DESCRIPTION OF THE DATABASE WITH LIULIN TYPE INSTRUMENTS' COSMIC RADIATION DATA

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Abstract: *A total of fourteen different space instruments were developed, qualified and used in numerous space missions between 1988 and 2018 by the scientist from the Solar-Terrestrial Physics Section, Space Research and Technology Institute, Bulgarian Academy of Sciences (SRTI-BAS). The first was used on MIR space station between 1988 and 1994. Six of them were flown on the International Space Station (ISS) in missions of more than one year duration. Another five were flown on satellites in short-term low-earth orbits. One experiment was for one year in a 100/200 km lunar orbit. The Liulin-MO instrument was launched toward Mars in 2016 and now is operating in a 400 km Mars orbit. During the implementation of the Contract No. 4000117692/16/NL/NDe (http://esa-pro.space.bas.bg/) with ESA a unified web based database with Liulin-type instruments' cosmic radiation data" was developed between 2016 and 2018. Two separate options were foreseen in the database. First option downloads to the user computer original, zipped "DATA SOURCES" (http://esa-pro.space.bas.bg/datasources) in comma separated values (CSV) format, which is directly opened in an EXCEL program. The data sources contain the measured flux and absorbed dose rate with a resolution between 10 sec and 1 hour and the time and the geographical and geomagnetic coordinates of the vehicle for each data point. The "DATABASE" allows (http://esa-pro.space.bas.bg/database) following functions: source selection; data export in CSV and TXT format; and several charts: visualization, synchronized zoom, tooltip and hairline; export to vector, JPEG and PDF format.*

ОПИСАНИЕ НА БАЗАТА ДАННИ ЗА КОСМИЧЕСКАТА РАДИАЦИЯ, ИЗМЕРЕНА С ПРИБОРИ ОТ ТИПА „ЛЮЛИН“

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Keywords: *Дозиметрия на космическата радиация, ГКЛ, Радиационни пояси*

Резюме*: Четиринадесет различни прибори за измерване на космическата радиация са разработени, квалифицирани и използвани в многобройни космически мисии между 1988 и 2018 г. от учените от секция "Слънчево-земна физика" от Института за космически изследвания и технологии към Българската академия на науките (БАН). Първият прибор е използван на станцията „МИР“ между*

1988 и 1994 г. Шест други са работили на Международната космическа станция (МКС) в мисии с продължителност повече от една година. Други пет са летели на спътници в краткосрочни мисии на околоземни орбити. Приборът „Люлин-МО“ полетя към Марс през 2016 г. и сега работи на орбита от 400 км около Марс. По време на изпълнението на договор № 4000117692/16 / NL / NDe (http://esa-pro.space.bas.bg/) с ESA (2016-2018 г) беше разработена единна уеб базирана база данни с данни за космическата радиация, измерена с прибори от типа "Люлин". В базата данни са разработени две отделни опции: Първата опция, наречена "DATA SOURCES" (http://esa-pro.space.bas.bg/datasources) изтегля в компютъра на потребителя файлове с данни във CSV формат. Втората опция, наречена "DATABASE" (http://esa-pro.space.bas.bg/database) позволява избор и визуализация на данни във векторен, JPEG и PDF формат, както и получаване на файл в CSV или TXT формат.

Introduction

Ionizing radiation is recognized to be one of the main health concerns for humans in space missions. Liulin type spectrometer-dosimeters were developed in the late 1980s and have been in use since then. Two major measurement systems have been developed by our team. The first one is based on one silicon detector and is known as a Liulin-type Deposited Energy Spectrometer (DES) (Dachev et al., 2002 and 2003), while the second one is a dosimetric telescope (DT) with two or three silicon detectors. The Liulin-type instruments were calibrated using a number of radioactive sources and particle accelerators.

1. Liulin instruments

A total of fourteen successful space instruments were developed, qualified and used in numerous space missions between 1988 and 2018 (Dachev et al., 2015a and 2017ab; Semkova et al., 2018) by the scientist from the Solar-Terrestrial Physics Section of SRTI–BAS. Data from ten experiments (eight DES and two DT experiments) are collected in the database.

