

**THE POTENTIAL OF USING
OPTICALLY STIMULATED LUMINESCENCE
FROM Al_2O_3 DOSIMETERS
FOR SPACE RADIATION DOSIMETRY:
BEHAVIOR TO HCP IRRADIATIONS**

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An astronaut personal dosimeter:

Choose:

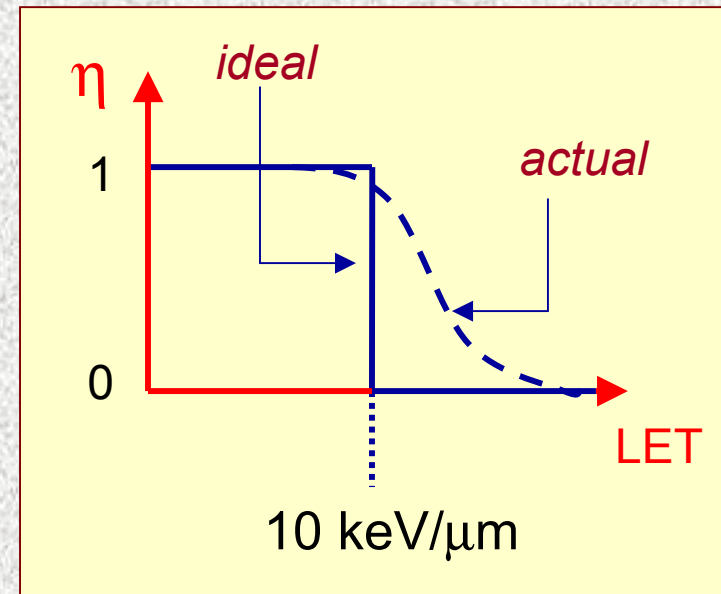
(a) A **luminescence dosimeter** (OSL/TL)
for $LET \leq 10 \text{ keV}/\mu\text{m}$
(*ideal*: $\eta = 1$ for $LET \leq 10 \text{ keV}/\mu\text{m}$
and $\eta = 0$ for $LET \geq 10 \text{ keV}/\mu\text{m}$)

and

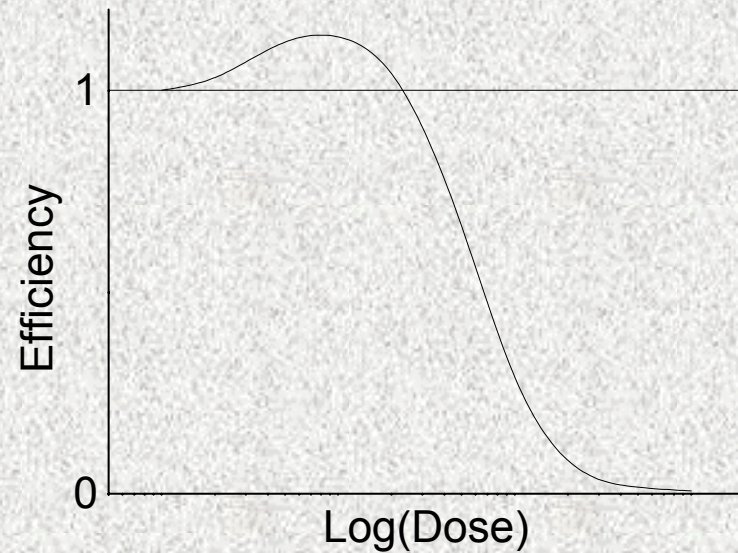
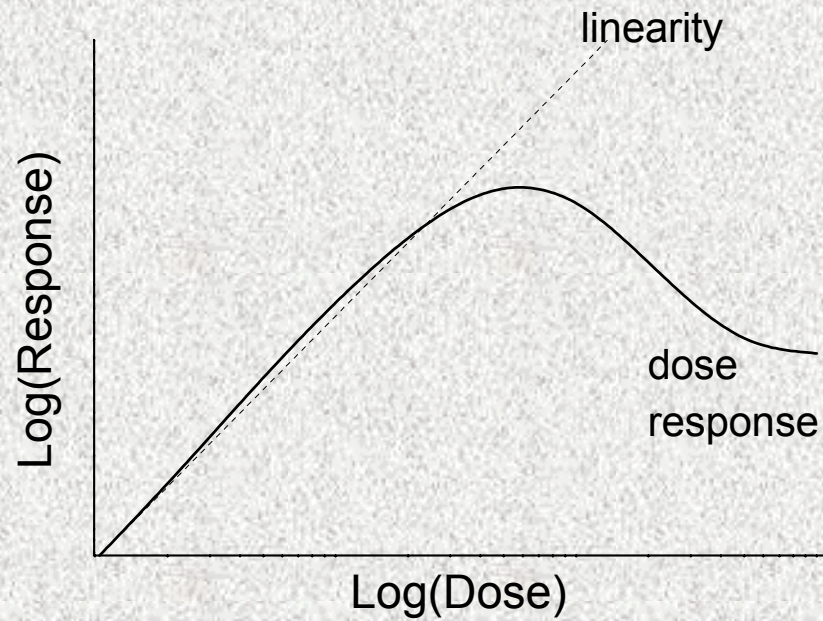
(b) a **PNTD** for $LET \geq 10 \text{ keV}/\mu\text{m}$

Therefore, dose equivalent is:

$$H = D_{LD} + \int D_{PNTD}(L)Q(L)dL$$



What determines the efficiency ?

