Project name

Control of Beam Loss in High-Repetition Rate High-Power PPM Klystrons

Classification (accelerator/detector:subsystem)

Accelerator

Institution(s) and personnel

Massachusetts Institute of Technology, Plasma Science and Fusion Center
Mark Hess (postdoctoral associate), Chiping Chen (principal research scientist)

Mission Research Corporation
David Smithe, Lars Ludeking

Stanford Linear Accelerator Center
George Caryotakis, Sami Tantawi (To be confirmed)

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Project Overview

The deleterious effect of beam loss has been measured in high-power PPM klystron experiments [1,2]. Beam loss has been shown to be a trigger for other problematic effects in microwave sources such as heating, structural damage, and generation of background radiation (e,g,, X-ray emission). Although beam loss may be tenable for low repetition rate (<10 Hz) microwave sources, it can be particularly harmful for higher repetition rate (>100 Hz) devices. For example, in the SLAC 75 MW XP-1 PPM klystron significant beam loss as well as X-rays were measured during high-power tests [2]. Due to inadequate cooling of the klystron, it was limited to 10 Hz repetition rate, which was well below the NLC requirement of 120 Hz.

In recent theoretical investigations, we have established a PPM klystron beam confinement criterion [3]. The confinement criterion is based on the 3-D interaction of a bunched pencil electron beam with a surrounding conducting wall, which would represent the drift tube section of an actual klystron. The relevant klystron parameters in the confinement criterion are the average beam current, magnetic focusing strength, conductor pipe radius, average beam energy, and the klystron device frequency. PPM klystrons operating above this criterion would experience beam loss. The SLAC 75 MW XP-1 PPM klystron is operating slightly above this criterion, which may be the cause of the observed beam loss.

We propose to study possible methods for controlling beam loss in high-repetition rate PPM klystrons. Our study will include theoretical analysis of possible mechanisms of beam loss, which is motivated by our recent work [3], along with extensive 3-D simulations of PPM klystrons using MAGIC 3D. This study could lead to a deeper understanding of how beam loss occurs in PPM klystrons, as well as, practical solutions for how to prevent or reduce it.

Description of first year project activities

The MIT group (Hess and Chen) will improve the beam confinement criterion by adding new effects that were not previously considered. The original model assumed that the bunched beam could be represented as periodic point charges which were moving with a fixed relativistic velocity. In the proposed study, we will include the effects of finite beam size and finite beam energy spread. These effects may be important in determining the interaction of the beam with the conducting wall, since finite beam size will tend to reduce the beam-wall interaction while the finite beam energy spread can act to increase the beam size.

MRC (Smithe and Ludeking) have expressed interest in performing MAGIC 3D simulations of PPM klystron tubes, especially the SLAC 75 MW XP-1, to examine the beam loss problem. The simulations will be important in determining both the rate of beam loss and where it may occur in the structure. The MAGIC simulations will also be valuable in validating the original beam confinement criterion as well as the modifications to the confinement criterion developed by the MIT group.

The theoretical and simulation work will be performed in close collaboration with the SLAC group (Caryotakis and Tantawi).

Budget

Institution	Item	Cost
MIT	Staff/Postdoc	$5,800
MIT	Graduate Student	$12,000
MIT	M&S	$400
MIT	Indirect Costs	$11,800
MIT Total		$30,000
MRC	David Smithe and Lars Ludeking	$10,000
	Grand total	$40,000

References

[1] D. Sprehn, *et al*, in: Proceedings of 19th International Linac Conference, Argonne National Laboratory Report ANL-98/28, 1997, p. 689.
[2] D. Sprehn, *et al*, in: H.E. Brandt (Ed.), Intense Microwave Pulses VII, SPIE Proc. 4301 (2000) 132.
[3] M. Hess, C. Chen, Phys. Lett. A 295 (2002) 305.