ICUIL News 2020

Volume 11

The International Committee on Ultra-High Intensity Lasers

Chairman's Remarks

Prof. Chris Barty, Chairman, International Committee on Ultrahigh Intensity Lasers

As the chairman of the International Committee on Ultrahigh Intensity Lasers (ICUIL), it is my honor to welcome you to the 11th ICUIL newsletter. It is our hope that you find this newsletter to be a convenient snapshot of worldwide ultrahigh intensity laser activities.

2020 has certainly been a challenging year. The ongoing COVID-19 pandemic has impacted lives, work and activities around the globe. For ICUIL it has meant the postponement of our biennial meeting that was to have been held in September of 2020 on Jeju Island in South Korea. Since 2004, the biennial ICUIL conferences have provided a unique venue for in-person interactions and community development. To maintain this tradition, it was decided that the 2020 meeting should not be rescheduled as a virtual event. With the state of the pandemic in 2021 likely to improve, but still uncertain, the decision has been made to reschedule the 2020 gathering to early fall/late summer of 2022. The venue will remain Jeju Island, South Korea.

While the events of 2020 have postponed our biennial conference, other ICUIL activities have proceeded online. An updated 2020 facility census was completed and new versions of the static and interactive ICUIL world maps were created. These updates are now available from the ICUIL website (www.icuil.org) and are described within this newsletter. The planned 2020 ICUIL leadership rotations have also proceeded despite the pandemic. Nominations were made and candidates for chair and co-chair positions were presented to the general assembly for discussion and approval via Zoom. I am delighted to announce that the new chair of ICUIL will be Prof. Dino Jaroszynski of the University of Strathclyde and the new co-chairs will be Dr. Catherine LeBlanc of the Laboratoire pour l'Utilisation des Lasers Intenses CNRS-Ecole Polytechnique and Prof. Chang Hee Nam of the Gwangju Institute of Science and Technology. Each has made significant contributions both to intense laser science and technology and to the growth of the community represented by ICUIL. I am confident that they will provide excellent leadership for the organization.

I would like to personally thank Prof. Alexander Sergeev and Prof. Ravindra Kumar, who will also be stepping aside as co-chairs. Their initiatives and contributions to ICUIL have been numerous and impactful despite their busy schedules. The community has benefited many times from their dedicated efforts.

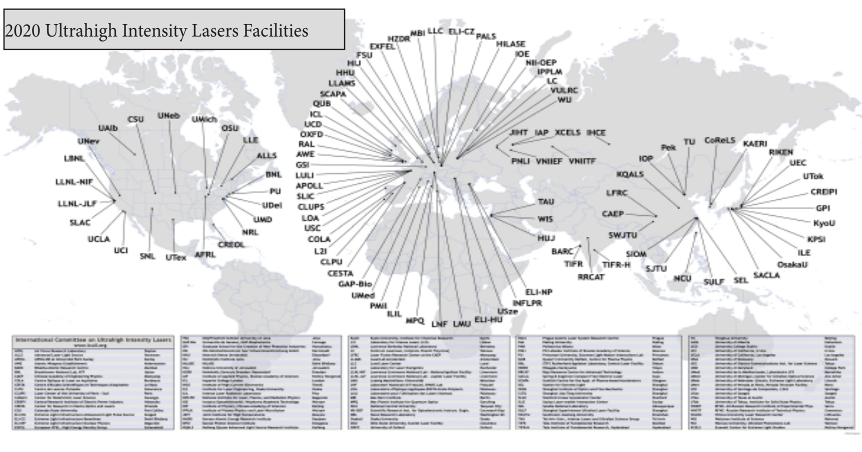
While the pandemic has raged, scientific and technical progress has not stood still. 2020 has seen the establishment of new operating capabilities within the Extreme Light Infrastructure facilities in Europe and the development of remote-use infrastructure at existing facilities. Both are highlighted in this newsletter. Of particular technical note has been the demonstration of the world's first 10 PW laser systems at the Extreme Light Infrastructure - Nuclear Physics facility in Romania. Clearly, there are many exciting days ahead for the ICUIL community.

It has been a distinct privilege to serve as the ICUIL chair for the past 4 years and my great pleasure to have been part of the ICUIL organization since its founding in 2004. Please stay safe in the days ahead and plan now to attend ICUIL 2022 in Jeju, South Korea!

2020 Facility Census and ICUIL World Map

For the past decade, ICUIL has maintained a database of worldwide laser facilities capable of producing intensities above 10E19 W/cm^2. This database has been updated in 2020 and used to create new static and dynamic maps of ICUIL facilities.

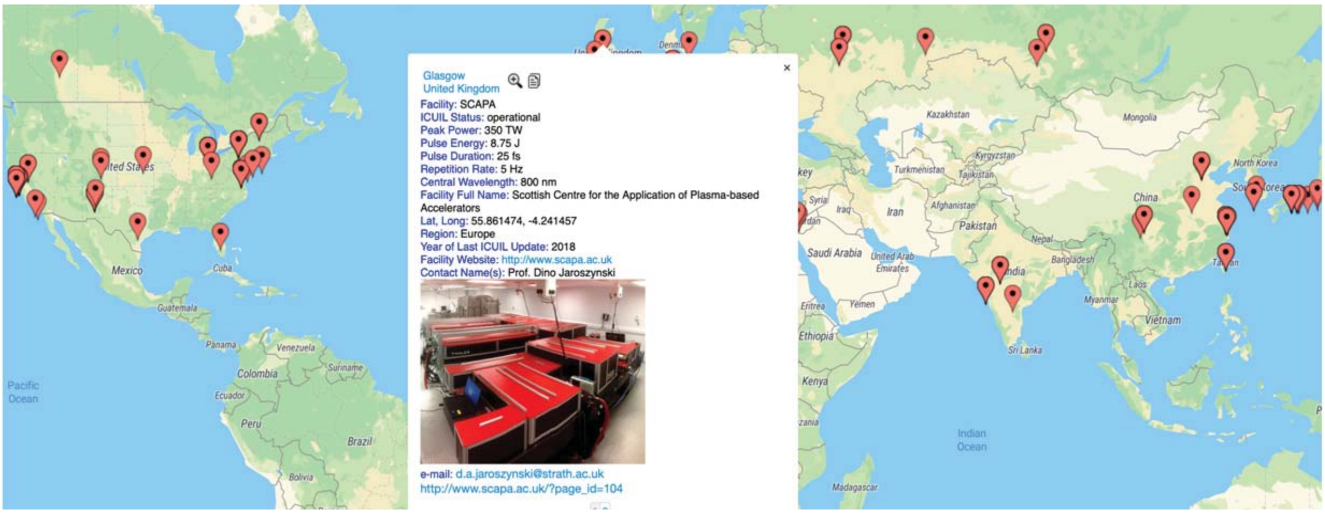
The new 2020 (shown below) and revised 2012 and 2009 high-resolution, static maps may be found and downloaded from the ICUIL website at (https://www.icuil.org/pdf/icuil-world-map-2020.pdf). The maps are free to use with the following attribution - "map provided by courtesy of the International Committee on Ultrahigh Intensity Lasers - www.icuil.org."



The ICUIL dynamic facility map is designed to enable users to rapidly identify facilities at which to conduct their specific experiments and to facilitate collaborations and travel associated with new projects. This map is based on street-level, interactive mapping software that may be zoomed and scaled as desired. Each facility shown includes a location marker which, when clicked, generates a pop up window containing pertinent information about the facility (see figure). This information includes the types of lasers, the precise geographical location of the facility and a contact address for those interested in learning more or in visiting the facility. The dynamic map also includes an updated ability to sort facilities based on the number of laser attributes that may be selected from pull down menus. The dynamic map may be found via links on the ICUIL website or directly at https://www.easymapmaker.com/map/ICUIL_World_Map_v3.

It is the intent of ICUIL to update the census of facilities and maps yearly.

ICUIL would like to thank graduate student, Michael Seggebruch, of Prof. C. Barty's group at the University of California, Irvine for his efforts in collecting 2020 census data and creating the interactive map.



2020 Interactive ICUIL world map

ICUIL Awards and Recognitions

Terry Kessler – Laboratory for Laser Energetics – Rochester, NY. Recipient of the inaugural Distinguished Service Award of the International Union of Pure and Applied Physics (IUPAP).

IUPAP is the parent organization under which ICUIL has been a formal working group since 2004. The IUPAP distinguished service award was established in 2019 and recognizes "those who have given long and meritorious service to the Union but have not been a President of IUPAP or a Chair of a Commission or Working Group". The role of secretary within any IUPAP working group or commission is extremely important as it is meant as a long term position. Besides handling the logistics of the organization, the secretary is charged with maintaining the tribal history and spirit of the organization. Terry was selected as the ICUIL secretary at the conclusion of the 2006 ICUIL conference in Cassis, France. As anyone who has attended an ICUIL event or participated in committee activities will attest, Terry is an exceedingly deserving recipient of this inaugural award.

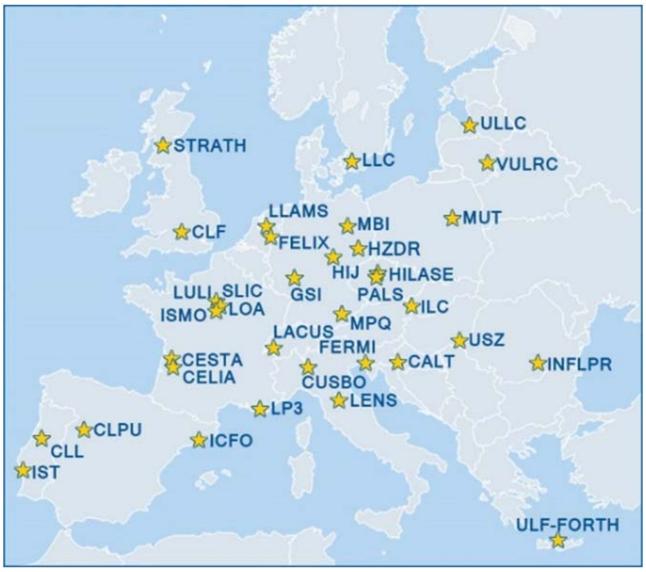
Prof. Toshiki Tajima – University of California, Irvine – Recipient of the 2020 Charles Hard Townes Medal of the Optical Society of America. The Townes Medal is presented annually to an individual or a group for outstanding experimental or theoretical work, discovery or invention in the field of quantum electronics. The medal was established in 1980 to honor Charles Hard Townes, whose pioneering contributions to masers and lasers led to the development of the field of quantum electronics. It is endowed by Bell Laboratories, Hewlett-Packard, The Perkin Fund, and students and colleagues of Charles Townes. Professor Tajima was cited for seminal contributions in broad and novel plasma physics and laser-based accelerator physics, introducing the concept of Laser Wakefield Acceleration. Professor Tajima was the chair of ICUIL from 2008 to 2016.

