CLPU CENTRO DE LÁSERES PULSADOS

Activities Report

2014

UNIÓN EUROPEA
FONDO EUROPEO DE DESARROLLO REGIONAL
"Una manera de hacer Europa"

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Junta de Castilla y León

VNIVERSIDAD D SALAMANCA
CAMPUS DE EXCELENCIA INTERNACIONAL

Welcome to the CLPU!

Message from the Director

Message from the Director

I am glad to present once again the Activity Report of the Pulsed Lasers Centre, which reflects our work during the year 2014, in the firm belief that we are consolidating our lines of work.

Undoubtedly, the most relevant milestone reached by the Pulsed Lasers Centre (CLPU) throughout this year was its inclusion into the new Roadmap of Unique Scientific and Technological Infrastructures of Spain.

The Science, Technology and Innovation Policy Council, which is the organ in charge of the general coordination of scientific and technical research, made up of representatives from the central government and the autonomous communities, approved on October 7th 2014, the updated Roadmap of Unique Scientific and Technological Infrastructures of Spain (ICTS). This update of the ICTS Roadmap carried out by the Council is included into the Spanish Strategy of Science, Technology and Innovation as a tool for the planning and development of these infrastructures in coordination with the autonomous communities of Spain.

In this update, a series of criteria of maximum scientific, technological and innovation quality have been taken into account, and the different ICTS have been subject to a strict process of independent assessment in which its economic sustainability was guaranteed, which means that priority was given to operating infrastructures and facilities under construction.

The 29 ICTS which include 59 different infrastructures have been grouped into three types: ICTS networks, distributed ICTS and single-location ICTS. The CLPU has been classified into this last section, and it is one of three infrastructures currently in its construction stage.

All the infrastructures went through a process of evaluation of their scientific and strategic plans and the CLPU was classified as excellent, with a report that highlighted the scientific, technological and even

political importance of this project, which will place Spain into a position of leadership. The assessment report also emphasizes its user-oriented nature and the strategic pillars included in the plan.

The CLPU, as a users and research centre and, in its role as an agent that channels knowledge on ultra-intense lasers, provides the necessary tools to activate the mechanisms of knowledge transfer and innovation, as will become evident during the rest of this report.

This report lists the activities that have been carried out in order to promote knowledge and support private-public collaboration through a distribution of contents that will make it possible to gain access to the relevant information on the centre, the evolution of its infrastructure, the scientific and technological results obtained and the objectives that have been reached.

Our challenge for the year 2015 is to carry on with the installation of the VEGA laser, one of the most powerful lasers in the world, and an element which makes the CLPU a truly unique centre.

I do not wish to forget my sincerest thanks to all the workers of the Pulsed Lasers Centre and to all the people who have contributed to promote the CLPU and to carry out the different research and innovation activities in favour of social development.

1. Description of the Centre

1.1. GENERAL INFORMATION

The Pulsed Lasers Centre (CLPU) is a Consortium created in December 2007 and composed by the Ministry of Economy and Competitiveness (MINECO), the Regional Government of Castile and León and the University of Salamanca (USAL), and it is located in the Villamayor Science Park (Salamanca).

This infrastructure is dedicated to researching and developing ultra-intense lasers, and it works with a titanium:sapphire laser system, VEGA, which uses CPA technology (chirped pulsed amplification) and can operate with pulses with a duration of 30 femtoseconds, with a peak intensity of 1 petawatt. This complex equipment will become one of the ten most powerful lasers in the world.

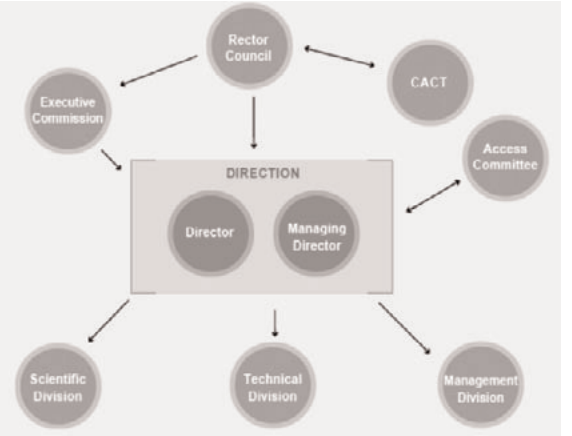
This technology has applications in different fields of interest, both in research and in the industry. Among others, we can mention the measurement and control of elemental nature processes in a time frame of attoseconds, the development of new sources of light, the production of nanoparticles and nano-surfaces, micromechanics of all kind of materials for industrial purposes (in aerospace, microelectronics, implantology,...), the development of microsurgery techniques, the visualization of biological tissue and molecules, research in new optical phenomena, etc.

We may summarize by saying that the CLPU is a unique, public infrastructure whose use is available for the entire research community, both from the public and the private sector, and that it has to reach the following objectives:

- Maximum scientific, technological and innovative quality.
- International scope.
- Economic sustainability over time.
- Capacity to cater to the scientific, technological and business community.

1.2. GOVERNING BODIES

The following graph illustrates the organization chart of the CLPU, and here is a detailed account of the main governing bodies.



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Mr. Juan Manuel Corchado Rodríguez

Research Vice-Chancellor. University of Salamanca.

Mr. Ricardo López Fernández

Financial Vice-Chancellor. University of Salamanca.

The Rector Council and the Executive Commission are composed of members from the three founding institutions of the Consortium.

Director	Mr. Luis Roso Franco Full Professor of Optics Area. Department of Applied Physics University of Salamanca
Managing Director	Mr. Pedro García García Managing Area CLPU

STAC meeting on the CLPU facility, in december 2014.

Scientific and Technical Advisory Committee (STAC)

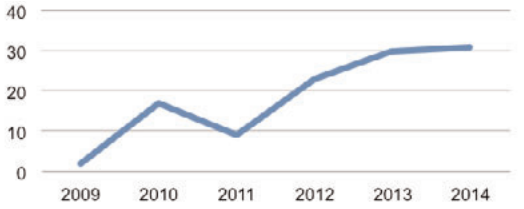
The Scientific and Technical Advisory Committee of the CLPU is made up of 10 members who do not belong to the institution; all of them internationally renowned scientists in the field of intense lasers. The objective of the Committee is to assist the Rector Council on the future scientific and technological programs, plans, activities and proposals which may contribute to promote the quality of the Centre. According to the statutes of the Committee, along this year there has been a partial renewal of its members, who held their first meeting in December 1st 2014, on the occasion of the Fourth Users Meeting of the CLPU.

1.3. HUMAN RESOURCES

The global economic crisis that took place in 2007 has had a significant impact on all the sectors of the Spanish market. This has led to the appearance of a series of very restrictive policies and measures aimed at reducing public expenditure in all areas, and particularly with regard to the incentives for research and innovation.

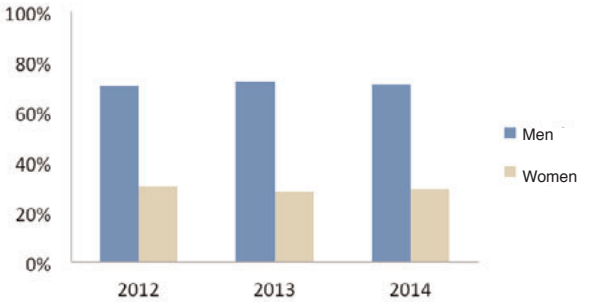
Staff overview

As can be seen in the figure below, the growth of human resources has come to a standstill in the last few years, which represents a substantial difficulty to undertake the different projects and strategy which has been laid down for the long-term aims of the CLPU.



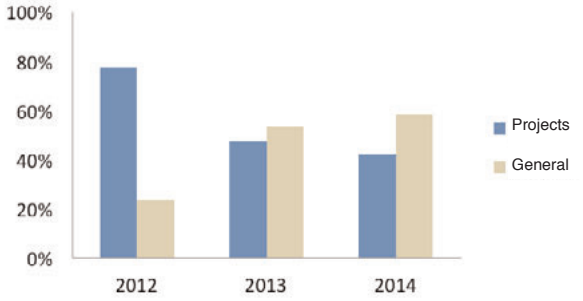
Staff evolution in the Centre.

Currently, there is a higher proportion of men than of women in the centre, and this same trend has remained stable over the last few years.



Gender comparative.

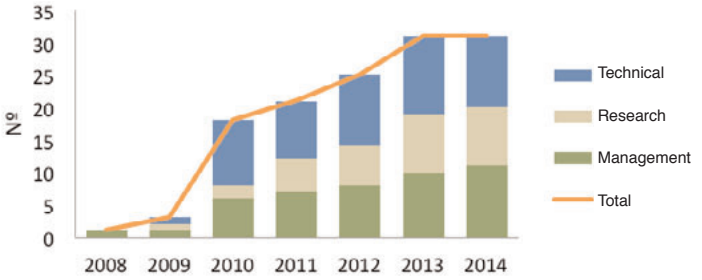
Due to the lower number of projects initiated over the last years, the staff has been hired thanks to the financing of the general budget of the centre, as can be seen in the following figure.



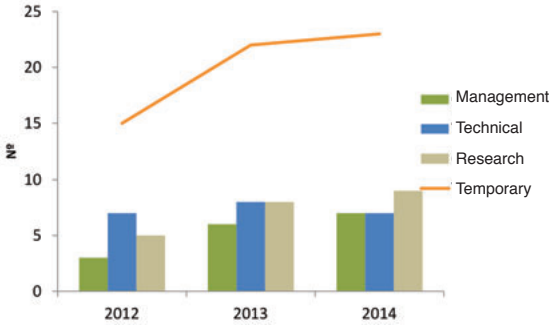
Comparative of the source of recruitment.

We cannot forget that the evolution of the staff is changing slightly, and that the scientific profile of our workers is gaining importance. In fact, 80% of our postgraduate staff is found in this area.

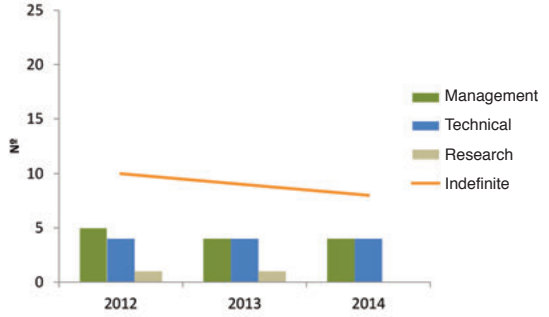
Similarly, the trend regarding the type of contract shows that the main contracts are temporary, mainly due to the fact that the staff is associated to projects which have a limited duration.



Changes in staff by area.



Temporary contracts by area.



Indefinite contracts by area.

1.4. TECHNICAL RESOURCES

VEGA

What makes the Pulsed Laser Centre a unique scientific and technological infrastructure is VEGA, a laser system which is able to reach a petawatt of power. This equipment can research in the frontier of knowledge, promote laser science and technology and turn it into an essential tool in industrial innovation.

Like the rest of the systems in the CLPU, VEGA is a CPA system based on the titanium:sapphire technology (Ti:za). It is unique because of its design, which starts from moderate levels of energy (30 J) and produces high-powered very short pulses (30/25 fs) with high contrast and a repetition rate (1 Hz) which also makes it exceptional from an international perspective. The high spatial quality of the beam makes it possible to focus it in very small areas, with a pulse intensity that reaches 10^{21} W/cm^2.

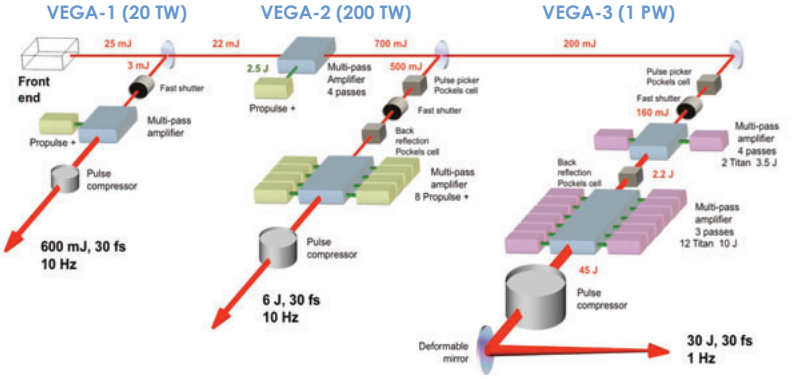
Another important characteristic is that it has three synchronized amplification lines with a single front-end, which makes it possible not only to work in parallel with the different beams, but also to carry out pump-probe experiments. The following table details the characteristics of the different outputs of VEGA:

Output	Energy/ shot	Duration/ Pulse	Wave leng. central	Peak power	Repetition rate
VEGA-1	600 mj	30 fs	800 nm	20 TW	10 Hz
VEGA-2	6 J	30 fs	800 nm	200 TW	10 Hz
VEGA-3	30 J	30 fs	800 nm	1 PW	1 Hz

This unique design has been developed in stages, which correspond to each of the outputs. The first two sections were assembled at the end of 2012, but it was in 2013 when the acceptance tests were carried out, once it had been checked that the pulse energy before compression, its duration and the repetition frequency coincided with what had been specified. Later, the vacuum chamber of VEGA-2 was received, designed and installed in collaboration with ICTS CELLS. This is a crucial element for the operation of this output from the system because it

must be taken into account that owing to its power this type of laser must propagate through a vacuum to prevent non-linear effects.

