Description of the Liulin-ISS-2 system for personal dosimetric control of Russian cosmonauts inside and outside ISS

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Outlook

- Introduction
- Description of the new Liulin-ISS-2 instrument
- Calibration results
- Conclusions

Introduction

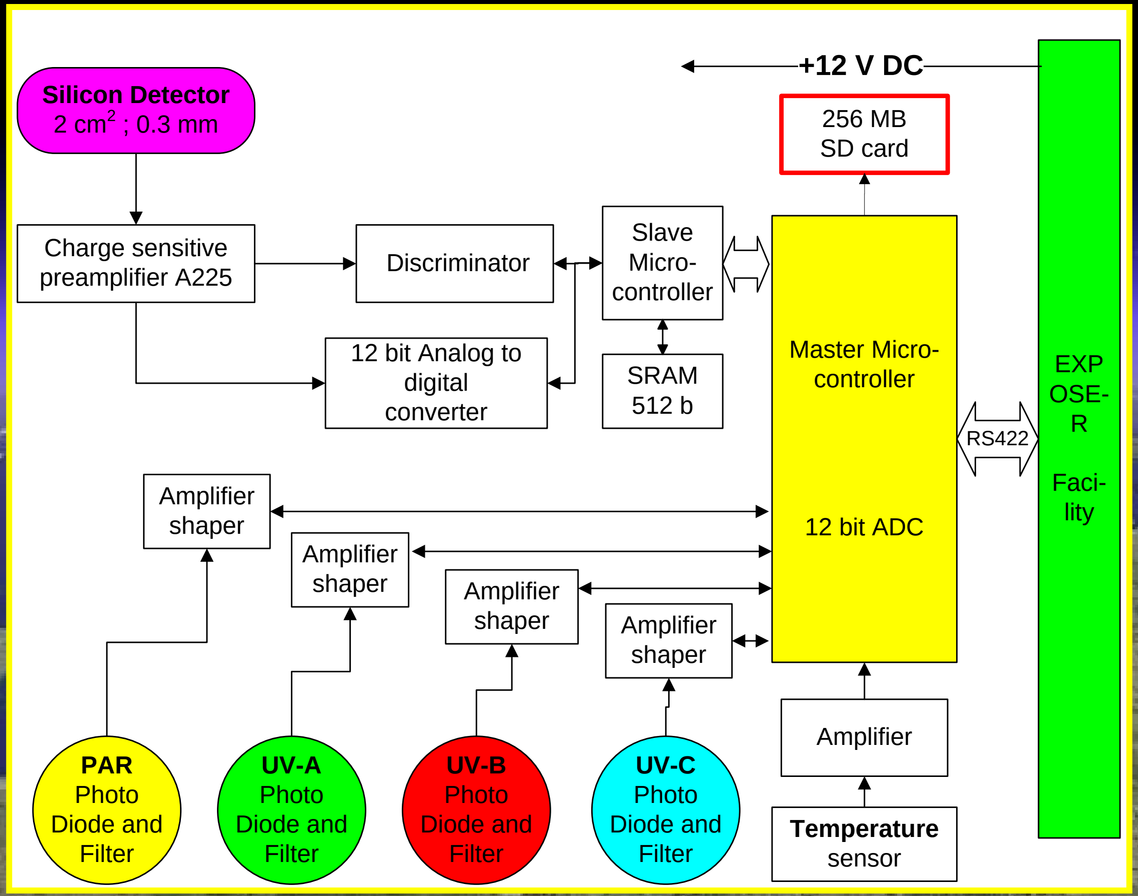
The significance of personal dose measurements during EVA was verified experimentally during the analysis of the large and rapid variations in space and time of the doses obtained simultaneously with the ESA R3DE and R3DR1 instruments located outside ISS in 2009 (Dachev, 2013)*.

*Dachev Ts., Analysis of the space radiation doses obtained simultaneously at 2 different locations outside ISS, Adv. Space Res., 52, 1902-1910, 2013, http://dx.doi.org/10.1016/j.asr.2013.08.011.

External view of R3DE and R3DR1 instruments

External view of both instruments

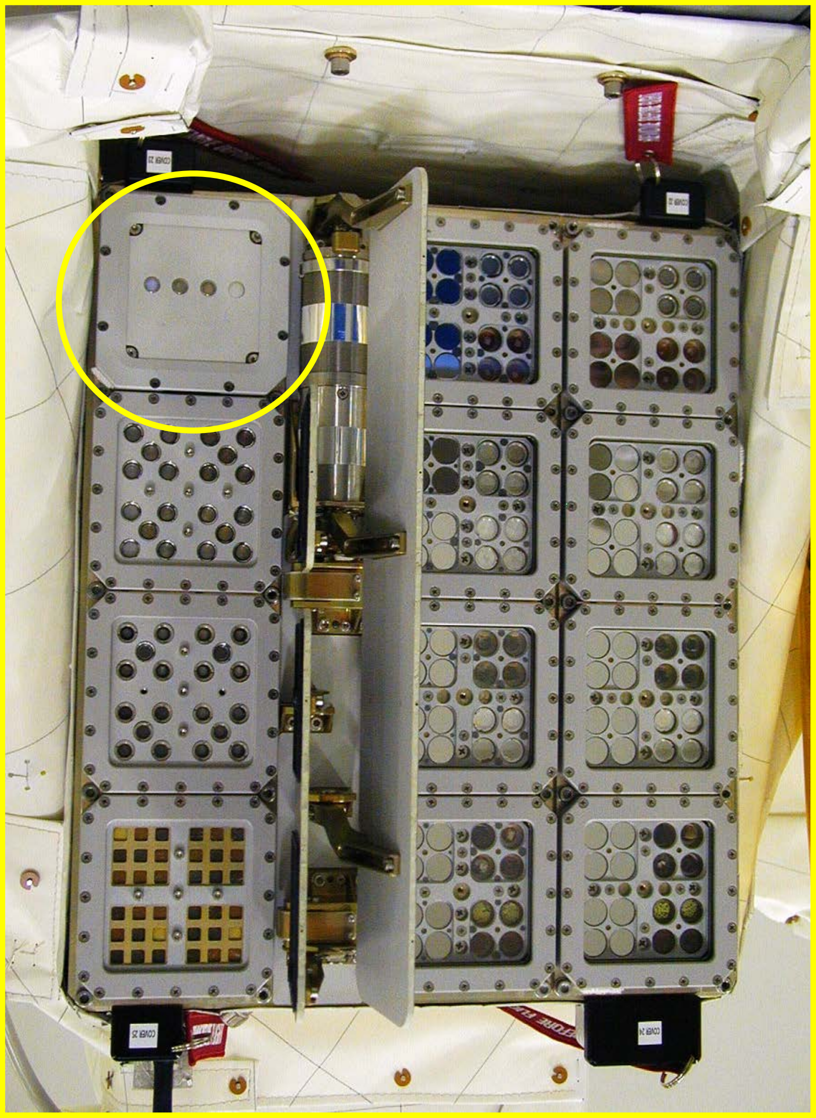
The R3DE/R1 instruments are active, low mass (120 g) and small consumption (150 mW) devices, which measure solar radiation in 4 channels and space ionizing radiation in 256 channels. Measurements have 10 s. time resolution. The spectrometers were mutually developed with University of Erlangen, Germany



