Space Charge Electric-Field Calculations for Coherent Tune Shift Estimations using the Electron-cloud Modelling Algorithm ECLOUD

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

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Electron Cloud Simulations Meeting

Wilson Lab

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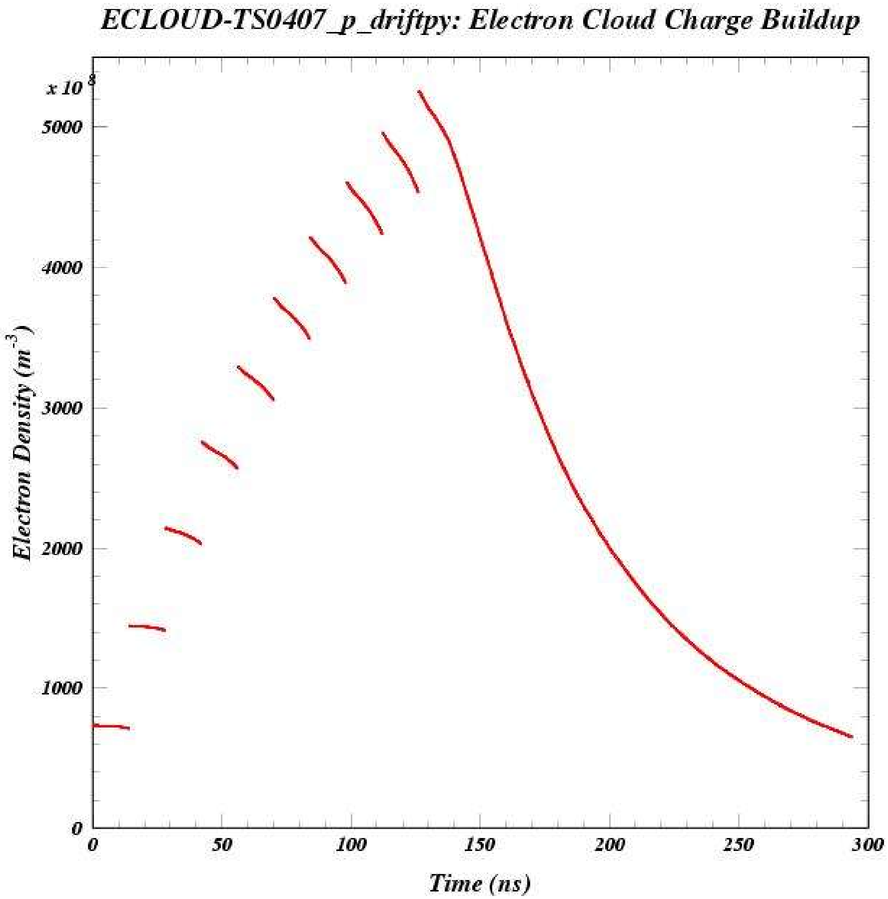
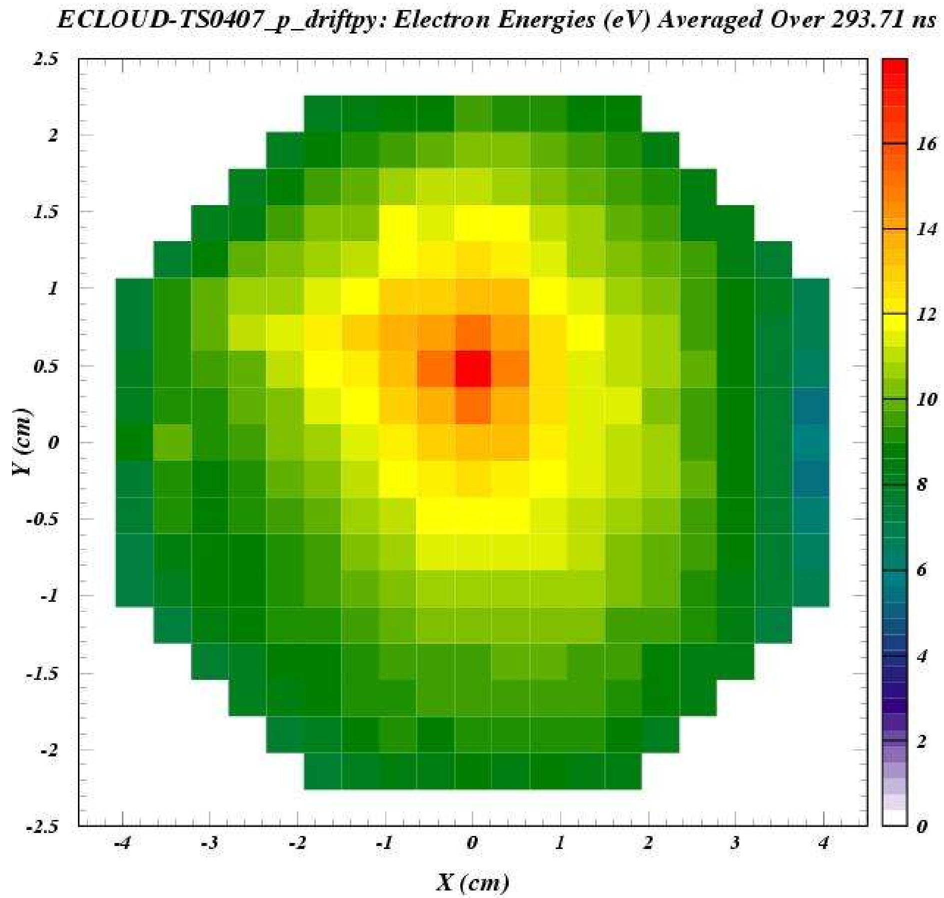
Overview of Modelling Parameters and Data Sets

- **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

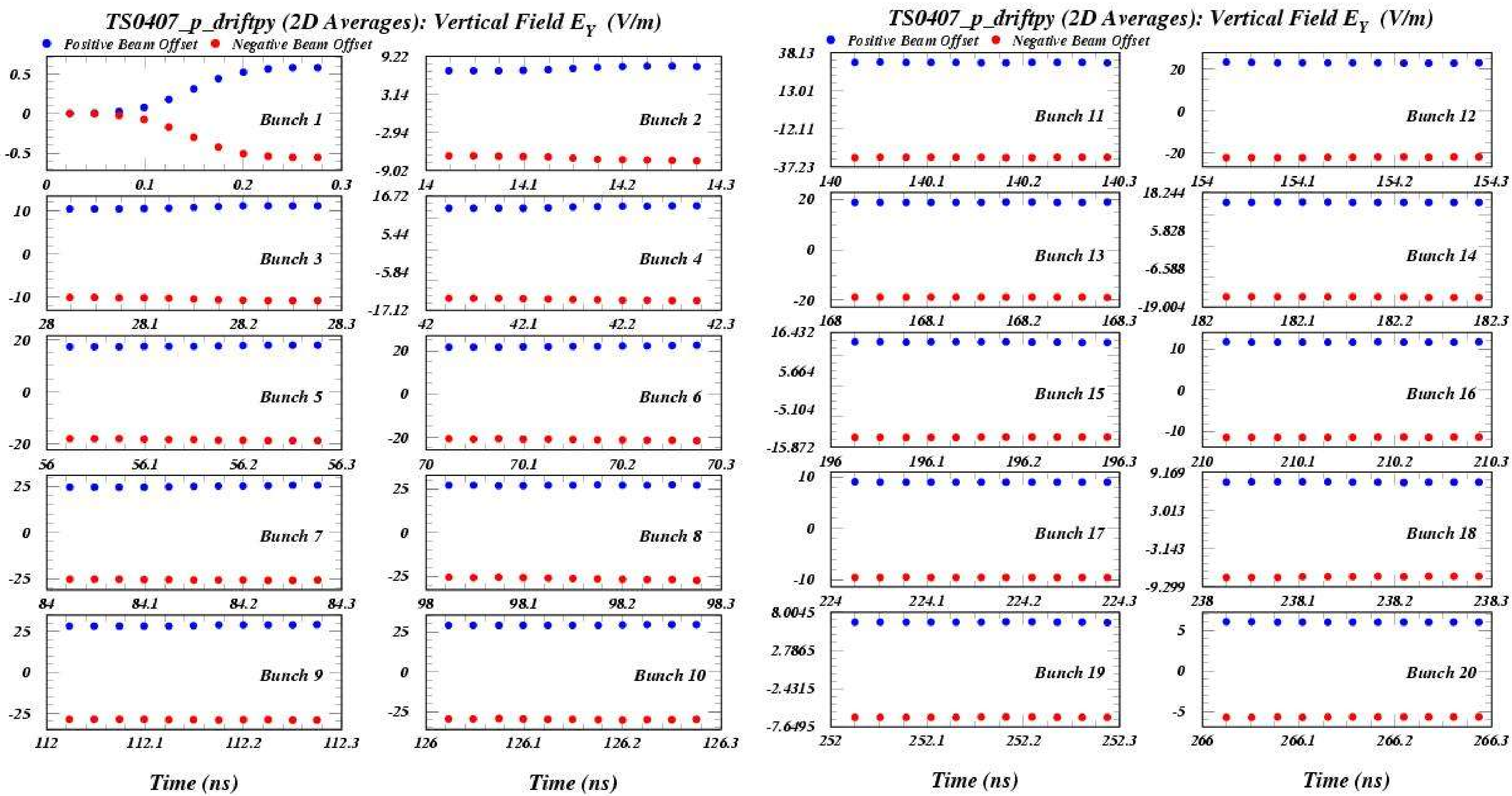
e+, Drift volume, Beam Y + 5 mm





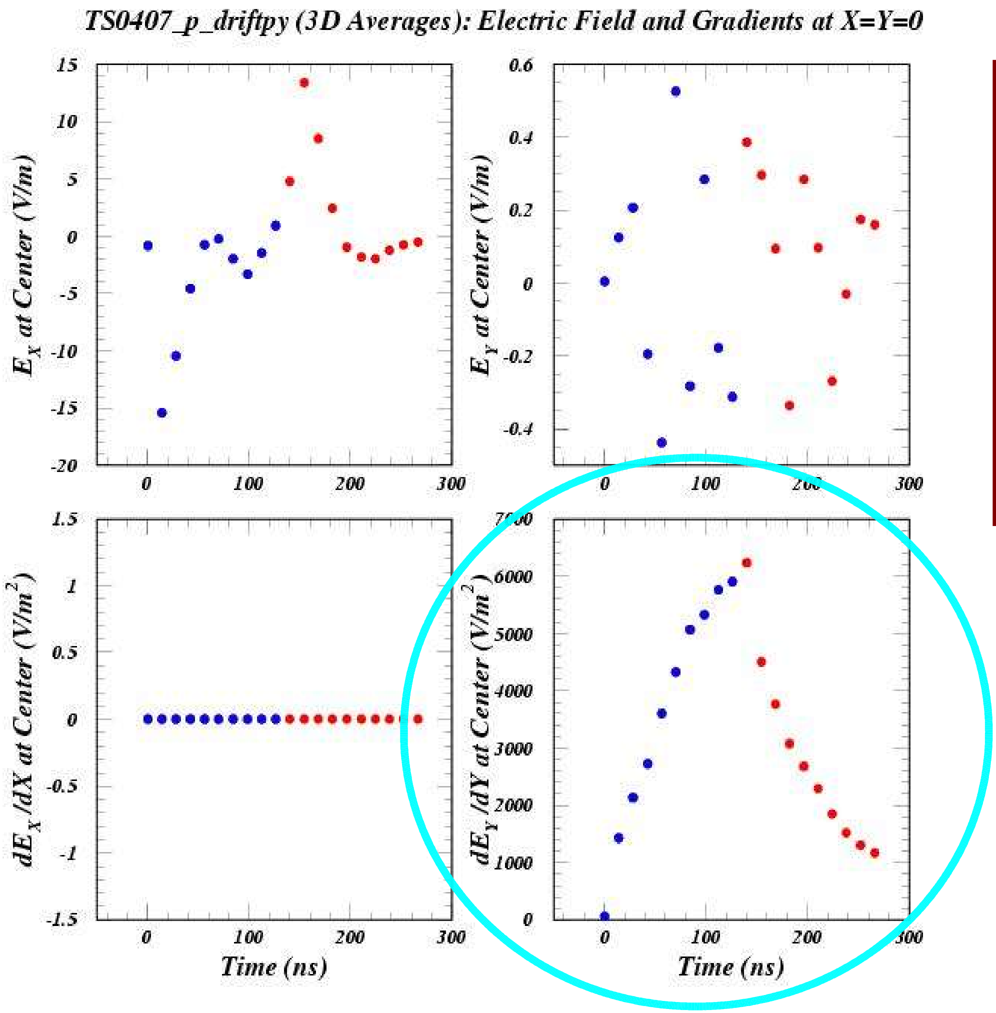
Beam offset observed in cloud particle energies

e+, Vertical Field, Drift, Beam Y +- 5 mm



No pinch effect on beam-averaged fields after first bunch

e+, Vertical Field, Drift, Beam Y +- 5 mm



Marco (8jan09/slide 6, +-5mm and +-0.5mm) and Gerry (28dec08/slide 4, +-0.5mm) find dEy/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.

