FP7 Project #218817

"HAMLET" Summary Description

FIGURE Summary-0: FP7 HAMLET LOGO

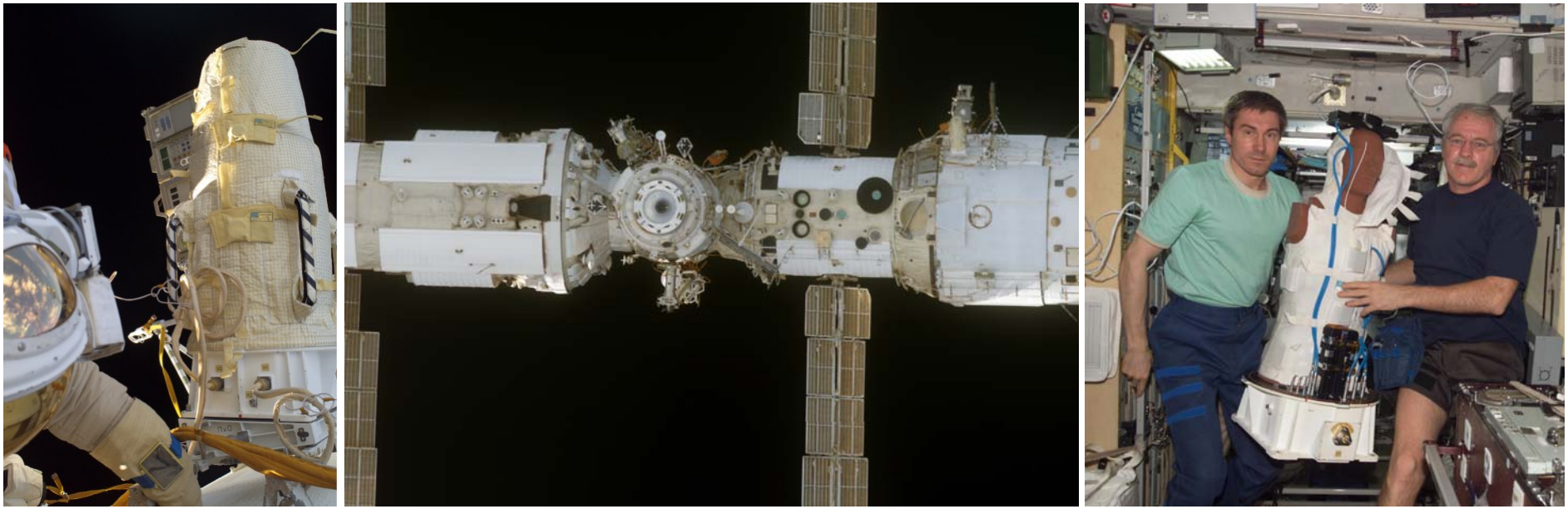


Figure Summary-1: MATROSHKA-1: The MATROSHKA facility during the MATROSHKA-1 experiment phase (2004-2005): (a) and (b) outside ISS exposure (simulation of a spacewalk); (c) inside the ISS.

Table Summary-1: MATROSHKA-1: Experiment Timeline: The MATROSHKA facility was launched with Progress 13P on the 29 January 2004 to the ISS. During the EVA on 26 February 2004 the facilty was mounted outside the Zvezda module of the International Space Station, starting its 539 days "Space Walk". The facility was brought back inside the station on 18 August 2005 followed by the dismounting of the passive detectors on 14 September 2005 and sending them back to earth with Soyuz TMA-6 in October 2005.

Experiment phase	Event	Performing crew	Date
MTR-1 (2004–2005)	MATROSHKA launch (Progress 13P)		Jan. 29, 2004
	Docking with International Space Station		Jan. 31, 2004
	Extravehicular activity	Kaleri, Foale	Feb. 26, 2004
	Outside exposure (active, passive detectors)		**Feb. 26, 2004–Aug. 18, 2005**
	Extravehicular activity	Krikalev, Phillips	Aug. 18, 2005
	Dismounting of passive detectors	Krikalev, Phillips	Sep. 14, 2005
	Passive detector download (Soyuz TMA-6)		Oct. 10, 2005 (undocked)

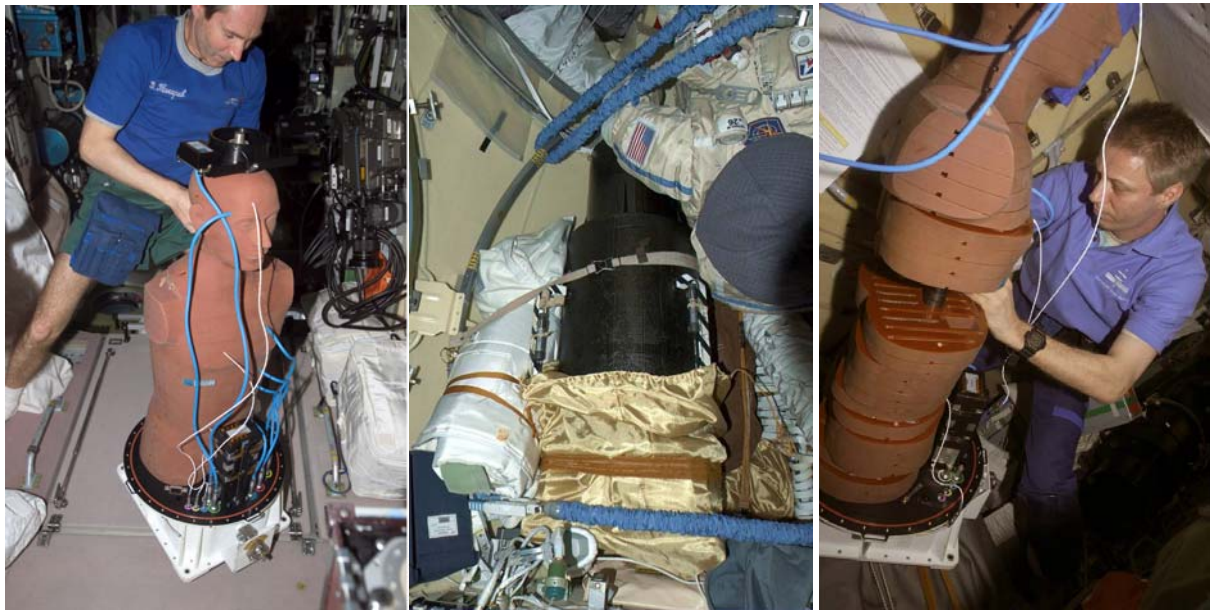


Figure Summary-2: MATROSHKA-2A: The MATROSHKA facility during the MATROSHKA-2A experiment phase (2006): (a) detector integration; (b) exposure inside the Russian PIRS module; (c) European astronaut Thomas Reiter removing the radiation detectors after the experiment for read out and data evaluation on ground.

Table Summary-2: MATROSHKA-2A: Experiment Timeline: The MATROSHKA-2A passive detector set was launched with Progress 20P on the 21 December 2005 to the ISS. The integration of the passive detectors in the MATROSHKA facility was performed on the 5th January 2006. After integration the facility was exposed inside the Russian PIRS module up to the 7th December 2006, followed by the dismounting of the detectors.

Experiment phase	Event	Performing crew	Date
MTR-2A (2006)	Passive detector upload (Progress 20P)		Dec. 21, 2005
	Integration of passive detectors	McArthur,Tokarev	Jan. 5, 2006
	Inside exposure (passive detectors)		**Jan. 5, 2006–Dec. 7, 2006**
	Dismounting of passive detectors	Reiter	Dec. 7, 2006
	Passive detector download (STS-116)		Dec. 22, 2006

Figure Summary-3: MATROSHKA-2B: The MATROSHKA facility during the MATROSHKA-2B experiment phase: (a) and (b) exposure inside the Russian Zvezda module; (c) removal of the radiation detectors after the experiment for read out and data evaluation on ground.

Table Summary-3: MATROSHKA-2B: Experiment Timeline: The MATROSHKA-2B passive detector set was launched with Soyuz TMA-11 on the 10th October 2007 to the ISS. The integration of the passive detectors in the MATROSHKA facility was performed on the 18th October 2007. After integration the facility was exposed inside the Russian Zvezda (Service) module up to the 18th March 2009, followed by the dismounting of the detectors and detector return with STS-119.

Experiment phase	Event	Performing crew	Date
MTR-2B (2007–2009)	Passive detector upload (Soyuz TMA-11)		Oct. 10, 2007
	Integration of passive detectors	Yurchikhin, Malenchenko	Oct. 18, 2007
	Inside exposure (active, passive detectors)		**Oct. 18, 2007– March 18, 2009**
	Dismounting of passive detectors	Lonchakov	March 18, 2009
	Passive detector download (STS-119)		March 30, 2009

FP7 Project #218817

"HAMLET" MAIN S&T Results

WP1: Data Processing and Compilation

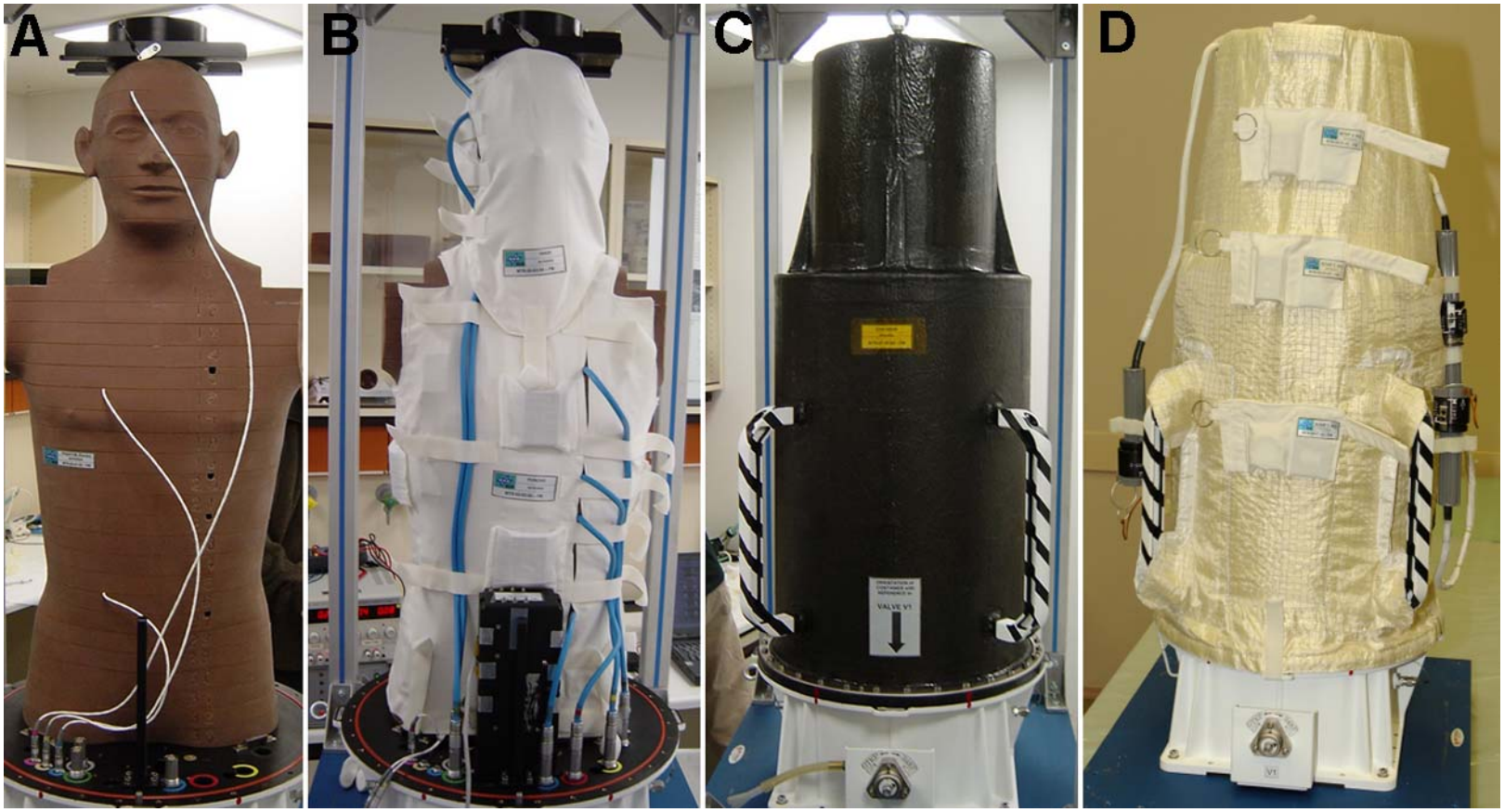


Figure Introduction-1: MATROSHKA-Facility: The MATROSHKA phantom from left to right: **A**: anthropomorphic upper torso equipped with active and passive detector systems, **B**: torso with poncho and hood equipped with passive detector systems for skin dose measurements, **C**: carbon fibre container to simulate the astronauts space suit, **D**: facility close to launch equipped with multi layer insulation (MLI) for thermal protection

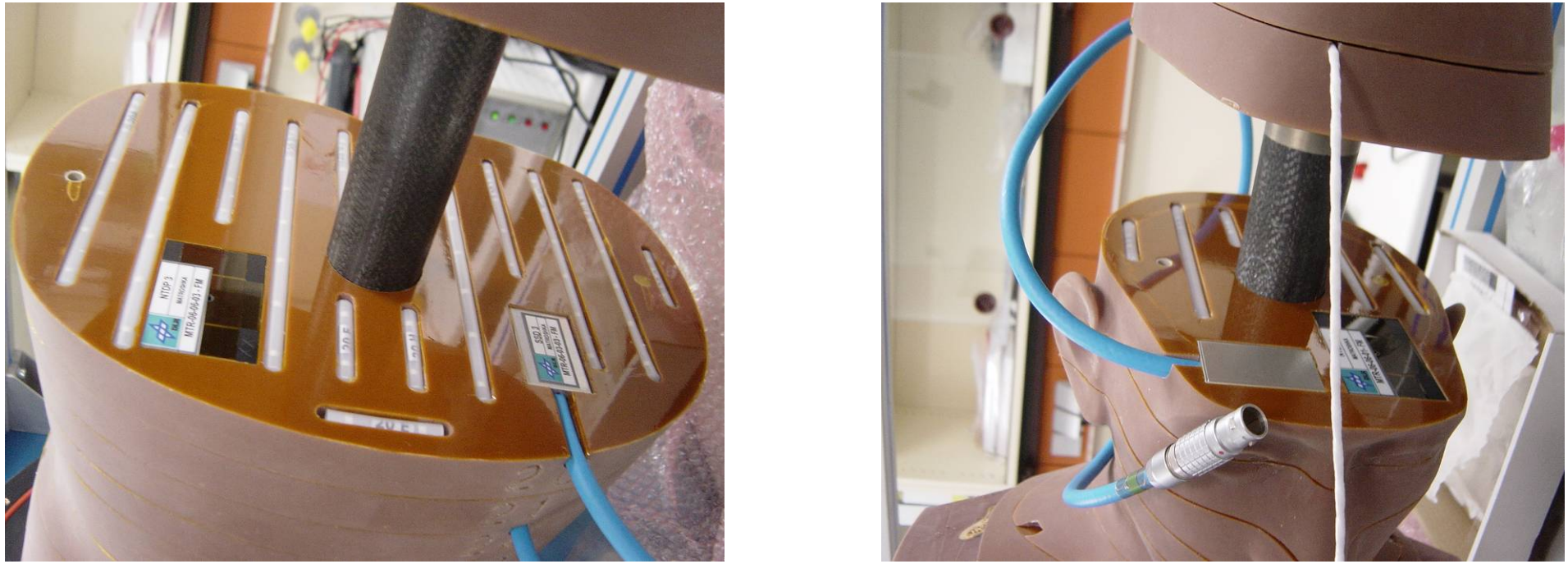


Figure Introduction-2: MATROSHKA-Detectors: View of the phantom upper torso (right) and the head (left) of MATROSHKA. It shows the phantom upper torso and the head of the phantom with the integrated passive and active radiation detectors. Passive detectors are integrated in polyethylene tubes and in the "organ dose" packages. The sensor for the active SSD instrument is shown with the blue cable connecting to the base structure. The white cable connects to a temperature sensor in the head of the phantom. Near the periphery, the outline of the skull can be perceived.

