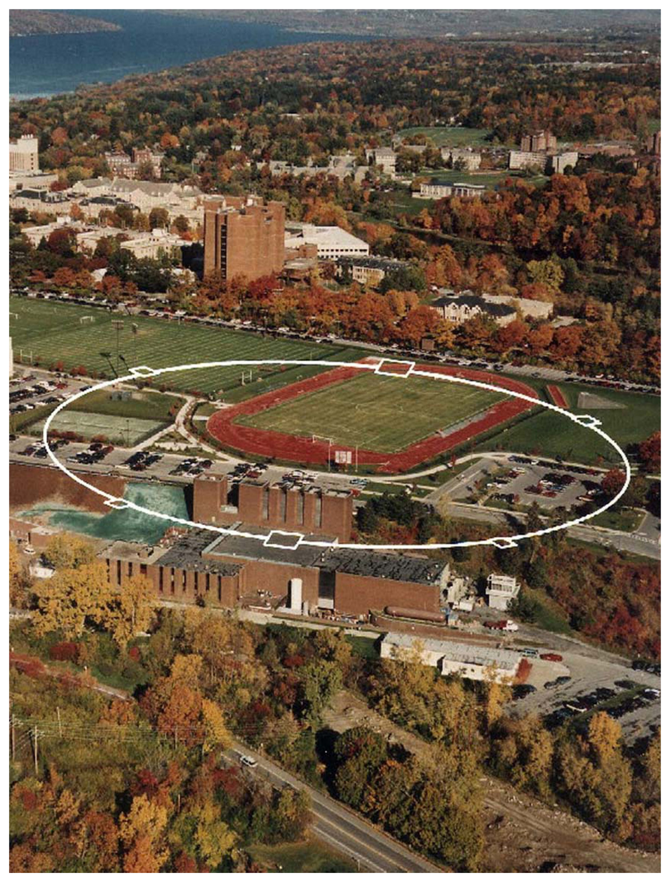
Studies of the Effects of Electron Cloud Formation on Beam Dynamics at CesrTA

J.A.Crittenden, J.R.Calvey, G.Dugan, D.L.Kreinick, J.A.Livezy, M.A.Palmer, D.L.Rubin (Cornell), K.Harkay (ANL), R.L.Holtzapple (Cal Poly), K.Ohmi (KEK), M.A.Furman, G.Penn, M.Venturini (LBNL), M.T.F.Pivi and L.Wang (SLAC)

The Cornell Electron Storage Ring Test Accelerator (CesrTA) has commenced operation as a linear collider damping ring test bed following its conversion from an e^+e^--collider in 2008. A core component of the research program is the measurement of effects of synchrotron-radiation-induced electron cloud formation on beam dynamics. We have studied the interaction of the beam with the cloud in various bunch train configurations, bunch currents, beam energies, and bunch lengths, for both e^+ and e^- beams. This paper compares a subset of these measurements to modeling results from the two-dimensional cloud simulation packages ECLOUD and POSINST. These codes each model most of the tune shift measurements with remarkable accuracy, while some comparisons merit further investigation.

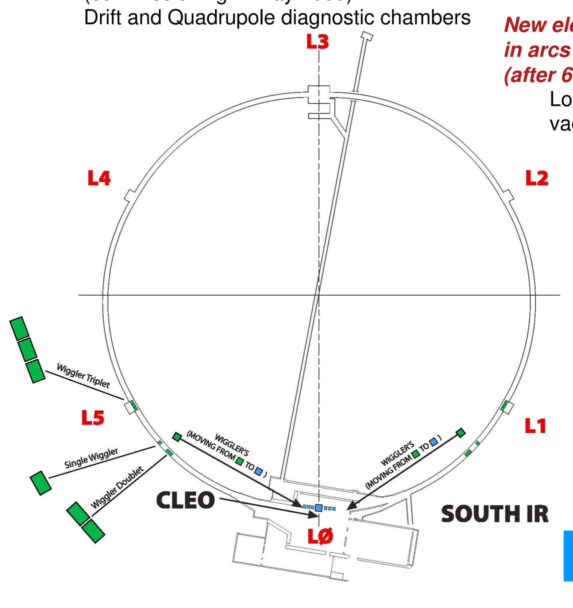
The CESR Tunnel under the Cornell Campus

