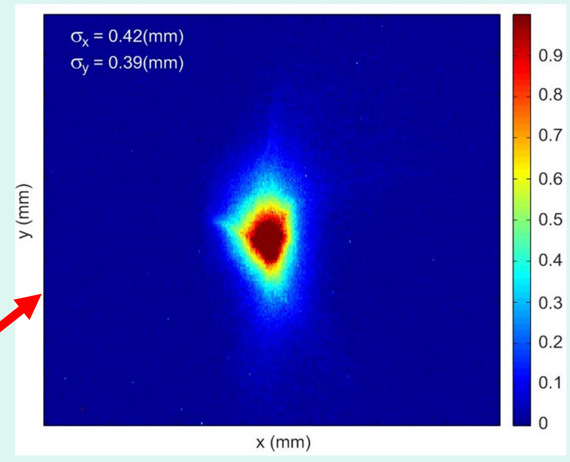
AREAL LOW ENERGY ELECTRON BEAM APPLICATION IN LIFE AND MATERIAL SCIENCES

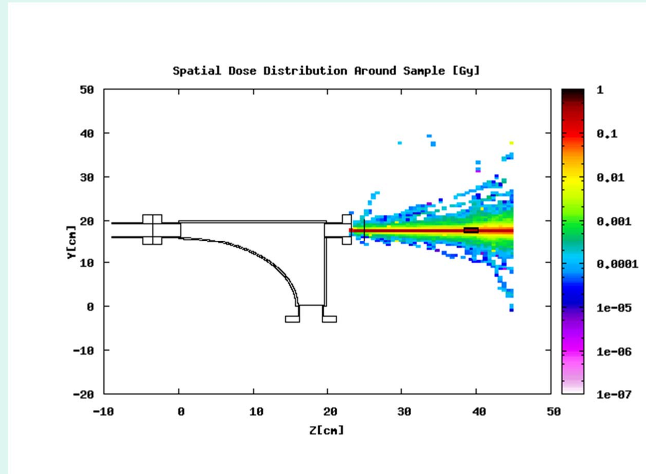
V. Tsakanov (CANDLE Synchrotron Research Institute), R. Aroutiounian (Yerevan State University),
H.N. Yeritsyan (Yerevan Physics Institute) , N. Martirosyan (State Engineering University of Armenia)
A. Petrosyan (Institute of Physical Research), S. Haroutiunian (State Committee of Science RA)