Professor John Llewellyn Collier – Central Laser Facility STFC, Rutherford Appleton Laboratory, UK – Recipient of the 2020 Richard Glazebrook Medal and Prize for the sustained leadership and strategic development of the UK's multi-disciplinary Central Laser Facility (CLF) and his pioneering developments in high peak power and high-energy, high-average power lasers. The Richard Glazebrook Medal and Prize is awarded annually by the Institute of Physics to recognise leadership in the field of physics. It was established in 1966 and named in honour of Sir Richard T. Glazebrook, the first president of the Institute of Physics.

Laserlab-Europe, the Integrated Initiative of European Laser Research

Sylvie Jacquemot, Laserlab-Europe EU project coordinator, LULI, Ecole Polytechnique

Building upon structuring activities amongst laser facilities in Europe initiated by the LASERNET cooperation network (2001-2004), Laserlab-Europe was created in 2004 under the 6th Framework Programme (FP6), introducing the concept and vision of a unified "European Distributed Laser Infrastructure." The first consortium (2004-2008) consisted of 17 laser research infrastructures (LRIs) from 9 European countries. Since then, it was continuously supported by the European Commission (EC), thanks to the remarkable achievements and dedication of its successive coordinators: Wolfgang Sandner (MBI, Germany - 2001-2012) and Claes-Göran Wahlström (LLC, Sweden - 2012-2020). In the framework of FP7, Laserlab-Europe II (2009-2012) aimed at extending the European dimension by reaching out to new member states and new scientific communities, thus growing to 27 individual LRIs in 16 countries, while Laserlab-Europe III (2012-2015) focused on internal consolidation, with only one new LRI. The H2020 Laserlab-Europe IV project (2015-2019) reinforced its integrating activities, especially towards other international laser networks (i.e. LaserNetUS and the AILN), and expanded beyond "traditional" optical LRIs, broadening its access offer from the IR to the XUV, thanks to inclusion of two accelerator-based free-electron lasers.



Maps showing the expansion of the Laserlab-Europe consortium from 2004 to 2020

Laserlab-Europe (www.laserlab-europe.eu) is today a consortium of 35 LRIs, plus 4 subcontractors and associate partners, located in 22 European countries, and coordinated, since July 2020, by Sylvie Jacquemot (LULI, France). The current 4-year EU Laserlab-Europe V contract started in December 2019 and allowed to get a 10 M€ funding for 3 key activities: networking, joint research, and transnational access.

The Networking activities are mainly devoted to maintaining a competitive interdisciplinary network among all the 43 labs involved. They are organized under three categories: (i) communication and information exchange, with key instruments, such as staff exchanges, bridge workshops (organized in collaboration with other light sources consortia), and the Laserlab-Europe newsletter, (ii) strategy, aiming at foreseeing future laser-related challenges and enhancing the long-term sustainability of Laserlab-Europe, and (iii) services to the user community. These latter encompass all the managerial aspects of academic and industrial user access and community development through, for instance, e-learning and training schools.

The second pillar of Laserlab-Europe - Joint Research - aims at addressing a broad range of important new developments in laser research and at improving the technical and scientific services provided to the community. Two collaborative activities have been defined under Laserlab-Europe V. PRISES deals with laser technology and laser science developments, focusing on strategic advances that are critical for short-pulse high-power lasers and laser metrology as well as for secondary sources of particle and radiation and their application workstations. ALTIS aims at developing innovative workstations, methodologies, and platforms for advanced nano- to macro-imaging and spectroscopy in materials science, environmental science, and biomedicine.

The third and last pillar is Transnational Access. Its objective is to offer access free of charge (including travel and accommodation) to a comprehensive consortium of state-of-the-art laser research facilities (currently 24 facilities in 12 countries) to researchers from all fields of science and from any laboratory or company in order to perform world-class research. The present contract supports this activity up to 3500 access days, which should represent roughly 350 projects over the 4-year duration and 790 visiting users. From the 4th to the 5th contract, the access offer has been enlarged with four new providers. CLPU in Spain offers a line of ultra-intense lasers for mainly plasma physics, partly in relation with the ELI consortium. HZDR in Germany specializes in ultra-short laser accelerated sources of particles for medical applications, such as proton cancer therapy. LACUS in Switzerland offers access to rare X-ray and deep-UV spectroscopic methods along with ultrafast electron-based techniques for the photochemical and solid-state physics communities. Finally, HiLASE in the Czech Republic provides a line of advanced high-repetition rate solid-state lasers ideal for industrial applications. The Transnational Access activity is organized as a joint activity among all participating infrastructures. It uses a common advertising platform on the internet, a common call for proposals and a unified, fully electronic, proposal processing platform. Once submitted, the proposals are evaluated by a common external Selection Panel, relying on a pool of more than 150 independent referees. The selection is done on the basis of scientific excellence with priority given to new users. Applications from countries outside the EU are welcome. As a result of the coronavirus pandemic, travelling to perform transnational access projects had to be either postponed or strongly limited. In order to support the activity, remote access is now offered to a majority of the labs. More information can be found at: https://www.laserlab-europe.eu/transnational-access.

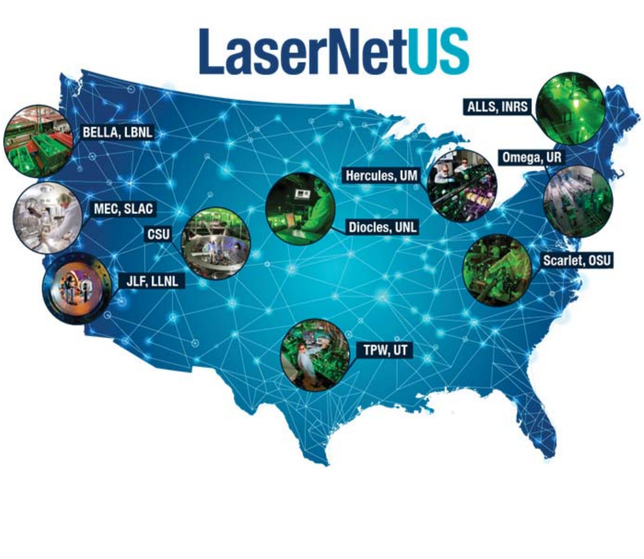
The Laserlab-Europe networking grid

In 2018, in addition to the EU-funded projects, an international not-for-profit association under Belgian law (AISBL) was created to ensure that Laserlab-Europe last as distributed LRI beyond any given EC funding period or framework programme, complementing national research policies and pan-European LRIs, such as the Extreme Light Infrastructures.

The LaserNetUS High-power Laser Consortium Continues and Expands Operations

Felicie Albert, Lawrence Livermore National Laboratory
Doug Schumacher, Ohio State University

In 2018, the U.S. Department of Energy (DOE) established a network of facilities operating ultra-powerful lasers, called LaserNetUS. Organized and funded through the Department's Office of Fusion Energy Sciences (FES), the new network was created to provide vastly improved access to unique lasers for researchers, and to help restore the U.S.'s once-dominant position in high-intensity laser research. In October 2020, the network was awarded new funding ($18 million) from the DOE, distributed among 10 partner institutions and including $1 million for user support, to continue and expand LaserNetUS operations for three years.



LaserNetUS includes the most powerful lasers in the United States and Canada, some of which have powers approaching or exceeding a petawatt. The many lasers of the network come in a variety of operating modes and configurations with varying repetition rates, pulse energies and durations, and focal geometries. A range of experimental diagnostics is available, varying from facility to facility, and users are encouraged to deploy their own systems.

All facilities in LaserNetUS operate high-intensity lasers, which have a broad range of applications in basic research, advanced manufacturing, and medicine. They can recreate some of the most extreme conditions in the universe, such as those found in supernova explosions and near black holes. They can generate particle beams for high energy physics research or intense x-ray pulses to probe matter as it evolves on ultrafast time scales. They are being used to develop new technology, such as techniques to generate intense neutron bursts to evaluate aging aircraft components or implement advanced laser-based welding. Several LaserNetUS facilities also operate high-energy longer-pulse lasers that can produce exotic and extreme states of matter like those in planetary interiors or many-times-compressed materials; they can also be used to study laser-plasma interaction, important to fusion energy programs.

In its first year of user operations, LaserNetUS awarded beamtime for 49 user experiments to researchers from 25 different institutions. Over 200 user scientists including well over 100 students and post-docs have participated in experiments so far. The LaserNetUS institutions are: Colorado State University, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, SLAC National Laboratory, The Ohio State University, University of Michigan, University of Nebraska-Lincoln, University of Rochester, University of Texas at Austin and, since 2019, Institut National de la Recherche Scientifique in Canada. The network recently closed its 3rd call for proposals, which was open to both U.S. and international researchers, and will issue the next solicitation in 2021. All proposals are peer reviewed by an external panel of national and international experts that is independent from LaserNetUS facility personnel. Proposals are submitted using the network website https://www.lasernetus.org/. This site also provides a description of the facilities and contacts who can help new users select the facility that is best for them and plan their proposal.

The network and future upgrades to LaserNetUS facilities will provide new opportunities for U.S. and international scientists in discovery science and in the development of new technologies.

