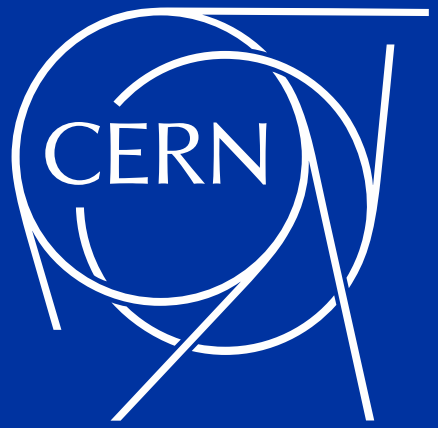

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Update of the transverse Proton Synchrotron impedance model

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Acknowledgments : N. Biancacci, E. Koukovini-Platia, S. Persichelli, B. Popovic, G. Rumolo, D. Ventura, C. Zannini

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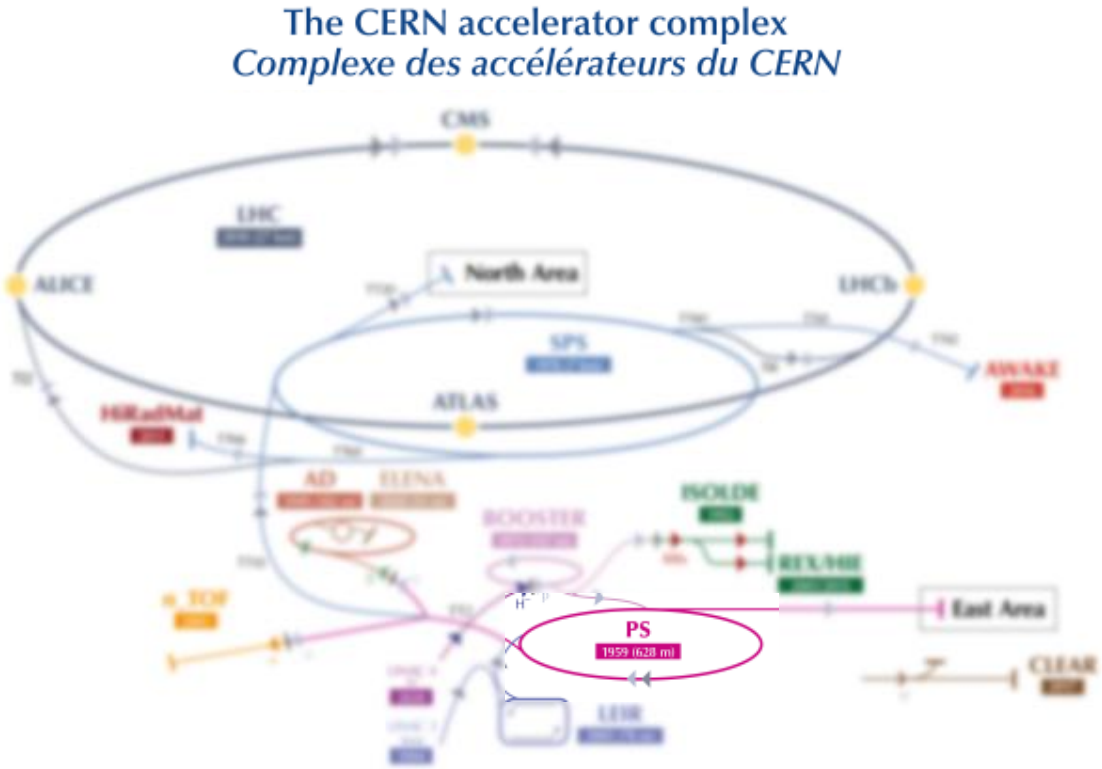
Introduction

In the framework of the Light Injector Upgrade project the CERN Proton Synchrotron (PS) has been upgraded to achieve a twofold increase in beam intensity and brightness. Major changes occurring during this upgrade need to be considered in the machine impedance model. An accurate impedance model is crucial to assess the impact of impedance on beam dynamics.

