ECLOUD Calculations of Electron Cloud Formation in the 3.2 and 6.4 km ILC Damping Ring Lattice Designs

- *Photon rates from the synchrotron radiation analysis of the DCO4 and DSB3 lattices (see Kiran's talk today)*
- *Densities, cloud snapshots and profiles, and SEY curve populations for drift regions, dipoles and quadrupoles*
- *Comparisons of the relative contributions to coherent tune shifts of each element type in the two lattices*

All material (much more than shown here) available at http://www.lepp.cornell.edu/~critten/ilcdr/10mar10

Jim Crittenden

Cornell Laboratory for Accelerator-Based Sciences and Education

ILC Damping Ring Electron Cloud Working Group Meeting

10 March 2010

Element-averages of Twiss functions, beam sizes and photon rates on the outer vacuum chamber wall

ε_x = 441 pm ε_Y = 2 pm
σ_Z = 5.6 mm δ_E = 0.127%

6.4 km (DCO4)

Element	Nr Seg	<Length>	Tot Length	Fraction	<Beta X>	<Beta Y>	<Sig X>	<Sig Y>	<Phot/m/e>
Dipole	5024	0.091	459.1	7.1%	10.5	24.8	0.214	0.007	0.283
Drift	56323	0.096	5397.7	83.3%	21.1	19.4	0.268	0.006	0.146
Wiggler	2251	0.095	214.9	3.3%	10.7	12.1	0.069	0.005	1.515
Quadrupole	3063	0.097	296.1	4.6%	21.6	20.6	0.291	0.006	0.182
Sextupole	1127	0.098	110.0	1.7%	20.1	20.6	0.364	0.006	0.037
Solenoid	0	0.000	0.0	0.0%	0.0	0.0	0.000	0.000	0.000
Octupole	0	0.000	0.0	0.0%	0.0	0.0	0.000	0.000	0.000
Non-dipole	62764	0.096	6019.1	92.9%	20.7	19.2	0.264	0.006	0.195
Non-drift	11465	0.094	1080.2	16.7%	14.6	20.7	0.222	0.006	0.475
Total	67788	0.096	6478.7	100.0%	20.0	19.6	0.261	0.006	0.201

ε_x = 525 pm ε_Y = 2 pm
σ_Z = 5.3 mm δ_E = 0.118%

3.2 km (DSB3)

Element	Nr Seg	<Length>	Tot Length	Fraction	<Beta X>	<Beta Y>	<Sig X>	<Sig Y>	<Phot/m/e>
Dipole	4332	0.091	393.8	12.2%	3.8	18.7	0.094	0.006	0.914
Drift	26553	0.093	2478.1	76.5%	22.9	23.2	0.149	0.007	0.154
Wiggler	804	0.097	78.2	2.4%	10.7	12.1	0.075	0.005	1.252
Quadrupole	2617	0.091	238.3	7.4%	20.4	20.6	0.213	0.006	0.250
Sextupole	546	0.091	49.5	1.5%	22.0	24.0	0.312	0.007	0.143
Solenoid	0	0.000	0.0	0.0%	0.0	0.0	0.000	0.000	0.000
Octupole	0	0.000	0.0	0.0%	0.0	0.0	0.000	0.000	0.000
Non-dipole	30520	0.093	2844.1	87.8%	22.3	22.7	0.155	0.006	0.192
Non-drift	8299	0.092	759.8	23.5%	10.9	19.0	0.144	0.006	0.690
Total	34852	0.093	3238.1	100.0%	20.1	22.2	0.148	0.006	0.280

The analysis of 23Feb10 used γ/m/e = 0.204 for both drifts and dipoles.
Note the higher ring fraction (factor 1.7) and radiation (factor 3.2) in dipoles for the 3.2 km ring.
This high rate in the dipoles will be mostly compensated for in the horizontal tune shift contribution by the remarkably small average horizontal beta function (3.8 m), as long as the cloud is roughly linear with the rate.