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Asian Research Activities on Ultrahigh Intensity Lasers

Chang Hee NAM, Center for Relativistic Laser Science, Institute for Basic Science, Korea

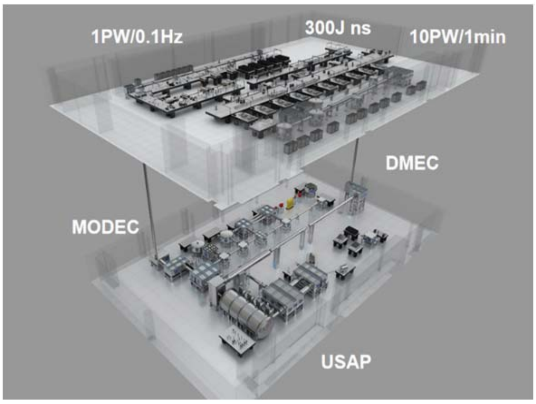
In Asia, research on ultrahigh intensity lasers has been very actively pursued in a number of institutes. In this article, the recent research activities of five institutes are presented: Shanghai Institute of Optics and Fine Mechanics (SIOM) of China, Raja Ramanna Centre for Advanced Technology (RRCAT) and Tata Institute of Fundamental Research (TIFR) of India, Kansai Photon Science Institute (KPSI) of Japan, and Center for Relativistic Laser Science (CoReLS) of Korea. All institutes, except TIFR at the planning stage, are running PW lasers or multi-PW lasers for the investigations of strong field physics.

A. Shanghai Institute of Optics and Fine Mechanics, CHINA

Yuxin Leng, State Key Laboratory of High Field Laser Physics, SIOM, Chinese Academy of Sciences, Shanghai 201800, China

The overview and status of the Shanghai Superintense Ultrafast Laser Facility (SULF) and Station of Extreme Light (SEL) toward 100-PW are presented here. SULF is one of the key projects as major science infrastructures belonging to science and technology innovation center with global influence, which includes two ultraintense and ultrashort laser beams (10 PW and 1 PW), and further three related experimental stations. SULF was built in 2020 and will soon be open for the end users from all over the world. Now, in 10 PW laser beam, more than 400 J pulse energy is obtained from the main Ti:Sappire amplifier. After compressor, <25 fs average pulse duration from full pulse is measured, and >11 PW peak power laser can be generated. With deformable mirror and F/2 OAP $>10^{22}$ W/cm^2 focused intensity is achieved with 10^{11} contrast, and the performance is being improved. At the same time, the in-house experiments have been carried out based on the 10 PW and 1 PW lasers in SULF.

Further, the Station of Extreme Light at the Shanghai high repetition rate XFEL and Extreme Light Facility (SHINE) approved in 2017 will be the product of the marriage of the two most powerful lasers, 100 PW optical laser and hard XFEL, for quantum electrodynamics (QED) physics and other high energy density physics research. The SEL-100 PW laser system uses an all-OPCPA technology, which is composed by an ultrabroadband seed, five NOPA stages and their pump lasers, a stretcher, a compressor, and a synchronization system. The bandwidth keeps over 200 nm all around the whole system to support 15 fs pulse width with 1500 J energy. The SEL project has been under construction since April, 2018. According to the schedule, the facility will be completed in 2025 and then be opened to users. At present, most of the engineering designs have been finished, and the 20 TW/15 fs frontend has been demonstrated.



SULF facility overview

B. Ultrahigh Intensity Laser Science in INDIA

(1) Raja Ramanna Centre for Advanced Technology

J. A. Chakera, Laser Plasma Division, RRCAT, Indore 452 013

The Laser Plasma Division at Raja Ramanna Centre for Advanced Technology (RRCAT) has been involved in laser-plasma interaction studies using ultrashort, ultrahigh intensity lasers since early 2000. It also hosts nanosecond, high energy lasers for studying shocks and related phenomena. The facility very recently added 1 PW Ti:Sapphire system to enhance the existing capabilities provided by the 10 TW, 150 TW and kHz Ti:Sapphire lasers. A number of important investigations have been performed in ultrashort, ultrahigh intensity laser-matter interaction related to fast electron generation and transport, electron acceleration in the LWFA regime, ion acceleration in thin foil structured targets, neutron generation in CD_2 targets, high-order harmonic generation from solid plasma plumes/gas cells, and K-α x-ray generation and its applications. Several x-ray and particle (electron, proton, and neutron) diagnostics with a high spatial and temporal resolution viz. streak cameras, Thomson Parabola Ion Spectrograph, Time of Flight Neutron detector, electron and gamma ray spectrographs have been also developed in-house to carry out the above studies.

The one petawatt laser acquired in 2019 is a Ti: Sapphire laser (Model ALPHA 0.1XS) custom built by Thales. The PW laser has the standard CPA architecture with an XPW filter. The regenerative and booster amplifiers are pumped by Nd:YLF pump lasers (Model: Jade), whereas the Pre-amplifier and Amplifier-1 are pumped by three pump lasers (Model: SAGA HP). The Final Amplifer-2 is pumped by four Nd:glass based pump lasers (Model ATLAS), each giving ~25 J energy per pulse on the amplifier crystal. The final beam from the Amplifier-2 passes through a beam attenuator and a wavefront correcting mirror (DM mirror). After the mirror, the beam is magnified and fed to the laser pulse compressor. The pulse compressor is based on Treacy configuration having four gratings. The beam passes through the gratings in a single pass and compresses to 25 fs (FWHM). The final beam after the compressor propagates through a vacuum beam line and beam turning chambers to the experimental hall. The beam lines, beam turning, and experimental vacuum chambers are designed and developed within the country with the help of Indian industries. The laser, as well as the plasma experiment area, are equipped with radiation and electronic safety control features to ensure user safety.

The laser is installed and is under commissioning. All the beam delivery optics are procured and are under deployment stage. The PW laser facility is expected to be in operation by April 2021. Later, two more experimental chambers will be added with the laser beam line. With this addition, the facility will have three independent experimental chambers for studies of electron acceleration, ion acceleration, and hot electron transport / high energy x-ray generation, respectively. Further, a plasma mirror setup is under design and development to enhance the beam temporal contrast by 2 orders. The plasma mirror setup will also have a beam diverting facility to different bays at a time to the three experimental chambers.

RRCAT - Petawatt Laser

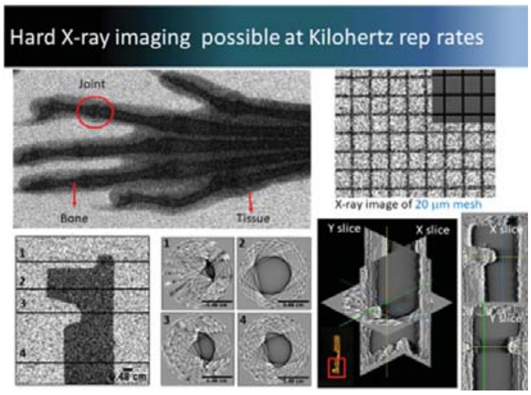
RRCAT - Petawatt Experimental Area

(2) Tata Institute of Fundamental Research

G. Ravindra Kumar, TIFR, Mumbai 400005

The Ultrashort Pulse High Intensity Laser Laboratory facility (UPHILL) at the Tata Institute of Fundamental Research is also advancing toward the petawatt level at 1 Hz. For about two decades the activity has been carried out at the main campus of the Institute in Mumbai investigating several aspects of high intensity light interaction with gases, clusters, and solids. Some of the highlights of this work have been the study of turbulent megagauss magnetic fields with astrophysical parallels, neutral atom acceleration to MeV levels, demonstration of high brightness hard x-ray sources by novel structuring of targets, new ways of monitoring relativistic electron transports in solids, etc. It hosts a 150 TW, femtosecond high contrast laser apart from a 20 TW laser. The PW arm is slated to come up at the new campus of TIFR at Hyderabad (TIFR-H) as a totally independent facility. The location of this facility in the Hyderabad campus provides opportunities for elaborate experiments on many aspects of intense laser-matter interaction. A new state-of-the-art laboratory is being built to keep many possibilities in view. It is anticipated that advanced accelerator and detector facilities may come up in this campus, which is ten times bigger in area than the campus in Mumbai. It is envisaged that the new PW facility will not only drive high energy density science, particle acceleration, and high brightness sources, but also focus on applications in imaging, industry, and medical therapies. A beginning towards such applications has already been made with relativistic electrons and hard x-rays produced by lower energy, kilohertz laser pulses. The Hyderabad campus is also home to the UK-India Extreme Photonics Innovation Centre (EPIC) which seeks to carry out collaborative research on the next generation of high power lasers, high repetition rate targetry, advanced detectors, and imaging applications. The location of several advanced high tech industries and research institutions in and around the city of Hyderabad is expected to enable these goals. The laser facility at TIFR-H is envisaged to have a petawatt high power and a 50-100 TW low power arms to enable a variety of experiments. The facility is expected to be operational in 2022 and will offer collaborative opportunities locally and globally.

TIFR - 150 TW, 25 fs facility in Mumbai



TIFR - kilohertz particle sources at Hyderabad

C. Kansai Photon Science Institute, JAPAN

Hiromitsu Kiriyama, KPSI, National Institutes for Quantum and Radiological Science and Technology (QST), Japan

The J-KAREN-P laser system is the flagship laser system at the Kansai Photon Science Institute (KPSI) of the National Institutes for Quantum and Radiological Science and Technology (QST). The main features of the laser system are: (1) a robust high contrast frontend featuring a saturable absorber and OPCPA operation with low gain; (2) high energy amplification by four Ti:Sapphire amplifiers with optimum and moderate amplification gain; (3) simple off-axis beam expanders based on reflective-type concave and convex mirrors with low aberrations; (4) active compensation of the residual spectral phase distortion with two high dynamic range acousto-optic programmable dispersive filters (AOPDFs) and active correction of the wavefront with an adaptive optic (deformable mirror); (5) a compressor consisting of four gold-coated holographic high quality large gratings. The laser is guided to two different target chambers for short focal length (f/1.3-3) and long focal length (f/3-10) configurations, providing flexibility for ultrahigh intense laser plasma interaction experiments. The J-KAREN-P can realize petawatt peak powers at a repetition rate of 0.1 Hz with an intensity capability of over 10^{22} W/cm^2. Recently, based on our experience and understanding of pre-pulse removal, we have achieved a high temporal contrast of 10^{-12} and removed most of the pre-pulses. This is the first demonstration of the high accurately estimated intensity of 10^{22} W/cm^2 on target and high temporal contrast of 10^{-12} with pre-pulse removal, to the best of our knowledge. The excellent temporal and spatial performance and overall high quality of the laser system will enable many high field applications.

