Space charge simulation update (2)

Shinji Machida
ASTeC, STFC Rutherford Appleton Laboratory
12 April 2012
KURRI-FFAG collaboration meeting

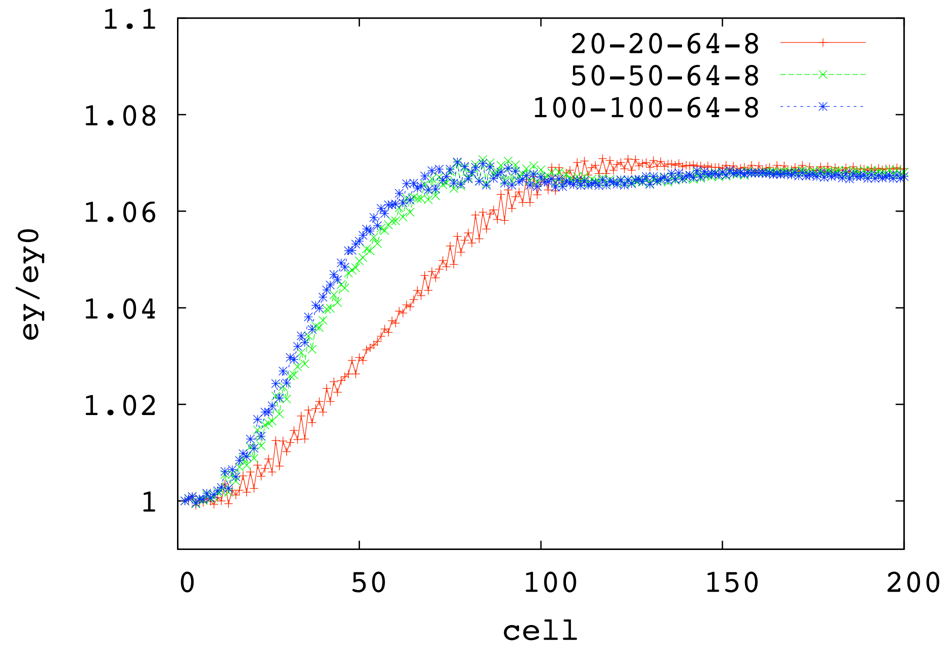
Contents

- Optimization of tracking parameters.
- Tracking on a perfect lattice.
- Tracking with alignment error.

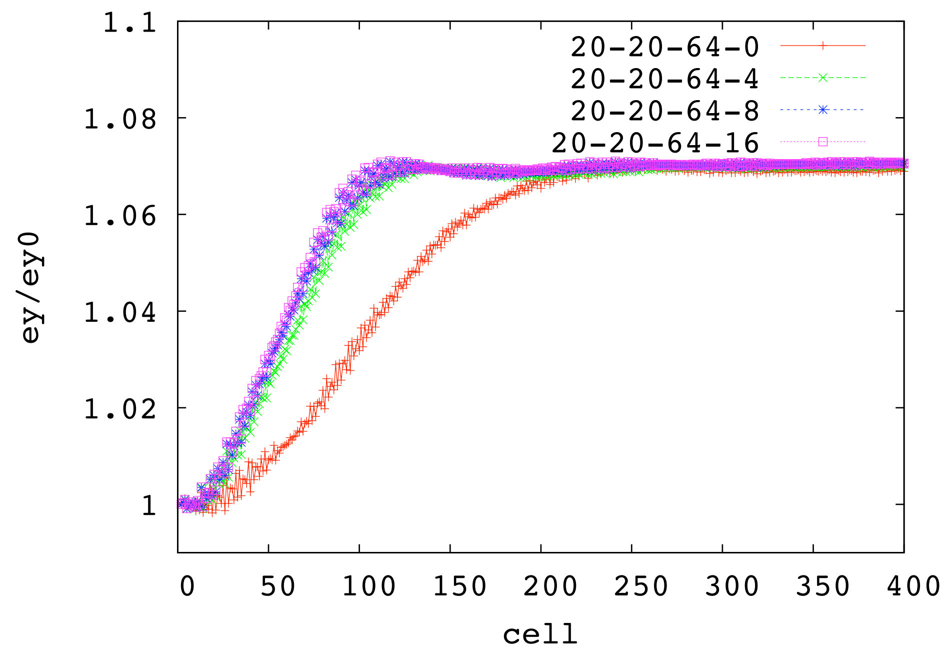
Optimization of tracking parameters (1)

- Number of grids (r and z).

