Simulations of the HL-LHC octagonal beam screens: effect of shape and weld

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Acknowledgments: N. Kos, E. Métral, G. Rumolo, B. Salvant

Overview

- Model
- Definition of the factors
- Simulation results
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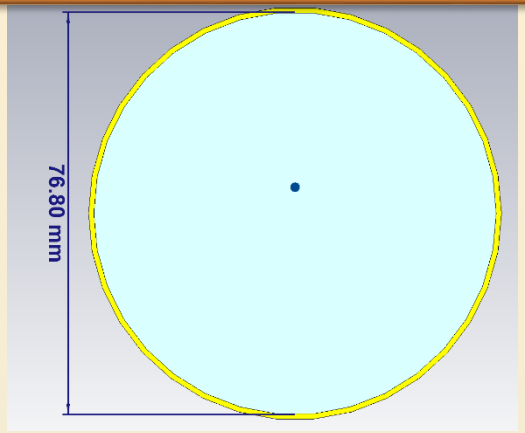
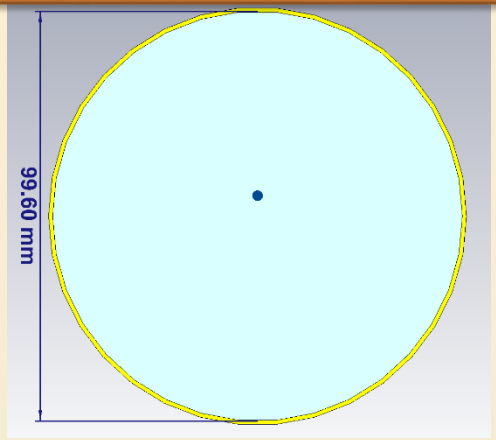
CST model

