# OSC at 1 GeV

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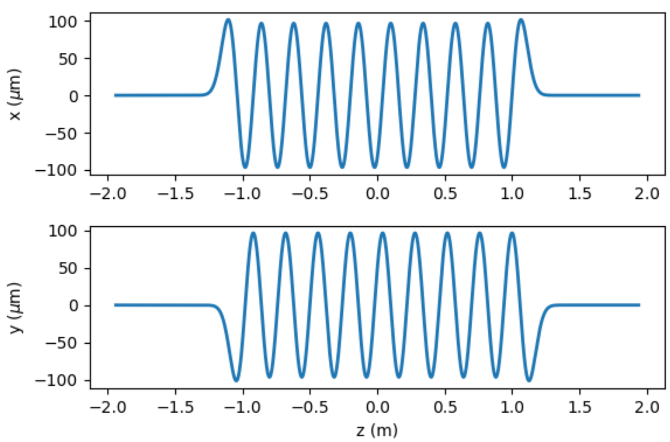
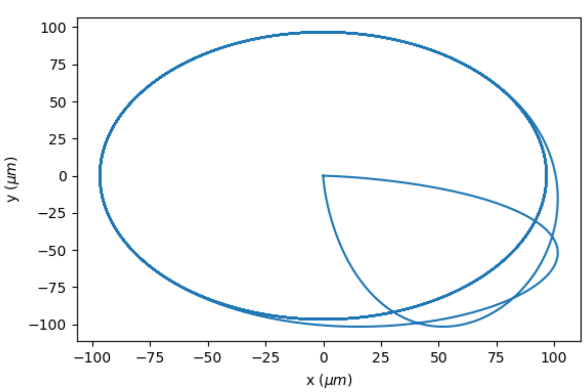
A switch to helical undulator in order to operate with larger wavelength for same K and physical undulator properties (length, periods)

planar $$\lambda_o = \frac{\lambda_u}{2\gamma^2}(1 + 1/2K^2)$$

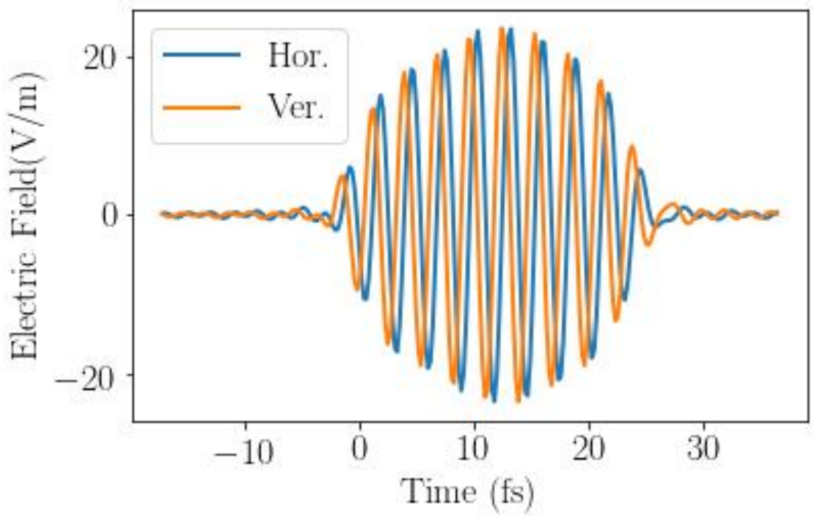
helical $$\lambda_o = \frac{\lambda_u}{2\gamma^2}(1 + K^2)$$



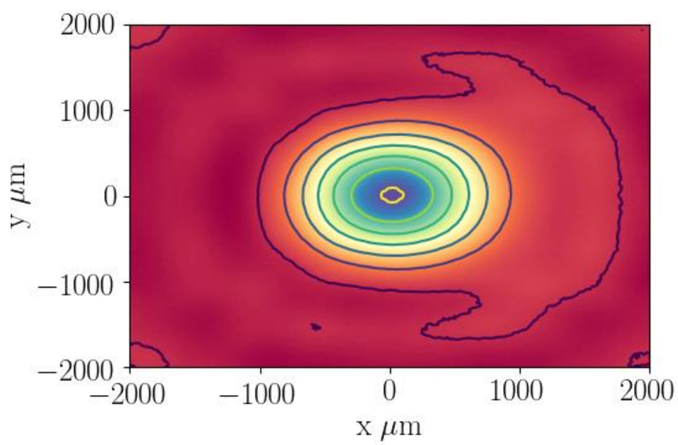

| Parameter | Value |
|---|---|
| Length (m) | 2.4 |
| Period (cm) | 24 |
| K | 4.95 |
| X-Y phase | π/2 |
| γ | 1957 |

