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Thu-Mo-Po.02-06: Design strategies for beam impedance reduction of kicker magnets in particle accelerators

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In high-energy particle accelerators, kicker magnets are essential for injecting and extracting particle beams using fast-pulsed magnetic fields. A key challenge in their design is minimizing beam coupling impedance to maintain beam stability and reduce induced power losses while preserving the fast rise and fall times of the magnetic pulse.

This paper presents innovative principles and mechanical approaches for reducing beam impedance in several kicker magnets operating under vacuum across the CERN complex. Kicker magnets use ferrite or laminated steel as a magnetic yoke, which is susceptible to beam-induced heating. The proposed techniques aim to screen the ferrite yoke, provide a low impedance path for the beam image current, and eliminate cavities that could generate resonances. Simultaneously, the screen must allow the passage of fast pulsed magnetic fields. Techniques include the insertion of ceramic chambers holding screen conductors, the serigraphy of conductive paint, and thin metallization by sputtering. Bridges eliminate cavities between adjacent magnets or vacuum vessels.

The performance of these design strategies is evaluated through a combination of high-frequency simulations, laboratory impedance measurements, magnetic field assessments, and temperature monitoring of kicker magnets after installation in accelerators. The results demonstrate significant improvements, which are discussed in detail. This work establishes a foundation for further innovations in kicker magnet design, with the potential to enhance existing systems and guide the development for future accelerators such as FCC ee with shorter bunches where the impedance is becoming even more important.

Author: TRUBACOVA, Pavlina (CERN)

Co-authors: ZANNINI, Carlo (CERN); VOLLINGER, Christine (CERN); STANDEN, Dylan (CERN); FAVIA, Giorgia (CERN); DUCIMETIERE, Laurent Sylvain (CERN); CORALEJO FELICIANO, Luis Miguel (CERN); NERONI, Michela; DIAZ ZUMEL, Miguel; BARNES, Mike; KRAMER, Thomas (CERN); NAMORA, Vasco (CERN)

Presenter: TRUBACOVA, Pavlina (CERN)

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