





Ultrafast Beams and Applications

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Ultrashort pulsed electron beam irradiation induced immune response in animal models

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Biological effects of

Ultrashort pulsed electron beam irradiation

Mechanisms involved in radiation damage and subsequent radiation response



Animal Experiments



Animal Experiments







Animal Experiments



Tsakanova et al., IJMS, 2021

Animal Experiments





Animal Experiments



Animal Experiments



Erythroid cell populations in bone marrow samples



Basophilic Erythroblasts

Animal Experiments

Two Photon Imaging of Oxidative Stress in rat living RBCs



Animal Experiments

The effect of electron beam exposure on Antioxidant system of rats



Example of Study Design



Pre-irradiation preparations

From several days to several weeks

From several hours to several days

Post-irradiation analyses and procedures From several weeks to several months, years

Laser Driven AREAL Facility



LABORATORY OF EXPERIMENTAL BIOLOGY



Main Molecular Biology Lab

Cell Culture Lab

Animal Surgery Lab



Experiment Types



Laboratory Main Activities

Long-term multidisciplinary projects:

1) Effect of low-energy ultrashort pulsed laser driven electron beam irradiation on whole body and glioblastoma in rat models, which is going in collaboration with the Yerevan State University (Yerevan, Armenia) and DESY (Hamburg, Zeuthen, Germany).

2) Effect of ultrashort pulsed electron beam irradiation on bacteria which is going in collaboration with the Yerevan State University (Yerevan, Armenia);

3) Radio-enhancing, radioprotective and/or neuroprotective effect of newly synthesized metal compounds on cancer and neuronal cell cultures conducted in collaboration with Rostock University (Rostock, Germany) and University California San Francisco (San Francisco, CA, USA);

4) Immune system, inflammation and synaptic plasticity in ischemic stroke using patients' and healthy volunteers' blood DNA and plasma samples to find biomarkers for targeted therapy and individualized medicine by genomics and proteomics approaches, as well as using *in vivo* two-photon approaches in rats, which is going in collaboration with the Aarhus University, Department of Biomedicine (Aarhus, Denmark) and Aalborg University (Aalborg, Denmark).

5) Drug discovery study of natural antiaging compounds (pharmacognosy) in rat models and human blood cells in collaboration with Broad Institute of MIT and Harvard (Cambridge, MA, USA);

6) Biosimulation studies of the dose distribution of ultrashort pulsed electron beam irradiation within the organism and studies of the effects of radiation on molecular structures.

Our Collaborations











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Fluorescence intensity 00







Tsakanova et al., Biomed Optics Express, 2017



Tsakanova et al., Biomed Optics Express, 2020



Experiments on human aging



Group	Young age group	Middle aged group	Elderly group
Number of participants (n)	20	20	20
Age range (years)	20-40	40-60	60>
Gender (Male/Female)	10/10	10/10	10/10

	Percentage of living cells (%); M ± SEM			
Age Groups Treatment groups	Young (n=20)	Middle aged (n=20)	Elderly (n=20)	
Intact RBCs	100 ± 0.000	100 ± 0.000	99.96 ± 0.075	
RBCs + Extract 0.03 μg/mL	100 ± 0.000	100 ± 0.000	100 ± 0.000	
RBCs + Extract 0.04 μg/mL	99.91 ± 0.061	100 ± 0.000	100 ± 0.000	
RBCs + Extract 0.08 μg/mL	99.9 ± 0.078	100 ± 0.000	100 ± 0.000	
RBCs + Extract 0.16 µg/mL	99.9 ± 0.064	100 ± 0.000	100 ± 0.000	
$RBCs + H_2O_2$	99.96 ± 0.037	100 ± 0.000	100 ± 0.000	
RBCs + H ₂ O ₂ + Extract 0.03 µg/mL	100 ± 0.000	100 ± 0.000	100 ± 0.000	
RBCs + H ₂ O ₂ + Extract 0.04 μg/mL	99.94 ± 0.046	100 ± 0.000	99.95 ± 0.049	
RBCs + H ₂ O ₂ + Extract 0.08 μg/mL	100 ± 0.000	100 ± 0.000	100 ± 0.000	
RBCs + H ₂ O ₂ + Extract 0.16 µg/mL	100 ± 0.000	100 ± 0.000	99.94 ± 0.065	



Tsakanova et all, Exp Gerontol, 2021

Ongoing experiments

Brain Research in Animals



Speckle Imaging of blood flow in deep brain



Two-photon imaging of neuronal structures

Ischemic Stroke Brain Cancer – Glioblastoma





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THANK YOU FOR ATTENTION

Two-Photon Laser Scanning Microscopy



0.0001 nm 0.01 nm	10 nm 1	000 nm 0.01 cm	1 cm 1 m	100 m
Gamma rays X-rays	s Ultra- violet	Infrared	Radio waves Radar TV FM	AM





Laser Sourse

- Diode-pumped Yb:KGW ultrafast oscillator ("t-pulse", Amplitude Systems, France)
- The laser generates a high-repetition-rate (50 MHz) train of ultrashort (240 fs) pulses of quasi-monochromatic (~5 nm bandwidth) light at 1030 nm wavelength.
- The output average power of the oscillator is 1.1 W (energy per pulse ~22 nJ) which is too high for safe imaging of the samples.
- The power of the excitation is therefore regulated using a PC-controlled power attenuation kit placed in the beam path to maintain final power of 300 mW at the sample.