Simultaneous Operation of Three Laser Systems at the FLASH Photoinjector

FLASH
Free-Electron Laser in Hamburg

FLASH – The Free-Electron Laser at DESY, Hamburg, Germany
flash.desy.de

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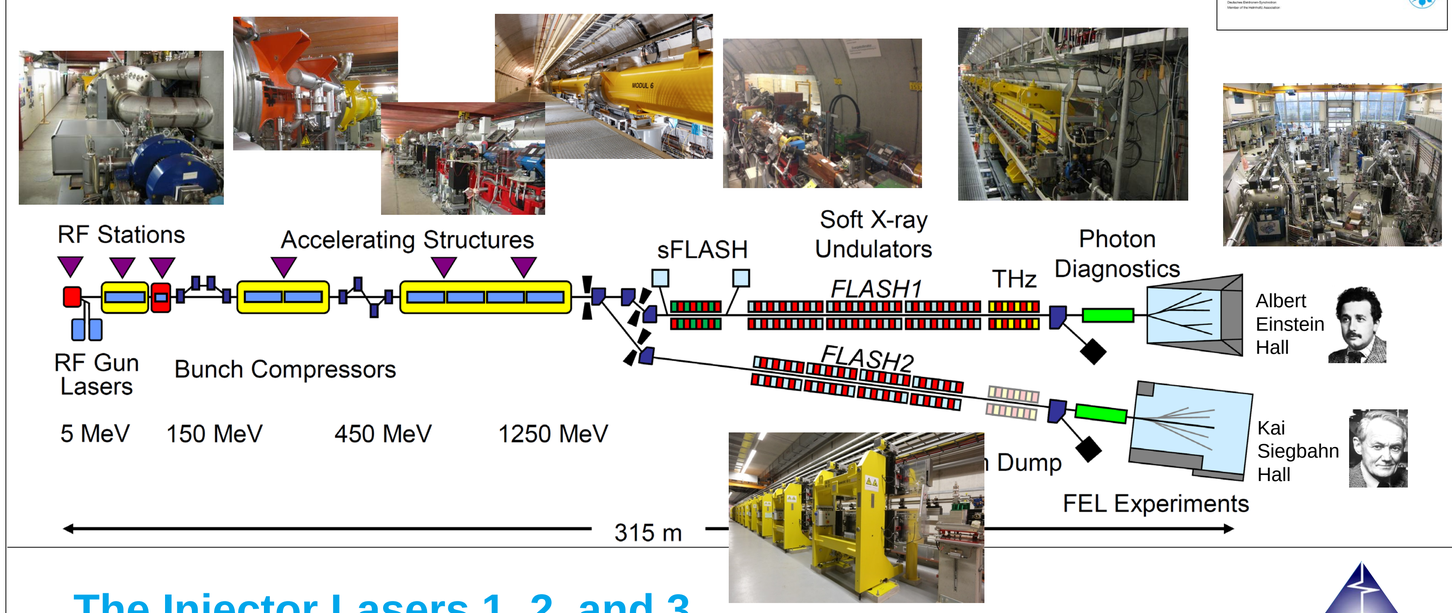
FLASH features

> Photon wavelength range from EUV to soft X-rays
> Uses superconducting TESLA accelerating technology
> Operates in a burst mode with high duty cycle (0.8 ms bursts with 10 Hz)
> Runs two undulator beamlines simultaneously



Main Laser Parameters

	Laser 1	Laser 2	Laser 3
Laser material	Nd:YLF		Yb:YAG
Wavelength	1047 nm		1030 nm
4th harmonic (UV)	261.7 nm		257.5 nm
Repetition rate	10 Hz		
Burst/train length	800 µs		
Intra-train rate	1 MHz (*)		
Pulses per train	1 … 800		
Pulse energy UV	50 µJ	50 µJ	1 µJ
Average power (IR)	2 W		10 W
Arrival time jitter	60 fs rms		--
Long. shape	Gaussian		
Pulse duration (sigma)	4.5 ps	6.5 ps	0.8 - 1.6 ps
Transverse profile	Flat, truncated Gaussian		
Spot size on cathode	1.2 mm diam.(**)		0.8 mm
Charge stability	<0.5 % rms		1 % rms

