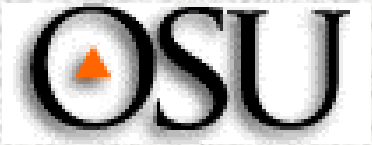

THE POTENTIAL OF USING OPTICALLY STIMULATED LUMINESCENCE FROM Al_2O_3 DOSIMETERS FOR SPACE RADIATION DOSIMETRY: BEHAVIOR TO HCP IRRADIATIONS

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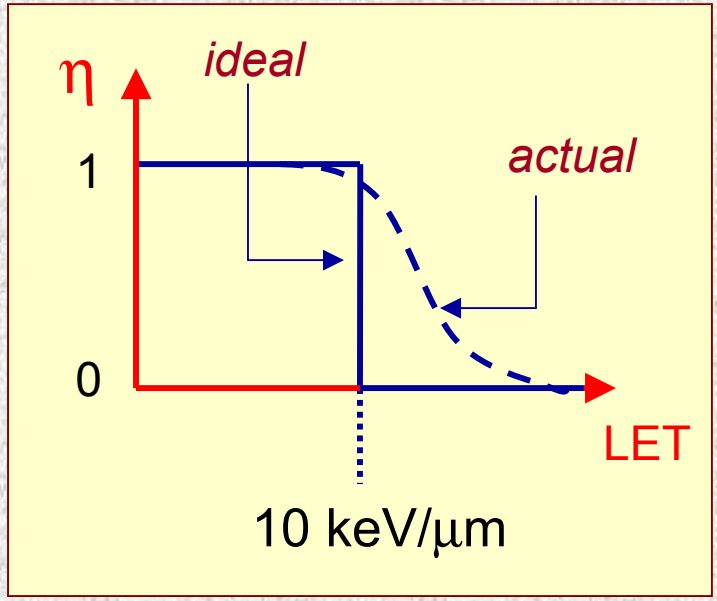
An astronaut personal dosimeter:

Choose:

(a) A **luminescence dosimeter** (OSL/TL) for LET ≤ 10 keV/μm
(*ideal*: η = 1 for LET ≤ 10 keV/μm and η = 0 for LET ≥ 10 keV/μm)

and

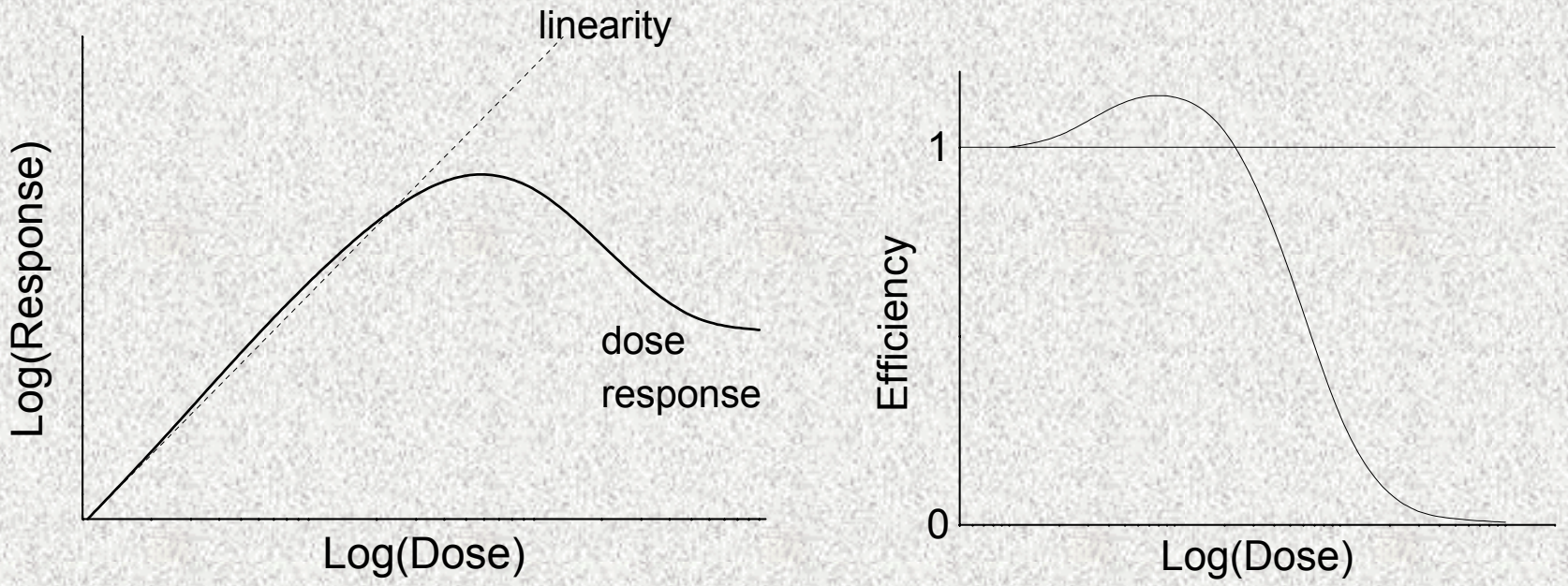
(b) a **PNTD** for LET ≥ 10 keV/μm



Therefore, dose equivalent is:

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

What determines the efficiency ?

