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POS — Poster Session

POS01

Status of the ALBA Project

M. Belgroune, D. Einfeld (CELLS)

The storage ring ALBA is a 3 GeV third generation synchrotron light source under construction in Barcelona (Spain). ALBA is optimized for high photon flux density with a beam emittance of 4.5 nm.rad and a large number of available straight sections for Insertion Devices (3x8 m, 12x4.2 m) in a relatively small circumference of 268.8 m. Top-up operation is foreseen from the start. The injector complex for ALBA will consist of a 100 MeV linac and a full energy booster with a roughly small emittance of 9 nm.rad. The design of the lattice and of the major components of the accelerator complex (linac and booster, magnets, RF system, vacuum system) has been completed and the procurement procedure has started for the large majority of them. The construction of the building is planned to start in the first half of 2006 and the commissioning of the storage ring is foreseen for the end of 2008. This report offers an overview of the status of the project.

POS02

Future Light Source at the Photon Factory

H. Kawata (KEK)

After extensive discussions with synchrotron radiation users and accelerator scientists in Japan, we came to the conclusion that a 5 GeV energy recovery linac (ERL) should be the most suitable candidate as the future light source at the Photon Factory to foster cutting edge experiments and support a large variety of user needs from VUV to X-rays. Given the state of the ERL developments worldwide, it is necessary to construct a prototype ERL, with the energy of ~200 MeV to develop several critical components such as electron guns and superconducting cavities. KEK and Japan Atomic Energy Agency (JAEA), which has already built a low energy (17 MeV) ERL and that is also proposing the construction of an ERL-based future light source, are planning to construct together the prototype ERL at the KEK site. To this end, the official organization of the ERL project office has started at KEK from 1st of April 2006. An R&D team for the prototype ERL is going to be organized in collaboration with accelerator scientists from the other facilities, ISSP, UVSOR and SPring-8.

PLT — Plenary Talk

First Experimental Experience at FLASH

PLT01

W. Wurth (Uni HH)

The FLASH user facility started operation in August 2005. Since then 16 groups have performed first experiments at FLASH. Every experiment had roughly 10^{-14} shifts with 12 hours of beamtime. During this first run the users have obtained first exciting experimental results demonstrating the scientific potential of FLASH. In addition, they have gained a lot of experience on how to perform experiments at a Free-Electron Laser facility. In my talk I will briefly review some of the first experimental results which were obtained at FLASH. Furthermore, I will try to give some impression on how experimenting at FLASH differs from the way many of us are used to perform experiments at third generation synchrotron facilities. A particular challenge for science at Free-Electron Laser facilities is the fact that the FEL process and its characterisation is an important part of the experiments.

Trends In X-Ray Synchrotron Radiation Research

PLT02

J.R. Schneider (DESY)

Today storage ring technology is approaching its theoretical limits and efforts are concentrated on improving insertion devices, X-ray optical elements, instrumentation and sample environment, as well as detectors. Focusing to nano-scale beam cross sections, increasing the degree of coherence and exploring ways to produce picosecond or even sub-picosecond pulses for time resolved studies attract a lot of attention. In most cases today X-rays probe matter in its equilibrium state. The logical next step is to extend the methodology to include the investigation of non-equilibrium, of new states of matter with atomic resolution in space and time. Free Electron Lasers provide the necessary very intense flashes of coherent X-rays with wavelengths down to 0.1 nm and they are expected to revolutionize condensed matter research, chemistry, materials science and structural biology. For the first time we will be able to study the structure and the dynamics of matter with atomic resolution in space and time. Referring to the first scattering experiments performed at FLASH, the VUV-FEL user facility at DESY, strategies for performing experiments at free electron X-ray lasers will be discussed.

Energy Recovery Linac Experimental Challenges

PLT03

D.H. Bilderback (Cornell University, Department of Physics)

ERL projects are ongoing at Jlab, Daresbury, KEK and Cornell. Here we describe the typical experimental concerns of using high-coherence and ultra-fast pulses from the Cornell ERL as an example of a new opportunities. The hi-flux mode is one where the ERL runs at 5 GeV and 100 mA. Many experiments are photon-starved, such as inelastic x-ray scattering. The high-coherence mode is obtained at 25 mA and the transverse emittances could be as low as 8 pm. The beam size will be at its smallest under this operating condition and average spectral brightness as high as 10^{23} (standard units) are calculated. (WG2 will discuss the ERL accelerator issues.) We expect to produce a 3 micron round emitting source for imaging and coherence experiments on individual biological cells. The ultra-fast mode is one obtained by reducing the repetition rate to 1 MHz and by increasing the bunch charge to 1 nC per pulse and compressing the natural 2 ps bunch length to less than 100 fs. We will present science opportunities for x-ray experiments on a single atom as well as the challenges in optics, other experiments, and beam control issues when making a 1 nm focused x-ray beam size.

PLT04

Design Considerations for Table-Top FELs

F.J. Gruener, S. Becker, T. Eichner, D. Habs, U. Schramm, R. Sousa (LMU) M. Geissler, J. Meyer-ter-Vehn (MPQ) S. Reiche (UCLA)

Refinements in laser technology (few-cycle pulse generation, chirped pulse amplification) combined with super-computer-based plasma simulations have brought the discipline of relativistic laser-matter interaction to a new level of predictability. This was recently demonstrated by the generation of brilliant electron bunches with energies on the 100-MeV-scale (and supposedly already around 1 GeV). Our plan is to utilize such laser-accelerated electron beams to realize table-top FELs. The essential feature of those electrons is their ultra-high beam current of up to few 100 kA in 10 fs. Such high currents make small-period undulators realistic, which require less electron energy for the same FEL wavelength. Together with low emittance and relatively large Pierce parameter the undulator length for reaching SASE saturation should be as small as only meter-scales. In this paper we present our first basic design considerations based upon start-to-end simulations including 3d PIC codes and GENESIS 1.3. In contrast to the large-scale XFELs, which will be dedicated user facilities, our aim is just to deliver the proof-of-principle of table-top FELs, starting from the VUV to the X-ray range.

PLT05

Inverse Compton Scattering: A Small Revolution in X-Ray Sources and Applications

D.E. Moncton (MIT)

The process of inverse Compton scattering, in which an electron of 20-50 MeV backscatters an optical photon into the hard x-ray spectral range, offers the opportunity to produce high-brilliance hard x-ray beams with a laboratory-scale facility. The basic physics of this process is well-understood, and a variety of demonstrations have taken place. Codes exist to determine the spectral performance depending on the detailed characteristics of the electron and laser beams. This talk will briefly review this history and describe the challenges that are presented by the goal of achieving synchrotron-like levels of flux and brilliance. While 3rd generation sources will maintain a significant advantage for the most demanding experiments, the ICS sources offer the potential advantages over synchrotron sources of small, axially symmetric spot size (less than 10 microns) and short pulse duration (less than 1 picosecond). A system could cost less than $10M and have footprint of order 100 square meters or less. Variations of this technology are possible using small storage rings or linacs as the electron source, and employing different laser technologies. Also, depending on the type of application, trade-offs can be made between flexibility and size/cost. We will describe applications to protein crystallography and imaging in both time dependent and static modes.

PLT06

Trends in XUV Synchrotron Radiation Research on Atoms, Molecules and Clusters

S.K.G. Svensson (Uppsala University)

A review of molecular and cluster physics at third generation facilities will be presented, and a few selected examples will be discussed in detail: The research in the field will be considered in light of the upcoming new sources: Ultra High Brilliant storage rings and FEL:s. A special focus will be on the challenges for new instrumentation.

CW Superconducting RF for Future Linac-Based Light Sources

PLT11

J. Knobloch (BESSY GmbH)

Superconducting RF has become a mature technology and has found many applications in both storage-rings and linacs, primarily in the particle and nuclear physics domain. In the last few years, an increasing number of new CW linac-based light sources have been proposed, which operate in the ERL and/or FEL mode. These include proposals such as the 4GLS, the Cornell ERL, the BESSY FEL and the KEK-ERL. Many such machines are based on TESLA technology to be used in the pulsed XFEL at DESY. Modified CEBAF technology is also being applied to machines such as the JLAB FEL. However, there are numerous issues that must be addressed to efficiently operate this technology CW and with high beam currents. An overview of a number of these issues is provided, with a more detailed discussion of a subset to illustrate the challenges that lie ahead.