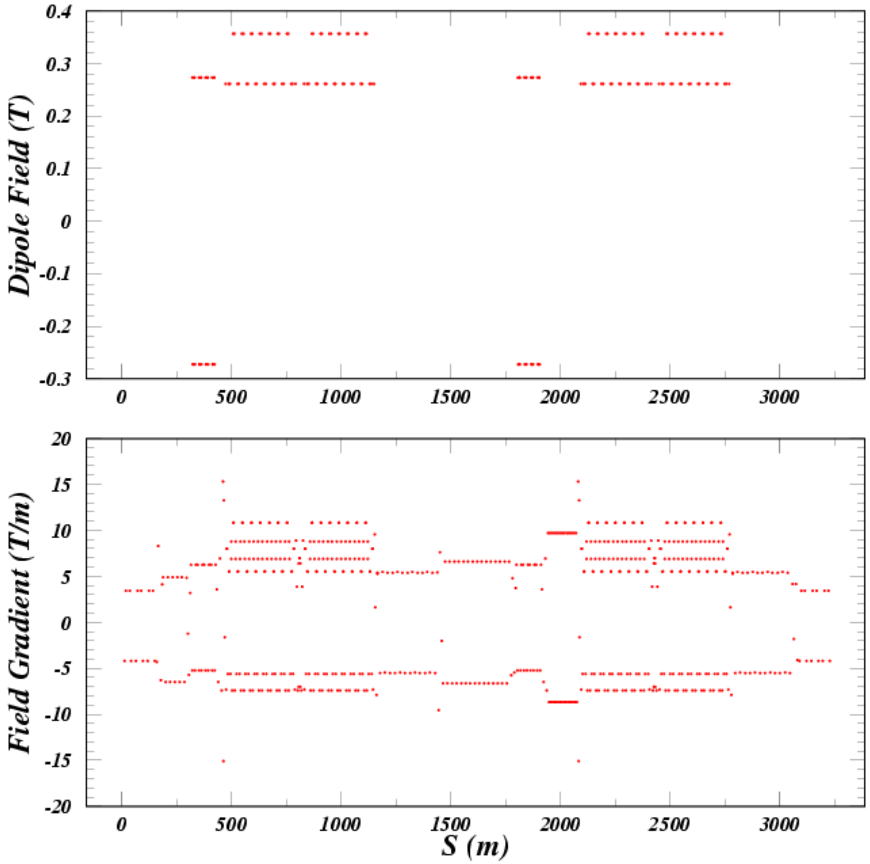
ECLOUD input parameters

Bunch population	N_b	2.1x10^{10}
Number of bunches	N_b	45 x 4 trains
Bunch gap	$Ngap$	15
Bunch spacing	$L_{sep}[m]$	1.8
Bunch length	$\sigma_z\,[mm]$	5.3 mm
Bunch horizontal size	$\sigma_x\,[mm]$	See previous slide
Bunch vertical size	$\sigma_y\,[mm]$	See previous slide
Photoelectron Yield	Y	0.1
Photon rate (e^-/e^+/m)	dn_γ/ds	See previous slide
Antechamber protection	η	90%
Photon Reflectivity	R	20%
Max. Secondary Emission Yeld	δ_{max}	1.2 (1.01 t.s. & 0.19 rediff)
Energy at Max. SEY	$E_m\,[eV]$	300
SEY model	Cimino-Collins $(\delta(0)=0.5)$	

