Unified webbased database with Liulin-type instruments' cosmic radiation data

T.P. Dachev[1], K. Lilovski[2], N.G. Bankov[1], B.T. Tomov[1], Yu.N. Matviichuk[1], P.G. Dimitrov[1], J.V. Semkova[1], R.T. Koleva[1], V.A. Shurshakov[3], V.V. Benghin[3]

[1]Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

[2]Linitrex LTD, Sofia Bulgaria

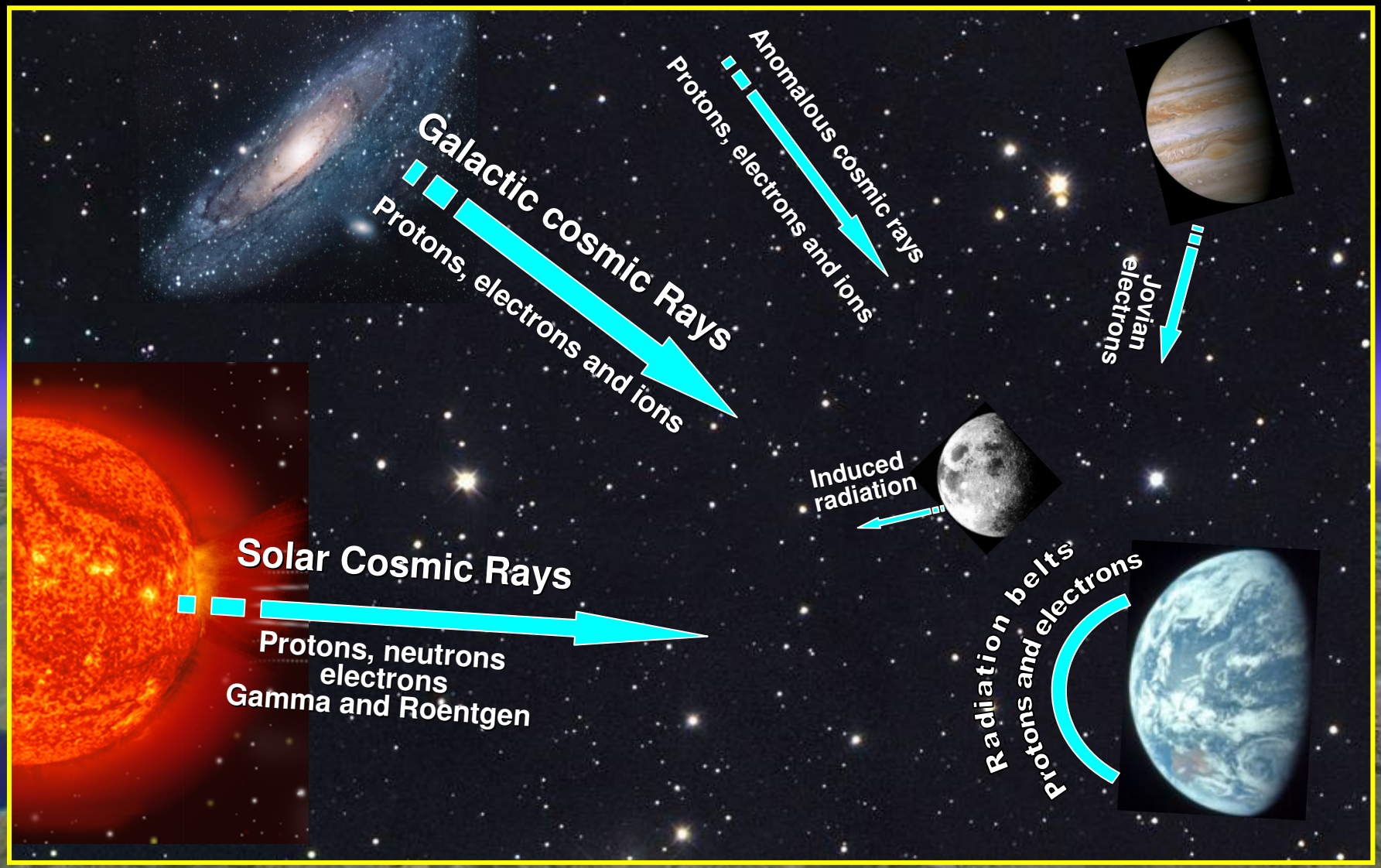
[3]State Research Center Institute of Biomedical problems, Russian Academy of Science, Moscow, Russia

Outlook

- Introduction
- Bulgarian build space dosimetry instruments;
- Online demonstration of the database;
- Future space experiments;
- Conclusions

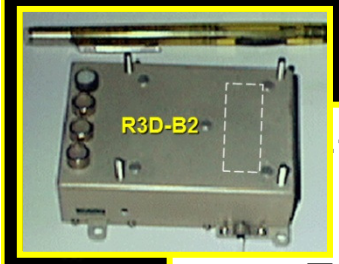

Introduction

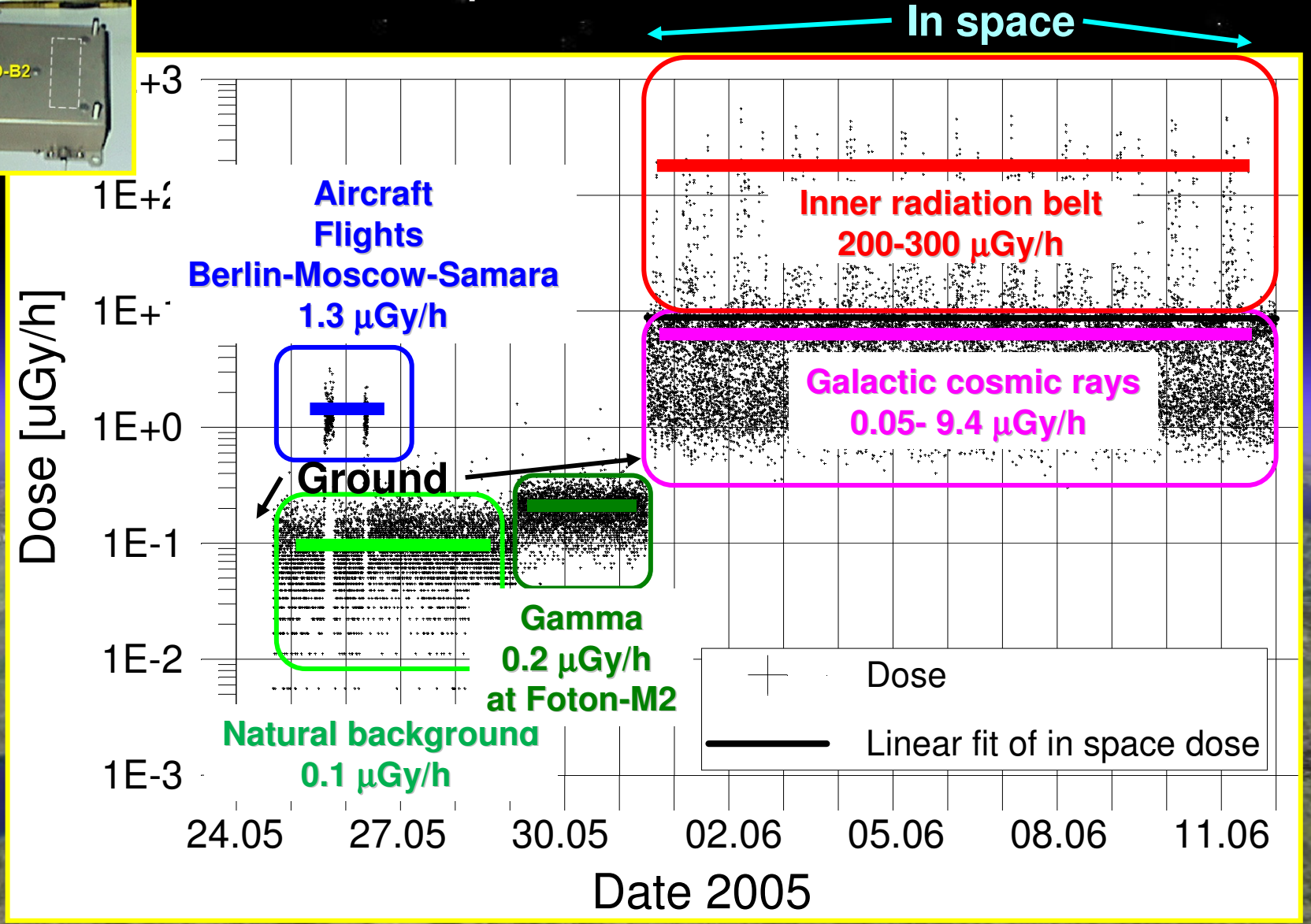
Radiation sources in the Earth and Moon space environment



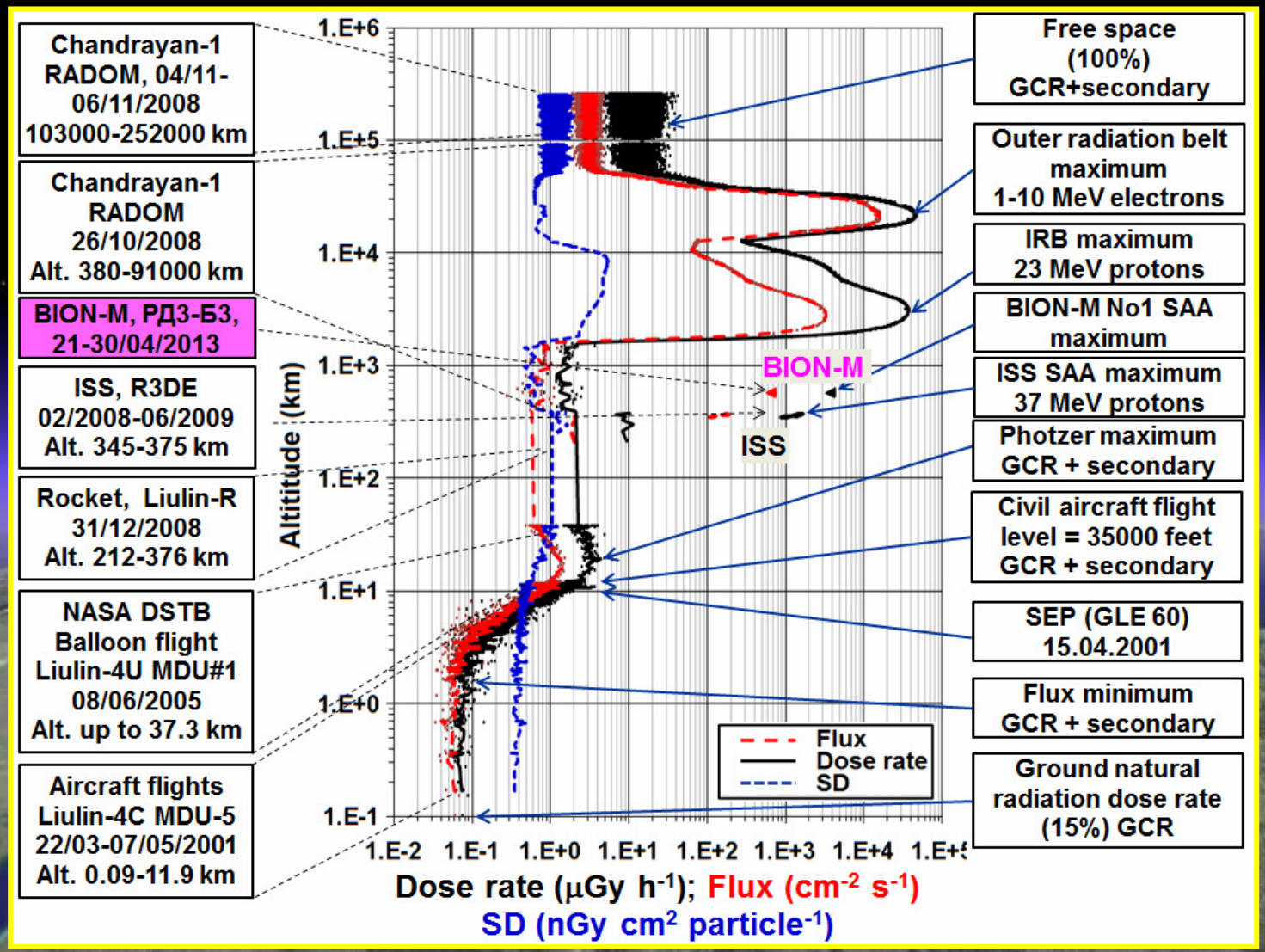
Unufied database...

Example of the dose distribution in near Earth radiation environment on the base of R3D-B2 measurements on Foton M2 spacecraft in June 2005





The space radiation profile from ground to free space was experimentally confirmed by Liulin data



*Dachev, T.P., Profile of the ionizing radiation exposure between the Earth surface and free space, Journal of Atmospheric and Solar-Terrestrial Physics, 102, September 2013, 148–156, 2013, 1.596
http://dx.doi.org/10.1016/j.jastp.2013.05.015

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Bulgarian build space dosimetry instruments

“Liulin” is the name of small mountain close to Sofia

R3D means “Radiation Risk Radiometer-Dosimeter”

Bulgarian space radiation experiments on satellite and rocket

1. LIULIN, 04/1979 - 09/1994, Roscosmos, MIR space station, (Dachev et al., 1989); 1
2. RADIUS-MD, Mars-96 satellite, 1996, unsuccessful launch, (Semkova et al., 1994);
3. Liulin-E094, 05 - 08/2001, ESA-NASA exp. on the International space station (ISS), (Dachev et al., 2002, Wilson et al., 2007, Nealy et al., 2007, Slaba et al., 2011, Badavi, 2014, 2016); 2
4. R3D-B1, 2002, ESA-Roscosmos, Foton M1 satellite – unsuccessful launch;
5. R3D-B2, 1 - 12/06/2005, ESA-Roscosmos, Foton M2 satellite, (Häder et al., 2008); 3
6. Liulin-ISS, 09/2005- , Russian segment of ISS, (Panasyuk et al., 2007) (Currently at ISS);
7. Liulin-5, 06/2007- 05/2016, Russian segment of ISS, Semkova et al., 2012); 4
8. R3D-B3, 14 - 26/09/2007, ESA-Roscosmos, Foton M3 satellite, (Damasso et al., 2008);5
9. Liulin-Photo, 14 - 26/09/2007, ESA-Roscosmos, Foton M3 satellite, (Damasso et al., 2008);
10. R3DE, 02/2008 - 09/2009, ESA Columbus module of ISS (Dachev et al., 2012); 6
11. RADOM, 10/2008 - 08/2009, Indian Chandrayyan-1 satellite around Moon, (Dachev et al., 2011);
12. R3DR, 03/2008 - 08/2009, ESA-Roscosmos, EXPOSE-R, Zvezda, ISS, (Dachev et al., 2012); 7
13. Liulin-Phobos, Russian Phobos-Ground, 2011, – unsuccessful launch, (Semkova et al., 2012);
14. RD3-B3, 04 - 05/2013, Roscosmos, BION-M1 satellite , (Dachev et al., 2014); 8
15. RD3-B3, 07 - 09/2014, Roscosmos Foton-M1 satellite, (Dachev et al., 2017a);
16. R3DR2, 10/2014 - 01/2016, ESA-Roscosmos, EXPOSE-R2, Zvezda, ISS, (Dachev et al., 2017b);9
17. Liulin-MO, since 14 March 2016 working at ESA-Roscosmos, ExoMars TGO satellite (Mitrofanov et al., 2017), (Currently at Mars orbit). 10

Unufied database...

