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MODEL DEVELOPMENT FOR TIME-RESOLVED RETARDING-FIELD ANALYZER MEASUREMENTS OF ELECTRON CLOUD BUILDUP AT CESRTA*

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The Cornell Electron Storage Ring Test Accelerator program includes investigations into electron cloud buildup mitigation techniques using custom vacuum chambers. Multibunch electron and positron beams of energies between 2.1 and 5.3 GeV with bunch spacings from 4 to 98 ns and bunch populations ranging from 1e10 to 16e10 provide highly differentiated sensitivity to the processes contributing to cloud buildup such as photoelectron production, cloud space-charge dynamics, and secondary electron emission. Measurements of the time dependence of cloud buildup using BPM-style shielded pickups have been shown to provide tight constraints on cloud buildup models. Recently, time-resolving retarding-field analyzers have been designed, installed and commissioned. These novel detectors combine the time-resolving feature of the shielded pickups with the fine transverse segmentation and cloud electronenergy sensitivity of the time-integrating retarding-field analyzers used previously. We report on progress in modeling these measurements and quantify their sensitivity to various parameters describing the underlying physical processes contributing to cloud buildup.

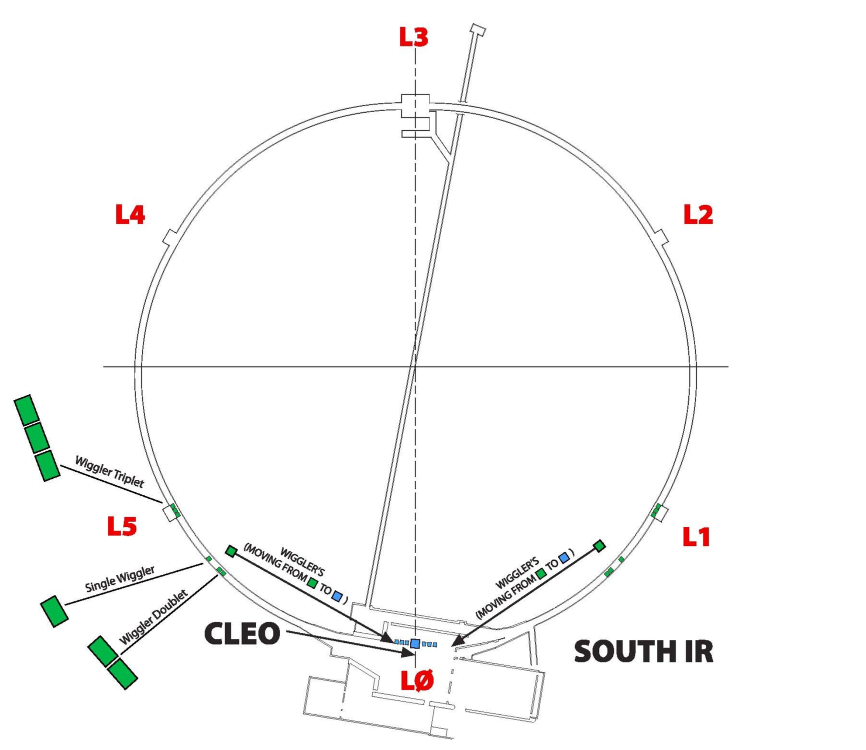
CESRTA reconfiguration July – October 2008

