

Follow-up of impedance open actions (triplet BPMs, beam screen design, unshielded vacuum valves for 11 T dipoles)

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All this is followed up in the
Impedance WG (**BenoitS**)

+ Updates on

- ◆ **New (back-up) RF fingers**
- ◆ HL-LHC stability limit with IR3 CFC collimators (instead of Mo coated Mo-Gr collimators as in IR7)
- ◆ **Crab Cavities**
- ◆ **Others**

TRIPLET BPMs

- ◆ Past discussion at 28th HiLumi WP2 Task Leaders Meeting on 23/05/2014
- ◆ Trials for striplines design for BI, but ThibautL informed us that design is changing (no tungsten anymore)... Nothing we can do for the moment... BenoitS is in close contact with ThibautL

BEAM SCREEN DESIGN (1/4)

- ◆ TE-VSC meeting on 24/02/15, where CarloZ presented “Impedance considerations on the aC coating of the LHC beam screen” (<https://indico.cern.ch/event/374692/contribution/2/material/slides/7.pdf>)

Why the imaginary part depends on the aC coating?

- Case without aC coating

- 1 layer structure
- 1st layer (Cu)

- Case with aC coating

- 2 layer structure
- 1st layer (aC)
- 2st layer (Cu)

From transmission line theory one can derive the surface impedance seen by the beam

$$\zeta_m = \zeta_{Cu}$$

$$\begin{aligned} \zeta_{Cu} < \zeta_{aC} \\ \delta_{aC} \gg s_{ac} \\ \omega \epsilon_0 \epsilon_r' \ll \sigma_{el(aC)} \end{aligned}$$

$$\zeta_m = \zeta_{Cu} + j\omega \mu s_{ac}$$

Coating thickness

The aC coating introduces an additional contribution to the imaginary impedance

BEAM SCREEN DESIGN (2/4)

- ◆ Then, NicolaasK sent us the most representative scenarios for LHC Runs 3 and 4 in the table below (info received this Monday)

=> Should use conservative values of 100 nm of Ti + 500 nm of aC

Ti & aC coating scenarios for impedance calculations

Beam screen configuration	LS2	CONS option		HL-LHC baseline	
		Run3	LS3	Run4	
LSS 2 & 8 - Existing IT, Q4/D2, Q5, Q6		Ti/aC coating		Ti/aC coating	
LSS 1 & 5 - Existing IT, Q4/D2, Q5, Q6		Ti/aC coating			
LSS 1 & 5 - New IT, Q4/D2, Q5, Q6				Ti/aC coating	

BEAM SCREEN DESIGN (3/4)

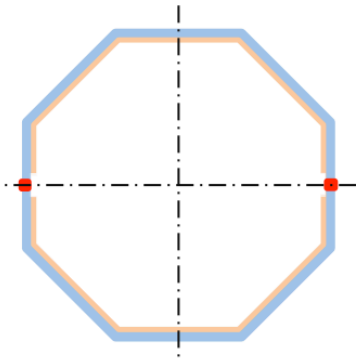
- The new design beam screens for IR1 & 5 will most likely have **2 longitudinal welds and may have a transverse weld every 3 m**
- The copper has to be locally removed from the weld zone to avoid welding defects (various geometries under consideration on next slide)
- The retained geometry will depend on technical feasibility and cost, but also taking into account important aspects like the impedance => **Feedback to be given (ongoing)**

BEAM SCREEN DESIGN (4/4)

N.Kos
03-03-2015

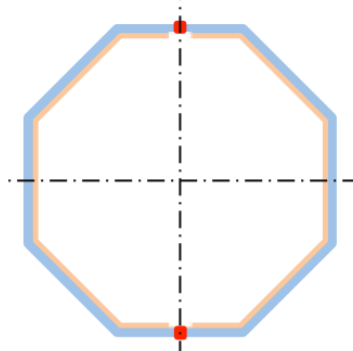
Longitudinal weld position in HL-LHC IT and LSS beam screens

- Width limitations for the production of co-laminated strip may imply two longitudinal welds along the full beam screen length.
- To avoid interference with the welding process, the copper has to be locally removed from the welding zone over a width of up to $2 \times 2 = 4$ mm.



