ICUIL News

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Chief Editor: Christine Labaune

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The International Committee on Ultra-High Intensity Lasers

Greetings from Chair: Epochal Lasers, Epochal Year

Toshiki Tajima ICUIL Chair Ludwig Maximilian University, Garching, Germany

One year since we last published our Newsletter, we had a series of epochal developments in the field of intense lasers of the world, and we at ICUIL experienced an epochal year, commemorating the 50th year of laser (on which I do not dwell on here, as it was already reported amply elsewhere).

The ICUIL Conference held last September at Watkins Glen, NY reviewed the status of intense lasers of the world, their reach, the world map of these lasers, and industrial impact. The world map we updated through the Conference (shown separately) is rapidly increasing and quite impressive.

The reach and subsequent science of intense lasers include the active collaboration on laser acceleration for high energies with ICFA (International Committee for Future Accelerators), following the ICUIL-ICFA Joint Task Force Workshop at Darmstadt, Germany in April, 2010. This workshop triggered the grassroots and more official movements of bridging the communities of intense lasers and high energy aspirations. It has stimulated activities such as the 'Bridgelab Symposium' at ILE (L'Orme, France), Physics under Intense Fields Symposium (PIF2010) at KEK, new initiatives at DESY toward lasers in high energy physics, and other similar efforts at Fermilab and UK. At CERN it is planned to hold an advanced accelerator workshop under the auspices of EuCARD (European Committee for Accelerator Research and Development) the coming May. LBL is planning a second JTF workshop in Berkeley in the near future.

On the other hand, even though less conspicuous than these but as important, productive and valuable efforts have been conducted. The scientific, technological, and managerial breakthroughs at such places as Max Born Institute, Berlin, and Los Alamos National Laboratory (Trident) advancing how to make high intensity lasers more reliable, more pristine relevant to demanding experiments (such as for ion acceleration) are noteworthy. It is highly desirable for the high intensity laser community to learn the secret ingredients of these successes.

We also witness a large number of petawatt class (and even 10PW class) lasers either to be built or in plan as national or regional projects around the world. There are even a few (sub-)exawatt laser projects under consideration. I would like to alert this community and broader academic community that so many initiatives in intense lasers have caused severe shortage of trained intense laser personnel and that we one way or another need to encourage and foster younger generations up to this task. Our success is our own cause for concern to cope with appropriate personnel developments.

Among these projects let me now single out the project of the Extreme Light Infrastructure (ELI) under EU. We have emphasized ELI is a game changer in the 21st Century science. This is first because ELI will change the way we conduct the fundamental scientific investigation we established in 20th Century with the fashion of the extrapolation of the current technology to ever larger sizes. An example is the accelerator to investigate high energy phenomena that is the most successful hallmark of 20th Century basic research tool. ELI will look for radically different ways to seek fundamental physics via photons, rather than charged particles in high energies. Secondly, ELI, unlike many other large scientific instruments, are not only for analysis, but also for synthesis, encompassing many disciplines ranging from high energy physics, nuclear physics, plasma physics, solid state physics, chemistry, biology, medicine, nuclear engineering, etc. and will serve to integrate these disparate disciplines, rather than to narrowly isolate a single discipline. Third, significantly, it involves a new participation from a geographical region that has never hosted a major international scientific installation. Not

ISTC-JAEA Joint Meetings

3rd International Symposium "Laser-Driven Relativistic Plasmas Applied to Science, Energy, Industry, and Medicine" jointly held with 12th Symposium on Advanced Photon Research (May 30 – June 02, 2011)

http://wwwapr.kansai.jaea.go.jp/istc-ws/ and http://wwwapr.kansai.jaea.go.jp/sympo12/

Kansai Photon Science Institute, Kizugawa-city, Kyoto, Japan

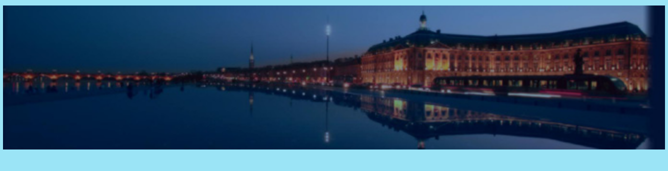
- High intensity lasers
- Lasers for energy production
- Relativistic interactions
- Laser-driven accelerators of charged particles
- Laser-driven X-ray and gamma-ray generation
- Medical and industrial applications.