2. System architecture of the Unified web-based database with Liulin-type instruments' cosmic radiation data

Software architecture serves as a blueprint for both the system and the project, clarifying the work scope and assignments that must be carried out.

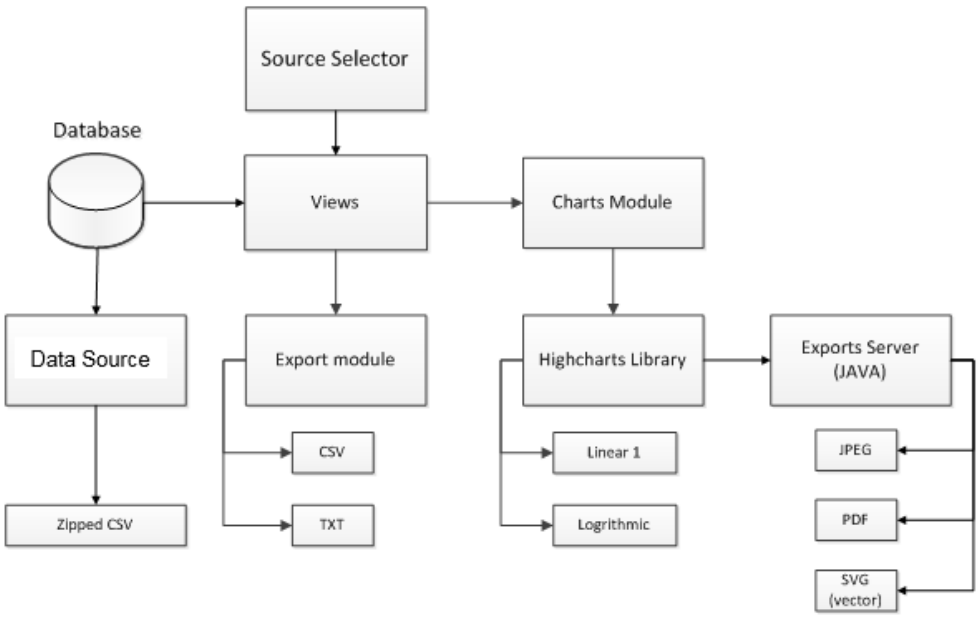


Fig. 1. The software architecture

Each dataset is extracted from the respective database using data views. Liulin-E094 and R3DR2 have separate view for each combination of their data sources. Data view provides data for the data export and plotting features. Paging is used whenever the data visualized takes more than 5 pages. Data export covers the most common data formats: Comma separated values (CSV) and ASCII text (TXT). Plotting features are based on data views, but forwards data to an external plotting library called Highcharts.

Highcharts is a SVG-based, multi-platform charting library that has been actively developed since 2009. It makes it easy to add interactive, mobile-optimized charts to your web and mobile projects. It features robust documentation, advanced responsiveness and industry-leading accessibility support.

The design of Liulin database user interface is very similar to the design of NASA, GSFC, Space physics data facility, Coordinated Data Analysis Web, (CDAWeb) https://cdaweb.sci.gsfc.nasa.gov/index.html/) interface. It follows the same logic. The idea of our team is that this will facilitate users, familiar with the high usage statistics (https://cdaweb.sci.gsfc.nasa.gov/CDAWeb_Statistics.html) CDAWeb, to use, more easily, the Liulin database.

3. Database operation

3.1. DATA SOURCES menu

Following the link: http://esa-pro.space.bas.bg/ the home page of the project: "DOSIMETRY: Dosimetry science payloads for ExoMars TGO & surface platform; unified webbased database with Liulin-type instruments' cosmic radiation data" will appear (Fig. 2). As seen in the Fig. 2 there are two choices to obtain Liulin instruments data: by menu-DATA SOURCES and by menu-DATABASE.