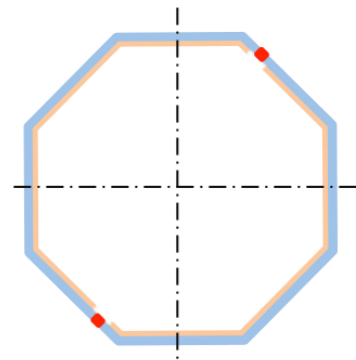
Variant 1D:

- Double weld on horizontal axis
- Copper removed over ≤ 4 mm width



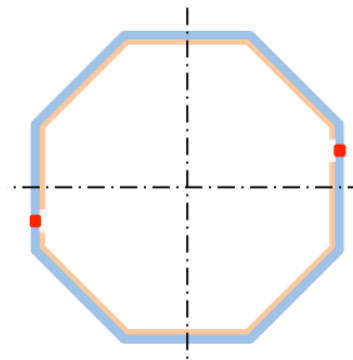
Variant 2D:

- Double weld on vertical axis
- Copper removed over ≤ 4 mm width



Variant 3D:

- Double weld, off-set by 11.25° from 45° axis
- Copper removed over ≤ 4 mm width



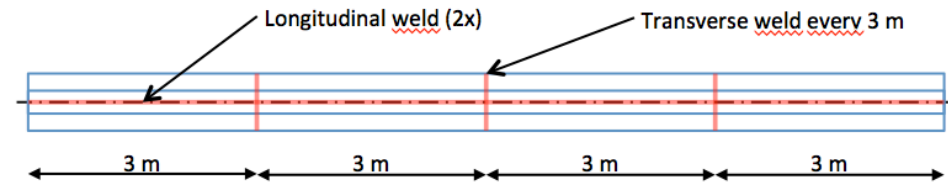
Variant 4D:

- Double weld, off-set by 11.25° from horizontal axis
- Copper removed over ≤ 4 mm width

N.Kos
06-03-2015

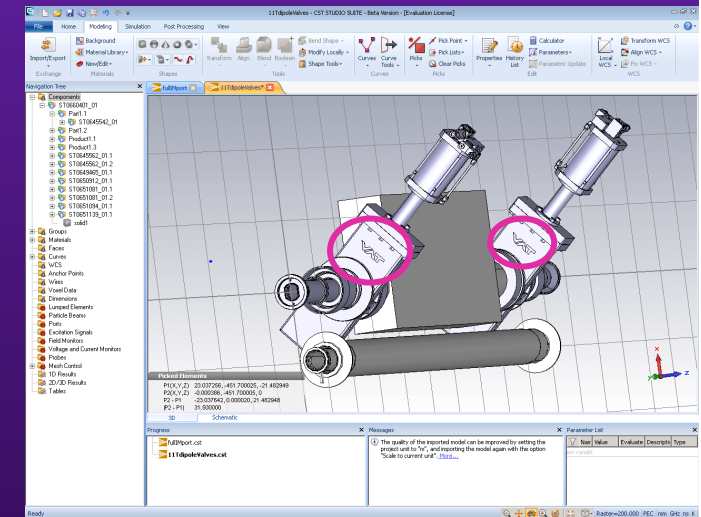
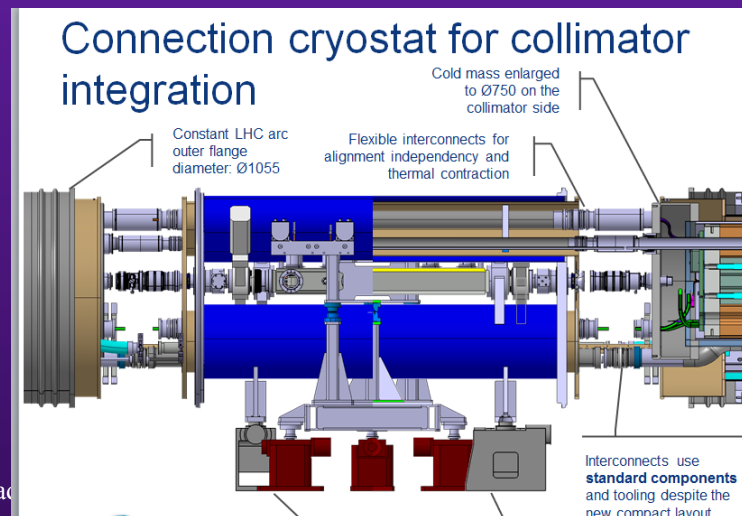
Transverse welds in HL-LHC IT and LSS beam screens