Synchronization and Timing Challenges for Future Light Sources

PLT12

G.J. Hirst (CCLRC/RAL)

The delivery of ever shorter pulses from accelerator-based light sources is now enabling femtosecond science in spectral ranges and at average powers beyond the reach of conventional lasers. The need for correspondingly precise management of pulse timing is driven both by the machines' users, who wish to exploit the full capability of multi-beam experiments, and by the machine scientists and engineers, who rely on it for stable operation of their increasingly complex installations. Timing systems interact with almost every component of a light source. Challenges include system design for ease of time-structuring and maximum passive stability, long distance transport of beams and signals through difficult environments, development of timing sensors and actuators with high sensitivity and resolution and the use of advanced electronics to suppress timing noise. This talk will give an overview of the current and future timing issues and of the techniques available for addressing them.

Short Radiation Pulses in Storage Rings

PLT14

S. Khan (Uni HH)

The time resolution of experiments with synchrotron radiation, presently limited by a typical bunch length of 30-100 ps in electron storage rings, can be improved by making the bunches shorter (e.g. reducing the momentum-compaction factor or increasing the rf gradient) or by establishing a temporal-transverse correlation (e.g. transverse rf deflection or fs-laser slicing). Several methods, their present status and their respective merits or shortcomings are discussed.

Attosecond Pulses in XFELs

PLT15

E. Saldin, E. Schneidmiller, M.V. Yurkov (DESY)

We present an overview of schemes allowing production of attosecond X-ray pulses in SASE FEL. Up to now six different schemes were proposed for potential realization at LCLS and European XFEL. Thorough analysis of potential advantages and possible physical and technical limitations is given as well.

PLT16

Seeding and Harmonic Generation in Free Electron Lasers

L. Giannessi (ENEA C.R. Frascati)

SASE FELs represent a mature technology to achieve ultra high brightness X-ray radiation sources. Nevertheless seeded FEL schemes, combined with harmonic generation FEL cascades, may provide superior photon quality and improved performances. The basic element of a harmonic generation cascade is composed by two undulator sections, where the first is resonant at w1 and the second is resonant at w2 = n w1 with n integer. In this layout, the first section modulates the current density while in the second section the emission process at the selected higher order harmonic takes place. The underlining idea consists in the fact that the current density modulation, which occurs during the FEL optical amplification, has higher order harmonic components which are responsible of the enhancement of the higher harmonics emission and which generate radiation when the beam is injected in a second undulator with the central frequency tuned to match the density modulation periodicity. In this communication a review of the basic concepts on challenges and perspectives of alternative (to SASE) FEL schemes will be presented.

WG1 — Working Group 1

Beam Physics Issues in CANDLE Synchrotron Light Source Project

V.M. Tsakanov, M. Ivanyan, Y.L. Martirosyan (CANDLE)

WG101

CANDLE- Center for the Advancement of Natural Discoveries using Light Emission - is a 3 GeV synchrotron light source project in Republic of Armenia. The summary of the facility beam physics study will be given, including the optimal beta performance in insertion devices, the machine impedances, instabilities cures, beam lifetime, non-linear and fringe field effects evaluation.

Discussion of the Design of the NSLS-II Storage Ring

S. Krinsky (BNL)

WG102

We shall discuss the conceptual design of the 3 GeV storage ring (NSLS-II) proposed to serve as a high-brightness source of x-rays at Brookhaven National Laboratory. The lattice is a 32-period double bend achromat (DBA) with damping wigglers used to produce an electron beam emittance below 1 nm. Specially designed insertions are provided for the use of small-gap short-period undulators. Both superconducting and in-vacuum permanent magnet insertion devices are envisioned. Our discussion will emphasize the key accelerator physics issues which limit the achievable source brightness.

High Current Effects in the NSLS-II Storage Ring

B. Podobedov (BNL)

WG103

I shall discuss the effects that become important at high current in the 3 GeV storage ring presently under design for the NSLS-II facility at Brookhaven National Laboratory. This talk will address the achievement of the high bunch density required in the ultra-low emittance (<1 nm) storage ring, and the challenges arising due to multiple small-gap short-period undulators. Specifically, I will focus on single and multiple intra-beam scattering, impedance estimates, and single bunch coherent instabilities.

Study of Dynamic Aperture for PETRA III Ring

Y.L. Li, K. Balewski, W. Decking (DESY)

WG104

PETRA III is a low emittance storage ring dedicated to synchrotron radiation. Twenty damping wigglers with a total length of 80 m are used to reduce horizontal emittance to 1 nm rad. For efficient injection in so called top-up mode, the dynamic aperture should be larger than 30 mm mrad in horizontal plane. This paper presents the beam dynamics study for the damping wigglers, the choice of suitable tunes of machine, and the optimization of sextupoles configuration. The simulation results including magnetic errors and misalignment will be given.

WG111

Featuring the Characteristics of the Super Coherent Teraherz Photon Ring

H. Hama, F. Hinode, K. Kasamsook, M. Kawai, T. Tanaka (LNS) H. Tanaka (JASRI/SPring-8)

A project of coherent synchrotron radiation source at Terahertz (THz) wavelength region has been developed at Tohoku University, Sendai *. The project may involve novel high brightness electron guns employing cathodes of single crystal LaB6 for production of a very short bunch length less than 100 fs **. The source has been designed based on isochronous ring optics to preserve the short bunch length, but the ring is not a storage ring. The optics of the racetrack type isochronous ring has resulted from consideration of path length differences due to both the betatron motion and the energy deviation. The coherent THz photons are emitted from circulating electron bunches injected from the linac. Even the beam turns by dipole magnets, the bunch shape does not collapse because of nearly complete isochronous optics of the ring. Since production of the coherent THz radiation requires the bunch length less than 100 fs (stdv, if Gaussian), the maximum path length difference created by passing through the dipoles is controlled to not exceed a couple of tens fs. Predicted spectrum of the Coherent Thz radiation and its characteristics will be also presented.
*H. Hama, Proc. the 27th Int. FEL Conf., Stanford, CA, (2005) pp1-6.
**T. Tanaka, F. Hinode, M. Kawai, H. Hama, Proc. the 27th Int. FEL Conf., Stanford, CA, (2005) pp142-145

WG112

Proposal of a Synchrotron Radiation Facility to Supply Ultraviolet Light, X-ray, MeV-photon, GeV-photon and Neutron

Y. Kawashima (JASRI/SPring-8)

This is a proposal of new facility, which consists of 1GeV-linac, booster synchrotron and storage ring. The synchrotron accelerates electron beam from 1GeV to 10GeV. The storage ring stores the beam at arbitrary energy from 1GeV to 10GeV and top-up operation is carried out at any stored beam energy. The stored beam current depends on the beam energy. In the energy region of 8GeV to 10GeV, maximum beam current is around 100mA. Under the energy of 4GeV, the targeted maximum current is 1A. The storage ring supplies ultraviolet light, MeV-photon, GeV-photon and neutron for solid-state physics, biology, protein structure analysis, drug development and particle physics. The main feature of the facility is to be able to supply the monoenergetic MeV-photon and neutron. With CO2 laser and stored electron beam, monoenergetic MeV-photons are produced through the inverse Compton process. To obtain the target monoenergetic MeV-photon, the wavelength of the laser is constant; on the other hand stored beam energy is changed. Using a superconducting wiggler, a lot of MeV photons are radiated from the wiggler. With the radiated MeV-photon and beryllium target, neutrons are produced.

WG121

Statistical Optics and Partially Coherent X-Ray Beams in Third Generation Light Sources

G. Geloni, E. Saldin, E. Schneidmiller, M.V. Yurkov (DESY)

A theory of transverse coherence properties of Undulator Radiation is described, based on a Statistical Optics approach, which accounts for the influence of the electron beam emittance. We propose a technique to calculate the cross-spectral density from undulator sources when quasi-homogeneous approximation of the source fails. Also, we find the region of applicability of the quasi-homogeneous model and we present an analytical expression for the cross-spectral density which is valid in free space. This expression characterizes the light source. In particular, it can be used to describe a virtual source which, put at a particular position along the photon beamline, produces, at any distance, the same field of the undulator device. Specification of the cross-spectral density at the virtual source position, together with Fourier Optics techniques, is the basis for any subsequent description of the propagation of the radiation beam through an optical imaging system.

