European XFEL & FLASH

11th Workshop on Longitudinal Electron Diagnostics

Bernd Steffen

Lille, June 29th – July 1st 2022

HELMHOLTZ

European XFEL

DESY.

The European XFEL

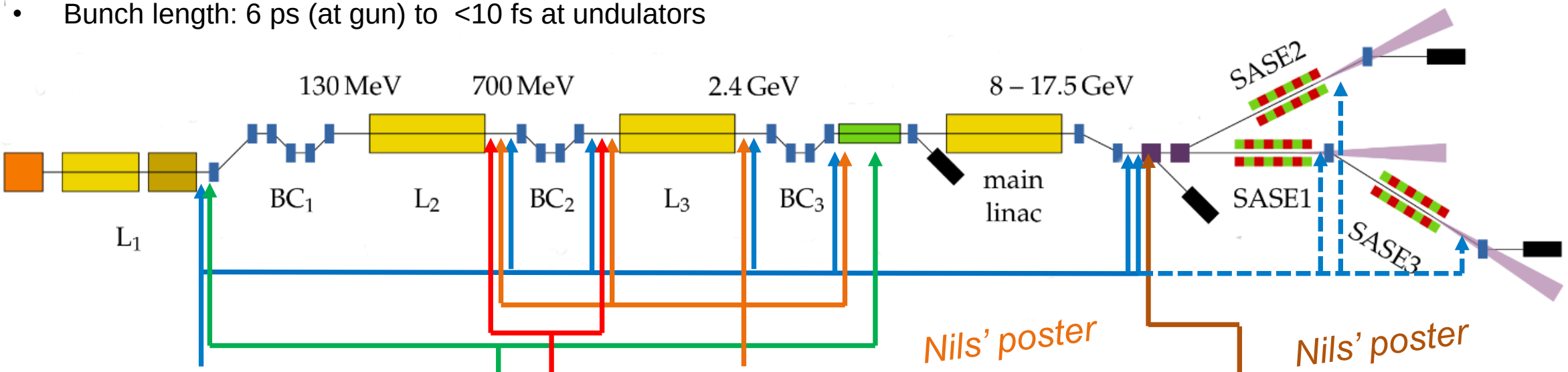
Overview

Accelerator

- Superconducting RF, up to 17.5 GeV
- 10 Hz pulsed operation
- Bursts of up to 2.7k bunches at 4.5 MHz
- Bunch length: 6 ps (at gun) to <10 fs at undulators

Beamlines

- 3 beamlines (room for extension)
- 6 instruments (more in preparation)
- 0.26keV (4.7nm) to 20keV (0.6nm)



7+3 BAM: Bunch Arrival time Monitor

2 TDS: Transversely Deflection Structure

3 BCM: Bunch Compression Monitor

2 EOD: Electro-Optic Bunch Length Diagnostics

Nils' poster

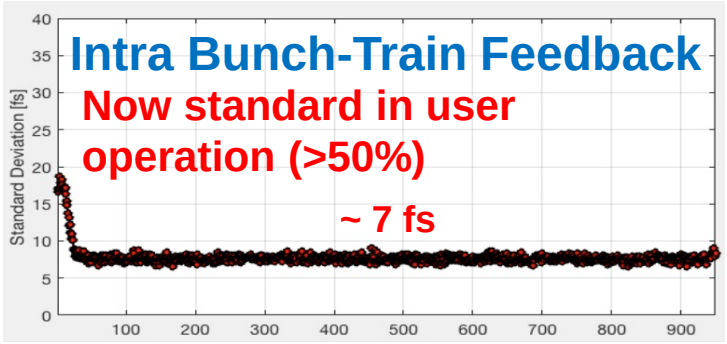
CRISP: Coherent Radiation Spectrometer

Nils' poster

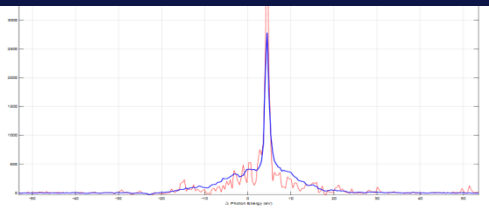
Longitudinal feedback: Marie Czwalinna's talk tomorrow