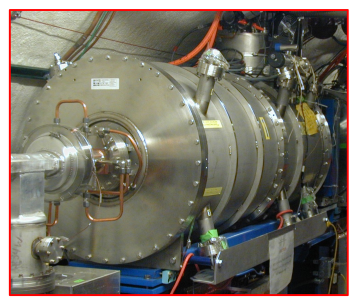


The CesrTA Reconfiguration July – October 2008

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





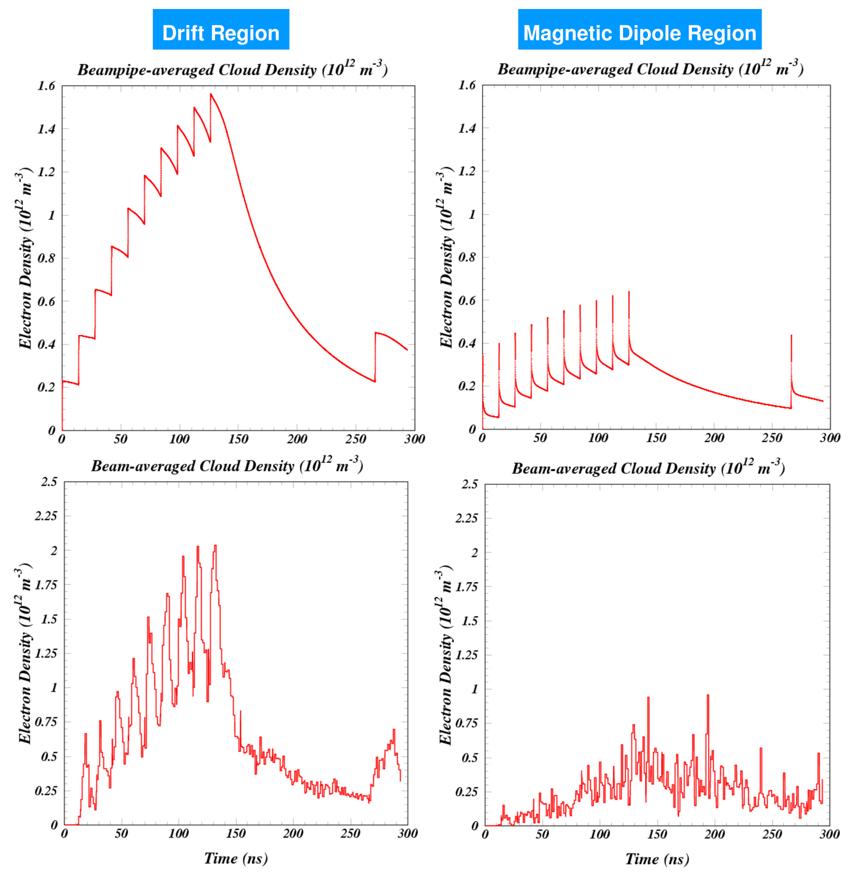
CESR superconducting wiggler

L0 region reconfigured as a wiggler straight
CLEO detector sub-systems removed
6 wigglers moved from CESR arcs to zero dispersion straight
Region instrumented with EC diagnostics and mitigation
Wiggler chambers with retarding field analyzers and various electron cloud mitigation methods
(fabricated at LBNL in CU/SLAC/KEK/LBNL collaboration)

