Unified web-based database with Liulin-type instruments' cosmic radiation data

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The view expressed herein can in no way be taken to reflect the official opinion of ESA

The data included in the database are obtained as a result of various international cooperations and with the help of different contracts

The aim of the database is to survey, collect and store in unified format the existing Liulin type instruments data sets from different satellites and to develop a web-based database that will serve users from all over the world

Outlook

- Introduction
- Bulgarian build space dosimetry instruments;
- Recent space experiments included in the database;
- Demonstration of the database;
- Acknowledgements;
- Future Liulin type space experiments;
- Conclusions

Introduction

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Bulgarian space radiation experiments on satellites and rockets (Yellow marked are included in the database)

1. LIULIN, 04/1989 - 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, EXPOSE-R2, Zvezda, ISS, (Dachev et al., 2017b); 9
17. Liulin-MO, since 14 March 2016 working on ESA-Roscosmos, ExoMars TGO satellite (Semkova et all., 2018), (Currently at Mars orbit). 10

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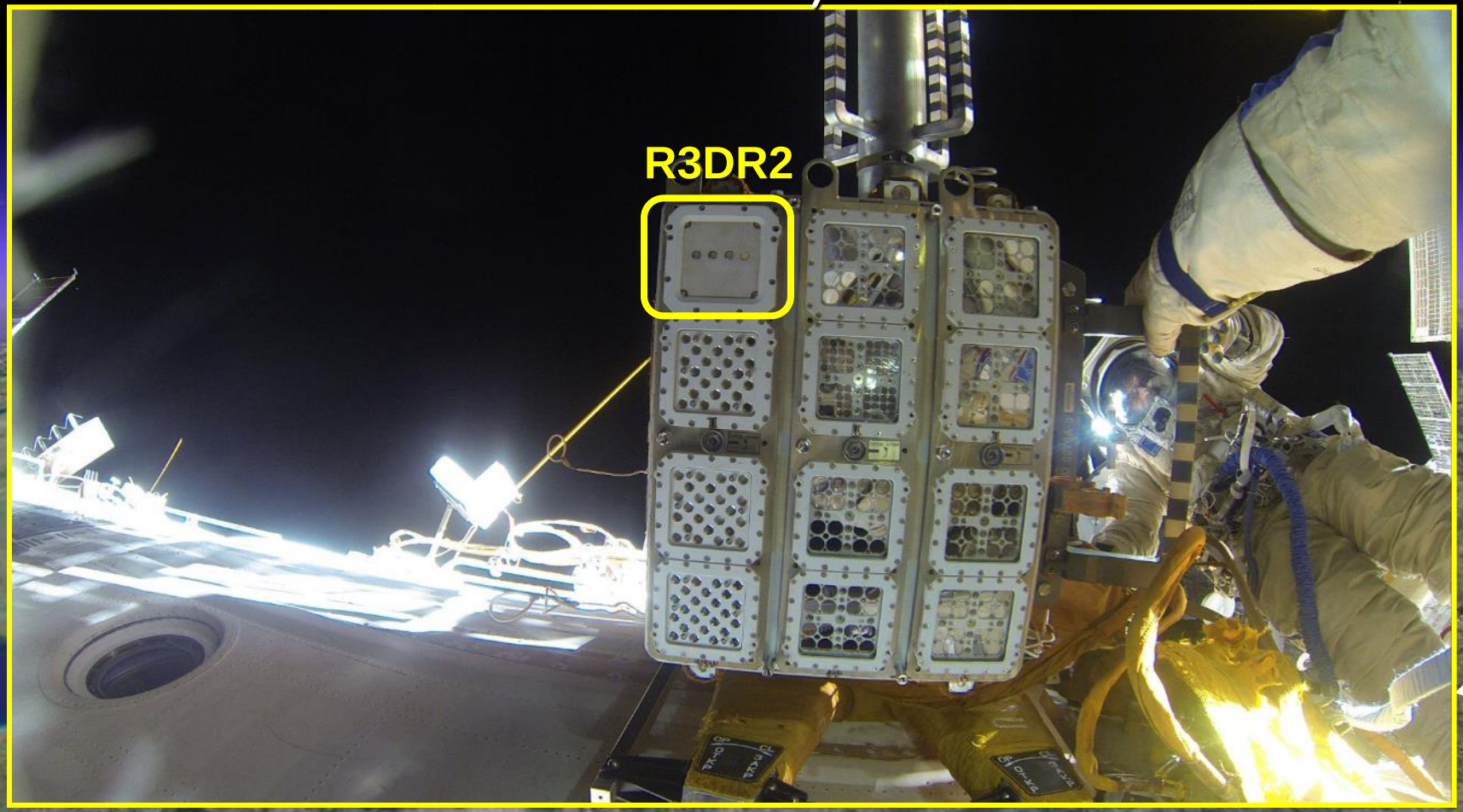
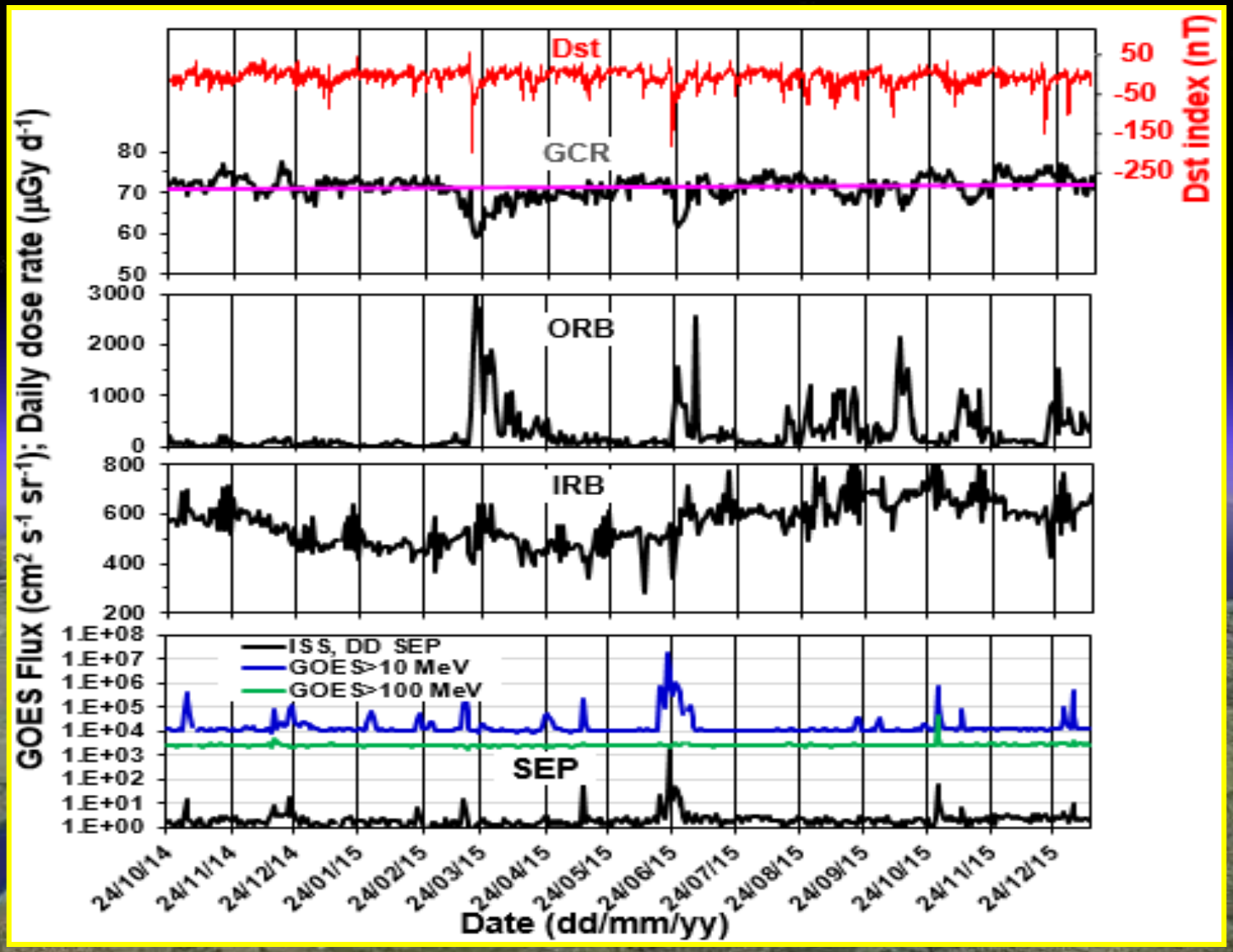
Recent space experiments included in the database

External view of R3DR2 instrument (in the yellow 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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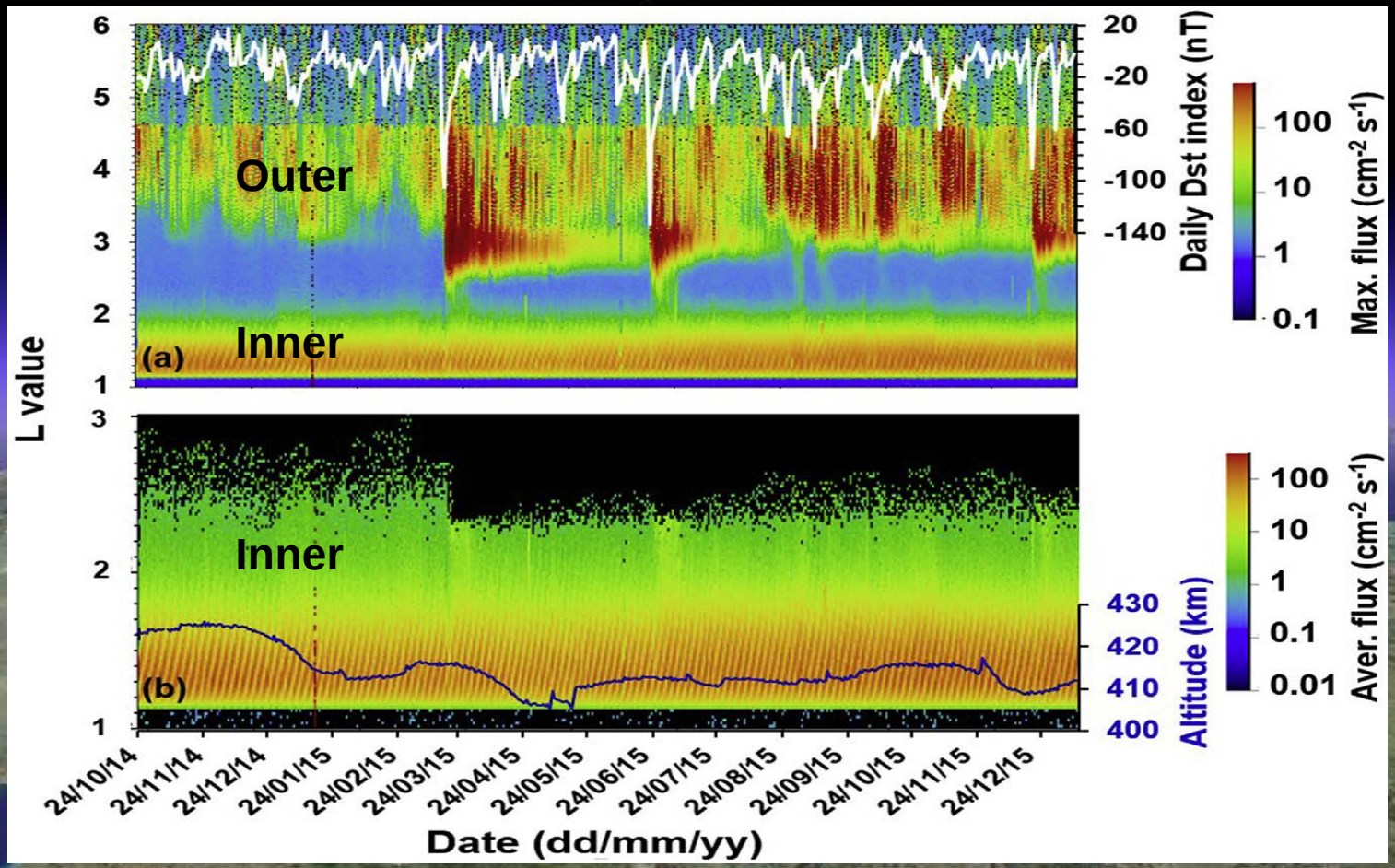
Fig. (a):The 3-dimensional L-value versus time plot of the observed by R3DR2 instrument maximal in the bin SAA and ORB flux rate in cm^{-2} s^{-1}.
Fig. b: The 3-dimensional L-value versus time plot of the observed by R3DR2 instrument average in the bin SAA flux rate in cm^{-2} s^{-1}



