



Special WP2/WP5 Meeting

Tuesday 22th February 2022, 10:00 – 12:00

Chairs: Stefano Redaelli, Rogelio Tomás

Speakers: Alessandro Bertarelli, Riccardo De Maria, Michal Krupa, Guido Sterbini

Participants: Hannes Bartosik, Alessandro Bertarelli, Francesco Bertinelli, Nicolò Biancacci, Roderik Bruce, Federico Carra, Marco D'Andrea, Joel Daricou, Riccardo De Maria, Mario Deile, Kay Dewhurst, Pascal Dominik, Ilias Efthymiopoulos, Paolo Fessia, Davide Gamba, Luca Gentini, Massimo Giovannozzi, Jorge Guardia, Michael Guinchard, Stefan Hoell, Dobrin Kaltchev, Michal Krupa, Andrea Mazzolari, Elias Métral, Nicolas Mounet, Joao Oliveira, Yannis Papaphilippou, Marcin Patecki, Antonio Perillo, Axel Poyet, Stefano Redaelli, Adriana Rossi, Óscar Sacristán, Francisco Sanchez Galan, Leonardo Sito, Kyriacos Skoufaris, Guido Sterbini, Yves Thurel, Ezio Todesco, Rogelio Tomás, Carlo Zannini, Markus Zerlauth.

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MEETING ACTIONS

Nicolas, Benoît, Assess wire impedance and e-cloud with and without coating.
Gianni Iadarola

Guido

Find out how to proceed for the studies of the wire EM field with the perturbation from the brazing material.

(see [action list](#) on the WP2 webpage, for the complete list of current actions)

GENERAL INFORMATION (STEFANO REDAELLI, ROGELIO TOMÁS)

The minutes of the previous WP2 meeting ([200th WP2 meeting](#)) were circulated. **Pascal Hermes** provided a correction to the discussion part related to his talk: the statement that was previously made, that the e-lens would be operated for no more than 5 minutes, was not fully correct, as one could also use it later during collisions with constant current - this could play a role for the degradation of the beam emittance.

Stefano Redaelli mentions the review, recently held ([148th ColUSM](#)), of the 2021 WP5 HiRadMat test “Multimat-2, in particular the discussions about extension of data taking for one of the experiments. At the same meeting, a clarification on the TCL settings for Run 4 was also shown. On Friday 4th of March there will be a ColIUSM meeting to discuss the design of the mask, with particular emphasis on the impedance of the design.

1. STATUS OF THE BEAM-BEAM LONG-RANGE WIRE COMPENSATION (ALESSANDRO BERTARELLI)

Alessandro Bertarelli covers the hardware design of the beam-beam wire compensator. Space reservation has been made on both sides of IP1 and IP5, close to Q4. The design assumptions are reviewed: a total of 8 wires are assumed, each wire having circular cross-section (1 mm diameter) and a length of 3 m. The current is assumed to be DC and of 450 Am. The wire is metallic (Mo) and uncoated, with the possibility to move to the required position. The design envisages a moveable vacuum chamber in which the wire is fixed. Each module is 1.2 m long and several modules can be installed side-by-side, and each module is independently moved. Numerical simulations indicate that the maximum temperature is 140°C and the deformations are in the 30 µm range. The brazing assumed in this design is rather challenging, and for this reason, a demonstrator has been built. This device is a short (290 mm) replica of the actual beam-beam wire compensator to provide validation of the design choices. Two wire diameters (0.8 mm and 1 mm diameter) have been produced and successfully brazed. Tests of the demonstrator were carried out by the end of 2021. Tests performed in air confirmed the results of numerical simulations about the wire temperature. Tests in vacuum were also carried out, which showed a smaller voltage drop than the predicted value, possibly due to the conductive brazing alloy. Tests with an 0.8 mm diameter wire were initially positive, but oxidation caused a breakage of the wire. Although this should not occur in vacuum, it probably indicates that 1 mm diameter is the safer choice for the nominal design

Discussion:

- **Nicolas Mounet** asks whether coating of the ceramic parts is planned. **Alessandro Bertarelli** replies that coating is excluded by design. **Nicolas** expresses concerns about the possible heating

generated by the ceramic parts. **Alessandro Bertarelli** comments that there are possibilities for improving the design, but an estimate of the expected heating would be useful input before launching any optimisation studies (**Action: Nicolas, Benoît, Giovanni Rumolo**, assess impedance and e-cloud with and without coating).