Electron Cloud Buildup

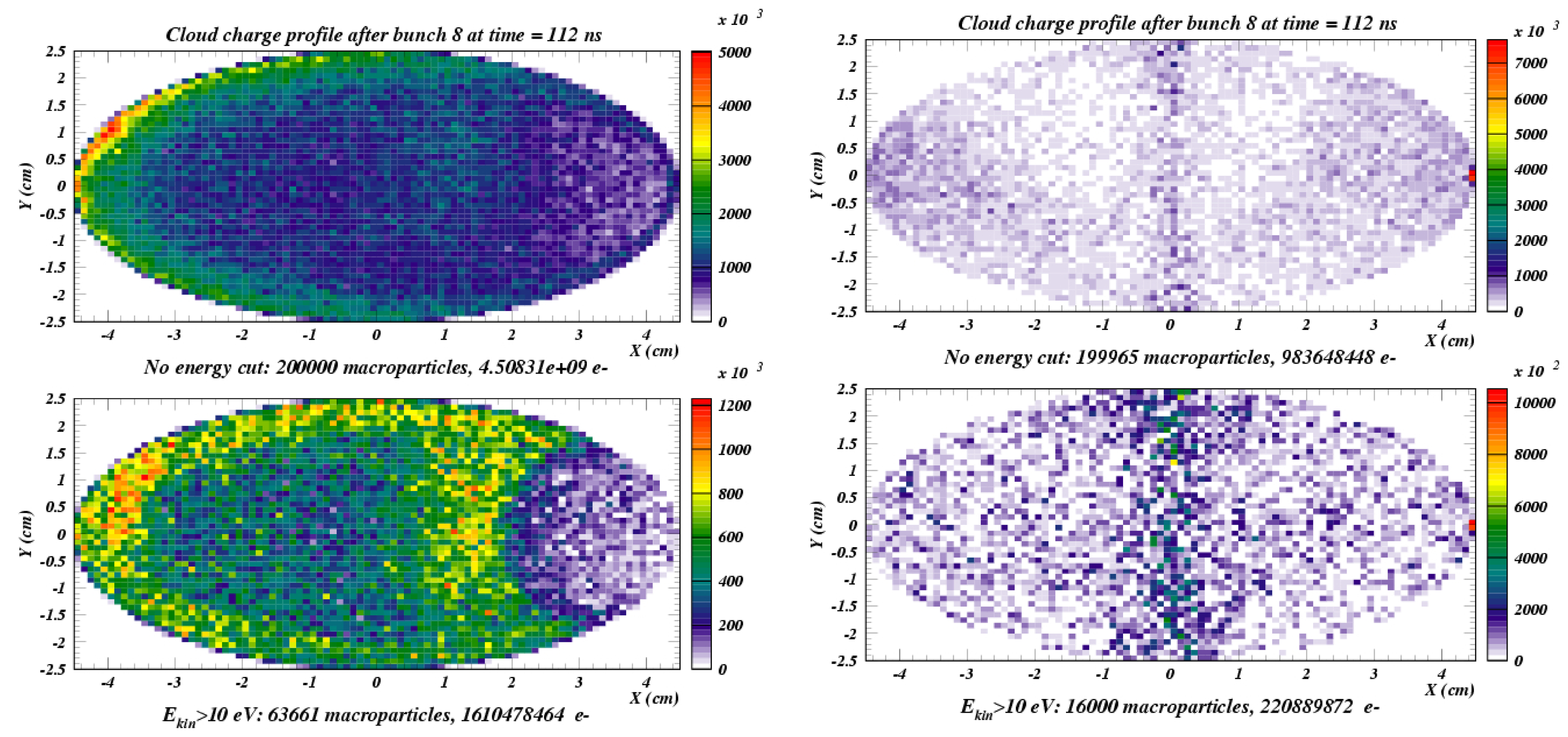
10 filled bunches and bunch 20 filled as witness bunch
Bunch spacing 14 ns RMS bunch length 13 mm