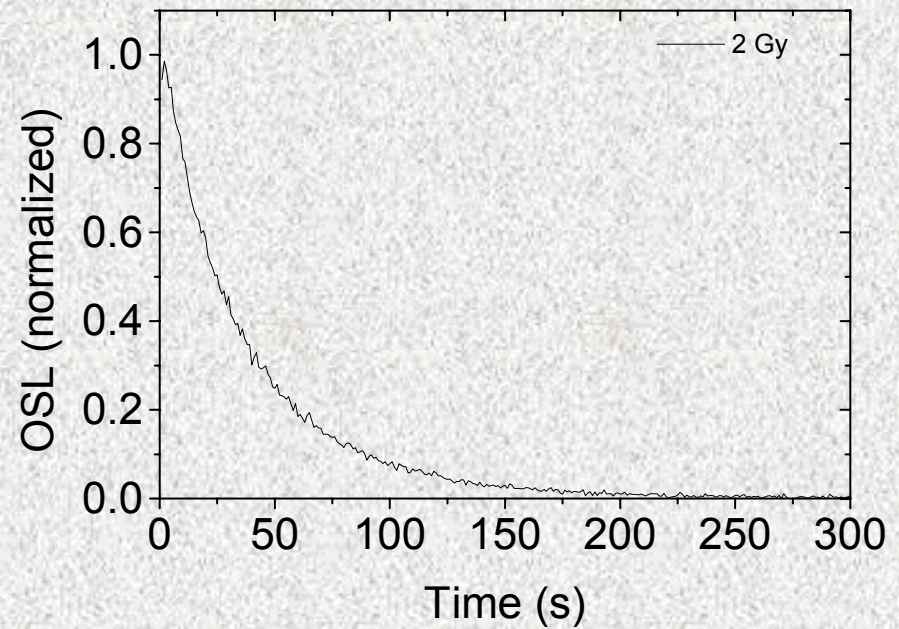
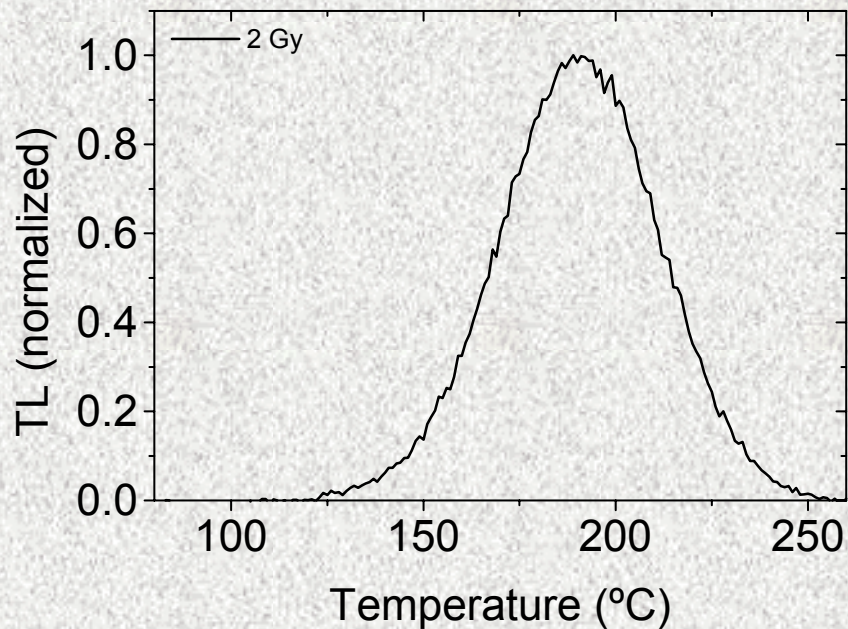


$$\text{Efficiency} = \text{Dose Response} / \text{Linear Response}$$

Example TL and OSL curves from Al_2O_3

TL: Heating rate = 1 °C/s
Beta irradiation

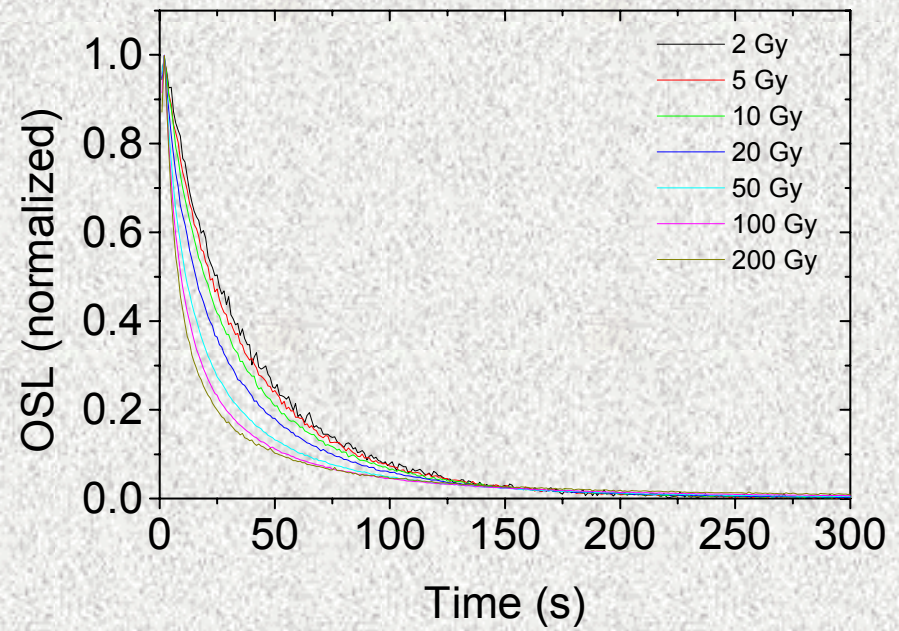
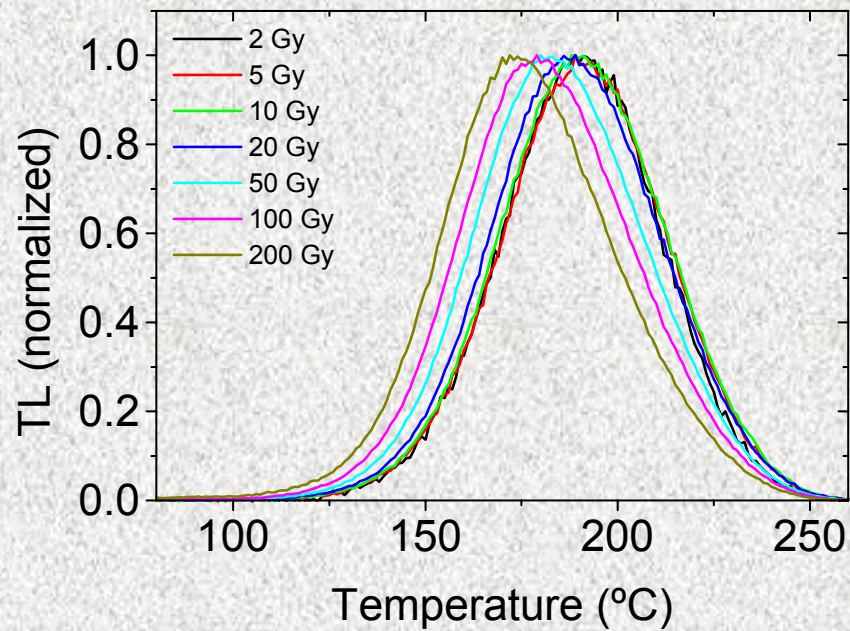
OSL: 525 nm stimulation
Beta irradiation

