Beam-beam - synchro-beta resonance

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Dec. 4, 2012

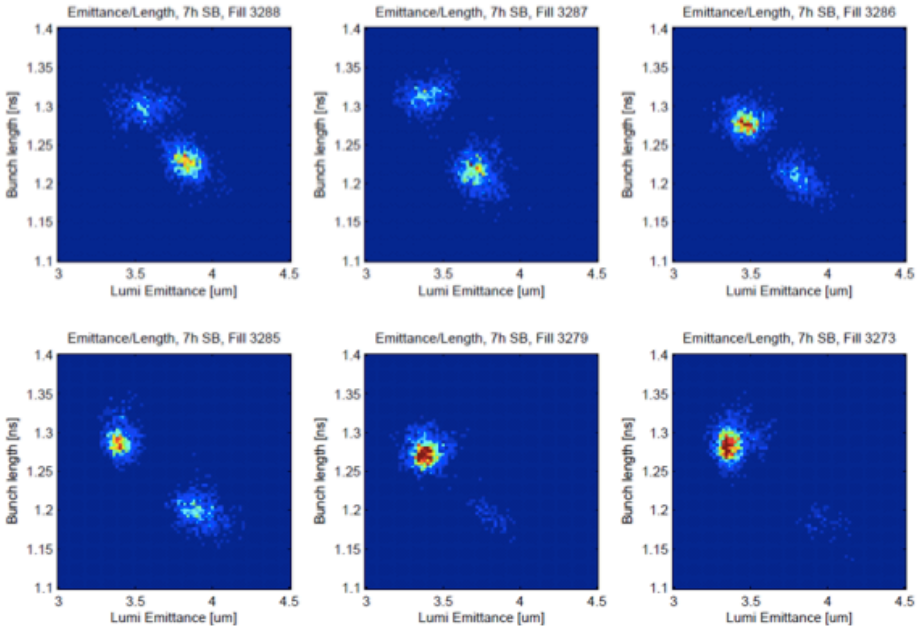
Thanks to F. Zimmermann

From Week 46 summary

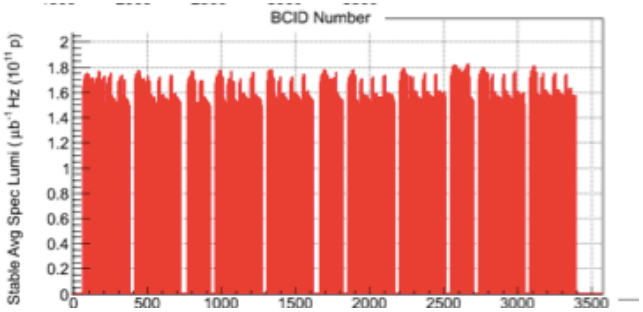
G. Arduini & J. Uythoven

Bunch length related to emittance

- Bunch length as a function of calculated emittance from Lumi
- Smaller emittance correlates to longer bunch length
  - The small transverse beams get unstable and blow up longitudinally ???
  - The large transverse beams are scraped, particles with larger momentum are scraped most ???

