Impact of Cu coating resistivity on HL stability; impedance mitigation scenarios

L. Giacomel, X. Buffat, N. Mounet

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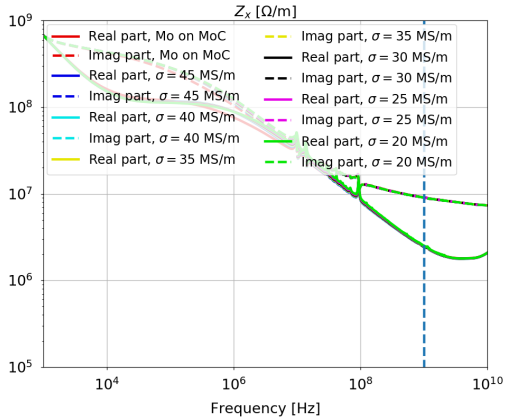
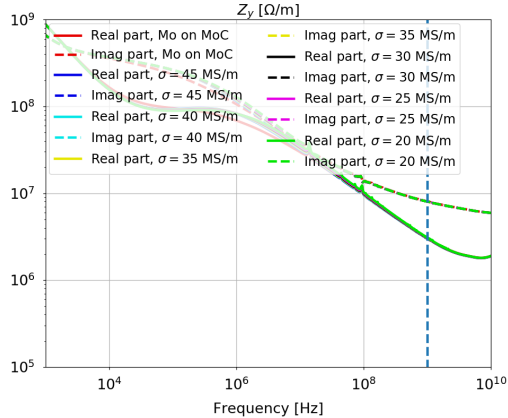
Many thanks to B. Lindström

Outline

Impact of the Cu coating on the Transverse Impedance Model





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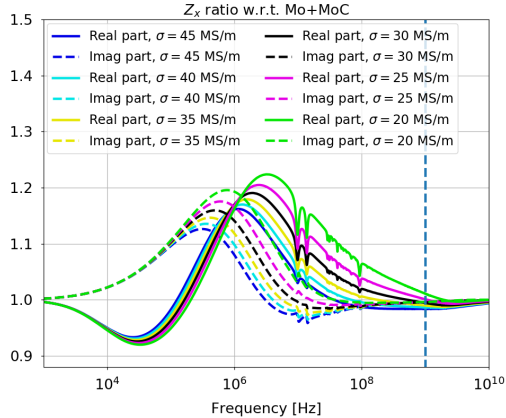

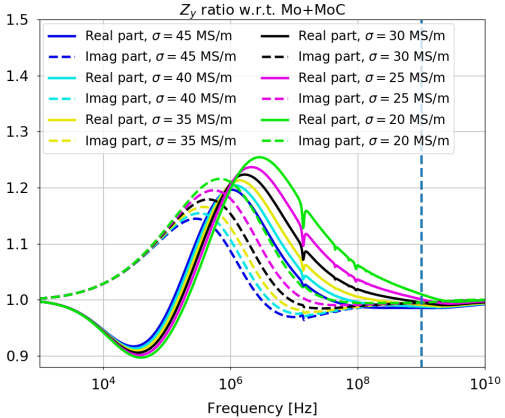

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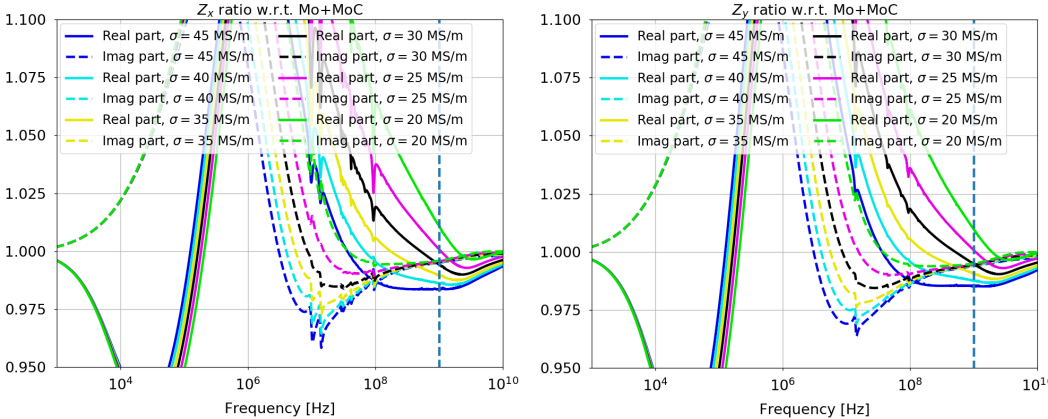

