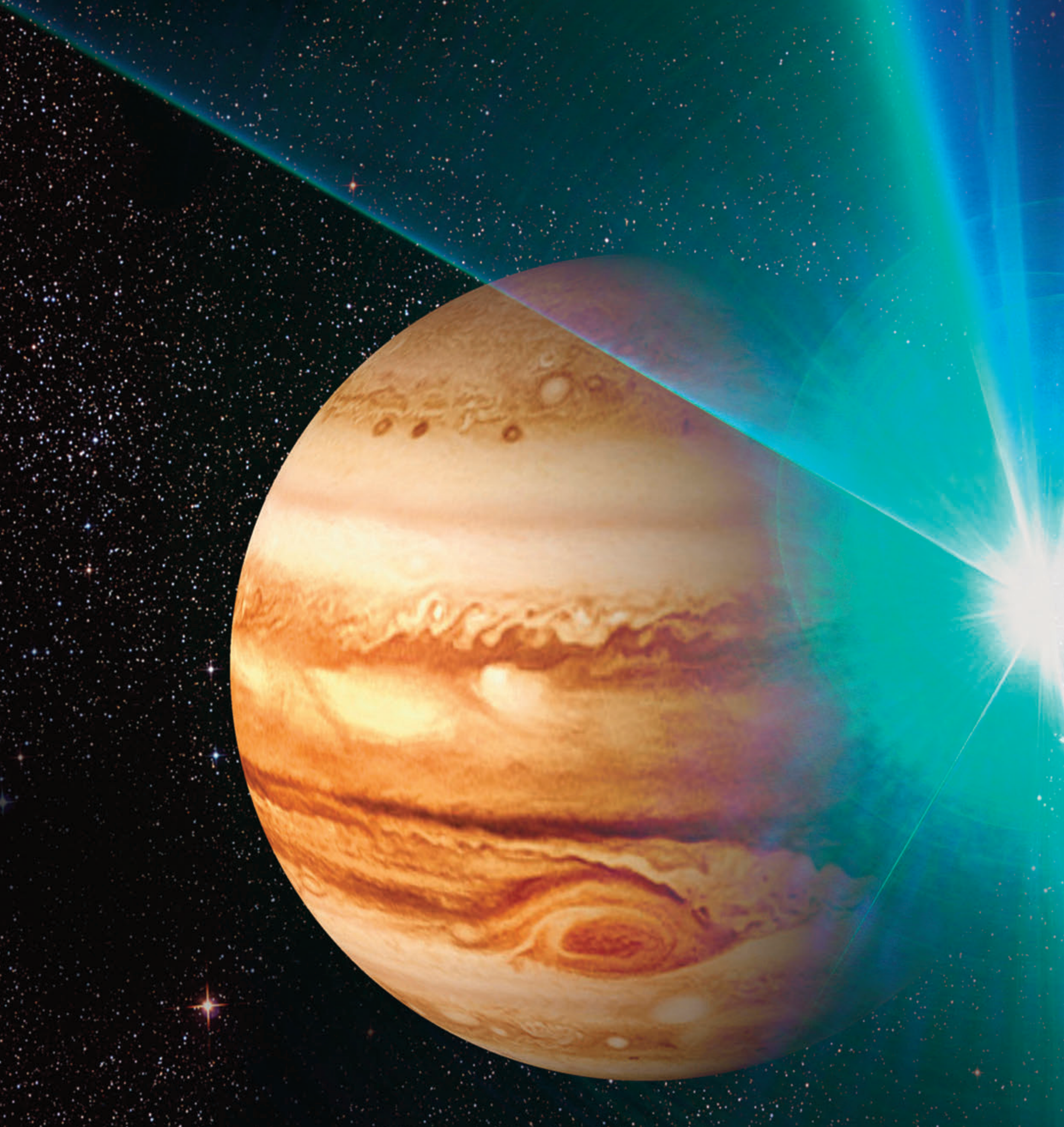


High-power Petawatt lasers

A new technology for space exploration

The road to Jupiter's moons is boosted by Petawatt lasers

With its 25 Joules/25 femtoseconds = 1 Petawatt laser, the Center for Advanced Laser Technology (CETAL) based at National Institute for Laser Plasma & Radiation Physics Romania is considered a world class facility for future LASER PLASMA ACCELERATORS (LPA) in Central East Europe. Among dozens of cutting edge scientific applications there are practical utilities such as generating radiation fields very similar to those surrounding outside planets so called radiation belts.

