FEL Timing Jitter Compensation???

W. Fawley, Z. Huang, Y. Ding, etc. etc.
(the more the merrier!)

LCLS-II meeting  17 March 2010
A Simple Thought Inspired by Y. Ding’s Slides Last Week

- Use of crystal filter or monochromator picks out narrow band radiation from a SASE device (also true for self-seeding)

- If underlying e-beam is chirped in energy, this picks out a particular region in time that has correct $\gamma$ for FEL resonance

- Energy chirp $d\gamma/dt$ can have arbitrary sign (in theory at least)

- Why can’t we pick a sign and absolute value that cancels out the jitter in arrival time at the undulator so that the photon pulse has no temporal jitter relative to an absolute clock?

- This presumes that arrival time jitter is dominated by a simple linear relation: $t_i = t_0 - R_{56}/c \times (E_i - E_0)$

  - if arrival time not tightly correlated with shot $<E>$, cancellation will not work
Y. Ding Self-seeding Simulations: LCLS beam + Wake-Caused Chirp + Crystal filter picks out narrow region in time

Si113: bw = 3e-5 at 8 keV

Energy fluctuation: ~15%.

wake-induced chirp
One can choose to either under-compress or over-compress in final BC

- In SXR case, wake-induced chirp may be less important (lower I, shorter undulators) than chirp left over from a BC
- If one under-compresses, tail has higher energy than head at BC exit
- If one over-compresses, (new) head exits BC with higher relative energy
- Positive energy jitter fluctuation (i.e., \( \Delta E > 0 \))
  - overall e-beam arrives \textit{earlier} at undulator entrance (relative to abs. clock)
  - in overcompression case, negative \( \frac{dE}{dt} \) energy chirp causes “correct \( \gamma \)” region for FEL resonance to occur \textit{later} within pulse => some cancellation
Some BOE numbers

- LCLS I --- $10^{-3}$ normalized energy jitter leads to 25 microns = 80 fs time jitter (dt/dE is positive) (private communication: Decker -> Z. Huang)

- To cancel this, e-beam chirp in (final) undulator should have same size ($\Delta E/E=10^{-3}$) in 80 fs but opposite sign

- 2008 example from Ding & Huang has correct sign (overcompressed) but appears 10X too large, i.e. 1% energy change in ~30 microns (= 100 fs)

Longitudinal phase space