L3 Electron cloud experimental region

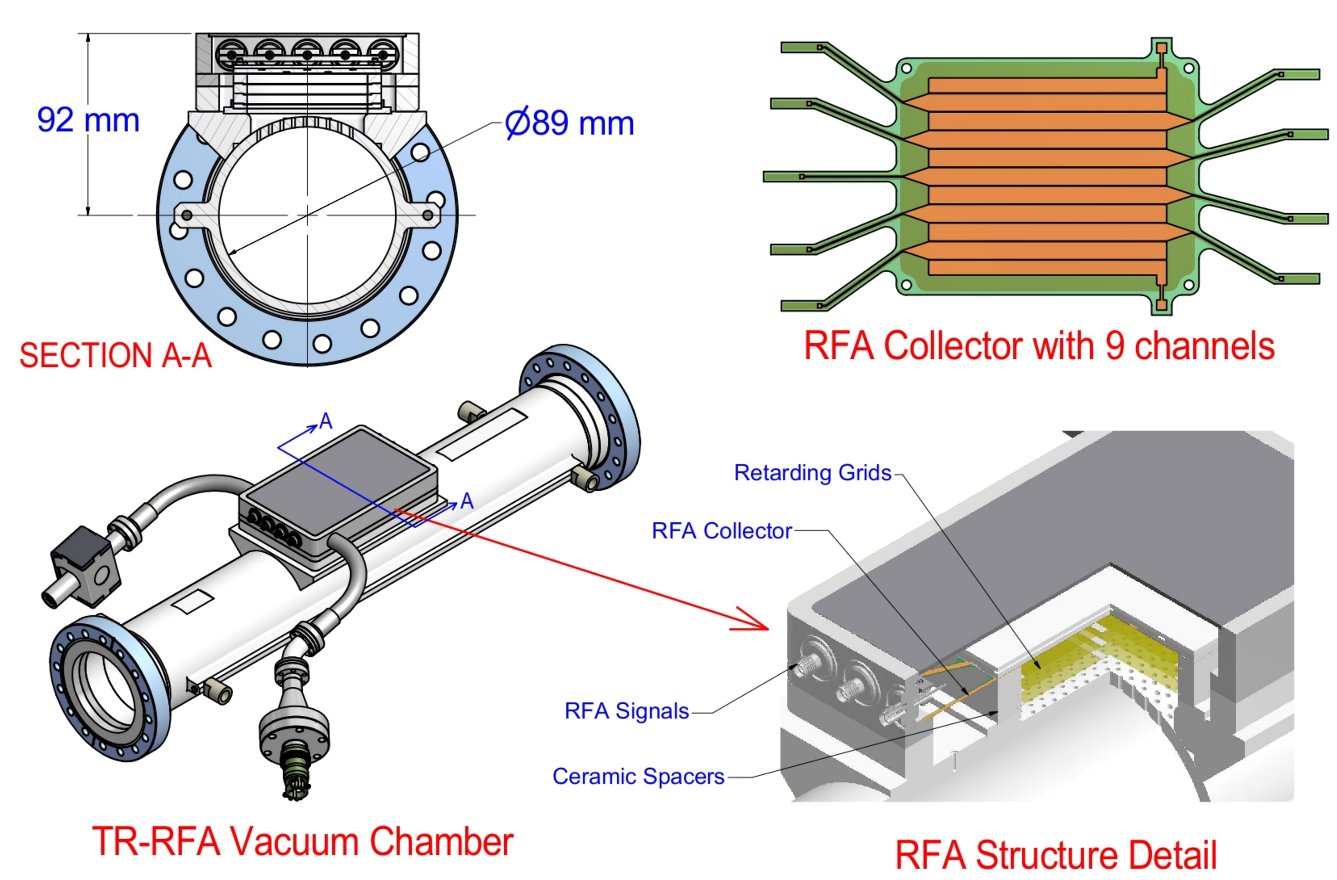
PEP-II EC Hardware:

Dipole chicane (810 G)