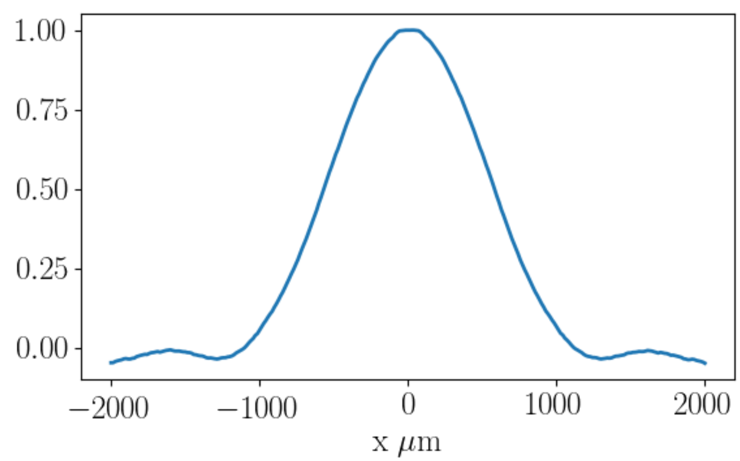
# Field in the kicker center with SRW




Wave-packet has two polarizations
90 degrees out of phase.

Particle rotates ~100 µm off axis. Field reduces <1%.

