

Impedance impact of material of HL-LHC Y chambers

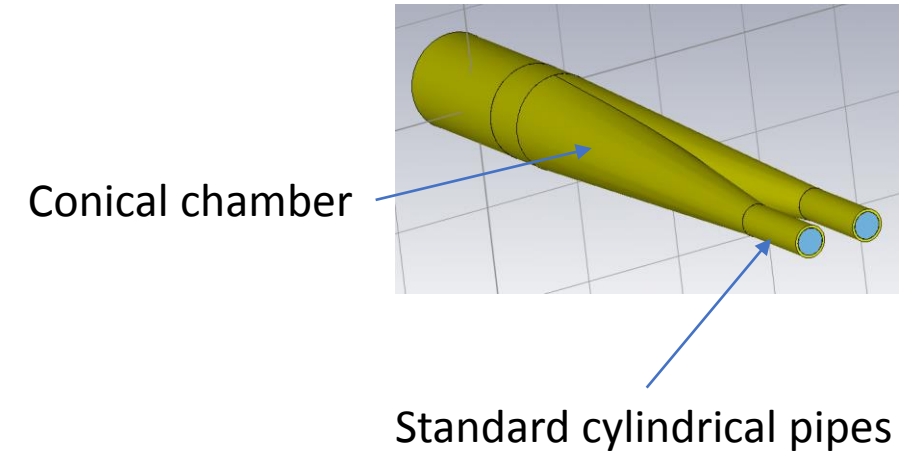
Benoit Salvant, Nicolas Mounet for the impedance WG

Many thanks to

Jan Hansen, Frederic Luiz, Francisco Sanchez Galan, Pablo Santos Diaz, Josef Sestak, Mauro Taborelli, Rogelio Tomás, Giovanni Rumolo and IWG members

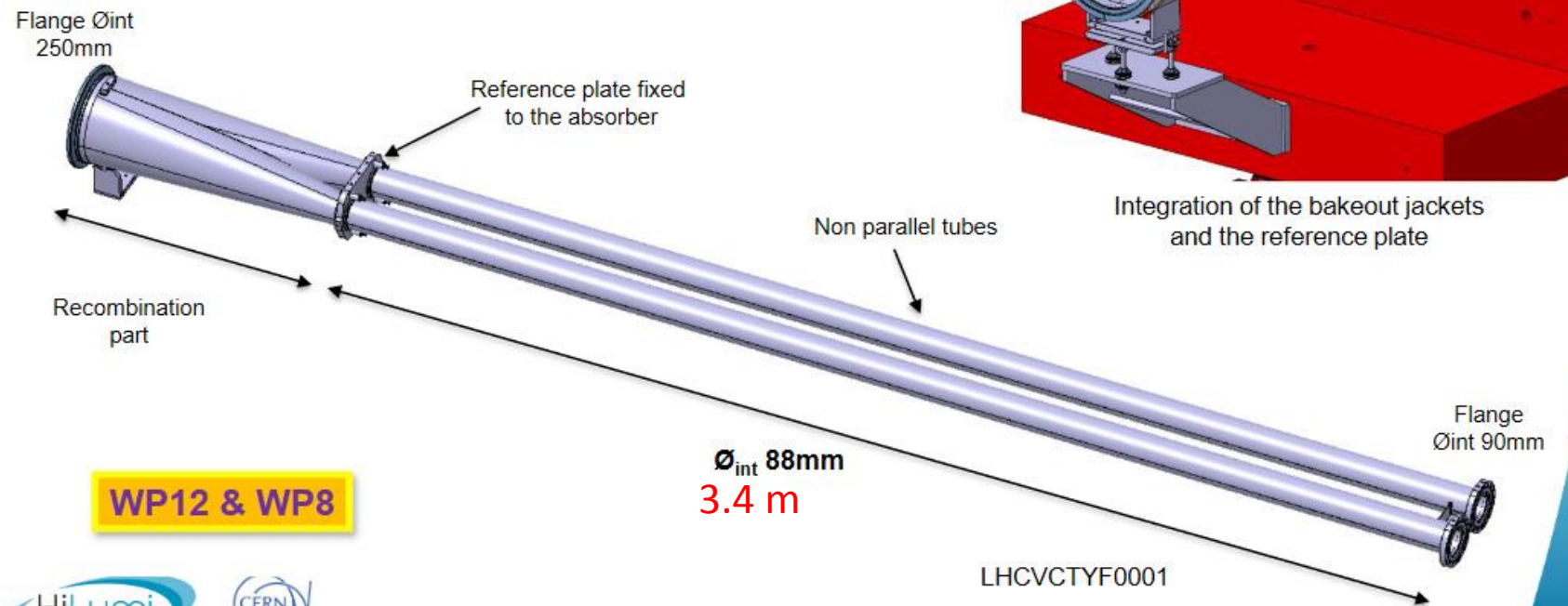
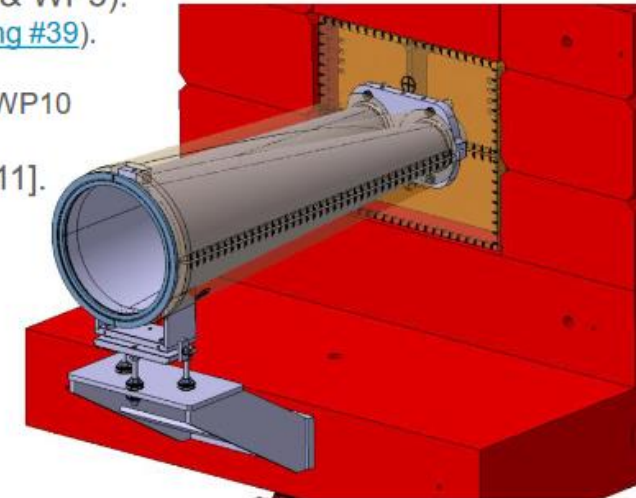
Context

