191\textsuperscript{th} WP2 Meeting
Tuesday 4\textsuperscript{th} May 2021, 15:00 – 16:30


table

\textbf{AGENDA}

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MEETING ACTIONS

\begin{itemize}
\item \textbf{Davide, Roderik} \hspace{1cm} Update \url{EDMS 2387369 v.1} for ions: add margins on the ion intensity, consider the strong intensity imbalance for proton-ion runs, and in general the parameters of proton-ion runs; add numbers for light ions.

\item \textbf{Davide, Rogelio} \hspace{1cm} Check the precision requirement on the pilot bunches, its scaling with intensity, and the fill-to-fill BPM precision requested for IR2 (\url{EDMS 2387369 v.1}, Table 5). Check the intensity imbalance between proton bunches within a beam and between the two beams.

\item \textbf{Davide, Jorg Wenninger} \hspace{1cm} Check the precision requirement on BPMs, for the injection orbit correction with high intensity bunches.
\end{itemize}
Davide, Michal, Roderik, Rogelio
Finalize EDMS 2387369 v.1.

Xavier, Gianni
Check if the option of having 8 bunches in the first train is possible for the injectors, and if all IP8 collisions can be avoided in this case (case of BCMS filling scheme). Update the filling schemes in the WP2 webpage (nominal, 8b4e and BCMS) with schemes avoiding IP8 collisions.

Xavier, Jorg
Check if the tune feedback can be used properly on the witness bunches.

GENERAL INFORMATION (ROGELIO TOMÁS)

Rogelio reviewed the minutes of the 190th WP2 meeting on April 19th, which were circulated (no comments received). During that meeting, Ezio Todesco gave updates on field quality measurements, showing in particular issues on D2. A new update by Ezio will come in June or July. Then Frederik presented the DA acceptance criteria, showing in particular the negligible impact of CP misalignment. Finally Xavier reported on the impact on stability of a residual kick from the e-lens, which is detrimental: the latency time is significantly reduced with a residual kick of 3 nrad.

Rogelio then reviewed the actions: one (for Elias and Rogelio) is to list the kind of measurements to be performed to understand the hollow e-lens (HEL), following a comment by Yannis Papaphilippou that the HEL is an in-kind external contribution and that in-house expertise has still to be built; a discussion was started. Another action (for Philippe Baudrenghien) concerns the emittance growth estimates when taking into account the beam-beam tune spread reduction over the fill (computed by Xavier). The SEY of crab cavities should also be provided by Rama Calaga (see also the heat loads review for HL-LHC on April 27th). A new WP2/WP4 joint meeting will be organized soon. Finally, one action is on Ezio on the update of the magnetic measurements.

A number of meetings occurring in the past two weeks were then reviewed. First, the heat loads review, where Elias was reviewer and Gianni presenter. Gianni mentioned that the aim of the review was for the cryo team (WP9) to assess the expected heat loads, and hence freeze the design of the new cryo plants to be built in points 1 and 5. The review went through all the equipment owners. The two talks on the beam-induced heat loads, by Gianni and by the FLUKA team (resp. on impedance/e-cloud in beam screens, and on collision debris), show a very solid work, with a very clear picture. There were no major remarks from the reviewers about the plan during the public meeting - they praised the quality of the collaboration over the years. Rogelio had the same general impression: a very solid, well prepared work.