- **Yannis Papaphilippou** mentions that the idea is to keep the beam-beam wire compensators in the shadow of the TCTs. **Roderik Bruce** comments on the opening of the TCTs, and **Adriana Rossi** states that there is indeed the idea of moving the wires closer to the beam than the TCTs opening, but this requires detailed studies. Additionally, **Stefano Redaelli** comments that the transverse dimensions of the wire supports are non-negligible and it would be useful to reduce them, which would require iterations on the proposed design.
- **Stefano Redaelli** asks about the optimisation of the costs of the demonstrator device. **Alessandro Bertarelli** replies that the current design has not been oversimplified to reduce the costs, but he also adds that in his opinion the design should be kept simple, independently of the costs.
- **Antonio Perillo Marcone** asks about the main constraints that affect the brazing. **Alessandro Bertarelli** replies that thermal contact is probably the key constraint, as it is essential to avoid local heating. **Antonio** asks whether tungsten wires would not be a better choice, for instance in terms of procurement and mechanical properties. **Antonio** also asks whether radiation damage has been taken into account in the numerical simulations. **Alessandro** replies that the studies performed so far are not at this level of detail yet.
- **Rogelio Tomás** asks whether imperfections on the wire cross section including the brazing material have been considered as they might be sources of perturbations of the generated electromagnetic fields. **Nicolas Mounet** and **Alessandro Bertarelli** reply that this study has not been carried out yet (**Action: Guido**).
- **Roderik Bruce** further comments on the positioning of the beam-beam wire compensator, as the new settings of the collimators, which have been agreed upon with WP2, foresee 10.1σ as opening of the secondary collimators. Hence, it is not evident how to consider a wire at 10σ , and this requires certainly detailed studies. **Yannis Papaphilippou** stresses that before any firm decision about the optimal transverse positioning of the wire is taken, it is essential to pursue the studies.
- **Roderik** asks whether the high operational temperatures are compatible with the UHV environment, and **Adriana** replies that this has still to be studied, but the demonstrator will provide useful information on this item.
- **Mario Deile** comments that background from the wires to the Roman Pots is not expected to be a serious issue. However, FLUKA simulations should be performed and they could confirm this hypothesis.
- **Stefano Redaelli** asks whether the ceramic parts have been studied in combination with failure scenarios involving beam impact. **Francesco Carra** replies that it has not been considered yet, and **Stefano** then suggests performing tests at HiRadMat.
- **Adriana Rossi** raises the key point that currently the wire compensator is not in the HL-LHC baseline. This, of course, poses some issues to the studies that are needed to assess the feasibility and performance of this device. **Markus Zerlauth** replies that it would be difficult to allocate resources to these studies now, as the wire compensator is not in the HL-LHC baseline. Therefore,

only a minimum effort should be devoted to this topic with the goal to make enough progress to review the baseline and include it, perhaps later this year, when a review is expected. **Paolo Fessia** comments that detailed integration studies are difficult in this framework and reminds that the design of the beam-beam wire compensator should be fully compatible with the Full Remote Alignment System (FRAS). **Roderik Bruce** comments that FLUKA studies and other WP5 activities needed for making progress with the wire compensator, will need non-negligible resources and a careful prioritization should be performed, to avoid issues with the baseline activities. **Adriana** also added that the concept to move the wire when the vertical crossing angle polarity is swapped is still to be devised.

2. POTENTIAL D2 DISPLACEMENT (RICCARDO DE MARIA)

WP3 is considering a change of the longitudinal position of the cold mass inside the cryostat of the D2 separation dipole by 20 cm. This change aims at optimizing the design of the current leads. This topic has been discussed with WP5 and **Riccardo** reports back the outcome of the discussions. Although there is some aperture loss, a few tenths of σ , for the flat optics, it is proposed to accept the hardware change without launching a re-design of TAXN and of the mask and knowing that there are various mitigations as shifting TAXN position or changing beam orbit.