In the last quarter of 2014, the last stage of the system, VEGA-3, was received, and its installation began immediately after and will continue for the next months.



Scheme of the three outputs of VEGA.

> VEGA-1

Scientific-technological interest: Filamentation, generation of high harmonics, attoscience...

> VEGA-2

Scientific-technological interest: Particle acceleration, applications in radiopharmacy, generation of coherent X-rays...

> VEGA-3

Scientific-technological interest: Laboratory astrophysics, nuclear energy, relativistic microphotonics, proton therapy...

COMPLEMENTARY SYSTEMS

Apart from its main foundational value, during the economic crisis the CLPU has decided to broaden its offer of laser technology. Thus, while

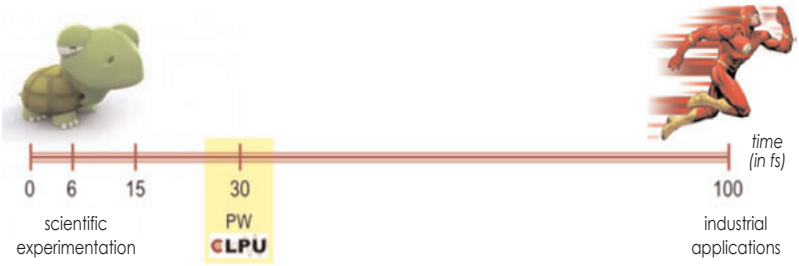
offering greater technological support to the research of its users it has had a noteworthy impact on a broader sector of the regional economy.

High Repetition Rate (HRR) laser system

This femtosecond laser system is a commercial Spitfire equipment from Spectra Physics. It is able to emit pulses at 7 mJ with a high repetition rate of up to one kilohertz. It operates at 800 nanometres, close to the infra-red and just outside the spectrum which is visible to the human eye.

The KHz – 100 fs laser may be considered a "long pulse" laser, compared with other lasers which operate in the facilities of the CLPU. It distributes 7 mJ to the microprocessing and radiation stations

The PW laser pulse operates at 30 fs, a range in which it can easily work between industrial development and the field of scientific experimentation.



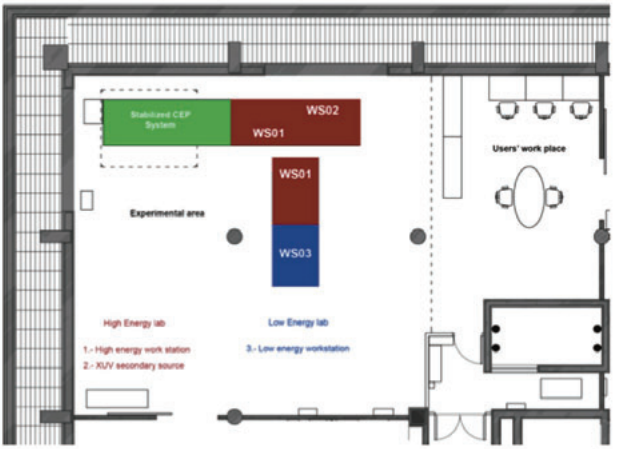
The Petawatt of the CLPU is situated between the scientific experimentation and the industrial applications.

The most important aspect of this system is not the high quality of its beam or its stability but the two laboratories it feeds, which were designed to study laser/matter interactions (microprocessing laboratory) and to promote research into X/gamma rays via laser/plasma acceleration (X-Ray generation laboratory).

> *Microprocessing Laboratory*

This has three work stations, two of which are operational: one is versatile (WS03) and the other is specific (WS01).

The third one, which is also specific, will deal with trepanning and automation processes, and it is currently in the process of installation (WS02). It is expected to start working in 2015.



> *X-Ray Generation Laboratory*

This has an optical table prepared for the investigation of new sources of incoherent X-rays and the study and characterization of energetic electron beams. As a Category 3 radioactive installation, permission for its use was requested from the Regional Government of Castile and León (the competences for such decisions have been granted).

CEP (Carrier Envelope Phase) SYSTEM

This laser is a Femtopower device able to generate ultrashort pulses (23 femtoseconds after amplification) and with just a few cycles

(5 femtoseconds or less after post-compression). It is able to work with a stabilized CEP and at a central wavelength of some 800 nanometres, in the Near Infra-Red range. The He Pro CEP has a fourth-generation stabilizing system, which enables complete control of the relative phase value in all the pulses emitted by the laser.

Among its applications, spectrometry and real-time measurements, broadband photonics, attoscience and XUV radiation are especially important.

The characteristics of the system, together with the design of its laboratory, offer reliable and highly stable experimental conditions as well as a very precise degree of control over the particularities of the radiation.

> *High-energy Laboratory*

This laboratory has two work stations. In one, the amplified beam (primary source) is used at power levels of dozens of GW or even 100 GW for studies in non-linear optics, femtochemistry or time-resolved spectroscopy. At the other work station, the amplified beam is focused (before or after post-compression) on a gas inside a vacuum chamber, generating coherent radiation in the ultraviolet ray region (XUV). This radiation can be used both in attoscience and in XUV applications.

> *Low-energy laboratory*

This laboratory has a work station fed either from the beam from the oscillator or from a leak from the CEP stabilization module. It was designed for applications using high-repetition rates, photonics, broadband experiments, etc.

SUPPORT UNITS

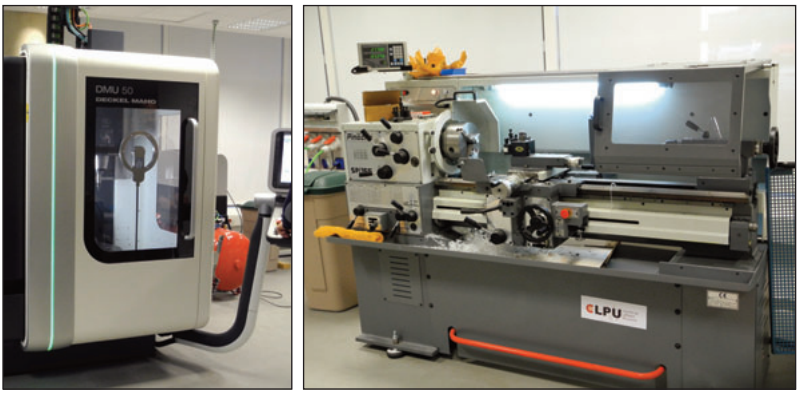
The CLPU is strengthening its strategy of innovation by setting up systems complementary to VEGA. Among them, the most important are the support units with which the CLPU helps to increase the spillover effect from the knowledge-economics axis.

> *Mechatronics Laboratory*

The Mechatronics Laboratory was born from a fusion of the mechanical and electronics workshops. It was created to provide service to both the users of the CLPU and other users from the industrial sector. One of its functions is to produce custom-built parts for the CLPU and to meet its needs so that there will not be a constant demand of parts from abroad or the need to modify commercially available parts that do not always match the desired purposes.

The key element at the workshop is a continuous five-axis milling machine able to manufacture highly complex parts, ranging from opto-mechanical mountings to personalized prototypes custom-built for users. The production process begins with a detailed 3D design of each of the elements to be made. Once that they have been approved these models are coded into specific instructions for the milling machine via a computer program. The material is prepared and the parts are adjusted by means of other equipment available at the laboratory: a lathe, a saw, a vertical drilling machine and other minor tools.

Additionally, the CLPU has an electronics section prepared for the design and production of custom-built circuits capable of integrating different types of sensors or actuators. To achieve this, there are oscilloscopes and generators of functions and delays, all of them digital and latest-generation.



Five-axis milling machine and lathe mechatronics laboratory.

> *Microscopy*

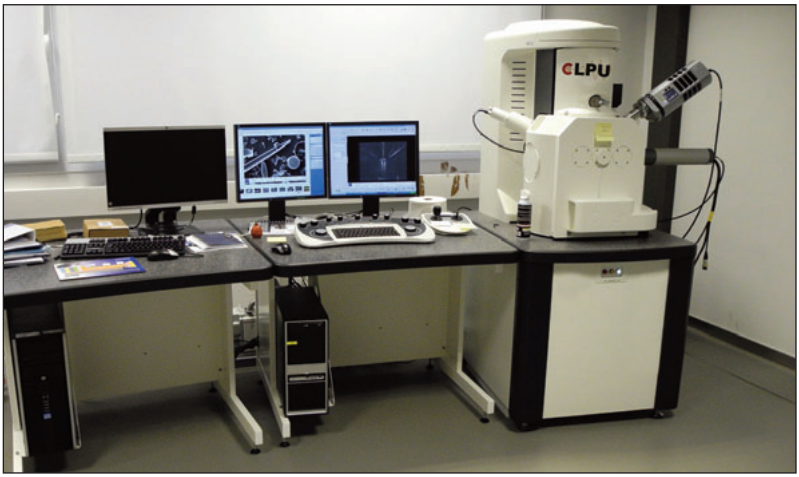
Microscopy encompasses a set of techniques and methods that allow objects to be seen that, owing to their size, would otherwise be invisible to the human eye. The CLPU contributes to this technological support area in research into chemistry, geology and mining with two devices: an Atomic-Force microscope and a Scanning Electron microscope.

Atomic Force Microscope (AFM)

The AFM is a mechanical-optical instrument to allow 3D (topographic) images of the surface of a sample to be acquired via a probe shaped like a pyramid.

This is a NANOTEC microscope that enables the characterization and visualization of samples at a nanometric scale and even at an atomic scale, with a scanned area of 80 × 80 microns.

The main working method is topographic in contact mode in air (measurement of terraces or how objects are distributed in the surface).



Scanning Electron Microscope (SEM) of the CLPU.

Scanning Electron Microscope (SEM)

The EVO HD25 is a last-generation device able to analyse samples with a resolution of 20 nm. The SEM methodology consists of scanning the sample surface with accelerated electrons. An electromagnet detector measures the amounts and intensity of the electrons interacting with the sample, generating images of its surface in black and white. The sample must be metalized to prevent electric charges from forming on the surface.

Technical details:

> A thermo-ionic electron gun with a LaB6 filament

> Clean vacuum, turbomolecular pump

> Variable pressure (10 – 400 Pa)

> Three different types of detector for results optimization:

  – SED (secondary electrons), which allows image capture in real time.

  – VPSE, this eliminates charge effects by a gas that ionizes the molecules, neutralizing the electrons trapped on the surface. Accordingly, the SE emission is stabilized.

  – BSD, detection of electrons by backscattering.

> Large sample holder (a rotating carousel with 9-12 mm diameter bases)

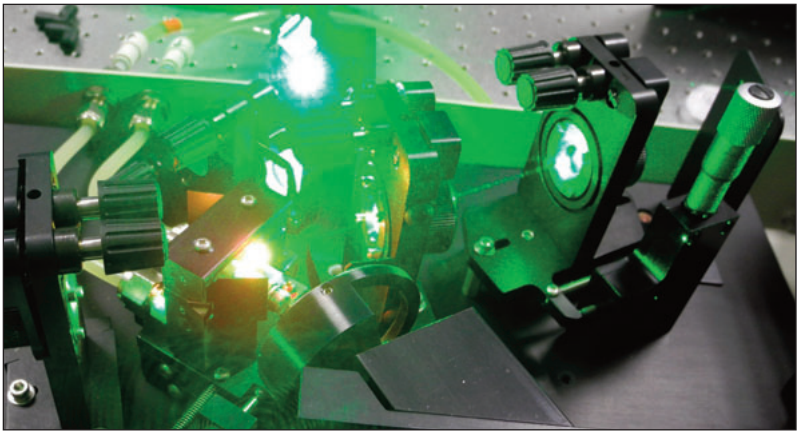
> Eleven ports for detector accessories and possible amplification to 3000 Pa.

