The Short-Pulse Facility at DELTA *

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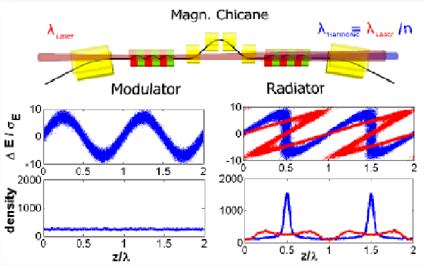
Introduction

Coherent Harmonic Generation (CHG) is a laser based method that enables the generation of ultrashort VUV pulses in a storage ring [1].



Energy modulation

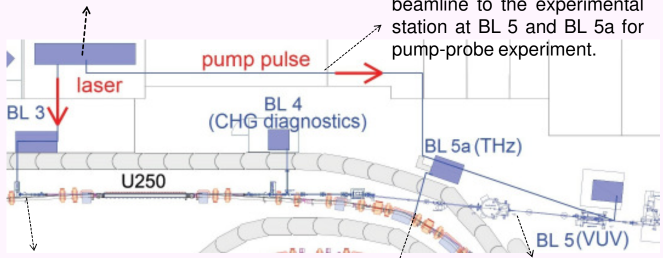
Density modulation (microbunching)

Electron Bunch	
Electron energy	1.5 GeV
Bunch current / Charge	10 mA / 8 nC
Bunch length	100 ps (FWHM)
Revolution frequency	2.6 MHz
Modulator / Radiator	
Period length	250 mm
Number of periods	17
K value	0 - 11
Chicane R_{56}	0 - 130 µm

A CHG facility is in operation since 2011 at the storage ring DELTA operated by the TU Dortmund University in Germany [2-6].

Ti:Sapphire laser and a telescope to focus the laser at the modulator.

A fraction of the laser (~10%) is sent by an evacuated beamline to the experimental station at BL 5 and BL 5a for pump-probe experiment.



mirrors, screens and viewports

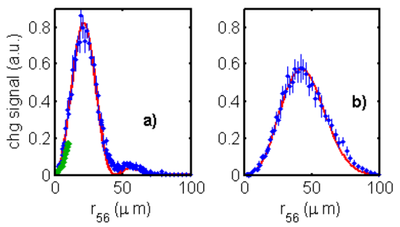
extraction of the THz radiation [6,10]

VUV beamline operated by FZJ [11]

Improvements and Results

Modification of the Magnetic Chicane

By rewiring the poles of the chicane, thus changing the longitudinal profile of the magnetic field, a much larger transverse excursion is created which leads to higher values of r_{56} and dramatic increase in the CHG intensity [7].



CHG intensity [8]:

$$I_{CHG} \propto f_n^2 J_n^2\left(4\pi n(N_u+N_d)\left(\frac{\delta E}{E}\right)\right)$$

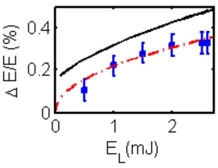
$$f_n = e^{-8(\pi n (N_u+N_d)\sigma_\gamma)^2}$$

$$N_d = R_{56}/(2\lambda)$$

CHG intensity vs. chicane strength a) for a laser pulse energy of E_L = 2.6 mJ and b) for E_L = 1.3 mJ. Fitting yields the energy modulation.

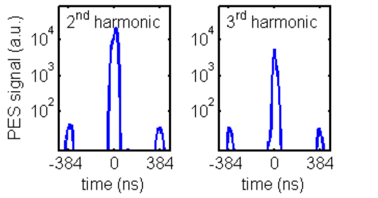
Energy Modulation vs. Laser Pulse Energy

Effective energy modulation amplitude versus laser pulse energy. The solid line is obtained by particle tracking simulation [10].

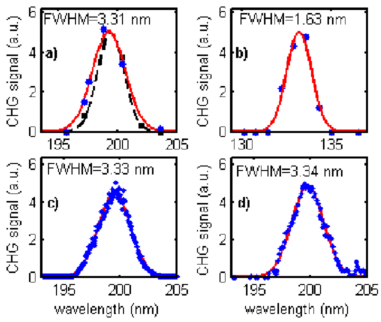


$$\frac{\delta E}{E} \propto \sqrt{E_L}$$

Detection of CHG Pulses Using Photoelectron Spectroscopy at VUV beamline



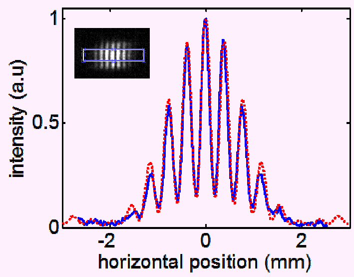
CHG (at t = 0) and spontaneous emission (at t=±384ns) signal from photoelectrons detected by the DLD [11,12] at λ= 199 nm (left) and λ=133 nm (right).
The ratio between photoelectron counts from a gold target due to CHG and due to spontaneous radiation was about 600 and 150 at 199 nm and 133 nm, respectively.



CHG spectra at the second/third harmonic obtained using photoelectrons under variation of the PGM wavelength (a, b), a Czerny-Turner spectrometer equipped with an APD [9] (c), and a linear CCD array spectrometer (d). The dashed curve was measured with a smaller PGM exit slit (600 µm), yielding a smaller width (2.62 nm).
Assuming a pulse duration of 50 fs, the time-bandwidth product is only a factor of two larger than the Fourier limit.

Transverse Coherence Measurement

First double-slit experiments to study the transverse coherence were performed. The interference pattern is measured by a fast gating intensified CCD camera [14].
slit width = 0.1 mm, slit separation = 0.5 mm, distance from the slits to the screen =1 m.
A preliminary analysis yields a central visibility of the fringes of 0.76 (≈coherence degree of the radiation).



Measured (solid line) and fitted (dashed line) interference pattern of CHG radiation at 199 nm obtained with a double-slit experiment.

Summary and Outlook

By modifying the chicane and achieving higher r_{56} values, a dramatic increase in the CHG signal was observed. The CHG pulses up to the fifth harmonic were detected using a photoelectron spectrometer. Seeding with 265 nm is the next step to generate lower wavelengths for pump-probe experiments at BL 5. For even lower wavelengths the EEHG[13]scheme is planned to be implemented at DELTA.

Aknowledgments

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