7th Inertial Fusion Sciences and Application (IFSA) *(September 12-16, 2011)*

Palais des Congrès de Bordeaux-Lac, France

http://ifsa11.org/#

- Physics of Inertial Fusion
- Laser, Particle Beams and Fusion Technology
- High Energy Density Physics and Applications



only is it significant for geopolitics, but also the new blood is good for the possibility to open doors to new entries with less constraints by the establishment approach and philosophy that may have been stuck, leading to opportunities for wide-open breakaway developments.

The ELI Science was designed based on the scientific recommendation by ELI SAC [1], which recognized four scientific missions of ELI: High field science, laser accelerated beam lines, photonuclear science, and attosecond science. It turned out that ELI Pillars are consisted of the above four scientific missions and that each Pillar is centered in so far three countries (Czech, Romania, and Hungary) for each of the three scientific missions, respectively, other than high field science listed above. The high field science pillar will be considered finally in 2012. The high intensity frontier is ELI's chief guiding direction. It will seek the highest laser intensity ever, which enables us to explore physics frontiers of the above four missions.

Let me take an example of ELI-Nuclear Pillar (ELI-NP). ELI-NP represents Nuclear Photonics, an emerging brand new discipline to explore and control nuclei by photons. Unlike the standard approach in the present nuclear physics where charged particle beam (or beams) bombards these charged particles to spew out deep interior secrets of the constituent particles through the large penetrating momenta, our approach is through photons, chargeless massless particles. Chargeless gamma particles can penetrate the nucleus without deflection by the nuclear charge. It can precisely resonate with the internal structure of the nucleus if the energy of the gamma is chosen appropriately. With the large amplitude laser, we may be able to excite and/or break up the nucleus. With these new tools, a large amount of new ideas and topics have been suggested. For example, the energy specific gamma beam is capable of exciting specific nuclear levels (or isomers) so that we can make use of these levels as a marker or an energy releaser, thus possibly as a diagnosis, and a cancer killer, yielding a new genre of nuclear medicine. The nuclear resonance fluorescence by the gamma beam should be able to identify the precise information of the specific nuclei at hand without contact and thus in safety and convenience with speed. We have also begun to see ELI-NP developments will bring hopes to new classes of beneficiaries such as patients with metastasized tumors and IAEA nuclear inspectors.

As Professor S. Gales has told us, the impact of progress of nuclear physics will be felt on the way to make progress in nuclear engineering such as the nuclear waste monitoring and management. Even though Fermi has made an impressive beginning of nuclear energy and engineering, few breakthroughs that rival his have happened. This is why I have been advocating the importance of what I called 'toilet science' as opposed to the predominant conventional efforts in 'kitchen science', where the latter focuses on the upstream side of energy and matter while the former on the downstream. In other words, the former tries to understand the science how best we can clean up what the nuclear energy production brings out. The new headway in this direction can only come with a brand new approach such as ELI-NP employs and new ideas and discoveries that it might bring out.

In retrospect of the recent nuclear reactor catastrophe after the most powerful earthquake in the recorded history of Japan, I believe that it is even more urgent to make further progress in 'toilet science' of nuclear energy. We are fortunate and proud that the ELI-NP research and the intense laser research around ICUIL as a whole can make such a contribution to the society in its urgent problems.