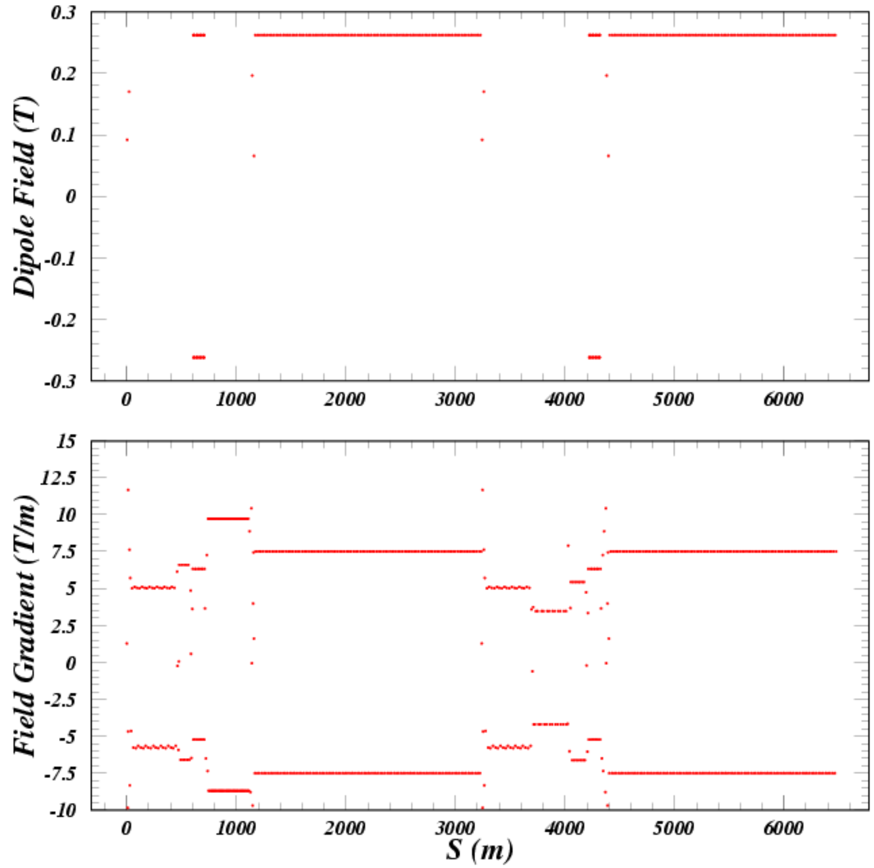
Dipole field: 0.27 T
Quadrupole field: 7.0 T/m

Distribution of dipole and quadrupole strengths

3.2 km lattice (DSB3)



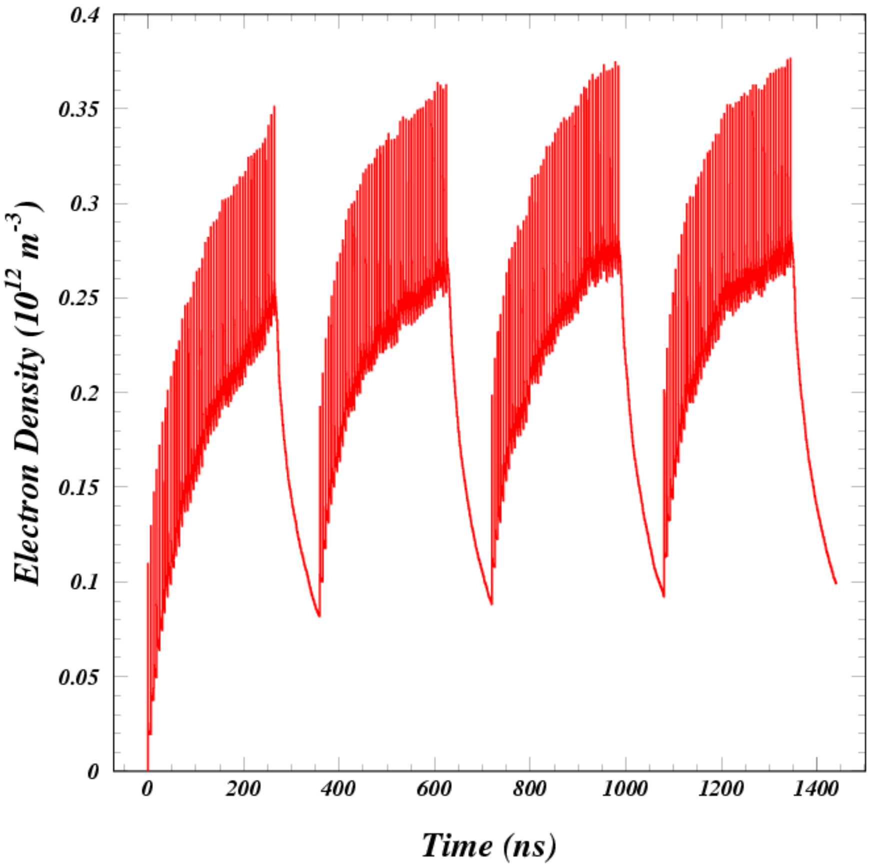
6.4 km lattice (DCO4)