We briefly introduce some experimental results obtained with the J-KAREN-P laser system and prospects for high field science experiments. One of the most attractive applications with ultrashort, ultrahigh intensity lasers is laser-driven particle acceleration, featuring high accelerating electric fields, short acceleration distance, and short bunch lengths compared to rf-accelerators. Proton and electron acceleration using the J-KAREN-P laser system is under investigation. More than 50 MeV protons were obtained with a laser intensity of ~ 10^{21} W/cm^2. At the laser intensity of 5 x 10^{21} W/cm^2, the effect of using a small focus spot on electron heating and proton acceleration were investigated and highly charged high-Z ions were accelerated to over GeV energies. Laser-plasma acceleration has the possibility to downsize conventional large accelerator systems. A unique system was proposed to accelerate short-lived

heavy ions dedicated to the study of exotic nuclei. In particular, the generation of carbon ions with an energy of 4 MeV/n and 10% energy bandwidth is being studied as an ion source for an injector for a future cancer radiotherapy accelerator at QST. The generation of high energy, highly charged heavy ion beams was also investigated, with a focus on understanding the ionization mechanism, which is extremely important for the control of laser-driven heavy ion beams. Electron acceleration is also being studied with a goal of downsizing X-ray free-electron laser facilities. Currently, experiments are ongoing to generate GeV electron beams from 1-2 cm gas jet targets with a focused irradiance of 10^{20} W/cm^2. Experiments on high-order harmonics from relativistic singularities, on high repetition rate multi-MeV pure proton beam generation from micron-scale hydrogen cluster targets and on x-ray spectroscopy of laser-plasma interaction in the ultra-relativistic regime are also in progress. Future prospects for high field science include the testing of quantum electrodynamics, which will be made possible even for a small facility, such as KPSI, QST. One of the QED processes that can occur is the generation of electron-positron pairs from the vacuum by colliding either strongly focused J-KAREN-P laser pulses or frequency upshifted pulses generated by relativistic flying mirrors produced by the J-KAREN-P laser in plasma with high energy GeV electron beams.

D. Center for Relativistic Laser Science, KOREA

Chang Hee NAM, CoReLS, Institute for Basic Science, Gwangju 61005, Korea

The Center for Relativistic Laser Science (CoReLS) has been running the 20-fs, 4-PW laser since 2017 for the investigations of strong field physics. We reported earlier the achievement of the laser intensity of 5x10^{22} W/cm^2 (Opt. Express **27**, 20412 (2019)), and this year the record-breaking laser intensity was further enhanced to 1.1x10^{23} W/cm^2 by focusing a wavefront-corrected 2.7-PW laser pulse with f/1.1 off-axis parabolic mirror. A number of prominent laser groups in the world have intensively pursued the realization of this laser intensity for the examination of strong field quantum electrodynamics in the strongly nonlinear regime.

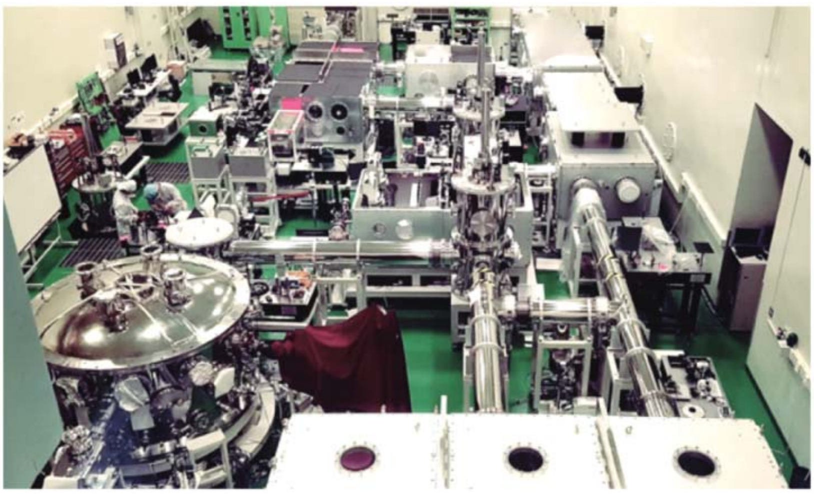
Stable operation of the PW laser has always been the top priority for collecting reliable and reproducible experimental data from ultrahigh intensity laser-matter interactions. The laser team at CoReLS has made intensive efforts to stabilize the operation of the 4-PW laser. In addition to improving the wavefront of the PW laser with two stages of adaptive optics systems, the laser spectrum has been stabilized by improving the stability of the frontend, especially the OPCPA spectrum.

CoReLS 4-PW Ti:Sapphire laser operated since 2017

In addition, a single-shot spatiotemporal diagnostics has been developed and implemented to characterize ultra-high intensity laser pulses. The measurement result showed that the intensity of the 4-PW laser at focus was slightly degraded (15%) due to spatiotemporal coupling effects, which can be considered good quality, but still implies that the laser intensity can be further enhanced.

This year we have been working intensively on nonlinear Compton scattering (NCS) for the exploration of strong field QED. For NCS experiments, two to three GeV electron beams have been stably produced by applying the laser wakefield acceleration scheme, in which He atoms in a gas cell are driven with multi-PW laser pulses. The interaction of multi-GeV electrons and ultrahigh intensity laser pulses are then carefully controlled in order to produce Compton scattering events and the produced gamma-rays are measured with gamma detectors. The all optical nonlinear Compton scattering experiments will offer the opportunity to access QED phenomena occurring in astrophysical plasmas.

CoReLS has offered about 20% of its PW laser beam times to external users. This year external users could not come from abroad due to COVID-19, which should be normalized in the coming years.



Experimental area for the 4-PW laser

Experimental Operations at the Omega Laser Facility amid COVID-19

Gregory Pien, Brian E. Kruschwitz, Samuel F. B. Morse, and Terrance J. Kessler
Laboratory for Laser Energetics, University of Rochester

The Omega Laser Facility comprises both the OMEGA 60-beam, ultraviolet target-compression system and the OMEGA EP four-beam system having two short-pulse, kJ-class petawatt beams. The Omega Laser Facility Users Group (OLUG) represents over 400 scientific users from 55 universities and over 35 centers and national laboratories in 21 different countries on 4 continents. In support of the OLUG community, the OMEGA 60 Laser System conducts up to 1500 target shots per year, while the OMEGA EP Laser System conducts about 800 target shots per year.

Fig. 1. The OMEGA EP and OMEGA 60 Laser Systems are shown on the left and right, respectively. Each system contains a target chamber for experiments and selected beams from OMEGA EP can be directed to the OMEGA 60 chamber for joint operations

In 2020, the COVID-19 pandemic presented an unprecedented challenge to this highly productive experimental facility. When New York State closed all businesses in late March in response to the COVID-19 pandemic, managers of the Omega Laser Facility realized that changes to the standard operating scheme were required in order to conduct experiments with high availability and effectiveness. This new challenge was delivering the standard 60-minute shot cycle and experimental flexibility with a reduced number of on-site staff who were physically distanced from each other and limited travel by the many scientific and technical collaborators and principal investigators (PIs).

Working from home while the Omega Facility was in standby mode, senior operations managers evaluated and modified the Omega operating processes to support "normal" operational throughput with scientists (a large percentage of whom are from other organizations and would not be allowed to travel to our location) and staff working remotely. Since the Omega user base is located around the globe, the experiment planning process was already conducted largely via online, e-mail, and video conferencing methods; therefore, little change was necessary. However, shot-day operations required extensive changes. Shot-day transactions between the PIs and the operations crew had been done in person only, requiring the PIs to be on site. New travel restrictions meant this was seldom possible. Additionally, new occupancy restrictions to support social distancing limited the number of personnel on site.

To address these new constraints the ***remotePI*** protocol was implemented. The primary objective was to facilitate PI-to-Operations shot-day transactions while complying with COVID-19 mitigation rules (social distancing and travel limitations) by implementing a minimal set of changes to our existing processes—changes that could be made on a very short development cycle, easy to learn, and using existing and available equipment. The challenge was to implement these changes while supporting efficient

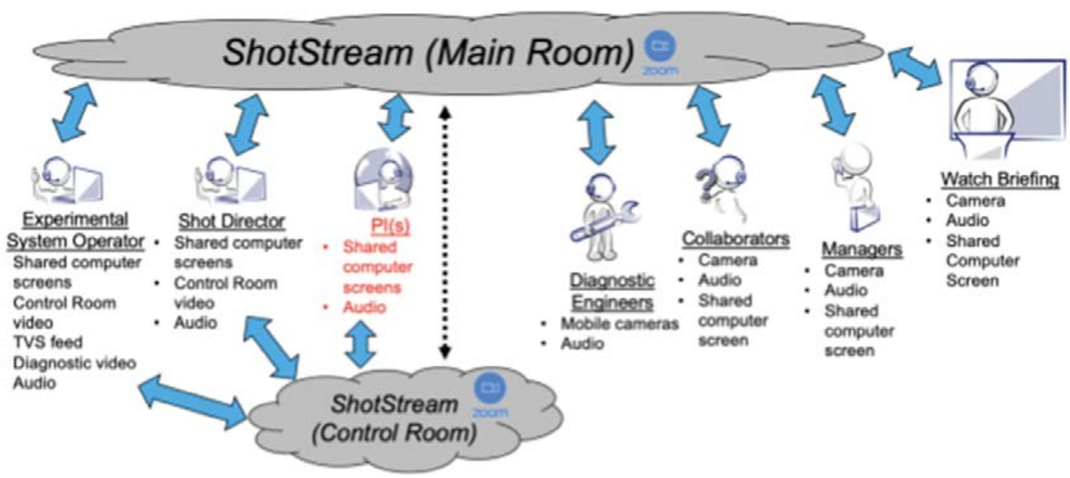


Fig.2. ShotStream virtual facility conceptual layout. The virtual main room is used by all participants as a collaboration area, for crew briefings, etc. The virtual control room is used for direct communication between the PI and shot crew

operations, meeting or exceeding "usual" Omega levels of effectiveness, availability, and flexibility.

Each OMEGA 60 or OMEGA EP shot cycle is governed by a series of transactions between the PI and the facility. ***RemotePI*** eliminates PI location dependence by creating a virtual venue for these transactions using an intuitive platform and commonly available equipment. The centerpiece of ***remotePI*** is an all-day Zoom meeting for each facility, which we dubbed "*ShotStream.*" *ShotStream* connects the PI to the facility, as well as to collaborators and technical staff. Each day there is one *ShotStream* opened for each facility, comprising two virtual rooms: one "main room" used as a collaboration space for PIs and the "control room" used exclusively for communication between the PI and the operations crew. A simple rule set is implemented to allow concise communication between the PI and the operations crew.