[1] ELI Scientific Advisory Committee Report: www.extreme-light-infrastructure.eu

Ultrafast Optics 2011 ***(September 26-30, 2011)***

Monterey Plaza Hotel & Spa

http://ultrafastoptics2011.org/

- Generation of atto-, femto- and piccosecond optical pulse from lasers
- Parametric and quantum amplifiers of ultrashort pulses
- Ultrahigh peak-power laser systems and related technologies
- Novel methods for shaping and measuring ultrashort pulses
- Advances in nonlinear frequency conversion techniques
- Few-cycle pulses, carrier-envelope phase control
- Ultrashort THz pulses
- Current and prospective applications requiring novel or improved ultrafast sources and technologies

LEI conference 2011 (Light at Extreme Intensities) ***(15 -18 November 2011)***

Szeged, Hungary

http://www.eli-laser.eu/

- High intensity and ultrashort pulse lasers
- Attosecond generation
- Secondary sources of particles
- Secondary sources of X-ray
- Interdisciplinary applications (Biology, Chemistry, Material Sciences, Medicine, etc.)
- Photonuclear Physics
- Exotic physics at high laser intensities

Bridging high energy and high intensity : The pulse-intensity conjecture

Just in time before the start of realization of the three pillars of the European ELI project (Extreme Light Infrastructure: ultra-high power laser systems with special emphasis on Beamlines in Prague, Attosecond Science in Szeged and Nuclear Physics in Bucharest-Magurele), Prof. Gerard Mourou and Prof. Toshiki Tajima have evaluated the potential of large-scale laser facilities with respect to the production of ultra-intense ultra-short pulses of coherent high-energy X-ray and γ-ray beams in the January 7 issue of "Science".

In their article the two experts show that not only are short laser pulses a method to create very high intensities at still manageable pulse energies, but also show that the converse was true: high intensities are required in order to produce very short pulses. To establish their conjecture, they plotted since the laser beginning the pulse duration as function of input intensities, covering a range from the kW/cm^2 to the yottawat/cm^2, representing an enormous span of 18 orders of magnitude. A corresponding inverse linear relation for pulse duration was obtained, ranging from microsecond to zepto- yoctosecond. The last points were the results of simulations (see Fig.1).

For the future the authors predict that by shaping relativistic mirrors (i.e. very dense bunches of electrons) laser intensities of 10^{22} W/cm^2 could produce few-attosecond backscattered X-ray or γ-ray pulses. High-density relativistic flying mirrors could be produced by imploding spherical targets with very intense laser pulses. By backscattering laser light from such mirrors, laser intensities of 10^{24} W/cm^2 could ultimately produce even γ-ray pulses of approximately 100 yoctoseconds (10^{-22} s) duration. In this way ELI class laser systems have the potential to create the shortest coherent pulses, suitable to probe the vacuum and take a look into the atomic nucleus. Thus the future of high-field science and that of ultrafast optical science are now merged. It is anticipated that there will be an emerging brand new cross-fertilized interdiscipline, such as the ultrafast streaking of vacuum structure going one step beyond atomic streaking.

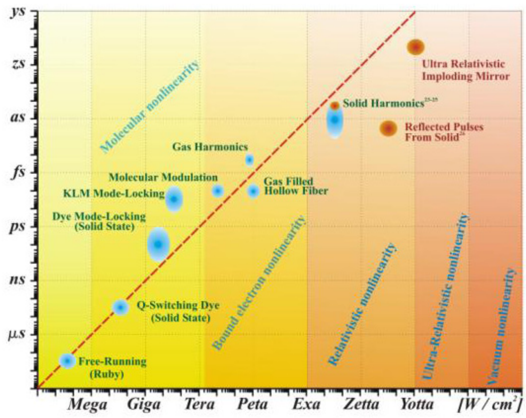


Fig.1: The Pulse Intensity-Duration Conjecture is shown. An inverse linear dependence exists between the pulse duration of coherent light emission and its intensity of the laser driver in the generation volume over 18 orders of magnitude. These entries encompass different underlying physical regimes, whose nonlinearities are arising from molecular, bound atomic electron, relativistic plasma, and ultra-relativistic, and further eventually from vacuum nature. The blue patches are from the experiments, while the red from the simulation or theory. (Science vol.331, p. 41 (2011))

International Coherent Amplification Network (ICAN)

Lasers are notorious for their poor efficiency. This is especially true for high peak power laser systems exhibiting wall-plug efficiency in the range of 1% at best. For many utilizations requesting average power in the range of kW to 10 MW, like particle acceleration, X- ray and gamma ray, this situation is economically unacceptable – even for research infrastructures – and seriously impairs the spread of important scientific and societal laser applications in science material science, environment, medicine and energy.