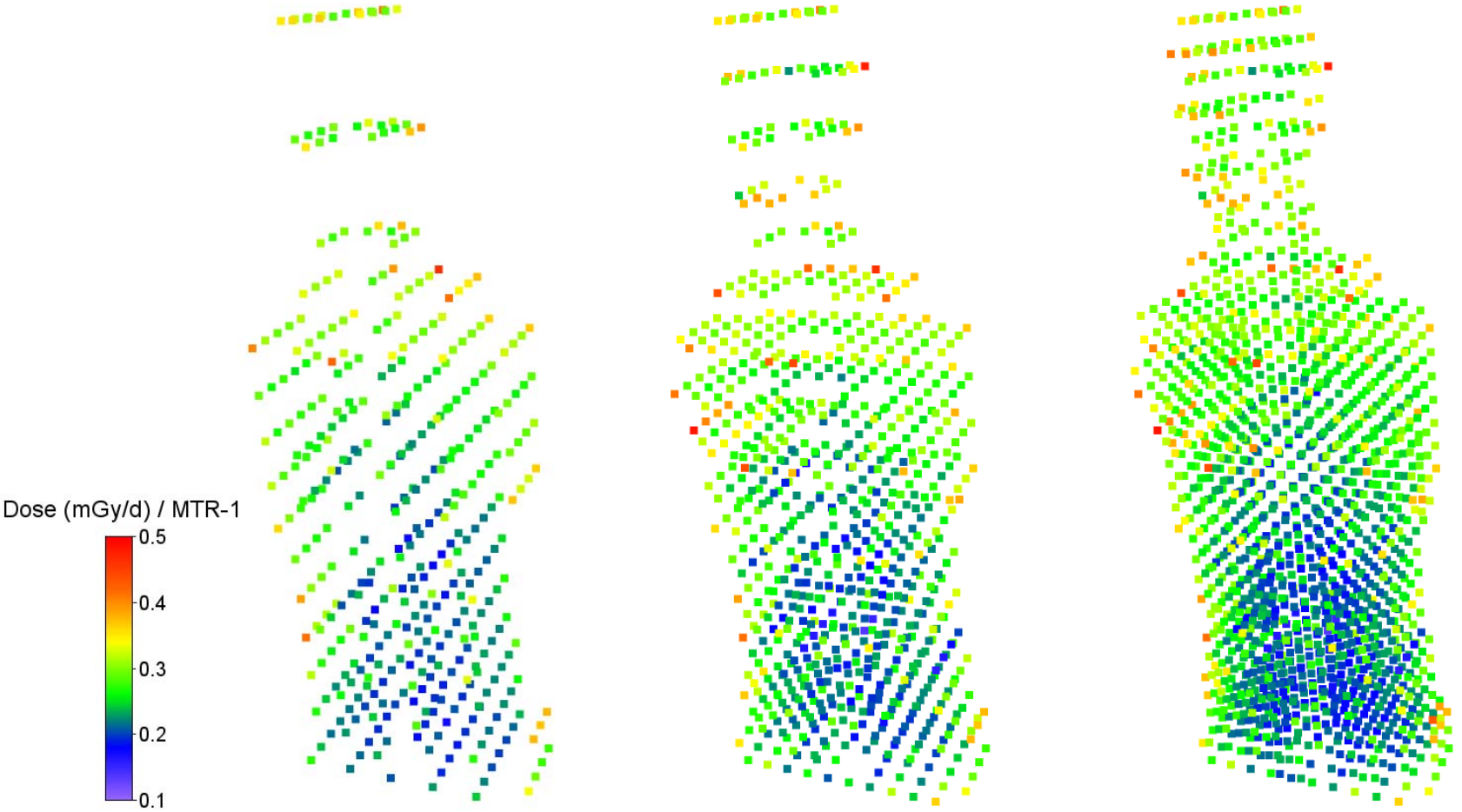


Figure WP1-3: MTR-1 3D: The built up of the discrete dose distribution using data from the passive thermoluminescence detectors for the MTR-1 experiment: (a) Data DLR, Cologne (b) Data DLR, Cologne + TUW, Vienna; (c) Data DLR, Cologne + TUW, Vienna, + IFJ, Krakow

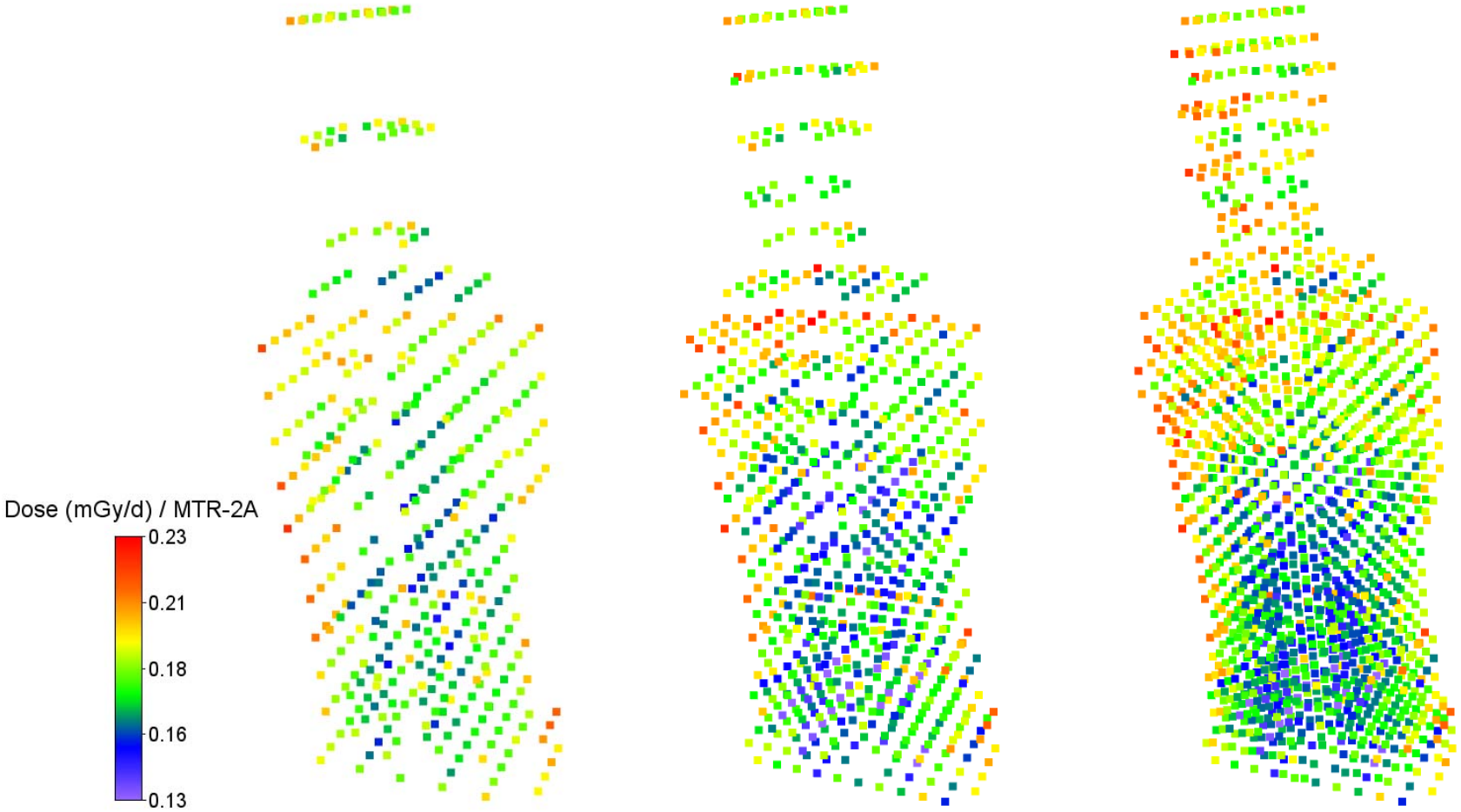


Figure WP1-4: MTR-2A 3D: The built up of the discrete dose distribution using data from the passive thermoluminescence detectors for the MTR-2A experiment: (a) Data DLR, Cologne (b) Data DLR, Cologne + TUW, Vienna; (c) Data DLR, Cologne + TUW, Vienna, + IFJ, Krakow

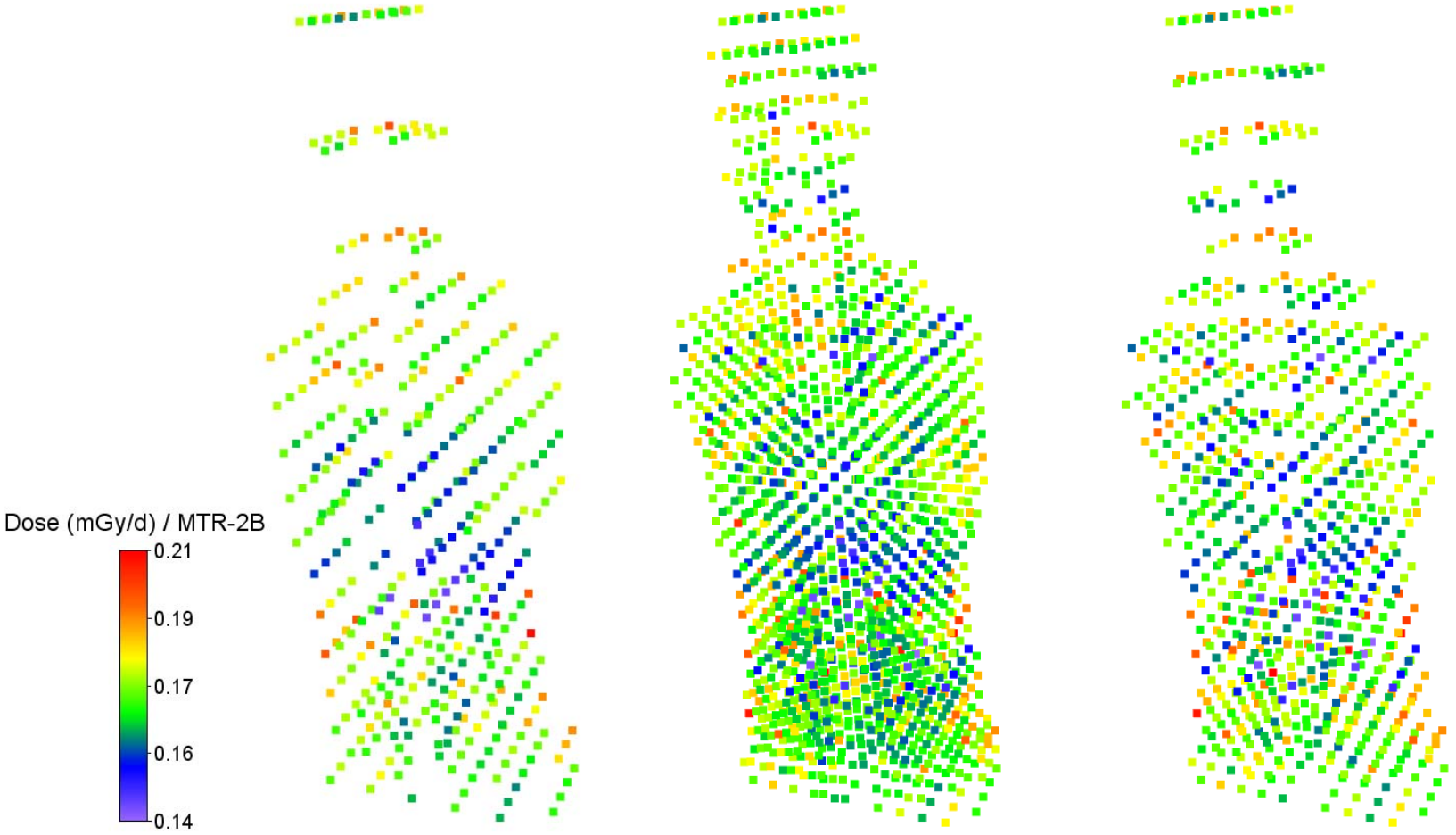


Figure WP1-5: MTR-2B 3D: The built up of the discrete dose distribution using data from the passive thermoluminescence detectors for the MTR-2B experiment: (a) Data DLR, Cologne (b) Data DLR, Cologne + TUW, Vienna; (c) Data DLR, Cologne + TUW, Vienna, + IFJ, Krakow

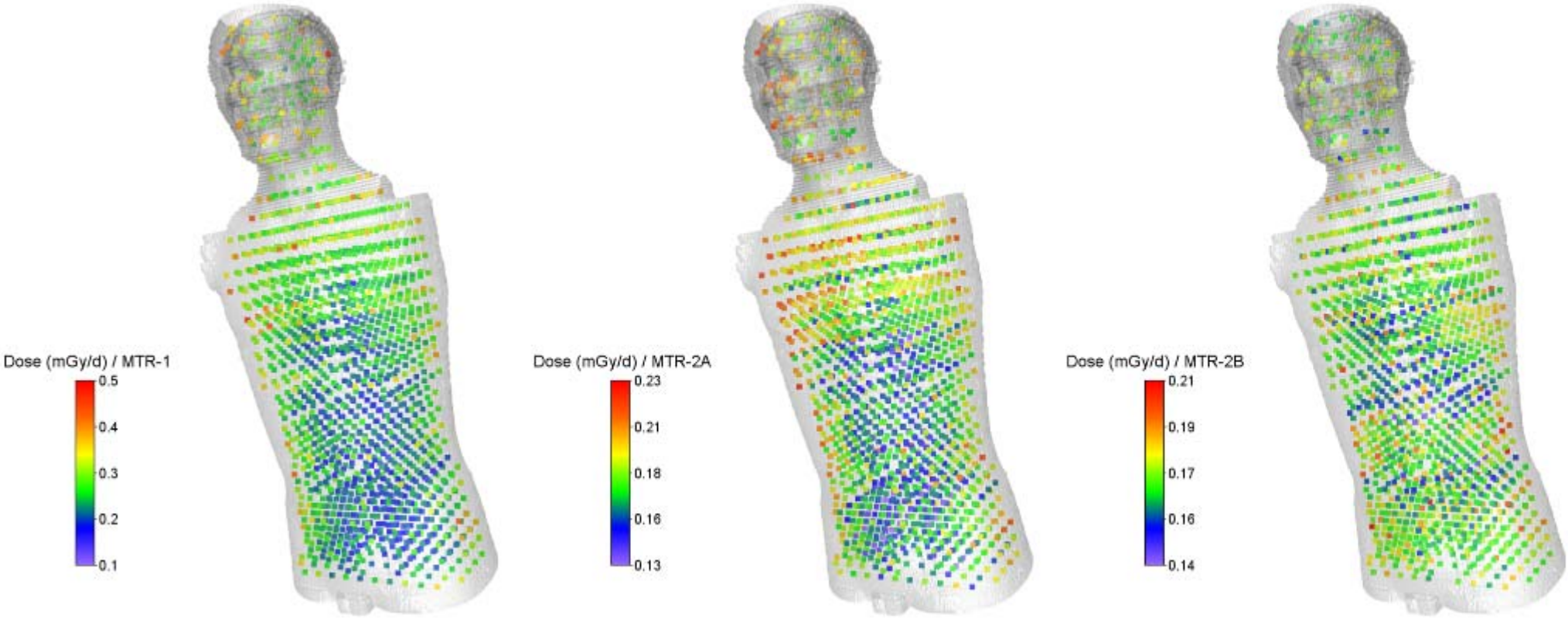


Figure WP1-6: MTR – All missions 3D: Absorbed dose distribution for the MTR-1 (a) and the MTR-2A (b) experiment measured by ~4,800 thermoluminescence dosimeters distributed in the MATROSHKA torso

