18th Meeting of the HL-LHC Technical Coordination Committee

Participants: A.Apollonio, G.Arduini, V.Baglin, I.Bejar Alonso, C.Bracco, H.Burkhardt, R.Bruce, K.Brodzinski, O.Brüning (chair), O.Capatina, R.De Maria, B.Delille, B.Di Girolamo, P.Fessia, T.Lefevre, H.Mainaud Durand, E.Metral, T.Otto, Y.Papaphilippou, S.Redaelli, L.Rossi, F.Sanchez Galan, R.Schmidt, L.Tavian, J.Wagner, D.Wollmann, M.Zerlauth, I.Zurbano.

Excused: -

O.Brüning opened the meeting by reviewing today's agenda.

The minutes of the last meeting have been approved with the comments sent to Y.Papaphilippou. The Indico Page contains the final version. There was only one action, regarding the cost estimate for the test stand of the e-lens with a resistive magnet, including its staged upgrade, to be presented at a later stage to the HL-LHC management.

Executive summary and recommendations from the hollow e-review, R.Schmidt – slides

R.Schmidt presented the executive summary and recommendations, as shown exactly at the close-out of the of the e-lens review, which took place at CERN from October 6 to 7, 2016. The panel was composed by Robert Appleby (Manchester University), Wolfram Fischer (BNL), Mike Lamont (CERN), Katsunobu Oide (KEK), Mike Seidel (PSI) and chaired by Rüdiger Schmidt, (CERN), with the HL-LHC project link person being Oliver Brüning (CERN). The scope of the review was to discuss and give recommendation for the need and potential benefits of an active halo depletion system for the HL-LHC. The agenda can be found in the Indico page of the review.

The committee has been requested to answer five main questions: The first one was regarding the existence of sufficient indications that active halo cleaning for HL-LHC is required. The committee answered positively. They elaborated that there is a considerable risk to reach design performance with the proposed baseline related to beam halo population. In fact, scaled to HL-LHC, the energy stored in the beam halo above 3.5 sigma would amount to 35 MJ (assuming overpopulated tails as observed in several MDs). When scaling the observations to the HL-LHC parameters from 2012, this would lead to an unacceptable performance in operation. Scaling from 2016, the situation would however be acceptable. In any case, an active halo depletion will mitigate the risks, in particular for the operation of crab-cavities, which are likely to introduce a new class of very fast failures. The reaction time of today's machine protection system is not sufficient to fully mitigate these failures in case of overpopulated tails that could damage collimators. A hollow e-lens will mitigate such failures up to certain kick amplitudes whereas for larger one's (e.g. in case of correlated failures of

several crab cavities) other mitigation measures need to be found. With (partially) depleted halo it is expected that the machine is also less sensitive to transients due to small variations of orbit, tune and other parameters. With HL-LHC, the LHC will operate in a challenging new regime with very different parameters. Active halo depletion will increase the margins during operation.

Regarding the efficiency of a hollow e-lens with respect to halo cleaning, the committee pointed out that there is substantial experience from Tevatron and RHIC using e-lenses during regular operation. At Tevatron, efficient cleaning was clearly demonstrated as a very elegant method to clean the beam halo. The operation of these devices had acceptable side effects on operation and worked very reliably over many years.

Regarding the adverse effects on the beams when operating a (hollow) e-Lens, the committee stressed that there are several failure modes that need to be mitigated by adequate design and interlocking. Depending on the mode of operation (DC, random and resonant) an e-lens could induce emittance growth of the core. These effects need to be further studied in simulations for the establishment of solid tolerances. There are tests currently taking place with the e-gun at Fermilab and there is interest from BNL to do some equivalent failure tests in an ion run, when the e-lens is not used as a compensator. Another point mentioned by the committee is the signal delay in case of fast beam movement, when the core is already close to the collimator and a depleted halo does not provide a continuously increasing loss signal of sufficient strength to set-off the BLM thresholds (e.g. in situations where the tails are not repopulated). When halo is cleaned with an e-lens, this effect can be mitigated by leaving an adequate number of particles in the tails or by not cleaning the tails for a small subset of the beam.

Regarding the alternative cleaning methods, the committee encouraged the studies to be continued and particularly noted the interesting option of using the ADT with shaped noise.. As most methods rely on detuning with amplitude, their efficiency is still not obvious for the HL-LHC beams with different bunch-by-bunch beam-beam footprints and changes during the operation cycle. The committee finally added that a faster orbit feedback than the present system would mitigate beam losses induced by orbit jitter and studies of such a system should be pursued.

