19th WRMISS, Krakow, Poland, September 9 – 11, 2014

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Long Term Dose Monitoring Onboard the European Columbus Module of the International space Station in the frame of the DOSIS and DOSIS 3D Project- Results from the active Instruments

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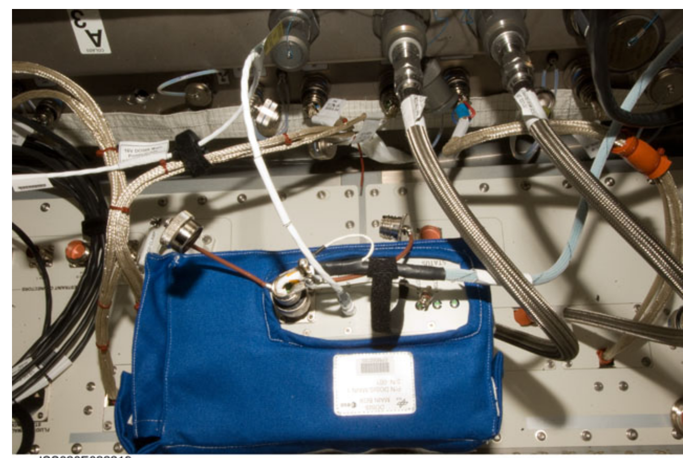
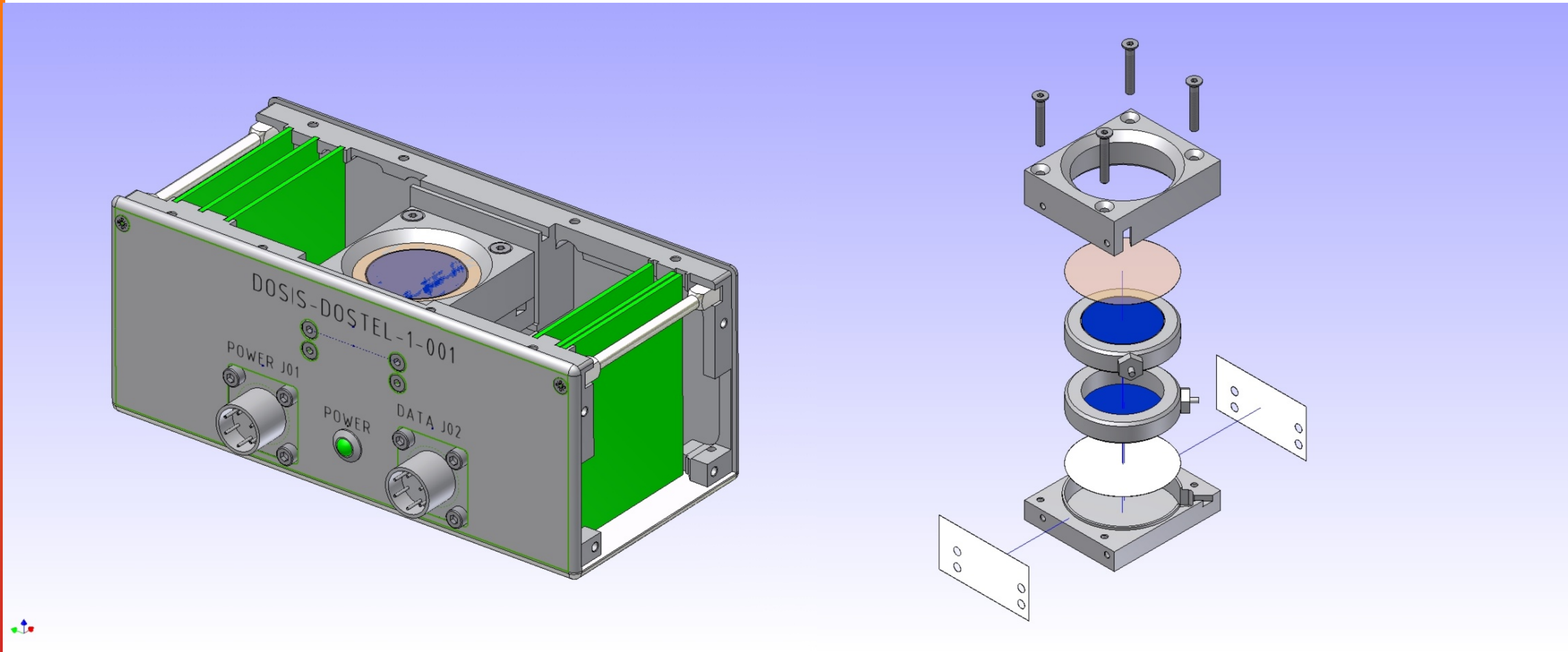
[2] German Aerospace Center, DLR, Institute for Aerospace Medicine, Cologne, Germany
[3] OHB Technologies, Bremen, Germany



ISS020E022219

DOSTEL Detector



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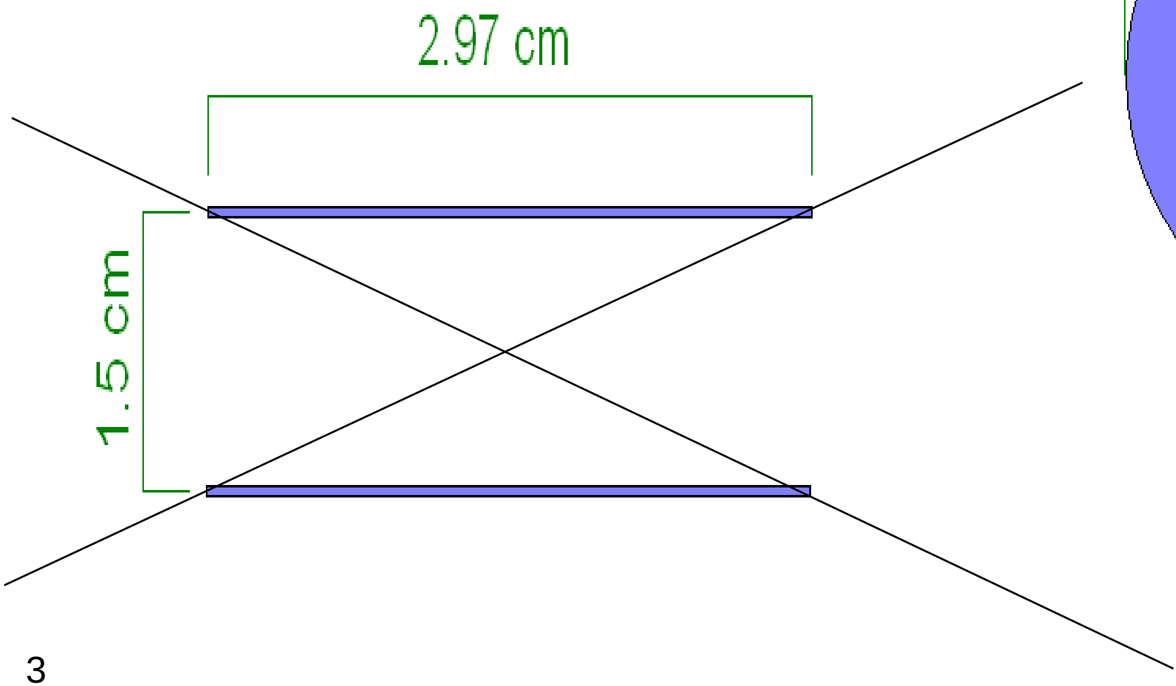
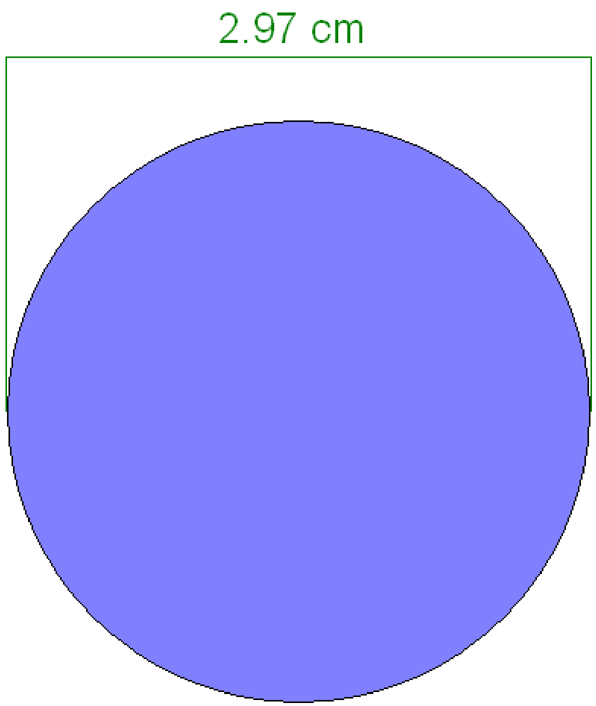
DOSTEL Detector

The DOSTEL Detecor Head consists two circular PIPS detectors by Canberra. These two are forming a telescope. The active area of the detectors is 6.93 cm². Mounted in a distance of 1.5cm this leads to an opening angle of 120°.



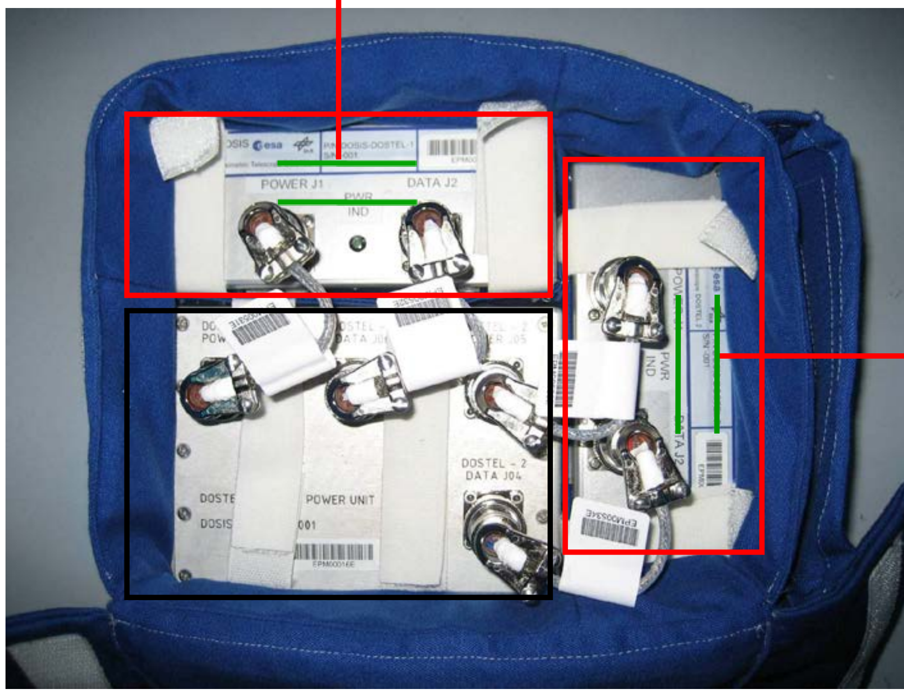


DOSTEL Data

- Each DOSTEL can provide count rate profiles, dose rate profiles and energy deposition spectra
- The energy spectra can be used to obtain LET-Spectra because of the path length limitation due to its telescope geometry
- The LET spectra can be used to get information such as average quality factors which leads to dose equivalent
- DOSTEL-1 has an additional mode 2 where the PHA data for every single particle is taken

DOSIS Main Box

DOSTEL 1



DOSTEL 2

DDPU – DOSTEL Data and Power Unit

DOSIS Main Box

DOSTEL

DDPU
(DOSTEL Data and Power Unit)

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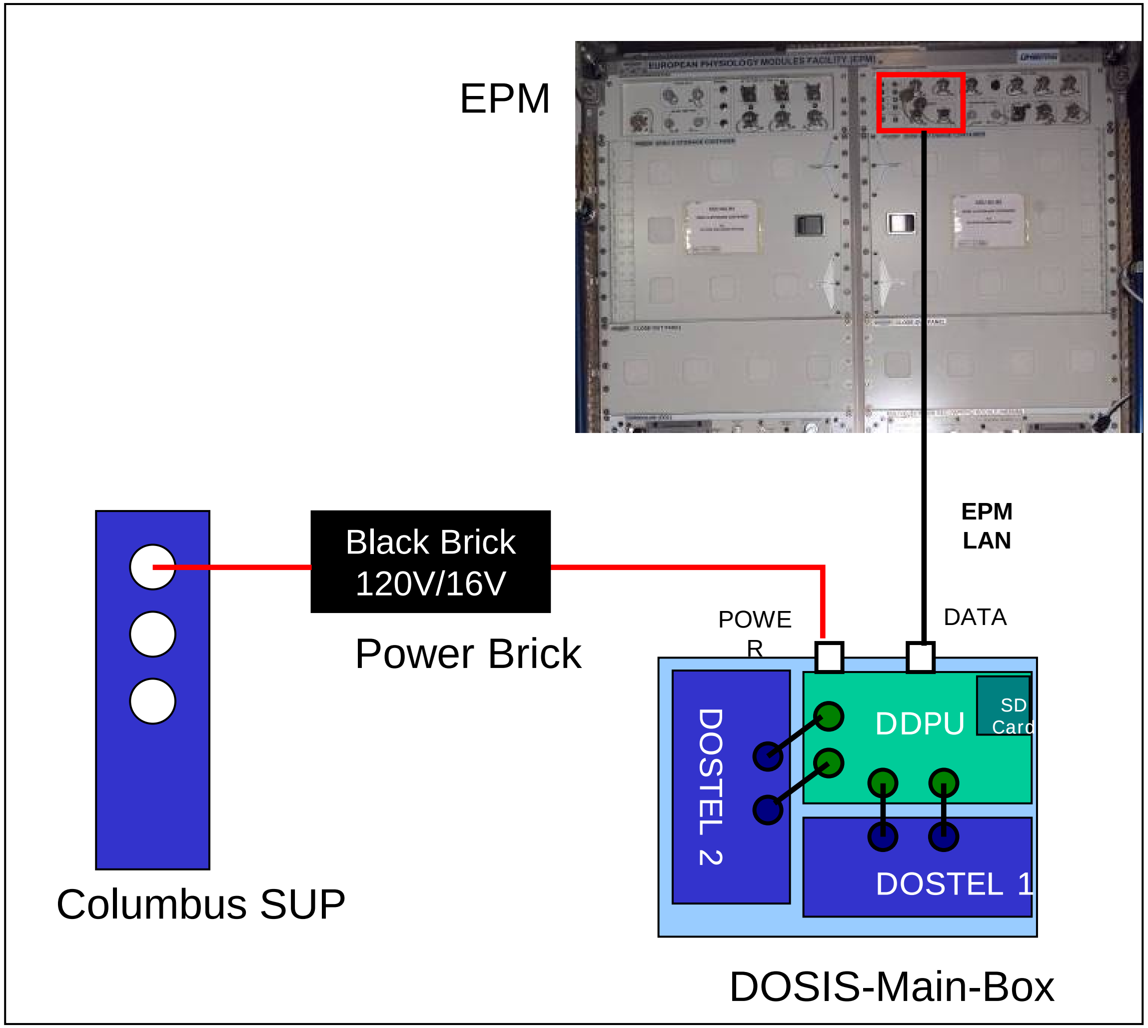
DOSIS - Launch 15.July 2009 STS-127

DOSIS 3D - Launch 15. May 2012 Soyuz TMA 04M / 30S

DOSIS Installation Inside COLUMBUS



DOSIS & DOSIS 3D: DOSTEL

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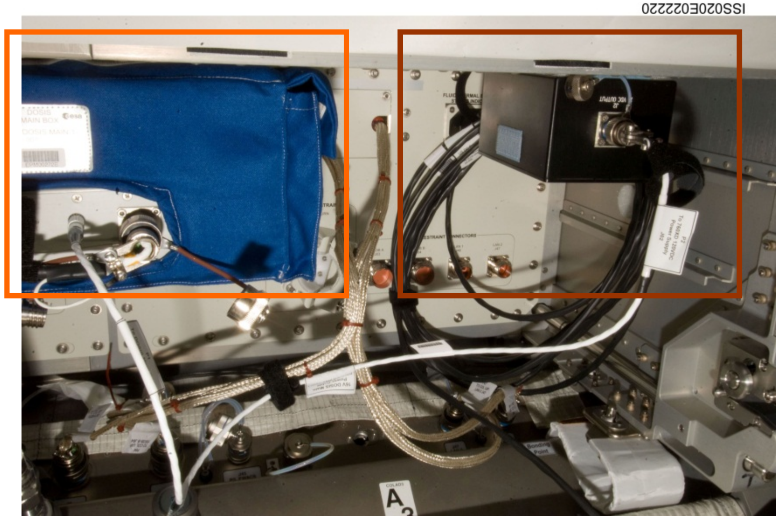
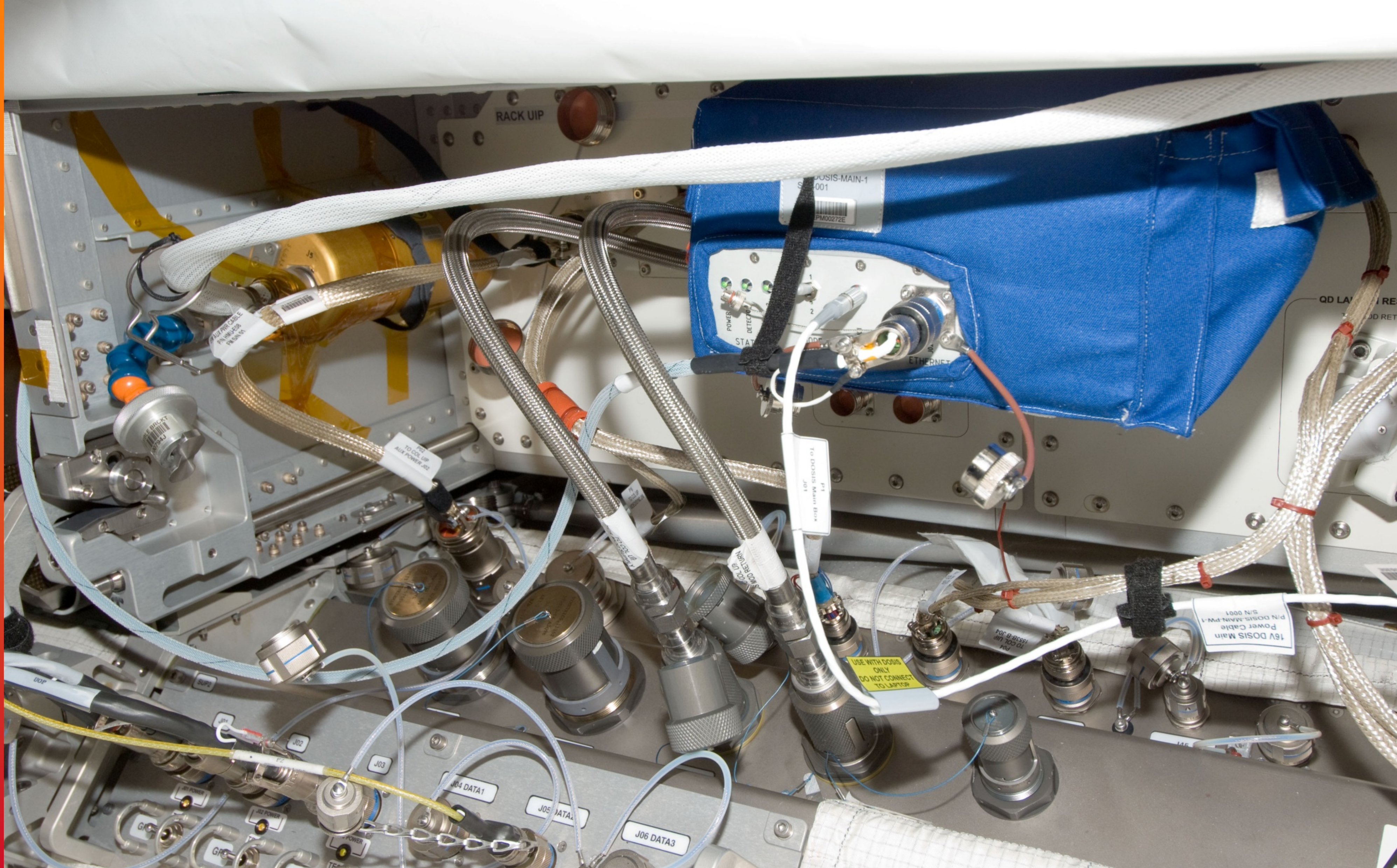
ISS020E022220



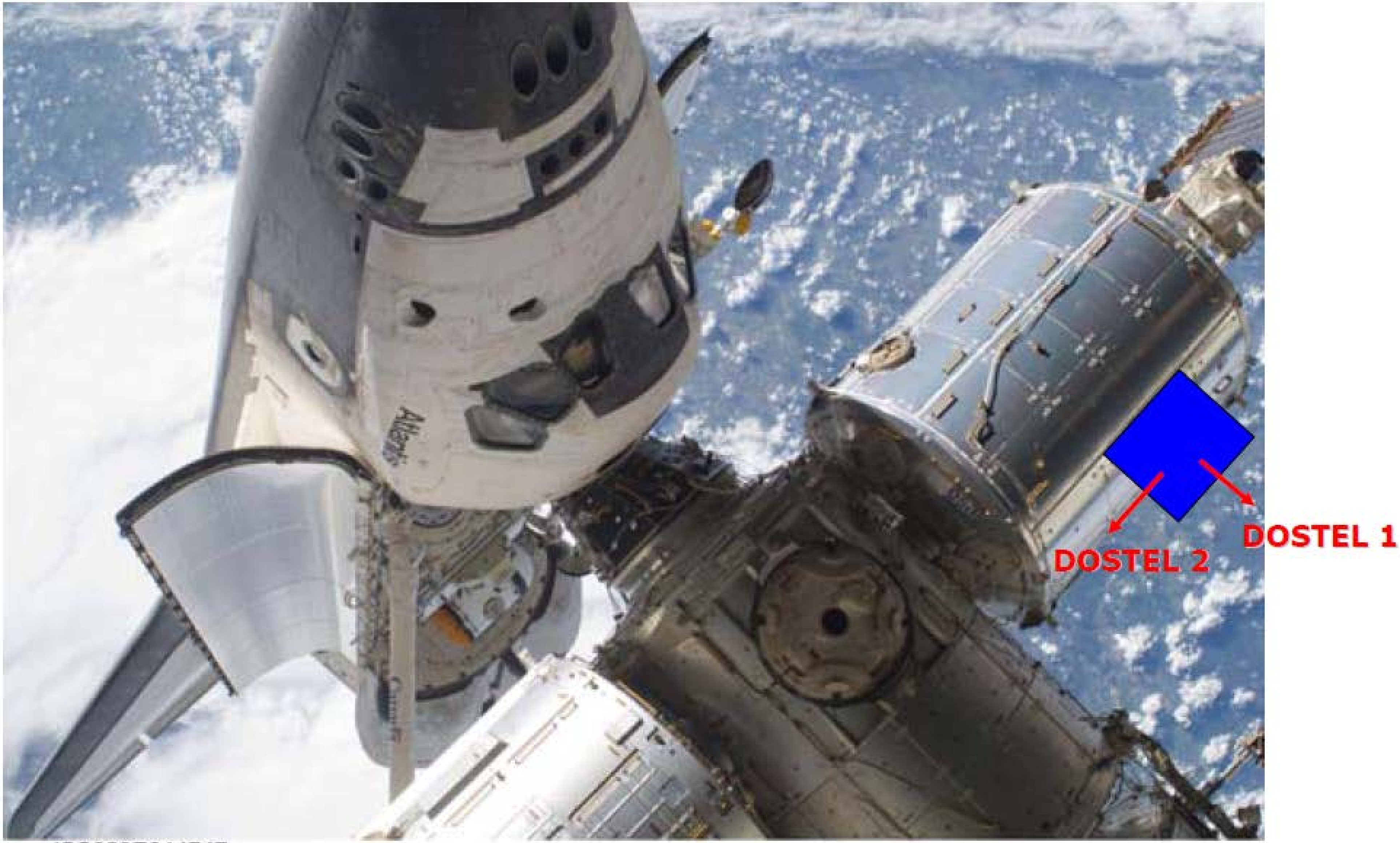
ISS020E033064

- Ethernet connection to EPM rack "Right Utility Distribution Panel"
- DOSIS MAIN BOX connected to EPM LAN like an external EPM instrument
- Data downlink is an EPM operation from ground performed once per month