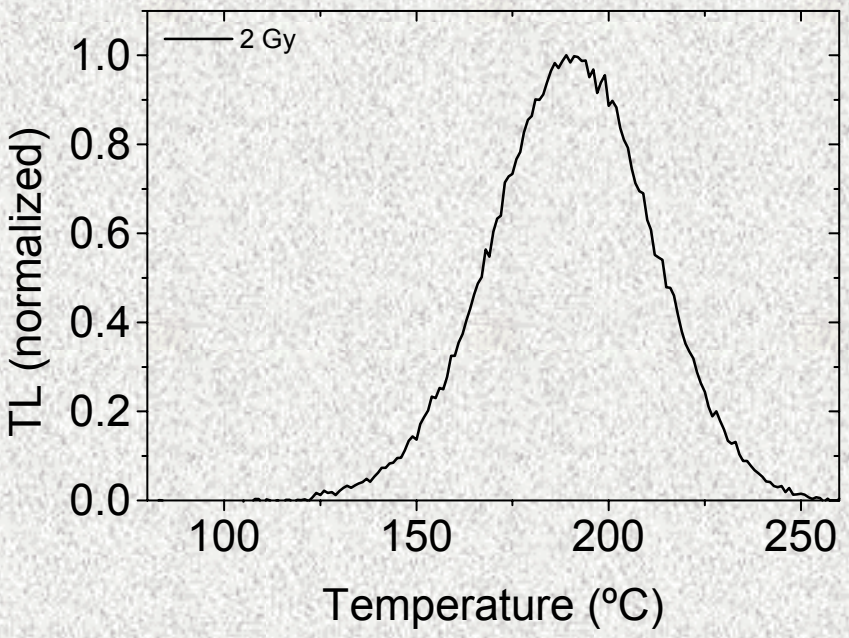


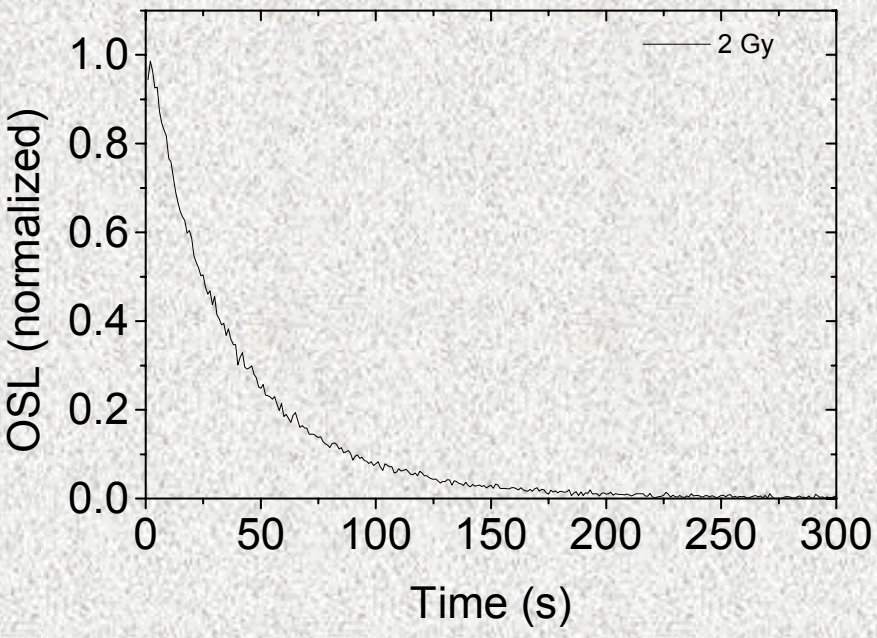
Efficiency = Dose Response / Linear Response

