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The CERN Accelerator School

Free Electron Lasers and Energy Recovery Linacs

Hamburg, Germany
31 May– 10 June 2016

Editor: R. Bailey

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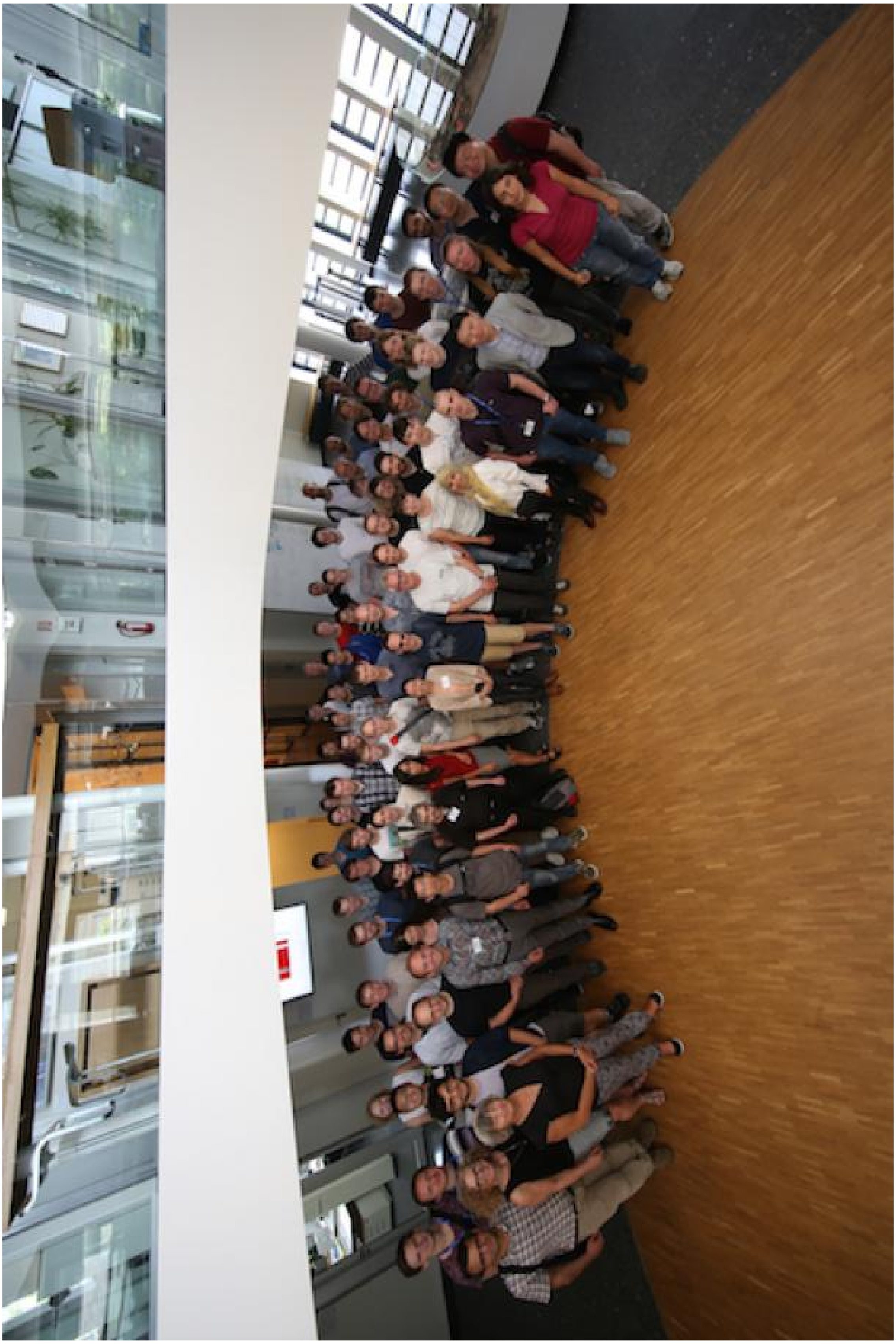
Abstract

These proceedings collate lectures given at the course on Free Electron Lasers and Energy Recovery Linacs (FELs and ERLs), organised by the CERN Accelerator School (CAS). The course was held at the Hotel Scandic Hamburg Emporio, Hamburg, Germany from 31 May to 10 June 2016, in collaboration with DESY. Following introductory lectures on radiation issues, the basic requirements on linear accelerators and ERLs are discussed. Undulators and the process of seeding and lasing are then treated in some detail, followed by lectures on various beam dynamics and controls issues.



Preface

The aim of the CERN Accelerator School (CAS) is to collect, preserve and disseminate the knowledge accumulated in the world's accelerator laboratories over the years. This applies not only to general accelerator physics, but also to related sub-systems and associated technologies, and to the development of novel, dedicated facilities. These wider aims are achieved by means of specialized courses currently held twice per year. The topic of the first 2016 specialized course was Free Electron Lasers and Energy Recovery Linacs (FELs and ERLs) and was held at the Hotel Scandic Hamburg Emporio, Hamburg, Germany from 31 May to 10 June 2016.

