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SEEDING AT ELECTRON STORAGE RINGS*

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S. Khan, B. Büsing, N. M. Lockmann, C. Mai, A. Meyer auf der Heide, B. Riemann, B. Sawadski, M. Suski

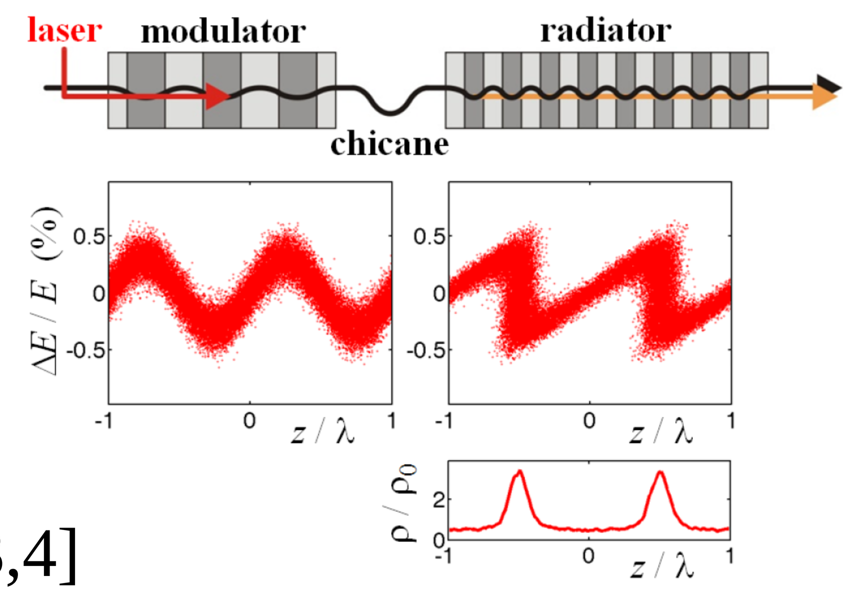
Zentrum für Synchrotronstrahlung (DELTA), TU Dortmund, 44227 Dortmund, Germany

Introduction

Seeding is the interaction of electrons with an external radiation pulse to produce a particular radiation output.
Free-electron laser (FEL): radiation with improved longitudinal coherence [1]
Storage ring: short pulses of synchrotron radiation [2]

Aspects of FEL seeding can be investigated at storage rings
- advantages: very stable beam, high repetition rate, additional beam time
- drawbacks: no FEL gain, no study of space charge, no electron chirp

Example: CHG (coherent harmonic generation) ↔ **HGHG** (high-gain harmonic generation)
laser-induced energy modulation, microbunching, coherent emission of harmonics [3,4]

