The DOSIS and DOSIS 3D Experiments onboard the International Space Station – Results From the Active DOSTEL Instruments

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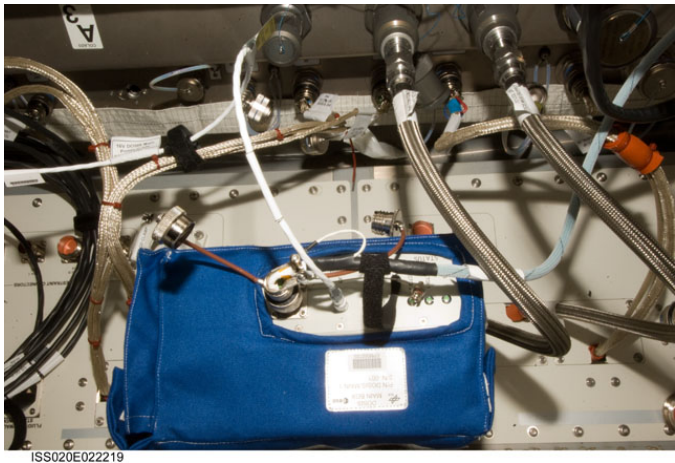
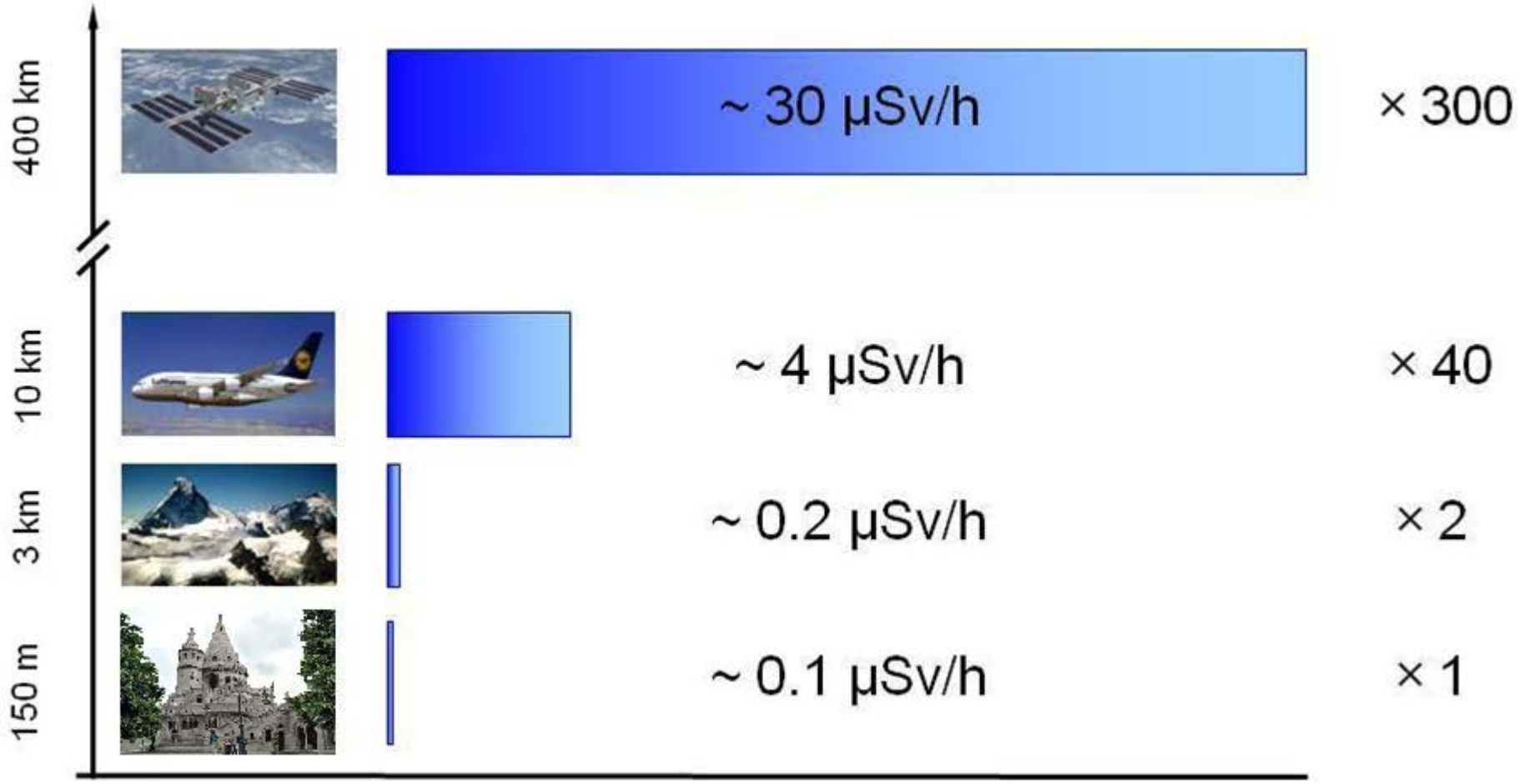
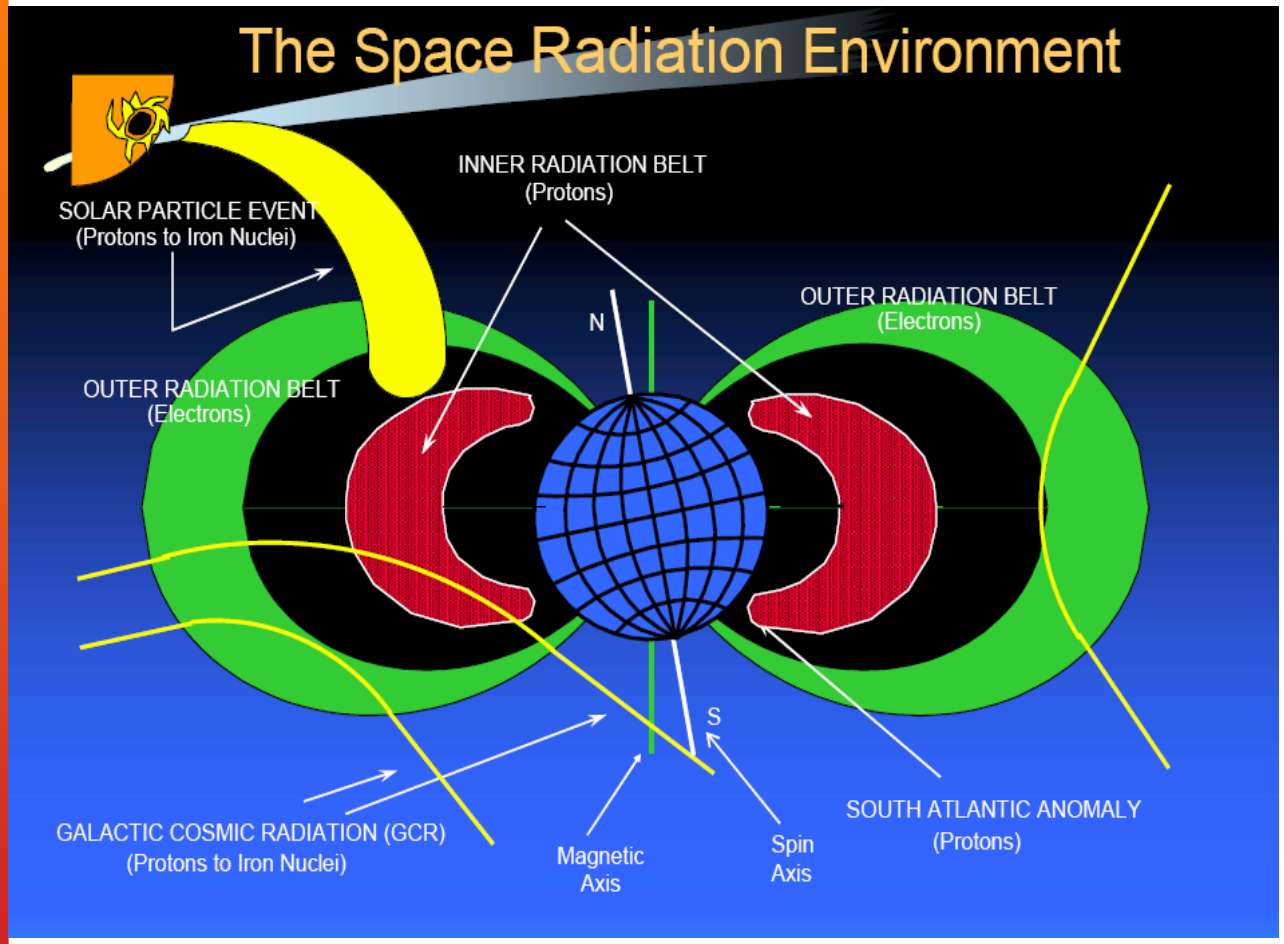


ISS020E022219

Radiation Exposure



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

DOSIS : Dose Distribution Inside the ISS

Measurement of the radiation environment inside the European Columbus Laboratory onboard the ISS

ESA Proposal #ILSRA-2004-167

- 2 active radiation detectors (DOSTEL)
- 11 passive radiation detector packages (PDP) distributed within Columbus

➔ July 2009 to June 2011

Reference Document:
SCI-ESA-HSF-ESR-DOSIS

DOSIS 3D - Dose Distribution Inside the ISS 3D
ESA Proposal # ILSRA-2009-0778

The main objective of the 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.

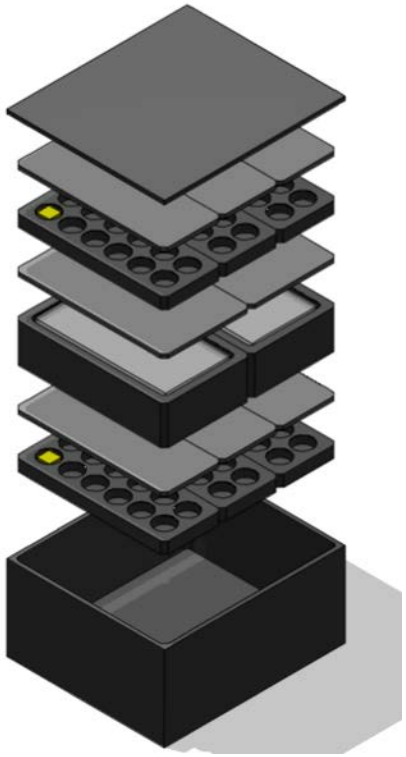
Monitor the radiation environment inside Columbus with active and passive radiation detectors (ESA) (same experiment suite as for DOSIS)

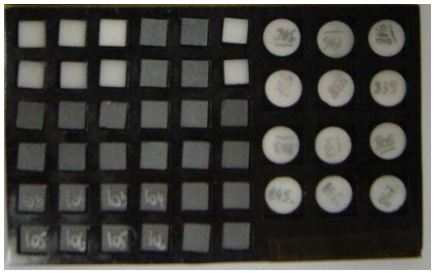
Combine data gathered by NASA; JAXA; IMBP and ESA into a 3D radiation map of the International Space Station

START: May 2012 (Soyuz 30S)
Experiment Runtime: 6 increments (up to end of 2014)

Reference Document: ESA-HSO-ESR-Dosis 3D

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



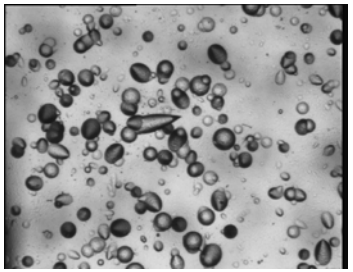


Thermoluminescence detectors (TLD)

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

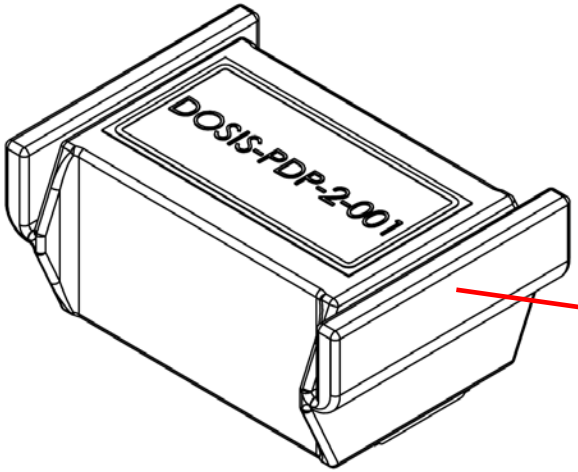
Heavy charged particles break chemical bonds in the material.This trail can be made visible by etching the material.

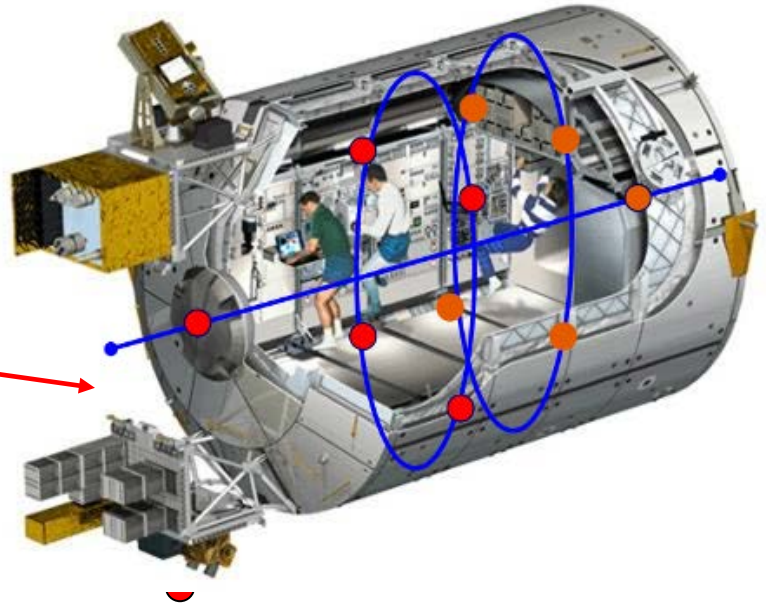
R. P. Henke and E. V. Benton, Nucl.Instr.Meth. 97 (**1971**) 483-9

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

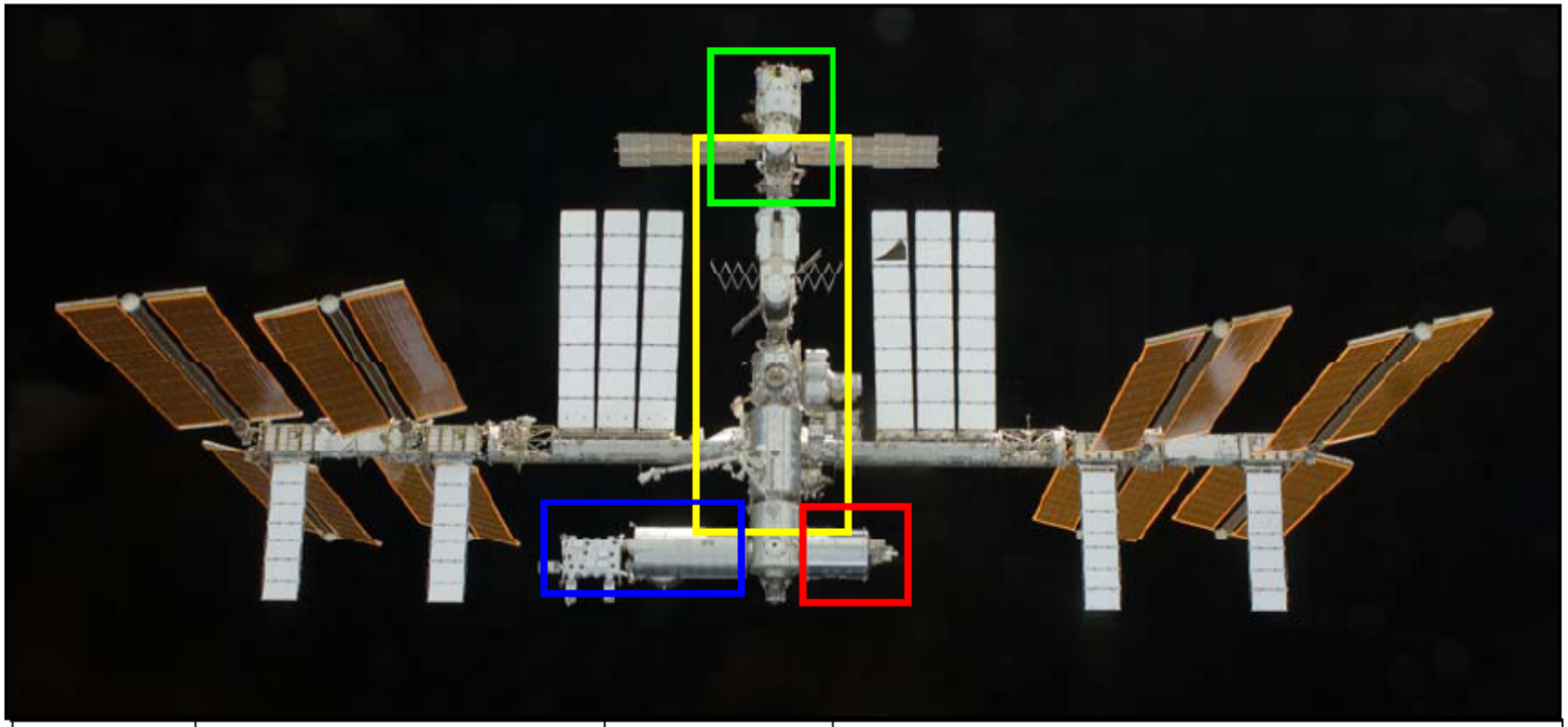
11 passive radiation detector packages (PDP) distributed within Columbus





DOSIS Passive Detector Packages (PDP)

DOSIS / DOSIS 3D

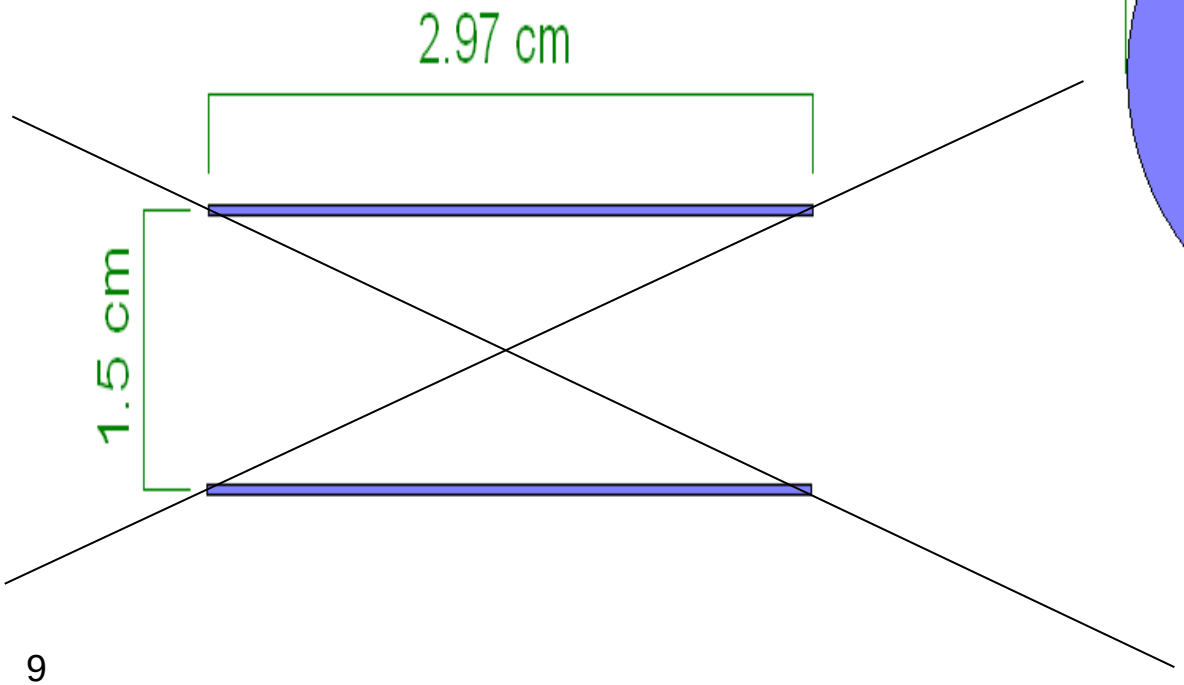


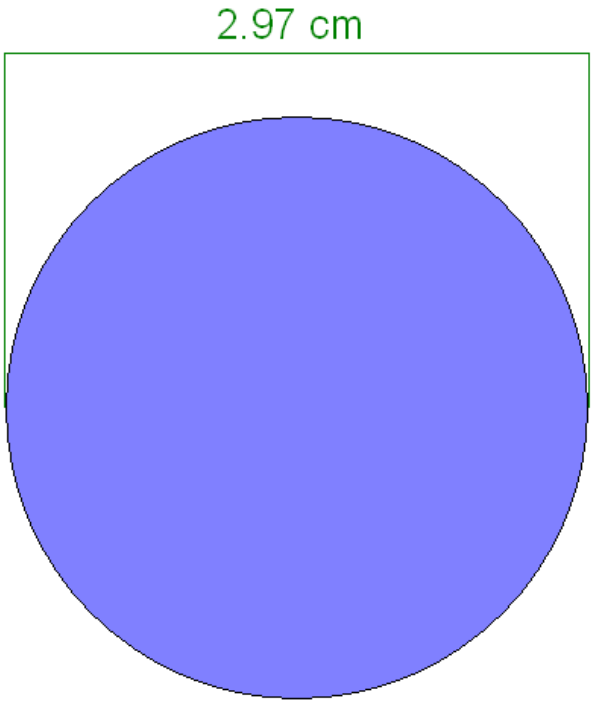
Agency	*Name of the detectors*	*Quantity*	*Position on ISS*
ESA	PDP	10 + 1	Columbus (red rectangle)
NASA	RAMs	24	All over the ISS (yellow rectangle)
JAXA	PADLES	12	KIBO (blue rectangle)
IBMP	SPD	6	Russian part of the ISS (green rectangle)
	Pille	10	

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.

