



# Special Joint WP2/WP5/WP10 Meeting

Tuesday 11<sup>th</sup> October 2022, 10:30 – 12:00

<i>Chairs:</i>	Rogelio Tomás
<i>Speakers:</i>	Francesco Cerutti, Sofia Kostoglou, Riccardo De Maria, Roderik Bruce, Lorenzo Giacomel
<i>Participants: 19</i>	Carlotta Accettura, Hannes Bartosik, Xavier Buffat, Francesco Cerutti, Riccardo De Maria, Stephane Fartoukh, Paolo Fessia, Lorenzo Giacomel, Sofia Kostoglou, Elias Métral, Nicolas Mounet, Francois-Xavier Nuiiry, Yannis Papaphilippou, Thomas Pognat, Stefano Redaelli, Ezio Todesco, Rogelio Tomás, Markus Zerlauth;

## AGENDA

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Meeting actions	1
General information (Rogelio Tomás)	2
TCLM4 mask optimization for magnet protection effectiveness and optics flexibility (Francesco Cerutti)	2
Impact of no MS10 on DA with flat optics (Sofia Kostoglou)	3
Studies on impact of no MS14 (Riccardo De Maria)	4
WP5 functional specs for TCL and TCT collimators (Roderik Bruce)	5

## MEETING ACTIONS

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<b>WP2 &amp; WP5</b>	Provide complete flat optics scenario for studies of collision debris with TCLM4 mask.
<b>Markus</b>	Revert previous ECR on MS10 to allow installation during LS3.

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

## GENERAL INFORMATION (ROGELIO TOMÁS)

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**Rogelio** showed the actions from the last WP2 meeting.

**Francesco** thanked for the organization of this meeting to allow for some discussion on the TCLM4 mask in preparation of the TCC.

**Stefano** mentioned that there will be a preparatory meeting on collimation material, as there are still a couple of open points to complete the assessment of the impedance with WP2. Furthermore, the CollUsm will wrap up crystal and ion tests in an upcoming meeting.

### 1. TCLM4 MASK OPTIMIZATION FOR MAGNET PROTECTION EFFECTIVENESS AND OPTICS FLEXIBILITY (FRANCESCO CERUTTI)

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**Francesco** presented an overview of the MCBY correctors in the Q4 assembly of the matching section. The MCBYs are less radiation resistant than the Q4 and therefore a mask is required for protecting the corrector from the collision debris. An increase of the peak power density of about 70 % was observed in simulations when increasing the radial aperture of the mask by 2 mm as requested from the optics team for aperture considerations to account for mechanical tolerances. On the other hand, decreasing the mask aperture the peak dose rate could be reduced by 65%. The unavoidable gap between the Cu chamber and the inner block shall not exceed 0.1 mm in order to achieve the expected shielding efficiency.

Different options of shapes were studied, including options with an adapted rectangle, a pure ellipse, a cut ellipse and an ellipse with a 2 mm Cu chamber. Comparing the different options in terms of the expected cumulative dose from Run 4 until Run 6, all cases result in a significant improvement with respect to the baseline presented at the 111th TCC. The cut ellipse with 1.8 mm thick Cu chamber is the best solution from the magnet protection point of view.

Discussion:

- **Stefano** asked if the simulations with round optics were conclusive, if not considering also flat optics options. **Stephane** mentioned that the losses at the IP do not depend on  $\beta^*$ . **Francesco** confirmed that the losses at the inner triplets do not depend on  $\beta^*$ , but in the matching settings the collimator settings might change in different optics configurations and this could impact the losses behind the TAN. He agreed that some simulations should be performed in the future once the flat optics scenario including collimator settings is available. **Action WP2 & WP5 to provide complete flat optics scenario for studies of collision debris with TCLM4 mask.**
- **Stefano** asked if in the table of all the scenarios, all tolerances are taken into account in a pessimistic way. **Francesco** confirmed that this is the case, while it was not the case in the design of the original baseline shape. Therefore, the new shapes are significantly better than the original design. **Francois-Xavier** added that he is looking together with Carlotta to review once more the tolerances.

- **Paolo** asked which was the less expensive and easier to produce solution. **Francois-Xavier** explained that the reduced outer diameter will reduce some cost of the raw material, which might compensate for higher production costs. The preliminary assessment shows that all options seem feasible from a production point of view considering electron welding of two half-blocks, and a shape accuracy of about  $\pm 0.15$  mm should be achievable on the inner tube. No big difference is expected between the presented options, as the cost drivers (inermet part and outer diameter) have already been optimized.
- **Paolo** asked if the radiation to personnel would be affected by the reduced outer diameter. **Francesco** replied that this needs to be evaluated by RP.
- **Markus** mentioned that the radiation resistance expected for the MCBY is not yet available, so for the moment it is still assumed to be 5 MGy. If there is no significant overcost, should decide for one of the optimized shapes as the expected improvement on cumulated dose is significant. **Francois-Xavier** clarified that from the raw material cost, the new design is cheaper. However, the high precision required was not considered in the original cost estimate. The final cost estimate still has to be made.
- **Thomas** asked if the effect of the beam screen on the magnetic field has been taken into account. **Francois-Xavier** explained that this is a negligible effect.
- **Stephane** asked if small orbit changes could change the results, since the optimized shapes differ only by less than 3 mm. **Francesco** explained that the important point is the mechanical alignment of the mask with respect to the MCBY. **Riccardo** added that there were even some investigations of using girders and BPM to reduce the relative misalignments. Finally, the FRAS will be sufficient to achieve the required alignment tolerance. **Francois-Xavier** added that after a 1st discussion with P. Bestmann they converged on an alignment tolerance of  $\pm 0.5$  mm, but this may be improved if needed. There could also be different tolerances between the incoming and the outgoing beam depending on the critical part of the magnet that needs to be protected. They will discuss with the magnet experts to define the best way of fiducialization.
- **Riccardo** highlighted that the new shapes improve the aperture for the beam. The mask is the local bottleneck for the beam in this area, so it was important to optimize the shape to improve the aperture. A gain of about 0.8 sigma is obtained for all presented options. This should also be mentioned at the TCC.
- **Riccardo** also agreed that the best option is the cut ellipse as proposed by Francesco, as it gives the best compromise for horizontal and vertical crossing, and the best arrangement of material where it is needed.