To solve this problem, we are proposing a novel laser concept known as CAN, (Coherent Amplification Network) that would guaranty, high peak, high average powers while exhibiting a high efficiency, >30%. The approach is based on fiber amplification. By far, fiber amplifier is the most efficient amplification system. Today it can reach 30% tomorrow 50% seems reachable. Fiber amplifier can also deliver remarkably high average power up to 10kW for a single fiber.

A proposal – under the name of ICAN – has been submitted in answer to the call "Study" of the European Community last November and has been accepted in April.

The aim of this project is to demonstrate the relevance of fiber laser solution for use in high energy physics applications including the drivers for particles accelerator and also many other applications. The initial objective is to demonstrate and federate a strong community made of experts from the laser and fiber communities and also of people from high energy physics, nuclear physics and oncology, all of them being ready to collaborate to the definition, conception, design of the laser, a laser with high peak power, high average power and high efficiency. At the end of the study a road map for the implementation of a facility based on the CAN concept will be established. Conferences, workshops and meetings will be organized on the subject.

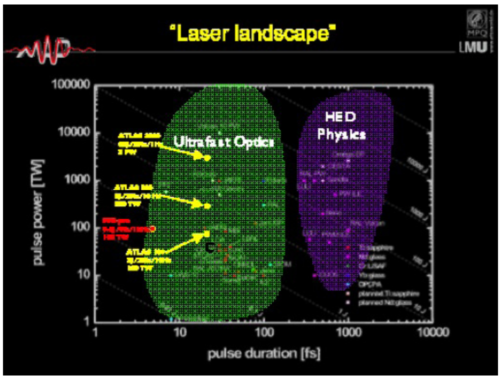
The coordinating laboratory will be ILE (with Gerard Mourou as the coordinator) with three partners from three different countries: UK with ORC in Southampton, Germany with University of Jena (FHG) and Suisse with CERN and 14 identified participants.

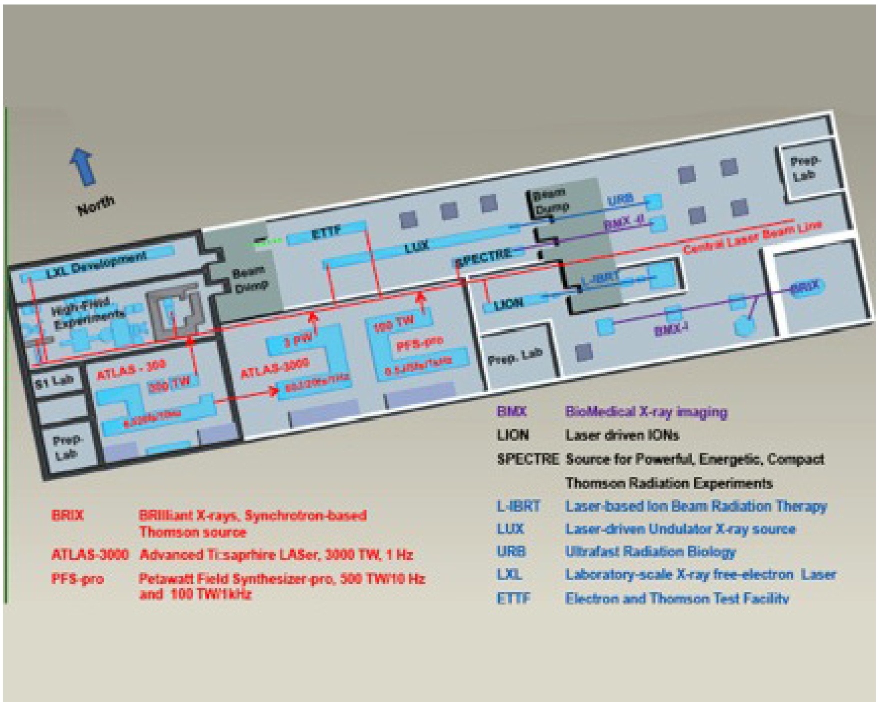
Centre for Advanced Laser Applications, CALA.

