CLPU CENTRO DE LÁSERES PULSADOS

Activities Report

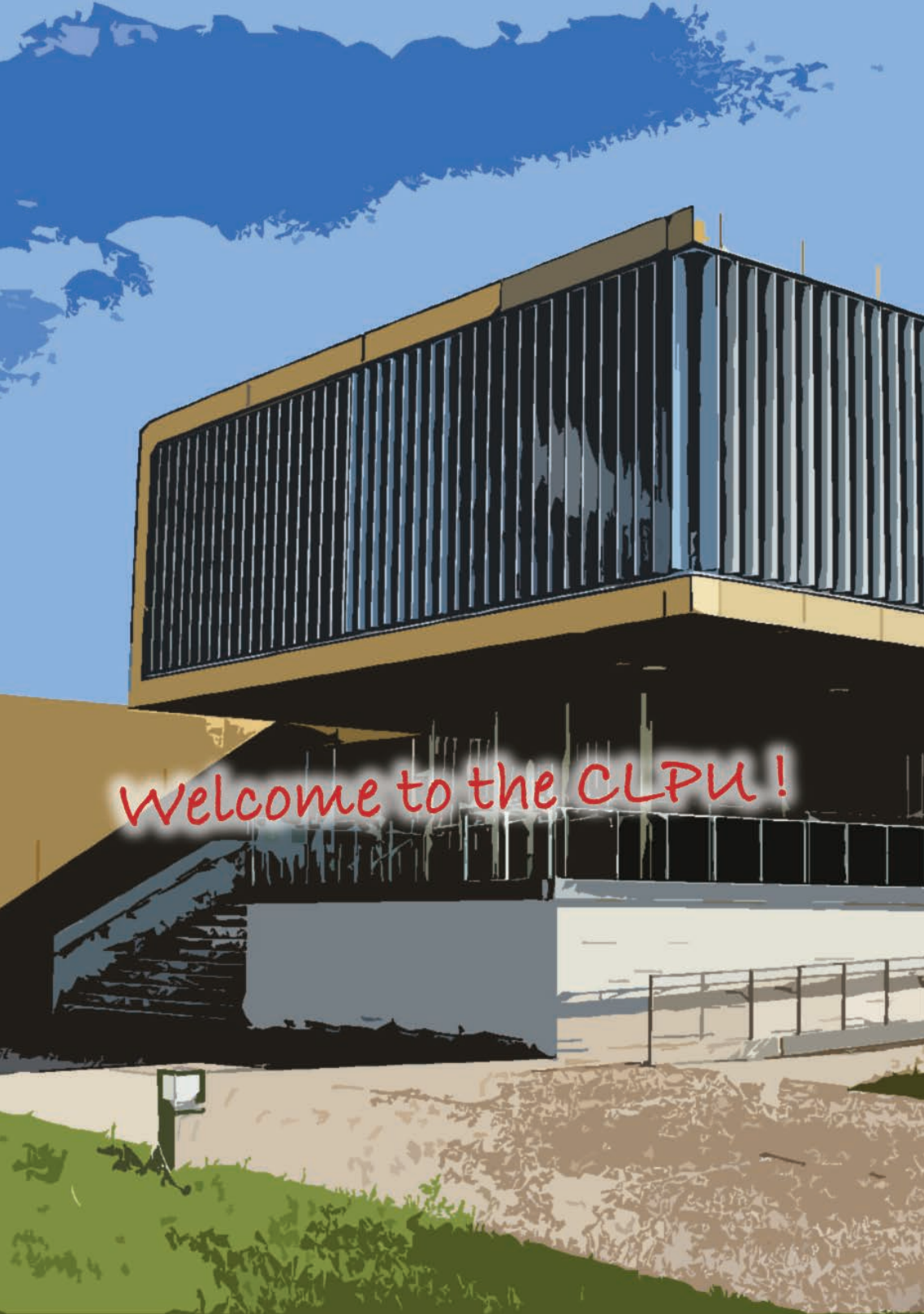
2016

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

Junta de Castilla y León

VNIVERSIDAD D SALAMANCA
CAMPUS DE EXCELENCIA INTERNACIONAL

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


Welcome to the CLPU !

MESSAGE FROM THE DIRECTOR

Welcome to the Pulsed Lasers Centre. As every year, it is my pleasure to show you through this Report the set of activities carried out by the CLPU to turn this national Singular Scientific and Technological Infrastructure specialized in ultraintense and ultrashort lasers into a reality.

As part of our efforts to implement the entire VEGA system —a petawatt laser system which grants the Centre its unique nature—, in 2016 we have focused our efforts on the development of the experimental area. In this regard, the commissioning experiment or zero experiment carried out in our facilities by Prof. Robert Fedosejev, from the University of Alberta, Canada, has played a fundamental role. Thanks to the acquired experience, the readjustment of the systems and the versatility with which the experimental area is now designed, we expect to be able to publish the first competitive open access call for VEGA-2 in the first quarter of next year. This will consolidate our original identity as a User's Centre. With each step we take, we move inexorably closer to becoming a full-functioning infrastructure which will nevertheless have to keep updating itself for its users and their research, because they are the most important piece in this process.

Beyond its unique nature, the Pulsed Lasers Centre has always strived to become a cornerstone to promote lasers technology and science in Spain, as can be seen by its leadership and support in the creation and maintenance of the national group of specialization in ultrafast lasers (which was first called SAUUL and is now GELUR —www.ultrafast.es—). It can also be seen in its versatility, with more than four operating services, two of which are laser systems which provide multiple applications. It is shown by the different initiatives carried out in those services. Finally, of course, it is clear from the public-private collabo-

ration which the Centre carries out through projects, patents and consulting services.

The Pulsed Lasers Centre keeps striving to consolidate its status as an international reference in the field of ultraintense lasers once that its equipment —one of the most powerful lasers in the world— is fully functional. The different events organized by the Centre and with the participation of its members are witness to these efforts. With all these activities we are not only looking outside, but mainly inside our field of action, consolidating intelligent and sustained growth in our immediate environment: by supporting local companies, the Centre promotes the Science Park in which it is located, and it never forgets that its main social objective is the town in which it has been set up: Villamayor (Salamanca).

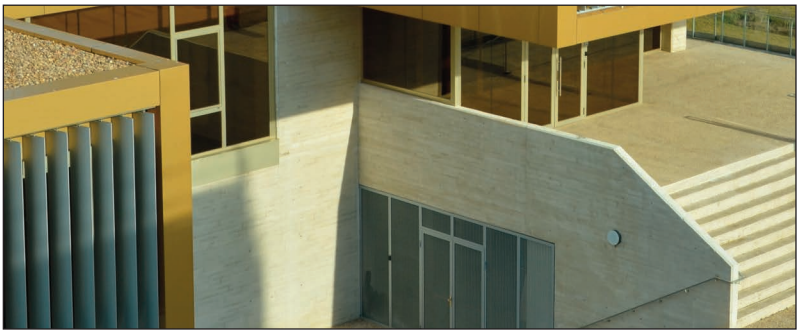
Like in previous years, I would like to finish this short message with some words of gratitude to the staff of the Centre for the constant effort they make with this project to keep it going —it is, more than ever, their project.

UNIQUE SCIENTIFIC AND TECHNICAL INFRASTRUCTURE (ICTS)

INTRODUCTION

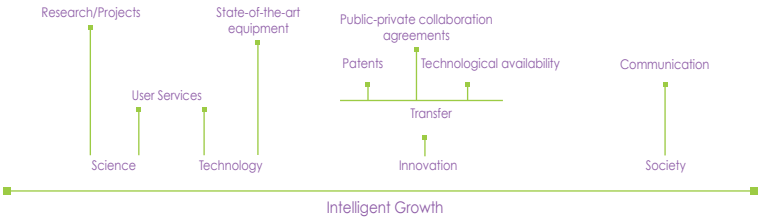
The Pulsed Lasers Centre is a Unique Scientific and Technical Infrastructure with a single location and it is part of the updated ICTS Roadmap, which was approved on the 7th of October 2014 by the Science, Technology and Innovation Policy Council (CPCTI). Its main target is to initialize VEGA, a laser system which is unique in Spain due to its capabilities, and which will become one of the nine most powerful lasers in the world. The CLPU, a unique infrastructure inside and outside of our country, accepts with enthusiasm the responsibility to become a revitalizing agent of science, technology and innovation. This will promote an open process of knowledge transfer which turns globalization into a positive factor for the development of our societies. Together with the CLPU, there are 58 other unique infrastructures which carry out their daily tasks of research, technological development and transfer to collaborate in increasing the competitiveness of Spain among different sectors.

In spite of the fact that another year will still be needed in order to consider that VEGA (and all its outputs) is fully functional, this report shows how the CLPU is aware of its own potential and its responsibility towards the areas of science, industry and society, and how it carries out a constant effort to increase its versatility, to develop state-of-the-art technology in the avant-garde of science, to consolidate its specialization in this field, to promote public-private collaboration and to keep looking at society



INTELLIGENT GROWTH (IG)

After a crisis which has affected the very structure of the progress system, the European Union and its Member States have focused their efforts on promoting intelligent and sustainable growth in all its regions. To do so, they have created tools which aim to establish a more direct and efficient link between research and innovation. The tetrad of progress, made up of science, technology, innovation and society, establishes the four pillars upon which the guidelines of action and strategy developed by the Centre are structured.



IG - State-of-the-Art Technology

As an ICTS, many efforts of the Pulsed Lasers Centre are devoted to optimizing, maintaining and perfecting the systems which make it a unique infrastructure. Also, as a User's Centre, the CLPU offers state-of-the-art equipment for the development of national and international research with an open access procedure. We list here the research which has been carried out thanks to the equipment of the Centre with a description of the initiatives that have been developed in our premises.

VEGA LASER SYSTEM → (vegaservice@clpu.es)

Technical Specifications		
	VEGA 1	**VEGA 2**
Energy/pulse	600 mJ	6 J
Peak Power	20 TW	200 TW
Duration/pulse	30 fs	30 fs
Repition rate	10 Hz	10 Hz
Central wavelength	800 nm	800 nm

Actions:

Experimental station: VEGA Workstation

User: University of Alberta (Canada)

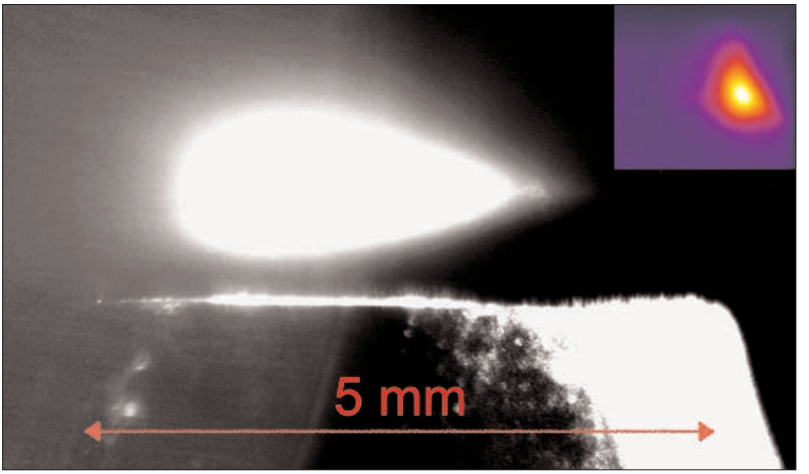
Project/Line of research: Plasma Physics

Action objectives: Study of time-resolved transmission spectrometry of the so-called warm dense matter (WDM).

Experimental development: Complex campaign which first had to obtain an ultrashort X-ray pulse. This beam was created through the interaction of a laser from VEGA-2 with over-dense helium plasma to produce electrons. Electrons move around the plasma field and generate a characteristic betatron radiation which is reflected on the WDM produced in a different output of the laser.

Duration: 6 months

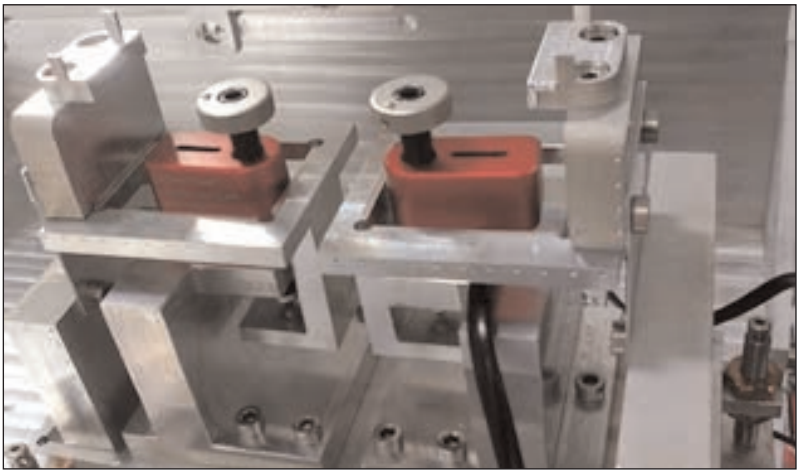
Results: The material and data obtained are being analysed.



Electron acceleration with VEGA-2

Other services: To develop this experiment, several procedures were undertaken by the Machining Workshop of the Centre, which were related to the adaptation of the experimentation area and with the experiment itself. More specifically, the following pieces were created:

- Design and manufacture of components to create a Kirkpatrick-Baez microscope.
- Manufacture of pieces for a filter support for an X-ray camera.
- Manufacture of an opto-mechanical PVC mounting.
- Manufacture of columns and adaptor plates to place the bread-board of the VEGA-2 interaction camera on its lower lid.
- Design and manufacture of an adaptor plate to place it over a stage.
- Adaptor and fixation aluminium plates to mount it over a magnetized support with strong magnetization.

