INFN

SAPIENZA UNIVERSITÀ DI ROMA

DIPARTIMENTO DI SCIENZE DI BASE E APPLICATE PER L' INGEGNERIA

FUTURE CIRCULAR COLLIDER
Innovation Study

Previous work on FCC-ee Booster collective effects

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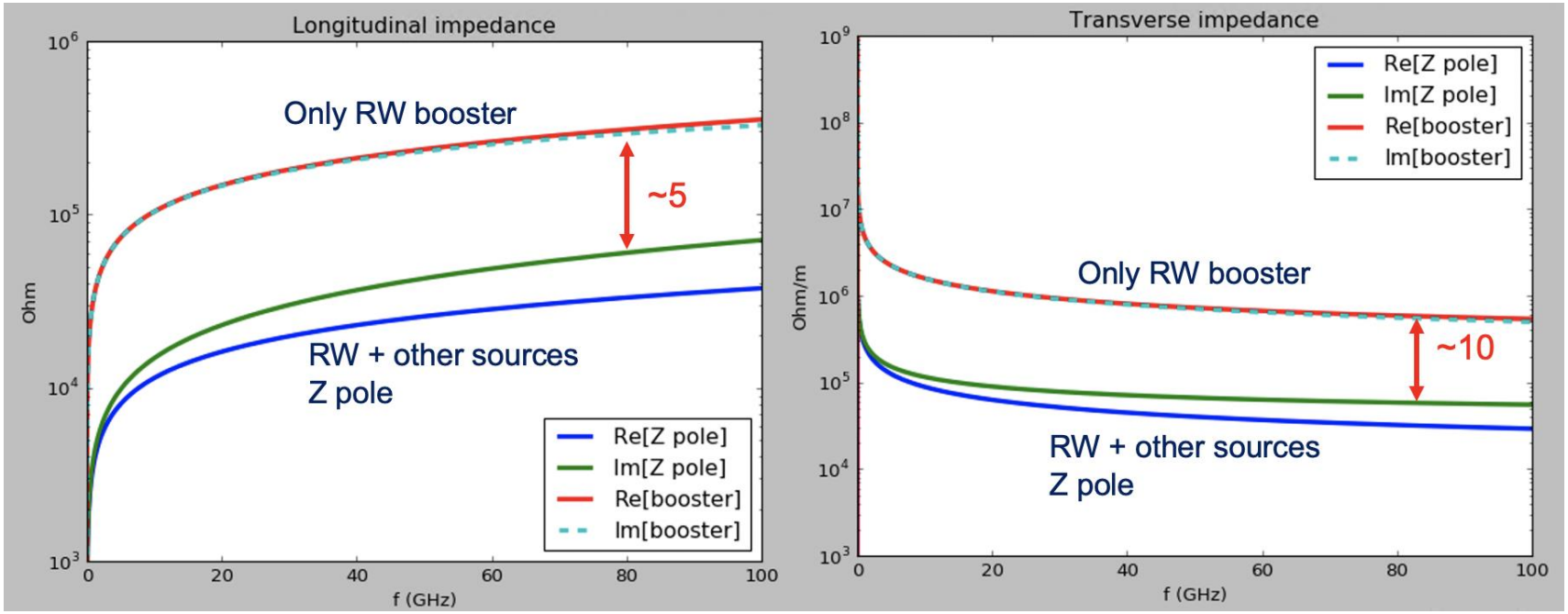
Parameter list comparison: Z-pole and booster (injection)

parameter	Z	Booster	
Beam energy (GeV)	45.6	20	
Bunch population [10^{11}]	1.7	.213	
Energy spread(SR/BS) [10^{-3}]	0.38/1.32	.166	
Energy loss/turn (MeV)	36.0	1.33	
RF frequency (MHz)	400	400	
RF voltage (MV)	100	60	
Arc optics		60° ph adv	90° ph adv
Mom compaction [10^{-6}]	14.8	14.8	7.27
Synchrotron tune	0.025	0.030	0.021
Bunch length [mm](SR/BS)	3.5/12.1	1.26	0.88

RW impedance in the Booster

- The main source of impedance for FCC-ee is the RW due to a copper beam pipe of 35 mm of radius
- For the booster the beam pipe is 25 mm and it is made of stainless steel
- The resistivity of stainless steel is 40 times larger than that of copper at room temperature.
- The longitudinal impedance is proportional to r^{-1}, and the transverse one to $r^{-3} \rightarrow$ for the booster we have a larger factor of 1.4 and 2.7 respectively.