Dachev, T. P., South-Atlantic Anomaly Magnetic Storms Effects as Observed outside the International Space Station in 2008-2016, JASTP, 251-260, 2018. https://doi.org/10.1016/j.jastp.2018.08.009

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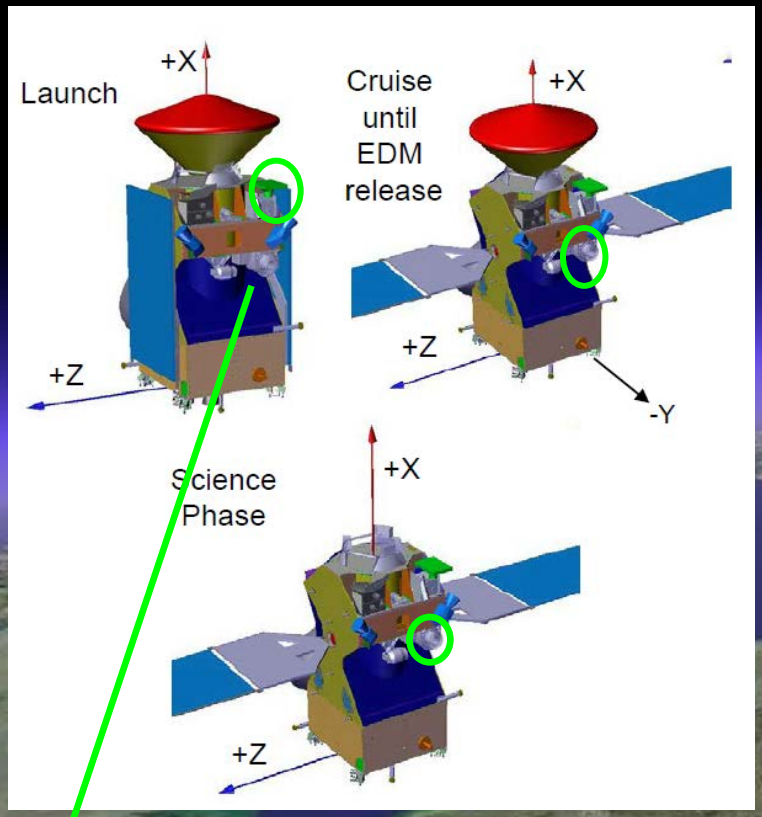
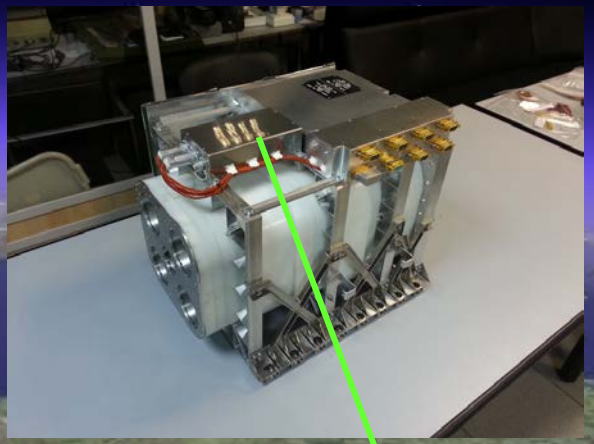
Orbital station ExoMars TGO and FREND with Liulin-MO

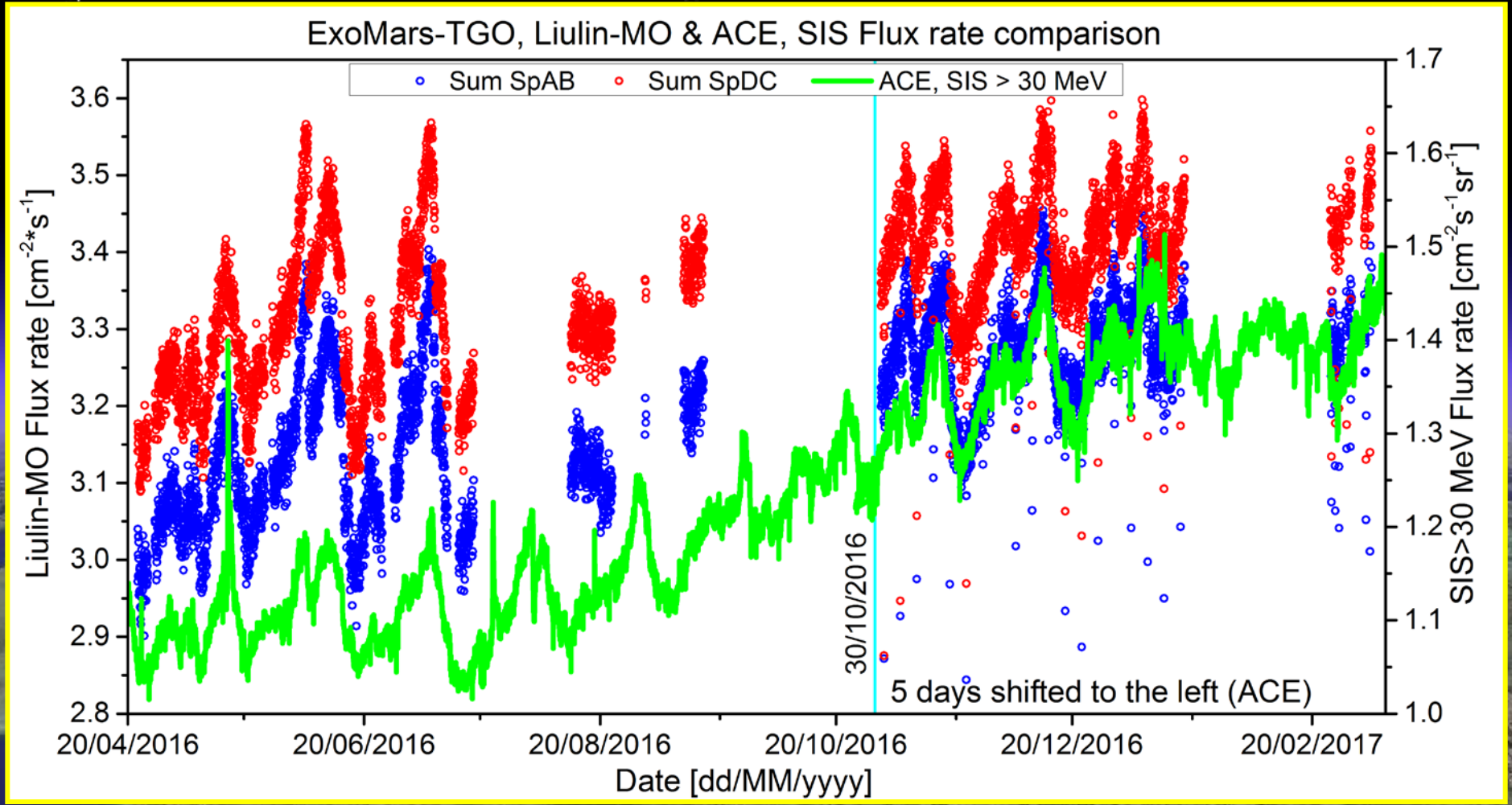


FREND on TGO



FREND with Liulin-MO *Credit: ESA/Roscosmos/FREND/IKI* .

Galactic cosmic rays flux measurement results obtained with the Liulin-MO device



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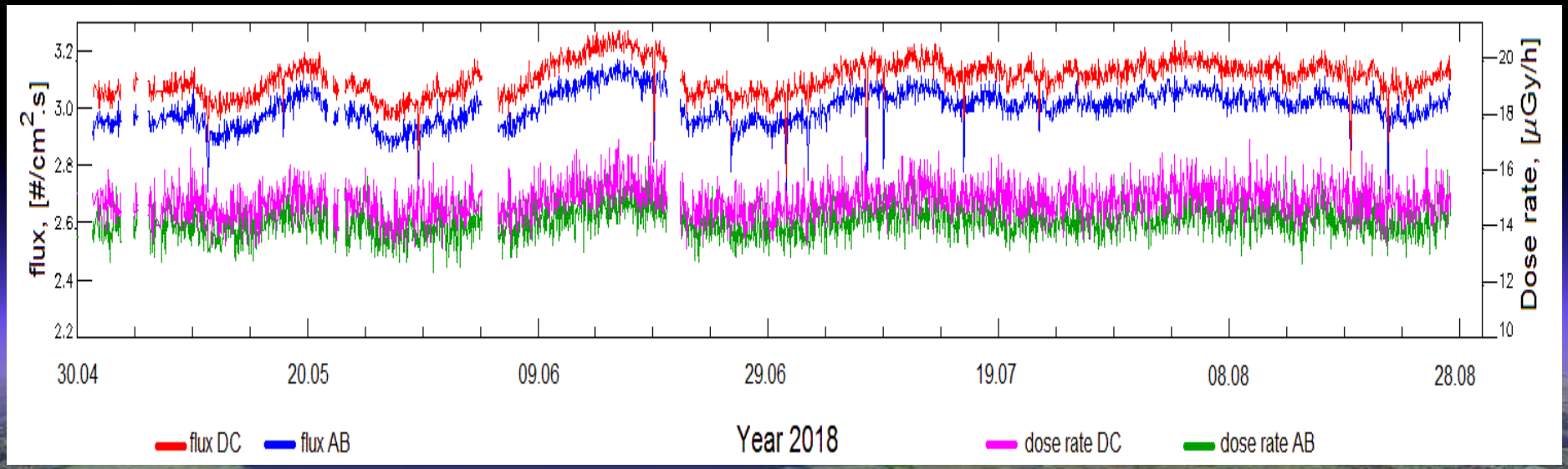
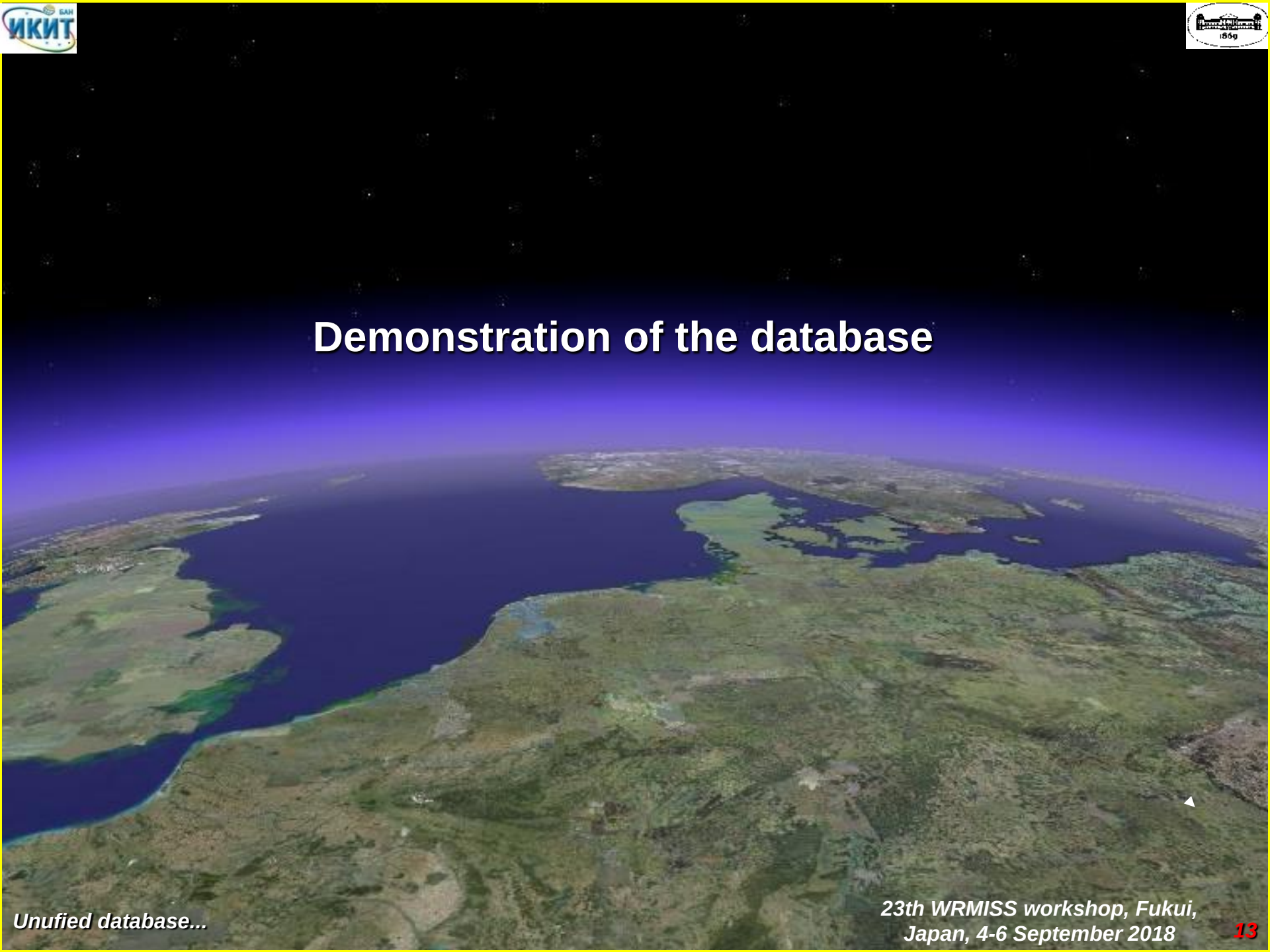
Fluxes and dose rates in the perpendicular detectors AB and CD of Liulin-MO in Mars science orbit