Max Planck Institute of Quantum Optics in Garching (Germany)

The major objective of CALA is the development of purely laser-based sources for the detection of tumors using x-ray phase-contrast imaging and proton or carbon ion beams for cancer treatment. Due to the fs-duration of these bunches, ultrafast biology is a further topic.

Two types of lasers will be used: ATLAS 3000 (Ti:Sa), an upscaled 3PW/1Hz version of ATLAS 100 presently running at MPQ, for particle acceleration and the generation of incoherent and coherent undulator radiation and the 100TW/1kHz/5fs





Petawatt Field Synthesizer (PFS-pro) for x-ray generation from 40 keV to 1 MeV. The energy range from 15 to 40 keV will be covered by a synchrotron-based x-ray source called BRIX. The ATLAS lasers are positioned on the Power/Pulse duration graph showing the different types of lasers.
The CALA building whose first section is commissioned by the end of this year will be finished early 2014.

Prospects of International Cooperation in Ultra-High Intensity Lasers for Civil Applications within the Frame of the ISTC Activities

Report edited by S.G. Garanin (2010)

The International Science and Technology Center in Russian Republic was able to establish and fund the first stage of the Targeted Initiative on Ultra-High Intensity Light Science and Technologies just at the year of 50th anniversary of the laser discovery. The aim of the study was to assess possible collaboration between the Russian laser research centers and large-scale international projects on super-high intensity lasers. The study provides information, related to science and technology potential of the leading Russian institutions and ways of their possible involvement in international projects such as ELI, HiPER.

In the recent decades progress of experimental laser technique, especially with high- and ultrahigh-intensity lasers and ultrashort pulses opened unique opportunities for research in nuclear physics, physics of atomic and radiation processes in plasma, solids chemistry, fast process measuring methods and particle acceleration techniques. Interaction of focused ultrahigh intensity, short pulse laser beams with matter opens a new dimension of ultrarelativistic physics.

ISTC has a solid record of supporting projects in laser technologies. Over 300 project proposals from 90 institutes of ISTC member states have been received at the Secretariat and about 50% of them were funded and successfully completed. Over 380 companies, institutes and governmental organizations have been involved in ISTC-funded projects as collaborators or partners. Many of the partners have developed long lasting cooperation at international level. At the same time, ISTC has successfully encouraged and facilitated national cooperation between institutes of Rosatom, Russian Academy of Sciences and Universities.

ICUIL has lent its support to assist and promote ISTC activities in advancing ultrahigh intensity lasers and their applications to science and technology in Russia. For example, ISTC had a special session at the ICUIL Conference at Watkins Glen on the intense laser development in Russia. ICUIL also facilitated it to have an international workshop in Kansai Photon Science Institute, Japan, this May.

2010 ICUIL Conference

26 September–1 October, 2010

Watkins Glen, New York

The 4th biennial ICUIL Conference was hosted by the University of Rochester's Laboratory for Laser Energetics with the ICUIL Secretary, T. Kessler, serving as the General Chairman. The conference was a spectacular success with 150 attendees representing 16 countries including Canada, China, Czech, France, Germany, India, Italy, Japan, Hungary, Korea, Portugal, Rumania, Russia, Sweden, United Kingdom, and United States. The program included 60 oral presentations and 45 poster presentations of very high quality, showing a thriving field of high intensity laser science.

As part of the technical program at the 2010 conference, ICUIL held its first technical workshop on the critical technological area of CPA compressor gratings. Six conference attendees from industry, academia, and government laboratories formed an expert panel to discuss grating design, fabrication, and laser damage testing.

Worshop on High Power Laser Technology for Future Accelerators,

April 8-10, 2010, GSI, Darmstadt, Germany.

