



LASERLAB-EUROPE

The Integrated Initiative of European Laser Research Infrastructures III

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Work Package 7 – Foresight Activities

Deliverable D7.1 – Foresight Workshop

Lead Beneficiary: The Institute of Photonic Sciences (ICFO)

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Project webpage: www.laserlab-europe.eu

<i>Deliverable Nature</i>	
R = Report, P = Prototype, D = Demonstrator, O = Other	R
<i>Dissemination Level</i>	
PU = Public PP = Restricted to other programme participants (incl. the Commission Services) RE = Restricted to a group specified by the consortium (incl. the Commission Services) CO = Confidential, only for members of the consortium (incl. the Commission Services)	PU

A. Abstract / Executive Summary

A Laserlab-Europe Foresight Workshop “Lasers for Life” was held at the Royal Society, London, from the 2nd-4th June 2014. The workshop featured lectures from leaders in the application of lasers to biology and medicine, and brought together two different communities; clinicians using lasers for disease diagnosis and treatment, and experts in the design and use of lasers and associated optics. The workshop was attended by 140 delegates, including 70 from Laserlab-Europe institutions, and ended with a panel discussion where delegates were invited to give their views on the future of the area.

B. Deliverable Report

1 Introduction

Lasers have a wide range of biomedical applications, ranging from fundamental research to disease diagnosis and treatment. The application of advanced lasers to frontier bio- and life science research is a rapidly developing scientific field, combined with significant innovation potential. The UK's Central Laser Facility STFC hosted a Laserlab-Europe foresight workshop entitled “Lasers for Life”, with the aim of providing a forward look at laser applications and technology in the biomedical and life sciences ranging all the way from fundamental research to treatments and diagnosis in the clinic. The workshop was expected to be of interest to life sciences researchers, technology developers, biomedical equipment manufacturers, clinicians and policy makers, and was intended to serve as a high profile vehicle to promote and highlight the impact of Laserlab-Europe in a key Grand Challenge area. Specific areas targeted were:

- Laser microscopy for biomedical research – super-resolution techniques, single molecule, label free imaging.
- Future applications of laser spectroscopy in the biomedical area – focus on ultrafast techniques for investigating the interactions of biological macromolecules.
- Imaging applications of laser driven secondary sources – focus on coherent x-ray techniques: phase contrast and diffractive imaging.
- Laser spectroscopy and imaging for disease diagnosis – Raman techniques, x-ray imaging
- Laser-based therapies and diagnosis, e.g. photodynamic therapy for cancer treatment, proton radiotherapy, laser based nuclear medicine, laser based diagnosis.
- Synergies with other source technologies, e.g. FELs, synchrotron radiation, neutron techniques.

2 Objectives

The objectives of the workshop were:

- 1) To bring together the biomedical and laser/optics communities with the purpose of initiating dialogue and identifying new ways of solving research and clinical problems.
- 2) *Via* the workshop lectures, to increase the level of understanding within the two communities of problems and opportunities arising from the use of lasers in biology and medicine.
- 3) To identify problems in biomedical research and in the clinic that might be addressed by new developments in laser technology
- 4) To identify requirements for new developments in lasers needed to enable new approaches in biomedical research and medicine.

3 Workshop description and results

A 2 ½ day workshop was held at the Royal Society, with a series of lectures by world leaders in the application of lasers in biology and medicine. Approximately 140 delegates attended the meeting, including 70 from Laserlab-Europe institutions. The programme of lectures was designed to cover a wide range of topics from clinical applications to fundamental research, and is shown below, together with a list of delegates. The workshop concluded with a panel discussion and comments from the floor. A summary of this discussion is also shown below.

In addition to the lectures and discussion, poster sessions and an exhibition by commercial sponsors were also held. In addition to funding from Laserlab, sponsorship for the workshop was provided by the UK's Biotechnology and Biological Sciences Research Council, Engineering and Physical Sciences Research Council, and Science and Technology Facilities Council, and British Medical Laser Association. Industrial participants were Fianium, Photonic Solutions, Spectra Physics, and Zeiss.

