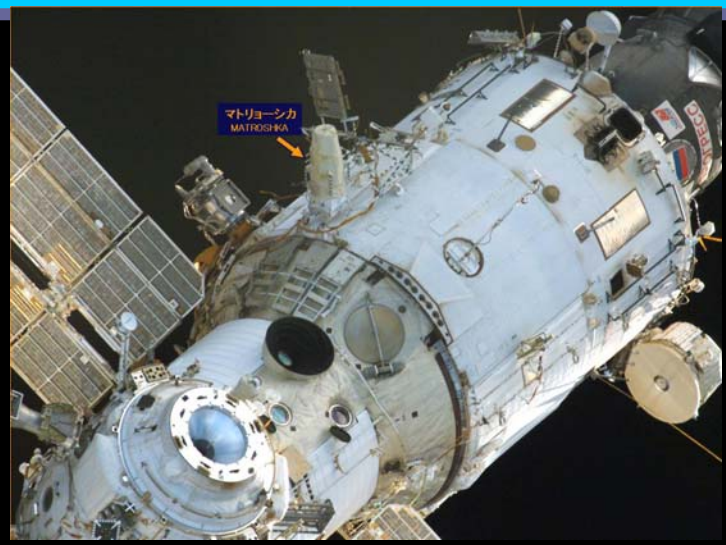
COMPARISON OF SPACE RADIATION DOSES INSIDE THE MATROSHKA-TORSO PHANTOM INSTALLED OUTSIDE THE ISS WITH DOSES IN A HUMAN BODY IN ORLAN-M SPACESUIT DURING EVA

V.A. Shurshakov, Petrov V.M., Kartashov D.A., Kolomensky A.V..

State Research Center of the Russian Federation
Institute of Biomedical Problems

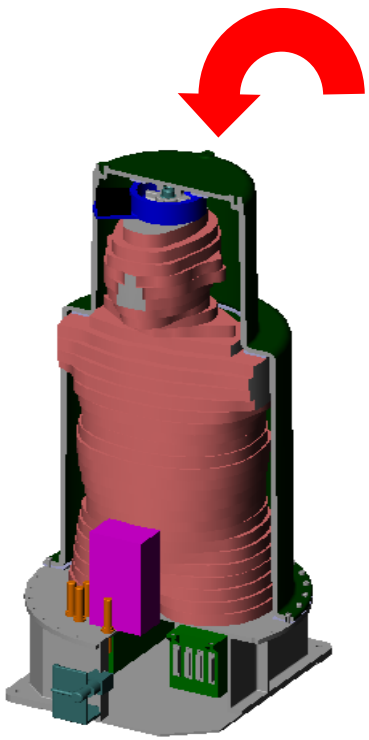
Russian Academy of Sciences, Moscow, Russia



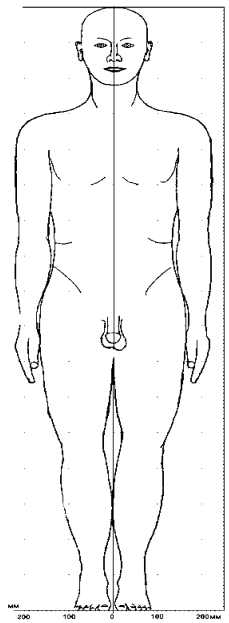
14th WRMISS
Dublin, Ireland, September 8-10, 2009

Purpose of the study

The purpose of the study is to compare the doses inside the Matroshka-Torso phantom with the doses in a human body in ORLAN-M space suit during an EVA.