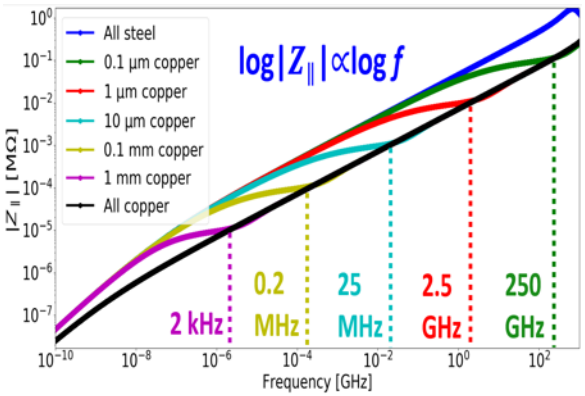


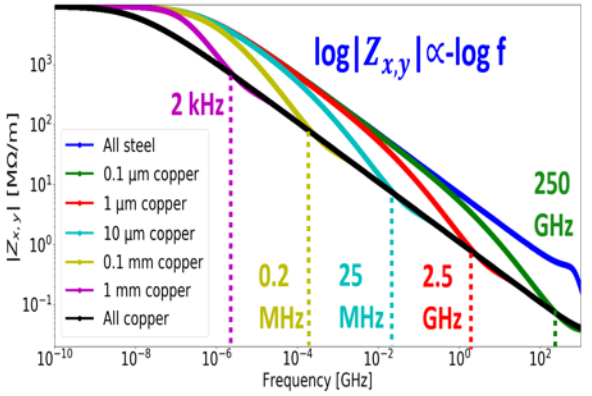
FCCee-Booster Beam Dynamics Studies

1) Simulated parameters

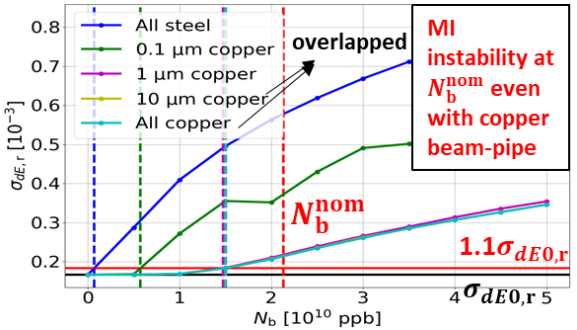
Parameters	Value
Machine circumference (C_r)	97.756 km
Beam energy at injection (E_0)	20 GeV
SR 1 σ rel. energy spread ($\sigma_{dE0,r}$)	0.166×10^{-3}
SR energy loss per turn (U_0)	1.33 MeV
SR damping time (τ_z)	15013 turns
RF frequency (f_{rf})	400 MHz
Harmonic number (h)	130432
RF voltage (V_{rf})	60 MV
Arc phase advance (φ_a)	60°
Mom. compaction factor (α_c)	1.48×10^{-5}
Synchrotron tune (Q_s)	0.0304
SR 1 σ bunch length (σ_{z0})	1.26 mm

