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Radiation Dosimetry for Microbial Experiments in the International Space Station

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Collaborating universities and institutes

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Dose measurements necessary for bacterial experiments in space

Two ESA projects:

- **MESSAGE 2:** effects of the space flight conditions on bacterial gene expression
 - TED's, TLD's and OSLD's
- **MOBILIZATION:** gene transfer between model bacteria
 - TLD's and OSLD's

Different types of dosimeters used

- **Track etch detectors:**

- Page: NPI >8.6 keV/ μm
- CR-39: DIAS >5 keV/ μm

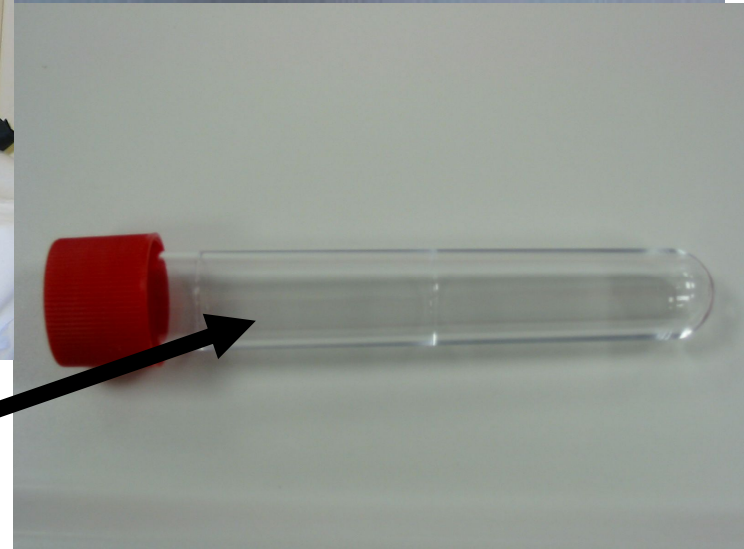
- **Thermoluminescence detectors**

- 7LiF:Mg,Ti SCK•CEN, NPI
- 7LiF:Mg,Cu,P SCK•CEN
- Al₂O₃:C NPI

- **Optically Stimulated luminescence detectors**

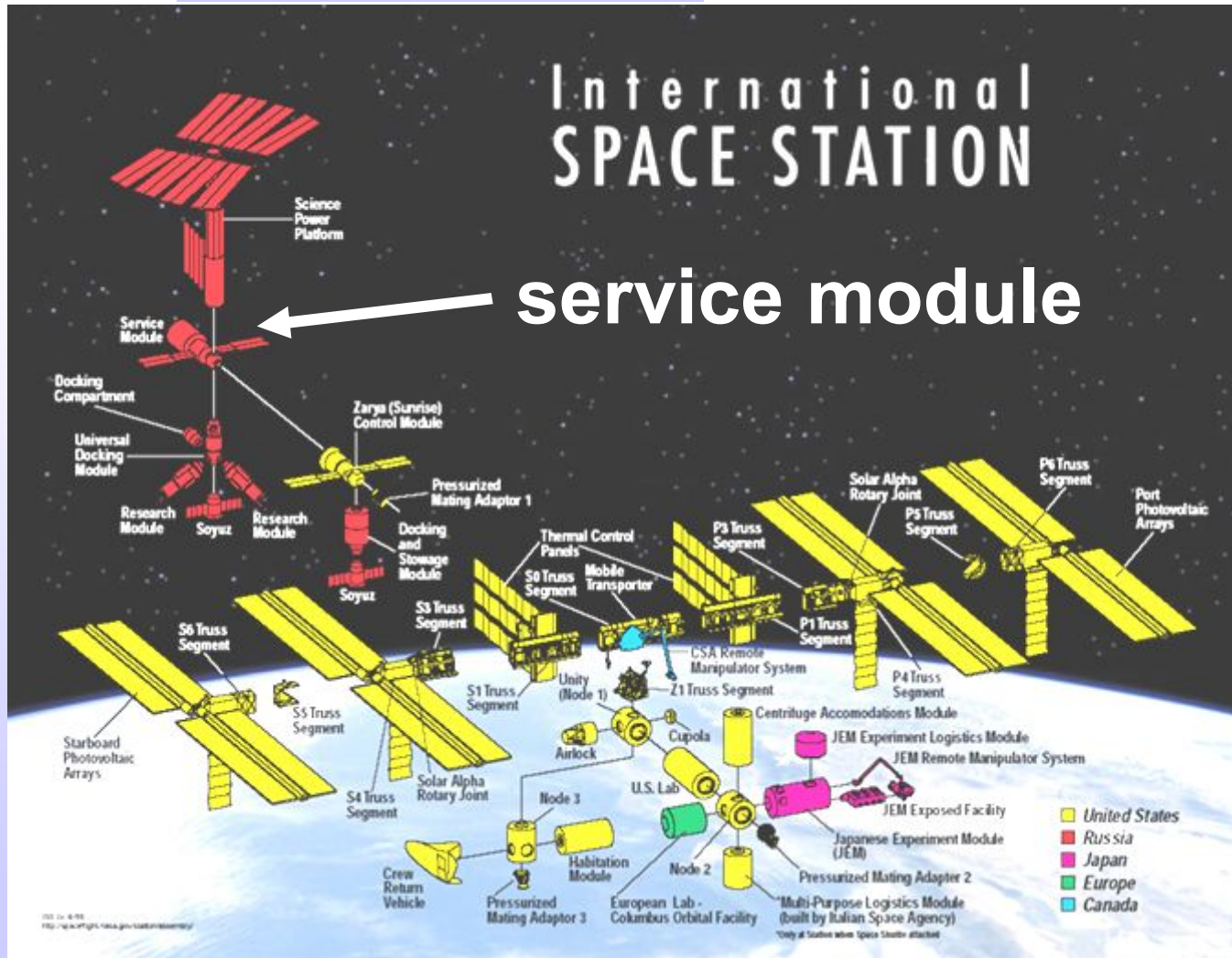
- Al₂O₃:C : SCK-CEN CW-OSL
- Al₂O₃:C : OSU CW-OSL

