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On-line beam synchronous phase calibration using beam-induced RF signals

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Accurate calibration of beam synchronous phase is essential for the optimal operation of accelerators. Traditional methods, such as the “phase scan method,” not only consume significant machine runtime but are also susceptible to environmental disturbances. DESY has introduced a novel method based on “transient beam loading effects” for calibrating synchronous phase. However, this method requires the RF system to operate in an open-loop mode, limiting its applicability in proton linear accelerators. In this paper, leveraging the classical cavity differential equations, we propose a new method based on the steady-state “vector diagram of beam-induced voltage” for calibrating beam phase. This method enables on line calibration of beam phase and beam current under closed-loop operation of the radio-frequency cavities. We validated our approach on the CAFE (the Chinese ADS Front-end proton facility) at the Institute of Modern Physics, China, and the European Spallation Source. The measurement errors for beam current and phase using our method and the beam diagnostic system were 2% and within ± 1 degree, respectively. Experimental results confirm the effectiveness of our method as a new solution for on line calibration of beam synchronous phase.

Footnotes

Funding Agency

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Yes

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