30th International
Free Electron Laser
Conference

Conference
Programme and Abstracts

FEL - 2008

Gyeongju, Korea
August 24-29, 2008

http://fel08.postech.ac.kr/

Organized by
Pohang Accelerator Laboratory

Sponsored by

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Contents

Welcome

Dear colleagues

We are so delighted to announce the opening of the 30th International Free Electron Laser Conference. Welcome to Gyeongju, an old capital of thousand years of history.

In the last few decades, we have seen that FEL has emerged from a subject of a group of ingenious scientists to an internationally central subject which hundreds of million dollars are invested to. At the same time, the FEL community has grown to a big and worldwide community. Holding the FEL Conference in Korea is one clear example of the rapidly expanding FEL community.

The history of FEL research in Korea is just repeating that of FEL. It began as a research subject of a small group. But, now, there are many scientists who work on FEL, from Terahertz to XFEL. We hope that this conference give a huge boost to Korean FEL community. It is a great pleasure and honor for us to host this conference.

JinHyuk Choi
ByungChul Lee

General Information

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General Information on Korea and Gyeongju

The entire city of Gyeongju, located about 360 km south of Seoul, can be considered to be a national monument. As the capital of the Silla Kingdom (B.C. 57 - A.D. 935), Gyeongju was the center of a golden period of Korean culture. Gyeongju is home to both cultural treasures and exceptional scenic beauty.

Perhaps the two most famous sights in Gyeongju are Bulguksa Temple, one of the most beautiful temples in Korea, and Seokguram Grotto, known worldwide for its stone statues and carved architectural ornaments. Both display exquisite architecture influenced by Korean Buddhist art. The city excursion and the companion program include visits to several of the well-known sights around Gyeongju.

Time Zone
UTC+9

Electric Current
Most Korean electric outlet provides 220V AC 60Hz with European type wall plug.

Climate
The average high / low temperatures in Gyeongju during the conference are 29.3 / 22.4 degree C, respectively. The average humidity is 78.3%. Usually, summer in the Gyeongju area is hot.

Currency
The unit of Korean currency is the Won. Currencies of major nations, foreign bank notes, and travelers' checks can be exchanged into Korean Won at any bank or major hotel. The exchange rate is subject to change. As of mid August, 2008, US $1 is equivalent to approximately 1,030 Won.

Credit Cards
Most shops, hotels, restaurants, and other places in Korea accept credit cards.

Hours of Business
Banks in Korea are open between 9:30 a.m. and 4:30 p.m Monday through Friday.
Frequently, you can find stores open on Sunday.

Tipping
Tipping is unusual in Korea. Most hotels charge you 10% service charge.

VAT
10% VAT is already included in the price in shops, stores, and restaurants. However, in many hotels, it is not included in the price.

Insurance and Emergency
The Organizing Committee will not be responsible for medical expenses, accidents, losses or other unexpected occurrences. Participants are advised to arrange for any insurance that they regard necessary. Emergency call numbers are 112 for police and 119 for fire/rescue and hospital services.

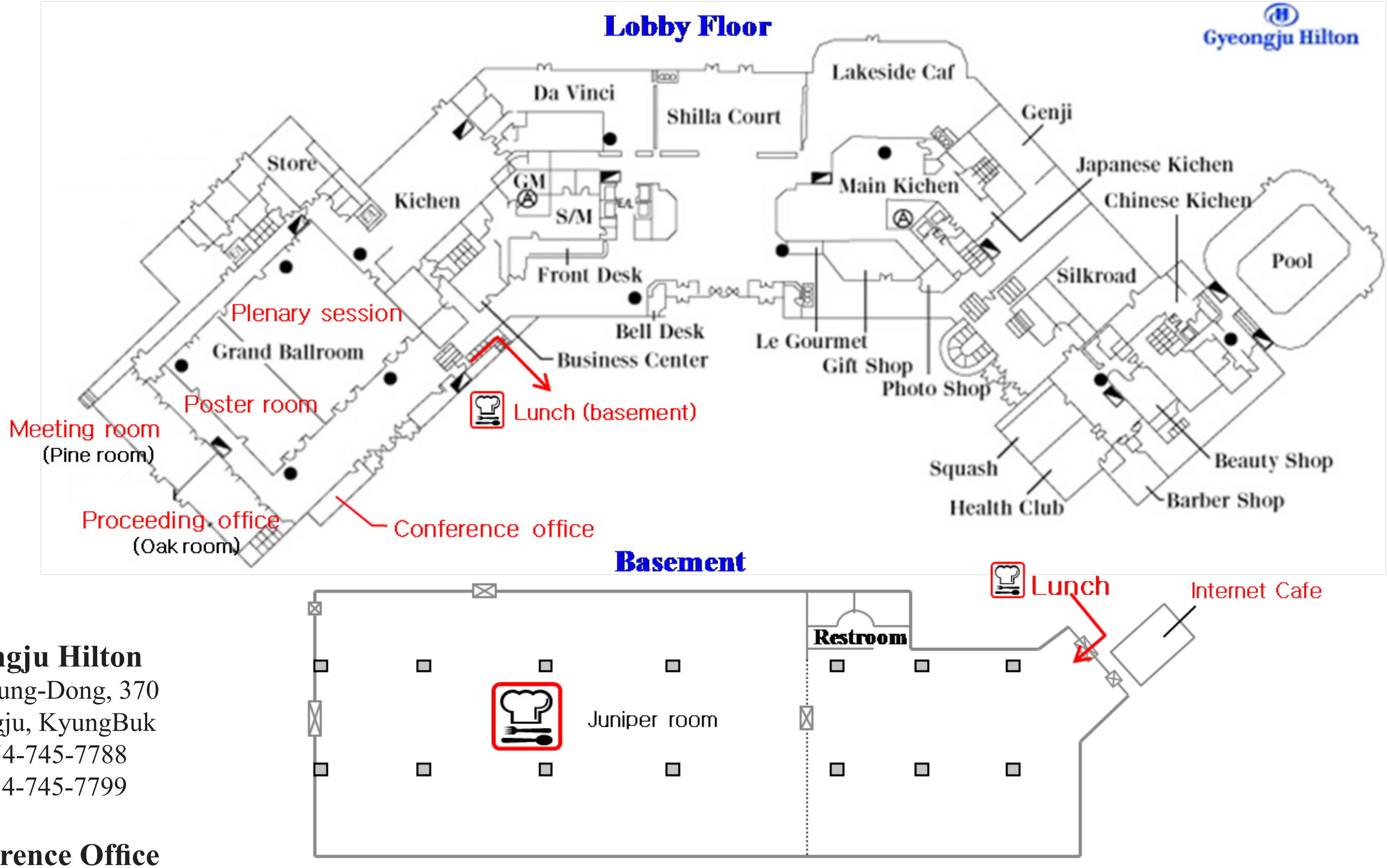
Scientific Programme

	Sun-day (8/24)	Monday (8/25)	Tuesday (8/26)	Wednesday (8/27)	Thursday (8/28)	Friday (8/29)
9:00 ~ 10:50	REGISTRATION	Opening and New Lasing	Long Wave-length FELs	Facility Tour	FEL Technology I	FEL Operation
10:50 ~ 11:10		Coffee Break			Coffee Break	
11:10 ~ 13:00		FEL Prize Lectures	X-ray FELs		FEL Technology II	Closing Remarks
13:00 ~ 14:00		Lunch		Symposium On Synchrotron Radiation Utilization	Lunch	
14:00 ~ 15:50		Poster	Poster		High Power FELs	City Excursion
15:50 ~ 16:10		Coffee Break			Coffee Break	
16:10 ~ 18:00		FEL Theory	Storage Ring FELs		FEL Appli-cations	

- Welcome Reception : 18:00 ~ 20:00 on Sunday August 24.
- PC Meeting : 18:30 ~ 21:00 on Monday August 25 at Pine Room.
- IEC Meeting : 18:30 ~ 21:00 on Tuesday August 26 at Pine Room.
- Banquet : 19:00 ~ 21:00 on Wednesday August 27.

Conference Venue

The conference will take place at Hotel Hilton in Gyeongju, one of the oldest and historic towns of Korea. The hotel is located at the resort area of Gyeongju, just next to the Lake Bomun as shown in the figure.



Gyeongju Hilton
ShinPyung-Dong, 370
Gyeongju, KyungBuk
Tel.) 054-745-7788
Fax) 054-745-7799

Conference Office
Tel.) 054-740-1298
Fax.) 054-740-1299
Mobile) 011-524-1049

On-site Registration and Welcome Reception

On-site registration desk is open between 9:30 a.m. and 6:00 p.m. on Sunday, 24 Aug. 2008. Registration is also possible during the conference. The welcome reception will take place at 6:00 p.m. at the outdoor swimming pool of Gyeongju Hilton.

Internet Cafe

Internet Café will be open between 9:00 a.m. and 6:00 p.m. Monday through Thursday, and between 9:00 a.m. and noon Friday.

Daily Lunches

Daily lunches will be available at the basement on Monday, Tuesday, Thursday, and Friday. Participants with conference badge are free to enter the place.

Facility Tour

An excursion to DaeDuk and Pohang is planned on Wednesday (August 27th) to visit FEL related facilities there. Busses will start from Gyeongju Hilton at 8:30 to DaeDuk that is a famous science town in Korea. The first tour place is Korea Atomic Energy Research Institute (KAERI), where FEL and other accelerator facilities reside. The next scientific facility of the tour list is K-STAR, recently constructed nuclear fusion facility of Korea. After having lunch at DaeDuk, on the way back to Gyeongju, the tour team will visit Pohang Accelerator Laboratory. Conference participants and guests who want to join the tour are required to list their names in the Organizing Committee Office.

Conference Dinner

The Conference Banquet will take place at 7:00 p.m. on Wednesday (August 27th) at the lawn garden near the outdoor swimming pool of Gyeongju Hilton. After the dinner, there is a performance of the Korean classical music.

Gyeongju Tour

On Friday (August 29th), after the closing session, an excursion is planned to historic sites of Gyeongju, one of the oldest and most popular tour places in Korea. Conference participants and guests who want to join the tour are required to list their names in the Organizing Committee Office.

The entire city of Gyeongju, located about 360 km south of Seoul, can be considered to be a national monument. As the capital of the Silla Kingdom (B.C. 57 - A.D. 935), Gyeongju was the center of a golden period of Korean culture. Gyeongju is home to both cultural treasures and exceptional scenic beauty.

Perhaps the two most famous sights in Gyeongju are Bulguksa Temple, one of the most beautiful temples in Korea, and Seokguram Grotto, known worldwide for its stone statues and carved architectural ornaments. Both display exquisite architecture influenced by Korean Buddhist art. The conference tours and the companion program include visits to several of the well-known sights around Gyeongju.

The tour course on Friday will be chosen among the following places.

Gyeongju National Museum
Various Relics of the Silla Period All Together

The Gyeongju National Museum exhibits numerous relics dating from the Silla Dynasty. The museum is divided into three main halls and an outdoor garden, housing a total collection of 2,700 pieces. The museum contains various items excavated throughout Gyeongju and neighboring areas, as well as sculptures and paintings. Relics unearthed from the old burial mounds of the Silla Period, including splendid jewels and ornaments can be found in the Ancient Tomb Hall.

The outdoor garden contains Korea's largest bell (National Treasure No. 29). Officially known as the Divine Bell of the Great King Seongdeok, this 3.3 meter-high bell is better known as Emile Bell because it is said to sound like a child crying for its mother.

Descriptions are available in English throughout the museum.
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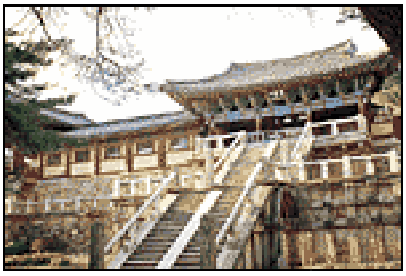
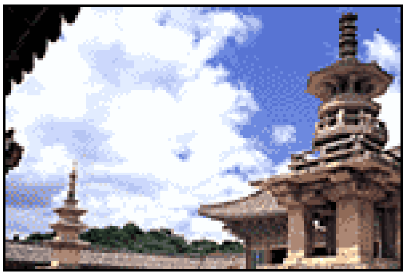




Bulguksa Temple

Trace the History of the Splendid Silla Culture

Lying half-way up Mt. Tohamsan, Bulguksa Temple exemplifies the refined arts and Buddhist culture of the Silla Period. The temple was established in 751 at the height of the Silla Kingdom, during a time of stability, prosperity, and a flourishing of culture.

According to records, the temple had nearly 60 buildings including total 2,000 rooms at one time. Much of the temple has been preserved intact, and it still contains many great treasures.

The stone pagodas Dapotap (Pagoda of Abundant Treasures) and Seokgatap (Pagoda of Shakyamuni) remain in the temple's courtyard. The stone stairs connecting various temple halls are also treasured: Yeonhwagyo (Lotus Flower Bridge), Chilbogyo (Seven Treasure Bridge), Cheong'ungyo (Blue Cloud Bridge) and Baek'ungyo (Blue Cloud Bridge). Bronze statue images of Vairocana (National Treasure No. 26) and Amitabha (National Treasure No. 27) are also enshrined at Bulguksa.

Bulguksa Temple was named a World Cultural Heritage site in 1995.

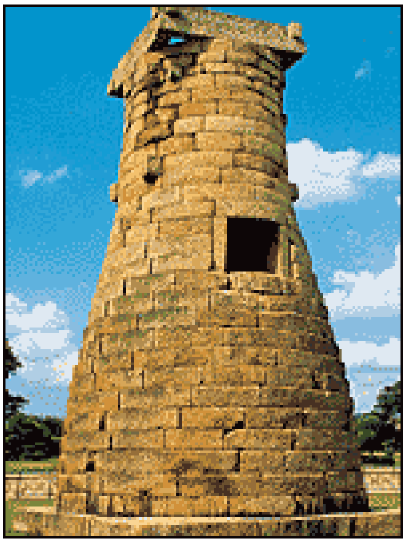
Seokguram Grotto

An Artificial Stone Cave at the Top of a Mountain

Seokguram is an artificial stone cave nestled at the top of Mt. Tohamsan, modeled after the stone cave temples found in India and China. Construction of this cave temple began in 751 and took 30 years to complete.

A 3.48 meter-tall statue of Buddha is enshrined in the middle of the cave with nearly 40 standing figures of Buddhist images elaborately carved around it on the walls. A glass wall has been built to preserve the Buddhist images while allowing visitors to view them.

Seokguram Grotto has been designated as National Treasure No. 24 and a World Cultural Heritage site.



Cheomseongdae
An Astronomical Observatory

Cheomseongdae is a stone tower well known as the oldest astronomical observatory in the East. Designated as National Treasure No. 31, Cheomseongdae is about 9 meters in height and looks like a round bottle. This stone tower was made by laying 27 stones in a neat pile on the square foundation stone and by putting a square stone on the piles like a lid. The tower has a 1-meter by 1-meter window facing south. The tower's architecture is highly valued for the beauty of its elegant curves and the exquisite harmony between a square and a circle.

Namsan
A Mountain with Buddhist Cultural Assets of the Silla Dynasty

Mt. Namsan, located to the south of Gyeongju, contains numerous important Buddhist and Silla Dynasty sites. Stretching 8 kilometers north and south, and 12 kilometers west and east, Namsan contains 180 peaks and about 40 valleys dotted with relics of temples, 80 stone images of Buddha and 60 stone pagodas.

Among the noteworthy treasures found at Namsan are the sitting stone statue of Buddha at Mireuk Valley (Treasure No. 136) and the sitting image of Bodhisattva carved on Sinseonam (stone wall) (Treasure No. 199). There are also twelve designated historic sites such as Poseokjeong (Historic Site No. 1), Najeong (Historic Site No. 245) and the site of Cheongwansa (Historic Site No. 340). Particularly striking is the sitting figure of Sakyamuni in Samneung Valley, carved on a huge natural rock 7 meters high and 5 meters in width.

Scientific Programme

Monday, August 25

Session 1: Opening Talks and New Lasing
Chair T.-Y. Lee, Alberto Renieri

10:00 Opening of FEL08
10:30 Jörg Rossbach, Hamburg University , “First Lasing below 7 nm Wavelength at FLASH/DESY, Hamburg”
10:55 Hideaki Ohgaki, Kyoto University Institute for Advanced Energy, “First Lasing of MIR-FEL at Kyoto University”

Session 2: FEL Prize Lectures
Chair Jörg Rossbach

11:50 James Rosenzweig, University of California, Los Angeles, “Real and Virtual Free-Electron Laser Experiments: From VISA to the Femtosecond Frontier”

14:00 – 15:50 Monday Poster Session
New Lasing, FEL Theory, Long Wavelength FELs, X-ray FELs, Storage Ring FELs

Session 3: FEL Theory
Chair Luca Giannessi

16:10 Erik Hemsing, University of California, “A Virtual Dielectric Eigenmode Expansion of High-Gain FEL Radiation for Study of Paraxial Wave Mode Coupling”
16:35 Avraham Gover, University of Tel-Aviv, “FEL Coherence below Shot Noise Limit, and Its Fundamental Limits”
16:50 Zhirong Huang, SLAC, “Statistical Analysis of Crossed Undulator for Polarization Control in a SASE FEL”
17:05 Brian W.J. McNeil, University of Strathclyde, “Retention of Attosecond Pulse Structure in a HHG Seeded FEL Amplifier”
17:20 Gianluca Geloni, Deutsches Elektronen-Synchrotron, “A Scheme for Stabilization of Output Power of an X-ray SASE FEL”

Tuesday, August 26

Session 4: Long Wavelength FELs
Chair Young Uk Jeong

09:00 Rui Prazeres, Laboratoire de Chimie Physique / CLIO, “Study of the ‘Power Gaps’ Phenomenon in the Infrared Free-Electron Lasers”
09:25 Heather L. Andrews, Vanderbilt University, “Superlinear Current Dependence in a Grating-Based Tunable THz Source”
09:40 Toshiteru Kii, Kyoto University, “Design Study on THz Seeded FEL Using Photocathode RF Gun and Short Period Undulator”
09:55 Vladislav Zaslavskiy, Institute of Applied Physics Russian Academy of Sciences, “Terahertz Band Bragg Reflectors for Free Electron Lasers”
10:10 Rienk Jongma, Radboud University Nijmegen Institute of Molecules and Materials, “Design of the Nijmegen High-Resolution FIR-FEL”
10:25 Heung-Sik Kang, Pohang Accelerator Laboratory, “Status of fs-THz Beam line Project of the PAL”

Session 5: X-ray FELs
Chair Takashi Tanaka

11:10 Toru Hara, The Institute of Physical and Chemical Research, “VUV Seeded FEL Experiment at the SCSS Test Accelerator”
11:35 Kwang-Je Kim, Argonne National Laboratory, “An X-Ray Free Electron Laser Oscillator with an Ultra-low Emittance Electron Beams”
12:00 Elke Plönjes, Deutsches Elektronen-Synchrotron, “FEL Wave-front Measurements in the Soft X-ray Region at FLASH”
12:15 James Rosenzweig, University of California, Los Angeles, “Generation of Sub-fsec, High Brightness Electron Beams for Single Spike SASE FEL Operation”
12:30 Moohyun Yoon, Pohang University of Science and Technology, “Design of A 0.1 nm Free Electron Laser at Pohang Accelerator Laboratory”
12:45 Yuji Otake, The Institute of Physical and Chemical Research, “Construction Status of XFEL/SPring-8”

14:00 – 15:50 Tuesday Poster Session
FEL Technology, High Power FELs, FEL Applications, FEL Operation

Session 6: Storage Ring FELs

Chair Giovanni De Ninno

16:10 Enrico Allaria, Sincrotrone Trieste S.C.p.A. ELETTRA, “Characterizing the efficiency of Harmonic Generation in Planar and Helical Undulators”
16:35 Masahito Hosaka, Nagoya University, “Intense Terahertz Radiation from a Storage Ring Driving a Free Electron Laser”
16:50 Christophe Szwaj, Laboratoire de Physique des Lasers, Atomes et Molécules, “Control of FEL Oscillator Instabilities Using Optical feedback: Phase-shift Effects”
17:05 Y. K. Wu, Duke University, “Second Harmonic Lasing with Storage Ring Based FELs”

Thursday, August 28

Session 7: FEL Technology I

Chair Alex Lumpkin

09:00 Geoffery Pile, Argonne National Laboratory, "Design and Production of the Undulator System for the Linac Coherent Light Source (LCLS)"
09:25 Jochen Teichert, Research Centre Dresden Rossendorf, "Initial Commissioning Experience with the Superconducting RF Photoinjector at ELBE"
09:50 Ryota Kinjo, Kyoto University, "Design Study on a Short-period Hybrid Staggered-Array Undulator by Use of High-Tc Superconducting Magnets"
10:05 Jonathan D. Jarvis, Vanderbilt University, "Development of Diamond Field-Emitter Arrays for Free-Electron Lasers"
10:20 Charles H. Boulware, Deutsches Elektronen-Synchrotron, "Latest Electron Beam Characterization Results at the Upgraded PITZ Facility"

Session 8: FEL Technology II

Chair Joachim Pflüger

11:10 Josef Frisch, Stanford Linear Accelerator Center, "Observation of Coherent Optical Transition Radiation in the LCLS Linac"
11:35 Florian Loehl, Deutsches Elektronen-Synchrotron, "Observation of 40 fs Synchronization of Electron Bunches for FELs"
12:00 Jung-Won Kim, Massachusetts Institute of Technology, "Femtosecond Synchronization of Large-Scale X-ray Free Electron Lasers"
12:15 Shaukat Khan, Hamburg University, "Results from the Optical Replica Experiments in FLASH"
12:30 Alex Lumpkin, Fermi National Accelerator Laboratory, "COTR and SASE Generated by Compressed Electron Beams"

Session 9: High Power FELs

Chair Ryoichi Hajima

14:00 Nikolay Vinokurov, Budker Institute of Nuclear Physics, "Commissioning of Novosibirsk Multi-pass Energy Recovery Linac"

14:25 Dinh C. Nguyen, Los Alamos National Laboratory, "Development of High-average-current RF Injectors"

14:50 Pavel Evtushenko, Thomas Jefferson National Accelerator Facility, "Electron Beam Timing Jitter And Energy Modulation Measurements At JLab ERL"

15:05 Shukui Zhang, Thomas Jefferson National Accelerator Facility, "Development and Upgrade of High-power Drive Lasers for High-current and High-charge Photocathode Injector at the Jefferson Lab Free-electron-laser Facility"

15:20 Nasr Hafz, Institute Gwangju Institute of Science and Technology, "Generation of stable GeV-class electron beams from laser-plasmas and their applications in compact FELs"

Session 10: FEL Applications

Chair Ingolf Lindau

16:10 Ulrike Fruehling, Deutsches Elektronen-Synchrotron, "Light Field Driven Streak-camera: Towards a Single Pulse Time Structure Measurement at FLASH"

16:35 Christian Gutt, Deutsches Elektronen-Synchrotron, "Resonant Magnetic Scattering with Femtosecond Soft X-ray Pulses from a Free Electron Laser at 1.59 nm"

17:00 Britta Redlich, FOM-Institute for Plasma Physics Rijnhuizen, "Action Spectroscopy with FELIX and FELICE"

17:25 Eisuke John Minehara, Japan Atomic Energy Agency, "Non-thermal Laser Machining with ERL-FELs for Nuclear Industries"

17:50 Vladimir N. Litvinenko, Brookhaven National Laboratory, "Progress with FEL-based Coherent Electron Cooling"

Friday, August 29

Session 11: FEL Operation
Chair Josef Feldhaus

09:00 Katja Honkavaara, Deutsches Elektronen-Synchrotron, “Status of FLASH”
09:25 Takashi Tanaka, The Institute of Physical and Chemical Research, “SASE Saturation at the SCSS Test Accelerator Ranging from 50 nm to 60 nm”
09:50 Peter Michel, Research Centre Dresden Rossendorf, “Investigation and Improvement of Beam Stability at the ELBE FEL’s”
10:05 Josef Frisch, Stanford Linear Accelerator Center, “Commissioning of the LCLS Linac and Bunch Compressors”
10:20 Siegfried Schreiber, Deutsches Elektronen-Synchrotron, “Cathodes Issues at the FLASH Photoinjector”
10:35 Sara Thorin, Lund University, MAX-lab, “Commissioning of the Test FEL at MAX-lab”

Session 12: Closing Session

11:10 Closing remarks and Conference closing

Poster Session Information

Poster sessions are scheduled for Monday and Tuesday afternoon, from 14:00 to 16:10. Please refer to the conference programme for the topics presented each day.
There will be enough stands to accommodate all posters simultaneously. What we suggest is putting up your poster on Monday and taking it off on Friday. You will only need to be near your poster on the day mentioned in the Programme.
Each poster is displayed on one board: The size of posters are limited to 820mm(Wide)x1188mm(High)-1 sheet of A0 size paper.
Tapes will be available for putting up posters. Posters can be mounted anytime in the Monday.

Poster Rules

Since no contributions are accepted for publication only, any paper not presented at the conference will be excluded from the proceedings. Furthermore, the Scientific Program Committee reserves the right to reject publication of papers that were not properly presented in the poster sessions.
Manuscripts of contributions to the proceedings (or large printouts of them) are not considered as posters and papers presented in this way will not be accepted for publication.
Papers for posters that were not displayed for the full poster session will not be published in the proceedings.

What happens after your paper has been submitted?

Since 2004 the proceedings of the International FEL conference series are published by JACoW, the Joint Accelerator Conferences Website. To ensure the most comfortable access to the conference proceedings on the JACoW website all papers have to meet some formal criteria, specified by JACoW. Moreover, it has been decided by the International Executive Committee of the FEL conference that every paper has to pass a "light" refereeing. Both processes are shortly described here.

With the end of the paper submission time the conference editors start to perform the formal paper checks and conversions according to the JACoW publishing requirements. Once an editor is assigned to your paper he produces a PDF-file from your uploaded PS-file. This PDF-file is checked and if necessary minor formal corrections are done. The corrected PDF-file is uploaded again into your conference database profile. As soon as the PDF-file is available a referee is automatically selected and informed. As result from the editing and refereeing process color dots are given, describing the status of your paper:

Editor:	**Referee:**
<u>Green dot</u>: the paper is ready for publication	<u>Green dot</u>: the paper is ready for publication
<u>Yellow dot</u>: changes or corrections have been made (on the PDF or the original WORD/LaTeX source file) and the author should contact the proceedings office to proof-read the modified version.	<u>Orange dot</u>: some modification are required before the publication of the paper, the referee's change requirements will be sent to the primary author through the JACoW system. The author will be requested to resubmit the corrected paper as soon as possible (max. within two weeks)
<u>Red dot</u>: a major problem occurred maybe a file is missing or is corrupt and the paper cannot be processed. The author should contact the proceedings office immediately to see one of the editors.	<u>Red dot</u>: the scientific quality of the paper is not sufficient for publication in the conference proceedings the paper is declined. The referee's justification will be sent to the primary author through the JACoW system.

Your paper is ready to be published in the conference proceedings when you have two green dots, on from the editor and one from the referee.

Special Session: Symposium On Synchrotron Radiation Utilization

"To take a new leap of synchrotron radiation technology in Korea"

The Pohang Accelerator Laboratory (PAL), which has operated the Korea's one and only leading-edge 3rd generation light source, Pohang Light Source (PLS), will hold the symposium titled "To take a new leap of synchrotron radiation technology in Korea" as a special session of the FEL conference. The objective of this symposium is to establish a general framework of collaboration and to promote the effective utilization of the PLS facilities in synchrotron radiation research. Also, this symposium is focused on expanding the synchrotron radiation user base on this occasion.

13:00~13:30	Registration	
13:30~14:00	Opening Remarks	President of KOSUA
Session A		Chair M.H. Yoon
14:00~14:20	Overview of the World-wide XFEL Projects	K.J. Kim (APS)
14:20~14:40	Outlook of Accelerator Science and Technology	W. Namkung (POSTECH)
14:40~15:00	Overview on UV & Soft X-ray Science	S.J. Oh (SNU)
15:00~15:20	New Drug Development Trend Based on the Synchrotron Facilities	J.M. Cho (CrytalGenomics, Inc.)
15:20~15:40	Coffee Break	
Session B		Chair B.S. Kim
15:40~16:00	Advanced Synchrotron Radiation Researches with 3rd Generation and 4th Generation (XFEL) Synchrotron Facilities	C.Y. Son(RIKEN, SPring-8)
16:00~16:20	X-ray Scattering Using Synchrotron Radiation Source	K.H. Char (SNU)
16:20~16:40	Chemical Dynamics Using 3rd and 4th Generation Synchrotron Facilities	T.K. Kim (BNU)
16:40~17:00	Coherent X-ray applications : Free Electron Laser Science	D.Y. Noh (GIST)
17:00~17:20	Past, Present and Future of PLS	M.H. Ree (PAL)
Closing		Chair S.H. Nam
17:20~17:50	Discussion	
17:50~18:20	Closing Remark	M.H. Ree (PAL)

* Official Language : Korean

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MOAAU Opening Talks and New Lasing, Monday, 10:00 - 11:20

MOAAU01: First Lasing below 7 nm Wavelength at FLASH/DESY, Hamburg

Jörg Rossbach (Uni HH, Hamburg)

After installation of a further superconducting accelerator module in 2007, the Free-Electron Laser in Hamburg, FLASH, reaches its original design value of up to 1 GeV electron energy. With this electron beam, FLASH has now achieved its design wavelength of 6.5 nm and delivers radiation at saturation level down to below 7 nm routinely to users. The radiation pulse length is in the 10 fs range. The talk will present some key features of the FEL performance at this wavelength.

MOAAU02: First Lasing of MIR-FEL at Kyoto University

Hideaki Ohgaki, Keisuke Higashimura, Toshiteru Kii, Ryota Kinjo, Kai Masuda, Tetsuo Yamazaki, Kiyoshi Yoshikawa, Heishun Zen (Kyoto IAE, Kyoto)

First lasing of Mid-Infrared Free Electron Laser was achieved at Institute of Advanced Energy (IAE), Kyoto University. The FEL driver, KU-FEL*, consists of a 4.5 cell thermionic RF gun, a 3-m S-band accelerator tube, and a 1.6-m plane undulator. The 25 MeV electron beam of 17 A peak current was employed for the lasing experiment. A beam loading compensation method with RF amplitude and phase control has been applied both for the RF gun and for the accelerator tube to extend the macro-pulse duration against the back bombardment effect in the thermionic RF gun. As a result the electron beam with about 6 micro-s duration has been available for the lasing experiment. About 10^6 times large light output than that from the spontaneous light was observed with a liq.N2 cooled IR detector. The FEL gain was 16% which was estimated from the exponential growth of the light and this shows good agreement with a gain simulation.

* H. Ohgaki et al., “Design studies of IR-FEL system at IAE, Kyoto University”, Nucl. Instrum. Methods in Phys. Res. A, vol.507, pp.150-153 (2003)

MOBAU FEL Prize Lectures, Monday 11:50 - 13:00

MOBAU01: Real and Virtual Free-Electron Laser Experiments: From VISA to the Femtosecond Frontier

James Rosenzweig (UCLA, Los Angeles, California)

The VISA experiment has been recognized for its role not only in exploring the physics of high-gain SASE free-electron lasers, but in its methodology as well. In VISA, a high degree of correspondence between intricate beam and FEL diagnostics, and detailed start-to-end simulations was developed. These tools worked together to uniquely reveal the underlying microscopic mechanisms that produce complex FEL behavior. We review examples of new and novel physics arising from VISA, and show how they challenged our conceptual and analytical picture of the FEL. We then look next-generation FELs, in which “virtual experiments” must reveal critical physical issues without direct experimental verification. As a relevant context, we take our proposal of using very low-charge beams to produce sub-fs, single-spike FEL pulses. With orders of magnitude lower charge, pulse length, and FEL wavelength beyond current practice, we must face a myriad of challenges enabling this exciting new path for FEL science. We show how simulations identify qualitatively new behavior in the beam/FEL system. The approach to benchmarking these phenomena with new experiments and extended simulation tools are discussed.