Highlights since last Workshop

(the slide from 10th WS 2019)

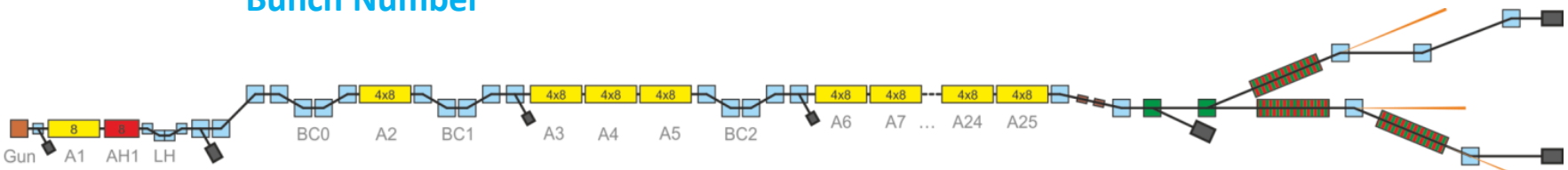


SASE2 Self Seeding @ 8 keV



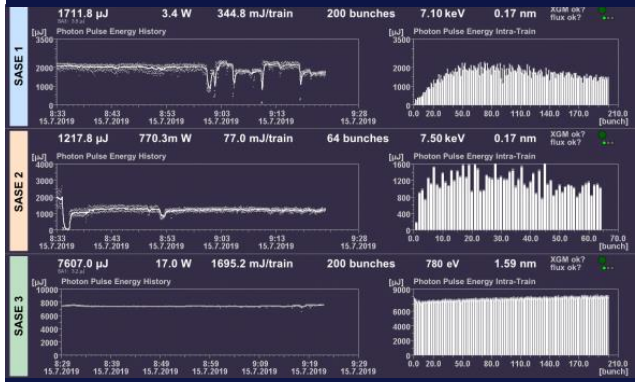
7 Sep 2019

Delivered to users since April 2022



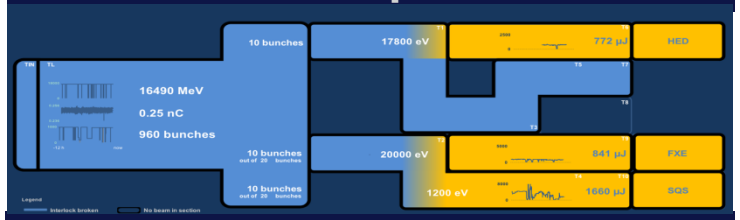
Max. 40W per beamline, limited by radiation safety

4.5 MHz User Operation ⇒ 20 W av. X-Ray Power!



July 2019

16.5 GeV User Operation



7 Oct 2019

SASE1 First lasing @ 20 keV Wavelength Record!

10 June 2019

18 keV photons, 700µJ for users

8 GeV, 11.5 GeV, 14 GeV, 16.3 GeV standard operation
11 weeks user time @16.3 GeV for 2022

New peer-reviewed papers

On results from collaborations started from this workshop series:

Review of Scientific Instruments ARTICLE scitation.org/journal/rsi

Compact single-shot electro-optic detection system for THz pulses with femtosecond time resolution at MHz repetition rates

Cite as: Rev. Sci. Instrum. 91, 045123 (2020); doi: 10.1063/1.5142833
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ABSTRACT