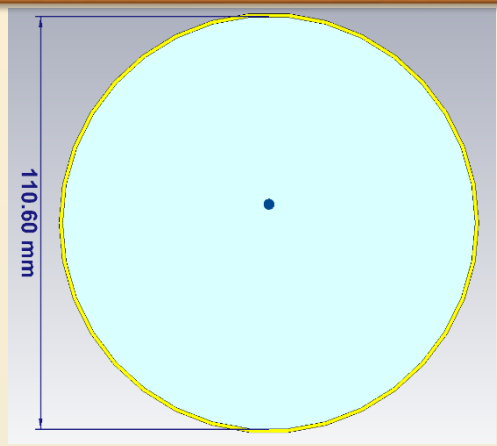
BS_88(D2): reference



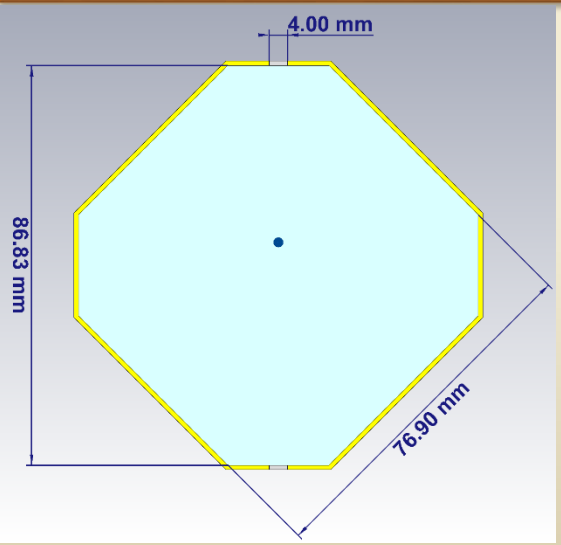
BS_101(Q1): reference



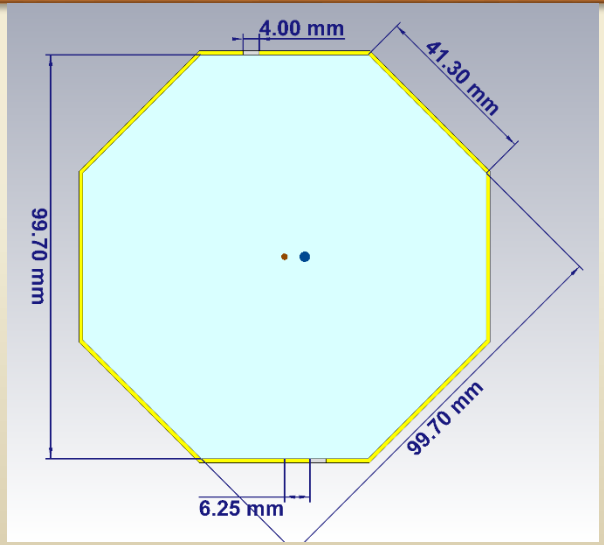
BS_121(Q2-Q3-CP-D1):reference



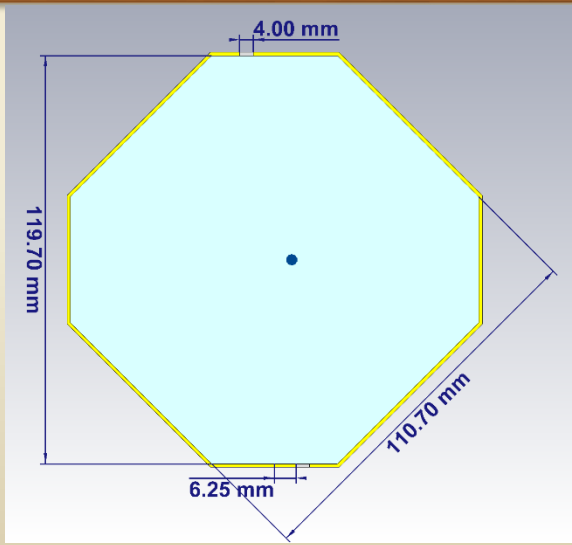
BS_88(D2): realistic



BS_101(Q1): realistic



BS_121(Q2-Q3-CP-D1):realistic



$\rho_{Cu} = 7.55 \times 10^{-10}\ \Omega\, m$
$\rho_{SS} = 6.0 \times 10^{-7}\ \Omega\, m$

$\rho_{Cu} = 2.65 \times 10^{-9}\ \Omega\, m$
$\rho_{SS} = 7.2 \times 10^{-7}\ \Omega\, m$