Example TL and OSL curves from Al_2O_3

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

OSL: 525 nm stimulation
Beta irradiation





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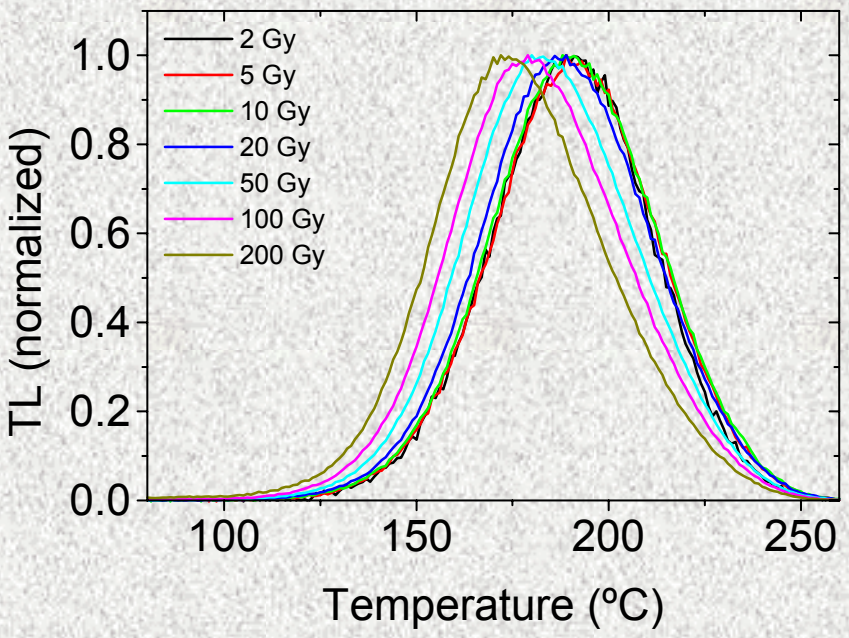
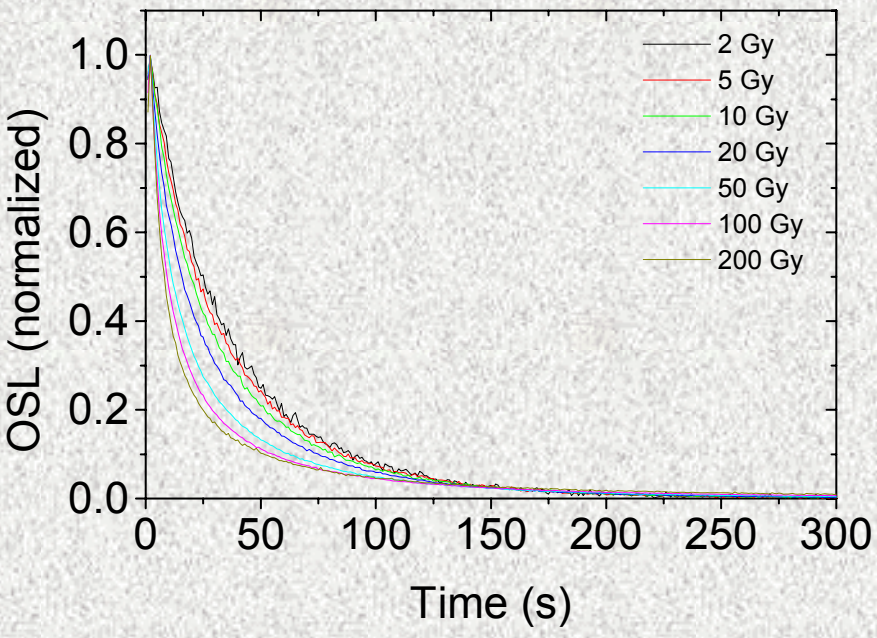
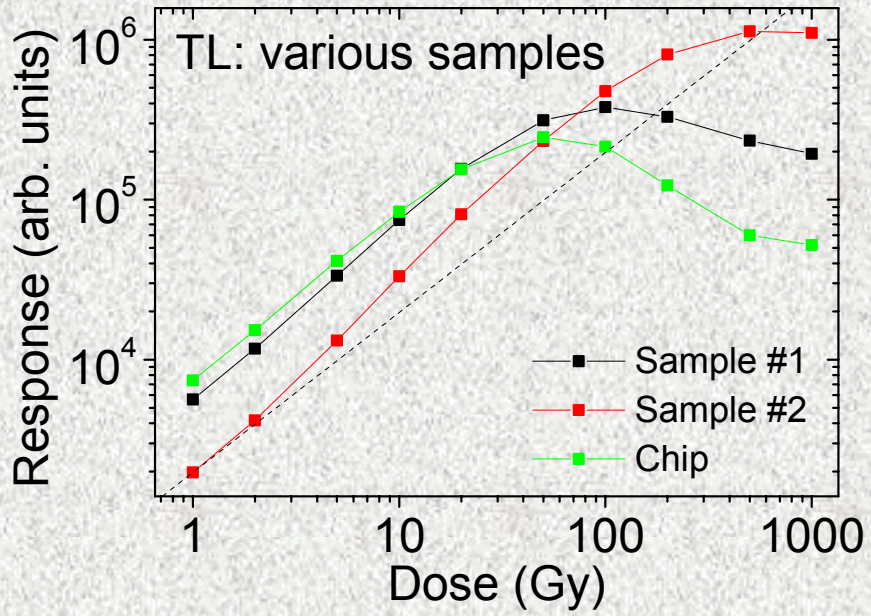
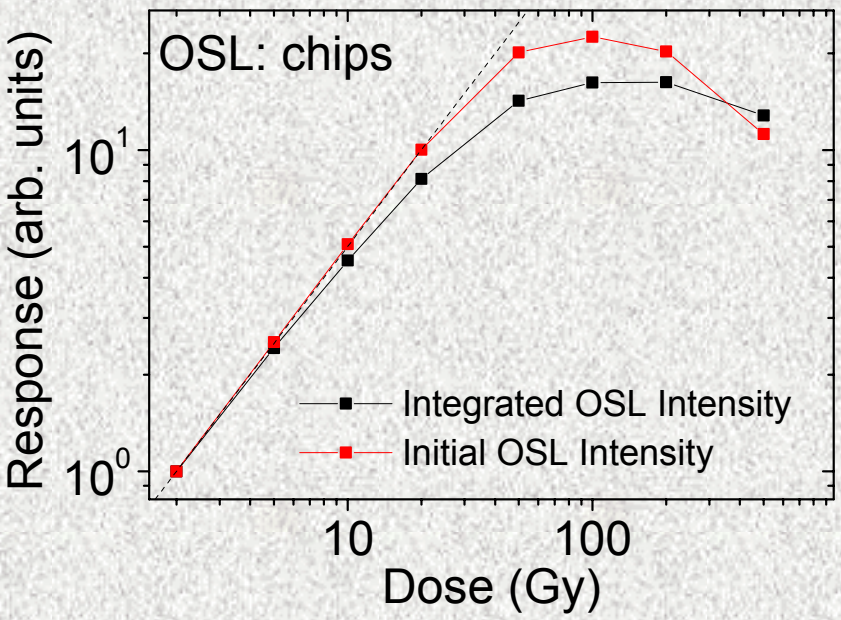
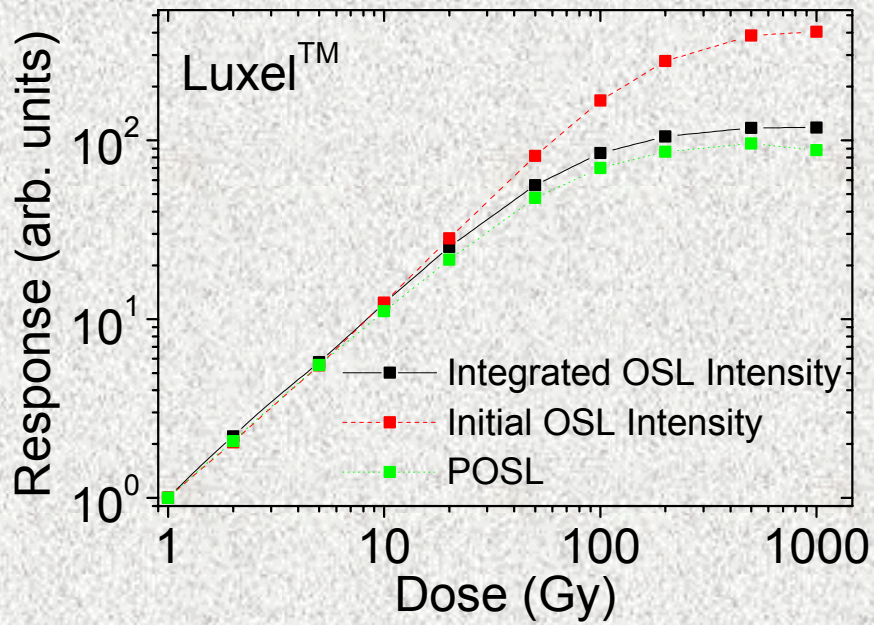








