Charge Spectrum, Dose Equivalent and Absorbed Dose Investigations on STS-108

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- Passive Detectors (CR-39) Employed
- Signals due to short range recoils from protons, neutrons and heavy nucleus interactions investigated
- Primary and secondary cosmic ray particle tracks identified

The DIAS method of measuring dose equivalent due to cosmic ray primary and secondary nuclei at aircraft altitudes is based on the investigation of short range recoil tracks with high LET values (≥ 5kev/μm).

An etch rate ratio (S) was measured for each event and the relationship between LET values and S was determined by calibrating the detectors with protons and carbon ions over most of the range of LET values observed

LET values were binned and the differential fluence was obtained from

$$\frac{d^3 n}{dA\,d\Omega\,dLET} = \left(2pA\cos^2 d_{cut}\right)^{-1}\frac{dN}{dLET}$$

The absorbed dose (G_y) is then

$$= 4p \text{ x } 1.6 \text{x} 10^{-9} \text{ x } \mathrm{LET}_{\infty} \text{ x F}$$

where LET_{∞} is the linear energy transfer (keV/μm) in water at the center of the relevant LET bin and F is the differential fluence in particles $cm^{-2}sr^{-1}(keV/\mu m)^{-1}$ in the same bin. The integral spectrum is generated by summing the differential spectrum from high to low LET.