The audio channel from one of the *ShotStream* rooms is connected directly to a facility intercom channel, allowing the PI to communicate with any of the on-site staff directly. Screen sharing and video feeds allow the PI to receive important information such as target images, pulse-shape predictions, and shot configuration database changes. Also available on the zoom are direct video from key diagnostics, such as the velocity interferometer system for any reflector/active shock breakout (VISAR/ASBO) cameras. Real-time video of any piece of equipment can be piped into *ShotStream*. Final approvals prior to the shot are conducted on *ShotStream*. Additionally, the PI conducts the pre-watch briefings to the operations crew. The PI observes Control Room operations during the shot and can participate whenever appropriate. Regardless of their actual location in the world, *ShotStream* puts the PI in our Control Rooms during the shot. Data from each shot are posted online for the PI to review. Electronic data [e.g., charge-coupled device (CCD), image plate, or oscilloscope readouts] have been traditionally available online, but film data usually had been handled in person. Film data are now scanned and posted to the LLE website shortly after each shot.

ShotStream is also used to communicate feedback between the PI and the operations crew following each shot. The post-shot feedback paper forms have been replaced with similar online forms for quick and precise feedback to the facility.

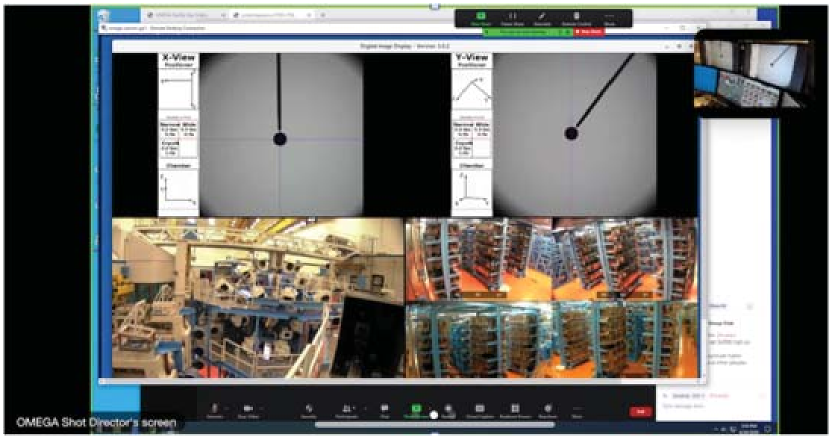


Fig.3. Typical ShotStream view shown on a mobile device

Additionally, mobile cameras can be deployed to the field and broadcast on *ShotStream* to allow on-demand video/audio communications between remote participants (PIs or technical staff) and on-site operators. This supports precise instrument setup and troubleshooting even when

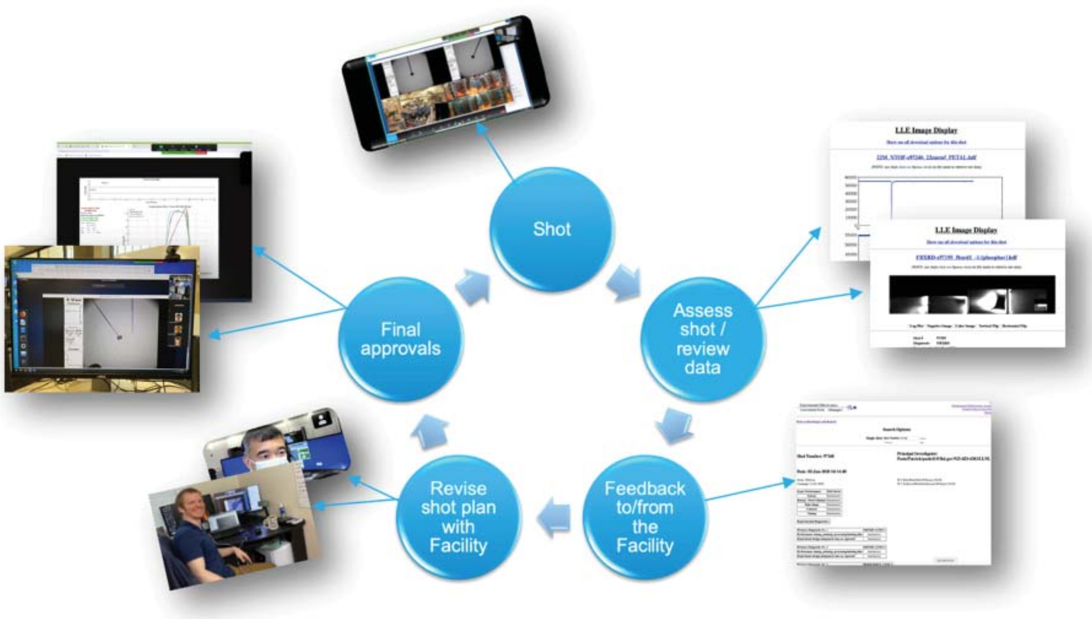


Fig. 4. All shot-day transactions between the PI and the facility are supported by the remotePI process

the system experts are not on site.

Today, PIs as well as many support staff and managers use the ***remotePI*** system to participate in shot operations on OMEGA and OMEGA EP on a daily basis while complying with the strict social distancing requirements that are essential to COVID-19 mitigation. While the modifications to the system to implement ***remotePI*** are modest in scope and now operate with little overhead cost, software and hardware updates needed to design and initially deploy the system required participation by many of our support staff, most of whom were working remotely themselves. Key to the success of ***remotePI***, only commonly available equipment (a PC or mobile device with an internet connection) is needed for a PI to fully participate in shot operations. Since resumption of shot operations in June 2020, all OMEGA and OMEGA EP shots have used the ***remotePI*** system. During our first seven months of operations, the effectiveness and availability results on both OMEGA and OMEGA EP are comparable to those of the seven months leading up to the pandemic. After-action reports from PIs have been largely complimentary.

Table 1

Comparison of OMEGA performance pre / post Covid-19

Date Range	Number of Shots	Average Availability	Average Effectiveness
9/1/19 – 3/22/20	648	93.9%	94.9%
6/3/20 – 12/14/20	658	91.1%	94.5%

Table 2

Comparison of OMEGA EP performance pre / post Covid-19

Date Range	Number of Shots	Average Availability	Average Effectiveness
9/1/19 – 3/22/20	503	96.7%	95.7%
6/3/20 – 12/14/20	516	93.9%	95.4%

In support of the remote PIs, most laser and experimental diagnostics are operated and maintained by LLE staff. In particular, the on-shot laser performance of the OMEGA EP short-pulse beams are thoroughly diagnosed with a suite of laser diagnostics in the Short-Pulse Diagnostic Package. Energy delivered to target is measured by the integration of images acquired with cooled, scientific-grade CCD cameras. These cameras are energy calibrated to 40-cm aperture calorimeters in the vacuum Grating Compressor Chamber. The transmission from the calorimeter to the target is calibrated offline using a ratiometer method. The temporal pulse is characterized using a spectral phase diversity measurement [1], and the measured pulse width is reported to the user. Timing errors are measured using a fast photodiode system with a pulse stacker. The prepulse contrast at the nanosecond scale is measured using a pair of fast InGaAs photodiodes, with a temporal resolution of approximately 200 ps [2].

The focal-plane irradiance profile is measured on shot using a remote wavefront sensor, calibrated to the target chamber using a process employing a focused single-mode laser back-propagating from the center of the target chamber [3]. A differential piston between the tiled-beam segments and other non-common-path wavefront errors are corrected using a phase-retrieval process [4]. The resulting wavefront and beam irradiance are used, along with the energy and pulse duration results, to calculate the irradiance distribution at the target plane. The irradiance at arbitrary defocus planes is also available to the remote PIs.

Laser-performance data from each target shot are available to users of the OMEGA EP laser via a web interface. On-shot energy, measured FWHM pulse duration, and timing error are displayed as text in data summary tables. The prepulse contrast is displayed as a plot of normalized power (dB) versus time for a period of approximately 500 ns prior to the pulse, with average energy and power contrast, as well as pedestal energy, summarized. The focal-spot irradiance data are displayed in a report showing target-plane irradiance distributions plotted on linear and logarithmic scales, and plots of encircled energy and a histogram of irradiance levels. The 80% encircled energy radius (R80, in μm) and peak irradiance in W/cm^2 are also displayed. While the data have been available online long before the advent of the COVID-19 pandemic, the existence of this infrastructure greatly simplified the transition to the new paradigm of supporting remote PIs.

Table 3

OMEGA EP performance with best compression, best focus, and maximum allowed energy

Laser parameter	Typical short-pulse performance
Energy	500 J
Pulse duration	700 fs FWHM
Prepulse contrast	Energy: >10^8, Power: >10^9, Irradiance: >10^{10}
Target plane 80% encircled energy radius (R80)	~17 μm
Peak irradiance	7×10^{20} W/cm^2

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First Commissioning Experiments with the 1 PW Beam Line of the Apollon Laser

Dimitrios N. Papadopoulos, Laboratoire pour l'Utilisation des Lasers Intenses (LULI), Palaiseau, France

The Apollon 10 PW laser has recently demonstrated its capacity of generating >1 PW pulses with <22 fs duration at 1 shot/minute, officially entering the phase of commissioning experimental demonstrations at ultrahigh intensity levels. Two experimental campaigns have already been conducted before the end of 2020 in one of the two interaction areas of the Apollon facility showing the high intensity capacity and reliability of the source. In this short letter we provide information on the laser system's current status and its mid-term upgrade perspectives, as well as a preliminary feedback from these two first experimental campaigns.