WG2 — Working Group 2

WG202

The JLab High Power ERL Light Source – Status and Plans

G. Neil (Jefferson Lab)

The THz/IR/UV photon source at Jefferson Lab is the first of a new generation of light sources based on an Energy-Recovered, (superconducting) Linac (ERL). The machine was designed with a 160 MeV electron beam and an average current of 10 mA in 75 MHz repetition rate 300 femtosecond bunches. These electron bunches pass through a magnetic chicane and therefore emit synchrotron radiation. Wavelengths longer than the electron bunch radiate coherently a broadband THz ~ half cycle pulse whose average brightness is > 5 orders of magnitude higher than synchrotron IR sources through the FIR with broadband THz production of 300 fs pulses with >200 W of average power. The FELs also provide record-breaking laser power: up to 10 kW of average power in the IR from 1 to 10 microns in 300 fs pulses at up to 74.85 MHz repetition rates. To date we have demonstrated 10 kW of power at 6 microns, 6.7 kW at 2.8 microns and 4.7 kW at 1.6 microns, and 2.4 kW at 1 micron. We have also lased at the third and fifth harmonics producing substantial average power. The THz and IR systems have been commissioned for users. The UV system is to follow in 2007 pending a resumption of funding. This paper will present the status of the system and discuss some of the discoveries we have made concerning the physics performance, and operational limitations of such a first generation ERL light source.

WG205

Status of the ERL Projects at KEK and JAEA

S. Sakanaka (KEK) R. Hajima (JAEA/FEL)

Two Japanese institutes, the High Energy Accelerator Research Organization (KEK) and the Japan Atomic Energy Agency (JAEA; formerly JAERI and JNC), proposed each own 5-6 GeV ERL project for the future light source. Thereafter, the two institutes agreed to promote an ERL-based next-generation synchrotron light source in Japan based on their stimulated technologies. As a first step towards this course, KEK and JAEA are planning to construct together an ERL test facility at KEK site in order to resolve technical and physical challenges. The ERL test facility will comprise a 5-10 MeV injector, a superconducting main linac, and a return loop. The beam energy of the main linac will initially be a few tens of MeV, and will be upgraded up to about 200 MeV. We are also promoting cooperation with the other Japanese SR facilities, SPring-8, UVSOR, and ISSP, to organize an R&D team for the ERL test facility. We present current status and plans of the KEK-JAEA ERL project.

WG214

What Should Start to End Simulations for Light Source ERLs Be Sure to Include?

M. Abo-Bakr (BESSY GmbH)

In ERLs as well as in any other synchrotron light source the quality of the electron beam determines the quality of the output radiation. In the last years big effort has been done to improve electron beam sources, especially with respect to the requirements of short wavelength FELs. To conserve the high beam quality during acceleration and transport from the gun to the undulator sections and in case of ERLS even to the dump, a careful machine design is mandatory, considering all physically relevant processes. In this talk a short introduction to the most important processes will be given together with a summary of simulation codes capable to consider one or more of them. Possibilities and effort to combine these codes for Start-to-End simulations will be discussed.

Beam Abort Strategies and Beam Loss Tolerances

WG215

G. Neil (Jefferson Lab)

High power ERL light sources will transport substantial currents and have to deal with sizeable beam powers. In storage rings such beams “clean up” themselves rapidly so that continual beam loss is generally not a major issue. In contrast, ERLs use a fresh beam which generates halo continuously and that can lead to problems. Even small fractions of the beam lost in an uncontrolled manner can lead to unacceptable vacuum excursions, opening of vacuum seals or, in the worst case, penetration of the vacuum components or other linac hardware. This working group discussion will deal with methodologies for establishing beam loss limits, approaches for detecting such loss before damage can occur, and various means for terminating the electron beam production rapidly.

Vacuum and Aperture Needs for Energy-Recovery Linac Light Sources

WG221

R. Hajima (JAEA/FEL)

Vacuum and aperture are general issue in all particle accelerators. Smaller aperture is beneficial for economical design of magnets, but harmful for good vacuum. In the design of storage-ring light sources, vacuum and aperture are crucial points to discuss, because the beam lifetime is mainly determined by beam-residual gas interactions. Vacuum and aperture needs for ERL light sources are not same as storage rings. In this talk, we examine vacuum and aperture needs for energy-recovery linacs from viewpoints of beam loss, ion trapping, shielding of coherent synchrotron radiation, etc.

What are Advantages and Limits of Multi Turn ERLs?

WG222

J. Bisognano (UW-Madison/SRC)

I will try to set the stage for discussions of the advantages and limitations of reciruclating an ERL for energy gain in addition to energy recovery. Issues such as relative costs, beam breakup, and CSR will be highlighted.

Limits on the Bandwidth for SRF Cavities for ERL linacs

WG223

J. Knobloch (BESSY GmbH)

The effective beam loading in energy recovery linacs is very close to zero. Theoretically, therefore, the optimal input loading of the cavities should be small for reflectionless operation, resulting in bandwidths on the order of 1 Hz or less. In practice, though, such operation is not possible because of issues such as microphonic detuning, rf-field stability and variations in beam loading. An overview of these issues and the state-of-the-art is presented, and the resulting constraints on the bandwidth will be discussed.

WG225

Undulator Issues for ERLs

J.A. Clarke (CCLRC/DL/ASTeC)

There are several issues that surround the use of undulators in ERLs that must be considered. In this talk I will discuss the impact of the undulators on the ERL beam and the impact of the ERL beam on the undulators. I will particularly highlight areas that are of low importance on present day storage ring light sources but that become important with the use of ERLs.

WG233

What are Good Beam Stabilization Strategies and their Limits for Light Source ERLs?

C. Steier (LBNL)

Extremely good beam stability is one of the major features of current storage ring based third generation light sources and for several types of experiments, stability is a more important merit function than brightness or flux. With the smaller emittances envisioned in future ERLs as well as the fundamentally different challenges of a non storage ring, stabilization strategies for ERLs cannot simply copy existing schems from 3rd generation sources but have to evolve beyond the current state of the art. They wil also have to include the full accelerator system starting with the gun laser system.

WG3 — Working Group 3

A Versatile UV-VUV Light Source Based upon a High Gain Distributed Optical Klystron FEL

Y.K. Wu (DU/FEL) N. Vinokurov (BINP SB RAS)

WG301

The FEL gain can be significantly increased using a distributed optical klystron (DOK) FEL with multiple wigglers and bunchers. The enhanced FEL gain of DOK FELs opens the door for storage ring based FEL oscillators to operate in the VUV region toward 150 nm and beyond. This presentation reports the first experimental results from the world's first distributed optical klystron FEL, the DOK-1 FEL, at Duke University. The DOK-1 FEL is a hybrid system, comprised of four wigglers: two horizontal and two helical. With the DOK-1 FEL, we have obtained the highest FEL gain among all storage ring based FELs at 47.8

Experimental Studies of Optical Guiding, Efficiency Improvement and Pulse Length Control in a laser seeded FEL Amplifier at the NSLS SDL*

X.J. Wang, J.B. Murphy, J. Rose, Y. Shen, T. Tsang, T. Watanabe (BNL)

WG302

The Source Development Lab (SDL) at the NSLS of Brookhaven National Laboratory (BNL) is the only facility in the world now capable of performing the laser seeded FEL R&D, such as high gain harmonic generation (HGHG) and direct laser seeded FEL amplifier. A laser seeded FEL amplifier experiment @ 800 nm was initiated at the SDL to demonstrate the critical FEL amplifier technologies for high average power applications. The recent experimental results of the laser seeded FEL amplifier will be presented in this talk. We have achieved more than 4 orders of magnitude of the FEL gain over the seed laser, and measured record FEL output energy of more than 500 uJ. We experimentally demonstrated the FEL guiding and efficiency improvement by frequency detuning. We have experimentally observed nonlinear evolution of the femto-seconds FEL pulse both in exponential gain and superradiance regimes.

