## Space radiation results obtained with R3D-B2 instrument on Foton M2 satellite in June 2005



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### **Outlook**

- Introduction
- Description of the spectrometer
- Outlook of the results
- Comparison with Liulin–E094 data on ISS
- Future space experiments
- Conclusions





#### Introduction

On 31 May 2005, the Foton M2 capsule, housing a payload complement of 39 experiments in physical sciences, biology, fluid physics, exobiology, materials science and technology, was be launched aboard a Soyuz-U rocket from Baikonur Cosmodrome in Kazakhstan, spending 15.6 days in Earth orbit at altitude 260-304 km.

Together with colleagues from Germany in STIL-BAS was developed the R3D-B2 instrument, which was situated inside of the ESA Biopan 5 platform together with other experiments devoted to radiation biology and exobiology. R3D-B2 instrument measured the UV radiation dose and the variation of the space radiation dose and flux at Foton M2 capsule. This is the first scientific presentation of the obtained results.

### **Soyuz-U launcher and Foton M spacecraft**



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### **Biopan 5 platform on Foton M2**





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10th WRMISS, Chiba, Japan, 7 September 2005 R3D-B2 instrument for ESA Biopan-5 facility outside of Foton M2 satellite. On June 16 2005 it was successfully returned after 2 weeks in space. The mission will be repeated in September 2006. The spectrometer is mutually developed with the University in Erlangen, Germany

## **Detector of 256 Channels LET spectrometer UV-C** channel **UV-B** channel **UV-A channel PAR channel**

Size: 82x57x25 mm Weight: 129 g Consumption: 84 mW Space radiation...

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#### Liulin-Photo was another experiment developed for Foton capsule as a part of Italian experiment Photo II



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#### **Block Diagram of R3D-B2**



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#### Main conditions of the R3D-B2 experiment

The solid state detector of R3D-B2 instrument were behind 1.0 mm aluminium + 0.1 mm cooper + 0.2 mm plastic material, + RADO experiment thermo-luminescence detectors, which were placed behind a layer of special glass, to measure the protective properties of electrically-charged glass coatings against space radiation.

Totally this gives about 0.6-0.9 g/cm<sup>2</sup> shielding, which is about 10-30 times less shielding than the shielding of Liulin-E094 experiment on ISS in 2001. From other hand the altitude of R3D-B2 experiment was 260-304 km, about 100 km less than Liulin-E094 experiment.



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#### All available data in the memory for doses and fluxes





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#### Aircraft flight Amsterdam-Samara by R3D-B2 data



DoseGraph **R3D-B2 60 sec exposition** Dose Cursors Start:24/05/05 18:00:00 Right\_\_\_ 03:09:00 C Left Time Dif: Number: 4.0414 1554 Total Avr. Dose [uGy]: Stop:12/06/05 02:04:00 1365 1.2830 Time: 25/05/2005 16:44:00 25/05/2005 19:53:00 Avr. Dose [uGy/h]: Number of Measurments: 26405 Sigma Dose: 0.0135 Dose: 1.050 82 Left Axis Range Max: 1.0E+1 Dose/Flux Rate 1.0E+1 Min: 1.0E-2 -ÖK DOSE[uGy/hour], FLUX[p/cm^2'sec] Dose 1.0E+0 Flux Both OK Axis Values Dose/Flux: 0.08 .0E-1 Msr. Index: 1531 Date: 25/05/2005 Time: 19:29:38 1.0E-2 1,351 1,323 1,379 1,407 1,435 1,463 1,491 1,519 1,547 1,575 1,603 Save Number of Measurments File:D:\PROJECTS\Biopan\R3D-B2 last 2005\R3D-B2&3 Sent items April 1 2005\Programs\01010001.D05

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#### Aircraft flight Amsterdam-Samara by Liulin-Photo data



Space radiation...