U.S. DoE High Energy Physics contract DE-FG03-92ER40693, U.S. DoE Basic Energy Sciences contract DE-FG02-07ER46272 and Office of Naval Research contract ONR N00014-06-1-0925.

MOPPH Monday Poster Session, Monday 14:00 - 15:50

MOPPH001: Tunable Narrowband Coherent THz Emission Induced by Laser-Electron Bunch Interaction

Masahito Hosaka, Yoshifumi Takashima (Nagoya University, Nagoya), Akira Mochihashi (JASRI/SPring-8, Hyogo-ken), Miho Shimada (KEK, Ibaraki), Serge Bielawski, Clement Evain, Christophe Szwaj (PhLAM/CERCLA, Villeneuve d'Ascq Cedex), Masahiro Katoh (UVSOR, Okazaki)

We present a new method to produce narrowband coherent synchrotron radiation in the terahertz region, using laser frequency conversion. The electron bunch interacts in an undulator with a laser pulse whose amplitude is sinusoidally modulated at the picosecond scale (duration in the 10 ps-300 ps range). This induces fast energy modulations at the optical frequency and its harmonics, which amplitudes are modulated at the THz scale. Then, as the electron bunch passes through a bending magnet, the modulations lead to a bunching at the THz scale, and brilliant narrowband THz emission occurs (coherent synchrotron radiation). Experimental results are obtained at the UVSOR-II storage ring, operating at 600 MeV, and the modulated pulses are obtained from a classical fs Ti:Sa laser, using the "chirped pulse beating" technique, and a setup similar to bunch slicing. In these conditions, emission is continuously tunable over a decade. Numerical and analytical results are also presented, including efficiency scalings with laser power, and accessible tunability ranges versus machine parameters.
S. Bielawski et al. Nature Physics 4, 390 (2008)

MOPPH002: Extension of the FERMI@Elettra FEL-1 to Shorter Wavelengths

Enrico Allaria (ELETTRA, Basovizza, Trieste), Giovanni De Ninno (ELETTRA, Basovizza, Trieste; University of Nova Gorica, Nova Gorica)

A modification of the first stage (FEL-1) of the FERMI project is proposed that allows us to extend the capabilities of the scheme described in the FERMI Conceptual Design Report*. The new setup takes advantage of a shorter period of the radiator undulator and, according to numerical simulations, is expected to be able to produce powerful harmonic radiation down to 20 nm. Thus it provides, over the wavelength range from 40 nm to 20 nm, a partial alternative to the 40 nm to 10 nm second stage of the FERMI project (FEL-2). In this paper we present all the relevant studies for the new proposed configuration.
* C.J. Bocchetta et al. "FERMI@Elettra Conceptual Design Report" ST/F-TN-07/12 (2007)

MOPPH003: The Effect of Shot-Noise on the Start-Up of the Fundamental and Harmonics in Free-Electron Lasers

Henry Freund, William Miner (SAIC, McLean), Luca Giannessi (ENEA C.R. Frascati, Frascati (Roma))

The problem of radiation start-up in FELs is important in the simulation of virtually all FEL configurations including oscillators and amplifiers in both seeded-MOPA (Master Oscillator Power Amplifier) and SASE (Self-Amplified Spontaneous Emission) modes. Both oscillators and SASE FELs start up from spontaneous emission due to shot-noise that arises from the random fluctuations in the electron phase distribution. The injected power in a MOPA is usually large enough to overwhelm the shot-noise; however, this noise must be treated correctly to model the initial start-up of the harmonics. We discuss and compare two different shot noise models that are implemented in both 1D wiggler-averaged (PERSEO) and non-wiggler-averaged (MEDUSA1D) simulations, and a 3D, non-wiggler-averaged (MEDUSA) formulation. These models are compared for examples describing both SASE and MOPA configurations in 1D in steady-state and time-dependent simulations, and remarkable agreement is found between PERSEO and MEDUSA1D. In addition, 3D correction factors have been included in the MEDUSA1D and PERSEO, and show reasonable agreement with MEDUSA for a sample MOPA in steady-state and time-dependent simulations.

This work was supported in part by the Office of Naval Research in the USA and in part by the EU Commission in the sixth framework programme, Contract No.011935 - EUROFEL.

MOPPH004: Effect of Energy Spread on the Start Current of Smith-Purcell BWO

Vinit Kumar (RRCAT, Indore (M.P.)), Kwang-Je Kim (ANL, Argonne, Illinois)

We perform a linear analysis of Maxwell-Vlasov equations for Smith-Purcell Backward Wave Oscillator, including the energy spread of the initial beam distribution. The expression for start current as a function of energy spread is obtained and its dependence on energy spread is discussed. The effect of beam emittance is also included through equivalent energy spread. Results of linear analysis are compared with full nonlinear numerical simulations.

MOPPH005: Three-Dimensional Theory for a Smith-Purcell Free-Electron Laser with Grating Sidewalls

Heather L. Andrews, Charles A. Brau, Jonathan D. Jarvis (Vanderbilt University, Nashville, TN)

We present an analytic theory for the operation of a Smith-Purcell free-electron laser in three dimensions that includes side walls bounding the grating. We allow the width of the electron beam and the width of the grating to vary independently, and require the walls be high compared with the wavelength of the evanescent wave. For both amplifier and oscillator operation, when the electron beam width is narrow compared to the grating, we find the system has a higher growth rate than that predicted by the two-dimensional theory*. Additionally, we find evidence of gain guiding in the system in this configuration. When the grating and electron beam widths are the same, we recover the results from the two-dimensional theory as expected.
* H. L. Andrews and C. A. Brau, Phys. Rev. ST Accel. Beams 7, 070701 (2004)

MOPPH006: Wave Mode Couplings in a Free-Electron Laser with Axial Magnetic Field in the Presence of Self-Fields

Behrouz Maraghechi, Hale Mahdavi, Taghi Mohsenpour (AUT, Tehran)

The one-dimensional analysis of the collective interaction in a free electron laser (FEL) with combined helical wiggler and axial guide magnetic field is presented. The effects of self-electric and magnetic fields on the dispersion relation of waves is studied to study interactions among all possible waves. Results are compared with interactions waves in FEL without considering self-fields. In group II orbits, whit relatively large wiggler induced velocities, coupling between the negative-energy space-charge waves are not found. By considering self-fields, the additional mode for the right and left circularly polarized electromagnetic waves are found.

MOPPH007: Optical Beam Quality in Free-Electron Lasers

Henry Freund (SAIC, McLean), Bahman Hafizi (Icarus Research, Inc., Bethesda, Maryland), Joseph Penano, Phillip Sprangle (NRL, Washington, DC)

The mode quality of the output of free-electron lasers (FELs) is near the diffraction limit. In this paper, we analyze the optical mode quality in FELs using the M2 parameter, which is a measure of the size and divergence of the optical beam. We calculate M2 in two ways: (1) by a direct integration over the transverse mode structure, and (2) by allowing the mode to expand beyond the wiggler and analyzing the divergence. A numerical analysis is conducted using the MEDUSA simulation code that shows that M2, as expected, is near unity at saturation but increases with the higher order mode content if the interaction proceeds past saturation.

Work supported by the Joint Technology Office & ONR.

MOPPH008: Waveguide Modes in a Relativistic Electron Beam in Connection with FEL with Ion-Channel Guiding

Behrouz Maraghechi, Borna Maraghechi (AUT, Tehran)

An analysis of waves in a cylindrical waveguide containing a relativistic electron beam is presented. The beam is guided by an ion channel and the analysis is performed in the rest frame of the beam with self-fields taken into account. Equations that permit calculation of the dispersion curves for five families of modes are derived. Numerical solutions for azimuthally asymmetric modes are presented to facilitate the development of free electron lasers. The dependence of the frequencies and dispersion curves of various modes on the ratio of the plasma radius a to the waveguide radius R is studied in detail.

MOPPH009: Comparison of HGHG and Self Seeded FELs in the Soft X-Ray Spectral Range

Agostino Marinelli (Rome University La Sapienza, Roma), Luca Giannessi (ENEA C.R. Frascati, Frascati (Roma)), Claudio Pellegrini, Sven Reiche (UCLA, Los Angeles, California)

One goal of several FEL facilities operating in the soft x-ray spectral range, is the production of narrow bandwidth FEL radiation. Several schemes have been proposed to obtain narrower bandwidths than that achievable with SASE-FELs. In this paper we investigate numerically, and compare, the properties of two schemes: Self-Seeding and High Gain Harmonic Generation. These schemes have been thoroughly studied analitically and numerically in the past. The aim of this work is to compare the performances of these schemes with respect to several non-ideal properties of the electron beam and seed laser, such as shot to shot energy fluctuations, nonlinear energy chirp and phase noise in the seed source. The work has been carried out with the aid of the time dependent FEL codes GENESIS (3D) and PERSEO (1D).

MOPPH011: A Simple Method for Timing an XFEL Source to High-Power Lasers

Gianluca Geloni, Evgeny Saldin, Evgeny Schneidmiller, Mikhail Yurkov (DESY, Hamburg)

We propose a technique for timing an XFEL to a high-power laser with femtosecond accuracy. The same electron bunch is used to produce an XFEL pulse and an ultrashort optical pulse that are, thus, naturally synchronized. Cross-correlation techniques will yield the relative jitter between the optical pulse (and, thus, the XFEL pulse) and a pulse from an external pump-laser with femtosecond resolution. Technical realization will be based on an optical replica synthesizer (ORS) setup to be installed after the final bunch-compressor. The electron bunch is modulated in the ORS by an external optical laser. Travelling through the main undulator, it produces the XFEL pulse. Then, a powerful optical pulse of coherent edge radiation is generated as the bunch passes through a long straight section and a separation magnet downstream of the main undulator. Relative synchronization of these pulses is preserved using the same mechanical support for X-ray and optical elements transporting radiation to the experimental area, where single-shot cross-correlation between optical pulse and pump-laser pulse is performed. We illustrate our technique with numerical examples referring to the European XFEL.

MOPPH012: The Electron Bunch Initial Energy Profile on a Seeded Free Electron Laser Performance

Juhao Wu, Alex Chao (SLAC, Menlo Park, California), Joseph Bisognano (UW-Madison/SRC, Madison, Wisconsin)

A single-pass high-gain x-ray free electron laser (FEL) calls for a high quality electron bunch. In particular, for a seeded FEL, and for a cascaded harmonic generation (HG) FEL, the electron bunch initial energy profile is crucial to preserve an FEL narrow bandwidth. After the acceleration, compression, and transport, the electron bunch energy profile entering the undulator can acquire temporal non-uniformity. During the cascading stages, the electron bunch energy profile is also not uniform temporally entering the next stage. We study the effects of the electron bunch initial energy profile on the FEL performance, cascaded HG FEL or single stage FEL amplifier. Concrete examples are discussed for seeded FEL projects being studied.

The work of AWC and JW was supported by the US Department of Energy under contract DE-AC02-76SF00515. The work of JB was supported by National Science Foundation Award No. DMR-0537588.

MOPPH013: Mode Growth and Competition in the X-ray FEL Oscillator Start-up from Noise

Ryan Roger Lindberg, Kwang-Je Kim (ANL, Argonne, Illinois)

We describe the radiation properties of an X-ray, free electron laser (FEL) oscillator starting with its start-up from noise through saturation. We decompose the initially chaotic undulator radiation into the longitudinal modes of the resonator whose properties are largely determined by the transverse gain profile and the bandwidth of the Bragg mirror. Because the radiation is initially comprised of several modes whose growth rates are comparable, we show that only after many oscillator passes is the output pulse dominantly characterized by the lowest-order, gaussian mode. We also comment on the transverse structure of the radiation, and discuss how the FEL gain can modify the free space resonator modes. Understanding the full longitudinal and transverse structure during the initial amplification will be critical in assessing the tolerances on electron beam, undulator, and optical cavity required for robust operation.

MOPPH014: Analysis of Terahertz Smith-Purcell Radiation from a Tapered Grating

Wenxin Liu (NHU, Hengyang), Kazuo Imasaki, Dazhi Li (ILT, Suita, Osaka)

A novel approach to produce terahertz Smith-Purcell radiation induced by tapered grating is presented in this paper. The dispersion relation is derived by the field mathes and is investigated through the numerial calcultions, as well as the optimum tapered grating for the beam-wave interaction efficiency is studied. The radation characteristics are studied by the simulation with the help of 2-dimension PIC. The results are in agreement with the reported linear theory.

This work is supported by the National Nature Science of foundation of P.R.China under grant 10775066

MOPPH015: Numerical Calculation of Electron Bunching Using Two-Parameter Poisson Distribution

Masoud Rezvani Jalal, Farzin Mojtaba Aghamir (IPM, Tehran)

The temporal and spatial evolution of mean value of electron bunching parameter at the initial stage of a SASE FEL for the special case of one-dimensional square pulse are evaluated numerically. The analysis involves a two-parameter Poisson distribution, for electrons arrival times at the undulator entrance and for their initial positions within the pulse. The calculation shows a full bunching (i.e. bunching parameter=1) for all frequencies at some specific location in the undulator and at a particular time.

MOPPH016: Gain Deterioration at Particular Wavelengths in a Partially Wave-guided FEL

Ulf Lehnert, Gerald Staats, Rudi Wuensch (FZD, Dresden)

At ELBE certain wavelengths within the working range of the FIR-FEL have been found to be inaccessible. The FEL either completely stops lasing or shows marked drop-outs in the observed optical spectra. The reason of this behaviour is sought in the use of a partial waveguide through the undulator to the downstream mirror combined with free optical propagation to the upstream mirror. The light pulse from the upstream mirror couples into the lowest transverse mode of the waveguide with minor contributions of other modes. The light generated in the gain process, however, is distributed over some of these modes and experiences dispersion over the waveguided propagation length. At the exit of the waveguide the different modes recombine with certain phase shifts. Depending on the amount of phase shift and the mode composition of the light a gain drop or even inversion is possible if a major part of the stimulated emission is out of phase to the primary beam. This work attempts to compute the mode distribution of the stimulated light emission and to translate this into a prediction of those wavelengths where the gain is markedly reduced by destructive interference of different modes.

MOPPH017: Theoretical Description of Thermal Fluctuations in a Free Electron Undulator Oscillator

Sergei Georgii Oganesyan, George Sergey Oganesyan (LT CSC, Yerevan), Yelena Hovhannisyan (RC, Dallas)

We have studied influence of the thermal noise on a free electron oscillator (FEO), which operates in a single mode regime. The device includes a undulator, two mirrors and an e-beam. Our semiclassical theory is based on Maxwell equations for the amplified field, a Klein-Gordon equation for the e-beam and a Schrödinger equation for atoms'media. It was adopted that the undulator and mirrors are at a fixed temperature. A black radiation produced by atoms is accumulated within the resonator and causes a noise on the laser mode. In accordance with*, we have described the noise formation with a random polarization vector. The vector is implanted into the Maxwell equations and its contribution leads to fluctuation effects. We have adopted that our device starts up from a field, which, a priory, is the mode of the FEO operating in steady-state regime. That allowed us to derive two equations, which describe the deviations of the field phase and amplitude due to the thermal noise. The equations enable, in principle, to estimate and consider the value of thermal fluctuations of the frequency, amplitude and intensity of the output laser radiation.

* A.Yariv, W.M. Catton, IEEE J. QE-10 (1974) 509

MOPPH018: FEL Sensitivity to Undulators Parameters and Requirements for Coherent Harmonic Generation at FERMI@Elettra

Enrico Allaria, Bruno Diviacco (ELETTRA, Basovizza, Trieste), Giovanni De Ninno (ELETTRA, Basovizza, Trieste; University of Nova Gorica, Nova Gorica)

In this work we present a study aimed at defining the undulator tolerances which are necessary for efficient production of harmonic radiation in a seeded FEL. An extensive campaign of simulations was carried out that have allowed us to evaluate the impact of different sets of undulator imperfections on the quality of the FEL signal. Correlation between field fluctuations and phase, tilt and offset errors has been taken into account. The study is based on the paradigmatic example of the FERMI@Elettra FEL.

MOPPH019: A First Step to Turkish Accelerator Center (TAC): An IR FEL Facility

Özlem Karsli, Avni Aksoy, Yesim Cenger, Omer Yavas (Ankara University, Tandogan, Ankara)

The third phase of Turkish Accelerator Center (TAC) Project has been studied since 2006, after feasibility and conceptual design phases were completed. This phase of the project has two main scientific goals which are writing Technical Design Report of TAC project and establishing an Infrared Free Electron Laser (IR FEL) facility as a first step until 2010. It is planned that TAC IR FEL facility will operate to obtain 2-185 microns wavelength FEL using 15-40 MeV energy range electron linac and two different undulators which will have 3 cm and 9 cm period lengths. Main research and application areas will be the material science, nonlinear optics, semiconductors, biotechnology, medicine and photochemical processes. In this study, the electron beam line design and the main parameters of electron beam, the characteristics of free electron laser were discussed with several options such as different bunch charge or different undulator material.
http://thm.ankara.edu.tr

This project supported by Turkish State Planning Organization (DPT).

MOPPH020: Research of Electromagnetic Interaction of Undulator Emitters from a Position of the Phase Transitions Theory

Marat Kumisbekuly Myrzakhmet, Aidos Baltabaevich Kanafin, Ruslan Viktorovich Ungefug (ENU, Astana)

Dependence of volume of area когерентности grouping force of an individual emitter from amplitude of undulator field, its period lengths and also the relativistic factor of a charge-emitter is investigated. Lorentz's force of interaction of two identical charges which move along an axis spiral undulator with equal speeds on the fixed distance from each other and co-operate with each other through a field of undulator radiations of one of its is calculated. The analytical description method of grouping force spatial structure of ultrarelativistic electrons undulator radiations field in spiral undulator is used. Electromagnetic interaction undulator emitters is investigated from a position of the phase transitions theory. Parameters of critical delay, critical fluctuations and symmetry infringement are considered. The hysteresis loop of the phase transition is discussed.

MOPPH021: Impact of a Chirp and a Curvature in the Electron Energy Distribution on a Seeded Free Electron Laser

Alberto Andrea Lutman (DEEI, Trieste), Paolo Craievich, Giuseppe Penco (ELETTRA, Basovizza, Trieste), Juhao Wu (SLAC, Menlo Park, California)

In an free electron laser, the electron beam entering the undulator can have an initial energy curvature besides an initial energy chirp. In this paper, we derive the FEL Green function for the case of the electron beam having both an energy chirp and an energy curvature by solving the coupled Vlasov-Maxwell equations. We give an integral representation as well as an analytic expression for the Green function. Convoluting the Green function with the seed, the FEL pulse properties, as In an free electron laser (FEL), the electron beam entering the undulator can have an initial energy curvature besides an initial energy chirp. In this paper, we derive the FEL Green function for the case of the electron beam having both an energy chirp and an energy curvature by solving the coupled Vlasov-Maxwell equations. We give an integral representation as well as an analytic expression for the Green function. Convoluting the Green function with the seed, the FEL pulse properties are studied.

MOPPH022: SASE FEL Mechanism for Pulsar Radio Emission

Hamlet Karo Avetissian, Ara Karapet Avetissian, Garnik Felix Mkrtchian (YSU, Yerevan)

Since the discovery of pulsars many competing theories have arisen for explanation of its intense radio emission. The existing theories differ both in the physical schemes responsible for the radiation and in the locations where the radiation is originated. However, none of these theories can explain the main observational facts. Hence any concept that can be used to formulate a self-consistent theory for radio emission from pulsars is of prime importance. In this work it is shown that the pulsar radio emission could, in principle, be generated effectively through the FEL analogous schemes operating in SASE regime. We consider two types of such FEL schemes that could operate in the pulsars magnetosphere: 1) schemes wherein electrons undergo periodic accelerated motion in diverse electromagnetic fields; 2) FEL schemes wherein electrons are unperturbed, but the coherent radiation is subjected to dispersion*. Calculations show that SASE FEL in the high gain regime is able to produce required high brightness and broadband radio pulses. Particular emphasis in this work is made to the Cyclotron-Resonance SASE FEL where the radiation is originated near the pulsar magnetosphere's border.
* H.K. Avetissian, Relativistic Nonlinear Electrodynamics (Springer-Verlag, New York, 2006).

This work was supported by International Science and Technology Center ISTC) Project No. A-1307.

MOPPH023: Phase Space Structures and Control in the FEL Interaction

Romain Bachelard, Cristel Chandre, Xavier Leoncini, Michel Vittot (CNRS/CPT, Marseille), Duccio Fanelli (Università di Firenze, Florence)

The interaction between a beam of electrons and an electromagnetic wave inside a FEL undulator can be described by a one-dimensional Hamiltonian model capturing the essence of the dynamics*. The wave, after reaching saturation, displays large oscillations due to an aggregate of particles, called the macro-particle. This clustering can be interpreted in terms of regular structures (KAM tori) in a low-dimensional phase-space. In particular, a dynamical phase transition can be observed when the energy spread of the electron beam is increased, where the phase space structures divide into smaller ones, shifting from a high-gain regime to a non-lasing one. A strategy to stabilize the intensity of the wave by re-shaping the macro-particle is proposed. As parameters of an additional perturbation are varied, bifurcations occur in the system**, which modify the topology of phase-space. This yields drastic effects on the modification of the self-consistent dynamics, especially of the macro-particle. We show how to obtain an appropriate tuning of the parameters which is able to strongly decrease the oscillations of the intensity without reducing its mean-value***.
* W.B.Colson, Phys. Lett. A 59, 187 (1976) ** R.S.MacKay, Nonlinearity 5, 161 (1992) *** R.Bachelard et al, Eur. Phys. J. D 42, 125 (2007).

MOPPH024: SASE Regime of X-ray Laser on the Channeled in a Crystal Electron Beam

Hamlet Karo Avetissian, Garnik Felix Mkrtchian (YSU, Yerevan)

Divers regimes of stimulated radiation of a channeled in a crystal electron beam have been considered as a potential source of shortwave coherent radiation*. Due to the existence of the bound transverse states at the channeling, the electron-photon interaction cross section resonantly enhances by several orders with respect to the free electron-photon scattering one. Besides, the spectral intensity of spontaneous x-ray radiation of the channeled electrons well exceeds the intensities of other radiation processes in this frequency range. Hence, SASE regime of x-ray laser by means of channeled electron beams is of certain interest and is the subject of the current work. The consideration is based on the self-consistent set of the Maxwell and relativistic quantum kinetic equations. We consider two different schemes of x-ray generation. First- at the existence of initial inverse population of transverse electronic levels in the crystal channel, and second- without it, but with the counter-propagating optical laser field. It is shown that the generation gain in both cases resonantly enhances by several orders with respect to the x-ray Compton-laser scheme on the free electrons.

* H. K. Avetissian et al., Phys. Rev. A 56, 4121 (1997); H. K. Avetissian, G. F. Mkrtchian, Nucl. Instr. and Meth. A. 507, 479 (2003).

This work was supported by International Science and Technology Center (ISTC) Project No. A-1307.

MOPPH025: Unaveraged Three-Dimensional Modelling of the FEL

Cynthia Kar Woon Nam, Pamela Aitken, Brian W.J. McNeil (USTRAT/SUPA, Glasgow)

A new three-dimensional model of the FEL is presented. A system of scaled, coupled Lorentz-Maxwell equations are derived in the paraxial limit. A minimal number of limiting assumptions are made and the equations are not averaged in the longitudinal direction of common radiation/electron beam propagation, allowing the effects of coherent spontaneous emission and non-localised electron propagation to be modelled. The equations are solved numerically using a parallel Fourier split-step method.

MOPPH026: High Gain FEL Amplification of Charge Modulation Caused by a Hadron

Vladimir N. Litvinenko, Ilan Ben-Zvi, Dmitry Kayran, Eduard Pozdeyev (BNL, Upton, Long Island, New York), Oleg A. Shevchenko, Nikolay Vinokurov (BINP SB RAS, Novosibirsk), Johan Bengtsson (BNL, Upton, New York), Sven Reiche (UCLA, Los Angeles, California)

In scheme of coherent electron cooling*, a modulation of electron beam density induced by a co-propagation hadron is amplified in high gain FEL. The resulting amplified modulation of electron beam, its shape, form and its lethargy determine number of important properties of the coherent electron cooling. In this talk we present both analytical and numerical (using codes RON and Genesis) evaluations of the corresponding Green functions. We also discuss influence of electron beam parameters on the FEL response.

* V.N.Litvinenko, Y.S.Derbenev, Proc. of 29th International FEL Conference, Novosibirsk, Russia, August 27-31, 2007, p.268, http://accelconf.web.cern.ch/accelconf/f07/HTML/AUTHOR.HTM

Work performed under contract No. DE-AC02-98CH10886 with the auspices of the DoE of United States

MOPPH027: The Parameters Study for the Enhanced High Gain Harmonic Generation (EHGHG) Scheme

Qika Jia (USTC/NSRL, Hefei, Anhui)

An easy-to-implement scheme has been recently proposed* and shown to be able to significantly enhance the performance of HG-FEL. The scheme perfects the physics process sequence of the existing HG-FEL scheme by adding an energy-spread suppression process after the process of density modulation. With the EHGHG scheme an electron-beam with smaller energy spread and stronger bunching can be provided, so that more powerful higher harmonic radiation can be generated. In this paper we investigate the effects of the system parameters, such as the electron energy tuning, the energy spread, the dispersive strength, amount of the phase shift, and the seed laser power. The numerical results show that with the electron energy above the resonance, the efficiency is enhanced for both the new scheme and the existing scheme comparing with the resonant energy cases; the output power (for the 16th harmonic of the seed laser) of the EHGHG scheme is still over three times stronger than that of the existing scheme, and is no more or less sensitive to the system parameters than that of the existing scheme.

* Jia Qika, “Enhanced high gain harmonic generation for X-ray Free-Electron Laser”, to be published in APPLIED PHYSICS LETTERS.

MOPPH028: Variable Polarised Dual Harmonic Undulator Free Electron Laser

Mona Gehlot, Ganeswar Mishra (Davi Ahilya University, Indore, Madhya Pradesh)

A variable polarised dual harmonic undulator free electron laser is proposed. The scheme proposed consist of two identical linearly polarised undulator field configuration with high permeablity shims inside the gap spacing of the undulator magnets. The advantage of our scheme is that it can enhance two harmonics on-axis simultaneously. Analytical theory of the spectral feature of the radiation and the gain of the free electron laser at these two harmonics are calculated. The analytical theory is supplemented by numerical analysis. The numerical method for intensity involves use of Runga-Kutta and Simpson rule. The spectral intensity is numericaly differentiate to calculate the gain. The numerical results agrees well with the analytical results.
"Variable polarised harmonic undulator free electron laser," V. Gupta, G. Mishra, Nuclear Instruments and methods in physics research A 574(2007)150-157.

The work is supported by BRNS/DAE Bombay.

MOPPH029: Hermite-Gaussian Decomposition of FEL Optical Fields

Sean P. Niles, Joseph Blau, William B. Colson (NPS, Monterey, California)

Free electron lasers are favored in many research applications due to their operation primarily in the fundamental (Gaussian) mode. In oscillator FELs, the appropriate basis set for decomposition is determined by the cavity parameters. Since FEL amplifiers generate and amplify the optical field over the length of the undulator influenced only by the electron beam (without mirrors), the appropriate basis set is not determined. For the amplifier, a methodology is presented to decompose the optical fields with a Hermite-Gaussian basis set chosen such that the number of higher-order modes is minimized. The methodology is implemented as an analysis module in the Naval Postgraduate School 4D FEL simulation to study amplifier FEL optical beams for comparison with experiment.This work has been supported by the Office of Naval Research and the Joint Technology Office.

This work has been supported by the Office of Naval Research and the High Energy Laser Joint Technology Office.

MOPPH030: Tunability, Exponential Growth, and Superradiance of a Seeded Free Electron Laser

Juhao Wu, Paul Robert Bolton (SLAC, Menlo Park, California), James Murphy, Xijie Wang (BNL, Upton, Long Island, New York), Kelin Wang (USTC, Hefei, Anhui)

Seeding a free electron laser (FEL) amplifier with an ultra-short laser seed provides a large wavelength tunable range for the output FEL. With such an operation regime, we revisit the exponential growth mode and the superradiance mode. We discuss how the detuning, electron bunch energy chirp, and slippage affect these two operation modes. General discussion on the evolution of the FEL pulse length and bandwidth is given within an ABCD formalism. With a high-order harmonic generation (HHG) of an infrared laser as the seed, we explore the effects of the intrinsic attosecond pulse train in the HHG on the FEL performance.

The work of JW was supported by the US Department of Energy under contract DE-AC02-76SF00515. The work of JBM and XW was supported by the US Department of Energy under contract DE-AC02-98CH10886.

MOPPH031: Four-Dimensional Simulations of FEL Amplifiers

Joseph Blau, William B. Colson (NPS, Monterey, California)

A four-dimensional simulation in (x,y,z,t) has been developed for studying Free Electron Laser (FEL) amplifiers. The parallelized program runs on a 128-node cluster computer, with each node following a slice along the optical pulse. Electrons are continually transferred to successive nodes to model the slower-moving electron pulse. This new 4D program is used to study the combined effects of transverse and longitudinal modes, and includes pulse slippage and optical guiding effects, which can be significant in FEL amplifiers. The electron beam is characterized by current density, pulse length, emittance, and energy spread. The undulator can have focusing in one or both planes, and either a linear or step taper. The seed laser is characterized by peak amplitude, waist radius and position, and pulse length and shape. The optical and electron beams can be tilted or shifted off-axis to study misalignment effects. The program has been benchmarked against well-known theoretical formulas for FEL gain and extraction, and by comparison to existing FEL amplifier experiments. Results of these simulations and comparisons are shown.

This work has been supported by the Office of Naval Research and the High Energy Laser Joint Technology Office.

MOPPH032: Three Dimensional Simulations on Harmonic Operation of Shanghai Deep Ultraviolet Free Electron Laser

Haixiao Deng, Zhimin Dai (SINAP, Shanghai)

In high gain harmonic generation (HGHG) free electron laser (FEL), with the right choice of the modulator undulator, the dispersive section and the seed laser, one may make the spatial bunching of the electron beam correspond to one of the harmonic frequency of the radiator radiation, instead of the fundamental frequency of the radiator radiation in conventional HGHG FEL. Thus, the radiator undulator is operated at harmonic mode and the harmonic power is expected to be significantly enhanced. In this paper, we study the possibility of harmonic operation of Shanghai deep ultraviolet (SDUV) free electron laser (FEL). Study shows that the 3rd harmonic radiation power in harmonic operation is ~10 times higher than that of in general FEL schemes. The principle of harmonic operation, the quasi-3D analytical estimates of harmonic operation, the 3D simulation results of harmonic operation, and the proof-of-principle experiment proposed at the SDUV FEL are presented.

MOPPH033: Study of Short Seed Pulse Effects in High Gain Harmonic Generation Free Electron Laser

Haixiao Deng, Zhimin Dai (SINAP, Shanghai)

In order to generate coherent hard x-ray free electron laser (FEL), cascaded high-gain harmonic generation (HGHG) scheme is expected to employ seed pulse with longitudinal length down to tens of femtoseconds. Thus, strong slippage effects will be introduced in the electron beam's energy-modulation. Moreover, since such short pulse, high intensity laser obtained by optical compression usually has pretty broad bandwidth in the spectral domain, the electron dynamics can not be appropriately characterized by monochromatic FEL equations. In this paper, we study the short seed pulse effects of HGHG FEL. A set of multi-frequency FEL equations is derived to describe the interaction between the short seed laser and the electrons in the modulator undulator. The short seed pulse effects on the electron beam's energy modulation, the output wavelength tuning, the output pulse length and the output peak power in HGHG are theoretically and numerically investigated. Study demonstrates that the short seed pulse significantly influences the HGHG performances, and these influences should be taken into accounts in the design and optimization of seeded FEL scheme.

