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THE LARGEST LASER IN THE WORLD – ECONOMIC AND RESEARCH PROSPECTS FOR ROMANIA

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Abstract
Extreme Light Infrastructure - Nuclear Physics Center (ELI-NP) in Bucharest-Magurele is one of the pillars of the international research program ELI-NP, along with other two centers to be developed in Hungary and the Czech Republic. The investment for the development center in Magurele amounts to €356 million and comes from the funds of the Sectoral Operational Programme "Increasing Economic Competitiveness". With ELI-NP there will be done research on ultra-high power lasers, laser-matter interaction and secondary sources of radiation.
Keywords: ELI-NP, Laser beams, Gamma beams.

1. INTRODUCTION

The Sectoral Operational Programme "Increasing Economic Competitiveness" by Priority Axis 2 “Research, Technological Development and Innovation for competitiveness” developed between 2007-2013 proposed for our country to increase the capacity for research, development and innovation, by improving the research infrastructure and by attracting specialists. The program also aimed to the creation of partnerships between universities, research centers and private institutions, in order to obtain applicable results in various economic fields.

In the economic crisis, budgetary constraints and the increasingly sharp competition on the world market, *“organization’s effectiveness is influenced by the managerial strategy to promote and maintain a work-team of talented and innovative people, and attract business partners able to support development - even when costs are reduced” (Vlăsceanu, 2014)*.

For Romania a viable alternative is to support and stimulate research, development and innovation.

One of the most important research projects funded through this program, which is operated in partnership with The National Institute of Research - Development for Physics and Nuclear Engineering "Horia Hulubei" is the laser from Magurele (ELI-NP).

In 2005, a team of physicists who worked in the field of lasers proposed a mega-project: building a laser hundreds of times more powerful than the most powerful existing laser in the world of one petawatt (a million billion watts).

To ensure the success of this project, the scientific community considered the proposal and decided to build a 10 times more powerful laser (of 10 petawatts).

Two years later the proposal was put on the list of the major European projects along with other 47 projects in all fields of science.

Extreme Light Infrastructure (ELI) is a pan-European scientific research project initiated in 2008, in which a consortium of 13 European countries (Bulgaria, France, Germany, Greece, Italy, Lithuania, the United Kingdom, Poland, Portugal, Czech Republic, Romania, Spain, Hungary) collaborate to build the most powerful laser in the world.

The host countries where the three pillars will be built are the Czech Republic, Romania and Hungary; there will be built one laser in each of these countries and research will be made regarding high light intensity. The characteristics of the tools of the three pillars of ELI project will be different, research areas being diverse and complementary. After completing the three centers the fourth pillar will be built, aiming to increase the laser power to 100 petawatts, its location being established later. This way the first major research infrastructure in Central and Eastern Europe is to be built (Zamfir, 2012).

The Romanian ELI – Nuclear Physics (ELI-NP) Pillar aims at deepening nuclear physics using laser beams coupled with gamma beams. It will be built in Măgurele, The National Institute of Research - Development for Physics and Nuclear Engineering "Horia Hulubei". Through this project, our country will develop superior technologies particularly important for the national economy, the educational and research system.

The total costs of the ELI-NP project are €356 million, funds provided up to 80% by the Sectoral Operational Programme "Increasing Economic Competitiveness" and the contribution from the state budget will be of 20%.

The novelty of the research center that will be built in Măgurele is that it will have two main tools: two high-power lasers (10PW) and a very intense beam of gamma radiation with variable energy up to 20 MeV. Due to the unique combination of these instruments in the world, the experiments will lead to significant and unique achievements in different fields (Zamfir, 2012).

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The main objectives of ELI-NP are:

- Building the infrastructure (2013-2015)
- Building and purchasing the two equipments (two high-power lasers and gamma beam system) (2014-2017)
- Developing and implementing technical memory for experiments by Romanian researchers in cooperation with colleagues from abroad
- Developing human resource need
- Promoting research opportunities for future ELI-NP users (Zamfir, 2013).

The Extreme Light Infrastructure - Nuclear Physics Center in Bucharest-Măgurele will become operational in 2017.

FIGURE 1 —THE ELI-NP BUILDING COMPLEX
Source: www.eli-np.ro

In 2013 the construction of the building started, being conducted by Strabag, one of the largest construction corporations in Europe with a branch in Romania, as well. The building will cover an area of over 30,000 square meters, the complex will be located on seismic dampers so there is no risk for an earthquake and it will have several buildings. They will use geothermal energy sources for heating and cooling.

In March this year they signed the contract with EuroGammaS Consortium representatives and it will allow the Gamma Beam System. The consortium comprises seven European institutions and companies working in the field in Italy, France and Sweden and its command center is the National Institute of Nuclear Physics in Italy.

The process of recruitment and selection for researchers, engineers and technicians in the ELI-NP project has begun, now the number of employees is 20 (mostly Romanians who have worked for prestigious universities). It is estimated that their number will gradually increase to 250 in 2018.

2. PROJECT APPLICATIONS

This investment which will be made in Magurele will be primarily an opportunity to develop the top research in our country in areas such as physical optics, nuclear physics, materials science, medicine, pharmacy.

According to some theoretical studies, in case very high intensity laser beams occur, transforming field into matter may be obtained or, in other words, getting material out of vacuum. Some researchers argue that using the ELI-NP technology such a beam could be obtained. This would represent a big step forward in research and beneficial implications could be found relatively quickly in industry, as well (ELI-NP White Book, http://www.eli-np.ro/documents/ELI-NP-WhiteBook.pdf).

