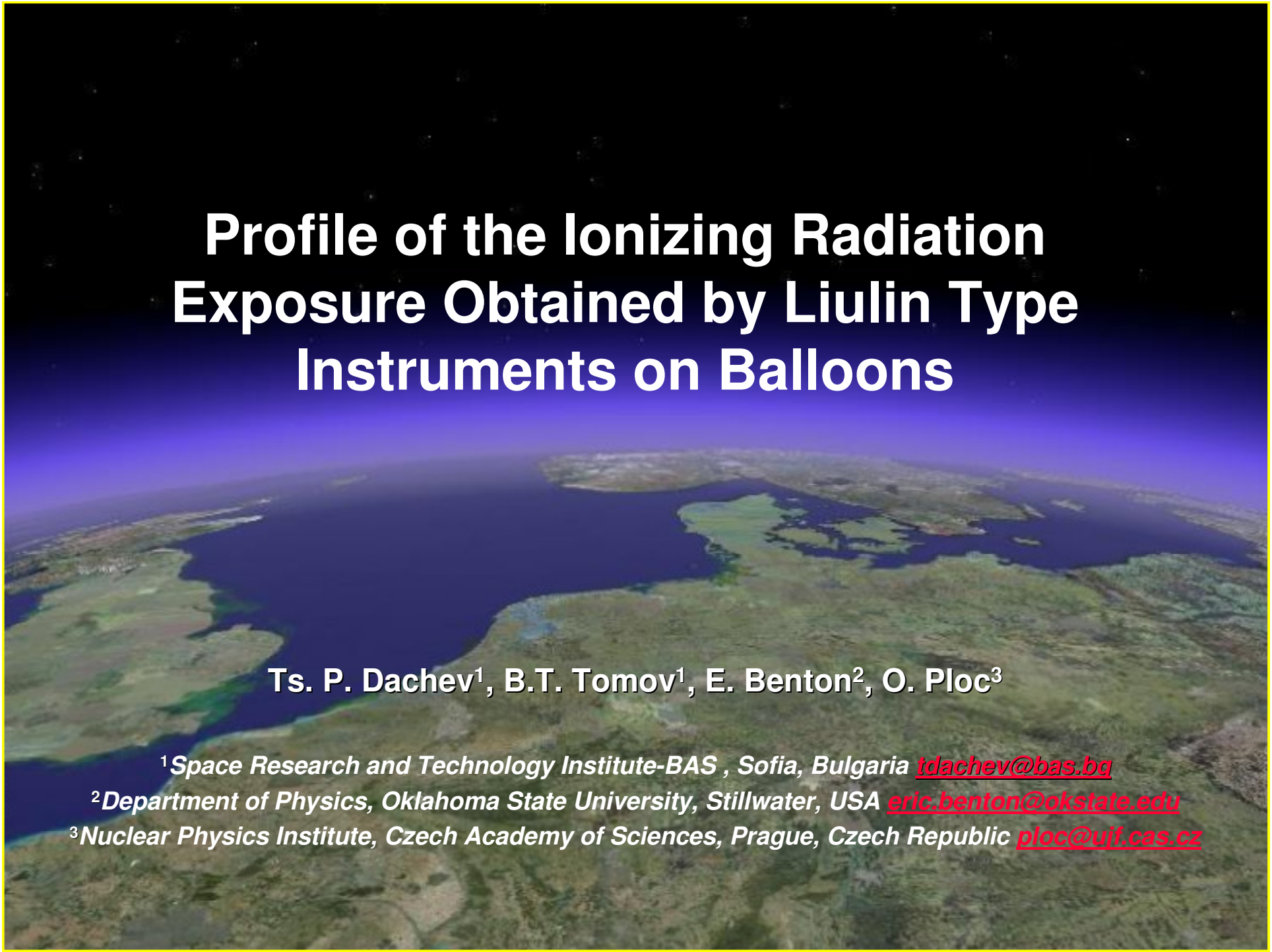


Profile of the Ionizing Radiation Exposure Obtained by Liulin Type Instruments on Balloons

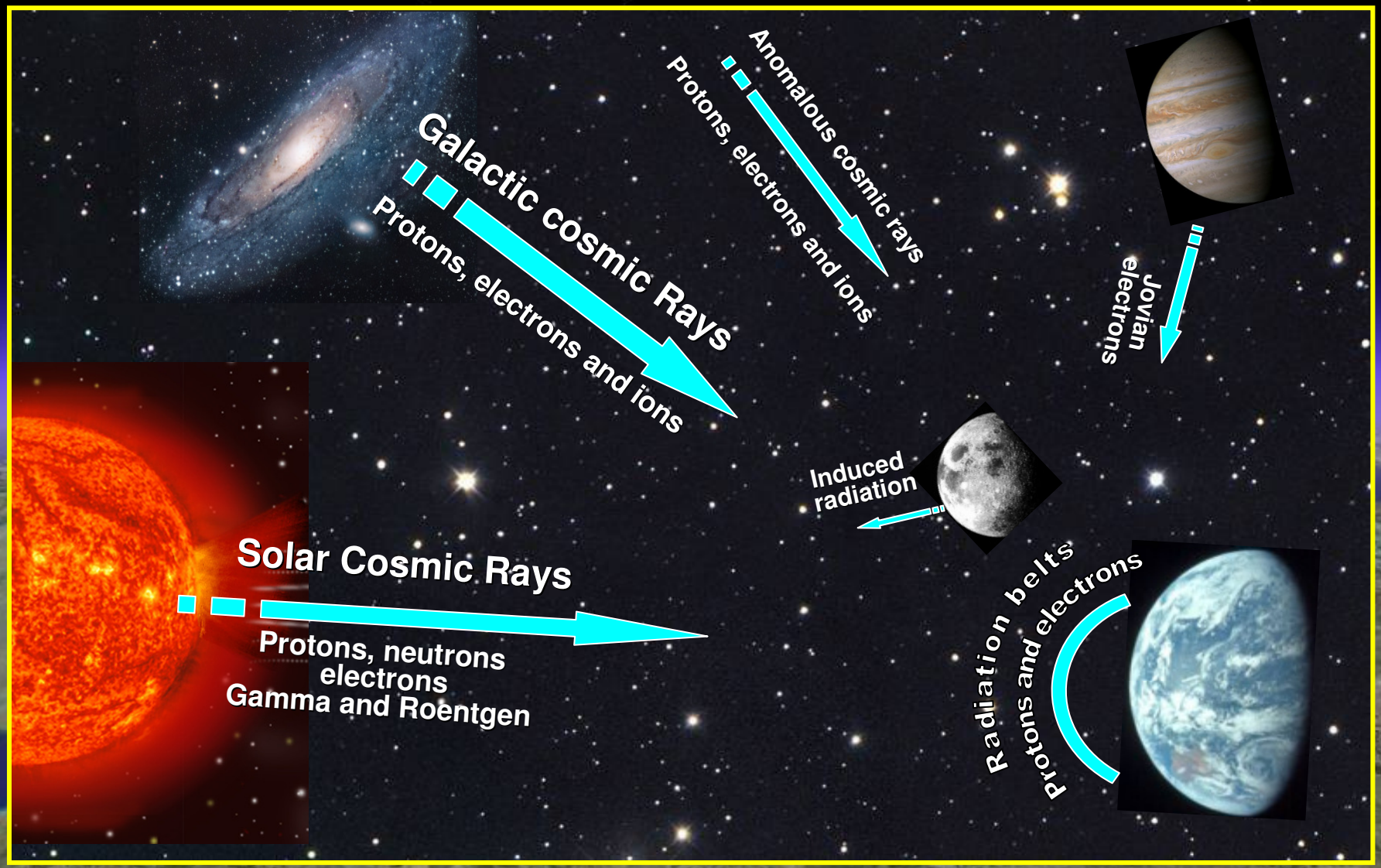
Ts. P. Dachev[1], B.T. Tomov[1], E. Benton[2], O. Ploc[3]

[1]Space Research and Technology Institute-BAS , Sofia, Bulgaria tdachev@bas.bg

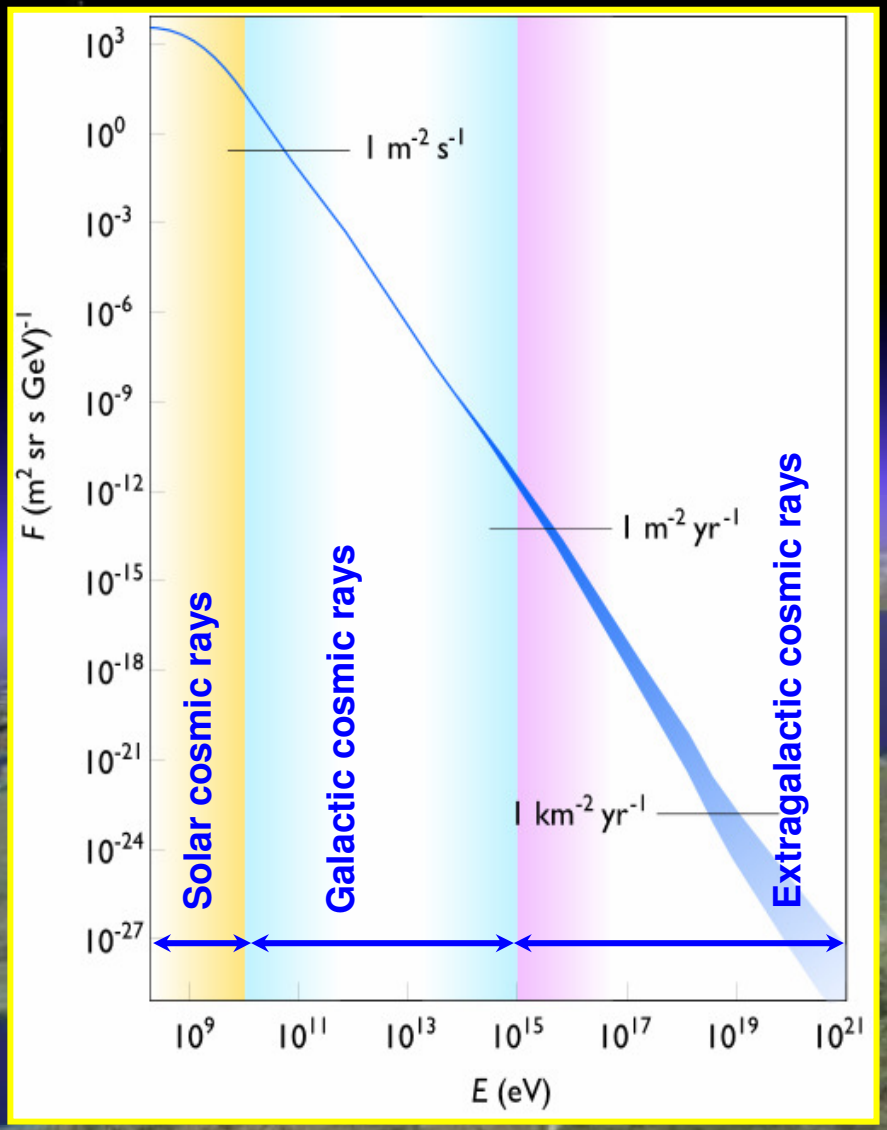
[2]Department of Physics, Oklahoma State University, Stillwater, USA eric.benton@okstate.edu

[3]Nuclear Physics Institute, Czech Academy of Sciences, Prague, Czech Republic ploc@ujf.cas.cz