Time-resolving RFAs commissioned in 2012



Time-resolving retarding-field analyzers



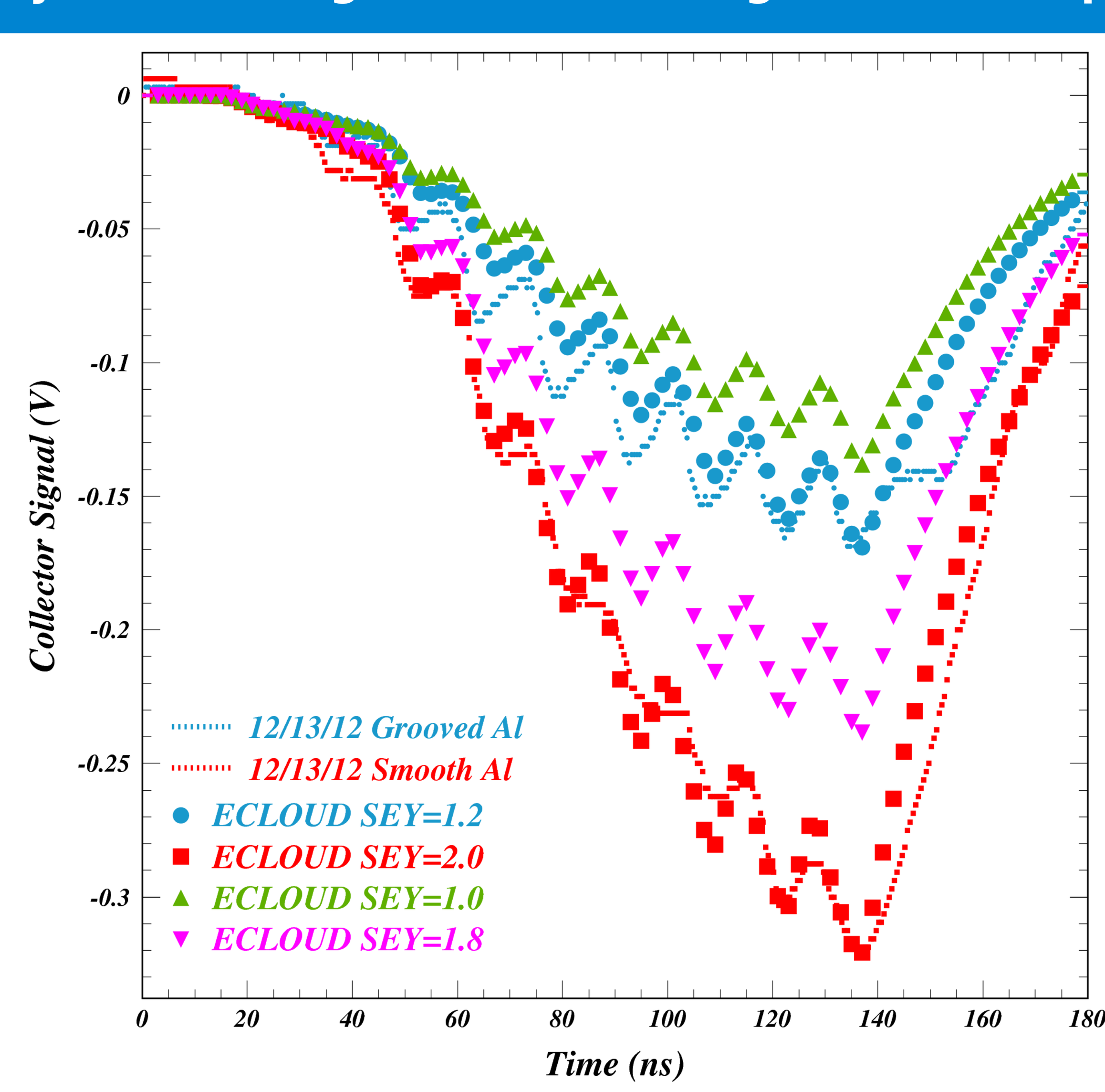
Electron cloud simulation package ECLOUD

* Originated at CERN in the late 1990's
* Widespread application for LHC, KEK, RHIC, ILC ...
* Under active development at Cornell since 2008
* Successful modeling of CESRTA tune shift measurements
* Interactive time-resolving RFA model implemented in 2013

I. Generation of photoelectrons
   A) Production energy, angle
   B) Azimuthal distribution (v.c. reflectivity)
II. Time-sliced cloud dynamics
   A) Cloud space charge force
   B) Beam kick
   C) Magnetic fields
III. Secondary yield model
   A) True secondaries (yields > 1!)
   B) Rediffused secondaries (high energy)
   C) Elastic reflection (dominates at low energy)
IV. Time-resolving RFA model
   A) Acceptance vs incident angle, energy
   B) Signal charge removed from cloud
   C) Non-signal charge creates secondaries