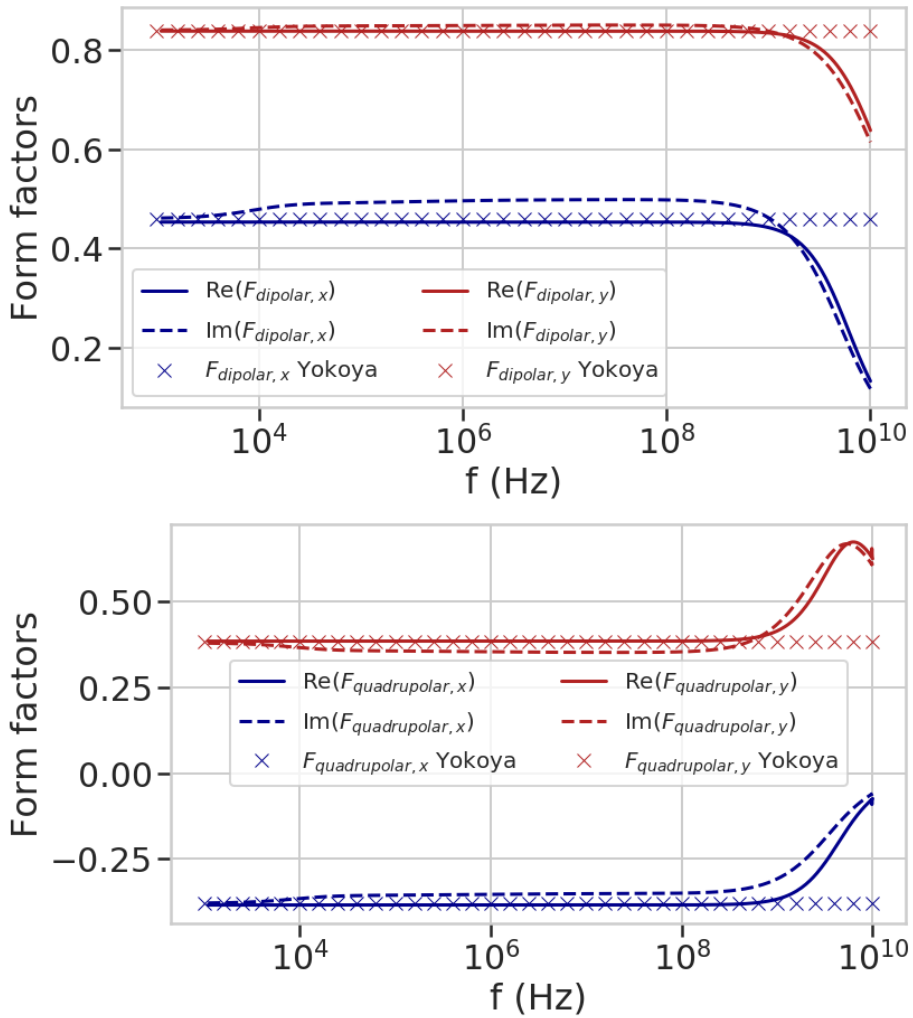
The largest source of impedance in the PS is the wall impedance from the elliptical beam pipe. Thanks to recent developments [1], it is now possible to compute the wall impedance of a multilayered beam pipe of any elliptic geometry in the non-relativistic case. This newly obtained wall impedance is used in the PS impedance model.



Elliptic wall impedance of a non-relativistic beam : going beyond Yokoya form factors

