Triennial Report to IUPAP
September 2014-2017

www.ICUIL.org

ICUIL Activity Overview

IUPAP Working Group 7, The International Committee for Ultrahigh Intensity Lasers, continues to promote the advancement of the international field of ultra-high intensity lasers. Our goals are to provide a venue for discussions, among representatives of high-intensity laser facilities and members of user communities on a variety of subjects including; international collaborations to define and develop the next generation of ultra-high intensity laser capabilities, exploration of new areas of fundamental and applied research and formation of a global research network for access to facilities by users. This report to IUPAP highlights progress made by members of the ICUIL community over the last three years.

ICUIL represents the global community working with ultra-intense lasers, i.e. lasers with capabilities exceeding 10^{19} W/cm^2. This community is rapidly increasing in size both in terms of capability and investment. The cumulative laser power from all "ICUIL" qualifying lasers in 2010 was estimated to be ~11 PW. By present estimates this total will exceed 120 PW by 2018. Ultra-high intensity laser projects worldwide now total more than $4B in research investment and involve more than 1500 FTEs of technical staff.

A multitude of laser facilities continue to push towards multi-petawatt power capability. For example, the Chinese initiative at the Shanghai Institute of Optics and Fine Mechanics (SIOM) is advancing towards a 10-PW laser facility has now suggested to the Chinese government an even larger project, the 100 PW Station for Extreme Light (SEL) at the proposed Shanghai Coherent Light Facility (SCLF). Lawrence Livermore National Laboratory (LLNL) activated their multi-kJ Advanced Radiographic Capability (ARC) PW scale laser and the PETAL laser at CEA began operations toward the 2-PW level this year. In South Korea, the Gwangju Institute for Science and Technology is presently commissioning a 4 PW capability that should be available to users in 2017. The University of Rochester's Laboratory for Laser Energetics continues to work on the OPAL multi-phase laser initiative that could evolve from 5-PW to 75-PW capability. In addition, the European ESFRI roadmap project, the Extreme Light Infrastructure (ELI), consisting of ELI-Beamlines (Czech Republic), ELI-Nuclear Physics (Romania), and ELI-ALPS (Hungary), is rapidly approaching initial operations.

ICUIL and ICFA (International Committee for Future Accelerators), another arm of the IUPAP Working Groups, are now jointly promoting the development of efficient, high-power, laser technology to enable laser-driven wakefield acceleration for future high energy accelerators. ICUIL has continued to collaborate with and support the activities of the Asian

Intense Laser Network and has helped sponsor the Russian Summer School on Intense Lasers to promote involvement by young scientists in the advancement of ultra-high intensity lasers.

ICUIL Biennial Conferences

The ICUIL biennial conferences aim to gather ultrahigh intensity enthusiasts from around the world, to report new results, exchange information and to establish and enhance collaborations across borders. Following past conferences, ICUIL 2014 and ICUIL 2016 focused on the following themes: (i) ultra-intense laser design and performance (such as Nd:glass-based, Ti:sapphire-based, DPSSL-based and OPCPA-based ultra-intense lasers, in addition to their pump lasers); (ii) novel technologies for ultra-intense lasers (such as grating and compressor modeling and fabrication, high-damage-threshold and ultra-broadband laser components, devices for spatial and temporal pulse control, diagnostics for ultra-intense lasers), and (iii) applications of ultra-intense lasers (such as laser acceleration, short-wavelength sources, attosecond sources, high-field physics and applications of extreme light).

The 6th biennial ICUIL conference was held September 12-17, 2014 in Goa, India and was hosted by the Tata Institute for Fusion Research (TIFR) in Mumbai, with Ravi Kumar of TIFR and Chris Barty of Lawrence Livermore National Laboratory serving as the conference co-chairs. The Goa meeting had more than 200 participants and was the highest attended meeting to that date. Of special note with respect to the Goa meeting were the larger number of asian and in particular Indian student attendees. These students presented their work both in oral presentations and as posters. The winners of the poster competition for the 2014 meeting was a young researcher from TIFR in Mumbai.

The 7th Conference of the International Committee on Ultrahigh Intensity Lasers (ICUIL 2016) was held in Montebello, Québec, Canada from the 11th to the 16th September 2016. ICUIL 2016 included more than 100 presentations that showcased the latest on multilateral projects such as ELI, XCELS and IZEST, in addition to the efforts in individual institutions across the world.

The conference was chaired by Dino Jaroszynski (U. Strathclyde, UK) and Tsuneyuki Ozaki (INRS, Canada), with strong support from the Technical Program Committee Co-Chairs, Marco Borghesi (Queen's U. Belfast, UK), Hiromitsu Kiriyama (QST, Japan) and Christophe Dorrer (UR/LLE, USA), along with 24 members of the Technical Programme Committee. The program consisted of 19 invited talks, 61 contributed talks and 77 poster presentations, held over the five days of the conference. The total number of participants was 148, coming from 56 institutes and 18 countries from around the world. We also had strong participation from young researchers, with 17 postdoctoral fellows and 11 PhD students, who are the future of the ICUIL community. The ICUIL 2016 conference was also strongly supported by a total of 22 companies, agencies and universities. Participation from these companies was also active, with 44 participants, some of whom gave oral presentations, while the majority of companies presented posters during the conference. The total number of conference attendees was 192, again showing continual growth in this field.

For contributions to the two poster sessions at ICUIL 2016, Student Poster Awards were awarded to three students: First Prize (including a US$500 cash award) went to Mr. N. Stuart (Imperial College, UK), for his poster on "OPCPA Pump-Depletion Contrast Enhancement using a Seeded OPCPA Fluorescence Diagnostic", Second Prize (US$300 cash award) went to Mr. J. Pilar (Czech Technical U Prague, Czech Rep), for his poster on "Adaptive optics development at HiLASE", and the Third Prize (US$200 cash award) went to Ms. S. Bucht (UR/LLE, USA) for her poster on "Transforming the Idler to Seed Raman Amplification". There were also five Student Travel Grants (US$1,000 each) were awarded to promote student participation. These went to Ms. C. Scullion (Queen’s University Belfast, UK), Ms. G. Cantono (Université Paris-Saclay, France), Mr. R. Budriunas (Vilnius U., Lithuania), Mr. D. E. Cárdenas (Ludwig-Maximilians-Universität, Germany) and Mr. J. Pilar (Czech Technical U Prague, Czech Rep).

ICUIL 2016 provided an occasion to honor and remember an important figure of the ICUIL committee and community, Prof. Wolfgang Sandner, who passed away unexpectedly in December 2015. Among his many illustrious roles (including Director of the Max Born Institute, Coordinator of Laserlab-Europe, President of the German Physical Society, and the General Director of the ELI-Delivery Consortium), Prof. Sandner served as Co-Chair of the ICUIL committee for many years. To pay tribute to Prof. Sandner, the ICUIL 2016 conference dedicated one of its plenary sessions in his honor. This special session was organized by Dr. Catalin Miron of the ELI-Delivery Consortium, and included invited speakers who worked closely with Wolfgang over many years. We also had the privilege of Mrs. Sandner accepting an invitation to attend the conference, and to remember Prof. Sandner with all his professional colleagues and friends.

The ICUIL 2014 and ICUIL 2016 were a great success, owing to the excellent presentations from the participants from around the world, and to the support from the various sponsors. The conferences again showed the strength of the ICUIL community.

Four potential sites were proposed for the 2018 ICUIL conference in Europe. Compelling proposals were provided by Germany, Russia, the UK, and Hungary; the largest number of proposals in the 12 year history of ICUIL. Although the General Assembly member votes were distributed among the proposals, Germany received the largest number of votes and was selected as the 2018 host. T. Kuehl will serve as Chairman of the next conference. Subsequently, T. Kessler agreed to serve as Co-Chairman. The location will be Lindau, Germany and the meeting will be held from September 9th through the 14th, 2018.

ICUIL Membership Rotation

After eight years of service, Toshiki Tajima stepped down from his Chairman position, but remains a voting member of the General Assembly (GA). Toshi nominated Chris Barty as the next ICUIL Chairman which was seconded by Tsuneyuki Ozaki. Following GA deliberation, including questions posed to the candidate, the GA unanimously voted to have Chris serve as Chairman of ICUIL for the next four years. T. Tajima recommended adopting a rotation philosophy that includes two of succession plans where the Board members are rotated from and to the GA, while the regular members of the GA are rotated in from the high intensity laser community. After lengthy deliberation of candidates who could take the vacant Co-Chair position, Chris Barty nominated Ravindra Kumar, an active GA member, for the position with Terry Kessler seconding the nomination. The GA unanimously voted to have Ravi serve as Co-Chair along with the existing Co-Chair, Alexander Sergeev. Several ICUIL members have completed two terms of service and are required to step down according to the bylaws of the ICUIL charter. A high priority in the coming year is the addition of new members that represent a broad diversity of continental, gender, racial, etc. backgrounds. GA members have been asked to generate a list of candidates for future rotation with an emphasis on increasing overall diversity.

During a recent 2017 ICUIL GA teleconference, Tsuneyuki Ozaki, the present treasurer of ICUIL and member of the ICUIL board, indicated that he desired to step down after many years from his role at treasurer. Professor Dino Jaroszynski, a current ICUIL GA member, was nominated to fill this role and has subsequently accepted. The transference of accounts and responsibilities is presently underway.

ICUIL Charter

The bylaws of the ICUIL Charter were revised by vote of the General Assembly to maintain the experience and dedication of the current membership that has been assembled over the last decade. In exceptional cases, more than two terms of service will be allowed for members who continue to be active in this field and are able to provide service to the ICUIL community. An electronic vote on the revised charter occurred in early 2017 and passed without objection. A more gradual member rotation will be used to maintain continuity and to ensure that ICUIL continues to advance while maintaining balance both geographically and between the various high field science working groups of IUPAP.

ICUIL Website and Newsletter

One of the features of the ICUIL website is an interactive world map that highlights the high intensity laser facilities around the world as shown later in this report. Surveys of the worldwide laser community are conducted by ICUIL in an effort to provide an accurate accounting of all existing and planned ultrahigh intensity laser facilities that are capable of reaching intensities above 10^{19} W/cm^2. An updated survey was carried out at the 2016 ICUIL conference.

ICUIL continues to achieve its goal of publishing an annual newsletter. The seventh ICUIL Newsletter (Volume 7) was sent out to the high intensity laser community in June 2016 and is also available at the ICUIL website. The eighth ICUIL Newsletter (Volume 8) was delivered to the community this past summer. The chief editor, Alexander Sergeev, managed the illustration and publication resources to distribute the newsletter to hundreds of readers, highlighting the major laser construction and laser science projects within the High Intensity Laser community, major conferences, and related workshops. Copies of the 2014, 2015, 2016 and 2017 newsletters are included as an appendix to this document and can also be found on the ICUIL website (www.icuil.org)

Fund Raising

In addition to support from IUPAP, ICUIL has continued its corporate participation program to enable maintenance of the ICUIL website, publish its annual newsletter, support biennial conferences, and provide prize funds to students. In addition, ICUIL will be seeking funds to finance a planned Wolfgang Sandner Prize for Scientific Leadership that will be presented at the biennial ICUIL conference. Student travel funds have been derived from IUPAP support and conference budgets which are funded through registration fees, contributions from host institutions and corporate sponsorships. Student poster prizes are also derived from the conference budget.

Recent Awards to ICUIL Members

Enrico Fermi Prize 2015

Toshiki Tajima
Norman Rostoker Chair Professor,University of California at Irvine, USA

For the invention of the laser-wakefield-acceleration technique which led to a large number of fundamental and interdisciplinary applications ranging from accelerator science to plasma physics and astrophysics

The Infosys Prize 2015 in Physical Sciences

G. Ravindra Kumar
Tata Institute of Fundamental Research, Mumbai

For his pioneering experimental contributions to the physics of high intensity laser matter interactions. In particular for providing, for the first time, unequivocal evidence of turbulent magnetic fields and the discovery of terahertz frequency acoustic waves, in laser produced hot dense plasmas. These results have significance to testing stellar and astrophysical scenarios.

Frederic Ives Medal / Quinn Prize 2016

Gerard Mourou
Distinguished Professor Emeritus from the University of Michigan and the Ecole Polytechnique in Palaiseau, France

For numerous pioneering contributions to the development of ultrafast and ultrahigh intensity laser science and for outstanding leadership of the international and commercial communities impacted by these technologies.

Harold E. Edgerton Award 2016

Christopher P. J. Barty
Lawrence Livermore National Laboratory

In recognition of his efforts in the development of foundational techniques that have enabled ultrafast, intense lasers and for pioneering contributions to time-resolved, x-ray and gamma-ray science conducted with such lasers

Present ICUIL Membership

Chris Barty	Chairman	United States
Alexander Sergeev	Co-Chairman	Russia
Ravi Kumar	Co-Chairman	India
Terry Kessler	Secretary	United States
Tsuneyuki Ozaki*	Treasurer	Canada
Gerard Mourou		France
Toshiki Tajima		International
Hiroshi Azechi		Japan
John Collier		United Kingdom
Dino Jaroszynski**		United Kingdom
Thomas Kuehl		Germany
Christine Labaune		France
Wim Leemans		United States
Ruxin Li		China
Chang Hee Nam		Korea
Bedrich Rus		Czech Republic
Heinrich Schwoerer		South Africa
Ken-ichi Ueda		Japan

Associate Members (without vote)

Ryosuke Kodama	Japan
Sandro de Silvestri	Italy
Nilson Dias Vieira Jr.	Brazil
Claes-Goran Wahlstrom	Sweden

*outgoing treasure
**treasurer elect

Recent ICUIL Related Science and Technology Highlights

I. Extreme Light Infrastructure (ELI)

ELI is a pioneer among the research infrastructures contained in the European ESFRI Roadmap in that it is using EU structural funds and not science funds for construction of its facilities. ELI consists of three separate sites of roughly equal funding magnitude: ELI-Beamlines, ELI-Nuclear Physics, and ELI-ALPS (attosecond science pillar). ELI-NP, a European research center to study ultra-intense lasers interaction with matter and nuclear science using gamma and laser driven radiation beams is located in Magurele, Romania. The total cost of the facility will be 300 million Euros and commissioning is scheduled to take place in 2018. The ELI-NP facility combines a high power laser system (HPLS) with two arms of 10 PW having intensities on the target in the range of 10^{23} W/cm^2. A gamma beam system (GBS) will deliver up to 19 MeV photons with extreme brilliance and bandwidth and is based on Compton scattering of a high repetition pulsed laser beam on a relativistic electron beam produced by a warm linac of 720 MeV. A new, international conference entitled Nuclear Photonics 2016 and devoted to science of direct relevance to ELI-NP will held this October in Monterey, California. (www.nuclearphotonics2016.org). Members of ICUIL have been instrumental in the formation of this new biennial meeting series. The 2018 meeting of the Nuclear Photonics series will be hosted by the ELI-NP facility and team.

II. International Center for Zetta-Exawatt Science and Technology

IZEST endeavors to unify a number of exawatt class facilities around the world. Almost 30 laboratories in 13 countries have signed a collaboration agreement. A new pillar within the IZEST organization, known as ZeptoScience, was formed. A ZeptoScience team is performing experiments to test the methods to efficiently compress existing laser technologies to the few-cycle, femtosecond regime with a sufficient intensity to pursue the creation of zeptosecond pulses. This work is being performed by a team based at Ecole Polytechnique (France), National Institute for Laser, Plasma and Radiation Physics (INFLPR, Romania), and ELI-NP (Romania).

III. The International School on Ultra-Intense Lasers

The School is organized by the International Committee on Ultra-Intense Lasers (ICUIL), Institute of Applied Physics of the Russian Academy of Sciences (IAP RAS), National Research Nuclear University MEPhI and Russian Federal Nuclear Center (RFNC-VNIIEF). The school was held in the Hotel@Resort “Yunost” 40 km from Moscow, Russia, from 4 to 9 October, 2015. The main objective of the School was to give an opportunity for postgraduate students and other early career researchers working in ultra-intense laser science to meet in person and listen to the lectures given by world renowned experts in high power laser physics, laser-matter interaction physics, laser-plasma accelerators, laser-based x-ray sources and inertial confinement fusion. Also, a poster session was organized for the young participants where they could present and discuss their own results. In addition to the lectures and poster session, evening interactive classes were conducted by distinguished specialists in the field. The main idea behind them was to make contact of students and teachers as close as possible. The classes were divided into 4 topics; High average power and high-energy lasers, Femtosecond-laser-plasma interaction and particle acceleration, Laser ceramics: fabrication and application and Interaction of strong lasers with quantum systems. About 80 young scientists from Asia, Western Europe and Russia took part in the school.

IV. Collaborations with the Accelerator Community

For laser-based particle accelerators, one of the main issues is the need to improve the laser technology, in particular laser efficiency and repetition rate, so that the beam generated has high enough luminosity for practical applications. Along this line, the ICUIL community is supporting the development of the Coherent Amplification Network (CAN) laser technology based on phased arrays of fiber lasers. A successful CAN system will have applications beyond particle acceleration and in particular a separate community is now considering the potential of this technology for laser-based management and removal of orbiting space debris.

Discussions of the CAN concept, updates on experimental demonstrations and consideration of other areas of overlap between the intense laser and high energy physics communities took place at an IZEST Conference at CERN last October and represented a giant step in collaboration between the communities of ICUIL and ICFA. The possibility of future collaboration on high fluence laser technology at CERN will be discussed in the future.

The 76th International Committee for Future Accelerators (ICFA) meeting was held at the J-PARC site (KEK Tokai campus) in Japan on 25th and 26th February 2016 and included discussion of ICUIL/ICFA collaborative science. The meeting summary can be found on the web page of ICFA at http://icfa.fnal.gov/.

In 2015 a working started with seed funding from the Japanese government to consider plasma-based deceleration as a technique for dramatically reducing the environmental issues associated with the 10-MW beam dump for the planned International Linear Collider (ILC). The members of the so-called “Green ILC Beam Dump” group include; KEK, UCI, SLAC and LAPP/IN2P3/CNRS.

In 2016 ICUIL, Chris Barty (at the time co-chair of ICUIL) became a member of the newly-formed, IUPAP Working Group on Accelerator Science (WG14). The first meeting of WG14 took place in May in Pusan, South Korea. Chris participated in this meeting via teleconference and provided insight with respect to generic issues faced upon formation in 2004 of the ICUIL working group.

V. XCELS

This project was launched in October 2015 and is aimed at fostering scientific cooperation between the Russian Federation and the European Union in the development and scientific exploitation of large-scale research infrastructures. 19 European research centers, including 6 Russian institutions, established a consortium to develop concrete coordination and support measures for each research infrastructure and common best practice and policies on international participation. The project is intended for 3 years during which each consortium member will organize working meetings and/or focus workshops with participation of other CREMLIN members to discuss problems of mutual interest and find ways for their solution. In addition, meetings of Consortium Board (CB) and Project Management Board with representatives of each party will be held regularly. An external Science Policy Advisory Board (SPAB) appointed by the CB shall assist and facilitate the CB decisions.

The CREMLIN kick-off meeting took place on 06-07 October 2015, at the National Research Center “Kurchatov Institute” in Moscow, Russia. The objectives, management and financial issues, exchange platform, milestones and other issues were addressed at the meeting. It was agreed that the CREMLIN project should be seen as a vehicle and platform to move the discussions around large-scale research infrastructures and as a means to establish links between the project participants and the European Strategy Forum on Research Infrastructures (ESFRI) and other relevant EU organizations. The first CREMLIN working meeting on exchange on policy and ESFRI-related issues was held at the Joint Institute for Nuclear Research in Dubna, Russia on the 20th April 2016. The meeting was intended to stimulate and enable mutual learning and exchange of best practice within the community, with a focus on policy issues. A second working meeting took place on 28–30 June 2016 and was dedicated to international relations to the megascience facilities. It was held at the European Spallation Source in Lund, Sweden. Still another CREMLIN event was organized by the Institute of Applied Physics of the Russian Academy of Sciences (IAP RAS). It was a workshop on novel applications of exawatt laser sources, with a focus on the XCELS facility developed at IAP RAS. The workshop was held on board a river ship cruising from Nizhny Novgorod to Saint Petersburg, Russia from the 17th to the 23d of July 2016.

VI. Recent Highlights - High Intensity Laser Facilities

National Ignition Facility’s ARC

The commissioning of the Advanced Radiographic Capability (ARC) laser system in the National Ignition Facility (NIF) was completed. ARC is designed to ultimately provide eight beamlets from one quad of NIF beams with pulse duration adjustable from 1 to 50 ps, and energies up to 1.7 kJ per beamlet. A special front end laser system enables ARC to achieve the high pulse contrast (80 dB) needed for unperturbed solid target interactions. The ARC beamlets will be used to create x-ray point sources for dynamic, multi- frame high-energy x-ray radiographs of the imploded cores of ignition targets. ARC x-rays are critical for precision x-ray imaging of NIF experiments studying complex hydrodynamics and material strength at extremely high energy densities. In principle, ARC can also produce MeV protons and electrons for future experiments in advanced fusion, TeV acceleration and proton radiography.

Extreme Light Infrastructure (ELI)

A High Power Laser System (HPLS) is being constructed for the ELI-NP (Nuclear Physics) pillar in Magurele, Romania. The HPLS consists of two main beams, each delivering 10 PW peak power at a repetition rate of 1 shot per minute. In addition, each leg will be capable of delivering 100 Terawatt at 10 Hz and 1 PW at 1 Hz. The ELI-NP team recently achieved compressed pulses with 28 J at 1 Hz with 21 fs pulsewidth, yielding 1.3 PW in a beam measured to have a Strehl ratio of 0.92.

