The Echo-7 Experiment at the NLCTA

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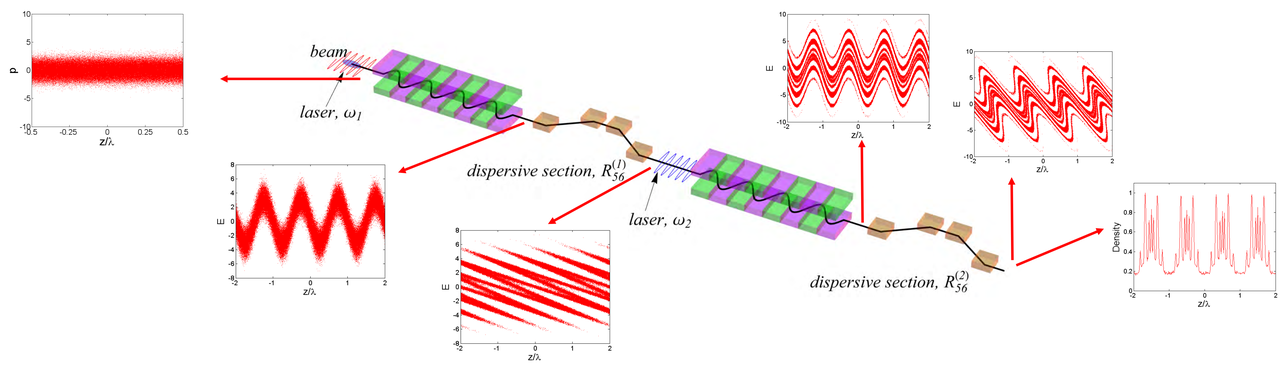
Free electron lasers (FELs) hold great promise for generation of coherent high-intensity short-wavelength radiation for studies of molecular and atomic dynamics. Recently a new working scheme of the FEL, the so-called echo-enabled harmonic generation (EEHG) FEL was proposed, developed, and demonstrated at SLAC. Here we describe the promises and challenges of the EEHG FEL, and the recent experimental demonstration of the proof-of-principle EEHG experiment at the Next Linear Collider Test Accelerator (NLCTA) at SLAC.

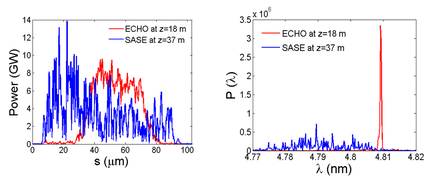


Advantages of seeded FELs

- Fully coherent FEL pulses
- Stable central wavelength
- Well-defined timing of the FEL pulse
- Less undulators required for saturation

Promises of EEHG

- Supreme frequency up-conversion efficiency
- High harmonics from small energy modulation
- Both bunching and gain at short wavelengths
- UV seed laser to soft x-ray in a single stage

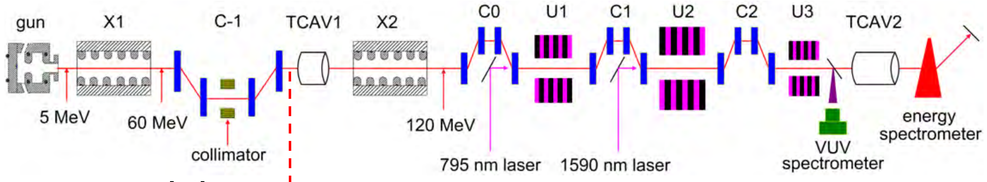


Simulated performance for LCLS-II

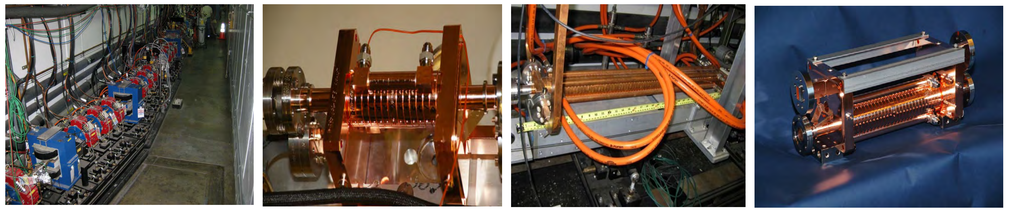
Challenges of EEHG

- Preserve long-term memory of phase space
- Incoherent synchrotron radiation and IBS
- Non-uniform energy modulation
- unwanted x-z coupling; 2nd order effects

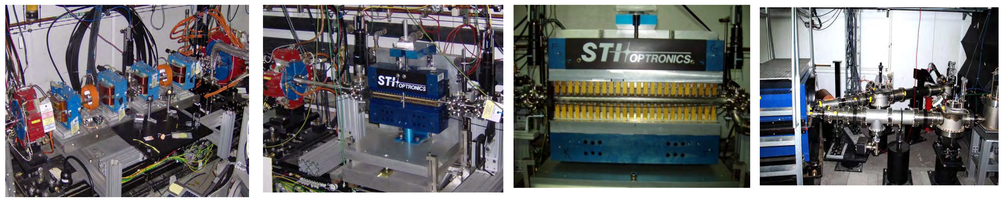
Echo-7 at SLAC's NLCTA



Existing → Main echo beam line constructed after 10/2009
→ TCAV1, TCAV2, energy spectrometer after 01/2011



C-1 | TCAV1 | X2 | TCAV2

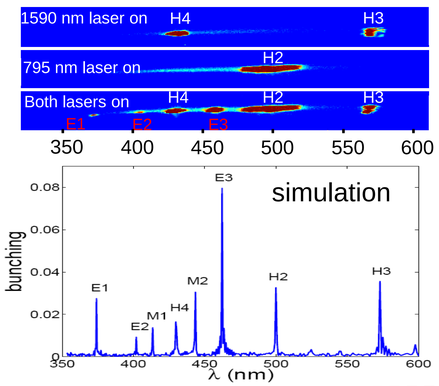


C1 | U1 | U2 | spectrometer

Milestones of the Echo-7 experiment

- 03-2009: First planning meeting
- 06-2009: LDRD funded
- 07-2009: First dipole constructed and tested
- 08-2009: Undulators ordered
- 09-2009: BES fund arrived & First chicane installed
- 12-2009: 120 MeV beam achieved
- 02-2010: First undulator installed
- 03-2010: Main echo beam line completed
- 04-2010: 795 nm laser interacted with electron beam
- 05-2010: 1590 nm laser interacted with electron beam
- 05-2010: First harmonic radiation observed
- 07-2010: First clear Echo-3 and Echo-4 signal
- 12-2010: Energy spectrometer upgraded
- 02-2011: VUV spectrometer installed
- 03-2011: Transverse cavities installed
- 05-2011: Echo-7 signal from large energy modulation
- 07-2011: Echo-7 signal from small energy modulation

Echo-7 results



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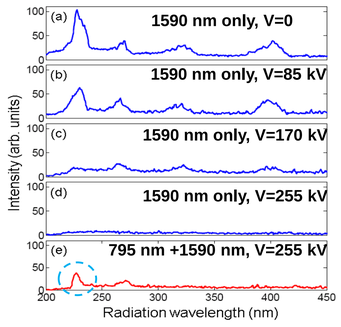

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First evidence of high harmonics from small energy modulation with EEHG

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