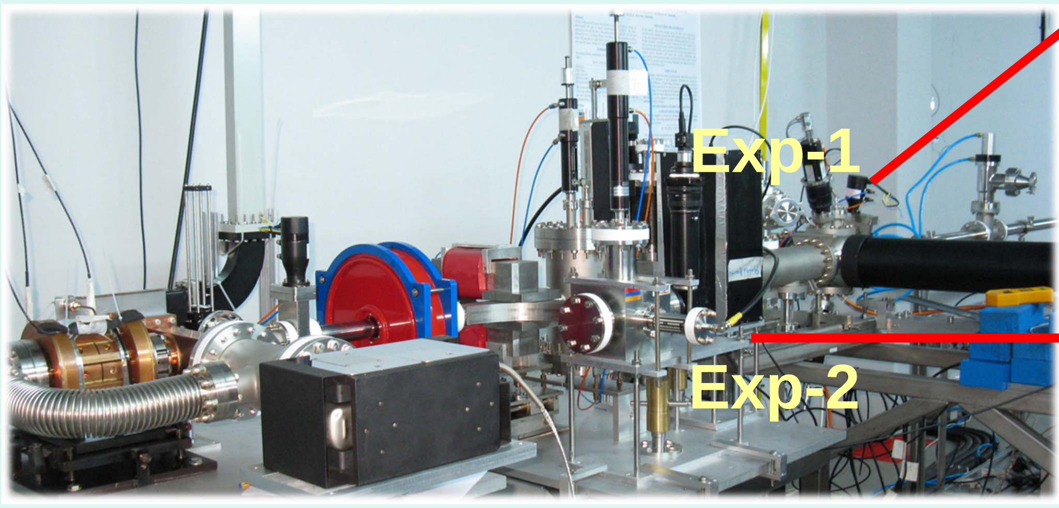
Abstract

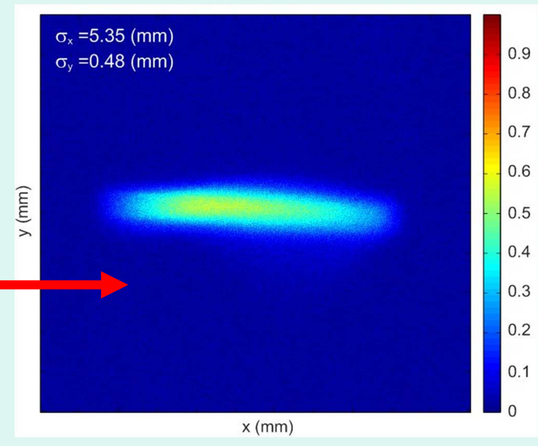
AREAL laser driven RF gun provides the 2-5 MeV energy ultrashort electron pulses for experimental study in life and materials sciences. We report the first experimental results of the AREAL electron beam application in the study of molecular-genetic effects of ultrafast radiation, electro-physical properties of silicon and silicon-dielectric structures, characteristics of ferroelectric nanofilms and the single crystals for scintillators.

AREAL Facility Performance





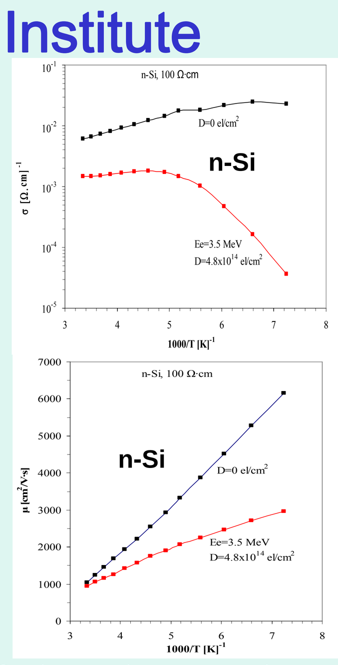




Beam Parameters
Energy – 2-4.5 MeV
Charge – 20 – 700 pC
Emittance ~ 0.5 um
Energy spread < 2 %

Silicon-dielectric Structures

Yerevan Physics Institute



Temp. dependence of conductivity (top) and carrier mobility (bottom).

The radiation defect formation of the Si crystals was observed after irradiation by 3.5 MeV energy AREAL electron beam. The last known experimental data predict that the cluster defects formation in Si crystals takes place at irradiation energy higher than 10 MeV, whereas at lower energies mainly point pair defects are created.

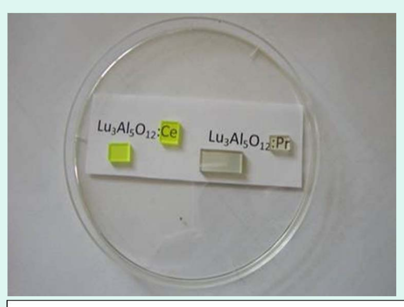
The defect formation in Si crystal at 3.5 MeV energy is unusual for these electron energies and most likely is the cluster type defects caused by the AREAL subpicosecond electron pulses. This preliminary conclusion was reached after measurements of main electro-physical parameters of n-Si crystals: electro-conductivity, Hall mobility and main charge carriers concentration.

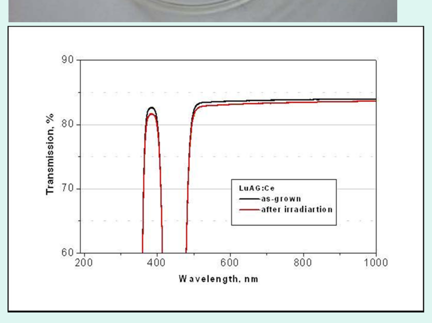
Scintillators for the next-generation calorimeters

Institute for Physical Research

Inorganic scintillators have various fields of applications in nuclear medicine, security and HEP. In High-Lumi LHC at CERN and colliders very high levels of ionizing radiation are expected. Performance requirements raise the problem of radiation hardness of materials, improving the timing properties and energy resolution of the detectors. Scintillators based on lutetium aluminum garnet ($Lu_3Al_5O_{12}$; LuAG) are in the list of most promising candidates for future detectors.

AREAL accelerator allows the material radiation tolerances study. Fig shows the optical transmission of LuAG:Ce and LuAG:Pr single crystals before and after irradiation. The 500 nm range is important as the emission peak of this scintillator is 520 nm. A small degradation is seen after 1 kGy applied dose. The next experiments are in progress.