Space experiments included in the database

First Liulin dosimeter-radiometer was developed for the program of the second Bulgarian cosmonaut A. Alexandrov It was successfully flown on Mir space station between 1988 and 1994

Control Block:
Size: 300x220x170 mm
Weight: 10.5 kg

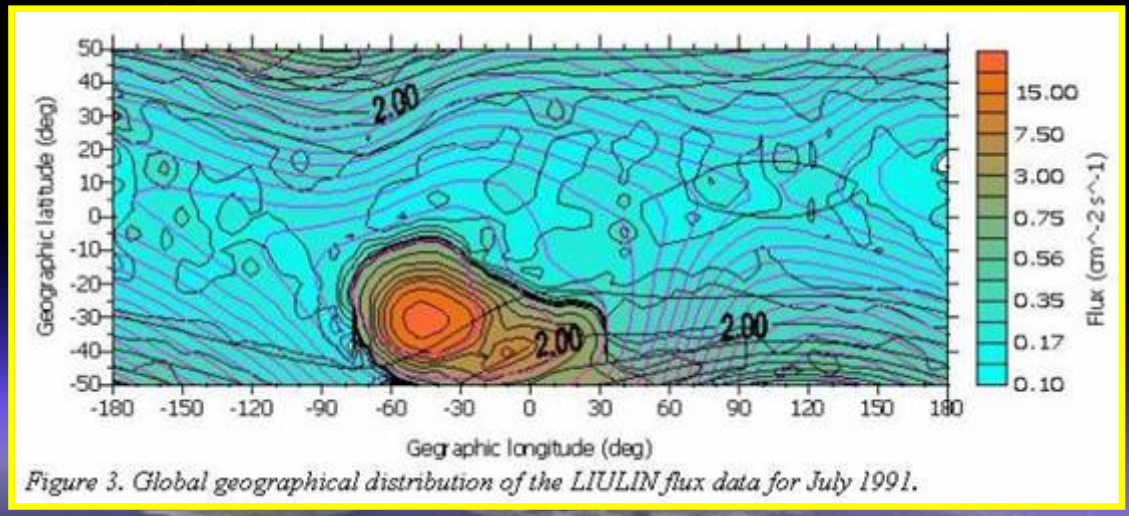
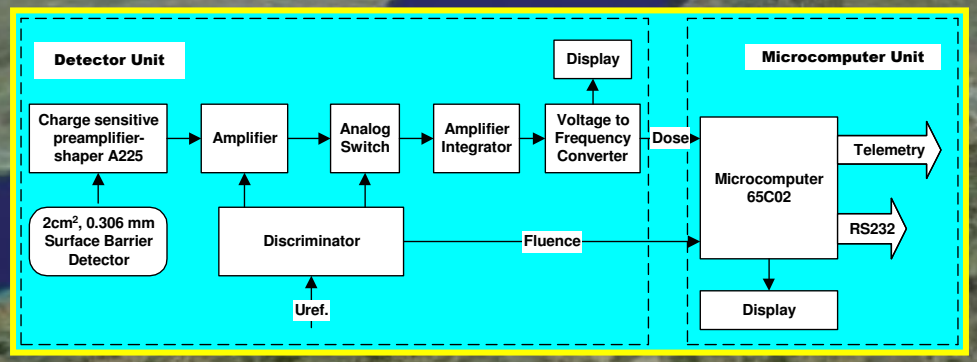


Figure 3. Global geographical distribution of the LIULIN flux data for July 1991.



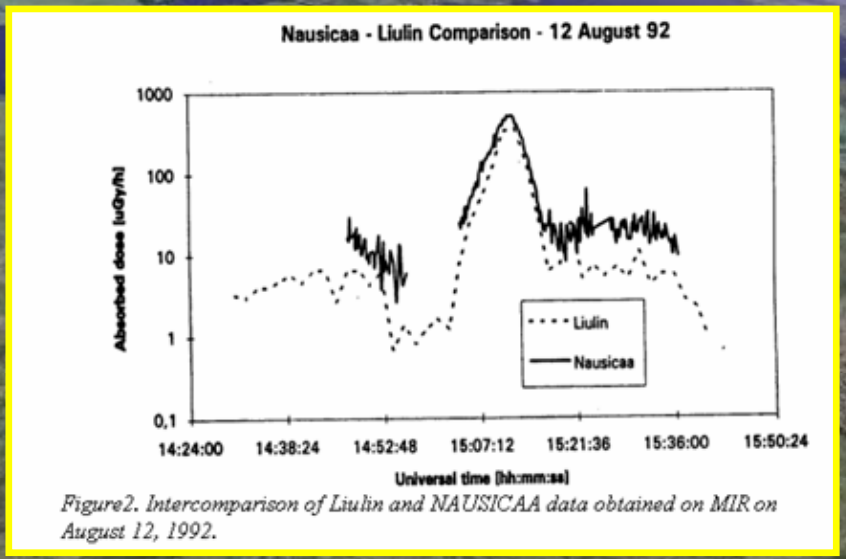


Figure2. Intercomparison of Liulin and NAUSICAA data obtained on MIR on August 12, 1992.

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Liulin-E094 instrument were used successfully on American Laboratory module May-August 2001 as a part of German lead Dosimetric mapping experiment

Liulin Control And Interface Unit (CIU)

Liulin Mobile Dosimetry Unit (MDU)

Liulin-E094

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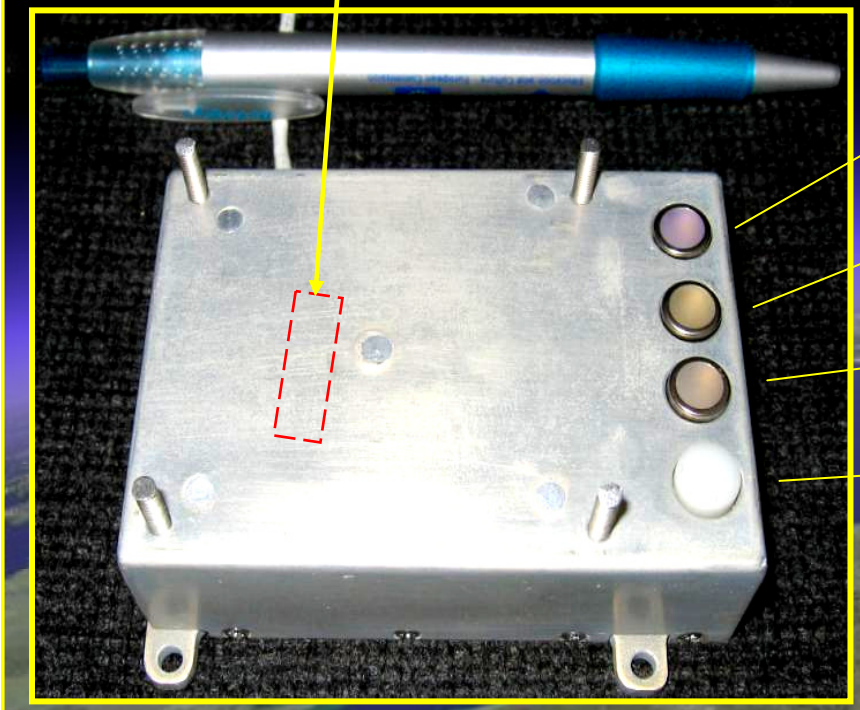
R3D-B2/B3 instruments for ESA Biopan 5/6 facilities outside of Foton M2/M3 satellites. The spectrometers are mutually developed with the University in Erlangen, Germany

3,5

Detector of 256 Channels

4 Channels UV spectrometer

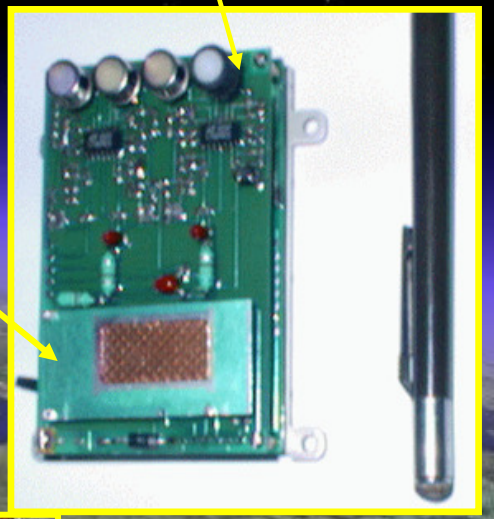


UV-C channel

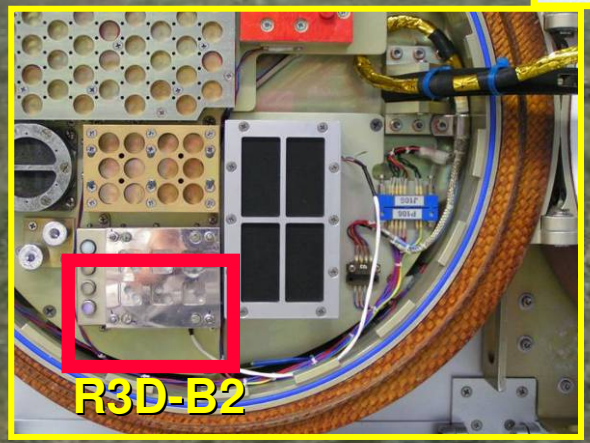
UV-B channel

UV-A channel

PAR channel



Size: 82x57x25 mm
Weight: 129 g
Consumption: 84 mW



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Liulin-5 dosimetric telescope is a part of Matroska-R facility. The telescope is jointly developed with IMBP, Moscow Russia. Matroska experiment is a mutual between ESA and Russia and was launched toward ISS in June 2007. It was active till 2015.

Weight 0.57 kg; P = 330 mW

Liulin-5 in the spherical phantom on PIRS module of ISS

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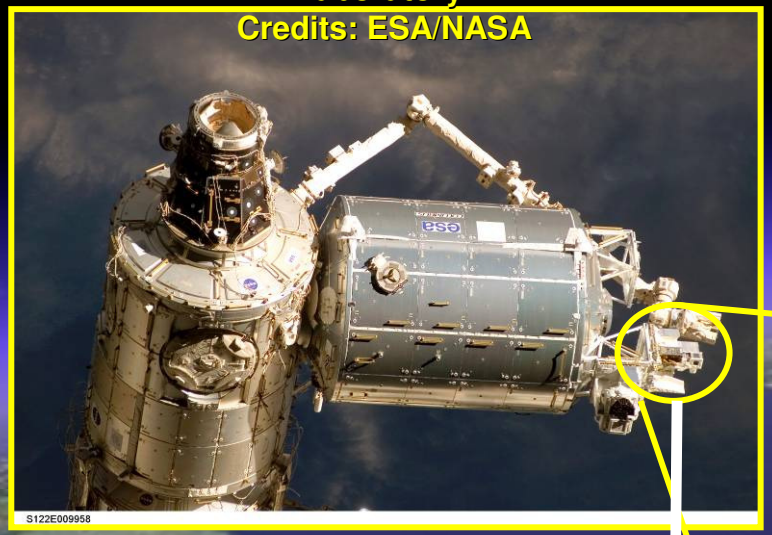
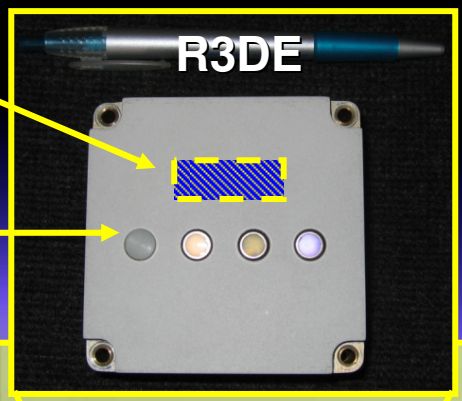
R3DE instrument, which is a part of the ESA EXPOSE facility worked continuously on the EuTEF platform of Columbus module on International space station from February 2008 to September 2009

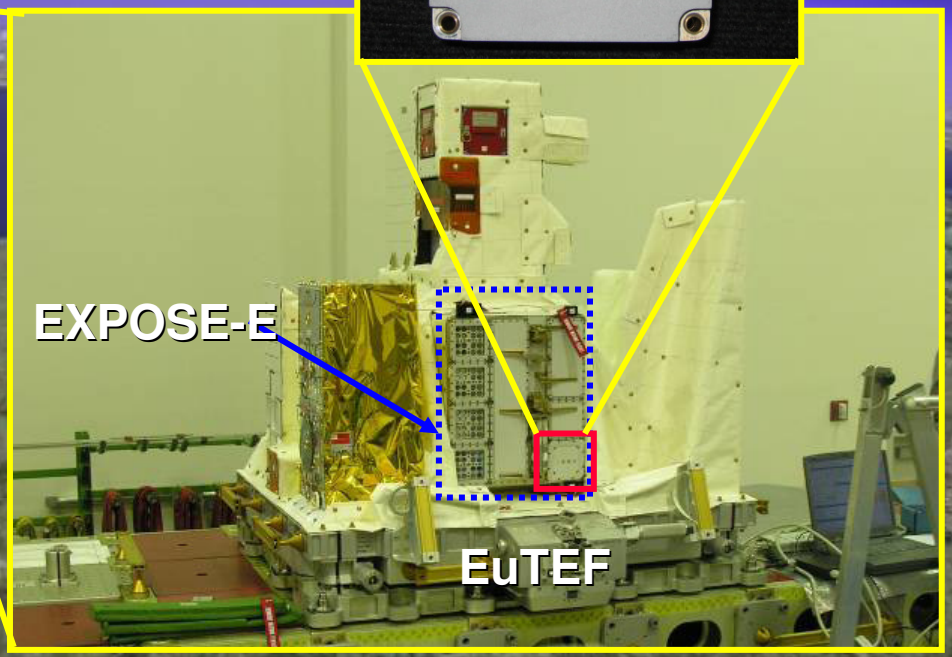
A close-up view of the Columbus laboratory
Credits: ESA/NASA



The detector of R3DE instrument is shielded by less than 0.4 g/cm^2 material including: 1 mm aluminum + 0.1 mm cuprum +0.2 mm plastic. This allows direct hits on the detector by electrons with energies higher than 0.78, MeV and protons with energies higher than 15.8 MeV