The meeting provided a first opportunity to formulate a strategy on the laser technology needed to meet the challenge of future accelerators that will use or rely on lasers with very high average power. Altogether, there were 47 participants from countries around the world, including China (1), France (4), Germany (18), Japan (4), Switzerland (2), the UK (4) and the US (14).

The workshop investigated the beam and laser parameters of a 1–10 TeV e+e− collider, with a luminosity of 10^{36} cm^{-2} s^{-1}, based on two different technologies – laser plasma acceleration and direct laser acceleration. The main challenges to the practical achievement of laser acceleration are high average power (around 100 MW), high repetition rate (kilohertz to megahertz), and high efficiency (around 40–60%) at a cost that ideally would be an order of magnitude lower than using technology based on RF. The workshop also studied the laser requirements for a 200 GeV $\gamma\gamma$ collider, proposed as the first stage of a full-scale ILC or CLIC.

50 Years of the Laser in the City of Light

June 22-23, Paris, Palaiseau, France

50 Years of the Laser in the City of Light has been an exceptional scientific event. Professor Charles H. Townes, inventor of the Laser and Nobel Prize winner, came to Paris to celebrate the 50th anniversary of the first laser demonstration by Theodore Maiman on May 16, 1960. The widowed Mrs. Maiman has also come, along with five other Nobel Prize winners and 13 important figures in the laser domain, to attend two extrordinary days filled with scientific conferences and demonstrations at the Palais du Louvre and the École Polytechnique. The two largest international associations in optics, the Optical Society of America (OSA) and SPIE, were also represented by their President and CEO. 600 participants from 23 countries and 4 continents, scientists, industrials, teachers, students and officials attended the scientific sessions.

On June 23rd, Ecole Polytechnique opened its doors to educational sessions and activities prepared for 700 young high school students from France and abroad. The students met the Nobel Prize winners and were able to ask them questions in a large round table. Additionally, several conferences were open to the general public in the afternoon.

G. Mourou , C. Kao, A. Zewail, C. Townes, C. Cohen-Tannoudji, K. Maiman, H. Kroemer, N. Bloembergen and C. Labaune at the 50 Years of the Laser in the City of Light.

International conference on the Physics in high Intensity Fields (PIF2010)

November 24-26, 2010, KEK, Tsukuba, Japan

The purpose of the confer ence was to gather experts on the strong-field dynamics from various areas of physics and discuss fundamental physics using high-intensity lasers, especially a new direction of the particle and nuclear physics. More than a hundred participants gathered, including those from Austria, Australia, China, England, France, Germany, Israel, Russia, United States, and Japan. The research subjects of the participants extended from laser plasma physics to particle and nuclear physics, astrophysics and even to condensed matter physics.

