



## 43<sup>rd</sup> Meeting of the HL-LHC Technical Coordination Committee (special meeting in preparation for Chamonix 2018) – 21/12/2017

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**Participants:** V. Baglin, O. Brüning (chair), H. Burkhardt, J-P. Burnet, R. Calaga, O. Capatina, F. Cerutti, P. Chigiato, S. Claudet, R. De Maria, D. Delikaris, B. Delille, A. Devred, S. Fartoukh, S. Gilardoni, M. Giovannozzi, G. Iadarola, S. Izquierdo Bermudez, R. Jones, H. Mainaud Durand, P. Martinez Urios, M. Martino, R. Martins, V. Mertens, E. Metral, M. Modena, C. Noels (1st part), V. Parma, D. Pellegrini, S. Redaelli, F. Rodriguez Mateos, A. Rossi, L. Rossi, F. Sanchez Galan, A. Siemko, L. Tavian, R. Tomas Garcia, A. Tsinganis, R. Van Weelden, M. Zerlauth.

**Excused:** C. Adorisio, G. Arduini, A. Ballarino, I. Bejar Alonso, L. Bottura, C. Bracco, B. Di Girolamo, P. Fessia, B. Goddard, M. Gourber-Pace, J. Jowett, T. Otto, Y. Papaphilippou, E. Todesco.

Oliver starts the meeting by listing the various issues and controversial topics that arose from the Madrid meeting. Some topics are briefly discussed and Oliver indicates that these issues will be resolved in smaller meetings after the Chamonix workshop.

Oliver then asks the participants to give their opinion on the format of the last Collaboration Meeting held in Madrid. The remarks will be collected by Cecile and taken into account for future meetings.

Elias points out that one WP2 session chaired by him was only attended by CERN people. He comments that such presentations and discussions could in fact be organized at CERN and do not necessarily involve external collaborators.

Rhodri emphasizes that holding joint sessions with the participation of external collaborators is extremely useful for discussions and should be continued. Lucio agrees that joint sessions should be given priority, unlike parallel sessions involving only CERN people, which should be reserved for Collaboration Meetings at CERN where participation will be open to all HiLumi collaborators.

Serge comments that the Madrid format was reasonable and allowed for a good combination of plenary and parallel sessions.

Lucio points out that Collaboration Meetings, unlike technical meetings, provide a good framework for presentations with an overall view on the topics.

Vincent highlights the added value of the quality training presentations organized by Isabel and Hector during the Madrid meetings. He regrets that the training sessions sometimes conflicted with parallel sessions involving his WP. Lucio proposes to repeat the training

sessions at future meetings and perhaps dedicate half a day for Quality topics after the Collaboration Meeting to limit the number of parallel sessions.

Since the next meeting will be held at CERN, Helmut suggests informing and inviting the Experiments early enough to organize joint sessions with wider participation on their side.

Rama notes that the format of Madrid was really dense but globally acceptable.

Lucio suggests sending additional remarks to Cecile after the TCC meeting if any.

## **Session 4: HL-LHC developments in Baseline - S. Izquierdo Bermudez (Sc. Secretary) ¶**

This is the first out of the three special TCCs dedicated to the preparation of the Chamonix 2018 sessions which will serve as a technical review of the HL-LHC project by the CERN Machine Advisory Committee (CMAC). The aim of the meeting is to review the content, the main results, issues and conclusions on each specific system.

### **Collimation update, S. Redaelli - [slides](#)**

The charge for the CMAC is to evaluate if the collimators are mature enough and with adequate margin to operate safely with good availability. The talk for Chamonix will be divided in 4 sections: 1) Overview on the baseline 2) Key achievements for LS2 3) Outcome from MDs in 2017 4) Planned studies for 2018.

S. Redaelli gives an overview of the baseline for the collimation upgrade. He shows that the baseline is very solid and stable, and did not change since early 2016. There is optimization on-going on the collimator design for IRs (TAN region), which can be mentioned during the review. It is recommended not to put too much emphasis on this aspect since the optimization affects only the non-cryogenic region where changes have little impact in the system.

The second part of the talk provides details on the key achievements and work on-going for the implementation of the required changes during LS2. S. Redaelli will describe the work on the prototypes, the status in terms of contract preparation and the work in collaboration with other WPs. It is important to emphasise the work on passive protection with new MQW configuration in IR7 and the cryo-bypass in the 11 T.