Dispersion measurement and correction in the VUV-FEL

E. Prat, W. Decking, T. Limberg (DESY)

WG304

Increase in transverse beam size in the undulator caused by dispersive effects is one of the major limitations for the operation of the VUV-FEL at DESY. Sources of the (spurious) dispersion are field errors and stray magnet fields in the undulator beam line as well as spurious dispersion created upstream of the undulator by, for instance, rf coupler kicks, magnet misalignments and field errors. In this contribution, a procedure for dispersion measurement and correction is described and simulations and first experimental results for the VUV-FEL are presented.

WG305

Operational Experience And Recent Results From Flash

E. Saldin, E. Schneidmiller, M.V. Yurkov (DESY)

Experience from comissioning and operating the user facility at FLASH is discussed. Recent results (lasing at 13 nm) are presented.

WG311

Quantum Regime of SASE FELS

R. Bonifacio (INFN-Milano) N. Piovella (Universita' degli Studi di Milano) G.R.M. Robb (Strathclyde University) A. Schiavi (Rome University La Sapienza)

The novel quantum regime of an high-gain FEL operating in the SASE mode is expected to produce high coherent x-ray radiation, with a narrow spectrum. The theory, based on a Schroedinger-like equation coupled self-consistently to the Maxwell equations, shows that the dynamics depends on a single quantum parameter r, interpreted as the ratio between the classical momentum spread and the photon recoil momentum. In the quantum regime, r < 1, the spectrum is a series of narrow lines, associated to transitions between discrete momentum eigenstates and resulting in high temporal coherence. The classical SASE regime, with random spiking behavior and broad spectrum, is obtained increasing r until the linewidth becomes larger than the frequency separation. We intend to investigate the feasibility of a future experiment of quantum SASE using an e.m. wiggler, by developing a 3D numerical code which will take into account transverse and emittance effects.

WG312

Optical Klystron Enhancement to SASE X-ray FELs

Z. Huang, Y.T. Ding, P. Emma (SLAC) V. Kumar (ANL)

We study the optical klystron enhancement to SASE FELs in theory and simulations. In contrast to a seeded FEL, the optical klystron gain in a SASE FEL is not sensitive to any phase mismatch between the radiation and the microbunched electron beam. The FEL performance with the addition of four optical klystrons located at the undulator long breaks in the Linac Coherent Light Source (LCLS) shows significant improvement if the uncorrelated energy spread at the undulator entrance can be controlled to a very small level. In addition, FEL saturation at shorter x-ray wavelengths (around 1.0 Angstrom) within the LCLS undulator length becomes possible.

WG313

BEAM PHYSICS HIGHLIGHTS OF THE FERMI@ELETTRA PROJECT

S. Di Mitri, M. Cornacchia, P. Craievich, G. Penco, M. Trovo (ELETTRA) P. Emma, Z. Huang, J. Wu (SLAC) D. Wang (MIT) A. Zholents (LBNL)

The electron beam dynamics in the Fermi Linac has been studied in the framework of the design of a single-pass free electron laser (fel) based on a seeded harmonic cascade. The wakefields of some accelerating sections represent a challenge for the preservation of a small beam emittance and for achieving a small final energy spread. Various analytical techniques and tracking codes have been employed in order to minimize the quadratic and the cubic energy chirps in the longitudinal phase space, since they cause, respectively, a shift and a spread of the fel bandwidth. As for the transverse motion, the beam breakup (bbu) instability has been recognized as the main source of emittance dilution; the simulations show the validity of non-local correction methods in order to counteract the typical "banana" shape distortion of the beam caused by the instability.

Start-To-End Simulations for the European XFEL

WG314

M. Dohlus, I. Zagorodnov (DESY)

The lattice and optics data of the s2e simulations are based on an Excel table with the XFEL component list. The simulation tools are ASTRA, CSRtrack, GENESIS and ELEGANT. Utility programms are used to convert particle files and to consider wake fields of cavities (calculated with ECHO) or due to space charge, surface effects and the undulator geometry. The simulations [2] for the XFEL STI review meeting (15/16 March 2006) are based on ASTRA calculations for the low energy part (including the first module) and on semianalytic estimations of space charge effects and particle propagation based on transport matrices for all non dispersive sections upstream of the undulator. Dispersive sections as the two bunch compressors are computed with the 1d model of CSRtrack. GENESIS is used for the SASE-FEL process in the undulator. The s2e simulation reported on the XFEL-s2e web page [3] uses ASTRA calculations for all non-dispersive parts of the XFEL before the second bunch compressor and even for the following eight rf modules. The injector dogleg as well as both bunch compressors are simulated with CSRtrack using a 3D sub-bunch approach. The rest of the machine before the undulator is treated with ELEGANT and semianalytic space charge wakes. SASE simulations are so far not available. There is a considerable difference in the numerical effort of the start-to-undulator simulations for [2] and [3]. The later simulation is intended as a reference solution. A method that is efficient and precise is probably based on the use of ELEGANT in combination with the semianalytic space charge estimation for parts of the XFEL even before the first bunch compressor and on the 1d CSR model in CSRtrack. This is subject of further investigations.

[1] http://www.desy.de/xfel-beam/data/component**list.xls**
 [2] TESLA-FEL Report 2005-10
 [3] http://www.desy.de/xfel-beam/s2e/xfelv4.html

Experience with Start-to-End Tolerance Studies in HGHG FEL Cascades

WG315

B.C. Kuske, M. Abo-Bakr, K. Goldammer, A. Meseck (BESSY GmbH)

Start-to-end simulations for today's FEL projects are tedious and time consuming. Tolerance studies easily extend the efforts to weeks of computation time. Comparisons between start-to-end simulations and perfect bunches show how important these studies are. Special emphasis is put on HGHG FEL cascades, where results of start-to-end simulations have direct impact on the hardware layout. Examples are given for the BESSY FEL, especially the 2 stage low energy FEL line.

Analysis of Spontaneous Emission and its Self-Amplification in Free-Electron Laser

WG316

Q.K. Jia (USTC/NSRL)

The spontaneous emission and the self-amplified spontaneous emission (SASE) in free-electron laser are investigated from the one-dimensional Maxwell wave equation in the time domain. The explicit expressions of the incoherent spontaneous emission and the coherent spontaneous emission are deduced for an arbitrary electron pulse profile, it show that both are related to the slippage distance. The effective start-up power of SASE for a long electron bunch is obtained with the time domain approach, it is composed of the shot noise term and the super radiant term, corresponding the incoherent spontaneous emission and the coherent spontaneous emission respectively. The shot noise term is found to be equal to the usual spontaneous undulator radiation in the one power gain length. An analytical estimation of saturation power and saturation length of SASE is presented.

WG317

An Analysis of Nonlinear Harmonic Generation

Q.K. Jia (USTC/NSRL)

The nonlinear harmonic generation in high gain free electron laser is analysed in a perspicuous way. The harmonic interactions and evolution is shown explicitly. One-dimensional analytical equations for nonlinear harmonic generation in both SASE FEL and HGHG FEL are given.

WG321

Commissioning Plans for the LCLS

J.J. Welch (SLAC)

The Linear Coherent Light Source (LCLS), an XFEL presently under construction at SLAC, will begin commissioning this fall, starting with the drive laser, the injector, and the first bunch compressor section of the linac. In this paper, we describe the overall commissioning plans for the entire LCLS up to and including commissioning the FEL beam.

Work supported in part by the DOE Contract DE-AC02-76SF00515.This work was performed in support of the LCLS project at SLAC.