MOPPH034: Mirror Aberrations in Low Gain FEL Oscillators

Peter van der Slot, Klaus Boller, Robert van der Meer (Mesa+, Enschede)

To generate radiation with high spatio-temporal quality in FELs, oscillators are to be used whch are based on the combination of low gain with a large number of roundtrips in a low-loss optical resonator. Clearly, in this situation any additional loss or aberration may seriously degrade the performance and beam quality, and this becomes extremely important for high average power FEL oscillators such as the JLAB system*. Nevertheless, so far no systematic study has been made how various mirror aberrations affect the performance of such low gain FEL oscillators. Here we present the first results of such a study. Ths approach is based on the optical propagation code OPC** with the Genesis 1.3*** gain code.

* SV Benson et.al. Nucl. Instr. and Meth. A483, 434 (2002). ** JG Karssenberg, et.al. J. Appl. Phys. 100, 093106 (2006). *** http://pbpl.physics.ucla.edu/~reiche/

MOPPH035: Using High Order Harmonics Generated in a Gas Jet to Seed the FERMI@Elettra Free Electron Laser

Enrico Allaria (ELETTRA, Basovizza, Trieste), Giovanni De Ninno (ELETTRA, Basovizza, Trieste; University of Nova Gorica, Nova Gorica)

The second phase (FEL-2) of the FERMI FEL facility is expected to cover the spectral range between 40 and 10 nm. The configuration studied for FEL-2 in the FERMI conceptual design report is based on a two-stage high gain harmonic generation scheme. In this scheme, the third harmonic of a Ti:Sa laser is up-converted to 40 nm in the first stage, and then down to 10 nm in the second stage. Numerical simulations show the feasibility of this approach. However, it comes out that such a configuration is very sensitive to the unavoidable fluctuations of input parameters, and further complicated by the need of a “fresh bunch” in the second stage. In this work we exploit the possibility to cover the nominal tuning range of FEL-2, and possibly to extend it to shorter wavelengths, by using a single- stage coherent harmonic generation scheme seeded directly in the VUV using the high order harmonics generated in a gas jet struck by an intense Ti:Saphire laser pulse. We present the requirements for the seeding source, as well as the expected FEL performance. Numerical results are compared to those obtained for the configuration described in the FERMI conceptual design report.

MOPPH036: Suppression of Thermal Fluctuations of the Terahertz Free Electron Oscillator Frequency

Sergei Georgii Oganesyan, George Sergey Oganesyan (LT CSC, Yerevan), Yelena Hovhannisyan (RC, Dallas)

We have considered the operation of a free electron oscillator, which contains a long undulator, two mirrors and a space-uniform e-beam. It was assumed that the device operates at indoor temperature in a terahertz single mode regime. Atoms of the device components produce a black radiation, which causes fluctuations of the oscillator frequency, phase and amplitude. Since the mean energy of a thermal photon is of order of the laser one, then the question of suppression of the thermal noise effect is an essential problem for such sources. Our study of the problem is based on a semi-classical approach. We have employed a random polarization vector, which is responsible for the thermal noise and derived an equation that describes the time evolution of the deviation of the laser frequency caused by the noise. On solving the equation we have found an expression for the root-mean-square deviation of the laser frequency. It is recognized that its value may be reduced either by increasing both the oscillator volume and the laser radiation intensity or with decreasing the resonator losses.

MOPPH037: Smith-Purcell BWO with Electron Beam Focussing

Vinit Kumar (RRCAT, Indore (M.P.)), Kwang-Je Kim (ANL, Argonne, Illinois)

We have recently studied the electron beam requirement for successful operation of Smith-Purcell Backward Wave Oscillator and found that one requires a flat electron beam*. Without focussing, the rquirement leads to a very stringent condition on vertical emittance. In this paper, we discuss another way to produce flat beam by focussing the electron beam and show that the method leads to an improved performance of Smith-Purcell FEL.

* K.-J. Kim and V. Kumar, Phys. Rev. ST Accel. Beams 10, 080702 (2007).

MOPPH038: Numerical Analysis of Electron Correlation Function in a SASE FEL Using Lienard-Wiechert Fields

Masoud Rezvani Jalal, Farzin Mojtaba Aghamir (IPM, Tehran)

The correlation function of an electron beam in the linear high gain regime of a SASE FEL is numerically calculated by means of Lienard-Wiechert field and Poisson distribution of electrons arrival times at the undulator entrance. The result is compared to the electron correlation function of Klimontovich-Maxwell approach as well as Shevchenko* approach to the electron correlation function equation for the SASE FELs. Their main similarity is the modulation of electron correlation function through the fundamental wavelength of the undulator radiation.

* O.A. Shevchenko, N.A. Vinokurov, Nucl. Instrum. Meth. Phys. Res. A, 507 (2003) 84-88.

MOPPH039: Super-Radiant Pulse Evolution in a High Gain THz FEL Oscillator at Zero Cavity Detuning

Mufit Tecimer (NHMFL, Tallahassee, Florida)

The analytical expression for the efficiency of a high gain FEL oscillator operating at synchronous cavity* breaks down for large rho parameters attained in the studied high power THz FEL oscillator. The studied system, an energy recovery (low frequency) rf linac high power THz FEL similar to the one described in **, employs relatively long bunches with nC charges. The simulations include the use of a multilayer THz outcoupler mirror and model an operation at zero cavity detuning to attain high extraction efficiency. In this 'long bunch case' as defined in [Bonifacio et al,Phy.Rev. Lett. 73,70] the radiation stored in the cavity evolves into an intense superradiant broadband THz spike with durations of few optical cycles which is at the order of the cooperation length and more than an order of magnitude shorter than the slippage length***. Stability of the output power to small variations in the cavity detuning at around synchronism is studied. Correction is introduced (with regard to[1]) in calculating the high system efficiencies.

* N.Nishimori.,Phy.Rev. E.74, 036502 (Sept. 2006) ** N.A.Vinokurov, FEL 2006 Proc., p *** M.Tecimer, 'THz-FEL Designs' FEL/HMF Workshop JLab, Jan. 2007

MOPPH040: Preliminary Design of a Compact and High Power THz FEL for Security Inspection

Young Uk Jeong, Pil Dong Ahn, Hyuk Jin Cha, Yong-Ho Cha, Byung Cheol Lee, Ji Young Lee, Kitae Lee, Yong Woo Lee, Jungho Mun, Seong Hee Park, Kwon-Hae Yea (KAERI, Daejon), Grigory Kazakevich (Fermilab, Batavia, Illinois)

We developed a compact terahertz (THz) free electron laser (FEL) and have shown its capability to the applications of spectroscopy, imaging, and material study. Based on the system and the present operation parameters, a high power and compact THz FEL has been designed for the practical application of security inspection. The targets of the design are the size of the system of 2x2 m2, the average power of 1 W, and the operation wavelength range from 0.5 to 2 THz. The FEL consists of a magnetron-based microtron having an energy of 5.5 MeV, two high performance electromagnetic undulators assisted by permanent magnets having the periods of 25 and 32 mm, and a waveguide-mode optical resonator having an effective width of 50 mm. The outcoupling of the FEL radiation is considered by low-loss, wide-band dielectric coated mirrors. The total loss of the resonator except the outcoupling ratio is calculated to be less than 2% for the whole wavelength range from 0.5 to 2 THz. With the macropulse beam repetition rate of 200 Hz, the average power of the FEL is expected to be 1 W for both resonators.

MOPPH041: Development of THz Light Source Using Pre-Bunched FEL

Mafuyu Yasuda, Hiroyuki Hama, Fujio Hinode, Kittipong Kasamsook, Masayuki Kawai, Ken-ichi Nanbu (Tohoku University, Sendai)

A project of pre-bunched FEL as a Terahertz (THz) light source using short electron bunch less than 100 fs has been progressed at Laboratory of Nuclear Science, Tohoku University. We expect that FEL with shorter electron beam (comparing with FEL wavelength) may generate shorter light pulse than conventional FEL with longer electron beam. By choosing an appropriate initial electron phase, the FEL gain will be higher. Since seed light of coherent synchrotron radiation is added in each round trip, the FEL will be saturated quickly so that long macro pulse won't be required. In order to produce very short electron bunch around 100 fs, we have been developing an independently-tunable-cells (ITC) RF gun with a small thermionic cathode and a bunch compressor employing α magnet. We have made a numerical simulation code based on 1-D FEL equations. This code can calculate interaction between short the electron bunch and the FEL field. We will report on characteristics such as a time structure and spectrum of pre-bunched FEL resulted from the simulations.

MOPPH042: FEL Scheme with Optical Cavity Round-Trip Frequency at Multiple of Electron Bunch Repetition Rate

David James Dunning (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire)

A study is carried out to develop an optimised scheme for a free electron laser operating in the far-infrared, based upon an electron beam delivered from a prototype superconducting linac module*. This collaboratively developed module is capable of delivering 123 pC of bunch charge at a repetition rate of 13 MHz, or alternatively, higher bunch charges are achievable at lower repetition rates (200 pC at 4.33 MHz for example). A conventional oscillator-type FEL design is compared with a proposed alternative design; wherein the radiation makes three passes of the optical cavity per electron bunch arrival. For both schemes, the output photon properties are predicted through simulations using Genesis 1.3 in combination with the optics code OPC, and tolerances to mirror alignment are investigated and compared to predictions from theory. The further potential of schemes where the radiation makes multiple passes of the optical cavity per electron bunch arrival is discussed.

*P.A. McIntosh et al, "Development of a Prototype Superconducting CW Cavity and Cryomodule for Energy Recovery" EPAC'06, Edinburgh, June 2006, pp. 436 - 438.

MOPPH043: Dynamics of Coaxial FEM with Two-dimensional Distributed Feedback (Quasi-Optical Approach)

Vladislav Zaslavsky, Naum Ginzburg, Nikolay Peskov, Alexander Sergeev (IAP/RAS, Nizhny Novgorod)

For an active media, that is spatially extended along two co-ordinates, including relativistic electron beams with sheet and annular geometry the use of two-dimensional (2D) distributed feedback is beneficial for providing spatial coherence of the radiation and, thus, can be used to increase the total radiation power. Such 2D feedback can be realized in planar and co-axial 2D Bragg resonators having double-periodic corrugations of the metallic side walls. High selectivity of two-dimensional Bragg resonators of planar and coaxial geometry are demonstrated for large Fresnel parameters in the frame of coupled-wave model as well in direct 3D simulations. In the paper modeling of non-linear dynamics of coaixil FEM with 2D distributed feedback have been carried out in the frame of quasi-optical approach to demonstrate possiblity selective exitation of azimathaly-symmetric mode up to system perimeter 100-1000 wavelength. For experimental realization a two-mirror resonators in the form of 2D and 1D corrugated sections should be used. It was shown, that under optimal conditions in the described scheme stable generation with the radiation frequency closed to Bragg frequency can be obtained.

MOPPH044: Megawatt THz Radiation Source at the Neptune Laboratory

Sven Reiche, Chan Joshi, Sergei Tochitsky (UCLA, Los Angeles, California), Stephen C. Gottschalk (STI, Washington)

We present design of a compact, ~10 MW power THz FEL source tunable in the range of 0.5-9 THz. The high-gain, single-pass THz FEL is driven by a 8-12 MeV, 10 ps (FWHM) electron beam of the Neptune photoinjector. To overcome the reduced efficiency of the FEL at the long wavelengths due to diffraction and slippage for the electron pulse containing limited number of the wave periods, a waveguide is embedded within the undulator and the FEL is seeded by an external source tunable in the 0.5-3 THz range with a power level of around 10 W. An optical klystron configuration is proposed to use in order to reach the output power level of ~10 MW. Additionally the gap of the second undulator-radiator can be varied to tune it to higher harmonics and thus extending the wavelength range to 9 THz. High-power, picosecond THz pulses are synchronized with 1 um (photoinjector driver) and 10 um lasers making this source suitable for time resolved pump-probe measurements.

MOPPH046: Phase Stability of a Microtron Driving a Terahertz FEL

Grigory Kazakevich, Viatcheslav Pavlov (BINP SB RAS, Novosibirsk), Young Uk Jeong, Byung Cheol Lee (KAERI, Daejon)

Phase stability of bunches accelerated by a magnetron-driven microtron-injector of a terahertz Free Electron Laser (FEL) has been studied to optimize the microtron regimes providing good operation of the FEL. The study is based on a simulation of the beam dynamics in the microtron considering 2-D motion of the electrons in the median plane. This allows the computation of the first harmonic of the current loading the accelerating cavity and the current as well. The time-dependent current has been used to calculate the frequency deviations caused by the incremental loading in the coupled accelerating and magnetron cavities. Further computations using the 2-D simulation show noticeable phase oscillation of the accelerated bunch leaving the microtron on the macro-pulse front. The phase oscillation is in agreement with measured one and affects the lasing in the microtron-based FEL. Optimization of the microtron regimes allows one to minimize the effect. As a result the terahertz microtron-based FEL provides radiated macro-pulse energy up to 0.2 mJ in the range of 100-350 μm with good stability. Results of the simulation and the measurements are presented in this article.

MOPPH047: Experimental Observation of the Evanescent Wave in a Smith-Purcell Free-Electron Laser

Heather L. Andrews, Charles A. Brau, Jonathan D. Jarvis (Vanderbilt University, Nashville, TN), Robert Durant, Christian Guertin, Thomas Lowell, Michael Mross, Aidan O'Donnell (Vermont Photonics, Bellows Falls, VT)

We present the first experimental observations of the evanescent wave in a Smith-Purcell free-electron laser (FEL). This wave, predicted by both theory and simulations*, has a wavelength longer than the Smith-Purcell radiation, can travel anti-parallel to the electron beam, and for sufficiently high current, will provide feedback to bunch the electron beam. This feedback is the basis of oscillator operation of the Smith-Purcell FEL. The wavelengths observed agree with theoretical predictions.

* Andrews and Brau, PRSTAB 7, 070701 (2004); Donohue and Gardelle, PRSTAB 8, 060702 (2005); Li, Yang, Imasaki and Park, PRSTAB 9, 040701 (2006); Kumar and Kim, PRE 73, 026501 (2006)

MOPPH048: Free-Electron Laser Options for the Energy-Recvory Linac Light Srouce in Japan

Ryoichi Hajima, Nobuyuki Nishimori (JAEA/ERL, Ibaraki)

A research and development program towards a future X-ray light source based on an energy-recovery linac (ERL) has been launched in Japan. The program is underway by collaboration team consisting of KEK, JAEA, ISSP, and other institutes. Since the ERL produces an electron beam of ultimately small emittance with a high repetition rate (MHz - GHz), it is a suitable device to operate a FEL oscillator in addition to spontaneous radiation from undulators. We are investigating possible FEL options both in the ERL test facility under construction (60MeV-200MeV) and a future ERL light source (>5GeV). Following the proposal of XFEL oscillator using Bragg reflectors*, we have conducted a 1D time-dependent simulation to study longitudinal mode evolution in an XFEL oscillator. The simulation shows that narrow-band FEL lasing in hard X-ray wavelength region is established by Bragg reflectors, and even a single supermode operation is possible by choosing appropriate cavity-length detuning.

* K-J. Kim et al., “1-A FEL Oscillator Using ERL Beams”, ERL-07 Workshop, Daresbury, May, 2007.

MOPPH049: Electron Beam Diagnostics with Transverse Deflecting Structures at the European X-Ray Free Electron Laser

Michael Roehrs, Christopher Gerth (DESY, Hamburg)

The operation of the European X-Ray Free Electron Laser puts stringent demands on the peak current, transverse slice emittance and slice energy spread of the driving electron beam. For monitoring and stabilizing these parameters, dedicated diagnostic beamlines are foreseen downstream of two magnetic chicanes for longitudinal bunch compression. Each diagnostic section comprises a transverse deflecting structure, which deflects electrons horizontally as a function of time so that the particle distribution in the longitudinal-vertical plane can be imaged with view screens. Usage of several screens and an appropriate accelerator optics allow for the measurement of the vertical slice emittance. By dispersing the beam vertically as a function of energy using a dipole magnet, the energy distribution along a bunch can be measured with high accuracy and single-bunch resolution. In this paper we give an overview on the layout of the diagnostic sections. The accuracy and time resolution of such measurements are discussed on the basis of numerical simulations.

MOPPH050: Experimental Demonstration of a Tunable Laser Seeded Harmonic FEL

Xijie Wang, Renkai Li, James Murphy, Yuzhen Shen (BNL, Upton, Long Island, New York), Juhao Wu (SLAC, Menlo Park, California)

Experimental characterization of a tunable harmonic FEL based on the Self-Amplified Spontaneous Coherent Emission (SASCE) is presented in this talk. The experiment was performed at the National Synchrotron Light Source (NSLS) Source Development Laboratory (SDL) in Brookhaven National Laboratory (BNL). Similar to SASE, SASCE FEL initiates with spontaneous coherent emission instead of spontaneous emission (noise), and then followed by an exponential growth (amplification) process along the undulator. The spontaneous coherent emission is generated by the micro-bunched electron beam through an Inverse Free Electron Laser (IFEL). The seed laser employed for the IFEL is a Ti:sapphire laser operating at 795 nm. The evolution of the FEL along the undulator was measured, and for the first time, we experimentally characterized both spontaneous coherent emission and exponential growth processes. The maximum FEL output is about 120 μJ. We have experimentally demonstrated more than 20% (250 nm to 310 nm) spectral tuning in the SASCE FEL. The spectral evolution along the undulator was also measured, the transform limited FEL was achieved by controlling the seed laser spectral width.

This work is supported by the U.S. Department of Energy under contract No. DE-AC02-98CH1-886.

MOPPH051: Beam Stability Studies in the LCLS Linac

James Leslie Turner, Ron Akre, Axel Brachmann, Franz-Josef Decker, Yuantao Ding, David Dowell, Paul Emma, Josef Frisch, Sasha Gilevich, Gregory R. Hays, Philippe Hering, Zhirong Huang, Richard Iverson, Cecile Limborg-Deprey, Henrik Loos, Alan Miahnahri, Stephen Molloy, Heinz-Dieter Nuhn, James Welch, William White, Juhao Wu (SLAC, Menlo Park, California), Daniel Ratner (Stanford University, Stanford, Califormia)

The beam stability specifications for the Linac Coherent Light Source (LCLS) Free-Electron Laser (FEL) at Stanford Linear Accelerator Center (SLAC) are critical for X-Ray power, pointing, and timing stability. Studies of the transverse, longitudinal, and intensity stability of the electron beam are presented. Some sources are identified, correlated, and quantified.

MOPPH052: Commissioning Experience with the Linac Coherent Light Source Feedback Systems

Juhao Wu, Ron Akre, Franz-Josef Decker, Yuantao Ding, David Dowell, Paul Emma, Diane Fairley, Josef Frisch, Sasha Gilevich, Gregory R. Hays, Philippe Hering, Zhirong Huang, Richard Iverson, Cecile Limborg-Deprey, Henrik Loos, Alan Miahnahri, Heinz-Dieter Nuhn, James Leslie Turner, James Welch, William White (SLAC, Menlo Park, California), Daniel Ratner (Stanford University, Stanford, Califormia)

The Linac Coherent Light Source (LCLS) is a SASE x-ray Free-Electron Laser (FEL) project under construction at SLAC. The machine commissioning includes the injector, the first and second bunch compressor stages, the linac up to 14 GeV, and the various beam diagnostics. To ensure the vitality of FEL lasing, it is critical to generate and preserve the high quality of the electron beam during acceleration and compression. The final beam quality can be very sensitive to system jitter. To minimize jitter, various transverse and longitudinal feedback systems are required. Here, we report the commissioning experience with these systems during the two phases of commissioning in 2007 - 2008.

The work was supported by the US Department of Energy under contract DE-AC02-76SF00515. This work was performed in support of the LCLS project at SLAC.

MOPPH053: Ultra-high Brightness Electron Beam by Plasma-based Injectors for Driving All Optical Free-Electron Lasers

Vittoria Petrillo (Universita' degli Studi di Milano, Milano), Andrea Sgattoni, Giorgio Turchetti (Bologna University, Bologna), Carlo Benedetti, Pasquale Londrillo (INFN-Bologna, Bologna), Alberto Bacci, Andrea Renato Rossi, Luca Serafini, Paolo Tomassini (INFN-Milano, Milano)

We studied the generation of low emittance high current mono-energetic beams from plasma waves driven by ultra-short laser pulse, for achieving beam brightness of interest for FEL applications. The aim is to show the feasibility of generating nC charged beams carrying peak currents much higher than those attainable with photoinjectrors, but with comparable emittance and energy spread, compatibly with typical FEL requirements. We have studied a LWFA plasma driving scheme on a gas jet modulated in areas of different densities with sharp density gradients. Currents up to 100 kA can be reached. We present simulations made with the new code Aladyn, implemented ah hoc for this problem, which show beams of 30 MeV with 20 kA of current, 0.3 mm mrad of emittance and 0.4% of energy spread. This beam has been injected in a e.m. wiggler, giving superradianat, strongly coherent X radiation.

MOPPH054: Spectral Characteristics of the Seeded FEL Using Higher Harmonic Generation in a Gas at the SCSS Test Accelerator

Takanori Tanikawa (Sokendai, Okazaki, Aichi), Bertrand Carré, David Garzella, Marie Labat (CEA, Gif-sur-Yvette), Guillaume Lambert (LOA, Palaiseau), Kazuhiko Tahara, Yoshihito Tanaka (RIKEN Spring-8 Harima, Hyogo), Toru Hara, Tetsuya Ishikawa, Hideo Kitamura, Tsumoru Shintake, Takashi Tanaka, Makina Yabashi (RIKEN/SPring-8, Hyogo), Marie-Emmanuelle Couprie (SOLEIL, Gif-sur-Yvette), Masahiro Katoh (UVSOR, Okazaki)

Seeding a FEL with high order harmonic generation (HHG) from a Xe gas cell at the SCSS test accelerator was achieved at a wavelength of 160 nm (the 5th harmonic of a Ti: Sa laser) in December 2006. After the improvement of the accelerator performance in 2007, we performed detailed studies of the spectral characteristics of the seeded FEL. Compared to the spiky spectrum of SASE, the seeded FEL can produce a quasi-Gaussian spectrum with a single peak. In addition, the lasing wavelength is fixed at the wavelength of the seed, even if the undulator K-parameter is shifted in a certain range. Therefore, the spectral stability becomes much better than SASE against the fluctuation of undulator fields or beam energy. In the recent experiments, we observed that the bandwidth of the amplified seed became narrower than that of the original seed light itself. It seems to be stretched the longitudinal coherent length in the FEL interaction. In the presentation, we will report the spectral characteristics of the seeded FEL.

MOPPH055: Realistic Thermal Emittance Measurements at the Low Emittance Gun Test Facility for PSI XFEL Project

Yujong Kim, Åke Andersson, Miroslaw Dach, Romain Ganter, Christopher Gough, Christoph P. Hauri, Rasmus Ischebeck, Frederic Le Pimpec, Martin Paraliev, Marco Pedrozzi, Thomas Schietinger, Bernd Steffen, Albin Friedrich Wrulich (PSI, Villigen)

To check performance of a planned low emittance gun (LEG) for the PSI XFEL project, a 500 kV pulsed diode based gun test facility was constructed at PSI in 2007. The gun was specially designed to have an adjustable gap between the cathode and the anode, and to allow extensive high gradient tests. Since the electron temperature at the cathode determines the minimum achievable slice emittance, we concentrated our efforts to measure the thermal emittance of a diamond turned copper cathode and stainless steel ones. To minimize emittance growth due to space charge effects, a single bunch with a charge of about 0.6 pC was used to characterize the beam. Since the experimental setup does not include an RF cavity, there was no dilution effects due to the non-linearity of the RF field. After optimizing the pulser to get a stable operation at 40 MV/m with the copper cathode, we could get about 0.2 mm.mrad range thermal emittance for a laser spotsize at the cathode of about 0.330 mm (RMS). In this paper, we report on our realistic thermal emittance measurements with copper and stainless steel cathodes at the LEG facility, which are much smaller than measured results by other laboratories.

MOPPH056: Generation of Attosecond X-ray Pulses with a Multi-Cycle Two-Color ESASE Scheme

Yuantao Ding, Philip Howard Bucksbaum, Zhirong Huang (SLAC, Menlo Park, California), Hamed Merdji (CEA, Gif-sur-Yvette), Daniel Ratner (Stanford University, Stanford, Californmia)

Generation of attosecond x-ray pulses is attracting much attention within the x-ray free-electron laser (FEL) user community. Several schemes have been proposed based on manipulations of electron bunches with extremely short laser pulses. In this paper, we extend the attosecond two-color ESASE scheme* to the long optical cycle regime using a detuned second laser** and a tapered undulator. Both lasers can be about ten-optical-cycle long, with the second laser frequency detuned from the first one in order to optimize the contrast between the central and side current spikes. A tapered undulator can be used to mitigate the degradation effect of the longitudinal space charge force in the undulator*** as well as to suppress the FEL gain of all side current spikes. Simulations using the LCLS parameters show a single attosecond x-ray spike of ~100 attosecond can be produced with a good contrast ratio.

* A. A. Zholents and G. Penn, Phys. Rev. ST Accel. Beams 8, 050704 (2005). ** H. Merdji et al., Opt. Lett., 32, 3134 (2007). *** G. Geloni et al., Nucl. Instrum. Methods A 583, 228 (2007).

MOPPH057: Status of SPARX Project

Luigi Palumbo, Massimo Ferrario, Cristina Vaccarezza (INFN/LNF, Frascati (Roma)), Giuseppe Dattoli, Luca Giannessi (ENEA C.R. Frascati, Frascati (Roma))

The SPARX project consists in an X-ray-FEL facility jointly supported 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 1.2 and 2.4 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 1.2 GeV and 2.4 GeV respectively, both in SASE and Seeded FEL configurations.

MOPPH058: Gun Emittance and Compact XFEL

Tae-Yeon Lee, Jinhyuk Choi (PAL, Pohang, Kyungbuk)

Role of gun emittance is discussed to build a compact XFEL machine. It is shown that low gun emittance plays the critical role of reducing the XFEL machine size.

MOPPH059: Analysis of Bunch Acceleration and Compression with Wakefields

Juhao Wu (SLAC, Menlo Park, California), Robert Arthur Bosch, Kevin J Kleman (UW-Madison/SRC, Madison, Wisconsin)

For a high quality electron bunch driving a hard X-ray free electron laser, collective effects during the bunch acceleration, transport, and compression can distort the phase space and even lead to instability. For a typical configuration, coherent edge radiation dominates and governs the overall bunch properties; while longitudinal space charge is the main cause of the microbunching instability. Random jitter couples to the wakefields and affects the final bunch properties. We study these effects and discuss their implication to general LINAC design.

The work of JW was supported by the US Department of Energy under contract No. DE-AC02-76SF00515. The work of RAB and KJK was supported by National Science Foundation Award No. DMR-0537588.

MOPPH060: Start-to-End Simulations for the 10 GeV PAL-FEL Project

Eun-San Kim (Kyungpook National University, Daegu)

The PAL-FEL is a fourth-generation ligth source project based on the SASE FEL concept that is in a proposing stage. It consists of a photoinjector, two stages of bunch compressors in a 10 GeV S-band linac and a undulator to generate intense radiation pulses of around 5 GW at 0.1 nm. We have performed beam tracking from injector to the undulator to examine the sensitivities to beam quality. The stuides show that a good quality beam can be maintained through the 10 GeV linac and delivered to undulator under the allowable rf system jitter errors and lattice errors. It is shown that the results of these simulations are well within our FEL performance goals. Simulation results of pulse-to-pulse stabilities due to variation of the rf parameters are also presented.

MOPPH061: Microbunching Beam Instabilities in the 10 GeV PAL-FEL

Eun-San Kim (Kyungpook National University, Daegu)

High bunch compression in bunch compressors is necessary to achieve a high peak beam current in FEL system that produce a short radiation wavelength. We investigated the effects of a longitudinal space charge wake and a linac wake on the microbunching instabilties in the 10 GeV PAL-FEL by utilizing well-known theory. It is shown that large energy modulations may be generated by the space charge wake and can enhance CSR microbunching in the two bunch compressors, depending on the magnitude of energy spread of the beam coming from the injector. We also investigated the effectiveness of a lase heater to suppress the microbunching beam instability in the PAL-FEL system.

MOPPH062: Linear Accelerator and Undulator for FEL Branch 3 of PSI XFEL Project

Yujong Kim, Andreas Adelmann, Micha Dehler, Romain Ganter, Terence Garvey, Anne Oppelt, Marco Pedrozzi, Jean-Yves Raguin, Leonid Rivkin, Volker Schlott, Andreas Streun, Frank Stulle, Albin Friedrich Wrulich (PSI, Villigen), Bagrat Grigoryan, Vitali Khachatryan, Vasili Mkrtich Tsakanov (CANDLE, Yerevan), Martin Dohlus (DESY, Hamburg)

In the planned PSI XFEL facility, three FEL branches will supply coherent, ultra-bright, and ultra-fast XFEL photons at wide wavelength range. FEL 1 will use a 6.0 GeV driving linac to generate hard X-rays from 0.1 nm to 0.3 nm, while FEL 2 is foreseen for X-rays from 0.3 nm to 1.0 nm. However, FEL 3 was designed to supply spatially as well as temporally coherent soft X-rays from 1.0 nm to 10 nm with the High-order Harmonic Generation based seeded HGHG scheme. To reach emittances of 0.2 mm.mrad and to squeeze consequently the whole facility within an 800 m long tunnel, PSI is presently developing an advanced low emittance gun based on a 1 MV high gradient pulsed diode and field emission. The advanced pulsed gun will be used for FEL 1 and 2, while an RF photoinjector will be used for the FEL 3. To test those two injector technologies, a dedicated 250 MeV injector test facility will be constructed at PSI from 2008. In this paper, we describe required beam parameters, linac layout, diagnostic section, undulator, and start-to-end simulations for FEL branch 3, which is based on the RF photoinjector, 3.7 GeV linac, and externally seeded HGHG.

MOPPH063: Transient Temperatures in Matter with Multiple Pulses of X-FEL

Lin Zhang (ESRF, Grenoble)

The potential thermal degradation of optics and samples by the ultra short pulses and extremely high peak powers delivered by the X-FEL is an on-going challenge for beamline design. For X-FEL applications and especially crystal monochromators it is very important to correctly estimate the transient temperature response of the matter due to the first multiple pulses of the X-FEL. The X-ray attenuation length (or absorption length) is one of key parameters in the temperature estimation. Complex physical processes of the interaction of the X-FEL radiation with solid matters suggest an effective absorption length longer than the Henke absorption length. Comparison with some published experimental results confirms the relevance of introducing this effective absorption length. Finite element analysis has been successfully used to simulate the fully transient temperature of a silicon crystal with TESLA X-FEL power. The covered time range from femto-second to tens of seconds was technically challenging. The temperature of the silicon crystal or other solid matter from the 1st pulse to quasi steady state with multiple pulses or repetitions of bunch train can be readily calculated.

MOPPH064: RMS Mode Size of the XFEL Radiation

Tae-Yeon Lee (PAL, Pohang, Kyungbuk)

Formula of the rms transverse mode size of the XFEL radiation is derived. Derivation uses information on the XFEL transvese coherence. Derived formula agrees well with the simulation result.

MOPPH065: Development towards Ultra-short Pulse, Single Coherent Spike for SASE X-ray FELs

Sven Reiche, Claudio Pellegrini, James Rosenzweig (UCLA, Los Angeles, California)

There is a large interest in the production of high power, ultra-short, one femtoseconds or less, coherent X-ray pulses, for atomic physics and other applications. However the present design of X-ray SASE FELs leads to an X-ray pulse about 100 times longer. The time structure of the X-ray pulse is determined by several factors, mainly the electron bunch length and the FEL cooperation length. Until now all FELs have been working in the regime where the electron bunch length is much larger than the cooperation length. In the case of an X-ray SASE FEL this means that the X-ray pulse consists of a series of spikes, a few hundred in the case of the LCLS, and the bunch length is of the order of 200 fs. We are considering here a method, using ultra-short, very low charge electron bunches, with a length of the order or shorter than the FEL cooperation length. In this case the Xray pulse length after amplification in the undulator is a few times the electron bunch length. Our simulations show that in the case of LCLS, operating with a 1pC or less electron beam, we obtain X-ray pulses as short as 300 as, close to the transformation limit.