**ACTION: Iterate with WP3 and WP11 to avoid overlap. F. Savary and E. Todesco will focus on the magnet aspects during the review. S. Redaelli will cover the passive protection in IR7 and the cryo-bypass in the 11 T.**

The third part of the talk focuses on the results from MDs in 2017, which validate the key design choices for HL-LHC. The contents will be similar to those presented during the collaboration meeting in Madrid. It is important to stress that the crystal collimation can recover part of the margin that was lost for ion runs after the reduction of the number of DS collimators from two to one. It should be outlined that the crystal cannot replace the collimator (and the 11 T), as designed, since the crystal system is not suitable for proton runs. The fourth part of the talk focuses on the studies planned for 2018. It is critical to refine the understanding of proton quench limits. The quench margin on the 11 T dipole and MBs has to be clarified before the TCC preparatory meeting on the 25<sup>th</sup> of January. Measurements are being done by R. Van Weelderen in a MQXF coil segment to have a better insight of the heat removal capabilities. First results expected beginning of 2018 (after Chamonix).

**ACTION:** Present a consistent set of numbers with the quench margins in the 11 T and neighbouring MB dipoles. Prepare a summary slide to be discussed the 25<sup>th</sup> of January.

The recent results for assessing the new materials (without and with coating) will also be described, covering both the one at HiRadMat and BNL, as well as the results with circulating beams in the LHC. New tests planned, in particular the coating robustness tests with high radiation doses that can only be performed at BNL, will also be presented.

## **Achromatic Telescopic Squeezing (ATS) scheme: principle, by-products and experience with beams, S. Fartoukh - [slides](#)**

The charge for the CMAC is to evaluate if the novel ATS optics is mature enough to be considered as definitive baseline with minimal risk also in terms of availability and operation flexibility. The talk for Chamonix will be divided in 4 sections: 1) Recap on the principle 2) MDs with flat and round optics 3) Results of the operation with ATS optics 4) ATS driven limitations for future LHC operation

S. Fartoukh will start with a description of the principle, stressing that it is the most cost-effective, if not the only way, to reach the targeted HL-LHC  $\beta^*$  of 10-15 cm. It shall be stressed that ATS induces  $\beta$ -beating bumps in 4 out of the 8 sectors in the machine to boost the sextupole and octupole efficient, so it has a big impact in machine operation.

The second part of the talk will be focused on the MDs with round and flat optics. In 2011-2012 (Run1), the basis were demonstrated down to 10 cm  $\beta^*$  in non-operation machine conditions with low intensity beams and not always with state of the art optics correction. In 2016-2017 (Run 2), ATS optics have been optimized for machine protection aspects. Flat optics developments have started.

The third part of the talk will address the results of operation with ATS optics in 2017. Emphasis on the fact that ATS works not only in paper, but it is very reliable in machine operation conditions.

The last section of the talk outlines the ATS driven limitations for future LHC operation, at lower beta\* in round or flat optics mode, higher beam current (LIU beam), and/or 7TeV beam energy. First of all, due to the telescopic squeeze and induced change of the optics in the dump insertion IR6, in particular the horizontal beta function at the TCDQ, and due to a (not that small) minimum gap imposed on the TCDQ at higher beam current, some functionality of the beam extraction system (LBDS) and/or attached interlock (Beam Energy Tracking System) shall be revisited as soon as possible (LS2). The motivation is two-folds, to fully qualify the HL-LHC choices, but also to exploit the LHC performance potential offered by the LIU beam already in Run III. It has also to be noted that the LHC is more challenging than HL-LHC concerning the LBDS optics requirement, due to the horizontal (vertical) crossing angle imposed in IR5 (IR1), and resulting phase advance constraint between the extraction kicker (MKD) and the TCTs in IR5 which is extremely difficult to achieve in practice w/o compromising on other aspect.

