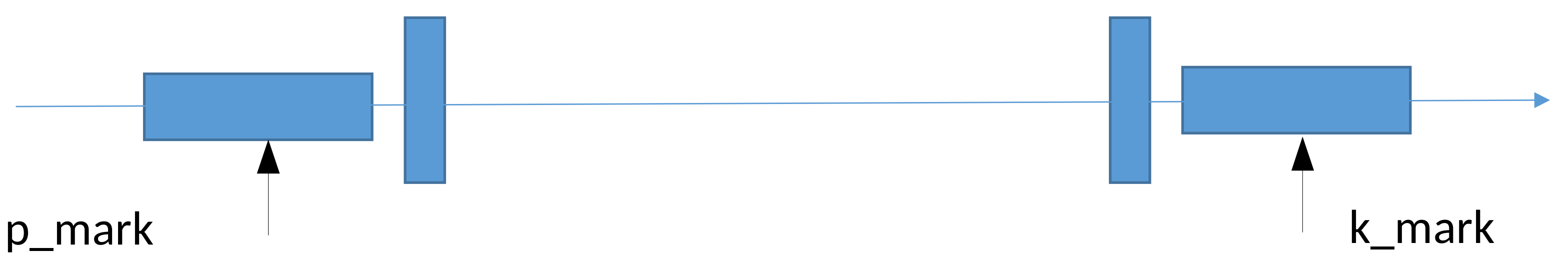
OSC simulation update

Suntao Wang

11/28/2017

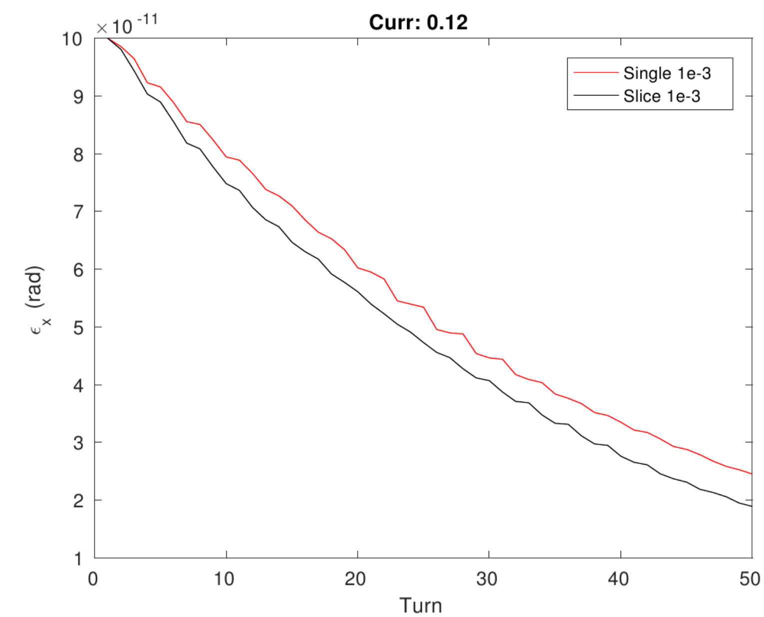
MPE's by passline:



1. $\varepsilon_{init} > \varepsilon_{max}$, no horizontal cooling and a_x>2.3 large

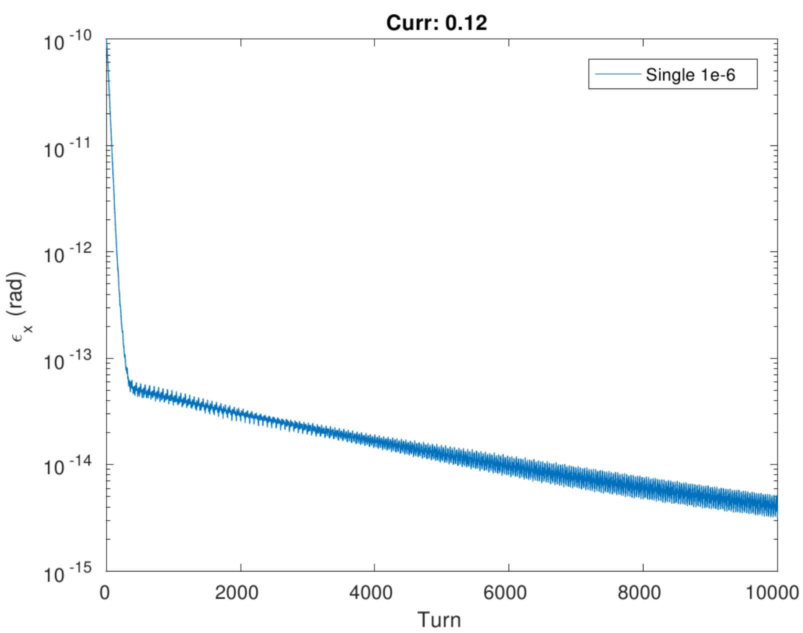
2. $\varepsilon_{init} < \varepsilon_{max}$, horizontal cooling but slow longitudinal cooling
   ε_{init}=1E-10, a_x=0.77

