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Ion Source Emittance Parameter Identification and Beam Optics Design Using Surrogate Optimization

Avalanche Energy is developing deuterium ion beams for the Orbitron fusion concept. To deliver a maximized, focused beam to the reactor, some of our experiment configurations utilize a Veeco Mark 1 broad beam ion source. To focus this beam into a small aperture, carefully designed optics are vital, the design of which is a nontrivial process.

The performance of the beam optics is a function of the ion source emittance and current characteristics upstream of the extraction region. We first measured the current density distribution downstream of the ion source without beam optics using electrostatic probe measurements. We then developed an iterative ion optics optimization procedure that evaluated the impact of electrode spacing and sizing on simulated and experimentally measured beam performance, using the previously identified ion source emittance parameters as an input.

The system identification procedure and the ion optics optimization utilize a surrogate optimization approach, which is uniquely suited for our simulation-based, computationally expensive objective function evaluations which have significant variability in time required to perform the evaluations. By implementing and testing the optics produced by this scheme, we show through a suite of diagnostics that the optimization significantly decreases the emittance of the beam and functions well for delivery of current to the Orbitron.

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