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Study of Local Water Shielding Efficiency to Space Radiation with the Protective Curtain in ISS Crew Cabin

R.V. Tolochek¹ *, V.A. Shurshakov¹, E.N. Yarmanova¹, I.S. Kartsev¹, I.V. Nikolaev², N. Yasuda³,
S. Kodaira³, H. Kitamura³, Y. Uchihori³, I. Ambrozova⁴

¹State Scientific Center of Russian Federation Institute of Biomedical Problems,
Russian Academy of Science, Moscow, Russia

²Rocket Space Corporation “Energia”, Moscow region, Russia

³National Institute of Radiological Sciences, Chiba, Japan

⁴Nuclear Physics Institute, Academy of Sciences of Czech Republic, Prague, Czech republic

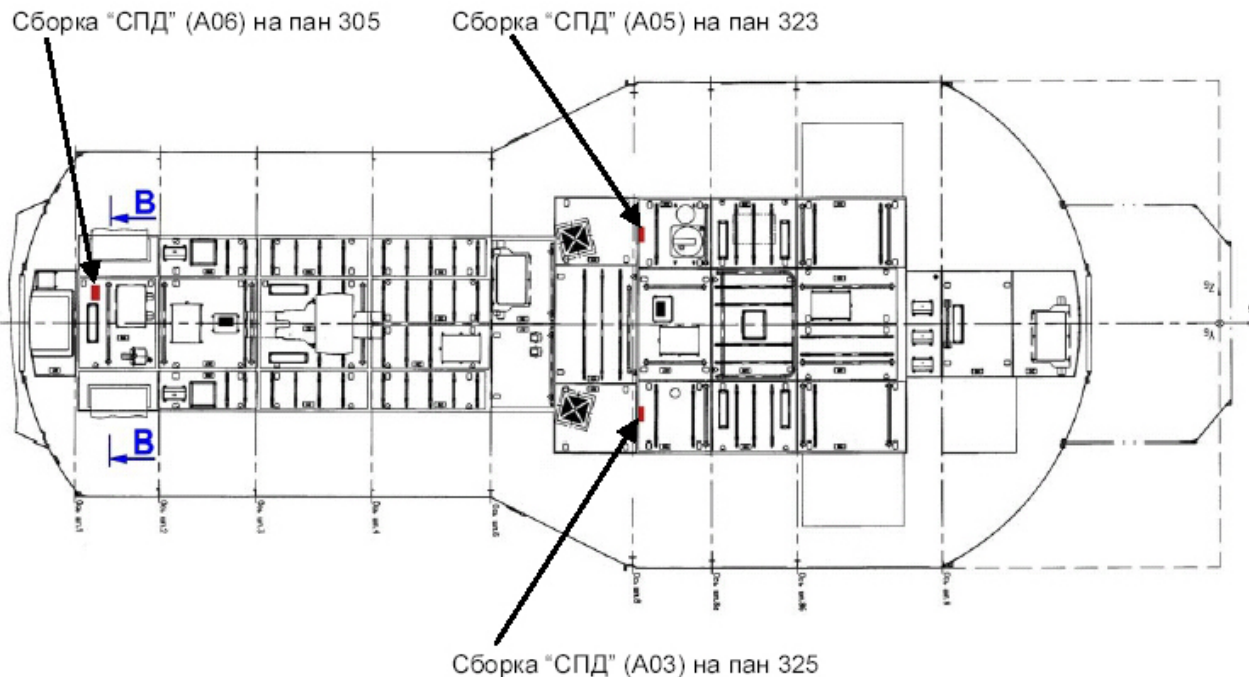


Crew cabin shielding characteristic

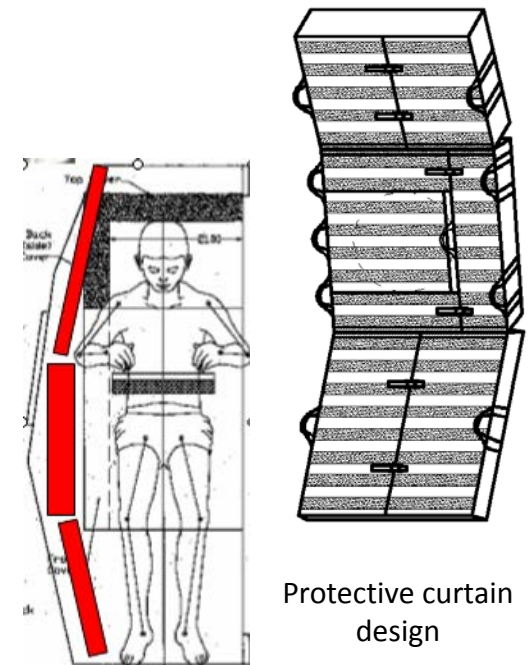
Crew cabin outer wall - 1.5 g/cm^2 aluminum