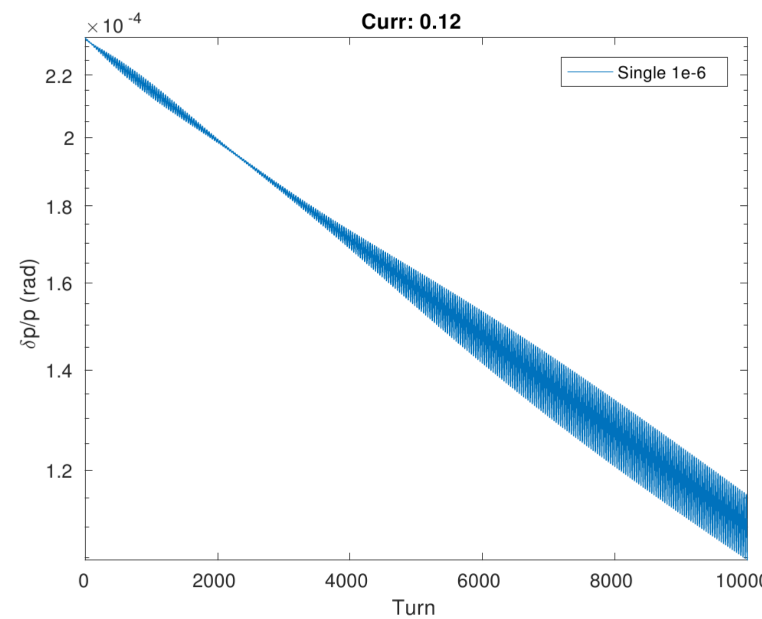
M_{51}= 1.89E-3, M_{52}= -4.09E-2, M_{56}= 1.176E-2, M_{56_T}= 5.35E-5,
undulator light wavelength: λ=1 μm, gain: ξ_0=1E-6
Cooling range: ε_{max}=9.835E-10, $(\Delta p/p)_{max}$ = 7.16E-3
Cooling rates: λ_x=3.68E-2, λ_s= 1.68E-4
Change emittance per turn: $\Delta\varepsilon$= -4.62E-11,
Path length delay: Δs < 3E-7 ($k\Delta s$ ~ 1.88)



MPE's bypass line

Excitation and damping off, ξ_0=1E-6





Horizontal: two cooling rates
1-500 turn: t_x= 32.6 turns
>500 turn: t_x=3806 turns