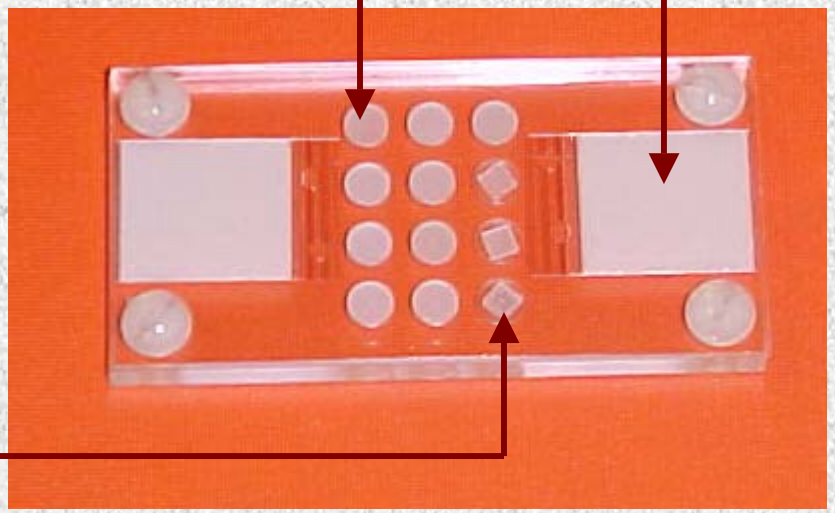


Example TL & OSL dose response curves, for Al_2O_3 Chips and Al_2O_3 Luxel™ Dosimeters (Landauer)

Results from the 2nd ICCHIBAN intercomparison
- for passive dosimeters

Samples:

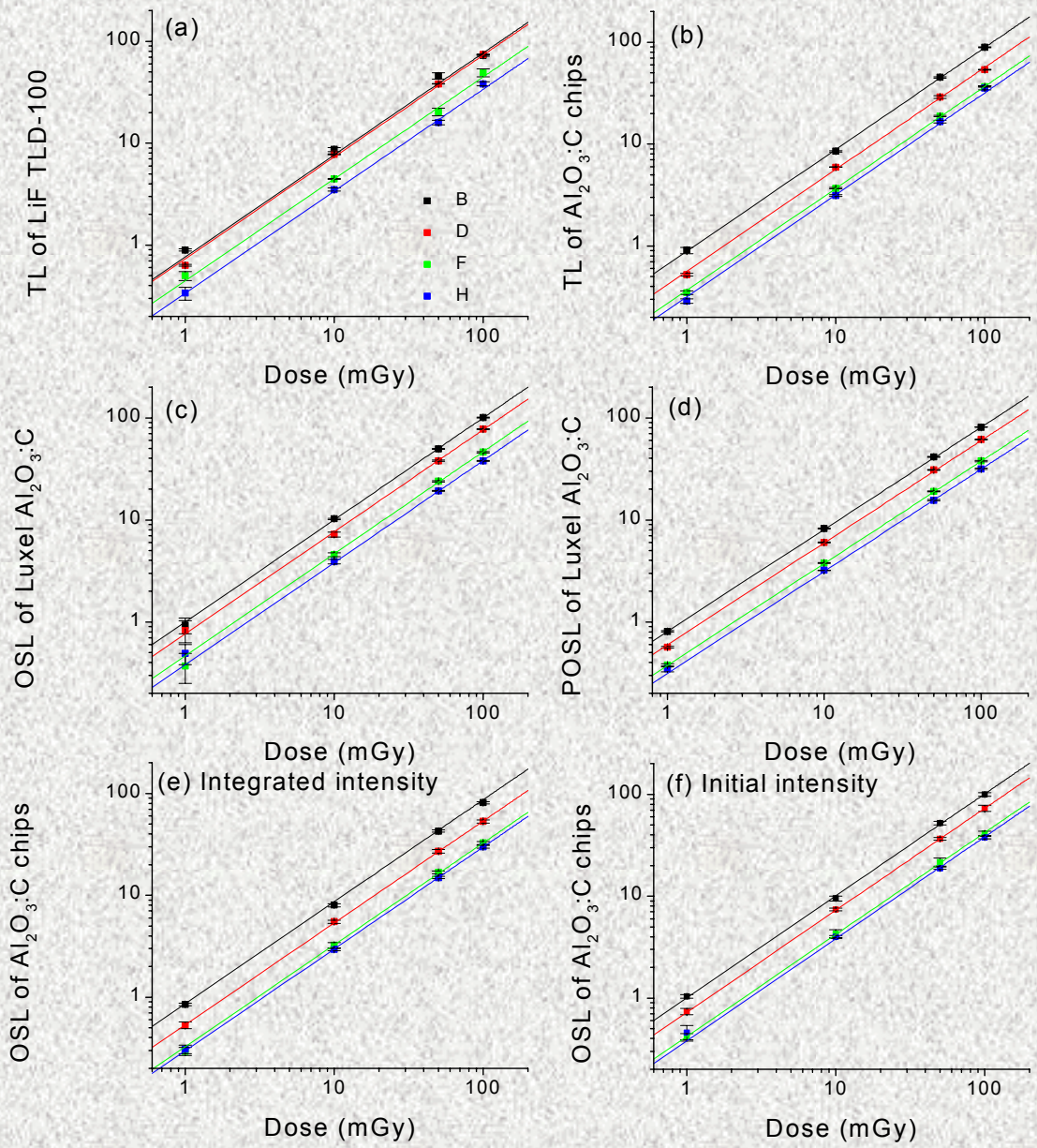
Al_2O_3 single crystal chips (TLD-500)
Al_2O_3 Luxel™ dosimeters (Landauer)
LiF chips (TLD-100)



Methods:

OSL - CW-OSL (constant stimulation intensity; 525 nm)
- POSL (Pulsed stimulation; 532 nm)

TL - 1 °C/s



2nd ICCHIBAN Results

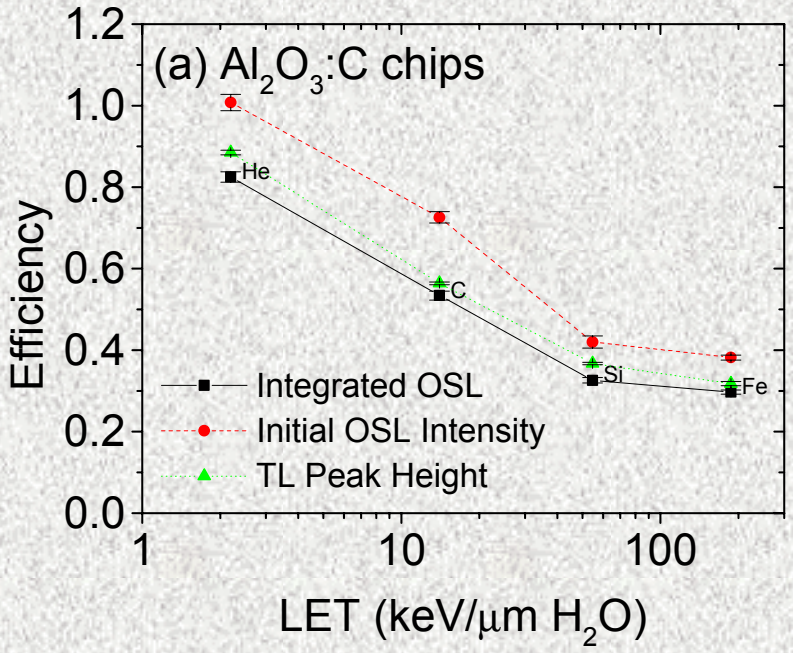
TL and OSL from:

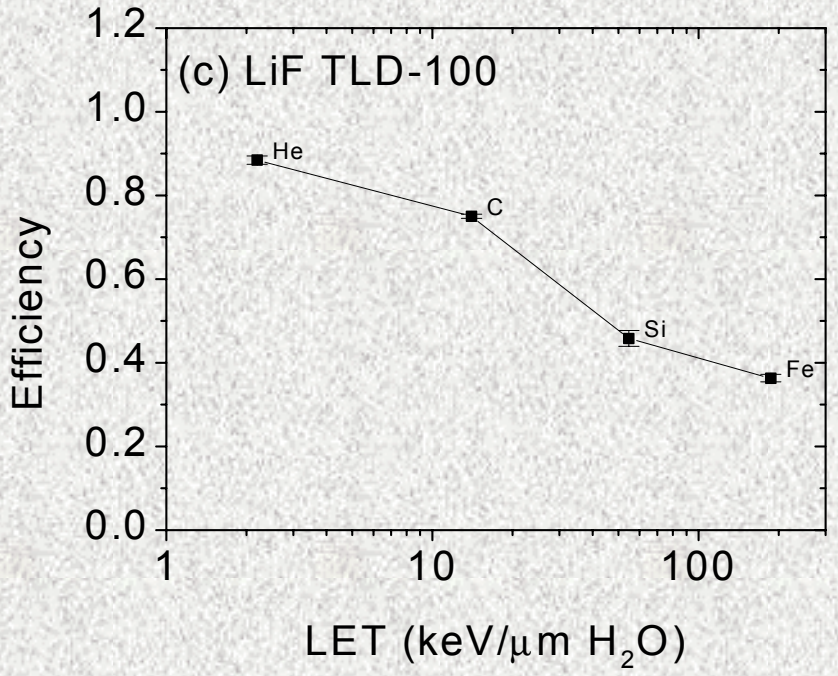
- TLD-100
- Al_2O_3 chips

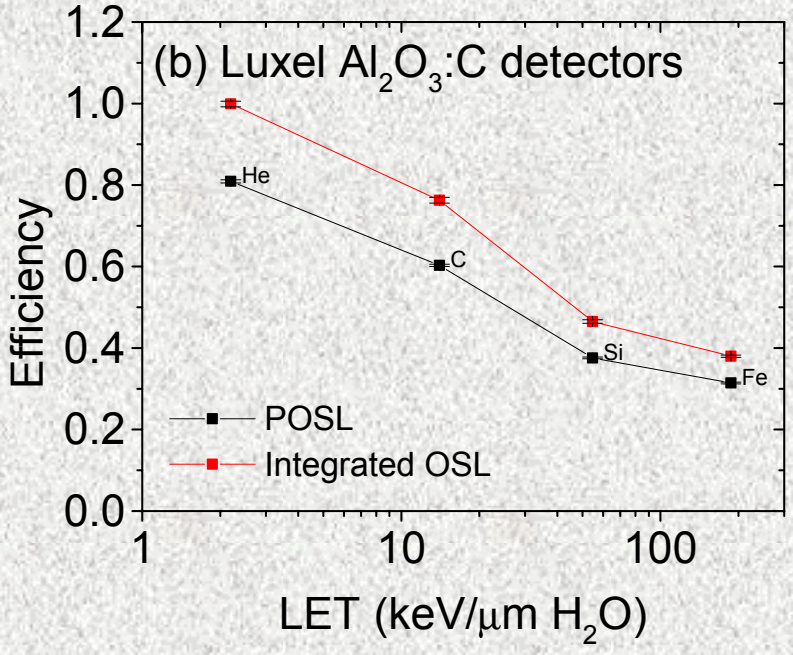
and

- 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

Particle (LET: keV.μm^{-1} H_2O)	*Al_2O_3:C Chip OSL Area*	*Al_2O_3:C Chip OSL I_0*	*Al_2O_3:C Chip TL*	*Al_2O_3:C Luxel™ OSL Area*	*Al_2O_3:C Luxel™ POSL*	*LiF TLD-100 TL*
He (2.19)	0.825	1.008	0.885	0.999	0.809	0.884
C (11.02)	0.534	0.726	0.564	0.763	0.603	0.750
Si (54.63)	0.326	0.420	0.367	0.465	0.375	0.458
Fe (186.84)	0.297	0.382	0.318	0.380	0.314	0.363

Fragmentation results:

Gamma-equivalent absorbed dose (Gy)

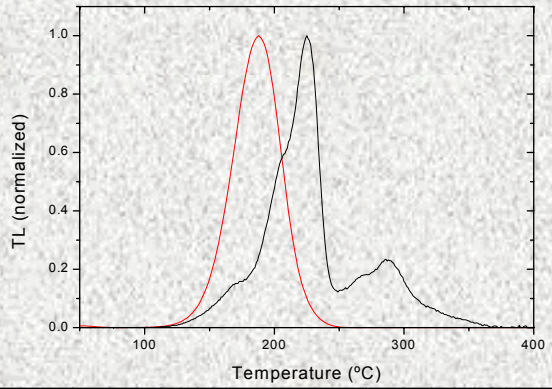
Particle	*Al_2O_3:C Chip OSL Area*	*Al_2O_3:C Chip OSL I_0*	*Al_2O_3:C Chip TL*	*Al_2O_3:C Luxel™ OSL Area*	*Al_2O_3:C Luxel™ POSL*	*LiF TLD-100 TL*
C	0.015(14)	0.046(24)	-	-	0.040(11)	-
Si	0.072(16)	0.13(4)	0.099(6)	-	0.13(7)	0.07(3)
Fe	0.369(22)	0.51(3)	0.355(7)	0.43(10)	0.387(13)	0.46(4)