DOSIS Main Box

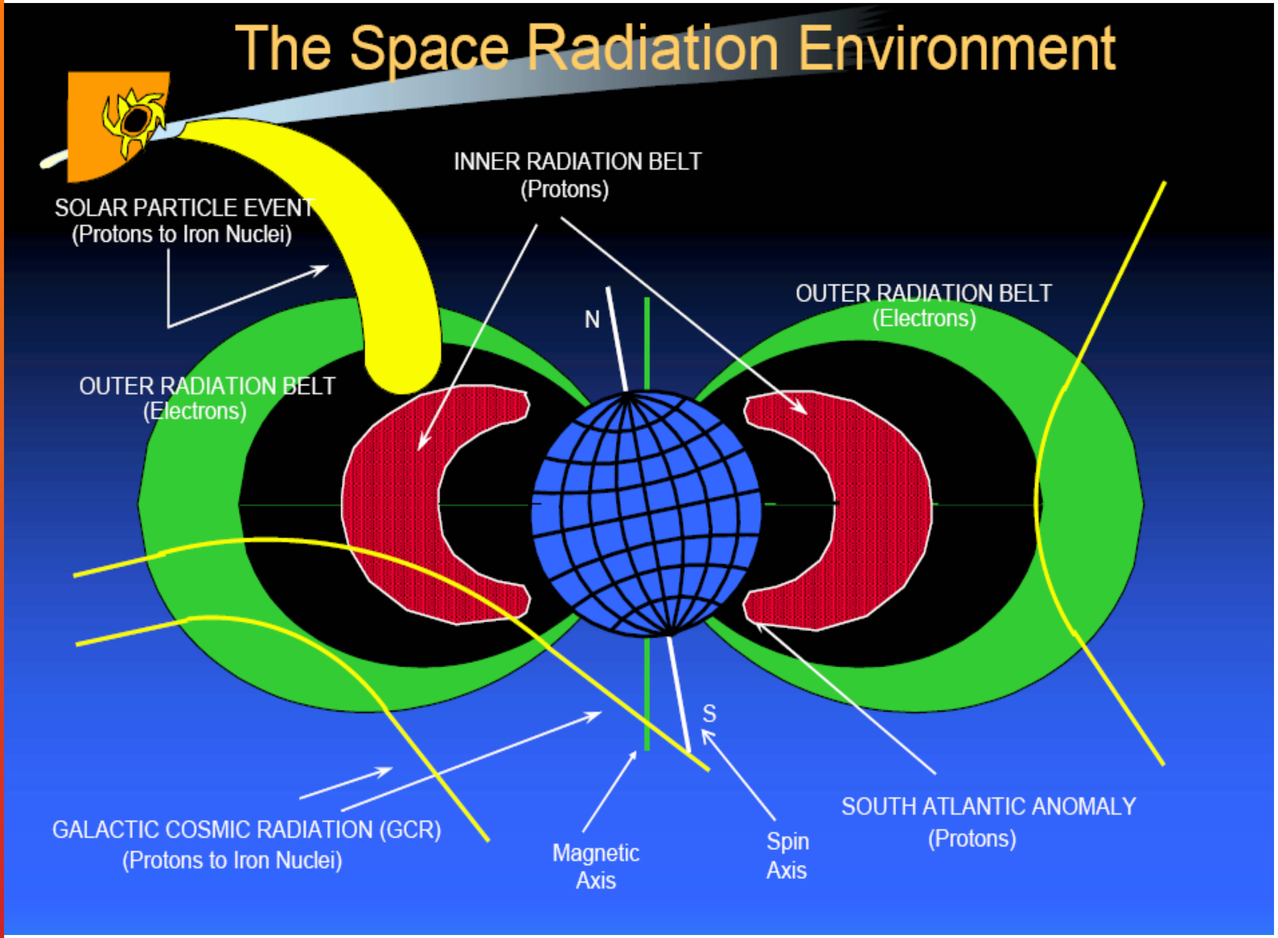


ISS020E033064



ISS023E044747

Radiation Environment in Space



Galactic Cosmic Rays (GCR)

- Ions from protons to iron

Trapped Radiation (Van Allen Belts)

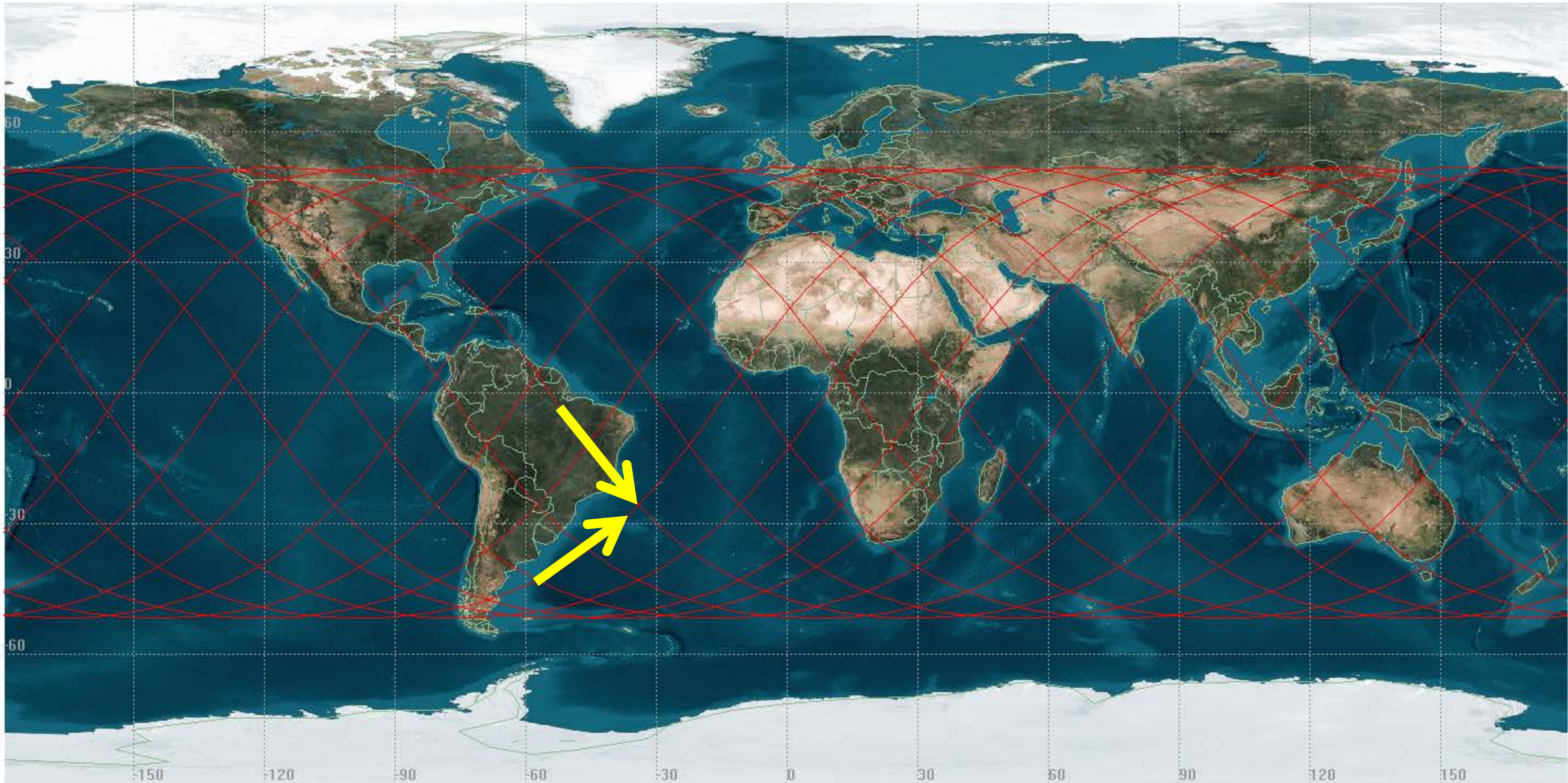
- Low energy protons and electrons

Solar particle events

- Protons (in dependence of the solar cycle)

Variation of the radiation load onboard the ISS with altitude, latitude and time

ISS Orbit



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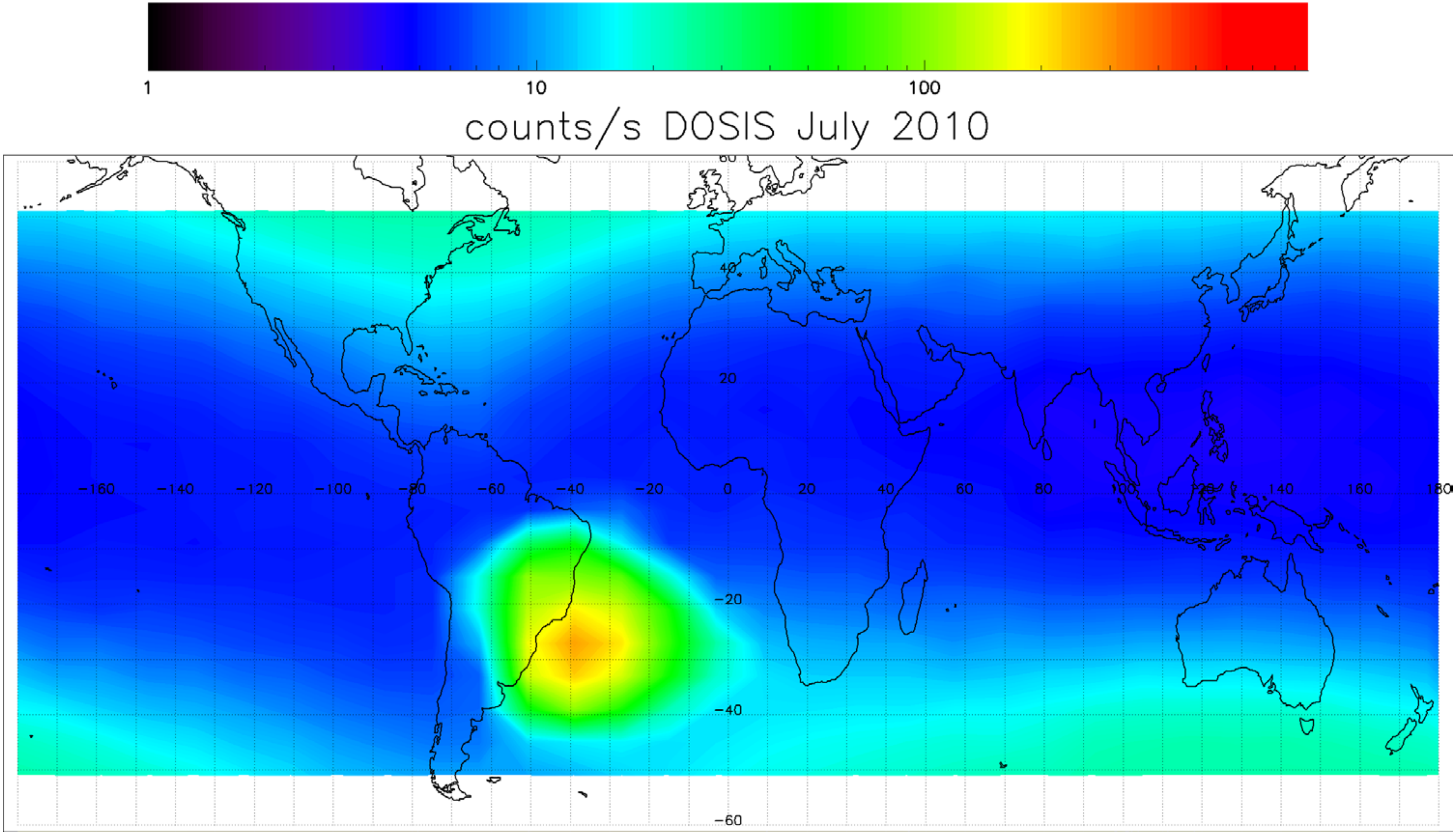
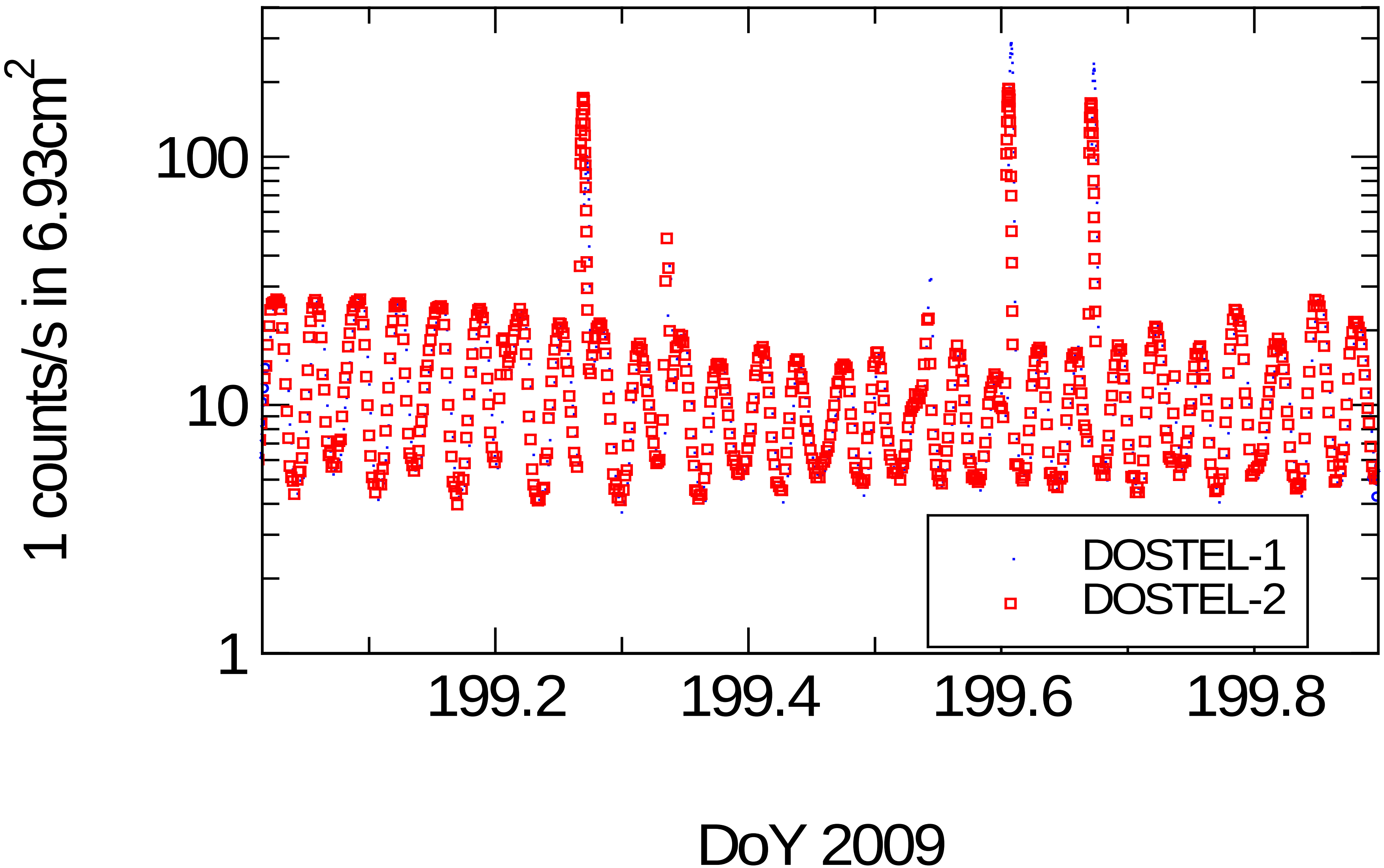
DOSIS - DOSTEL




1 counts/s in 6.93cm²
100
10
1
199.2
199.4
199.6
199.8
DoY 2009
DOSTEL-1
DOSTEL-2

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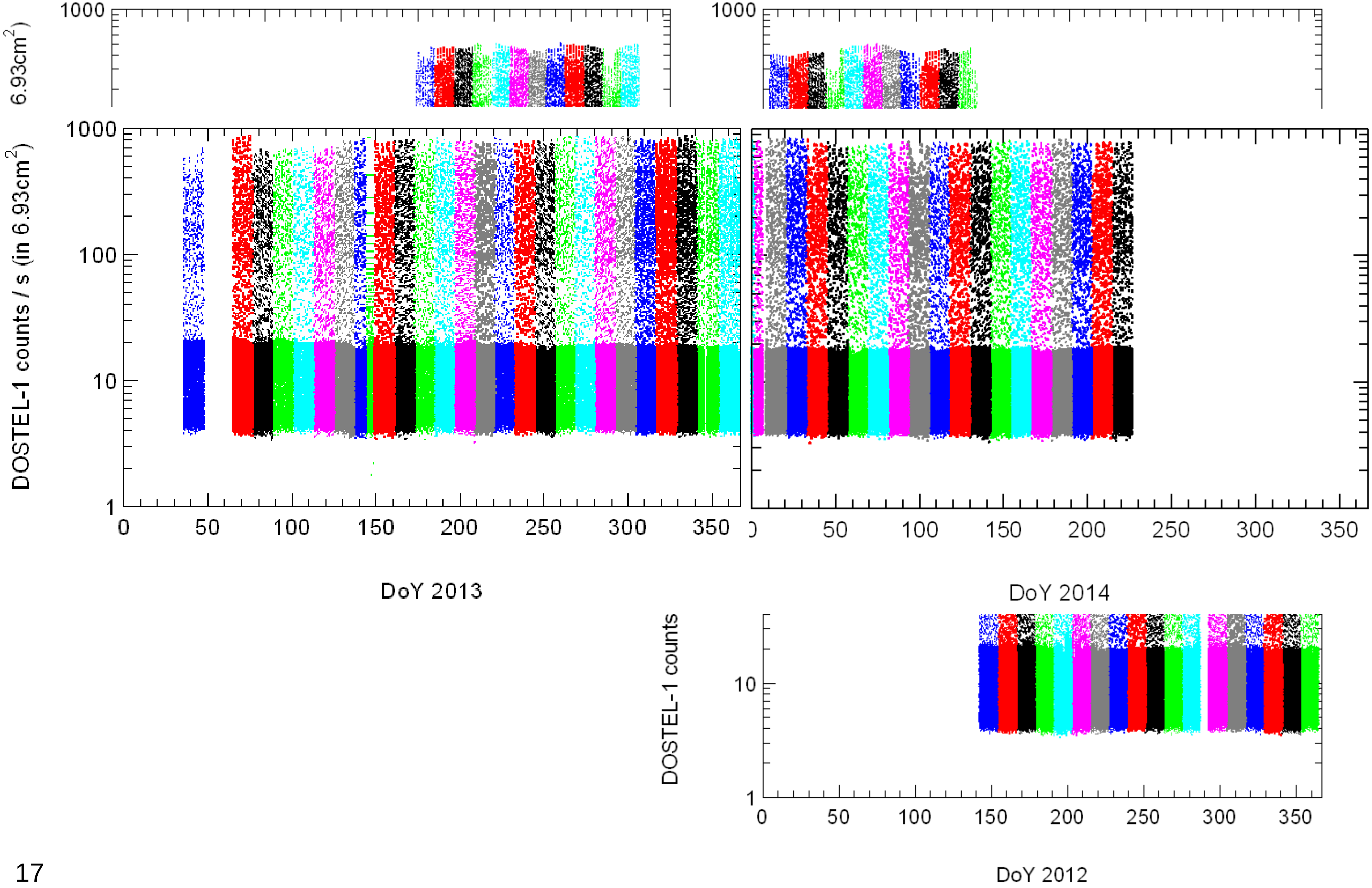
DOSIS / DOSIS3D DOSTEL-1 Count Rates



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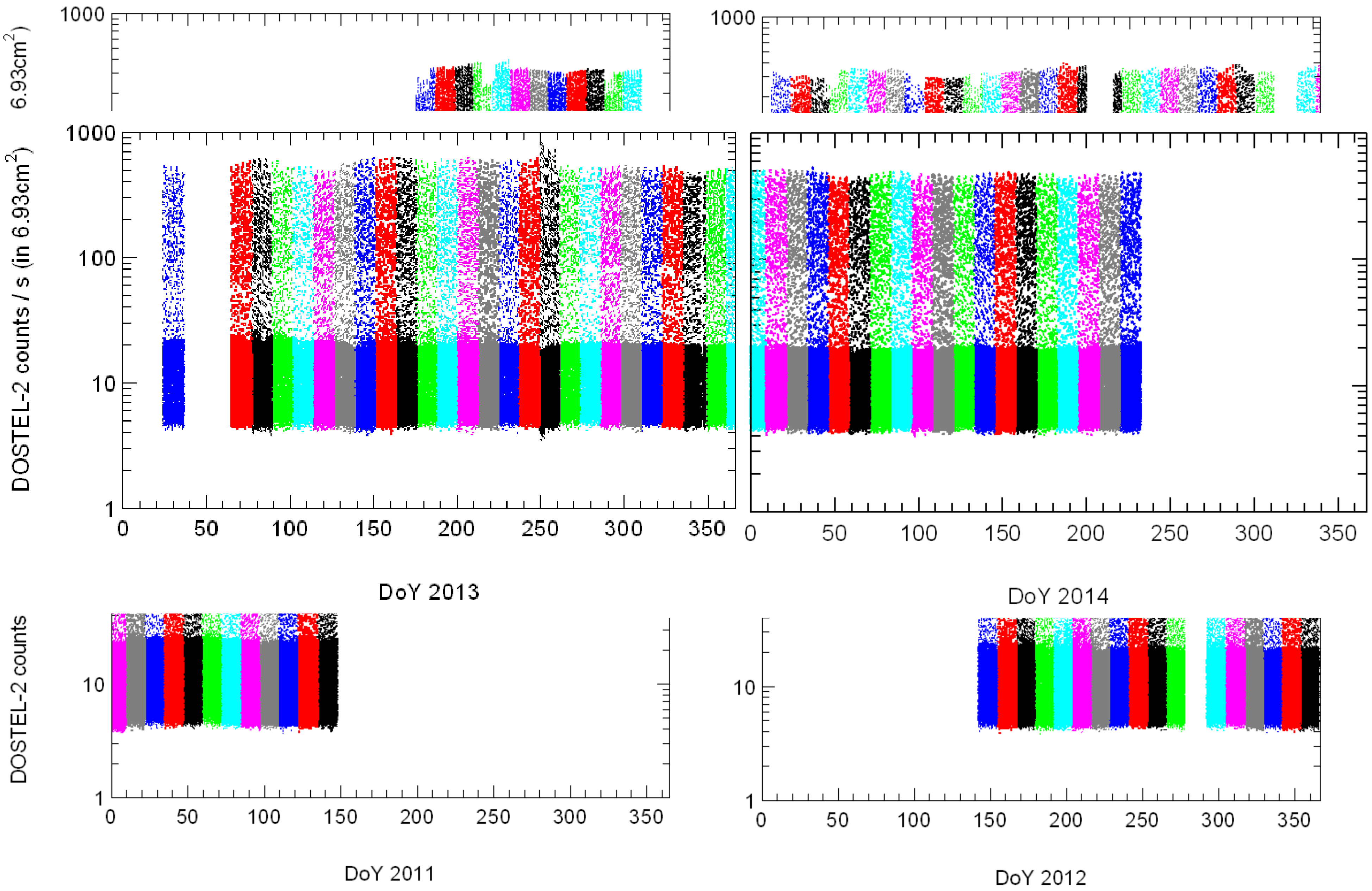
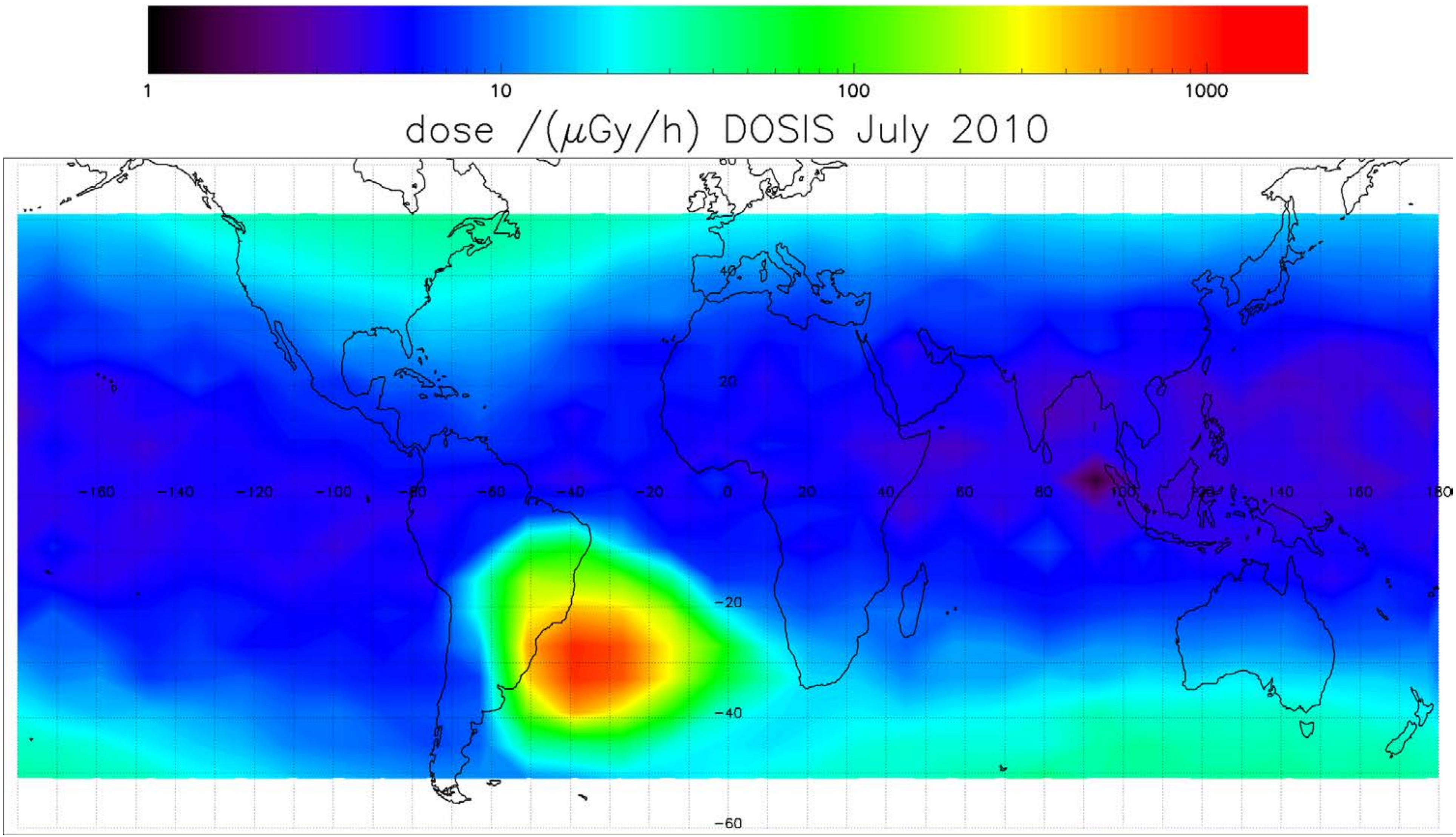
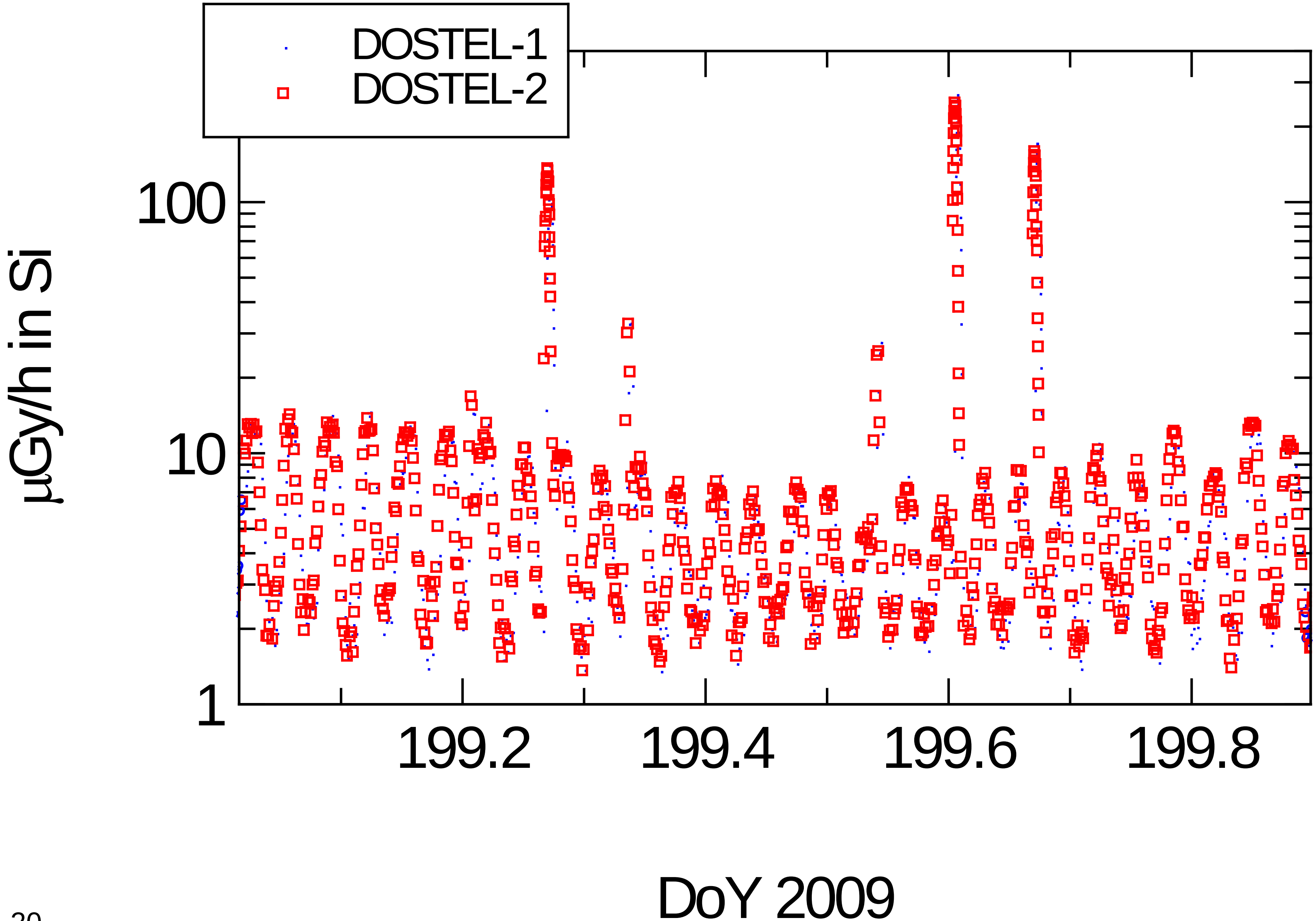
DOSIS / DOSIS3D DOSTEL-2 Count Rates



