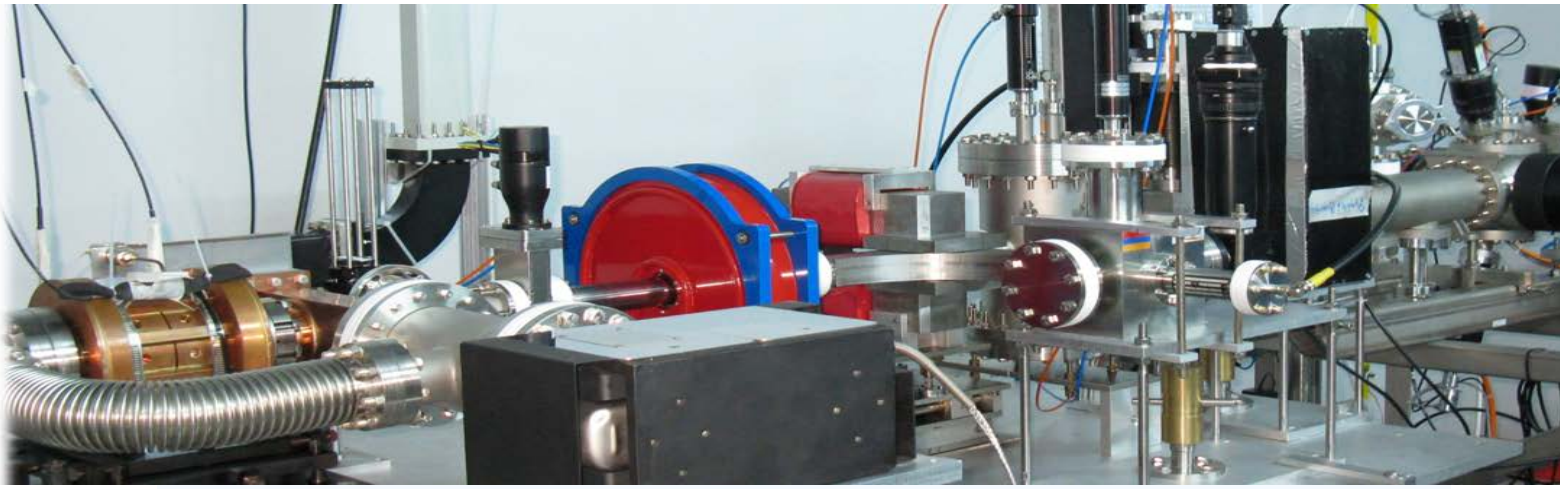
Ultrafast Beams and Applications

International Workshop



04-07 July 2017, CANDLE, Armenia

Abstracts

State Committee of Science RA

Preface

The tremendous progress in the generation of ultrafast electron and photon beams during the last decade has opened new horizons for dynamic process studies at cell, molecular and atomic levels. The aim of the workshop is to organize a forum for the scientists from diverse fields of accelerator physics, laser physics, life and materials sciences to discuss the highlights of physics and applications of ultrafast electron and photon beams, with an emphasis on low energy relativistic electron and Infrared–THz photon beams. The main topics of the workshop are:

- Ultrashort electron beam sources
- Radiation sources and FELs
- Advanced accelerator concepts
- Instrumentation and experimental techniques
- Applications in life and materials sciences

The host institution has recently completed the construction of laser driven AREAL electron accelerator and DELTA laboratory with laser scanning two-photon microscopy and laser microfabrication stations.

Workshop co-chairs:

Klaus Floettmann (DESY, Germany)

Vasili Tsakanov (CANDLE, Armenia)

