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Developing radiation-tolerant transverse beam imaging using machine learning

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Transverse beam-profile monitoring is crucial for the safe and efficient operation of particle accelerators. In high-radiation zones near fixed targets and beam dumps, imaging sensors—especially cameras used for beam-profile measurements—degrade rapidly, compromising beam diagnostics.

In this study, we propose using a single multimode fiber (MMF) to relay optical signals from an interceptive screen located in a high-radiation area to a low-radiation area, combined with a machine learning model to reconstruct the transmitted signals. To overcome the lack of sufficient and balanced real data for training, we developed an unnormalized Gaussian Mixture Model to generate synthetic data. The machine learning model trained exclusively on this synthetic dataset reconstructs beam profiles from speckle patterns transmitted through the MMF. Experimental validation was conducted in the laboratory using a laser-illuminated Digital Micromirror Device (DMD) and real transverse beam samples from the CLEAR facility. The results demonstrate the potential of this approach for radiation-resistant transverse beam imaging.

Footnotes

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