(2 aluminum layers 2 mm thickness ($0.4 \text{ cm} * 2.7 \text{ g/cm}^3 = 1.08 \text{ g/cm}^2$) and also an additional shielding of the anti-meteorite protection (outside) and the cabin interior cover (inside))

Protective curtain $\sim 8 \text{ g/cm}^2$ (density = 1.3 g/cm^3)



Scheme of Service Module of Russian Segment of ISS



Participants of the current project

- IBMP, Russia (TLD)
- NPI, Czech republic (TLD, SSTD)
- NIRS, Japan (TLD, SSTD)
- MTA KFKI AEKI, Hungary (Pille-ISS)
- CCA, Canada (BUBBLE detectors)
- STIL BAS , Bulgaria (Lulin-ISS)

In this report only IBMP TLD data is presented

Protective curtain design

- tissue bag containing 4 layers of hygienic wipes and towels



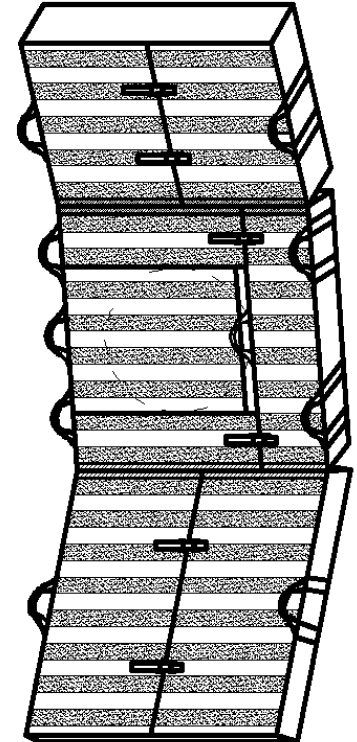
photo of protective curtain made during pre-flight preparations
(Baikonur, Kazakhstan, 2010)



Protective curtain design

	Sizes, mm	Mass, kg
Upper	682x525x260	25,600
Middle	730x430x235	24,000
Lower	540x470x150	14,600
In total		64,200

- The protective curtain is only 10 cm.
- The internal surface of the protective curtain is made similar style to the station wall surface
- There is a separate part that allows opening of the illuminator area



Hygienic wipe and towel characteristics



Technical parameter	Space hygienic tool	
	Wipe	Towel
Size, cm	7.0 x 7.0 x 1.5	13.5 x 9.0 x 2.0
Mass, g	95	220
Density, g/cm ³	1.3	0.9
Mass density of single layer, g/cm ²	1.3 x 1.5 = 1.95	0.9 x 2.0 = 1.80
Mass density of four layers, g/cm ²	7.8	7.2

Crew cabin outer wall - 1.5 g/cm² aluminum

Measuring instrument

To study radiation effect thermoluminescent detectors (TLD) have been used.

