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Impact of dipole component change on quadrupole beam-based alignment accuracy for circular accelerators

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Beam-based alignment (BBA) for quadrupoles is a routine process for circular accelerators to steer beam orbit through the magnetic centers such that the orbit is unperturbed when the strengths of quadrupoles are varied. The random errors associated with BBA are well known, but a type of systematic error appears to be neglected by the community. A standard measurement procedure involves variation of the quadrupole gradient. This systematic error is introduced when there is a non-zero dipole component after quadrupole strength is changed. This dipole component can be also interpreted as a shift in the magnetic center. The analytical formulas for this error and its amplification factor with respect to the magnetic center motion have been derived and confirmed with simulations. We demonstrate the significance of this error, potentially on the order of hundreds of microns, through both simulations and recent experimental results at NSLS-II. In addition, a special term in this error that is not extractable from orbit measurements alone will be discussed in detail.

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Footnotes

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