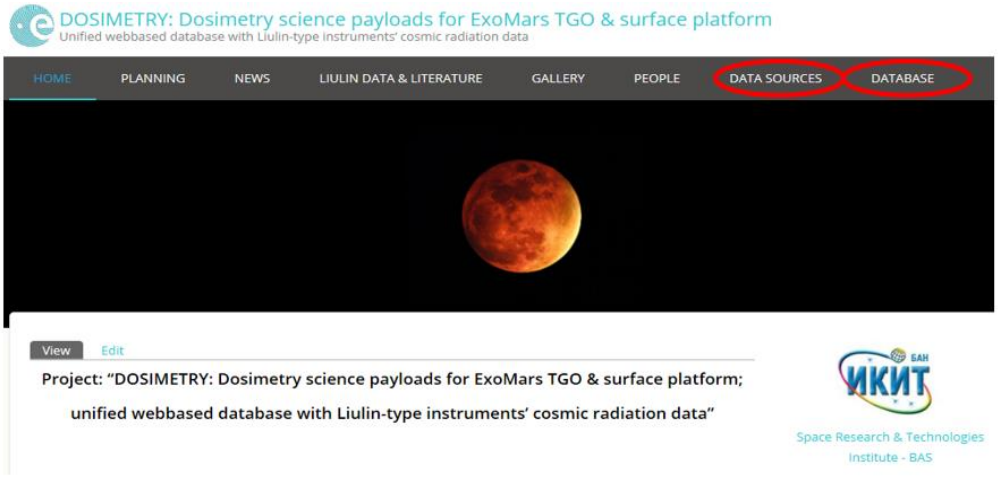


Fig. 2. The "Home page" of the site

Choosing the menu DATA SOURCES (http://esa-pro.space.bas.bg/datasources) following page will appear page as seen in Fig. 3.

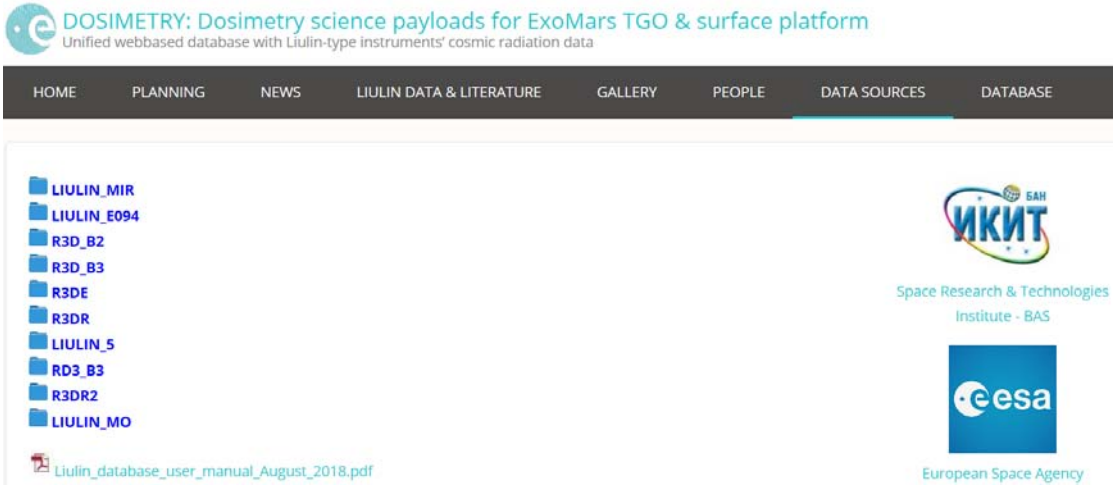


Fig. 3. The "DATA SOURCES" menu

The DATA SOURCES menu presents all ten data sets from the ten Liulin experiments. Each data set is subdivided in files, which are in "CSV" format and compressed by "ZIP". The main idea for the creation of this menu was fast direct access of the user to the data sources of the ten Liulin

instruments. Usually the data sources files are with 50-80 MB size. After compression it is about 10% of the original size, which a few MB, which can be downloaded to the computer of the user in seconds. Further the user can continue in deep analysis using EXCEL or other programs directly in the own computer. (The exact content of the columns of the ten data sources tables is presented in Table 3. in the User manual http://esa-pro.space.bas.bg/sites/default/files/Liulin_database_user_manual_August _2018.pdf.)

3.2. DATABASE menu

Choosing menu DATABASE (http://esa-pro.space.bas.bg/datasbase) and selecting the R3DR2 source a page as in Fig. 4 will be produced.