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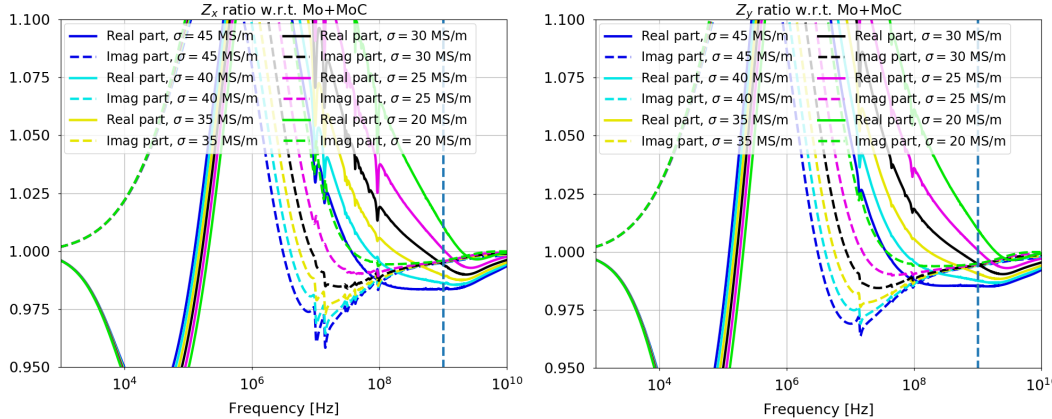
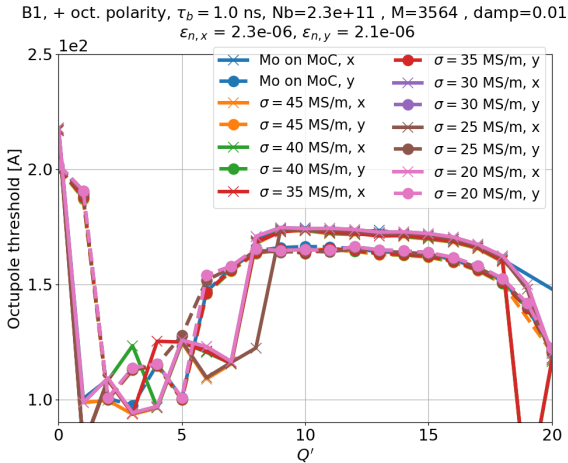


In order to not increase the impedance around 1 GHz with respect to the Mo+MoC case, CuHIPIMS should have a conductivity of at least 30MS/m.

Impact of the Cu coating on the Octupole Thresholds - I_{oct} vs Q'

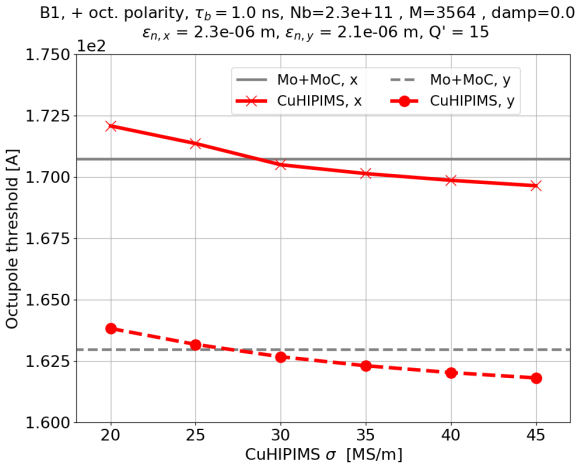
- Octupole threshold: the minimum octupole current needed to stabilize the beam
- We compute it with the Vlasov solver DELPHI



The impact of the material choice on the threshold amounts only to a few amps.

