FEL Simulations of Energy-Chirped Bunches

Some Numerical Tests

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S2E Meeting

DESY

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Motivation

\[ \lambda_r = \frac{\lambda_u}{2 \gamma_r^2} \left( 1 + \frac{K^2}{2} \right) \]

- transverse field \textit{(slowly-varying envelope approximation)}

\[ E(\vec{r}, t) = \tilde{E}(\vec{r}, t) \exp(ik_0(z - ct)) + c.c. \]

\[ E = E_x + iE_y \]

\[ \left[ \nabla_\perp^2 + 2ik_0 \left( \frac{\partial}{\partial z} + \frac{1}{c} \frac{\partial}{\partial t} \right) \right] \tilde{E} = ik_0 \mu_0 c \frac{K}{\gamma} \tilde{j}_1 \]
Motivation

\[ \delta_E \quad \text{Phase space} \]

\[ Q = 500 \text{ pC} \]

\[ \gamma_r = \langle \gamma \rangle ? \]

\[ \lambda_0 = \lambda_r ? \]
Figure 1. Spectral power versus $\lambda - \lambda_0$ for a series of LCLS-like GINGER simulations for different shifts of $\lambda_0$ from the wavelength $\lambda_r$ corresponding to FEL resonance (0.15000 nm for these runs).
SASE Simulations (FLASH1 Parameters)

**Spectrum (averaged over 100 shots)**

\[
S(\lambda)[\text{a.u}] = 10^{10}
\]

\[
\lambda_0 = \lambda_r
\]

\[
\frac{\lambda_0 - \lambda_r}{\lambda_r} = 40\rho
\]

\[
\frac{\lambda - \lambda_r}{\lambda_r\rho}
\]
SASE Simulations

\[ S(\lambda) [\text{a.u}] \]

\[ \lambda_r - \lambda \]

\[ \lambda_r \rho \]
SASE Simulations

\[ S(\lambda)[\text{a.u.}] \]

\[ \frac{\lambda_0 - \lambda_r}{\lambda_r} \pm 20 \rho \]

\[ \lambda [\text{nm}] \]

Error in spectrum
\[
\left| \frac{W - W_0}{W_0} \right| \text{ [%]}
\]

**Error in energy**

\[ \frac{\lambda_r - \lambda_0}{\lambda_r \rho} \]