Electron Cloud Studies

Thesis Proposal for Peter Lane by Bob Zwaska (proposed adviser)

The study of electron cloud effects in the Main Injector is needed to understand limitations to future MI performance, particularly for the Project X upgrade. Better understanding of electron cloud production could also aid in the design of other future accelerators, such as the ILC, muon collider, light sources, and generally any high-intensity ring. The electron cloud growth rate depends on several factors such as the secondary emission yield of the beampipe surface, bunch intensity and frequency, and externally applied magnetic fields. The present plan of Project X is to coat the entirety of the beam pipe's interior with a low secondary emission yield material, such as Titanium Nitride.

The proposed project is to measure the secondary emission yield (SEY) and associated electron cloud build-up with different materials in the Main Injector, and how these properties change with beam exposure. There will be a device for measuring the SEY of materials directly within the Main Injector based on a prototype built at Cornell University. Cornell will be sending most of the parts for a similar one to be built at Fermilab. Much of the needed electronics is already in hand. The SEY measurement apparatus will first be assembled and operated in the lab in order to debug it and adapt it to fit in the Main Injector. Once installed, it will run for months with different sample materials and occasional in-tunnel measurements. Occasional beam studies will also test the materials response with varying beam conditions.

The thesis work would involve hardware development and beam study work. Additionally, there are several Electron Cloud simulation codes available for modeling. The computing background of Mr. Lane renders any computational portion of the research to be done with reasonable ease. These codes can be used for a theoretical understanding of the Main Injector measurements, and for extrapolation to different regimes of beam intensity.

Two other new installations are also being planned in the Main Injector for study of the electron cloud (in addition to the above apparatus and an existing experimental stations). These could optionally augment the thesis work. One, using microwave phase modulation as a measurement technique, is in the middle of planning. The other is only at the conceptual phase, but would include dipoles to arbitrarily change the magnetic field, an SEY station like above, and additional instrumentation. Mr. Lane may also help with the design (and possibly implementation) of these other experiments.