Radiation sources in the Earth and Moon space environment

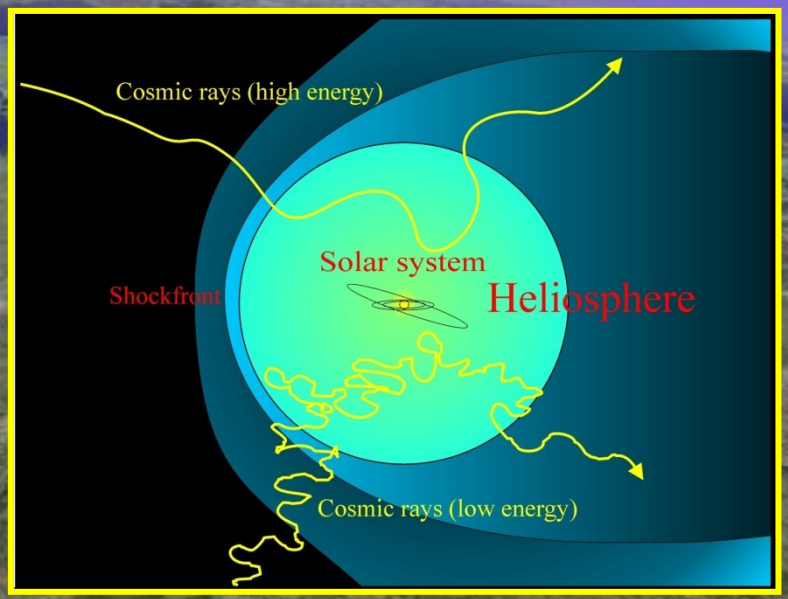


Cosmic Rays*

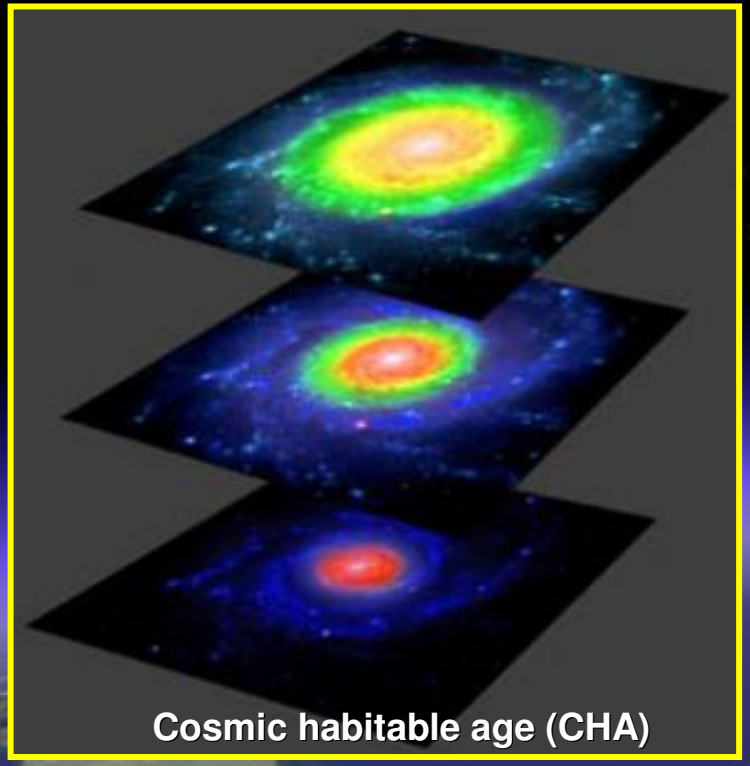


*http://en.wikipedia.org/wiki/Cosmic_ray

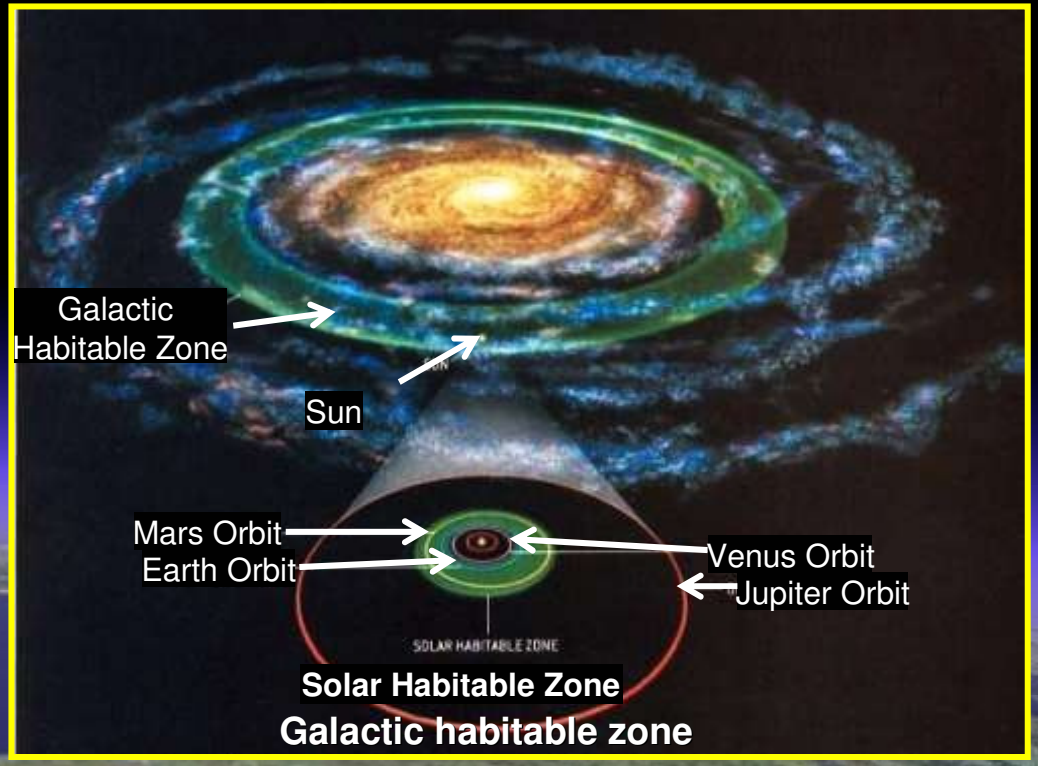
- Cosmic rays are energetic charged subatomic particles, originating from outer space;
- About 88% of cosmic rays are protons , 10% alpha particles, and 1% are heavier elements. Last 1% are electrons;
- Cosmic rays have a primary role in the formation of the lithium, beryllium, and boron in the universe, through the process of "cosmic ray nucleosynthesis". They also produce some radioisotopes on Earth, such as carbon-14;



Cosmic rays have major role in formation of Galactic Habitable Zone (GHZ)



Cosmic habitable age (CHA)



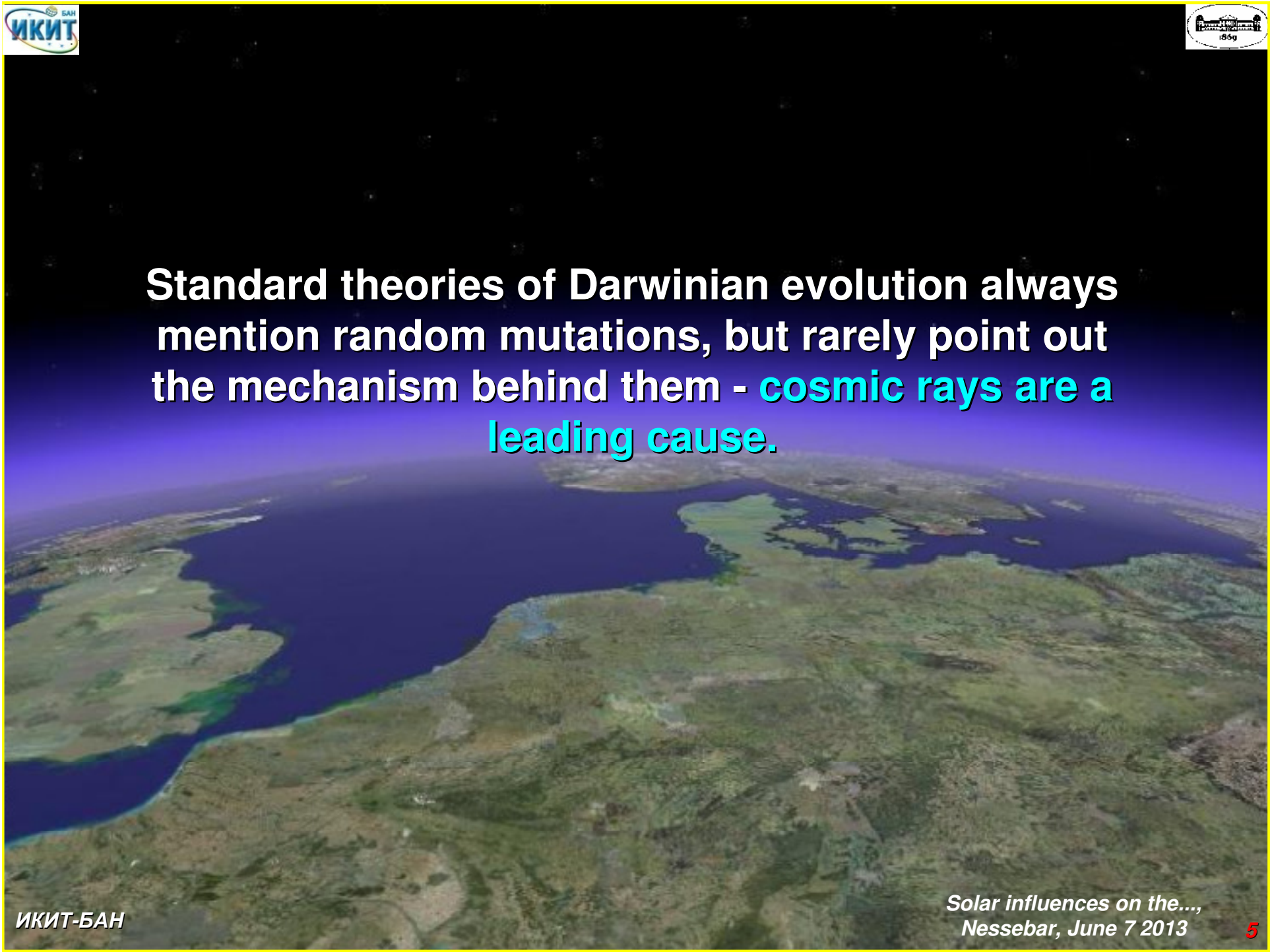
Solar Habitable Zone

Galactic habitable zone

In the early stages of galaxy formation (lower panel) there were not enough heavy elements to form terrestrial planets except in the most central regions of the Galaxy, where the danger due to nearby supernovae was very high (shown in red). As heavy elements spread through the Galaxy, terrestrial planets formed. The CHA is between 4 and 8 billion years after the sun formation. The Sun is 5.3 By old.

The Sun is out of the spiral arms of the Milky way galaxy and at 8.3 kparsecs from it center. This forms good conditions for the life formation away from harmful zones of high radiation and strong gravitational forces and perturbations. From other hand at this distance there are enough large amount of heavy elements spread round. (1 kparsec = 3.26 light years.)

*http://www.centauri-dreams.org/?p=428
*http://www.astrobio.net/exclusive/139/galactic-habitable-zones

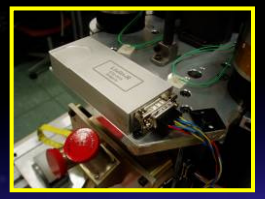

Standard theories of Darwinian evolution always mention random mutations, but rarely point out the mechanism behind them - cosmic rays are a leading cause.

SRTI-BAS space radiation measurements experiments since 2000

1. Liulin-MDU1, June 14, 2000, ESA balloon flight up to 33 km over Gap, France;
2. Liulin-MDU5, more than 10000 hours from 2001 till 2009 on Czech airlines aircrafts;
3. Liulin-E094, May-August 2001, ESA-NASA exp. on the International space station (ISS);
4. 2 Liulin-MDU, June 2001, NASA ER-2 flights at 20 km altitude in USA;
5. R3D-B1, October 2002, ESA Foton M1 satellite – unsuccessful launch;
6. R3D-B2, 1-12 юни 2005, ESA Foton M2 satellite;
7. 3 Liulin-MDU, June 11, 2005, NASA balloon flight up to 40 km over New Mexico, USA;
8. Liulin-ISS, ROSCOSMOS, launched to ISS in September 2005 (active now);
9. Liulin-6R, since October 2005 working in Internet (active now);
10. Liulin-Moussala, since June 2006 working in Internet (active now);
11. Liulin-5, ROSCOSMOS, since June 28, 2007 working at ISS (active now);
12. R3D-B3, September 14-26 2007, ESA Foton M3 satellite;
13. Liulin-6S, since October 2007 working at Jungfrau peak in Internet (active now);
14. Liulin-R, January 31, 2008, ESA rocket experiment up to 380 km from Norway;
15. R3DE, worked at ESA Columbus module at ISS between 17/02/2008 and 01/09/2009;
16. Liulin-6SA, since October 2009 working at Lomnitski stit peak in Internet (active now);
17. RADOM, worked at Chandrayyan-1 satellite around Moon between 22/10/2008 and 29/08/2009;
18. R3DR, worked at ESA EXPOSE-R facility on Russian Zvezda module of ISS between March 2009 and August 2010;
19. Liulin-LS, April 19-May 19 2013, BION-M No1 satellite;
20. Р3Д-Б3, April 19-May 19 2013, BION-M No1 satellite.

Since 2005 SRTI-BAS scientists participate with 15 instruments in the scientific programs of:
4 manned space flights (4 instr.) – 1 at ESA Columbus and 3 at the Russian segment of ISS
1 Moon spacecraft (1 instr.) – Chandrayaan-1
2 spacecrafts (3 instr.) - Foton M2/3
2 HotPay rockets (2 instr.), 1 balloon (1 instr.), flight and many airplane flights (4 instr.)

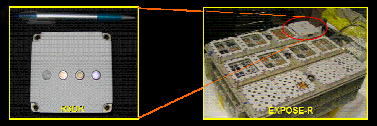
Rocket and balloon instruments



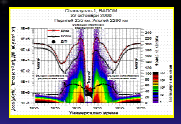
Liulin-R
Flown on HotPay 2
Rocket in 2008

Liulin-J
Flown on NASA
Balloon in 2005

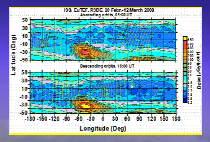
March 2009
STIL-BAS, FAU DLR, ESA



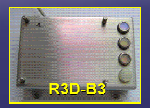
October 2008
STIL-BAS, ISRO

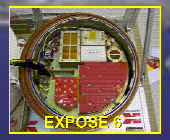


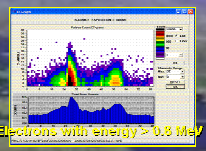
February 2008
STIL-BAS, FAU DLR, ESA



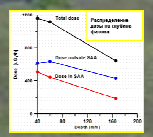
September 2007
STIL-BAS, FAU IC-IRC, DLR ESA

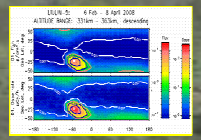






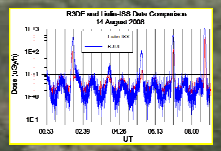
June 2007
STIL-BAS, IBMP, RKK Energia





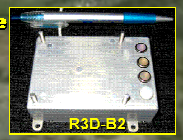
In use!

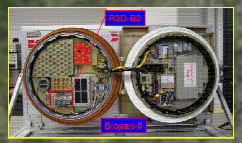
September 2005
STIL-BAS, IBMP, RKK Energia

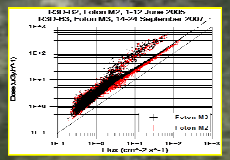


In use!