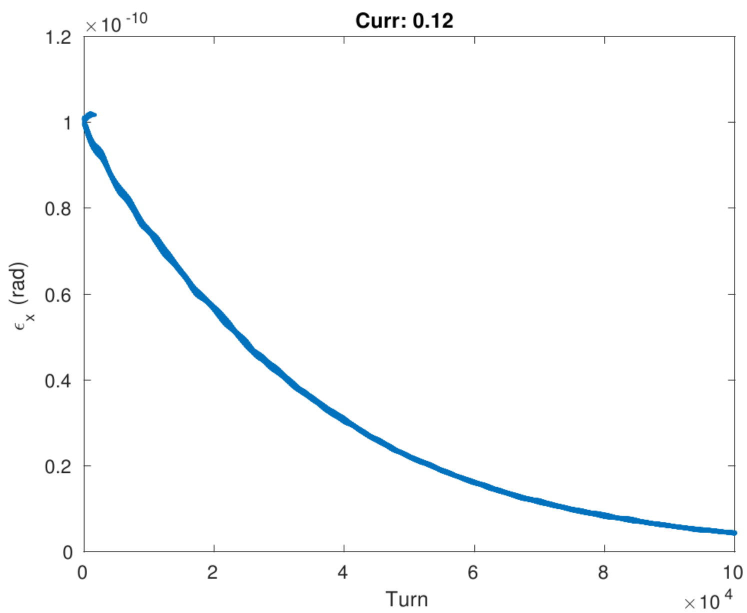
Energy cooling rate:
t_s=13390.06 turns

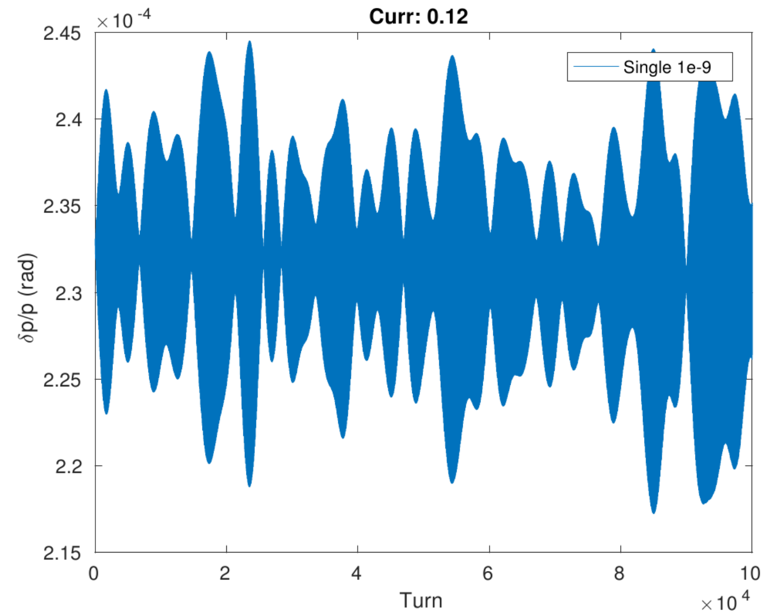
Theoretical cooling rate ratio: λ_x/λ_s=3.68E-2/1.68E-4 = 219

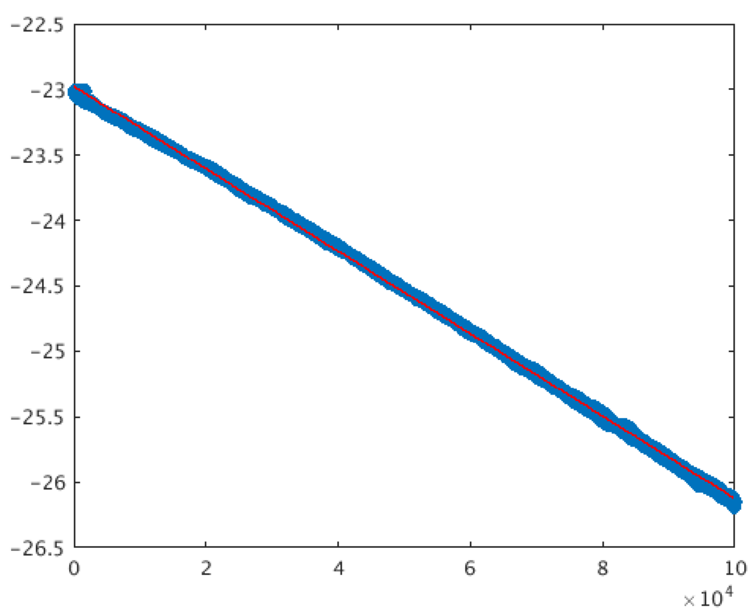
Tracking: t_s/t_x= 410.7

MPE's bypass line

Excitation and damping off, ξ_0=1E-9







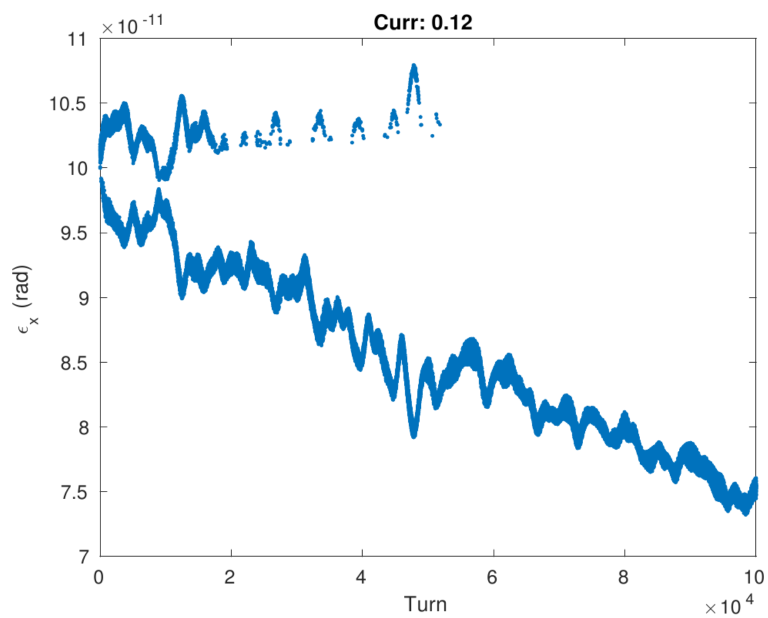
Horizontal cooling rate:
t_x= 3.1E4 turns