DOSIS - DOSTEL




DOSTEL-1
DOSTEL-2
100
10
1
µGy/h in Si
199.2
199.4
199.6
199.8
DoY 2009

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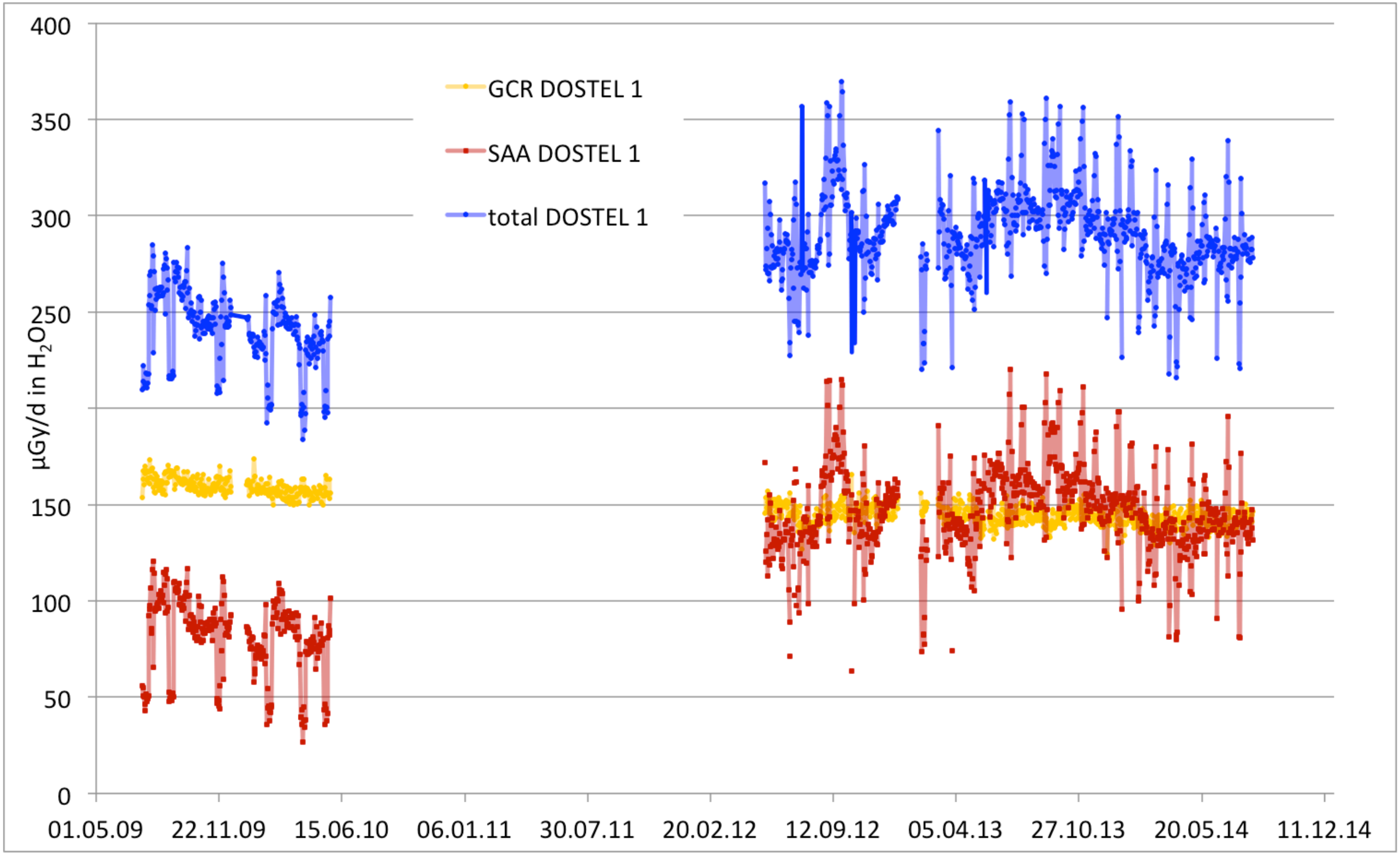
Absorbed Dose Rates DOSTEL 1



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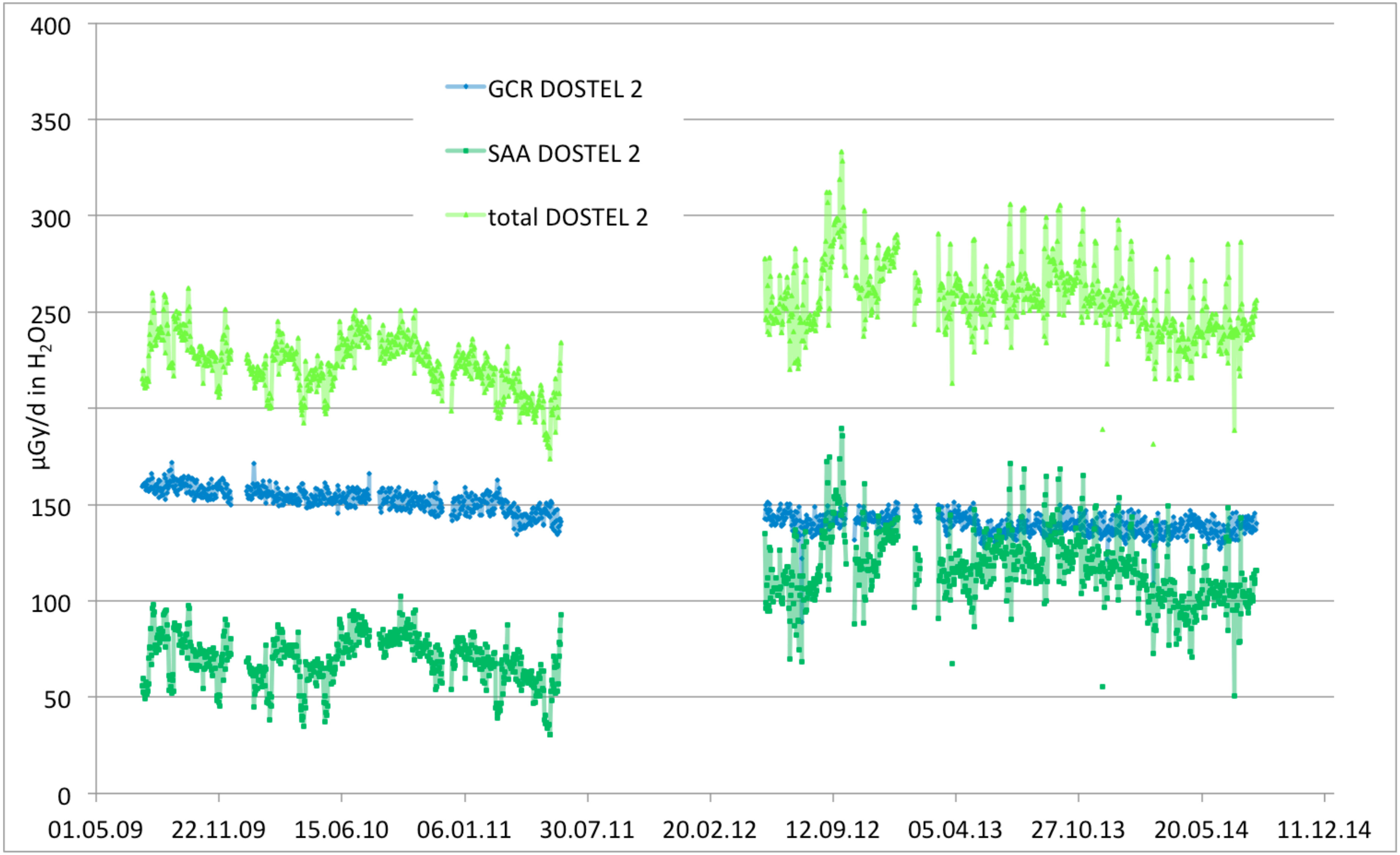
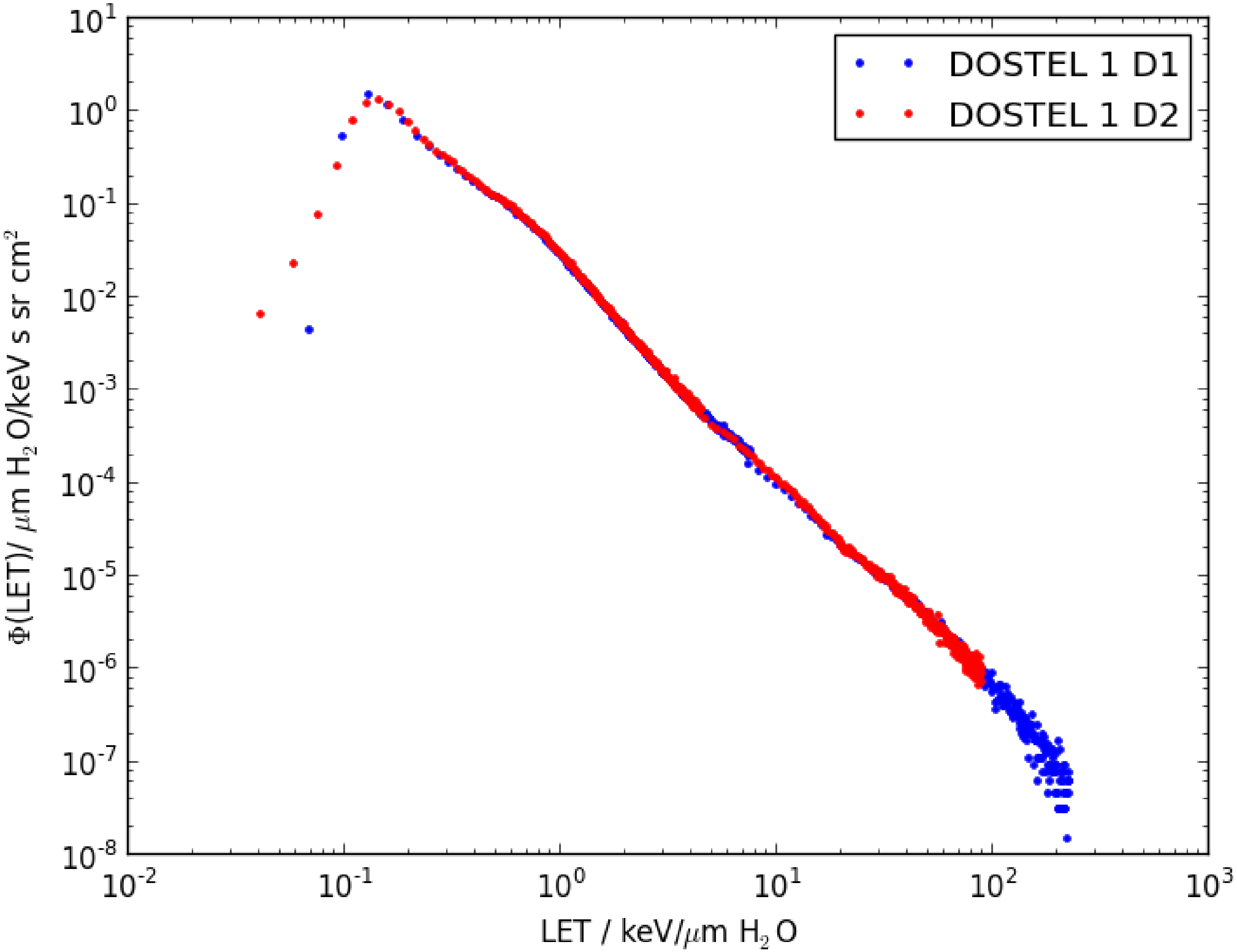
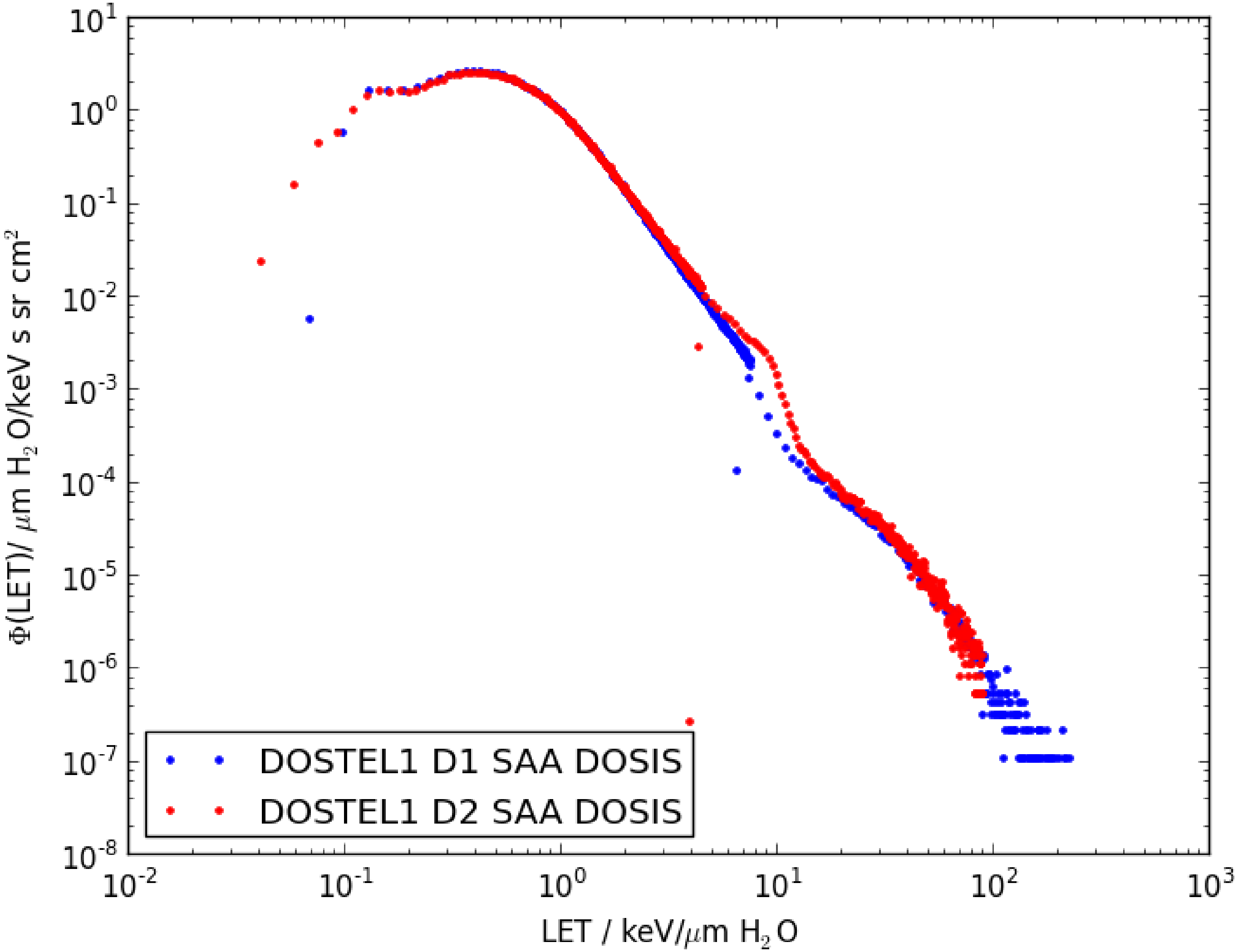
Absorbed Dose Rates DOSTEL 2