May-June 2005
STIL-BAS, FAU DLR, ESA



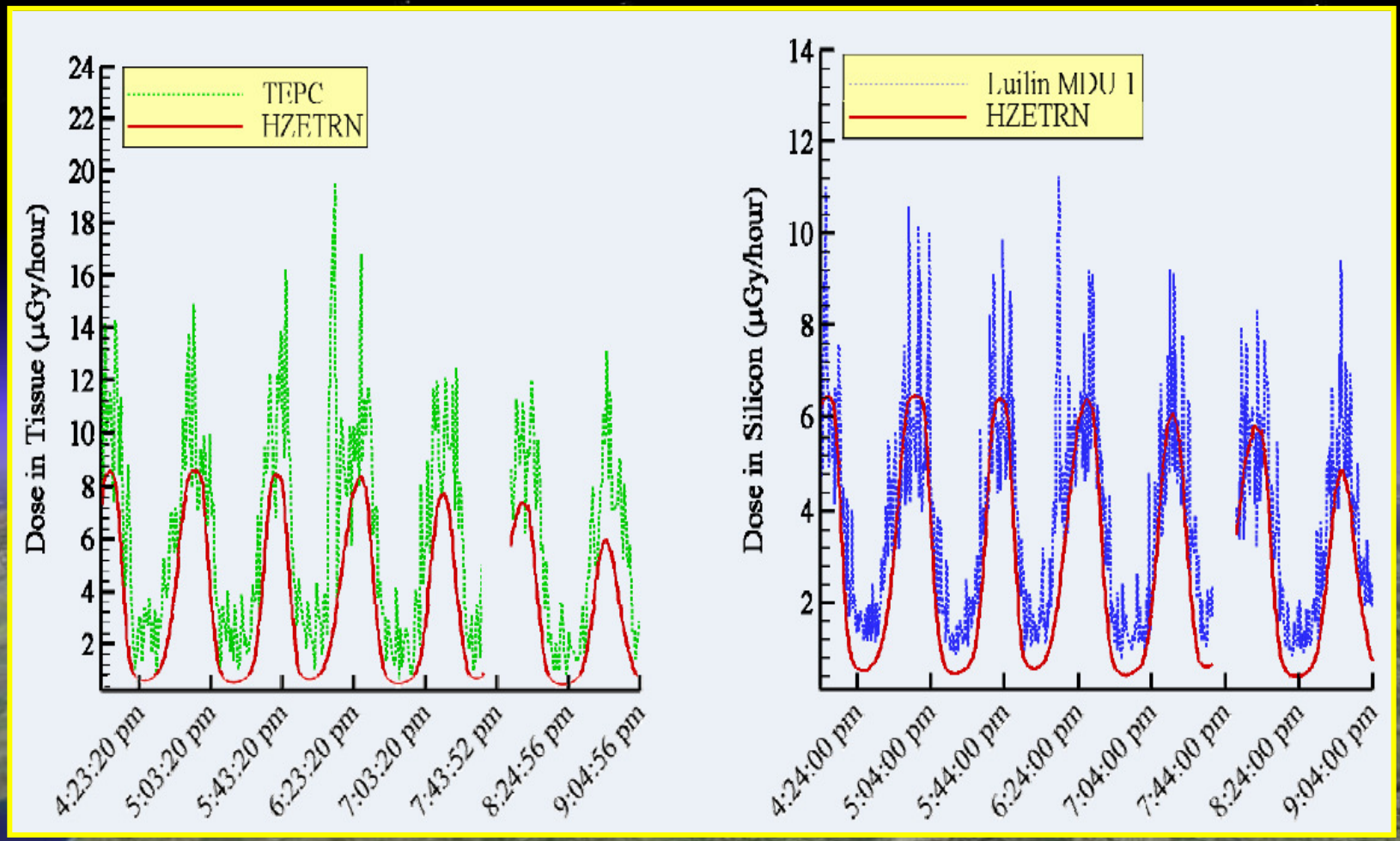




Aircraft instruments

Liulin-MDU-5 type flown for more than 6000 hours on CSA aircraft

Comparison of simulated results using HZETRN and measured data on ISS from July 6, 2001 4:00 pm to July 6, 2001 9:00 pm*

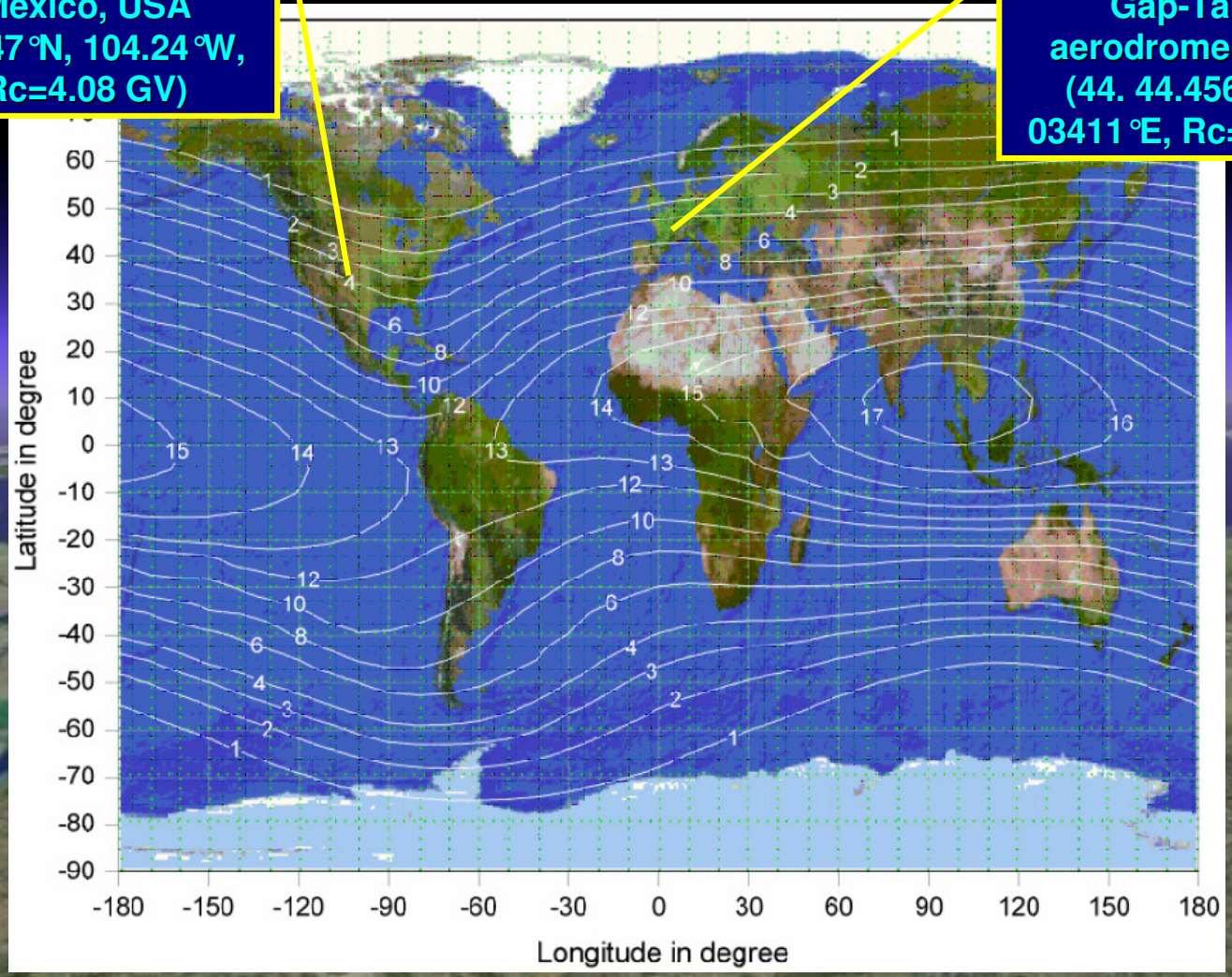


*Slaba, T.C., S.R. Blattnig, F.F. Badavi, N.N. Stoffle, R.D. Rutledge, K.T. Lee, E.N. Zappe, T.P. Dachev and B.T. Tomov, Statistical Validation of HZETRN as a Function of Vertical Cutoff Rigidity using ISS Measurements, Adv. Space Res., 47, 600-610, 2011. doi:10.1016/j.asr.2010.10.021

Places of the 2 balloon flights

Ft. Sumner, New Mexico, USA (34.47°N, 104.24°W, Rc=4.08 GV)

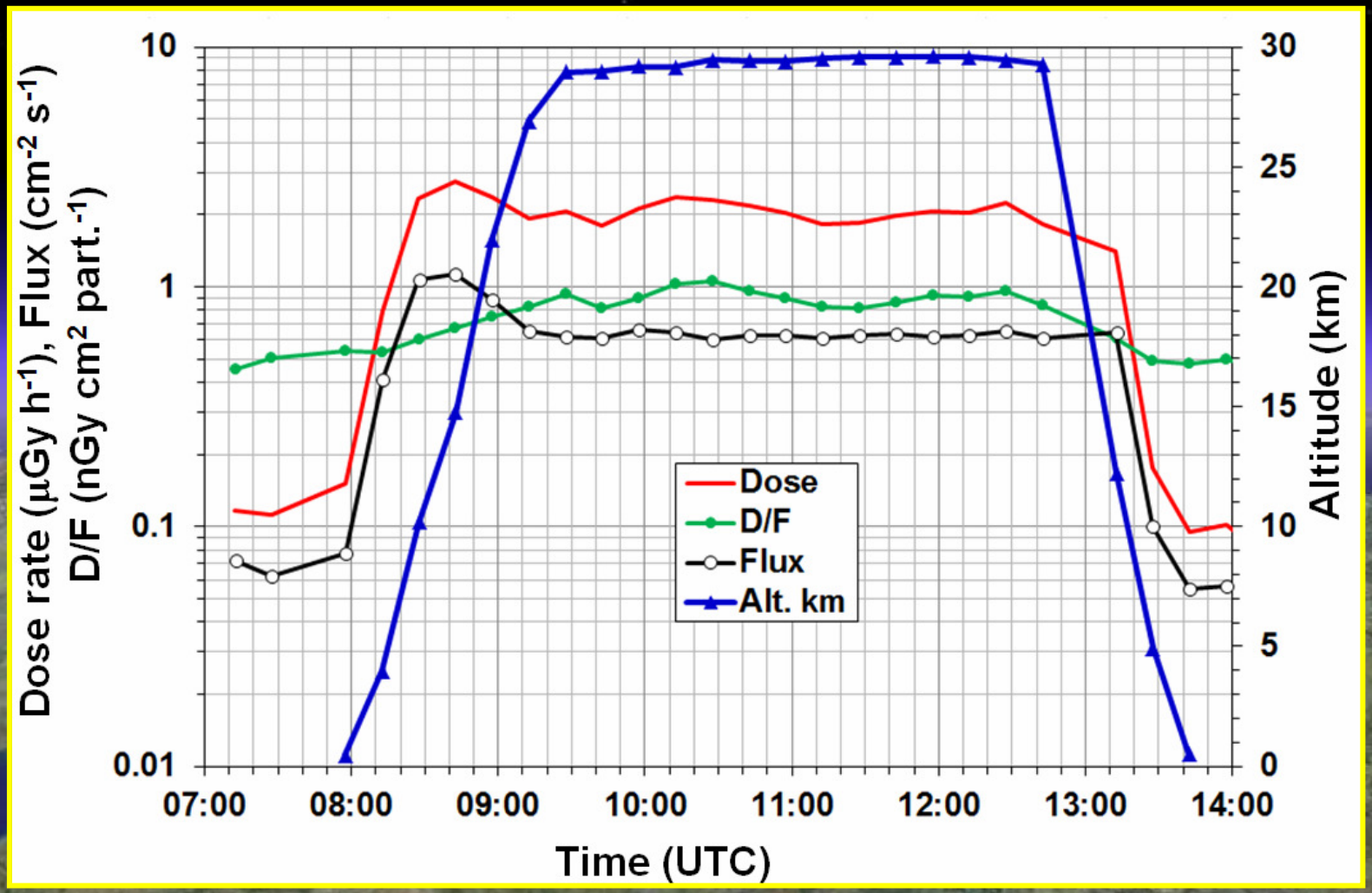
Gap-Tallard aerodrome, France (44. 44.4564°N, 6. 03411°E, Rc=5.18 GV)



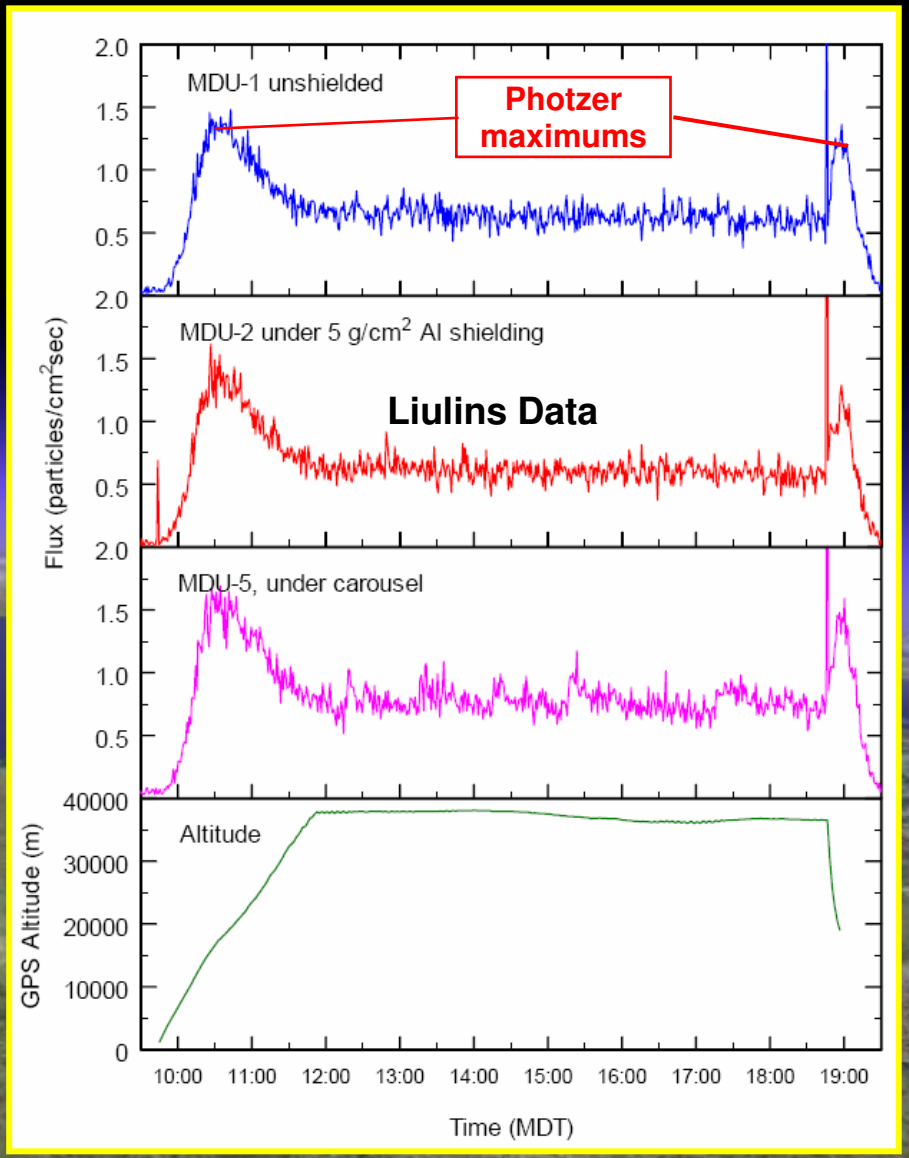
MDU#1 of Liulin-4C was used during the CNES balloon flight 14 June 2000.

