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Study of the systematic error contributions to the measurement of beam size using sextupole magnets

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We present a study of the systematic uncertainties in beam size determination using sextupole strength variations. Variations in strength of a sextupole magnet in a storage ring result in changes to the closed orbit, phase functions and tunes which depend on the position of the beam relative to the center of the sextupole and on the beam size. We take advantage of the beam-based measurements of sextupole alignment errors and calibration correction factors obtained in 2022 to improve our model of the Cornell Electron/positron Storage Ring optics and assess accuracy limits in the beam size determination. Two measurement sets for the 76 sextupole magnets are compared: 1) the commonly used method of measuring tune variation for a single sextupole strength change at a given set of beam positions in the sextupole, and 2) using the linear term in the dependence of orbit and quadrupole kicks resulting from a set of sextupole strength changes. The latter are determined from polynomial fits to the difference orbits, phase functions and tunes arising from the sextupole strength changes. The first analysis neglects the effect of the beam size, leading to a small error in the offset determination. The second method fully accounts for the beam size and gives a second estimate for the alignment error. The differing sources of uncertainty in the two methods are assessed and discussed.

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