FLASH Photoinjector Laser Systems.

FLASH
Free-Electron Laser in Hamburg

FLASH – The Free-Electron Laser at DESY, Hamburg, Germany

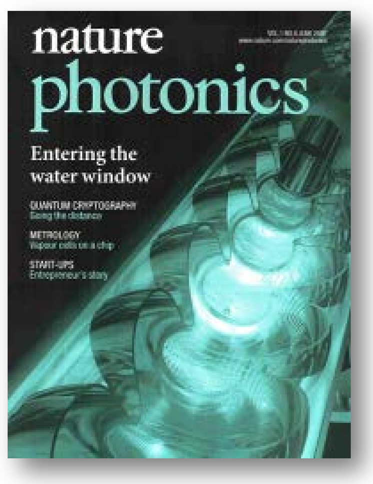
flash.desy.de

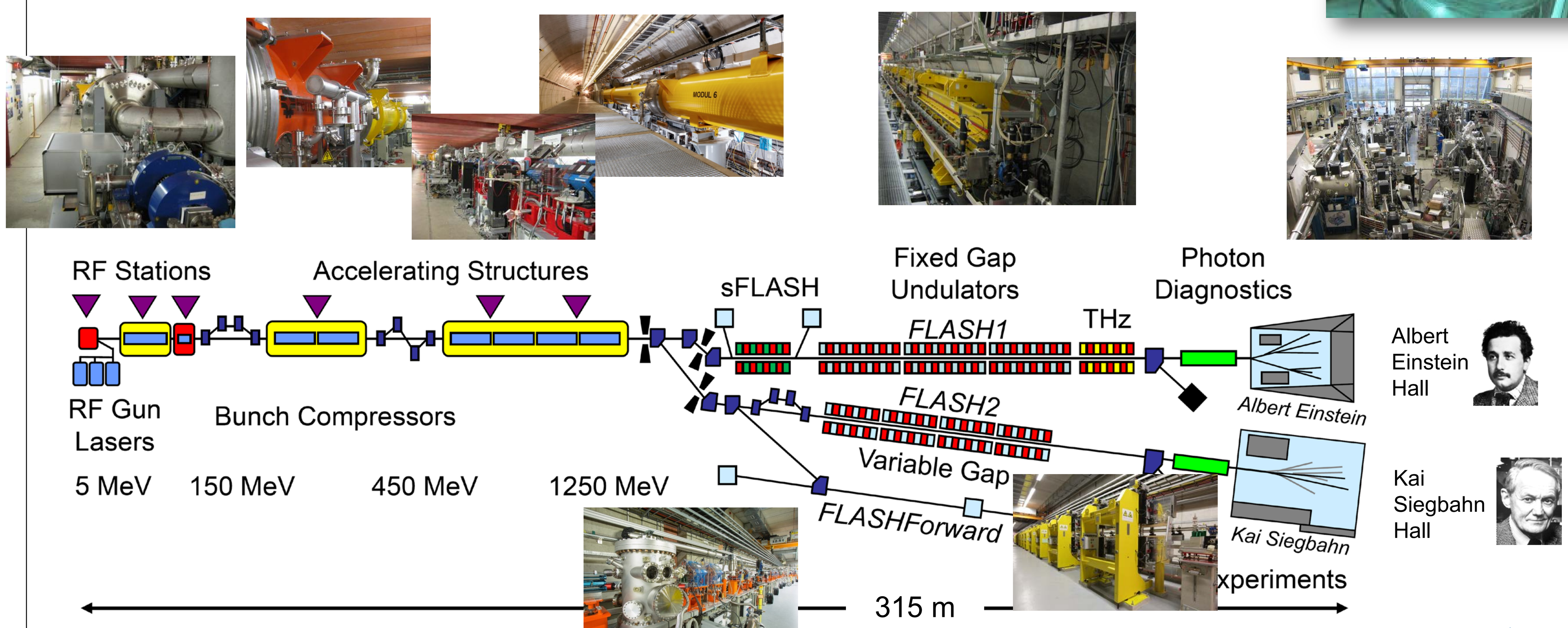
S. Schreiber, J. Rönsch-Schulenburg, B. Steffen, C. Grün, K. Klose, DESY

FEL2019 , Hamburg, Germany ID 2170 – WEP048

FLASH features

- Photon wavelength range from XUV to soft X-rays (90 – 4 nm)
- 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 plus a 3rd beamline





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	< 40 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.

