Cornell University
Laboratory for Elementary-Particle Physics

Resolution of the Puzzle for ECLOUD Simulations of the Shielded Button Measurements for an Electron Beam

I. The Cause

II. The Solution

III. Effect of the Solution on the Simulation for a Positron Beam

IV. Next Steps

V. Premature Preview of the Consequences for Modelling Coherent Tune Shifts

All material for this talk, including full sets of the analysis plots, may be obtained at www.lepp.cornell.edu/~critten/cesrta/ecloud/21apr10

Jim Crittenden

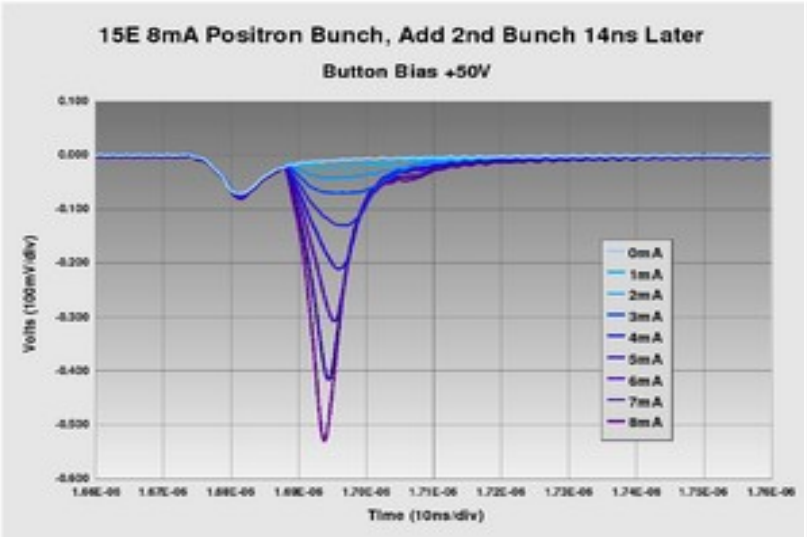
Cornell Laboratory for Accelerator-Based Sciences and Education