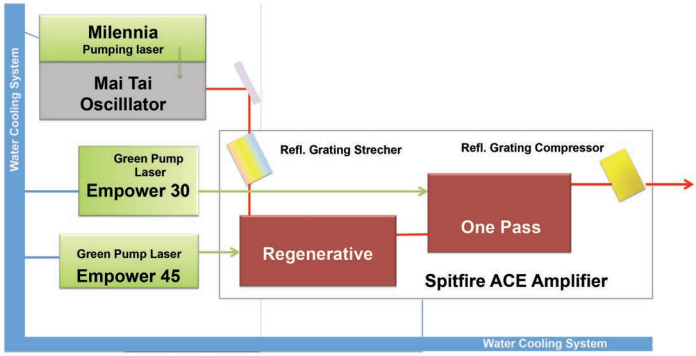


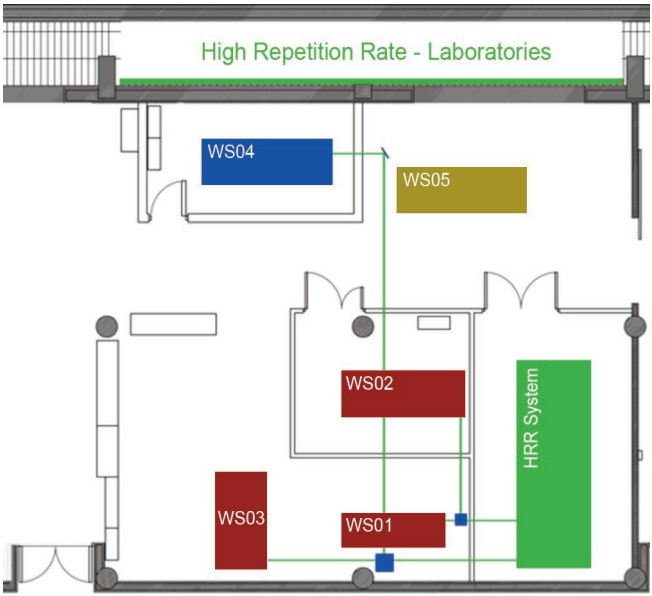
Mounting with mechanized pieces of a Kirkpatrick-Baez microscope

HIGH REPETITION RATE LASER SYSTEM

→ (highrepservice@clpu.es)

Technical Specifications	
Commercial model	*Spitfire (Spectra Physics)*
Energy/pulse	7 mJ
Peak Power	60 GW
Duration/pulse	120 fs
Repetition Rate	1 kHz
Central wavelength	800 nm
Pre-pulse contrast	>1000:1
Polarization	Lineal


Water Cooling System
Milennia
Pumping laser
Mai Tai
Oscilllator
Green Pump
Laser
Empower 30
Green Pump Laser
Empower 45
Refl. Grating Strecher
Refl. Grating Compressor
Regenerative
One Pass
Spitfire ACE Amplifier
Water Cooling System


High Repetition Rate - Laboratories
WS04
WS05
WS02
HRR System
WS03
WS01

Actions:

Processing area (WS01-WS03)

Experimental Station: High-precision processing WS01

User: Non-linear optics group. Department of Materials Physics. Autonomous University of Madrid (UAM).

Project/Line of research: Laser-processed devices for microfluidics and integrated optics.

Action objectives: Producing microchannels through laser surface processing.

Experimental development: Use of an experimental setup which was prepared and mounted in the microprocessing station and slightly modified from the optical model system in order to control different numerical apertures.

Duration: 4 days

Results: Microchannels in different sizes were obtained, both regarding depth and breadth (from tenths to hundredths of micrometres in both cases), with dielectric materials transparent for laser radiation and with ferroelectric properties. The samples were provided by the user, and only some of them had been doped with Fe. Currently the processed samples are waiting to be tested and processed in order to define the next campaigns and actions.

Microchannels

Experimental station: High-precision processing WS01

User: Material Science Institute of Aragón (ICMA-CSIC). Department of Applied Physics of the Autonomous University of Madrid (UAM).

Project/Line of research: Effects of surface roughness on the emission of secondary electrons with models of geometrical structures.

Action objectives: Microperforating metal sheets with the femtosecond laser and a periodical structure.

Experimental development: Experimental mounting of the WS01 work station with higher XY control to create the mesh with the highest possible precision.

Duration: 3 days

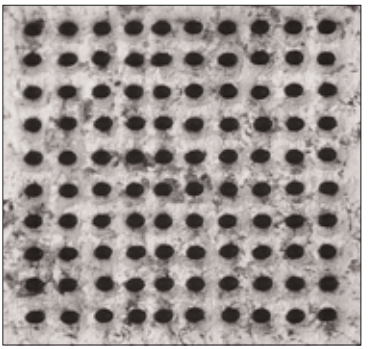


Image of one of the mesh pieces obtained

Results: Different microperforated mesh pieces were successfully obtained with sheets of different metals (Al, Cu and Ag) for secondary electron applications. This work will be continued by improving the depth of the microperforations and trying new materials.

Experimental station: High-precision processing WS01

User: Deneb Medical S.L.

Project/Line of research: Design and development of a system of laser-guided surgery with selective tissue discrimination.

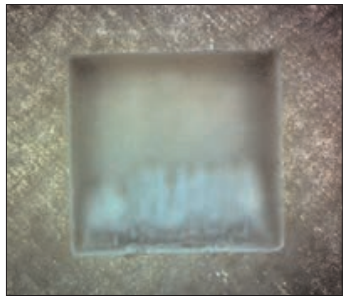
Action objectives: Studying and identifying the mechanisms of laser ablation (processing with fs laser) on hard tissue, such as bone.

Experimental development: Standard microprocessing set-up, but adapted for biological materials. Longer focal distances than in microprocessing and larger Rayleigh regions.

Duration: 1.5 months

Results: All the necessary laser parameters to control the laser processing of hard tissues, including efficient laser ablation with the fem-

tosecond laser of the Centre were obtained and studied. The damage and ablation thresholds were obtained through different approximation techniques and the cutting depth and bone elimination rates were defined according to different laser parameters. The most efficient procedures and mechanisms for this task were identified.



Deep hard tissue ablation

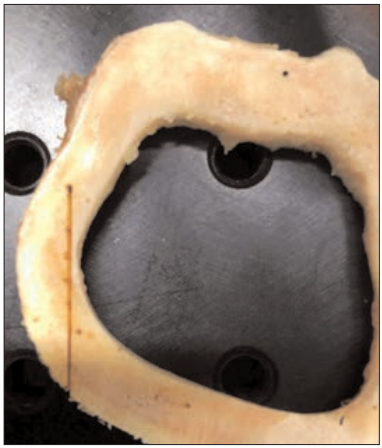
Experimental station: High-precision processing WS01

User: Deneb Medical S.L.

Project/Line of research: Design and development of a system of laser-guided surgery with selective tissue discrimination.

Action objectives: Studying and comparing bone laser ablation with two different types of femtosecond laser.

Experimental development: Standard microprocessing set-up, but adapted for biological materials. Alterations were made to the beam expander for the Carbide laser.



Result of one of the tests

Duration: 1 week

Results: In this case, the measurements that had been done with the Ti-sapphire femtosecond laser were repeated with an Yb laser with a different wavelength and variations on the laser repetition rate and pulse duration. This made it possible to identify the best parameters to perform laser cuts and ablations on hard biological tissue with the bone of cows, pigs, etc.

Experimental station: Microprocessing WS02

User: Deneb Medical S.L.

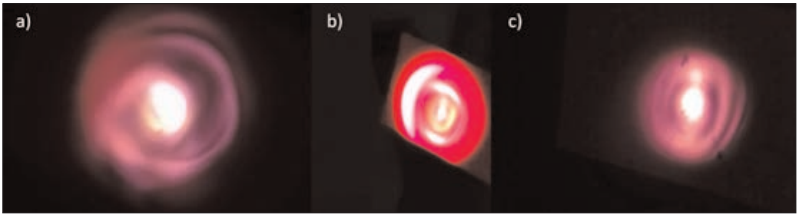
Project/Line of research: Design and development of a system of laser-guided surgery with selective tissue discrimination.

Action objectives: Proving that laser filaments can be generated and manipulated in linear conditions to generate a laser-formed filamentation plane. Using it in short circuit systems.

Experimental development: A series of spherical and/or cylindrical lenses were assembled with a controlled system of mechanical movement. The laser filaments were analysed with 100 fs pulses and energies of 1.3-4 mJ, both in linear conditions and on the plane.

Duration: 3 days

Results: Laser filaments of different length were obtained and used in the first tests of electrical short circuit. These types of experiments are expected to continue in 2017.



Sections of the filament under different conditions

Experimental station: Microprocessing WS02

User: Osborne Group

Project/Line of research: Tests of laser cutting for the meat industry

Action objectives: Testing the possibility of obtaining an effective cut of meat and bone samples.

Experimental development: Standard processing set-up with higher laser energy. The concept tests proved that bones with soft tissue

could be cut with different lasers, ranging from femtoseconds to microseconds. The wavelength, pulse duration and laser energy were critical factors for the final appearance of the cuts.

Duration: 8 days

Results: The concept test was successful, since perfectly clean cuts were performed.

Experimental station: WS05 General Laboratory

User: Department of Organic Chemistry of the University of Salamanca.

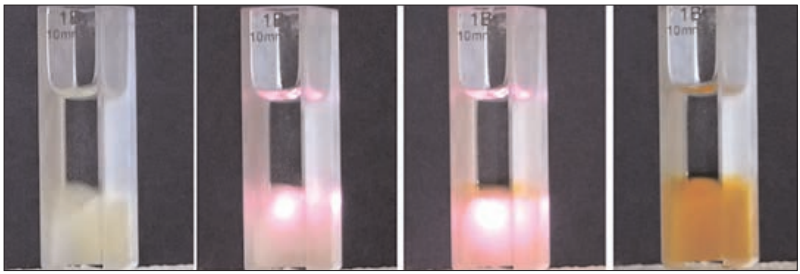
Project/Line of research: Laser applications in Organic Chemistry.

Action objectives: Studying the effects of a femtosecond laser on the catalysis of different organic compounds.

Experimental development: With a simple system of beam focalization control, laser filaments were generated to increase irradiance on the material that was being processed.

Duration: 5 days

Results: An improvement was observed in the catalysis time of organic compounds when the reactions were accelerated. This research is part of an end-of-degree project. More experiments will be held in this same line.

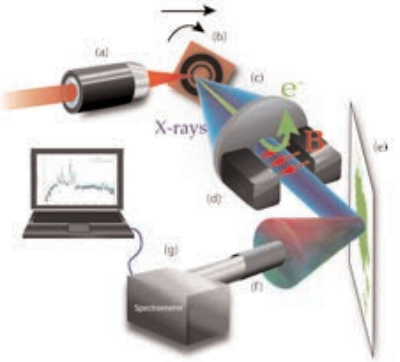


Effect of laser radiation on the catalysis of an organic compound

X-Ray Laboratory [IRA 3254] (WS04)

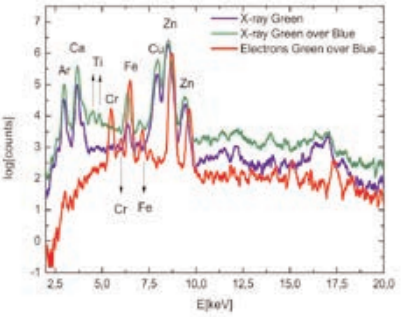
User: Centre's own research

Project/Line of research: Spectroscopy for the analysis of different layers of paint in works of art and/or heritage pieces. X-ray fluorescence (XRF) is widely used in the analysis of works of art. The excitation of the atoms in the paint through X-rays generated in a conventional tube makes it possible to analyse the characteristic lines of the atoms and to identify the substances that the paint is made of. This makes it possible to verify the authenticity of a piece or even to date it. However, conventional techniques do not enable layer-by-layer analysis.



Experimental setup: (a) microscope objective, (b) cooper target, (c) collimator, (d) magnets, (e) sample, (f) collimator, (g) spectrometer.

Action objectives: the aim of this experiment is to be able to perform such an analysis thanks to the use of a laser source of X-rays, such as the one designed and installed in the CLPU. During the tests, a surface analysis could be carried out by using the electrons that had been accelerated by this source. At the same time, a deeper analysis could be obtained with X-rays. Several samples were analysed in this experiment, and we verified how electrons made it possible to identify the surface layer of paint whereas X-rays revealed the paint which hid in the deeper layers of the sample.



X-ray fluorescence spectrum for the green pigment when excited by X-rays, and for the composed sample green over blue when excited by X-rays and electrons.

Experimental development: For this experiment, magnets were used to divert the electrons, and the sample can be placed so that it only receives X-rays or electrons. A conventional spectrometer was used to analyse the characteristic lines emitted by the paint.

Duration: 3 months

Results: The experiment was a success, and it has opened the way to look for collaboration of other ICTS which may have an interest on this topic, such as CENIEH and CNA, to study practical cases (paintings, archaeological remains, etc.). Also, an article on this topic has been accepted, although not yet published, by Applied Physics B (APHB-D-16-00244R1).

User: Centre's own research

Project/Line of research: Study and development of personal dosimeters based on scintillation crystals and adapted to the radiation fields generated in a high-intensity laser station.

Action objectives: Obtaining measures for the development of a DAQ system for a detector based on YSO (Y2SiO5) crystal scintillators coupled to SiPM.

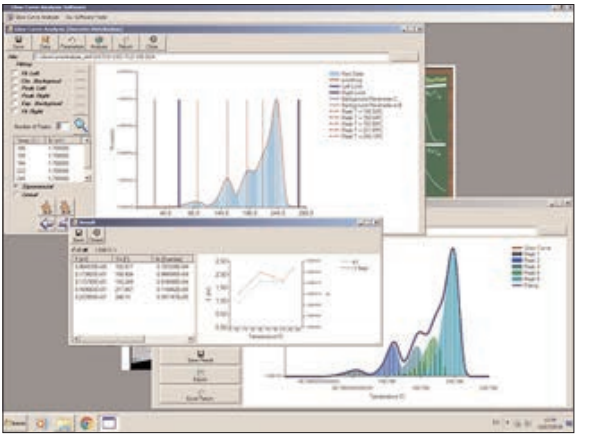
Experimental development: Design and manufacture of a LabVIEW-based DAQ system.

Duration: 1 day

Results: The action was carried out in the framework of a Master's Thesis which, due to its characteristics, has been selected as part of the University of Salamanca T-CUE plan for the development of prototypes.

User: Centre's own research

Project/Line of research: Study of the response of thermoluminiscent dosimeters (TLDs) exposed to pulsed and mixed radiation fields (photons and electrons) generated in the X-ray laboratory.



Software for the analysis of curves of TLDs

Action objectives: Exposure of several batches of TLDs for the reading and analysis of light curves in order to establish the average doses.

Experimental development: Study of light curves obtained from TLDs exposed to the X-ray source of the CLPU. The study used software developed at CIEMAT. This ongoing project intends to obtain an initial adjustment of the parameters and the potential needs to adapt the software for its use at the CLPU.

