Development of a portable OSL reader for spaceflight activities

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and
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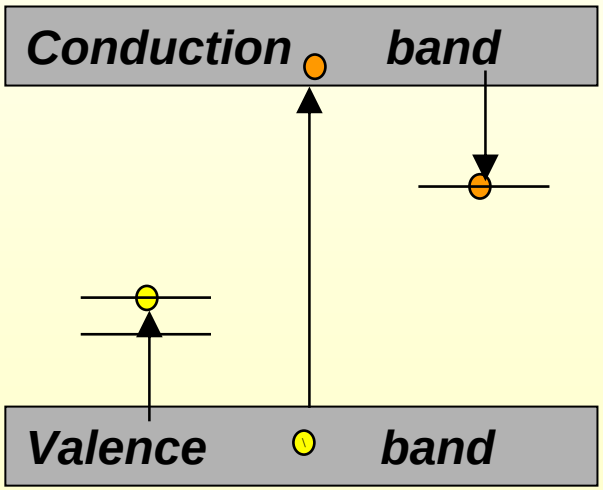
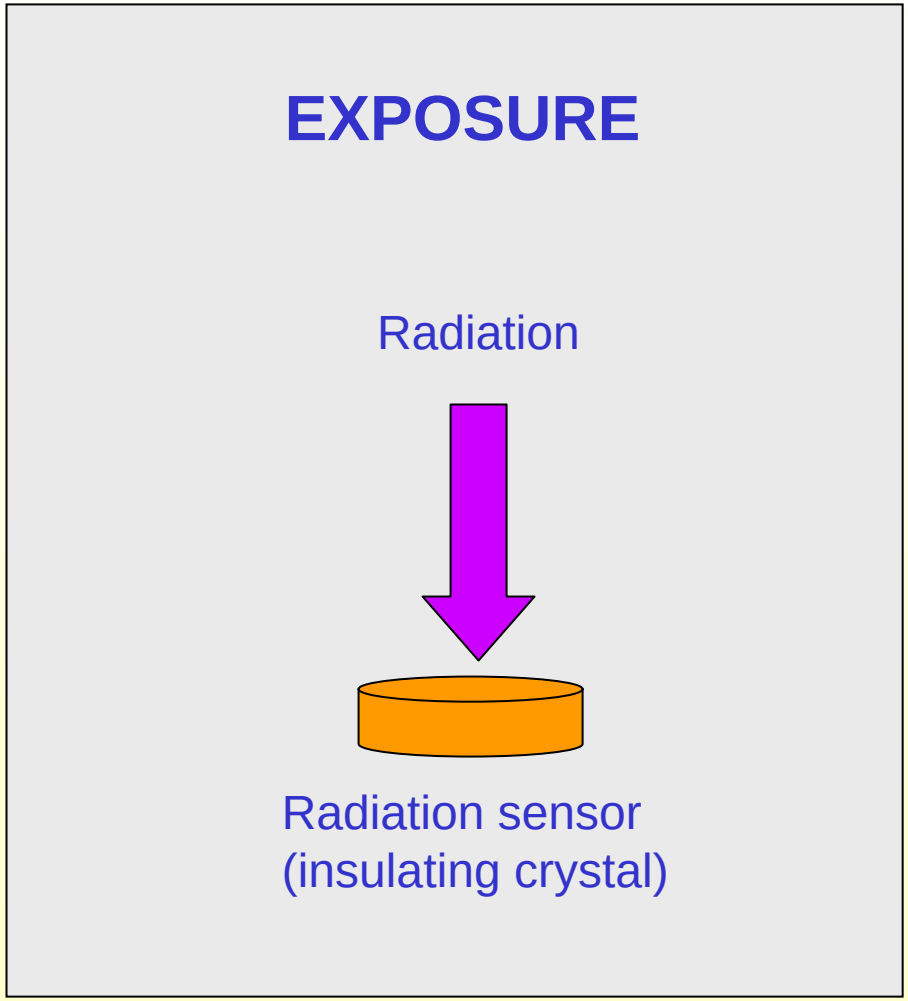
Oklahoma State University