Electron Cloud Meeting

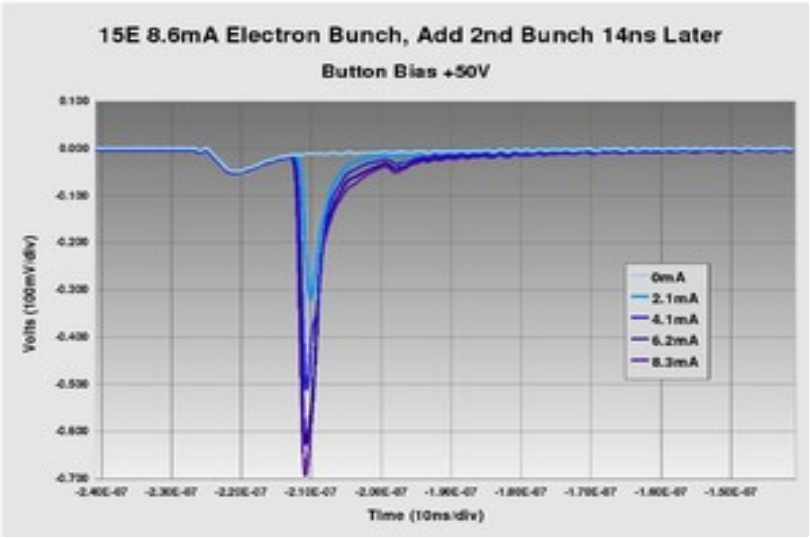
21 April 2010

Status as of Last Week's Meeting

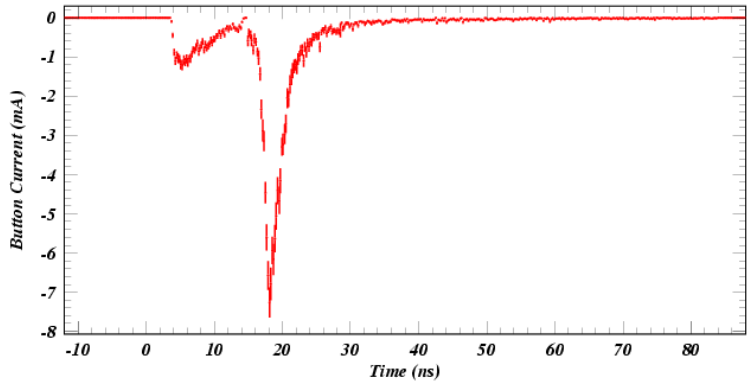
Positron beam

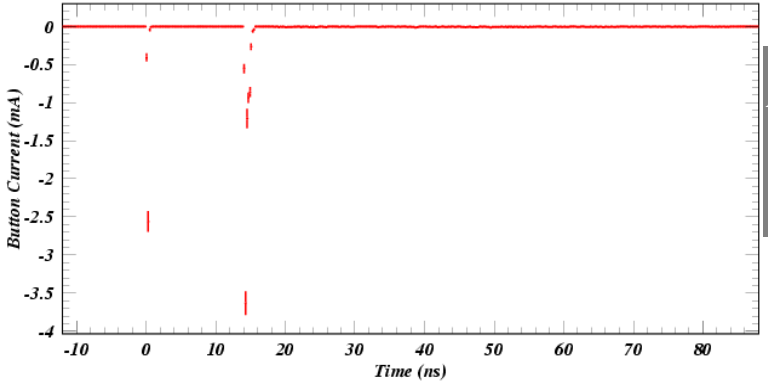


Electron beam



Measurements Central Button

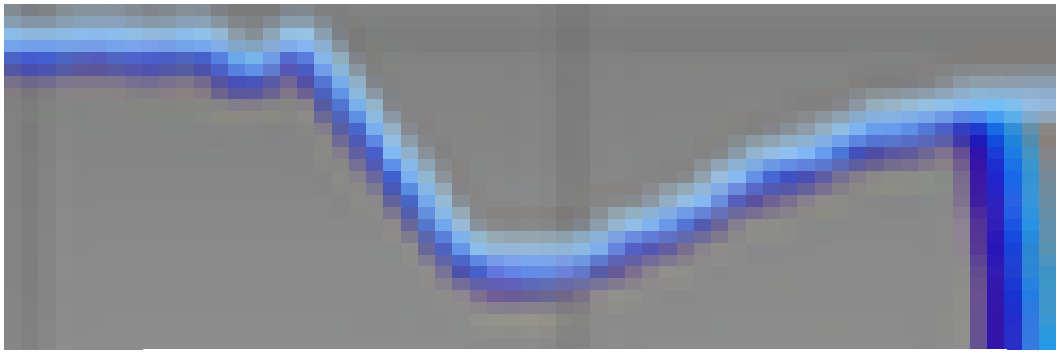




ECLOUD Simulation Central Button 2x8 mA

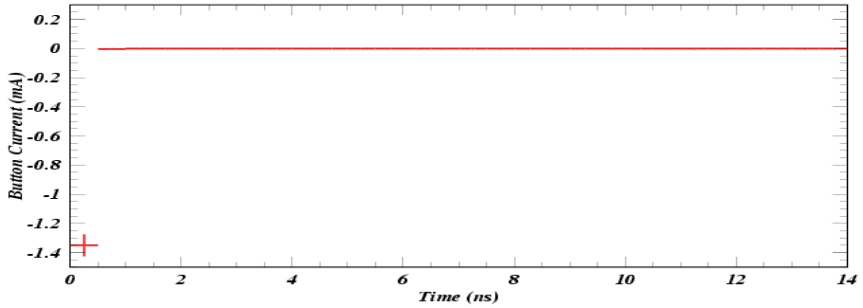
Movies showed that the cloud particles producing the e+ beam signal between the bunches originate on the floor of the pipe. For the electron beam, those particles are reabsorbed during the first bunch passage. Similarly, those produced on the ceiling are immediately reabsorbed, producing the prompt signal inconsistent with the measurement.