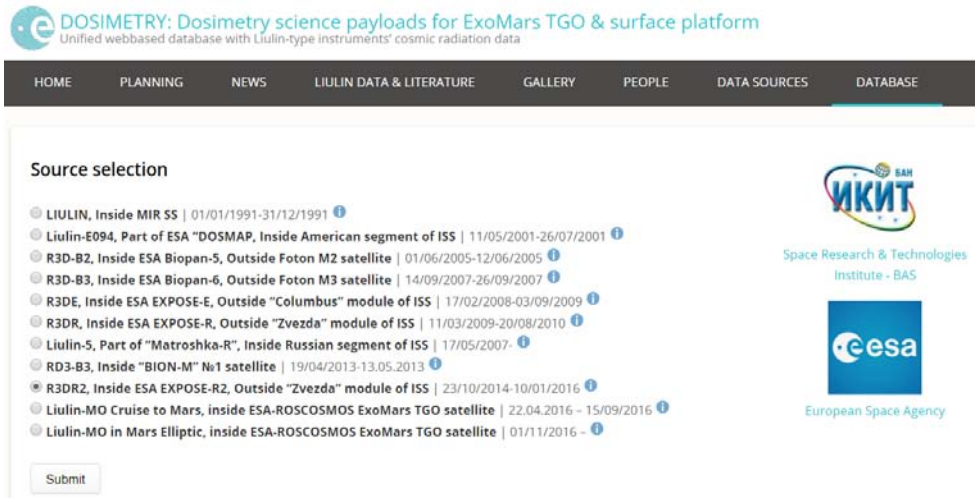


Fig. 4. The "DATABASE" submenu with selected R3DR2 source

Pressing "Submit" button a page as in Fig. 5 will appear.

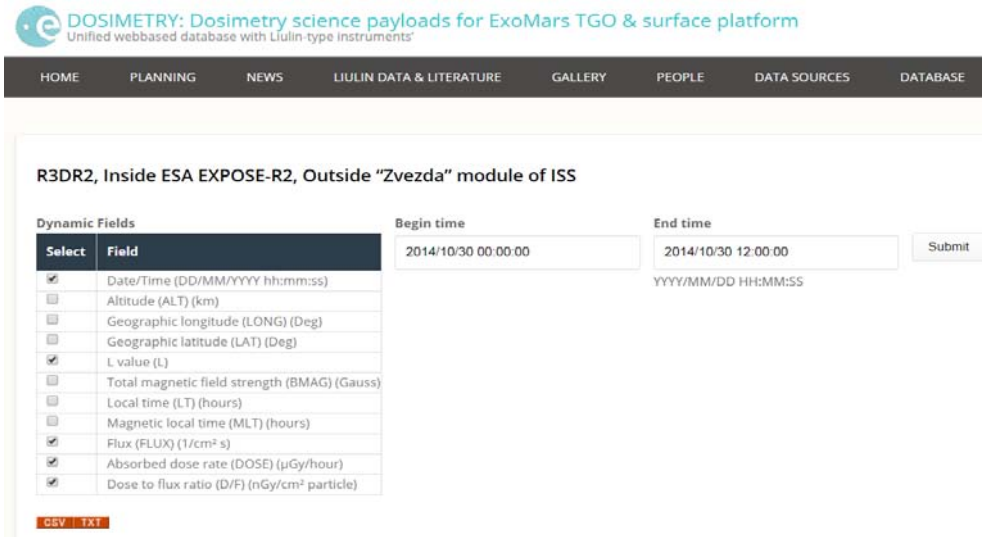


Fig. 5. The R3DR2 submenu

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).

OPTION 1*: Receiving graphics* - pressing “Submit” button a figure as in Fig. 6 will be produced.