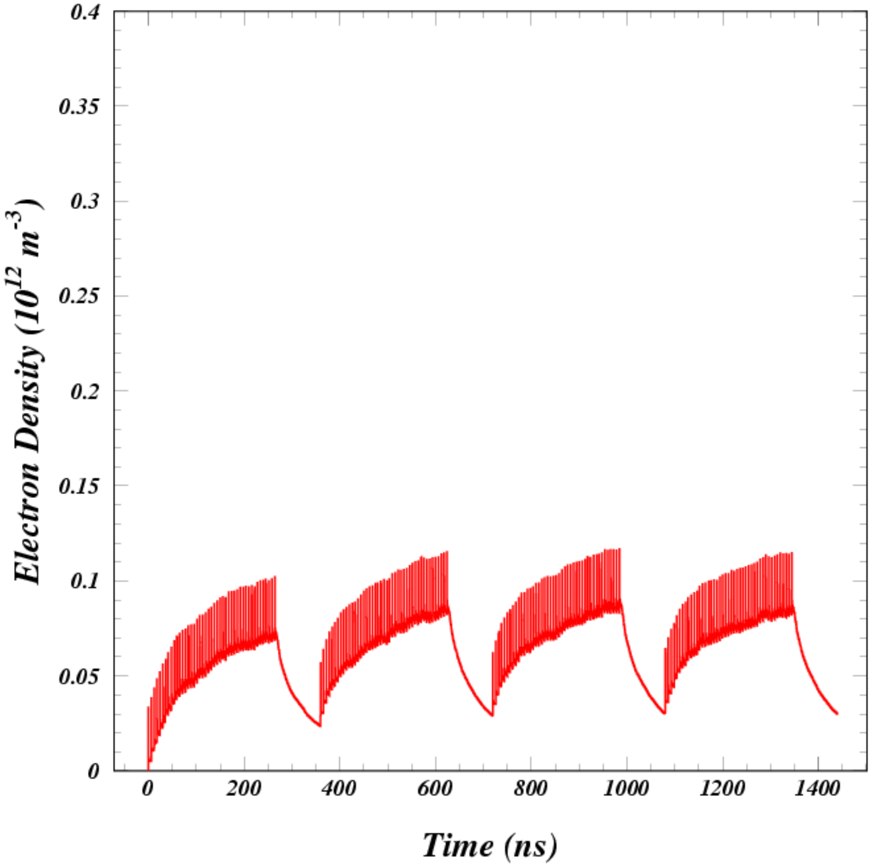
The 3.2 km lattice has similar magnet strengths, but the density of dipoles in the arcs is higher.

Cloud density averaged over the vacuum chamber for the dipole regions

3.2 km lattice (DSB3)



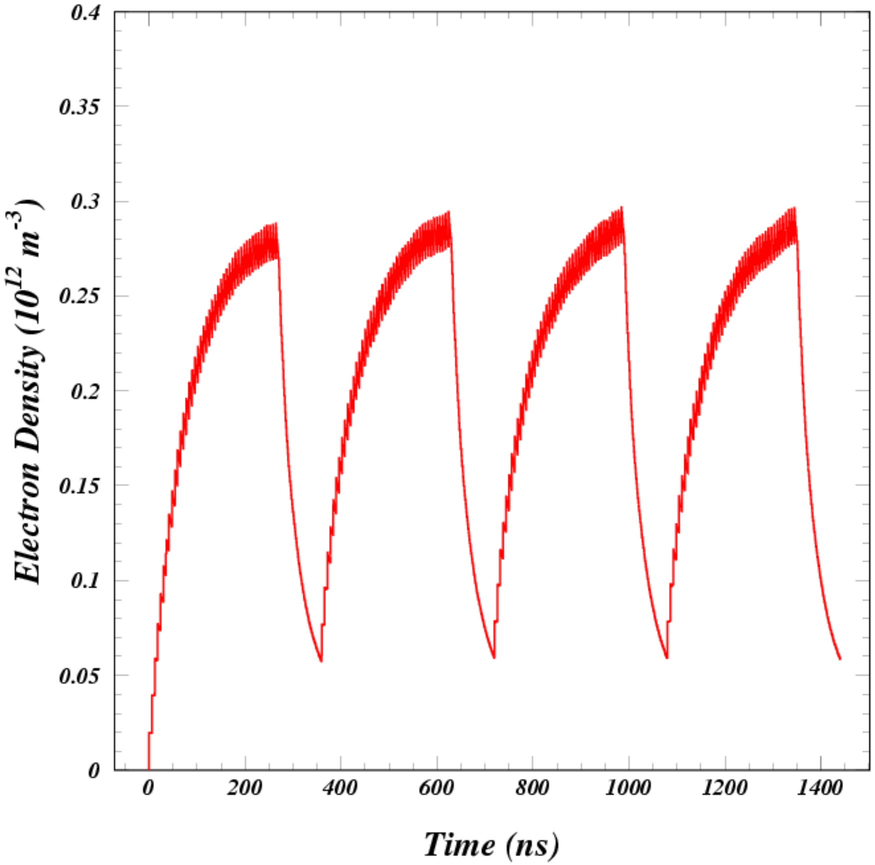
6.4 km lattice (DCO4)