+Z





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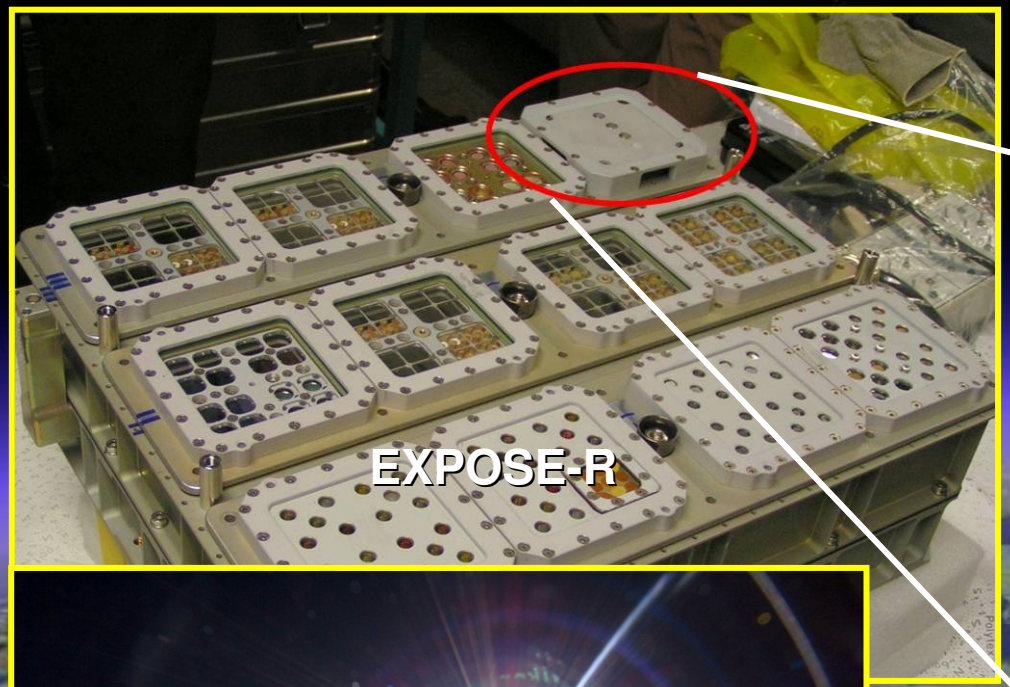
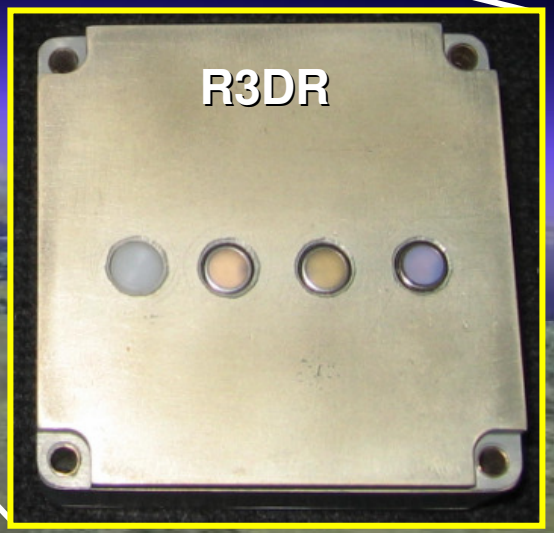
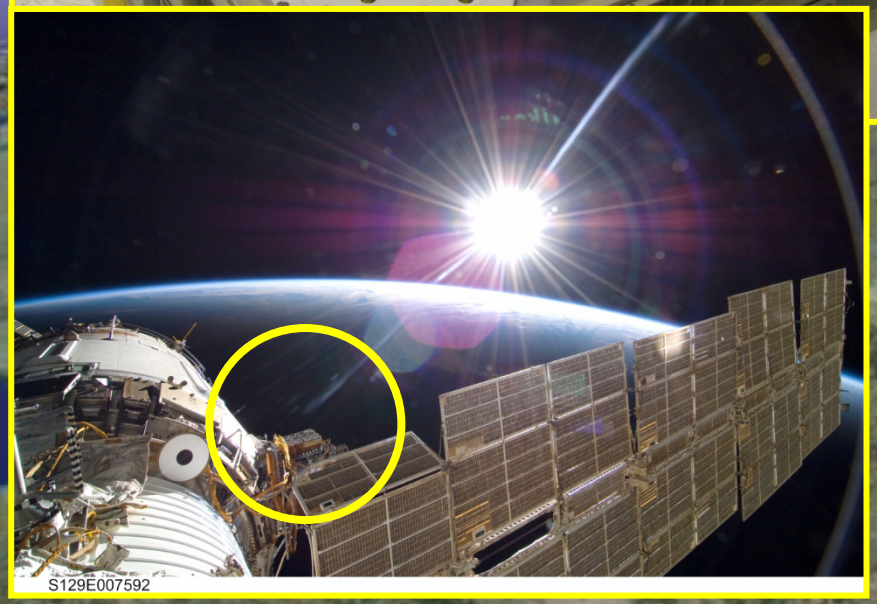
R3DR instrument as part of ESA EXPOSE-R facility worked at the Russian segment of ISS between March 2009 and August 2010







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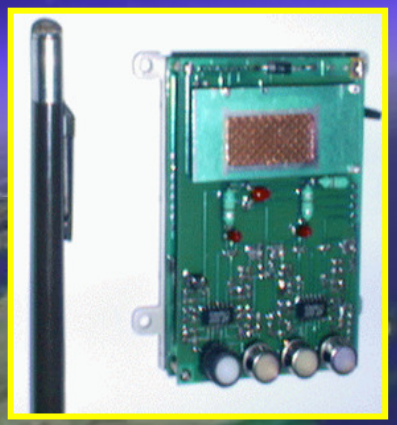
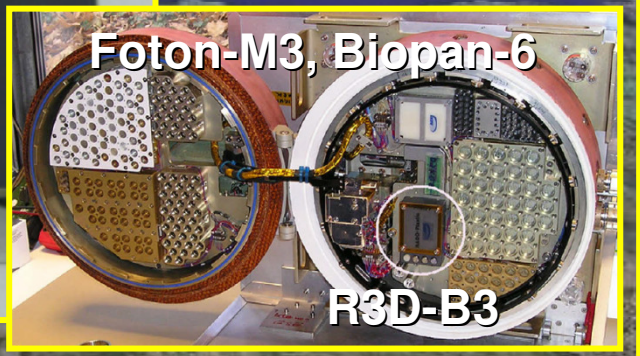
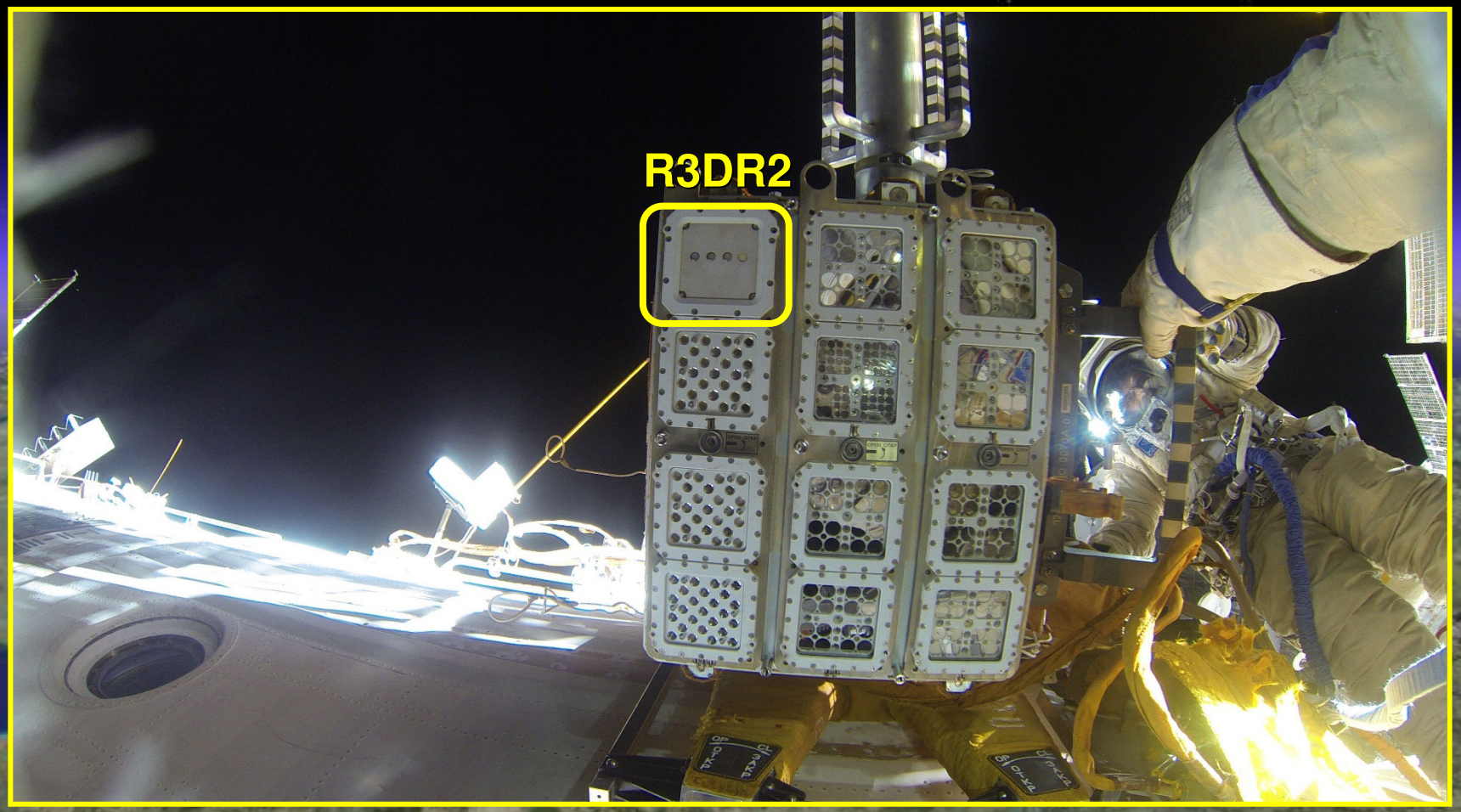
ИКИТ-БАН в сотрудничестве с Университетом в г. Эрланген, Германия и Институтом медико-биологических проблем, Россия, участвовал в эксперименте на спутнике “БИОН-М” №1 с прибором РЗД-БЗ

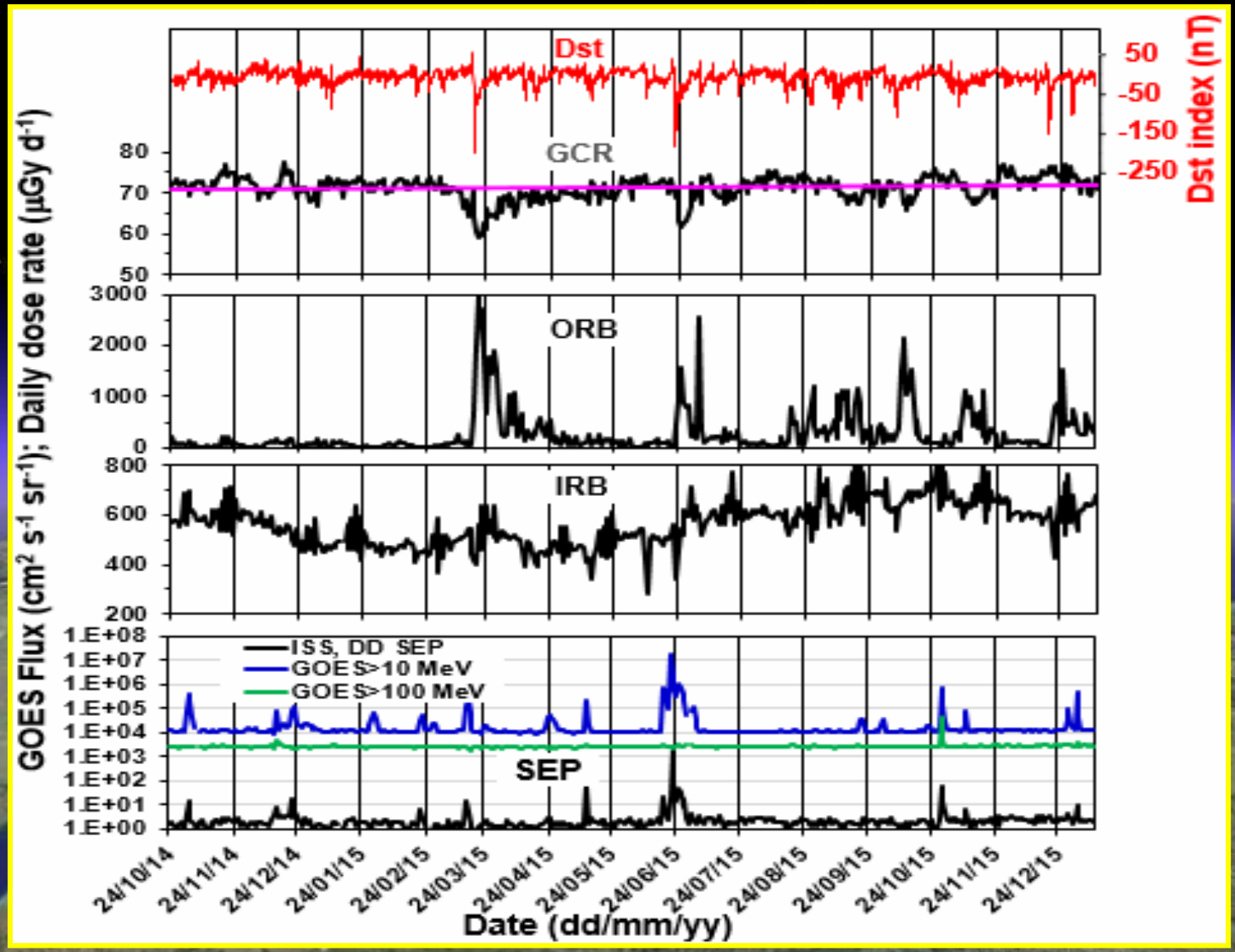




External view of R3DR2 instrument (in the red square) as mounted in the EXPOSE-R2 facility. (Picture taken by Russian cosmonaut G. Pedalka (only his arm is seen in the left-upper corner, while cosmonaut M. Kornienko is seen in the left middle plan) on 15 August 2015 during EVA for examination EXPOSE-R2 facility outside Russian "Zvezda" module.) (Picture credit of ESA/RKA).



Final result of the separation of the R3DR2 instrument data for the period 24 October 2014-11 January 2016 in four radiation sources*



*Dachev, T. P., N. G. Bankov, G. Horneck, D.-P. Häder; Letter to the Editor. *Radiat Prot Dosimetry,* 174 (2), 292-295, 2017, https://doi.org/10.1093/rpd/ncw123.