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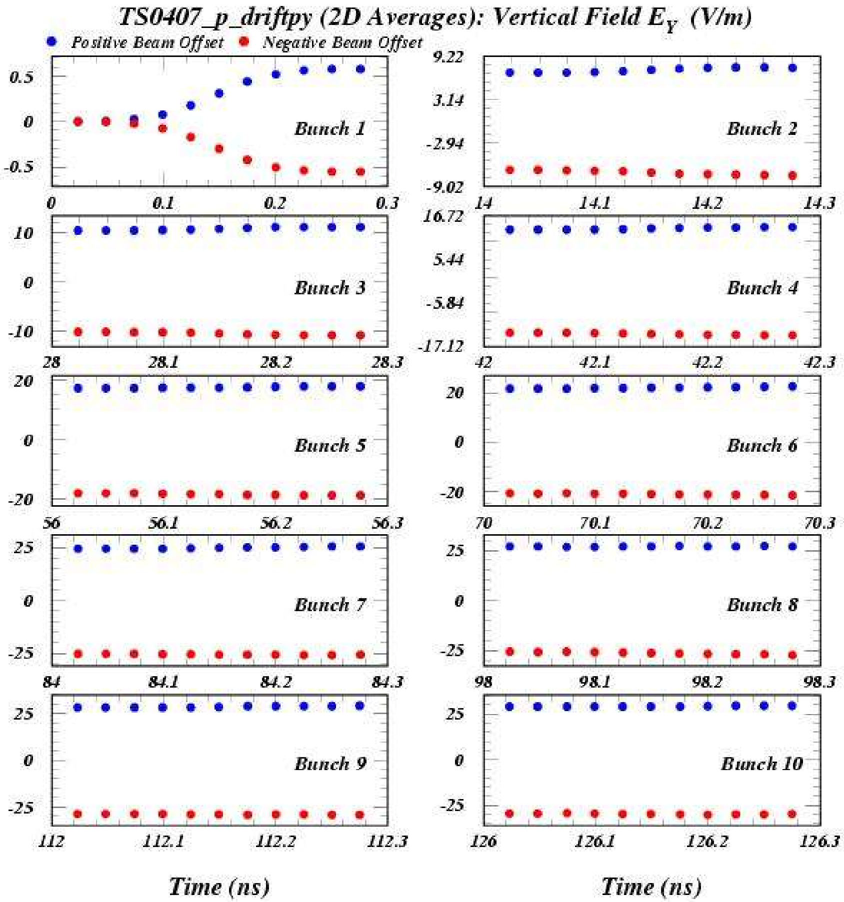
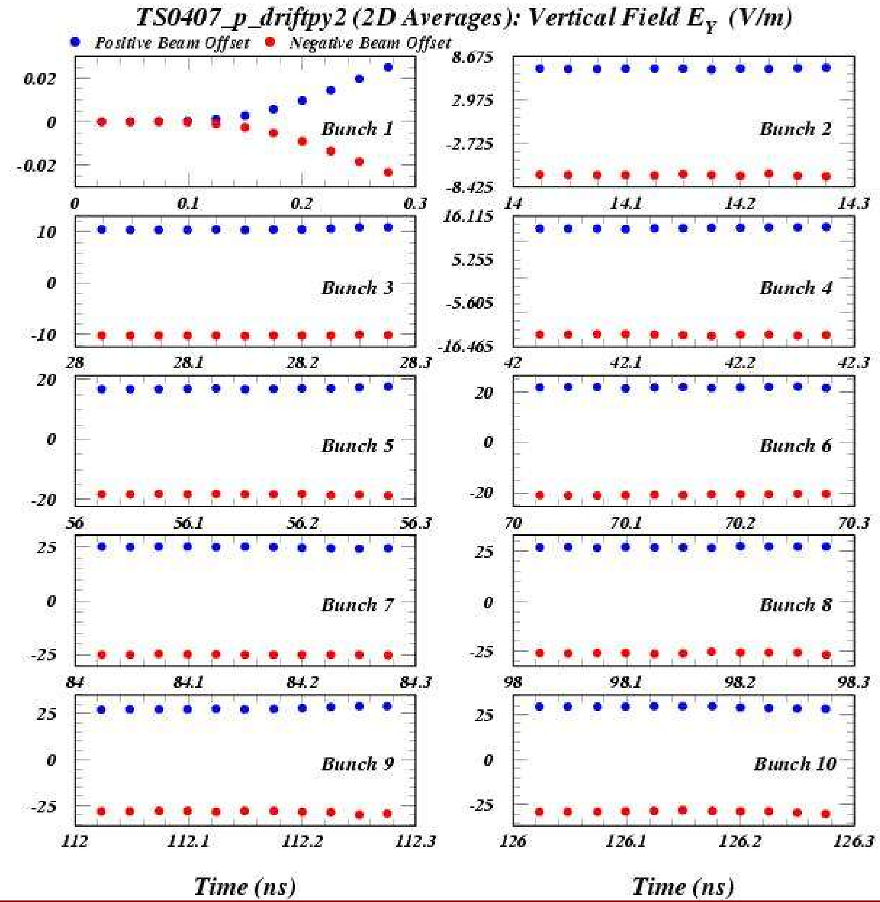
e+, Vertical Field, Drift, Beam Y +- 5 mm

Grid Field Sources (21x21)