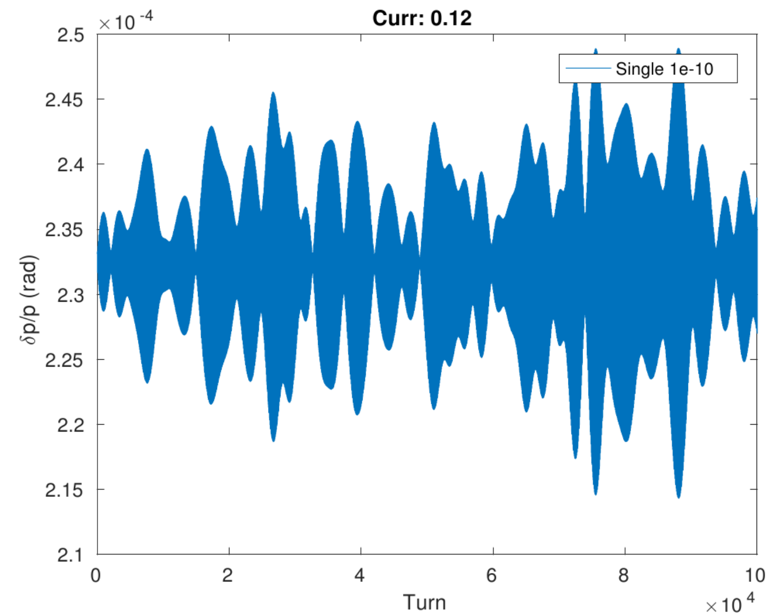
1000 times slower than ξ_0=1E-6 case

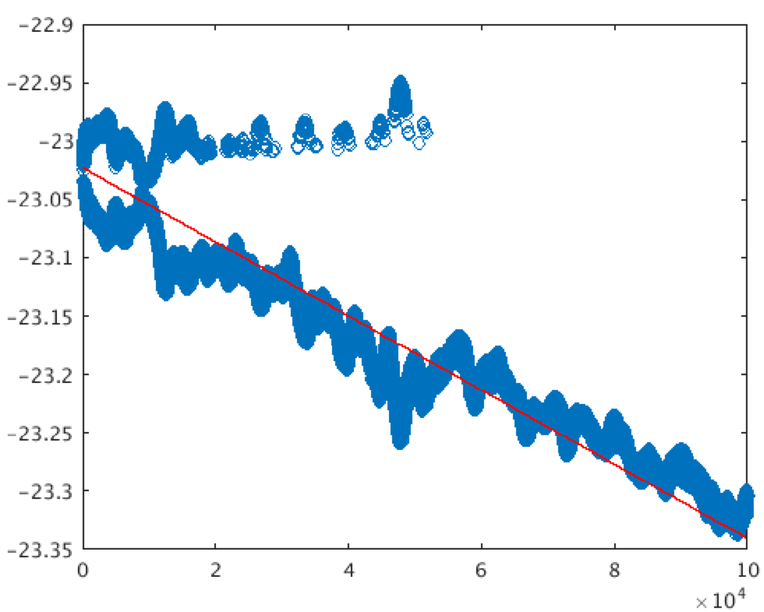
No longitudinal cooling

MPE's bypass line

Excitation and damping off, ξ_0=1E-10







Horizontal cooling rate:
t_x= 3.3E5 turns

1E4 times slower than ξ_0=1E-6 case

No longitudinal cooling

Energy lost due to quantum excitation and damping: $\Delta p_z = \frac{\Delta E}{E_0} = -k_E\,(1+p_z)$

$$k_E = k_d + k_f \qquad k_d \equiv \frac{2\,r_e}{3}\,\gamma_0^3\,\langle g_0^2\rangle\,L_p\,(1+p_z)$$

$$k_f \equiv \left(\frac{55\,r_e\,\hbar\,c}{24\sqrt{3}\,m_e}\,L_p\,\gamma_0^5\,\langle g_0^3\rangle\right)^{1/2}\,(1+p_z)\,\xi$$

For a normal CESR bend at 0.5 GeV: k_d~3.37E-9, k_f~6.5E-9*R

R is a Gaussian distributed random number with unit sigma and zero mean.