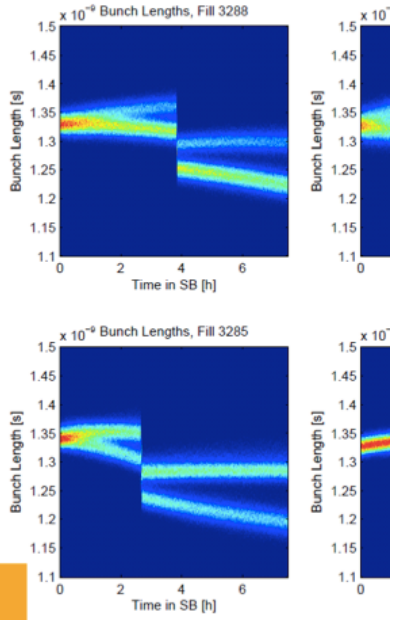


M. Hostettler



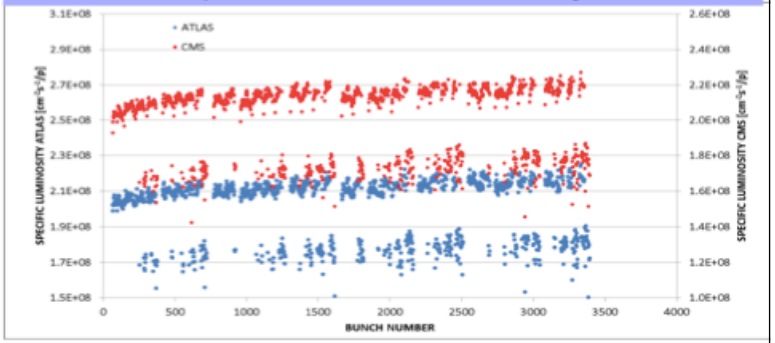
Bunch length reduction

Beam 1 only !



ostettler

Specific bunch luminosity



Parameters

- E=4TeV, N_p=1.65x10^{11}, γε=2.63x10^{-6}, β*=0.6m, θ=290μrad, θσ_z/σ_x=0.75
- Horizontal and vertical crossing.
- Base (Qx,Qy)=(64.31, 59.32)
- Qx,Qy=(32.155x2, 29.66x2) or = (32.5+31.81, 29.5+29.82)
- Qs=0.0019 ?
- Weak-strong simulation, N_{macrop}=131,072, 10^6 turns

Beam-beam map

K. Hirata, F. Ruggiero, H. Moshammer, PartAcc(1992)

- 3D symplectic

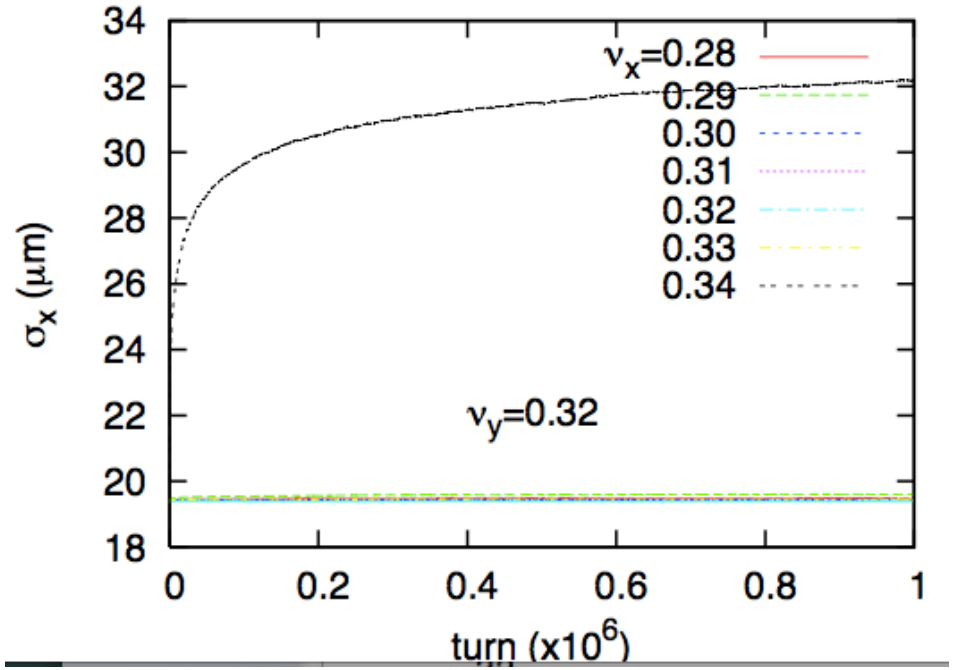
$$\Delta p_{r,1}(s) = \frac{2n_2(z_2)\Delta s r_p}{\gamma}\frac{1}{r}\left[\exp\left(-\frac{r^2}{2\sigma_{r,2}(s)^2}\right)-1\right]$$