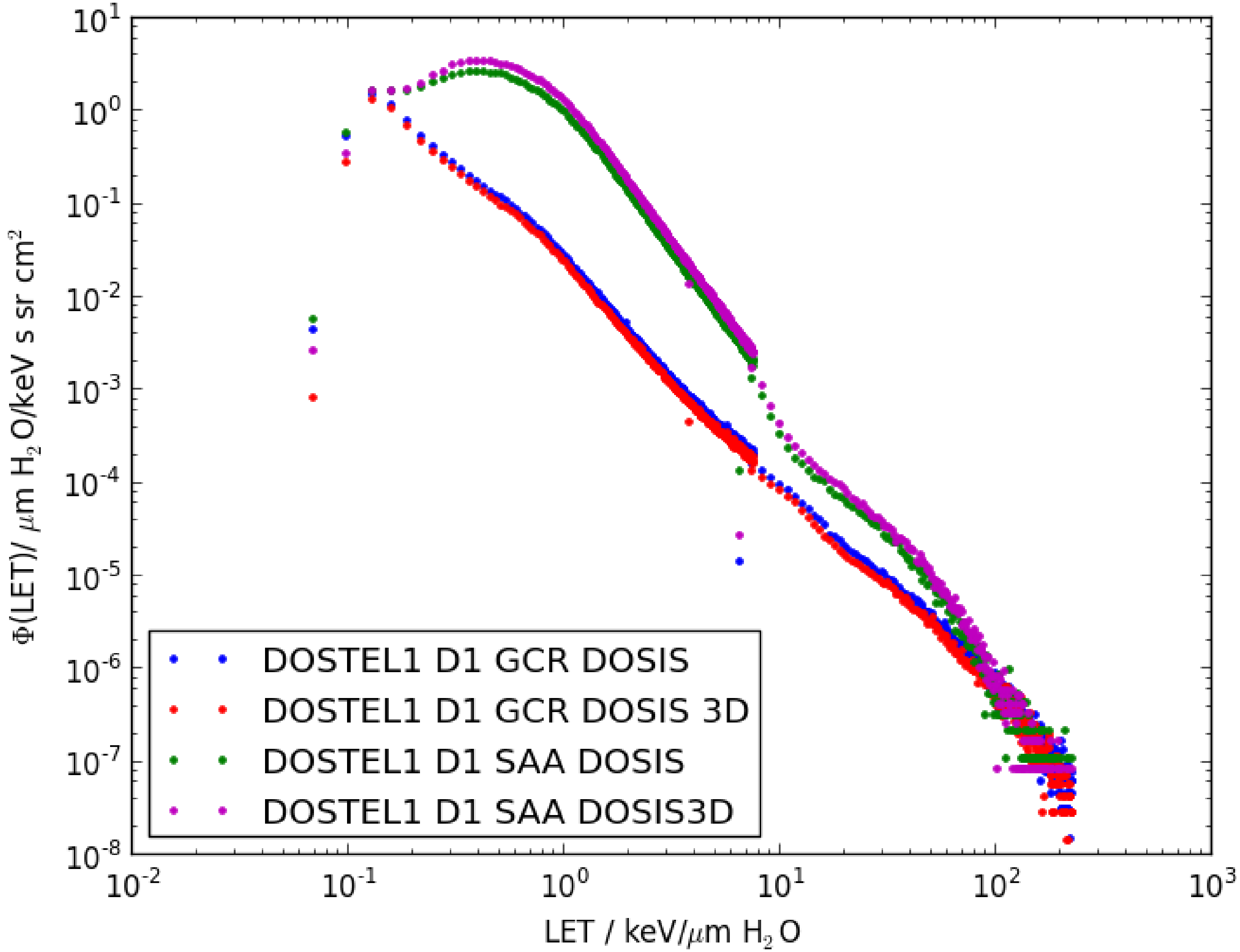
DOSIS GCR LET Spectra DOSTEL-1



DOSIS SAA LET Spectra DOSTEL-1



LET Spectra DOSTEL-1 Detector 1



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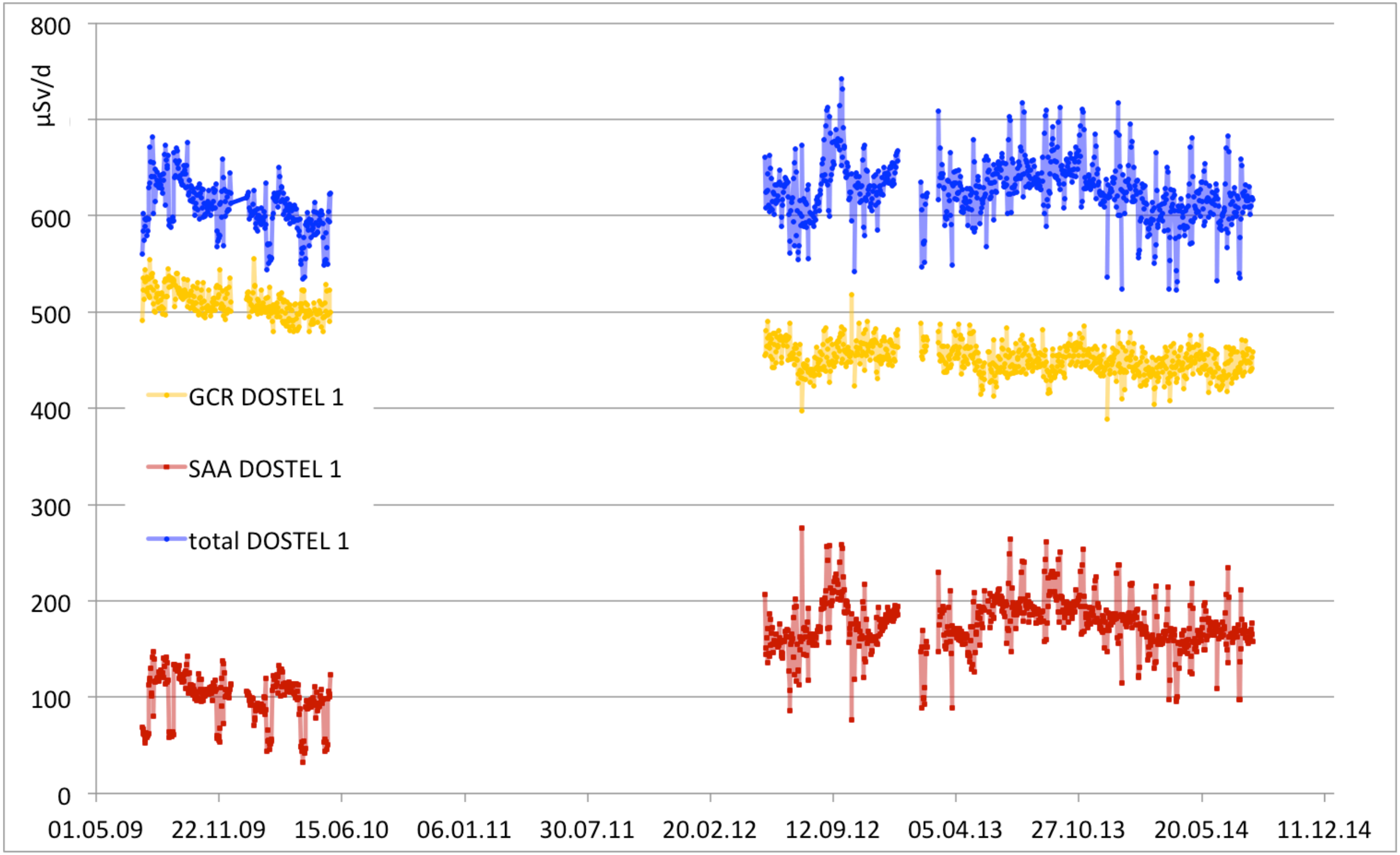
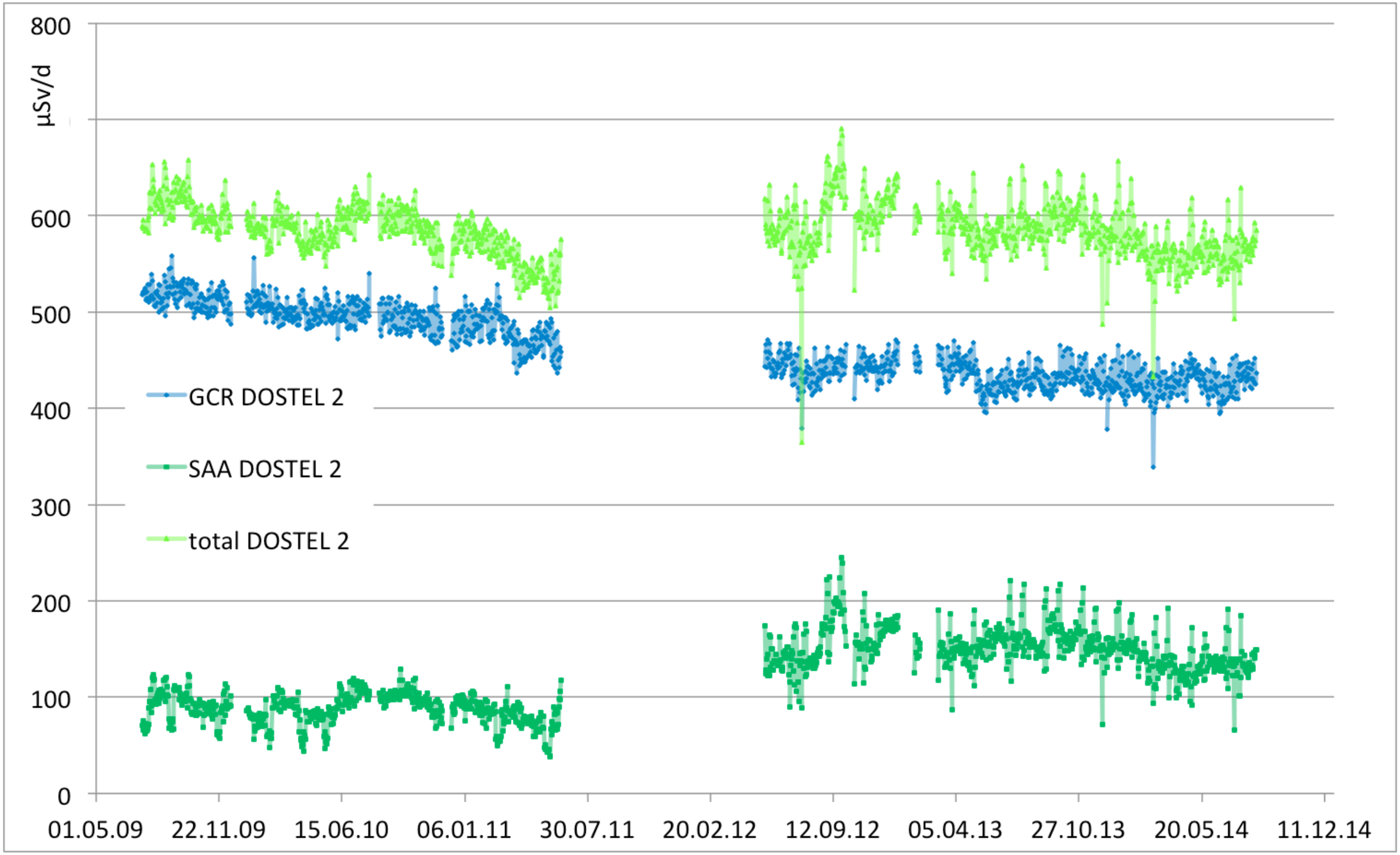
Dose Equivalent Rates DOSTEL 1



Dose Equivalent Rates DOSTEL 2



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DOSIS / DOSIS 3D Results

DOSTEL-1: July 18, 2009 - May 28, 2010
DOSTEL-2: July 18, 2009 - June 16, 2011

DOSIS	Total				GCR				SAA			
	µGy/d in Si	µGy/d in tissue	Q	µSv/d	µGy/d in Si	µGy/d in tissue	Q	µSv/d	µGy/d in Si	µGy/d in tissue	Q	µSv/d
DOSTEL-1	195	240	2.5	609	130	159	3.2	510	66	81	1.22	99
DOSTEL-2	181	222	2.6	584	124	153	3.3	497	57	70	1.26	88

DOSIS 3D	Total				GCR				SAA			
	µGy/d in Si	µGy/d in tissue	Q	µSv/d	µGy/d in Si	µGy/d in tissue	Q	µSv/d	µGy/d in Si	µGy/d in tissue	Q	µSv/d
DOSTEL-1	236	291	2.2	627	117	144	3.1	451	119	147	1.20	176
DOSTEL-2	208	256	2.3	583	113	139	3.1	433	95	116	1.29	150

DOSTEL-1: May 21, 2012 – August 13, 2014
DOSTEL-2: May 21, 2012 – August 19, 2014

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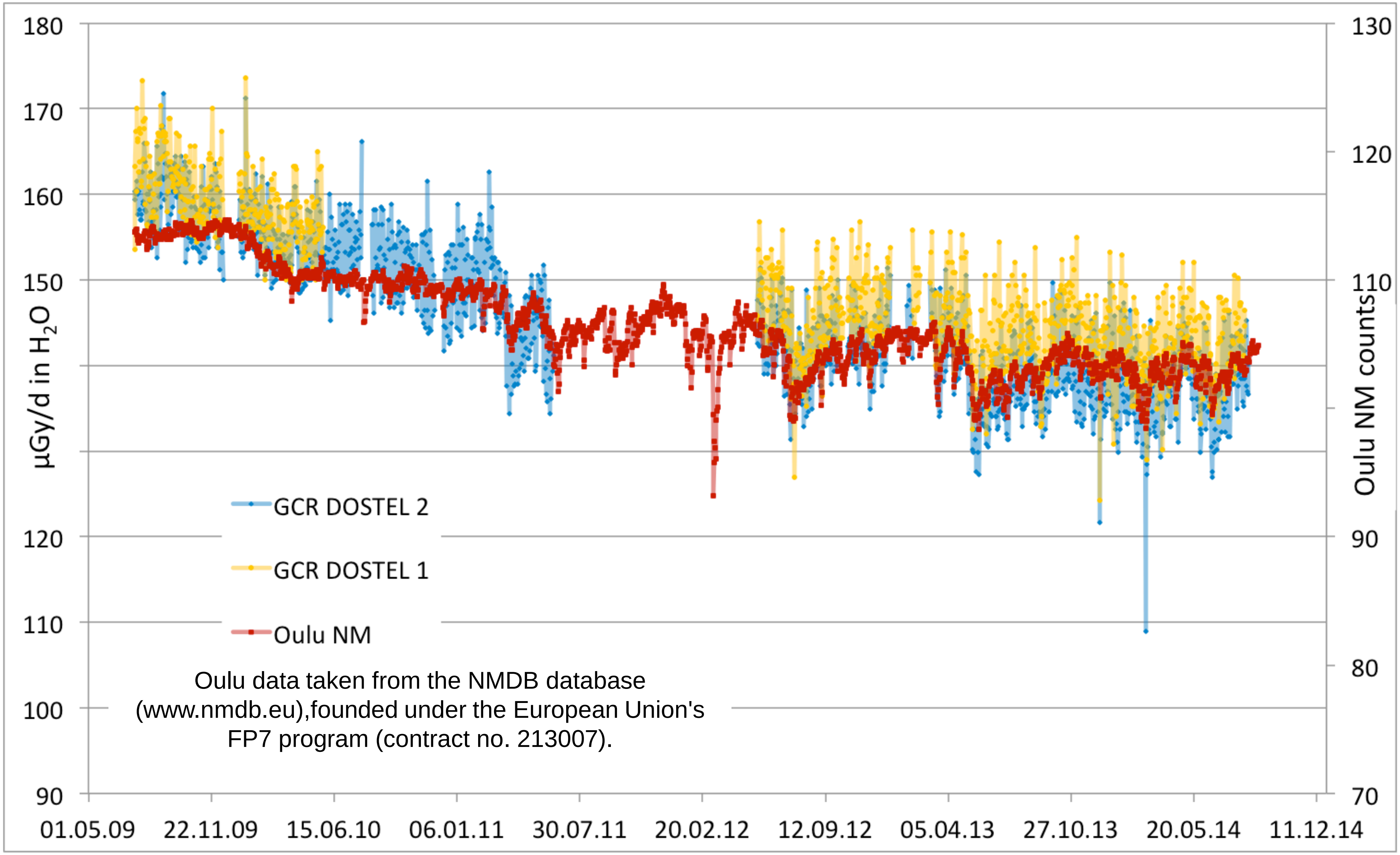
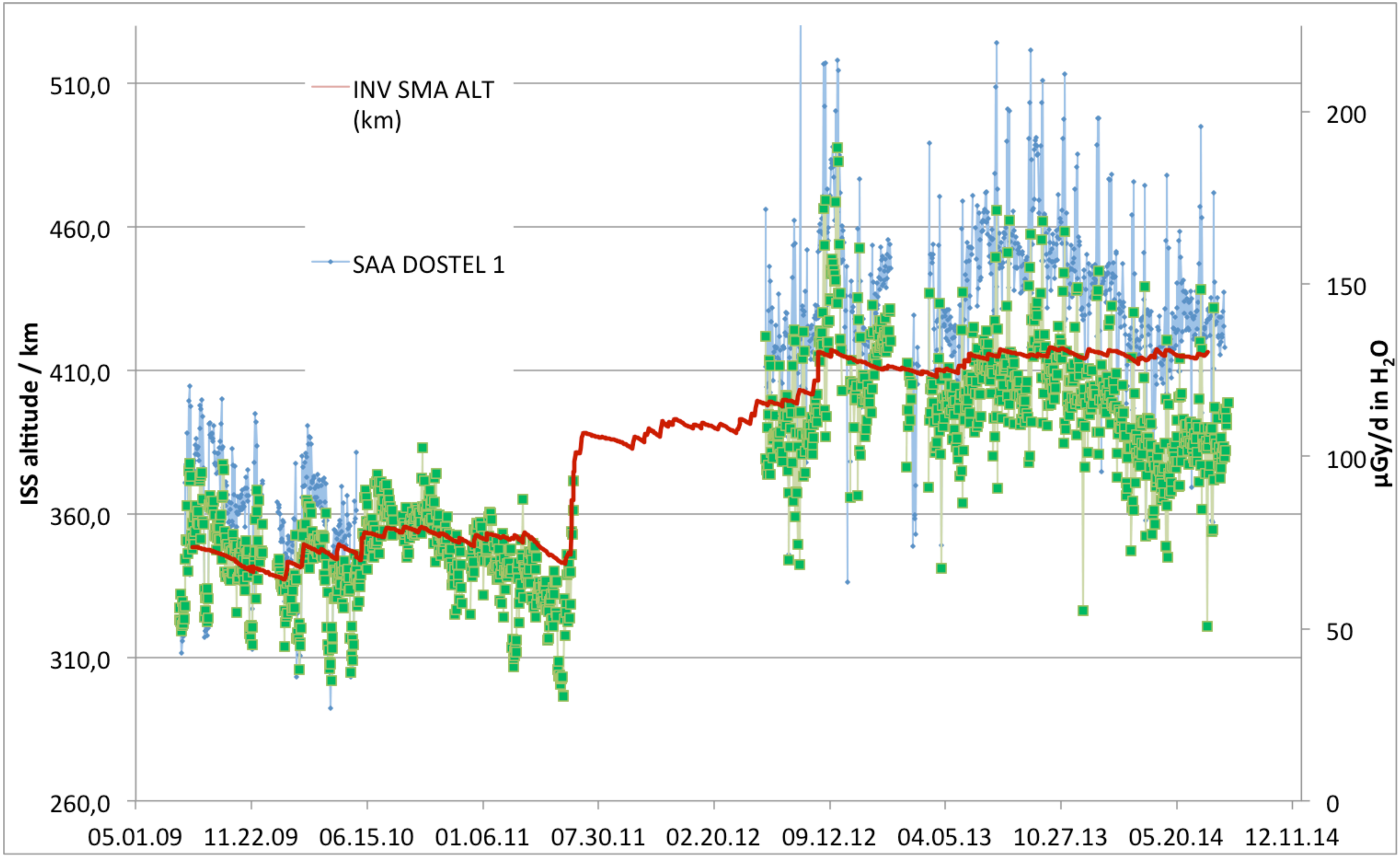
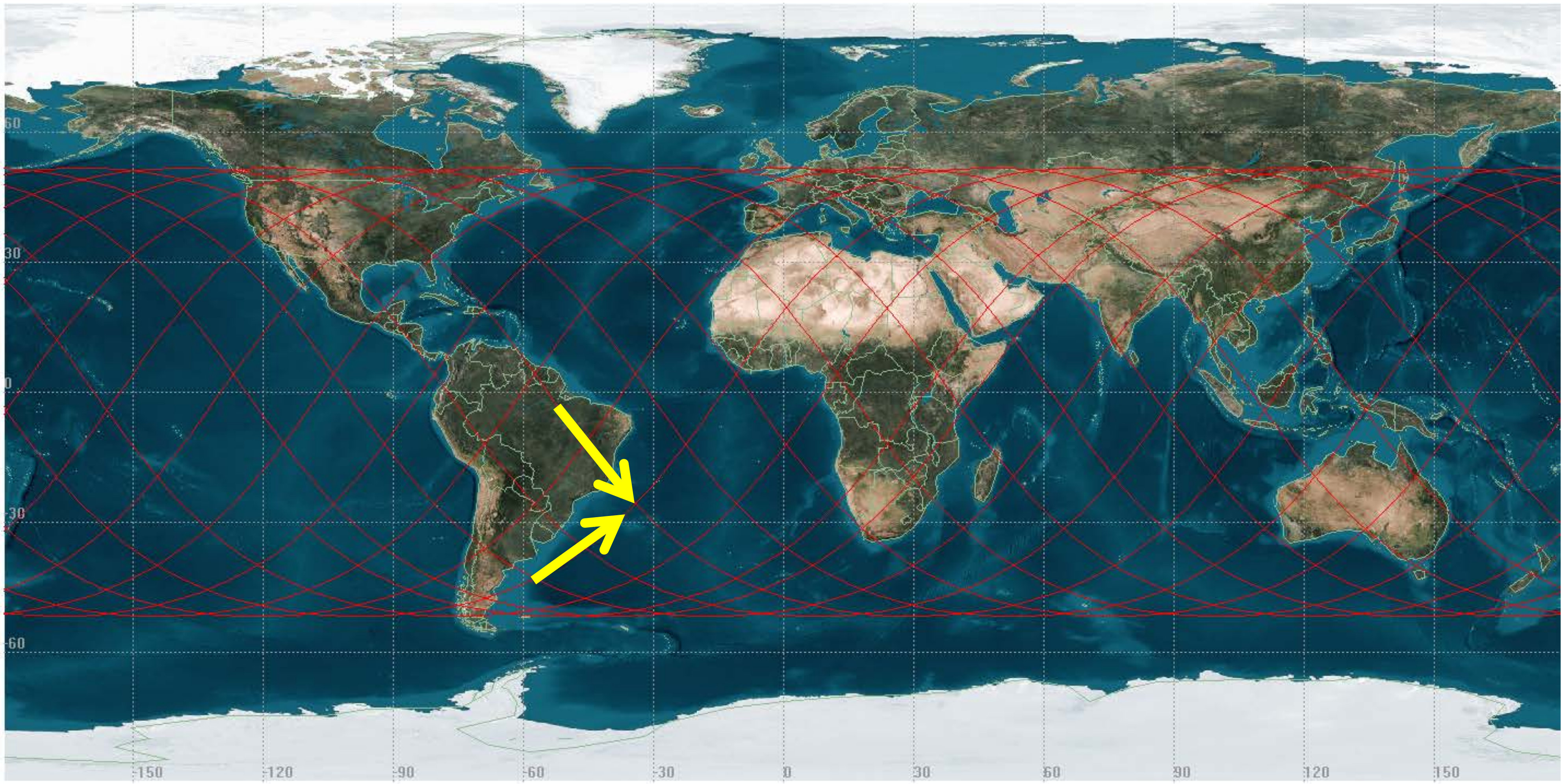
GCR Dose Rates



SAA Dose Rates



ISS Orbit



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DOSIS SAA Energy Deposition Spectra

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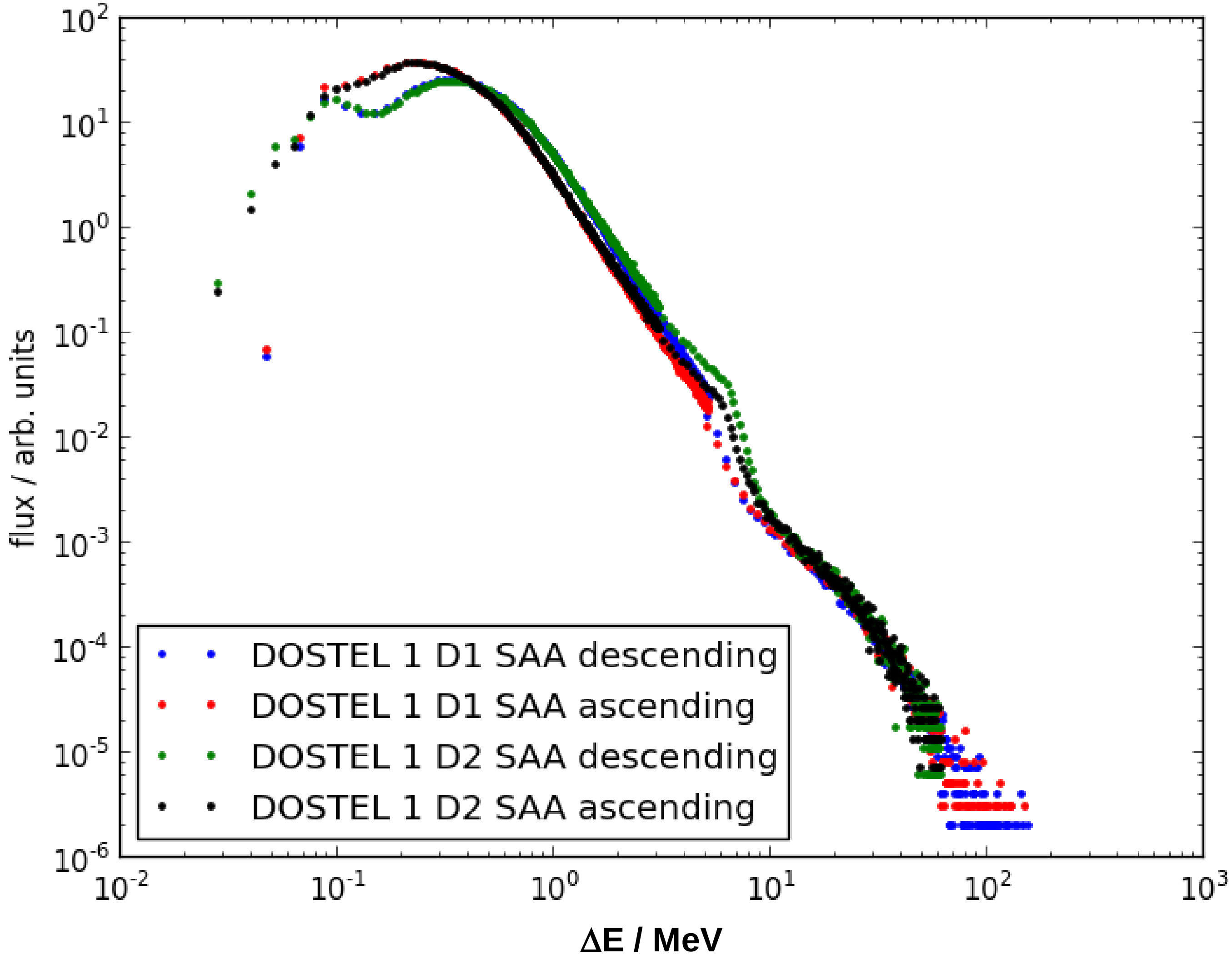

