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ELECTRON CLOUD SIMULATIONS FOR THE LOW-EMITTANCE UPGRADE AT THE CORNELL ELECTRON STORAGE RING

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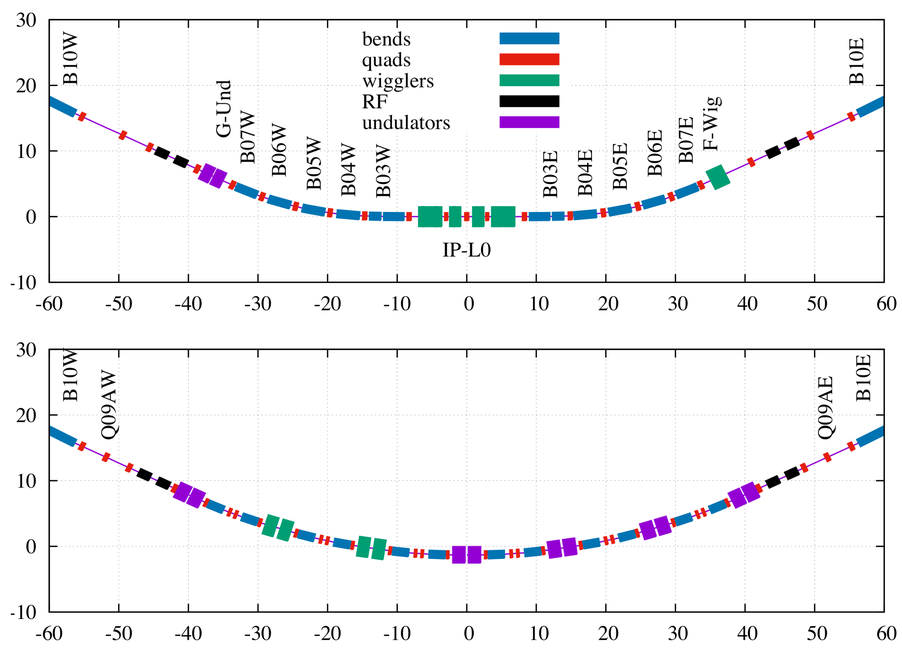
The Cornell Electron Storage Ring operations group is planning a major upgrade of the storage ring performance as an X-ray user facility. The principal modification foresees replacing the former e-e+ interaction region with six double-bend achromats, reducing the emittance by a factor of four. The beam energy will increase from 5.3 to 6.0 GeV and single-beam operation will replace the present two-beam e-e+ operation. The initial phase of the project will operate a single positron beam, so electron cloud buildup may contribute to performance limitations. This work describes a synchrotron radiation analysis of the new ring, and employs its results to provide ring-wide estimates of cloud buildup and consequences for the lattice optics.

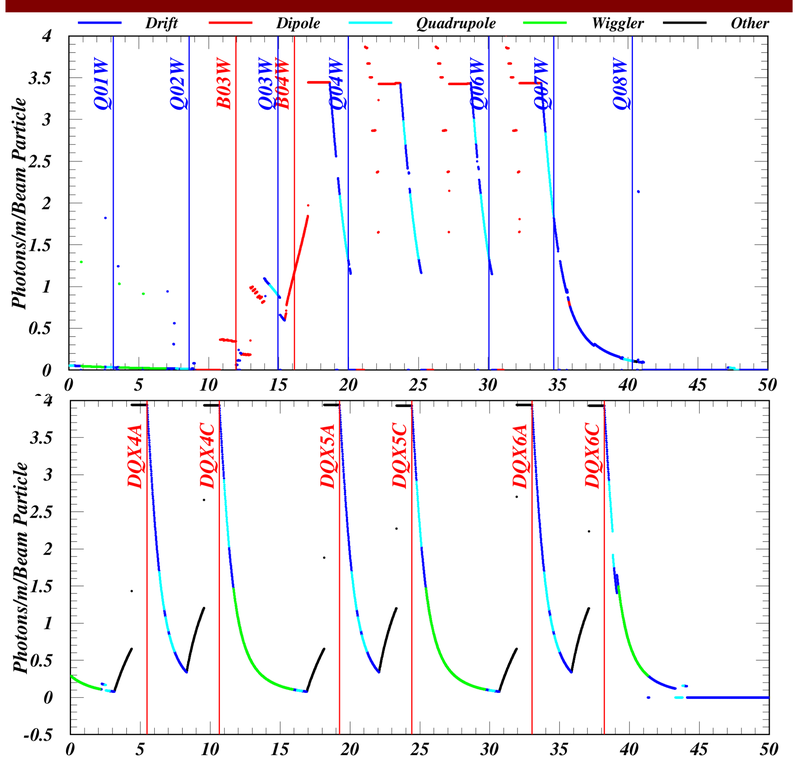
Modifications to the South Arc Region of the CESR Ring