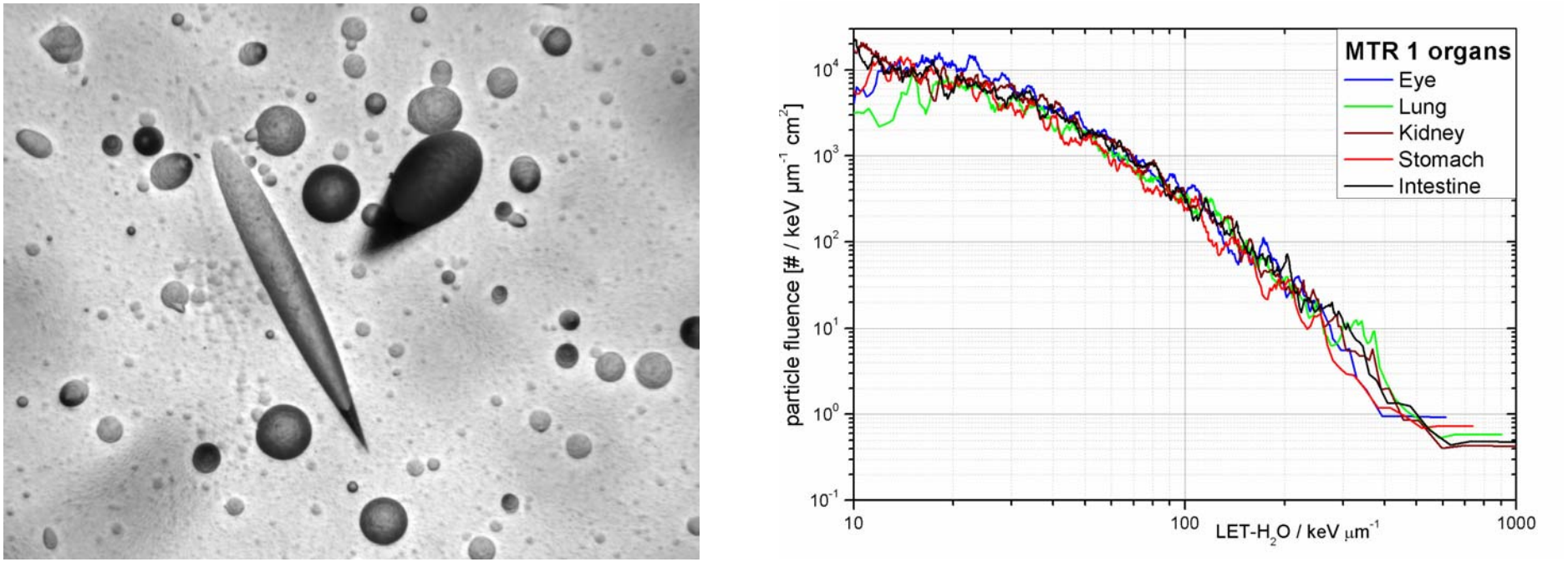


Figure WP1-7: MTR CR-39: (a) left part of the figure shows a picture of nuclear track etch detector exposed during the MATROSHKA-2A mission with a dimension of 320 x 150 µm. Each visible track (round or elliptical shaped) accounts for one heavy charged particle passing the detector surface. (b) the right part of the figure shows an example of measured Linear Energy transfer spectra – showing the fluence of heavy ions in dependence on their LET.

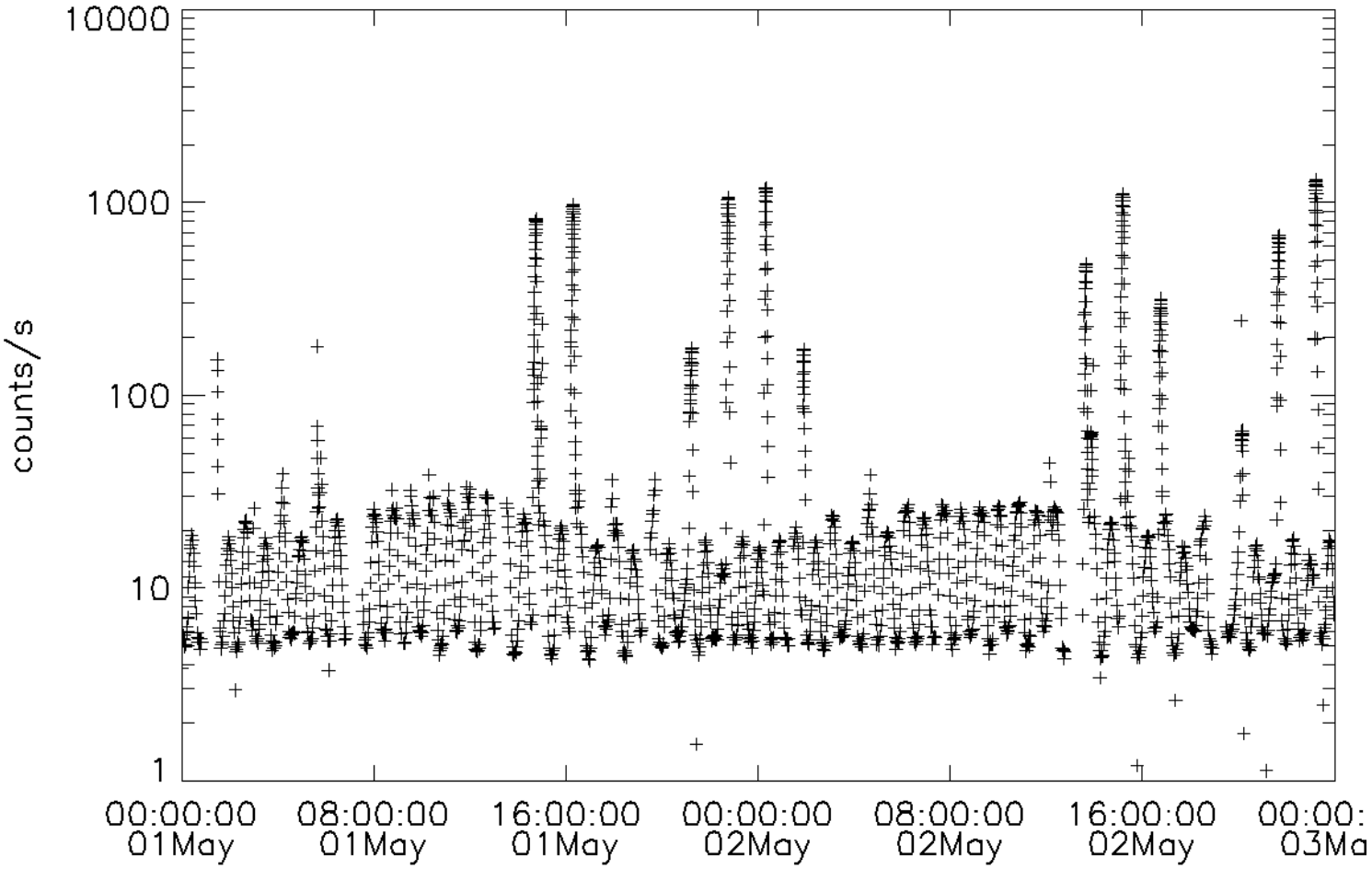


Figure WP1-8: DOSTEL-1: Active dosimetry telescope DOSTEL count rates measured in the silicon detector for a two day time interval in May 2004.

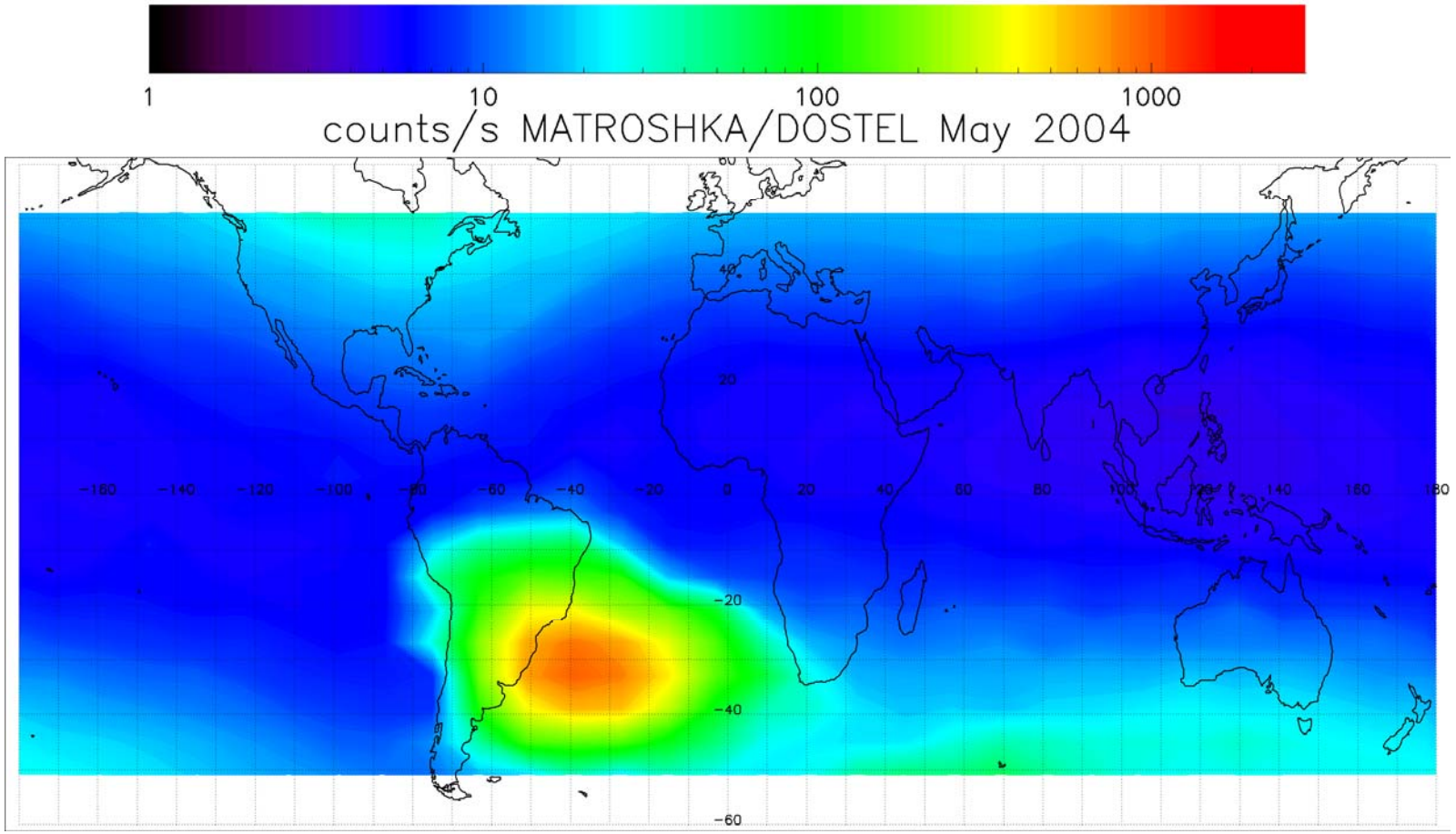


Figure WP1-9: DOSTEL-2: Active dosimetry telescope DOSTEL count rates over the orbit of the space station highlighting passage for different time periods as well as the change in radiation environment conditions over time and orbit of the space station.

Table WP1-1: DOSTEL-MTR-1: Results measured by the active DOSTEL instrument located on top of the head of the MATROSHKA facility for the outside MATROSHKA-1 experiment

Experiment phase		Dose Equivalent H (µSv/day)	Absorbed Dose D (µGy/day)	Mean Quality Factor Q
MTR-1 (2004–2005)	Galactic Cosmic Rays (GCR)	245	78	3.2
	South Atlantic Anomaly (SAA)	367	296	1.2
	Total	**612**	**374**	**1.6**

Table WP1-2: DOSTEL-MTR-2B: Results measured by the active DOSTEL instrument located on top of the head of the MATROSHKA facility for the inside MATROSHKA-2A experiment

Experiment phase		Dose Equivalent H (µSv/day)	Absorbed Dose D (µGy/day)	Mean Quality Factor Q
MTR-2B (2007–2009)	Galactic Cosmic Rays (GCR)	310	116	2.8
	South Atlantic Anomaly (SAA)	72	46	1.6
	Total	**382**	**162**	**2.4**

WP2: Detector Characterization

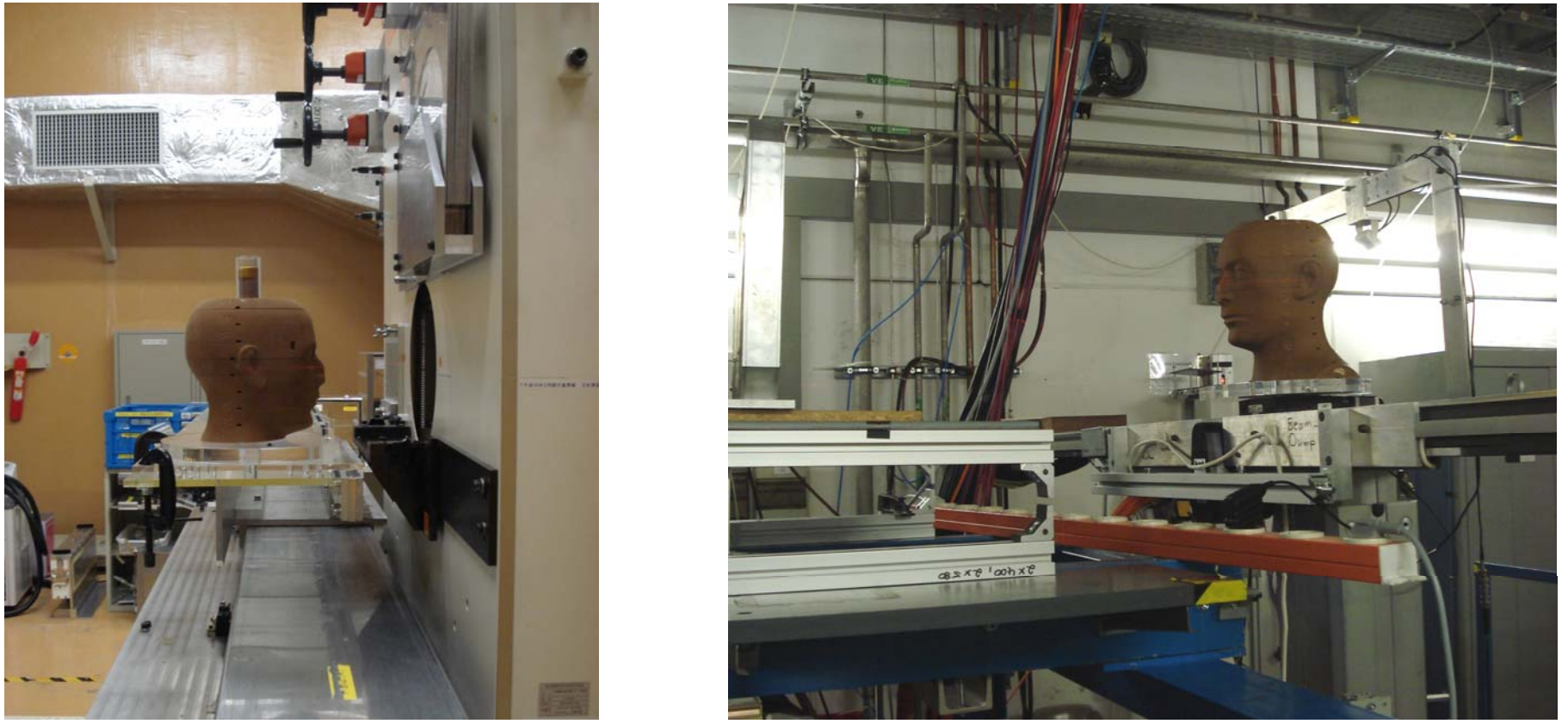
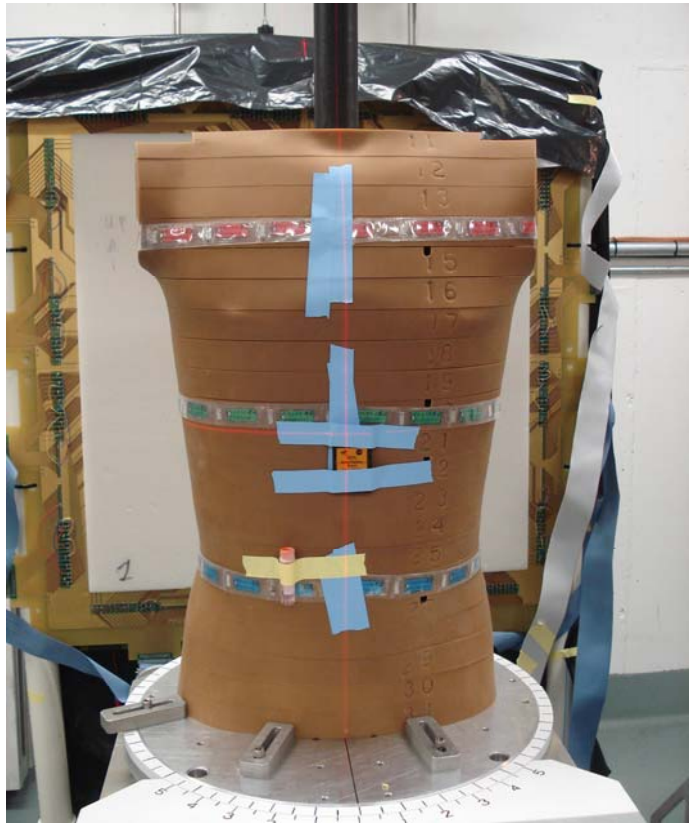


Figure WP2-1: HIMAC-GSI: (a) left part of the figure: The phantom head positioned for the ion irradiation at the Heavy Ion Medical Accelerator (HIMAC) at the National Institute of Radiological Sciences (NIRS), Chiba, Japan and (b) right part of the figure: at the Gesellschaft für Schwerionenforschung (GSI), Darmstadt, Germany.