International Workshop

Ultrafast Beams and Applications

Date

04-07 July 2017

Venue

CANDLE SRI (str. 31 Hr. Acharyan)
Yerevan, Republic of Armenia

Program

3 July Monday	
Arrival	
16:00	***Institute of Ancient Manuscripts - Matenadaran***
18:00 - 20:00	***Registration and Reception*** (***CANDLE SRI***)
4 July Tuesday	
9:00 - 9:20	***Registration***
Session 1: Facilities and New Projects (*Chairman: V. Tsakanov*)	
9:20 - 9:30	***Workshop Opening***
9:30 - 9:55	***Ultrafast Electron Beam Irradiation Effects on DNA Damage and Repair in Normal and Cancer Cells*** Rouben Aroutiounian (Yerevan State University/NAS RA, Armenia)
9:55 – 10:20	***REGAE - The Relativistic Electron Gun for Atomic Exploration*** Klaus Floettmann (DESY, Germany)
10:20 – 10:45	***Considerations of an Ultrafast Electron Diffraction Experiment at HZB*** Georgios Kourkafas (Helmholtz-Zentrum Berlin, Germany)
10:45- 11:10	**Coffee Break**
11:10 - 11:30	***AREAL - Facility for Ultrafast Applications*** Bagrat Grigoryan (CANDLE SRI, Armenia)
11:30 – 11:50	***Design of the Ultrashort Bunch Accelerator Complex*** Mariya Maltseva (Budker Inst. of Nuclear Physics, Russia)

11:50- 12:10	***IPM Accelerator Projects*** Hamed Shaker (IPM, Iran)
12:10 – 12:30	***A Phase Matching Accelerator with Tapered Waveguides*** Francois Lemery (DESY, Germany)
12:30 - 14:30	**Lunch**
	Session 2: Photon Beams (*Chairman: D. Nikiforov*)
14:30 - 14:55	***A New Scheme of High-Energy THz-Pulses Source Using Nonlinear Crystal with Attached Multistep Phase Mask*** Yuri Avetisyan (Yerevan State University, Armenia)
14:55 - 15:15	***Experimental Demonstration of Spectral Self-Compression of Super-Continuum Radiation Fraction*** Hrach Toneyan (CANDLE SRI, Armenia)
15:15 - 15:30	***Similariton Based Technique for Determination of Femtosecond Pulse Duration*** Karapet Manukyan (Yerevan State University, Armenia)
15:30 - 15:45	***Phase Regularities of Spectron: Numerical Analysis*** Narek Karapetyan (Yerevan State University, Armenia)
15:45 - 16:00	***Numerical Study of Femtosecond Signal Spectral Self Compression*** Minas Sukiasyan (CANDLE SRI, Armenia)
16:00	**Yerevan Cognac Factory ARARAT**
5 July Wednesday	
	Session 3: Electron Beams (*Chairman: H. Shaker*)
9:00 - 9:25	***SRF Gun Development for High Brightness, Short Pulse Applications*** Thorsten Kamps (Helmholtz-Zentrum Berlin, Germany)
9:25 - 9:50	***Linearization of the Longitudinal Phase Space Without Higher Harmonic Field*** Benno Zeitler (University of Hamburg & CFEL, Germany)
9:50 - 10:15	***SRF Implementation in BESSY VSR for Picosecond X-Ray Pulse Production*** Andranik Tsakanian (Helmholtz-Zentrum Berlin, Germany)
10:15 - 10:40	***RF Photogun Based on a Parallel Coupling Accelerating Structure for High Charge and Low Emittance*** Danila Nikiforov (Budker Institute of Nuclear Physics, Russia)
10:40 - 11:05	**Coffee Break**
11:05 - 11:25	***Synchrotron Radiation Reflection from Outer Wall of Vacuum Chamber***

	Suren Arutunian (Yerevan Physics Institute, Armenia)
11:25 - 11:50	***Wakefields and Impedances*** Martin Dohlus (DESY, Germany)
11:50 - 12:15	***The THz Radiation in Laminated Structures*** Mickayel Ivanyan (CANDLE SRI, Armenia)
12:15 - 12:30	***THz Undulator Radiation in Waveguide*** Armen Grigoryan (CANDLE SRI, Armenia)
12:30 - 14:30	**Lunch**
Session 4: Applications and Experimental Techniques (*Chairman: B. Grigoryan*)	
14:30 - 14:50	***Laser Driven Facility for Irradiation Experiments, Two-Photon Microscopy and Microfabrication*** Arsham Yeremyan (CANDLE SRI, Armenia)
14:50 - 15:10	***The Study of Natural Anti-Aging Compounds at DELTA Two-Photon Microscopy Station*** Gohar Tsakanova (Institute of Molecular Biology NAS RA, Armenia)
15:10 - 15:25	***Peculiarities of Ultrafast Irradiation Effect on the Properties of Silicon Crystals*** Hrant Yeritsyan (Yerevan Physics Institute, Armenia)
15:25 - 15:45	***The Effects of Ultrafast Irradiation on Baxsr1-Xtio3 Ferroelectric Thin Films*** Norayr Martirosyan (National Polytechnic University of Armenia, Armenia)
15:45 - 16:00	***AREAL Ultrafast Beam Application for Modeling the Microorganisms Survival in Space*** Garnik Khachatryan (Yerevan Physics Institute, Armenia)
16:00 - 16:15	***Material Research under Extreme Conditions at AREAL Facility*** Aram Sahakyan (Yerevan Physics Institute, Armenia)
18:30	**Concert**
6 July Thursday	
Session 5: Tour to AREAL and CANDLE-15 Years (*Chairman: K. Floettmann*)	
9:30 – 9:45	***Low Emittance CANDLE Storage Ring*** Artsrun Sargsyan (CANDLE SRI, Armenia)
9:45 – 10:10	***CANDLE-15 Years: Learning from the Past and Inventing the Future*** Vasili Tsakanov (CANDLE SRI, Armenia)
10:10 – 10:30	**Official Event**