Workshop Programme

Monday 2nd June 2014

12:30 Meeting open for registration

13:30 Welcoming remarks by Claes-Göran Wahlström (Laserlab-Europe) and John Collier (STFC Central Laser Facility)



Scientific Session 1: Medical Imaging, Diagnosis, and Therapy (Part 1)

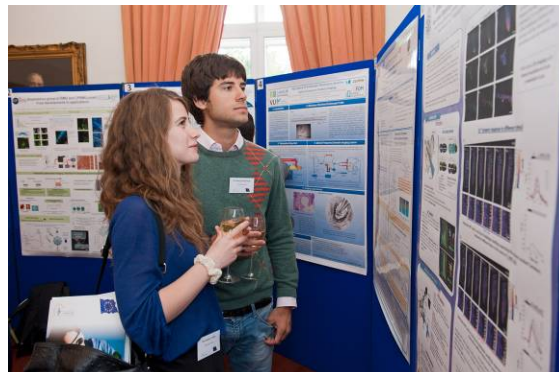
Chair: Brett Bouma (Harvard, USA)

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|--------------|---|--|
| 14:00 | Plenary: <u>Serge Mordon (INSERM, Lille, France)</u> | <i>Laser applications in medicine</i> |
| 15:00 | Sally Ibbotson (Dundee, UK) | <i>Phototherapy, photodiagnosis</i> |
| 15:30 | Adrian Podoleanu (Kent, UK) | <i>Master/Slave optical coherence tomography</i> |
| 16:00 | Coffee break | |
| 16:30 | Samantha Hills (Lynton Lasers, UK) | <i>Lasers for cosmetic therapy</i> |
| 17:00 | Vasilis Ntziachristos (IBMI, Munich, Germany) | <i>In vivo targeted fluorescence</i> |
| 17:30 | Carsten Philipp (Evangelical Elisabeth Clinic, Germany) | <i>Laser surgery, endoscopy</i> |
| 18:00 | Drinks reception, poster session, commercial exhibition, and networking opportunity | |
| 19:30 | Dinner | |
| 22:00 | Departure for hotels | |

15:30 Jörg Schreiber (MPI, Germany)

Laser-driven ion acceleration

16:00 Coffee break



Scientific Session 4: Future Applications of Laser Spectroscopy & Imaging for Biological and Medical Research (Part 1)

Chair: Stan Botchway (STFC Central laser Facility, UK)

16:30 Plenary: Ernst Stelzer (Buchmann Inst, Germany)

Advanced light microscopy

17:30 Christian Eggeling (Oxford, UK)

STED microscopy

18:00 Neil Hunt (Strathclyde, UK)

2DIR of proteins & peptides

18:30 Drinks, poster session, commercial exhibition, and networking opportunity

19:30 Dinner

22:00 Departure for hotels

Wednesday 4th June 2014

Scientific Session 5: Future Applications of Laser Spectroscopy & Imaging for Biological and Medical Research (Part 2)

Chair: Neil Hunt (Strathclyde, UK)

09:00 Susan Quinn (UCD, Ireland)

Ultrafast spectroscopy of nucleic acids

09:30 Marisa Martin-Fernandez (STFC, UK)
tissues

Single Molecule techniques in cells &

10:00 Maria Garcia Parajo (ICFO, Spain)

Single Molecule Biophotonics

10:30 Erwin Peterman (VU Amsterdam, NL)

Super-resolution & Optical Tweezers

11:00 Coffee break



Scientific Session 6: Horizon Scanning – Exploration of emerging areas

Chair: Susan Quinn (University College Dublin, Ireland)

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|--------------|---|---|
| 11:30 | Maria Farsari (IESL-FORTH, Greece) | <i>2.5D and 3D printing of biomedical implants</i> |
| 12:00 | Aleksandr Ovsianikov (Vienna Uni. of Tech.) | <i>Laser-based tissue engineering</i> |
| 12:30 | Michael Hausser (University College London) | <i>Optogenetics</i> |
| 13:00 | Ken Ledingham (Strathclyde, UK) | <i>Opportunities for international collaboration in laser therapy</i> |
| 13:30 | Lunch | |
| 14:30 | Discussion forum: Presentations from policy leaders and open discussion with delegates | |
| | Rowan Mckibbin (BBSRC and Euro-Bioimaging) | <i>Update on Euro-Bioimaging ESFRI project</i> |