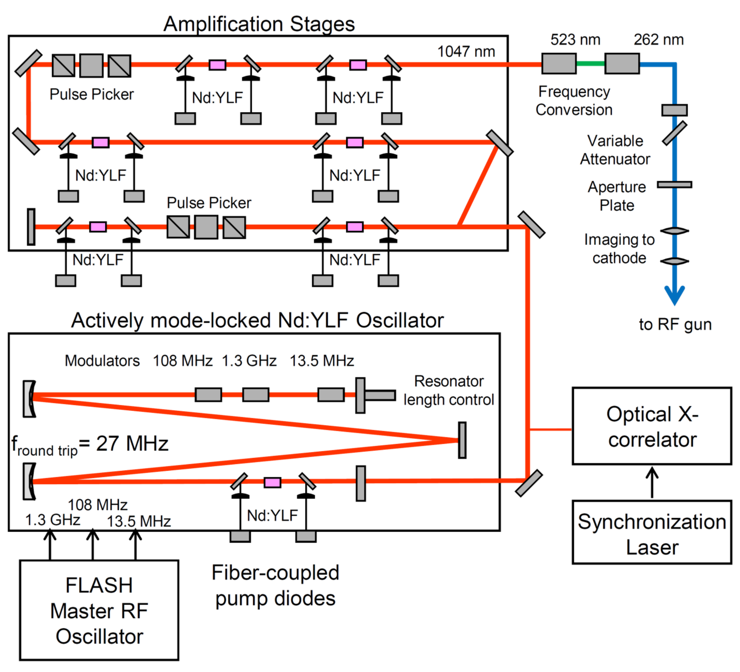
The Injector Lasers 1, 2, and 3

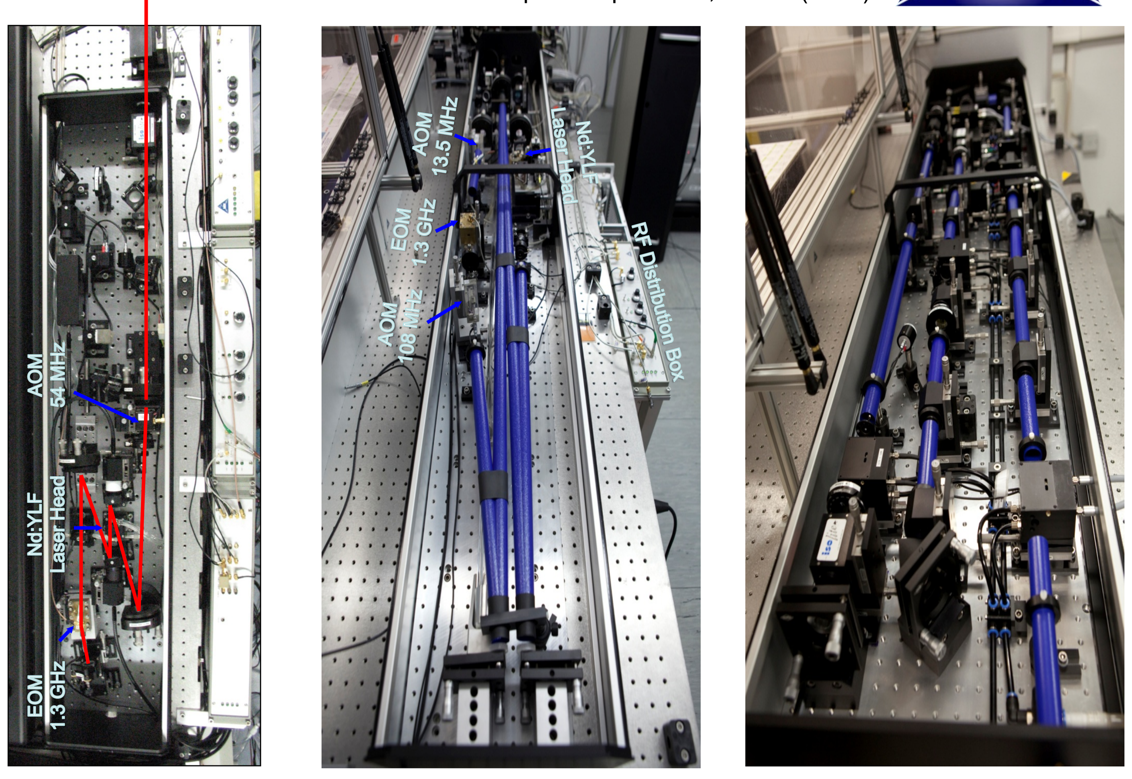
I. Will, H.I. Templin, S. Schreiber, and W. Sandner, Optics Express **19**, 23770 (2011)