http://www.cnes.fr/imagezoom.php?location=public&file=p3691_18c3b61fcf880544c2a57d9d9b7c513cP28258.jpg&label=Cr%E9dits+%3A+CNES%2FE.GRIMAULT%2C2000&popup=true

Dose rate, flux and dose to flux ratio (D/F) profiles measured by Liulin-4C MDU#1 during the CNES balloon flight 14 June 2000. Also shown is the altitude profile in kilometers

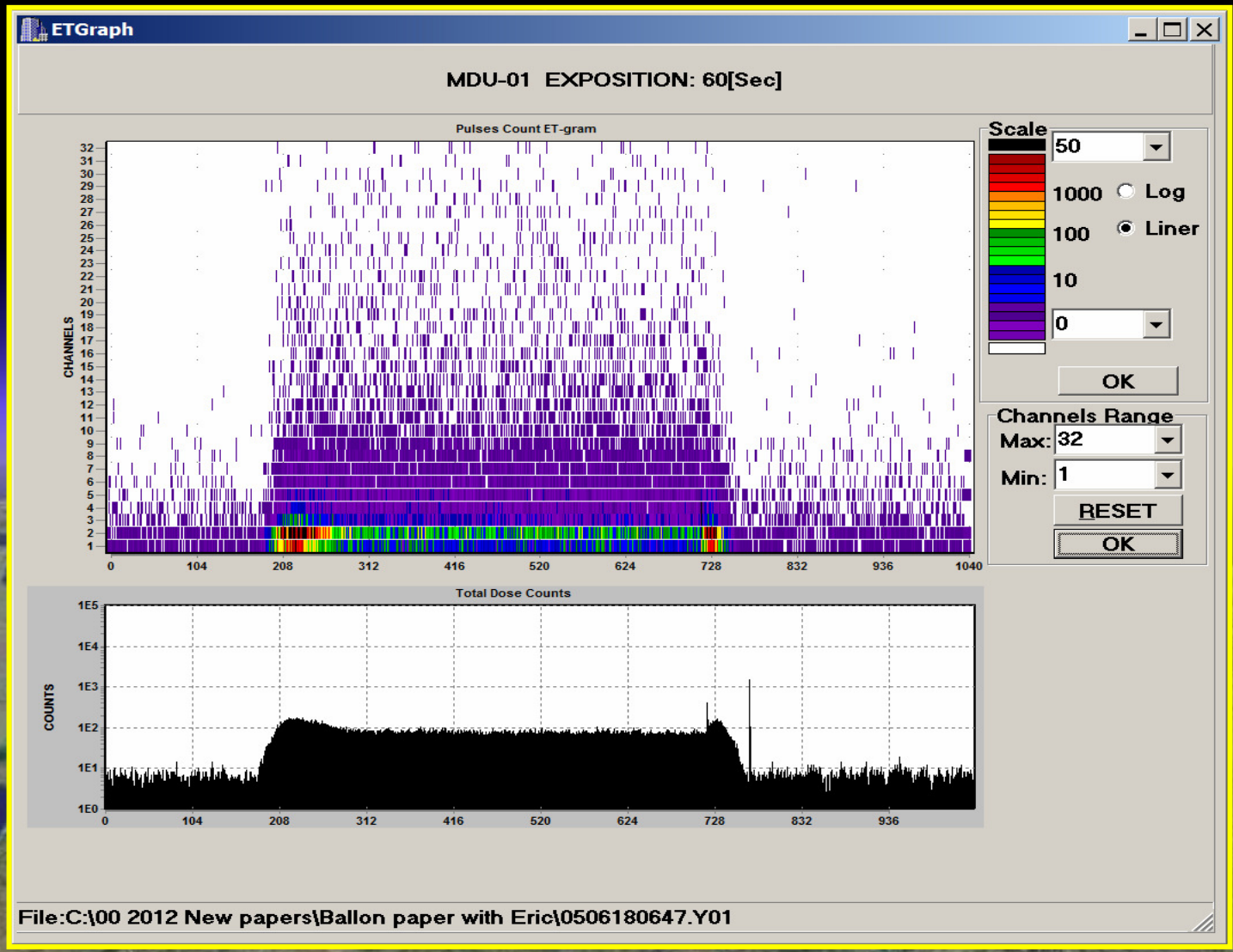


NASA Deep Space Test Bed (DSTB) balloon certification flight on June 11 2005, New Mexico, USA*

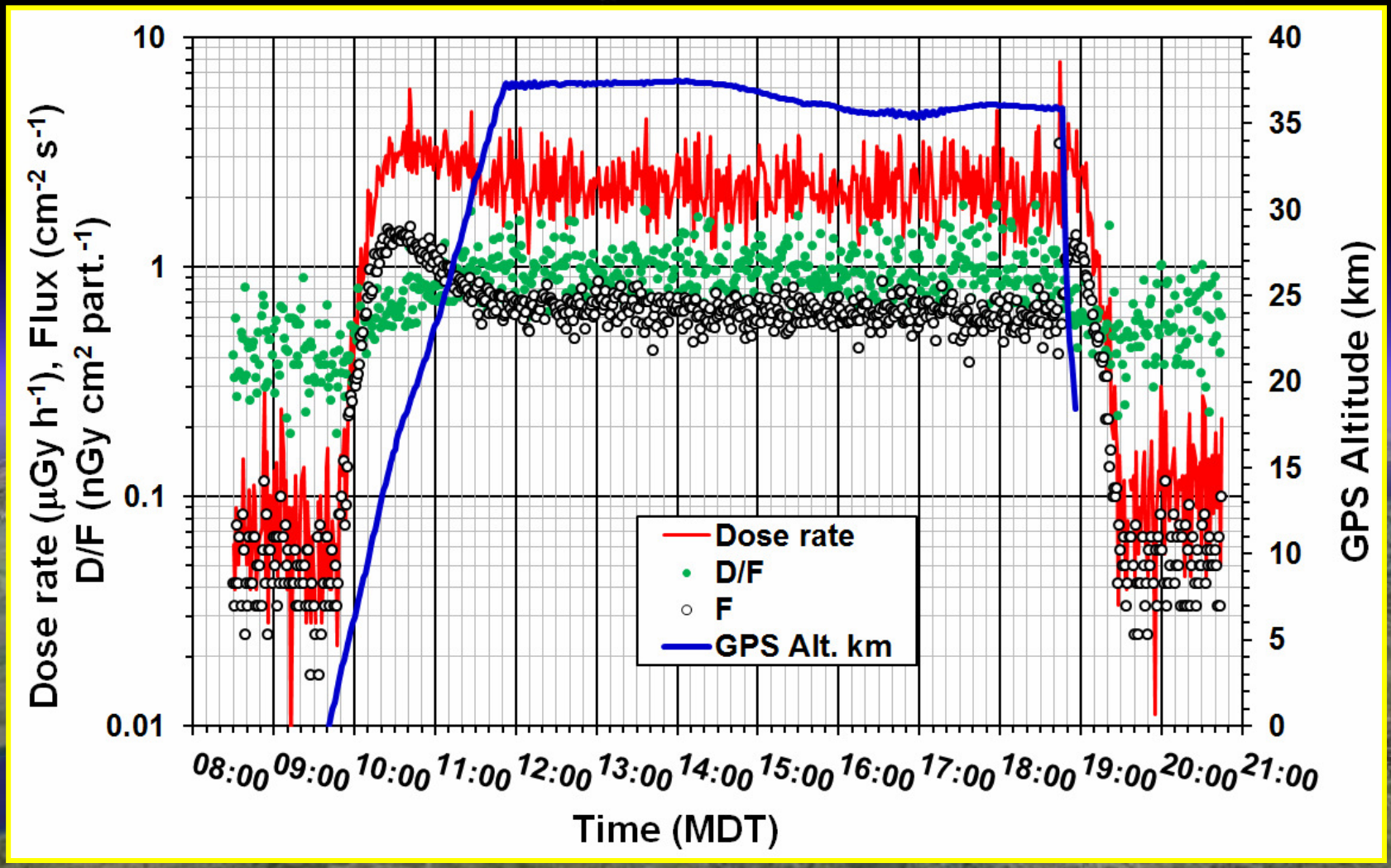


*Benton, E., Deep Space ICCHIBAN: An International Comparison of Space Radiation Dosimeters aboard the NASA Deep Space Test Bed, 10th WRMISS, Chiba, Japan, 7-9 September 2005. http://wrmiss.org/workshops/tenth/pdf/08_benton.pdf

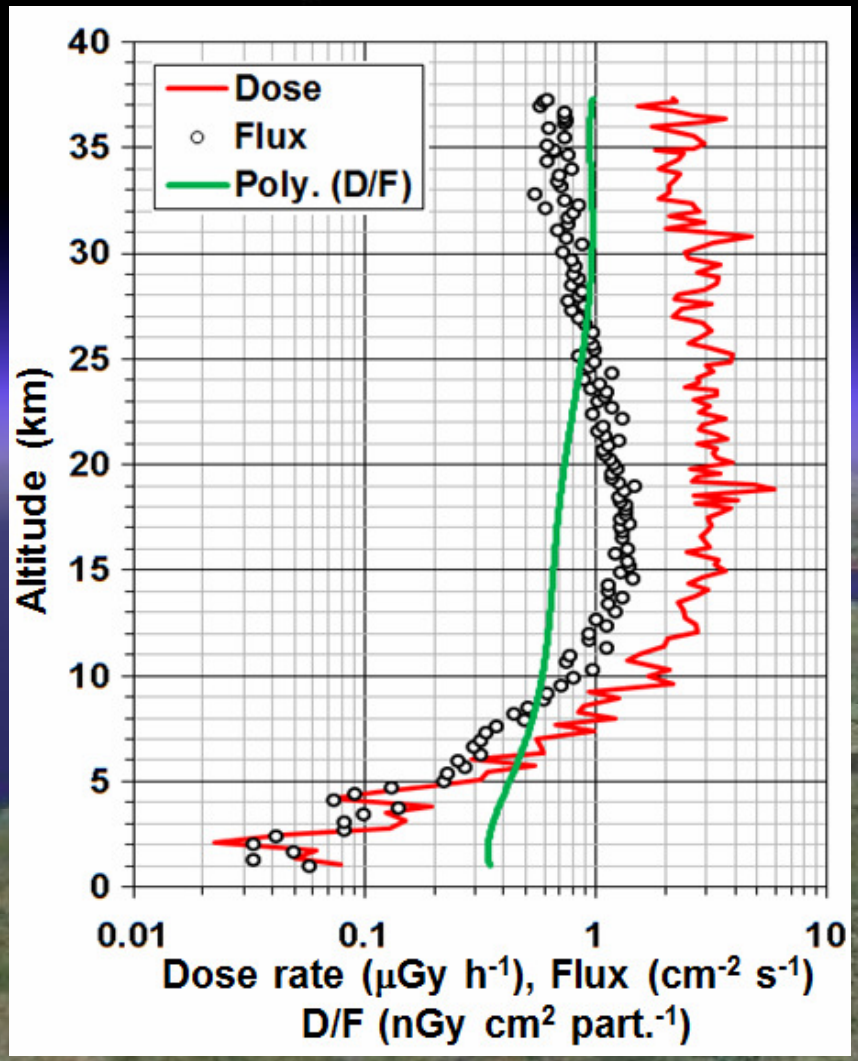
3D presentation of the spectra measured by Liulin-4U MDU#2 during the NASA DSTB Certification Flight 8 June 2005