Impact of the Cu coating on the Octupole Thresholds - I_{oct} vs Q'

What conductivity should CuHIPIMS have in order to not increase the octupole threshold with respect to Mo+MoC? (e.g. at Q'=15)

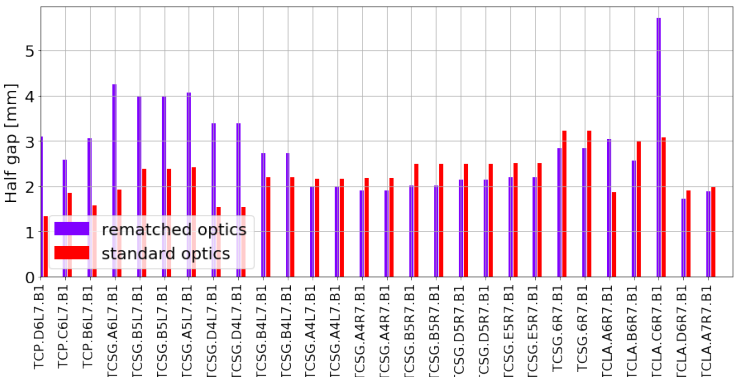


With $\sigma = 30$ MS/m the threshold is even lower than with Mo+MoC

Outline

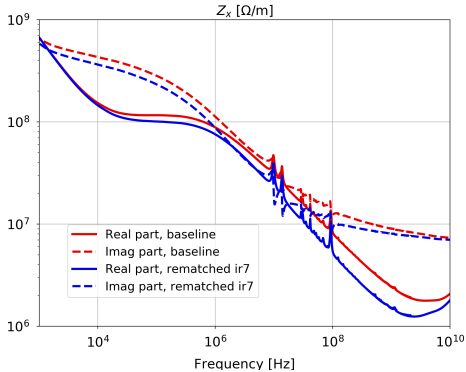
Re-matched IR7 Optics

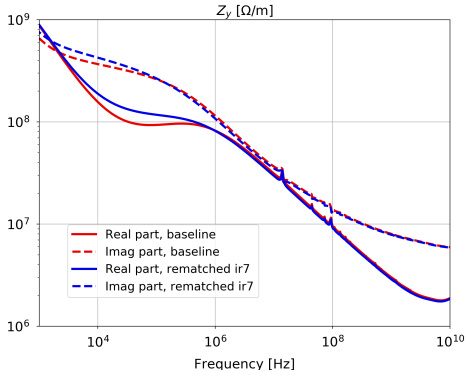
- A new flat-top optics layout for the LHC IR7 was studied in simulations and (partially) in an MD (see B. Lindström at the Joint LNO-NDC meeting on 22/08/2022)
- This configuration has larger beta functions at the IR7 collimators allowing to increase their physical gaps (i.e. lowering the impedance) and providing better cleaning
- Can this improvement be extended to the HL-LHC optics?



The final re-matched optics for the HL-LHC is not available yet, so this study is carried out by re-matching the HL-LHC optics with the same constraints as the LHC. Even better performance can be achieved in the HL-LHC by relaxing the phase advance constraint.

HL-LHC Impedance Model with the Re-matched IR7 Optics ($\beta^* = 1$ m)