10:30 – 10:45	**Coffee Break**
10:45 – 11:45	**Tour to AREAL Facility**
11:45 – 12:30	**Refreshments**
12:30-14:00	**Hotel + Lunch**
14:00 - 17:30	**Garni- Gegard**
19:30	**Workshop Dinner**

7 July Friday

Session 6: Sources, Diagnostics and Control (*Chairman: B. Zeitler*)

9:00 - 9:20	***Middle Infrared and THz Sources at AREAL*** Vahe Sahakyan (CANDLE SRI, Armenia)
9:20 - 9:40	***Diagnostics at REGAE Facility*** Hossein Delsim Hashemi (DESY, Germany)
9:40 - 10:00	***Lego Radio Frequency Timer for Kev Energy Electrons*** Simon Zhamkochyan (Yerevan Physics Institute, Armenia)
10:00 - 10:20	***Faraday Cup Simulation for Electron Beam Measurements*** Vaagn Gambaryan (Budker Inst. of Nuclear Physics, Russia)
10:20 - 10:40	***Accelerating Structure Design for the AREAL THz –IR FEL*** Ashot Vardanyan (CANDLE SRI, Armenia)
10:40 - 11:00	**Coffee Break**
11:00 - 11:25	***The Utca Based Control System Development for Advanced Accelerators*** Ludwig Petrosyan (DESY, Germany)
11:25 - 11:40	***An Overview of Beam Diagnostic and Control Systems for AREAL Linac*** Gayane Amatuni (CANDLE SRI, Armenia)
11:40 - 12:00	***Beam Diagnostics with THz Radiation*** Francois Lemery (DESY, Germany)
12:00 - 12:30	**Workshop Summary**
12:30 - 14:30	**Lunch**

Ultrafast Electron Beam Irradiation Effects on DNA Damage and Repair in Normal and Cancer Cells

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The advantage of laser-generated ultrafast electron beams for biological and clinical application was reported, since they typically feature a monoenergetic spectral profile and are better directed (less lateral spread) than other laser-driven ions. In addition, they have very high instantaneous dose rate within a time interval shorter than many chemical reactions.

Before translating the usage of laser-generated accelerators into clinical practice, the radiobiological effectiveness of such ultrafast electron beams should be approved. We obtained preliminary characterization of dose, dose-rate effects based on biological endpoints such as DNA damage/repair and cell viability, to promote the application of ultrafast electron bunches, generated by AREAL linear accelerator.

During recognition and repair of DNA double-strand breaks (DSBs), the dynamic microstructures, called foci, are formed. They contain hundreds to thousands of copies of various proteins involved in these processes. The quantitative analysis of the foci of repair proteins and their localization/colocalization allows to determine not only the number of DSBs and their spatial distribution in the cell nucleus, but also the efficiency of their repair. DSBs detection will be realized for evaluation of the dose and dose-rate effects of ultrafast pulsed electron beam irradiation in human tumor and normal cells.

REGAE-the Relativistic Electron Gun for Atomic Exploration

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REGAE - the Relativistic Electron Gun for Atomic Exploration is a small electron accelerator build and operated within the framework of the Center for Free-Electron Laser Science CFEL, i.e. in a collaboration of the Max Planck Society, the University of Hamburg and DESY. REGAE provides high quality electron bunches for time resolved diffraction experiments and serves as test bed for accelerator R&D.