National Energetics is working to deliver the L4 beamline, a 10 PW (1.5 kJ in 150 fs) at 1 shot per minute, to ELI Beamlines in Czech Republic. The laser system is based on Nd-doped glass as a gain medium. The thermal management of the power amplifiers includes liquid cooling of multiple slabs in a split-disk configuration. The spectral width is increased to support 150 fs pulses by mixing Silicate and Phosphate glass amplification media.

Texas Petawatt Laser

Researchers at the University of Texas, Center for High Energy Density Science have benefitted from a successful project to improve the pulse contrast on the Texas Petawatt Laser while reaching 150 J in 150 fs. This laser has produced the brightest ultrashort pulse neutron source yet measured (>10^{18} n/cm^2 in a 50 ps pulse), the highest measured positron-to-electron ratio pair creation in a solid (~50% in a Pt rod), and high energy (~100 MeV) proton yields. Following improvements to the laser wavefront and focusing system, the Texas group expects to reach intensities above 10^{22} W/cm^2.

CEA's PETAL

Petawatt Aquitaine Laser (PETAL) will allow unique experiments in the field of ultrahigh intensity sciences, extreme plasma physics, astrophysics, radiography, and fast ignition by a combination of its own multipetawatt kilojoule beam and the nanosecond multikilojoule beams of the Laser Mégajoule (LMJ). The PETAL facility is designed and constructed by the French Commissariat à l'énergie Atomique et aux énergies alternatives (CEA) to deliver laser pulses in the kJ-picosecond range at the wavelength of 1053 nm and is an additional short pulse beam to the Laser MegaJoule (LMJ) facility. In May 2015, PETAL had achieved 1.4 kJ at 2 ns with a 3.5 nm bandwidth to produce 1.15 PW. In December 2016, PETAL delivered 0.9 PW to the LMJ target chamber. The PETAL goal is to reach 10^{20} W/cm^2 on target.

SIOM's Petawatt Lasers

The Shanghai Institute of Optics and Fine Mechanics (SIOM) in China introduced their 10 PW laser project called SULF (Shanghai Superintense Ultrafast Laser Facility). At the end of 2014, a high gain chirped pulse amplifier based on a 150 mm diameter, Ti:sapphire crystal was demonstrated. To date the highest output pulse peak power of 5.3 PW has been demonstrated. In addition A CPA/OPCPA hybrid laser system has achieved the peak power of 1.02 PW, where an LBO of 100 mm in diameter was used in the final OPCPA, and the output energy of 45.3 J was obtained. A 10 PW level femtosecond laser system, combining the Ti:sapphire based CPA chain and the OPCPA booster amplifier, is currently being constructed and is the basis for a proposed 100 PW system known as the Station of Extreme Light (SEL) that would be part of the proposed Shanghai Coherent Light Facility (SCLF).

Kansai Photon Science Institute (KPSI)

The J-KAREN laser system at the KPSI National Institutes for Quantum and Radiological Science and Technology (QST) was upgraded over a two-year period between 2014 and 2016. Previously, J-KAREN system delivered laser intensities of 10^{21} W/cm^2 to high field physics experiments to successfully obtain energetic hadron beams. The J-KAREN-P laser is a Ti:sapphire system with double-chirped pulse amplification (CPA), capable of providing a laser pulse with intensity over 10^{22} W/cm^2 and a high contrast ratio of 10^{-10} at -500 ps. The laser system has successfully amplified a pulse up to 65 Joules and compressed it to 30 fs (FWHM) on target. The J-KAREN-P laser system promises to open the door to relativistic particle acceleration, especially hadron beams, bright x-ray and γ-ray radiation generation and photo-nuclear science.

ICUIL *News*

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Chief Editor: Christine Labaune

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The International Committee on Ultra-High Intensity Lasers

Greetings

T. Tajima, Chair of ICUIL

Norman Rostoker Chair Professor – University of California at Irvine

Toshi Tajima at the 4th IZEST Conference at the French Embassy in Tokyo in November 2013 (KEK: host)

Year 2013 started with a bang to us the high intensity laser community as well. The Extreme Light Infrastructure (ELI)-Delivery Consortium (DC) International Association has been founded on April 11, 2013 and as Director General and CEO appointed as of July, 2013 was Professor Wolfgang Sandner, our former Co-Chair of ICUIL. As among the early birds of European ESFRI roadmap projects, ELI has started at 850M Euro budget and as of 2018 it is expected to be operational. ELI-Beamlines, ELI-Nuclear Physics, and ELI-ALPS (attosecond science pillar) have now already started construction and well into their way. Also in a serious launching stage is the XCELS (Extreme Center for Exawatt Laser Science) at the level of subexawatt (200PW). They have launched an impressive workshop "Laser Ascent to Subatomic and Applications" in Moscow as a step toward this realization in Russia. This aspires to be the fourth and final pillar of ELI, ELI-High Field Science. Meanwhile, Professor Peter Higgs joined the second IZEST (International Center for Zetta- Exawatt Science Technology) Conference at Strathclyde as Featured Speaker to strengthen the tie between the high energy physics community and the high intensity laser community in November 2012. Just about a year later (December, 2013) he and Professor Francois Englert have been awarded last year's Nobel Prize for Physics for their pioneering contributions on 'Higgs' bosons. Also last year Dr. Weiren Chou and Professor Mayda Velasco along with Dr. Nikolay Solyak, Professor Gerard Mourou and myself suggested a Higgs factory using the CAN (Coherent Amplification Network) laser in the Tevatron tunnel. These are just a few that signify the bang of 2013.

There has been a new initiative at SLAC (Stanford Linear Accelerator Center) to hold a first meeting "High Power Laser Workshop" on Oct. 1-2, 2013. This workshop will be repeated this year again. The workshop took place in parallel to (or in conjunction with) SSRL/LCLS Annual Users Meetings and Workshop (a synchrotron and X-ray Free Electron Laser community meeting), another sign that the high intensity laser community and accelerator community have come closer to work together. In a similar line with this, in Europe the European Network for Novel Accelerators (EuroNNAc) organized its first European Advanced Accelerator Conference (EAAC) 2013. This year in turn in US the 2014 Advanced Accelerator Conference will be hosted, counting 16th this time from the very first AAC in Malibu, CA, in 1985. ICUIL would like to salute AAC's historic, pioneering, and heroic efforts in these three decades in pushing the envelope of high field science from the advanced accelerator research perspective.

One of the major recommendations of the collaborative endeavors between ICUIL and ICFA (International Committee for Future Accelerators) in the Joint Task Force Report (in ICFA Newsletter, 2011, eds. W. Leemans, W. Chou, and M. Uesaka) stated that we need a new development of laser technology that has higher repetition rate and higher efficiency. International Coherent Amplification Network (ICAN) has produced a credible breakthrough on this and is on its way to start a development consortium this year. Representing ICUIL, on this development I (along with Professor Kuehl) reported to the ICFA General Assembly this February.

I am continuously impressed with our Asian colleagues' progress. If I am not mistaken, the current highest intensity laser is at GIST (Gwangju Institute of Science and Technology, Korea) at 1.5PW. Fast in its footsteps are Chinese initiatives such as at SIOM, IOP, Peking University, Shanghai Jiaotong University in China, with which I have had an in-person in-depth impression last September when I was invited as Einstein Professor in these institutions. Osaka University in Japan is also pursuing an exawatt initiative. The picture (see attached) was taken at the 4th IZEST Conference (hosted by KEK last November) when I was giving a talk on the report of IZEST world science activities, in which Asian colleagues play important roles.

And lastly but perhaps most importantly, India is stepping up its aspiration and camaraderie to volunteer to host the 2014 ICUIL Conference. As you see in this Newsletter written by Professor Ravi Kumar, he is hosting the ICUIL at Goa and also is mounting the Indian showcasing of the high intensity laser efforts and their liaison with wider scientific and industrial communities of India. The ICUIL community is very grateful for their effort and in turn is most interested in promoting our continued ascent of our science and technology extended to India and at the same time to broaden our reach into many other corners of the world. This year we shall mark an important step in making our inroad into the Indian subcontinent.

Greeting from the Director General of CERN

Rolf-Dieter Heuer

High-energy physics studies the fundamental particles and forces that make up and govern our universe. Large facilities like the LHC at CERN are needed to observe these tiny particles and determine their properties with higher and higher resolution. Accordingly, the last decades have shown a clear trend: every new accelerator at the energy frontier, being more power full than its predecessor, could provide a significant step forward in resolution and beam energy. The energy of the particle beams however dictates the technology, which in turn determines the size of machine and tunnel. As you know, a team of worldwide experts is already studying a next possible machine at CERN that could have a tunnel of up to 100 kilometres.

But that doesn't mean that we aren't looking around for other, better technologies that could make acceleration of particles more efficient, e.g. using plasma wake acceleration. In particular with CERN's AWAKE project we even contribute to the basic research in this field. The update of the European Strategy for Particle Physics recommends design studies for accelerator projects in a global context for high-energy-frontier machines coupled to "vigorous" accelerator R&D. That is because high gradients and high energies will remain a core challenge of particle physics, and tackling them with ingenious technologies like high-intensity and high-coherence lasers that could shorten accelerators dramatically would be a revolution in the field. Laser technology has changed our daily lives in many ways, and I am curious to see whether your studies at the forefront of technology will lead to applications that we cannot imagine right now.

Of course every R&D project has its hurdles, and the quality of the accelerated beam in terms of energy spread, intensity and some other areas remains a challenge. We know, however, that challenges can be tackled by a global network of experts, and that a laser that provides extremely coherent light also needs a coherent community. In the world of research, be it for laser, accelerators or detectors, it is very important that we bundle and coordinate our studies in a worldwide effort. It is encouraging to see so much coherence in your field – so let there be light!

Seventy-first meeting of ICFA (International Committee for Future Accelerators)

On February 20-21 2014, the regular board meeting of ICFA took place at DESY in Hamburg. ICUIL was represented by Toshiki Tajima with a SKYPE presentation, and by Thomas Kuehl, who participated in this meeting. ICFA is leading a concerted international effort to coordinate and support these world-wide activities, aiming to define the future of high-energy physics in the next twenty-to-thirty years. The agenda included reports and discussion on a number of future accelerator projects. Ideas for large scale facilities were presented which will be proposed to be installed in Japan, Europe, China and Korea. In his short Skype presentation, which was attended by all representatives, ICUIL chairman Toshiki Tajima explained the latest progress in laser technology towards an improvement of average power, as needed for a wide application of laser drivers for high energy accelerators.

The connection between the ICFA and ICUIL communities was further documented in the report of Brigitte Cros, Univ. Paris-Sud, chair of the ICFA Panel on Advanced and Novel Accelerators. Although the main line of discussions was centered on the extension of classical accelerator schemes, the importance of novel laser acceleration approaches is well recognized. It was emphasized that a next dedicated meeting on laser acceleration would be a timely step to encourage a close interplay between international developments towards novel acceleration schemes.

XCELS, the Exawatt Center for Extreme Light Studies

XCELS is a prospective project for international collaboration that was presented in ICUIL News n°4. XCELS aimed at establishing an international center for the study of extreme light fields is the only Russian mega-science project in the field of laser physics.

In the frame of the first Memoranda of collaboration in the area of extreme light between CEA, Ecole Polytechnique and IAP, and between CEA, Ecole Polytechnique and Russian National Nuclear University (MEPHI), the parties have agreed to cooperate in the following mutually beneficial areas:

– Promoting creation of XCELS, the Exawatt Center for Extreme Light Studies, a new mega-science class research infrastructure in Russia with the international vocation that is based on construction at IAP RAS of a 200 PW laser with the OPCPA (Optical Parametric Chirped Pulse Amplification) architecture.
– Promoting development of IZEST, the International Center for Zetawatt and Exawatt Science and Technology, a joint research and development project of EP and CEA that is dedicated to unite efforts of scientists and research organizations worldwide in exploration of new routes in mastering the beyond-Exawatt power level.
– Supporting collaboration between French and Russian research laboratories in the area of extreme light science, application, and technologies; promoting partnership of appropriate laboratories to form consortia capable of performing complementary research and going into international competition.

On May 16, a delegation of the Directorate-General for Research and Innovation of the European Commission met with leaders of the mega-science projects at the RF Ministry of Education and Science. The delegation was headed by Mrs. Ana Arana Antelo, the head of Unit for Research Infrastructures, and included several European experts, well-known scientists Robert Aymar, Susana Gota Goldmann, Jean Moulin, Steve Myers, Horst Stoeker. By this meeting the EC started evaluation of prospective cooperation between ESFRI and the Russian mega-science program and inclusion of some Russian projects to the European research infrastructure roadmap. The EC appointed certain experts for each project, Susana Gota Goldman (CEA) and Wolfgang Sandner (ELI) being responsible for XCELS evaluation.

A particular interest of the EC to the XCELS project is explained by its complementarity to the European research infrastructure ELI that is one of the major projects of the ESFRI roadmap ELI – Extreme Light Infrastructure – aims at creating in Europe new scientific centers based on superhigh-power laser complexes the radiation of which may be used for a wide scope of basic and applied research.
The ELI project is intended for construction of 4 research centers dedicated to different trends:
1) creation of sources of charged particles and hard electromagnetic radiation with unique characteristics;
2) attosecond physics;
3) nuclear optics; and
4) producing laser fields of extreme intensity for studying new states of matter and vacuum.

First three centers based on lasers with a peak power of about 10 petawatt will be located in Czech Republic, Hungary, and Romania. Construction of the fourth ELI center that is intended to be equipped with the world's most powerful subexawatt laser complex is currently pending in the EC countries for financial and technological reasons. The Russian project XCELS has characteristics comparable or even superior to those planned by European colleagues for the fourth ELI center. That is why evaluation of a possibility to combine the efforts of the EC and Russia for constructing a unified pan-European infrastructure ELI+XCELS functioning on the basis of coordinated activity of 4 centers. The European experts believe that this cooperation opens up a unique opportunity for EC countries to implement in full the ELI project and for Russia to become an equitable partner of the All-European scientific community. A legal form of Russian participation in the ELI+XCELS alliance may be associated membership in the European research infrastructural consortium (ERIC) – a new type of legal entity specially developed by EC for construction and functioning of research infrastructures comprising several centers in different countries.

On June 19, the second evaluation meeting took place at the EC headquarters in Brussels. Both appointed experts, Susana Gota Goldmann and Wolfgang Sandner, supported the ELI+XCELS alliance. Following this meeting, on behalf of EC they visited Nizhny Novgorod in July and were acquainted with the state-of-the art in developing of the XCELS project.

High Power Laser Science and Technology in China

Ruxin Li

Celebrating its 50th anniversary, the Shanghai Institute of Optics and Fine Mechanics has pioneered important advances in high power lasers, high-field laser physics and solid-state lasers.

Ruxin Li

Founded in May 1964, the Shanghai Institute of Optics and Fine Mechanics (SIOM) has been widely recognized as the most important research center of laser science and technology in China. SIOM has become a comprehensive research institute with primary research fields that include high power laser technologies, high-field laser physics, information optics, quantum optics, solid-state laser technologies and their applications, and materials for laser and optoelectronics. Here, in commemoration of our 50th anniversary, I would like to highlight some of our recent progress.

SIOM has been engaged in the research and development of high power laser technology and engineering for decades, and developed in recent years the first Chinese multikilojoule laser facility, Shenguang (SG for short and means "magic light" in Mandarin) –II facility. The SG-II laser facility includes nine laser beams [see Fig.1(a) and (b)], that has been stably operated for more than10 years and will be upgraded to be a 20 kJ-class laser facility in the near future. This facility has become an international user facility for high energy density physics research.[1]

SIOM developed the first Chinese petawatt (PW) femtosecond laser facility in 2007 based on the chirped pulse amplification (CPA) scheme. This laser system was recently upgraded to 2 PW based on a 100-mm dia. Ti:sapphire amplifier [see Fig.2].[2] Now, a 10 PW level femtosecond laser system combining the Ti:sapphire-based CPA chain and an OPCPA booster amplifier is being built. A hybrid Ti:sapphire-CPA and LBO-OPCPA laser system as prototype,[3] has been developed to produce 0.61 PW/33.8 fs pulse output near 800nm.

SIOM has successfully developed large aperture (up to 400 mm) Nd-doped laser glass slabs, which are the key active material of high-power laser-fusion drivers. Moreover, optical coatings for high-power laser applications can be customized for wavelength ranges from deep ultraviolet to infrared. The laser-induced damage thresholds for mirrors and polarizers are higher than 60 J/cm^2 and 30 J/cm^2 (1064 nm, 10 ns) respectively.

Driven by the PW laser facility, a two-stage laser wake field accelerator (LWFA) with near-GeV quasi-monoenergetic electron beams (QMEBs) was demonstrated in 2010.[4] The collimated QMEBs with peak energy of ~0.8 GeV are achieved with an acceleration gradient of 187 GV/m. More recently, by optimizing the seeding phase of electrons into the second stage, electron beams beyond 0.5 GeV with 3% RMS energy spread were produced over a short acceleration distance of 2 mm.[5]

SIOM has been developing space-borne solid-state lasers and lidar systems since 2001. The first space-qualified solid-state laser developed in SIOM was the transmitter of the laser altimeter on China's lunar explorer Chang'E-1, which was launched in 2007 and operated for about 16 months in orbit. On the Chang'E-3 launched last December, an ytterbium (Yb)-doped pulsed fiber laser system was developed as the transmitter of the scanning image lidar. To our knowledge, it was the first space-qualified fiber laser source operating in deep space.

Fig. 1. (a)The SG-II laser facility with eight beams was completed in 2000, with a beam aperture of 240 mm and total output energy of 6 KJ at 1053nm/1ns and 3 KJ at 351 nm/1 ns, respectively. (b)The ninth beam of SG-II facility, which was built in 2005 as a probe and high-pressure shock-wave driver; its output reaches 5.2 KJ per pulse with a beam aperture of 350 mm.

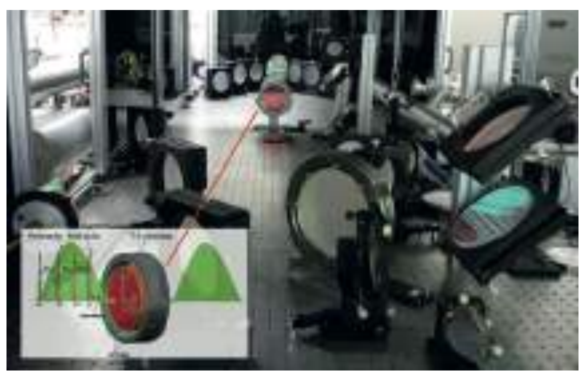

Fig. 2. The 100 mm diameter Ti:sapphire multi-pass amplifier for the 2 PW femtosecond laser facility, in which both active and passive schemes for suppressing transverse parasitic lasing was successfully implemented.

1. J. Zhong, *et al.*, Nature Phys. 6, 984 (2010)
2. Y. X. Chu, *et al.*, Opt. Express 21, 29231 (2013)
3. J.-Y. Lee, *et al.*, Opt. Lett. 38, 4837 (2013)
4. J. S. Liu, et al., Phys. Rev. Lett. 107, 035001 (2011)
5. W. T. Wang, et al., Appl. Phys. Lett. 103, 243501(2013)

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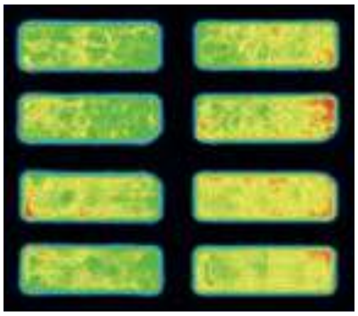
NIF's High Energy Petawatt Laser Is on the Fast Track to Completion



Output beamlet profiles measured at RMDE, totaling 10.41 kJ in eight 365x160 mm2 beamlets, from shot N140218-004-999.

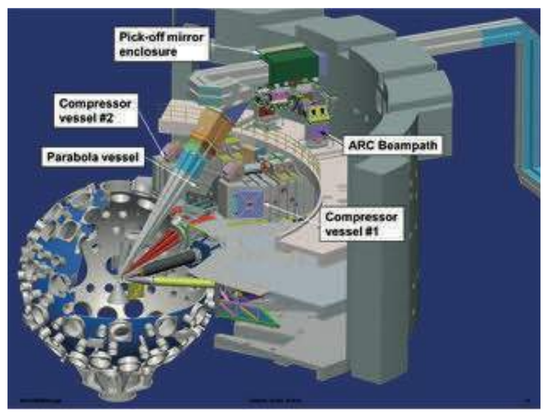
The National Ignition Facility's Advanced Radiographic Capability (ARC), a petawatt (1015-watt) laser system, is rapidly moving along the path to completion and commissioning. Over the past year, the ARC utilities, including electrical cabling, vacuum and ventilation systems, platforms, and cleanrooms, have been installed. On Sept. 12, the ARC team completed a major milestone by propagating first light into ARC Compressor Vessel 1, and the first ARC main laser system shot to the Roving Mirror Diagnostic Enclosure (RMDE) calorimeters (at the exit of the NIF laser bay) was fired in November. A recent series of laser shots to the RMDE calorimeters operationally tested a subset of the ARC systems, including the ARC Injection Laser System (ILS), Integrated Computer Control System (ICCS) automated shot software and Laser Performance Operations Module (LPOM) shot setup and analysis software. An ARC shot on Feb. 18 fired 10.41 kJ in 4 beams (8 beamlets or split beams), as recorded by the RMDE calorimeters in the image at right.