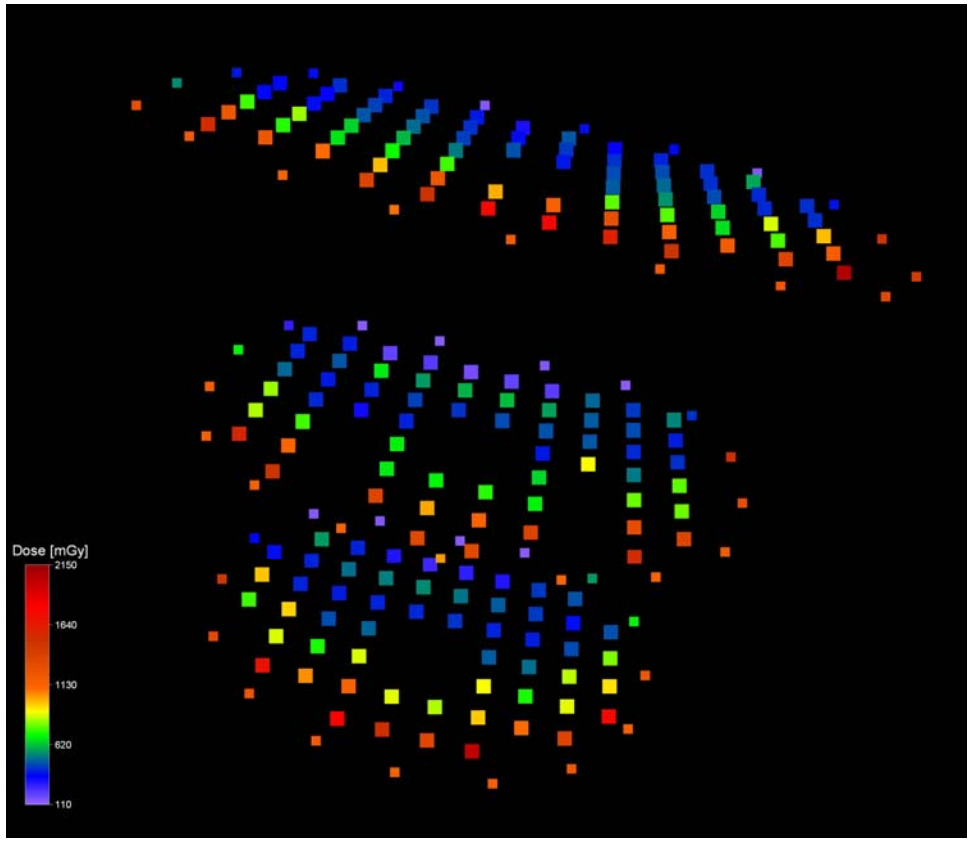
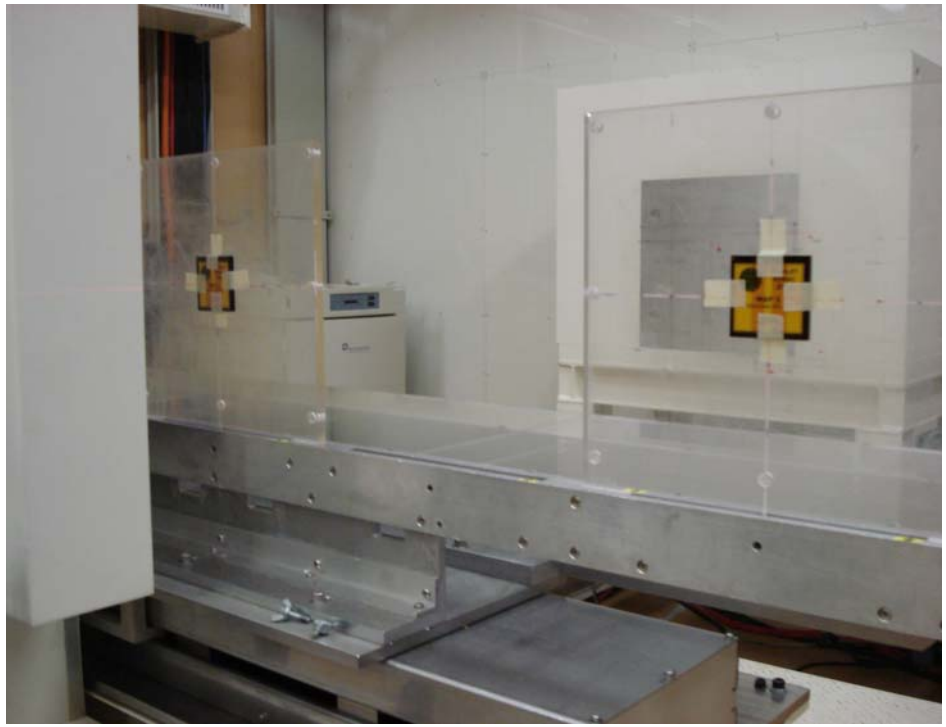


Figure WP2-2: NSRL: The MATROSHKA ground based phantom at the NSRL in Brookhaven, USA for the simulation of a Solar Particle Event (left); the depth doseprofile measured with thermoluminescence detectors after irradiation with 1 Gy of absorbe dose given by protons simulating a Solar Particle Event



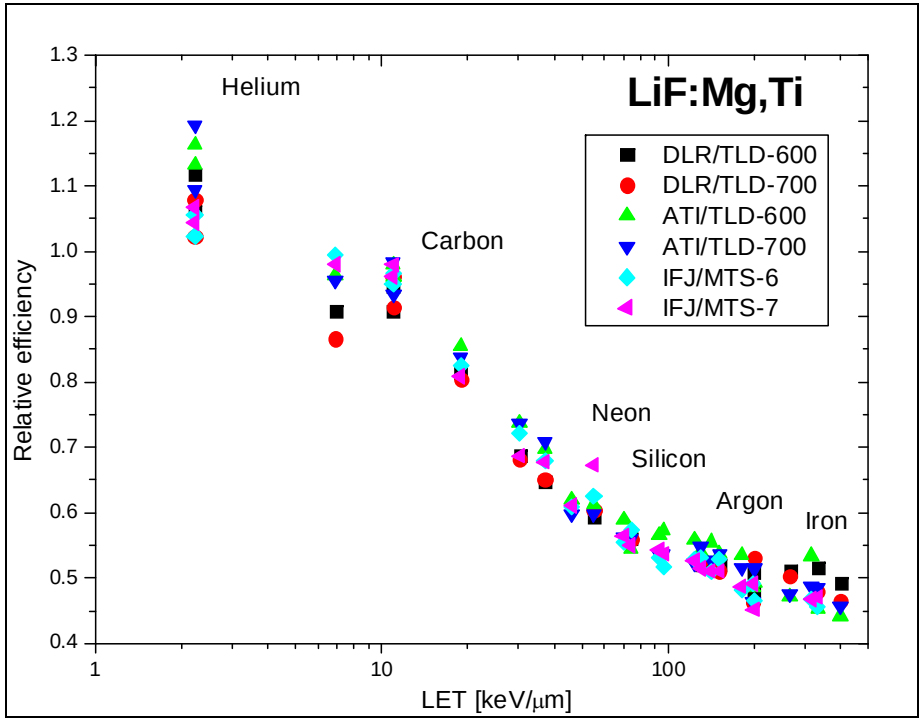


Figure WP2-2: TLD -1: (a) left part of the figure: Thermoluminescene detectors in detector holders exposed to heavy ions at the HIMAC at NIRS, Chiba, Japan (b) right part of the figure: The relative thermoluminescence efficiency vs. LET for various LiF:Mg,Ti detectors used by the HAMLET partners.

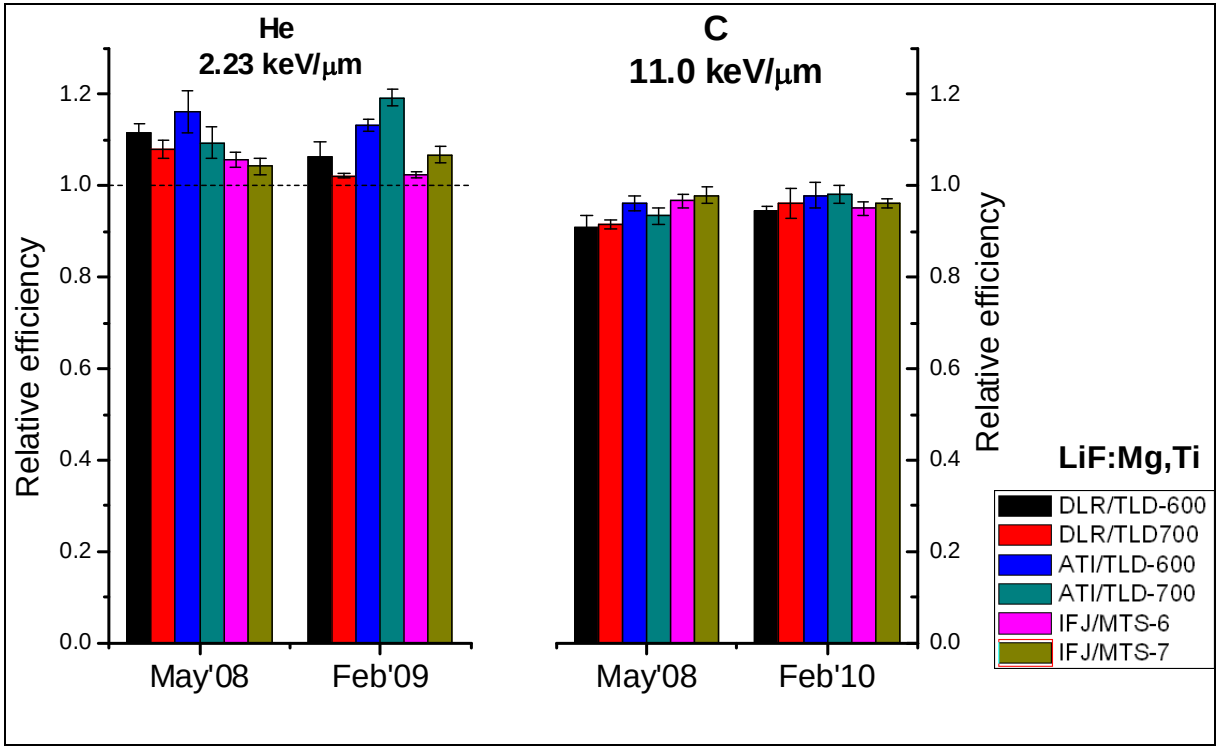
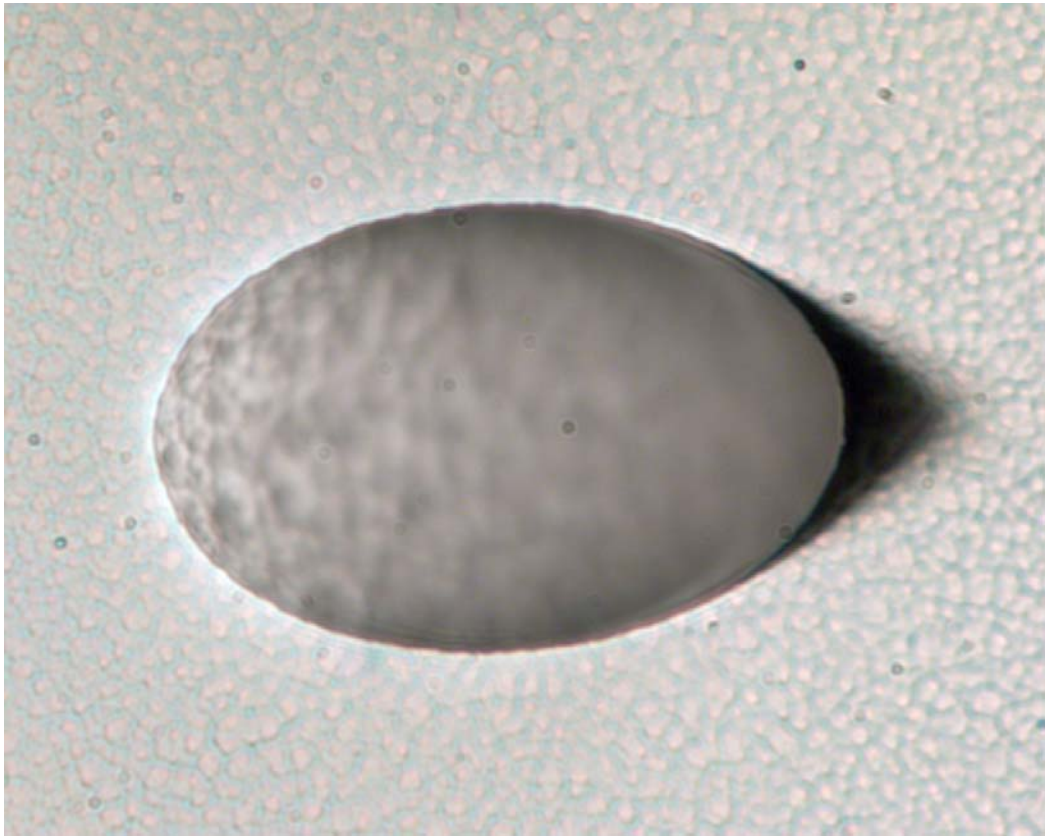


Figure WP2-3: TLD-2: Comparison of relative thermoluminescence efficiency of various TLDs measured during different irradiation campaigns at the HIMAC for helium and carbon ions.