Drift Region | Magnetic Dipole Region

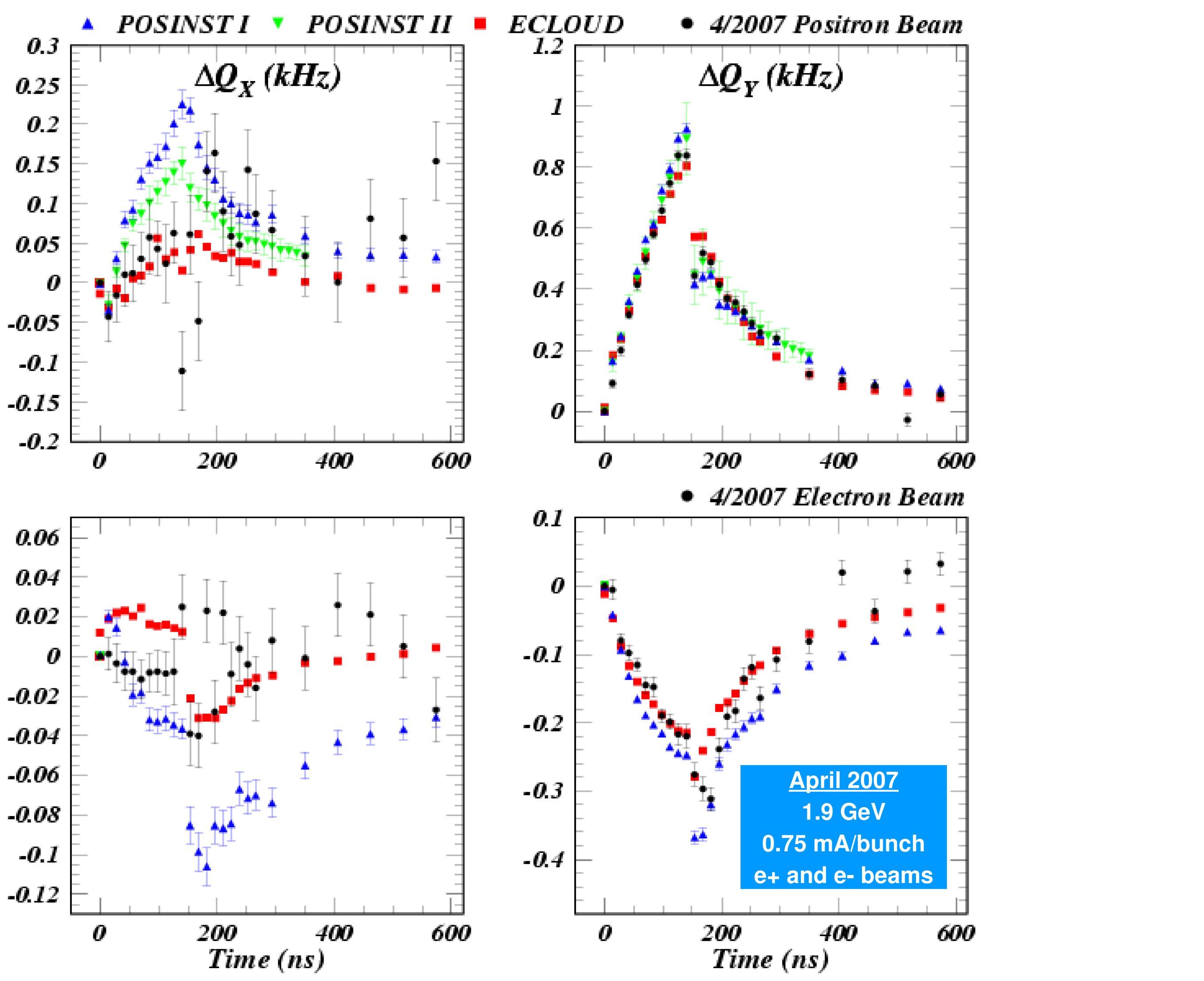


Snapshots of Cloud Profiles prior to passage of bunch 9

Drift Region | Magnetic Dipole Region



$$\Delta f_x = f_{rev}\frac{e}{4\pi E_{beam}}\oint \beta_x \left\langle \frac{dE_x}{dx}\right\rangle_{beam} ds \approx f_{rev}\frac{e}{4\pi E_{beam}} C \langle\beta_x\rangle_{ring}\left\langle\left\langle\frac{dE_x}{dx}\right\rangle_{beam}\right\rangle_{ring}$$



Modeling Coherent Tune Shift Measurements Using ECLOUD and POSINST Cloud Simulation Packages