RANDO phantom



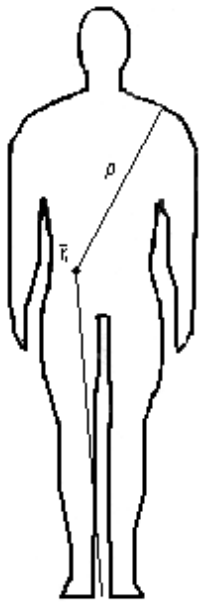
Human body phantom

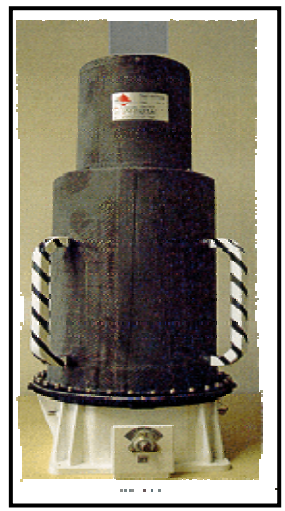
- Matroshka container mass is 4.07 kg
- Orlan-M spacesuit mass is 110 kg

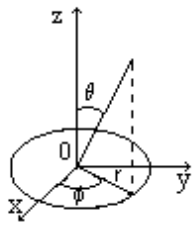
Method for the dose comparison study

- Shielding probability functions are calculated for every point in a human body that are representative for the human body critical organs.