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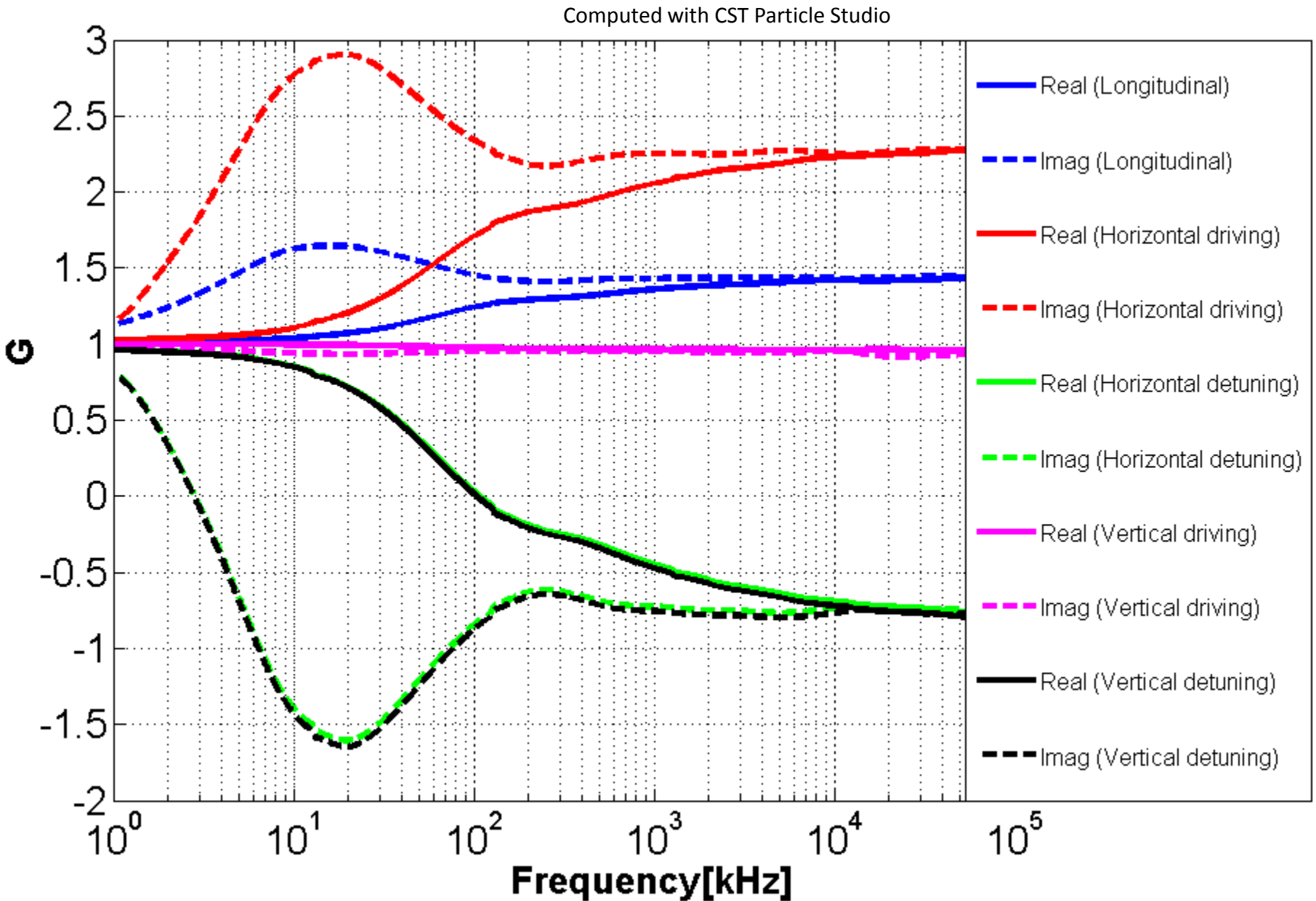
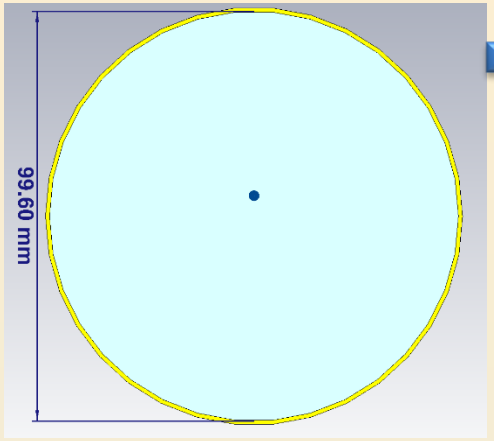
The LHC beam screen: effect of the weld