WG322

The SPARX FEL Proposal

C. Vaccarezza (INFN/LNF)

SPARX is a proposal for a X-ray-FEL facility jointly funded by MIUR (Research Department of Italian Government) , Regione Lazio, CNR, ENEA, INFN and Rome University Tor Vergata. It is the natural extension of the ongoing activities of the SPARC collaboration. The aim is the generation of electron beams characterized by ultra-high peak brightness at the energy of 1and 2 GeV, for the first and the second phase respectively. The beam is expected to drive a single pass FEL experiment in the range of 13.5-6 nm and 6-1.5 nm, at 1 GeV and 2 GeV respectively, both in SASE and SEEDED FEL configurations. A hybrid scheme of RF and magnetic compression will be adopted, based on the expertise achieved at the SPARC [1] high brightness photoinjector presently under installation at Frascati INFN-LNF Laboratories. The use of superconducting and exotic undulator sections will be also exploited. In this paper we discuss the present status of the collaboration.
on behalf of the SPARX team

Shanghai DUV-FEL Progress

WG323

Z. Zhao, Y. Cao, M. Chen, Z.M. Dai, H.X. Deng, Q. Gu, D.M. Li, D.G. Li, D.K. Liu, K.R. Ye, M.H. Zhao, X.F. Zhao, Q.G. Zhou (SINAP) S.Y. Chen (IHEP Beijing) J.P. Dai (IHEP) H. He, Q.K. Jia (USTC/NSRL)

The SDUV-FEL has been designed as an HGHG type high gain FEL facility to provide high power coherent radiation from 262nm to 88nm, which consists of a 300MeV S-band Linac, seeding laser, six sections of 1.5m radiator undulator, one 0.8m modulator undulator and one dispersion section. Its first 100MeV Linac section has been successfully commissioned with a ns grid gun injector in 2005. A photocathode injector will replace the existing gun and buncher of the 100MeV Linac in this year. The magnetic bunch compressor has been completed and will be installed in this year. The first 1.5m radiator undulator has been fabricated and measured, and other five sections of radiator undulator are being under manufacture. The laser system for photocathode has been installed and commissioned. The photocathode RF gun and the FEL required beam diagnostics are under manufacture. In this paper, we also present the design optimization on the SDUV-FEL facility.

Single Bunch Emittance Preservation in XFEL Linac

WG324

V.M. Tsakanov, G.A. Amatuni (CANDLE) R. Brinkmann, W. Decking (DESY)

The single bunch emittance preservation in booster and main linacs of European XFEL project is presented. The wakefield and chromatic dilution of the beam emittance caused by free betatron oscillations, cavity and modules offset misalignments and random tilts are evaluated. The effects of cavities misalignments correlation along the linac are discussed. The effects of quadrupole misalignments and the corresponding trajectory steering based on one-to-one correction technique are given. The residual chromatic emittance dilution of the corrected trajectory is evaluated.

Simulation Studies on the Self-Seeding Option at FLASH

WG331

V. Miltchev, J. Rossbach (Uni HH) B. Faatz, R. Treusch (DESY)

In order to improve the temporal coherence of the radiation generated by FLASH, a two-stage seeding scheme* is presently being realized. It consists of two undulator stages and a magnetic chicane and a monochromator located between them. In this contribution we investigate various configurations of the electron optics of the seeding set-up. The optimization of the lattice in the first seeding stage and the parameters of the magnetic chicane will be discussed. Simulation results for the performance of the seeded FEL at different resonant wavelengths will be presented.

J. Feldhaus et. al. "Possible application of X-ray optical elements for reducing the spectral bandwidth of an X-ray SASE FEL". Optics Communications,Volume 140, Pages 341-352

Fully Coherent X-Ray Pulses from a Regenerative-Amplifier FEL

WG332

Z. Huang, R.D. Ruth (SLAC)

We propose and analyze a regenerative-amplifier FEL to produce fully coherent, hard x-ray pulses [1]. The method makes use of narrow-bandwidth Bragg crystals to form an x-ray feedback loop around a relatively short undulator. Self-amplified

spontaneous emission (SASE) from the leading electron bunch in a bunch train is spectrally filtered by the Bragg reflectors and is brought back to the beginning of the undulator to interact repeatedly with subsequent bunches in the bunch train. The FEL interaction with these short bunches regeneratively amplifies the radiation intensity and broadens its spectrum, allowing for effective transmission of the x rays outside the crystal bandwidth. The spectral brightness of these x-ray pulses is about 2 to 3 orders of magnitude higher than that from a single-pass SASE FEL.
[1] Z. Huang and R. Ruth, Phys. Rev. Lett. 96, 144801 (2006).

WG333

HHG Seeding and the 4GLS XUVFEL

B. Sheehy (Sheehy Scientific Consulting) J.A. Clarke, D.J. Dunning, N. Thompson (CCLRC/DL/ASTeC) B.W.J. McNeil (Strathclyde University)

The Fourth Generation Light Source (4GLS) project, proposed by the CCLRC in the U.K., will include free electron lasers in the XUV, VUV, and IR. It is proposed that the XUV-FEL, operating between 8-100 eV, be seeded by a high harmonic (HH) source, driven by an ultrafast laser system. This offers advantages in longitudinal coherence, synchronization, and the potential for chirped pulse amplification and pulse shaping. In this talk we discuss the issues of HH generation relevant to its use as a seed (energy, spectrum, tunability, synchronization and time structure) and the current planned implementation in the 4GLS XUV-FEL.

WG334

Femtosecond Synchronism of X-Rays and Light in an X-Ray Free-Electron Laser

B.W. Adams (ANL)

An important tool to study the fundamental processes of chemistry and solid-state physics is the femtosecond-resolving visible/IR pump, x-ray probe technique. It requires ultrashort pulses of light and x-rays in few-femtosecond synchronism with each other. Here, a scheme is proposed to derive both types of radiation from the same electrons in an emittance-sliced XFEL [1]. For this, the same emittance contrast that is imposed onto the bunches in an XFEL to modulate the SASE process is also used to generate a coherence enhancement of transition undulator radiation [2] (TUR). This results in an intense single-cycle pulse of near-infrared, coherent TUR (CTUR) light that is perfectly synchronized to the SASE x-rays, and has about 100 micro-Joules of energy (based upon LCLS parameters). The idea will be presented and conceptual issues will be discussed, such as near-field effects in the CTUR. Furthermore, practical issues arising from the integration into an XFEL facility will be adressed, such as impact on beam-position monitoring, direct use of the CTUR for pumping vs. cross-correlation with a short-pulse laser, and scanning delays.
[1] P. Emma et al., Phys. Rev. Lett. 92, 074801 (2004)
 [2] K.-J. Kim, Phys. Rev. Lett. 76, 1244 (1996)
 [3] B.W. Adams, Rev. Sci. Instrum. 76, 063304 (2005)

WG341

Flat Electron Beams for a Smith-Purcell Backward Wave Oscillator for Intense Terahertz Radiation

K.-J. Kim (ANL) V. Kumar (RRCAT)

A Smith-Purcell device can operate as a backward wave oscillator (BWO) producing a few watts of narrow bandwidth, CW Terahertz radiation. We discuss the requirements on electron beam properties for achieving the operation of such a device based on the results of a 2-D theory of Smith-Purcell BWO [1]. It is found that a specially designed non-relativistic electron beam is necessary with the current exceeding a certain threshold value and a flat transverse profile. Two methods for producing electron beams of required characteristics are discussed, one based on a line source and one employing the flat beam technique.

[1] V. Kumar and K.-J. Kim, Physical Review E 73, 026501 (2006).

Design of the Thomson Source at SPARC/PLASMONX for Incoherent and Coherent X-Rays

WG342

L. Serafini (INFN-Milano)

The SPARC Project, presently commissioning its photo-injector, will be upgraded, in the frame of the Project PLASMONX, by installing at LNF an ultra-high intensity Ti:Sa laser system, delivering 30 fs laser pulses, synchronized to the SPARC electron beam, carrying up to 200 TW. The collision of the two beams will produce X-rays by Thomson back-scattering with unprecedented characteristics of: monochromaticity (in the range 1-10 % bandwidth), tunability in the 20-500 keV spectral region, rapidity (from 100 fs to 10 ps pulses) and brilliance, which is comparable to the one of synchrotron light sources. Applications of this Thomson X-ray Source range from advanced radiological imaging to radio-therapy with micro-beams, from X-ray microscopy to national security applications. Studies are under way to assess the existence of FEL collective instabilities, in the classical and quantum regime, by operating the Thomson Source either with extremely high brightness beams or with very high laser pulse energies: we will discuss the experimental conditions under which the FEL instability can be driven and observed. This would produce coherent X-rays with much higher brilliance.