$$f(\vec{r}_0, x) = \frac{d\rho(\vec{r}_0)}{dx}$$





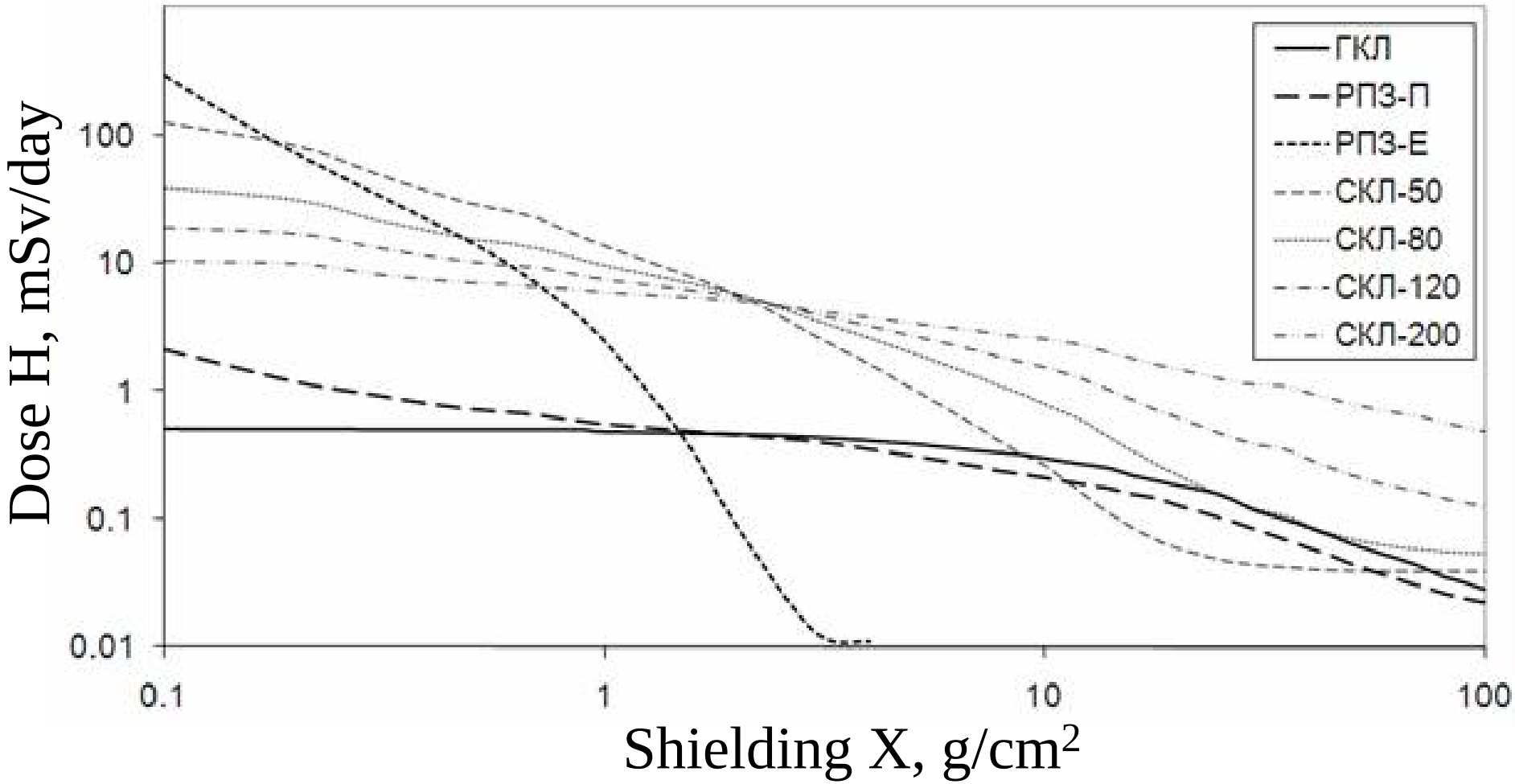


- The doses are calculated using depth-dose curves for space radiation sources in ISS orbit

$$H(\vec{r}_0) = \int f(\vec{r}_0, x) \cdot H(x) dx$$

- *H(x)* – depth-dose curve *H(x) =H(GCR,x) + H(ERBp,x) + H(ERBe,x) + H(SEP,x)*

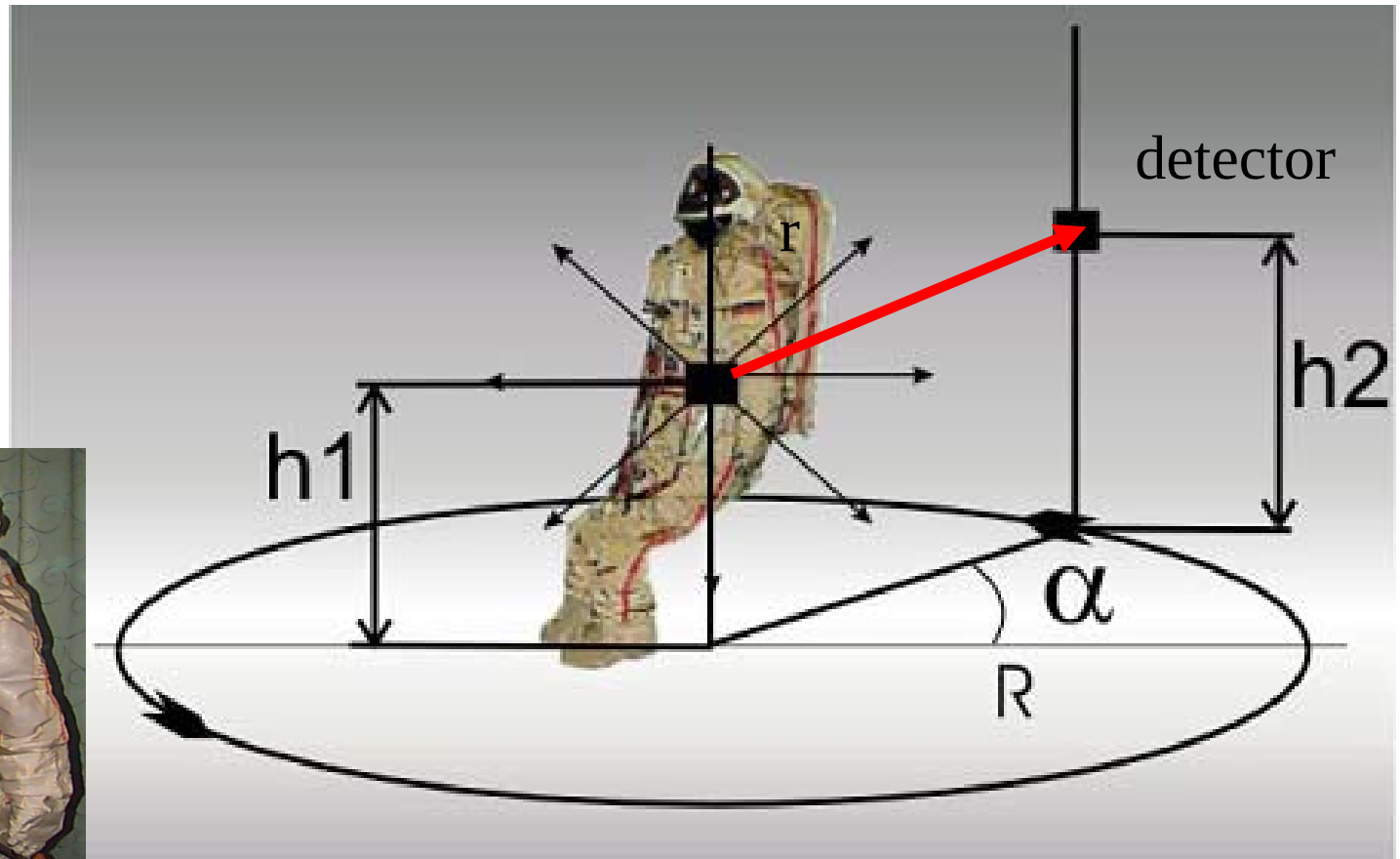
Depth-dose curves at ISS orbit (i=51.6º, h=400 km, solar maximum)



