Electron Cloud Studies at the Cornell Electron Storage Ring

-- Matt Lawson --

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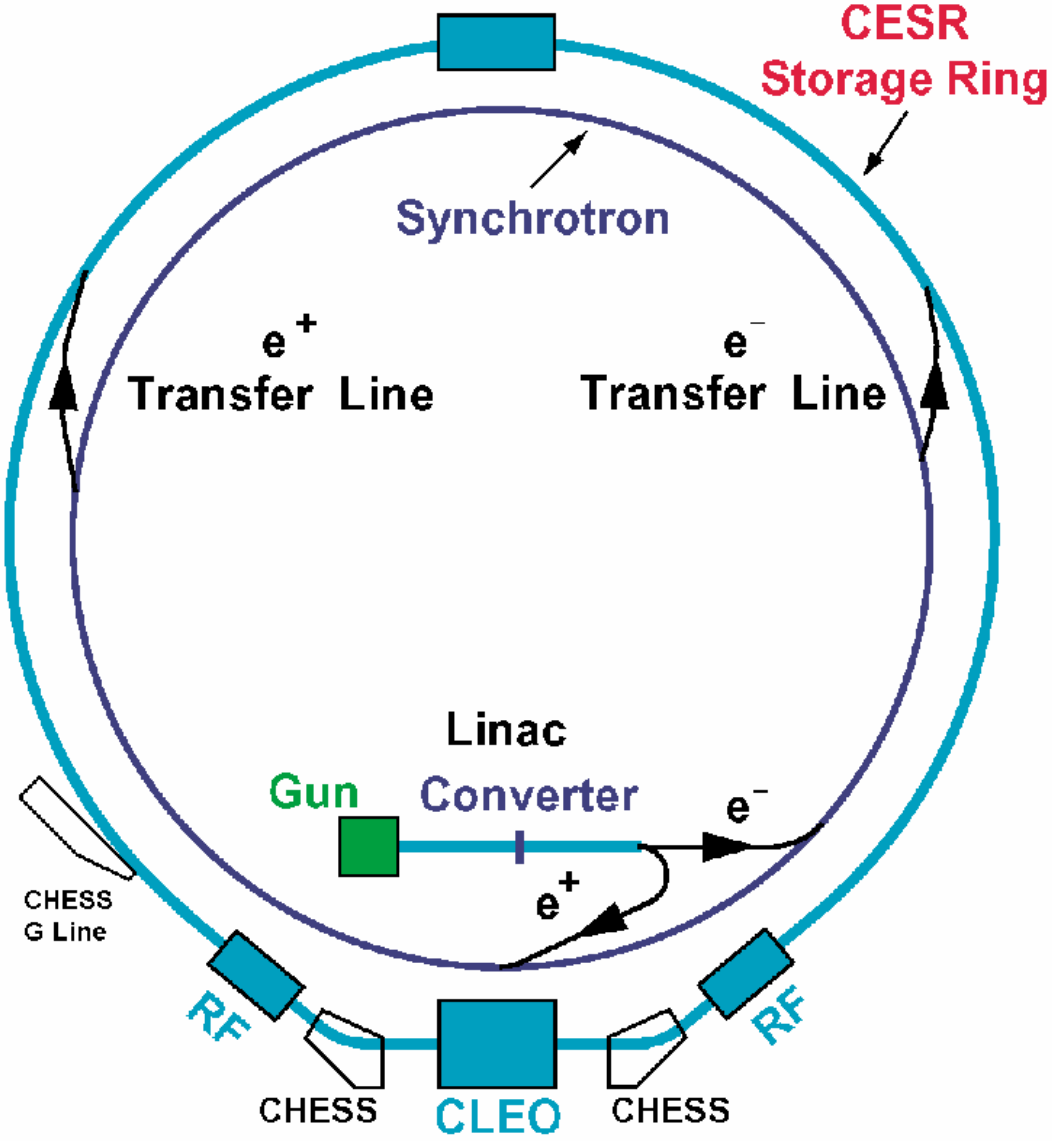
The Storage Ring

