Cornell University
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ECLOUD Calculations of Coherent Tune Shifts for the April 2007 Measurements

- Study of SEY Model Effects -

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Electron Cloud Simulations Meeting

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Conversion of Space-charge Field Values to Tune Shifts

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

I. ECLOUD input parameters

1. *Sync rad photon rate per meter per beam particle at primary source point (Drift R=0.23, Dipole R=0.53)*
2. *Quantum efficiency (12%)*
3. *Beam particles per bunch (0.75 mA/bunch -> 1.2e10 e/bunch).*
4. *Ten bunches filled, followed by ten empty bunches.*
   - *In the POSINST calculations, only the first ten bunches and the witness bunch for which the tune is calculated are filled.*
5. *Contribution of reflected sync rad photons uniform in azimuth (15%).*
   - *This contribution is also subtracted from the primary source point.*
6. *The primary p.e. generation model is identical to POSINST's (panghel=1).*
7. *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 very 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, see my presentation 18 Feb 09)*
   - *e+ beam: Drift $\beta_X(\beta_Y)$= 19.6(18.8), Dipole $\beta_X(\beta_Y)$ = 15.4(18.8)*
   - *e- beam: Drift $\beta_X(\beta_Y)$ = 19.4(19.3), Dipole $\beta_X(\beta_Y)$ = 15.3(19.4)*

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

1. *Ring length fraction*
   - *Drift: (174.9/768) = 0.228*
   - *Dipole: (473.9/768) = 0.617*

The sole difference relative to slide 2 of the March 4 talk is that ten rather than eleven bunches are filled.

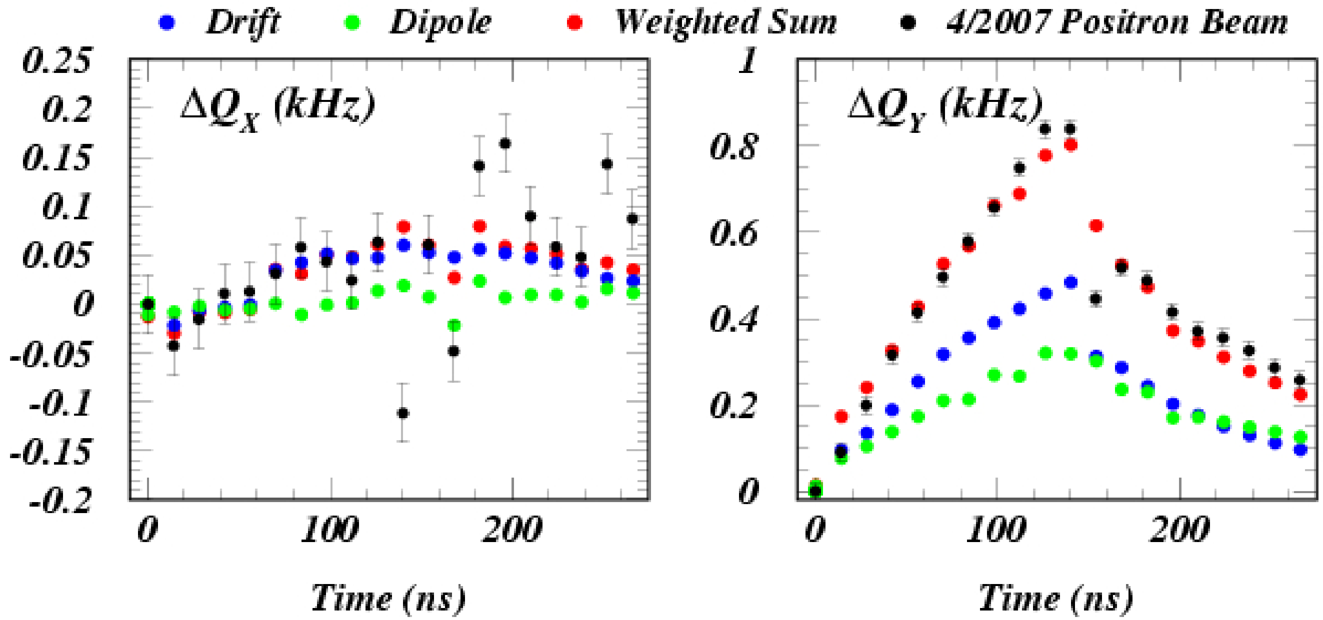
ECLOUD Tune Shift Calculations -- Positron Beam --