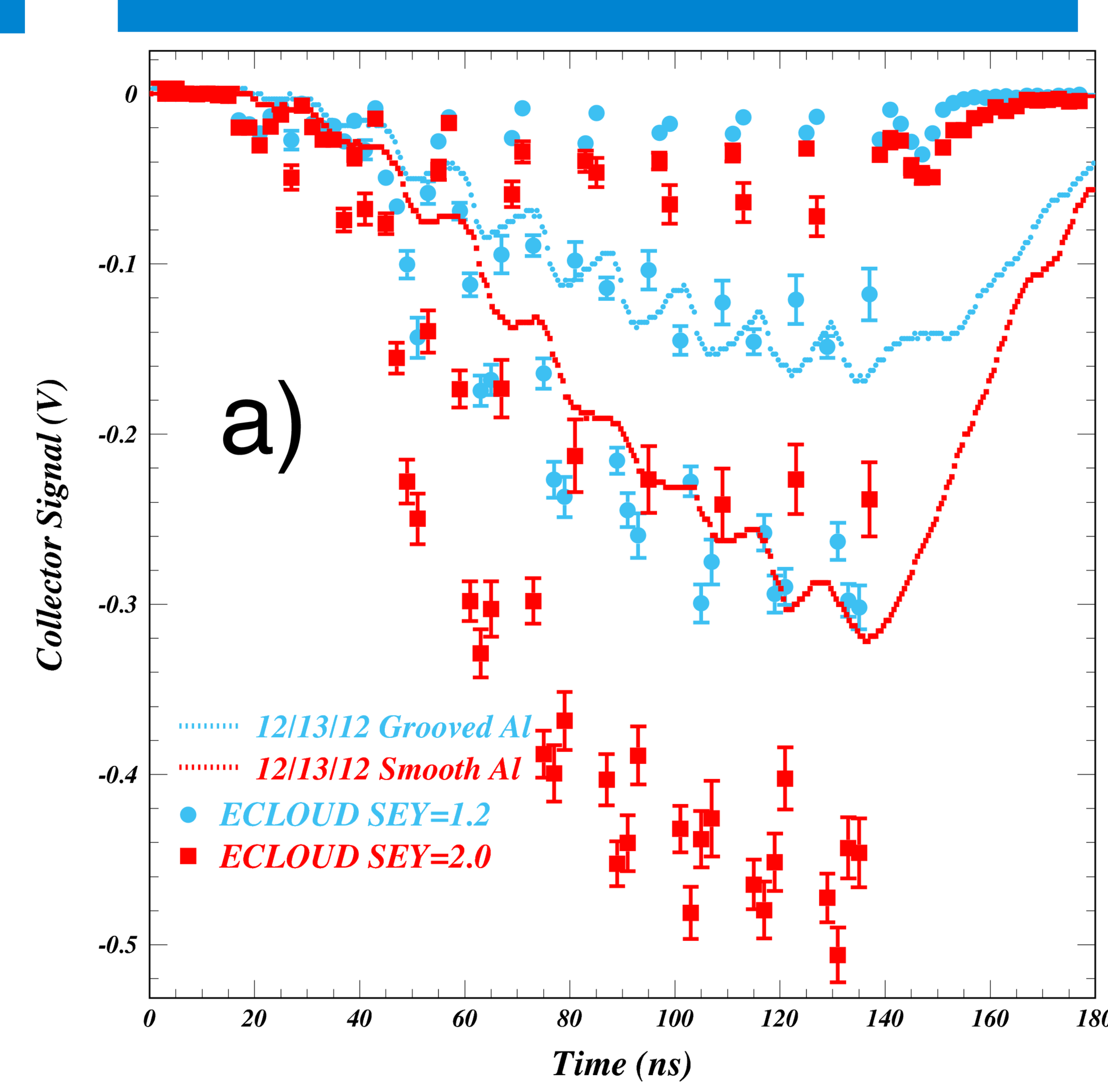
Effectiveness of grooves

TR-RFA measurements and ECLOUD model results for a 10-bunch train of 5.3 GeV positrons in the smooth and grooved uncoated vacuum chambers. The bunch spacing is 14 ns and the bunch population is 1.28e11. ECLOUD models with peak SEY value of 2.0, 1.8, 1.2 and 1.0 are shown to illustrate the sensitivity of this comparison to the effective reduction in secondary emission afforded by the use of grooves as a mitigation technique.



