

LET distributions measured by RRMD-III on board the STS-84, -89 and -91

**T.Doke^{1,3)}, T.Hayashi¹⁾, J.Kikuchi¹⁾, T.Sakaguchi¹⁾, E.Yoshihira¹⁾,
S.Nagaoka²⁾, T.Nakano³⁾, S.Takahashi³⁾**

¹⁾ Advanced Research Institute for Science and Engineering, Waseda University

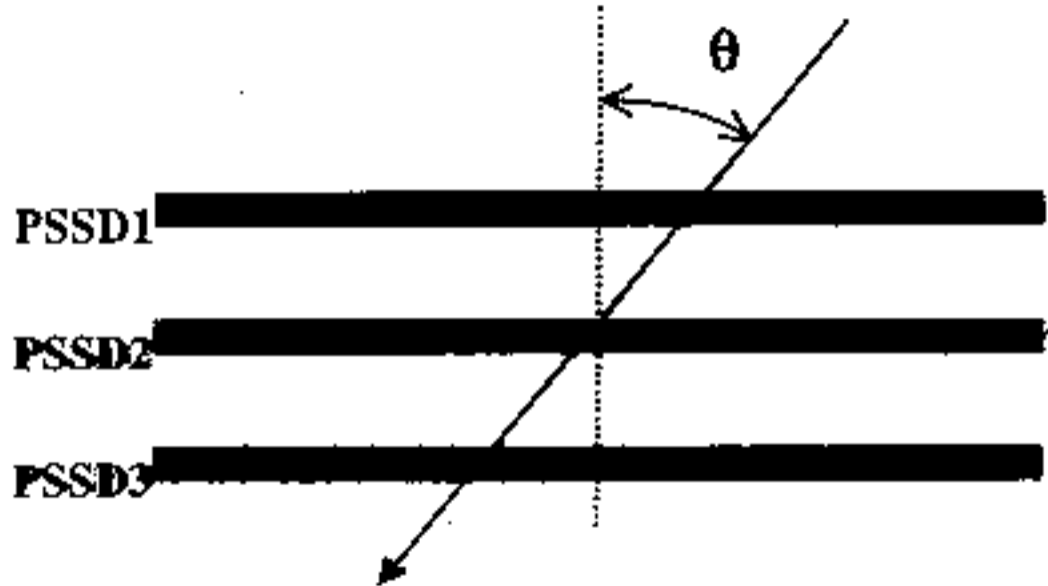
²⁾ Fujita Health University

³⁾ Tsukuba Space Center, National Space Development Agency of Japan

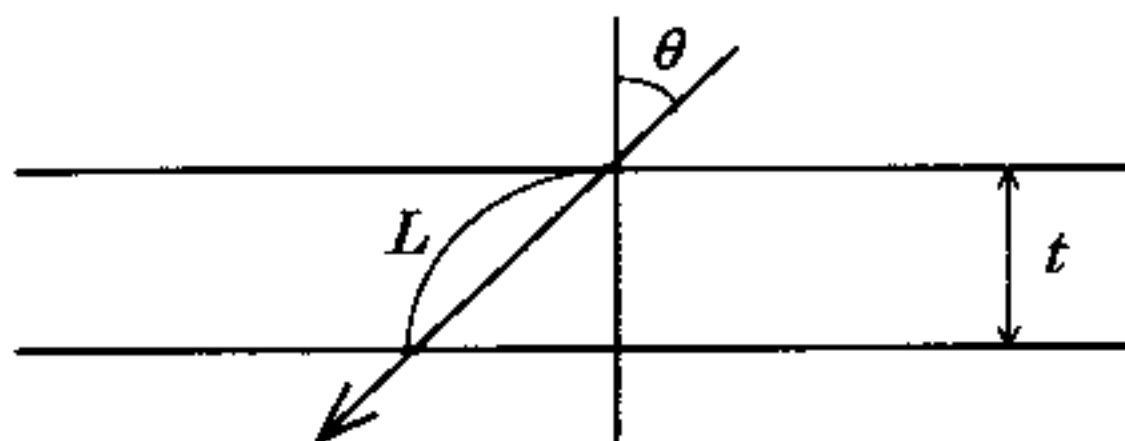
WRNISS

at DERA Farnborough, England

November 4th, 1999



For penetrated particles,



$$\text{LET} = E_d / L = (E_d \cdot \cos\theta) / t,$$

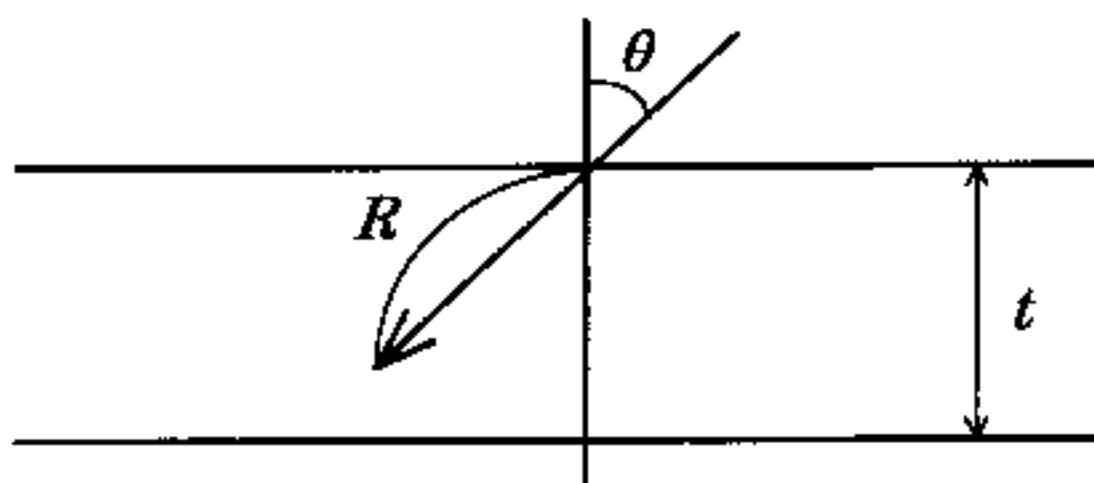
where E_d : deposited energy

L : path length of particle in silicon

θ : incident angle of particle

t : thickness of silicon detector

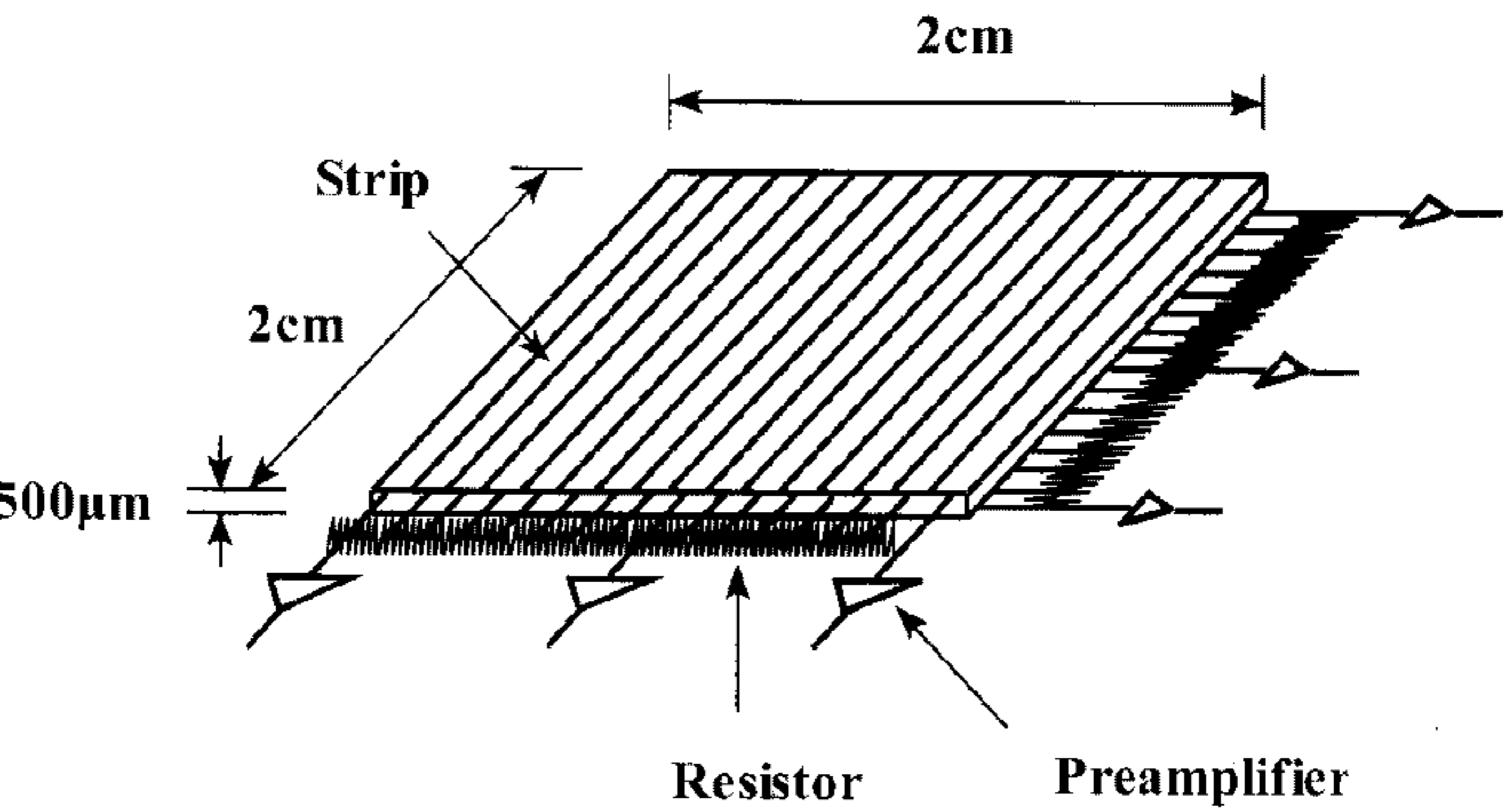
For particle stopped in silicon detector,



$$\text{LET} = E_d / R,$$

where R : the range of incident particle.