The Jupiter Icy Moon Explorer (JUICE) is a planned European Space Agency (ESA) space mission to explore the Jovian system. The spacecraft will be loaded with complex scientific instrumentation needed to perform detailed investigations of Jupiter and its system of moons. The highly capable state-of-the-art scientific payload consists of up to a dozen instruments grouped by discipline into a set of packages. These are intended for probing the Jovian and satellites atmosphere, estimating gravity fields, the exploration of the surface and subsurface structure of the moons.

The problem

Jupiter possesses a very strong magnetic field. The dipole moment of Jupiter is 10.000 times larger than that of the Earth. Charged particles are trapped by the Jovian magnetosphere which gives rise to powerful radiation belts. The JUICE radiation environment is similar to the Geostationary Earth Orbits environment but it is much more severe, as the trapped particles exhibit much higher energies and density values. According to existing data, the trapped radiation in the Jovian belts is a million times more intense compared to the van Allen belts. Mitigation of radiation effects can be implemented by performing intensive tests on electronic components and by using optimised shielding configurations, quite similar to the practices employed for satellites and spacecraft in Geostationary and Medium Earth Orbits. The radiation environment near Jupiter is characterised by significant fluxes of trapped protons and electrons with energies up to 100 MeV. Both the proton and electron components encountered in the Jovian system will lead to a cumulative degenerative (and possibly catastrophic) effects in electronic components, as well as surfaces and coatings.

The solution

Using the Petawatt laser at CETAL infrastructure we propose to experimentally reproduce the Jovian environment to directly assess these effects on the JUICE mission.

Assessing radiation sensitivity levels for electronic components is a fundamental issue in space systems radiation hardness assurance (RHA) programmes. Due to the extreme radiation environment around Jupiter and its satellites, the on-board equipment has to be extremely radiation tolerant, either by design, shielding or some form of mitigation. The CETAL team considers that a major step forward in the JUICE RHA programme lies in reproducing the electron flux near Jupiter and its moons, while at the same time being able to characterise its effect on onboard equipment. We propose a new method to achieve these objectives by using the laser plasma accelerators (LPA) technique. As our proposal alligns coherently with the ESA objectives in the short and medium term, it is our opinion that in the longer term the CETAL facility would also make an excellent calibration and test facility for instruments that operate in extreme environments.

Laser Plasma Acceleration techniques

The use of high-energy particle accelerators to simulate the space radiation environment is complex and very resource consuming, as the particle species are delivered individually. The same thing holds for particle energies. In order to perform the tests more than one machine has to be considered, since machines are particle specific. The LPA technique has proven itself to be able of generating different types of particles (electrons, protons, neutrons and ions), as well as photons. Compared to the large size and high complexity of particle accelerators, laser plasma accelerators (LPAs) occupy a much smaller volume, while being simpler and more cost effective to realise and operate. This is why LPAs are considered to be very promising candidates for beam delivery systems, for routinely performing radiation component screening and testing. They represent an alternative approach and technology, able to generate particle spectra (electron, proton) with a defined energy distribution.

Laser Plasma Acceleration is a technique for accelerating charged particles, such as electrons, positrons and ions, using the electric field associated with an electron plasma wave or other high-gradient plasma structures. These structures are created using ultra-short laser pulses that are matched to the plasma parameters. Such technique enable the realisation of highly effective particle accelerators, which are physically much smaller in size than conventional devices (linear accelerators). In addition, state-of-the-art experimental setups emphasise accelerating gradients that are several orders of magnitude larger compared to existing particle accelerators.

The most important advantage of plasma acceleration is that its acceleration field can be much stronger, by a factor of 1000 than that encountered in conventional radio-frequency (RF) accelerators, thus strongly reducing the dimensions of LPAs

The experimental facility: Center for Advanced Laser Technology

INFLPR History. At Magurele campus, nearby Bucharest Romania, Professor Agarbiceanu set up in 1956 Optical Methods in Nuclear Physics Laboratory and made Romania the fourth country in the world to report on laser effects in 1962. Later in 1977 this laboratory merged with the plasma laboratory and accelerator laboratory providing a single facility – the National Intitute for Laser Plasma and Radiation Physics. In 1996 the Institute of Space Science became a branch of INFLPR, enlarging the research activity again.