Abstract

Spring, 2008, will witness the revamping of the CESR for the purpose of accelerator physics R&D, concluding 27 years of colliding electron and positron beams to study the production and decays of charm and bottom quark bound states. The widespread enthusiasm among particle physicists for the discovery potential of a 20-mile long International Linear Collider (ILC) to study the interactions of 500 GeV electrons and positrons has resulted in a global effort to which LEPP is making a variety of essential contributions. In particular, the need for extremely small beam sizes necessitates the design of novel damping rings upstream of the linear accelerators which will serve to ``cool'' the beams to their final sizes at 5 GeV prior to acceleration in the linacs. A major performance limit of these two 4-mile-circumference rings is the buildup of electron clouds in the evacuated beam-pipe, clouds which are produced by photo-emission from the beampipe walls bombarded by synchrotron radiation from the beam. These clouds become so dense for the very intense ILC beams that their electric fields distort the guide-field optics, causing beam loss. CESR has been charged by NSF to study cloud mitigation techniques over the next two years.

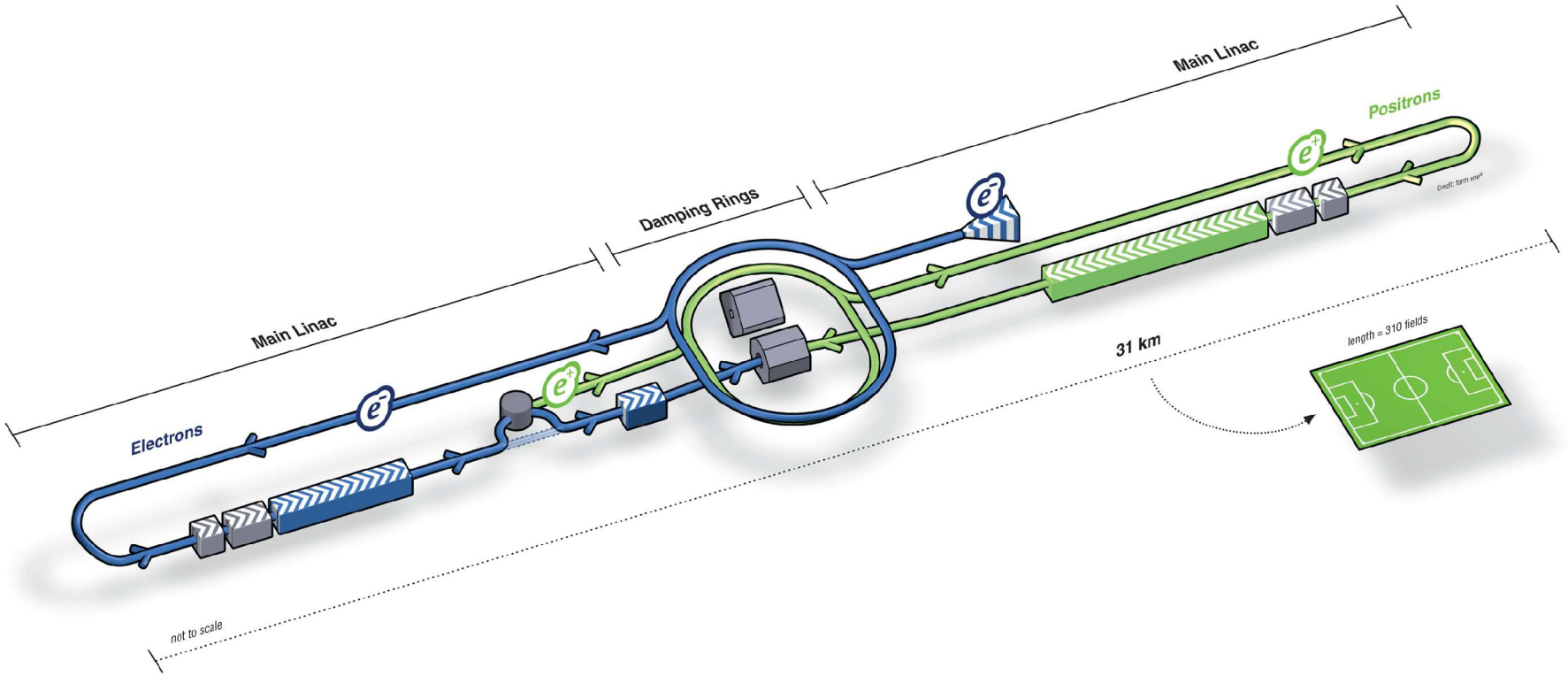
This REU project will focus on this new high-priority mission of CESR which includes both software simulation and experimental measurement.



