Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

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Electron Cloud Modeling for the ILC Damping Rings

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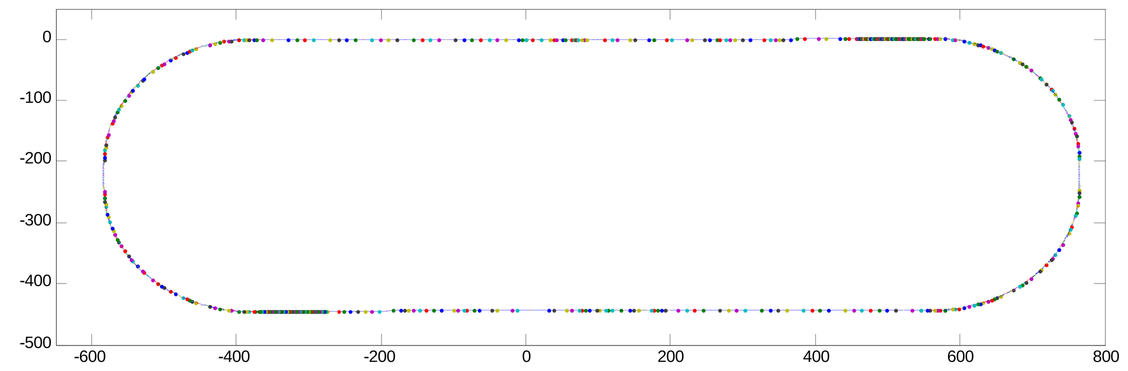
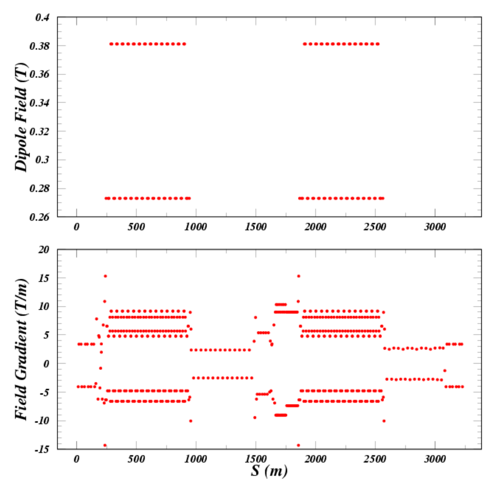
Electron cloud buildup is a primary concern for the performance of the damping rings under development for the International Linear Collider. We have performed synchrotron radiation rate calculations for the recent 3.2-km DSB3_2 lattice design using the SYNRAD utility in the Bmad accelerator software library. These results were then used to supply input parameters to the electron cloud modeling package ECLOUD. Contributions to coherent tune shifts from the field-free sections, and from the dipole and quadrupole magnets have been calculated, as well as the effect of installing solenoid windings in the field-free regions. For each element type, SYNRAD provides ring occupancy, average beam sizes, beta function values, and beta-weighted photon rates for the coherent tune shift calculation. An approximation to the antechamber design has been implemented in ECLOUD as well, moving the photoelectron source points to the edges of the antechamber entrance and removing cloud particles which enter the antechamber.