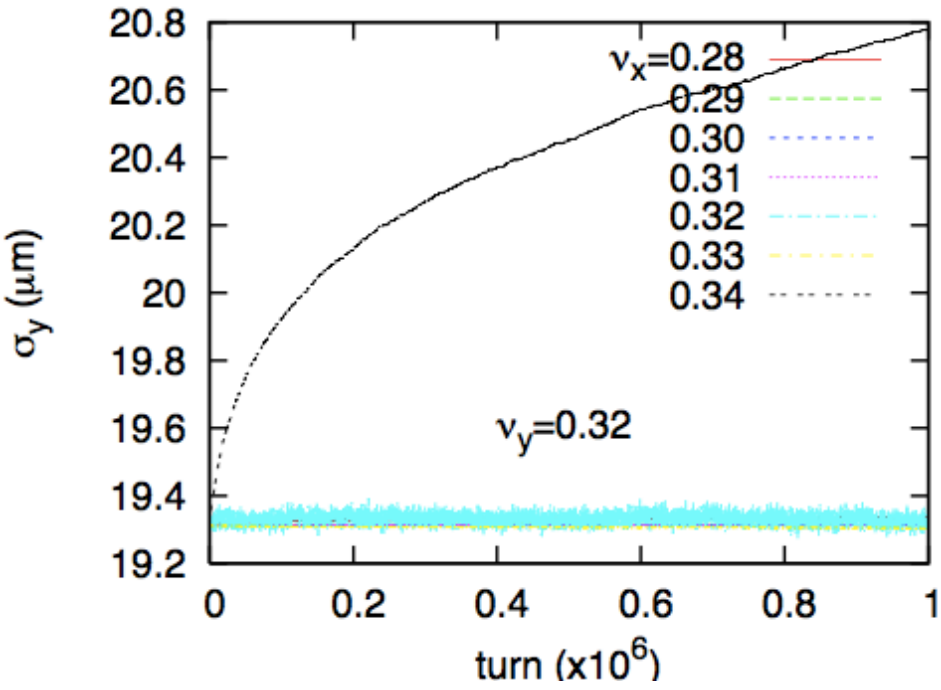
$$\Delta p_{z,1}(s) = \frac{n_2(z_2)\Delta s r_p}{\gamma}\frac{1}{\sigma_{r,2}(s)^2}\frac{d\sigma_{r,2}^2(s)}{dz}\exp\left(-\frac{r^2}{2\sigma_{r,2}(s)^2}\right)$$

$$s = \frac{z_1 - z_2}{2}$$

Qx scan

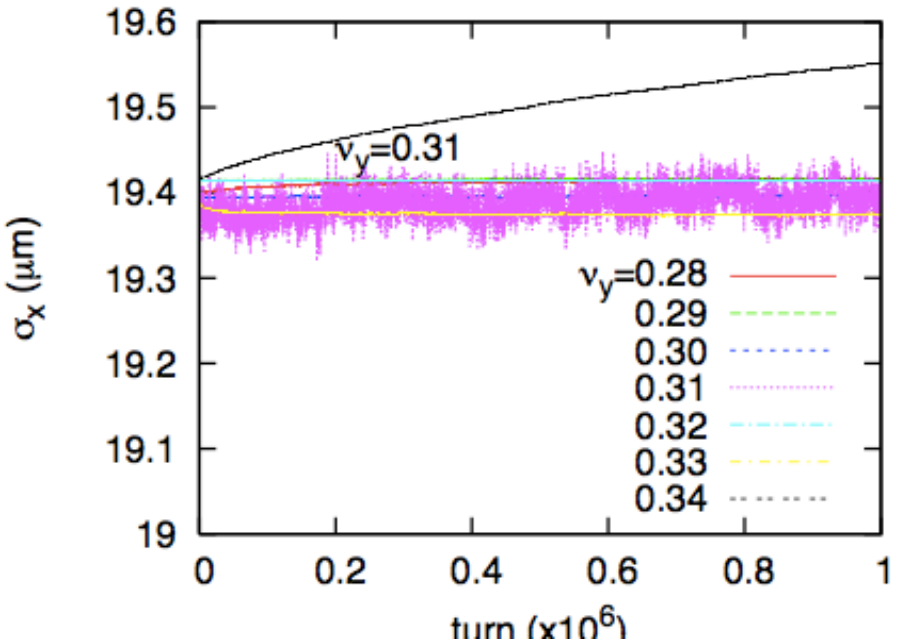
- Strong emittance growth at Qx=0.34.
- Beam size fluctuation is seen for Qx=Qy=0.32

