ICUIL News

N°10

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COMPRESSION OF AMPLIFIED CHIRPED OPTICAL PULSES ☆

Donna STRICKLAND and Gerard MOUROU

Laboratory for Laser Energetics, University of Rochester, 250 East River Road, Rochester, NY 14623-1299, USA

Received 5 July 1985

We have demonstrated the amplification and subsequent recompression of optical chirped pulses. A system which produces 1.06 μm laser pulses with pulse widths of 2 ps and energies at the millijoule level is presented.

A PASSION FOR EXTREME LIGHT

For the greatest benefit to human kind (Alfred Nobel)

The best is yet to come!

The International Committee on Ultra-High Intensity Lasers

Chairman's Remarks

Chris Barty, ICUIL Chair

As the chairman of the International Committee on Ultrahigh Intensity Lasers (ICUIL), it is my honor to welcome you to the 10th ICUIL newsletter.

It has been a very eventful and exciting year for our community starting with the October 2018 announcement of the selection of Prof. Gerard Mourou, Prof. Donna Strickland and Prof. Arthur Askin as co-recipients of the 2018 Nobel Prize in physics. Professors Mourou and Strickland were cited for their pioneering development of chirped pulse amplification (CPA) which is the cornerstone technology behind nearly every ultrahigh intensity laser system operating today. Prof. Mourou was also a co-founder and the first chairman of ICUIL. Just prior to the Nobel announcement, our community gathered in Lindau, Germany for the biennial International Conference on Ultrahigh Intensity Lasers. The Lindau meeting was the 8th in the ICUIL series and set a record for attendance. Not only was the hotel sold out but there were literally all seats were filled in the conference room. Student participation was strong, particularly from European countries. At the annual meeting, 7 new voting members and 6 non-voting associate members were also elected to be part of the committee. Of the 7 new voting members four were female scientists and one of these was from the African continent. The 2020 ICUIL conference will take place in Jeju, South Korea next September.

Finally, over the past year, a completely new census of worldwide, ultrahigh intensity capabilities has been conducted. This has resulted in a new map of international facilities, a set of historical maps illustrating the rapid evolution of the field and an interactive map that enables users to identify specific laser capabilities of interest around the world.

It is our hope that you find this newsletter to be a convenient snapshot of worldwide ultrahigh intensity laser 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.

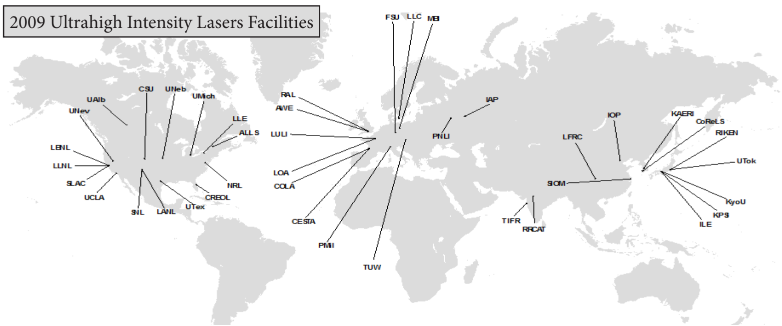
2019 Facility Census and World Maps

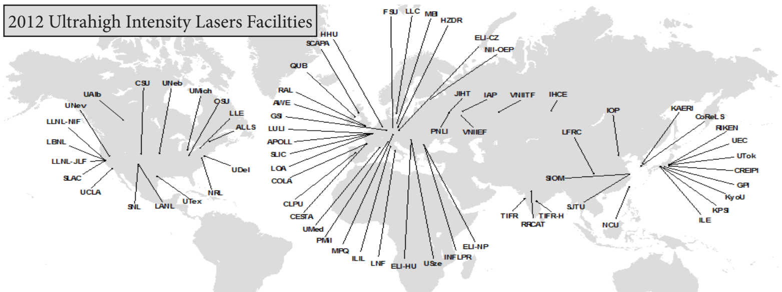
M. W. L. Seggebruch and C. P. J. Barty

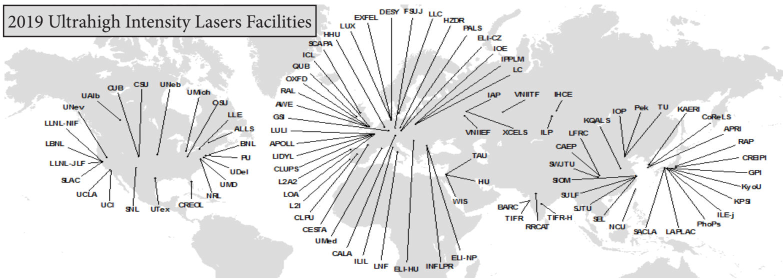
Over the past year, ICUIL has conducted an extensive survey of ultra-high intensity laser systems throughout the world. The result is a database containing relevant details on almost 200 laser systems. This information is made digestible and openly available via an interactive map, found at https://www.easymapmaker.com/map/ICUIL_World_Map_v3. (see below)

Here, you will find many map markers located at the specific GPS coordinates of the laser systems they represent. When clicked, a map marker reveals the peak power, pulse duration, pulse energy, and other performance parameters of the laser system at that location. Also present are non-performance details such as contact information and the status of the laser system (op-

2019 Interactive ICUIL world map







erational, in development, decommissioned, etc.). Links to the laser system's url and travel information are also available. (Note that when multiple laser systems are at the same GPS coordinates, they share a map marker, and their marker descriptions are stacked on top of each other.) Filter options are found at the top of the map. Users can use filters to select for specific performance parameters, as well as countries, continents, system status, and how up to date a laser's information is. Multiple filters can be selected at once.

ICUIL intends for the interactive map to remain relevant and up to date for years to come. If you know of an ultrahigh intensity laser system that is not on the map, please email icuil.world.map@gmail.com with information about the laser. Lasers that are achieving, or trying to achieve, 10^{19} W/cm^2 focused intensity, or that produce >10 TW of peak power, are eligible for the map.

From the new data collected, three historical maps of capabilities spanning the past decade have also been created and are downloadable from the ICUIL website. These maps shown below illustrate the dramatic and rapid growth of ultrahigh intensity laser capabilities worldwide.

2019 ICUIL Membership

Officers:

Christopher P.J. Barty,	*University of California, Irvine, USA*	Chairman
Alexander Sergeev,	*Russian Academy of Sciences*	Co-Chairman
G. Ravindra Kumar,	*Tata Institute of Fundamental Research, India*	Co-Chairman
Terry Kessler,	*University of Rochester, USA*	Secretary
Dino Jaroszynski,	*University of Strathclyde, UK*	Treasurer
Gerard Mourou,	*ÉcolePolytechnique, France*	Advisor

Members:

Toshiki Tajima, *University of California, Irvine, USA*
Tsuneyuki Ozaki, *INRS-ÉMT, Canada*
Bedrich Rus, *Institute of Physics PALS, Czech Republic*
Chang Hee Nam, *Gwangju Institute of Science and Technology, Korea*
Claes-Goran Wahlstrom, *Lund University, Sweden*
Hiroshi Azechi, *Institute of Laser Engineering, Osaka University, Japan*
Heinrich Hora, *University of New South Wales, Australia*
John Collier, *Central Laser Facility STFC Rutherford Appleton Laboratory, UK*
Ken-ichi Ueda, *Institute for Laser Science, University of Electro Communications, Japan*
Nilson Da Vieras Jr., *Instituto de Pesquisas Energéticas e Nucleares, Brazil*
Ruxin Li, *Shanghai Institute of Optics and Fine Mechanics, China*
Ryosuke Kodama, *Osaka University, Japan*
Sandro De Silvestri, *Politecnico Milano, Italy*
Thomas Kuehl, *GSI Helmholtzzentrum, Germany*
Wim Leemans, *Lawrence Berkeley National Laboratory, USA*
Jonathan Zuegel, *University of Rochester, USA*
M. Krishmamurthy, *Tata Institute of Fundamental Research, India*
Efim Khazanov, *Institute of Applied Physics RAS, Russia*
Constantin L. *Haefner, Lawrence Livermore National Laboratory, USA*
Kazuo Tanaka, *ELI-NP, Romania*
Zsuzsanna Major, *GSI Helmholtzzentrum, Germany*
Catherine Le Blanc, *CNRS-École Polytechnique, France*
Georg Korn, *ELI Beamlines, Czech Republic*
Tetsuya Kawachi, *Kansai Photon Science Institute, Japan*
Lotfia Mohamed El Nadi, *Cairo University, Egypt*
Alexandre Bonatto, *Federal University of Health Sciences, Brazil*
Felicie Albert, *Lawrence Livermore National Laboratory, USA*

ICUILERS’ Awards 2018–2019

Nobel Prize

Year 2018 was especially remarkable for the ICUIL community, as one of its members, the honorable Gérard Mourou was awarded the Nobel Prize. The Nobel prize is regarded to be the most prestigious award. It was funded by Alfred Nobel, the Swedish chemist, engineer and industrialist in 1895. According to his will a special foundation would reward those who serve humanity. Alfred Nobel left his fortune to finance annual prizes in Chemistry, Literature, Peace, Physics, and Physiology or Medicine to be awarded “to those who, during the preceding year, shall have conferred the greatest benefit on mankind”. The prizes were first awarded in 1901.

