Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

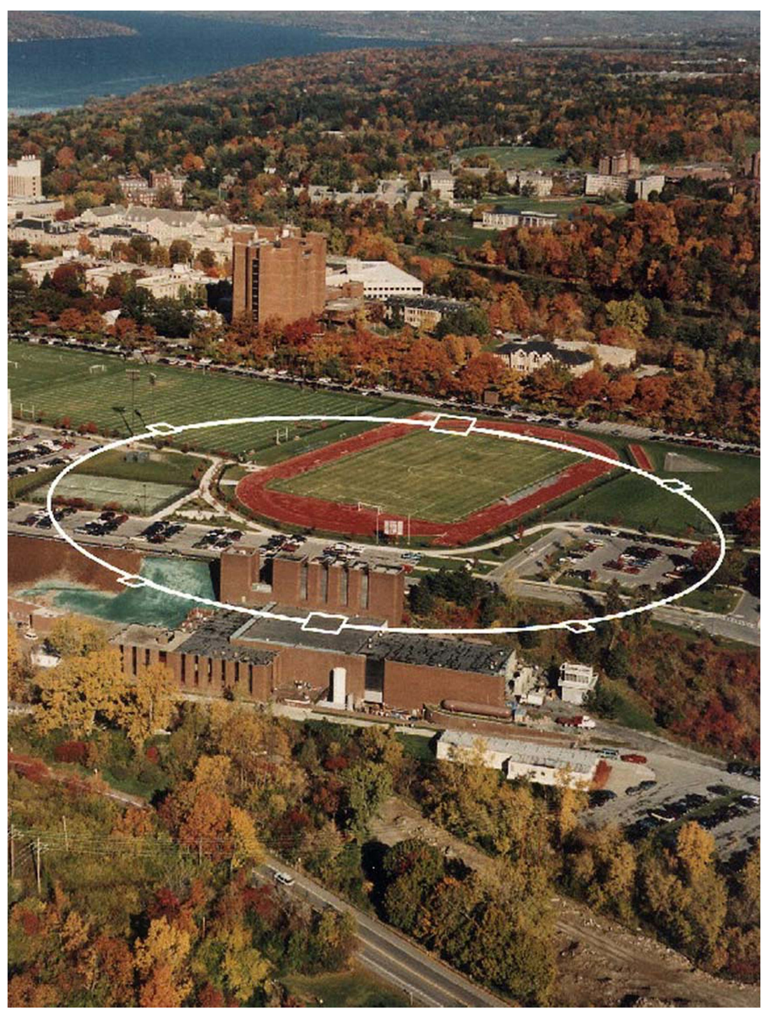
ecloud 10
49th ICFA Advanced Beam Dynamics Workshop
October 8 –12, 2010

Electron Cloud Modeling Results for Time-Resolved Shielded Pickup Measurements at CesrTA

J.A.Crittenden, Y.Li, X.Liu, M.A.Palmer, J.P.Sikora (Cornell)
S. Calatroni, G. Rumolo (CERN)

The Cornell Electron Storage Ring Test Accelerator (CesrTA) program includes investigations into electron cloud buildup, applying various mitigation techniques in custom vacuum chambers. Among these are two 1.1-m-long sections located symmetrically in the east and west arc regions. These chambers are equipped with pickup detectors shielded against the direct beam-induced signal. They detect cloud electrons migrating through an 18-mm-diameter pattern of holes in the top of the chamber. A digitizing oscilloscope is used to record the signals, providing time-resolved information on cloud development. Carbon-coated, TiN-coated and uncoated aluminum chambers have been tested. Electron and positron beams of 2.1, 4.0 and 5.3 GeV with a variety of bunch populations and spacings in steps of 4 and 14 ns have been used. Here we report on results from the ECLOUD modeling code which highlight the sensitivity of these measurements to model parameters such as the photoelectron azimuthal and energy distributions at production, and the secondary yield parameters including the true secondary, rediffused, and elastic yield values. In particular, witness bunch studies exhibit high sensitivity to the elastic yield by providing information on cloud decay times.

