Overview on Dosimetric Activities on the ISS

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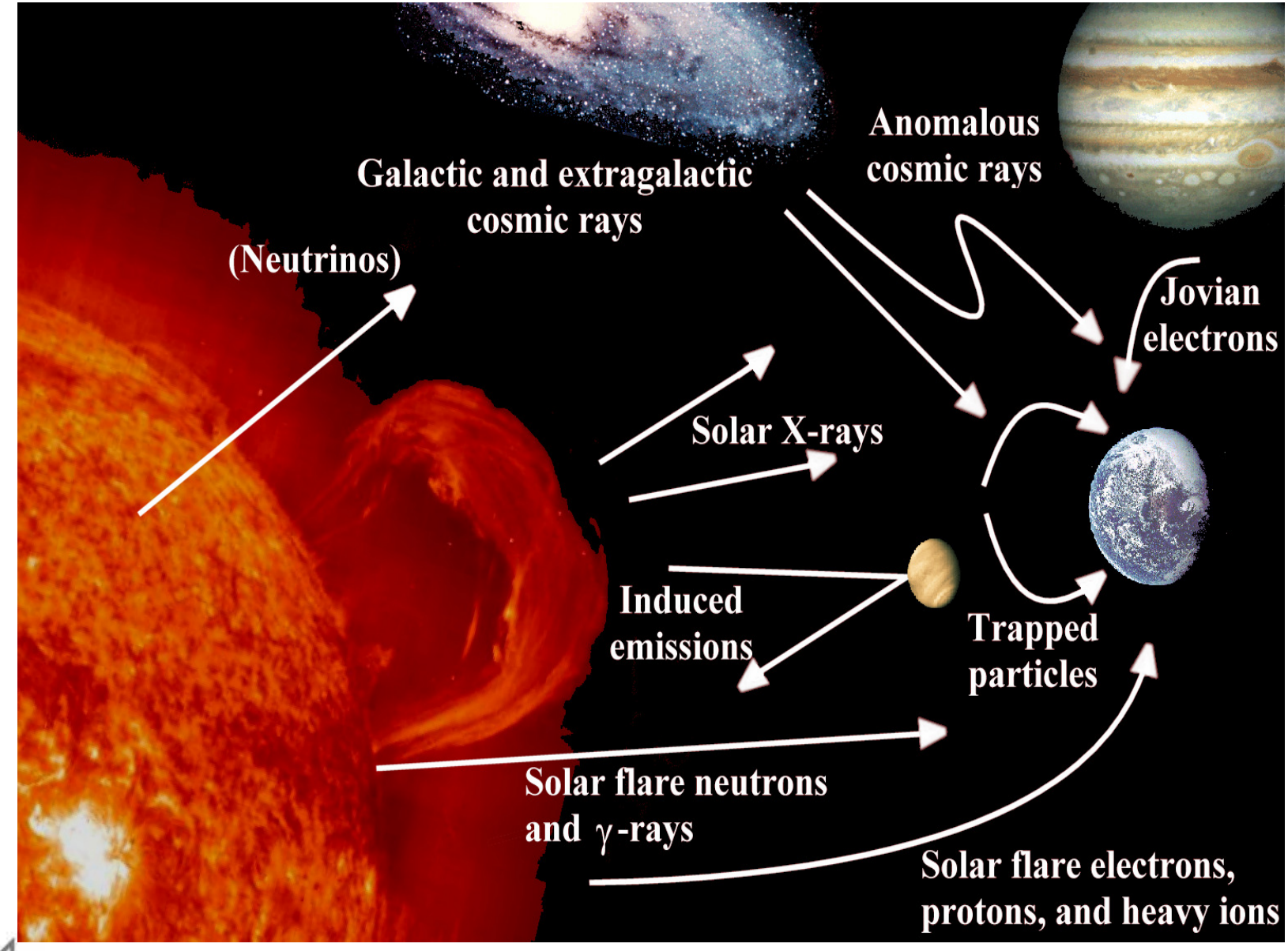
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft


Galactic and extragalactic
cosmic rays
(Neutrinos)
Anomalous
cosmic rays
Jovian
electrons
Solar X-rays
Induced
emissions
Trapped
particles
Solar flare neutrons
and γ-rays
Solar flare electrons,
protons, and heavy ions

Radiation Environment in Low Earth Orbits

- Radiation Sources
  - Galactic Cosmic Radiation (protons and heavier ions)
  - Solar particle Events (protons, low contribution of heavier particles)
  - Radiation belts (protons and electrons)
- Magnetic Field Effects
  - Solar modulation
  - Geomagnetic shielding
- Altitude Effects
- Production of Secondaries in Interactions with Shielding Material
  - Projectile and target fragments
  - Neutrons
  - Secondary protons and electrons and bremsstrahlung

Dosimetry on ISS

Operational Dosimetry

- Area Monitoring detectors from USA and RUSSIA
- Personal dosemeters from IMBP, NASA and ESA

Research projects :

- DosMap, BRADOS, MATROSHKA, MATROSHKA – R,
- ALTEA/Alteino

Primary Objectives of Operational Dosimetry

- Accurate monitoring of astronaut radiation exposure
- Implementation of ALARA Principle
- Provision of warning of heightened exposures levels
- Document and provide an archival record of each astronaut‘s radiation exposure
- Inform astronauts on their risk
- Provide evidence that no limits have been exceeded
- Provide supplimentary information related to intepreation of instrument readings and results and epidemiological assessments

Current Instrumentation

Active Detectors

- Tissue Equivalent Proportional Counter (JSC)
- IV/EV Charged Particle Directional Spectrometer (JSC)
- R 16 (IMBP)
- DB8 (Liulin Type) (IMBP/STILBAS)
- Altea/Alteino (IFN/Rome Univ.)
- Dosimetry Telescope (DLR/Univ. Kiel)
- Bonner Ball Detector
- RMD3 (JAXA/Waseda Univ.)

Semi-Active

- Pille TLD System (KFKI)

Passive detectors

- TLD/OSL (various Labs)
- CR-39 PNTD (various Labs)
- *Bubble Dosemeters (CSA)*

Area Monitoring in and outside the ISS

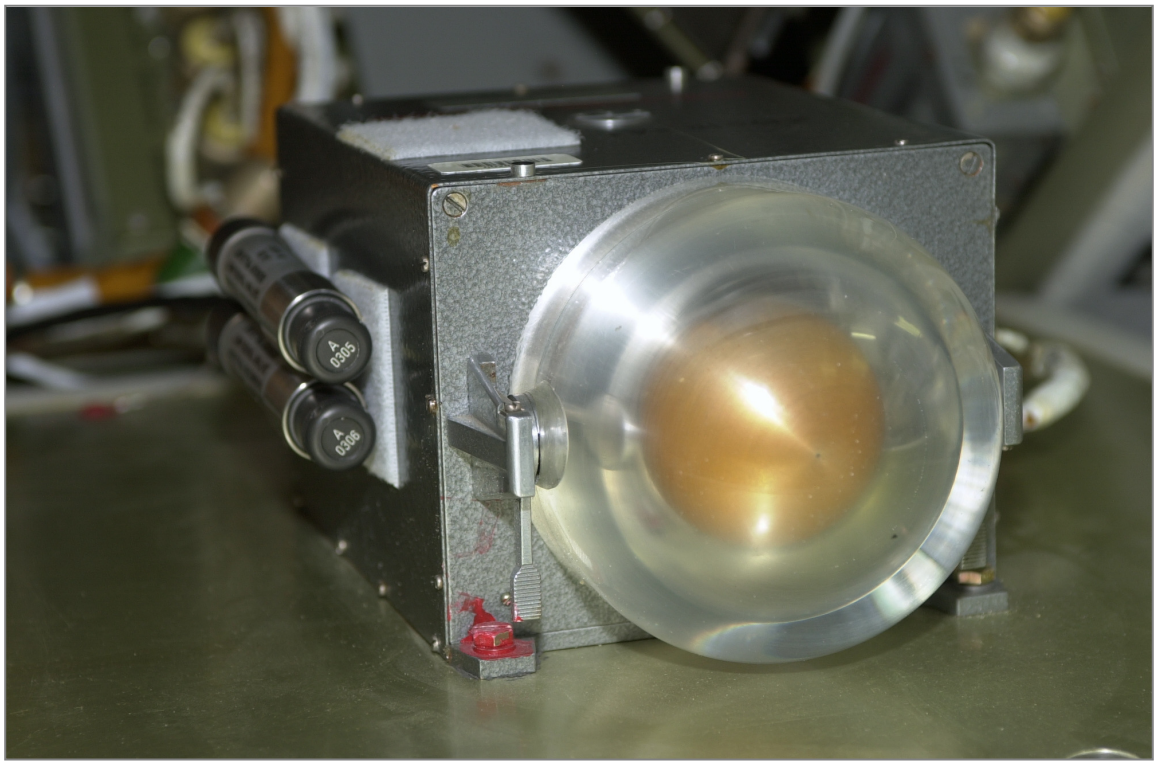
Active radiation measurement devices onboard the ISS - US contribution (1/3)

Tissue Equivalent Proportional Counter (TEPC)

Active radiation measurement devices onboard the ISS - US contribution (2/3)

Charged Particle
Directional Spectrometers
(Internal) IV-CPDS

Active radiation measurement devices onboard the ISS - Russian contribution (1/3)

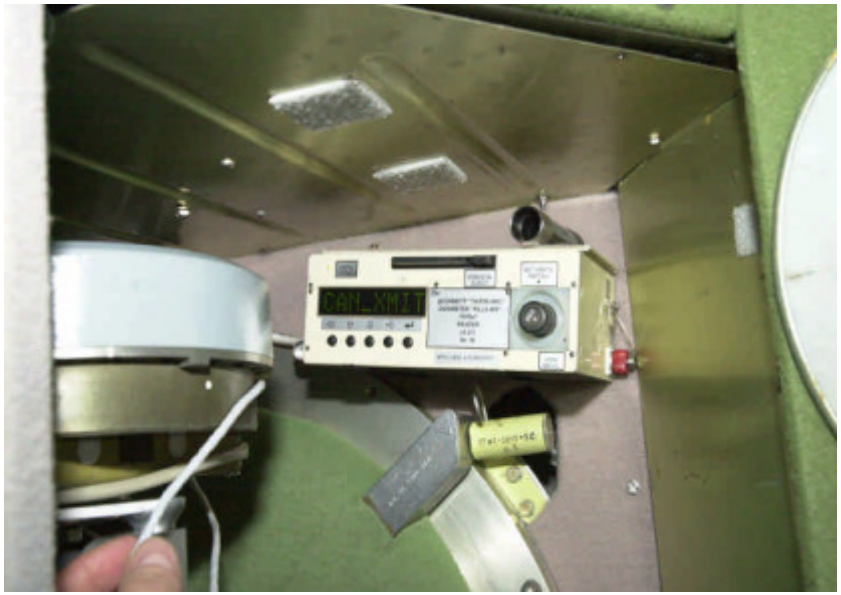


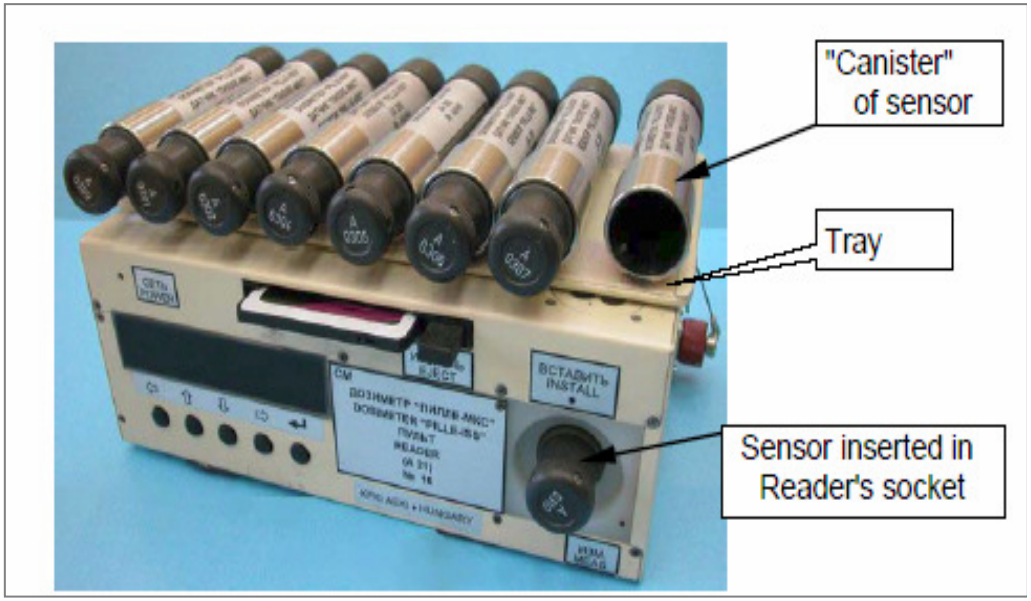
Radiometer
R16

Active radiation measurement devices onboard the ISS - Russian contribution (2/3)

