is of 150 mm diameter and 2.5 m length. Some pictures are shown with the cryostat in assembly during February-March 2016.

M.Bajko further details the cluster D characteristics, which is the major test stand for HL-LHC, and is associated with an impressive CE work, including the construction of a 10 m deep pit. A remarkable amount of work was undertaken during the last year. A few delays were experienced but nothing major. Services are also upgraded enabling to carry out the full test programme without constraints. Cryogenic cooling production upgrade and powering from the network is currently on-going, with the rest of the activities completed. Some photos are also shown for the new control room and CE work for cluster D.

Regarding the progress, for cluster G, the installation is finished. The commissioning, which was foreseen in May is delayed for July-August and the cluster will be operational in September. For cluster D, the CE works are finished and installation has started. The commissioning is foreseen to take place the earliest in September, and become operational most probably in December.

The present plan of commissioning is very long. All the steps presented were reviewed (essentially regarding cryo and magnets) and tried to identify what could be done faster, leaving out the most “academic part” of the commissioning steps. With this planning, the tests can start only in November. E.Todesco stresses that the first magnet will be available for testing in July.

M.Bajko continuous by presenting an alternative plan2, allowing to test at the end of September, where some steps are left out for later and there is a combination of some tests, namely the current leads and the cryostat assessment. This is indeed the fastest that can be allowed. This leaves 1-week for every step with almost no contingency and brings in the installation of the magnet for tests in September. This indeed does not include availability of people during the summer and M.Bajko got already some feedback for the non-availability of one person and expects also other to come. L.Rossi stresses that it would be a pity if the C&S review is taking place and the stands are not ready for magnet tests. E.Todesco further points out that magnets in US are being tested in July and August and it would be a bit embarrassing not to have by September the tests at CERN, especially if we are not talking about a couple of week delays, but months. He further asks if this is due to resources or prioritisation of work. M.Bajko replies that her feeling is that this is mostly due to the fact that the cryo and magnet group are very busy, certain things are discovered by progressing on them and it is sometimes extremely difficult to evaluate better the progress.

S.Claudet stresses that, although not familiar with all the details, he can assert that non-conformities for any group can be dealt quite fast, but most of the times, interleaved activities from different groups delay the progress. A fixed duration needs to be defined for the work to be finished. This is also similar for the Cluster D cryostat. D.Delikaris points out that the progress for the HFM is indeed in better shape and the work is very close to the final cool-down. The Cluster D work is shifted by two months. Time can be saved when possible but sequential operations cannot be avoided. Once interconnections are finalised, real commissioning can take place. It is very difficult though to recover three months of delay. The idea is to start HFM (Cluster G) commissioning as on plan 2 presented by M.Bajko by the end

of July. L.Rossi stresses that cluster G should receive all the attention right now. M.Zerlauth points that it would be good to see what is not compressible in the schedule and what are the critical interdependencies. M.Bajko reminds that SM18 is also operating at the same time. E.Todesco would like also to remind that the tests will start with a very critical magnet in a new station. It looks like the test stand commissioning is taking place with this magnet. Marta replies that certain critical operations would be verified, such as a dry run of current leads made at 20 kA of full current. This is one week of test in the limit of what A.Ballarino asked and indeed some operations will have to be done for the first time during the first magnet test. L.Tavian also points out that the complete cool down and warm up will be done without the magnet. He questions the risk if this is done with the magnet installed. M.Bajko thinks from her point of view that this may be acceptable but there may be risks. On the other hand, in case we would like to start commissioning with the magnet, M.Bajko pointed out that the test could start only with 3 weeks delay (magnet arrives in July and needs to be installed) and therefore the gain in time with respect to her plan2 would be zero. L.Rossi points out that the only risk is to have one cool down missing. M.Zerlauth suggests that an iteration of key players should be made in order to further optimise the commissioning procedure.

M.Bajko finishes her presentation with the SC magnet test stands' workshop, which extended an already existing collaboration. Its purpose was to have an overview of the number of different magnets tested and different labs to harmonize the tests and built up a good communication channel. It is important to establish the right contacts, ensure what the US labs are testing and maybe even exchange more performant equipment when needed. It was also important to look into the future and rethink about magnet testing in the FCC era. The workshops will be annual and will rotate to the main labs in the future years. There were 65 registered participants, with 1.5 days of presentations of different test stands, where guidelines were given prior to the workshop in order to be able to compare the test capabilities. During the second day, interactive visits in SM18 took place.

L.Rossi would finally like to congratulate M.Bajko and V.Mertens (and all TE colleagues involved) for all the work carried out for the SM18 upgrade, which is a key feature for HL-LHC. V.Mertens iterates that the congratulation should be particularly addressed to all the groups for their hard work and dedication.

Update on cryogenic HL-LHC baseline for IR4 - Decision following feasibility study of cryogenic backup for EXP from LHC, S.Claudet – slides

S.Claudet combined his two presentations regarding the cryogenic baseline in IR4 and the feasibility study on the cryogenics for experiments.