DSB3_2 Lattice Design

M. Biagini, LCWS08 & ILC08, 15-20 November, Chicago, Illinois
S. Guiducci, LCWS 2010, 26-30 March 2010, Beijing, China

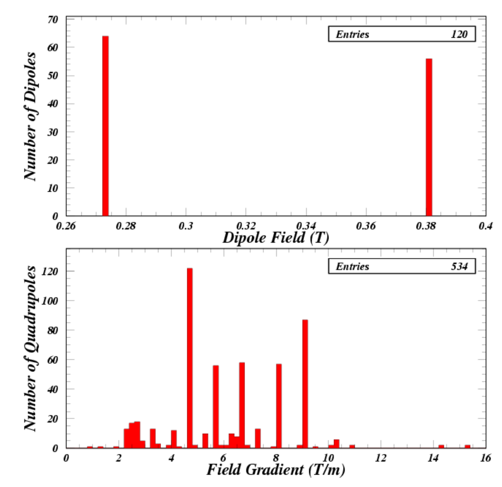




Magnet Counts

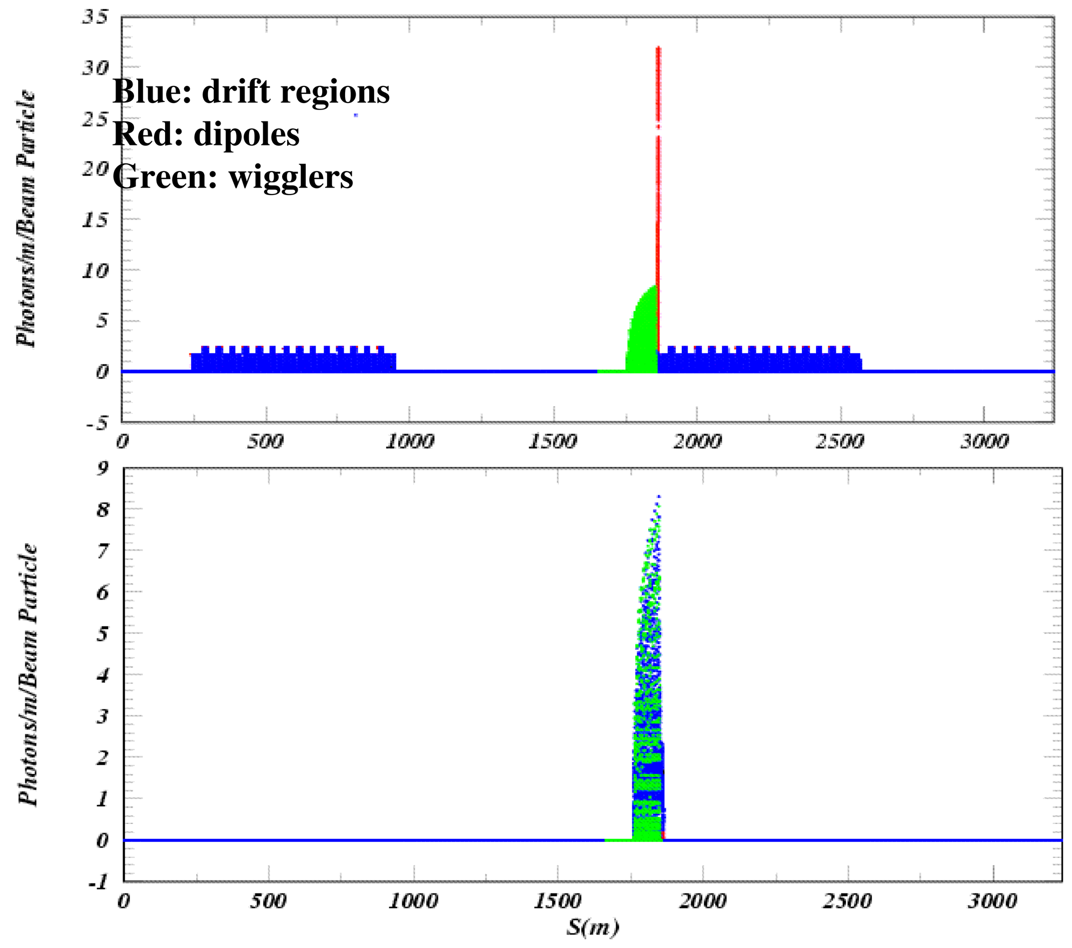
Dipoles

Quadrupoles



Synchrotron Radiation Analysis

Photon Rates (γ/m/beam particle)