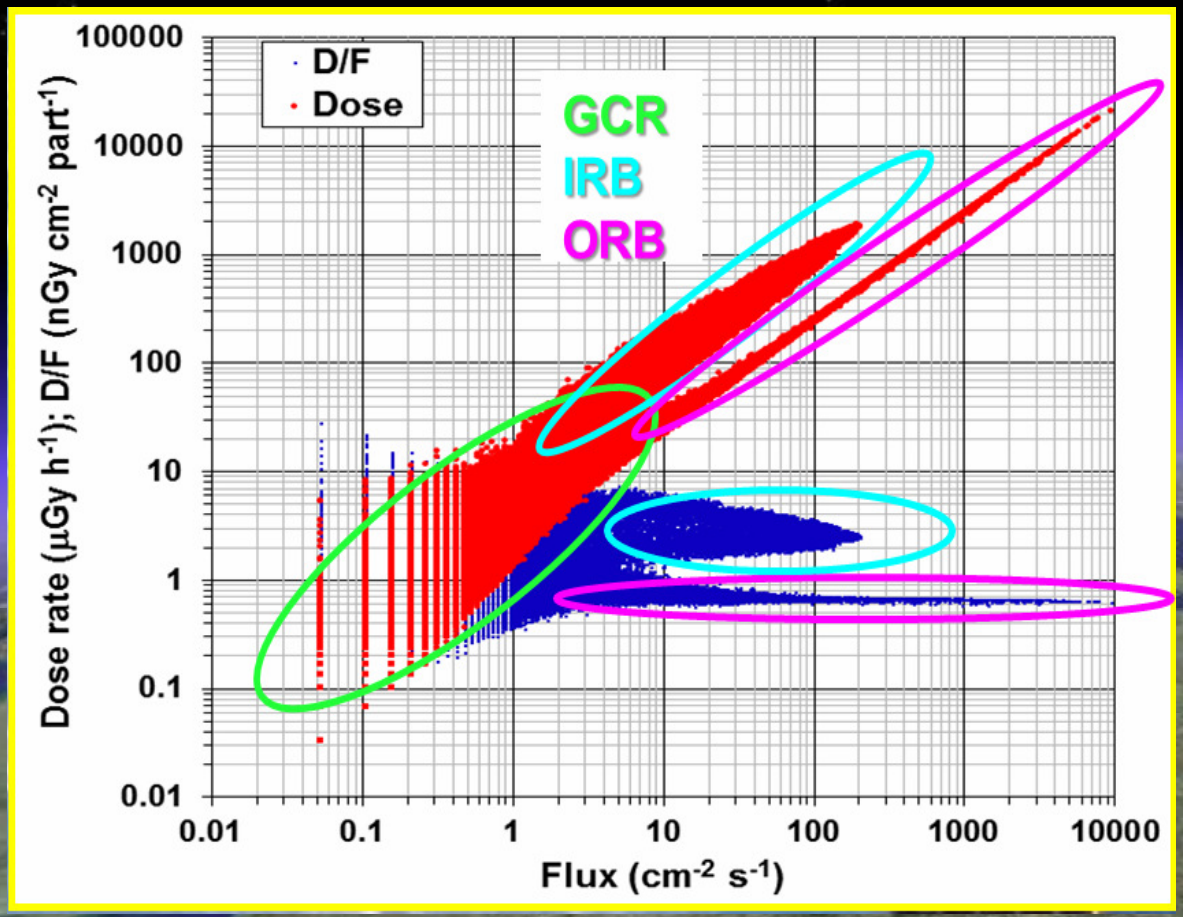
Dose rate, flux and dose to flux ratio (D/F) profiles measured by Liulin-4U MDU#2 during the NASA DSTB Certification Flight 8 June 2005



Altitudinal profiles od the dose rate, flux and dose to flux ratio (D/F) measured by Liulin-4U MDU#2 during the NASA DSTB Certification Flight 8 June 2005

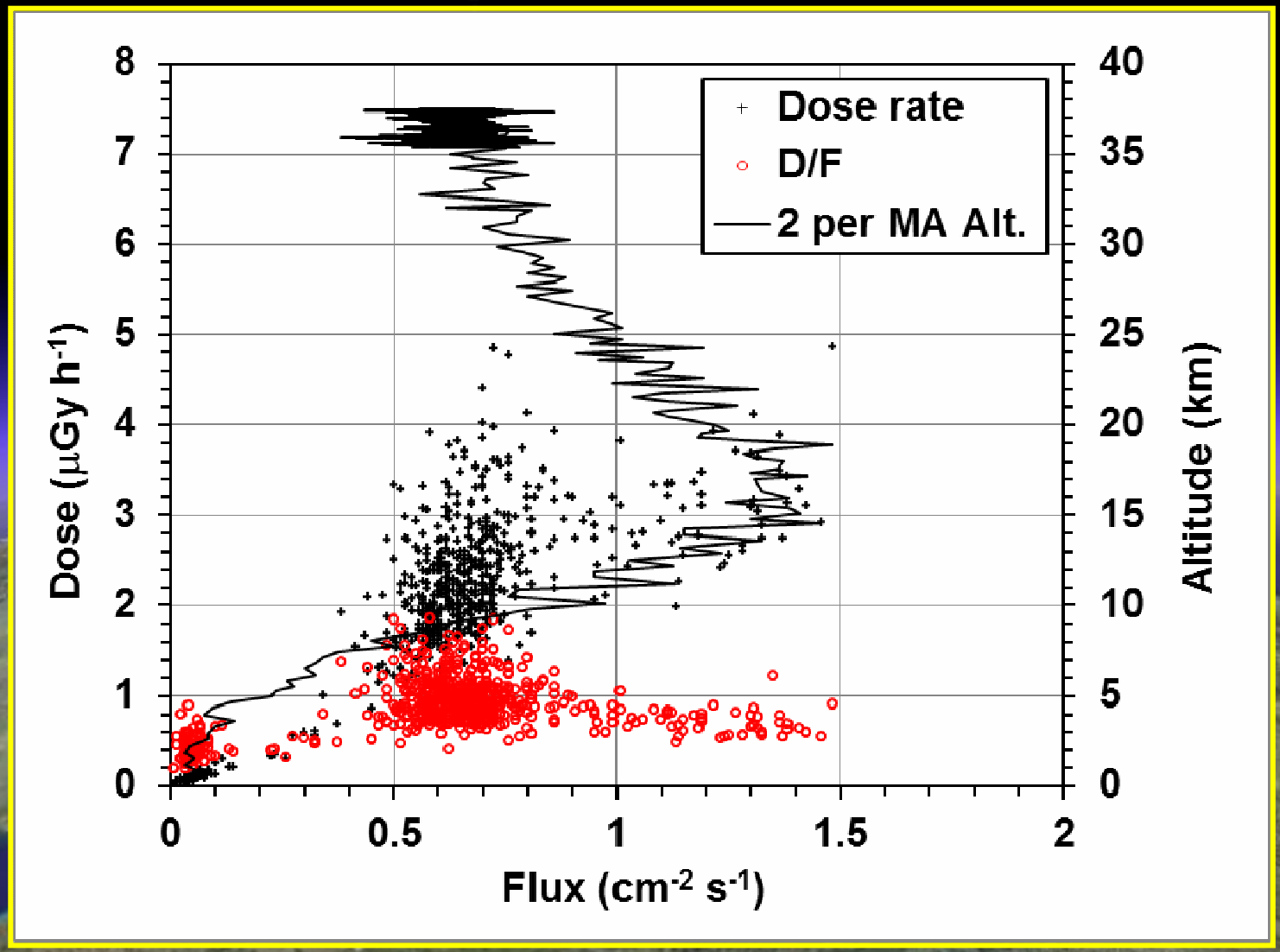


Characterization of the R3DR predominant radiation sources by the dose rate from flux and dose to flux (D/F) dependencies

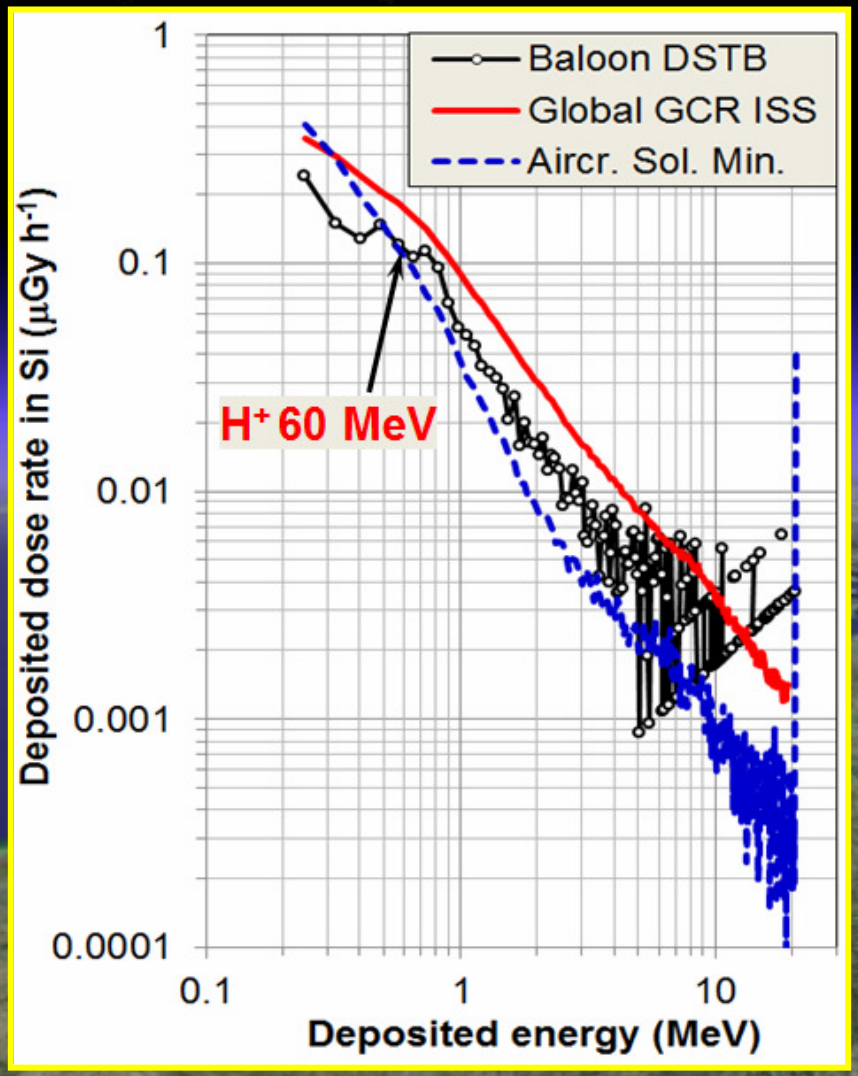


- The points into the diagonal of the figure is responsible for the dose rate values, which are in linear dependence from the flux;
- The horizontally plotted points presents the D/F ratio;
- Data can be simple split in 2 parts by the requirements for the ratio D/F<1 and D/F>1 nGy cm^{-2} $part^{-1}$. This will generate graphics, which will divide the IRB(SAA) and ORB sources.

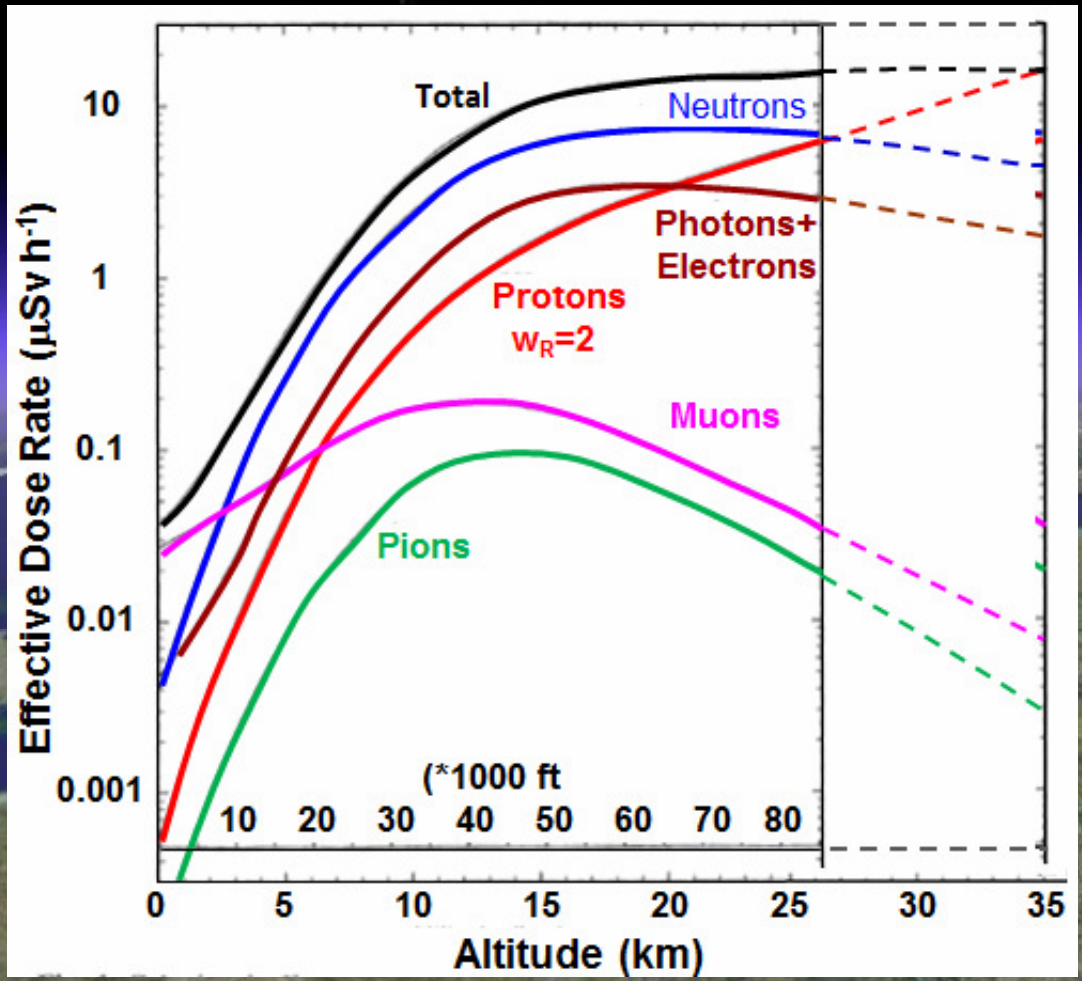
*Dachev, T.P., J. Semkova, B. Tomov, Yu. Matviichuk, Pl. Dimitrov, R. Koleva, St. Malchev, G. Reitz, G. Horneck, G. De Angelis, D.-P. Häder, V. Petrov, V. Shurshakov, V. Benghin, I. Chernykh, S. Drobyshev, N. G. Bankov, Space Shuttle drops down the SAA doses on ISS, Adv. Space Res., 47, 2030-2038 2011. doi:10.1016/j.asr.2011.01.034