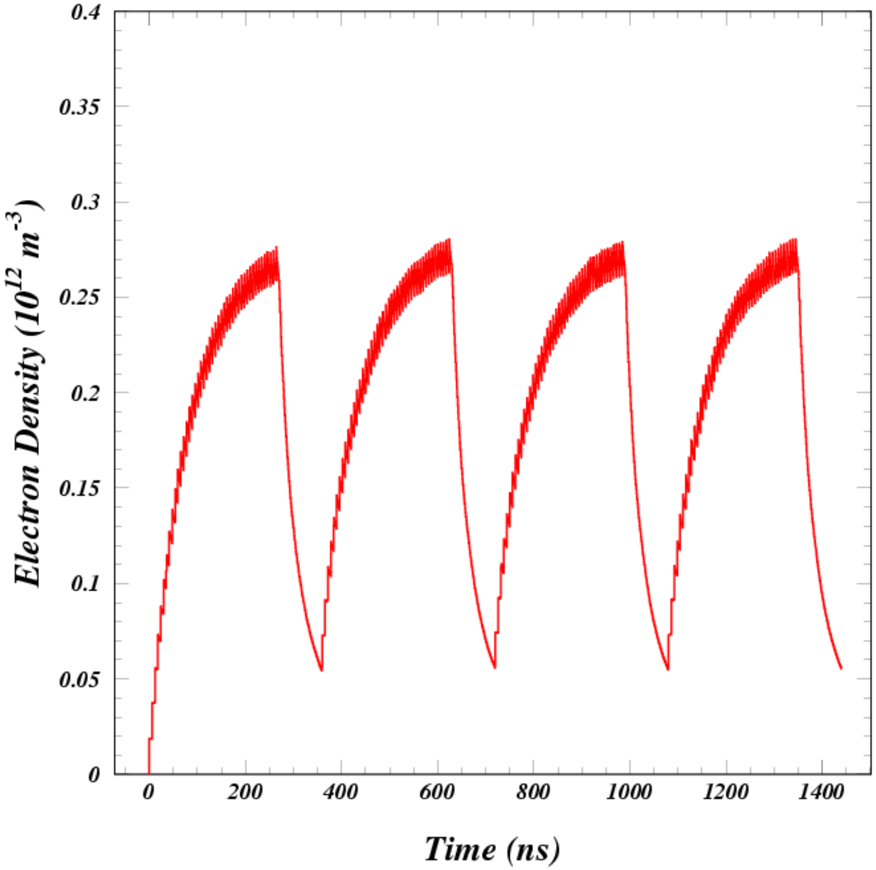
The 3.2 km lattice has similar magnet strengths, but the density of dipoles in the arcs is higher. The analysis of 23Feb10 found 0.05e12. Introducing a rediffused component of 20% of the total SEY of 1.2 was later found to increase this maximum density value to about 0.1e12 without crossing the runaway threshold.

Cloud density averaged over the vacuum chamber for the drift regions

3.2 km lattice (DSB3)



