ECLOUD Calculations of Coherent Tune Shifts for the April 2007 Measurements

- Thanks to Marco for clarifying the drift/dipole weighting -
- Thanks to Gerry for updating comparisons of 11 Feb 2009 -

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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. *Eleven bunches filled, followed by nine empty.*
   - *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 (MV used 377.99 m. I weight his tune shift by 473.9/377.99 in this talk.)*
2. *β-averaged photon rate values*
   - *e+ beam: Drift $R_X(R_Y)$ = 0.987(1.061), Dipole $R_X(R_Y)$ = 1.100(0.911)*
   - *e- beam: Drift $R_X(R_Y)$ = 0.957(1.030), Dipole $R_X(R_Y)$ = 1.098(0.911)*

Example Tune Shift Calculation

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

Example: $\Delta E/\Delta Y$ = 1000 V/m^2, β_Y = 20 m => Δf = 253 Hz

<u>April 2007 Conditions</u>

<u>Positron beam beam-averaged field values for vertical offsets +- 5 mm</u>

$\Delta E/\Delta Y$ averaged over bunch 11

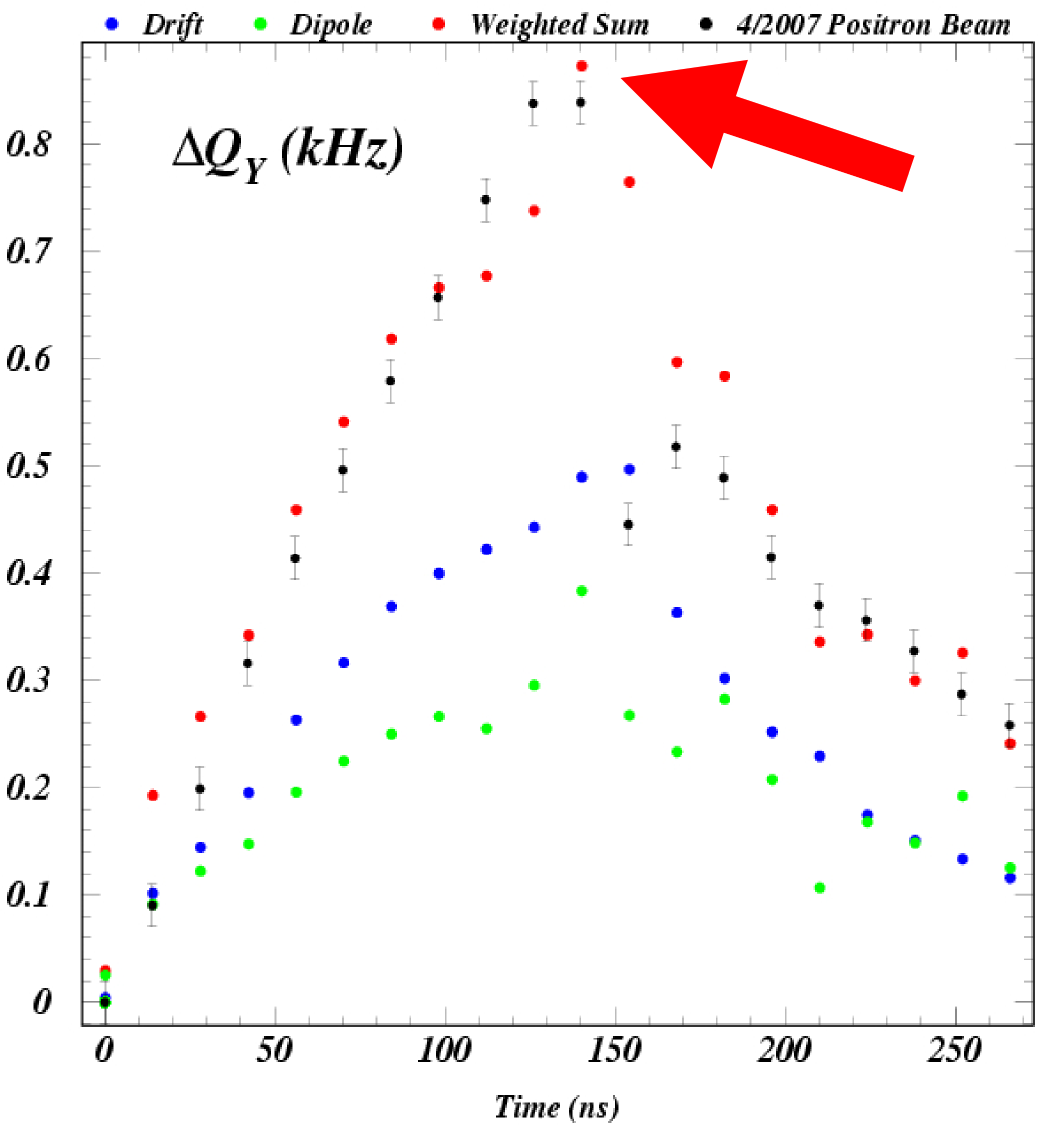
Drift: 9.038e3 V/m^2 Dipole: 2.610e3 V/m^2

