Cornell University
Laboratory for Elementary-Particle Physics

First Results on the Introduction of the Rediffused SEY Component in ECLOUD

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Cornell Laboratory for Accelerator-Based Sciences and Education

Electron Cloud Simulations Meeting

23 September 2009

Problems with ECLOUD tune shift calculation for long bunch trains

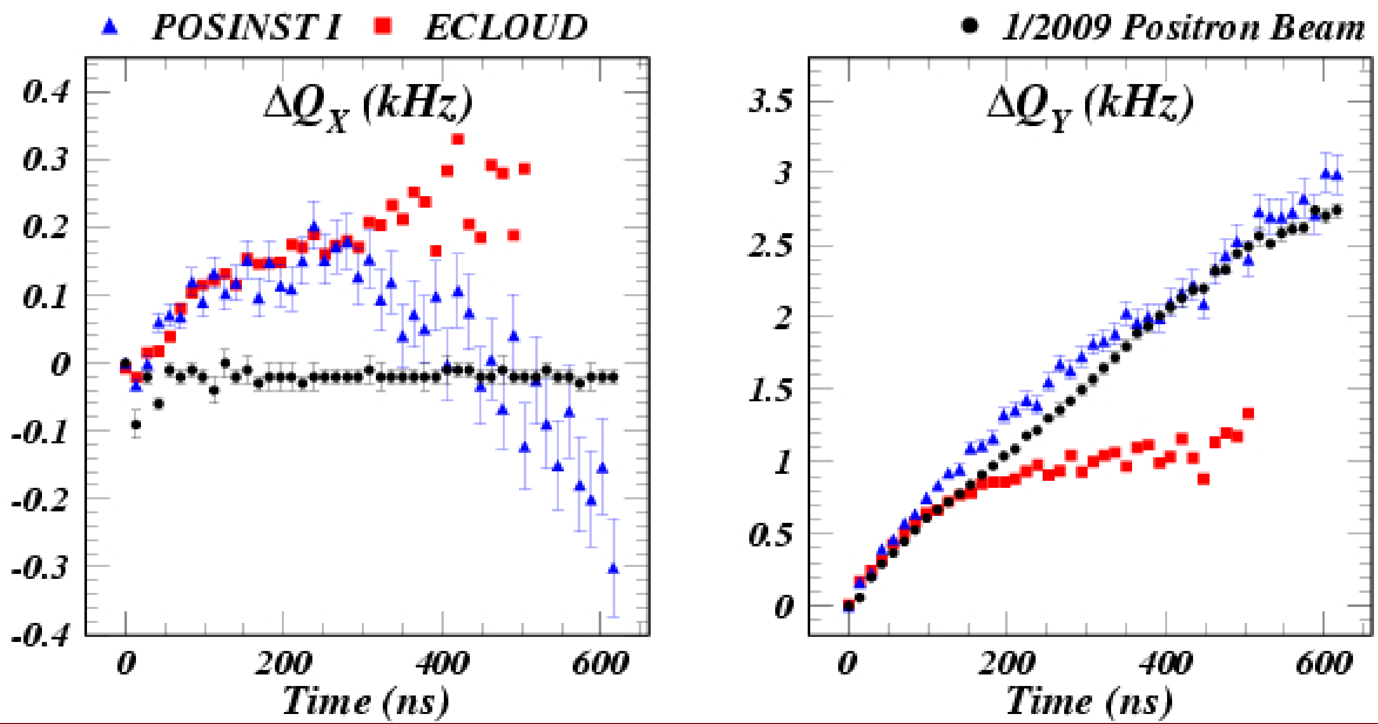
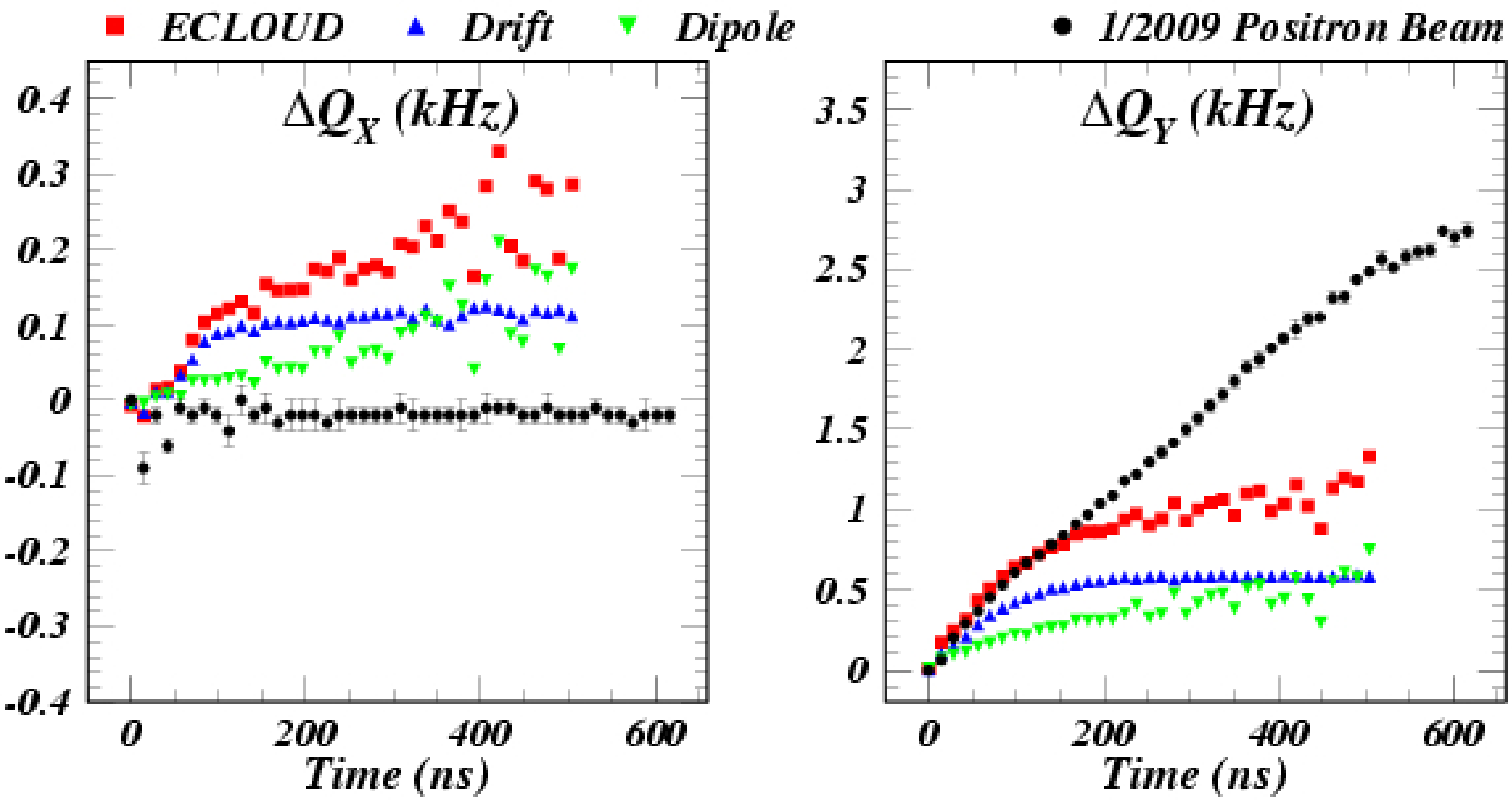