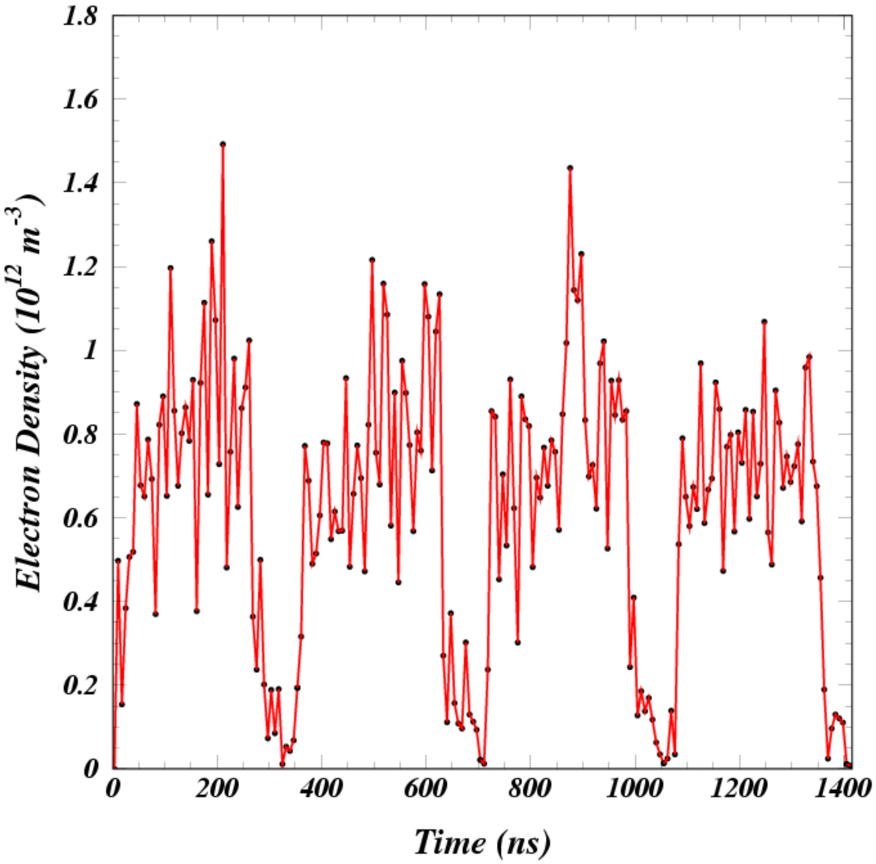
6.4 km lattice (DCO4)



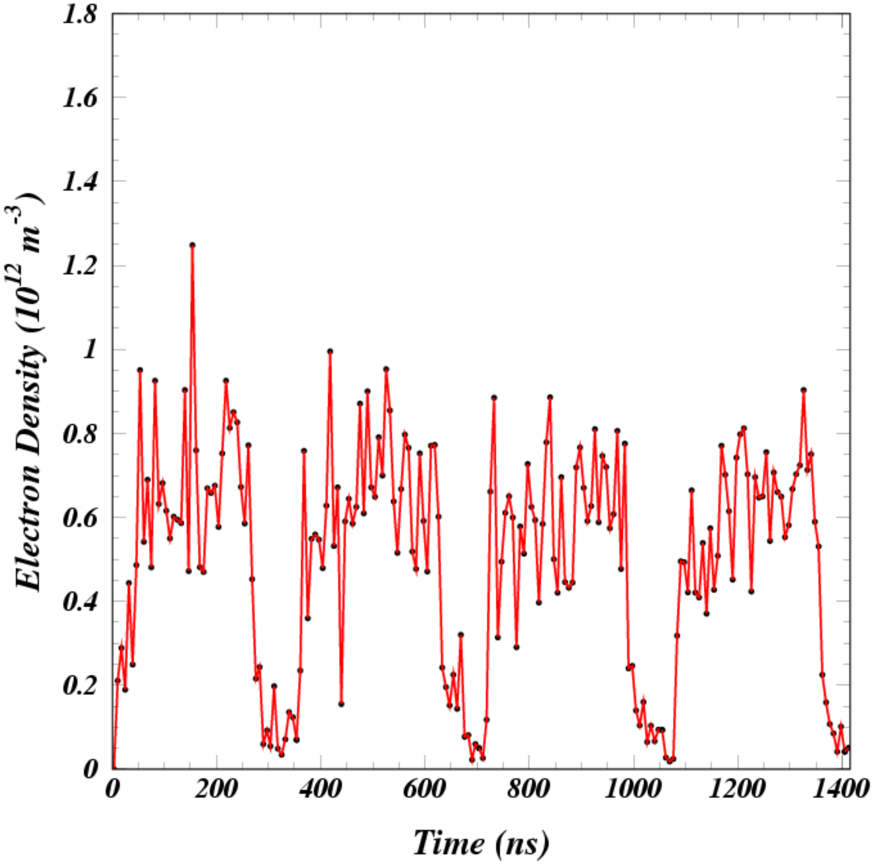
The vacuum-chamber average of the cloud density is similar in the two rings.