TheARC ILS consists of the ARC master oscillator, dual regenerative amplifiers for the A and B beamlets, the split-beam injection system, and modifications to the NIF preamplifier module to switch between NIF to ARC operation using ICCS controls. The laser shots were performed in parallel with the installation and alignment of the compressor and Parabola Vessel line replaceable units (LRUs) in the Target Bay and the ARC short-pulse diagnostics LRUs in the Target Bay and switchyard. Grating alignment in the compressor vessels is now complete.

Engineer JB McLeod inspects one of the first four high-efficiency diffraction gratings installed in the ARC compressor vessels. ARC's one-meter-wide multilayer dielectric gratings were specially developed at LLNL to withstand the record levels of energy generated by NIF's lasers.

When complete, ARC will be the world's most energetic short-pulse laser, capable of creating picosecond-duration laser pulses to produce energetic x rays in the range of 50-100 keV for backlighting NIF experiments. ARC is designed to deliver kilojoule laser pulses with adjustable pulse durations from 1 to 50 picoseconds and a peak focused intensity above 1017 W/cm2. ARC uses up to four NIF beamlines, propagating two short-pulse beams per NIF aperture in a split-beam configuration. Staggering the arrival of the eight ARC beamlets onto backlighter targets will produce an x-ray "movie" to diagnose the fuel compression phase leading up to ignition of a cryogenic deuterium-tritium target with tens-of-picoseconds resolution. "ARC is important to help us understand what's happening in the compressed core of NIF targets," said John Edwards, NIF program director for inertial confinement fusion.

ARC will also enable new experiments in frontier science and high-energy-density stewardship science.



After amplification in the NIF laser, the ARC beams are compressed in the Target Bay and focused to backlighters near Target Chamber center. The ARC quad of beamlines can provide up to eight backlighters for ignition evaluation.

Technicians monitor the successful insertion of transport mirrors in the 11-foot-high ARC Parabola Vessel. The Parabola Vessel will focus ARC's quadrillion-watt beams on backlighter targets near Target Chamber center to produce an x-ray "movie" to diagnose NIF target implosions.

Get ready for ICUIL 2014 in Goa, India (October 12-17)!

The ICUIL 2014 website

Come October and high intensity laser enthusiasts across the world will make a beeline for Goa, the lovely beach city on the west coast of India, for the ICUIL2014 conference. Preparations are in full swing – website (www.icuil2014.org) launched many months ago, registration opened and abstract submissions slated to close on May 23, 2014. The Conference Co-Chairs Chris Barty and G. Ravindra Kumar and the Technical Programme Committee Co-Chairs Catherine Le Blanc, Chang Hee Nam and Jake Bromage along with the Local Organizing Committee are trying their best to put together an exciting programme. Hit the website and see what is unfolding!

ICUIL is expected to showcase the latest on multilateral projects like the ELI, XCELS and IZEST as well as the efforts in individual institutions across the world. The laser community is truly going global in its aspirations and collaboration seems to lead the way to scale newer peaks. The horizon has now moved to the multi-petawatt scale and exciting breakthroughs in the application arena have brought in GeV electron acceleration and novel EM radiation sources. ICUIL 2014 will see intense discussions on these and many others.


Aerial view of the TIFR campus with its picturesque location beside the Arabian Sea

The Tata Institute of Fundamental Research (TIFR), Mumbai (see pic) has been the hub of preparations for ICUIL2014. Located on the west coast of India (and literally next to the sea!), the Institute has, over the past 68 years focused on fundamental questions in the physical and biological sciences, computer science and mathematics. It has paid particular attention to basic questions in particle physics and astronomy and probes these using its own facilities as well as in international collaborations. It has conducted pioneering experiments on proton decay in the 1970s and 1980s, has radio telescopes in different parts of the country (one of the world's largest radio telescopes, the Giant Meter wave Radio Telescope is about 200 kms from Mumbai) and is currently setting up the India-based Neutrino Observatory (INO), an international effort, in the southern part of India. TIFR has led Indian contributions to collaborative efforts at CERN, Fermi lab and KEK. Since the 1990s, the Institute has been interested in high power laser driven research in basic physics. It currently hosts 100TW and 20 TW, femtosecond Ti-sapphire lasers. Like TIFR, another centre of the Department of Atomic Energy (DAE), the Raja Ramanna Centre for Advanced Technology in another city, Indore, has a 150 TW, femtosecond Ti-Sapphire laser. With these lasers and a multiplicity of set ups and diagnostics, these two Indian centres have made many advances in high intensity laser–plasma interaction studies and laser driven particle acceleration (see the collage below for some recent work).

Currently both centres have approved and funded plans for the installation of petawatt laser facilities by 2016. They seek to expand their activities many fold and are seeking new talent and collaborations with international groups. India aspires to become a centre where multinational groups can get together and perform experiments and simulations. Lastly, she seeks to participate as a significant partner in the development of international laser facilities.

On a broader scale, India is majorly expanding its effort in basic sciences with government funding slated to double in the next few years. Several new institutes dedicated to basic research have started functioning in the last decade. Since the opening of the economy in 1991, the country has benefited from a high trajectory of growth and basic sciences have been a major beneficiary of this progress. The DAE funds the biggest of these projects including the INO while the Department of Science and Technology administers large funding in the university sector in the physical sciences. The DAE has also facilitated India's participation at a significant level in ITER and is currently encouraging its foray into the LIGO project. The scene certainly looks very promising for high intensity laser science and related disciplines.


Some members of the TIFR group

ICUIL2014 Goa just precedes 2015, declared by the UN as the 'International Year of Light'. May it boost the global as well as Indian efforts in the years to come!

Breaking Points for ELI

It was celebrated as a a "breaking point" on the cover pages of newspapers in Szeged, Hungary, on February 6: Prime Minister Victor Orban, together with ELI-ALPS Managing Director Lorant Lehrner and with the ELI-DC Director General, Wolfgang Sandner, laid the cornerstone for the building of the ELI Attosecond Light Pulse Source (ELI-ALPS).

The presence of the Prime Minister indicates the support that ELI-ALPS enjoys from the Hungarian Government. While still waiting for the arrival of Structural Funds from the European Union the Hungarian Government had already pre-financed building planning and construction preparation such that a contract with an international consortium of constructors had already been concluded early in the year. Similarly, ELI-ALPS' international industrial and scientific partners, including many from the ICUIL community, have already concluded contracts to help developing the Technical Design Report and supplying scientific equipment.

Recently, however, the waiting was finally over and ELI-ALPS – and, hence, ELI as a whole - has taken another huge step on its way towards implementation. The European Commission, more precisely, the Directorate General on Regional Policy (DG Regio), during the first week of May has officially released the first and major part of the over 200 Mio Euro EC contribution towards the construction of ELI-ALPS. Therewith, construction of the ELI facilities in the Czech Republic, Hungary and Romania is now fully secured at a total level of 850 Mio Euro, with roughly 85% percent coming from the European Union and 15% from the host countries. ELI is a pioneer among the research infrastructures contained in the European ESFRI Roadmap in using EU structural funds for construction.

Similar progress as in Hungary occurs at the other pillars. The building construction at ELI-Beamlines in Prague and at ELI Nuclear Physics (ELI-NP) in Magurele, Romania, is making impressive progress, as can be monitored in real time on their web sites www.eli-beams.eu/about/building/ and www.eli-np.ro/civil-construction/construction_photos.php respectively. ELI-NP recently celebrated the conclusion of a multi-ten-million-Euro contract for delivery of a world-wide unique gamma beam source. A contract over delivery of two 10-petawatt lasers had already been concluded earlier, similar to a contract over a 10-Hertz, diode-pumped petawatt laser to be built by Livermore for ELI-Beamlines in Prague. The Romanian lasers will be built by a French company, while the gamma beam source will be developed by a European consortium of companies and institutions under the leadership of the Italian nuclear physics institute INFN – demonstrating the international character of ELI and its close cooperaton with industry and academia during implementation.

The pan-European character of the ELI project has recently been further strengthened by the British Science and Technology Facilities Council STFC with its CEO John Womersley (also ESFRI Chair) having officially joined the ELI-DC International Association. STFC and RAL's Central Laser Facility will jointly represent UK in the Association. It now contains members from the three host countries CZ, HU, and RO, as well as from Italy, Germany, and the United Kingdom. Wolfgang Sandner, Director General of the ELI-DC International Association AISBL, is already negotiating with other countries to join, and is inviting the international ICUIL community to maintain its strong support for this world-wide unique laser project.

Further information of the ELI project can be found on www.eli-laser.eu.

The Hungarian Prime Minister Victor Orban (right) and Wolfgang Sandner, General Director of the ELI-DC International Association (left), laying the Foundation Stone for the ELI-ALPS facility in Steged, Hungary, on February 6, 2014 together with Lorant Lehrner, Managing Director of ELI-ALPS (hidden behind Orban). In the back József Pálinkás, President of the Hungarian Academy of Sciences (left), and Zsuzsa Németh, Minister of National Development (center).

The entrance of the ELI-ALPS building in Szeged, Hungary, as it will present itself to the users and visitors after 2018 when ELI is expected to commence operation as the world's first international laser user facility in Hungary, Czech Republic and Romania (Copyright: ELI-HU Nonprofit Kft.)

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ICUIL News N°6

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Chief Editor: Alexander Sergeev

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- New Perspectives for Modeling in the Laboratory Extreme Astrophysical Phenomena Using High-power Lasers Coupled to Strong Magnetic Fields
- Topical meetings

The International Committee on Ultra-High Intensity Lasers

Greetings from the Chairman

Toshi Tajima, ICUIL Chair

The community of ICUIL has witnessed a host of efforts that pushed the frontier of high intensity lasers in 2014–2015. One of the new phenomena in our community is that the high power of PW lasers has become industrial top birds, whose fruits originated coming out of the national or international research labs but with additional industrial R&D added with healthy collaborative relations between the industry and academia being developing. For example, Thales' PW laser was commissioned at the Lawrence Berkeley National Lab. More such are occurring around the world. In the research labs around world, on the other hand, they began looking at the high power laser far beyond PW, such as SIOM (Shanghai, China)'s 5 PW laser ribbon-cutting this year. Korean IBS's 2 PW lasers are continually producing new results such as laser ion acceleration. At ELI, they have started 10 PW class laser development with a variety of architectures. Some are now looking far beyond this. Such as Chris Barty's "Nexawatt" laser, which tries to utilize LLNL NIF laser architecture for highest power based on large energy laser whose backbone was build as the fusion driver. Similar efforts have been advocated in the past ICUIL efforts such as a proposal to LMJ PETAL, as well as a proposal at ILE, Osaka University and the consideration at LLE at Rochester, all looking at the level of EW, though all these still remain on the drawing board.

These activities were reviewed in the last October (2014)'s ICUIL Conference at Goa, India. This ICUIL meeting was the first in that Indian subcontinent. We all felt that India and its scientists had a very high enthusiasm toward high intensity lasers and high field science. We duly note with fond appreciation that Dr. Ravi Kumar's leadership and heroic devotion along with the entire members of the Program Committee and the Local Organizing Committee in successfully organizing and attracting so many world's talents and superhigh quality talks on the high intensity lasers there. Our heartfelt bravos are due here. A lot of their applications at the cutting edge from the leading groups such as WimLeemans and Mike Downer were very exciting and of high quality, reflecting the exploding applications areas. The social gatherings on the beach of Goa were also unforgettable. For example, we were led to the church visit where still the mummy of Saint Francesco Xavier was shown as if he is still talking to us with the holy man's experience and message emanating in the hall. Some of us after or before the ICUIL Conference gave public speeches to further promote high intensity laser and high field science in India. The next ICUIL Conference was decided to be held near Quebec hosted by Dr. Tsuneyuki Ozaki.

The collaboration between ICUIL and ICFA communities continues. For example, the technology of high rep-rated high efficient laser (CAN) fit for collider applications has been considered at institutions including CERN. The collective decelerator technique sprung out of our community has been considered at KEK's ILC research.

A new trend that started in 2014 is to develop a technique to compactify an optical PW laser into a single cycle laser proposed by G. Mourou et al. Once such a technique is established, its impact could be immense, leading to a possible (again) single cycled X-ray laser with the level of EW power. Such a technique should have applications from X-ray wakefield acceleration ("TeV on a chip") to vacuum self-focus toward Schwinger field. I would like to draw your attention to such a potential so that the world can soon harness this technology.

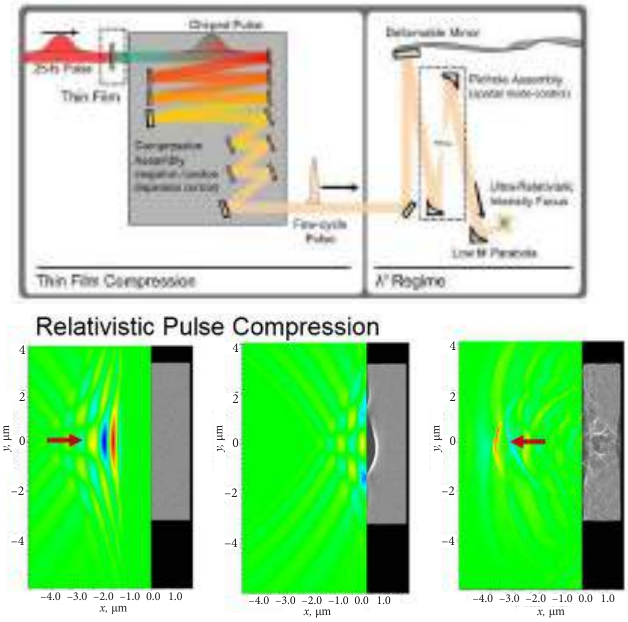
The casket of mummified St. Francesco Xavier at a Goa church

ICUIL is also collaborating with the world or international organizations. It will help launch / send our members (ex officio) to the new toddler of our sister Working Group in Accelerator Science, in addition to the above mentioned ongoing ICUIL-ICFA collaboration. We also collaborate with Asian Intense Laser Network. We sponsor the International School on Ultra-Intense Lasers to be held in Russia in October 2015. It is intended to promote the young generation in furthering the reach of high intensity lasers.

IZEST is Exploring Uncharted Territory in the High Energy Single Cycle Pulse Regime

Gérard Mourou, Jonatan Wheeler, Ecole Polytechnique, France

IZEST (www.izest.polytechnique.edu) is exploring novel horizons for the laser community in amplification to peak intensities (C3), laser efficiencies (ICAN), and applications based on extreme laser fields (100-GeV Ascent, Dark Fields) and, now add to that, timescales. This comes with the addition of a new pillar within the IZEST organization known as ZeptoScience for its concentration on zeptosecond-scale science. Preliminary theoretical models show the possibility to convert single-cycle femtosecond, near-infrared, ultra-relativistic intensity laser pulses to atto or zeptosecond, gamma ray pulses through the interaction with a thin, superdense plasma [1]. This can be considered as an extension of the creation of XUV, attosecond pulses through sub-cycle processes at the femtosecond-scale within the strong-field processes of atomic, molecular and solid target plasmas. With increasing field strength, the subsequent gradients involved within a relativistic laser-plasma interaction create a small sub-cycle window for the photon up-conversion to reach gamma-ray energy scales. The theoretical work is already 10 years in the literature but to date the possibility to compress existing pulses with joules of energy to a single-cycle time duration was believed too cost prohibitive to make an experimental attempt. The recent suggestion [2] of efficiently post-compressing these types of pulses using a thin film of thermoplastic to produce the spectral broadening to support a single-cycle pulse (~250 nm) followed by dispersion controlled chirped mirrors offers the possibility to produce the driving NIR pulses required to produce zeptosecond-scale x-ray pulses within a plasma. In light of this exciting possibility a work group within the ZeptoScience project is performing experiments to test the methods to efficiently compress existing laser technologies to the few-cycle, femtosecond regime with a sufficient intensity to begin pursuing the creation of zeptosecond pulses. This begins with the efficient temporal compression of a femtosecond pulse within a plastic thin-film. This work is being performed by a collaboration of researchers based at Ecole Polytechnique (France), National Institute for Laser, Plasma and Radiation Physics (INFLPR, Romania), and ELI-NP (Romania). As these activities are underway on the NIR compression, theoretical plasma studies are underway to understand and identify the ideal conditions for zeptosecond pulse generation and the relativistic pulse compression and upconversion that might ultimately be achieved. Within another workgroup based at the University of California Irvine (UCI), theoretical studies are already underway to theoretically explore the potential properties and applications of such short gamma-ray pulses [3]. These applications include areas such as laser wakefield acceleration within solid-density plasmas leading to crystal accelerations of TeV/cm, and vacuum QED studies leading to x-ray nonlinear responses through vacuum propagation.



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5 PW CPA Amplifier and 1 PW OPCPA Amplifier Demonstrated at SIOM

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In 2013 the output energy of the Ti:sapphire CPA laser system at SIOM reached 72.6 J at a pump energy of 140 J, corresponding to a peak power of 2.0 PW. At the end of 2014, a high gain chirped pulse amplifier based on a Ti:sapphire crystal 150 mm in diameter was demonstrated, with the highest output pulse energy of 192.3 J at the pump laser energy of 312 J, corresponding to a pump-laser efficiency of 50.4%. The amplified chirped pulse had a bandwidth of 53 nm at 800 nm central wavelength. With the grating compressor efficiency of 72% and the 27.0 fs compressed pulse width obtained with part of the energy, this Ti:sapphire laser system could support a peak power of 5.13 PW. Meanwhile, a CPA/OPCPA hybrid laser system has achieved the peak power of 1.0 PW, where an LBO 100 mm in diameter was used in the final OPCPA, and the output energy of 45.3 J was obtained.

1. The 5 PW CPA laser amplifier

The laser system is a typical CPA Ti:sapphire laser with the front-end at a repetition rate of 5 Hz with an output energy of 3.5 J. The laser pulse is then amplified by two large aperture Ti:sapphire amplifiers pumped by an Nd:glass laser system operating on single shot basis. A Ti:sapphire crystal with a diameter of 80 mm was used in the first amplifier, which is a 4-pass structure and can provide sufficient laser energy to seed into the final 4-pass booster amplifier. To get a high energy output, the Ti:sapphire crystal used in the final booster amplifier is 150 mm in diameter with a thickness of 46.7 mm. The parasitic lasing (PL) in these two amplifiers is a major issue of concern. The active PL control technique, where the time delays between the signal laser pulses at different passes and the pump laser pulse are optimized, is implemented with the passive method of PL suppression based on an index-matching cladding of crystal. However, for the 150 mm-Ti:sapphire amplifier, the injected signal energy has to be improved to effectively suppress PL.

Figure 1 shows the output laser energy as a function of the pump energy at two different injection laser energies. With the injected laser energy of 28 J, the maximum output energy is 155 J at a pump energy of 260 J. When the pump energy is higher, serious PL occurs and the output decreases significantly. For the injected laser energy of 35 J, the output laser energy achieves 192.3 J at a pump energy of 312 J. Meanwhile, the conversion efficiency of pump-signal is 50.4%. The spectral bandwidth of the output laser pulse from the 150 mm-Ti:sapphire amplifier is 53 nm (FWHM). Due to the lack of large aperture gratings, only part of laser energy is compressed in a four-grating compressor. The measured autocorrelation trace demonstrates that the compressed pulse is 27.0 fs in length, as shown in Fig. 2, and the compressor efficiency is 72%.

2. The 1 PW OPCPA laser amplifier

The CPA/OPCPA hybrid laser system was first demonstrated in 2013 with a peak power of 0.61 PW. The conversion efficiency from pump to signal in OPCPA and the final pulse compression to get transform limited short pulse output are important issues of concern. Therefore, optimizing both the pump and the signal pulse intensities for a given-size crystal, is particularly important. Based on the theoretical simulation and experimental optimization of the main parameters, the amplified energy from the final OPCPA reached 45.3 J with a 100×100×17 (mm^3) LBO, corresponding to a conversion efficiency of 26.3% at a pump energy of 169.1 J. The peak power of the CPA/OPCPA hybrid laser system was upgraded to 1.02 PW with a pulse duration of 32.0 fs after pulse compression.

3. Conclusion

The output energy of 192.3 J was obtained from a 150 mm Ti:sapphire chirped pulse amplifier, showing that the parasitic lasing can be effectively suppressed in a Ti:Sapphire crystal 150 mm in diameter. Due to the lack of meter size compressor gratings, only part of laser energy has been compressed with the compressed pulse duration of 27.0 fs and the compressor efficiency of 72%, indicating the capability of generating potentially a 5.13 PW peak power laser pulse. Additionally, the output energy of 45.3 J was obtained by the CPA/OPCPA hybrid system with the 100-mm size LBO crystal as the final amplifier, and the peak power of 1.02 PW with a pulse duration of 32.0 fs after pulse compression. The above experimental results (5 PW CPA amplifier and 1 PW OPCPA amplifier) are a notable progress on the road towards a 10 PW laser system.

