# Minutes of the 112th WP2 Meeting held on 5/12/2017

Participants: G. Arduini, P. Fessia, D. Gamba, R. De Maria, P. Hermes, H. Mainaud Durand, E. Metral, A. Oeftiger, Y. Papaphilippou, D. Pellegrini, K. Skoufaris, M. Sosin, G. Sterbini, R. Tomas, F. Van Der Veken.

## General Information (G. Arduini)

The minutes of the previous meeting have been circulated. Gianluigi summarises the outcomes and the actions of the previous meeting. The minutes are approved without comments.

Gianluigi expresses the intent of having a series of presentations on the results of the HL-LHC oriented MDs.

## Discussion on remote alignment specifications (H. Mainaud Durand)

The possibilities for the alignment system consist in manual and motorized actuators using standard jacks or, alternatively, standardised platforms for loads up to 2 tonnes (200 kg for the small version).

The layout of the jacks is presented. Riccardo asks if the tilt can also be corrected. Helene replies that it is possible. Mateusz adds that the system is 5D, the longitudinal axis being locked. Gianluigi asks if it is possible to intervene manually on the longitudinal, Helene confirms. Rogelio asks the reason for the different layout of Q1 and D1, Helene and Paolo explain that it has to counteract strong pressure forces.

The requirements of the jack system are collected in a table summarising range, resolution and reliability of the jacks. In particular it shall be possible to install the motorization in less than 3 minutes. Riccardo asks if this will allow installing the motorization also in a technical stop. Helene replies that it is not possible due to radiation constraints.

Gianluigi wonders if the high stiffness of the cryostat support is a good strategy. Paolo replies that the design was made on purpose by WP3 trying to push the modes to high frequencies, the design is now in the drawings and purchases are going to be made. Gianluigi is worried that moving the spectrum towards the range of 4-8 Hz might make the feedback less effective. Paolo concludes that the discussion should be taken to WP3. **Action: Gianluigi.**

Gianluigi asks about the radiation level at the motors, Mateusz replies that it will be around 300~400 kGy, compared to the 1 MGy at the magnet.

Riccardo comments that the foreseen step resolution results in an excellent 10 nrad angular resolution for the triplet displacement.

Concerning the standardised platform the plug-in motors can be installed very quickly (30 s) and easily. This solution also allows intervening on the motors being further away from the element, although Paolo clarifies that the radiation levels may still not be compatible with interventions in the technical stops, depending on the available space.

BPM, Vacuum components and collimators are specific cases whose requirements are collected in a slide.

A synoptic plot of IR5 highlights with different colours the elements for which motorization is already foreseen, the ones for which is has been requested and the ones with manual adjustment.

Riccardo points out that having small manual adjustable elements in between motorised adjustment systems can be suboptimal and has an impact on the required aperture. Paolo replies that one could install links so that some elements will move together with the ones aligned remotely. Concerning the bellows with RF bridges the tolerance is up to 5 mm and it is very unlikely that consecutive elements will be moved in opposite directions by so much. Paolo points out that not all the new requests for motorised alignment are actually remotely controllable, e.g. BPMs.

The adjustment systems foreseen for various components are collected in a summary table.

Gianluigi recalls that BPMs and masks are generally very close to the cryostat, he asks if they can be attached to it. Paolo replies that for the case of the masks, their weight of ~1 ton would unbalance the feet.
Gianlugi asks about the interlocking system. Mateusz replies that currently the motors are interlocked. Massimo reports an on-going discussion with OP, the intent is to be able to realign with safe beams, and therefore the interlock should take into account the intensity.

Paolo adds that what presented in the IR5 diagram is the current baseline. He raises three points:
1. All the equipment owners are now ready to accept that their equipment can be moved in cold and in vacuum by a total of +/-2.5 mm. RF also agreed on this, having to provide flexible RF guides for the CCs.
2. Is there anything that has not yet been identified?
3. If this system should reach the scope of avoiding exposing people to high radiation, the remote alignment should be vast enough, ECRs have been prepared and further discussion is foreseen in Chamonix. The rapid plug in system will not be controlled from the control room; the cost for a permanent installation including cabling has not been estimated. Riccardo asks if it will be possible for Chamonix. Helene replies that the difficulty comes from not having yet a clear scenario.