Two systematic improvements since the March 4 results:

1) Reduced space charge grid size by factor 2 from 4.5 mm x 2.5 mm to 2.25 mm x 1.25 mm

This brought the calculated horizontal tune into agreement with the measurements.

2) Removed a limit on the number of macroparticles which was causing fluctuations in the dipole results.



I. Remarkable overall scale agreement for ΔQ_Y. Cloud decay time constant also very good.

- *Used POSINST input parameters without tuning, e.g. reflectivity. This ECLOUD result is an even better match. (See GD/February 5)*

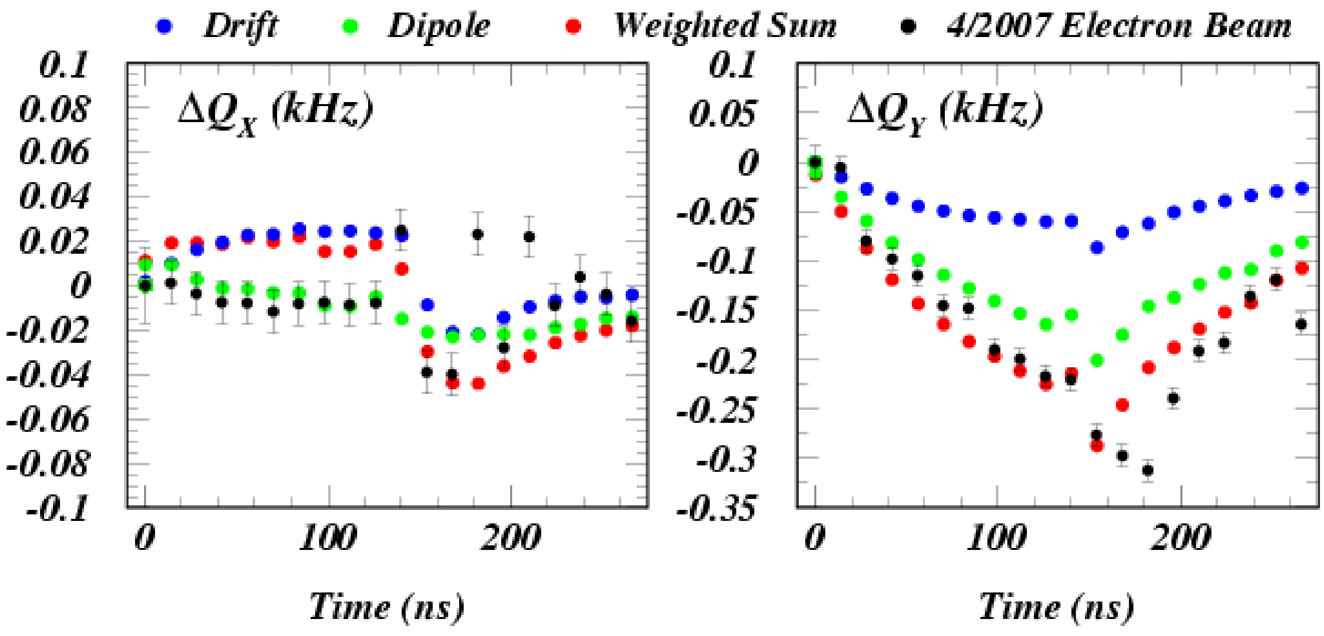
II. Large $\Delta Q_Y/\Delta Q_X$ ratio now accurately reproduced (Holy Grail since ILCDR08 last July)

- *This required the accounting for dynamic effects related to the pinger kick used for measuring tunes*