- All currently installed Y chambers in LHC are either:
 - in bulk OFHC copper (IP1 and IP5)
 - or stainless steel 316LN with 0.4mm copper plating (IP2 and IP8)
- Specification for coating of LHC and HL-LHC beam pipes (e.g. [EDMS 1902591](#)):
 - ID<130 mm: copper (or, in specific cases, stainless steel with a copper layer of ~0.5 mm facing the beam)
 - ID>130 mm: stainless steel without copper coating
- History of requests on material:
 - February 2018: design proposed in copper (OFHC)
 - October 2019: request to change to copper plated stainless steel and NEG coated
 - December 2019: question on whether coating of the conical part could be dropped
 - January 2020: agreement between TE-VSC and IWG to coat with 0.005 mm of copper to ease production
→ [IWG 37](#)
 - January 2021: engineering review → request to drop copper coating everywhere (conical chamber + pipes)



Recombination chamber

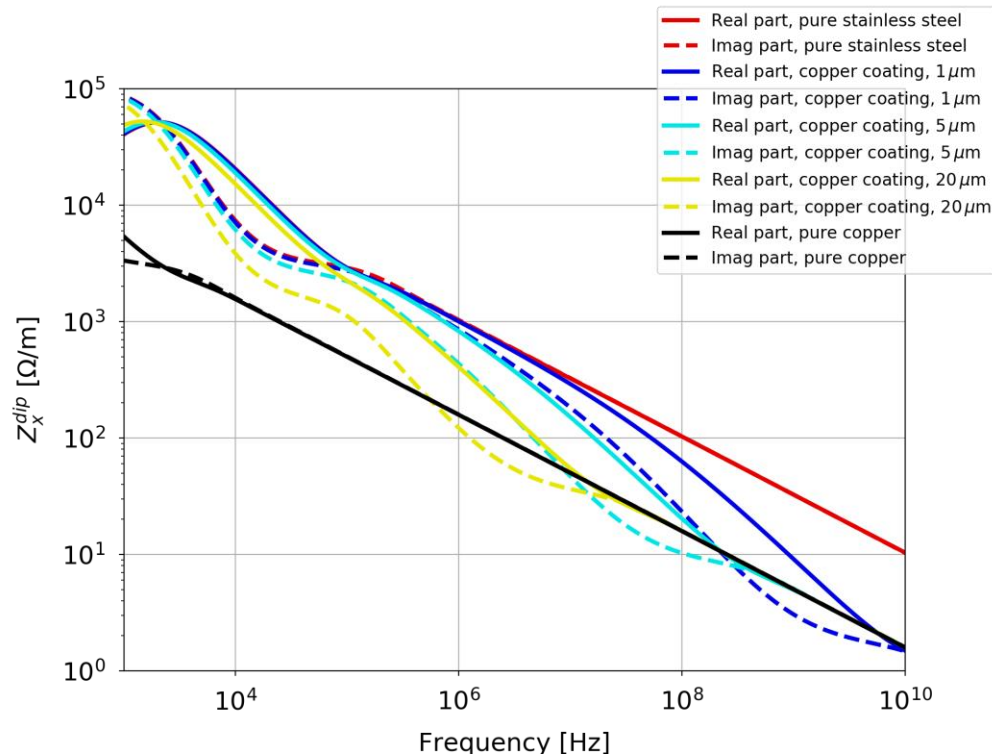
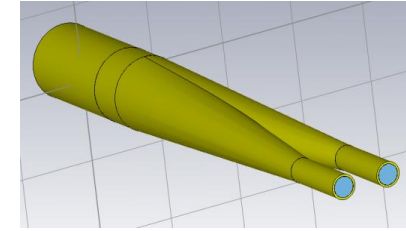