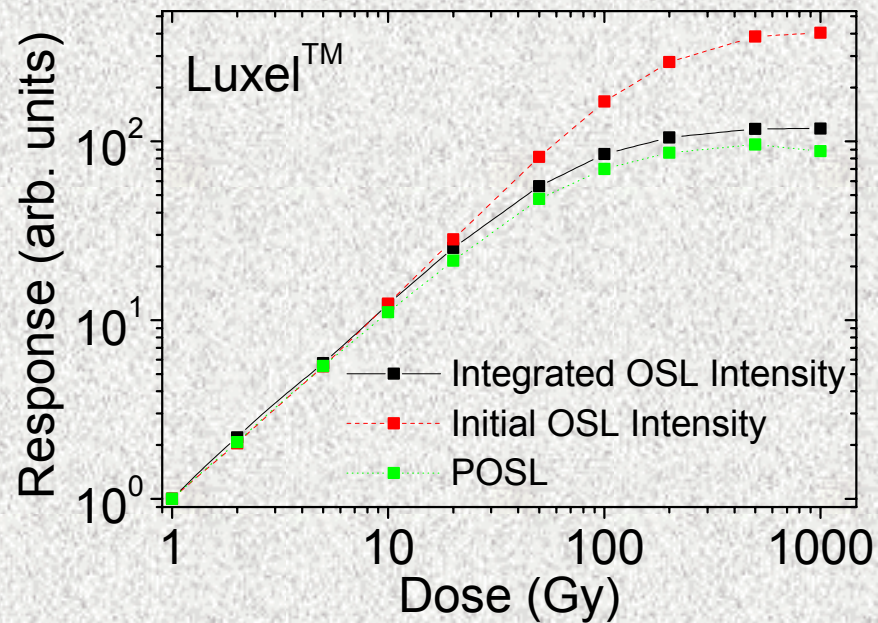
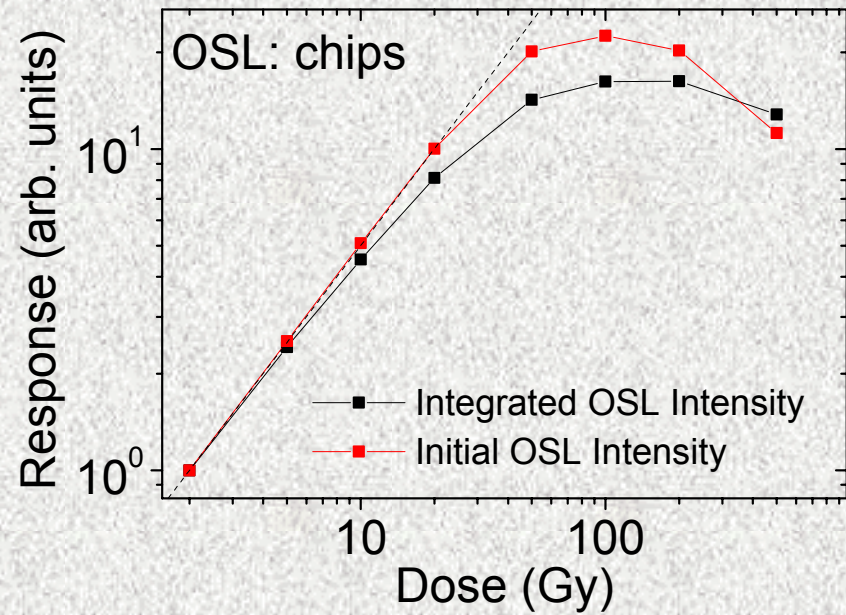
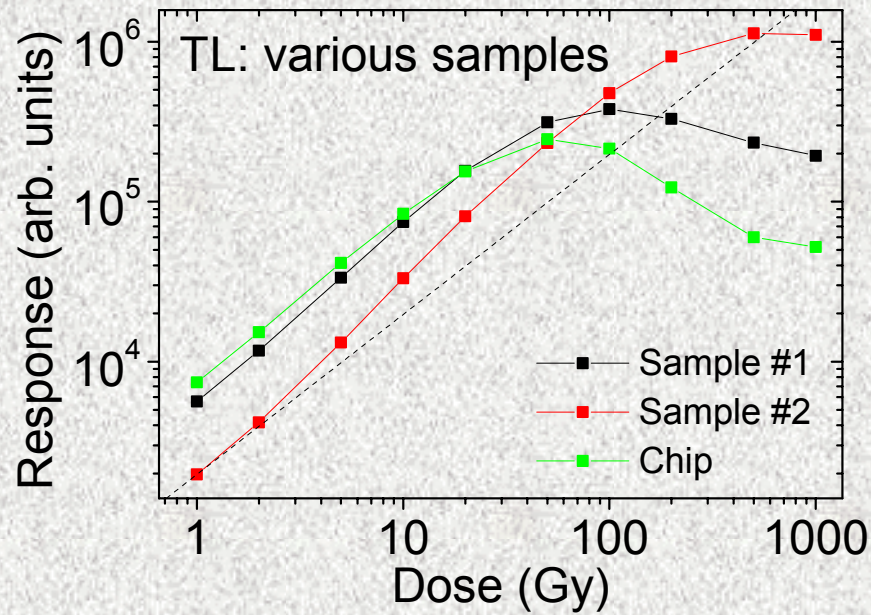