Block schema of the R3DE/R1 devices

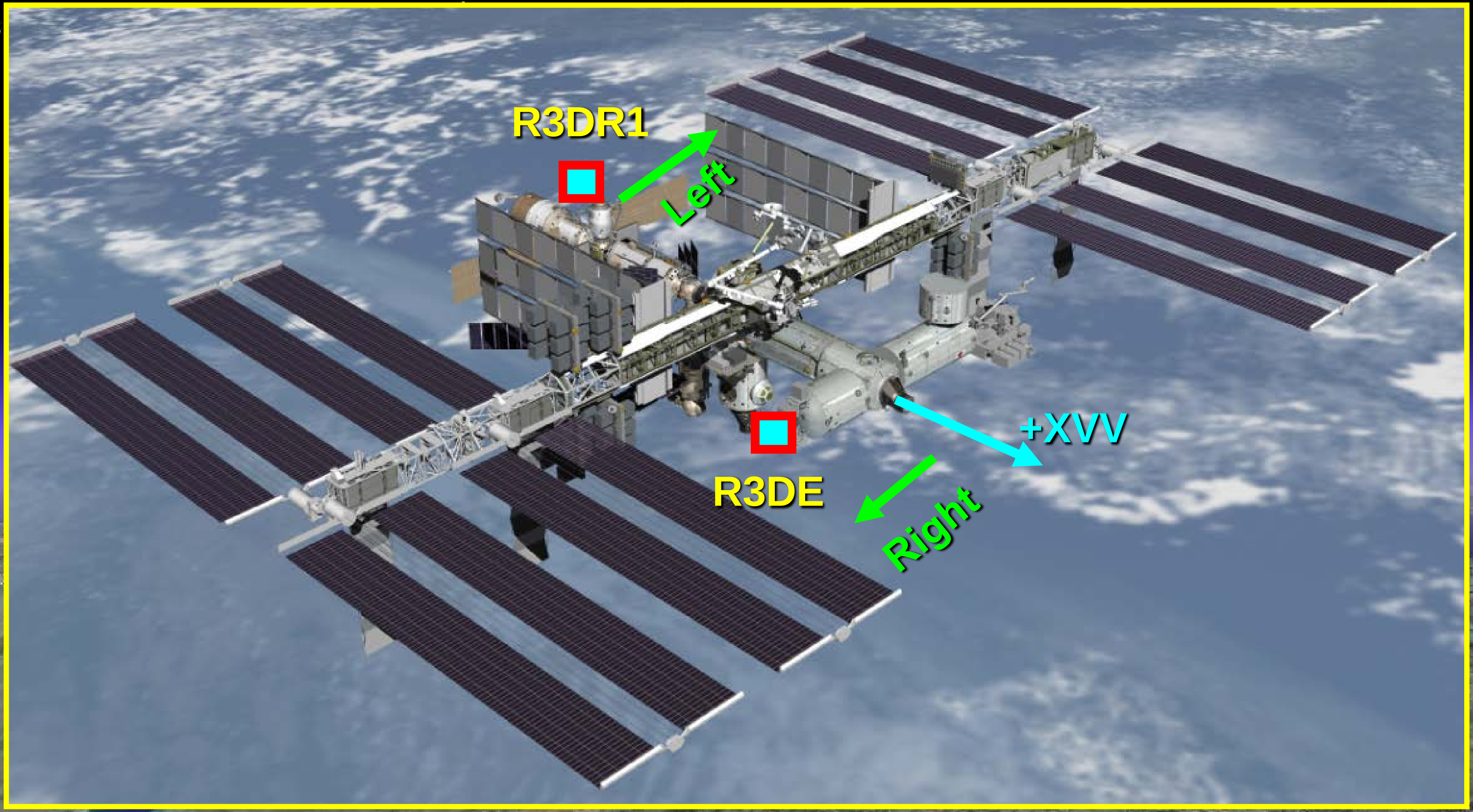
External view of both EXPOSE platforms

EXPOSE-E

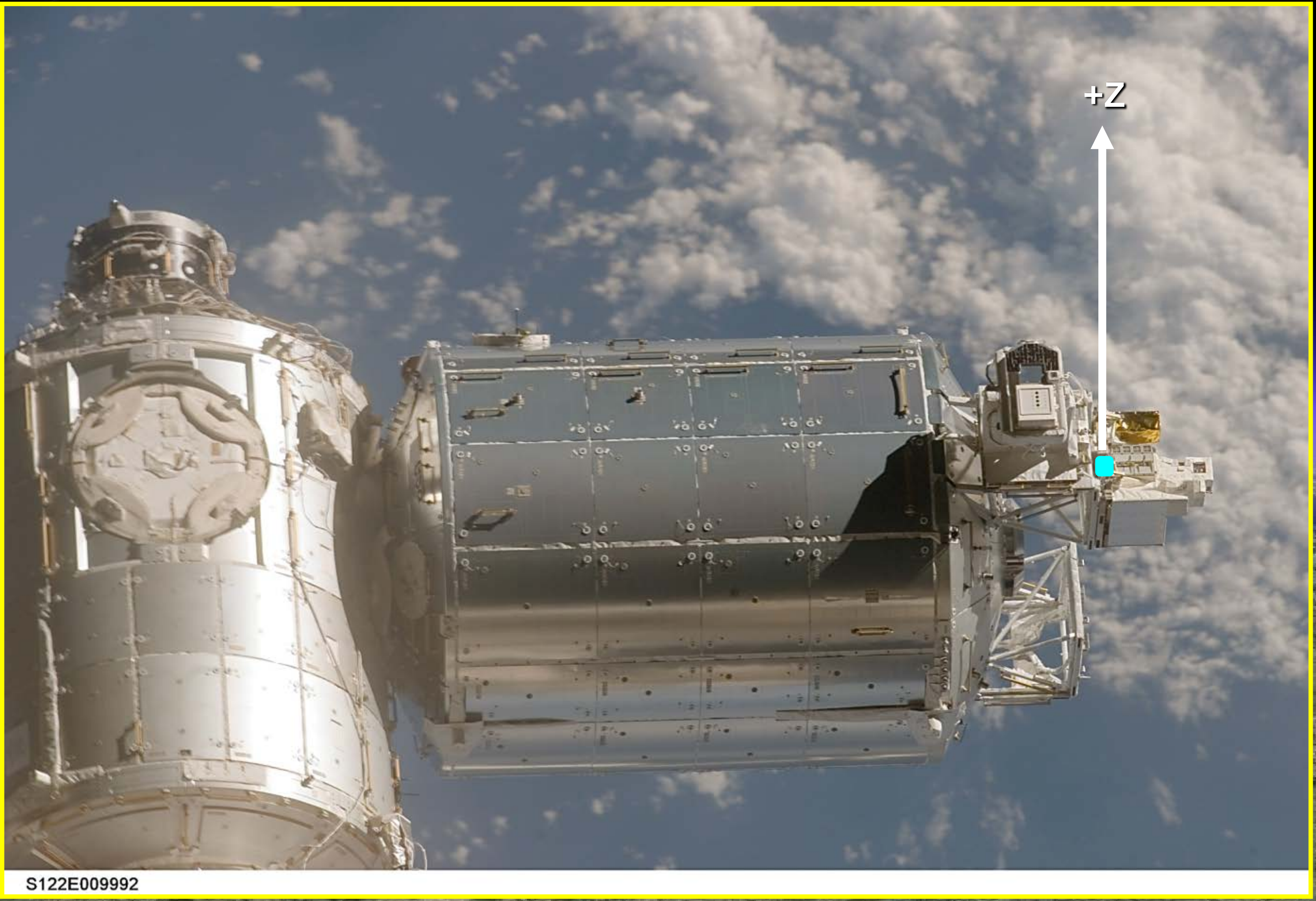


EXPOSE-R1

General positions of the R3DE/R1 instruments in the ISS coordinates

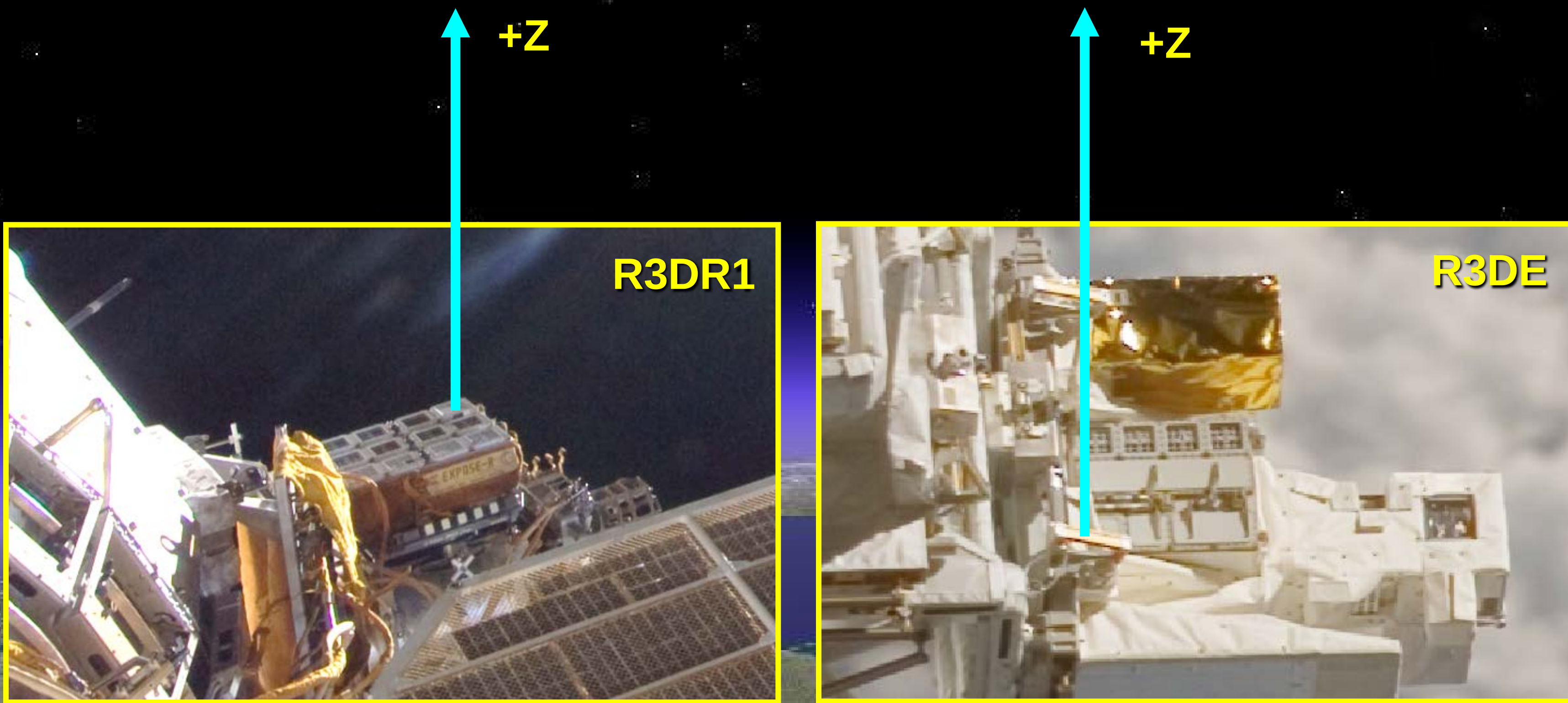


Location and orientation of the R3DE instrument



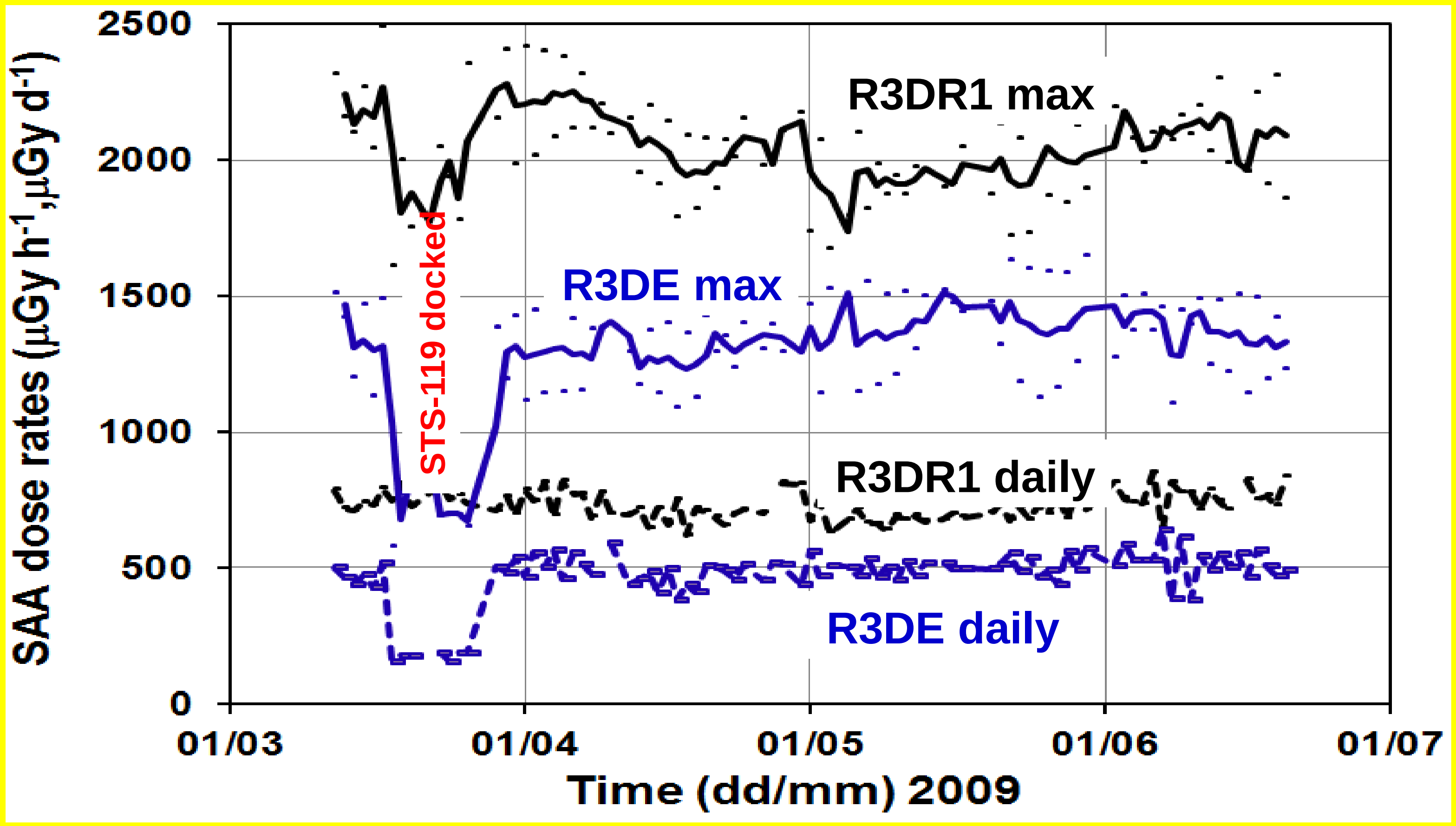
Location and orientation of the R3DR1 instrument

Comparison of the R3DE and R3DR1 shieldings



- Both instruments are in same way shielded from the EXPOSE-E/R platforms in forward and backward 2π angles;