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Orbital station ExoMars-TGO. The disk in the right part of the figure is the EDM landing module

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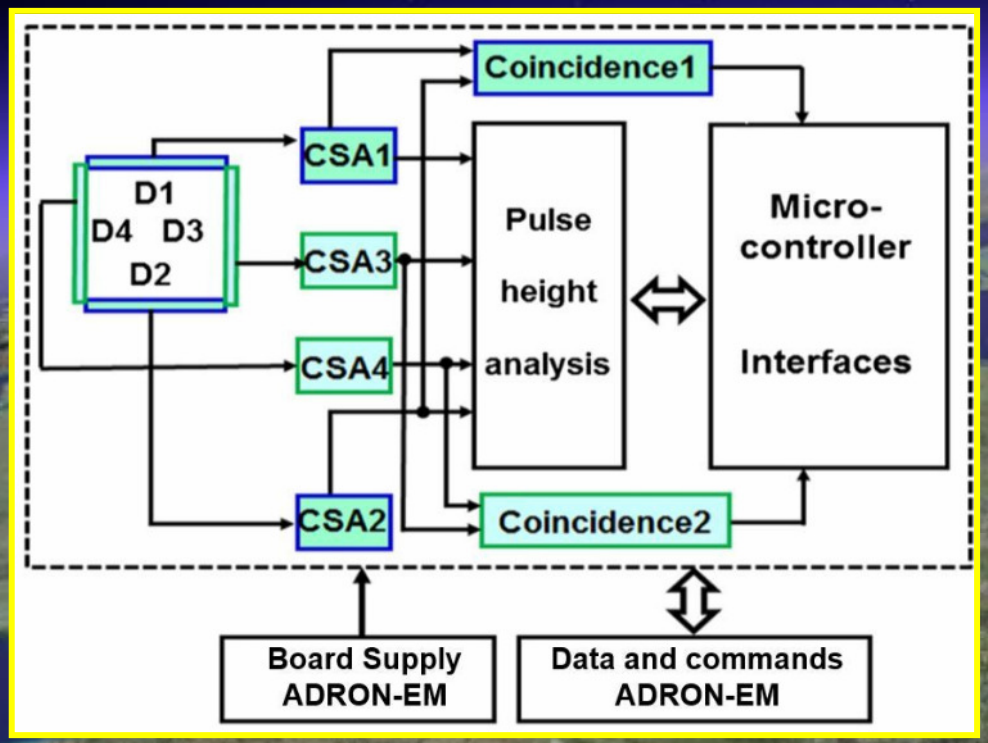
Functional scheme and external view of the "Liulin-MO" dosimeter



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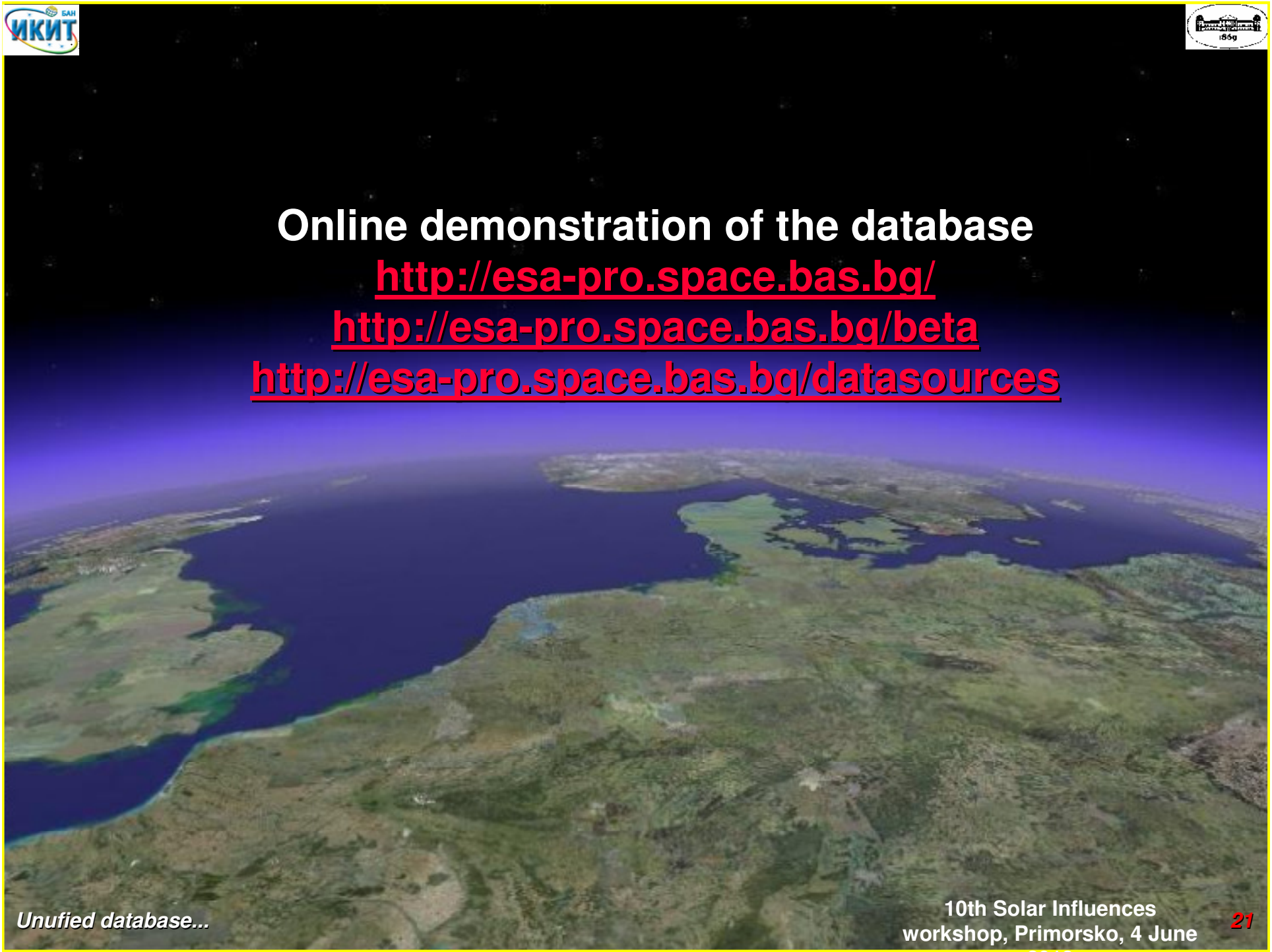


