PROCEEDINGS OF SPIE

Advances in X-ray Free-Electron Lasers Instrumentation III

Sandra G. Biedron
Editor

13–16 April 2015
Prague, Czech Republic

Sponsored by
SPIE

Cooperating Organisations
HiPER Project (United Kingdom)
ELI Beamlines (Czech Republic)
Laserlab Europe

Published By
SPIE

Volume 9512

Proceedings of SPIE 0277-786X, V. 9512

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Advances in X-ray Free-Electron Lasers Instrumentation III, edited by Sandra G. Biedron
Proc. of SPIE Vol. 9512, 951201 · © 2015 SPIE · CCC code: 0277-786X/15/$18
doi: 10.1117/12.2199444

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:
Author(s), "Title of Paper," in *Advances in X-ray Free-Electron Lasers Instrumentation III*, edited by Sandra G. Biedron, Proceedings of SPIE Vol. 9512 (SPIE, Bellingham, WA, 2015) Article CID Number.

ISSN: 0277-786X
ISBN: 9781628416336

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Copyright © 2015, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is $18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/15/$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIE Digital Library
SPIEDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print. Papers are published as they are submitted and meet publication criteria. A unique citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc.

The CID Number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages.

Contents

vii *Authors*

xi *Conference Committee*

xiii *Introduction*

SESSION 1 MAGNETS AND LIGHT SOURCE APPLICATIONS

9512 02 **Linear polarizing undulator and optical alignment system for a THz-FEL test facility** [9512-2]

9512 03 **Segmented undulator operation at the SPARC-FEL test facility** [9512-3]

9512 04 **Cryogenic undulators (Invited Paper)** [9512-4]

9512 05 **Construction of CHESS compact undulator magnets at Kyma** [9512-5]

9512 06 **Status of the PAL-XFEL undulator program (Invited Paper)** [9512-6]

SESSION 2 NOVEL PHOTON BEAM CHARACTERIZATION TECHNIQUES

9512 09 **Characterization of partially coherent ultrashort XUV pulses** [9512-8]

9512 0A **Design and characterization of the ePix10k prototype: a high dynamic range integrating pixel ASIC for LCLS detectors** [9512-9]

9512 0B **Measure of the transverse coherence of a self amplified spontaneous emission of a free electron laser with the heterodyne speckle method (Best Student Paper Award)** [9512-10]

SESSION 3 DIAGNOSTICS, CONTROLS, TIMING AND SYNCHRONIZATION I

9512 0D **The new design of the THz streak camera at PSI (Invited Paper)** [9512-12]

9512 0E **6D electron beam diagnostics at SPARC LAB (Invited Paper)** [9512-13]

9512 0F **Diagnostic for a high repetition rate electron photo-gun and first measurements (Invited Paper)** [9512-14]

9512 0G **FERMI longitudinal diagnostics: results and future challenges** [9512-16]

SESSION 4 FEL INSTRUMENTATION AND NOVEL EXPERIMENTAL TECHNIQUES I

9512 0I **Optically induced Fe magnetization reversal in Fe/MnAs/GaAs(001)** [9512-19]

SESSION 5 STATUS OF OPERATIONAL AND PLANNED FEL FACILITIES I

9512 0P **Status of PAL-XFEL (Invited Paper)** [9512-26]

SESSION 6 STATUS OF OPERATIONAL AND PLANNED FEL FACILITIES II

9512 0S **Operation of FERMI FELs for users** [9512-29]

9512 0T **Seeded FEL with two energy level electron beam distribution at SPARC LAB** [9512-30]

SESSION 7 DIAGNOSTICS, CONTROLS, TIMING AND SYNCHRONIZATION II

9512 0U **A single-shot, high-repetition rate scheme for electro-optic detection of short pulses (Invited Paper)** [9512-31]

9512 0V **The SPARC LAB femtosecond synchronization for electron and photon pulsed beams (Invited Paper)** [9512-32]

SESSION 8 FEL INSTRUMENTATION AND NOVEL EXPERIMENTAL TECHNIQUES II

9512 10 **Grating-based pulse compressor for applications to FEL sources** [9512-38]

9512 12 **FEL-based transient grating spectroscopy** [9512-40]

SESSION 9 ELECTRON BEAM EFFECTS ON FEL EMISSION INCLUDING EMISSION EFFICIENCY

9512 18 **Polarization control in x-ray FELs by a reverse undulator tapering** [9512-46]

9512 19 **The universal method for optimization of undulator tapering in FEL amplifiers** [9512-47]