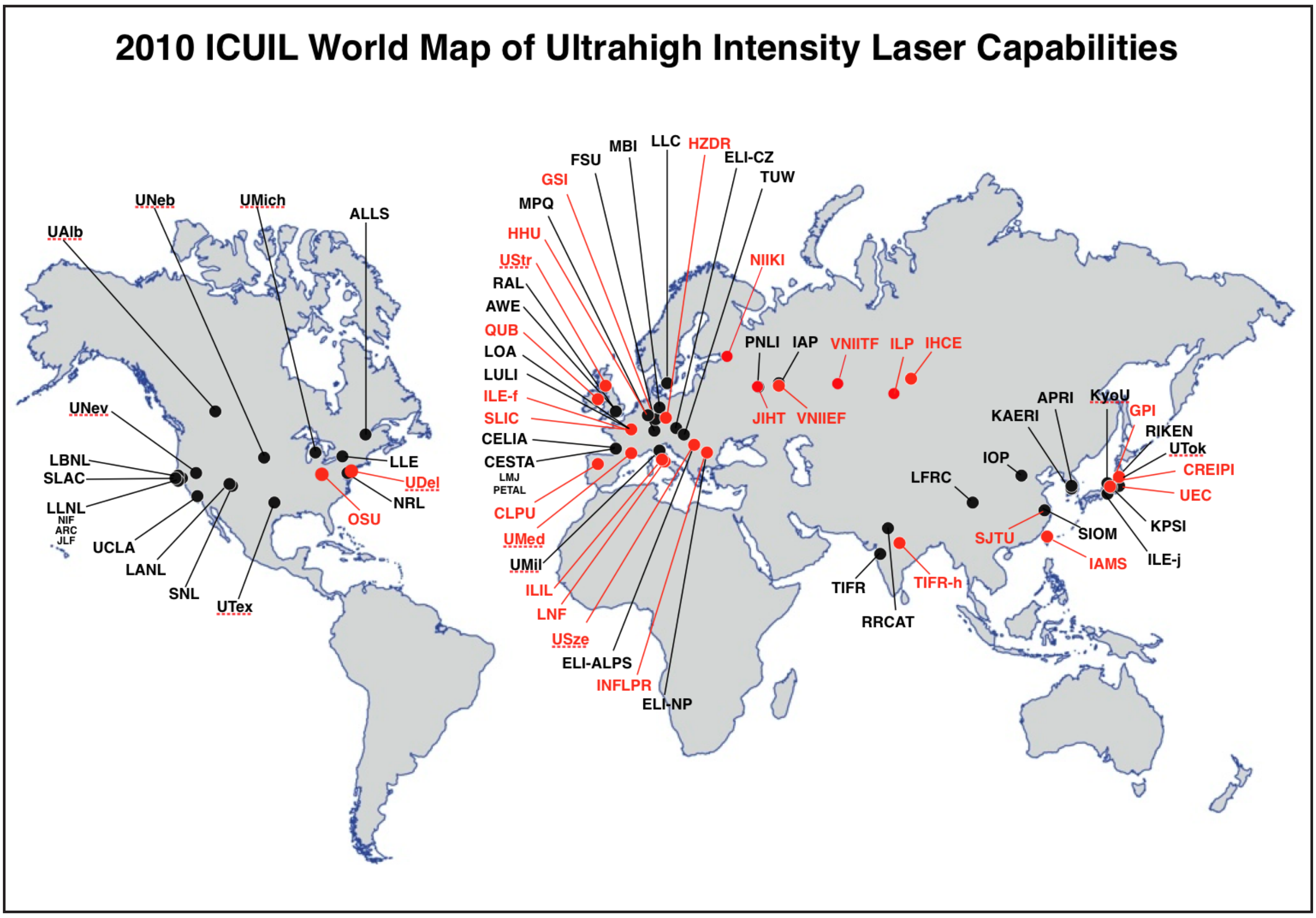
Annual Meeting of the ICUIL Committee

Toshiki Tajima, Chris Barty, Wolfgang Sandner, Terry Kessler, Tsuneyuki Ozaki, Gerard Mourou, Thomas Kuehl, Ravi Kumar, Christine Labaune, Wim Leemans, Heinrich Schwoerer, Alexander Sergeev, Zheng Ming Sheng, Ken-ichi Ueda.

The International Committee on Ultra-High Intensity Lasers (ICUIL) is actively concerned with the growth and vitality of the whole international field of ultra-high intensity laser science, technology and education. The primary goal is to promote unity and coherence in the field by convening conferences dedicated to ultra-high intensity lasers and their applications. The ICUIL Committee is also promoting exchange between scientists and engineers by organizing highly focused technical sessions at the biennial conferences. A summary of the 4th biennial ICUIL Conference and workshop is given in page 6.

The annual General Assembly meeting was held on the last day of the 2010 ICUIL Conference, with a nine member quorum. The agenda for the three-hour meeting consisted of member rotation, website development, the world map, fund raising, and the ICUIL/ICFA joint task force (JTF). Member rotation was carried out to maintain continuity and ensure that ICUIL continues to advance while maintaining balance between the various high field science sections of IUPAP. Three of the seventeen positions in ICUIL were filled by J. Collier, H. Azechi, and B. Rus. A large amount of attention was given to cooperative (JTF) efforts between ICUIL and ICFA, regarding the potential development of lasers for future accelerators. Lastly, in traditional form, the General Assembly voted on the location of the next ICUIL conference. Our destination in 2012 will be Rumania.