Cloud density averaged over 5σ of the beam size at the center of the chamber for the drift regions

3.2 km lattice (DSB3)



6.4 km lattice (DCO4)

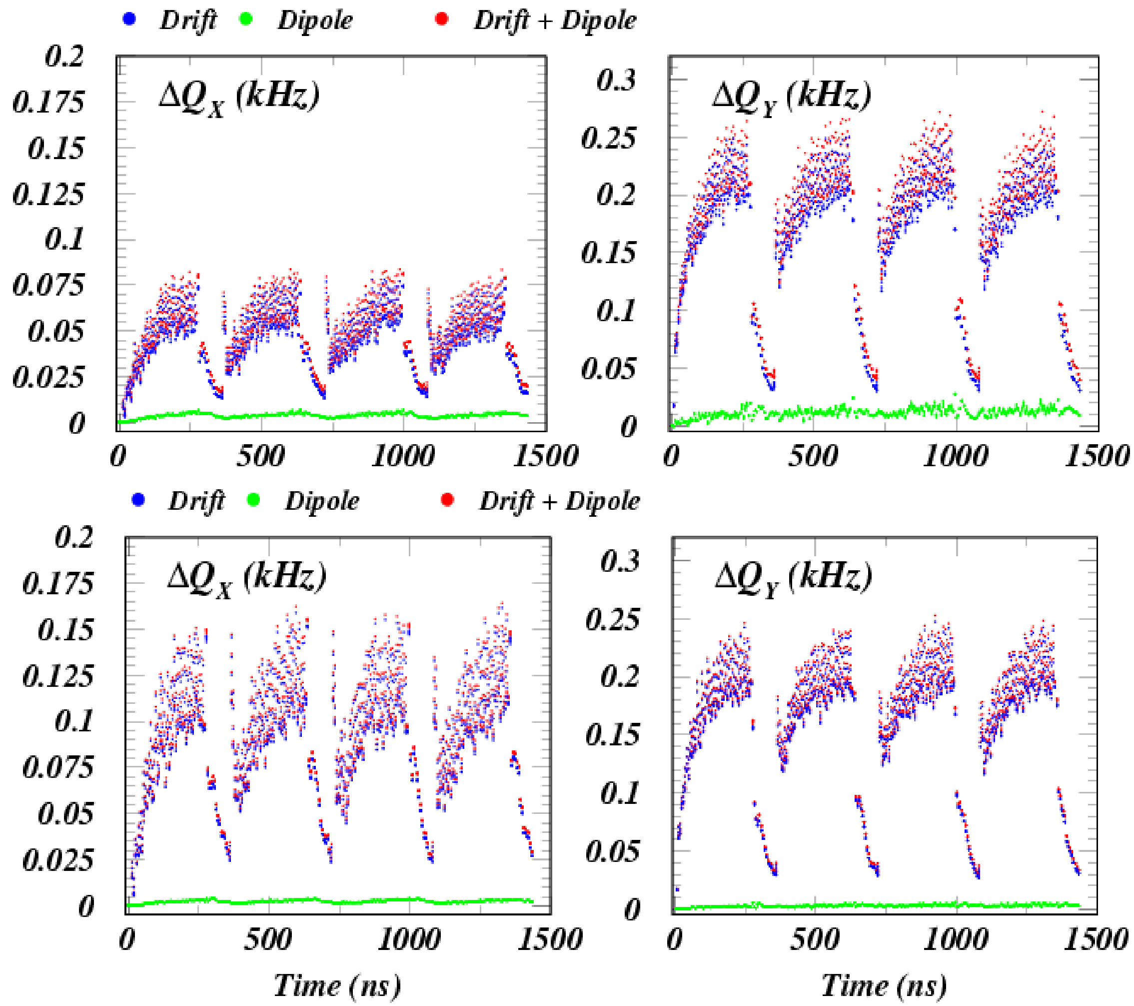


The 5σ average of the cloud density is also similar in the drift regions of the two rings.