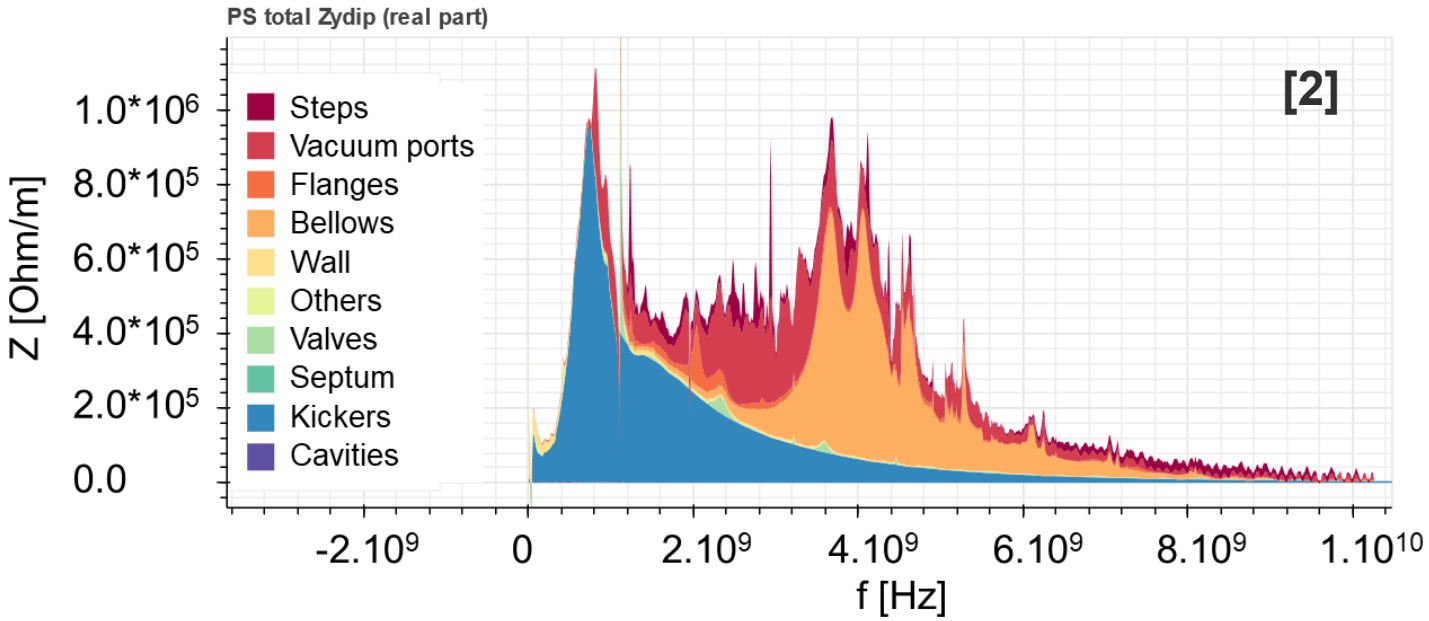
[1] can be used to derive generalized form factors valid for a non-relativistic beam and to study the validity of the usual Yokoya form factors.

- **Yokoya form factors are valid for an ultra-relativistic beam and only depends on the geometry of the beam pipe.**
- **Generalized form factors are valid for a non-relativistic beam and depends on the geometry, k_0 the wave number in free space, $\beta_{relativistic}$ and the frequency.**
- **Yokoya form factors remain valid for a non-relativistic beam until a threshold around 1 GHz.**

