

The "PHOENIX" radiobiological experiment on-board the Russian segment of the ISS supported by passive dosimetry - First results

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The Russian "Phoenix" Space Experiment

- Goal: studying the impact of space radiation on dried human lymphocytes and mouse bone marrow cells
- Locations: Pirs, Poisk (MRM-2) and Zvezda (Service) module of the ISS
- Total duration: 2 years (started on November 24th, 2014), one-by-one recovery of samples in 4 sessions (after 0.5, 1, 1.5 and 2 years)
- Dosimetric measurements in the direct vicinity of the samples by applying sets of passive detectors (TLD, SSNTD)





Experimental setup

Applied TLD Materials & Methods

	ΜΤΑ ΕΚ	IBMP/MEPhI
Material	MTS-6 & MTS-7 (enriched LiF)	DTG-4 (7% ⁶ Li, 93% ⁷ Li)
Readout system	Harshaw 3500	Harshaw 3500
Heating rate	10°C/s	4°C/s
Calibration	single chip	same batch
Calibration source	¹³⁷ Cs	⁶⁰ Co
Glow curve eval.	peak 5 height	peak 5 integral

TLD Results

- > 1st session, November 24, 2014 June 11, 2015
- > Total exposure: 199 days

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Applied Detector Materials & Methods



	MTA EK	IBMP/MEPhI
Material	TASTRAK (polyallyl-diglycol-carbonate)	
Etching	Two-steps etching (6h & 15h)	One-step etching (6 hours)
Etching conditions	6 N NaOH @ 70°C	6 N NaOH @ 70°C
Analyzed area (cm ²)	0.5 after each of the two etching steps	0.1 & 6.3 in case of HZE tracks
Bulk layer	8.04/20.1	8.1
Actual magnification	1000x/500x	2000x + 4x digital zoom
Resolution	0.2 μm/pixel	0.1 μm/pixel
LET calibration fuction	Szabó and Pálfalvi, 2012	3D tracks: Inozemtsev et al. 2016, otherwise Szabó and Pálfalvi, 2012

Track Detector Results

LET spectra

mta

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Track Detector Results

Absorbed Dose Rate





	ΜΤΑ ΕΚ	IBMP/MEPhI	
	Quality Factor		
Service Module	10.8	13.7	
MRM2	10.7	14.8	
Pirs	11.7	9.6	

Total Dose Rates

Absorbed Dose Rate Dose Equivalent Rate 2000 800 MTA EK MTA EK MEPhl 1800 MEPhl 700 1600 600 Abs. Dose Rate (μGy/d) Dose Eqiv. Rate (µSv/d) 1400 500 1200 1000 400 800 300 600 200 400 100 200 0 0 MRM-2 MRM-2 Pirs Service Pirs Service Module Module

	ΜΤΑ ΕΚ	IBMP/MEPhI	
	Quality Factor		
Service Module	2.9	2.9	
MRM2	1.9	1.9	
Pirs	2.2	2.4	

Results in Context





Biological Results

- Good survival of human lymphocytes and mouse bone marrow cells nuclei
- Samples from the Pirs module: formation of smaller DNA fragments than in the other modules
- Standard methods for evaluation of the nucleus integrity revealed no apparent damage



human lymphocytes (right). Upper left in in each picture – control sample. each picture - control sample.



Figure 1. Hoechst 33258 staining (trypan Figure 2. Romanovsky–Giemsa staining: mouse blue exclusion test): mouse BMC (left), BMC (left), human lymphocytes (right). Upper left

Karganov et al., The "PHOENIX" Space Experiment: Study of Space Radiation Impact on Cells Genetic Apparatus on Board the International Space Station, Journal of Physics: Conf. Series 784 (2017). doi:10.1088/1742-6596/784/1/012024



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TLD Results Trom The First 3 Sessions

• Exposure: November 23rd, 2014 - June 18th, 2016



Preliminary SSNTD Results From All Sessions

• Cumulated data (MEPhI) - the last session landed on September 7th, 2016





The Mission Continues

- The 2nd "PHOENIX" experiment launched on November 19, 2016
- The first set landed after a 173-day exposition



Conclusions

Dosimetric quantities near solar maximum conditions inside 3 modules of the Russian segment were measured using SSNTDs and TLDs

- Results of the joint measurements of IBMP RAS/NRNU MEPHI & MTA EK:
 - SSNTD: reasonable agreement, but differences in the LET spectra (thus in the dose values and quality factors) due to dissimilar evaluation methods
 - TLD: same tendency of doses between modules Dose rate differences within one module: DTG-4 & LiF-6: 0.5% - 14% DTG-4 & LiF-7: 5% - 21%
- Highest dose rates were measured in the Pirs module, as expected, but the D_{Pirs}/D_{Service module} ratio was higher than anticipated
- \rightarrow Due to the high orbital altitude and intensive proton flux (based on NOAA data)
- The evaluation of cumulated data revealed a possible mix-up of the dosimeters in the Pirs and the MRM2 modules
- PHOENIX 2 launched last November, the first set is under evaluation





Thank You for Your Attention!



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