Duration: 3.5 days

Results: Joint presentation of results in the V Joint conference SEFM-SEPR

User: Centre's own research

Project/Line of research: Research carried out within the framework of the FURIAM project (Search of New Sources of Ionizing Radiation for Medical Applications)

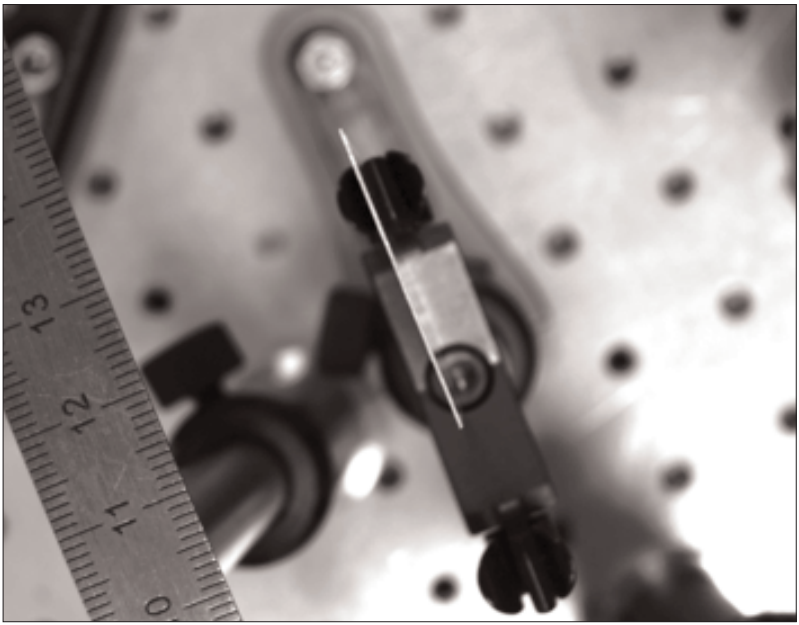
Action objectives: Development of a third harmonic generation system for the design of a proton diagnosis system.

Experimental development: The main target was to use an ultraviolet light source generated through a third harmonic system in order

to stimulate a scintillating sheet and determine the output emission. One of the most important parts was the setup of the ultraviolet light source and the imaging system to capture the output signal of the scintillator. The final aim of this action was to design an online detection system with a scintillator sensitive to the protons of the VEGA laser system.

Duration: 3.5 days

Results: The results are being assessed for the publication of an article or a contribution to a specialized event. The research will continue to improve the resolution of the imaging system.

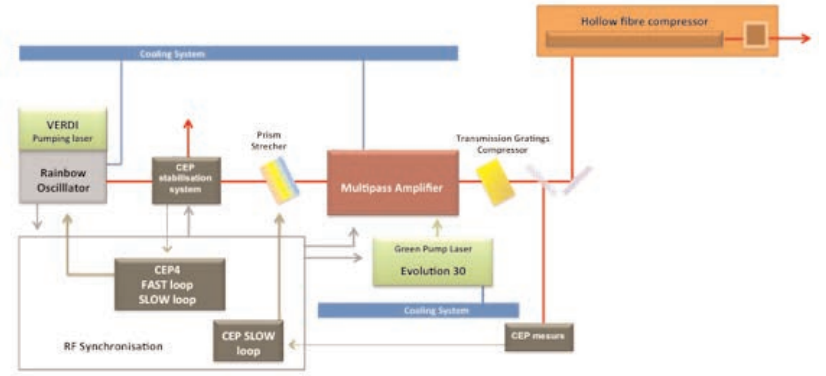


250 micron scintillating sheet

LASER SYSTEM WITH CEP STABILIZATION

(Carrier-Envelope Phase) → (cepservice@clpu.es)

TECHNICAL SPECIFICATIONS	
Commercial Model	*Femtopower PRO-HE CEP4*
Energy/pulse	2 mJ | < 0,6 mJ (post-compression)
Duration/pulse	25 fs | < 5 fs (post-compression)
Repetition rate	80 MHz (oscillator) | 1 kHz (amplification- post-compression)
Central wavelength	790 nm
Pre-pulse contrast	10^8:1
Polarization	Linear, p

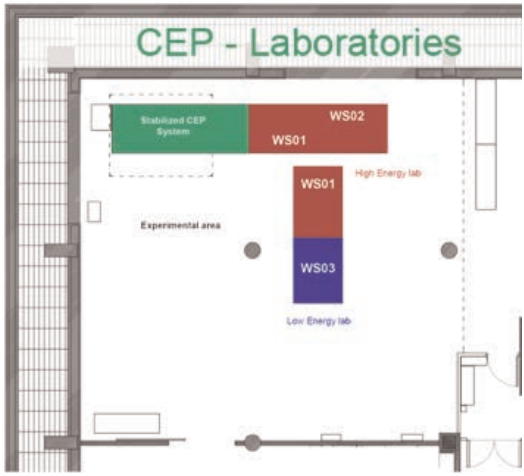


Experimental Station: High Energy Laboratory WS01

User: University of Salamanca, in collaboration with the University of Porto (Portugal)

Project/Line of research: FIS2013-44174-P, item 'Generation and characterization of ultrashort pulses in different spectral ranges'

Action objectives: This proposal is based on a previous joint campaign which worked on the post-compression of laser pulses with chirped mirrors with large bandwidth and coherent control using the Dazzler system of the laser. This new campaign intends to repeat the experiment with new-generation chirped mirrors in order to



achieve an even higher post-compression. Theoretically, those mirrors may enable pulse post-compression down to less than 3 femtoseconds.

Experimental development: The post-compression system was aligned, and the new-generation mirrors were placed for phase compensation. Next, the researchers looked for the optimal conditions for the nonlinear process in the gas (Ar, Ne) inside the hollow fibre by modifying the experimental parameters. The output pulses were identified with an adapted d-scan system for pulses with few cycles. After spectral phase compensation was optimized, measurements were taken for 2.5-femtosecond pulses around the optical cycle and in the Fourier limit. Therefore, the post-compression technique which had been prepared in previous campaigns has been optimized with the use of new-generation chirped mirrors and the cutting edge results obtained are superior to those of the rest of the post-compression systems with single-channel compensation

Duration: 4 days

Results: At the time of completion of this report, an article was being prepared for publication.

Experimental station: High Energy Laboratory WS02

User: University of Salamanca

Project/Line of research: Part of Project FIS2013-44174-P

Action objectives: High harmonic generation with beams spatially dependent on polarization.

Experimental development: After verifying the proper operation of the harmonic generation chamber, the beam was focused with different lenses for an optimization of the HHG (High Harmonic Generation) process. The polarization response of the detection system (spectrometer) was calibrated to use it as an analyser. Finally, harmonic generation was studied with a special retarder which generates vector beams. Thanks to the selective polarization of the spectrometer, the extreme ultraviolet beam (XUV) generated remained a vector beam.

Duration: 4 days

Results: The results are enough to verify the theoretical simulations. Consequently, no complementary experiments are scheduled. At the date of completion of this report, the research team was preparing an article for publication.

Experimental Station: High Energy Laboratory WS01

User: ELI – Attosecond Light Sources

Project/Line of research: Generation of X-rays through laser.

Action objectives: Researching X-ray generation with a laser with characteristics similar to those of the CEP and obtaining experimental evidence of the theoretical results of Dr Papp, from the ELI-ALPS (Extreme Light Insfrastructure-Attosecond Light Pulse Source).

Experimental development: X-ray generation involves the focalization of a laser over a metal target in a vacuum. Since this is an experiment which had not been previously carried out in this laboratory, a custom set-up was installed. A retarder line was assembled to obtain a pre-pulse that would improve the efficiency of X-ray pro-

duction and a vacuum chamber was installed to place the target. After the assembly, different targets were tested to compare the efficiency of X-ray production.

Duration: 1 month

Results: The data obtained support the previous simulations, and an article will be published with the experimental results.

Experimental Station: High Energy Laboratory WS01

User: University of the Basque Country

Project/Line of research: Generation of a third harmonic in air for experiments of ultrafast molecular dynamics.

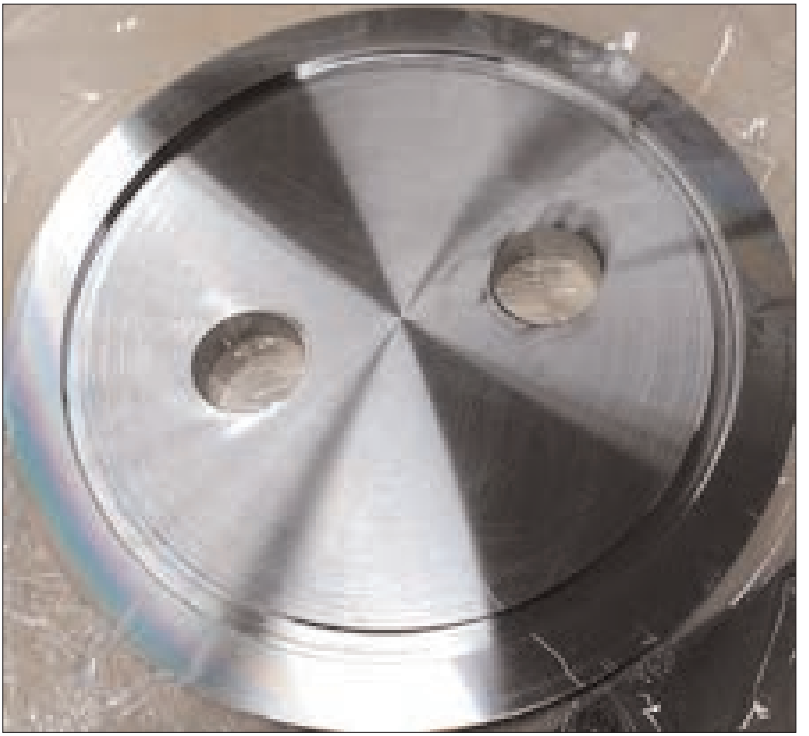
Action objectives: Using the temporal resolution of the CEP laser for studies in ultrafast molecular dynamics with molecules of biological interest.

Experimental development: Due to the ultrashort temporal duration of the CEP laser and in an attempt to maintain the highest possible temporal resolution, the third harmonic generated in air did not cross any material, but was coupled to the experimentation chamber —under ultra-high vacuum conditions— through a system of differential vacuum. The third harmonic was used in pump-probe experiments —with a portion of the CEP laser in the infrared region as a probe—, and the ultra-rapid de-excitation dynamics of the naphthalene molecule were temporarily solved.

Duration: 3 weeks

Results: A publication with the experimental results of this campaign will be prepared. Once that the system has been tried the ultra-rapid de-excitation of molecules in this spectral range will be subject to further research. Also, attempts to improve the temporal resolution of the system will soon be carried out by using the post-compression offered by the system, which obtains pulses of 7 fs rather than 25 fs.

Other services: During the development of this experimental campaign, the Machining Workshop of the Centre was requested to adapt an ISO-K 160 blind lid. The objective was to accurately bore two holes on the lid so that mechanical elements could pass through it, namely a sealed bracket which transmitted movement under vacuum conditions.



Custom piece

OSCILLATORS SERVICE → (oscillatorsservice@clpu.es)

Experimental Station: Oscillators Area

User: Deneb Medical S.L.

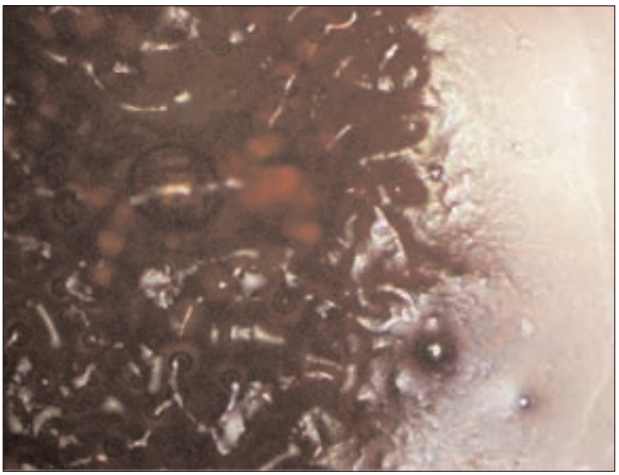
Project/Line of research: Design and development of a laser-guided surgery system with selective tissue discrimination.

Action objectives: Preliminary experiments to identify the best conditions to cauterize and coagulate blood vessels.

Experimental development: The set-up is a reduced version of material processing in which the complexity lied on controlling the blood vessel and introducing blood under relatively controlled conditions.

Duration: 3 days

Results: Blood coagulation and tissue cauterization were shown to be feasible both with a femtosecond laser in the infrared region and with a continuous visible laser. Experiments are expected to continue in 2017.



Laser coagulation sample.

Experimental Station: Oscillators Area

User: Institute of Materials Science of Madrid (ICMM-CSIC) & Jeanologia.

Project/Line of research: Development of ultrashort laser pulses with advanced features at a low cost for application in new industries.

Action objectives: To try pulsed laser operation in new Yb-doped crystals.

Experimental development: This experiment uses the laser designed for the previous Femtolaser project, in which only the crystal was changed.

Duration: 22 days

Results: The results show instability which is expected to be corrected, at least with picoseconds and femtoseconds, in upcoming campaigns.

Experimental Station: Oscillators Area

User: Institute of Materials Science of Madrid (ICMM-CSIC) & Jeanologia.

Project/Line of research: Development of ultrashort laser pulses with advanced features at a low cost for application in new industries.

Action objectives: Carrying out LIDT tests with new laser crystals in the new PS2 fibre laser prototype.

Experimental development: Standard microprocessing set-up for the analysis of the optical damage of the equipment with wavelength close to the laser emission of the oscillator.

Duration: 3 days

Results: The degree of damage could not be properly established because the PS2 FYLA laser was too close to the damage threshold, or even below it. For this reason, tests will continue in 2017 through experiments with a higher energy laser.

Experimental Station: Oscillators Area

User: Jeanologia.

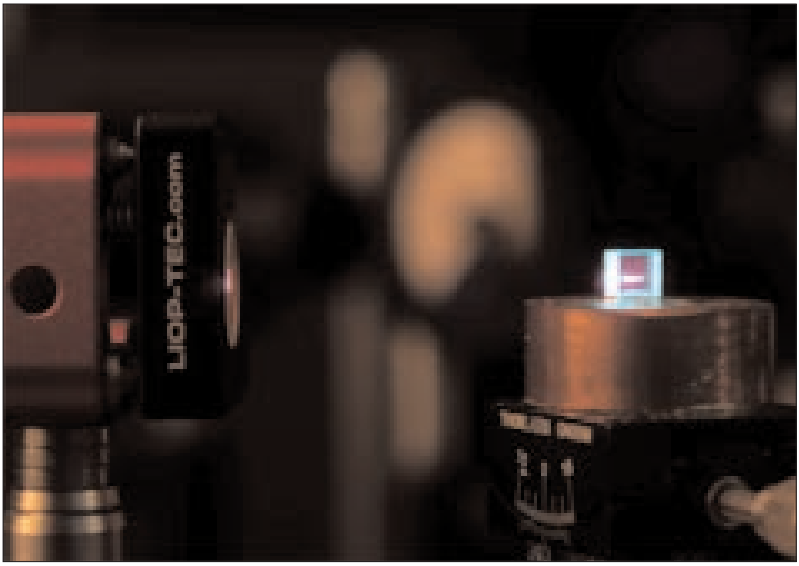
Project/Line of research: Development of ultrashort laser pulses with advanced features at a low cost for application in new industries.