$\frac{\Delta p}{p} = -\xi \sin(k\,\Delta s)$

To observe OSC cooling effect over SR damping: $\xi > k_E$ ~ 1E8

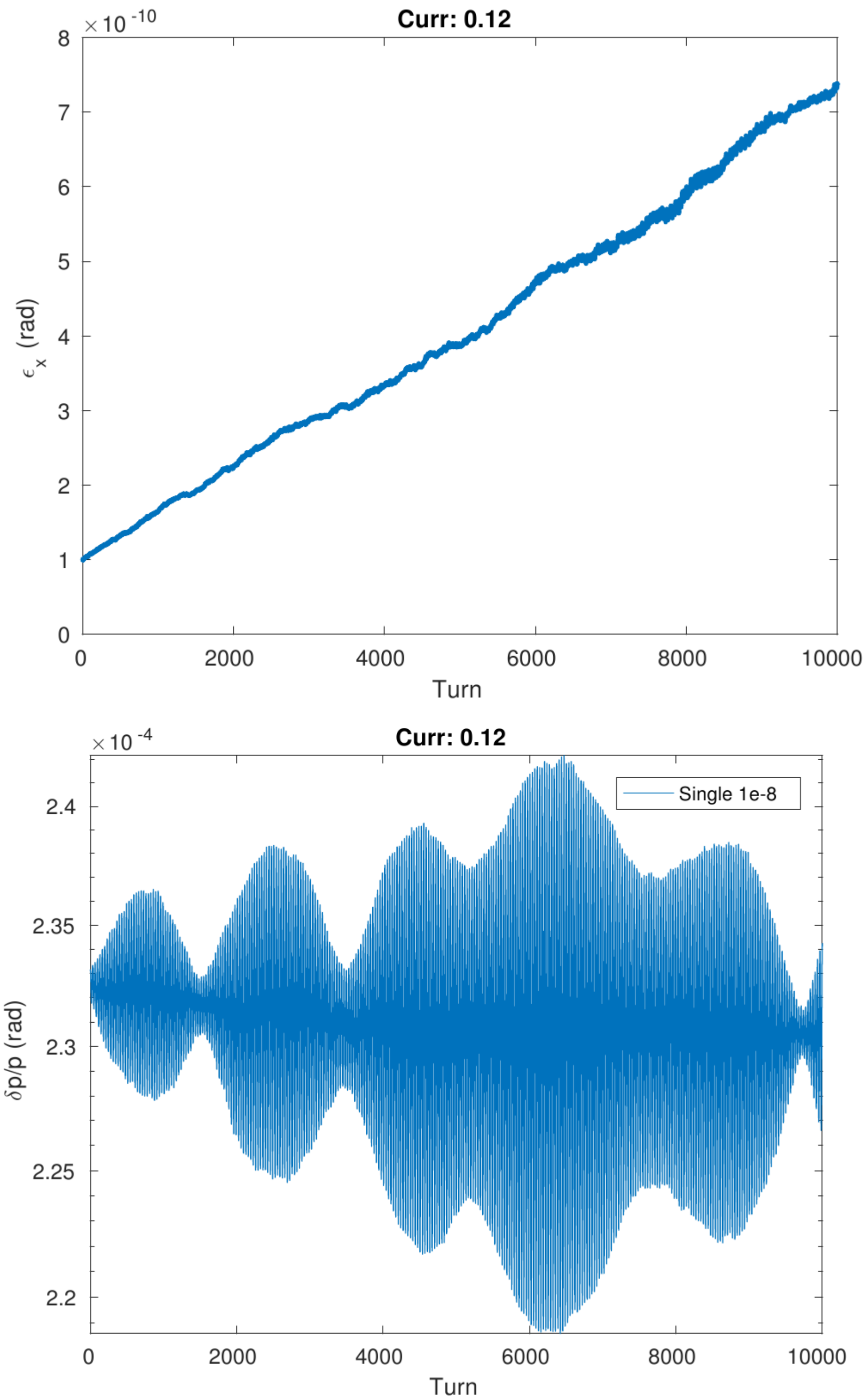
Estimate the passive cooling ξ:

