Minutes of the 81st WP2 Meeting held on 24/11/2016


Minutes, Follow-up of Actions, General Information (G. Arduini)

The minutes of 11/10 have been approved.

There was a presentation at the coordination meeting from ATLAS. They are relying on beam based IP alignment (± 2 mm) and they asked to be informed promptly if there is a change to that. CMS has no possibility for realignment at the moment and they would therefore rely on the possibility of moving the IP transverse position. They are going to study the implications of moving the detector.

IP, crab cavity alignment and orbit correctors (R. De Maria)

Riccardo begins introducing the current status: experiments, vacuum, services are all refining their specifications and the tunnel layout flexibility is fading. The motivation for this talk is to converge towards a consistent baseline among all the WPs, in particular to refine the specifications, the operational procedures and the hardware requirements.

Riccardo explains that the possibility to align the beam in the CC was already foreseen in optics V1.1, together with the cavities aligned on the closed orbit of the crossing angle. V1.2 added the possibility to adjust the beam also at the IPs in the range of ±2 mm. Gianluigi adds that this concept follows from the current experience (aperture and strength limitations that we are suffering).

There are strict tolerances on the beam position at IP coming from the experiments (an offset in the inner tracker increase occupancy and peak radiation dose) and at the CCs due to beam loading (±1 mm). The pre-alignment of the cavity can achieve ± 0.5 mm.

In order to realign at the IPs, the experiments need luminosity data: ideally the alignment should be performed during the first technical stops. Paolo Fessia and Gianluigi comment that need further discussion with experiments is needed to define their requirements. The triplet remote alignment should be kept.

Beam loading in the CCs poses a constraint in the offset in the crabbing plane to max ±1mm per cavity, or up to ±2mm for transients of few ms. Gianluigi asks if this is also the case when CCs are off (eg. injection, ramping). Rama replied that in this case the tolerance is higher: ±3 mm.

In the non-crabbing plane the tolerances are up to ±5 mm, but HOMs are not considered. Rama commented that he will check soon, he added that although there is no specification in the non-crabbing plane, he would prefer to have the beam going through the centre also for aperture issue. Gianluigi comments that we need to determine the limits as this has an impact on the corrector
Rama to provide the beam alignment tolerances in the non-crabbing plane. Riccardo concludes that the baseline foresees that beam can be equally centred in the crab cavities in both planes.

As the cryomodule contains 2 cavities the question of how well can they be aligned is still pending confirmation from SPS test. The cryomodule can only be aligned as a whole. For the moment a tolerance of ±0.5 mm has been assumed.

From the survey team, we know that local ground motion is expected in the area between D2 and Q4 of IR1/5. The detectors are stable for the time being but the tunnel is not. The present range for manual alignment of the triplet is ±10 mm (slides reported ±20 mm). Davide asks how much the triplet moves. Helene replies that it has moved by few millimetres over several years. The remote alignment is foreseen up to Q5 for HL-LHC, but not for warm BPM and masks, which, for displacement larger than 1mm, would need to follow to avoid aperture restrictions. Paolo Fessia points out that there are only 3 warm BPM. The TAXN is going to be motorised. There is no really a requirement to displace the TAXS for aperture issues.

The result of a survey around P5 is presented. Francisco comments that the initial alignment can/should be done so that additional margins are kept for long terms drift in the known direction. Davide adds that one would need to compare the current picture with the one of 5 years ago, for a better understanding.

Riccardo presents the maximum misalignment in between alignment campaigns that it is assumed for loss of aperture, he asks survey team to review those numbers. **Action: Survey team to provide feedback.**

The baseline for the orbit correctors is presented, pointing out that this resulted from the requirement from the Project Management to keep open the possibility of installing two additional carb cavities per IP side and beam for crab kissing or for the exchange of crossing planes.

The crossing bumps are shown, they leaks a bit in Q4, so that the CCs need to be displaced (static alignment) according to the average crossing angle foreseen.

The shapes of the CC orbit knobs are shown: one allows to displace both beams in each side of the IR (± 0.5 mm), one allows to increase or decrease the separation of the two beams in each side. The knobs can be combined together and they are independent from left to right. In addition, an expensive knob is provided to change the beam position (±0.25 mm) at two consecutive cryomodules, which is useful only in the scenario of 4 CCs per IP side and beam.

The orbit knob at the IP is shown. For adjustments beyond 0.5 mm, the CCs need to be moved to be centred on the reference beam position. The total shear of the CCs can go up to 4mm. Cedric commented that this is ok for bellows, but needs confirmation for the RF fingers. **Action: Cedric to verify whether this is acceptable.** Paolo Fessia asks about the cryogenic connections as the ones of the magnets are rigid and doesn't allow big movements. Gianluigi remembers that alignment of this range have already been performed in the machine. Ofelia Capatina replied that she does not doubt on the
feasibility, but this takes time and preparation and cannot be done remotely (not requested) as some components may need to be dismounted. Delio adds that the most rigid bellows are the ones on the vacuum vessel. Gianluigi asked how much time the realignment would take. Rama comments that one should just move the inner tracker but Gianluigi points out that the margin for that has already been eaten up in CMS. In addition Atlas would also like to keep the 2 mm margin as they might have the same problem as CMS.

Riccardo shows the summary table for the orbit corrector budget, pointing out that we are now within the specifications, but sometimes the margin is just few %.

The only uncertainty to achieve the 2mm offset at the IP, is the possibility to displace the CC by a total of 5 mm. In the case of only 2 CC the additional margin can be used to enhance the knob.