Action objectives: Verifying the best laser oscillator designs in picoseconds and femtoseconds with an optical table prototype.

Experimental development: Tests with different set-ups for the creation of laser cavities.

Duration: 84 days.

Results: The first part of the designs has been completed with picosecond pulses with repetition rates of up to 300 MHz. This means that the necessary knowledge has been obtained for an optimal selection of components, which will make it possible to move forward with the global objective of the project.



Ytterbium-doped laser crystal during the first experiments with the prototype.

Experimental Station: Oscillators Area

User: Jeanologia & FYLA

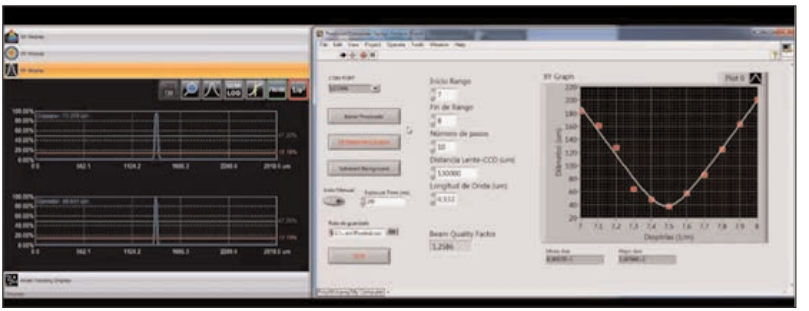
Project/Line of research: Development of ultrashort laser pulses with advanced features at a low cost for application in new industries.

Action objectives: Obtaining a compact and fast system for the characterization of the laser beam and its divergence.

Experimental development: An M2 characterization module has been developed with a beam profiler or CCD, neutral filters and a liquid lens.

Duration: 33 days.

Results: It has been shown that the classic set-up can be minimized and a custom software prototype has been developed. Application for the results is being researched, as well as improvements to the software for its implementation in an integrated prototype.



Screen capture of the control software for M2 characterization.

Experimental Station: Oscillators Area

User: Jeanologia & FYLA

Project/Line of research: Development of ultrashort laser pulses with advanced features at a low cost for application in new industries.

Action objectives: Verifying the correct operation of prototypes and assessing their characteristics for later improvements.

Experimental development: A standard set-up is prepared to characterize the PS2 Laser Fibre prototype. Studies were carried out to control polarization and output beam. The laser beam was characterized on the focus of PS2 and different tests of laser processing were carried out with the prototype.

Duration: 64 days

Results: Results were satisfactory, and the expected improvements were made on the prototype.

Experimental Station: Oscillators Area

User: Jeanologia & FYLA

Project/Line of research: Development of ultrashort laser pulses with advanced features at a low cost for application in new industries.

Action objectives: Proving the compression of stretched ultrashort pulses through some optical components.

Experimental development: Several systems for pulse compression were designed with prisms and diffraction gratings. It has been proven that the initial pulse values could be recovered. Also, the system was characterized to optimize the parameters of the optical components.

Duration: 45 days

Results: The results were used to design and obtain FBG devices with specific parameters for the laser fibre prototype. Also, the best specifications were studied and measured for VBG devices used as pulse compressors.

Experimental Station: Oscillators Area

User: University of Salamanca

Project/Line of research: Master's Thesis.

Action objectives: Development of solid-state oscillators with ytterbium.

Experimental development: Set-up of laser cavities with two mirrors and Yb crystals.

Duration: 9 days

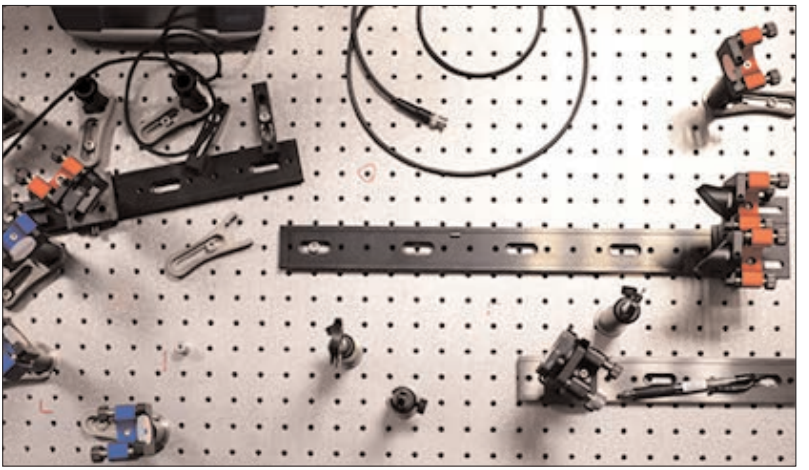
Results: Research will continue before the Master's thesis defence.

Experimental Station: Oscillators Area

User: University of Salamanca

Project/Line of research: End-of-Degree Project.

Action objectives: Systems for SESAM device characterization.



Experimental set-up.

Experimental development: Experimental set-up with optics of broad-band mirrors, beamsplitters and photodiodes which showed the operation of a system for the characterization of semiconductor saturable absorber mirrors.

Duration: 12 days

Results: The results of this research were presented before a panel for assessment.

MICROSCOPY SERVICE → (microscopyservice@clpu.es)

Experimental Station: SEM (Scanning Electron Microscopy)

User: Department of Inorganic Chemistry of the University of Salamanca.

Project/Line of research: Society Challenges MAT2013–47811–C2–R, line of research focused on the study of the modification of clay-like materials through different methods and new applications of the resulting solid materials. Spanish-Brazilian Programme of Inter-University Cooperation, reference no. PHBP14/00003, in collaboration with researchers from the Universidade de Franca (Brazil).

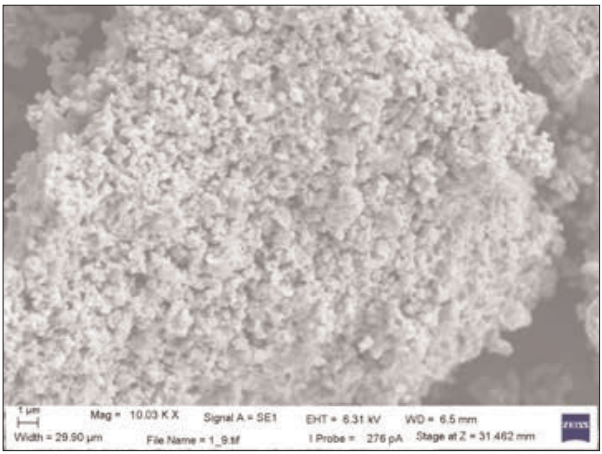
Action objectives: During the observation stage, the starting materials and the solids were studied in order to verify the alterations caused by the different treatments. The two main samples analysed were montmorillonite (plate-shaped clay) that had been pillared with titanium polycations doped with different transition elements, which has later been used to remove methylene blue and the antibiotic trimethoprim from water; and a diatomaceous earth (silica derived from single-cell algae) treated with acid that has later been used as support for active catalytic phases.

Results: The results obtained have been published in different scientific communications:

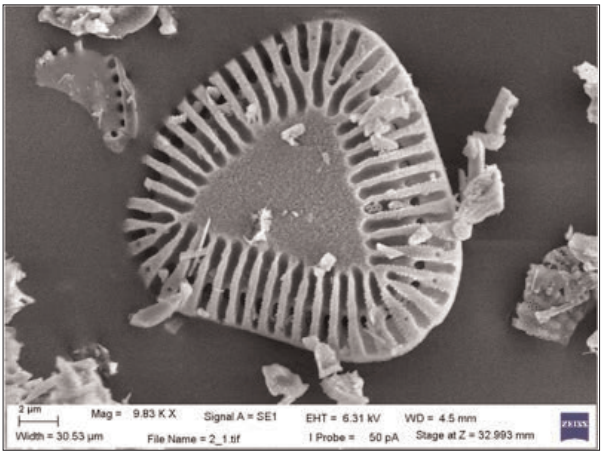
- Gestión de contaminantes utilizando montmorillonita pilareada con policationes de titanio [Management of contaminant elements with pillared montmorillonite with titanium polycations], B. González, R. Trujillano, V. Rives, M.A. Vicente, A. Gil, S. Korili, K.J. Ciuffi, E.H. de Faria, for the 17th Biennial Conference of the Specialized Group of Inorganic Chemistry and the 11th Biennial Meeting of the Specialized Group on Solid-State Chemistry of the Royal Spanish Society of Chemistry (QIES16). Torremolinos, June 2016.
- Removal of Methylene Blue and Trimethoprim from Aqueous Solutions using Doped Ti-Pillared Clays, B. González, R. Trujillano, V. Rives, M.A. Vicente, A. Gil, S. Korili, T.H. da Silva, L. Bonfim, K.J.

Ciuffi, E.H. de Faria. Interfaces Against Pollution (IAP 2016). Lérida (Spain), September 2016.

- Diatomaceous earth as efficient support for heterogeneous ironporphyrin catalysts, M.V. do Prado, E.J. Nassar, E.H. de Faria, K.J. Ciuffi, B. González, M.A. Vicente, R. Trujillano, V. Rives. XVIII Brazilian Meeting on Inorganic Chemistry (BMIC). São Pedro (Brazil), September 2016.



Pillared montmorillonite with iron-doped titanium polycations



Diatomaceous earth treated with HCl

Experimental Station: SEM

User: Department of Inorganic Chemistry of the University of Salamanca.

Project/Line of research: Matusalén Project, Collaboration Challenges 2014, Ministry of Economy and Competitiveness.

Action objectives: The materials studied are conductive polymers which have been subject to degradation procedures. An analysis of the surface texture of the materials has been carried out, and tests will be performed to verify the correlation between surface changes and degradation patterns.

Results: Results will be shown first to the collaborator companies during the coordination meeting.

Experimental Station: SEM

User: University of Salamanca, in collaboration with Newcastle University.

Project/Line of research: Analysis of microbial diversity in the Atacama Desert (Chile)

Action objectives: Analysis of the morphology of colonies.

Results: At the time of completion of this report, an article was being prepared for publication.

Experimental Station: SEM

User: Service of X-ray diffraction, University of Salamanca

Project/Line of research: Research group's own research

Action objectives: Study of different morphologies of composite isomeric crystals.

Results: Study in progress.

Experimental Station: SEM

User: Department of Pharmaceutical Sciences of the University of Salamanca.

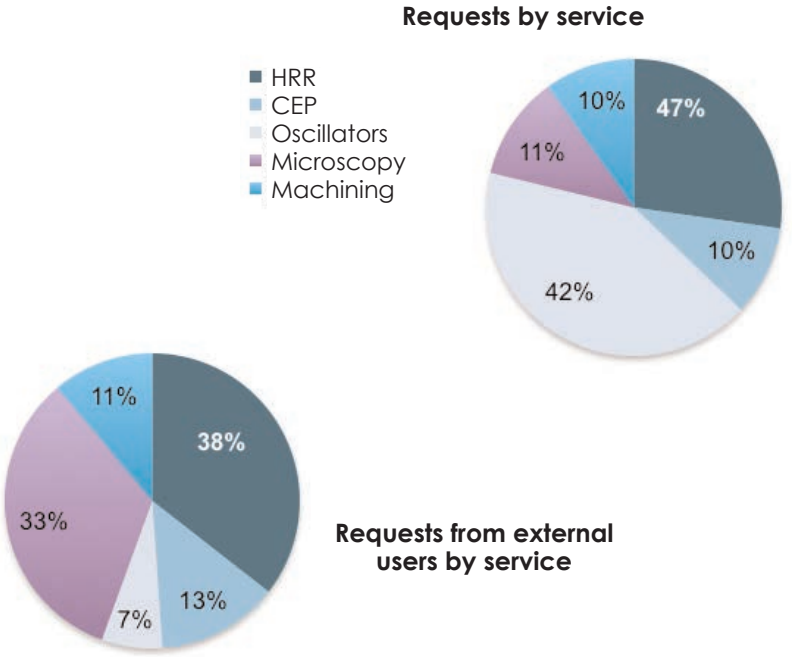
Project/Line of research: Research group's own research.

Action objectives: Characterization of liposomes.

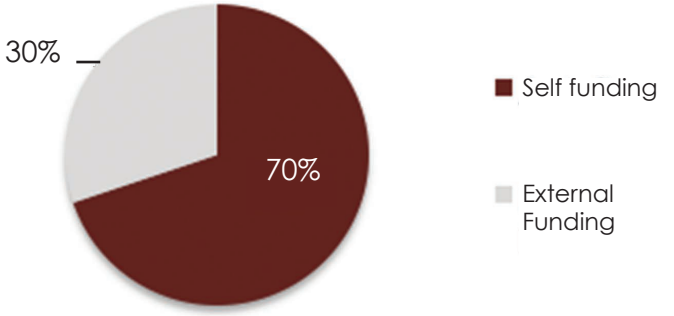
Results: The analyses have led to an article that will be published next year.

ACTIONS SUMMARY

This report includes the actions from users who have submitted a summary of the procedures carried out in our facility. However, it does not include all the initiatives that have taken place. The following summary presents all the requests that have been accepted and carried out in the Centre.