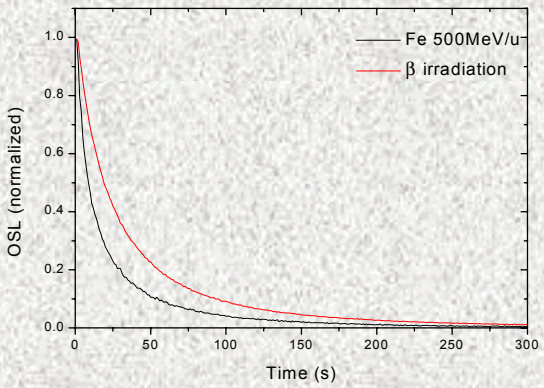
Blind results:

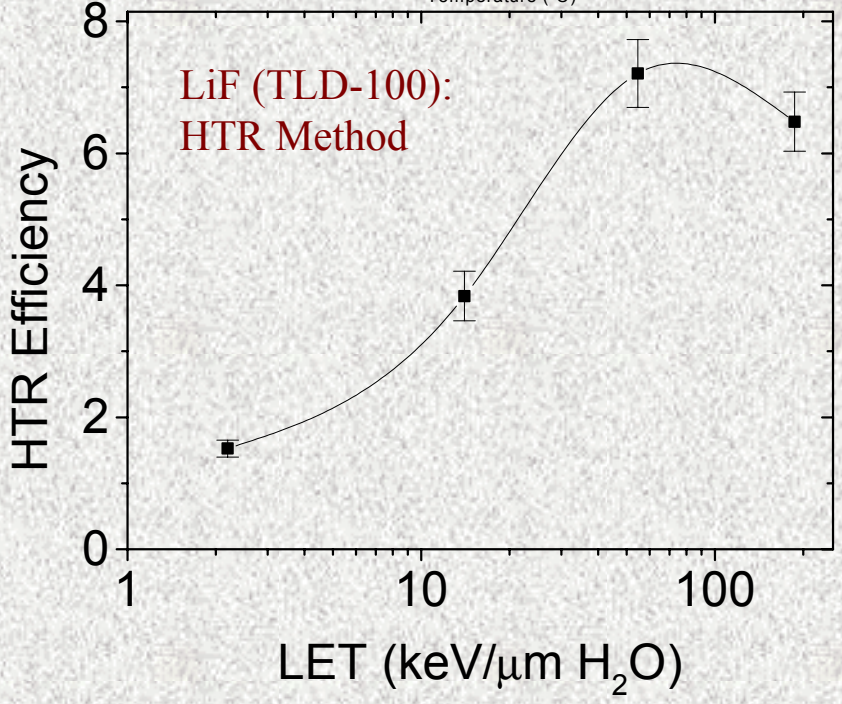
Gamma-equivalent absorbed dose (Gy)

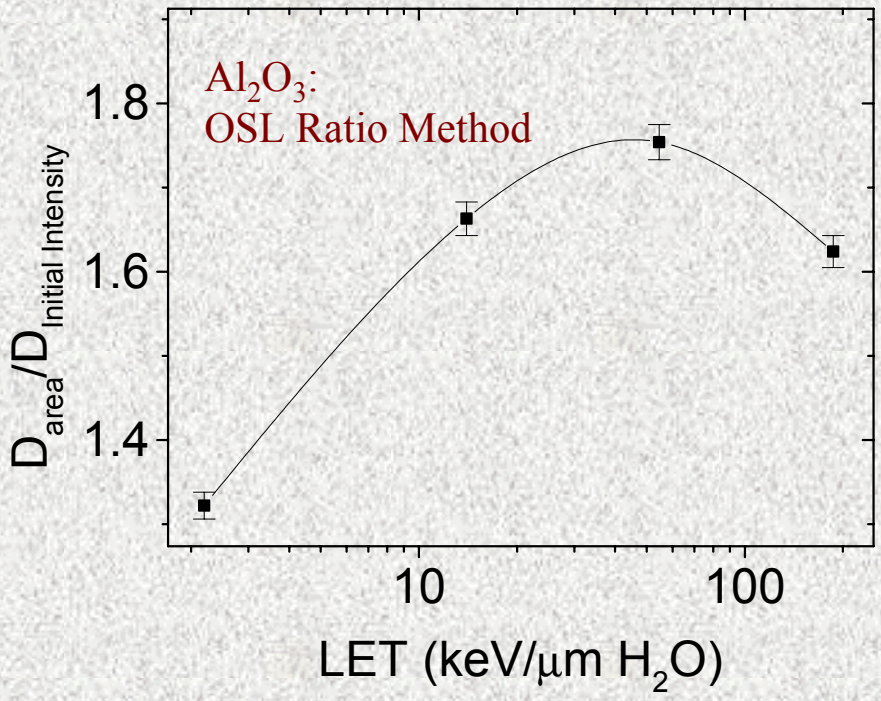
	Al_2O_3:C Chip OSL Area	Al_2O_3:C Chip OSL I_0	Al_2O_3:C Chip TL	Al_2O_3:C Luxel™ OSL Area	Al_2O_3:C Luxel™ POSL	LiF TLD-100 TL
Blind 1	91(3)	108(5)	88.5(21)	98.9(6)	85.1(9)	91.16(24)
Blind 2	4.07(11)	5.65(22)	4.02(4)	5.04(9)	4.16(4)	4.39(24)
Blind 3	10.5(5)	14.1(11)	10.38(1)	12.98(23)	10.58(11)	12.05(5)
Blind 4	0.127(17)	0.19(3)	0.132(6)	-	0.154(11)	0.14(2)
Blind 5	8.5(4)	11.3(6)	8.19(21)	11.45(22)	9.43(10)	10.82(74)
Blind 6	2.06(6)	2.89)8)	2.14(1)	2.65(12)	2.26(3)	2.58(5)
Blind 7	1.05(7)	1.43(14)	1.044(28)	1.39(13)	1.145(14)	1.26(5)
Blind 8	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?