Electron Beam
Parameter Study: Energy Spectrum of Primary Photoelectrons



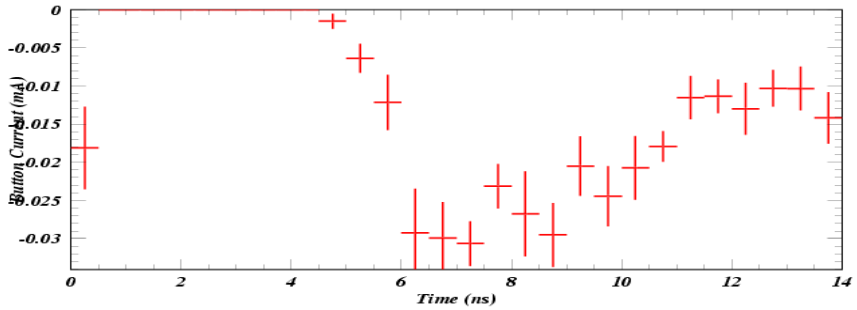
Measurements
Central Button

Primary p.e.
$E_{peak} = 5$ eV
$\sigma_E = 5$ eV



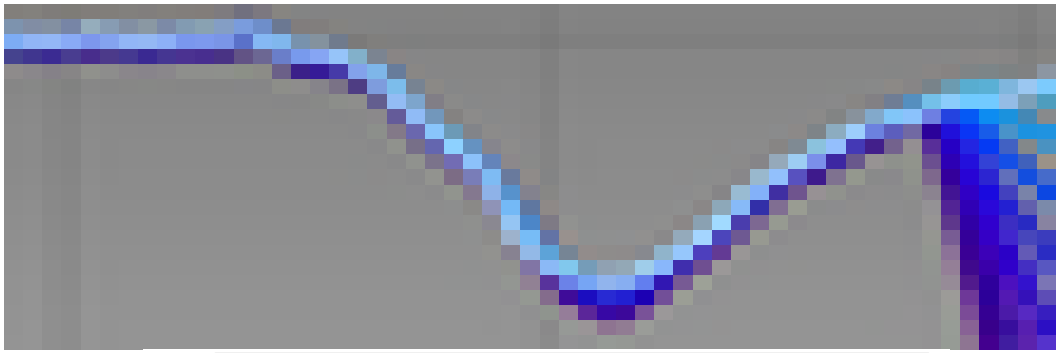
ECLOUD Simulation
Central Button
2x8 mA

Primary p.e.
$E_{peak} = 100$ eV
$\sigma_E = 100$ eV



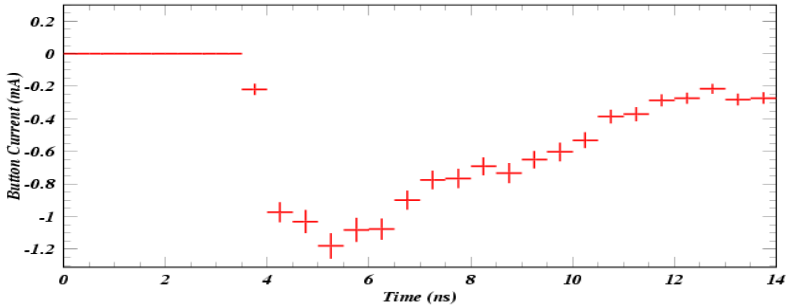
The cloud particles produced on the floor must overcome the potential barrier of the electron beam to reach the ceiling. Their arrival time is very sensitive to the high end of the energy spectrum and to the production angular distribution. For example, the signal arrives at 12 ns for $E_{peak} = 40$ eV $\sigma_E = 20$ eV, rather than at 5 ns for $E_{peak} = 100$ eV $\sigma_E = 100$ eV.

How do the parameters improved for the electron beam affect the simulation for a positron beam?