Demonstration of the database



The database is situated in two pages of the home page:

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

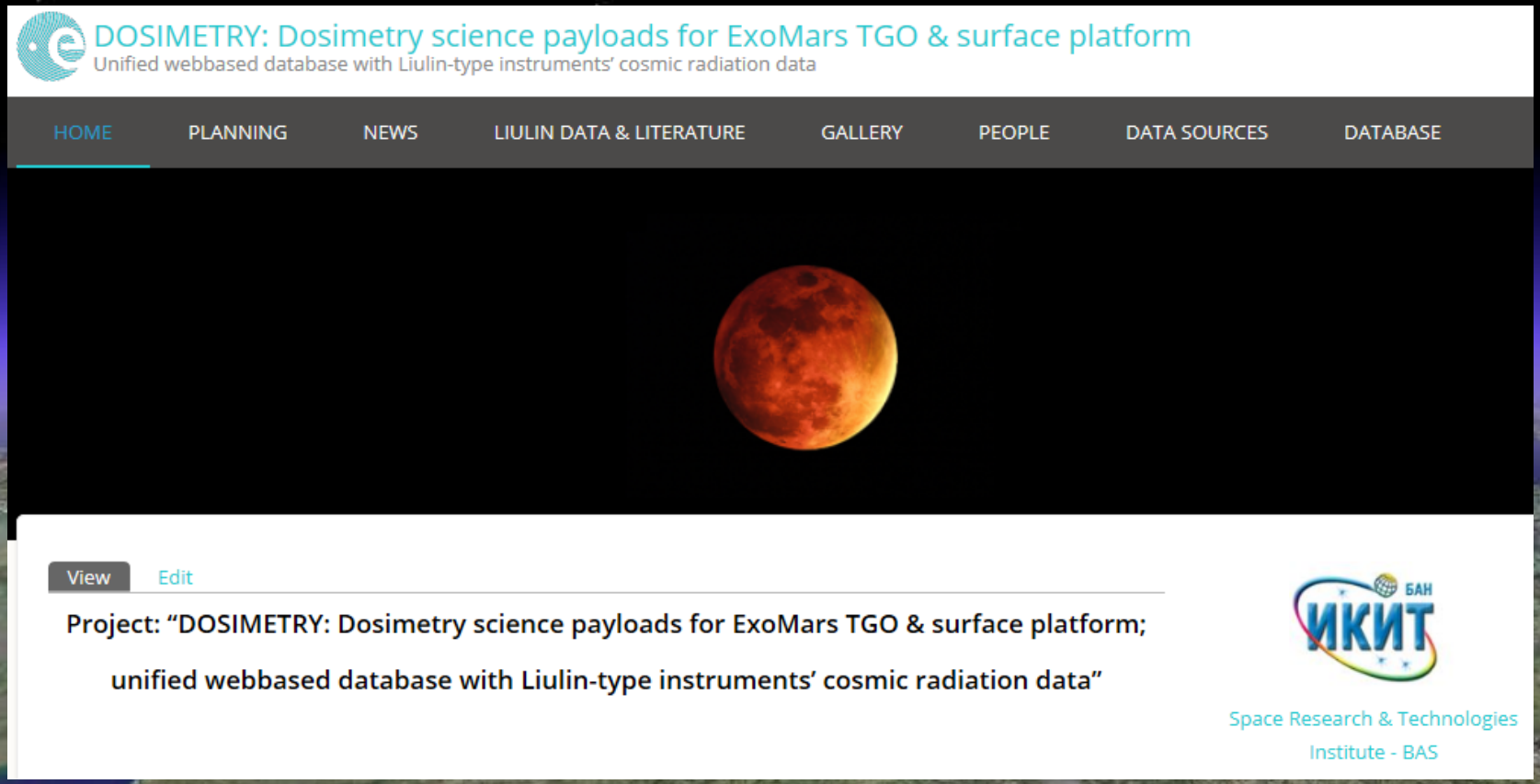
Page 1: http://esa-pro.space.bas.bg/datasources:

Downloads to the user computer original, zipped “DATA SOURCES”, which contain lists of the measured parameters together with the time and space coordinates in comma separated values (CSV) format, directly opened in an EXCEL program.

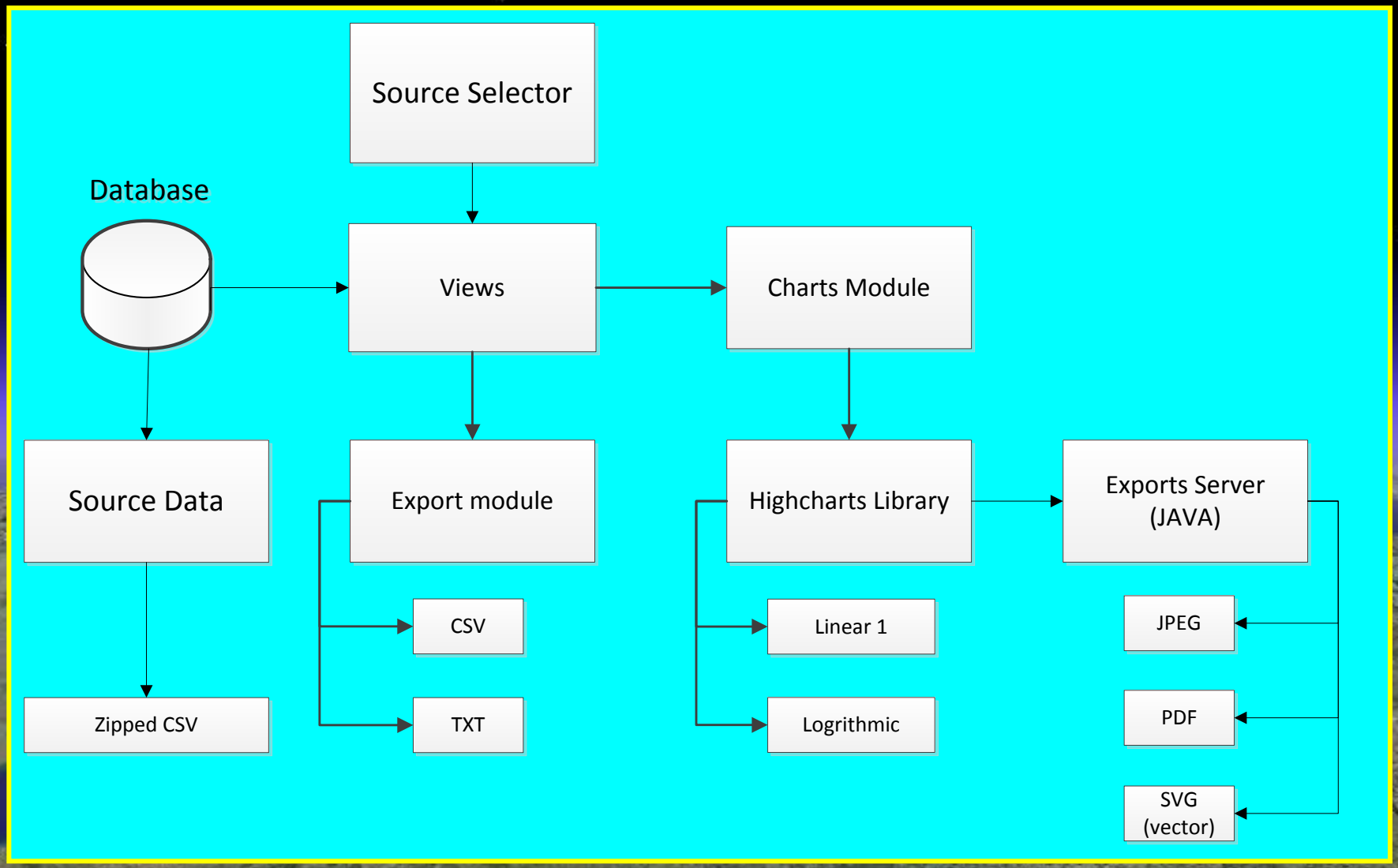
Page 2: http://esa-pro.space.bas.bg/database:

Allows source (experiment) selection, visualization, synchronized zoom, tooltip and hairline; export of the charts to vector, JPEG and PDF format; data export in CSV and TXT format.