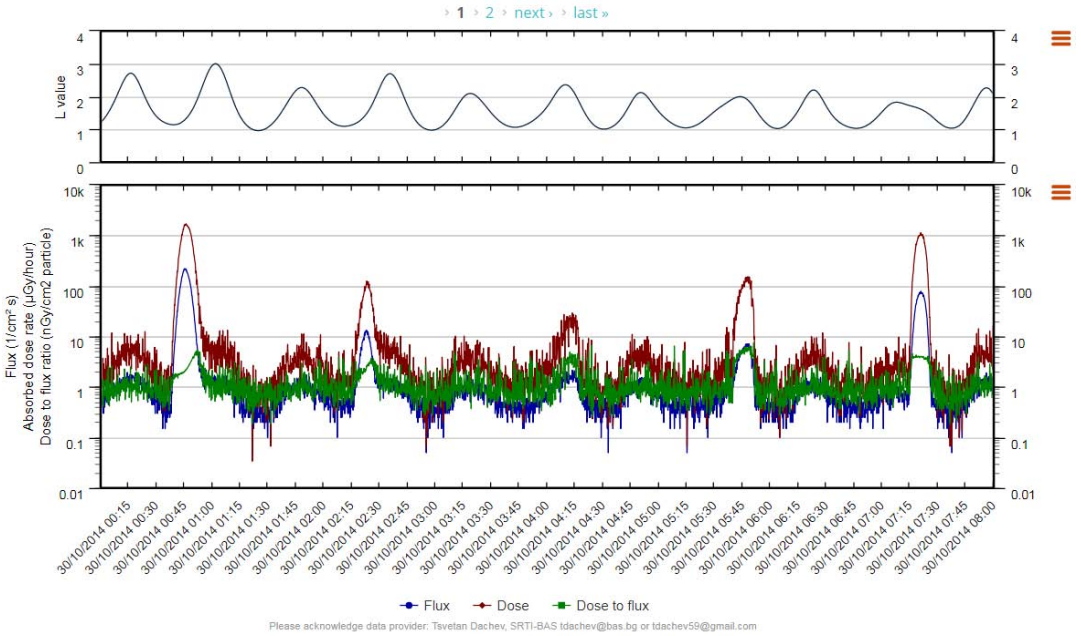


Fig. 6. R3DR2 data (First) page 30/10/2014 in the time interval 00:00:00–08:00:00

Movement of the cursor on the figures automatically generates labels, which contains the different variable values at the point of interest, as shown in Fig. 7.

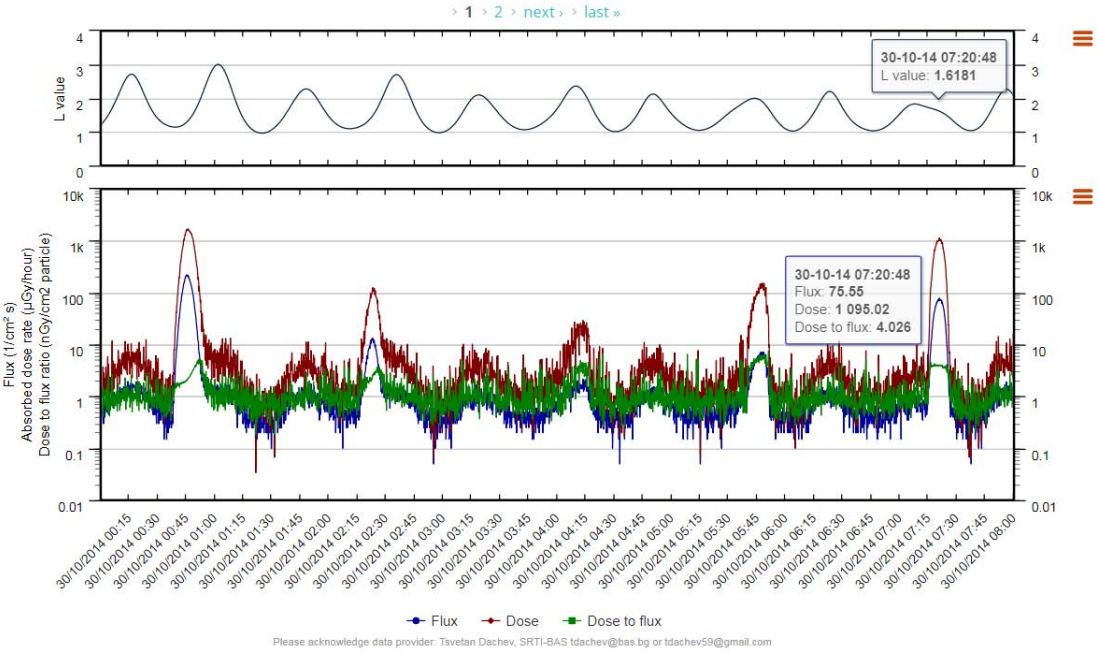


Fig. 7. R3DR2 data (First) page with value labels on the figure

The “Zoom” of any part of the figure can be obtained by pressing and holding down of the left button of the mouse as shown in Fig. 8.