SESSION 10 NOVEL SOURCE DEVELOPMENTS I

9512 1A **Gamma-ray production from resonant betatron oscillations in plasma wakes (Invited Paper)** [9512-48]

9512 1B **Generation of femtosecond to sub-femtosecond x-ray pulses at free-electron lasers (Invited Paper)** [9512-49]

9512 1D **Longitudinal space charge assisted echo seeding of a free-electron laser** [9512-51]

9512 1E **Dual color x-rays from Thomson or Compton sources** [9512-52]

SESSION 11 NOVEL SOURCE DEVELOPMENTS II

9512 1F **Super-radiant high-field THz sources operating at quasi-cw rep rates** [9512-53]

9512 1G **Experiment preparation towards a demonstration of laser plasma based free electron laser amplification** [9512-54]

9512 1I **An XUV source using a femtosecond enhancement cavity for photoemission spectroscopy** [9512-57]

9512 1J **Optical klystron SASE at FERMI** [9512-58]

SESSION 12 ACCELERATOR HARDWARE AND FEL OPERATIONAL EXPERIENCES

9512 1L **The new IR and THz FEL facility at the Fritz Haber Institute in Berlin (Invited Paper)** [9512-60]

9512 1M **Operational experience at ELBE** [9512-61]

9512 1N **Tests of photocathodes for high repetition rate x-ray FELs at the APEX facility at LBNL** [9512-62]

9512 1O **Optimization of high average power FEL beam for EUV lithography** [9512-63]

9512 1P **FERMI magnet power supplies: design strategies and five years of operational experience** [9512-64]

9512 1Q **Operational experience on the generation and control of high brightness electron bunch trains at SPARC LAB** [9512-65]

9512 1R **Design and initial characterisation of x-ray beam diagnostic imagers for the European XFEL** [9512-66]

POSTER SESSION

9512 1T **Laser arrival measurement tools for SwissFEL** [9512-67]

9512 1U **Construction status of CXI beamline at PAL-XFEL** [9512-68]

9512 1W **High-efficiency bispectral laser for EUV** [9512-70]

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Abela, R., 0D
Alaimo, M., 0B
Alesini, David, 0T, 1Q
Allaria, E. M., 0G, 0I, 1J
Anania, Maria Pia, 03, 0E, 0T, 0V, 1A, 1Q
Andriyash, I., 1G
Artioli, Marcello, 03, 0T
Bacci, Alberto, 0E, 0T, 1E, 1Q
Battistoni, A., 12
Bellaveglia, Marco, 03, 0E, 0T, 0V, 1Q
Benabderrahmane, C., 04, 1G
Bencivenga, F., 12
Berteaud, P., 04, 1G
Bespalov, V. G., 1W
Biagioni, A., 0V, 1Q
Bielawski, S., 0U, 1G
Blaj, G., 0A
Bluem, Hans, 1L
Bourassin-Bouchet, Charles, 09, 1G
Bouvet, F., 1G
Briquez, F., 04, 1G
Brubach, J.-B., 0U
Brunetti, E., 1A
Capotondi, F., 0I, 12
Caragiulo, P., 0A
Cardelli, F., 1Q
Carini, G., 0A
Carpanese, Mariano, 03, 0T
Casolari, F., 12
Cassinari, L., 0U, 1G
Castellano, Michele, 0E, 0T, 1Q
Chapuis, L., 04, 1G
Chiadroni, Enrica, 03, 0E, 0T, 0V, 1Q
Cho, Moo Hyun, 06, 1U
Cianchi, Alessandro, 03, 0E, 0T, 1Q
Ciavardini, A., 0I
Cinquegrana, P., 0G
Ciocci, Franco, 03, 0T
Cipiccia, S., 1A
Coreno, M., 0I
Couprie, Marie-Emmanuelle, 04, 09, 0U, 1G
Croia, M., 1Q
Csatari Divall, Marta, 1T
Cucini, R., 12
Curatolo, C., 1E
Damascelli, Andrea, 1I
Danailov, M. B., 0I, 12
Dattoli, Giuseppe, 03, 0T
Davoine, X., 1G
De Ninno, Giovanni, 0I, 10, 1J
Delaunay, R., 0I
Demidovich, A., 0I
Dennetiere, D., 1G
Di Giovenale, Domenico, 03, 0E, 0T, 1Q
Di Palma, Emanuele, 03, 0T
Di Pirro, Giampiero, 03, 0E, 0T, 1Q
Dias, J. M., 1A
Ding, Yuantao, 1B
Doolittle, L., 0F
Dragone, A., 0A
Duval, JP., 1G
Eddrief, M., 0I
El Ajjouri, M., 1G
El Ajjouri, T., 04
Elizarov, V. V., 1W
Endo, Akira, 1O
Ersfeld, B., 1A
Evain, C., 0U, 1G
Fajardo, Marta, 10
Feng, Jun, 1N
Ferianis, M., 0G
Ferrari, E., 0G, 0I, 1J
Ferrario, Massimo, 03, 0E, 0T, 1E, 1Q
Filippetto, Daniele, 0F, 1N
Filippi, Francesco, 0T, 1Q
Frassetto, Fabio, 10
Freund, Wolfgang, 1R
Froelich, L., 0G
Gallo, Alessandro, 0T, 0V, 1Q
Gatti, Giancarlo, 0T, 0V, 1Q
Gauthier, David, 10
Gensch, Michael, 1F
Geometrante, Raffaella, 05
Gessini, A., 12
Gewinner, Sandy, 1L
Giangrisostomi, E., 12
Giannessi, L., 0G, 1J
Giannessi, Luca, 0T
Giribono, Anna, 0T, 1Q
Gorgisyan, I., 0D
Grant, D. W., 1A
Grant, P., 1A
Green, Bertram, 1F
Grishkanich, A. S., 1W
Grünert, Jan, 1R
Hacker, Kirsten, 1D
Haller, G., 0A
Hamilton, D., 1A