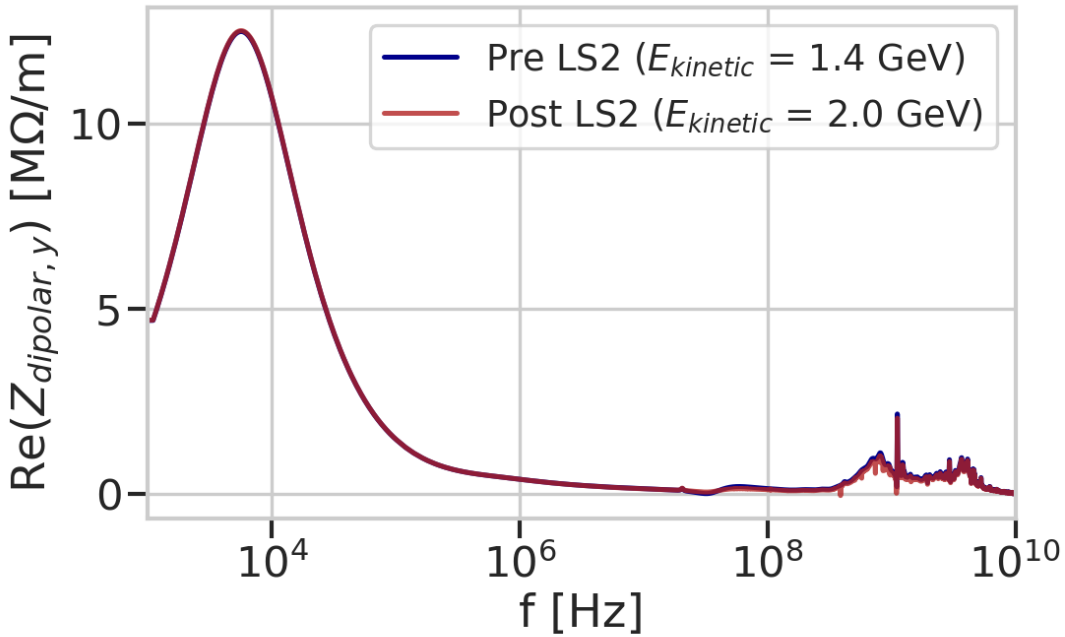


PS elliptical beam pipe of 73 mm horizontal and 35 mm vertical half axis with $\gamma_{relativistic}$ = 2.49.

PS impedance model and changes introduced by Long Shutdown 2



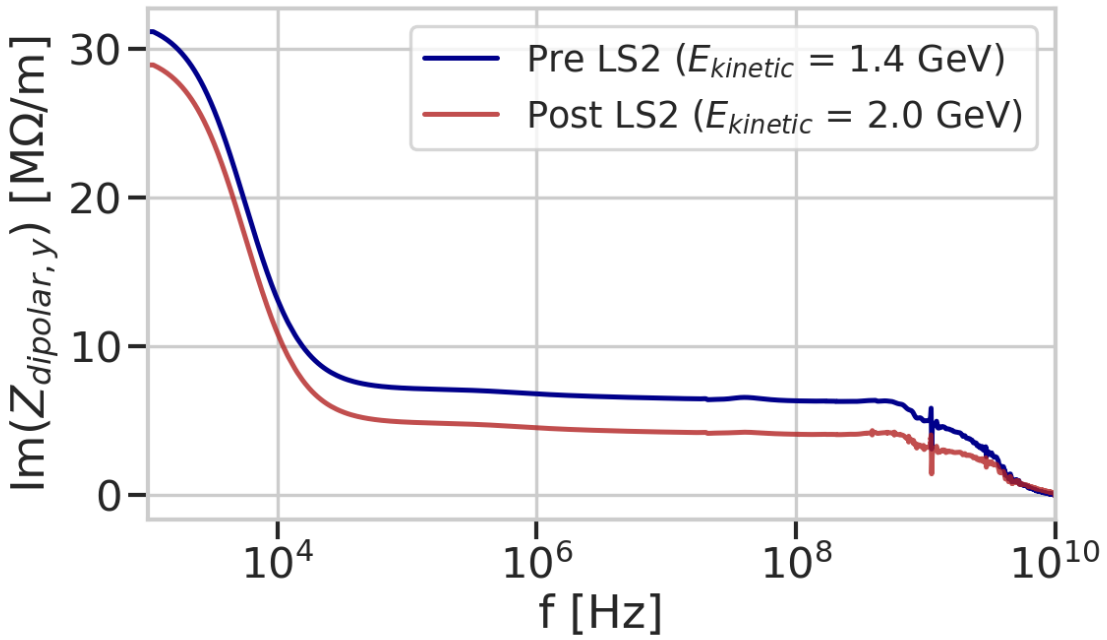
Frequency spectra of the real part of the impedance for different machine elements.