- Manufacturing tooling limitations may imply that beam screens will have to be built up from longitudinal sections with unit lengths of 3 m, connected with transverse welds along the full beam screen perimeter.
- To avoid interference with the welding process, the copper will have to be locally removed over $2 \times 2 = 4$ mm from the welding zone (as for the longitudinal welds).



UNSHIELDED VACUUM VALVES FOR 11 T DIPOLES

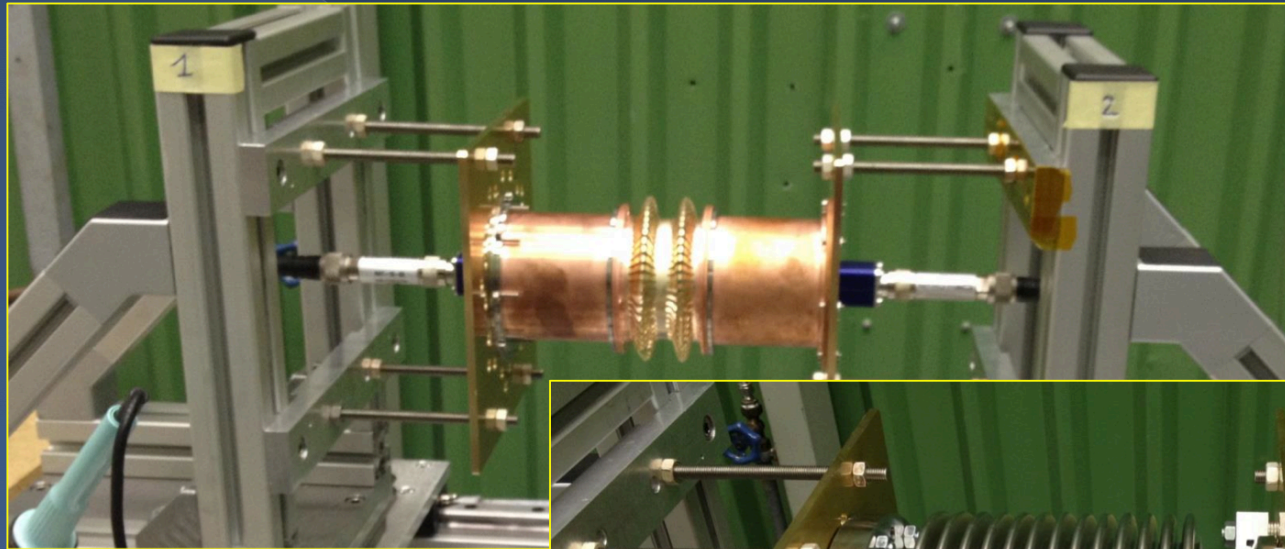
- ◆ Question for us: is RF shielding of sector valves really needed? (they anticipated a yes...)
- ◆ Deadline: May 2015
- ◆ Current status
 - 3D model available, but inside of VAT sector valve missing
 - From work from Jose Varela for SPS sector valves, it is likely that the RF fingers are needed
 - Info from GianluigiA yesterday: **A solution (with shielding) has been found => Great!**