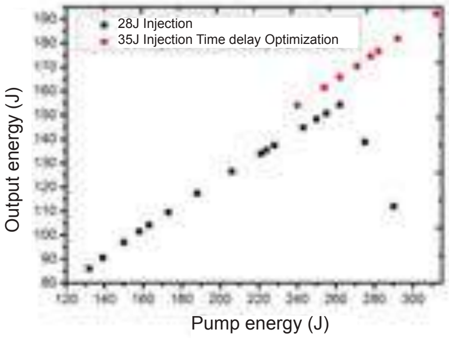

Fig. 1 Output laser energy vs pump energy

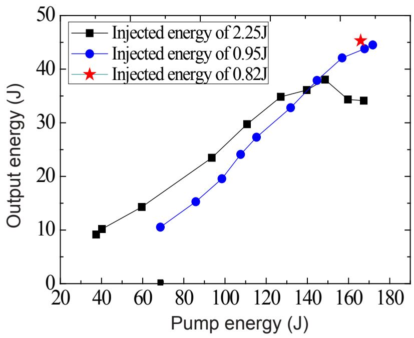

Fig. 3 Output vs pump energy at different injection

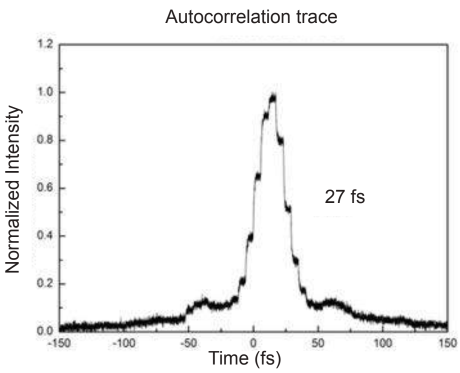

Fig. 2 Measured autocorrelation trace of the pulse

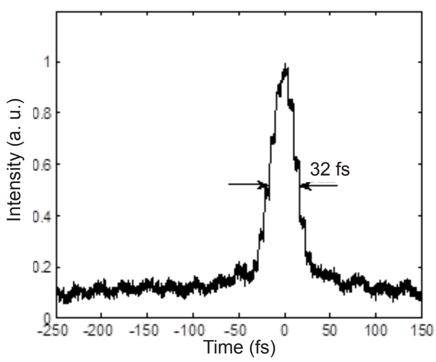

Fig. 4 Measured autocorrelation trace of the pulse

Extreme Light Infrastructure – Nuclear Physics (ELI-NP) Project: Status of Implementation

Victor Zamfir, ELI-NP, IFIN-HH, Bucharest-Magurele, Romania

The project Extreme Light Infrastructure – Nuclear Physics (ELI-NP) [1] will be an European research centre to study ultra-intense lasers interaction with matter and nuclear science using gamma and laser driven radiation beams. The new research centre will be located in Magurele, a town a few kilometres away from Bucharest, Romania.The total cost of the facility will be 300 million Euros. Commissioning is expected to take place in 2018.

The ELI-NP facility combines two major research equipment with beyond state-of-the-art parameters, namely:

• A high power laser system (HPLS), with two arms of 10 PW and intensities on the target in the range of 10^{23} W/cm^2. The HPLS is being built by Thales Optronique France and Thales Romania.

• A gamma beam system (GBS) to deliver up to 19 MeV photons with extremely good brilliance and bandwidth, based on Compton scattering of a high repetition pulsed laser beam on a relativistic electron beam produced by a warm linac of 720 MeV. The GBS is being constructed by EuroGammaS, a European Consortium of academic and research institutions and industrial partners with expertise in the field of electron accelerators and laser technology from 8 European countries, the consortium led by INFN Italy.

The ELI-NP buildings complex, covering more than 30000 m^2, comprises the experimental building hosting the main research equipment, the experimental areas, laboratories, workshops, control rooms and user area, the office building, a guest house and a canteen. The figure below shows the status of the construction in May 2015.

The scientific program for ELI–NP [2, 3, 4] was elaborated by an international collaboration of more than 100 scientists from 30 countries.

The main research topics of interest are: laser driven nuclear physics experiments, characterization of the laser–target interaction by means of nuclear physics methods, photonuclear reactions, exotic nuclear physics and astrophysics. In addition to fundamental themes, applications of HPLS and GBS are also considered.

The ELI-NP team together with their collaborators from the international scientific community shaped the future scientific program of ELI-NP in a series of workshops and defined ten development directions for the facility. The Technical Design Reports (TDRs) are being finalized and in June 2015 will be approved by ELI-NP International Scientific Advisory Board, chaired by Toshiki Tajima.

1. www.eli-np.ro
2. Dietrich Habs, Toshiki Tajima, Victor Zamfir, Extreme Light Infrastructure – Nuclear Physics (ELI-NP): New Horizons for Photon Physics in Europe, Nuclear Physics News vol.21 No. 1 (2011) p.23-29.
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New Perspectives for Modeling in the Laboratory Extreme Astrophysical Phenomena Using High-power Lasers Coupled to Strong Magnetic Fields

Julien Fuchs, LULI, Ecole Polytechnique, France

Remarkable progress in the understanding of our universe has been made in the 20th century, partly due to significant advances in astronomical observations, leading to a new vision of its formation and evolution. However, major scientific questions still stay open since spatial measurements still allow access, with limited resolution, only to "snapshots" of the systems and not to their full evolution. This has led to founding of the domain of "Laboratory Astrophysics", a way to locally, in the laboratory and using plasma machines, investigate fundamental processes pertaining to the understanding of the Universe. With this approach, major successes have been achieved, mostly in planetary science, studying the thermodynamics of compressed and hot plasmas. A new possibility has been recently emerging, i.e. coupling of plasmas produced by high-power lasers with tunable, external and strong magnetic field systems (see Fig. 1). This offers new and wide perspectives to investigate in the laboratory astrophysical phenomena where magnetic fields are thought to be a crucial ingredient and have profound effects. A key aspect, compared to what could be achieved with Z- or X-pinches machines, of such new platforms is that they allow decoupling of plasma generation and magnetization. This is an essential point since this allows to arbitrarily vary plasma magnetization in magnitude or direction.

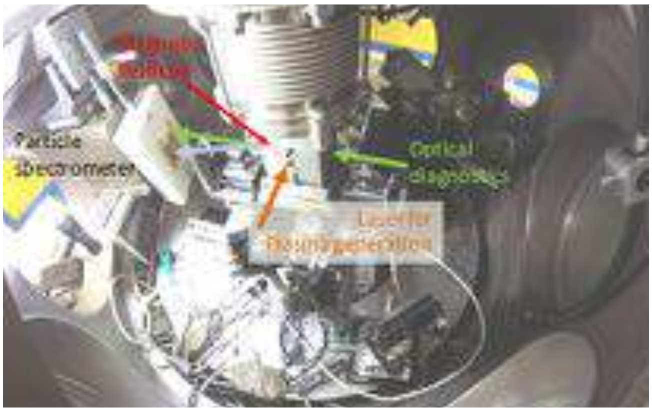
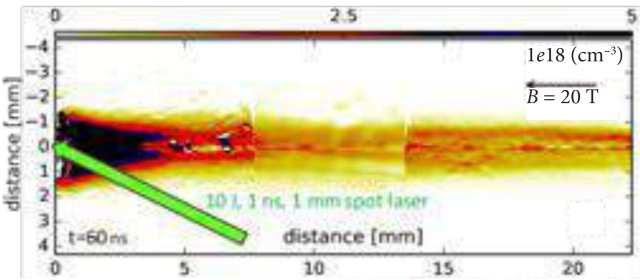


Fig. 1. *Picture of a magnetized plasma shaping experiment as setup in the target chamber of the ELFIE laser facility at LULI (France)*

Quantitative investigations are possible taking advantage of the fact that laser-produced plasmas are scalable in space and time to astrophysical flows. A concrete example of a recent study is illustrated in Fig. 2. Narrow plasma outflows ejected from a young star have quite well known parameters, although the mechanism of the formation of stable, long-range outflows was debated. They are embedded in extremely large scale ~1 μT magnetic fields that are perpendicular to the disk. Taking advantage of dimensionless MHD equations, this flow, and a magnetized plasma flow produced by a high-power laser can be formally scaled to each other, e.g. 20 ns of the laboratory flow are equivalent to 6 years for the astrophysical flow; 1 mm is equivalent to 300 AU, or $4.5 \cdot 10^{13}$ m; and 20 T is equivalent to 1 μT. This scaling allowed understanding the source of the collimation of the astrophysical outflow by its deciphering in the laboratory: the compression, near the source of the plasma flow, of the magnetic field aligned with the jet axis induces a shock that redirects the plasma flow axially, inducing the strong observed collimation. Without magnetization, the laboratory plasma is completely dissimilar: it expands hemispherically.

Similar scaling can be established for other systems for which the underlying physics is still debated. Figure 3 illustrates a possible setup that should allow soon to investigate colliding relativistic plasmas, in view of addressing the formation of collisionless shocks, a subject of intense debate. Such shocks can result from the interaction of relativistic, magnetized outflows stemming from astrophysical sources (e.g. following a supernova explosion) with ambient magnetic field and matter, and are predicted to lead to particle energization (cosmic-rays) and high-energy radiation via reflections of ions on high amplitude electric or magnetic fields. Therefore, laboratory investigations are a great opportunity to bring new significant results to compare with existing observations and to simulations of these phenomena. To investigate colliding relativistic plasmas of relevance for high-energy cosmic rays, the emerging process of radiation pressure acceleration of plasmas could be exploited using the extreme light pressure that will be accessible with the next generation multi-PW laser facilities like "Apollon" (France) or the ELI facilities in Eastern Europe.



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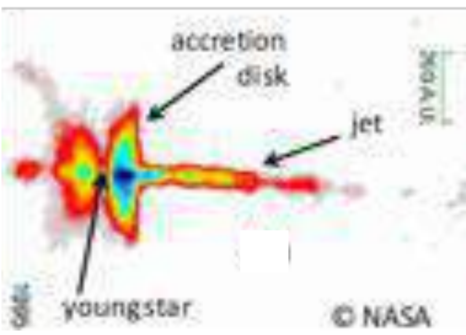


b

Fig. 2. *(a) Experimental image [B. Albertazzi et al., Science, 2014] (recomposed from 3 images) of a long, stable plasma jet produced by irradiating a Teflon target by a high-power laser. The jet is magnetically confined by the homogeneous 20 T magnetic field, (b) Hubble space-telescope image of the object HH30*

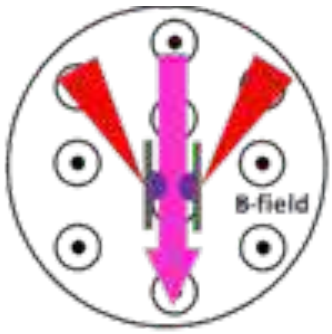


Fig. 3. *Schematic of a possible experiment using two ultraintense laser beams (in red) driving relativistic plasmas (in blue) colliding in a transverse magnetic field, probing laser light (purple)*

As a witness of the emerging importance of this area of magnetized plasmas, it has become one of three focus topics this year of the Department of Energy (USA) for the development of High-Energy-Density science. A forum was also created a few years ago to discuss the possibilities it offers: The "LaB" series of workshops. Three meetings already took place: in 2012 and 2013, in the USA and in France. The two next ones will be held in the USA, at Princeton, in Nov. 2015, and in the summer of 2017, in Russia to strengthen the collaborative exchanges between the USA, Europe, Russia and Asia.

ICFA Meeting at DESY in Hamburg

Thomas Kuehl, DSI, Germany

An important achievement of ICUIL over the last years was to foster a closer connection with the traditional accelerator community. This was documented with dedicated meetings in Darmstadt 2011 and Berkeley 2013, and also includes a general invitation from the ICFA chair to have ICUIL representatives participating to the ICFA meetings. In February 2014, the regular board meeting of ICFA took place at DESY in Hamburg. ICUIL was represented by Toshiki Tajima with a SKYPE presentation, and by Thomas Kuehl, who participated in this meeting. ICFA is leading a concerted international effort to coordinate and support world-wide activities, aiming to define the future of high-energy physics in the next twenty-to-thirty years. The agenda included reports and discussion on a number of future accelerator projects. Ideas for large scale facilities were presented which will be proposed to be installed in Japan, Europe, China and Korea. In his short Skype presentation, which was attended by all representatives, ICUIL chairman Toshiki Tajima explained the latest progress in laser technology towards an improvement of average power, as needed for a wide application of laser drivers for high energy accelerators. The connection between the ICFA and ICUIL communities was further documented in the report of Brigitte Cros, Univ. Paris-Sud, chair of the ICFA Panel on Advanced and Novel Accelerators. Although the main line of discussions was centred on the extension of classical accelerator schemes, the importance of novel laser acceleration approaches is well recognized. It was emphasized that a next dedicated meeting on laser acceleration would be a timely step to encourage a close interplay between international developments towards novel acceleration schemes.

1st Workshop on Laser Solutions to Orbital Space Debris

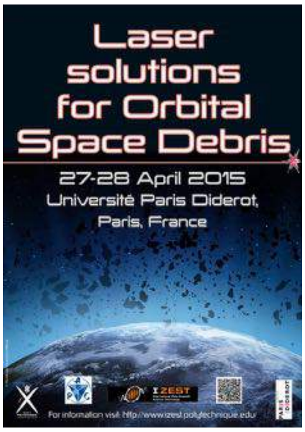
Mark N. Quinn, IZEST, Ecole Polytechnique, France

The first international workshop on the topic of «Laser Solutions to Orbital Space Debris» was held recently in Paris.

Organised by Ecole Polytechnique researchers including Dr. Mark N. Quinn and Prof. Gerard Mourou from the IZEST group, the workshop was held from the 27–28 of April, hosted with collaborators at the Astro Particle Cosmology (APC) Laboratory at the University of Diderot Paris.

Over 30 million kg of debris including small fragments, rocket bodies and whole satellites have accumulated in Earth's orbit since the beginning of the space age. The more numerous fragments are the main threat of impacting larger satellites both functional and derelict. With large relative velocities in orbit surpassing 10 km/s, even small cm size debris can impact and explode large multi-ton bodies creating many more additional fragments. This increasingly leads to the chain reaction known as the Kessler Syndrome. Potentially, the very useful orbits containing the majority of communications satellites could be lost in a few decades unless strong mitigation and active remediation are introduced.

Lasers of different technologies and sizes have many applications to this increasing problem including the detection and tracking of small debris that are rarely catalogued to the removal using short picosecond pulses to ablate and push the debris to burn up in the atmosphere. Development of new efficient laser technologies such as the XCAN laser at Ecole Polytechnique opens the doors to exciting applications of higher powered lasers for space based science where energy-saving, low cost, compact and robust systems are required. Indeed, in the past few weeks there has been much international attention focused on the recent work involving French and Japanese scientists from the IZEST collaboration on using such a laser system situated on the International Space Station to begin testing applications for visualizing and eventually actively pushing space debris fragments from useful earth orbits [1].



This workshop brought together over 60 researchers from many different fields and nationalities, including Japan, Australia, Europe and the USA together with representatives from aerospace companies, including ESA, NASA and Airbus. During the two days many topics were presented including laser tracking of debris from Earth, space-based and ground based removal of debris, novel laser technologies and laser-plasma interactions.

Afterwards, it has become clear that these different pursuits can collaborate together, and a key outcome of the workshop is the building of links in this world-wide community. There have already been invitations from Japan and Australia to host the next workshops on «Laser Solutions to Orbital Space Debris».

All of the presentations of the workshop are available online on the Ecole Polytechnique/IZEST website [2].

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The International School on Ultra-Intense Lasers

Artem Korzhimanov, Institute of Applied Physics RAS, Russia

The International School on Ultra-Intense Lasers will be held in the Hotel@Resort "Yunost" 40 km from Moscow, Russia, from 4 to 9 October, 2015.

The School is organized by the International Committee on Ultra-Intense Lasers (ICUIL), Institute of Applied Physics of the Russian Academy of Sciences (IAP RAS), National Research Nuclear University MEPhI and Russian Federal Nuclear Center (RFNC-VNIIEF).

This event is primarily aimed at providing postgraduate students and other early career researchers working in ultra-intense laser science with a thorough pedagogical grounding in high power laser physics, laser-matter interaction physics, laser-plasma accelerators, laser-based x-ray sources and inertial confinement fusion.

The lectures will be given by distinguished experts in the field representing world leading research centers from around the world, including *Sergey Belkov* (RFNC-VNIIEF, Russia,"Problems of laser fusion"); *Dimitrios Charalambidis* (the Univ. of Crete, FORTH-IESL, Greece, "Attosecond science"); *Eric Cormier* (CELIA, France, "Metrology of ultrashort laser pulses"); *Julien Fuchs* (LULI, France, "Laboratory astrophysics with ultra intense lasers"); *Mikhail Kalashnikov* (ELI-HU, Hungary, "CPA at petawatt level"); *Igor Kostyukov* (IAP RAS, Russia, "Electron acceleration with ultra-intense lasers"); *Thomas Kuehl* (GSI, Germany, "At the interface between ultra-intense lasers and nuclear and high-energy physics"); *Gérard Mourou* (Ecole Polytechnique, France, "Horizons of exa-zepto physics"); *Nikolay Narozhny* (MEPhI, Russia, "Extreme light physics"); *Alexander Pukhov* (University of Duesseldorf, Germany, "Particle-in-cell codes for plasma-based particle acceleration", "High intensity laser interaction with solid density targets: novel sources of x rays and energetic ions"); *Vladimir Tikhonchuk* (CELIA, France, "Physics of laser-plasma interaction in application to ICF").

The organizers believe that quite a wide scope of topics and the brilliant lecturers will attract more young researchers to this promising field of modern science. This is really one of the key goals and the intrinsic stimulus to hold the school.

School website www.isuil.iapras.ru

2016 ICUIL Conference: 11–16 September 2016, Montebello, Canada

Tsuneyuki Ozaki, Institut National de la Recherche Scientifique, Canada

The 2016 ICUIL Conference will be held at the Fairmont le Château Montebello, situated within a 65,000 acre forested wildlife sanctuary and 70 lakes, on the shore of the Ottawa River. The hotel is located between Ottawa and Montreal, about 80 minutes by car from both international airports. The conference will be held in the hotel's newly renovated congress centre, with plenty of adjacent space for participants and vendors to discuss. Following past successful conferences, this biennial meeting will focus on the generation, amplification, compression, and measurement of ultra-high-intensity lasers as well as their applications.

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The International Committee on Ultra-High Intensity Lasers

Report of Recent ICUIL Activities

T. Tajima
Chair, ICUIL
Department of Physics and Astronomy, UC Irvine

ICUIL represents the community of utraintense (>10^{19} W/cm^2) lasers around the world. The community is exponentially increasing the world total cumulative laser power from 11PW in 2010 to the expected 132PW in 2017. The community projects total more than $4B research investment and 1500 FTEs technical staff now around the world. Here I concentrate on some typical activities of ICUL accentuating the works that relate to collaborative works with other IUPAP Working Group ICFA and topics that encompass other fields and cross-Group activities.

Brief History of the ICUIL-ICFA collaboration

In 2008 the Chair of ICUIL (T. Tajima) spoke with the incoming Chair of ICFA (A. Suzuki) to initiate joint collaborative work on laser acceleration to examine its promise and challenge for its future collider application. In 2009 ICUIL and ICFA launched the Joint Task Force for laser accelerators (W. Leemans was named chair of the task force). JTF produced its report in 2011 (published in ICFA Newsletter in 2011, W. Chou et al. as editors). It was found that: (1) The science of laser acceleration has matured and validated; (2) The high rate rated, high fluence laser technology needs to be developed in order to meet the collider luminosity. Since then a fiber laser technology called CAN (coherent amplification network) was invented (2013) in order to meet the above challenge. Currently, the community is trying to develop this technology.

Meanwhile, the world-wide laser wakefield acceleration (LWFA) experiments have advanced to produce several GeV over a few cm in typically 10^{17-18} /cc plasma (Kim et al. 2013; Leemans et al. 2014).

The Higgs energy by laser wakefield acceleration

In order to reach and go beyond the Higgs energy (>100GeV), three paths have been considered. One path is to have multi-stages to boost the acceleration in the above mentioned technology.

The second path and third path have been recently considered through examining the scalings of the LWFA (Tajima-Dawson, 1979; Nakajima et al. 2011). The energy gain in the wakefield is proportional to the inverse of the plasma density and proportional to the normalized vector potential of the laser $E_b = 2/3 m_e c^2 a_0 n_c / n_e =$ $= 38[\text{GeV}] a_0 (1\mu\text{m}/\lambda_L)^2 ((10^{16}\text{cm}^{-3})/n_e)$. The accelerating length is typically decided by the dephasing length Ldp, which scales as the 3/2 power of the density of plasma, square of the frequency of the laser, and square-root of the laser vector potential (see, e.g., Nakajima, et al. 2011). They suggested that the density should be scaled from the typical of 10^{18-17}/cc in the present day experiments to the typical of 10^{17-16}/cc in the near future. This would increase the electron energy by 1–2 orders of magnitude of which the contemporary experimental energy gain from several GeV to on the order of 100 GeV.

However, in order to achieve this goal, we have to increase the laser power in inverse proportion to the plasma density. This is the main reason why we suggested to employ the world largest energy lasers that are available in a compressed fashion such as the laser at GSI, PETAL at LMJ and ARC at NIF.

Increase of the laser frequency: the third path

From the LWFA energy gain scaling, there is an alternative and third path by increasing the laser frequency (i.e. n_{cr}) using the 3ω frequency laser in place of 1ω, which would increase n_{cr} nearly by an order of magnitude and reduce the accelerating length nearly by 30.

The recent additional breakthrough in the laser compression (Mourou et al. 2014) indicates the possibility of single-cycle laser radiation, which opened up a path toward the single-cycled X-ray pulse (even at EW power). Because of this development, we can also follow the third path. This approach was suggested by Tajima (2014) to adopt nanomaterials driven by intense X-ray laser suggested above. This “TeV on a chip” acceleration allows accelerating the gradient on the order of TeV/cm staring from an originally PW optical laser driver.