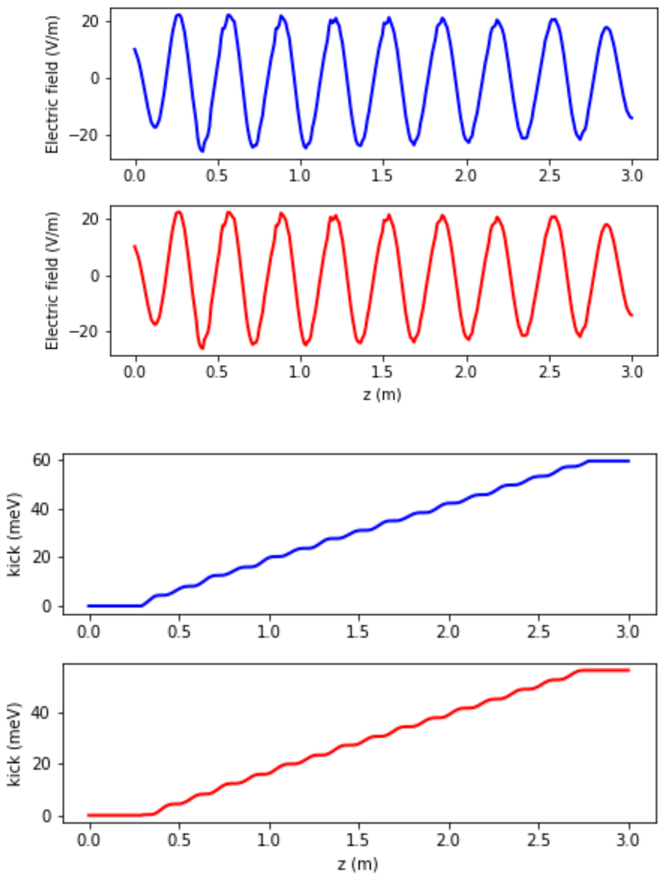


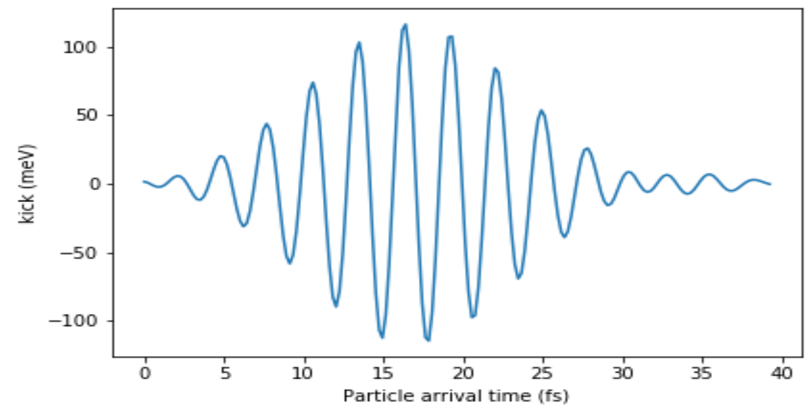



# Helical kick calculation example:

$$\Delta\mathcal{E} = \frac{q}{c}\int \boldsymbol{E}(z,x,y)\cdot\boldsymbol{v}(z)dz \qquad v_x = \frac{c}{K\gamma}\sin(k_p z)$$

$$v_y = \frac{c}{K\gamma}\cos(k_p z)$$



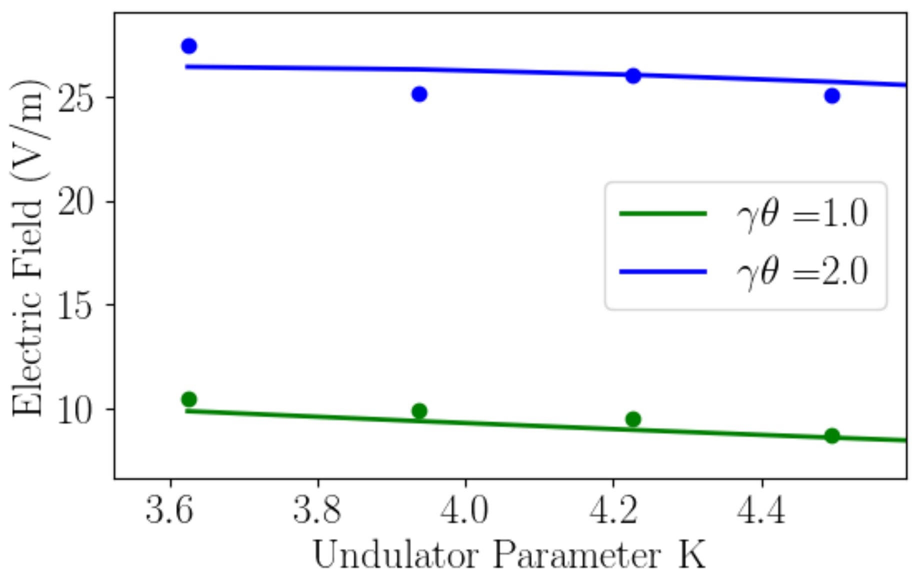



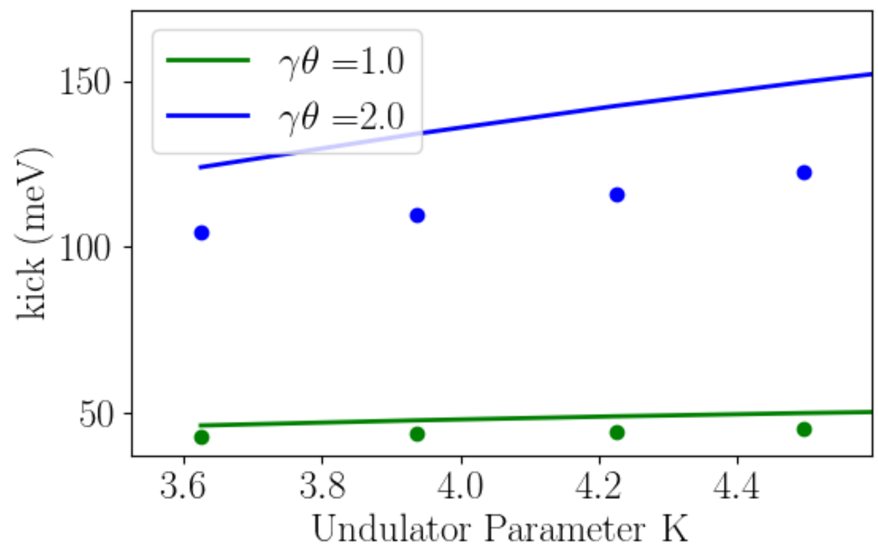

Notice initial arrival time between pulse and particle needs to be ~20 fs before any effect on the beam will be observed.