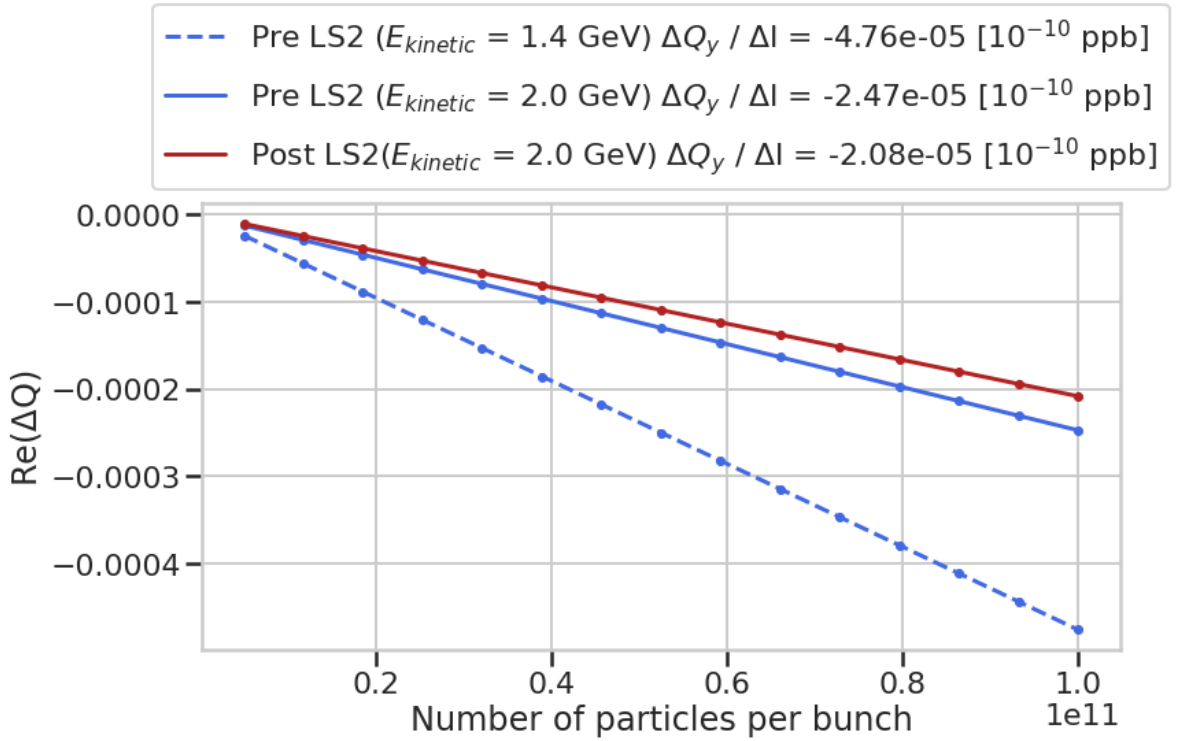
Real part of the vertical dipolar impedance pre and post LS2.

- **The Continuous Transfer equipment removal during LS2 has almost no impact on the real part of the impedance.**
- **Neither has the higher injection energy.**

Impact on vertical dipolar impedance and tune shifts



Imaginary part of the vertical dipolar impedance pre and post LS2.



Vertical tune shifts (computed with DELPHI Vlasov solver) with and without matching injection energy.

- **The higher injection energy has a stronger impact on the imaginary part of the impedance by reducing it by ~25%.**
- **The hardware modifications lead to ~15% smaller tune shifts. Whereas the higher injection energy results in a ~90% smaller vertical tune shift.**

Conclusion

- **Yokoya form factors use can be extended to non-relativistic beam given the $\beta_{relativistic}$ is close to 1 or low frequencies are computed.**
- **Pre and post LS2 impedance models remain similar. The LS2 hardware change effect on the impedance model is almost unnoticeable. However, the higher injected energy has a large beneficial effect on the wall impedance.**
- **Both the hardware change and the higher injected energy have a beneficial effect on the vertical tune shifts.**

References

[1] M. Migliorati, L. Palumbo, C. Zannini, N. Biancacci, and V.G. Vaccaro, "Resistive wall impedance in elliptical multilayer vacuum chambers", Phys. Rev. Accel. Beams,22:121001, Dec.2019

[2] S. Persichelli, "The beam coupling impedance model of CERN Proton Synchrotron", Ph.D thesis, Universita di Roma La Sapienza, Rome, Italy, 2015.