Semi - Active radiation measurement devices onboard the ISS - Russian Hungarian contribution (3/3)

Operational Dosimeter PILLE-ISS (TLD type with on board reader)
(also used as EVA-Dosimeter)





Passive Area Dosemeters

Active radiation measurement devices onboard the ISS - US contribution (3/3)

Charged Particle Directional Spectrometers (External) EV-CPDS

Crew Personal Dosemeters

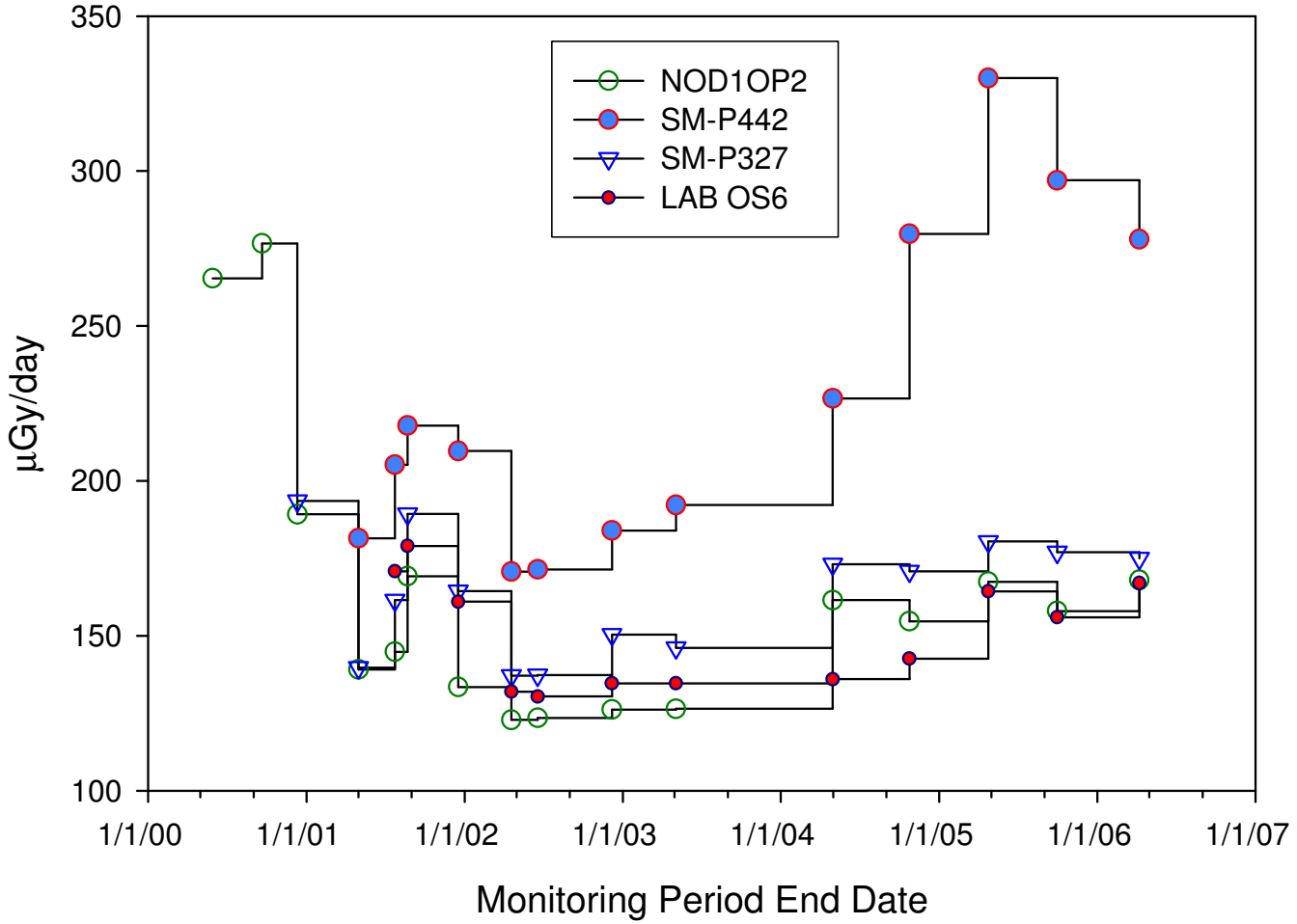
Passive radiation measurement devices onboard the ISS (personal dosemeters)

ESA
IBMP
NASA
Personal
Dosemeters

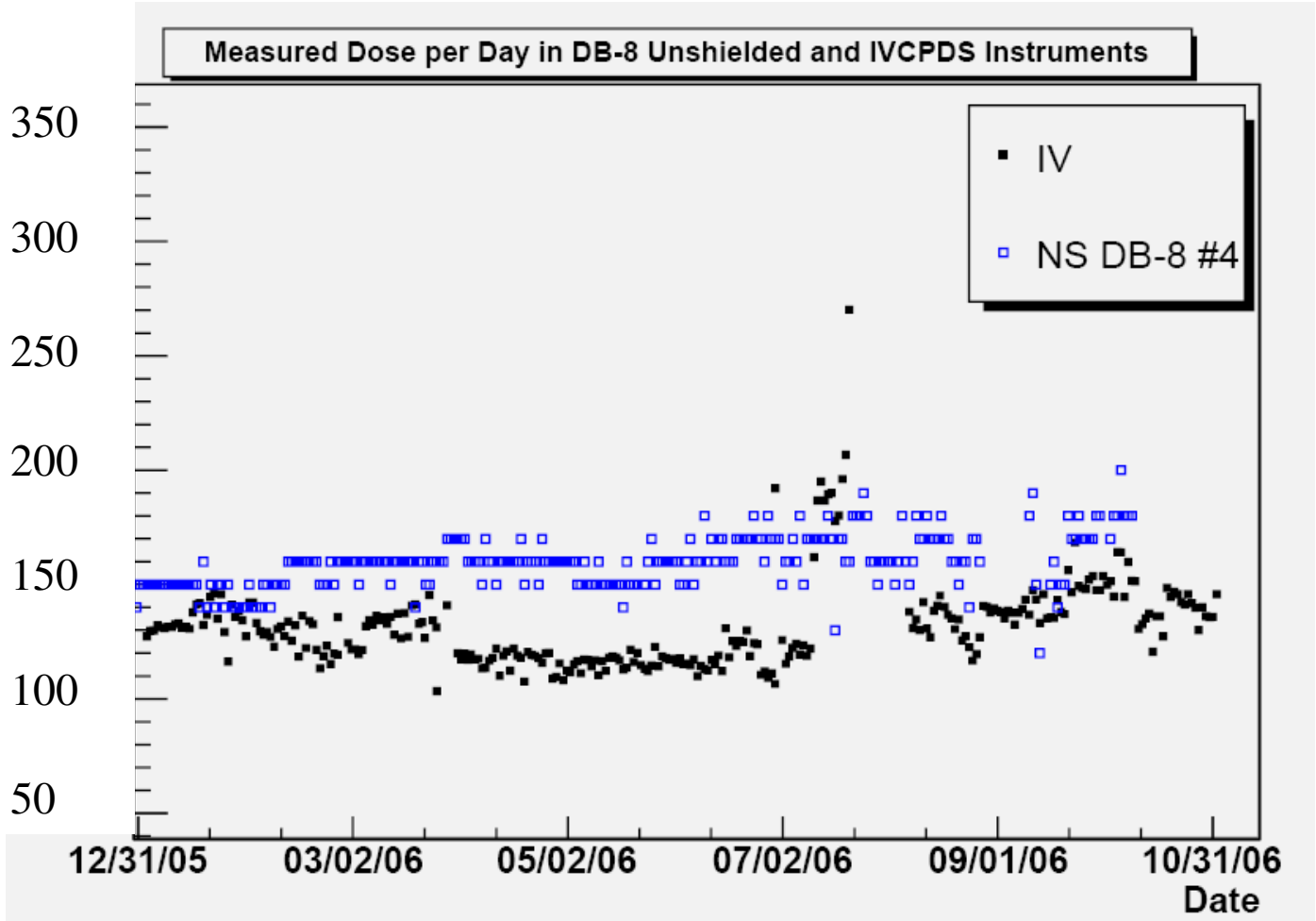
Christer Fuglesang and Thomas Reiter with the EuCPD