For example, 20-20-64-8:
- 20 grids in radial
- 20 grids in longitudinal
- 64 grids in azimuthal
- use 8 modes in azimuthal after Fourier decomposition.

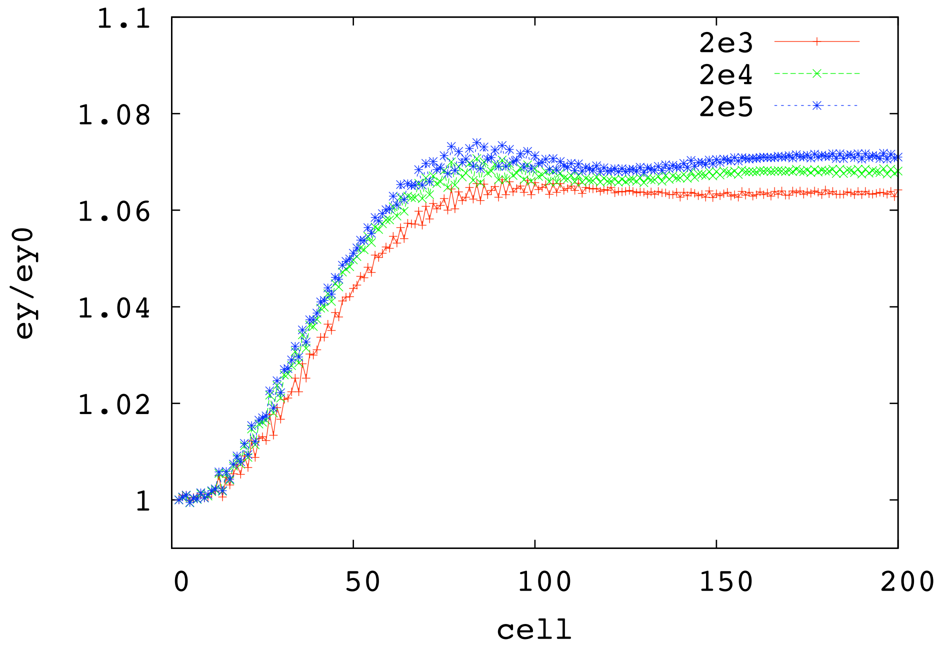


- Number of modes used after Fourier decomposition.



Optimization of tracking parameters (2)

- Number of macro particles



Grids used
- 50 grids in radial
- 50 grids in longitudinal
- 64 grids in azimuthal
- use 8 modes in azimuthal after Fourier decomposition.

Space charge tune shift

- Gaussian distribution in 3-D (cut at 2.5 sigma), the maximum tune shift is

$$\Delta Q_y = -\frac{r_p n_t}{\pi (4\epsilon_{rms,un}) \frac{1+\sqrt{e_x/e_y}}{2} \beta^2 \gamma^3} \frac{1}{B_f}$$

- $e_{y,\ rms,\ unnor}$=6.3 x 10^{-6}, n_t=3 x 10^{11}, B_f=0.42 gives
  - Effectively, e_x ~ 4 e_y because of dispersion function.
  - \Delta Qy=-0.391

- Tune in the model lattice is (1.816, 2.292).