Davide reported about the IT String Validation Program Meeting on April 27th, in particular regarding the flux jumps and the link between the ground motion and the cold mass. Regarding the flux jumps, Lucio Fiscarelli mentioned future measurements in the lab on spare magnets, to check if there is a cross talk between different circuits. Regarding the transfer function from the ground to the cold mass, the triplet magnets appear to be very close to the LHC dipoles in terms of mechanical construction, and simulation
results look good. There will be measurements only at the string for the moment, and sensors on the ground and in the cold mass to measure the transfer function (for a Q1-like magnet and half a Q2 magnet). For cross talks between magnets, the situation is a bit more complex, and one cannot do it at cold. The plan is rather to look at the autoresponse of the sensor on the ground, and get an idea of the frequency shift between warm and cold (in qualitative only). The frequency sweeping interferometry (FSI) system could maybe check what happens with the beam, but can only measure around 1 Hz, which is not interesting for vibrations. Regarding the possibility of using a wire, it is also not a very interesting option as it is attached to the cryostat, and not to the cold mass. Still, one should get enough information regarding the transfer function. Rogelio mentioned that for the fringe fields, some measurements are being planned with Ezio (see Massimo and Thomas Pugnat). Davide added that if other topics are to be raised about the string, it is the right time to discuss them.

Rogelio also reported about the TCC meeting on April 29th, where Sofia Kostoglou presented about the no-MS10 option - results were fully endorsed by the TCC. Oliver Brüning mentioned that the budget will be transferred to the installation during LS4.

Rogelio finally provided some news on the coronagraph from Thibaut Lefèvre, in particular about the fact that it was not clear if the coronagraph will be able to measure the halo at 5 σ.

The schedule of the meeting then followed as foreseen.

1 WP13 COMMENTS TO THE DRAFT BPM SPECIFICATION (Michal Krupa)

The future successive upgrades of the LHC BPM system are first reviewed. During LS3, the new HL-LHC BPM system will be installed in the inner triplets (Q1-D1) with new BPMs, cables and electronics. During LS4, the electronics of the rest of the LHC BPMs will be replaced (while cables and BPMs themselves will remain the same, hence limiting the performance reach). Regarding the Diode ORbit and OScillation (DOROS) system, decision is still pending whether to install it or not in the new IR1/5 BPM system - the signal splitting needed between the standard Wide Band Time Normaliser (WBTN) and the DOROS, will indeed reduce the new system’s accuracy.

It is also highlighted that, since the vast majority of BPMs will not change until Run 5, the expression “HL-LHC BPM system” can be considered misleading.

The main objective of the presentation is actually to review all the comments to the draft BPM specification (EDMS_2387369_v.1, 10/03/21, version 1.2). The main challenges were highlighted, in particular the large dynamical range requested for the triplets BPMs, while requesting at the same time to be effectively 35 times more precise than the arc BPMs. Given the 45° angle of the electrodes and the large dynamical range, the requested non-linearity over the operational range (250 μm) is also very challenging, and so is the performance requested for Optics Measurement and Correction (OMC) - close to the accuracy of a light source, but with larger vacuum chambers.
On the first comment (slide 6), regarding the ability of the BPM acquisition chain to “digest” high single bunch charges ($4.5 \times 10^{11}$), Rogelio said that we are not asking for a very fine resolution for such bunch charges, but simply that the system works. Davide commented that maybe one should just make sure there is no saturation. Michal said that one should say what “reduced performance” actually means (i.e. which reduction in accuracy). He added that surviving the bunch is not the issue, but providing the data is. Roderik mentioned that in the parameter table one needs to add some margin on the ion bunch intensity, as there were already higher intensities in 2018 (Action on the general update of the document for ions and proton-ion runs: Davide, Roderik).

Regarding the comments on the intensity imbalance (slide 7) and the various special cases, Davide mentioned that for protons in the same beam, at the end of the fill one can typically observe a factor 2 between a non-colliding and a colliding bunch, at the same BPM. The experiments want to be able to measure either one or the other. For the proton-lead runs, Roderik said there is indeed a factor 2 of charge difference between protons and Pb, but Pb depletes much quicker, hence at the end of the fill the imbalance factor can reach up to 10 - this should be written somewhere. Rogelio confirmed it should be included in the report (Action on the general update of the document for ions and proton-ion runs: Davide, Roderik).

