Details of SASE FEL radiation parameters

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Table of the main parameters

	Units	SASE 1	SASE 2	SASE 3*
Wavelength range**	Å	1-3.1	1-4	4-64
Photon energy range**	keV	12.4-4	12.4-3.1	3.1-0.2
Peak power	GW	24	22	100-135
Average power***	W	72	66	300-800
Photon beam size (FWHM)$^{+}$	μm	110	110	65-95
Photon beam divergence (FWHM)$^{++}$	μrad	0.8	0.8	3-27
Bandwidth (FWHM)	%	0.09	0.08	0.28-0.73
Coherence time	fs	0.3	0.3	0.3-1.9
Pulse duration (FWHM)	fs	100	100	100
Number of photons per pulse	#	1.2×10^{12}	1.1×10^{12}	$2\text{-}43\times10^{13}$
Average flux of photons***	#/sec	3.6×10^{16}	3.3×10^{16}	$0.6\text{-}26\times10^{18}$
Peak brilliance	B^{+++}	5.4×10^{33}	5.4×10^{33}	$17\text{-}0.6\times10^{32}$
Average brilliance***	B^{+++}	1.6×10^{25}	1.6×10^{25}	$5.2\text{-}0.3\times10^{24}$

* Uses electron beam coming out of SASE 2.

** Tunability is achieved by electron energy and gap variation. In the case of SASE2 only energy variation is possible. The following parameters are presented for the shortest wavelength of each device, except for SASE 3 where parameters for the extreme wavelengths are given.

*** Average radiation parameters assume 10 Hz operation and maximum filling of the bunchtrain.

$^{+}$ At the exit of the undulator.

$^{++}$ Far field divergence.

$^{+++}$ In units of photons/(sec·mrad^2·mm^2·0.1 % bandwidth).

Main properties of radiation

Classical field

Degeneracy parameter (number of photons per mode) > 10^9

Almost perfect transverse coherence

Mechanism: transverse modes selection

Partial longitudinal coherence

Reason: correlations develop on the scale of a slippage per gain length. Electron bunch is much longer.

Stochastic object

Input signal: shot noise in the electron beam

Linear regime: classical chaotic light (like SR).
Fluctuations of pulse energy:
(coherence time/pulse duration)$^{1/2}$

Saturation: fluctuations are suppressed by a factor of 2-3

Advanced schemes

Better coherence, stability
Shorter pulses

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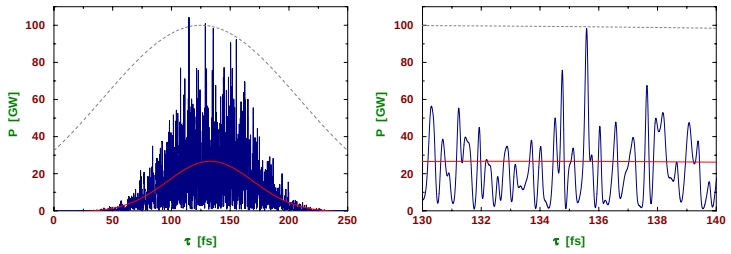
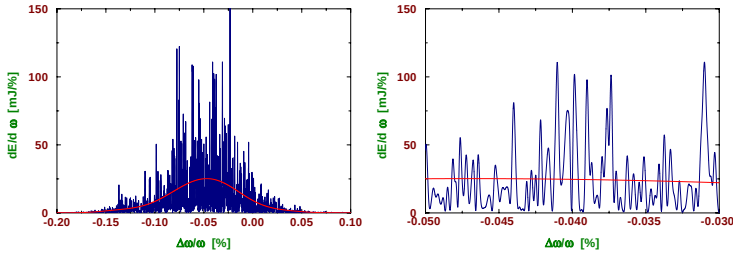
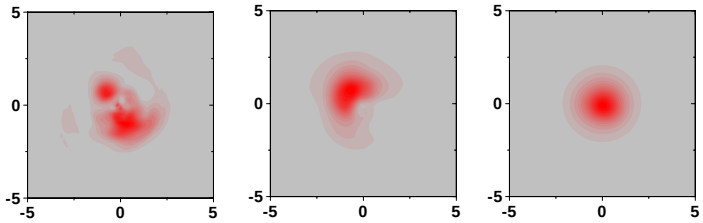
Time domain picture



Frequency domain picture

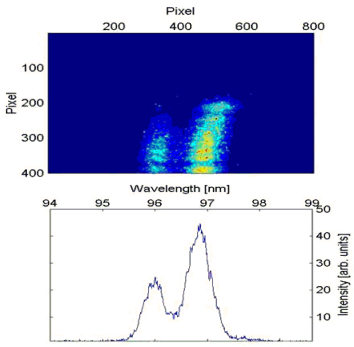


Formation of transverse coherence (qualitatively)

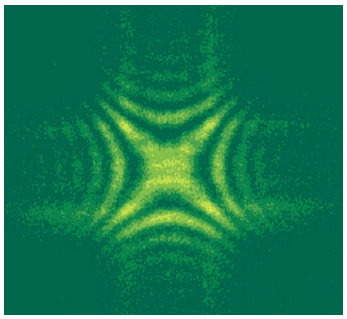


1/3 undulator **2/3 undulator** **undulator end**

Experimental results from TTF1



Single shot spectrum



Diffraction pattern of crossed slits