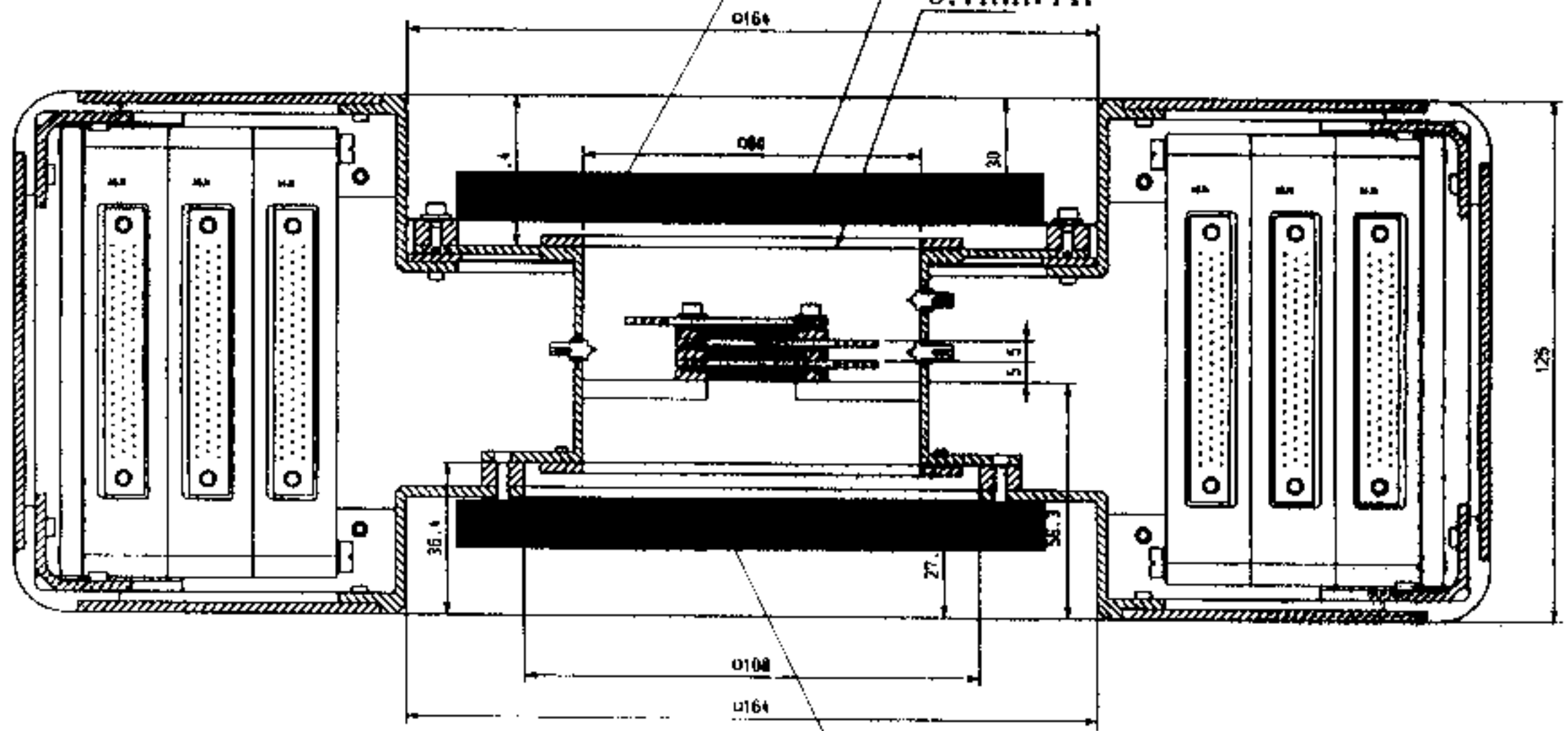
The element of incident particle is identified by ΔE - E method (here, ΔE detector is PSSD-1, E -detector is PSSD-2). If so, the range of the particle is obtained from E_d by using the range-energy relation of silicon.