Regarding the proton-ion operation (slide 9), Rogelio and Roderik said one should update the document to include this case as well, to have all the info in a single document - to be discussed offline. Michal confirmed that knowing the beam parameters helps them design the system (Action on the general update of the document for ions and proton-ion runs: Davide, Roderik).

Concerning the data logging (slide 10), Rogelio said the underlying request may be that the system should be able to gate - this is a recurrent need. Michal answered the system is designed to measure bunch-by-bunch, and for him the question is the logging. Rogelio replied that choosing to log everything or only the mask, is a detail for now. Andrea compared the situation with the current system: now one performs the average of all the bunches, and then gate. At the same time, the bunch orbit is provided, but with lower statistics. The proposal here would be to provide all this data and let the user decide what to keep. Rogelio answered this would fit their request. Davide said the question is if we can give all this data, and if the consolidated BPMs can do this. Andrea answered that the consolidated BPMs will indeed have troubles to do the same. Michal mentioned it is not impossible, but there is a technical discussion to take place with the storage people (NXCALS is limited, in particular).

Regarding the alignment accuracy (slide 11), Davide mentioned the remote alignment system will keep moving - hence it is correct to say the Full Remote Alignment System (FRAS) will compensate for the ground motion. He also agreed on writing “electric center” instead of “mechanical center” for the BPM. Stefano asked whether the FRAS can be considered static for most of a run. Rogelio said it will be checked at every technical stop. For Stefano, the last point of the slide, i.e. the question whether the FRAS will compensate for ground motion, remains in question, and he wondered if there is a quick action on this to follow up. Rogelio answered it was asked by the TCC, and it would be good to get an answer by the end of the year. It is also a request from machine
protection. Riccardo added that the machine should be as stable as possible, avoiding drifts with time, in particular. Stefano mentioned that now they can stay a full year without changing the position for collimators, but it is not easy to have an idea on how it will perform in the future. If they see an offset, they would realign the collimator, but the procedure is not clear. The discussion has to continue with machine protection.

- Concerning the triplet BPMs precision requirements (1 µm, see slide 13), Rogelio said the goal of the exercise is that BI tells WP2 what they can achieve. Michal answered he cannot say now, but measurements to be performed later next year could tell. He is sure the precision will be worse. Rogelio said they have to check the timeline and see the consequences of this. Michal stated the timeline is no sooner than next year. Davide said the table does not specify with which averaging one gets this resolution - it could be on seconds. He mentions that such a resolution can be useful, but we might not rely on it to keep the beams in collision - one would instead do luminosity scans. In other words, if the resolution cannot be close to this value, the request will disappear because we cannot rely on BPMs to keep collisions. Michal said they always try to deliver what is specified, but this value really stands out as a challenge. Riccardo also mentioned Van der Meer scans, Davide answered there is another table for this in the document.

- Regarding the comment on the assumption on machine stability (slide 14), Davide said they indeed disregard machine stability, as written in the text. For the second point and the fact that the same fill-to-fill precision is requested for IR1/5 and IR2/8 (14 µm), Rogelio said that IR8 is very similar, but IR2 might be different indeed. Davide confirmed that they need to cross check (Action on the various checks on precision requirement on pilot bunches: Davide, Rogelio).

- Regarding the pilot bunch (third point of slide 14, and slide 15), and in particular the inconsistent specification between Ref. [2] (500 µm) and the EDMS document (100 µm), Davide said it could indeed be a mistake. About the square root scaling with intensity (which is not correct for BPMs with adjustable gains according to Michal - see slide 15), he said he will check as well (Action on the various checks on precision requirement on pilot bunches: Davide, Rogelio).

- Regarding the fact that the 100 µm requested for pilot bunches is seen as too tight (third point of slide 15), Rogelio disagreed that 100 µm is too strict, because it is the current precision for pilot bunches. Roderik added that lead ions have a similar charge as proton pilot bunches, and one should not degrade the performance for ions. Rogelio mentioned that he heard from BI in the past that improving the pilot bunch performance is feasible; for sure the performance must not be degraded.