S116E06402

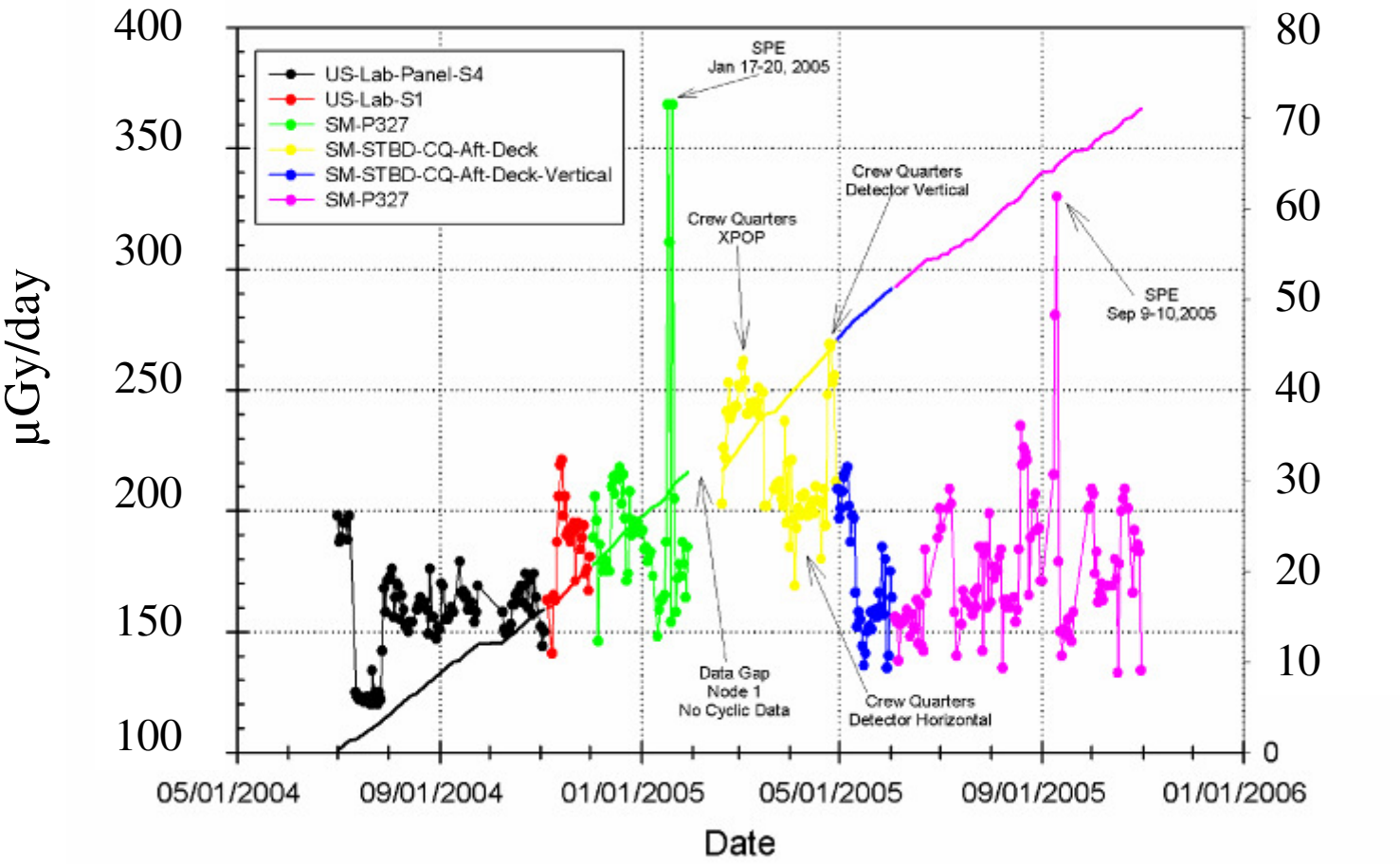
ISS TLD 100 Dose Rate Summary



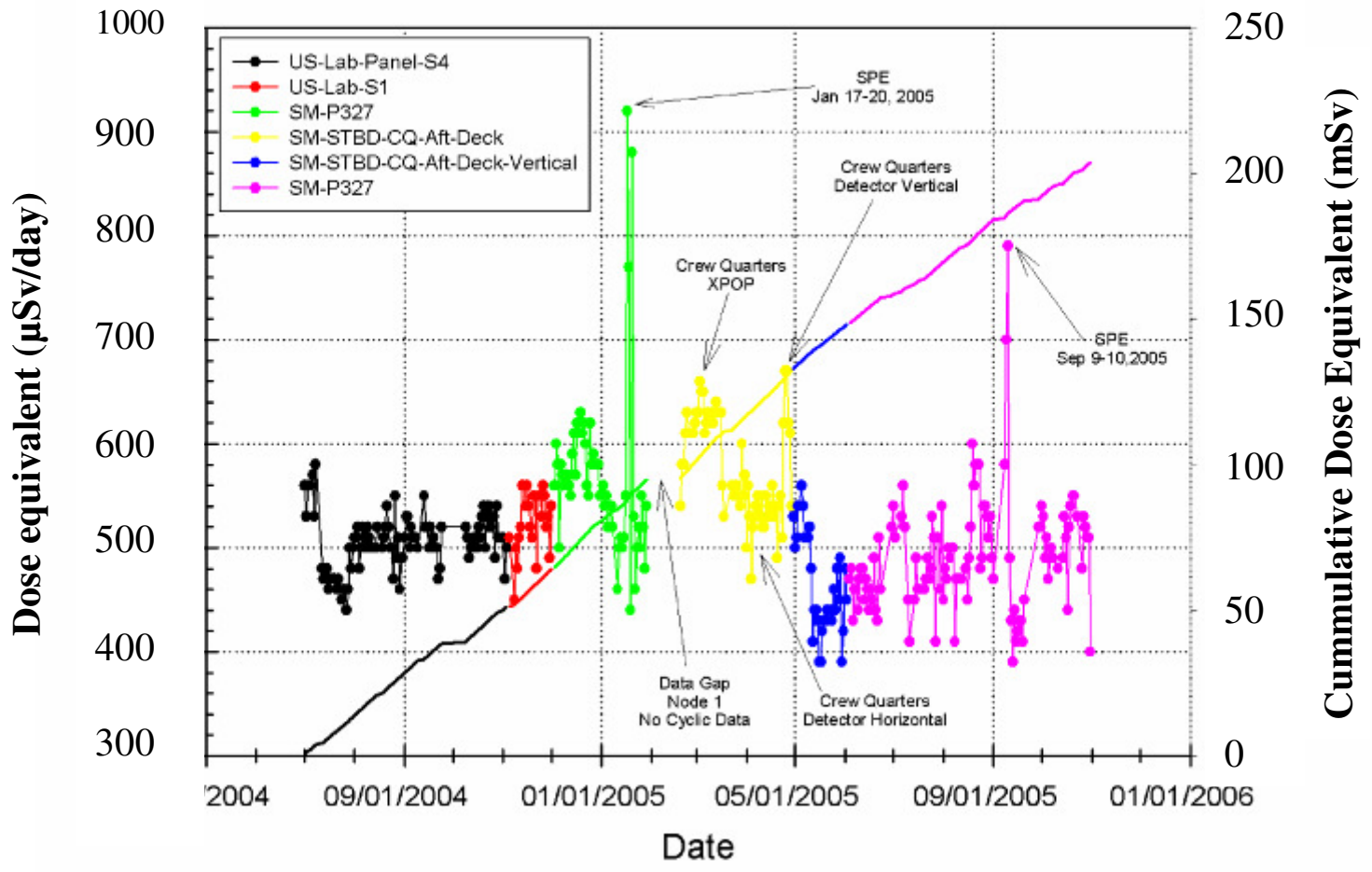
IV-CPDS Daily Dose Rate Data – US LAB S4 Zenith



ISS TEPC During 2005 (Dose Rate)



ISS TEPC During 2005 (Dose Equivalent Rate)



Capabilities of Operational Dosemeters

Capability (Req. by MORD Rev C.)	TEPC	TLDs and CR-39	IV-CPDS	EV-CPDS	Russian R-16 (Failed)	Russian Pille	Russian DB8
Time Resolved LET Spectra	Yes 0.3-1200 keV/µm	No	Partly ~0.5-38 keV/µm	Partly ~0.5-38 keV/µm	No	No	Partly ~0.5-50 keV/µm
Active Radiation Monitoring	Yes	No	Yes	Yes	Yes	Yes	Yes
Charged Particle Monitoring	No	No	Yes	Yes	No	No	No
Alarm Capability	Yes	No	No	No	No*	No	No*
Crew Read Out Capability	Yes	No	Yes	No	No	Yes	No
Neutron Monitoring	No	No	No	No	No	No	No
ISS Surveying Capability	Yes	Yes	No	No	No	Yes	Yes
ISS Locations Covered	ALL	ALL	USOS ONLY	External	RS ONLY	RS ONLY	RS ONLY

RESEARCH
Projects

Active Dosemeter Equipment of DOSMAP on ISS Expedition 2

Liulin with Charging Unit

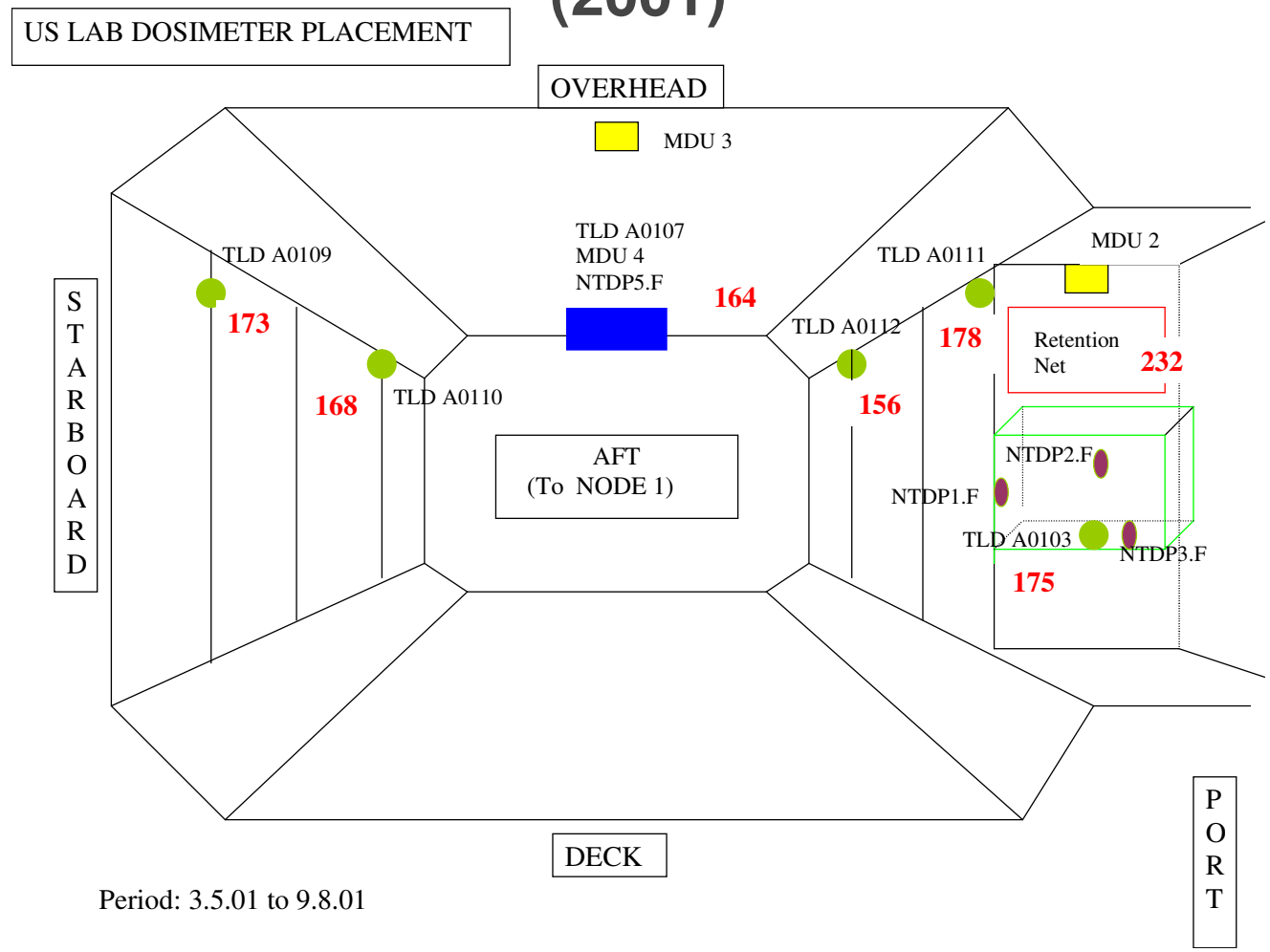
Detector Telescope DOSTEL

TLD Reader PILLE

Pille Dosemeter with CR39

Power Distribution Box

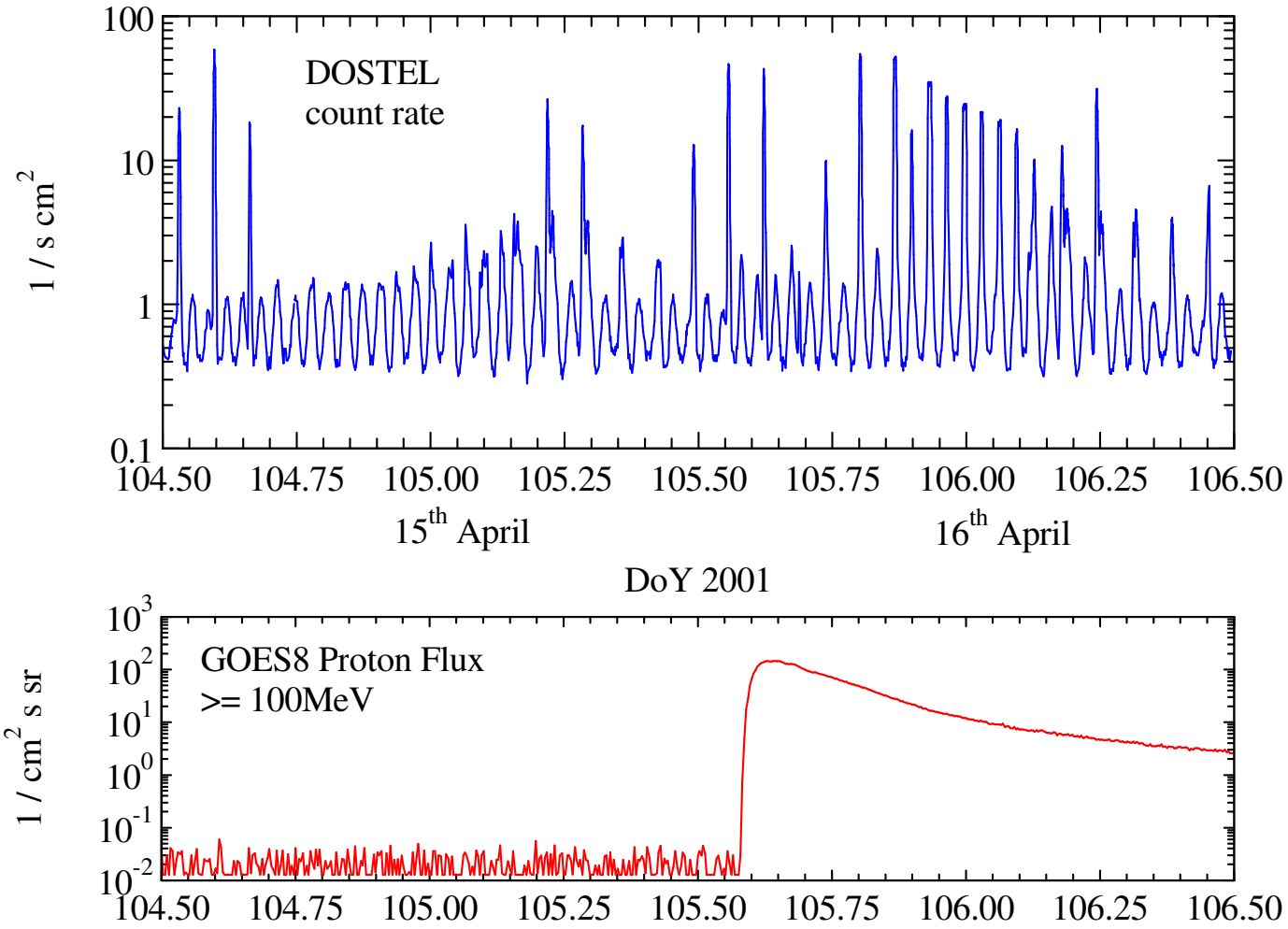
Dosimeter Placement and TLD Results in µGy/d (2001)