Production of Coherent X-Rays with a Free-Electron Laser Based on Optical Wiggler

WG343

C. Maroli, V. Petrillo (Universita' degli Studi di Milano) A. Bacci (INFN/LASA) M. Ferrario (INFN/LNF) L. Serafini (INFN-Milano)

The interaction between high-brightness electron beams and counter-propagating laser pulses produces X-rays via Thomson scattering. If the laser source is long enough the electrons bunch on the scale of the emitted X-ray wavelength and a regime of collective (coherent) emission can be established. The emitted radiation grows exponentially and the system behaves as a FEL with optical undulator. The bandwidth of the emitted X-rays is sharper than that of the usual incoherent emission. Emittance of the beam and gradients and irregularities of the laser intensity spatial distribution are the principal factors that limit the growth of the X-ray signal. The characters of the emission and the corresponding X-ray spectra are analyzed on the basis of a 3D code. The scalings typical of the optical wiggler with very short gain lengths and short time duration of the ineteraction allow considerable emissions also in violation of criteria valid for static wigglers. The parameters chosen in the cases examined allow a classical treatment of the lasing process.

Effects of Helical Wiggler on Relativistic Modes in a Coaxial Plasma Waveguide

WG344

B. Farokhi (IPM)

An analysis of the fully relativistic high-frequency eigenmodes of a coaxial wave guide containing a magnetized annular plasma column with effects of helical wiggler is presented. A transcendental equation is derived from the boundary conditions in the form of an eighth-order determinant equated to zero. Simulataneous solution of this determinantal equation and a polynomial equation derived from the wave equation yields, the dispersion relations for the eigenmodes. The electrostatic treatment of a coaxial cylindrical waveguide is also presented. Numerical solutions are obtained for some azimuthaly symetric EH (perturbed TM) and HE (perturbed TE) waveguide modes, cyclotron modes, and space-charge modes. A strong dependence of the frequencies of these electromagnetic-electrostatic waves on the radii of the coaxial wave guide and the plasma column is revealed.

Self-Field Effects on Free-Electron Laser with a Planar Wiggler, Ion-Channel Guiding and Axial Magnetic Field

B. Farokhi (IPM)

A one-dimensional theory of ion-channel guiding with a planar wiggler and axial magnetic field is presented. A numerical study of the growth rate for the planar wiggler, ion-channel guiding and axial magnetic field with the effects of self-fields is made and compared with that for without self-fields. Significantly higher growth rate in some parameters, is also obtained compared to a similar FEL and without self-fields. Stability analysis is performed by assuming small perturbations around steady-state solutions, and we have found the new unstable part of trajectory in group I and group II orbits at the presence of self-fields.

WG4 — Working Group 4

Advantages of the Superconducting $3\frac{1}{2}$ Cell SRF Gun in Rossendorf

WG401

F. Staufenbiel (FZR)

This paper describes the features of the $3\frac{1}{2}$ cell SRF gun from Rossendorf and the advantages and challenges of superconductivity. One advanced working regime of the SRF photo injectors is to produce short pulses with high bunch charges and low transverse emittance running in cw-mode. The quality of this electron beam is crucially for future FEL's with very short wave lengths. The main challenge is to compensate the growing transverse and longitudinal emittance with increasing bunch charges. Therefore, some procedures for emittance compensation for the $3\frac{1}{2}$ cell SRF gun will be discussed.

High-Brightness Source R&Ds for a XFEL Development in the Pohang Accelerator Laboratory (PAL)

WG402

S.J. Park, J.Y. Huang, C. Kim, I.S. Ko, T.-Y. Lee (PAL)

We have constructed a photo-injector test facility for developing a high-brightness electron source for use in the PAL XFEL - a SASE XFEL machine to be built in the Pohang Accelerator. The facility consists of a 1.6-cell photocathode RF gun, a Ti:Sa laser, and special beam-diagnostic devices. Follwed by the first-beam achievements in November last year, much efforts have been made for improving laser-beam qulaities including timing & pointing stabilities, transverse uniformity, and remote control capabilities. In this article, we report on these activities and the beam-diagnostic results of basic gun performances. We also address our research efforts on the generation and diagnostic of high-brightness beams.

Laser System of Photocathode RF Gun in Pohang Accelerator Laboratory

WG403

C. Kim, J.Y. Huang, I.S. Ko, S.J. Park (PAL)

A photocathode RF gun have been installed in a photo-injector test facility for the PAL XFEL in the Pohang Accelerator Laboratory. The photocathode RF gun will provide electron bunches which have high charge (1 nC), short bunch length (10 ps). For this purpose, a new laser system was installed and it can provide laser pulses of 2 mJ energy, 110 fs pulse width at 800 nm wavelength. A tripple harmonic generator and Ultraviolet (UV) stretcher system were added to generate UV laser pulses with controllable pulse widths which can be increased up to 10 ps. In this article, we introduce our laser system and report recent progress of electron beam generations under the various laser conditions.

WG404

Commissioning of SPARC Photo-Injector

D. Filippetto (INFN/LNF)

We report the first stage of the SPARC photo-injector commissioning. For a detailed study of the emittance compensation scheme and to find the best accelerator working point in order to minimize the emittance at the end of the linac, detailed and systematic studies on the emittance and on the beam envelope were performed with a new movable device, called e-meter.

WG411

An Estimation of Dark Current at the European XFEL Gun

J.H. Han (DESY)

At FLASH, high radiation dose at the undulator is crucial problem in the long pulse operation of the SASE. Dark current generated at the rf gun is the most responsible source of the high dose. The L-band gun is operated with a maximum rf field of 42 MV/m at the cathode. At the rf gun of the European X-ray FEL, an rf field up to 60 MV/m at the cathode will be applied to decrease 1 nC beam emittance below 1 mm mrad. According to the Fowler-Nordheim equation, much higher dark current is estimated at the XFEL gun. In this article, ideas to reduce the dark current at the gun and a collimator design are presented.

WG412

Low Emittance Electron Guns Employing the LaB6 Single Crystal Cathode

H. Hama, F. Hinode, K. Kasamsook, M. Kawai, T. Tanaka (LNS)

Two different ways to approach low emittance electron beam have been studied at Tohoku University, i.e., independently tunable cells thermionic RF gun and conventional thermionic DC gun employing extremely lower extraction voltage around 50 kV without a grid structure. The specific common feature of these guns is introducing a cathode of single crystal LaB6. Beam of much higher current density can be generated from the LaB6 crystal than that from conventional dispenser cathodes, so that the size of the cathode area is able to be reduced. The 50 kV DC gun is designed so as to drive a teraherz (THz) free electron laser and it will be very much compact to exclude the high voltage stage. Because the distance between the anode and the wehnelt is very short, the extracting electric field should be very high. On the other hand, a thermionic RF gun with two independently tunable cells has been developing towards femtosecond short bunch beam*. By using a simulation code based on finite difference time domain method, effects of wakefield and coherent radiation in a bunch compressing and energy filtering section followed by accelerating structures are evaluated.

*T. Tanaka, F. Hinode, M. Kawai, H. Hama, Proc. the 27th Int. FEL Conf., Stanford, CA, (2005) pp142-145

WG421

Production of Ultra-Short, High-Brightness Waterbag Bunches

S.B. van der Geer, O.J. Luiten, M.J. Van der Wiel, S.B. van der Geer (TUE)

At Eindhoven University of Technology several closely related projects aim at the production of ultra-short high-brightness electron bunches. An overview of these efforts is given, with emphasis on micrometer precise rf-photogun manufacture and three dimensional compression of uniformly filled (waterbag) electron bunches.

WG422

Proposal of a Photocathode Impulse-Gun and Followed by Impulse Accelerating Structures to Produce Low Emittance Electron Beam

Y. Kawashima (JASRI/SPring-8)

The photocathode impulse-gun must be one of the best methods to produce low emittance electron beam for FEL. To raise the beam energy up to around 10MeV, RF cavity will be used. However, there is drift space between the photocathode impulse-gun and RF cavity. The beam emittace will get worse due to space charge effect in passing through the drift space. Thus the drift space should be as shorter as possible. Minimizing the space charge effect is essential for the early stage of beam acceleration at an electron beam source and a following pre-acceleration. Mechanically unavoidable drift space degrades the beam emittance drastically. We propose a combined structure of a photocathode impulse-gun followed by an impulse accelerator.

