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Machine Learning techniques for betatron diagnostics in AWAKE Run 2

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Following the successful experimental demonstration of proton-driven plasma wakefield acceleration in AWAKE Run 1 (2016-2018), the subsequent Run 2 (2022-) experiment aims to achieve high-quality electron beam acceleration to several-GeV energies, applicable for high-energy physics experiments. Non-invasive betatron diagnostics could play a crucial role in determining key witness beam parameters, such as emittance and beam profile. Betatron radiation (BR) in AWAKE Run 2 has been investigated through simulation studies, demonstrating a synchrotron-like broadband spectrum spanning from UV to X-ray ranges. Here, advanced machine learning (ML) techniques are being explored to reconstruct witness beam parameters from the associated BR. To achieve this, we will generate the dataset using particle-in-cell simulations, conducting a systematic parametric study of the AWAKE configuration by methodically varying the parameters. The witness beam acceleration and its betatron emission are investigated over a 10-meter-long plasma acceleration using the AWAKE baseline parameters. ML models are then trained, validated, and tested for their prediction of beam parameters. Particularly, they will be utilized to explore energy, emittance, and beam profile of the witness beam.

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