OSC simulation update

Suntao Wang

1. Estimate the optical amplifier gain
2. Compare to the theoretical G value

1/30/2018

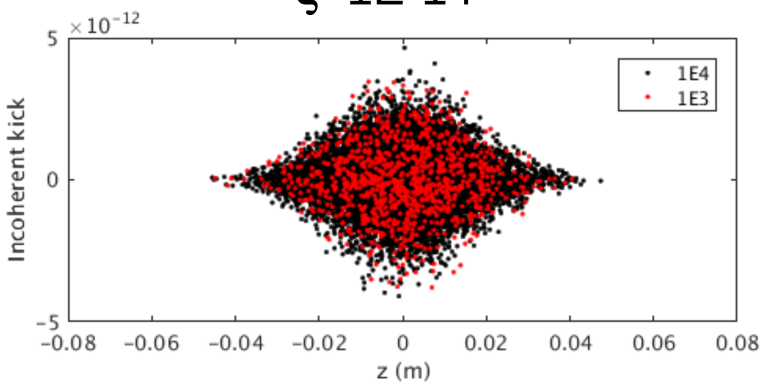
Gaussian distribution for incoherent kicks

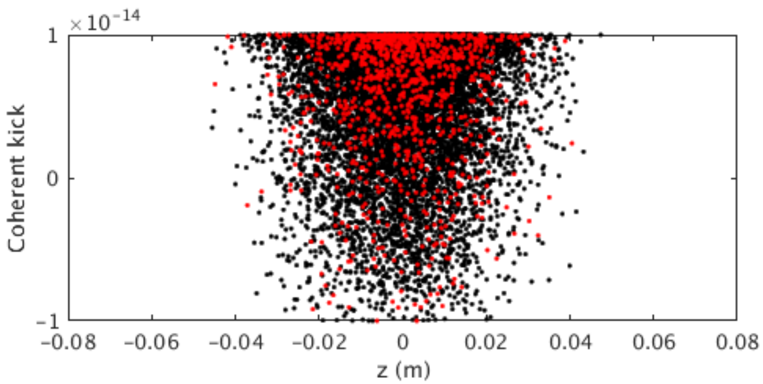
500MeV lattice with MPE's first bypass matched to CESR

Track 1E3 particles for 1E5 turns
Each particle got a coherent and incoherent kick

$$\delta_{ic} = \delta_i + G\,\sin(\Delta\phi_i) + G\sum_{k\neq i}^{N_s}\sin(\Delta\phi_i + \psi_{ik})\ .$$