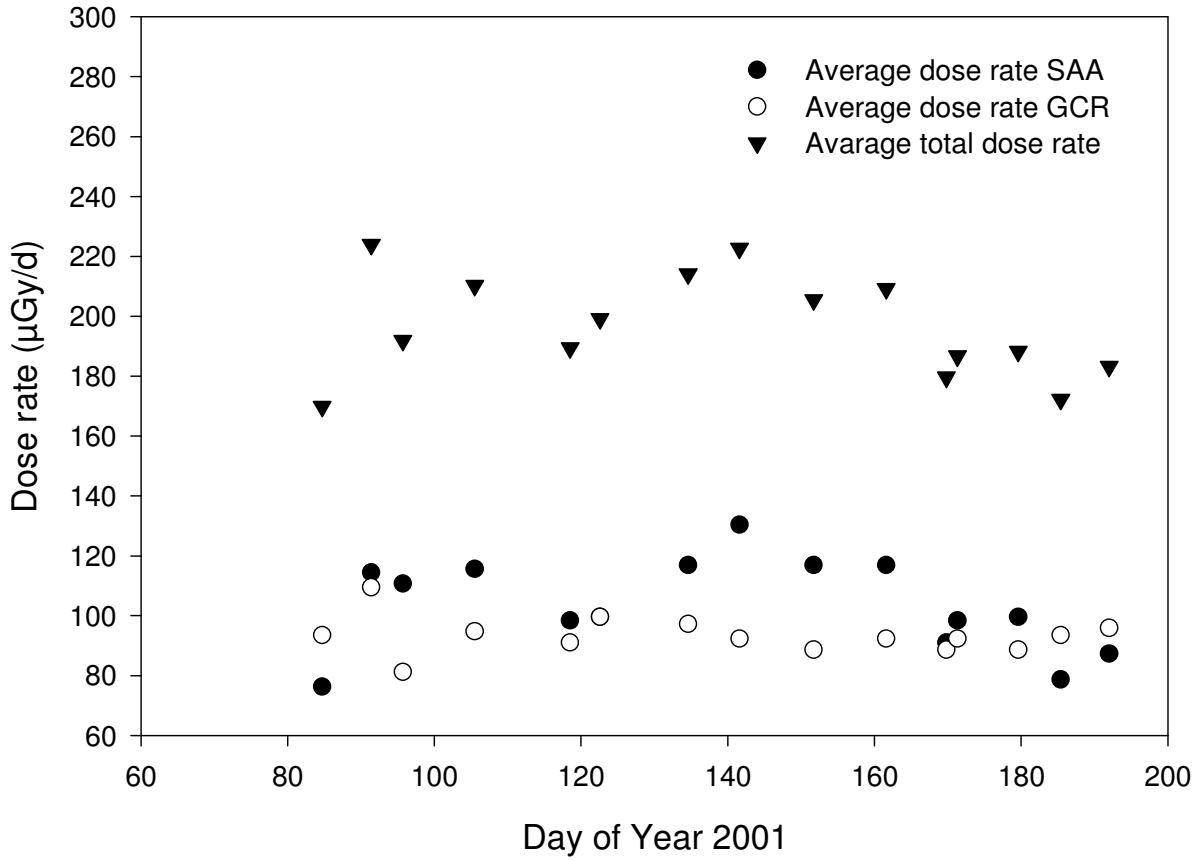
Period: 3.5.01 to 9.8.01

DOSTEL Count Rate (top panel) and Particle Fluxes

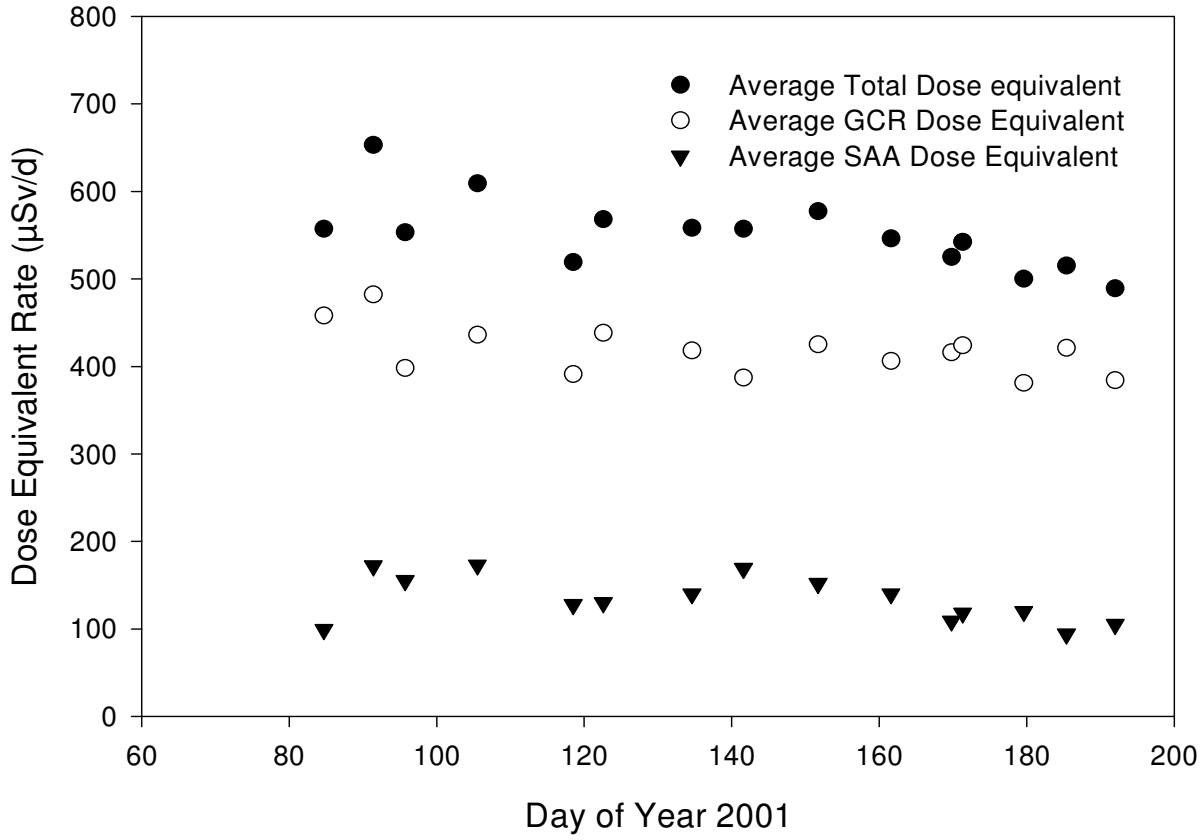
Monitored by the GOES Satellite (bottom panel)



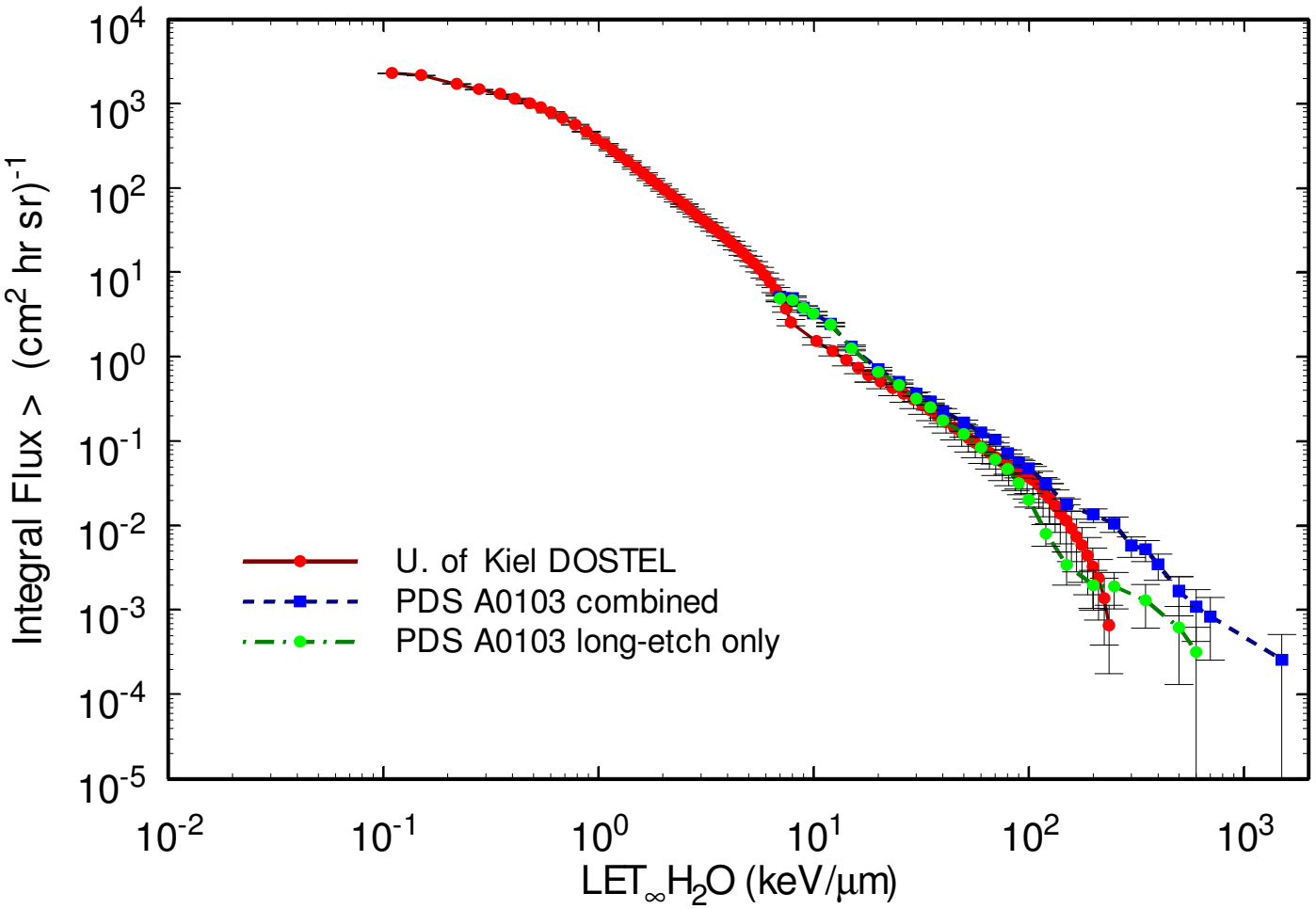
DOSTEL Dose Rates versus Mission Time



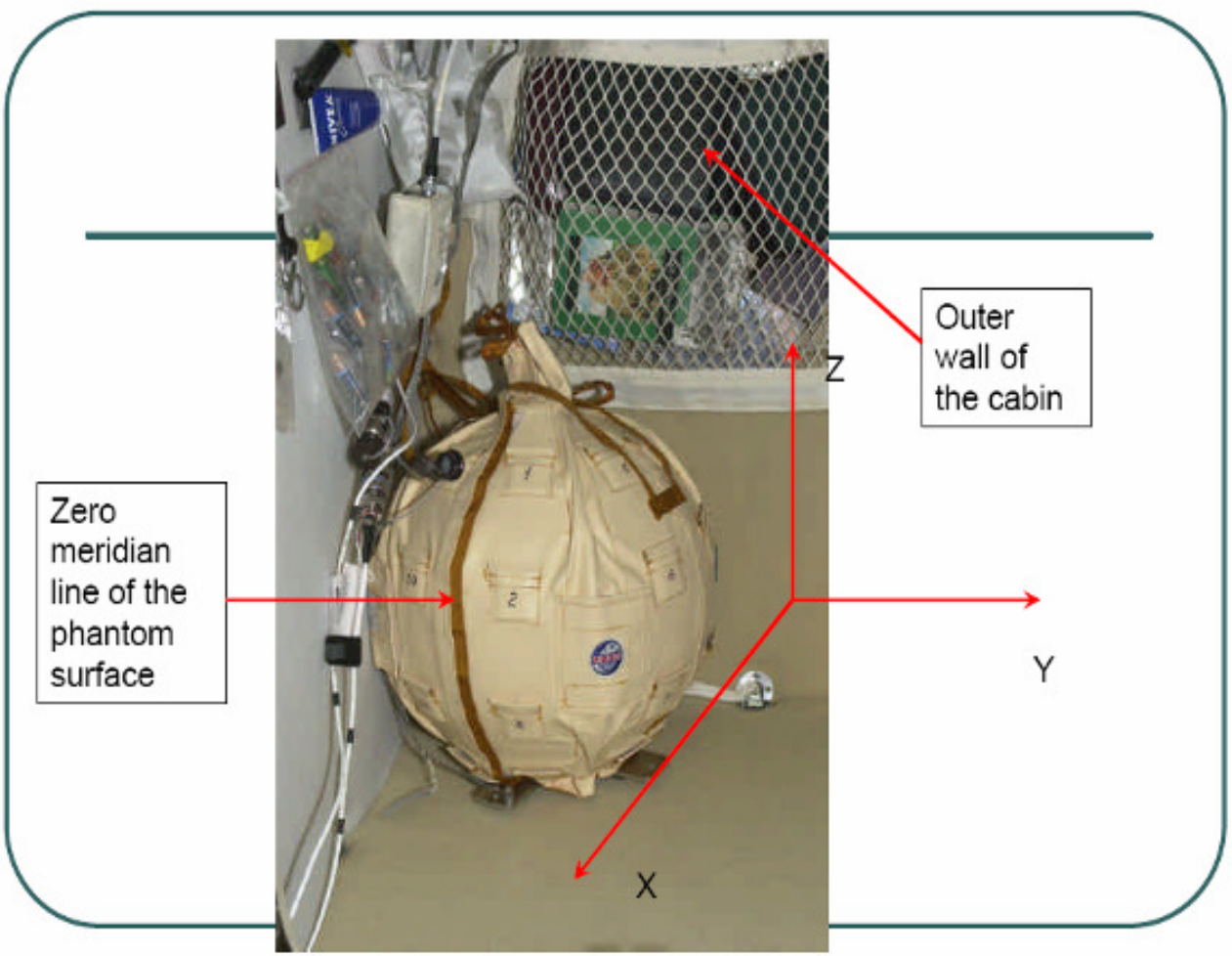
DOSTEL Dose Equivalents Rates versus Mission Time