- R3DR1 instrument is less shielded by surrounding construction elements than R3DE by EUTeF facility. That is why the R3DR1 IRB and ORB doses are larger than R3DE SAA doses, while the GCR dose is smaller.

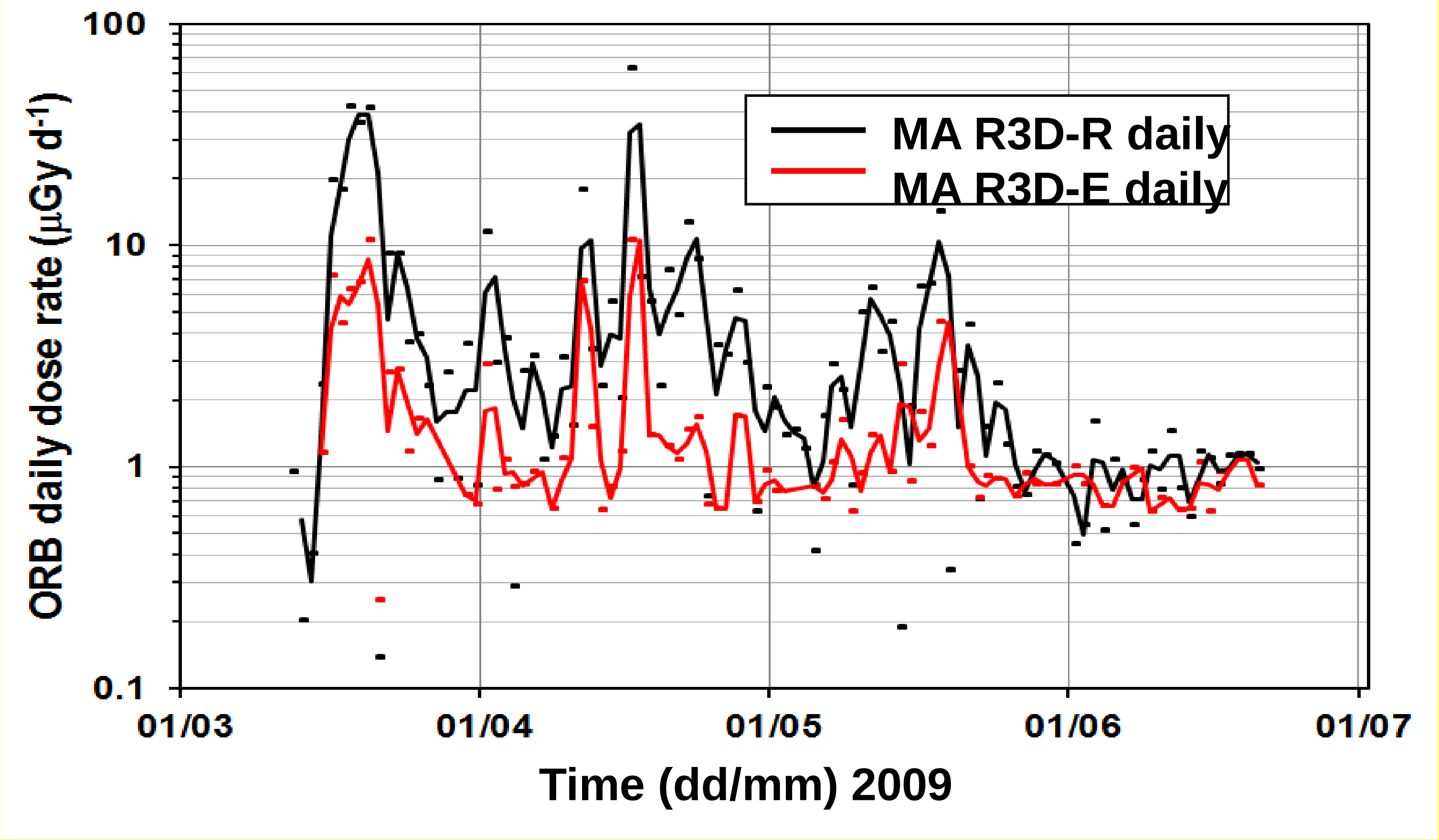
Comparison of the averaged and maximal IRB daily dose rates measured by D3DE/R1 instruments



The daily average IRB dose rate over the whole period from R3DR1 is 729 μGy d^{-1}
The daily average and the maximal observed IRB dose rate over the whole period from R3DE is 473 μGy d^{-1}.

Averaged R3DR1 IRB dose rates are higher than R3DE because less surrounding shielding of the detector

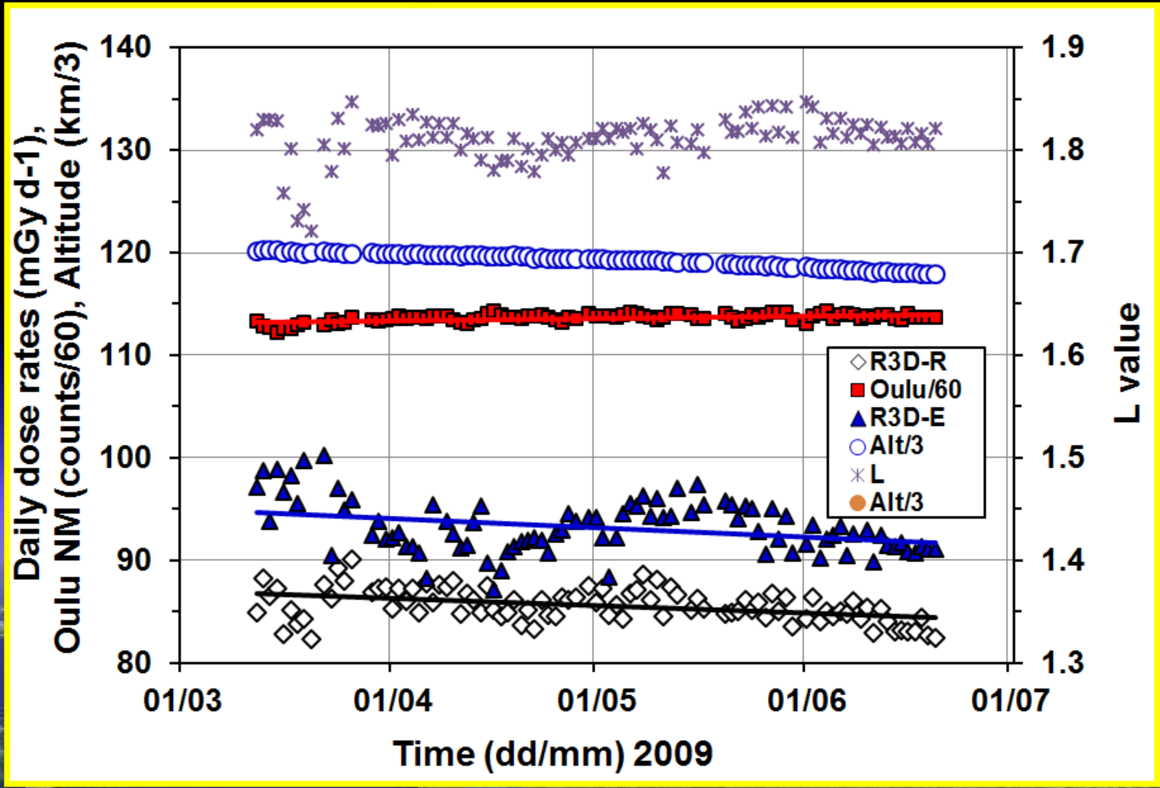
Comparison of the averaged ORB daily dose rates measured by D3DE/R1 instruments