For a single electron: ΔE=80meV, E=0.5GeV, $\xi \sim \Delta E/E$ ~ 2E-10

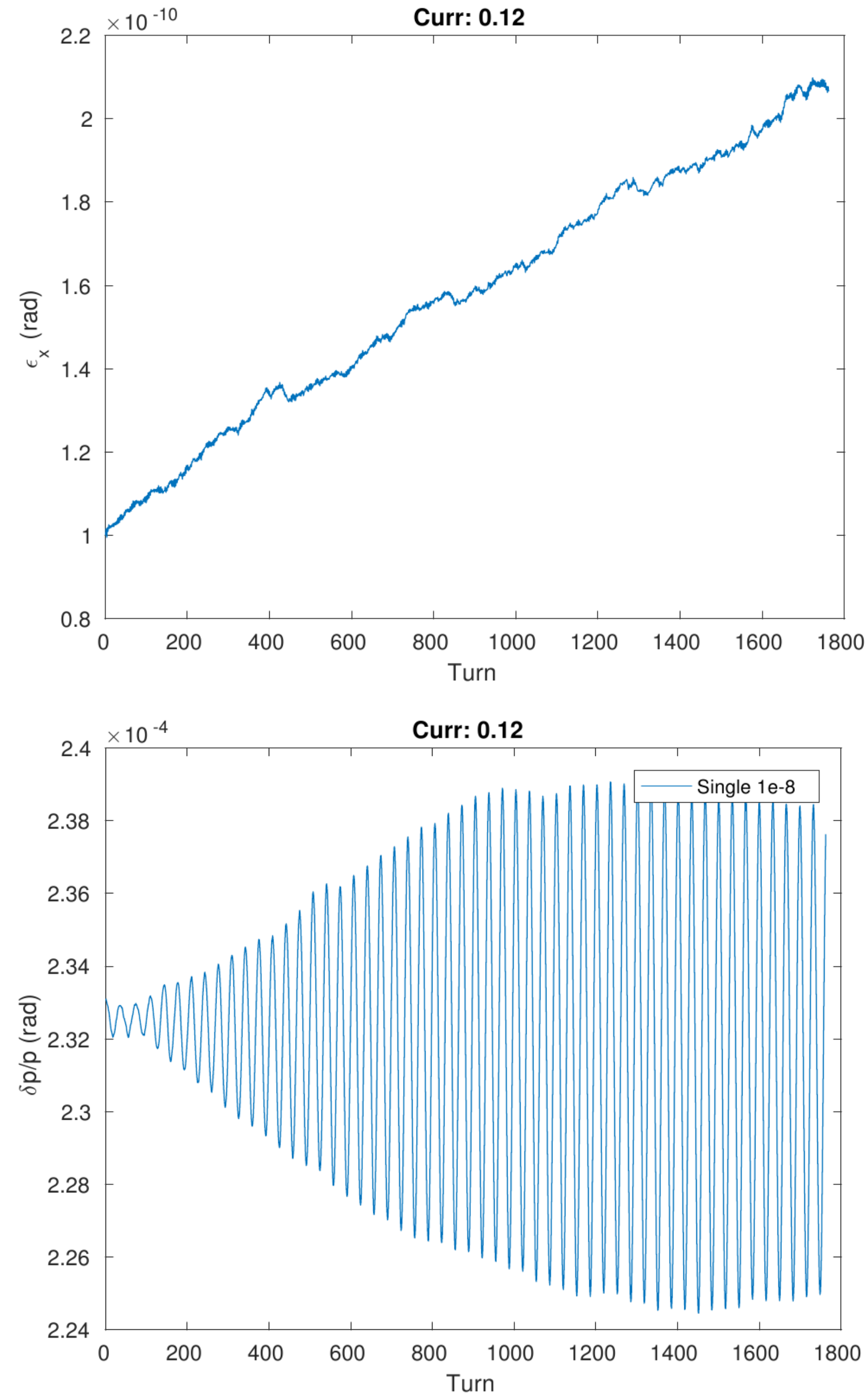
Optical amplifier Gain > 1E8/2E-10 = 50 (>17 dB)

Reasonable?