REGAE employs a photo cathode RF gun operated at 3 GHz (S-Band) for the production of electrons. The 1½ cell gun cavity, a scaled version of the cavity in operation at the FLASH FEL, accelerates the electrons to energies of up to 5 MeV. A second RF cavity is operated in bunching mode, i.e. the electrons pass the cavity at the zero crossing of the field, such that a correlated energy spread is introduced. In the following drift section the bunch length decreases due to the different velocities and reaches a minimum about 4 m downstream of the bunching cavity where the target chamber is located. Extraordinary emittance requirements in the nm range (normalized) and pulse lengths down to a level of ~10 fs require operation at low bunch charges on the sub-pC scale.

Considerations of an Ultrafast Electron Diffraction experiment at HZB

Georgios Kourkafas, Helmholtz-Zentrum Berlin, Germany
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An overview of beam-dynamics studies, bunching approaches and diagnostics towards a UED facility, using SRF technology at HZB.

AREAL – Facility for Ultrafast Applications

Bagrat Grigoryan, CANDLE SRI, Armenia
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The current status and the upgrade plans of AREAL facility will be presented. Capabilities for new experiments will be discussed.

Design of the Ultrashort Bunch Accelerator Complex

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At Budker institute of nuclear physics the accelerator complex, on the base of RF photogun, is being developed. Complex operating frequency is 2856 MHz. On its base one can perform interdisciplinary research with electron beam with a charge up to 2 nC and a ps length. One of the first possible experiments is plasma excitation by the electron bunches with a period of 1 mm. For these purposes we plan to use the electron beam from

the VEPP-5 injection complex. The beam should previously be divided into bunches with a period of 1 mm by means of mm wavelength cavities. To excite these cavities, one can use wakefields of the electron beam from the photogun. In our study we described calculations of the photogun parameters. We also performed calculations of the magnet focusing structure which is necessary during the excitation of the mm wavelength cavities.

IPM Accelerator Projects

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A Phase Matching Accelerator with Tapered Waveguides

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Low-energy particle acceleration is typically achieved with radio frequency sources operating with 100 MV/m accelerating gradients and ~10 cm wavelengths. Scaling to smaller wavelengths requires correspondingly larger accelerating fields to achieve the scaled dynamics which is challenging for future mm-scale accelerators. Here we discuss an alternative approach based on a tapered waveguide where the phase velocity of the structure matches the velocity of an accelerating electron bunch. We describe the theory of the device and present some beam dynamics simulations.

Session 2: Photon Beams

A New Scheme of High-Energy THz-Pulses Source Using Nonlinear Crystal with Attached Multistep Phase Mask

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Intense THz pulses hold promise for the development of a new generation of compact particle and x-ray sources. Laser- and THz-driven particle accelerators with unprecedented flexibility can be important for free-electron lasers [1, 2]. In this report we

present a new scheme of THz source using a multi-step phase mask (MSPM) to provide discretely tilted pulse-front in nonlinear crystal. In essence, MSPM split a single input beam into many smaller time-delayed “beamlets”, which together create a discretely tilted pulse front. In contrast to commonly used diffraction grating, in the proposed scheme the problems related to the introduction of the large amounts of angular dispersion are eliminated.

We calculate the horizontal and vertical dimensions of the steps, which are required to generate THz-pulse with maximal energy and high efficiency of the pump-to-THz conversion. The optimal number of the steps in MSPM is estimated taking into account the separate beamlets broadening in MSPM and problems of the mask fabrication. The different methods, which can be used for MSPM fabrication, are discussed. The proposed method is promising to realize a high power and alignment-free table-top THz source.

[1] E. A. Nanni, W. R. Huang, K.-H. Hong, K. Ravi, A. Fallahi, G. Moriena, R. J. D. Miller, and F. X. Kärtner, Nat. Commun. 6, 8486 (2015).
[2] J. Hebling, J. A. Fülöp, M. I. Mechler, L. Pálfalvi, C. Tőke, and G. Almási, “Optical manipulation of relativistic electron beams using THz pulses,” 1109.6852 (2011).