Transport bags

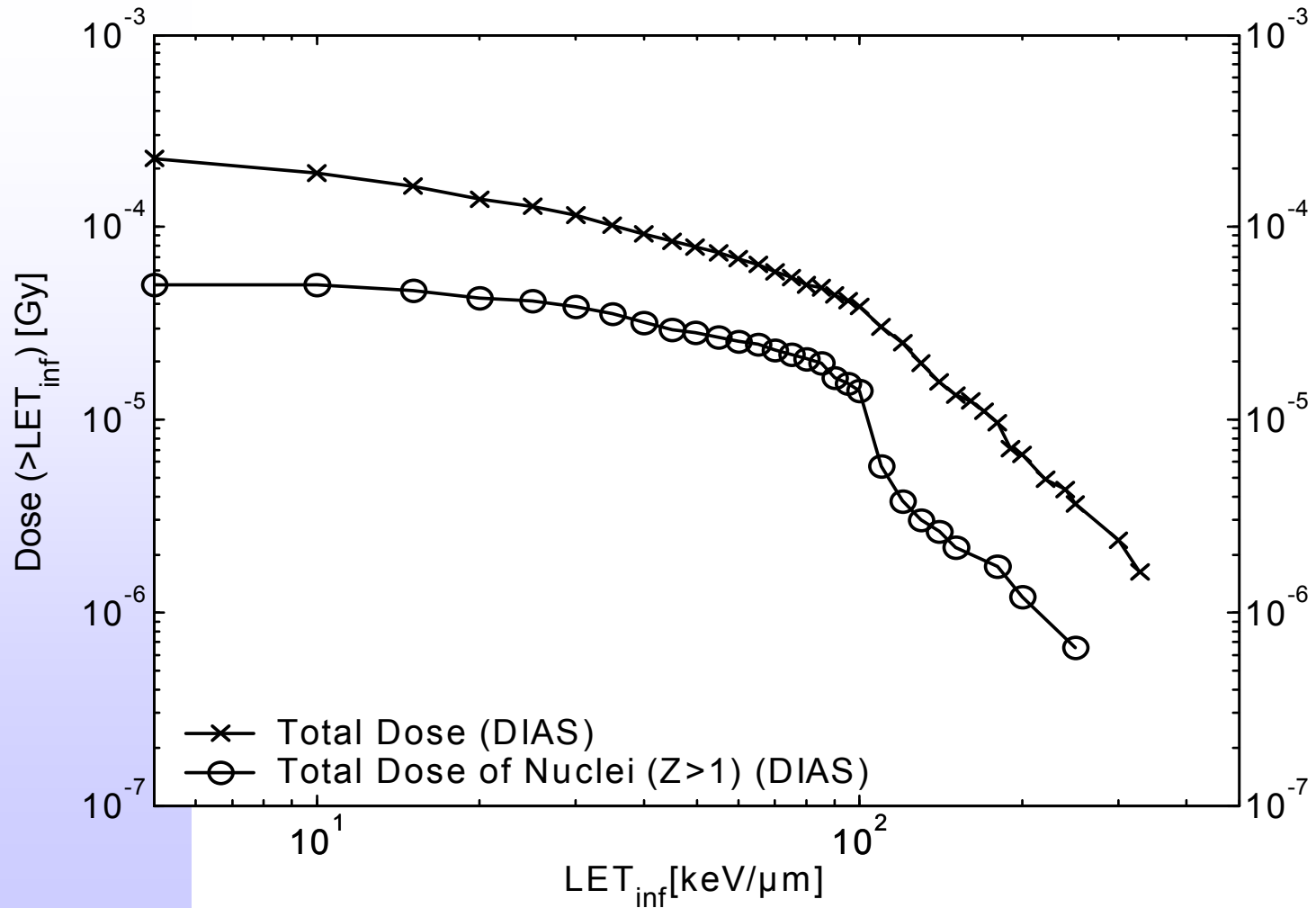


dosemeters inside

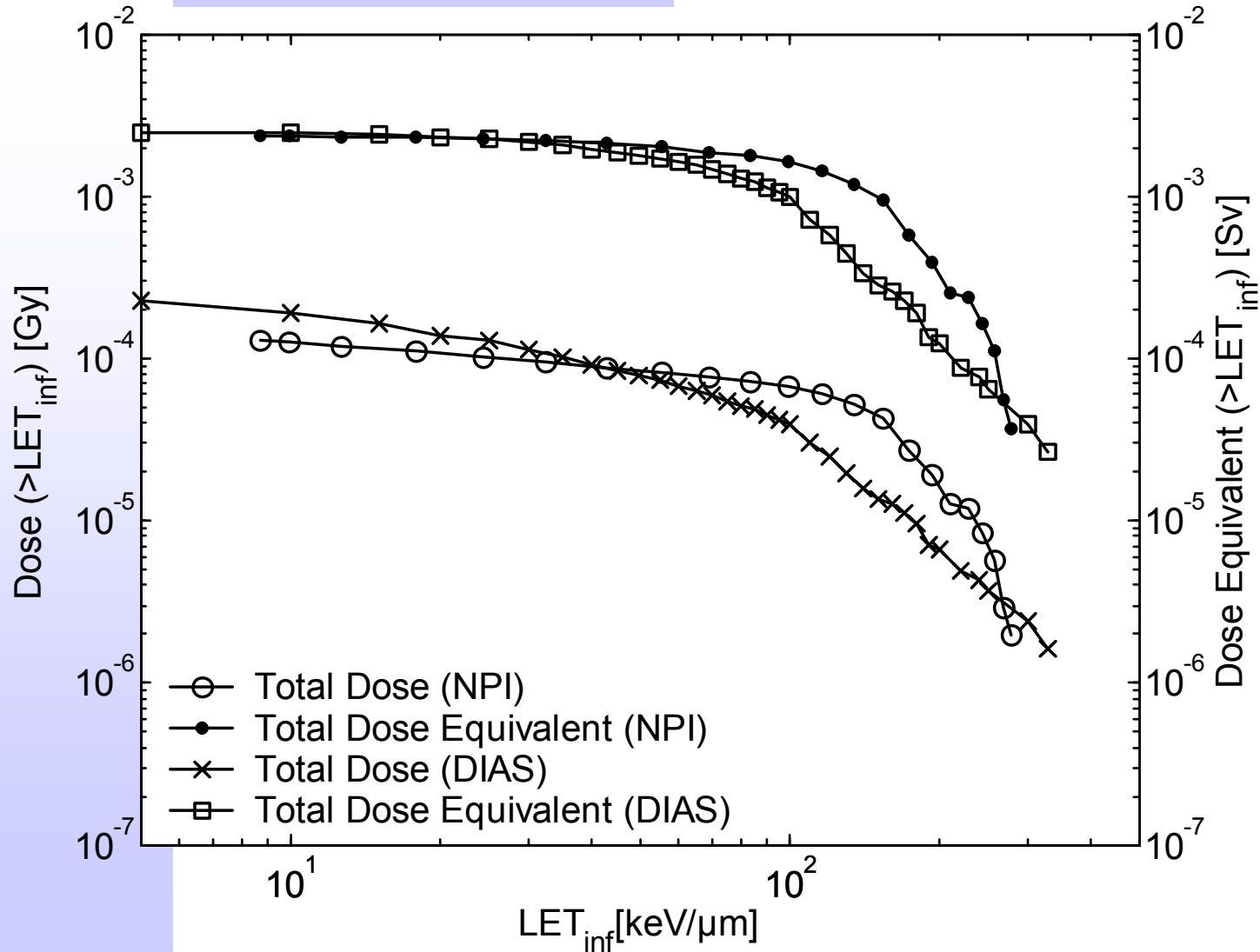
International Space Station



Track-etch detectors: large contribution from protons



Track-etch detectors: small differences between DIAS and NPI results



Track-etch detectors: resulting dose

Institution		LET Threshold \geq (keV/ μ m water)	Absorbed Dose Rate μ Gy/day	Equi. Dose Rate (ICRP 60) μ Sv/day	Quality Factor
DIAS	Total	5	23.0 \pm 0.8	251.2 \pm 8.8	10.9
DIAS	HZE	5	5.1 \pm 0.4	86.2 \pm 6.4	17.0
DIAS	HZE	20	4.4 \pm 0.4	84.4 \pm 6.9	19.3
NPI	Total	8.7	13.2	235.3	17.8

OSL and TL Detectors: results

Institution	Material	Technique	ISS-7S Test Tubes Dose rate [$\mu\text{Gy d}^{-1}$]	ISS-7S Containers Dose rate [$\mu\text{Gy d}^{-1}$]	ISS-8S Test Tubes Dose rate [$\mu\text{Gy d}^{-1}$]
SCK-CEN	$\text{Al}_2\text{O}_3:\text{C}$	CW-OSL	148 ± 5	162 ± 3	157 ± 7
OSU	$\text{Al}_2\text{O}_3:\text{C}$	CW-OSL	170 ± 2	165 ± 2	163 ± 5
SCK-CEN	${}^7\text{LiF}:\text{Mg},\text{Ti}$	TL	152 ± 8	194 ± 17	-
SCK-CEN	${}^7\text{LiF}:\text{Mg},\text{Cu},\text{P}$	TL	143 ± 1	154 ± 4	-