Between 1901 and 2018, the Nobel Prizes (and the Prizes in Economic Sciences from 1969 on) were awarded 590 times to 935 people and organizations.

The Nobel Prize in Physics has been awarded 112 times to 210 Nobel Laureates, Wilhelm Röntgen being the first to receive the Physics Prize for his discovery of X-rays.

The Nobel Prize in Physics 2018 *“for groundbreaking inventions in the field of laser physics”* was awarded to:

Arthur Ashkin, Bell Laboratories, Holmdel, USA *“for the optical tweezers and their application to biological systems”* and jointly to

Gérard Mourou, École Polytechnique, Palaiseau, France, University of Michigan, Ann Arbor, USA and

Donna Strickland, University of Waterloo, Canada *“for their method of generating high-intensity, ultrashort optical pulses”*

Their inventions have revolutionised laser physics. Arthur Ashkin invented optical tweezers that grab particles, atoms, viruses and other living cells with their laser beam fingers. Donna Strickland and Gérard Mourou invented a technique called chirped pulse amplification, that is currently known worldwide and has become a standard for high-intensity lasers. They really invented “tools made of light”.

In the morning of the Nobel Ceremony. Gerard was to be dressed in the formal attire approved by the Nobel Committee. Toshiki Tajima was Gerard’s “suit dresser”

On the way to the prize and glory

Gerard Mourou with Princess Sofia heading for the Nobel Prize banquet

The Nobel banquet, Gerard with Queen Silvia of Sweden

At the Nobel lecture

Other ICUILERS' awards for the covered period are:

2018 R. W. Wood Prize

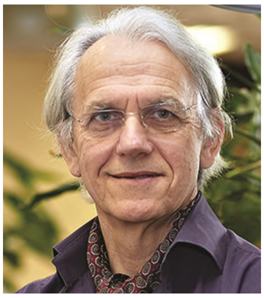
"For the pioneering contributions to ultrahigh intensity laser science".

Christopher Barty
University of California, Irvine, USA

The R. W. Wood Prize of the Optical Society of America recognizes an outstanding discovery, scientific or technical achievement, or invention in the field of optics. The accomplishment for which the prize is given is measured chiefly by its impact on the field of optics generally, and therefore the contribution is one that opens a new era of research or significantly expands an established one. The award was established in 1975 to honor the many contributions that R.W. Wood made to optics. It is endowed by the Xerox Corporation.

Arthur L. Schawlow Prize in Laser Science

"For fundamental contributions in ultrafast, ultrahigh-field laser inventions, such as chirped pulse amplification, that led to the new discipline of relativistic optics."

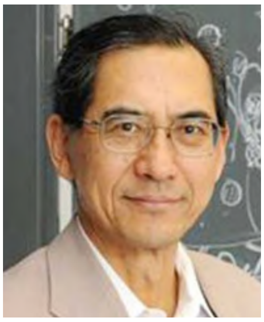


Gérard Mourou
École Polytechnique
Palaiseau, France

The Arthur Schawlow Prize of the American Physical Society endowed by the NEC Corporation in 1991 recognizes outstanding contributions to basic research which uses lasers to advance our knowledge of the fundamental physical properties of materials and their interaction with light. Some examples of relevant areas of research are: nonlinear optics, ultrafast phenomena, laser spectroscopy, squeezed states, quantum optics, multiphoton physics, laser cooling and trapping, physics of lasers, particle acceleration by lasers, and short wavelength lasers. The prize consists of $10,000 plus an allowance for travel to the meeting at which the prize is awarded and a certificate citing the contributions made by the recipient. The prize is awarded annually.

T. Tajima was awarded three prizes in 2018–2019.

AAPPS Subramanyan Chandrasekhar Prize of Plasma Physics



Toshiki Tajima
University of California at Irvine, USA

"For wide-ranging contributions to plasma physics, in particular for the discovery and invention of extremely intense (relativistic) laser-driven wakefields as robust and long-lasting plasma states, with broad impacts on high energy particle acceleration and other applications, including medicine; in which he exerted leadership to launch high field science and to form large new research communities"

The Association of Asia Pacific Physical Societies selected Professor Toshiki Tajima as the 2018 Laureate of S. Chandrasekhar Prize of Plasma Physics, which is awarded to scientists who have made seminal/pioneering contributions in the field of plasma physics. The S. Chandrasekhar Prize is an internationally authoritative annual prize awarded to an outstanding scientist(s) in the field of plasma physics as a basis for astrophysics or fusion research, and plasma applications.

2019 Robert R. Wilson Prize for Achievement in the Physics of Particle Accelerators

"For the invention and leading the first realization of laser wakefield acceleration, which opened the way to compact acceleration applications such as ultrafast radiolysis, brilliant x-rays, intra-operative radiation therapy, wakefield beam dump, and high energy cosmic acceleration."

Robert R. Wilson Prize was established in 1986 by friends of Robert R. Wilson, the Division of Particles and Fields, and the Division of Physics of Beams to recognize and encourage outstanding achievements in the physics of particle accelerators. Serving a diverse and inclusive community of physicists worldwide is a primary goal for APS. Nominations are open to scientists of all nations regardless of the geographical site at which the work was done. The prize shall ordinarily be awarded to one person but may be shared when all recipients have contributed to the same accomplishment. The prize is presented annually and is comprised of $10,000, an allowance for travel to the meeting at which the prize is awarded and a certificate citing the contributions made by the recipient.

EPS Hannes Alfvén Prize 2019

The EPS Hannes Alfvén Prize 2019 for outstanding contributions to plasma physics was jointly awarded to:

- Professor **Victor Malka**, of the Laboratoire d'Optique Appliquée of the CNRS/ENSTA-ParisTech/ Ecole Polytechnique, France, and the Weizmann Institute of Science, Israel *for "His major contributions to the development of compact laser-plasma accelerators, and to their innovative applications to science and society, which span ultra-fast phenomena, accelerator physics, medicine, radiobiology, chemistry and material science."* and

- Professor **Toshiki Tajima**, of the Department of Physics and Astronomy, University of California, Irvine, U.S.A. *for "His seminal, broad, and novel contributions to plasma physics and plasma-based accelerator physics, including the concept of laser wakefield acceleration."*

The European Physical Society Plasma Physics Division Hannes Alfvén Prize *for outstanding contributions to plasma physics* was established by the EPS Plasma Physics Division in 2000 and is awarded for research achievements which have either already shaped the field of plasma physics or have demonstrated the potential to do so in future. To recognize collaborative research, a group of up to three individual scientists may be nominated. The prize is awarded each year at the EPS Conference on Plasma Physics.

We cordially congratulate our colleagues with the outstanding results and the well-deserved awards.

ELI News

Events

The ELI-ALPS laser research facility held a ceremonial event with Nobel Prize winning physicist and founder of ELI, Gerard Mourou, to inaugurate the SYLOS 2A laser system, designed by the Lithuanian companies EKSPLA and Light Conversion, in collaboration with ELI-ALPS. The laser will provide research opportunities emitting pulses with durations of <10 femtoseconds at 1 kHz repetition frequency and drive four beamlines including two gas-based and one solid surface based plasma generation stations for coherent soft x-ray sources and associated detection stages. An additional source for high peak intensity electron pulses is also part of the portfolio. Beyond fundamental research, this laser system will be utilized in a project aiming the reduction of the radioactive radiation of used nuclear fuel by a laser-related transmutation method, based on the idea and with the cooperation of Mourou and colleagues.

