STATISTICAL FLUCTUATIONS OF COOPERATIVE QUASI-CHERENKOV RADIATION

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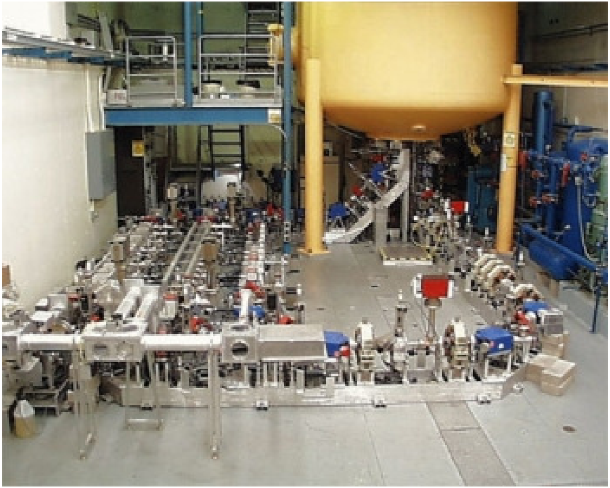
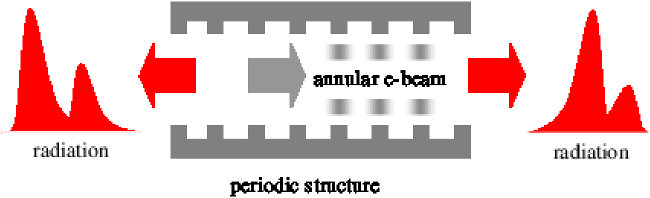
THz sources

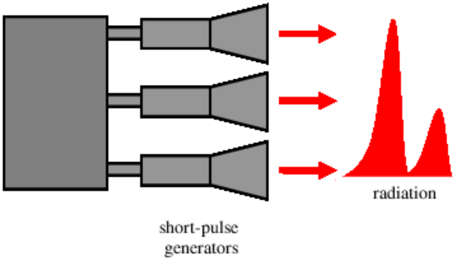


The Cherenkov FEL [1]



[1] S.V. Anishchenko, V.G. Baryshevsky, Nucl. Instrum. Methods B355 (2015) 76–80.

Statement of the problem[2]



[2] Jinchuan Ju et al. Scientific reports 6, 30657 (2016); N.S. Ginzburg et. al. Phys. Rev. Lett. 115, 114802 (2015)

Nonlinear theory[3]

$$\frac{\partial^2\theta_\phi}{\partial\zeta^2} = -L^2\left(1+\frac{\nu}{L}\frac{\partial\theta_\phi}{\partial\zeta}\right)^{3/2} Re(Fe^{i\theta_\phi}), \frac{\partial F}{\partial\tau} - \frac{\partial F}{\partial\zeta} = -\frac{L}{\pi}\int_0^{2\pi} e^{-i\theta_\phi} d\phi,$$

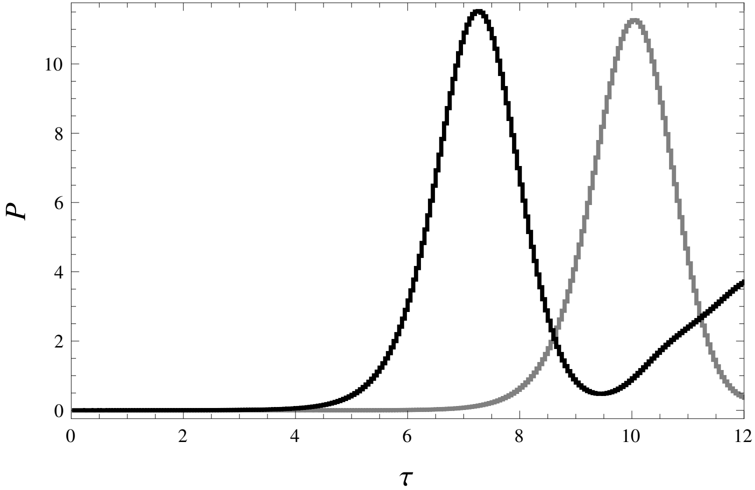
$$\theta|_{\zeta=0} = \phi + \delta_\phi \cos(\phi) + \Delta_{Penman-McNeil},$$