Online demonstration of the database

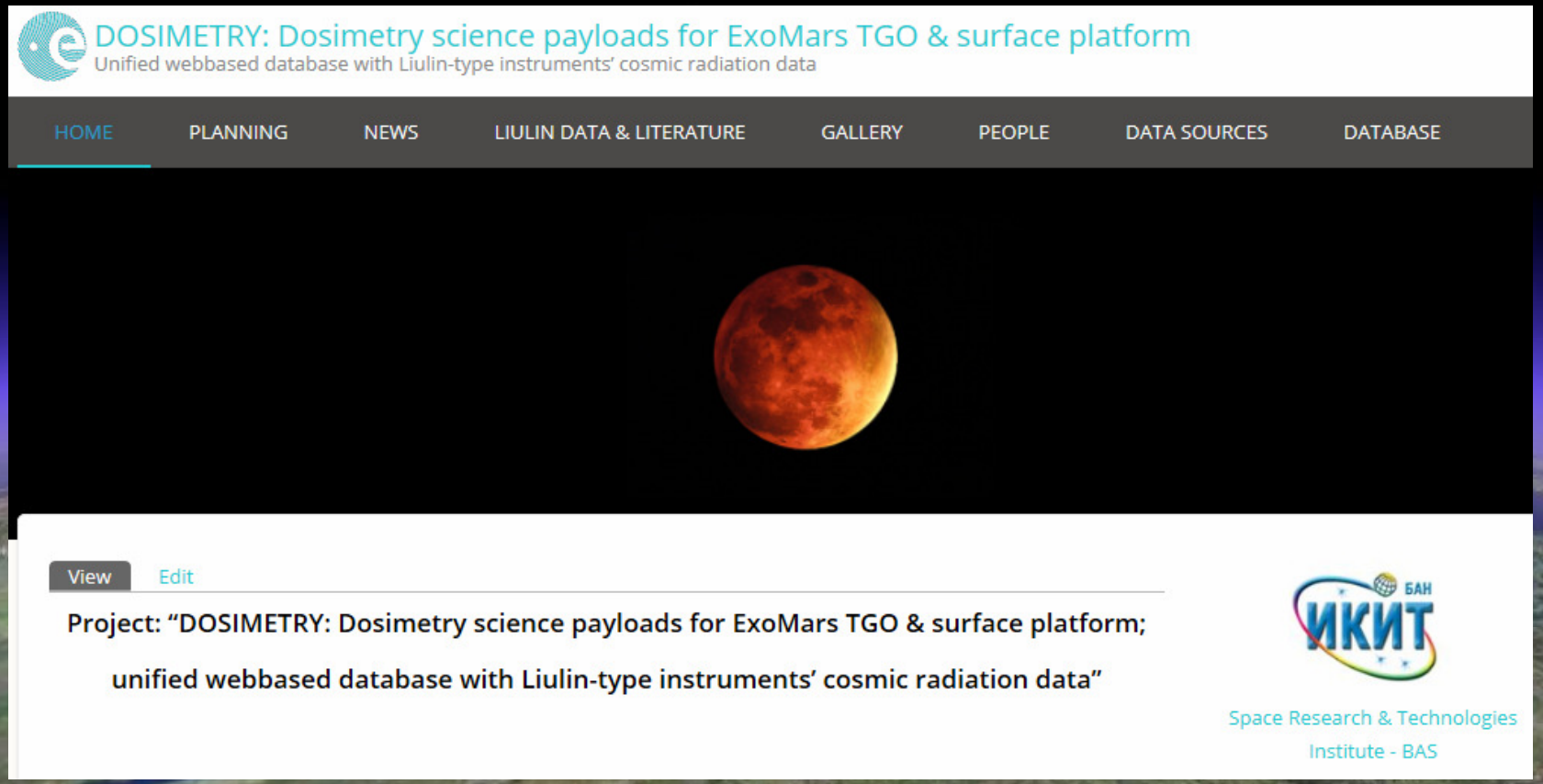
http://esa-pro.space.bas.bg/

http://esa-pro.space.bas.bg/beta

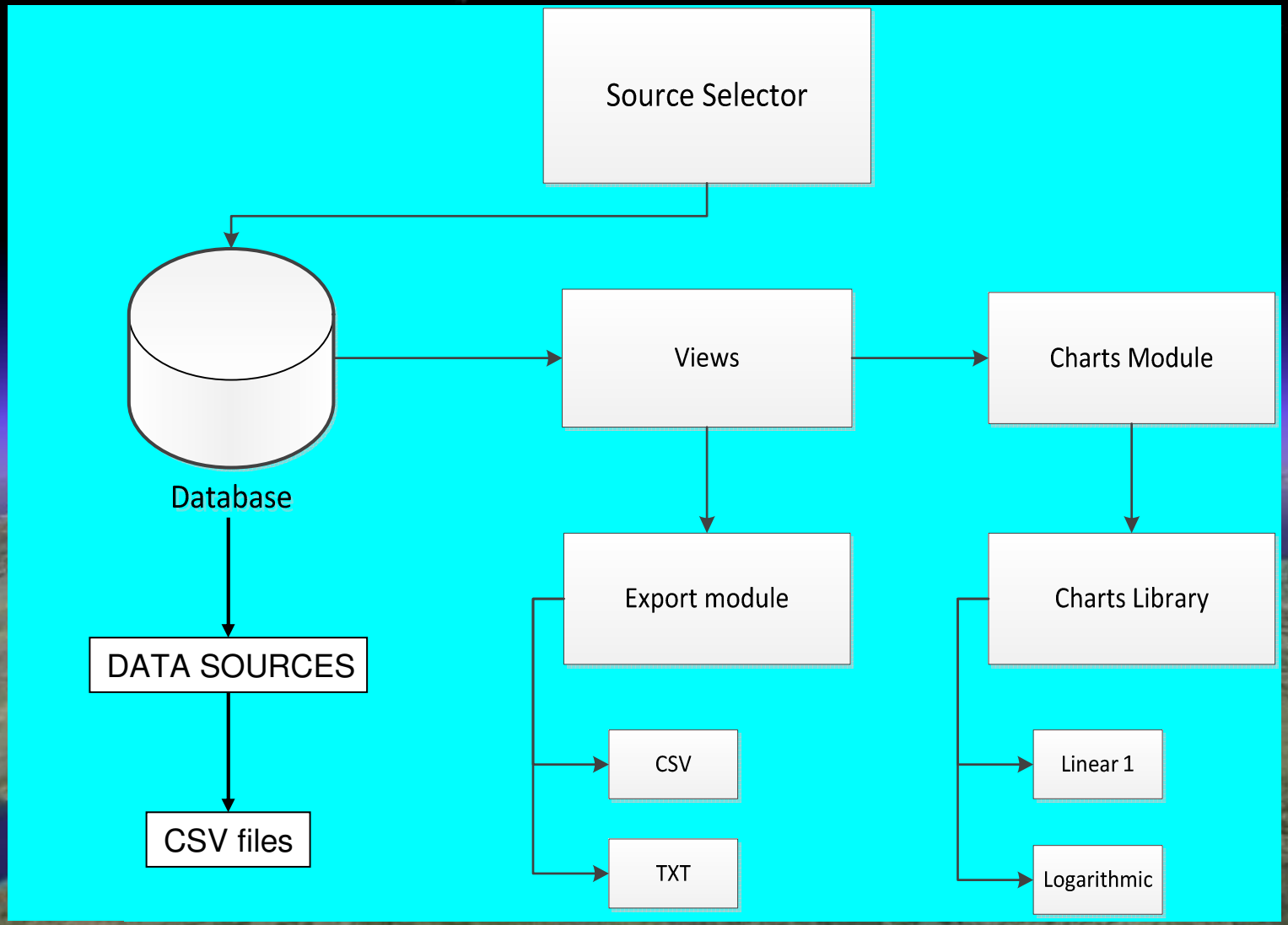
http://esa-pro.space.bas.bg/datasources

Home page of the site

http://esa-pro.space.bas.bg/

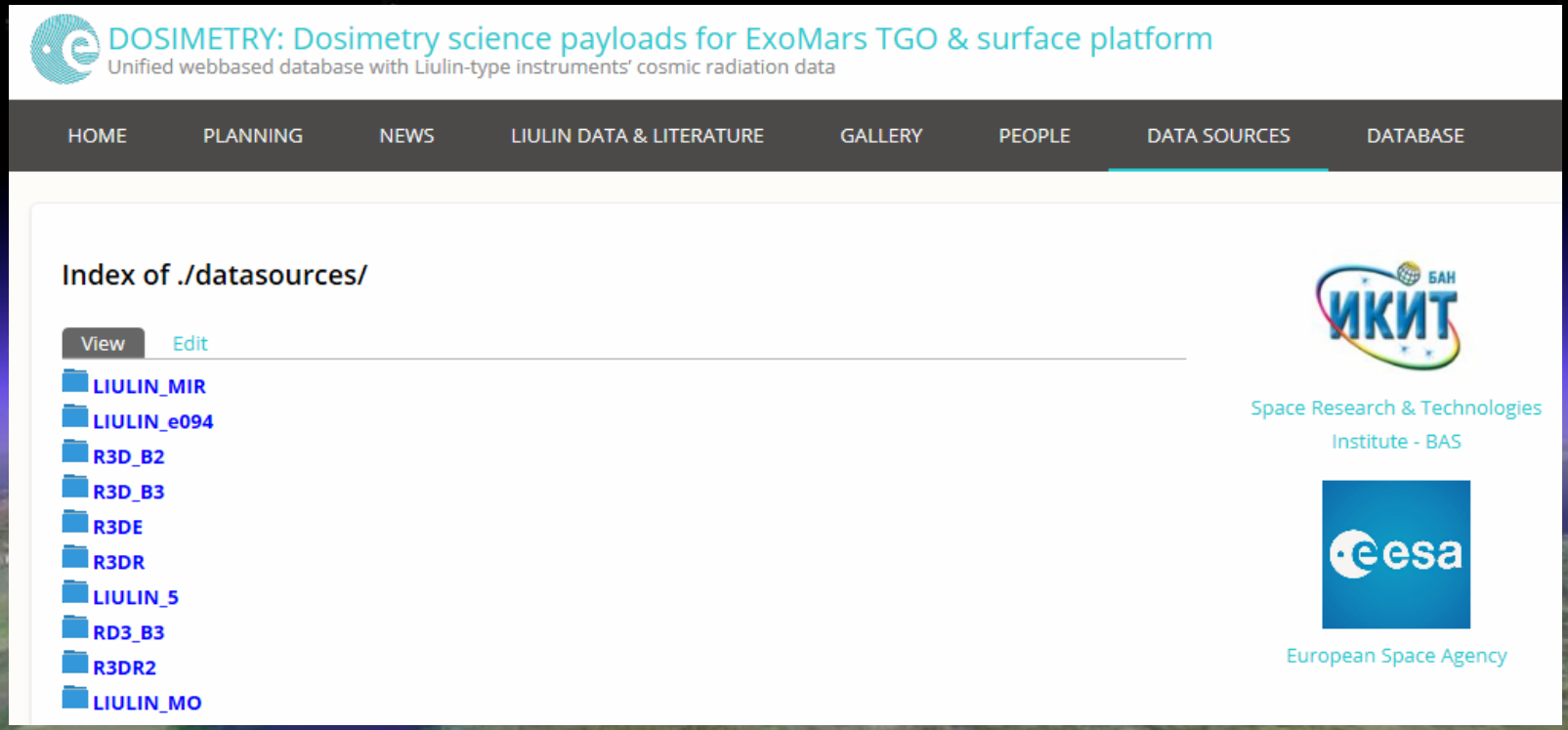


Software architecture



DATA SOURCES

http://esa-pro.space.bas.bg/datasources



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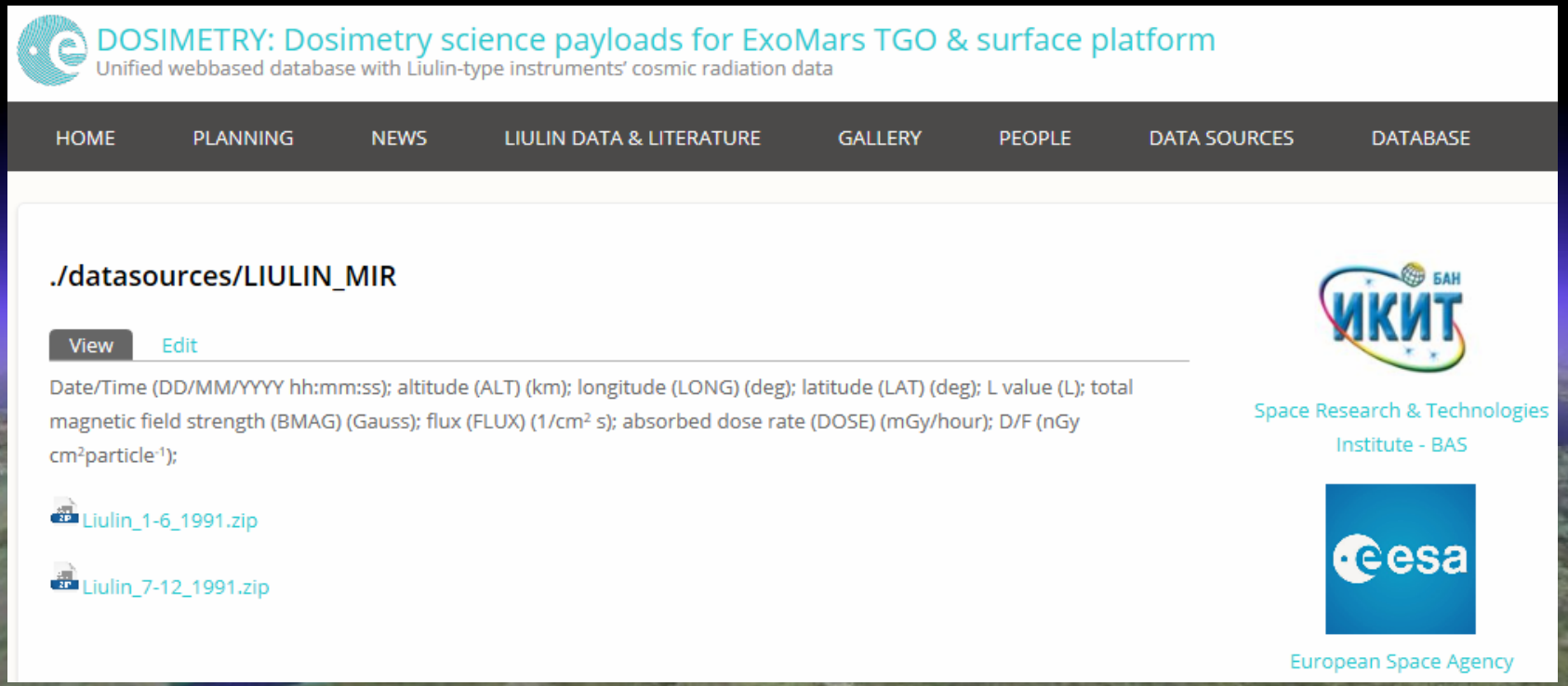
LIULIN_MIR data sources

http://esa-pro.space.bas.bg/datasources/LIULIN_MIR



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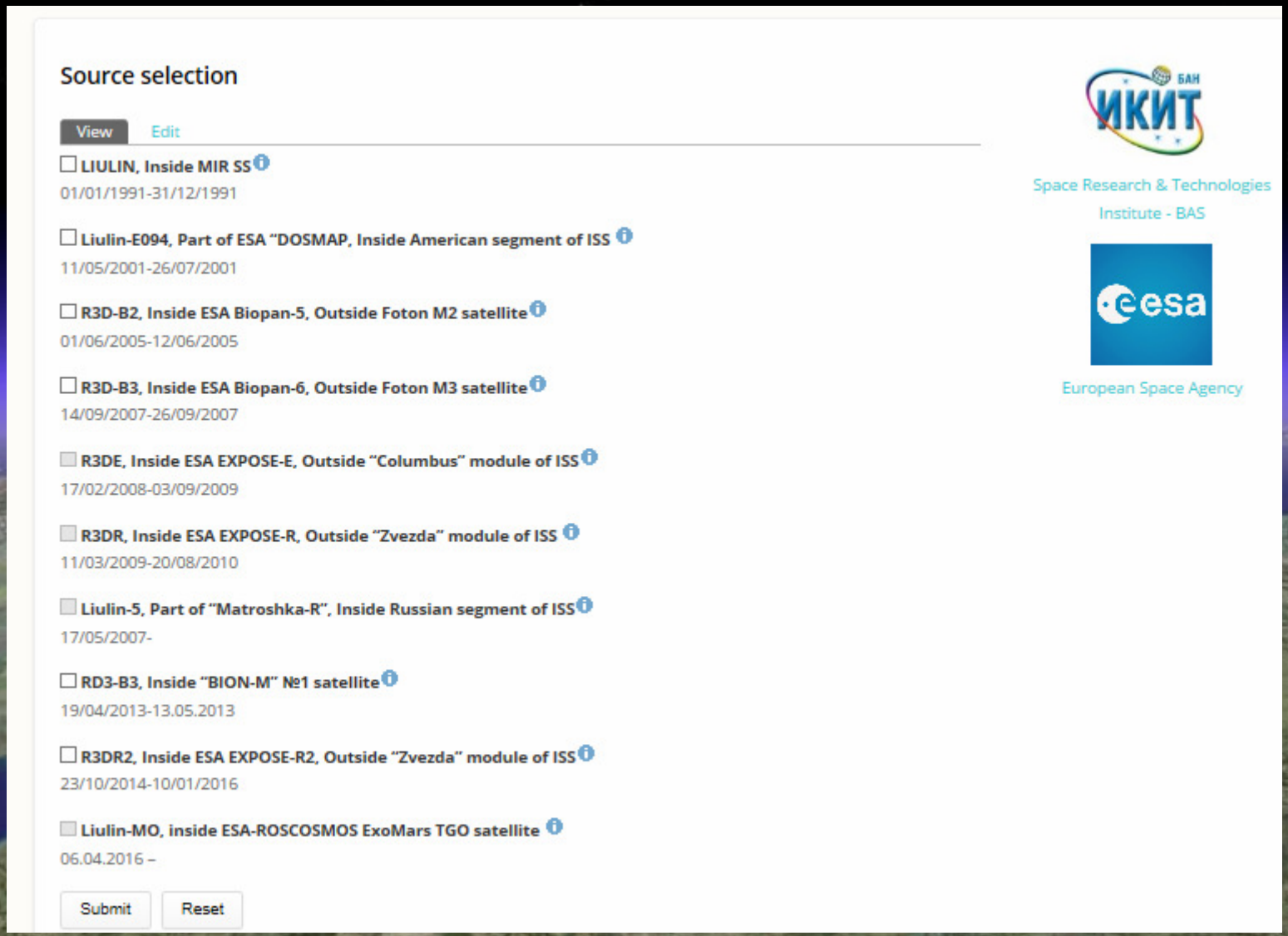
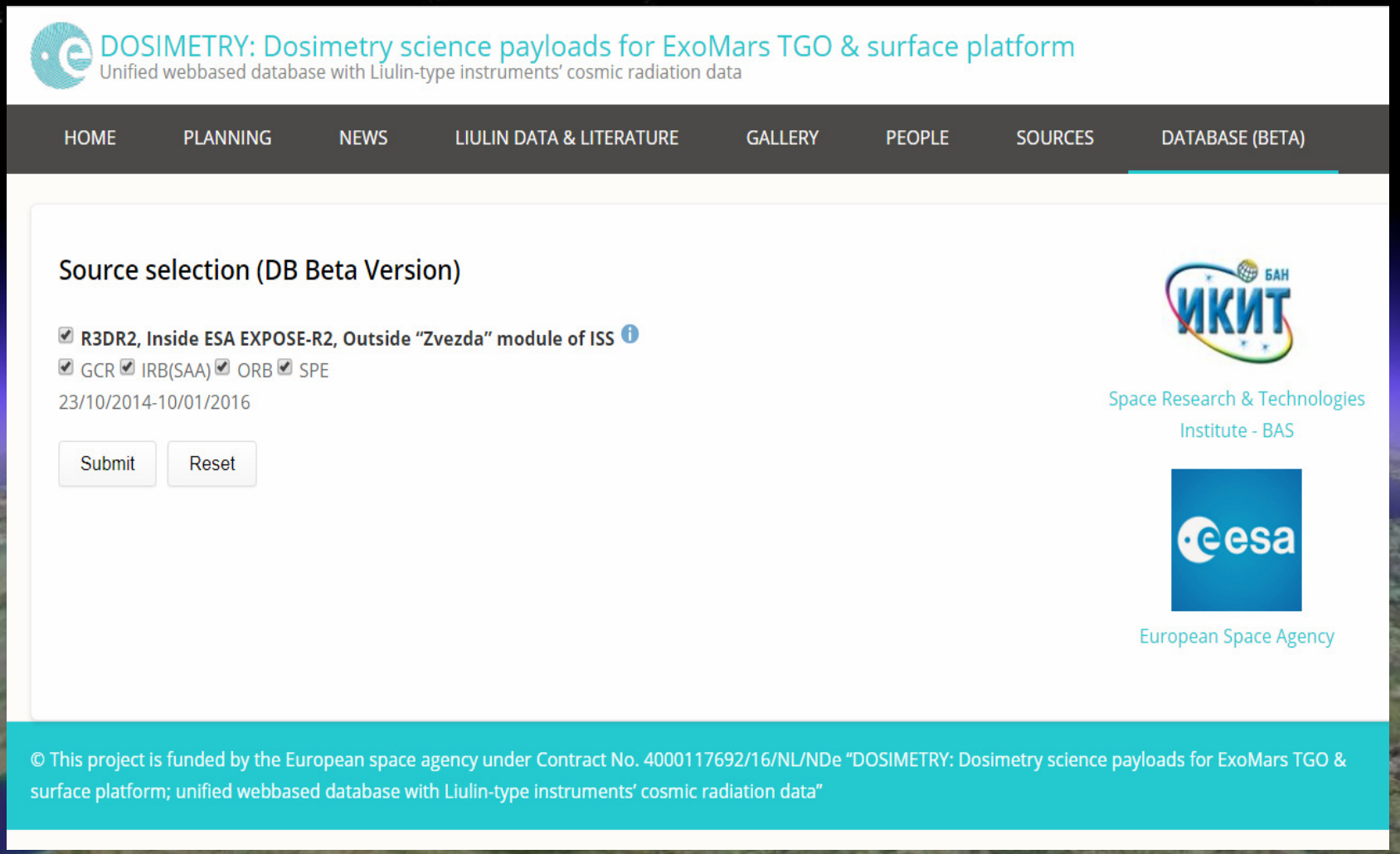
Source selection