I. ECLOUD and POSINST cloud simulation input parameters

1. Sync rad photon rate per meter per beam particle at primary source point (2007: Drift R=0.23 γ/m/e, Dipole R=0.53 γ/m/e)
2. Quantum efficiency for producing photo-electrons on the vacuum chamber wall (12%)
3. Beam particles per bunch (0.75 mA/bunch -> 1.2e10 e/bunch).
4. Contribution of reflected sync rad photons distributed uniformly in azimuth around the beampipe wall (15%).
   - This contribution is also subtracted from the primary source point.
5. Secondary emission peak yield (SEY=2.0) at peak energy (E_{peak}= 310 eV)
   - These values are also used by POSINST, but the POSINST SEY model is quite different from ECLOUD's.

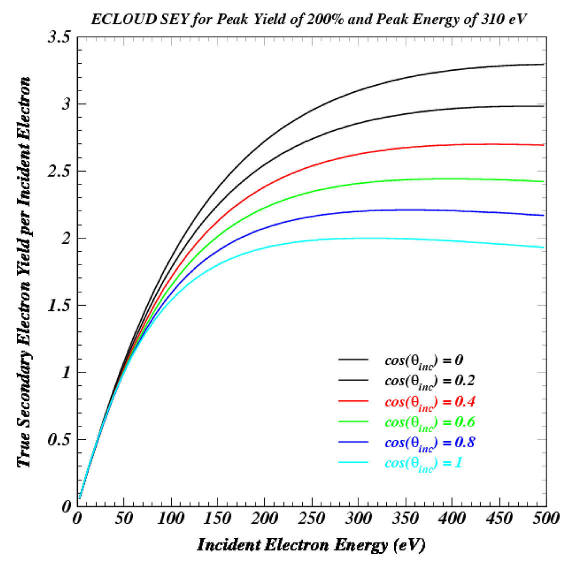
II. Field difference or gradient --> tune shift conversion parameters

1. E_{beam} = 1.885e9 eV
2. f_{rev} = 390 kHz
3. Ring circumference C=768 m ($C f_{rev}$ = c = 2.998e8 m/s)
4. Ring-averaged β values (from sync rad summary tables derived from lattice model)
   - e+ beam: Drift $\beta_X(\beta_Y)$ = 19.6m (18.8m), Dipole $\beta_X(\beta_Y)$ = 15.4m (18.8m)
   - e- beam: Drift $\beta_X(\beta_Y)$ = 19.4m (19.3m), Dipole $\beta_X(\beta_Y)$ = 15.3m (19.4m)

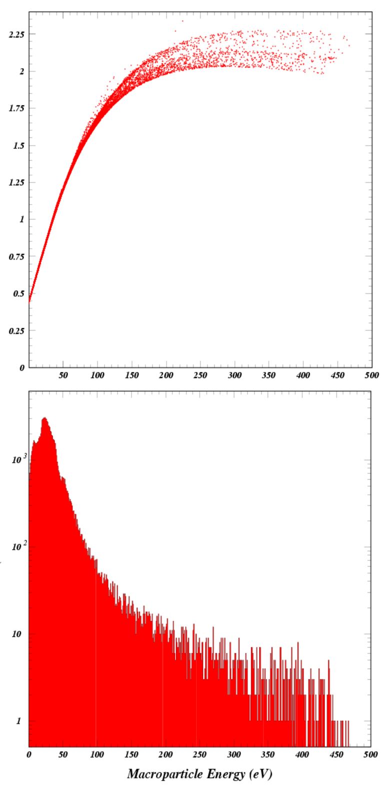
III. Relative drift/dipole weighting (from sync rad summary tables)