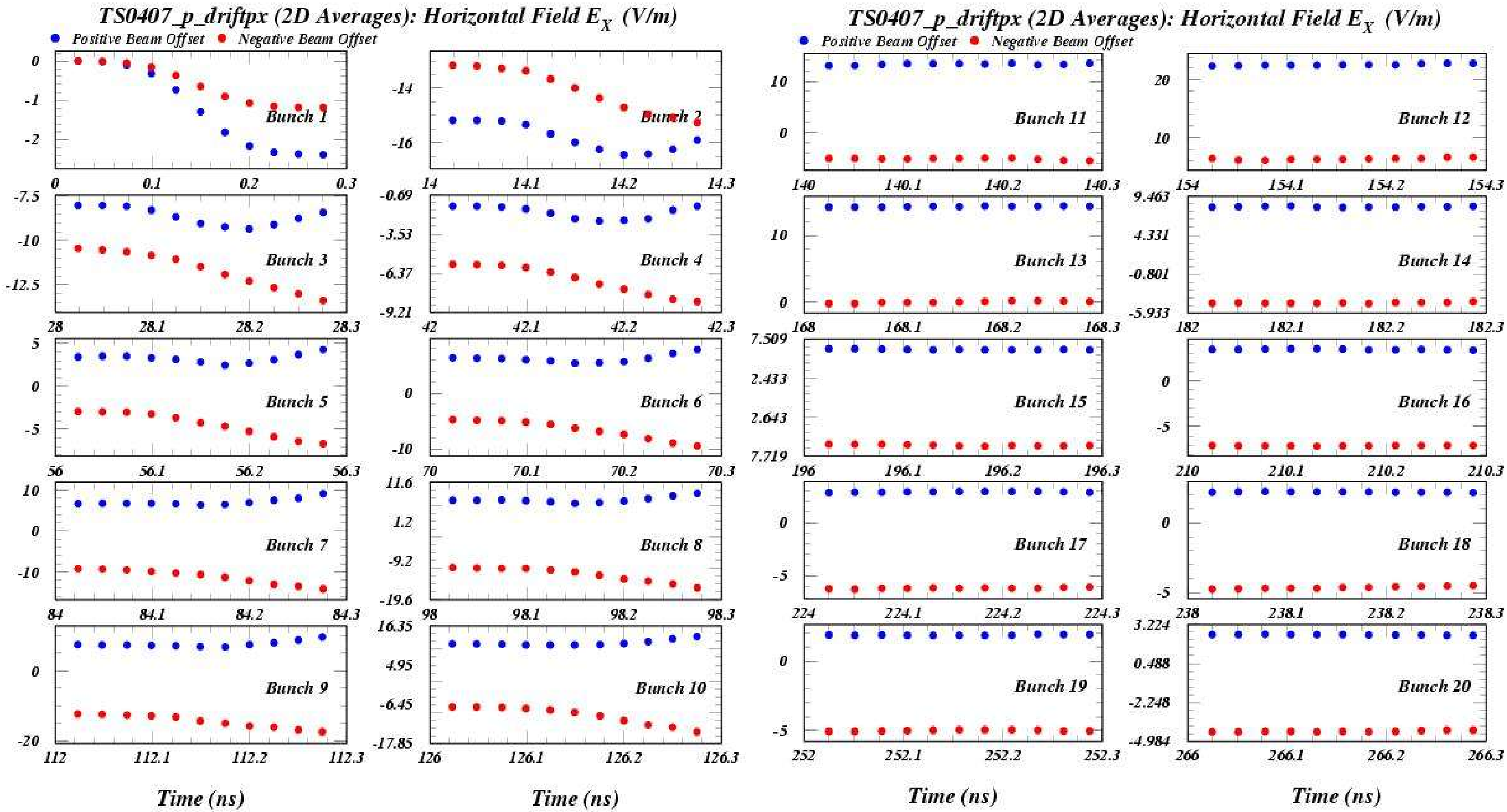


Macroparticle Field Sources



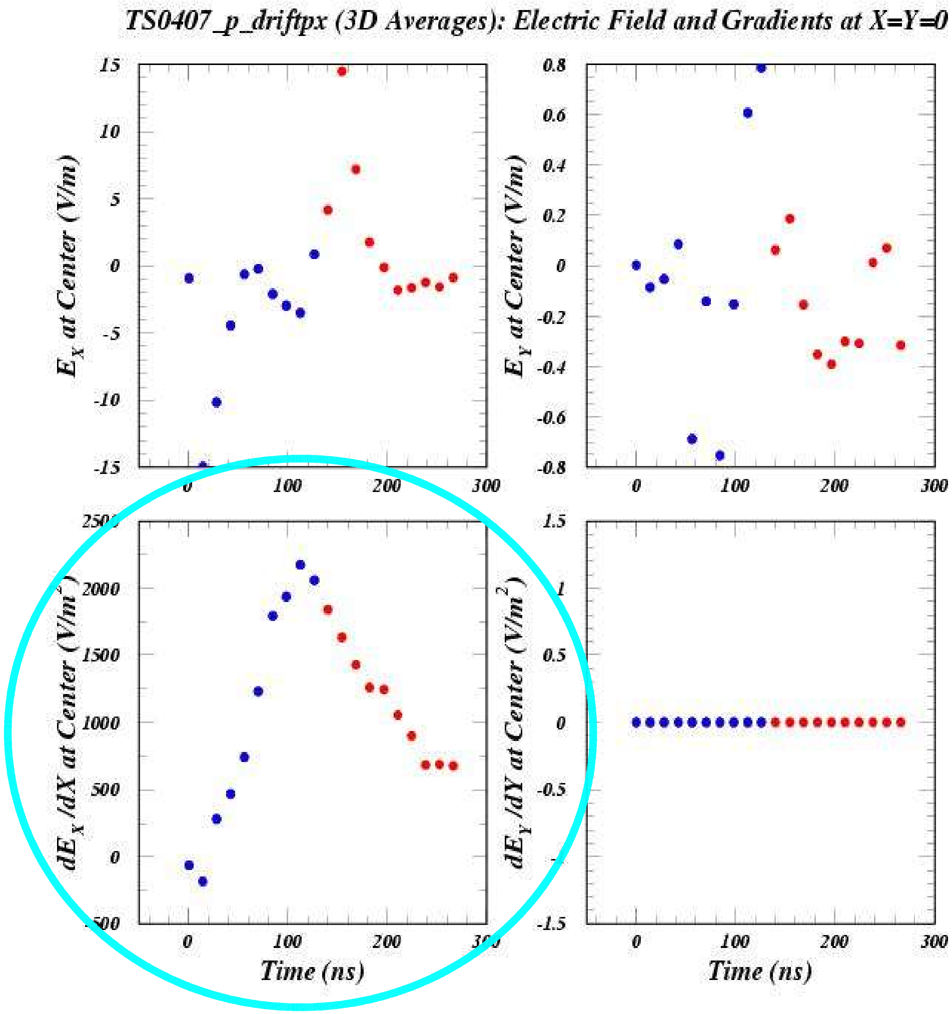
The charge-clustering algorithm in the space-charge field calculation which reduces the processing time by a factor of two is a very good approximation for this case of dy=+-5mm. The grid size is 4.5x2.5 mm.
Slides 9 and 10 will show that this approximation is poor for dy=+-0.5mm.

e+, Horizontal Field, Drift, Beam X +- 5 mm



Some pinch effect present

e+, Horizontal Field, Drift, Beam X +- 5 mm



This ECLOUD result for dE/dx at bunch 11 is about 1800 V/m²

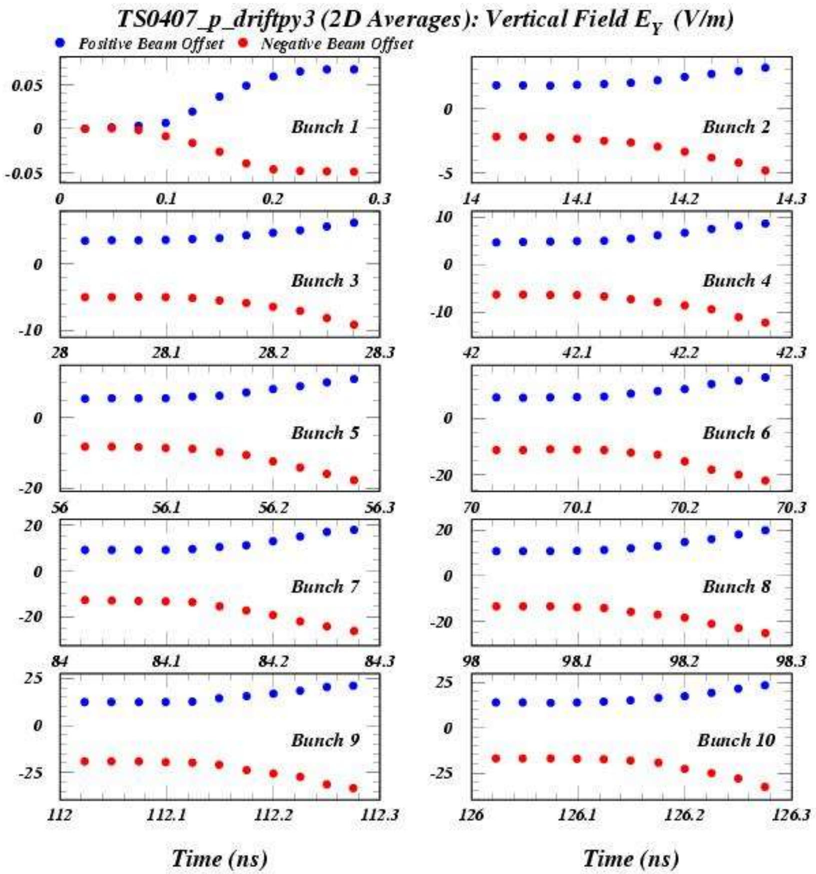
Marco (8jan09/slide 11, +-5mm) finds a value for dEx/dx of about 1500 V/m² using POSINST

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

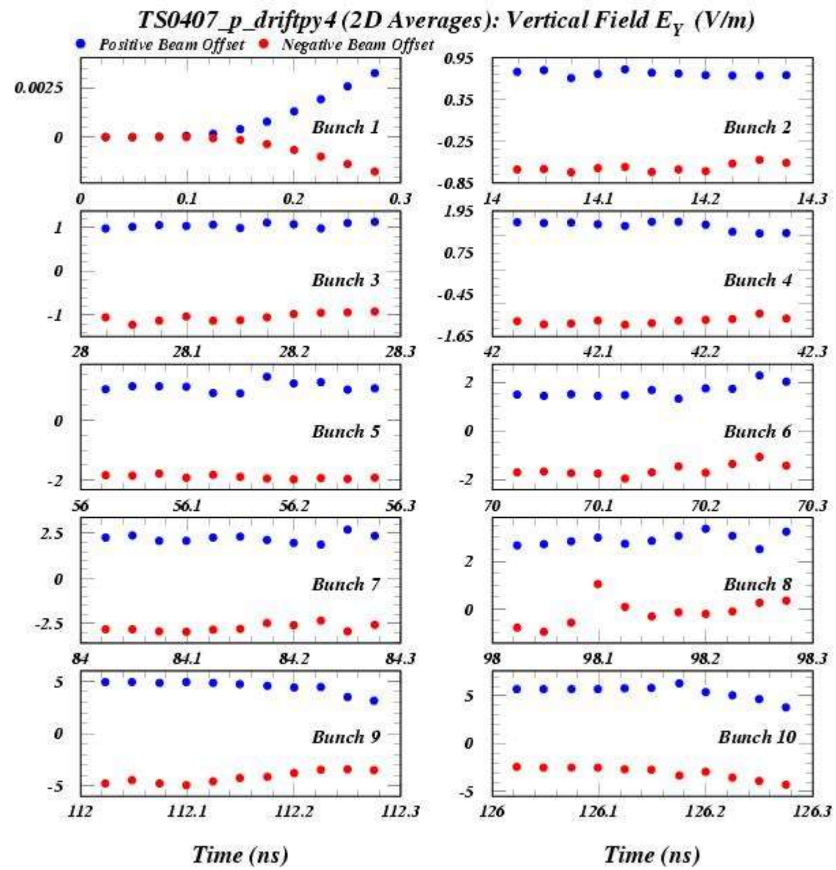
The time dependence of dE/dx calculated in ECLOUD is very similar to that presented by Marco.

e+, Vertical Field, Drift, Beam Y +- 0.5 mm

Grid Field Sources (21x21)



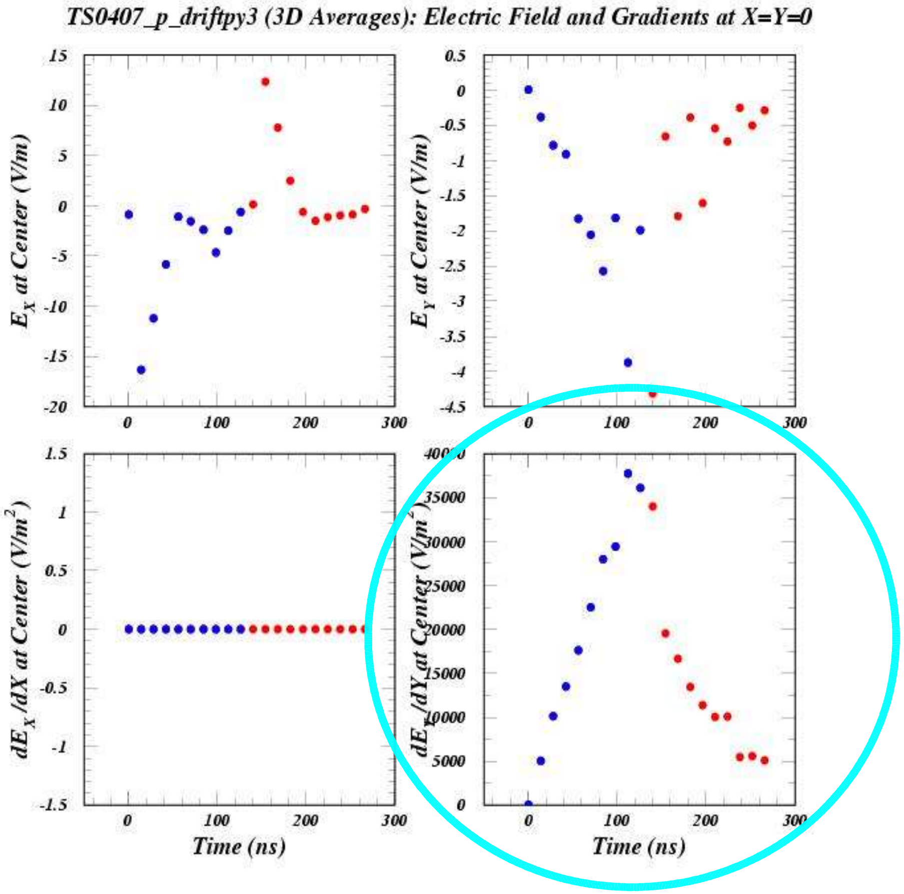
Macroparticle Field Sources



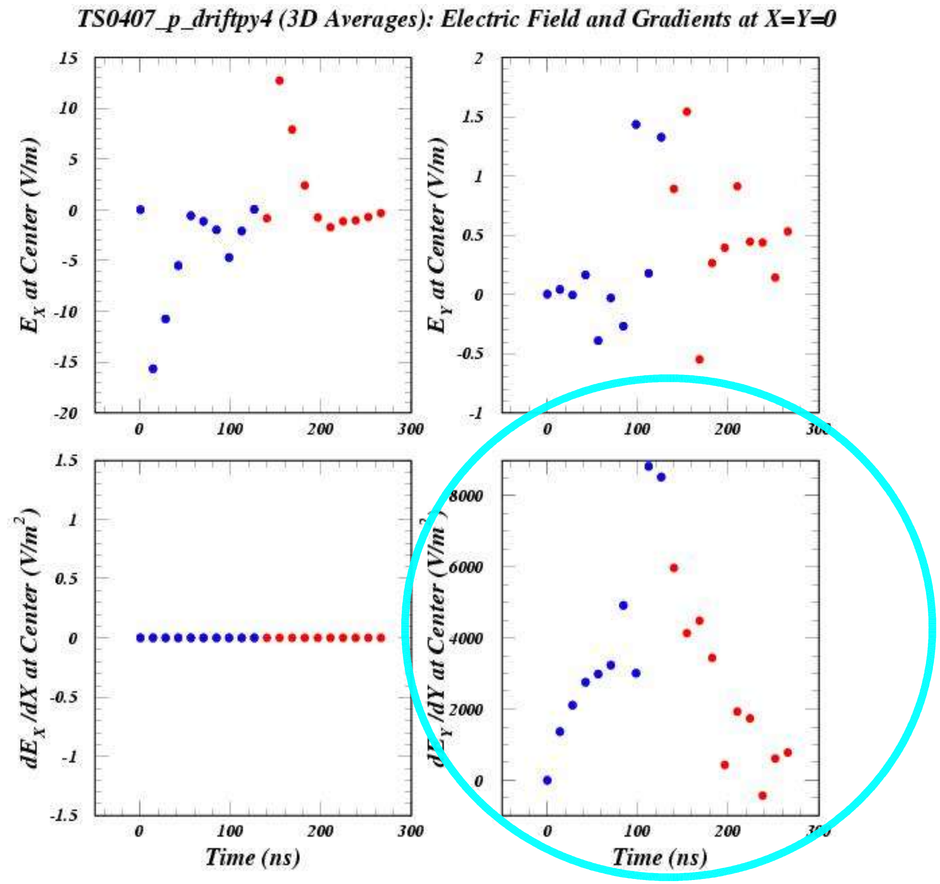
A beam offset of +-0.5 mm in ECLOUD using the grid field calculation approximation yields field differences which are much too large (e.g. 25-50 V/m in bunch 10 as compared with 60 V/m for dy=+-5mm).
Using instead the individual cloud particle charges and positions does better.