The Apollon laser, currently under construction at Orme des Merisiers, Saclay, France, aims to be among the first multi-PW installations in the world devoted to the study of high intensity laser-matter interaction at unprecedented regimes and peak intensities above $2{\cdot}10^{22}$ W/cm^2. The final goal of the Apollon laser is the generation of 10 PW pulses corresponding to an energy of 150 J and 15 fs duration at a repetition rate of 1 shot/minute [1-3]. The architecture of the Apollon laser is hybrid, combining a high contrast OPCPA based Front End [4] followed by 5 Ti:Sapphire multipass amplifiers, allowing it to reach up to 300 J before compression. Apollon provides up to four beam lines (10 PW, 1 PW, 100 TW, uncompressed beam), all generated by the same beam after the last amplifier with the possibility to be combined on the target under different geometries and synchronization configurations. The Apollon facility offers two experimental areas: 1) The Long Focus Area (LFA), where mostly gas targets and electron acceleration experiments will be realized and 2) the Short Focus Area (SFA), where tight focusing (F#2.5) on solid targets and ion acceleration is the principal objective.

Recently, the Apollon laser demonstrated the capacity of generating >1 PW pulses [5]. In Fig. 1 we give an overview of the obtained performances. A maximum energy of 38 Joules has been reached at the output of the 4-th amplifier with a uniform high quality flat-top beam (Fig.1, top-left). The pulse spectrum evolution in the laser chain is shown in the next graph (Fig.1, top-center), corresponding to a bandwidth of ~50 nm FWHM (at ~820 nm) at full power operation. Full aperture (140 mm) compression of the amplified pulses in the 1 PW compressor resulted in 21.5 fs pulses (for 21.3 fs Fourier transform limited duration), measured with a Wizzler device (Fig.1, top-right). Taking into account the beam transport losses (10%) and the compression efficiency (67%) (precisely measured for the full beam aperture), we estimate the peak power capacity of Apollon to be >1 PW at the output of the compressor. The end chain focal spot optimization is realized with the use of a single Adaptive-Optics closed-loop wavefront control system,

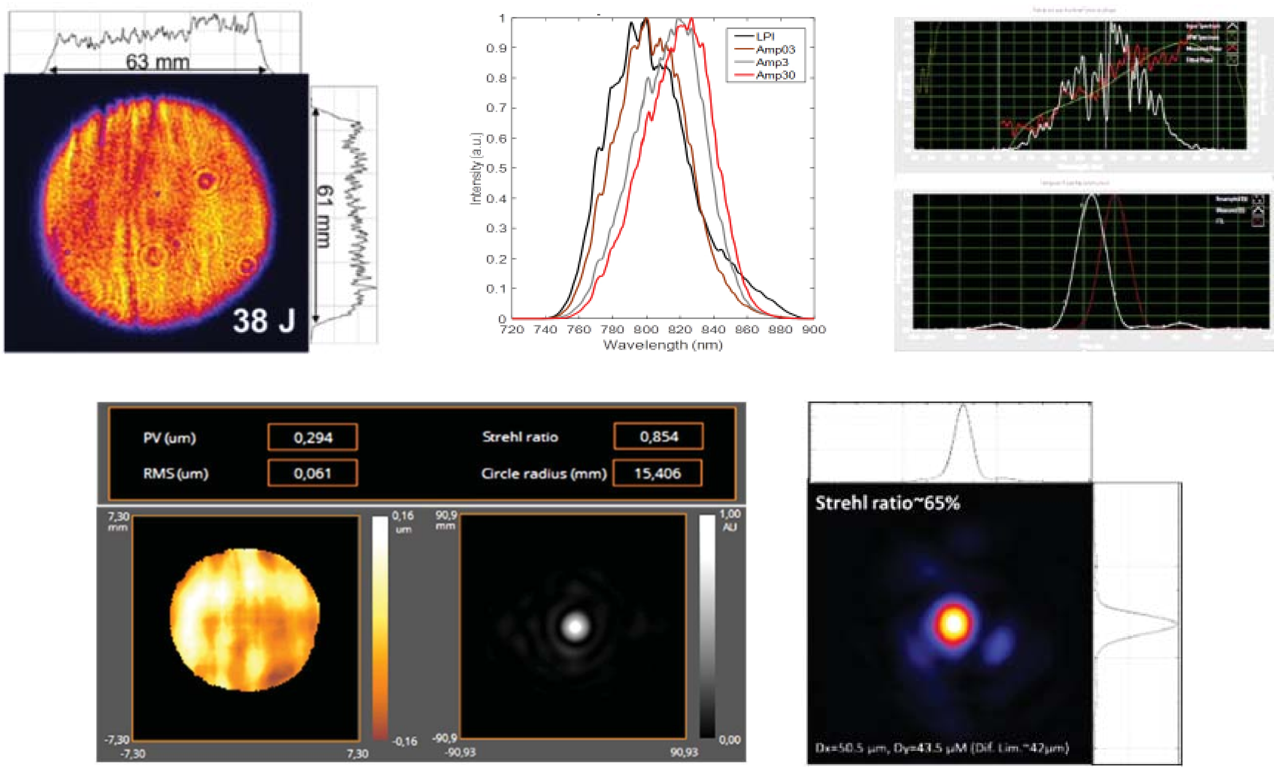

Fig. 1. Near-field beam profile at the output of the 4-th amplification stage (out of 5 in total) operating at 38 Joules (top row-left). Spectrum evolution throughout the laser chain: Front End (black line) to the 4-th Amplifier (red line) (top row-center). Wizzler measurement of the compressed pulses in the 1 PW beam line compressor (top row-right). Wavefront correction of the amplifiers output with 85% Strehl ratio (bottom row-left). Typical focal spot delivered on the target in the Long Focus Area (bottom row-right)

employing a 52-mechanical-actuators deformable mirror (ILAO-star, Imagine Optic) installed at the output of the amplification section. The optimization is based on a two-step process, starting with a closed loop correction before compression and followed by a manual optimization of the focal spot measured directly on the target. A Strehl ratio of >85% is routinely obtained in the first step and >60% for the on target beam (Fig.1, bottom-row).

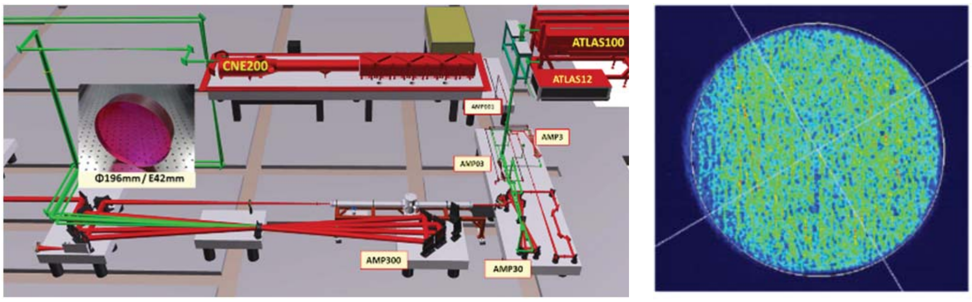

Fig. 2. Schematic of the complete amplification and pump section of the Apollon laser (left). Near field of the 200 Joules pump system already operational in our facility (right)

Two experimental campaigns, of two weeks total duration each, were realized using the 1 PW beam line in the LFA during the last two months of 2020. The main objective of both campaigns was the commissioning of the laser and the Apollon facility operational aspects as a whole.

The first one, in collaboration with the International Center for Zetta-Exawatt Science and Technology (IZEST), had as a goal the post compression of the Apollon beam, based on the spectral broadening effect in thin glass and plastic plates used at full aperture inside the LFA experimental chamber. For these experiments the delivered peak power has been adjusted up to ~250 TW with in total ~1000 shots realized. The obtained results are promising for the suggested technique, showing significant spectral broadening and the possibility of a twofold pulse compression with only moderate and controllable nonlinear impact on the focal spot quality. These experiments also allowed the qualification of fundamental characteristics of the Apollon laser, such as the end-chain near-field beam quality, the pulse compression fidelity, and stability, as well as the source day-to-day reliability.

The second campaign, and in fact the first laser plasma interaction experiment in the Apollon facility, has been a considerable milestone linked to the capacity demonstration of Apollon to handle safely the potential radiological dangers and the first step for the required formal authorization (Nuclear Safety Authority, ASN) for high intensity experiments on gas and solid targets. These experiments have been conducted by three collaborating laboratories: the Laboratoire Leprince-Ringuet (LLR), the Laboratoire d'Optique Appliquée (LOA), and the Laboratoire Interactions, Dynamiques et Lasers (LIDYL). In this first campaign, a typical electron acceleration configuration has been chosen with gas jets targets and moderate focal length end-chain focusing optics (f=3m, F#21). The electron energy diagnostics was used in correlation to a parametric optimization of the laser operation point and the interaction configuration with the target. The maximum, on the target, peak power in these experiments reached ~ 500 TW and ~ 500 shots in total were realized. The exact results from this first electron acceleration campaign in Apollon are currently under analysis and will be presented soon in a separate communication. The maximum observed electron energies are in the range that is expected from simulations for this laser power and plasma targets. Also, they clearly allowed qualifying the laser focal spot quality through the interaction volume and the peak power capacity of Apollon. Another significant result has been the contribution of this experience on the improvement of the on-shot diagnostics data archiving protocols.

With these two first demonstrations, Apollon made a significant step forward, but a lot is left to be done. 2021 will be particularly charged by both the next experimental campaigns (2 in SFA and 2 in LFA) and the scheduled upgrades of the system towards the multi-PW operation. In the following experiments, the qualification of the source (intensity, pulse contrast, stability…) will still be among the objectives, with the scientific innovation becoming progressively the main goal for Apollon and collaborators. The system upgrade will be mostly oriented towards the operation of the 10 PW beam line and the activation of the last amplification stage of the system (Fig. 2). For this, Apollon has recently acquired 3 ATLAS (Thales) pump laser systems (300 Joules). Added to the already operating 200 Joules pump source (CNE, Amplitude), they will allow the operation of the amplifier at ~250 J during 2021. The scheduled upgrade of the CNE source to 300 Joules (2022) will lead to the operation of the Apollon at the specified 300 Joules energy before compression. Pulse compression of the 10 PW beam line is scheduled for the second half of 2021 and beam delivery to the experimental areas for the first half of 2022.