Biological material, $\sim 3\text{g/cm}^2$

0.3mm Al

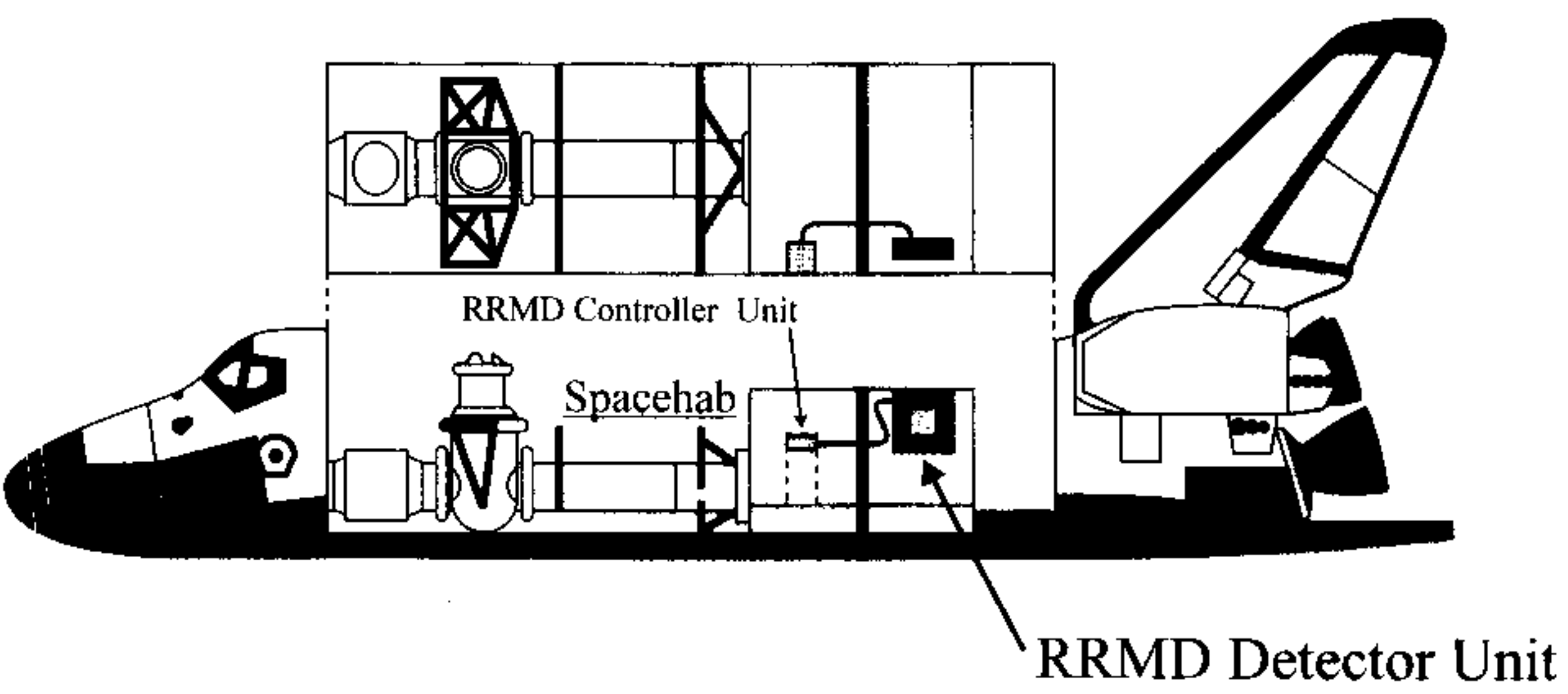
0.1mm Al

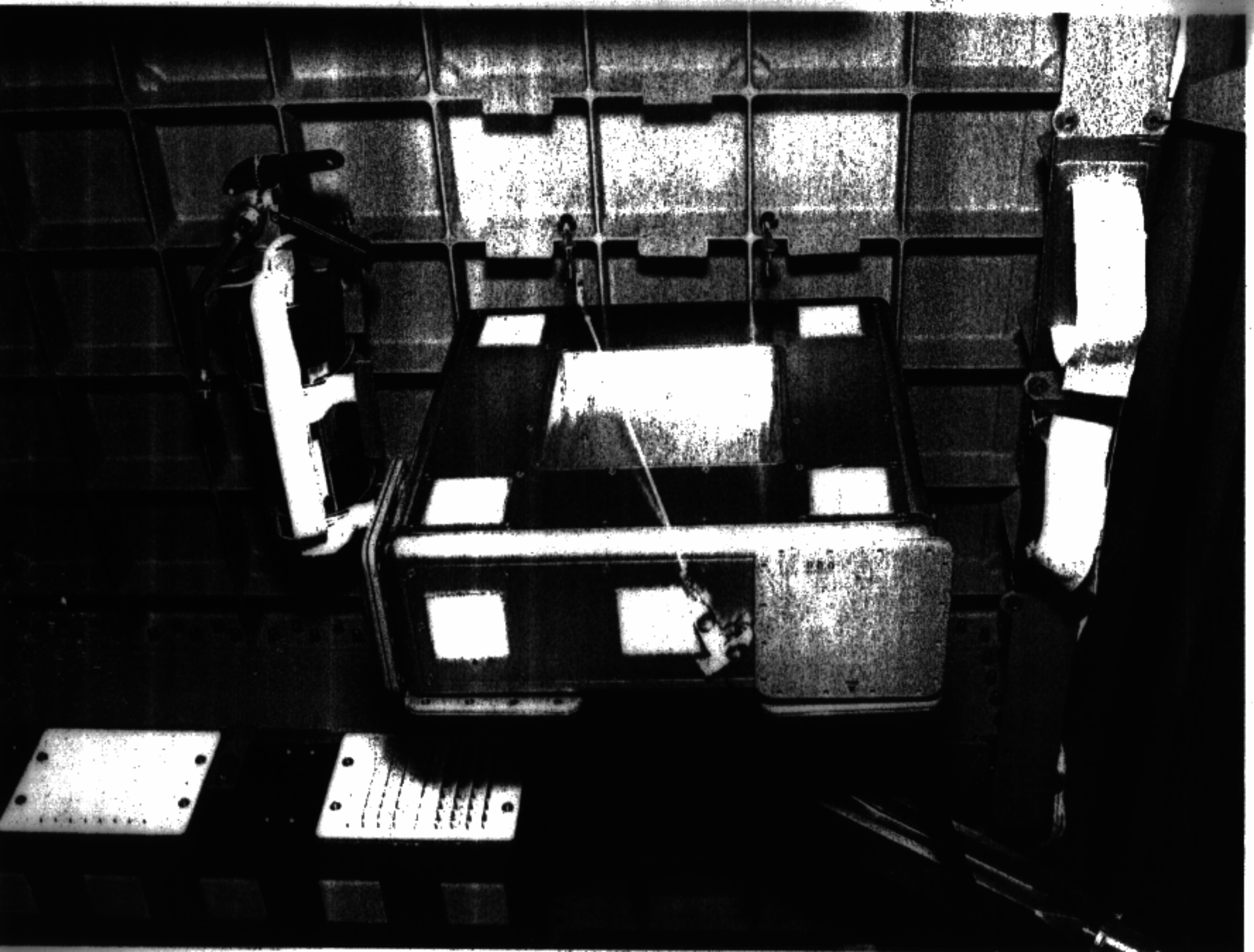


Biological material, $\sim 3\text{g/cm}^2$

Mission	Launch date	Active detector duration	Thickness of bio sample
STS-84	May 15, 1997	178.3 hours	2g / cm ² (one side)
STS-89	Jan. 22, 1998	75.2 hours	1g / cm ² (both sides)
STS-91	Jun. 2, 1998	141.1 hours	3g / cm ² (both sides)

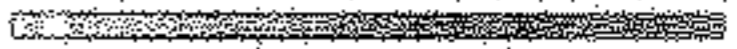
inclination angle : 51.6 °
altitude : 300-400 km



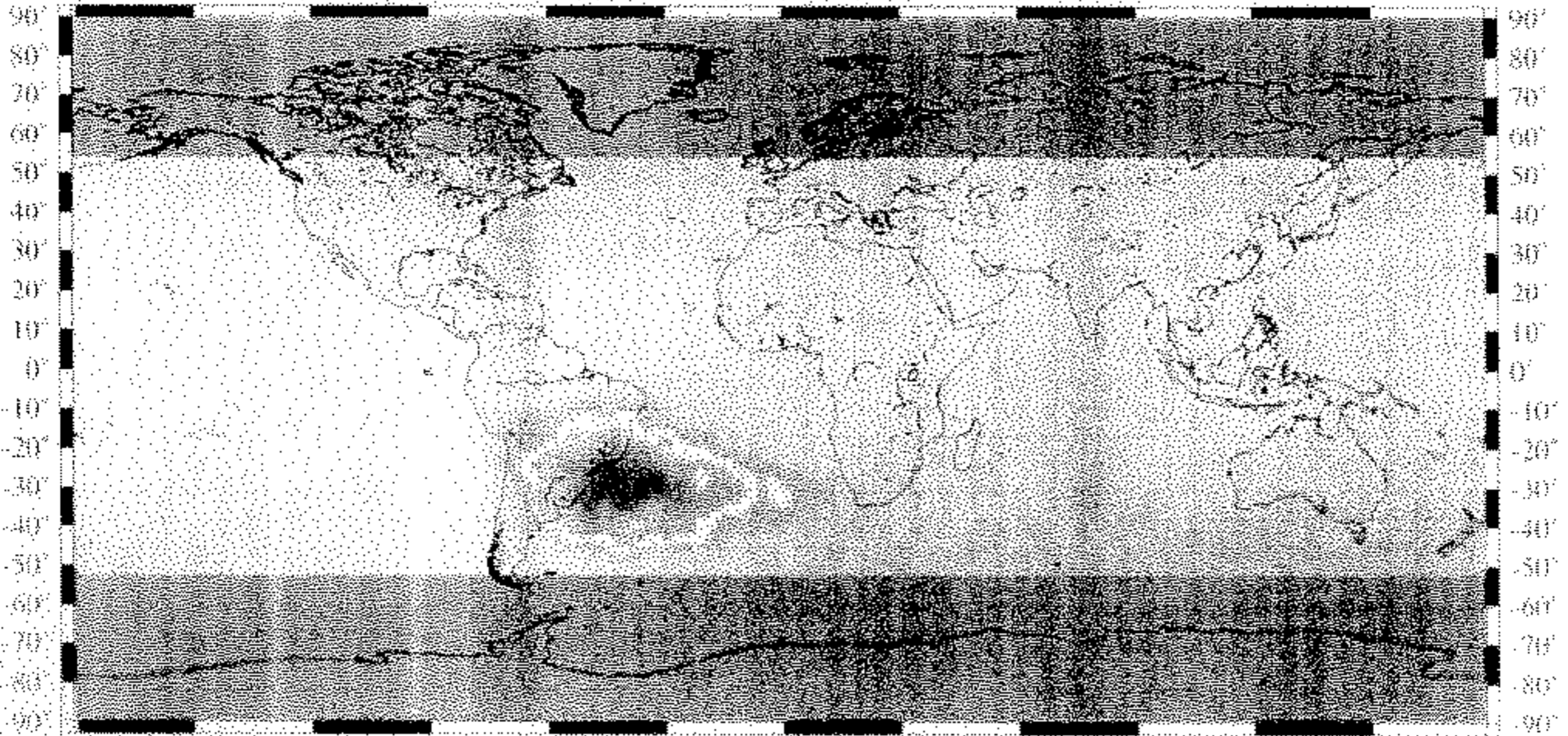


STS-91 RRMD-III Count Map

June 5th-11th, 1998



180° 210° 240° 270° 300° 330° 0° 30° 60° 90° 120° 150°



180° 210° 240° 270° 300° 330° 0° 30° 60° 90° 120° 150°

LET [keV/ μm -water]