Electro-optical detection has proven to be a valuable technique to study temporal profiles of THz pulses with pulse durations down to femtoseconds. As the Coulomb field around a relativistic electron bunch resembles the current profile, electro-optical detection can be exploited for non-invasive bunch length measurements at accelerators. We have developed a very compact and robust electro-optical detection system based on spectral decoding for single-shot longitudinal bunch profile monitoring at the European X-ray Free Electron Laser (XFEL) for

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https://doi.org/10.1038/s41377-021-00696-2

Official journal of the CIOMP 2047-7538
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ARTICLE Open Access

Phase Diversity Electro-optic Sampling: A new approach to single-shot terahertz waveform recording

Eléonore Roussel[1], Christophe Szwaj[1], Clément Evain[1], Bernd Steffen[2], Christopher Gerth[2], Bahram Jalali[3] and Serge Bielawski[1]✉

Abstract

Recording electric field evolution in single-shot with THz bandwidth is needed in science including spectroscopy, plasmas, biology, chemistry, Free-Electron Lasers, accelerators, and material inspection. However, the potential application range depends on the possibility to achieve sub-picosecond resolution over a long time window, which is a largely open problem for single-shot techniques. To solve this problem, we present a new conceptual approach for the so-called spectral decoding technique, where a chirped laser pulse interacts with a THz signal in a Pockels crystal, and is analyzed using a grating optical spectrum analyzer. By borrowing mathematical concepts from photonic time stretch theory and radio-frequency communication, we deduce a novel dual-output electro-optic sampling system, for which the input THz signal can be numerically retrieved—with unprecedented resolution—using the so-called phase diversity technique. We show numerically and experimentally that this approach enables the recording of THz waveforms in single-shot over much longer durations and/or higher bandwidth than previous spectral decoding techniques. We present and test the proposed DEOS (Diversity Electro-Optic Sampling) design for recording 1.5 THz bandwidth THz pulses, over 20 ps duration, in single-shot. Then we demonstrate the potential of DEOS in accelerator physics by recording, in two successive shots, the shape of 200 fs RMS relativistic electron bunches at European X-FEL, over 10 ps recording windows. The designs presented here can be used directly for accelerator diagnostics, characterization of THz sources, and single-shot Time-Domain Spectroscopy.

FLASH – The Free-Electron Laser at DESY

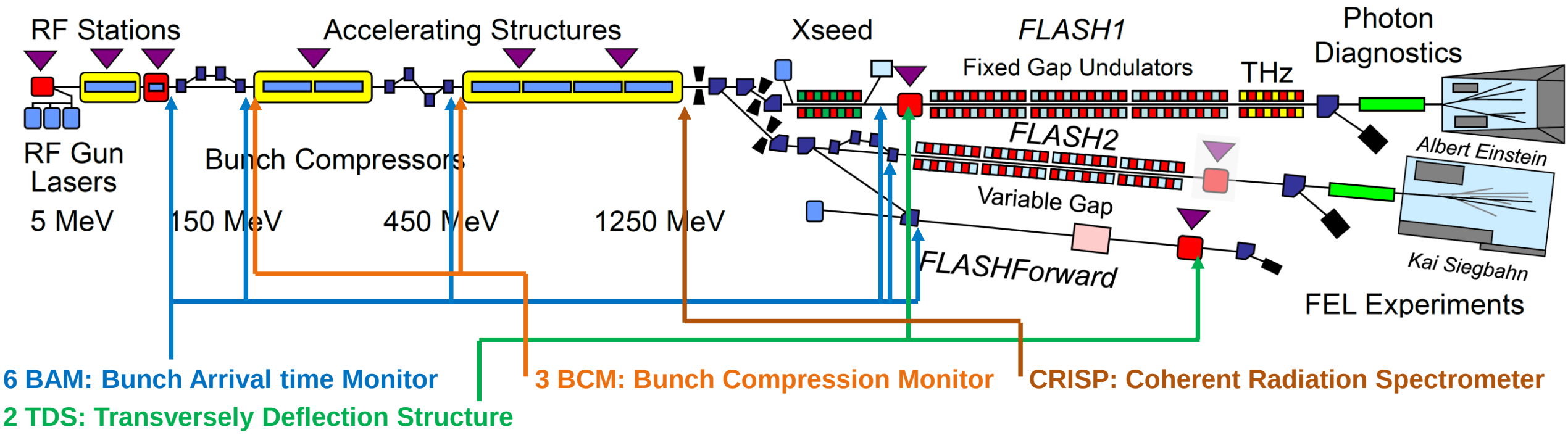
The first soft X-ray FEL operating two undulator beamlines simultaneously