MOPPH066: The ARC-EN-CIEL Fourth Generation Light Source Proposal

Marie-Emmanuelle Couprie, Chamseddine Benabderrahmane, Oleg Chubar, Jean-Claude Denard, Paul Dumas, Jean-Marc Filhol, Mourad Idir, Marie Labat, Pierre Lebasque, Alain Lestrade, Alexandre Loulergue, Marc Louvet, Patrick Marchand, Olivier Marcouillé, Pascal Mercere, Paul Morin, Laurent Stanislas Nadolski, Laurent Nahon (SOLEIL, Gif-sur-Yvette), Jan Luning (CCPMR, Paris), Christelle Bruni (LAL, Orsay), Michael Meyer (LIXAM, Orsay), Guillaume Lambert, Philippe Zeitoun (LOA, Palaiseau), Eric Collet (University of Rennes, Rennes)

The ARC-EN-CIEL project proposes a suit of novel light sources for the scientific community. Three FEL (LEL1, LEL2 and LEL4) sources rely on High Gain Harmonic Generation radiation and their Non Linear Harmonics seeded with the High Order Harmonics generated in gas. LEL1 will cover the 200-1.5 nm spectral range with 100-30 fs FWHM pulses, adjustable in polarisation, at a few kHz. LEL2 will provide 10-0.6 nm radiation with planar polarisation, with 100-30 fs pulses at a few kHz repetition rate. LEL4 will cover the 2-0.2 nm range, with 50-30 fs pulses at 1 kHz. LEL3 is a FEL oscillator in the 40-8 nm range with a repetition rate of 4.5 MHz. These FEL sources will reach MW to GW of peak power. In addition, undulator radiation will provide 200 fs pulses with energies up to 20 keV. FEL calculations are presented. The accelerator is based on superconducting technology to enable a high repetition rate. ARC-EN-CIEL is well adapted for studies in various scientific domains using coherent imaging, linear spectroscopy, pump-probe experiments, non-linear and high intensities studies. The use of plasma acceleration in the project is under investigation.

MOPPH067: Parameter Study of an X-ray FEL Oscillator

Ryan Roger Lindberg, Kwang-Je Kim (ANL, Argonne, Illinois)

An X-ray radiation source based on a free electron oscillator (FEL) was recently proposed as a complimentary facility to those based on self-amplified spontaneous emission*. Such a source uses Bragg mirrors and a low emittance, high-brightness electron beam to produce coherent, intense pulses of radiation near one angstrom. We present the FEL performance and radiation characteristics for a variety of beam and undulator parameters.
* K.-J. Kim, Y. Shvyd'ko, S. Reiche, submitted to Phys. Rev. Lett.

MOPPH068: Controlling Wiggler Harmonic Radiation to Reduce Damage to FEL Cavity Mirrors

Senlin Huang, Y. K. Wu (FEL/Duke University, Durham, North Carolina)

Wigglers emit both fundamental and harmonic radiation. For oscillator FELs, UV-VUV harmonic radiation can cause serious damage to the downstream mirror of the FEL cavity. Compared to a planar wiggler, harmonic radiation from a helical wiggler is peaked off-axis, and using a helical wiggler can significantly improve the FEL mirror lifetime. With a helical wiggler. However, the off-axis harmonic radiation from helical wigglers can still cause serious damage to the downstream mirror or limit the maximum beam current for FEL operation due to UV-VUV power loading on the mirror. At Duke FEL lab, we have developed a mechanism to control the off-axis harmonic radiation from the helical wigglers by using a set of motorized, water-cooled, in-vacuum apertures. These apertures can reduce the harmonic power load on the downstream mirror by one order of magnitude. With these apertures, operation with high electron beam currents becomes feasible for stable, high power UV-VUV lasing. In this work, we report the effectiveness of the apertures in reducing the wiggler harmonic radiation under various operation conditions and for different configurations of the Duke FELs.

This work is supported by the medical FEL grant F49620-001-0370 from the Air Force Office of Scientific Research.

MOPPH069: A Pass-by-Pass Gain Measurement Technique for Oscillator FELs

Stepan F. Mikhailov, Senlin Huang, Jingyi Li, Victor Popov, Y. K. Wu (FEL/Duke University, Durham, North Carolina)

We present a new pass-by-pass gain measurement technique for a storage ring FEL Typically, the FEL oscillator gain is obtained by measuring the growth of the envelope of an optical macropulse using a slow photo-detector. While successfully used for low-gain FEL operation at Duke FEL laboratory for many years, this technique does not provide the information on the optical power growth from pass to pass. In addition, this method was not adequate for measuring higher gains of distributed optical klystron FELs. We have developed a new gain measurement technique based upon the direct measurement of the optical energy in micropulses. Using fast photo-detectors, the growth of an FEL macro-pulse can be recorded from pass to pass. This new gain measurement technique provides a powerful tool to study the details of the FEL gain process, including the onset of the FEL lasing. In the work, we describe this new gain measurement technique in detail and compare it with the old technique. Using fast photo-detectors with a sub-nanosecond time response, this new technique can be adopted for many oscillator FELs, including those driven by super-conducting linacs.

This work is supported by the medical FEL grant F49620-001-0370 from the Air Force Office of Scientific Research.

MOPPH070: Commissioning of a Seeded FEL Facility at the Elettra Storage Ring

Carlo Spezzani, Enrico Allaria, Giuseppe Cautero, Miltcho B. Danailov, Alexander Demidovich, Bruno Diviacco, Rosen Ivanov, Emanuel Karantzoulis, Paolo Pittana, Luca Romanzin, Rudi Sergo, Paolo Sigalotti, Svetla Tileva, Mauro Trovo (ELETTRA, Basovizza, Trieste), Marcello Coreno (CNR - IMIP, Trieste), Giovanni De Ninno (ELETTRA, Basovizza, Trieste; University of Nova Gorica, Nova Gorica), Francesca Curbis (MAX-lab, Lund)

We have implemented on the storage ring free electron laser beamline at Elettra an experimental setup for the generation of sub-picosecond coherent optical pulses in the VUV range. The setup is based on the frequency up-conversion of a high-power external signal (provided by a Ti:Saphire laser) and makes use of a relativistic electron bunch as resonating medium. The produced pulses have peak power in MW range, variable polarization, high shot to shot stability and control of the timing parameters at the ps level. We describe the experimental setup and present the preliminary characterization of the obtained radiation. Results show that the CHG source we have implemented may be attractive for the investigation the fields of dynamical phenomena, non-linear physics, magnetism and biology.

MOPPH071: Spectral Analysis of the UVSOR-II Free Electron Laser

Marie Labat (CEA, Gif-sur-Yvette), Masahito Hosaka, Naoto Yamamoto (Nagoya University, Nagoya), Marie-Emmanuelle Couprie (SOLEIL, Gif-sur-Yvette), Masahiro Katoh, Miho Shimada (UVSOR, Okazaki)

Single pass Free Electron Lasers (FELs) are intense and short duration light sources with a wide spectral range. In the seeded configuration, an external laser source is injected inside a first undulator which induces energy modulation of the bunch, further converted into a density modulation, producing coherent radiation in a second undulator. These FELs are expected to reproduce the seed properties, and therefore provide a radiation with a high temporal coherence degree. The spectral properties of a seeded FEL are studied in the case of UVSOR-II storage ring FEL (Japan), set in the Coherent Harmonic Generation configuration. The 600 MeV electron beam stored is seeded using a 800 nm Ti:Sa laser, allowing radiation at 400 and 266 nm (second and third harmonics). A spectrometer coupled to an iCCD camera records the coherent emission spectra as a function of the seeding laser and beam parameters. The experimental results reveal that the FEL spectral structure depends on the seeding parameters. They have to be controlled to prevent the degradation of the spectrum via over-modulation of the electronic distribution, which drives sideband growth together with wavelength shift.

MOPPH072: Optimization of a Seeded Free Electron Laser with Helical Undulators

Marie Labat (CEA, Gif-sur-Yvette), Masahito Hosaka (Nagoya University, Nagoya), Marie-Emmanuelle Couprie (SOLEIL, Gif-sur-Yvette), Masahiro Katoh, Miho Shimada (UVSOR, Okazaki)

Seeded Free Electron Lasers (FELs) - an external laser source is injected inside the undulator to perform energy modulation of the electron beam - deliver intense, short duration, short wavelength light pulses with a high temporal coherence degree. Since the polarization of the radiation depends on the undulator magnetic field, the FELs operated with adjustable undulators are unique candidates for providing flexible polarized light of high quality, required for probing symmetry properties of matter. Experiments have been performed on the UVSOR-II storage ring FEL in the seeded Coherent Harmonic Generation (CHG) scheme operated with helical undulators. The electron beam stored at 500 MeV is seeded using a 800 nm Ti:Sa laser, allowing radiation at 400 nm (second harmonic). A quarter-wavelength plate allows the tuning of the polarization of the seeded laser from linear to elliptic or circular. We show that the FEL radiation intensity can be significantly improved via the seed polarization matching. Other parameters of optimization are also presented, such as the focussing mode. The experimental results are analysed using a simple 1D analytical model and the 3D numerical code GENESIS.

MOPPH073: Near-Infrared Free Electron Laser Experiment with the Storage Ring NIJI-IV

Norihiro Sei, Hiroshi Ogawa, Kawakatsu Yamada, Masato Yasumoto (AIST, Tsukuba, Ibaraki)

The studies of the storage ring free electron lasers (SRFELs) and their applications have been progressed with the compact storage ring NIJI-IV at the National Institute of Advanced Industrial Science and Technology. To frontier the wavelength of the SRFEL oscillation, we have developed an infrared SRFEL with the NIJI-IV. A new optical klystron ETLOK-III, which was designed for the infrared FEL oscillations in a wavelength region of 1-10 micron, was installed in a long straight section of the NIJI-IV in 2004. Moreover, new mirror chambers were set at both ends of an optical cavity for the infrared FEL in 2007. Their stand and vibration dumper could decrease the vibration amplitude on the mirror chamber by about 80%. The amplitude of the vibrations at the cavity mirror would be controlled within 0.5 micron on the axis of the optical beam. High-reflection mirrors whose loss is below 0.1% at the wavelength around 850 nm have been obtained. The maximum FEL gain is estimated to be about 1.3% with the mirrors. We will restart experiments for near-infrared FEL oscillations in summer. In this article, recent progress of the FEL experiments with the NIJI-IV will be discussed.

MOPPH074: Image Analysis of the UVSOR-II Free Electron Laser

Guyve Khalili, Oleg Chubar, Marie-Emmanuelle Couprie (SOLEIL, Gif-sur-Yvette), Marie Labat (CEA, Gif-sur-Yvette), Miho Shimada (KEK, Ibaraki), Masahito Hosaka, Naoto Yamamoto (Nagoya University, Nagoya), Masahiro Katoh (UVSOR, Okazaki)

Coherent Harmonics Generation was obtained on the UVSOR-II storage ring (Okazaki, Japan) by injecting a Ti:Sa laser at 800 nm and high repetition rate (1kHz) in an optical klystron, operating in planar and helical configuration. We describe here the imaging experiment of the spatial distribution for the second and third harmonics radiations in the planar configuration, and for the second harmonic in the helical configuration. Both spontaneous and coherent radiations were recorded for several parameters(optical klystron gap, laser power and polarisation). The optical and imaging setup is described. Obtained results are compared with theory.

MOPPH075: Experimental Study of an Unneutralized Relativistic Electron Beam Transportation through the Waveguides

Lalit Gupta (IPS ACADEMY, Indore), Y. Choyal (Davi Ahilya University, Indore, Madhya Pradesh)

The experimental results of unneutralized electron beam transportation in an evacuated cylindrical metallic drift tube have been obtained. Marx generator is used as a high voltage source to energize the cathode. A 300 keV, 2 kA, and 150 ns pulsed electron beam has been generated by the field emission diode. For axial guidance of the electron beam a 1 Tesla, 260 μs, guide magnetic field has been used. The guide-magnetic field is generated by the discharge of a capacitor bank into a solenoid. A synchronized circuit ensures the triggering of the electron beam at the instant when the axial magnetic field attains its peak value. Experimental studies of the electron beam transportation through various metallic tubes of different wall-materials, and different thicknesses in the presence of varying magnetic fields have been made. Our experimental results show that the transportation properties of the beam get substantially affected because of the different diffusivity of the guide magnetic field through the different materials, and different thicknesses of the wall of the drift tube.

MOPPH076: Design of 60 MeV Linac for Coherent Femto-Second THz Radiation

Changmook Yim, In Soo Ko (POSTECH, Pohang, Kyungbuk), Heung-Sik Kang (PAL, Pohang, Kyungbuk)

High intensity coherent THz radiation from ultra-short electron bunches is a great radiation source for THz research related to biological molecules and imaging science. In order to generate femtosecond THz radiation, A 60-MeV electron linac was constructed at the Pohang Accelerator Laboratory (PAL). It consists of a photocathode RF gun, two accelerating columns (AC1 and AC2), two magnetic chicane bunch compressor(Chicane1 and Chicane2). The optical transition radiation (OTR) and undulator radiation are used for producing THz radiation. In this article, the PARMELA code simulation results and current status of fs-THz linac will be present.

MOPPH077: Electron-Linac Based fs-THz Program at Pohang Accelerator Laboratory

Jaehun Park, Heung-Sik Kang, Changbum Kim (PAL, Pohang, Kyungbuk)

A 60 MeV electron linac for the source of coherent fs-THz pulses is under construction at PAL, Korea. The 266 nm pulses provided by the 3rd harmonic conversion of 800nm Ti:Sapphire amplifier system are to be delivered to the photocathode rf-gun. The electron bunches produced from the photocathode rf gun are accelerated and compressed down to several tens of femtosecond in the linac. Then the relativistic electron bunches are used to generate intense fs-THz pulses by coherent transition radiation (CTR). The radiated THz pulses are extracted from the linac vacuum pipe through a CVD diamond window. The beam, which is took up part of the 800nm beam out of the fs-regenerative amplifier, is sent to the THz laboratory to do THz pump-Optical/IR probe experiment.

MOPPH078: Terahertz Cherenkov Free-Electron Laser

Dazhi Li, Kazuo Imasaki (ILT, Suita, Osaka), Makoto R. Asakawa (Kansai University, Osaka), Gang Huo (Oil Production Research Institute, Dongying), Wenxin Liu (UESTC, Chengdu, Sichuan)

In the development of compact terahertz radiation source, a table-top Cherenkov free-electron laser is proposed. The simplified model is consisted of a double-slap device, including a rectangular waveguide partially filled with two lined parellel dielectric slabs, driven by a 50 KeV electron beam. The dispersion relation of such a model is investigated theoretically and the dispersion equation is solved numerically. With the help of a particle-in-cell simulation code, the mechanism of beam-wave interaction is carefully analized. According to those simulation results, we found the optimum parameters for this kind of device to operate at the terahertz wave region.

MOPPH079: Terahertz Radiations from Thin Foil Targets Irradiated by an Ultra-intense Laser Pulse

Jungho Mun, Pil Dong Ahn, Hyung Ki Cha, Yong-Ho Cha, Young Uk Jeong, Byung Cheol Lee, Ji Young Lee, Kitae Lee, Yong Woo Lee, Seong Hee Park, Kwon-Hae Yea (KAERI, Daejon)

Terahertz (THz) radiations generated from thin foil targets irradiated by an ultra-intense laser pulse of 30 fs, 200 mJ were observed. Simultaneous measurements of THz, x-ray and proton yields show quite different behaviours on target materials, aluminium and Mylar. In the case of the metal target, THz signal and proton yields show a linear relationship and they are much higher than that of the plastic target. This is considered to be caused by different transport properties of hot electrons on target materials. The spectral properties of the THz radiations measured by a Michelson interferometer will be also presented.

MOPPH080: Considerations for a New Light Source for the UK

Richard Walker (Diamond, Oxfordshire)

Following a review of light source provision for UK scientists in 2007, a New Light Source (NLS) project was initiated by the Science and Technology Facilities Council (STFC) in April 2008. Over the following 18 months the aim of the NLS study project is firstly to examine the likely key scientific drivers over the next few decades that will require new source facilities, and what part should be met by a new national facility. An early indication is that any such facility will be based on a close integration of conventional and accelerator-based laser sources (i.e. FELs). After reviewing the technical options available for meeting the scientific needs, a more detailed design study will then be made leading to a proposal for funding. In this paper we report on the source requirements that have emerged from a series of science workshops in May/June 2008 and subsequent preliminary considerations of options for a future New Light Source facility.
on behalf of the NLS Source Design Team

MOPPH081: OPALS: The Oxford Plasma Accelerator Light Source Project

Riccardo Bartolini (Diamond, Oxfordshire), Nicolas Delerue, Ken Peach (JAI, Oxford), George Doucas, Simon Hooker, David Urner (OXFORDphysics, Oxford, Oxon)

Recent progress in Laser Plasma Accelerators has demonstrated the possibility of generating GeV electron bunches with very interesting beam qualities. It is now conceivable that the further development of such devices could generate beams with emittance, energy spread and peak current suitable for FEL operation in the XUV range with relatively short undulator trains. In this context the OPALS project aims at the construction of a XUV radiation source, driven by a Laser Plasma Accelerator, capable of generating ultrashort fs XUV pulses. Such a source is small enough to be hosted in an academic or industrial institution and could therefore have a major impact on time-resolved science.

MOPPH082: Demagnetization Study of Undulator Magnet using 2.5 GeV Electron Beam

Hee-Seock Lee, Minho Kim, Tae-Yeong Koo (PAL, Pohang, Kyungbuk), Rui Qiu (TUB, Beijing), Junli Li (Tsinghua University, Beijing)

The steady performance of a long undulator is one of the most important requirements for successful operation of XFEL. The performance should be affected seriously by a demagnetization of undulator permanent magnets due to irradiation of high energy electron beam. The same type NdFeB permanent magnets with undulator magnets exposed to 2.5 GeV electron beam directly or indirectly. The reduced remanences are measured using an in-situ type hall probe system. The demagnetization phenomena depending on radiation fields generated from the Ta target of different thicknesses and the variation of hysteresis loop are observed and it gives an information to solve the origin of that demagnetization phenomena. The high radiation hardness of high-coercivity magnet is proved again in this study. The distribution of demagnetization amount behind the different thick Ta targets follows the electromagnetic shower profile. The demagnetization due to high energy electron is found to be irreversible effects and also to result mainly from photonuclear reaction and secondary particles comparing to neutrons.

MOCAU FEL Theory, Monday 16:10 - 17:35

MOCAU01: A Virtual Dielectric Eigenmode Expansion of High-Gain FEL Radiation for Study of Paraxial Wave Mode Coupling

Erik Hemsing, James Rosenzweig (UCLA, Los Angeles, California), Avraham Gover (University of Tel-Aviv, Tel-Aviv)

A theoretical approach that uses eigenmodes of a dielectric wave guide to describe the signal field of an FEL is presented. This formulation can provide an efficient characterization of the FEL self-similar eigenmodes and enables a clear descriptive connection to free-space propagation of the input and output radiation. The entire evolution of the radiation wave through the linear gain regime is described with arbitrary initial conditions. By virtue of the flexibility in the expansion basis, this technique can be used to find the direct coupling and amplification of specific modes of interest. A simple transformation converts the derived coupled differential evolution equations into a set of coupled algebraic equations and yields a matrix determinant equation for the FEL eigenmodes. Laguerre-Gaussian modes used as an expansion basis allows investigation of coupling and amplification of optical modes that contain orbital angular momentum, suggesting new regimes of operation for future FELs.

MOCAU02: FEL Coherence below Shot Noise Limit, and Its Fundamental Limits

Avraham Gover, Egor Dyunin (University of Tel-Aviv, Tel-Aviv)

SASE X-UV Free Electron Lasers (FEL) operate as noise amplifiers. They are spatially coherent, and extremely bright, but not temporally coherent. Pre-bunching scheme, such as HGHG, and seed radiation injection schemes (HHG) make it possible to attain, in principle, fully coherent FELs, which would have also extremely high spectral brightness. To achieve this goal, the coherently amplified FEL power must be significantly higher than the SASE power, which in this case is just an undesirable noise. An alternative way, suggested here, is to provide a scheme for reducing the SASE input power, namely the shot noise, by a scheme of current fluctuation smoothing, based on controlled e-beam (Langmuir) plasma wave oscillation in non-radiating sections along the accelerator and FEL e-beam transport line. This will permit to achieve full laser coherence with lower seeding power than required presently, and can provide a significant short-cut to achieving coherent FEL radiation in the X-UV regime. We further derive the theoretical limits for the coherence of noise-reduced FEL amplifiers, and find that it is ultimately limited only by quantum noise.

MOCAU03: Statistical Analysis of Crossed Undulator for Polarization Control in a SASE FEL

Yuantao Ding, Zhirong Huang (SLAC, Menlo Park, California)

There is a growing interest in producing intense, coherent x-ray radiation with an adjustable and arbitrary polarization state. In this paper, we study the crossed undulator scheme* for rapid polarization control in a self-amplified spontaneous emission (SASE) free electron laser (FEL). Because a SASE source is a temporally chaotic light, we perform a statistical analysis on the state of polarization using FEL theory and simulations**. We show that by adding a small phase shifter and a short (about 1.3 times the FEL power gain length), 90-degree rotated planar undulator after the main SASE planar undulator, one can obtain circularly polarized light - with over 80% polarization - near the FEL saturation.

* K.-J. Kim, Nucl. Instrum. Methods A 445, 329 (2000). ** Y. Ding and Z. Huang, Phys. Rev. ST Accel. Beams 11, 030702 (2008).

MOCAU04: Retention of Attosecond Pulse Structure in a HHG Seeded FEL Amplifier

Brian W.J. McNeil (USTRAT/SUPA, Glasgow), David James Dunning, Neil Thompson (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire), Brian Sheehy (Sheehy Scientific Consulting, Wading River, New York)

A model is presented which demonstrates that the attosecond pulse structure of an HHG seed may be retained through to saturation in an FEL amplifier. At wavelengths of ~12 nm, a train of attosecond pulses of widths ~300 attoseconds with peak powers in excess of 1GW are predicted from full 3D simulation. Methods for improving these results are discussed.

MOCAU05: A Scheme for Stabilization of Output Power of an X-ray SASE FEL

Gianluca Geloni, Evgeny Saldin, Evgeny Schneidmiller, Mikhail Yurkov (DESY, Hamburg)

Stability of XFEL radiation is naturally linked to stability of the linac RF system through bunch compression, leading to very tight requirements on RF amplitude and phase. We propose a new scheme that allows to relax these requirements by a large factor.

TUAAU Long Wavelength FELs, Tuesday 09:00 - 10:50

TUAAU01: Study of the "Power Gaps" Phenomenon in the Infrared Free-Electron Lasers

Rui Prazeres (LCP/CLIO, ORSAY CEDEX)

A phenomenon of "Power Gaps" is observed in far-infrared FELs using partial waveguiding : the laser power falls down to zero at some particular wavelengths, whatever the beam adjustments are. We show that this effect is related to losses increasing and hole coupling variations due to the waveguide inside the optical cavity. A code including diffraction effects exhibits good agreement with the measurements.

TUAAU02: Superlinear Current Dependence in a Grating-Based Tunable THz Source

Heather L. Andrews, Charles A. Brau, Jonathan D. Jarvis (Vanderbilt University, Nashville, TN), Robert Durant, Christian Guertin, Thomas Lowell, Michael Mross, Aidan O'Donnell (Vermont Photonics, Bellows Falls, VT)

Recent experiments have demonstrated a strongly superlinear dependence of Smith-Purcell radiation on electron-beam current, similar to previous observations*. This results in an increase of output power of up to 1000 times that expected from a linear current dependence, which makes the device a useful source of THz radiation. This behavior strongly suggests superradiant effects caused by bunching of the electron beam on length scales on the order of the optical wavelength**. However, the observed spectrum of emitted radiation remains unchanged over the entire current range. For this to be consistent with a superradiant mechanism, the bunching frequency must be smaller than the spectrometer resolution, which is on the order of 10 GHz. The magnitude of such bunching would increase with increasing current to account for the large power increase. The modulation might be caused by virtual-cathode oscillations or other electron-beam instabilities. To test this mechanism, we can look for peaks in the output radiation spectrum with a higher-resolution spectrometer or measure the GHz modulation on the electron beam directly.

* Urata, Goldstein, Kimmitt, Naumov, Platt and Walsh, PRL 80, 516 (1998) ** Andrews, Boulware, Brau and Jarvis, PRSTAB 8, 110702 (2005)

TUAAU03: Design Study on THz Seeded FEL Using Photocathode RF Gun and Short Period Undulator

Toshiteru Kii, Keisuke Higashimura, Ryota Kinjo, Kai Masuda, Hideaki Ohgaki, Heishun Zen (Kyoto IAE, Kyoto), Ryunosuke Kuroda (AIST, Tsukuba, Ibaraki)

A compact, high-power, narrowband, tunable coherent light source in THz regime will be a quite useful tool for bimolecular science and advanced imaging for security and so on. In this work, we propose a compact seeded THz (frequency: 0.5 - 2 THz) high-gain single pass free electron laser (FEL) amplifier using a multi-bunch photocathode RF gun* and a compact hybrid staggered undulator** and injection-seeded terahertz parametric generator (IS-TPG)***. The proposed configuration has following advantages: 1. The Fourier transform limit of the THz seeded pulse can overcome the disadvantage of broad spectrum of a self-amplified spontaneous emission (SASE). 2. The resonant FEL wavelength can be rapidly controlled by changing solenoid current of the staggered undulator. 3. The single pass configuration without optical cavity mirrors helps to achieve the rapid frequency tuning. In the conference, the detailed design and numerical estimation will be discussed.
* R. Kuroda, et al., International Journal of Modern Physics B, vol. 21, pp.488 (2007) ** S. Sasaki, Proc. of PAC 2005, pp. 982 (2005) *** K. Kawase, et al., APL, vol. 80, pp. 195 (2002)

TUAAU04: Terahertz Band Bragg Reflectors for Free Electron Lasers

Naum Ginzburg, Andrey Malkin, Nikolay Peskov, Alexander Sergeev, Vladislav Zaslavsky (IAP/RAS, Nizhny Novgorod), Reiko Ando, Keiichi Kamada (Kanazawa University, Kanazawa)

Bragg reflectors based on coupling of counter-propagating waves in the periodically corrugated waveguide are widely used in millimeter wave FELs and allow to combine the electron beam transport with effective mode selection. However, the advance to shorter wave bands is limited by the fact that the increase of oversize factor would lead to the increasing of the number of coupled pairs of modes. As a result, the radiation generated by electron beam would represent an uncontrolled mixture of waveguide modes. Besides, with the increase of oversize factor absolute values of reflection coefficients decrease. These problems can be solved in a scheme of Bragg scattering based on coupling of propagating and quasi-cutoff modes. This coupling is realized in a planar Bragg structure side walls of which are corrugated with period close to the wavelength. Coupled waves analysis together with direct 3D numerical simulations demonstrate the operability of novel scheme up to 10-15 wavelengths between resonator plates that may encourage the use of novel Bragg reflectors in terahertz band FEL.

TUAAU05: Design of the Nijmegen High-Resolution FIR-FEL

Rienk Jongma (Radboud University Nijmegen, Nijmegen), Alexander van der Meer (FOM Rijnhuizen, Nieuwegein), Ulf Lehnert, Peter Michel, Rudi Wuensch (FZD, Dresden), Wim J. van der Zande (Institute for Molecules and Materials, Radboud University Nijmegen, Nijmegen), Kees van der Geer (Pulsar Physics, Eindhoven), Peter van der Slot (Twente University, Enschede)

In 2006, the Radboud University in Nijmegen received funding via the Netherlands NWO-BIG program to realize a THz laser system and a 45 T hybrid magnet system. The specifications of the THz FEL system are geared towards material science at high (30-45 T) magnetic fields (saturation spectroscopy and pulse-echo experiments), and applications e.g. in the field of biomolecular spectroscopy. A study performed during the last year demonstrated the feasibility of a THz FEL that will cover the 100-1500 micron spectral range and that operates in either a “spectroscopic mode” providing 100 Watt bandwidth limited pulses of several microsecond (spectral resolution better than 100000/1) or pump-probe pulsed mode providing macropulses with 3 GHz. micropulses. Technical challenges are in the 3 GHz operation of the source, and the narrowband operation. The latter will be obtained by filtering a single mode out of the frequency comb, realized by ensuring full coherence between the micropulses. Coherence is imposed by the stability of the electron beam micro pulses (“spontaneous” coherence) or by the use of an intra-cavity (Fox-Smith) interferometer. We will present details of the chosen design.

TUAAU06: Status of fs-THz Beam line Project of the PAL

Heung-Sik Kang, Sei Jin Kwon, Sung-Duck Jang, Changbum Kim, Hyung-Gyun Kim, Wol Woo Lee, Chong-Do Park, Sung-Ju Park, Yong Jung Park, Jae Hak Seo, Yoon-Gyu Son (PAL, Pohang, Kyungbuk)

A femto-second THz radiation (fs-THz) facility is under construction at the Pohang Accelerator Laboratory (PAL), which is one of the beamline projects of Pohang Light Source (PLS). The facility will use a 60-MeV electron linac, which consists of an S-band photocathode RF gun with 1.6 cell cavity, two S-band accelerating structures, and two chicane-type bunch compressors. To generate intense femto-second THz radiation up to 3 THz, the electron beam with charge of 0.5 nC should be compressed down to below 150 fs. Two kinds of radiator will be prepared for pump-probe experiments for beamline: transition radiation for THz radiation (probe) and Cherenkov radiation for visible radiation (pump). The installation of the accelerator components was completed in April 2008 and the rf conditioning will end by July 2008, and the electron beam test will start in August 2008. In this article, we will present the status of the construction and commissioning of the accelerator as well as the beam dynamics design and its simulation results.

TUBAU X-ray FELs, Tuesday 11:10 - 13:00

TUBAU01: VUV Seeded FEL Experiment at the SCSS Test Accelerator

Toru Hara, Tetsuya Ishikawa, Hideo Kitamura, Tsumoru Shintake, Takashi Tanaka, Makina Yabashi (RIKEN/SPring-8, Hyogo), Bertrand Carré, David Garzella (CEA, Gif-sur-Yvette), Guillaume Lambert (LOA, Palaiseau), Kazuhiko Tahara [on leave], Yoshihito Tanaka (RIKEN Spring-8 Harima, Hyogo), Marie-Emmanuelle Couprie, Marie Labat (SOLEIL, Gif-sur-Yvette), Takanori Tanikawa (Sokendai, Okazaki, Aichi)

Short wavelength seeded FEL has been demonstrated at the SCSS test accelerator using high order harmonics generated in gas of a Ti:Sa laser as an external seed source. After the improvement of the accelerator stability and undulator magnetic errors in 2007, the FEL gain was drastically increased and detailed measurements have been carried out on the spectral characteristics and seeding power level of the seeded FEL. Although the wavelength of the seed is 160 nm for the moment, we have succeeded to observe up to 7th nonlinear harmonics (23 nm) of the 160 nm FEL fundamental including both odd and even harmonics. It leads to the development of a short wavelength seeded FEL. Currently we are working on the modification of the seeding system in order to reach a 50-60 nm range using high order harmonics in the plateau region. By combining a short wavelength seed with nonlinear harmonics, a seeded FEL below 10 nm becomes feasible. In the conference, we will present the recent results of the experiments together with the technical issues of the seeded FEL, such as temporal jitter between laser pulses and electron bunches.

TUBAU02: An X-Ray Free Electron Laser Oscillator with an Ultra-low Emittance Electron Beams

Kwang-Je Kim (ANL, Argonne, Illinois)

A free-electron laser for photon energies 5-20 keV is feasible in an oscillator configuration using Bragg mirrors driven by low-intensity, ultra-low emittance electron bunches considered for a multi-GeV energy recovery linac. Several configurations for optical cavities are possible, including a tunable one with four crystals. We discuss issues of the evolution of the transverse and longitudinal mode profiles, stability requirements, and options for electron beam injector design. The FEL will produce coherent x-ray pulses of 10^9 photons at a repetition rate starting from a few MHz to perhaps 100 MHz. Although the pulse energy of the x-ray FEL oscillator is smaller by three orders of magnitudes compared to that of a self-amplified spontaneous emission (SASE) from a high-gain FEL, the peak spectral brightnesss is comparable due to an extremely narrow bandwidth, about a few meV. The average brightness is higher by several orders of magnitudes than SASE due to the high bunch repetition rate. An x-ray FEL oscillator will offer breakthrough scientific opportunities, for example, imaging, nuclear resonance scattering, determination of Fermi surfaces in bulk materials, etc.