Example TL and OSL curves from Al_2O_3

TL: Heating rate = 1 °C/s
Beta irradiation

OSL: 525 nm stimulation
Beta irradiation





Example TL & OSL dose response curves, for Al_2O_3 Chips and Al_2O_3 Luxel™ Dosimeters (Landauer)

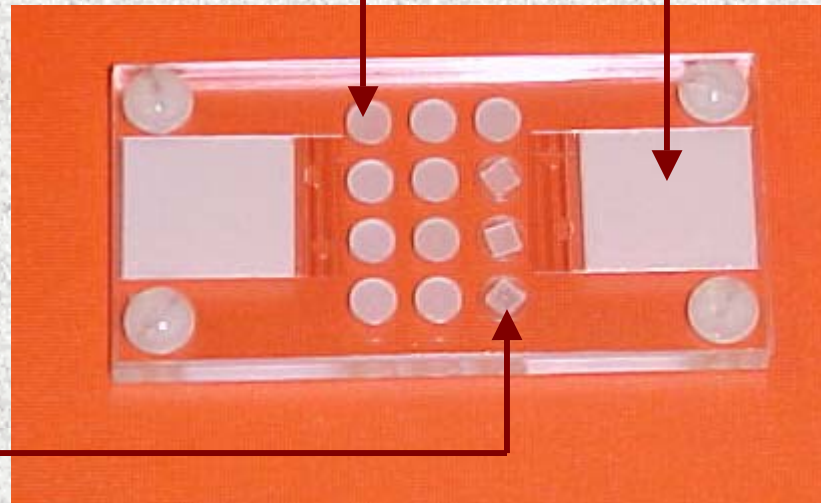
Results from the 2nd ICCHIBAN intercomparison - for passive dosimeters

Samples:

Al₂O₃ single crystal chips (TLD-500)

Al₂O₃ Luxel™ dosimeters (Landauer)

LiF chips (TLD-100)