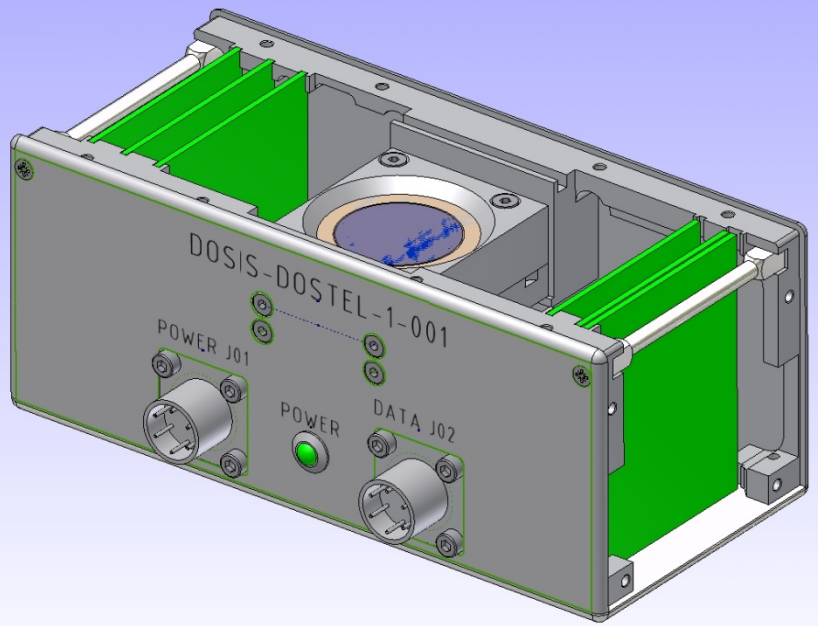
DOSTEL Detector

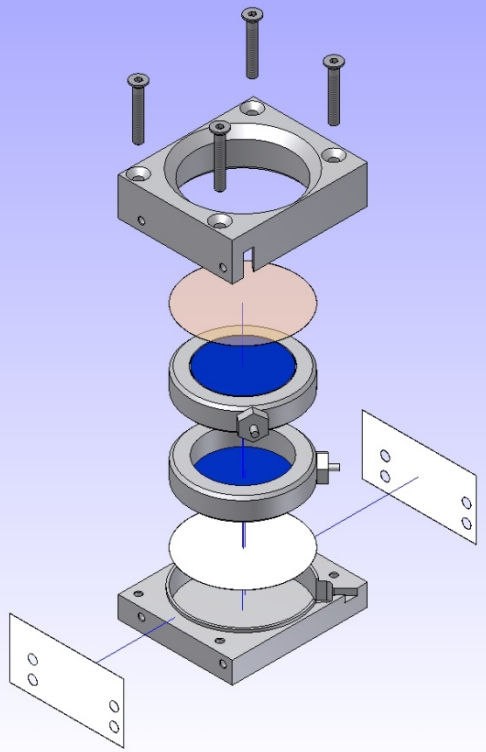
The DOSTEL Detecor Head consists two circular PIPS detectors by Canberra. These two are forming a telescope. The active area of the detectors is 6.93 cm². Mounted in a distance of 1.5cm this leads to an opening angle of 120°.





DOSTEL Detector



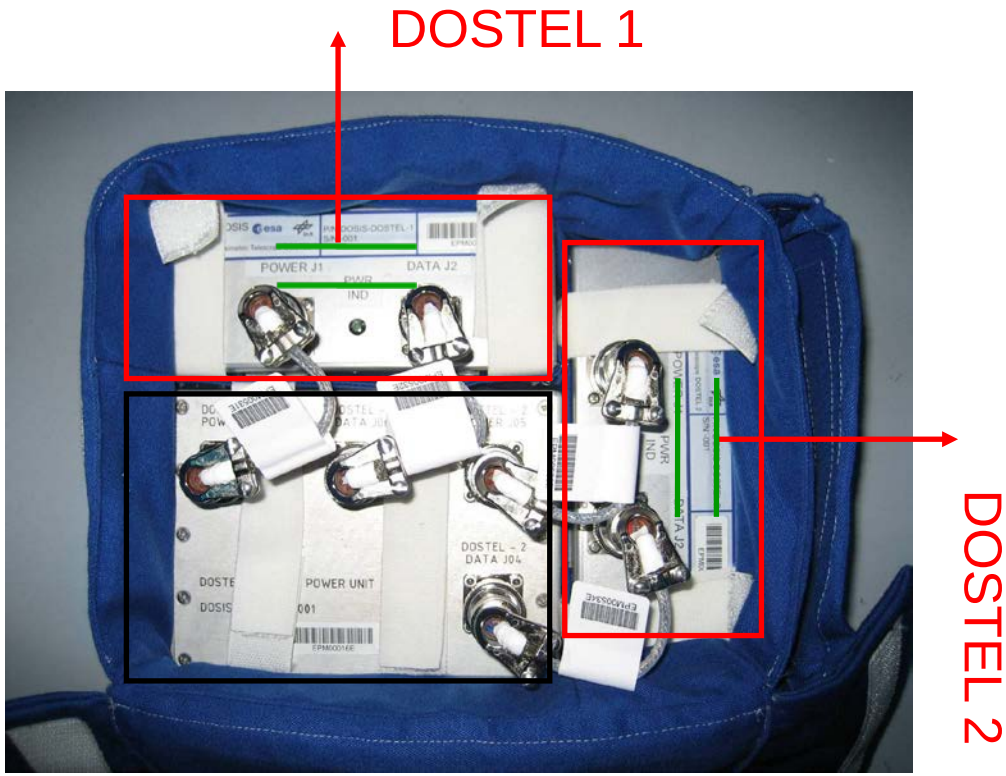


DOSIS Main Box

DOSTEL

DDPU
(DOSTEL Data and Power Unit)

DOSIS Main Box



DDPU – DOSTEL Data and Power Unit

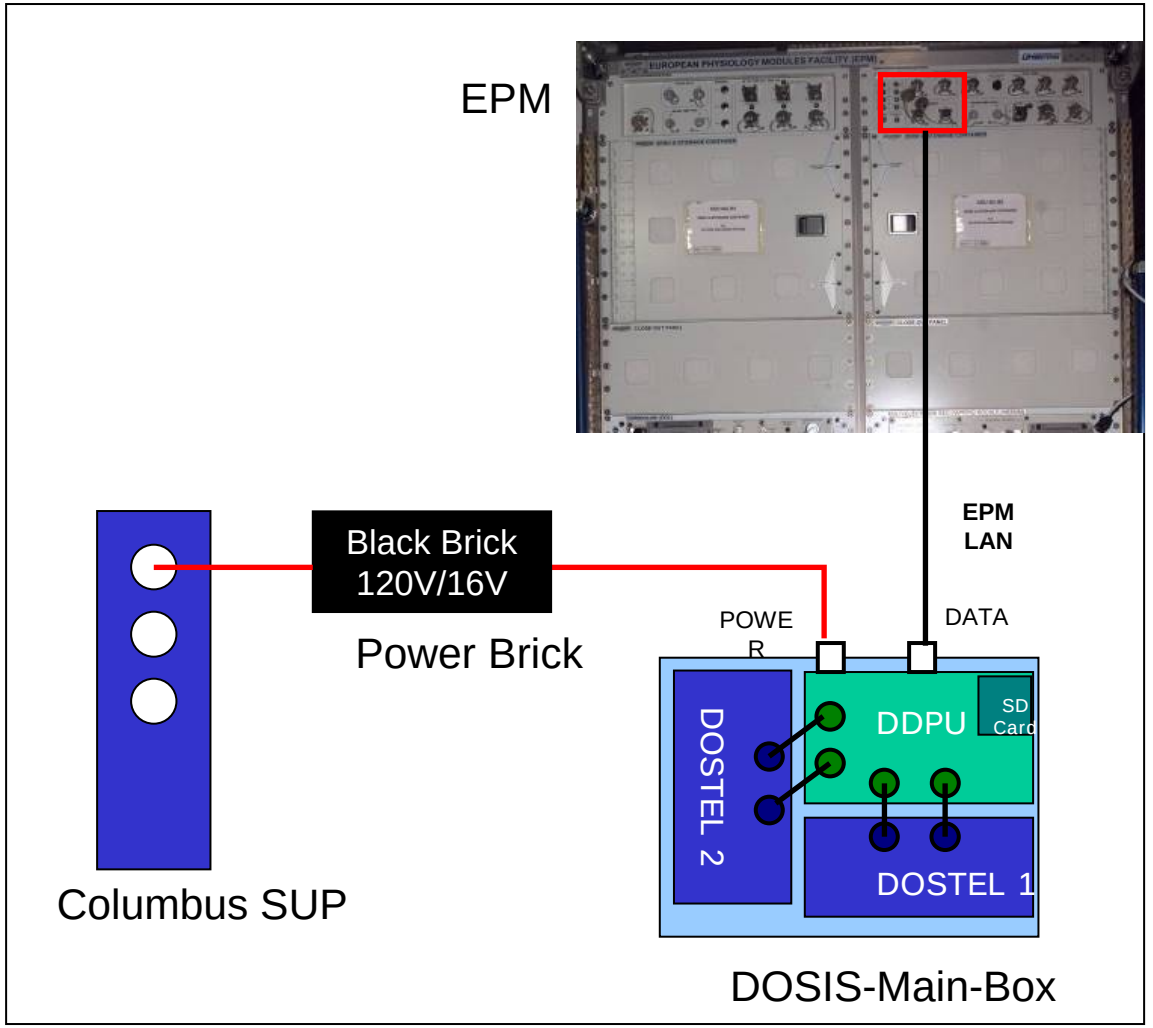
DOSTEL Data

- 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

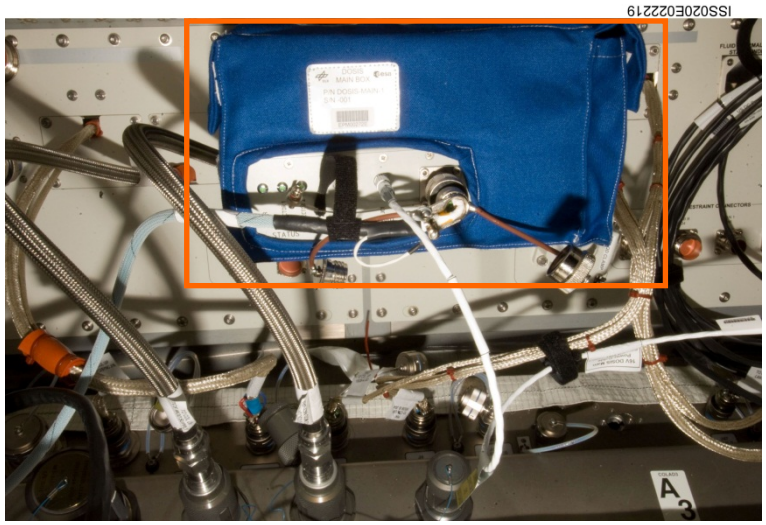
DOSIS - Launch 15.July 2009 STS-127

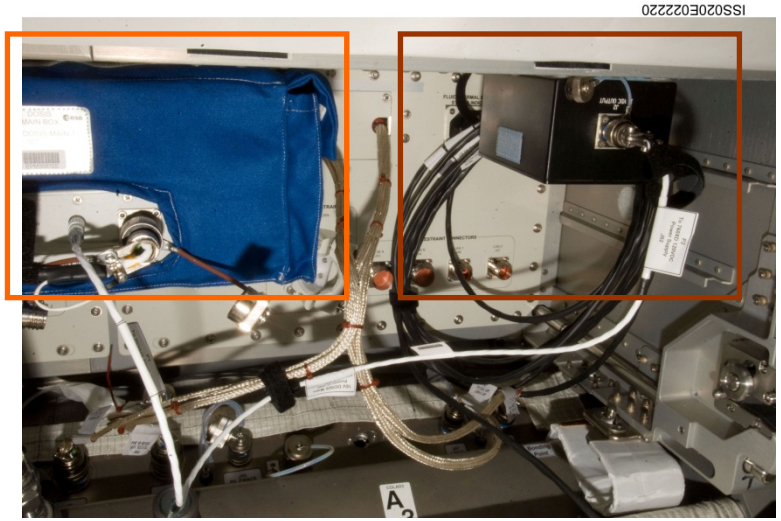
DOSIS 3D - Launch 15. May 2012 Soyuz TMA 04M / 30S