Furthermore, the SEM of the CLPU has been equipped to deal with semiquantitative EDS (energy-dispersive spectroscopy) microanalysis to obtain the composition of the sample, which must be polished for such work to be successful. Towards the end of this year, the pertinent training courses were completed prior to starting up service for the next year.

> Oscillators

The Laser Oscillator Unit was created with a view to promoting laser technology for professionals working in the industrial sector. The unit contributes strategically to the transfer of know-how, fostering the passage from research to application and from application to innovation.

Currently, this Laser Oscillator Unit is available for use by all users at the CLPU who request its services. Users can find information ranging from consultations about laser equipment to its use or integration in different applications. In 2014, activities were performed upon request for Spanish Universities, CSIC agencies and Spanish companies working in the laser sector.



Mounting experimental laser oscillator unit.

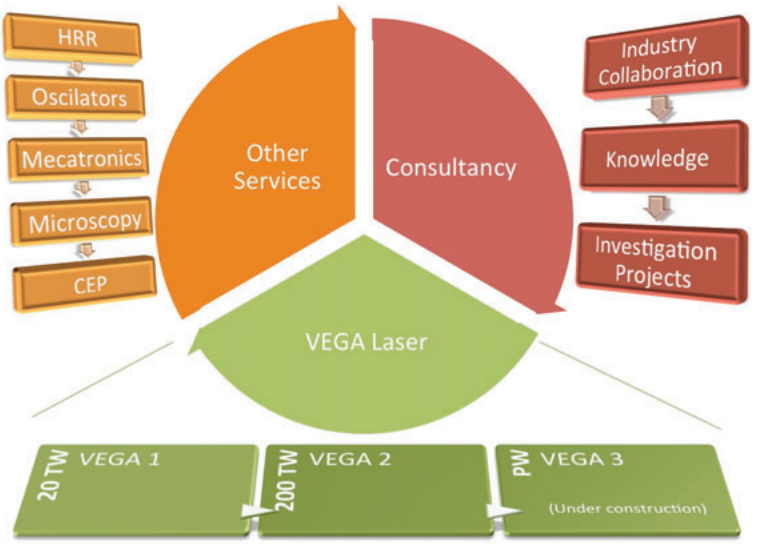
This unit has the following elements:

- Coherent Verdi-G20 continuous laser at 532 nm and up to 20 W.
- Ti:sapphire laser in continuous wave mode and tunable from ~ 700 up to 1000 nm with an output power of the order of 2 to 3 W.
- An He-Ne laser (CW, 632 nm, 7 mW) and a low-power NdYAG laser.
- 1 femtosecond laser oscillator, under construction, with Ti:sapphire.

- 1 laser oscillator based on ytterbium doped crystals at picoseconds and femtoseconds regime which was developed in this unit. This oscillator is currently operational.
- Measuring equipment for laser pulse times (APE-Berlin Pulse Check 60 fs-150 ps).
- Power meters (Gentec, from μW to hundreds of W), laser beam profile meters (Gentec Beamage 3.0) and spectrometers (APE and Mightex of 300-2,600 nm).
- Photodiodes from 40 ps to a few ns (Alphalas, Hamamatsu and Thorlabs).
- Tektronix 4-channel oscilloscope (500 MHz) with RF (3 GHz)
- Specialized software: LASCAD, Zemax, etc.

1.5. SERVICES

As a users facility under construction, the main objective of the centre is the creation of an avant-garde infrastructure oriented to research



and experimentation in all the fields of ultrashort and ultra-intense lasers. Based on all the facilities and technical resources available, we have established seven different lines of work in which the Centre provides its services. These seven services can be classified into three product blocks: VEGA laser, Consulting services and Other services.

What follows is an outline of each of these services:

– VEGA services. The main laser equipment in the CLPU centre is the VEGA laser. This device has two different outputs: one of 20 terawatts (VEGA1) and one of 200 terawatts (VEGA2), which are currently available for the users. They can be operated to work on different applications, such as very high-order harmonic generation, proton and electron acceleration, intense beam and X-ray propagation. The third output (VEGA3) is in its installation stage, and it is expected to start operating in the year 2016.

- HRR (High Repetition Rate), kilohertz laser system.

- CEP (Carrier Envelope phase), which includes experiments from two areas of the spectrum, the infra-red range and the extreme ultraviolet range.

- Oscillators. The main objective of this unit is to provide support to the different users in the advanced technologies of photonics, optics and the design and optimization of laser systems and components.

- Mechatronics, which create custom-made pieces, mountings, tools, etc, for the centre.

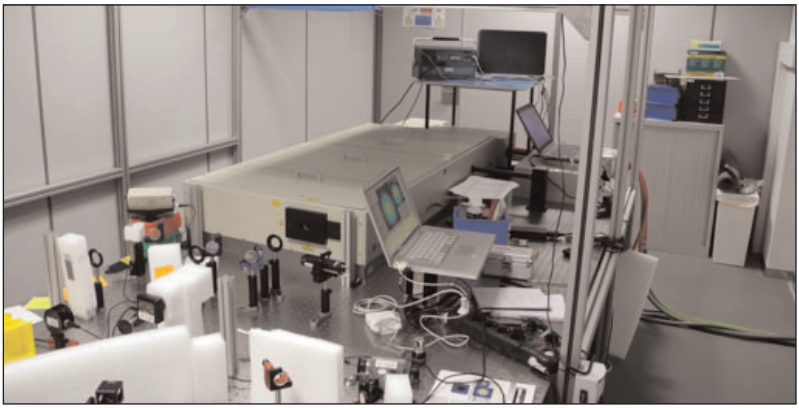
- Microscopy, which includes the set of methods and techniques that allow objects to be seen that, owing to their size, would otherwise be invisible to the human eye.

- Consultancy. The CLPU has a specialized team for collaboration tasks between the research and the industry fields. One of the premises of the staff in the centre is the responsibility of economic growth and knowledge transfer with the companies that require their services.

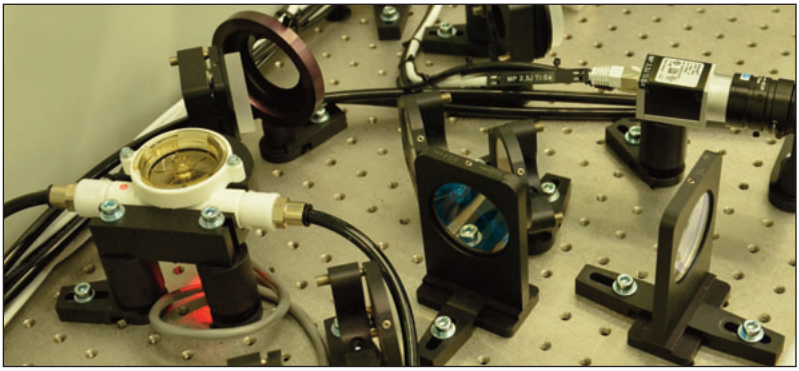
2. Infrastructure Management

2.1. LATEST GENERATION FACILITIES

During the last three years the CLPU has focused on equipping its installations with the necessary facilities to carry out different national and international projects, and to promote it as an essential tool in industrial innovation. In the year 2014, the CLPU has installed the petawatt laser system (VEGA) and studied and designed its optimal configuration, including the area target and the experimental mountings that can be adapted to the different experiments and projects that the users may want to develop.



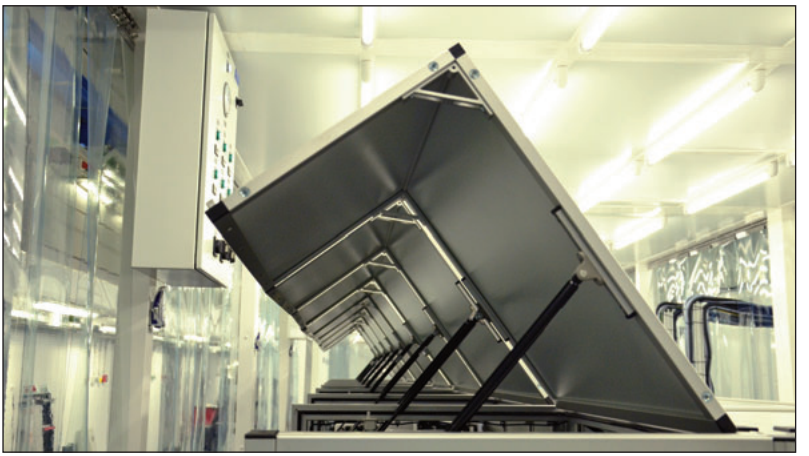
Kilohertz laser system.



Detail of one of the assemblies of equipment VEGA-2.

The first two stages are currently operational and have previously been described in the technical resources section of the Centre. These facilities have already received different test users who used their services.

Stage 3 (also called VEGA3) is the Petawatt laser, whose installation started in the year 2013, and its technology makes this a unique Centre. With it, Salamanca becomes the first Spanish city to have one of the ten more powerful lasers in the world.



Overview of the system hosting the equipment VEGA-3.

All these activities are co-funded by the ERDF agreements (European Regional Development Fund)

This system is located in the bunker of the lower-ground floor of the M5 building, in the Science Park of the University of Salamanca, in Villamayor, and more specifically in a $60 \times 10 \times 6$ m lower-ground area which includes the laser area, compressors area, experimentation area and control area.

Since the use of this laser is highly restricted, its installations and facilities must comply with a particularly demanding set of security requirements. In fact, the security measures associated to this facility have

View of the main entrance M5, CLPU headquarters.

been supervised and monitored by the Spanish Nuclear Safety Council (CSN).

The following section details the evolution of the infrastructure and reviews its main areas and the most relevant projects that have been carried out in them during the year 2014.

2.2. LASER AREA

The laser room includes a system for the strict control of temperature, humidity, environmental radiation and geological stability to guarantee a proper operation of the laser. Also, the building has had to meet a series of very strict technical specifications, including measures to guarantee the structural stability of the construction, the placement of a casing which absorbs vibrations from the subsoil or the erection of concrete walls separated by polystyrene sheets in order to prevent the transmission of vibrations from the rest of the building. Additionally, and due to the critical nature of the system, it is essential to guarantee thermal stability, humidity control and energetic efficiency.

This area was equipped with the corresponding optical tables and laminar flow cabinets which create at all times a clean environment for work.

After the laser system was received from the factory, the installation works started in September, and at the end of the year the front end had been activated, the oscillators and amplifiers aligned and the control command programming started. A technical corridor and a maintenance room were designed and built to service the pump lasers and, more specifically, their power supply units.

Partial view of the technical corridor that hosts sources power pump lasers.

2.3. COMPRESSORS AREA

The compressors area of the M5 building has the main objective of compressing the necessary energy pulses, whose duration is approximately 30-25 fs. To do so, it will hold two rooms which correspond to the output of VEGA2 (200 TW) and VEGA3 (1 PW). These rooms have been jointly designed by the CLPU and another ICTS of reference in Spain: the ALBA Synchrotron.

The first of these rooms, which has already been completed, has dimensions of 1.48 × 1.78 × 0.68 m, and it is entirely made of stainless steel. The two most innovative elements of this room are the laser viewports and the breadboard. Due to their large size, viewports are hard to find in the market, and it was finally decided to design and create a set of viewports which met all the requirements established by the Centre. This designed was approved on this year 2014 as a uti-

lity model. The breadboard was also an innovative design which combined different ideas to achieve a very high mechanical stability as well as a great robustness. This makes it possible to properly isolate the optic compressor from mechanical vibrations.

The second room, which is now under construction, is a 3.48 × 1.81 × 1.75 m chamber built in stainless steel and aluminium. The design of this new compressor evolves from the two most innovative aspects of the previous one. The viewports increased their size and, subsequently, their mechanical requirements. The breadboard was also larger, and it was necessary to introduce more supporting pillars and to improve the design in order to achieve a very high mechanical stability and robustness. Also, due to the size of the chamber, a study on the ergonomics of the room has been carried out so as to improve its usability.

In energies over 1 Terawatt (1 Petawatt = 1,000 Terawatts), pulses need to propagate through a vacuum in order to prevent the non-linear effects that appear. Therefore, and in order to guarantee the correct operation of these chambers, a centralized primary vacuum system has been implemented with two vacuum units (vacuum pump

Compressor vacuum chamber.

NC0200B and roots pump WV0500C), tubes for the lines of rough vacuum and fore-vacuum and connections for the pipes and the valves. The chamber also has an electric board for manoeuvre and power, programmed for the control of the installation.

2.4. EXPERIMENT AREA

The installation has a main experiment area, which will hold all the beam transport systems, as well as the experimentation chambers for the output of VEGA2 and VEGA3. In the year 2014 the area has been shielded in order to guarantee its radiological safety and the necessary flexibility to adapt it in the future to the requirements of its potential users.