The daily, average ORB dose rate over the whole period from R3DR1 is 4.9 µGy d^{-1}
The daily, average SAA dose rate over the whole period from R3DE is 1.7 µGy d^{-1}

Averaged R3DR1 ORB dose rates are higher than R3DE because less surrounding shielding of the detector

Comparison of the averaged GCR daily dose rates measured by D3DE/R1 instruments



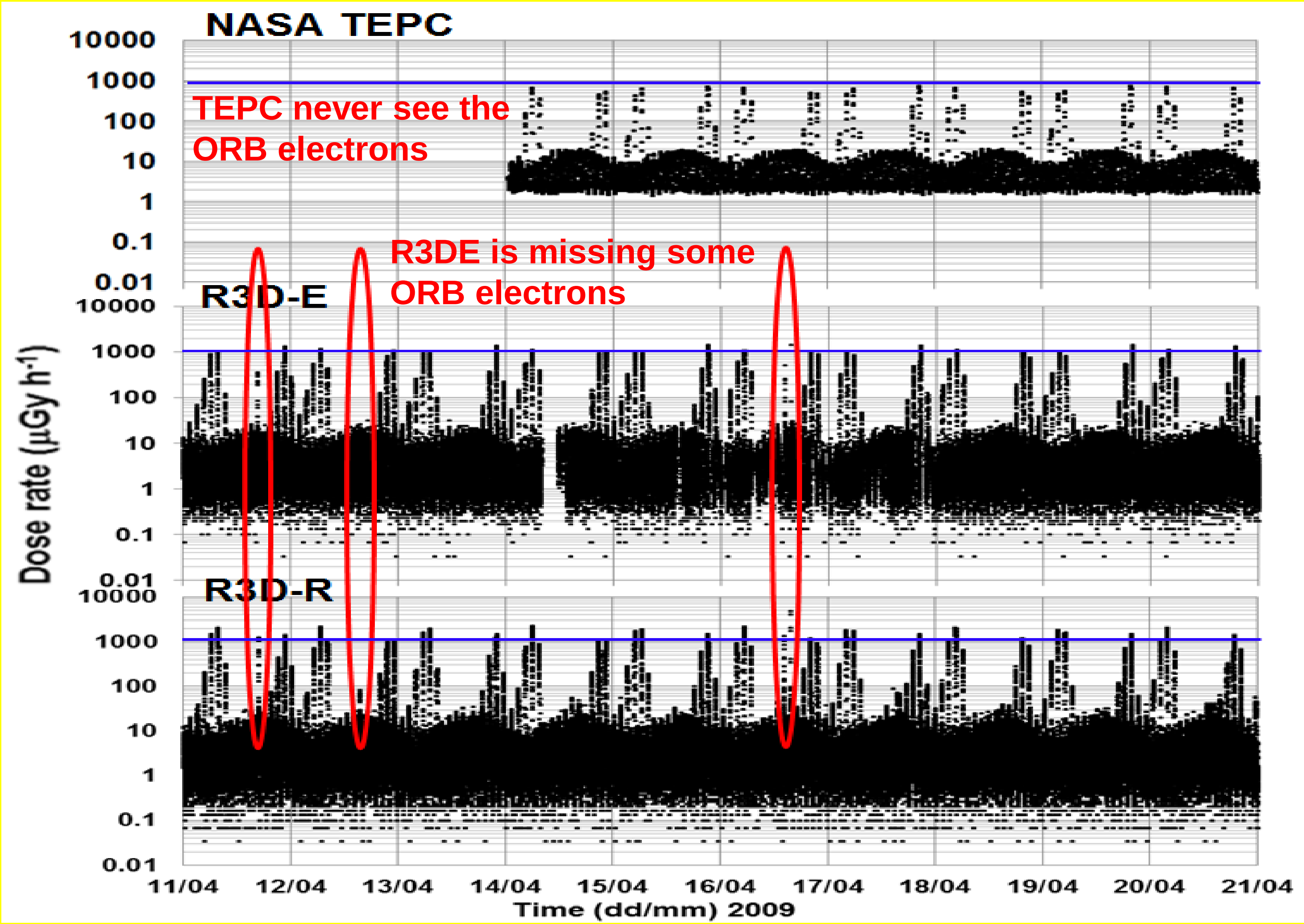
The daily, average GCR dose rate over the whole period from R3DR1 is 85.6 μGy d^{-1}

The daily, average GCR dose rate over the whole period from R3DE is 93.2 μGy d^{-1}

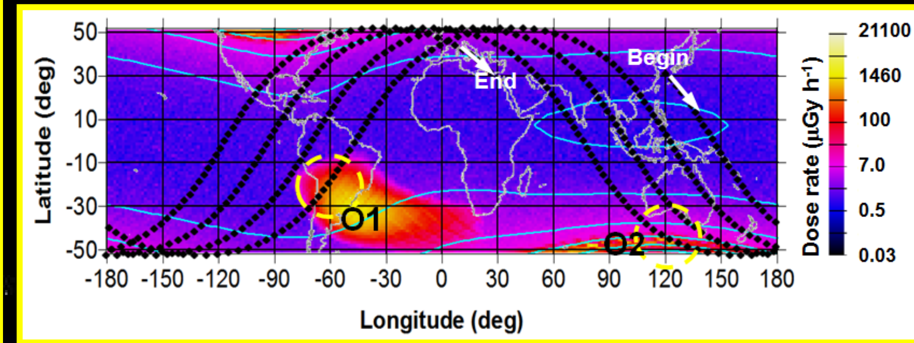
The averaged R3DE GCR dose rates are higher than R3DR1 because the build in secondary in the heavier shielding (Mrigakshi et al., 2013)*

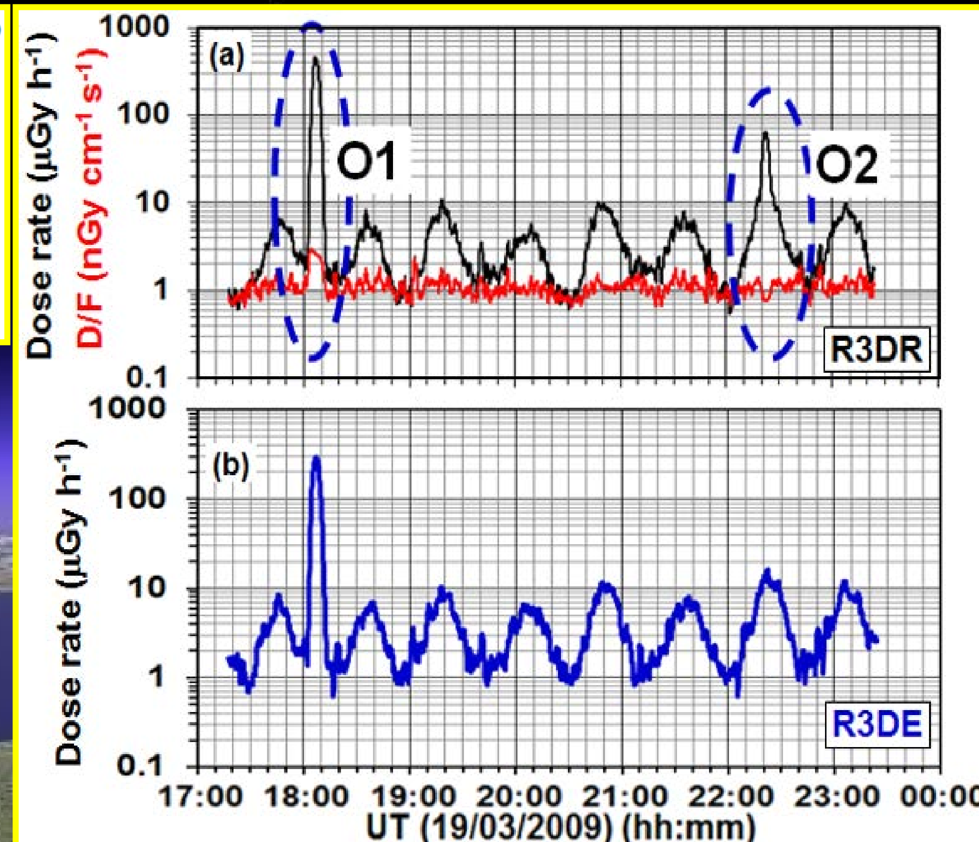
*Mrigakshi, A.I., D. Matthiä, T. Berger, G. Reitz, R.F. Wimmer-Schweingruber, (2013) Estimation of galactic cosmic ray exposure inside and outside the Earth's magnetosphere during the recent solar minimum between solar cycles 23 and 24, Advances in Space Research, 52, 979-987, http://dx.doi.org/doi:10.1016/j.asr.2013.05.007.