$$\frac{\partial\theta}{\partial\zeta}|_{\zeta=0} = 0, F(1,\tau) = 0.$$

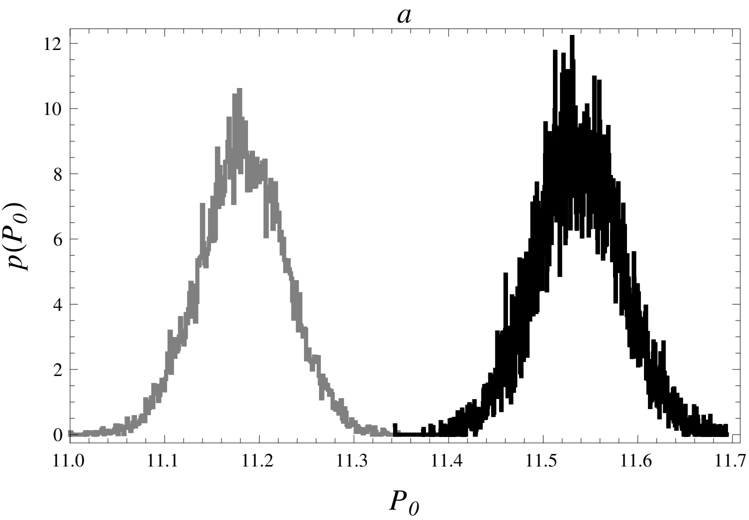
Here, δ_ϕ is the premodulation parameter, L is the normalized generator length, and $\nu = 2C(\gamma_0^2 - 1)$ (C is the amplification parameter, γ_0 is the Lorentz factor)

[3] S.V. Anishchenko, V.G. Baryshevsky Nucl. Instrum. Methods B https://doi.org/10.1016/j.nimb.2017.03.055 (2017); N.S. Ginzburg, S.P. Kuznecov, T.N. Fedoseeva, Radiophys. Quantum Electron. 21 (1978) 728–739; C. Penman, B.W.J. McNeil, Opt. Commun. 90 (1992) 82–84

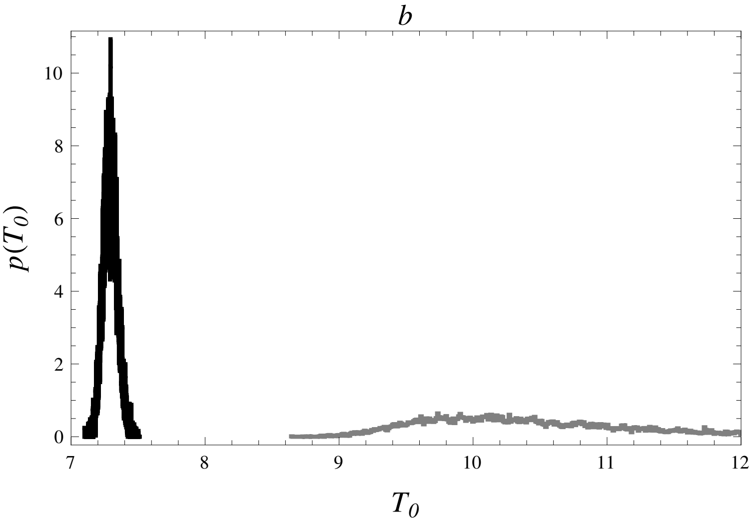
Radiation pulses ($L = 4$, $N_e = 1.08 \cdot 10^6$, $\delta_\phi = 0.05$)