For this experiment area, a request has been submitted to the Nuclear Safety Council to classify it as a second-category installation.

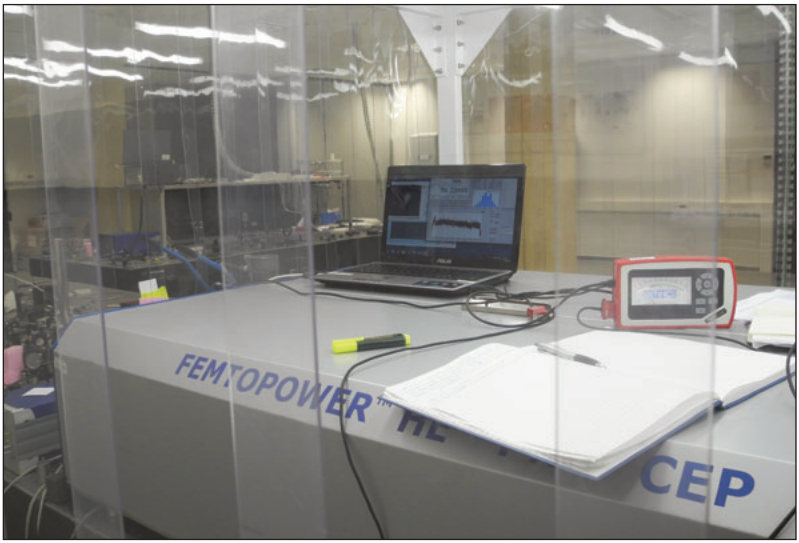
The infrastructure also has a secondary experiment area with four different laboratories, with their respective experimental stations. The most significant advance in this area throughout the year has been the authorization to start the IRA 3254 radioactive installation, which corresponds to the X-ray station.

Control screen experimental area.

With regard to the microprocessing laboratory, the second work station (WS03) started to operate around mid-year for internal use of the experimental set-up process, technical area, conoscopy systems and characterization of waveguides processed by the WS01 work station.

During the year 2014, the Oscillator Unit initiated 1 laser oscillator based on ytterbium-doped crystals with a picosecond and femtosecond regime.

With regard to the experimental area of the CEP system the original characteristics set by the manufacturer (energy and duration) were improved in the post-compression stage, and the experimental harmonics station was completely and satisfactorily reinstalled in summer. In parallel with these events, towards the end of the year a shielding structure for the laser beam was installed for safety reasons and to transport the beam to the experimental stations. Also, two experimental stations are installed provisionally: a structure for an atmospheric pressure time of flight (ToF) system and a prototype for the INNPACTO project, which required the use of the CEP laser system in several experimental campaigns.



CEP system installed on a laboratory CLPU.

2.5. CONTROL AREA

As has been mentioned before, the laser area requires a series of advanced systems for the control of the different devices and infrastructures. For this reason, a specific control room has been designed and built for the management of the systems that guarantee a correct operation of the laser. This room is separated from the laser area by a protective screen.

The room includes five different pieces of equipment:

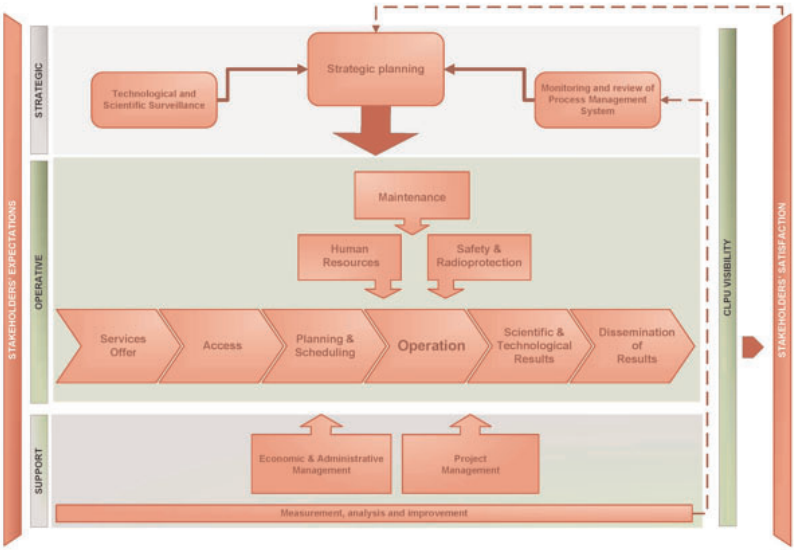
- Security control. It provides a real-time security system.
- Building monitoring. It guarantees a correct operation of the Centre.
- Laser-related infrastructure. These installations include flow cabinets, sensors for vibration and temperature, etc.
- Laser-related control system. This system is restricted to the laboratory area.
- A collaboration has started with the Automatic Control Group of the University of the Basque Country in an attempt to contribute to the quality of our installations and to position the control systems associated to the experiments of our centre in an EPICS network.

VEGA control room.

2.6. PROCESS OPTIMIZATION

Parallel to the technological and scientific development of the installation, new management processes are implemented so as to place the centre in a lead role regarding the different organizational and functional models.

The process management system has already been implemented in the CLPU, as can be seen in the following figure:



With regard to the area of electronic administration, and in an attempt to establish a more effective and sustainable model, the CLPU has implemented an electronic billing system and a database with the profile of the centre's contractors, as well as a new website and a new management software package.

Thanks to this tool, which has become a collaborative platform, users can complete all the necessary stages to access the installations of the centre through a completely electronic system.

Also, and as part of our commitment to continuous improvement, a procedure was implemented to obtain information on user satisfac-

tion with regard to the services provided by the centre which will make it possible to analyse and assess their opinion.

Finally, apart from the recognition represented by the inclusion of the centre in the ICTS Roadmap, the annual report from the Operational Programme 'Research, Development and Innovation for and by Enterprises - Technology Fund' from 2013 has praised the processing system of the ERDF agreements of the centre as a model of good practice.

3. Scientific and Technological Excellence

3.1. RESULTS

3.1.1. Patents

As a result of its collaborations with the private sector, and particularly with the industrial sector, the CLPU is already co-owner of several patents, jointly with Iberdrola Ingeniería (System and procedures for the recovery of gaseous substances from gaseous flows) and with Proton Laser Applications (Intra-Operatory Carbon Ion Radiation Therapy System and Optical Pulse Generator). As a result of the work carried out in 2014, two new requests have been filed, one of them for a patent and another for a utility model:

Name: Vacuum Vessel and a Part of the bounding Thereof

Ownership: CLPU

Area: International

Date: 06/03/2014 - No.: 14382080.1

Name: New viewport design compatible with high vacuum

Co-ownership: Synchrotron Alba Cells

Area: Domestic

Date: 17/10/2014 - No.: u201431357

3.1.2. Publications

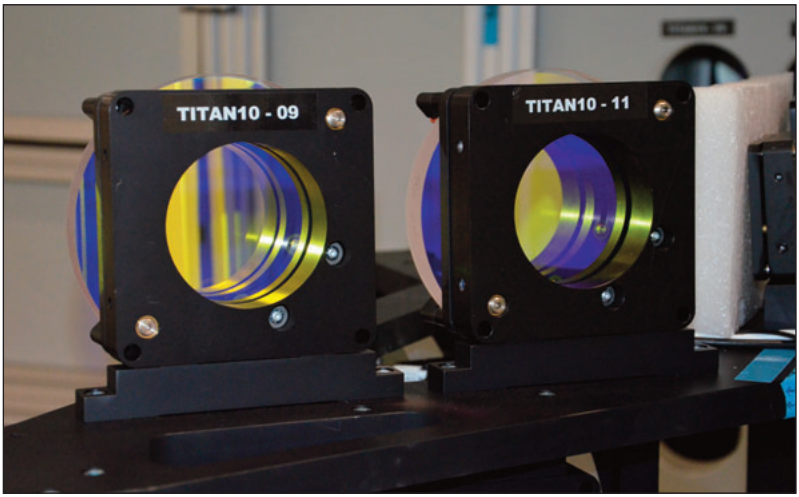
From the Centre

- M.F. Ciappina, J.A. Pérez-Hernández and M. Lewenstein, CLASS-STRONG: Classical simulations of strong field processes, Computer Physics Communications 185, 398-406 (2014). IF (2013): 2.407.
- M.F. Ciappina, J.A. Pérez-Hernández, T. Shaaran, M. Lewenstein, M. Krüger and P. Hommelhoff, High order-harmonic generation driven by metal nanotip protoemission: Theory and simulations, Physical Review A 89, 013409 (2014). IF (2013): 2.991.
- M.F. Ciappina, J.A. Pérez-Hernández, T. Shaaran and M. Lewenstein, Coherent XUV generation driven by sharp metal tips photoemission, Eur. Phys. Journal, 68:172 (2014). IF (2013): 1.398.
- R. Montero, V. Ovejas, M. Fernández-Fernández, A. Peralta Conde and A. Longarte, Revisiting the relaxation dynamics of isolated pyrrole, The Journal of Chemical Physics 141, 014303 (2014). IF (2013): 3.122.
- J.A. Pérez-Hernández, M.F. Ciappina, M. Lewenstein, A. Zaïr and L. Roso High-order harmonic generation at high laser intensities beyond the tunnel regime, Eur. Phys. Journal D, 68:195 (2014). IF (2013): 1.398.
- R.J. Gray, D.A. MacLellan, B. González-Izquierdo, H.W. Powell, D.C. Caroll, C.D. Murphy, L.C. Stockhausen, D.R. Rusby, G. G. Scott, R. Wilson, N. Booth, D.R. Symes, S. J. Hawkes, R. Torres, M. Borghesi, D. Neely and P. McKenna, Azimuthal asymmetry in collective electron dynamics in relativistically transparent laser-foil interactions, New Journal of Physics 16 (2014). IF (2013): 3.673.
- L. Volpe, J-L. Feugeas, Ph. Nicolai, J. J. Santos, M. Touati, J. Breil, D. Batani, and V. Tikhonchuk. Controlling the fast electron divergence in a solid target with multiple laser pulses. Phys. Rev. E 90, 063108 – Published 9 December 2014.
- S. Teichmann, P. Rácz, M. Ciappina, J.A. Pérez-Hérnandez, A. Thai, J. Fekete, A. Elezzabi, L. Veisz, J. Bieger and P. Dombi, "Strong-field plasmonic photoemission in the mid-IR at < 1 GW/cm^2 intensity", Accepted (in press) in Scientific Reports, IF (2013): 5.078.

- M. F. Ciappina, J. A. Pérez-Hernández, L. Roso, A. Zaïr and M. Lewenstein, High-order harmonic generation driven by plasmonic fields: a new route towards the generation of UV and XUV photons? Accepted (in press) in Journal of Physics. IF (2013): 1.715.
- R. He, I. Hernández-Palmero, C. Romero, J.R. Vázquez de Aldana and F. Chen, Three-dimensional dielectric crystalline waveguide beam splitters in mid-infrared band by direct femtosecond laser writing, Optics Express, 32 (2014) 31293. IF (2013): 3.525.

From users (acknowledgements to the CLPU)

- B. Martín-García and M.M. Velázquez, Nanoparticle Self-assembly assisted by polymers: the role of shear stress in the nanoparticle arrangement of Langmuir and Langmuir–Blodgett Films, American Chemical Society, Langmuir 2014, 30, 509-516.
- Mª C. Lorenzo Luengo, DOCTORAL THESIS: Aplicación del láser de femtosegundos en esmalte: análisis morfológico y mejora de la eficacia adhesive bracket-esmalte [Application of femtosecond laser on enamel: morphological analysis and improvement of the adhesive bracket-enamel effectiveness], 2014.

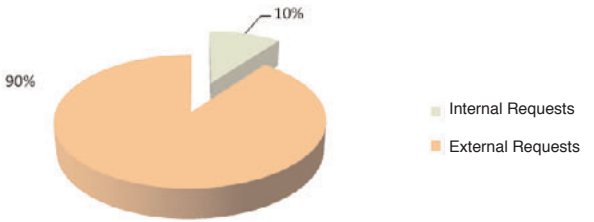


Lens belonging to TITAN systems.

