ECLOUD Modelling of Electron Cloud Buildup in CesrTA Quadrupole Magnets

Synopsis of presentations in the CesrTA Electron Cloud meetings of 9Dec09, 16Dec09 and 3Mar10.

All material for this presentation (and more) can be found in www.lepp.cornell.edu/~critten/cesrta/ecloud/9mar10.

Jim Crittenden

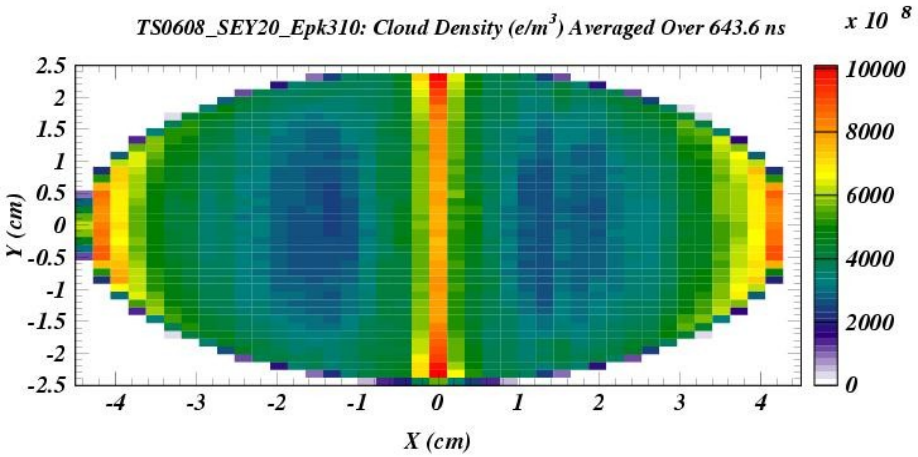
Cornell Laboratory for Accelerator-Based Sciences and Education

CesrTA Collaboration Meeting

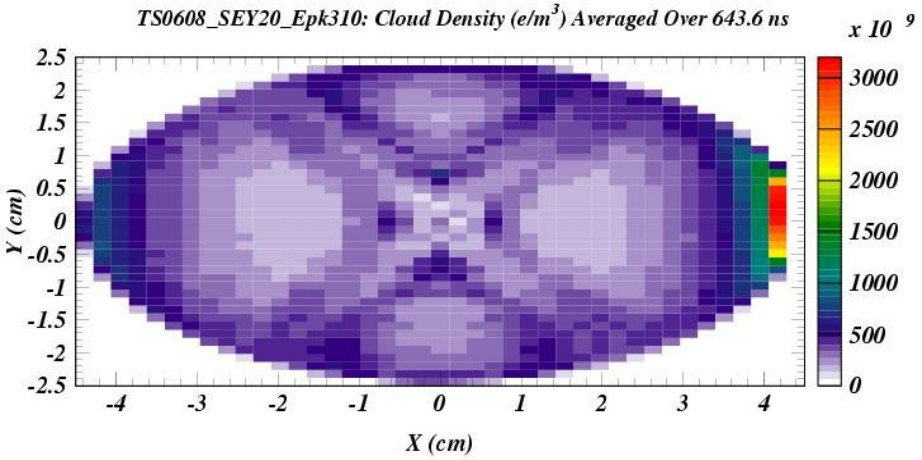
9 March 2010

Conditions of June, 2008 tune shift measurements
5.3 GeV 11 bunches 14-ns spacing 1.2e10 e+/bunch
Figure 2 of our PAC2009 paper

Dipole (0.2 T)



