Radiation Measurements for DOBIES (DOsimetry of BIological Experiments in Space)

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DOBIES OBJECTIVE

- To Develop a Reliable,Standard Dosimetric Method to Estimate Absorbed Dose,Dose Equivalent and Linear Energy Transfer (LET) Spectra in Biological Samples Exposed in Space Using :
- Nuclear Track Detectors
- TLDs
- OSLDs

High LET Radiation in LEO

GCR (Galactic Cosmic Rays)

SAA (South Atlantic Anomaly) Particles

Solar Energetic Particles

Albedo Neutrons and Protons Scattered from the Earth's atmosphere

Short Range Recoils & Fragments resulting from interactions between primary particles and nuclei of shielding & payload.

Radiation Damage

- High Energy Particles From All Of these Sources can Penetrate Humans and Bacteria In Space and Cause Damage Leading to effects Like Chromosome Abberations and Damage to DNA
- Bacteria Play an Important Role in Recycling of Organic Waste.
- They Can Be a Problem if Mutations Occur

Importance of High LET Radiation

Biological impact is dominated by high LET radiation

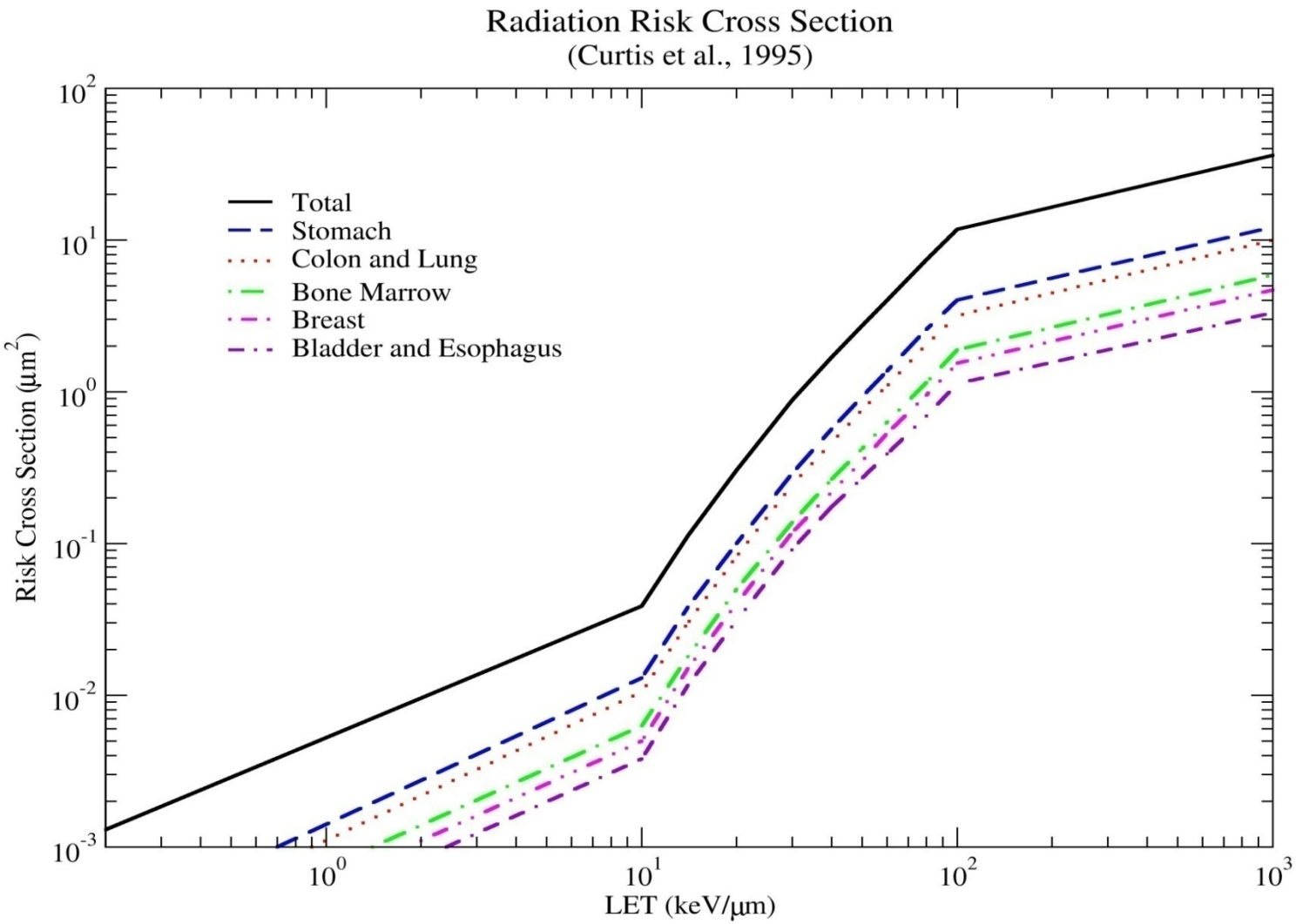

Figure 1: Risk Cross Section as the Function of LET

Risk cross section from high LET (≥10 keV/μm) radiation is ~ two orders higher than that from low LET (≤10 keV/μm).

Contribution from low LET can be treated as insignificant

Approach to DOBIES is the same as Matroshka

Employ Track Detectors and TLDs

Configurations of DOBIES Passive Dosimeters (TLDs/OSLDs + CR-39 PNTDs)