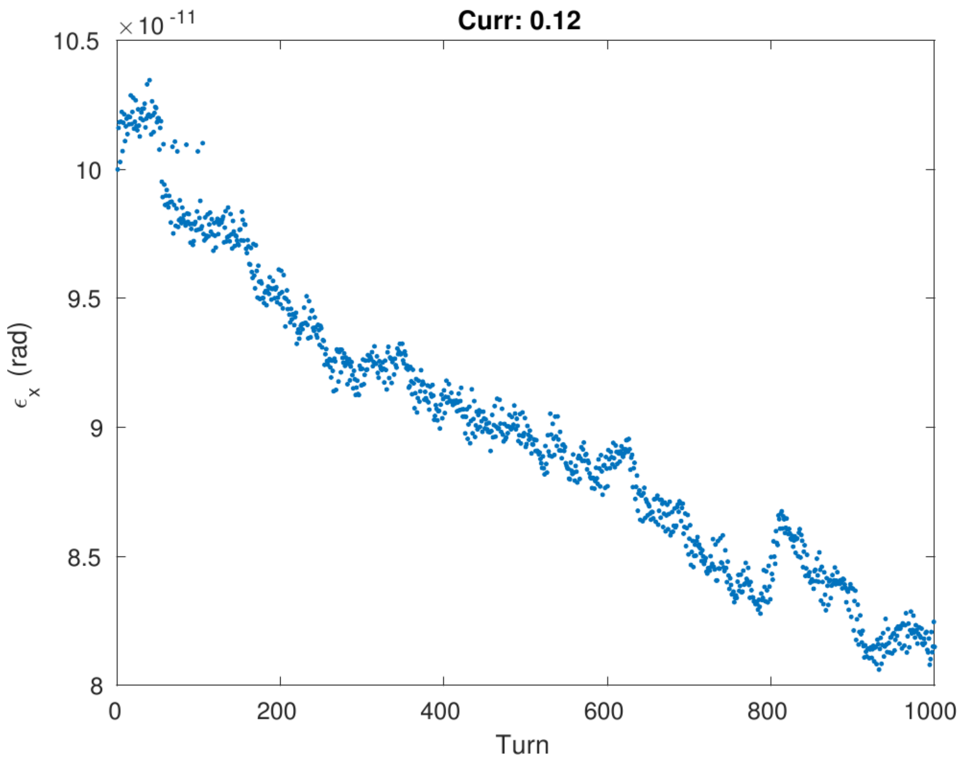
Excitation and damping on, ξ_0=1E-8

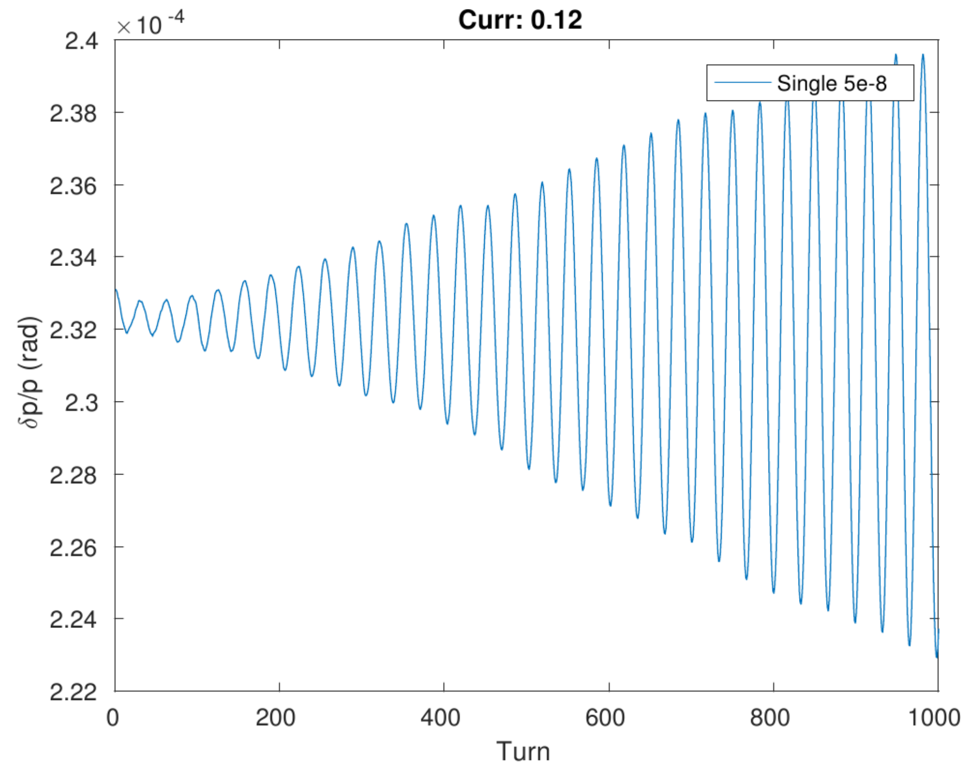


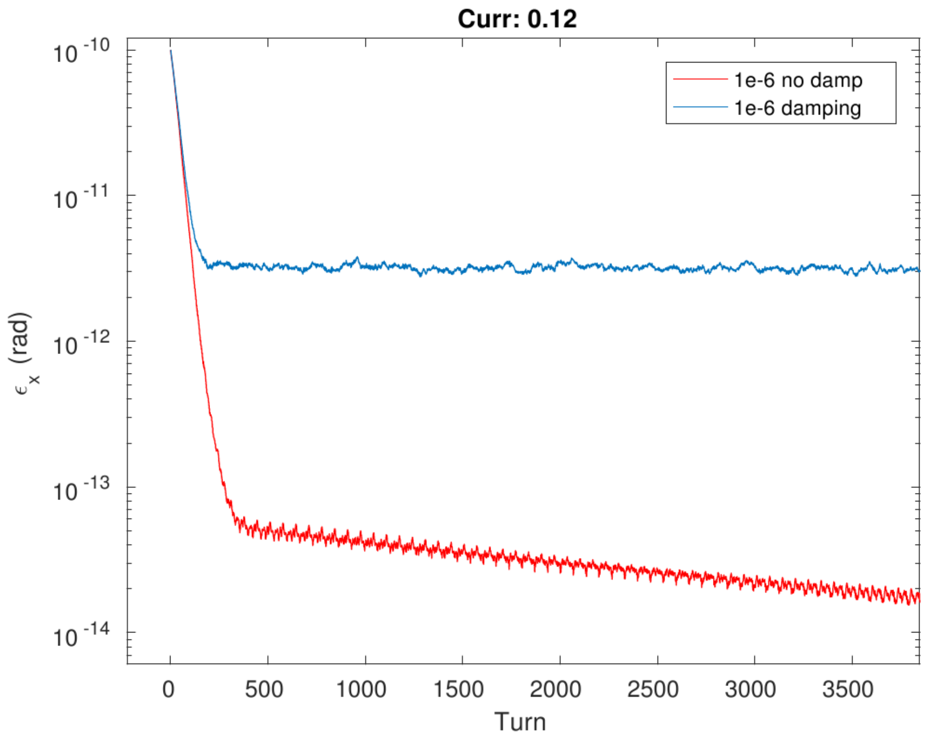
Only excitation on, ξ_0=1E-8