The **ELI Summer School** took place in ELI-Beamlines 2019 in Dolní Břežany in the Czech Republic from 26.-30-8.2019. Over 50 participants from many countries attended 20 seminars and hands-on activities. The hands on activities, new part of ELISS programme, became the most popular part of the programme. A part of the programme was a poster session and we announced also the winner of Wolfgang Sandner Poster Prize. The winners, Diana Gorlova and Ivan Tsymbalov, are from Lomonosov University, Moscow, Russia. The Summer School 2020 will be organized by ELI ALPS colleagues in Szeged, Hungary.

In September, the Czech and Hungarian Ministries for Innovation and Research have agreed on their readiness to submit a joint request to the European Commission by the end of September 2019, together with Italy, to form the ELI European Research Infrastructure Consortium (ERIC). The organization will be set up by the end of 2019. Germany, the UK and France are also expected to join the consortium as founding members and thus take over the operation and financing of ELI ERIC, with the possibility that Romania will join with a third ELI facility at a later date.

The **7th International Conference on Attosecond Science and Technology (ATTO2019)** took place in Szeged, Hungary earlier this summer from July 1-5 2019, hosted by ELI-ALPS Research Institute. ATTO2019 was attended by more than 300 scientists and coverered all aspects of attosecond science and technologies from sources and metrology to applications. The main research topics included attosecond pulse generation and characterization, high-order harmonic generation and applications as well as ultrafast phenomena on the attosecond and femtosecond timescales.

The **3rd International Conference on Extreme Light 2019 (ICEL 2019)** combining the scientific conference with a subsequent prospective ELI user meeting will be hosted by ELI-Beamlines from 21-25 October. Topics include new concepts for high-peak-power and high-average-power generation, laser-driven secondary sources of soft and hard x-rays and their applications in different areas such as bio-medical and materials science, attosecond pulse generation and new societal applications of laser-driven secondary sources (medical imaging and therapy, transmutation, fuel cycles, etc.) among other topics.

Also, later this year is the **ELI-ALPS is 7th User Workshop** November 7 and 8, 2019, in Szeged, Hungary. As an international user facility, and is forming an international user community incorporating users from a broad spectrum of disciplines, research areas and technological/industrial application. The program includes talks on finalized experiments, of ongoing and scheduled campaigns, future commissioning experiments of beam-line and end-station developers. In addition to the new user programme plans, Hungarian national research projects at ELI-ALPS as well as users related news from ELI-BL are planned to be part of the program. Talks are by invitation but a restricted number of user experiment talks from colleagues interested in becoming ELI-ALPS users are welcome.

Research

BIO-LAB @ELI-BL. In the basement of ELI-Beamlines, only meters away from the experimental halls, a state-of-the-art biological laboratory is currently being established. The ELIBIO project, led by professor Janos Hajdu, is a six year joint research project of ELI Beamlines and the Institute of Biotechnology (IBT) of the BIOCEV Centre nearby, and was funded in 2016 by the Czech Ministry of Education, Youth and Sports. The aim of the project is to develop a Centre of Research Excellence for life sciences to explore new frontiers in light and optics to create breakthrough science in biology, chemistry, and physics.

‘Essentially, the BIO-LAB at ELI Beamlines is built as a part of the ELIBIO project,’ says Rachael Jack, who will be in charge of the day-to-day running of the lab. ‘What makes this lab so different from most university labs, is that it combines so many stations and its proximity to the high power lasers of ELI-Beamlines. This enables researchers to investigate a sample with a multitude of experimental methods to gain as much information about them as possible before using valuable beamtime.’

The BIO-LAB will have wet room, a cold room, two biohazard labs, a crystallization room, two microscopy rooms that will eventually house both optical and electron microscopes, and a large laser spectroscopy room where two laser beams from the femtosecond sources are generated to perform spectroscopy measurements with super resolution.

Technology

Finding the Perfect Mirrors @ELI-ALPS. The ultrafast laser systems at ELI-ALPS supply high average power beams at high repetition rates with a large spectral bandwidth, short pulse duration and exceptional phase stability. In case of the laser systems of ELI-ALPS, such as the HR1 and SYLOS lasers, the huge bandwidth and the need for precise spectral phase control can be rather challenging, explains Roland Nagymihály, Research Fellow at ELI-ALPS's High Field Laser Group.

If a mirror heats up, thermal expansion will cause it to become a curved reflective surface. 'During alignment, you would typically use lower powers,' says Nagymihály. 'However, when the mirrors change shape as a result of heating when you turn up the power, the beam experiences a drift away from its original position and it can start to diverge, ruining the alignment, and finally the experiment, as well,'

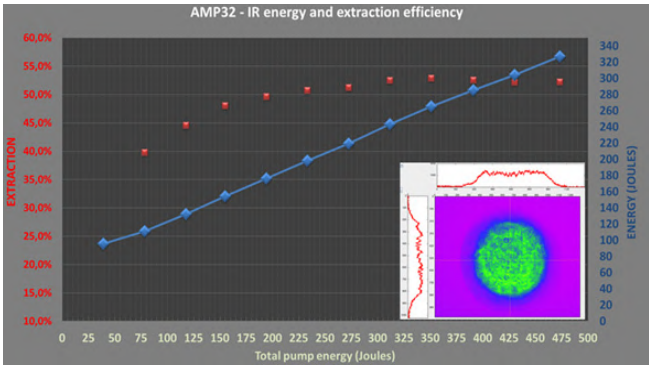
Over the past couple of months, ELI-ALPS researchers have investigated the behaviour of three different types of mirrors and it is clear that hybrid mirrors will probably be the most suitable candidates for the beam delivery of the HR1 laser system. However, the mirrors that are currently available still suffer from thermal effects. Now ELI-ALPS is cooperating with HiLASE from Prague, Czech Republic, to investigate water cooled mounting systems. The main challenge for the system has to do with the bandwidth.

'We have asked our collaborators in the Czech Republic to bond hybrid mirrors to a water cooled mount of their design,' says Nagymihály. 'With this setup, I expect that we will end up with a coating that has the highest performance in terms of dispersion flatness and reflection bandwidth, which will be combined with a robust mounting design and will be cooled by water.''

The Extreme Light Infrastructure for Nuclear Physics (ELI-NP) project in Romania has recently reached a significant milestone: the ultra-high intensity laser system developed by Thales has successfully generated its first pulses at a peak power level of 10 petawatts (10^{15} W).

After an initial development and production phase and preliminary verification of subsystem performance in France, Thales began delivery and installation of the world's most powerful laser system at the Măgurele facility near Bucharest in late 2016. This system is designed to generate twin laser beams of 10 PW each and will be the core instrument of a unique new advanced technology and fundamental research facility in nuclear physics. The Thales system is now fully integrated and was tested step by step. The Thales team of French and Romanian engineers has been working on finalizing and scaling up the system. After demonstration of a beam delivering pulses of 3PW then 7 PW for more than 4 hours continuously, the Thales system generated its first pulses with a record power level of 10 PW on 7 March 2019. Thales has thus achieved an unprecedented level of performance, which means that the Romanian National Institute of Physics and Nuclear Engineering (IFIN-HH) and ELI-NP now have the most powerful laser in the world.

HPLS laser system installed in a dedicated 2400m² clean room at ELI NP, Romania



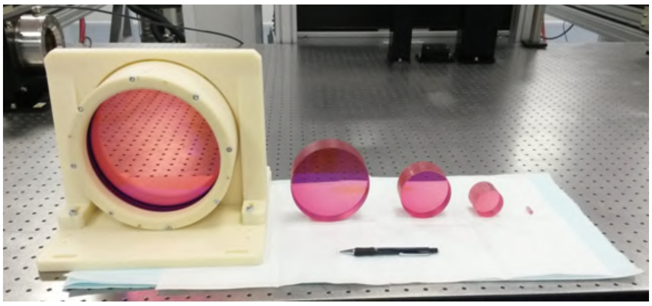
Energy recorded after the last amplifier

The High Power Laser System (HPLS) is made of two beamlines which deliver each a main beam of 10 PW peak power at 1 shot per minute, with possible intermediate outputs at 100TW, 10Hz and 1PW, 1Hz.