INFLPR Current Activity. Nowadays the Institute is the second largest research institute in Romania with 477 employees to conduct frontier research ranging from basic photonic materials and high power lasers, nanomaterials and nanotechnologies, quantum dots and information technologies, plasma physics and X-ray microtomography to industrial photonics, biophotonics and plasma coatings. Institute of Space Science branch conducts research on astrophysics, space engineering and gravitation.The Institute is currently a member of the EURATOM association, a partner in the Extreme Light Infrastructure (ELI), partner in LASERLAB EUROPE. The Institute encourages the pursuit of appropriate partnerships with the industry and transfer the knowledge and technology for the benefit of the society.

CETAL Structure. The political decission of Romania's involvement in the construction of the European funded Extreme Light Infrastructure was supplemented by the strategical decission of developing THE INTEGRATED CENTER FOR ADVANCED LASER TECHNOLOGIES – (CETAL).

The CETAL facility was developed at the National Institute for Laser, Plasma and Radiation Physics (NILPRP), Bucharest-Măgurele. This multipurpose facility enable new basic/applied exploratory research activities in physics, chemistry, biology/medicine, energy, material science, manufacturing, etc., providing a direct benefit to the Romanian economy and to society. Moreover, it helps to prepare the experiments planned to be conducted at the future ELI, prepare the human resource for advanced multidisciplinary research.

The major laboratory "Hyper-intense laser – mater interaction" provides a unique facility, as far as we know, combining one of the most powerful state of the art laser with fully equipped interaction chamber housed into a radiation shielded bunker. It's purpose include cutting edge research as one provided as example in this paper.

Following the practical requirements of applied research the second part of this facility provides access of Romanian companies to the most advanced laser technologies ranging from avionics and space to bio-nano-photonics applications.

State of the art fully equiped Laboratory for advanced technologies by laser processing and Laboratory for photonics investigations cooperate in synergy for fulfilling this goal.

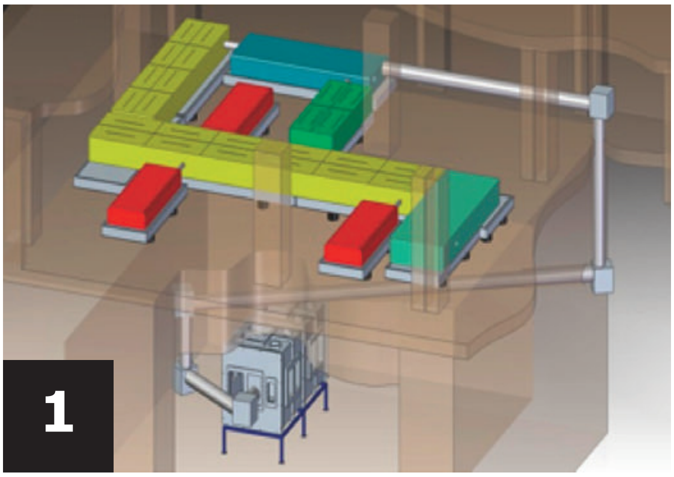
Dr Traian Dascalu
Scientific Director
National Institute for Laser Plasma & Radiation Physics
Tel. (40)746 227 888
www.inflpr.ro

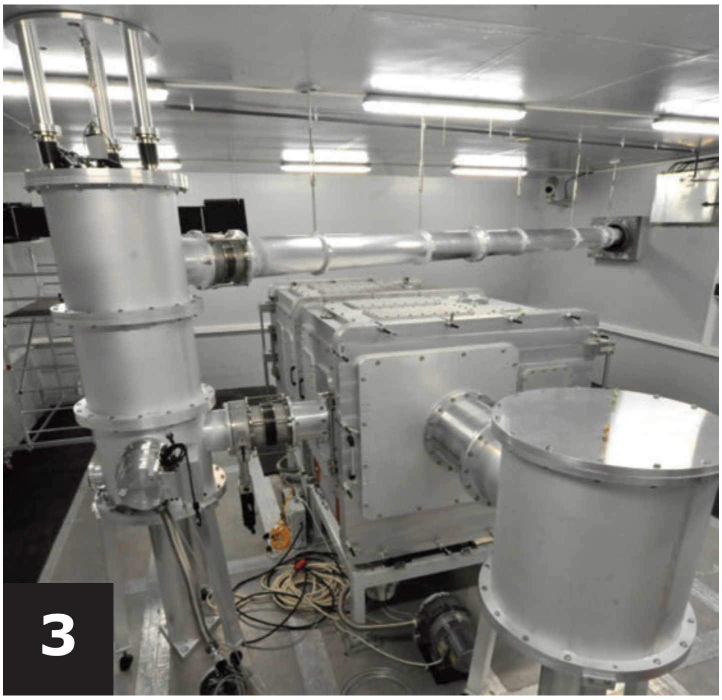
1.) Layout of the 1 PW laser, beam transport line, interaction chamber and the radiation shielded bunker.

