MATROSHKA-R experiments: Results obtained with passive detectors in 2005-2009

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Introduction

- MATROSHKA-R experiments (various compartments of the ISS, inside and on the surface of the spherical phantom)
- □ several exposures during 2005–2009
- passive detectors (thermoluminescence and plastic nuclear track detectors)
- LET spectra, absorbed dose, dose equivalent, and quality factor

Passive detectors

D TLD

- Al₂O₃:C, CaSO₄:Dy, Al-P



Passive detectors PNTD

 HARZLAS TD-1, Page, USF-4, Tastrak, Baryotrak



Spherical phantom MTR-R

- □ 35 cm diameter
- □ mass 32 kg
- □ 32 pockets
- 4 thick and 16 thin containers



SPD boxes

SPD box #	Panel #, position	
1	102; Piers-1, floor	
2	401; Piers-1, star board	
3	325; SM, cone, ceiling	
4	462; SM, star board	
5	323; SM, cone, ceiling	
б	305; SM, ceiling	



Exposures

Experimental run	Duration [days]	ISS altitude [km]	Location
phantom 2006	273 (Dec. 2005 – Sep. 2006)	351 (344–361)	SM
SPD 2007	163 (May - Oct. 2007)	346 (338–353)	SM, Piers-1
phantom 2008	206 (May – Dec. 2008)	356 (345–366)	Piers-1
SPD 2008	163 (May – Oct. 2008)	355 (345–365)	SM, Piers-1
phantom 2009	158 (May - Oct. 2009)	356 (350–361)	Piers-1
SPD 2009	158 (May – Oct. 2009)	356 (350–361)	SM, Piers-1

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Results

MTR-R spherical phantom

- LET spectra
- D, H on the surface of the phantom
- D inside the phantom
- □ SPD boxes
 - LET spectra
 - D, H

MTR-R - spectra LET



MTR-R - pockets



□ 2006: Al-P + Page; 2008: Al-P + TD-1; 2009: Al-P + USF-4

MTR-R - containers

MTR-R - absorbed dose inside the phantom



□ CaSO₄:Dy

MTR-R - absorbed dose measured with TLD

□ inside: CaSO₄:Dy, pockets: Al-P

Experimental run	D inside [µGy/day]	D pockets [µGy/day]	
MTR-R 2006	129 ± 10	202 ± 35 (145 - 254)	
MTR-R 2008	163 ± 6	245 ± 37 (173-314)	
MTR-R 2009	222 ± 11	312 ± 46 (246 - 396)	

SPD - spectra LET



SPD - spectra LET



SPD - total absorbed dose and dose equivalent



□ 2007: Al-P + Page; 2008: CaSO₄:Dy + TD-1; 2009: Al-P + TD-1

Summary

Experimental run	$D_{low-LET} \left[\mu Gy/day ight]$	$D_{total} \left[\mu Gy/day ight]$	$H_{total} \left[\mu Gy/day ight]$	Q
2006 SM (MTR-R)	146 ± 26 (98 – 180)	209 ± 35 (157 - 265)	381 ± 60 (323 - 490)	2.0 ± 0.2 (1.8 - 2.4)
2007 Piers-1	225 ± 43	260 ± 53	577 ± 151	2.2 ± 0.1
2007 SM	168 ± 21	203 ± 21	498 ± 71	2.5 ± 0.5
2008 Piers-1 (MTR-R)	187 ± 29 (128 - 233)	250 ± 38 (177 - 322)	731 ± 142 (496 - 991)	2.9 ± 0.4 (2.2 - 3.4)
2009 Piers-1	392 ± 24	438 ± 19	883 ± 40	2.0 ± 0.2
2009 Piers-1 (MTR-R)	271 ± 39 (214 - 350)	312 ± 46 (246 - 396)	783 ± 127 (593 - 987)	2.5 ± 0.2 (2.2 - 2.9)
2009 SM	314 ± 35	351 ± 41	748 ± 114	2.1 ± 0.2

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Conclusion

various positions on the phantom

- D inside the phantom about 30% lower than on the surface
- on the surface difference up to factor 2
- various positions inside the ISS
 - in Piers-1 Module D is about 30% and H about 20% higher than in SM; in Columbus Module D and H are about 40% lower than in SM
 - thickness of the wall, shielding distribution and surrounding materials (usually unknown)

Dependence on the thickness



calculation using PHITS

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Conclusion

experimental phase

- from 2005 to 2009 increase of dose characteristics (from 2007 to 2009 D increased by about 70%; from 2008 to 2009 by about 40%)
- decreasing phase of the solar cycle
- different altitude of ISS (in 2008 and 2009 about 10 km higher than in 2007)

Dependence on the ISS altitude



calculation using PHITS

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