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Data-driven hysteresis compensation in the CERN SPS main magnets

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Magnetic hysteresis and eddy current decay continue to challenge beam quality and operational consistency in multi-cycling machines like the Super Proton Synchrotron (SPS) at CERN. Building on our previous work, this paper presents improvements in the data-driven approach for magnetic field modelling to enhance the reproducibility of SPS dipole and quadrupole fields and thus maintain stable beam parameters across all operational cycles. The method is based on feed-forward correction using magnetic field forecasting with machine learning. It now includes additional operational experience and demonstrates that the field error compensation can reliably be used in operation. This contribution proves that hysteresis compensation can be achieved without a feedback system based on expensive installations with online field measurements in reference magnets. The performance improvements achieved by eliminating the need for manual adjustments and reducing time- and energy-consuming accelerator pre-cycles are presented. The paper also sets the stage for future application in higher-order magnets, like sextupoles and octupoles, as well as on other CERN synchrotrons.

Footnotes

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