Regarding the alternative applications of the e-lens, the committee noted first that with halo cleaning it might be possible to set the collimators closer to the beam, therefore gaining margin in the aperture which would finally allow to further reduce beta*, but with a rather small gain (2%) in integrated luminosity. Other bonus features include enhanced collimation, scraping functionality, control of impact parameters on collimators for ions and complementary halo measurement (as presented by G.Stancari for the Tevatron).

Regarding the consequences on other systems of having an e-Lens, the committee noted that there will be indeed some space requirement but could not make a concrete comment, without a clear knowledge of the alternative equipment occupation. The committee felt that halo diagnostics is obligatory in any case.

The committee made three main recommendations: First, to implement an active beam halo control using a hollow e-lens to the HL-LHC, based on the above mentioned risks and extrapolation of beam losses from the actual LHC and the risk they present to HL-LHC. The committee also stressed that an e-lens available in Run 3 would allow exploration of halo cleaning in the HL-LHC beam parameter regime. Secondly, the committee recommended to address with high priority the not very well understood failure modes (LLRF, cavity quenches, beam impact…) of the crab cavities and to investigate them experimentally during the SPS tests, including tests with high beam current. Finally, the committee recommended to pursue tests with bunch intensities as planned for HL-LHC during Run 2, to test beam losses, tail formation and beam stability

O.Brüning mentioned that he had been surprised by the very strong recommendation from all the panel, but underlined that he is very pleased of its clear message given to the project. H.Burkhardt mentioned that he is also rather pleased to hear about the recommendation that the studies of fast failure scenarios should be pursued. R.Schmidt agrees by adding that although some failure modes can be quite unrealistic, one should be aware of them. L.Rossi asks about some details on the mentioned good reliability of e-lenses in RHIC and Tevatron. R.Schmidt answered that there were around 5 dumps in 10 years at the Tevatron and no dumps at RHIC that were associated to the e-lens. L.Rossi points-out that one should really study this in detail as the beam is 1000 times less powerful in the Tevatron, as compared to HL-LHC. S.Redaelli underlined that, although he agrees with the principle of more detailed failure studies, the Tevatron e-lens was regularly used for abort gap cleaning, and the failures of the device were indeed very few. R.Schmidt adds that indeed this device has to be designed for high-availability and reliability. S.Weiss would like to have a clarification about space availability for the e-lens. In that area of IR4, there is space allocated for the transverse dumper. O.Brüning points out that right now a large part of the space allocation covers several options that are not yet in the baseline and they all intend to occupy the same space. One should be careful at this stage not to exclude any equipment. There is also the upgrade of the cryogenic system which is related to the e-lens and will be presented by S.Claudet in one of the future TCCs. The water cooling needs have also to be better specified. He adds that from the project point of view it is difficult to estimate the correct moment for taking a decision to go ahead with the e-lens. It would be important first to finalize the technical design in collaboration with LARP and then have a technical review for implications of installing the e-lens and a timeline. L.Rossi mentions that there will indeed be a presentation during the review about the options that can increase the cost as they are associated to performance gain. O.Brüning would like finally to thank the review committee and reiterated that the next steps should be a technical design and then a review including the implications for installation and detailed timeline. G.Apollinari mentioned that this could be done during spring next year. S.Redaelli informed that although there are some open points, the design is well advanced based on the parameters readily achieved at FNAL. There is some more time needed regarding simulations on the impact on the core particle distribution and the non-linear dynamics. P.Fessia stressed that all refurbishment of infrastructure needs to be known before LS2, e.g. the space for the power convertor, cables, etc. S.Redaelli mentioned that he has already informed cryogenics of the potential implications of the installation. P.Fessia added that the height of the bunker may need to be increased as well to have QRL on the top with a flexible

connection and manipulation space will be needed. O.Brüning pointed out that the LS2 interventions should be dealt with during Chamonix. T.Lefevre would like to make an update on the halo monitor. During this year, the team is fighting for a better dynamic range (now limited to 10^{-3}-10^{-4} while the goal is one order of magnitude better). The implementation should follow. O.Brüning stressed that during the review it seems that beam tails are quite non-Gaussian and a dynamic range of 10^{-3} could be already sufficient for observations on the non-Gaussian aspect of the tails and could be very interesting to get experience during beam operation. T.Lefevre stresses that the monitor is still in a prototype stage but of course he would be happy to have it operational the sooner possible.