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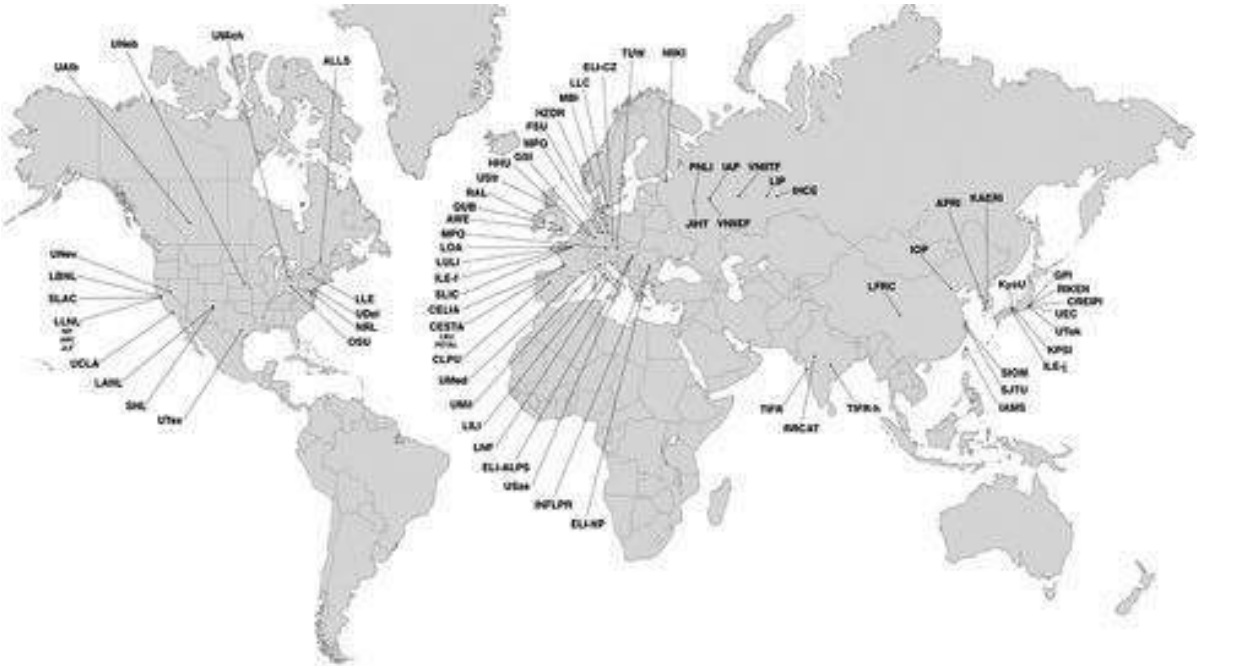
ICUIL Worldmap

Terry Kessler, ICUIL Secretary
University of Rochester, NY

The international committee on ultra-high intensity lasers (ICUIL) is actively engaged in the advancement of lasers and their scientific applications. Our goals are to provide a venue for discussions, among representatives of high-intensity laser facilities and members of user communities, on international collaborative activities such as the development of the next generation of ultra-high intensity lasers, exploration of new areas of fundamental and applied research, and formation of a global research network for access to advanced facilities by users. ICUIL continues to promote collaborations required to establish high-intensity laser infrastructures for the benefit of the international physics community.

Periodic teleconferences held throughout the year continue to be effective in maintaining progress in each of the following activities. One of the features of the ICUIL website is an interactive world map that highlights the high intensity laser facilities around the world as shown below. Surveys of the worldwide laser community are conducted by ICUIL in an effort to provide an accurate accounting of all existing and planned ultrahigh intensity laser facilities that are capable of reaching intensities above 10^{19} W/cm^2. An updated survey will be implemented at the 2016 ICUIL conference. The bylaws of the ICUIL Charter are being revised to maintain the experience and dedication of the current membership that has been assembled over the last decade. More than two terms of service would be allowed for members who continue to be active in this field and are able to provide service to the ICUIL community. A gradual member rotation will be used to maintain continuity and ensure that ICUIL continues to advance while maintaining balance both geographically and between the various high field science working groups of IUPAP. ICUIL has continued its corporate support program to afford maintenance of the ICUIL website, publish an annual newsletter, and support biennial conferences. The remaining funds are being targeted towards support of new outreach activities including student competitions held at the biennial conferences.

Extreme Light Infrastructure (ELI) is a pioneer among the research infrastructures contained in the European ESFRI Roadmap in using EU structural funds for construction. One of the three ELI pillars is Nuclear Physics (ELI-NP), a European research center to study ultra-intense lasers interaction with matter and nuclear science using gamma and laser driven radiation beams. The Technical Design Reports were approved by ELI-NP International Scientific Advisory Board, chaired by Toshiki Tajima, and submitted in July, 2015. ICUIL and ICFA (International Committee for Future Accelerators), another arm of the IUPAP Working Groups, are continually collaborating on laser-driven wakefield acceleration for future high energy accelerators. Since publication of the first ICUIL-ICFA Joint Taskforce Report on the laser accelerators in 2011, we worked to address one of the main points of the report, the need to improve laser technology, particularly its efficiency and repetition rate, so that the beam generated will have



ICUIL World Map of Ultrahigh Intensity Laser Capabilities sufficient luminosity. Along this line, the ICUIL community has invented the CAN laser technology based on the fiber laser technology. In addition, with the CAN laser having high rep rate and high efficiency, additional important applications have been found, including the driver for the management of space debris. These were further reviewed at the IZEST Conference at CERN in October, 2015.

Laser facilities around the world continue to push towards multi-petawatt power capability. For example, the Chinese initiative at the Shanghai Institute of Optics and Fine Mechanics (SIOM) is advancing rapidly towards a 10 PW laser facility. Lawrence Livermore National Laboratory (LLNL) is in the process of commissioning their Advanced Radiographic Capability (ARC) PW scale laser and the PETAL laser at CEA will begin operations at the 2 PW level this year. The University of Rochester's Laboratory for Laser Energetics announced its OPAL multi-phase laser initiative that could lead towards a 75 PW capability. In addition, the European ESFRI roadmap project, the Extreme Light Infrastructure (ELI), consisting of ELI-Beamlines, ELI-Nuclear Physics, and ELI-ALPS (attosecond science pillar), is moving towards an initial operation date of 2018.

The commissioning of the Advanced Radiographic Capability (ARC) laser system in the National Ignition Facility (NIF) is currently in progress. ARC is designed to ultimately provide eight beamlets with pulse duration adjustable from 1 to 50 ps, and energies up to 1.7 kJ per beamlet. The beamlets will be used to create x-ray point sources for dynamic, multi- frame high-energy x-ray radiographs of the imploded cores of ignition targets. They are critical for creating precision x-ray backlighters needed for NIF experiments studying complex hydrodynamics and material strength at extreme high energy density regimes. ARC can also produce MeV protons and electrons for future experiments in advanced fusion, TeV acceleration and proton radiography. Recently, a new front-end was installed to achieve higher pulse contrast, resulting in 80 dB for the preceding 200 ps. The ARC laser is integrated into the NIF laser system utilizing four of the NIF beams (1 quad) to produce 8 beamlets. The quad of beams can either be configured for NIF 3ω operation or for high-energy ps pulses, using hardware controlled during the automated shot cycle. Commissioning of 4 of the 8 beamlets is currently underway to operate at 1.2 KJ energy in 30 ps pulses to irradiate Au-wire backlighting targets.

Center for High Energy Density Science researchers have completed a year-long project to improve the pulse contrast on the Texas Petawatt Laser. The new design started with two BBO-based OPCPA stages pumped by an optically synchronized pump laser. These stages amplify slightly chirped few ps pulses by six orders of magnitude and reduce the contrast pedestal width to a few ps. There are two LBO-based OPCPA stages that are pumped by 4 ns pulses. These have much less gain and the overall reduction in parametric fluorescence is about three orders of magnitude. All lenses in the glass amplifiers were replaced with off axis parabolic mirrors, eliminating all discrete prepulses. All problematic wave plates and thin transmissive optics in the laser were eliminated to prevent post pulses that would result in prepulses by nonlinear conversion. An Acousto-Optic Programmable Dispersive Filter was added to improve fourth order dispersion and steepen the rising edge of the compressed pulse. These enhancements resulted in a final contrast of nine orders of magnitude. This improvement enables the use of thin and reduced mass targets for ion acceleration and reduces pre-plasma effects for all experiments.

Petawatt Aquitaine Laser (PETAL) will allow unique experiments in the field of ultrahigh intensity sciences, extreme plasma physics, astrophysics, radiography, and fast ignition by a combination of its own multi-petawatt kilojoule beam and the nanosecond multikilojoule beams of the Laser Mégajoule (LMJ). The PETAL facility is designed and constructed by the French Commissariat à l'énergie Atomique et aux énergies alternatives (CEA) to deliver energy up to 3 kJ in 500 fs at the wavelength of 1053 nm and is an additional short pulse beam to the Laser MegaJoule (LMJ) facility. PETAL has recently achieved 1.4 kJ at 2 ns with a 3.5 nm bandwidth to produce 1.15 PW with a 700 ps pulsewidth. The focal spot was measured to have 60% of its energy contained within a 20 µm and 80% within an 80 µm diameter. The goal is to reach 10^{20} W/cm^2 on target. The facility will be operated at a 1 kJ energy level for initial experiments due to the current damage threshold of the final optics.

The University of Rochester's Laboratory for Laser Energetics is developing plans to construct a 15 PW laser system that is pumped by its existing OMEGA EP facility, with a potential upgrade to 75 PW. Optical parametric chirped-pulse amplification (OPCPA) provides broadband gain for large-aperture beams by using Nd:glass lasers to pump deuterated potassium dihydrogen phosphate crystals. Scaling to kilojoule energies would enable focused intensities exceeding 10^{23} W/cm^2 with 20 fs pulses. A mid-scale optical parametric amplifier line (OPAL) pumped by the Multi-Terawatt laser (MTW) is being constructed to produce 7.5-J, 15-fs pulses and demonstrate technologies that are suitable for a kilojoule system pumped by OMEGA EP (EP-OPAL). In parallel, a novel Raman plasma amplifier is being developed where MTW is the picosecond pump laser and MTW-OPAL provides a tunable femtosecond seed. The ultra-broadband front end consists of a white-light continuum seed that is amplified by three noncollinear optical parametric amplifiers (NOPA's). The pulses are stretched to 1.5 ns before further amplification in NOPA4. The radial group delay of the lens-based image relays is compensated before the final DKDP amplifier, NOPA5, which is pumped by MTW using three switchyards to provide narrowband pump pulses at 526.5 nm. Completion of MTW-OPAL would lead to the final design and planning for an EP-OPAL laser system.

Chris Barty presented his vision of the next generation of high intensity lasers at several conferences this year. With the implementation of chirped pulse amplification (CPA), it is possible for beam lines at the National Ignition Facility at the Lawrence Livermore National Laboratory, the Laser Mega-Joule (LMJ) facility in Bordeaux, France, the LFEX laser at the Institute for Laser Engineering in Osaka, Japan and the Omega EP facility at the Laboratory for Laser Energetics in Rochester, New York to create petawatt peak power laser pulses of nominally 1-ps duration and 1-kJ energy. New short pulse amplification architectures based on chirped "beams", novel pulse compressors and existing beam phasing technologies are capable of extracting the full, stored energy of a NIF or NIF-like beam line and in doing so produce from one beam line a near-diffraction-limited, laser pulse whose peak power would be in excess of 200 petawatts. This architecture is well suited to either low-f-number focusing or to multi-beam, dipole focusing concepts. With dipole focusing, it is anticipated that a single beam line of a NIF exawatt or so called Nexawatt system will be capable of reaching intensities in excess of 10^{26} W/cm^2 or more than 5 orders of magnitude beyond existing systems. The novel amplification architecture is based entirely on existing technologies, proven optical damage performance and straightforward extensions of existing manufacturing technologies.

2016 ICUIL Membership

Toshiki Tajima	Chairman	International
Chris Barty	Co-Chairman	United States
Alexander Sergeev	Co-Chairman	Russia
Terry Kessler	Secretary	United States
Tsuneyuki Ozaki	Treasurer	Canada
Gerard Mourou		France
Hiroshi Azechi		Japan
John Collier		UK
Dino Jaroszynski		UK
Thomas Kuehl		Germany
Ravi Kumar		India
Christine Labaune		France
Wim Leemans		United States
Ruxin Li		China
Chang Hee Nam		Korea
Bedrich Rus		Czech Republic
Heinrich Schwoerer		South Africa
Ken-ichi Ueda		Japan
Associate Members		
Ryosuke Kodama		Japan
Sandro de Silvestri		Italy
Nilson Dias Vieira Jr.		Brazil
Claes-Goran Wahlstrom		Sweden

ICUIL Report to ICFA General Assembly

Takayuki Saeki, KEK

The 76th International Committee for Future Accelerators (ICFA) meeting was held at the J-PARC site (KEK Tokai campus) in Japan on 25th and 26th February 2016. The meeting summary is found on the web page of ICFA at http://icfa.fnal.gov/. I presented the activities related to the collaborations between ICUIL and ICFA at this meeting, which is entitled "Report on ICFA-ICUIL activities". Such a report at the ICFA meeting was initiated between two Chairs of ICFA and ICUIL in late 2008, i.e. between Prof. Suzuki and Prof. Tajima. Prof. Suzuki was Director General of KEK at that time and I was working with him as a staff member of KEK on the International Linear Collider (ILC). I also was working with Prof. Tajima on the application of plasma deceleration to the beam dump of ILC. In such a situation, I was asked to present the report on behalf of Prof. Tajima at this meeting. I would like to write about the report in this article.

Since the participants of the ICFA meeting are mostly from the High Energy Physics (HEP) community, I briefly explained in the presentation that ICUIL is providing a venue for discussions among representatives of high-intensity laser facilities and members of user communities, and IZEST is mastering the scientific community based on the concept of Laser-based High Field Fundamental Physics which might lead to the new alternative ways to provide more compact and cheaper accelerators by amplifying laser to extreme energy. The main part of the presentation was about the workshop "Outlook on WAKE FIELD ACCELERATION: The next Frontier" which was held at CERN on 15th and 16th October 2015. The workshop was organized by Prof.

Mourou (Polytech), Prof. Tajima (UCI) and Prof. Holzer (CERN), and more than 60 participants joined, most of them are somehow related to the HEP activities. I also joined the workshop and I really was convinced that the plasma acceleration is the new promising technology to be the alternative to the conventional acceleration techniques. The Large Hadron Collider (LHC) at CERN, which is the largest conventional collider discovered the Higgs particle at 126 GeV in 2013, but the new physics or new particles beyond the Standard Model have not been discovered yet. This means we need more acceleration and higher energy to open the new frontier. The workshop fully covered the possibilities of plasma acceleration to open the new frontier. I also introduced the international conference Ultrahigh Intensity Laser at Goa during 12th – 17th October 2014, which covered the ultra-intense lasers, pump lasers, and the applications. Following such workshop and conference, I showed an example of collaborative work between ICUIL and ICFA, which is organized by myself, i.e. an application of plasma deceleration technique to the beam dump of ILC. The ILC is a future accelerator to collide electrons and positrons at the center of mass energy of 500 GeV in the first phase and 1 TeV in the second phase. The energy consumption of ILC is estimated as 200 MW including surrounding facilities. In particular, at the beam dump, 10 MW is lost and the radiative activity is very high. In order to improve the existing design of ILC beam dump, we started studying the possibility to replace the conventional beam dump with the novel technique of plasma deceleration, where almost no radiation is expected because the beams are decelerated by electromagnetic reaction instead of nuclear reaction. Moreover, there is a possibility that we might recover the electric power from the plasma in the beam dump because the energy is in the purely electromagnetic shape. The working group started in 2015 with a small funding from the Japanese government. The organization members of the group includes KEK, UCI, SLAC and LAPP/IN2P3/CNRS as shown in Fig. 1. The new concept of beam dump was named the Green ILC Beam Dump because the new design is more environmentally friendly. This work is a very good example of collaboration between ICUIL and ICFA community.

To summarize the experiments of plasma acceleration, I presented a plot shown in Fig. 2, which is representing the state-of-the-art experiments and the resultant data for beam energy vs. plasma density. I also showed the laser acceleration experiment at LMJ/NIF aiming at the energy of 100 GeV which would be eventually reaching the Higgs mass (100 GeV UV LWFA experiment at ARC) as an example of the state-of-the-art experiments.

Finally, I introduced and advertised the 2016 ICUIL conference at Montebello/Quebec during 11th – 16th September 2016, which will cover ultra-high intensity lasers, pump lasers, laser acceleration, and so on.

As shown in my presentation at the ICFA meeting, recently, the activities of ICUIL community are becoming more and more closely related to the activities of ICFA community. I would say that the report on ICUIL-ICFA activities will be more and more intense and higher density in the next ICFA meeting.

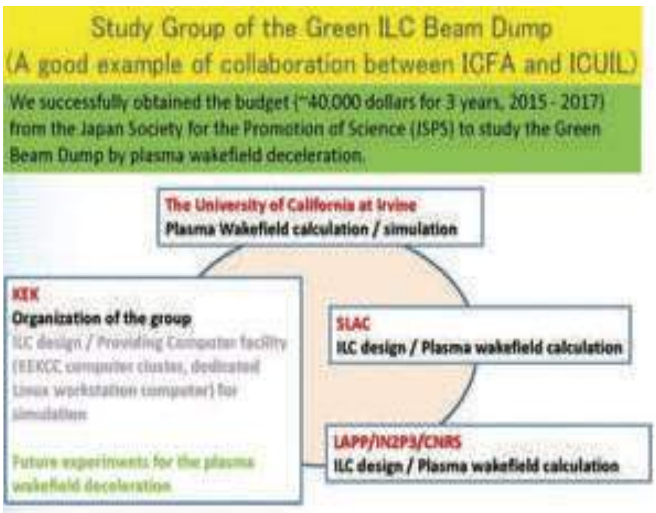


Fig. 1. *The organization of study group of the Green ILC beam Dump*

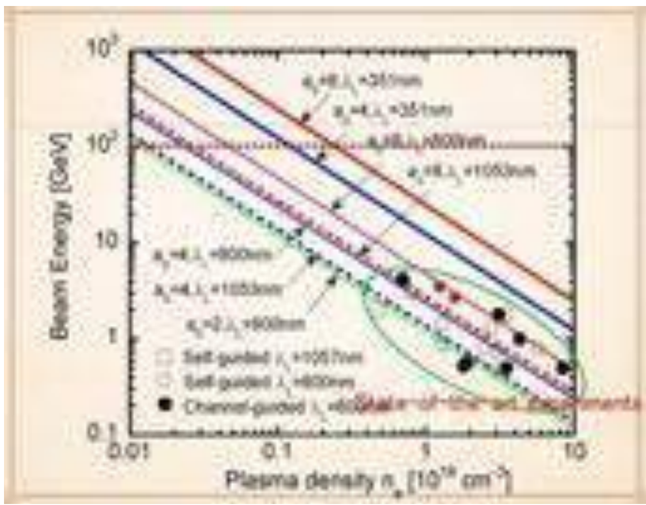


Fig. 2. *Current experimental data for beam energy vs. plasma density*

Recent Results on Proton Acceleration at PEARL Facility

Mikhail Starodubtsev, Institute of Applied Physics RAS

The peak of investigations on laser-driven ion acceleration was in the middle of the first decade of the 21-st century. By now, quite a number of laser-plasma interaction schemes have been developed that provide accelerated ion energies up to 40-70 MeV/nucleon.

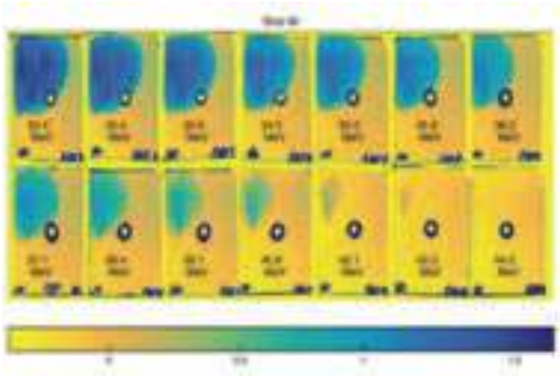


Fig.1. *Radiochromic films exposed to a record proton beam accelerated by 7J laser pulse. The depicted energies correspond to the proton Bragg peak in energy deposition for a sensitive layer of particular film. Maximum proton energy is 43.3 MeV.*

Recently, experiments on TNSA proton acceleration (target normal sheath acceleration) were started at the IAP RAS laser facility PEARL with laser radiation (7.5 J, 60 fs) focused on the surface of a thin (0.1-10 μm) foil. The laser radiation intensity on the foil surface amounted to $3 \cdot 10^{20}$ W/cm^2, the foil was ionized, and the laser-accelerated electrons were escaped from its opposite side. The formed negatively charged electron cloud produced an electric field that accelerated ions at the rear surface of the foil (hydrogen ions, i.e., protons, in the first place).

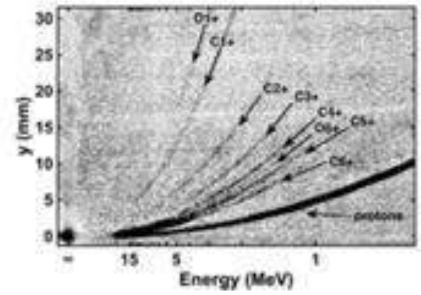


Fig.2. *Measurement of emitted ion spectra obtained using Thomson parabola. Traces of H+, C1+– C6+, O1+ and O6+ ions are marked according to calculations of ion trajectories. Proton energy is laid off on the horizontal axis*

The angular and energy distribution of the protons accelerated from the foil rear surface was measured by means of RCF films (fig.1) and by a Thomson parabola spectrometer (fig. 2).