This work is supported by U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under contract No. DE-AC02-06CH11357.

TUBAU03: FEL Wave-front Measurements in the Soft X-ray Region at FLASH

Elke Plönjes, Pavle Juranic, Barbara Keitel, Marion Kuhlmann, Kai I. Tiedtke (DESY, Hamburg), Guillaume Dovillaire (Imagine Optic, Orsay), Bernhard Floeter, Klaus Mann, Bernd Schaefer (LLG, Goettingen)

FEL wave-fronts in the soft X-ray region were measured for individual pulses at FLASH, the Free-Electron Laser in Hamburg, using a Hartmann sensor. The Hartmann principle is based on an array of pin holes, which divides an incoming photon beam into a large number of sub-rays monitored in intensity and position on a CCD camera. Thus, a Hartmann type sensor is largely independent of the photon wavelength. The FEL wave-front is identified by comparison of the local slopes of the incident wave-front to a perfect spherical wave generated by a pinhole. Ray tracing in upstream direction based on the measured wave-front allows determination of focal spots in size and position. The wave-front sensor is used for alignment of FLASH beam lines, in particular the focusing optics, and it proved a valuable tool to observe the FEL beam quality as well as performance of optical elements, such as metal foil filters or a gas attenuator.

TUBAU04: Generation of Sub-fsec, High Brightness Electron Beams for Single Spike SASE FEL Operation

James Rosenzweig, Michael P. Dunning, Atsushi Fukasawa, Erik Hemsing, Gabriel Marcus, Pietro Musumeci, Brendan Donald O'Shea, Claudio Pellegrini, Sven Reiche (UCLA, Los Angeles, California), Luca Giannessi, Concetta Ronsivalle (ENEA C.R. Frascati, Frascati (Roma)), Vittoria Petrillo (INFN-Milano, Milano), Manuela Boscolo, Massimo Ferrario, Luigi Palumbo, Bruno Spataro, Cristina Vaccarezza (INFN/LNF, Frascati (Roma)), Luigi Faillace, Agostino Marinelli (Rome University La Sapienza, Roma; UCLA, Los Angeles, California)

We present here the theory and computational modeling of beams in a new regime, where <1 pC beams are strongly velocity bunched at low energy, and then compressed at several GeV to less than a fsec. This regime of operation produces beams with thermally dominated transverse emittance, and mitigates many problems associated with the nC-level operation. These problems include CSR induced instability and intra-undulator wakes. The resulting beams have extremely high brightness, enabling very high gain, efficiency, and single spike operation. We present the scaling laws governing this regime, and the detailed example of the proposed SPARX FEL design.

U.S. DoE High Energy Physics contract DE-FG03-92ER40693, U.S. DoE Basic Energy Sciences contract DE-FG02-07ER46272 and Office of Naval Research contract ONR N00014-06-1-0925.

TUBAU05: Design of a 0.1 nm Free Electron Laser at Pohang Accelerator Laboratory

Moohyun Yoon (POSTECH, Pohang, Kyungbuk), Eun-San Kim (Kyungpook National University, Daegu), Dong Eon Kim, Sung-Ju Park (PAL, Pohang, Kyungbuk)

Since January 2008, design study of a free-electron laser has been in progress at Pohang Accelerator Laboratory (PAL) aiming at producing hard X-ray of 0.1 nm wavelength. Electron energy of 10 GeV has been chosen to fit the facility inside the existing PAL site. In-vacuum undulators of 120 meter long (including breaks) with 5.3 mm gap combined with a 800 meter-long conventional S-band rf linac are expected to generate intense x-ray pulses of 5 GW peak power at the saturation length of 100 m. The start-to-end simulation results support initial design parameters based on the theory. Effect of undulator wakefields are examined and 30% reduction in power is anticipated.

TUBAU06: Construction Status of XFEL/SPring-8

Yuji Otake (RIKEN/SPring-8, Hyogo)

At RIKEN, the XFEL project aimed at generating a 0.1 nm X ray laser at SPring-8 is in progress. The key concepts of our XFEL machine is a small emittance of 0.6 pmmmrad achieved with a CeB6 thermionic electron gun, short length acceleration realized with C-band cavities with 35 MV/m, and a short saturation length of SASE achieved by the small emittance and a short period and strong magnetic field of in-vacuum undulators(Kmax=2.2). The beam optics design with a bunch compression scheme by using velocity bunching in low-b and magnetic bunching in high-b was finished. Validity of the compactness concepts and design has been assessed in the SCSS test accelerator with SASE saturated at 60 nm, 30 uJ/pulse, and 11 %(1 sigma) fluctuation. By using the accelerator, stability of developed elements, such as a klystron high-voltage power supply with a 10 ppm(rms) variation at a 45 kV PFN charging voltage, was verified to satisfy an e- beam energy variation of 10-4 demanded for XFEL. The XFEL machine using an 8 GeV linac and 18 in-vacuum undulators is now under construction. The developed elements are now under a mass production stage. This report presents construction status of XFEL/SPring-8.

TUPPH Tuesday Poster Session, Tuesday 14:00 - 15:50

TUPPH001: Comparison of High Gradient Achievement for Different Materials in DC and Pulsed DC Mode

Frederic Le Pimpec, Romain Ganter, Christopher Gough, Christoph P. Hauri, Martin Paraliev (PSI, Villigen)

For the PSI XFEL project, an advanced high gradient low emission gun is under development. Reliable operation with an electric field preferably above 125 MV/m at a 4 mm gap, and in presence of an UV laser beam, has to be achieved in a diode configuration in order to minimize the emittance dilution due to space charge effects. In the first phase, a DC breakdown test stand was used to test different materials with different preparation methods at voltages up to 100 kV. In addition high gradient stability tests were also carried out over days in order to prove reliable spark-free operation with a minimum dark current. In the second phase, electrodes with selected materials were installed in the 250 ns FWHM, 500kV electron gun and tested for high gradient breakdown and for quantum efficiency using a 266 nm UV laser.

TUPPH002: The Photonic FEL: Toward a handheld THz FEL

Peter van der Slot, Klaus Boller (Mesa+, Enschede)

Low energy, slow wave, electron beam based radiation devices, like travelling wave tubes and Cerenkov free-electron lasers, have the disadvantage that the gain seriously degrades when the operating frequency is upscaled from microwave to teraHertz frequencies. Here we propose to obtain a successful scaling with what may be called a photonic free-electron laser (pFEL). In our approach, a photonic structure serves for phase matching the radiation field to a set of copropagating electron beams. This follows an earlier suggestion based on distributed feedback*. The photonic structure additionally provides transverse coupling between the individual electron beams, such that phase locking through the interaction with the radiation field leads to the generation of transversly coherent radiation. This phase locking mechanism allows power scaling by extending the number of parallel beams propagating through the structure. We expect to be able to produce Watt-level output at THz frequencies from a handheld device and will present the basic ideas behind this concept.

* V.G. Baryshevsky, K.G. Batrakov. Nucl. Instr. and Meth. A507, 35 (2003).

This research is supported by the Dutch Technology Foundation STW, applied science division of NWO and the Technology Program of the Ministry of Economic Affairs (OCW).

TUPPH003: Tolerance Studies on the High-Harmonic Laser Seeding at Flash

Velizar Miltchev, Armin Azima, Joern Boedewadt, Hossein Delsim-Hashemi, Markus Drescher, Shaukat Khan, Theophilos Maltezopoulos, Jörg Rossbach, Roxana Tarkeshian, Marek Wieland (Uni HH, Hamburg), Stefan Düsterer, Josef Feldhaus, Tim Laarmann, Holger Schlarb (DESY, Hamburg)

Currently, the Free-electron-LASer at Hamburg (FLASH) operates in the Self-Amplified Spontaneous Emission (SASE) mode, delivering to users photon beams with wavelengths between 6.5 nm and 40 nm. In order to improve the temporal coherence of the generated radiation, it is planned to externally seed FLASH with higher harmonics of an optical laser. The project aims at seeding in the 30-13 nm range with stability suitable for user operation. In this contribution the performance of the seeded FEL is studied in simulations. Emphasis is placed on the tolerances of the most critical parameters such as transverse offset and angle between the electron beam and the external seed, timing jitter, energy of the seed pulse and the influence of the electron optics.

Work supported by BMBF contract No. 05 ES7GU1

TUPPH004: Study of Controllable Polarization of a SASE FEL using a crossed-planar Undulator

Bart Faatz, Yuhui Li, Joachim Pflueger, Evgeny Saldin, Evgeny Schneidmiller, Mikhail Yurkov (DESY, Hamburg)

Several methods to produce variable polarization have been under discussion for the European XFEL facility. One such method is to utilize a crossed-undulator scheme. In this paper, the polarization of X-ray radiation for longer wavelengths (0.4 nm and longer) of the XFEL is investigated. The degree of polarization and the Stokes parameters are calculated for different configurations. A first attempt at optimization of the configuration for XFEL parameters is presented.

TUPPH005: A Concept of Ultra-low Emittance Injector for Future X-Ray FEL Oscillator

Kwang-Je Kim, Peter Ostroumov (ANL, Argonne, Illinois)

An XFELO proposed recently [K.-J. Kim,et al.,Phys.Rev.Letters, in print] requires a continuous sequence of electron bunches with ultra-low transverse emittance less than 0.1 mm-mr, bunch charge of 40 pC, rms energy spread of 1.4 MeV, repeating at a rate between 1 MHz to 100 MHz. The bunches are to be compressed to an rms lengths less than 2 ps at the final energy of 7 GeV. A Cornell group is developing an L-band injector consisting of a 750 keV DC gun with a photocathode and emittance compensation section[I.V. Bazarov and C.K. Sinclair, Phys. Rev. STAB, 8, 034202(2005)]. Another option is to start from a thermionic gun*. We discuss a concept for an injector satisfying the requirements of an XFELO by using a small diameter thermionic cathode to extract low emittance beam, providing 500 kV extracting voltage using low frequency ~50 MHz room temperature RF cavity**, using chicane and slits to form a short ~ 1 nsec bunch, using a pre-buncher an booster buncher to form low longitudinal emittance of the bunched beam, accelerating to ~50 MeV using higher harmonic cavities, and using an RF cosine-wave chopper to form any required bunch repetition rate between 1 MHz and 50 MHz.

* K. Togawa,et al.,Phys. Rev. STAB 10, 020703(2007) ** J.W. Staples, et al.,Proc. PAC 2007

The research at ANL is supported by the U.S. DOE under Contract No. DE-AC02-06CH11357 and at NIU under DOE Contract No. DE-AC02-76CH0030, respectively

TUPPH006: Undulator System of the Seeded HGHG-FEL at MAX-lab

Johannes Bahrdt, Winfried Frentrup, Andreas Gaupp, Karsten Holldack, Michael Scheer (BESSY GmbH, Berlin), Jochen Kuhnhenn (FhG, Euskirchen), Filip Lindau, Sara Thorin, Sverker Werin (MAX-lab, Lund)

Within the EUROFEL Design Study a one stage seeded HGHG FEL has been set up at the MAX-lab injection linac. BESSY has built the undulator system consisting of a modulator, a radiator and an electromagnetic chicane. BESSY also provided various diagnostic tools including Cherenkov glass fibres, powermeter glass fibres and THz detectors. After installation the undulators have been measured in the final position with a pulsed wire and residual field integrals have been compensated with air coils. During first injections with the laser driven rf-gun the Cherenkov system has delivered detailed spatial information on the losses of electrons within the beamline. The powermeter system which provides information on absolute doses deposited in the permanent magnets has collected data over half a year and the high sensitivity and low drift of the system has been demonstrated. Two types of THz detectors have been used close to the electron beam dump giving information on the electron bunch compression and on the seed laser induced beam energy modulation. We will report on the measurements taken with the diagnostic tools mentioned above.

TUPPH008: Experimental Approaches of Emittance Dilution Induced by Misalignments in a Photoinjector

Jangho Park, Marcus Babzien, Karl Kusche, Vitaly Yakimenko (BNL, Upton, Long Island, New York)

One of the main issues in the generation of a high-brightness electron beam is the preservation of beam emittance. Here we discuss one of possible source of emittance dilution, the rf kick, due to misalignment. The emittance of a high-brightness electron beam from a photoinjector is affected by the status of alignments due to deflection force by the accelerating field. The misaligned beam with the accelerating field axis experiences emittance growth by an electron-beam defection that is proportional to the electric field strength in the cavity. Misalignments of beam axis induce different deflections on beam particles with different energy, causing emittance dilution of the beam. In order to reduce the emittance dilution the photoinjector is required well alignments of all components. We show significant emittance growth as misalignments function against the electron beam-axis to accelerating column. We also measured the emittance change as the function of the laser position on the cathode.

TUPPH009: Impact of the Electron Beam Steering in the Undulators and on the FERMI FEL Performance

Simone Spampinati, Simone Di Mitri, Bruno Diviacco (ELETTRA, Basovizza, Trieste)

The extension of Free Electron Laser (FEL) operations to VUV and X-ray range places stringent requirements on the straightness of the electron beam trajectory along the undulator chain. The misalignment of magnetic active elements such as quadrupoles and undulators has a great impact on the beam trajectory. The FERMI FEL project foresees the adoption of the Beam Based Alignment (BBA) technique with open undulators to steer the electron beam on a straight path along the whole undulator chain. Quadrupole magnets will be centered on desired trajectory and steerer will be used to mantain that trajectory when quadrupol strengths are changed for different quadrupolo polarization. Steering elements at the undulator edges counteract the steering action of strong focusing of the apple type devices restoring the correct trajectory between the undulators. This article analyzes the effect of this trajectory distortion on the FERMI FEL performance.

TUPPH010: Development of an S-band RF Deflector at IHEP

Jianping Dai (IHEP, Beijing)

Transverse RF deflectors are widely used for the measurements of ultra-short bunch length and other slice parameters. This paper presents the design and fabrication issues of an S-band LOLA-type RF deflector developed at IHEP.

Work supported by Major State Research Development Program (2002CB713606)

TUPPH011: First Results Of Optical Diffraction Radiation Measurements at CE-BAF

Pavel Evtushenko, Arne Freyberger (Jefferson Lab, Newport News, Virginia), Chuyu Liu (CASA, Newport News), Alex Lumpkin (Fermilab, Batavia, Illinois)

Optical diffraction radiation (ODR) is a promising technique, which could be used for non interceptive beam size measurements at future light sources. An ODR diagnostic station was designed and installed on a CEBAF transfer beam line. The purpose of the setup is to evaluate experimentally the applicability range for an ODR based non interceptive beam size monitor an to collect data to benchmark numerical modeling of the ODR. An extensive set of measurements were made at the electron beam energy of 4.5 GeV. The ODR measurements were made for both pulsed and CW electron beam of up to 80 uA. The wavelength dependence and polarization components of the ODR were studied using a set of insertable bandpass filters and polarizers. The typical transverse beam size during the measurements was ~150 microns. Complete ODR data, wavelength and polarization, were recorded for different beam sizes and intensities. The beam size was also measured with an optical transition radiation (OTR) as well as wire scanner located next to the ODR station. In this contribution we describe the experimental setup and present first results of the measurements with the comparison to the numerical simulations.

Authored by Jefferson Science Associates, LLC under U.S. DOE Contract No. DE-AC05-06OR23177.

TUPPH012: Single spike experiments with the SPARC SASE FEL

Massimo Ferrario, Manuela Boscolo, Luigi Palumbo (INFN/LNF, Frascati (Roma)), Luca Giannessi, Concetta Ronsivalle (ENEA C.R. Frascati, Frascati (Roma)), Alberto Bacci, Ilario Boscolo, Simone Cialdi, Vittoria Petrillo, Luca Serafini (INFN-Milano, Milano), Maurizio Serluca (INFN-Roma, Roma), Gerard Andonian, Erik Hemsing, Gabriel Marcus, Sven Reiche, James Rosenzweig (UCLA, Los Angeles, California)

We describe in this paper a possible experiment with the existing SPARC photoinjector to test the generation of sub-picosecond high brightness electron bunches able to produce single spike radiation pulses at 500 nm with the SPARC self-amplified spontaneous emission free-electron laser (SASE-FEL). The main purpose of the experiment will be the production of short electron bunches as long as few SASE cooperation lengths and to validate scaling laws to foresee operation at shorter wavelength in the future operation with SPARX. We present in this paper start to end simulations of the expected FEL performance and discuss the layout of the machine, including the diagnostics to measure the FEL pulse length and other aspects of FEL performance. The experience gained from this experiment, will help in the configuration of the VUV and X-ray FEL SPARX to obtain FEL pulses below 10 fs.

TUPPH013: Initial RF Measurements of the CW Normal-conducting RF Injector

Frank L. Krawczyk, Gerald Owen Bolme, Felix A. Martinez, Nathan A. Moody, Dinh C. Nguyen, Karen Ann Young (LANL, Los Alamos, New Mexico), Lloyd Martin Young (AES, Medford, NY)

The 2.5-cell, normal conducting radio-frequency (NCRF) injector has been fabricated and installed at Los Alamos. We present initial results of low-power RF measurements (cavity Q, cavity field map, coupling beta, etc.) of the NCRF injector. The measured cavity Q and relative fields are found to be in good agreement with the design calculations and earlier measurements of Glidcop properties. However, the coupling beta of the ridge-loaded waveguides is found to be significantly higher than the design point. The impact of these low-power measurement results on the planned high-power RF and electron beam tests will be discussed.

This work is supported by the Office of Naval Research and the High-Energy Laser Joint Technology Office.

TUPPH014: Transverse Emittance of Diamond Field-Emitter Arrays

Jonathan D. Jarvis, Heather L. Andrews, Charles A. Brau (Vanderbilt University, Nashville, TN), Bo Kyoung Choi, Jimmy Davidson, Weng Kang, Supil Raina, Yong Mui Wong (Vanderbilt University, Nashville, Tennessee)

We present progress in transverse-emittance measurements of ungated diamond field-emitter arrays. Fine-pitch arrays are conditioned to provide uniform emission prior to emittance testing. The testing will be performed using a pepperpot technique with microlithographed silicon aperture arrays and a ZnO phosphor screen. Results will be compared to simulations performed in POISSON/GPT.

TUPPH015: Construction Of Short Period Apple II Type Undulators at SOLEIL

Fabien Briquez, Oleg Chubar, Marie-Emmanuelle Couprie, Tarik El Ajjouri, Charles Agbehonou Kitegi, Fabrice Marteau, Arnaud Mary, Keihan Tavakoli, José Vétéran (SOLEIL, Gif-sur-Yvette)

We present here the conception, construction and magnetic measurements of APPLE II type undulators of period 44 mm and 36 mm at SOLEIL. Such short period undulators are difficult to design and construct because of the little dimensions of the magnets, leading to small support structures which are more easily bent by the magnetic forces. The design of the support structures consists in individual aluminium holders grouped in assemblies of three or five magnets called modules and fixed on the girders using dovetails. Special extremity modules are designed to reduce field integrals of the undulator. The magnets are independently measured using Helmoltz coils and sorted in modules. Then the modules are measured using Hall probes and bodyless coil, and sorted to assemble the undulator. After assembling, a shimming is done to correct phase errors and field integrals, and a final correction of the integrals is made by little extremity magnets called "Magic Fingers". For each step of sorting, we use the home-made IDBuilder software, based on genetic algorithms. Short period undulators are of interest for the ARC-EN-CIEL project, which considers APPLE-II with a 30 mm period.

TUPPH016: Fabrication of Diamond Field-Emitter-Array Cathodes for Free-Electron Lasers

Jonathan D. Jarvis, Heather L. Andrews, Charles A. Brau (Vanderbilt University, Nashville, TN), Bo Kyoung Choi, Jimmy Davidson, Weng Kang, Supil Raina, Yong Mui Wong (Vanderbilt University, Nashville, Tennessee)

Field-emitter arrays (FEAs) have several advantages as cathodes for free-electron lasers (FELs): they are rugged, require no laser driver, and generate little heat. We have developed two methods to fabricate diamond FEAs for FEL applications. In the first method, pyramids are formed on a Si substrate and sharpened by microlithography and then coated with CVD nanodiamond. The advantages of this approach are a rigid, planar Si substrate, and microelectronic type fabrication. Typically, tip radii on the order of hundreds of nanometers are formed on 20-μm pyramids. In the second method, all-diamond pyramids are formed by a mold-transfer process in which they become sharpened from an oxide layer in the mold process. The diamond array is then brazed to a Mo substrate and the Si mold removed. The advantage of this process is that the tips are sharper, with tip radii smaller than 10 nm formed on 10-μm pyramids. The fabrication techniques and the performance of these cathodes will be discussed and compared.

TUPPH017: In Vacuum Undulator System for PAL-FEL

Dong Eon Kim, Hong Sik Han, Young-Gyu Jung, Chang-Kyun Kim, Hong-Gi Lee, Sang Hoon Nam, Chong-Do Park, Ki-Hyeon Park, Hyung Suck Suh (PAL, Pohang, Kyungbuk), Moohyun Yoon (POSTECH, Pohang, Kyungbuk)

Pohang Accelerator Laboratory (PAL) is planning to develop a 0.1 nm SASE based FEL as a next generation light source. It will be based on the 10 GeV S-band linac with In Vacuum Undulator system. The proposed in vacuum undulator has 22.3 mm magnetic period with 5.0 mm vertical clearance aperture. The magnetic length will be 4014 mm with breaks between undulators for diagnostic and focusing elements. The mechanical and magnetic requirements of the IVUN system are very challenging. In this report, the design issues related to the development of the IVUN with preliminary magnetic design will be presented.

This work is supported by Minister of Education, Science and Technology and POSCO.

TUPPH018: Longitudinal Diagnostic for Single-Spike SASE FEL Operation

Gabriel Marcus, Gerard Andonian, Sven Reiche, James Rosenzweig (UCLA, Los Angeles, California), Luca Giannessi (ENEA C.R. Frascati, Frascati (Roma)), Massimo Ferrario, Luigi Palumbo (INFN/LNF, Frascati (Roma))

The possibility of ultra-short beam, very low charge, short wavelength FELs at SPARC has been recently investigated. This paper explores the development of a longitudinal diagnostic that will provide the capability to characterize the short wavelength radiation based on the Frequency Resolved Optical Gating (FROG) technique. The paper includes studies of pulses simulated for the SPARC case using GENESIS and reconstructed using the FROG algorithm as well as proposed experimental layouts for the device.

TUPPH019: Laser Pulse Shaping for Generation of Low-Emittance Electron-Beam

Changbum Kim (PAL, Pohang, Kyungbuk)

A photocathode RF gun can provides a high-charge short-bunch-length electron beam, so that it can be used for an injector of the 4th generation light source. However, owing to the high-charge in short-bunch-length, generated electron beam experiences severe space-charge effect in the beginning of acceleration and the emittance becomes bad rapidly. To reduce this space-charge effect, we made a preliminary study of pulse shaping technique. First, Parmela simulations are performed to check the beam quality improvement when the plat-top profile laser is used. Given geometry of the photocathode RF gun in the Pohang Accelerator Laboratory, Parmela simulations show 40% decrease of the emittance in electron beams. Next, by stacking four Gaussian pulses to the longitudinal direction, we tried a generation of a plat-top profile laser, and its profile is checked with a cross-correlator.

TUPPH020: Self-Heating Beams: Removing the Laser Heater

James Rosenzweig, Pietro Musumeci (UCLA, Los Angeles, California)

We discuss mechanisms, using only the space-charge of the beam itself, for inducing a level of slice energy spread sufficient to stabilize high brightness beams needed in X-ray FELs against CSR microbunching instability. These include strong velocity bunching as well as the expansion of very short beams in the blowout regime of operation. Theoretical models are compared with detailed simulations.

U.S. DoE High Energy Physics contract DE-FG03-92ER40693, U.S. DoE Basic Energy Science contract DOE DE-FG02-07ER46272 and Office of Naval Research contract ONR N00014-06-1-0925.

TUPPH021: An Ultra-high Repetition Rate S-band RF Gun

Luigi Faillace, Atsushi Fukasawa, Brendan Donald O'Shea, James Rosenzweig (UCLA, Los Angeles, California), Bruno Spataro (INFN/LNF, Frascati (Roma)), Luigi Palumbo (INFN/LNF, Frascati (Roma); Rome University La Sapienza, Roma), Pedro Frigola (RadiaBeam, Marina del Rey)

We present here a preliminary design, including RF modeling, cooling, and thermal stress and frequency detuning, of an S-band RF gun capable of running near 500 Hz, for application to FEL and inverse Compton scattering sources. The RF design philosophy incorporates many elements in common with the LCLS gun, but the approach to managing cooling and mechanical stress diverges significantly. We examine the new proprietary approach of RadiaBeam Technologies for fabricating copper structures with intricate internal cooling geometries. We find that this approach may enable very high repetition rate, well in excess of the nominal project this design is directed for, the SPARX FEL.

U.S DoE High Energy Physics contract DE-FG03-92ER40693, U.S. DoE Basic Energy Science contract DOE DE-FG02-07ER46272 and Office of Naval Research contract ONR N00014-06-1-0925.

TUPPH022: Measurements of an FEL Oscillator Sensitivity to the Electron Beam Phase Noise

Pavel Evtushenko (Jefferson Lab, Newport News, Virginia)

A design of an experiment aimed to measure sensitivity of an FEL oscillator is discussed. Initial tests of required instrumentation and measurements techniques were made.

TUPPH023: Quasicrystalline Beam Formation in RF Photoinjectors

James Rosenzweig, Michael P. Dunning, Erik Hemsing, Gabriel Marcus, Pietro Musumeci (UCLA, Los Angeles, California), Massimo Ferrario (INFN/LNF, Frascati (Roma)), Agostino Marinelli (Rome University La Sapienza, Roma; UCLA, Los Angeles, California)

The recent observation of coherent optical transition radiation from the beam after the injector line at the LCLS has raised serious questions concerning the present model of beam dynamics in RF photoinjectors. We present here an analysis of what we term quasicrystalline beam formation. In this scenario, the relatively low longitudinal temperature, in combination with strong acceleration and, finally, temporal rearrangement due to bending, allows the longitudinal beam dimension to become more regular, on the microscopic scale of optical wavelengths, than expected from equilibrium statistical properties. This beam distribution then may then display a strong degree of coherence in its optical transition radiation output. We discuss further experimental investigations of this phenomenon.

Department of Energy Basic Energy Science contract DOE DE-FG02-07ER46272, and Office of Naval Research contract ONR N00014-06-1-0925.

TUPPH024: Review of Manipulation Technology on 3D-Pulse-Shape & Polarization of Laser on the Cathode for the Conventional Photocathode RF Gun & the Future Z-polarization Schottky Emission Gun

Hiromitsu Tomizawa (JASRI/SPring-8, Hyogo-ken)

I developed an adaptive 3D shaping UV-pulse laser system for an RF gun. To suppress emittance growth due to space charge effect, the 3D shape of the laser pulse is optimized as spatially top-hat and temporally a smooth square macro pulse stacked with chirped micro pulses. I applied a deformable mirror that automatically shapes the spatial profile with a feedback routine, based on a genetic algorithm, and a pulse stacker consisting of three birefringence crystal rods for temporal shaping at the same time. The homogeneity of temporal stacking is automatically maximized with a feedback routine between AOPDF UV-pulse measurement and DAZZLER as a micro chirped pulse shaper. I proposed a hollow normal incidence as the third incidence method to suppress asymmetrical wake field effect. I developed the optical elements for a new hollow laser incidence with an axicon final focusing. In 2006, I propose a laser-induced Schottky-effect-gated photocathode gun using Z-polarization of the laser on the cathode. I am applying the hollow laser incidence after a radial polarizer with a convex lens focusing. This concept of laser-induced Schottky emission can be applied to photocathode RF and DC guns.

TUPPH025: Compressor Studies for High Gain FELs at the BNL ATF

Gerard Andonian, Michael P. Dunning, Erik Hemsing, Gabriel Marcus, Sven Reiche, James Rosenzweig (UCLA, Los Angeles, California), Marcus Babzien, Karl Kusche, Jangho Park, Vitaly Yakimenko (BNL, Upton, Long Island, New York), Alex Murokh (RadiaBeam, Marina del Rey)

A dedicated chicane compressor has been built for use with the 4-meter VISA undulator at the Accelerator Test Facility at BNL. The compressor has been commissioned and analysis shows that sub-ps pulse lengths are attainable. A recent experiment using Coherent Transition Radiation (CTR) interferometric methods was conducted to determine the dependence of observed bunch length versus transverse beam size for compressed beams. The results of this study are presented here.

TUPPH026: Emittance Measurement of A Low Emittance DC Gun for Smith-Purcell Backward Wave Oscillator FEL

Kittipong Kasamsook, Kazushi Akiyama [on leave], Hiroyuki Hama, Fujio Hinode, Masayuki Kawai, Ken-ichi Nanbu, Mafuyu Yasuda (Tohoku University, Sendai)

An electron DC gun capable for producing very low emittance beam is under developed at Laboratory of Nuclear Science, Tohoku University. The DC gun employs a high voltage of 50 kV to extract electrons, which is suitable to drive Smith-Purcell backward wave oscillator free electron laser (BWO FEL). From numerical simulation usings a 3-D finite deference time domain (FDTD) method, it has been found the BWO FEL oscillation at the terahertz wavelength region maybe achieved by using the electron beam with a normalized emittance around 1 mmmrad. A double-slit method has been employed to measure the phase space distribution of the beam. By applying special bias voltage between the cathode and the wehnelt, the equi-potential surface around the cathode, which is very crucial for emittance growth, is able to be manipulated. We have observed the change of the phase space distribution due to the bias voltage. Applying an appropriate bias voltage, the normalized emittance has been deduced to be less than 1 mmmrad. The paper will present the emittance measurements of the beam from the DC gun and the status of the terahertz BWO FEL project as well.

TUPPH027: Measurements of Coherent Synchrotron Radiation and its Impact on the LCLS Electron Beam

Zhirong Huang, Karl Leopold Freitag Bane, Franz-Josef Decker, Yuantao Ding, David Dowell, Paul Emma, Josef Frisch, Richard Iverson, Cecile Limborg-Deprey, Henrik Loos, Heinz-Dieter Nuhn, Gennady Stupakov, James Leslie Turner, James Welch, Juhao Wu (SLAC, Menlo Park, California), Daniel Ratner (Stanford University, Stanford, Califormia)

The Linac Coherent Light Source (LCLS) is a SASE x-ray Free-Electron Laser (FEL) project presently under construction at SLAC. Two separate magnetic dipole chicanes are used in the SLAC linac to compress the electron bunch length in stages, in order to reach the high peak current required for an x-ray FEL. In the bunch compressors, coherent synchrotron radiation (CSR) can be emitted-induced either by a short electron bunch, or by any longitudinal density modulation that may be on the bunch. We present measurements, simulations, and analysis of 1) the CSR-induced energy loss, 2) the related transverse emittance growth, and 3) the microbunching-induced CSR directly observed at optical wavelengths.

TUPPH028: Uniformity Conditioning of Diamond Field-Emitter Arrays

Jonathan D. Jarvis, Heather L. Andrews, Charles A. Brau (Vanderbilt University, Nashville, TN), Bo Kyoung Choi, Jimmy Davidson, Weng Kang, Supil Raina, Yong Mui Wong (Vanderbilt University, Nashville, Tennessee)

We present results in the conditioning of diamond field-emitter arrays towards uniform emission. Post-fabrication conditioning procedures consisting of thermal annealing, gas exposure, and high field/emission operation have been examined. A high degree of emission uniformity was successfully achieved by thermal-assisted field evaporation of the diamond nanotips. This uniform emission was stable up to currents of 15 microamps per tip, at which point the phosphor anode began to degrade from the high input power density.