Total Funding / Access [1]



STRUCTURE SERVICES

LASER SYSTEMS

VEGA
Petawatt system
vegaservice@clpu.es

HHR
High Repetition Rate System
highrepservice@clpu.es

CEP
CEP System
cepservice@clpu.es

SUPPORT UNITS

Oscillators
oscillatorsservice@clpu.es

Microscopy
microscopyservice@clpu.es

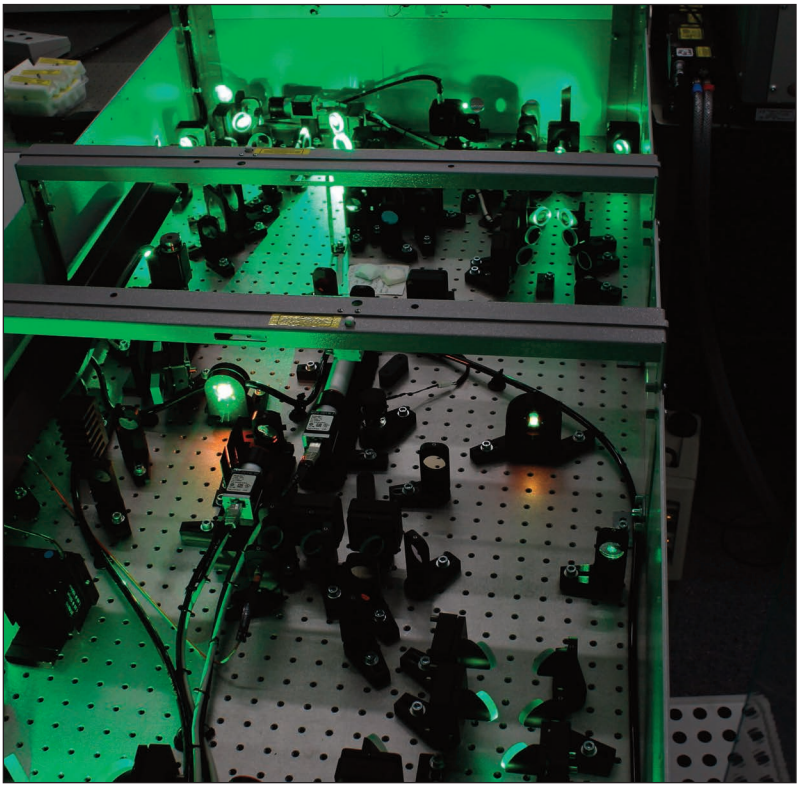
Machining and Electronics
mechatronics@clpu.es

1 Access to the Oscillators Service not included, because they were not done through FARO, and there is no estimated budget.

IG - Science of Excellence

KNOWLEDGE MANAGEMENT

In 2015, the Regional Government of Castile and León granted the Pulsed Lasers Centre the title of "Consolidated Research Unit", as part of its Programme of Excellence in Science and Technological Leadership. With this initiative, it endorsed an essential research activity with which the CLPU tries to promote the specialization of its infrastructure and its establishment as a reference of quality support for its users. It does so through different means: projects, institutional research collaborations, scientific production, international stays and participation and/or organization of specialized events.



VEGA-1 operating.

Projects

Applied Research

(1) Development of a system for continuous over-critical density laser targets

[MINECO - Incentives for Infrastructures and Scientific-Technical Equipment]

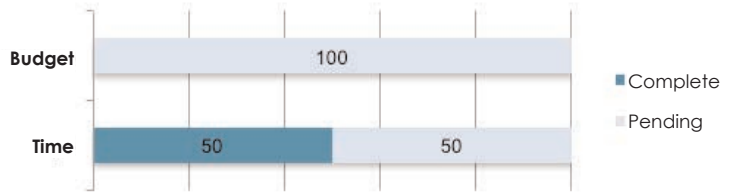
Description: In order to achieve a return on the high repetition rate features of a unique equipment such as VEGA it is necessary to have targets which may be replaced at that speed while maintaining the necessary conditions of vacuum and cleanliness. This project wants to promote the development of continuous targets with critical or over-critical density, since in the field of particle acceleration —the main line of research of the Centre—, plasma is generated with those densities.

Milestones 2016:

- Start of the technical document for the tender for the equipment. The final decision to approve it was published in December 2016.

Information

Start	End	Duration	Budget
01/01/2016	31/12/2017	24 months	92.188,20 €



(2) Barium Tagging

[MINECO - Research Challenges – R+D+i Projects 2014.
Funded by the EU - ERDF]

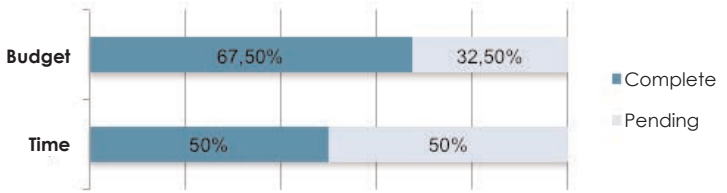
Description: This project is an activity that stems from the NEXT project, coordinated from the Institute of Corpuscular Physics (Valencia). The objective of this project is to prove that Ba^{++} ions produced by xenon double beta decay can be tagged and detected.

Milestones 2016:

- Design and implementation of an electronic ionization system to carry out a spectroscopy of Ba ions with laser. This milestone has also involved acquiring all necessary material, the design and construction of a support for the nozzle and of the condensation plates for ion extraction in the time-of-flight spectrometer.
- Optimization of the ion source with experimental tests.
- Relocation of the experimental set-up in order to carry out new spectroscopy measurements and to use new techniques, such as LIF in the next level of the Ba^{+} scheme.
- Experiment to verify the decay from Ba^{++} to Ba^{+} through Xe collisions.

Information

Start	End	Duration	Budget
01/01/2015	31/12/2018	48 months	78.650,00 €



(3) Extreme Diagnosis

[Regional Government of Castile and León – Support for Research Projects 2016. Funded by the EU - ERDF]

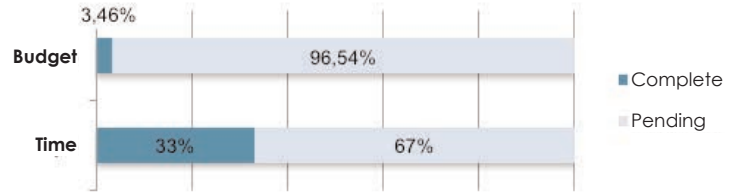
Description: The goal of this project is to move forward in the area of detection of different procedures of light-matter interaction in the femtosecond range, and to generate new tools for extreme diagnosis with high intensity and high pulse repetition rate.

Milestones 2016:

- Preparation of the experimentation area with a versatile design for the beam transport system under vacuum.
- Advances in the detection and characterization of the VEGA-2 laser pulses using conventional metrology systems.
- Preliminary design of mechanisms for extreme detection.
- Preliminary set-up of the intensity detector.
- Study of the optimal location extreme detection systems along the beam trajectory in the experimental area.

Information

Start	End	Duration	Budget
01/01/2016	31/12/2018	36 months	68.460,00 €



(4) FURIAM – Ultrafast Sources of Ionizing Radiation for Medical Applications

[MINECO - Research Challenges – R+D+I 2014.
Funded by the EU – ERDF]

Description: The goal of this project is to obtain ultrafast sources of ionizing radiation (femtoseconds) which can be used by the biomedical community.

Milestones 2016:

- The final supporting document was finished.
- Analysis of results and continuity based on them in the PALMA Project (Laser-Accelerated Particles for Medical Applications).

Information

Start	End	Duration	Budget
01/01/2014	31/12/2016	36 months	232.320,00 €

Promotion of Research - Network Projects

(1) CATLUR – Science, Applications and Technology of Ultrafast Lasers

[MINECO - Excellence Networks]

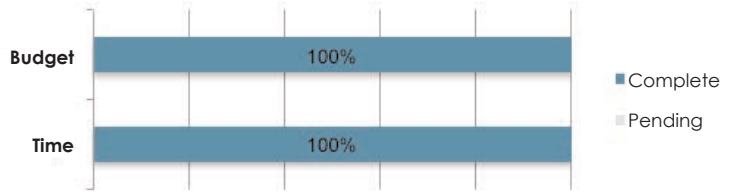
Description: This project aims to generate a tool to maintain the cohesion of GELUR, the Group of Specialization in Ultrafast lasers created as a consolidation of the expert work team which emerged after the end of the CONSOLIDER SAUUL Project (Science and Applications on Ultraintense Ultrafast Lasers).

Milestones 2016:

- Consolidation of the platform of the specialized group.
- Creation of the last reports edited within the framework of the project.
- Maintenance of the group website.

Information

Start	End	Duration	Budget
01/12/2014	30/11/2016	24 months	35.000,00 €



(2) Laserlab Europe IV

[UE - H2020 - INFRAIA 2014-2015]

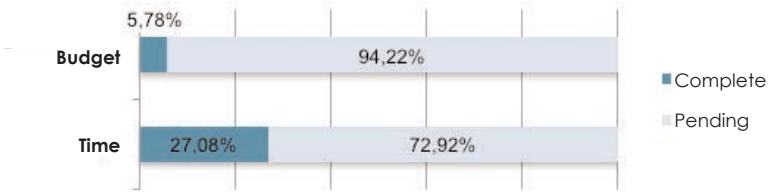
Description: *Laserlab Europe* is a European consortium which initiates its fourth stage with 33 European laboratories and associated companies which work on basic and applied research in the field of intense lasers, as well as on the study of laser-generated high-energy particle beams and their potential applications in the areas of industry, applied research and medicine. The CLPU works in three different areas: development and applications of compact light sources (WP01); radiotherapy and imaging based on laser-accelerated proton beams and advanced instruments (WP02); and development of interaction targets for high-energy photons and laser-generated particle sources (WP03).

Milestones 2016:

- Start of activities of the VEGA-2 laser (WP01).
- Experiment with VEGA-2 to obtain a Betatron radiation source by accelerating electrons at relativistic energies (<1 MeV) (WP01).
- Set-up and optimization of the experimentation area with VEGA to achieve proton acceleration (WP02).
- Design of an online proton detector based on a matrix of scintillators and a 1.2 Tesla magnet.
- Study and design of advanced instruments based on the development of interaction and diagnosis targets for X-ray laser sources (WP03).

Information

Start	End	Duration	Budget
01/12/2015	30/11/2019	48 months	66.250,00 €



Training

(1) FPU 2012

[MECD - Grants for the Training of University Lecturers]

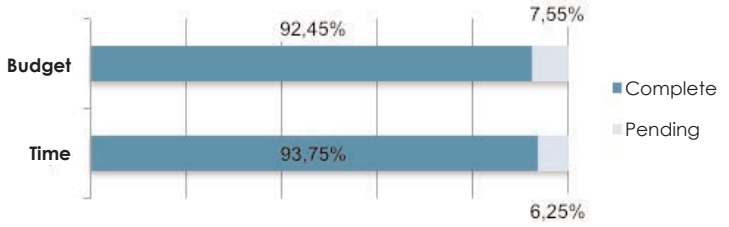
Description: The work proposal is a doctoral thesis focused on the study and design of a proton source which can cause nonlinear damage of materials.

Milestones 2016:

- First studies of nonlinear damage on materials.
- Optimization of the experimental set-up.
- Final proposals for the characterization of a high flow system.
- Experimental campaign to optimize the techniques used in the study.

Information

Start	End	Duration	Budget
01/04/2013	31/03/2017	48 months	71.234,16 €



(2) Promotion of Youth Employment and Implantation of Youth Guarantee

[MINECO - Promotion of Talent and Employability]

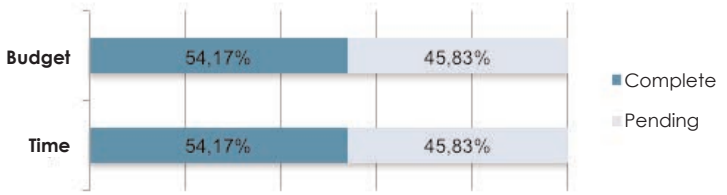
Description: This project is aimed at the hiring of technical staff in the Technical Area of the CLPU to support the constant tasks of set-up, activation and maintenance of the VEGA laser system while received specialized training in this field.

Milestones 2016:

- Training and preparation of an inventory and maintenance procedures for the material of the Centre.
- Training in the use of PCB Piezoelectronics accelerometers to measure vibration in the VEGA laboratory
- Participation in the study and design of a portable laminar flow hood to protect diffraction networks on VEGA-3 and VEGA-2 compressors, with training in 3-dimensional design and modelling (SolidWorks).

Information

Start	End	Duration	Budget
30//11/2015	29/11/2017	24 months	39.200,00 €

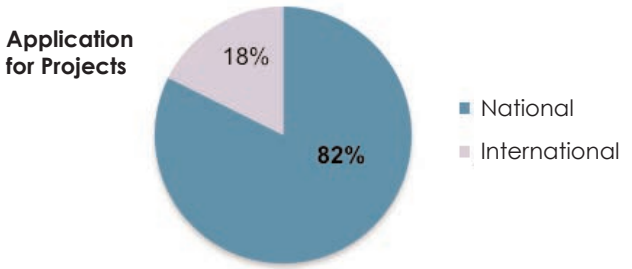


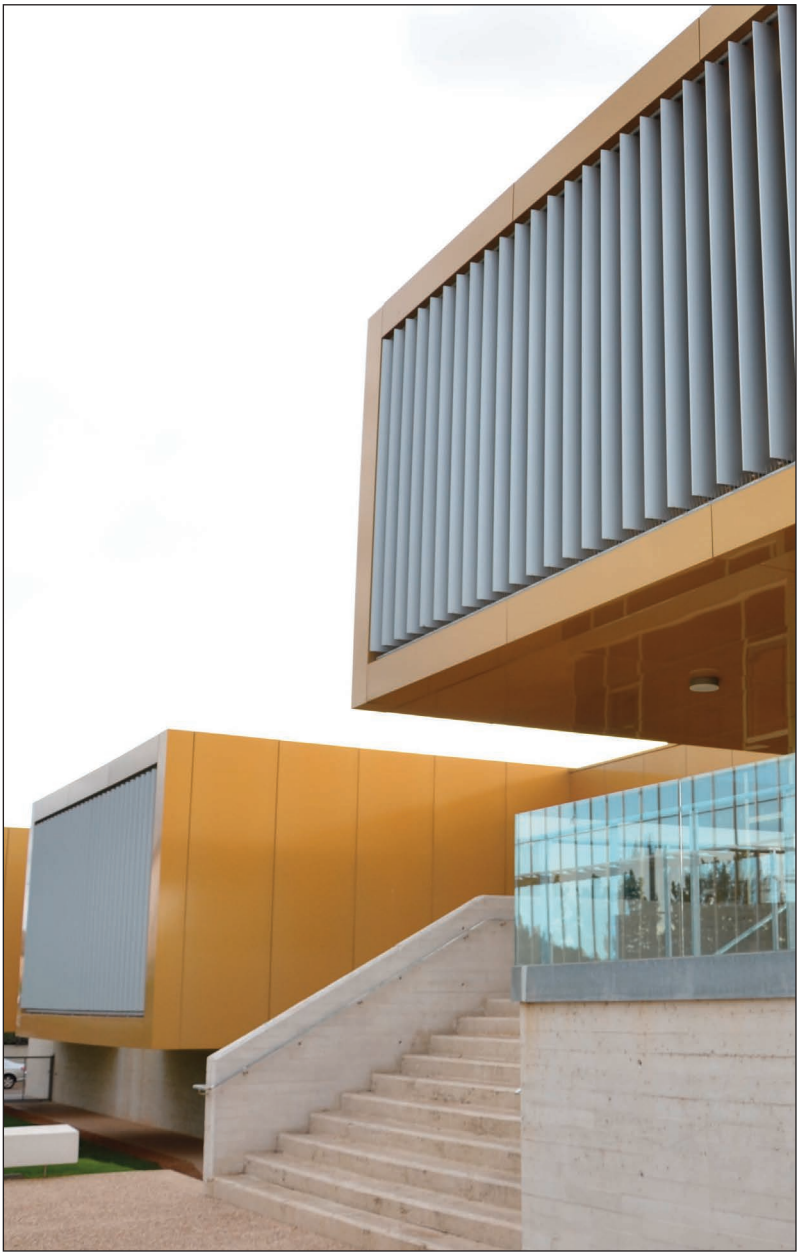
APPLICATIONS FOR NEW GRANTS

National calls			
Type	**Name**	**Submitted**	**Result**
MINECO. Society challenges	PALMA. Laser-Accelerated Particles for Medical Applications	April	Granted
MINECO. Excellence Networks	RedLUR. Spanish Network of Ultrafast Lasers	July	Pending
MINECO. Promotion of Talent and Employability	Ramón y Cajal Programme (2)	June	Denied
Regional Govt. of Castile and León – Support for Research Projects	Extreme Diagnosis	March	Granted
MINECO. Promotion of Talent and Employability	Juan de la Cierva Programme (2)	June	Denied
MINECO. Promotion of Talent and Employability	Technical Support Staff (PTA) (4)	June	Denied
CDTI Neotec	Protection against ultrafast lasers	Sept.	Pending
Regional Govt. Of Castile and León - Grants for Predoctoral Contracts	Predoctoral contracts (2)	Dec.	Pending