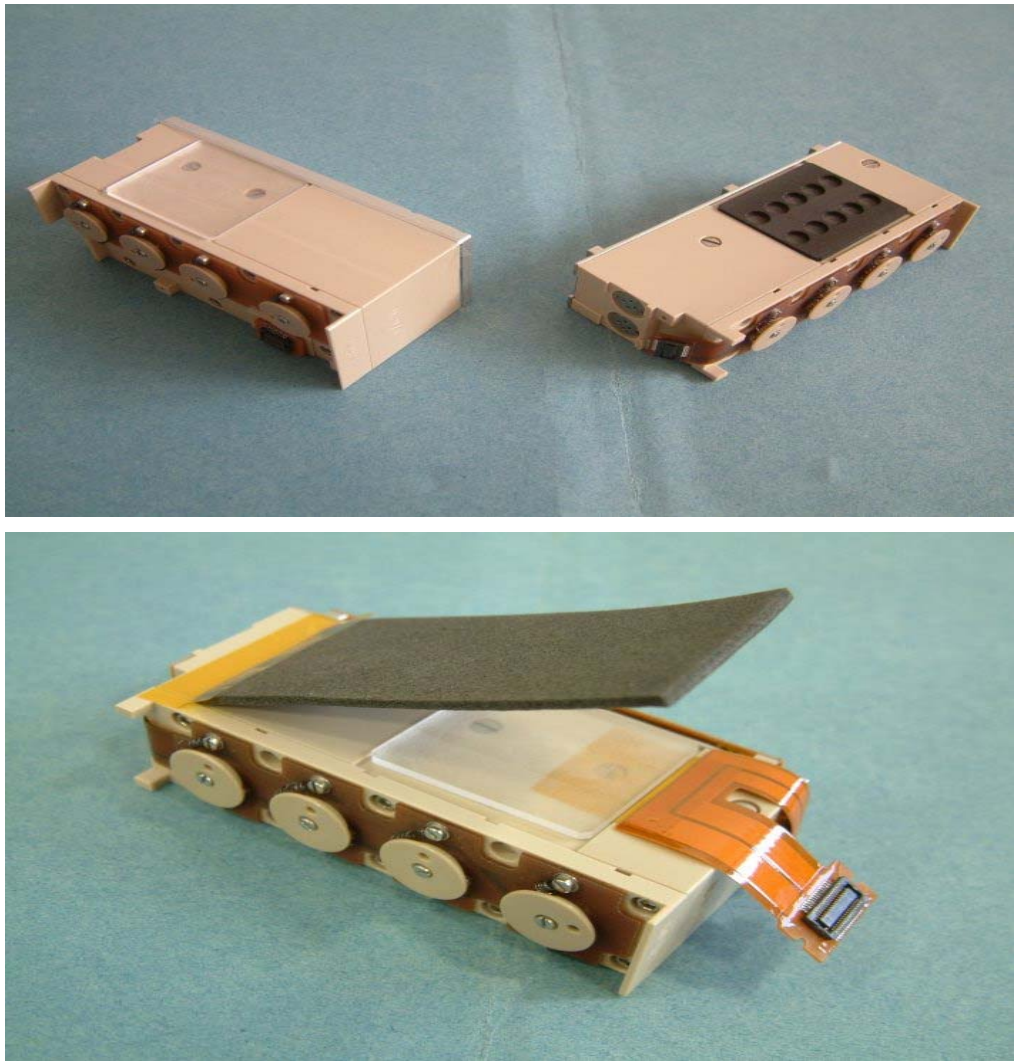

Figure 2: Configurations of Dobies Passive Dosimeters

Exposure Time

12 - 24 October 2008 with the exposure time of ~ 11.67 days in the Russian Zvezda service module on ISS.

Processing and Analysis

After exposure the CR-39 detectors were recovered and chemically etched in JSC-SRAG (Space Radiation Analysis Group).

Data scan and analysis were conducted in JSC-SRAG and DIAS


esa
esa

LET Spectrum Method Using CR-39 Detectors

LET Spectrum Method for Radiation Measurement Using CR-39

(1) CR-39 Exposure and Chemical Etch

(a) Radiation Exposure of CR-39 Detectors

(b) Chemical Etch of CR-39 Detectors

(c) Bulk Etch Measurement

$$B = \frac{(m_1 - m_2)T_2}{2m_2}\left(1 - \frac{pT_2}{2A_d}\right)$$

(2) Data Scan and Acquisition

Events were identified and the major and minor axes of the etched track cones on the CR-39 surface were measured by manual scan.

(3) Data Analysis and LET Spectra Generating

Scanned data were then analyzed, the LET spectra were generated and the radiation quantities were obtained. **(To be continued)**

Results Measured with CR-39 Detectors

Figure 3 shows integral LET spectra of dose equivalent measured with CR-39 detectors for DOBIES 2008, including that for HZEs (Stack 1).