TL and OSL Principles

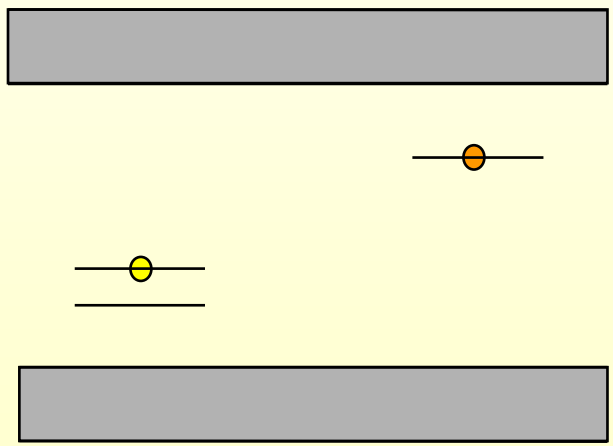
TL = *thermally* stimulated luminescence

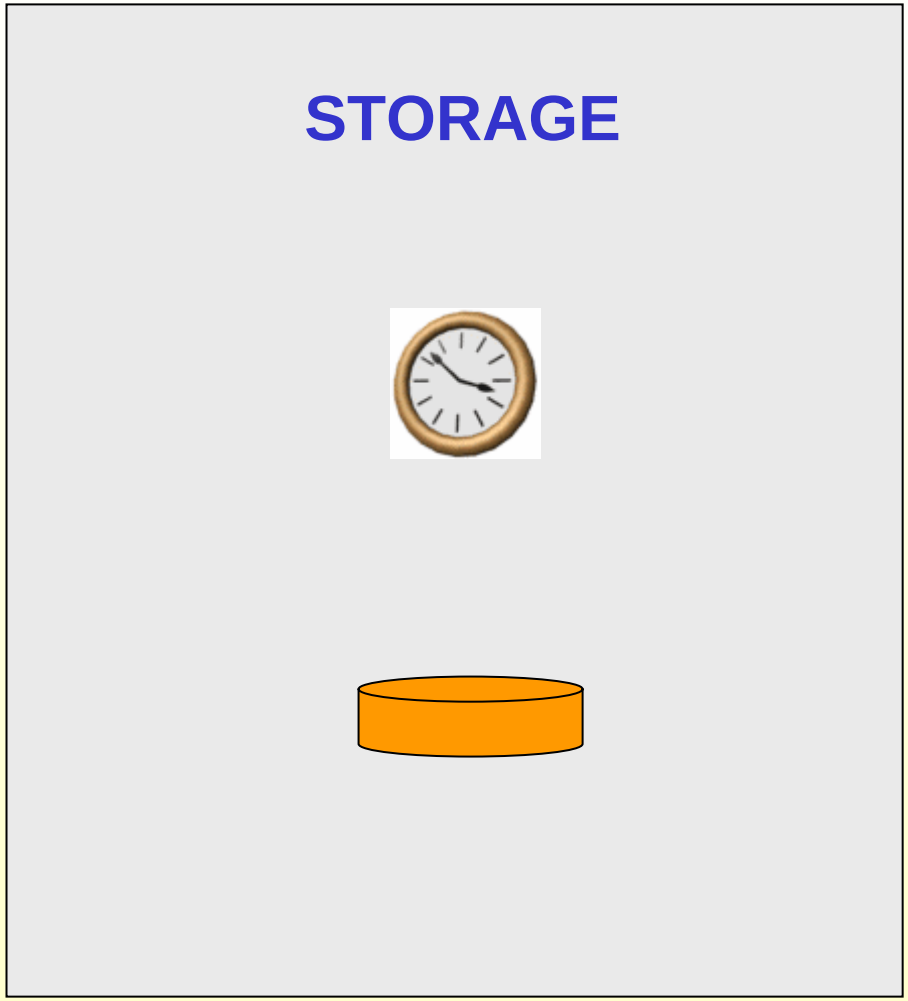
OSL = *optically* stimulated luminescence