International calls / Pending resolution			
Type	**Name**	**Submitted**	**Participation**
ESA	e-ASTROGAM	October	Collaborator
H2020 - INFRAIA	PACT: Pair & Compton Telescope	October	Collaborator

International calls / Denied			
H2020 - MSCA ITN 2016	NOVA	February	Partner





SCIENTIFIC PRODUCTION - RESULTS

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- **Valle Brozas, F.; Salgado, C.; Apiñániz, J.I.; Carpentier,A.V.; Sánchez-Albaneda, M.; Roso, L.**; Raposo, C.; Padilla, C. and **Peralta-Conde, A.**, *Determination of the species generated in atmospheric-pressure laser-induced plasmas by mass spectrometry techniques*, Laser Physics, 26, 55602.
- **Döpp, A.**; Guillaume, E.; Thaury, C.; Lifschitz, A.; Sylla, F.; Goddet, J.P.; Tafzi, A.; Iaquanello, G.; Lefrou, T.; Rousseau, P.; Conejero, E.; Ruiz, C.; Ta Phuoc, K. and Malka V., *A bremsstrahlung gamma-ray source based on stable ionization injection of electrons into a laser wakefield accelerator*, Nuclear Instruments & Methods in Physics Research, 830, 515-519 (Sep.2016).
- King, M.; Gray, R.J.; Powell, H. W.; MacLellan, D.A.; González.Izquierdo, B.; **Stockhausen, L.C.**; Hicks, G.S.; Dover, N.P.; Rusby, D.R.; Carroll, D.C.; Padda, H.; Torres, R.; Kar, S.; Clarke, R.J.; Musgrave, I.O.; Najmudin, Z.; Borghesi, M.; Neely, D. and McKenna, P., *Ion acceleration and plasma jet formation in ultrathin foils undergoing expansion and relativistic transparency*, Nuclear Instruments & Methods in Physics Research, A, 829, 163-166 (Sep.2016).
- **Valle Brozas, F.**; Crego, A.; **Roso, L.** and **Peralta, A.**, *Laser-based X-ray and electron source for X-ray fluorescence studies*, Applied Physics B, 122:220.
- **Döpp, A.**; Guillaume, E.; Thaury, C.; Gautier, J.; Andriyash, I.; Lifschitz, A.; Goddet, J-P.; Tafzi, A.; Rousse, A. and Ta Phuoc K., *An all-optical Compton source for single-exposure X-ray imaging*, Plasma Physics and Controlled Fusion, 58, 3.
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- **Döpp, A.**; Guillaume, E.; Thaury, C.; Gautier, J.; Ta Phuoc K. and Malka, V., *3D printings of gas jet nozzles for laser-plasma accelerators*, Scientific Instruments, 87, 073505.

- Castillo, G.C.; Romero, C.; Lifante, G.; Jaque, D.; Chen, F.; **Varela, Ó.; García-García, E.; Méndez, C.**; Camacho-López, S. and R. Vázquez de Aldana, J., *Stress-induced waveguides in Nd:YAG by simultaneous double-beam irradiation with femtosecond pulses*, Optical Materials, 51, 84-88.
- Choi, S.; Ciappina, M.F.; **Pérez-Hernández, J.A.**; Landsman, A.S.; Kim, Y.J.; Kim, S.C. and Kim D., *Active tailoring of nanoantenna plasmonic fields using few-cycle laser pulses*, Physical Review A, 93, 21405.
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INSTITUTIONAL COLLABORATION

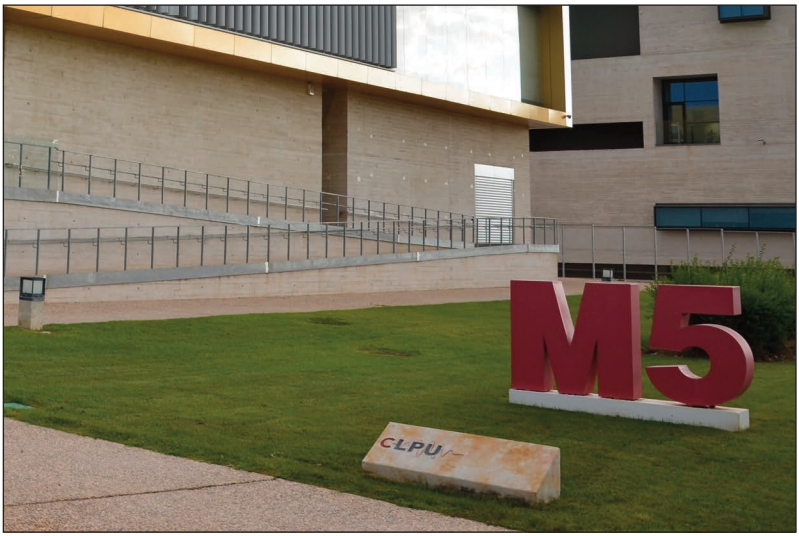
Research and Development		
Institution	**Type of Collaboration**	**Entry into force**
University of Alberta, Canada	Memorandum of Understanding	29/01/2016
University of Alberta, Canada	Addendum to the MOU for the development of an experimental campaign on VEGA-2	16/03/2016
Institut National de la Recherche Scientifique, Univ. Quebec, Canadá.	Contract for the manufacture of specific experimentation material	23/03/2016
ELI-NP – Horia Hulubei National Institute of Physics & Nuclear Engineering	Memorandum of Scientific Collaboration	04/05/2016
Syncrotron ALBA	Addendum to the Specific Collaboration Agreement to acquire a vacuum chamber for the compressor of a 1-petawatt laser system	01/09/2016

Training		
Institution	**Type of Collaboration**	**Entry into force**
University of Salamanca	Collaboration (8) in the Training Project	Jan/Feb 2016
University of Vigo	Agreement on Education Cooperation	01/02/2016
IES Vasco de la Zarza	Extension to the agreement signed as part of the CICERON Programme	02/02/2016
IES Venancio Blanco	Extension to the agreement signed as part of the CICERON Programme	19/02/2016

COLLABORATION IN EXPERIMENTS AND SCIENTIFIC VISITS

Collaboration in Experiments

Researcher	Destination	Dates
Jon I. Apiñaniz; Luca Volpe	GSI Darmstadt, Germany	10-30 january
José A. Pérez	ICFO, Barcelona, Spain	28 mach - 01 april
Luca Volpe; Marine Huault	Lawrence Livermore National Laboratories, California, USA	03 july - 07 august
Luca Volpe, Xavier Vaisseau, Sophia Malko	LULI, France	13 november 17 december
Carlos Salgado	CELIA, France	22 october - 06 november



Scientific Visits

Researcher / Institution	Objectives	Dates
Prof. Robert Fedosejevs / University of Alberta, Canada	Preparation of the 'zero' experiment for VEGA 2	January-May
Prof. Wendell T. Hill III / University of Maryland, USA	Expert advice from a CACT member.	23-27 mayo
Prof. Robert Fedosejevs / University of Alberta, Canada	Execution of the 'zero' experiment for VEGA 2	Noviembre-diciembre

SPECIALIZED EVENTS

Contributions		
Event	**Type of contribution**	**Main Researcher**
Conference on High Intensity Laser and Attosecond Science (CHILLI2016), Israel.	Intense and fast laser-matter interaction at CLPU (presentation).	Luca Volpe
Reunión de Usuarios Apollon, Paris, France.	Expert advice to workgroup	Luis Roso
Radiation Test Workshop 2016 'EEE Components Radiation Testing', Seville, Spain.	Laser-driven for space applications at the CLPU (presentation).	José M. Álvarez
ELI Perspectives (1), Prague, Czech Republic.	Expert advice to workgroup	Luis Roso
ELI Perspectives (2), Bucharest, Romania	Expert advice to workgroup	Luis Roso
COST MPA1208 'Developing the Physics & the Scientific Community for Inertial Fusion'	'Intense & Fast laser matter interaction at CLPU (presentation)	Mauricio Rico
18th International Conference on Solid State Dosimetry, Munich, Germany.	Response of EPDs to the radiation field generated from laser-solid interaction at High-Repetition-Rate (poster).	José M. Álvarez
18th International Conference on Solid State Dosimetry, Munich, Germany.	Toward a new generation of electronic personal dosimeters for high intensity laser facilities (poster).	José M. Álvarez
Laser Optics 2016, San Petersburgo	Science with a Petawatt laser. (Guest presentation)	Luis Roso
12th Direct-Drive and Fast Ignition Workshop, Bordeaux, France.	Parametric study of fast electron beam guiding using two-consecutive laser pulses (presentation).	Sophia Malko
International Conference and School on Plasma Physics and Controlled Fusion (ICCPCF2016), Prague, Czech Republic.	Relativistic electron beam guiding using two consecutive laser-pulses (poster).	Sophia Malko
Laserlab IV Meeting for JRA 'Laser-driven high energy Photon and Particles towards industrial and societal applications', Lisbon, Portugal.	Expert advice to workgroup	José A. Pérez, Luca Volpe

Contributions (cont.)		
Event	**Type of contribution**	**Main Researcher**
International Symposium on Ultrafast Intense Laser Science (ISUILS17), Marseille, France	Presentation of one of the panels int he conference. Moderator in one of the sessions and participation in the Scientific Committee of the event	Luis Roso
General Assembly of Laserlab IV, Amsterdam. NL	Participation in a meeting	Luis Roso, G. Gatti
LA3NET Novel Accelerators Workshop, Orly. France	High Repetition Rate Laser-Driven Proton / Ion Sources (Guest presentation).	Luis Roso
Mechanical Engineering Design of Syncrotron radiation equipment & instruments, Barcelona, Spain	Presentation of prototype	Juan Hernández
Laserlab IV Meeting for JRA 'Innovative Laser Technologies', Prague, Czech Rep.	Expert advice to workgroup	Mauricio Rico
LA3NET Novel Accelerators	High Repetition Rate Laser-driven Proton/Ion Electron Sources	Luis Roso
ELI-ALPS Users meeting, Szeged, Hungary	From particle acceleration to vacuum polarization (Guest presentation)	Luis Roso

Attendance	
Event	**Researcher**
POPRA seminar 'Programme Optique Physique Radiothèrapie en Aquitaine', Bordeaux. France	Marine Huault
COST MP1203 'Advanced x-ray spatial & temporal metrology', Athens. Greece	José M. Álvarez
Eupraxia Meeting, Pais. France	Luis Roso

SEMINARS TAUGHT IN THE CENTRE

Speaker	Title	Date
Marine Huault & Carlos Salgado	CLPU & ELI-ALPS experiment. Liquid target laser-driven hard x-ray	10/02/2016
José M. Álvarez	Background & test performed with personal dosimeters at the CLPU	14/04/2016
Ramon Corbalán & Jordi Mompart	Inversionless lasers	20/04/2016
José A. Pérez	High Order Harmonic Generation	20/04/2016
Jon I. Apiñániz	Proton beam tayloring by imposed magnetic field generated by laser	24/05/2016
Robert Fedosejevs	GeV Electrons by confirmed laser wakefiled and plasma wakefield acceleration and probing warm dense matter using LWFA Betratron Radiation	29/06/2016
Andrew Longman	Mega-gauss magnetic field generation from optical vórtices in laser produced plasmas	12/12/2016

SPECIALIZATION COURSES

Course
Safety in Maintenance Operations
ELISS Summer School 2016
Training School in High Power Laser Experiments at Rutherford Appleton Laboratories
Basic Training in Open FOAM software
Workshop for the analysis, assessment and verification of electrical security of the facility
EPLAN Electric P8

IG - Scientific-Technological Innovation

KNOWLEDGE TRANSFER

Patents

As a final result of a first approach from the company TECNIVIAL to the CLPU through the Centre Consultancy Service, both institutions signed a confidentiality agreement for the development of a project on road safety focused on the use of laser technology for road signalling systems. The objective was to submit a joint tender for Public Procurement of Innovation offered by the Ministry of Industry for a section of the A-8 highway. During this process, different needs came up which required technological development leading to a new patent request.

NEW REQUESTS
Road signalling system through laser lighting

Reference: National Patent P201630434

Owners: Tecnivial (50%), CLPU (50%)

Status: Published in the Official Industrial Property Gazette, 09/09/16

Notes: The CLPU has already received an authorization from the Ministry to license his percentage of ownership to TECNIVIAL through a direct grant.

STATUS OF GRANTED PATENTS
1) Window with interchangeable glass for pressure chambers

Reference: Utility model u201431357

Owners : Synchrotron ALBA (50%), CLPU (50%)

Grant date: 09/02/2015

Status: Publication of a joint technological offer in September 2016. The PCT procedure which started on 08/09/2015 continues.

2) System and procedure to recover gas substances from gas currents

Reference: National patent P201330318

Owner: Iberdrola Ingeniería y Construcción (80%), CLPU (10%), USAL (10%)

Grant date: 15/07/2015

Status: licensing in process.