Study of the Orlan-M spacesuit shielding properties with Cs^{137} gamma-transmission method

R=1.88 m

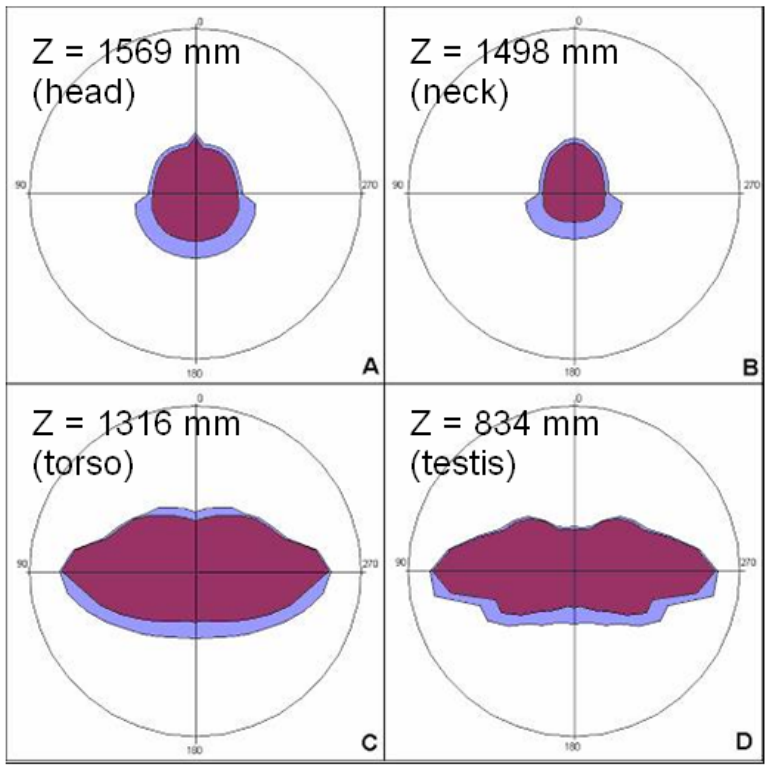
$$\delta_{\text{òêàíü}} = \frac{1}{\mu} \cdot \ln\left(\frac{k \cdot N_0}{N \cdot r^2}\right) \quad r^2 = R^2 + (h1 - h2)^2$$



Beta-transmission of tissue: x_{tissue}=0.2 g/cm^2 $x_{water\ cooling}$=0.2 g/cm^2

