Comparison of ECLOUD and POSINST Calculations of Coherent Tune Shifts with Emphasis on the Relative Drift and Dipole Contributions

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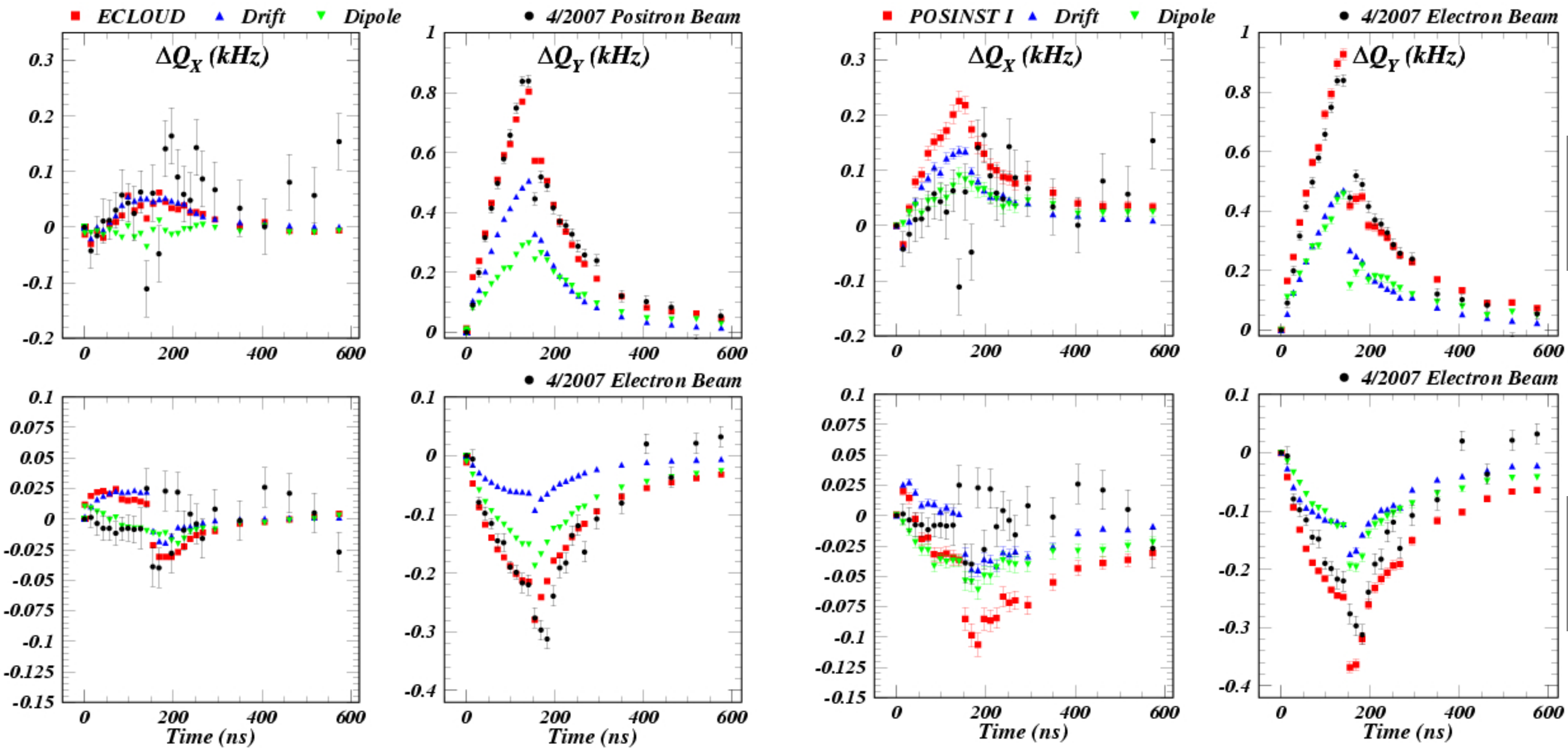
April 2007 Measurements (1.9 GeV, 0.75 mA/bunch)

ECLOUD

POSINST (from Gerry)