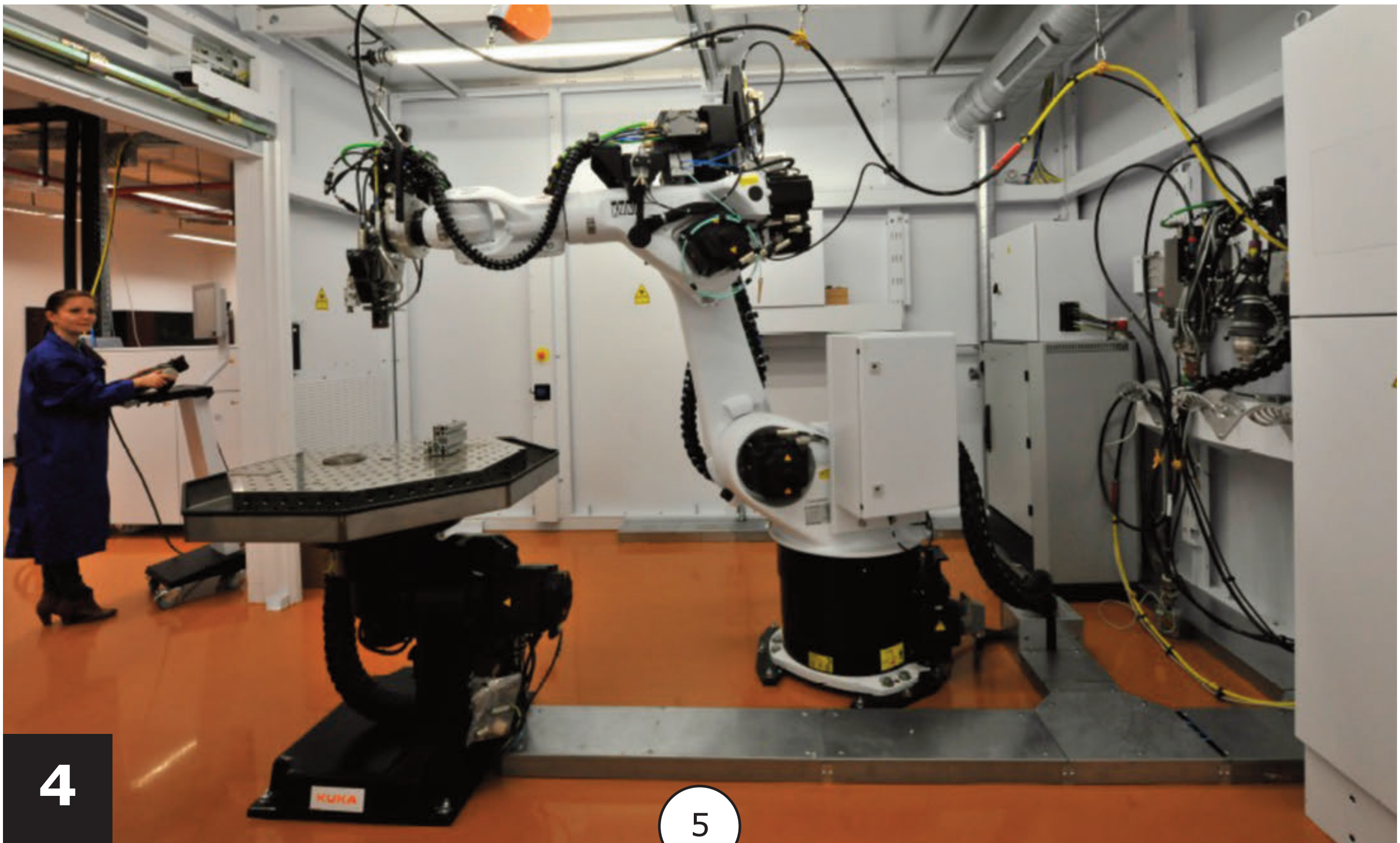
2.) 1 PW laser room.

3.) Interaction chamber and beam transport line.