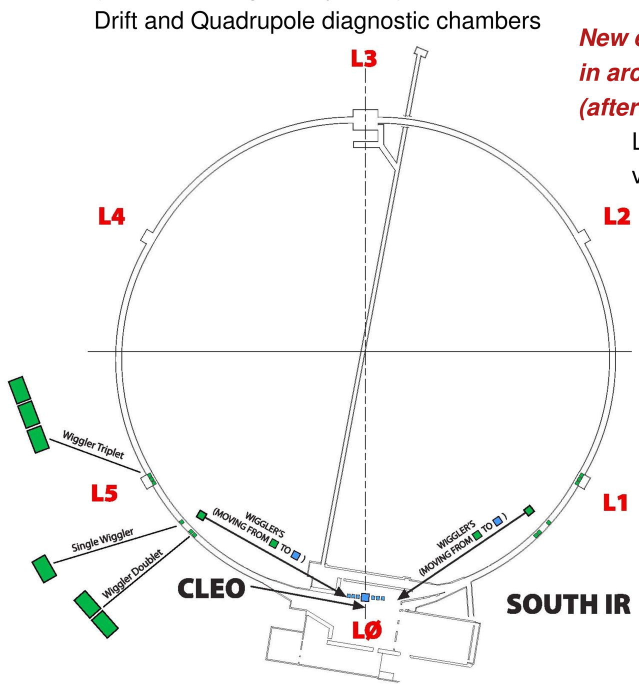
The CESR Tunnel under the Cornell Campus

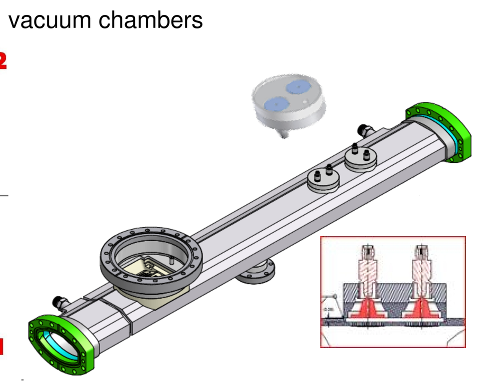


The CesrTA Reconfiguration July – October 2008

L3 Electron cloud experimental region
PEP-II EC Hardware:
Chicane, upgraded SEY station
(commissioning in May 2009)
Drift and Quadrupole diagnostic chambers

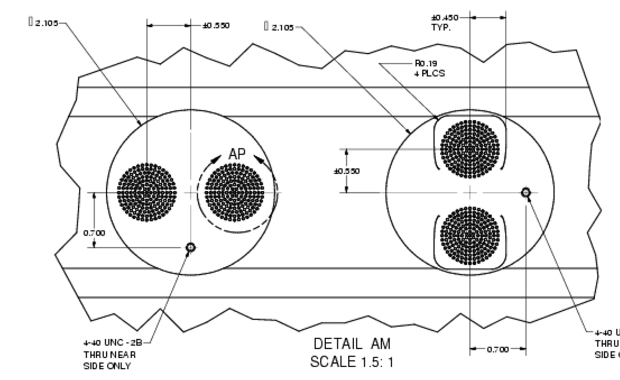
New electron cloud experimental regions in arcs near L1 and L5 (after 6 wigglers moved to L0 straight)
Locations for collaborator experimental vacuum chambers