Drift and Dipole Contributions to the Coherent Tune Shifts f_{rev} = 47 kHz (6.4 km) and 94 kHz (3.2 km)

3.2 km lattice (DSB3)

6.4 km lattice (DCO4)

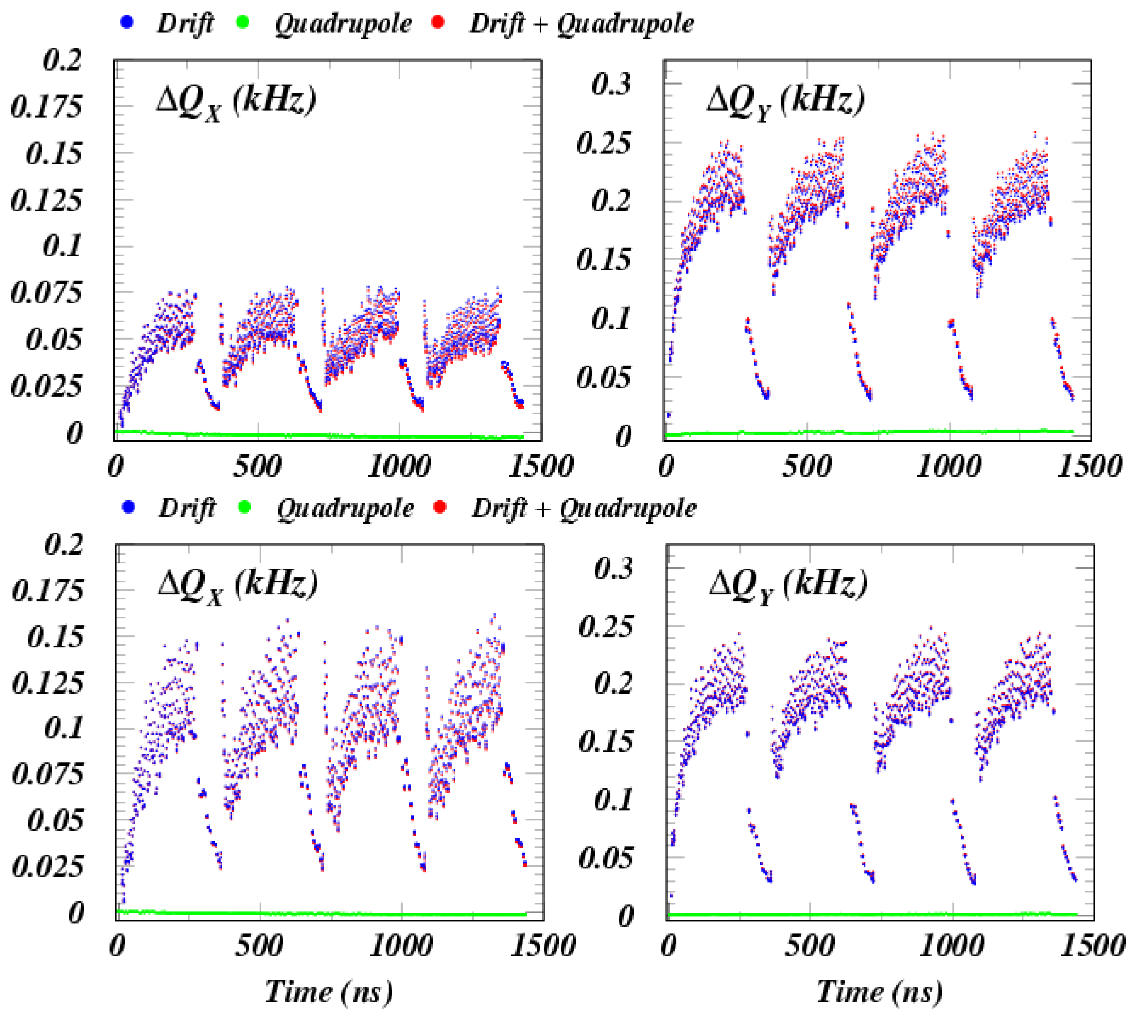


The tune shifts are dominated by the drift regions in both cases.
The horizontal tune shift in the 6.4 km lattice is about a factor of two higher.

Drift and Quadrupole Contributions to the Coherent Tune Shifts
f_{rev} = 47 kHz (6.4 km) and 94 kHz (3.2 km)

3.2 km lattice (DSB3)

6.4 km lattice (DCO4)



The quadrupole contribution is even smaller than the drift contribution,
but we may want to study trapping effects.