Latest results on PSB space charge simulations

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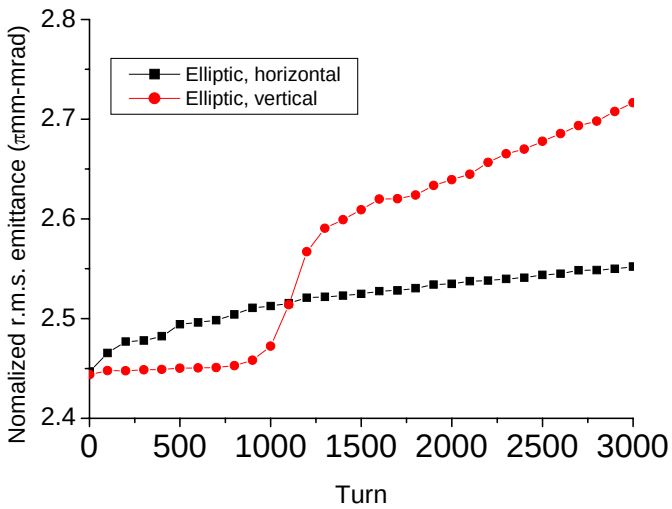
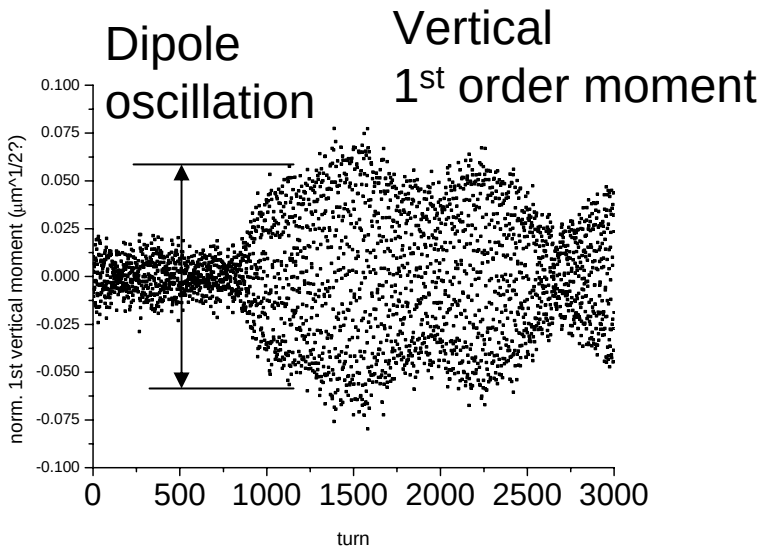
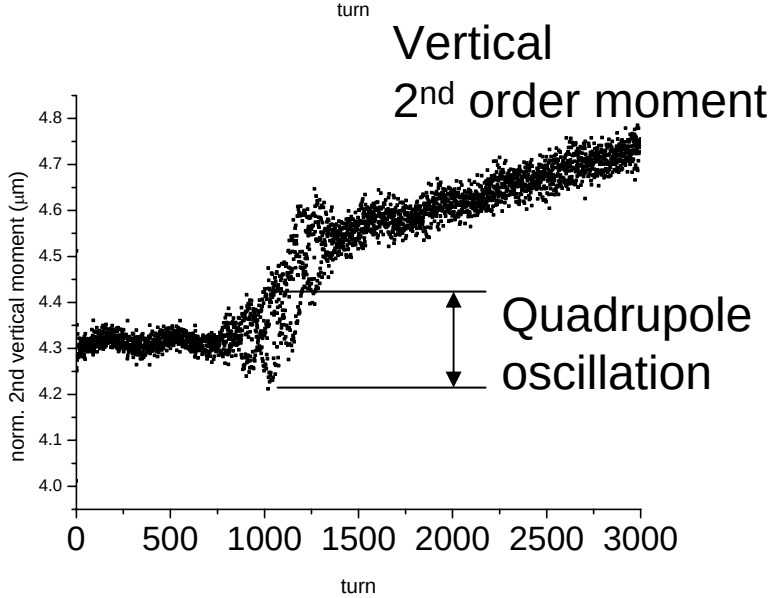
Recent simulation, beam moment