## 2. IMPACT OF NO MS10 ON DA WITH FLAT OPTICS (SOFIA KOSTOGLOU)

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**Sofia** presented DA simulations investigating the effect of not installing the MS10 at the end of levelling for flat optics. Unlike with round optics, the flat optics with  $\beta^* = 7.5/30$  cm suffers from an important reduction of DA without MS10 for all the possible H/V and V/H crossing schemes. Without including beam-beam effects, a significant increase in the chromatic coupling is observed, similar to what has been

observed for the round optics. With beam-beam the reason for the difference between with and without MS10 is less clear, when looking at the FMAs.

Discussion:

- **Stephane** asked how the optics was matched without MS10. **Sofia** explained that the MS10 is removed, and the W function is re-optimized without changing phase advance. The on\_disp bump uses the same orbit correctors of the nominal as the phase advance is not changed. **Stephane** asked what was the source of chromatic coupling. **Sofia** explained that the chromatic coupling comes from spurious vertical dispersion in sextupoles.
- **Yannis** commented that the reason for the reduced DA without MS10 could be the crossing of resonances that were not crossed when including the MS10, as can be seen from the FMAs. It appears that the tune spread is increased without MS10, as there is one sextupole missing making a pair of sextupoles and so some resonance driving terms are not self-compensated.
- **Markus** commented that for round optics it was fine to delay the installation of the MS10 after LS3, but now even for Run 4 it might be needed to go to a beta\* below 20 cm and thus might require to have the MS10, and for the flat optics will need it as well.

### 3. STUDIES ON IMPACT OF NO MS14 (RICCARDO DE MARIA)

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**Riccardo** showed what could be possible scenarios in case the MS10 could not be installed. In Run 4, without MS10 the LHC could be limited in the achievable beta\* before being limited by aperture in the triplets. Installing the MS10 would restore the symmetry of the chromatic sextupole scheme, such that it would consist of an even number of sextupoles so that the sextupole pairs compensate the induced resonance driving terms in first order.

A possible mitigation in case the MS10 is not installed could be to optimize the phase advance between IP1 and IP5, but the risk is that there is not enough optics flexibility due to the lack of CuCD collimators in HL, or that the optimal phase advance for DA made in conflict with the beam-beam orbit.

Another option could be to remove one sextupole next to Q14 instead of adding the MS10, which would reduce the arc correction capabilities with more off-momentum beta-beating, less aperture in the arcs and increase the octupole resonances due to a change of one strong family. The resonances could be cured with the phase advance optimization which is not a good choice for a baseline for the risks stated above.

Another option could be to remove two sextupoles. In this way, the baseline DA with MS10 might be restored, at further costs for chromatic correction and apertures.

In conclusion, installing the MS10 is still the preferred option to keep the beta\* reach capabilities of the triplets.

Discussion:

- **Stephane** commented that the telescopic optics was accepted as baseline to be able to achieve chromaticity correction without changing 600 sextupoles in the machine. He asked what was the main reason for considering not installing MS10? **Ezio** replied that the question was, if the main argument for installing the MS10 is to have an even number of sextupoles, the same might be achieved by removing the MS14. Stephane explained that the telescopic optics is needed because below a certain  $\beta^*$ , the chromatic correction cannot be achieved any more with the available chromaticity sextupoles. So removing one sextupole instead of adding one would reduce chromatic correction capability by 20%, and therefore the minimum pre-squeeze  $\beta^*$  would be increased with all the drawbacks of reduced aperture in the arcs and increased chromatic beta-beating. In order to compensate the reduced chromatic correction capability, the tele-index would need to be increased. Without MS10 the beam lifetime would be reduced due to the reduced DA.
- **Markus** added that the installation of MS10 is and was in the baseline, only the installation had been delayed from LS3 to LS4. Now with the delayed start of LS3, the installation during LS3 will be feasible again and should be done, as it would allow reaching below 20cm  $\beta^*$  in the round optics in case needed, or would allow good performance with the flat optics. **Markus** confirmed that the project management is advocating to go for installation in LS3 as baseline, clearly stating the performance loss in case of not doing it. A decision will be taken in the TCC (ideally even before the C&S review), and then a new ECR will have to be prepared. **Action Markus to revert the previous ECR on MS10 to allow installation during LS3.**

## 4. AOB INSTABILITY STUDIES FOR UPDATED DESIGN OF 80 MM VALVE (LORENZO GIACOMEL)

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**Lorenzo** showed an update on the Q4 vacuum valves impedance and instability thresholds. The updated version of the 80 mm valve as proposed by VSC is only slightly worse than the 80 mm version scaled from the 100 mm design, and is acceptable from the instability and impedance team point of view.

Discussion:

- **Markus** said that this is good news. He also mentioned that the vacuum group is still looking at the option of keeping the 63 mm version. **Lorenzo** added that this would be the best option, but also the 80 mm version would be acceptable.

*Reported by Hannes Bartosik*