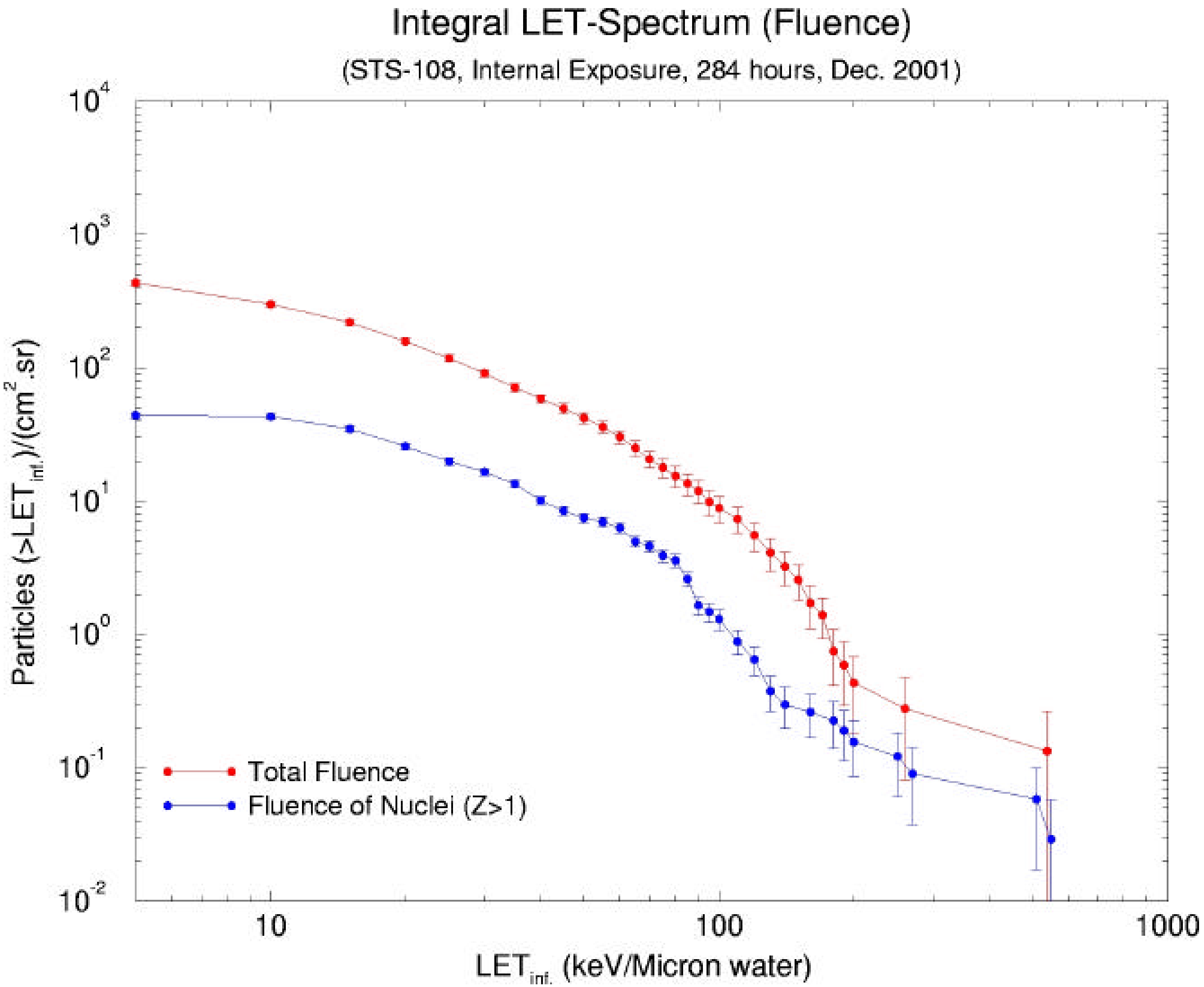

Figure 1: Integral LET spectra of fluence for cosmic rays in low Earth Orbit

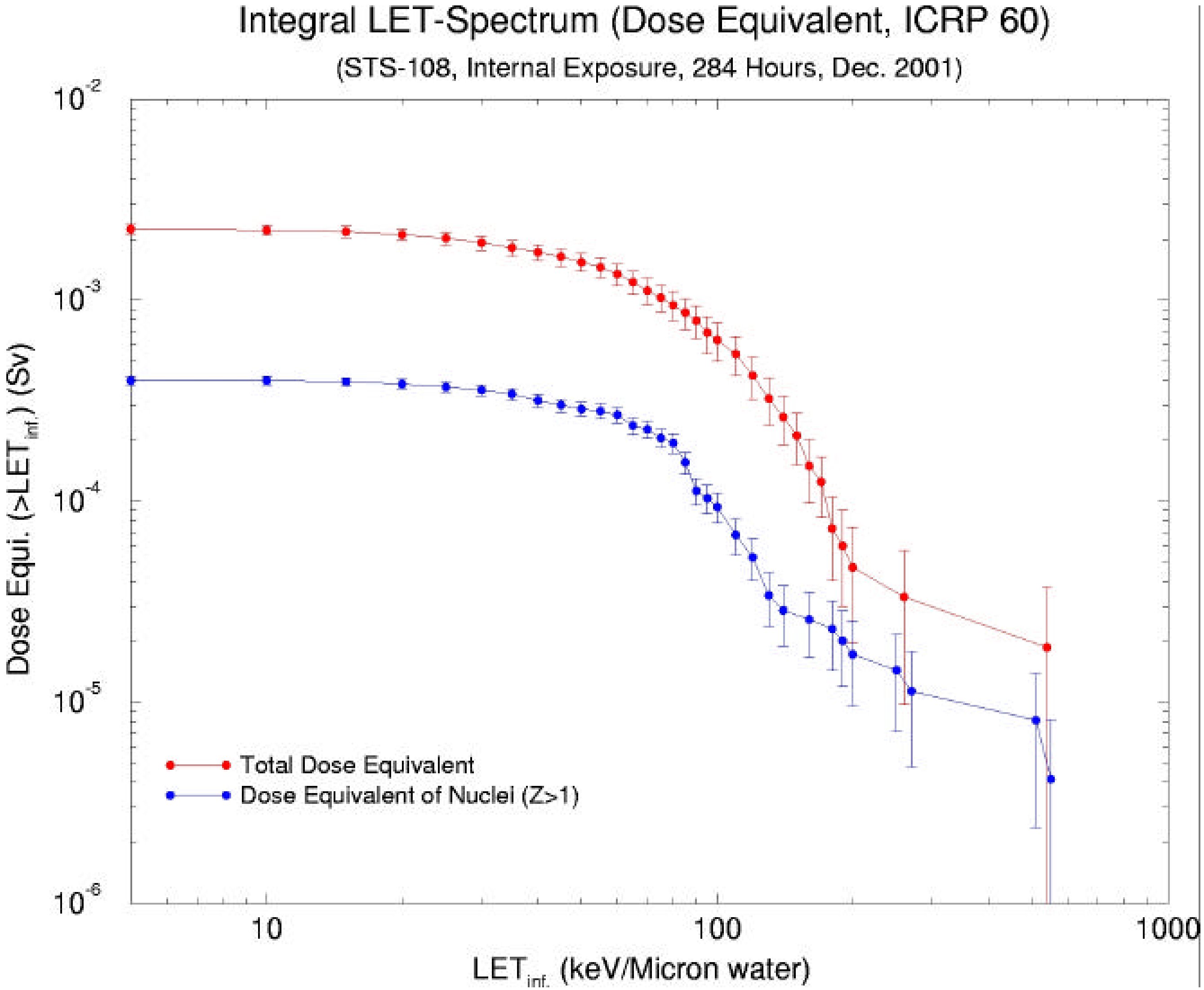

Figure 2: Integral LET-spectra of dose equivalent for cosmic rays in low Earth orbit.

Table 1: Comparison of dose rate and dose equivalent rate of cosmic rays for ISS Expedition and STS-108

Mission	**Altitude/ Inclination**	**LET Threshold**	**Absorbed Dose Rate**	**Dose Equivalent Rate (ICRP 60)**	**Quality Factor**
Date	**Km/Degree**	**³ KeV/mm water**	**mGy/d**	**mSv/d**	
ISS Expedition **May-Aug 2001** ***Benton et al*** Total	398/51.6°	10	26.2 23.8 30.2 29.8	235 233 240 214	8.97 9.79 7.95 7.18
STS-108 - Dec 2001 ***DIAS*** Total HZE HZE	390/51.6°	 5 5 20	 17.17 2.51 2.05	 189.94 33.60 32.35	 11.06 13.38 15.75

Charge Spectrum

The charge spectrum of $Z \geq 2$ nuclei was determined for nuclei that stopped in the 1.2 cm thick stack. Investigation of high energy and relativistic particles is continuing. All particles penetrating one or more sheets were noted and followed to the end of their range. HZE particles can be identified by measuring effective etch rate ratio S_{eff} and fractional etch rate gradient G ($g^{-1}cm^2$).