2010 ICUIL Conference Attendees



The ICUIL World Map reflects worldwilde activity in the “ultrahigh intensity” lasers and applications. It includes all existing and planned “ultrahigh” intensity facilities. “Ultrahigh” intensity facilities means any laser with focal capability within 3 orders of the published intensity record.

The total peak power of all the CPA systems operating today is ~11.5 PW
- by the end of 2015 planned CPA projects will bring the total to ~127 PWs
- these CPA projects represent ~$4.3B of effort by ~1600 people (no NIF or LMJ)
- these estimates do not include Exawatt scale projects currently being planned.

ELI getting real

"ELI is getting real"! It is under this promising title that more 150 representatives of the scientific community, funding agencies and the industry gathered, on December 10th 2010, to celebrate the successful conclusion of the 3-year preparatory phase of the Extreme-Light-Infrastructure project (ELI), an initiative which aims at endowing Europe with the most intense laser infrastructure worldwide. In a dedicated event hosted by the Czech Embassy in Paris, the three ELI host countries – the Czech Republic, Hungary and Romania – officially took the lead of the project from the ELI Preparatory Phase Consortium thereby announcing the imminent launch of implementation of the first three pillars of ELI.

5 years after the inception of the project by Gérard Mourou, the success of ELI is undeniable. Recognized in 2007 by the European Strategy Forum on Research Infrastructures as one of Europe's priority research infrastructure projects, ELI immediately received a strong support from the European scientific community. More than 40 research and academic institutions from 13 EU member States joined the ELI Preparatory Phase Consortium (ELI-PP) with the aim of bringing the project to the level of scientific, technical, legal, organisational and financial maturity. After three years of collective and countless efforts, and thanks to the €6-million financial support of the European Commission, the hopes placed in the preparatory phase of ELI have largely been fulfilled.

The decision on the location of ELI represented the first major achievement of the Preparatory Phase. On October 1st 2009, in Prague, the Steering Committee of the ELI Preparatory Phase Consortium gave the mandate to the Czech Republic, Hungary and Romania, to jointly implement the project through the construction of three sites with respective mission in the beamline, attosecond and photonuclear applications of ELI, three of the four Grand Challenges identified and described in the scientific case of the project. Nearly €800 million from structural funds have been committed to build, commission and open ELI to users by end 2015, thus contributing to the technological developments necessary for the development of the ultra-high field facility, the ultimate objective of the project. The three sites will be jointly operated under the umbrella of a pan-European consortium.

The ELI White Book, which is about to be issued, will represent the other major achievement of the Preparatory Phase and the most accomplished expression of these 3 years of work. It will provide an overview of the strategic vision underpinning the project, a detailed description of the multidisciplinary applications that the new generation of ultra-short ultra-intense ELI laser systems will enable, as well as a presentation of the conditions of implementation of the three sites.

Jointly chaired by Her Excellency Marie Chatardová, the Ambassador of the Czech Republic to France, and Dr Alain Fuchs, the President of the French National Centre for Scientific Research (CNRS), the "ELI getting real" event was the occasion to highlight and celebrate these exceptional achievements. In an afternoon seminar, key players of the Preparatory Phase reported on the progress accomplished over the past three years by the ELI-PP Consortium. The three plenipotentiaries representing the three ELI host countries presented each of the sites as well as the mission, organization and work plan of the ELI Delivery Consortium, a structure they have established to facilitate the coordination of all European efforts towards the operational phase. Introduced by Nobel Prize Winner Claude Cohen-Tanoudji, Toshiki Tajima, Chairman of the ELI Scientific Advisory Committee, concluded the seminar by giving a lecture with the title "Extreme Light Infrastructure: Icebreaker and Integrator of 21st Century Science". An evening reception held in the salons of the Embassy represented the festive complement to the afternoon conference and an occasion to wish good luck to ELI.

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