- Mª T. Alejo Cuesta. Películas delgadas de Quantum Dots, Tensioactivos y Polímeros Autoensamblados [Thin films of quantum dots, tensoactives and self-assembled polymers], 2014. Dpto. Química Física. Facultad de Ciencias Químicas.
- G. Liu et al., Optical waveguides in LiTaO3 crystals fabricated by swift C5+ ion irradiation, Nuclear Instruments and Methods in Physics Research, B 325 (2014) 43-46.
- H Liu, et al., Continuous wave lasing at 1.06 μm in femtosecond laser written waveguides, Optical Materials, 37 (2014) 93-96.
- R. Borrego-Varillas, et al., Spatio-temporal dynamics of femtosecond pulses shaped by diffractive optical elements, Communication in Ultrafast Phenomena, 2014.
- W. Holgado et al., Temporal and spectral structure of the infrared pulse during the high order harmonic generation, Optics Express 22 (2014) 10191.
- J.A. Novóa López, Doctoral thesis, University of Vigo, September 2014.

3.1.3. User Access

In 2014, the Centre has received requests from many users who wished to access its operative infrastructure and work with the different research lines that are currently available. In total, 49 requests have been received. 90% of these requests came from external users. Virtually 100% of the requests have been accepted, although ultimately only 96% have been executed. The cases in which the process was interrupted it was due to the users' decision.

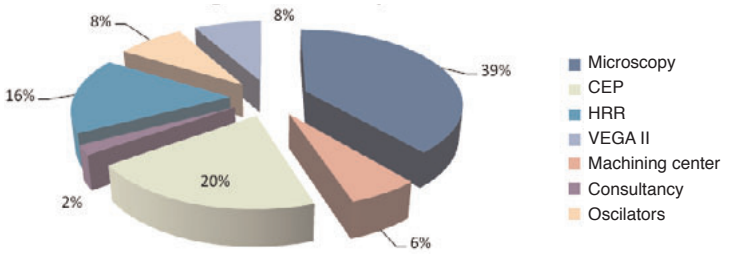


Received requests.

As can be seen in the following graph, the research line of microscopy is clearly, and as in previous years, the recipient of the highest number of requests (39%). However, on the previous year it represented 93% of all requests, which means that the rest of the services are starting to receive more requests.

It may be highlighted that the CEP line is now in second place, with 20% of the requests, compared with only 3% in the previous year. This can be explained by the intense activity of this service along the year. There have been two experiment campaigns with external users (from four different academic institutions). An article was published and 4 presentations delivered in international conferences, as well as an external thesis whose experimental work was carried out in the CEP laboratory. Also, there was a growing internal demand (from the CLPU centre) for the use of the laser.

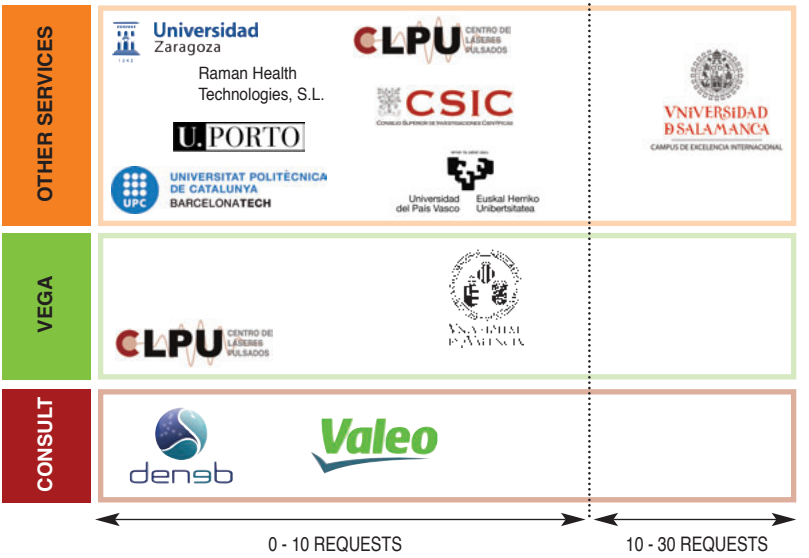
What follows is a chart with the different requests submitted, classified according to the research lines.



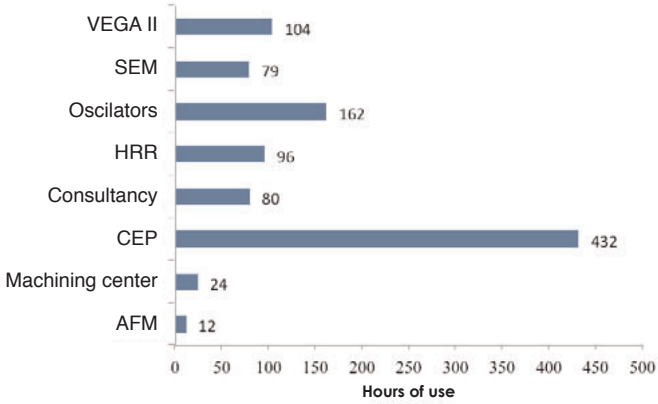
Requests depending on equipment.

During the year 2014, several users from different institutions and organizations have made use of the equipment of the CLPU. Below there is a figure detailing the different institutions who have submitted a request for each type of service.

In view of the fact that the Centre is only now starting to be operational, we want to show in the graph the time of use for each of the different installations which were available during the year 2014. We have to factor in that the Centre is still not operating at 100% of its capacity, and that, consequently, the staff in the CLPU have combined



their activities as researchers with their support for external users, apart from the tasks derived from working in a building under construction.



Timing of the use of the equipment.

3.1.4. Contributions to Conferences

In the year 2014, the CLPU has participated in the following workshops and presentations:

ECLIM.
Date: 31/08/2014 to 5/09/2014
Place: Paris (France)
Title of contribution: "Laser Particle Acceleration at the Pulsed Laser Center (CLPU)"

HILAS2014.
Date: 18/03/2014 to 20/03/2014
Place: Berlin (Germany)
Title of contribution: "Harmonic Emission Beyond the Carbon Kedge Using Spatially and Temporally Synthesized Laser Field" and "Laser-matter phenomena driven by plasmonic near-fields"

LasersForLife Conference
Date: 1/06/2014 to 5/06/2014
Place: London (United Kingdom)

INREX Meeting
Date: 31/03/2014
Place: Poland
Title of contribution: "Coherent radiation beyond the water window driven by 800 nm laser pulses: theory and simulations"

Induciencia 2014 Platform
Date: 7/03/2014
Plce: San Sebastián (Spain)
Title of contribution: Perspectivas y oportunidades en el ámbito de las instalaciones científicas de láseres pulsados [Perspectives and opportunities in the area of pulsed laser scientific installations].

University of Sevilla
Date: 21/04/2014
Place: Sevilla (Spain) (Physics Department)
Title of contribution: Vega: A unique Petawatt laser for Science & Innovation

Charlas en el Bulevar
Date: 22/04/2014
Title of contribution: El láser: principios y aplicaciones. Todo un mundo más allá de la depilación láser [Laser: principles and applications. A whole new world beyond laser hair removal]

Target Interaction Challenges and Developments
Place: Abingdon (United Kingdom)
Date: 29/04/2014
Title of contribution: VEGA Targetry Related issues

Hipolin 2014
Date: 30/06/2014 to 11/07/2014
Place: Crete (Greece)
Title of contribution: High Power Laser Technology Part II

International Summer School: "Frontiers on Photonics and Laser Technologies"
Place: Santiago de Compostela (Spain)
Date: 2/09/2014
Title of contribution: High Power Laser Technology: Systems and applications

COST MP1203
Date: 29/09/2014 to 1/10/2014
Place: Dubrovnik (Croatia)
Title of contribution: X-ray source based on a HRR Laser: A User Facility

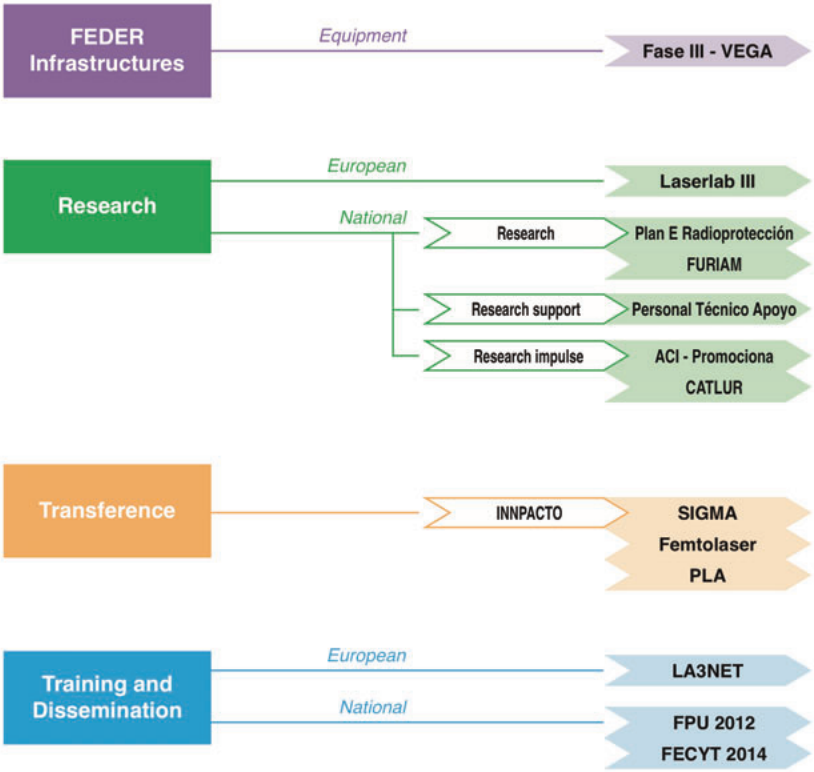
Technical Workshop on UltraFast Lasers
Date: 11/11/2014
Place: SECPhO, Madrid (Spain)

Technical Workshop on CO_2 treatment
Date: 16/12/2014
Lugar: Hospedería Fonseca, Salamanca (Spain)
Title of contribution: Presentation of the PW

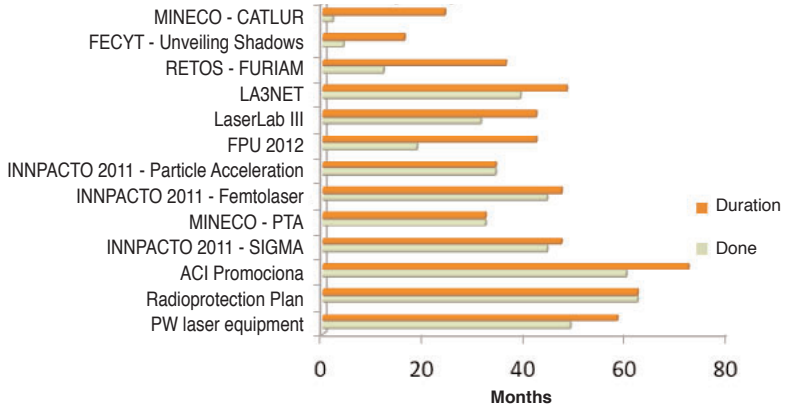
3.2. RESEARCH, DEVELOPMENT AND INNOVATION

3.2.1. Scientific and Technological Projects

Over the year 2014 the CLPU took part in 13 scientific projects, as can be seen in the following figure:



As can be seen, three projects have been completed in 2015: an INNPACTO project (particle acceleration), a technical support team project and the radioprotection project. All the remaining projects will continue during 2015.

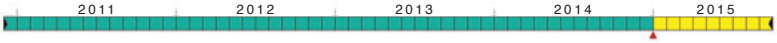


Project implementation

Here is a list which describes the characteristics of each of the projects and activities that have been carried out until the end of December 2014.

MICINN > ICTS co-funded by the Operational Programme of the Technology Fund

Equipment of the petawatt laser (Phase III)

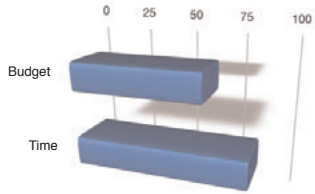


Director: Luis Roso		**Collaborators:** CLPU	
Start: 29/11/2010	**End:** 31/09/2015	**Duration:** 58 months	**Completed:** 84%

Description: Co-funding of a petawatt laser device to be coupled to VEGA-2 (200 TW) and VEGA-1 (20 TW). Key device of the CLPU as a unique scientific-technological infrastructure.

Actions:

In February 2014 an extension of the current ERDF agreement was requested, and it was granted until September 30th 2015.
The acceptance tests were carried out in the factory in March. Two tenders related to these actions have been published: on the one hand, the supply of a centralized vacuum system made up of a pump system that creates primary vacuum in the compressor chambers; and on the other hand, the supply of two laminar flow cabinets which will cover the entire laser system, in order to protect the two areas of the laboratory where the main elements of the petawatt laser will be installed, and to keep them clean and stable.
In September 2014, the petawatt laser system was received in the CLPU from the Amplitude factory in France.
Prior to the installation of this laser system, and given its complex nature, different actions have been undertaken, including the building of an enclosure, the creation of a technical corridor, the installation of additional power panels, the reconfiguration of the HVAC system, the acquisition of compatible optical tables and the completion of the reinforced shielding for the experimental area.