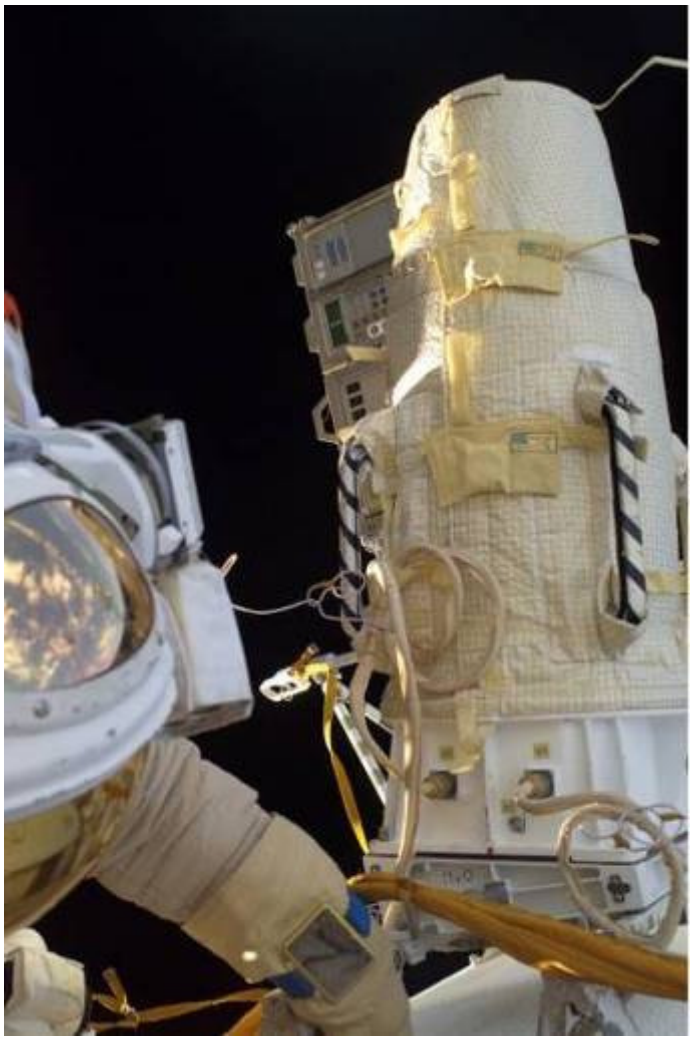
Comparison of LET Spectra for GCR of DOSTEL and CR-39



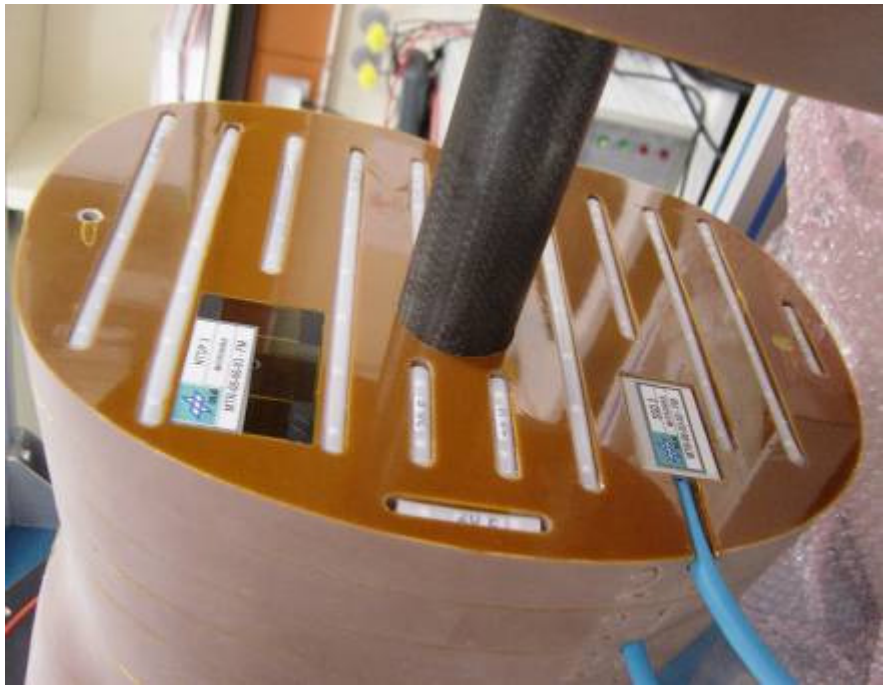
MATROSHKA - R


Outer
wall of
the cabin
Z
Zero
meridian
line of the
phantom
surface
Y
X

The MATROSHKA-Facility



The MATROSHKA Facility – Radiation detectors



Thermoluminescence detectors (TLDs) and Nuclear Track Etch detectors, Scintillator/Silicon detectors, silicon telescope, tissue equivalent proportional counter (TEPC)

ALTCRISS

Long term monitoring inside ISS using Alteino

Selected by ESA in the Life Science AO

“Anticipated” to ESA Long Duration Mission of Thomas Reiter

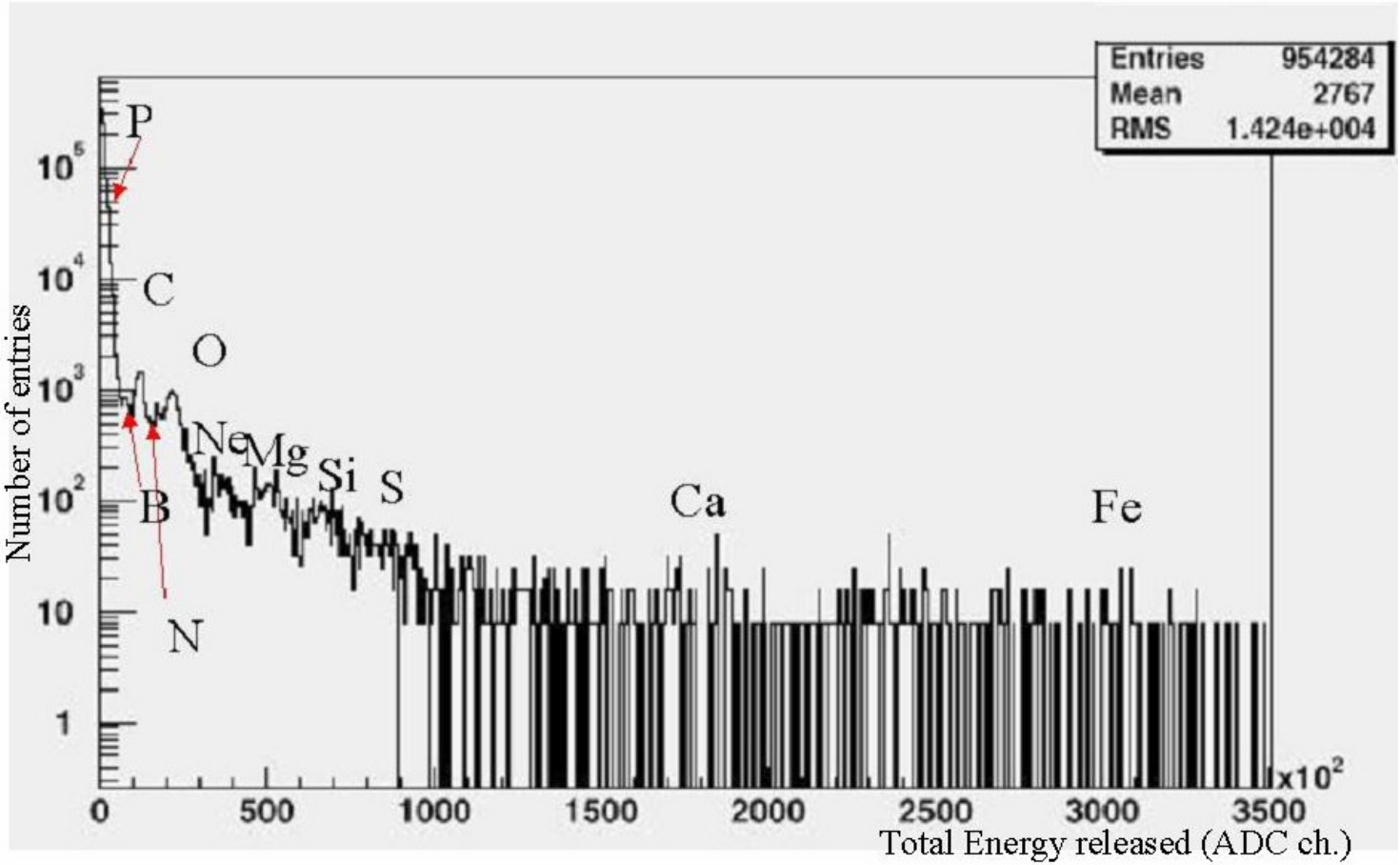
Intercomparison with other detectors in the framework of MATROSHKA II

Currently 6 month mission: 3 locations with and without shielding (Polyethylene shielding only on top of Alteino detector – 5g/cm^2)