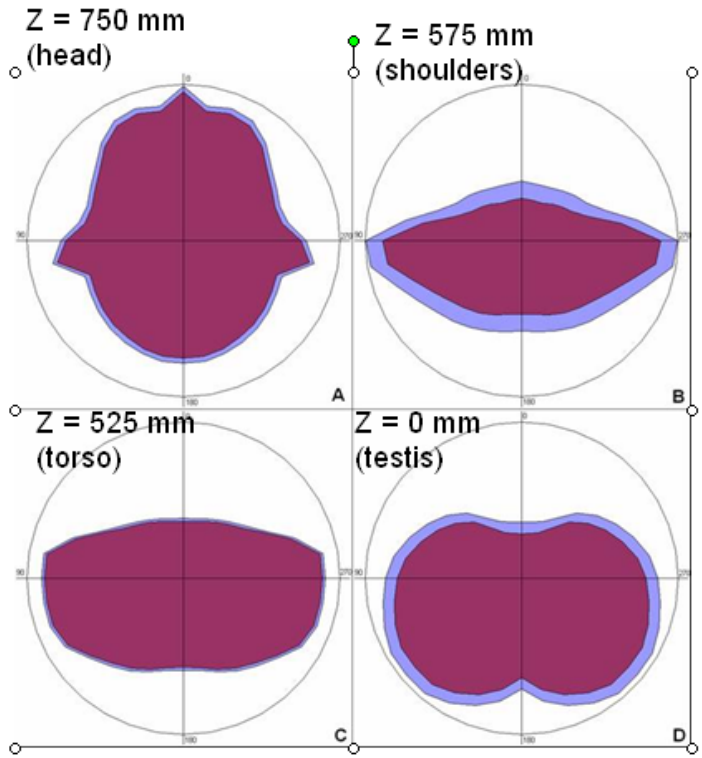
Profiles of Horizontal Cuts

Human body in Orlan-M spacesuit



Asymmetry in frontward-backward direction

RANDO phantom in the Matroshka container



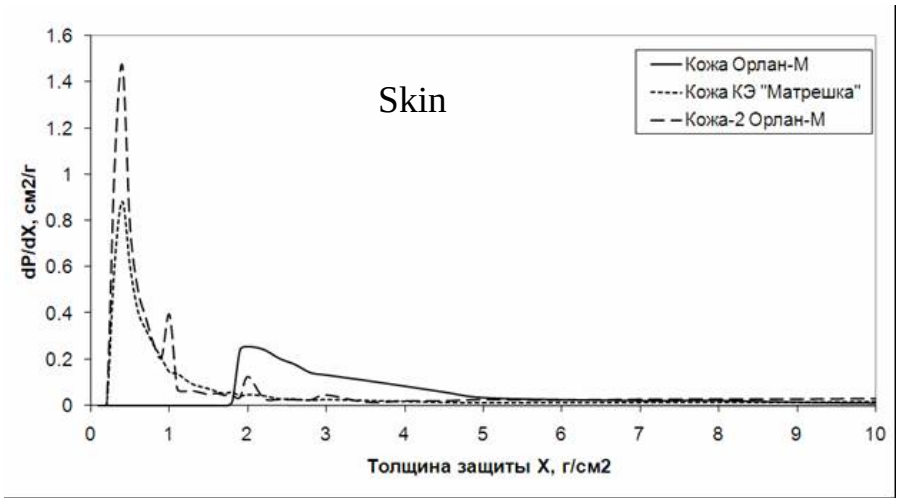
No asymmetry

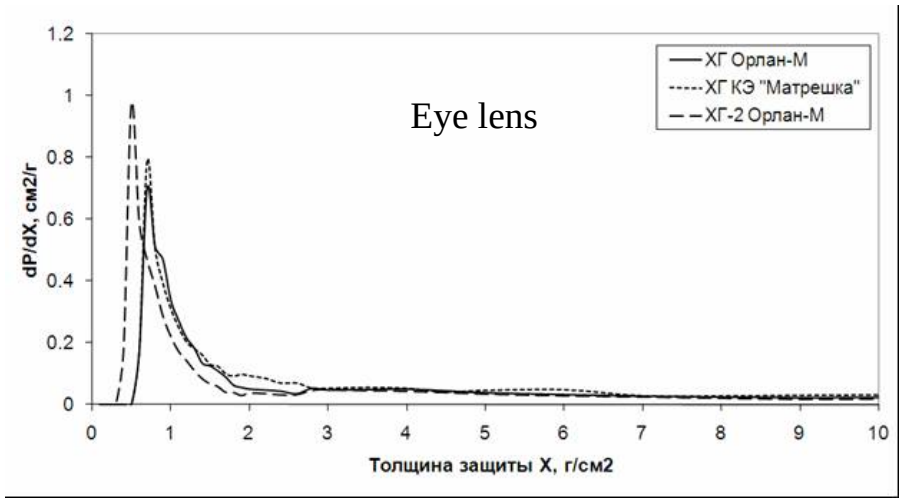
Minimum Shielding of Orlan-M Spacesuit Parts