Ferroelectric Nanofilms

State Engineering University

The research group from of Microelectronics and Biomedical Devices Chair has successfully started experimental program on the AREAL. The purpose of this research is to improve the characteristics (frequency, dielectric permittivity, residual polarization) of ferroelectric nano-films that are important for the development of functional microelectronics and nanotechnology.

In ferroelectric materials there exist oxygen vacancies, which show a "donor"-like behavior and the corresponding trap level energy lies in the forbidden region near the conductance band and not all trap levels are occupied. Therefore, the part of electrons can be trapped by those levels due to films irradiation by electron beam. This can result in an improvement of the dielectric permittivity, polarization, electrical tunability, operating frequencies, fatigue properties important for memory applications.

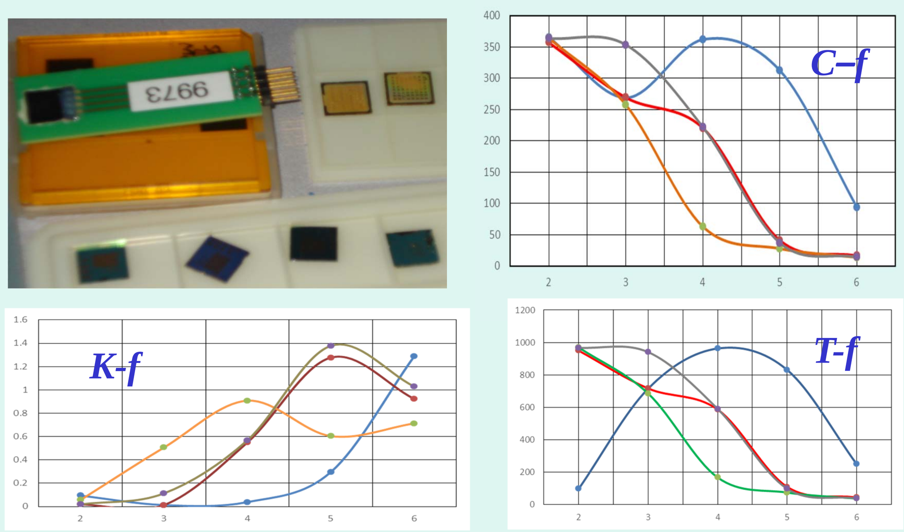
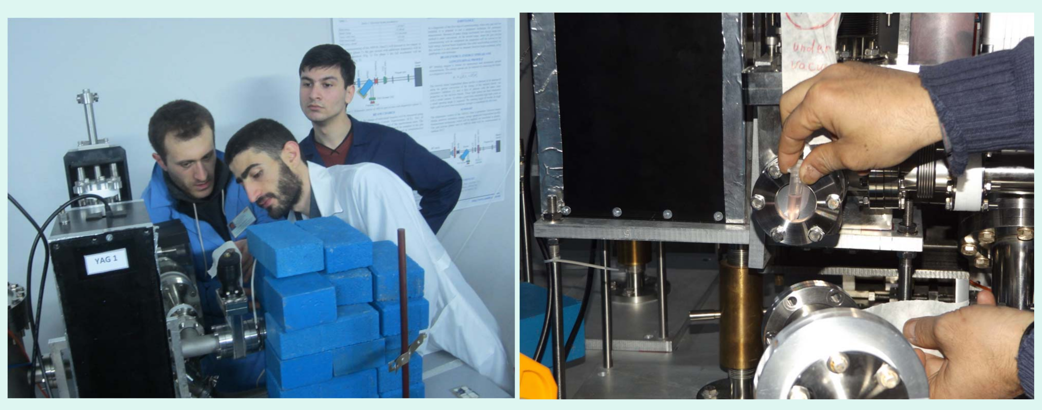
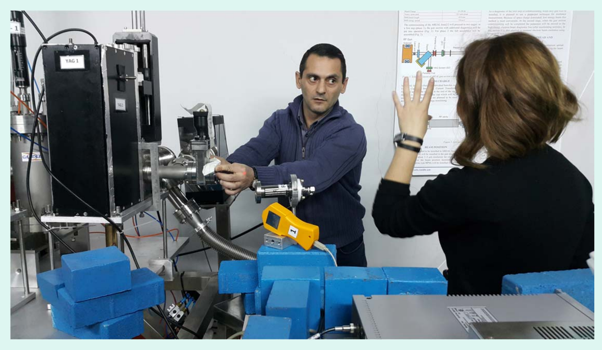


Fig. The C–f , K- f , T-f dependences before (blue) and after irradiations (red-1, green- 2, purple - 3 irradiation. C-capacitance, K- permitivity, T- loss tangent (tgδ).



