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Data-Driven Exploration of High Average Power Laser-Plasma Accelerators

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Recent advances in high-power lasers approaching kilohertz repetition rates are pushing laser-plasma accelerators (LPAs) into the watt-level average-power regime, offering unprecedented statistical access to their intrinsic properties. In this talk, we outline how the Kaldera project at DESY employs fast diagnostic measurements to explore key performance aspects of high-average-power LPAs. We outline our real-time data-acquisition framework—designed to capture key experimental observables on every shot—and describe how scalable processing pipelines integrate these measurements with advanced modeling tools. We show how large, high-repetition-rate datasets can reveal sources of shot-to-shot variability and how, when combined with tailored real-time modeling techniques, they form the basis for efficient control and optimization. Finally, we will present recent results on data and machine-learing-driven operation at Magma–Kaldera's high average power laser plasma accelerator.

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