Comparison of the measured dose rates with R3DR1, R3DE and NASA TEPC* (http://cdaweb.gsfc.nasa.gov/)



Comparison of the measured with the R3DE/R1 instruments dose rates during 6 hours as real EVA





R3DR1 values:
Total Abs. dose = 57 µGy
GCR Abs. dose = 18.6 µGy
SAA Abs. dose = 32 µGy
ORB Abs. dose = 5.2 µGy

R3DE values:
Total Abs. dose = 45 µGy
GCR Abs. dose = 22 µGy
SAA Abs. dose = 23 µGy
ORB Abs. dose = 0 µGy

The total absorbed dose rate obtained with R3DR1 instrument is with 12 µGy larger than R3DE values.

Description of the new Liulin-ISS-2 instrument

Under a contract between Space Research and Technology Institute, Bulgarian Academy of Sciences, Institute of Biomedical problems, Russian Academy of Sciences and S.P. Korolev Rocket and Space Corporation Energia an engineering model of new system named “Liulin-ISS-2” for personal dosimetric control of Russian cosmonauts inside and outside ISS was developed.

It is expected that the new system will replace the Liulin-ISS system, launched to ISS in 2005.

The "Liulin-MKS-2" priority is focused on the active measurement with 10 seconds resolution of the dose rate dynamics from galactic cosmic rays (GCR), protons from internal and energetic electrons from external radiation belts, and solar energetic particles (SEP) inside ISS modules and during the extravehicular activity (EVA) of Russian and international cosmonauts.

Liulin-ISS-2 system consists of 4 portable dosimeters (PD) and interface block (IB) with internal dosimeter.

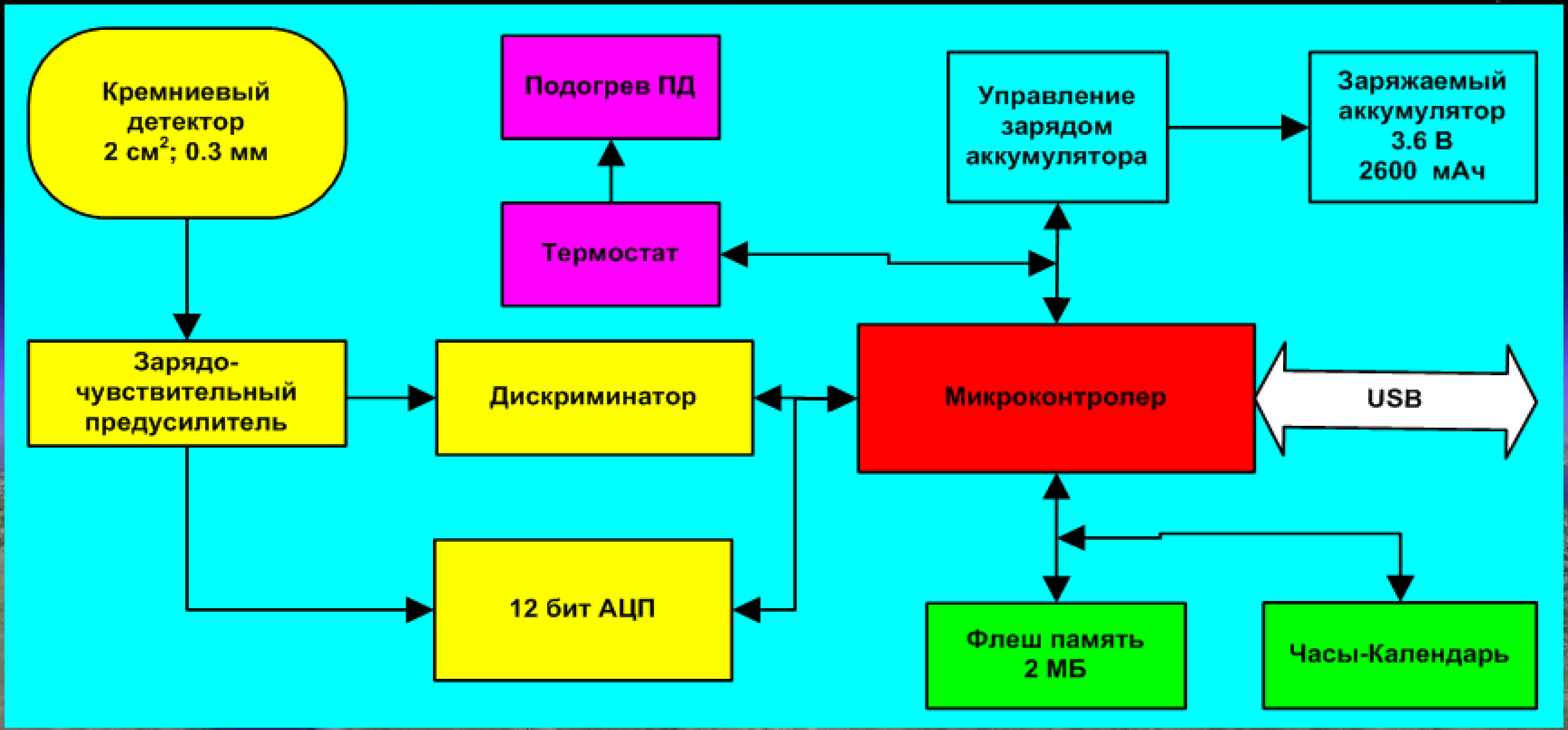
The PD with size 64x60x30 mm is based on the traditional Liulin type DES (Dachev et al., 2015) block diagram with 2 cm2 0.3 mm PIN diode. The analysis of the obtained deposited energy spectra will be performed according the ideas for intelligent crew personal dosimeter (Dachev et al., 2011) and new experience obtained during the data analysis from the R3DR2 instrument outside ISS in the period October 2014-January 2016 (Dachev et al., 2016a and 2016b).

SAFT prismatic lithium-Ion rechargeable battery, endorsed for space use, is used in the PD and allows more than 7 days independent work of the PD with 10 sec resolution.
Thermostat and manageable heater are implemented to keep the temperature of the PIN diode not smaller than -20 °C during EVA when in the external spacesuit pocket.

The interface block with size 250x180x80 mm is based on a Getac T800 (http://www.getac.com/) fully rugged tablet PC in compliance with the requirements and procedures of MIL-STD-810G, and under Windows-8 operational system. Through 8 ports industrial USB hub the PC manage the system and data transfer toward CAN interface and/or flash memory stick. Continuously the last 90 minutes data, obtained with the internal dosimeter are visualized on the screen of the PC.

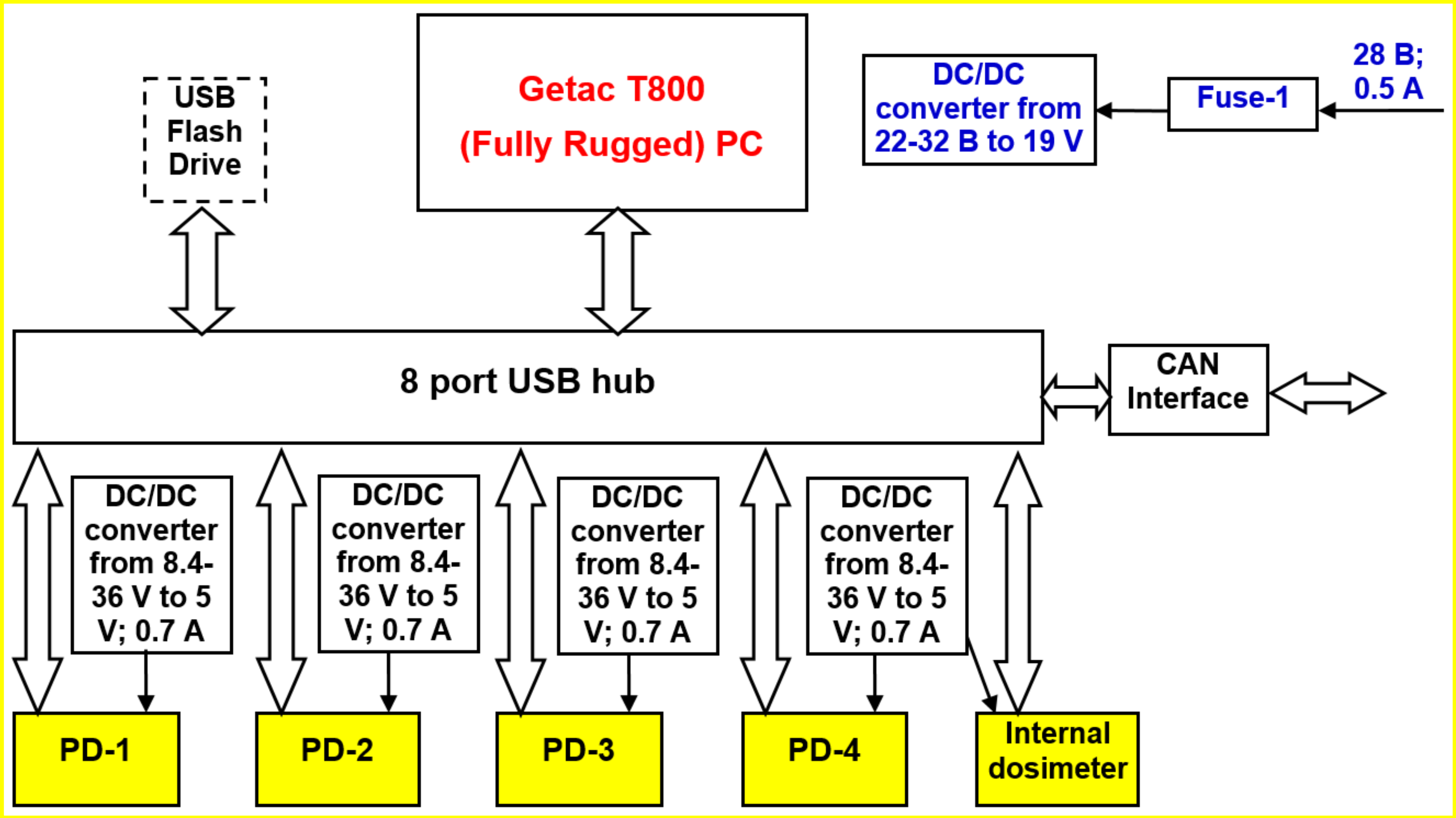
External view of the portable dosimeter (64x60x30 mm; 120 gr)