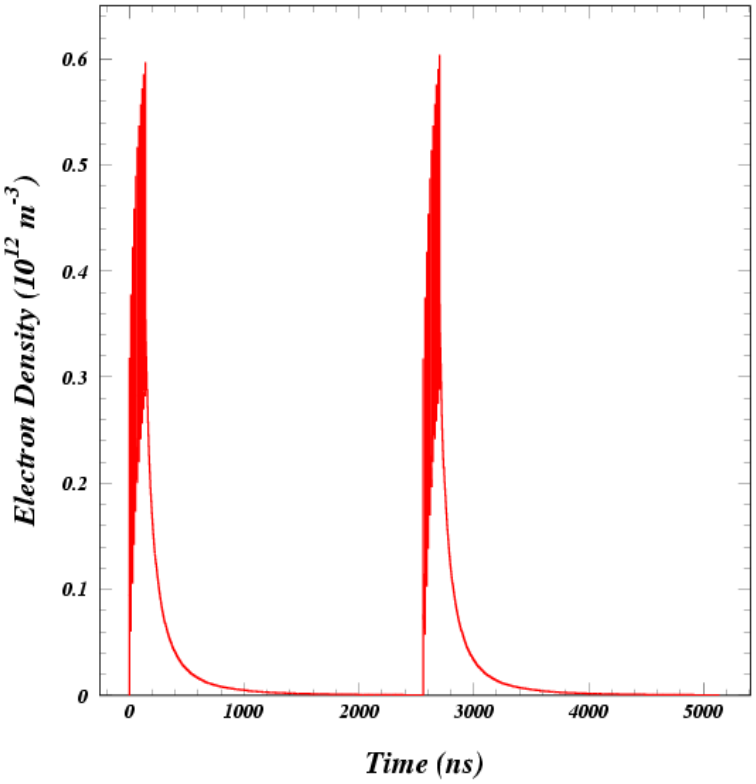
Quadrupole (9.2 T/m)



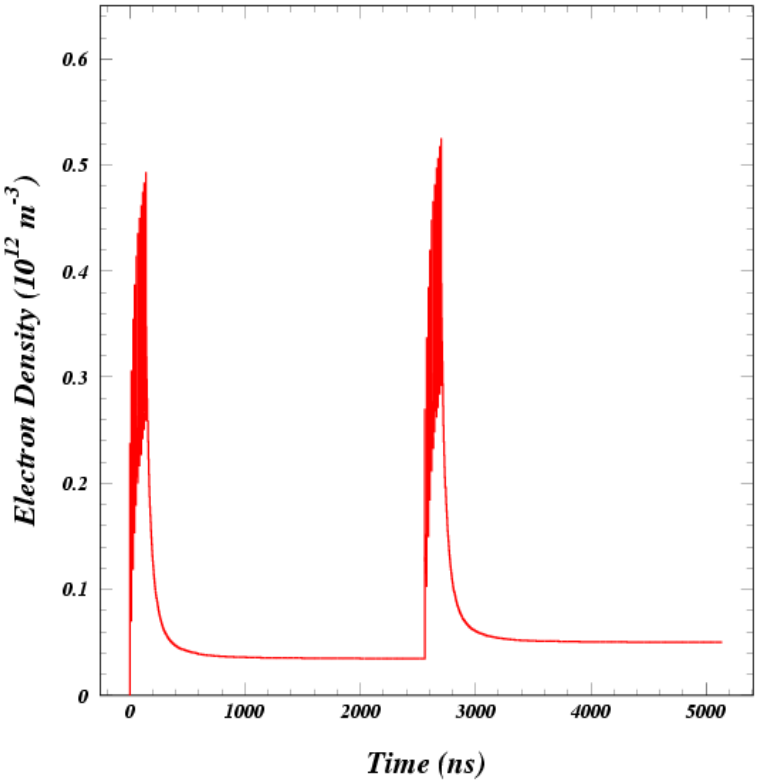
These conditions were chosen to give an estimate of the quadrupole contribution to the coherent tune shifts and to estimate the cloud persistence in quadrupoles relative to dipoles. 11 filled bunches followed by 34 empty ones. Assumed 1.1 photons/m/e (the ring-average for dipoles) and 15% reflectivity in both simulations. The SEY model parameters are the PAC2009 values, whereby ECLOUD now includes the rediffused eomponent.

Time development of cloud density averaged over the 4.5 x 2.5 cm elliptical vacuum chamber

Dipole (0.2 T)



Quadrupole (9.2 T/m)