The International Linear Collider

Electron cloud buildup in the damping rings is considered the primary limitation on the colliding beam intensity.

As a consequence, this topic has been given top priority in the ILC damping ring R&D program.

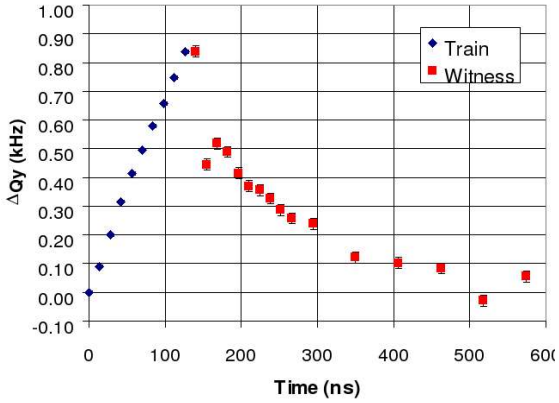


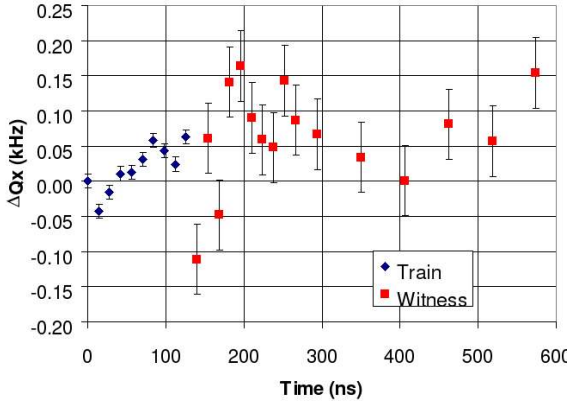
Overview

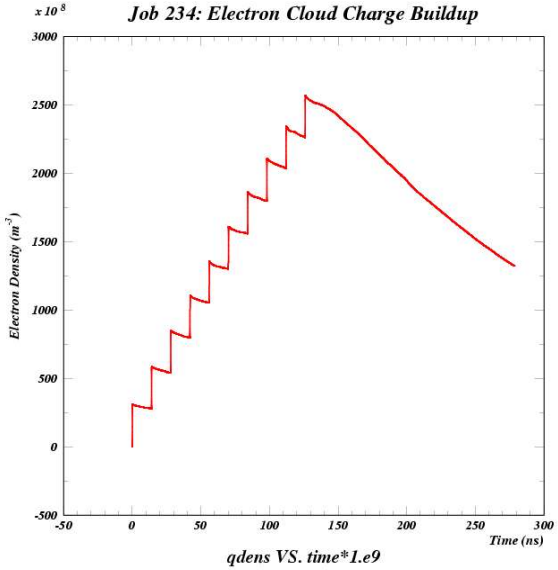
- **ECLOUD program V3.2** (2D, developed at CERN 1997-2003)
  - Adapted to CesrTA machine studies experiments
  - CESR-c tune shift measurements 2007
  - CesrTA North Area Triple-RFA arrangement
  - Continued development (output info, graphics, field calculations)
- **Standalone RFA modeling** (Previously MatLab, now F90)
  - Compute expected RFA currents incl. tracking & secondary generation
- **Vector Fields OPERA model for RFA detectors**
  - Includes electrostatics calculation with B field superposed
  - Calculates electron trajectories (no energy loss, no secondaries)
  - Electric field map provided to local standalone development
- **POSINST and CLOUDLAND ramping up**