Figure 3 of ***Studies of the Effects of Electron Cloud Formation at CESRTA***
PAC 2009

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

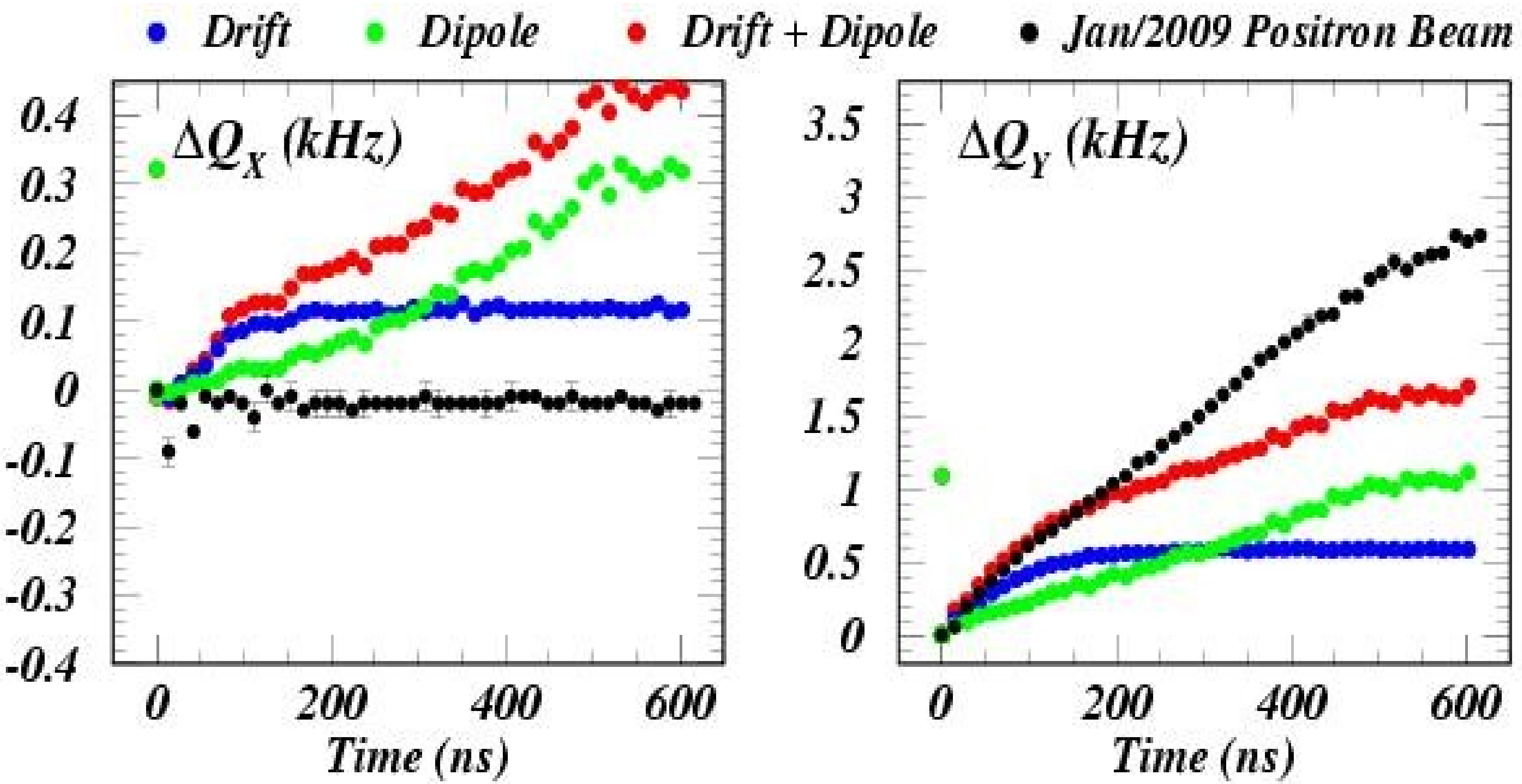
See also slides presented on 22 April 2009 in preparation for PAC 2009 and the followup on 20 May 2009