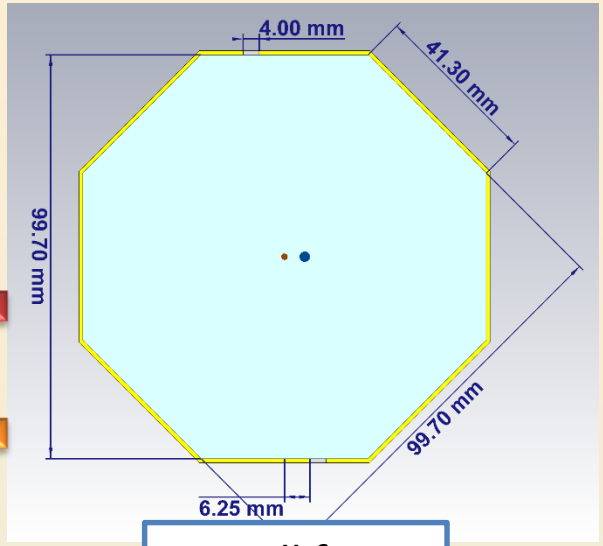
Definition of the form and weld factors



$Wake_{ref}^{BS\_101}$

$Wake_{weld}^{BS\_101}$

$Wake_{oct}^{BS\_101}$



Form factor

$$F_{BS\_101} = \frac{Wake_{oct}^{BS\_101}}{Wake_{ref}^{BS\_101}}$$

Weld factor

$$W_{BS\_101} = \frac{Wake_{weld}^{BS\_101}}{Wake_{oct}^{BS\_101}}$$

Overall factor

$$G_{BS\_101} = \frac{Wake_{weld}^{BS\_101}}{Wake_{ref}^{BS\_101}}$$

All factors are defined with respect to the vertical driving impedance

$$G_{BS\_101} = W_{BS\_101}\, F_{BS\_101}$$

S. Heifets, A. Wagner, B. Zotter. *Generalized Impedances and Wakes in Asymmetric structures*

Generalized expansion of transverse wake/impedance at the first order

$$W_x(s) = c_{10} + x_0 c_{11} + 2x c_{20} - y_0 d_{11} - 2y d_{20}$$

$$W_y(s) = -d_{10} - x_0 d_{11} - 2x d_{20} - y_0 \bar{c}_{11} - 2y c_{20}$$

Coupling terms

Constant terms

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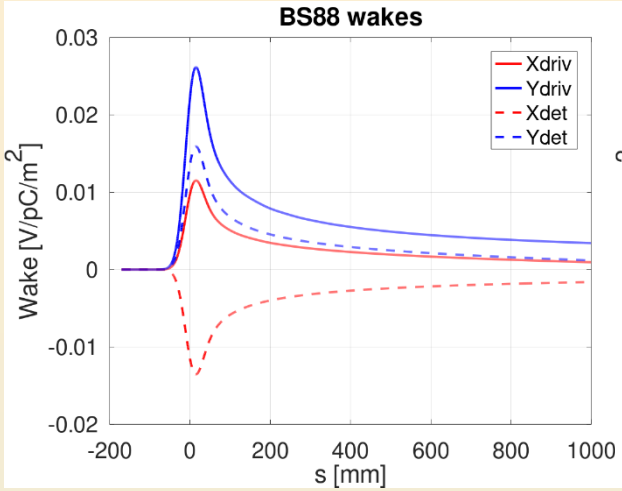
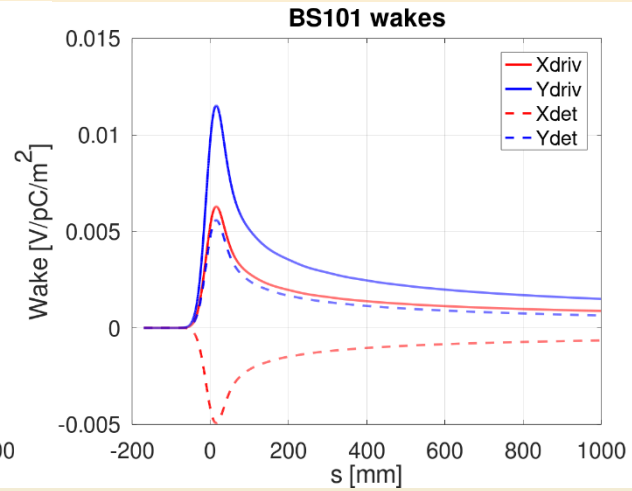
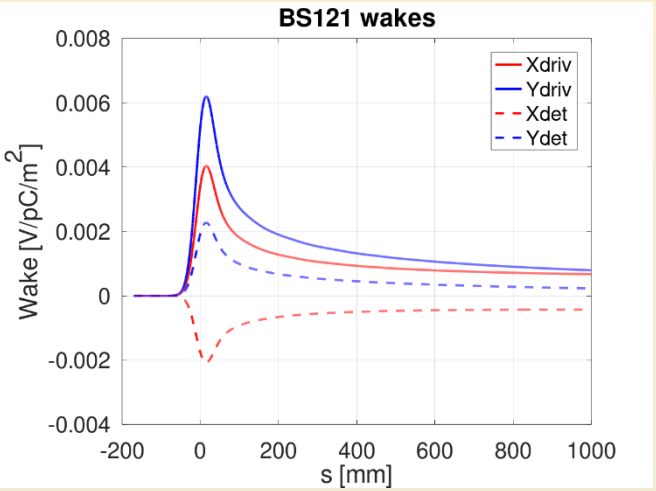
Simulation results



