Project name

Investigation of acoustic localization of rf cavity breakdown

Classification (accelerator/detector:subsystem)

Accelerator

Institution(s) and personnel

University of Illinois at Urbana-Champaign, Department of Physics:
George D. Gollin (professor), Michael J. Haney (electrical engineer)

University of Illinois at Urbana-Champaign, Department of Electrical and Computer Engineering:
William D. O'Brien (professor)

Stanford Linear Accelerator Center:
Marc Ross (staff scientist)

Contact person

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Project Overview

Electrical breakdown in warm accelerating structures produces electromagnetic and acoustic signals that may be used to localize (in a non-invasive fashion) the breakdown site inside a cavity. Other indications of breakdown (microwave, X-ray, and dark current measurements) have proven insufficient to elucidate the basic physics of cavity breakdown. During tests of the NLC design it will be important to record information describing electrical breakdown in order to understand why cavities break down, and how cavity design and operating conditions influence accelerator reliability.

We propose to study the behavior of the acoustic signal generated when a cavity breaks down in order to determine how well a system of (external) ultrasound transducers can measure the position of the discharge site inside a cavity. The proposed work could lead to the design of an affordable, large-scale acoustic system that could be used to instrument a substantial fraction of the accelerator. This project will extend work already underway at SLAC.

Description of first year project activities

Using 2.25 MHz ultrasound transducers borrowed from William O'Brien's lab, we find that we may be able to determine the relative arrival times of (ideal) acoustic pulses detected by a pair of transducers to an accuracy of a dozen nanoseconds. (O'Brien is a

Professor of Electrical and Computer Engineering at the University of Illinois.) Since the speed of sound in copper is approximately 5,000 m/sec, it is conceivable that a trio of sensors could triangulate the location of electrical breakdown in an NLC accelerating structure to an accuracy of better than a millimeter. We would like to investigate this in detail in order to determine the feasibility of building a large-scale system to monitor electrical breakdown in warm Linear Collider accelerating structures.

It is possible that the details of acoustic propagation through the rf structures will produce complex signals at the transducers. Will some amount of signal processing be necessary to extract timing information, or will a simple threshold-crossing time measurement suffice? Are the polarization of the acoustic signal and the directionality of the transducer matters that will complicate a breakdown sensing system? Is the efficiency of transfer of acoustic energy into the transducer an important parameter of a system, or are the signals so large that this is not an issue?

Ross plans to send a 9-disk section of NLC accelerating structures to the Illinois group for use in our studies. Using transducers and electronics borrowed from O'Brien's ultrasound lab, Haney and Gollin will characterize the acoustic properties of signals from spark discharges inside the NLC structures in order to answer the questions posed above. After learning more about the nature of the breakdown signals we will begin to study the feasibility of using several sensors to determine the positions of electrical breakdowns. We expect to make use of existing University of Illinois laboratory infrastructure (some of which will be borrowed from colleagues in the Electrical and Computer Engineering) for most of the work during the first year. However, we would like to acquire a PCI bus signal digitizer to extend the capabilities of an existing test stand (presently used in maintaining CLEO III trigger electronics). This test stand will serve as the core of the measurement system to be used in these investigations.

This is an ideal project for student participation so we are also requesting a modest amount of support to fund one undergraduate physics major (who could use the work as the basis for a senior thesis).

Future work is likely to involve the investigation of the use of inexpensive plastics to fabricate a system of affordable sensors for instrumenting a section of the NLC test accelerator.

Budget

Institution	Item	Cost
Illinois	National Instruments NI 5112 two-channel digitizer	$2,300
Illinois	Summer + academic year salary for one undergraduate	$4,400
Illinois	Indirect costs	$2,332
Illinois	Illinois total	$9,032
SLAC	SLAC total	$0
	Grand total	$9,032