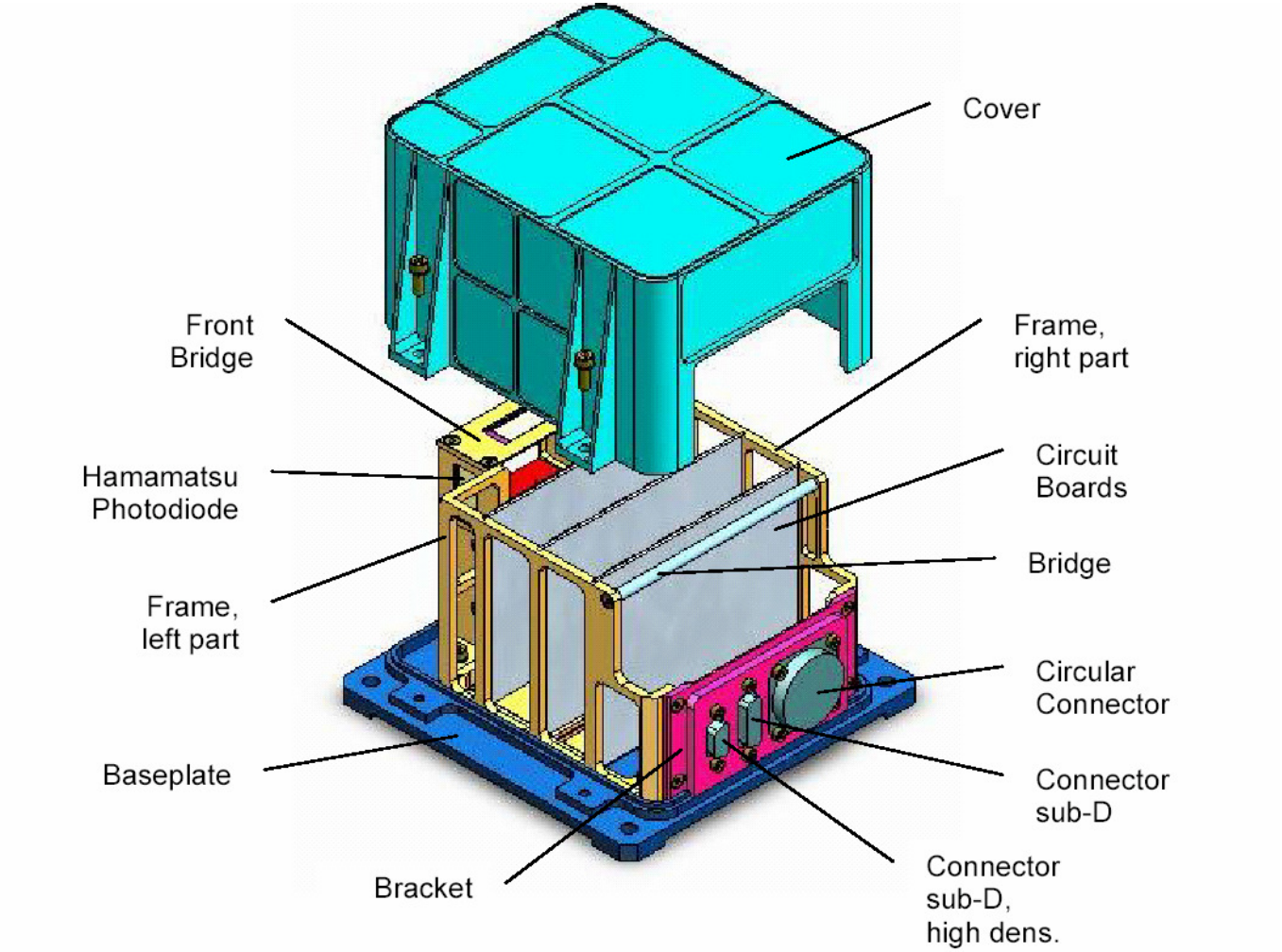
Various dosemeters: Napoli + DLR

Comparison with ground data & simulations

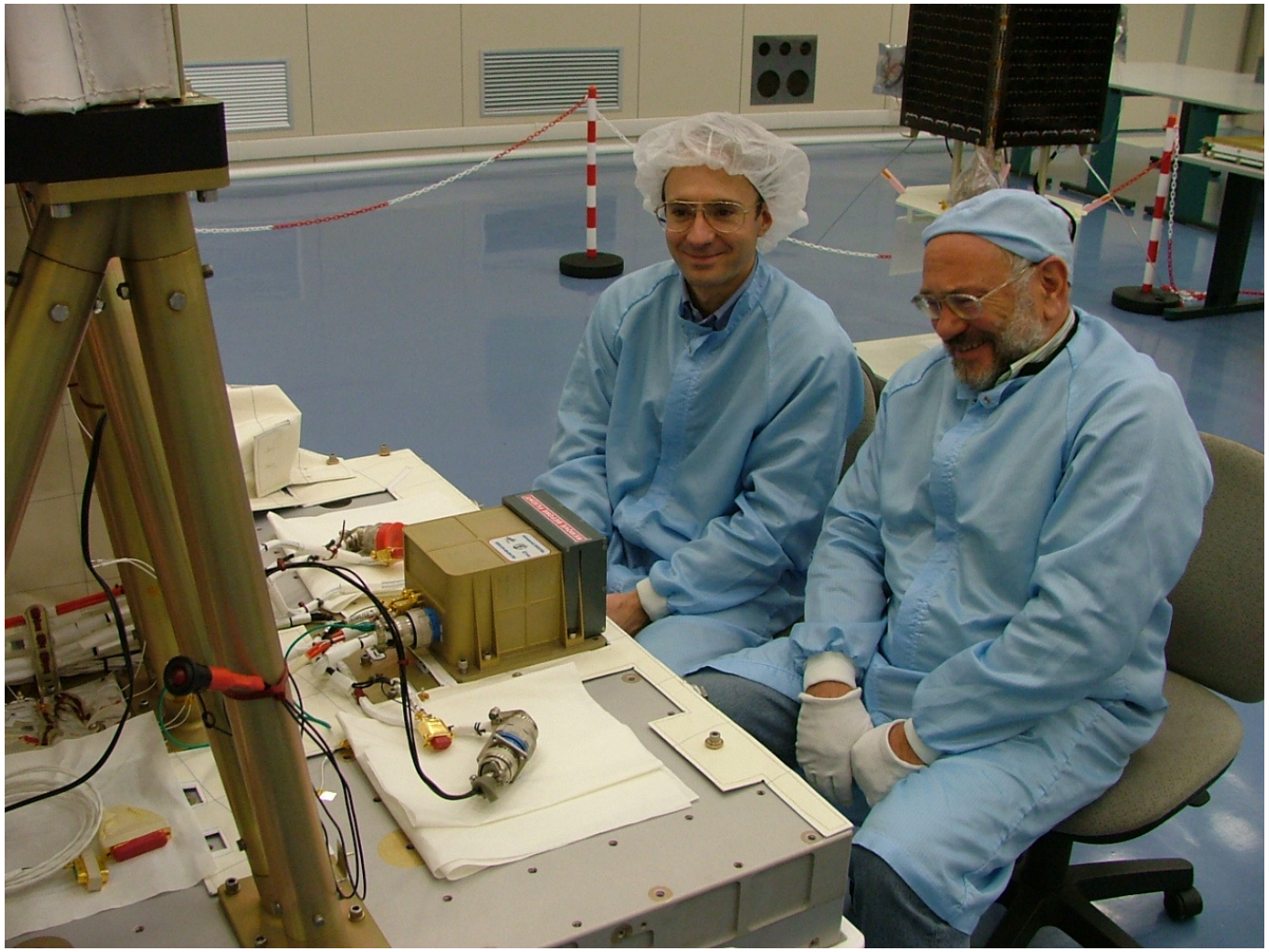
Charged Particle Spectra on ISS



Advanced DOSTEL on EuTEF



Advanced DOSTEL during Interface Test



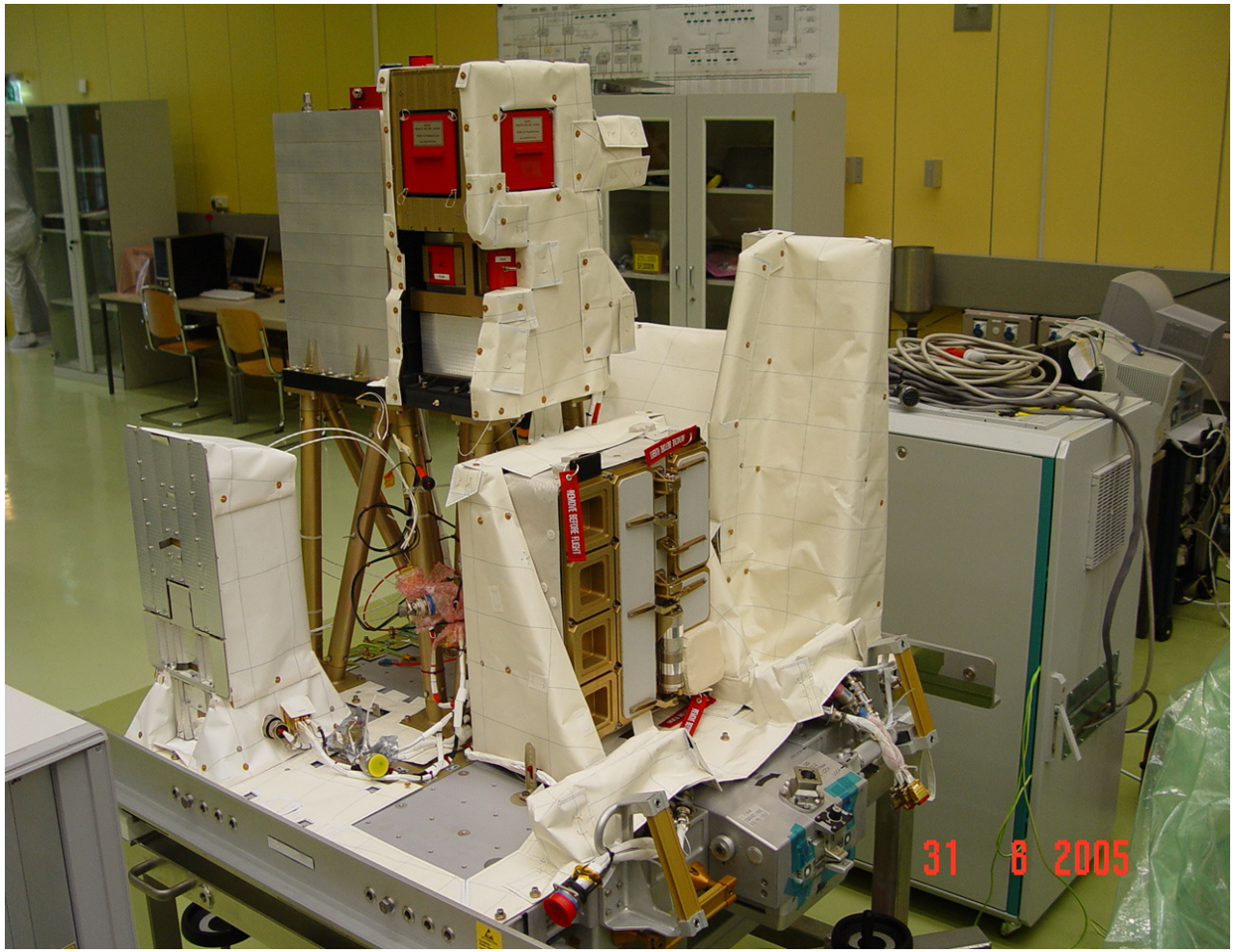
ESA Dosimetry Planning

	Inc15	Inc16	Inc17	Inc18	Inc19	Inc20
	Apr07-Oct07	Oct07-Apr08	Apr08-Oct08	Oct08-Apr09	Apr09-Oct09	Oct09-Apr10
ALTCRISS	SM & FGB 6	FGB & COL 3	COL 3			
ALTEA-SHIELD			US-Lab Reserve	US-Lab 2	US-Lab 2	US-Lab 2
MATROSHKA-2B	SM [4]	SM [4]				
MATROSHKA-2C TBC		SM External [8]	SM External 0	SM External [8]		
DOSIS DOS/NTDP			COL: EPM 0,5	COL: EPM 0,5	COL: EPM	COL: EPM
DOSIS TLD			COL: Pille Reserve	COL: Pille Reserve	COL: Pille Reserve	COL: Pille Reserve
DOBIES	RS 0	RS 0	RS 0,5	RS 0	COL 0,5	
TRITEL					COL 0,5	COL 0,5
LIULIN-5E				SM 1	SM 1	
DOSIS / DOBIES External		COL: EXPOSE 0	COL: EXPOSE 0	COL: EXPOSE 0	COL: EXPOSE 0	
Total crew time	6	3	4	3,5	4	2,5
Crew time vailable	6	3	2	2	2	4

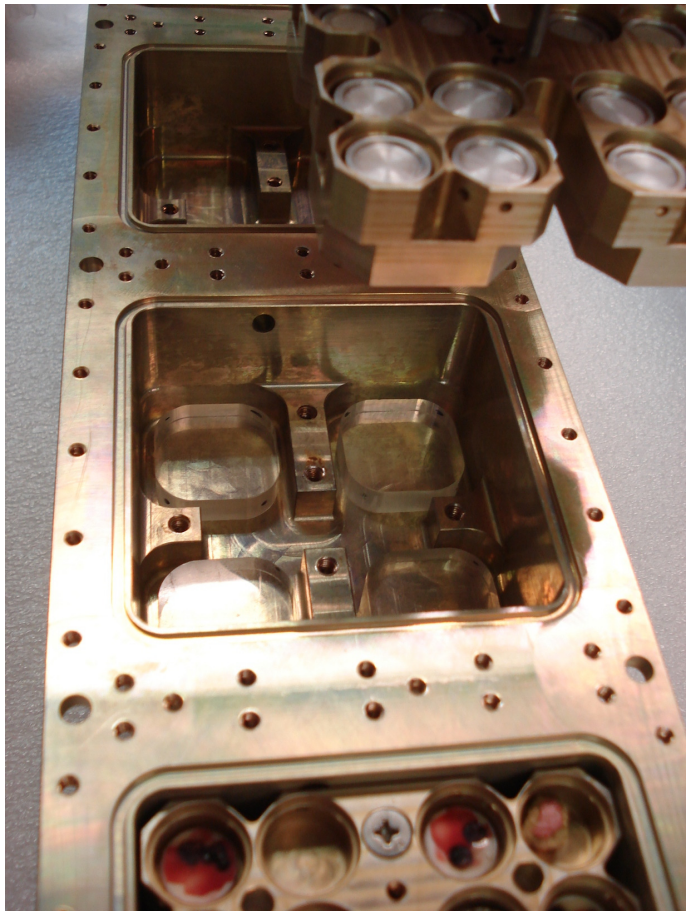
DOSIS and DOBIES/ Expose-EuTEF

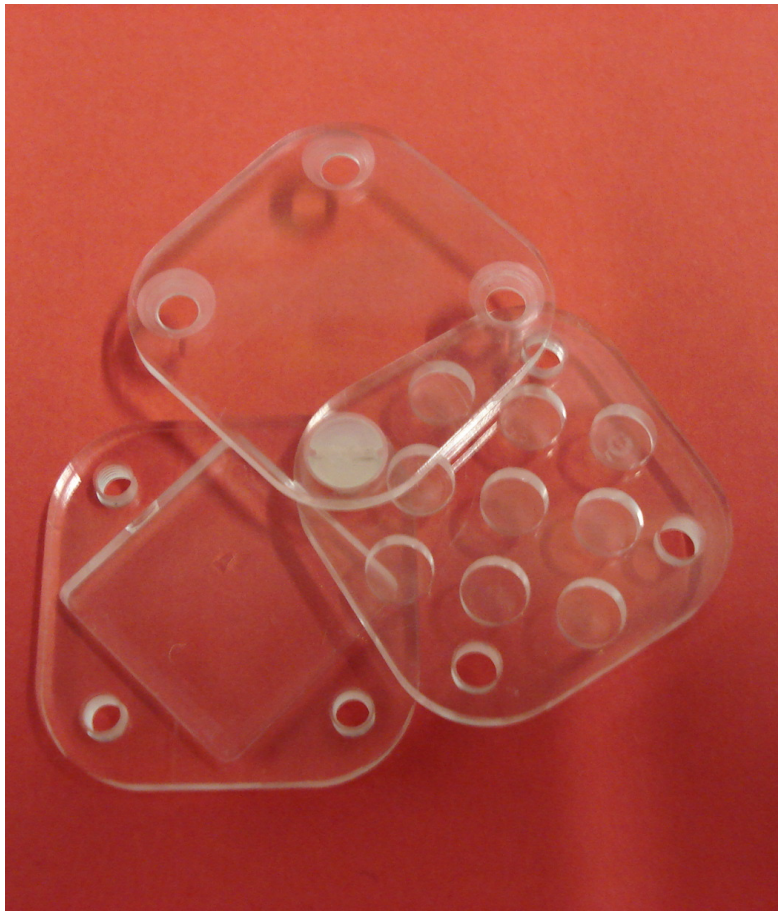
- Passive Dosimetry in the Expose-EuTEF facility for the determination of the radiation environment at the location of the biological samples
- 32 TLD / OSL – CR-39 packages as “Dark Control”
- 32 “Depth Dose Stacks” for the depth dose measurements