III. ECLOUD does not reproduce the bunch 13 'bounceback' in ΔQ_Y

- *POSINST gets it right! This motivates a study of the effects on the tune shift calculations of the SEY model*

ECLOUD Tune Shift Calculations
-- Electron Beam --



I. *Again overall scale agreement for ΔQ_Y quite good*

1. *Used tuned POSINST parameters, e.g. reflectivity. This ECLOUD result is even better. (See GD presentation of February 5)*

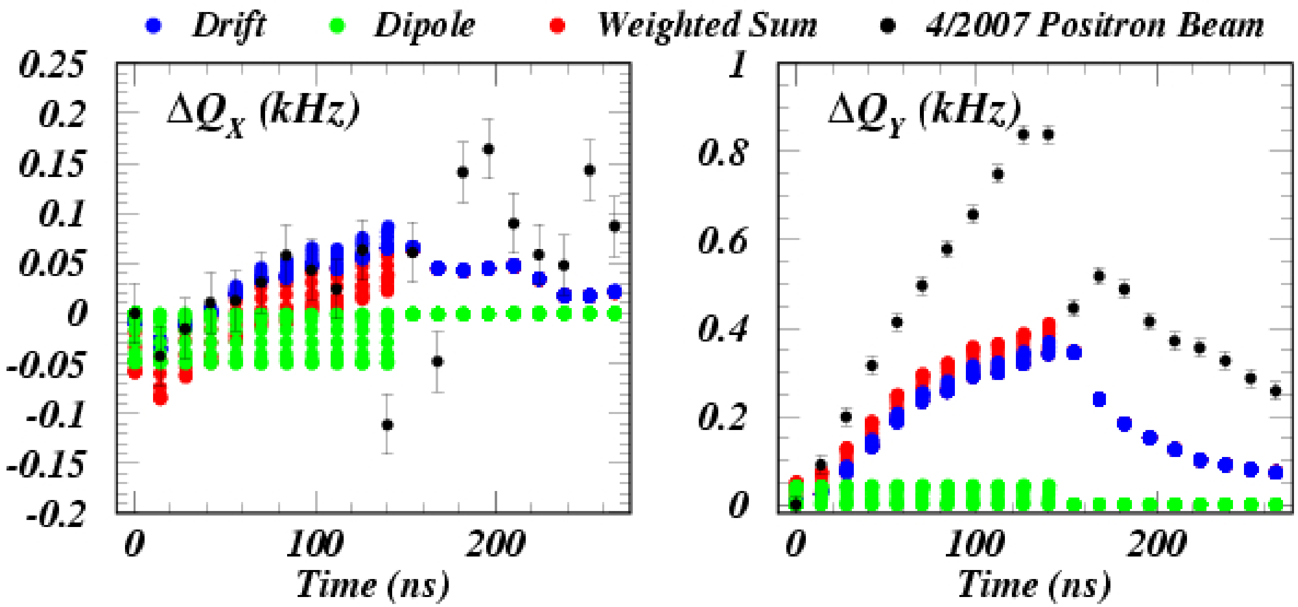
II. *ΔQ_X agreement not good and raises the issue of relative drift/dipole contribution*

1. *POSINST found equal contributions to ΔQ_Y during buildup for both positrons and electrons. It matches ΔQ_X much better.*
2. *ECLOUD finds ΔQ_Y dominated by dipole regions for electrons and by driftregions for positrons.*

III. *ECLOUD finds too little post-beam increase in ΔQ_Y.*

1. *POSINST finds a greater effect. This again motivates a study of the effects on the tune shift calculations of the SEY model*

REFL = 15% --> 0 %



I. Turning off reflectivity does two things:

- *It removes the azimuthally uniform contribution to primary generation on the beampipe wall*
- *It increases the primary rate at the source point by 15%*

II.This calculation used the field gradients averaged over the transverse cross section of the bunch

- *So it does not account for the dynamic effects associated with kicking the beam*
- *The longitudinal dependence during bunch passage are shown.*