Intensity dependence

- Tune shift vs intensity

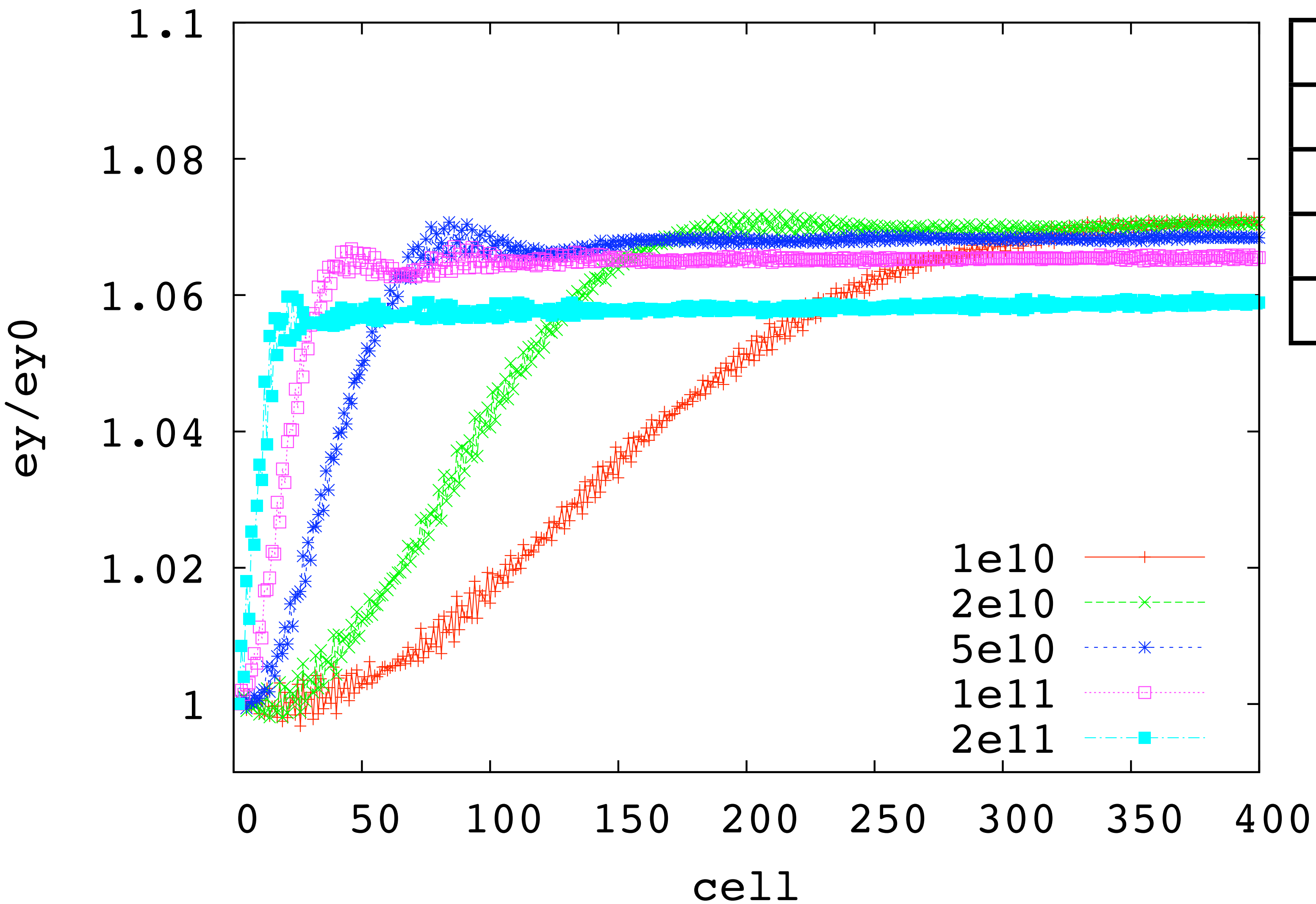
intensity in per bunch	cell dq_y (q_y)	ring dQ_y (Q_y)
2×10^{10}	-0.020 (0.267)	-0.156 (2.136)
3.5×10^{10}	-0.034 (0.252)	-0.274 (2.018)
5×10^{10}	-0.049 (0.238)	-0.391 (1.900)
7×10^{10}	-0.069 (0.218)	-0.548 (1.744)

(red box) when maximum tune shift hits q_y=0.250

(purple box) when coherent tune shift hits q_y=0.250.