Riccardo mentions that the TAXN-D2 area is heavily constrained by the alignment and corresponding aperture requirements. At the moment the present nominal gaps for TAXN and D2 are 85 mm and 86 mm. Vacuum asked for 91 mm to cope with the alignment tolerances since they do not have remote alignment. The stroke of the TCPH and TCLX is limited to 30 mm (bottleneck for flat optics) due to the vacuum equipment requirements. A global optimization involving remote alignment for all the equipment in TAXN-D2 would allow reducing the vacuum sizes and increase the stroke range. Paolo asked if this point could be discussed in a joint WP2-5-12-15 meeting.

Gianluigi asks if BPMs and vacuum valves could be connected to the cryostat. Paolo replies that the vacuum valves weights around 100 kg and it is not clear if they can be connected. He adds that Pablo Santos put together a table trying to summarise for every interconnection what is needed and, on the base of that, one should be able to draw the specifications.

Paolo points out a possible issue with space in the CC location; a discussion is foreseen in two weeks.

Gianluigi asks if we are monitoring the position of the cold mass. Helene replies that it is done only for the triplet, Paolo identifies also the CC. The sampling rate will be low, around 1 Hz. Gianluigi points out that it would be important to have a higher sampling rate for on the string to measure the response to vibrations, although once in the machine the beam itself becomes the best probe.

## Required corrector strength and residual orbit as function of the capabilities of the alignment system (D. Gamba)

Davide presents possible alternative orbit knobs taking into account the possibility of remote alignment. He starts presenting the optics setup and the considered alignment errors. Rogelio points out that the quadrupole error should be half. **Action: Riccardo and Davide to verify the consistency of the assumption with those provided by the OMC team and update the numbers accordingly**

Riccardo comments that the study relies on the assumption that after a realignment campaign in the YETS the residual error will be within +/-0.5 mm for all the elements for the entire following year. Paolo points out that the ground motion will build up along the year. Riccardo replies that it should be included in the 0.5 mm. Gianluigi points out that the ground motion could be corrected with the remote alignment in the TS. Gianlugi asks if these requirements are realistic, Helene does not reject them, she explains that the adjustment can be very accurate, but the measurements come with large uncertainties, also the fiducialisation plays a role. Mateusz points out that for instance a quench may misalign a magnet in an unpredictable way at some point in the year.

Gianluigi suggests providing the alignment requirements at the beginning of the run together with the expected ground motion per month. **For Chamonix it will be important to point out what are the gains in performance or HW simplification resulting from the full remote alignment capabilities. Action: Riccardo**

Davide presents a summary plot showing which orbit knobs are using the budget in terms of corrector strengths for the baseline configuration. Paolo asks if the budget for the 4 CC offset knob could be recovered in case they are not installed, he asks if Lucio made the case of installing them or not. Gianluigi replies that the baseline is with two crab cavities and we should spell out what are the gains in terms of corrector strength if we abandon the option of adding two crab cavities later.

Davide points out that the IP offset and the crossing angle leaks to the CC area, requiring flexible bellows. Paolo asks if only the entire CC cryomodule can be moved. Mateusz replies that the two CC inside the cryomodule can also be moved independently. Davide clarifies that the crossing angle bump are evaluated with 295 µrad. Riccardo added that this is done for margin in case it would be needed to recover DA or for smaller beta*.
Dario and Yannis confirm that there is no need of crossing angles larger than 250 µrad for 15 cm beta* although investigations at smaller beta* have not been made yet. Gianlugi stresses that it is important to use the baseline settings in order to avoid mismatches in the evaluated strengths. The possibility to operate at ultimate energy should be also guaranteed.

With remote alignment capabilities many additional possibilities open up for the orbit knobs.
The offset knob could be entirely generated by far correctors (from Q5 to Q10) if realigning the entire interaction region. Another possibility is to move the triplet only and using the corrector at D2. Paolo replies that this option is very interesting in view of the ECRs. Rogelio points out that these knobs cannot be used with beam, Riccardo replies that the idea is to setup the alignment during a TS. Paolo asks about the advantages of the two versions, Davide replies that the far away version frees corrector strength in the IR with better margins for the crossing angle knob and aperture (therefore beta* reach).