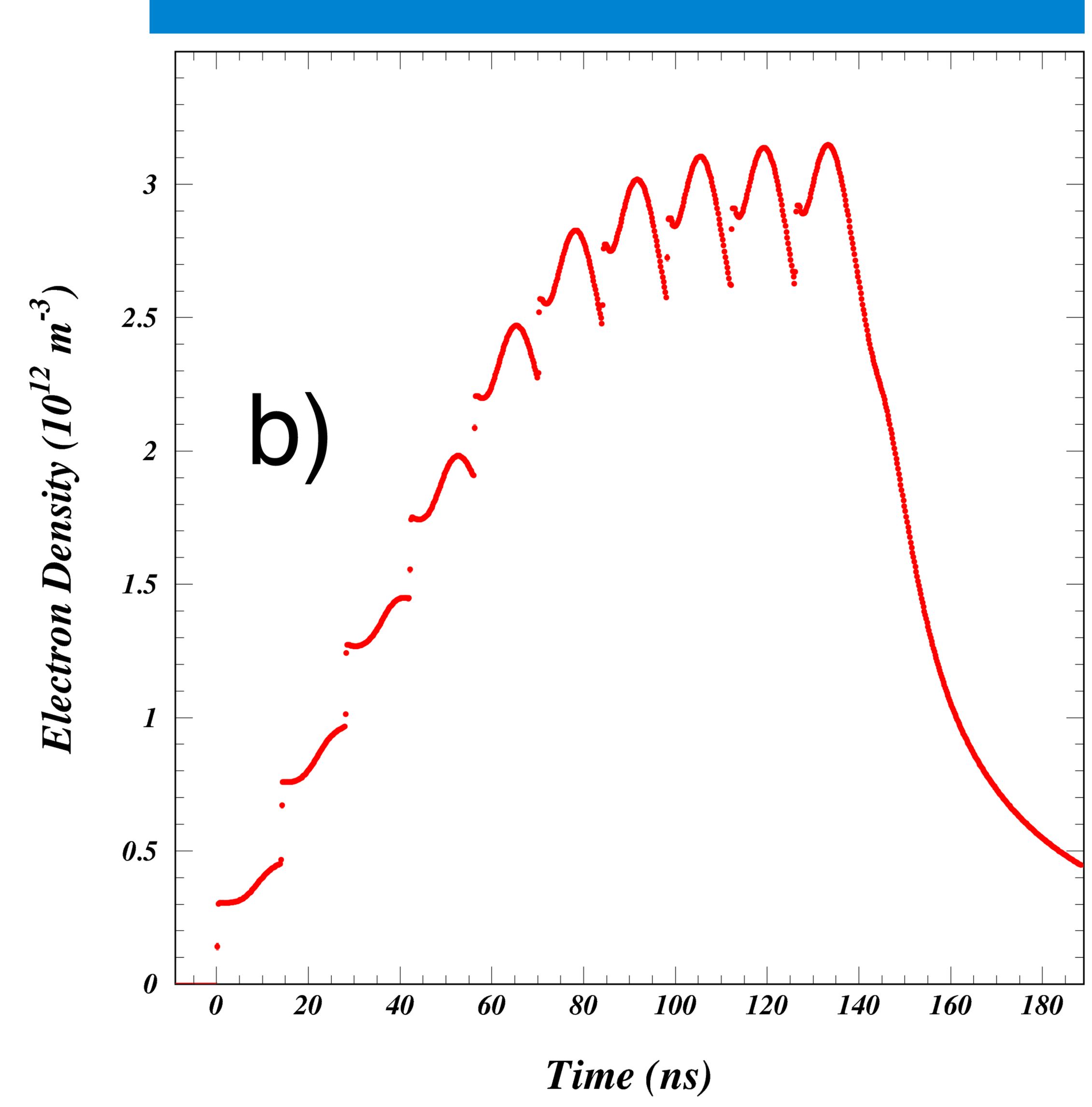
Underlying time structure

ECLOUD model central collector signals for the smooth and grooved uncoated chambers with the TR-RFA time resolution convolution removed in order to show the underlying time structure of the cloud signal



Cloud density

Time structure of the cloud density, which both increases and decreases during the 14-ns between bunch passages, reaching a maximum value of about 3e12 e/m3



Summary

Four time-resolving retarding field analyzers have been installed and commissioned in a dipole chicane at CESRTA. The electron cloud buildup simulation code ECLOUD has been adapted to describe the recorded signals in the four custom vacuum chambers with uncoated aluminum and TiN-coated interior surfaces, smooth and grooved. The modeling results have shown that the grooves in the uncoated chamber reduce the effective peak secondary yield from a value of 2.0 to 1.2 with a sensitivity of better than 10%. The measurements in the TiN-coated chambers in an 810 G dipole field show that the grooving and TiN-coating mitigation technique proposed for the dipole sections of the ILC positron damping ring reduces cloud buildup by more than an order of magnitude.

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