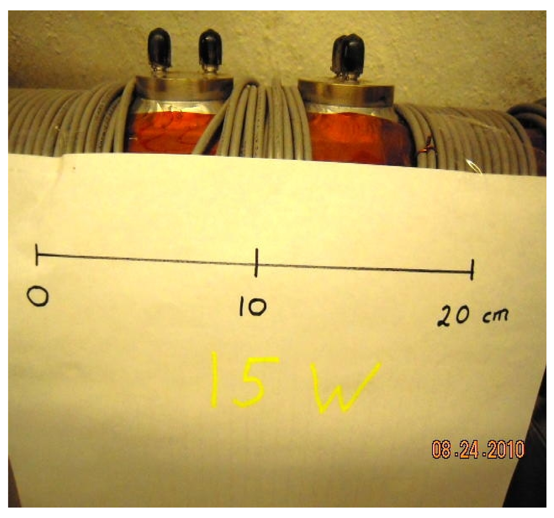




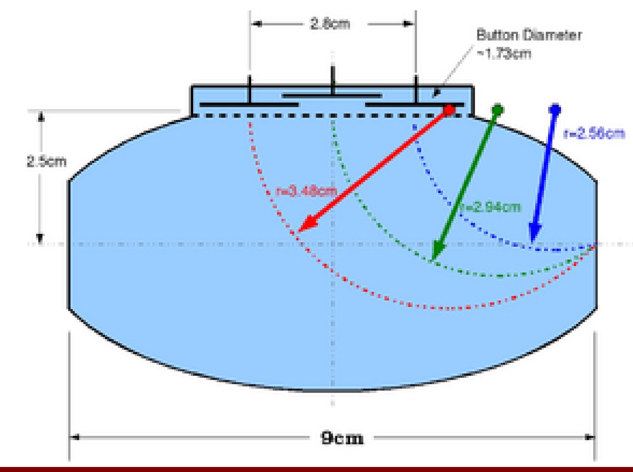
Custom vacuum chambers (Al, TiN, amorphous carbon) with shielded pickups

Shielded pickup port geometry and solenoid windings





Solenoidal magnetic field 0-40 G provides spectrometer-like analysis of photoelectron energies



This schematic illustrates one way the shielded pickups can be used to constrain physical parameters determining electron cloud development. The solenoidal field produces photoelectron trajectories from the primary synchrotron radiation source point as shown, constrained by the perpendicular acceptance of the port transmission holes, i.e. the centers of the circular trajectories must lie in the horizontal plane of the port holes. The positions of the buttons thus sample different (but overlapping) regions of the photoelectron energy distribution. Note also that they accept different production angles.

Analysis of the measurements with solenoidal field are just beginning.
This poster will address two other ways in which the shielded pickup data are used to determine model parameters:
1) using the shape of the signal from the first bunch passage to estimate the photoelectron energy distribution
2) using witness bunches with varying spacing from the first bunch to estimate the cloud lifetime

Electron cloud simulation package ECLOUD

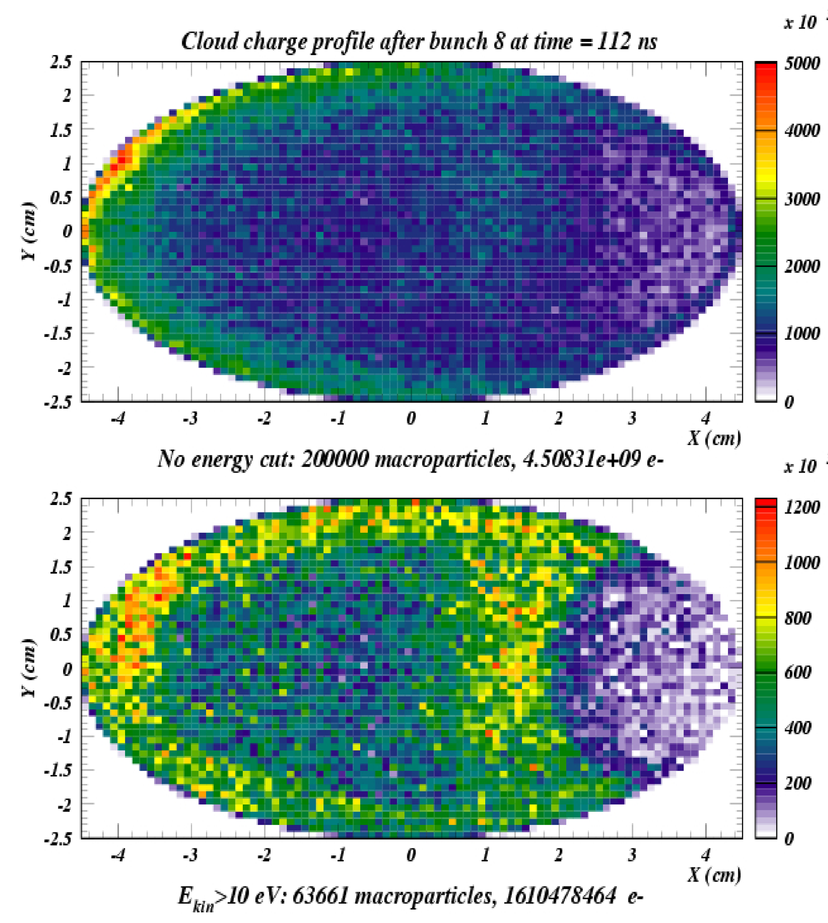
* Originated at CERN in the late 1990's
* Widespread application for LHC, KEK, RHIC, ILC ...
* Under active development at Cornell since 2008
* Successful modeling of CESRTA tune shift measurements
* Interactive shielded pickup model implemented in 2010

