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Optical Synchrotron Radiation as a Non-Invasive Tool for emittance diagnostics

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As next-generation accelerators target higher brightness and lower emittance, conventional diagnostics may fall short. Optical Synchrotron Radiation (OSR), while coupled with an optimized optical transport system, offers a scalable, high-resolution alternative. We apply a robust simulation framework for using OSR as a non-invasive tool to extract the transverse emittance of relativistic electron beams in advanced accelerator facilities.

Using the Synchrotron Radiation Workshop (SRW) code, we model OSR emission and propagation through realistic optics, incorporating detector and transport effects. Feasibility of this emittance measurement study was assessed using a microlens array (MLA) system to capture angular beam distributions from OSR. To validate the imaging performance, we integrate SRW with optical ray-tracing simulations in Zemax. Successful reconstruction of the emittance and Twiss parameters from the simulated results in the end validate the framework's accuracy in optimizing beam diagnostics.

The method is benchmarked using beam conditions from the CLEAR facility at CERN, while also providing a blueprint for extending OSR-based emittance diagnostics to other facilities.

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