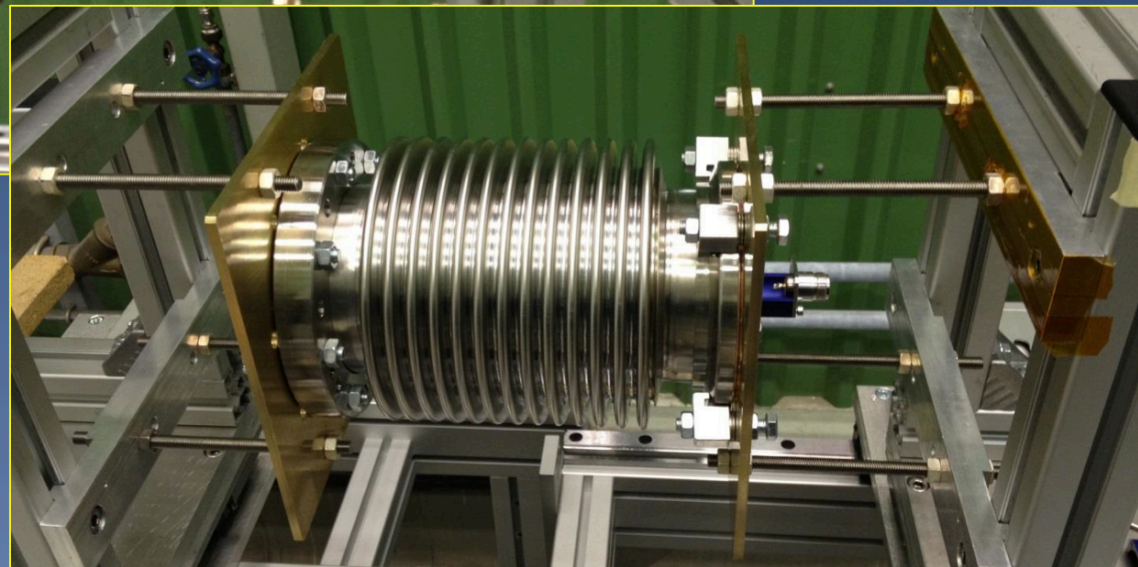
NEW (BACK-UP) RF FINGERS (1/4)

- ◆ **Talk from ChristineV about the “Outcome of measurements for the new backup RF fingers”**: <https://indico.cern.ch/event/358583/contribution/2/material/slides/1.pdf>

*The structure WITH the outer bellow becomes “coaxial line like”
→ We expected to see resonances when the outer bellow is mounted.*



Wire measurement is
“standard”, i.e.:
0.5 mm wire
diameter and
matching resistors.