Hart, P., 0A
Hasi, J., 0A
Hauri, Christoph P., 0D, 1T
Herbeaux, C., 1G
Herbst, R., 0A
Herrmann, S., 0A
Hoek, M., 1A
Huang, G., 0F
Huang, Ruixuan, 1N
Hubert, N., 1G
Hunziker, Stephan, 1T
Innocenti, Luca, 0E, 0T, 1Q
Ischebeck, R., 0D
Islam, M. R., 1A
Issac, R. C., 1A
Ivanov, R., 0D, 0I
Jaroszynski, D. A., 1A
Jones, David J., 1I
Junkes, Heinz, 1L
Juranic, P. N., 0D
Kang, Heung-Sik, 06, 0P
Kascheev, S. V., 1W
Katayama, T., 0D
Kenney, C., 0A
Khojoyan, M., 1G
Kim, Bongsoo, 1U
Kim, Dong-Eon, 06
Kim, K.-W., 0P
Kim, Sangsoo, 1U
Kiskinova, M., 0I, 12
Ko, In-Soo, 06, 0P, 1U
Koch, Andreas, 1R
Kokole, Mirko, 05
Kovalev, Sergey, 1F
Kramasz, Toby, 1N
Labat, M., 0U, 1G
Lambert, G., 1G
Le Parquier, M., 0U
Leclerc, N., 1G
Lehnert, U., 1M
Lei, X., 02
Lemos, N. R.C., 1A
Lestrade, A., 1G
Levy, Giorgo, 1I
Liu, J., 0D
Liu, K. F., 02
Liu, X., 02
Loulergue, A., 1G
Lounis, L., 0I
Lyamayev, Viktor, 1R
Lyndaker, Aaron, 05
Mahieu, Benoit, 10
Malka, V., 1G
Manceron, L., 0U
Maneuski, D., 1A
Manfredda, M., 0B, 12
Marcouillé, O., 04, 1G
Markovic, B., 0A
Marlats, J.-L., 1G
Marocchino, A., 1Q
Maroli, C., 1E
Marteau, F., 04, 1G
Masciovecchio, C., 12
Michel, P., 1M
Milharčič, Tadej, 05
Mills, Arthur K., 1I
Mincigrucci, R., 12
Miotti, Paolo, 10
Mirian, Najmeh Sada, 0T
Monoszlai, B., 0D
Montgomery, R., 1A
Morin, P., 1G
Mostacci, Andrea, 03, 0E, 0T, 0V, 1Q
Mutter, Patrick, 1T
Nam, Ki-Hyun, 1U
Nasiatka, James, 1N
Nikolov, I. P., 0I, 12
Nishimura, K., 0A
Norum, E., 0F
Ogawa, K., 0D
O'Shea, V., 1A
Owada, S., 0D
Paarmann, Alexander, 1L
Padmore, Howard, 1N
Papadopoulos, Christos F., 1N
Parisse, P., 12
Park, Jaehyun, 1U
Park, Ki-Hyeon, 06
Paroli, B., 0B
Patthey, L., 0D
Pedersoli, E., 0I, 12
Pei, Y. J., 02
Peier, P., 0D
Penco, G., 0G, 1J
Petralia, Alberto, 03, 0T
Petrarca, M., 0V, 1Q
Petrillo, Vittoria, 03, 0T, 1E
Pflueger, Jochaim, 06
Piersanti, L., 0V, 1Q
Pioli, S., 1Q
Planas, Marc, 1R
Počkar, Jure, 05
Polack, F., 1G
Poletto, Luca, 10
Pompili, Riccardo, 03, 0E, 0T, 0V, 1Q
Popescu, H., 0I
Portmann, G., 0F
Potenza, M. A. C., 0B
Pradervand, C., 0D
Predonzani, M., 0G
Principi, E., 12
Qian, Houjun, 0F, 1N
Qin, B., 02
Radovic, M., 0D
Raimondi, L., 0I
Rajeev, P. P, 1A
Rau, Julietta V., 0T, 1E
Reboredo Gil, D., 1A
Reese, B., 0A
Ricaud, J.-P., 0U

