Project name

Investigation of Breakdown in 17 GHz Accelerator Structures

Classification (accelerator/detector: subsystem)

Accelerator

Institution(s) and personnel

MIT Plasma Science and Fusion Center (PSFC), MIT Department of Physics:
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Project Overview

A serious problem in the development of a room temperature copper structure for the proposed NLC / JLC is understanding the highest possible accelerating gradient at which such structures may be safely operated. A great deal of research has been conducted at frequencies in the 2.856 to 11.4 GHz range to understand this problem. Much of that work is empirical and an understanding of breakdown from a fundamental or microscopic point of view is still lacking.

The MIT Plasma Science and Fusion Center (PSFC) proposes to undertake theoretical and experimental research on the problem of breakdown in copper cavities and structures. MIT PSFC has available extensive equipment at 17.1 GHz for application to the experimental portion of the research, including the Haimson Research Corporation (HRC) 25 MW, 17 GHz klystron and a 25 MeV 17 GHz high gradient electron linear accelerator. A 17 GHz photoinjection gun is also being operated at MIT to produce high brightness electron bunches. A surface field of up to 300 MV/m has been demonstrated in the 17 GHz rf gun when powered by 100 ns pulses from the HRC klystron. The calculated instantaneous wall temperature rise in those studies was over 60 C. This rf gun has been previously used to study breakdown but has not been used in any systematic fashion. The new research, proposed here, would be a systematic experimental and theoretical study of breakdown using this available equipment.

The MIT research group has an active program of experimental research on photonic band gap (PBG) accelerator structures. The PBG accelerator structure is built of a stack of PBG cavities made of metal rod lattices with a defect in the center (the beam line). The operating mode of the PBG cavity is a defect mode confined in the defect. This mode is similar to the TM_{010} mode of a conventional pillbox cavity. The advantage of the PBG cavities is that only the operating, accelerating mode is confined in the defect whereas all other modes are not confined and can be damped. This feature is important for the Next Linear Collider where the wakefield formed by higher order modes is intense and should be suppressed. The PBG cavities have been designed using the computational tools available at MIT: the HFSS code and the Photonic Band Gap Structure Simulator (PBGSS) code developed at MIT. The PBG accelerator structures have been measured in cold test. A PBG accelerator experiment using the 17 GHz gun as an injector is under construction.

Description of first year project activities

The MIT research group will design a photonic band gap (PBG) structure specifically for breakdown experiments. The HRC 17.1 GHz, 25 MW relativistic klystron will be employed for these experiments. A single or multi-cell accelerator structure will be used. In contrast to a PBG accelerator structure, a PBG structure for breakdown studies will be composed of very thin metal rods surrounding the defect. The structure will be designed to provide a substantial field enhancement at the rods. A PBG structure with non-uniform rod radii will be designed to optimize the coupling into the structure. The damage of the structure will be monitored using a higher frequency, low power rf signal transmitted through the structure. A goal of the research will be to develop new diagnostics of the breakdown effects. These diagnostics should help to understand the role that plasma formation plays in the breakdown process.

A PBG structure has several advantages for these studies. Coupling into PBG structures can be done through an open waveguide coupler without pinholes or small apertures. Thus, high fields are confined to the central rods. The PBG cavity can be designed to make it possible to easily replace damaged rods. Rods made of different material (copper, tungsten, or coated rods) will be utilized.

Estimated Budget

Institution	Item	Cost
MIT	Graduate Research Assistant (6 months)	$20k
	Postdoc / Research Staff / Engineer	$10k
	Materials	$10k
	MIT total (including overhead)	$40k
SLAC	SLAC total	$0
	Grand total	$40k