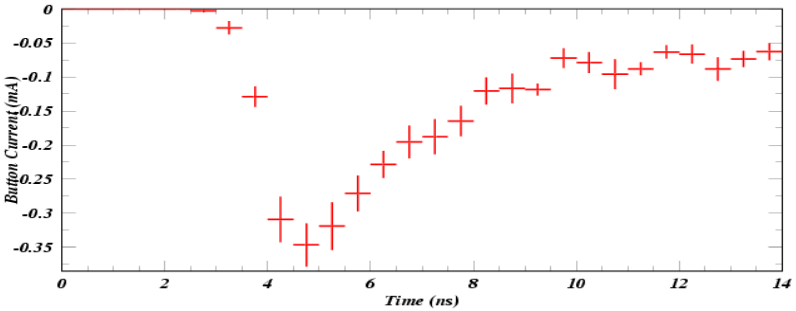
Measurements
Central Button

Primary p.e.
$E_{peak} = 5\ eV$
$\sigma_E = 5\ eV$



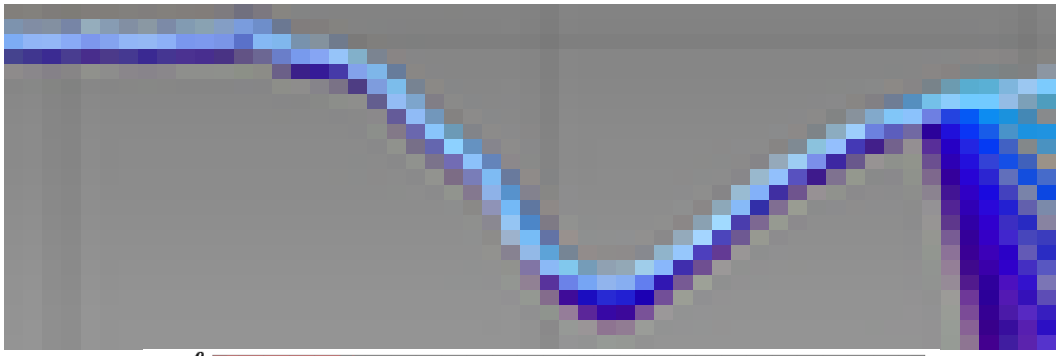
ECLOUD Simulation
Central Button
2x8 mA

Primary p.e.
$E_{peak} = 100\ eV$
$\sigma_E = 100\ eV$

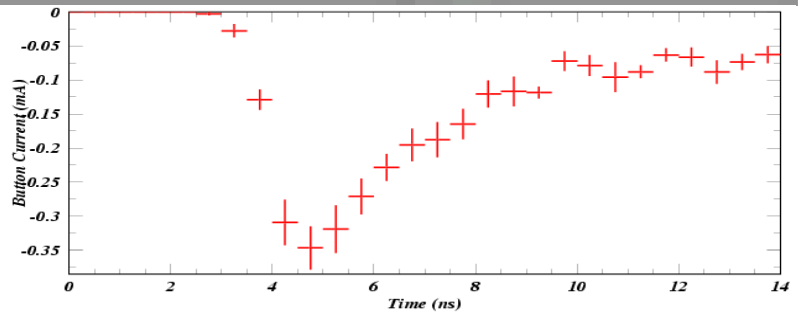


The parameters which improve the electron beam simulation also improve the positron beam simulation. However, the simulated signal peaks about 3 ns too early.

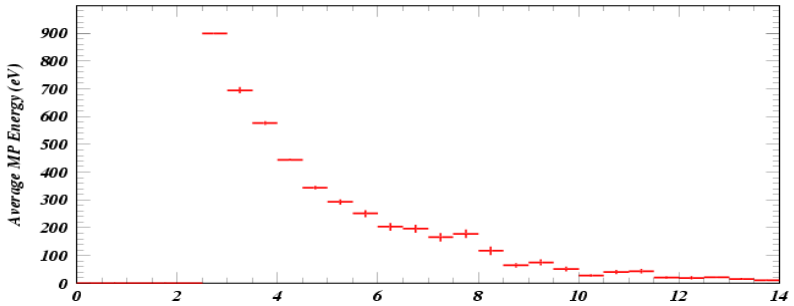
Positron Beam
Macroparticle Arrival Time and Arrival Energy



Measurements
Central Button



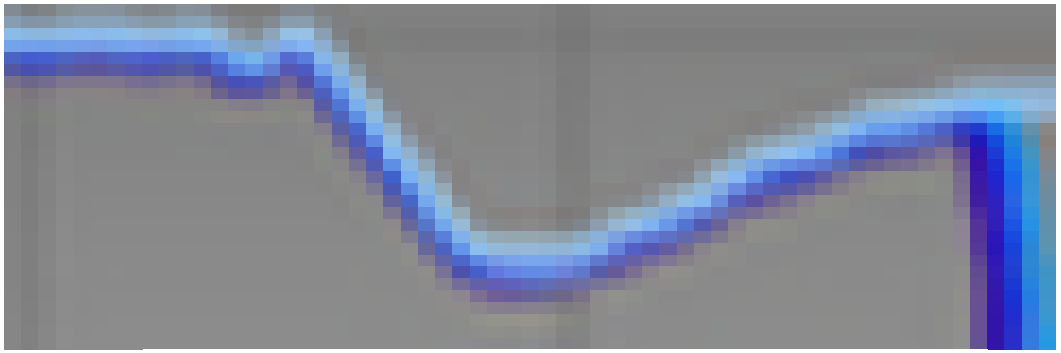
Primary p.e.
$E_{peak} = 100\ eV$
$\sigma_E = 100\ eV$



