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Metamaterial absorbers for beam-coupling impedance mitigation

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Charged particle bunches traversing cavity-like discontinuities in the beam pipe at relativistic velocities excite electromagnetic resonant modes that can detrimentally affect the dynamics of trailing bunches. This beam-cavity interaction, characterized in the frequency domain through the concept of beam-coupling impedance, poses significant challenges for beam stability and performance in high-energy particle accelerators. While conventional mitigation strategies encompass higher-order mode (HOM) couplers and lossy ferrite insertions, novel approaches leveraging metamaterial properties offer promising alternatives for selective mode damping. This investigation explores advanced metamaterial-based structures designed to specifically target and attenuate higher-order modes, thereby selectively reducing the beam-coupling impedance resonances.

Footnotes

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Author: SITO, Leonardo (University of Naples Federico II)

Co-authors: SALVANT, Benoit (European Organization for Nuclear Research); ZANNINI, Carlo (European Organization for Nuclear Research); FIENGA, Francesco (European Organization for Nuclear Research); BREGLIO, Giovanni (University of Naples Federico II)

Presenter: SITO, Leonardo (University of Naples Federico II)

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