Riccardo moves on explaining the possible options.

The residual bump in the CC can be mitigated by using stronger correctors. It should be noted that a reduction of the crossing is always feasible without altering the orbit in the CCs. For the two-cavity scenario and round optics it is also possible to design a bump with x=0, px≠0 at the centre of the cryomodule at the cost of some aperture in Q4.

The position of the IP can be shifted by means of triplet movements. Assuming that the line TAXS to D1 could be rigidly realigned, this would our best option as it comes with no loss of aperture, smaller displacement of the CC (± 2 mm instead of ± 4mm) and smaller corrector strengths. The triplet realignment can easily be done in a YETS, but it would be better to have the possibility also within a TS. Francisco adds that we need to better understand the feasibility as for CMS the TAXS had never been realigned. Riccardo points out that 2 mm of triplet movement is equivalent to the full strength of an MCBX but with no loss of aperture. Paolo Fessia proposes to consider a hybrid scenario in which the correctors are used along the year and a "reset" with the triplet is made in the YETSs. Gianluigi concludes that this needs some discussion with the experiments.

Riccardo explains the advantages coming from freezing the crossing planes. In this case each IR is more constrained in one plane and the solution of 4 correctors in Q4 give more margin in one plane. However due to the alternating plane of the orbit corrector for each beam, it is not possible to optimize the orbit budget in each plane to save one corrector in Q4 without introducing a new type of MCBY with contains HH and VV orbit correctors. In alternative one has to restore the symmetry including Q5 in the crossing knobs. Gianluigi noted that we should use the possibility to extend the crossing bumps beyond Q4 and Q5 only as operational margin in case of non-conformities of the MCBY correctors (as we observe in the LHC). We should not use that as a baseline assumption.

Paolo Fessia reminds that on 16 Dec there will be a presentation from Helene where we could discuss, Gianluigi agrees and adds that it is important to determine if the options are feasible or impossible. Riccardo proposes to make an EDMS document, Paolo adds that this could be a task for Helene, after her presentation, he adds that Riccardo could provide a start for the discussion that will be developed in the meeting.
Delio Ramos proposes to look at dynamic tolerances as a next step, as now we can expect the same stability as in dipoles, but if more is needed something needs to be done.

Gianluigi asks for the factors limiting the tolerances at CC. Benoit replies that from the impedance point of view there is no issue. Rama adds that he will check the max offset in the non-crossing plane considering the HOMs.

**TDI Impedance (N. Biancacci)**

Nicolò presents the status of the impedance calculation for the new TDI.

In the 2015 TDI tune shifts in Beam 2 was much larger than Beam 1. This year single bunch measurement were carried out and the tune shifts are within expectation, consistently with simulations. Copper coating is effective in reducing beam induced heating.

The new TDIS (segmented) will have three segments to improve mechanical reliability. There are three options for the jaws, which are 3D carbon, graphite and copper coated graphite.

The segmenting introduces additional HOMs. Longitudinal RF fingers reduce the HOM from 600 MHz to higher frequency. Gianluigi asked for the difference in power loss. Two methods are used for power loss calculation, the worst case gives 2400 W, the simulated case without uncertainty results in 240 W. It is difficult to quantify how realistic or probable the pessimistic methods. Single modes (if overlapping with a spectral line) will generate localized heating but it is highly unlikely that all of them will do that. Gianluigi and others gave a suggestion to improve the power loss estimates assigning probabilities to the estimates.

Copper coating is recommended from the beam induced heating reduction if the cooling cannot be designed to stand this. The tapering of the jaw extremities is beneficial for transverse impedance reduction, but additional HOMs are introduced on the supporting envelope edge which is not cut along the tapering profile. Cutting the envelope along the taper profile would cure these HOMs but introduce additional ones. There is no concern for the 55 mm half opening (parking position).

A follow-up will presented for the TDIS review.

**AOB: Scaling of DA (D. Pellegrini)**

The talk address the points emerged on the 79th WP2 meeting on beam-beam scaling and simulations.

The nominal case ($\beta^*$ levelling) is conservative when aiming at a dynamic aperture of 5 $\sigma$ (and some margin even with 6 $\sigma$). Gianluigi asked if a quantitative analysis can be carried out to decide on the target dynamic aperture. **Action: Yannis and Dario to review the target dynamic aperture for HL-LHC**

A scan on the number of LR encounters in D1 show that they are not relevant for DA calculation as it was mentioned in previous presentations by T. Pieloni.
The dependence of the DA on the momentum offset is linear. Riccardo commented that there is still a large difference between on momentum DA and the off-momentum one, therefore one should distinguish calculation to be related with physical observable and the ones for operational margins.

The impact of LR in IR8 is visible. However the additional HO of IR8 is not visible. Gianluigi asked to perform more tests to understand the underlying physical behaviour. **Action: Yannis and Dario to qualify the impact of IP8 on the performance and define the machine settings for IP8 accordingly also taking into account the possible operation at higher luminosity.**

Dario noted also a degradation with the LSF service that has slowed done the production of the results. Gianni observed the same behaviour for his simulation. Massimo suggested to use LHC@Home.

Gianluigi asked Dario to look at the history and revalidate the standard choice of delta for DA simulations. In particular we should define the criterion based on the operational margin (expected maximum momentum offset – see the recent notes on the aperture estimates published both for injection and collision settings) and on realistic distributions, in that respect Elena Shaposhnikova has provided expected distribution for the longitudinal plane to Rogelio. **Action: Yannis, Massimo and Dario to come back with a proposal.**

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