- For the comments on Van der Meer scans, in particular about the quantification of the intensity range (see slide 18), Davide mentioned that the numbers are given in Table 1.

- Regarding the stability of the BPM length-scale over a Van der Meer scan (row 3 of Table 8, see slide 19), Davide mentioned the number indicated is actually 0.1*sqrt(2), in percent. Michal said that it cannot be distinguished from 0.1%.
• Regarding the alternative, faster method to be used for OMC (see slide 20), namely AC-dipole measurements, Davide mentioned that the text below the paragraph quoted, implies the actual use of this alternative method. Regarding the last point (the question about the choice of the IP BPMs to which this would apply), he said the question is indeed on the table.

• Regarding the challenging precision requested for OMC (slide 21), Davide mentioned that it is comparable to what we have now in the machine. Rogelio added they would need quantitative values that can be achieved. If it is, for instance, only a factor 2 higher than the specification, it might be sufficient. Michal the numbers can be given once we start converging on a hardware solution, but for sure this is a difficult challenge. Rogelio said the discussion will continue offline.

• Concerning the requirements for injection orbit correction (slide 22), Davide said the 20 μm quoted for high intensity bunches, is a guess from Jorg Wenninger, so maybe 50 μm is good enough indeed (Action on checking the precision requirement in the high intensity bunches: Davide, Jorg).

• Michal asked about the doublets. Rogelio replied they were removed, as they are not interesting anymore for electron cloud. Gianni confirmed that they will not come back - this is from the experience during Run 2. Still, he wondered if the system would work if they were to come back. Michal said it is possible, but he does not know if it will work out of the box. Gianni confirmed anyway that we should not make it a specification.

• Finally, Roderik mentioned the lighter ions, which are not yet baseline, but already seriously considered by some experiments. He wondered if one should not include them in the document. Rogelio answered that it could be mentioned as a candidate for operation, if Roderik can provide some numbers. Roderik confirmed he can (in particular, the numbers from the injectors). One should in particular avoid falling between “good” BPM gains. Michal insisted that the real intensity limitation for the BPMs, comes from the bunch intensity ratio inside the same beam. Roderik asked whether there is a bunch intensity range that may not work. Michal answered that indeed it would be appropriate to include all the specific options, to see everything that could be required. Andrea said the system will be very different from the current system: while now it is a kind of on/off behaviour (between high and low intensity), the new system will be rather progressive from one intensity to the other. Roderik summarized by stating that we need to specify the parameters for ions (light ions and lead), and proton-ion runs (Action: Davide, Roderik). Rogelio added to this list the check of the maximum intensity ratio of beam 1 vs. beam 2, and within one beam (Action: Davide, Rogelio).

• In conclusion, Rogelio said a smaller meeting should be organised to converge on the document (Action: Davide, Michal, Rogelio, Roderik).
2 STABILITY OF THE WITNESS BUNCHES (XAVIER BUFFAT)

This presentation reviews the stability situation of the 12 witness bunches required for background measurement, which do not collide in IP1/5. The stability of these bunches have to be ensured to avoid beam dumps on losses.

Witness bunches may still collide in IP2 and/or IP8, with offset levelling. In IP2, leveling occurs at large separation (>4 σ), hence no significant loss of Landau damping occurs. On the other hand, in IP8 the skew crossing angle makes the situation less favourable, and the combination of a low β* and a small separation, triggers a loss of Landau damping until a separation less than 1.3 σ is reached (at the very end of the leveling).

Hence, the required octupole current for bunches colliding only in IP8 is high (>450 A) even at one fourth of the nominal brightness, and may compromise the DA of production bunches. Bunches colliding in IP2 and IP8 are also more critical than bunches colliding only in IP2, or non-colliding bunches: with a brightness one fourth of the nominal value, these bunches need an octupole current of 120 A, vs. 80 A for the non-colliding ones.