First, he reminds the baseline for the P4 cryogenics, with the new cryo-line to be connected with the existing equipment. L.Rossi points that this is indeed the baseline of cryogenics, although some equipment is not baseline per se. S.Claudet continuous by mentioning the solid

integration study performed. Regarding P4, the original baseline was foreseeing a dedicated refrigerator for RF. The pros and cons have been put forward and an alternative proposal was made to upgrade with a dedicated cryogenics' distribution system. A mobile refrigerator could be used to cool down while doing maintenance work.

It was important to assess the cryo-availability during LHC operation, which points out that 50% of the number of failures is due to cryo, but this corresponds 70% of the time lost. The number of cryo losses are shared in one-third due to cryoplants and two-thirds due to instrumentation in the tunnel. On the other hand, the cryoplant losses correspond to the grand majority of time lost (almost 90%), and this is not a good perspective for HL-LHC, as the number of cryoplants will be further increased to eleven with respect to the present eight. It was indeed important to limit the number of cryoplants to the strict minimum for HL-LHC.

A detailed feasibility study was done to asses by how much the cryoplants could be reduced, while serving the needs of HL-LHC. The evolution for cryo configuration during the different runs was illustrated. Regarding the needs of HL-LHC, the main difference w.r.t. LHC is dominated by the extra load of 2.6 kW @ 4.5 K for RF.

Regarding the heat load capacity in each sector, it was apparent that something had to be done in order that sector 4-5 does not become the weak point. A study was undertaken of what would be the margin and equivalent heat load in order to have a viable situation, where S3-4 and not S4-5 is the weakest one. As compared to LHC, the refrigeration requirements of S4-5 are more or less balanced. In the question of L.Rossi regarding the needs of the 800MHz RF system, S.Claudet replies that it is indeed small and the e-lens is in the noise of the estimation.

He proceeds by explaining that a feasibility study was launched last autumn, and then the manufacturer was further contacted and asked to study a performance diagram for an upgrade of a 18kW@4.5K refrigerator. The request was sent in May, a clarification meeting took place in mid-June, and the results will be presented in September for the feasibility of the upgrade.

Regarding cryo-distribution aspects in P4, the extension of QRL and distribution along the existing and "future" RF zone is currently being studied for the present baseline and alternative scenario. Presently, discussions are taking place with the integration team for the required space. A false ceiling with "LEGO" blocks is present in this area and there is need of lifting this floor by 1 m. The feasibility of this operation is currently being checked. M.Zerlauth asks if there is an impact on shielding. S.Claudet replies that this is being taken into account. In case this alternative is followed, a small unit will used for the warm compressor. A mobile cold box and local transfer line will be necessary to do the cool down.

The present schedule foresees that by end of September the feasibility study would be finalised, followed by a decision on the baseline or the alternative by end of 2016. The specification work should take place during 2017, so that tendering could be initiated by the end of next year. This is indeed the major HI-LHC activity for cryo, although there are also activities related to SPS in BA6 (crab-cavity prototype beam tests) and the one in SM18 mentioned by M.Bajko. L.Rossi asks whether a decision on the RF system options could affect

the cryogenics study. S.Claudet answers that this may help, as the upgrade is very complex, and if the load is reduced by supposedly one-third, it will make the whole concept feasible. L.Rossi feels that the study for the necessity of the 800 MHz option should be finalised and maybe have the decision before the C&S review. Indeed, the 200 MHz option is cost neutral for cryo.

G.Arduini, asks why there is this important asymmetry between S3-4 and S4-5 (as shown in slide 14 of the presentation). Actually S3-4, S5-6 and S6-7 look quite similar. S.Claudet replies that this is because, for this study, the system RF needs are concentrated in S4-5. M.Zerlauth asks if the mobile box is for left and for the right part. S.Claudet explains that this is only for one cryomodule. L.Rossi stresses that this solution is not for operation, but for gaining only flexibility to cool down during a shut-down, while the SPS is not using the mobile box.

S.Claudet proceeds to the second part of his presentation on the possible cryogenic back-up of detectors. He first presents the cryo architecture in P1 and 5. The basic approach is not to add capacity but only marginally if desired. When results are ready, and cost effective alternatives are found, management will be asked for a decision. He further details the work done on P1, namely a cryo-box with transfer line similar to the QRL, but slightly smaller, in case it is in the tunnel. There is no possibility to do this in the surface, as the gallery duct is a very crowded area. Following the double decker solution, a line could be pulled from the cold-box with a duct to ATLAS for 2.1 K cool-down. The design of this gallery was studied and presented in the LIU/HL-LHC executive committee of June 1st. The underground study being the preferred one, was followed by a feasibility and cost estimate (around 6 MCHF). Cost-effective alternatives are also studied. Due to the cost impact, it was decided (in the Executive Committee) not to further consider this option, but study what could be done with 1-2 MCHF for the detector infrastructure. L.Rossi stresses that in the present financial situation, 6 MCHF was too much of an expenditure and need to find a more cost-effective solution.

AOB

G.Arduini mentions that it is too early for WP2 to present the impact of the new baseline in the TCC. He asks for delaying this point in the agendas of September 2016.

The next TCC meeting will take place on the 21st of July.