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Beam shaping using an ultra-high vacuum multileaf collimator and emittance exchange beamline

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We report the development of a multileaf collimator (MLC) for charged particle beams, based on independently actuated tungsten strips which can selectively scatter unwanted particles. The MLC is used in conjunction with an emittance exchange beamline to rapidly generate highly variable longitudinal bunch profiles. The developed MLC consists of 40 independent leaves that are 2 mm wide and can move up to 10 mm, and operates in an ultra high vacuum environment, enabled by novel features such as magnetically coupled actuation. An experiment at the Argonne Wakefield Accelerator, which previously used inflexible, laser-cut masks for beam shaping before an emittance exchange beamline, was conducted to test functionality. The experiment demonstrated myriad transverse mask silhouettes, as measured on a scintillator downstream of the MLC and the corresponding longitudinal profiles after emittance exchange, as measured using a transverse deflecting cavity. Rapidly changing between mask shapes enables expeditious execution of various experiments without the downtime associated with traditional methods. The many degrees of freedom of the MLC can enable optimization of experimental figures of merit using feed-forward control and advanced machine learning methods.

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