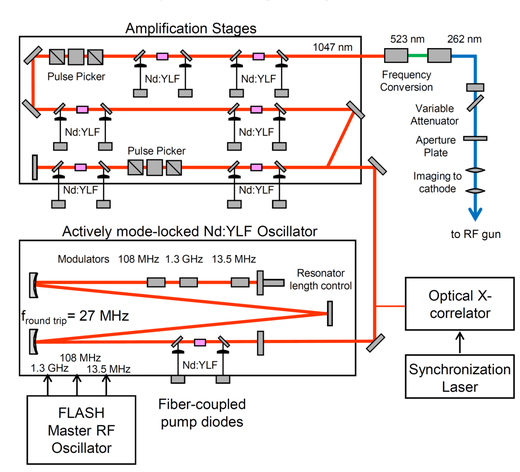
(*) to be adjusted according to the desired bunch or bunch train properties:
1 MHz, 500, 250, 200, 100, 50, or 40 kHz; 3MHz optional.
(**) Various spot sizes are possible and are adjusted according to the desired bunch charge.

The Injector Lasers 1, 2, and 3

I. Will, H.I. Templin, S. Schreiber, and W. Sandner, Optics Express **19**, 23770 (2011)

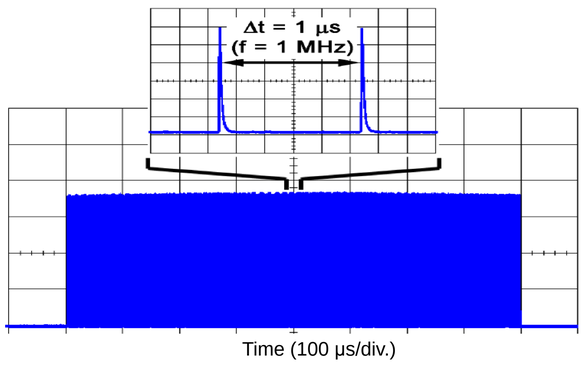
Lasers 1 and 2

> built at MBI, Berlin together with DESY
> Pulsed actively mode-locked oscillator
> Linear Amplification stages
> Nd:YLF, fully diode pumped



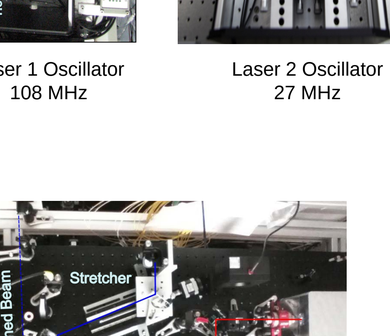
Laser 3

> Passive mode-locked cw oscillator (54 MHz Origami 10 from OneFive)
> 2 stage Innoslab amplifier (Amphos)
> Yb:YAG, 10 W, 1 MHz, 600 fs

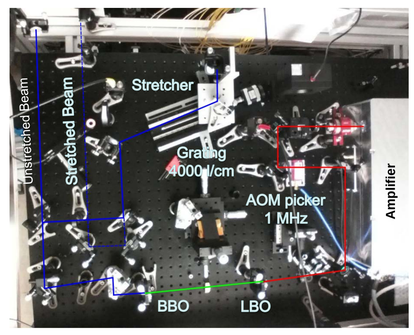


Laser Pulse Train Burst of 0.8 ms with a 1 MHz pulse train

> Transverse shaping (truncated Gaussian)
> No longitudinal shaping is applied
> Pulse length of lasers 1 and 2 are fixed: σ = 4.5 ± 0.1 ps and σ = 6.5 ± 0.1 ps resp.
> Laser 3 special feature: adjustable pulse length from σ = 0.8 to 1.6 ps

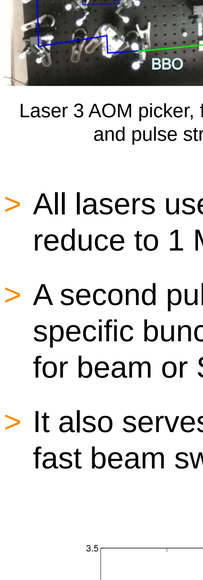


Single shot longitudinal pulse shape laser 2 (Streak camera, FESCA 200)

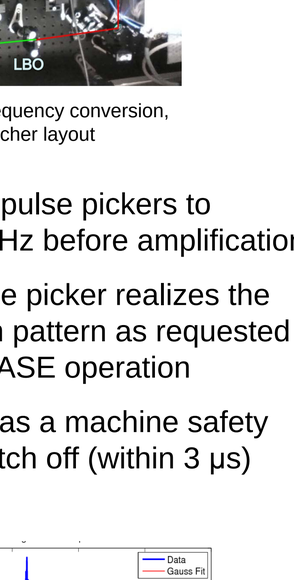


Laser 3 AOM picker, frequency conversion, and pulse stretcher layout

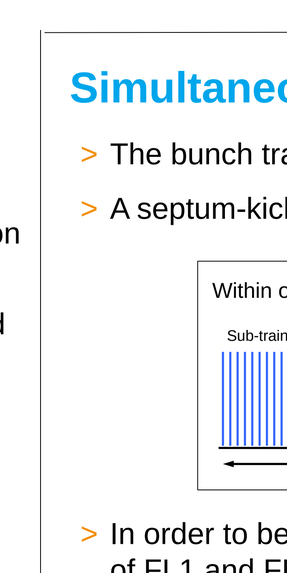
Detail of the oscillator with gain medium Nd:YLF and 1.3 GHz EO-Modulator