Block diagram of the portable dosimeter



External view of the interface block with Getac T800 fully rugged tablet PC (250x180x80 mm; 3.6 kg)

Block diagram of the system

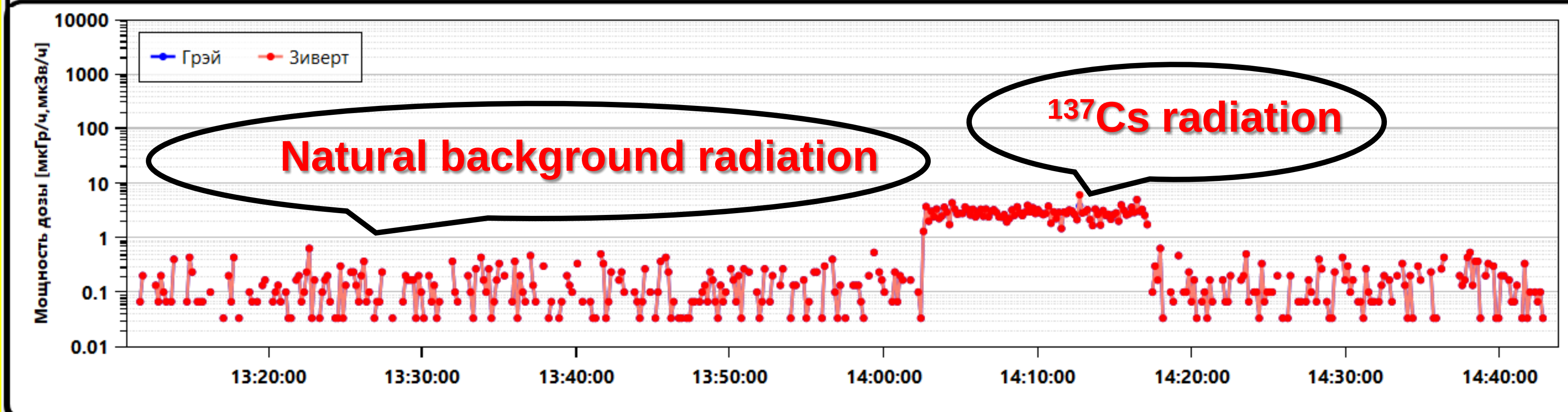


Interfaces

Preliminary management and information screenshot

ЛЮЛИН МКС-2

Мощность дозы:		Суточная доза [чч]: 2		Накопленная доза [дд]: 0	
0.034 мкГр/ч	0.034 мкЗв/ч	0.90 мкГр	0.92 мкЗв	0.0 млГр	0.0 млЗв

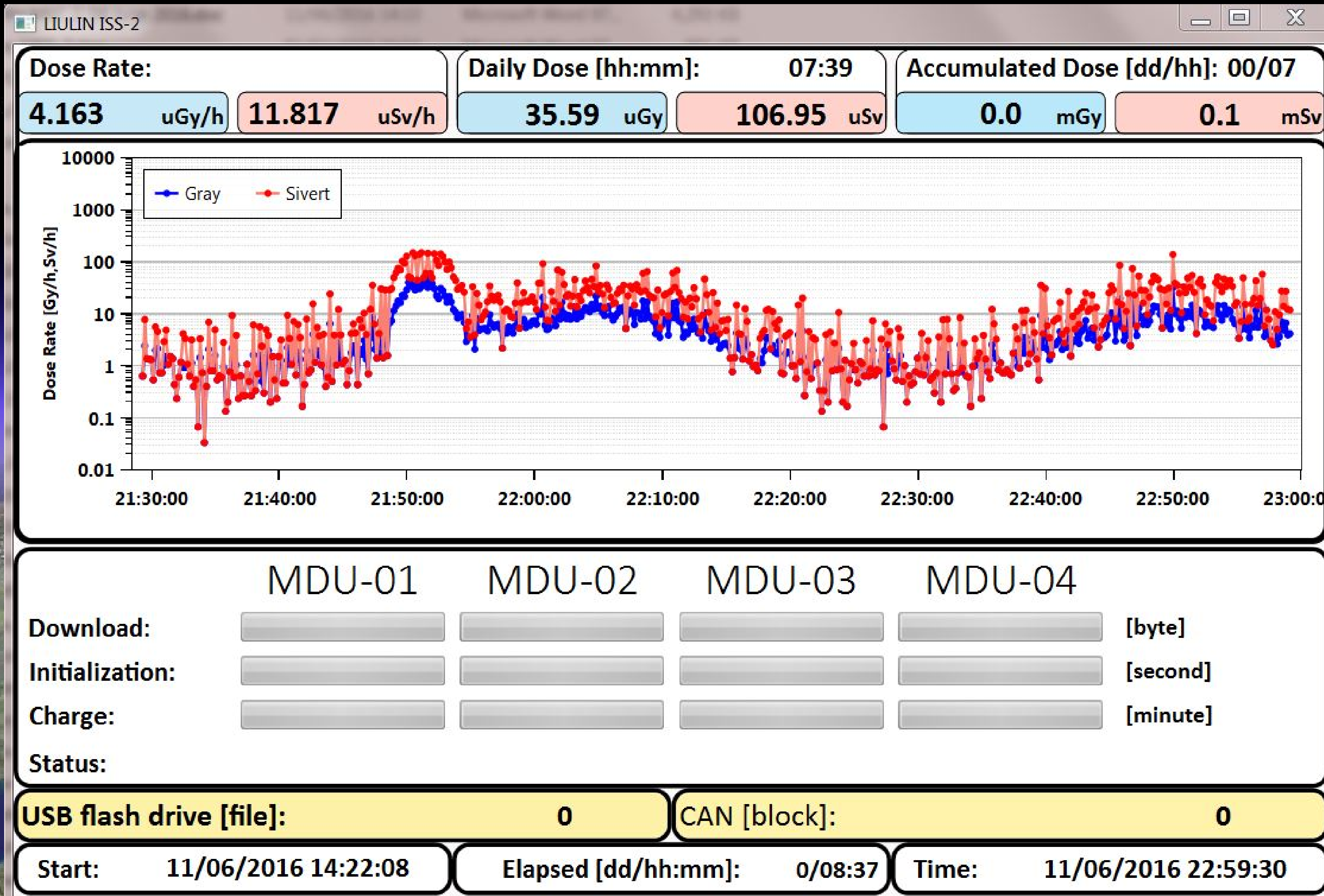


	ПД-1	ПД-2	ПД-3	ПД-4	
Объем данных:		82944		79360	[байт]
Инициализация:		21		21	[секунды]
Заряд:		1		1	[минуты]
Состояние:					