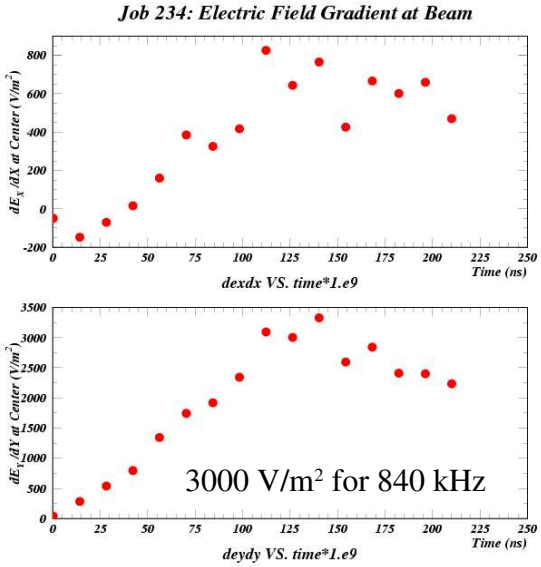
CESR-c Tune Measurements

- Train of ten 1.9 GeV, 0.75 mA positron bunches generates the electron cloud
- Measure tune shift and beamsize for witness bunches at various spacings









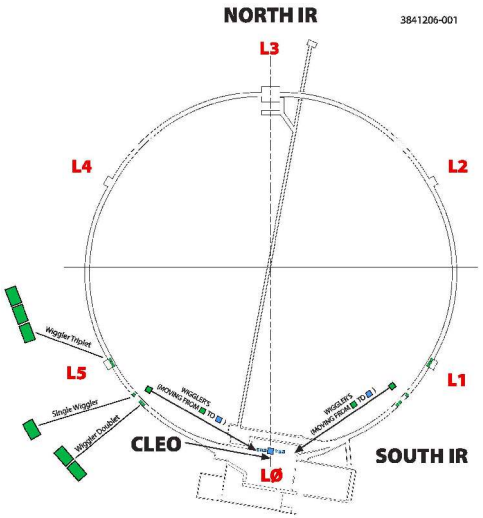
ECLOUD points to parameters critical for determining tune shifts:

- **Beam-pipe shape**
  - **4.5 x 2.5 cm elliptical**
- **B-field**
  - **Field-free rather than 800 G**
- **% reflected s.r. photons**
  - **Less than 20-30%**

Successfully predicts magnitude of vertical tune shift, but predicted horizontal tune shift is too high.

Further investigation of E-field calculation underway.

