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Online reinforcement learning control of beam collision for BEPCII

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For the Beijing Electron-Positron Collider II (BEPCII), operators need to tune the transverse offsets—including displacement and angular deviation (x, x', y, y')—of the two beams at the interaction point (IP) to maintain high luminosity as the beam current decays during normal operation. Given that the optimal offset exhibits a non-linear variation with beam current within a single run and also differs across individual runs, sustaining the optimal beam offset at the IP for consistent high luminosity at all times is laborious. Consequently, operators typically adopt a linear model for automatic offset tuning. In this study, a Deep-Q-Network (DQN) agent was trained using historical data to adjust the beam offset at the IP. The DQN agent employs 18 input parameters (including IP offset, beam position monitor (BPM) readings, and beam current) and 8 output parameters (Q-values for action selection). This DQN agent has been successfully deployed in daily offset tuning, essentially replacing both the linear model and manual operator adjustments. Furthermore, it has achieved an increase in integrated luminosity compared to the previous approach.

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