Home page of the site
http://esa-pro.space.bas.bg/



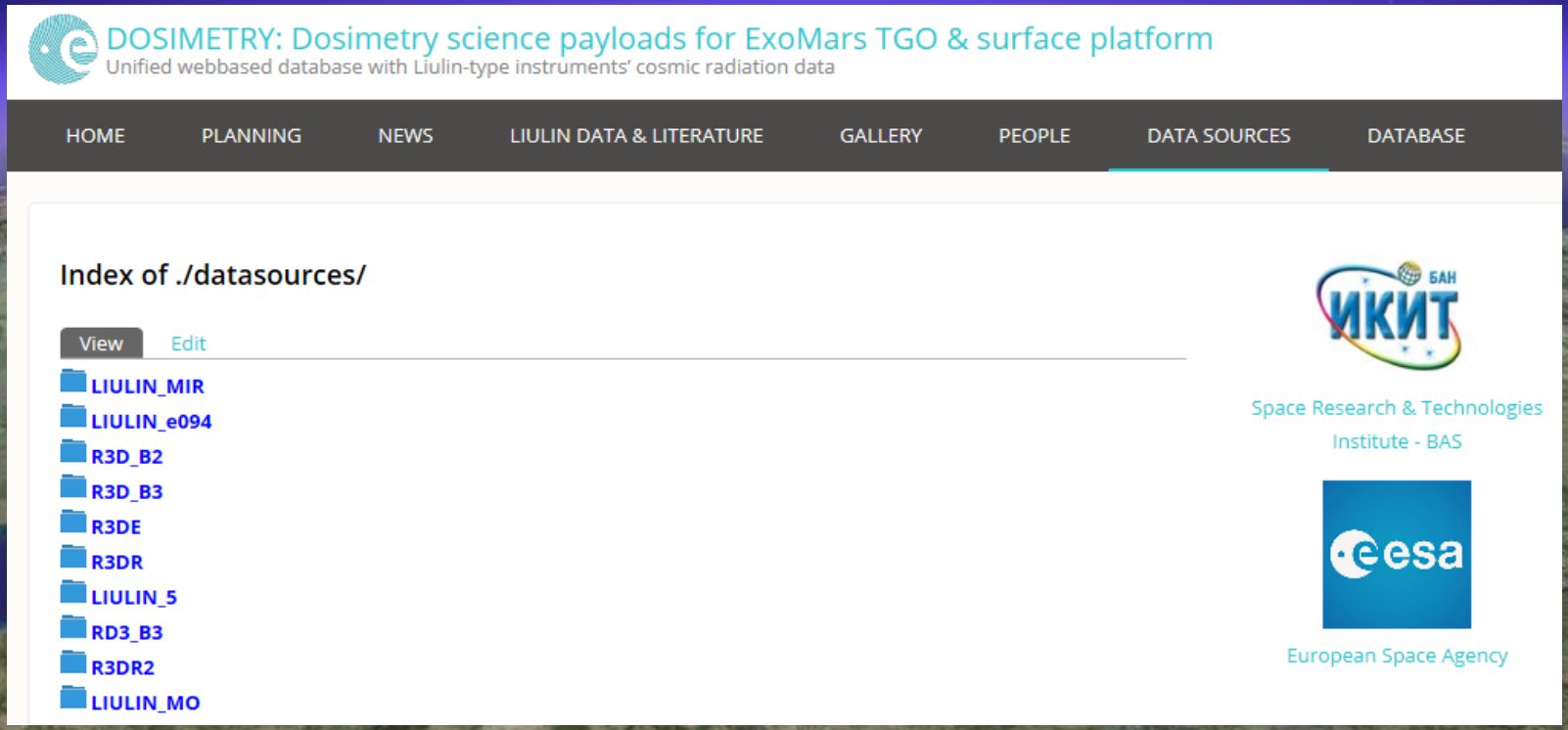
Database software architecture



Menu: DATA SOURCES

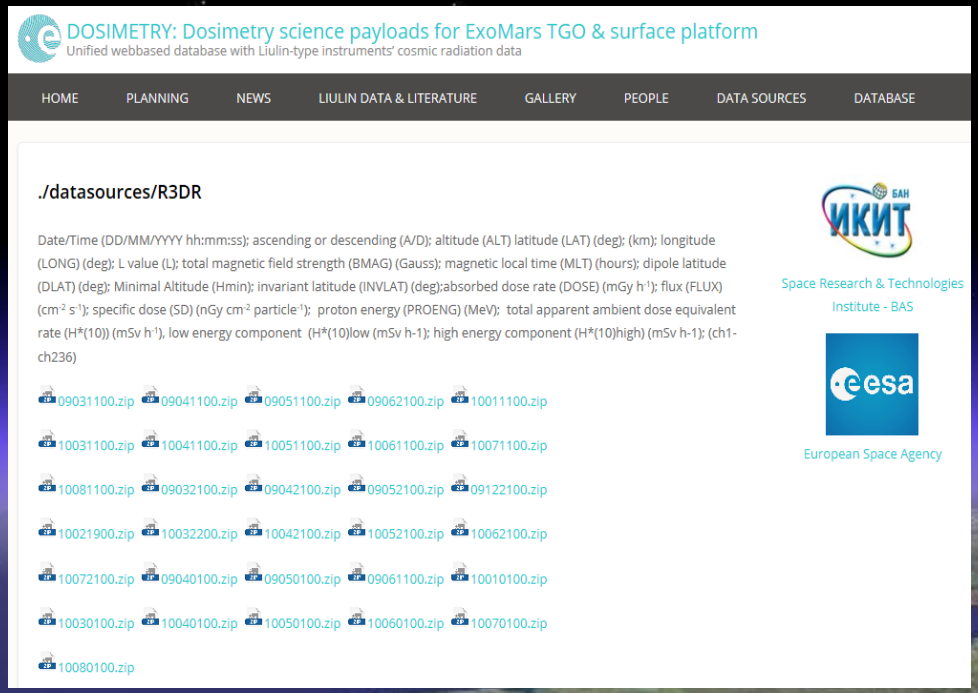
http://esa-pro.space.bas.bg/datasources

downloads to the user computer original, zipped “DATA SOURCES”, which contains lists of the measured parameters together with the time and space coordinates in comma separated values (CSV) format, directly opened in an EXCEL program.



Example of the R3DR2 data sources

http://esa-pro.space.bas.bg/datasources/R3DR2



Each of the 44 files is a list of 10 days data with 10 seconds resolution, which contains the following 276 parameters:

UT date and time (DD/MM/YYYY hh:mm:ss); UT (hh:mm:ss); ascending or descending (a/d); type of predominated radiation source (galactic cosmic rays (GCR); inner radiation belt (IRB) protons); outer radiation belt (ORB) relativistic electrons; solar energetic particles (protons) and secondary radiation (SEP); altitude (ALT) (km); longitude (LONG) (deg); latitude (LAT) (deg); L value (L); total magnetic field strength (BMAG) (Gauss); local time (LT) (hours); magnetic local time (MLT) (hours); dipole latitude (DLAT) (deg); invariant latitude (INVLAT) (deg); flux (FLUX) (cm^{-2} s^{-1}); absorbed dose rate (DOSE) (μGy h^{-1}); dose to flux ratio (D/F) (nGy cm^{-2} $particle^{-1}$); proton energy (PROENG) (MeV); total apparent ambient dose equivalent rate (H*(10)) (μSv h^{-1}), low energy component (H*(10)low (μSv h-1); high energy component (H*(10)high) (μSv h-1); (counts in channel1 to channel 256)

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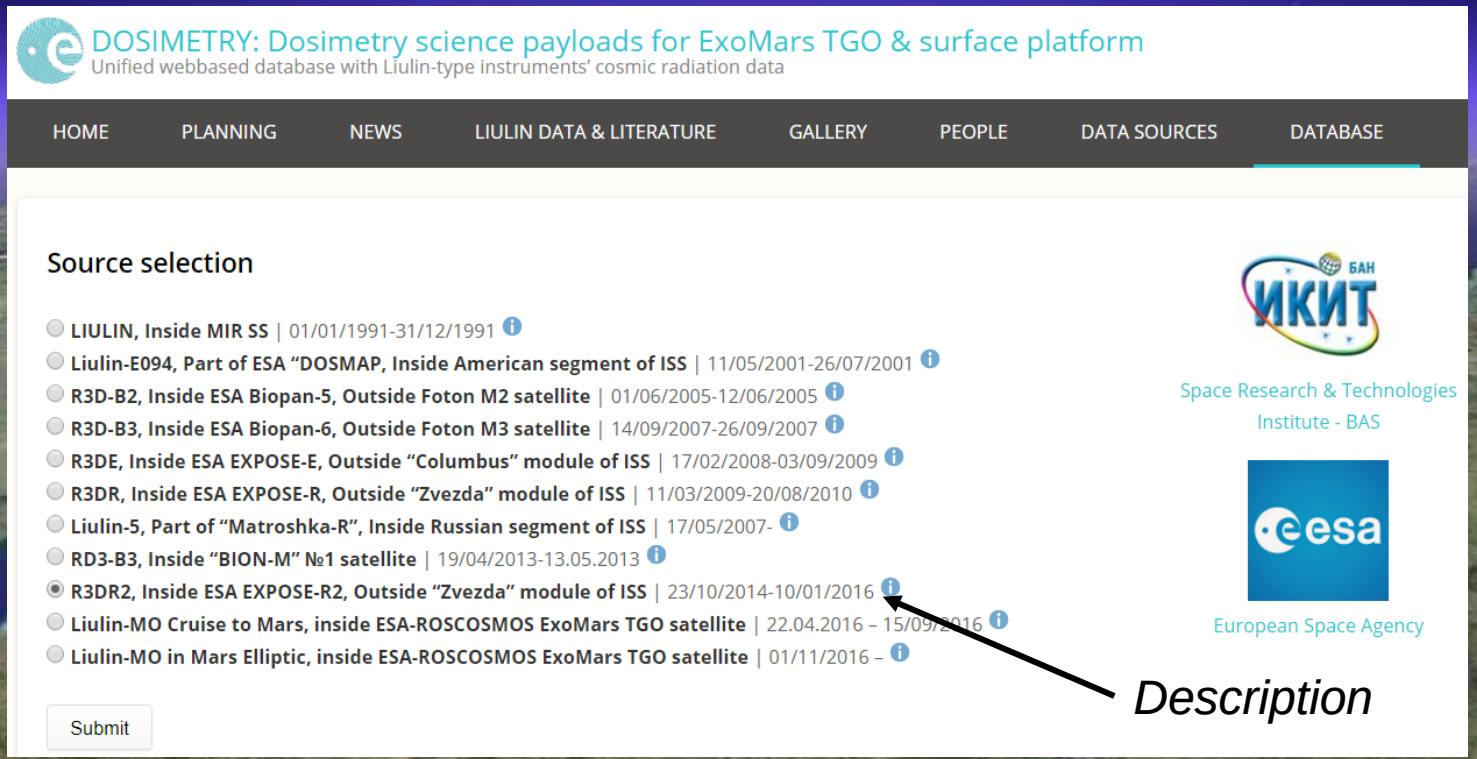
Menu: DATABASE (Source selection)

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

Allows source selection, visualization, synchronized zoom, tooltip and hairline; export of the charts to vector, JPEG and PDF format; data export in CSV and TXT format.

