



STUDIECENTRUM VOOR KERNENERGIE  
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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

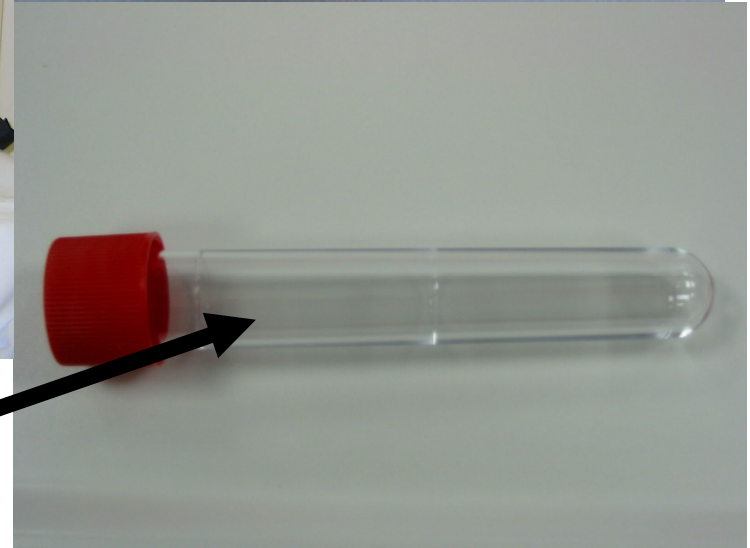
- **Thermoluminescence detectors**

- 7LiF:Mg,Ti SCK•CEN, NPI
- 7LiF:Mg,Cu,P SCK•CEN
- Al<sub>2</sub>O<sub>3</sub>:C NPI

- **Optically Stimulated luminescence detectors**

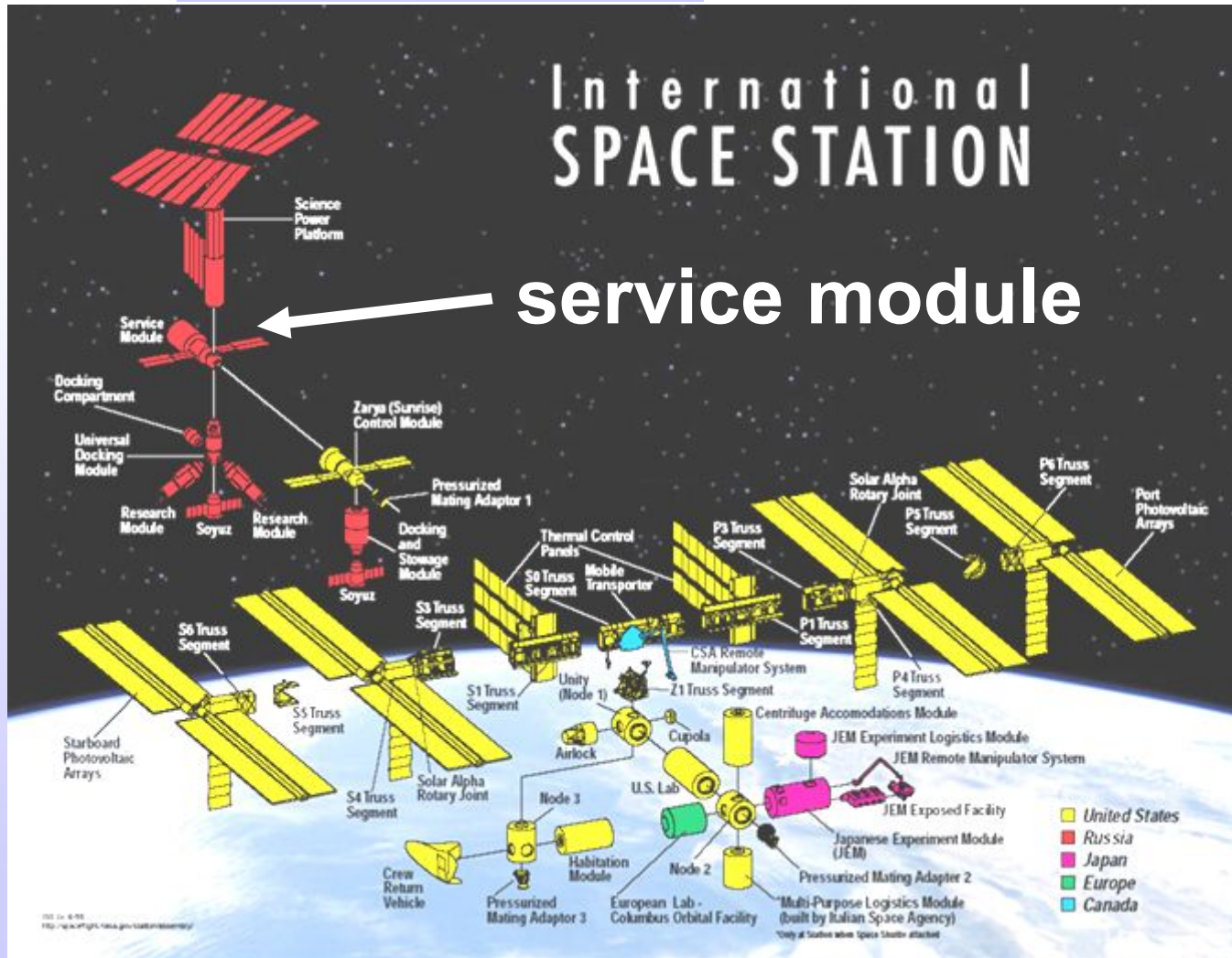
- Al<sub>2</sub>O<sub>3</sub>:C : SCK-CEN CW-OSL
- Al<sub>2</sub>O<sub>3</sub>:C : OSU CW-OSL