AOB: Summary of the ECFA workshop, G.Arduini, H.Burkhardt - slides

H.Burkhardt presents a short summary of the ECFA workshop, which took place from 3rd to 6th of October, in Aix-les-Bains. Most of the AT sector participants stayed only for a couple of days for the machine related discussions. He summarises indeed some of impressions and invites the other participants to add comments.

The Monday morning sessions were organised by D.Contardo and K.Einsweiler, who coordinated the HL-LHC upgrade from CMS and ATLAS. There was a talk by F.Gianotti on CERN's scientific strategy, a theory talk and an accelerator overview from F.Bordry. followed by a session with four talks for each experiment upgrade status and plans. During Monday afternoon, there was a joined session from accelerators and experiments chaired by himself and O.Brüning. There was a presentation on beam operation and luminous region scenarios by. G.Arduini, followed by talks on ATLAS and CMS performance. Regarding beam background and failure, there were two talks: one by R.Bruce on accelerator scenarios and one on the impact on ATLAS and CMS. The last session was dedicated to LS2, LS3 and planning. It was indeed very impressive to have details on how big the changes are on the experimental side. L.Rossi adds that he was indeed surprised by the fact that LHCb can barely fit their planning in the two years of LS2. O.Brüning also points out that all experiments rely heavily on general CERN services and this needs to be carefully coordinated with the other LS2 activities in order to avoid conflicts and eventual shortcomings. H.Burkhardt agrees, as it seems indeed that the same resources are needed at the same time.

From his point of view, there was no real novelty, but this shows that the project becomes a reality and everyone is now working on finalizing the details. L.Rossi mentioned that indeed the number of participants was reduced to the ones who do the real technical work. R.Schmidt asked whether there were any news on the experiment's budget for the upgrades. H.Burkhardt replied that there was not really anything mentioned but it seems that it is getting better controlled.

H.Burkhardt adds that it is still very useful to bring together LHC experiments to discuss on a yearly basis. He gives as example a common problem encountered in the electronics of a pixel detector for both CMS and ATLAS and they found a common way to solve it.

He finally proceeds on giving some suggestions and questions, that may not have answers yet. In general, experiments are very much interested in the details of the machine running schemes and options. It is though quite difficult to answer how important is pile-up density for experiments. It seems even that a pile of 200 events is no longer such a hard limit, but it depends on the physics processes. O.Brüning thinks that indeed pile-up density appears much less critical than in the workshop two years ago. There was indeed quite some interest in tests related to risks and damage level. Some pixel tests in HiRadMat for measuring irradiation could be done, maybe combined with collimation tests. B.Di Girolamo mentions that there was indeed a follow-up meeting on this. R.Bruce adds that there was also a meeting with the collimator team. It is clear that there is first some work to be done for establishing the set-up, electronics, do additional simulations for showers and then relate this to expectations. M.Zerlauth mentions that failure scenarios should be made consistent for the machine and experiments side. S.Redaelli adds that indeed in some scenarios the collimator would survive but experiments may be damaged. R.Bruce adds that there can be TCT shower levels that may damage the detectors. M.Zerlauth stresses indeed that there is need of an increase in the understanding of the damage limit of the experiments to allow for a better consistency with the surrounding machine (and protection) equipment. O.Brüning adds that indeed the two highlights of the meeting that he retained are the need for a coherent planning during LS2 from machine and experiments' side and that pile-up density looks less critical for HL-LHC performance optimisation.

AOB: Preparations for C&S review, L.Rossi

L.Rossi mentions that the rehearsals for the C&S review were done and he does not have any major comments. The WP leaders have to check the planning with B.Dellile for having it updated and coherent. There is indeed a confidentiality issue regarding cost estimates and the risk of diffusing this information to companies that could jeopardise the tendering process, so the web-site was changed for allowing only presenters to have access to the slides. He reminds the TCC that this is not a technical review but a cost and schedule one, but of course people should be prepared to receive technical questions and provide clarifications. The C&S graphs of B.Dellile have been sent to the WP leaders and they should not hesitate to ask questions and/or to give comments. From a few WPs final detailed information is still needed. S.Redaelli mentions that in the previous review, there was a recommendation on the lack of available resources. He asks if such comments should be mentioned during the review. L.Rossi replied that of course it should be mentioned and the idea is to find a partner and collaboration that does solve resource issues. This is also a question to the AT sector directorate and department management that there is enough support for the project.

Before closing the meeting L.Rossi would like to share with the committee the sad news about the loss of G.Volpini, an INFN collaborator working since quite some time with CERN magnet teams.

The meeting is closed with a summary of the next agenda.

The next TCC meeting will take place on the 27th of October 2016.