MICINN > ICTS agreements

Creation of a radioprotection plan for the CLPU

2009 2010 2011 2012 2013 2014

Director: Luis Roso		**Collaborators:** CLPU	
Start: 18/10/2009	**End:** 31/12/2014	**Duration:** 62 months	**Completed:** 100%

Description: The aim of the CLPU is to lay down, for the first time in Spain, the bases of radiological protection for a laser installation such as the one housed at the CLPU.

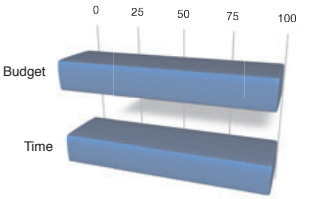
Actions:

Thanks to the Plan E, a Category 3 authorization has been granted, the first one in Spain for a laser radiological installation.

The basis of the project lies in the determination of the generated radiation in the interaction between laser radiation and matter. After all these years of work, it has been observed that the generated radioactivity depends on three parameters: the laser wavelength, that is, the energy of the photons used, the intensity with which the laser is focused, and the density of the target on which the laser is focused.

These three aspects have been detailed in an attempt to systematize the entire process with the highest possible simplicity and efficiency.

It is worth mentioning that 13 specialists have been hired during the implementation of this project, with a total of 294 person months generated in total. Physics and Computer Engineering graduates have contributed to the development of the Radioprotection Plan with different simulation works, the description of algorithms, software, etc., for the PIC codes, and the identification of three axes to control radioprotection in the CLPU. They have also created a database in collaboration with the ELI infrastructure, visited the National Accelerator Centre of Sevilla, contributed to several seminars, etc.



MICINN > Promotion of International Scientific Cooperation > ACI-PROMOCIONA

Promotion of the Spanish participation in ELI through CLPU

Director: Luis Roso		**Collaborators:** CLPU	
Start: 15/12/2009	**End:** 15/12/2015	**Duration:** 72 months	**Completed:** 83%

Description: Creation of an ELI scientific community, creation of an ELI technical and industrial community, training of Spanish scientists and technologists specialized in ultra-intense lasers, and promotion of Spanish outreach in the ELI.

Actions:

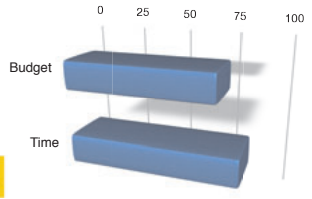
The CLPU has requested access to the ELI Delivery Consortium to the Ministry of Economy and Competitiveness, although the decision on the final location of the official headquarters of the fourth pillar of the ELI is still pending. In parallel, a study is being carried out on the three pillars of the ELI, and particularly on the impact that they had in the areas where they have been placed.

Contacts are maintained with the ELI branch in Hungary, and a formal agreement between both parties has been signed.

A series of ACI PROMOCIONA contents have been developed in LA3NET, which are relevant to Laserlab III. It is worth highlighting the presence of the CLPU in the request of Laserlab IV.

On the other hand, an active work has been carried out towards a consolidation of the Spanish laser community in an attempt to generate one hundred percent Spanish knowledge. The GELUR (Specialized Group in Ultra-Fast Lasers) is already a reality, and the most important Spanish research groups on lasers, who come from the SAUUL project, now ended, participate in it.

Recently, the CLPU has been elected by the Ministry of Economy and Competitiveness to coordinate the network action CONSOLIDER, in order to continue the vast contribution carried out in the SAUUL network.



MICINN > Instrumental lines of action of system articulation and internationalization – Public-private collaboration > INNPACTO 2011

SIGMA – Research and development of advanced systems for atmospheric gases separation by electric/photonic ionization and their applications in CO_2 capture

Director: Álvaro Peralta		**Collaborators:** CLPU, Iberdrola Ing., USAL	
Start: 03/05/2011	**End:** 31/03/2015	**Duration:** 47 months	**Completed:** 94%

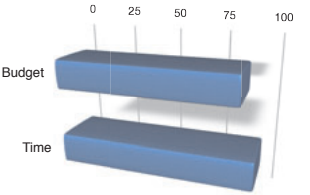
Description: Development of a novel system of separation of atmospheric gases by ionization and magnetism which will mainly allow the viable capture and concentration of CO_2.

Actions:

The proposed technology has the potential to reduce the cost of equipment by simplifying the installation.

All along the year 2014 a series of experiments have been carried out in different scenarios of laser-matter interaction in order to optimize the results of the prototype. For example, research has been done on the dependence of results on energy, pressure, or the electrical fields applied. These results have led to the conclusion that the relevant physical and chemical processes are more complex than what was originally envisaged by the research team, and that it is necessary to gain a greater knowledge on laser-matter interactions and on the dynamics between plasma and femtochemistry.

In order to move forward in these fields, an atmospheric pressure map spectrometer has been built, the only one with these characteristics, which may be even patented, and with which we can have access to dynamic information on the different species which are generated or which disappear when the light pulse interacts with the molecules in the sample. This device is still in its testing and optimization stage. It may be highlighted that some preliminary results have already been presented in international conferences and have awakened remarkable scientific interest.



MICINN > Instrumental Line of Action of Human Resources
> Technical Support Staff 2011

Personal Support Staff Member 2011: Isabel Gallardo González

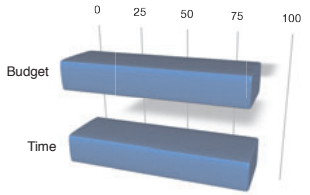
Director: Luis Roso		**Collaborators:** CLPU	
Start: 01/01/2012	**End:** 25/08/2014	**Duration:** 32 months*	**Completed:** 100%

Description: Work to be performed by the hired technician: Training in the use and maintenance of the laser systems of the Centre; participation in experimental work, etc.

Actions:

Support in the activation of the new auxiliary lasers of the Centre (stabilized CEP laser from Femtolasers GmbH; 200 TW peak power laser from Amplitude Technologies). The beneficiary carried out different actions for the activation and maintenance of those systems, as well as system monitoring, characterization and diagnosis: measurement of the temporal duration of the pulses, spectrum, contrast, power, energy, stability, divergence, and propagation.

The beneficiary carried out support activities in the preparation of the physical spaces for these auxiliary laboratories: Contacting with suppliers and purchasing the necessary equipment for the different spaces and laboratory users once that the auxiliary equipment was installed: optical tables, siding, cranes, mobility equipment, air conditioning system, fungibles, optomechanic material, computer material, design software, controllers, furniture or cleaning supplies, among others; identification of requirements for an optimal service to internal and external staff; support in the organization of beam distribution in experiment areas; schedule management of the laser service and safety protocols; protocols of maintenance and use of the laboratories; analysis of work-related risks, etc.



* Early extinguishment of contract by express with of the beneficiary.

MICINN > Instrumental lines of action of system articulation and internationalization – Public-private collaboration > INNPACTO 2011

FEMTOLASER – Development of a "low-cost" femtolaser for industry

Director: Mauricio Rico **Collaborators:** CLPU, Easy Laser, UV, ICMM

Start: 03/05/2011	**End:** 31/03/2015	**Duration:** 47 months	**Completed:** 94%

Description: Creation of a low-average-power femtosecond laser system of small dimensions and at a reasonable cost for industrial use.

Actions:

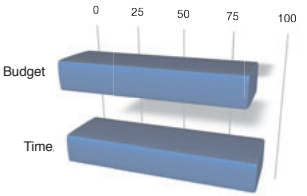
A laser oscillator with femtosecond pulses has been prepared on an optical table of the CLPU.

The prototype of laser oscillator has been prepared and installed in the ICMM, in collaboration with the CLPU, which has also implemented a second prototype in their installations.

Different elements of equipment and pieces which are part of the fibre laser prototype have been characterized together with the University of Valencia. Part of the work has focused on the laser characterization of pump systems in fibre lasers. Different improvements have been achieved in the pulse compression. An intense work has been carried out in collaboration with both groups from the Madrid Material Science Institute (ICMM) and the University of Valencia in an attempt to improve the different parts of laser compression. Some actions by the University of Valencia are still pending to complete this section.

With regard to the reduction in the repetition rate, different measures have been implemented to reduce it to the range of 1-2MHz without the use of expensive or large systems. The CLPU team has provided different solutions and has analysed the feasibility of the systems, and is awaiting the final decision from the company.

Additional work has been carried out for the characterization of specific pulses for those lasers.



MICINN > Instrumental lines of action of system articulation and internationalization – Public-private collaboration > INNPACTO 2011

Design and development of technological elements for particle acceleration by means of ultrashort and ultra-intense lasers

Director: Mauricio Rico		**Collaborators:** CLPU, PLA, I3M (UPV)	
Start: 03/05/2011	**End:** 28/02/2014	**Duration:** 34 months	**Completed:** 100%

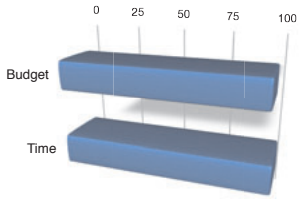
Description: This project aims at designing and producing a particle generator based on ultrashort ultra-intense pulsed laser technology for mainly biomedical applications, for both diagnosis and therapy. It also seeks future applications in the field of energy and diverse industrial processes.

Actions:

This project was active for two months during 2014. In that time, an optical pump laser system and amplifier prototype was finished in the company Proton Laser Applications. Favouring a policy of continuity, this project is still in operation, after its official completion, with the objective to obtain pulses of dozens of terawatts in femtoseconds.

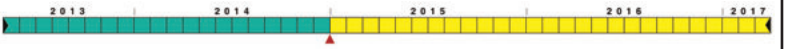
On the other hand, and also after the end of this project, a series of experiments are being carried out on solid targets of aluminium in order to study proton acceleration.

For its part, the I3M (Institute for Molecular Imaging Technologies of the Polytechnic University of Valencia) has used its own detectors, which were developed within the framework of this project and which revealed the radiation emitted in these experiments (protons, electrons, X-rays, brehmsstrahlung, etc.) whenever it was present. In this case, the I3M itself has acted as a user of the Centre.



MECD > Grants for the Training of University Lecturers 2012

FPU 2012 - Francisco Valle Brozas



Director: Luis Roso		**Collaborators:** CLPU	
Start: 01/04/2013	**End:** 31/03/2017	**Duration:** 48 months	**Completed:** 44%

Description: The thesis entitled "Design and Construction of an extreme instantaneous flux proton source", associated with this project, seeks to obtain a model with which to achieve maximum flow at moderate energy.

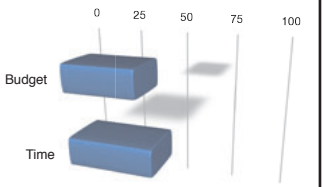
Actions:

During the time in which this project has been active, an analysis of the literature on laser-driven particle acceleration has been carried out. After establishing the framework of the thesis, the experimental set-up to perform experiments involving proton acceleration has been specified, including the laser focusing system, focus diagnosis and target-positioning system. The I3M of the University of Valencia will be used for particle detection.

All the necessary materials for the experimental set-up have been acquired and installed in a provisional laboratory. A preliminary campaign has been organized in order to test the set-up.

In the theoretical part of the project, the requirements necessary for simulating the experimental situation have been analysed and a first round of simulations has been carried out. The goodness of single-dimension techniques has been analysed, considering that the project looks for an extensive source of protons. On the other hand, the research analysed proposals for new acceleration schemes and the problems of simulation techniques for laser-driven particle acceleration.

In parallel, the researcher has worked on the adjustments of the Category 3 radioactive installation of the CLPU which is associated to a laser-generated X-ray and electron source.



European Union > FP7 > CAPACITIES

Laserlab III

Director: Luis Roso		**Collaborators:** CLPU	
Start: 01/06/2012	**End:** 30/11/2015	**Duration:** 42 months	**Completed:** 74%

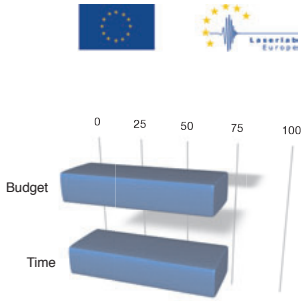
Description: Third phase of a European network that is developing a project with a consortium of more than 30 European organizations that have front-line laser infrastructures in research.