#### Comparison of aircraft flight results for 3 hours and 9 minutes

	R3D-B2	Liulin-Photo
Mean dose [µGy/hour]	1.283	1.263
Total dose [µGy]	4.041	3.977
Sigma dose	0.0135	0.0125





# Comparison of the R3D-B2 and Liulin-E094 mean daily data with (Johnson et al, 1993)





#### **Data close to launch**





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# Sequence of descending and ascending orbits

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#### E-T grams from Liulin MDU#1 and MDU#2 on ISS in 2001

#### MDU-02 EXPOSITION = 30[sec]





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#### Sequence of descending Foton M2 orbits



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#### **Descending crossing of SAA**











#### Typical descending node crossing of SAA as seen by Liulin-E094 MDUs data



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#### **Distribution of Liulin-E094 phenomena inside of SAA**



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#### **Summary plot of the phenomena**







#### **Comparison with Spenvis model**







#### **Comparison with Spenvis model 2**







#### **Future space experiments**

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Liulin-ISS: Weight: 229 g incl. 80 g battery Size: 110x80x25 mm Consumption: 84 mW



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Date/Time[mm.dd.yy hh:mm:ss]:

Dose[IIGv/h]

06.18.2005 05:50:00

06.18.2005 05:40:00

06.18.2005 05:30:00

06.18.2005 05:20:00

06.18.2005 05:10:00

0.088

0.104

0.149

0.094

0.116



Weight: 140 g Size: 84x40x40 mm Cons.: 200 mA from 5 VDC

Space radiation...

Dopolling?ull	•••		Donella Ohull.	0.1	
Flux[(cm <sup>-2</sup> *sec <sup>-1</sup>	)]: 0.	053	Flux[(cm <sup>-2</sup> *sec <sup>-1</sup> )]	: 0.0:	59
Dose/Flux Exposition Value: Dose/Flux Average Value:					<u>alue:</u>
Date [mm.dd.yy] [hh:mm:ss]	Dose [µGy/h]	Flux [(cm <sup>-2</sup> *sec <sup>-1</sup> )]	Date [mm.dd.yy] [hh:mm:ss]	Dose [µGy/h]	Flux [(cm <sup>-2</sup> *sec <sup>-1</sup> )]
06.18.2005 08:00:00	0.097	0.058	06.18.2005 08:00:00	0.125	0.063
06.18.2005 07:50:00	0.139	0.072	06.18.2005 07:00:00	0.109	0.058
06.18.2005 07:40:00	0.102	0.059	06.18.2005 06:00:00	0.108	0.061
06.18.2005 07:30:00	0.118	0.060	06.18.2005 05:00:00	0.114	0.063
06.18.2005 07:20:00	0.184	0.067	06.18.2005 04:00:00	0.114	0.063
06.18.2005 07:10:00	0.106	0.059	06.18.2005 03:00:00	0.107	0.055
06.18.2005 07:00:00	0.105	0.062	06.18.2005 02:00:00	0.104	0.061
06.18.2005 06:50:00	0.102	0.061	06.18.2005 01:00:00	0.098	0.059
06.18.2005 06:40:00	0.123	0.054	06.18.2005 00:00:00	0.107	0.062
06.18.2005 06:30:00	0.114	0.059	06.17.2005 23:00:00	0.117	0.063
06.18.2005 06:20:00	0.106	0.055	06.17.2005 22:00:00	0.106	0.059
06.18.2005 06:10:00	0.102	0.057	06.17.2005 21:00:00	0.113	0.060
06.18.2005 06:00:00	0.093	0.062	06.17.2005 20:00:00	0.109	0.063

0.053

0.054

0.075

0.054

0.067

07:30:00

0.115

Date/Time[mm.dd.yy hh:mm:ss]:

DosefuGv/hl·

07:00:00

0.115

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0.100

0.118

0.101

0.103

0.099

0.059

0.064

0.057

0.061

0.059

31

06.17.2005 19:00:00

06.17.2005 18:00:00

06.17.2005 17:00:00

06.17.2005 16:00:00

06.17.2005 15:00:00





- 2 different modifications of Liulin type spectrometers was developed, build and flown on Foton M2 satellite. The differences between both instrument data during the aircraft flights do not exceed few percent;
- R3D-B2 spectra data show presence of 4 different formations in the region of SAA: First is the maximum of protons with high energies in the north-west side; 2) The protons lower their energy in the south-east direction; 3) In the south-east side of anomaly, where maximum of electrons with energies larger then 0.1 MeV is predicted by AE model is observed a pure electron or bremsshtrahlung spectra; 4) Pure electron or bremsshtrahlung spectra are observed in the region of outer radiation belt also;
- The comparisons of R3D-B2 with Liulin-E094 data allows us to confirm results obtained with Liulin-E094;
- Future experiments in space are under development and will be performed up to 2019;