I. Generation of photoelectrons
- A) Production energy, angle
- B) Azimuthal distribution (v.c. reflectivity)

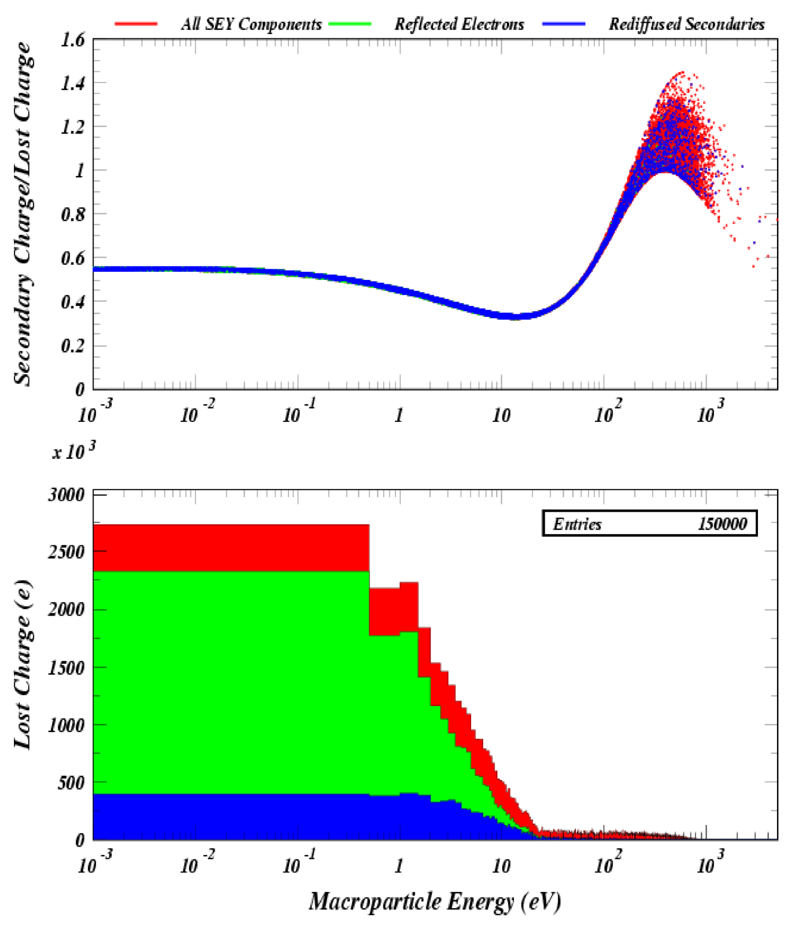
II. Time-sliced cloud dynamics
- A) Cloud space charge force
- B) Beam kick
- C) Magnetic fields

III. Secondary yield model
- A) True secondaries (yields > 1!)
- B) Rediffused secondaries (high energy)
- C) Elastic reflection (dominates at low energy)