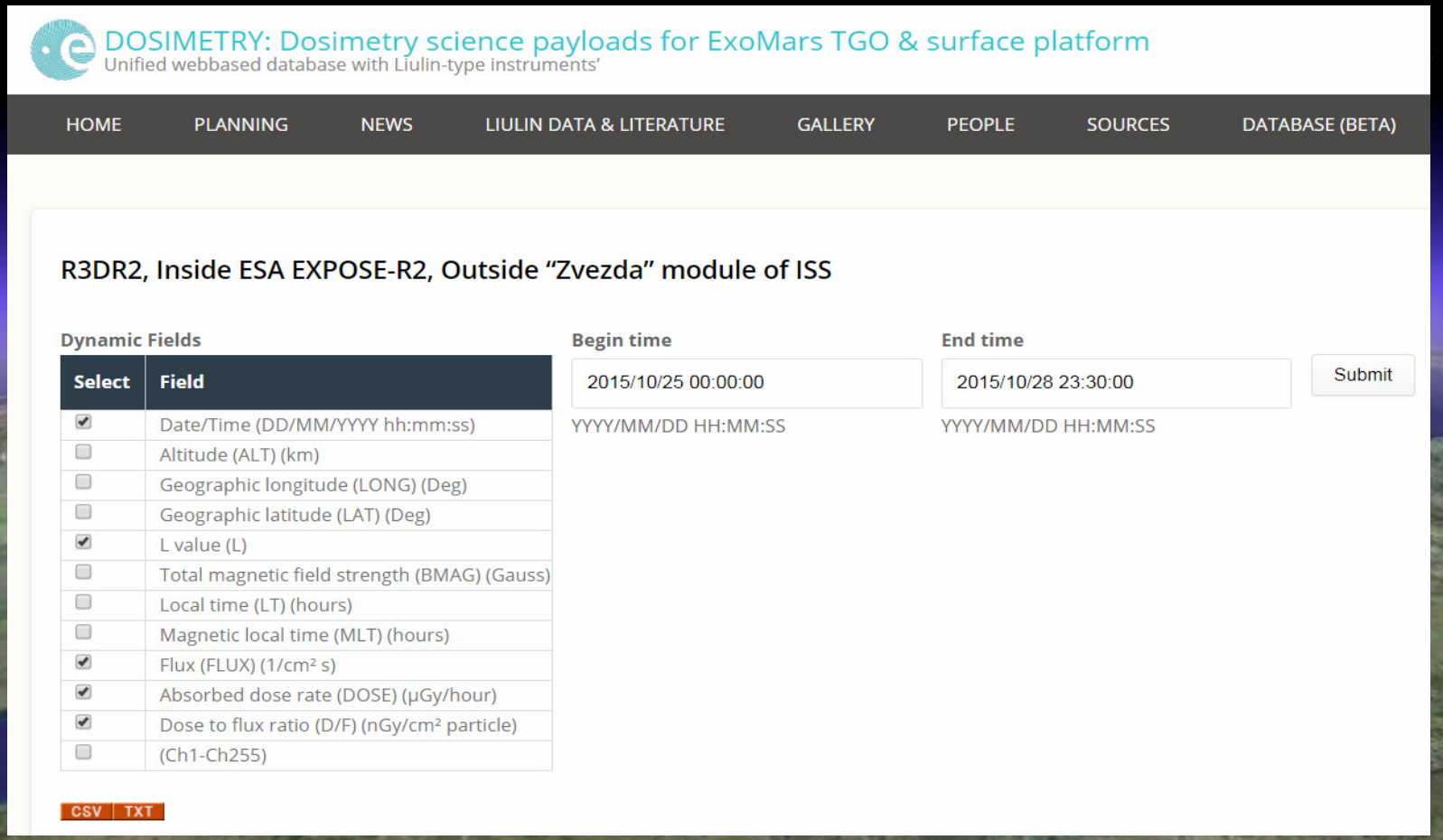
http://esa-pro.space.bas.bg/beta



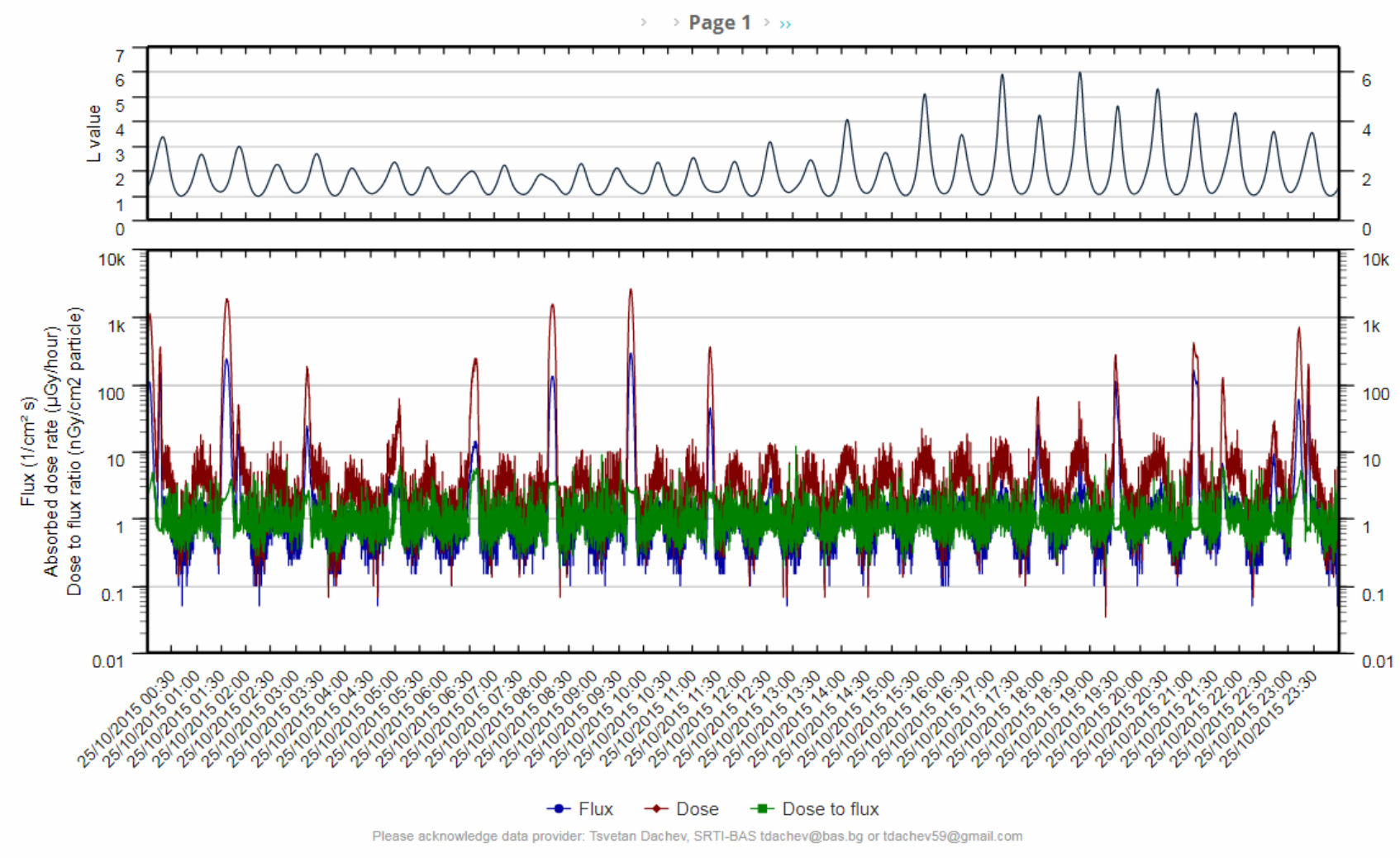
Choose “R3DR2” press “Submit”



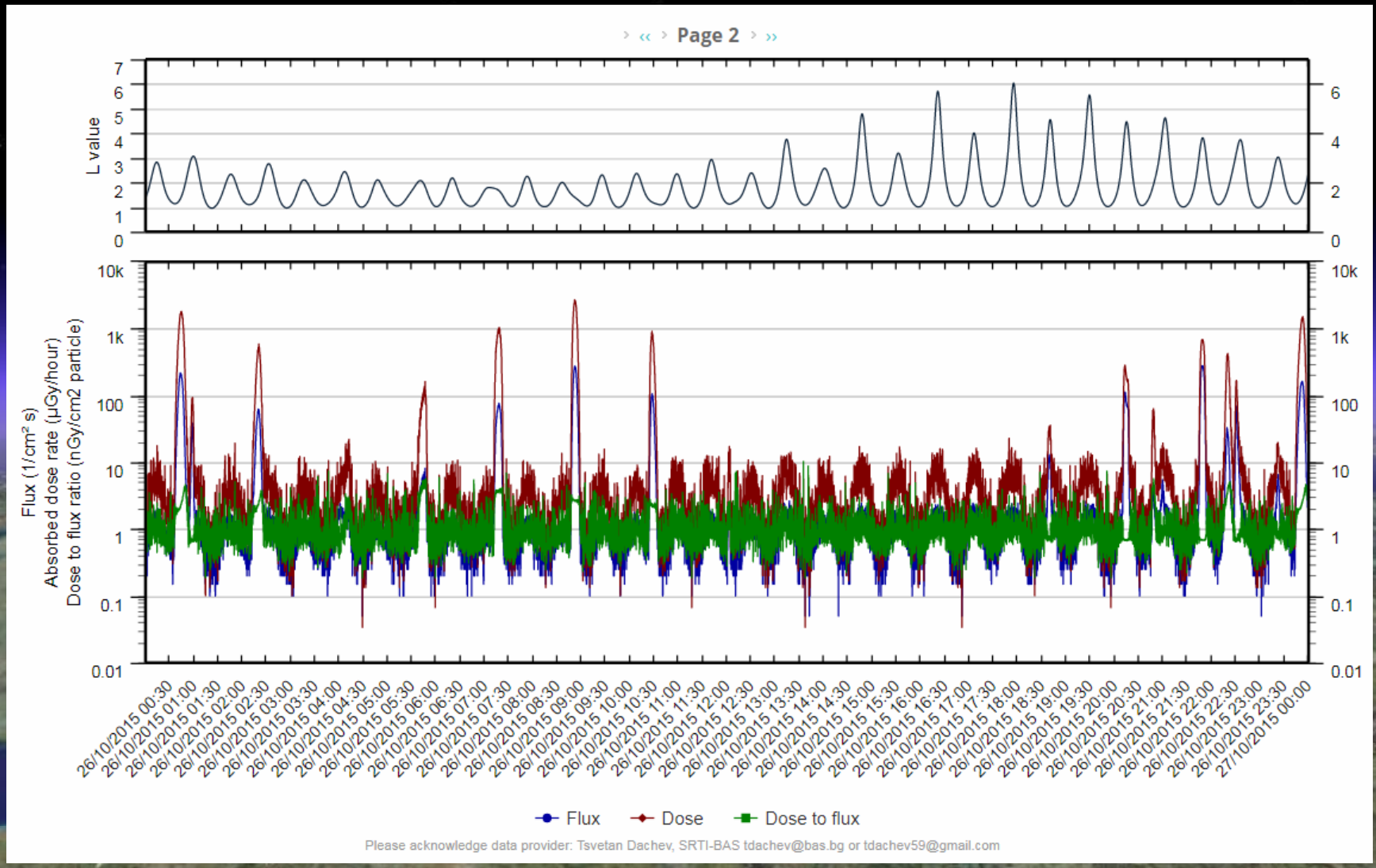
Choose the time interval* (in the example: 2015/10/25 00:00:00-2015/10/28 00:00:00) and variables (in the example: Date/Time/; L value (L); Flux; Absorbed dose; Dose to flux ratio) (* if the time interval is larger than 24 hours than the software divide the output pictures at 24 hours)



OPTION 1*: Receiving graphics* - press “Submit”. As a result you obtain the following figures (Page 1; 25/10/2015)



OPTION 1*: Receiving graphics* - press “Next page”. (Page 2; 26.10.2015)



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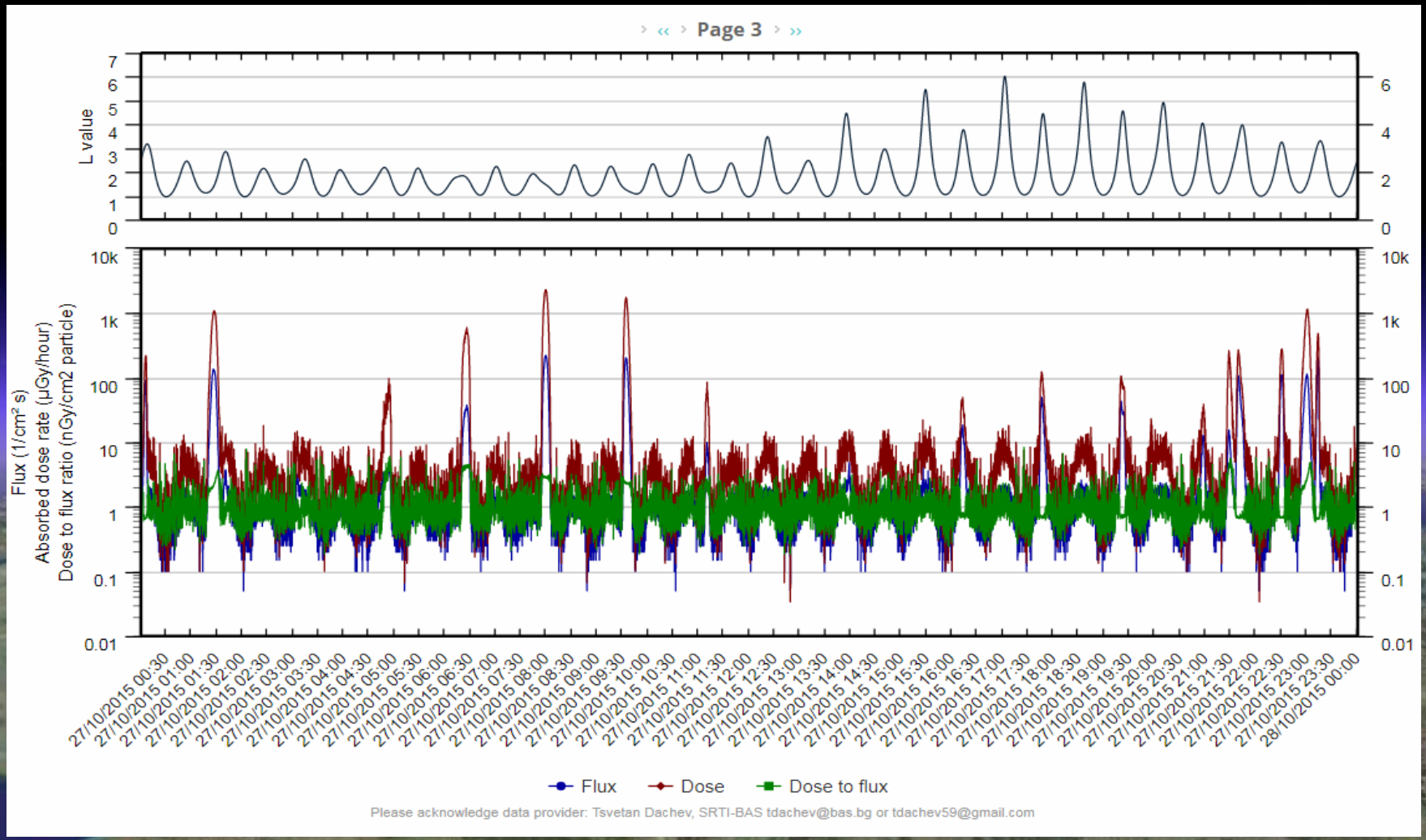
OPTION 1*: Receiving graphics* - press "Next page". (Page 2; 27.10.2015)



