BE 12: Free-Electron Lasers

Time: Thursday 9:30–12:30 Location: MOL 213

Group Report BE 12.1 Thu 9:30 MOL 213
FLASH1 Seeding Plans — •Christoph Lechner — University of Hamburg, Hamburg, Germany

Many free-electron lasers (FELs) producing light in the UV and extreme ultraviolet (XUV) wavelength ranges start up from noise and operate in the self-amplified spontaneous emission (SASE) mode. Therefore they have typically poor longitudinal coherence. It has recently been demonstrated that when starting with an external laser beam (the so-called 'seed'), it is possible to generate photon pulses with greatly improved longitudinal coherence and higher shot-to-shot stability of the pulse spectra and energy.

For the investigation of FEL seeding, an experiment was built at the FLASH FEL user facility in Hamburg. This beamline can be used with seeds generated by high-harmonic generation (HHG), as originally planned, but also to test more sophisticated concepts. The results from these tests of high-gain harmonic generation (HGHG) and echo-enabled harmonic generation (EEHG) will be considered in the design process of the seeding option at the currently being constructed FEL beamline FLASH2. The baseline design of this upgrade foresees delivery of seeded radiation down to 20nm.

In this contribution, we present the FLASH1 seeding beamline including the diagnostics needed to establish six-dimensional overlap of electron bunches and seed pulses and give an overview of the FLASH1 seeding plans.

BE 12.2 Thu 10:00 MOL 213
Modal Analysis of a Seeded Free-Electron Laser — •Sven Ackermann[1,2], Bart Faatz[1], and Velizar Miltchev[2] — [1]Deutsches Elektronen-Synchrotron (DESY), Hamburg — [2]Universität Hamburg, Hamburg

The free-electron lasers (FEL) are bright photon sources which emit light in a broad wavelength range down to some tenth of an Angstrom. The FELs became an indispensable tool for the scientific research in many fields like physics, biology, chemistry and medicine. Some FELs can amplify the radiation from an external laser field ("seed") which is a promising option to improve the coherence and temporal stability of the FEL radiation. In this contribution, we study the impact of the quality of the seed beam on the power of the output FEL radiation. By the means of numerical simulations the authors investigate the power of the radiation from an FEL seeded using a laser beam of different quality. The obtained results are then compared to experimental results from a directly seeded FEL operated in the XUV range. In addition, a method to measure the beam quality factor from single transverse intensity profiles is discussed and applied.

[1] S. Ackermann, B. Faatz, and V. Miltchev, Phys. Rev. ST Accel. Beams 16, 100702 (2013)

BE 12.3 Thu 10:15 MOL 213
Sub-Femtosecond Single-Spike X-Ray Pulses from Electron Bunches with very low Charge — •Violetta Wacker[1], Juliane Rönsch-Schulenburg[1], Yuantao Ding[2], Zhirong Huang[2], and Alberto Lutman[2] — [1]Universität Hamburg, Edmund-Siemers-Allee 1, 20146 Hamburg — [2]SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, CA 94025

The Linac Coherent Light Source (LCLS) is an x-ray free-electron laser (FEL) at SLAC National Accelerator Laboratory, supporting a wide range of scientific research with an x-ray pulse length varying from a few to several hundred femtoseconds. There is also a large interest in even shorter x-ray pulses consisting of a single spike only, which will allow the investigation of matter at the atomic length (Å) and time scale (fs). Based on start-to-end simulations we investigate the FEL performance of LCLS at 4.3 GeV and 13.6 GeV using 5 pC, 10 pC and 20 pC electron bunches. With an optimization of the machine set up, simulations show that single spike, sub-fs, hard x-ray pulses are achievable at such a low charge.

BE 12.4 Thu 10:30 MOL 213
Commissioning and Characterization of an Optical Compressor for the Ultrashort-Pulse Laser System at FLASH — •Nils Lockmann[1], Tim Plath[1], Juliane Rönsch-Schulenburg[1], Bernd Steffen[2], and Jörg Rossbach[1] — [1]Universität Hamburg — [2]Deutsches Elektronen Synchrotron, Hamburg

It is of high scientific interest to generate stable ultrashort FEL pulses in the few fs range for e.g. a better time-resolved imaging of nanoparticles. In order to extend the parameter range of FLASH towards short pulses, a new photo-injector laser system is introduced to provide a much shorter laser pulse on the photo-cathode than is regularly possible at FLASH. In this way, the longitudinal compression factor needed is reduced way below then the standard operation compression factor which eases beam dynamics issues and relaxes RF stability requirements. The new laser system includes an optical compressor, which in this case is used to stretch the originally very short injector laser pulse to the exactly required value thus providing the optimum length of the electron bunch directly at the injector.

The compressor consists of two diffracting transmission gratings, which introduce dispersion counteracting the chirp of the incoming laser pulse. The strength of the dispersion is controlled by the distance of the gratings, which allows to vary the pulse length from the original length up to a value determined by the beam dynamics requirement.

In this contribution the principle, layout and the characteristics of the optical compressor as well as its influence on the electron bunch will be presented.