(Omit β-weighted photon rate correction for purposes of this comparison)

$$\Delta f_Y = \frac{2.998e8}{4\pi 1.885e9} (0.228 * 18.8 * 9.038e3 + 0.617 * 18.8 * 2.610e3)$$

$$\Delta f_Y = 0.873\,kHz$$

ECLOUD Vertical Tune Shift Calculations



GD LBNL/Cornell POSINST Comparison
11 Feb 09 (update 3 Mar 09)
11 bunches offset, bunch 11

Drift ΔY=+5mm

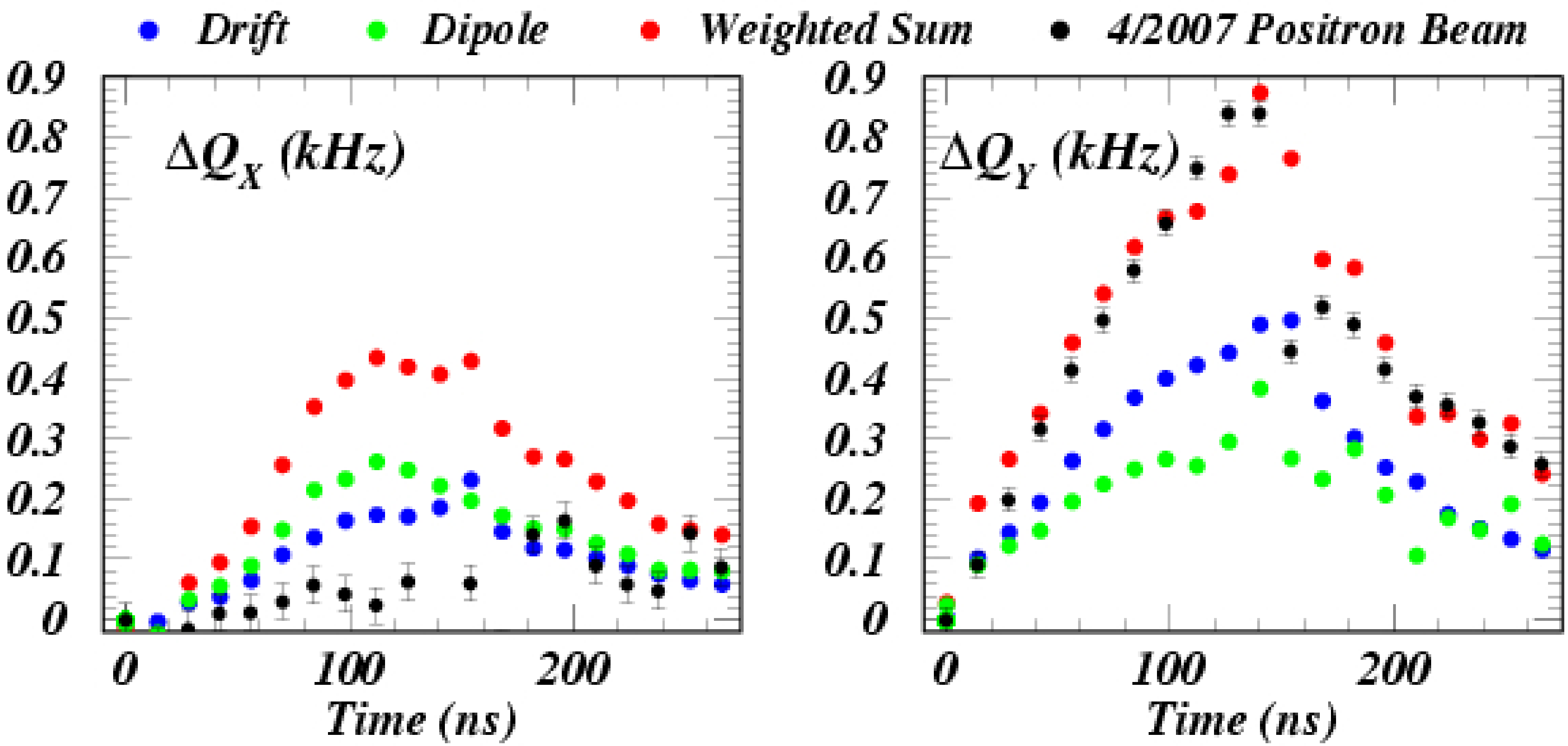
	E_Y	Δf_Y
Cornell:	42.35 V/m	0.426
LBNL:	-41.06 V/m	0.445
ECLOUD:	48.05 V/m	0.490

Dipole ΔY=+5mm

	E_Y	Δf_Y
Cornell:	13.77 V/m	0.406
LBNL:	-13.71 V/m	0.41
ECLOUD:	9.62 V/m	0.383

Note that the tune shifts are derived from the differences of fields calculated for two different beam offsets. The above fields are for the positive beam offset only.

ECLOUD Tune Shift Calculations
-- Positron Beam --



ECLOUD Tune Shift Calculations
-- Electron Beam --