TUPPH029: Space Charge Effect for Short Electron Bunches in an Alpha Magnet

Hiroyuki Hama, Fujio Hinode, Kittipong Kasamsook, Masayuki Kawai, Ken-ichi Nanbu, Mafuyu Yasuda (Tohoku University, Sendai), Toshiya Muto (KEK, Ibaraki)

To develop a coherent Terahertz (THz) light source, a project for producing very short electron bunch has been progressed at Laboratory of Nuclear Science, Tohoku University. We have developed an independently-tunable-cells (ITC) RF gun consisted with two cavities and thermionic cathode in order to produce bunch length of several tens femto-second. Though the alpha magnet has been often used for the bunch compressor, beam dynamics including the space charge effect has been not well studied. To evaluate the both longitudinal and transverse phase space of the short electron bunch, we have developed a simulation code employing a 3-D finite deference time domain (FDTD) method for solving the Maxwell's equations. From the simulations it was found out that the field strength of the alpha magnet should be considerably increased as increasing the bunch charge to obtain the shortest bunch length. The transverse emittance is also significantly growing up. The paper will describe characteristics of the beam quality after passing through the alpha magnet.

TUPPH030: Longitudinal and Transverse Self-forces in Relativistic Line-charge Beam

Gennady Stupakov (SLAC, Menlo Park, California)

An attempt to compute self-fields of a beam with negligible transverse dimensions (line-charge beam) leads to logarithmically diverging result. On the other hand, the well known expression* for the steady state coherent synchrotron radiation (CSR) wake does not involve the transverse beam size and is applicable to beams with infinitely thin transverse dimensions. In this work, we formulate the general problem of calculation of longitudinal and transverse forces in a relativistic beam in such a way that, in its essential part, does not involve the transverse dimensions of the bunch, and can be computed using a line-charge model for the beam. Our approach covers the case of short magnets and beams with energy chirp. We also show that there is a potential part of the longitudinal force (neglected in most previous considerations) that is responsible for the so called compression work. Our approach can be useful for quick calculation of the CSR effects in bunch compressors.
* Ya. S. Derbenev et al. “Microbunch Radiative Tail-Head Interaction”, DESY FEL Report TESLA-FEL 95-05, 1995; J. Murphy et al. Part. Accel., vol. 57, 9 (1997).

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TUPPH032: LCLS Undulator Magnet Temperature Control

James Welch, Heinz-Dieter Nuhn, Javier A. Sevilla (SLAC, Menlo Park, California)

Undulator magnets for the LCLS need to be maintained at a very stable and accurate temperature in order to stay within the tolerance required for the FEL. At the LCLS the temperature of the undulator magnets is mainly determined by the temperature of the surrounding air. Furthermore, the climate control system which controls the temperature of the air must never accidentally go out of a safe operating range of +/- 2.5 C or the magnets may lose calibration and have to be removed and remeasured. This was one motivation for the sighting the Undulator Hall underground in a tunnel where the thermal inertia of the surrounding earth provides stability. In this paper we describe the technical solution adapted by the LCLS for controlling the air temperature in the Undulator Hall and its initial performance. We also discuss thermal issues of heat balance and steady state and transient temperature behavior of the undulators system and the surrounding earth.

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TUPPH033: LCLS Chicane Dipole Field Quality and Beam Measurements

James Welch, Scott DeBarger, Paul Emma, Nanyang Li, Juhao Wu (SLAC, Menlo Park, California)

FELs typically use special arrangements of dipole magnets called chicanes to create an energy dependent path length needed for bunch compression. Ideally a chicane takes a beam with a linear correlation of energy and longitudinal position, and forms a compressed bunch with the same energy spread. To a very high degree the chicane should not generate residual dispersion which can convert energy spread into emittance and degrade the FEL. Linear dispersion is correctable but it is impractical to correct non-linear dispersion or non-linear focussing effects. Thus there are stringent demands on dipole field quality. The first LCLS chicane was initially found to generate substantial emittance growth. We made beam-based measurements of the net integrated magnetic field and determined that the dipole field quality was not adequate. Subsequently we modified two of the four dipoles to improve their good-field region. When reinstalled we found the chicane generated very little emittance growth. Beam-based measurement of the integrated field confirmed the improved dipole field quality.

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

TUPPH034: Toward Energy-Spread Measurements of Diamond Field-Emitter Arrays

Jonathan D. Jarvis, Heather L. Andrews, Charles A. Brau, Chris L. Stewart (Vanderbilt University, Nashville, TN), Bo Kyoung Choi, Jimmy Davidson, Weng Kang, Supil Raina, Yong Mui Wong (Vanderbilt University, Nashville, Tennessee)

A high-resolution retardation energy analyzer is being developed to examine the energy spread of electron beams from diamond field-emitter arrays. Analyzer design was guided by previous work at UMER*, and simulations performed in SIMION. The anaylzer incorporates a cylindrical focusing electrode which, when properly tuned, gives millivolt resolution for multi-kilovolt beams. The analyzer is integrated into a low-energy cathode teststand, which allows arbitrary adjustment of the anode-cathode spacing and planarity during operation.

* Y. Cui, Y. Zou, A. Valfells, M. Reiser, M. Walter, I. Haber, R. A. Kishek, S. Bernal, and P. G. O'Shea, Rev. Sci. Instrum. 75, 8 (2004).

TUPPH035: Optimization and Sensitivity Studies for PAL FEL Injector

Ilmoon Hwang, Moohyun Yoon (POSTECH, Pohang, Kyungbuk), Eun-San Kim (Kyungpook National University, Daegu)

Pohang Accelerator Laboratory (PAL) is preparing a 0.1 nm free electron laser based on Self-Amplified Spontaneous Emission (SASE). S-band rf linear accelerator will produce a 10 GeV electron beam and in-vacuum undulators of 5mm gap make output radiation power of 5 GW. To determine basic design parameters, start-to-end tracking simulations are performing by several codes. We present simulation result of injector part by PARMELA. It consists of electron gun, solenoids, two 3 m linac and quadrupoles. The photoinjector produces 10 ps long electron bunches of 1 nC with a normalized transverse emittance of less than 1mm mrad at 135 MeV. Sensitivity studies of laser pulse, solenoid and linac are presented also.

TUPPH036: Status of the FEL Project at INFLPR

Florea Scarlat, Eugenia Simona Badita, Geo Georgescu, Rares Medianu, Ecaterina Mitru, Mihai Oane, Anca Mariana Scarisoreanu (INFLPR, Bucharest - Magurele), Cristian Bontoiu (ELETTRA, Basovizza, Trieste)

FEL project at INFLPR is based on electron beams provided by the one of NILPRP electron accelerators or made availableby imported accelerators. This paper summarizes the layout of the FEL project, the main parameters and the expected performances with particular emphasis on its components. Some of the details on the project finalization and a discussion of planned improvements will also be presented. This work supported by the Romanian National Authority for Scientific Research - ANCS and the Institute of Atomic Physics - IFA, Contract CERES: 11 - 35 -2006.

TUPPH037: A Transverse Slice Emittance Measurement System Using a Quadrupole Scan Technique and Streak Camera Readout at PITZ

Roman Spesyvtsev, Galina Asova, Juergen W. Baehr, Charles H. Boulware, Hans-Juergen Grabosch, Levon Hakobyan, Marc Hänel, Yevgeniy Ivanisenko, Martin Avetic Khojoyan, Mikhail Krasilnikov, Sven Lederer, Bagrat Petrosyan, Sakhorn Rimjaem, Juliane Roensch, Thomas Scholz, Andrey Shapovalov, Lazar Staykov (DESY Zeuthen, Zeuthen), Dieter Richter (BESSY GmbH, Berlin)

The Photo Injector Test facility at DESY, Zeuthen site, (PITZ) has been built to develop and optimise electron beam sources that fulfil the requirements of the European XFEL photo injector. The European XFEL requires a transverse emittance of less than 1 mm mrad at the photo injector exit. Simulation results of beam dynamics show that although the head and tail of the electron bunch contribute to the projected emittance, they have very little influence on the FEL process. Thus it is important to optimise the emittance of the central slices of the bunch. For this purpose, a setup for transverse slice emittance measurements using a quadrupole scan technique with streak camera readout is being developed at PITZ. In this paper, the measurement procedure is discussed including error estimation and present system limitations. Slice emittance simulations are also presented together with results of initial test measurements.

This work has partly been supported by the European Community, contracts RII3-CT-2004-506008 and 011935, and by the ‘Impuls- und Vernetzungsfonds’ of the Helmholtz Assciation, contract VH-FZ-005.

TUPPH038: Longitudinal Phase Space Measurements along the PITZ Photoinjector.

Juliane Roensch, Jörg Rossbach (Uni HH, Hamburg), Dieter Richter (BESSY GmbH, Berlin), Galina Asova, Juergen W. Baehr, Charles H. Boulware, Hans-Juergen Grabosch, Levon Hakobyan, Marc Hänel, Yevgeniy Ivanisenko, Bagrat Petrosyan, Sakhorn Rimjaem, Thomas Scholz, Andrey Shapovalov, Roman Spesyvtsev, Frank Stephan (DESY Zeuthen, Zeuthen), Sven Lederer (DESY, Hamburg)

The Photo Injector Test facility at DESY, Zeuthen site (PITZ) was built to optimize electron sources and to study electron beam characteristics for short wavelength Free-Electron Lasers (FELs). In addition, using a further accelerating (‘booster’) RF cavity, the so-called emittance compensation mechanism is under investigation at PITZ. Due to the upgrade of the PITZ facility the gap width of the dipole spectrometer downstream the RF gun cavity was too small and had to be modified. A slit was added in front of the spectrometer to improve the momentum resolution. Furthermore, a new dipole spectrometer was installed downstream the booster cavity during the last shut-down period. It is used to measure the momentum distribution, longitudinal phase space and slice emittance of the electron bunch. The first measurements on the longitudinal phase space and high-resolution momentum distributions using the new systems are presented in this paper.

This work has partly been supported by the European Community, contracts RII3-CT-2004-506008 and 011935, and by the ‘Impuls- und Vernetzungsfonds’ of the Helmholtz Assciation, contract VH-FZ-005.

TUPPH039: A Longitudinally Focusing Compact RF Photoinjector

Brendan Donald O'Shea, Hristo Badakov, Luigi Faillace, Atsushi Fukasawa, Pietro Musumeci, James Rosenzweig (UCLA, Los Angeles, California), Avraham Gover (University of Tel-Aviv, Tel-Aviv)

We present the RF design and beam dynamics a new type of RF photoinjector design in which a simple short (~0.5) cell is added to an existing 1.5 cell gun, which provides a strong bunching gradient. The beam current out of the gun can be greatly enhanced by using this method, with excellent emittance, with a space-charge dominated waist occurring in both the transverse and longitudinal dimensions simultaneously. This gun design is ideally compatible with the blowout regime of the RF photoinjector, as it mitigates and reverses excessive pulse lengthening. Shorter pulses at low energy enable not only enhanced FEL injectors, but also other applications, such as ultra-fast electron diffraction systems, and production of THz or inverse Compton radiation from such beams.

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TUPPH040: A Hybrid Standing Wave-Traveling Wave Photoinjector

Atsushi Fukasawa, Hristo Badakov, Brendan Donald O'Shea, James Rosenzweig (UCLA, Los Angeles, California), David Alesini, Luca Ficcadenti, Bruno Spataro (INFN/LNF, Frascati (Roma)), Luigi Palumbo (INFN/LNF, Frascati (Roma); Rome University La Sapienza, Roma)

We present here the RF aspects and beam dynamics study of a hybrid photoinjector, where the cathode section is standing wave, and the section downstream of the third (coupling) cell is traveling wave. This device has strong RF advantages: there is a single feed, mitigating expense, and there is a nearly complete suppression of reflected power during the SW section fill. This, critically, allows one to scale these devices to higher field and frequency, which should dramatically improve beam brightness. Further, the beam dynamics are fundamentally changed, as the TW section acts as a velocity buncher. Thus one may produce low emittance, >kA beams at 20-30 MeV from such a device. We discuss here results of detailed beam dynamics simulations, RF design and initial cold-testing, and preparations for high power testing.

Department of Energy Basic Energy Sciences contract DOE DEFG02-07ER46272, High Energy Physics contract DE-FG03-92ER40693, and Office of Naval Research contract ONR N00014-06-1-0925

TUPPH041: Three-dimensional Analysis of Longitudinal Space Charge Microbunching Driven by Shot Noise

Daniel Ratner (Stanford University, Stanford, Califormia), Alex Chao, Zhirong Huang (SLAC, Menlo Park, California)

The commissioning of the Linac Coherent Light Source injector shows unexpected coherent optical transition radiation (COTR) for an uncompressed electron bunch downstream of a dog-leg transport line*. In this paper, we develop a three-dimensional analysis of the longitudinal space charge microbunching in attempting to explain the phenomenon. The analysis takes into account the transverse correlation of the longitudinal space charge field due to shot-noise startup** and nonlinear transport optics. We also discuss its applications to the LCLS COTR observations***.

* R. Akre et al., PRST-AB 11, 030703 (2008). ** M. Venturini, PRST-AB 11, 034401 (2008). *** H. Loos et al., these proceedings.

TUPPH042: Proposed Pulse Wire Setup for Undulator Field Characterization

Mona Gehlot, Ganeswar Mishra (Davi Ahilya University, Indore, Madhya Pradesh), Sanjay Chouksey, Vinit Kumar (RRCAT, Indore (M.P.))

A pulse wire method for undulator characterization is proposed and under development at Devi Ahilya University, Indore in collaboration with Raja Ramana Center of Advanced Technology,Indore ,India .A six period gap varying undulator is under fabrication which will be used in the pulse wire measurement.A 5 milli watt,635 nanometer diode laser will be used with less than 300 pico second rise time silicon detector to pick up the vibrations of the wire. Cu-Be wire with diameter 100-250 micrometer will be used for the measurement of first and second integral of wire motion.The paper will describe design details and objectives of the pulse wire setup. The undulator will be planar and PPM Type with NdFeB*.

* Technical specifications for mechanical,design,febrication, essembly,installation & testing of pulsed wire magnetic measurement system, DAVV/Phy/FELLAB/08/02

The work is suported by BRNS/DAE, Bombay, India.

TUPPH043: Diagnostics of the Laser Heater Induced Beam Heating in FERMI@elettra

Simone Spampinati, Simone Di Mitri, Mario Ferianis, Marco Veronese (ELETTRA, Basovizza, Trieste)

The FERMI@elettra project foresees a laser heater at low energy (~ 100 MeV); this tool has been proposed to cure the microbunching instability that affects the high brightness electron beam. It consists of an undulator located in a small magnetic chicane that allows seeding of the electron beam with an external laser. The particles interact in a short undulator with the laser pulse and then gain an energy modulation on the scale of the optical wavelength. As a result, the laser-electron interaction together with with the R52 transport term leads to an effective beam heating. This article describe the capability of diagnostic dedicated to enlighten the laser heater operation

TUPPH044: Investigation of Quadrupole Magnets for the XFEL Project Using a Rotating Coil Set-up

Fredrik Hellberg, Håkan Danared, Anders Hedqvist (MSL, Stockholm), Yorck Holler, Bernward Krause, Alexander Petrov, Joachim Pflueger (DESY, Hamburg)

In the European X-ray free electron laser (XFEL) undulators quadrupole magnets focus the electron beam. The magnetic centre of these quadrupoles must be within 0.002 mm (rms) distance from a straight line over the length of an undulator. This can only be achieved with beam based alignment (BBA). For BBA to work, it is essential that changes of field strength do not significantly change the position of the magnetic centre of the quadrupole. Also, temperature stability of the position of the magnetic center is important. To investigate magnet excitation effects and sensitivity to temperature changes, a rotating coil system has been setup at the Manne Siegbahn Laboratory to measure the stability of the magnetic centre with accuracy better than 0.001 mm. This instrument was used to investigate the properties of several magnet yokes of different materials, solid and laminated, for the XFEL quadrupoles.

TUPPH045: Tolerance Margins for Shimmed Undulators

Bettina Christa Kuske, Johannes Bahrdt (BESSY GmbH, Berlin)

Errors in the undulator fields are a potential source of performance degradation especially in FELs where the undulator sections reach lengths of up to 100 m. The strong transverse field variations of APPLE undulators tighten the tolerances even further. Beyond sorting methods of the magnetic blocks, the shimming of undulators is a widely accepted tool to improve the field quality of undulators and wigglers. In order to calculate realistic tolerance margins for undulator errors it is essential to take the effect of the shimming into account when the FEL performance is simulated. This paper presents GENESIS calculations for STARS, the planned BESSY FEL test facility, and for the 4GeV lattice of the LCLS.

TUPPH046: Development of the Optical Timing and rf Distribution System for XFEL/SPring-8

Yuji Otake, Kenji Tamasaku (RIKEN Spring-8 Harima, Hyogo), Kazuhiro Imai, Motonobu Kourogi (OPtical Comb, Inc., Yokohama), Naoyasu Hosoda, Masanobu Kitamura, Hirokazu Maesaka, Takashi Ohshima (RIKEN/SPring-8, Hyogo), Mituru Musya (University of electro-communications, Tokyo)

At RIKEN, a coherent X ray source is under construction. Timing and rf phase accuracy of several femto-seconds is required to the timing and LLRF system for an XFEL accelerator. We already realized an electron beam timing stability of 46 fs (rms) with electronic circuits in the SCSS test accelerator. However, realizing the required timing accuracy is more 10 times difficult than that achieved with the electronic circuits. We try to obtain this accuracy by a laser system. This system comprises 4 parts; a) an optical comb generator, having 5712 MHz, 1 ps width pulse train, as which has LN crystal installed into an optical Fabry-Perot cavity, b) a DFB laser locked to an acetylene absorption spectrum (1538 nm), c) an optical fiber length regulation system, which has a control function of its thermal length change reduced within 25μm for 25 km by a Michelson interferometer, and d) a WDM optical system to transmit timing and rf signals, such as 5712 MHz and 238 MHz for the acceleration. In this paper, we describe the system configuration, and the results of the developed laser instruments. The instruments noise of less than -100 dBc showed great possibility to realize the requirement.

TUPPH047: Permanent Magnet Phase Shifter for the European-XFEL

Huihua Lu (IHEP Beijing, Beijing), Joachim Pflueger (DESY, Hamburg)

In undulator systems with variable gaps phase shifters are needed to exactly match the phase between individual segments so that constructive superposition of the emitted light occurs. A phase shifter based on Permanent Magnet technology for the use in the European XFEL has been developed and tested. This paper will explain its magnetic principle and focus on the applied correction schemes and the presentation of the final results.

TUPPH048: SPARC FEL Project Status Report

Massimo Ferrario (INFN/LNF, Frascati (Roma))

The SPARC project foresees the realization of a high brightness photo-injector to produce a 150-200 MeV electron beam to drive 500 nm FEL experiments in various configurations. The SPARC photoinjector is also the test facility for the recently approved VUV FEL project named SPARX. The second stage of the commissioning, that is currently underway, foresees a detailed analysis of the beam matching with the linac in order to confirm the theoretically prediction of emittance compensation based on the “invariant envelope” matching , the demonstration of the “velocity bunching” technique in the linac and the characterisation of the spontaneous emission radiation in the SPARC undulators. In this paper we report the experimental results obtained so far.

TUPPH049: Magnetic Field Mapping and Error Analysis of the Emittance Compensating Solenoids in an RF Photoinjector

Nathan A. Moody, Dinh C. Nguyen (LANL, Los Alamos, New Mexico)

Modern RF photoinjectors use a solenoidal magnetic field for emittance compensation to create high-brightness (high bunch charge, low transverse emittance) electron beams to drive high-gain FELs. The main function of the solenoidal magnetic field is to limit the space-charge-induced expansion of the electron beam inside the injector and to rotate the different axial slices of the electron bunch in transverse phase space such that they line up at a location downstream from the injector exit. It is also important to zero out the axial magnetic field right at the cathode, as any residual field would cause the electrons to acquire an angular momentum that would be expressed as a thermal emittance. To this end, we have carefully mapped the magnetic fields of both the focusing solenoid and the bucking coil. The field-mapping results will be presented together with an error analysis that takes into account both measurement and alignment errors.

This work is supported by the Office of Naval Research and the High-Energy Laser Joint Technology Office.

TUPPH050: Femtosecond-Stable Microwave Signal Generation

Matthias Felber, Vladimir Arsov, Patrick Gessler, Kirsten Elaine Hacker, Florian Loehl, Bastian Lorbeer, Frank Ludwig, Karl-Heinz Matthiesen, Holger Schlarb, Bernhard Schmidt, Axel Winter (DESY, Hamburg), Sebastian Schulz, Johann Zemella (Uni HH, Hamburg)

For the stabilization of amplitude and phase of the accelerating RF in the FEL-based light sources FLASH and the planned European XFEL, a femtosecond-stable 1.3 GHz microwave signal is required. This is obtained from an optical synchronization system which uses the precise repetition rate of a mode locked laser as a timing reference. The laser pulses are distributed to remote locations via length stabilized fiber links. There, the optical pulse train (216 MHz repetition rate) is converted to the microwave signal using an electro-optical phase detection scheme based on a Sagnac loop interferometer. In this paper we present measurements of the phase stability of this conversion scheme. The characterization was done using a second Sagnac-loop interferometer. In addition we discuss the amplitude stability of the extracted microwave signal.

TUPPH051: Conceptual Ideas for the Temporal Overlap of the e-beam and the Seed Laser for sFLASH

Roxana Tarkeshian, Joern Boedewadt, Markus Drescher, Jörg Rossbach (Uni HH, Hamburg), Holger Schlarb, Siegfried Schreiber (DESY, Hamburg), Rasmus Ischebeck (PSI, Villigen)

sFLASH is a seeding FEL experiment at FLASH/DESY, to introduce a 30 nm HHG-based XUV-beam laser to the electron bunches of FLASH at the entrance of a 10 m variable-gap undulator. The temporal overlap between the electron beam and HHG is important for the FEL process. The installation of a 3rd harmonic cavity at FLASH will provide a long high current electron beam (at kA level) over ~600 fs (FWHM) bunch duration. The duration of the HHG laser pulse will be about 30 fs (FWHM). The desired overlap can be achieved in steps. One approach will be to synchronize the drive laser (Ti:Sapphire, 800 nm) of HHG and the incoherent spontaneous synchrotron radiation of the undulator at a sub-picosecond precision. In a following step the overlap can be improved by scanning within the sub-picosecond uncertainty. The possibility of using a streak camera to detect both the 800 nm laser and the spontaneous undulator radiation pulses without perturbing FLASH user operation is investigated. To match the power levels, the laser beam has to be attenuated by several orders in magnitude. The layout of the experiment and preliminary simulation results of generation and transport of both light pulses are presented.

TUPPH052: Beam Loading Compensation by RF Detuning in a Thermionic RF Gun

Heishun Zen, Keisuke Higashimura, Toshiteru Kii, Ryota Kinjo, Kai Masuda, Hideaki Ohgaki (Kyoto IAE, Kyoto)

The thermionic RF gun is suitable to realize a compact and economical free electron laser, because it doesn’t require a buncher system or a high power laser system. However, due to the back bombardment effect, the beam current increases and the beam energy decreases during macro-pulse duration. To overcome the effect, some cures have been introduced e.g. the sweep magnet* and the RF amplitude control**. Recently we found a new method to mitigate the energy decrease by analytical and numerical investigations of the beam loading effect in our RF gun. When the frequency of the RF power to the gun is detuned to higher frequency (several hundred kHz) than the resonant frequency of the cavity, the energy degradation of the electron beam is mitigated. The effectiveness of the detuning method has been confirmed with the experiment. In the conference, results of the analysis and the experiment will be presented.

* C.B. Mckee, et al., NIM A, vol.304, pp.386-391 (1991) ** N. Okawachi, et al., Proceedings of FEL 2006, pp.664-667 (2006)

TUPPH053: Measurement of SPring-8 XFEL Undualtor Prototype with the SAFALI System

Takashi Tanaka (RIKEN Spring-8 Harima, Hyogo), Takamitsu Seike (JASRI/SPring-8, Hyogo-ken), Hideo Kitamura (RIKEN/SPring-8, Hyogo)

The in-vacuum undualtor (IVU) is one of the key technologies of the SPring-8 XFEL. This makes it possible to select a shorter magnetic period, and thus a lower electron energy. One concern on the use of IVUs is that the magnetic performance cannot be checked easily after assembly, because the magnetic array is placed inside the vacuum chamber and thus the conventional system is not available. To solve this, we have recently developed a new measurement system called “SAFALI”, based on laser instrumentation and dynamic feedback of the magnetic sensor position. With the SAFALI system, we measured the magnetic field of the prototype IVU (18 mm period and 5 m length) for the SPring-8 XFEL and checked the reproducibility of the magnetic performance before and after vacuum chamber assembly. We also checked the variation of the magnetic performance due to temperature change and gradient in the measurement laboratory of SPring-8. In addition, we attached high-precision digital gauges to the magnetic array on 6 different longitudinal positions to observe correlation between the gap variation, temperature gradient, and undualtor phase error, which will be reported in this paper.

TUPPH054: Multilayer Dielectric Mirrors for High Power THz-FEL Applications

Mufit Tecimer (NHMFL, Tallahassee, Florida), Erik Bruendermann (Ruhr-Universität Bochum, Bochum)

For the proposed srf linac based FSU THz FEL the possibility of adopting multilayer mirrors is being investigated among various types of outcouplers presented in* **. The negligible mode distortion achieved at the coupling makes them also an ideal coupler type for injecting the generated THz pulses into an external high Q cavity. The latter has been proposed to extend the capabilities of the FEL in terms of outcoupled power and the ability to manipulate the spectral bandwidth[2] Recently THz multilayer mirrors have been constructed and tested for experiments in the THz Spectroscopy*** In order to cope with FEL design requirements, the proposed mirrors** differ from the previously built ones by an accurate adjustment of reflectivity (variable coupling ratio) and by providing the necessary focusing in an FEL resonator and external high Q cavity. A novel layer material configuration is proposed for the construction of high reflectivity ~99.9% broadband THz mirrors which leads to a robust structure well suited for high power applications. We will report preliminary results obtained by the performance measurements of a test cavity that comprises the constructed multilayer THz mirrors.

* M.Tecimer et al.,FEL Conf Proc 2006,p.327 ** FSU THz-FEL Design Review,JLab July 2007
*** R.Schwion et al.,Appl.Phys.Lett. 86, 20116 (2005)

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TUPPH055: Optical Guiding Beyond Saturation in a FEL Amplifier

Xijie Wang, James Murphy, Yuzhen Shen, Takahiro Watanabe (BNL, Upton, Long Island, New York)

Optical guiding in a laser seeded FEL amplifier was experimentally investigated at the National Synchrotron Light Source (NSLS) Source Development Lab (SDL). We have observed optical guiding in both fundamental and harmonic of the FEL output for the first time, and further more, we have experimentally demonstrated more than 5 mrad steering for both FEL fundamental and harmonic. The FEL transverse profile evolutions before and after the FEL saturation were investigated.

This work is supported by the Office of Naval Research under contract No. N0002405MP70325 and U.S. Department of Energy under contract No. DE-AC02-98CH1-886.

TUPPH056: The Impact of the Space Charge on the STARS Performance

Atoosa Meseck (BESSY GmbH, Berlin)

BESSY is proposing a two-stage high-gain harmonic generation (HGHG) FEL, STARS, to demonstrate and investigate the cascading proposed for the BESSY Soft X-ray FEL. STARS will have a target wavelength range from 70 nm to 40 nm with peak powers up to a few hundred MWs and pulse lengths less than 20 fs (rms). In an HGHG stage an energy modulation is imprinted to the electron beam by a seeding radiation. A dispersive section converts this energy modulation to a spatial modulation which is optimized for a particular harmonic. The subsequent radiator is optimized for this harmonics and generates radiation with high power which is used as seeding radiation for the next stage. During the passage through the Dispersive section, subsequent drifts and the radiator, space charge effects can reduce the generated bunching and degrade the FEL Performance. We present simulation studies for the impact of the space charge forces in the undulator section on STARS performance.

TUPPH057: Study of Optical Frequency Chirping and Pulse Compression in a High-Gain Energy-Recovery-Linac-Based Free-Electron Laser

Shukui Zhang, Stephen Vincent Benson, David Douglas, George R. Neil, Michelle Diane Shinn (Jefferson Lab, Newport News, Virginia)

In this paper we report a direct experimental investigation of optical frequency chirping effects induced by ultrashort electron bunches in a high-gain energy-recovery-linac (ERL) free-electron laser (FEL) cavity. Our measurement and analysis shows clear evolution of the optical pulse chirp verses the electron bunch energy chirp. Further study also provides important evidence that under certain conditions much shorter FEL pulses can be obtained through properly chirping electron bunches and optical pulse compression. Although studies about the chirp measurement on Self-amplified-spontaneous-emission (SASE) FEL were reported recently, we believe this paper for the first time provides a comprehensive and close observation into the very unique temporal and spectral characteristics of ultrashort optical pulses from a high-gain ERL FEL. This is made possible by the stable operation and unique capability of the Jefferson Lab machine to change the electron bunch energy chirp with no curvature. Preliminary simulations will also be presented.

TUPPH058: Developments in Cascaded HGHG-FELs

Atoosa Meseck, Bettina Christa Kuske (BESSY GmbH, Berlin)

Seeding in combination with frequency up conversion is widely recognized as a method to provide FEL radiation with properties superior to the SASE output. In addition to High Gain Harmonic Generation (HGHG) scheme, successfully demonstrated in Brookhaven* and proposed for the BESSY soft X-ray FEL, several alternative schemes have been proposed during the last years. This paper discusses and compares these proposals to the original cascading of HGHG-stages which includes the fresh bunch technique.

* L.H. Yu, Phys. Rev. Letters, 91, 074801, 2003

TUPPH059: Transmission THz Imaging of Large-scale Samples by Using the KAERI THz FEL

Pil Dong Ahn, Do Young Jeong, Young Uk Jeong, Byung Cheol Lee, Kitae Lee, Jungho Mun, Seong Hee Park (KAERI, Daejon)

We have been studying an application of terahertz (THz) imaging with a compact THz free-electron laser (FEL) in the Korea Atomic Energy Research Institute (KAERI). The THz imaging is considered to be a potent technology of security inspection for airports and publics facilities. We could get relatively high-resolution THz imaging of small-scale bugs and materials. To apply the technology for large-scale goods like bags and briefcases, we have developed a 2D scanning system having a stroke more than 1 m. The scanned transmission data is automatically normalized by the reference signal and displayed as a 2D image. For sensitive measurement of the large-scale goods, we have used a wavelength range less than 2 THz and a sensitive liquid-Helium-cooled InSb detector. In this paper, we will show the results of THz imaging for several samples and estimate the prospect of the THz technology for security inspection.

TUPPH060: Three Years of CW-Operation at FELBE - Experiences and Applications

Wolfgang Seidel, Manfred Helm, Matthias Justus, Ulf Lehnert, Peter Michel, Rico Schurig, Stephan Winnerl, Sergei Zvyagin (FZD, Dresden)

This paper reviews the basic properties of the infrared free-electron laser FELBE at the Forschungszentrum Dresden-Rossendorf. A few highlight experiments using the cw-operation are discussed. Driven by a superconducting linear accelerator, FELBE continuously generates infrared pulses with a repetition rate of 13 MHz. In addition, operation in a macropulse modus (pulse duration >100 microsec, repetition rate ≤ 25 Hz) is possible. At present FELBE delivers microJ pulses with typical duration of about 0.9-30 ps in the wavelength range 4-230 micrometer. Furthermore we give an outlook on the experiments will use the beam of FELBE in the High Magnetic Field Laboratory Dresden (HLD). The HLD will provide pulsed magnetic fields up to 60 T. It operates as a user facility since 2007. Submitted as a poster to the FEL 2008 conference.