DOSIS Installation Inside COLUMBUS



DOSIS & DOSIS 3D: DOSTEL

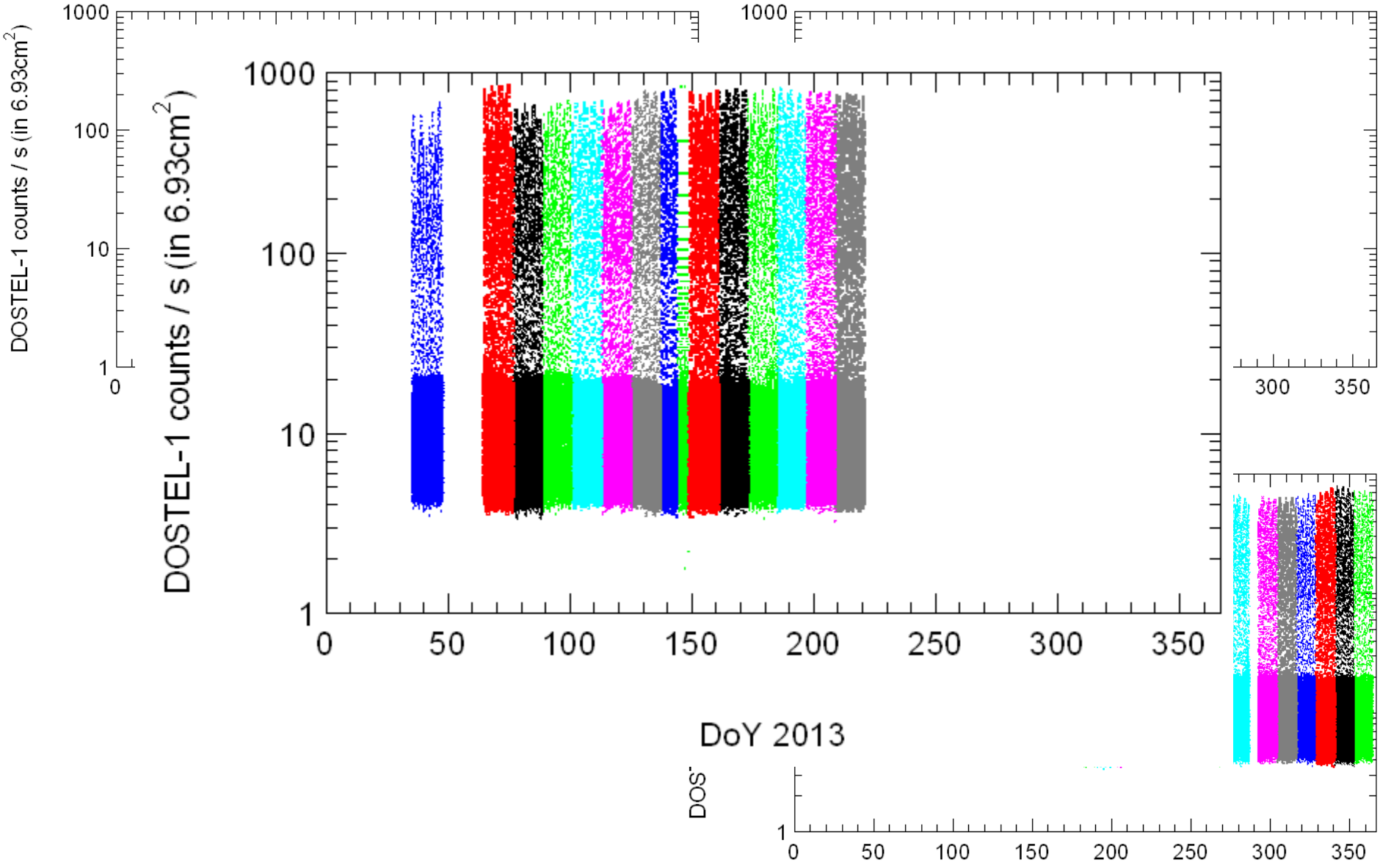




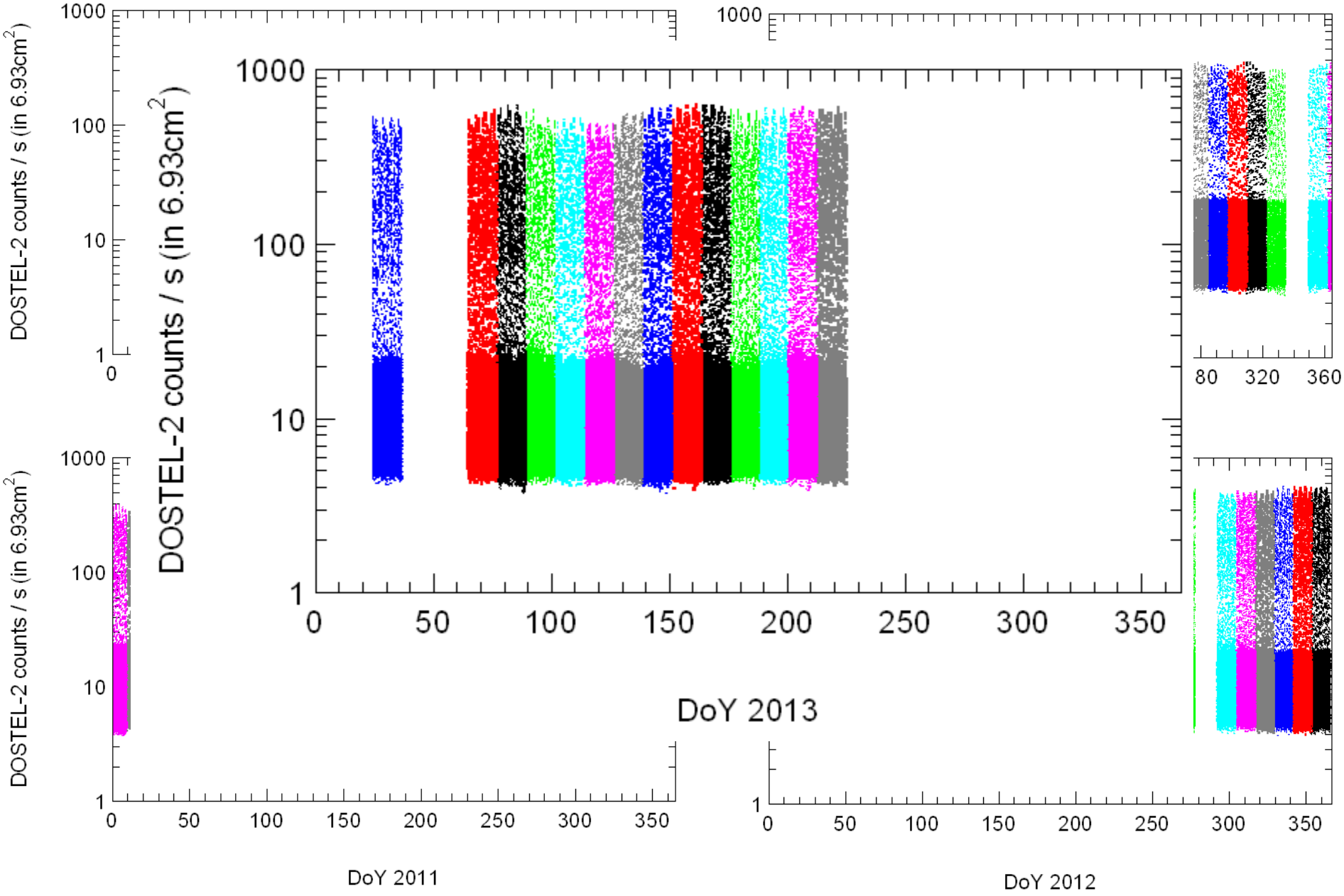
ISS020E033064

- 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

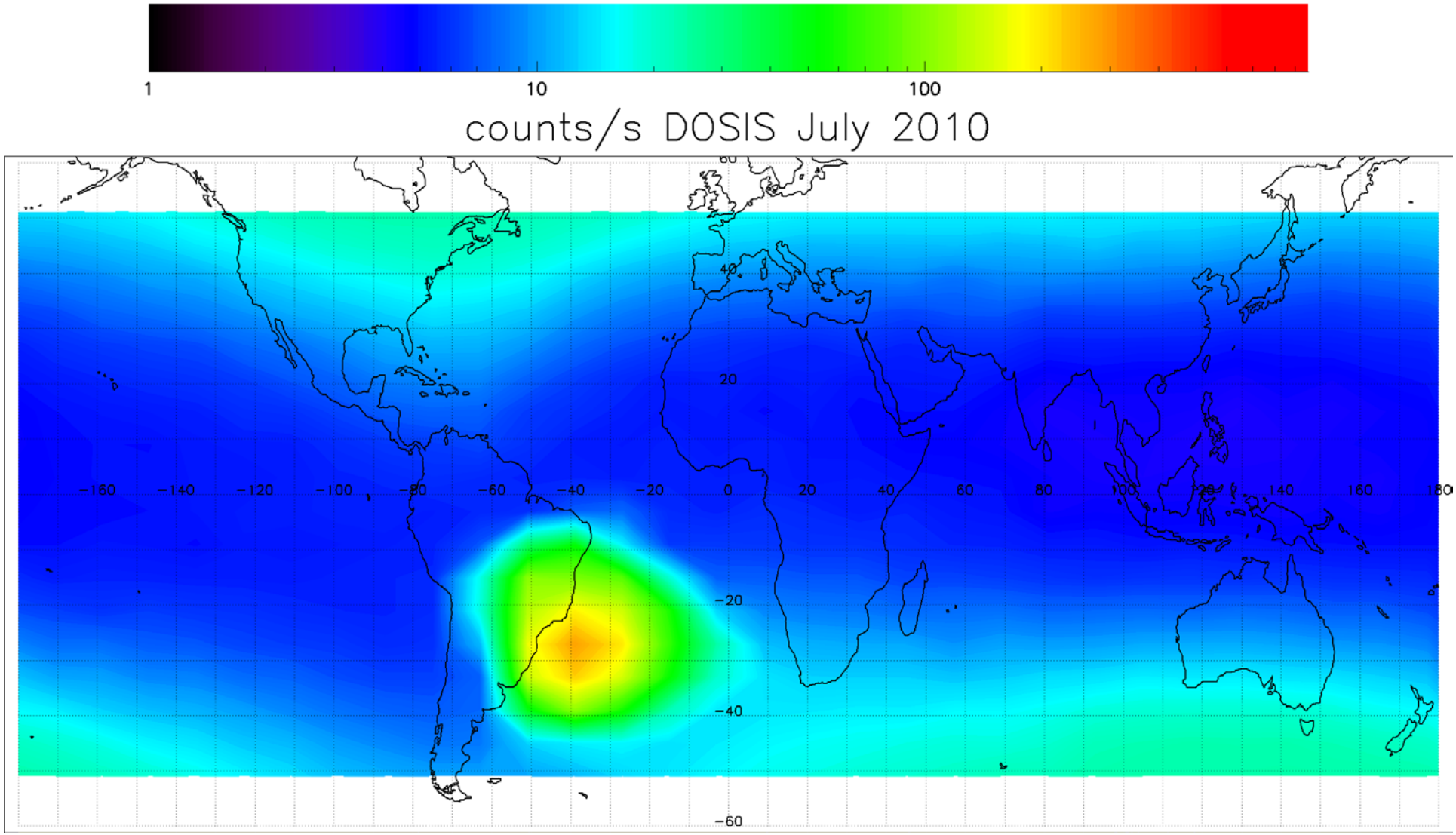
DOSIS DOSTEL-1 Count Rates

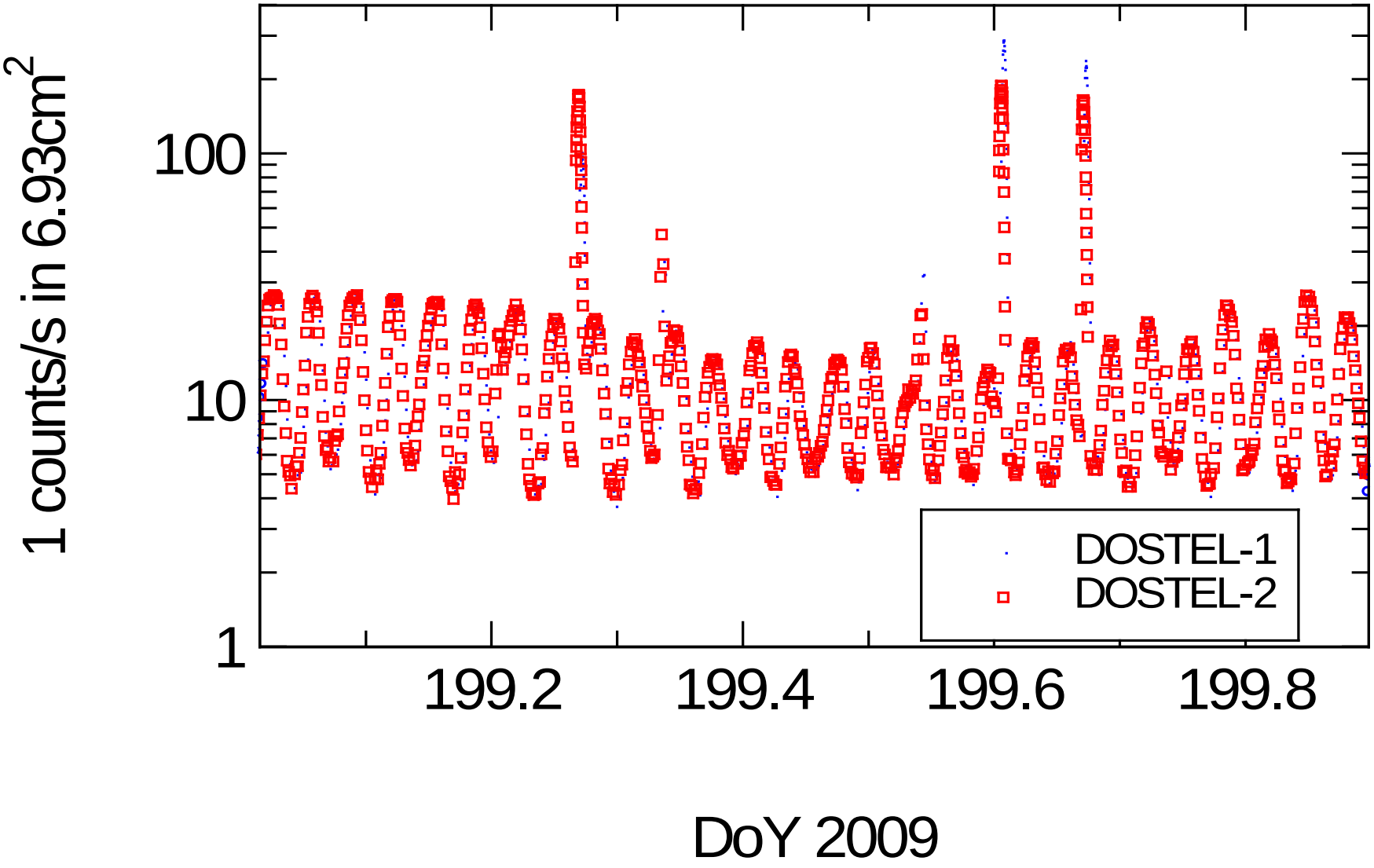


DOSIS DOSTEL-2 Count Rates

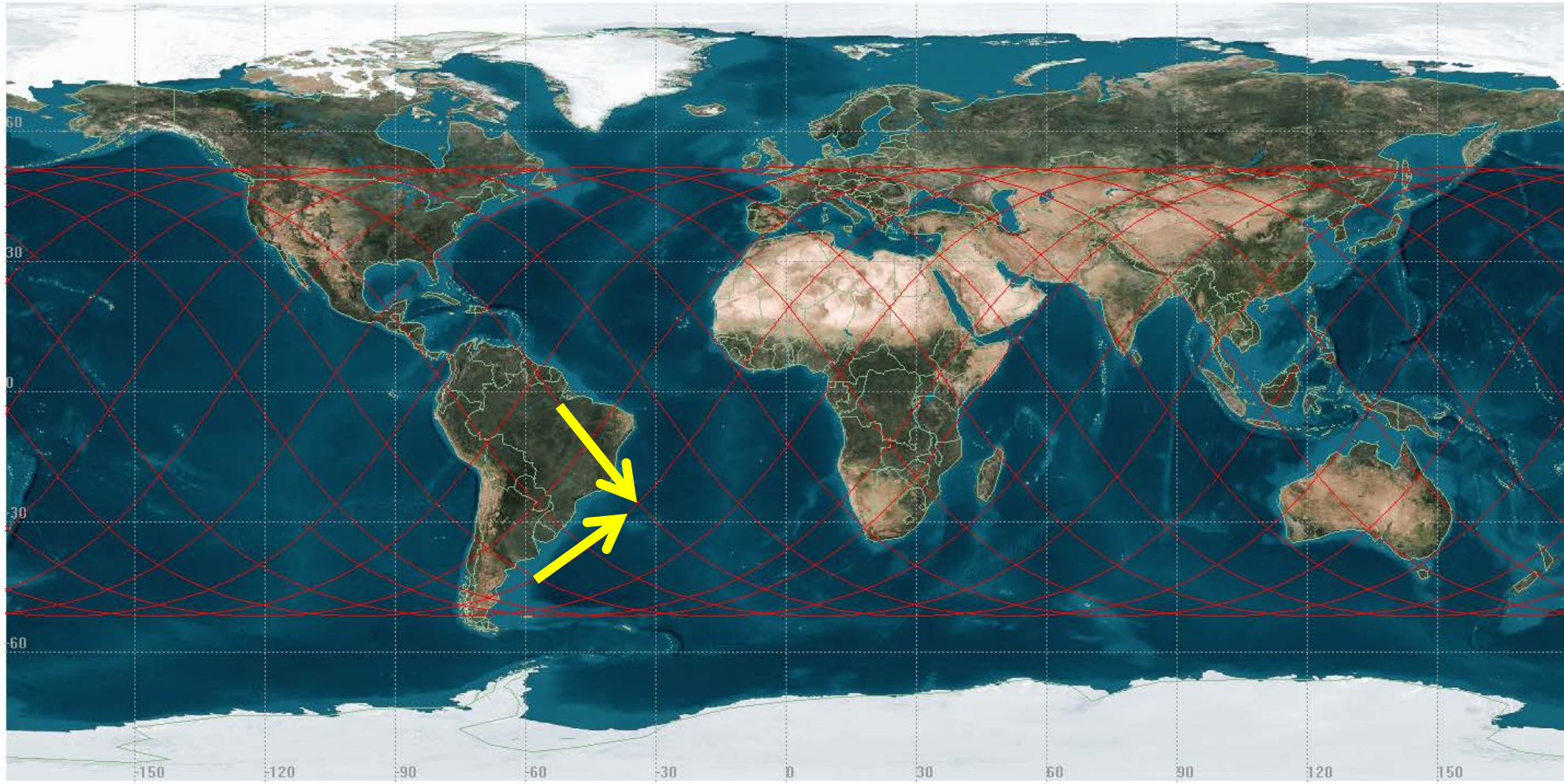


DOSIS - DOSTEL

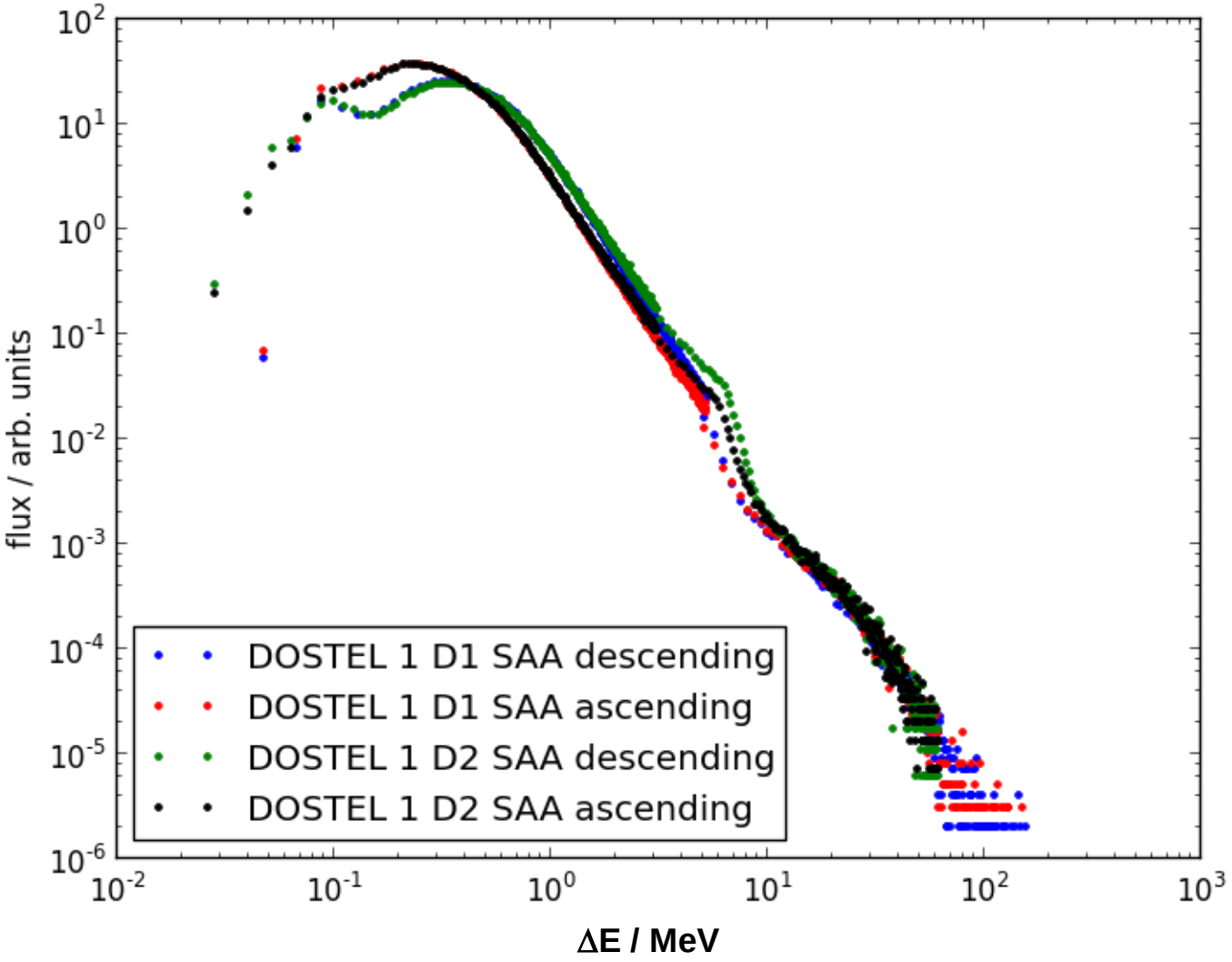



1 counts/s in 6.93cm2
100
10
1
199.2
199.4
199.6
199.8
DoY 2009
DOSTEL-1
DOSTEL-2