North Area RFA's



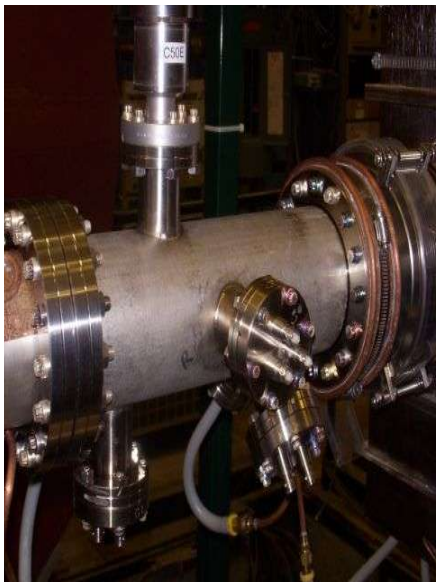
North Area RFA Setup

3.5-inch round beampipe

5.3 GeV electron beam

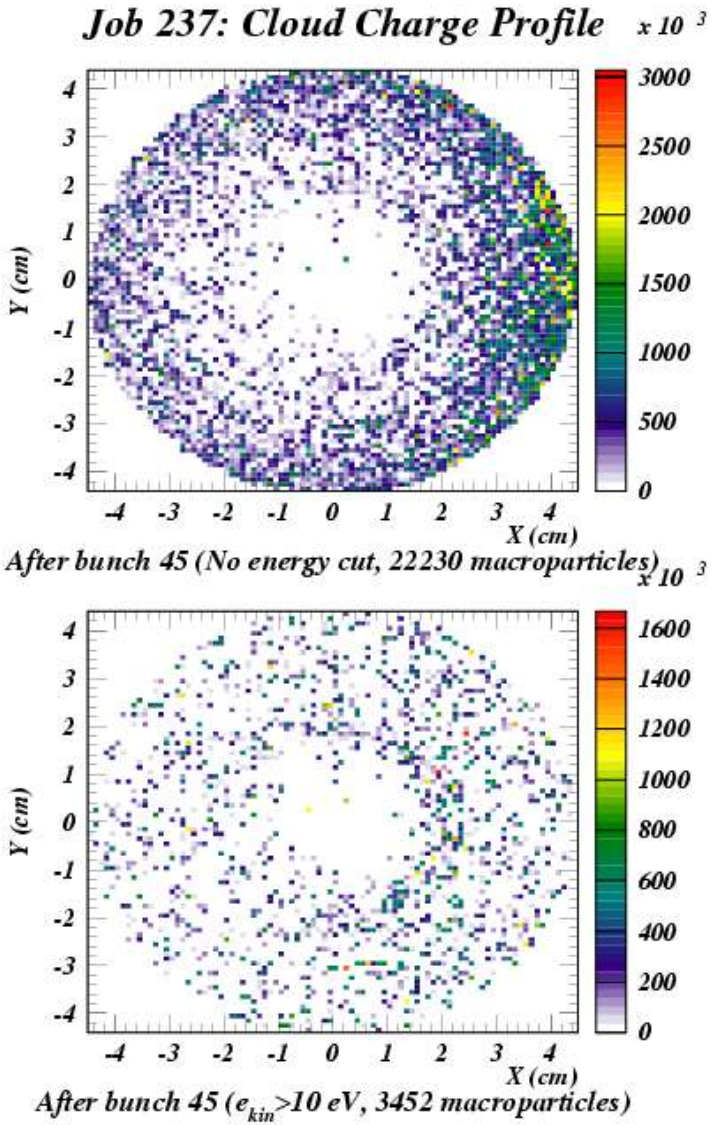
Flexible bunch pattern

Now investigating energy spectrum and azimuthal dependence

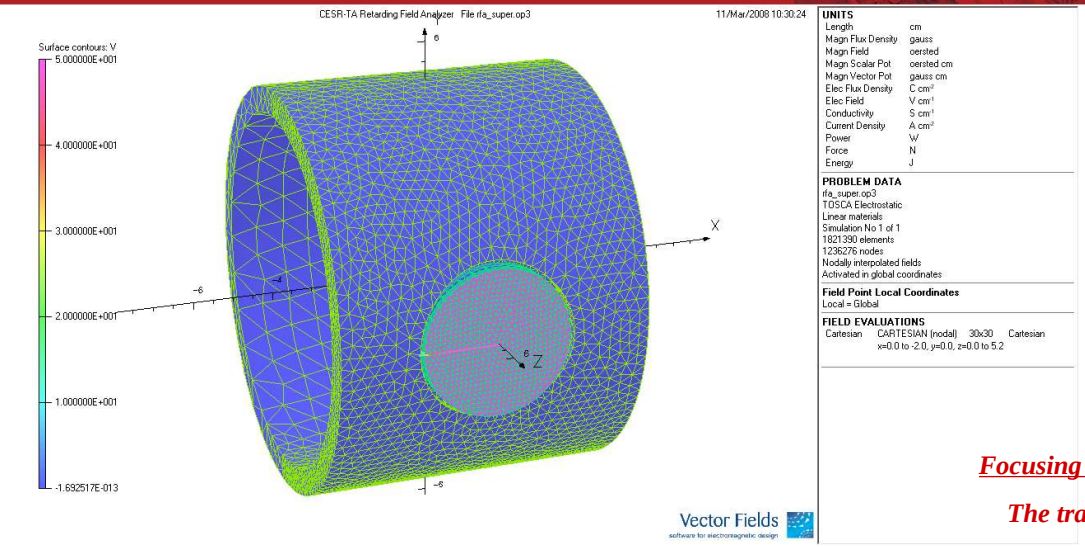


- Two APS-type RFA's
- One CESR-design thin RFA

Now using electron beam owing to occlusion of e^+ sr photons



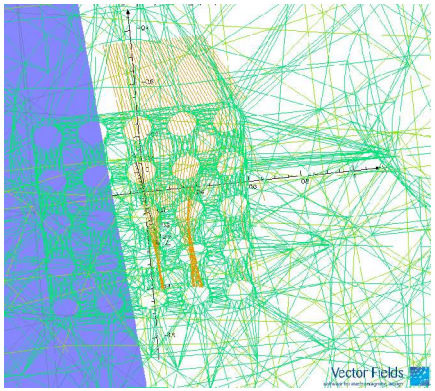
OPERA 3D RFA Model



The Vector Fields OPERA package used to design the CESR-c superconducting wigglers (c.f. PAC2003/2005) now serving as baseline for the ILC DR wigglers has been used to model the field shaping in the RFA detectors. Tracking in the RFA