Space Charge Electric-Field Calculations for Coherent Tune Shift Estimations using the Electron-cloud Modelling Algorithm E C L O U D

(Updated to include results in dipole fields – 29 Jan 2009)

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CesrTA Electron Cloud Simulation wiki page: Simulation Guidance Parameters TS0407

CESR measurements in CESR-c configuration in April, 2007

1.89 GeV - Ten 0.75 mA bunches, followed by ten empty bunches, 14 ns spacing

Beam RMS size 1.6 x 0.16 x 12.6 mm.

ECLoud bunch time +/- 3.4 sigma: 0.29 ns

Elliptical beam pipe 4.5 x 2.5 cm

QE 10%, 0.23 s.r. photons per beam particle (mistake: should have been 0.53 for dipole)

25k macroparticles generated per filled bunch

SEY parameters: SEY=1.8, Epk = 310 eV

150 steps per bunch length, 300 steps between bunches

11 field calculations during each of 20 bunches

Transverse field grid 7x7 spanning +/- 3 sigma

Field calculation includes beampipe image charges, no contribution from beam

Five data sets: e+ & e-(-5mm/grid sources), e+(+0.5mm/grid sources&cloud sources),e+(+5mm/cloud sources)

Ten runs per data set: zero beam offset, +/- X and Y beam offsets, each for both drift and 715 G dipole volumes
Beam offset observed in cloud particle energies
No pinch effect on beam-averaged fields after first bunch
Marco (8jan09/slide 6, +-5mm and +-0.5mm) and Gerry (28dec08/slide 4, +-0.5mm) find \( dE_y/dy \) about 25% higher for this case using POSINST.

This factor is approximately consistent with the assumption of a 20% higher quantum efficiency (POSINST 12%, ECloud 10%)

NB: My use of the word “gradient” in the plot title of this slide and succeeding slides is a poor choice. The value of \( dE/dy \) here is derived from the difference of beam-averaged fields in each of two different cloud-buildup modeling calculations where the beam is offset by \(+/-dy\) from the nominal beam position. The resulting “gradient” accounts for the contribution of dynamic effects to coherent tune shifts (from cloud-particle motion during bunch passage) which are not accounted for by field gradients calculated at the beam position in a single modeling calculation without a beam offset.
The charge-clustering algorithm in the space-charge field calculation which reduces the processing time by a factor of two is a very good approximation for this case of dy=+-5mm. The grid size is 4.5x2.5 mm. Slides 9 and 10 will show that this approximation is poor for dy=+-0.5mm.
Some pinch effect present
This ECLoud result for dE/dx at bunch 11 is about 1800 V/m²

Marco (8jan09/slide 11, +5mm) finds a value for dEx/dx of about 1500 V/m² using POSINST

Gerry (28dec08/slide 4, +0.5mm) finds a value for dEx/dx of about 1300 V/m²

The time dependence of dE/dx calculated in ECLoud is very similar to that presented by Marco.
A beam offset of +/-0.5 mm in ECLoud using the grid field calculation approximation yields field differences which are much too large (e.g. 25-50 V/m in bunch 10 as compared with 60 V/m for dy=+/-5mm).

Using instead the individual cloud particle charges and positions does better.
However, the improvement using the cloud particle sources is erratic and further study will be needed before beam offsets of +/-0.5 mm can be used reliably in ECLOUD.
Electrons: little “anti-pincho” effect observed, consistent with Gerry's POSINST calculation (30 Dec08/slide 7)
ECLOUD calculates $dE_y/dy = 800 \text{ V/m}^2$, to be compared to Gerry's POSINST result of 1500 V/m$^2$ (30 Dec0/ slide 7)
ECLOUD does not find the large horizontal field in bunch 11 calculated using POSINST
(30Dec08/slide 3: -23 V/m)
This ECLOUD result for $dE/dx$ at bunch 11 with an electron beam is about $-300$ V/m$^2$.

Gerry (30dec08/slide 4) finds a value for $dE_x/dx$ of about $-1180$ V/m$^2$. 

"TS0407_e_driftp (3D Averages): Electric Field and Gradients at $x=y=0"
This result for bunch 11, +2.5 V/m is about a factor of 6 smaller than Gerry’s POSINST result of +1.5 V/m (28Dec08/slide 12) for +0.5mm. Marco gives only tune shifts for the dipole runs.
Gerry (28dec08/slide 13, +0.5mm) finds $\frac{dE_y}{dy} = 3000$ V/m$^2$ in bunch 11 using POSINST, while ECL OUD calculates 650 V/m$^2$. 
POSINST finds similar field values in bunch 11 (28Dec08/slide 9), but for one tenth the beam offset!
This ECLiOUD result for $dE/dx$ at bunch 11 is about 220 V/m$^2$

Gerry (28dec08/slide 10, +-0.5mm) finds a value for $dE_x/dx$ of about 2000 V/m$^2$
This result for bunch 11, +2.0 V/m, is smaller than Gerry's POSINST result of +0.3 V/m (30Dec08/slide 12) for +0.5mm. The POSINST result is not as up/down-symmetric as these results from ECL OUD.
Gerry (30dec08/slide 13, +-0.5mm) finds $dE_y/dy = 600 \text{ V/m}^2$ in bunch 11 using POSINST, while ECloud calculates 370 V/m$^2$. 
POSINST finds much smaller field values in bunch 11 (30Dec08/slide 9) for one tenth the beam offset. ECLOUD also finds a larger pinch effect. (Remember – bunch 11 is filled in the POSINST calculation.)
This ECLoud result for dE/dx at bunch 10 is about 25 V/m². Note that the pinch effect evident on the previous slide dramatically suppresses the field difference.

Gerry (30dec08/slide 10, +-0.5mm) finds a value for dEx/dx of about 260 V/m². Those results show a much smaller pinch effect.