Six new double-bend achromats with combined-function magnets and Cornell Compact Undulators



Comparison of Synchrotron Radiation Pattern

Very high rate of photons incident on combined-function magnet vacuum chamber walls



Electron cloud simulation package ECLOUD

* Originated at CERN in the late 1990's
* Widespread application for LHC, KEK, RHIC, ILC …
* Under active development at Cornell since 2008
* Successful modeling of CESRTA tune shift measurements
* Validated with CESRTA measurements of electron trapping in a quadrupole magnet (PRSTAB 18, 041001 2015)

I. Generation of photoelectrons
- A) Production energy, angle
- B) Azimuthal distribution (v.c. reflectivity)

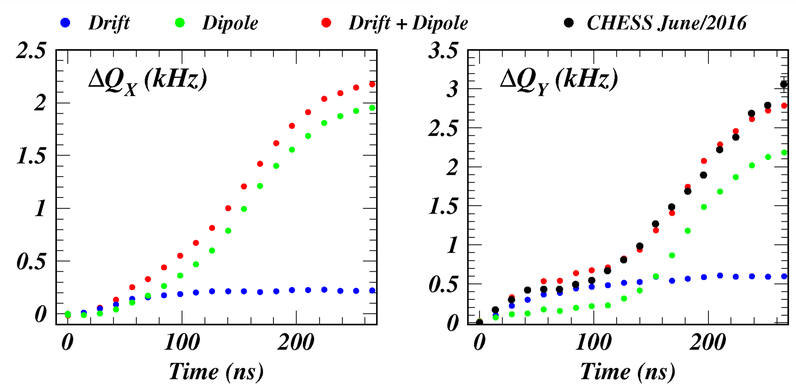
II. Time-sliced cloud dynamics
- A) Cloud space charge force
- B) Beam kick
- C) Magnetic fields

III. Secondary yield model
- A) True secondaries (yields > 1!)
- B) Rediffused secondaries (high energy)
- C) Elastic reflection (dominates at low energy)

IV. Model for a stripline detector in a quadrupole field
- A) Acceptance vs incident angle, energy, B-field
- B) Charge entering holes removed from cloud
- C) Charge hitting wall creates secondaries

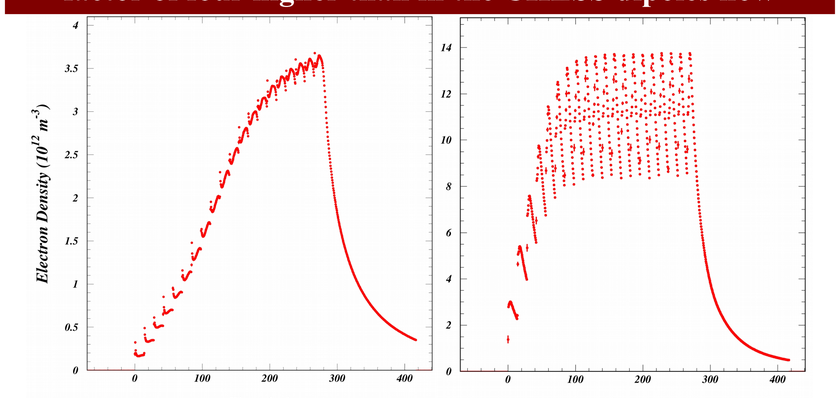
Electron Cloud Model Tuned to Measured Tune Shifts