Panel discussion:

David Clarke (STFC Central Laser Facility, UK); Maria Garcia Parajo (ICFO, Spain); Neil Hunt (Strathclyde, UK); Harry Moseley (Dundee, UK); Erwin Peterman (VU Amsterdam, The Netherlands)

15:30 Closing remarks

16:00 Workshop ends

List of Delegates

First Name	Surname	Institution
Richard	Abel	Imperial College
Katarzyna	Baczynska	PUBLIC HEALTH ENGLAND
Suresh Anand	Bala Subramanian	European Laboratory for Non Linear Spectroscopy
Philippe	Balcou	Université Bordeaux
Ferenc	Bari	University of Szeged
Luis	Batista de Carvalho	University of Coimbra
Jens	Biegert	Institut de Ciències Fotòniques (ICFO)
Elaine	Blackwood	Photonic Solutions
Lindsey	Bobrowski	Aurora Health Physics Services Ltd
Stanley	Botchway	STFC Central Laser Facility
Brett	Bouma	Massachusetts General Hospital/Harvard Medical School
Nicolas	BOURG	ISMO
Boy	Braaf	LaserLaB, Department of Physics and Astronomy, VU University, Amsterdam, The Net
Lizzy	Brama	Cancer Research UK
Theresa	Brümmer	Universität Hamburg
Petr	Bruza	ELI Extreme Light Infrastructure
Raj	Bunger	Aurora Health Physics Services Ltd
Alessia	Candeo	Politecnico di Milano
ANDRES	CANTARERO	University of Valencia
Maria Ana	Cataluna	University of Dundee
Pascale	Changenet-Barret	CNRS
Henry	Chapman	CFEL DESY
Sophia	Chen	LULI
Dusan	Chorvat	International Laser Centre
Arūnas	Čiburys	Vilnius university Departmen of Quantum Electronics and Laser Research Center
silvia	cipiccia	University of Strathclyde
David	Clarke	STFC Central Laser Facility
Benji	Coles	STFC Central Laser Facility
John	Collier	STFC Central Laser Facility
ASHLEY	CRANE	Newport Spectra-Physics Ltd
Claudia	Crocini	LENS
Beata	Cunderlikova	International Laser Centre
Charlotte	Cureton	BBSRC
Traian	Dascalu	INFLPR
Sheryl	Davey	STFC Central Laser Facility
Johannes	de Boer	VU University
Sandro	De Silvestri	Politecnico di Milano - CUSBO
Liz	Duke	Diamond Light Source
Paul	Dumas	SOLEIL Synchrotron
Guillaume	Dupuis	Université Paris-Sud
Dr. Turgut	Durduran	Institut de Ciències Fotòniques (ICFO)
Christian	Eggeling	University of Oxford
MARIA	FARSARI	IESL-FORTH
Fabio	Feroldi	VU Amsterdam
Inesa	Ferulova	University of Latvia
Henryk	Fiedorowicz	Military University of Technology, Institute of Optoelectronics
Gonçalo	Figueira	Instituto Superior Tecnico
George	Filippidis	IESL-FORTH
Harald	Fuest	Max Planck Institute for Quantum Optics
Roaldas	Gadonas	Vilnius University
Matteo	Galletti	European Laboratory for Non-linear Spectroscopy (LENS)
Maria	Garcia-Parajo	ICFO-Institute of Photonic Sciences
Eric	Gloaguen	CNRS
Moritz	Haeuser	University of Hamburg
Michael	Hausser	University College London