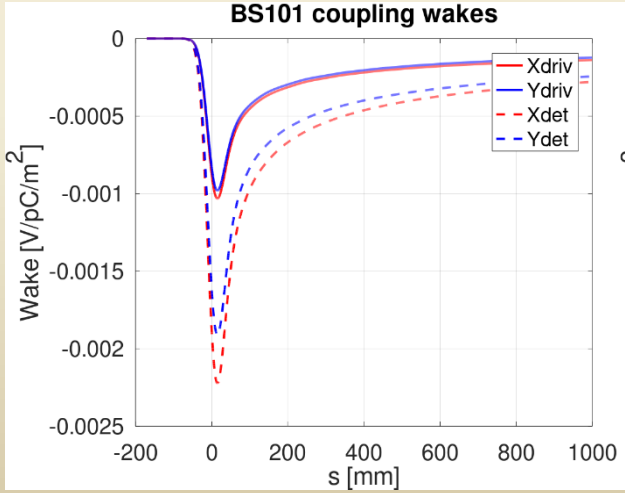


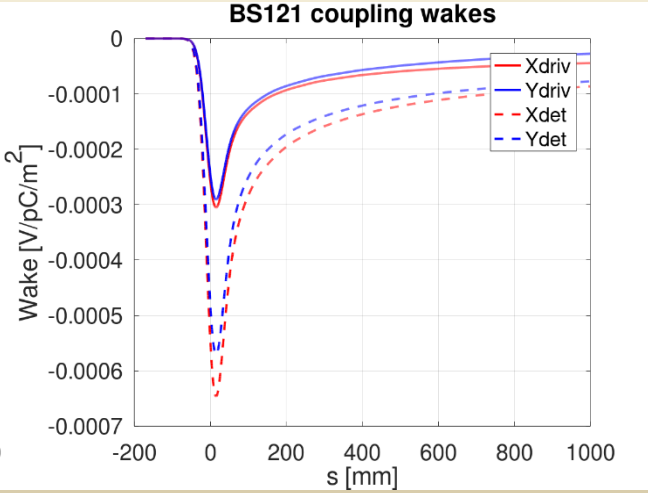


$$c_{10} + x_0 c_{11} + 2x c_{20} - y_0 d_{11} - 2y d_{20}$$

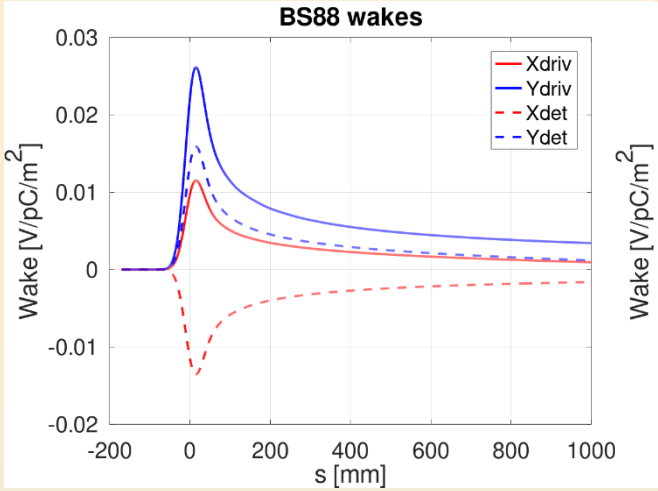
$$-d_{10} - x_0 d_{11} - 2x d_{20} - y_0 \bar{c}_{11} - 2y c_{20}$$

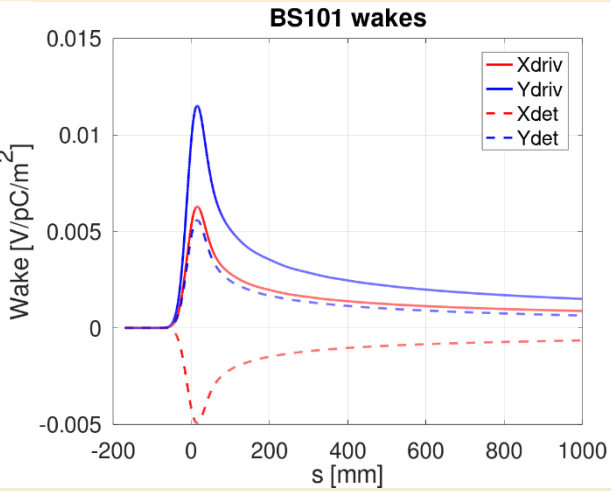
Coupling terms are all negatives
Xdriv=Ydriv and Xdet=Ydet