Relative Drift and Dipole Contributions



Fluctuations set in for late bunches in long trains in dipole regions.
Frank suggested testing numerical approximations.
Time step size, field calculation frequency – no help (see 20 May).
Problem resolved by increasing number and reducing charge of macroparticles (see 2 Sep).

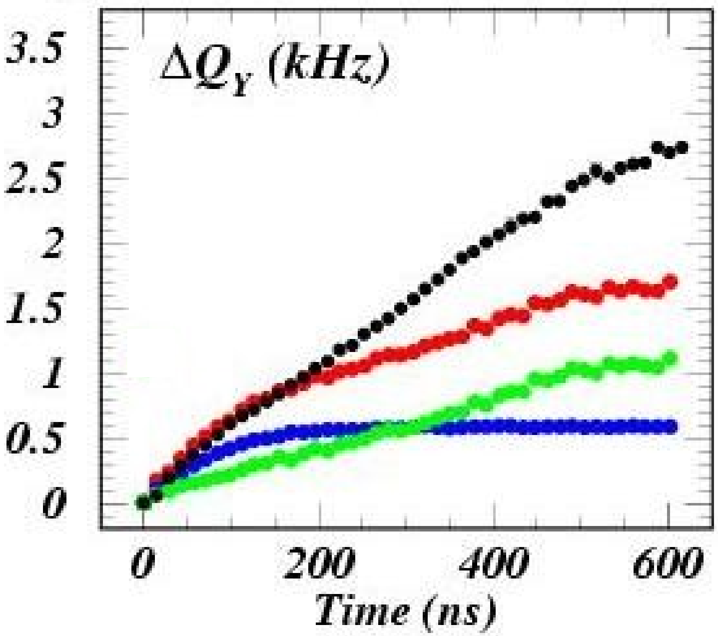
Replacement for figure 3 following resolution of the fluctuation problem



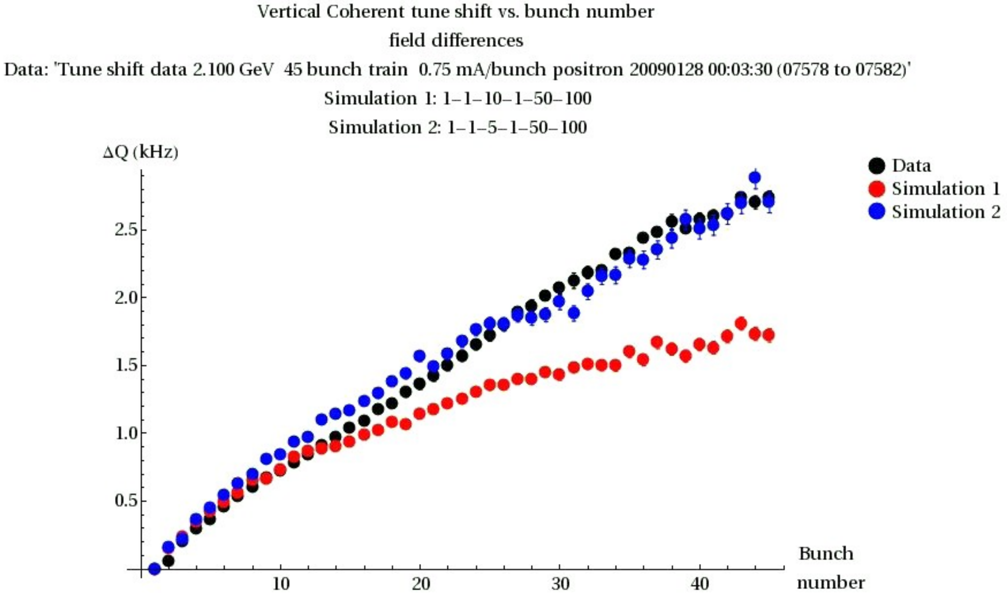
Next step: Does POSINST exhibit a similar problem if the rediffused component is removed?