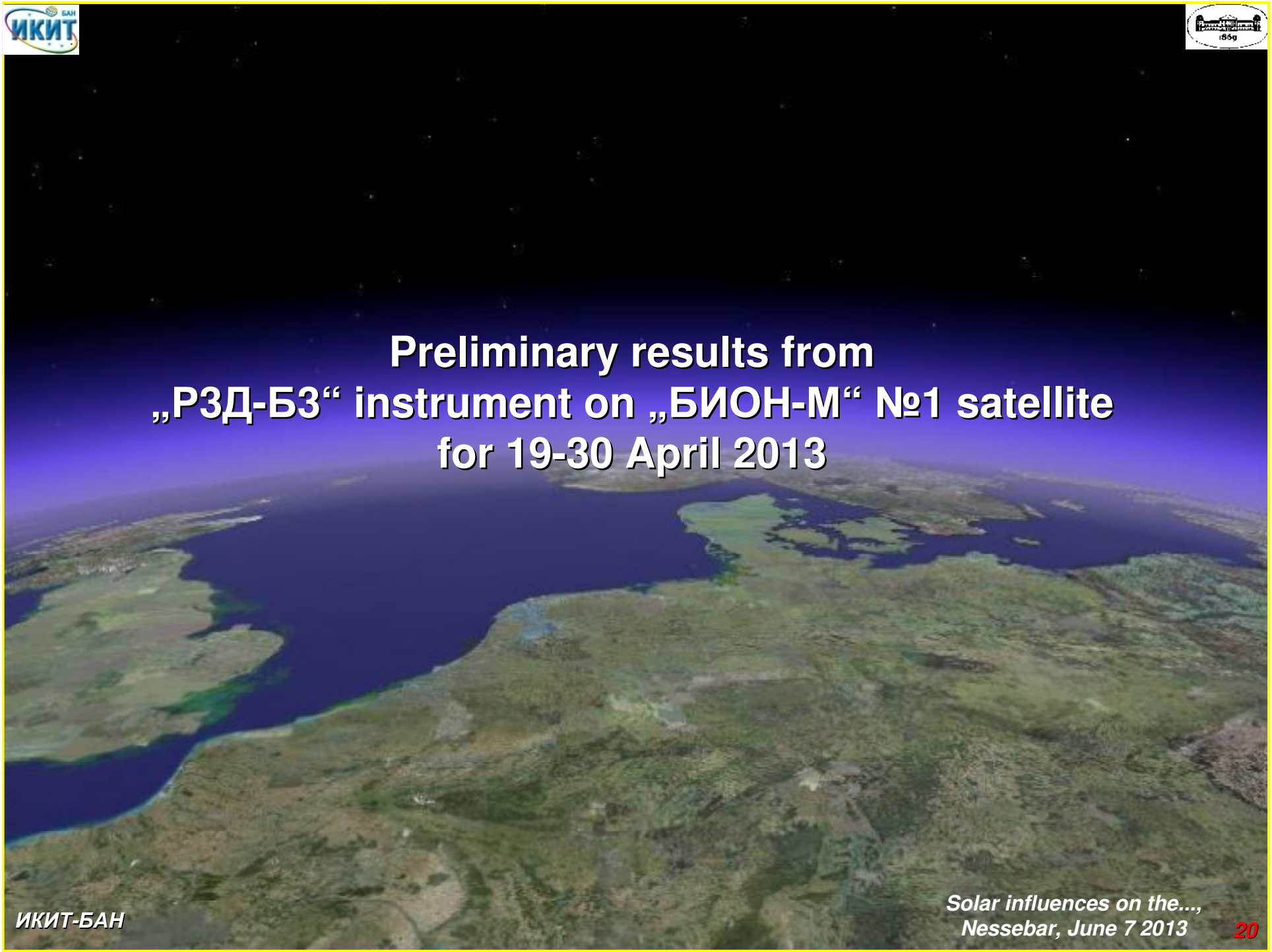

Dose rate
D/F
2 per MA Alt.
Dose (μGy h-1)
Altitude (km)
Flux (cm-2 s-1)
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35
40
0
0.5
1
1.5
2

Comparison of deposited energy spectrum obtained during the balloon DSTB with the global ISS GCR spetrum and aircraft solar minimum spactrum



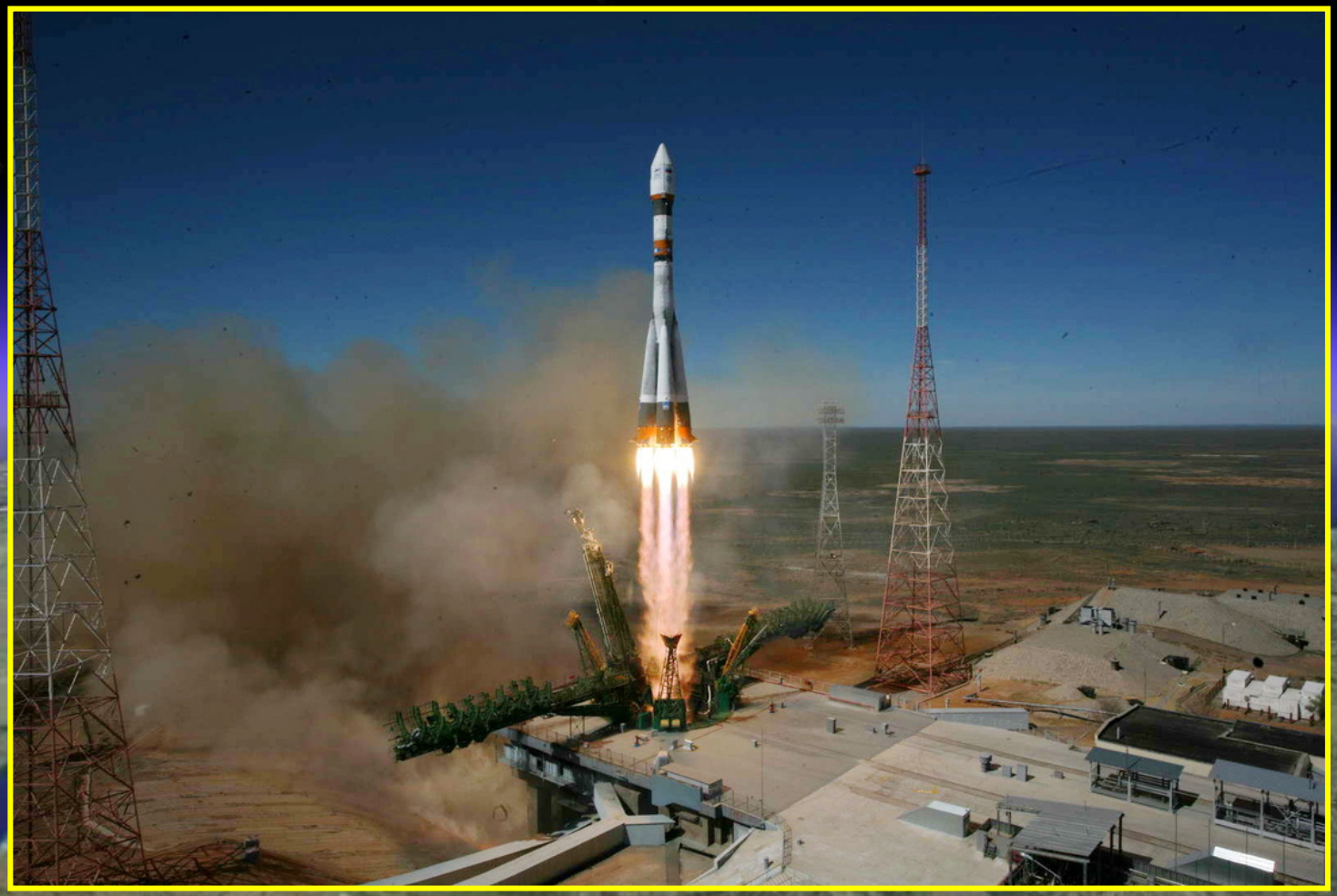
Calculated effective dose rate as a function of altitude for various particles of GCR in the atmosphere near the polar plateau (cutoff – 0.8 GV) at solar minimum (June 1997). Data are courtesy of K.O. Brian calculated using his LUIN-98F radiation transport code, but with wR for protons equal to 2 (NCRP 1993) rather than 5.





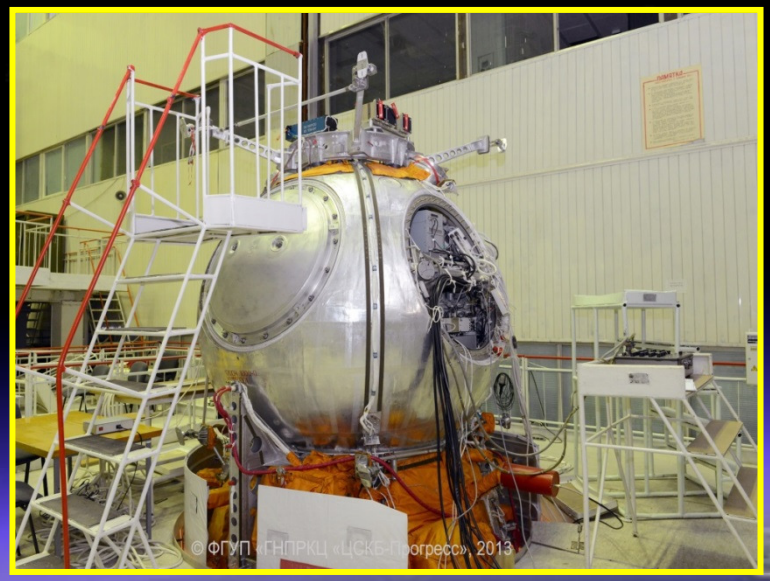
Preliminary results from „РЗД-БЗ“ instrument on „БИОН-М“ №1 satellite for 19-30 April 2013

On 19 April 2013 at 10:00 GMT from Baikonur was launched the „Бион-М“ № 1 satellite with „Союз-2.1.а“ carier