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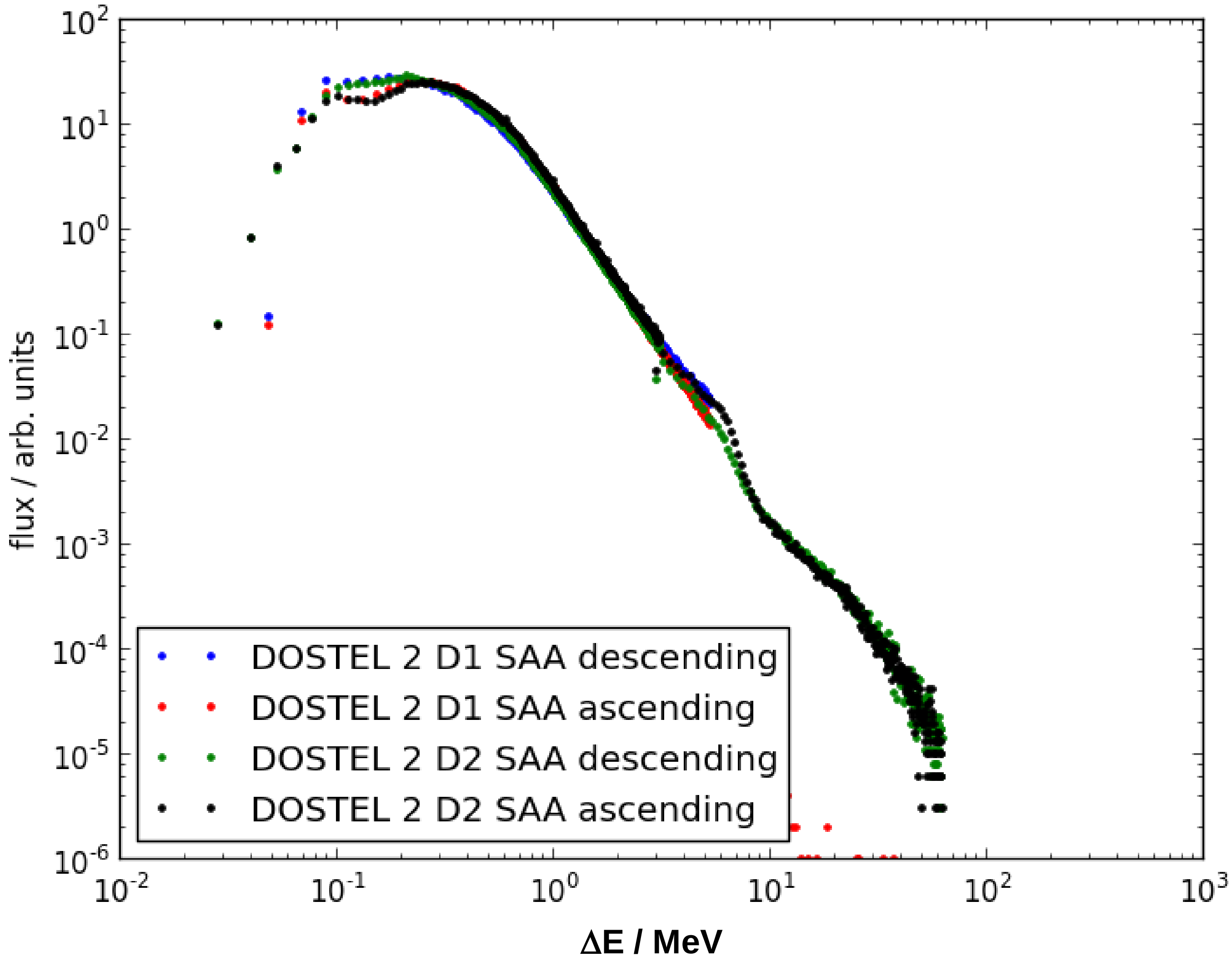
DOSIS SAA Energy Deposition Spectra



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DOSIS 3D SAA Mode 2 Data

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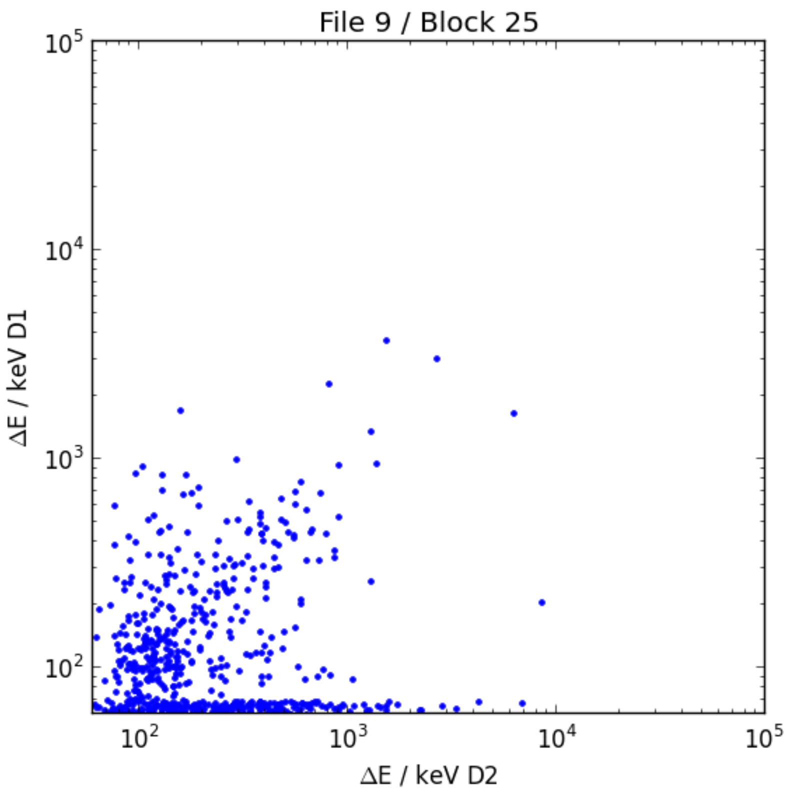
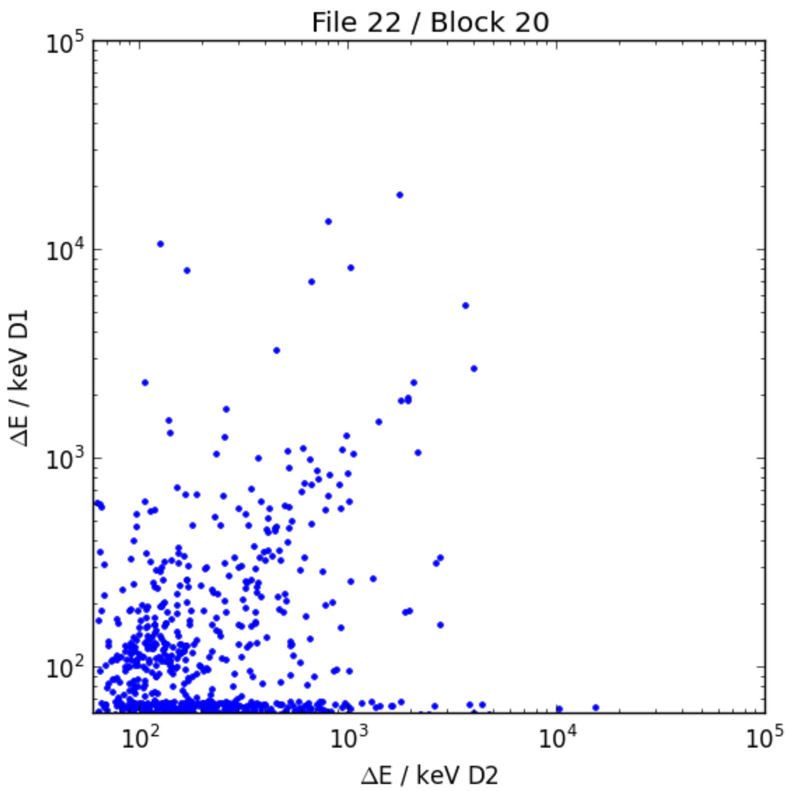
ascending

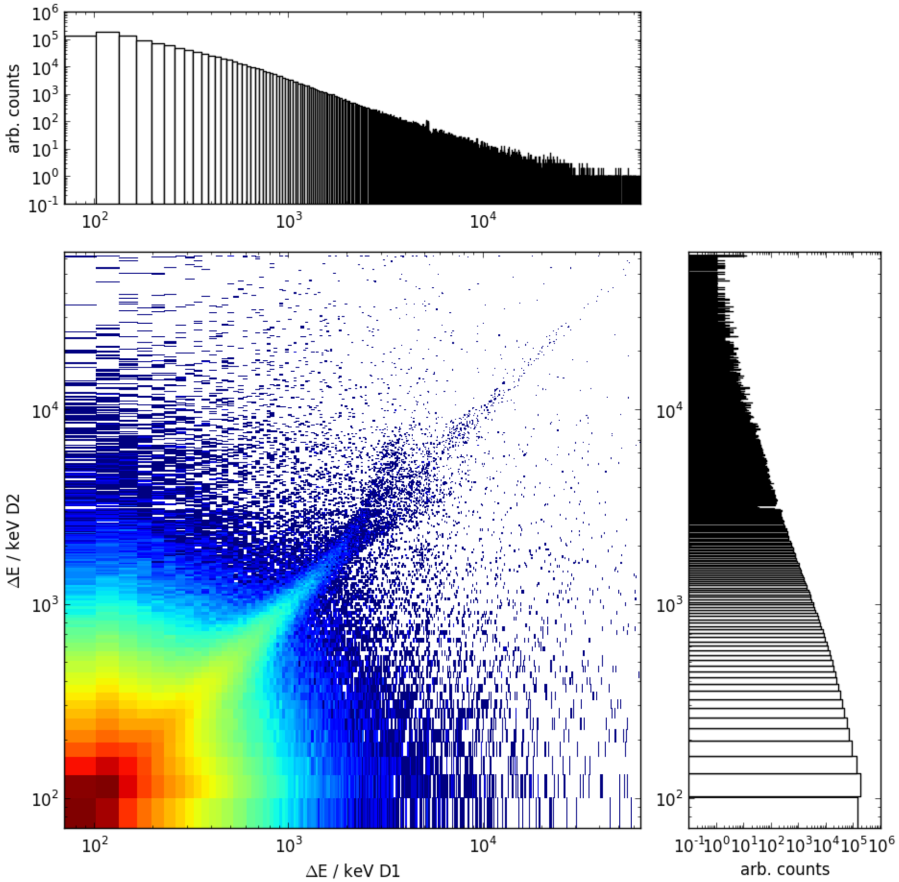


descending

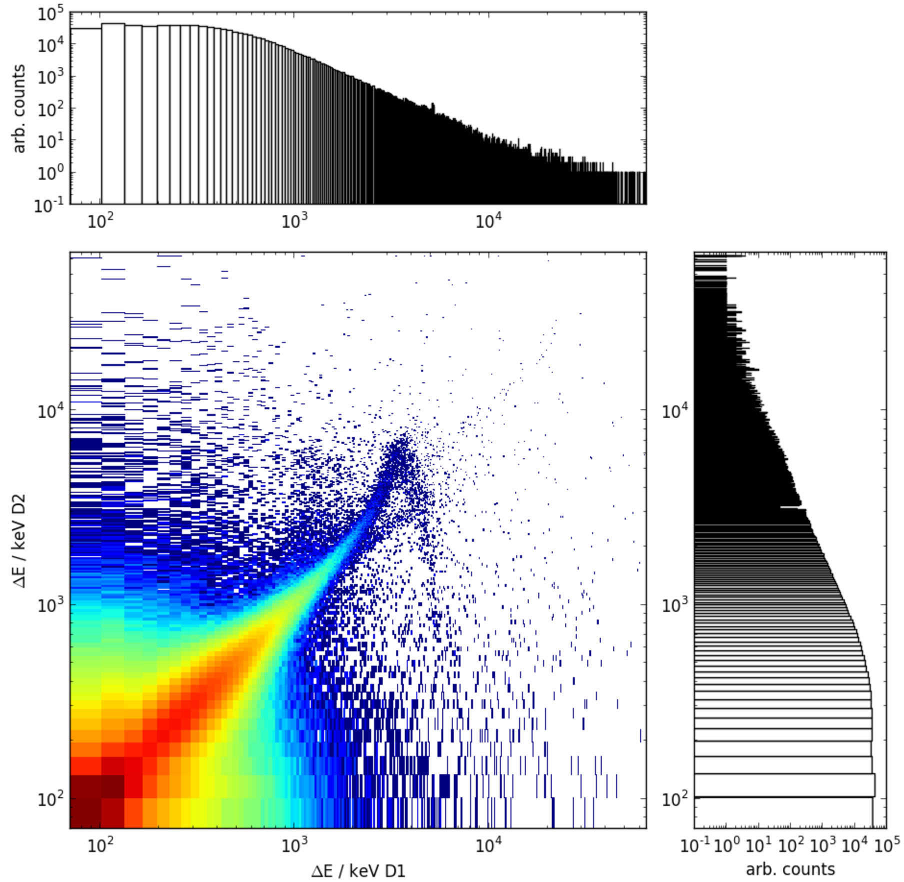


DOSIS 3D Mode 2 Data

GCR (mainly)



SAA (mainly)



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DOSIS 3D Mode 2 Data

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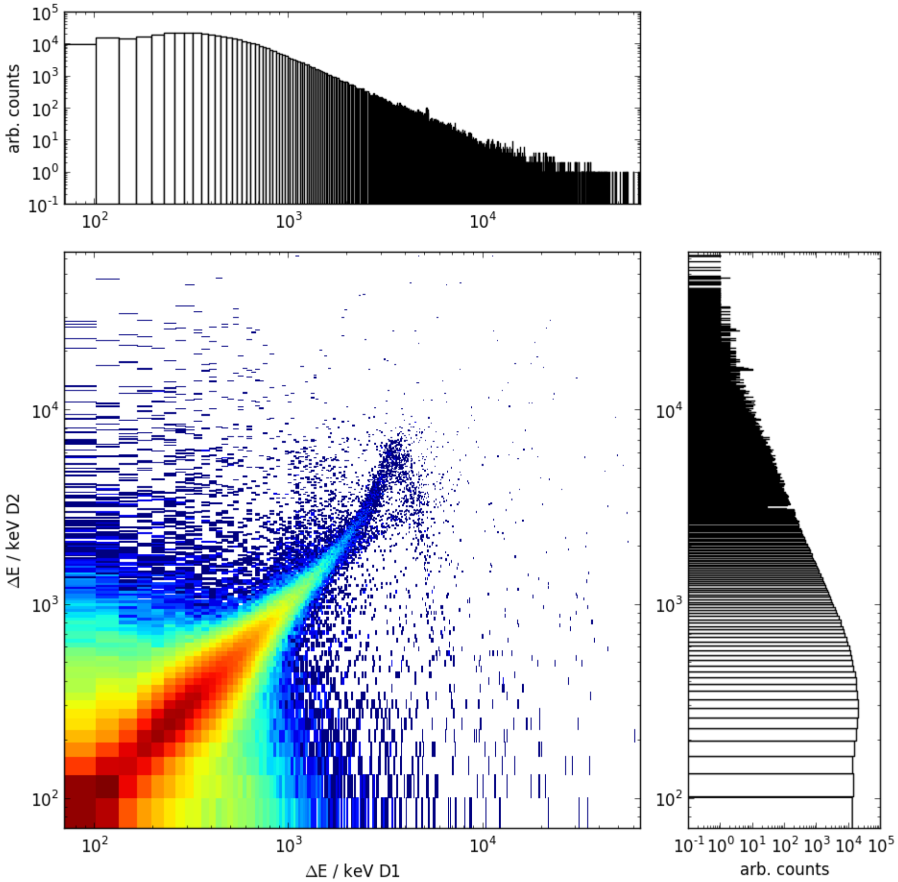
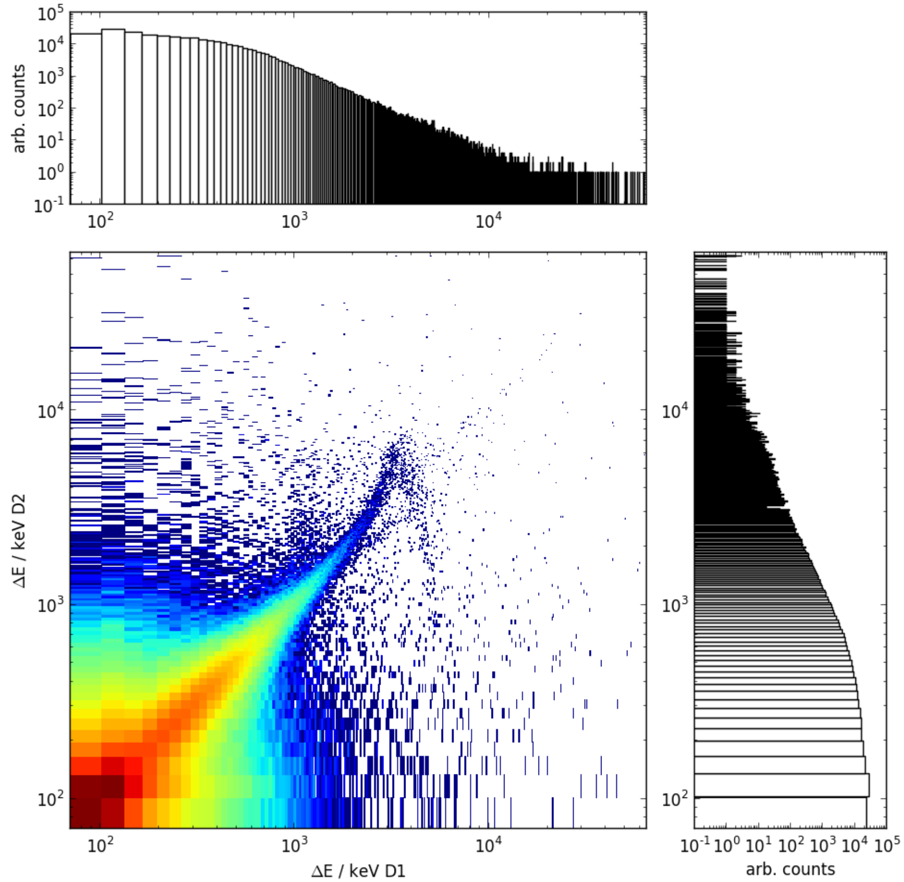
Ascending SAA (mainly)



Descending SAA (mainly)



Conclusions

- Up to now we have data for 1395 days of measurement with DOSTEL-2 (DOSTEL-1: 1046d)

- During the passes of the SAA region stopping Protons can clearly be seen in the second detector of DOSTEL-1, i.e. protons mainly reaching the DOSTEL-1 telescope from aft direction

- Contribution of GCR to the dose rate is obviously correlated with the GCR flux measured by NM while the contribution of trapped particles is correlated with the stations altitude

Acknowledgements

- Special Thanks to the ICCHIBAN Workinggroup and the HIMAC facility for a lot of support

Supported by:

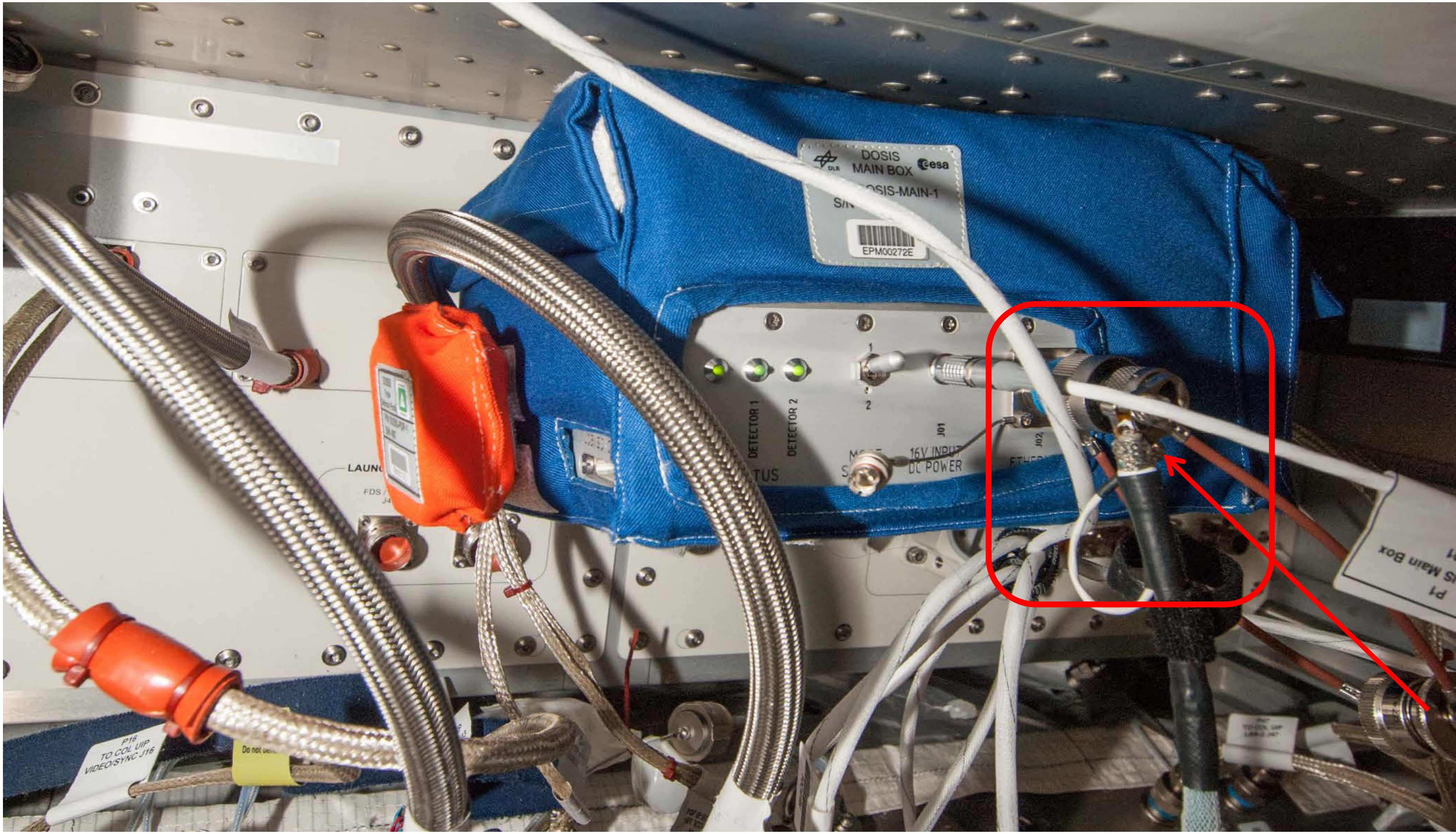
- Federal Ministry of Economics and Technology under grants 50WB0826, 50WB1026, and 50WB1232

on the basis of a decision by the German Bundestag

- Thank you very much for your attention!

Backup slides…

DOSIS 3D: 38S


DOSIS
MAIN BOX
esa
EPM00272E
DETECTOR 1
DETECTOR 2
16V INPUT
DC POWER
P16
TO COL UIP
VIDEO/SYNC J16

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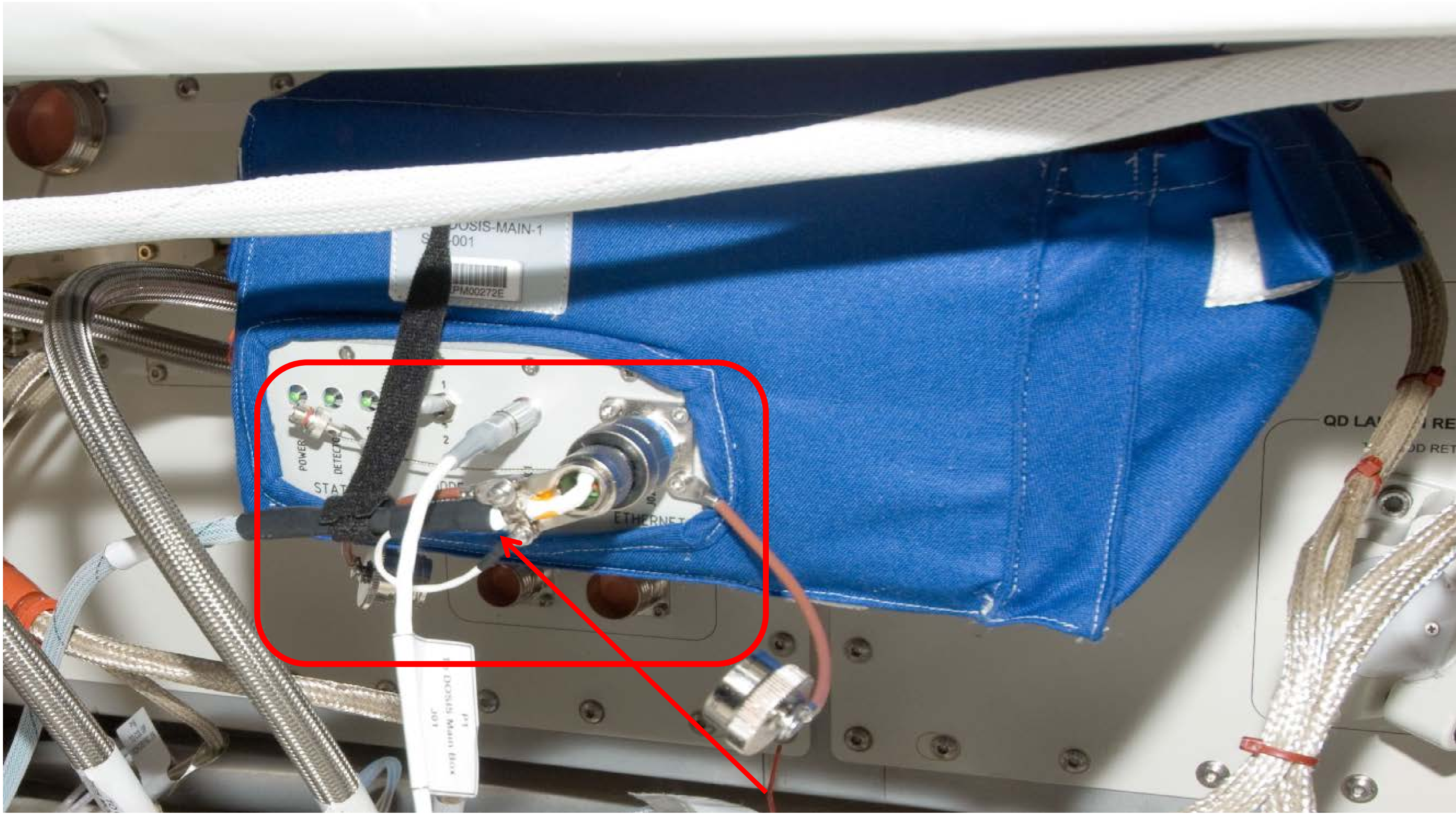
DOSIS: 2009