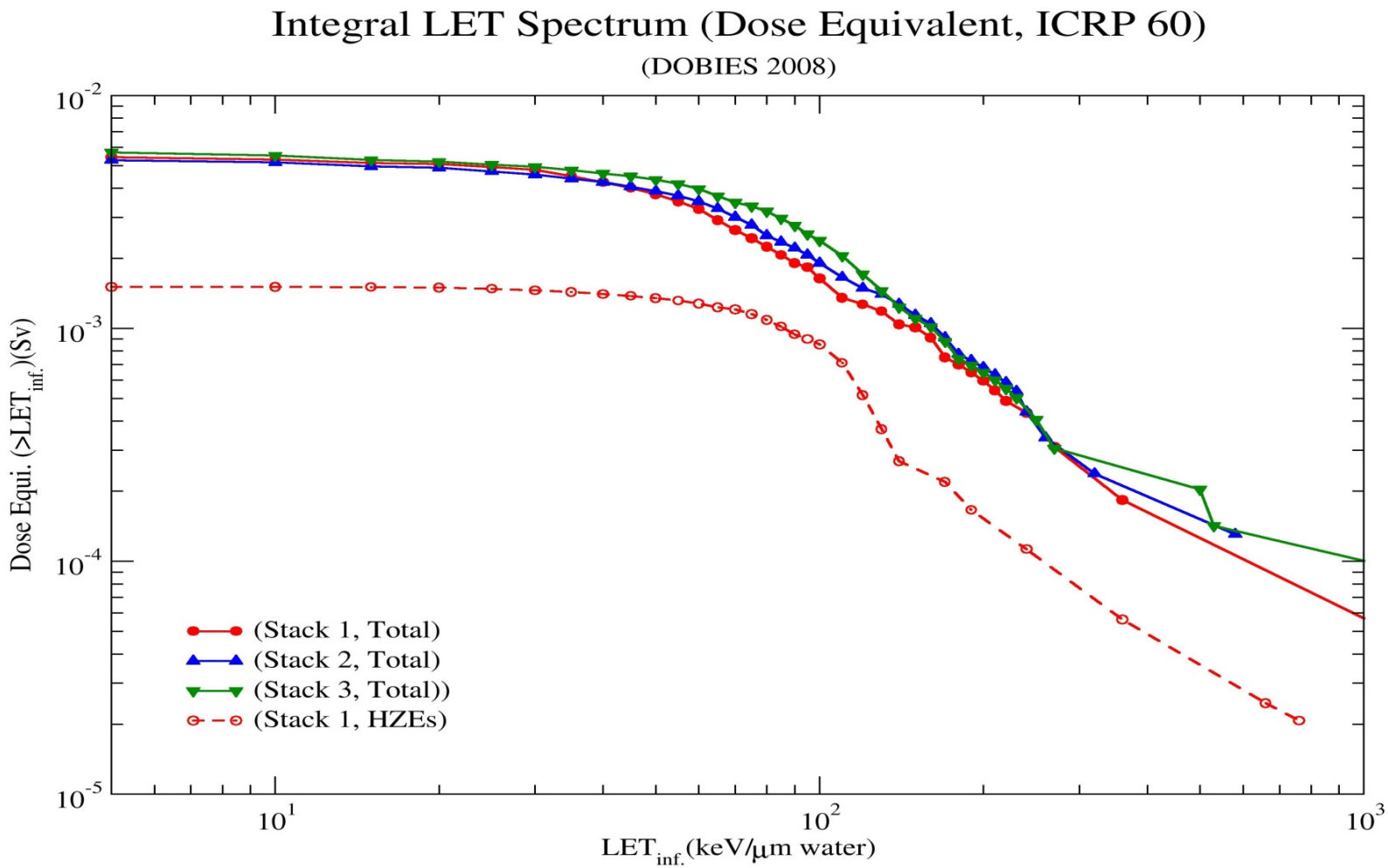

Figure 3: LET Spectra of Dose Equivalent (Total Means All Types of Particles)

Figure 4 shows average quality factor measured with CR-39 detectors for DOBIES 2008, including that for HZEs (Stack 1).