NPI	${}^7\text{LiF}:\text{Mg},\text{Cu},\text{P}$	TL	-	154 ± 12	118 ± 7
NPI	$\text{Al}_2\text{O}_3:\text{C}$	TL	-	178 ± 14	180 ± 18

Different efficiencies for high-LET

- **LET > 10 keV/μm: small contribution in response
~5 μGy/day**
- **1 < LET < 10 keV/μm: qualitative agreement**

LiF:Mg,Ti > Al₂O₃:C > LiF:Mg,Cu,P

LET [keV/μm]	⁷ LiF:Mg,Cu,P	⁷ LiF:Mg,Ti	Al ₂ O ₃ :C (OSLD)	Al ₂ O ₃ :C (TLD)
2.26	0.78	1.12	0.83	0.89
10.8	0.51	0.92	0.53	0.56
55.5	0.32	0.55	0.33	0.37
189	0.29	0.45	0.3	0.32

ICCHIBAN 1&2 (taken from HIMAC-078 report)

Future: DOBIES

Dosimetry for Biological Experiments in Space

The objective of this project is to develop a standard dosimetric method (as a combination of different techniques) to measure accurately the absorbed doses and equivalent doses in biological samples.

Plan of activities

- Determination of response characteristics of thermoluminescent detectors to low and high LET radiation
- Determination of response characteristics of optically luminescent detectors to low and high LET radiation
- Calibration of track etch detectors to high LET radiation

Plan of activities

- Development of a measurement and calculation procedure for the absorbed doses and equivalent doses in biological samples
- Development of a standard measurement kit for different biological and microbiological samples (in vitro cells, tissue, bone,...)
- Comparison of the results obtained from space flights and the calculated doses for different sample materials and geometries

Conclusions

- Dose rate measured by the OSL and TL detectors: 162 $\mu\text{Gy}/\text{day}$
 - high-LET ($>10 \text{ keV}/\mu\text{m}$) particles
 $\sim 5 \mu\text{Gy d}^{-1}$
- High LET dose ($>5 \text{ keV}/\mu\text{m}$) measured by TED's: 23 $\mu\text{Gy}/\text{day}$
 - dose equivalent for high-LET radiation is $\sim 250 \mu\text{Sv d}^{-1}$

Conclusions

- Total dose rate: $\sim 180 \mu\text{Gy}/\text{day}$
- Different results for different types of detectors: \neq efficiencies to HCP with $\text{LET} < \text{detection threshold of TED's}$
- No difference found between ISS-7S and ISS-8S