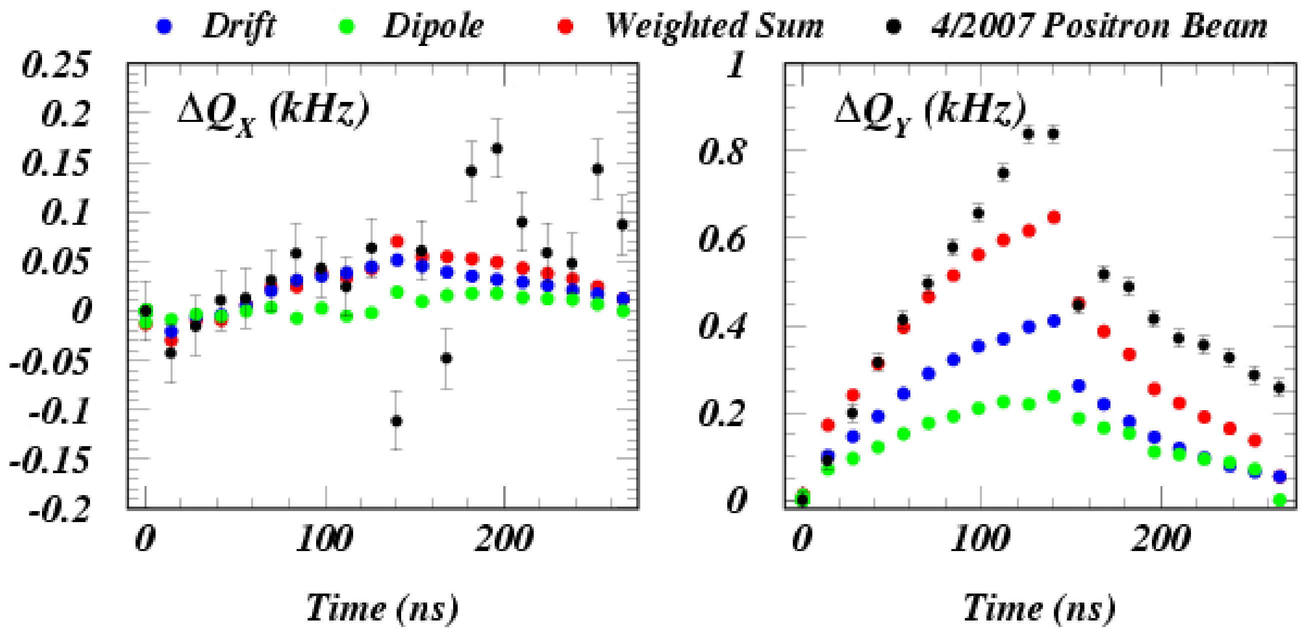
III. The dipole contribution depends critically on the poorly known reflectivity parameter

IV. The reflectivity contribution need not be proportional to the direct contribution (MAP)

- *Need to modify the ECLOUD primary generation model to account for this added flexibility*

Study of SEY Model Effects (I)