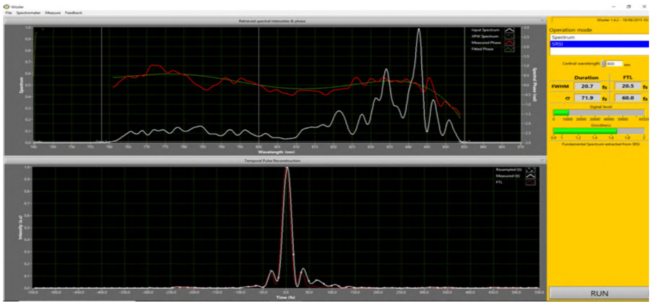
The 10 PW beamline is based on an hybrid scheme involving a first TiSa based kHz CPA of mJ level, a XPW filter for temporal contrast enhancement, an optically synchronized 532 nm-pumped OPCPA stage delivering 10 mJ at 10 Hz capable to enlarge the bandwidth and enhance the temporal contrast and a second TiSa based CPA built with three amplification stages (each level of energy corresponding to one peak power value 100TW, 1PW or 10PW). The design has been supported by a technology transfer from CNRS Apollon project leading to a fruitful collaboration between Thales engineers and Scientists of the French Institution.

The system is delivered with two Front End including kHz CPA, XPW filter and OPCPA stage. In operation one will be used to seed the two beamlines with 5mJ for each arm, the second one being a backup system.

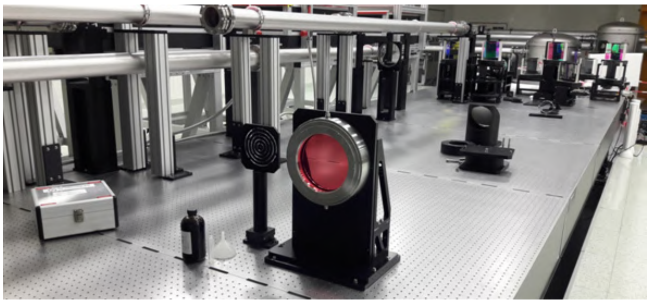
All pumping lasers of high energy TiSa amplifiers are nanosecond laser products manufactured by Thales, SAGA HP for 100 TW amplifiers, GAIA HP for 1 PW amplifiers, ATLAS 100 for 10 PW amplifiers. ATLAS 100 was developed to achieve the 10 PW performances and each of 16 units installed at ELI NP delivers at 527 nm energy per pulse of 100 J at 1 shot/min.



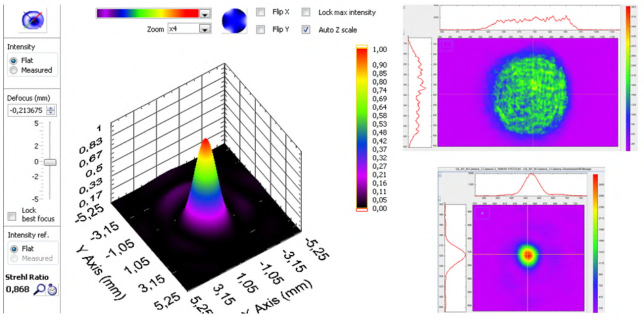
Ti:Sa crystals used in the Thales system, from 6mm up to 200mm in diameter



Pulse duration with Wizzler device



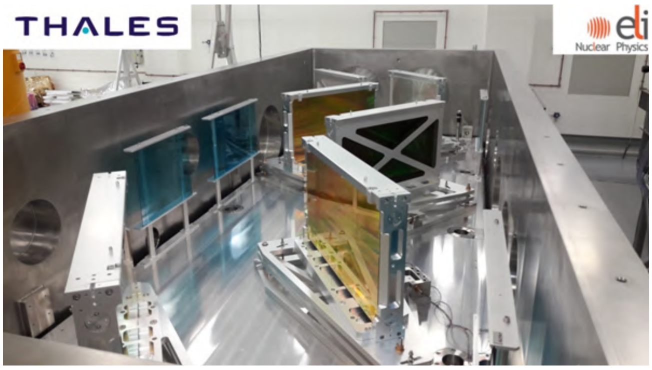
200mm Ti:Sa crystal during installation at ELI NP, Romania



Beam parameters recorded on the diagnostic bench after the compressor by using the full beam aperture (clockwise: Strehl ratio, near field beam profile on last grating, far field beam profile)

A critical aspect for the overall laser performance is the management of transverse lasing effects and Amplified Spontaneous Emission (ASE). This is primarily achieved by using an optimized proprietary design for the crystal mechanical mount of final amplifiers allowing index refraction matching and fluorescence absorption in the medium surrounding the Titanium Sapphire crystal and taking into account the heat load in the crystal associated to the repetition rate. In addition Thales uses a patented energy deposition strategy for high energy laser in the last amplifier.

Another aspect is the management of the spectral bandwidth through the amplifier. The gain narrowing and wavelength red-shifting effects in TiSa amplifiers is compensated through properly designed spectral filter mirrors in order to maintain the spectral bandwidth, necessary to achieve the shortest pulse duration after the compressor.



10PW compressor integrated with four metric size gold coated gratings

The two beams have been entirely built within ELI NP premises, Magurele, Romania. The seed of the last amplification stage (AMP 3) comes from 1PW level amplifier capable to deliver energy of 36J. By seeding AMP3 with 20J, the Energy per pulse of more than 300J has been demonstrated from a 3 pass amplifier using a 130 mm in diameter Titanium Sapphire crystal and pumped by 2 ATLAS 100 lasers and from a 3 pass amplifier using a 200 mm in diameter Titanium Sapphire crystal and pumped by 6 ATLAS 100 lasers. The output energy of ATLAS100 laser was tuned below 80 J each for the last amplifier.

The short term energy stability at 800 nm has been measured as low as 1.4% rms over 100 shots. No sign of ASE & parasitic lasing have been observed. A uniform beam profile has been obtained following the profile of the ATLAS 100 pumps. A spectral width FWHM of 70 nm has been measured after amplification.

The unique quality Titanium Sapphire crystals were manufactured by GTAT, Advanced Sapphire Material group led by Kurt Schmidt (Salem, USA).

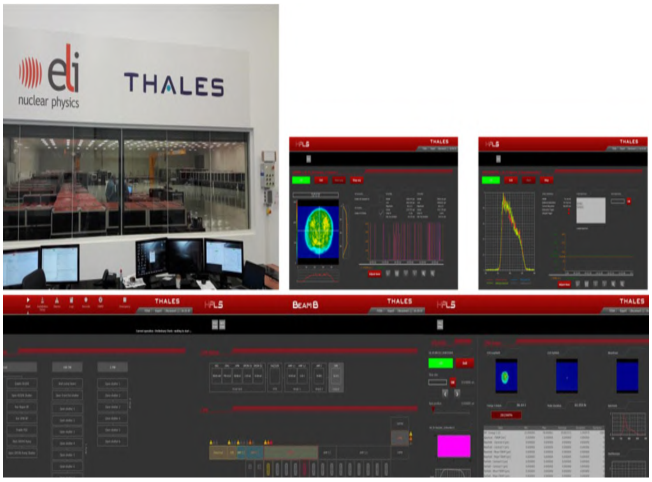
The laser was run at full energy and the beam was attenuated before the compressor in order to compress the pulse duration and to characterize the beam parameters over the full aperture after compressor with a dedicated diagnostic bench.

The 10PW compressor was entirely built with four meter size gold coated optical gratings provided by Horiba France in order to compress the pulse coming from AMP3 and to confirm the shortest pulse duration.

The pulse duration was measured at 20.7fs by using a Wizzler. The beam quality was also confirmed at the focus spot with a Strehl ratio superior to 0.8 after compensating the wavefront error with a deformable mirror provided by Imagine Optic and installed before the compressor. The beam pointing stability was checked better than 1.2 µrad rms over 100 shots.

Thales has developed a dedicated stations based on Tango-Panorama devices to enable the users to operate the laser system from a control room outside of the clean room.

Therefore Thales has developed and delivered to ELI NP a unique worldwide laser system which delivers two beams of 10PW. Thales is currently involved in the installation of the 10PW beam transport towards the experimental areas which are under preparation by the ELI NP team overseen by the Horia Hulubei National Institute of Physics and Nuclear Engineering (IFIN-HH).