4.) Complex, high precision, gas assisted macro-processing equipment for 3D cutting, drilling, welding, coating; this facility together with complex investigation methods is used by SME for developing laser based technologies.







Driving smart, sustainable growth

Commissioner for Regional and Urban Policy, Johannes Hahn explains what smart and sustainable growth means for European cities…

It is becoming increasingly clear that economic growth in the EU will come primarily from Europe's towns and cities. The reality is therefore that these days neither Member States nor the EU can achieve their economic or social policy objectives without engaging with cities. The figures speak for themselves: metropolitan regions host 59% of the EU population and 62% of all jobs – generating 67% of the Union's gross domestic product (GDP).

Since cities are places where challenges are raised and where solutions can be most effectively delivered, they are in the driving seat to implement many EU or national policies at local level. For example, if the EU is to meet its climate targets, it needs cities to better address resource and energy efficiency, notably in transport, housing and in overall urban design. Working across levels is also essential for cities to solve problems such as poverty concentration, spatial segregation, ageing populations, etc.

Therefore, the EU offers a wide framework of support for cities and urban areas, with a great deal of European Commission work impacting in some way or another on cities – seeking a holistic approach to their growth and development.

My job, as Commissioner for Regional and Urban Policy, is to ensure that all these initiatives are coherent and create synergies, and that we work in partnership with Europe's cities. This will, I believe, unleash the potential of cities to help deliver EU-wide goals of green and balanced growth. Cities have to be at the heart of our plans to create a Europe that is prosperous, environmentally sustainable, and where no citizen is marginalised.

With the dawn of a new budgetary and development programming period for 2014-2020, EU Regional and Urban Policy continues to devote its resources to boosting the economy through targeted action in all EU regions – and pioneering work in its cities that can help boost competitiveness throughout the Union.

Under the new Regulations approved recently, all regions have to target between 50 and 80% of their European Regional Development fund (ERDF) investments on innovation, information and communication technologies (ICT), small and medium-sized enterprises (SMEs) and the low-carbon economy. Overall, there will be a very significant amount of EU funding devoted in the next period to making cities 'smarter', 'greener' and 'more inclusive'. It is essential for cities to ensure that all ERDF-funded projects are aligned with strategic planning policies for their regions.

For cities, smart growth means that urban areas should support a transition towards a knowledge society, building on social, organisational and technical innovation. Cities should develop new educational pathways and a favourable entrepreneurial environment. They should foster a dynamic local & social economy.

In the EU Smart cities and Communities Initiative, smart cities are regarded as places where flows and interactions become smart through making strategic and relevant use of information and communication in a process that is responsive to the social and economic needs of society.

We have to look for projects that do not look at technology in isolation but together with other key issues such as public space, soft mobility, spatial integration, social innovation, and so on.

Green growth means changing a city's development path towards a model that uses fewer resources to achieve more. Initiatives and projects can include the redevelopment of brownfield sites such as disused dockyards or steelworks, turning them over to business, educational or cultural use – or a combination of these. Cities are supported to develop sustainability strategies or tools to assist the transition to a carbon-free energy system, as well as exploring new green options to reduce their carbon footprint. For example, the 'Retrofit South East' project carried out in Petersfield is a good example of the reduction of energy consumption as one of the aims of housing intervention. The Petersfield project improved the energy efficiency of housing aimed to stimulate the emerging retrofit market and has led to the creation of new quality jobs in the region.

In order to advance the inclusive growth of cities, our Policy invests in local responses stimulated by strategies such as neighbourhood management. Tools include education, health and social infrastructure and the development of local services. It is driven by local actors and plays an important role in creating social inclusion. The vital ingredient of an inclusive growth strategy is lively partnerships, which bring in civil society organisations representing people at risk of exclusion, and which embrace the various tiers of government.

Cities must reposition themselves in looking at these various pillars of urban development. They should use the ERDF and other financial resources to provide good public spaces, efficient administrative services as well as physical workspaces with a range of facilities.

Experience tells us that nearly half of our future funding will be spent in urban areas in one way or another. Our philosophy is that effective investments in urban areas should follow an integrated strategy, based on synergies across sectors. We need to bring together the necessary actions in a holistic view of the development of our urban centres.