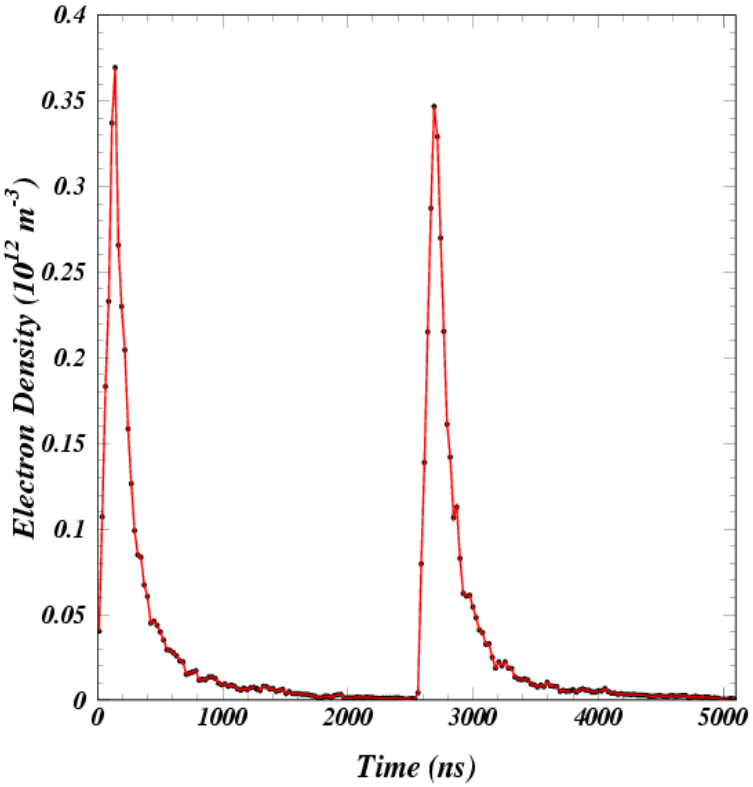


Conditions of June, 2008 tune shift measurements: 5.3 GeV 14-ns spacing 1.2e10 e+/bunch
Two turns, each comprising 11 filled bunches followed by 172 empty ones.
Assumed 1.1 photons/m/e (the ring-average for dipoles) and 15% reflectivity.
The SEY model parameters are the PAC2009 values, whereby ECLOUD now includes the rediffused eomponent.

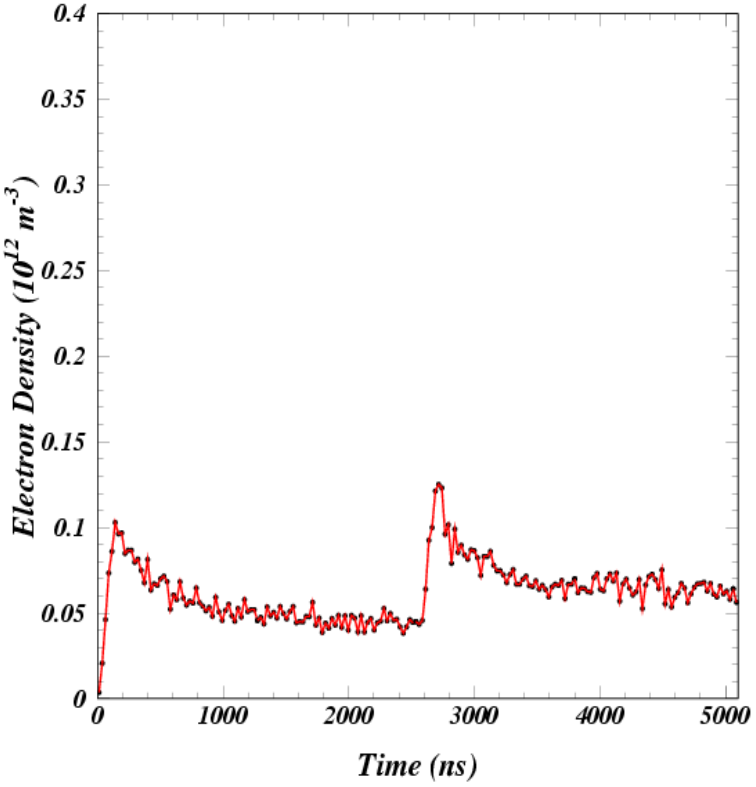
The beam-pipe-averaged density indeed shows cloud trapped in quadrupoles carrying over to the second turn.