Perfect lattice (1)

- Number of macro particles



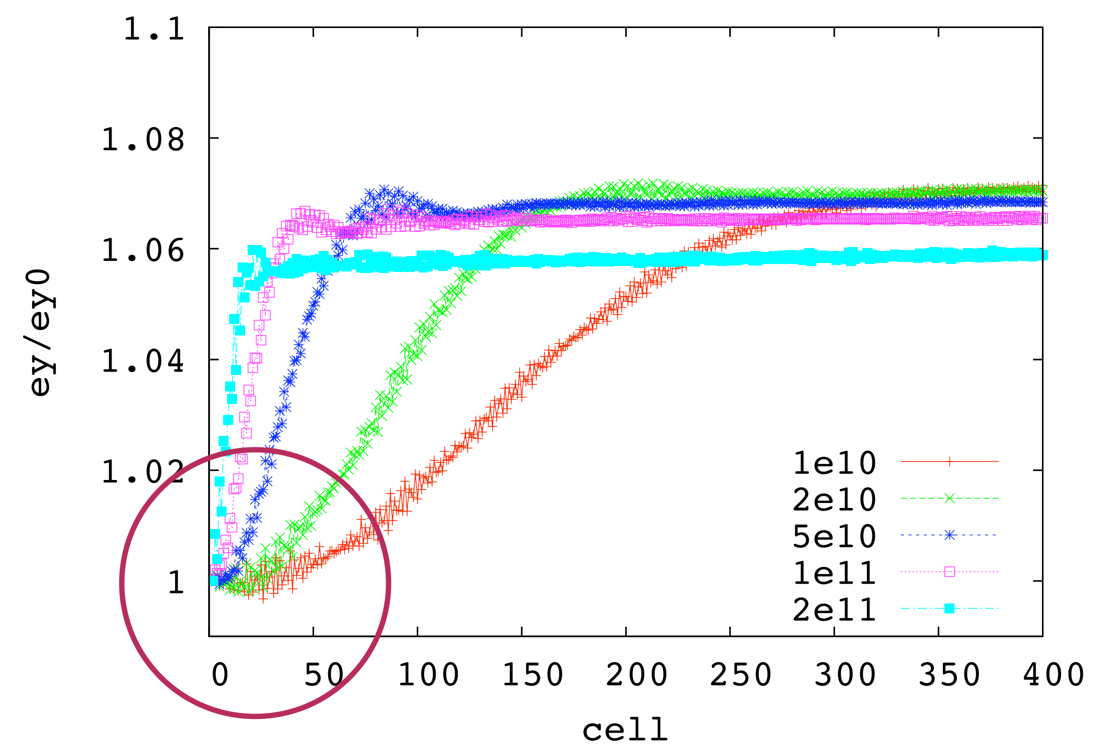
intensity in per	cell dq_y (q_y)	ring dQ_y (Q_y)
2×10^{10}	-0.020 (0.267)	-0.156 (2.136)
3.5×10^{10}	-0.034 (0.252)	-0.274 (2.018)
5×10^{10}	-0.049 (0.238)	-0.391 (1.900)
7×10^{10}	-0.069 (0.218)	-0.548 (1.744)

Almost no intensity dependence.

Simply shows initial mismatch is filled with different time scale (tune spread).

Perfect lattice (2)