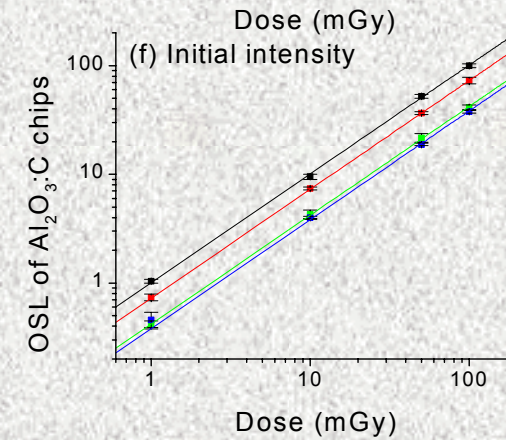
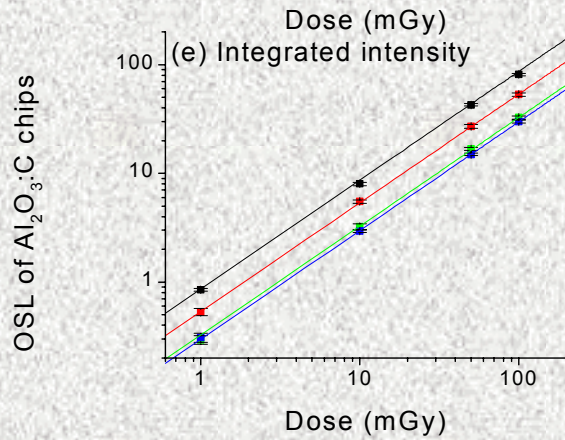
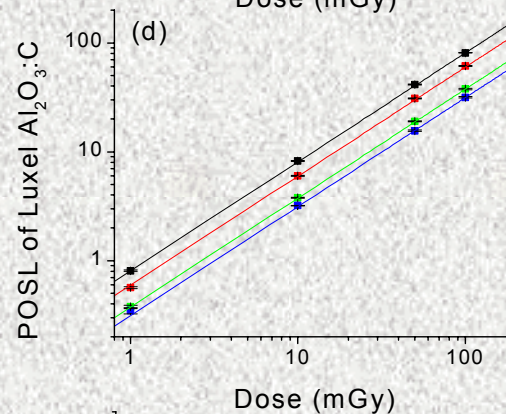
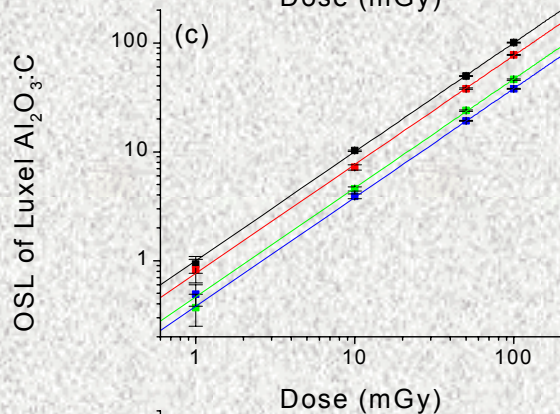
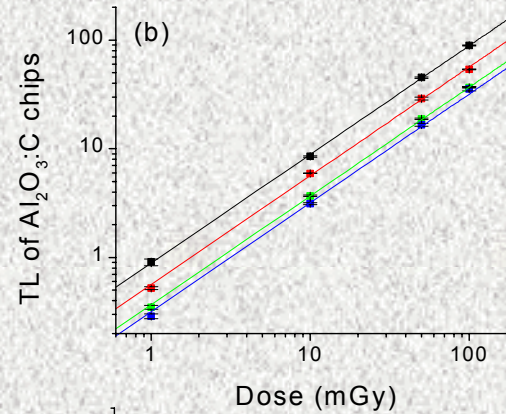
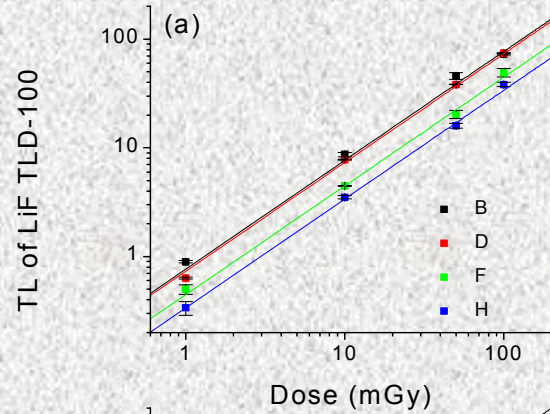
Methods:

OSL - CW-OSL (constant stimulation intensity; 525 nm)

- POSL (Pulsed stimulation; 532 nm)

TL - 1 °C/s

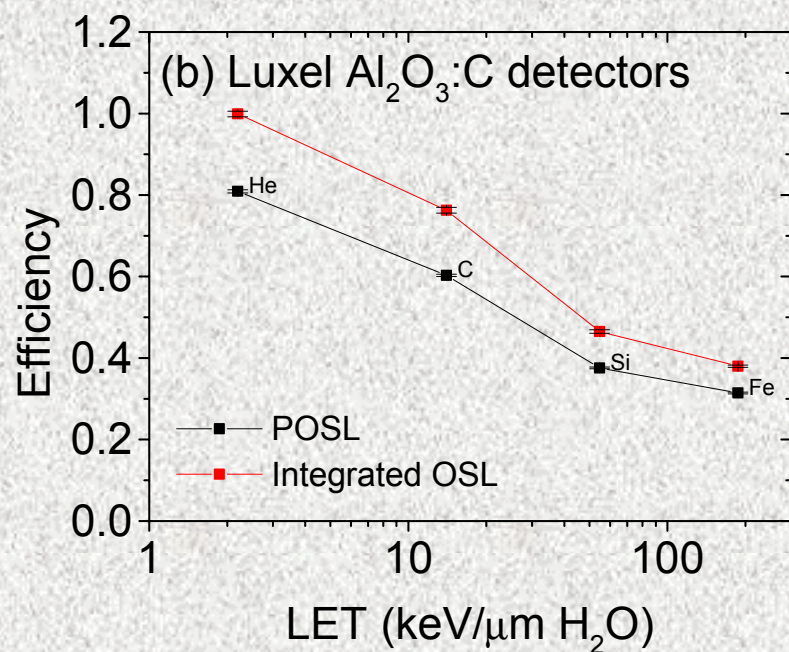
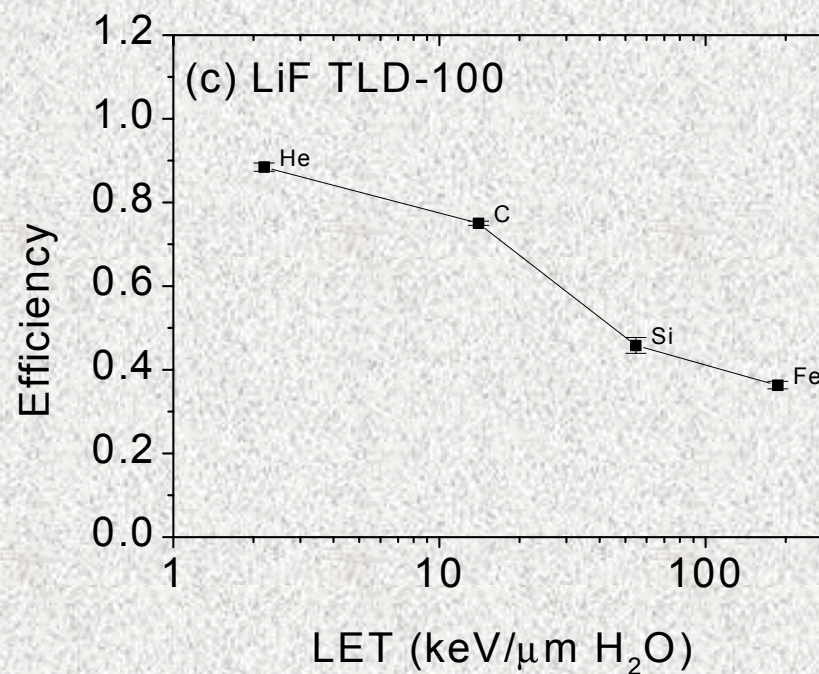
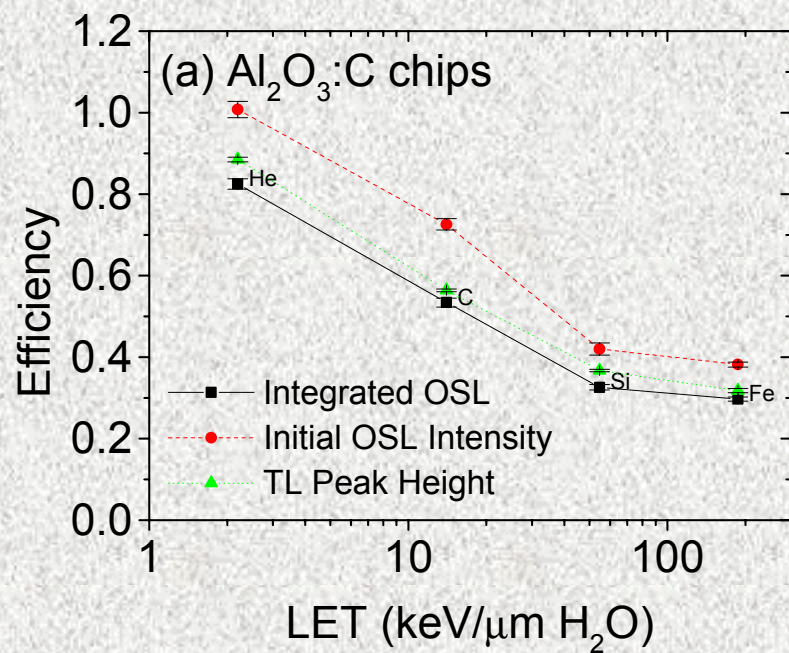
2nd ICCHIBAN Results