e+, Vertical Field, Drift, Beam Y +- 0.5 mm

Grid Field Sources (21x21)

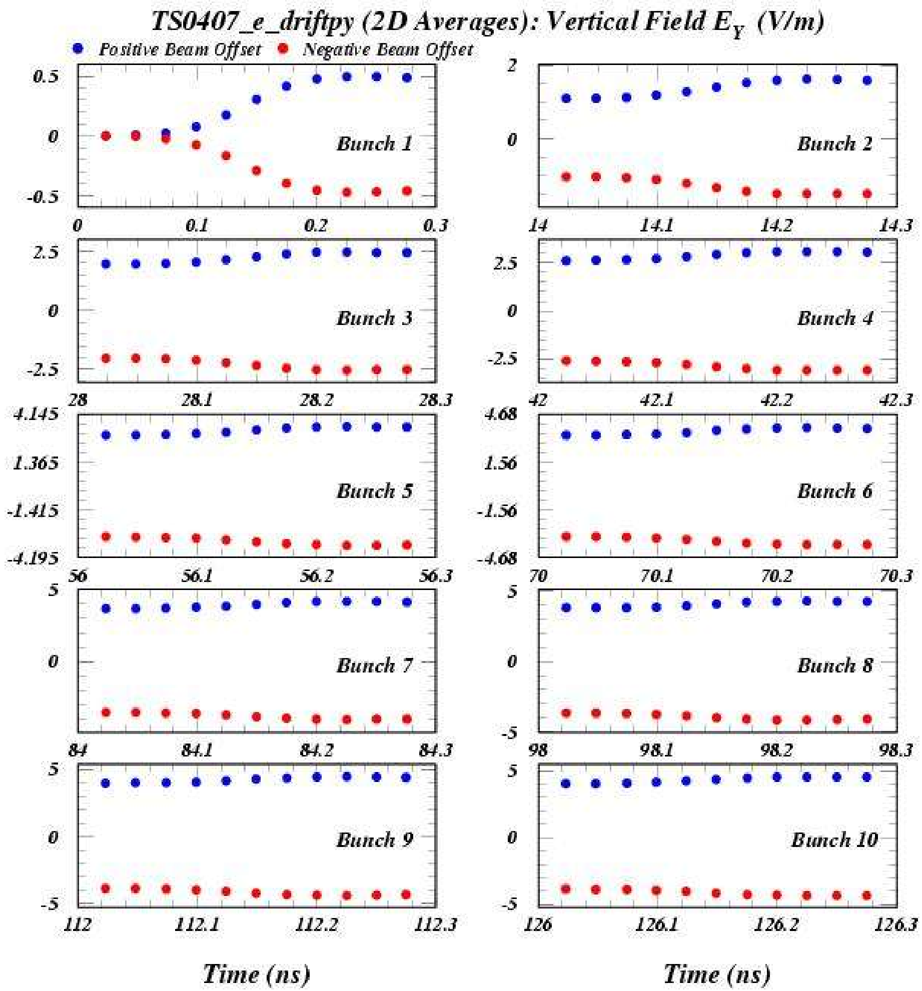


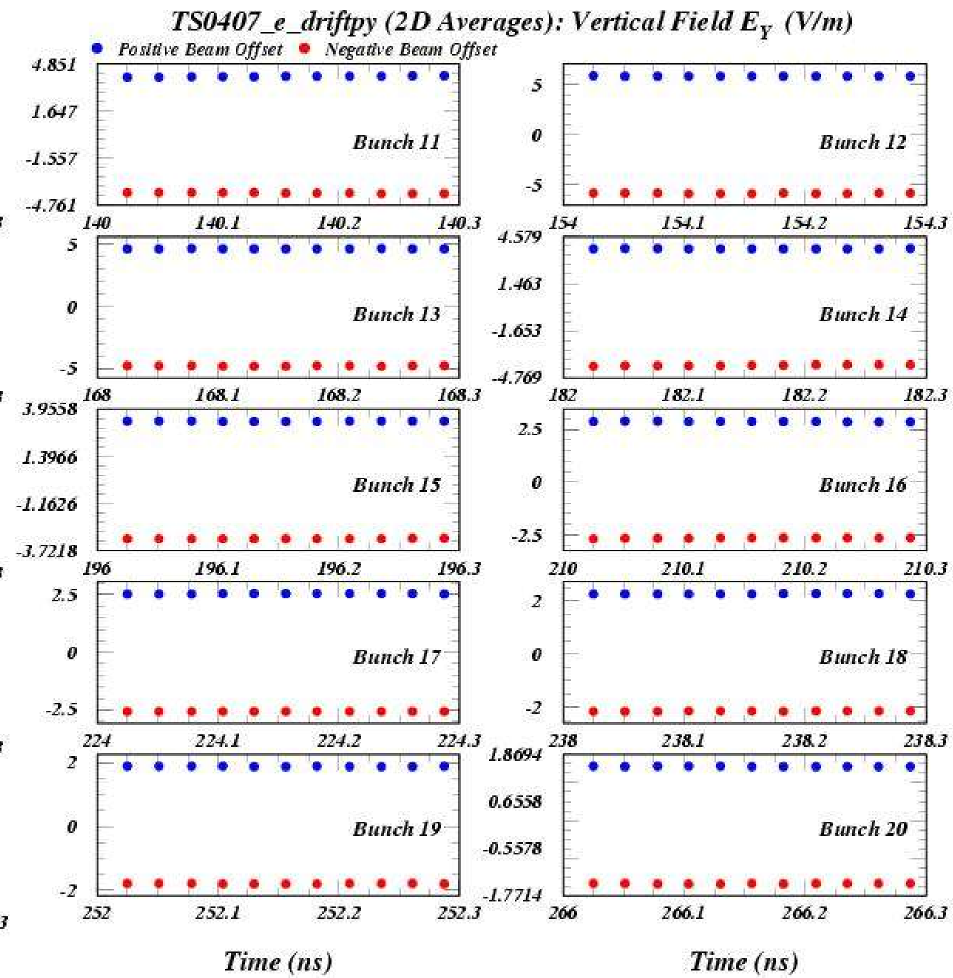
Macroparticle Field Sources



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.

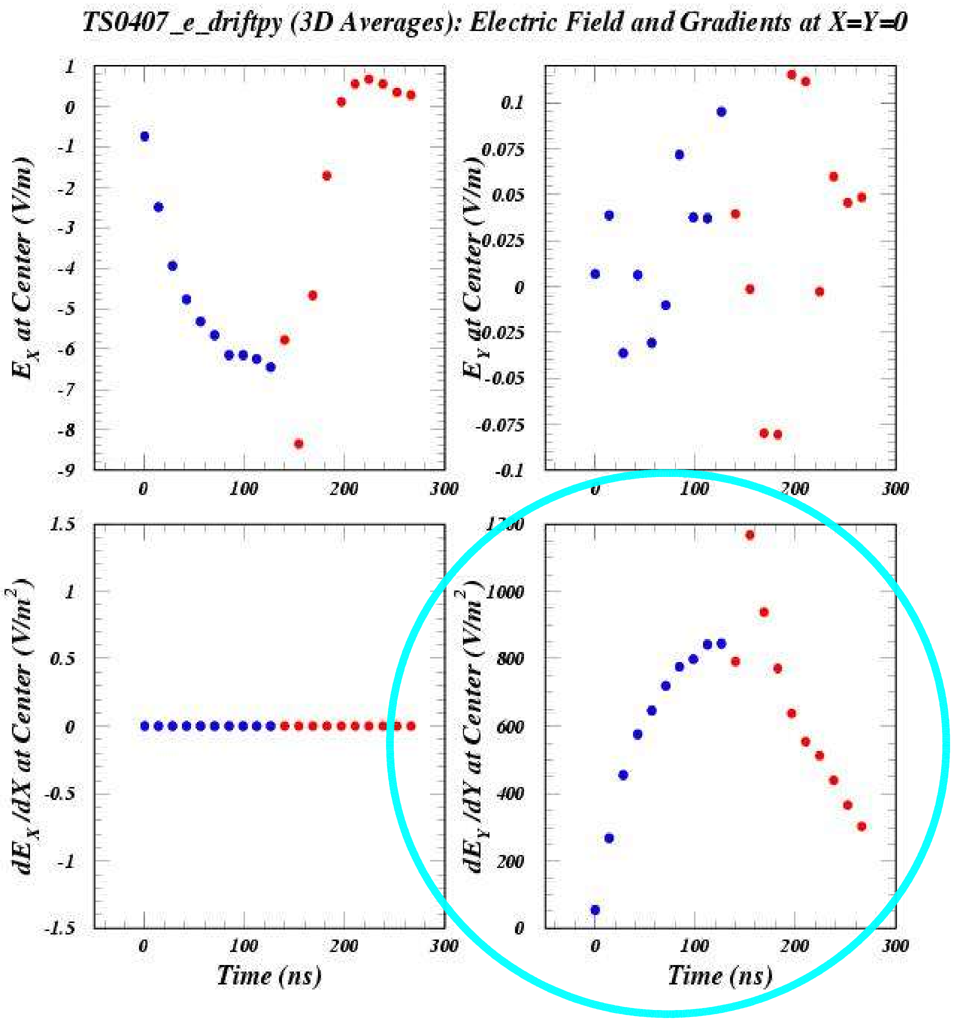
e-, Vertical Field, Drift, Beam Y +- 5 mm