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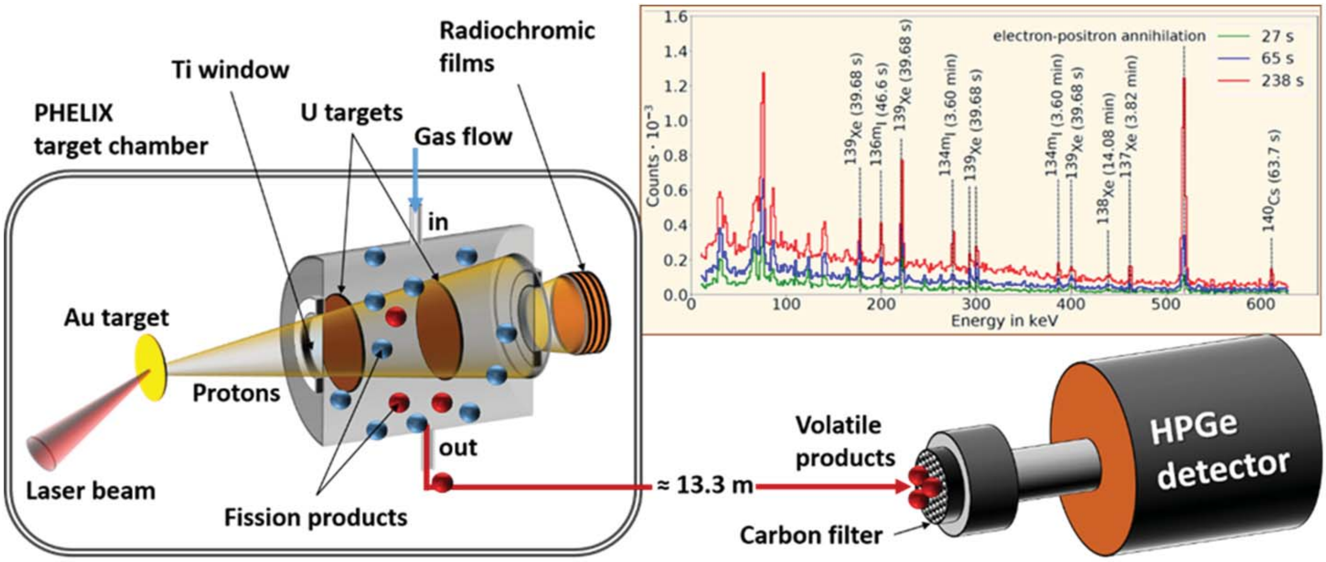
First Online Detection of Radioactive Fission Isotopes Produced by Laser-accelerated Protons

Thomas Kühl, GSI Helmholtzzentrum, HI Jena and Mainz University

The collaboration between the GSI research departments "Plasma Physics" from APPA and "SHE Chemistry" from NUSTAR, and a group from LLNL, USA, succeeded in using energetic TNSA protons generated with 500 fs pulses, of the high-intensity PHELIX laser (200 J), which, in turn, were used for the first time to induce a nuclear reaction. The protons irradiated a uranium-238 target, inducing fission. This produced, among others, the volatile fission fragments, iodine and xenon, which were transported from the target chamber to an activated carbon filter by means of a fast gas-jet transport, as it is often used in the chemical study of superheavy elements. The fragments' decay was registered with a germanium detector.

For the first time, it was possible in the experiments to combine the two techniques and thus to generate a variety of cesium, xenon, and iodine nuclei isotopes via the fission of uranium, to reliably identify them via their emitted gamma radiation, and to observe their short life time. This provides a methodology for studying fission reactions in high-density plasma-state matter. The results were published in Scientific Reports 10 (2020) 17183. The paper was advertised in a GSI media release.



Schematic of the experimental setup and an obtained spectrum. Credit: Alexander Yakushev and Pascal Boller

Report on ICUIL-related Activities

T. Tajima, Norman Rostoker Chair Professor, University of California at Irvine

I would like to make a brief report on the ICUIL-related activities I was either involved in or witnessed over the year that may be of interest to the ICUIL Community.

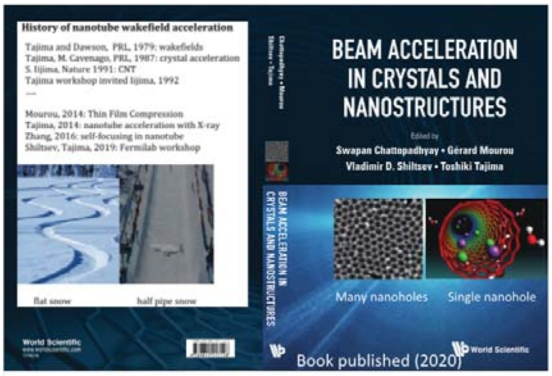
Perhaps the largest in terms of the impact was the Workshop on Beam Acceleration in Crystals and Nanostructures at Fermilab (June, 2019), organized by Vladimir Shiltsev and me. This was triggered by G. Mourou's invention of the Thin Film Compression (2014; verified now at EP, UCI, UM among other places) that opened up an efficient path to a single-cycle optical laser, which, in combination with the known Relativistic Compression of such a laser, can turn itself into a viable (single-cycle) X-ray laser pulse of high intensity. This provides a route toward attosecond, coherent, relativistic intensity X-rays. This technology, in turn, opened up X-ray-driven laser wakefields in nanotubes (2014). The above Fermilab Workshop showed the alert interest in this subject by the high-energy accelerator community and the laser and X-ray communities as well. In fact, so much so that the Workshop proceedings have been made into a book with the same title (see the figure). Dr. S. Hakimi (now at LBNL), for example, starred in her simulated X-ray wakefield acceleration "TeV on a chip" presentation. This Workshop spawned out a number of subsequent movements. I was asked to hold a colloquium at CERN (Geneva, Feb., 2020) on this subject while Dr. F. Zimmermann, who invited me to CERN, decided to follow up with the CERN-sponsored Workshop on this subject at Lake Geneva (March, 2020).

The interest did not stop there. I was asked to deliver a JST (Japan Science and Technology Agency) Nanotechnology Division Workshop (Sept., 2020) Lecture on this subject, showing the interest of the Japanese Government. I was also asked to write in a document on such a topic at the International Advisory Committee (Nov., 2020) to SIOM (Shanghai Institute of Optics and Materials, China).

In addition, I was invited to serve as Co-PI of a proposal to SLAC FACET II facility to test an e-beam drive version of nanotube wakefield acceleration (Oct., 2020).

In another distinct laser-related technology, we developed an efficient technique in the laser ion acceleration method (called CAIL). This method has been applied to accelerate deuterons to trigger energy-efficient fusion neutrons. Such neutrons may be employed to transmute radioactive nuclear waste. The Hungarian Government has been interested in this and we receive their support and collaboration (2020).

In a personal note, I was the recipient of the 2020 Charles Townes Award and inducted into a Fellow of OSA.



Gathered for nanotube wakefield acceleration (Fermilab, 2019)

CREMLINplus: European-Russian collaboration Grant agreement 871072

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

Efim Khazanov, Institute of Applied Physics, Nizhny Novgorod

In the earlier newsletters, the ICUIL community got acquainted with the international project CREMLIN (Connecting Russian and European Measures for Large-scale Research Infrastructures) that was a Coordination and Support Action supported by the Horizon 2020 framework programme of the European Union. The Project aimed at fostering scientific cooperation between the Russian Federation and the European Union in the development and scientific exploitation of large-scale research infrastructures (RI). The project was intended for 3 years, during which each consortium member organized working meetings, focus workshops, and round tables with participation of other CREMLIN members to discuss problems of mutual interest and find ways for their solution. CREMLIN was seen as a vehicle and platform to move the discussions around large-scale research infrastructures and as a means to establish links between the project participants and the European Strategy Forum on Research Infrastructures (ESFRI) and other relevant EU organizations.

The project CREMLIN was completed successfully and clearly demonstrated that the collaboration can be continued with the ambitious aim to achieve a significantly higher level of cooperation between European and Russian partners. The new project CREMLINplus aims at European-Russian scientific and technical collaboration in the field of research infrastructures. It addresses all the recommendations that were worked out in the close European-Russian collaboration within the three years of the Horizon 2020 project, CREMLIN, and its implementation is scheduled for a period of 4 years.

30 European and 5 Russian participants of the project have come together to build the broad and balanced consortium, connected through a history of trustful collaboration. The project has two main strategic objectives:

• Technical preparation of the megascience projects for European and international utilisation. The project will allow European-Russian collaborative top teams to develop and deliver the finest, novel, cutting-edge technologies for both the Russian megascience projects and their European counterparts. The specific objectives range from design of special instruments and neutron sources for the PIK facility for research with neutron beams, the state-of-the-art detector technologies for particle accelerators and for neutron sources, the development of instrumentation for NICA, and designing linear accelerator and beamlines for the USSR, to the development of components and diagnostics for the high-power laser facility XCELS, and others.

• Preparation of a set of Russian research infrastructures for international access and utilisation by developing and implementing suitable framework conditions for opening and accessing these Russian facilities, and also by creating a broad base of knowledge and expertise for RI managers and scientists at various levels. This objective also implies implementing a targeted EU-Russian training and staff exchange programme. Also, the preparation of the Russian megascience projects for European and international users is part of this strategic objective.

The project tasks will be implemented by 10 work packages (WP). Each work package includes several partners. For example, the Institute of Applied Physics of the Russian Academy of Sciences is the leading partner of work package 6 (WP6). The other WP6 partners are Commissariat à l'Énergie Atomique et aux Énergies Alternatives, France (CEA), Association Internationale Extreme-Light-Infrastructure Delivery Consortium, Czech Republic (ELI-DC AISBL), and Laserlab-Europe AISBL, Belgium (LLE-AISBL). WP6 is dedicated to joint technology development around XCELS – Exawatt Center for Extreme Light Studies.

One of the major motivations of XCELS is reaching the non-linear QED regime using an approach based on the combination of 12 multi-PW laser beams. Such a huge laser will provide peak intensities that will be around 10^{26}W/cm^2, 3 orders of magnitude below the Schwinger limit, but still 2 orders of magnitude above the intensity of any other laser project under construction. Finding realistic approaches to reaching XCELS' intensity and further is essential for such a project. WP6 aims at developing the necessary technologies to provide the key technological foundations for the XCELS project, namely

For nonlinear optical devices:

• Conceptual design of a relativistic plasma mirror well-suited for XCELS;

• Design and development of a prototype of nonlinear compressor of ultraintense laser pulses.

For ultrashort beams:

• Technologies for ultrashort laser pulse contrast enhancement based on non-linear optical devices;

• Design of a single-shot spatio-temporal diagnostic device for ultrashort / ultraintense laser pulses well-suited for XCELS.