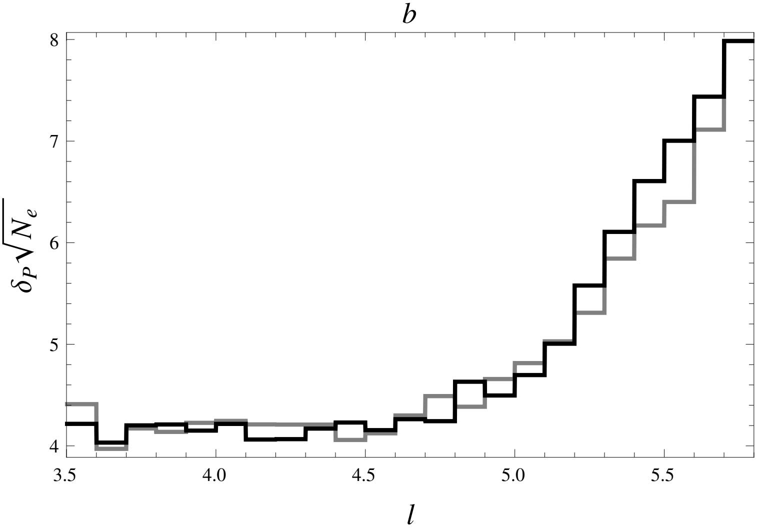
Peak power distribution



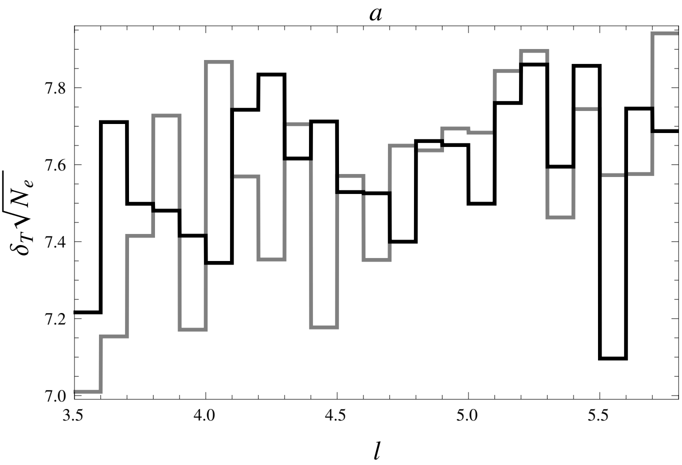
Instability growth time



Power spread ($\delta_\phi = 0.05$)



Time spread $(\delta_\phi = 0.05)$[4]

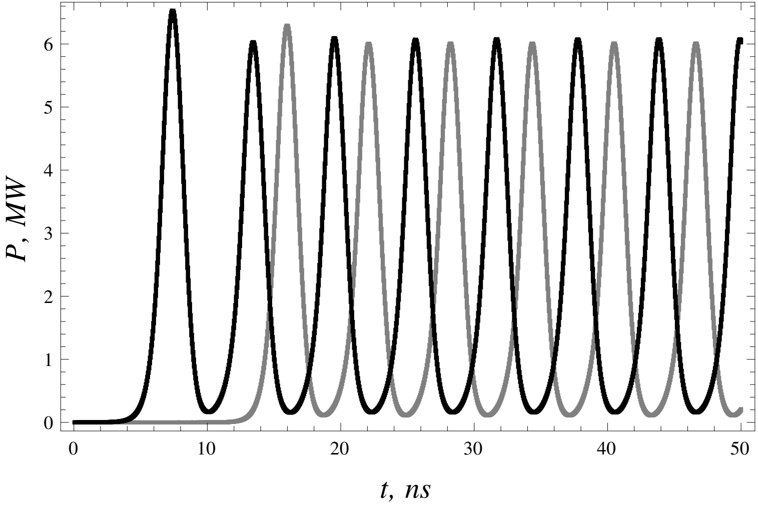


[4] Similar to the ensemble of nonisochronous electron-oscillators (S.V. Anishchenko, V.G. Baryshevsky, Tech. Phys. 61 (2016) 934–937.)

Acceleration facilities

- The UCSB electrostatic accelerator
  G. Ramian, Nucl. Instrum. Methods A318 (1992) 225–229.
  $I = 2$ A, $eU = 6$ MeV
- The Israeli electrostatic accelerator
  $I = 1 - 2$ A, $eU = 1 - 3$ MeV
  A. Gover et al., Nucl. Instrum. Methods A528 (2004) 23–27.

Repetitive mode



Simulation results ($\delta_\phi = 0.05$)

- Repetition rate: 170 MHz
- Radiation freaquency: 1 THz
- HWHM of each pulse: 2 ns
- Peak power: 6 MW
- The number of particles: $7 \cdot 10^9$
- Timing jitter: 1 ps

Conclusions

- For a nonstationary operation regime, it has been shown that the relative root-mean-square deviations of peak radiated power and instability growth time are $\delta_P \approx 4.2/\sqrt{N_e}$ and $\delta_T \approx 1.4/\ln N_e$, respectively.
- We show that when the degree of premodulation exceeds a certain value depending on the number of particles, the logarithmic dependence of the relative RMSD of the instability growth time on the number of electrons ($\delta_T \sim 1/\ln N_e$) goes to a square-root dependence ($\delta_T \sim 1/\sqrt{N_e}$).
- A nonstationary low-noise quasi-Cherenkov generator can operate at a 170 MHz repeatition rate. Peak radiated power of about 6 MW is obtained in simulations for a 6 MeV 2 A electron beam avaible with modern acceleration facilities.

Thank you for the attention!