Cloud snapshot

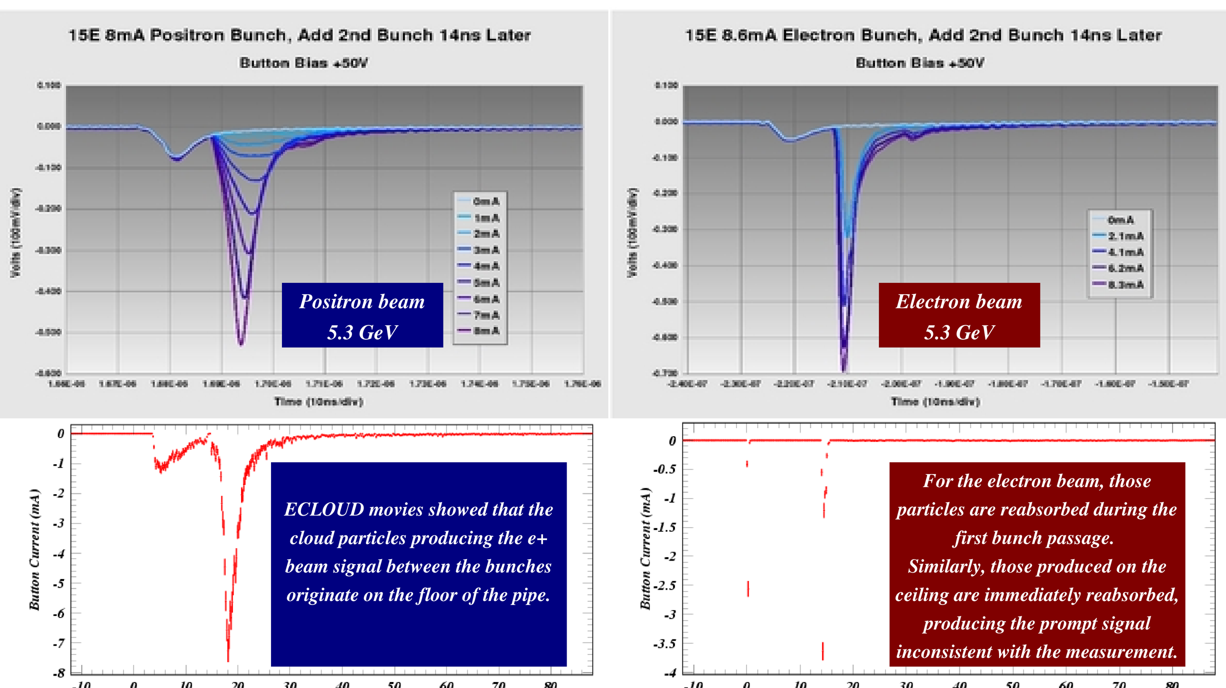


Secondary yield contributions



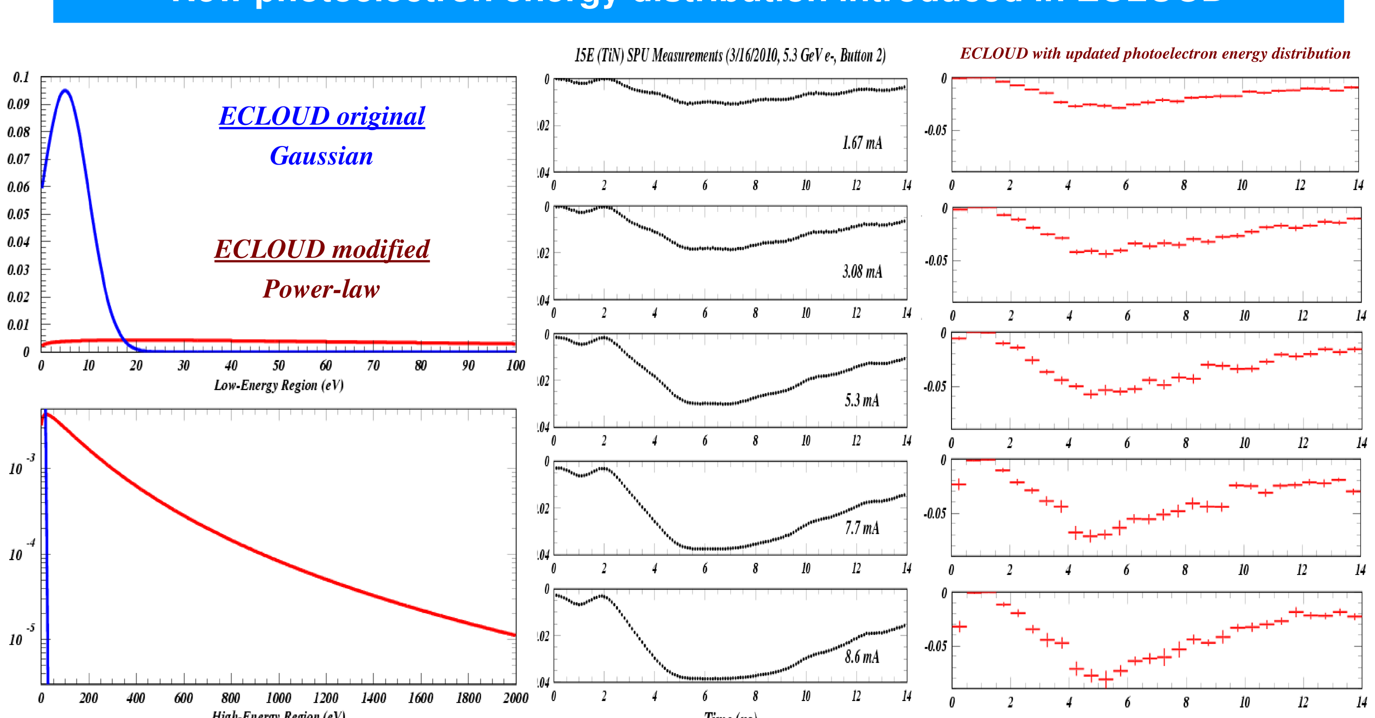
Shielded pickup model in ECLOUD

Model for pickup port transmission probability: transparency, angular dependence.
Cloud charge contributing to pickup signal is