Experimental Demonstration of Spectral Self-Compression of Super-Continuum Radiation Fraction

Hrach Toneyan* [1, 2], Minas Sukiasyan [1, 2], Vardan Avetisyan[1] and Levon Kh. Mouradian [1, 2]
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The process of ultrashort pulse spectral self-compression (self-SC) is demonstrated experimentally. The combined effect of negative dispersion and weak nonlinearity, required for this process, is achieved in both standard single-mode fiber at wavelengths of 1.3 μm and hollow core fiber at 800 nm. To reach the wavelengths in range of 1.3 μm, broadband supercontinuum is generated from the femtosecond laser + amplifier source at 1030 nm. The self-SC of fraction of supercontinuum spectrum resulted in ~4x spectral narrowing of the signal.

Similariton Based Technique for Determination of Femtosecond Pulse Duration

Karapet Manukyan*[1], Hrach Toneyan[1, 2], Minas Sukiasyan[1, 2], Aghavni Kutuzyan[1] and Levon Kh. Mouradian[1, 2]

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We demonstrate a similaritonic technique of femtosecond pulse duration determination alternatively to classic autocorrelation method. The new technique is based on spectral properties of the nonlinear-dispersive (NL-D) similariton, generated in a single-mode fiber without gain. We studied the spectral peculiarities of NL-D similaritons, both numerically and experimentally. We experimentally checked that the spectral bandwidth of the similariton is proportional to the square root of the input pulse peak power and, thus, inversely proportional to the square root of the input pulse duration. In our study we investigated this property of the NL-D similariton, by testing it for various input pulse forms. This allowed us to state that the similaritonic technique of the pulse duration determination has the important advantage of measurements being independent from the pulse shape, compared to the autocorrelation method.

Phase Regularities of Spectron: Numerical Analysis

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The spectron pulse, generated in the far zone of dispersion, images its spectrum in temporal analogy to the Fraunhofer diffraction. The spectron shaping was studied in the scope of dispersive Fourier transformation (DFT) or real-time Fourier transformation. Our study is targeted to the spectron phase peculiarities. Particularly, to test whether the DFT method, along with the amplitude imaging the spectrum, works also for the phase, i.e. to find conditions under which the temporal phase of the spectron pulse images the initial spectral phase. In our numerical study, we first tested the spectrons generated from

various input pulses of Gaussian, sech2, super-Gaussian shapes, as well as from the asymmetric, two- and three-peak pulses. We examined also the peculiarities of spectrons generated from pulses with initial spectral phase. Finally, we generated the spectron from a two-peak pulse with strong self-phase modulation. For all variety of these pulses, the temporal phase of the spectron repeats the spectral phase of the initial pulse. The results of our studies on the spectron phase peculiarities can be prospective for the pulse spectral phase measurement, and so for femtosecond pulse complete characterization alternatively to spectral interferometric techniques.

Numerical Study of Femtosecond Signal Spectral Self Compression

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The nonlinear process of ultrashort pulse spectral self-compression (self-SC or soliton effect spectral compression) in a medium with anomalous dispersion and weak nonlinearity is studied numerically. Up to 33x self-SC is shown for Gaussian, sech2, super-Gaussian, as well as for randomly amplitude- and phase-modulated pulses. The study shows that the proposed new technique is useful for the radiation noise suppression.

Session 3: Electron Beams

SRF Gun Development for High Brightness, Short Pulse Applications

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A short summary of the SRF photo injector activities related to bERLinPro, an energy-recovery linac fest facility will be presented.

Linearization of the Longitudinal Phase Space without Higher Harmonic Field

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SRF Implementation in BESSY VSR for Picosecond X-ray Pulse Production

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The BESSY VSR upgrade of the BESSY II light source represents a novel approach for simultaneous store of long (ca. 15ps) and short (ca. 1.5ps) bunches in the storage ring with the “standard” user optics. The realization of this project will allow production of intense picosecond X-ray pulses of synchrotron radiation with 1.25 MHz to 250 MHz repetition rate while at the same time maintaining the high average flux BESSY II users are accustomed to. The achievement of this challenging goal requires installation of four new SRF cavities (2x1.5GHz and 2x1.75GHz) in a single module. These cavities must handle HOM power an order of magnitude higher than state-of-the-art systems. The cavities are equipped with strong waveguide and beam tube HOM dampers necessary for stable operation. The design aspects of SRF cavities and expected HOM power levels for various BESSY VSR bunch filling patterns will be presented.