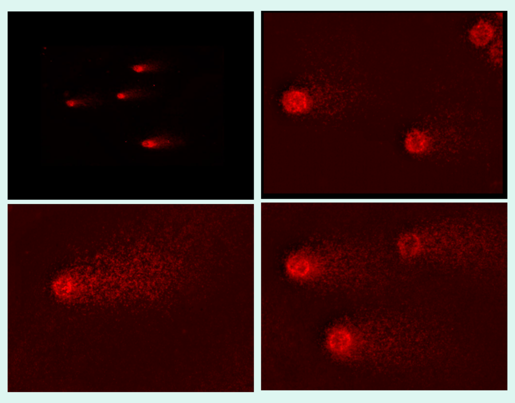
Molecular-genetic effects

Yerevan State University



Innovative experimental *in vitro* investigations at the interface of laser physics and radiation biology are of crucial importance for understanding the basic mechanisms of radiation damage of the cell. Application of relativistic electron bunches in radiation biology and medical physics might clarify penetrating radiation effects.

The first step toward the application of ultrafast radiation in radiobiology is the development of biodosimetry based on molecular-genetic effects of radiation on DNA as a principal biological target for the radiation damaging action. Radiation-induced DNA damage in living cells occurs either by direct ionization or indirectly, through generation of free radicals that attack DNA, resulting in single-strand breaks and oxidative damage to sugar and base residues; later they may be converted into DNA double strand breaks.



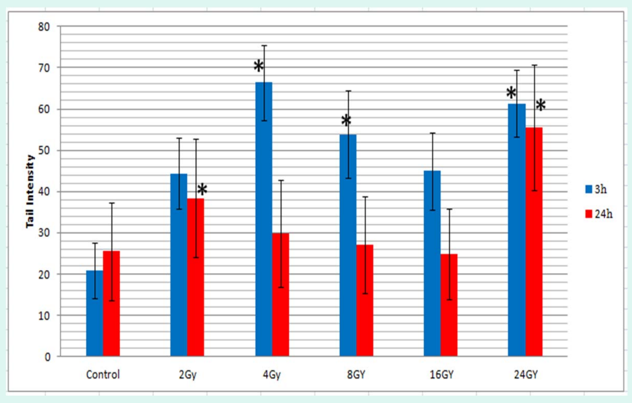
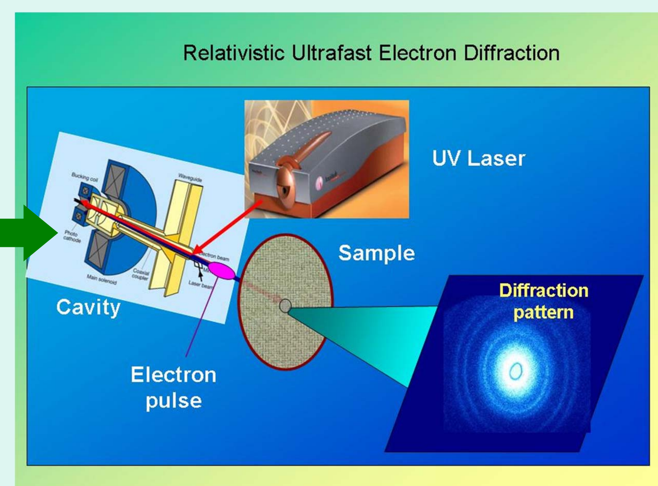


Fig. **Comet assays and DNA repair after irradiation.**

Genetic effects of accelerated ultrafast electron beams generated in AREAL were studied using the comet assay (single-cell gel electrophoresis) . The primary DNA damage and the dynamics of DNA lesions repair have been evaluated.

DNA damage and repair capacity was evaluated in K562 human chronic myelogenic leukaemia cells irradiated with doses 2-24 Gy. We received the first dose-response curves, confirming that the alkaline comet assay is suitable technique for accelerated ultrafast electron beams effect detection and biodosimetry.

Highlights
RU Electron Diffraction
Pump-Probe Experiments
In-vivo experiments



Experimental research is supported by the State Committee of Science of MES RA

tsakanov@asls.candle.am

http://www.candle.am