Cloud density averaged over a region extending over 5-sigma of the beam size

Dipole (0.2 T)



Quadrupole (9.2 T/m)

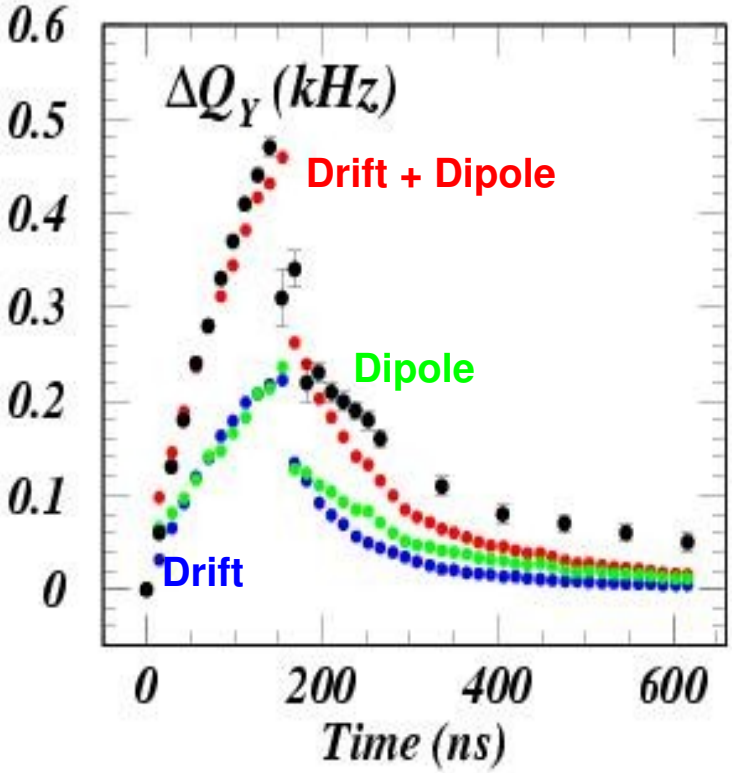


Some of the cloud trapped in the beam region carries over to the second turn.
How will this trapped cloud contribute to tune shifts over several turns?

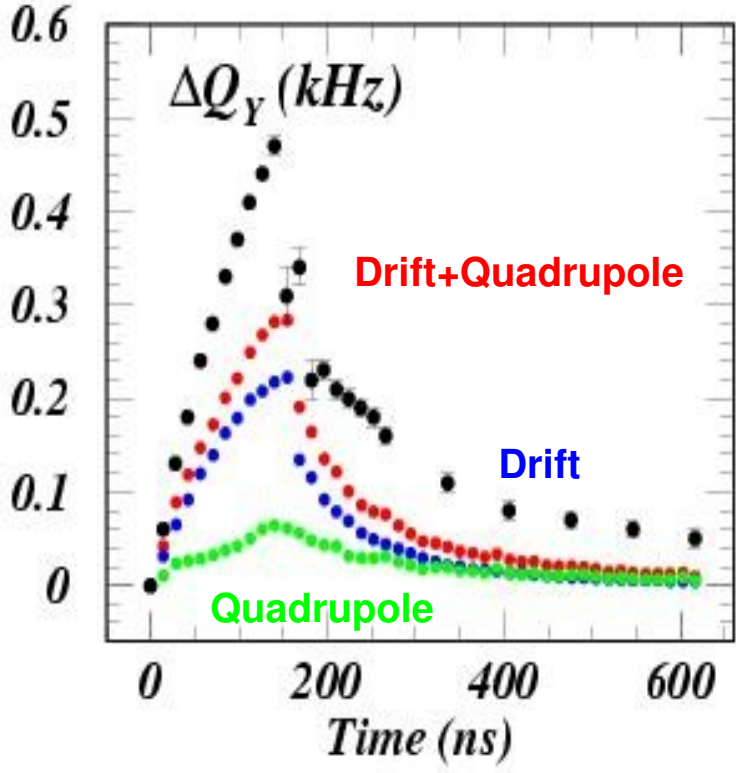
Quadrupole tune shift contribution assuming dipole ring averages
June, 2008 vertical tune shift measurements

Measurements from Fig. 2 of PAC2009 FR5RFP044
5.3 GeV, 0.75 mA/bunch

Dipole (0.2 T)



Quadrupole (9.2 T/m)