Compare ECLOUD Result to POSINST with Rediffused SEY Component Removed

ECLOUD



POSINST without rediffused SEY component



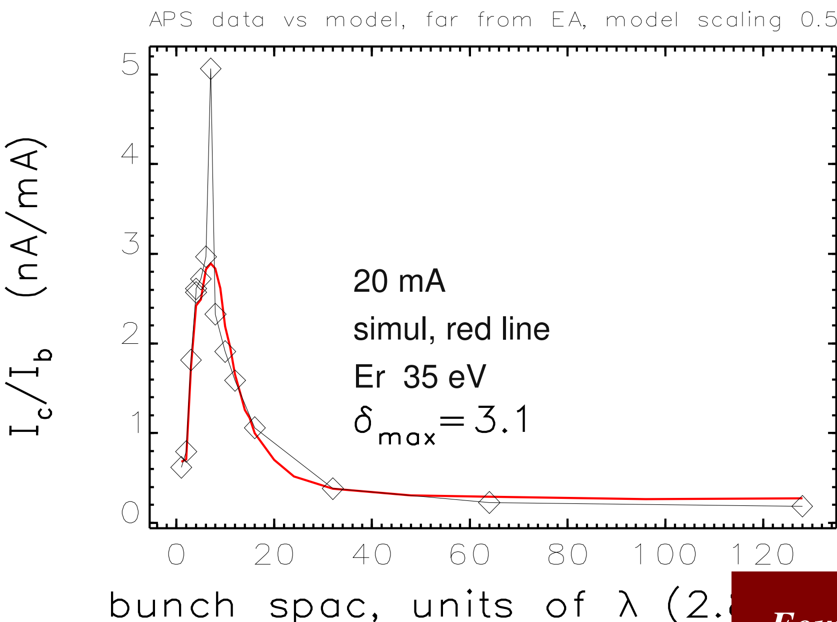
YES ! And very precisely. *(See D.L.Kreinick talk of 9 Sep)*

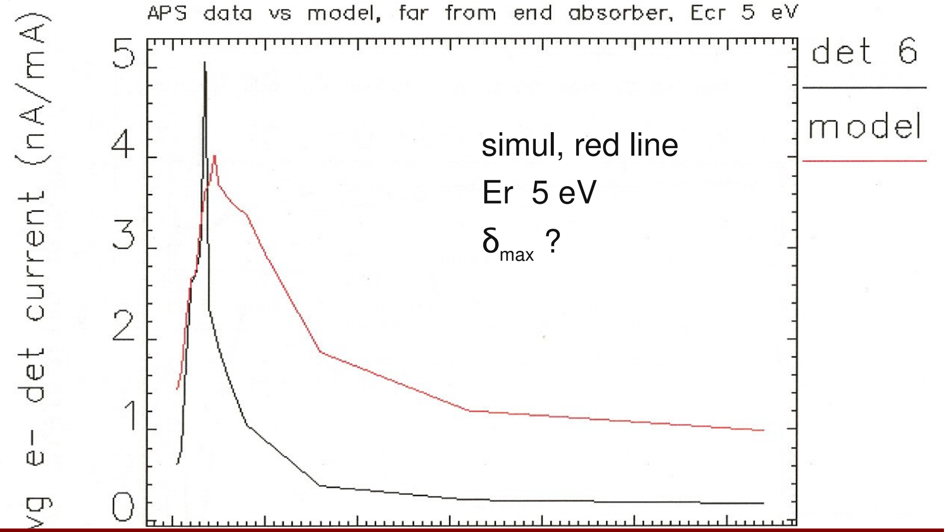
Physics lesson:

Long bunch trains (>20) are sensitive to cloud energy spectrum/SEY curve near E_{peak}/multipacting

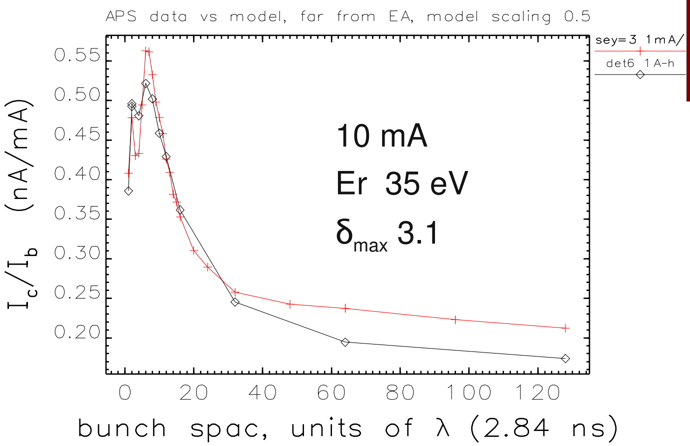
Sensitivity to the Rediffused Component Also Reported by Kathy Harkay/ANL

APS RFA Studies and Modeling, Kathy Harkay, CesrTA Webex 13 November 2008





Found consistency with Er =35 eV (ss), inconsistent with Er=5 eV (Cu).
The APC chamber is Al.
NB: Our POSINST simulations use Cu parameters for our Al chamber.



RFA vs. POSINST: $f_{ts} \propto E^{p_n - 1} e^{-E/\varepsilon_n}$

- **Peak at 20 ns bunch spac. (7 bkt) sensitive to true secondary electron spectrum**
- **Amplitude (max current) sensitive to δ_{max}**
- **Peak width sensitive to rediffused component**

Introduction of Rediffused SEY Component in ECLOUD (This is not the first time. Previously done for stainless.)

Furman & Pivi, PRSTAB 5, 1244041 (2002)

$$\delta_{rediffused} = P_{red} \, (1 - \exp (-(E - E_{red}) / r_{red})) \, (1 + 0.26 (1 - \cos^2\Theta))$$