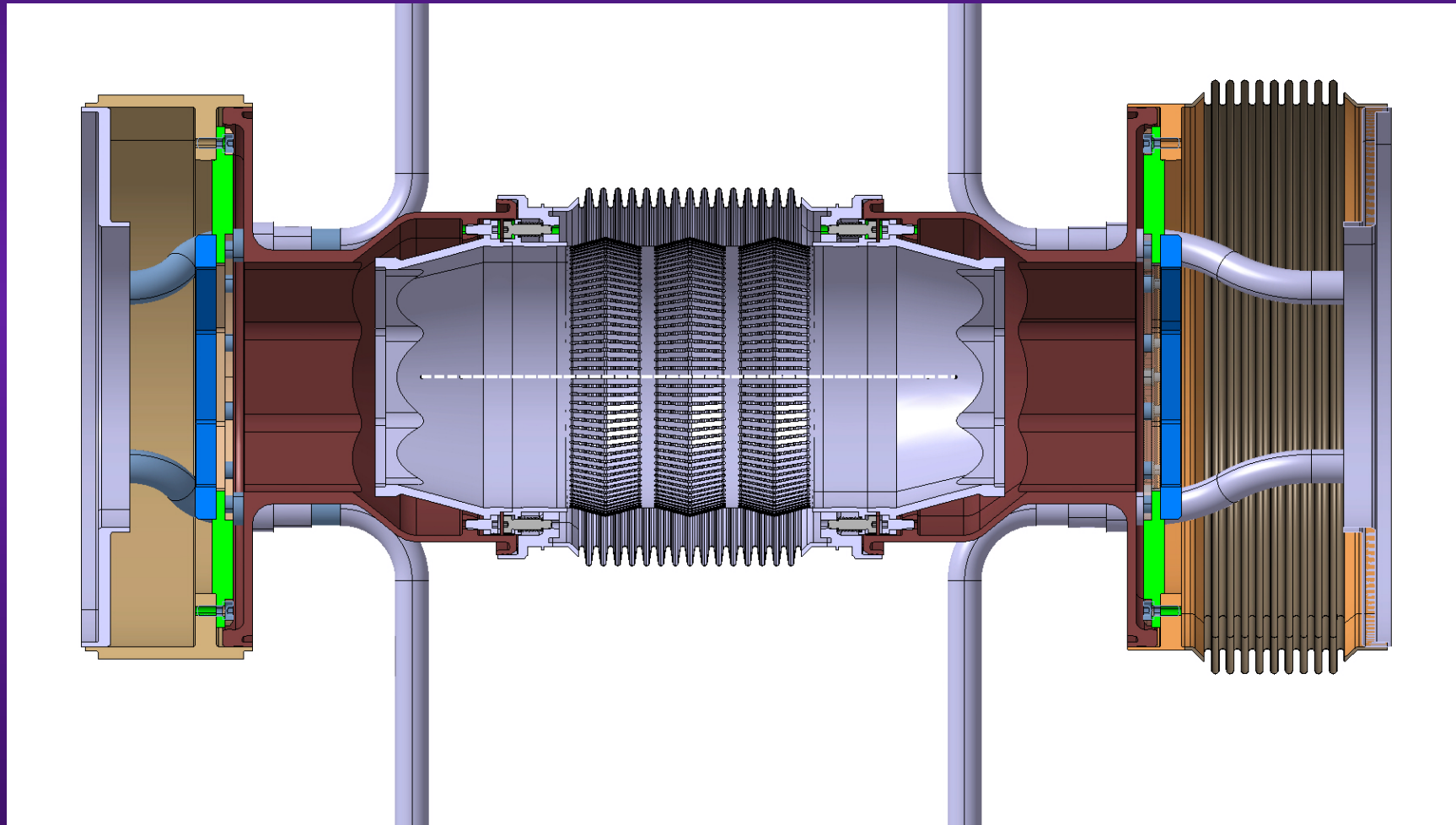


NEW (BACK-UP) RF FINGERS (2/4)

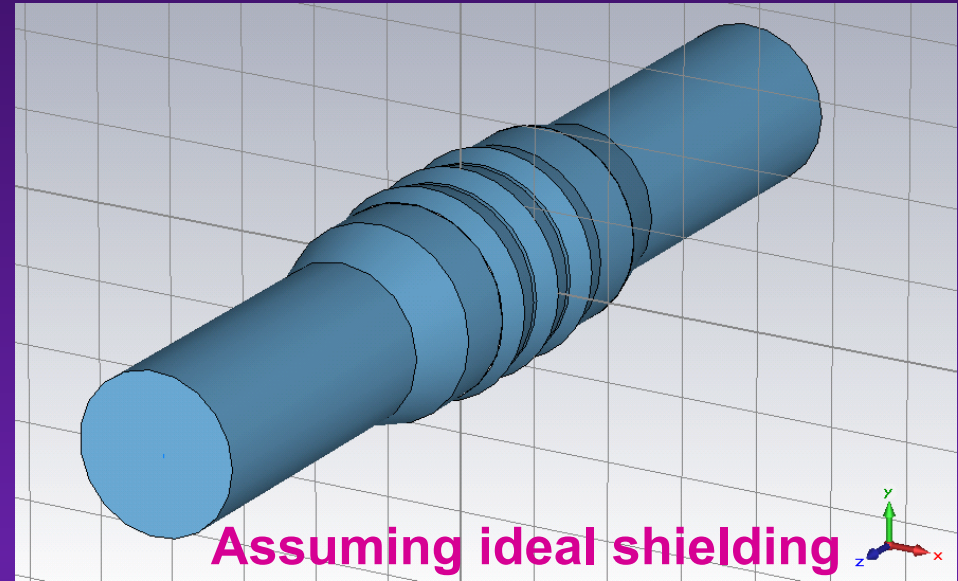
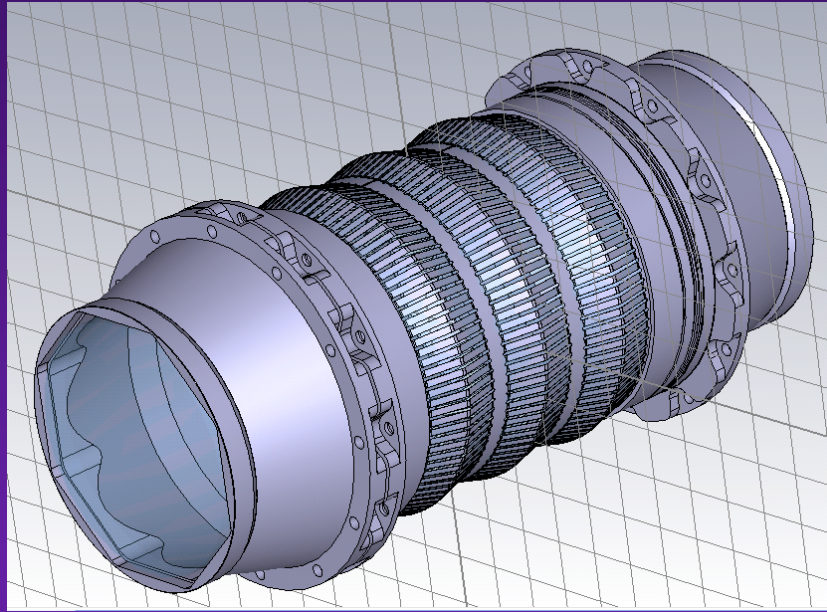
- ◆ The pb is the EM leak through the fingers at the convolutions (leading to important resonances with the bellow)
- ◆ **Reminder:** Initially these new (back-up) RF fingers were considered to be used only around collimators (to replace the old VMTSA with long RF fingers + spring, with which some pbs have been observed)
- ◆ **The large resonances with bellow could give serious implications on the RF fingers applicability and in particular a large betas (triplets) => CedricG mentioned that 20 such equipment could be installed in the LHC (5 / IP side)... To be followed-up / optimized**
- ◆ **Simulations are ongoing in order to confirm the measurements. If understood, one could envisage some mitigation measures (reminder: cold and radiation area)**