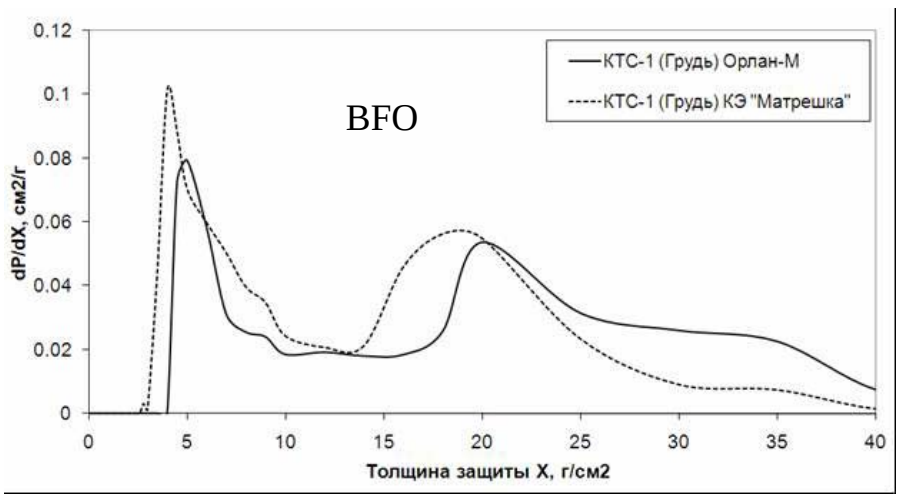
Part of the space suit	Minimum shielding, g/cm^2	Minimum electron energy, MeV	Minimum proton energy, MeV
Helmet	0.2	0.54	12
Helmet + sun light protector	0.4	0.93	18
Soft tissue with water cooling suit	0.4	0.93	18
Cuirass (chest)	2.1	4.1	47
Cuirass (back)	3.9	7.8	66

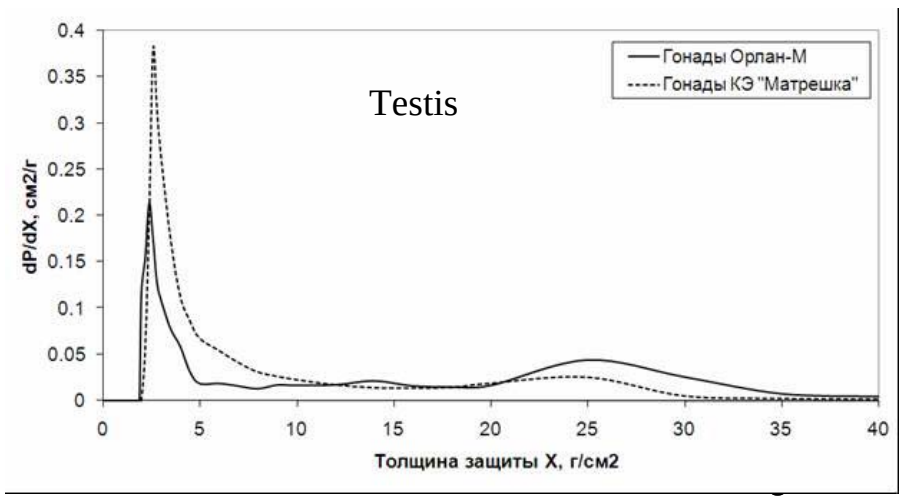
Averaged Matroshka container thickness is 0.4 g/cm^2

Comparison between shielding functions of the Orlan-M spacesuit and Matroshka container for some representative points in a human body