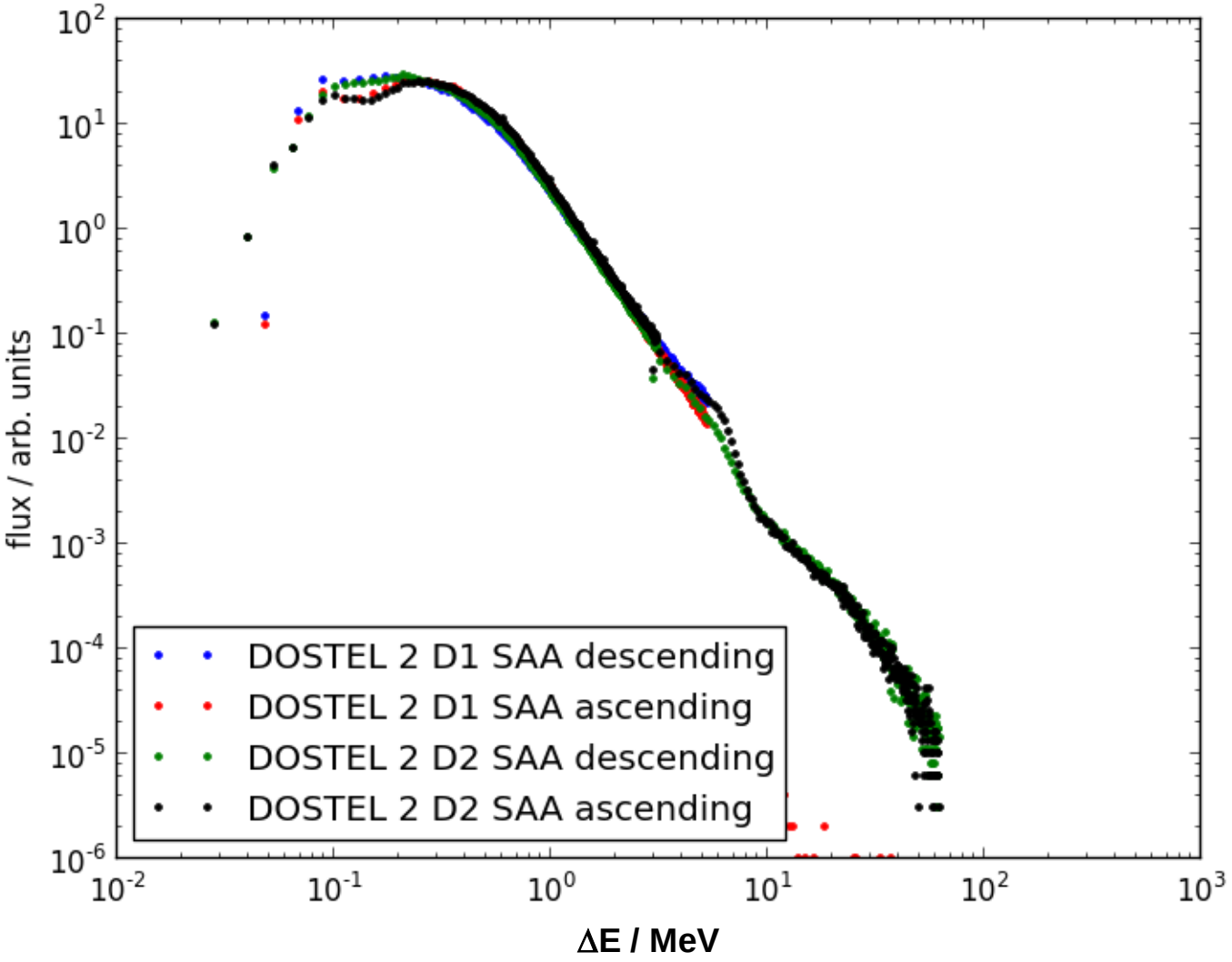
DOSIS SAA spectra



DOSIS SAA spectra



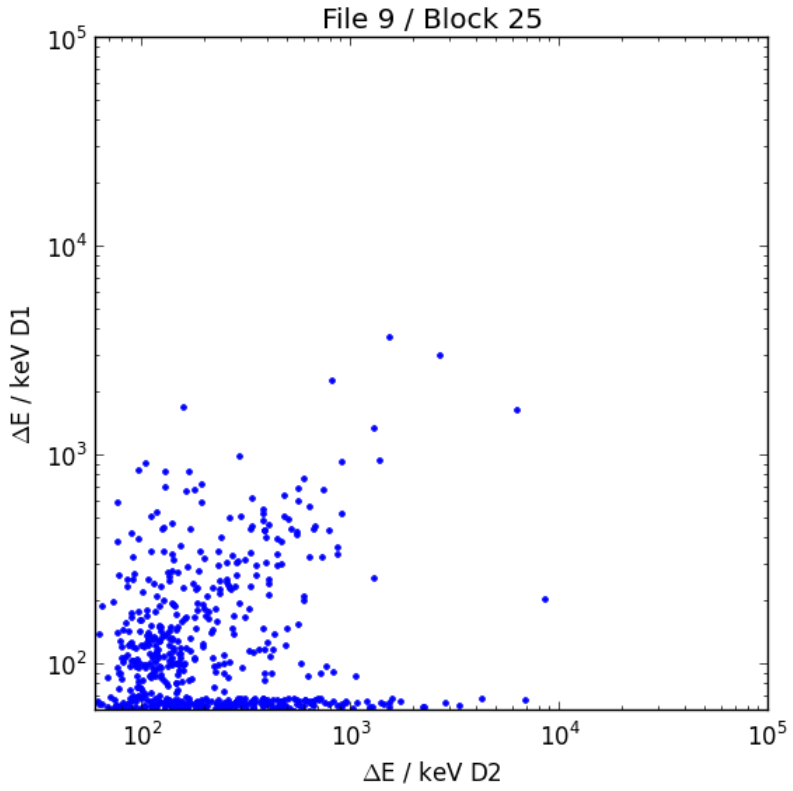
DOSIS SAA spectra

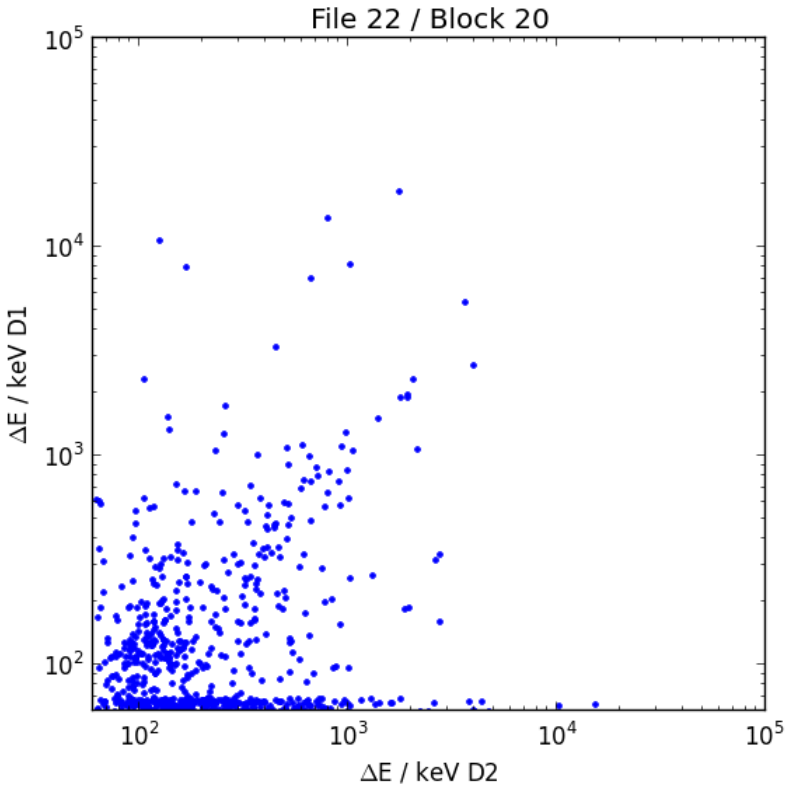


DOSIS 3D SAA Mode 2 Data

ascending

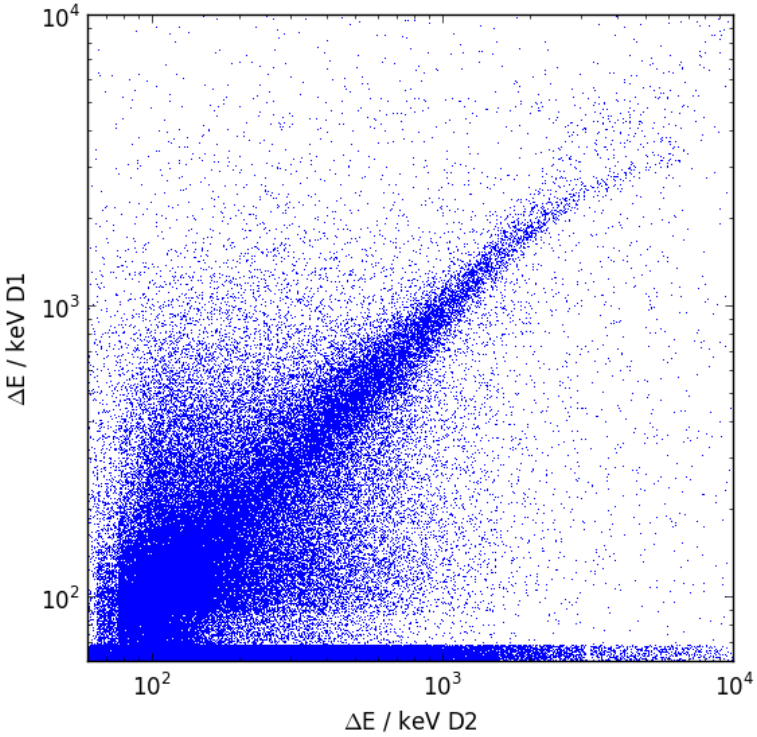
descending



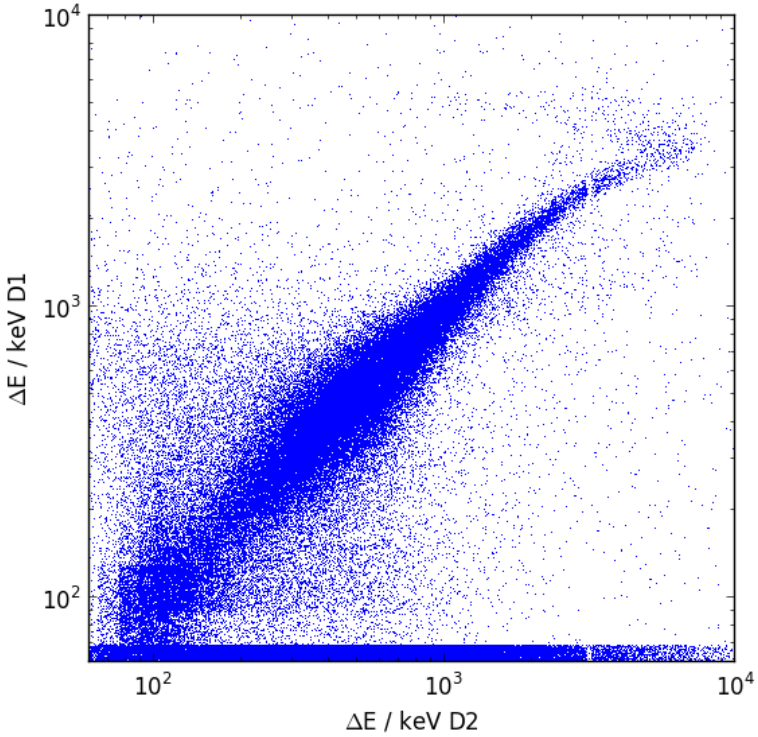


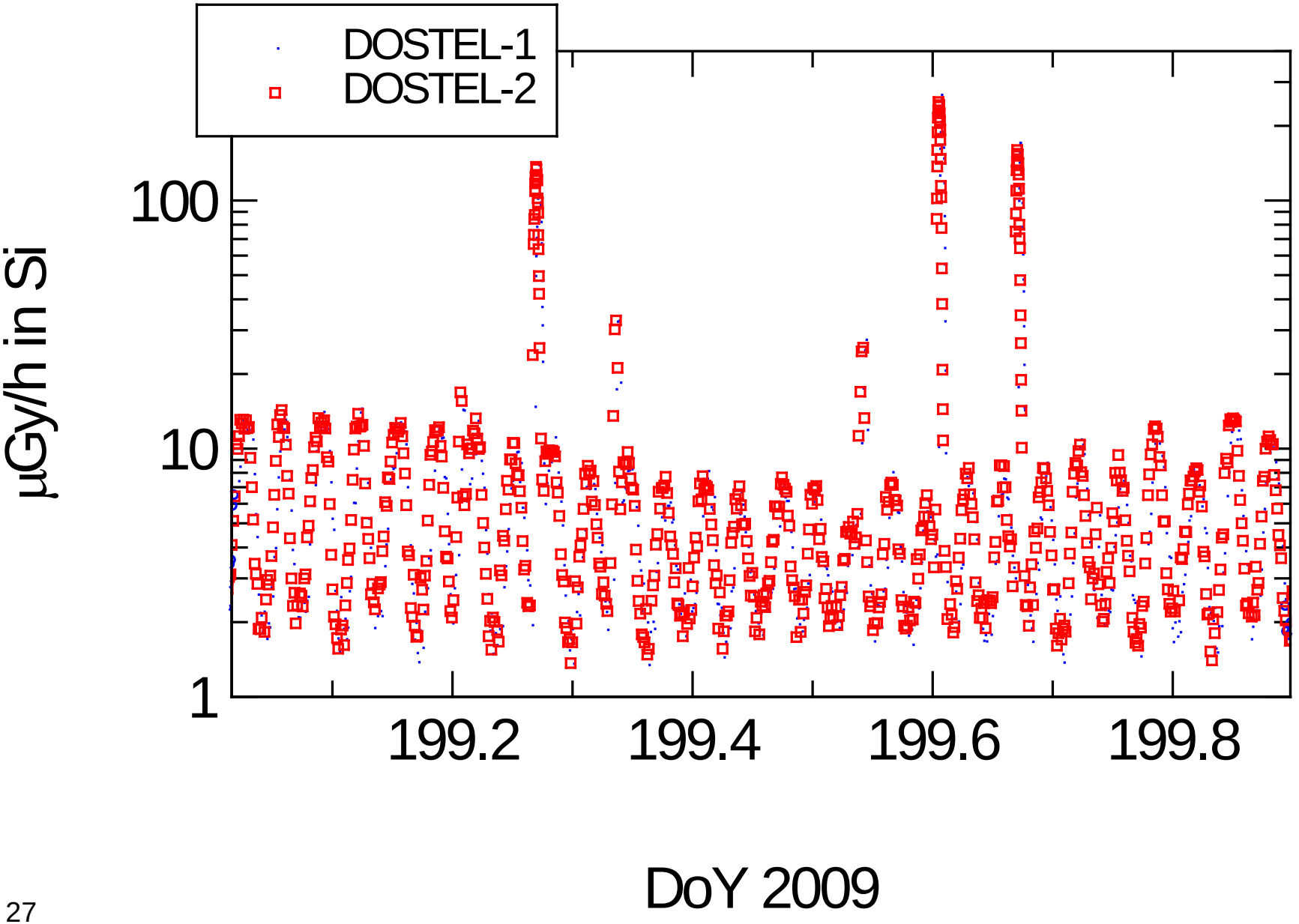
DOSIS 3D Mode 2 Data

GCR (mainly)

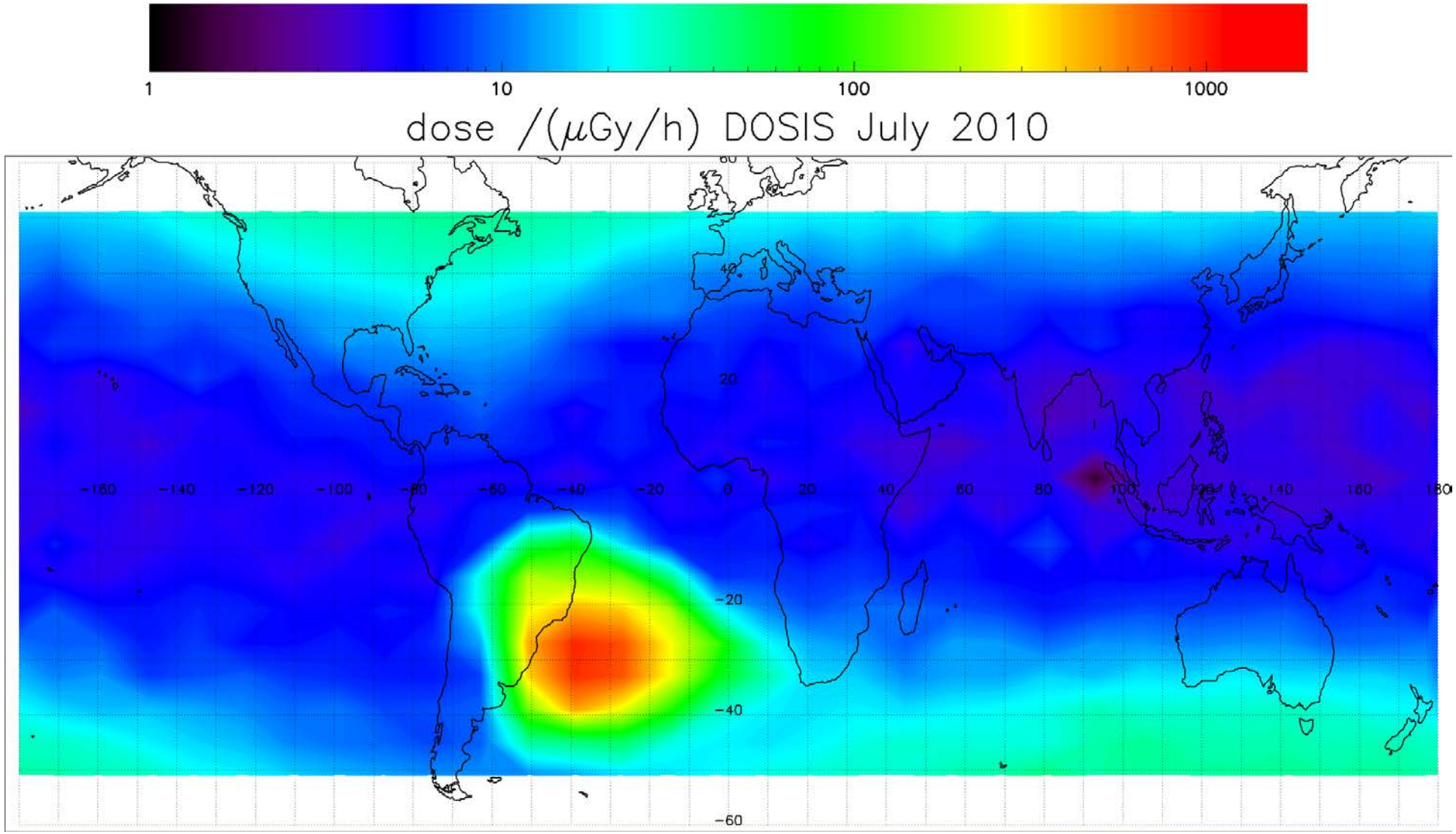


SAA (mainly)