WG423

Transverse to Longitudinal Emittance Exchange to Improve Performance of High-Gain x-Ray Free Electron Laser

K.-J. Kim (ANL) P. Emma, Z. Huang (SLAC) P. Piot (Northern Illinois University)

The ability to generate small transverse emittance is a limiting factor for the performance of high-gain free electron lasers for x-rays. Noting that beams from an RF photocathode gun can have energy spread much smaller than that required for an x-ray FEL, we present a method to produce a normalized transverse emittance 0.1 mm-mr, an order of magnitude smaller than the state-of-the-art. The method consists of producing a pancake-shaped beam of emittance (1, 1, 0.1) mm-mr in the (x-y-z-) direction, applying the flat beam technique [1] to obtain (10, 0.1, 0.1) mm-mr, and then exchanging the x-emittance with the longitudinal(z)-emittance, finally obtaining (0.1, 0.1, 10) mm-mr. We show that the space charge effect does not degrade the small longitudinal emittance of the pancake-shaped beam. We found that the optical scheme studied previously [2] for an approximate longitudinal-transverse exchange is not adequate for the present case due to the large emittance ratio. However, we found a new scheme giving rise to an exact exchange necessary for the method. Results of preliminary simulation confirm the analytical theory.

[1] R. Brinkmann, Ya Derbenev, and K. Floettmann, Phys. Rev. ST Acc. Beams 4, 053501 (2001)
 [2] M. Cornacchia and P. Emma, Phys. Rev. ST Acc. ST-AB 7 074401 (2004)

WG5 — Working Group 5

WG502

Feedback Concepts: Experience at SPPS, LCLS Plans

P. Krejcik, S. Allison, P. Emma, D. Fairley, J. Wu (SLAC)

The LCLS will operate with single bunches at a repetition rate of 120 Hz. The control system is designed to measure and respond to beam errors within the 8.3 ms between pulses. Single-shot, high-resolution measurements of the beam position are required for trajectory feedback control as well as beam energy control in the bunch compressor chicanes and dog-leg beam lines. A single-shot measurement of the bunch length at the exit of bunch compressor chicanes is also required to provide full feedback control of the longitudinal phase space. The amplitude and phases of linac klystrons are controlled pulse-by-pulse within one global feedback loop to maintain the correct energy and bunch length of the beam. The bunch length is determined from measurements of the coherent radiation of the beam, but the type of detector employed varies with bunch length at each location and hence wavelength of the coherent radiation. Experience has been gained with single-shot pyroelectric detectors at the SLAC Sub-Picosecond Pulsed Source (SPPS) and simple feedback control was implemented to stabilize the bunch length. The plans for implementing a full feedback system at LCLS will also be presented.

WG503

Synchronization System for the XFEL

H. Schlarb, F. Loehl, F. Ludwig, S. Simrock (DESY) F.X. Kaertner, J. Kim (MIT) A. Winter (Uni HH)

The production of ultra-short electron bunches in Free Electron Lasers puts complete new demands on the sychronisation systems for the accelerator and its sub-system. Novel new techniques using laser pulses, distributed in optically stabilized fiber-links, provide the possibility to synchronize with femtosecond stability critical components such as mode-locked lasers for pump-probe experiments, or diagnostic purposes, and local RF oscillators for the LLRF controls to the machine reference. In this talk an overview of the layout for the XFEL synchronization system and its sub-components is given.

WG504

Recent Developments and Layout of the Master Laser System for the VUV-FEL

A. Winter, H. Schlarb (DESY) F.O. Ilday (Bilkent University)

Mode-locked fiber lasers are promising candidates to serve as optical master oscillators in optical synchronization systems. This talk will present recent measurements regarding the phase noise of these lasers. Furthermore, the layout of the optical master oscillator for the VUV-FEL will be discussed and first results concerning its reliability will be presented.

Compact Ultra-High Precision Beam Phase Monitor System

F. Loehl, K.E. Hacker, F. Ludwig, H. Schlarb, B. Schmidt (DESY) A. Winter (Uni HH)

WG506

For the operation of free-electron lasers, in particular for experiments carried out in pump-probe configurations, a precise synchronization between the photo-injector laser, low-level RF-systems, probe lasers, and other components is mandantory. A measurement of the jitter in the arrival-time of the electron bunch with respect to the clock signal of a master oscillator is, therefore, of special importance. We present an ultra-precise arrival-time monitor system based on a broadband beam pick-up which permits measurements in the sub-100 fs regime. With the inductively shaped RF-pulse from the beam pick-up the amplitude of an ultra-short laser pulse is modulated using an electro-optical modulator with appropriate bandwidth. This modulation is detected by a photo detector and sampled by a fast ADC. As sampling laser the master laser oscillator of the machine is used directly. Therefore, no additional devices are required that may add timing jitter. We present the layout of the system and first experimental results.

Timing Issues for the BESSY Femtoslicing Source

S. Khan (Uni HH)

WG507

Intrinsic synchronization of laser pump and x-ray probe pulses is one of the key features of the fs slicing scheme published by A. Zholents and M. Zolotorev (PRL 76 (1996), p. 912), allowing to obtain 100 fs time resolution while timing laser pulses on the ps and ns level. This paper reports the relevant issues as experienced at the BESSY slicing source in Berlin.

Time-Resolved Measurements using a Transversely Deflecting RF-Structure

M. Roehrs, C. Gerth, H. Schlarb (DESY)

WG511

In SASE-based Free Electron Lasers as FLASH at DESY, the knowledge of time-related parameters of electron bunches as bunch length, energy-time correlation and time-sliced emittance is important for FEL-operation and for analysing bunch compression processes. In order to measure such parameters, a vertically deflecting rf-structure has been installed at FLASH and taken into operation in early 2005. The structure allows to establish the longitudinal density profile of single bunches on the vertical axis of an OTR-screen. The horizontal time-sliced emittance can be reconstructed from measurements of the slice widths for different quadrupole settings. By dispersing vertically streaked bunches horizontally with a dipole, the energy-time correlation can be directly obtained in a single shot measurement. In this paper some results of recent measurements are presented.

Longitudinal Diagnostics with THz Radiation

H. Delsim-Hashemi, P. Schmüser (Uni HH) O. Grimm, B. Schmidt (DESY)

WG512

According to the FEL theory, the longitudinal charge distribution in an electron bunch has an important effect on lasing process. For FLASH at DESY, structures in the order of 10 micrometers play a crucial role in SASE production. The investigation of the electron bunch longitudinal charge distribution and its bunch to bunch changes is one of the most important issues for optimizing the operation of the machine and improving its stability. Single shot spectroscopic in the 10 – 200 micrometer regime is beyond the capability of existing spectroscopic diagnostic tools. This paper introduces a new diagnostics method based on fast spectrally resolved detection of coherent infrared radiation from electron bunches. Measurement results at FLASH with this spectrometer in both scanning mode and single shot mode are presented and discussed.

WG513

Status of the Optical Replica Synthesizer Project at DESY

V.G. Ziemann (UU/ISV) M. Larsson, P. van der Meulen (FYSIKUM, AlbaNova, Stockholm University) E. Saldin, H. Schlarb, E. Schneidmiller, M.V. Yurkov (DESY)

We present the status of the optical replica synthesizer project to measure ultra-short electron bunches in the VUV-FEL. The device is based on the creation and diagnosis of a coherent light pulse that mimics the longitudinal profile of the electron bunch as described by Saldin, et.al. in Nuclear Inst. and Meth. A 539 (2005) 449.

WG514

Electro-optical measurements of the longitudinal bunch shape at FLASH

B. Steffen, E.-A. Knabbe, B. Schmidt (DESY) G. Berden (FOM Rijnhuizen) S.P. Jamison (CCLRC/DL/ASTeC) P.J. Phillips (UAD) P. Schmüser (Uni HH)

Latest results on spectral decoding and temporal decoding EO measurements of the longitudinal bunch shape at FLASH will be presented, showing sub-200fs EO signals.

