Long term, slow emittance growth due to EC

Benchmark of HEADTAIL and G.Franchetti's code

E.Benedetto, RLC meeting-2/12/05

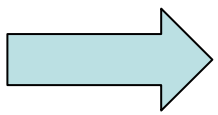
Why this benchmark?

- Electron cloud induced slow emittance growth, seen w. HEADTAIL, can be due to:

RESONANCE CROSSING

and TRAPPING

- Similar to what happens in Space Charge dominated bunches

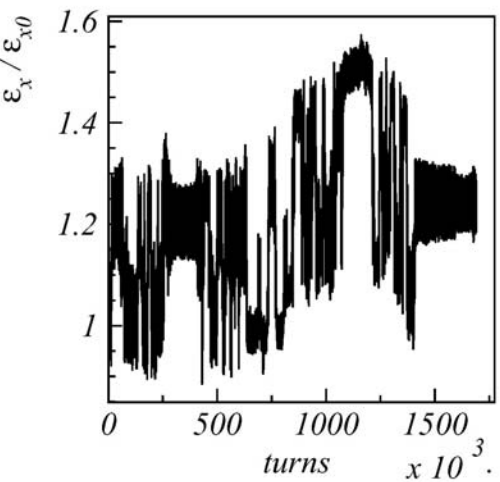


Collaboration w. G.Franchetti, GSI

Mechanism of resonance crossing and trapping-detrapping

- Similar to what happen in space charge dominated bunches
  - G.Franchetti's talk at CARE-HHH'04

    http://care-hhh.web.cern.ch/care-hhh/HHH-2004/Talks%20Session%202/Franchetti.pdf



Single particle action vs. # turns
(synchrotron motion is present)

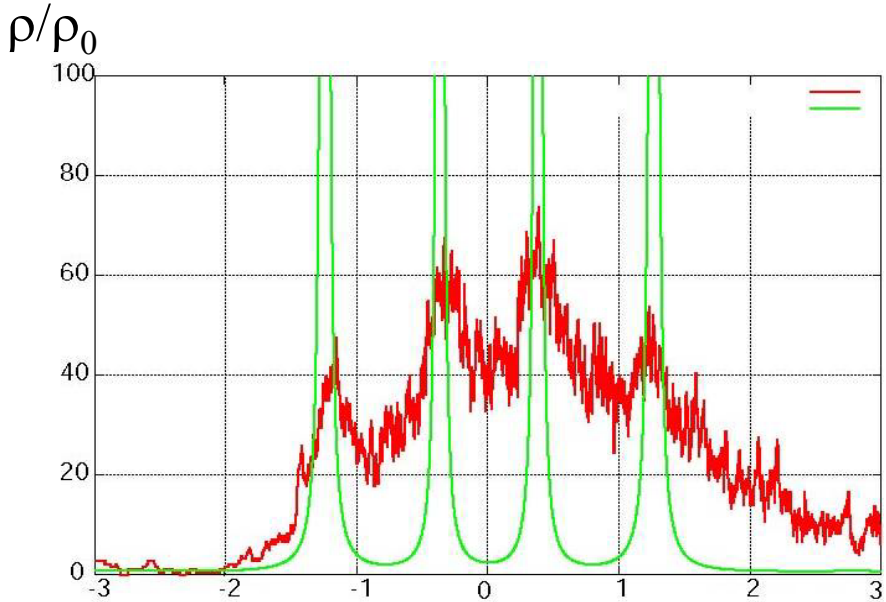
Found the same kind of behavior w. HEADTAIL

Main “ingredients”

- Longitudinal variation of Tune Shift
- Synchrotron motion

In EC problems, the tune shift varies along the bunch because the electrons pinch:

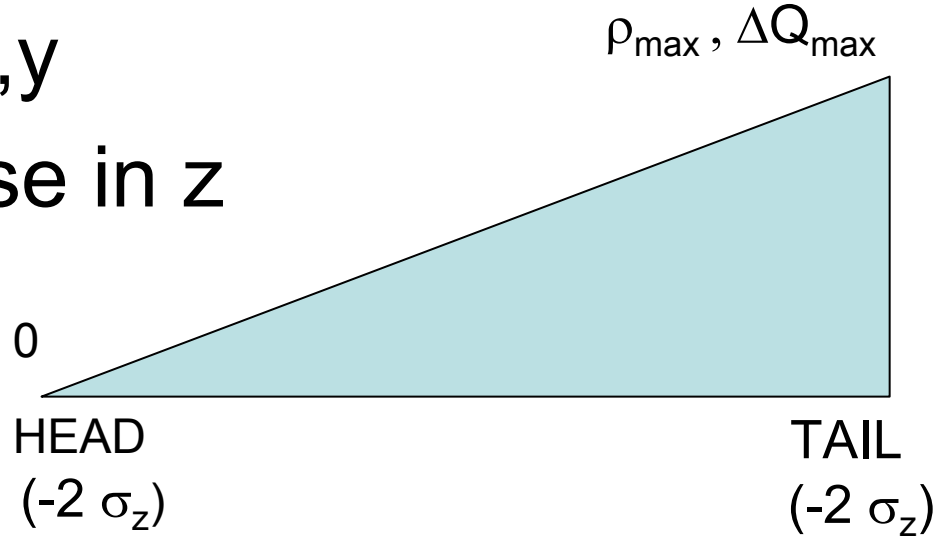
$$\Delta Q_x \approx \frac{\bar{\beta}\ 2\pi \mathrm{R}\ r_p}{2\gamma}\rho_e$$



Simplified model

- round beam σ_b
- linearized synchrotron motion

- round cloud $\sigma_e = f\,\sigma_b$
- Gaussian shape in x,y
- linear density increase in z



BUT OF COURSE: the dependence in z is more complicated

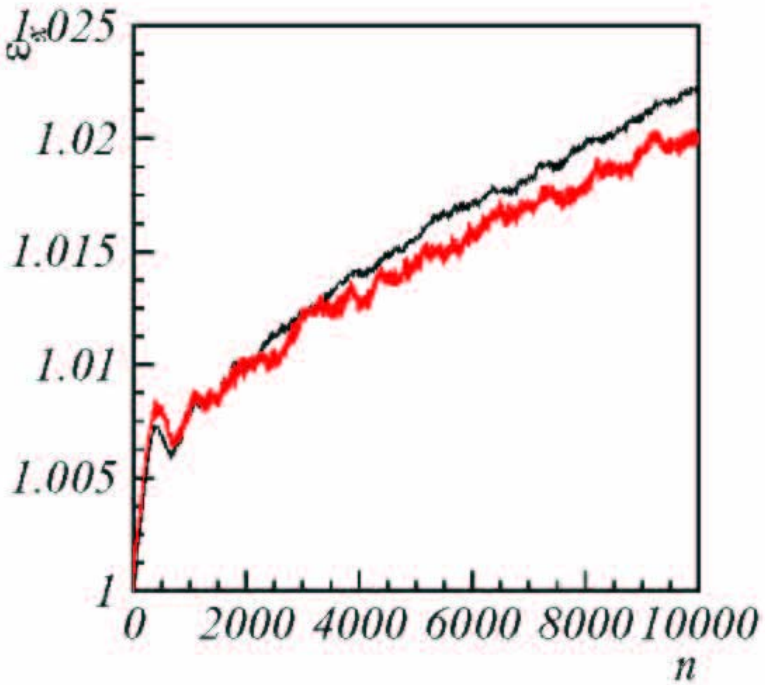
Transverse Electric Field :

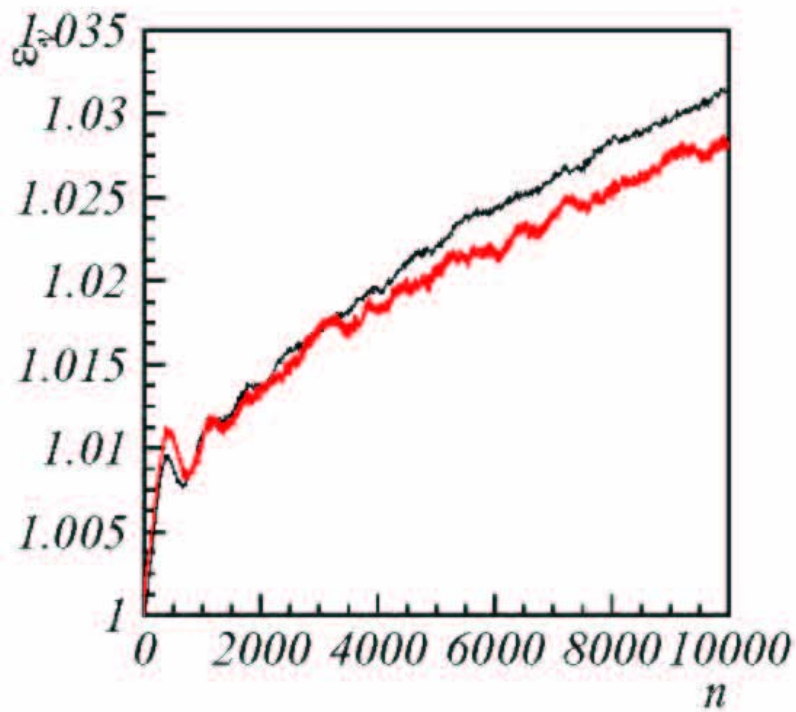
- GIULIANO's:
  - Analytical expression, assuming electron Gaussian shape
- HEADTAIL:
  - PIC module