Cristina	Hernandez-Gomez	STFC Central Laser Facility
Katalin	Hideghéty	Oncotherapy Dept. Univ. Szeged
Samantha	Hills	Lynton Lasers Ltd
Colin	Hopper	University College London
Neil	Hunt	University of Strathclyde
Sally	Ibbotson	University of Dundee
Jan	Jabczynski	Military University of Technology, Institute of Optoelectronics
Dino	Jaroszynski	University of Strathclyde
Sören	Johansson	Lund Laser Centre
Libor	Juha	Institute of Physics ASCR
Karel	Jungwirth	Institute of Physics AS CR
Stefan	Karsch	Max-Planck-Institut für Quantenoptik
DALIA	KASKELYTE	Vilnius University Quantum Electronics department and Laser Research Center
Andrew	Kaye	STFC Central Laser Facility
Catherine	Kendall	GHNHSFT
Michelle	King	STFC Central Laser Facility
Krzysztof	Kopczynski	Institute of Optoelectronics, Military University of Technology
Ken	Ledingham	University of Strathclyde
Sandrine	LEVEQUE-FORT	ISMO
Aleksejs	Lihacovs	University of Latvia
Dr. Pablo	Loza-Alvarez	Institut de Ciències Fotòniques (ICFO)
Fiona	Lyng	Dublin Institute of Technology
Victor	MALKA	LOA
Stuart	Mangles	Imperial College London
Rosy	Manser	Carl Zeiss
Maria Paula	Marques	Univ Coimbra
Philippe	Martin	CEA
Edoardo	Martinenghi	Politecnico di Milano
Marisa	Martin-Fernandez	STFC Central Laser Facility
Rowan	Mckibbin	Biotechnology & Biological Sciences Research Council
João	Mendanha Dias	Instituto Superior Tecnico
Pavol	Miskovsky	International Laser Centre
Serge	Mordon	INSERM
Ion	Morjan	INFLPR
Harry	Mosely	University of Dundee
Riccardo	Muolo	LENS
David	Neely	STFC Central Laser Facility
Vasilis	Ntziachristos	Technische Universität München & Helmholtz Zentrum München
Karoly	Osvay	ELI-Hu
Aleksandr	Ovsianikov	Vienna University of Technology (TU Wien)
Siddharth	Patankar	Imperial College London
Rajeev	Pattathil	STFC Central Laser Facility
Nicolaie	PAVEL	National Institute for Laser, Plasma and Radiation Physics
Álvaro	Peralta Conde	Pulsed Laser Center (CLPU)
Erwin	Peterman	VU University Amsterdam & LaserLab Amsterdam
Carsten M.	Philipp	Ev. Elisabeth Klinik, Dept. Lasermedicine
Daniel	Phillips	Carl Zeiss
Karsten	Plamann	LOA
Adrian	Podoleanu	University of Kent
Gowsihan	Poologasundarampillai	University of Manchester
Susan	Quinn	University College Dublin
ANTHI	RANELLA	IESL FORTH
Emma	Roberts	STFC Rutherford Appleton Laboratory
Luis	ROSO	Pulsed Lasers Centre, CLPU
Romain	Royon	Centre Lasers Intenses et Applications
Gianluca	Sarri	Queen's University of Belfast
Jörg	Schreiber	LMU Munich / MPQ Gar
Graeme	Scott	STFC Central Laser Facility
Valdas	Sirutkaitis	Vilnius University
Janis	Spigulis	University of Latvia, IAPS
Tadeusz	Stacewicz	Institute of Experimental Physics, Warsaw University

Ernst	Stelzer	Goethe University Frankfurt am Main, Buchmann Institute for Molecular Lifescienc
James	Stone	University of Bath
Daniela	Stozno	Laserlab-Europe
Chris	Stubbs	STFC Central Laser Facility
Katarina	Svanberg	Dept of Oncology Lund University
François	Sylla	SourceLAB
François	Sylla	SourceLAB
Lluis	Torner	Institut de Ciències Fotòniques (ICFO)
Jiri	Ullschmied	Institute of Plasma Physics ASCR
Gianluca	Valentini	Politecnico di Milano
Claes-Göran	Wahlström	Lund Laser Centre, Lund University
Roman	Walczak	University of Oxford
Gregor	Welsh	University of Strathclyde
Ailidh	Woodcock	BBSRC
Eckart	Wrede	Durham University
Giannis	Zacharakis	FORTH - IESL
Philippe	ZEITOUN	LOA
Dániel	Zölei-Szénási	University of Szeged

Summary of Closing Discussion Session

Panel Members: Neil Hunt (Strathclyde, UK), Erwin Peterman (VU Amsterdam, The Netherlands), Maria Garcia Parajo (ICFO, Spain), Harry Moseley (Dundee, UK), David Clarke (STFC-CLF, UK)

The panel was invited to give their views on future applications of lasers in biology and medicine, to comment on issues currently facing uses of lasers in these areas, and to speculate on potential new laser sources. Comments were then invited from the floor.