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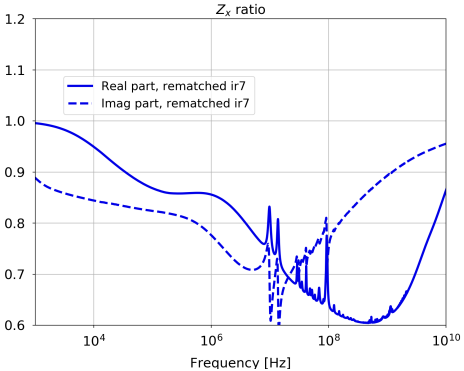
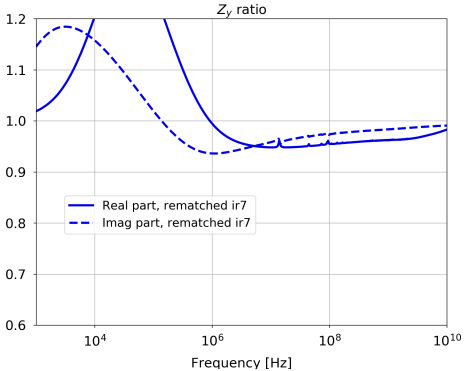
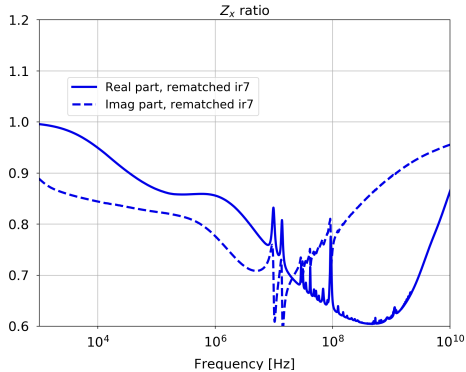
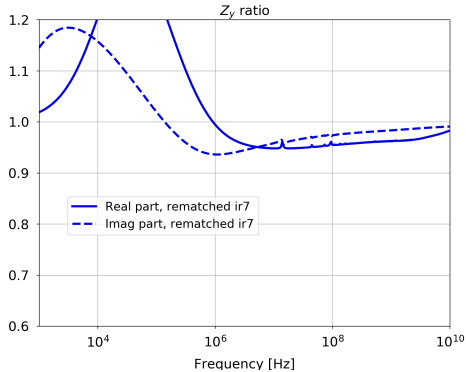




HL-LHC Impedance Model with the Re-matched IR7 Optics ($\beta^* = 1$ m)

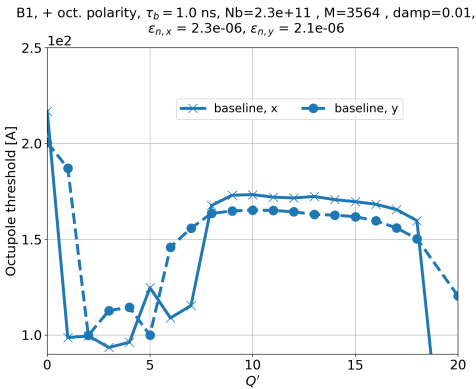




The impedance is significantly improved in the x plane, while in the y-plane the improvement is less significant (but still present around 1 GHz).

Comment on the HL-LHC Re-matched IR7 Optics

A full DELPHI study on the re-matched IR7 optics could not be [erformed yet (here we show only the baseline scenario, without crab cavities)



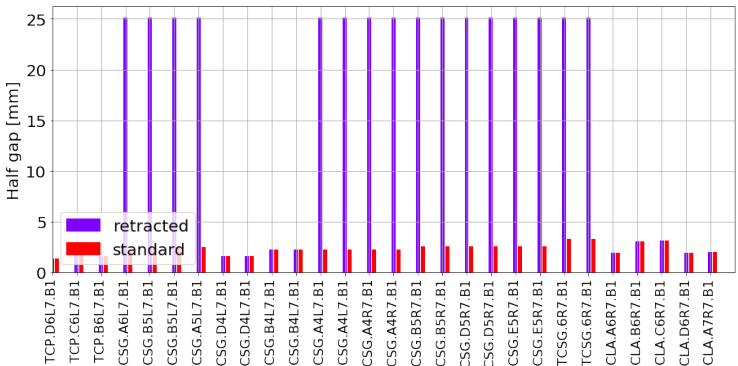
The impedance improvement is mostly in the x-plane, which is the most unstable plane between $Q' = 7$ and $Q' = 20$ in the baseline scenario, therefore there are good hopes that the octupole threshold will be improved.

Outline

Retract the Secondaries!

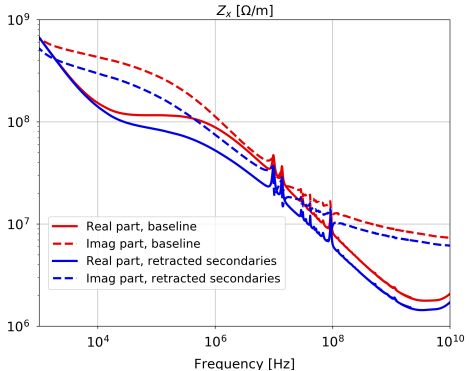
Purely theoretical idea: we can study the impedance improvement obtained by retracting all secondaries but two of them: tcsg.d4l7.b1 (horizontal) and tcsg.b4l7.b1 (vertical).

