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Analytical study on measurement errors induced by nonlinear transport and fringe fields in a sector-based energy analysis system

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Energy Analysis (EA) systems based on sector-magnets, with simple structure and high resolution, are widely applied in particle accelerators. As core components, sectors directly determine the accuracy of beam momentum spectra evaluations. However, for low-energy electron beams below 15 MeV, nonlinear-transport in large-dispersion sectors causes errors in results from linear-transport models; unavoidable fringe fields from magnet design/manufacturing introduce extra errors. The longitudinal transport of 1D beams in the sector-based system is first theoretically derived. A compensation scheme (considering high-order momentum spread terms) is proposed and verified via 1D dynamic virtual measurements. Further, fringe field-induced aberrations and their impact on momentum spectra are studied analytically; high-order optical transport is validated with beam dynamics simulations, and correction of second-order aberration errors via data processing is explored. These methods and conclusions improve the accuracy of built/operational EA systems without extra costs.

Footnotes

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