SEY = 2.0 --> 1.6 E_{peak} = 310 eV



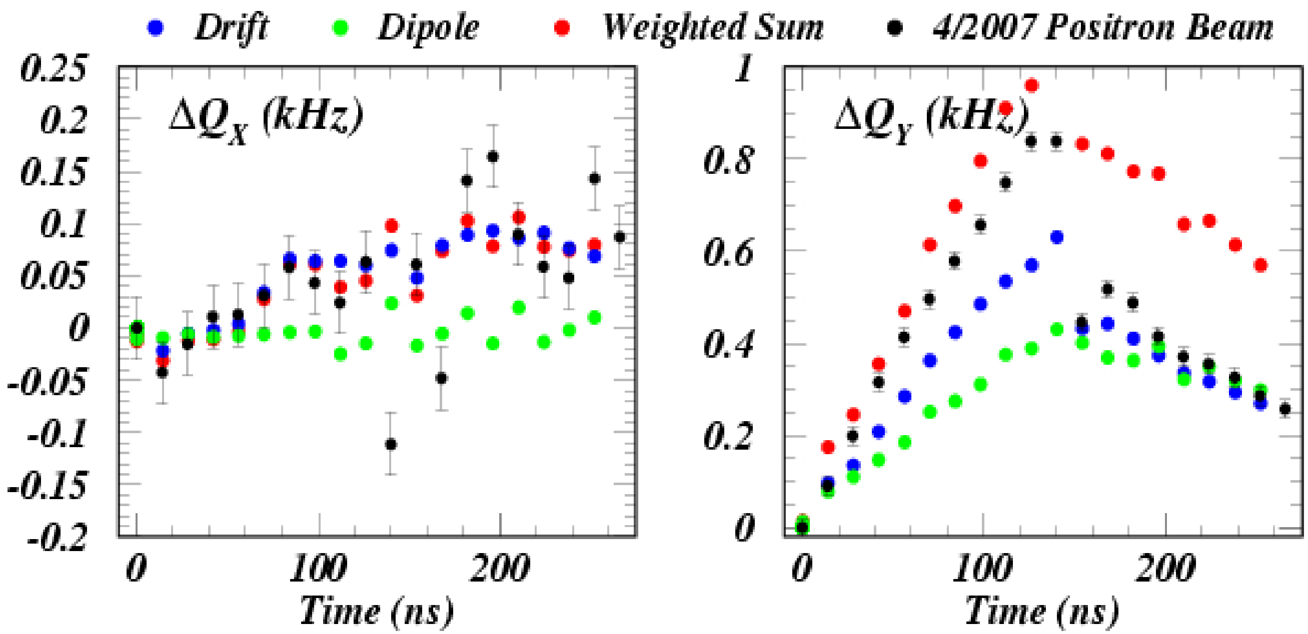
I. Insufficient SEY contribution during buildup of ΔQ_Y

II. Cloud decay time remains accurate

III. ΔQ_X modelling also accurate

Study of SEY Model Effects (II)

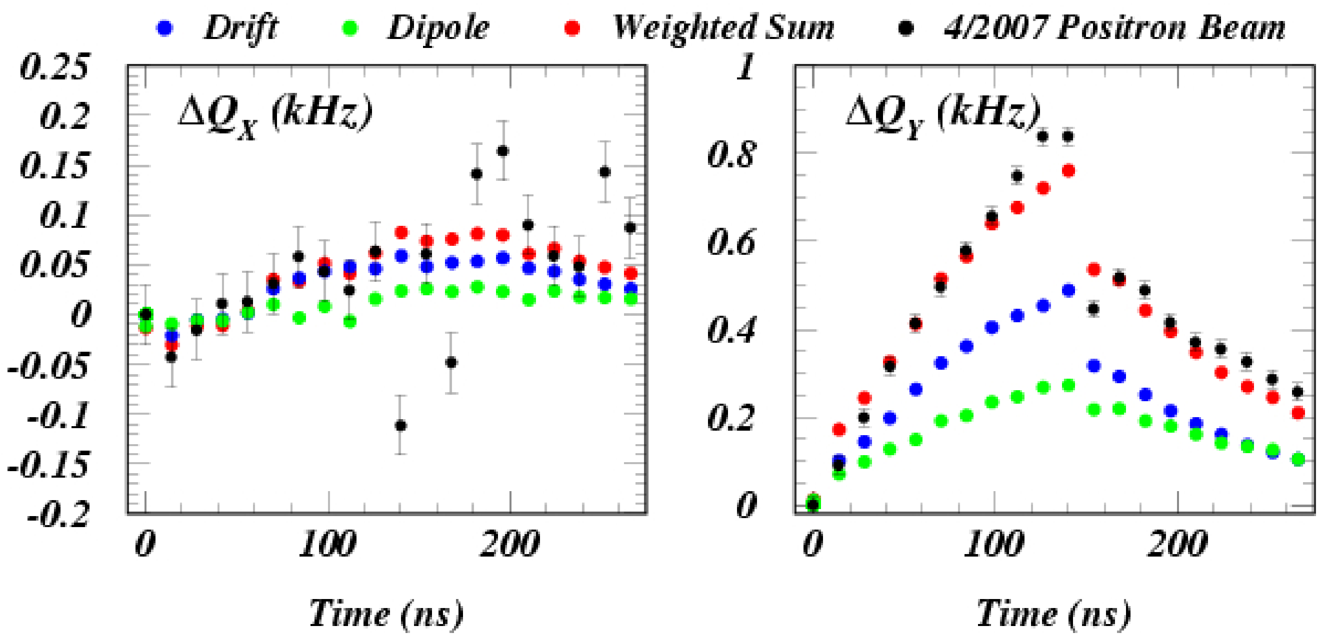
SEY = 2.0 --> 1.6 E_{peak} = 310 eV --> 170 eV