EuTEF - EXPOSE Facility

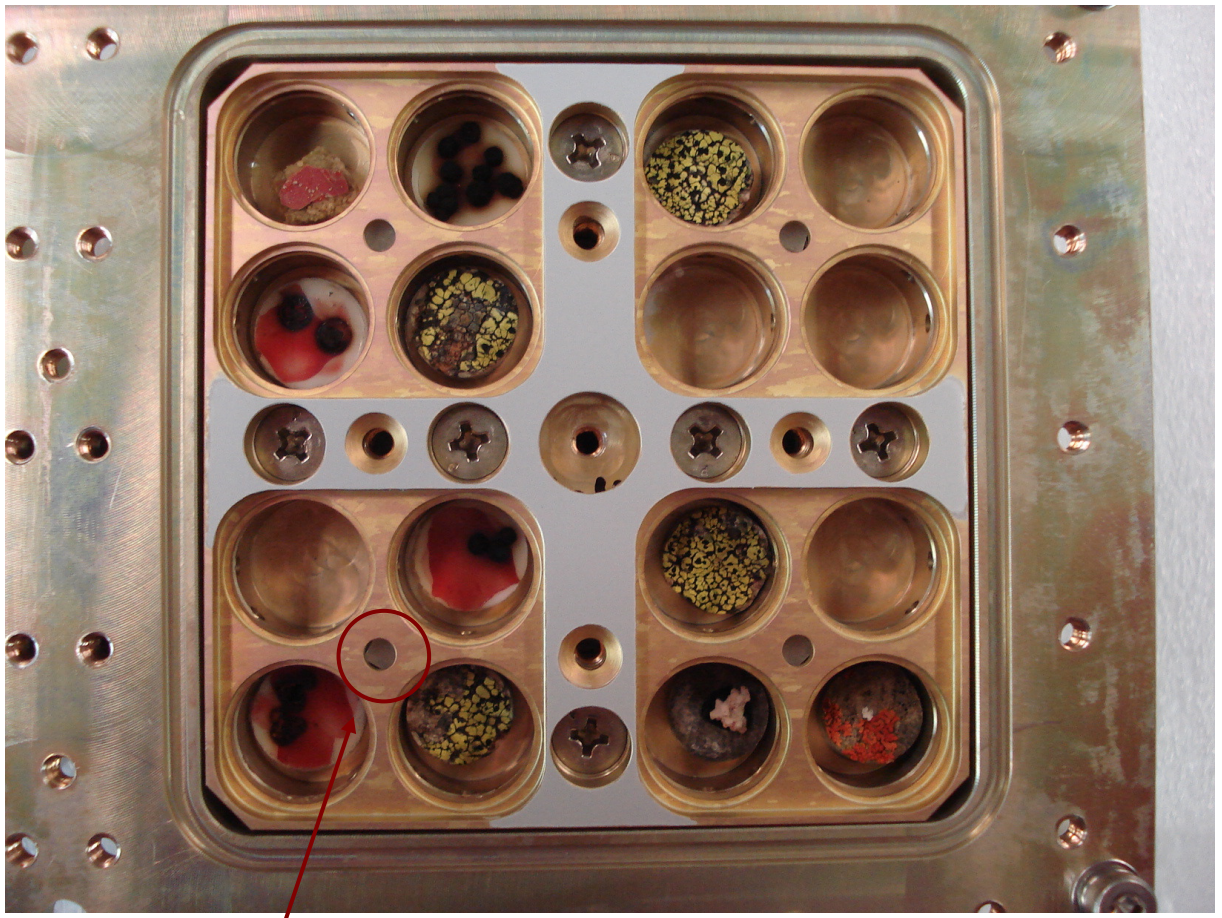


DOSIS / Expose-EuTEF





DOSIS / Expose-EuTEF



Depth dose TLD stack

DOSIS and DOBIES Inside COLUMBUS

- Area monitoring inside Columbus with active and passive radiation detectors
- Timeframe: 1 – 2 increments
- Outlook: operational phase

Constant monitoring of the radiation environment in the Columbus module

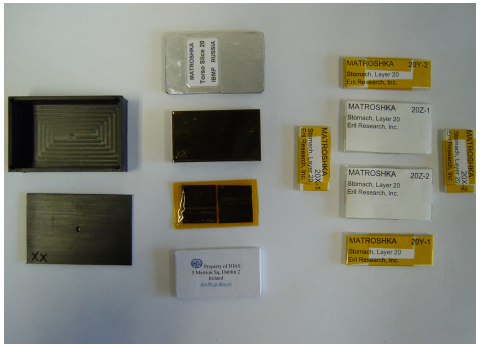
DOSIS (Radiation Detectors – active / To be uploaded)

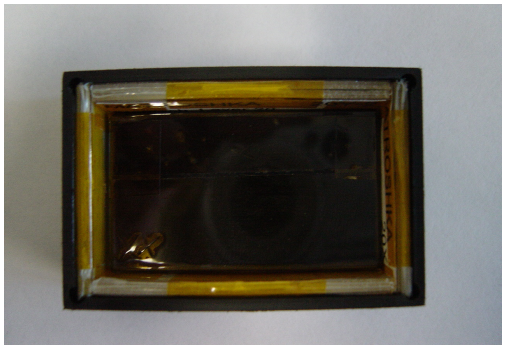
160 x 85 x 65 mm
800 gram

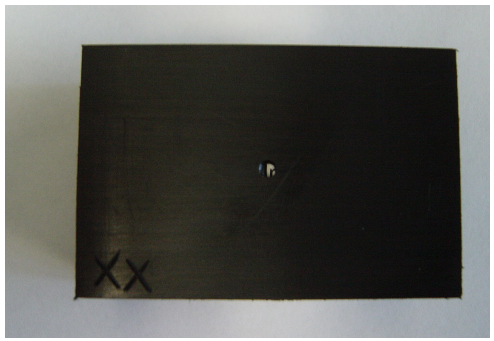
Detector Telescope DOSTEL

(Flight Hardware from Dosmap)

DOSIS (Radiation Detectors - passive)





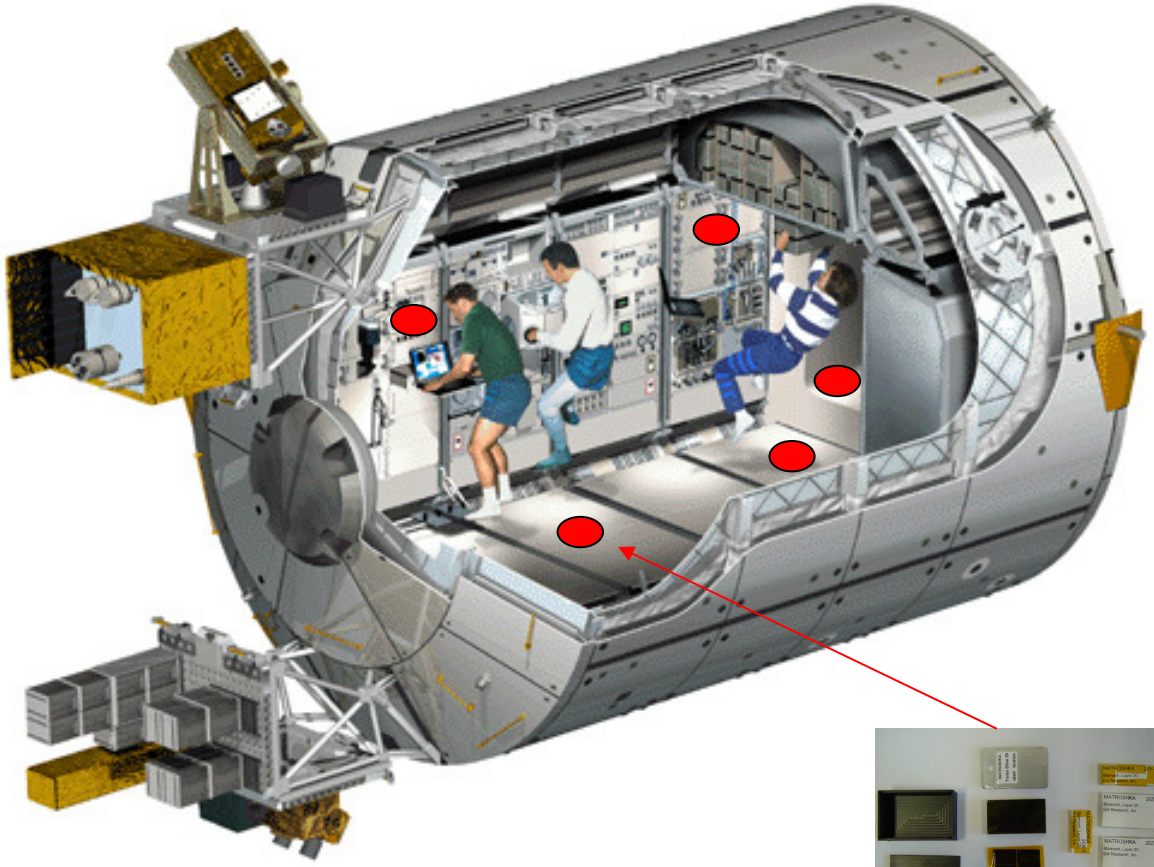


Nuclear Track Detector packages

60 x 40 x 25 mm

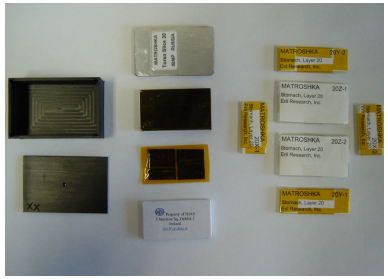
50 gram

DOSIS (passive detector locations)



10 NTDP packages / PILLE detectors inside Columbus
Exchange of NTDP packages every 6 months

DOSIS (EPM)



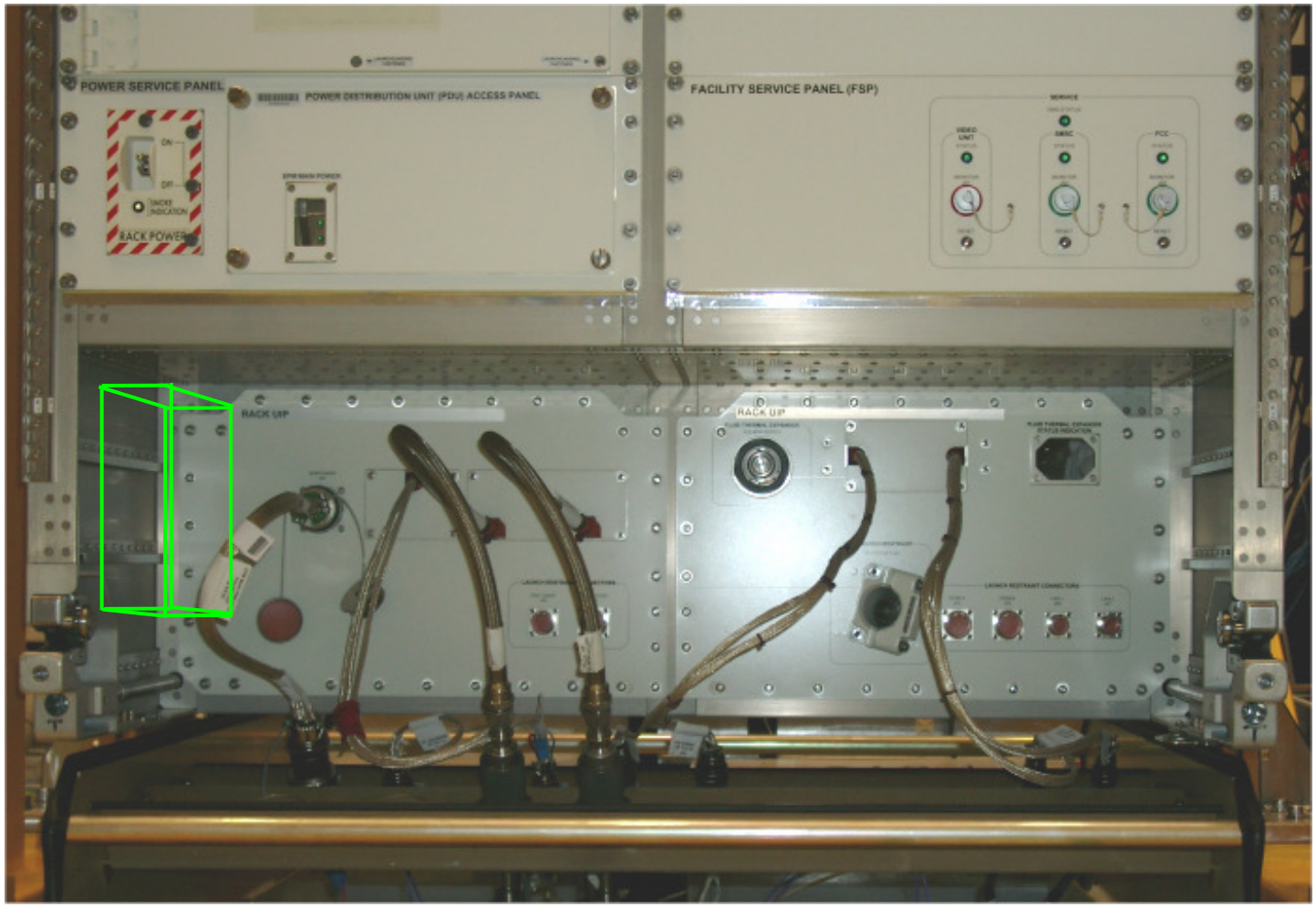
2 DOSTEL and up to three NTDP packages attached to EPM