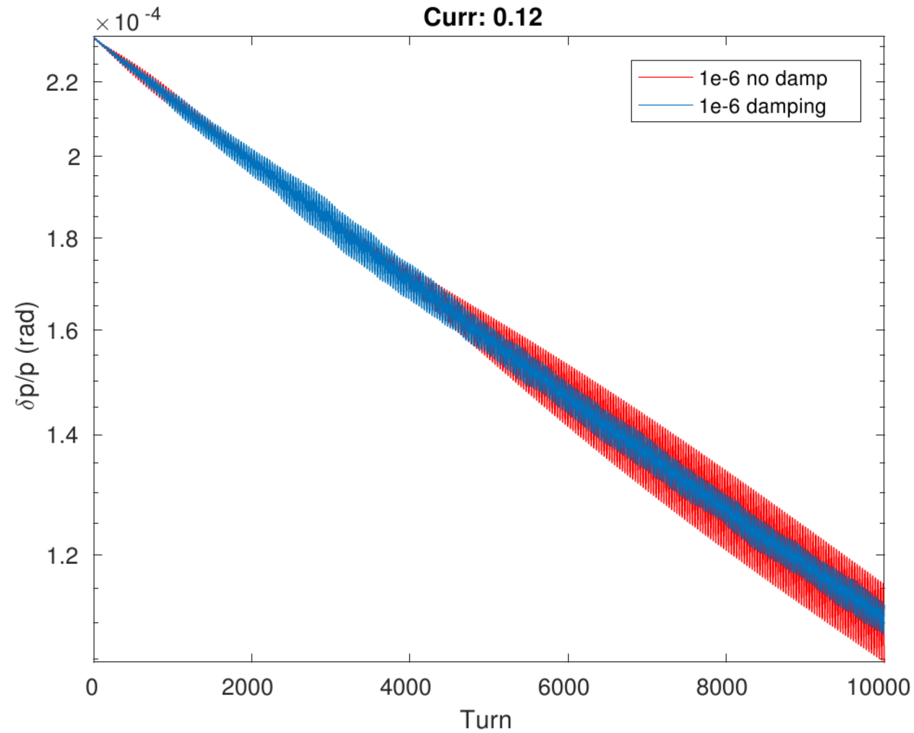
Excitation and damping on, ξ_0=5E-8







Horizontal cooling rate
1-100 turn: t_x= 38 turns



Longitudinal cooling rate:
t_s=13390.06 turns