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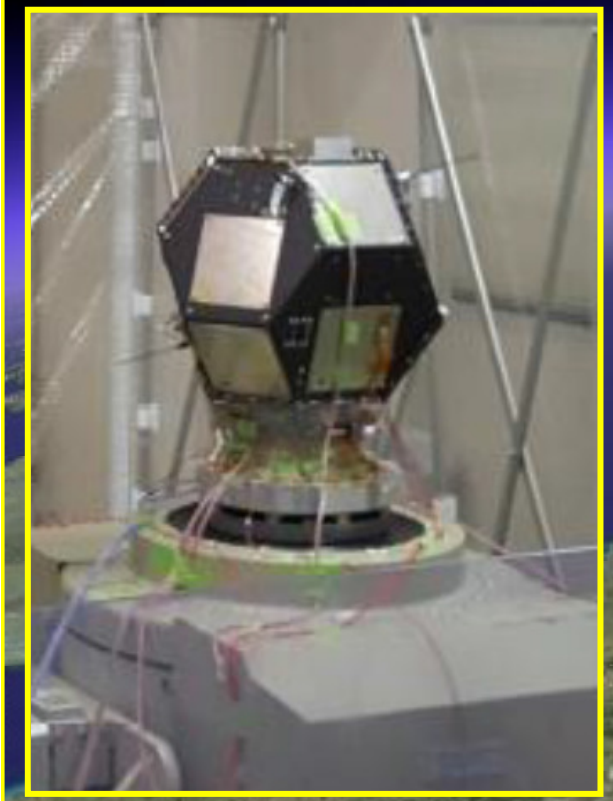
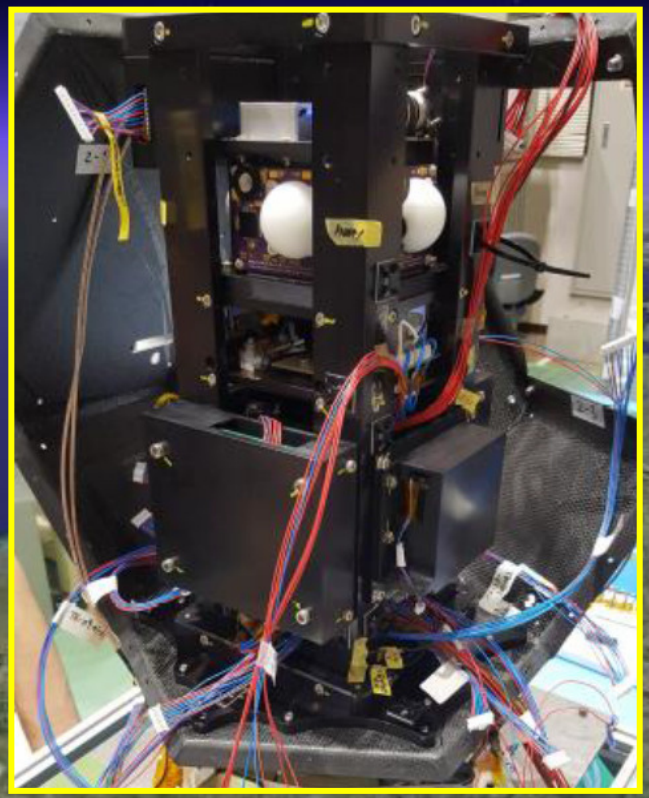
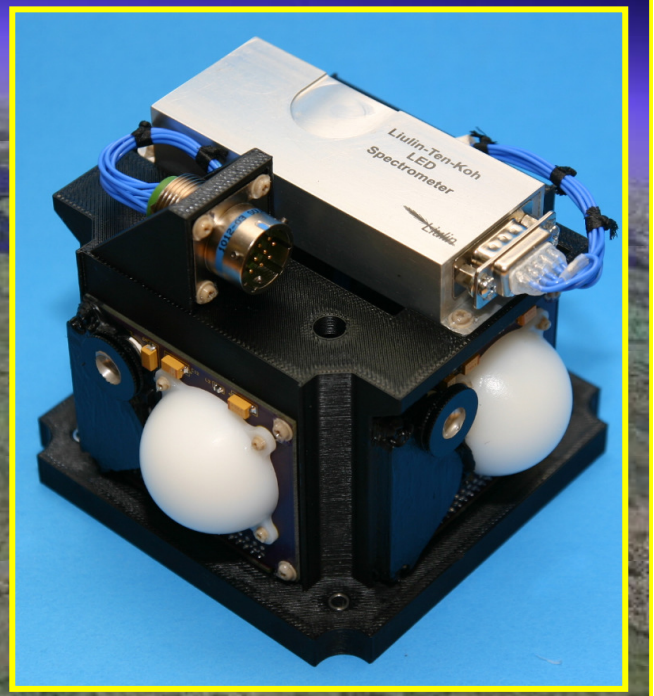
Liulin-Ten Koh spectrometer for radiation environment observation on the Japanize Ten-Koh satellite at 600 km orbit

2018

Kei-Ichi Okuyama, Kyushu Institute of Technology, Japan
Premkumar Saganti, Prairie View A&M University, Prairie View, Texas, USA
S. Douglas Holland, NASA / Johnson Space Center, USA
T. Dachev, Space Research and Technologies Institute, Bulgarian Academy of Sciences, Bulgaria







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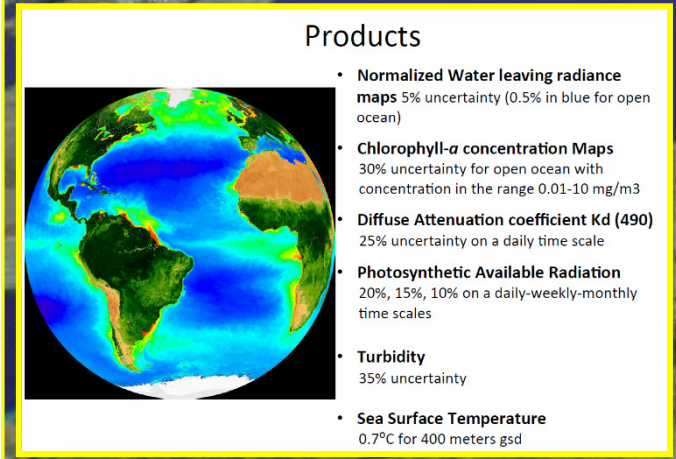
Liulin-AR spectrometer for radiation environment observation on SABIA-MAR 1 satellite

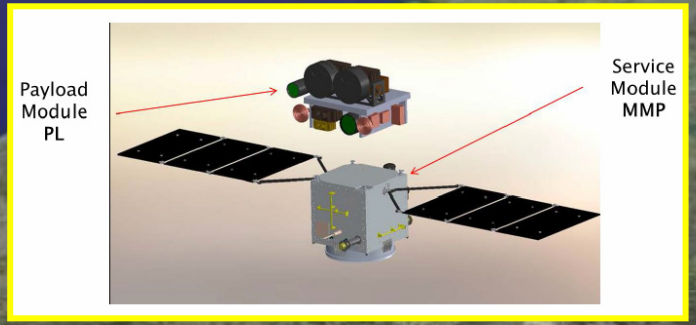
2020

T. Dachev[1], A. Zanini[2], M. Colazo[3], D. Caruso[3], V. Ciancio[4]

[1]Space Research and Technologies Institute, Bulgarian Academy of Sciences, Bulgaria, tdachev@bas.bg
[2]Istituto Nazionale di Fisica Nucleare, Sez. Torino, Torino, Italy, zanini@to.infn.it
[3]Comisión Nacional de Actividades Espaciales, Buenos Aires, Argentina, caruso@conae.gov.ar,
[4]Universitad National de La Plata, La Plata, Argentina, ciancio@netverk.com.ar

The SABIA-Mar (Satélite Argentino Brasileño para Información del Mar) is a dual satellite joint Argentine-Brazilian Earth observation mission, which objective is to study the oceanic biosphere, its changes along time and how it is affected and reacts to human activity. The Argentinian SABIA-Mar 1 satellite is planned to be launched at 702 km sun-synchronous circular orbit in 2021. The platform and the instruments for ocean color observation and sea surface temperature determination are: 1. developed and built in Argentina. A Liulin instrument for determination and quantification of the global distribution of the 4 possible primary sources of space radiation outside the satellite: The Liulin -R dimensions are 10x40x20 mm and weight of 0.092 kg.





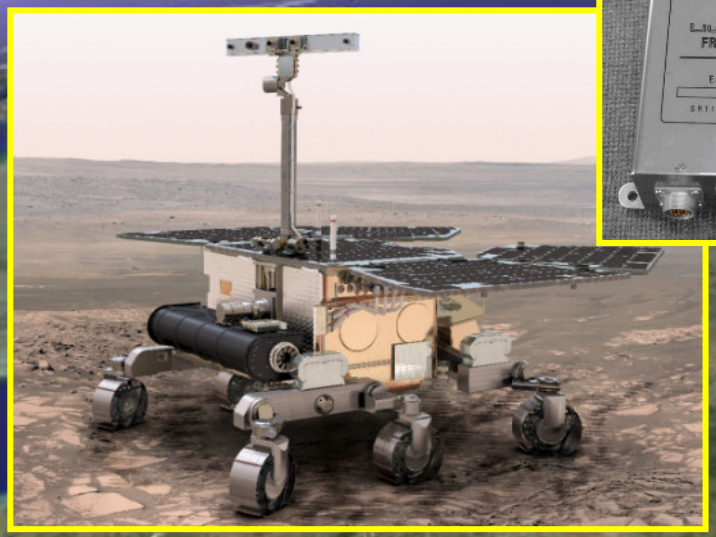
The SABIA-Mar satellite

The Liulin-AR instrument

Unufied database...

The Liulin-ML instrument is under development for the ESA-Roscosmos ExoMars 2020 (ESA project: "DOSIMETRY: Dosimetry science payloads for ExoMars TGO & surface platform" http://esa-pro.space.bas.bg/)

20. 07. 2020



ESA's ExoMars Rover

Roscosmos ExoMars Surface platform

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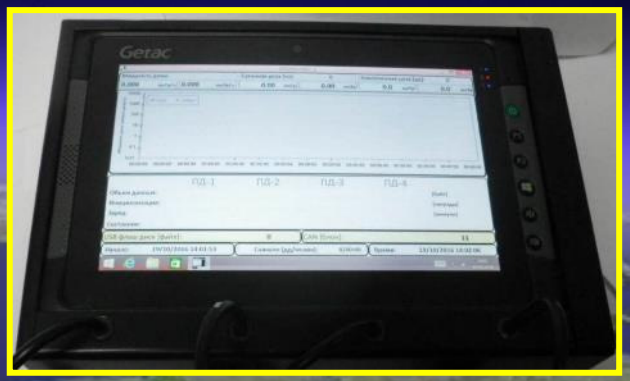
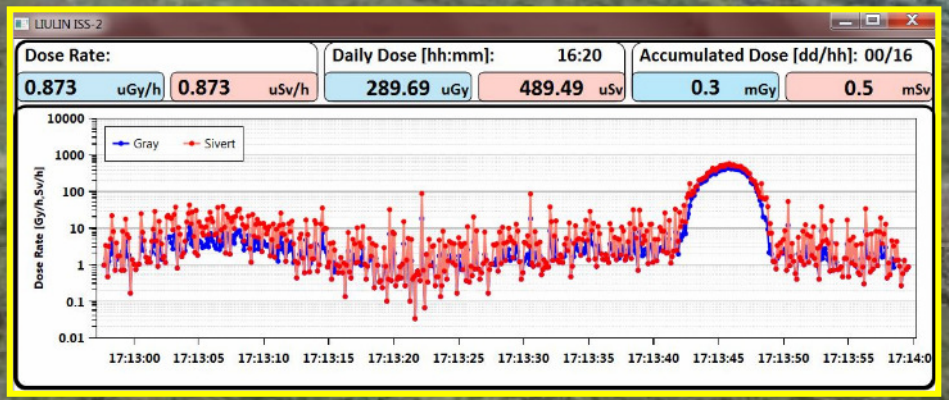
The Lyulin-MKS-2 is being developed from 2014 to 2018. The aim is to create an service dosimetric system for monitoring the personal dose of crew members in the Russian segment and outside the ISS

The instrument's priority is to measure the dynamics of dose accumulation during exit into open space. Similar measurements of “MIR" and ISS have not been done so far!

2020





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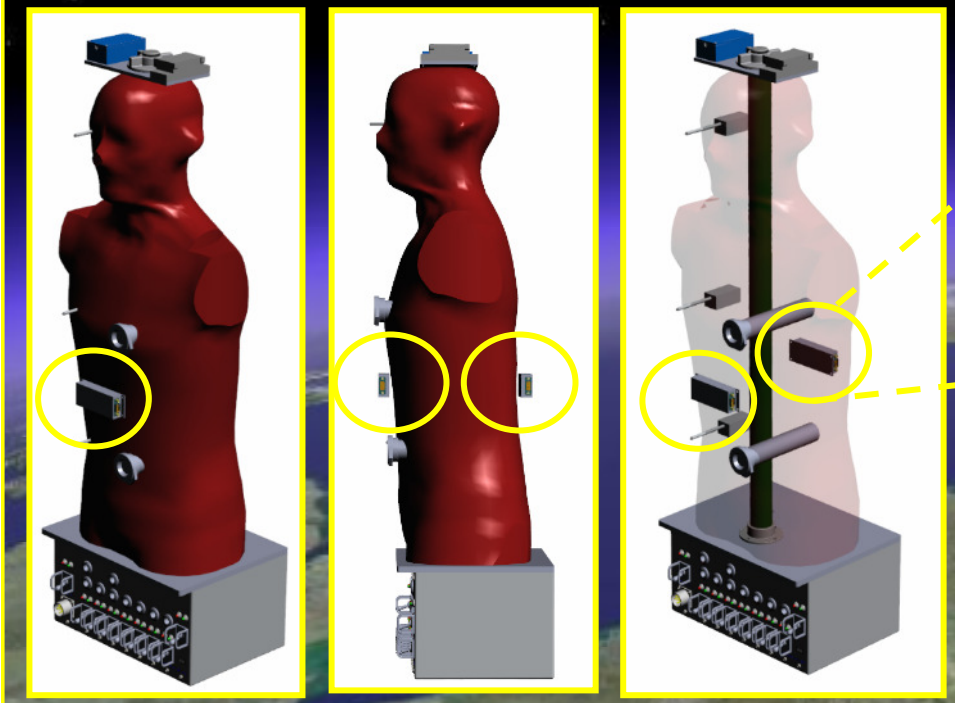
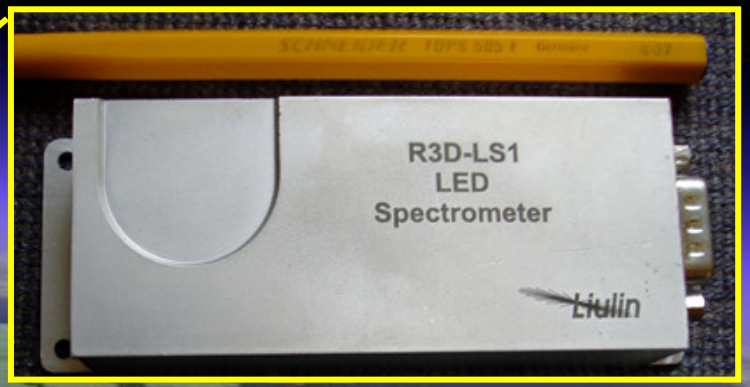
2 Liulin-AF instruments are part of the Matroshka III research project with participants from Germany, Japan, Poland, Hungary, Russia and Bulgaria to study the dynamics of cosmic radiation accumulation in tissue-equivalent phantom in the Russian segment of ISS