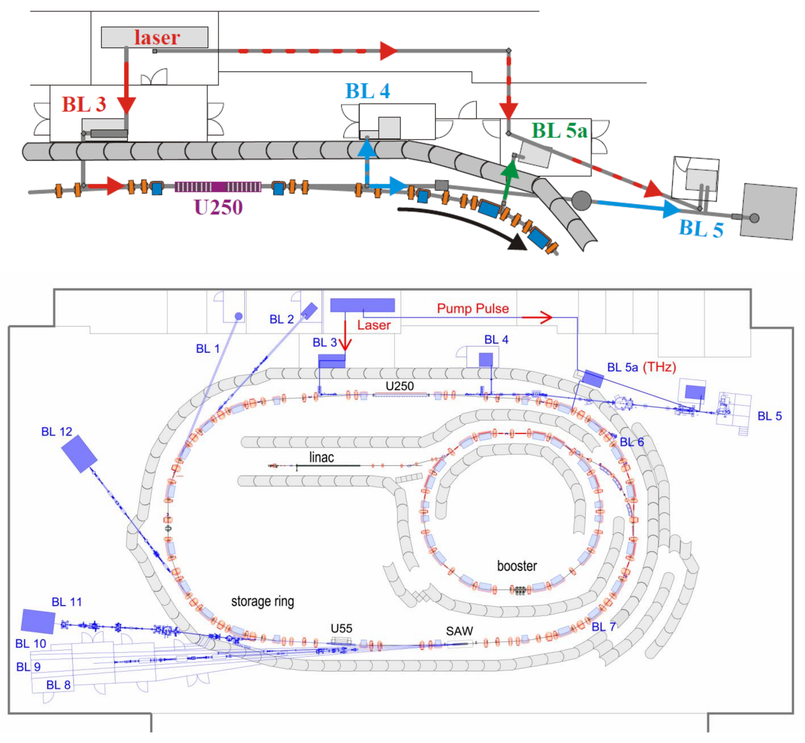


The Short-Pulse Facility at DELTA

DELTA: 1.5 GeV synchrotron light source at TU Dortmund
Short-pulse facility: constructed in 2011 [5,6]
- Ti:sapphire laser pulses guided through beamline BL 3
- undulator U250: modulator + chicane + radiator
- diagnostics beamline BL 4: streak camera, iCCD [7] ...
- soft-X-ray beamline BL 5: photoelectron spectrometer
- THz beamline BL 5a: FTIR spectrometers ... [8,9]

Table 1: Parameters of the DELTA short-pulse facility

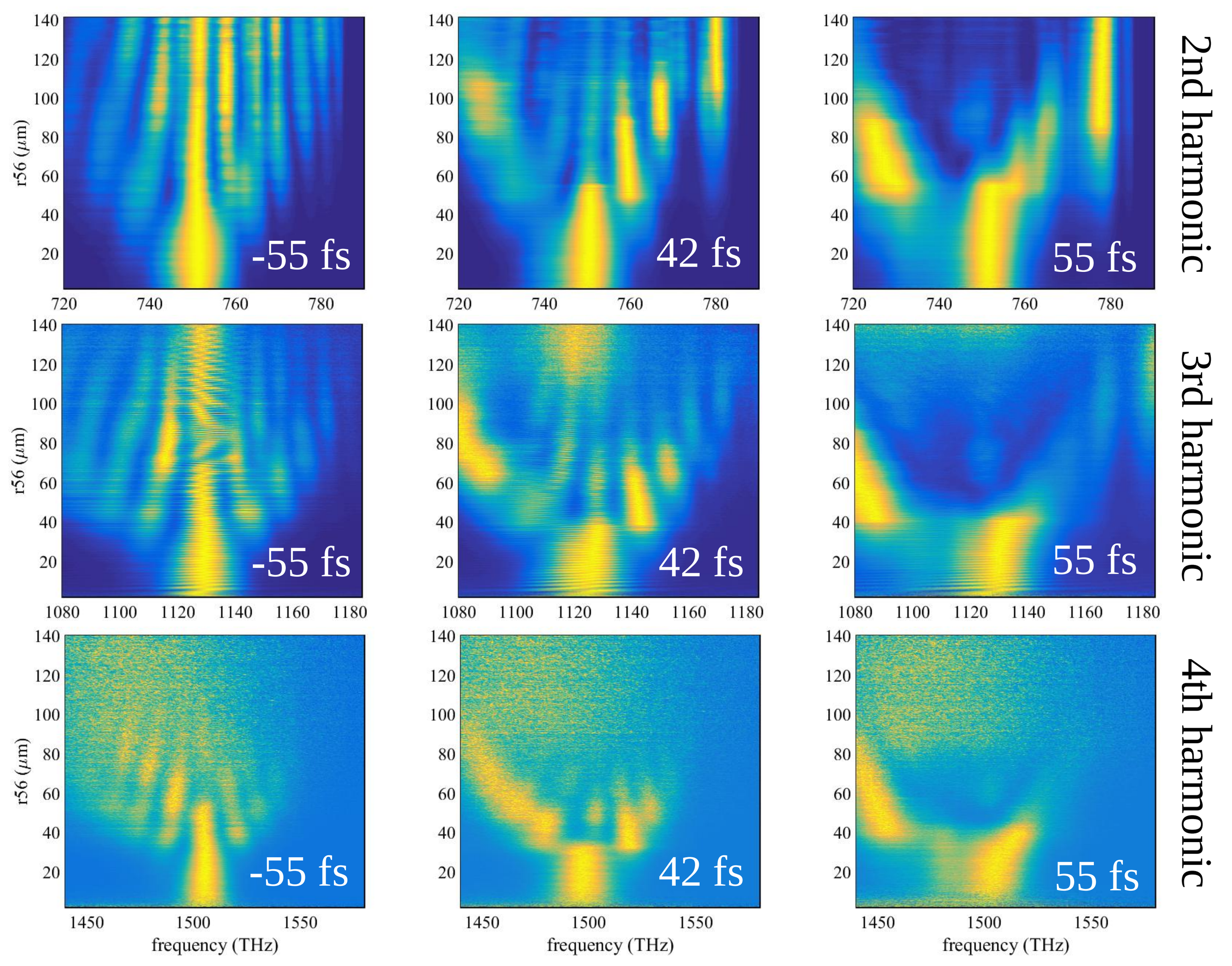
electron storage ring	
beam energy	1.5 GeV
circumference	115.2 m
beam current (single-/multibunch)	20/130 mA
horizontal emittance	15 nm rad
relative energy spread	0.0007
typ. bunch length (FWHM)	100 ps
titanium:sapphire laser system	
wavelength	800 nm
pulse energy at 800/400 nm	8.0/2.8 mJ
repetition rate	1 kHz
min. pulse duration (FWHM)	40 fs
undulators and chicane	
modulator/radiator period length	250 mm
number of modulator/radiator periods	7
undulator periods used as chicane	3
max. modulator/radiator K parameter	10.5
max. chicane r_{56} value	130 μm