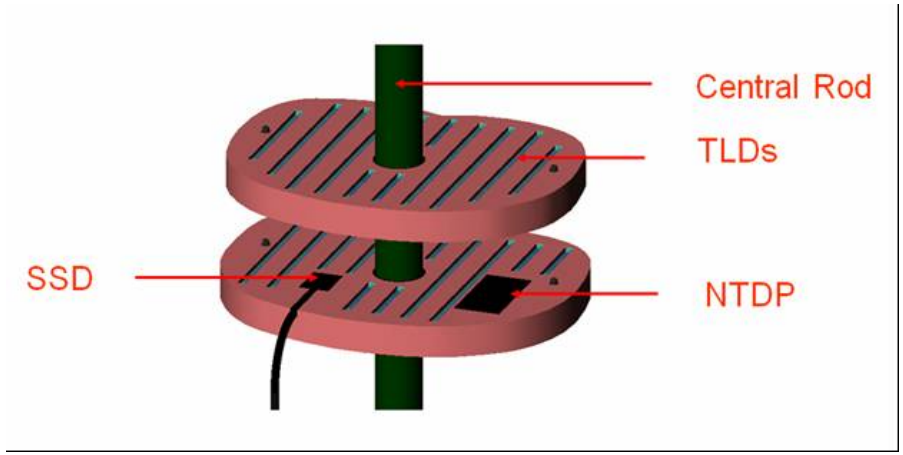


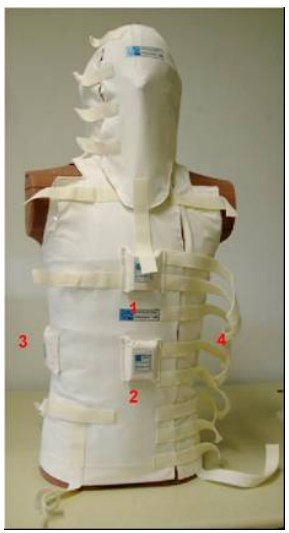


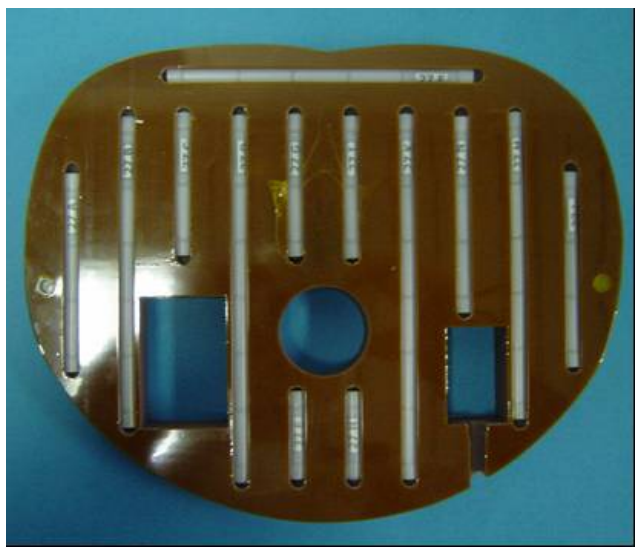




Passive detectors of Matroshka experiment

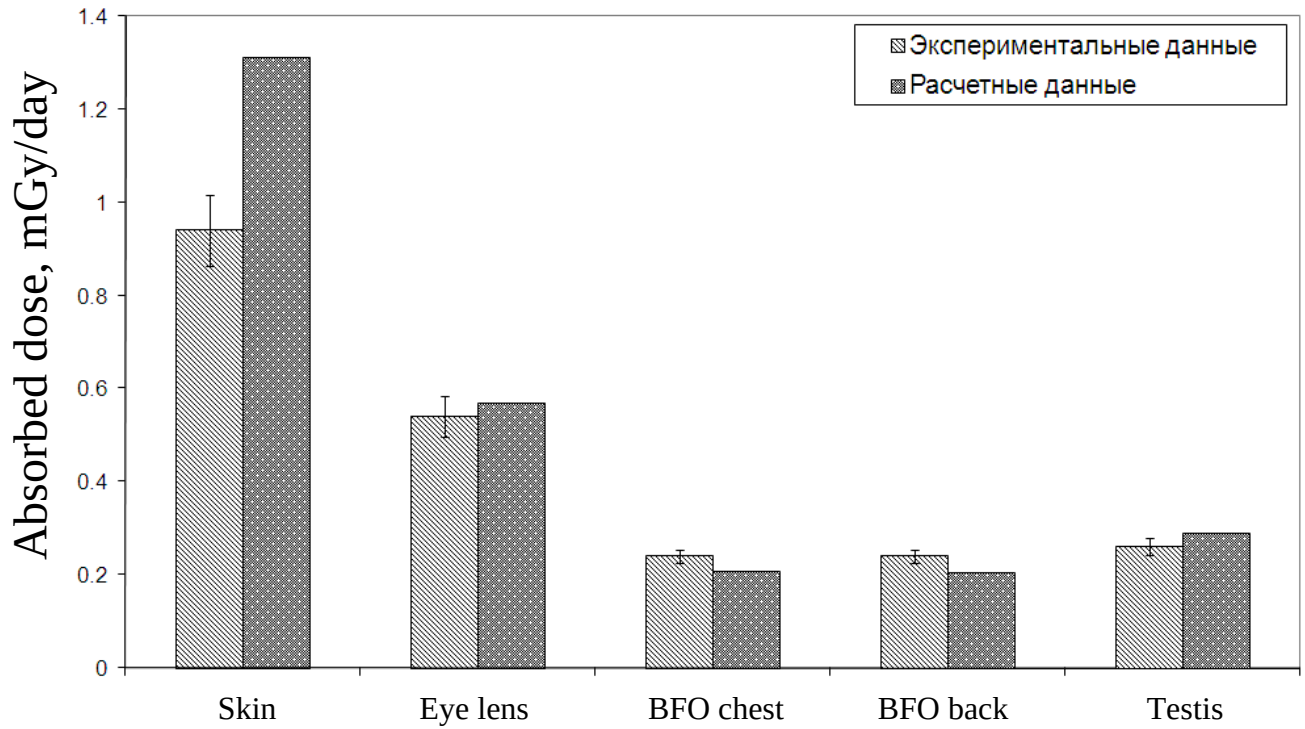






Comparison between experimental and calculated absorbed doses for Matroshka experiment

Exposure duration outside ISS is 540 days from Feb. 2004 to Aug. 2005



GCR model

- AP8/AE8 models
- Linear interpolation between solar max and solar min

G. Reitz, T. Berger, P. Bilski, et al., Astronaut's organ doses as inferred from measurements in a human phantom outside the ISS. Radiation Research. 2009.

Ratios of dose equivalents in critical organs of the ORLAN-M space suit to that in Matroshka-Torso *H(ORLAN-M)/H(Matroshka-Torso)* (h = 350 km)

	H(ORLAN-M)/H(Matroshka-Torso)							
	Earth Radiation Belts				GCR		Total ERB+GCR	
	Solar min		Solar max		Solar min	Solar max	Solar min	Solar max
	P	e	P	e				
Skin	0.5	<0.01	0.6	<0.01	0.8	0.8	0.3	0.1
Eye lens	0.9	1.0	0.9	1.0	0.9	0.9	0.9	0.9
BFO chest	0.7	1.0	0.8	1.0	0.8	0.8	0.8	0.8
BFO back	0.7	1.0	0.7	1.0	0.7	0.7	0.7	0.7
Testis	0.7	1.0	0.7	1.0	0.7	0.7	0.7	0.7
Skin-2	1.3	1.6	1.3	1.5	1.2	1.2	1.4	1.5
Eye lens 2	1.1	2.5	1.0	2.6	0.9	0.9	1.3	1.8

Conclusion

- Comparison of the doses inside the Matroshka-Torso phantom with the doses in a human body in ORLAN-M space suit during realistic EVA has been carried out
- Torso *H(ORLAN-M)/H(Matroshka-Torso)* ratios vary from 0.1 to 1.8 as dependent on the selected critical organ and solar cycle phase
- The best agreement is observed for the eye lens when protected from solar light with extra screen
- In some practical cases considered in the study, Matroshka-Torso doses are well below or above the doses in real space suit
- The results obtained should be taken into account when transferring the data of Matroshka-Torso experiment to the real EVA radiation conditions in ORLAN-M space suit.