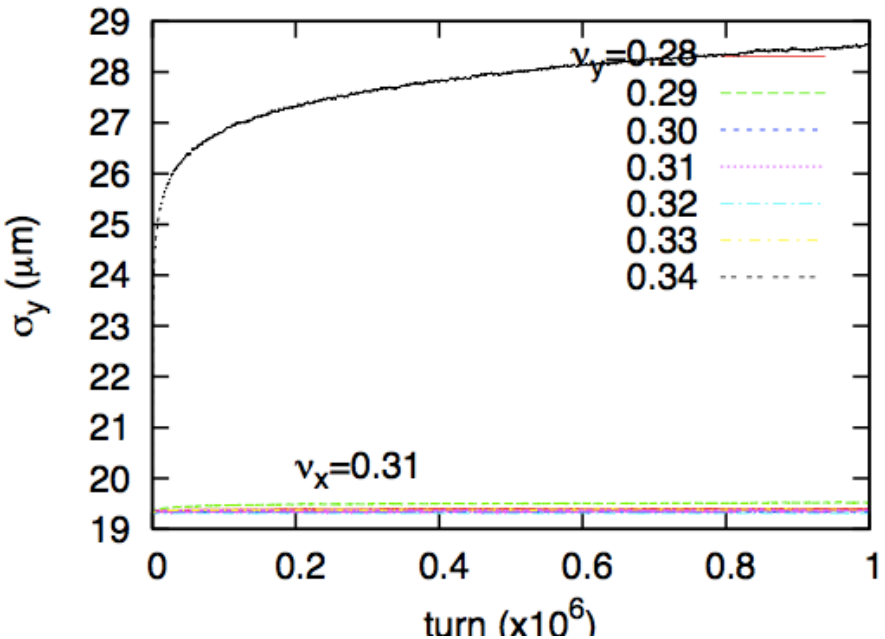




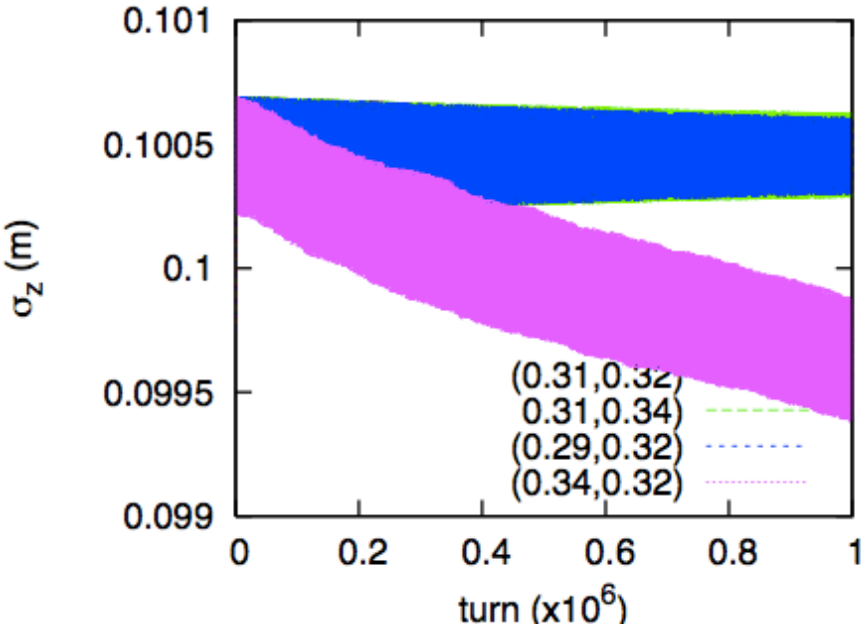
Qy scan

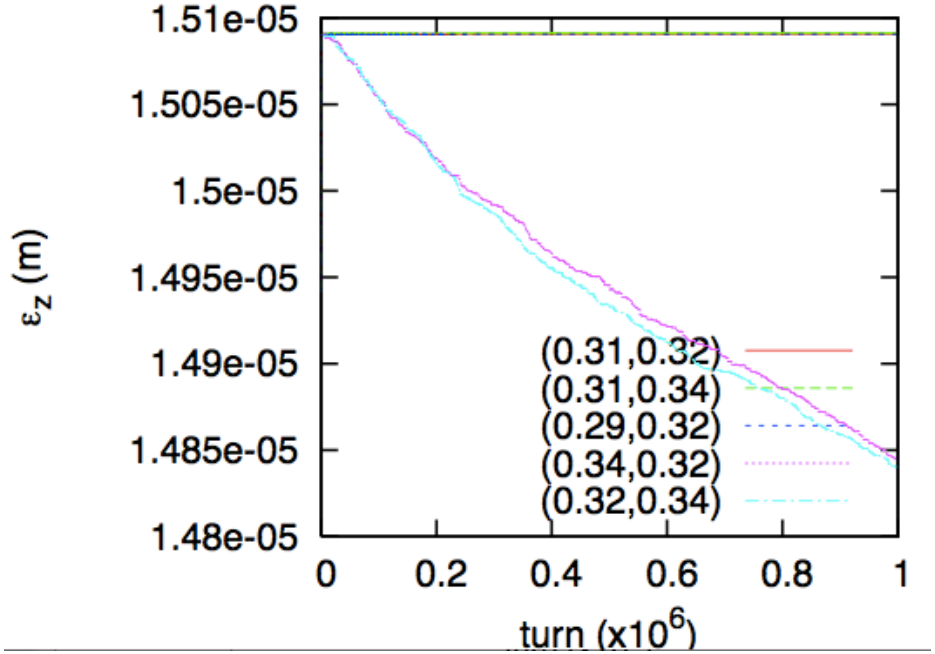
- Strong emittance growth at Qy=0.34.
- Beam size fluctuation is seen for Qx=Qy=0.31