$$E_{rediffused} = E_{incident} \; ran^{**}(1 / (1 + q_{red}))$$

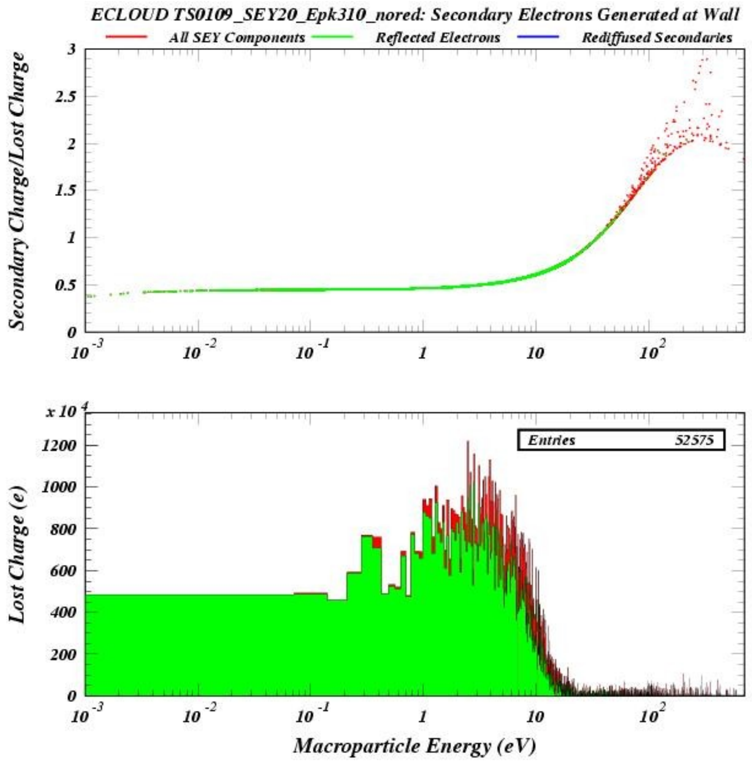
Copper (used for Al in POSINST)

$P_{red} = 0.2$ $E_{red} = 0.041$ eV $r_{red} = 0.104$ $q_{red} = 0.5$

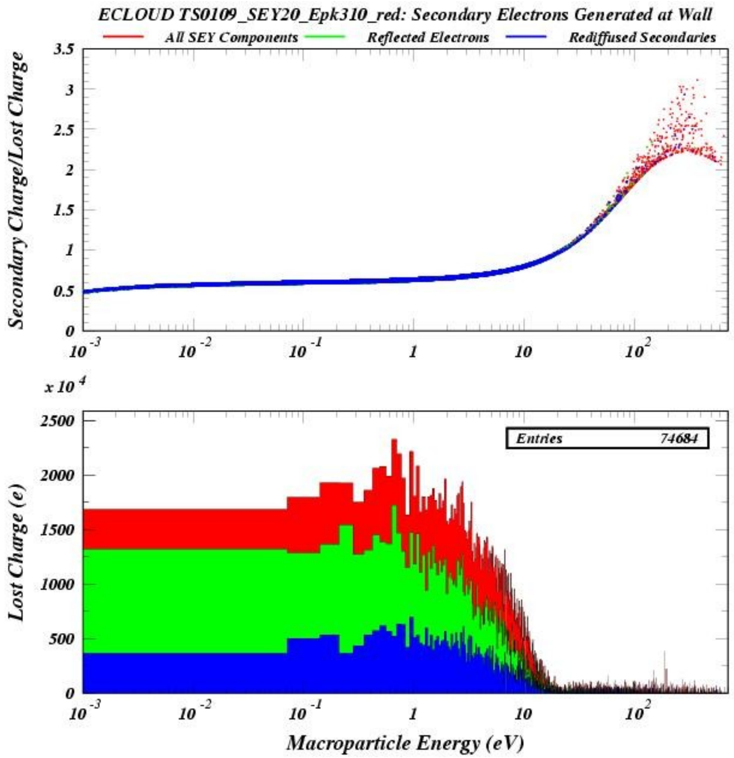
Substantial modification of ECLOUD SEY routines finished 24 Sep 09.
Removed redundant code, introducing new subroutines.
Comments, citations.

Rediffused SEY Component in ECLOUD
-- SEY Curve Population --

$P_{red} = 0$



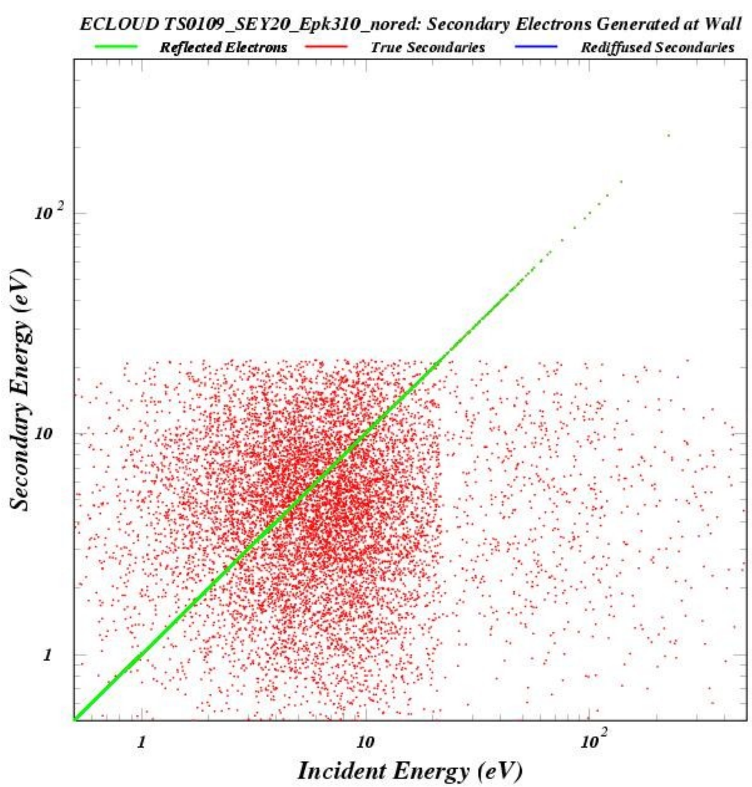
$P_{red} = 0.2$ (Cu)