Then for a beam energy of 7 TeV, some magnet strength limitations show up in the nominal LHC configuration, especially for flat optics operation. A few RSD circuits have to operate at (slightly) more than 600 A (which already corresponds to the ultimate current of the sextupoles). Then Q5.L6, in particular Q5.L6b1 should be pushed beyond its nominal current of 3610A, up to 3900A in the worst case of pushy HL-LHC flat optics. This current value however correspond to the ultimate field of the MQY, as it would be the case for many

matching quadrupoles for the far future operation of the (HL-)LHC at ultimate energy. In this respect, before taking any decision on the strategy to adopt in order to push the Q5.L6 integrated strength (1.9K which is the present baseline for Q5.L6/R6, or a consolidation with a warm quadrupole which would be installed on the nip side of Q5), the magnet limits should be tested as soon as possible.

**ACTION:** Re-discuss magnet limits and needs to test in presence of L. Bottura the 25th of January and clarify the difference between the magnet limitations for the nominal LHC configuration and the HL-LHC configuration.

## **Session 5: HL-LHC open issues and options - D. Pellegrini (Sc. Secretary)**

### **Summary of the HL-LHC baseline and operational scenario,**

#### **L. Rossi**

Lucio will present the baseline stressing the novelties introduced with respect to the TDR v0.1. Various requests have been sent to the WP Leaders for this. The aim is to show that the baseline is now more solid and the design performances are within reach. It will also be a good occasion to verify that each proposed change has a corresponding ECR.

Francesco asks if the Q5 is now 56 or 70 mm. Lucio replies that it is still 70mm in the baseline, this is not in contrast with the scope of the analysis that is under way (if less aperture would suffice).

The talk should also cover the performance of the crab cavities both for the measurements in the US and here.

### **Optics correction strategy, cycle optimization and implications for power converter and magnetic measurements performance, R. Tomas – slides ([optics](#); [parameters](#))**

#### Parameter tables:

Oliver asks for the reason to show this table. He suggests to mention the note prepared by WP2 and to stress that it will be accompanied by an ECR. Oliver suggests to leave the table in the Indico for WP leaders, and to highlight all the recent changes. Oliver recommends to all the people that are going to quote parameters to check them in the table.

#### Optics challenges:

Rogelio summarizes the various challenges including beta star levelling and optics corrections, both linear and non-linear. Lucio asks about the b6 correction in the triplet. Rogelio replies that for the time being it is not in use. Lucio suggests rephrasing this aspect in a way that points out that it is a work in progress, e.g. “we are thinking about how to use it”.

The peak beta beat increases in HL w.r.t. LHC, going up to about 20 %. The beta beat in the arcs is not well controlled for large telescopic optics. The tune oscillations are shown; it is not known how badly they will be in HL.

The target for the luminosity imbalance is 5%. The replacement of the power converters of the arc main dipoles (upgrading the class of stability) could allow to reduce the luminosity imbalance from the expected 15% to 10% by reducing the fast tune ripple and improving the optics correctability. Lucio points out that this intervention will be expensive for 4 arcs! Michele says quote of 0.5 M was produced; it is rather limited as we only need to replace the control electronics. Lucio anticipates that the question about the source of the money will come. Lucio asks why this point is coming out only now. Rogelio replies that nobody ever checked the impact of the dipoles on the tune ripple before.

Stephane points out that the connection between the 100 s tune oscillations and the power supplies is not known. Rogelio clarifies that these are separated results; the quoted ripple is at higher frequency and comes from different studies by Davide. The discussion between Rogelio and Stephane will continue offline.

Oliver proposes to take as an input that studies have been conducted and that the source is to be identified.

The non-linear errors are a killer for the DA in HL. Lucio: will you ever be able to correct at the required level? Rogelio replies that it is challenging but possible.

Lucio asks if the magnetic tolerances are the same as discussed by the magnet group. Rogelio replies that they are. Stephane points out that maybe one needs to step back a bit in beta\* to be able to perform the first correction, in the case of a very limiting DA.

Lucio: what is the reason to have the AC dipole slide? Isn't it too detailed? Rogelio replies that it is important for the measurements of the optics and that the hardware should be reviewed.

Lucio suggests that this could go in the list of options; maybe it is better to discuss it first in the TCC.

Concerning the turn-around time, the triplets in IR2 and IR8 will be the next bottleneck. An upgrade of their power supplies could reduce the length of the cycle by 15 minutes.

Oliver comments that one might conclude that the strategy exposed in these slides is not very far from the baseline, while one would like to highlight the improvements. Oliver suggests making a clear table of what we would like to get and what we have in the baseline, clarifying the performance reach for each option with the associated cost.