WG516

Femtosecond Data Reconstruction at FELS Using EOS

A.L. Cavalieri (MPQ) P.H. Bucksbaum, D. Fritz, S. Lee, D.A. Reis (Michigan University)

Observation of laser initiated lattice vibrations in bismuth at the Sub-Picosecond Pulse Source at SLAC proves that precise pulse-to-pulse timing information determined by EOS can be used for femtosecond x-ray data reconstruction, enabling high-resolution pump-probe experiments at future FELs.

WG517

X-ray Pulse Length Characterization Using the Surface Magneto Optic Kerr Effect

P. Krejcik (SLAC)

It will be challenging to measure the temporal profile of the hard X-ray SASE beam independently from the electron beam in the LCLS and other 4th generation light sources. A fast interaction mechanism is needed that can be probed by an ultrafast laser pulse in a pump-probe experiment. It is proposed to exploit the rotation in polarization of light reflected from a thin magnetized film, known as the surface magneto optic Kerr effect (SMOKE), to witness the absorption of the x-ray pulse in the thin film. The change in spin orbit coupling induced by the x-ray pulse occurs on the subfemtosecond time scale and changes the polarization of the probe beam. The limitation to the technique lies with the bandwidth of the probe laser pulse and how short the optical pulse can be made. The SMOKE mechanism will be described and the choices of materials for use with 1.5 Å x-rays. A schematic description of the pump-probe geometry for x-ray diagnosis is also described.

An Intra Bunch Train Feedback System for the European XFEL

WG521

B. Keil, M. Dehler, R. Kramert, A. Lounine, G. Marinkovic, P. Pollet, T. Schilcher, V. Schlott, D.M. Treyer (PSI)

After joining the preparatory phase of the European X-FEL project, the Paul Scherrer Institut (PSI) agreed in taking over responsibility for electron beam stabilization by developing a fast intra bunch train feedback (IBFB) system, which will be tested in its prototype version at the VUV-FEL facility at DESY. The IBFB will make use of the long bunch trains provided by the superconducting drive accelerators of the VUV- as well as the European X-FEL allowing to damp beam motions in a frequency range of a few kHz up to several hundreds of kHz applying modern control algorithms in a feedback loop. The FPGA-based, digital data processing and the low latency time (preferably < 200 ns) allow the elimination of long range (from bunch train to bunch train) and ultra fast (bunch by bunch) repetitive beam movements by adaptive feed forwards. This report will introduce the IBFB design concept and report on the status of the project.

Conceptual Fast Orbit Feedback Design for PETRA III

WG522

G.K. Sahoo, K. Balewski, H.T. Duhme, J. Klute, I. Krouptchenkov, R. Neumann (DESY)

PETRA III, a 6 GeV synchrotron light source will have a horizontal beam emittance of 1nm.rad and a 1% emittance ratio. As the vertical beam sizes are ~5–10 micron in the low gap undulator sections the beam position stability requirement in the vertical plane is between 0.5 and 1 micron whereas the stability requirement in the horizontal plane is more relaxed. In order to obtain and maintain the small emittances imposes tight tolerances on spurious dispersion and orbit quality and stability. A fast orbit feedback is foreseen to achieve the required orbit stability. The conceptual layout and the basic design parameters of this system will be described in this presentation

Large Aperture BPM for use in Dispersive Regions of Magnetic Chicanes

WG523

K.E. Hacker, N. Baboi, F. Loehl, D. Noelle, H. Schlarb (DESY)

A beam position monitor with a large horizontal aperture is being developed for use in dispersive regions of magnetic chicanes as part of an energy measurement. It will have a horizontal detection range of 16 cm and a resolution of better than 30 um. This is achievable with a stripline design, mounted perpendicularly to the electron beam direction. A high-precision phase measurement at both ends of the stripline will allow for determination of the beam postion. The phase measurement of the short RF pulses from the stripline will be done with a technique that utilizes a timing laser that samples the RF pulse traveling though an electro-optical modulator.

WG524

Cavity BPMs for LCLS

P. Krejcik, Z. Li, S. Smith, T. Straumann (SLAC) R.M. Lill (ANL)

Stabilization and alignment of the beam trajectory in the LCLS undulator requires single-shot measurement of the beam position with a resolution of 1 micron or better at a charge per bunch of 200 pC. A stripline beam position monitor is limited by signal to noise at this resolution since it relies on determining the precise difference between the signals from two opposite strips. In our high Q cavity beam position monitor we selectively look at the signal from a transverse mode excited by an off-axis beam, which grows in amplitude proportionally with beam offset. The LCLS undulator and launch region will be equipped with 40 X-band cavity BPMS. A mixer is located beside each BPM and the IF is transmitted via cable to surface buildings housing the digitizer electronics. The design choices effecting the construction and layout of the system will be discussed along with prototype tests and installation plans for the LCLS.

WG535

Basic Tools for SASE Commissioning

V. Kocharyan, K. Rehlich, E. Saldin, E. Schneidmiller, K. Tiedtke, M.V. Yurkov (DESY)

This report describes operating experience of the on-line monitoring of the radiation intensities at FLASH (former VUV-FEL at DESY). Several tools for photon diagnostic detectors are used to measure peak and average radiation intensity. Basic tool for searching and fine tuning SASE is MCP-based radiation detector. With present set of targets and geometrical acceptances of MCPs we safely cover the whole operating range of the light intensities, from nJ up to mJ level. During user runs a non-destructive monitoring of the radiation is performed with the Gas Monitor Detector (GMD), a kind of ion chamber filled with low-pressure gas. The number of ions and photoelectrons produced in the gas chamber is proportional to the photon beam intensity. Measurement of the ion current (of pA level) allows to monitor absolute average radiation intensity. Measurement of the electron current allows monitoring intensity of single pulses. Dynamic range of the GMD detector is controlled by means of the gas pressure. Interface between detectors and operator is performed via user friendly programs MCP Tool and GMD Tool.

WG541

Synchrotron Radiation Based Transverse Emittance Diagnostics At Light Sources

G. Kube (DESY)

The transverse particle beam emittance of a synchrotron light source is a crucial parameter because it is directly related to the brilliance of the emitted radiation. Therefore a precise online control of the beam profile which is typically in the order of a few 10^{-100} microns is highly desirable from which the corresponding emittance can be calculated. Due to its non-destructive nature synchrotron radiation is a versatile tool for beam profile measurements and is used in nearly every light source. While in principle synchrotron radiation from insertion devices or bending magnets can be utilized, in reality most light sources use bending magnet radiation based profile monitoring because of space limitations. There exist a number of different techniques in order to overcome limitations due to resolution broadening effects which may strongly affect the measured profiles. In this talk an overview over these methods will be given which are commonly applied in most of the present light sources.

The Machine Protection System for PETRA III

M. Werner, T. Lensch (DESY)

The intense synchrotron radiation beams generated in the undulators of PETRA III can – in the case of a mis-steered beam – damage the beam chamber and components inside the chamber within a time in the order of a millisecond. The PETRA III machine protection system is designed to trigger a beam dump within 100us after fault recognition and to support the operator with helpful information for a fast machine operation recovery.

Experience from the Commissioning of the FLASH Machine Protection System

L. Fröhlich (DESY)

The machine protection system (MPS) of the FLASH linac at DESY Hamburg prevents production and transport of the electron beam upon detection of a potentially dangerous condition. The talk gives an overview of the slow and fast MPS subsystems, and summarizes the experience gained during the first operation of the accelerator with macropulses of up to 300 bunches.

Post-Linac Collimation System for the European XFEL

V. Balandin, R. Brinkmann, N. Golubeva (DESY)

The collimation system should simultaneously fulfil several different functions. In first place, during routine operations, it should remove with high efficiency off-momentum and large amplitude halo particles, which could be lost inside undulator modules and become source of radiation-induced demagnetization of the undulator permanent magnets. The system also must protect the undulator modules and other downstream equipment against mis-steered and off-energy beams in the case of machine failure without being destroyed in the process. From beam dynamics point of view, the collimation section should be able to accept bunches with different energies (up to ± 1.5% from nominal energy) and transport them without deterioration not only of transverse, but also of longitudinal beam parameters. In this article we present the post-linac collimation system which fulfils the listed above requirements and compare some of its properties with properties of the collimation system of the FLASH linac.

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