Example of the DATABASE submenu with selected R3DR2 source



R3DR2, Inside ESA EXPOSE-R2, Outside "Zvezda" module of ISS

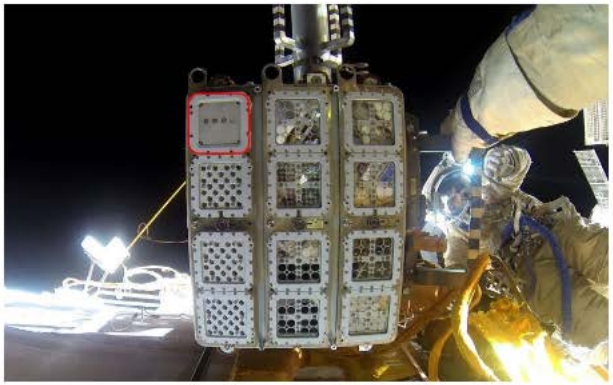
Satellite provider: Roscosmos
Satellite name: ISS, Zvezda module
Experiment name: ESA, EXPOSE-R2
Instrument name: R3DR2

Cooperation: Bulgaria, Germany
Begin-end of data: 23/10/2014-10/01/2016
PI/CoPI: G. Horneck, DLR; D. Häder, UE; Ts. Dachev, SRTI
Main description Reference: (Dachev et al., 2017), https://doi.org/10.1002/2016SW001580

Units: Size [mm]/Mass [kg]: 1 DU (76x76x36 mm, 0.17 kg)
Place: Outside of ISS, outside Zvezda module, in the EXPOSE-R2 facility. (Please see figure below).
Shielding [g cm^{-2}]: >0.3 g cm^{-2}
Resolution [sec]/[min]: 10 s

Space Research & Technologies Institute - BAS

European Space Agency



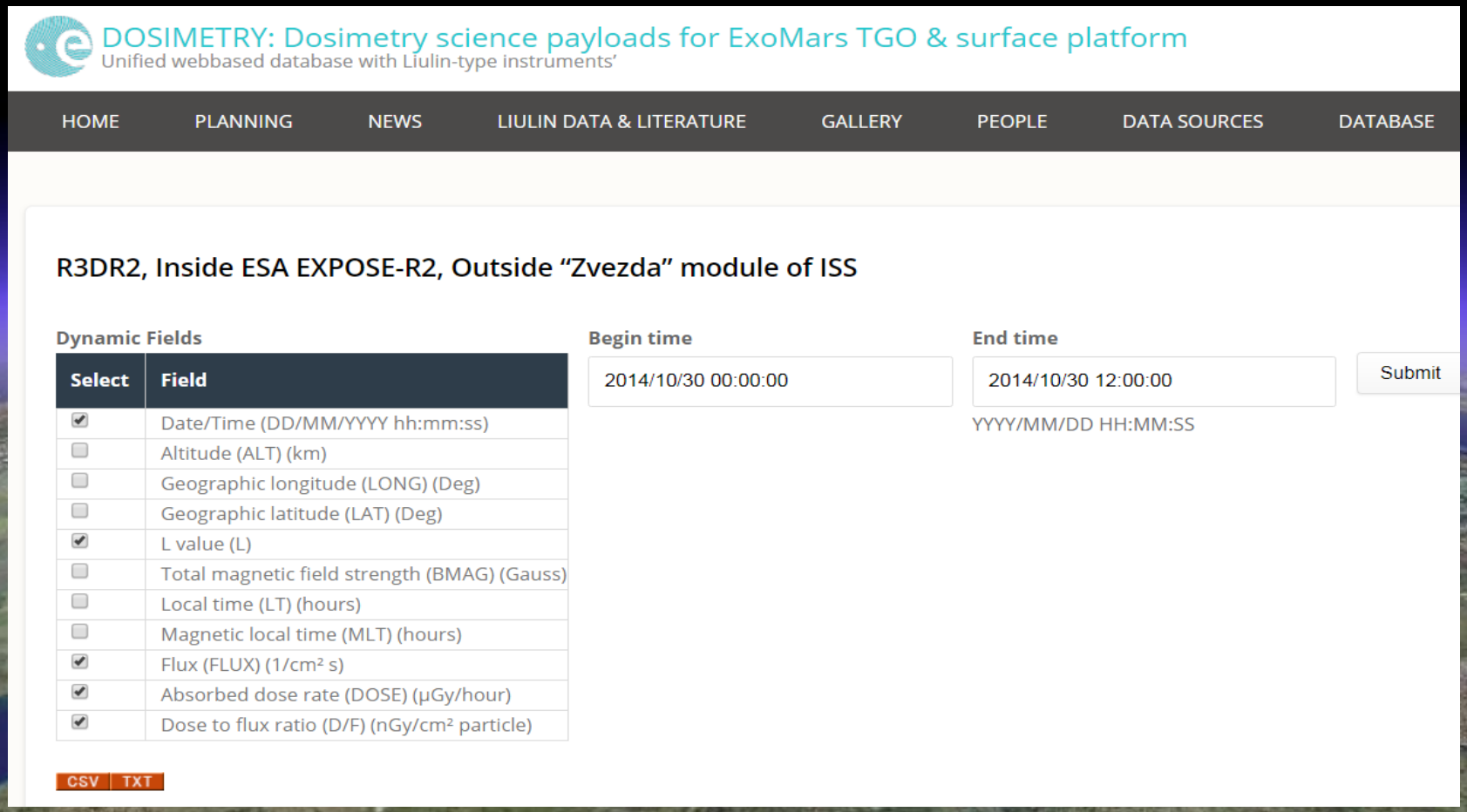
External view of EXPOSE-R2 facility and R3DR2 instrument (in the red square)

External view of R3DR2 instrument

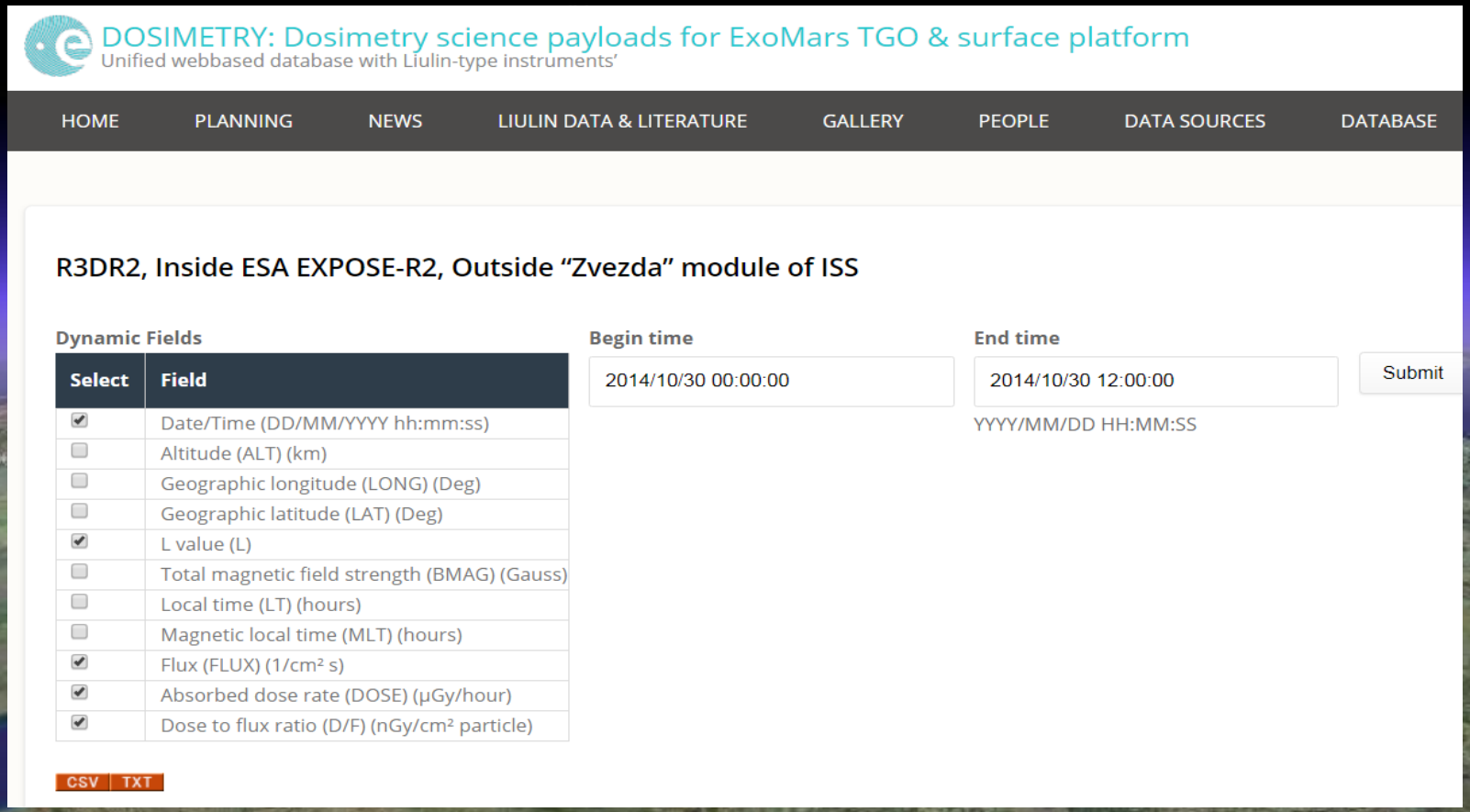
Part of the description of the experiment

Choose “R3DR2” press “Submit”

The following screenshot appears:



Choose the time interval* (in the example: 2014/10/30 00:00:00-2014/10/30 12:00:00) and variables (in the example: Date/Time/; L value (L); Flux; Absorbed dose; Dose to flux ratio) (* if the time interval is larger than 6 hours than the software divide the output pictures at 6 hours)