#### Actions:

- Close the loop with the magnet people making sure that the base is common.
- Better clarify the point of the power supplies upgrade.
- Summarize the various requests highlighting their performance/cost ratio.

## Outcome of the recent review on the e-lens, O. Brüning

In the second e-lens review in October, the following points were raised:

- Readiness for evaluating the budget,
- Need to clarify the manpower availability, for which a proposal is going to circulate before Christmas,

- Understand what can be outsourced; a table for scheduled production will be prepared for this comparing the benefits of external contributions.

A technical overview of costs and schedule will also be presented.

Rhodri asks if the budget point will be mentioned. Oliver replies that he will, as it was already collected by Stefano.

Benoit points out that if the budget will be coupled to the design, then the various groups will be required to approve it. Lucio comments that normally there are no talks on budget, but this is a special case, the aim is to show the readiness, probably it is not to be discussed in detail (the givens figures must be global for each big part, in the form of budgetary envelope, since the site is not protected, lie it is in the C&SR).

Rhodri points out that human resources are difficult point and it will delay the preparation of the schedule; he adds that this could come in the two following months in order to achieve better solidity. Oliver explains that he would like to give an idea. Lucio confirms that we should give to the committee the ballpark figures.

Oliver would also like to give to CMAC a chance to provide questions, so he thinks that an overview should be given. Lucio adds that it is good to point out that the cost is under control, 10M is a good deal!

Oliver suggests that indeed group leaders are not ready to commit for human resources, Rhodri agrees. Lucio points out that the group leaders might reshuffle their priorities when plans are made.

Oliver thanks the teams involved.

## Session 6: Infrastructure, Test facilities and plans for HL-LHC prior/for LS2 - M. Modena (Sc. Secretary)

### Update on the HL-LHC CE plans, L. Tavian - [slides](#)

- Inventory of Civil Engineering works
- Work schedule
- Worksite organization
- Impact on ground surroundings:  
***Laurent will stress mitigations actions on dust confinement, logistics (with independent entrance to CE worksites with respect to ATLAS and CMS standard site entrances), etc.***
- Impact on underground surroundings:  
***Laurent will stress the potential impact due to vibration due to excavation and transports that can especially impact the end of Run3.***  
***Lucio suggests to eventually think of a system of monitoring and information on-line with Experiments to make them aware of critical periods/hours***
- Connection with LHC Tunnel (UPR openings as safety exit to LHC):  
***This will be one of the critical aspects; tight coordination needed: risk for dust, impact on tunnel activities (transport) due to SAS presence.***  
***Lucio: be aware of the "rumours" about a possible proposal of shift and/or extension in LS2 plan.***

***Lucio: possibly mention the deal done at Point 5 (and extra costs) to compensate the loss of CMS storage areas (dismounting of barracks...).***

## **SPS Crab Cavity Tests, R. Calaga - [slides](#)**

- ***Status of project: (after discussion: Rama will stress the advancement compared to Chamonix 2017 presentation).***
- ***Planning: (after discussion: Rama will stress that today schedule is feasible but with zero contingency. Lucio: about to possibly mention the “extra 3 days” (that will probably become a week since SPS is also interested). Anyway Oliver stresses that for Chamonix date we will know much better the status about this point. Serge suggests to present the revised plan for cryogenic part now updated by G. Vandoni.***
- ***Performance: Serge suggests to underline the excellent thermal results (18 W@2K).***
- ***Test sequence in SPS: Lucio suggests not to enter in details since not changed with respect to the (approved) plan presented at Chamonix1.***
- ***Phase and Amplitude NOISE: Lucio stresses to sell these aspects “in the good way”. Rogelio also commented this. Rama proposes to add a slide with a clear comparison between SPS and LHC needs on noise.***
- ***Lucio general comment: Add 2 slides with table showing the difference with the American crab cavities (of Niowave) that made them difficult – or impossible - to be used in SPS and also present limitations in SPS (couplers, feedthroughs,...).***
- ***About DETUNING tests: General agreement (Lucio, Oliver, Markus) that must be in one of the Chamonix presentations probably better in the Session 5 (with Gianluigi). Rama will anyway add a slide with comparison between RF needs in SPS and LHC.***

The next special TCC meeting will take place on the 18<sup>th</sup> of January 2018.