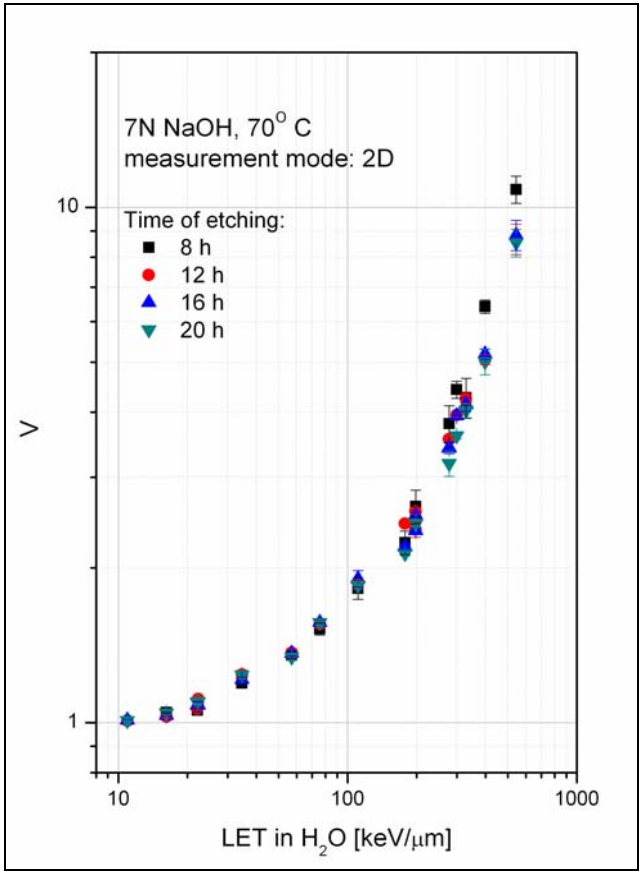
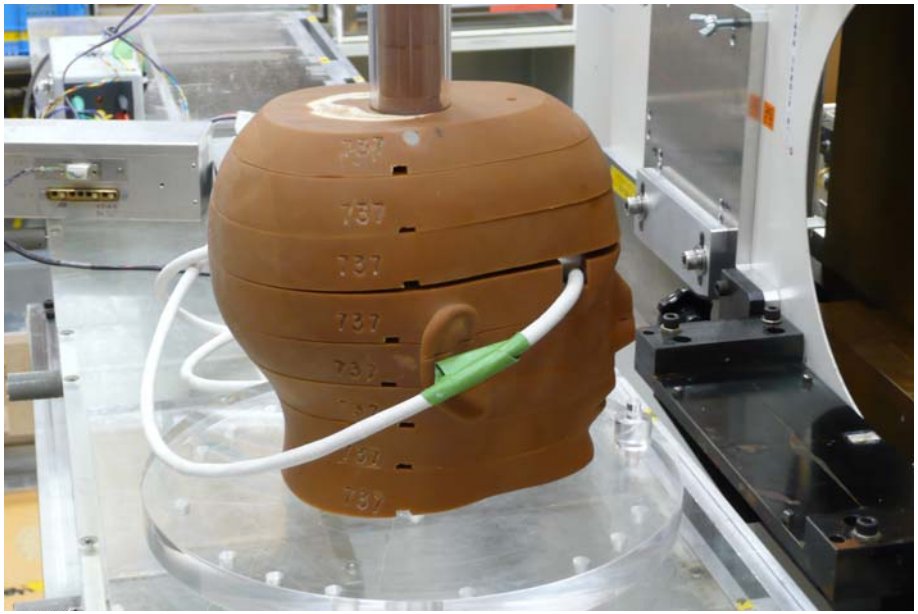


Figure WP2-4: CR-39: (a) left part of the figure: A microscopic picture of an iron ion passing through a CR-39 detector and (b) right part of the picture: the calibration curve (etch rate ratio vs. LET) for PNTD from IFJ, Krakow, Poland as measured for of ions from HIMAC and GSI exposures.



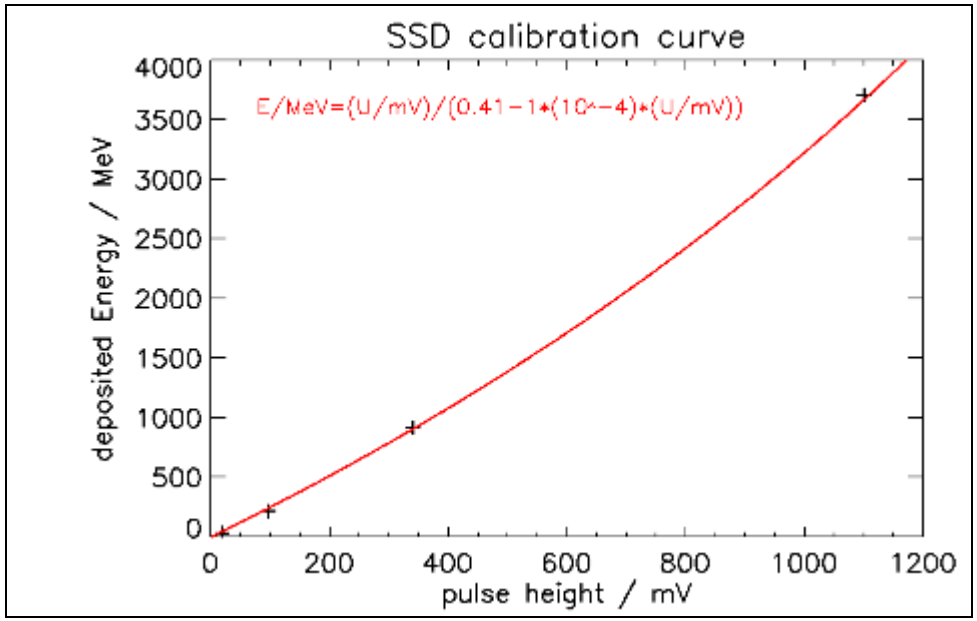


Figure WP2-5: SSD-Detectors: (a) left part of the figure: The SSD Detector positioned inside the head of MATROSHKA and (b) right part of the figure: the relevant calibration curve established based on the calibrations performed at the HIMAC at NIRS, Chiba, Japan

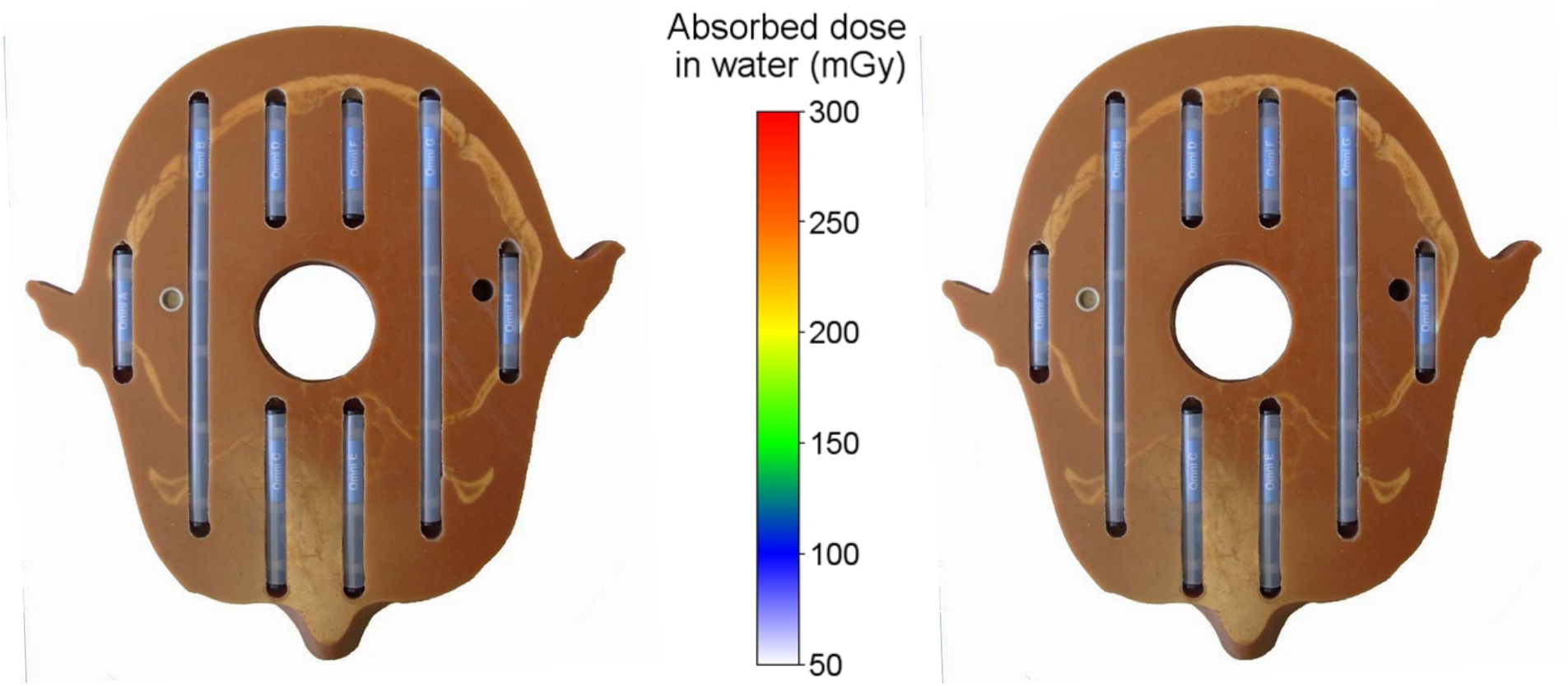


Figure WP2-6: HIMAC – Depth Dose: The dose distribution measured inside the head of the phantom (a) left part – after exposure to monodirectional Helium ions (b) right part – after exposure to omnidirectional Helium ions

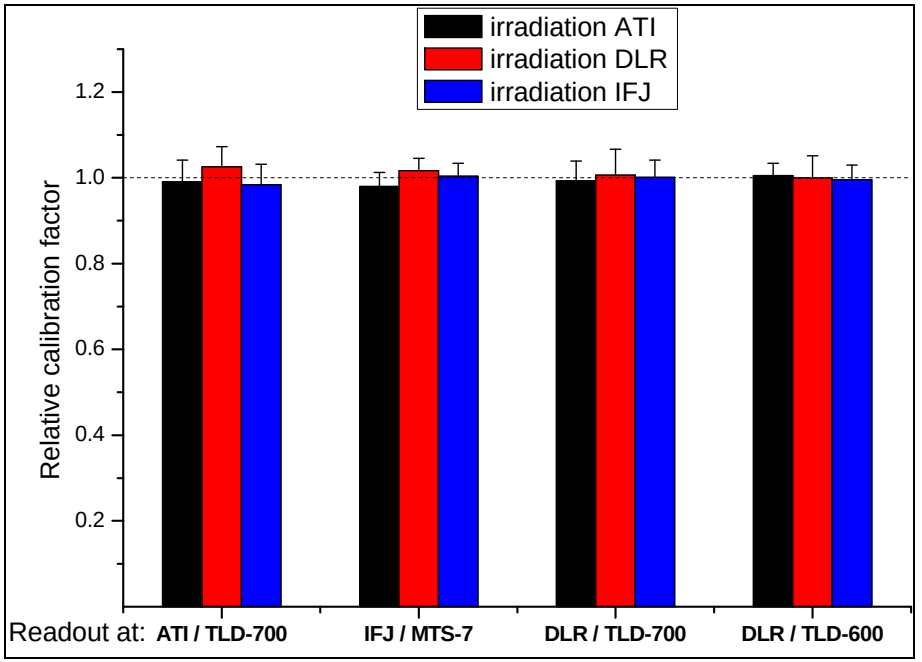


Figure WP2-6: TLD – Properties: (a) left part of the figure: Calibration stand of the Materialprüfungsamt (MPA), Dortmund, and (b) right part of the figure: Comparison of relative calibration factors for the applied thermoluminescence detectors used by the HAMLET partners in the frame of the experiment.

WP3: ISS Space Data Intercomparison

Table WP3-1: Space Experiments: Timelines of MATROSHKA and other radiation-related research conducted in parallel on the ISS. Green: external exposure; blue: Pirs Module; red: Zvezda Service Module.

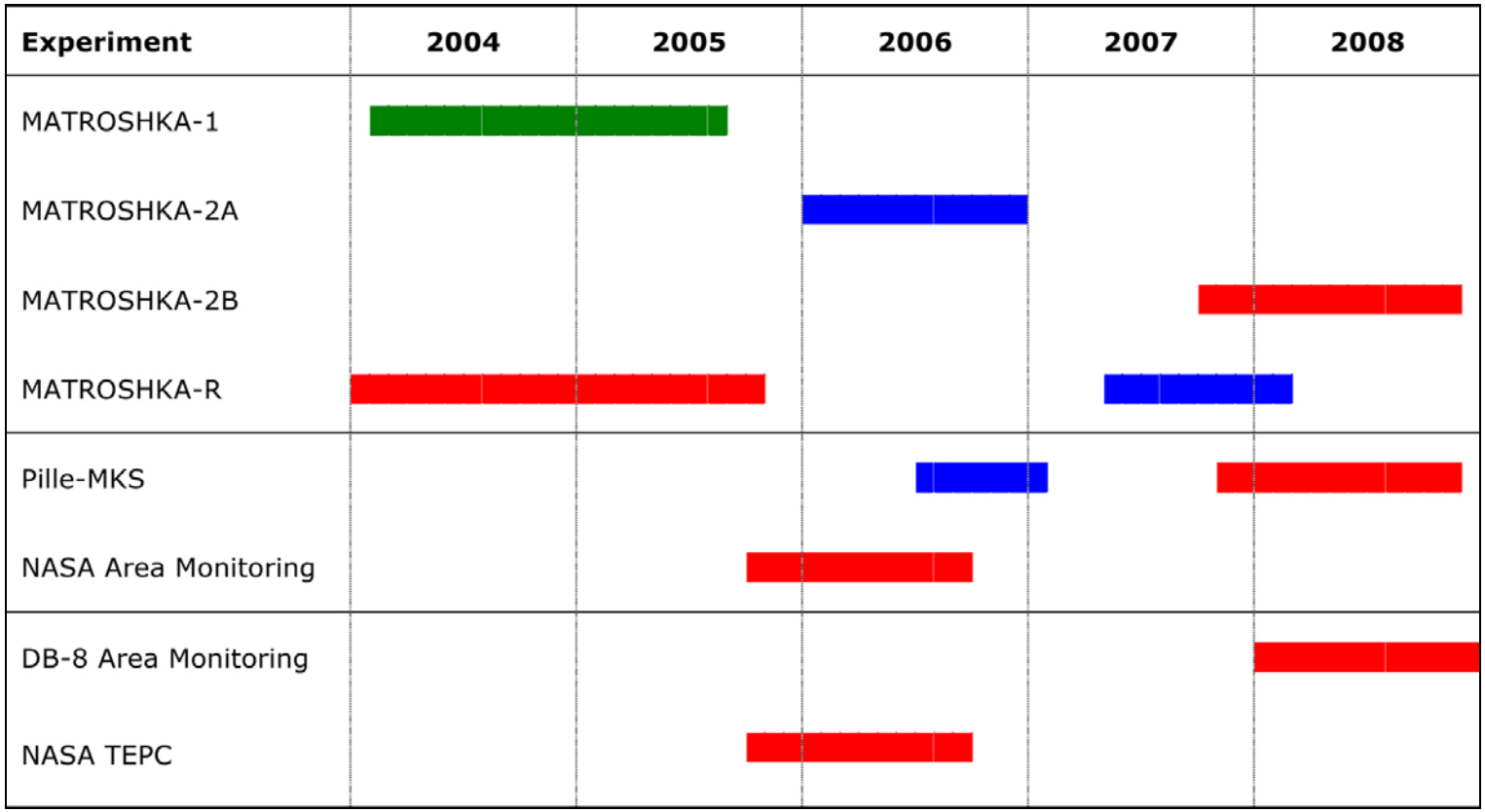


Figure WP3-1: HAMLET-Database-Literature: A comprehensive literature database has been setup and updated frequently on the HAMLET website.