Radiation in the Arcs

Dipoles shine into downstream dipoles

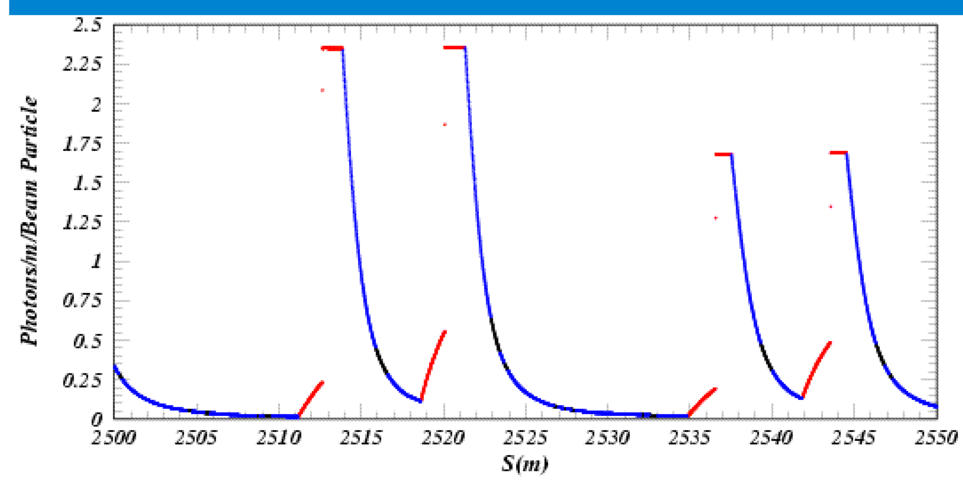


Table of Element-Type-Specific Ring Averages

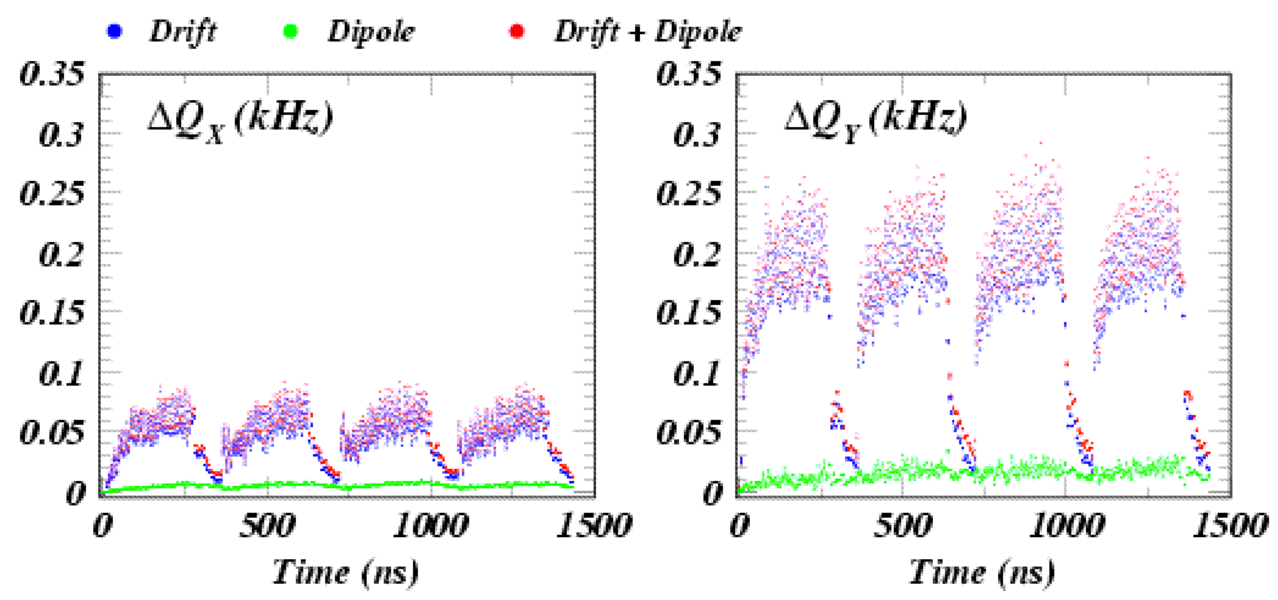
Beta functions, beam sizes and photon rates

Element	Tot Length [m]	Ring Fraction	<Beta X> [m]	<Beta Y> [m]	<Sig X> [mm]	<Sig Y> [mm]	<Photon Rate> [Phot/m/e] Outside	Inside
Dipole	324.2	10.0%	3.6	18.6	0.1207	0.0166	1.083	0.000
Drift	2560.8	79.1%	33.3	31.8	0.2269	0.0210	0.145	0.027
Wiggler	101.9	3.1%	10.8	14.1	0.0899	0.0145	0.729	0.719
Quadrupole	206.8	6.4%	21.5	23.4	0.2897	0.0177	0.236	0.067
Sextupole	44.3	1.4%	20.7	25.3	0.4207	0.0191	0.129	0.000
Non-dipole	2913.8	90.0%	31.5	30.5	0.2295	0.0205	0.171	0.053
Non-drift	677.2	20.9%	11.3	19.8	0.1873	0.0168	0.709	0.129
Total	3238.1	100.0%	28.7	29.3	0.2186	0.0201	0.263	0.048

Table 1: Element-type-specific ring lengths, and averages of beta functions, beam sizes, and photon rates on the outside and inside walls of the vacuum chamber for the DSB3_2 ILC damping ring lattice design