MBI

Lasers 1 and 2

- built at MBI, Berlin together with DESY
- Pulsed actively mode-locked oscillator
- Linear Amplification stages
- Nd:YLF, fully diode pumped
- In operation since 10 years, very reliable





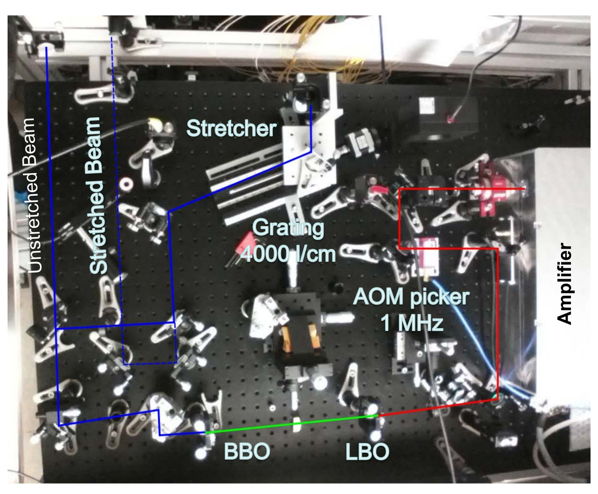
Laser 1 Oscillator 108 MHz

Laser 2 Oscillator 27 MHz

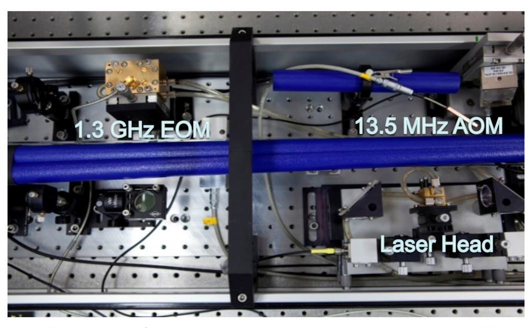
Amplification stages

Laser 3

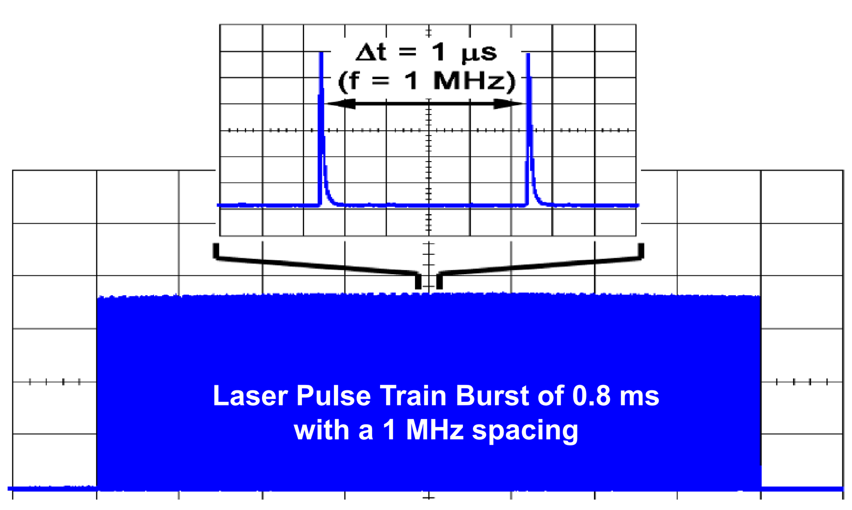
- Passive mode-locked cw oscillator (54 MHz Origami 10 from OneFive)
- 2 stage Innoslab amplifier (Amphos)
- Yb:YAG, 10 W, 1 MHz, 600 fs