LaserNet US: a New Network of High Power Laser Facilities

LaserNet US is a newly created network of high power laser facilities funded by the US Department of Energy. Its mission is to provide access to high power lasers to US and international users who do not have regular access to such facilities. The creation of LaserNet US by the Department of Energy is a response to the 2018 National Academies report “Opportunities in intense ultrafast lasers: reaching for the brightest light”. It is intended for supporting innovation and the best science, and supporting an active and healthy community in high intensity and high energy density science, as well as growing the community of scientists in other areas of science and technology that can benefit from applications of high intensity lasers. At present the network groups five universities and four national laboratories: Colorado State University, the University of Michigan, the University of Nebraska, Ohio State University, the University of Texas, Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, SLAC, and the Laboratory for Laser Energetics at the University of Rochester.

LaserNet US has developed an open and transparent peer review process for awarding user beam time. The proposal review panel (PRP) is independent of the facilities personnel and is made of national and international experts in the field. The PRP selects the proposals based on scientific merit. The first call for proposals was launched in February 2019, and the first experiments are being performed in 2019. The second call for proposals was made in August 2019 for experiments to be conducted during 2020.

Five-fold Compression of 250 TW Laser Pulses

Vladislav Ginzburg[1], *Ivan Yakovlev*[1], *Alexandr Zuev*[1], *Anastasia Korobeynikova*[1],
Anton Kochetkov[1], *Alexey Kuzmin*[1], *Sergey Mironov*[1], *Andrey Shaykin*[1], *Ilya Shaikin*[1], *Efim Khazanov*[1],
and Gerard Mourou2

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Abstract

The pulse spectrum at the laser output was broadened due to self-phase modulation in fused silica and then the pulse was compressed by chirped mirrors. It was demonstrated that with an optimal choice of mirror dispersion, a pulse with an energy of 17 J can be compressed from 70 fs to 14 fs. This Compression after Compressor Approach (CafCA) has undoubted merits: simplicity, low cost, negligible pulse energy losses, and applicability to any high-power laser.

Introduction

In just a few years of their existence, lasers reached an intensity of 10^{14} W/cm^2. However, the next 20 years, the intensity practically did not grow. The reason for this plateau was that the laser amplifiers reached their limits stipulated by the optical breakdown threshold of laser media. In 1985 [1] Chirped Pulse Amplification (CPA) was proposed. Now almost all high-power lasers comprise CPA: stretcher on diffraction gratings with positive dispersion, amplifier, and compressor on diffraction gratings with negative dispersion, Fig. 1(a). For CPA, it is fundamentally important that, when a pulse is compressed, its energy does not increase, i.e. compression can be done without pulse propagation in the medium, using only reflective optical elements – diffraction gratings. The discovery of CPA led to a dramatic laser power enhancement; by the beginning of the 2000s, the record intensity reached 10^{22} W/cm^2 [2]. After that, however, the intensity almost did not grow – there appeared a second plateau. The reason for this was that in the early 2000s the power (and intensity) increased so much that it was no longer limited by the fact that the laser pulse could not be further amplified, but that it could not be compressed. Diffraction gratings damage threshold limits the intensity at the laser output. Thus, the compressor is now the weakest link in the stretcher-amplifier-compressor chain.

What next? The enhancement of laser power and intensity is possible in two ways. Firstly, it is the creation of a mosaic compressor or of phase-locked parallel CPA channels, each having its own compressor at the output. This pathway has a number of significant drawbacks: technical and technological difficulties, the need for a multiple pulse energy increase, as well as the size and price of the laser. We prefer the second, much simpler and cheaper way: an increase in power not due to an increase in energy, but due to a decrease in pulse duration [3, 4]. We call this method the Compression after Compressor Approach (CafCA) [5]. The idea is as follows, see Fig. 1(b).

The pulse duration at the CPA output is usually a little more than the Fourier limit, so for substantial shortening, it is necessary to increase the width of the spectrum, i.e. stretch the pulse spectrum rather than its duration as in CPA. The simplest and most suitable way is to use self-phase modulation (SPM) in a Kerr-nonlinear medium, the refractive index of which, n, depends on pulse intensity I: $n = n_0 + n_2 I$, where n_0 is the linear index of refraction, and n_2 is the nonlinear index of refraction. At the output of the medium, the pulse is positively chirped. Chirped mirrors induce the negative chirp of the same absolute value, just like the compressor does in CPA, see Fig. 1. As a result, the pulse is shortened and the laser power is increased. As shown

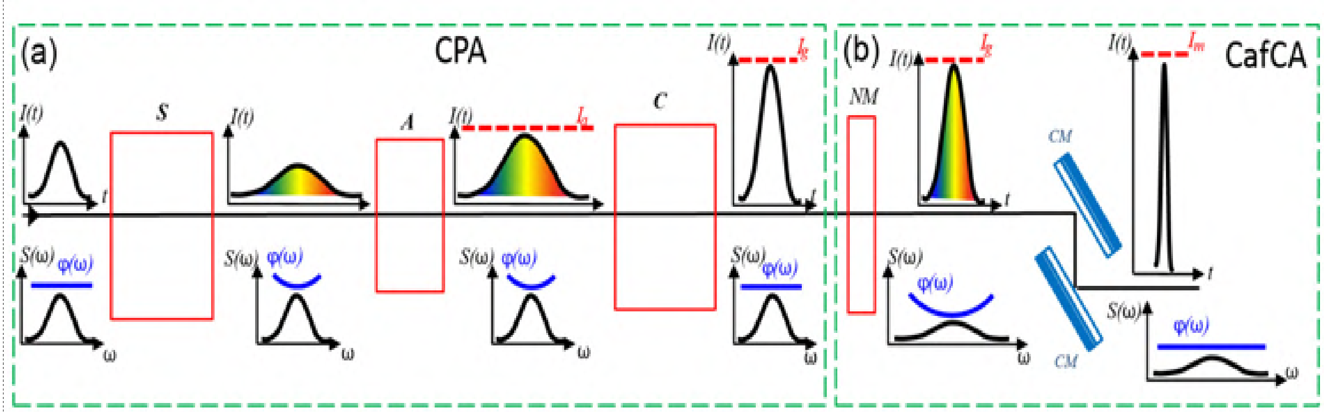

Fig. 1. The idea of CPA (a) and CafCA (b). S – stretcher, A – laser amplifier, C – compressor, NM – nonlinear medium, CM – chirp mirror; Ia , Ig and Im – breakdown threshold of the amplifiers, diffraction gratings and chirping mirrors

in [6], the intensity increase factor $F_i = I_{out}/I_{in}$ at small linear dispersion may be estimated as

$$F_i = 1 + B/2, \qquad (1)$$

where $B = kLn_2I$ is called a break-up integral or the B-integral, $k = 2\pi/\lambda$, L is the length of the nonlinear medium, and λ is the central wavelength in vacuum.

The idea to use SPM for pulse compression was put forth in 1969 in [7], and the same year several-fold compression of a 20 ps pulse in a CS_2-filled cuvette was demonstrated in [8]. Later the SPM was implemented in the femtosecond range in a fiber [9], in gas filled hollow waveguides [10] and in solid-state with restricted propagation [11]. However, in all further experiments (see the detailed review [12]) the pulse power was below 30 GW as the beam diameter was less than 1 mm. Evidently, power scaling is possible only with free propagation in a bulk nonlinear medium.

Overcoming CafCA limitations for TW and PW pulses

There are three problems that impede the implementation of CafCA for a laser beam propagating in free space.

The first group of problems is associated with nonuniform intensity distribution of the beam: self-focusing of the beam as a whole, phase aberrations, and, most importantly, nonuniform temporal pulse compression across the beam. Using a negative lens as a nonlinear medium for solution of these problems was proposed in [4] and then implemented experimentally in [13, 14], which immediately brought the CafCA from the multi-GW to the TW range.

Another problem is appearance of small-scale self-focusing (SSSF) induced by the Bespalov-Talanov instability [15]. The instability increment is determined by the B-integral. Usually, at $B = 3$ the beam breaks up into multiple filaments. At the same time, as seen from (1), at $B < 3$ only a 2.5-fold power enhancement is possible. Thus, a significant increase in power using CafCA seems impracticable at first sight: one and the same effect (cubic nonlinearity) and, moreover, the same parameter (B-integral) are both, useful and parasitic. Consequently, until recently it was believed that CafCA is possible only in a narrow $2 < B < 3$ range [3, 16–19]. The solution proposed in [20] is based on a fundamental feature of SSSF in ultra-high-power (intensity after compressor about 1 TW/cm^2) lasers: a very large (tens of mrad) value of the angle θ_{max} – angle of propagation of spatial noise with the largest instability increment. Such large values of θ_{max} allow using self-filtering of the beam freely propagating in vacuum for SSSF suppression. The most dangerous noise components (θ on the order of θ_{max}) come out of the beam aperture. In [5, 21, 22] it was demonstrated that self-filtering mitigates the once inviolable limitation $B < 3$.