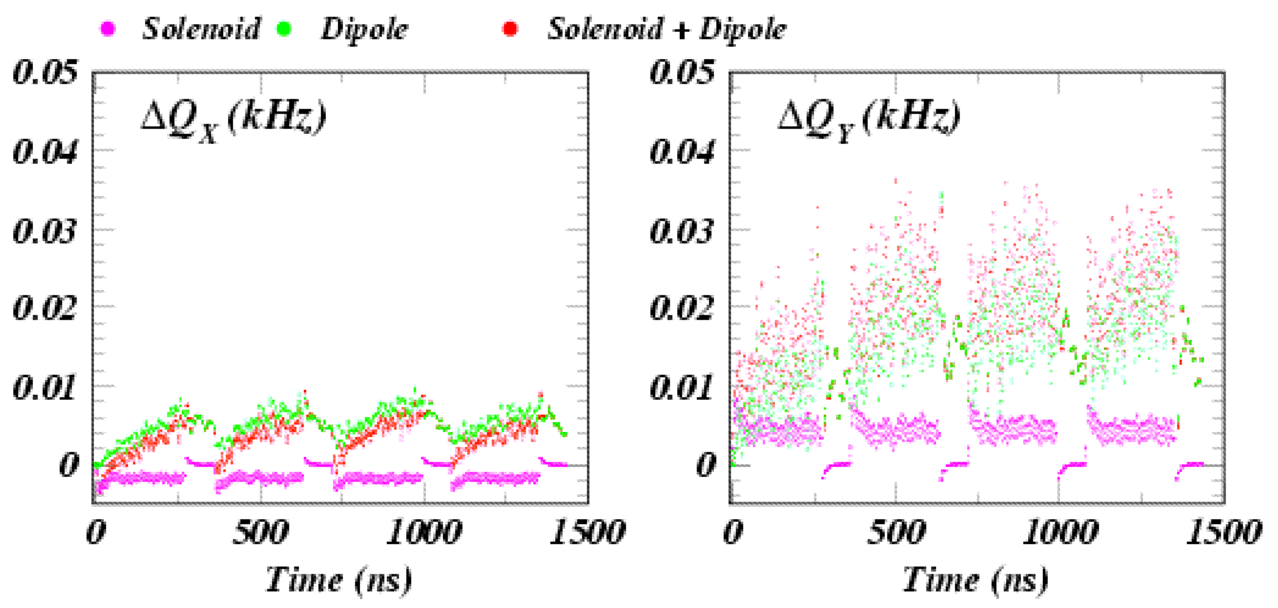
Coherent Tune Shifts Calculated from Field Gradients Along Four 45-Bunch Trains

Contributions from drift and dipole regions
Compare to the fractional design tunes of 17.5 kHz and 22.3 kHz.



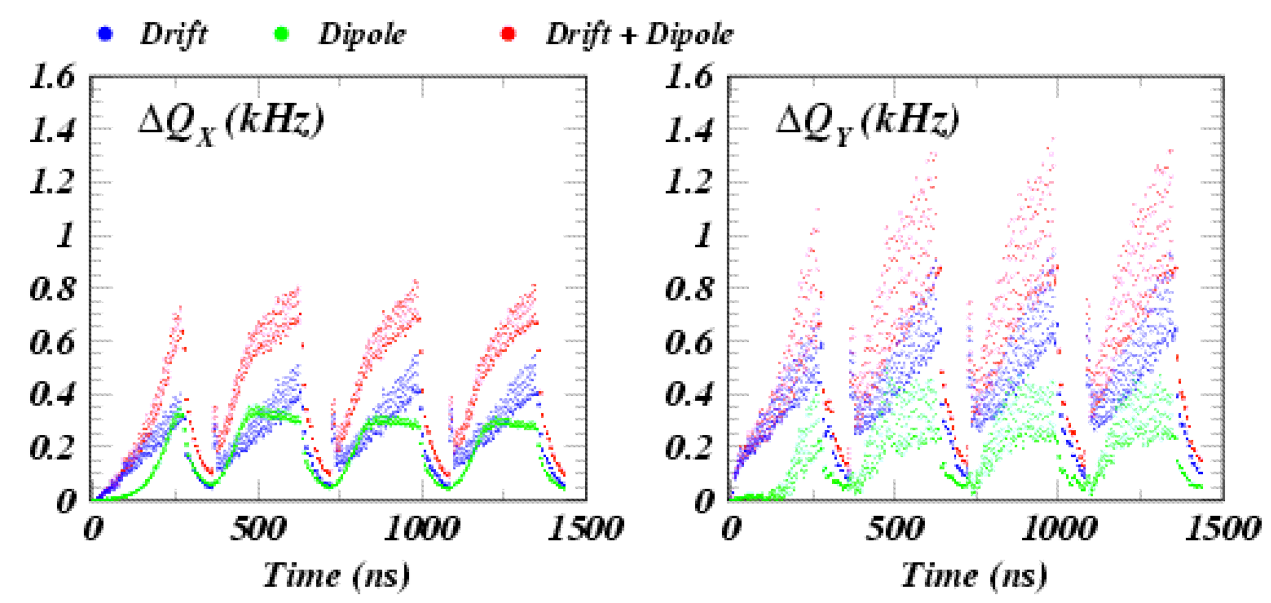
Effect of 40-Gauss Solenoidal Magnetic Fields in the Drift Regions

Dipoles dominate the tune shift. Combined tune shifts are lower by an order of magnitude.