NEW (BACK-UP) RF FINGERS (3/4)

- ◆ BenoitS started simulations with the geometry sent by CedricG last week

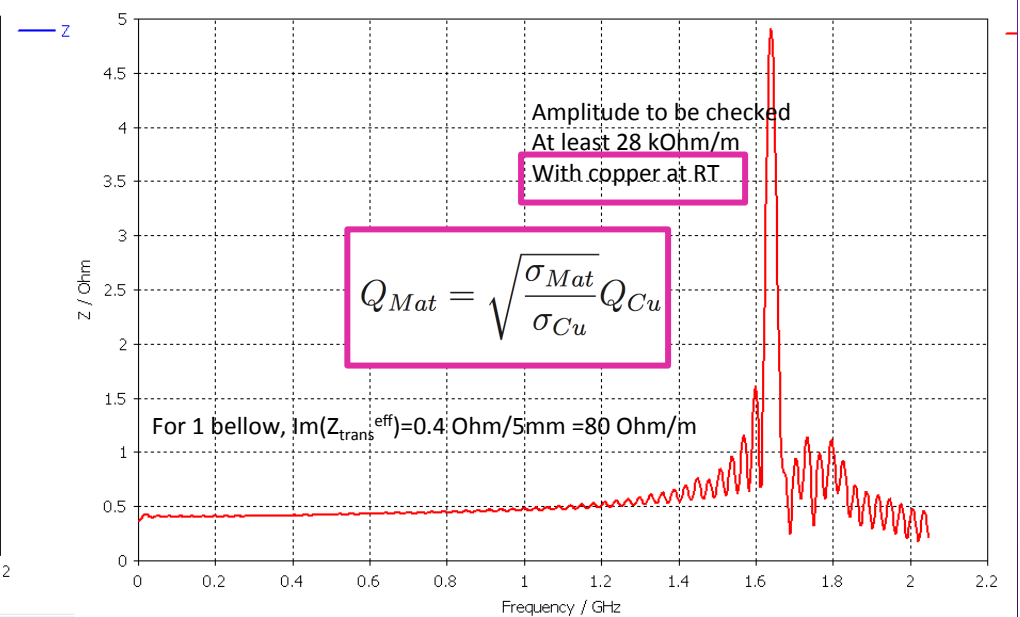
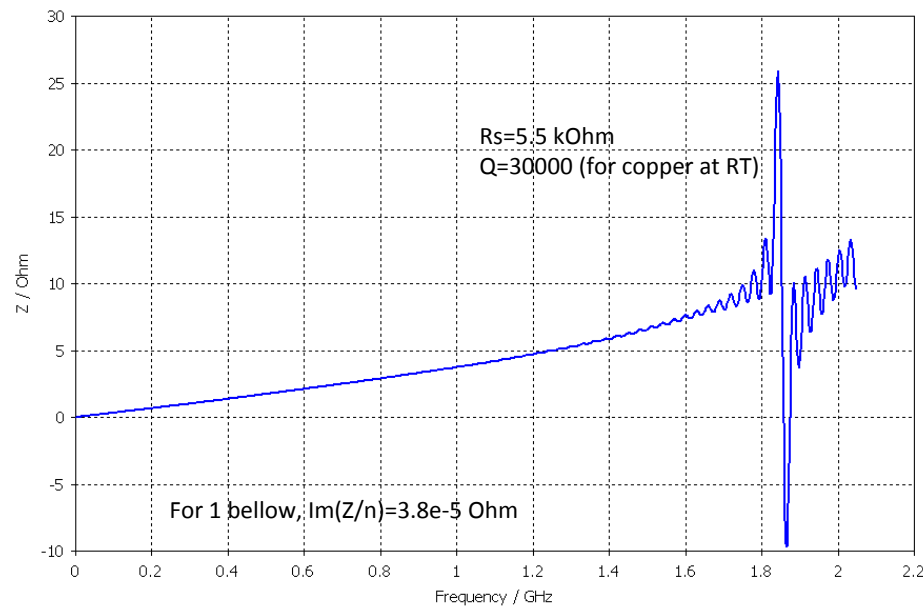