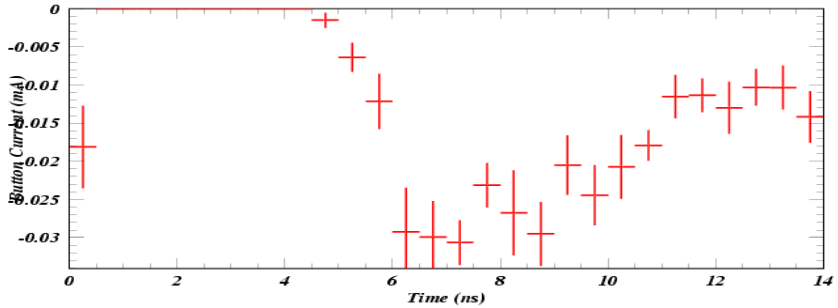
ECLOUD Simulation
Central Button
2x8 mA

The arrival time of the macroparticles is strongly correlated to the arrival energy. The earliest energy is 900 eV. The energy spectrum (truncated gaussian) overemphasizes higher energies, though the maximum energy is about right.

Electron Beam
MP Arrival Time and Arrival Energy

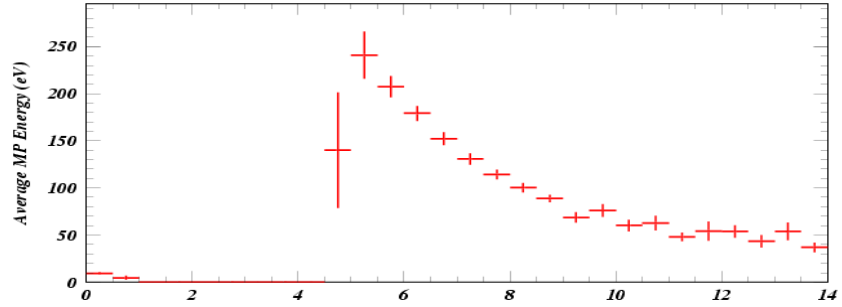


Measurements
Central Button



Primary p.e.
$E_{peak} = 100$ eV
$\sigma_E = 100$ eV

ECLOUD Simulation
Central Button
2x8 mA