electric field with an arbitrary superposed magnetic field is possible. Secondary emission in the RFA cannot be modeled in this approach.

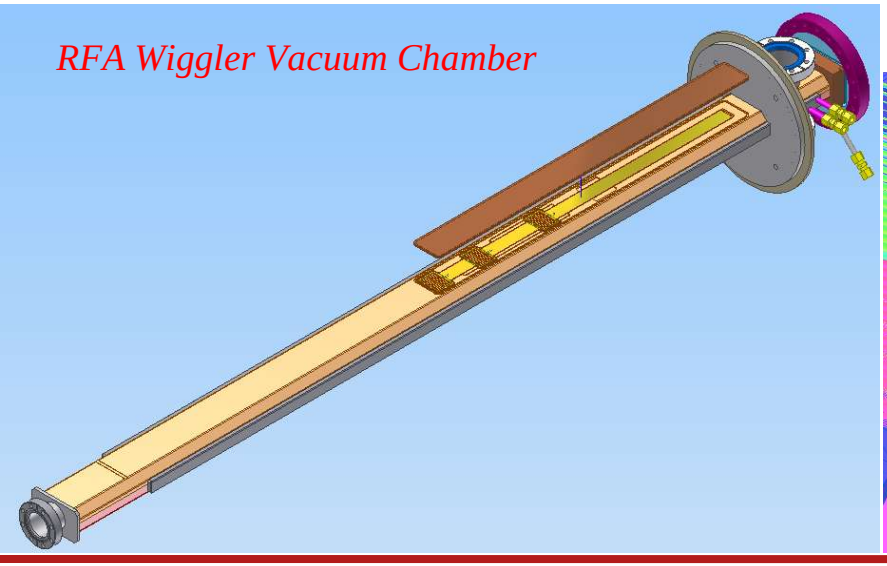
Focusing effect of the RFA grid holes

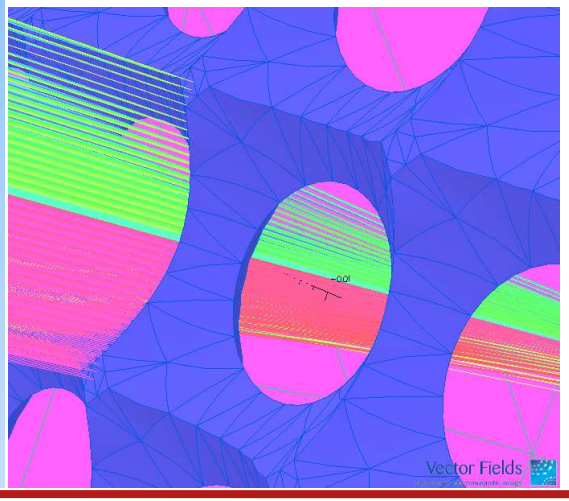
The transmission for electrons is greater than the optical transmission, and depends on the energy spectrum.



CesrTA will measure electron cloud charge buildup in both dipole and wiggler magnets

RFA Wiggler Vacuum Chamber





Detailed modeling of the grid holes

The sophisticated 3D finite-element mesh algorithm allows calculation of subtle effects in the RFA geometry. An exaggerated example of the effect of etching the grid holes is shown here.