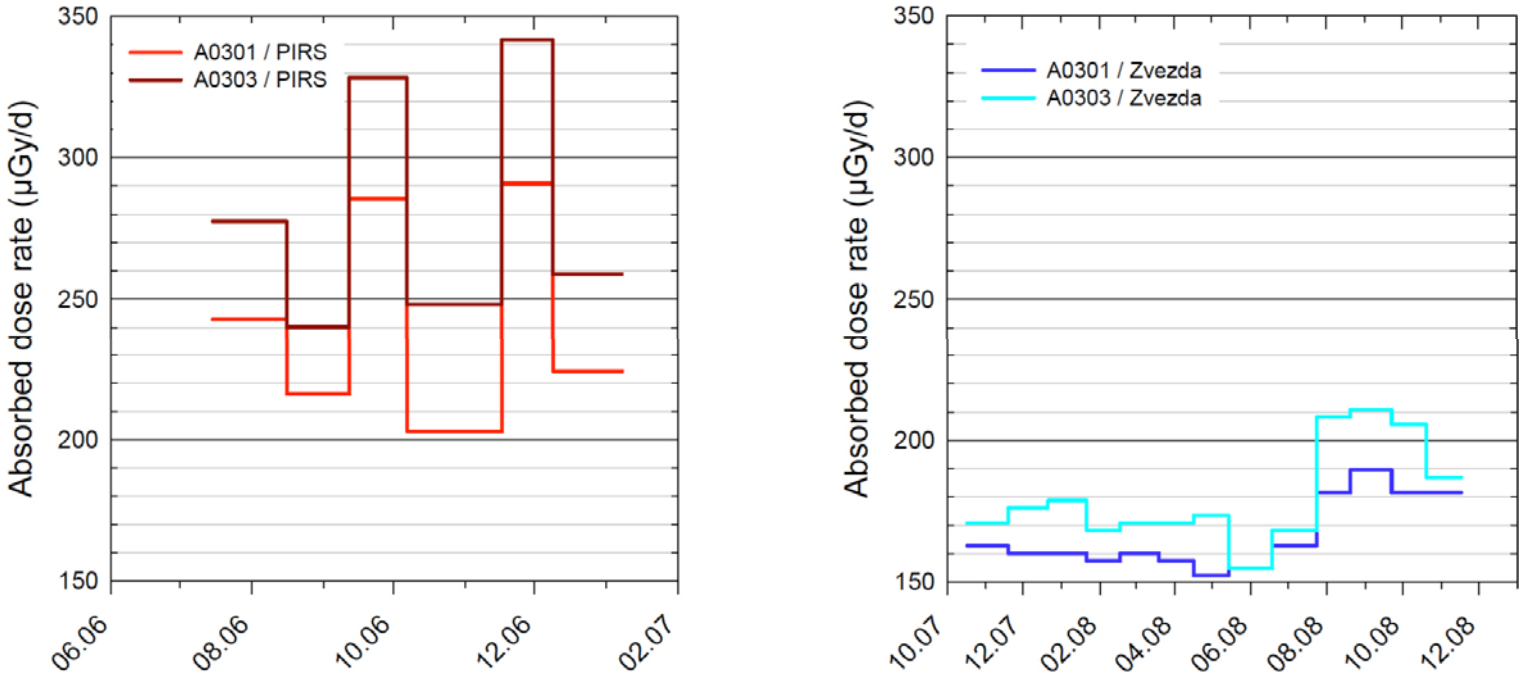


Figure WP3-2: PILLE –Results: Dose rates determined by Pille-MKS $CaSO_4$:Dy thermoluminescence dosimeter bulbs attached to different sides of the MATROSHKA containment during the exposures in Pirs (left) and Zevzda (right) proved to be in overall agreement with the mission-averaged dose rates of 235 ± 12 µGy/d in Pirs and 180 ± 9 µGy/d in Zvezda determined at the surface of MATROSHKA.

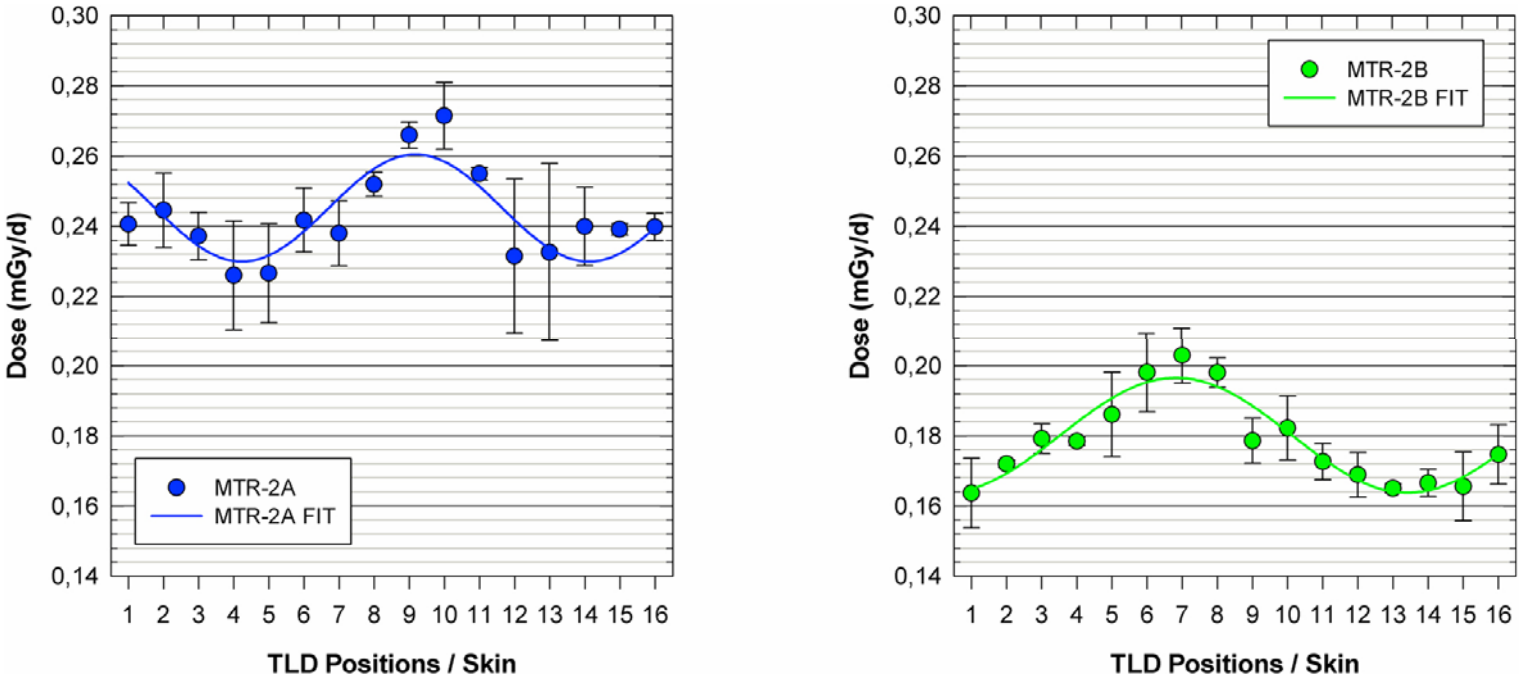


Figure WP3-3: MTR-Skin dose: The skin dose profile measured in the anthropomorphic MATROSHKA mannequin in Pirs (left) and Zvezda (right) showed a high level of both qualitative and (particularly for the heavier shielded Zvezda Service Module) quantitative consistency with dose distributions determined in the MATROSHKA-R spherical phantom (Pirs: 0.24–0.36 mGy/d; Zvezda: 0.17–0.28 mGy/d).

WP4: Experimental and Calculated 3D Radiation Model

Figure WP4-1: CT-Model: The figures shows from left to right (a) the real MATROSHKA phantom, (b) and (c) CT scans of the MATROSHAK phantom, (d) the Voxel phantom NUNDO with the relevant organs.

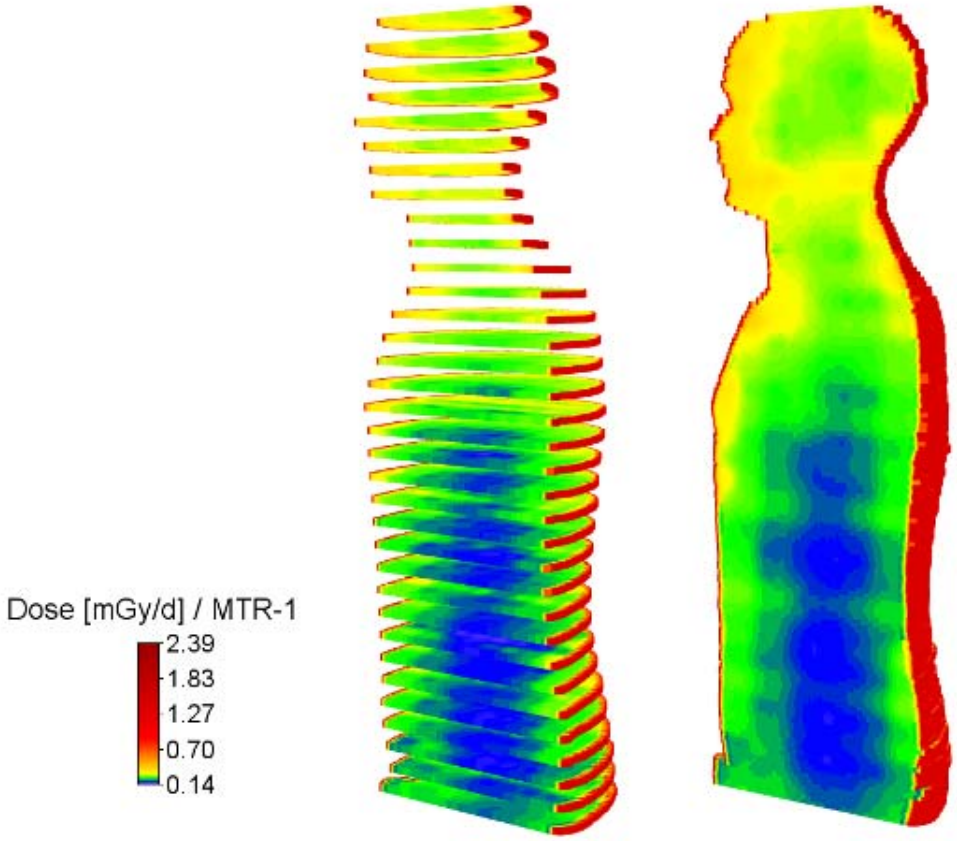


Figure WP4-2: MTR-1 3D: The 3D dose distribution for the MATROSHKA-1 experiment based on the results from the measurements inside the phantom combined with the data from the skin dose measurements

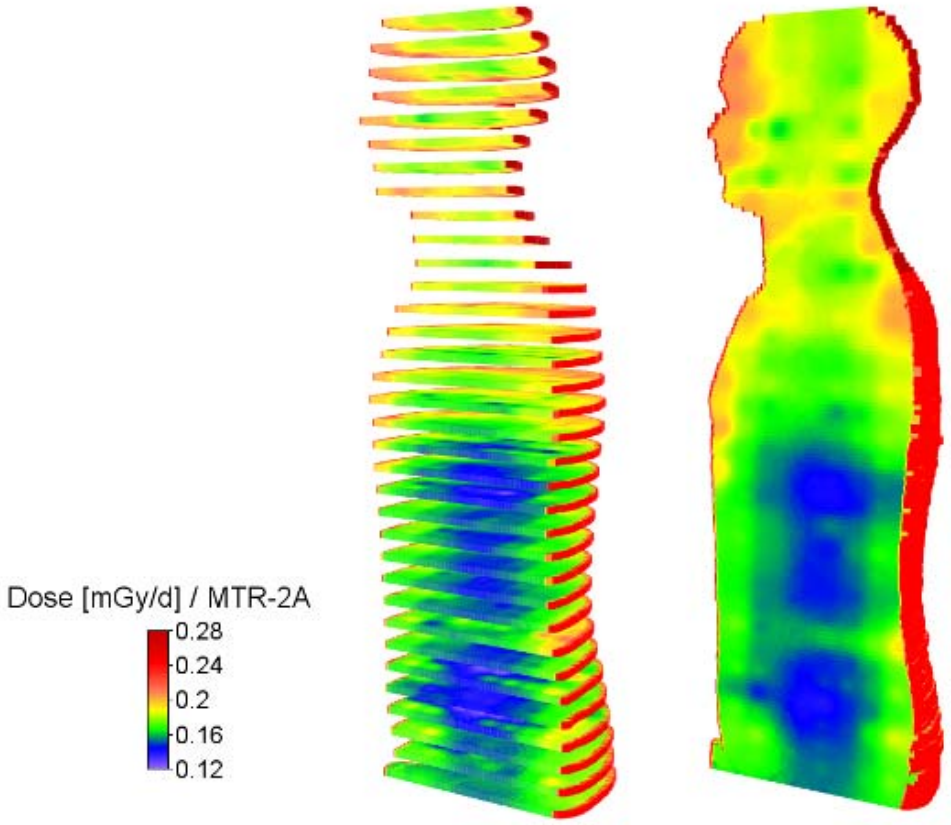


Figure WP4-3: MTR-2A 3D: The 3D dose distribution for the MATROSHKA-2A experiment based on the results from the measurements inside the phantom combined with the data from the skin dose measurements

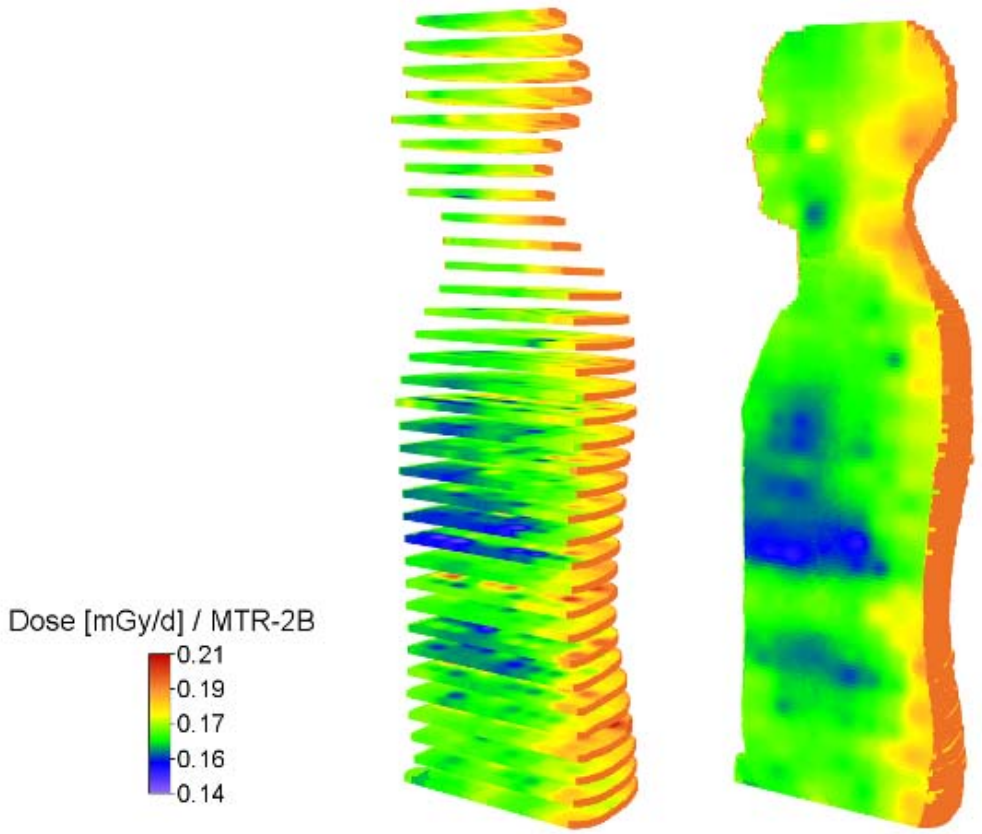


Figure WP4-4: MTR-2B 3D: The 3D dose distribution for the MATROSHKA-2A experiment based on the results from the measurements inside the phantom combined with the data from the skin dose measurements