Davide shows different implementations of the luminosity scan knob and of a knob controlling the beam separation at the CC which uses more correctors but overall less strength.

The crossing angle knob can be improved by removing the residual orbit at the CC, although this solution uses the entire budget of one corrector, triplet displacement allows to relax a bit. This was developed to relax the requirements for flexible bellows in the crab cavities and therefore save on impedance budget.

Davide points out that only two BPMs are presently close to the CC. Paolo and Riccardo recall an extra instrument in the area (the BPTX) normally used by the experiments for timing measurements. It could be used for orbit as well although BI expressed some reserve to avoid additional complexity. Gianluigi asks if the CC themselves could be used to probe the orbit, Riccardo replies that it will be for sure possible with high intensity beams, although they might be not effective with low intensity beams.

Gianluigi suggests presenting the baseline, a scenario with the current alignment system, and a scenario with alignment system with full remote alignment capabilities.

The strategy for quadrupole alignment is presented. Error on the BPMs can have a large impact on the orbit. One should also take into account that the offset of the quadrupoles are correlated between the two beams.

The need of aligning the quadrupoles is discussed. Paolo comments that one could realign the quadrupoles but this has an impact on physics as one need to access the TAXN. Riccardo suggests that about 1% of the total luminosity is lost per day of access. Riccardo points out that the scope of alignment is also to minimise corrector strength. Rogelio asks about the details of the procedure involving k-modulation. Riccardo replies that it would only be used to measure. Rogelio suggests that this might not be required and should be avoided unless the procedure really requires realigning the quadrupoles, he points out measurements with the ballistic optics as an alternative.

Paolo wonders how forward physics will integrate into this landscape. Gianluigi replies that the extra cost of forward physics will be determined in the future. Riccardo points out that the area between Q5 and Q6 is more stable and could be used to host equipment. Paolo would like to make sure that any additional equipment to be installed in the area fulfils the conditions required by remote alignment. Gianluigi agrees.

Gianluigi asks to check if there are differences between nominal and ultimate currents for the correctors point. **Action Riccardo and Davide.**

## AOB: Results of the BBLR MDs after MD4 (G. Sterbini)

Guido presents preliminary results from MD4 concerning the compensation of long range beam-beam interactions by means of longitudinal wires. The idea consisted in testing different configurations, approaching the wires to the beam. The current is optimised in order to compensate mostly the octupolar component. One limitation is the need to close the primary collimators, cutting the tail and therefore reducing the observable. Due to two unexpected dumps, only one position could be tested, however positive results were observed.

The differences between the MD1 and MD4 setups consist in different beta*, revised crossing angle and wire distance, optimised wire current, the use of high octupoles for the strong beam (beam2) and no octupoles for the weak beam (beam1). The impact of the wire on tune and orbit is now feed-forwarded with a local correction, the not-masked interlock on Q4 and Q5 caused a dump at the first wire powering.

The blow-up of the emittance of beam2 was performed with separated beams, to avoid cross talk through the head-on interaction which was observed to create blow-up also in beam1. In the process the octupoles were switched on again to avoid instabilities.

A clear impact on lifetime is observed when cycling the current in the beam-beam long range compensator, this is now visible both when switching the wire on and off. Elias asks if the lifetime could recover also without turning on the wire. Yannis points out that the lifetime naturally fluctuates due to machine drifts, in addition a long wait comes with reduced intensity, less burn off and therefore the lifetime increases naturally with time. He stresses that what one looks for are sharp lifetime transients in coincidence with the powering cycles of the wire. The effective cross section also presents clear transients.

Orbit excitations in the order of 50 um have been observed with the DOROS in coincidence with the wire cycles. The tune data is noisier and is being analysed.

Gianlugi asks if the TCT are closed symmetrically, Guido confirms.

Additional data coming from the coronagraph is being analysed by George.

In conclusion, although only a fraction of the MD program could be performed, the results confirm and improve the ones previously found in MD1. Plans for 2018 are being made. Gianluigi congratulates Guido and the teams involved.

*Reported by Dario, Gianluigi, Riccardo and Rogelio.*