Training and scientific exchange on beam delivery, laser pulse contrast issues, metrology, and best practices are also among the important project tasks.

CREMLINplus is a grand project setting out to fully implement jointly elaborated European-Russian collaboration roadmaps and to ensure that the framework conditions will be improved and continually harmonized. The project participants are the relevant entities in the domain of research infrastructures in Europe and in Russia, and thus provide the necessary strength, commitment, and power to implement the project plan.

Tribute to David Neely

Prof. John Collier, Central Laser Facility, Rutherford Appleton Laboratory

2020 will be remembered as a tragic year for one dominant thing – the coronavirus and its new words, like "COVID-19". But, for the ICUIL community around the world, it will also be remembered for another tragic reason – the untimely passing of one of our most respected colleagues, Prof. David Neely from the UK's Central Laser Facility (CLF), after a short and sudden illness.

Dave was one of the outstanding scientists of his generation and one of the eternal scientific pillars of the CLF, our local Community in the UK and the international scientific community at large. He was fiercely bright, full of ideas, and a natural collaborator who loved working with others, new and old, close and far and who always had time for everyone. He was a passionate advocate for our user Community, its science, and above all else he wanted it, rather than himself, to be successful. He worked tirelessly to that aim, and in so doing became one of the preeminent minds in high energy density science globally. He was universally admired.

We all remember him as a brilliant mentor to people, especially students, at all stages of their career, and countless numbers have been guided and helped to where they are today. He had collaborators and friends from the ICUIL community all over the world, winning prizes on far away shores. Dave exuded energy, warmth, positivity, and oomph – always can do, will do with his hugely infectious personality.

He will be sorely missed, and as we now move into 2021 and the hope of a more positive year, the hole that Dave has left behind will sadly remain. I want to close with a positive thought in that, even though Dave was taken far too early, we were all lucky to have had the time with him that we did. He was a splendid human being that enriched us all. The ICUIL community is better for him having been part of it. Dave lifted us all, quietly, and we are profoundly grateful to have known him as a colleague and a friend.

International Seminar “Classical and Quantum Physics in Extreme Light Fields” dedicated to Nikolay Narozhny’s 80-th birthday

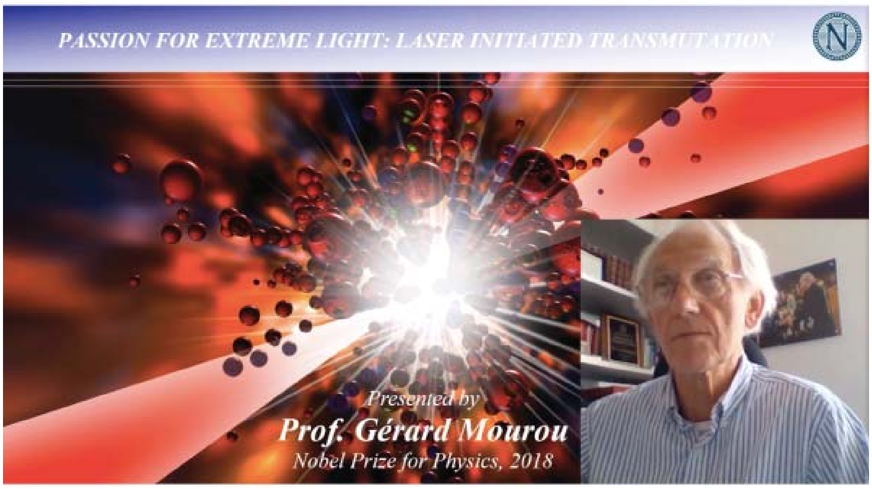
Sergey Popruzhenko, Prokhorov General Physics Institute RAS, Russia

An international online seminar on recent advances in the generation of extreme electromagnetic fields and their application for studies of fundamental phenomena in physics was conducted by the National Research Nuclear University MEPhI on the 6-th of November, 2020. The seminar was dedicated to the 80-th birthday of Nikolay Narozhny (1940–2016), the Russian theorist world-renowned in the field of strong-field classical and quantum electrodynamics.

Professor Narozhny belongs to the famous cohort of physicists who founded, in the mid-1960s, the nonlinear quantum electrodynamics, a new branch of physics studying the phenomena of dynamics, radiation, and creation of particles in the field of intense electromagnetic radiation, which can be delivered by high-power lasers. Over his more than half-century research career, Nikolay Narozhny made pivotal contributions to the theory of nonlinear QED effects in superstrong electromagnetic and gravitational fields, quantum optics, the theory of radiation, and the theory of ponderomotive scattering in focused laser pulses. His works of the recent years were closely connected with the ongoing projects of high-power laser facilities aimed at entering the expanse of extreme light physics. They include, in particular, the calculations of pair production and quantum cascading under the conditions close to those expected in exawatt laser sources of the near future. These recent works have rapidly become highly recognized and frequently cited in the research community.

Over more than 30 years, Nikolay Narozhny was chair of the Theoretical Physics Department at MEPhI, where he founded an internationally recognized scientific school in nonlinear quantum and classical phenomena in intense electromagnetic fields. The school keeps growing and successfully works in this presently thriving research area.

The seminar brought together about 150 researchers from more than 10 countries. The MEPhI rector, Mikhail Strikhanov, and Gerard Mourou, the Nobel Laureate of 2018 in Physics, opened the seminar with a presentation about N. Narozhny’s work at MEPhI and with the greetings to the seminar participants. Sergey Popruzhenko gave a talk dedicated to Narozhny’s scientific legacy. The invited speakers of the seminar presented the state-of-the-art overviews in the field of extreme light physics. The presentations reported on the progress of the recently commissioned multi-petawatt lasers, Apollon (Michael Crech, Ecole Polytechnique) and Extreme Light Infrastructure (Georg Korn, ELI), and the plans for the future exawatt laser facility XCELS (Efim Khazanov, IAP RAS). Recent and future strong-field experiments and their theoretical interpretations were also reviewed, including the generation of high-power gamma flares (Sergei Bulanov, ELI), self-trapping of extreme light (Valery Bychenkov, Lebedev Institute RAS), and proposals for the LUXE experiment (Ben King, University of Plymouth). Finally, an overview of the strong-field theoretical concepts was made in connection with the Narozhny-Ritus conjecture (Alexander Fedotov, MEPhI), the radiation reaction concept (Antonino DiPiazza, Max Planck Institute for Nuclear Physics), and QED cascades in super-intense laser fields (Igor Kostyukov, IAP RAS).



Inaugural 10 PW and Users Symposium: Moving into Uncharted Territories

Kazuo A. Tanaka, Extreme Light Infrastructure: ELI-NP

ELI-NP (Extreme Light Infrastructure: Nuclear Physics) in Romania has started constructing both large laser and gamma beam facilities as part of the project financed by Romania and the European Commission under the structural funds programme since 2010 and aims to operate them for the world users in a year or so. ELI-NP is located in Magurele, just at the outskirts of Bucharest in Romania. On Nov. 17, 2020, ELI-NP held the Inaugural 10 PW and Users Symposium: Moving into Uncharted Territories on Zoom with more than 230 worldwide scientists and professors attending. This symposium was intended to show the capability of the laser system that can deliver multiple high-power shots at 10 PW every minute.

After the Symposium was opened by Prof. Nicolae Victor Zamfir, Project Director, Prof. Donna Strickland, 2018 Nobel Physics Laureate at the University of Waterloo, Canada, congratulated everyone with this unprecedented moment by stating that ELI-NP had opened a totally new path to the high-intensity laser science. Then, Prof. Kazuo A. Tanaka, Scientific Director, reported on the current status of ELI-NP for the user facility, including several fascinating research plans for the upcoming commissioning experiments on electron acceleration, non-linear QED, and dark matter physics.

Dr. Ioan Dancus, Laser Department Head, then started showing the laser performance test in real time with Dr. Olivier Chalus (Thales, France) [1]. This real time demonstration showed the laser system shooting every minute starting at 3 PW, 7 PW, and finally at 10 PW for several consecutive shots, while 223 participants watched this on Zoom. The laser beam was forwarded to the pulse compressor chamber and was transported through the vacuum laser beam channel connected to one of the large experimental chambers planned for the user experiments. The laser characteristics for each shot, including the near and far field patterns, pulse width, laser spectrum, and output energy in the experimental chamber, were shown on the large display screen. The peak power was determined as the measured laser energy divided by the laser pulse width.

The tours to the experimental areas had been recorded a few days before the Symposium and were guided by Dr. Catalin Ticos, Head of Laser Experiment Department. The Symposium participants watched the movie about the started 100 TW laser experiments, such as electron acceleration with an energy more than 200 MeV and a very good control of the energy spectral shape. The chambers for 1 PW and 10 PW output waiting for the user experiments were also demonstrated.

Prof. Gianluca Sarri, Queens University of Belfast UK, gave an invited talk on the New Intensity Frontier: The opportunities of the 10 PW scale by describing the possibility of QED. He predicted that more than 10^3 pair productions may occur by shooting the 10 PW laser against 4 GeV relativistic electrons, which can be considered to be one of the most exciting experiments performed at ELI-NP.

Prof. Gerard Mourou, 2018 Nobel Physics Laureate at IZEST, France, gave an invited talk at the end of the Symposium. It is well known that the original pulse compression scheme, called the chirped pulse amplification (CPA) technique, proposed by him and Prof. Donna Strickland in 1985 was recognized to be the base for laser systems in the ELI three pillars (ELI-ALPS in Hungary, ELI-BL in the Czech Republic, and ELI-NP in Romania) and was awarded with the Nobel prize. In his talk, he proposed another idea of further pulse compression that can intensify the 10 PW, laser by more than 10 times, namely up to 100 PW, and showed many new sciences that have become possible, such as the medical applications and nuclear fuel waste transmutation.

Reference

1. High Energy Hybrid Femtosecond Laser System Demonstrating 2x10 PW Capability, F. Lureau, G. Matras, O. Chalus et al., High Power Laser Science and Engineering, **8**, e43(2020); DOI10.1017/hpl.2020.41.

The laser shot demonstration at 10 PW output.
The large display screen showed various laser data such as the near and far field patterns, spectrum bandwidth, and output laser energy

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