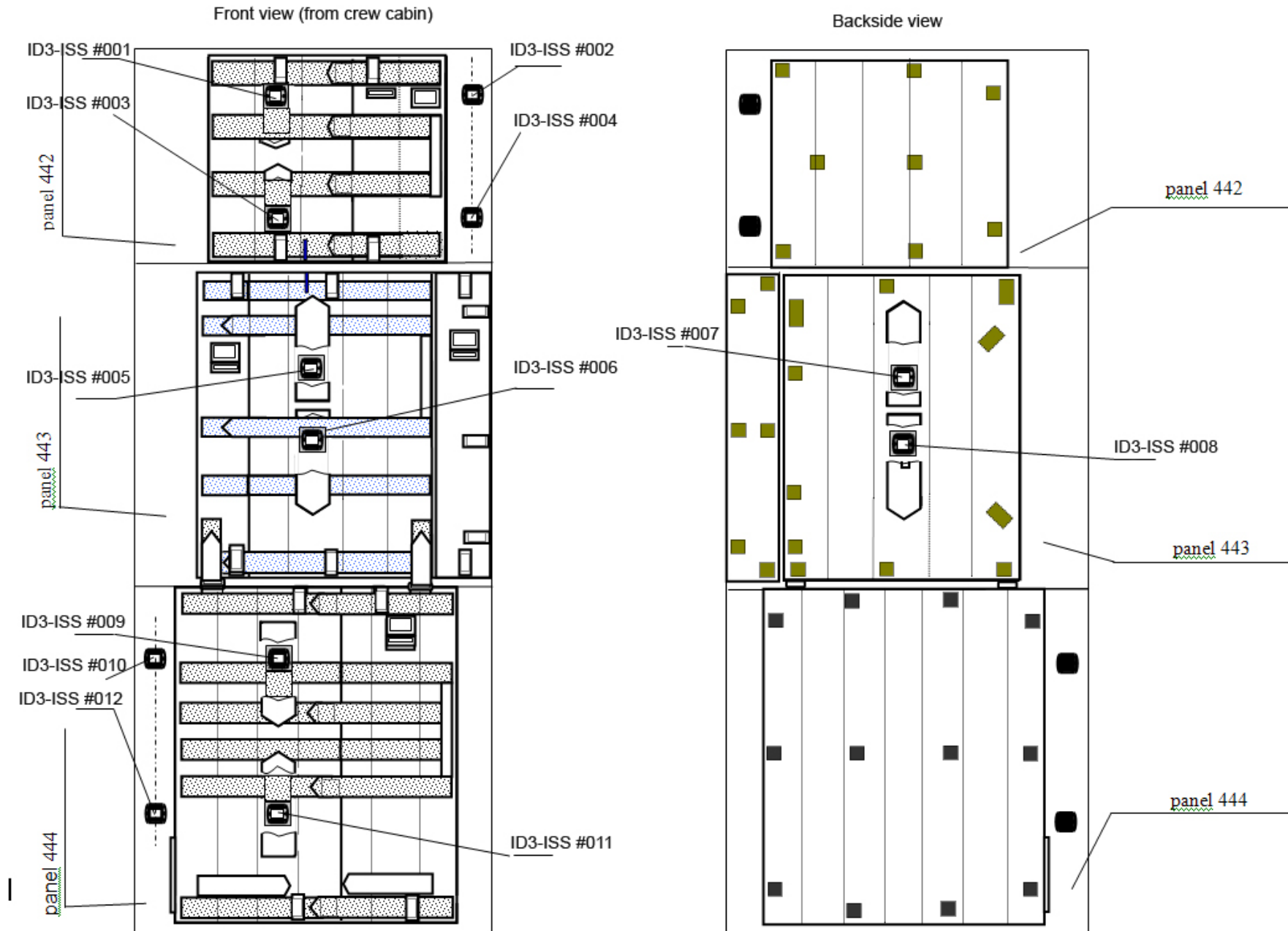


12 passive detectors packages ID3-ISS

ID3-ISS

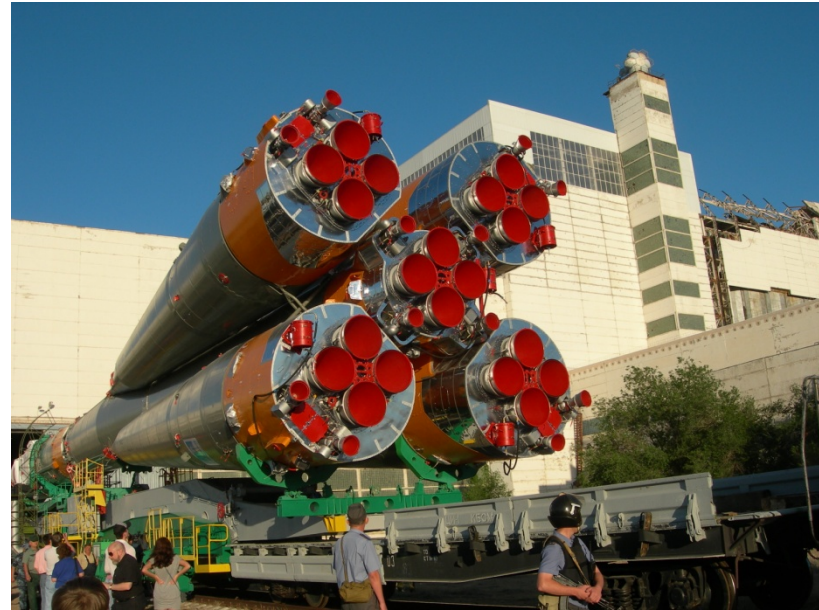


ID3-ISS arrangement



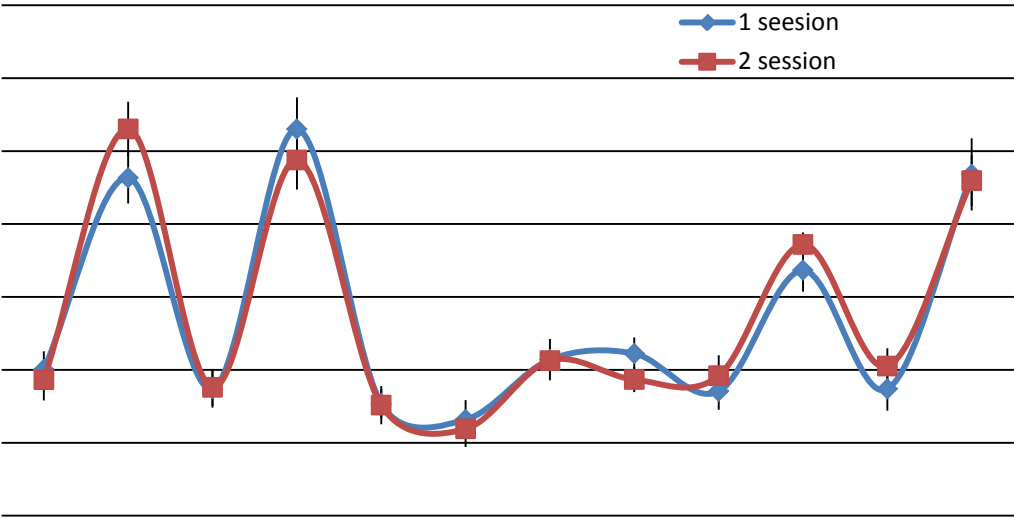
The passive detector packages were exposed in the Service Module starboard crew cabin during 2 sessions:

- July 4 to November 29, 2010 (149 days)
- December 17, 2010 to May 5, 2011 (139 days)