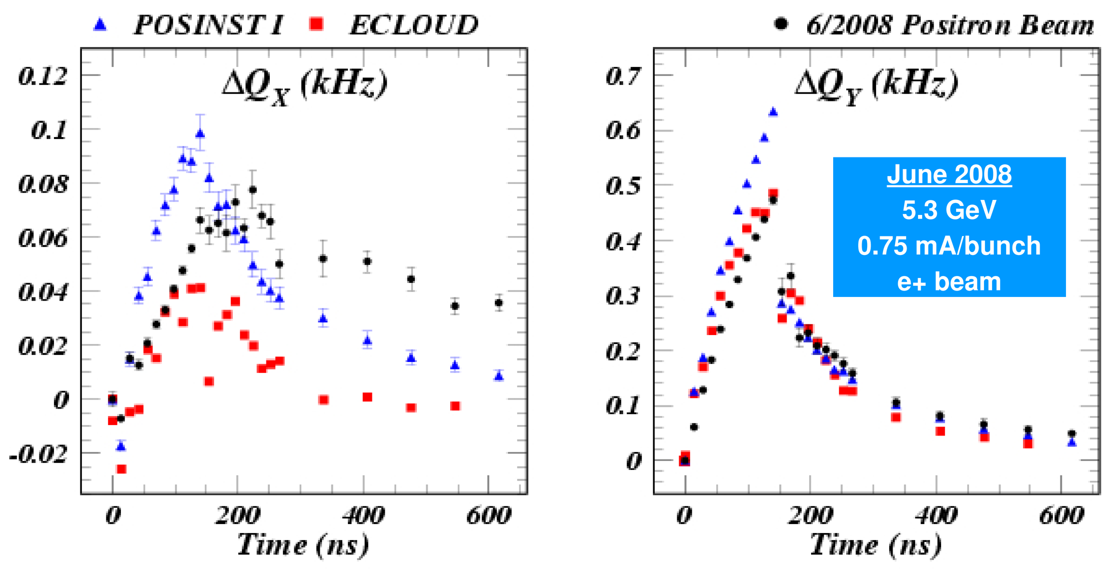
1. Ring length fractions: Drift: (174.9m/768m) = 0.228, Dipole: (473.9m/768m) = 0.617. Remaining 15% of ring ignored.

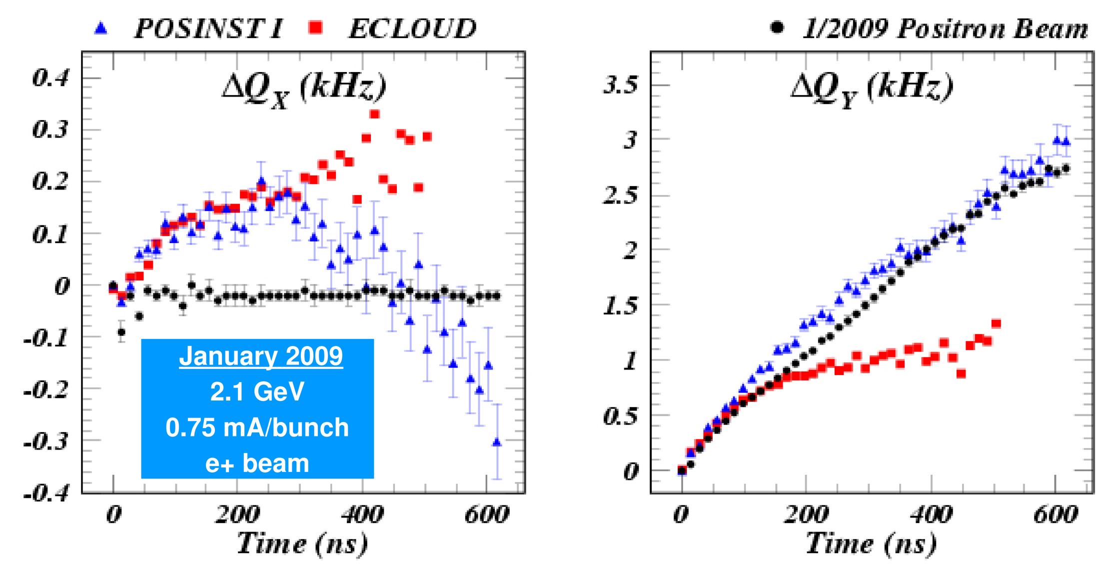
Yield curve for true secondaries for peak yield 2.0 and peak energy 310 eV



ECLOUD: simulated SEY yield population including elastics in the case of a drift volume for the April 2007 input parameters







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