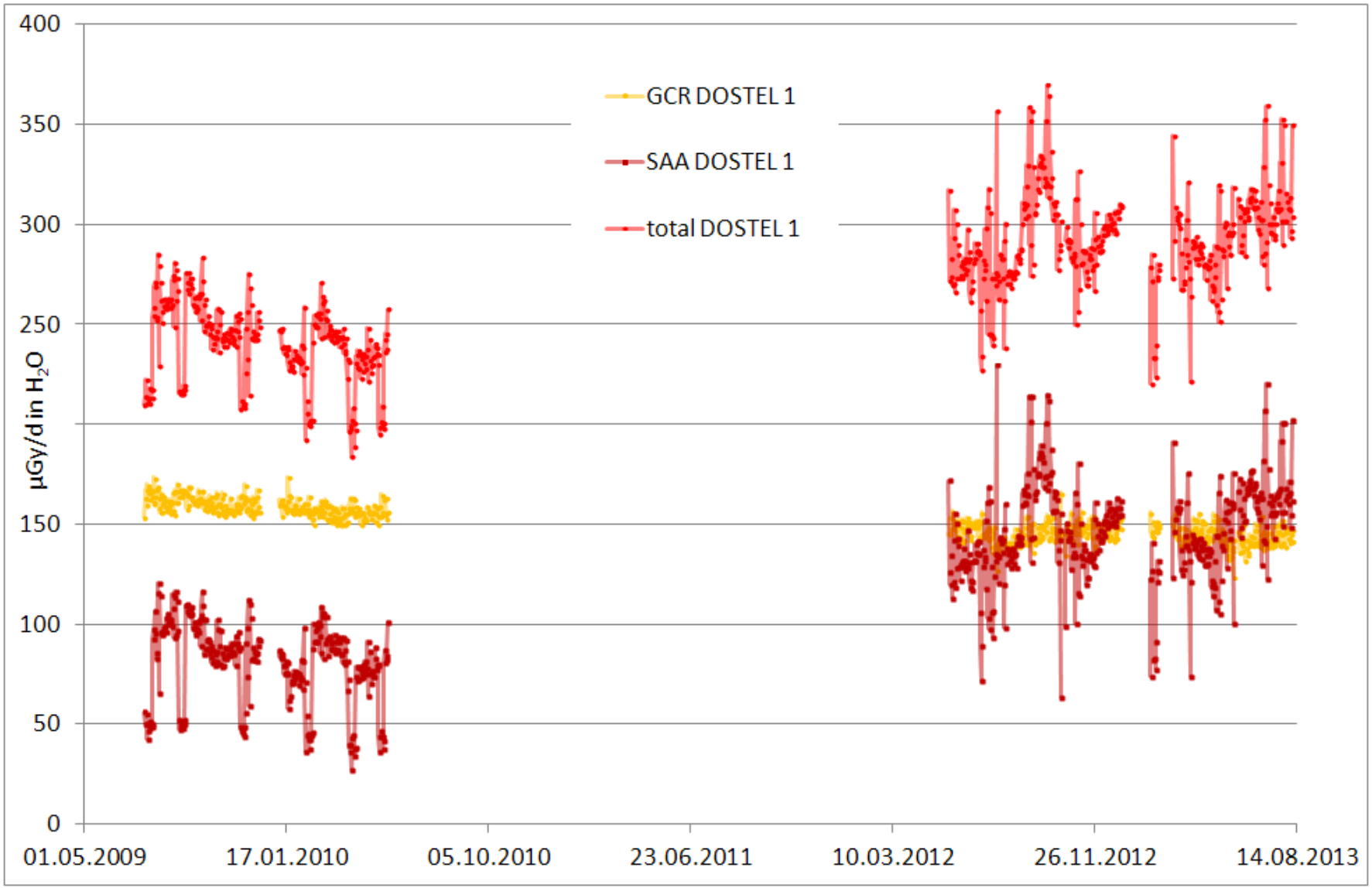



DOSTEL-1
DOSTEL-2
100
10
1
µGy/h in Si
199.2
199.4
199.6
199.8
DoY 2009

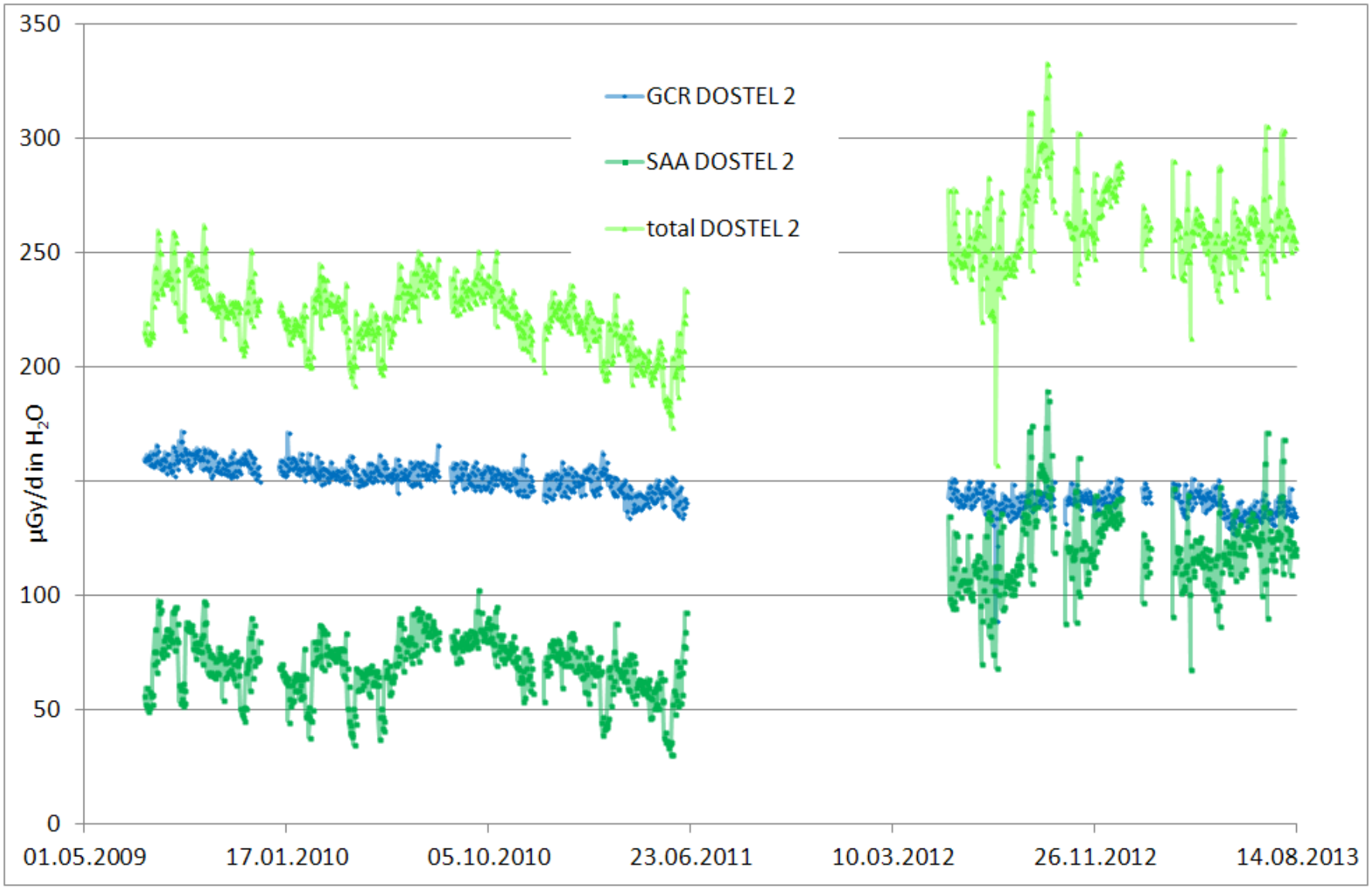
DOSIS - DOSTEL



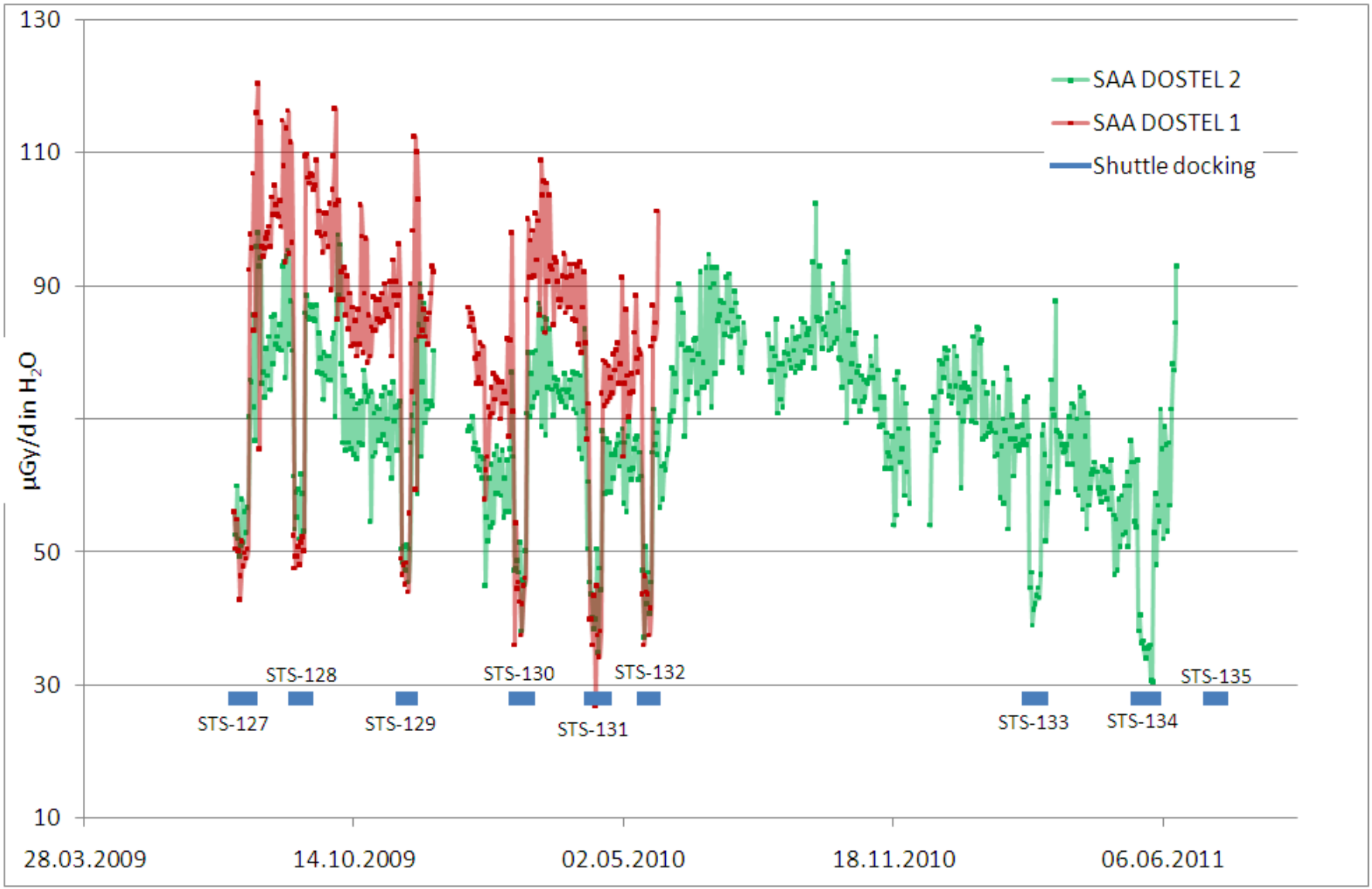
Absorbed Dose Rates DOSTEL 1



Absorbed Dose Rates DOSTEL 2



Absorbed Dose Rates SAA



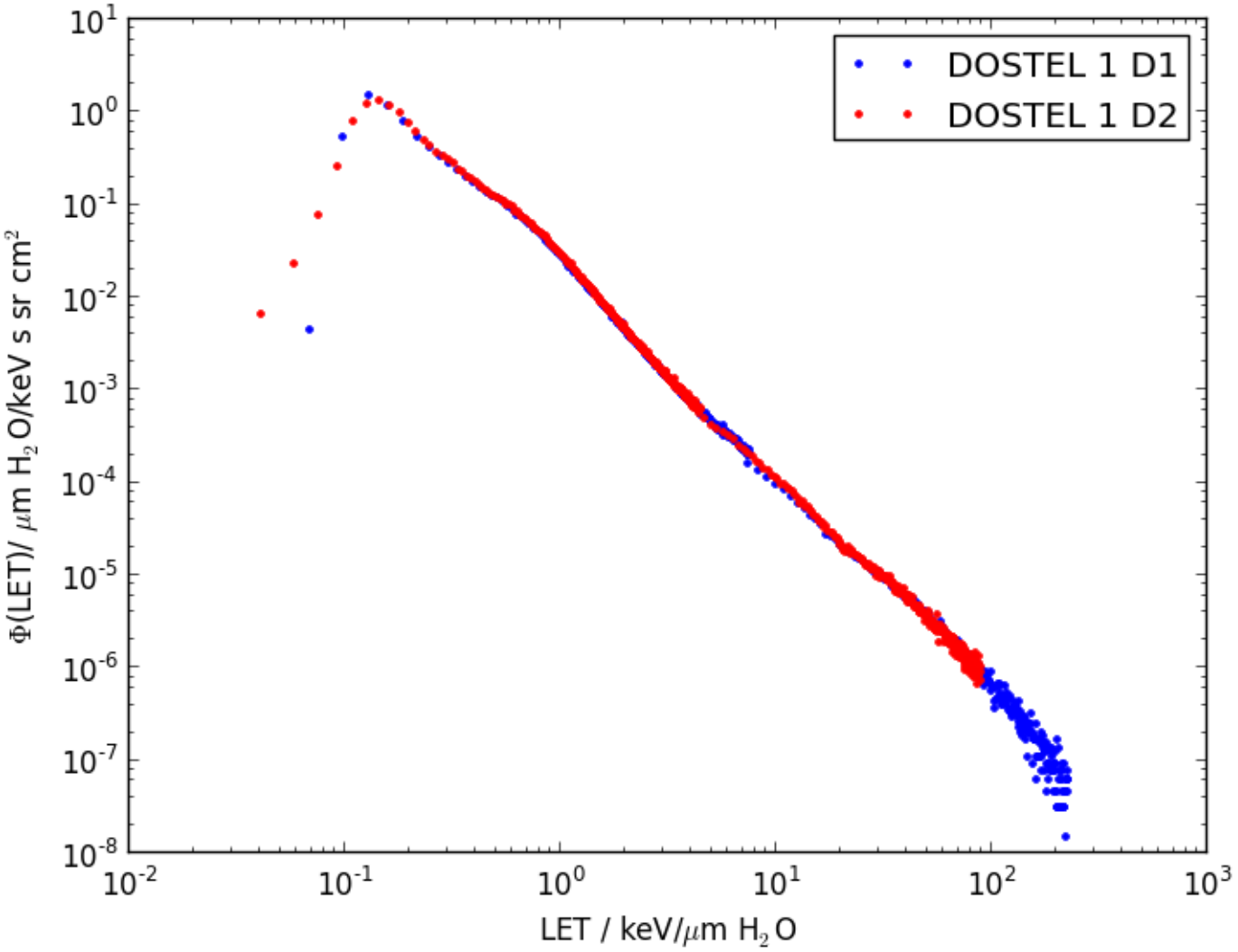
Dose Values During Shuttle Docking

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

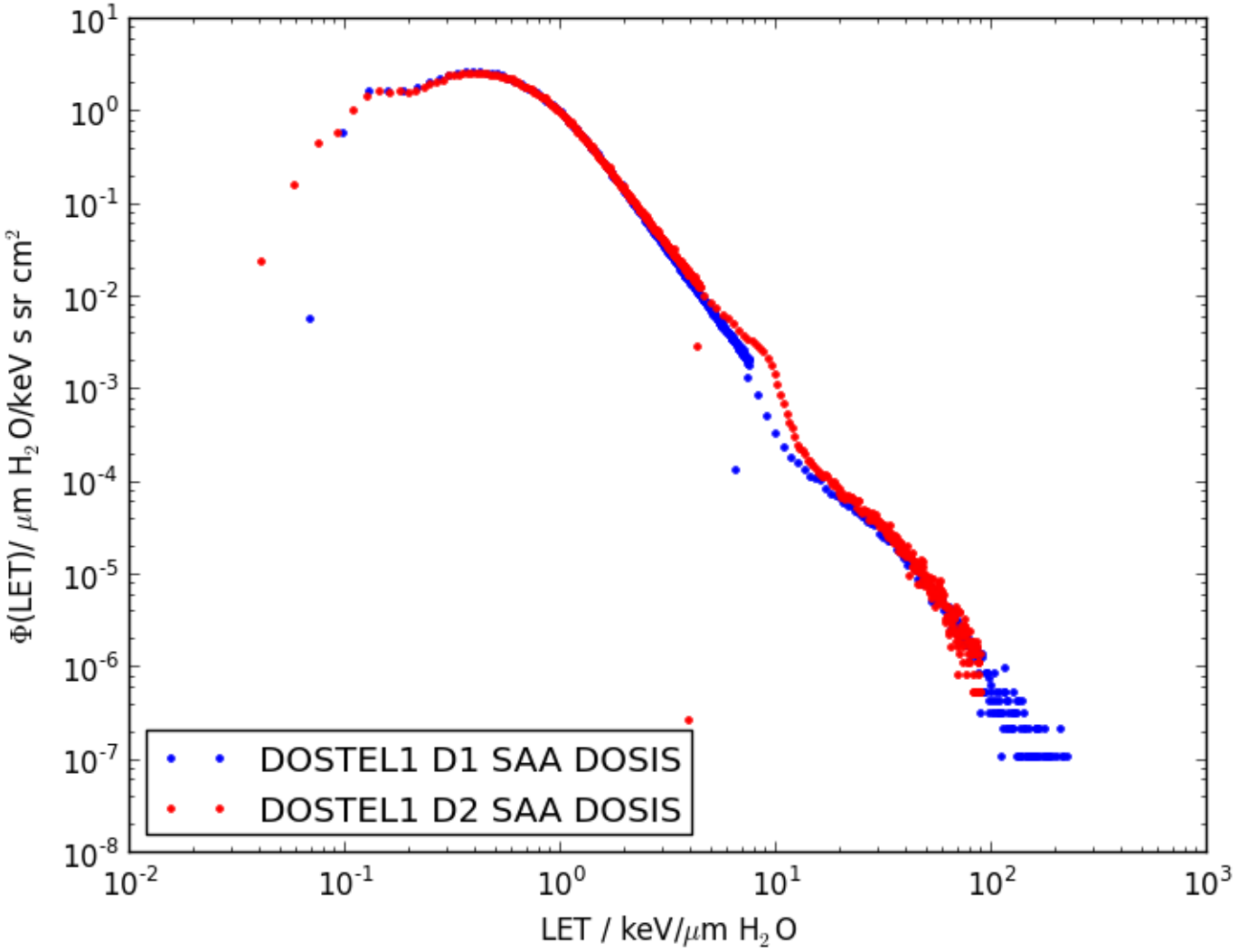
- The effect occurs mainly during the south-eastward passages through the SAA