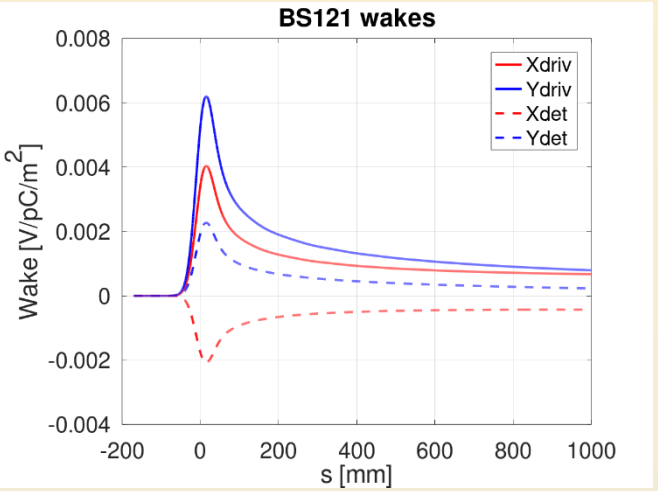


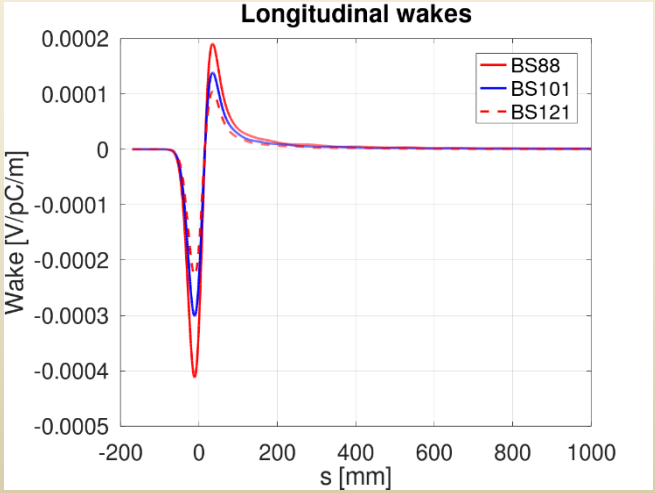


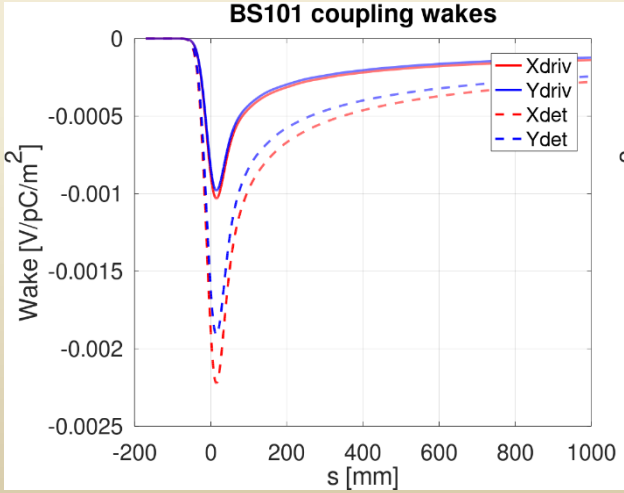
Simulation results

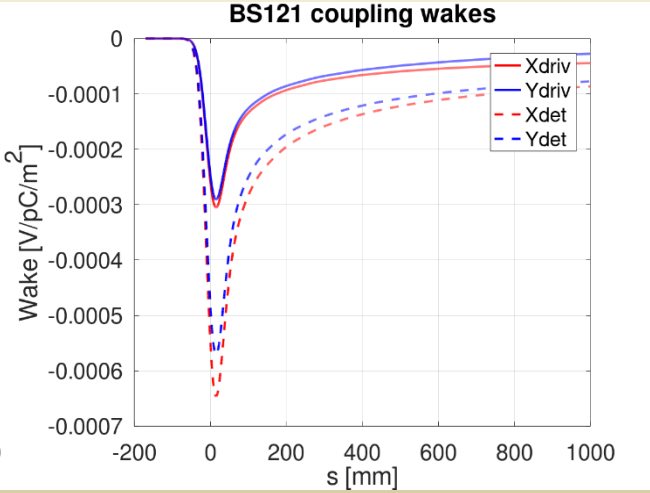




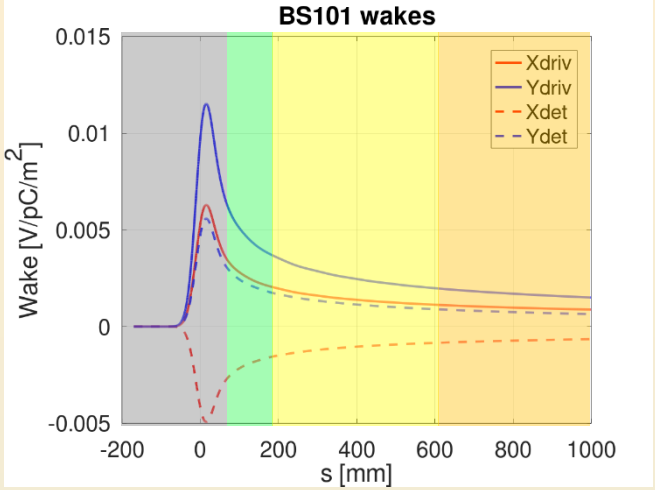


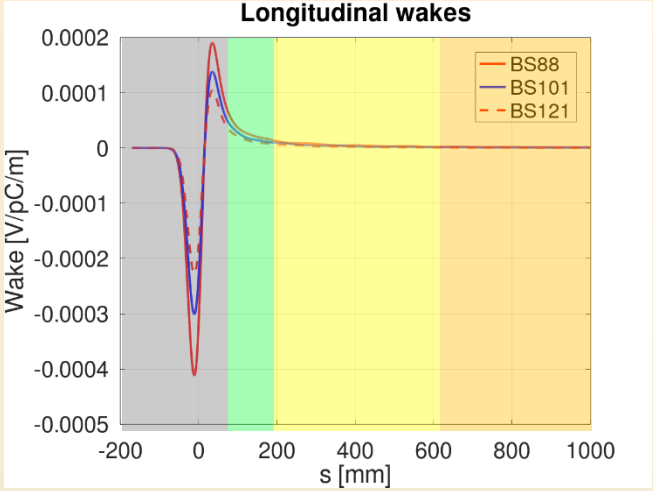


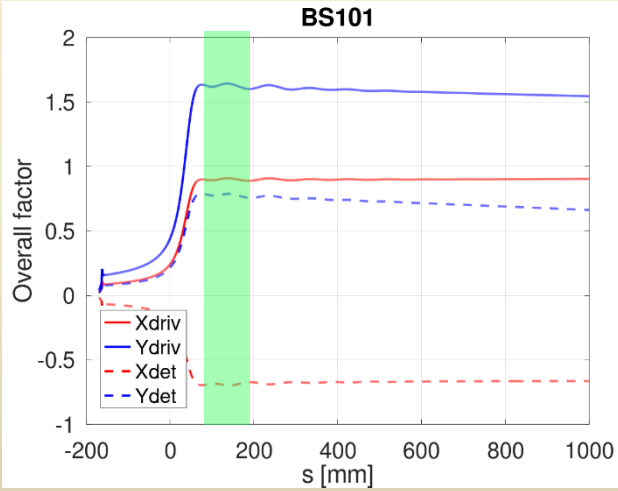


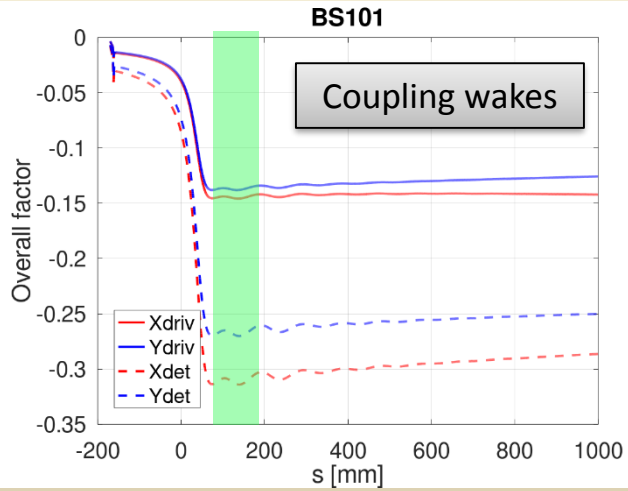


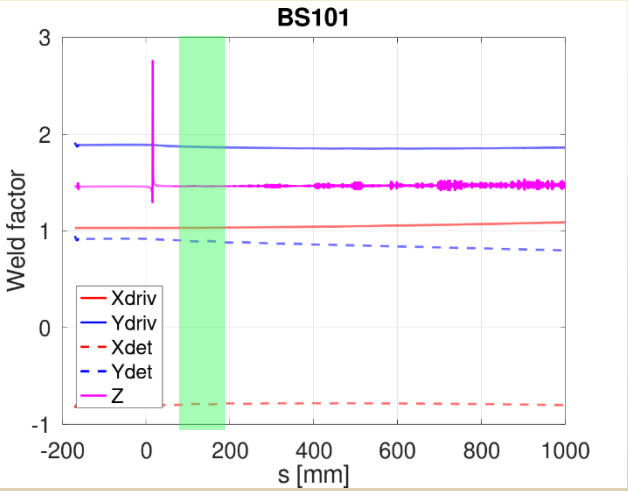
Simulation results











Factors are defined in the green area where the simulation is expected to have the higher reproducibility

Weld factors are more accurate since are obtained using exactly the same discretization of the domain of calculus

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Summary table of all factors