# Transport bags

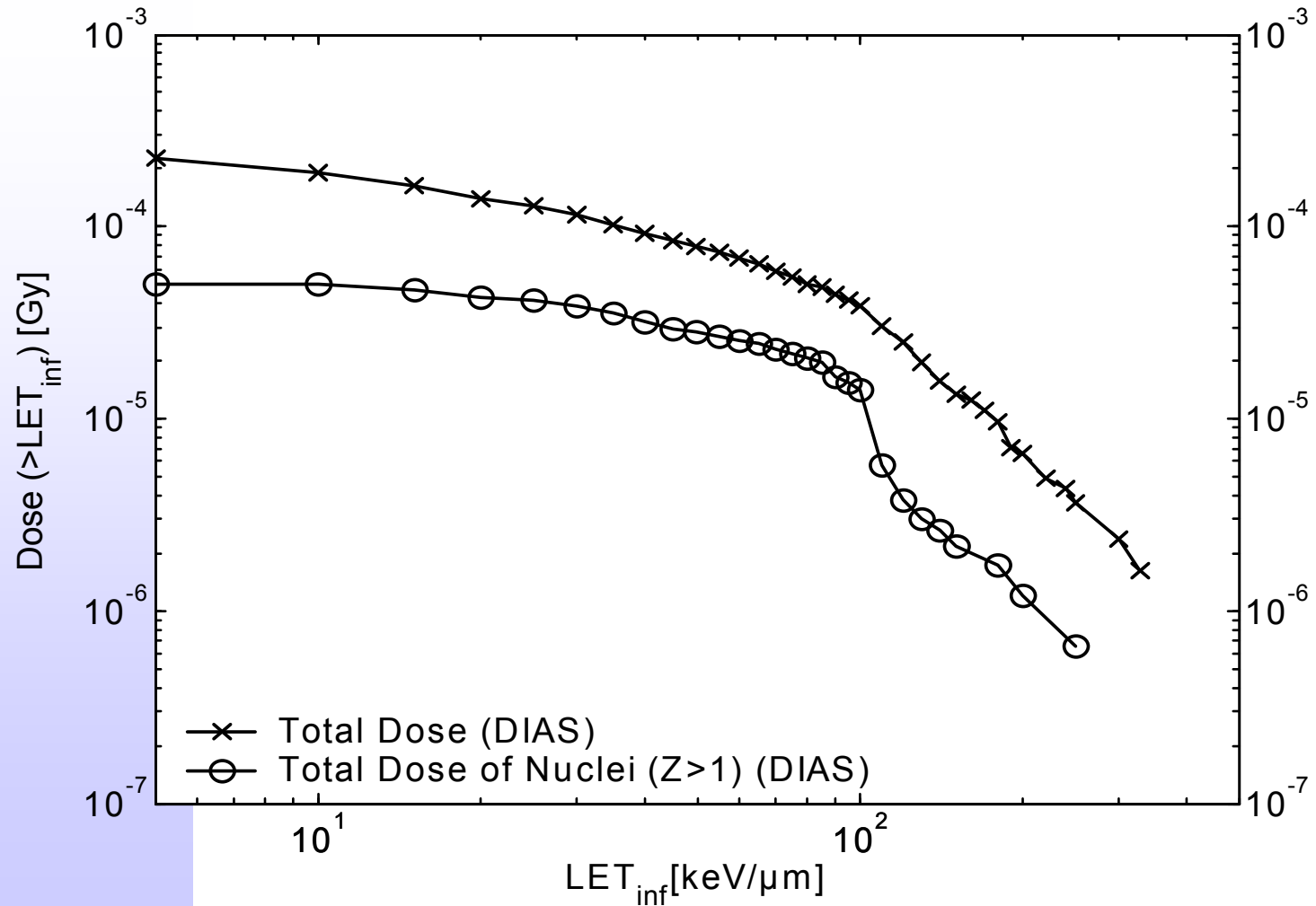


dosemeters inside

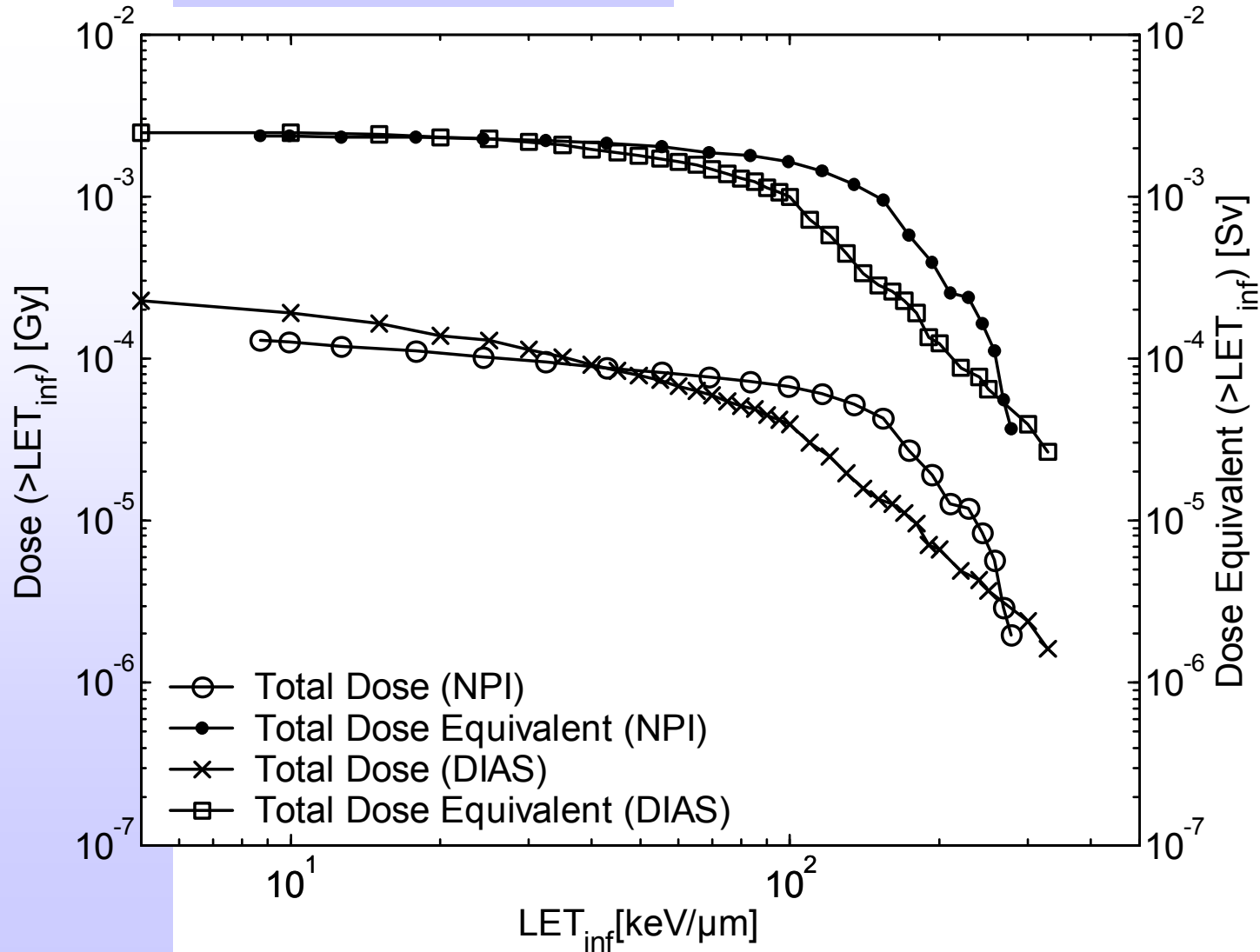
# International Space Station



# 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/ $\mu$ m water)	Absorbed Dose Rate $\mu$ Gy/day	Equi. Dose Rate (ICRP 60) $\mu$ 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	<b><math>148 \pm 5</math></b>	<b><math>162 \pm 3</math></b>	<b><math>157 \pm 7</math></b>
OSU	$\text{Al}_2\text{O}_3:\text{C}$	CW-OSL	<b><math>170 \pm 2</math></b>	<b><math>165 \pm 2</math></b>	<b><math>163 \pm 5</math></b>
SCK-CEN	$^7\text{LiF}:\text{Mg},\text{Ti}$	TL	<b><math>152 \pm 8</math></b>	<b><math>194 \pm 17</math></b>	-
SCK-CEN	$^7\text{LiF}:\text{Mg},\text{Cu},\text{P}$	TL	<b><math>143 \pm 1</math></b>	<b><math>154 \pm 4</math></b>	-
NPI	$^7\text{LiF}:\text{Mg},\text{Cu},\text{P}$	TL	-	<b><math>154 \pm 12</math></b>	<b><math>118 \pm 7</math></b>
NPI	$\text{Al}_2\text{O}_3:\text{C}$	TL	-	<b><math>178 \pm 14</math></b>	<b><math>180 \pm 18</math></b>

## 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 > Al<sub>2</sub>O<sub>3</sub>:C > LiF:Mg,Cu,P**

LET [keV/μm]	<sup>7</sup> LiF:Mg,Cu,P	<sup>7</sup> LiF:Mg,Ti	Al <sub>2</sub> O <sub>3</sub> :C (OSLD)	Al <sub>2</sub> O <sub>3</sub> :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

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- 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:  $\sim 180 \mu\text{Gy/day}$
- 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