The best option is to avoid bunches colliding only in IP8, which is possible in all the filling schemes considered (nominal, BCMS, 8b4e) without loss of performance. It is also possible to avoid bunches colliding in IP2 and IP8 in the nominal and 8b4e filling schemes, without loss of performance. For the BCMS scheme, it is not possible to get rid of bunches colliding in IP 2 and 8 without sacrificing a full 48-bunch train. Therefore the current BCMS filling scheme would rather need at least 120 A in the octupoles (with one fourth of the nominal brightness) without telescope (so 60 A with the low β* reached at the end of leveling), which seems still compatible with DA.

In conclusion, Xavier proposes to update the operational scenario with these new filling schemes.

- Rogelio and Gianni agreed with the proposal, which looks very reasonable for them. Xavier confirmed that the luminosity loss is zero. Rogelio asked if the proposal is to accept that some bunches still collide in IP2/IP8, in the BCMS scheme. Xavier said that some bunches do not collide at all, and only 2 or 3 still collide in IP2 and IP8. He thinks indeed the situation is still fine with respect to DA, even with these bunches. Rogelio agreed, and said one should update the filling scheme on the webpage (Action on updating the filling schemes: Gianni, Xavier).

- Gianni said that for the BCMS scheme one can have a train of 8 instead of 12 - this is easy for the injectors. In the past, a train of 6 bunches was realized, and 8 bunches have been discussed as well. Rogelio approved the idea, and said we can confirm this again. Xavier said he has to check as well if one can remove all the IP8 collisions (Action on checking this option and updating the filling schemes: Gianni, Xavier). Rogelio concluded that for nominal and 8b4e schemes, we remove all IP8 collisions, while for BCMS we will check if we put 8 bunches in the train or keep the bunches colliding in IP2 and 8.

- Rogelio mentioned the current progress on the update of the operational scenarios - it will be reported to the WP2 in due time.
Wolfgang wondered whether these bunches are those used by the tune feedback. Xavier answered in the affirmative. Wolfgang then asked if this has an impact on the tune measurement. Xavier replied this is a good point, there can indeed be an issue if one reduces the gain on those bunches too much. Rogelio mentioned that in the past one could decrease the gain very quickly and perform a measurement. Wolfgang replied that this measurement was then slightly blowing up their emittance. He added that in collision, one needs the tune feedback. Xavier added that it is also critical during the ramp. Rogelio asked Xavier if he will look at this issue, Xavier replied he will, but he cannot know how good the tune signal has to be - this is an operational information. He wondered if one can assume the same gain factor as in the LHC. Rogelio suggested contacting Jorg on the subject (Action: Xavier, Jorg).

3 AOB - CHOICE OF CONFIGURATION OF DEFORMABLE RF FINGER MODULES (BENOÎT SALVANT)

The presentation discusses different options for the deformable RF module, proposed by TE-VSC. To minimize the angle in the fingers during operation at cold, a sliding contact may be introduced, with the disadvantage that a small cavity is created when the module is too long. A trade-off between the angle of the fingers and the cavity created, has hence to be found in such a hybrid solution.

CST simulation results are presented for two different scenarios: with the sliding contact or without it. Looking at a single module, the scenario with the sliding contact is clearly beneficial when the impedance is large (nominal, or module too short) but detrimental for the case when the module is too long, because of the 7 mm cavity created, in which case the impedance without the contact is much better (and small). Nevertheless, when considering several modules for which at first order the length offsets should compensate (i.e. if one module is too long, another one should be too short), the overall impedance is always smaller with the hybrid option containing the sliding contact.

In conclusion, using the sliding contact always improves the situation impedance-wise.

Rogelio agreed with the conclusion, which he found very robust.

4 ROUND TABLE (ROGELIO TOMÁS, ELIAS MÉTRAL)

The next WP2 meeting will be announced in due time.

Reported by N. Mounet