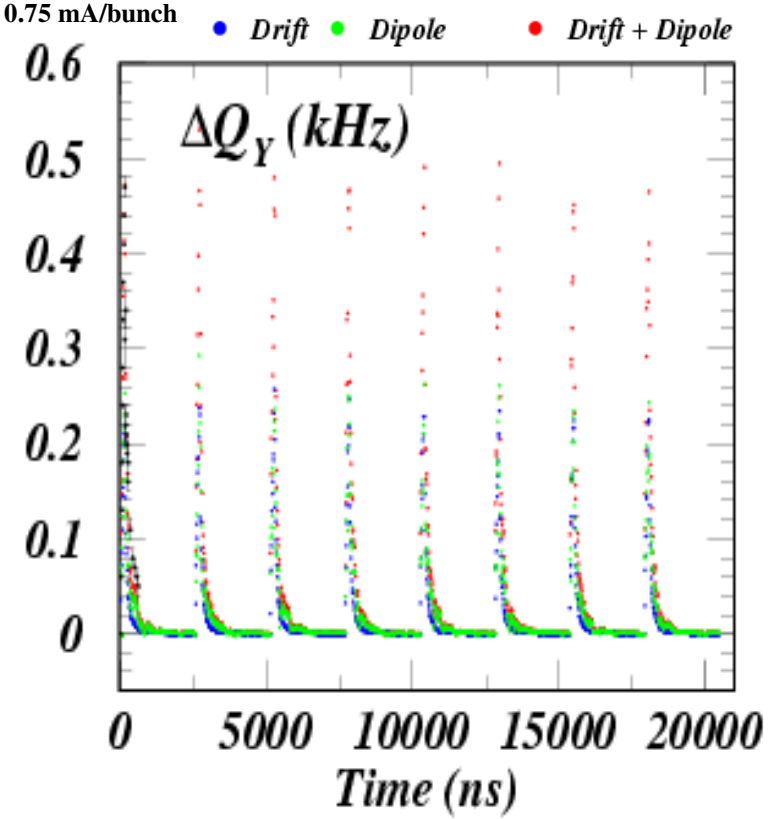


The assumption of dipole ring averages (61.5% occupancy and 1.16 photons/m/e) exaggerates the quadrupole contribution (8.5%, 0.78 photons/m/e) by more than a factor of 10. The quadrupole contribution thus calculated is nonetheless only about 20% of the dipole contribution during the passage of the filled bunches. It can be neglected at the 2% level.

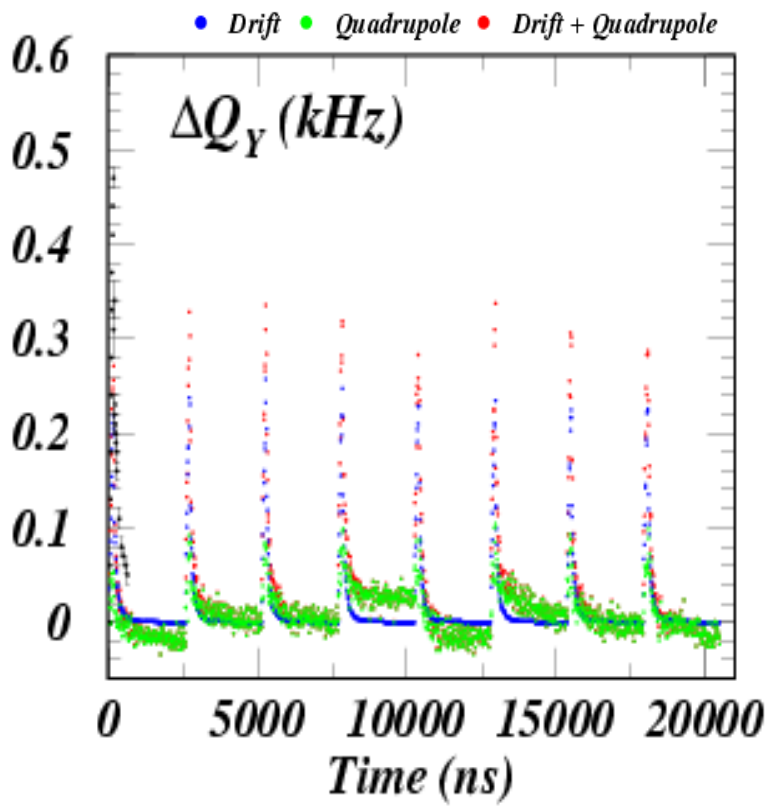
But does the quadrupole contribution accumulate over many turns?