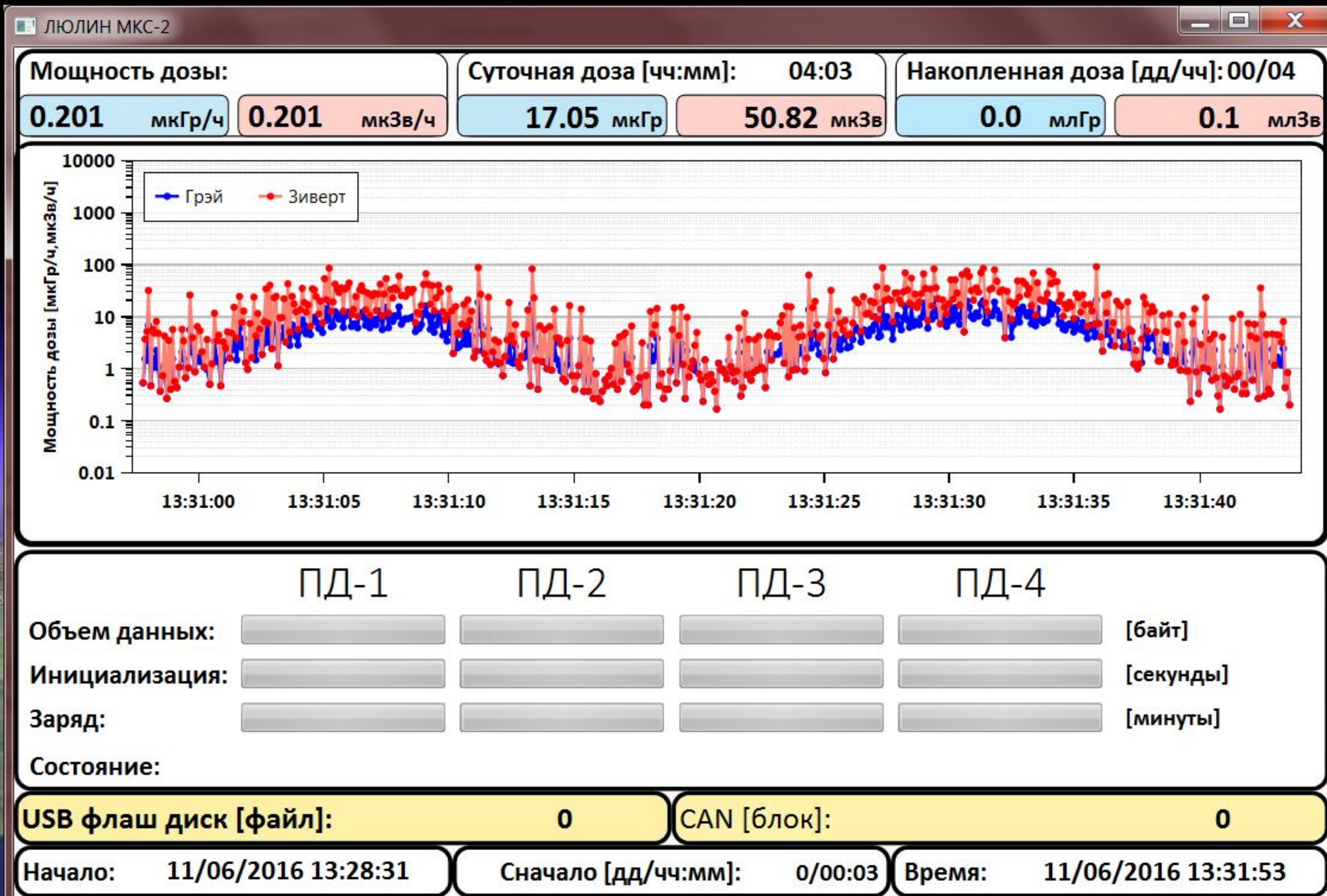
USB флаш диск [файл]: 0 | CAN [блок]: 11

Начало: 09/06/2016 12:25:07 | Сначало [дд/чч:мм]: 0/02:17 | Время: 09/06/2016 14:43:05

Screenshot data simulation (1)

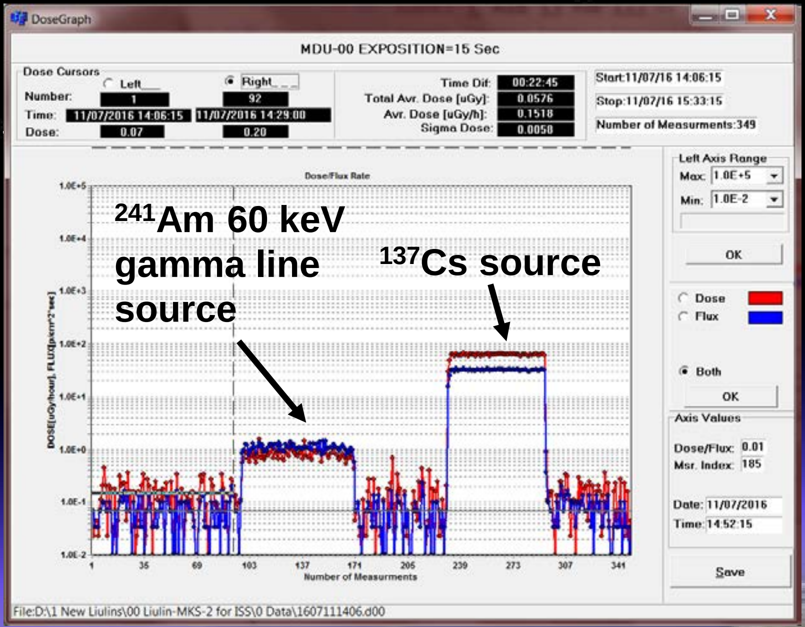


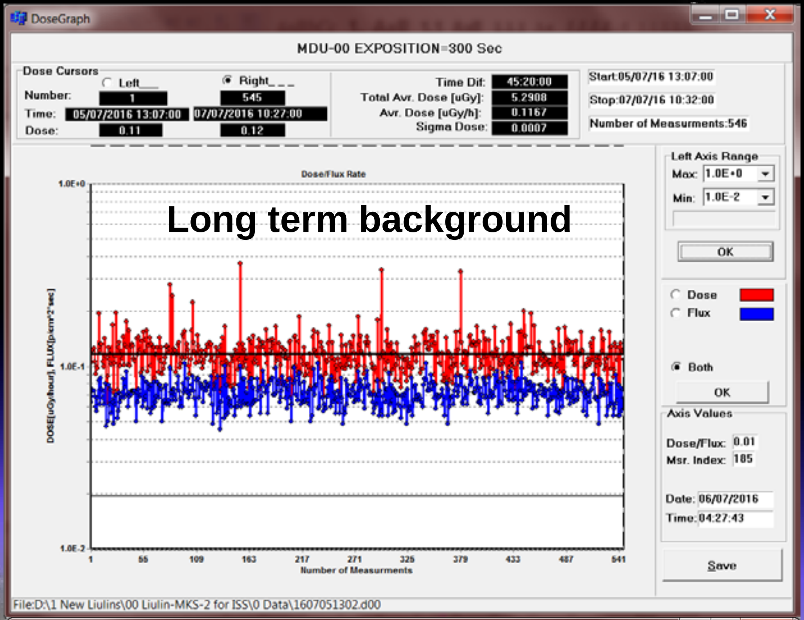
Screenshot data simulation (2)