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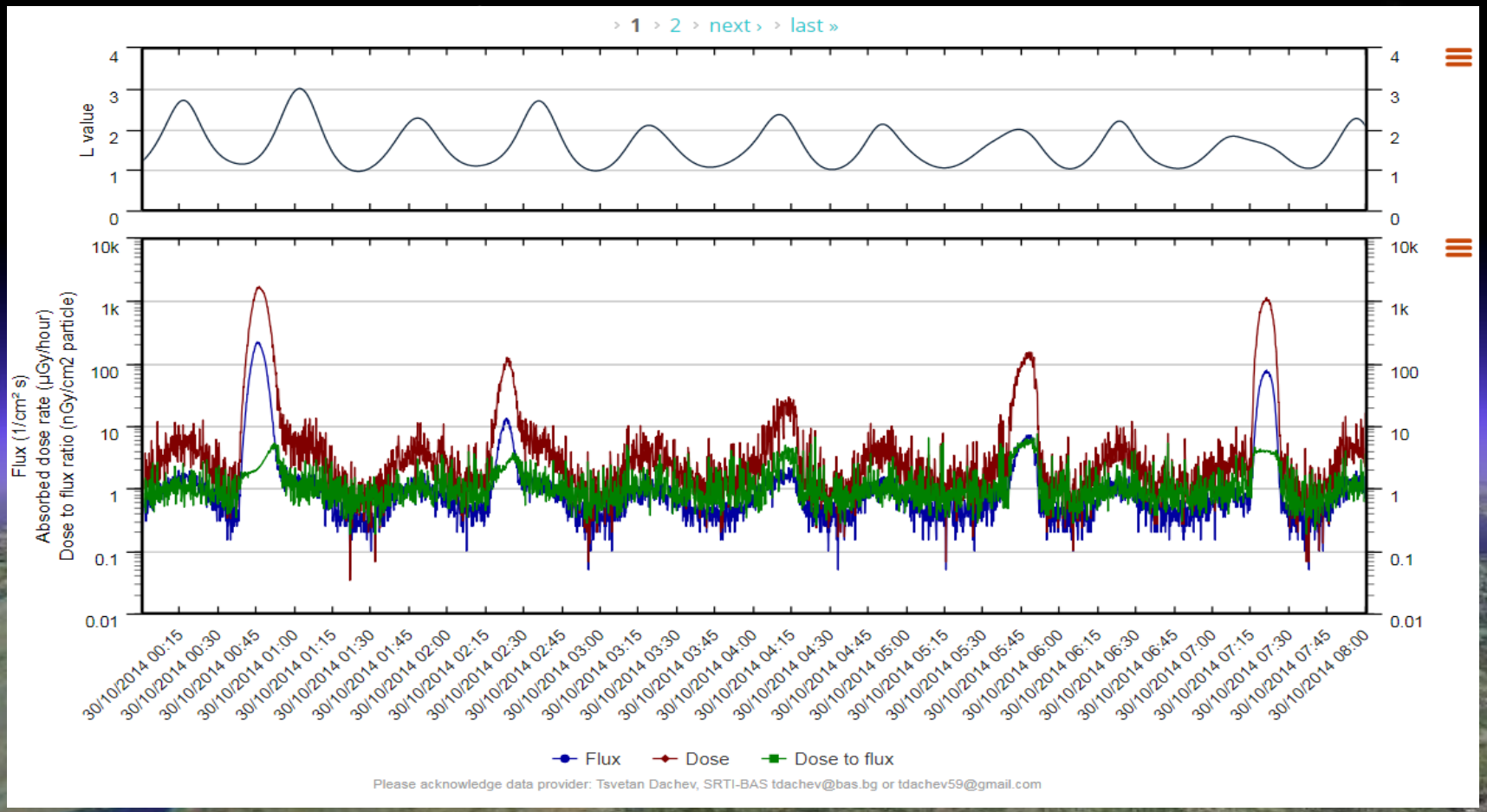
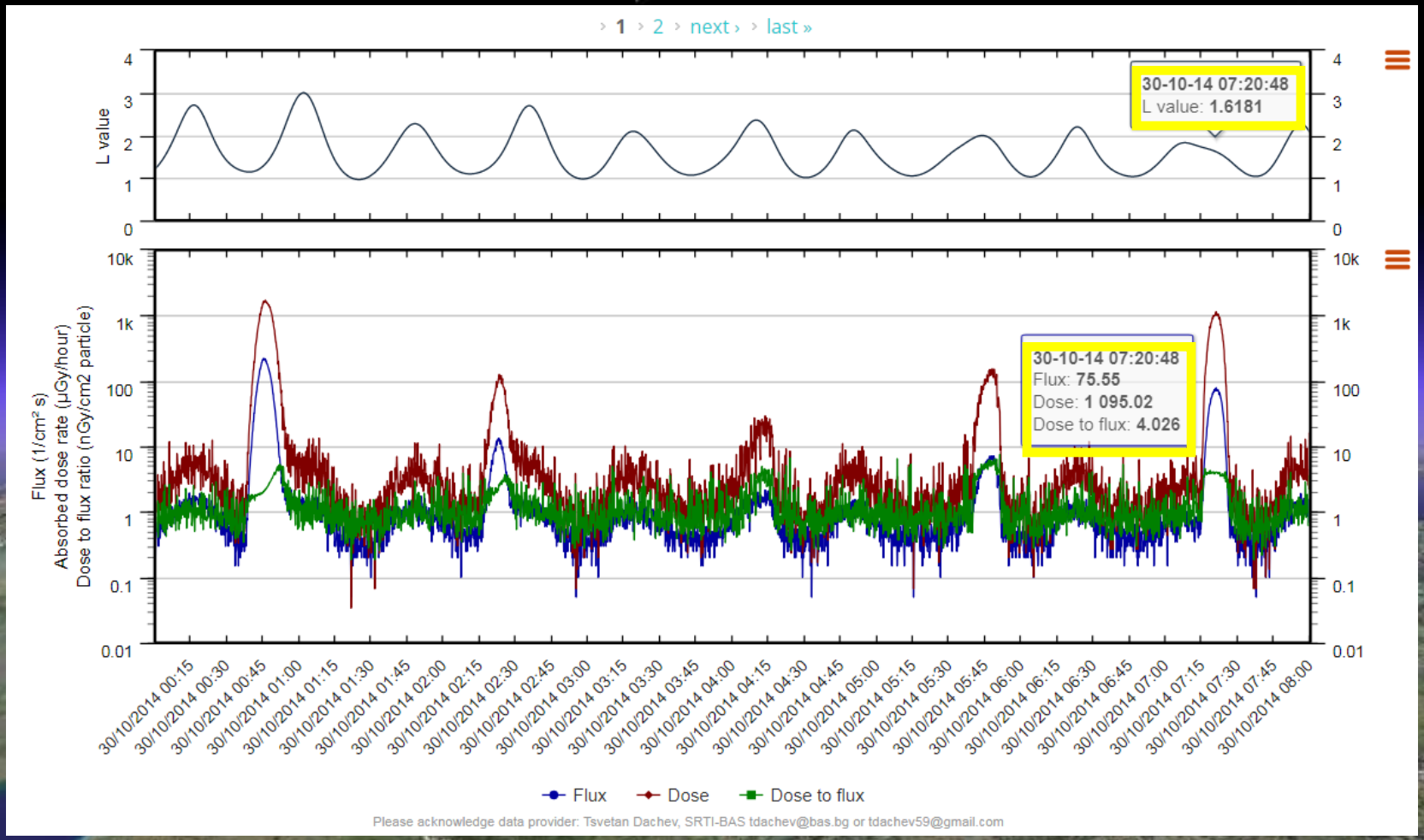
OPTION 1: Receiving graphics - press “Submit”. As a result you will obtain the following figure:



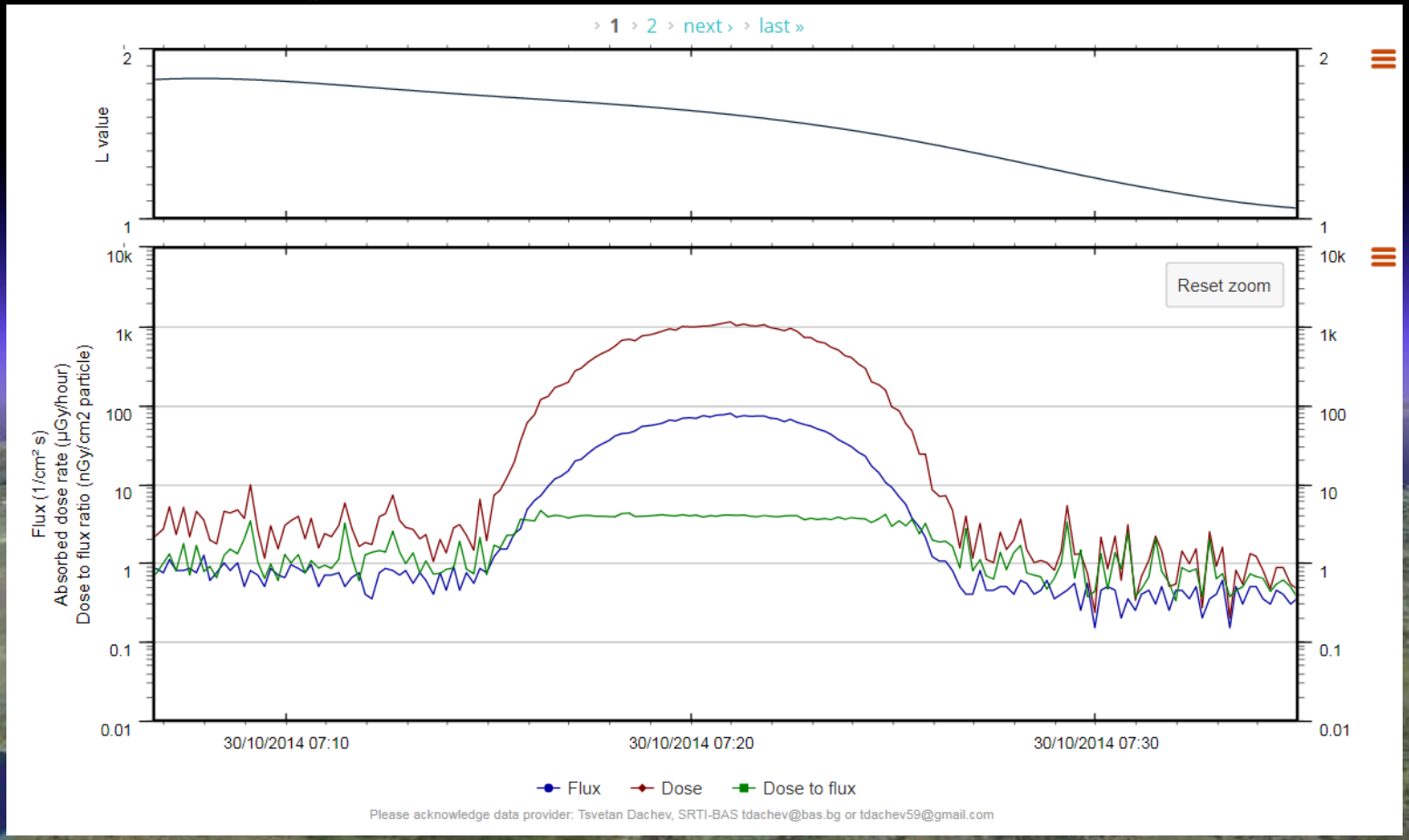
R3DR2 data (First) page 30/10/2014 in the time interval 00:00:00 - 08:00:00

Movement of the cursor on the figures automatically generates labels, which contain the different variables values at the point of interest, as shown below



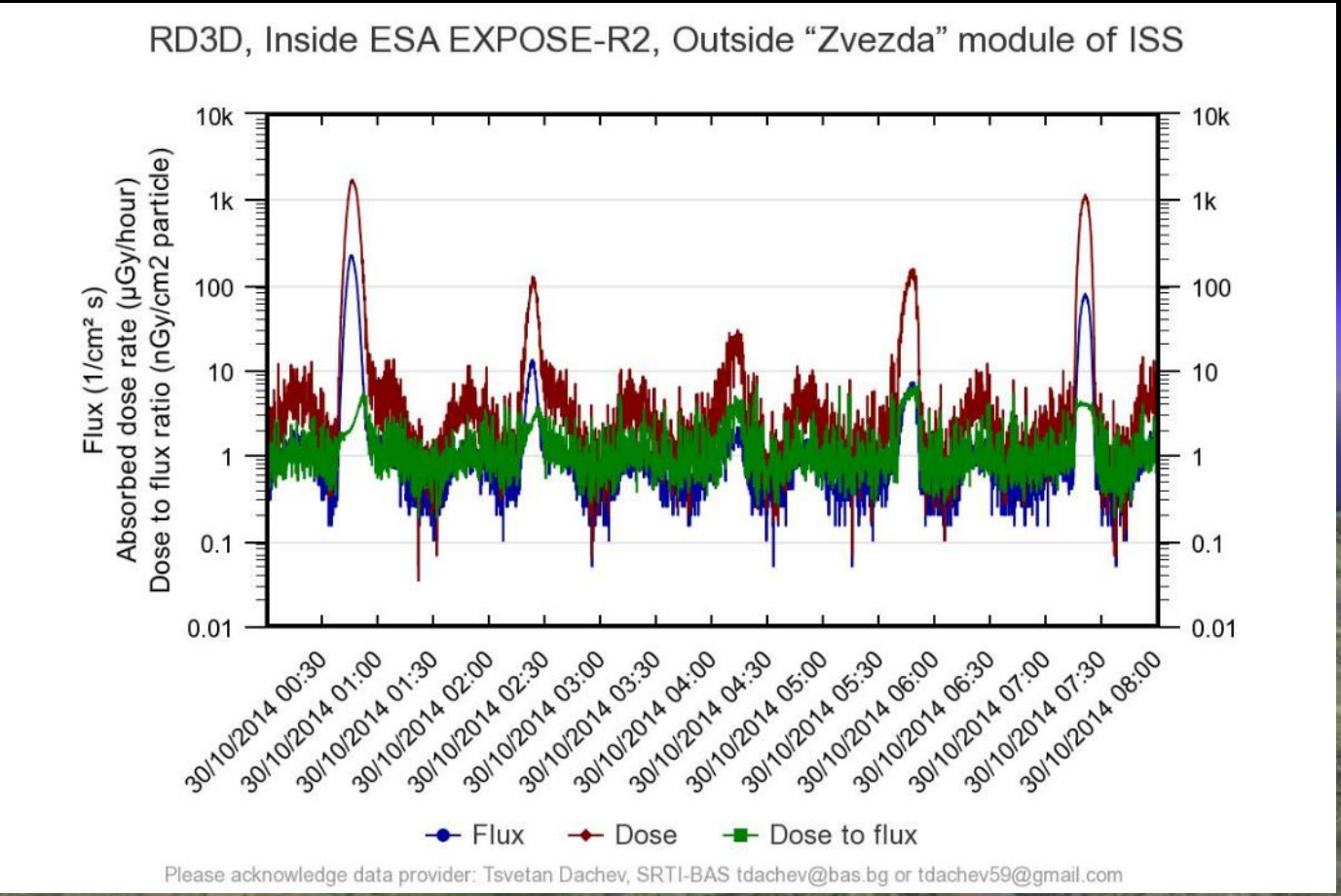
R3DR2 data (First) page 30/10/2014 in the time interval 00:00:00- 08:00:00 with labels.