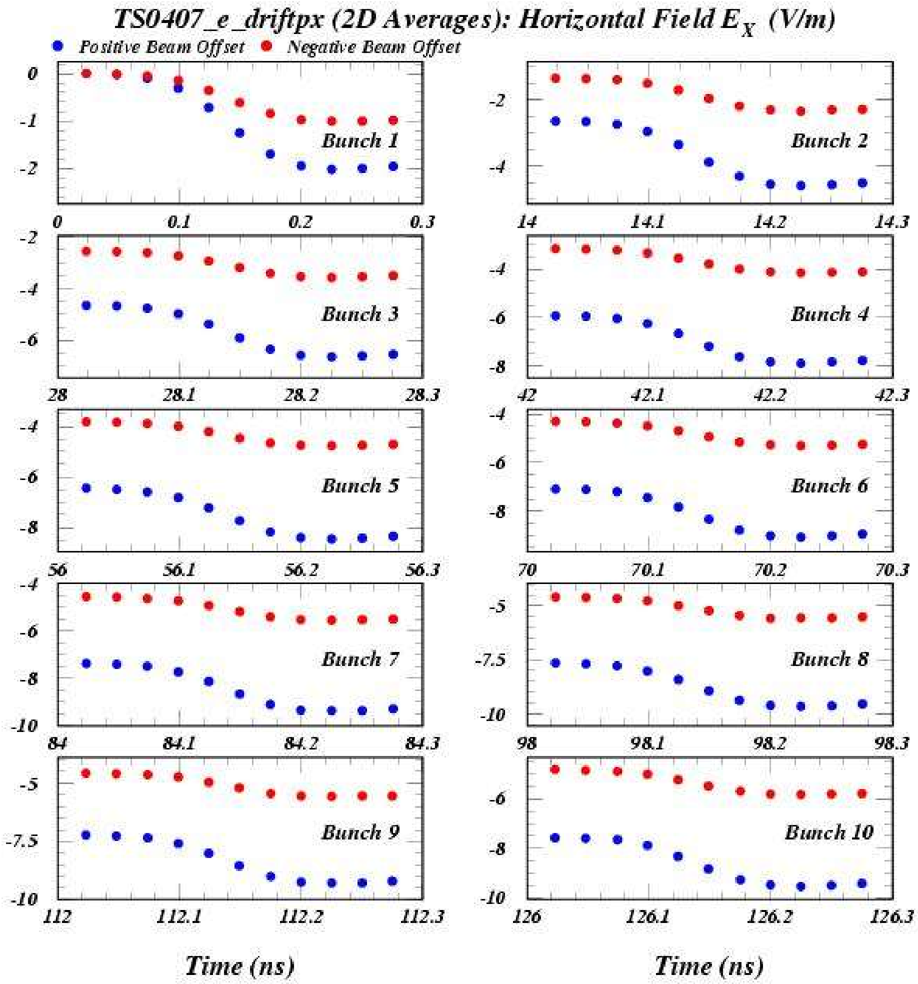
Electrons: little "anti-pinch" effect observed, consistent with Gerry's POSINST calculation (30 Dec08/slide 7)

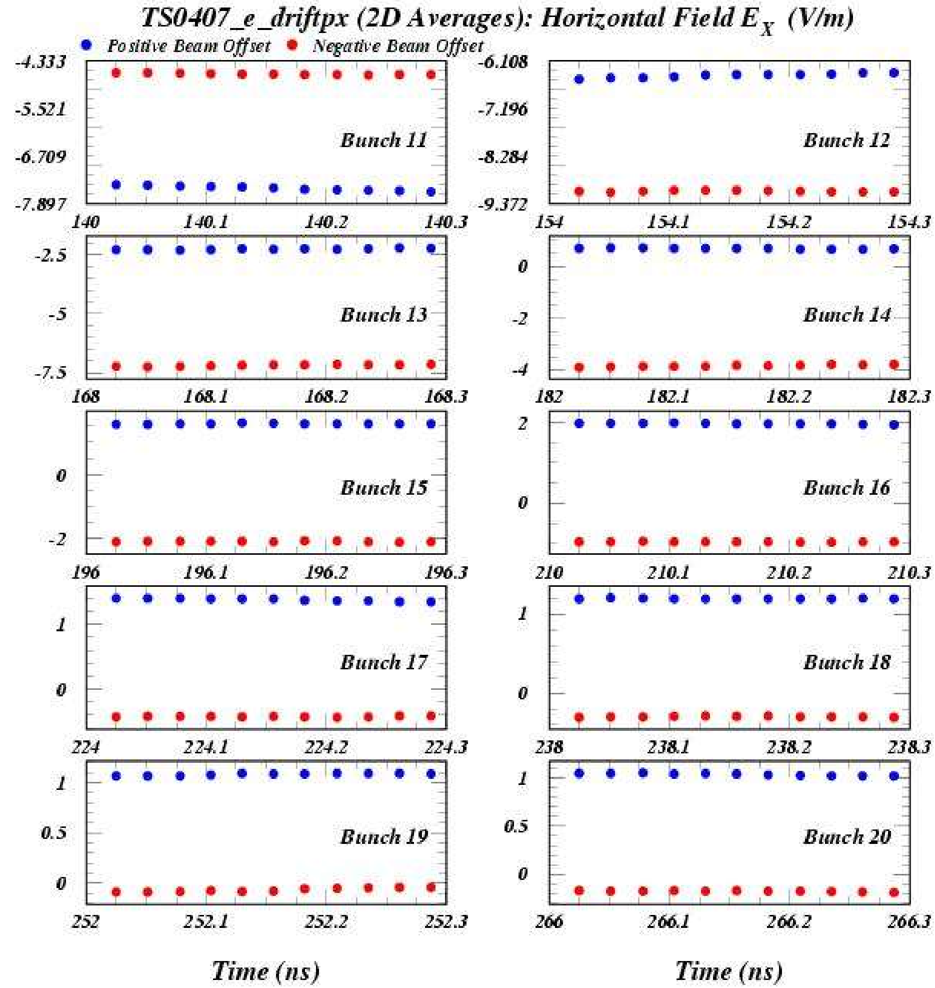
e-, Vertical Field, Drift, Beam Y +- 5 mm



ECLOUD calculates dEy/dy = 800 V/m², to be compared to Gerry's POSINST result of 1500 V/m² (30 Dec0/ slide 7)

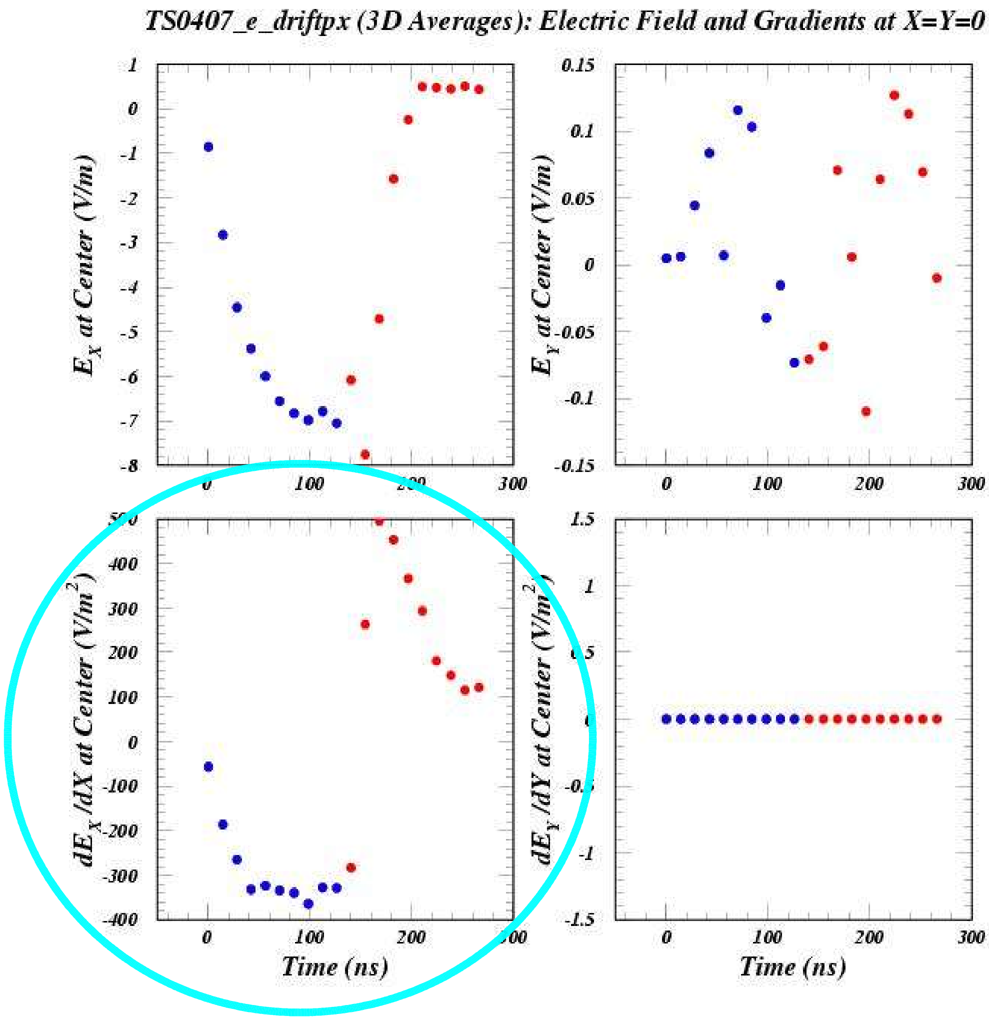
e-, Horizontal Field, Drift, Beam X +- 5 mm





ECLOUD does not find the large horizontal field in bunch 11 calculated using POSINST (30Dec08/slide 3: -23 V/m)

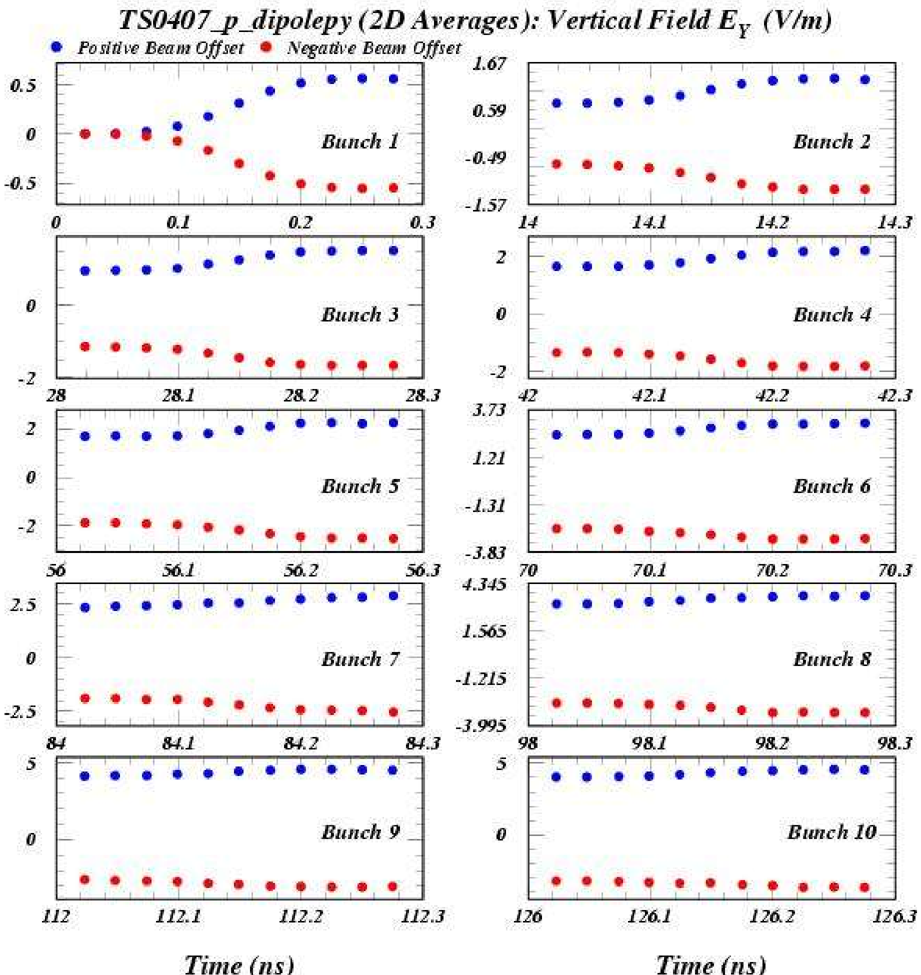
e-, Horizontal Field, Drift, Beam X +- 5 mm