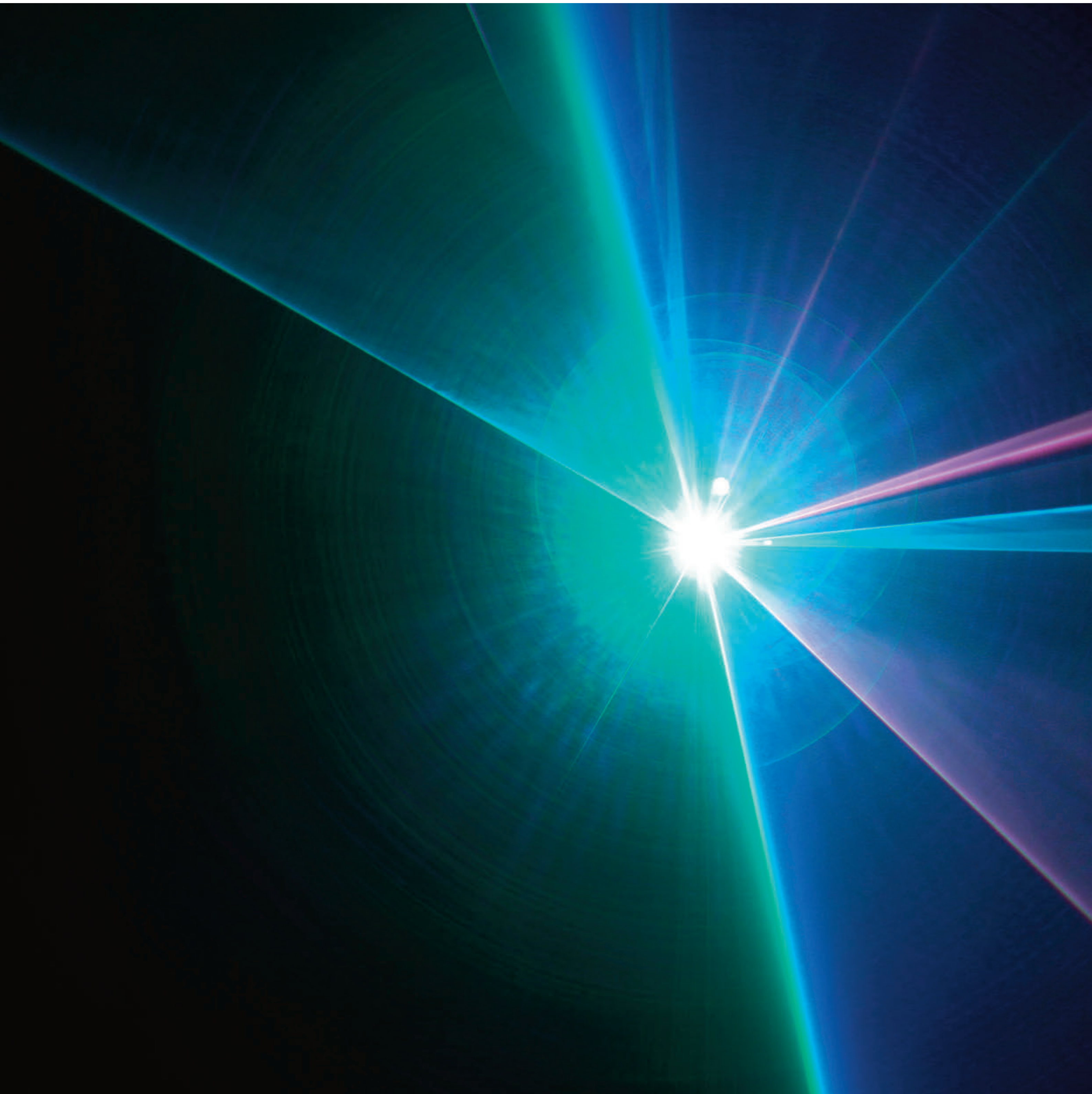
A strategic approach is a key element of Regional and Urban Policy, and therefore, we are obliging every Member State to devote at least 5% of total investments under ERDF specifically on integrated sustainable urban development. We will continue to work with URBACT, who provide a platform for exchange of experience and work on the development of local action plans in the various fields of cooperation between European cities. We will also invest €330m in innovative actions in sustainable urban development which will explore new solutions to today and tomorrows urban challenges.

The key to achieving the Europe 2020 goals of smart, sustainable and inclusive growth is indeed in harnessing the potential of our cities.

Johannes Hahn
Commissioner for Regional and Urban Policy
European Commission
www.ec.europa.eu

cetal

CENTER FOR ADVANCED LASER TECHNOLOGY



www.inflpr.ro