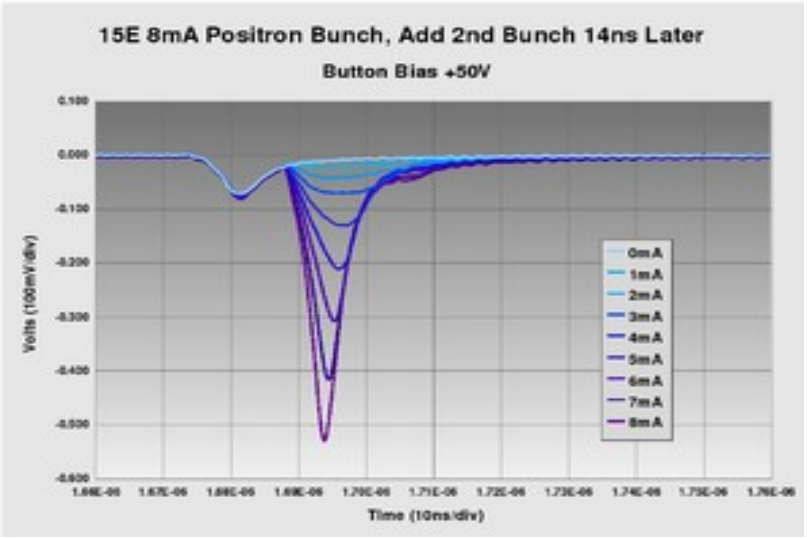


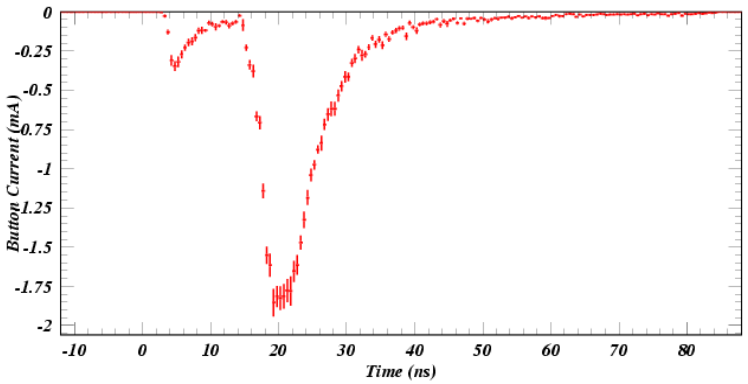
For the electron beam, the earliest energy is 250 eV, rather than 900 eV. This is too low to correctly model the arrival time.
Note that most of the energy is due to acceleration by the cloud.
Such comparisons with various values for the bunch charge should allow a mapping of the underlying energy spectrum.

Present Status of the Measurement/Simulation Comparison

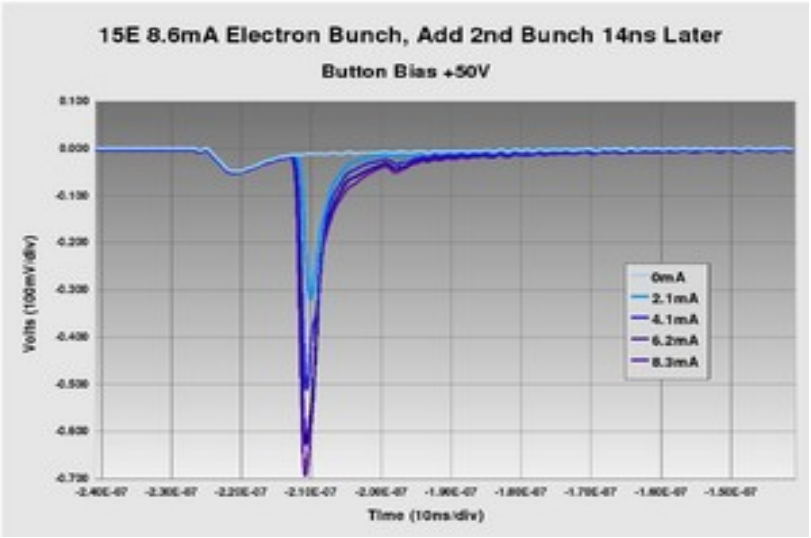
$E_{peak} = 100\ eV \quad \sigma_E = 100\ eV$