Dose rate, $\mu\text{Gy/day}$

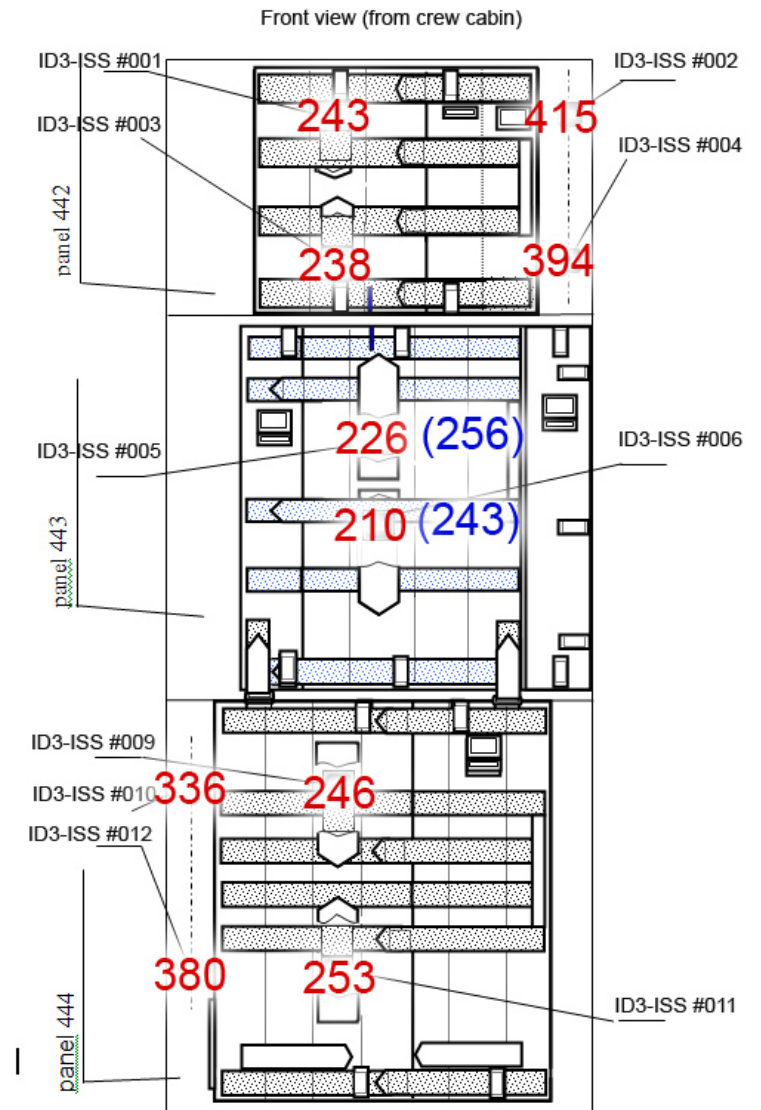
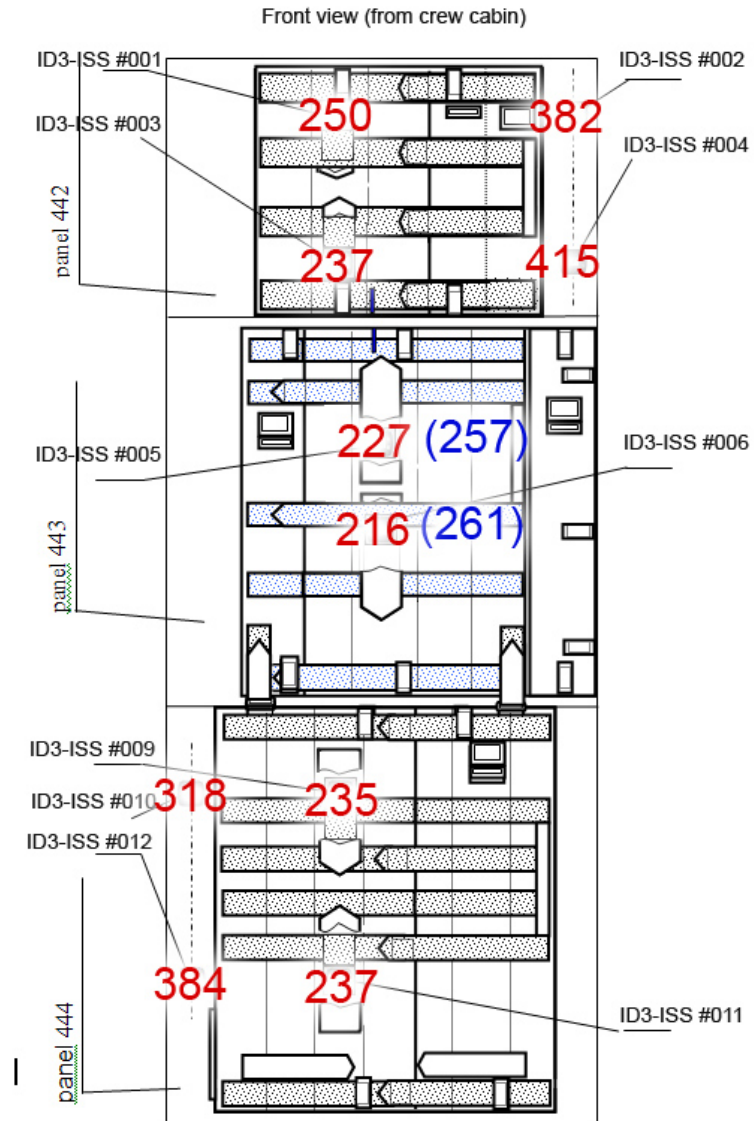
	1 session			2 session		
	dose rate, $\mu\text{Gy/day}$			dose rate, $\mu\text{Gy/day}$		
ISS number	average	RMS	%	average	RMS	%
1	250	14	6	243	13	5
2	382	19	5	415	18	4
3	237	13	5	238	13	5
4	415	20	5	394	22	6
5	227	13	6	226	10	4
6	216	12	6	210	13	6
7	257	6	2	256	14	6
8	261	9	3	243	11	5
9	235	14	6	246	13	5
10	318	8	3	336	15	4
11	237	12	5	253	15	6
12	384	17	5	380	25	7