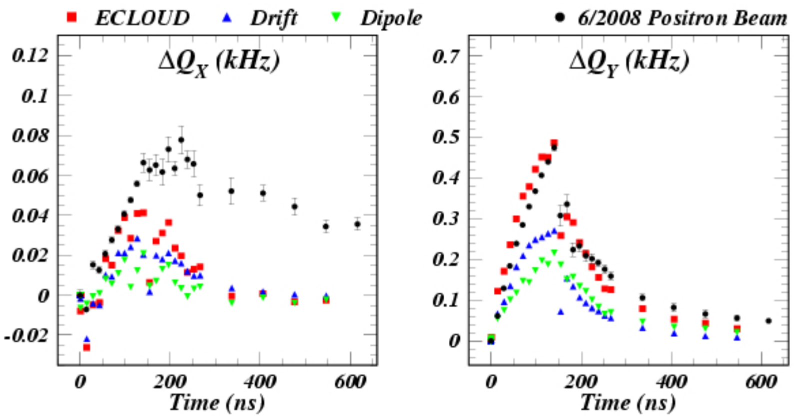
e+ beam

e- beam

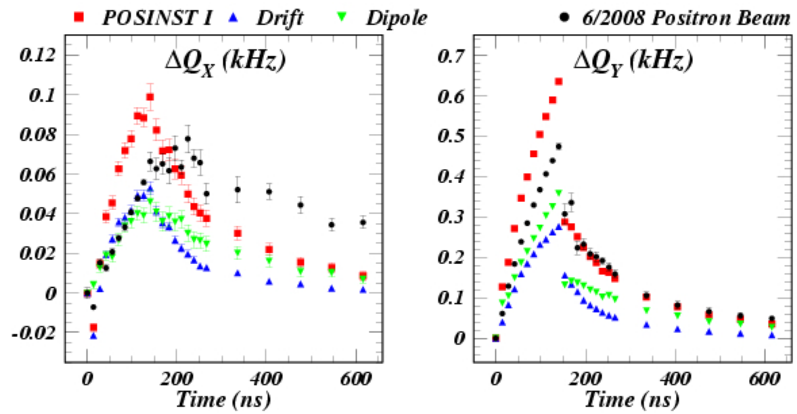
- ECLOUD and POSINST both show remarkable agreement with the data, especially the time development
- Q_Y: POSINST shows similar contributions from drift and dipoles, while ECLOUD shows drifts dominating for e+ beam and dipoles dominating for e- beam.
- Q_Y: POSINST overestimates effects immediately following train passage; ECLOUD underestimates them.
- Q_Y: POSINST dipole contribution provides bunch 13 bounceback.
- Q_X: ECLOUD calculates smaller horizontal tune shift.

June 2008 Measurements (5.3 GeV, 0.75 mA/bunch)

ECLOUD



POSINST (from Gerry)

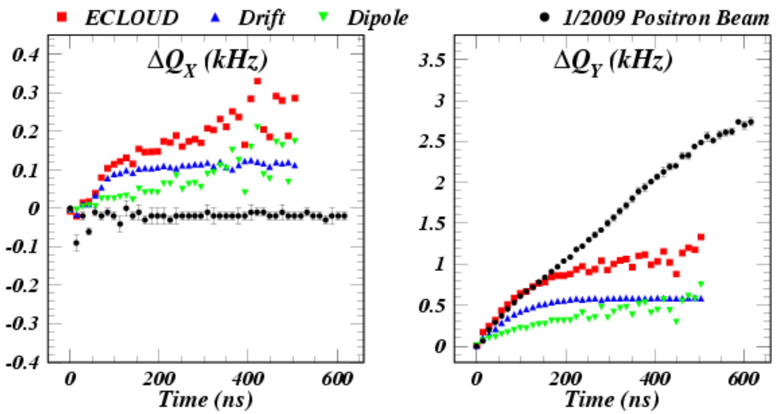


e+ beam

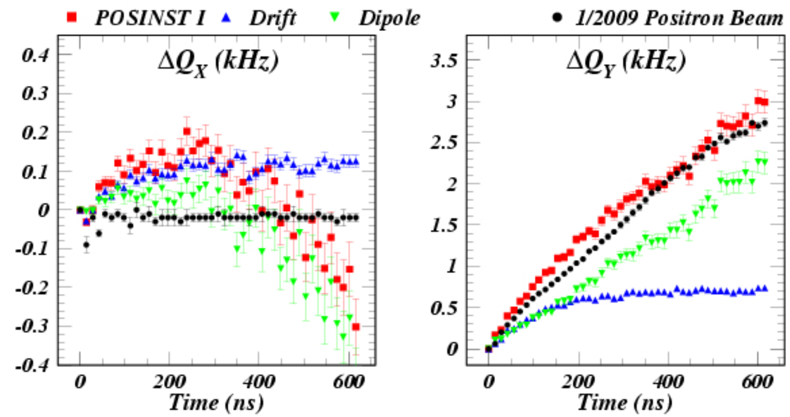
- *Primary input parameter differences relative to 2007: Sync rad flux = 0.23 -> 0.56 γ/m/e for drifts, 0.53 -> 1.12 γ/m/e for dipoles*
- *Q_Y: Some evidence of non-linear effects, since buildup and decay regions no longer agree.*
- *Q_Y: ECLOUD now models the bunch 13 bounceback, but gets it from the drift contribution.*
- *Q_X: ECLOUD again calculates smaller horizontal tune shift than POSINST, but now neither match the data well.*