The third problem is technological – a very large aspect ratio of the nonlinear medium, which is especially acute for petawatt powers. It is caused by the need of higher peak power of laser pulse, larger beam diameter and thinner nonlinear medium. The idea of using polymer materials [23] promoted the solution of this problem significantly. The linear and nonlinear optical properties of polymer materials are currently actively investigated and the results are highly promising. In particular, a 2.6-fold compression of a pulse with a power of 100 TW was obtained with the use of polyethylene terephthalate [24].

Over the last years several successful experiments with CafCA were performed with pulse power from 1–200 TW [5, 6, 24–26] with up to three fold compression factor. The next step – 5-fold pulse compression – was demonstrated in experiments at $B = 7.5$.

Experimental results

The schematic diagram of the experiment is presented in Fig. 2. The beam of the laser PEARL (central wavelength 910 nm, pulse duration 65–75 fs, pulse energy up to 17 J, diameter 18 cm) was reflected at the final diffraction grating of the compressor and propagated 2.5 meters in free space for self-filtering. After that the beam successively passed through three 1 mm thick fused silica plates spaced apart by about 1 cm. The use of three plates instead of a single 3 mm plate allows decreasing the SSSF [12]. Further, after free propagation over a distance of 4 meters the beam arrived at the system of chirping mirrors (CM). Each mirror (UltraFast

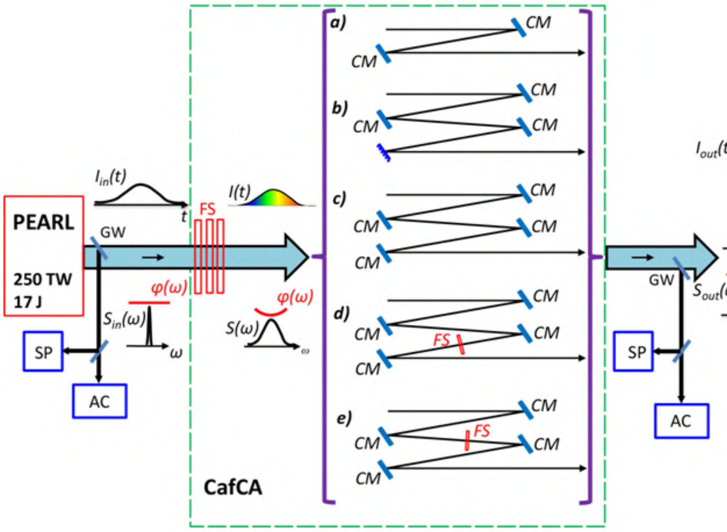

Fig. 2. Schematic diagram of the experiment. FS – fused silica plates, CM – chirped mirrors, GW – small-aperture glass wedges, AC – autocorrelators, SP – spectrometers

Innovations GmbH) had dispersion $\alpha_1 = -100$ fs^2 and reflectivity 99.5% in 810–1010 nm bandwidth. Five variants of CafCA were investigated: three single-stage versions with 2, 3 and 4 mirrors, and two two-stage [23] versions with 3+1 and 2+2 mirrors, as shown in Figs. 2(a)–2(e), respectively. In all variants the first two CMs were 20 cm in diameter and the other CMs were 5 cm in diameter. So in the last four variants only the central part of the beam with 5 cm diameter was compressed.

For measuring the parameters of the input and output pulses, two glass wedges with an aperture of 1×2 cm and mat back surface were placed on the beam path: one at the PEARL output, and the other at the CafCA output. On reflection from the wedges the beams were directed to two spectrometers and two autocorrelators. The beam from the laser PEARL had a rather homogeneous cross-section; therefore without fused silica plates the spectra and durations of the input and output pulses coincided to an accuracy up to 10%. For pulses having a duration of 65–75 fs, the dispersion introduced by the chirping mirrors did not appreciably increase the duration. Thus, the radiation characteristics were measured in one “shot”.

The dependence of the compression factor F_{ACF} – the ratio of the FWHM duration of intensity autocorrelation functions (ACF) of the pulse at the CafCA input and output – on the B-integral was measured for all five CafCA variants shown in Fig. 2. The results of the measurements for a single-stage CafCA [Figs. 2(a)-2(c)] and two-stage CafCA [Figs. 2(d) and 2(e)] are presented in Fig. 3. As is seen from Fig. 3, the dispersion of two chirping mirrors is insufficient. For moderate values of the B-integral ($B < 6$), the variant with four mirrors is optimal, and for the maximum values of the B-integral ($B > 6$) the optimal variant is with three mirrors. This is in a qualitative agreement with the theory [12] for Fourier transform limited (FTL) Gaussian pulses at the CafCA input according to which the higher B-integral, the lower optimal value of CM dispersion is needed. In our experiments, the pulse at the CafCA input was neither Gaussian nor FTL. Its shape and duration slightly varied from pulse to pulse. The spectra, ACFs, and pulse shapes for the three different pulses are presented in Fig. 4. The solid red lines correspond to the experimental data. Based on the measured spectra, we chose the pulse shapes whose ACFs were closest to the measured ACFs. Their shapes and ACFs are shown by the blue dotted lines in Fig. 4.

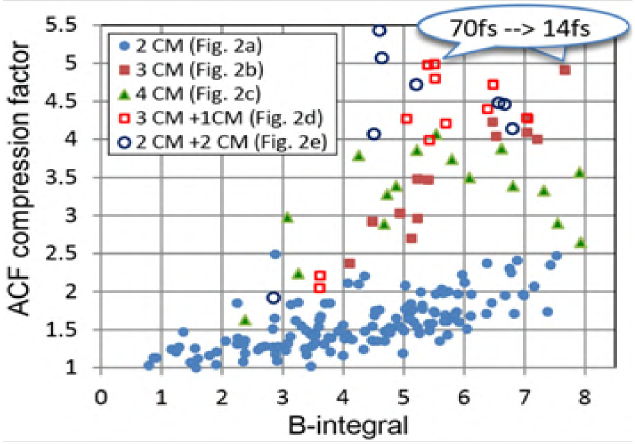

Fig. 3. Compression factor FACF versus B-integral for five variants of CafCA shown in Figs. 2(a)–2(e)

For the input pulses obtained in this way, we calculated the propagation dynamics in a nonlinear medium (in fused silica plates). The calculations took into consideration cubic nonlinearity ($n_2 = 3\times10^{-16}$ W/cm^2) and dispersion ($k_2 = 28$ fs^2/mm). A quadratic phase introduced by CMs (–100 fs^2 per each mirror) was added to the pulse spectrum at the output of the nonlinear medium. The results of the calculations are shown in Fig. 4 by bold dotted lines. Significant spectrum broadening at the CafCA output [compare the bold and thin solid lines in Fig. 4(a)], as well as the emergence of narrow peaks instead of a smooth modulation typical of FTL pulses after SPM are clearly seen in Fig. 4. These peaks arise because the pulses at the CafCA input are not FTL. This effect was discussed in detail in [6]. The theoretical and experimental spectra at the CafCA output agree qualitatively, although the peak widths and amplitudes differ quantitatively [compare the bold solid and dotted curves in Fig. 4(a)]. Comparison of the theoretical and experimental ACF of the output (compensated) pulses also gives a good agreement [see Fig. 4(b)]. For the three shots shown in Fig. 4, the experimental ACF compression factor $F_{ACF,\ exp}$ is very close to the theoretical factor $F_{ACF,\ th}$ and to the pulse duration shortening $F_{pulse} = T_{in}/T_{out}$, see Table I. As the compressed pulses are not Gaussian, their intensity increase factor $F_i = I_{out}/I_{in}$ is not equal to F_{pulse}. As seen from Table 1 for these three shots F_i is smaller than F_{pulse} but the difference is not crucial. This is in a good agreement with the detailed theoretical study [12] where it was shown that F_i is typically smaller than F_{pulse} by 10–20% only. The other shots also showed good coincidence of experimental data with theory. As is seen from Fig. 3, the highest compression factor $F_{ACF,\ exp}$ is about 5 (70 fs pulse is compressed to 14 fs pulse).