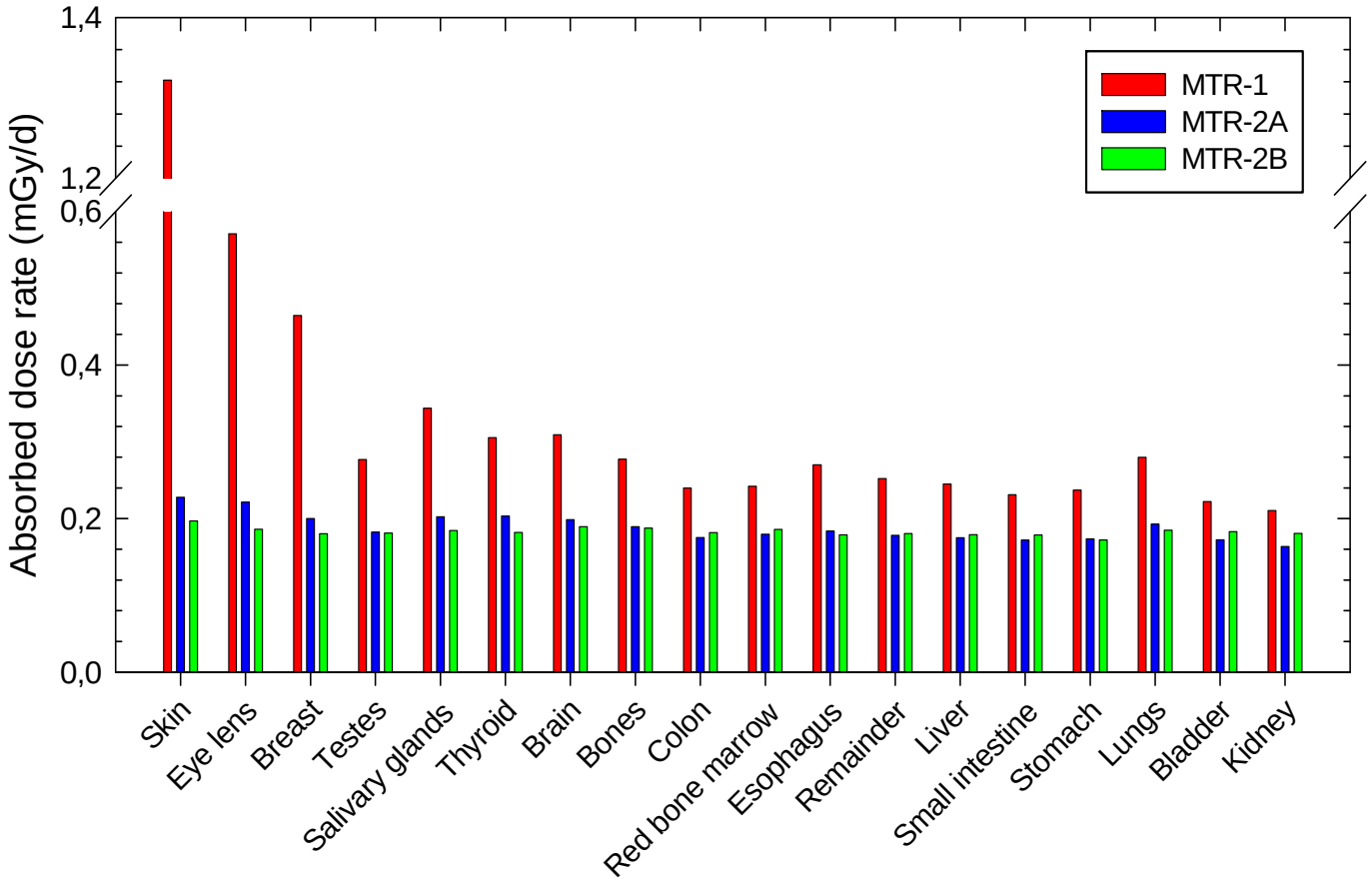


Figure WP4-5: MTR Organ Absorbed Dose: The organ absorbed doses for the MATROSHKA-1 the MATROSHKA-2A and the MATROSHKA-2B experiment

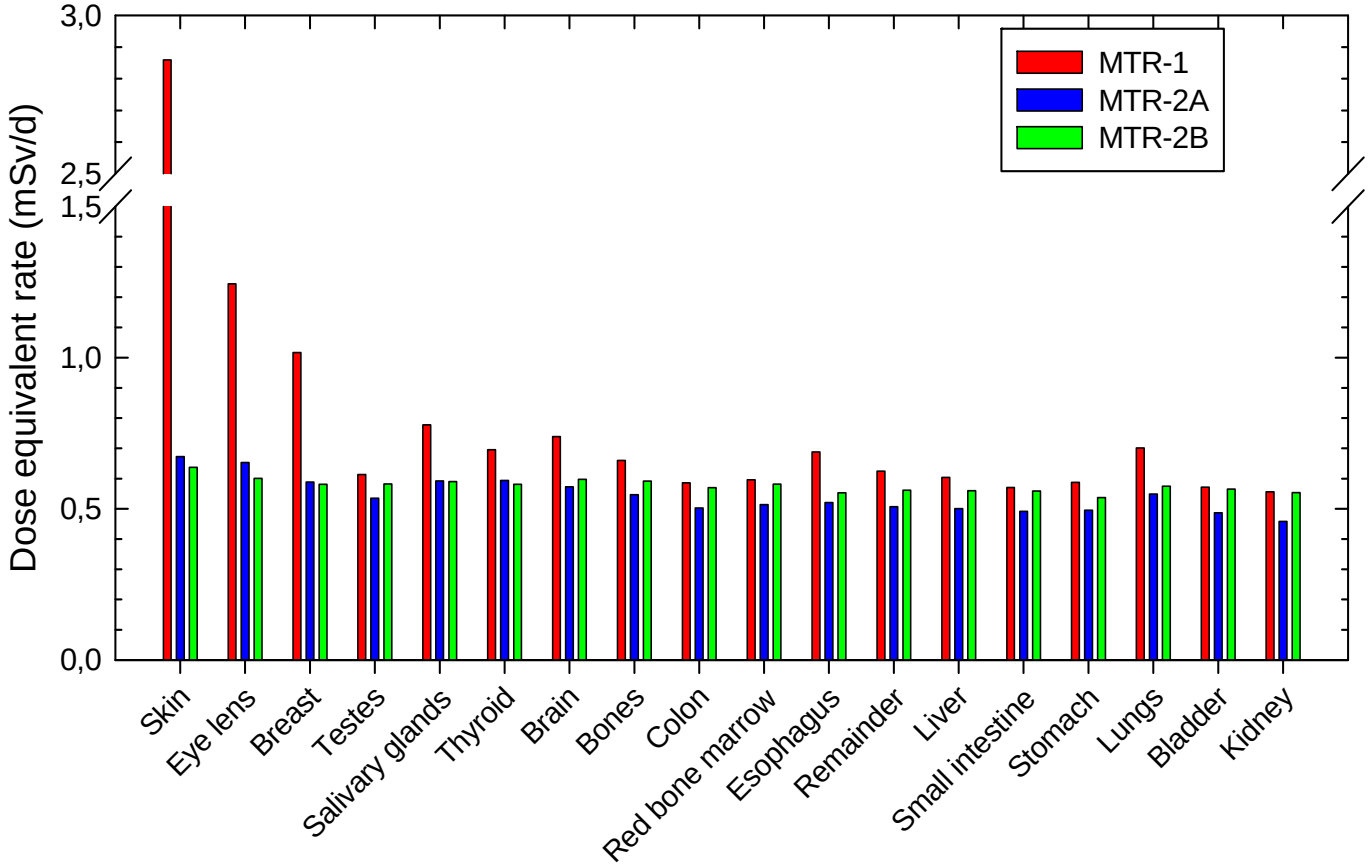
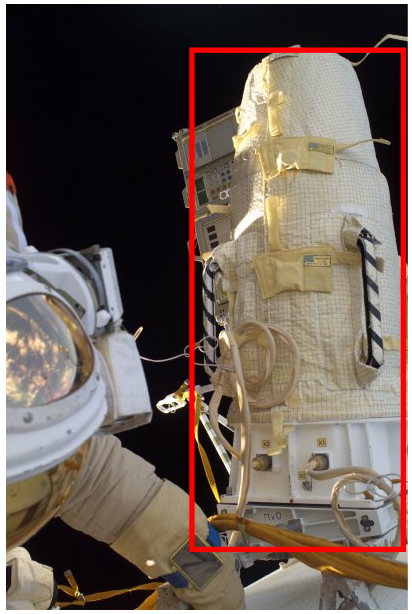


Figure WP4-6: MTR Organ Dose Equivalent: The organ dose equivalent for the MATROSHKA-1 the MATROSHKA-2A and the MATROSHKA-2B experiment



MATROSHKA-1
Effective Dose (mSv/d)
0.69

MATROSHKA-2A
Effective Dose (mSv/d)
0.53

MATROSHKA-2B
Effective Dose (mSv/d)
0.57

Figure WP4-7: MTR Effective Dose: The effective dose for the MATROSHKA-1 the MATROSHKA-2A and the MATROSHKA-2B experiment

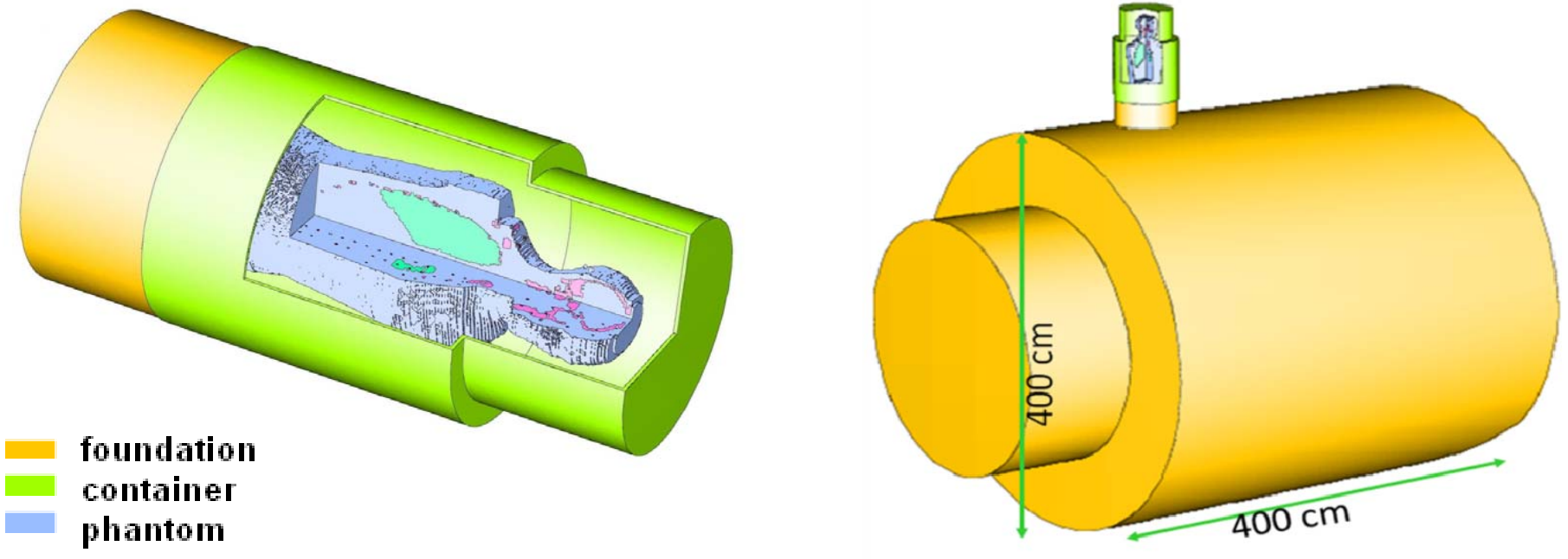


Figure WP4-8: MTR-1 Simulation Set up: The simulated geometry of the phantom, container and foundation (a) and the simplify ISS geometry with MTR facility (b) as input for the calculations performed for the MATROSHKA-1 outside exposure

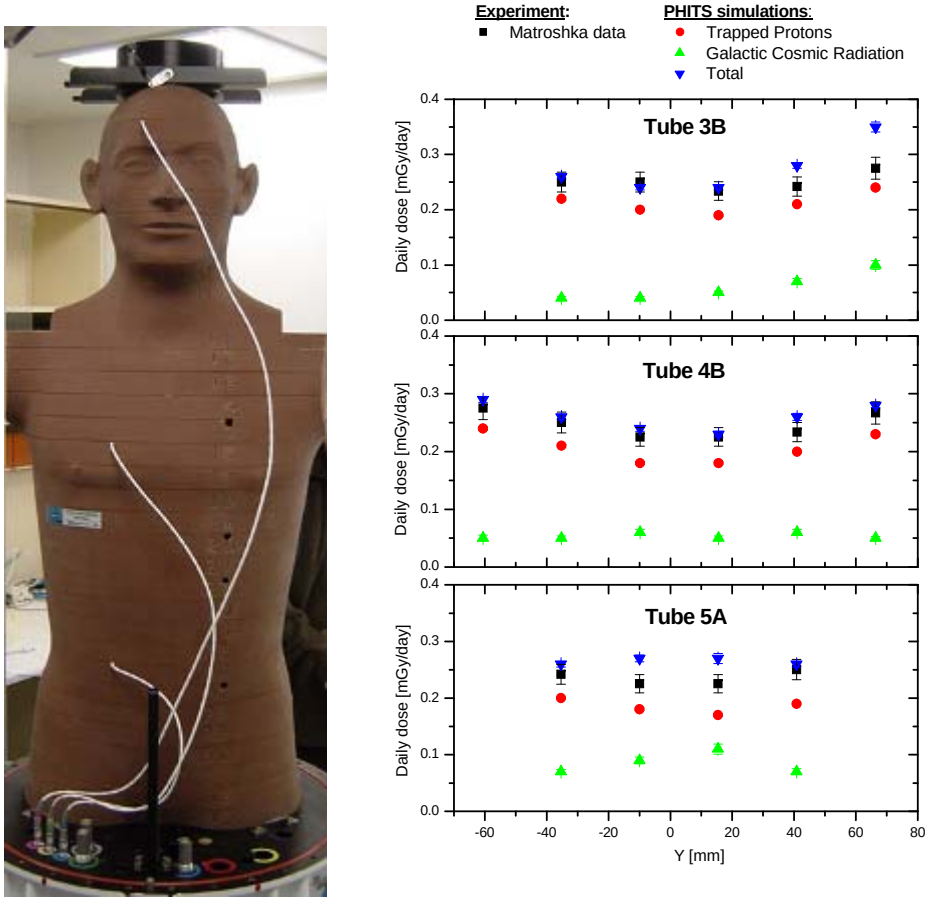


Figure WP4-9: Simulation Results 1: Simulated daily doses values for slices 3-5 compared to the MTR experimental data ATI, IFJ and DLR.

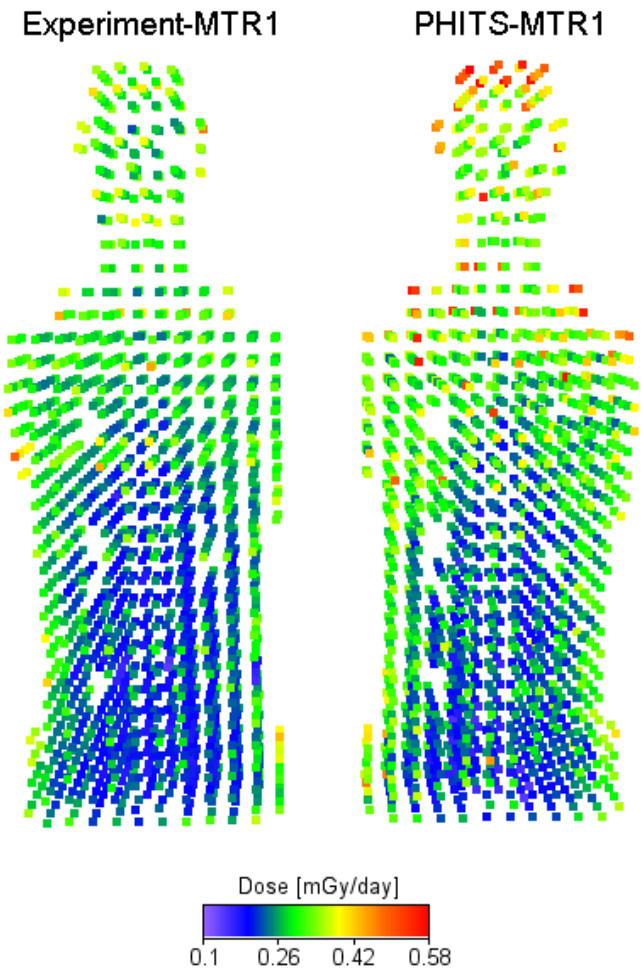


Figure WP4-10: Simulations Results 2: Comparison of simulated and measured discrete dose values within the MATROSHKA-1 experiment.