10

20

40

60

80

100

150

100

90

80

70

60

50

40

30

20

10

0

Counts

STS-84

0

5

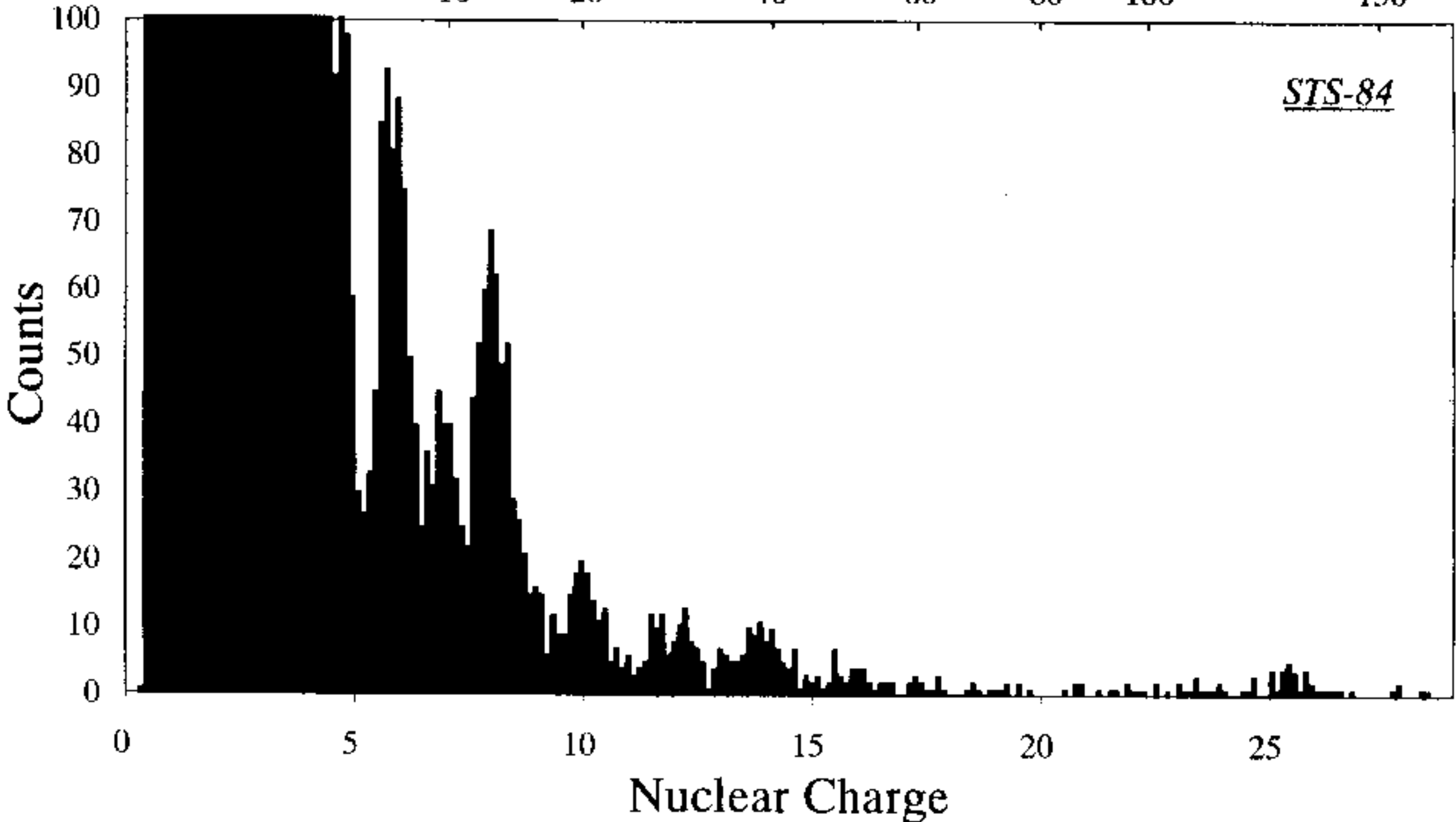
10

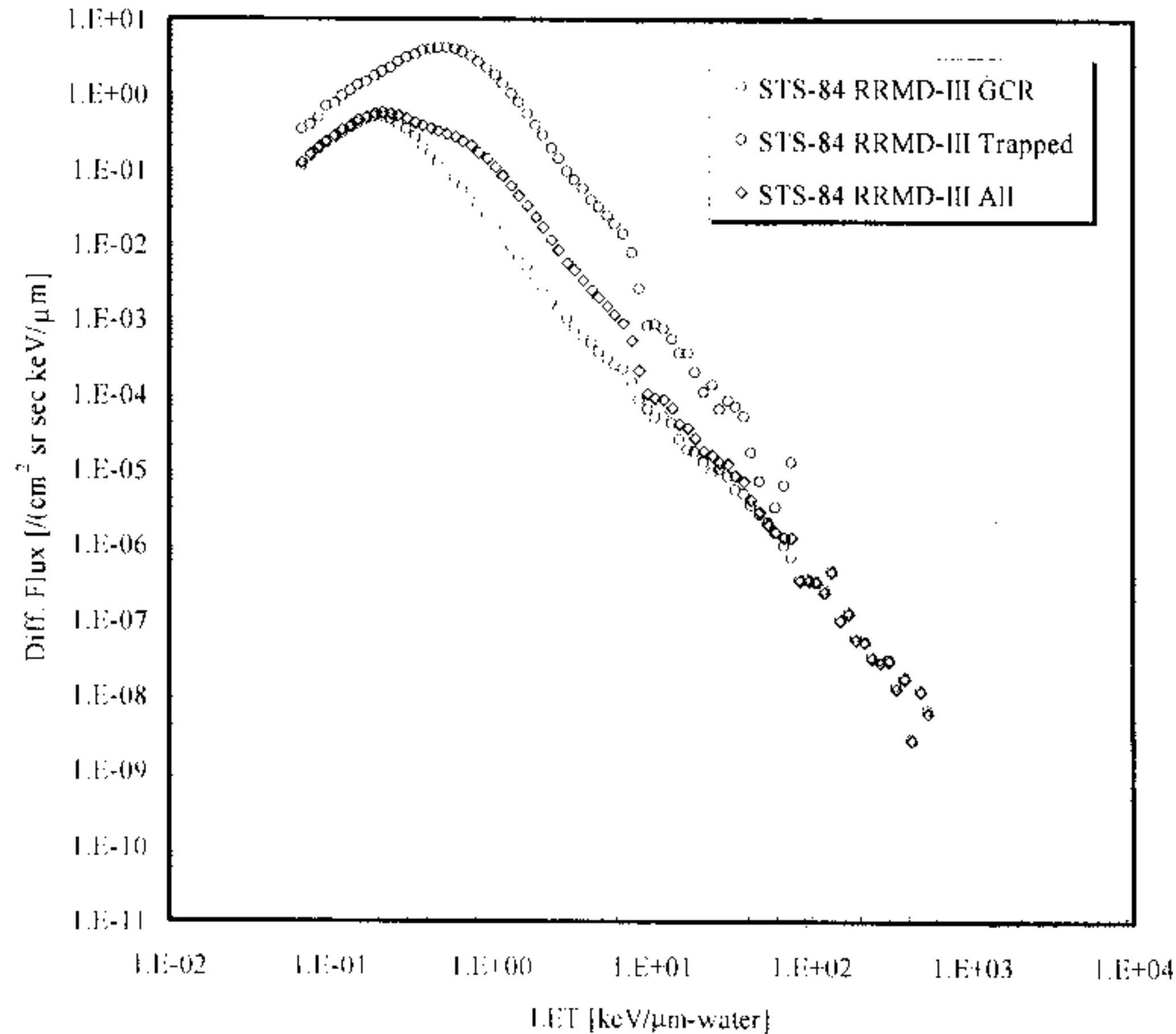
15

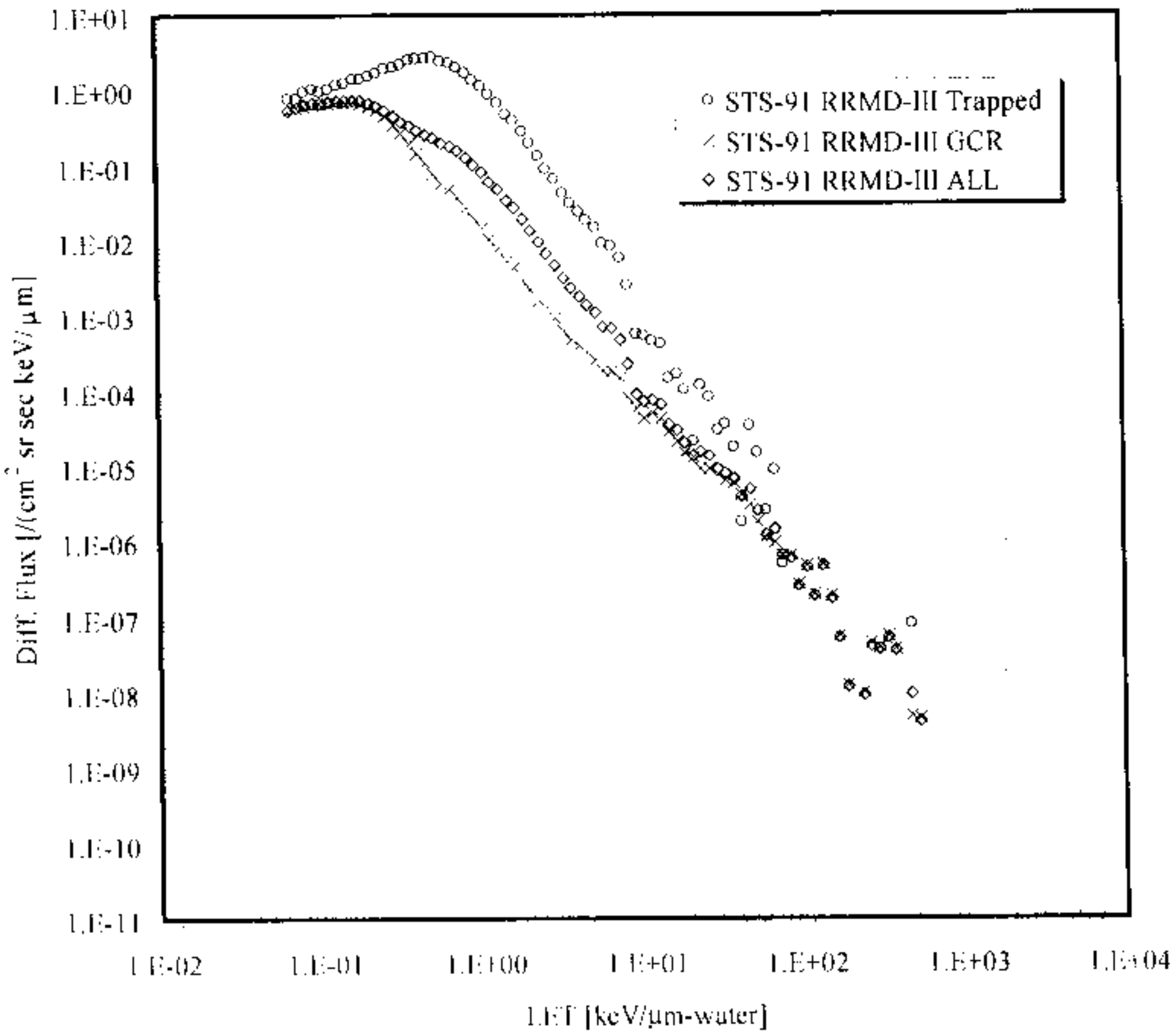
20

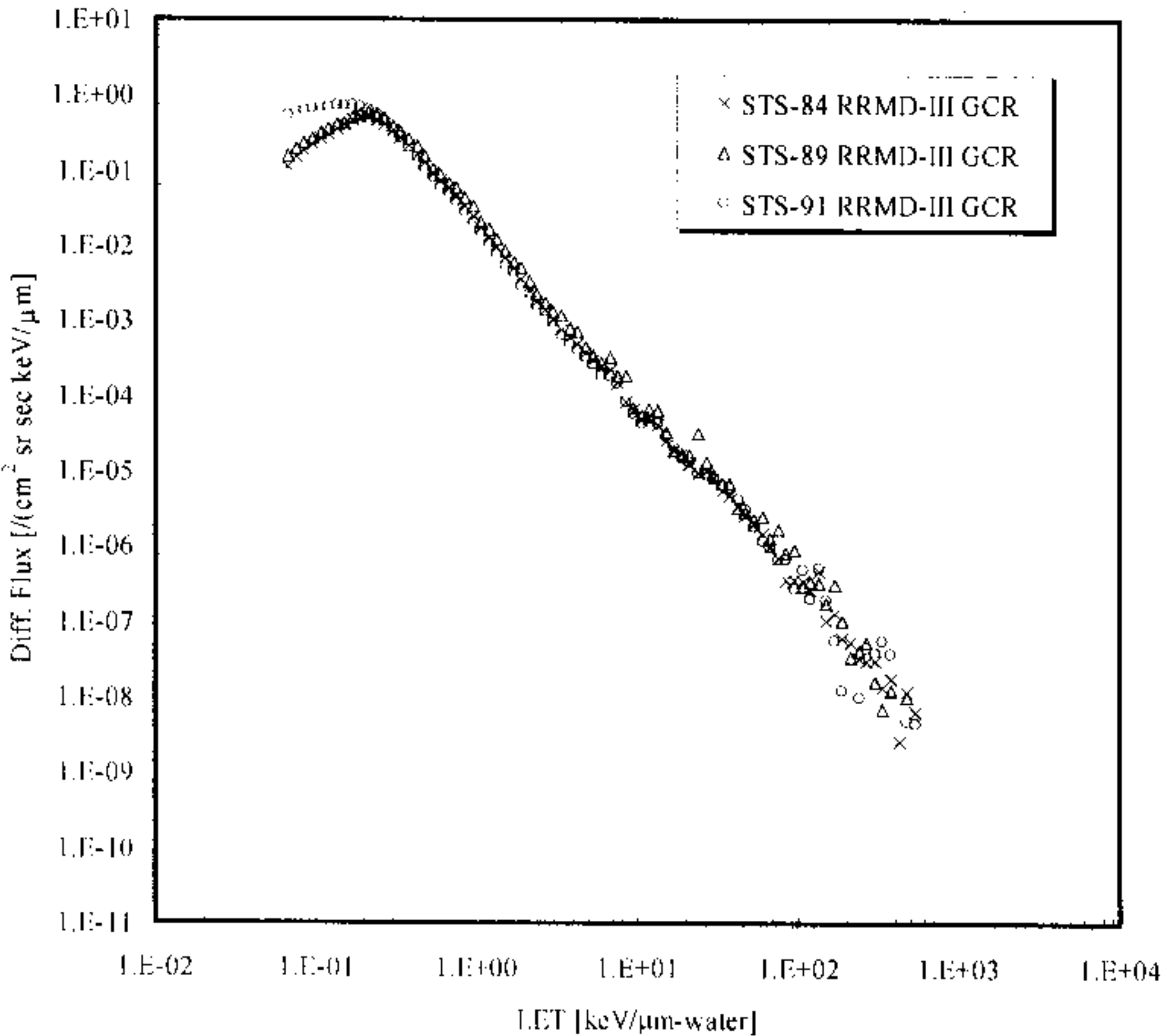
25

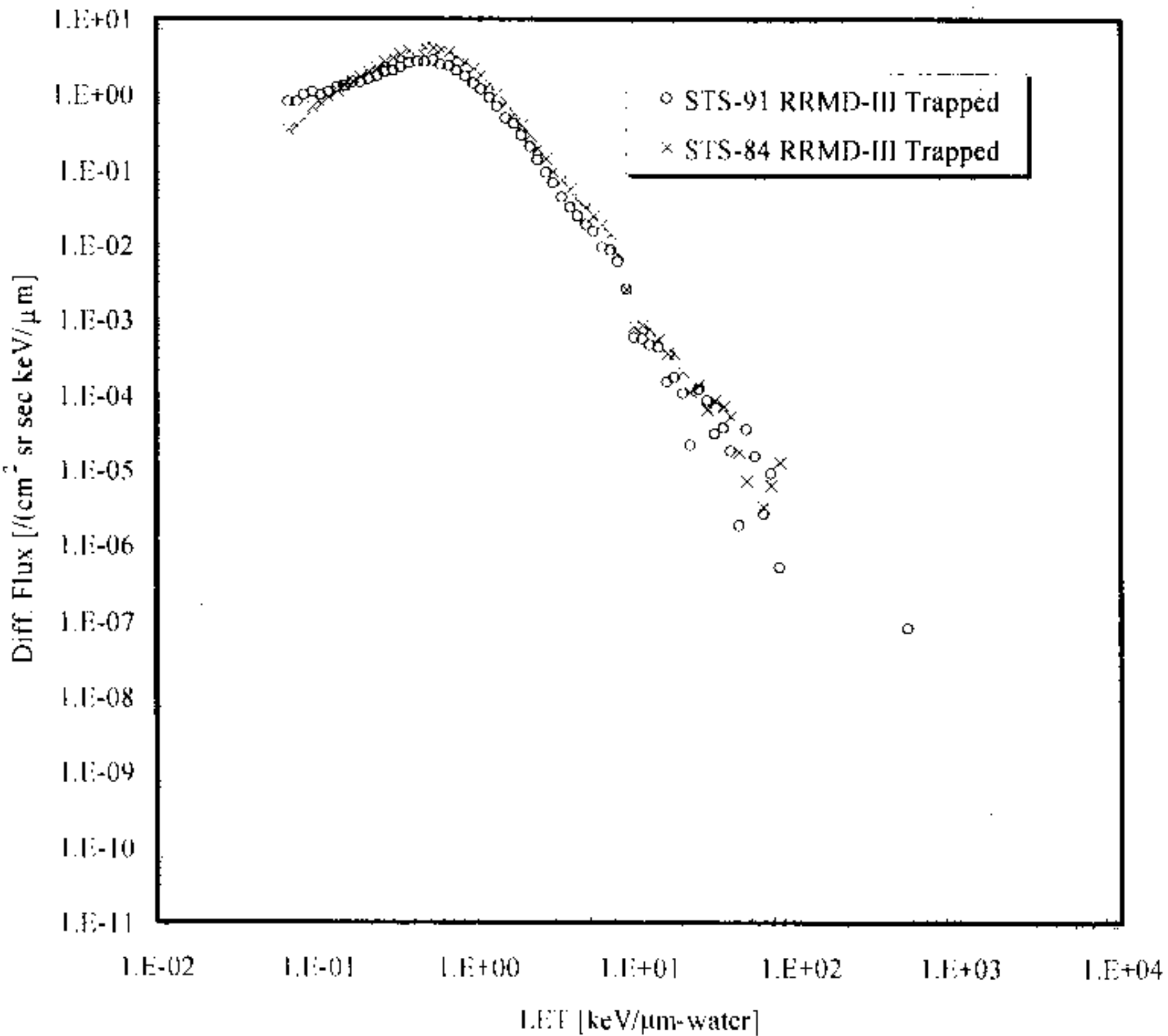
Nuclear Charge

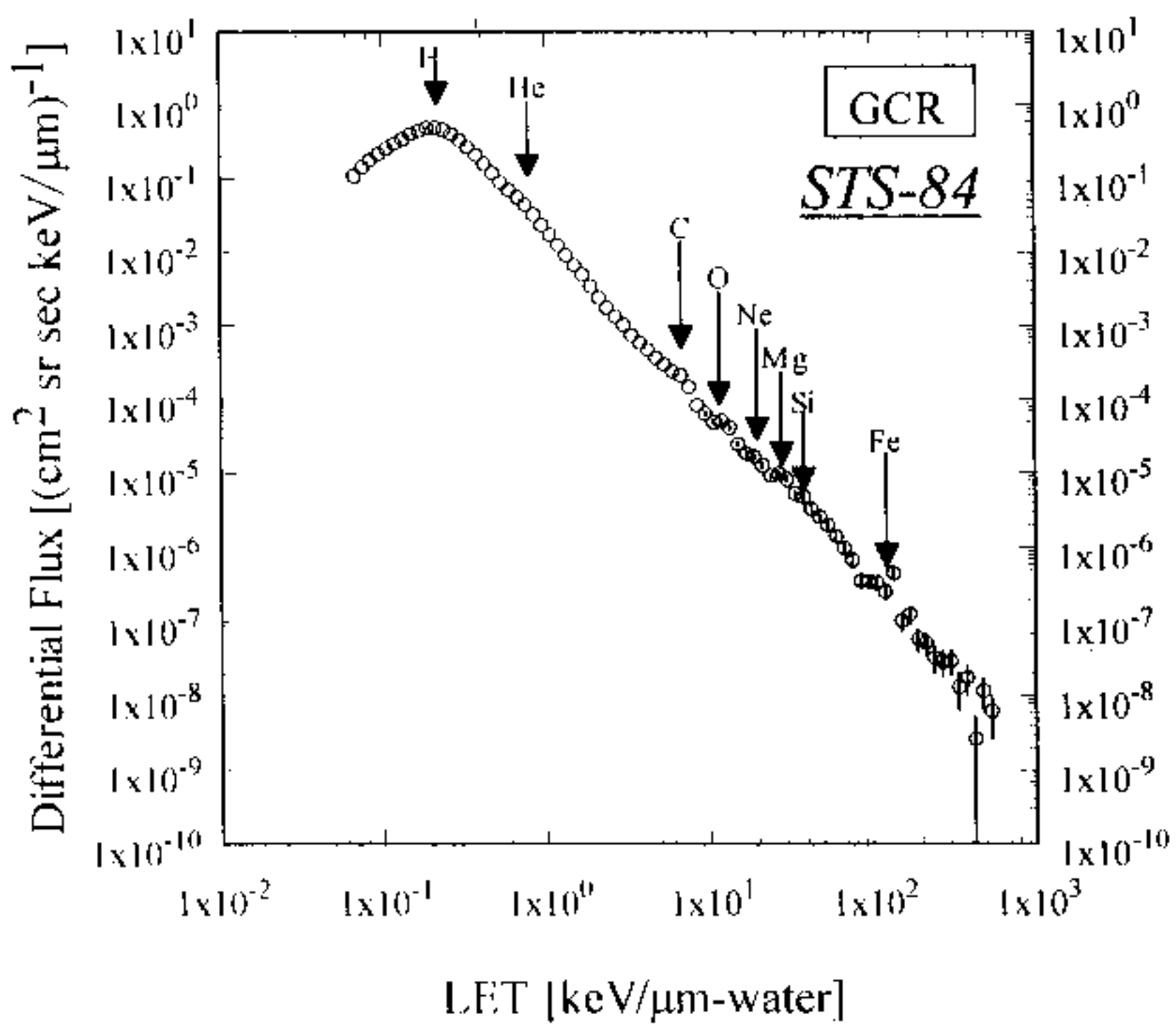












STS-84 RRMD-III