Actions:

In the year 2014, the LA3NET school has started its activities under the name: "Advanced School on Laser Applications at Accelerators", which took place in September, in Salamanca, in collaboration with Laserlab III, with different talks and scientific knowledge-spreading activities.

Clear advances have been made in the innovative X-ray line of work, which is part of the workpackage no. 32 of Laserlab III, called "INnovative Radiation sources at EXtremes, INREX".

The new website of the Lasers Centre includes a link to Laserlab from the main page of the site. There is also a link in the partnership section.



European Union > FP7 > PEOPLE > Marie Curie Action

LA3NET - Lasers for Applications at Accelerator facilities

Director: Luis Roso **Collaborators:** CLPU

Start: 01/10/2011	**End:** 30/09/2015	**Duration:** 48 months	**Completed:** 81%

Description: European consortium interested in the development of laser applications for particle accelerators within a training network in order to establish long-term collaboration.

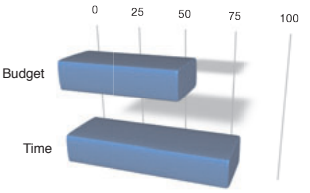
Actions:

There are two researchers participating in this project. As part of the work that has been carried out, they participated in February-March 2014 in an experiment at VULCAN with Paul McKenna, from the University of Strathclyde (United Kingdom).

In May-June, the researchers carried out a series of PIC simulations in the OSIRIS system of the Instituto Superior Técnico of the University of Lisbon. In April, the researchers participated in the 3rd Topical Workshop "Acceleration Techniques", in Germany, and in September in the 3rd school on Laser Applications at Accelerators in Salamanca (Spain). This is a specialized school which was organized by the University of Liverpool and the CLPU.

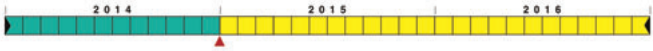
One of the members of this project has participated in the 4th LA³NET Topical Workshop, entitled "Laser and Accelerator Physics" in November in Berlin (Germany), and has been in February-March in Didcot (United Kingdom) and in May-June in Lisbon (Portugal), with a total of over two months and a half of work.

The other member of the group has attended the 3rd Topical Workshop "Acceleration Techniques", in Germany and the 3rd School on Laser Applications at Accelerators in Salamanca. He also participated in the 4th LA³NET Topical Workshop, "Laser and Accelerator Physics", in Berlin (Germany), and started a three-and-a-half-month stay at the LOA (Laboratoire d'Optique Appliquée), in France.



MINECO > National Programme for Research, Development and Innovation Aimed at the Challenges of Society > R&D+I Projects (Research Challenges)

FURIAM - Ultrafast Sources of Ionizing Radiation for Medical Applications

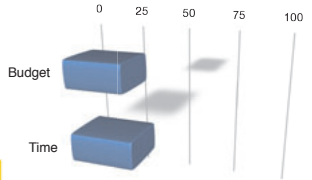


Director: Luis Roso **Collaborators:** CLPU

Start: 01/01/2014	**End:** 31/12/2016	**Duration:** 36 months	**Completed:** 33%

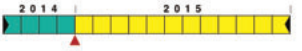
Description: Conventional radiotherapy uses doses in the gray range (one gray is defined as the absorption of one joule of radiation energy per one kilogram of matter). This energy is emitted in a matter of minutes and the problem is that, while the cell receives this energy, it responds and keeps receiving more radiation. There is an alternative to conventional radiotherapy in which this energy is transmitted instantaneously. Up to now, it has not been possible to apply this approach efficiently, but modern laser sources capable of surpassing hundreds of terawatts of peak power offer new and interesting possibilities in this regard. The ultimate goal of this project is to obtain two ultrafast sources of ionizing radiation (femtoseconds) which can be used by the biomedical community when the project ends.
Apart from having a more effective influence on cell development and using lower doses, a radiation source such as the one we are proposing will contribute to the well-being of the patients who require therapeutic treatment.

Actions:
In this year we have built a pulsed laser X-ray source, which is a source of ultrashort X-ray pulses. The innovative aspect of the project lies precisely in this factor.
The intensity and direction of that source of radiation is being established, and the mandatory license has been obtained from the Spanish Nuclear Safety Council.
As of yet, the source of radiation still does not produce the expected dose for the objectives of the project.



FECYT > Grants for the Promotion of Scientific, Technological and Innovation Culture 2014

Unveiling shadows



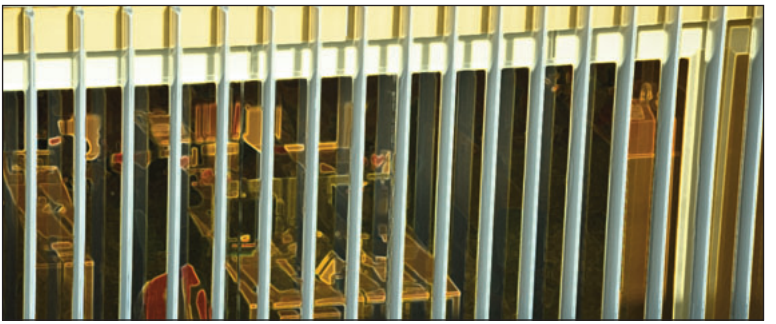
Director: Francisco Valle **Collaborators:** CLPU

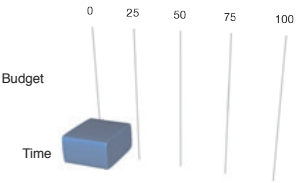
Start: 01/09/2014	**End:** 31/12/2015	**Duration:** 16 Months	**Completed:** 25%

Description: The project involves one main action, called the "Classroom of Light", and a complementary, although also relevant, action: the creation of a virtual space for knowledge, called "Sparking Web". These two actions are part of the "International Year of Light and Light-Based Technologies" (as proclaimed by the UNESCO for 2015).

Actions:

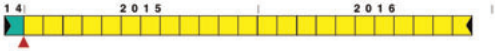
In 2014, several talks have been given in educational centres and in different local associations of Salamanca in order to spread knowledge on the CLPU activities and on the presence of lasers in our daily lives.





MINECO > National plan for the Promotion of Scientific and Technical Research Excellence > National Subprogram for Knowledge Generation > Excellence Networks

CATLUR – Spanish Network on Science, Applications and Technology of Ultra-Fast Lasers



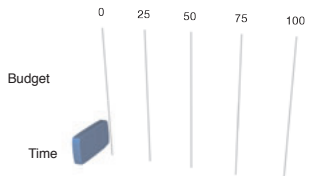
Director: Luis Roso		**Collaborators:** CLPU + 7 laboratories	
Start: 01/12/2014	**End:** 30/11/2016	**Duration:** 24 months	**Completed:** 8%

Description: The CONSOLIDER SAUUL Project (Science and Applications of Ultrafast Ultraintense Lasers) ended in December 2013. This project gathered more than 100 researchers who shared their know-how on science and technology regarding femtosecond lasers with intensities of gigawatts, terawatts and beyond. The project was a success, and this could be seen by the more than complete fulfilment of the indicators which were agreed from the start. The central objective of this project is to generate an appropriate tool to maintain the cohesion of the group. The aim is to create a Specialized Group on Ultra-Fast Lasers (GELUR) which consistently unites this human group. The group will be involved in Scientific Societies and it will be associated to technological clusters such as SECPhO or others.

Actions:

The proposed action is structured around two axes: one on–site meeting (as a follow-up to the periodical meetings of the SAUUL group) and an off-site initiative: the maintenance and expansion of a specific website.

At the beginning of 2015, a new employee will be hired to manage the administrative tasks of the project, as well as to coordinate the activities of the 8 work groups. The work will begin with the collection of data and services of the laboratories that are part of the project and the creation of a website which includes all the information that has been gathered.



Additionally, the CLPU has participated in the following projects:

CLPU Participation in other projects

Type	Name	Coordinator	Participation
Apoyo a Proyectos de Investigación 2012, Junta de Castilla y León	3D-Microstructuring with femtosecond laser pulses	Pablo Moreno Pedraz (Univ. de Salamanca)	Participant
Apoyo a Proyectos de Investigación 2012, Junta de Castilla y León	Material for the nonlinear processing of photonic signals based on new-synthesized lanthanide complexes	Pedro Chamorro Posada (Univ. de Valladolid)	Participant
INNPRONTA	LIFE: "Breast cancer integral challenge"	Exploraciones Radiológicas Especiales, S.A.	Contractor

Finally, another activity which has been carried out in the year 2014 is the submission of requests for new projects, which are shown in the following tables, as well as the current status of the request.

Regional projects			
Type	**Name**	**Date request**	**Status**
Programa Apoyo a Proyectos de Investigación 2014	Design and characterization of a compact mass spectrometer for the detection and analysis of ionized species with atmospheric pressure laser	March 2014	Partially Granted 2014
Programa Apoyo a Proyectos de Investigación 2014	Towards a new generation of electronic dosimeters adapted to ionizing radiation fields generated by a plasma laser accelerator.	March 2014	Denied
Desafío 2014 Universidad-Empresa TCUE	Development of new photochemical techniques for the production of drugs with laser.	April 2014	Denied

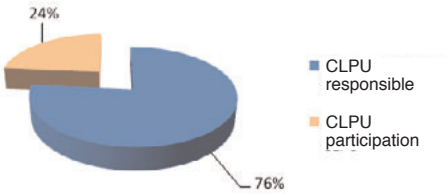
National projects

Type	Name	Date request	Status
FECYT. Programa de Cultura Científica y de la Innovación 2014	Particle race: Exploring natural radiation and laser acceleration	June 2014	Denied
MINECO. RRHH	Ramón y Cajal programme 2014.	January 2014	No candidates
MINECO. Retos de la Sociedad. I+D+i	Construction, operation and R+D+I for the NEXT experiment in the Canfranc Underground Laboratory	September 2014	Pending resolution
MINECO. Retos de la Sociedad. EXPLORA 2013	Design and characterization of a compact mass spectrometer for the detection and analysis of ionized species with atmospheric pressure laser	January 2014	Denied
MINECO. Retos de la Sociedad. EXPLORA 2013	Frontier tools for external light sources.	January 2014	Denied
MINECO. Retos de la Sociedad. EXPLORA 2013	Feasibility analysis on the use of pulsed lasers for the design of electronic systems immune to electromagnetic pulses in civil and military applications.	January 2014	Denied
MINECO. Retos de la Sociedad. EXPLORA 2014	Development of a selective ion source based on laser techniques for Barium Tagging.	November 2014	Pending resolution
MINECO. Retos de la Sociedad. EXPLORA 2014	Laser-driven source to reproduce near-Earth space radiation environment.	November 2014	Pending resolution
MINECO. Retos de la Sociedad. EXPLORA 2014	Development of new radiotherapy methods which combine laser-based ultra-short ionizing radiation and Drosophila	November 2014	Pending resolution

European projects			
Type	**Name**	**Date request**	**Status**
H2020-INFRAIA 2014	Laserlab IV: The integrated initiative of European Laser Research Infrastructures	September 2014	Pending resolution
H2020-INFRASUPP 2015	Cohesion Forum for Stackeholders of Research and Innovation Projects co-funded by Structural Funds	September 2014	Pending resolution
H2020-MSCA ITN 2014	Novel Acceleration Schemes - A collaborative research and training network	April 2014	Denied
H2020-MSCA ITN 2014	Optimization of Electron Beams - A European Training Network	April 2014	Denied

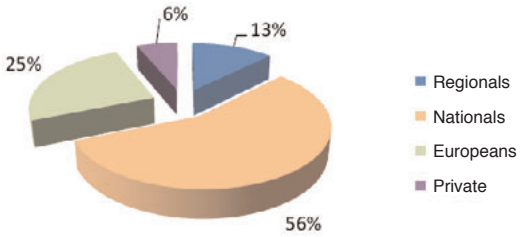
Private Initiative projects			
Type	**Name**	**Date request**	**Status**
Fundación BBVA. Ayuda a Proyectos de Investigación 2014	New laser-based technologies for radiotherapy sources	July 2014	Denied

As a summary, during the year 2014, the CLPU has been the main organism responsible for 76% of the projects in which it has participated. The remaining 24% corresponds to projects in which the CLPU has been collaborating as well.



Projects in process.

With regard to the projects requested, 16 requests were submitted in 2014, most of which were national (56%), followed by European projects (25%). The lowest number of proposals corresponded to private or regional projects.



Requested projects.

Regarding the projects submitted in 2013 and granted in 2014, the MINECO project of the Research Challenges Programme was approved with the title "Ultra-fast sources of ionizing radiation for medical applications". The project started on January 1st 2014 and it is described in the list of projects which are currently active.