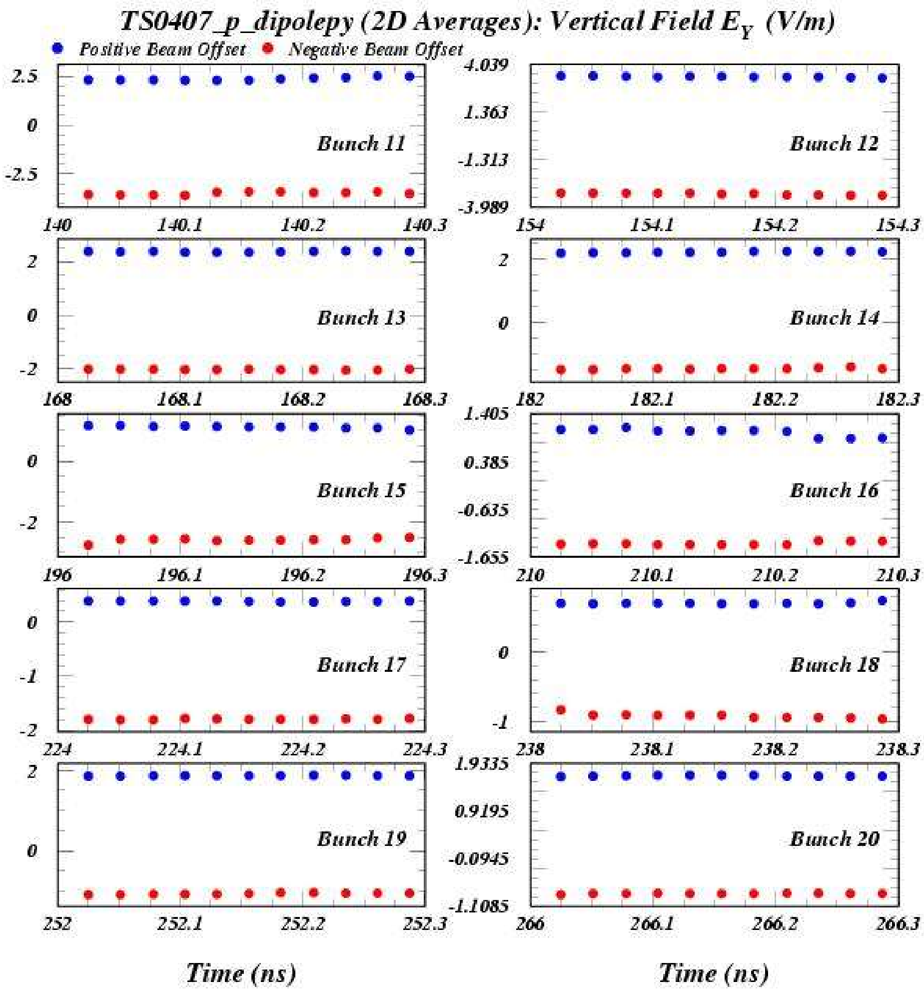


This ECLOUD result for dE/dx at bunch 11 with an electron beam is about -300 V/m²

Gerry (30dec08/slide 4) finds a value for dEx/dx of about -1180 V/m²

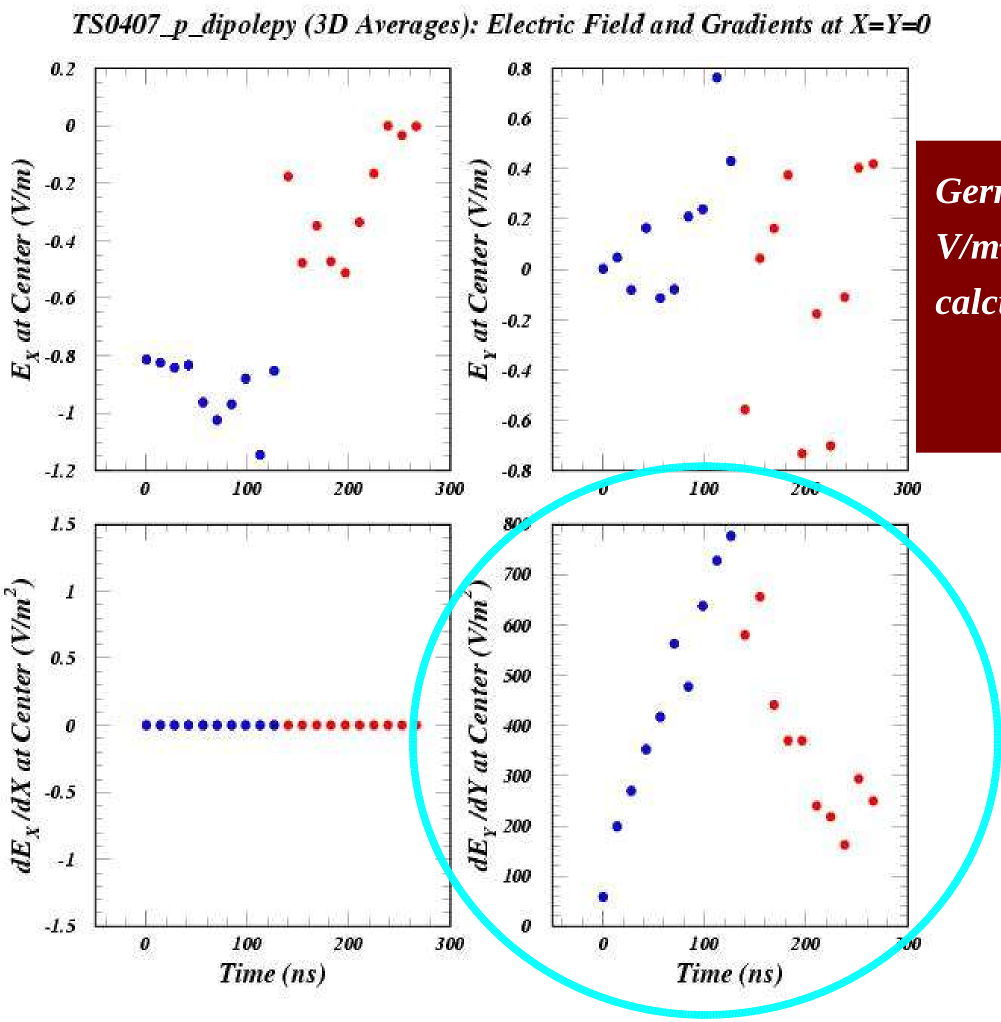
e+, Vertical Field, Dipole, Beam Y +- 5 mm





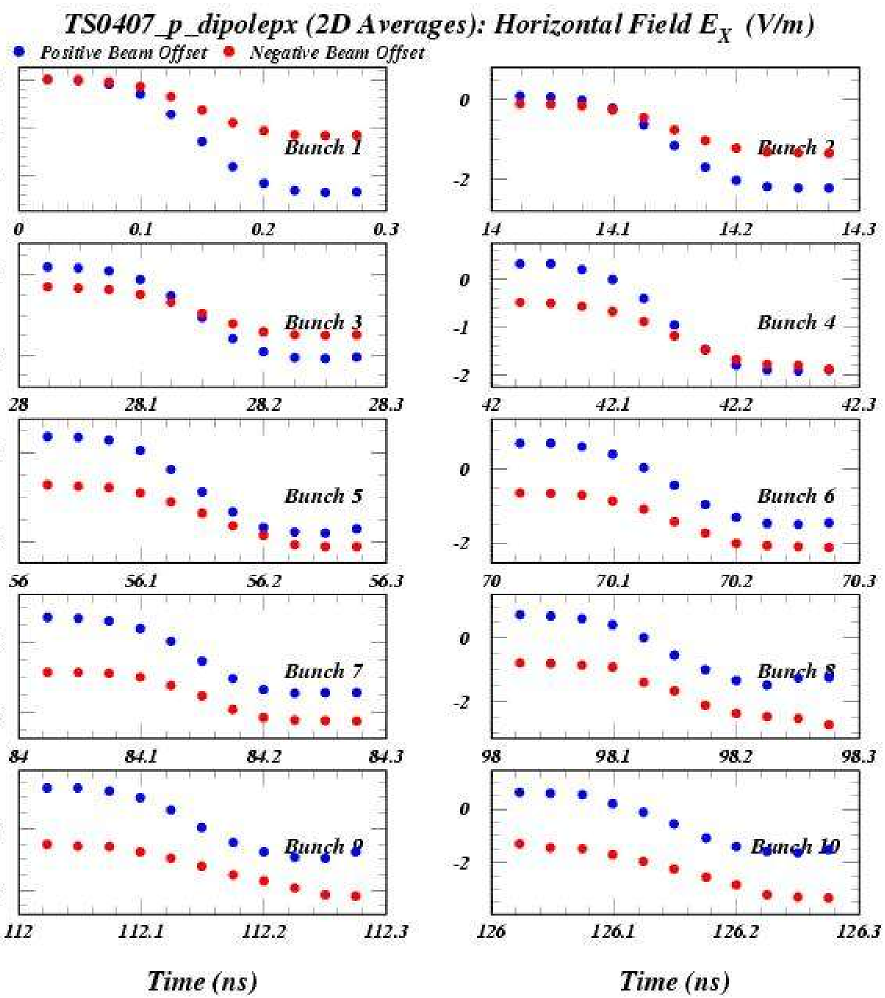
This result for bunch 11, +-2.5 V/m is about a factor of 6 smaller than Gerry's POSINST result of +-1.5 V/m (28Dec08/slide 12) for +-0.5mm.
Marco gives only tune shifts for the dipole runs.

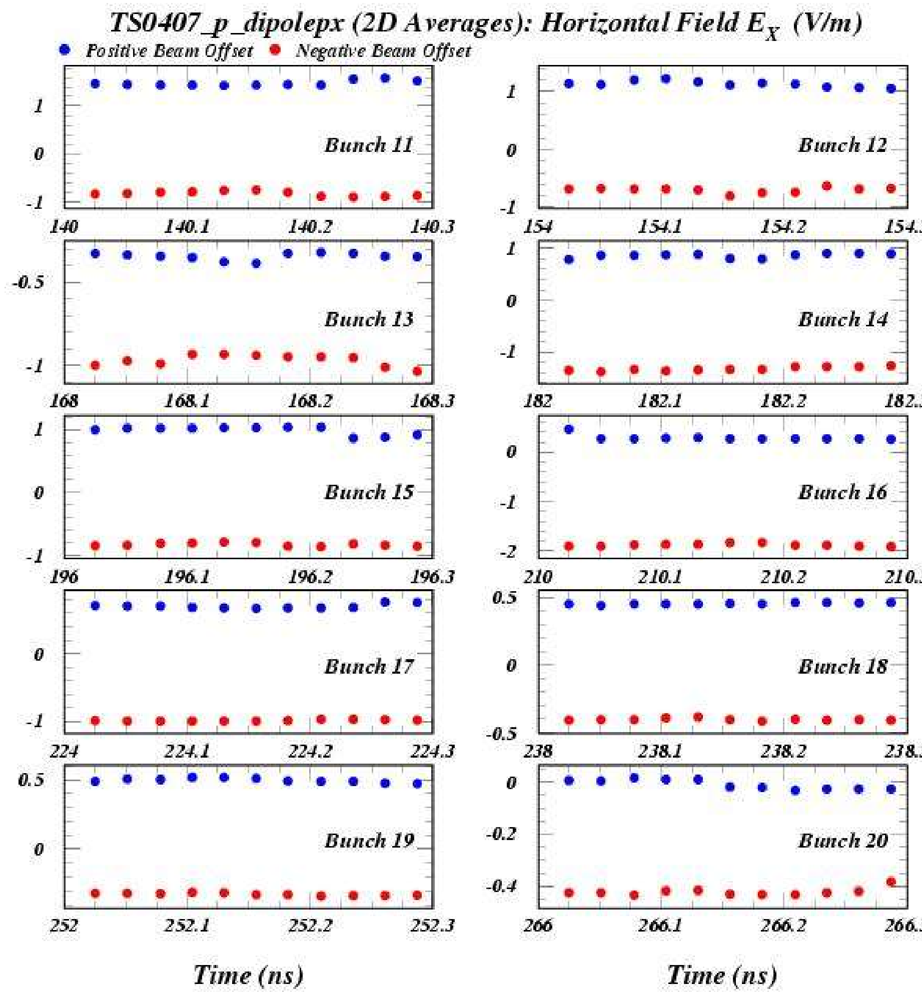
e+, Vertical Field, Dipole, Beam Y +- 5 mm



Gerry (28dec08/slide 13, +-0.5mm) finds dEy/dy= 3000 V/m² in bunch 11 using POSINST, while ECLOUD calculates 650 V/m².