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DOSIS 3D: 30S

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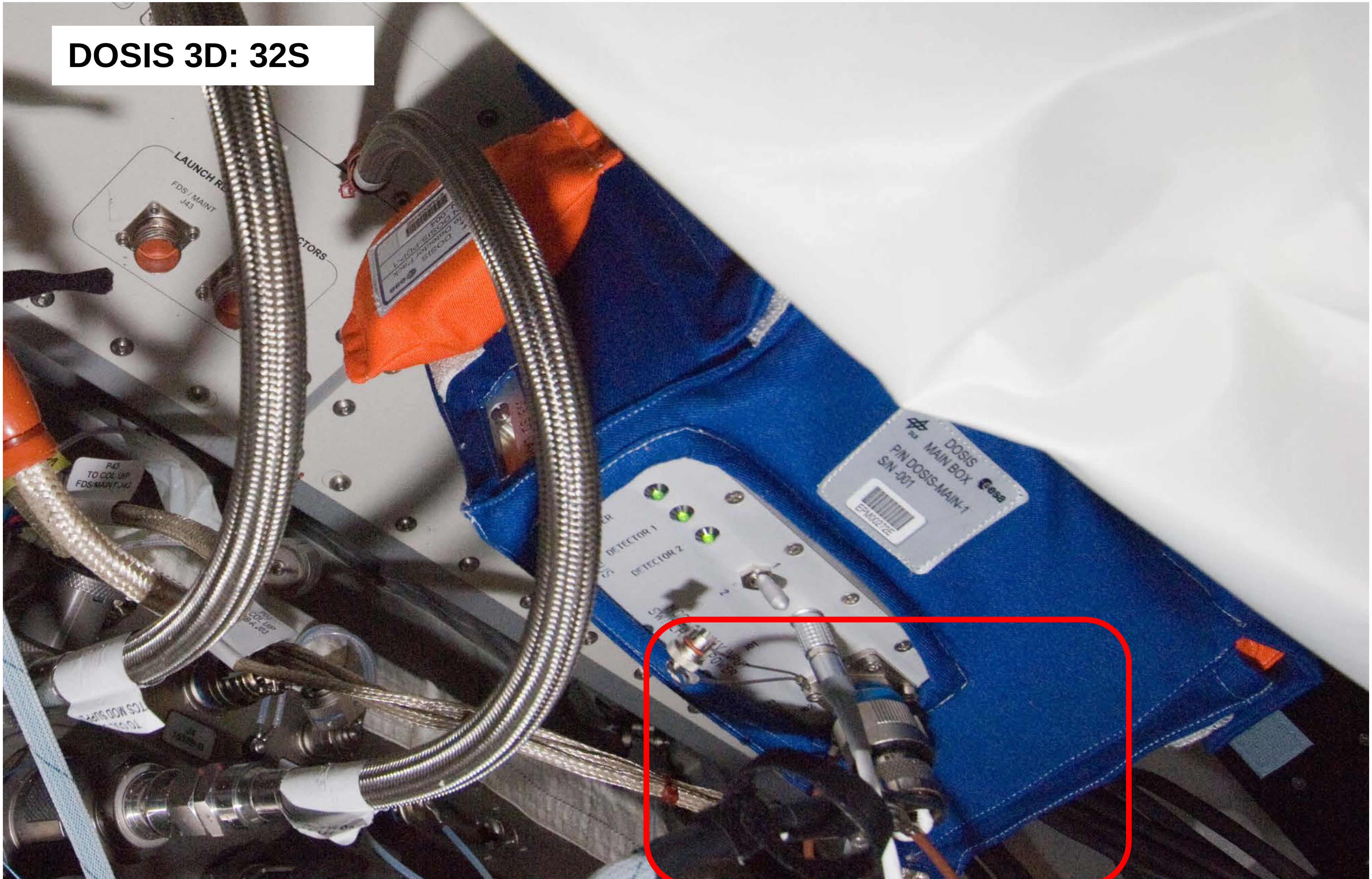
DOSIS 3D: 32S



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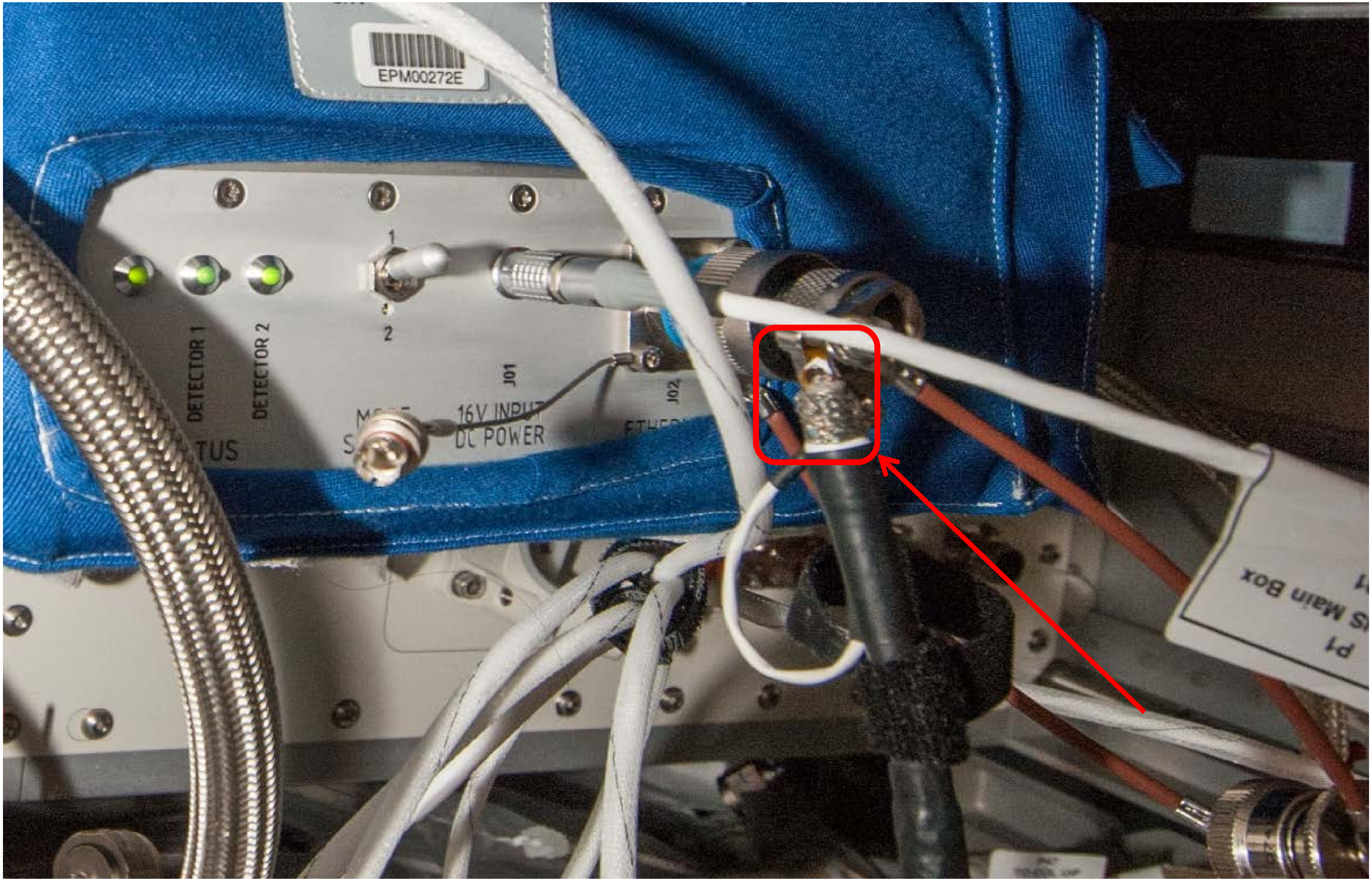
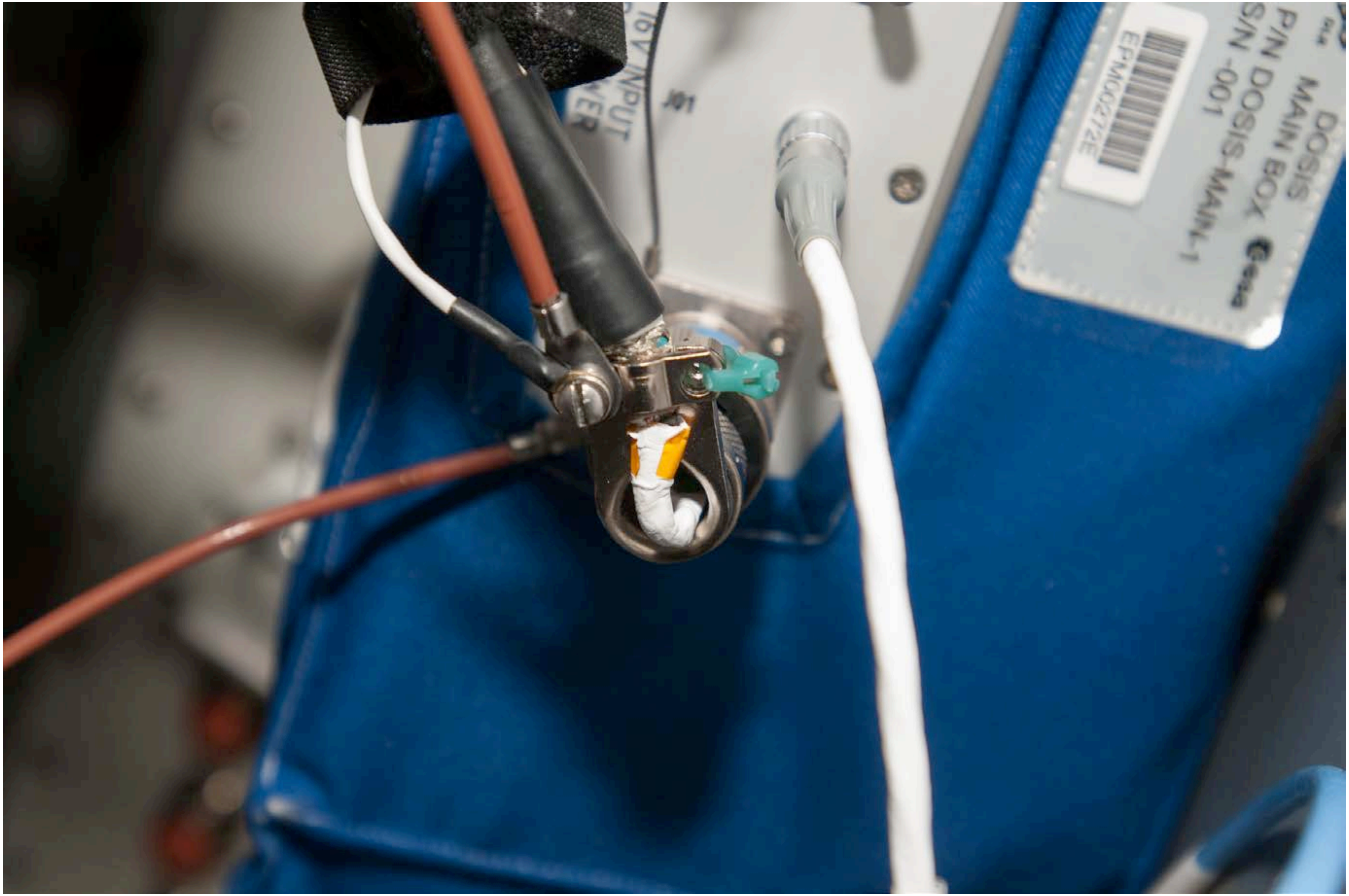
DOSIS 3D: 36S

DOSIS 3D: 38S


EPM00272E
1
2
DETECTOR 1
DETECTOR 2
J01
16V INPUT
DC POWER
J02
P1
Main Box


MODE
SWITCH


DOSIS
MAIN BOX
P/N DOSIS-MAIN-1
S/N -001
J01

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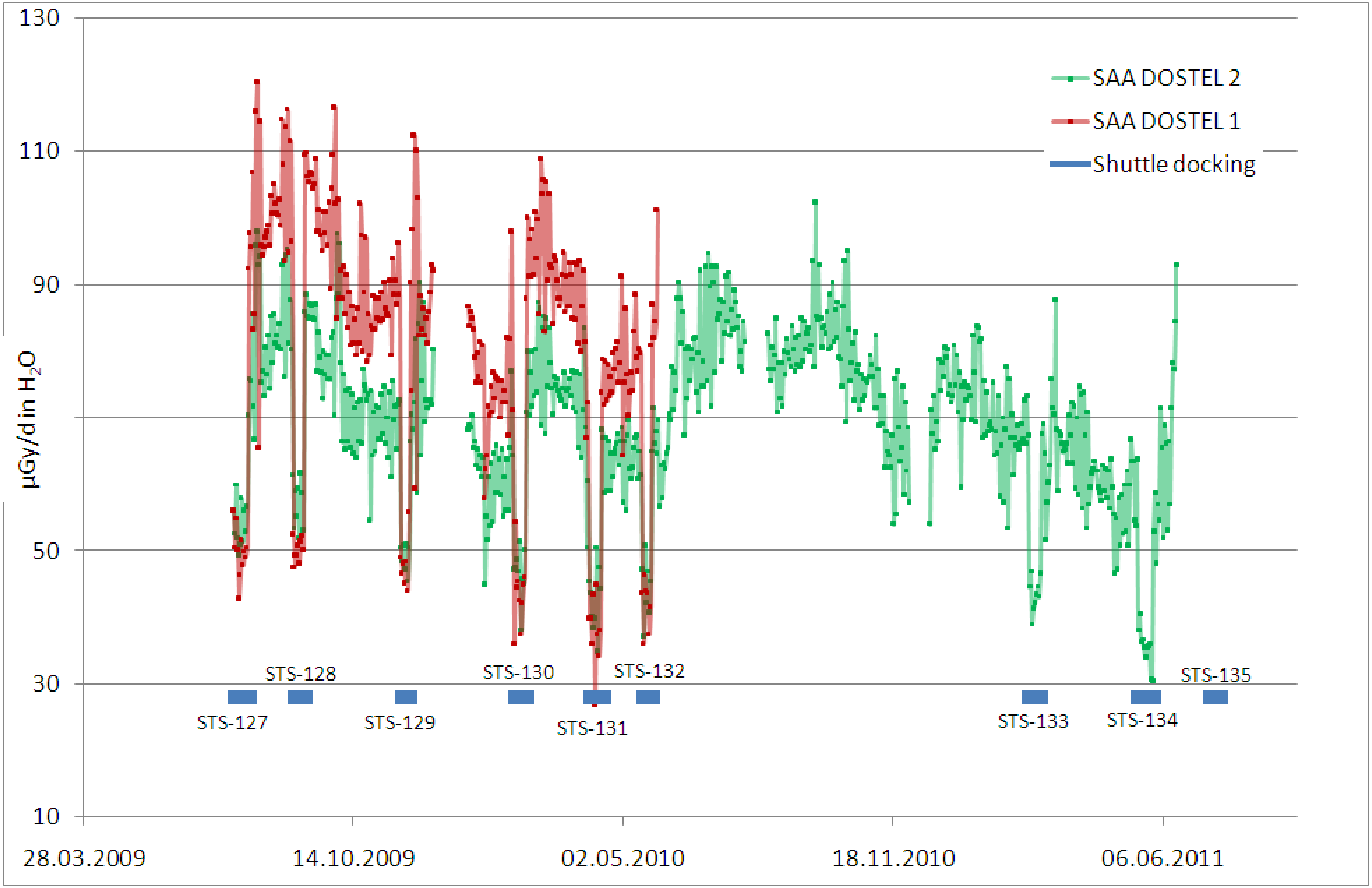
Absorbed Dose Rates SAA



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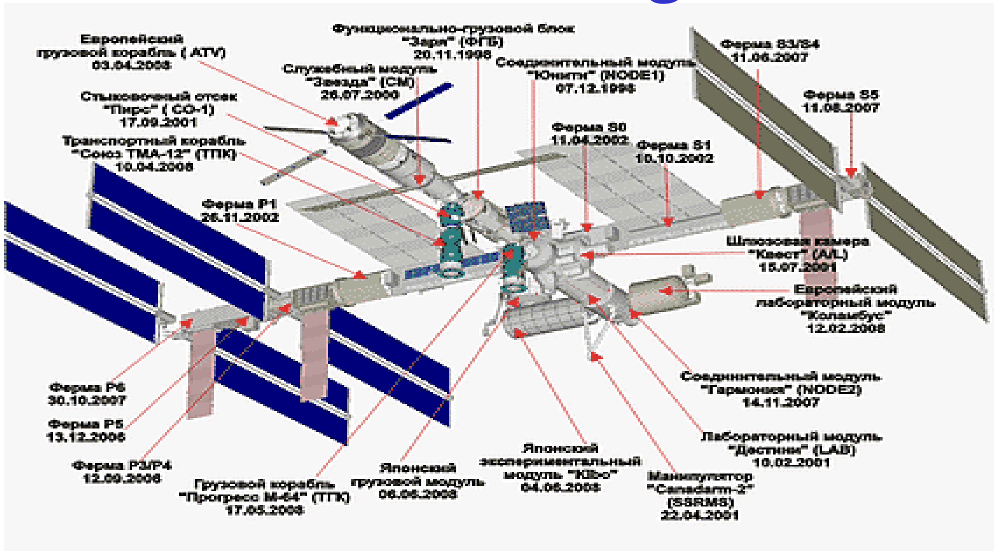
ISS configuration



Service Module

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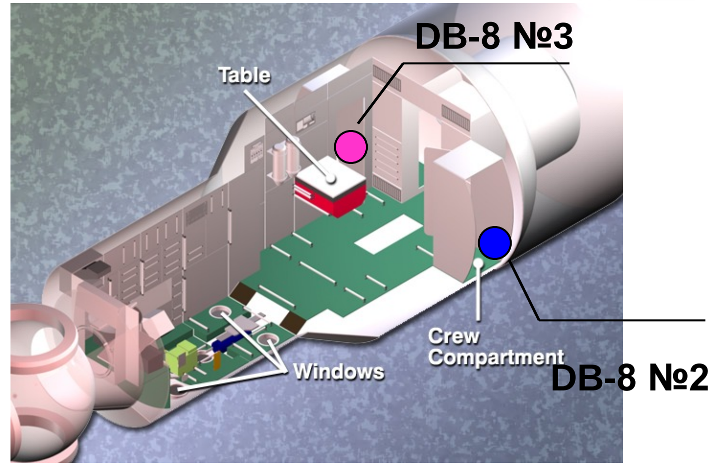
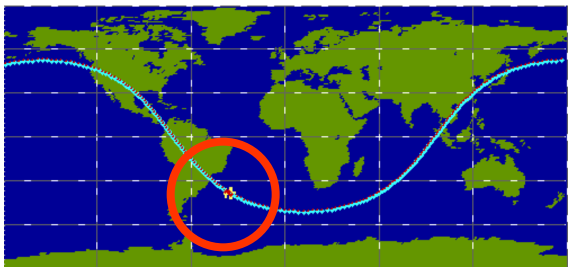
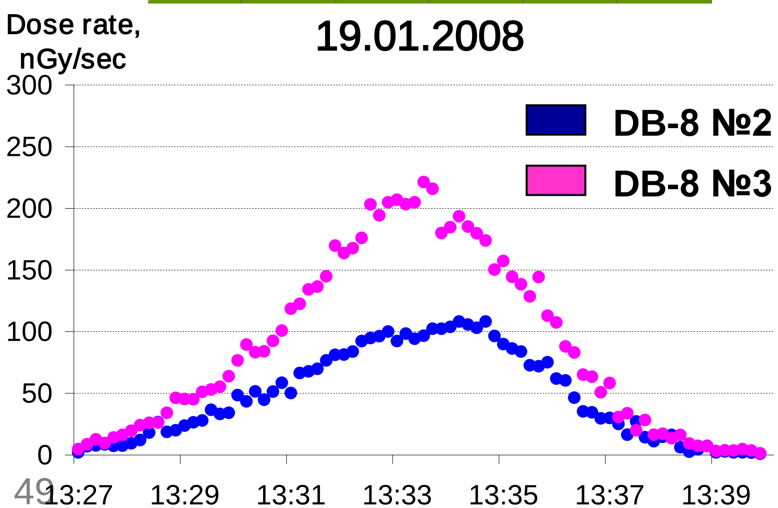
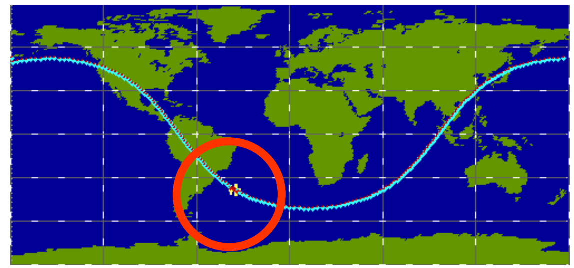