Dose rate, $\mu\text{Gy}/\text{day}$

1 session

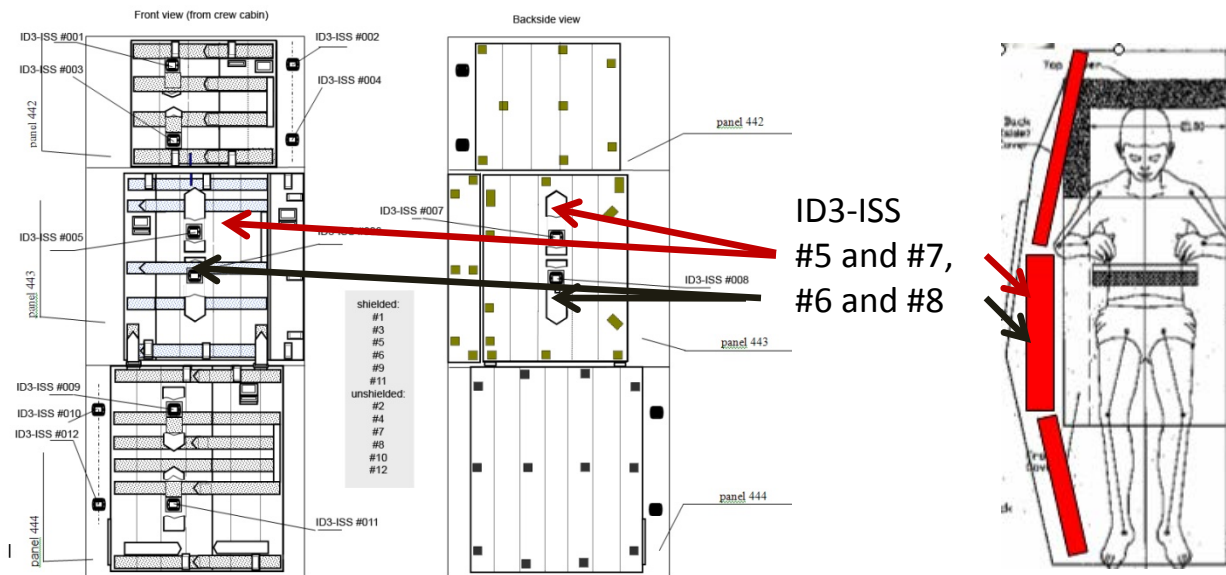
2 session



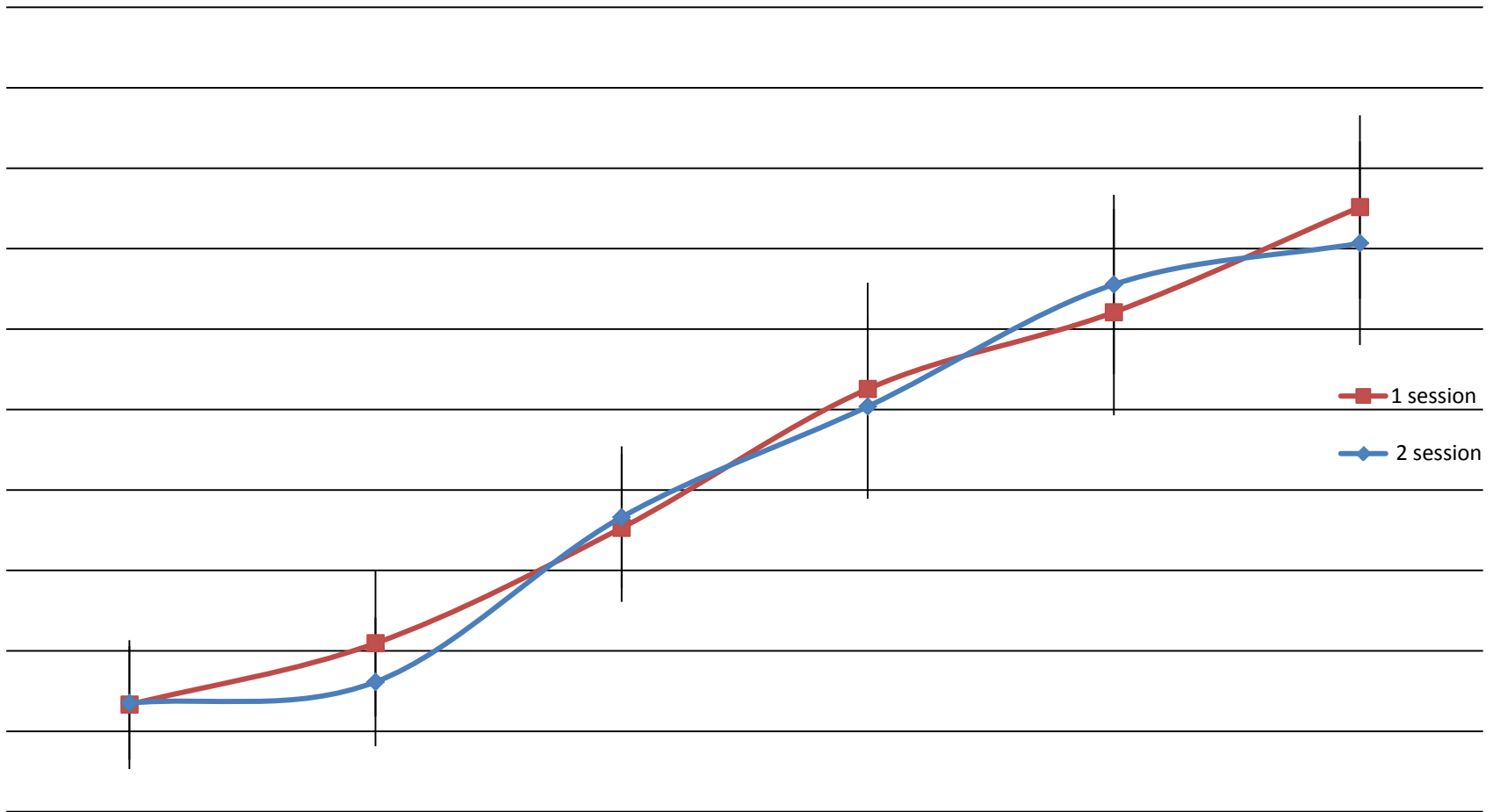
Dose ratio of shielded ID3-ISS to unshielded

		1 session			2 session		
		ratio	error	error, %	ratio	error	error, %
unshielded / shielded ratio	07/05	1,13	0,07	6	1,14	0,08	7
	08 / 06	1,21	0,08	7	1,16	0,09	8
	04/ 03	1,75	0,13	7	1,66	0,13	8
	02/ 01	1,53	0,11	8	1,71	0,11	7
	10/ 09	1,35	0,09	7	1,37	0,09	7
	12/11	1,62	0,11	7	1,50	0,13	9

Illuminator is a thick layer of glass, it's shielding characteristic is higher, then shielding characteristic of the outer wall of cabin



Dose ratio



Conclusion

- The special facility for additional shielding of the crew cabin and detector arrangement was developed and delivered to ISS and has been used in the protective curtain study
- Dose rates measured by ID3-ISS in the crew cabin in the protective curtain study vary from 216 $\mu\text{Gy/day}$ to 415 $\mu\text{Gy/day}$ in 1st session, and from 210 $\mu\text{Gy/day}$ to 415 $\mu\text{Gy/day}$ in 2nd session.
- The unshielded- shielded dose ratio changes from 1.13 to 1.75 in 1st session, and from 1.14 to 1.71 in 2nd session
- Now there is no adequate crew cabin shielding model that can be used for simulation of the protective curtain experiment results. However, it should be mentioned that the higher the unshielded dose the higher the protective curtain shielding effect. In this situation the experimental data obtained are considered to be of big practical validity.
- In this report, only IBMP TLD data is presented. The above presented data can be corrected when the detector processing and analysis by all space intercomparison participants is completed. Track detector processing that requires more time and efforts can give us additional important information on the LET spectra and thus on radiation quality factors and dose equivalents.
- When available from international participants, SSTD detectors, Pille-ISS, BUBBLE-ISS and Lulin-ISS data will be analyzed and used in future investigations

Thank you for your attention!