You may obtain a Zoom of any part of the graphic by pressing and holding down of the left button of the mouse to select the area of interest



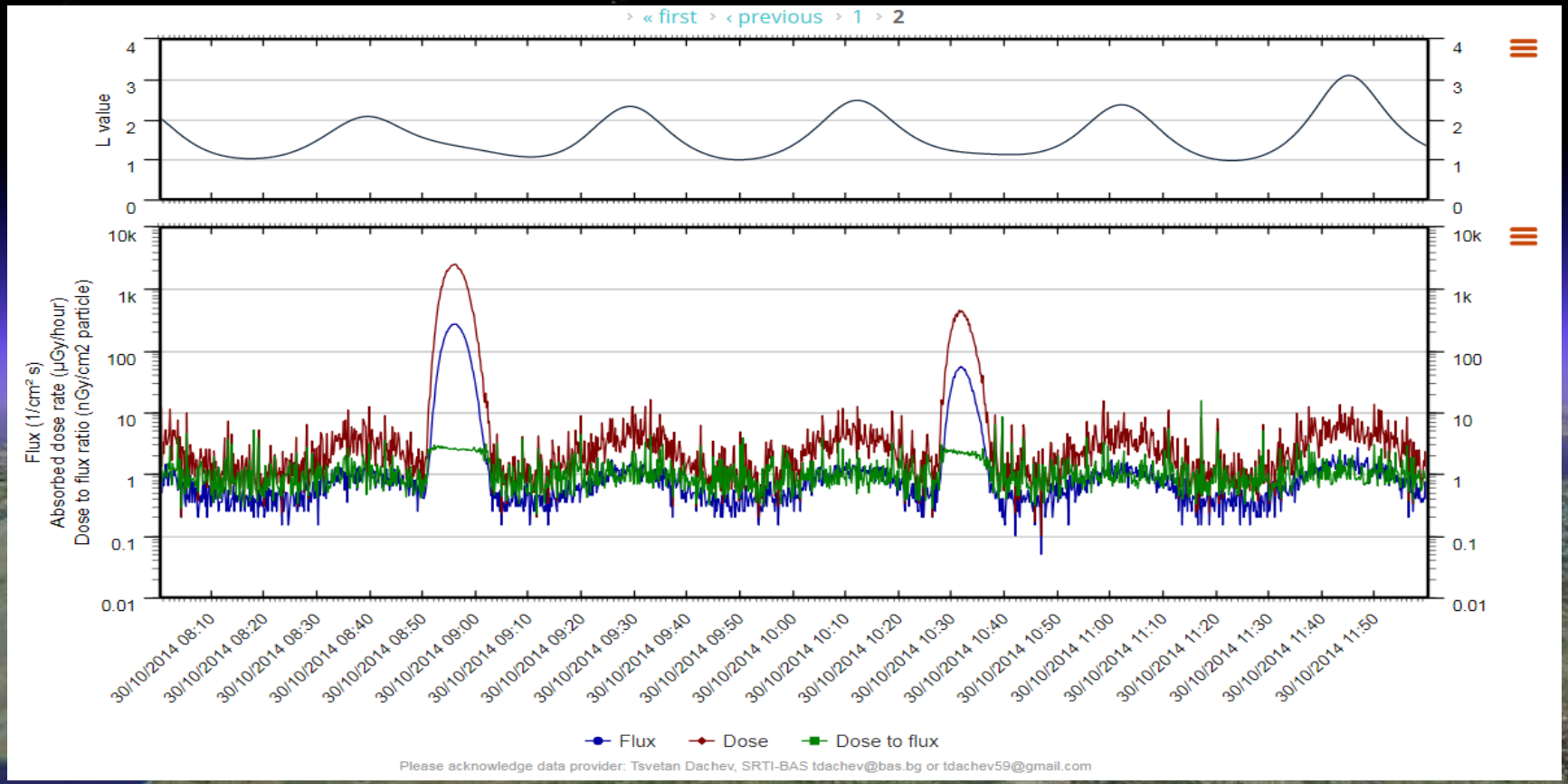
Zoom of part of R3DR2 data (First) page 30/10/2014 in the time interval 00:00:00- 08:00:00.

Pressing of the ≡ button generates submenu where the user may choose the format of the figure output. The options are: “JPEG image”, “PDF document and “SVG image”. Choosing “JPEG image” creates and sends to the user’s computer an output picture as shown in the figure below



JPEC image of R3DR2 data (First) page 30/10/2014 in the time interval 00:00:00- 08:00:00.

Receiving second page of the graphics - press “Next page”



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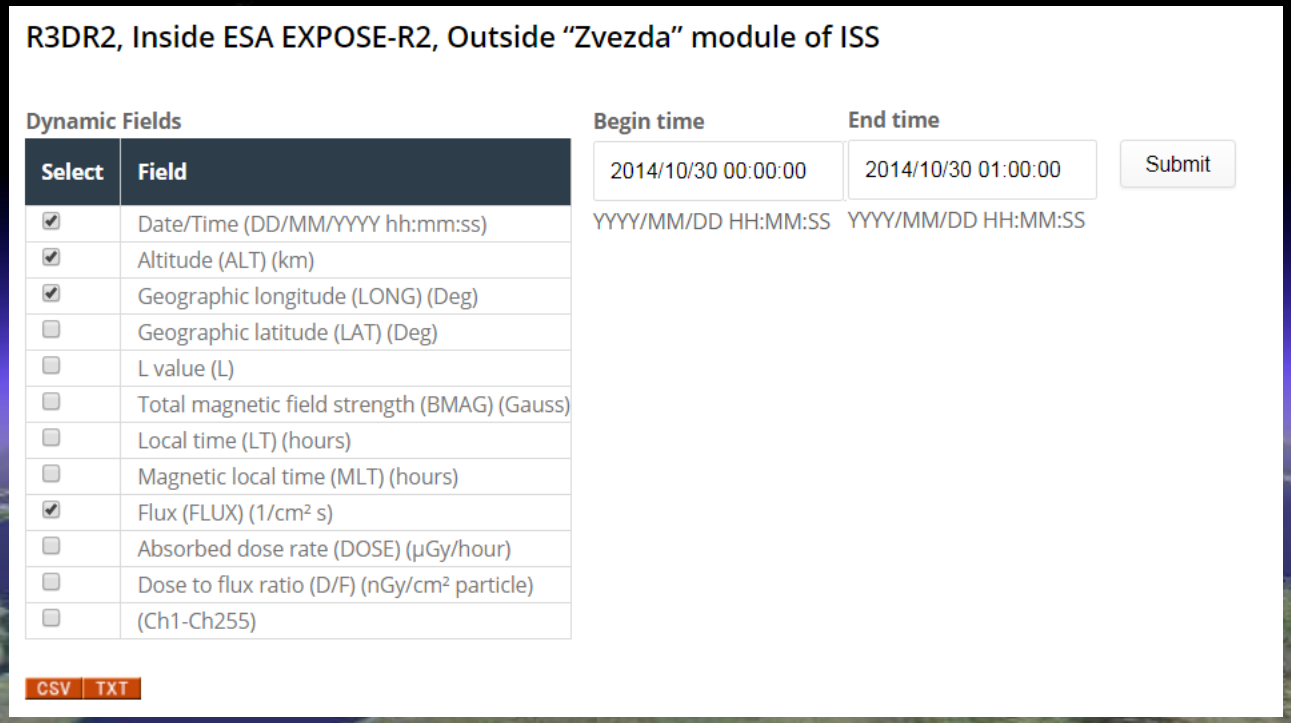
OPTION 2: Obtaining numeric data

In the main menu choose the necessary parameters. In the example – time interval, Altitude, Geographic longitude and Flux

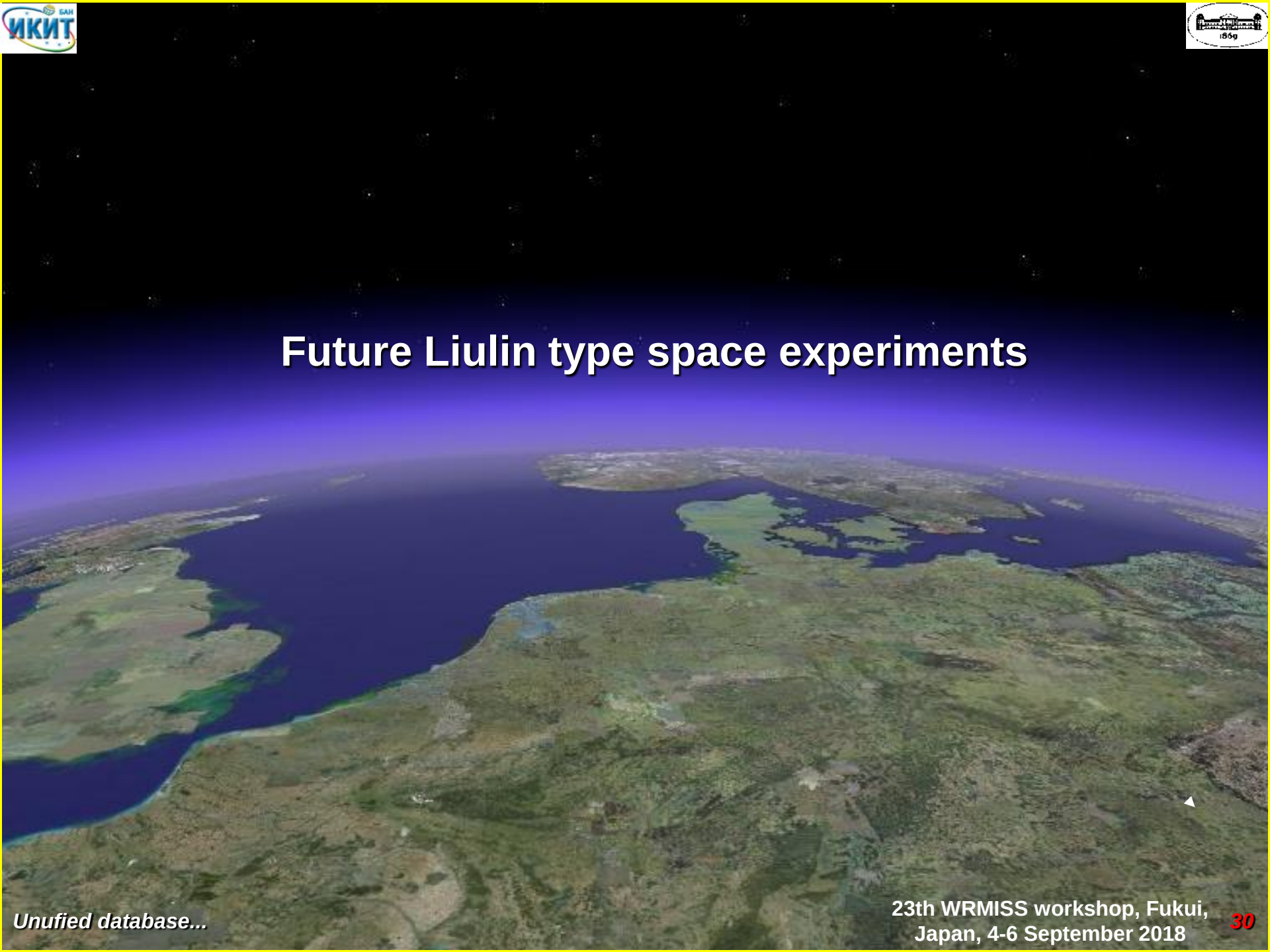


Press one of the red buttons CSV/TXT below the table. A file is ready for downloading. The user can save it in a chosen location under a chosen name