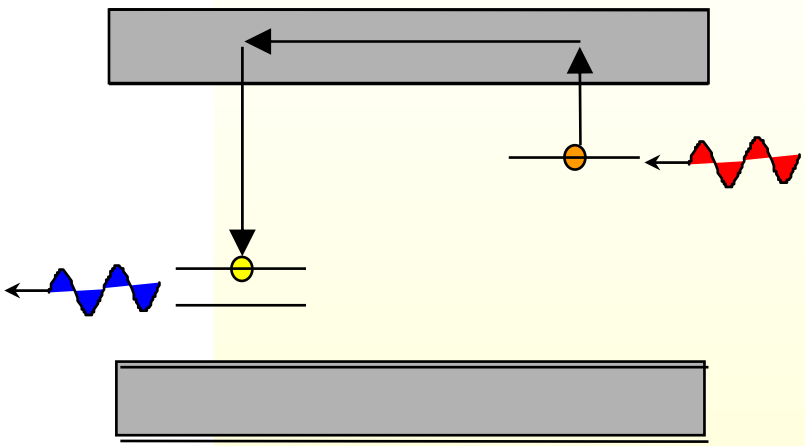


TL and OSL Principles



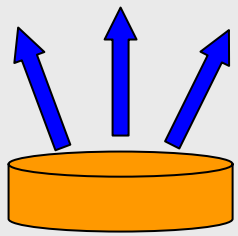


TL and OSL Principles



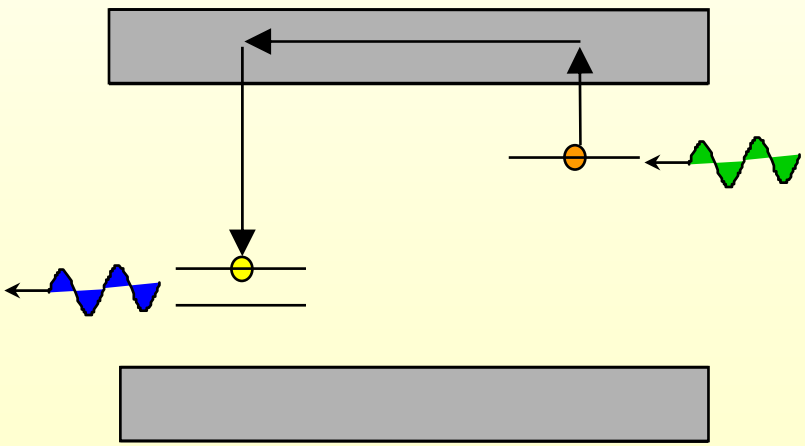
READOUT

Light emission – **TL**
(e.g., blue, UV)



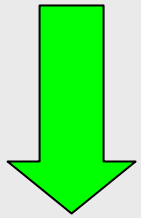
Thermal
stimulation
(heating)