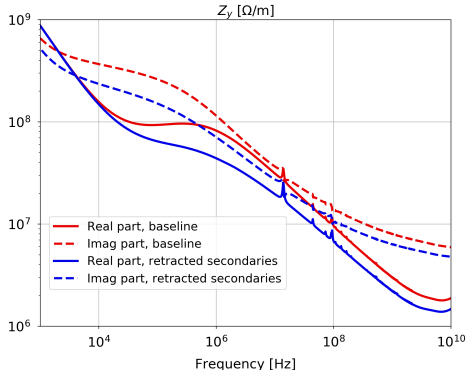
This scenario is clearly not feasible in practice - the goal here is simply to study what is the theoretical lowest impedance that can be achieved by retracting the secondaries.



HL-LHC Impedance Model with the Retracted Secondaries ($\beta^* = 1$ m)

Let us check the improvement in impedance with the retracted secondaries:





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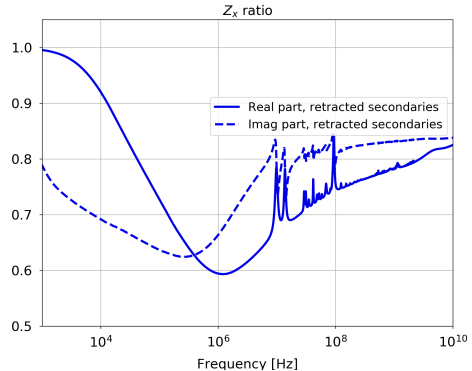
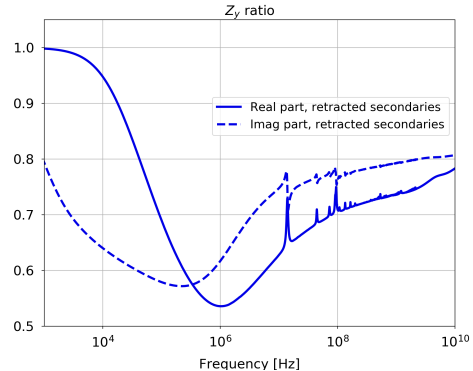
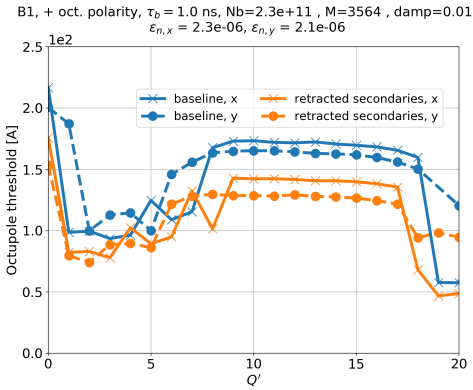




Impedance improvements: $\sim 20\%$ in x, $\sim 25\%$ in y

Octupole Thresholds with the Rectracted Secondaries

We also compute the improvement in the octupole thresholds with the retracted secondaries.



The octupole thresholds are improved by $\sim 20\%$.

Conclusion

- Impact of Cu Coating:
  - If the conductivity of the CuHIPIMS coating of the new secondary collimators is higher than 30 MS/m, the impedance of the HL-LHC and octupole thresholds are slightly lower than with the old Mo+MoC coating.
  - If the conductivity is between 20 and 30 MS/m, the increase of octupole thresholds is only of a few amps.
- Re-matched IR7 optics:
  - It has the promise to reduce the impedance, in particular in the x-plane, which is the most unstable plane.
  - Therefore we can expect an improvement of the instability thresholds.
  - More precise DELPHI simulation will be carried out when the full HL-LHC optics with the rematched IR7 will the available.
- Mitigate the impedance by retracting all secondary collimators but two:
  - Purely theoretical study to check the best possible impedance improvement which can be obtained by retracting secondaries.
  - Results in a $\sim$ 20% improvement in the octupole thresholds.