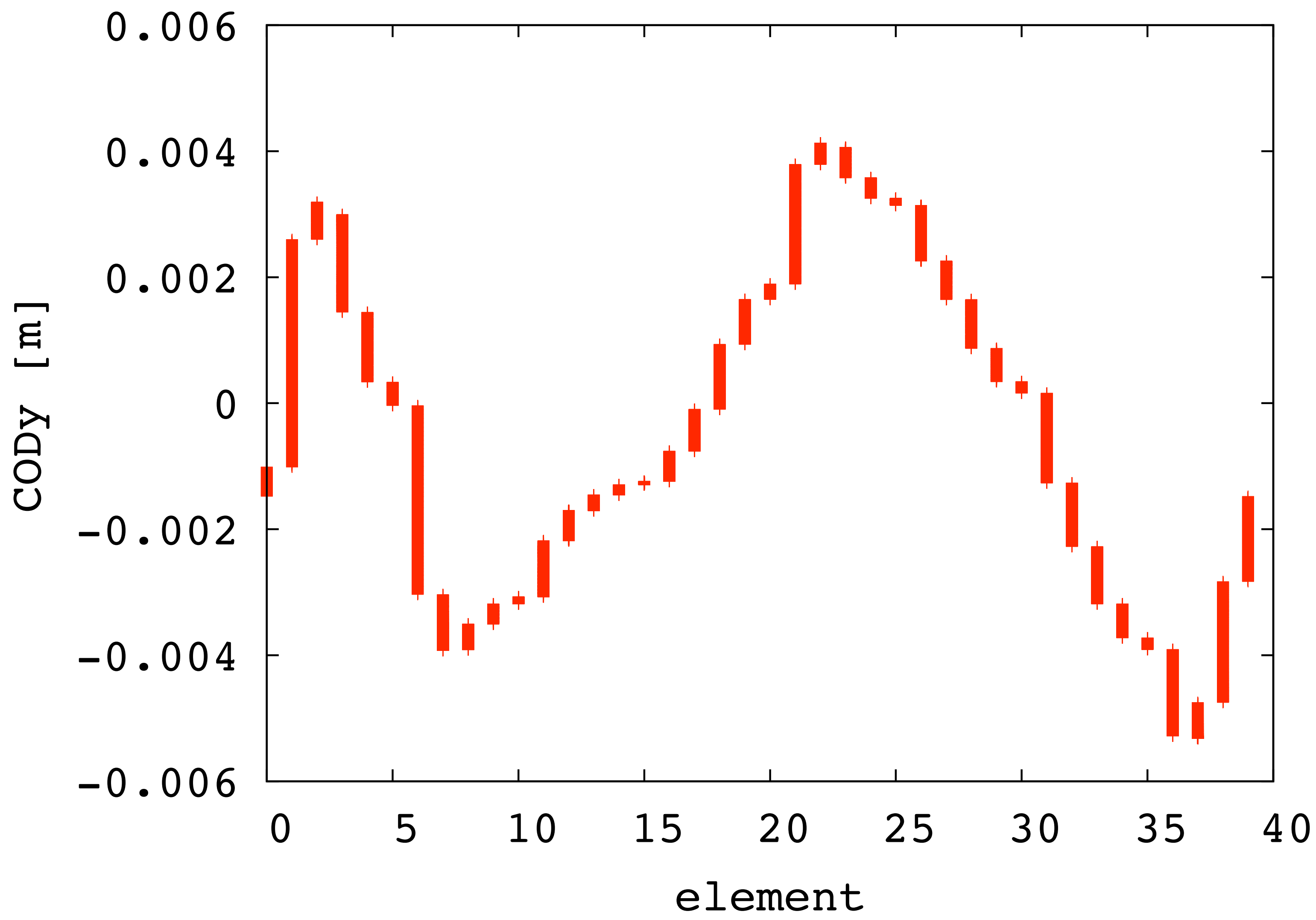
- Last time, I looked at only the first 5 turns (40 cells).
- "observation of parametric resonance at qy=0.25" may be wrong.



8

With alignment error (1)