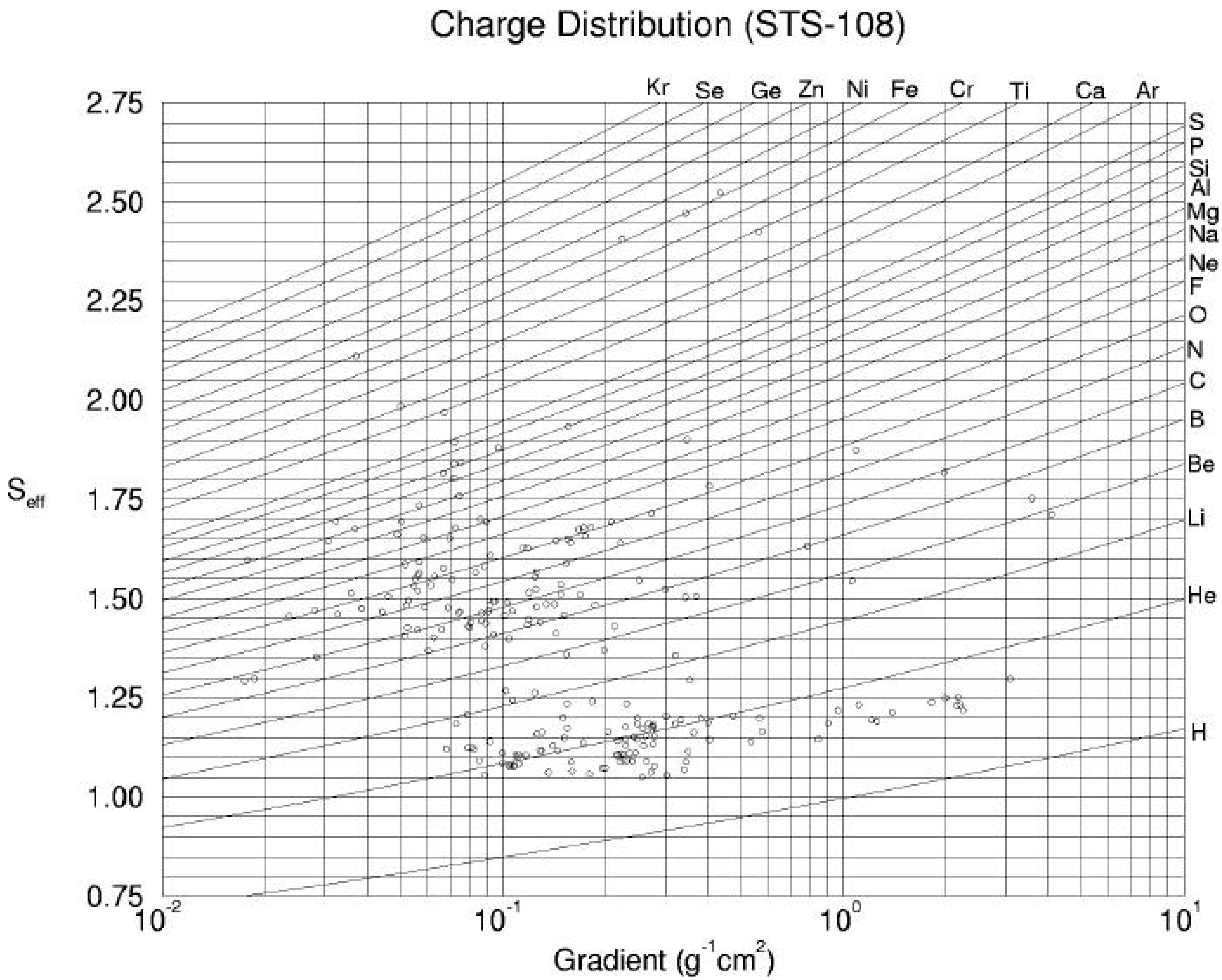

Figure 3: S_{eff} versus gradient for cosmic rays (Z ^{3} 2) in low Earth orbit

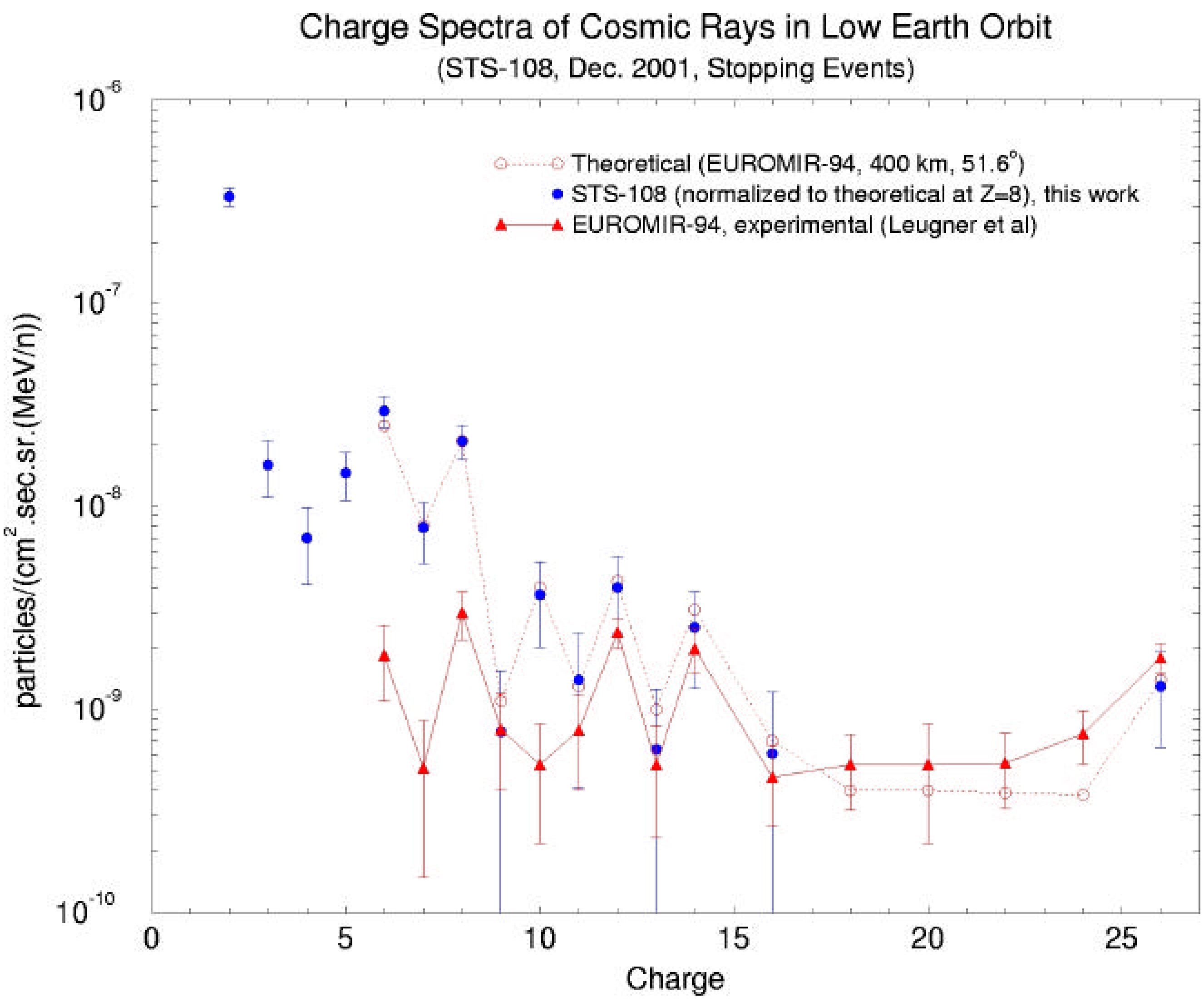

Figure 4: Charge distribution of cosmic rays (Z ^{3} 2) in low Earth orbit.

Table 2: Energy Intervals for stopping events

Nucleus	Charge	Energy Interval
		MeV/n
He	2	7-27
Li	3	12-60
Be	4	15-75
B	5	18-85
C	6	20-95
N	7	25-105
O	8	30-120
Ne	10	35-130
Mg	12	40-145
Si	14	45-155
Fe	26	50-265

Conclusions

- Assuming shielding of ~20 g/cm^2 the dose and dose equivalent rates observed on STS-108 were 17 μGy/d and 189.9 μGy/d, respectively
- The quality factor (13.38) for HZE ($Z \geq 2$) agrees well with that predicted by (Heinrich, 1977)
- The charge spectrum shows higher abundances in the range ($2 \leq Z \leq 10$) than those observed in Euromir-94. This may be due to the higher scanning efficiency of the DIAS method
- The charge spectrum data show very good agreement with results predicted by the Siegen University Model