- Bolted to the IP face of the absorber and clamped between the two absorber halves.
- Made of stainless steel, NEG coated and bakeable.
- 88mm inner diameter in the legs pipes (approved by WP2, WGA & WP5).
 - Tolerances defined together with the absorber ([Alignment WG meeting #39](#)).
 - Beam aperture validated by WP2 ([184th HiLumi WP2 Meeting](#)).
 - Heat deposition on the downstream collimators and D2 validated by WP10 ([CoUSM #133](#)).
- Beam impedance validated by the Impedance Working Group [11].
- Technical specifications document updated [12].



WP12 & WP8

Main contributor to resistive wall impedance are the cylindrical tubes (smallest diameter and largest length)

Impedance impact of removing copper layer



Replacing bulk copper by bulk stainless steel:

- Increase by a factor 6 to 7 of both transverse and longitudinal impedance over the frequency range of interest
- Clear benefit from impedance point of view of using copper

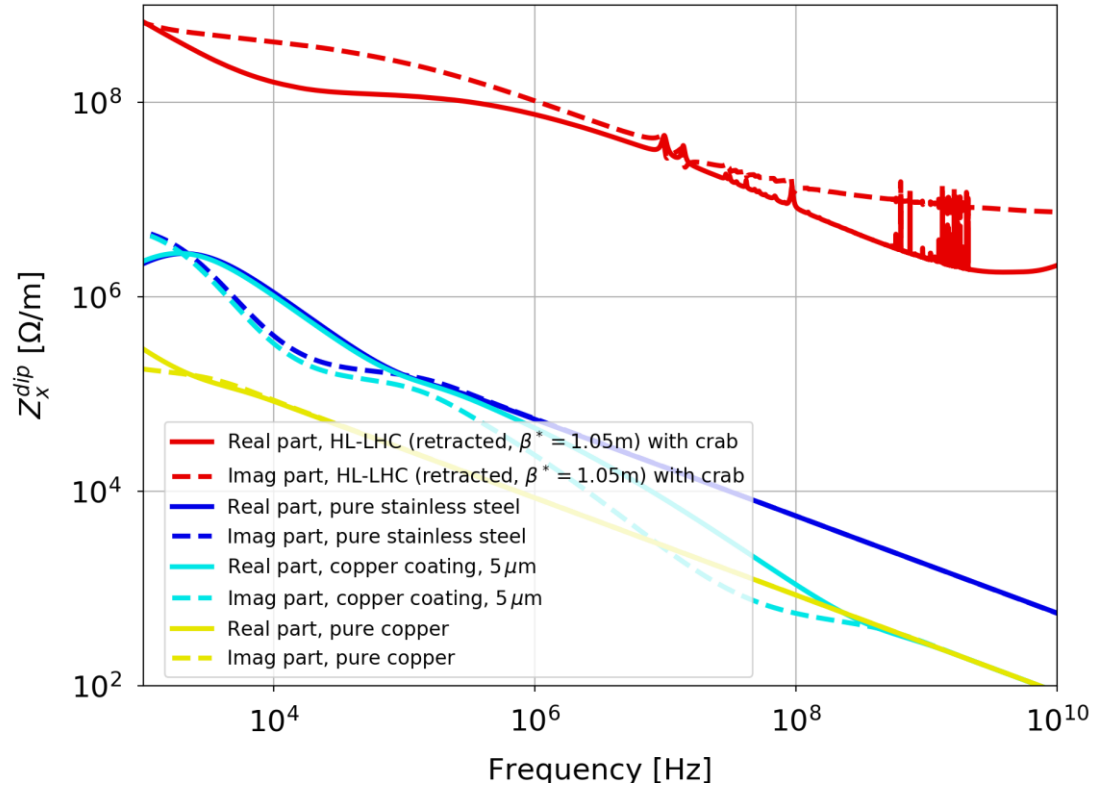
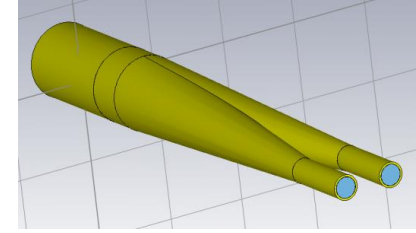
Using a thin copper layer:

- The factor 6 to 7 with respect to bulk stainless steel is maintained at high frequencies
 - $f > 100$ MHz for 5 microns layer
 - $f > 10$ MHz for 20 microns layer
- Lower factor at lower frequencies

Removing copper layer on conical chamber

- Small length
- Large effective diameter
- Small impact

Impedance impact of removing copper layer



→ As expected, Y chamber contribution very low compared to HL-LHC impedance model for all frequencies at the most critical moment for instabilities (just before collisions)

→ As expected, very low impact on HL-LHC beam stability (tiny length compared to the full LHC)

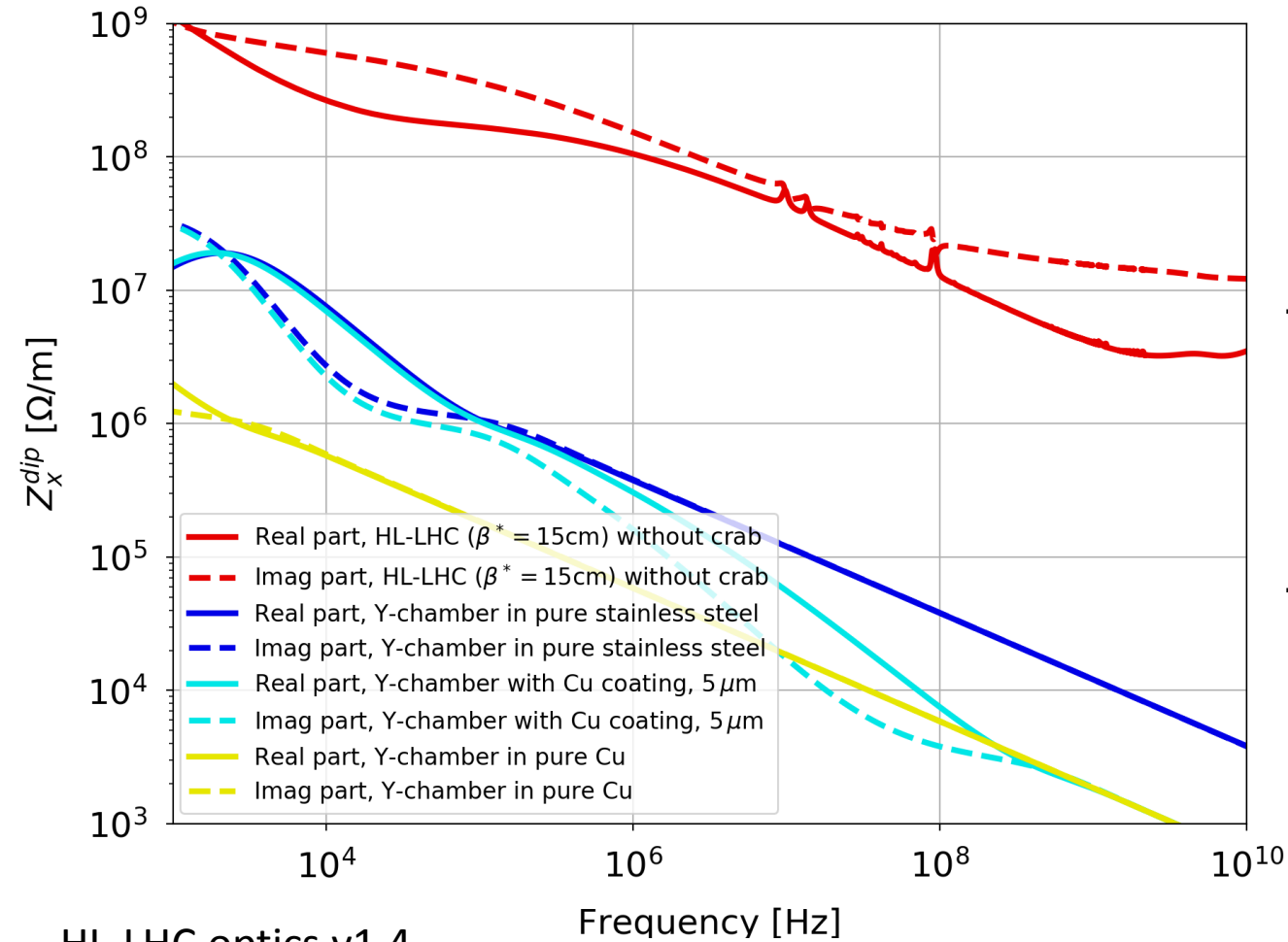
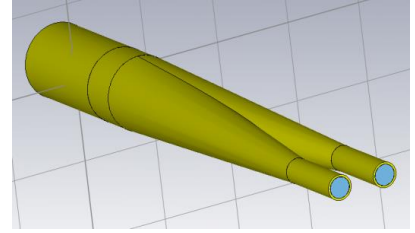
HL-LHC optics v1.5

$\beta^* = 1.05\text{ cm}$

$\langle \beta \rangle$ at Y chambers = 935 m

4 Y chambers of 3.4 m

Impedance impact of removing copper layer



→ Even for the largest β -function at the Y chambers (reached at the very end of levelling), Y chamber contribution remains very low compared to HL-LHC impedance model

→ As expected, very low impact on HL-LHC beam stability