BE 12.5 Thu 10:45 MOL 213
Comparison of transverse beam profile measurement techniques — •Jan-Niclas Gruse[1], Sven Ackermann[1,2], Christoph Lechner[1], Jörg Rossbach[1], and Markus Drescher[1] — [1]University of Hamburg, Hamburg, Germany — [2]Desy, Hamburg, Germany

Free-electron lasers in the UV and extreme ultraviolet are typically operated in self-amplified spontaneous emission (SASE) mode. Starting up from shot-noise, there are typically multiple longitudinal modes present, resulting in poor longitudinal coherence. Using so-called 'seeding' techniques it is possible to produce photon pulses with greatly improved longitudinal coherence. For successful direct FEL-seeding the energy coupling of the electron bunch and the seed pulse inside the undulator is critical. This requires low divergence photon beams which can be characterized by the beam quality factor M^2. One standard technique to determine the M^2 is to measure the photon beam size at different longitudinal positions. Due to space constraints such a measurement would be challenging in the undulator. Therefore the seed beam characterization is performed with a dedicated setup. The drawback of using two separated beamlines is that error sources (i.e. deformed mirrors) in one of those branches will result in unpredictable seeding performance. In a recent publication a different approach using modal decomposition of a single image was proposed, holding the promise of a M^2 estimation in the undulator beamline.

In this contribution we present studies comparing the results obtained with the longitudinal scanning technique and the modal decomposition method.

15 min. break

Group Report BE 12.6 Thu 11:15 MOL 213
Status of FLUTE — •Marcel Schuh[1], Andrii Borysenko[2], Nicole Hiller[2], Erhard Huttel[3], Vitali Judin[3], Sebastian Marsching[1], Anke-Susanne Müller[1,2,3], Somprasong Naknaimueang[3], Michael Johannes Nasse[1], Robert Rossmanith[3], Robert Ruprecht[3], Markus Schwarz[1], Manuel Weber[1], and Pawel Pawel Wesolowski[3] — [1]LAS, KIT, Karlsruhe — [2]IPS, KIT, Karlsruhe — [3]ANKA, KIT, Karlsruhe

FLUTE, a new linac based test facility and THz source is currently being built at the Karlsruhe Institute of Technology (KIT) in collaboration with DESY and PSI. It consist of an RF Photo Gun and a traveling wave linac accelerating electrons in the charge range from pC up to 3nC up to 40-50 MeV. The electron bunch will then be compressed in a magnetic chicane down to 1-300fs depending on the charge in order to produce coherent THz emission. An overview of the hardware and the construction status will be given.

BE 12.7 Thu 11:45 MOL 213
Simulations of Radiation Production in the Undulator for the THz Source Project at PITZ — •Prach Boonpornprasert, Barbara Marchetti, Mikhail Krasilnikov, and Frank Stephan — Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738

Zeuthen, Germany

The Photo Injector Test facility at DESY, Zeuthen site, (PITZ) develops high brightness electron sources for modern linac based Free Electron Lasers (FELs). A normal conducting L-band PITZ linac delivers electron bunches of various bunch charge with low emittance and unique pulse train structure. As one possible application of such beams, this generation of IR/THz radiation is under consideration now. Based on the PITZ linac Terahertz light sources using synchrotron radiation, transition radiation and undulator radiation can provide remarkable properties. Due to its infrastructure PITZ can be considered as a proper site for the development of a THz source prototype that could be placed at the European XFEL site, allowing pump and probe experiments with X-rays and THz radiation with a time structure that is identical to that of the XFEL. On the other hand the THz/IR radiation can be used for the electron beam characterization. This work presents GENESIS1.3 simulations of the radiation produced in the undulator. The simulations were performed by considering the PITZ facility as the accelerator and adding an APPLE-II type undulator as the radiator. In this presentation the simulations setup, procedure and results will be described.

BE 12.8 Thu 12:00 MOL 213

Compact Optical Free Electron Laser with Traveling-Wave Thomson Scattering — •Klaus Steiniger, Michael Bussmann, Alexander Debus, Arie Irman, Axel Jochmann, Richard Pausch, Ulrich Schramm, and René Widera — Helmholtz-Zentrum Dresden-Rossendorf

We present a fully analytical description of the field and the electrons in an optical free electron laser in the Travelling-Wave Thomson Scattering (TWTS) configuration. This scheme allows for long interaction lengths of an ultra-short, high-intensity pulsed laser with an electron bunch. The latter can be either provided by laser-accelerated electrons or by a conventional accelerator. TWTS provides for high peak brightness, high brilliance pulses from the EUV to the gamma spectrum with high flexibility in the wavelength and bandwidth of the emitted radiation.

BE 12.9 Thu 12:15 MOL 213

Resonant coherent X-ray diffractive imaging in ultra intense laser interactin with matter — •Thomas Kluge[1], Christian Gutt[2], Lingen Huang[1], Malte Zachias[1], Thomas Cowan[1,3], Ulrich Schramm[1,3], and Michael Bussmann[1] — [1]Helmholtzzentrum Dresden-Rossendorf — [2]Universität Siegen — [3]Technische Universität Dresden

We describe a novel proposed experimental method for X-ray diagnostics of terawatt class laser - solid interaction. Here resonant bound-bound electron transitions in ions give rise to a diffraction pattern that can be used to derive the distribution of ions. The transition energy of a specific transition (e.g. K alpha) is sensible to the degree of ionization, so that an intense mono energetic X-ray beam (XFEL) can be used to select a given in species. The feasibility is studied using quantitative simulations and the great potentials and unique possibilities of this method are highlighted.