Rivkin, L., 0D
Romann, Albert, 1T
Romeo, Stefano, 0T, 1Q
Rommeluère, P., 1G
Ronsivalle, C., 1E
Rossi, Andrea R., 0E, 0T, 1Q
Rossi, F., 0G
Roth, Thomas, 1R
Roussel, E., 0U
Roy, P., 0U
Sabia, Elio, 03, 0T
Sacchi, M., 0I
Samoylova, Liubov, 1R
Sannibale, Fernando, 0F, 1N
Schlott, V., 0D
Schneidmiller, E. A., 18, 19
Schöllkopf, Wieland, 1L
Scifo, J., 1Q
Segal, J., 0A
Seidel, W., 1M
Seisyan, R. P., 1W
Serafini, L., 1E
Shanks, R. P., 1A
Sharma, G., 04
Sheyerman, Alex, 1I
Shpakov, Vladimir, 0E, 0T, 1Q
Siano, M., 0B
Sigalotti, P., 0G
Smith, G., 1A
Spassovsky, Ivan P., 03, 0T
Spezzani, C., 0I
Staples, John W., 1N
Stepanov, A., 0D
Surrenti, Vincenzo, 03
Svandrlik, M., 0S
Svetina, Cristian, 0I, 10, 12
Symes, D., 1A
Szwaj, C., 0U, 1G
Tan, P., 02
Tavakoli, K., 1G
Temnykh, Alexander B., 05
Thaury, C., 1G
Todd, Alan M. M., 1L
Togashi, T., 0D
Tomada, A., 0A
Tordeux, M.-A., 0U
Vaccarezza, Cristina, 03, 0E, 0T, 1E, 1Q
Valléau, M., 04, 1G
Venturelli, M., 1E
Veronese, M., 0G
Vétéran, J., 04
Vidal, F., 0I
Vieux, G., 1A
Villa, Fabio, 03, 0E, 0T, 0V, 1Q
Visintini, Roberto, 1P
von Helden, Gert, 1L
Wang, Y. B., 02
Wei, W., 02
Weiwei, L., 1Q
Wells, Russell, 1N
Welsh, G. H., 1A
Wiggins, S. M., 1A
Xiong, Y. Q., 02
Yabashi, M., 0D
Yang, W., 1G
Yang, X., 1A
Yurkov, M. V., 18, 19
Zangrando, Marco, 0I, 10
Zeitoun, Philippe, 10
Zerbib, D., 1G
Zhdanovich, Sergey, 1I
Zhevlakov, A. P., 1W
Zolotorev, Max, 1N

Conference Committee

Symposium Chairs

Jiri Homola, Institute of Photonics and Electronics of the ASCR, v.v.i. (Czech Republic)
Chris Edwards, Central Laser Facility, Science and Technology Facilities Council (United Kingdom)
Mike Dunne, SLAC National Accelerator Laboratory (United States) and Linac Coherent Light Source (United States)
Ivo Rendina, Istituto per la Microelettronica e Microsistemi, CNR (Italy)

Honorary Symposium Chair

Miroslav Miller, Institute of Photonics and Electronics of the ASCR, v.v.i. (Czech Republic)

Conference Chair

Sandra G. Biedron, Colorado State University (United States)