RF Photogun Based on a Parallel Coupling Accelerating Structure for High Charge and Low Emittance

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The concept of RF photogun with high charge, short length and ultralow emmitance is presented. The gun is basis with new type accelerating structure. This structure consists of accelerating cavities, which are fed by RF power with help of common exciting cavity by parallel way through the individual small coupling slots. Under such design the accelerating cavities are not connected with each other by electromagnetic field and the focusing system based on the permanent magnets can be used. The features, advantages

of the system and comparison with the structures based on the sequential RF power feeding are discussed. Dynamics for the beam with charge 5 nC are presented. The beam emmitance behavior is calculated and discussed.

Synchrotron Radiation Reflection from Outer Wall of Vacuum Chamber

Suren Arutunian, Yerevan Physics Institute, Armenia
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Synchrotron radiation reflection of a bunch from outer wall of vacuum chamber is investigated in Lienard-Wiechert approach. The induced charges moving with greater than speed of light are introduced. Characteristic wake fields of these charges are calculated.

Wakefields and Impedances

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The concepts of wakefields and impedances are introduced as well as different properties and computational methods. Some examples of short- and long range wakes are given.

The THz Radiation in Laminated Structures

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The report presents the results of studies on the radiation of a point charged particle in the cylindrical and planar laminated structures. It is shown that in two-layer metal structures (a two-layer metal waveguide and in a structure consisting of two double-layer parallel metal plates) under certain conditions (high conductivity of the main upper layer and low conductivity of the thin lower layer) the frequency spectrum of the wakefield radiation has a single-mode and narrow-band resonance character. The generated eigenmode of the structure is synchronous to the motion of the particle. The experimental

results, confirming the theoretical calculations, are presented. The planned experiments are also described and their results are predicted. The possibility of generation of narrow-band and narrow-beam radiation in the terahertz and sub-terahertz range is demonstrated at acceptable geometric and electromagnetic parameters of the structure.

THz Helical Undulator Radiation in Cylindrical Waveguide

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In this report the helical undulator radiation in cylindrical waveguide will be presented. The radiation spectrum in THz region is different from free space results for small radiuses of vacuum chamber. Under certain conditions the THz undulator radiation in waveguide could lead to radiation energy redistribution between the waveguide modes filtrating and enhancing the selected modes.

Session 4: Applications and Experimental Techniques

Laser Driven Facility for Irradiation Experiments, Two-Photon Microscopy and Microfabrication

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Parallel operation of AREAL linac and DELTA experimental stations provides a unique capability to perform a comprehensive chain of multidisciplinary experiments on the same facility. The beam delivery scheme implemented on the laser system for parallel operation will be presented, along with a summary of experimental results demonstrating the multidisciplinary research capabilities of the facility and the diversity of applications.

The Study of Natural Anti-Aging Compounds at DELTA Two-Photon Microscopy Station

Gohar Tsakanova[*1,2], Elina Arakelova[1], Violetta Ayvazyan[1], Gayane Ghazaryan[1], Anna Ayvazyan[2], Stepan Tatikyan[2], Arsen Arakelyan[1]

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Aging is an intricate phenomenon characterized by progressive decline in physiological functions and increase in mortality that is often accompanied by many pathological diseases. Oxidative stress (OS) plays a pivotal role in aging processes. To suppress OS, synthetic antioxidants are often used, that, nevertheless, violate the natural metabolism of the cells. In this regard, finding of natural compounds protecting against OS is currently considered especially important. The aim of this study was to reveal the potential protective effects of snails albumen gland protein extract against aging at the cellular level using human red blood cells (RBCs) and two-photon laser scanning microscopy.

The RBCs were isolated from the blood samples of 30 healthy volunteers (25-35 years young age group, male/female, 5/5; 45-55 years middle-aged group, male/female: 5/5; 65> years older-aged group, male/female: 5/5). The albumen gland extract was isolated from 40 adult specimens of snails. After the generation of an *in vitro* model of OS the intracellular reactive oxygen species (ROS) were monitored in human RBCs by two-photon laser scanning fluorescence microscopy at AREAL facility by using a ROS-sensitive, membrane-permeable fluorescent dye, 5(6)-carboxy-2',7'-dichlorofluorescein diacetate (carboxy-DCFDA). Image processing and subsequent statistical analysis were performed using "ImageJ" and "Graphpad Prism 3.03" softwares, respectively.