January 2009 Measurements (2.1 GeV, 0.75 mA/bunch)

ECLOUD



POSINST (from Gerry)



e+ beam

- *Primary input parameter differences relative to 2007: Beam size smaller in 2009 by 20-30% in x, y, and z.*
- *Q_Y: POSINST model very good for this case where the dipole contribution dominates.*
- *Q_Y: ECLOUD dipole model now clearly wrong, requiring investigation.*
- *Q_X: ECLOUD and POSINST both model a greater tune shift than measured during the first 30 bunches.*

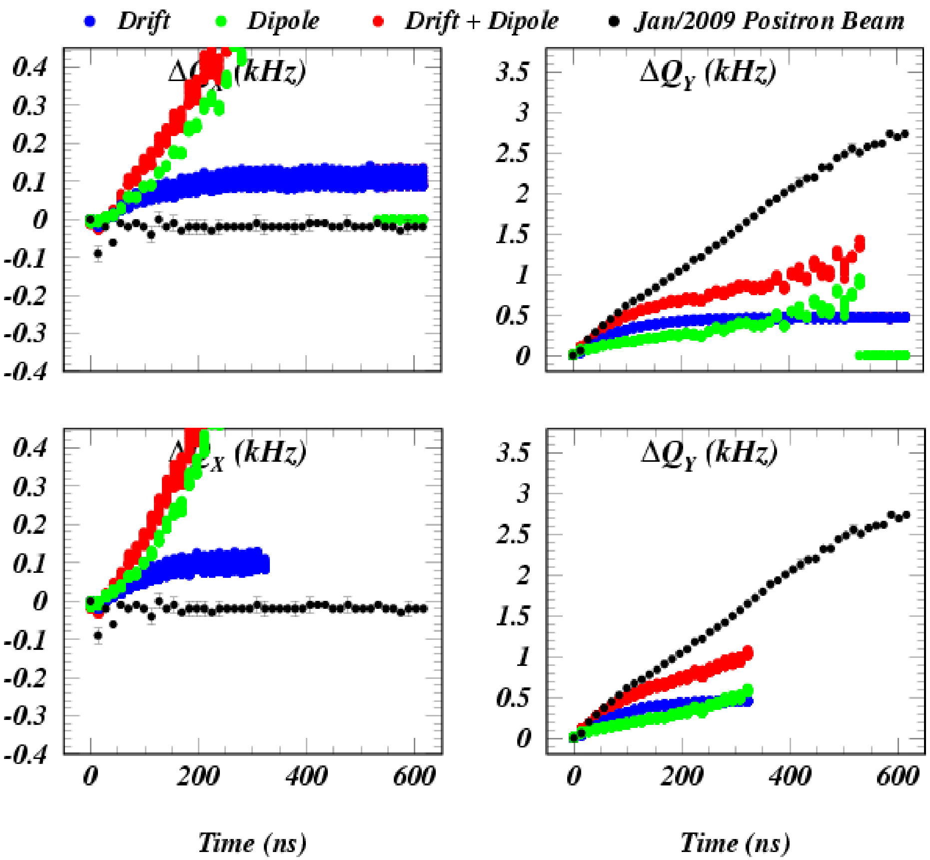
ECLOUD dipole model investigation

Today I report on followup to Frank Zimmerman's suggestion to check numerical approximations.

ECLOUD Dipole Model Numerical Approximations (I)

The simpler tune shift calculation using the space charge field gradients without beam offsets suffices for this study, since it also shows the poor modelling of the time dependence.

The field gradients are averaged over the beam in the transverse plane for each of 11 time slices during the bunch passage. The space charge field and gradients are recalculated for each time slice.