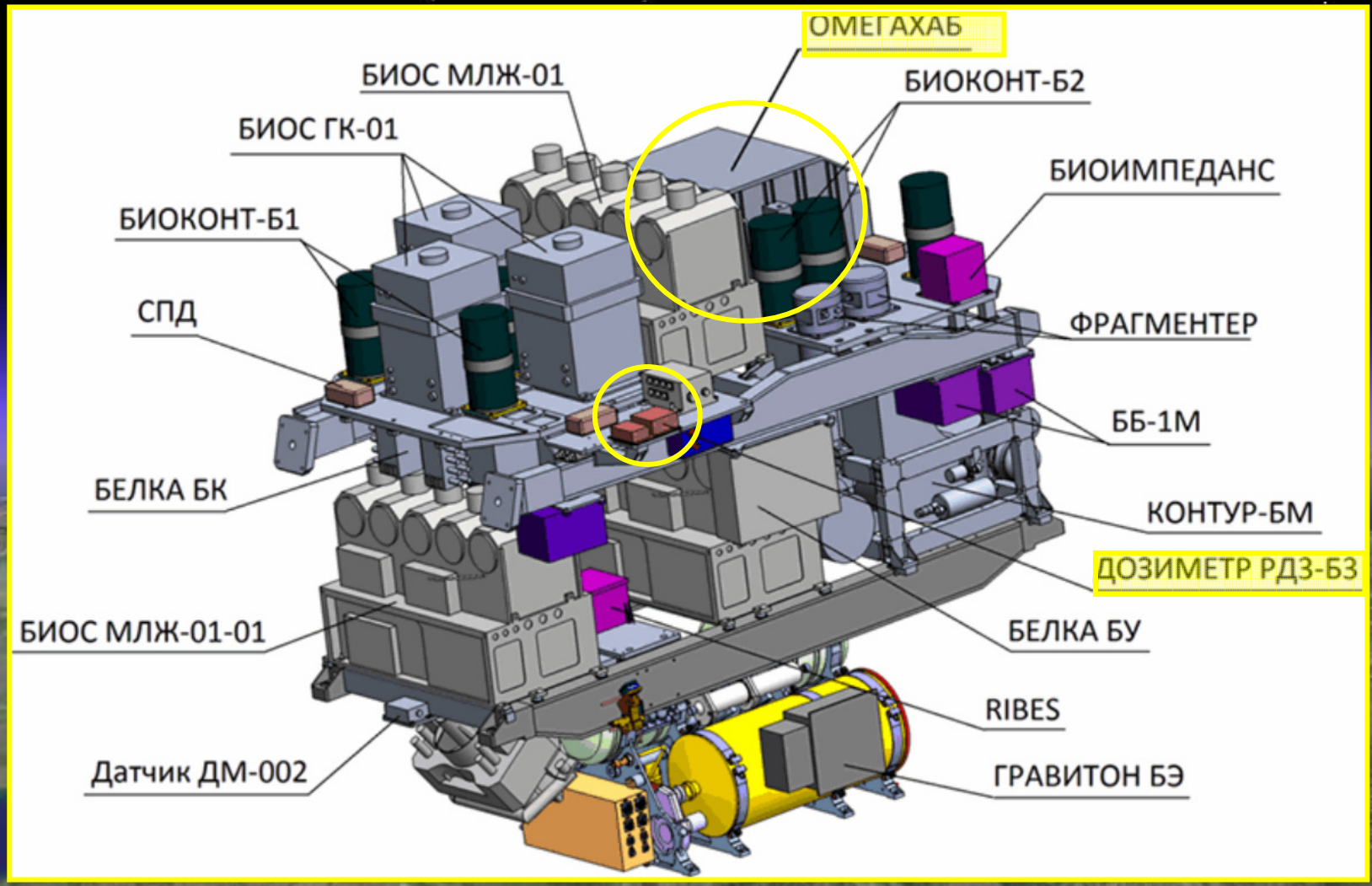


http://www.spaceflight101.com/bion-m1-mission-updates.htm

Preparation of the „БИОН-М“ №1 satellite

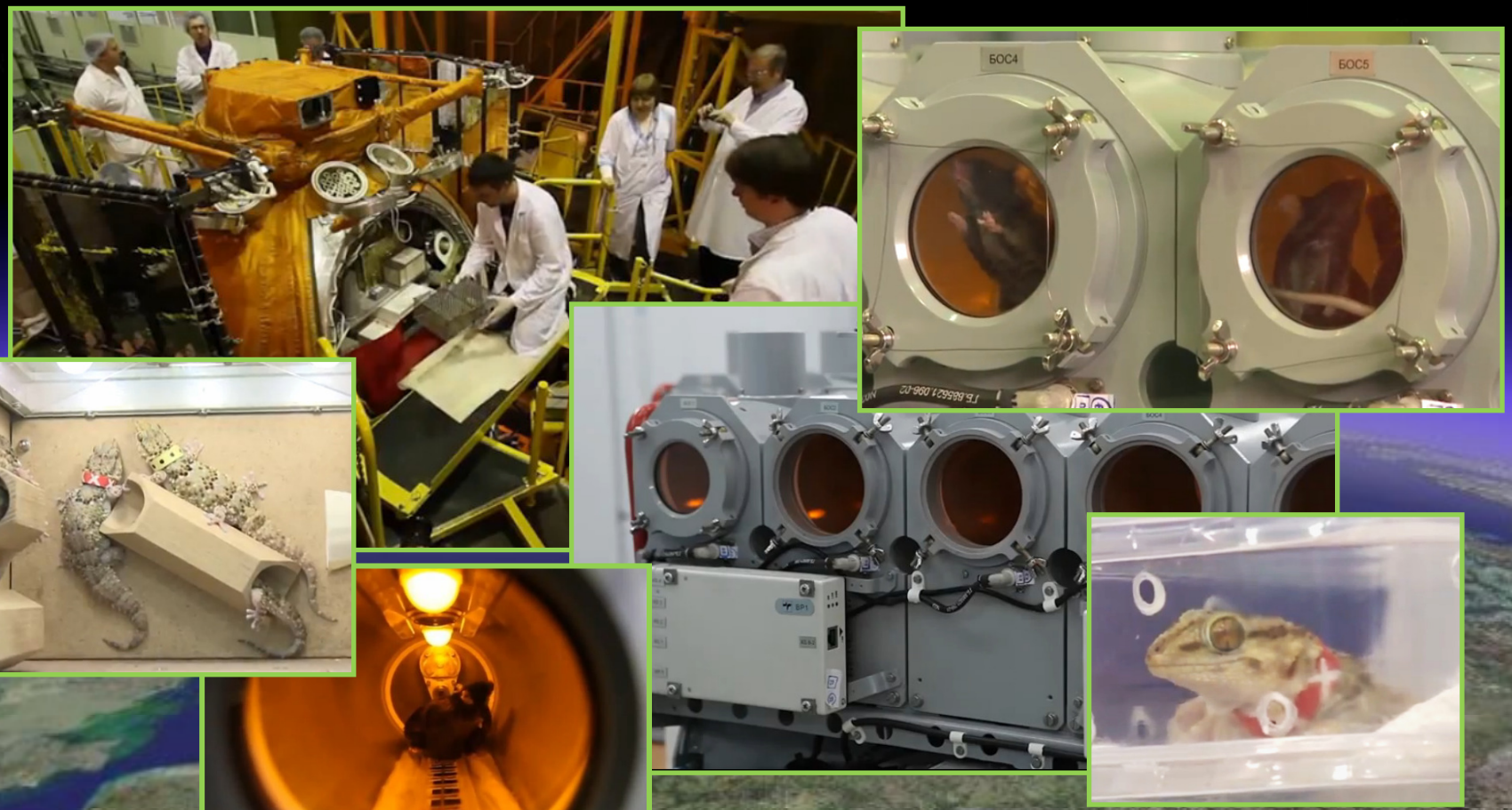


Experiments distribution inside the „БИОН-М“ №1 satellite



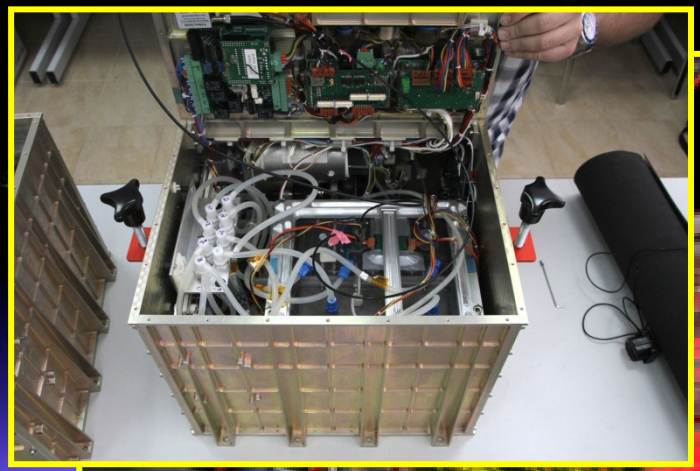
http://www.youtube.com/watch?v=UUEMJoBvGaE

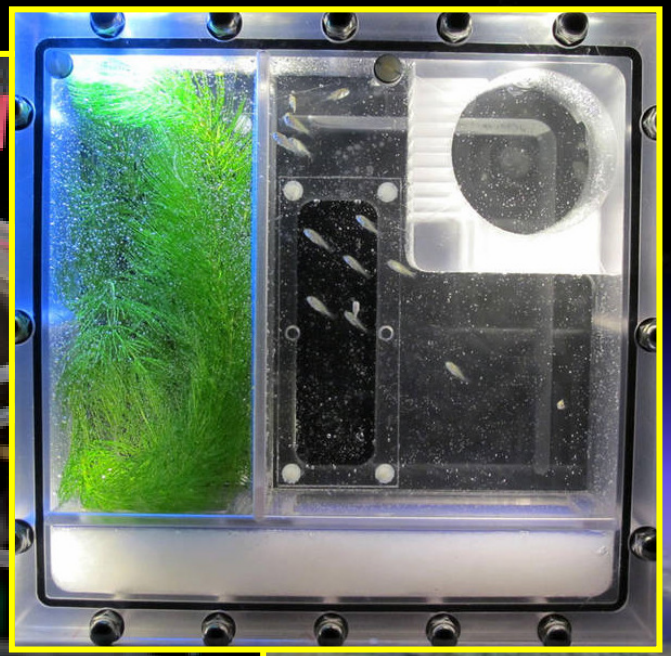
There are 24 scientific groups of experiments in „Бион-М“ № 1 satellite



Inside of the capsule there were situated 45 mouse's, 8 Mongolian mouse's, 15 tritons etc.

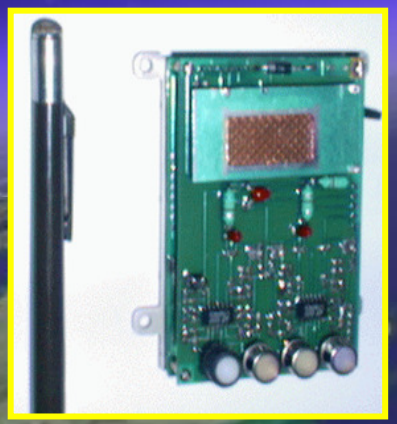
SRTI-BAS participate with 2 dosimetric spectrometers of Liulin-LS type in the University of Erlangen - Omegahab experiment in the "БИОН-М" №1 satellite

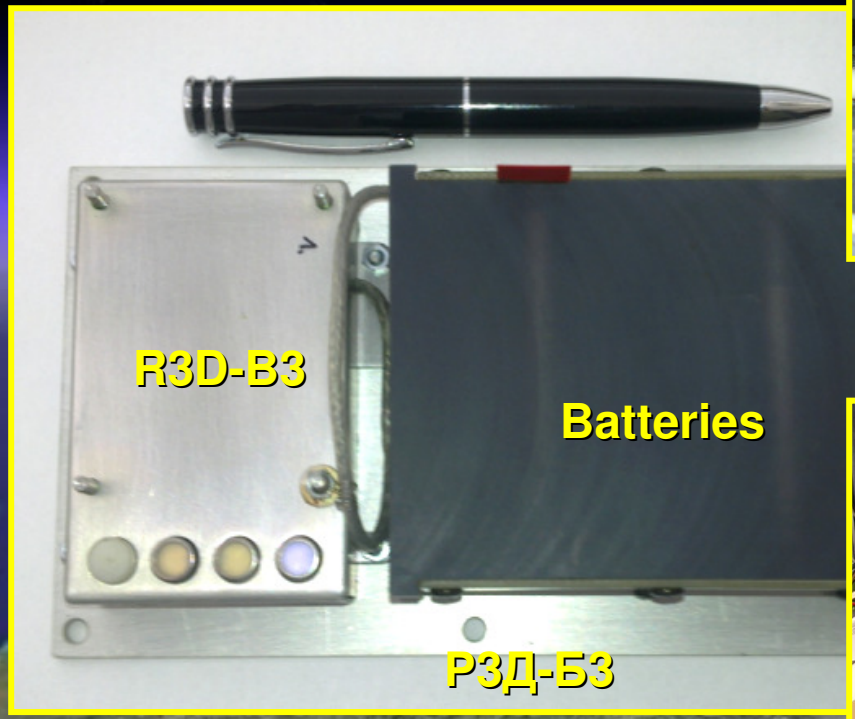


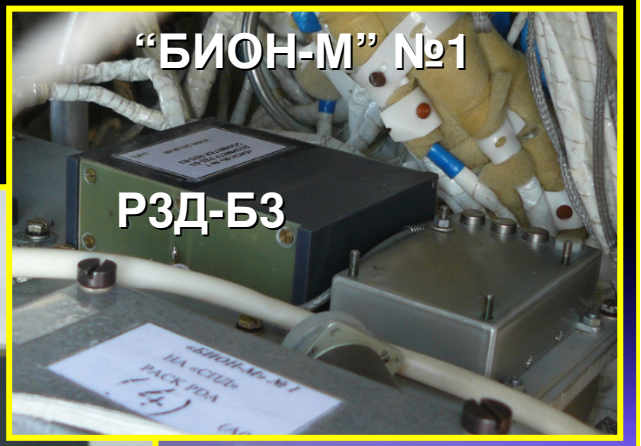


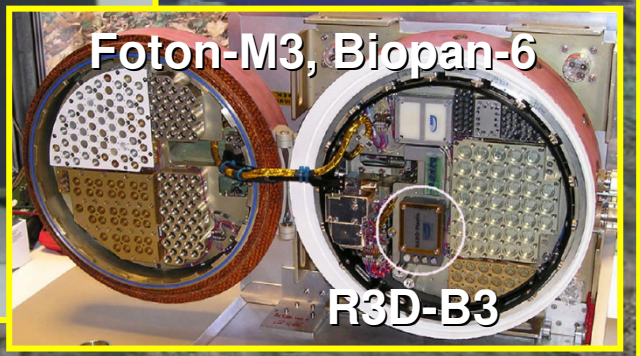
http://www.dlr.de/dlr/presse/desktopdefault.aspx/tabid-10172/213_read-6797/year-all/#gallery/9409

SRTI-BAS participate also with the dosimetric spectrometers of РЗД-Б3 type in the IMBP experiment in the “БИОН-М” №1 satellite