NEW (BACK-UP) RF FINGERS (4/4)



Wake impedance Z [Imaginary Part]

Wake impedance X [Magnitude]



HL-LHC STABILITY LIMIT WITH IR3 CFC COLLIMATORS

- ◆ **At the KEK workshop in November 2014, we considered that both IR3 and IR7 CFC collimators will be replaced by Mo-coated Mo-Gr collimators**
- ◆ **Request from StefanoR to study also the case keeping the IR3 CFC collimators => Analysis ongoing (Nicolo) and results should be sent to StefanoR next Tuesday**

CRAB CAVITIES

- ◆ **Computations done in terms of transverse kick factors (NicoloB: <https://indico.cern.ch/event/377643/contribution/1/material/slides/0.pdf>) => Still under (other) checks: Order of $\sim 1 \text{ V} / \text{pC mm}$**
- ◆ **Crab Cavity HOM Coupler Design & Fabrication Review II, US, on 25/02/15: <http://indico.cern.ch/event/371427/timetable/#20150225.detailed>**
- ◆ **2 infos from RamaC (through BenoitS on 12/03/15)**
 - The modes have been confirmed by an independent benchmark (initially there was a disagreement)
 - One should consider that 1 IP will have 1 type of Crab Cavity and the 2nd IP will have the other type of Crab Cavity
- ◆ **Task 2.4 (and 2.7) meeting next Wednesday to review all the past recommendations for the impedance of the Crab Cavities + update the list of modes to be considered**

OTHERS

◆ LHCb VELO

- **VELO Upgrade RF Foil Workshop (LHCb) at CERN from 05/02/15 to 06/02/15: <https://indico.cern.ch/event/367805/>**
- **Talk from OlgaZ: <https://indico.cern.ch/event/367805/session/0/contribution/3/material/slides/1.pdf>**
- **Longitudinal impedance $\text{Im}(Z/n) \sim 5\%$ of full LHC (instead of 1% now). Impact on transverse smaller thanks to low beta***

◆ Stochastic cooling => New design by LarsT

◆ Impact of radiation on conductivity of materials => Tolerance limit?

◆ Hollow E-lens => Waiting for 1st design

◆ New TDI (waiting for first design) => Proposal to split the jaw in 3 for mechanical reason but it is not optimal for impedance (more transitions) => With OscarF and MikhailZ

◆ MKI => MKI Strategy Meetings where BenoitS goes (e.g. yesterday <http://indico.cern.ch/event/378612/>): some degree of freedom on the length of the overlap between screen conductors and metallic coating