Project CREMLIN Connecting Russian and European Measures for Large-scale Research Infrastructures

Alexander Sergeev, Institute of Applied Physics RAS

This project was launched in October 2015 aimed at fostering scientific cooperation between the Russian Federation and the European Union in the development and scientific exploitation of large-scale research infrastructures.

19 European research centers, including 6 Russian institutions, established a consortium the principal goal of which is development of concrete coordination and support measures for each research infrastructure and common best practice and policies on internationalisation and opening. The project is intended for 3 years during which each consortium member will organize working meetings and/or focus workshops with participation of other CREMLIN members to discuss problems of mutual interest and find ways for their solution. In addition, meetings of Consortium Board (CB) and Project Management Board with representatives of each party will be held regularly. An external Science Policy Advisory Board (SPAB) appointed by the CB shall assist and facilitate the CB decisions.

The CREMLIN kick-off meeting took place on 06-07 October 2015, at the National Research Center "Kurchatov Institute" in Moscow, Russia.

The objectives, management and financial issues, exchange platform, milestones and other issues were addressed at the meeting.

It was agreed that the CREMLIN project should be seen as a vehicle and platform to move the discussions around large-scale research infrastructures and as a means to establish links between the project participants and the European Strategy Forum on Research Infrastructures (ESFRI) and other relevant EU organizations.

The first CREMLIN working meeting on exchange on policy and ESFRI-related issues was held at the Joint Institute for Nuclear Research in Dubna, Russia on the 20th April 2016. The meeting was intended to stimulate and enable mutual learning and exchange of best practice within the community, with a focus on policy issues.

The next working meeting is schedule for 28–30 June 2016 and will be dedicated to internationalisation aspects of megascience facilities. It will be held at the European Spallation Source in Lund, Sweden.

Still another forthcoming CREMLIN event is organized by the Institute of Applied Physics of the Russian Academy of Sciences (IAP RAS). It will be a workshop on novel applications of exawatt laser sources, with a focus on the XCELS facility developed at IAP RAS. The workshop will be held on board a river ship cruising from Nizhny Novgorod to Saint Petersburg, Russia from the 17th to the 23d of July 2016.

The consortium members believe that their close collaboration will be mutually beneficial for all the parties.

Recent ICUILERS' awards

Enrico Fermi Prize 2015

Toshiki Tajima
Norman Rostoker Chair Professor,
University of California at Irvine,
USA

For the invention of the laser-wakefield-acceleration technique which led to a large number of fundamental and interdisciplinary applications ranging from accelerator science to plasma physics and astrophysics

Frederic Ives Medal / Quinn Prize 2016

Gerard Mourou
Distinguished Professor Emeritus
from the University of Michigan and
the Ecole Polytechnique in Palaiseau,
France

For numerous pioneering contributions to the development of ultrafast and ultrahigh intensity laser science and for outstanding leadership of the international and commercial communities impacted by these technologies.

The Infosys Prize 2015 in Physical Sciences

G. Ravindra Kumar
Tata Institute
of Fundamental Research, Mumbai

For his pioneering experimental contributions to the physics of high intensity laser matter interactions. In particular for providing, for the first time, unequivocal evidence of turbulent magnetic fields and the discovery of terahertz frequency acoustic waves, in laser produced hot dense plasmas. These results have significance to testing stellar and astrophysical scenarios.

Harold E. Edgerton Award 2016

Christopher P. J. Barty
Lawrence Livermore
National Laboratory

In recognition of his efforts in the development of foundational techniques that have enabled ultrafast, intense lasers and for pioneering contributions to time-resolved, x-ray and gamma-ray science conducted with such lasers.

Obituary: Wolfgang Sandner

We suddenly lost Professor Wolfgang Sandner, a beloved laser scientist and the international leader in high intensity laser, on Dec. 5, 2015. He was attending the Extreme Light Infrastructure (ELI) Workshop in Romania just a few days prior to his passing, chatting with our colleagues affably. He left a gaping hole in the ELI-Delivery Consortium's General Directorship, which leads the world's highest intensity laser initiative. He was GD of ELI-DCfrom its inception in 2013. This followed his leadership activities in ELI-Preparatory Phase 2008-2011 (which was initiated by Prof. G. Mourou). Under his leadership Europe was firmly set as the undisputed world leader in the field of intense laser research.

Among other services (I won't list all of his illustrious career and positions here, as other such pronouncements no doubt have been written) he served as Director of Max Born Institute from 1993 till 2013, as the leading advocate of high field science there. At MBI he launched a strong team of intense laser matter interaction research. His team published, among other important papers, the first experimental observation of what is called the Radiation Pressure Acceleration of ions driven by intense laser (I had a privilege to be part of the paper) in 2009. (He was also Professor at Technical University of Berlin, 1994-2014). As a member of MBI Science Advisory Board (2009-2013) I had a pleasure of advising and interacting with him and his team deeply. During his tenure (2003-2013), he had become the leader in Europe (and the world) to integrate many intense (and not so intense) laser labs in Europe, most active in the world, serving as Coordinator of Laser Lab Europe, a shining example how best different labs can complementally coordinate with each other to produce far more than the sum of the all. His scientific leadership also included his Presidency of German Physical Society, the world's largest physical society (2010-2012).

He was among a couple of dozens of internationally prominent intense laser scientists when Prof. Yoshiaki Kato invited them and hosted an OECD-sponsored inaugurating meeting of what had become International Committee for Ultrahigh Intensity Lasers (a Chapter of International Union of Pure and Applied Physics) at Kyoto's Advanced Photon Research Center in 2002. These people including Wolfgang pushed the envelope of the development of world's highest intensity laser ever since. Dr. Sandner led ICUIL activities and served as Co-Chair of ICUIL from 2008 till 2012.

Before he came back to Germany, he served as full professor at the University of Tennessee from 1991-1994. He was a Fellow of American Physical Society. He graduated from the University of Freiburg with PhD in atomic physics in 1979.

He was an avid sportsman such as enjoying a long oceanic cruise by yacht every so often. He was survived by a wife and two children. He was 66.

Toshiki Tajima
Chair, ICUIL Chairman,
ELI-NP International Scientific Advisory Board
Norman Rostoker Chair Professor, University of California at Irvine

It was so sudden! so unexpected! The earth seemed to stop when I heard "Wolfgang Sandner is dead" from Cathy. The optics community, he worked so much to shape, had just lost his flag captain. I was invaded by a tremendous sense of nothingness. We were together only a few days before at the ICEL conference in Bucharest. During light moments we chatted about swimming, which was our favorite topics and the number of laps we would do the week-end. How ironic?

WS personality combined a great scientist, an architect, a great manager and an accomplished diplomat with a knack for the unification and organization of science. Over the years his influence in the field of laser physics grew to become global.

Following his return from the University of Tennessee in 1993 he was one of the Max Born Institute's Directors. In 2001, under the leadership of the OECD, Wolfgang was one of the founders of a IUPAP working group called ICUIL. He was its vice-chair for the past 4 years. ICUIL was created to organize the community around the field of ultra intense laser and their applications.

His pieces of advice were sought after by many scientific organizations and scientific boards. His role reached to the governmental level to define the science of German and European policies.

In 2002 he managed to weave an extended network, named LASERLAB Europe (2002-2012) formed by the top laser laboratories in EU. It has been a resounding success that arguably is at the root of the optics European leading position in the world.

Building the Highest Intensity Laser: how ELI came to be?

In 2005 when I came back from the University of Michigan, I proposed the first ultra high intensity laser infrastructure, ELI for Extreme Light Infrastructure. Wolfgang was a strong supporter of this initiative. In 2006 after only one year, ELI made it to the ESFRI Road Map. For the EU, ELI had the making to become the first European Infrastructure that could be installed in a European emerging country like Czech Republic, Romania and Hungary. After numerous fruitless meetings trying to select a country to build ELI "under one roof", it dawned on us that the only way was to build an integrated infrastructure based on 4 pillards, specialized in different emerging fields of extreme light; namely Beam Generation in Prague, Nuclear-Physics in Bucharest and Attosecond Physics in Szeged. It was decided to give priority to the 3 first pillars. The last one will focus on Extreme Intensity Physics and would be dealt within a few years later. At the cost of almost 1B€, this integrated facility will form the world largest civilian laser facility. However, the budget was far more expensive than we expected and we had to find solutions to circumvent this major showstopper. Wolfgang's role here was invaluable to convince the EU to use its Structural Funds normally reserved for civilian infrastructures, Roads, Bridges, Hospitals, and the like, to build these three research infrastructures. In 2010 the ELI Preparatory Phase was completed and the project was transitioned to the ELI Delivery Consortium.

In 2013, because of his recognized scientific aptness combined with his seasoned experience and incomparable managerial skills WS was rightly selected General Director of the world's largest, civilian laser research, the ELI-Delivery-Consortium.

Wolfgang Sandner has contributed to make Europe arguably the top place in laser research and applications. But his most extraordinarily teaching, so much needed today, has been that science is an unifying element that makes possible to endeavor with serenity together to the benefit of all.

Gerard Mourou
Distinguished Professor Emeritus the University of Michigan
and Ecole Polytechnique in Palaiseau, France

Tribute to Nikolay Narozhny

Professor Nikolay Borisovich Narozhny, an eminent Russian theoretical physicist and Head of the Department for Theoretical Nuclear Physics at the National Research Nuclear University MEPhI, died on February 15, 2016 in Moscow. With his passing away, physics of intense electromagnetic fields lost one of the most outstanding representatives.

In 1964 he graduated from the Moscow Engineering Physics Institute and began work on his PhD under supervision of Anatoly Nikishov, one of the founders of the physics of superstrong electromagnetic fields. The first paper by Nikolay "Quantum processes in the field of a circularly polarized electromagnetic wave" published in JETP jointly with Anatoly Nikishov and Vladimir Ritus is widely quoted and appreciated up to now.

Since then and up to the end of his life Nikolay's scientific interests were concentrated on the theory of strong field phenomena. For more than 50 years of research N. Narozhny pioneered a number of problems, including radiation corrections in superintense electromagnetic fields, the theory of relativistic ponderomotive scattering in tightly focused laser pulses, collapse and revival in quantum systems, the dynamical Casimir and Lamb effects, mistakes around the theory of the Unruh effect and many more.

His most recognized contribution was to the theory of electron-positron pair production from vacuum by superstrong electromagnetic fields. Being one of the founders of the theory of laser vacuum breakdown in the mid 1960s, Prof. Narozhny recently returned to that topic again when the plans for construction of new high-power laser facilities showed prospects for attaining the QED critical field in a foreseeable future. Recently, he predicted a new effect of laser-induced QED cascades generation. That work gave rise to a new branch of the strong field physics – simulation of laser plasma in extreme light fields.

In the nearest future, several laser facilities of unprecedented exawatt-scale power are expected to come into operation. At these new facilities, at a laser intensity of 10^{24} W/cm^2 and above, it will be possible to study the fundamental effects of nonlinear QED that have been long considered experimentally inaccessible. Such novel opportunities boomed the field of extreme light science, and Prof. Narozhny was at the center of this activity. Nikolay's life was never restricted by his routine scientific interests. It was always interesting and instructive to speak with him about the history of physics, arts, literature, sports, cuisine and wines – the list would be difficult to complete. He was deeply involved in the life of his *alma mater* where he ruled the Department for Theoretical Nuclear Physics for more than 30 years, was Head of the Dissertation Council on Theoretical and Solid State Physics and Vice-Head of the Scientific Council. His life was full of activities and he was exceptionally successful in each of them. Still, physics always remained his greatest devotion.

Sergey Popruzhenko, MEPhI

International School on Ultra-Intense Lasers

Evgeny Perevezentsev, Institute of Applied Physics RAS

The International School on Ultra-Intense Lasers was held not far from Moscow, Russia, from 4 to 9 October, 2015.

The School was organized by the International Committee on Ultra-Intense Lasers (ICUIL), the Institute of Applied Physics of the Russian Academy of Sciences (IAP RAS), the National Research Nuclear University MEPhI and the Russian Federal Nuclear Center VNIIEF.

The main objective of the School was to give an opportunity for postgraduate students and other early career researchers working in ultra-intense laser science to meet in person and listen to the lectures given by world renowned experts in high power laser physics, laser-matter interaction physics, laser-plasma accelerators, laser-based x-ray sources and inertial confinement fusion. Also, a poster session was organized for the young participants where they could present and discuss their own results.

In addition to the lectures and poster session, evening interactive classes were conducted by distinguished specialists in the field. The main idea behind them was to make contact of students and teachers as close as possible. The classes were divided into 4 topics:

- High average power and high-energy lasers.
- Femtosecond-laser-plasma interaction and particle acceleration.
- Laser ceramics: fabrication and application.
- Interaction of strong lasers with quantum systems.

An excursion to Moscow was organized for the school participants. They walked around the Kremlin and visited the cathedrals inside. Special priority was given to the Armoury chamber with its collections of precious items that had been preserved for centuries in the tsars' treasury and the Patriarch's vestry.

The participants were free of any charges except travel expenses. The number of available places was, however, limited and the registration was open until the limit was reached. About 80 young scientists from Asia, Western Europe and Russia took part in the school.

ICUIL 2016 Conference in Montebello Canada (11-16 Sep. 2016)

Tsuneyuki Ozaki, INRS-EMT, Varennes, Quebec

The ICUIL 2016 conference will welcome high intensity laser enthusiasts from across the world, to the Fairmont le Château Montebello from the 11 to the 16 September. The hotel is located between Ottawa and Montreal, about 80 minutes by car from both international airports. The conference site is situated within a 65,000 acre forested wildlife sanctuary including 70 lakes, on the shores of the Ottawa River. The conference will be held in the hotel's newly renovated congress centre, with plenty of adjacent space for participants and vendors to interact.

ICUIL 2016 is also expected to showcase the latest on multilateral projects like the ELI. Following past successful conferences, this biennial meeting will focus on the following themes: (i) ultra-intense laser design and performance (such as Nd:glass-based, Ti:sapphire-based, DPSSL-based and OPCPA-based ultra-intense lasers, as well as their pump lasers); (ii) novel technologies for ultra-intense lasers (such as grating and compressor modelling and fabrication, high-damage-threshold and ultra-broadband laser components, devices for spatial and temporal pulse control, diagnostics for ultra-intense lasers), and (iii) applications of ultra-intense lasers (such as laser acceleration, short-wavelength sources, attosecond sources, high-field physics and applications with extreme light). XCELS and IZEST as well as the efforts in individual institutions across the world.

Preparation for the conference is going forward at full speed. The Conference Co-Chairs, Dino Jaroszynski (U. Strathclyde, UK) and Tsuneyuki Ozaki (INRS, Canada), and the Technical Programme Committee Co-Chairs, Marco Borghesi (Queen's U. Belfast, UK), Hiromitsu Kiriyama (JAEA, Japan) and Christophe Dorrer (U. Rochester, USA) along with the 24 members of the Technical Programme Committee have been working hard to come up with an exciting conference programme. The list of confirmed invited speakers currently counts 16, who are all prestigious, world-renowned researchers from around the world. The conference website (www.icuil2016.org) was open for several months, and abstract submission was closed on the 25th of April. We have received enthusiastic 150 contributed abstracts from around the world, which underlines the strong interest and passion from the community. I have received many comments from the programme committee that there are numerous strong papers, and we are looking forward to organizing a conference with many exciting presentations.

In December 2015 the ICUIL community learned with deep regret about passing of one of its true leaders and colleague, Professor Wolfgang Sandner. Among his many illustrious roles (including Director of the Max Born Institute, Coordinator of Laserlab-Europe, President of the German Physical Society, and the General Director of the ELI-Delivery Consortium), Wolfgang served as Co-Chair of the ICUIL committee. To pay tribute to Prof. Sandner, the ICUIL 2016 conference will dedicate one of its plenary sessions in his honour. This special session is being organized by Dr. Catalin Miron of the ELI-DC, and will include invited speakers who worked closely with Wolfgang.

The ICUIL 2016 conference will be supported by many companies, agencies and universities one of which is the Institut national de la recherche scientifique (INRS). The Énergie Matériaux Télécommunications (EMT) Centre of the INRS is located about 20 minutes by car east of Montreal, focusing on research and development in the fields of ultra-fast optics, advanced materials, telecommunications and sustainable energy. The Centre offers a unique educational environment for its students, welcoming each year approximately 140 graduate and postgraduate students and 30 postdoctoral fellows. The Centre is also the host to the Advanced Laser Light Source (ALLS), an international laser user facility that houses an array of intense femtosecond lasers. This national laboratory for laser science was financed through the "International Joint Ventures Fund" program of the Canadian Foundation for Innovation (CFI) with an investment of $20.95 million. With the powerful lasers at ALLS, a series of new ultrafast light sources for revolutionary applications have been developed, with wavelengths from the terahertz regime (300 micron wavelength) to hard X-rays (Angstrom wavelength). Since these light sources are generated in an all-optical way, light pulses of different wavelengths can be spatially and temporally synchronized. This opens the door to explore the potential of dynamic imaging of atomic, molecular and condensed matter systems and provides the unique tools to explore the fundamental questions of physics and chemistry.

We look forward to welcoming many of you to the ICUIL 2016 conference this September!

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ICUIL News N°8

Volume 8 – June 2017

Chief Editor: Alexander Sergeev

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The International Committee on Ultra-High Intensity Lasers

ICUIL Chairman's statement and welcome

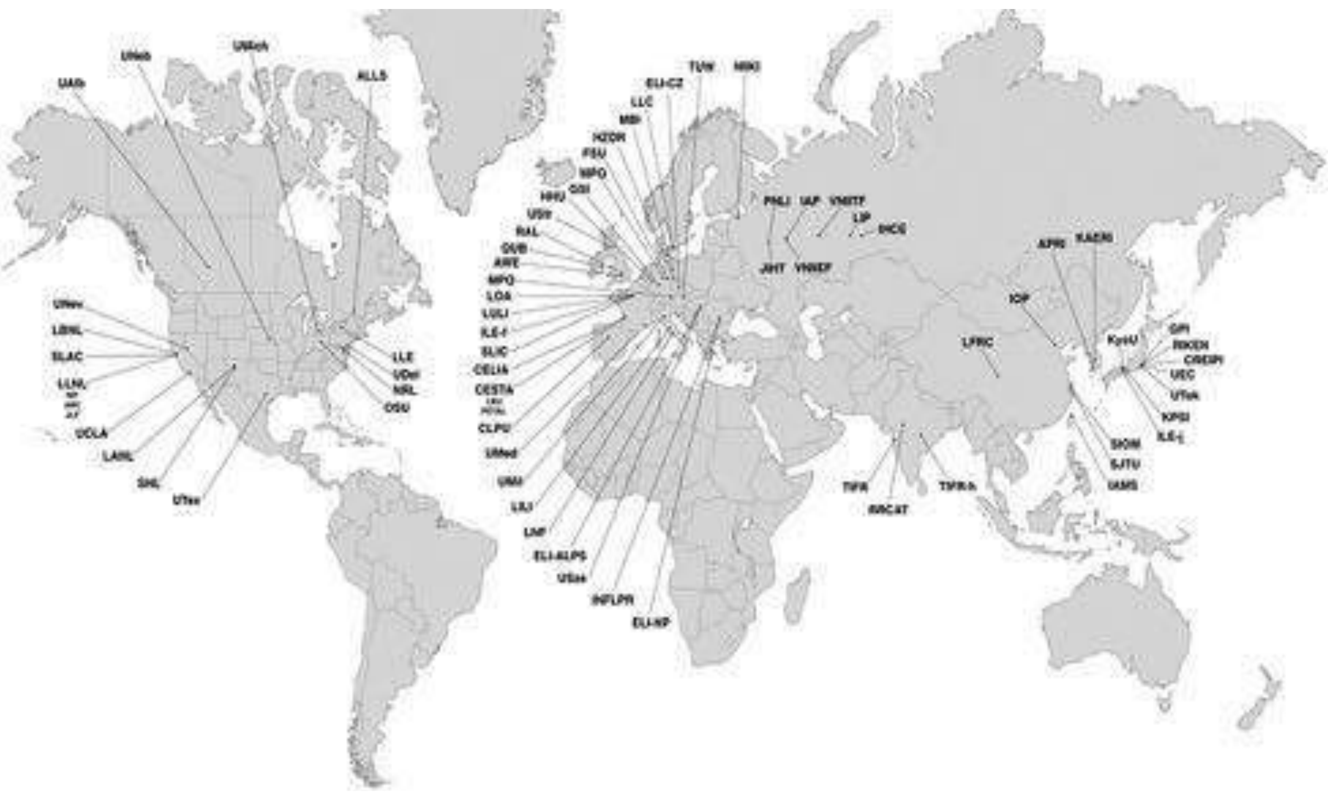
As the incoming chairman of the International Committee on Ultrahigh Intensity Lasers (ICUIL), it is my honor to both welcome you to our 8th newsletter and to offer on behalf of the entire ICUIL community our sincere thanks to Professor Toshiki Tajima who for the previous eight years has served as ICUIL's chairman. Under Professor Tajima's leadership, ICUIL's activities have greatly flourished and new relationships with important, related communities have been formed. The strong linkage that exists today between ICUIL and the accelerator community is in large part due to Prof. Tajima's unwavering drive and leadership.