Source	Period	Absorbed Dose	Dose Equivalent (ICRP Pub.26)	Dose Equivalent (ICRP Pub.60)	Effective Quality Factor (ICRP Pub.26)	Effective Quality Factor (ICRP Pub.60)
GCR	9579 min	1059 μ Gy (151.1 μ Gy/day)	3038 μ Sv (433.5 μ Sv/day)	3373 μ Sv (481.3 μ Sv/day)	2.87	3.19
Trapped	512 min	2473 μ Gy (352.9 μ Gy/day)	3029 μ Sv (432.3 μ Sv/day)	2889 μ Sv (412.2 μ Sv/day)	1.23	1.17
Total	10091 min (7.01 days)	3532 μ Gy (503.9 μ Gy/day)	6067 μ Sv (865.8 μ Sv/day)	6261 μ Sv (893.5 μ Sv/day)	1.72	1.77

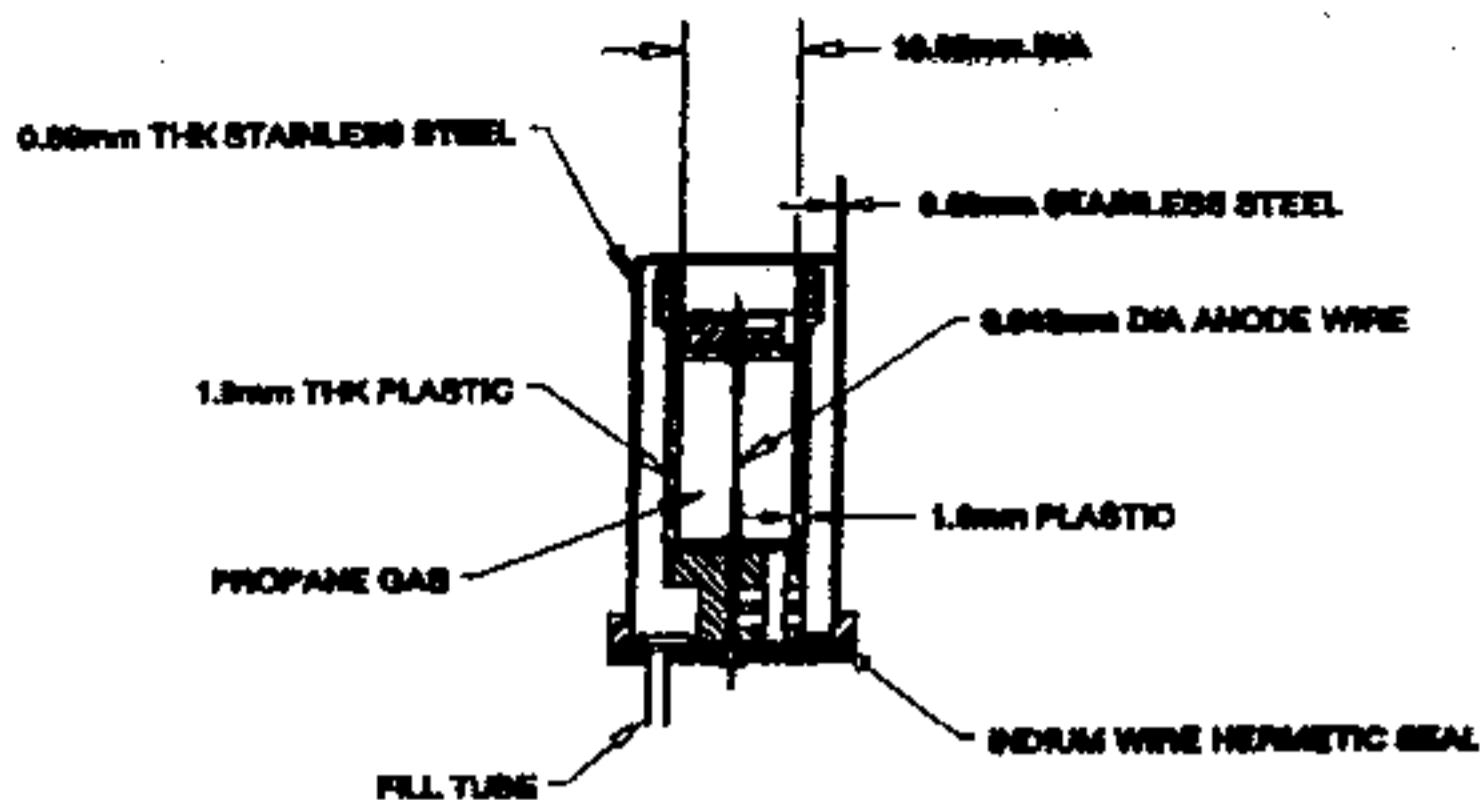
STS-89 RRMD-III

Source	Period	Absorbed Dose	Dose Equivalent (ICRP Pub.26)	Dose Equivalent (ICRP Pub.60)	Effective Quality Factor (ICRP Pub.26)	Effective Quality Factor (ICRP Pub.60)
GCR	4511 min	626 μ Gy (199.8 μ Gy/day)	1829 μ Sv (583.5 μ Sv/day)	2102 μ Sv (670.7 μ Sv/day)	2.92	3.36