Table I

Parameters of the three shots shown in Fig. 4

CafCA variant	B	$F_{ACF,exp}$	$F_{ACF,th}$	F_{pulse}	F_i	T_{in}, fs	T_{out}, fs
Fig. 2(b)	7	4.1	4.4	4.3	4.1	67	15.5
Fig. 2(c)	6.8	3.9	3.8	3.5	3.1	70	20
Fig. 2(c)	7.3	3.4	3.3	3.4	2.8	67	20

Note that, despite the extremely large values of the B-integral (about 8), thanks to the self-filtering, optical breakdown was not observed either in the fused silica plates used for SPM or in the CMs.

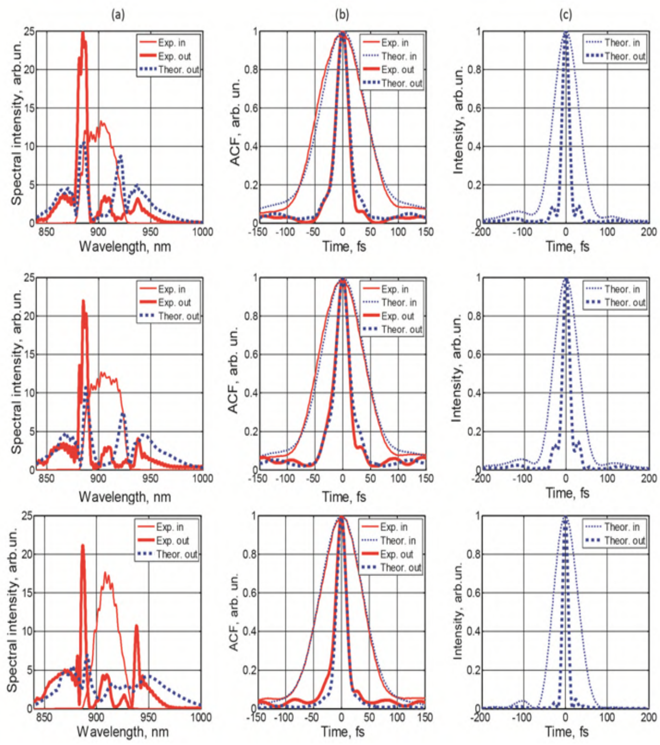

Fig. 4. (a) Spectra, (b) ACFs, and (c) shapes of three different pulses at the input (thin curves) and output (bold curves) of the CafCA system: experimental (solid red curves) and theoretical (dotted blue curves). Parameters of these three pulses are shown in Table I

We also studied two-stage CafCA [Figs. 2(d) and 2(e)]. The experimental results are shown by the empty symbols in Fig. 3, where the B-integral at the first stage is plotted along the horizontal axis. The addition of the second stage with three mirrors in the first one [Fig. 2(d)] resulted in an insignificant increase of the CafCA efficiency; cf. the empty and filled squares in Fig. 3. The operation of the second CafCA stage is demonstrated best of all with the use of two mirrors at the first stage [Fig. 2(e)]; cf. the empty and filled circles in Fig. 3. Note that in both two-stage variants the compressed pulse duration was measured to be 14–15 fs, which is, probably, a limiting resolution of the used diagnostics. A detailed study of the two-stage CafCA will be given in a separate publication.

Conclusion

The results presented here demonstrate that five-fold shortening (from 70 fs to 14 fs) of a 250 TW pulse can be attained by means of nonlinear compression. The efficiency of two-stage compression has been demonstrated. The CafCA has three principal merits. First, simplicity and low cost: only a plane parallel plate and chirping mirrors, the fabrication technique of which is well developed, are needed. Second, high efficiency: energy loss, taking into account a possibility of placing a plate at a Brewster angle, does not exceed 1%. Third, almost all ultrahigh-power lasers may be upgraded without any modification inside the laser.

It is expected that CafCA will find a wide application in the near future in petawatt and multipetawatt lasers, including lasers with a pulse duration of 15–25 fs, as well as with a duration of hundreds of femtoseconds, at the kJoule energy level [27, 28].

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Report on the “Workshop on Beam Acceleration in Crystals and Nanostructures” (Fermilab, June 24-25, 2019)

by Profs. Toshi Tajima (UCI) and Vladimir Shiltsev (Fermilab), co-chairs

The concept of beam acceleration in solid-state plasma of crystals or nanostructures like CNTs (or alumna honeycomb holes) has the promise of ultra-high accelerating gradients $O(1–10)$ TeV/m, continuous focusing and small emittances of, e.g., muon beams and, thus, may be of interest for future high energy physics colliders. The goal of the “Workshop on Beam Acceleration in Crystals and Nanostructures” which took place at Fermilab on June 24 and 25 , 2019, was to assess the progress of the concept over the past two decades and to discuss key issues toward proof-of-principle demonstrations and next steps in theory, modeling and experiment. The Workshop was endorsed by APS DPB, APS GPAP, ICUIL and ICFA ANA.

The Workshop had 40 participants from 6 countries, representing all relevant areas of research such as accelerators and beam physics, plasma physics, laser physics, and astrophysics. More than 20 presentations covered a broad range of topics relevant to acceleration in crystals and carbon nanotubes including:

1. overview of the past and present theoretical developments toward crystal acceleration, ultimate possibilities of the concept;
2. concepts and prospects of PeV colliders for HEP;
3. effective crystal wake drivers: beams, lasers, other;
4. beam dynamics in crystal acceleration;
5. instabilities in crystal acceleration (filamentation, etc.);
6. acceleration in nanostructures (CNTs, etc);
7. muon sources for crystal acceleration;
8. application of crystal accelerators (X-ray sources, etc.);
9. astrophysical evidence of wakefield acceleration processes;
10. steps toward “proof-of-principle”: 1 GeV gain over 1 mm, open theory questions, modeling and simulations
11. possible experiments at FACET-II, FAST, AWAKE, AWA, CEBAF, or elsewhere.

There were many vivid discussions on these subjects. All the talks and summaries of the discussions are available at https://indico.fnal.gov/event/19478/

Several interesting proposals for further explorations or experimental tests were made by Sahel Hakimi et al (UCI, on how to drive wakes in CNTs by ultimate or existing Xray pulses from, e.g. the LCLS SASE FEL); by Aakash Sahai et al (U.Colorado, on production of detectable number of muons either in BELLA or FACET-II of FAST facilities and their subsequent acceleration); by Toshi Tajima et al (UCI, on demonstration of effective micromodulation of electron beams at FAST and FACET-II); by Vladimir Shiltsev et al (Fermilab, on experiments with micromodulated beams sent through CNTs at FAST (kA peak current type beams) and then at FACET-II (upto 300 kA bunches) and the CNT channeling demonstration); by Gennady Stupakov (SLAC, on possibility to use 1-nm-SASE-modulated electron bunches at the end of LCLS-I undulators to excite crystals and demonstrate acceleration); by Vladimir Shiltsev et al (FNAL, to study specific electron beam filamentation features in structured materials, crystals and CNTs, at FAST and FACET-II); by Johnathan Wheeler et al (Ecole Polytechnique, to use the APOLLO laser facility to demonstrate PW optical pulses/single cycle pulses via thin-film-compression technique); by Valery Lebedev et al (FNAL, to explore effectiveness of the wake excitation in crystals or CNTs by high-Z high energy ions, e.g. by 450 GeV ion beams from the CERN SPS available at the AWAKE facility, and observation of possible acceleration of externally injected electrons).

Formation of the research teams has began and followup presentations are being planned for the FACET-II Annual Science Workshop (Oct-Nov 2019).

We plan to summarize the results of the Workshop in the book of Proceedings which will be co-edited by Profs. Gerard Mourou (Ecole Polytech, 2018 Nobel Prize in Physics), Toshiki Tajima (UCI), Swapan Chattapdhyay (NIU) and Vladimir Shiltsev (Fermilab) and published by the World Scientific.