The course was made possible through the fruitful collaboration with DESY, in particular through the efforts of Ruth Mundt, Christel Oevermann and Kay Wittenburg.

A full day visit to DESY and the European XFEL in Hamburg Bahrenfeld provided a practical insight into the field. Participants also had the opportunity to work on realistic case studies as an integral part of the programme. For the organisation and execution of the latter we are indebted to Sven Reiche from PSI. The backing of the CERN management and the guidance of the CAS Advisory and Programme Committees enabled the course to take place, while the attention to detail of the Local Organising Committee and the management and staff of the Hotel Scandic Hamburg Emporio ensured that the school was held under optimum conditions.

Special thanks must go to the lecturers for the preparation and presentation of the lectures, even more so to those who have written a manuscript for these proceedings.

For the production of the proceedings we are indebted to the efforts of Barbara Strasser and to the CERN Publishing Service, especially Valeria Brancolini for her very positive and efficient collaboration.

These proceedings have been published in paper (black and white) and electronic form. The electronic version, with full colour figures, can be found at https://e-publishing.cern.ch/index.php/CYRSP/issue/view/47.

Roger Bailey, Editor
CERN Accelerator School

PROGRAMME

Free Electron Lasers and Energy Recovery Linacs (FELs and ERLs), 31 May – 10 June, 2016

Time	**Tuesday 31 May**	**Wednesday 1 June**	**Thursday 2 June**	**Friday 3 June**	**Saturday 4 June**	**Sunday 5 June**	**Monday 6 June**	**Tuesday 7 June**	**Wednesday 8 June**	**Thursday 9 June**	**Friday 10 June**
08:30 09:30	**ARRIVAL DAY**	Opening Talks	Wakefields U. Van Rienen	Lasers in FEL Facilities M. Divall	Concept of ERL A. Jankowiak	**EXCURSION**	Quantum FEL G. Robb	LLRF Controls and Feedbacks S. Pfeiffer	Advanced Undulator Concepts J. Rosenzweig	Undulator Tapering M. Yurkov	**DEPARTURE DAY**
09:30 10:30		Electro-magnetic Theory W. Herr	Linear Beam Optics I B. Holzer	Motion in an Undulator S. Reiche	High Gain Regime 1D I K.-J. Kim		High Gain Regime 3D K.-J. Kim	Coherence Properties of the Radiation from SASE FEL M. Yurkov	Photon Beam Transport M. Yabashi	Crystallography and Molecular Imaging using X-Ray Lasers T. White	
		COFFEE	**COFFEE**	**COFFEE**	**COFFEE**		**COFFEE**	**COFFEE**	**COFFEE**	**COFFEE**	
11:00 12:00		Special Relativity W. Herr	Linear Beam Optics II B. Holzer	Pendulum Equations and Low Gain Regime S. Reiche	High Gain Regime 1D II K.-J. Kim		Temporal Coherence K.-J. Kim	The European XFEL H. Weise	Electron Beam Diagnostics R. Ischebeck	Machine Protection L. Froehlich	
12:00 13:00		Synchrotron Radiation I L. Rivkin	Coherence in Beams J. Rossbach	Bunch Length Compressors S. Di Mitri	Seeding Schemes I L. Giannessi		Experience from FLASH: FEL Theory versus Experiment M. Yurkov	Plasma Wake Driven FEL R. Assmann	Timing and Synchronisation M. Bellaveglia	Different ERL Applications K.Aulenbacher	
		LUNCH	**LUNCH**	**LUNCH**	**LUNCH**		**LUNCH**	**LUNCH**	**LUNCH**	**LUNCH**	
14:30 15:30		Synchrotron Radiation II L. Rivkin	Space Charge Mitigation M. Ferrario	Coherent Synchrotron Radiation and Microbunching Instability S. Di Mitri	Seeding Schemes II L. Giannessi		XFELO K.-J. Kim	**VISIT TO DESY**	Case Study Work	Case Study Presentations	
15:30 16:30		Undulators J. Pflueger	SC Cavities (High Q) J. Knobloch	Electron Sources and Injector Systems E. Chiadroni	Beam Dynamics of ERLs A. Jankowiak		Case Study Work		Case Study Work	Case Study Presentations	
		TEA	**TEA**	**TEA**	**TEA**		**TEA**		**TEA**	**TEA**	
17:00 18:00	**Registration**	Linear Accelerator Technology D. Alesini	Historical Survey of FELs M. Couprie	Energy Efficiency E. Jensen	Transverse Optics in the ERL Arcs A. Valloni		Case Study Work		Case Study Work	**Seminar** Gravitational Waves R. Schnabel	
18:30		Case Study Introduction									
19:30		**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	

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