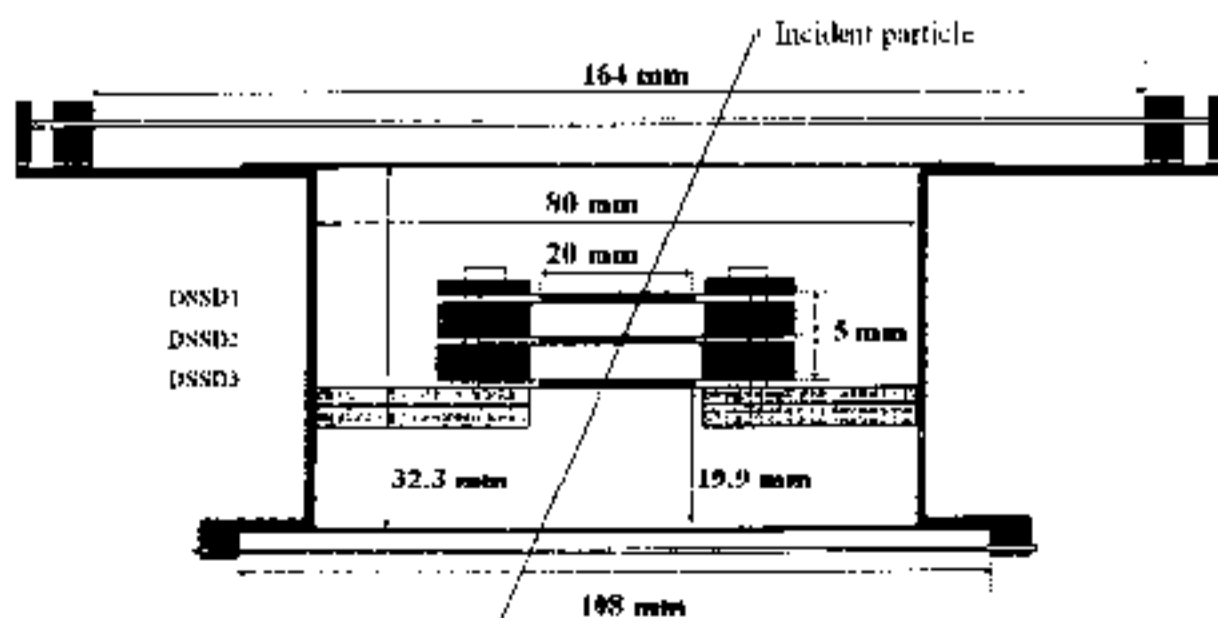
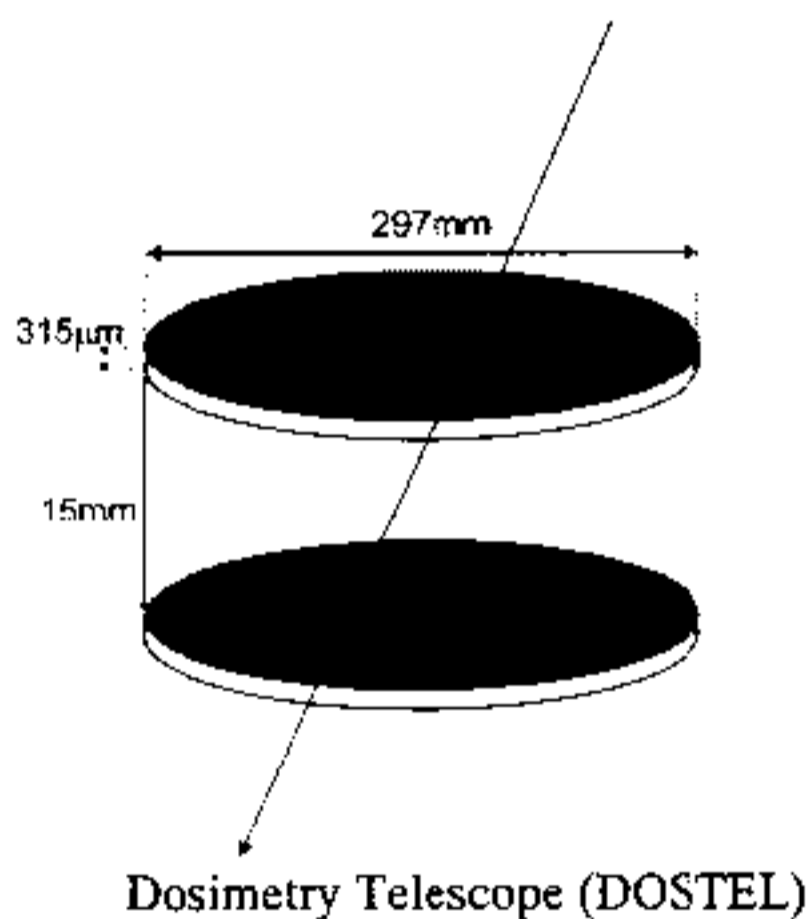
STS-91 RRMD-III

Source	Period	Absorbed Dose	Dose Equivalent (ICRP Pub.26)	Dose Equivalent (ICRP Pub.60)	Effective Quality Factor (ICRP Pub.26)	Effective Quality Factor (ICRP Pub.60)
GCR	6446 min	726 μ Gy (152.3 μ Gy/day)	2141 μ Sv (449.6 μ Sv/day)	2383 μ Sv (500.4 μ Sv/day)	2.95	3.28
Trapped	408 min	1289 μ Gy (270.6 μ Gy/day)	1610 μ Sv (338.3 μ Sv/day)	1538 μ Sv (323.1 μ Sv/day)	1.25	1.19
Total	6854 min (4.76 days)	2014 μ Gy (423.2 μ Gy/day)	3751 μ Sv (787.9 μ Sv/day)	3921 μ Sv (823.9 μ Sv/day)	1.86	1.95