Accelerator

- Superconducting RF, up to 1250 MeV
- 10 Hz pulsed operation
- Bursts of up to 800 bunches a 1 MHz
- Bunch length: 6 ps (at gun) to 30 fs at undulators

Beamlines

- User facility since 2005
- Since 2014 two beamlines with parallel SASE delivery
- Demonstrated wavelength range: 90 nm to 4 nm (from XUV to soft X-rays)
- integrated powerful THz source



Courtesy: J. Rönsch-Schulenburg
with adaptations

FLASH shutdown 2021/2022

Major Upgrades to the facility

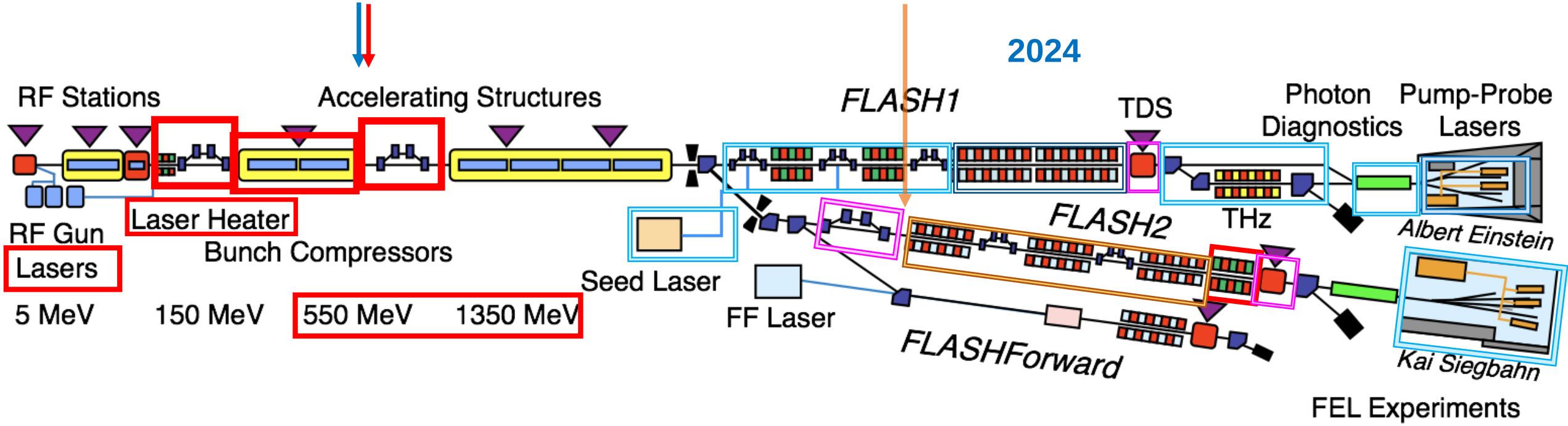
New installations (FLASH linac):

- Energy upgrade 1250 MeV => 1350 MeV
- Laser heater
- Bunch compressors (2nd BC becomes moveable)
- Injector lasers (for the old ones no support and spare parts)
- FLASH2 afterburner

New installations (longitudinal diagnostics):

- BCM upgrade (to Eu-XFEL standard, incl. new vacc.)
- BAM upgrade (to Eu-XFEL standard) + 1
- New EOD (with laser and electronics outside the tunnel)

Bernd's poster



Thank you

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