Thanks to S.G. Drobyshev, V.V. Benghin



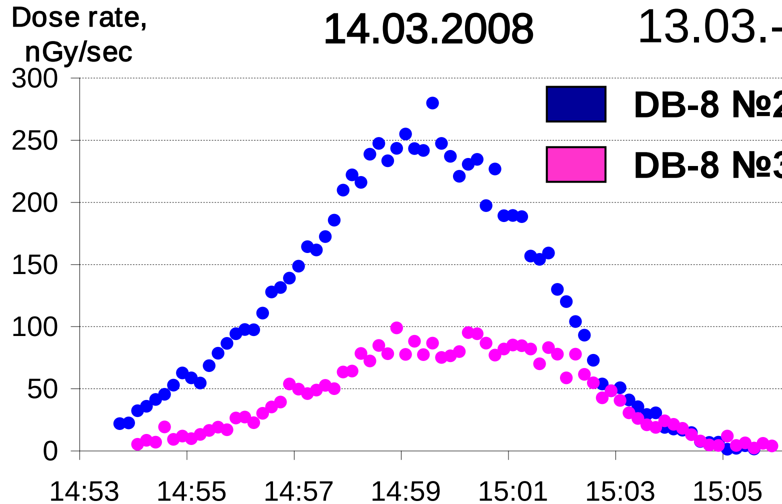
19.01.2008





14.03.2008

STS-123 docking: 13.03.-25.03.08



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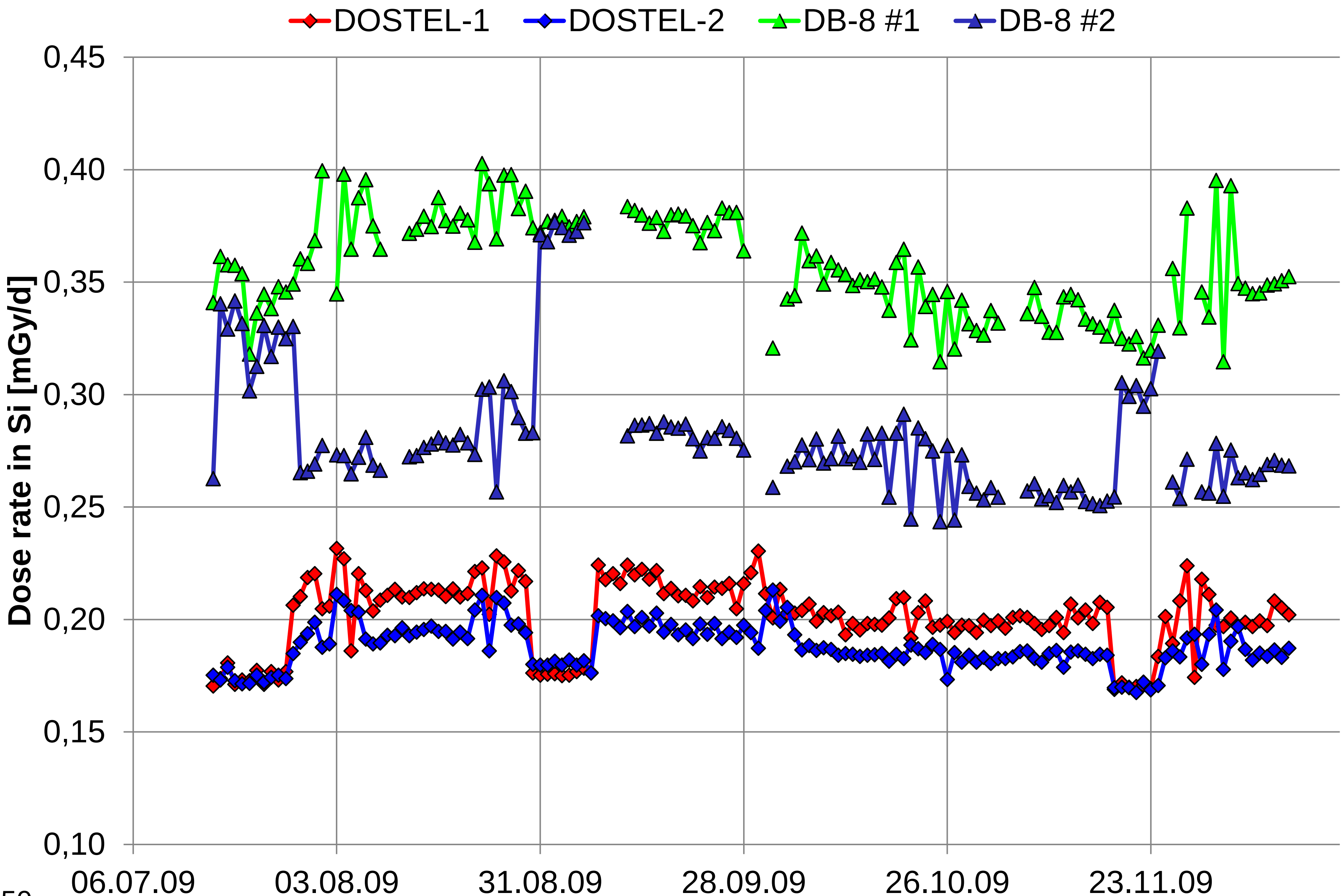
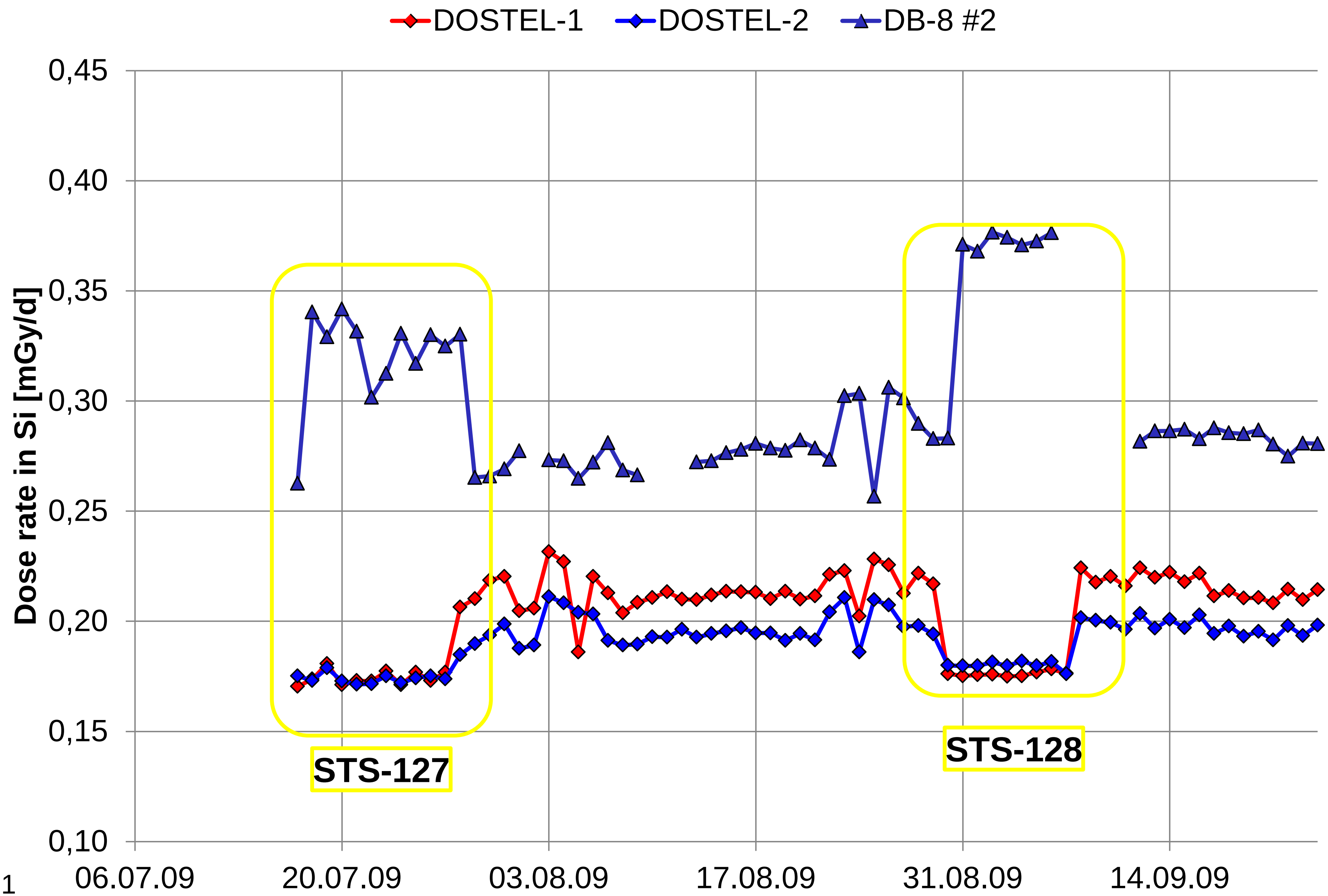
Shuttle Docking



Shuttle Docking



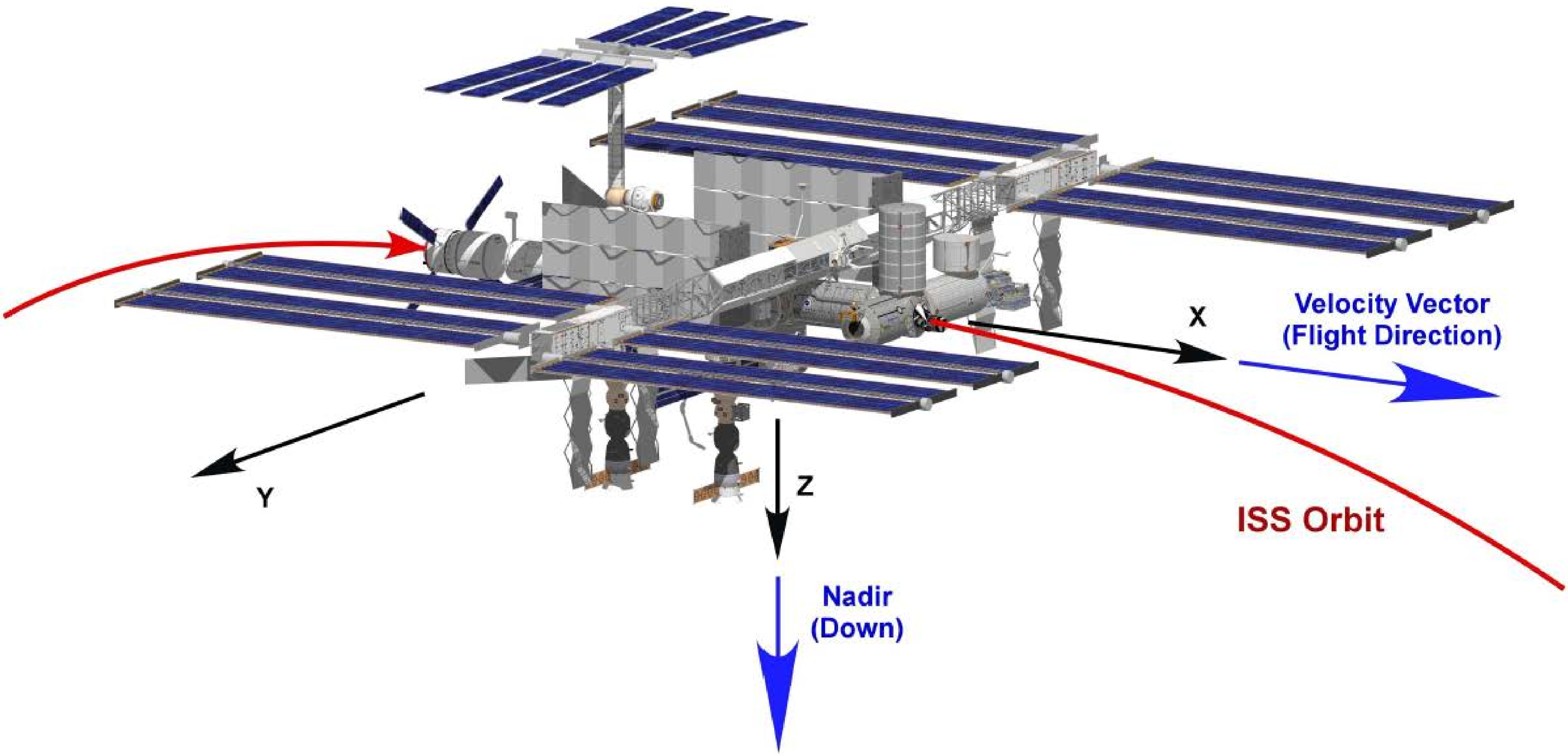
Dose Values During Shuttle Docking

- The mean contribution to the daily dose drops roughly 30-40% from ~100 µSv/d to ~60-70µSv/d during the Shuttle docking phases

- The effect occurs mainly during the south-eastward passages through the SAA

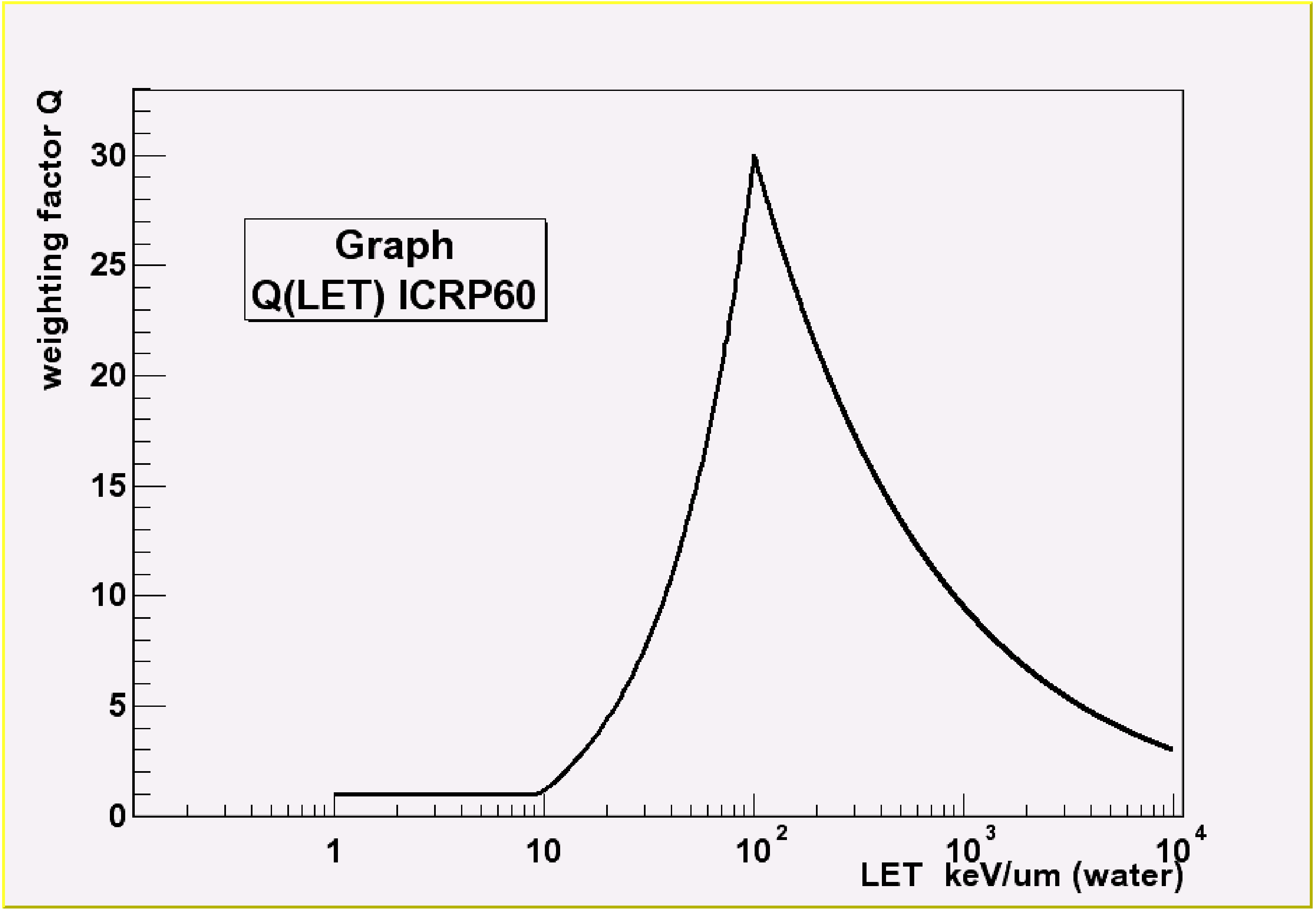
- It is most likely due to the attitude change of the station from +Xvv to -Xvv

ISS +Xvv Attitude



[European Users Guide to Low Gravity Platforms, UIC-ESA-UM-0001]

Mean Quality Factor



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DOSIS 3D, DOSIS and DOSMAP comparison

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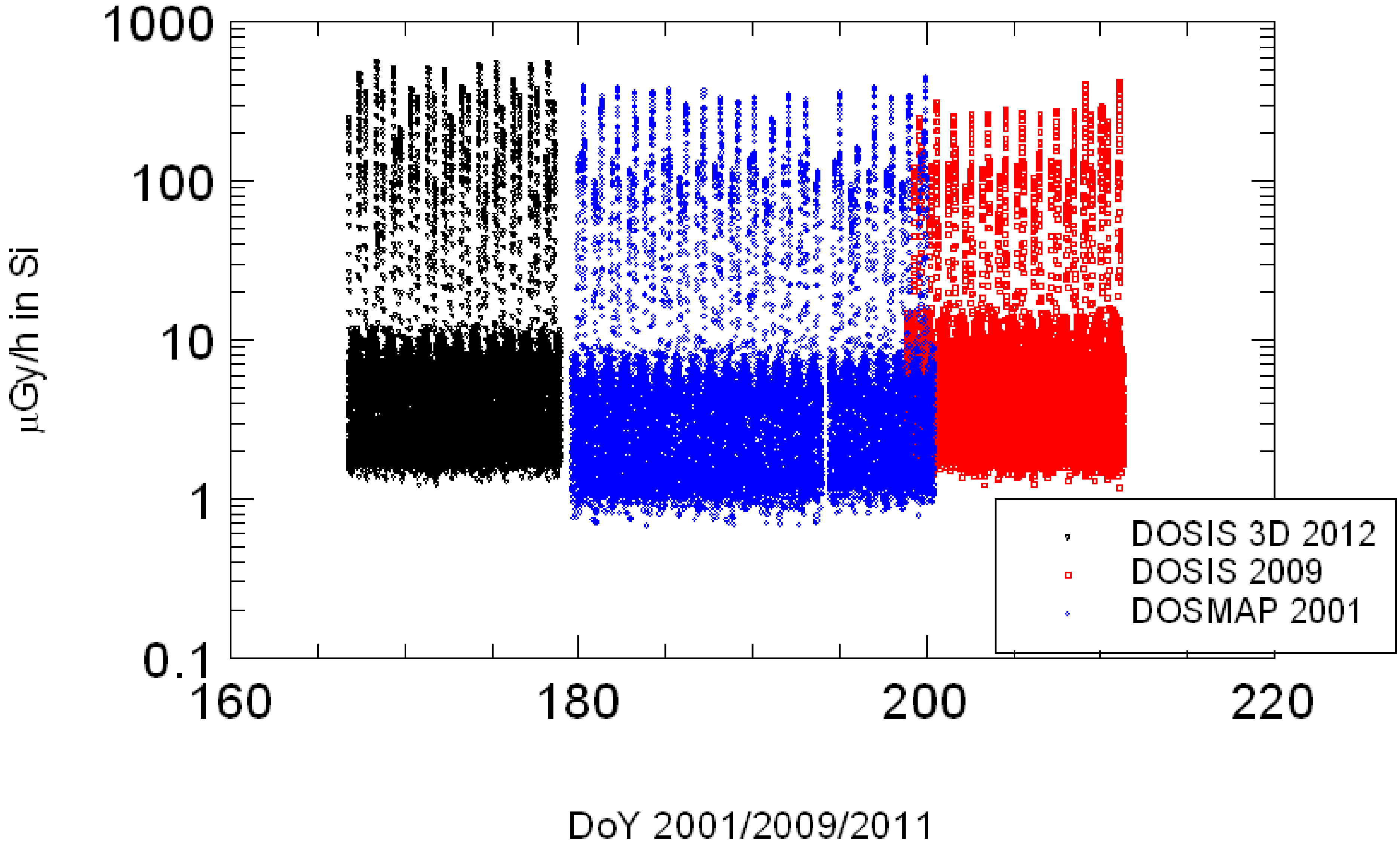
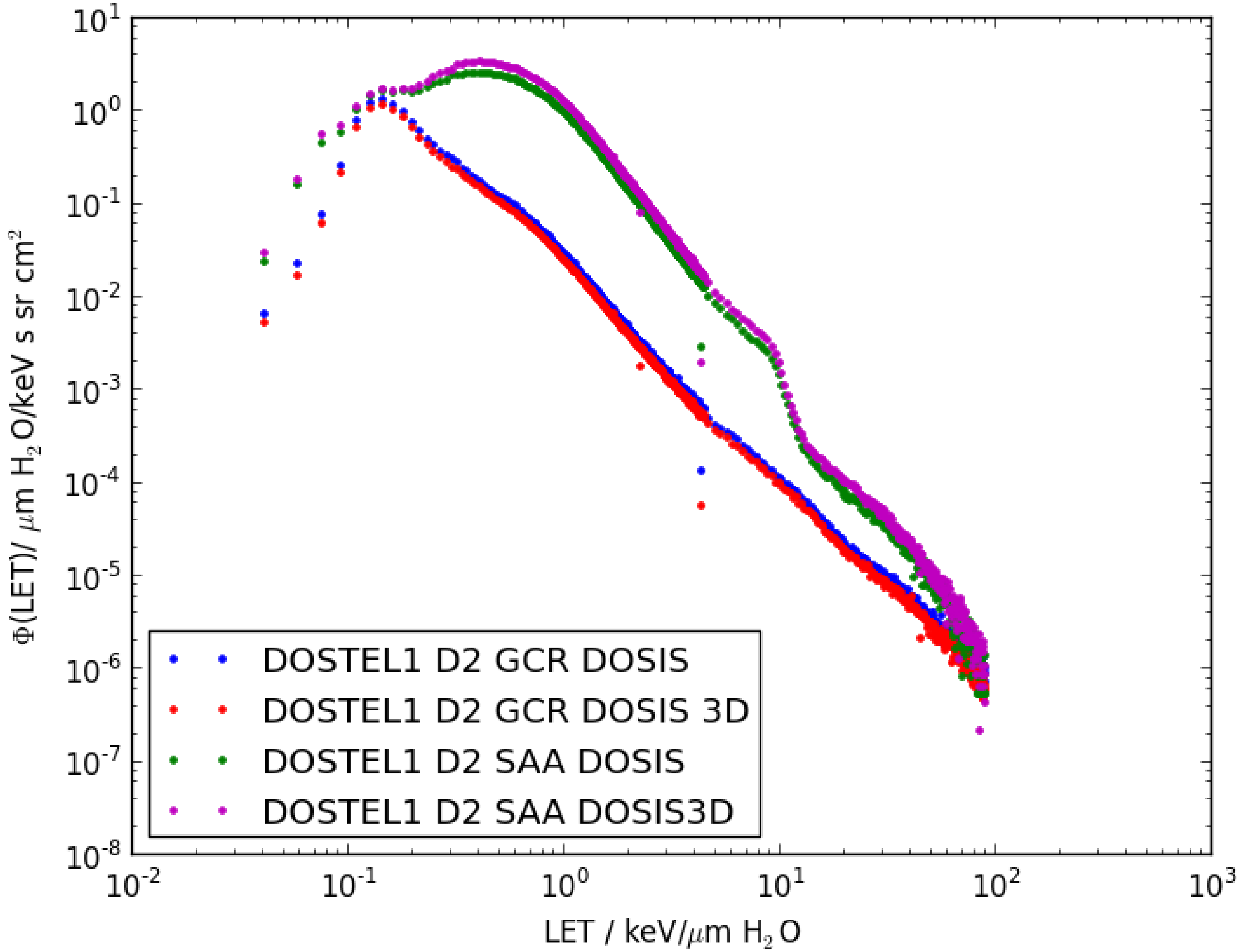


LET Spectra DOSTEL-1 Detector 2



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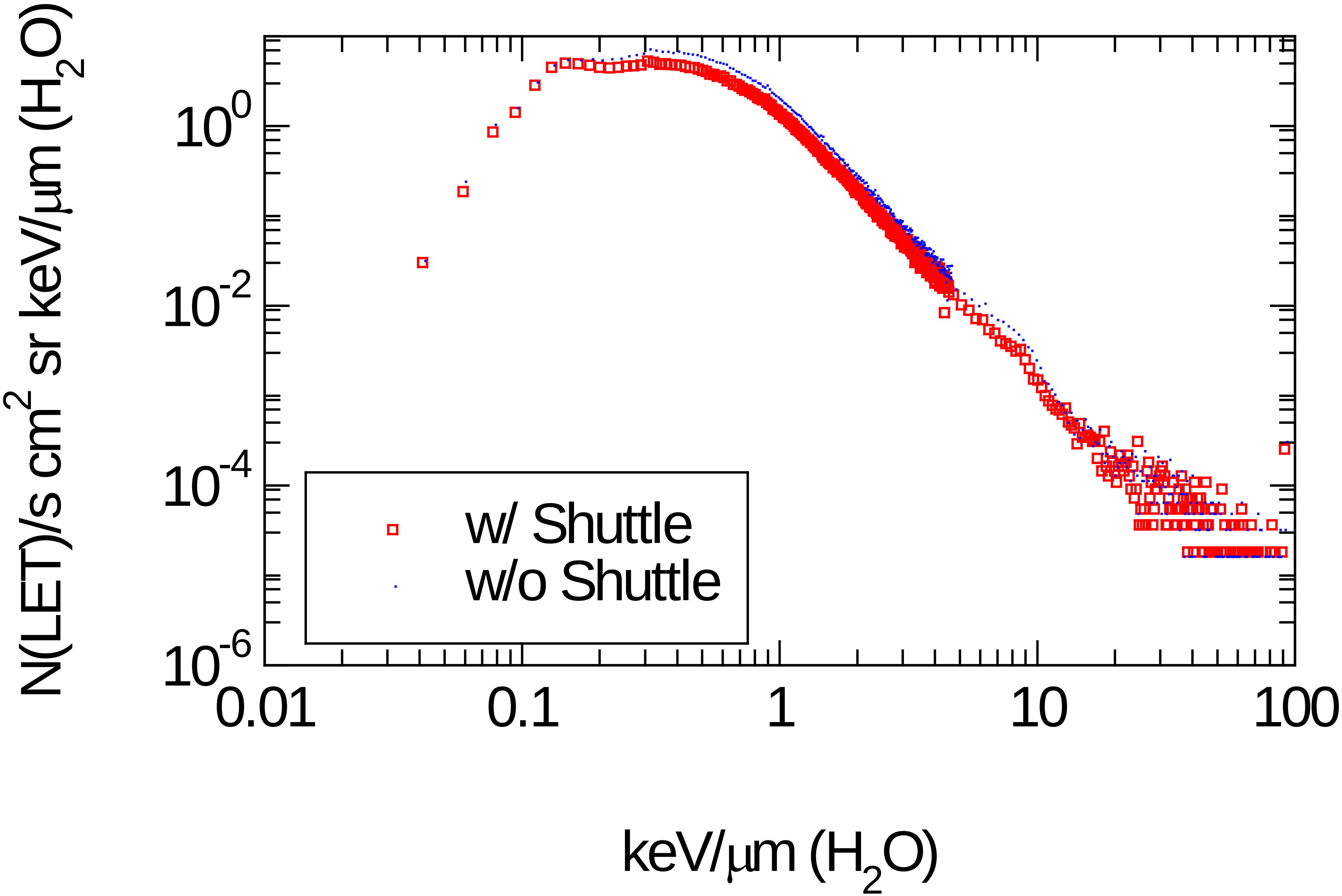
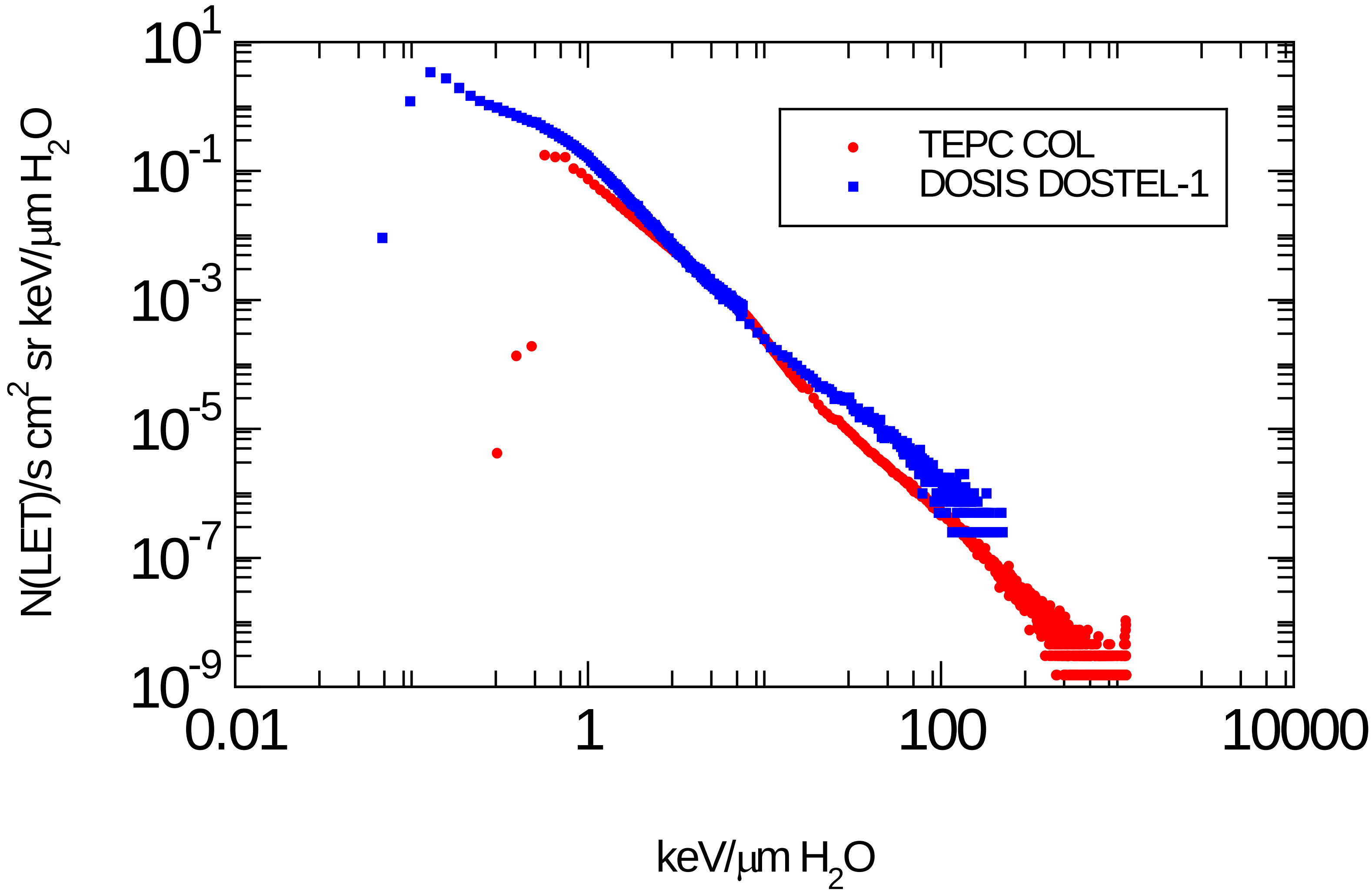
SAA LET Spectra