TUPPH061: Absorption Spectroscopy by Using the Coherent Radiation from Linac Electron Beams

Shuichi Okuda, Takao Kojima, Yasukazu Sakamoto, Ryoichi Taniguchi (Osaka Prefecture University, Sakai), Toshiharu Takahashi (KURRI, Osaka)

The coherent transition radiation light source has been established by using an L-band electron linear accelerator (linac) at Kyoto Universtiy Research Reactor Institute (KURRI). The light spectra have been measured with a Martin-Puplett type interferometer and a liquid-He-cooled silicon bolometer. The intensity of the radiation is sufficiently stable for spectroscopic applications. The light source has been applied to absorption spectroscopy for optical window materials, oxide particles, water, liquid solutions and various kinds of other matters. Some of these have shown the effect of the light intensity. The coherent radiation is a picosecond pulsed light. It can be applied to the pump-probe experiment using the electron beam and the coherent radiation. A new light source of the pulsed coherent synchrotron and transition radiation from the beams of an S-band electron linac will be developed at Osaka Prefecture University (OPU) in the near future.

TUPPH063: Comparison for Simulations with Measurements of Undulator Demagnetization due to Radiation Losses at FLASH

Bart Faatz, Yuhui Li, Joachim Pflueger, Jochen Skupin, Thorsten Vielitz (DESY, Hamburg)

The high-gain SASE free-electron laser FLASH at DESY in Hamburg has been in operation since 2004. It has a fixed gap, multi segmented undulator with a total length of about 30 m. In order to monitor the demagnetization of the undulator due to radiation loss, a diagnosis undulator (DU) with only 3 pole pairs and corresponding magnets was installed in front of the SASE undulator consisting of the same material, and with the same gap and period. The accumulated dose of DU and undulator system is derived by weekly measurements with thermoluminescence dosimeters (TLDs). The DU is dismounted and magnetically measured regularly. In this contribution, we show results of simulations of the FEL performance for a given, position dependent demagnetization of the undulator field based on comparison of accumulated dose with demagnetization as measured in the DU.

TUPPH064: Free Electron Lasers in 2008

William B. Colson, Robert Edmonson, Robert Alexander Neuerman, Benjamin Wilder (NPS, Monterey, California)

Thirty-two years after the first operation of the short wavelength free electron laser (FEL) at Stanford University, there continue to be many important experiments, proposed experiments, and user facilities around the world. Properties of FELs in the infrared, visible, UV, and x-ray wavelength regimes are tabulated and discussed.

This work has been supported by the Office of Naval Research and the High Energy Laser Joint Technology Office.

TUPPH065: Control and Support System for LEBRA FEL Operation

Keisuke Nakao, Ken Hayakawa, Yasushi Hayakawa, Kyoko Nogami, Toshinari Tanaka (LEBRA, Funabashi), Manabu Inagaki, Takeshi Sakai, Isamu Sato (Nihon University,)

The near infrared Free Electron Laser (FEL) has been provided for scientific studies in various fields since 2003 at the Laboratory for Electron Beam Research and Application (LEBRA) in Nihon University. The operation time of the LEBRA 125 MeV Linac reached approximately 2000 hr/year in 2007. About half of the machine time was scheduled for the experiments using FEL. So far only 3 staffs have been dedicated to the operation of the Linac and the FEL beam line. Therefore, the control and support system has been required to realize stable oscillation of FEL during a long operation time and to reduce the work load of the operators. The architecture and the main capabilities of the control and support system for LEBRA FEL are described in this report. The system consists of the electron beam energy feedback program and the FEL resonator mirror control program. The beam energy feedback program has successfully operated to suppress the pulse-to-pulse fluctuation of the beam energy to less than 0.1%.

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TUPPH066: Conceptual Design of the Synchronization System for the European XFEL

Axel Winter, Vladimir Arsov, Matthias Felber, Florian Loehl, Frank Ludwig, Karl-Heinz Matthiesen, Holger Schlarb, Bernhard Schmidt, Sebastian Schulz, Stefan Simrock, Henning Christof Weddig, Johann Zemella (DESY, Hamburg), Krzysztof Czuba (Warsaw University of Technology, Warsaw)

To fully explore the potential of the femtosecond x-ray pulses generated by the superconducting linac-driven European X-ray Free-Electron Laser, a laser-based timing and synchronization system is required, in conjunction with a high-precision RF regulation for the accelerating cavities. In this paper, we describe the baseline design of the optical synchronization system for the European X-Ray Free Electron Laser and its integration with the low-level RF system. These two systems will ensure electron beam stability on the order of a few ten femtoseconds and synchronization between the FEL pulses and experimental lasers in the same range.

TUPPH067: Status of the NPS Free-Electron Laser

John Wesley Lewellen, William Armstrong, William B. Colson, Sean P. Niles (NPS, Monterey, California), Todd Iversen Smith (NPS, Monterey, California; Stanford University, Stanford, Califormia)

The Naval Postgraduate School (NPS) has begun the design and assembly of the NPS Free-Electron Laser (NPS-FEL). The basic NPS-FEL design parameters are for 40-MeV beam energy, 1 nC bunch charge, and 1 mA average beam current, in an energy-recovery linac configuration. The NPS-FEL will make use of portions of the Stanford Superconducting Accelerator (decommissioned in 2007), in particular the injector system, Stanford/Rossendorf-style cryomodules and RF system. The injector will be gradually upgraded to improve beam properties and increase the injection voltage. Each cryomodule contains two 9-cell TESLA-type 1.3 GHz cavities, each cavity powered by an individual 10-kW CW klystron. As of April 2008, the injector system has been reassembled. We are working towards beam tests with the injector system, including upgrades to support photocathode experiments. This paper describes the basic machine and laboratory configuration, initial experimental plans, and current status of the overall program.

This research is supported by the Office of Naval Research and the High Energy Laser Joint Technology Office.

TUPPH068: Coherent Micro-Bunching Radiation in the 10 Micrometer Wavelength Range from Electron Bunches at FLASH

Bernhard Schmidt, Christopher Behrens, Stephan Wesch (DESY, Hamburg), Hossein Delsim-Hashemi, Peter Schmüser (DESY, Hamburg; Uni HH, Hamburg)

At FLASH (DESY), a single shot broad band spectrometer THz spectrometer has been developed and installed which allows to measure the spectra of coherent bunch radiation for wavelengths between 2 micrometer and 300 micrometer. The spectrometer uses coherent transition radiation from an off-axis screen, extracted through a diamond window. Using this instrument, we found that the electron bunches emit coherent radiation in the regime 5 - 15 micrometer with an intensity which is almost independent of the bunch compressor strength. The radiation is present even for bunch lengths of several picoseconds. The shape of the spectrum indicates that the radiation is produced by a 'micro-bunching' of the charge density with a characteristic length in the 10 micrometer range. In this paper, we present systematic studies into the origin of this radiation, including its charge dependence, dependence on the photon injector parameters and on the strength of the magnetic chicanes and the bunch compression scheme.

TUPPH069: High-Resolution Online Spectrometer at FLASH

Marion Kuhlmann, Elke Plönjes, Rolf Treusch (DESY, Hamburg)

A new online diagnostic instrument is currently being implemented at FLASH. A combination of a mirror and two variable line spacing gratings with blazed surface has been installed in the non-monochromatized beamline branch of FLASH. In contrast to a standard grating the blazed angle is optimized for the zero order transferred to the experimental stations, leaving approx. 1 - 10 percent intensity for recording the wavelength in the spectrometer. The detector, an intensified CCD imaging the dispersed beam on a Ce:YAG crystal, can follow the focal plane of the gratings for wavelengths of 6 - 60 nm. The spectrometer is designed for a resolving power between 500 and 3000. First measurements will be presented and compared with the design expectations. Furthermore, the importance of the online spectrometer for both the FEL operation and the growing demands of user experiments will be discussed.

TUPPH070: Drift-Free, Cost-Effective Detection Principle to Measure the Timing Overlap between Two Optical Pulse Trains

Johann Zemella, Vladimir Arsov, Matthias Felber, Kirsten Elaine Hacker, Florian Loehl, Bastian Lorbeer, Frank Ludwig, Karl-Heinz Matthiesen, Holger Schlarb, Bernhard Schmidt, Axel Winter (DESY, Hamburg), Sebastian Schulz (Uni HH, Hamburg)

For pump probe experiments between a FEL and external lasers a synchronization on the 10 fs time scale is needed. At FLASH an optical synchronization system based the distribution of laser pulses over actively stabilized fiber links is applied. In this system, the timing overlap between two optical pulse trains has to be measured at different locations. For the main links, which extend to 300 m, this is done by optical cross-correlation techniques which require short laser pulses and free space optics. In addition to the main links, a variety of shorter links of only a few meter length are required to distribute the signals at the end of the main links to several clients. For those links, the optical stabilization system is too ambitious and too expensive. In this paper, we present a drift-free, low-cost detection principle based on a photo detector and RF devices which has a resolution of better than 50 fs. We plan to use this cost-effective scheme for the stabilization or length measurement of short optical fiber links.

TUPPH071: Tunability Ranges of Laser-Induced Narrowband Coherent Synchrotron Radiation

Serge Bielawski, Clement Evain, Christophe Szwaj (PhLAM/CERCLA, Villeneuve d'Ascq Cedex), Akira Mochihashi (JASRI/SPring-8, Hyogo-ken), Miho Shimada (KEK, Ibaraki), Toshiharu Takahashi (KURRI, Osaka), Masahito Hosaka, Yoshifumi Takashima (Nagoya University, Nagoya), Toru Hara (RIKEN/SPring-8, Hyogo), Masahiro Katoh, Shin-ichi Kimura (UVSOR, Okazaki)

Tunable narrowband Terahertz radiation can be obtained experimentally using the interaction between an electron bunch, and a long laser pulse possessing a longitudinal modulation*. Here we focus on the modeling of the process. The starting point is similar to the theory of bunch-slicing. Then slowly varying envelope approximation allows to derive analytical approximations of the tunability curves, and scalings of efficiency with laser power. Comparisons of analytical results versus numerical integration and experimental results will be presented, in the case of the UVSOR-II narrowband CSR setup.
* S. Bielawski et al. Nature Physics 4, 390 (2008)

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TUPPH072: sFLASH: An Experiment for Seeding VUV-Radiation at FLASH

Shaukat Khan, Armin Azima, Joern Boedewadt, Hossein Delsim-Hashemi, Markus Drescher, Velizar Miltchev, Manuel Mittenzwey, Jörg Rossbach, Roxana Tarkeshian, Marek Wieland (Uni HH, Hamburg), Atoosa Meseck (BESSY GmbH, Berlin), Stefan Düsterer, Josef Feldhaus, Tim Laarmann, Theophilos Maltezopoulos, Holger Schlarb (DESY, Hamburg)

The paper describes an FEL seeding experiment at VUV wavelengths,to be installed at the existing SASE FEL user facility FLASH.Beyond a proof-of-principle demonstration in the VUV, the emphasis will be on high stability in terms of intensity and timing thus providing a future alternative operation mode of FLASH for users.The seed laser generates high harmonics (HHG) by focusing a near-infrared laser into a noble gas jet.The efficient transport of the short wavelength (30nm) radiation and the spatial and temporal overlap with the electron beam are among the challenging tasks. The interaction of the seed laser and the electron beam takes place in a new undulator section to be installed in front of the existing FLASH undulator.Four hybrid variable-gap undulators are foreseen with a total length of 10 meters.In the space between undulator sections there are diagnostics devices for both the electron beam and the seed laser.After the undulators there is a weak magnetic chicane as a separator of the electron beam and the seeded FEL radiation.Finally a VUV beamline transports the radiation to an experimental hutch where the temporal characterization of the amplified pulses takes place.

TUPPH073: Laser Profile Shaping and Electron Beam Emittance Measurement

Shengguang Liu (IHEP Beijing, Beijing)

Laser Undulator Compact X-ray source (LUCX) is a test bench for compact high brightness X-ray generator at KEK, which is based on the Compton Scattering. For the project, one of the challenged problems is to generate and to accelerate high charge and low emittance, multi-bunch electron beams. In this paper, we analyze the contribution on the beam transverse emittance from the electron beam transverse distribution in the gun, comparing the uniform electron beam with the Gaussian beam. The working principle of laser profile shaper-- π-shaper is introduced. We redesign the laser beam line for the shaper and convert the Gaussian laser beam into semi uniform laser beam successfully. With the uniform laser pulse, the transverse emittance for the 1nC electron bunch decreases from 5.46 πmm.mrad (Gaussian laser) to 3.66 πmm.mrad.

TUPPH075: Nonlinear Thomson Scattering of a Tightly Focused Laser Pulse by a Copropagating Electron

Kitae Lee, Young Uk Jeong, Seong Hee Park (KAERI, Daejon), Sang Young Chung, Dong Eon Kim (POSTECH, Pohang, Kyungbuk)

The relativistic nonlinear Thomson scattered (RNTS) radiaion of an intense laser pulse by high energy electron beam is considered to be an ultrashort x-ray pulse in attosecond range. To generate an ultrahigh laser intensity on an electron beam, it is required to tightly focus a laser beam. When a laser pulse is focused in a beam waist comparable with the laser wavelength, the usual paraxial Gaussian description of the laser fields cannot be applied any longer. It has been found in numerical study that with an accurate description of the laser fields, which can be obtained in a series solution of the wave equations, the RNTS radiations get enahanced more than 100 times.

TUPPH076: Electro-optic Techniques for Longitudinal Electron Bunch Diagnostics

Giel Berden, Alexander van der Meer (FOM Rijnhuizen, Nieuwegein), Bernhard Schmidt, Peter Schmüser, Bernd Steffen (DESY, Hamburg), Steven Jamison (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire), Allan MacLeod (UAD, Dundee), William Allan Gillespie, Paul Jonathan Phillips (University of Dundee, Nethergate, Dundee, Scotland)

Electro-optic (EO) techniques are becoming increasingly important in ultrafast electron bunch longitudinal diagnostics and have been successfully implemented at various accelerator laboratories. The longitudinal bunch shape is directly obtained from a single-shot, non-intrusive, measurement of the temporal electric field profile of the bunch. Furthermore, the same EO techniques are used to measure the temporal profile of terahertz / far-infrared optical pulses generated by a CTR screen, at a bending magnet (CSR) or by an FEL. This contribution summarizes the results obtained at FELIX and FLASH.

TUPPH077: Generation and Application of Laser-Compton Scattering from Relativistic Electron Beams

Khalid Chouffani (IAC, Pocatello)

Laser Compton scattering experiments were carried out at the Iadho Accelerator Center (IAC)using the 5-44 MeV LINAC. LCS X-rays were generated using a 5 ns electron beam interacting with a 100 MW, 7 ns laser and a 50 ps electron beam colliding with a 4 GW, 250 ps laser. X-rays resulting from the approximate head-on collision of relativistic electrons with a high peak power Nd:YAG laser fundamental, second and fourth harmonic lines were generated respectively. The LCS x-ray peak widths (FWHM) were measured as a function of the electron beam energy-spread and LCS spatial scans across the x-ray cone were also carried out using x-ray generated from the electron beam interaction with the laser second harmonic line. LCS angular measurements enabled us to determine the electron beam parameters in a single experiment. LCS x-rays were also used for XRF experiments and x-ray transmission/absorption measurements in Al, Nd, Pb and Bi foils of different thicknesses. Our experiments showed the dual applications of LCS as a useful x-ray source with application to biomedical imaging, hybrid k-edge densitometry and material science as well as a non-destructive electron beam monitor.

TUPPH078: Vibration Stability Studies of a Type III+ XFEL/FLASH Superconducting Accelerating Module Operating at 2K

Ramila Amirikas, Alessandro Bertolini, Juergen Eschke, Mark Lomperski (DESY, Hamburg)

The European X-ray Free Electron Laser (XFEL) superconducting accelerating modules, containing a string of Niobium (Nb) cavities and a quadrupole, will operate at 2K. In this paper, vibration stability studies of a high gradient XFEL/FLASH type III+ superconducting accelerating module with its quadrupole operating at 2K for the first time and with the latest design of the cryogenic inner layout will be reported. These measurements are possible using geophones which operate at cryogenic temperatures in both horizontal and vertical directions. In addition, investigation of vibration stability in relation with positioning the quadrupole in the center or the middle of the modules will be presented.

Work supported by the Commission of the European Communities under the 6th Framework Program "Structuring the European Research Area," contract number RIDS-011899.

TUPPH079: Slice Emittance Measurements Using an Energy Chirped Beam in a Dispersive Section at PITZ

Yevgeniy Ivanisenko, Galina Asova, Juergen W. Baehr, Charles H. Boulware, Hans-Juergen Grabosch, Marc Hänel, Mikhail Krasilnikov, Sven Lederer, Bagrat Petrosyan, Dieter Richter, Sakhorn Rimjaem, Juliane Roensch, Thomas Scholz, Andrey Shapovalov, Roman Spesyvtsev, Lazar Staykov, Frank Stephan (DESY Zeuthen, Zeuthen), Levon Hakobyan [on leave] (YerPhI, Yerevan)

The photo injector test facility at DESY, Zeuthen site, (PITZ) develops and characterizes high brightness electron sources for FEL facilities like FLASH and European XFEL. For this purpose a variety of beam diagnostics is being developed and implemented. This article describes an approach for transverse emittance measurements of the electron beam temporal slices. For the method, the beam is run off-crest in the booster cavity to produce a linear correlation between the particles energy and their longitudinal position. Then a 180 deg dipole acts as spectrometer and converts the longitudinal profile into a transverse distribution. In the final step, the beam emittance in the transverse direction orthogonal to the dipole bending plane is measured using a quadrupole scan. A further possibility by using a slit mask emittance measurement technique is discussed as well. First measurement results are presented along with corresponding simulations, discussion and conclusions.

This work has partly been supported by the European Community, contracts RII3-CT-506008 and 011935, and by the 'Impuls- und Vernetzungsfonds' of the Helmholtz Association, contract number VH-FZ-005.

TUPPH080: Study of the Impact of the HHG Seed Level on the FEL Emission at 160 nm on the SCSS Test Accelerator

Guillaume Lambert (LOA, Palaiseau), Bertrand Carré, David Garzella (CEA, Gif-sur-Yvette), Tetsuya Ishikawa, Kazuhiko Tahara, Yoshihito Tanaka (RIKEN Spring-8 Harima, Hyogo), Toru Hara, Hideo Kitamura, Tsumoru Shintake, Makina Yabashi (RIKEN/SPring-8, Hyogo), Marie-Emmanuelle Couprie (SOLEIL, Gif-sur-Yvette), Takanori Tanikawa (UVSOR, Okazaki)

Recently it has been proved that seeding a Free-Electron Laser with Harmonics Generated in gas can drastically improve the properties of the light emission and in particular the temporal coherence, which is quite limited in the Self-Amplified Spontaneous Emission configuration. Here, the impact of the seed level on the FEL emission has been characterized at 160 nm on the SCSS Test Accelerator. Actually, at extremely low level of HHG injection (0.5 pJ, 10 W), i.e. approximately ten times the effective noise power of the SASE emission, the FEL emission starts to be amplified and the number of spikes decrease. Then, the FEL energy per pulse begins clearly proportional to the HHG energy per pulse. More specifically for a seed power (<175 W) 230 times larger than the effective SASE noise power, the FEL spectrum exhibits a stable quasi Gaussian shape. As it is theoretically feasible to generate XUV harmonics which can be dominating with a similar factor, one can imagine High Gain Harmonic Generation configurations with only two or three stages for reaching wavelengths of a few nanometers.

TUPPH081: Smith-Purcell Free-Electron Laser with Sidewall Grating

Dazhi Li, Kazuo Imasaki (ILT, Suita, Osaka), Gun-Sik Park (SNU, Seoul), Ziqiang Yang (UESTC, Chengdu, Sichuan)

A sidewall grating for the Smith-Purcell device is proposed to enhance the coupling of the optical mode with the electron beam and consequently relax the stringent requirements to the electron beam. With the help of three-dimensional particle-in-cell simulations, it has been shown that, comparing with the general grating the usage of a sidewall grating improves the growth rate and dramatically shortens the time for the device to reach saturation. The transverse profile of the electric field is also addressed.

TUPPH082: Generation and Applications of Radial Polarized Laser Beam for Accelerator

Akira Maekawa, Mitsuru Uesaka [on leave] (The University of Tokyo, Ibaraki-ken), Hiromitsu Tomizawa [on leave] (JASRI/SPring-8, Hyogo-ken)

We are developing the methods to generate the radial/azimuth polarized laser beam for accelerator applications. Radial polarized laser propagation modes exists theoretically and were recently generated practically. We generate radial polarized beam from linear polarized beam using a liquid crystal (LC) cell or 8-divided wave plates. A LC cell utilizes the twisted nematic effect and we apply it for broad spectral bandwidth EOS applications. We have several applications with radial polarization. For example, radial polarization consists of TEM01 and TEM10 mode which have orthogonal linear polarization. So, we can decompose radial polarization into TEM01 and TEM10 mode using a polarizer and switch the two modes easily using a half wave plate. It is the quite simple and robust method to generate pure TEM01 mode and available for laser wire monitor with high spatial resolution of less than micrometer. Radial polarization can be also effective for 3D EOS bunch monitors and generation of Z polarization for a high brightness photocathode.

TUPPH083: Positron Generation through Laser Compton Scattering Gamma-ray

Dazhi Li, Kazuo Imasaki (ILT, Suita, Osaka)

Positron sources are important for linear colliders and are valuable tools in research of materials science, atomic physics and solid state physics. The proposal of positron generation through high-energy photon beams was presented several years ago, however, experiments are rare. In this paper, we report an experiment for generating positron beams. The experiment is based on a high-energy gamma-ray produced through Compton scattering of laser light from a high energy electron beam in a storage ring. The gamma-ray is then arranged to impinge on a thin Pb target to generate positrons and electrons via pair creation reaction. This process is also studied with the help of MCNP5 Monte Carlo simulation, for comparison with the experimental results. The imaging plate is used to record generated particles. Processing those images we can get information of positrons, electrons and photons, such as flux and energy spectrum.

TUPPH084: Field Measurement System for 30 MeV Cyclotron Magnet

Ki-Hyeon Park, Seong-Hun Jeong, Young-Gyu Jung, Dong Eon Kim, Young-Duck Yun (PAL, Pohang, Kyungbuk), Jong-Seo Chai, Joonsun Kang (KIRAMS, Seoul), Bong-Koo Kang (POSTECH, Pohang, Kyungbuk)

This paper presents a Hall probe mapping system for measuring a cyclotron magnet, which has been fabricated for the 30 MeV cyclotron at the Korea Institute of Radiological and Medical Sciences. The Hall probes are mounted on a precision mechanical stage and map magnetic field in the Cylindrical coordinate system. The mapping system uses the “flying” mode field mapping method to reduce data-acquisition time. The time required for mapping the whole gap-area of the cyclotron magnet is ~ 70 minutes. The relative random fluctuation error during the entire mapping process is less than ±0.02 %. The cyclotron magnet has been corrected using field measurement data, and the achieved total phase excursion of the cyclotron after correction is less than ±15°, which is within the tolerance of ±20° for the total phase excursion.

TUPPH085: Digital Power Supply for Air Core Magnet

Seong-Hun Jeong, Jinhyuk Choi, Dong Eon Kim, Ki-Hyeon Park (PAL, Pohang, Kyungbuk)

This paper presents the air core magnet power supply for the Pohang Light Source. The required current to energize the air core magnet was ±5 A with the high precision of ~2 ppm resolution to accomplish a stable beam orbit correction. This power supply has been implemented using the digital signal processing technology and shows the high stability and other good responses. Various experimental results such as stability, bandwidth and simulation are given in this paper.

TUPPH086: A High Resolution DAC System for the Magnet Power Supply

Ki-Hyeon Park, Yeong-Jin Han, Seong-Hun Jeong, Dong Eon Kim (PAL, Pohang, Kyungbuk), Bong-Koo Kang (POSTECH, Pohang, Kyungbuk)

Many different kinds of magnet power supply (MPS) are used to the accelerator machine in PLS. Nowadays the digital technology using the DSP and FPGA has been applying to the MPS to achieve the good performance. But in some cases the conventional analog controller for the MPS is required, if then, the DAC board is inevitably needed to set the reference voltage. As demand for the high precision on the MPS was increased, the high resolution of the DAC board has to be applied to the MPS. Here, a simple method to get the more than 20-bit resolution, 32-bit resolution theoretically, was introduced. Two 16-bit DACs was connected in series using the digital and analog techniques, which showed the good responses while circuits was simple and the cost was cheap. The architecture of the DAC board and various test results are presented in this paper.

TUPPH087: Real-Time Ellipsometry for Monitoring the Growth of Cesium-Telluride Photocathodes

Peter van der Slot, Klaus Boller, Rolf Loch, Mark Luttikhof, Liviu Prodan (Mesa+, Enschede)

Semiconductor photocathodes, especially Cesium-Telluride photocathodes, are vital for generation of high brightness electron beams used in free-electron lasers. However the quantum efficiency and lifetime depends critically on manufacturing and operational conditions. Monitoring the formation of the photocathode is essential for understanding these dependencies. For example, the deposition rate of the Cs correlates to the quantum efficiency and adversely correlates to the lifetime. We will discuss the use of ellipsometry for monitoring the formation of the photocathode, describe our experimental configuration and discuss preliminary results obtained with CsTe photocathodes. These results seems to indicate that ellipsometry is a viable method for monitoring the formation of CsTe photocathodes.

This research is supported by the European Community, Research Infrastructure Activity under the FP6 “Structuring the European Research Area” program (CARE, Contract No. RII3-CT-2003-506395).

TUPPH088: Magnets, Supports, and Controls for the Linac Coherent Light Source (LCLS) Undulator System

Marion White, Jeffrey Todd Collins, Geoffery Pile, Shigemi Sasaki, Steven Shoaf, S. Joshua Stein, Emil Trakhtenberg, Isaac Vasserman, Joseph Z. Xu (ANL, Argonne, Illinois)

The LCLS, now under construction at the Stanford Linear Accelerator Center (SLAC) in California, will be the world’s first x-ray free-electron laser when it comes online next year. Design and production of the undulator system is the responsibility of a team from the Advanced Photon Source (APS) at Argonne National Laboratory (ANL). Forty 3.4-m-long high-precision undulators, 37 laminated quadrupole magnets, plus 38 support and motion systems with micron-level adjustability and stability have been constructed and delivered to SLAC. Argonne’s computer control and monitoring system enables the undulator girders and all components mounted on them to be accurately positioned. An overview of these systems will be presented, including achieved results.

Work supported by U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

TUPPH089: Vacuum and Beam Diagnostics for the Linac Coherent Light Source (LCLS) Undulator System

Marion White, William Berg, Patric Den Hartog, Mark Erdmann, Soon-Hong Lee, Robert M. Lill, Geoffery Pile, Emil Trakhtenberg, Dean Walters, Greg Edward Wiemerslage, Bingxin Yang (ANL, Argonne, Illinois)

The LCLS, now under construction at the Stanford Linear Accelerator Center (SLAC) in California, will be the world's first x-ray free-electron laser when it comes online next year. Design and production of the vacuum and beam diagnostics is the responsibility of a team from the Advanced Photon Source (APS) at Argonne National Laboratory (ANL). The 3.4-m-long vacuum chambers are made from aluminum extrusions, machined to tight tolerances, and with together with a suite of precision beam diagnostic instrumentation, has been constructed and delivered to SLAC for installation. An overview of these systems, including achieved results, will be presented.

Work supported by U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357

TUCAU Storage Ring FELs, Tuesday 16:10 - 17:35

TUCAU01: Characterizing the efficiency of Harmonic Generation in Planar and Helical Undulators

Enrico Allaria, Miltcho B. Danailov, Bruno Diviacco, Carlo Spezzani, Mauro Trovo (ELETTRA, Basovizza, Trieste), Marcello Coreno (CNR - IMIP, Trieste), Giovanni De Ninno (ELETTRA, Basovizza, Trieste; University of Nova Gorica, Nova Gorica), Francesca Curbis (MAX-lab, Lund)

A detailed experimental study for the characterization of the process of coherent harmonic generation in single-pass free electron lasers has been done at the Elettra storage ring. For this purpose, a powerful seed Ti:Sa laser has been used in combination with two independently tunable APPLE II undulators. This configuration allowed us to explore the different configurations producing coherent emission at the harmonics of the seed wavelength. Particular attention has been devoted to the characterization of the spatial distribution of the produced emission in order to contribute to the debate about a presence of coherent emission on-axis in helical undulators. The power spatial distribution was compared with theoretical predictions: experimental results provide a confirmation of recent theoretical studies*, which predict no harmonic coherent signal on-axis in case of helical undulators.

* G. Geloni et al., Nucl. Instr. Meth. A 581, 856 (2007).

TUCAU02: Intense Terahertz Radiation from a Storage Ring Driving a Free Electron Laser.

Masahito Hosaka, Yoshifumi Takashima (Nagoya University, Nagoya), Akira Mochihashi (JASRI/SPring-8, Hyogo-ken), Miho Shimada (KEK, Ibaraki), Toshiharu Takahashi (KURRI, Osaka), Masahiro Katoh, Shin-ichi Kimura (UVSOR, Okazaki)

We have discovered a new process of production of coherent synchrotron radiation in the terahertz region. At the UVSOR-II, a storage ring free electron laser is operated from visible to DUV (199 nm) region. An intense terahertz radiation is observed from an electron beam when the FEL is operated in Q-switch mode. The experiment was made with a visible wavelength FEL around 520 nm and the terahertz radiation from a bending magnet was detected using a bolometer. Simultaneous measurement of the terahertz radiation and the FEL pulse reveals that the intense radiation is emitted in the growing phase of the laser. The spectrum of the radiation was measured by using a Martin-Puplett interferometer and it was found that the radiation ranges from 5 to 20 cm^{-1}. However, the pulse duration of the Q-switch FEL around 50 pico-sec seems too long to produce the radiation. Microstructure of the Q-switch FEL pulse, which originates from the shot noise startup, is considered to be the origin of the radiation.

TUCAU03: Control of FEL Oscillator Instabilities Using Optical feedback: Phase-shift Effects

Christophe Szwaj, Serge Bielawski, Clement Evain (PhLAM/CERCLA, Villeneuve d'Ascq Cedex), Akira Mochihashi (JASRI/SPring-8, Hyogo-ken), Masahito Hosaka, Yoshifumi Takashima (Nagoya University, Nagoya), Marie-Emmanuelle Couprie (SOLEIL, Gif-sur-Yvette)

When detuned, the output of a FEL oscillator is dominated by a transient amplification of the spontaneous emission noise. This leads to strong fluctuations of the intensity, and appearance of laser pulse microstructures. It is known that such instabilities can be suppressed by using optical feedback from an external mirror (the so-called coherent photon seeding technique). The key ingredient of the control scheme is to take advantage of the large transient amplification of the detuned SR-FEL. This allows to perform efficient control (noise suppression), using extremely small amounts of re-injected power (<1e-8 in the UVSOR-II experiments). Here we study experimentally and theoretically this control process and in particular the effect of phase-shift ocuring in the optical feedback path. We show that it can lead to the creation of new patterns in the laser pulse structure.

TUCAU04: Second Harmonic Lasing with Storage Ring Based FELs

Y. K. Wu, Jingyi Li, Stepan F. Mikhailov, Victor Popov (FEL/Duke University, Durham, North Carolina), Stephen Vincent Benson, George R. Neil (Jefferson Lab, Newport News, Virginia)

The study of forbidden processes in many types of physical systems is critical for understanding the underlying symmetry breaking. The FEL second harmonic lasing of provides a unique opportunity to study the "forbidden" FEL gain mechanisms which are otherwise not allowed under normal operation conditions of an FEL. Because of its very low gain, the sole study of second harmonic lasing in the optical region was reported by the JLab using its high-gain IR FEL (PRL, 084801, 2001). This work reports the first second harmonic lasing results at Duke University with the storage ring based optical klystron and distributed optical klystron FELs. Several different mechanisms have been proposed for the second harmonic lasing, including relative misalignments between electron and optical beams, transverse field gradients, and longitudinal coupling (NIM A483, p. 527, 2002). Different gain mechanisms can also lead to preferred polarization states. In order to understand and distinguish various gain mechanisms, our work focuses on measurements of the gain and polarization of the second harmonic lasing under various optical and electron beam conditions and for a variety of FEL configurations.

This work is supported by the medical FEL grant F49620-001-0370 from the Air Force Office of Scientific Research.