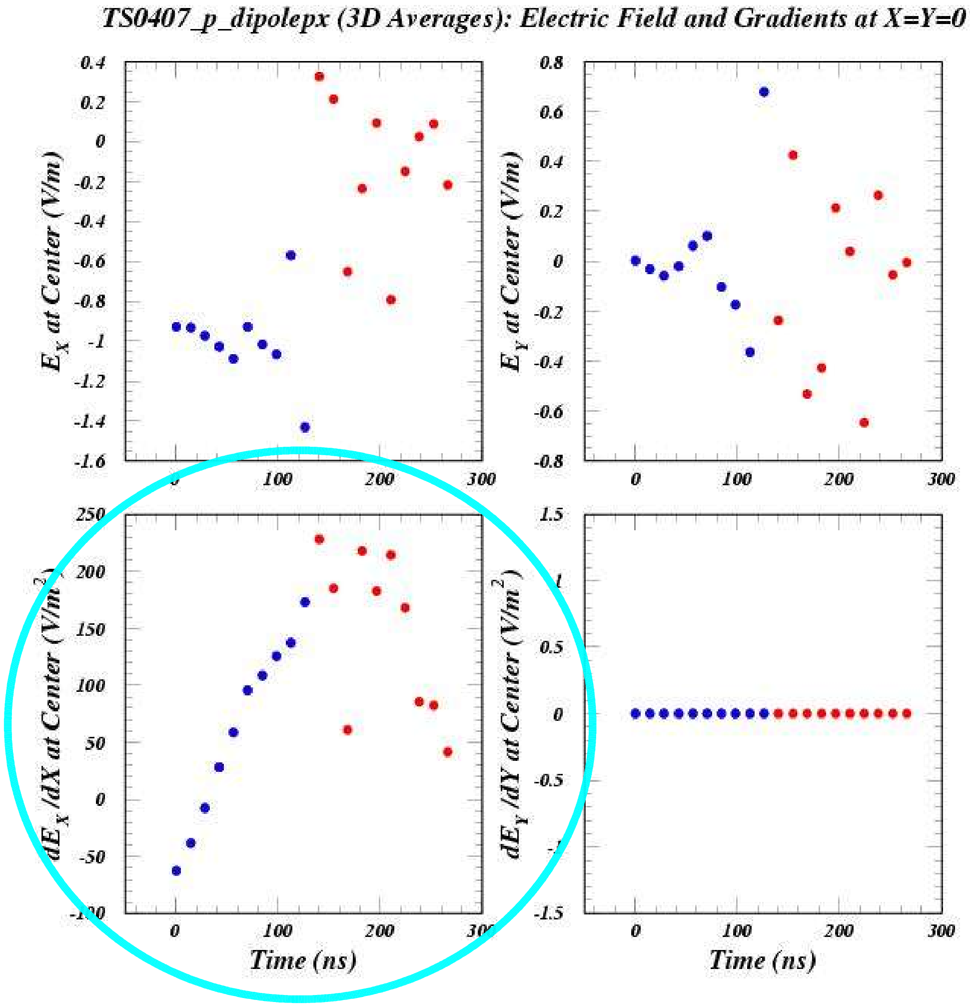
e+, Horizontal Field, Dipole, Beam X +- 5 mm





POSINST finds similar field values in bunch 11 (28Dec08/slide 9), but for one tenth the beam offset!

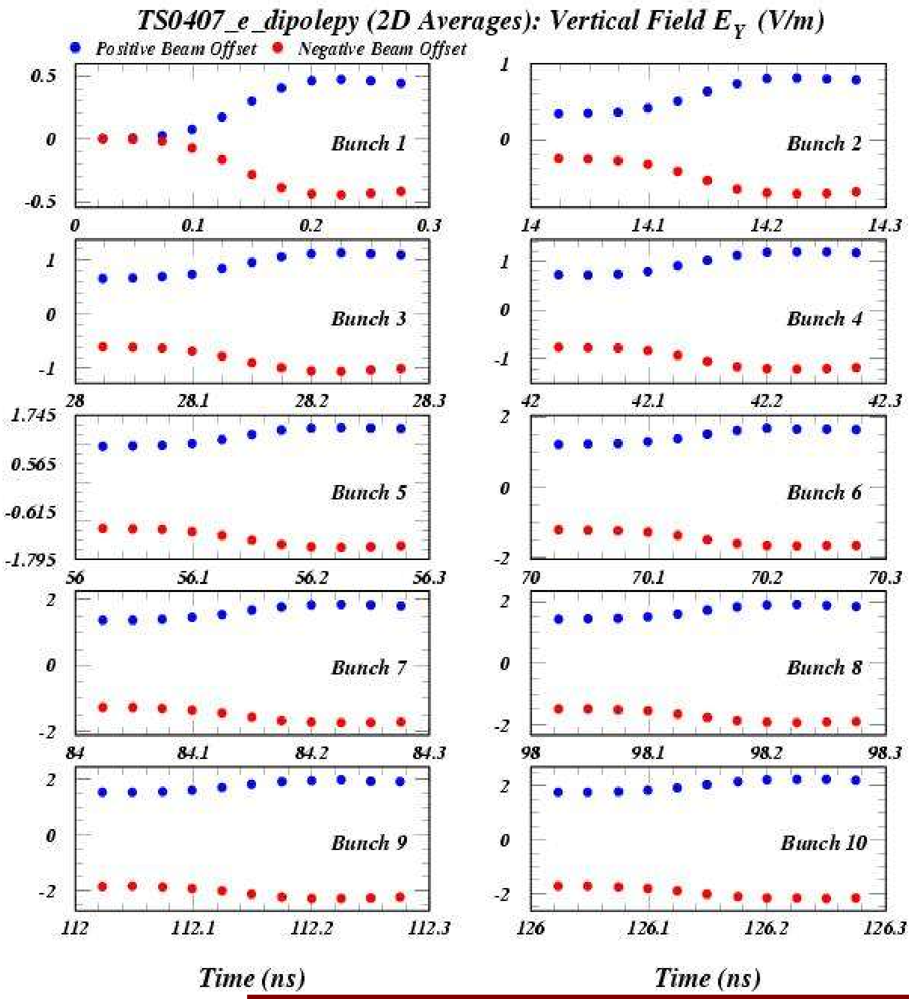
e+, Horizontal Field, Dipole, Beam X +- 5 mm