Laser 1 Oscillator 108 MHz



Laser 2 Oscillator 27 MHz

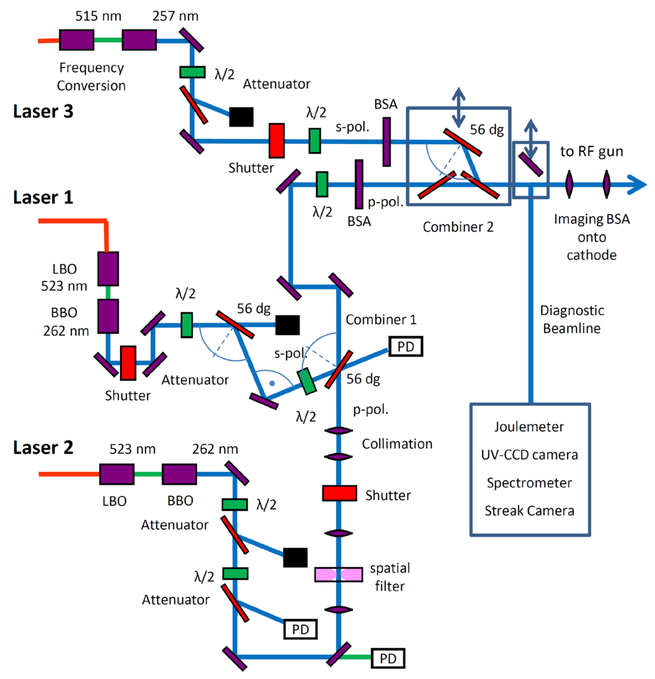


Amplification stages

> All lasers use pulse pickers to reduce to 1 MHz before amplification
> A second pulse picker realizes the specific bunch pattern as requested for beam or SASE operation
> It also serves as a machine safety fast beam switch off (within 3 µs)

Beamline and combiners

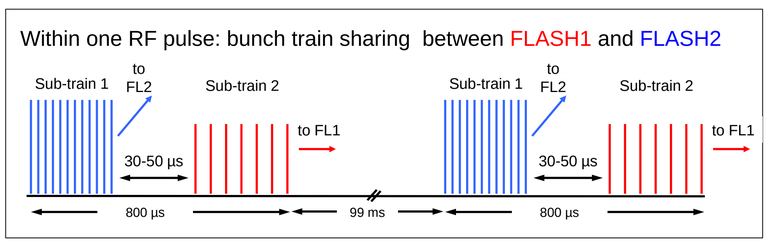
> All 3 lasers are merged to one beamline using thin Brewster angle polarization plates
> Transverse shaping with a hard edge aperture (BSA) imaged to cathode
> Diagnostic beamline incl. streak camera (FESCA 200)



BSA: Beam Shaping Aperture (plate with 15 pinholes of various sizes); λ/2 = half wave plate; PD: Photodiode

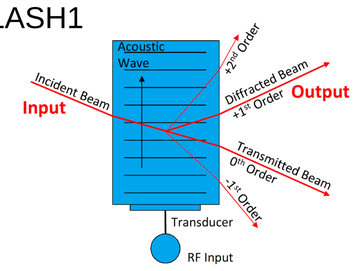
Simultaneous operation FLASH1 and FLASH2

> The bunch train is divided into two parts: one for FL1, one for FL2
> A septum-kicker system kicks the 1st part to FL2, 2nd goes straight to FL1



> In order to be flexible for the experiments, the train pattern of FL1 and FL2 may differ: in bunch distance, in number of bunches, in charge
> Usually laser 1 runs for FLASH2 and laser 2 for FLASH1
> Laser 3 is used for specific experiments
> Any laser can be launched into any beamline

> A pulse kicker in the UV based on an AOM has been developed and is being tested
> It can pick an arbitrary pulse pattern from a 1 MHz train



AOM based kicker is used as a UV pulse picker (M. Gross at al, FEL2012, Nara, p.189)

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