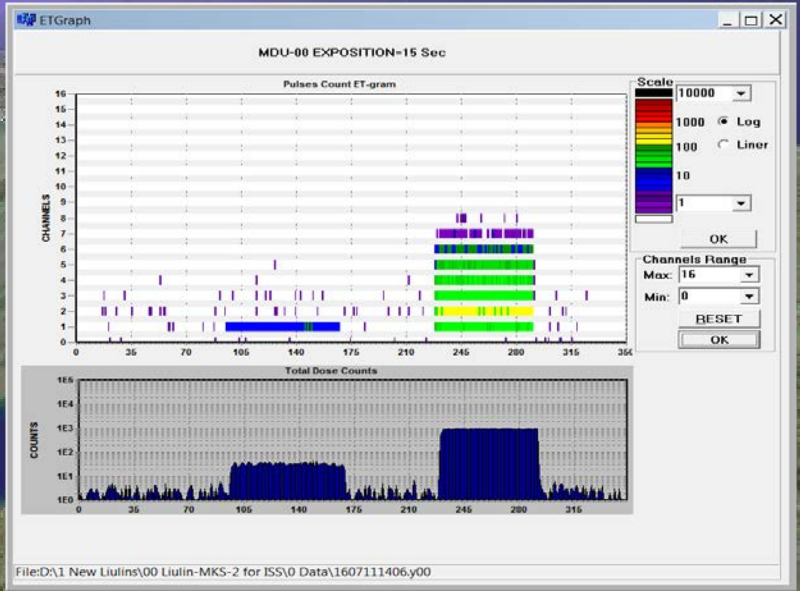


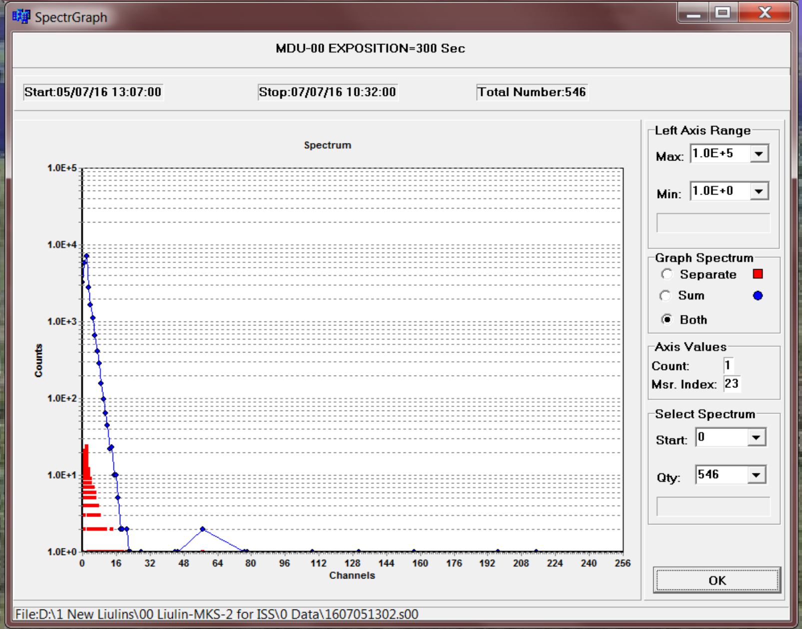
Liulin-ISS-Eng.exe

Calibration results of the internal dosimeter

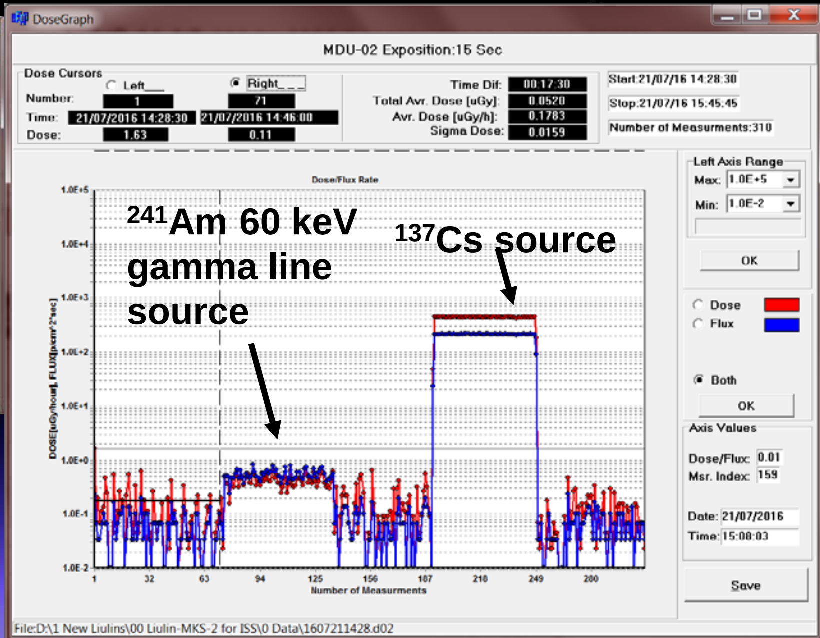


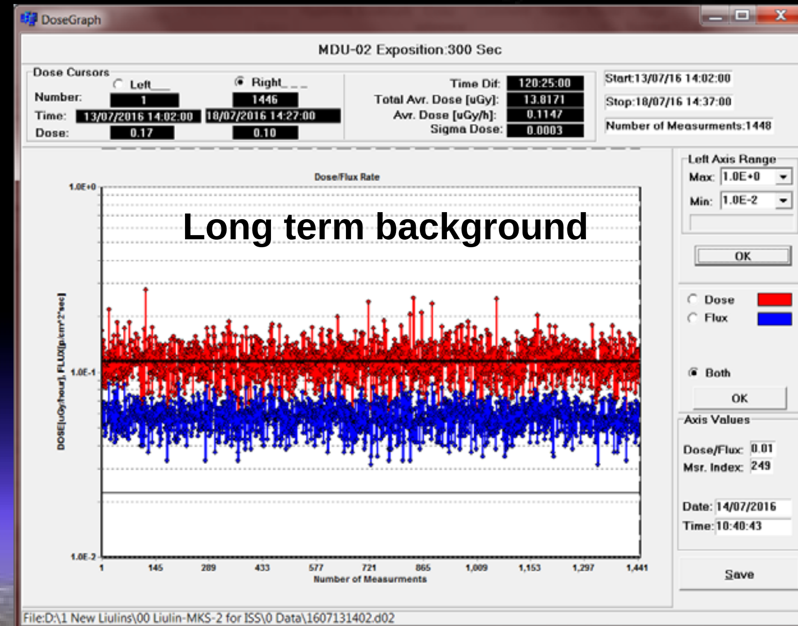


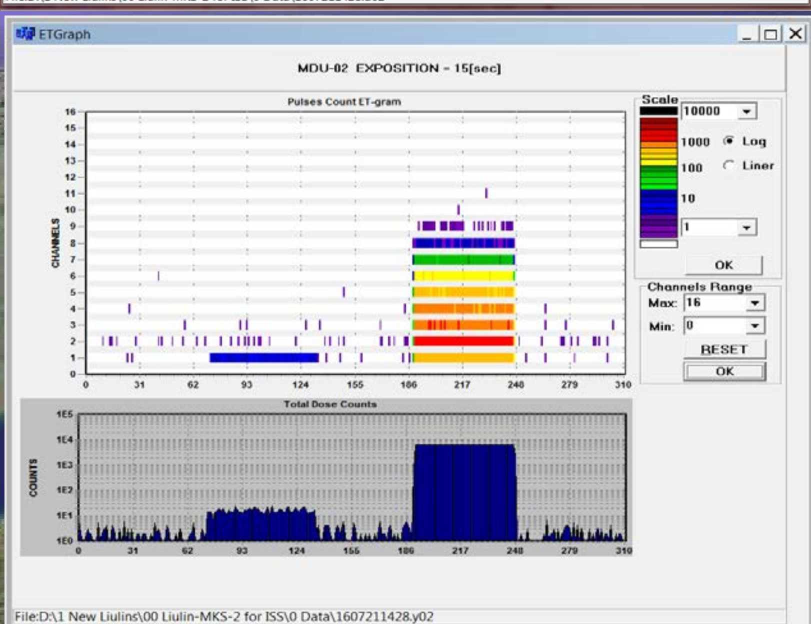


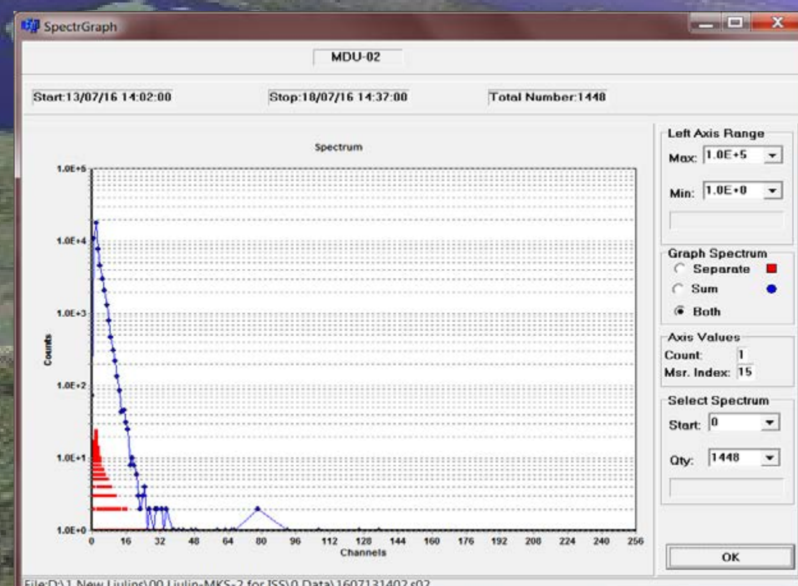


Calibration results of the PD-2 external dosimeter

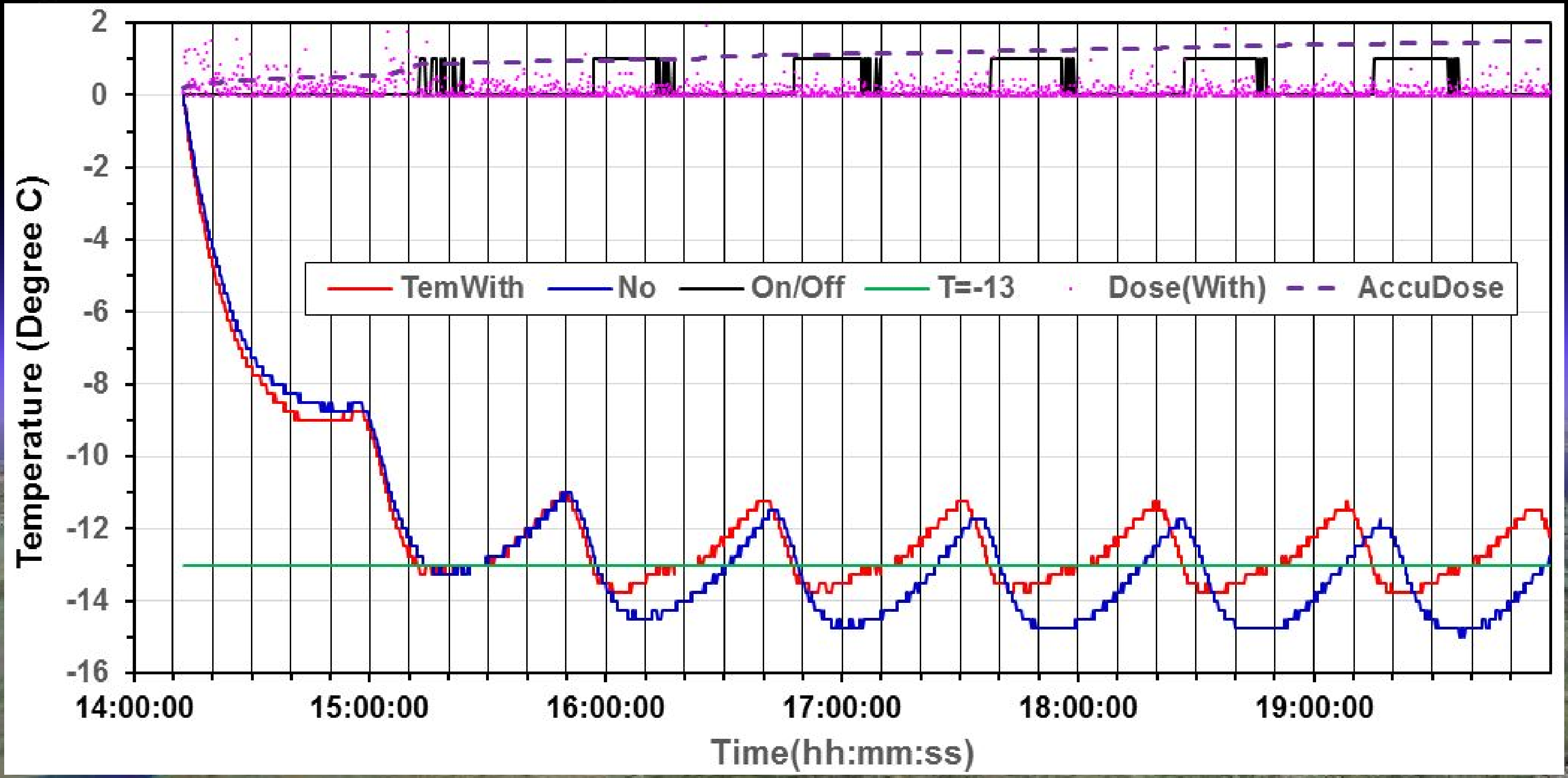








Temperature control of the PD



Conclusions

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Thank you for your attention