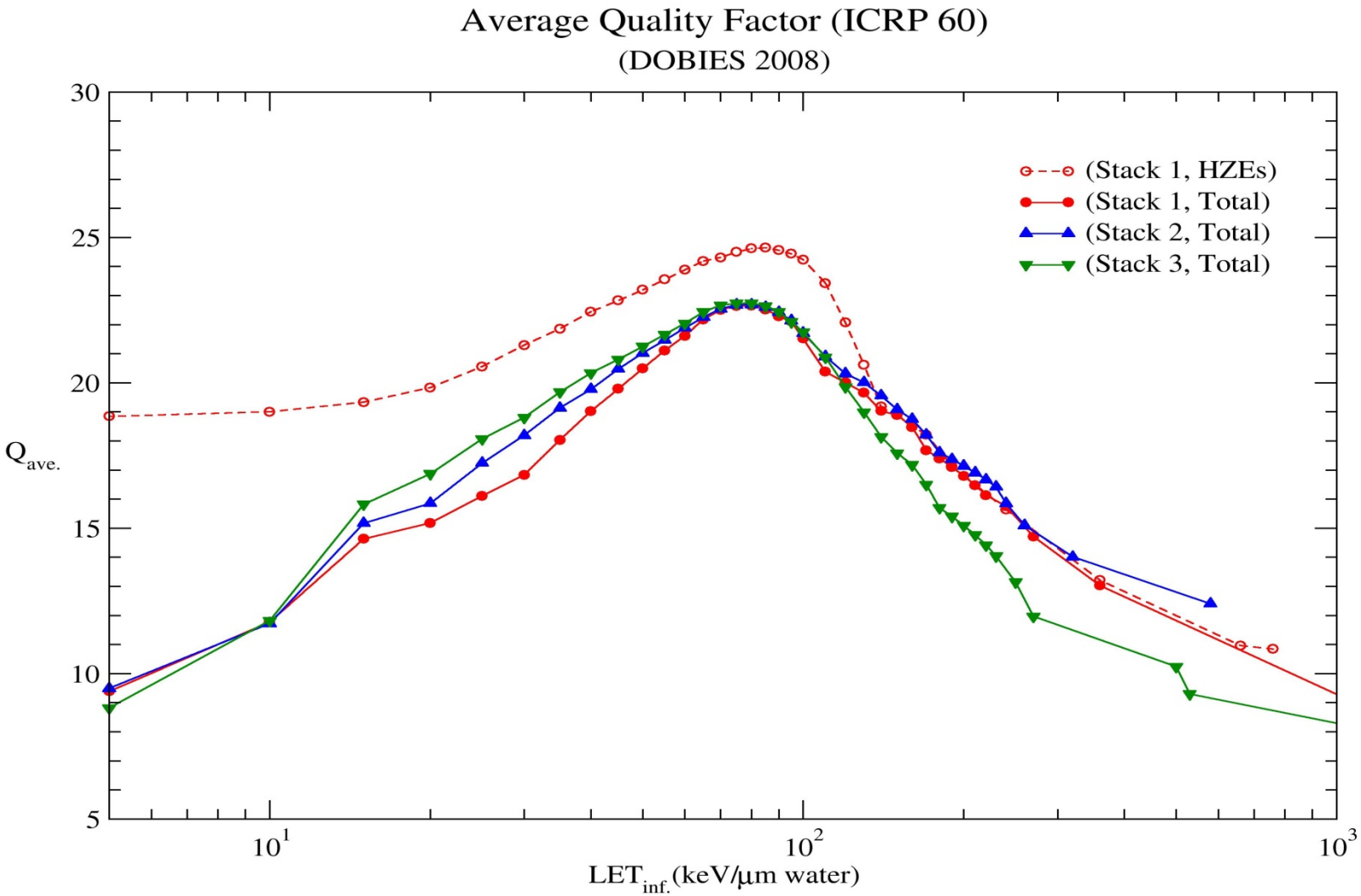

Figure 4: Average Quality Factor for Dobies 2008 Experiments.

Figure 5 is a comparison of the dose equivalent measured in 2006 and 2008 for DOBIES experiments.