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

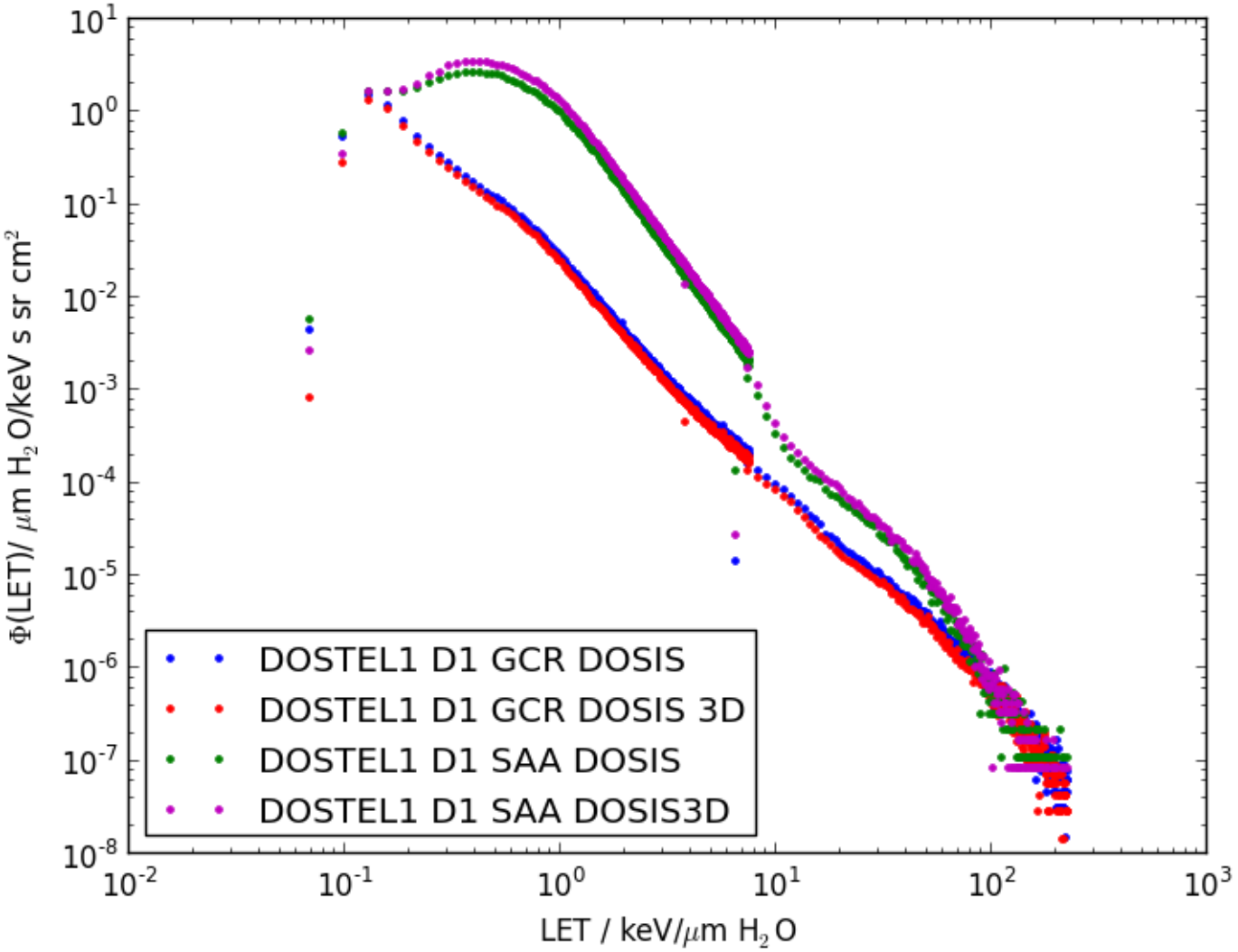
DOSIS GCR LET Spectra DOSTEL-1



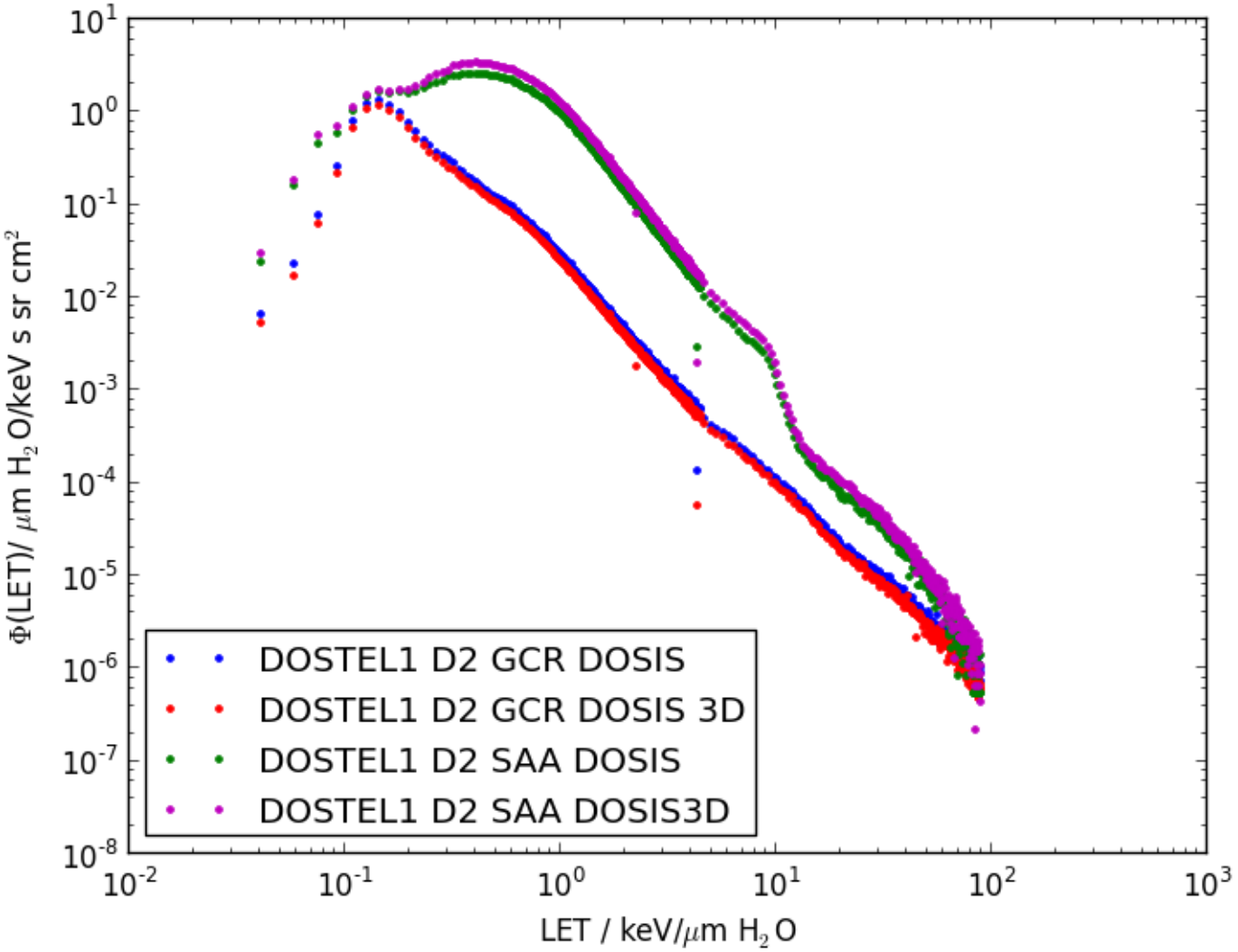
DOSIS SAA LET Spectra DOSTEL-1



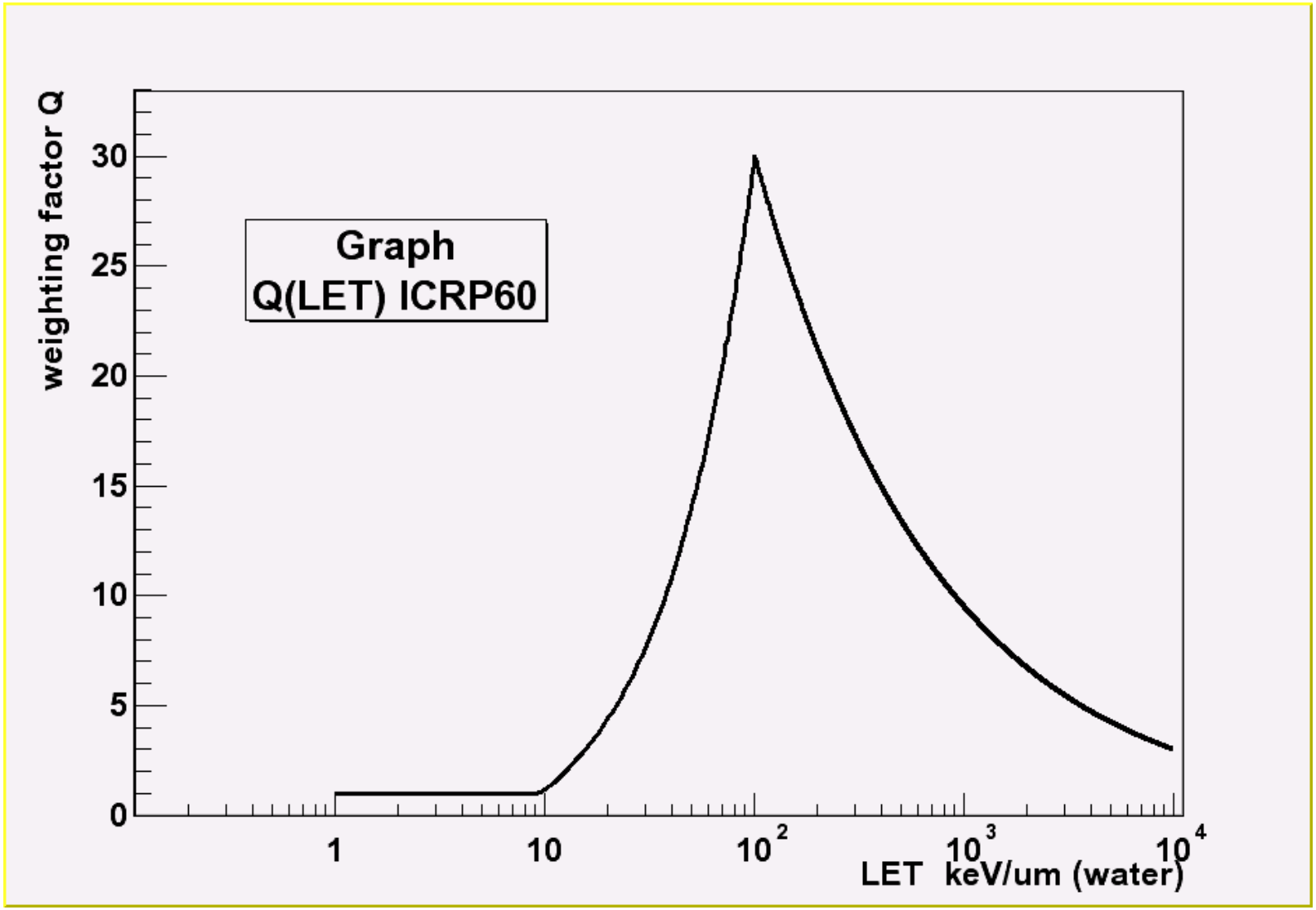
LET Spectra DOSTEL-1 Detector 1



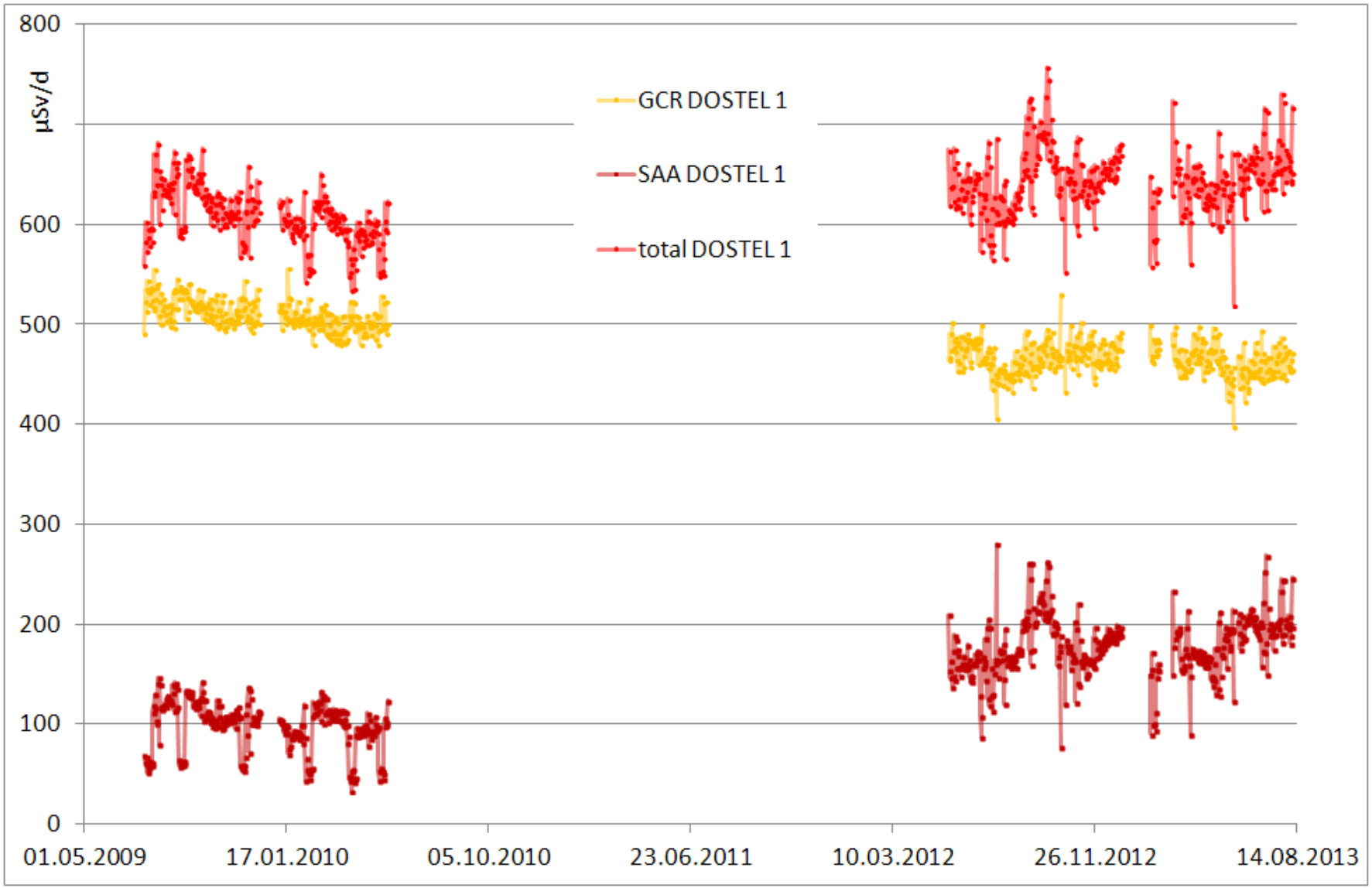
LET Spectra DOSTEL-1 Detector 2



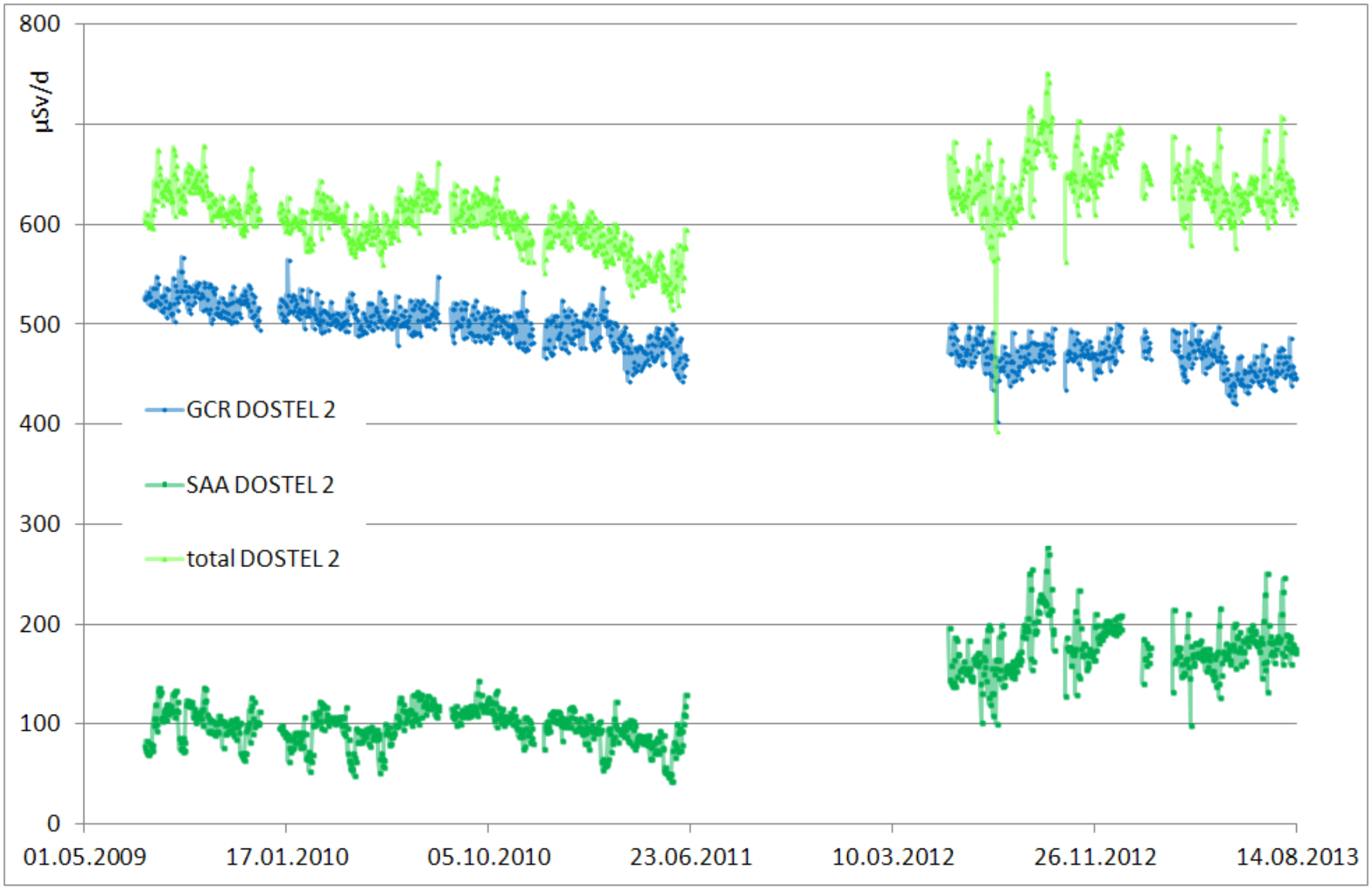
Mean Quality Factor



Dose Equivalent Rates DOSTEL 1



Dose Equivalent Rates DOSTEL 2

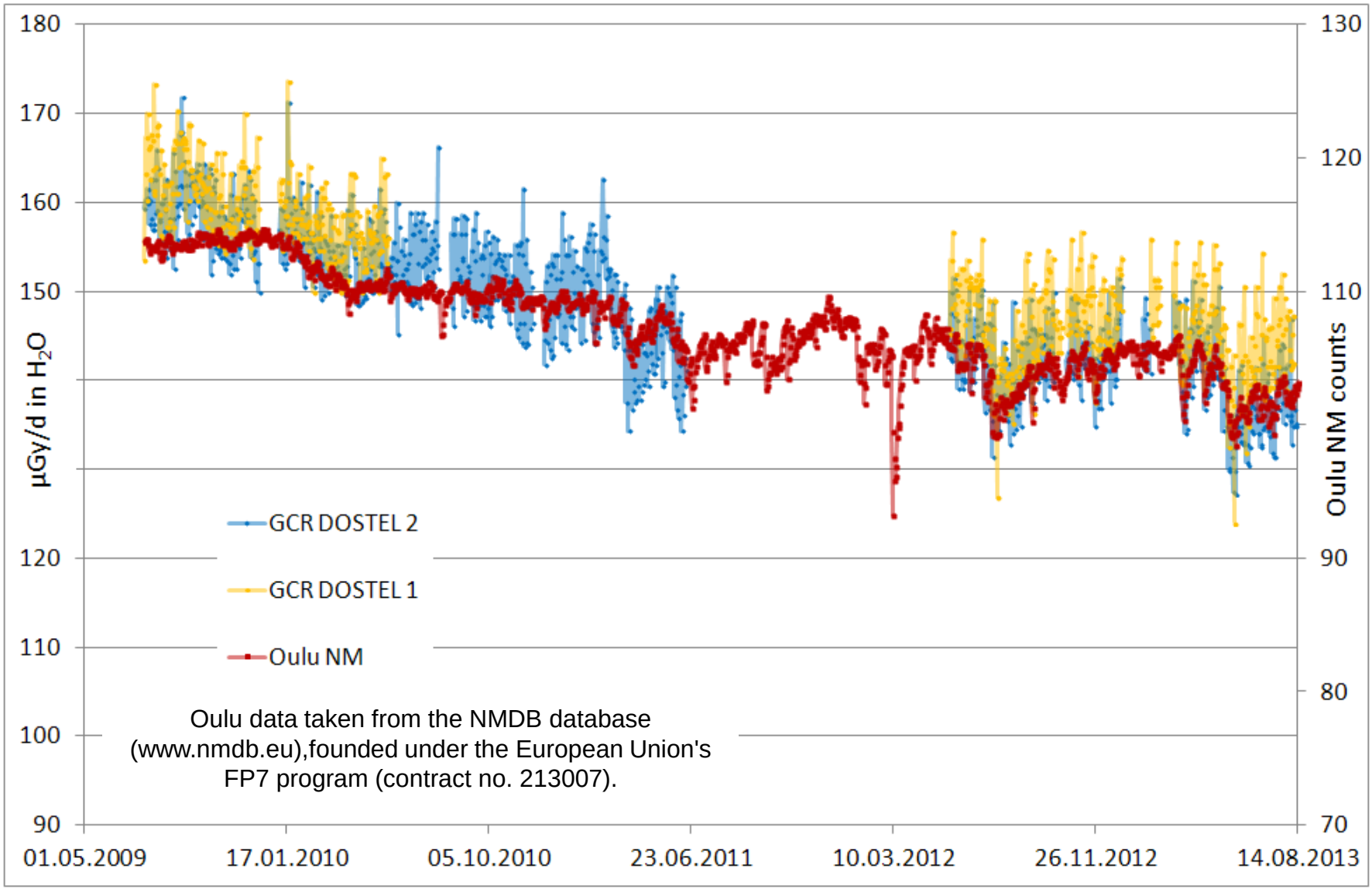


DOSIS / DOSIS 3D Results

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

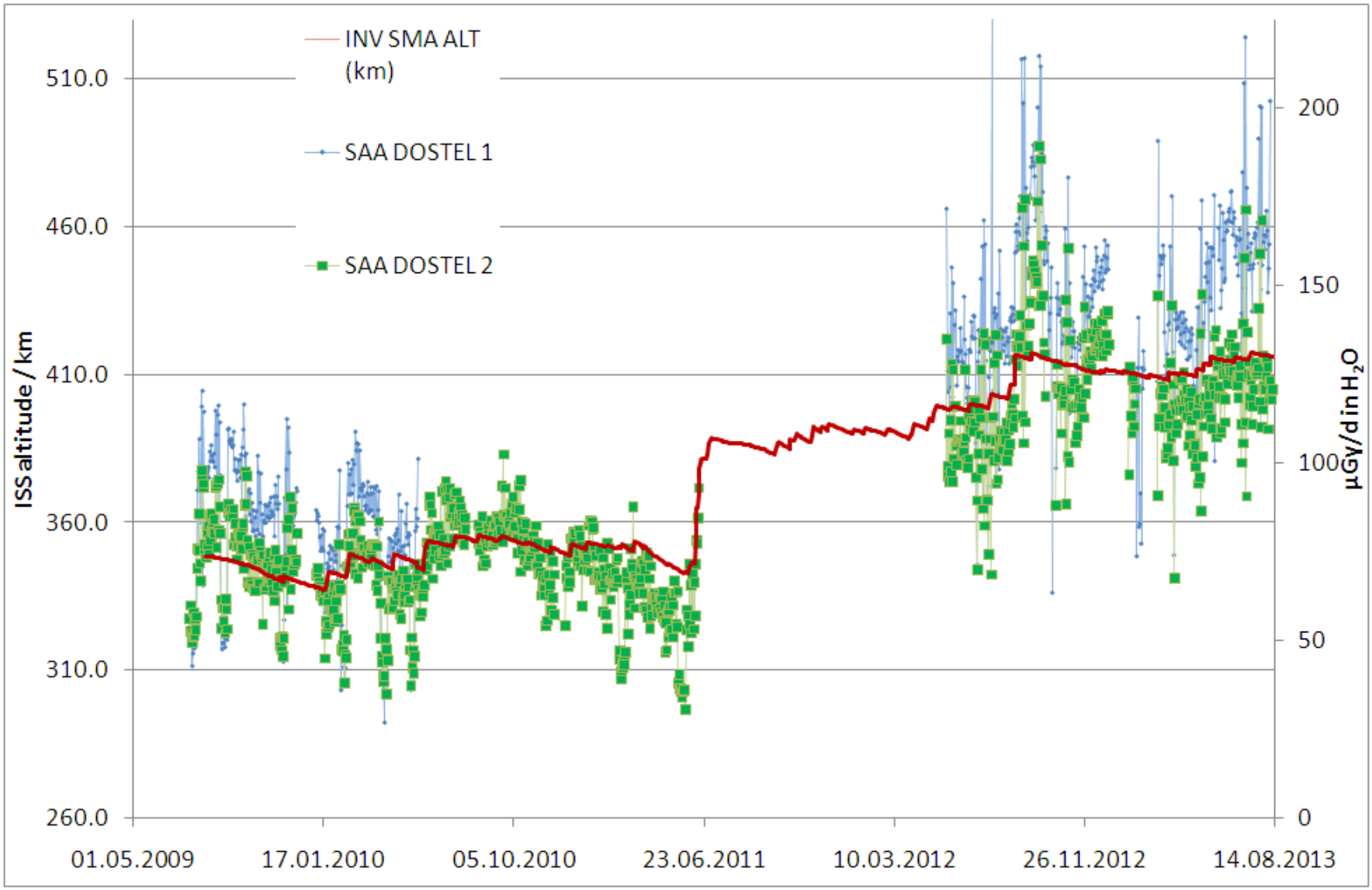
DOSIS 3D	Total				GCR				SAA			
	µGy/d in Si	µGy/d in tissue	Q	µSv/d	µGy/d in Si	µGy/d in tissue	Q	µSv/d	µGy/d in Si	µGy/d in tissue	Q	µSv/d
DOSTEL-1	237	292	2.2	630	118	145	3.1	455	119	146	1.20	175
DOSTEL-2	212	261	2.3	593	114	141	3.1	438	98	120	1.29	155