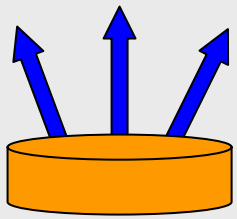
TL and OSL Principles



READOUT

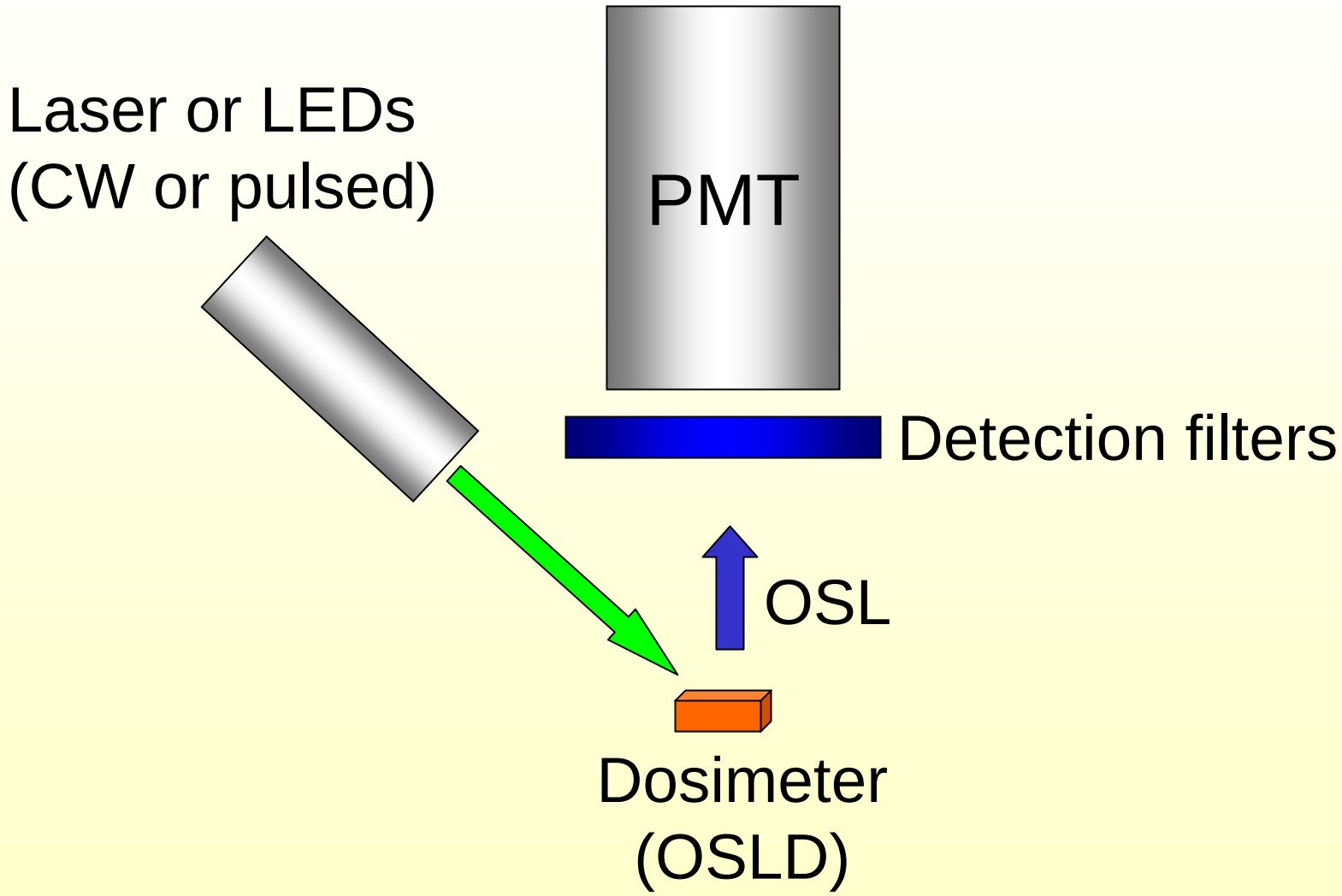
Light stimulation (e.g., green)