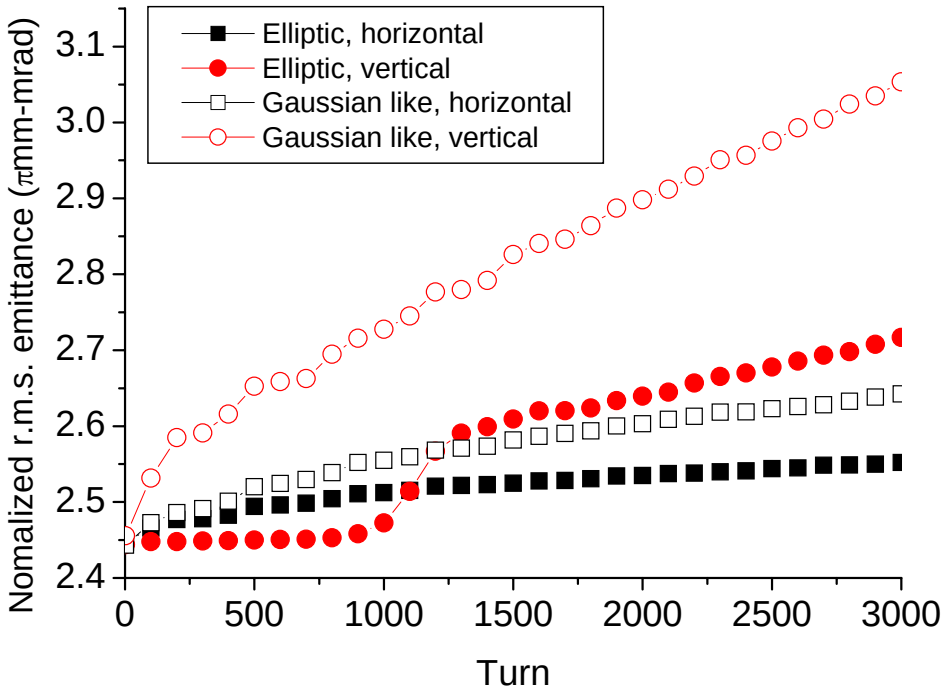
RMS emittance evolutions
(LHC nominal beam, 160MeV, 3.25e12 protons)





- Coherent dipole and quadrupole oscillation
  →Halo particles
- Feed back is applicable??

Recent simulation, Gaussian vs. Elliptic



- Sudden blow-up is not seen in Gaussian dist.
- Faster blow-ups in Gaussian than Elliptic.
- Strong dependence on distribution

Nonlinear tracking model in ORBIT

- Quadrupole modeling (for horizontal motion, F mag.)
  - Main body

$$\begin{pmatrix} \cos(kL/2) & \frac{\sin(kL/2)}{k} \\ -k\sin(kL/2) & \cos(kL/2) \end{pmatrix} \begin{pmatrix} 1 & -\frac{dP}{P}L \\ 0 & 1 \end{pmatrix} \begin{pmatrix} \cos(kL/2) & \frac{\sin(kL/2)}{k} \\ -k\sin(kL/2) & \cos(kL/2) \end{pmatrix}$$

  - Fringe

$$x = x_0 \pm \frac{k(x_0^3 + 3x_0 y_0^2)}{12\left(1+\frac{dP}{P}\right)}, \qquad x' = x_0' \mp \frac{k\left[x'(x_0^2 + y_0^2) - 2y_0' x_0 y_0\right]}{4\left(1+\frac{dP}{P}\right)}$$