STATUS OF PATENTS IN PROCESS

1) Optical Pulse Generator

Reference: European patent EP2787582

Owner: Proton Laser Application (85%), CLPU (15%), CSIC-UV (5%)

Grant date: 05/04/2013

Status: Waiver in process

2) Intra-operatory Carbon Ion Radiation Therapy System

Reference: European patent 2887379

Owner: Proton Laser Application (80%), CSIC (7,5%), I3M (7,5%), CLPU (5%)

Grant date: 23/12/2013

Status: Waiver in process

3) Vacuum vessel & a part of the bounding thereof

Reference: European patent 2887379

Owner: CLPU (100%)

Grant date: 06/03/2014

Status: Test requested on 08/03/2016

INDUSTRIAL PROJECTS

(1) ULTRALASER - Development of ultrashort pulse lasers with advanced features at low cost for their application in new industries

[MINECO - Collaboration Challenges 2015]

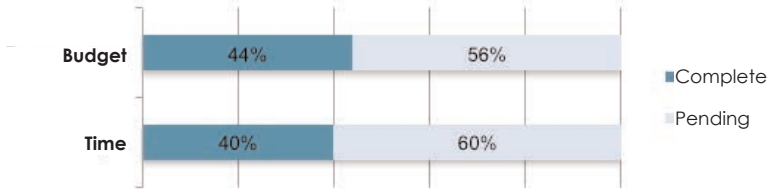
Description: This project is the result of the cooperation with Spanish Centres working with state-of-the-art laser technology (CSIC, CLPU and UPV). It aims to produce a range of lasers of ultrashort pulses with advanced features and at a low cost which provide high versatility for new emerging applications.

Milestones 2016:

- Coordination of the project.
- Optimization of the low cost pico/femtosecond optical fibre laser.
- Characterization of the components of the pico/femtosecond optical fibre oscillator.
- New studies for the research of systems and techniques to regulate the pulse duration in the pico/femtosecond oscillator.
- New analyses of methods to reduce the repetition rate in the pico/femtosecond oscillator.
- With regard to the development of a low-cost solid-state femtosecond laser, optimization of the growth process of different types of garnets continues.
- Comparative assessment of the laser efficiency of single crystal and ceramic garnets in continuous mode and in mode-locked form.
- Design of a pumping system with a diode laser for a compact optical resonator with chirp pulse correction through Bragg mirrors, and design of the solid-state laser prototype.
- Technological monitoring and market approach.

Information

Start	End	Duration	Budget
01/09/2015	31/12/2018	40 months	318.666,20 €



(2) RTF Laser - Design and development of a laser-guided surgery system with selective tissue discrimination

[MINECO - Collaboration Challenges 2015]

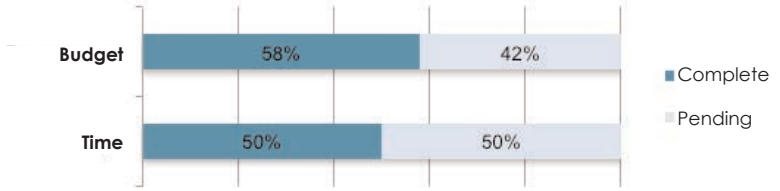
Description: The main objective of this project is to develop a prototype for a modular surgical platform to operate with laser ablation on biological tissue. It aims to develop systems that make it possible to discriminate biological tissue in real time and to offer medically relevant information, such as the depth of the cut and real-time burn control.

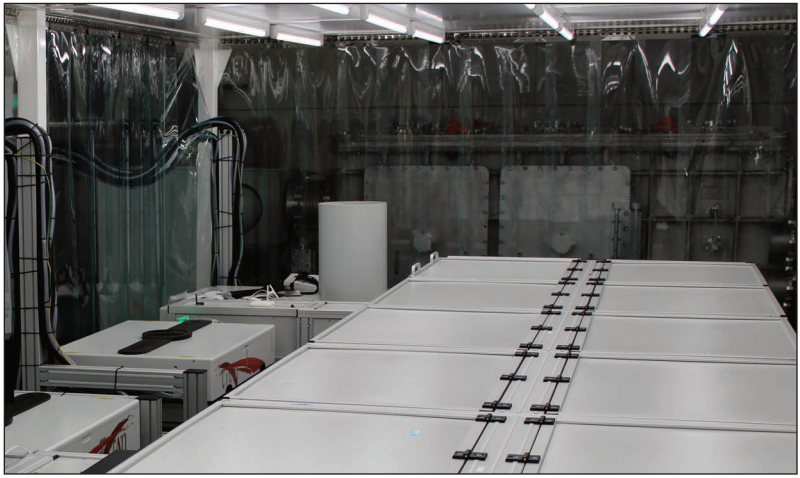
Milestones 2016:

- Studies on the state of the art have been completed.
- Previous studies of laser parameters for the ex vivo laser processing of bones and muscle tissue.
- Experimental ablation tests with analysis of the depth of the cut, cauterization and tissue hardness discrimination.

Information

Start	End	Duration	Budget
01/10/2015	31/03/2018	30 months	158.616,00 €





INDUSTRIAL COLLABORATION

Knowledge Transfer		
Company	**Type of collaboration**	**Entry into force**
AERTEC, Investigación y Desarrollo	Confidentiality agreement	20/01/2016
SIDISEL	Confidentiality agreement	09/05/2016
ADECyL (Agency for Business Innovation, Funding and Internationalization of Castile and León)	Agreement for the promotion of knowledge, cooperation in innovation, technology transfer and company creation through the RIS 3 Network of Innovation and Entrepreneurship	01/06/2016
Sánchez Romero	Confidentiality agreement	30/05/2016
TECNIVIAL, S. A	Agreement for shared patent ownership	29/06/2016

TECHNOLOGICAL PLATFORMS

One of the strategic initiatives of the Pulsed Lasers Centre is to increase the possibilities to participate with other organizations through its collaboration with different technological platforms:

SECPhO - Southern European Cluster in Photonics and Optics
www.secpho.org

It is a cluster which includes companies, technological centres and research groups which want to promote technological innovation through the application of photonic and/or light-based technologies on different industrial sectors. The Pulsed Lasers Centre is a founding partner of the cluster and is responsible for the workgroup that focuses on laser technology.

Induciencia
www.induciencia.es

It is a structured forum, led by companies in the field, with the participation and collaboration of all agents interested in the Industry of Science, in which they cooperate to define the medium and long-term goals of research and technological development, with a clear market orientation. The relationship with this platform became stronger in 2016, and this platform became one of the collaborators in the 6th Management Conference of Consortiums/ICTS which took place at the CLPU on the 28th and 29th of September.

FOTÓNICA 21
www.fotonica21.org

This platform includes key players in the sector. It was born to coordinate all the national activities in the field of photonics in the same way as those carried out by the European Technology Platform Photonics21. One of the main goals of Fotónica21 is to increase the Spanish participation in European Union programmes in the key fields of Infor-

mation and Communication Technology (ICT), Nanotechnologies, Materials and Production Processes (NMP) and Security (SEC), to mention just the most important ones.

PEPRI - Plataforma Nacional de I+D de Protección Radiológica (PR) de España
www.sepr.es

The Pulsed Lasers Centre has been a member of this platform since October 2014, three months after it was created. Its objective is to identify the economic contribution and the work areas for research and development of radiological protection in Spain through different strategies: promoting the growth of scientific and technological knowledge, creating a coordination group for national R+D+i initiatives by promoting collaboration between the different actors, creating a Strategic R+D Plan for Radiological Protection and promoting and coordinating the Spanish participation in international R+D programmes, and particularly in the Horizon 2020 programme of the European Union on radiological protection.

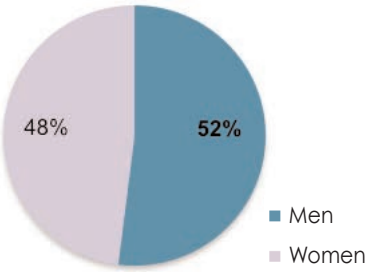
IG - Communication

KNOWLEDGE TRANSFER

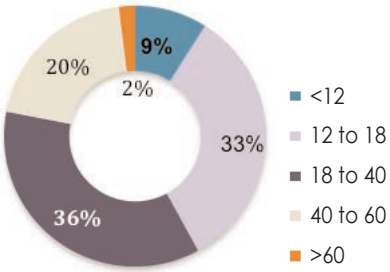
The Pulsed Lasers Centre has developed a constant activity of communication and education which was always adapted to the different stages of development and implementation in which it found itself. In 2015, the Centre redoubled its efforts to offer a vast communication project ('Unveiling Shadows' FCT-14 9107) to mark the International Year of Light. The effort led to good results, such as being able to continue with the exhibition "The Science of Light" in 2016, when it moved to the National Museum for Science and Technology, in Alcobendas. After the visit to the CLPU by the director of the Spanish Foundation for Science and Technology (FECYT), José Ignacio Fernández Vera, who was also able to enjoy the exhibition, steps were taken to loan the exhibition temporarily until December 2016. This agreement included the training of museum staff, since the exhibition required specialized knowledge and management by the guides.

Taking into account the time passed between the agreement, the submission of the material, the process of assembly, training, etc., the exhibition, which was renamed 'Laboratory of Light' was inaugurated at the end of April. Since the end of the academic year was getting closer, it was possible to promote it to the general public. From May to August, the workshop received 461 participants, which were distributed as follows:

Distribution by sex



Distribution by age



During the beginning of the school year, the 'Laboratory of Light' had such a favourable reception that the Museum applied for an extension of the agreement until June 2016.

At the same time, we received a request for a new loan of the exhibition by the Museum of Energy, better known as the 'Factory of Light'.

Together with this important milestone, in 2016 the CLPU has developed several activities target at different groups, always taking into account the constant dialogue it maintains with the different social sectors:

General public

Apart from the exhibition, the CLPU launched a series of informative videos focused on the science show mentioned above. Based on the

modular division which structured the visits to the exhibition and their storyline, short explanatory videos were filmed about the key concepts included in the exhibition, together with a longer one which offered a complete tour. The videos were uploaded to the YouTube channel of the Centre, and they were promoted on the banner of the website and among the education centres of Salamanca. They will shortly be available directly on the CLPU website.

Specialized public

Objective: Addressing the undergraduate or graduate public to reroute their scientific careers towards laser technology.

Activities:

- *Students of the Technical High School of Industrial Engineering.* On the 1st of April the students visited our facilities to learn first-hand from the engineers of the Centre about the specific tasks that laser technology demands in this field. For approximately 2 hours, the students toured the premises and saw the machining workshop of the CLPU, the experimentation area of the VEGA laser and, more specifically, its laboratory 2, the high repetition rate laser and the experimental set-up that the CLPU was working on in collaboration with another company.
- *Participants in the 26th Summer Course of Civil Engineering 'O Miño'*. The then general deputy director of Promotion of Competitiveness of the Ministry of Economy and Competitiveness, María Luisa Delgado Medina, president of the Engineering and Society Foundation, proposed a visit to the Centre facilities as part of the 26th Summer Course of Civil Engineering, organized by the Foundation. The director of the CLPU, Luis Roso, talked to the participants about the unique features of the ICTS and led them through a guided tour to show them VEGA and to explain its functions.

Specific public

Objective: In this case the informative initiative was targeted to a specific group in the social environment close to the Centre, and a specific activity with low technical requirements was designed.

Activities:

- *Open Day for companies of the Science Park of the University of Salamanca.* There are two reasons that explain why the initiative to organize an open day so that the workers of the Science Park in which the Centre is located could come and get to know our facilities had not been put into practice: the VEGA laser which defines the unique scientific and technical nature of Centre had not been installed yet, and now its experimentation area has been developed. That is, this was the right moment to show who we are and what we do before starting to work at full capacity, something that would make these visits more difficult to organize. Also, we believe that this was the perfect moment to show our transparency, since the Spanish Nuclear Safety Council had classified the CLPU as a Category 2 radioactive installation, a distinction whose consequences might be distorted. In July and August a plan was drawn out with the companies who expressed an interest, and groups of approximately 15 people were formed to visit the Centre from 8 to 11 am. The visits were designed with a dual approach: on the one hand, the Head of the Radio Protection Unit of the Centre, José Manuel Álvarez, explained what it meant to be a Category 2 radioactive installation; and on the other hand, a scientific and technical perspective was shown by the researcher Jon I. Apiñaniz, who showed the visitors the VEGA laser from the observatory and explained its technology and uses.

- *XVI Stone Fair of Villamayor.* Once again, the Pulsed Lasers Centre was invited to the main event hosted by the Town Hall of Villamayor: the Stone Fair of Villamayor, an exhibition which promotes the use and art of the typical stone from Salamanca, whose quarry is located in this town. The Centre had a stand in which it could give a demonstration to the groups of schoolchildren who came to visit, both from the Piedra de Arte School and from the Ciudad de los Niños School. The ages of children this year ranged from pre-primary to the first years of primary school. They were told about the Pulsed Lasers Centre, Vega and the way in which light is amplified in our systems with precious stones. They were shown how these crystals grow in laboratories and they could see a demonstration of diffraction, fluorescence and three-dimensional vision.

As it can be seen, the communication activities of the Pulsed Lasers Centre have a main target audience, which is the first one considered when this type of activities is organized: the citizens and workers of Villamayor. This relationship has promoted the CLPU since it arrived in the town, and it led the Town Hall of Villamayor, in appreciation of this work, to award the Centre a sculpture made in Villamayor stone for its work. The unveiling act took place on the 28th of September 2016, with the attendance of members of the current and past government teams of the town and most of the researchers and staff of the CLPU who participate in these activities.

INSTITUTIONAL COLLABORATION

Communication		
Institution	**Type of Collaboration**	**Entry into force**
FECYT (Spanish Foundation for Science and Technology)	Temporary loan of equipment and material for the exhibition 'La Ciencia de la Luz'.	18/02/2016

IM - INFRASTRUCTURE MANAGEMENT

As we have seen, the long-term goal of the Pulsed Lasers Centre is to become a de facto agent for the dynamization of the economic system of intelligent growth based on state-of-the-art science and technology. For the development of all the activities involved in this process and included in this report, it is necessary to have an efficient and effective management structure.