removed from the cloud. Remaining charge produces secondaries.



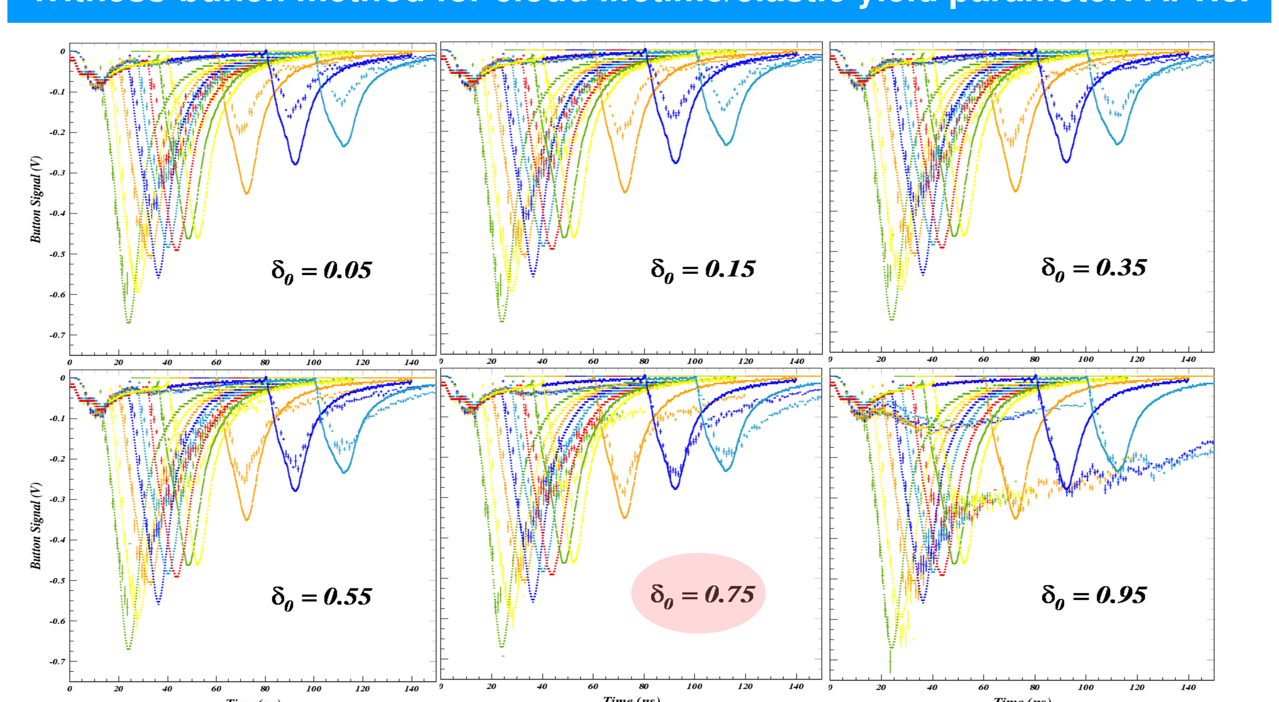
ECLOUD fails to model the signal for an electron beam with high bunch current, because the production energies of the photoelectrons are too low to overcome the repulsion of the beam kick.