THAAU FEL Technology I, Thursday 09:00 - 10:50

THAAU01: Design and Production of the Undulator System for the Linac Coherent Light Source (LCLS)

Geoffery Pile, James L. Bailey, Thomas Barsz, William Berg, Jeffrey Todd Collins, Patric Den Hartog, Horst Walter Friedsam, Mark Jaski, Soon-Hong Lee, Robert M. Lill, Elizabeth Rahm Moog, James Morgan, Shigemi Sasaki, Steven Shoaf, Laura Skubal, S. Joshua Stein, William F. Toter, Emil Trakhtenberg, Isaac Vasserman, Dean Walters, Marion White, Greg Edward Wiemerslage, Joseph Z. Xu, Bingxin Yang (ANL, Argonne, Illinois), Heinz-Dieter Nuhn (SLAC, Menlo Park, California)

The LCLS, now under construction at the Stanford Linear Accelerator Center (SLAC) in California, will be the world's first x-ray free-electron laser when it comes online next year. LCLS design and construction are being performed by a partnership of three US National Laboratories, Argonne National Laboratory (ANL), Lawrence Livermore National Laboratory (LLNL), and SLAC. A team from Argonne's Advanced Photon Source is responsible for design and construction of the high-precision, state-of-the-art undulator system, including the undulators, quadrupoles, sub-micron-precision beam diagnostics, vacuum chambers, ultra-stable and micron-level-settablesupport and motion system, and computer control and monitoring. An overview of the design, achieved precision, and stability results will be presented, together with the production status of the LCLS undulator system.

Work supported by U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

THAAU02: Initial Commissioning Experience with the Superconducting RF Photoinjector at ELBE

Jochen Teichert, Andre Arnold, Hartmut Buettig, Dietmar Janssen, Matthias Justus, Ulf Lehnert, Peter Michel, Petr Murcek, Arndt Schamlott, Christof Schneider, Rico Schurig, Friedrich Staufenbiel, Rong Xiang (FZD, Dresden), Thorsten Kamps, Jeniffa Rudolph, Mario Schenk (BESSY GmbH, Berlin), Guido Klemz, Ingo Will (MBI, Berlin)

A radio frequency photo injector with a superconducting acceleration cavity (SRF gun) for installation at the Radiation Source ELBE was developed within a collaboration of BESSY, DESY, FZD, and MBI. The aim of the project is to improve the electron beam quality and to extend the parameter range of the ELBE accelerator. Especially the bunch charge will be increased up to 1 nC and the transverse emittance will be reduced to 1 - 3 mm mrad. At present, the thermionic injector at ELBE delivers bunches of 77 pC at about 8 mm mrad. Furthermore, the SRF gun together with its diagnostic beam line is an excellent test bench for extended studies and improvements of this new and promising injector type. The gun cryostat, the electron diagnostic beamline, and the driver laser with optical beamline were installed in summer and fall 2007. In November the first beam was produced. It will be reported on the experience gained at the first phase of commissioning. Results of rf and beam parameter measurements with Cu and Cs2Te photo cathodes will be presented.

THAAU03: Design Study on a Short-period Hybrid Staggered-Array Undulator by Use of High-Tc Superconducting Magnets

Ryota Kinjo, Keisuke Higashimura, Toshiteru Kii, Kai Masuda, Hideaki Ohgaki, Heishun Zen (Kyoto IAE, Kyoto)

Development of short-period undulators is one of the most intensive interests in FEL research, with reduced energy requirements and accordingly reduced cost for electron linacs, which is supposed to expand the use of FELs in diverse applications. In this context, we propose use of high-Tc superconducting magnets in the hybrid staggered-array undulator configuration*. The reason for the choice of the configuration is that magnetization of the superconducting magnets can be performed by a single solenoid, since the magnetization direction of the magnets to be set are all in the axial direction. The present undulator is expected to show such advantages as a short period with high magnetic induction by the superconducting magnets, and a rapid control of undulator fields and the resultant FEL wavelength by means of the solenoid current. In this paper, we discuss the results from characteristic analyses to show the potential advantages of the present undulator, by the use of a magnetic field solver taking into account the distinctive magnetic field distribution induced by high-Tc superconducting magnets. Also presented are the measurement results of undulator fields in a prototype.

* S. Sasaki, Proceedings of 2005 PAC, pp. 982-984 (2005)

THAAU04: Development of Diamond Field-Emitter Arrays for Free-Electron Lasers

Jonathan D. Jarvis, Heather L. Andrews, Charles A. Brau (Vanderbilt University, Nashville, TN), Bo Kyoung Choi, Jimmy Davidson, Weng Kang, Supil Raina, Yong Mui Wong (Vanderbilt University, Nashville, Tennessee)

We report recent advances in the development of diamond field-emitter arrays as a promising electron source for free-electron lasers. Both sparse and close-packed arrays have been produced using an inverse-mold transfer process. High-pitch arrays have been used in the development of conditioning techniques, which drive the emitters toward uniformity in a self-limiting fashion. Properties of these cathodes including I-V response, emitted energy spread, transverse emittance, temporal stability, and operational lifetime are being examined in two DC teststands. Highly uniform, stable emission current of 15 microamps (DC) per tip has been achieved. The resulting high-input-power density destroyed the phosphor anode locally; therefore, higher currents could not be attempted. In an RF gun, pulsed picosecond operation will allow much higher peak currents, and back bombardment from sublimated anode material will not be present. The maximum DC-current densities observed scale to approximately 300 Amps per square centimeter for fine-pitch arrays, demonstrating great promise for use in free-electron lasers.

THAAU05: Latest Electron Beam Characterization Results at the Upgraded PITZ Facility

Charles H. Boulware, Galina Asova, Juergen W. Baehr, Hans-Juergen Grabosch, Levon Hakobyan, Marc Hänel, Yevgeniy Ivanisenko, Martin Avetic Khojoyan, Mikhail Krasilnikov, Sven Lederer, Bagrat Petrosyan, Dieter Richter, Sakhorn Rimjaem, Juliane Roensch, Thomas Scholz, Andrey Shapovalov, Roman Spesyvtsev, Lazar Staykov, Frank Stephan (DESY Zeuthen, Zeuthen)

The Photo Injector Test facility at DESY, Zeuthen site, (PITZ) develops and optimizes electron sources for high-power, short-wavelength FELs such as FLASH and the European XFEL. PITZ has now restarted operation after a very significant upgrade. A new laser system has been installed which, when fully commissioned, is expected to deliver 20 ps-long pulses with rise and fall times of 2 ps. According to beam dynamics simulations, these pulse profiles will result in a further reduction in the obtainable transverse projected emittance when compared to the results presented in the last several years. Also, a new 1.5-cell L-band gun with improved cooling channel design has been installed. A new dry-ice cleaning method was employed during this gun's preparation, and conditioning results from this gun show significantly decreased dark current compared with the summer 2007 run. We describe the new stage of the facility, report the complete conditioning results from the new electron gun, give an overview of the experimental results from the 2008 run period, and present a description of the additional planned upgrades toward the full operating design of the facility.

This work has partly been supported by the European Community, contracts RII3-CT-2004-506008 and 011935, and by the 'Impuls- und Vernetzungsfonds' of the Helmholtz Association, contract VH-FZ-005.

THBAU FEL Technology II, Thursday 11:10 - 13:00

THBAU01: Observation of Coherent Optical Transition Radiation in the LCLS Linac

Henrik Loos, Ron Akre, Franz-Josef Decker, Yuantao Ding, David Dowell, Paul Emma, Josef Frisch, Sasha Gilevich, Gregory R. Hays, Philippe Hering, Zhirong Huang, Richard Iverson, Cecile Limborg-Deprey, Alan Miahnahri, Heinz-Dieter Nuhn, James Leslie Turner, James Welch, William White, Juhao Wu (SLAC, Menlo Park, California), Daniel Ratner (Stanford University, Stanford, Califormia)

The beam diagnostics in the linac for the Linac Coherent Light Source (LCLS) X-ray FEL project at SLAC includes optical transition radiation (OTR) screens for measurements of transverse and longitudinal beam properties. We report on observations of coherent light emission from the OTR screens (COTR) at visible, near-IR and UV wavelengths from the uncompressed and compressed electron beam at various stages in the accelerator.

Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract DE-AC03-76SF00515

THBAU02: Observation of 40 fs Synchronization of Electron Bunches for FELs

Florian Loehl, Vladimir Arsov, Matthias Felber, Lars Froehlich, Kirsten Elaine Hacker, Bastian Lorbeer, Frank Ludwig, Karl-Heinz Matthiesen, Holger Schlarb, Bernhard Schmidt, Axel Winter (DESY, Hamburg), Wojciech Jalmuzna (TUL-DMCS, Lodz), Jaroslaw Szewinski (The Andrzej Soltan Institute for Nuclear Studies, Swierk/Otwock), Christopher Behrens, Sebastian Schulz, Stephan Wesch, Johann Zemella (Uni HH, Hamburg)

State of the art XUV-light and X-Ray light sources like FLASH or the planned European XFEL produce light pulses with durations down to a few femtoseconds. To fully exploit the experimental opportunities offered by these light pulses, synchronization of the FEL facility on the same time scale is required. To meet these high demands, which can not be fulfilled by conventional, coaxial RF distribution schemes, at different laboratories, optical synchronization systems are developed. At FLASH, a prototype system consisting of a mode-locked, Er-doped fiber laser, two fiber links which are stabilized by optical cross-correlation to sub-10 fs, and two electro-optical bunch arrival time monitors with resolutions below 10 fs has been installed and tested recently. We report on our experience with the system and describe its use for an intra bunch train arrival time feedback with which we could improve the arrival time stability of the electron bunches from above 200 fs for the unstabilized case to 40 fs with the feedback active.

THBAU03: Femtosecond Synchronization of Large-Scale X-ray Free Electron Lasers

Franz Xaver Kaertner, Jeff Chen, Jung-Won Kim (MIT, Cambridge, Massachusetts)

Future X-ray free-electron lasers require femtosecond timing accuracy between electron beams and optical lasers for improved FEL performance and to study the spatiotemporal dynamics of ultrafast processes. We present a set of new ultrafast optical techniques for long-term stable femtosecond synchronization of large-scale X-ray free-electron lasers. We use low-noise optical pulse trains generated from mode-locked lasers as timing signals, and distribute them via timing-stabilized fibre links to end-stations where tight synchronization is required. At the end-stations, optical and microwave sub-systems are synchronized with the delivered timing signals. Using these techniques, we demonstrate that remotely located lasers and microwave sources can be synchronized with femtosecond accuracy over typical operating periods of free-electron lasers. Specifically, we experimentally demonstrate timing and synchronization of multiple lasers and microwave sources over 300 m long fiber links with sub-10 fs precision over more than eight hours.

This work was supported by the EuroFEL program, ONR, AFOSR, DARPA, NSF and the University of Wisconsin. J.K. acknowledges a doctoral fellowship from the Samsung Scholarship Foundation.

THBAU04: Results from the Optical Replica Experiments in FLASH

Shaukat Khan, Joern Boedewadt (Uni HH, Hamburg), Atoosa Meseck (BESSY GmbH, Berlin), Florian Loehl, Evgeny Saldin, Holger Schlarb, Evgeny Schneidmiller, Axel Winter, Mikhail Yurkov (DESY, Hamburg), Peter Salen, Peter van der Meulen (FYSIKUM, AlbaNova, Stockholm), Mats Larsson (Stockholm University, Stockholm), Gergana Vasileva Angelova, Volker Ziemann (UU/ISV, Uppsala)

We present experimental results from the optical replica synthesizer,a novel device to diagnose sub-ps electron bunches by creating a coherent optical pulse in the infrared that has the envelope of the electron bunch and analyzing the latter by frequency resolved optical gating methods. Such a device was recently installed in FLASH at DESY. During an experiment period the spatial and temporal overlap of a several ps long electron bunch and a 200 fs laser pulse were achieved within an undulator. Coherent transition radiation due to the induced micro-bunching was observed on a silver-coated silicon screen and varying the timing between electrons and laser pulse produced two-dimensional images of the slices as a function of the longitudinal position within the electron bunch. In a second experiment the strongly compressed electron bunch is modulated by the laser pulse and replica pulses that are emitted from a second undulator are observed and diagnosed by frequency resolved optical gating methods.

supported by UU-SU-KTH FEL-Center

THBAU05: COTR and SASE Generated by Compressed Electron Beams

Alex Lumpkin (Fermilab, Batavia, Illinois), Nicholas Sereno (ANL, Argonne, Illinois)

Observations of strongly enhanced optical transition radiation (OTR) following significant bunch compression by a chicane of photoinjector beams have been reported during the commissioning of the Linac Coherent Light Source (LCLS) accelerator and at the Advanced Photon Source (APS) linac. These localized transverse spatial features involve signal enhancements of nearly a factor of ten in the APS case at the 150-MeV and 375-MeV OTR stations. They are consistent with a coherent process seeded by noise and may be evidence of a longitudinal microbunching instability which leads to coherent OTR (COTR) emissions. Additionally, we suggest that localized transverse structure in the previous self-amplified spontaneous emission (SASE) free-electron laser (FEL) data at APS in the visible-UV regime as reported at FEL02 may be attributed to such beam structure entering the FEL undulators and seeding the SASE. In one specific case, the SASE process enhanced separate beam structures 120 microns apart in x and 2.9 nm apart in wavelength. The details of these observations and operational parameters will be presented.

Operated by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the United States Department of Energy.

THCAU High Power FELs, Thursday 14:00 - 15:50

THCAU01: Commissioning of Novosibirsk Multi-pass Energy Recovery Linac

Nikolay Vinokurov, Evgeny Dementyev, Boris Dovzhenko, Nikolai Gavrilov, Boris Aleksandrovich Knyazev, Evegeniy I. Kolobanov, Vitaly V. Kubarev, Gennady N. Kulipanov, Alexander N. Matveenko, Lev E. Medvedev, Sergey Vladimirovich Miginsky, Leontii Mironenko, Vladimir Kirilovich Ovchar, Vasiliy M. Popik, Tatiana Vladimirovna Salikova, Mikhail A. Scheglov, Stanislav S. Serednyakov, Oleg A. Shevchenko, Alexander Skrinsky, Vladimir G. Tcheskidov, Yury Tokarev, Pavel Vobly (BINP SB RAS, Novosibirsk)

Novosibirsk energy recovery linac (ERL) facility is planned to use the same RF system and electron gun to run three different FELs. First FEL, installed on the ERL orbit, which lies in the vertical plane is in operation from 2003. It provides average power up to 500 W in the wavelength range 110 - 240 micron since 2004 works for users. Four orbits in the horizontal plane were added this year. It is planned to have two additional FELs at the second (20 MeV) and fourth (40 MeV) tracks of ERL. The operation mode with one of three FELs may be chosen by switching of some magnets. Recently the two-orbit mode of ERL (for the second FEL operation) was commissioned successfully. The beam passed four times through the accelerating RF cavities and was absorbed in the beam dump. Thus, the first in the world two-orbit ERL is in operation now. Some details of design, status of the facility and plans are discussed.

THCAU02: Development of High-average-current RF Injectors

Dinh C. Nguyen (LANL, Los Alamos, New Mexico)

A key component of the high-average-power free-electron laser is a low emittance, high-average-current RF injector. The RF injector typically consists of a high gradient structure with integer-and-a-half RF cells. The cathode is located on the wall of the first half cell where very high accelerating gradients are applied to quickly accelerate electrons to relativistic velocities. While the average gradient can exceed 100 MV/m in a pulsed normal conducting RF injector, it is only 7 MV/m in a cw normal-conducting RF gun and approximately 25 MV/m in a cw superconducting RF gun. Emittance compensation has been achieved in NCRF injectors with an axial solenoid magnetic field near the photocathode to generate nanocoulomb bunch charge with low rms emittance. The use of emittance compensation eliminates the need for ultrahigh accelerating gradients, and enables the generation of nanocoulomb bunches with normalized rms emittance on the order of a few mm-mrad. This paper reviews the current state-of-the-art of cw, high-average-current RF injectors, using both normal-conducting and superconducting RF accelerator technologies.

D.C. Nguyen et al., Nucl. Instr. Meth. Phys. Res., A 528 (2004) 71-77. A. Arnold et al., Nucl. Instr. Meth. Phys. Res., A 577 (2007) 440-454.

THCAU03: Electron Beam Timing Jitter And Energy Modulation Measurements At JLab ERL

Pavel Evtushenko, Daniel Sexton (Jefferson Lab, Newport News, Virginia)

When operating JLab high current ERL a strong reduction of the FEL efficiency was observed when increasing the average electron beam current. Investigating the FEL efficiency drop-off with the electron beam average current we also have measured the electron beam phase noise and the fast energy modulations. The so-called phase noise is essentially a variation of the time arrival of the electron bunches to the wiggler. That could be a very effective way of reducing the FEL efficiency if one takes in to account that the accelerator is routinely operated with the RMS bunch length of about 150 fs. Under a fast energy modulation we mean a modulation which can not be followed by the FEL due to its time constant, defined by the net gain. Such a modulation also could be a possible cause of the efficiency drop-off. Having the measurements made we could rule out the FEL efficiency drop-off due to either the fast energy modulation or the phase modulation. We also have learned a lot about instrumentation and techniques necessary for this kind of beam study. In this contribution we describe the used instrumentation and present results of the measurements.

Authored by Jefferson Science Associates, LLC under U.S. DOE Contract No. DE-AC05-06OR23177.

THCAU04: Development and Upgrade of High-power Drive Lasers for High-current and High-charge Photocathode Injector at the Jefferson Lab Free-electron-laser Facility

Shukui Zhang, Stephen Vincent Benson, Al Grippo, Joe Gubeli, George R. Neil, Matt Poelker, Tom Powers, Daniel Sexton, Michelle Diane Shinn (Jefferson Lab, Newport News, Virginia)

Over the last few years we have steadily increased the laser power at the Jefferson Lab Free-electron-laser (FEL) Facility culminating most recently with over 14 kW average power in tunable femtosecond optical pulses. The photocathode injector for the Energy-recovery-linac (ERL) accelerator, capable of delivering 10 mA of short electron bunches, was driven by a flash-lamp-pumped CW modelocked YLF laser. Our next generation injector is expected to produce ten times higher current and requires much more laser power than this laser can provide. In this paper we describe the recent upgrade of a drive laser system that allows generation of both high current at 100 mA level and nC high charge electron bunches. We will focus on the aspects of our development efforts and experience dealing with key issues specifically related to drive lasers for ERL-based high power FELs such as phase noise, temporal and spatial manipulation of beams, synchronization and essential controls. A brief review and discussion about the pros and cons of different technical routes using state-of-the-art lasers for building photoinjector drive lasers, including possible configurations will also be presented.

This work is supported by the Office of Naval Research, JTO, the Commonwealth of Virginia, the Army Night Vision Laboratory, the Air Force Research Laboratory, and by DOE Contract DE-AC05-060R23171.

THCAU05: Generation of stable GeV-class electron beams from laser-plasmas and their applications in compact FELs

Nasr Hafz, Jongmin Lee (APRI-GIST, Gwangju)

Laser-plasma produced by ultraintense femtosecond laser pulses is an emerging particle acceleration technology which promises a revolutionary impact in the field of high-energy particle accelerators. Electric fields inside a plasma bubble created by intense ultrashort laser pulse can be several orders of magnitude higher than those available in conventional RF-based particle accelerator facilities. Therefore, an electron bunch can gain relativistic energies within an extremely short distance. We present results* that demonstrate the first generation of stable and reproducible sub GeV, GeV and beyond 1 GeV electron beams from a few-millimeters long plasma channels produced by self-guided laser pulses in gas jet targets. The qualities of those electron beams are now approaching the requirements for applications such as compact synchrotrons and FELs. Based on our laser-plasma electron beams, we are planning on building undulators at APRI aiming to realize compact synchrotron and FEL light sources.

* N. Hafz et al., “Stable generation of GeV-class electron beam from self-guided laser-plasma channels “ Nature Photonics, in press.

This work was supported by the Ministry of Knowledge and Economy of Korea through the Ultra-short Quantum Beam Facility Program.

THDAU FEL Applications, Thursday 16:10 - 18:00

THDAU01: Light Field Driven Streak-camera: Towards a Single Pulse Time Structure Measurement at FLASH

Ulrike Fruehling, Michael Gensch, Elke Plönjes (DESY, Hamburg), Filip Budzyn, Markus Drescher, Thomas Gebert, Oliver Grimm, Roland Kalms, Maria Krikunova, Jörg Rossbach, Marek Wieland (Uni HH, Hamburg)

The Free-Electron Laser in Hamburg (FLASH) produces short intense XUV light pulses using Self-Amplified Spontaneous Emission (SASE). Because the lasing in a SASE-FEL starts from shot noise energy, wavelength and time-structure fluctuate from shot to shot. Thus, a single shot measurement of the FLASH temporal profile is of significant interest. For this purpose, the XUV pulses from FLASH are superimposed with far infrared (FIR) light pulses, that are generated by the same electron bunch in a second undulator* and therefore are expected to be intrinsically synchronized to the XUV pulse. In contrast to a conventional streak camera, the solid state photocathode is substituted by free noble gas atoms, which are ionized by the XUV pulses. The created photoelectrons are accelerated by the time-dependent electric field of the infrared light pulse, where the momentum gain depends on the FIR electric field at the ionization time. By measuring the photoelectron momenta we are able to sample the FIR light field. Moreover, single-shot spectra have been obtained that deliver information on the temporal profile of individual XUV pulses.

* M. Gensch et al., Infrared Phys. Techn.,(2008)

THDAU02: Resonant Magnetic Scattering with Femtosecond Soft X-ray Pulses from a Free Electron Laser at 1.59 nm

Christian Gutt, Lorenz Stadler (DESY, Hamburg)

Single pass FEL provide uniquely intense, coherent short-pulse radiation in the EUV range with the shortest wavelength being 6.5 nm up to now. Spectacular new possibilities open up when extending the photon energy of today's FEL to the x-ray regime where inner shell electrons carrying magnetic moments can be excited. It was shown recently that bright emission SASE can actually be produced at harmonics of the fundamental mode. Using the fundamental wavelength of the free electron laser facility FLASH at 8 nm we were able to detect the third harmonic at 2.66 nm and the fifth harmonic at 1.6 nm with an average energy of 4 nJ per pulse which constitutes the shortest wavelength ever measured with a SASE FEL. With this wavelength we were able to reach the L3 absorption edge of Co and performed the first ever resonant magnetic scattering experiment using SASE radiation with pulses of durations of about 10 femtoseconds. This breakthrough paves the way for single pulse, ultrafast magnetic scattering experiments yielding information about the fundamental physics of magnetization dynamics which is of outmost importance for magnetic storage technology.

THDAU03: Action Spectroscopy with FELIX and FELICE

Britta Redlich (FOM Rijnhuizen, Nieuwegein)

It has been demonstrated that FELs such as FELIX provide unique opportunities for studies of (bio) molecules, ions, clusters and complexes in the gas-phase using different methods of action spectroscopy, combining infrared spectroscopy and mass spectrometry. As the absorption cross section of the various gas samples is very low these methods require a widely tunable and intense infrared laser source. An overview on recent activities in this field at the FELIX facility will be presented. Examples of studies on biomolecules are discussed, where the standard methods in mass-spectrometry predominantly yield information on the primary structure of the biomolecule but the combination with infrared spectroscopy potentially also gives (detailed) insight into the higher order structures. Relevant to the field of heterogeneous catalysis are pure metal cluster systems as well as cluster complexes. These have been studied at great detail especially motivated by the structural information that can be collected in the far-infrared spectral regime. First examples of experiments in the field of action spectroscopy with the new beam line FELICE for intra-cavity experiments will be discussed.

THDAU04: Non-thermal Laser Machining with ERL-FELs for Nuclear Industries

Eisuke John Minehara (JAEA/FEL, Ibaraki-ken)

Continuous-wave (CW) lasers such as fiber lasers and CO2 laser have been used in cutting and welding of thick metal material in heavy metal industries. A high-power ERL-FEL, which produces femto-second laser pulses, first realizes non-thermal laser machining as totally opposed to thermal machining by the CW lasers. We have applied ERL-FELs to machining of structural material and fuel assemblies of nuclear power plants. After the machining, we also made x-ray residual stress measurement and hardness testing for the testing material. From these experiments, we have clearly demonstrated non-thermal machining by high-power femto-second FEL pulses, which can be applied to large-scale machining such as nuclear industries.

Work supported by in part by Grants-in-Aid for Scientific Research(A19206103)

THDAU05: Progress with FEL-based Coherent Electron Cooling

Vladimir N. Litvinenko, Ilan Ben-Zvi, Michael Blaskiewicz, Alexei V. Fedotov, Dmitry Kayran, Eduard Pozdeyev, Dejan Trbojevic, Gang Wang (BNL, Upton, Long Island, New York), Yaroslav Derbenev (Jefferson Lab, Newport News, Virginia), George I. Bell, David L. Bruhwiler (Tech-X, Boulder, Colorado), Sven Reiche (UCLA, Los Angeles, California)

Cooling intense high-energy hadron beams remains a major challenge for accelerator physics. Synchrotron radiation is too feeble, while efficiency of two other cooling methods falls rapidly either at high bunch intensities (i.e. stochastic cooling of protons) or at high energies (i.e. e-cooling). Possibility of coherent electron cooling based on high-gain FEL and ERL was presented at last FEL conference*. This scheme promises significant increases in luminosities of modern high-energy hadron and electron-hadron colliders, such as LHC and eRHIC. In this talk we present progress in development of this concept, results of analytical and numerical evaluation of the concept as well our prediction for LHC and RHIC. We also present our plan and design for proof-of-principle experiment at RHIC using existing R&D ERL.

* V.N.Litvinenko,Y.S. Derbenev, Proc. of 29th International FEL Conference, Novosibirsk, Russia, August 27-31, 2007, p.268, http://accelconf.web.cern.ch/accelconf/f07/HTML/AUTHOR.HTM

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FRAAU FEL Operation, Friday 09:00 - 10:50

FRAAU01: Status of FLASH

Katja Honkavaara, Bart Faatz, Siegfried Schreiber (DESY, Hamburg)

FLASH, the FEL user facility at DESY, is operated with an electron beam energy up to 1 GeV corresponding to a photon wavelength down to 6.5 nm. The shutdown in summer 2007 was followed by a three month commissioning and study period. A new run of FEL experiments started in November 2007. The full year 2008 is dedicated to beam operation: about half of the time is scheduled for FEL users, and the rest for accelerator and FEL physics studies. Here we report the present status of FLASH as a FEL user facility.

FRAAU02: SASE Saturation at the SCSS Test Accelerator Ranging from 50 nm to 60 nm

Takashi Tanaka, Takanori Tanikawa (RIKEN Spring-8 Harima, Hyogo), Takao Asaka, Haruhiko Ohashi, Sunao Takahashi (JASRI/SPring-8, Hyogo-ken), Toru Fukui, Toru Hara, Atsushi Higashiya, Naoyasu Hosoda, Takahiro Inagaki, Shinobu Inoue, Tetsuya Ishikawa, Hideo Kitamura, Masanobu Kitamura, Hirokazu Maesaka, Mitsuru Nagasono, Takashi Ohshima, Yuji Otake, Tatsuyuki Sakurai, Tsumoru Shintake, Katsutoshi Shirasawa, Hitoshi Tanaka, Kazuaki Togawa, Makina Yabashi (RIKEN/SPring-8, Hyogo)

At SPring-8, XFEL facility based on the SCSS (SPring-8 Compact SASE Source) concept is now under construction. As a prototype of the XFEL machine, a test accelerator was constructed in 2005. First FEL amplification was observed in June 2006 although SASE saturation was not achieved at that time. This is mainly attributable to large magnetic error components in one of the two undulator segments. In order to achieve saturation, magnetic arrays of the erroneous undulator have been replaced with new ones in August 2007. In September 2007, beam commissioning aiming at SASE saturation at 60 nm, the longest wavelength available at the minimum undulator gap of 3 mm, has been started. The SASE saturation was confirmed in October, by measuring the radiation power and fluctuation as a function of the undulator gap, instead of measureing the gain curve, i.e., the radiation power as a function of the undulator length. Detailed analysis of the measurement results made with a 3-D FEL simulation code suggests that the electron beam emittance does not deteriorate during the bunch compression process. This is a very encouraging result toward realization of the XFEL based on the SCSS concept.

FRAAU03: Investigation and Improvement of Beam Stability at the ELBE FEL's

Peter Michel, Matthias Justus, Ulf Lehnert, Dieter Proehl, Rico Schurig, Wolfgang Seidel, Jochen Teichert (FZD, Dresden)

At the radiation source ELBE in the Forschungszentrum Dresden-Rossendorf two free electron lasers (4-20 µm and 20-230 µm) are in routine user operation for a wide range of IR experiments for some years. The lasers are driven by a superconducting RF Linac which permits the generation of a cw-beam with high average beam power. For many experiments the frequency and power stability of the laser beam is of outstanding importance. Therefore studies on fluctuations and drifts in different time scales (from µs to hours) were accomplished and possible causes for these instabilities were investigated. To improve the long and short term stability we developed and implemented active feed back controls for electron energy and thus laser wavelength and out-coupled IR-beam power at ELBE.

FRAAU04: Commissioning of the LCLS Linac and Bunch Compressors

Paul Emma, Ron Akre, Axel Brachmann, Franz-Josef Decker, Yuantao Ding, David Dowell, Josef Frisch, Sasha Gilevich, Gregory R. Hays, Philippe Hering, Zhirong Huang, Richard Iverson, Cecile Limborg-Deprey, Henrik Loos, Alan Miahnahri, Stephen Molloy, Heinz-Dieter Nuhn, James Leslie Turner, James Welch, William White, Juhao Wu (SLAC, Menlo Park, California), Daniel Ratner (Stanford University, Stanford, Califormia)

The Linac Coherent Light Source (LCLS) is a SASE x-ray Free-Electron Laser (FEL) project under construction at SLAC*. The injector section, from drive-laser and RF photocathode gun through the first bunch compressor chicane, was commissioned in the spring and summer of 2007. The second phase of commissioning, including the second bunch compressor chicane and various main linac modifications, was completed in January through August of 2008. We report here on experience gained during this second phase of machine commissioning, including the injector, the first and second bunch compressor stages, the linac up to 14 GeV, and the various beam diagnostics and measurements. The final commissioning phase, including the undulator and the long transport line from the linac, is set to begin in December 2008, with first light in July 2009.

* J. Arthur et al. SLAC-R-593, April 2002.

Work supported by US DOE contract DE-AC02-76SF00515

FRAAU05: Cathodes Issues at the FLASH Photoinjector

Siegfried Schreiber, Sven Lederer (DESY, Hamburg), Paolo Michelato, Laura Monaco, Daniele Sertore (INFN/LASA, Segrate (MI))

At the free-electron laser user facility FLASH at DESY cesium telluride photocathodes are in use in the laser driven rf gun based injector. We report on issues concerning quantum efficiency, lifetime, and darkcurrent emission observed recently.

FRAAU06: Commissioning of the Test FEL at MAX-lab

Sverker Werin, Francesca Curbis, Nino Cutic, Filip Lindau, Sara Thorin (MAX-lab, Lund), Johannes Bahrdt, Karsten Holldack (BESSY GmbH, Berlin)

An installation for testing techniques related to seeding and harmonic generation has been completed at MAX-lab. The aim is to study the processes around seeded harmonic generation at 130/88/54 nm, the 2/3/5 harmonic of a Ti:Sapphire laser. During the spring 2008 the commissioning work has begun and this paper will report on the progress. The test FEL is built around the existing linac injector at MAX-lab. This source can provide 4-500 MeV electrons from an RF-gun. A combined laser system both driving the photo cathode in the gun and, synchronised via an optical fibre, the seed laser pulse has been put into operation. An optical klystron, consisting of two 30 period undulators and a 4-magnet chicane, is in operation. Beam loss monitors along the optical klystron are in use and a THz system for additional synchronisation studies under installation. Results from electron beam optics and operation generating spontaneous radiation is already available and synchronisation results immediate. The work is in progress and new results are added continuously to the portfolio.

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