Discussion:

- **Francisco Sanchez Galan** comments that the technical specification of the Y-chamber has been launched and manufacturing is already on-going. The movement of the TAXN, introducing a voluntary displacement as a mitigation measure for the aperture loss, could be implemented by using the FRAS.
- **Paolo Fessia** comments that following the green light from today's meeting, WP15 will launch all actions to implement this decision. Furthermore, he states that the voluntary displacement will not be implemented by means of the FRAS, to avoid reducing the available margin.
- **Nicolas Mounet** stresses that any change to the TAXN or the Y-chamber design should be carefully validated in terms of impedance. However, as this is not the case, there should be no problem for a voluntary displacement in terms of beam impedance.
- WP2 agrees to this proposal. **Rogelio** stresses that this severe change to the layout should not happen at this advanced state of the project. An ECR will be prepared by WP3 in collaboration with **Riccardo**.

3. HL-LHC BPM ELECTRODE ORTHOGONALITY (MICHAL KRUPA)

The BPMs installed in the triplets area are all directional stripline devices. While those on Q1 are not rotated, those in Q2, Q3, and D1 are. The error on the orthogonality of the electrodes was not measured for LHC BPMs, but it is planned to be measured for the HL-LHC BPMs. The rough estimate obtained from

the construction drawing, assuming linear addition of all mechanical tolerances, is 11.5 mrad (for the case of the LHC BPMs it is 16.6 mrad). The proposal consists of measuring the orthogonality and the deviation from the cardinal orientation. Hence, two angles will be measured for each of the BPMs for HL-LHC.

Discussion:

- **Davide Gamba** asks whether the long-term mechanical stability of the electrodes is guaranteed, given the very complicated design. **Michal Krupa** comments that tests will be carried on the pre-series and in case of need, design changes might be implemented.
- **Guido Sterbini** asks about the technique for measuring the two angles. **Michal** replies that the measurements will be carried out by the metrology laboratory. Hence, no electrical measurement is envisaged as it is not deemed accurate enough.

4. DA STUDIES FOR RUN4 WITH $\beta^*=30$ CM (GUIDO STERBINI)

Guido Sterbini presents some recent results of DA studies carried out by **Sofia Kostoglou**. Tune scans studies have been carried out to assess the optimal conditions for the year 2029 of Run 4, when $\beta^* = 30$ cm will be used. A proposed value of 380 μ rad (total crossing angle) provides a marginal DA and does not seem suitable as an operational choice. The value of 450 μ rad is a much more promising value, in particular as the phase advance between IP1 and IP5 can be used as a free parameter to optimize the DA value. Indeed, by performing a scan over the phase advance, DA in excess of 6σ could be found, which are deemed suitable for operational use.

Discussion:

- **Riccardo De Maria** asks whether the crab cavities are assumed in this scenario for the first year of operation. **Rogelio** replies that they are not, but will be extensively used in experiments.
- **Riccardo De Maria** comments that the optimization of the phase advance between IP1 and IP5 generates sizable effects on the DA when Landau octupoles are strongly powered.
- **Nicolas Mounet** asks about the impact of the Landau octupoles on the DA value, as it should be possible to reduce their strength to, e.g. 80 A, depending on the brightness of the witness bunches. **Guido** replies that their impact should be rather limited, i.e. of the order of a few tenths of sigma for 20 A.
- **Rogelio** comments that this configuration has been already included in the Run 4 operational configuration document, which is almost in final form.

5. ROUND TABLE AND NEXT MEETINGS (STEFANO REDAELLI, ROGELIO TOMÁS)

The next WP2/WP5 joint meeting will be on Friday, March 4th. Its agenda will be circulated in due time. There might also be a regular WP2 meeting on Tuesday, March 8th.

Reported by Massimo Giovannozzi