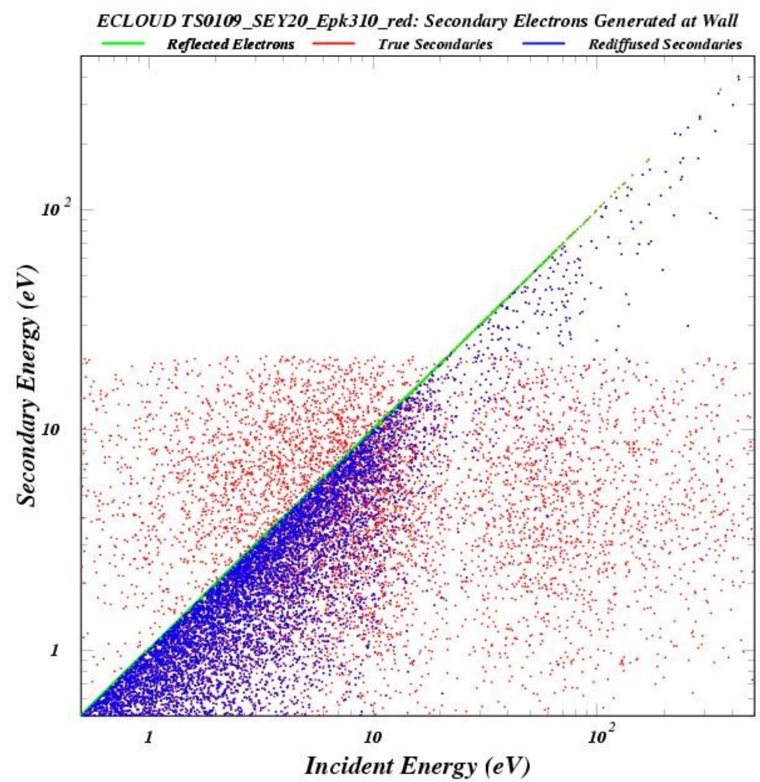
The charge of the generated secondary is $Q_{tot} = Q_{el} + Q_{ts} + Q_{red}$.
The energy of the secondary is determined by the type generated.
The frequency of type i is given by Q_i/Q_{tot}.