k: $(B'/B\rho)^2$
L: Q length
sign: entree/exit

Features of nonlinear tracking

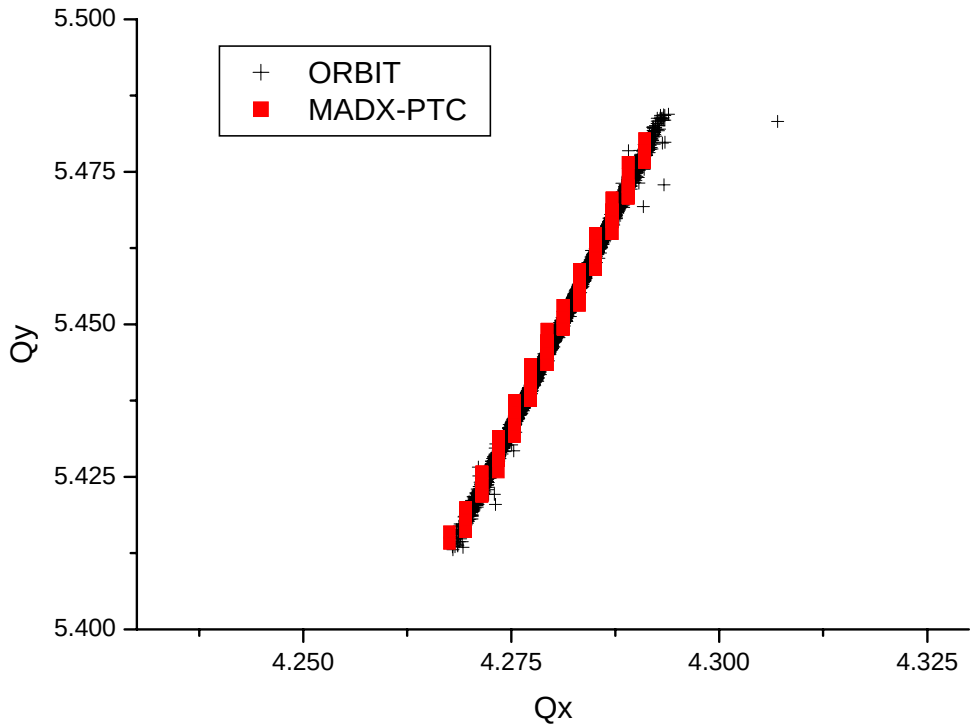
- dP/P terms in transfer matrix

  →chromatic tune shift
- Higher order components in fringe field

  →nonlinear motion
- Nonlinear elements, sextupole, octupole... are also available (not used in the present simulations)

Comparison to PTC

- Chromatic tune shift
  - Tune calculation
    - 1 turn in ORBIT
    - 512 turns in PTC (FFT)
    - Space charge OFF
    - RF OFF

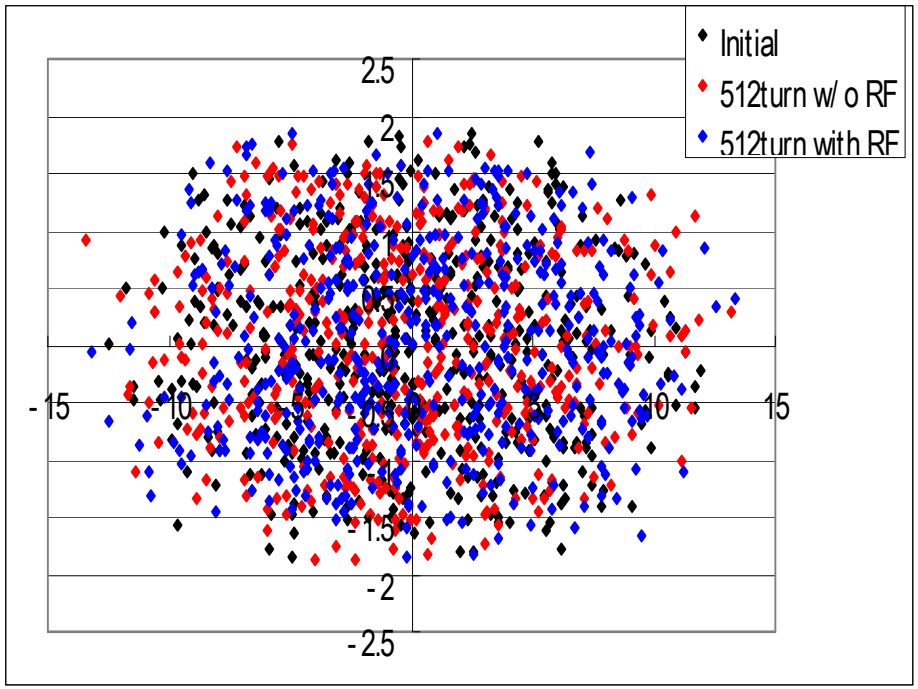


Remarks

- Recent simulations for LHC nominal beam
  (160MeV, 3.25e12 protons)
  - Coherent dipole and quadrupole oscillations trigger the sudden vertical emittance blow-up
  - Emittance evolutions depend on distribution
- Nonlinear tracking model
  - includes dP/P effects and nonlinear fringe
  - shows a good agreement of chromatic tune shifts to PTC tracking

Phase space (ORBIT)

Horizontal



Vertical