Measurements from Fig. 2 of PAC2009 FR5RFP044
5.3 GeV, 0.75 mA/bunch

Dipole (0.2 T)



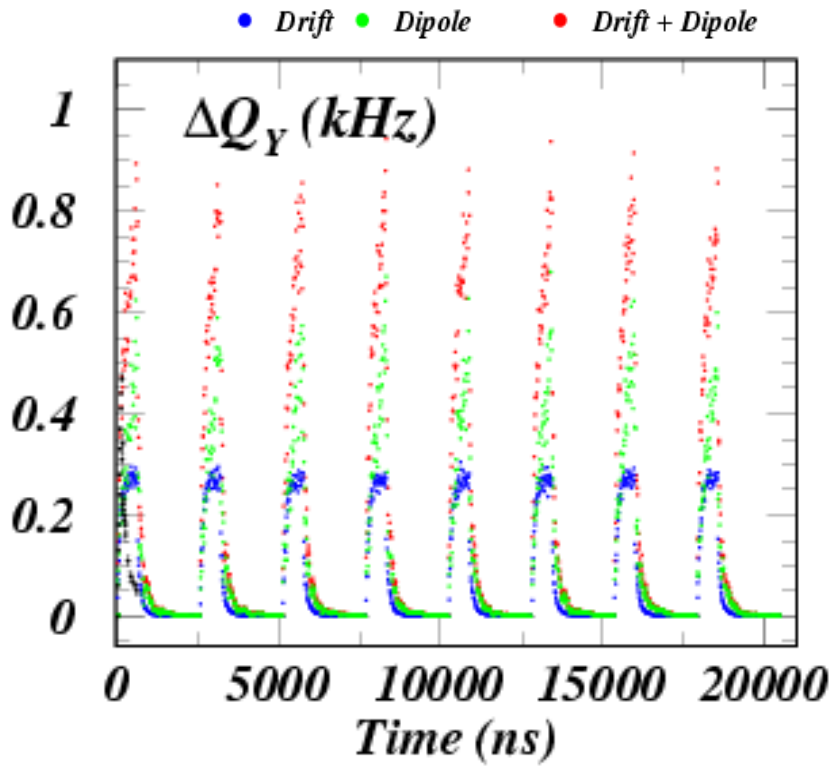
Quadrupole (9.2 T/m)



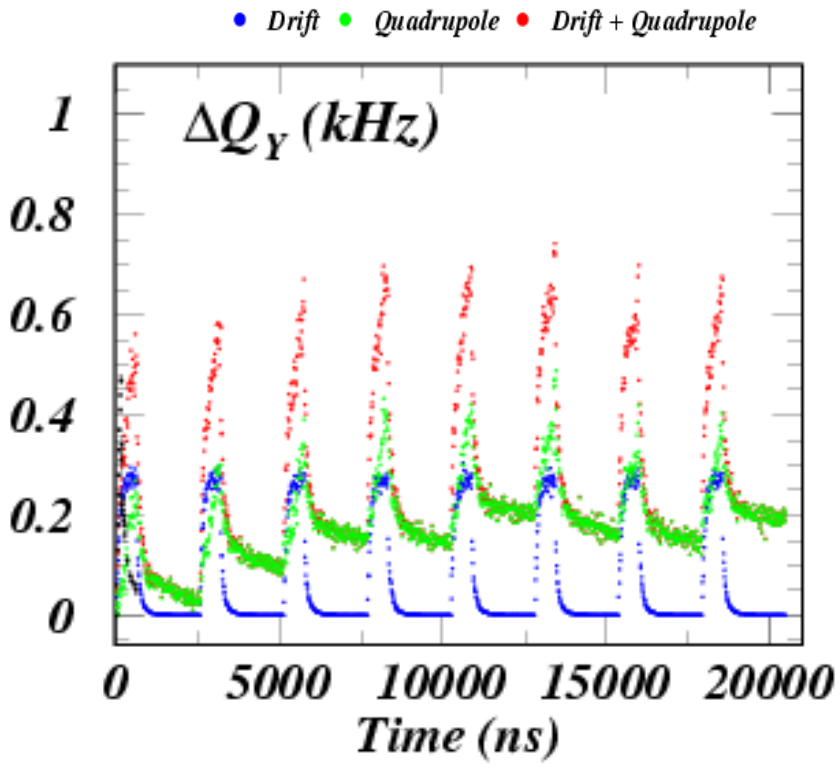
No systematic buildup trend is observed for 11-bunch trains at this statistical accuracy. What about for 45-bunch trains, where secondary emission dominates the tune shifts?