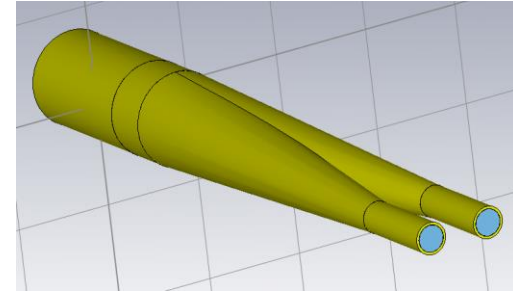
HL-LHC optics v1.4

$\beta^* = 15\text{ cm}$

$\langle\beta\rangle$ at Y chambers = 6392 m

4 Y chambers of 3.4 m

Impedance impact of removing copper



- Very low impact on impedance and stability
- However, impedance is clearly not optimized for that geometry (by a large factor)
- IWG can understand that impedance is not optimized when there are good reasons
- Here:
 - Simple pipe geometry
 - If we waive the need for copper facing the beam for this case, why should any future LHC or HL-LHC pipe respect this need?
 - If there is a valid reason for not coating/plating, copper coating/plating should not have been considered a valid alternative to replace copper from the beginning.
 - The impedance of the LHC chambers would be more optimized than the impedance of the HL-LHC chambers despite the clear increase in criticality from all points of view (intensity and beta function)

IWG cannot decide to accept or refuse that request and wonders why the specifications cannot be respected in this case.