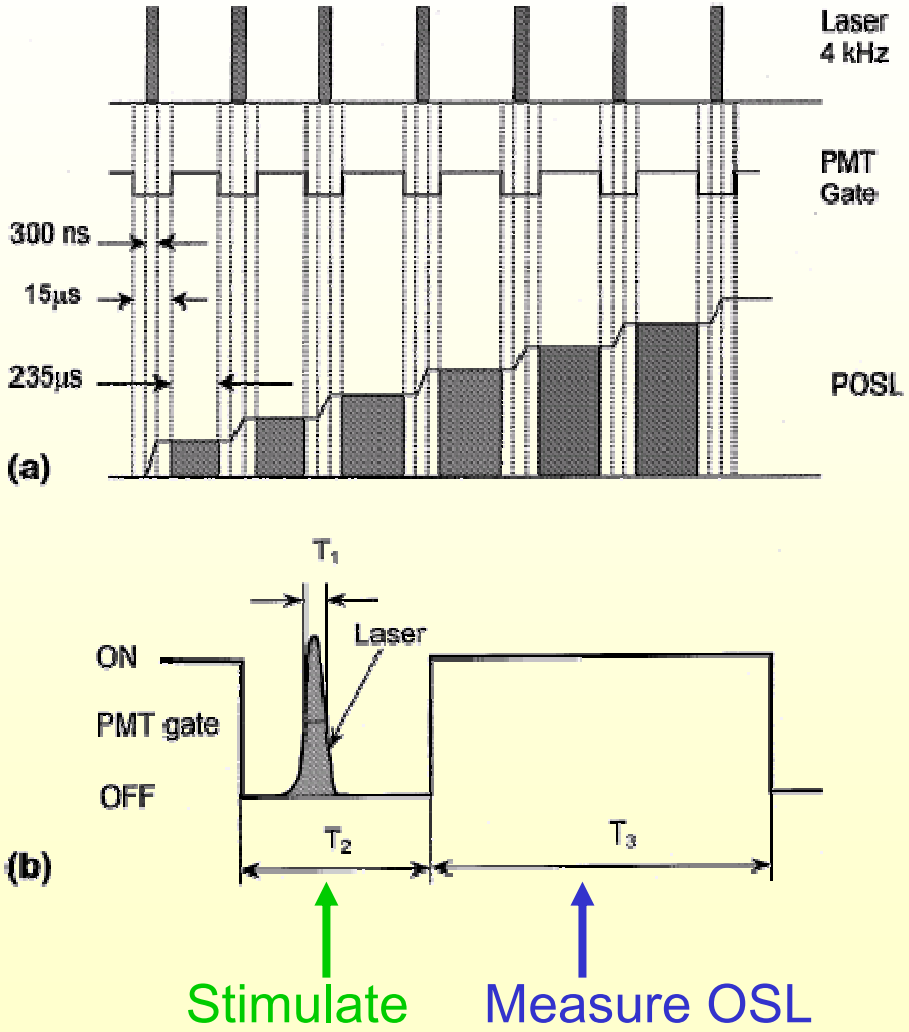


Light emission (e.g., blue, UV) - **OSL**

TL and OSL Principles



The Pulsed OSL (POSL) Technique

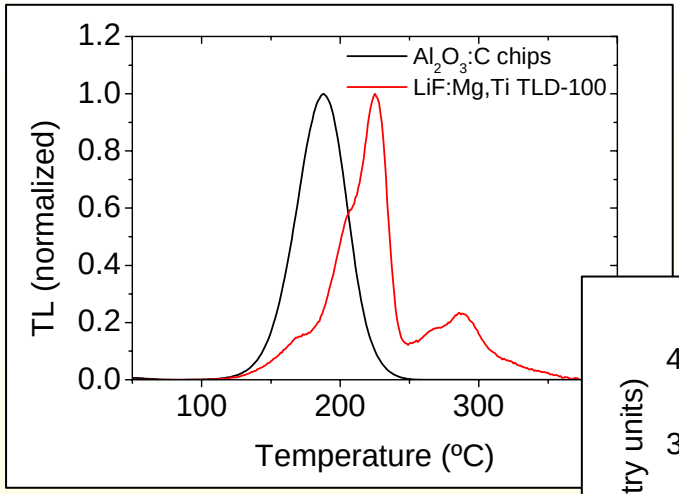


Pulsed OSL (POSL) Measures OSL emission between stimulation pulses, not during the pulse. Better separation between the signal and the stimulation light.

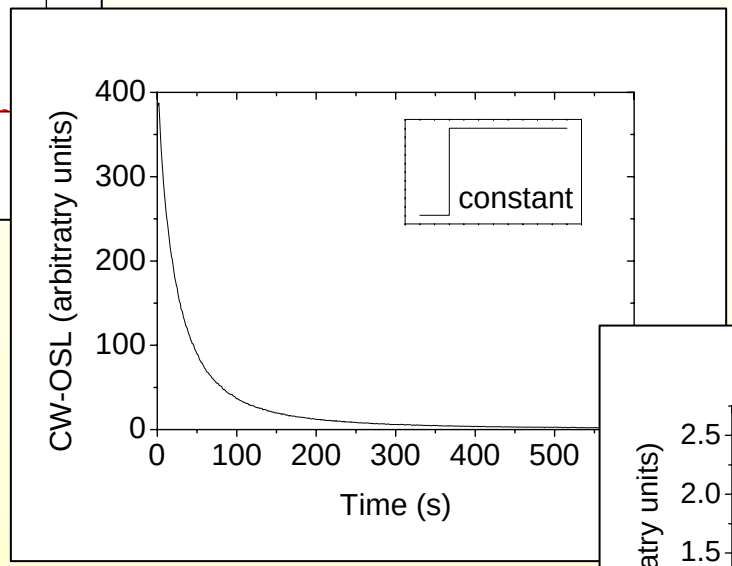
Akselrod and McKeever, Radiat. Prot. Dosim. 81, 167-176 (1999)

