

AREAL-Unique Possibilities for Biologists As Well

Experimental researches at AREAL (Advanced Research Electron Accelerator Laboratory) were launched in 2015. AREAL project incorporates advanced technologies in the fields of laser physics, high-frequency technology, ultra-vacuum equipment, high precision diagnostic systems, control and synchronization of various processes.

AREAL is a laser driven RF gun accelerator which gives ultrashort precise electron beams for advanced researches in accelerating technologies, coherent radiation sources and dynamics of ultrafast processes. Nowadays, these researches are in the scope of the most important areas of leading accelerator centers and help us to deepen our understanding of microcosm. The research groups from CANDLE SRI, Yerevan State University, National Polytechnic University of Armenia, A. I. Alikhanyan National Scientific Laboratory (Yerevan Physics Institute), Institute of Molecular Biology and Institute for Physical Research of NAS RA and other scientific groups and institutions participate in the experimental program. A number of researches are carried out in the fields of molecular physics, genetics, molecular biology, microelectronics, semiconductor and solid state physics, development of new materials and accelerating technologies.

Being controlled by an ultrafast high precision laser, AREAL linac generates ultra-short relativistic electron beams. This gives the opportunity to examine ultrafast processes at cellular and molecular levels. The duration of these pulses is hundred times shorter than in case of regular accelerators. This allows carrying out precise and pure experiments with minimal disruptions, as a result of it identifying the structural features of the object. Due to these experiments the ultrafast radiation becomes a very important research area in various science spheres. Usually the experimental researches on new accelerators require a long period for an adequate interpretation of the results received and for the determination of new directions for experimental research.

An important step in accelerator user case formation was the cooperation of Armenian and Russian scientists in the realization of a long-term experimental program at AREAL on ultrafast radiation biomedicine.

The project incorporates experimental researches on the interaction of ultra-short relativistic electron pulses with biological objects, molecular-genetic effects, DNA damage and repair dynamics at ultrafast radiation and the development of new methods. The first results of these researches were introduced by the Head of Experimental Radiobiology and Radiation Medicine Division of Russian Federal Medical Biophysical Center after A. I. Burnazyan (Moscow, RF) Prof. A. Osipov (the 18th of November 2016) when the delegation of the scientific and educational ministerial delegations from Belarus, Georgia, Moldova and Ukraine visited CANDLE SRI in the framework of the “8th Eastern Partnership Informal Ministerial Meeting in Armenia”.

The obtained results and supposed perspectives of this cooperation will definitely contribute to the acquirement of new scientific data, which are important for the understanding of many processes in biological systems and the development of new methods in the sphere of radiation biomedicine.

“The idea of cooperation arose some years ago when we got acquainted with corr. member of NAS RA, Prof. R. M. Aroutiounian at an international conference in Japan”, tells Prof. A. Osipov. “Both of us deal with DNA damage and repair, genetic effects of environmental factors, the investigation of genome radiation damages. Last year Rouben Mikhailovich gave a talk at our center and some months ago me and our senior researcher Natalia Vorobyeva received an invitation to work on AREAL laser driven electron accelerator. This offer interested us a lot, since pulse accelerators of charged particles are unique installations, which will be able to replace the traditional accelerators (used to treat cancer) in future due to their compactness and high precision. By developing such installations, physicists open new opportunities for biologists as well. AREAL accelerator (developed in Armenia) generates a beam of accelerated electrons with ultra-short pulses. However, little is known about the biological operation of this radiation yet.

If we speak about the usage of radiation therapy for cancer treatment then the main principle is the selective damage of tumor cells by ionizing radiation, while the normal cells should remain viable. The primary experiments show that pulse radiation damages the tumor cells more effectively than monotonic ones. Why? This is still difficult to explain but the output of difficultly repaired DNA damages, under the influence of pulsed radiation, is higher, which is very satisfying at cancer therapy, since lower dose can be applied, saving healthy cells. This is principally a more gentle method. So far everything is good in theory but the results are still fragmentary, and there are few people who work with ultrashort pulses. Such installations have appeared relatively recently and they are unique. AREAL accelerator is the only one in CIS territory. It can be used to study the biological effects of accelerated electrons' ultra-short pulses.

Together with the biologists from Yerevan State University and Institute of Molecular Biology NAS RA we have started the experiment of DNA double strand breaks after human cell radiation at AREAL. We hope to reveal damage molecular mechanisms (being a result of pulse radiation) in human normal and tumor cells. For this purpose one of the most progressive and sensitive methods of DNA double strand break and repair evaluation is supposed to be used. The method of DNA protein repair focus analysis is based on the usage of fluorescent dye labeled proteins which participate in DNA repair. This is a very sensitive technology which allows to observe even a very small number of breaks, to see their distribution on cells, as well as to determine reparation mechanisms. Till now the effects of ultrashort accelerated electrons have not been investigated by this method.

I hope that a new start of a long-term cooperation is given. I really liked the scientific atmosphere and the active youth working at AREAL, in YSU and Institute of Molecular Biology. An agreement of cooperation is ready. Being an accelerator of new generation,

AREAL gives unique possibilities for research conducting. And if we manage to show that ultrashort pulses of ionizing radiation are more effective than the monotonous radiation, then cancer centers will be equipped by such accelerators in future. We are talking about new approaches in malignant tumor treatment”, said Prof. Osipov.

In the investigation of this program young scientists are also involved. Dr. Nelli Babayan (Assistant at General and Molecular Genetics laboratory (Faculty of Biology, YSU), head of “Cellular Technologies” group (Institute of Molecular Biology, NAS RA)) tells, “I represent one of the first groups of biologists, who conducted basic radiobiological researches at AREAL accelerator. Within the grant of State Committee of Science of RA we have conducted the first dosimetric investigations of ultrashort pulse radiation of electrons at cellular level. We have managed to set DNA primary damages, which is impossible to do using the traditional radiation sources. The thing is, on common installations, for getting a specific dose, the necessary radiation time can last from one minute to several hours. Naturally, the protective mechanisms in the cell become active already during radiation process and at the output we cannot see the pure effect. AREAL allows to get the same doses just in some seconds, giving a unique chance to explore the ultra-early effects of the ionizing radiation. For already two years we have been using the method of DNA-comets- a new, rapid and sensitive method of DNA damage (caused by radiation or chemical mutagens in separate cells) evaluation. If there are damages in DNA then under the influence of an electric field negatively charged DNA broken ends migrate from the nucleus forming a comet with a “head” and a “tail”. Under a fluorescent microscope this sensitive method allows to see DNA damages in each separate cell, starting approximately from 50 breaks.

AREAL accelerator construction gave new possibilities for radiobiology development in Armenia. The scientific staff and students from YSU and also from Institute of Molecular Biology together managed to carry out basic radiobiology researches, the results of which are published in international reviewed journals. A new stage of investigations at AREAL was the joint project with one of the leading radiobiologists of Russia Prof. Andrean Osipov, who together with Natalia Vorobyeva, held a master class on advanced methods in radiobiology and together with us got the first results on DNA repair protein focus. As a present we received also the focus analyzing computer program developed at their laboratory. Already on Monday I am invited to the laboratory of Prof. Osipov in Moscow to go on with the analysis of the results received on AREAL. I am sure that our cooperation will turn out to be really productive”, said N. Babayan.