2020



"Liulin-AF" spectrometers
location in the Matroshka-III Phantom



Expected appearance of
"Liulin-AF" spectrometers

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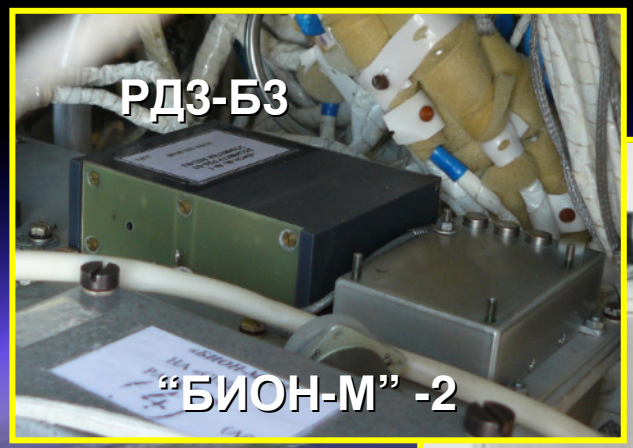
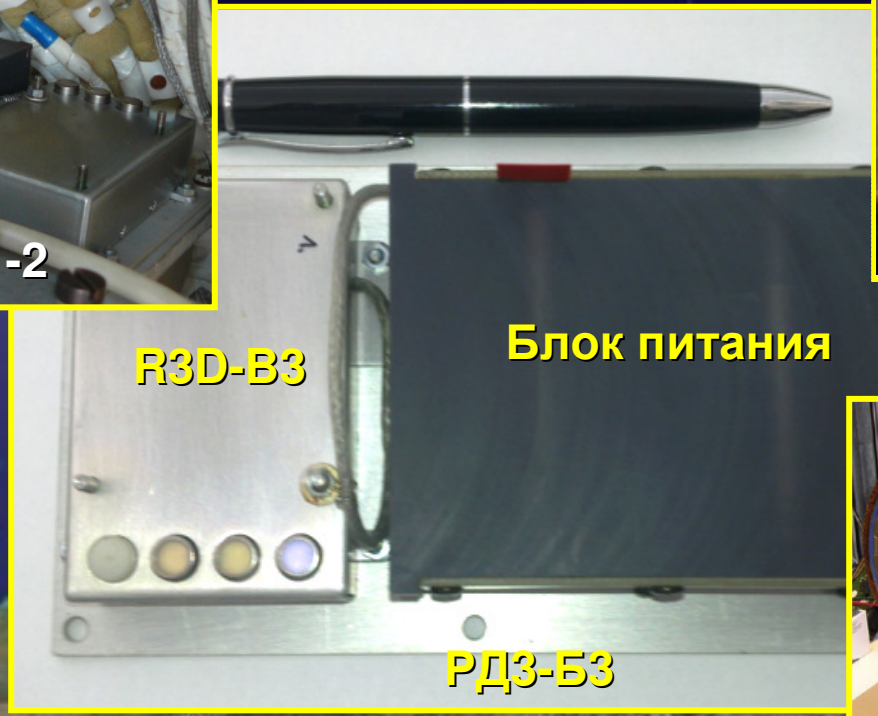
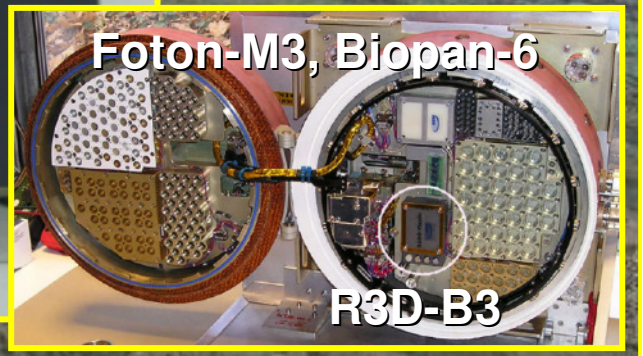
IKIT-BAS in cooperation with the University of Erlangen, Germany and IMBP-RAS, Russia will participate in the experiment BION-M-2 satellite with the P3D-B3 instrument in 2021 at an altitude of 800-1000 km and orbit inclination 62°

2021







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Conclusions

- Liulin type spectrometers proved its availability to characterize the radiation field from different radiation components (GCR, SAA, ORB) in the Earth and Moon radiation environment;
- Main advantage of the Liulin type spectrometers are: low weight and relatively high scientific and application value of the obtained data;
- The Liulin instruments database include 10 experiments performed in space between 1991 and 2018;
- The fully operable database is expected to be available on-line till the end of June 2018.

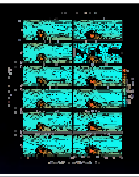
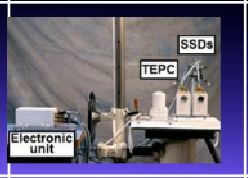
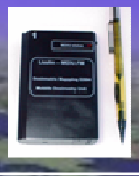
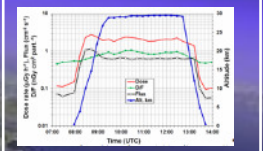
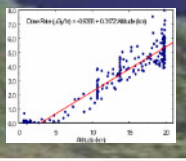
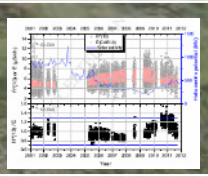
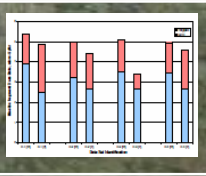
Acknowledgements and data availability

This work was partially supported by Contract No. 4000117692/16/NL/NDe funded by the Government of Bulgaria through an ESA Contract under the Plan for European Cooperating States (PECS).

The data used in this paper are part of the above mentioned contract entitled: "DOSIMETRY: Dosimetry science payloads for ExoMars TGO & surface platform; Unified web-based database with Liulin-type instruments' cosmic radiation data". The database of the Liulin instruments dose rate and flux data and some time-spatial coordinates of the ISS are available online at the following URL: http://esa-pro.space.bas.bg/
http://esa-pro.space.bas.bg/beta
http://esa-pro.space.bas.bg/datasources


Thank you for your attention

More significant experiments with Liulin type instruments (1)

No	Instrument, Platform, PI, Time period	Platform	Instrument	Scientific result
1	"LYULIN", "MIR" Station, V. Petrov, IMBP-RAN, T. Dachev, SRTI, 1988 - 1994			
2	RADIUS-MD, Mars-96, ИМБП-РАН, CNES and IPRSN, France 16/11/1996 г.			Квалифици-ран прибор
3	Liulin-4C, Stratosphere balloon, F. Spurny, NPI, Czech Rep., Gap, France, 14/06/2000			
4	Liulin-J, MDU-1, NASA aircraft - ER-2 - (U2S), Y. Uchihori, NIRS, Japan, Oct.-Nov. 2000			
5	Liulin-C, MDU-5/6, CSA aircrafts, F. Spurny, O. Ploc, NPI, Czech Rep., from 01/04/2001 up to now			
6	Liulin-E094, MDU1-4, American segment of ISS-Destiny, G. Reitz, DLR, Germany, April-August 2001 г.			

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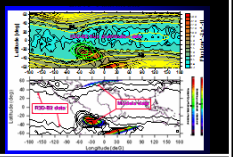
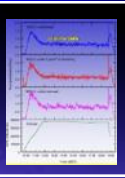
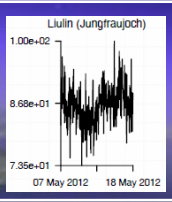
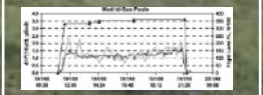
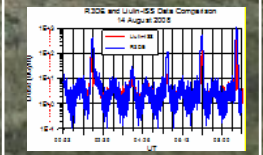
More significant experiments with Liulin type instruments (2)

No	Instrument, Platform, PI, Time period	Platform	Instrument	Scientific result
7	R3D-B2, Foton-M2, ESA, G. Horneck, DLR, D.-P. Haeder, UE, Germany, 1-12 June 2005			
8	Liulin-4J, Balloon of NASA Deep Space Test Bed certification flight, E. Benton, OSU, USA, 8 June 2005			
9	Liulin-6I, Jungfrau, E. Fluekiger, UB, Switzerland, от септ. 2005 г. December 2016 (http://130.92.231.184/)			
10	Liulin-4SA, Quantas Airlines aircrafts, J. Getley, UNSV, Austarlia, 2005-2010			
11	Liulin-4S, IBERIA Airlines aircrafts, Saez Vergara, CIEMAT, Spain, от 2005 up to now			
12	„Liulin-ISS“ Russian segment of ISS, V. Petrov, IMBP-RAN, Russia, T. Dachev, SRTI, 2005 up to now			

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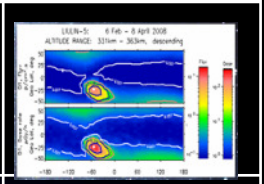
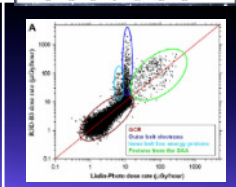
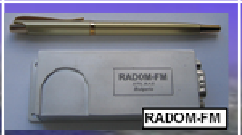
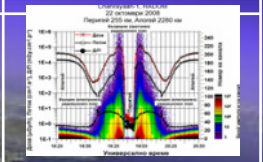
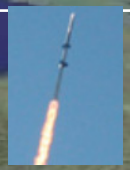
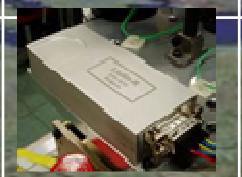
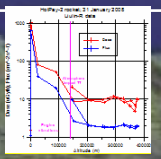
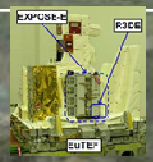
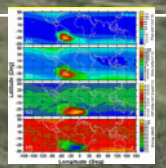
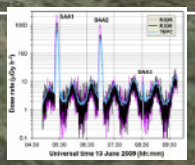
More significant experiments with Liulin type instruments (3)

No	Instrument, Platform, PI, Time period	Platform	Instrument	Scientific result
13	„Liulin-5“, Russian segment of ISS, V. Petrov, IMBP-RAN, Russia, Semkova, SRTI, 2007 - 2016			
14	R3D-B3, Foton-M3, ESA, G. Horneck, DLR, D.-P. Haeder, UE, Germany, Dachev, SRTI 14-26 September, 2007			
15	RADOM, Indian Moon satellite Chandrayaan-1 Dachev, SRTI 22/10/2008-29/09/2009			
16	Liulin-6R, Rocket flight from Andoya, Norvey up to 380 km 31/12/2008 г.			
17	R3DE, ESA, Columbus, ESA, G. Horneck, DLR, D.-P. Haeder, UE, Dachev SRTI, 17/02/2008-03/09/2009			
18	R3DR, ESA, Zvezda, ESA, G. Horneck, DLR, D.-P. Haeder, UE, Dachev, SRTI 11/03/2009-20/08/2010			

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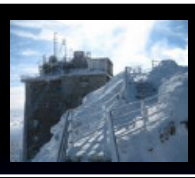
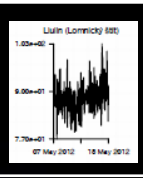
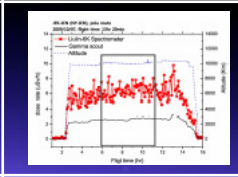
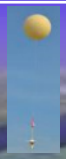
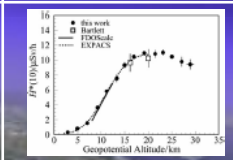
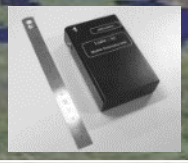
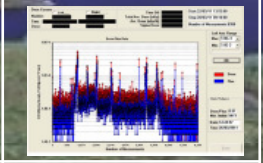
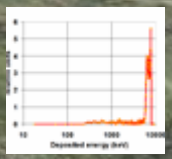
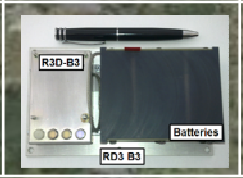
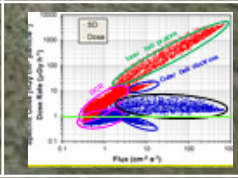
More significant experiments with Liulin type instruments (4)

No	Instrument, Platform, PI, Time period	Platform	Instrument	Scientific result
19	Liulin-6MB, Lomnisky Shtit peak, K. Kudela, UPJS, Slovak Rep., from 2009 to 2014			
20	Liulin-6K, Korean commercial flights , J. Hwang, KASI, Korea, 2010 г.			
21	Liulin-RG, 5 Balloons of PTB, F. Wissmann, PTB, Germany, July 2011 and July/August 2012			
22	Liulin-J, Fukushima AEP, Y. Uchihori, NIRS, Japan, 22-28 March 2011			
23	Liulin-F, Phobos-Grunt, V. Petrov, IMBP-RAN, Russia, Semkova, SRTI, 09/11/2011			
24	RD3-B3, „BION-M“ №1, V. Shurshakov, IMBP-RAN, Russia, T. Dachev, SRTI, 19/04 - 19/05/2013			

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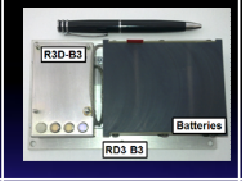
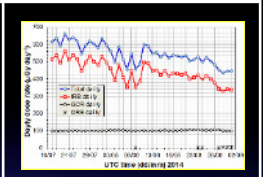
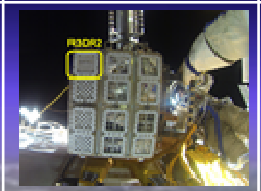
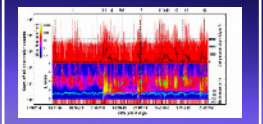
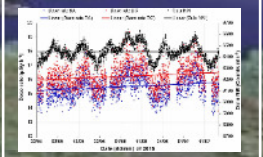
More significant experiments with Liulin type instruments (5)

No	Instrument, Platform, PI, Time period	Platform	Instrument	Scientific result
25	RD3-B3, „FOTON-M“ №4, V. Shurshakov, IMBP-RAN, Russia, T. Dachev, SRTI, 08/09 - 20/10/2014			
26	R3DR2, ESA, Zvezda, ESA, G. Horneck, DLR, D.-P. Haeder, UE, Germany, Dachev, SRTI 24/10/2014-11/01/2016			
27	Liulin-MO, ExoMars-TGO, I. Mitrofanov, SRI J. Semkova, SRTI 22 April 2016 – till now			

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