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

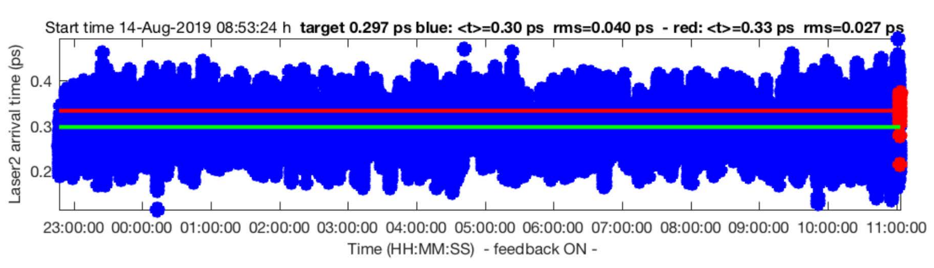


Detail of the laser oscillator, Nd:YLF, 1.3 GHz EO-Modulator (active mode-locked)



- No longitudinal shaping is applied
- Pulse length of lasers 1 and 2 are fixed: $\sigma = 4.5 \pm 0.1$ ps and $\sigma = 6.5 \pm 0.1$ ps resp.
- Laser 3 special feature: adjustable pulse length from $\sigma = 0.8$ to 1.6 ps

- Transverse shaping (truncated Gaussian)
- With a plate of 15 apertures (diam. 50 μm to 2 mm), relay imaged onto the cathode



- Slow arrival time feedback using optical X-correlation with the FLASH synchronization systems master laser oscillator (MLO)
- Measured stability of the laser oscillator ~40 fs rms
- OXC provided by J. Müller, S. Schulz, T. Kozak (server)

S. Schulz et al, Nature Comm., 6:5938 doi 10.1038/ncomms6938

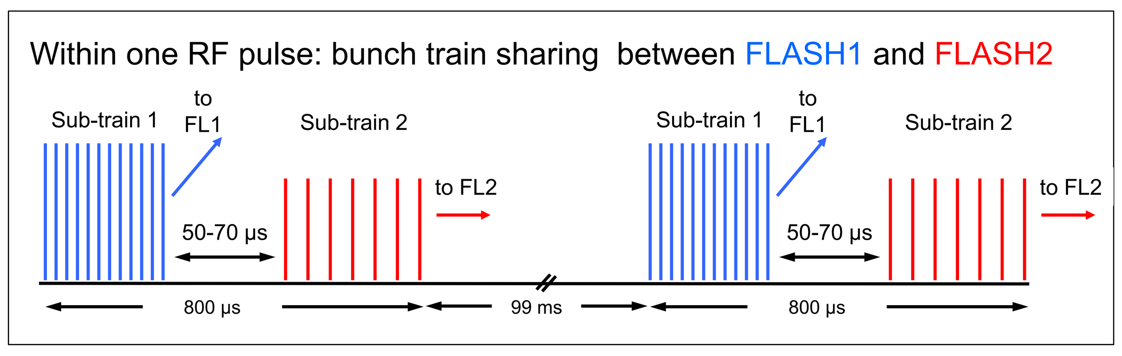
S. Schulz et al., Precision Synchronization of the FLASH photoinjector laser, Proc. IPAC'10, Kyoto, Japan WEPEB076

Beamline and combiners

- All 3 lasers are merged to one beamline using thin Brewster angle polarization plates
- This allows simultaneous use of all lasers in all beamlines
- Double pulse generation by:
  - Split-and-delay for THz/SASE runs (21 ns)
  - Two lasers in one beamline with adjustable distance (from ns to μs – from one RF bucket to many)

Simultaneous operation FLASH1 and FLASH2/FLASH3

- The bunch train is divided into three parts, for FL1, FL2, and FL3 (not shown)
- Usually the 1st part goes straight to FL1
- A septum-kicker system kicks the 2nd part to FL2
- Option: a dipole may guide the beam to FL3 (FLASHForward plasma accelerating experiment)



- In order to be flexible for the experiments:
  - the train pattern of FL1 and FL2/FL3 may differ
  - in bunch distance, in number of bunches, in charge, and in compression
- Most beam based feedbacks (charge, arrival time, compression) act on the beamlines independently
  - Orbit feedbacks in the specific beamline
- Usually laser 1 runs for FLASH2 and laser 2 for FLASH1
- Laser 3 is used for specific experiments especially for ultra-short pulse runs (laser 3 pulse length is shorter)