3.2.2. Collaboration in Experiments

CELIA
Dates: 2/03/2014 to 29/03/2014
Description: Training course Laserlab Europe. This program is part of a Staff Exchange.

CELIA
Dates: 6/04/2014 to 2/05/2014.
Description: 2nd Training course Laserlab. Staff Exchange

Laser Lab III
Dates: 14/07/2014 (4 weeks)
Description: in Rutherford Appleton Laboratory, Oxfordshire (UK) to use Vulcan (or Astra) as part of the Laserlab program.

LULI
Dates: 20/04/2014 to 17/05/2015
Description: Staff Exchange Course as part of Laserlab program.

3.2.3. *Scientific Visits*

LA3NET (HZDR —Helmholtz-Zentrum Dresden-Rossendorf—, Germany)
Dates: 27/04/2014 to 1/05/2014
Description: Workshop on Novel Acceleration Technique.

NAUUL (Abingdon, United Kingdom)
Dates: 27/04/2014 to 1/05/2014
Description: Targetry Workshop

COFIL2014 (Shanghai, China)
Dates: 18/09/2014 to 24/09/2014
Description: 5th International Symposium on filamentation.

LA3NET (Salamanca, Spain)
Dates: 29/09/2014 to 3/04/2014
Description: Advanced School on Laser Apps at Accelerators.

LMJ-PETAL (Bordeaux, France)
Dates: 7/03/2014
Description: Workshop LMJ-PETAL Scientific Programme &COST. MP1208 Kick Off-Meeting.

3.3. KNOWLEDGE TRANSFER

3.3.1. *Technological Platforms*

The CLPU has committed itself to being part of the key European networks in the field of lasers, in order to increase the added value of the Centre. Thus, it is part of the international programs of Laserlab Europe and LA3NET (see Project section). At a national level, it participates in the main technological platforms currently existing in the fields of Optics and Photonics:

SECPhO: Southern European Cluster in Photonics and Optics. CLPU is a founding partner and also responsible for the main work team created around laser technology.

SECPhO
Southern European Cluster in Photonics and Optics

FOTÓNICA21. It comprises more than 180 members distributed in different work teams. It aims to coordinate the different national activities, similarly to what the European Technological Platform Photonics21 does at an international level.

National Spanish R+D Platform on Radiological Protection (PEPRI). In This platform was created in July 2014, and its general objective is to promote R+D+I activities aimed at protection against ionizing radiations, as well as at the promotion of knowledge on them and the minimization of their effects. Since October 2014, the CLPU is a member of that platform, where it is part of the Work Group in different projects and tasks.

Spanish International Committee for Celebrating the International Year of Light 2015. On December 20th 2013, the United Nations declared 2015 as the International Year of Light and Light-based Technologies. The CLPU is part of the Spanish Committee which created the IYL2015 portal. This portal is directly controlled by the Spanish Optics Society and its main objective is to inform about all the activities and materials which are organized as part of the commemoration projects for this year.

Spanish Technological Platform for Science Industry (Induciencia). This platform is a forum led by industry, with the participation and collaboration of all the agents interested in Science Industry, in order to define jointly the research and technological development objectives in the middle and long term. This platform is clearly market-oriented. The CLPU has collaborated indirectly with this platform and has attended some of its meetings as a special guest.

3.3.2. *Event organization*

Fourth users meeting: Particle physics

Date: 2-3 December
Place: Hospedería Fonseca, Salamanca (Spain)

As part of the Pan-European Project Extreme Light Infrastructure (ELI), the CLPU promotes an annual meeting of users at the end of the year in an attempt to offer its services to the scientific and industrial community by providing access to the most innovative systems of high-intensity lasers. Each year, this meeting focuses on one subject and, in this edition, the objective is to start different discussions on the scientific possibilities of ultra-intense lasers in fields in which laser applications are extremely recent. For this reason, the main topic this year is particle physics, after considering the important collaboration of the CLPU in the European NEXT Project on Neutrinos, led by the Spanish researcher Juan José Gómez Cadenas.

In this edition, as in the previous three, the CLPU included a visit to its installations.

Advanced School on Laser Applications at Accelerators LA3NET

Date: 29 September - 3 October
Place: Hospedería Fonseca, Salamanca (Spain)

These specialized schools, which take place every year, are an adequate forum to gather all the participants of the project and to consolidate the network in an informal teaching environment in which students do not only attend the talks, but also carry out different tasks to strengthen their knowledge. This specialized course is part of the European Project "Laser for Applications at Accelerators" LA3NET and it was organized by the University of Liverpool (project coordinator) and the Pulsed Lasers Centre (member of the consortium).

XII Week of Science in Castile and León

Date: 7-11 November
Place: Different Secondary Schools in Salamanca (Spain)

One more year, the Pulsed Lasers Centre wishes to participate in the Week of Science which the Spanish Foundation of Universities organi-

zed every year. To do so, part of the team of scientists of the Centre has prepared a series of talks in order to bring laser technology and scientific research closer to high school students.

Shown further below is a list with the talks that have been prepared and a brief summary of each of them, as well as the target audience for which they were created.

The Stone and The Mineral - II Provincial Fair
XIV Stone Fair of Villamayor

Date: 14 - 18 May
Place: Hábitat Minero (Villamayor, Spain)

The Town Hall of Villamayor organizes a celebration dedicated to the mineral resources of the province, which are not only used as ornaments or in construction, but which also can be historically considered as an element of cultural and historical identification.

For this reason, the Town Hall wants to pay homage to these activities and to offer the different professionals who work in Villamayor the possibility to show the services they provide and the activities they perform. In this line, the CLPU has contributed with a stand in the Fair so as to spread knowledge on the research projects it carries out to the general public, which is considered an elemental pillar in the spreading of knowledge, as has been said before.

3.3.3. Training

The training courses also include the previously mentioned international collaborations which are linked to a training course.

CELIA (France)
Dates: 2/03/2014 to 29/03/2014
Description: Training course Laserlab Europe. This program is part of a Staff Exchange.

Special Radio Programme. Hoy por Hoy Salamanca.
Dates: 17/03/2014
Place: Salamanca

CELIA
Dates: 6/04/2014 to 2/05/2014.
Description: 2nd Training course Laserlab. Staff Exchange

Training course in LULI (France)
Dates: 20/04/2014 to 17/05/2014
Description: This course is part of the Laserlab Europe Project. Staff Exchange Programme.

Talk at the University of Sevilla.
Dates: 21/04/2014
Place: Faculty of Sciences. University of Sevilla. (Spain)

Ciencia en el bulevar
Fechas: 22/04/2014

Stone and Mineral Fair (Villamayor, Salamanca, Spain)
Dates: 14/05/2014 to 18/05/2014

Erasmus Intensive Programme.
Dates: 20/06/2014 to 11/07/2014
Description: Summer Course

Salamanca sabe de Ciencia
Dates: 29/07/2014
Place: El Ateneo, Salamanca (Spain)

Summer course. Internet Summer School.
Dates: 2/09/2014
Place: Santiago de Compostela (La Coruña, Spain)

Participation in the blog "Desayuno con Fotones"
Date: 11/09/2014 and 15/09/2014

Science Week (Castile and León, Spain)
Dates: 7/11/2014 to 11/11/2014
Place: Salamanca (Spain)

Luca Volpe Talk
Dates: 11/07/2014
Place: CLPU
Description: Laser driven electron beams transport and collimation in solid targets and applications

François Sylla Talk
Dates: 4/09/2014
Place: CLPU
Description: Laser Ion Acceleration exploring the near-critical regime with dense gas jets

Seminar
Dates: 31/10/2014
Place: CLPU
Description: Eye on Flame Laser activities

Seminar
Dates: 2-3/12/2014
Place: CLPU

With regard to the training courses taken by the employees of the Centre, here is a list:

Course: Expert in Radiological Protection.
Dates: 1/10/14 to 14/03/15.
Organizer: CIEMAT

Course: New guidelines in public contracting: main changes and practical effects.
Dates: 6/11/2014 to 7/11/2014.
Organizer: EIPA

Course: Red IRIS Course.
Dates: 24/11/2014 to 25/11/2014

Course: Course on Administration of Linux Networks and Servers.
Dates: 1/11/2014 to 01/05/2015.
Organizer: SEAS Estudios superiores 350 h Online

Course: Systems for performance assessment.
Organizer: ASE psique.

Course: Emergency Plan. Function of the 1st intervention team and the alarm and evacuation team.
Place: FREMAP

Course: Posts, scientific and operative areas and mechanization workshop.
Organizer: FREMAP

Course: Ultrafast Laser.
Organizer: SECPhO.

Course: Creativity and Competitive Vigilance
Dates: 6/2014 to 10/2014
Organizer: BM Training, Regional Government of Castile and León.

4. Corporate Communication

4.1. INFORMATION AND COMMUNICATION

One of the main pillars of the activities at the CLPU is communication, whose main objective is the increased visibility of the Centre and of the different activities and national and international projects which take place in it. The spreading of knowledge and projects have been already discussed before, but this section intends to highlight the interventions targeted to the general public by the scientists and technicians in an attempt to bring science closer to society. We cannot forget, and here at the CLPU we certainly do not, that as scientists, we have a social responsibility concerning the communication of scientific discoveries to society as part of our culture, and we also must

promote the vocation of students and the possibilities they are offered as part of their professional development.

To do so, different actions have been implemented to spread information on the activities of the Centre and of its objectives in different media: press, radio, conferences (for the general public rather than for a scientific audience which, as we have said before, has been already discussed). There have been three interventions in the radio and 24 articles have been published on events or news regarding the Centre.

These activities also promote the image and visibility of the Centre, which is one of the objectives of the year 2014.

In addition, a news bulletin is published periodically in order to inform about the most relevant news regarding the Centre and its activities. In the year 2014, bulletins 14, 15 and 16 were published, and they can be accessed on the Centre website (www.clpu.es).

It may be highlighted that the bulletin has informed about the visit of the president of the Salamanca Council to the CLPU; the mention from the Ministry of Economy and Competitiveness in which the Centre is praised as a model of good practices; the final adjustments of

the VEGA 2; the new scientific alliances which have taken place in the year 2014; the advances in the laser emission of X-rays; the organization of the LA3NET school; the fitting-out of the room which will host the VEGA system; the arrival of the petawatt system and its front-end; the IV Users Meeting; the continuity of CLPU in the ICTS Roadmap of the Ministry; and the presence of the Centre in the Science Week of Castile and León.

On the other hand, in July 2014, the CLPU received the visit of the members of the Rector Council who wanted to see the installations and the advances in the works of the stage III of the building of the Science Park.

In the field of communication, we have worked actively to promote internal communication in order to promote motivation and identification with the Centre and with its objectives. As part of its action lines, it has optimized the Centre website and included different improvements regarding navigation, usability and contents, and thanks to the collaboration of the Obra Social La Caixa, the CLPU has edited a generic promotional video and has created a series of informative posters on the installations of the Centre.

4.2. INSTITUTIONAL COLLABORATION

Materials Science Institute of Madrid (ICCM) - Madrid
Date: 10/03/2014
Description: Activities related to research, scientific training and technological development.

University of the Basque Country (EPICS)
Date: 24/03/2014
Description: This project analyses the EPICS system to use it as part of the control system.

University of Sevilla.
Date: 24/04/2014
Description: Internship and final project for degree and master agreements with students

Synchrotron ALBA CELLS (Barcelona)
Date: 12/05/2014
Description: Design of the vacuum chamber of the petawatt laser system compressor

University of Jaén
Date: 29/10/2014
Description: Different tasks for project development in the automotive sector.

Canfranc Underground Laboratory (Huesca)
Date: 14/11/2014
Description: Framework agreement

Institute of Corpuscular Physics (Valencia)
Date: 16/09/2014
Description: Collaboration agreement.

ELI Hungary
Date: 1/10/2014
Description: Framework agreement for future research lines

With regard to the industrial sector, the following collaboration agreements have been signed with the entities described here, with the objective to work jointly in different research projects.

Deneb Medical SL
Date: 1/10/2104
Description: We are offering this company consultancy services: a technical study on the state of the art in ultra-short pulsed lasers with a specific power with regard to technology and costs, as well as their evolution expectations over the next years.

Valeo
Date: 7/10/2014
Description: This is a collaboration for the development of studies, research and actions related to the use of laser in the production of components and systems which can be applied to the automotive system. There are currently two active research lines.

ENUSA
Date: 21/10/2104
Description: This company deals with the design, production and storage of fuel for nuclear power stations. Our potential fields of collaboration are radiological protection, metrology, non-destructive essays on fuel, laser-driven gadolinium enrichment, development of laser inspection devices, etc.