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Searches for RF breakdown precursors using Cherenkov light in optical fibers

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RF breakdown studies are crucial for machines relying on high-gradient, normal-conducting RF accelerating cavities. Searches for breakdown precursors in high-gradient test-stand data have been conducted*and highlight the need for a new diagnostic with improved temporal response. Emission of Cherenkov light in optical fibers has been identified as one such diagnostic*[**], which occurs when charge showers due to breakdown are incident on the fiber.

Optical fibers have been used previously as distributed Beam Loss Monitors. At the X-Band Laboratory for Accelerators and Beams (X-LAB), we position optical fibers adjacent to X-band cavities being conditioned for the proposed Compact Linear Collider (CLIC). We assess sensitivity of fibers to charge emitted by field emission and breakdown events. Since breakdown precursors may occur at sub-microsecond timescales[**], we survey photon detectors best suited to examining fiber response and identifying precursors. We compare fiber signals to dark current captured by upstream and downstream Faraday Cups. In search of precursory phenomena, pulse-by-pulse evolution of fiber signals is examined for field-emission activity prior to breakdown.

Footnotes

*Engelberg, E. Z. et al. Dark current spikes as an indicator of mobile dislocation dynamics under intense dc electric fields. Phys. Rev. Accel. Beams 23, 123501 (2020).

**Paszkiewicz, J. Studies of Breakdown and Pre-Breakdown Phenomena in High Gradient Accelerating Structures. (University of Oxford, St. John's College, Oxford, 2020).

***Wolfenden, J. et al. Cherenkov Radiation in Optical Fibres as a Versatile Machine Protection System in Particle Accelerators. Sensors 23, 2248 (2023).

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