As is evident throughout the contents of this newsletter, worldwide activities related to the development and use of ultrahigh intensity lasers are growing. New user facilities are coming on line and existing facilities are making significant upgrades to their existing capabilities. It is our hope that you find this newsletter to be a convenient snapshot of worldwide activities and that you will use this document as motivation to visit the ICUIL website at www.icuil.org and to participate in upcoming ICUIL related activities.

sincerely

Dr. C. P. J. Barty - Chairman ICUIL

ICUIL World Map of Ultrahigh Intensity Laser Capabilities



2017 ICUIL Membership

The International Committee on Ultrahigh Intensity Lasers (ICUIL) created by the International Union of Pure and Applied Physics in 2003 at the Council and Commission Chairs meeting in Vancouver, Canada currently includes the following laser scientists

Officers:

Christopher P. J. Barty
Chair
Chief Technology Officer for NIF and Photon Science LLNL (Lawrence Livermore National Laboratory), USA

Alexander Sergeev
Co-Chair
Director, Institute of Applied Physics, Russian Academy of Sciences, Russia

G Ravindra Kumar
Co-Chair
Professor, Tata Institute of Fundamental Research, India

Terrance Kessler
Secretary
Group Leader of Optics and Imaging Sciences LLE, University of Rochester, USA

Tsuneyuki Ozaki
Treasurer
Director, ALLS INRS-ÉMT

Members:

Gerard Mourou, France
Toshiki Tajima, United States
Bedrich Rus, Czech Republic
Chang Hee Nam, Korea
Christine Labaune, France
Claes-Goran Wahlstrom, Sweden
Dino Jaroszynski, United Kingdom
Hiroshi Azechi, Japan
Heinrich Schwoerer, South Africa
John Collier, United Kingdom
Ken-ichi Ueda, Japan
Nilson Da Vieras Jr., Brazil
Ruxin Li, China
Ryosuke Kodama, Japan
Sandro De Silvestri, Italy
Thomas Kuehl, Germany
Wim Leemans, United States

The principal goals pursued by the ICUIL members are

- to provide a venue for discussions among representatives of the Ultrahigh Intensity Lasers facilities and members of the user communities on international collaborative activities such as the development of the next generation ultrahigh intensity lasers, exploration of new areas of fundamental and applied research, and formation of a global research network for access to advanced facilities by users;
- to promote unity and coherence in the field by convening conferences and workshops dedicated to ultrahigh intensity lasers and their applications;
- to accelerate progress in the field by exploring opportunities of sharing information, joint procurement, and the exchange of equipment, ideas and personnel among laser laboratories world-wide;
- to attract students to high-field science by promoting their education and training, interactions with prominent scientists, and access to the latest equipment, results and techniques;
- to strengthen and exploit synergy with other relevant fields and techniques, notable accelerator-based free electron lasers.

The Extreme Laser Infrastructure: an international user facility

ELI is a new laser research infrastructure, which is part of the European ESFRI Roadmap. ELI currently consists of three different sites, which will be hosting the most intense and short pulsed lasers in the world, made available to an international academic and industrial user community to perform experiments.

The scientific profiles of the ELI pillars will be complementary, and the operation of the Research Infrastructure, starting progressively from 2018, will be unified under one single legal umbrella of the ELI-ERIC. Currently, the organization is transforming towards this ERIC-governed unified operation.

In this article, we briefly describe the current activities of the three pillars of ELI and their foreseen facilities.

ELI Nuclear Physics Facility

In Măgurele, Romania, the ELI Nuclear Physics (ELI-NP) facility will focus on photonuclear physics studies and applications, comprising unique features at the limits of the present-day's technology: a very High Power Laser System (HPLS) of 2 × 10 PW and a very intense Gamma Beam System (GBS) with $E\gamma$ up to 19.5 MeV.

Kazuo A. Tanaka, Scientific Director of ELI-NP: ‘Our laser system will have an intensity which is higher than ever before, and the gamma beam will be the brightest one ever made. We can have the laser beam colliding with relativistic electron beams, which will cause dynamics predicted by QED theory which could not be tested before. Also for many other applications like fusion or fission, exciting possibilities will be tested. The name of the facility says it all: extreme laser infrastructure nuclear physics. It is all about combining laser technology and gamma beams on scales which have never been performed before. This will become a very attractive site for scientists from all over the world, namely a game changer in the field.’

ELI-Attosecond Facility

The ELI Attosecond Light Pulse Source (ELI-ALPS) in Szeged, Hungary is establishing a unique facility which provides light sources between THz (10^{12} Hz) and X-ray (10^{18}–10^{19} Hz) frequency range in the form of ultrashort pulses with high repetition rate.

Károly Osvay, Research Technology Director ELI-ALPS: ‘The lasers which are going to be available at ELI-ALPS distinguish themselves in three major aspects: They have a high repetition rate, they will cover broad spectral ranges, and they will have as short pulses as possible, sometimes even consisting of a single optical cycle. But most of all, what we are aiming for is to achieve a combination of high average power and high peak intensity laser systems which are highly stable and reliable. We generate pulse durations as short as few tens of attoseconds, that is, 10^{-17} s. The major focus of ELI-ALPS is to use these pulses to investigate how fast atoms, molecules, clusters, and even proteins react to an excitation.’

ELI Beamlines Facility

In Dolni Brezany, near Prague, Czech Republic, the ELI-Beamlines facility will mainly focus on the development of short-pulse secondary sources of radiation and particles, and on their multidisciplinary applications in molecular, biomedical and material sciences, physics of dense plasmas, warm dense matter, laboratory astrophysics. In addition, the pillar will utilize its high-power, high-repetition-rate lasers for high-field physics experiments with focused intensities of about 10^{23} W/cm^2, investigating exotic plasma physics, and non-linear QED effects.

Georg Korn, Chief Scientist at ELI Beamlines: ‘ELI-Beamlines is designed as the high-energy pillar of ELI. The laser sources were designed to address specific scientific aspects, namely in the fields of particle acceleration by lasers, generation of high-brightness XUV and X-ray pulses, and high-field physics. The generated ultra-short pulsed sources of energetic particles and radiation will serve fundamental research and multidisciplinary applications.’

Most of the laser systems will be shipped and installed in 2017 and 2018. From 2018 onwards, first experiments will be possible, and the facilities will be open to scientists from all over the world via a scientific excellence based selection process supported by an international peer review committee.

At the moment, all three pillars of ELI are actively looking for researchers and technicians to join their teams. If you are interested, present job openings can be found on:

www.eli-np.ro (Romania)
www.eli-alps.hu (Hungary)
www.eli-beams.eu (Czech Republic)


ELI ALPS, Szeged


ELI Beamlines, Dolni Brezany


ELI-Nuclear physics, Măgurele

Development of a 4 PW Ti:Sapphire Laser at CoReLS

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Department of Physics and Photon Science, GIST, Gwangju 61005, Korea

A high-contrast 4 PW Ti:sapphire laser with a repetition rate of 0.1 Hz was developed at the Center for Relativistic Laser Science (CoReLS), Institute for Basic Science (IBS) in Korea, for the exploration of superintense laser-matter interactions. Ultrahigh power lasers with peak power of 1 PW or higher have been constructed in a number of institutes around the world. Laser-driven particle acceleration has been one of intensively pursued research topics with such ultrahigh power lasers. A multi-GeV electron beam can be produced from a He gas target driven by a PW laser, and the GeV electron source can be used for Compton backscattering to produce MeV gamma rays. The development of ultrahigh power lasers, thus, offers a new generation of particle and radiation sources, which can initiate another new challenging physics in astrophysics and nuclear physics as well as in plasma physics.

At CoReLS, two PW laser beamlines with outputs of 1.0 PW and 1.5 PW at 30 fs have been utilized for research on laser-driven particle acceleration since 2012. One of the PW beamlines was upgraded to a 4 PW beamline, as shown in Fig. 1. In order to boost the PW beamline to a multi-PW laser, we shortened the pulse duration while increasing pulse energy. For the reduction of the pulse duration, the spectral width of amplified laser pulses has to be broadened, while flattening the spectral phase over the whole spectral range as much as possible. We adopted the cross-polarized wave generation (XPW) and the optical parametric chirped-pulse amplification (OPCPA) techniques in order to compensate for gain narrowing and gain depletion effects.

For the upgrade, the front-end part of the existing PW beamline was significantly modified. An XPW stage consisting of a hollow-core fiber, a BaF_2 crystal, and a Glan-laser analyzer was installed after the front-end amplifier in order to broaden the laser spectrum and to enhance the temporal contrast. A 30 fs, 3 mJ laser pulse was sent through the XPW stage, and the XPW output had a spectral width of 107 nm, a temporal contrast ratio

Fig. 1. CoReLS PW laser beamlines with outputs of 4 PW (left) and 1 PW (right).

of about 10^{-12} and an energy of 0.5 mJ. Its spectral width and the temporal contrast were improved by a factor of two and by 4 orders of magnitude, respectively. The OPCPA amplifier was employed as a preamplifier of the PW laser for the generation of a broadband laser spectrum without the gain narrowing problem observed frequently in a high gain preamplifier. In addition, the spectral narrowing due to the gain depletion effect, occurring while extracting the maximum energy available at the subsequent amplifiers in the CPA scheme, was taken care of by shaping the laser spectrum at the OPCPA stage.

For the increase of the output energy, a final booster amplifier was added. The booster amplifier was pumped with the second harmonic of Q-switched Nd:Glass lasers with a total energy of 170 J in green. After double passage of the amplifier, the laser pulse was amplified to 112 J. With the pulse compressor made of four gratings we obtained compressed laser pulses with an energy of 83 J and a pulse duration of 19.4 fs, producing 4.2-PW laser pulses at the repetition rate of 0.1 Hz with the low energy fluctuation of 1.5 % (rms). In addition, the temporal contrast was measured to be 3×10^{-12} up to 100 ps before the main pulse. Consequently, we successfully upgraded one of the PW laser beamlines to the 20 fs, 4 PW beamline.

A series of commissioning experiments are planned this year. Three target chambers are available at CoReLS for physics experiments, as shown in Fig. 2. As its first run of the 4PW laser commissioning, an electron acceleration experiment has been performed in April, 2017 using the laser wakefield acceleration (LWFA) scheme. LWFA has been investigated at CoReLS to produce quasi-mono-energetic collimated GeV electron beams of centimeter-scale acceleration length. In the previous exploration of LWFA, we succeeded in controlling the acceleration process by manipulating the temporal structure of PW laser pulses, generating stable multi-GeV electron beams. We plan to carry out the Compton backscattering to generate MeV gamma-rays from the interaction of a GeV electron beam and another laser beam. Furthermore, the newly upgraded 4-PW laser can offer opportunities to produce a 10-GeV electron beam and 10-MeV gamma rays. Consequently, the development of high energy electron beam and ultrafast gamma-ray sources with multi-PW lasers will open a route to explore strong field QED processes in photon-particle, photon-photon interactions, laboratory astrophysics, and photo-nuclear physics as well as plasma physics at extreme laser intensities.

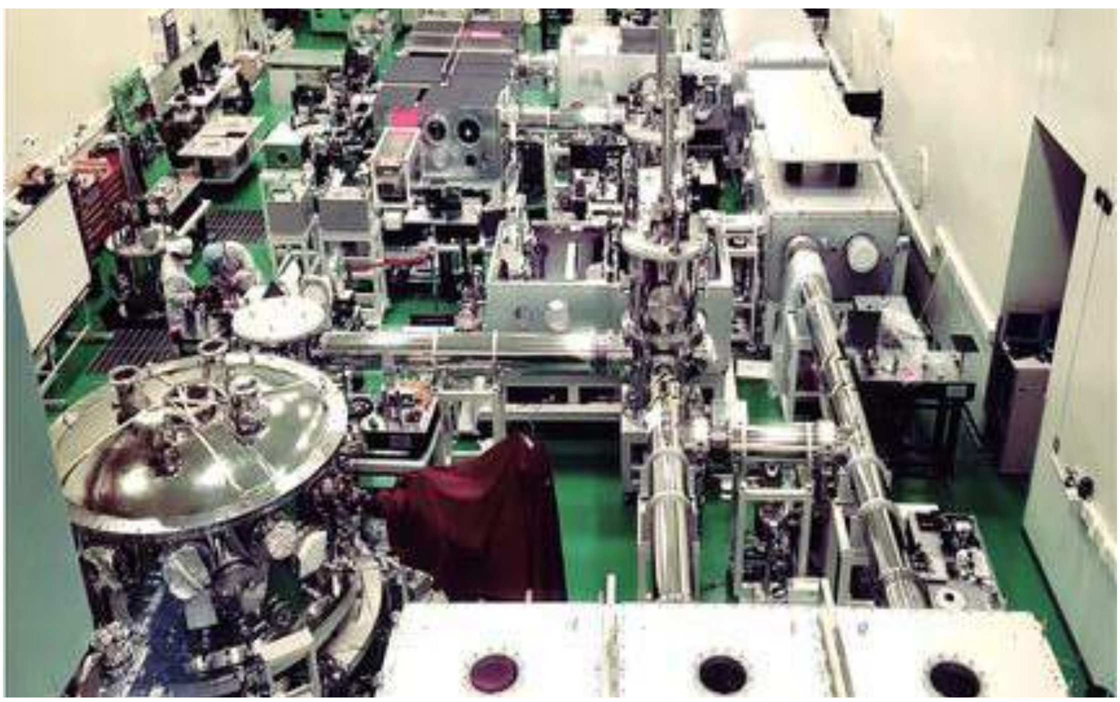

Fig. 2. Experimental area showing three target chambers and a double plasma mirror chamber along with two pulse compression chambers.

The European Cluster of Advanced Laser Light sources (EUCALL)

Synergy between accelerator and laser-driven light sources

Within the EUCALL project, which was launched in October 2015 and is coordinated by the European XFEL in Germany, the accelerator-driven and laser-driven X-ray sources of Europe collaborate for the first time in a comprehensive way on technical, scientific, and strategic issues. EUCALL involves approximately 100 scientists from European XFEL, DESY, and Helmholtz Zentrum Dresden-Rossendorf in Germany; ESRF in France; Elettra Sincrotrone Trieste in Italy; Lund University in Sweden; PSI in Switzerland; and each pillar of the Extreme Light Infrastructure (ELI) in the Czech Republic, Hungary, and Romania, including the ELI Delivery Consortium (ELI-DC). The project also involves the previously established scientific networks *FELs of Europe* and *Laserlab Europe.*

EUCALL's primary output consists of new technologies for standardisation and optimised access to different types of light sources for staff and users. Software is being developed to fully simulate photon science experiments at the light sources; and also for ultrafast data acquisition and data processing for experiments at the facilities. New hardware is under development for an intelligent, standardised sample delivery system for both X-ray and laser experiments at EUCALL's facilities, as well as advanced photon beam diagnostic tools for use at these light sources.

Further initiatives are dealt with under EUCALL's "Synergy" Work Package, which focuses on enhancing the combined research and innovation potential of the new cluster of facilities. An optimized database is under development, which will allow potential users to enter their requirements helping them to identify the most suitable beamline for their experiments. During 2017 and 2018, EUCALL will organize several workshops that aim to provide exchange of experience from the management of EUCALL's operational light sources like DESY and ESRF, to the facilities under implementation such as ELI and European XFEL. Further events planned for the scientific community involve experience exchange on the application of synchrotron, free-electron laser, and high-power laser-driven X-ray radiation to biology, as well as to problems of societal relevance such as climate change and green energy.

"EUCALL is a unique opportunity for two formerly independent scientific communities to meet, discuss, and work in synergy to identify joint solutions to common scientific and societally relevant challenges," said Catalin Miron, Deputy Director General of the ELI-DC. "From the operational point of view, newly established research infrastructures such as ELI have lots to learn from the well-established, accelerator-based user facilities, and EUCALL is the ideal forum for expertise and knowledge transfer."

"The EUCALL project brings together experts from different types of light sources", said Thomas Tschentscher, European XFEL scientific director and EUCALL's project director. "The exchange of know-how and the joint developments provide new impulses to the individual light sources, and also pave the way towards new science and technology applications."

At the halfway point of its three-year project period, EUCALL has successfullycompleted all of its project milestones and deliverables to date. In June 2017, the project partners will meet for the 2nd EUCALL Annual Meeting at ESRF in Grenoble, where a major goal will be to define a path for the "Future of EUCALL" after the end of its funding period in September 2018.

EUCALL has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654220.

www.eucall.eu / contact@eucall.eu

EUCALL's project participants gathered at the Annual Meeting 2016 at HZDR.

ICUIL 2016 Conference in Montebello, Canada (11-16 Sep. 2016)

T. Ozaki and D.A.Jaroszynski

The7th Conference of the International Committee on Ultrahigh Intensity Lasers (ICUIL 2016) was held in Montebello, Québec, Canada from the 11th to the 16th September 2016. This biennial meeting aims to gather ultrahigh intensity enthusiasts from around the world, to report new results, exchange information and to establish and enhance collaborations across borders. Following past conferences, ICUIL 2016 has focused on the following themes: (i) ultra-intense laser design and performance (such as Nd:glass-based, Ti:sapphire-based, DPSSL-based and OPCPA-based ultra-intense lasers, in addition to their pump lasers); (ii) novel technologies for ultra-intense lasers (such as grating and compressor modelling and fabrication, high-damage-threshold and ultra-broadband laser components, devices for spatial and temporal pulse control, diagnostics for ultra-intense lasers), and (iii) applications of ultra-intense lasers (such as laser acceleration, short-wavelength sources, attosecond sources, high-field physics and applications of extreme light). ICUIL 2016 included talks that showcased the latest on multilateral projects such as ELI, XCELS and IZEST, in addition to the efforts in individual institutions across the world.

The conference has been chaired by Dino Jaroszynski (U. Strathclyde, UK) and Tsuneyuki Ozaki (INRS, Canada),with the strong support from Technical Program Committee Co-Chairs, Marco Borghesi (Queen's U. Belfast, UK), Hiromitsu Kiriyama (QST, Japan) and Christophe Dorrer (U. Rochester, USA), along with 24 members of the Technical Programme Committee. The program consisted of 19 invited talks, 61 contributed talks and 77 poster presentations, held over the five days of the conference. The total number of participants was 148, coming from 56 institutes and 18 countries from around the world. We also had strong participation from young researchers, with17 postdoctoral fellows and 11 PhD students, who are the future of the ICUIL community. The ICUIL 2016 conference was also strongly supported by a total of 22 companies, agencies and universities. Participation from these companies was also active, with 44 participants, some of whom gave oral presentations, while the majority of companies presented posters during the conference.

The conference consisted of 14 oral sessions and 2 poster sessions, where Student Poster Awards were awarded to three students: First Prize (including a US$500 cash award) went to Mr. N. Stuart (Imperial College, UK), for his poster on "OPCPA Pump-Depletion Contrast Enhancement using a Seeded OPCPA Fluorescence Diagnostic", Second Prize (US$300 cash award) went to Mr. J. Pilar (Czech Technical U Prague, Czech Rep), for his poster on "Adaptive optics development at HiLASE", and the Third Prize (US$200 cash award) went to Ms. S. Bucht (U. Rochester, USA) for her poster on "Transforming the Idler to Seed Raman Amplification". There were also five Student Travel Grants (US$1,000 each) that were awarded to promote student participation. These went to Ms. C. Scullion (Queen's University Belfast, UK), Ms. G. Cantono (Université Paris-Saclay, France), Mr. R. Budriunas (Vilnius U., Lithuania), Mr. D. E. Cárdenas (Ludwig-Maximilians-Universität, Germany) and Mr. J. Pilar (Czech Technical U Prague, Czech Rep).

ICUIL 2016 provided an occasion to honour and remember an important figure of the ICUIL committee and community, Prof. Wolfgang Sandner, who passed away in December 2015. Among his many illustrious roles (including Director of the Max Born Institute, Coordinator of Laserlab-Europe, President of the German Physical Society, and the General Director of the ELI-Delivery Consortium), Prof. Sandner served as Co-Chair of the ICUIL committee for many years. To pay tribute to Prof. Sandner, the ICUIL 2016 conference dedicated one of its plenary sessions in his honour. This special session was organized by Prof. Catalin Miron of the ELI-DC, and included invited speakers who worked closely with Wolfgang over many years. We also had the privilege of Mrs. Sandner accepting an invitation to attend the conference, and to remember Prof. Sandner with all his profession colleagues and friends.

The ICUIL 2016 was a great success, owing to the excellent presentations from the participants from around the world, and to the support from the various sponsors. The conference again showed the strength of the ICUIL community, and we look forward to the ICUIL 2018 conference to be held in Germany.

ICUIL 2016 Student travel grant to promote student participation

Relativistic surface plasmon driven electron acceleration and high harmonic generation

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Since the latest 20 years, laser-driven particle and radiation sources have been experiencing a continuous development, also encouraged by the tireless advance in the relativistically intense and ultra-short laser pulse technology. Acceleration schemes based on laser-solid interaction are now being explored as alternative mechanisms to produce high quality ion, electron beams and XUV pulses. A key element to these processes trusts in the most efficient laser-target coupling, which can be cleverly increased by employing nano-structured targets. In particular, solid targets with a sharp engraved surface (gratings) allow for the excitation of resonant surface plasmons (SPs), which already have many applications in the limit of low electromagnetic fields [Nat. Mat. **9**, 193 (2010)]. Yet, it has been recently demonstrated that ultra-high contrast laser pulses make SP excitation accessible also in the relativistic regime (i.e. for laser intensities $>10^{18}$ W/cm^2), where new possibilities for the manipulation of intense electromagnetic fields and the development of short, high-energy, laser-synchronized radiation sources can be explored.

