Electron Cloud Trapping in High Energy Accelerators

Overview

Accelerators are powerful tools for scientific discovery and engines for industry. Our ability to accelerate and manipulate particle beams is crucial to modern scientific research, enabling the discovery of the Higgs boson and the mapping of molecular dynamics. The electron cloud effect is a well known phenomenon in high-energy particle accelerators, consisting of the buildup of a high density of low-energy electrons inside the vacuum chamber. These electrons can cause a variety of undesirable effects, including emittance growth, beam instabilities and cryogenic heat load. The goal of this proposal is to further our understanding of the behavior of electron cloud observed to be trapped in the fields of quadrupole magnets. Such trapped cloud may limit the spacing of bunches in proton and positron synchrotrons and storage rings, and ultimately the beam quality and intensity.

We propose to instrument a quadrupole magnet with a shielded electrode detector for measuring the flux of cloud electrons into the wall of the chamber, as well as with resonant microwave detectors to measure the density of electrons in the chamber volume. The quadrupole will be installed in the Cornell electron/positron storage ring test accelerator (CESRTA) and used to measure cloud properties under a variety of beam conditions as a function of quadrupole field strength. The designs of the two types of detectors are based on prior CESRTA experience. Simulation code will be further developed to aid in the interpretation and analysis of the data. The proposed study will be coordinated within the framework of the ongoing CESRTA program.

Intellectual Merit

The high-energy storage ring CESR is our vehicle for systematic study of the phenomena that emerge and ultimately limit particle density in intense compact beams. These studies contribute to the performance of fourth generation synchrotron light X-ray sources, electron-positron colliders, and proton accelerators and colliders, as well as to our understanding of particle beam dynamics. The studies inform the manipulation of intense beams. Previous studies at CESRTA are the basis of the design of damping rings for linear and circular colliders now under construction or in advanced stages of design.

Broader Impacts

A better understanding of the physics of particle beams and related technology paves the way for new accelerators that are ever more powerful probes of materials, biological systems, molecules, atoms, nuclei and the most fundamental particles in nature. Research accelerators may be used to develop new drugs, to design lighter and stronger jet engine components, or better battery technology. Accelerators are tools of discovery that may inspire young scientists to explore our mysterious universe. This work will advance the capability of particle accelerators, the world's most powerful microscopes, and train the next generation of accelerator scientists.

The undergraduate, graduate and postdoctoral students trained through this program will have the rare opportunity to operate the state-of-the-art particle accelerators that are at the heart of their investigations of the accelerator technology and the properties of accelerated beams. That operational experience prepares them for leadership roles in the development of the future accelerators that will push back the frontiers of science. The public will gain deeper understanding of accelerator-based research through guided tours.