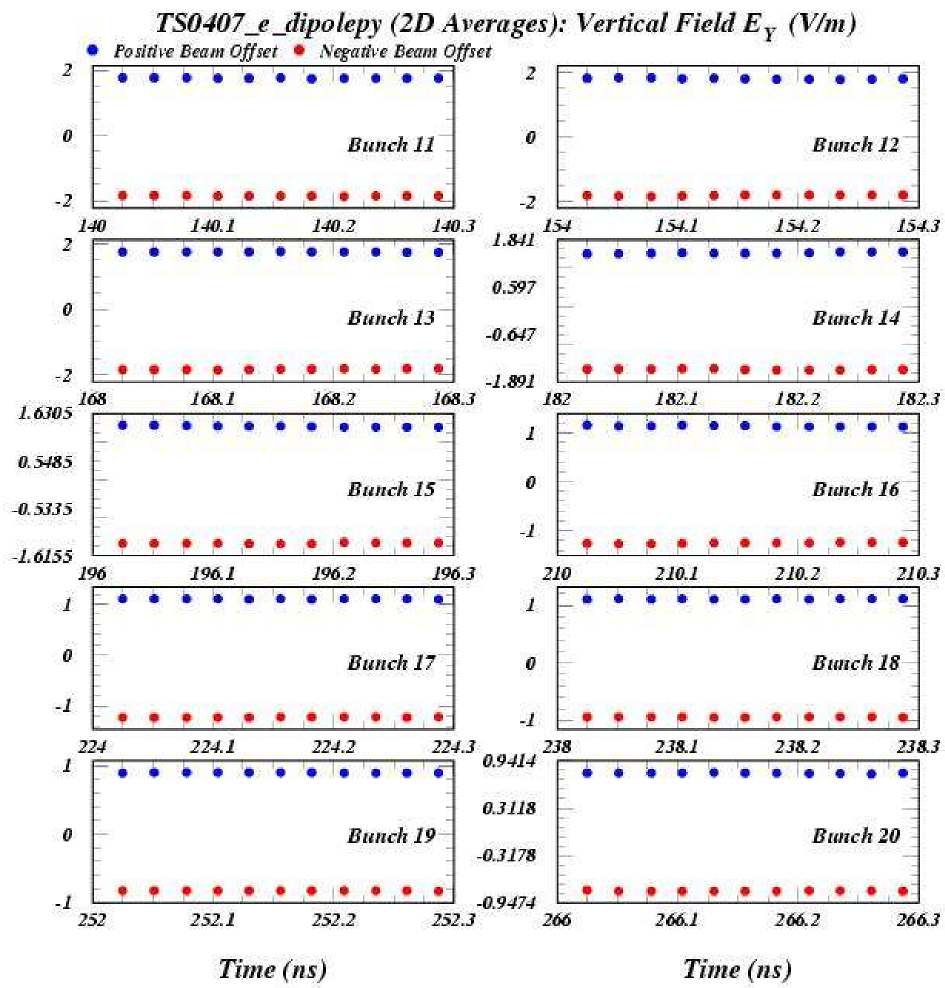


This ECLOUD result for dE/dx at bunch 11 is about 220 V/m²

Gerry (28dec08/slide 10, +-0.5mm) finds a value for dEx/dx of about 2000 V/m²

e-, Vertical Field, Dipole, Beam Y +- 5 mm

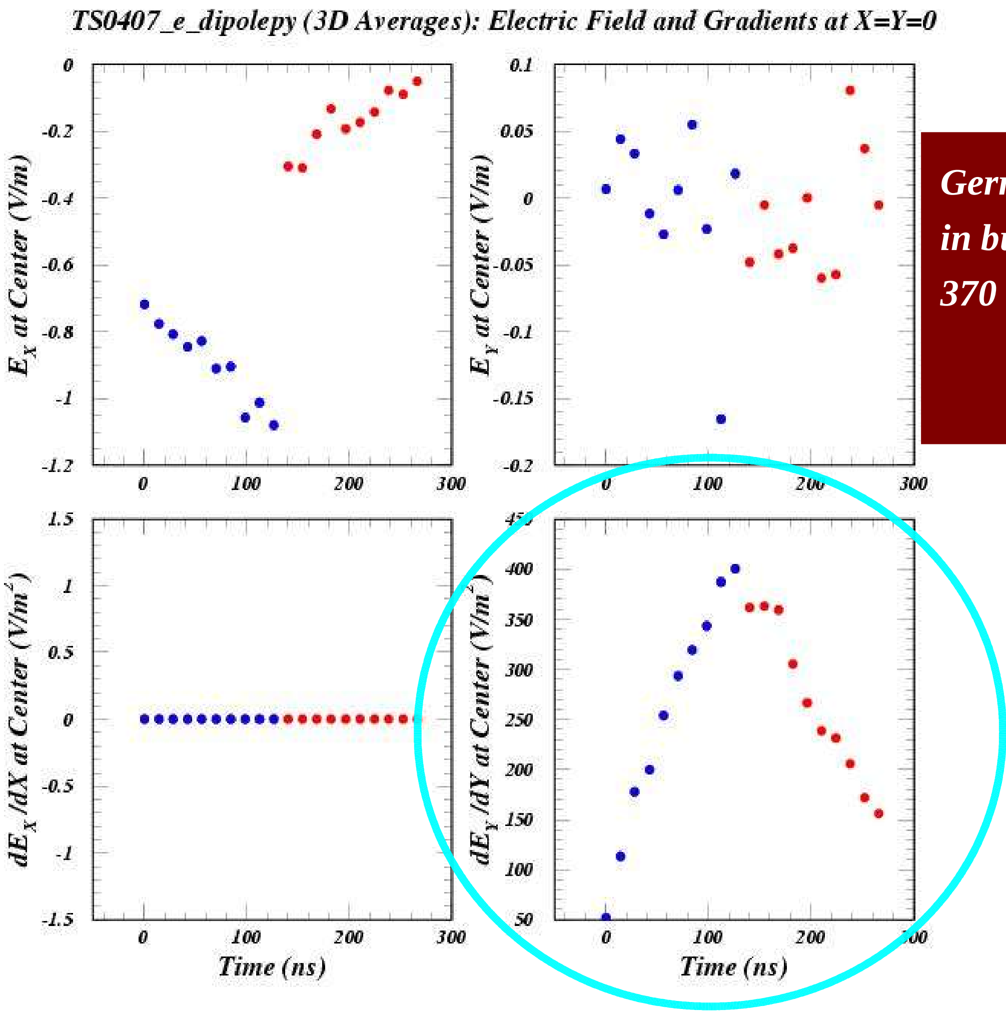




This result for bunch 11, +-2.0 V/m, is smaller than Gerry's POSINST result of +-0.3 V/m (30Dec08/slide 12) for +-0.5mm.

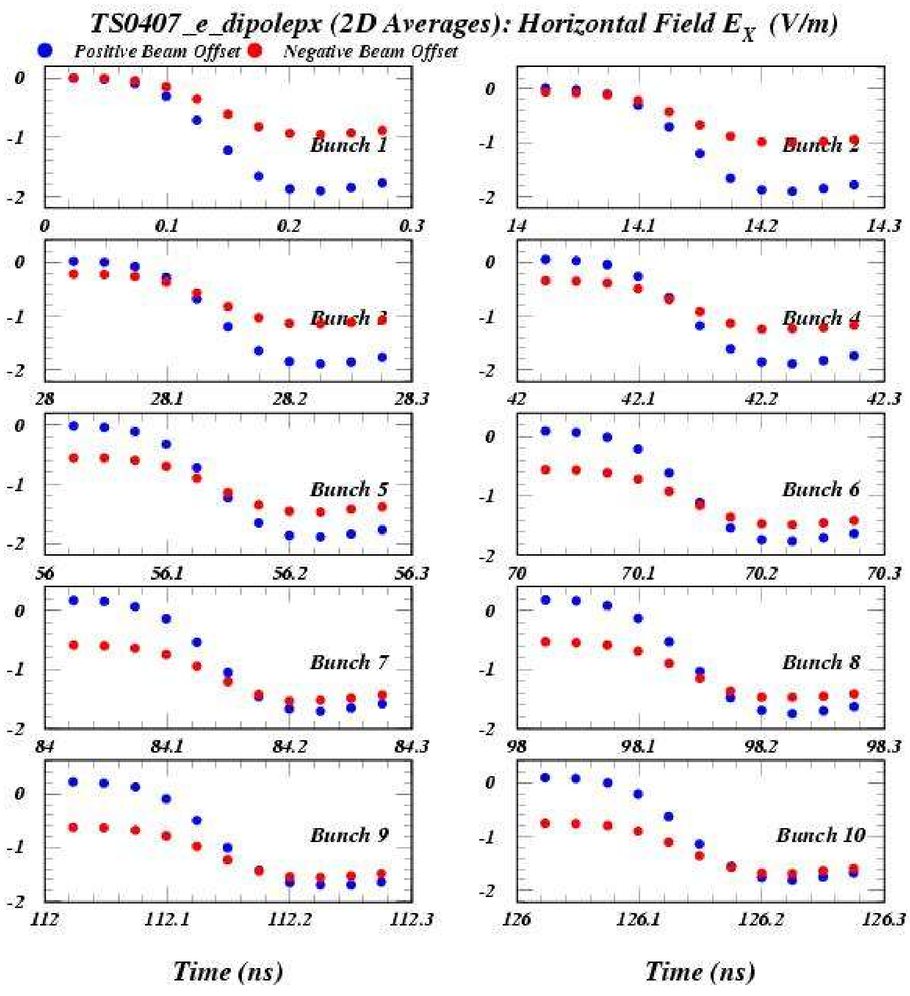
The POSINST result is not as up/down-symmetric as these results from ECLOUD.

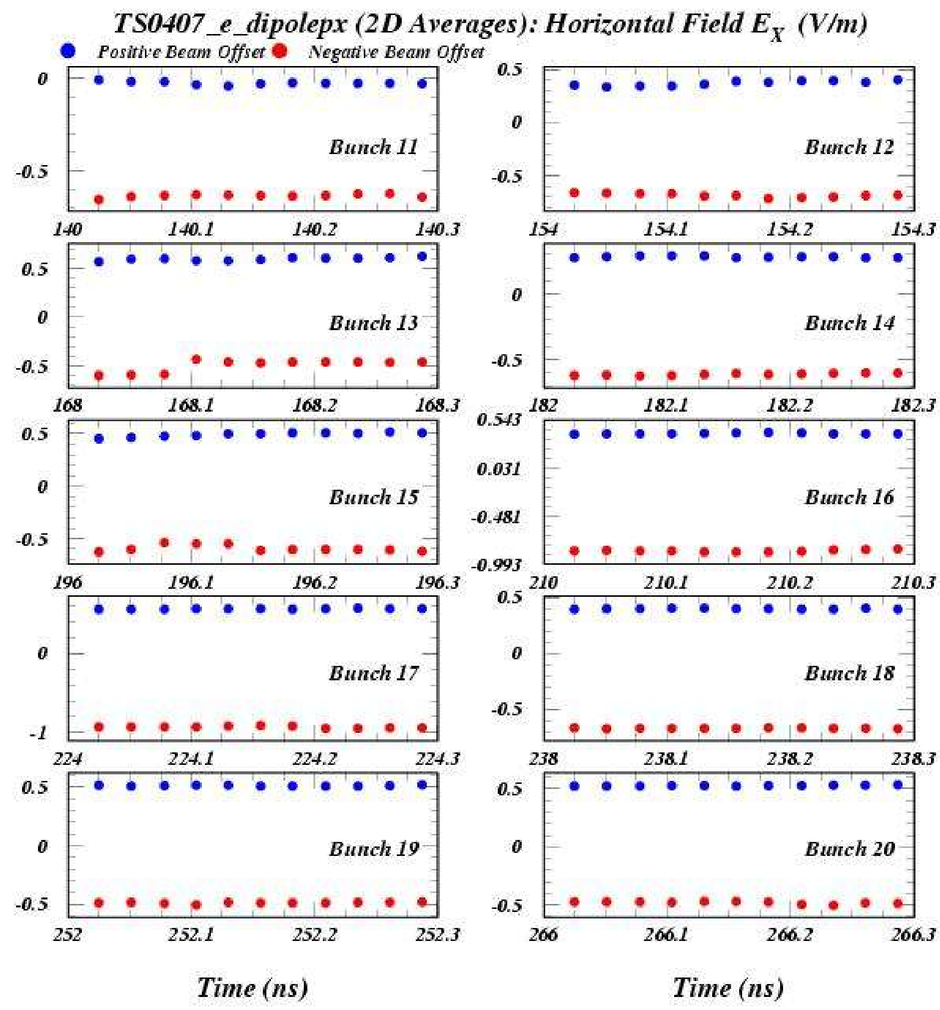
e-, Vertical Field, Dipole, Beam Y +- 5 mm



Gerry (30dec08/slide 13, +-0.5mm) finds dEy/dy= 600 V/m² in bunch 11 using POSINST, while ECLOUD calculates 370 V/m².

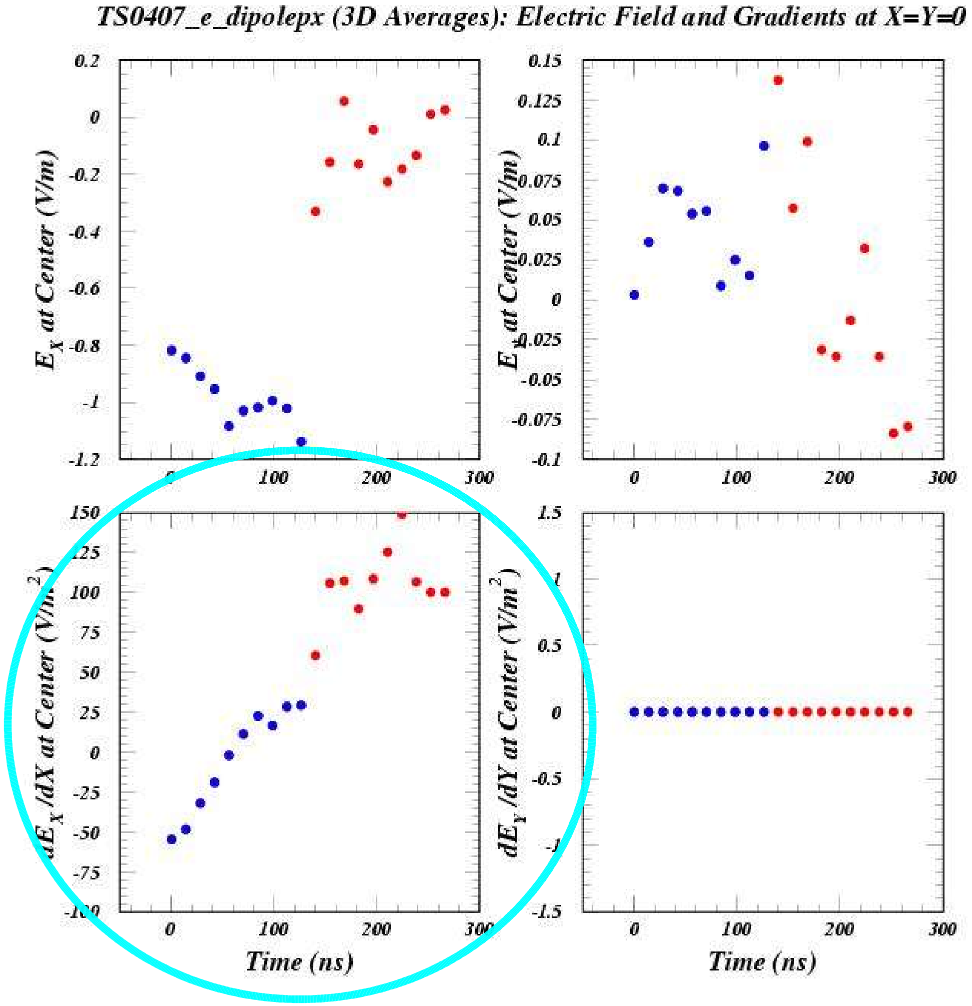
e-, Horizontal Field, Dipole, Beam X +- 5 mm





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.)

e-, Horizontal Field, Dipole, Beam X +- 5 mm



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.