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Spatio-Temporally Resolved Measurement of Runaway Electron Momentum Distributions during Controlled Dissipation[1]

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We report the first spatially, energetically, and temporally resolved reconstructions of runaway electron (RE) momentum distributions (f_e) in tokamaks and their dependence on plasma parameters [1]. These measurements provide unique validation for models of RE evolution and quantify the importance of collisional and synchrotron damping to controlled RE dissipation. Measurements are made with a tangentially viewing pinhole camera where each collimated sightline is equipped with a pulse-height counting hard X-ray (HXR) detector to infer f_e. REs are produced in well-diagnosed quiescent Ohmic plasmas, with synchrotron and collisional damping terms actuated by varying the toroidal field and thermal electron density. Comparing experimental and modeled f_e evolution, nearly all qualitative trends are captured: 1) increasing synchrotron damping shifts f_e towards lower energy, 2) increasing collisional damping decreases f_e at all energies, 3) both develop non-monotonic f_e features at consistent energy, 4) f_e are more parallel-directed at high energy. The f_e shape and location of non-monotonic features are thus generally in agreement with modeling as collisional and sychrotron damping terms are varied. Comparing dissipation rates, good agreement with modeling is found at high energy and experimental evidence for a predicted enhancement in the critical electric field for RE decay is shown. A notable disagreement between experiment and theory is found at low energy, where systematically stronger dissipation rates are observed than predicted. The agreement between theory and experiment improves confidence that model-based optimizion of RE mitigation can be achieved, while the identified discrepancies can guide improvements to RE dissipation models. [1] C. Paz-Soldan et al, *Phys. Rev. Lett.* **118** 255002 (2017)

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