Does the quadrupole contribution accumulate over many turns for 45-bunch trains?

Dipole (0.2 T)



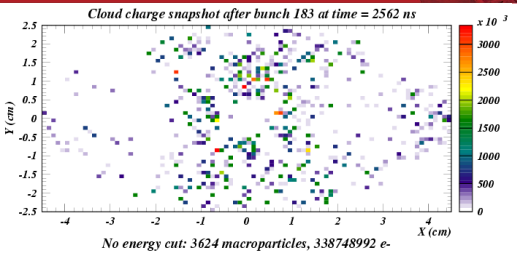
Quadrupole (9.2 T/m)



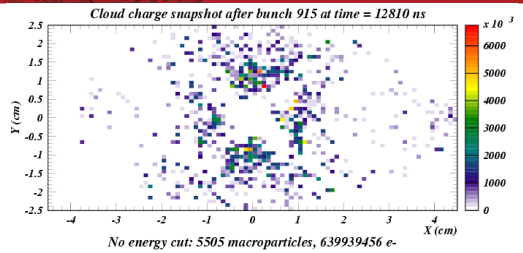
The estimate of the turn-to-turn carryover of the space charge field gradients for eight turns suffers from statistical fluctuations.

Cloud snapshots at the end of each turn in the quadrupole field

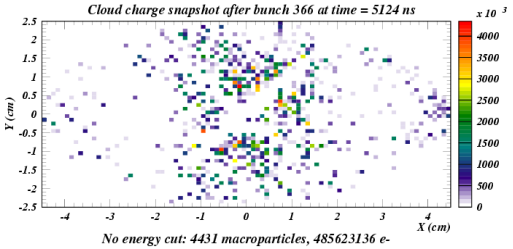
After Turn 1



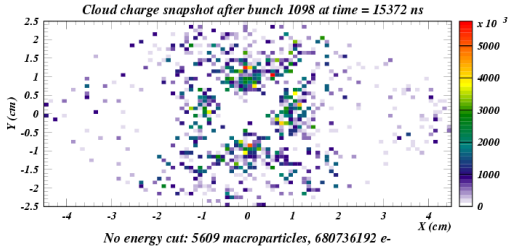
After Turn 5



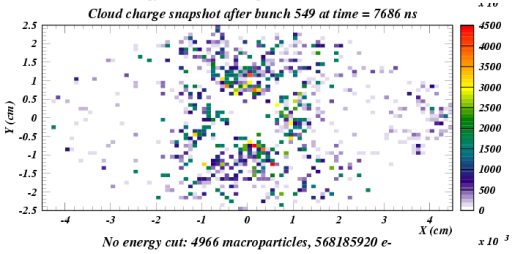
After Turn 2



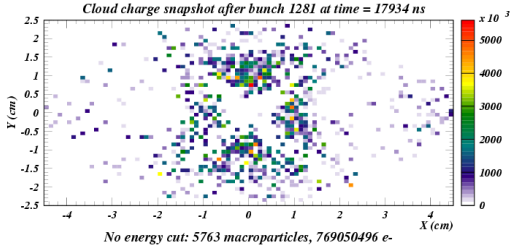
After Turn 6



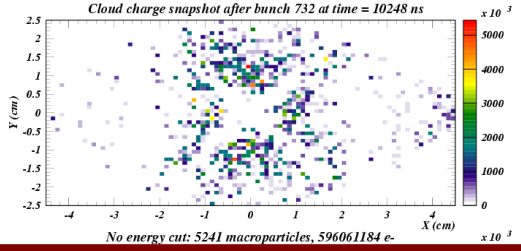
After Turn 3



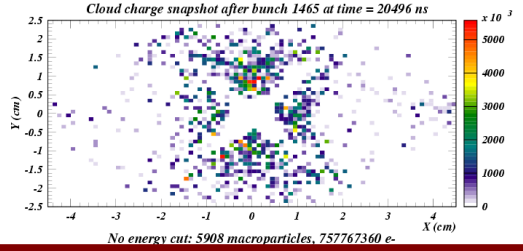
After Turn 7



After Turn 4



After Turn 8



The calculation of field gradients at the beam long after the passage of the last filled bunch on each turn is sensitive to distant cloud structure owing to the cloud self-repulsion. Work on the buildup and trapping of electron clouds in quadrupole fields will continue.