Combined LET spectra



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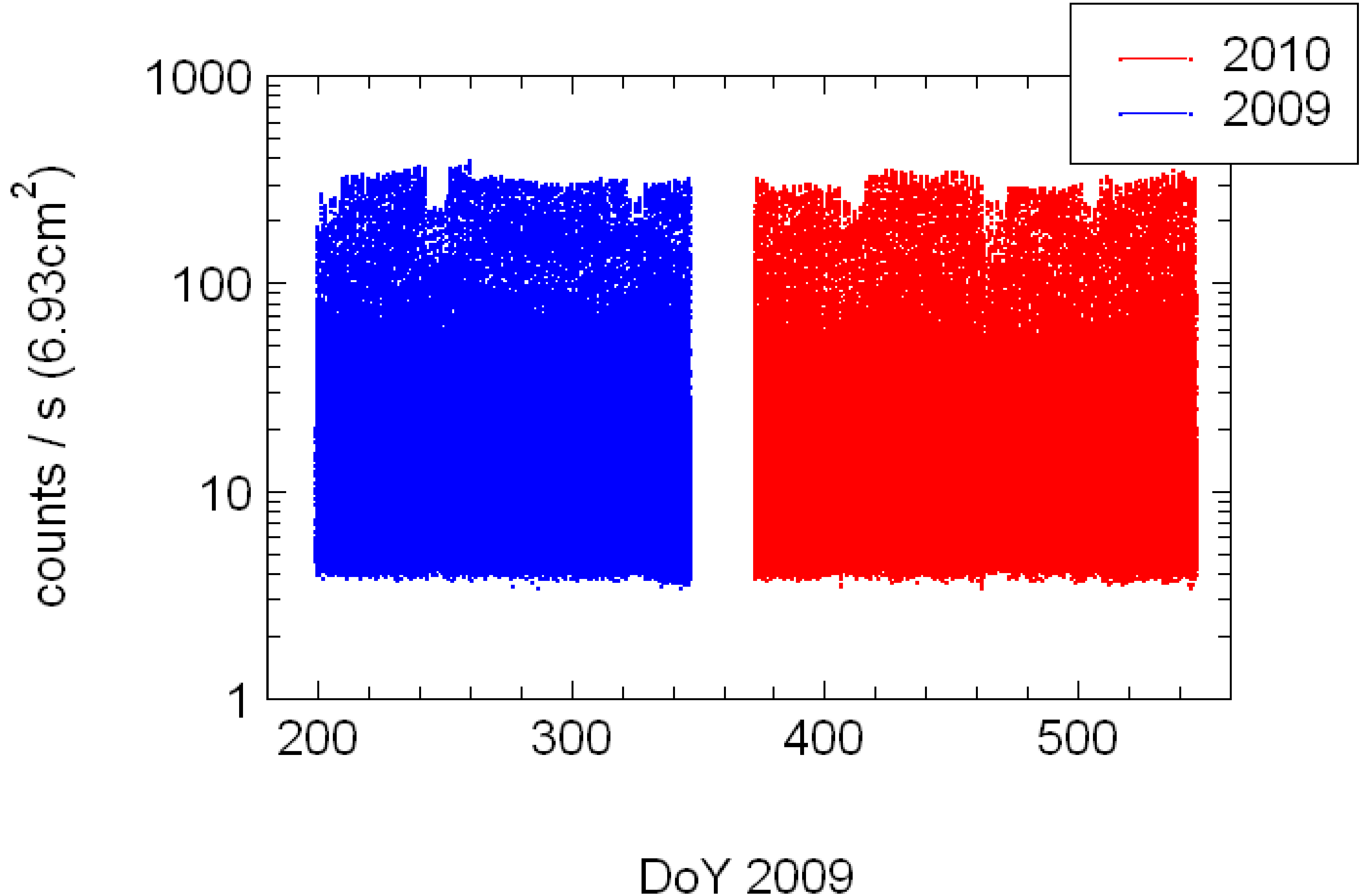
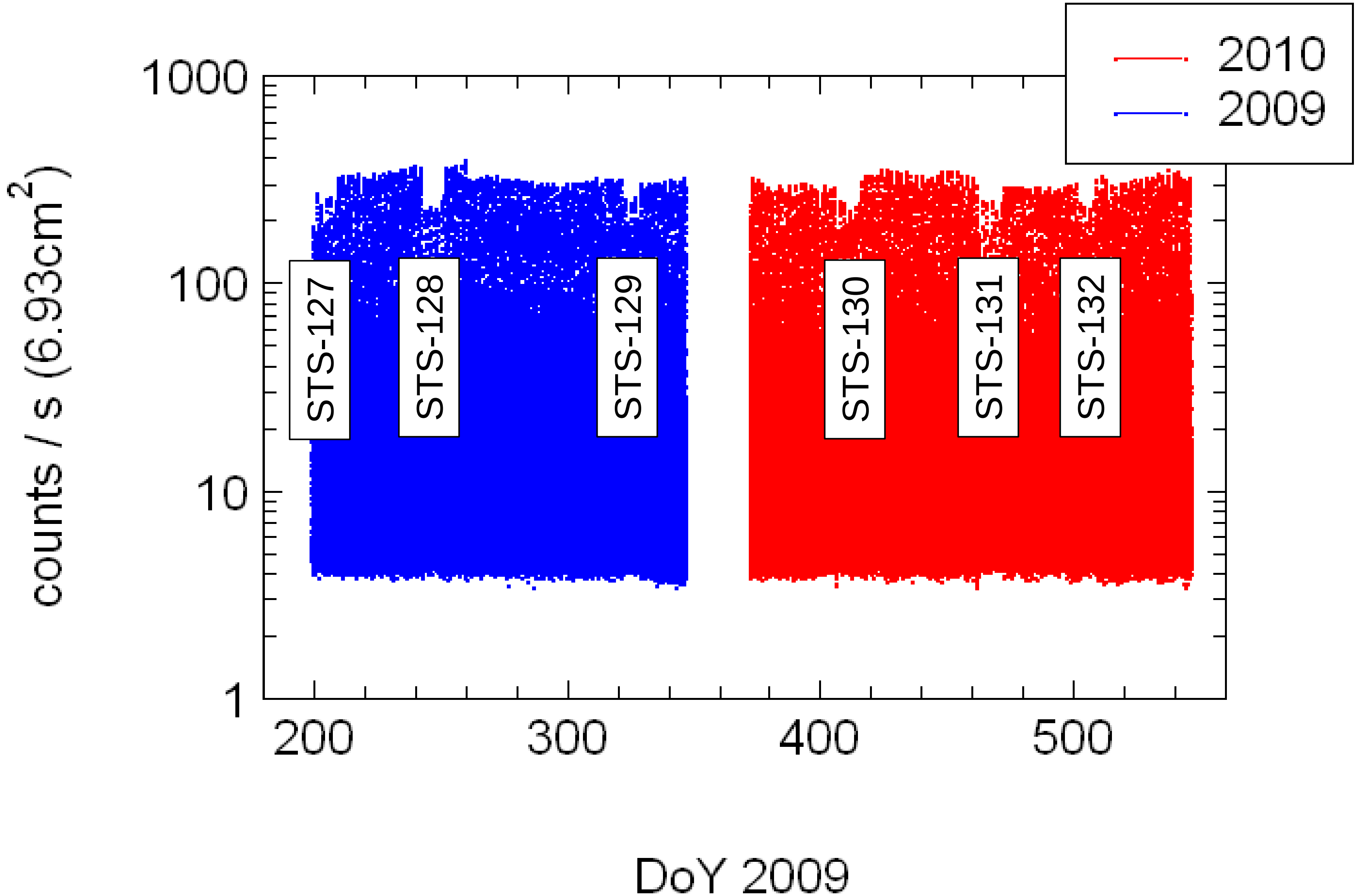
DOSTEL-2 Count Rate Profile



DOSTEL-2 Count Rate Profile



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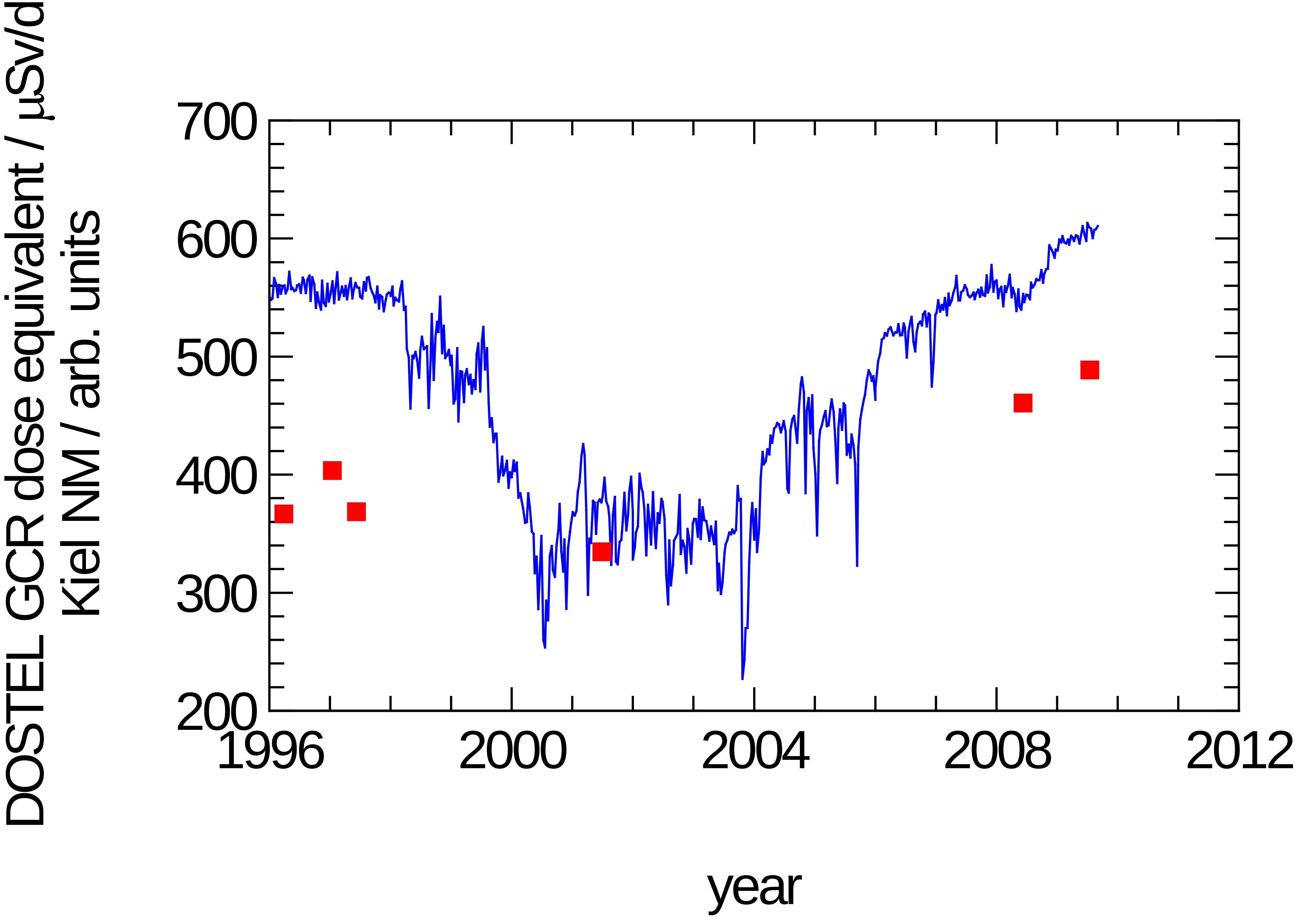
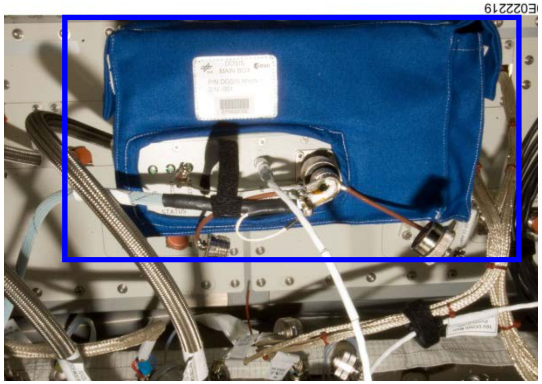


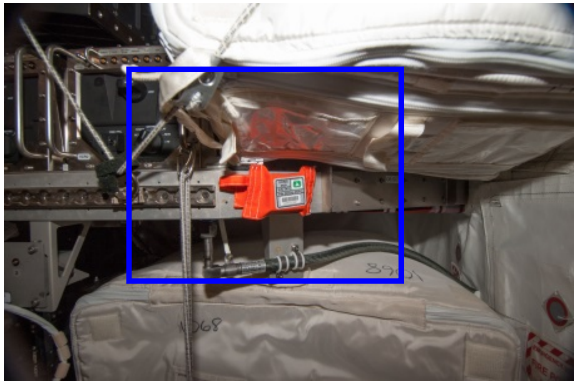
DOSIS & DOSIS 3D: Scientific Goals

The main objective of the **DOSIS & DOSIS 3D** experiment is the determination of the absorbed dose and dose equivalent using a variety of active and passive radiation detector devices distributed throughout the ISS.

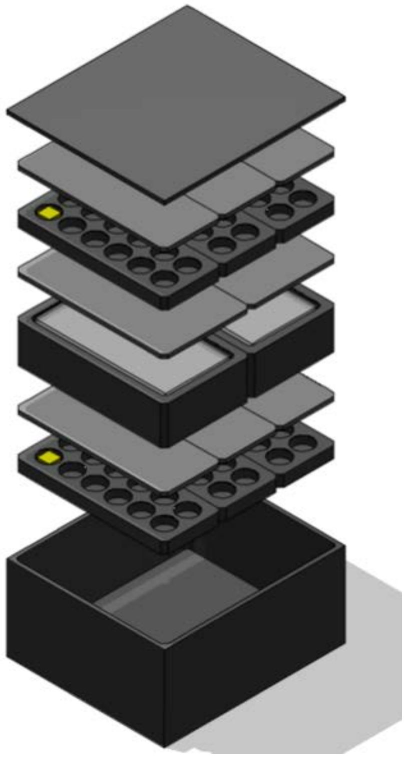
- Monitor the radiation environment inside Columbus with **active** and **passive** radiation detectors (ESA) for the determination of the temporal and spatial dose distribution

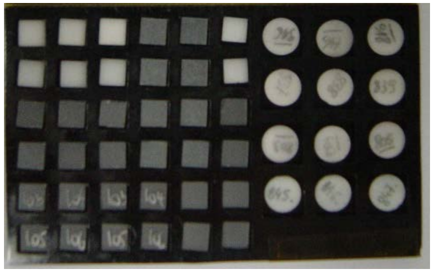
- Combine data gathered by NASA, JAXA, IMBP and ESA into a 3D radiation map of the International Space Station





DOSIS & DOSIS 3D : Passive Detector Packages (PDP)



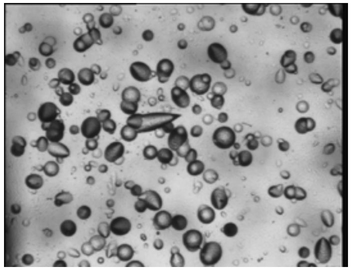


Thermoluminescence detectors (TLD)

First usage of LiF (Lithiumfluoride) for the measurement of radiation following an atomic weapon test

Measurement of internal radiation dose received by cancer patients treated with radioactiv isotopes at Oak Ridge Institute for Nuclear Studies

F. Daniels *Science* **117**, 343, **1953**



Nuclear Track Etch Detectors (CR-39)

Material : CR-39 = allyl diglycol carbonate

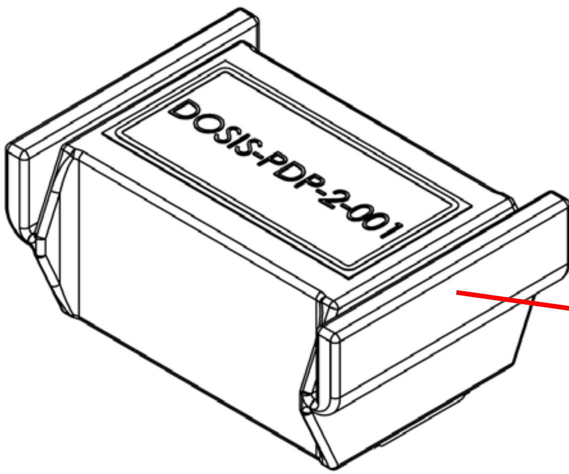
Heavy charged particles break chemical bonds in the material.This trail can be made visible by etching the material.

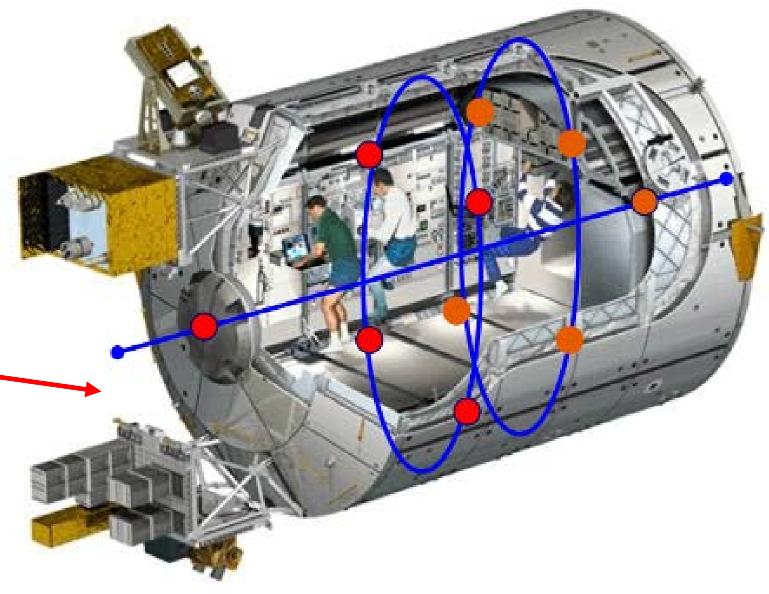
R. P. Henke and E. V. Benton, Nucl.Instr.Meth. 97 (**1971**) 483-9

The combination of passive thermoluminescence detectors and nuclear track etch detectors allows to determine the absorbed dose (in Gray) and the dose equivalent (in Sievert).

DOSIS Passive Detectors

11 passive radiation detector packages (PDP) distributed within Columbus





DOSIS Passive Detector Packages (PDP)

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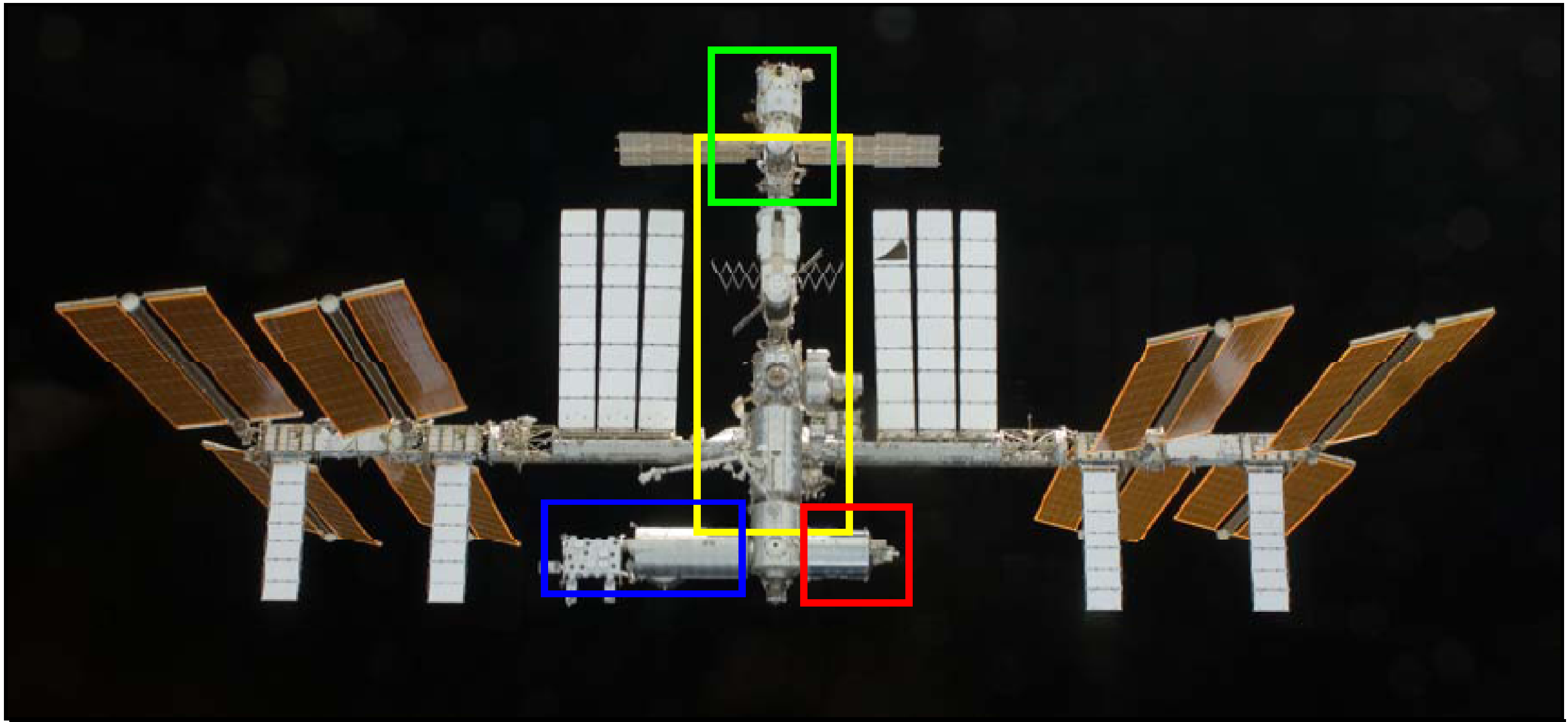
DOSIS / DOSIS 3D



Agency	*Name of the detectors*	*Quantity*	*Position on ISS*
ESA	PDP	10 + 1	Columbus (red rectangle)
NASA	RAMs	24	All over the ISS (yellow rectangle)
JAXA	PADLES	12	KIBO (blue rectangle)
IBMP	SPD	6	Russian part of the ISS (green rectangle)
	Pille	10	

Fig. 3: Passive detectors on the ISS. The RAMs, PADLES, SPD and Pille detectors are permanently on board of the ISS. The PDPs from ESA are not. To reach the scientific goals set by Dosis 3D the PDPs shall be re-introduced on Columbus.