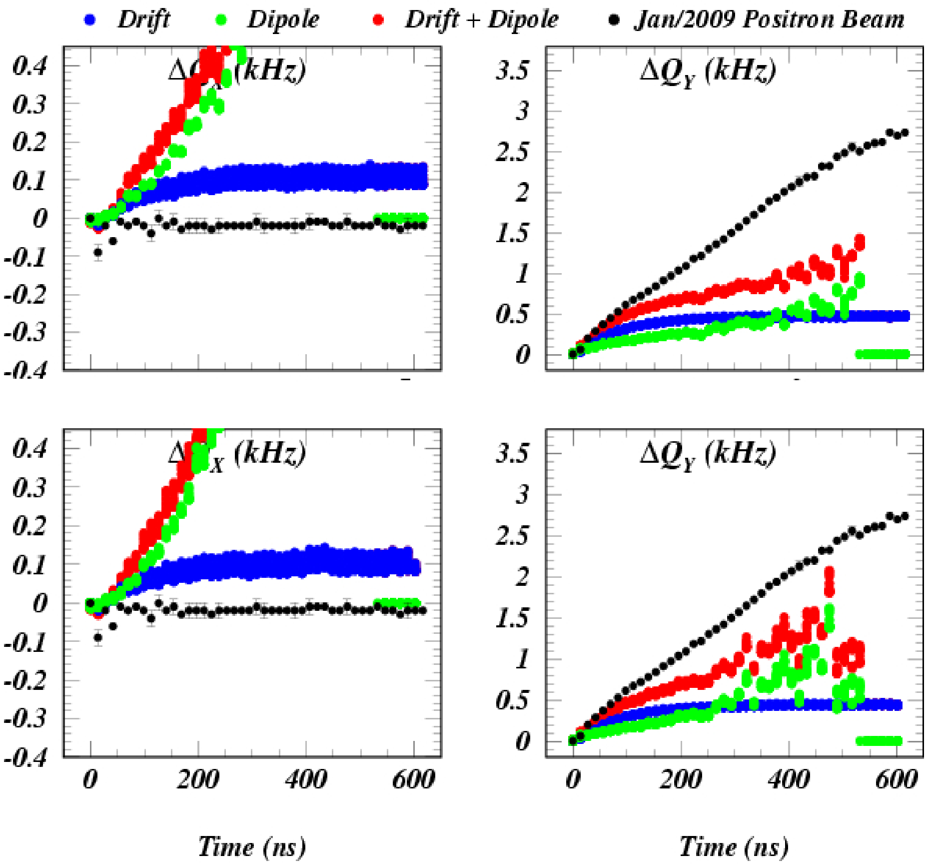
Reference Calculation

Field recalculations during bunch passage: 11
Time steps during bunch passage: 150
Time steps between bunches: 300

Check Calculation

Field recalculations during bunch passage: 11 --> 21
Time steps during bunch passage: 150
Time steps between bunches: 300

ECLOUD Dipole Model Numerical Approximations (II)



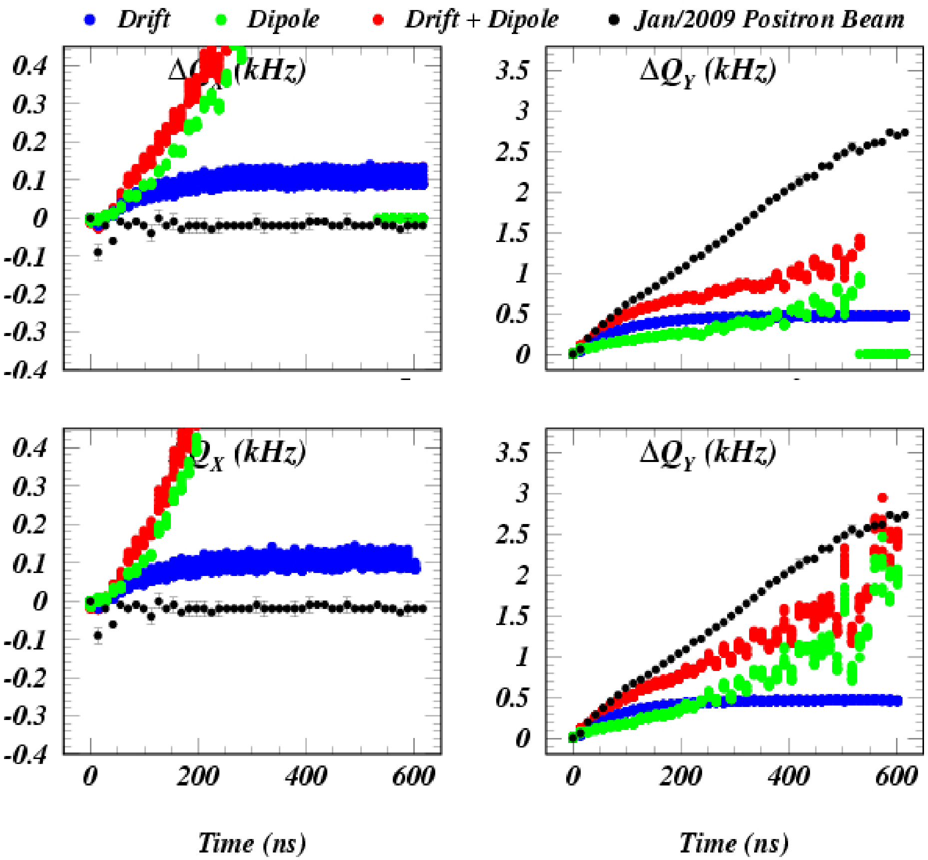
Reference Calculation

Field recalculations during bunch passage:	*11*
Time steps during bunch passage:	*150*
Time steps between bunches:	*300*

