Recent Studies with ECLoud

I. ECLoud/POSINST comparison for Feb 2009 tune shift data

II. Improvement using $\beta_{x,y}$-weighted photon rates

III. Sensitivity to vertical beam size

IV. Predictions for 4 GeV wiggler-on/wiggler-off lattices

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POSINST simulations with nominal parameters
45 bunch trains, 14 ns spacing, Feb 2009

Positron Tune Shifts vs. Bunch Number

- Data: horizontal
- Data: vertical
- Simulation 1: horizontal
- Simulation 1: vertical

Parameters:
- 1 mA = 1.6 x 10^{10}
- 0.4 mA
- 0.5 mA
- 0.75 mA
- 0.8 mA
- 1.0 mA
- 1.2 mA
- 1.4 mA

Graphs show tune shifts vs. bunch number for different currents from 0.4 mA to 1.4 mA.
I. ECLOUD/POSINST Comparison for the February 2009 Measurements
2.1 GeV e+ 45-bunches, 14 ns spacing

Resolving the remaining discrepancies exhibited in our PAC2009 beam dynamics paper required:

Reducing fluctuations due to large individual macroparticle charges
Introducing the rediffused SEY component
Using the more realistic 2-mm beam offset rather than 5 mm
Refining the space charge grid 41x41 --> 81x81 over the 45mm x 25mm vacuum chamber ellipse.
The ECLOUD and POSINST calculations on the previous slide were done with the same input parameters for photon rates, beta functions, SEY parameters and beam sizes.

The photon rates were 0.28 (0.57) photons/m/beam particle for the drift (dipole) region averages.

The lattice synchrotron radiation tables can provide separate horizontal and vertical beta-averaged rates as well. For this lattice, they turned out to be 0.217/0.220 (0.482/0.482) for the drift (dipole) regions. This correction preferentially affects primary-related phenomena.
The modelled vertical tune shifts appear to depend strongly on this parameter, perhaps owing to the varying number of cloud particles in the beam region.

The nominal rms vertical beam sizes in our data sets range widely from $30\,\mu m$ (Feb 2009) to $160\,\mu m$ (April 2007).
We should consider whether such effects can be produced by other input parameters. The dependence on photon rate appears to decouple in cases where multipacting becomes significant. This sensitivity may present an opportunity to provide useful information to the LET effort.
IV. Predictions for 4 GeV lattices

Wigglers on ($\varepsilon_v = 23 \text{ nm}$)
Wigglers off ($\varepsilon_v = 42 \text{ nm}$)

**Wigglers on**
- $\sigma_h = 843 \mu$
- $\sigma_v = 65 \mu$
- $\sigma_z = 13.4 \text{ mm}$

**Wigglers off**
- $\sigma_h = 887 \mu$
- $\sigma_v = 88 \mu$
- $\sigma_z = 7.1 \text{ mm}$

The photon rates are about a factor of 2 higher than at 2.1 GeV.
The tune shifts are inversely proportional to the beam energy.
So the wiggler-off prediction is about what one might have expected.

The prediction for the wiggler-on lattice is surprising, especially since the model input parameters are so similar.
The culprit turns out to be $\sigma_v = 88 \mu \rightarrow 65 \mu$.

What is the physics? Is it physics?
ECLOUD's explanation of the suppressed vertical tune shift in the 4 GeV wiggler-on lattice (e+ beam, 0.8 mA/bunch)

ECLOUD finds that the pinch effect suppresses the vertical tune shift at a precise vertical beam size.