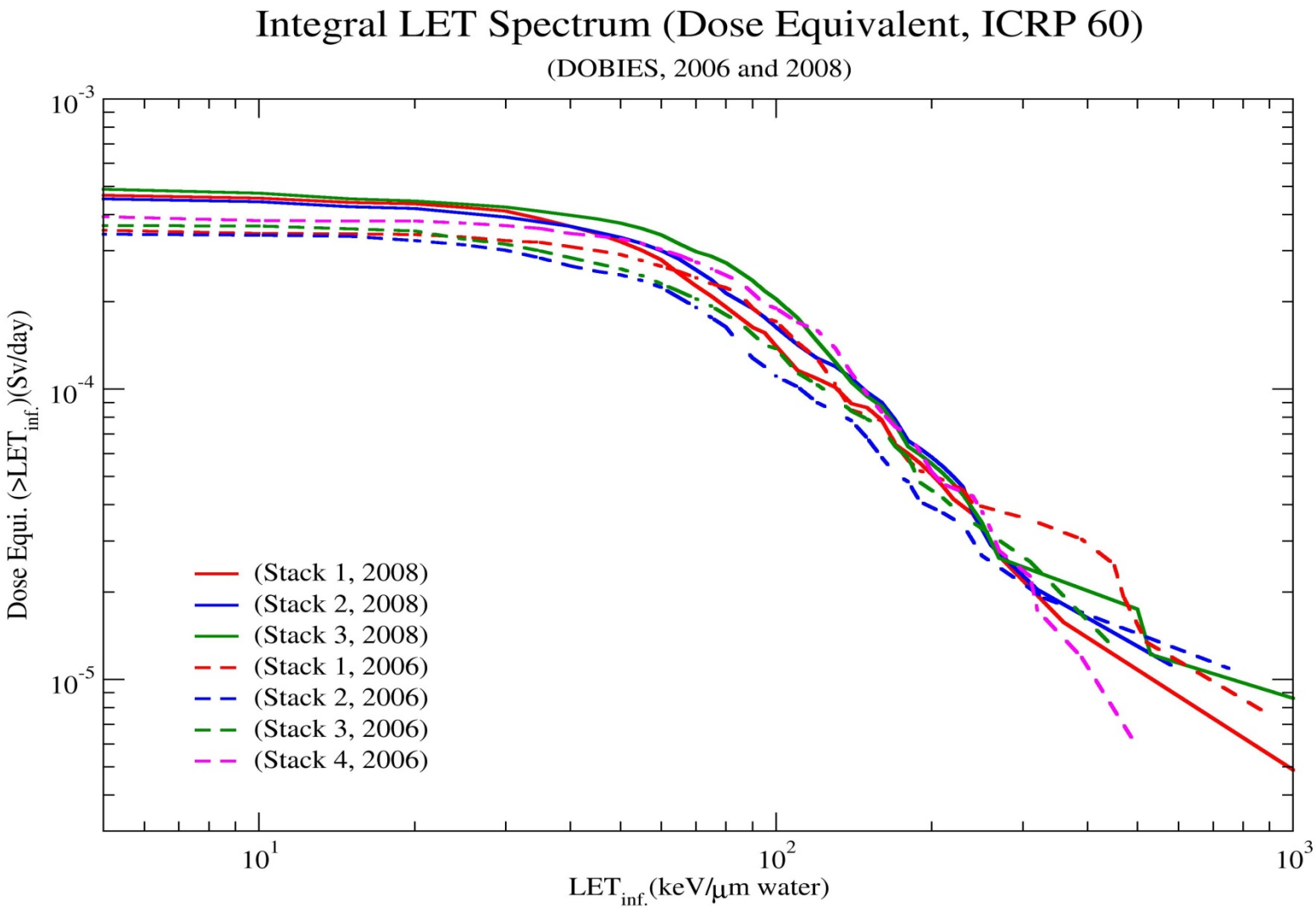

Figure 5: Comparison of Dose Equivalent Measured in 2006 and 2008.