EXTERNAL FUNDING

Funding by projects

Funding by Project - Total			
IG – Science of excellence			
	Applied Research	Promotion Research Networks	Training
	471.618,20 €	101.250,00 €	229.850,16 €
			802.718,36 €
IG – Innovation			
			477.282,20 €

IG - Science of Excellence - Applied Research

Development of a system for continuous over-critical density laser targets	92.188,20 €
Barium Tagging [ERDF]	78.650,00 €
Extreme Diagnosis [ERDF]	68.460,00 €
FURIAM [ERDF]	232.320,00 €

IG - Science of Excellence - Promotion of Research Network Projects

CATLUR	35.000,00 €
LASERLAB IV	66.250,00 €

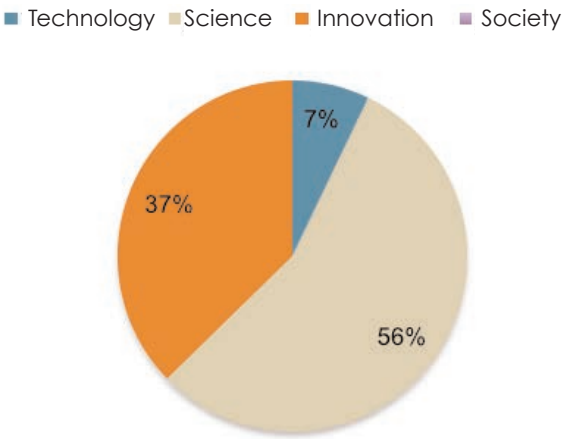
IG - Science of Excellence - Training

FPU2012	71.234,16 €
Youth Guarantee	39.200,00 €

IG - Innovation - Knowledge Transfer

ULTRALASER [ERDF]	318.666,20 €
RTF Laser [ERDF]	158.616,00 €

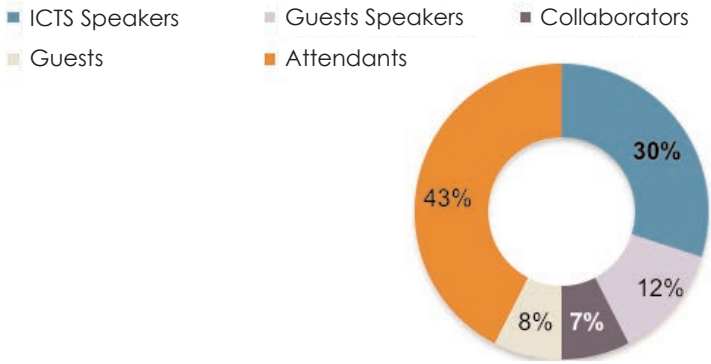
This means that the total amount registered as external funding coming from projects is €1,280,000.56, distributed as follows according to the different areas in which the initiative aims to achieve intelligent and sustainable growth:



EFFICIENT MANAGEMENT

Transmission / communication mechanisms

In our endeavour to coordinate all the activities which take place in the Centre to promote intelligent and sustainable growth and to optimize the time and resources available, there is another essential element in this organization: the staff in charge of the administration of the Centre. Managing an ICTS involves organizing a unique type of infrastructure with its own idiosyncrasy. In order to promote an efficient management, the Consortiums/ICTS gather every year to share their practice and their experiences. In this regard, 2016 has been a key year for the Pulsed Lasers Centre, because it was the organizer of the 6th Management Meeting. Also, for the first time, the CLPU has held an event of such magnitude. The Meeting was held in the 28th and 29th of September, with the attendance of 40 participants, distributed as follows:



Course	Training type
Electrical Risks	External - FREMAP
Intellectual Property – Introduction	External - OEPM
Health and Safety Plans and Radio Protection	Internal
Overhead crane and aerial work platform	External

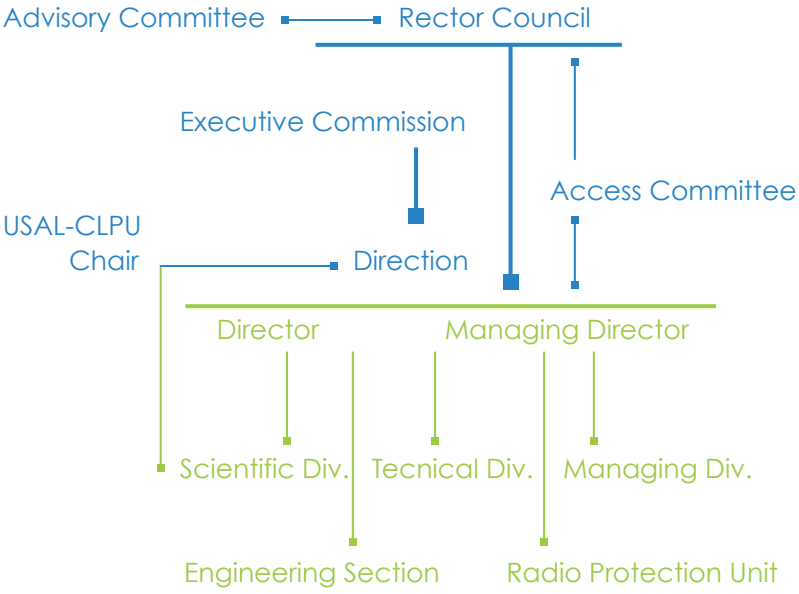
Management Optimization

All along 2016, the Managing Division of the Centre has carried out different initiatives in order to optimize the management process:

Actions of the Managing Division
Automation of the purchasing procedures via web and connection to SAAP platform.
Procedure update for the creation of the Annual Training Plan and creation of the Procedure for Annual Performance Evolution.
Implementation of improvements in the FARO system for online service requests.
Design of the Procedure for calls for telematic requests to use the VEGA services.
Related to e-management (Implantation in process): • **REÚNETE**, United Service for Virtual Meetings of the SARA Network. Implemented. It is a system that offers collaboration tools to optimize team work, contribute to reducing travel costs and promote a reduction in the carbon footprint of public administrations. • **GEISER**, Integrated Management of Registration Services. In process. It is a comprehensive registration solution which works in the cloud. It manages its incoming/outgoing registration offices and the reception and submission of registration entries by the offices which will receive the documentation. • **SARA** Network, Systems of Applications and Networks for Administration. In process. It is a set of communication and basic service infrastructures which connects the networks of the different Spanish Public Administration offices and European Institutions and promotes information exchange and access to services.

STRUCTURE OF THE CENTRE

The structure of the Pulsed Lasers Centre is structured around a Direction Section which has two key and complementary lines of work: science and technology, represented by the Director of the Centre, and management, led by the Managing Director. Above them, there are two organisms:



RECTOR COUNCIL. It is the main governing organism of the Centre. It is made up of nine members who belong to the three founding institutions. It has an annual rotation system for the positions of President and Vice-President, which are appointed by the Ministry of Economy and Competitiveness and by the Regional Government of Castile and León. In 2016 the Presidency was occupied by Ms. María Luisa Castaño, General Director of Research Policies, Development and Innovation of the Ministry of Economy and Competitiveness, and the Vice-presidency was occupied by Ms. Pilar Garcés García, General Director of Universities and Research of the Regional Government of Castile and León.

EXECUTIVE COMMISSION. It is in charge of overviewing the implementation of the activities of the Centre. It is made up of two members from each founding entity. As in the case of the Rector Council, it follows a rotation system for its main positions, and both organisms cannot be presided over by the same institution at the same time. In 2016 these positions were held by Ms. Pilar Garcés García, General Director of Universities and Research of the Regional Government of Castile and León (Presidency) and Ms. Ángela Fernandez Curto, General Deputy Assistant Director of Major Scientific and Technological Infrastructures of the Ministry of Economy and Competitiveness (Vice-Presidency).

As it can be seen in the organization chart, there are also three support structures:

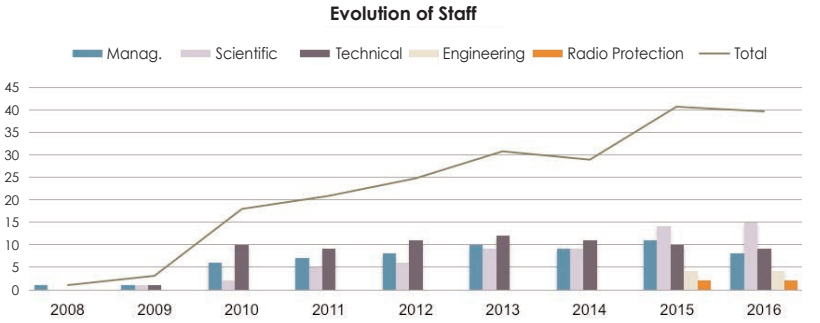
- **Advisory Scientific-Technical Committee:** It is made up of 8 researchers of international renown who are in charge of advising the Rector Council about the current and future scientific programmes of the Centre.
- **USAL-CLPU Chair:** This chair was created as part of the founding relationship between both entities for the development of common objectives and interests in the field of scientific and technological experimentation and research on all the aspects related to ultrashort and ultraintense lasers.
- **Access Committee:** This organism is necessary for a correct operation of the unique equipment of the Centre and the implementation of open-access calls. It has not yet been established, pending the final design of the process for competitive access to VEGA.

More information:

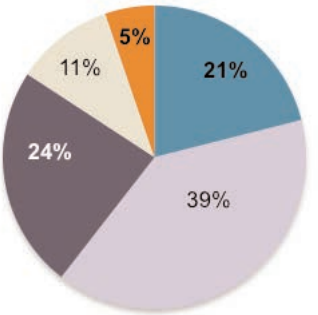
Structure of the CLPU *(www.clpu.es)*

Rector Council	
Executive Commission	
Direction	
Scientific-Technical Advisory Committee	
Scientific Division	
Technical Division	
Managing Division	
Engineering Section	
Radio Protection Unit	

HUMAN RESOURCES



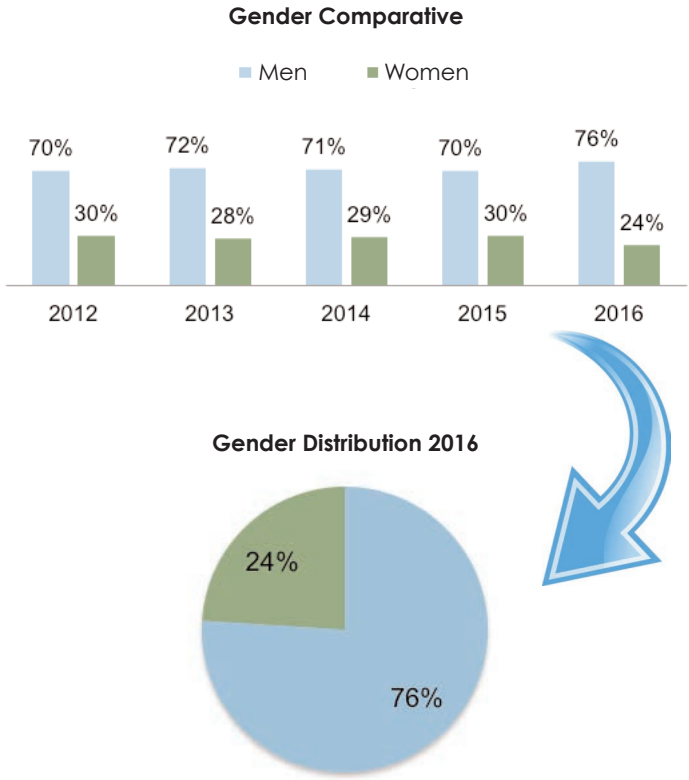
Staff by Area - 2016



As it can be seen in the chart, there has been a slight decrease in the total evolution, in spite of the growth in the scientific area. This reduction has taken place mainly in the Managing Division, in which two positions have been lost after the projects that led to their creation came to an end in 2016. As a consequence, and contrary to previous years, the Managing Division is now the third department in number of workers. As in previous years, the scientific area occupies the first place, and the technical area now holds the second position, after being split to create the engineering section. The difficulties derived from the economic and social situation have contributed in 2016 to the fact that different ministries have rejected proposals submitted by the Cen-

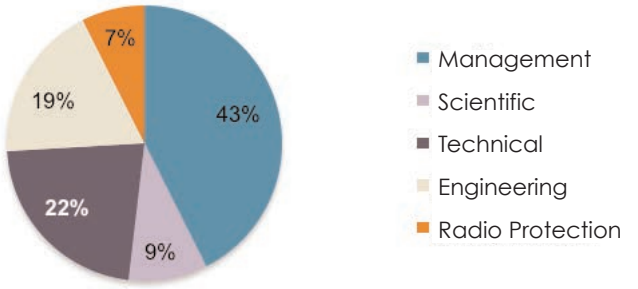
tre regarding the human resources invitations to tender. [See Projects section].

With regard to gender equality, there have been no significant changes, particularly when considering the negligible changes in staff at the end of the year:



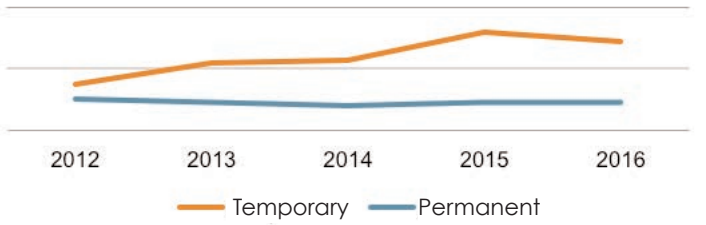
The staff of the Centre has done 54 specialization courses, and the Managing Division is the area in which the highest number of courses were taken due to the different profiles included in it:

Training by Area

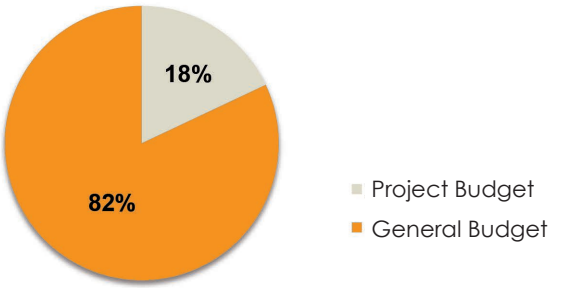


We will now analyse the types of contract of the staff and the types of contracts signed throughout the year, which were for temporary positions in all cases.

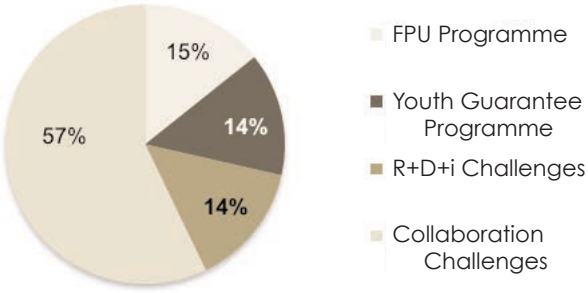
Evolution of Types of Contract / Staff



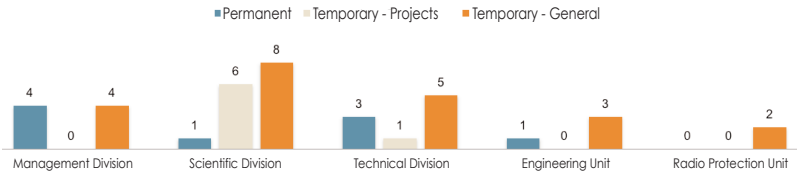
Division of Budget for Temporary Staff 2016



Temporary Staff According to Projects



Staff - Types of Contract / Area



Evolution of Types of Temporary Contracts