Check Calculation

Field recalculations during bunch passage:	*11*
Time steps during bunch passage:	*150 -->600*
Time steps between bunches:	*300*

ECLOUD Dipole Model
Numerical Approximations (III)



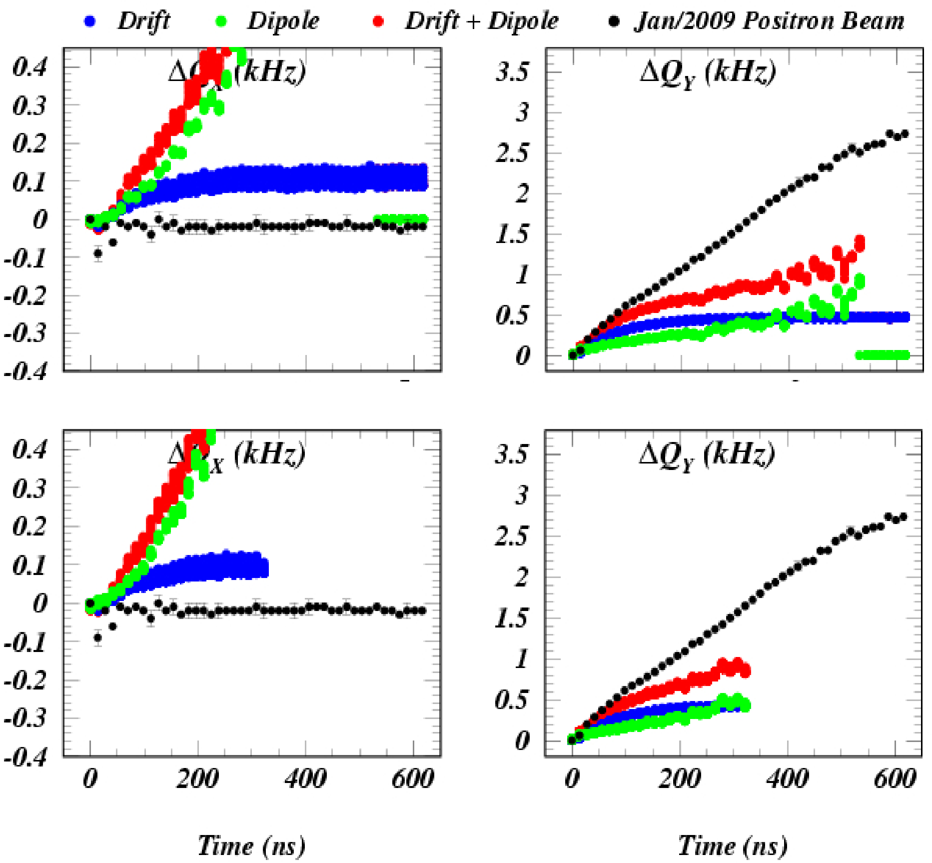
Reference Calculation

Field recalculations during bunch passage:	*11*
Time steps during bunch passage:	*150*
Time steps between bunches:	*300*

Check Calculation

Field recalculations during bunch passage:	*11*
Time steps during bunch passage:	*150*
Time steps between bunches:	*300 -->1000*

ECLOUD Dipole Model Numerical Approximations (IV)



Reference Calculation

Field recalculations during bunch passage:	*11*
Time steps during bunch passage:	*150*
Time steps between bunches:	*300*

Check Calculation

Field recalculations during bunch passage:	*11 --> 21*
Time steps during bunch passage:	*150 --> 600*
Time steps between bunches:	*300 -->1000*

Preliminary Conclusion

Successful modelling of coherent tune shifts in long bunch trains may require a modification of the physical model. The principal difference remaining between ECLOUD and POSINST is the SEY model.

A useful piece of evidence could be provided by following up on Frank's second suggestion, which was to calculate the 45-bunch coherent tune shifts in POSINST using Gerry's mockup of the ECLOUD SEY model.