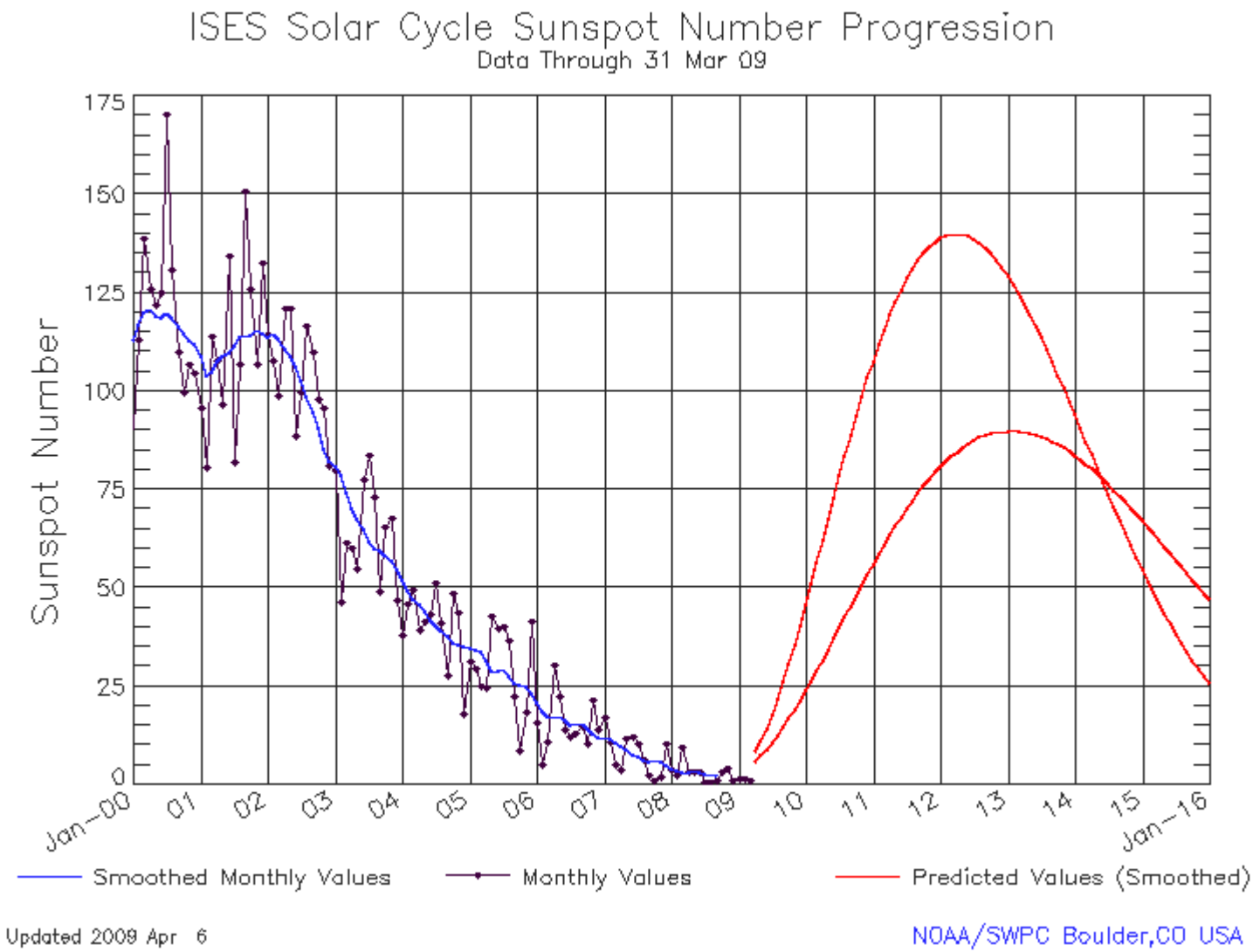
ISES Solar Cycle Sunspot Number Progression
Data Through 31 Mar 09
Sunspot Number
175
150
125
100
75
50
25
0
Jan-00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
Jan-16
Smoothed Monthly Values
Monthly Values
Predicted Values (Smoothed)
Updated 2009 Apr 6
NOAA/SWPC Boulder,CO USA

Table 1 collects results measured with CR-39 PNTDs for DOBIES experiments.

Table 1: Radiation Results Measured with CR-39 Detectors (DOBIES 2006 and 2008, ICRP 60, ≥ 10 keV/μm water)

Detector	Absorbed Dose	Dose Equivalent	Q Factor
	(μGy/Day)	(μSv/Day)	
2006			
Stack 1 (Total)	29.9 ± 1.9	353 ± 22	11.81 ± 0.74
Stack 2 (Total)	29.2 ± 2.8	342 ± 32	11.70 ± 1.10
Stack 3 (Total)	31.5 ± 3.2	366 ± 37	11.61 ± 1.17
Stack 4 (Total)	33.4 ± 2.1	392 ± 25	11.74 ± 0.75
Average (Total)	31.0	363	11.72
2008			
Stack 1 (Total)	38.7 ± 3.4	455 ± 40	11.77 ± 1.04
Stack 1 (HZEs)	6.8 ± 0.9	129 ± 17	19.00 ± 2.47
Stack 2 (Total)	37.7 ± 3.1	442 ± 36	11.72 ± 0.95
Stack 3 (Total)	40.0 ± 3.3	473 ± 39	11.82 ± 0.98
Average (Total)	38.8	457	11.77
Ave. 2008/Ave.2006	125%	126%	

RESULTS FOR RHODOSPIRILLUM RUBRUM

- The Belgian Team found that even at the low doses of the 2006 exposure,there was evidence that the bacterium was more sensitive to ionising radiation than to microgravity

Conclusions

1. **Results obtained with CR-39 detectors for DOBIES 2006 and 2008 experiments were consistent with that expected for the different phases of the solar cycle**

2. **Radiation dose equivalent contributed by HZE particles is ~ 28% of total dose equivalent contributed by all types of particles.**

- THANK YOU FOR LISTENING