Rediffused SEY Component in ECLOUD -- Energy Distribution --

$P_{red} = 0$



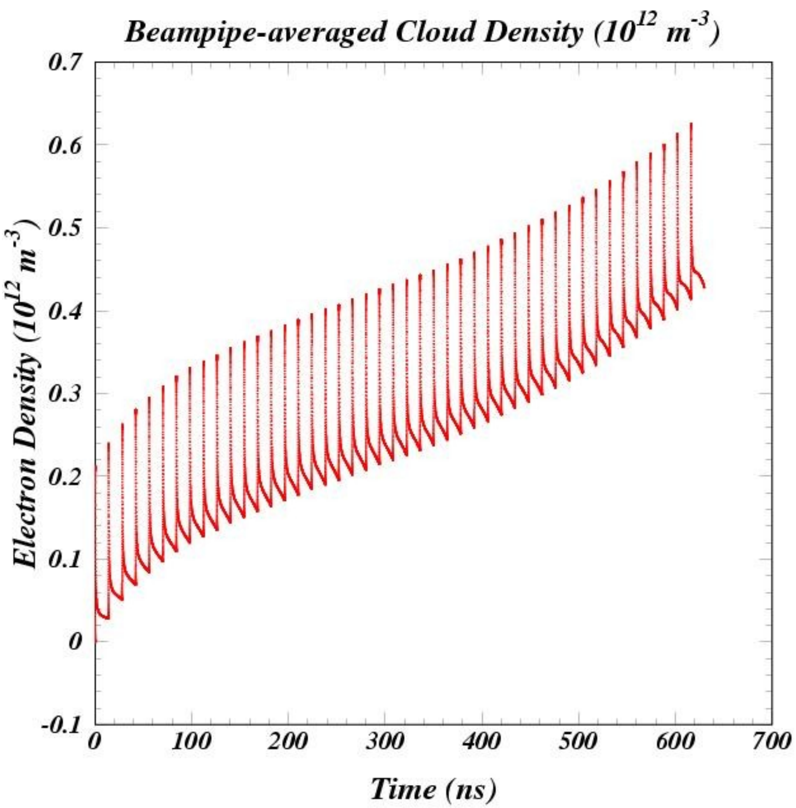
$P_{red} = 0.2$



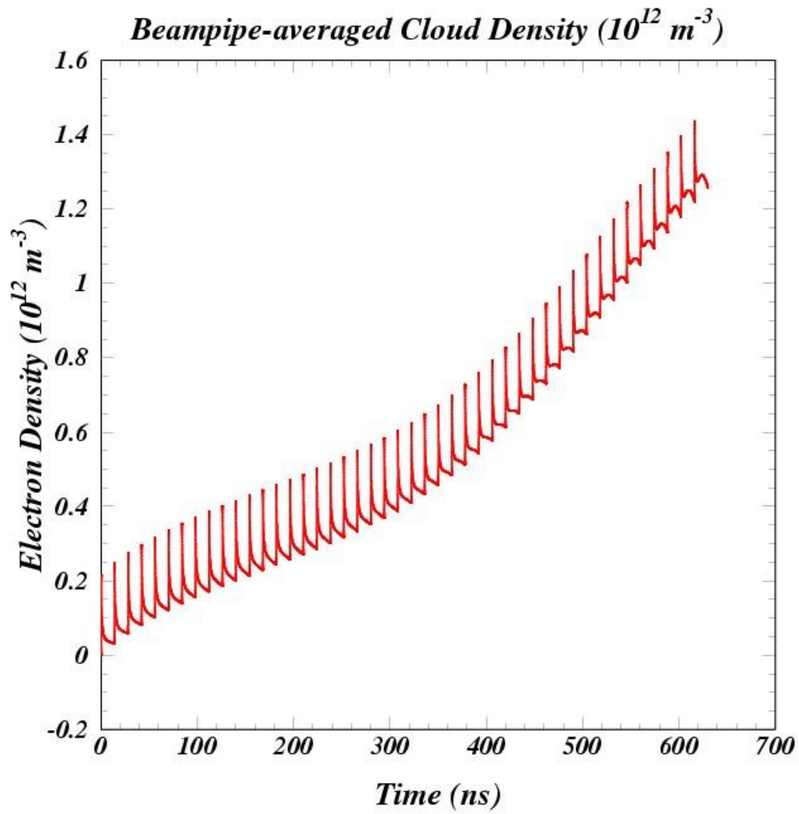
Rediffused parameter E_r = 0.04 eV means there is negligible energy dependence for E>0.04 eV.
ECLOUD true secondary energies are limited to 12*1.8=21.6 eV max.

Modelling Tune Shift Measurements of Jan 2009
-- 45 e+ bunches, 0.75 mA/bunch, 2.085 GeV --

$P_{red} = 0$



$P_{red} = 0.2$



Dipole Region
Cloud density averaged over beampipe volume

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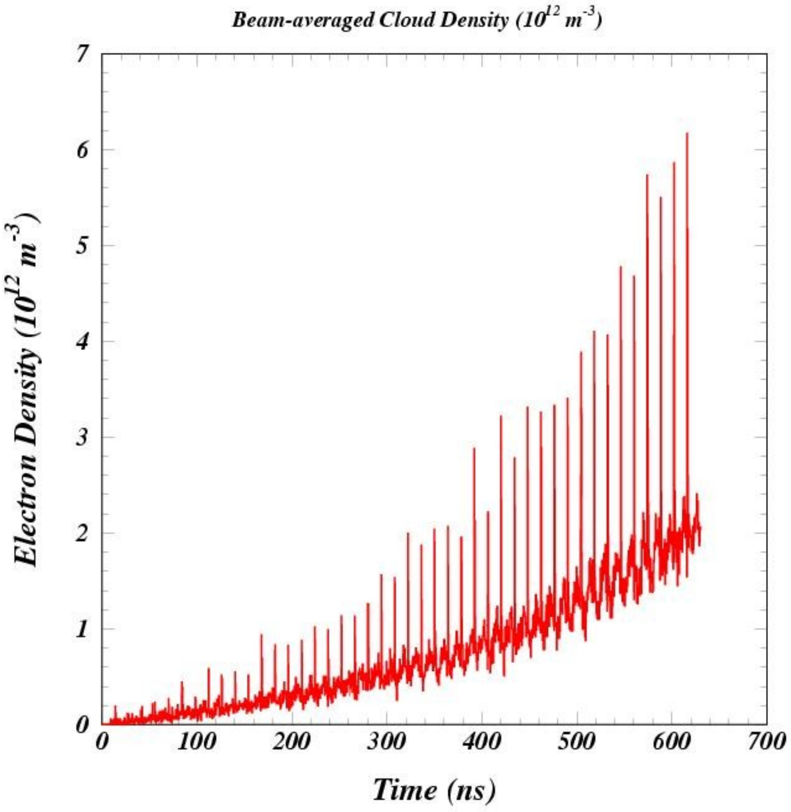

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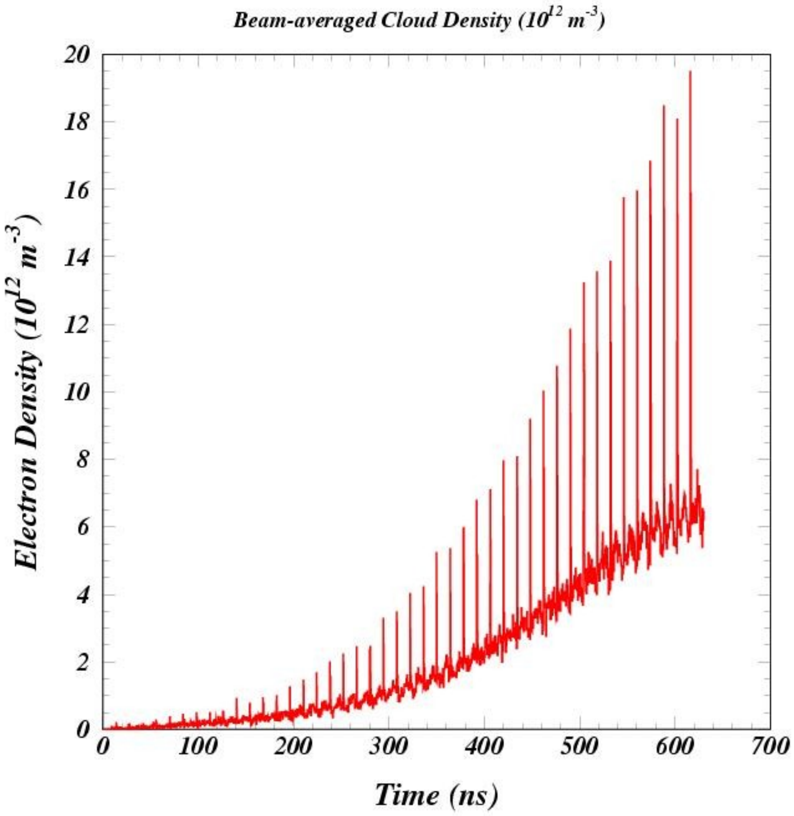