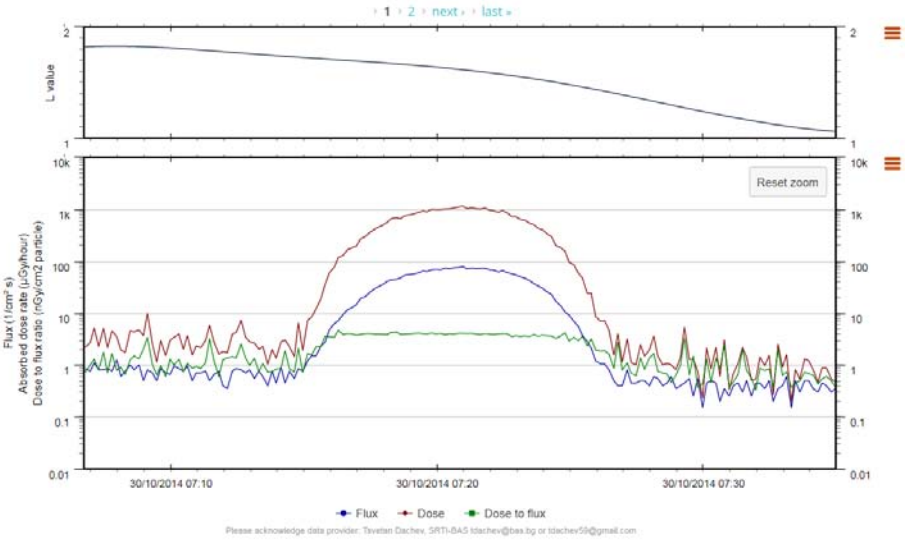


Fig. 8. Zoom of part of R3DR2 data (First) page

Pressing of the “Reset zoom” button return the picture to the original size.