New photoelectron energy distribution introduced in ECLOUD



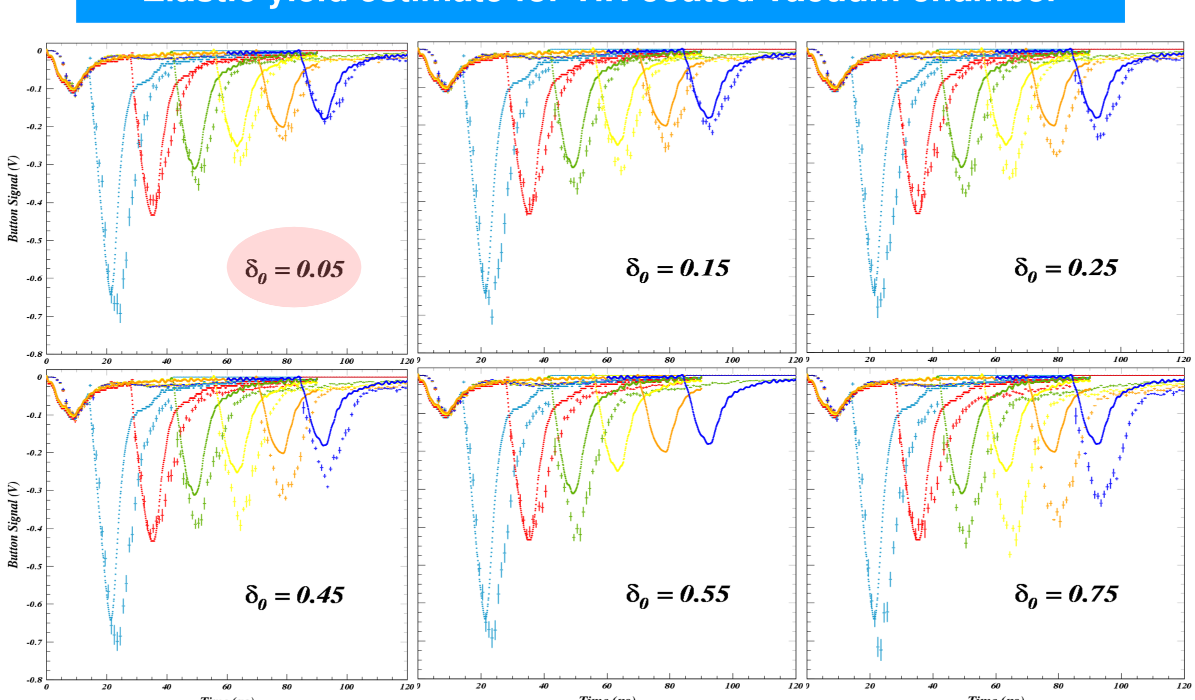
Time dependence insensitive to bunch current and cloud density (ρ = 0.9e12 –> 3.0e12 m^{-3}).
Magnitude dependence well modeled. Simulated arrival/production energy comparison shows space charge effect.
Prompt signal appears with higher bunch current, arising from photoelectrons produced near the button.

Witness-bunch method for cloud lifetime/elastic yield parameter: Al v.c.



The witness bunch data with bunch spacing in multiples of 4 ns requires accurate modeling during cloud buildup. Further study of cloud parameters is needed.

Elastic yield estimate for TiN coated vacuum chamber



ECLOUD model for the witness bunch data is very sensitive to the elastic yield parameter. Many systematic studies of parameter correlations remain to be done.

LEPP, the Cornell University Laboratory for Elementary-Particle Physics, has joined with CHESS to become the Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE).
LEPP's primary source of support is the National Science Foundation. Visit us on the web at: www.lepp.cornell.edu