Electronic circuits used in the manufacture of satellites require a complex test procedure, meant to simulate as accurately as possible the conditions of the environment in which they will operate, in order to verify their proper functioning when exposed to cosmic radiations. In this respect, researchers estimate that in Magurele they will be able to generate radiations similar to those found in space and thus to test the protection of circuits and their functioning during natural parameters in such conditions. This can attract investments in our country from the manufacturers of such circuits, both through research contracts and by opening test centers, helping to increase the number of jobs.

Another possible application is the effect the laser could have on the various materials. The electronics that we have today, from remote controls to smartphones and super-computers, is based on material science (e.g. silicon or germanium); through a special treatment these materials change their properties of storing information. With the existing beams, silicon pills change their properties and are capable of storing information (memory) or to implement binary logic (microprocessors), but with the new beams some new properties can be foreseen. Direct consequence: the ability to store much more dense information or implement a more complex computational logic. This could decisively influence the evolution of entire electronics, opening new paths of development.

Applications in the medical field will be multiple and extremely useful ones. Techniques that do not exist at present or that exist but are very expensive and can not be used widely will be developed. They will investigate and implement techniques for the production of radioisotopes needed in medicine, new radioisotopes or isotopes that are already used, but produced through a more judicious (economic) method developed with ELI -NP compared to current production techniques.

Currently there are several radioisotopes known and used in medicine (e.g. Fluorine-18, used as a radiopharmaceutical substance when performing tomographies or radioactive iodine used in the

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treatment of thyroid malignancies). In the future, using gamma beam technology new isotopes will be created. An example is Molybdenum-99, a very expensive isotope used to treat cardiovascular diseases. It is currently obtained in nuclear reactors as a fission product of uranium. This fission is followed by a wide range of isotopes of which only 0.33% is Molybdenum-99. The process of obtaining it in high concentrations is very expensive, and global demand is much higher than the existing production capacity worldwide. Using ELI-NP techniques, they foresee possibilities to produce this isotope with greatly reduced costs, enabling its use on much larger scale (ELI-NP White Book, http://www.eli-np.ro/documents/ELI-NP-WhiteBook.pdf).

In the chemotherapy field they are trying to produce a isotope of platinum, platinum 195, which once introduced in the substance used in treatment act only on the ill organ or tissue. Currently, chemotherapy is a treatment technique that works not only on diseased organs, but the entire body, which makes the method sometimes ineffective or even harmful. In addition to that, chemotherapy costs are high, but if you get such an isotope treatment will become more effective medically and economically (Habs and Köster, 2010).

At present, radiation therapy is used for the treatment of cancer, which is a method based on the photon radiation that allows the destruction of 10% of irradiated cancer cells, while the rest of the cells are at a high risk of recovery. Moreover, the entire tissue is irradiated, not only the diseased part.

Countries with high economic potential have developed an accelerator by using a technique called hadronotherapy irradiation, which is the use of hadrons (protons and carbon ions) to destroy malignant tumors. The technique has much higher accuracy than the classical one, allowing to immediately destroy all irradiated cells. In addition, they act only on diseased tissues, and not on the healthy ones. But technology is very expensive and few countries afford such an accelerator, which can end up costing tens of millions of Euros. Because of high costs, few patients have the chance of such treatment. The research that will be done with ELI-NP will allow the study the method of obtaining hadronotherapy gamma beams, so these accelerators will be much cheaper and affordable in economically less developed countries, as well.

Another important application is the detection of sensitive nuclear materials. In the current socio-economic environment, the management of sensitive nuclear materials is very important in terms of security due to increase of nuclear materials trafficking. There are attempts to develop different methods to identify illicit nuclear materials accurately. One example is uranium and plutonium which are used in the nuclear bomb. Uranium is of two types, U235 (fissionable) uranium and U238 (non-fissionable) uranium. In the natural environment, uranium useful in nuclear or atomic bombs is in the very low concentration, below 1%, mostly U238. In order to be used uranium is separated or "enriched" to increase the concentration of U235. ELI- NP technology will not be able to make the separation, but it will detect the presence of significant quantities of enriched uranium when exceeding limits (ELI-NP White Book, http://www.eli-np.ro/documents/ELI-NP-WhiteBook.pdf). What is hoped to be accomplished in Măgurele will work similarly to x-ray machines at museums or airports, namely non-invasive inspection of freight containers using gamma radiation that can penetrate their walls, so that it is able detect hazardous substances.

Identification and characterization of radioactive waste is another application that will be developed with ELI-NP. Radioactive waste is a huge problem worldwide. They will develop applications where the waste will be scanned; they will also investigate the possibility of neutralization and changing the composition of highly radioactive waste, so their lifetime decrease greatly, from tens of thousands of years to a few minutes (Zamfir, 2012).

3. CONCLUSIONS

By means of ELI-NP - the most comprehensive research infrastructure ever built in Romania - Romania will significantly increase the attractiveness of the region in terms of excellence in research, development and innovation being able to attract investments of many companies that can benefit from both the new developed technologies, as well as the trained specialists. Investments in this project will be found later in the economy in different industries, but also in health and education.

Extreme Light Infrastructure is not only beneficial for the Magurele platform. It is a large infrastructure, which changes the perception of the country. It will be a center where "bright light" applications will be able to be actively promoted for the benefit of society and around which research, education, business environment and services will generate economic growth and urban development.

The Magurele project will have a huge impact on changing attitudes about scientific research and economic environment in Romania.

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