DOSTEL data transfer and download (via EPM LAN)

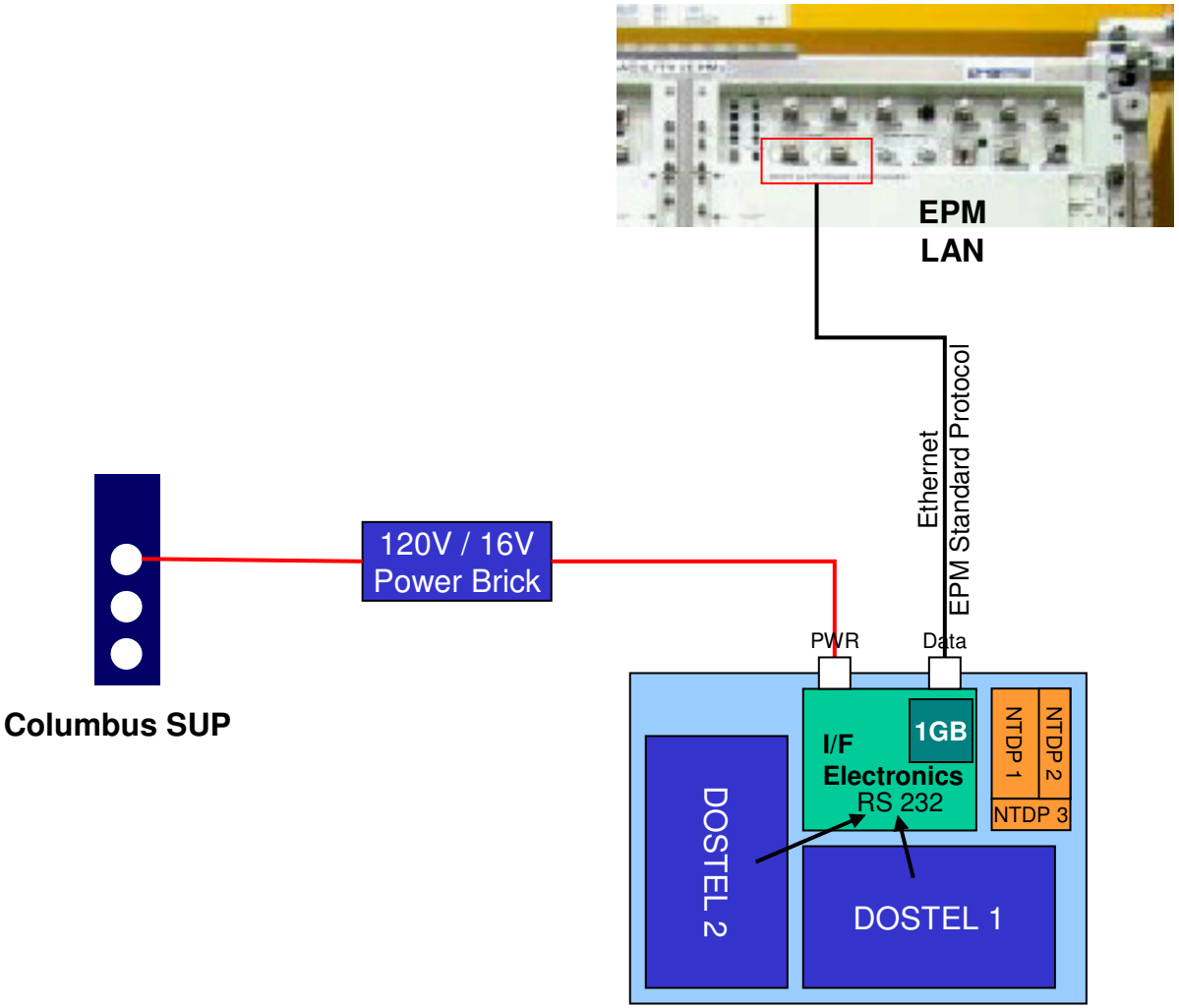
Exchange of NTDP packages every 6 month

Mechanical Accommodation

Velcro fixation of Main Box in EPM rack UIP area is suggested, e.g. on the left side



Power and Data Interface



Space Dosimetry : The next Generation

Redesign of the Tissue Equivalent Proportional Counter

Silicon Telescopes such as DOSTEL, RRMD-II and Alteino/Altea

Active Neutron Detectors such as phoswich detectors, scintillation detectors, Bonner spheres

Portable TLD or OSLD systems for crew and area dosimetry

Portable Silicon Dosimeters (e.g. Liulin-4) for area and crew dosimetry (IVA and EVA)

DLR Science Projects

- Dose Distribution inside ISS Columbus and EXPOSE including Crew Dosimetry (DOSIS)
- Continuation of MATROSHKA and MATROSHKA-R Experiments
- Continuation of ALTCRISS-Alteino and BRADOS
- Advanced DOSTEL on EuTEF
- Radiation Sensor (IRAS) on ExoMars and Radiation Assessment Detector (RAD) on NASA Mars Science Lab
- Radiation Sensors on ESA/DLR Moon missions and on small satellites

Conclusion

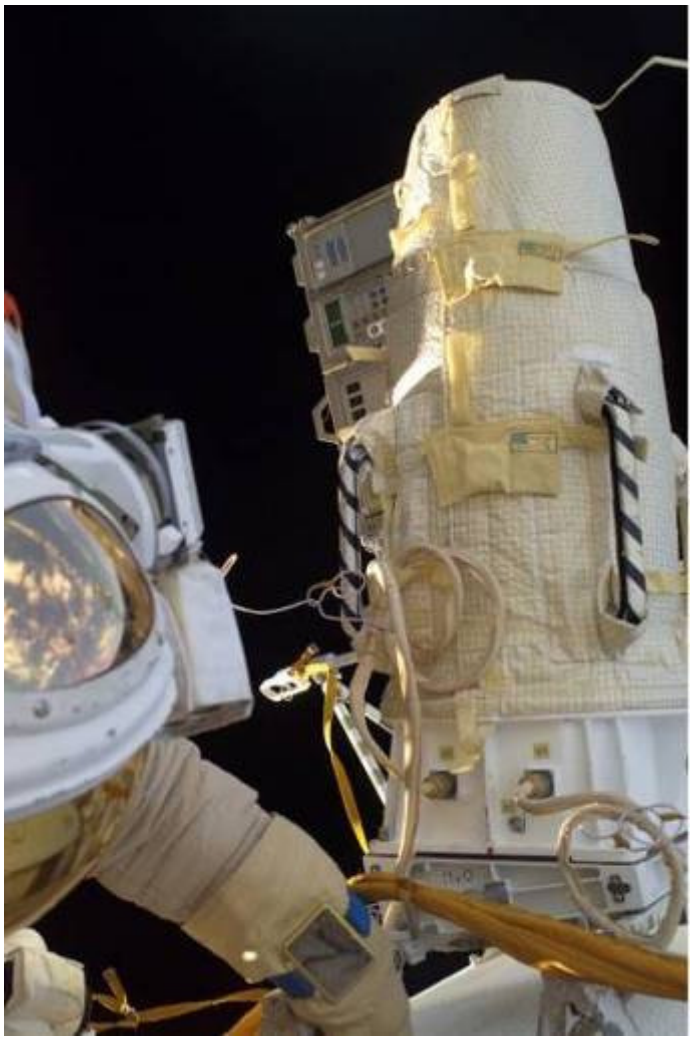
Europe has an excellent instrument suite available to cover the work still to be done :

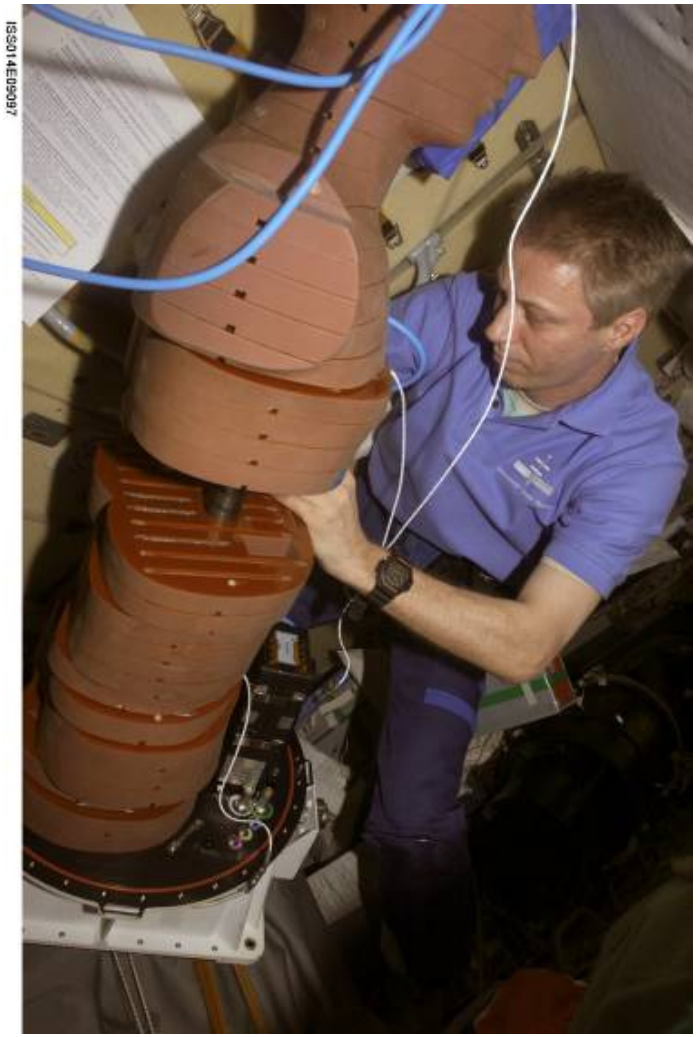
- Realisation and provision of advanced and new instrumentation and their implementation in future missions
- Characterisation and cross- calibration of instruments
- More accurate and reliable data by improved characterisation of the different environments
- Improved Calculation of Radiation Exposure of Astronauts
- Model benchmarking
- Reduction of uncertainties in risk assessment

Achievement-Actions

- Workshop on Radiation Monitoring on the ISS (WRMISS)
- Instrument Calibration Programm ICCHIBAN
- ESA Programm IBER
- Cooperation in Space Experiments eg STS-114, ISS Expedition 2, MATROSHKA, BRADOS, etc.
- Design and implementation of the next generation space dosimetry system needs to be a colloborative effort making use of the skills of the different group

MATROSHKA





DOSIS (International Contribution)

Günther Reitz, Thomas Berger	German Aerospace Center, DLR, Cologne, Germany
Rudolf Beaujean	Christian-Albrechts-Universität Kiel, Kiel, Germany
M. Luszik-Bhadra	Physikalisch-Technische Bundesanstalt, PTB, Braunschweig, Germany
V. Petrov	Institute for Biomedical Problems, IMBP, Moscow, Russia
P. Olko, P. Bilski	Institute for Nuclear Physics, INP, Krakow, Poland
I. Aphaty, S. Deme, J. Palfalvi	Atomic Energy Research Institute, AERI, Budapest, Hungary
D. O´Sullivan	DIAS, Dublin, Ireland
D. Bartlett, L. Hager	National Radiological Protection Board, NRPB, Chilton, UK
M. Casolino	INFN, Rome, Italy
M. Hajek	Atominstitute of the Austrian Universities, ATI, Vienna, Austria
Y. Uchihori, N. Yasuda	NIRS, Chiba, Japan
A. Nagamatsu	JAXA, Japan
N. Zapp, E.Semones	NASA JSC, Houston, TX, USA
E. Benton	Eril Research Inc., Stillwater, USA
S. McKeever, E. Yukihara	Oklahoma State University, Stillwater, USA
J. Miller and C. Zeitlin	Lawrence Berkeley Laboratory, Berkeley, CA, USA