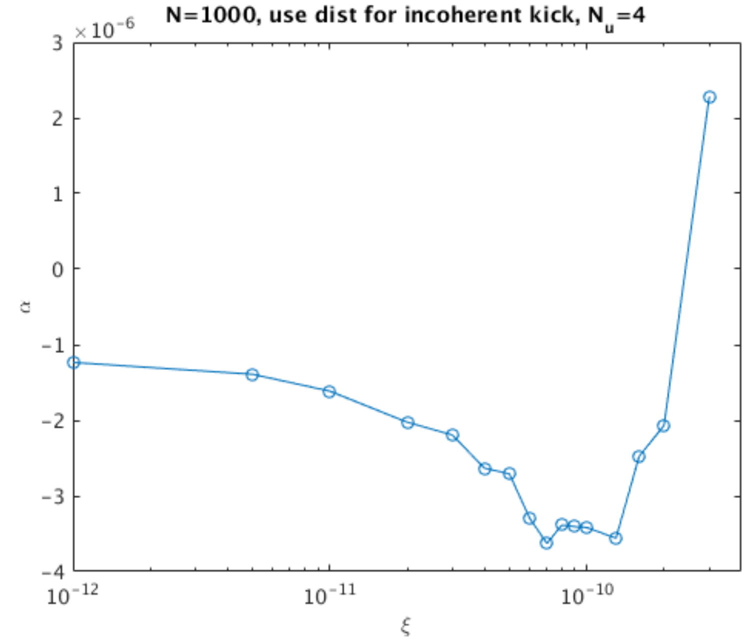
ξ=1E-14

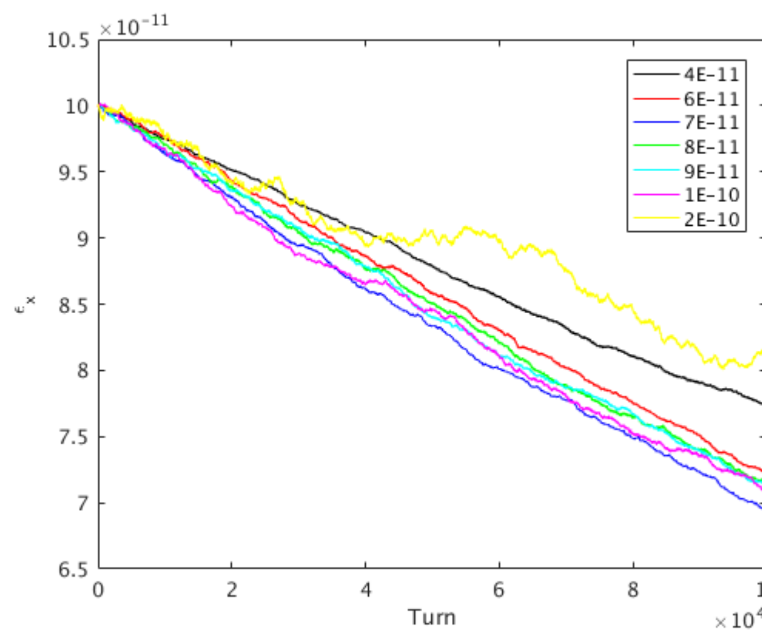




α=3.63E-6, N_u=4 @ G=1.3E-10

> α_x=6.0E-7 (ring)





Gain of the Optical Amplifier

$G = \mathrm{sqrt}(g)\ \Delta E/E_0$

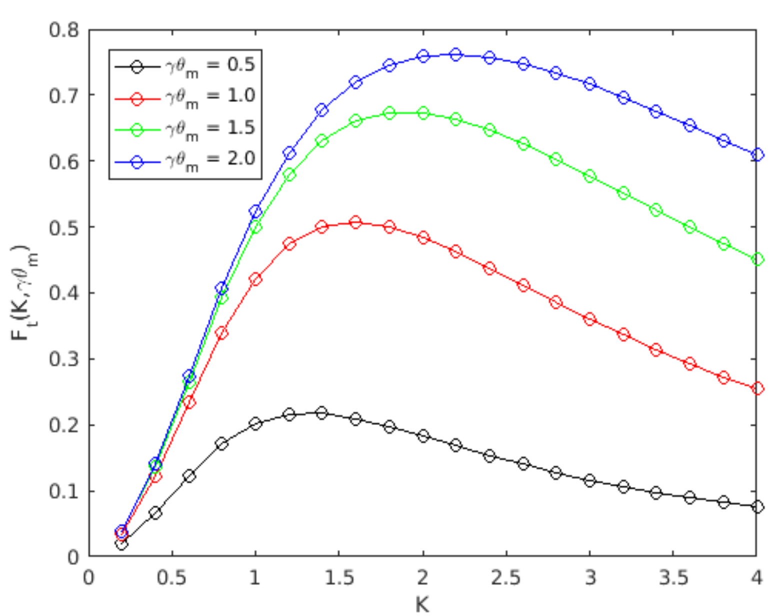
g: Gain of the Optical Amplifier
ΔE: energy gain of a single electron at the kicker undulator
E_0: beam energy