Factor	BS88	BS101	BS121
Wxdriv	0.98966	1.032	1.0172
Wydriv	2.2307	1.8726	1.5425
Wxdet	-1.1364	-0.79581	-0.51968
Wydet	1.3255	0.89992	0.55881
Wz	1.6343	1.4569	1.2853
Gxdriv	0.72855	0.89452	0.8587
Gydriv	1.6422	1.6231	1.3022
Gxdet	-0.83659	-0.6898	-0.43872
Gydet	0.97578	0.78005	0.47175
Gz	1.5942	1.36	1.0738
Gcxdriv	-	-0.14438	-0.063557
Gcydriv	-	-0.1368	-0.060006
Gcxdet	-	-0.31057	-0.13479
Gcydet	-	-0.26701	-0.11903

Summary table of all factors: enforcing impedance symmetries

Factor	BS88	BS101	BS121
Wxdriv	0.98966	1.032	1.0172
Wydriv	2.2307	1.8726	1.5425
Wxdet	-1.2309	-0.84787	-0.53924
Wydet	1.2309	0.84787	0.53924
Wz	1.6343	1.4569	1.2853
Gxdriv	0.72855	0.89452	0.8587
Gydriv	1.6422	1.6231	1.3022
Gxdet	-0.90619	-0.73493	-0.45524
Gydet	0.90619	0.73493	0.45524
Gz	1.5942	1.36	1.0738
Gcxdriv	-	-0.14059	-0.0618
Gcydriv	-	-0.14059	-0.0618
Gcxdet	-	-0.28879	-0.12691
Gcydet	-	-0.28879	-0.12691

Known symmetries

Coupling terms
Xdriv=Ydriv and Xdet=Ydet
Detuning terms
Xdet=-Ydet

Average between the two numerical factors

Enforcing symmetries

Conclusions

- Form factors with respect to the circular reference shape used in the present impedance model have been calculated
- The effect of the weld has been evaluated and expressed in terms of a weld factor.
- The coupling terms have been also estimated
- Time (frequency) dependent weld factors could be obtained using the simulation scaling technique if there is a strong interest in this sense.

Thank you for your attention