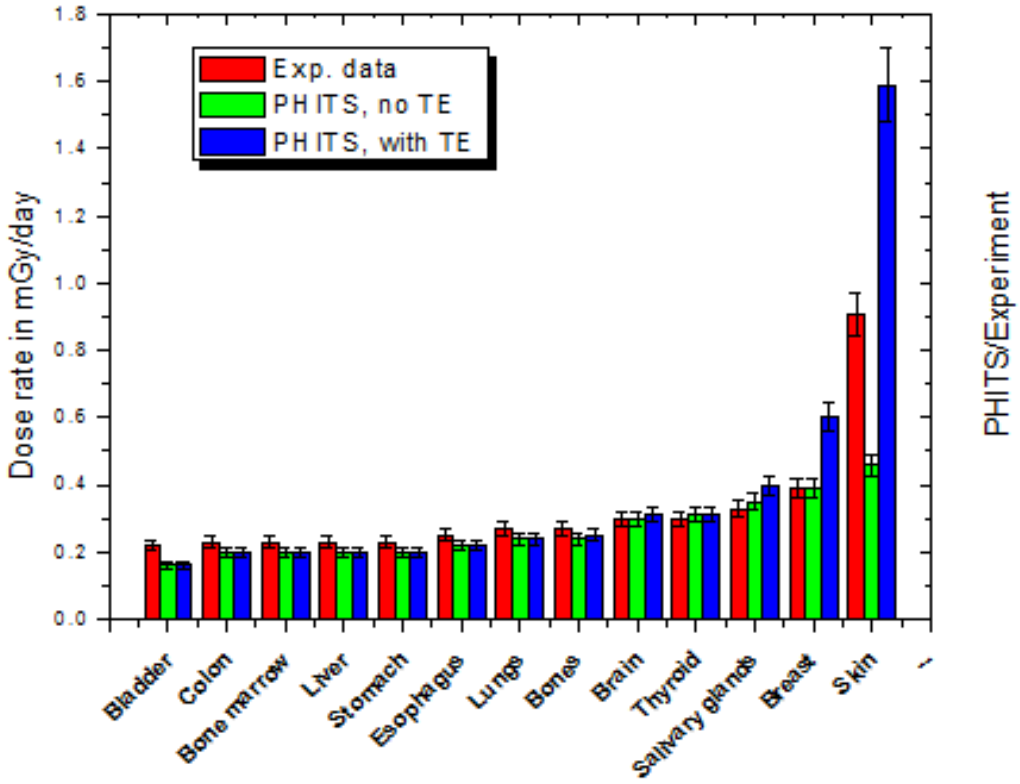


Figure WP4-10: Organ Dose: Comparison of simulated organ dose rates to the MTR-1 experimental data. Simulations were done for TP and TE at solar minimum and GCR for year 2004.

Table WP4-1: Organ Dose: Organ dose and dose equivalent rates, as simulated by PHITS, in comparison to the corresponding measured data in MTR-1 experiment outside the ISS.

	Dose rate (mGy/day)		Dose equivalent rate (mSv/day)	
Organ/tissue	**Measured**	**Calc.**	**Measured**	**Calc.**
Skin	0.94	1.59	1.64	1.87
Salivary glands	0.33	0.39		0.56
Breast	0.39	0.62		0.88
Lungs	0.26	0.25		0.41
Esophagus	0.24	0.21		0.34
Stomach	0.24	0.20	0.62	0.33

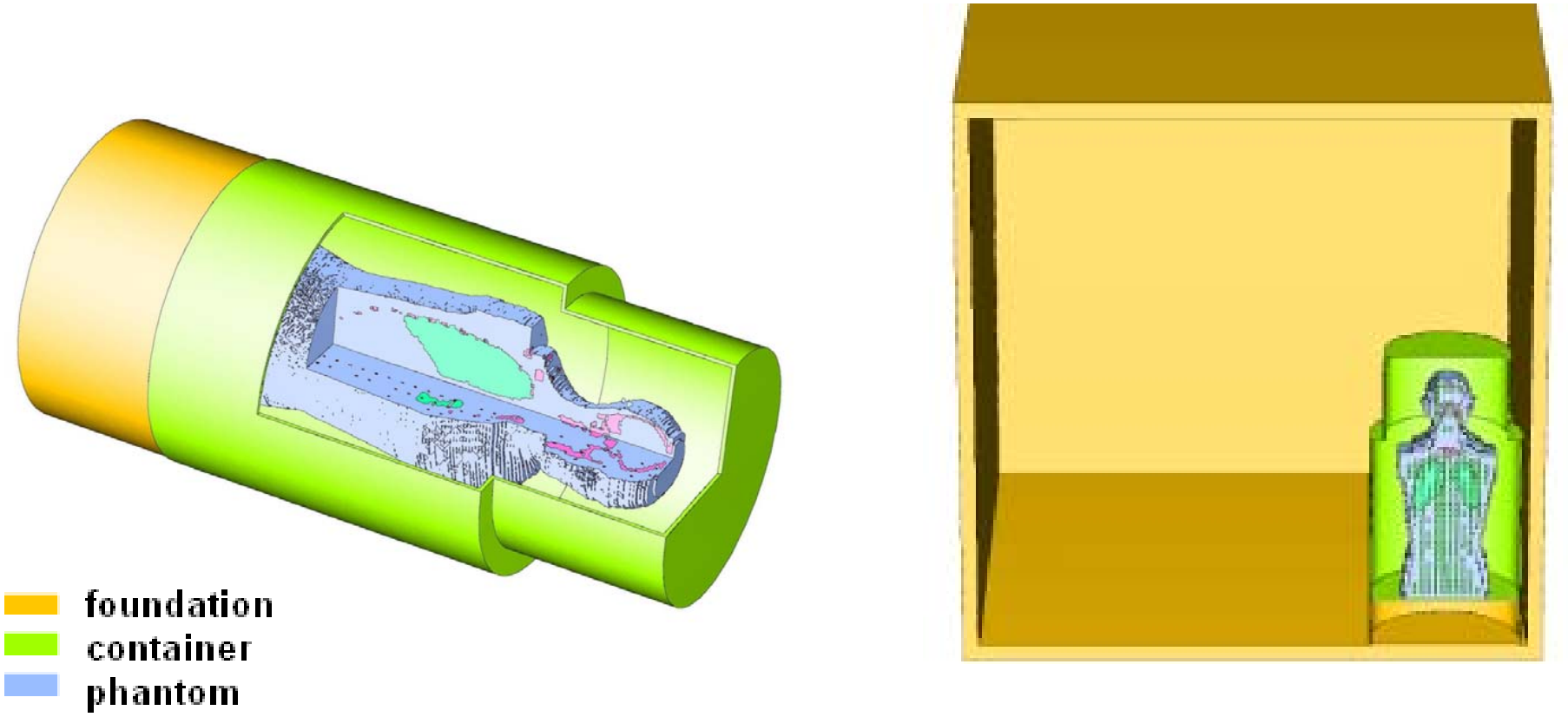


Figure WP4-11: MTR-2B Simulation Set up: The simulated geometry of the phantom, container and foundation (a) and the simplify ISS geometry with MTR facility (b) as input for the calculations performed for the MATROSHKA-2B inside exposure

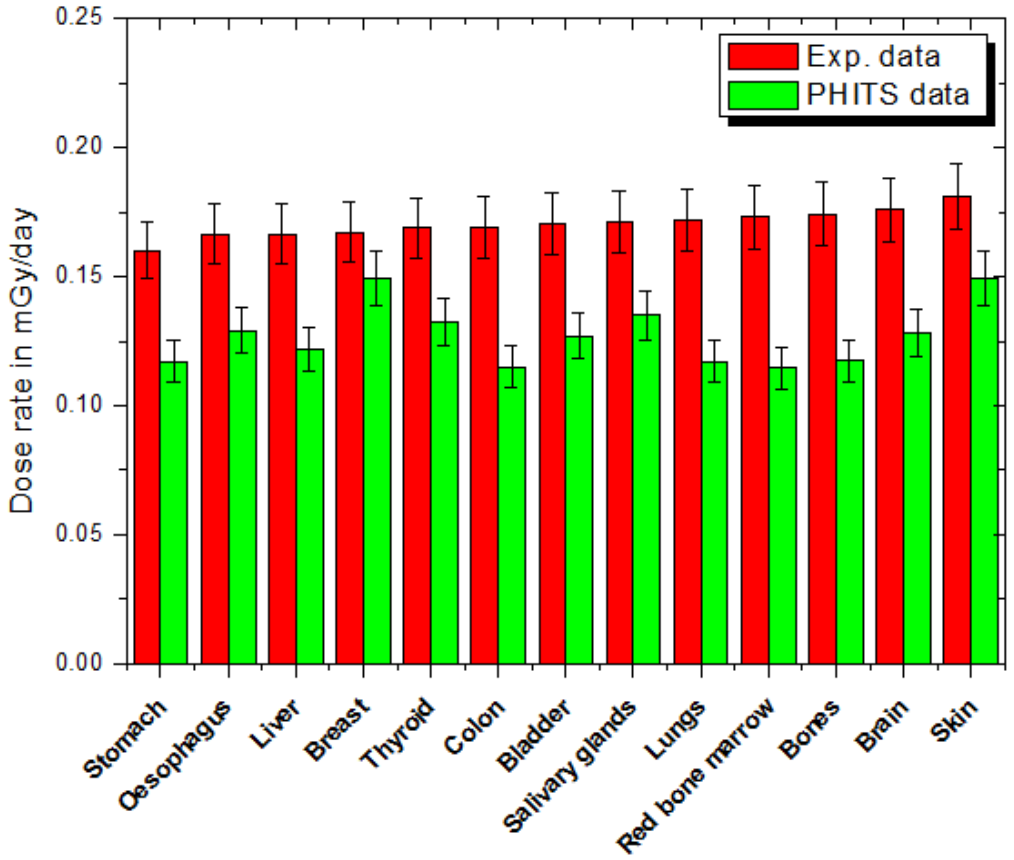


Figure WP4-11: Organ Dose MTR-2B: Comparison of the simulated organ dose rates to the MTR-1 experimental data. Simulations were done for TP and TE at solar minimum and GCR for years 2007-2009.

WP5: Dissemination of Results

Figure WP5-1: HAMLET-Science-Database: Screenshot of the MATROSHKA Data Archive included in the HAMLET webpage

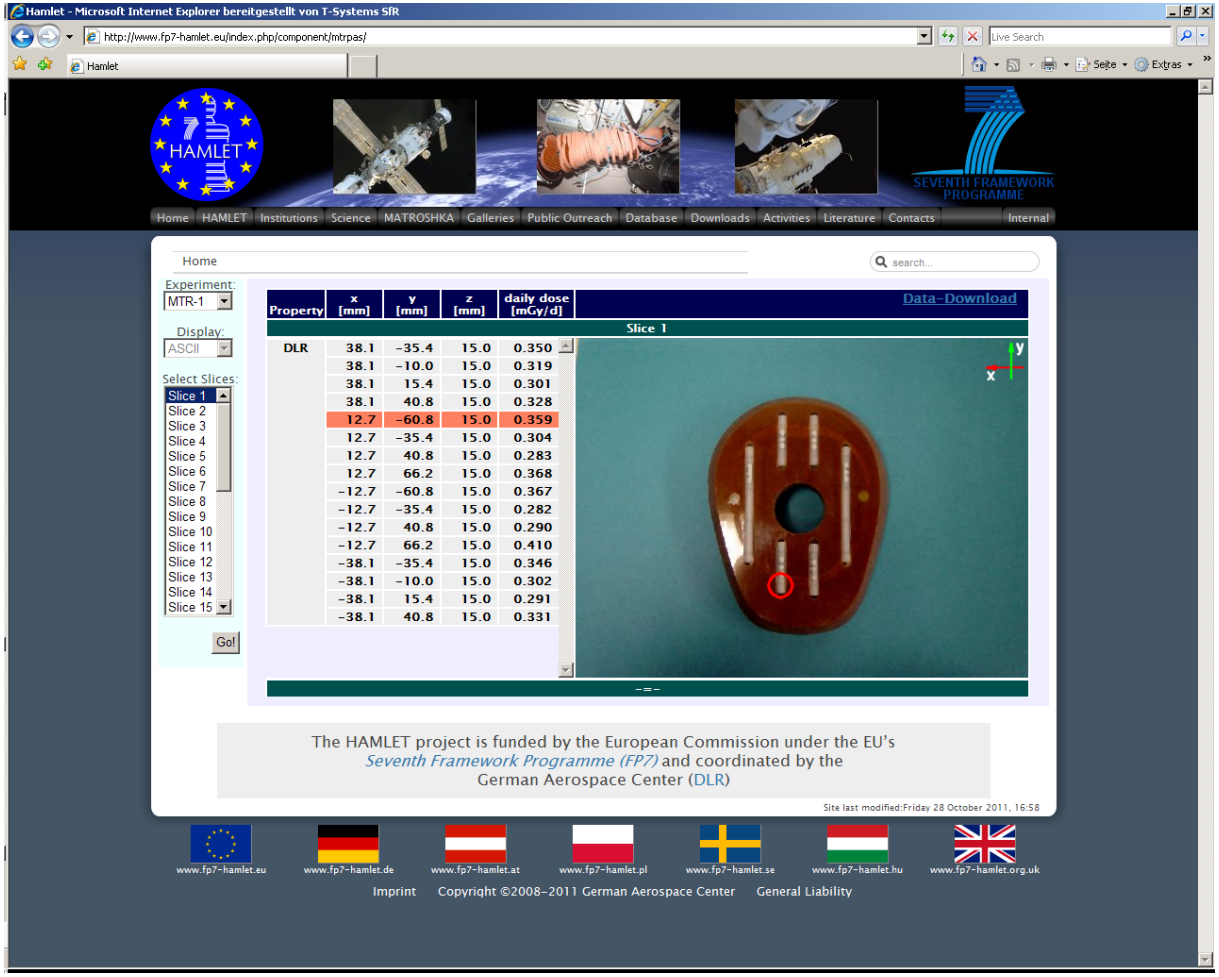


Figure WP5-2: HAMLET-Science-Database II: Screenshot of the MATROSHKA Data Archive showing one of the slices of the phantom with the related dose values recorded

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"HAMLET" IMPACT / Dissemination

Figure MAIN-1: HAMLET Webpage http://www.fp7-hamlet.eu

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Figure MAIN-2: PO-1 Vienna: HAMLET 1st Public Outreach Event, 1-2 April 2009, Vienna, Austria

Figure MAIN-3: PO-2 Oxford: HAMLET 2nd Public Outreach Event, 21 January 2010, Oxford, United Kingdom

Figure MAIN-4: PO-3 Budapest: HAMLET 3rd Public Outreach Event, 12 October 2010, Budapest, Hungary

Figure MAIN-5: PO-4 Krakow: HAMLET 4th Public Outreach Event, 5 April 2011, Krakow, Budapest

Figure MAIN-6: PO-5 Rheinbach: HAMLET 5th Public Outreach Event, 15 September 2011, Rheinbach, Germany

FP7 Project #218817 "HAMLET" WEBPAGE

http://www.fp7-hamlet.eu
http://www.fp7-hamlet.de
http://www.fp7-hamlet.at
http://www.fp7-hamlet.se
http://www.fp7-hamlet.hu
http://www.fp7-hamlet.org.uk

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