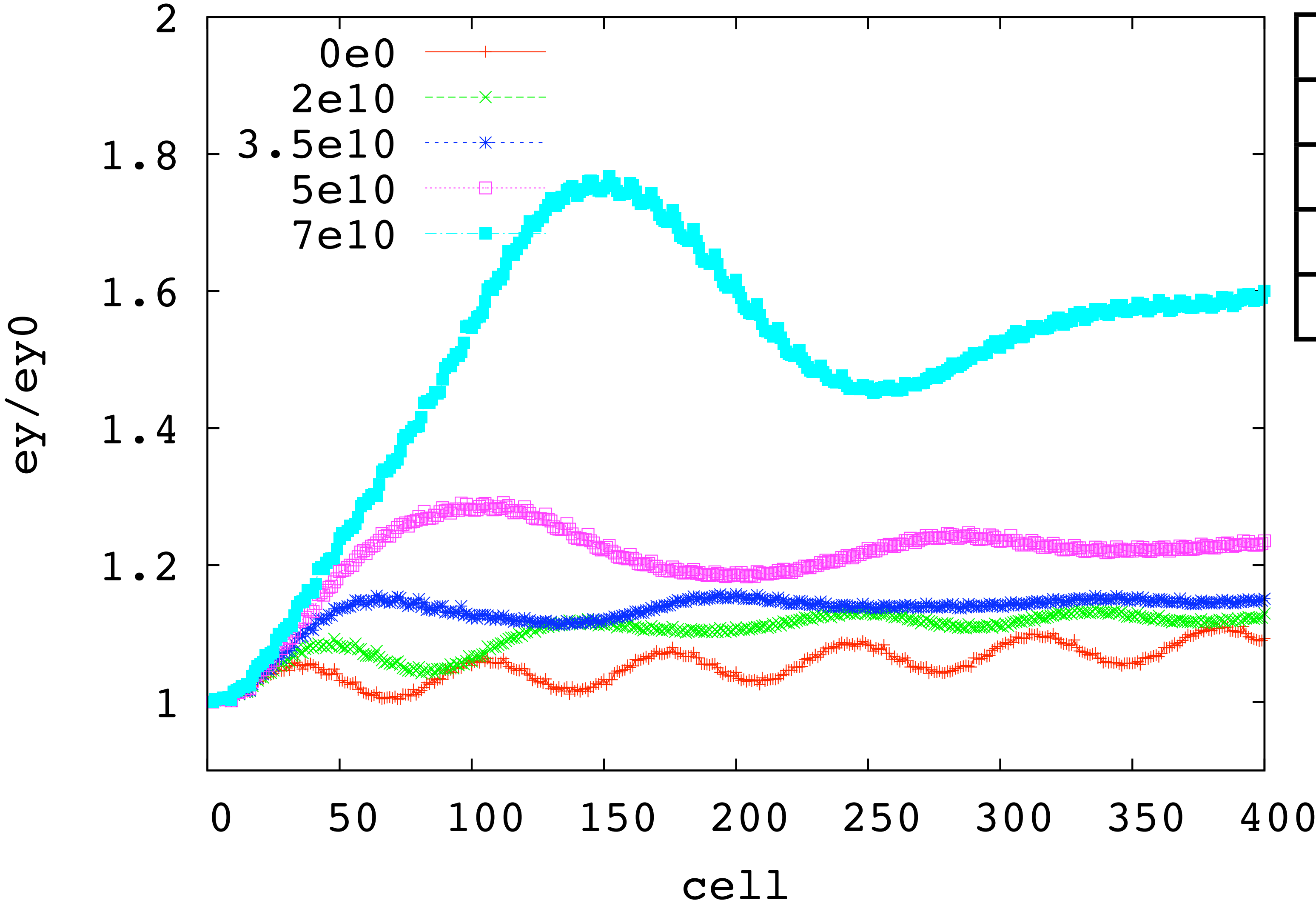
- COD with alignment error of +/- 2 mm.



5 elements in one cell

With alignment error (2)

- Number of macro particles



intensity in per	cell dq_y (q_y)	ring dQ_y (Q_y)
2×10^{10}	-0.020 (0.267)	-0.156 (2.136)
3.5×10^{10}	-0.034 (0.252)	-0.274 (2.018)
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Almost no intensity dependence.

Simply shows initial mismatch is filled with different time scale (tune spread).

Discussion

- Because of 8-fold symmetry, Q_y=2.0 is quarter resonance (q_y=0.250) in each cell.
  - Cell tune without tune shift is (0.227, 0.286).
  - q_y=0.250 is second order (?) parametric resonance. (Okamoto and Yokoya, NIM A482 p.51 2002).
- With alignment error, non-systematic resonances affect a beam.
  - Q_y=2.0 is no-systematic integer resonance.

Summary

- The results in a perfect lattice is unexpected. It may still have some problems in a code.
- With alignment errors, clear signal of intensity dependence due to non-systematic integer and half-integer resonances.
- Growth should be observed in ~20 turns.