TL and OSL from:

- TLD-100
- Al_2O_3 chips
- and
- Al_2O_3 Luxel

versus HCP dose



TL & OSL versus LET:

- TLD-100
 - Al_2O_3 chips
- and
- Al_2O_3 Luxel

The curve shape depends upon luminescence readout method

Summary of results: Efficiencies

<i>Particle (LET: keV.μm⁻¹ H₂O)</i>	<i>Al₂O₃:C Chip OSL Area</i>	<i>Al₂O₃:C Chip OSL I₀</i>	<i>Al₂O₃:C Chip TL</i>	<i>Al₂O₃:C Luxel™ OSL Area</i>	<i>Al₂O₃:C Luxel™ POSL</i>	<i>LiF TLD-100 TL</i>
<i>He (2.19)</i>	0.825	1.008	0.885	0.999	0.809	0.884
<i>C (11.02)</i>	0.534	0.726	0.564	0.763	0.603	0.750
<i>Si (54.63)</i>	0.326	0.420	0.367	0.465	0.375	0.458
<i>Fe (186.84)</i>	0.297	0.382	0.318	0.380	0.314	0.363

Fragmentation results:

Gamma-equivalent absorbed dose (Gy)

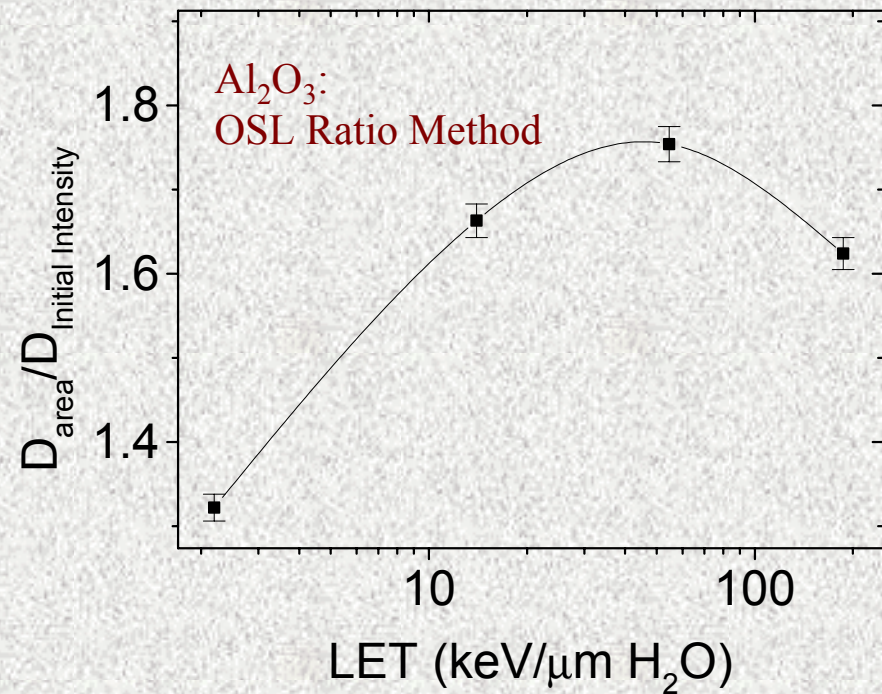
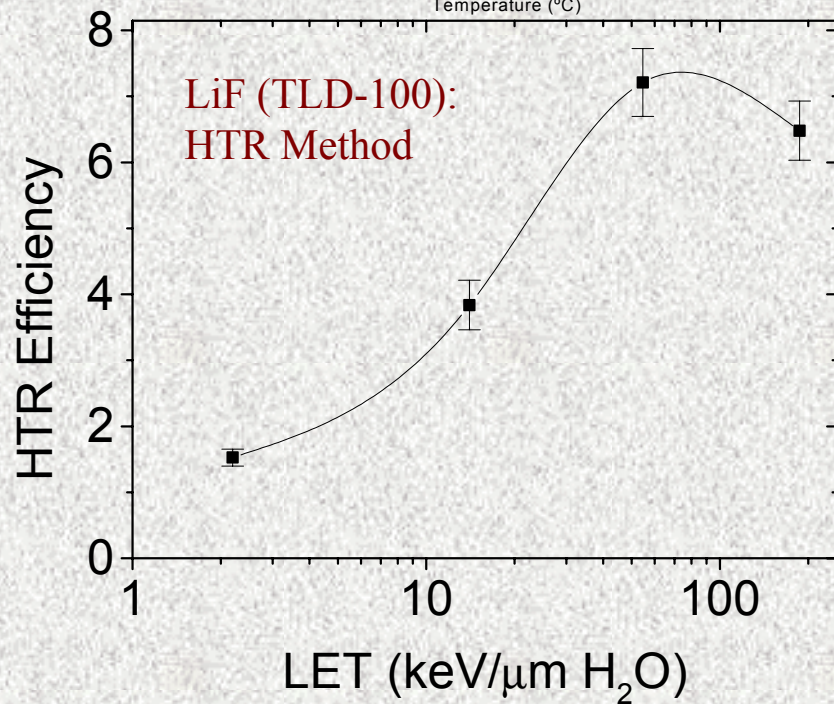
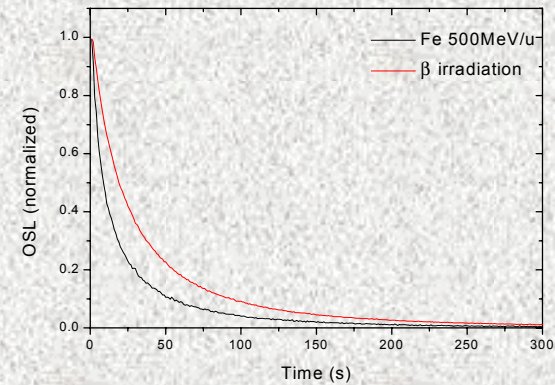
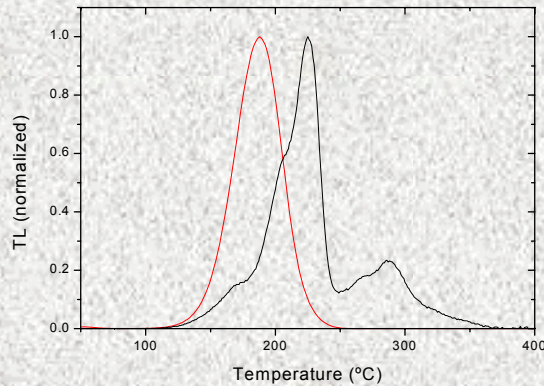
<i>Particle</i>	<i>Al₂O₃:C Chip OSL Area</i>	<i>Al₂O₃:C Chip OSL I₀</i>	<i>Al₂O₃:C Chip TL</i>	<i>Al₂O₃:C Luxel™ OSL Area</i>	<i>Al₂O₃:C Luxel™ POSL</i>	<i>LiF TLD-100 TL</i>
<i>C</i>	0.015(14)	0.046(24)	-	-	0.040(11)	-
<i>Si</i>	0.072(16)	0.13(4)	0.099(6)	-	0.13(7)	0.07(3)
<i>Fe</i>	0.369(22)	0.51(3)	0.355(7)	0.43(10)	0.387(13)	0.46(4)

Blind results:

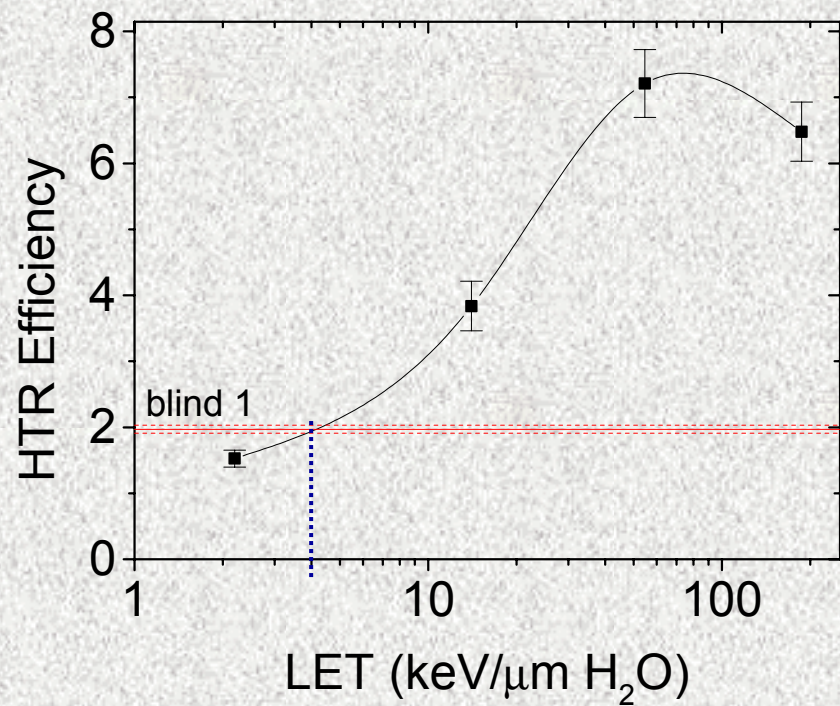
Gamma-equivalent absorbed dose (Gy)

