Using Coherent Tune Shifts to Evaluate Electron Cloud Effects on Beam Dynamics at CESrTA


One technique used at CESrTA for studying the effects of electron clouds on beam dynamics is to measure electron and positron bunch tunes under a wide variety of beam energies, bunch charge, and bunch train configurations. Comparing the observed tunes with the predictions of various simulation programs allows the evaluation of important parameters in the cloud formation models. These simulations will be used to predict the behavior of the electron cloud in damping rings for future linear colliders.

THE MEASUREMENTS

Bunches were set into oscillation by displacing them horizontally or vertically for one turn and Fourier transforming their turn-by-turn positions for up to 4096 turns measured at up to six places around the ring. Tunes of the bunches of the cloud-inducing train and of “witness” bunches spaced 14 to 490 nsec after the trains place around the ring. Tunes of the bunches of the cloud-inducing train and of “witness” bunches spaced 14 to 490 nsec after the trains place around the ring. Tunes of the bunches of the cloud-inducing train and of “witness” bunches spaced 14 to 490 nsec after the trains place around the ring.

DETERMINING SIMULATION PARAMETERS

Initial parameters for driving the POSINST simulations were determined by trial and error on measurements made at 2.1 GeV with 2.2 mA each bunch. The parameters were varied until a fit was obtained for the observed tunes.

FURTHER MEASUREMENTS

To help parameter determination, we try to choose conditions where one of the parameters may dominate. Here are several of the most recent measurements and the usual POSINST simulations. Only vertical tune shifts are shown. Data block and simulation code are shown for 2.1 GeV positron and electron beams (left top and bottom), 5.3 GeV positrons and electrons (middle top and bottom), and 4.0 GeV positron beams of higher bunch occupancy that we have recently been able to achieve. The minimal POSINST simulations generally give the worst range of data well. At the highest bunch occupancy (5.3 GeV positrons), POSINST simulations are more plausible, but the quantification of discrepancy represents an opportunity to further refine the model input parameters.

SOLENOIDS IN THE DRIFT REGIONS

Alemany have been installed to increase the electron cloud in the dipoles as opposed to the drift regions by reducing the contribution of the POSINST simulations. By limiting the electron cloud to the dipoles, the models are more applicable to the data. Data were simulated and tested in the standard way, but the excitation of the dipoles was limited in the simulations. For example, the solid curve shows data taken with solenoids off and on, respectively. Data are shown for 2.1 GeV positron and electron beams, left top and bottom, and 0.8 m/s bunch-spacing.

SPONTANEOUS OSCILLATIONS

As can be seen in the plots under the DETERMINING SIMULATION PARAMETERS heading, horizontal tune shifts are suppressed in the dipoles in the usual pinging technique, which damp all the oscillations. The dipole effect is not observed in the horizontal location of the cloud centroid and the beam centroid in the dipoles. Unpinged cell-edges data allow the observation of sizable horizontal tune shifts. The oscillations in the unpinged bunches have two periods excited, but each period is suppressed in the pinging technique. The solid curve shows data taken with solenoids off and on, respectively. Data are shown for 2.1 GeV positron and electron beams, left top and bottom, and 0.8 m/s bunch-spacing.

PLANNED IMPROVEMENTS

A new low-energy injection technique with a beam dump should allow the injection of very high energy electron bunches into the CESrTA. This new technique will provide much more stability for the goodness-of-fit comparisons used to optimize parameters. Parameter space will remain to be explored with some of the newer data.

Recently, instrumentation to excite bunches individually has been deployed in order to further refine the models. This new technique is the subject of a separate paper.