Yield for low-energy cloud electrons too high

Study of SEY Model Effects (III)

SEY = 1.6 --> 1.2 E_{peak} = 310 eV --> 170 eV



I. Lower values of SEY and Epeak cannot be excluded

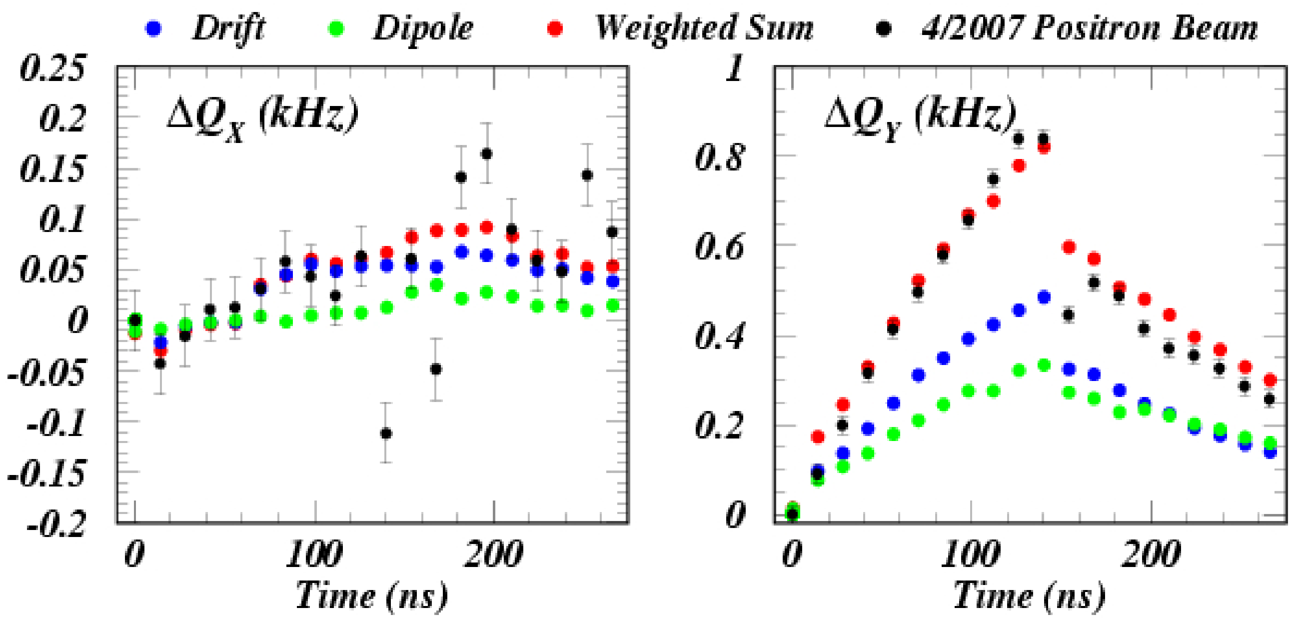
- *Epeak can likely be determined independently using dipole RFA data*

II. Cloud decay time remains accurate

III. ΔQ_X modelling still good

Study of SEY Model Effects (IV)