Conference Programme Committee

John M. Byrd, Lawrence Berkeley National Laboratory (United States)
Carlo Callegari, Elettra-Sincrotrone Trieste S.C.p.A. (Italy)
Enrica Chiadroni, Istituto Nazionale di Fisica Nucleare (Italy)
Marie-Emmanuelle Couprie, Synchrotron SOLEIL (France)
Eugenio Ferrari, Università degli Studi di Trieste (Italy)
Raffaella Geometrante, Kyma s.r.l. (Italy)
Kirsten Hacker, Deutsches Elektronen-Synchrotron (Germany)
Timothy J. Maxwell, SLAC National Accelerator Laboratory (United States)
Giuseppe Penco, Elettra-Sincrotrone Trieste S.C.p.A. (Italy)
Daniel F. Ratner, SLAC National Accelerator Laboratory (United States)
David A. Reis, SLAC National Accelerator Laboratory (United States)
Siegfried Schreiber, Deutsches Elektronen-Synchrotron (Germany)
Pierpaolo Stabile, CERN (Switzerland)
Alan M. M. Todd, Advanced Energy/Tower Electronics (United States)
Zhentang Zhao, Shanghai Institute of Applied Physics (China)

Session Chairs

1 Magnets and Light Source Applications
Raffaella Geometrante, Kyma S.r.l. (Italy)

2 Novel Photon Beam Characterization Techniques
Raffaella Geometrante, Kyma S.r.l. (Italy)
Marie-Emmanuelle Couprie, Synchrotron SOLEIL (France)

3 Diagnostics, Controls, Timing and Synchronization I
Sandra G. Biedron, Colorado State University (United States)

4 FEL Instrumentation and Novel Experimental Techniques I
Carlo Callegari, Elettra-Sincrotrone Trieste S.C.p.A. (Italy)
David A. Reis, SLAC National Accelerator Laboratory (United States)

5 Status of Operational and Planned FEL Facilities I
Giuseppe Penco, Elettra-Sincrotrone Trieste S.C.p.A. (Italy)
Zhentang Zhao, Shanghai Institute of Applied Physics (China)

6 Status of Operational and Planned FEL Facilities II
Giuseppe Penco, Elettra-Sincrotrone Trieste S.C.p.A. (Italy)
Zhentang Zhao, Shanghai Institute of Applied Physics (China)

7 Diagnostics, Controls, Timing and Synchronization II
Sandra G. Biedron, Colorado State University (United States)

8 FEL Instrumentation and Novel Experimental Techniques II
Carlo Callegari, Elettra-Sincrotrone Trieste S.C.p.A. (Italy)
David A. Reis, SLAC National Accelerator Laboratory (United States)

9 Electron Beam Effects on FEL Emission Including Emission Efficiency
Kirsten Hacker, Deutsches Elektronen-Synchrotron (Germany)
Eugenio Ferrari, Elettra-Sincrotrone Trieste S.C.p.A. (Italy)

10 Novel Source Developments I
Enrica Chiadroni, Istituto Nazionale di Fisica Nucleare (Italy)
Daniel F. Ratner, SLAC National Accelerator Laboratory (United States)

11 Novel Source Developments II
Enrica Chiadroni, Istituto Nazionale di Fisica Nucleare (Italy)
Daniel F. Ratner, SLAC National Accelerator Laboratory (United States)

12 Accelerator Hardware and FEL Operational Experiences
Siegfried Schreiber, Deutsches Elektronen-Synchrotron (Germany)

Introduction

Welcome to the proceedings for the 2015 SPIE Conference: Advances in X-ray Free-Electron Lasers Instrumentation. This is the third in the series of this conference, the former being held in 2011 and 2013. This year we had 66 presentations and posters.

This year, we expanded the conference to include many wavelength regimes of free-electron lasers and electron-based coherent light sources. In addition to many exciting presentations on photon-based instrumentation, we included instrumentation for the electron portions of the machines – diagnostics, controls, synchronization, etc. We also discussed hardware advancements in the undulator systems for our light sources, heard about new machines under construction and those proposed, discussed sub-system improvements, such as electron sources, heard about exciting science on the operational machines, learned about operational challenges and successes of facilities, and were intrigued with the many novel source concepts. This compilation of 40 papers illuminates the many aspects of coherent, electron beam lased light source systems, their systems, and their uses.

The talks led to many discussions and many of the delegates continued their technical discussions into the coffee breaks and even dinners. Colleagues from related fields were introduced and new discussion groups and new collaborations were formed.

I wish to thank the SPIE staff that helped our team organize and carry out this conference. I also wish to thank the members of the conference program committee, dear friends who worked tirelessly to make this conference a success. Thank you John M. Byrd, Carlo Callegari, Enrica Chiadroni, Marie-Emmanuelle Couprie, Eugenio Ferrari, Raffaella Geometrante, Kirsten Hacker, Timothy J. Maxwell, Giuseppe Penco, Daniel F. Ratner, David A. Reis, Siegfried Schreiber, Pierpaolo Stabile, Alan M. M. Todd, and Zhentang Zhao.

I wish you informative reading!

Sandra Biedron