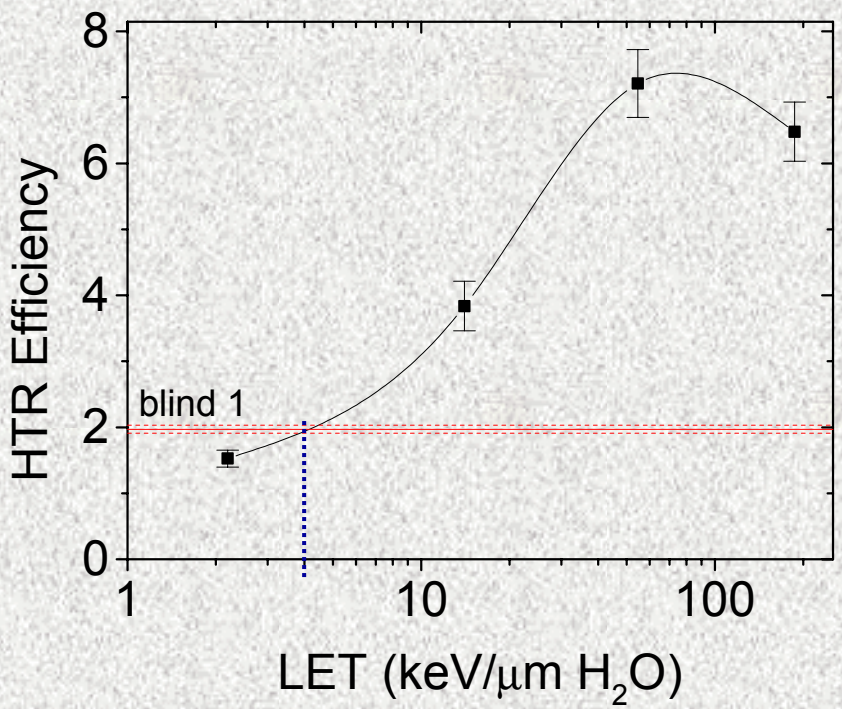




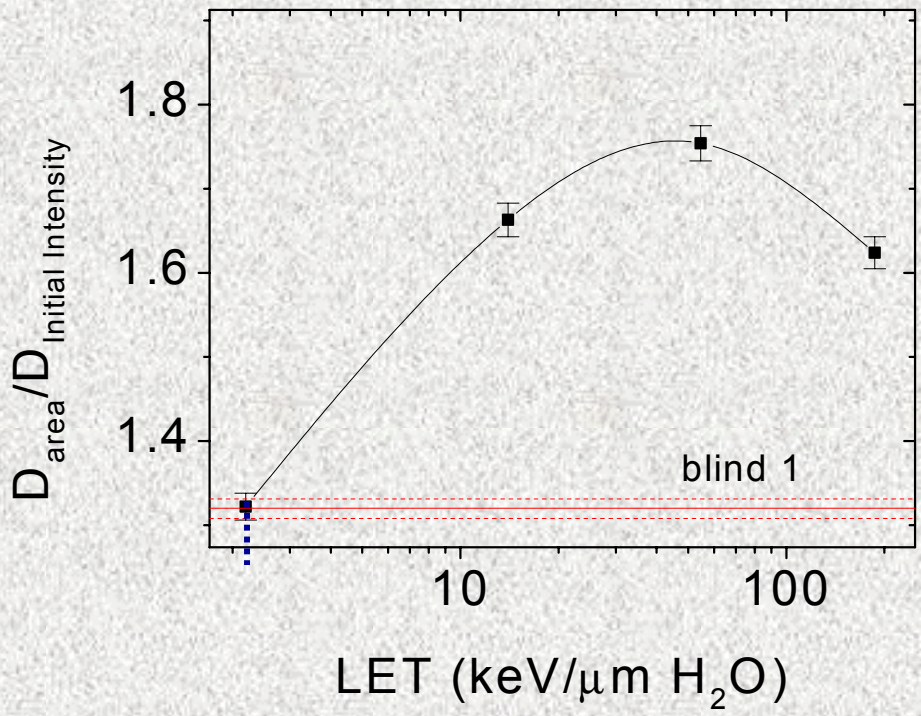




LiF (TLD-100): HTR Method



Al_2O_3: OSL ratio Method



If we identify Blind 1 with He particles……

	Al_2O_3:C Chip OSL Area	Al_2O_3:C Chip OSL I_0	Al_2O_3:C Chip TL	Al_2O_3:C Luxel™ OSL Area	Al_2O_3:C Luxel™ POSL	LiF TLD-100 TL
Measured Dose (Gy)	91(3)	108(5)	88.5(21)	98.9(6)	85.1(9)	91.16(24)
Efficiency	0.825(13)	1.008(20)	0.885(6)	0.999(7)	0.809(4)	0.884(10)
Corrected Dose (Gy)	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