	<i>Al₂O₃:C Chip OSL Area</i>	<i>Al₂O₃:C Chip OSL I₀</i>	<i>Al₂O₃:C Chip TL</i>	<i>Al₂O₃:C Luxel™ OSL Area</i>	<i>Al₂O₃:C Luxel™ POSL</i>	<i>LiF TLD-100 TL</i>
<i>Blind 1</i>	91(3)	108(5)	88.5(21)	98.9(6)	85.1(9)	91.16(24)
<i>Blind 2</i>	4.07(11)	5.65(22)	4.02(4)	5.04(9)	4.16(4)	4.39(24)
<i>Blind 3</i>	10.5(5)	14.1(11)	10.38(1)	12.98(23)	10.58(11)	12.05(5)
<i>Blind 4</i>	0.127(17)	0.19(3)	0.132(6)	-	0.154(11)	0.14(2)
<i>Blind 5</i>	8.5(4)	11.3(6)	8.19(21)	11.45(22)	9.43(10)	10.82(74)
<i>Blind 6</i>	2.06(6)	2.89(8)	2.14(1)	2.65(12)	2.26(3)	2.58(5)
<i>Blind 7</i>	1.05(7)	1.43(14)	1.044(28)	1.39(13)	1.145(14)	1.26(5)
<i>Blind 8</i>	0.463(19)	0.58(2)	0.446(6)	0.63(9)	0.56(11)	0.57(3)

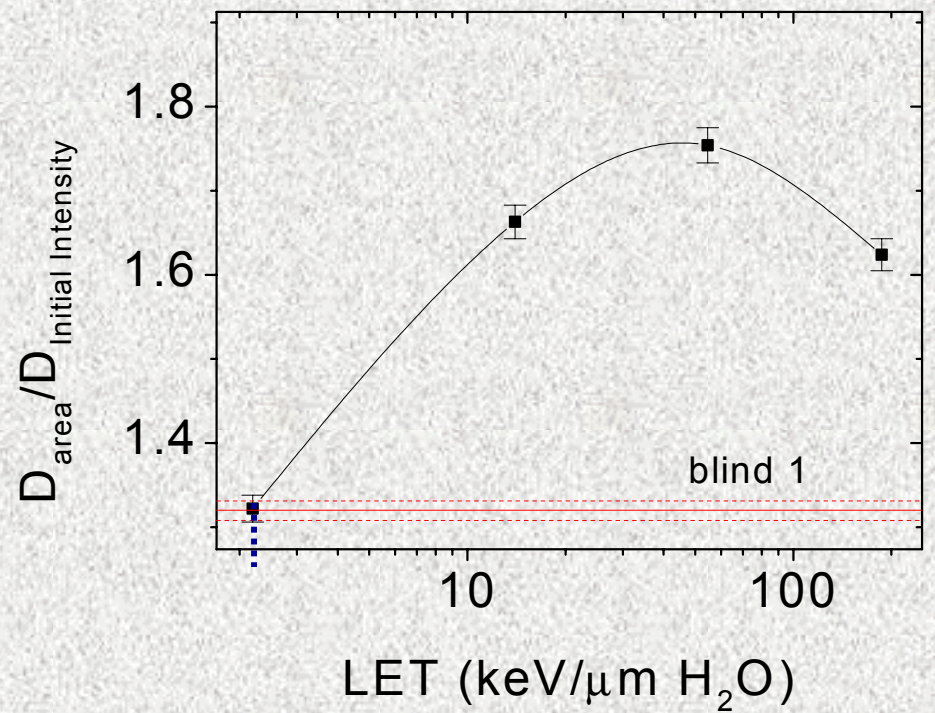
Can the “mean” LET of an unknown radiation-type be determined?



LiF (TLD-100):
HTR Method



Al₂O₃: OSL ratio
Method



If we identify Blind 1 with He particles.....

	<i>Al₂O₃:C Chip OSL Area</i>	<i>Al₂O₃:C Chip OSL I₀</i>	<i>Al₂O₃:C Chip TL</i>	<i>Al₂O₃:C Luxel™ OSL Area</i>	<i>Al₂O₃:C Luxel™ POSL</i>	<i>LiF TLD-100 TL</i>
<i>Measured Dose (Gy)</i>	91(3)	108(5)	88.5(21)	98.9(6)	85.1(9)	91.16(24)
<i>Efficiency</i>	0.825(13)	1.008(20)	0.885(6)	0.999(7)	0.809(4)	0.884(10)
<i>Corrected Dose (Gy)</i>	110.3(30)	107.1(50)	100.0(21)	99.0(6)	105.2(9)	103.1(24)

Weighted Mean Corrected Dose: 102.4 ± 6.7 Gy

Conclusions:

- OSL from Al_2O_3 can determine absorbed dose.
- Al_2O_3 almost 2 orders of magnitude more sensitive than TLD-100
- Efficiency versus LET dependent upon OSL readout mode
- Key determining factor is mean dose within the track, and gamma/beta dose response function
- Efficiency versus LET lower than that of TL from LiF (TLD-100)
- Evaluation of “mean” LET using either OSL or TL HTR method uncertain
- If LET response properly calibrated and mean LET independently determined (e.g. PNTDs), OSL of Al_2O_3 can provide estimate of dose equivalent