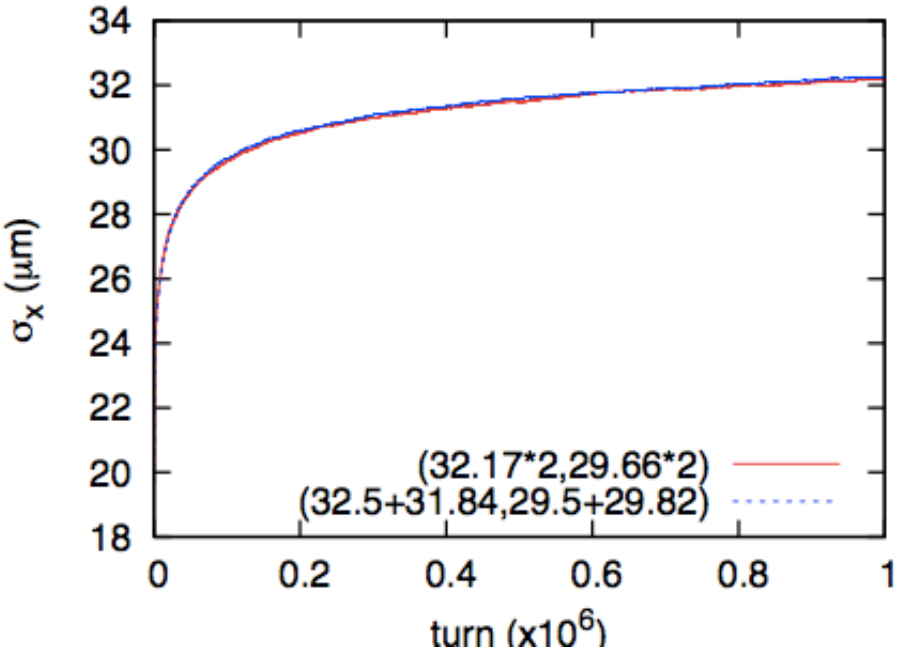
Bunch length, longitudinal emittance

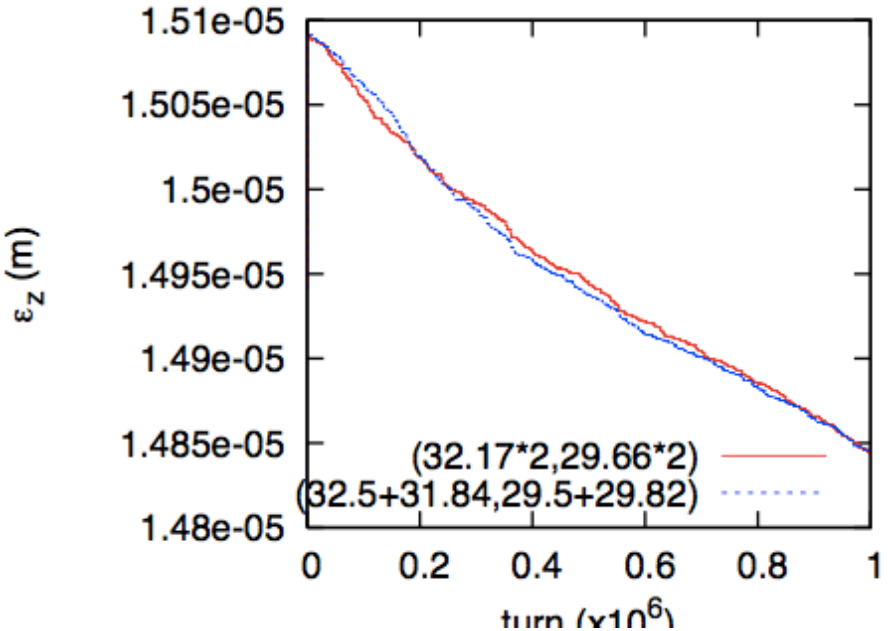




- Correlation of Strong emittance growth and bunch shortening

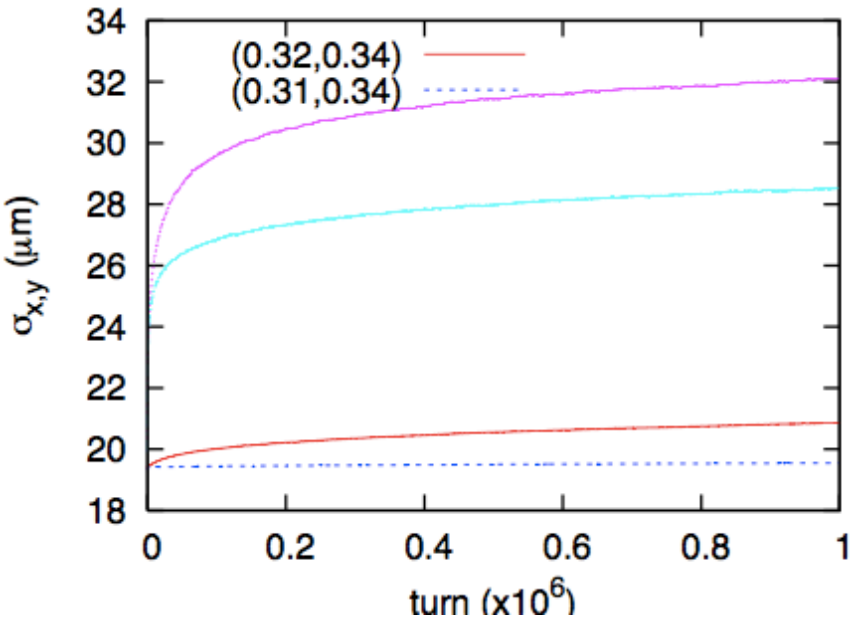
Phase difference

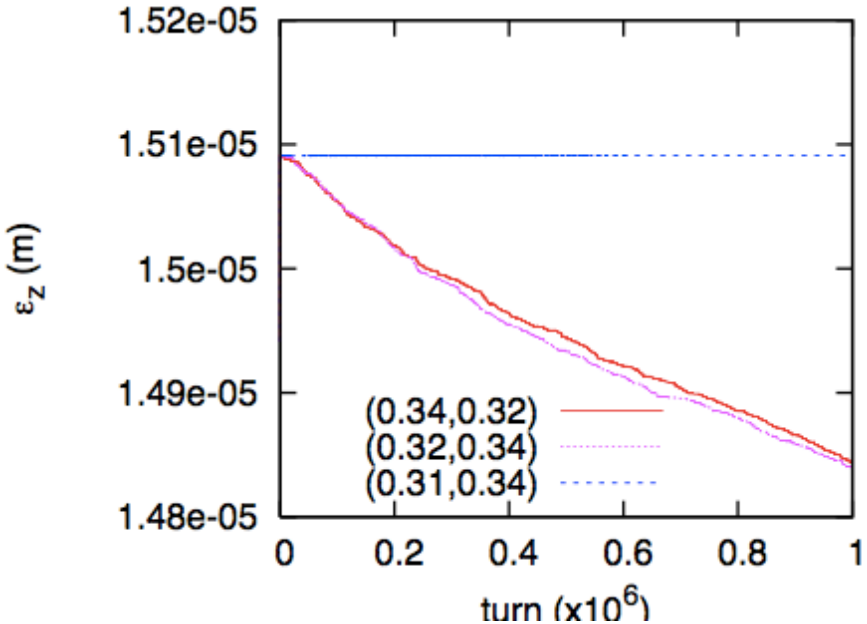




- Qx,Qy=(32.155x2, 29.66x2) or (32.5+31.81, 29.5+29.82)