GCR Dose Rates

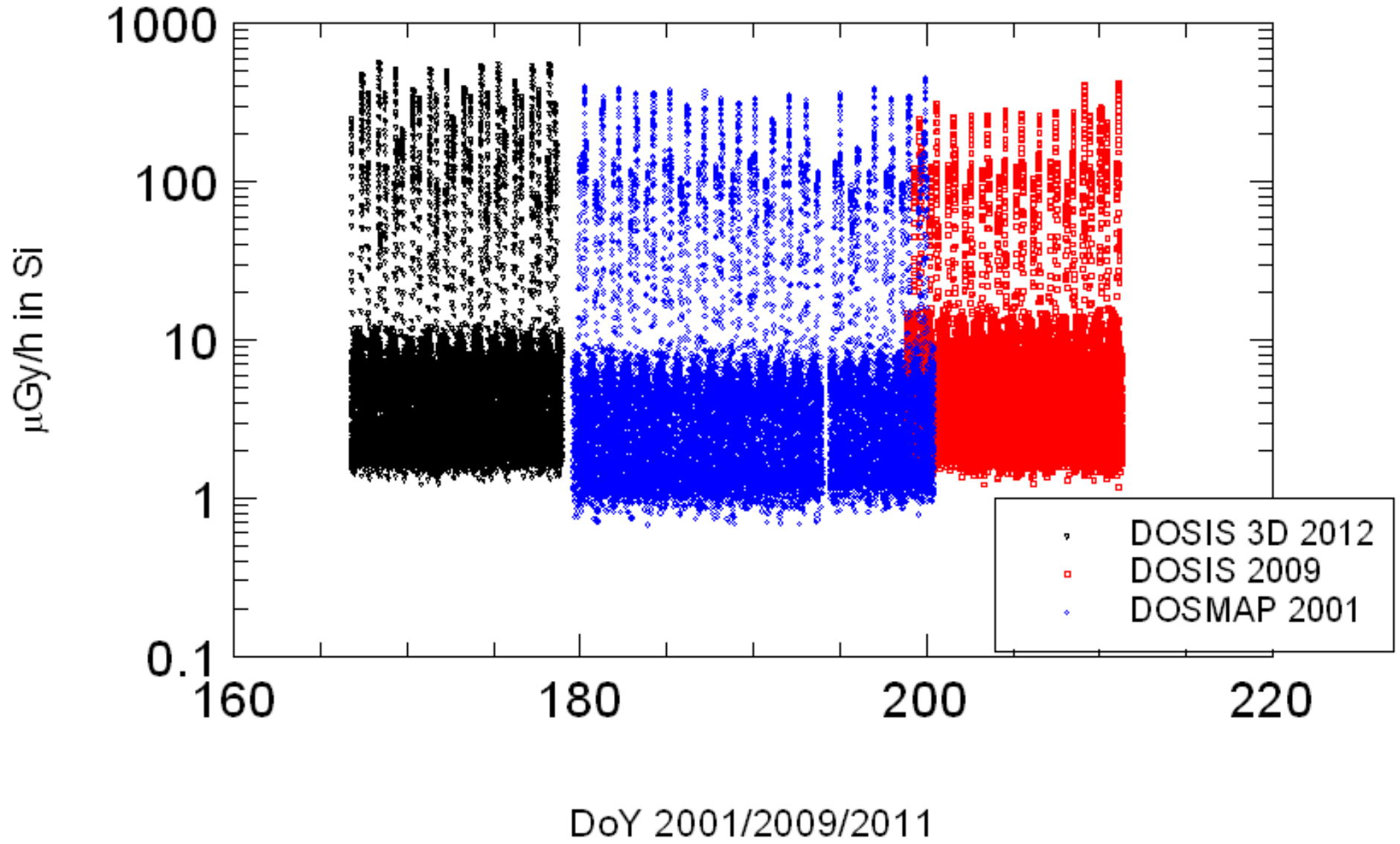


Oulu data taken from the NMDB database (www.nmdb.eu),founded under the European Union's FP7 program (contract no. 213007).

SAA Dose Rates



DOSIS 3D, DOSIS and DOSMAP comparison



Conclusions

- Up to now we have 1023 days of measurement with DOSTEL-2 (DOSTEL-1: 677d)

- 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:

- 

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 / DOSIS 3D Results

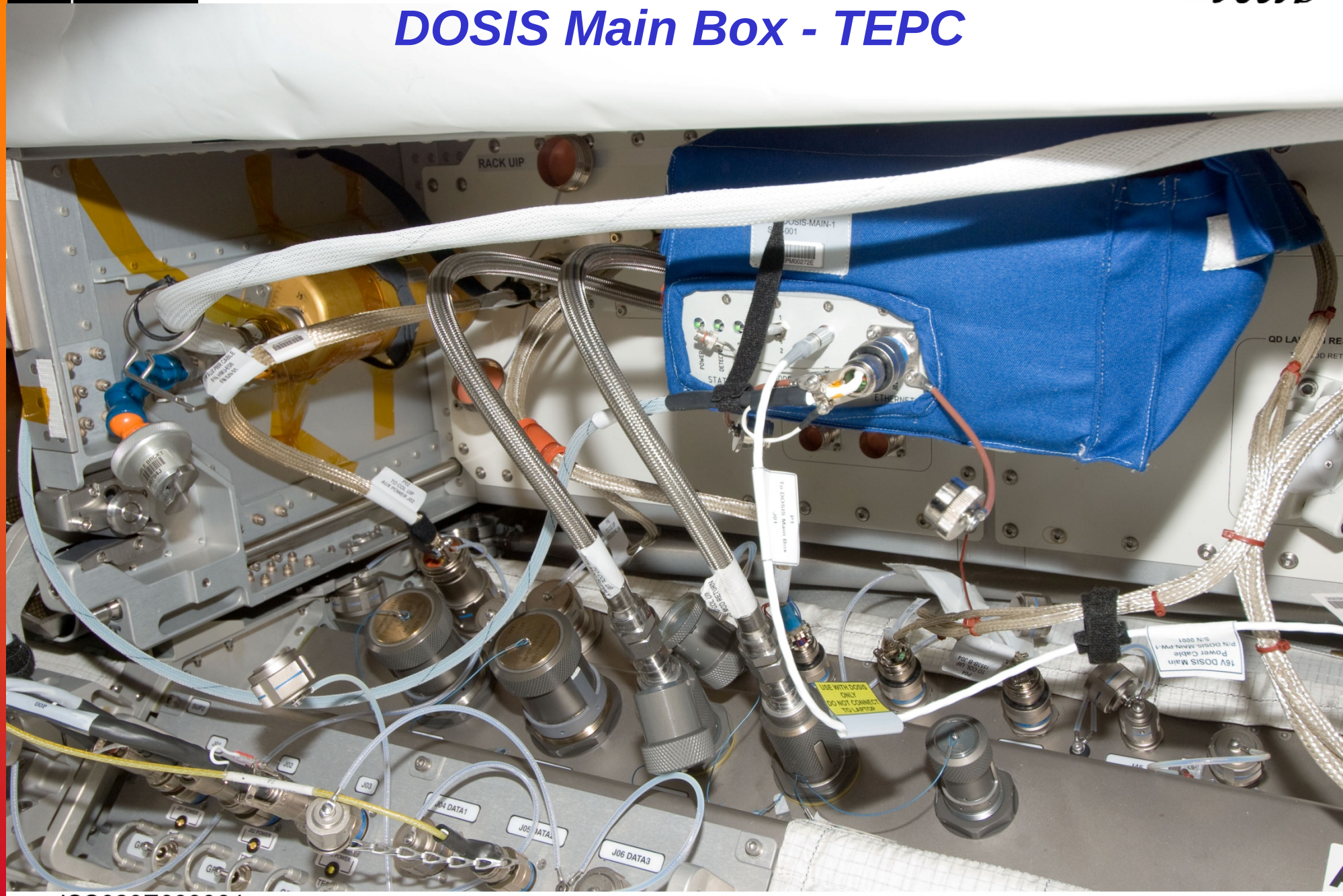
DOSIS	Total				GCR				SAA			
	µGy/d in Si	µGy/d in tissue	Q	µSv/d	µGy/d in Si	µGy/d in tissue	Q	µSv/d	µGy/d in Si	µGy/d in tissue	Q	µSv/d
DOSTEL-1	195	240	2.5	609	130	159	3.2	510	66	81	1.22	99
DOSTEL-2	181	222	2.6	584	124	153	3.3	497	57	70	1.26	88

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	237	292	2.2	630	118	145	3.1	455	119	146	1.20	175
DOSTEL-2	212	261	2.3	593	114	141	3.1	438	98	120	1.29	155