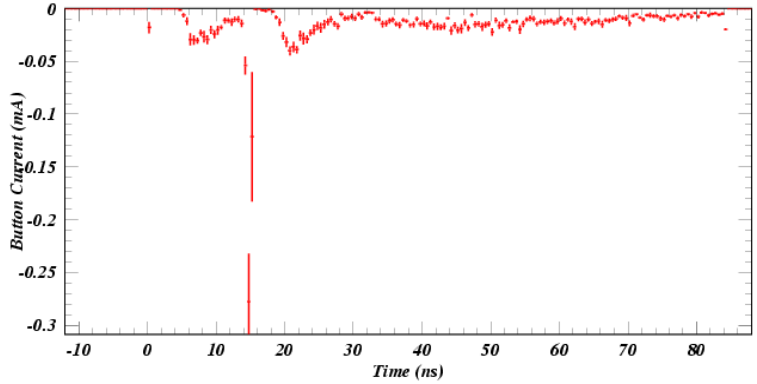
Positron beam





Electron beam





Measurements Central Button

ECLOUD Simulation Central Button 2x8 mA

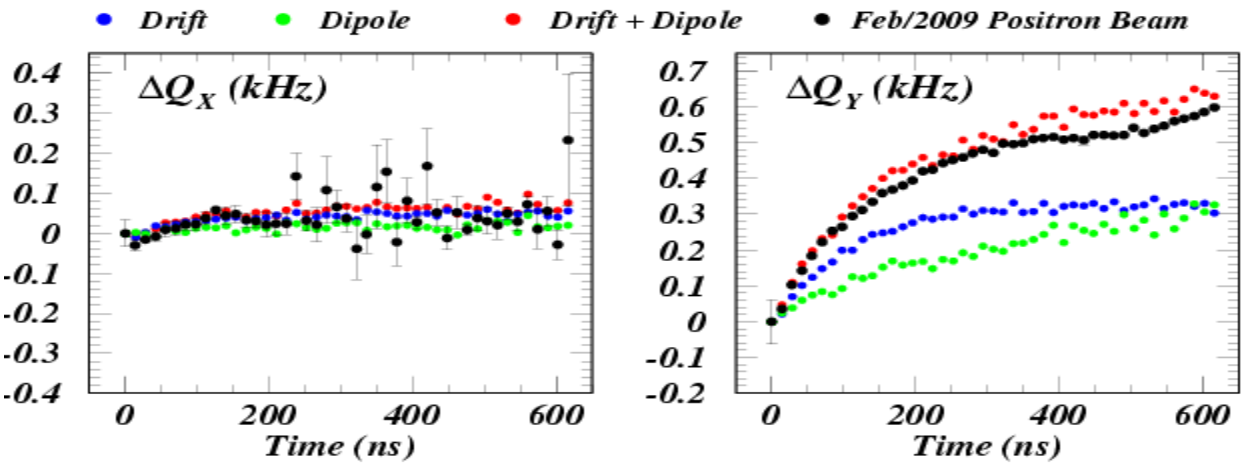
In addition to the work on the photoelectron energy spectrum, the electron beam simulation will require modelling of secondary production in the vacuum chamber holes.

Why is the second-bunch peak so broad for the positron beam?

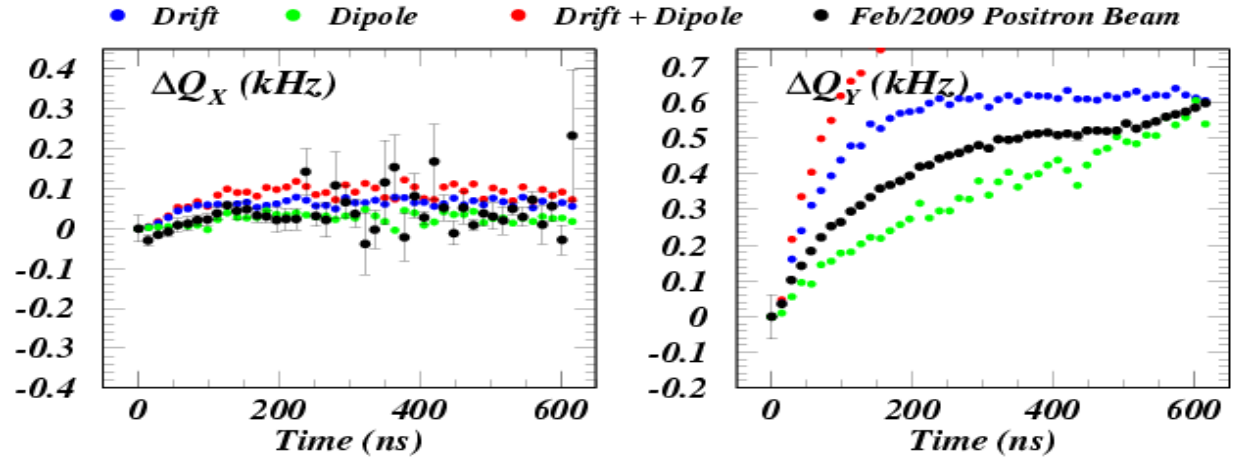
Premature Preview of the Effect of the Photoelectron Energy Spectrum on the Modelling of Coherent Tune Shifts

Example: 45 e+ bunches, 0.4 mA/bunch, 2.1 GeV

Primary p.e.
$E_{peak} = 5\ eV$
$\sigma_E = 5\ eV$



Primary p.e.
$E_{peak} = 100\ eV$
$\sigma_E = 100\ eV$



The consequences of the photoelectron energy spectrum are exaggerated here, because it is too hard on average. Nonetheless, we can expect the drift region contribution to be enhanced relative to that of the dipole regions.