Results from benchmark:

- $\sigma_e = 0.5\ \sigma_b$, $\Delta Q_{max} = 0.04$

HEADTAIL
Giuliano's

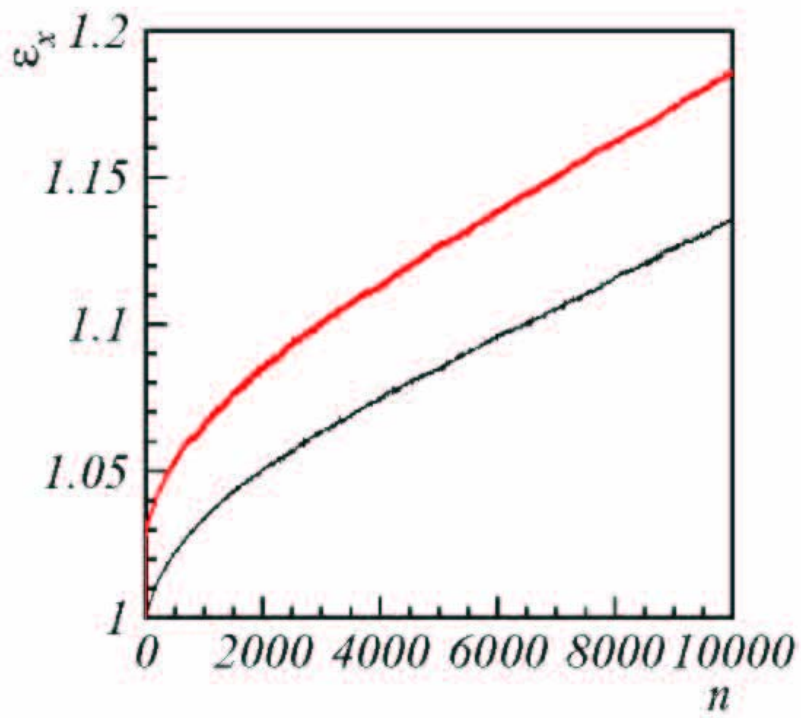


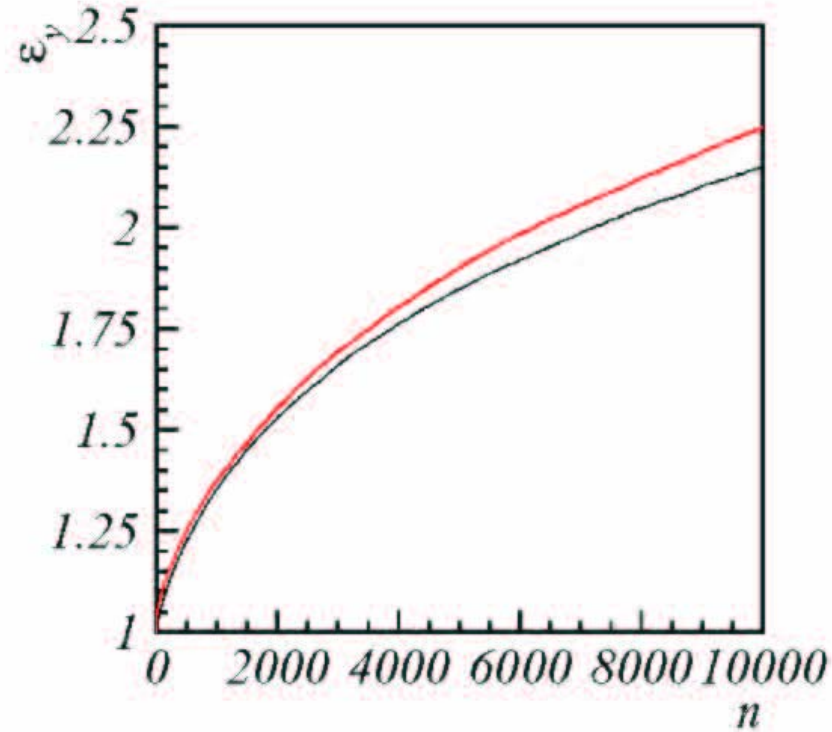


Results from benchmark:

- $\sigma_e = 1\ \sigma_b$, $\Delta Q_{max} = 0.1$

HEADTAIL
Giuliano's

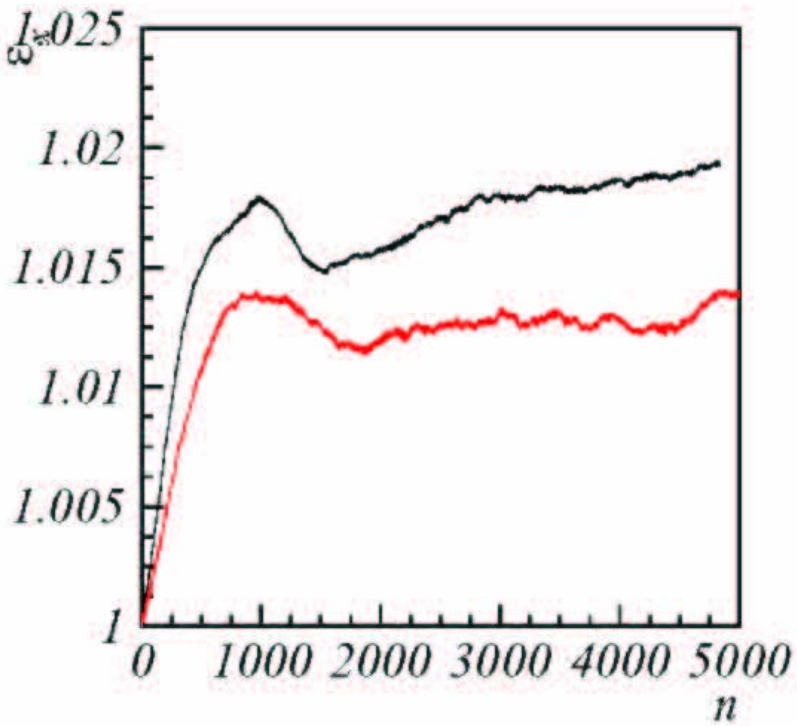


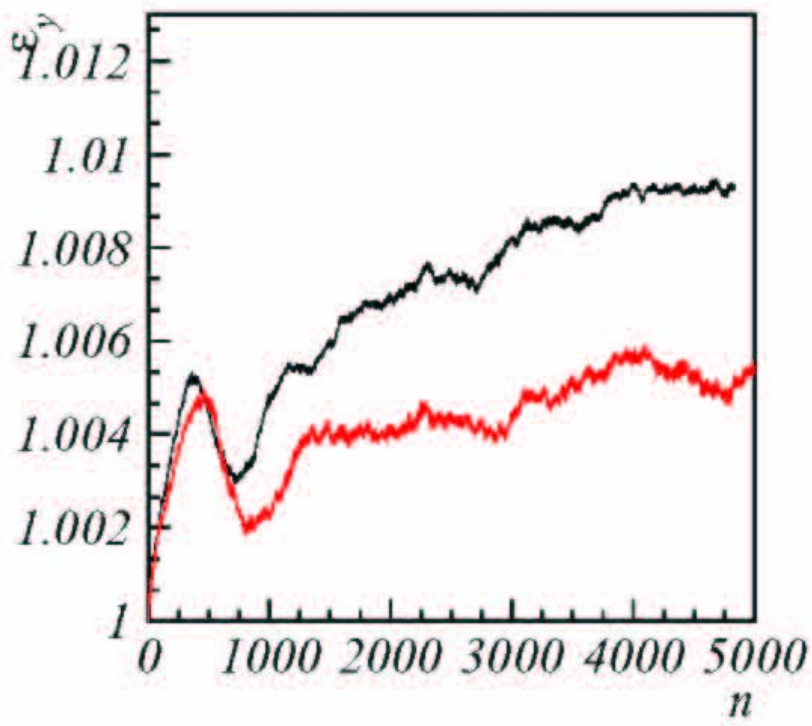


Results from benchmark:

- $\sigma_e = 0.25\ \sigma_b$, $\Delta Q_{max} = 0.04$

HEADTAIL
Giuliano's

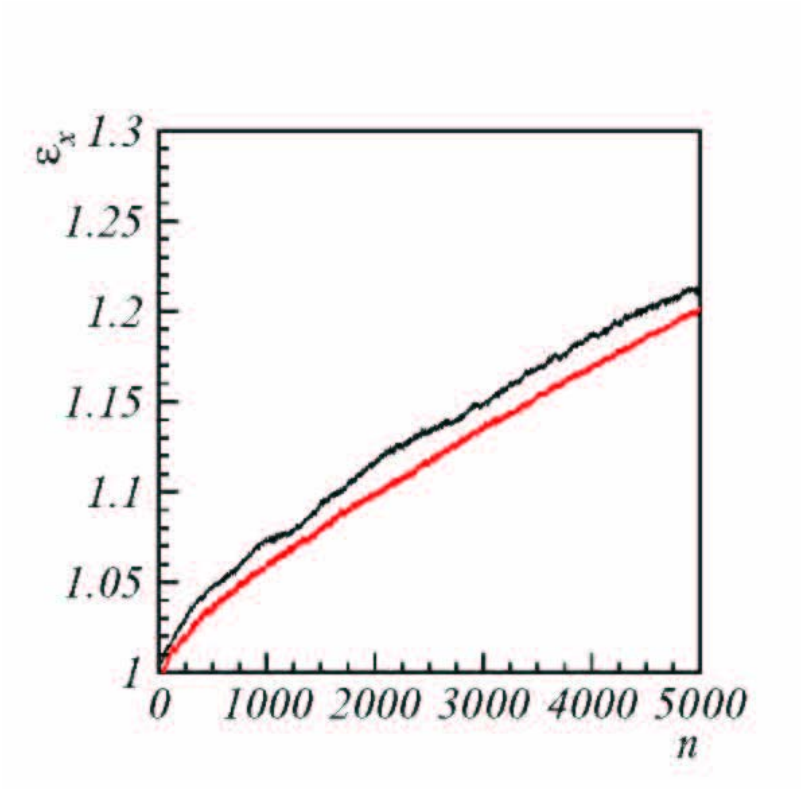


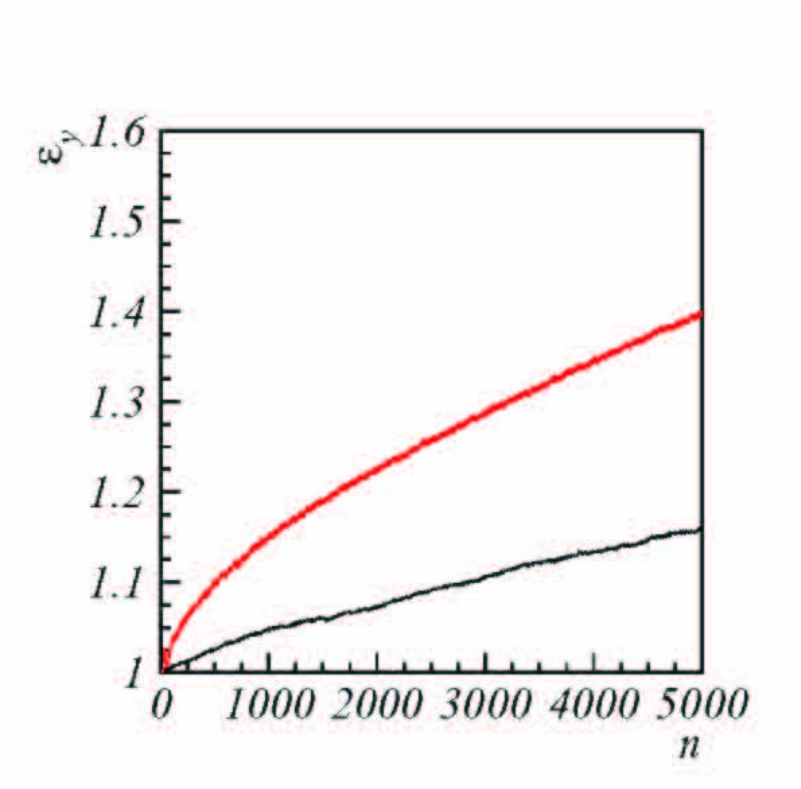


Results from benchmark:

- HEADTAIL: real pinch, $\Delta Q_{max} = 0.04$
- Giuliano's: $(\pi \sigma_e^2 \rho) = \text{const}$

  $\sigma_{e,\,ini} = 0.65\ \sigma_b$ (to match horiz. emittance growth)





Ongoing work…

- Other results: found same non-monotonic dependence w. # kicks → fully explained by the resonance crossing model
- Discussion of the noise level → ongoing
- Benchmark with the real pinch → ongoing
  - problems due to grid size if pinch is too narrow
  - how to model correctly the electron evolution