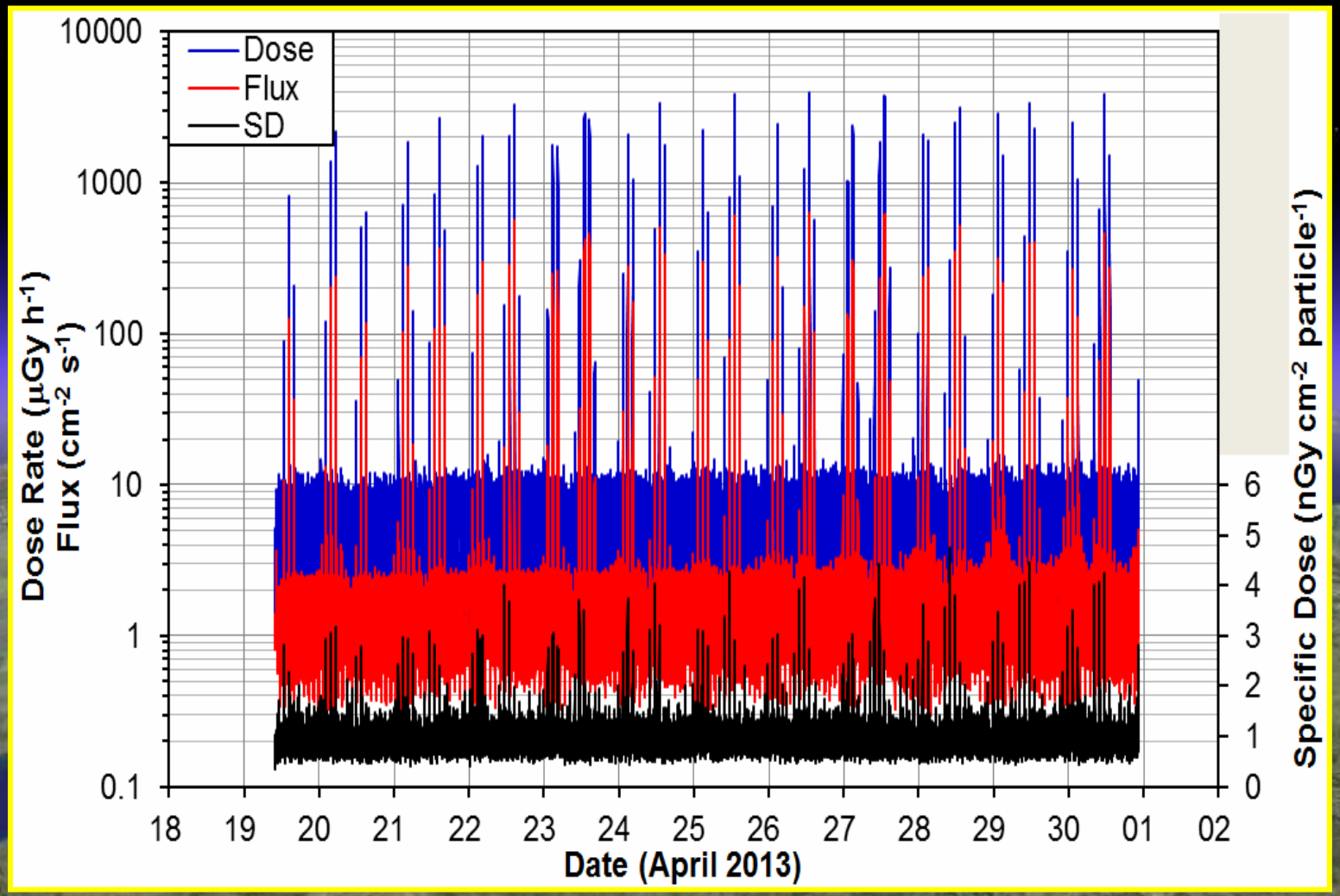






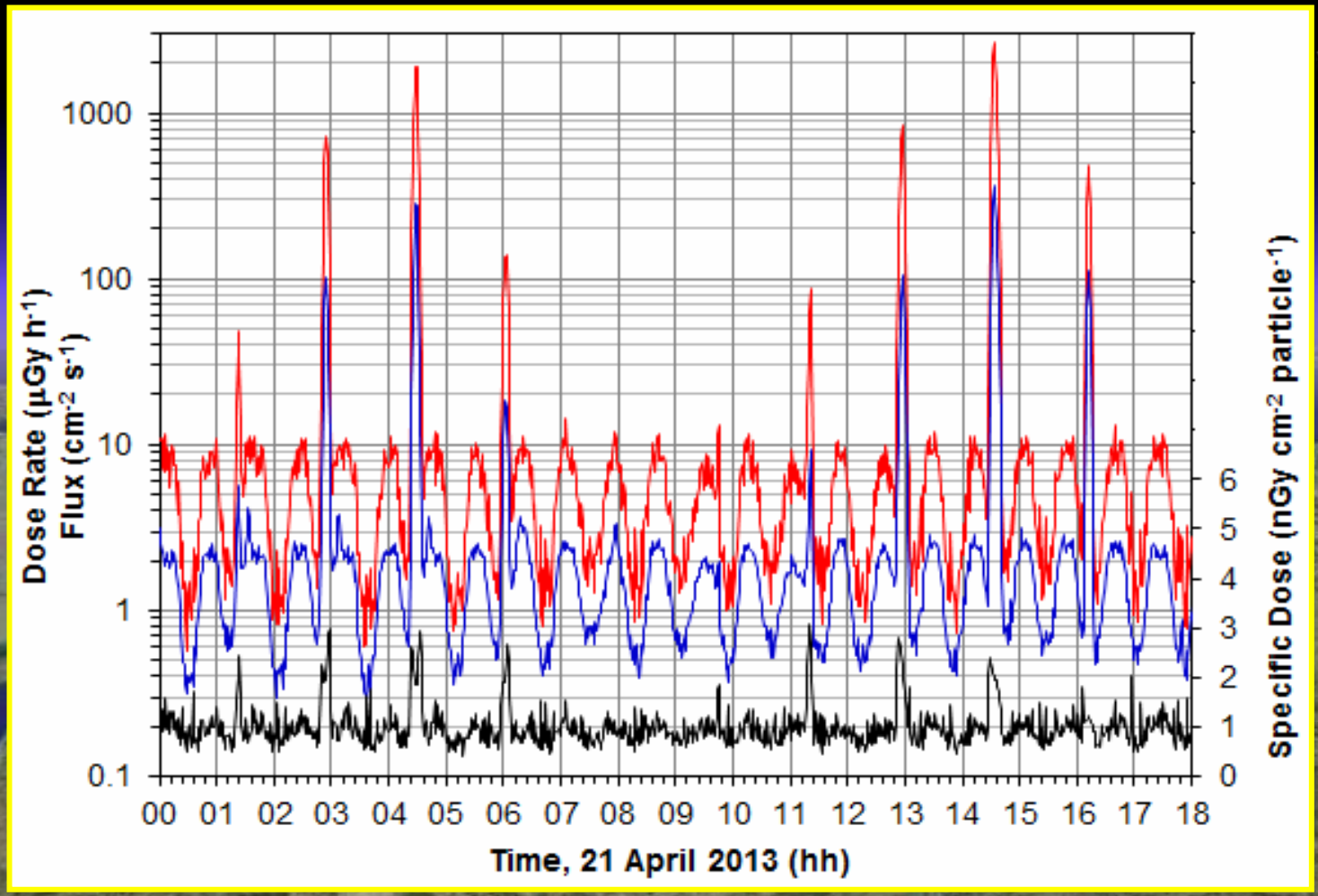
The R3D-B3 instrument was first used at the Foton-M3 satellite as apart of ESA - Biopan 6 facility in September 2007

Variations of the flux, dose rate and specific dose obtained by „РЗД-Б3“ instrument on „БИОН-М“ №1 satellite in the period 19-30 April 2013

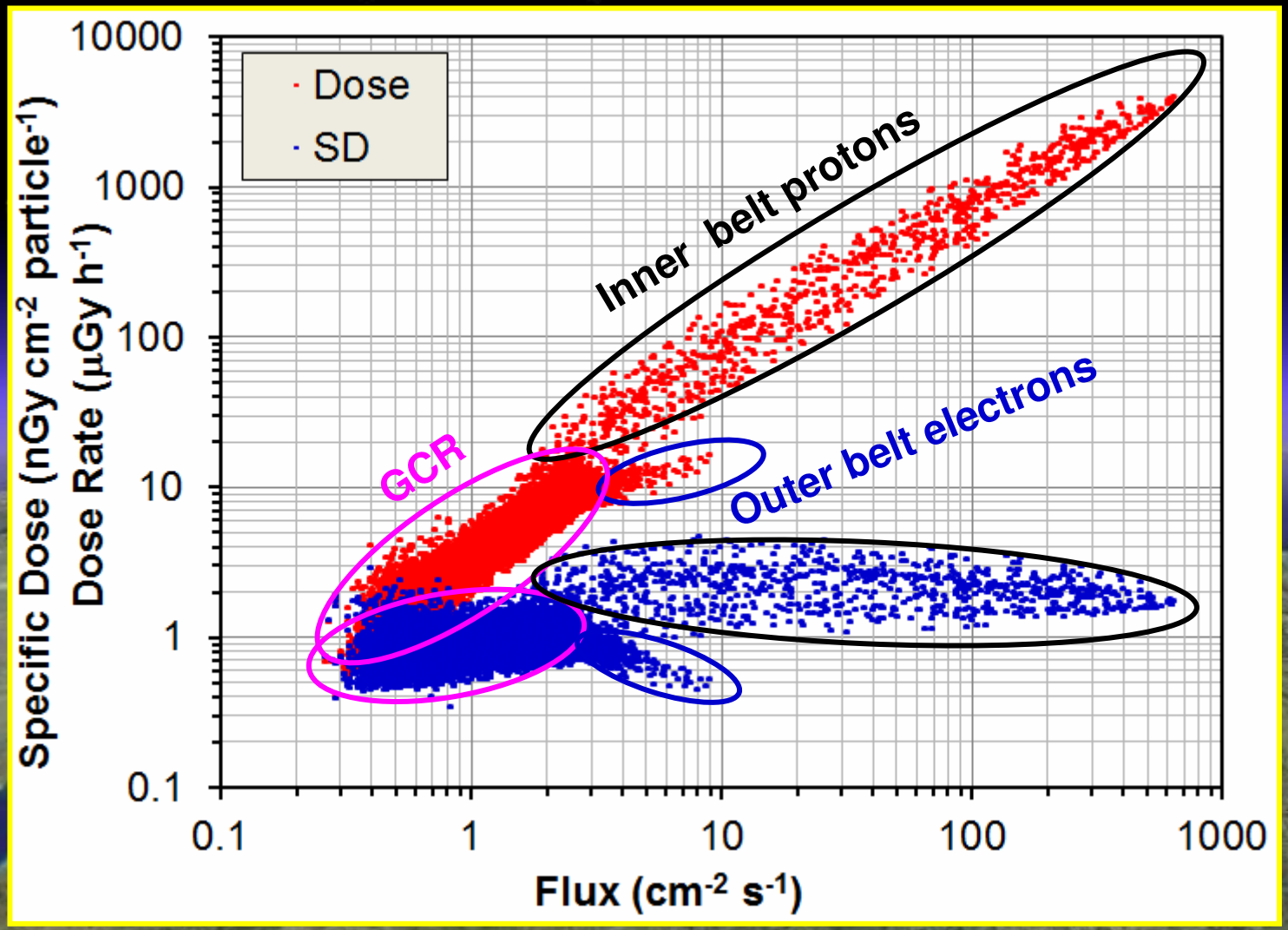


Preliminary results

Variations of the flux, dose rate and specific dose obtained by „РЗД-Б3“ instrument on „БИОН-М“ №1 satellite on 21 April 2013

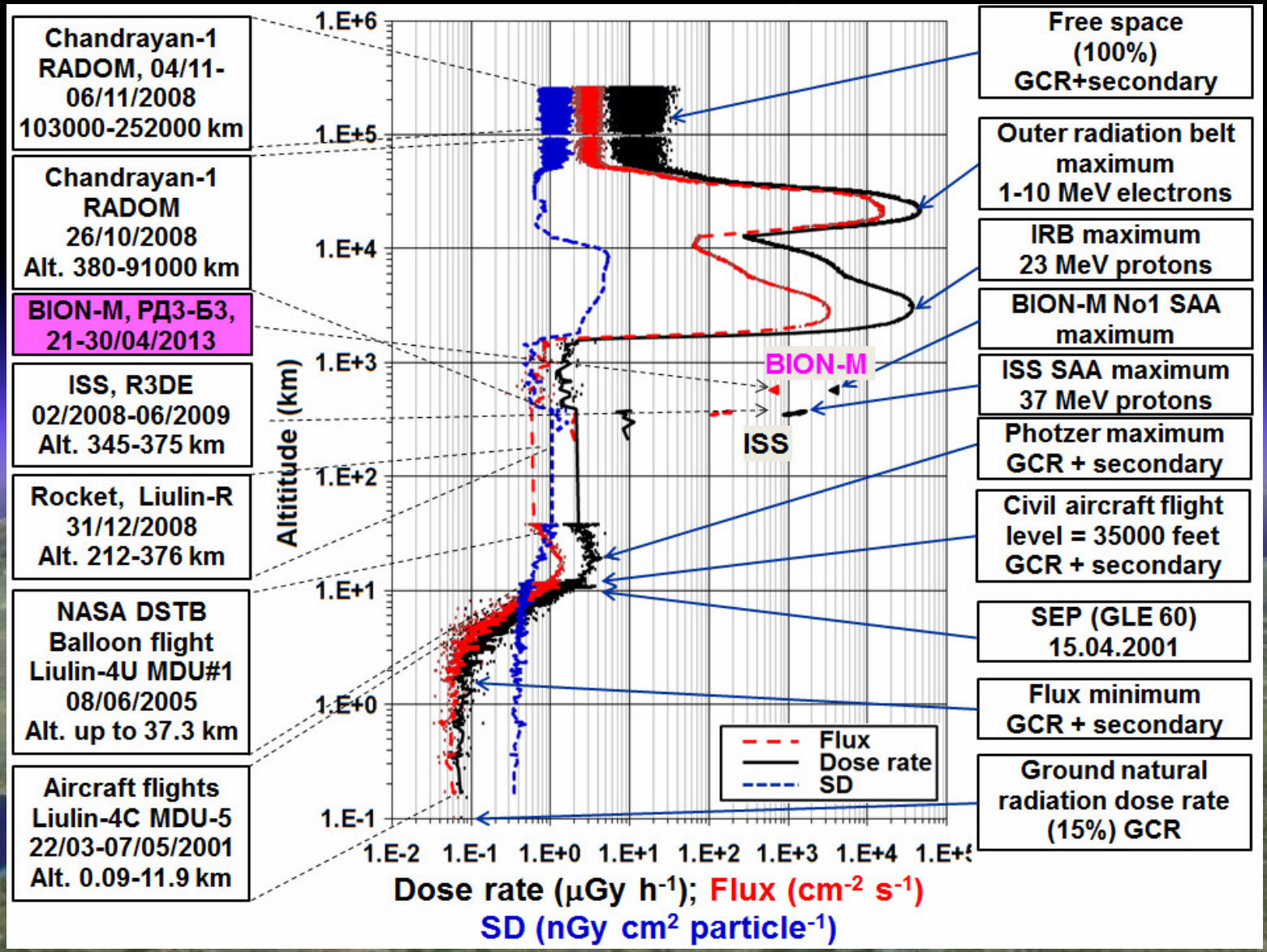


Radiation field components in the „РЗД-БЗ“ data on the на „БИОН-М“ №1 satellite



Preliminary results

Space radiation profile from ground to free space



Preliminary results


Thank you for your attention