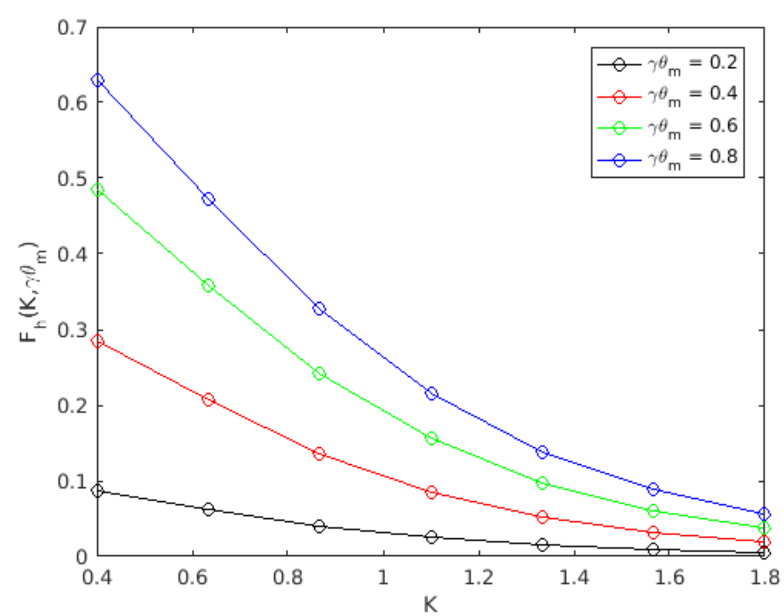
$\Delta E = 2\pi\alpha_F N_u \varepsilon_0 F_t(K,\gamma\theta_m)/3$

(Eq. 50 in Lebedev's paper)

α_F: the fine structure constant (1/137.036)
ε_0: undulator 1st harmonic photon energy
K: undulator deflection parameter
θ_m: Optical lens acceptance angle

$F_t(K,\gamma\theta_m) = K^2(1+K^2/2)F_h(K,\gamma\theta_m)F_u(K)$





Consider CESR: E_0=500MeV, K=2.8, N_u=4, λ_u=0.4, λ=1μm
$\gamma\theta_m$=1 => ΔE=28.4 meV, $\Delta E/E_0$=5.68E-11 , g=5.24
$\gamma\theta_m$=inf => ΔE=64.4 meV, $\Delta E/E_0$=1.28E-11 , g=1.02 , almost passive mode

Compare to theoretical value

SY Lee's paper: $\delta P_i/P = -[\mathrm{sgn}(I_D)]\,G\sin(\Delta\phi_i),\qquad \Delta\phi_i = k(\ell_i - \ell_0) = k\,[x_i I_1 + x_i' I_2 + \delta_i I_D]$

Cooling when $I_p>0$ ($I_D>0$)

$$I_\perp = -\frac{\beta_1}{\beta_2}\left\{P_{D2}\left[\left((\beta_2 M_{21}+\alpha_2 M_{11}) - \frac{\alpha_1}{\beta_1}(\beta_2 M_{22}+\alpha_2 M_{12})\right)(I_1 - \frac{\alpha_1}{\beta_1}I_2) + \frac{1}{\beta_1^2}(\beta_2 M_{22}+\alpha_2 M_{12})I_2\right] + D_2\left[(M_{11}-\frac{\alpha_1}{\beta_1}M_{12})(I_1-\frac{\alpha_1}{\beta_1}I_2) + \frac{1}{\beta_1^2}M_{12}I_2\right]\right\}$$

Optimum gain factor: $G_x = \frac{2kI_\perp\epsilon_x}{N_s\mathcal{H}_2}e^{-u}\qquad u = \frac{1}{2}k^2[(\beta_1 I_1^2 - 2\alpha_1 I_1 I_2 + \gamma_1 I_2^2)\epsilon_x + I_D^2\sigma_\delta^2]$.

Pickup: β_1=11.41, α_1=-0.6420, γ_1=0.1237, η_1=0.2430, η'_1=0.2970
Kicker: β_2=26.07, α_2=0.1216, γ_2=0.0389, η_2=2.6740, η'_2=-0.1702

Lebdev's formula:

$$s = M_{51}x + M_{52}\theta_x + M_{56}(\Delta p/p)$$

Pickup to kicker transfer matrix elements:
M_{11}=-1.792, M_{12}=10.287, M_{21}=3.654E-3, M_{22}=-0.5791
M_{51}=1.9108e-3, M_{52}=-4.1053E-2, M_{56}=1.176E-2

σ_δ=2.331E-4, ε_x=0.1 nm, N_s=1.6E5, λ=1E-6, k=$2\pi/\lambda$

→ Ip=1.173E-2 u=0.295 + 148.33

Without exp(-u) term, G_x=1E-10
With exp(-0.295) term, G_x=7.5E-11
With exp(-148.33) term, G_x~0