SEY = 1.2 --> 1.0 E_{peak} = 170 eV --> 120 eV



I. Even lower values of SEY and Epeak give good results

- *Tune shift data with differing bunch currents will likely distinguish these cases*

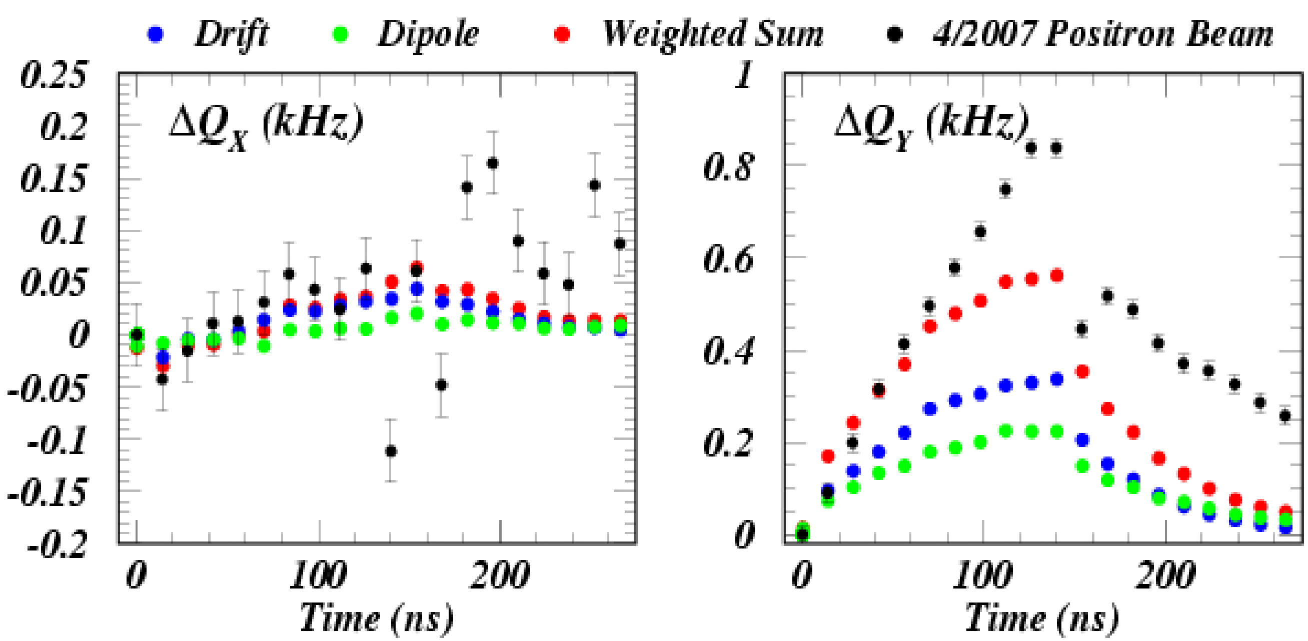
II. Cloud decay time still accurate

III. ΔQ_X modelling unaffected

Study of SEY Model Effects (V)

SEY = 1.2 --> 1.0 E_{peak} = 170 eV --> 120 eV

Elastic secondaries turned off



The contribution of elastic secondary yield component is important !

Conclusions

I. The measurements of coherent tune shifts provide a wealth of information

1. *The azimuthal distribution of primary generation determines the contribution of the dipole regions*
2. *The SEY model parameters can be narrowly constrained, but are highly correlated*
3. *The two SEY parameters can likely be distinguished by the measurements at differing bunch currents*
4. *Additional info from electron beam will likely address the drift/dipole contribution issue*
5. *Will the new feedback-notch means of measuring tune shifts obviate the need for modelling beam offsets?*

II. ECLOUD / POSINST comparison

1. *So far unclear if the more sophisticated POSINST SEY model is necessary to model the tune shift data*
2. *The two models disagree on the relative drift/dipole contributions, even for the same reflectivity*