SPs are collective oscillations of the electrons at a steep metal-dielectric interface. They can propagate along the surface through µm distances and they are evanescent across nm lengths in the transverse direction. Gratings are usually employed to excite SPs with laser pulses. For a metal described by the cold plasma dielectric function $\varepsilon(\omega) = 1 - (\omega p/\omega)^2$, phase-matching requirements between laser and SP result in a resonance condition that links the laser wavelength λ_L and the incidence angle θ to the grating period d, giving: $\sin(\theta res) \sim 1 + n\lambda_L/d$ (Eq.1). This last actually derives from a linear, non-relativistic theory, but both experiments and simulations performed in the relativistic regime show that resonance still occurs at the angles predicted by Eq.1. Laser-driven relativistic SPs increase the laser-target coupling and consequently affect ion acceleration via the TNSA mechanism, surface electron acceleration as well as high-order harmonic generation. The most recent investigation concentrated on electron and harmonic emission, the cut-off energy enhancement of TNSA-driven proton beams having been already demonstrated in the previous experimental work [Phys. Rev. Lett. **11**, 5001 (2013)]. Electrons can be extracted from the target plasma by the transverse component of both the laser and the SP electric field, and accelerated along the surface by the longitudinal component of the Lorentz force [Phys. Plasmas **22**, 3103 (2015)] as long as they stay in phase with the SP. This can occur over few µm distances, allowing electrons to reach tens of MeV energy [Phys. Rev. Lett. **116**, 5001 (2016)]. Electrons oscillating at the target surface also generate high-order harmonics (HHs), so the field enhancement achieved by SP excitation is also expected to increase HHs intensity while overlapping with the angular dispersion performed by the grating, this point being beneficial for practical applications. This effect was recently shown by means of numerical simulations [App. Phys. Lett. **110**, 1002 (2017)], where an enhanced HH emission was observed along the surface of grating targets irradiated at the resonance angle.

Experiments in this regime were recently performed at CEA-Saclay with the UHI100 laser system. The laser pulse (100 TW, 25 fs, $\lambda_L \sim 0.8$ µm) was focused down to a ~7µm 1/e^2 focal spot, reaching an intensity of about 5×10^{19} W/cm^2. A double plasma mirror ensured a ~10^{12} pulse contrast, which was crucial to preserve the periodic structure of the targets from pre-pulse induced damage. Gratings with sinusoidal profile (~250 nm depth) were produced by embossing 13µm thick Mylar foils: the step d was chosen according to Eq.1 to give a resonance angle of 30° (i.e. $d = 2\lambda_L$). The electrons spatial distribution was recorded with a scintillating Lanex screen covering the laser-irradiated side of the target, from tangent (0°) to normal (90°), and energies were measured by an electron spectrometer in the 2–30 MeV range. The harmonic emission at different observation angles was recorded with an XUV spectrometer within a 20–90 nm spectral range (i.e. ω_H/ω_L from 9 to 40).

Figure 1 (*a*) shows the profile of the electron spatial distribution recorded on the incidence plane for, respectively, a grating (blue curve) and a flat target (red curve) irradiated at the SP resonance angle (30°). Gratings produce a highly collimated bunch in the tangent direction, where the maximum signal is ~25 times more intense than the emission from a flat target, which in turn is localised around the specular reflection of the laser pulse

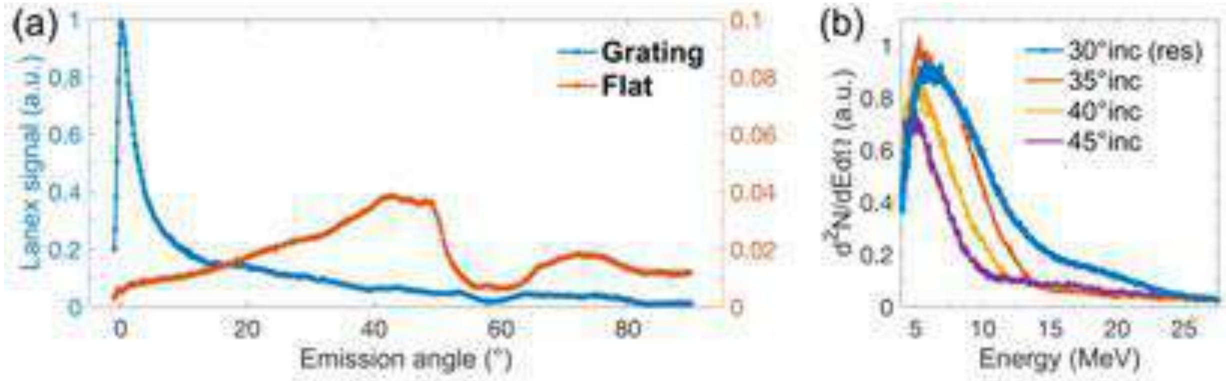

Figure 1(a): Electron spatial distribution from tangent (0°) to normal (90°) for flat and grating targets irradiated at 30°; (b): electron energy spectra collected at tangent for gratings irradiated at various incidence angles.

(i.e. 60°). The charge amount contained in the electron bunch (~6° full angle cone) was estimated after running the absolute calibration of the scintillating screen to be about 100 pC. Electron energy spectra collected in the tangent direction for different incidence angles are shown in Fig. 1 (*b*): no signal above the noise level was ever recorded with a flat target, whereas gratings show electron acceleration up to ~15 MeV with most of the population around 7 MeV. When moving out of the resonant configuration, degradation of the electron bunch is proved by both a loss of intensity and weaker maximum energies. A SP-induced effect on HH generation was observed in the increase of the maximum harmonic order obtained with gratings with respect to flat targets. HH spectra collected in the tangent direction with gratings irradiated at resonance expand over the 30th order of the laser frequency, whereas flat targets produced at most 25 orders in the specular direction. Simulations performed with a laser intensity ~10 times higher than in the experiment suggest that HHs above $40\omega_L$ could be stronger along the tangent rather than at specular, leaving room for further optimization of this process.

ICUIL 2016 Student travel grant to promote student participation

Ion acceleration from ultra-thin solid targets using femtosecond laser pulses

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Centre for Plasma Physics, Queen's University Belfast, United Kingdom

The acceleration of ions generated by the irradiation of thin solid targets by ultrashort linearly polarized (LP) and circularly polarized (CP) laser pulses has been investigated. The work presented aims to further understand the ion acceleration mechanisms which take place when thin solid targets are irradiated under different conditions as part of the Advanced Strategies for Accelerating Ions with Lasers (A-SAIL) project, which involves the investigation and optimization of emerging ion acceleration schemes, with a focus on processes based on the radiation pressure of an intense laser pulse, namely Light Sail, Hole Boring and shock acceleration; and assessment of the radiobiological effects of ultrafast ion energy deposition.

Experimental Setup

Investigations of the interactions of high intensity, ultrashort LP and CP laser pulses with ultrathin amorphous carbon foils (10–100 nm) were carried out on the GEMINI Ti:Sapphire laser system at the Rutherford Appleton Laboratory, STFC, UK. The laser delivered ~6 J energy on target in pulses of 800 nm wavelength (λ), and 45 fs full width at half maximum (FWHM) duration (τ), after being reflected off a double plasma mirror arrangement. The recollimated laser beam after the plasma mirrors was focused on the targets at normal incidence by an *f*/2 off-axis parabolic mirror, delivering peak intensities on target ~ 6×10^{20} W·cm^{-2}. The laser polarization on the target was varied from LP to CP by employing a zero order quarter wave plate (WP), placed between the plasma mirror and the focusing parabola (Fig. 1).

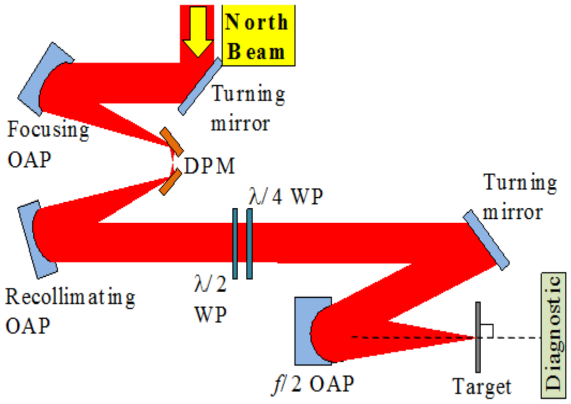

Fig.1. Experimental setup at the Gemini laser. Central Laser Facility, UK.

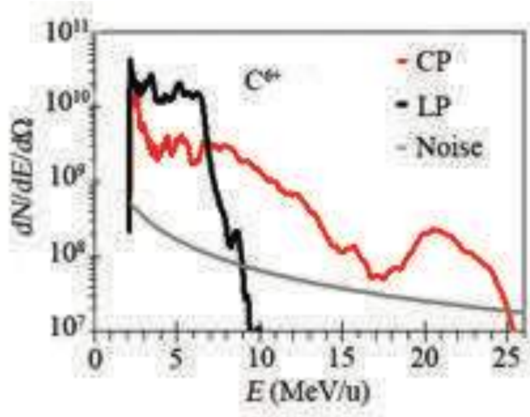

Fig.2. C^{6+} spectra with vertical axis units of particles/MeV/sr for 10 nm amorphous carbon targets irradiated with CP (red) and LP (black) laser pulses.

Amorphous carbon targets of thickness in the range of 10–100 nm were irradiated. The energy spectra of the ions accelerated from the interaction were diagnosed by a Thomson Parabola Spectrometer (TPS) with BAS-TR image plate (IP) detectors, along the laser axis (also target normal axis) with an acceptance angle of 1.1 μsr.

Results

These experiments demonstrated a strong dependence of the characteristics of the accelerated ions on the target thickness and the laser polarization. Figure 2 shows spectra obtained from 10 nm carbon targets irradiated by LP and CP laser pulses. Figure 3 shows representative experimental measurements of the proton beam profile for CP and LP pulses and a comparison with similar data obtained through 3D PIC simulations. It is evident that there is qualitative agreement with the experimental images, as the most prominent features and differences between CP and LP are broadly reproduced by the simulation, which gives confidence in the theoretical interpretation.

Conclusion

In conclusion, in an interaction regime employing ultrashort (50 fs) laser pulses and ultrathin foils (10–100 nm carbon), we have observed a strong dependence of the characteristics of the accelerated ions on the target thickness and the laser polarization, providing evidence that a regime in which RPA is the dominant acceleration mechanism can be accessed at current intensities by careful control of the interaction parameters (pulse contrast, polarization and target thickness).

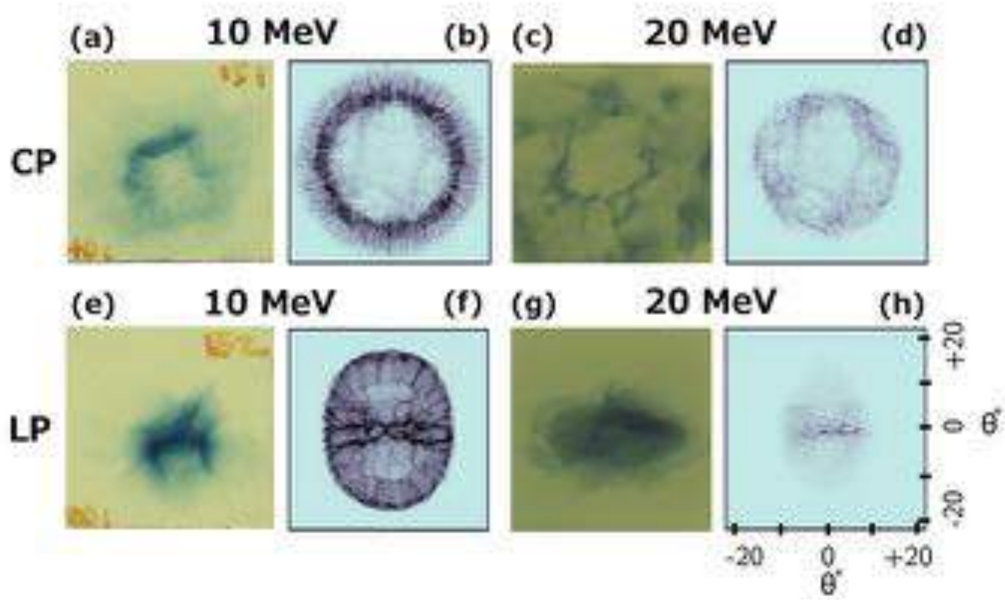

Fig.3. CP (a-d) and LP (e-h) proton beam profiles at 10 MeV (left) and 20 MeV (right) obtained experimentally from 10 nm amorphous carbon targets on RCF (a,c,e,g) and through 3D PIC simulations (b,d,f,h). All images represent the same solid angle of the beam profile (marked in h).

Nuclear Photonics 2016

The first international conference devoted to the pursuit of photon-based nuclear science and applications, Nuclear Photonics 2016 (http://nuclearphotonics2016.org), took place at the Monterey Plaza Hotel and Spa in Monterey, California from October 16th to the 21st, 2016. The conference brought together 144 participants from 17 countries and included experts in gamma-ray source development, ultrahigh intensity laser development, nuclear physics and nuclear-related applications.

The rapidly evolving field of nuclear photonics has been enabled by the development of ultra-bright, quasi-mono-energetic gamma-ray sources based on laser-Compton scattering and by the worldwide development of $B-scale user facilities housing ultrahigh intensity lasers capable of producing field strengths of relevance to nuclear interactions.

Nuclear-related topics discussed during the Monterey meeting included:

- fundamental nuclear science and spectroscopy,
- nuclear medicine including radiography and radiotherapy,
- industrial non-destructive material imaging and evaluation,
- isotope-specific, nuclear materials detection and management,
- photo-fission and materials transmutation,
- photon-based production of rare isotopes,
- photon-enabled pulsed neutron generation and science,
- photon-enabled pulsed positron generation and science,
- photon-based hadron beams and applications,
- nuclear astrophysics and cosmology
- gamma-ray science above the giant dipole resonance

Sessions devoted to mono-energetic gamma-ray technology and to ultrahigh intensity laser technology were also a key part of the meeting. The former included discussion of the development of compact accelerators, optimization of laser-Compton interactions, novel detectors for bright gamma beams, gamma-ray monochromators, gamma-ray optics, advanced lasers for Compton light sources, high-brightness photoguns and novel scintillator materials. The latter included overviews of state-of-the-art laser facilities, advances in beam focusing and transport, novel pulse diagnostics, methods for control of pulse contrast, and the development of high average power, intense laser systems. Special efforts were made to integrate applications and technology development sessions so that each could motivate the other with respect to the development of nuclear photonics as a new scientific discipline.

Nuclear Photonics 2016 was the first of a planned series of biennial topical meetings devoted to this topic. At the conclusion of the Monterey conference it was announced that Nuclear Photonics 2018 will be held in Romania and will be hosted by the ELI – Nuclear Physics project.

IZEST: Searching for a Particle Physics Renaissance

The IZEST Spring meeting was held at Ecole Polytechnique, Palaiseau, France on April 4, 2017. 64 researchers from around the world took part in the meeting focused on the different techniques leading to efficient and affordable particle acceleration schemes in the TeV regime.

Invited talks were given by Roy Aleksan- Georg Korn- Ralph Assmann / Massimo Ferrario- Catalin Miron- Patrick Audebert- Gerard Mourou- Franck Brottier /Federico Canova- Karoly Osvay- Jean-Christophe Chanteloup- Michel Spiro- Pisin Chen- Toshiki Tajima- Toshikazu Ebisuzaki- Kazuo Tanaka- Sydney Gales- Satoshi Wada- Spencer Gessner- Jonathan Wheeler- Bernhard Holzer.

Extreme light is one of the most exciting domains in the field of lasers today. It relies on the generation of ultrahigh peak power obtained by delivering the energy within a short time. Today, laser peak power typically exceeds the PW or a thousand times the world's grid power. The ability to produce and focus this gargantuan power over a size 10 times smaller than a hair offers unfathomable possibilities in science, technology, medicine and is a harbinger of the flood gate of socio-economic applications to come.

Towards the demonstration of the shortest pulse duration in the X-ray regime the highest field gradient and Schwinger Intensity: IZEST looks beyond the horizon set by the ELI-Apollon facilities. It wants to push the most avant-garde laser concepts to demonstrate short time structures down to the attosecond-zeptosecond regime. Pulses will be so short that the highest peak power in the x-ray regime could be reached with a modest amount of energy at the joule level yielding intensities in the Schwinger regime enough to materialize light. Among the remarkable applications we note the generation of gargantuan accelerating gradient in solids enough to accelerate electrons over a centimeter to the TeV level or relativistic protons widening the range of applications in subatomic physics, cosmology, vacuum physics and the like. In addition, trying to develop a new breed of laser sometime opens the way to new applications, like space debris removal which is a big issue in space activity in the near future.

Relativistic Proton Generation: The generation of ultrahigh energy particles like protons in the GeV regime strongly depends on high peak power and short pulse duration. One technique recently proposed and actively investigated is the thin film compression concept. Used in conjunction with a PW laser, this technique could produce a single cycle pulse with energy in the tens of joules. The simulation showed that relativistic GeV protons can be produced by interacting the single cycle pulse with a thin target.

Fundamental Physics: Black hole information Paradox: A newly proposed experiment promises to create a “tabletop” black hole that could prove whether information is truly lost when black holes evaporate. The idea that information could be lost this way has created a paradox in our current understanding of basic physics.

Societal Application: Novel laser-based architecture finds an important application in the mitigation of space debris produced by the few thousands launches. Novel laser architecture and pulse compression technique open the door to new societal space field.

CFA Mini-workshop on Future Gamma-Gamma Colliders

On April 23–26, 2017 IUPAP's International Committee on Future Accelerators (ICFA) convened a mini-workshop on future gamma-gamma colliders. The purpose of the gathering was to discuss the status and prospects for gamma-gamma colliders. The meeting brought together experts in conventional accelerators, advanced accelerator concepts, high-energy physics, laser-Compton technology and high peak and average power laser science. The gamma-gamma collider is a challenging new type of particle collider based on interactions of energetic gamma-rays produced via Compton scattering of intense, high power laser radiation on highly energetic electron or positron beams. This type of collider can produce complimentary and unique new physics when compared with conventional proton and electron-based machines and enables access to annihilation reactions with precisely understood point like interactions without requiring positron beams. Such gamma-gamma collider systems allow emerging accelerator concepts such as laser wake field acceleration to become part of the conversation for future high field physics. For example, one proposal suggests that relatively low energy electron (or positron) beams could be used in a gamma-gamma configuration as a "Higgs factory". The required e-beam energy for such a machine is in the sub-70 GeV range. The workshop discussed gamma-gamma colliders based on several different technologies: linear colliders (e.g. ILC, CLIC), recirculating LINACs (e.g. SAPPHiRE, HFiTT), circular colliders (e.g. FCC-ee, CEPC) as well advanced accelerator concepts (e.g. laser driven plasma acceleration, beam driven plasma acceleration, dielectric wakefield acceleration). Discussions of near term light source opportunities and of applicable high peak and average power laser technology were also key part of the meeting. Workshop presentations may be found on line at http://indico.ihep.ac.cn/event/6030/overview

Because gamma-gamma colliders require both a high power laser system in addition to an accelerator, this concept provides a strong opportunity for the laser and accelerator communities to work together. The gathering included participation by both the present ICUIL chairman Dr. Chris Barty and ICUIL's first chairman Prof. Gerard Mourou as well as leading laser experts from the United States and China.

ICUIL 2018 Conference in Lindau Germany (09-14 Sep. 2018)

Thomas Kuehl, GSI-Helmholtzzentrum, Darmstadt, Germany

The ICUIL 2018 Conference, the 8th CONFERENCE OF THE INTERNATIONAL COMMITTEE ON ULTRAHIGH INTENSITY LASERS will again welcome high intensity laser enthusiasts from across the world, this time back in Europe. The conference will take place at Hotel Bad Schachenin Lindau, Germany, from September 9th to 14th, 2018. The hotel is located right on the shore of Lake Constance boasting a wonderful view of the lake, but also the panoramic backdrop of the Austrian and Swiss Alps. It can be reached via the international airports in Munich (2 hours by car or 3.5 hours by train) and Zurich (2 hours by car or 2 hours by train). There is also a local airport at Friedrichshafen (30 minutes by taxi) with several connections per day from Frankfurt and London. The hotel offers park-like grounds with a spacious lakeside lido, a private boat jetty and a beautiful terrace. The conference will be held in the hotel's congress center, with plenty of adjacent space for participants and vendors to interact.

ICUIL 2018 is again expected to showcase the latest on multilateral projects like ELI, XCELS and IZEST as well as other efforts across the world in the direction of ultra-intense lasers. Following the spirit of the ICUIL conferences, in particular the last meeting at Montebello, Canada, technical and scientific themes concerning ultra-intense lasers will be addressed: (i) ultra-intense laser design and performance including Nd:glass-based, Ti:sapphire, DPSSL and OPCPA and novel architectures, (ii) novel technologies for ultra-intense lasers, e.g compression components and strategies, modelling and fabrication, high damage-threshold and ultra-broadband laser components, pulse control, and diagnostics, and (iii) applications of ultra-intense lasers for laser acceleration, short-wavelength sources, attosecond sources, exploration of warm-dense matter, high-field physics and more. This conference will emphasize the many contributions from students and young scientists in this dynamic field of ultra-high intensity lasers.

Preparation for the conference has started in November 2016. A Local Organization Board has been formed by members of the GSI Helmholtz Center Darmstadt and the Helmholtz Institute Jena: V. Bagnoud, A. Blazevic, Ch. Brabetz, T. Kuehl, S. Kunzer, D. Schumacher, T. Stoehlker, B. Zielbauer, and D.Lang.

We invite the interested community and industrial partners to mark down the date, and hope to meet you in Germany in September 2018!

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