Dipole Region
Cloud density averaged over beam

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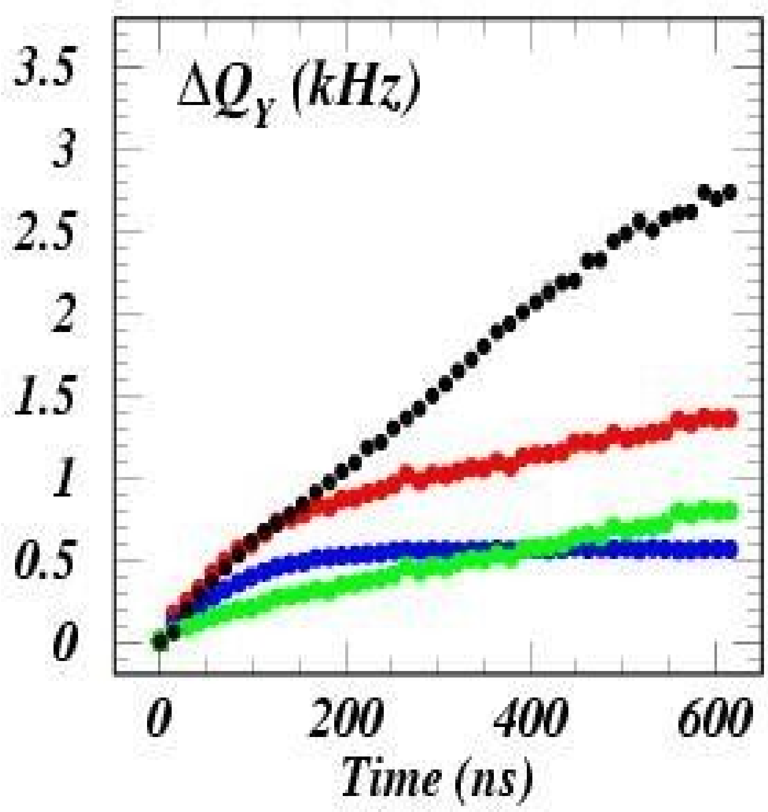

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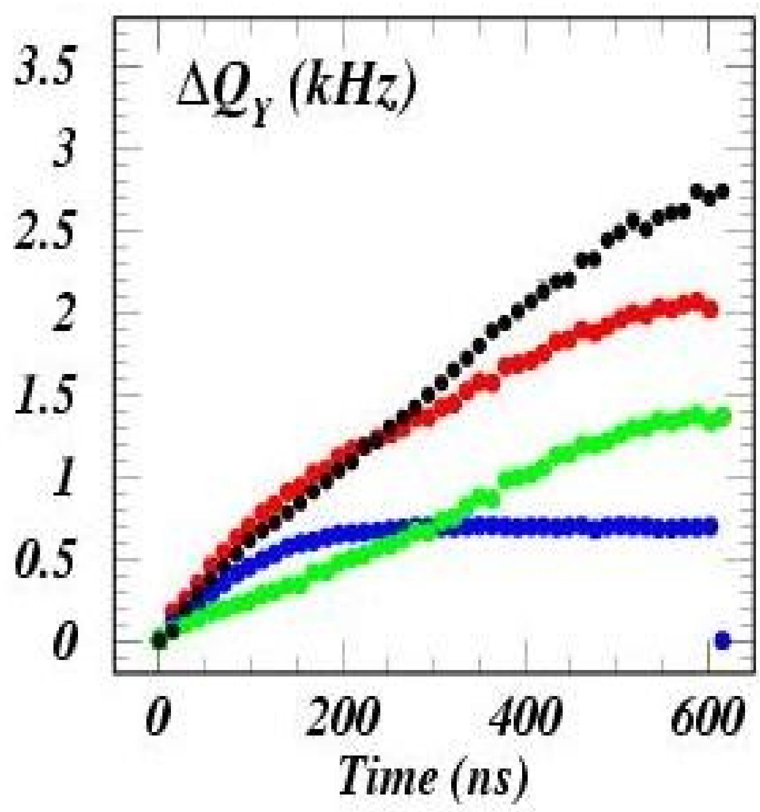

ECLOUD vertical tune shift calculation
with and without the rediffused SEY component
(New replacement figure for PAC2009)

Conclusions

The qualitative differences in the vertical tune shift calculation for long bunch trains are largely resolved by introducing the rediffused SEY component in ECLOUD.

The SEY parameters are likely to be somewhat different since the SEY models differ. Parameter tuning must be done taking into account the range in bunch currents for which tune shift data are available.

Next Steps

Test the ECLOUD model against the wealth of tune shift measurements with long bunch trains obtained in early 2009.

Install and test the RFA model in ECLOUD.
Compare the RFA model to RFA data.

Revisit the chicane cyclotron resonance data to see if realistic modelling is possible.

Quantitatively test the sensitivity of the measurements to the SEY parameters.