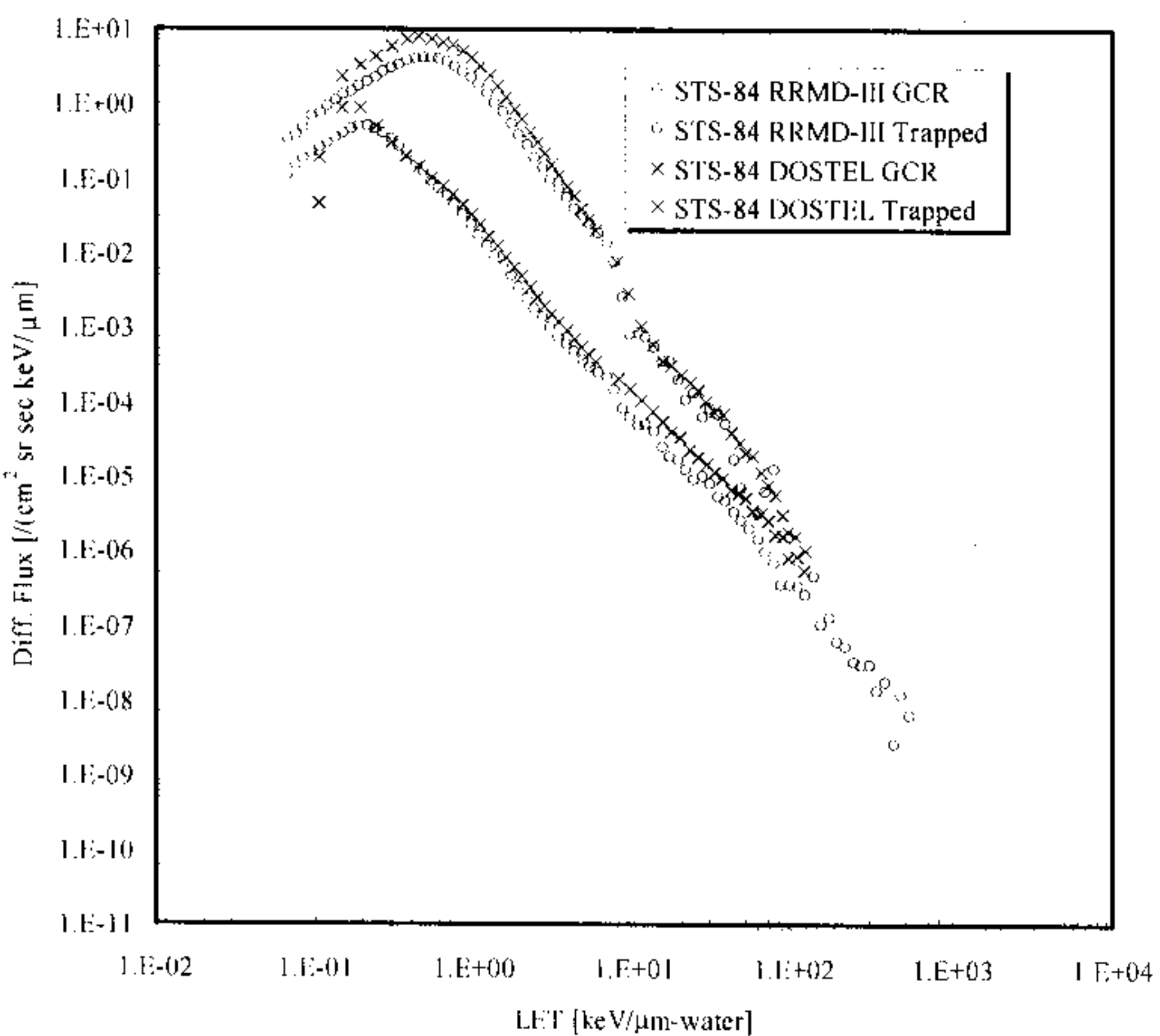
() is the average rate

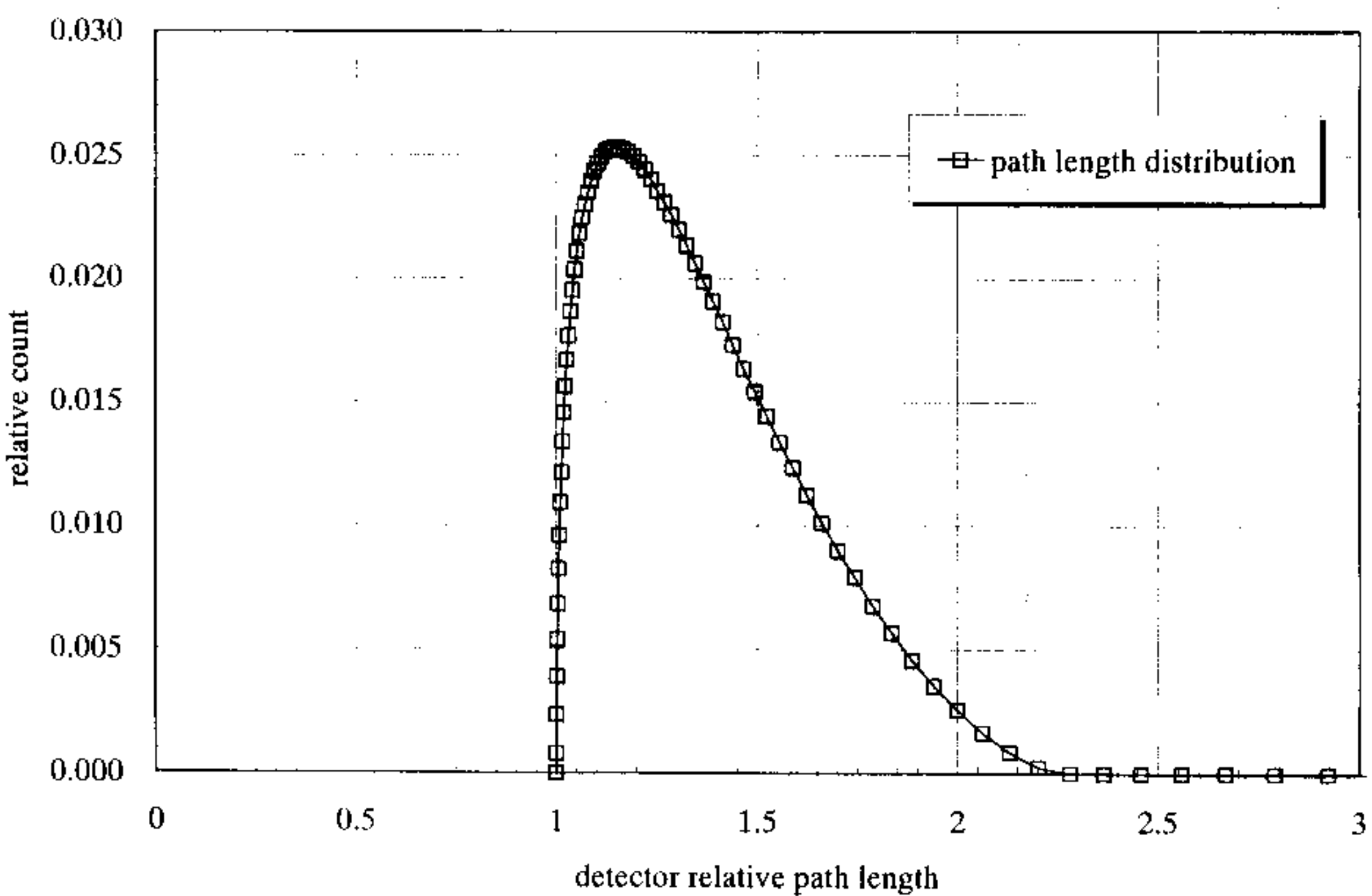


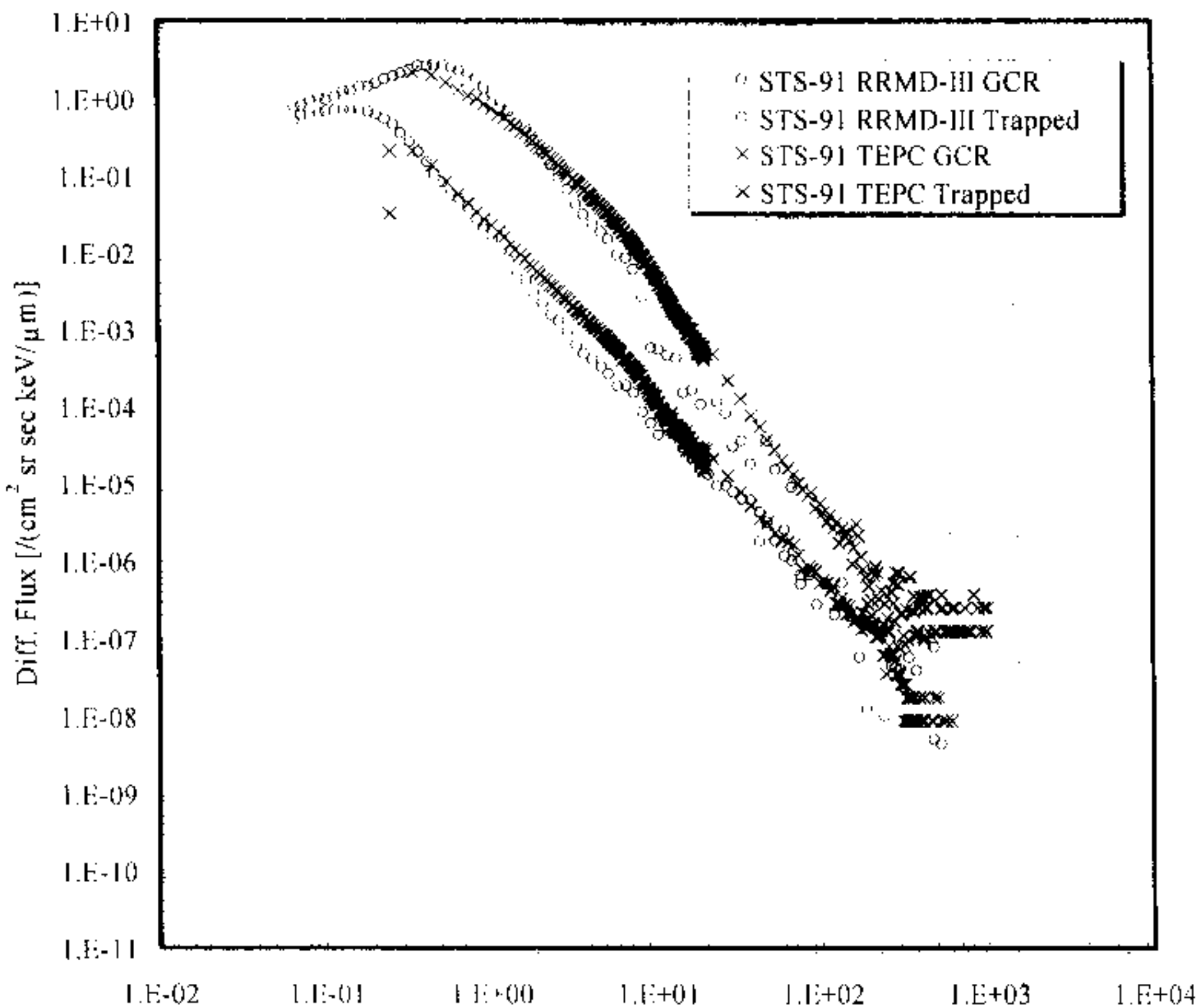
Tissue Equivalent Proportional Counter (TEPC)



Real-time Radiation Monitoring Device-III (RRMD-III)







		STS-84				STS-89				STS-91					
		GCR		Trapped		Total		GCR		GCR		Trapped		Total	
		D. E.	QF	D. E.	QF	D. E.	QF	D. E.	QF	D. E.	QF	D. E.	QF	D. E.	QF
RRMD-III	0.06-600 keV	433.5	2.87	432.3	1.22	865.8	1.72	583.5	2.92	449.6	2.95	338.3	1.25	788.0	1.86
RRMD-III	0.2-600 keV	418.4	3.08	429.5	1.23	847.9	1.74	571.3	3.05	429.6	3.24	335.3	1.25	764.9	1.91
RRMD-III	0.1-120 keV	304.9	2.13	432.1	1.23	736.9	1.49	424.2	2.22	302.1	2.13	332.9	1.23	634.9	1.54
DOSTEL M6	0.1-120 keV	343	2.60	303	1.30	657	1.80	-	-	-	-	-	-	-	-
DOSTEL M7	0.1-120 keV	320	2.50	257	1.20	583	1.70	-	-	-	-	-	-	-	-
TEPC	0.2-1200 keV	-	-	-	-	-	-	-	-	554.1	3.27	669.1	2.13	1223.3	2.53

() is the absorbed dose ($\mu\text{Gy/day}$)

D.E. = Dose Equivalent QF = Quality Factor (ICRP Pub. 26)

		GCR QF	Trapped QF	Total QF
TEPC STS-63	0.2-1200 keV	3.37	1.97	2.33
TEPC MIR	0.2-1200 keV	3.35	1.94	2.44
TEPC STS-81	0.2-1200 keV	3.27	1.81	2.37
DOSTEL STS-81	0.1-120 keV	2.60	1.30	1.80

Comparison of RRMD-III and TEPC

1. Reduction of sensitivity in the low LET region due to the high threshold level($0.4 \text{ keV}/\mu\text{m}$). From the TEPC data, we can not see the peaks of 0.2 and $0.5 \text{ keV}/\mu\text{m}$.
2. Edge point due to relativistic iron particles is slightly higher than the theoretical value($135 \text{ keV}/\mu\text{m}$).
3. LET distribution obtained by TEPC has a special shape over 1 to $100 \text{ keV}/\mu\text{m}$ for GCR particles and for trapped protons.