CHG Spectra

Example: seeding with 800 nm, study 2nd, 3rd, 4th harmonic, variation of
- chicane strength r_{56}
- laser compressor setting (chirp)

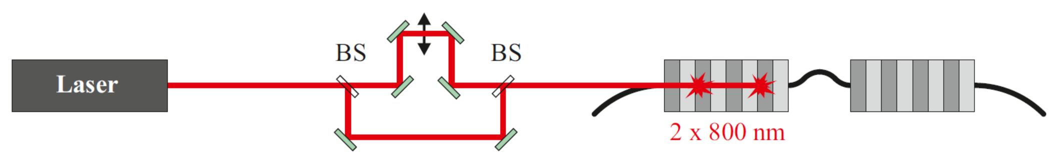
Results at large r56 values: overbunching, double-peak structure [10]
- negative-chirp pulse (-55 fs in laser lab) has little chirp at modulator (compensated by lenses and vacuum window)
- interference fringes for unchirped pulse
- interference vanishes for large chirp } see also FERMI [11]
- linear + nonlinear chirp → asymmetric spectra



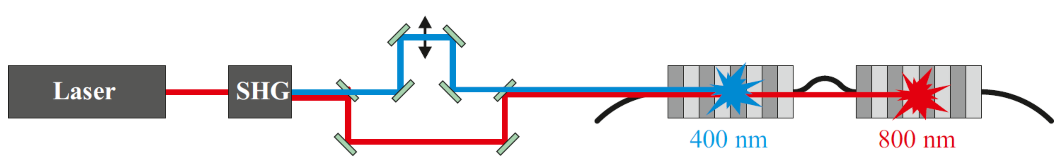
Seeding with Double Pulses

Preparation for EEHG [12,13], two setups:

(a) 800 + 800 nm with 1 modulator

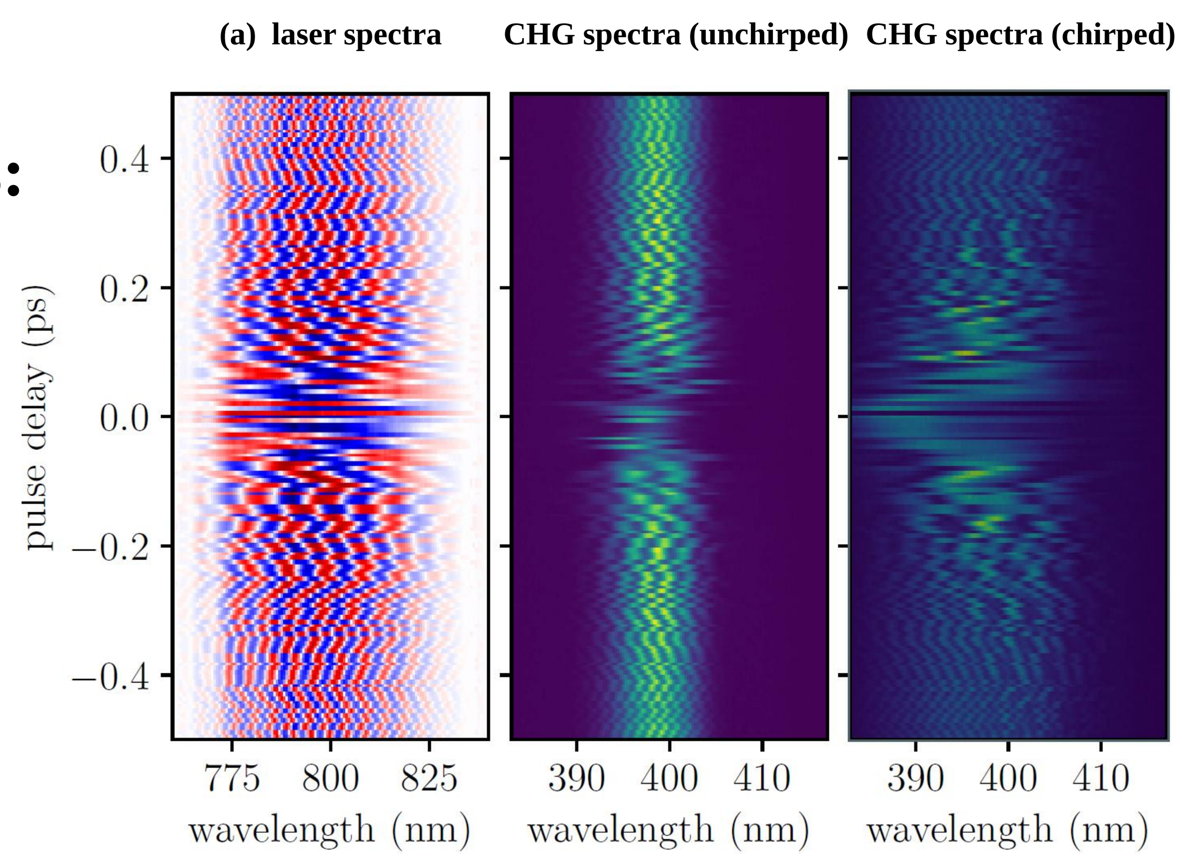


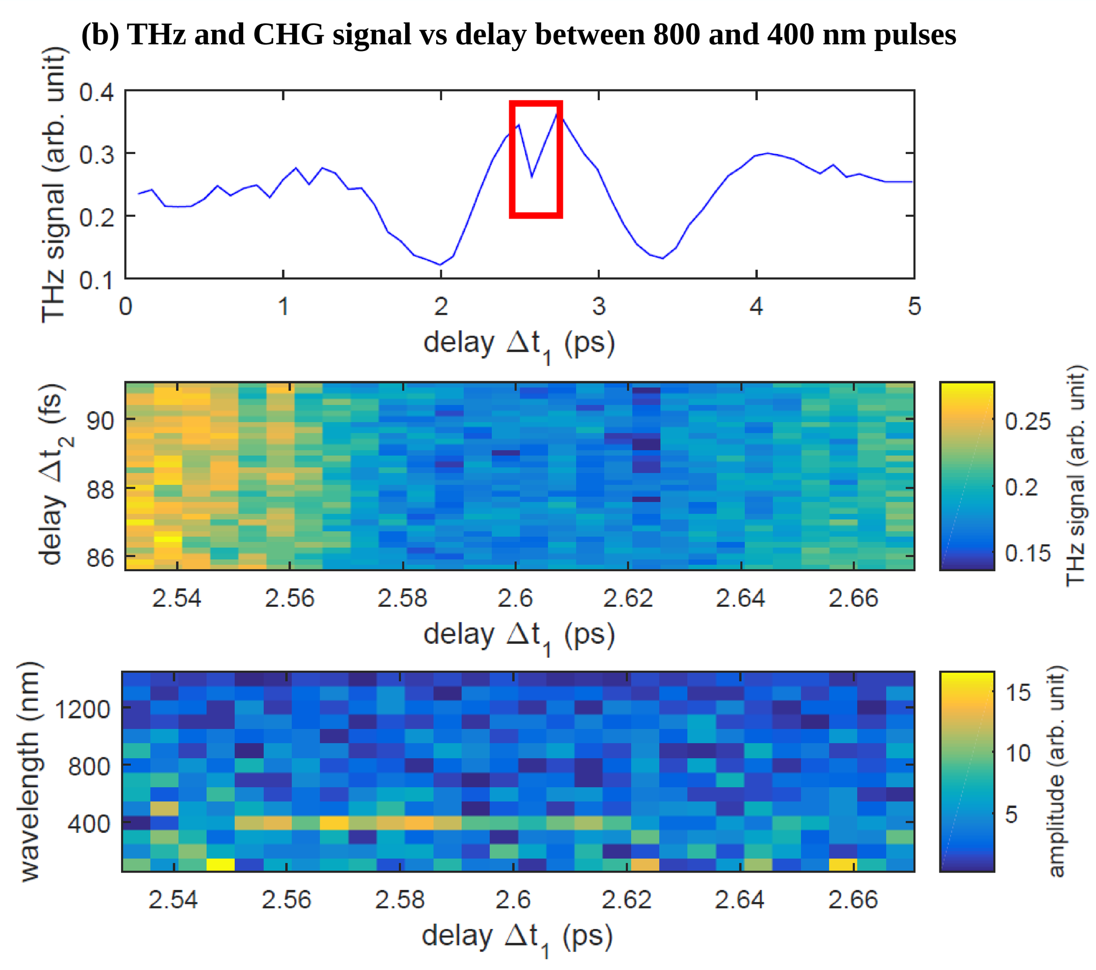
(b) 800 + 400 nm with 2 modulators

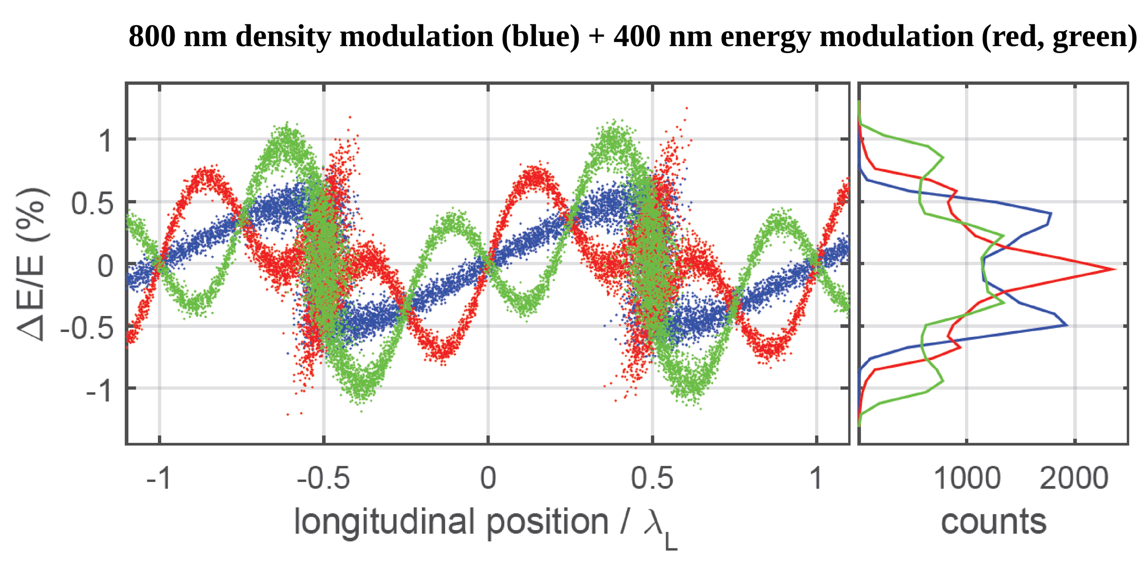


Results for (a): [14] interference between
- two laser pulses (measures delay)
- two CHG pulses (for small delay)
- two THz pulses (for large delay)

Results for (b): [15] temporal overlap
- center of THz interferogram
- sensitivity to small delay ($\Delta t_2 = r_{56}/2$)
- drop of beam lifetime (reduced RF power)







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