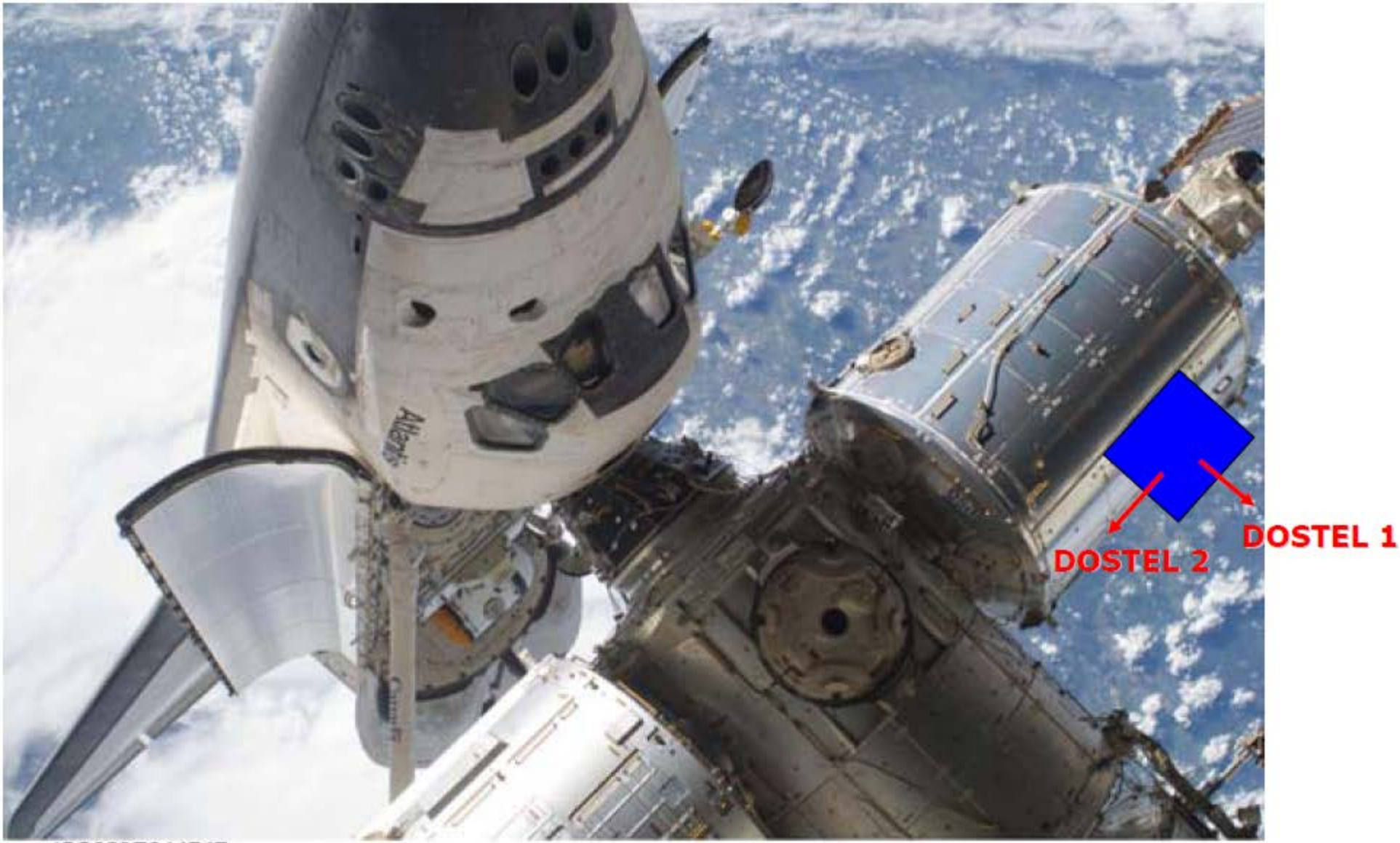
C | A | U

ieab

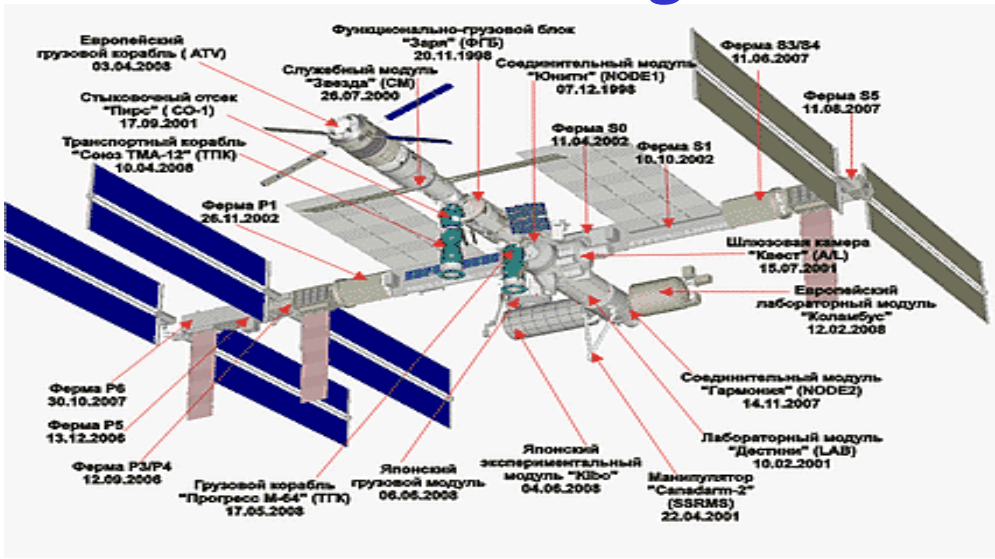
DOSIS Main Box - TEPC



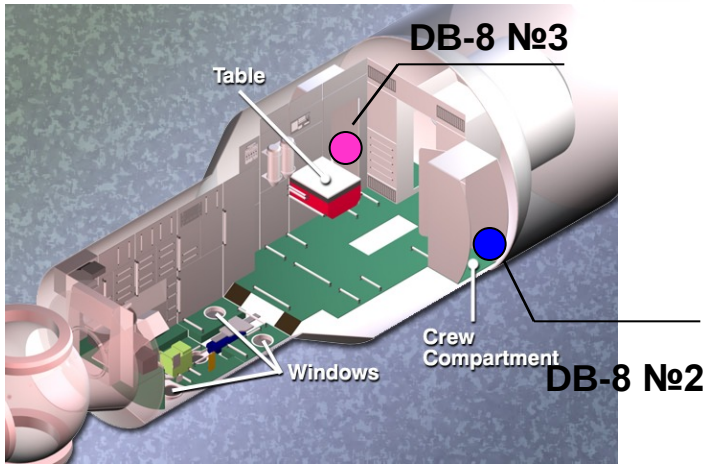
ISS020E033064


DOSTEL 2
DOSTEL 1
ISS023E044747

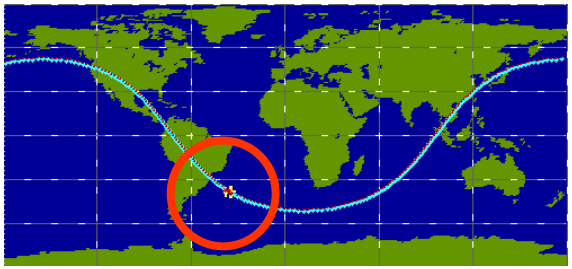
ISS configuration



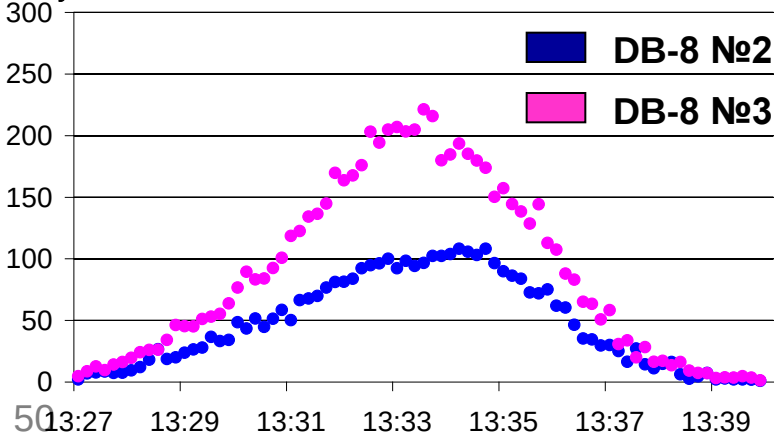
Service Module

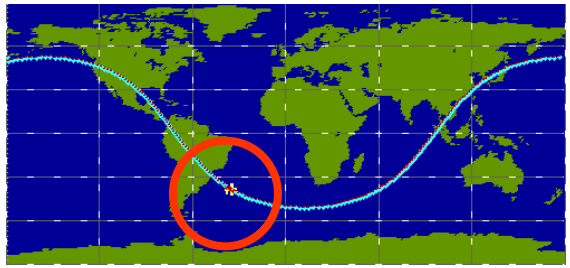


Thanks to S.G. Drobyshev, V.V. Benghin



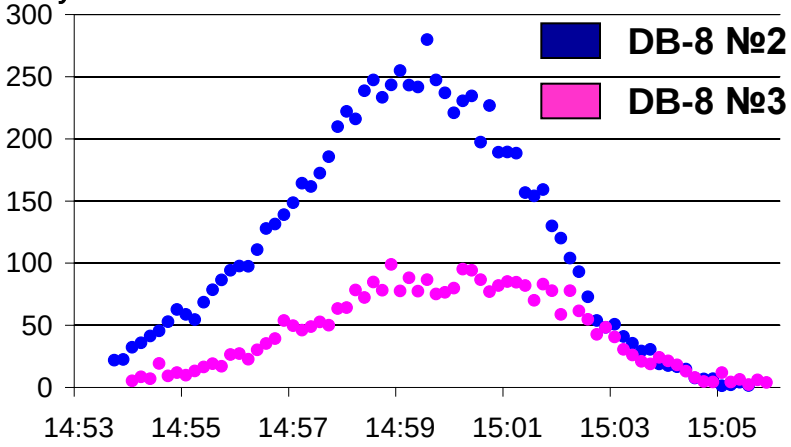
19.01.2008



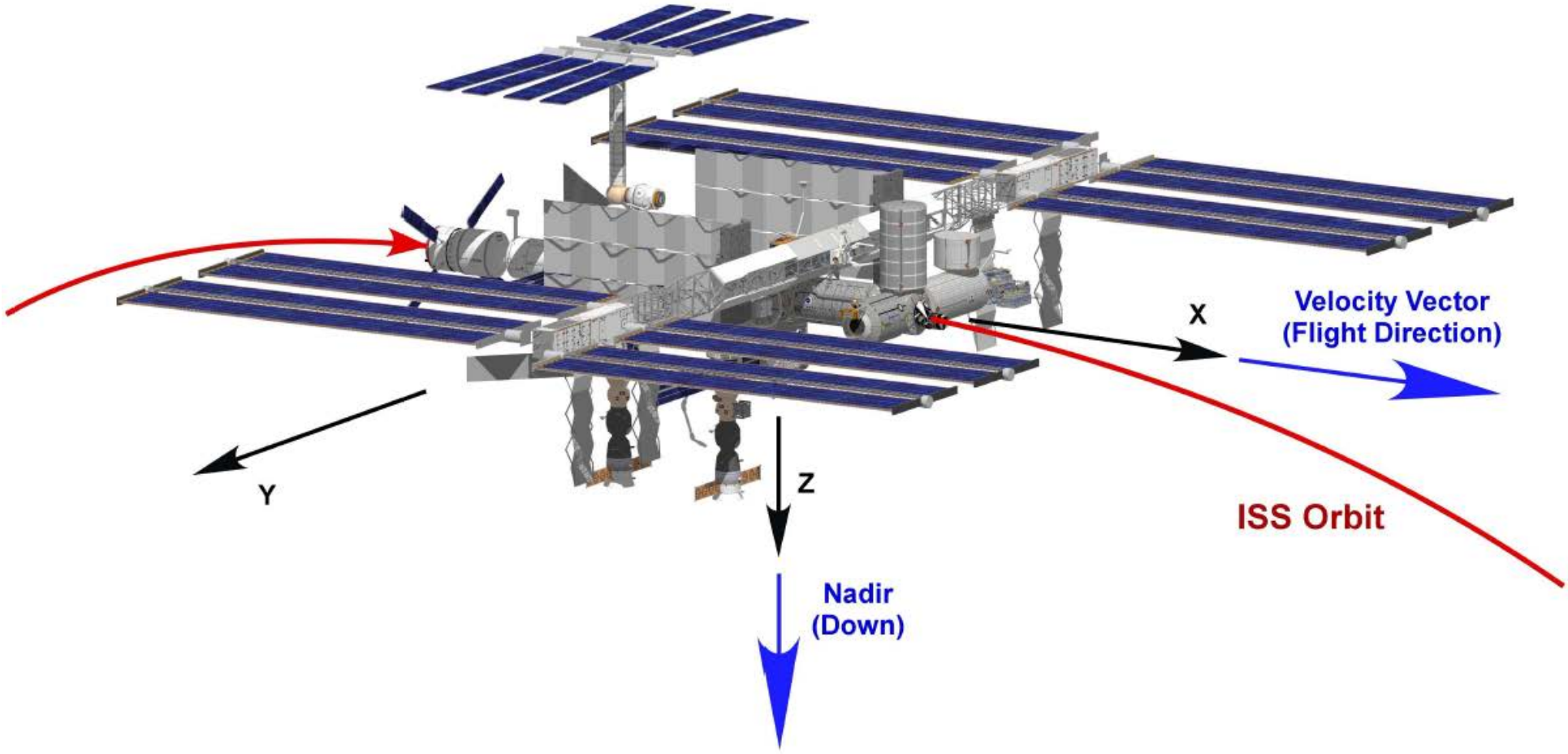


14.03.2008

STS-123 docking: 13.03.-25.03.08

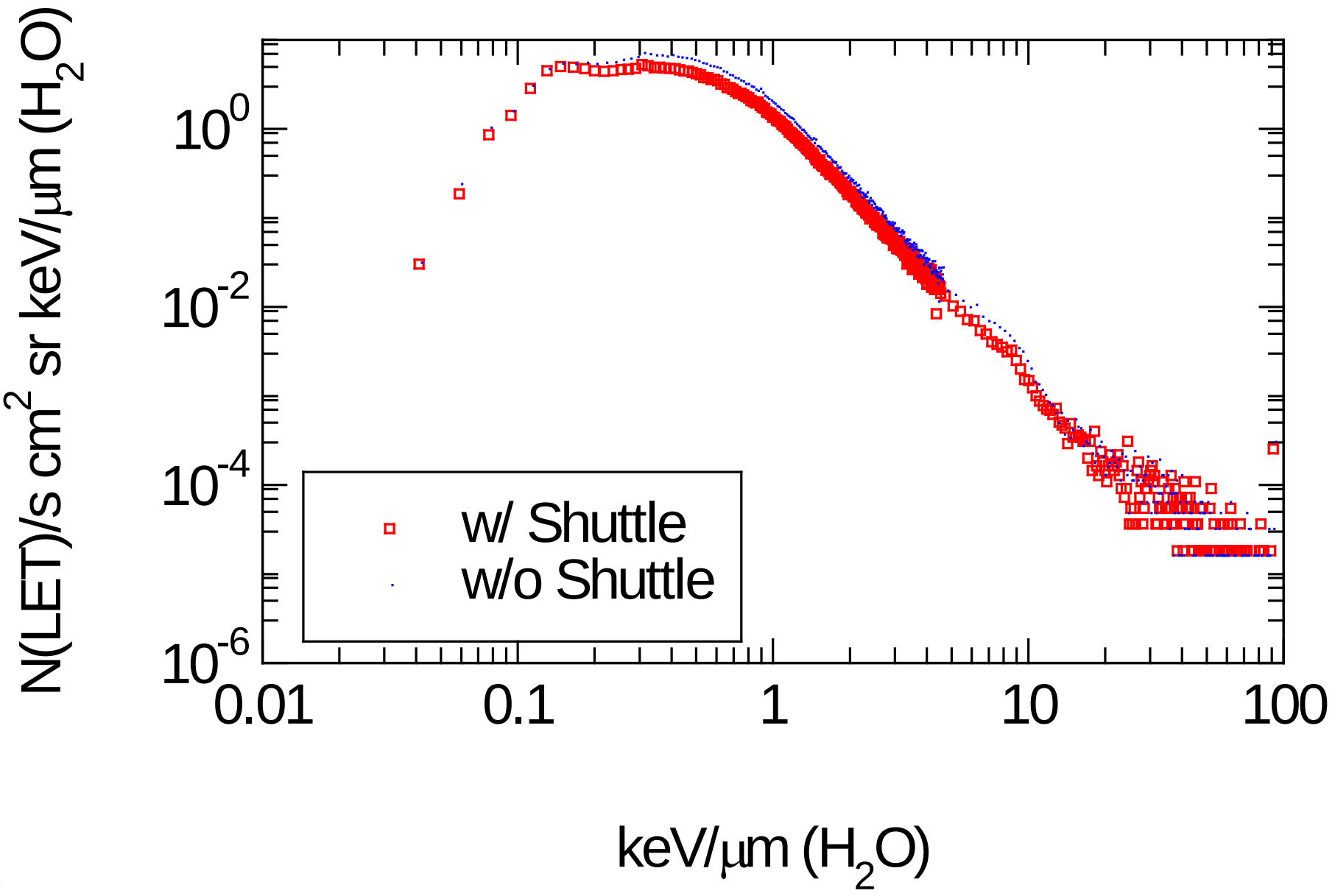


ISS +Xvv Attitude

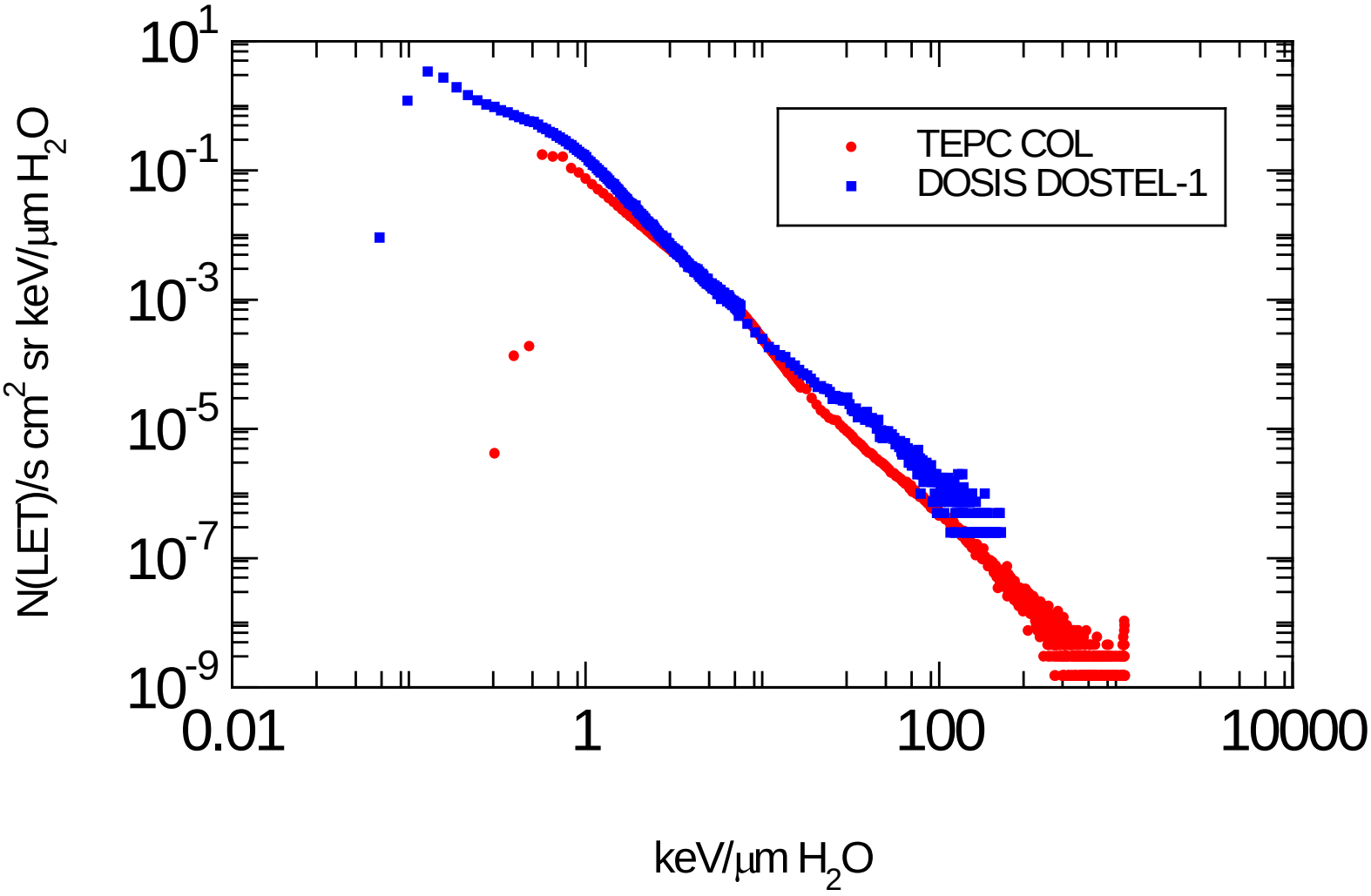


[European Users Guide to Low Gravity Platforms, UIC-ESA-UM-0001]

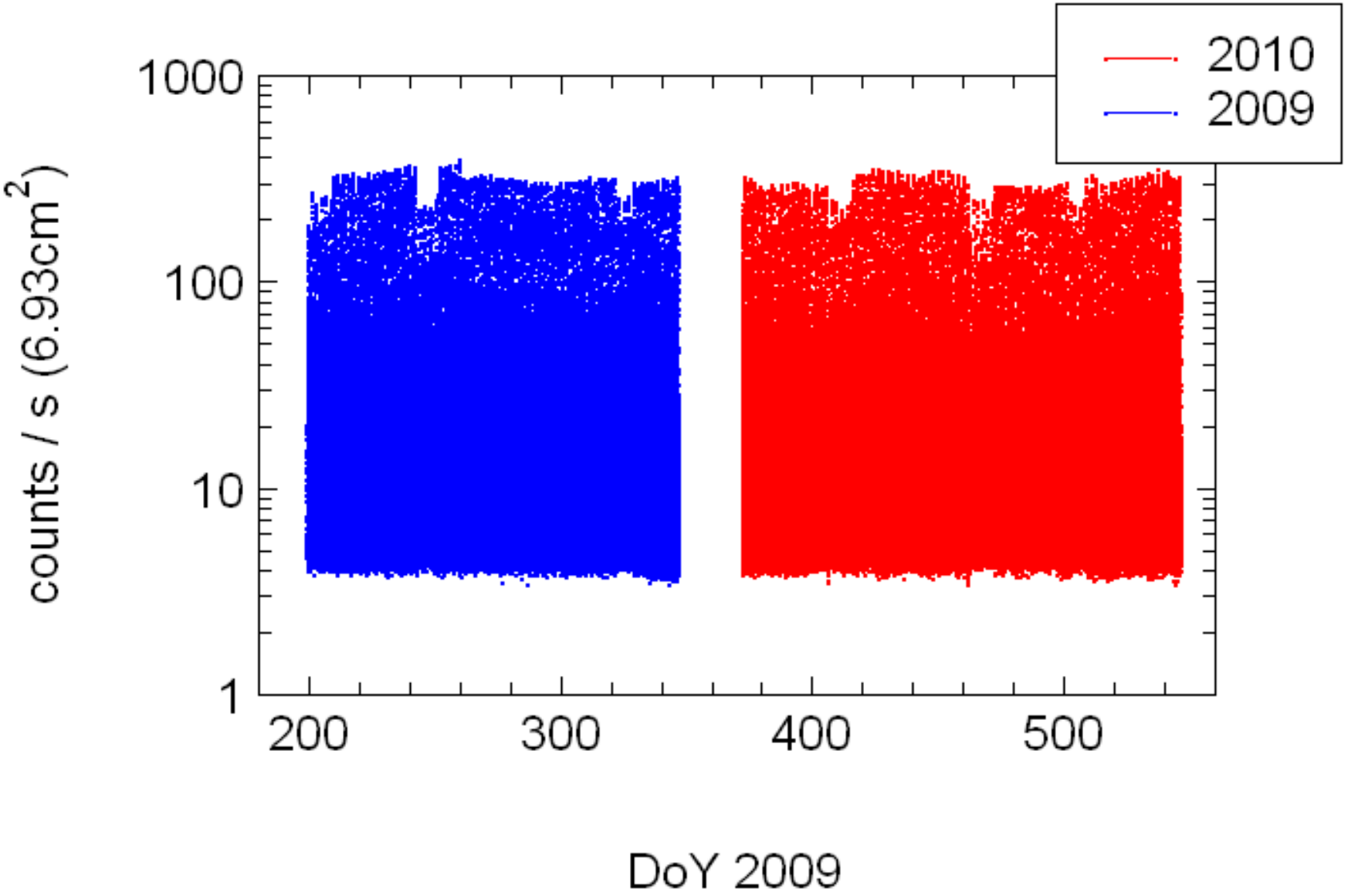
SAA LET Spectra



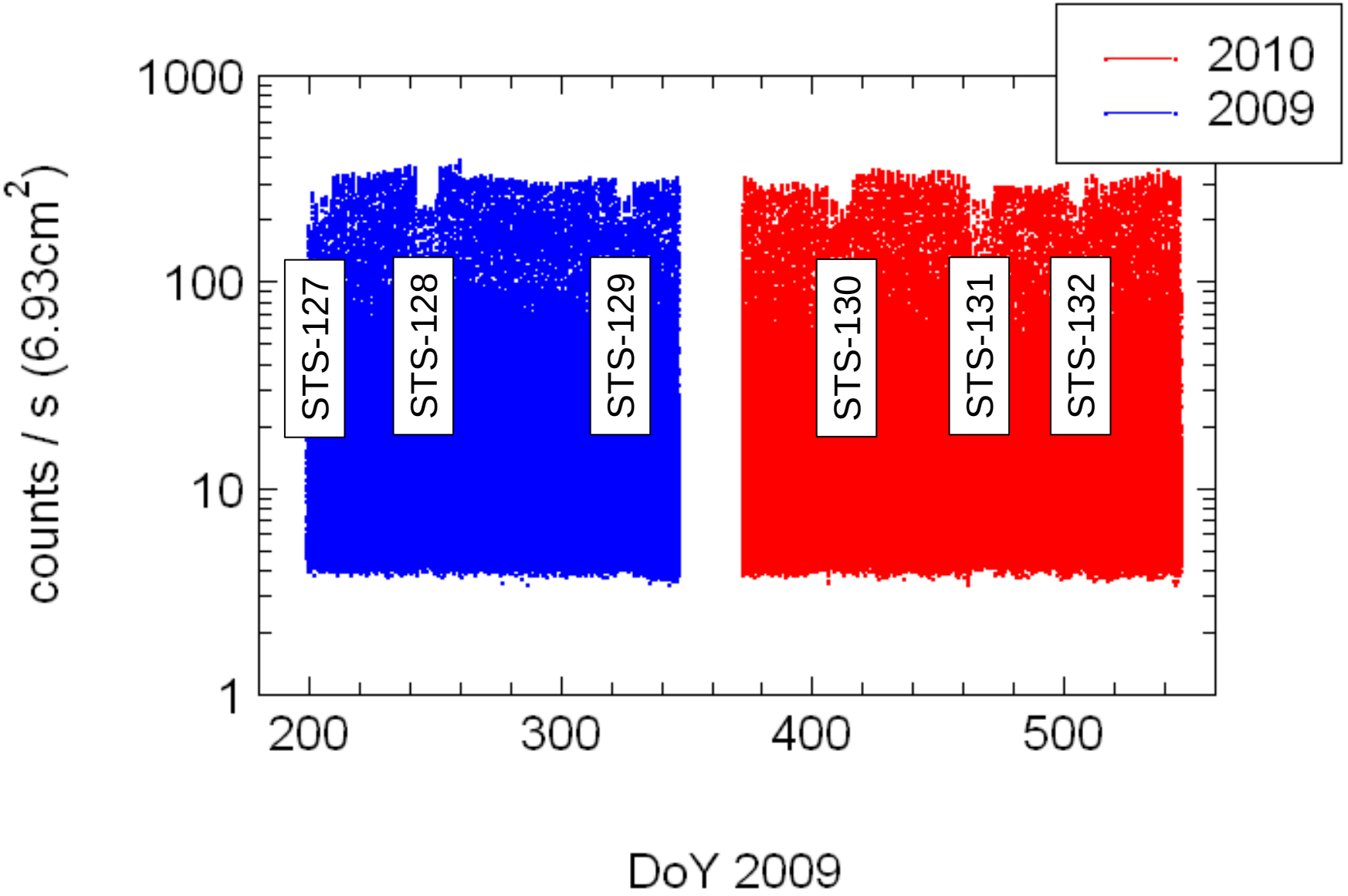
Combined LET spectra

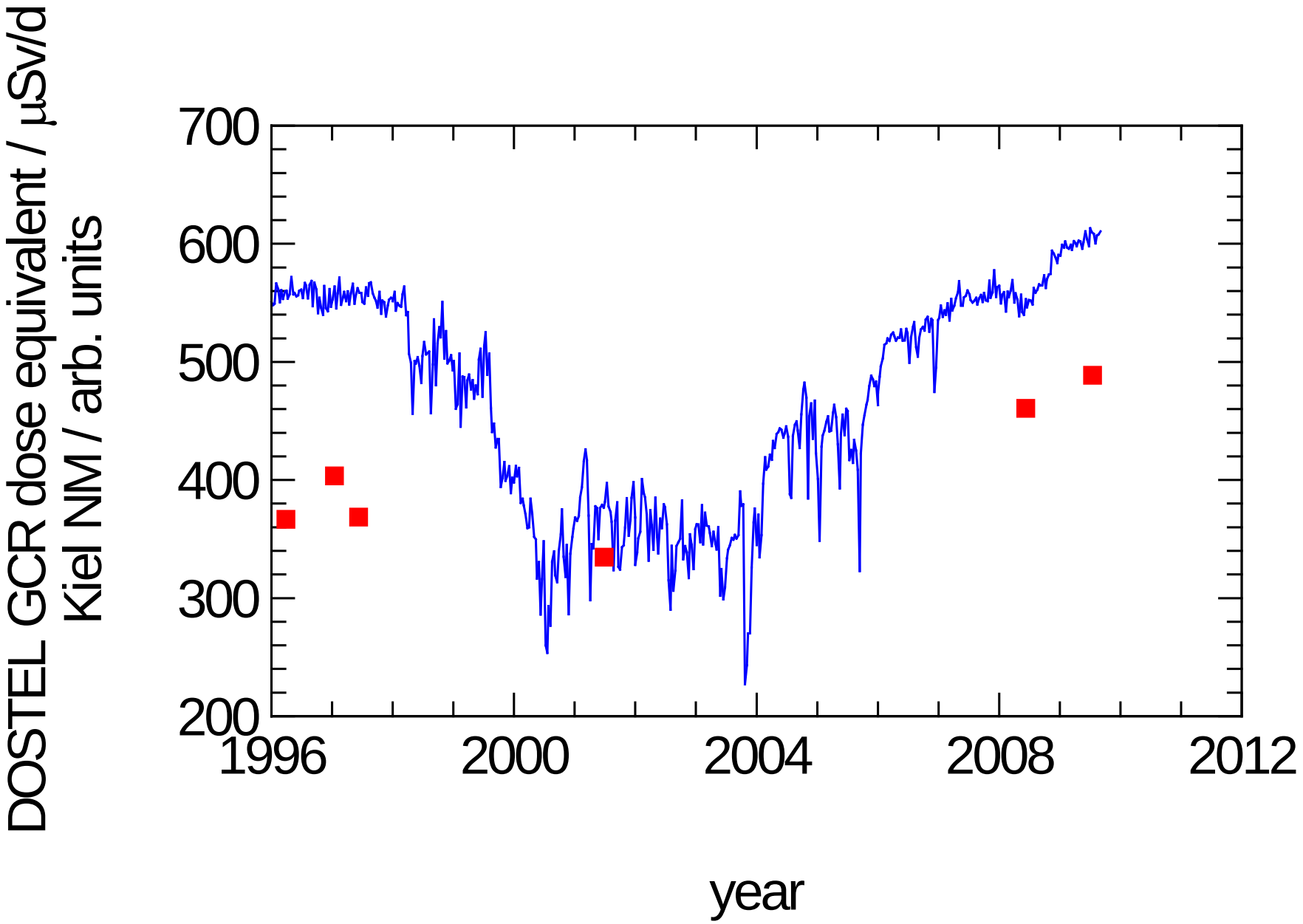


DOSTEL-2 Count Rate Profile



DOSTEL-2 Count Rate Profile




DOSTEL GCR dose equivalent / µSv/d
Kiel NM / arb. units
700
600
500
400
300
200
1996
2000
2004
2008
2012
year