In conclusion, we demonstrated a novel approach for the investigation of oxidative stress in living human RBCs and that two-photon laser scanning imaging is a valuable tool for studying oxidative stress in living RBCs under different pathological conditions. The snail albumen gland protein extract effectively prevents the generation of intracellular ROS, thereby demonstrating powerful antioxidant properties, and possesses a protecting effect against aging-generated ROS in human RBCs. And finally, the snail albumen gland protein extract can be considered as harmless and effective natural antioxidative means in prevention of the aging-related pathological processes associated with OS.

This work was supported by the State Committee of Science MES RA in the frames of 13YR-1F0028, 14AR-1f09 and 16YR-1F011 research projects.

Peculiarities of Ultrafast Irradiation Effect on the Properties of Silicon Crystals

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The influence of ultrafast (pico-second pulse duration) electron irradiation with energy 3.5 MeV on the electro-physical properties of silicon crystals is presented. The behavior of main charge carrier mobility, charge carrier concentration and electro-conductivity, depending on temperature and irradiation dose, are analyzed, and scattering mechanisms are elucidated: on the ionized impurities and on the radiation defects. Dose dependencies of electro-conductivity and carrier mobility for samples of different specific resistivity are given. It was shown that in spite of relatively low electron irradiation energy and intensity, the created radiation defects, in the end, have a cluster character. The details of these behaviors are explained in terms of thermal effects which do not take place at ultrafast irradiation.

The Effects of Ultrafast Irradiation on Baxsr1-Xtio3 Ferroelectric Thin Films

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Different compositions of BaxSr1-xTiO3 ferroelectric ceramic targets were obtained by the method of self-propagating high temperature synthesis, and on their basis, the BaxSr1-xTiO3 nano-film structures, with Pt interdigital electrodes, were fabricated by pulsed laser deposition technique. The Pt/BaxSr1-xTiO3/Pt structures were examined under ultrafast low-energy electron beam irradiation at AREAL (Advanced Research Electron Accelerator Laboratory) and the dielectric/electric properties (ε-f, tgδ, and I-V) were characterized over a frequency range from 100 Hz to 1 MHz. It was found that the

dielectric permittivity and loss tangent, in general, are shifted to a lower frequency range and decreased after electron beam irradiation.

AREAL Ultrafast Beam Application When Modeling The Survival of Microorganisms in Space

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The presentation is dedicated to investigation of survival of microorganisms under the conditions as close as possible to cosmic ones. The short overview of situation in the field, and last data on the survival of microbes in near space is given. The proposed technical and scientific methodology for performing investigations at AREAL facility is described, namely: effect of radiation on microorganisms using AREAL accelerator at normal and ultra-low temperature conditions, and also under the vacuum application. The technical characteristics of AREAL provide a unique opportunity to study radiation influence on biological objects. It is possible to vary the beam power, energy and the frequency of electron bunches in a wide range. Some data received during the initial investigations, as well as further experiments, are discussed, including the possibility of the new mutant strains obtaining that are able to transform some xenobiotics.

Material Research under Extreme Conditions at AREAL Facility

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A facility was designed for study of materials and devices at simulating extreme physical conditions (Space environment up to 20 thousand km from Earth, nuclear reactors and so on). Following conditions are provided at the vacuum chamber with volume 60 liters: Vacuum - 10-5 Torr. (1,33x10-3 Pa), electron beam with energy up to 4 MeV, pulse duration 4x10-13 sec. Different temperatures from -100 ^{0}C to +100 C, Solar ultraviolet radiation.

Low temperatures up to 100K are achieved by liquid nitrogen evaporation trough copper tubes welded in the vacuum chamber so that the electron beam and ultraviolet radiation do not catch their surface. Besides, the incidence angles of these beams are

mounted so that the testing sample is under these beams simultaneously. The sample irradiation area is 20mm x 20mm. The peculiarity of this equipment is the possibility of complex simultaneous influence of mentioned 4 factors on the sample.

Session 5: Tour to AREAL and CANDLE-15 Years

Low Emittance CANDLE Storage Ring

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The presentation gives an overview of CANDLE light source project. Scenarios for low emittance upgrade and recently designed low emittance lattices are described. Plans for future development are presented.