Report on the ICUIL 2018 Conference

The international committee on ultra-high intensity lasers (www. icuil. org) is an international expert board within IUPAP that promotes communication, unity and coherence in the field of ultrahigh intensity laser research and its applications. The organization emphasizes education of young scientists äs well äs overreach to related fields, notably accelerator-based free electron lasers. A significant activity of ICUIL is the organization of an international Conference that is held every other year. The location for the Conference is rotating between North America, Europe and Asia, with Europe being the next foreseen location in 2018. Thanks to an active lobbying by scientists working in Germany, the Conference took place in Lindau, Germany, from September 9th to 14 , 2018. The decision to grant Germany the organization ofthe next ICUIL Conference was due to the very sträng involvement and recognition of German universities (Jena, Munich, Heidelberg, Düsseldorf, Darmstadt, and Dresden) in the field.

The specific subject of the event was the case of ultra-intense lasers. The ICUIL Conference series is regarded by many äs the major event of the field, because ICUIL has established itself aver the years äs a network that is represented in all the continents and major laboratories active in high intensity laser developments and applications. As the 8th of a series of ICUIL Conferences, it again showed the leading efforts across the world in the direction of ultra-intense lasers including progress reports on the European ELI centers.

The Conference covered three main aspects related to ultra-high intensity lasers:

1) to present the most significant advances and Updates on high intensity laser facilities worldwide. As it can be seen from the previous Conferences that date back to 2004, the ICUIL Conference is traditionally very efficient in acting äs the main venue to report on major steps forward in the field.

2) to give time to laser users, mostly scientists working at universities worldwide, and also in Germany, to present results obtained with these lasers and give feedback to improve the performance ofthese. Therefore the second topic covered by ICUIL is about science driven by these facilities.

3) The last topic was about components and Systems for high-intensity lasers, where the emphasis is put on cutting edge technology pushed by the laser requirements.

Finally, an objective of the 2018 ICUIL Conference was the interaction and synergy between the high-intensity laser and the free-electron laser communities that is emerging around the XFEL that was commissioned in summer 2017 in Hamburg, and similar developments world-wide.

Holding the Conference in Germany gave a unique opportunity for the many German and European research groups active in the field to learn about the most recent developments and present theirs. Thanks to the financial support offered to young scientists (50% discount in lodging and Conference fee) and the low transport costs due to the proximity of the Conference venue, the incentive for German young scientists to present their work at an international level was very high too. There is a sträng commitment from ICUIL to encourage the participation of female researchers at all stages of the scientific career. A first step for a balanced selection of contributions was the installation of established female scientists into the science board, including the co-chair (Felicie Albert from LLNL, USA).

The Local Organization Board was formed by members ofthe GSI Helmholtz Center Darmstadt and the Helmholtz Institute Jena: V. Bagnoud, A. Blazevic, B. Zielbauer, T. Kuehl, S. Kunzer, D. Schumacher, Ch. Spielmann, T. Stoehlker, and D. Lang.

More than 220 scientists including 50 students from all over the world participated and made the Conference a successful discussion forum.

We want to thank the EMMI Institute for making this possible!

Prof. Dr. Thomas Kühl, Conference Chair
Dr. habil. Vincent Bagnoud, Program Committee Chair

Nuclear Photonics 2020 (June 1–5, 2020, Kurashiki, Japan)

The 3rd International Conference on **Nuclear Photonics** will be held during June 1–5, 2020 in Kurashiki, Japan. The conference will be organized by the Institute of Laser Engineering (ILE) and Research Center for Nuclear Physics (RCNP), under Institute for Open and Transdisciplinary Research Initiatives, Osaka University, Osaka Japan.

Scope of the conference

The field of photon–based nuclear science and applications is evolving rapidly being driven by the major worldwide developments of ultrahigh intensity lasers and brilliant quasi–monochromatic gamma-ray beam systems. Nuclear Photonics 2020 aims at bringing together leading scientists, researchers and research schol-

ars from around the world involved in the fields of high energy density physics, high power laser photonics, nuclear physics, astrophysics, accelerator and detector science, and their applications for exchanging and sharing the experience and most recent results

The focus of Nuclear Photonics 2020 will be on the following main topics: Interactions between photons and nucleus/hadrons/particles, Laser-plasma nuclear physics, High intensity laser-plasma interactions, Laser Compton scattering gamma rays, Photon-enabled secondary beams (ion, neutron, electron, positron, etc.) generation and its applications, Photon-based production of rare isotopes, Nuclear astrophysics and cosmology, Fundamental photon science, Strong field QED, Photon vortex and unique wave function photons, Isotope-specific nuclear materials detection, imaging, and evaluation, Medical radioisotopes for radiography and radiotherapy, Ultrahigh intensity laser optics and technology, Accelerator and detector science.

Venue

The conference venue, "Kurashiki Ivy Square" preserves the outward appearance of Kurabo spinning mill factory built in 1889, and was proclaimed as National Modernization Industrial Heritage by Japanese government in 2007. Kurashiki Ivy Square is close to the historical area of Kurashiki city.

Contact e-mail: np2020@photon.osaka-u.ac.jp

ICUIL 2020 in Jeju Island, Korea

Chang Hee Nam

Center for Relativistic Laser Science (CoReLS), Institute for Basic Science (IBS), Korea & Dept. of Physics and Photon Science, Gwangju Institute of Science and Technology, Korea

The 9th International Conference on Ultrahigh Intensity Lasers (ICUIL 2020) will be held in the Jeju Island, a beautiful volcanic island, of Korea from Sep. 6th to 11th, 2020. The conference is organized by Center for Relativistic Laser Science, Institute of Basic Science (IBS), Korea, and the title of IBS Conference on Ultrahigh Intensity Lasers (also ICUIL 2020) is used in parallel. Jeju Island is the largest island and top tour site in Korea and thus has very convenient flight connections from Seoul, Japan, and China. Born through a volcanic activity about a million years ago, the island as a whole is a volcanic cone; the peak is located at 1950 m above sea level. Moving from the seashore to the peak, one can experience a change of climate from subtropical to temperate and find exotic geographical shapes such as columnar jointing, lava tubes, and parasitic volcanoes: one of the well-known is shown in the figure below. More information about the island is available at the homepage https://ijto.or.kr/english. As of August 2019, the specific venue is about to be fixed, but all the candidates are located in the Seogwipo area, a southern part of the island, have beautiful seashore, meeting the tradition of the ICUIL conferences.

As in the previous ICUIL conferences, ICUIL 2020 is organized to promote the report of recent achievements and the communication among researchers in the field of high-intensity laser development and applications. The topical areas of the conference comprise (i) ultra-intense laser design and performance including Ti:sapphire, Nd:glass, OPCPA, DPSSL, and novel architectures; (ii) novel technologies for ultra-intense lasers such as grating and compressor, high-damage-threshold and ultra-broadband laser components, spatial and temporal pulse control, diagnostics for ultra-intense lasers, beam combination technique, high repetition rate ultra-intense lasers, and new technologies, e.g., Raman and Brillouin amplification in plasma; (iii) applications of ultra-intense lasers for laser acceleration, short-wavelength sources, relativistic laser-plasma interactions, high-energy-density physics, strong-field quantum electrodynamics, and attosecond physics. In addition to the continued progress in these areas, in ICUIL 2020, we expect to see groundbreaking results produced with multi-PW lasers around the world, of which proliferation was witnessed in ICUIL 2018 held in Lindau, Germany. We hope that ICUIL 2020 becomes a festive venue in which the community celebrates the emergence of pioneering science revealed with unprecedented physical parameters.

Seongsan Ilchulbong, a volcanic cone in Jeju Island and UNESCO world natural heritage (photo from korea.net)

The conference is prepared by International Committee on Ultrahigh Intensity Lasers and active scientists in the community. Chang Hee Nam (CoReLS, IBS) shares the conference chair with Chris Barty (Univ. California, Irvine). Seong Ku Lee (CoReLS, IBS), Felicie Albert (LLNL), and Bedrich Rus (ELI Beamlines) are the program chairs to organize the conference program with program committee members. The local organizing committee includes Chul Min Kim, Jae Hee Sung, Ji Yeon Yeo, and Young Min Kim, all from CoReLS, IBS.

The official announcement will be made in January 2020, but we like to propose researchers and entrepreneurs in the community to visit the conference homepage (https://ibsconference.org/2020/icuil), which will be updated continually. Any inquiry to icuil2020@ibs.re.kr is welcome. Look forward to meeting you in Jeju in 2020.

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