Acknowledgements

We devote this work to the memory of Prof. F. Spurny, Dr. V.M. Petrov and Dr. I.V. Chernykh for their invaluable contribution to the Liulin instrument developments and data analysis. The authors would like to thank: Dr. J. Miller, Lawrence Berkeley National Laboratory, Berkeley, USA for the post-calibrations of LIULIN instrument (Dachev et al., 1998a); Dr. E.G. Stassinopoulos, former Director of NASA-GSFC Radiation Physics Office for the support and help in the LIULIN-3M calibrations (Dachev et al., 2003); Dr. R. Beaujean, former scientist in Christian-Albrechts-Universitaet zu Kiel, Germany for the cooperation and financial support in the development of the Liulin-4 instrument (Dachev et al., 2002); Prof. J. Lemaire, from Institut d'Aeronomie Spatiale de Belgique for the help in the interpretation of LIULIN data and for the financial support in the development of the Liulin-ISS instrument; Prof. Gh. Gregoire and Dr. H. Schmitz from Institut de Physique, Universite Catholique de Louvain, Belgique, for the Liulin-ISS calibrations (Dachev et al., 2002); Prof. E.R. Benton from the Department of Physics, Oklahoma State University, USA for support and NASA balloon data (Benton, 2005a, b); as well as other co-authors and organizations listed in the text and in the references for their contribution in the use and data interpretation of the Liulin-type instruments. Many thanks to the cosmonauts and astronauts onboard the Mir space station and the ISS for conducting the experiments with Liulin instruments.

Future Liulin type space experiments



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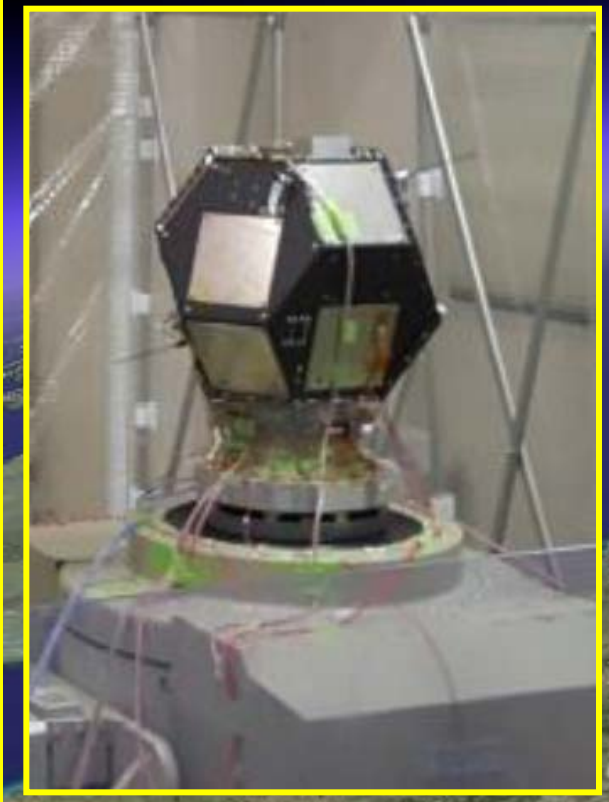
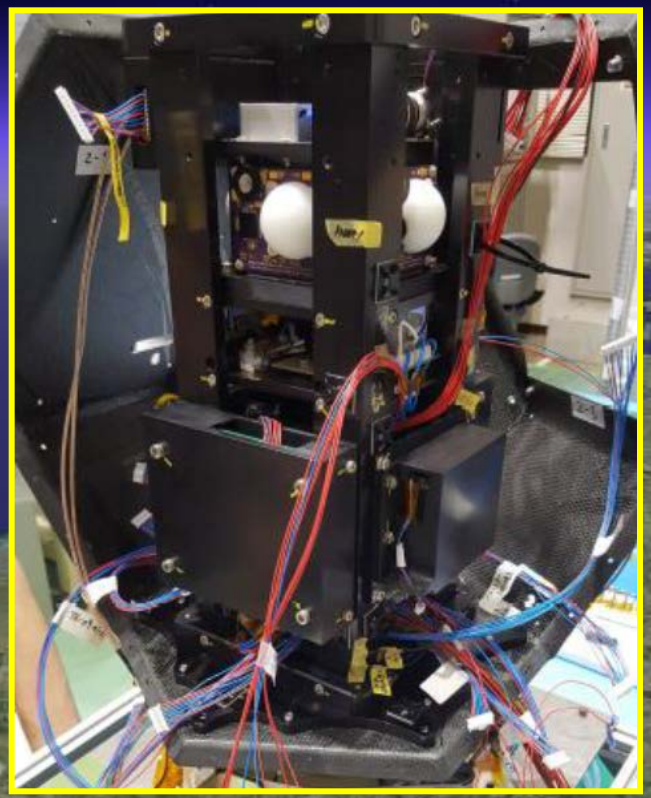
Liulin-Ten Koh spectrometer for radiation environment observation on the Japanize Ten-Koh satellite at 600 km orbit

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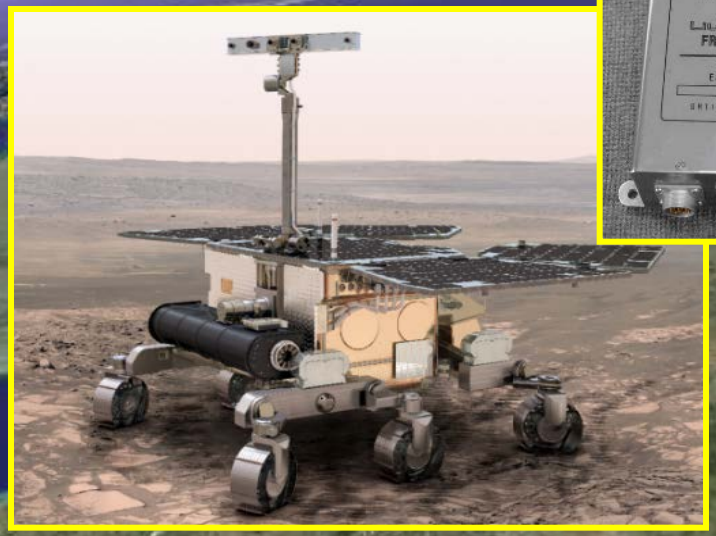
The Liulin-ML instrument is under development for the ESA-Roscosmos ExoMars 2020 (ESA project: "DOSIMETRY: Dosimetry science payloads for ExoMars TGO & surface platform" http://esa-pro.space.bas.bg/)

20. 07. 2020



ESA's ExoMars Rover

Roscosmos ExoMars Surface platform

Unufied database...

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

2021

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

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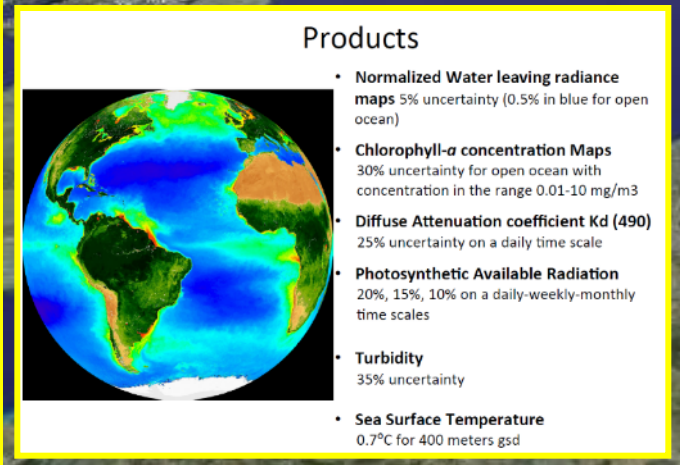
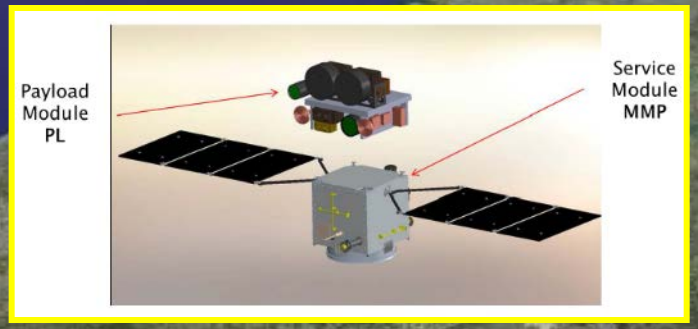
[2]Istituto Nazionale di Fisica Nucleare, Sez. Torino, Torino, Italy, zanini@to.infn.it
[3]Comisión Nacional de Actividades Espaciales, Buenos Aires, Argentina, caruso@conae.gov.ar,
[4]Universitad National de La Plata, La Plata, Argentina, ciancio@netverk.com.ar

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.





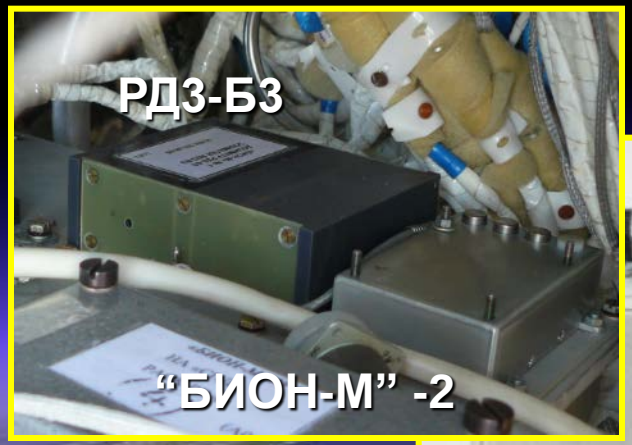
The SABIA-Mar satellite

The Liulin-AR instrument

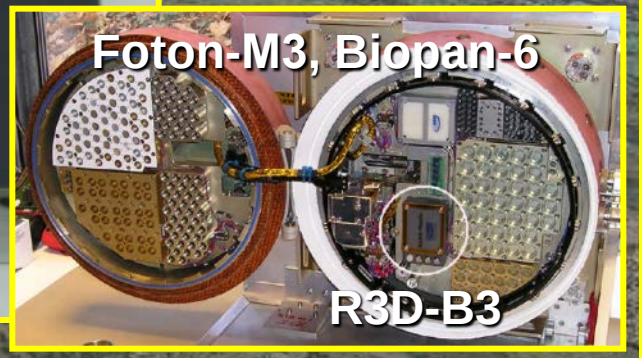
Unufied database...

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




“Фотон-М” №4



Unufied database...

Conclusions

- The objective of the database was to survey, collect and store in unified format the existing Liulin type instruments data sets from different satellites and to develop a web-based database that will serve users from all over the world;
- http://esa-pro.space.bas.bg/datasources : downloads to the user computer original, zipped “DATA SOURCES”, which contain lists of the measured parameters together with the time and space coordinates in comma separated values (CSV) format, directly opened in an EXCEL program;
- http://esa-pro.space.bas.bg/database: allows source selection, visualization, synchronized zoom, tooltip and hairline; export of the charts to vector, JPEG and PDF format; data export in CSV and TXT format.


Thank you for your attention