CANDLE-15 Years: Learning from the Past and Inventing the Future

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The origin of the accelerator physics and technology in Armenia dates back to the 60's, when the construction of ARUS 6 GeV electron synchrotron started. In the same period, the construction of DESY 7.5 GeV electron synchrotron in Hamburg was launched. The close relations between two institutions promoted a long term collaboration between Armenian and German scientists resulting to a cooperation between the new generations of scientists from both countries.

In 2002 CANDLE institute was established in Armenia with the aim to create a state-of-the-art 3 GeV synchrotron light facility. Following the recommendations of international experts, the first stage of the project –AREAL laser driven electron facility- was constructed during 2011-2014.

In this report, the past, present and future accelerator research and development issues will be presented with an emphasis on advanced technology and international cooperation.

Middle Infrared and THz Sources at AREAL

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The middle infrared and THz sources at AREAL will be presented. The 50 MeV upgrade program of AREAL linac will be discussed with detailed descriptions of modifications for each subsystem. Numerical simulation results for middle infrared FEL will be given. Also the possibilities of THz radiation generation using undulator superradiant radiation principle will be discussed.

Diagnostics at REGAE Facility

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Diagnostics of ultra-low charge electron-bunches at REGAE are presented.

Lego Radio Frequency Timer for KeV Energy Electrons

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A demountable radio frequency (RF) timing processor for keV energy electrons, the Lego RF Timer will be presented. The technique can be used to time photoelectrons or secondary electrons with a few picosecond resolutions and MHz rates. Such a device potentially has a large range of applications in fields ranging from accelerator physics, ultrafast science to nuclear physics experiments. The principles of operation of the technique are described, current experimental results are presented and possible applications in nuclear physics are outlined.

Faraday Cup Simulation for Electron Beam Measurements

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For measurement 1-10 pC electron beams with energy about 100 MeV faraday cup (FC) design was developed. In this talk we discuss the FC performance CST simulation results with beam length from 10 ps to 2 ns. High frequency oscillation excitation criteria was investigated. From simulation results the constructive capacity was calculated.

Accelerating Structure Design for the AREAL THz-IR FEL

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AREAL facility development implies energy upgrade to 50 MeV in order to drive a THz free electron laser. To reach this goal, the installation of two 1.6 m long S-Band travelling wave accelerating sections, with nominal accelerating gradient of 15 MV/m, are foreseen. In this paper the design study of accelerating sections along with the matching performance of RF couplers are presented. The simulations are performed using the CST Microwave Studio. The first results of the accelerating structure prototype fabrication are discussed.

The Utca Based Control System Development for Advanced Accelerators

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MicroTCA (Micro Telecommunications Computing Architecture) originated from telecommunications hardware and was formally introduced by PICMG in October 2011 as a standard describing a new class of modular computer systems. MicroTCA.4 is an enhancement of this open standard and was developed by DESY and several other research institutes and industrial partners.

MicroTCA.4 has rapidly evolved to become a viable standard for demanding applications in large-scale research facilities e.g. particle accelerators, high-energy physics, plasma fusion sources, etc.

Since 2011 several facilities within DESY FLASH have been upgraded with a MicroTCA.4 based system. The FLASH2 and the XFEL control systems are completely based on this MTCA system. These systems are in permanent operation and provide high quality control system. This talk summarizes the ongoing activities and the future upgrades, as well as the operational experiences and lessons learned from failures.

An Overview of Beam Diagnostic and Control Systems for AREAL Linac

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Advanced Research Electron Accelerator Laboratory (AREAL) is an electron linear accelerator project with a laser driven RF gun being constructed at CANDLE Synchrotron Research Institute. After the successful operation of the gun section at 5 MeV, a program of facility energy enhancement up to 50 MeV is launched. The purpose of this report is to present the current status of existing diagnostic and control systems, as well as the results of electron beam parameter measurements, approaches of intended diagnostic and control systems for the upgrade program.

Beam Diagnostics with THz Radiation

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The recent emergence of quasi-efficient (~1 %) laser-based THz generation is appealing for beam manipulation and diagnostics. We discuss a transverse deflection cavity based on mm-scale dielectric-lined waveguides powered with THz radiation. We present theory and example backed with a simulation.