- No clear difference, not sensitive for IP phase diff.

Tune sensitive?



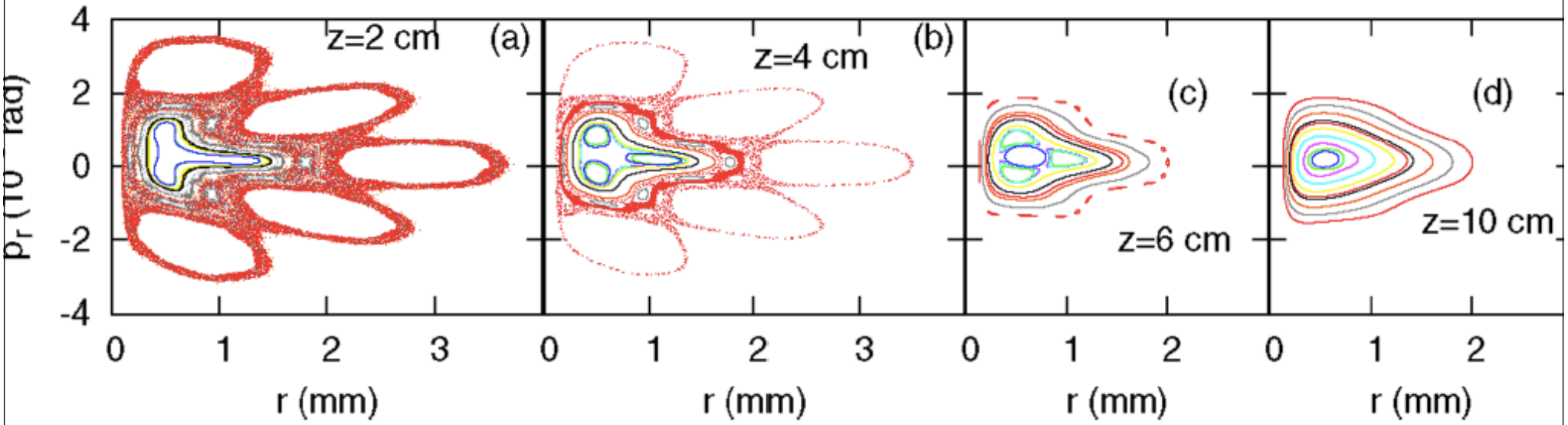


- Difference in ε_z between (0.31,0.34) and (0.32,0.34) ?

Summary

- Strong emittance growth above 3-rd order resonance.
- Synchrotron motion and z dependent beam-beam force are essential for the growth.
- Bunch shortening follows the strong emittance growth.
- Strong growth is not seen at 7-th order resonance ~0.29.
- The bunch shortening is sensitive for Qx in 3Qy=1.
- Tune of some bunches exceeds 0.33 in LHC? Electron cloud?

Note: Emittance growth- synchrotron motion



Particles diffuse during traveling between different phase space structures for z (K.O.x2, PRST10, 2007). Resonance crossing (G.Franchetti)