NH: Speaking from the point of view of molecular spectroscopy. There is a requirement to bridge the gap between experiment and theory, and between molecular dynamics simulations, experiments, and other techniques such as NMR. There is a need to push the performance of lasers, to enable us to follow biological processes in real time. It is important to make the experiments accessible to non-specialists, including help in handling and analysing data. For this reason it is important to continue to support the provision of molecular spectroscopy through facilities.

MGP: Considering super-resolution techniques. More needs to be done to make them generally applicable. This includes the development of new probes/fluorescent markers. There is a requirement for people to be trained so that they are able to recognise artefacts. Software algorithms are currently limiting and more work is needed in this area. More could be done to manipulate systems using light (e.g. interfering with biological function). Optogenetics is beginning to make an impact and will become more important in the future.

EP: It should be recognised that the super-resolution techniques are not “plug and play” and considerable levels of expertise are needed to use them successfully. More efforts should be made to make the techniques more user-friendly. Sample preparation is the key to success. An important factor to be considered for the future is the training of students. Biology students do not appear to receive adequate training in physics and mathematics.

HM: Lasers need to be developed for two types of medical application – photoacoustic and photoreactive. There is a lot of scope for improvement, particularly for diseases that do not hit the headlines but cause serious problems for patients. Better ways of interrogating skin are required, and for analysing what is beneath the skin. For surgery, fluorescence-guided techniques might become more important. Two-photon excitation for photodynamic therapy has potential. There is a need to improve communication between the medical community and those developing lasers and optics.

Comments from the floor:

- Cheap fibre lasers with 5 ps pulse lengths will become available and may be suitable for bringing new techniques to the clinic. There is a need for multimode fibres (~1mm diameter) that preserve images.
- In the area of laser ionisation, there has been a lot of investment in high power laser systems. More facility time is needed for the work and there's a need to convince the plasma physics community that time should be made available.
- Training of people is essential. We need people with the right skills if innovation is to continue. A supply of good people with expertise in the physical sciences is needed.
- The area of data is an important one. Volumes of data are increasing rapidly with the availability of new techniques like super-resolution microscopy. There's a need to easily access the data and look for links between results from different techniques. Establishing standards for metadata is essential.
- In the UK, the British Medical Laser Association (BMLA) could be a useful resource for bringing clinicians and laser experts together, and promoting communication. Closer links between the BMLA and Laserlab-Europe would be useful.
- In general, medics appear to be satisfied with lasers that would not be considered to be state-of-the-art. The big issue is delivering laser light into the human body (e.g. the talk which showed the direct delivery of light into the brain). This is an area that is often overlooked and there are no good, flexible fibres that can deliver the light effectively. This is a problem for surgery (cutting), diagnostics, and remote sensing.

4 Conclusions

The consensus from the workshop is that it was successful in bringing together two communities who do not often communicate. It is hoped that this will result in an increase in collaboration and promote further dialogue. An immediate result is that the British Medical Laser Association has expressed an interest in Laserlab-Europe participating in their next annual conference. At an individual level, a number of delegates have indicated that they have formed new contacts for potential collaborations.

An important conclusion is that clinicians are not generally aware of many developments in the laser area. Better communication would allow the more rapid application of new laser technologies to the clinic and to the biomedical research laboratory.

In the area of international collaboration, the presentation on the Euro-Bioimaging ESFRI project provoked discussion with the conclusion that stronger links should be forged between Laserlab-Europe and Euro-Bioimaging. This will be facilitated by Prof. Pavol Miskovsky, who is involved in both activities.

To assist further collaboration, the full list of delegates will be made available on the Laserlab-Europe website. Additionally, where speakers agree, presentations from the workshop will be available.

5 References/Publications

Workshop website:

<http://www.laserlab-europe.eu/events-1/laserlab-events/2014/june-2014-lasers-for-life>