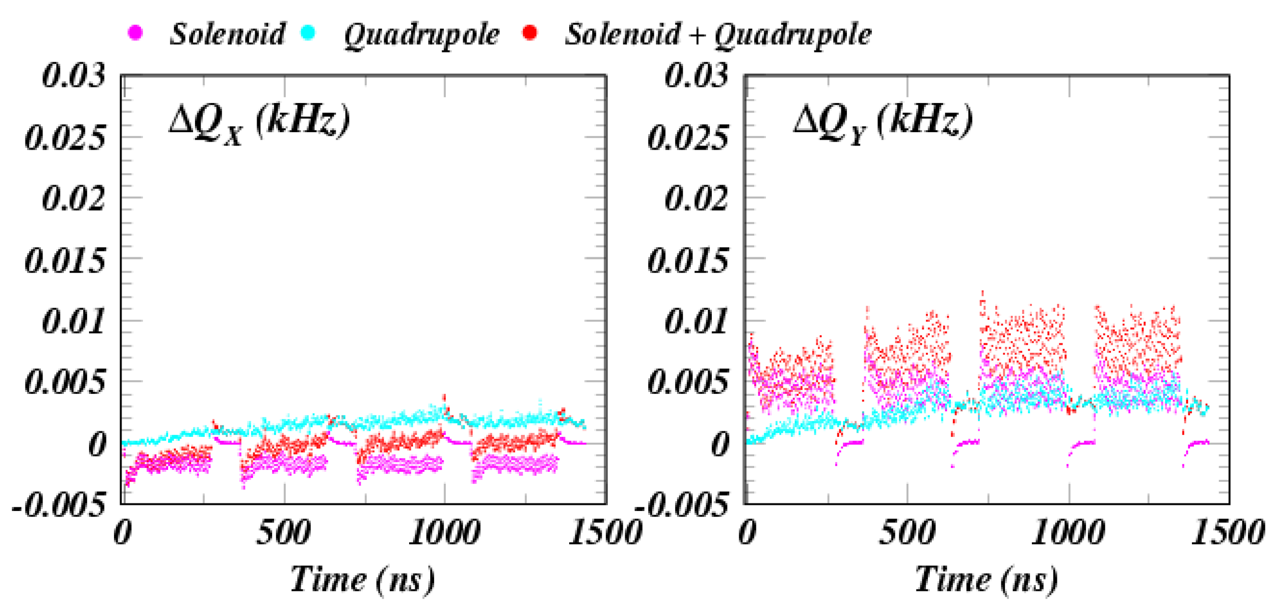
Effect of raising assumed secondary yield from 1.4 to 2.0, the value typical of uncoated aluminum vacuum chambers.

Tune shifts increase by a factor four to 5% of the design fractional tunes.



Contribution to the tune shift from quadrupole magnets

Comparable to the contribution from drift regions with solenoids.



Summary

We have applied the modeling analysis technique developed in the context of the CesrTA program for estimating coherent tune shifts induced by the buildup of electron clouds in the ILC damping rings. The synchrotron radiation characteristics of the recent DSB3_2 lattice design have been calculated and applied as input to the cloud buildup code ECLOUD, allowing the calculation of contributions to the coherent tune shifts from field-free, dipole, and quadrupole regions of the ring, as well as the effect of adding 40-Gauss solenoidal magnetic field windings to the drift regions. The tune shifts are found to arise primarily in the drift regions, reaching 1% of the fractional tune under the assumption of a total secondary yield value of 1.4. The mitigating effect of the solenoids reduces the contribution from the drift regions such that the dipole regions then dominate, and the combined tune shifts are reduced by an order of magnitude. The contribution from the 6% of the ring occupied by quadrupole magnets is calculated to be less than half that from the dipole regions. It should be noted however, that this analysis does not account for cloud electrons trapped in the quadrupoles from turn to turn. Raising the value assumed for the secondary yield to 2.0, a value typical of an uncoated aluminum vacuum chamber, results in solenoid-off tune shift estimates reaching 5% of the fractional tune.

Future work includes incorporating a more detailed model of the vacuum chamber profile. The 3D photon tracking code SYNRAD3D now implemented in Bmad and in use for modeling the CesrTA measurements will provide estimates of the mitigating effect of the antechamber on photon rates and azimuthal impact distributions. We also plan to employ finite-element electrostatics calculations to account for the boundary conditions of more complicated vacuum chamber profiles such as those including an antechamber.

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