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Analytical and Numerical Studies of Dark Current in Radiofrequency Structures for Wakefield Acceleration

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RF breakdown limits the attainable acceleration gradient in normal conducting RF structures, challenging high-gradient operations. Recent experiments at the Argonne Wakefield Accelerator (AWA) suggests short RF pulses (a few nanoseconds) can mitigate this breakdown. We simulated dark current emission in the short-pulse regime to study breakdown initiators including field emission and multipacting. This study integrates analytical and numerical modeling of dark electron generation to understand multipacting and RF breakdown in structures driven by short RF pulses. We simulated electron trajectories under various conditions in the electromagnetic fields. Our analytical model, compared against simulations, predicted multipacting resonance modes and secondary electron yield. Our findings have revealed the dependence of dark current generation on the RF field strength, pulse duration, and surface properties. These insights guide the design of RF structures with enhanced performance and reduced breakdown susceptibility, advancing the next-generation short-pulse accelerators.

Working group

WG4 : Novel structure acceleration

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