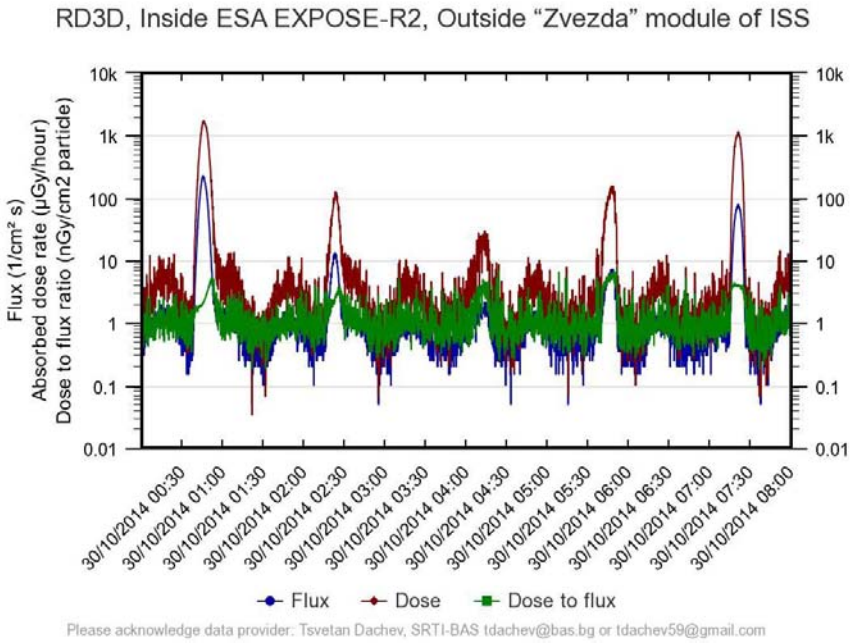


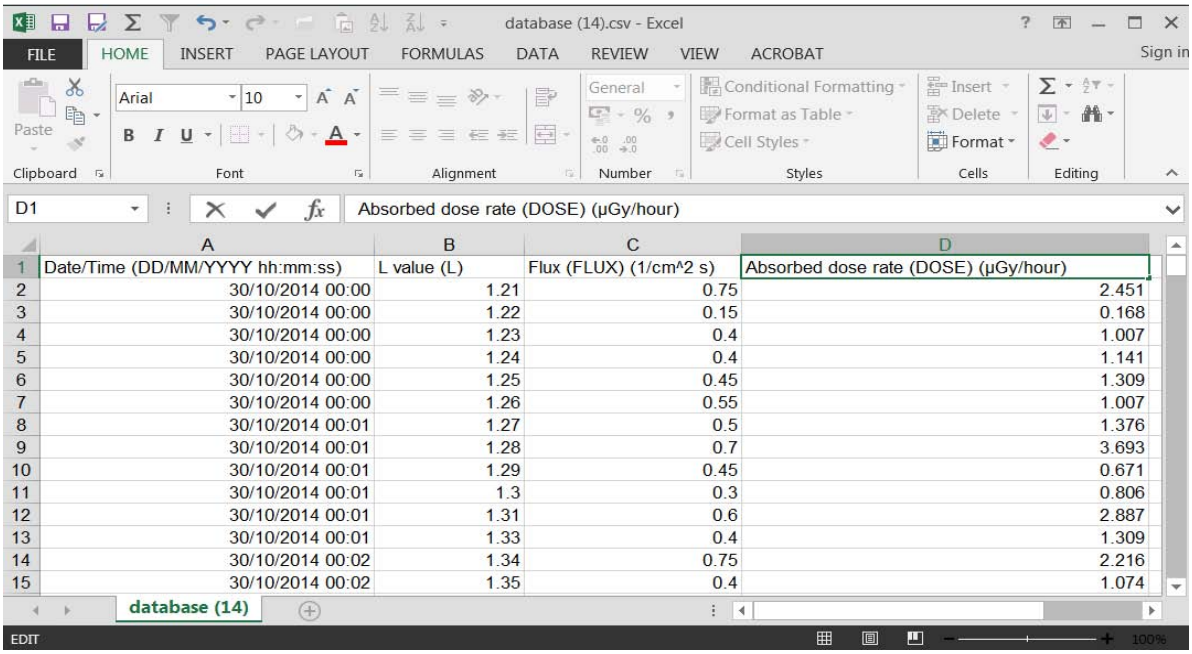
Fig. 9. JPEC image of R3DR2 data (First) page

Pressing of the ☰ button generate submenu where the user may choose the format of the figure output. The options are: “JPEC image”, “PDF document and “SVG image”. Choosing “JPEC image” the software send to the user’s computer an output picture is shown in Fig. 9.

OPTION 2: *Obtaining numeric data*

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

Pressing one of the red buttons CSV TXT in the R3DR2 menu generate CSV or TXT format file. A file is ready for downloading. The user can save it in a chosen location under a chosen name. In the example a text file is selected. The file has a content, which reflects the chosen parameters in the R3DR2 menu (date/time, L value, flux, absorbed dose rate, D/F ratio). The view of the first 15 rows of the file in “CSV” format are shown in Fig. 10.



	A	B	C	D
1	Date/Time (DD/MM/YYYY hh:mm:ss)	L value (L)	Flux (FLUX) (1/cm^2 s)	Absorbed dose rate (DOSE) (µGy/hour)
2	30/10/2014 00:00	1.21	0.75	2.451
3	30/10/2014 00:00	1.22	0.15	0.168
4	30/10/2014 00:00	1.23	0.4	1.007
5	30/10/2014 00:00	1.24	0.4	1.141
6	30/10/2014 00:00	1.25	0.45	1.309
7	30/10/2014 00:00	1.26	0.55	1.007
8	30/10/2014 00:01	1.27	0.5	1.376
9	30/10/2014 00:01	1.28	0.7	3.693
10	30/10/2014 00:01	1.29	0.45	0.671
11	30/10/2014 00:01	1.3	0.3	0.806
12	30/10/2014 00:01	1.31	0.6	2.887
13	30/10/2014 00:01	1.33	0.4	1.309
14	30/10/2014 00:02	1.34	0.75	2.216
15	30/10/2014 00:02	1.35	0.4	1.074

Fig. 10. R3DR2 data in the downloaded “CSV” format file

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