Chicane delay of 2 mm=7 ps. This corresponds to an initial accuracy of ~0.3%.

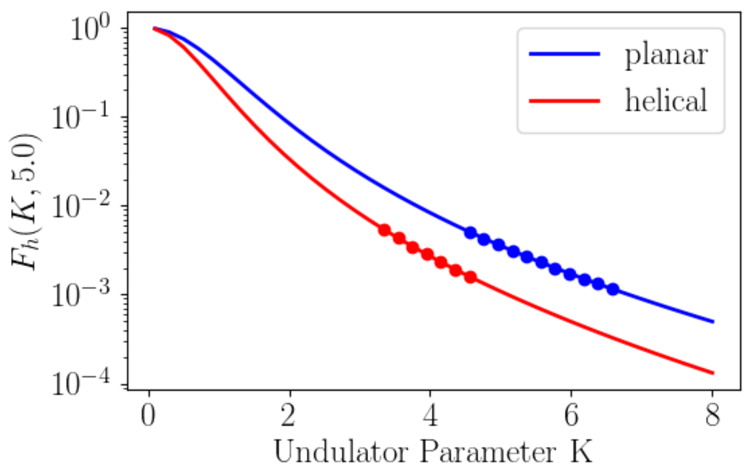
Fine tuning of timing done with light optics.

# SRW simulations and theory



# Planar vs Helical



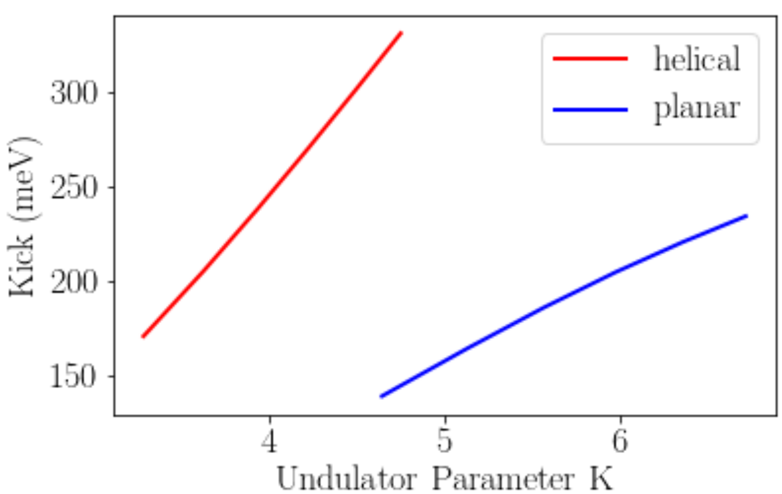

$$\Delta\mathcal{E} = \Delta\mathcal{E}_{tot} F_h(K, \gamma\theta_m) F_u(\kappa)$$

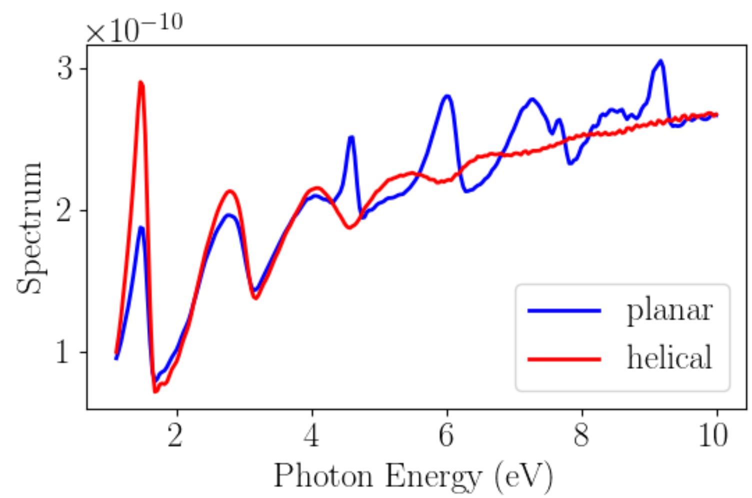
$F_h(K,\gamma\theta_m)$ are defined differently for helical and planar undulators.
For the helical $F_u$ =1 since there is no longitudinal oscillation for a helical undulator.