Pinged 20-bunch train provides measurements of vertical tune shifts along train



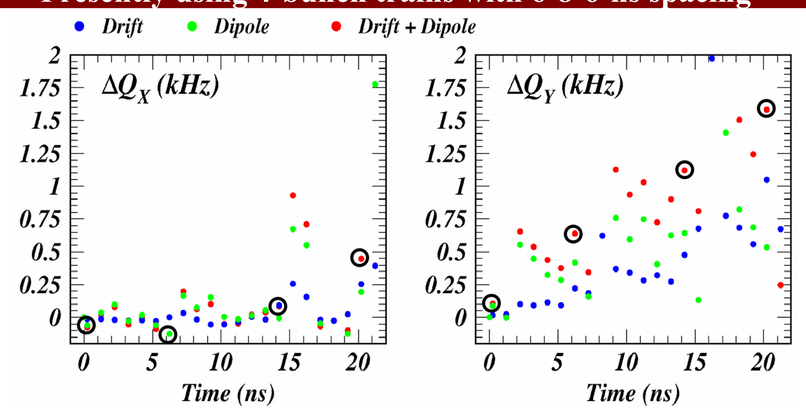
Comparison of Modeled Electron Cloud Buildup

The cloud density in the c-f magnets is predicted to be a factor of four higher than in the CHESS dipoles now



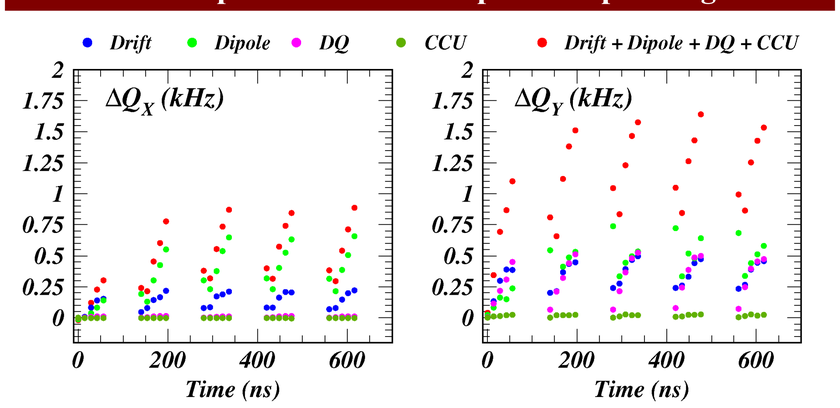
Validated Model Used to Calculate Tune Shifts Along Train in Present CHESS Operating Conditions

Presently using 4-bunch trains with 6-8-6-ns spacing



Tune Shifts Predicted for the Upgraded Ops

For 17 trains of 5 bunches each, the tune shifts are limited to values comparable to those in present operating condx



Summary

We have performed analyses of the synchrotron radiation patterns for the present 5.3 GeV operating conditions of the Cornell Electron Storage Ring (CESR) as a light source for the Cornell High-Energy Synchrotron Source (CHESS), and extended them to the optics and modified vacuum chamber design of the 6-GeV CESR/CHESS upgrade. These calculations are applied to electron cloud buildup modeling, which is tuned to reproduce 2016 measurements of coherent tune shifts in present CHESS lattice. The tuned model is then used to calculate the magnitude of tune shifts to be expected during 200-mA upgraded operation with seventeen trains of five positron bunches each. We determine that performance limitations due to electron cloud buildup can be expected to be no more severe than during present CHESS operations, despite unusually high cloud densities in the combined-function magnets. Our calculations are based on the beam-processed aluminum vacuum chamber surface properties typical of the present CESR ring, so we conclude that special cloud mitigation techniques such as grooves or coatings will not be necessary in the new south arc region of the ring.

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