2) RW-impedance evaluation with IW2D adding a copper layer to beam-pipe

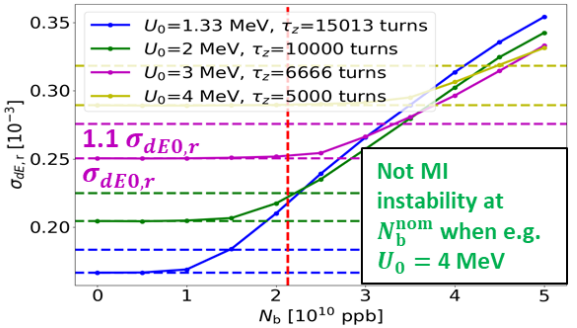




3) BLonD longitudinal beam dynamics simulations

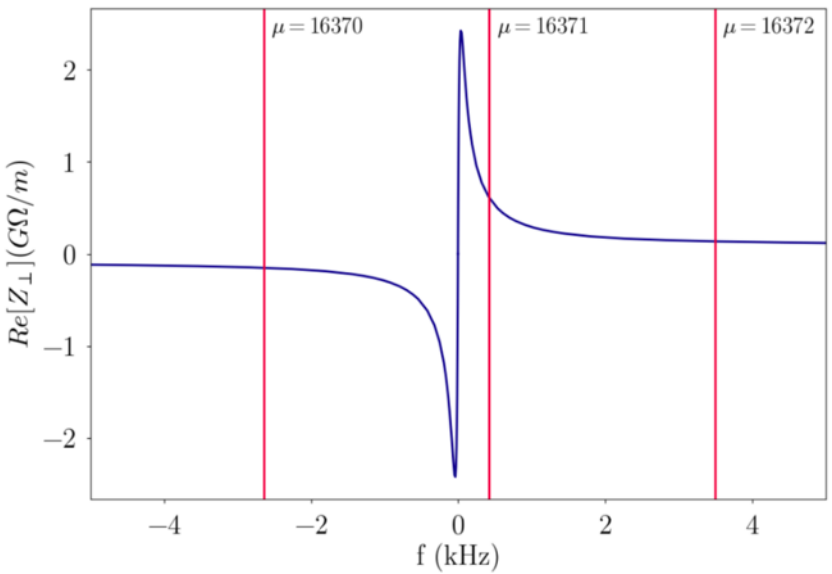


4) BLonD simulations using 1 μm copper-layer increasing SR power-loss

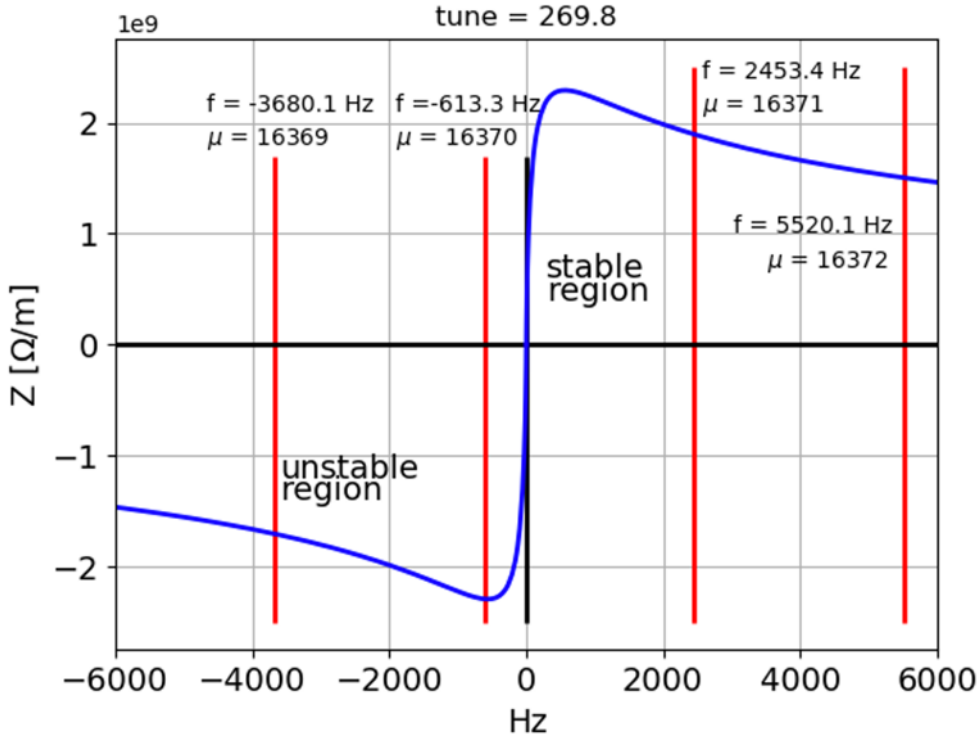


No tracking code simulations had been performed in the transverse plane for TMCI

RW Transverse coupled bunch instability
60º optics



Z pole: real part of the RW impedance for a copper beam pipe of 35 mm.



Booster: real part of the RW impedance for a stainless steel beam pipe of 25 mm.

For the booster, the peak of the impedance at low frequency is similar to that of the Z-pole , even in presence of stainless steel. However, a variation of the fractional part of the tune here affects only slightly the growth rate. The rise time is in the order of few turns.