**A switch to helical undulator results in**

- moderate improvement in kick while using a smaller K.
- Slight increase in longitudinal diagnostic visibility.

- Is there any improvement to emittance contributions?




All polarizations. 8 period undulator used as example.

$$\lambda_p + \lambda_x = \frac{k_o M_{56}}{2\tau_s}\frac{\Delta\mathcal{E}}{U_s}$$

$$a_p = k\left(M_{51}D + M_{52}D' + M_{56}\right)\left(\frac{\Delta p}{p}\right)$$

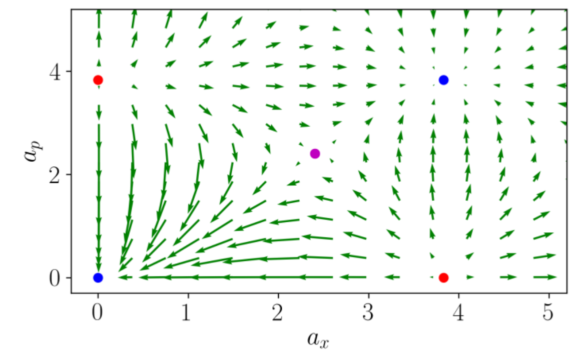
$$a_x = k_0\sqrt{\tilde{\varepsilon}\left(\beta M_{51}^2 - 2\alpha M_{51}M_{52} + \left(1+\alpha^2\right)M_{52}^2/\beta\right)}$$

$$n_{\sigma s} \approx \frac{\mu_{01}}{\left(2\Delta s - \Phi D^* h\right)k_0\sigma_p} \qquad n_{\sigma x} \approx \frac{\mu_{01}}{2k_0 h\Phi\sqrt{\varepsilon\beta^*}}$$

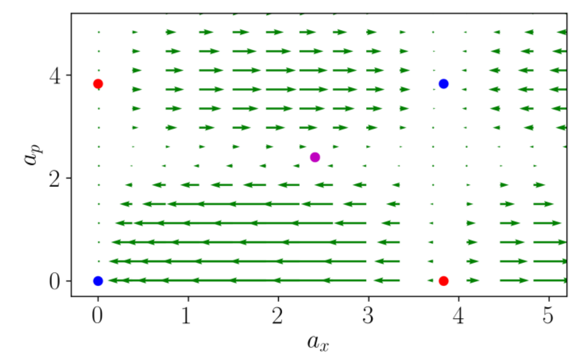
**For pure horizontal cooling use $\mu_{o1}$=2.40.**

**For pure longitudinal cooling if $M_{51}$ and $M_{52}$ can be made zero, $\mu_{o1}$ can be replaced with $\mu_{11}$=3.83.**

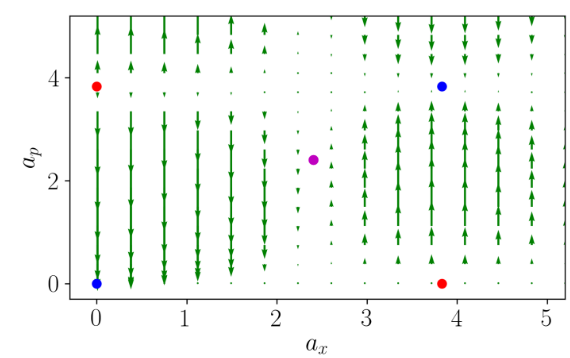
Questions: When we cool the beam IBS will increase as the beam density increases. Are IBS contributions coming equally from all three planes? If we damp in only one plane will we cause growth in the other plane?



Cooling in both planes



Cooling transversely



Cooling longitudinally