Typical TL and OSL Signals

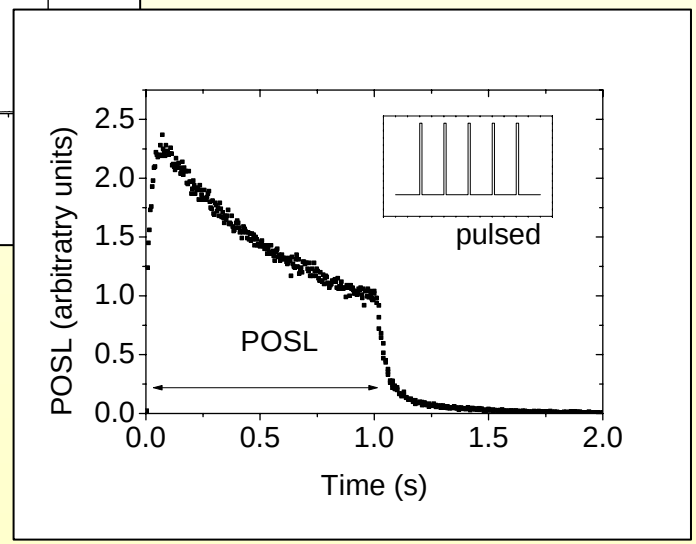
TL



CW-OSL

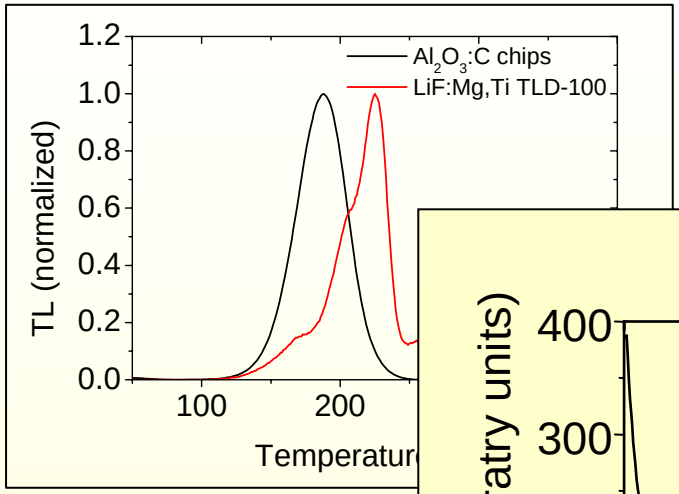


POSL

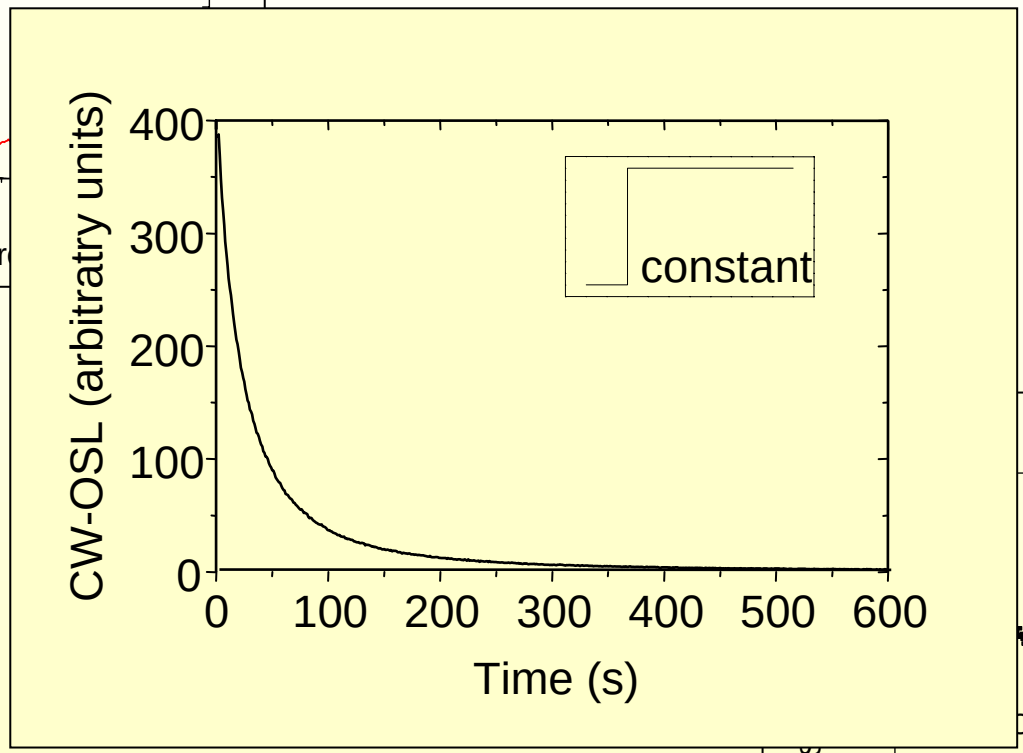


Typical TL and OSL Signals

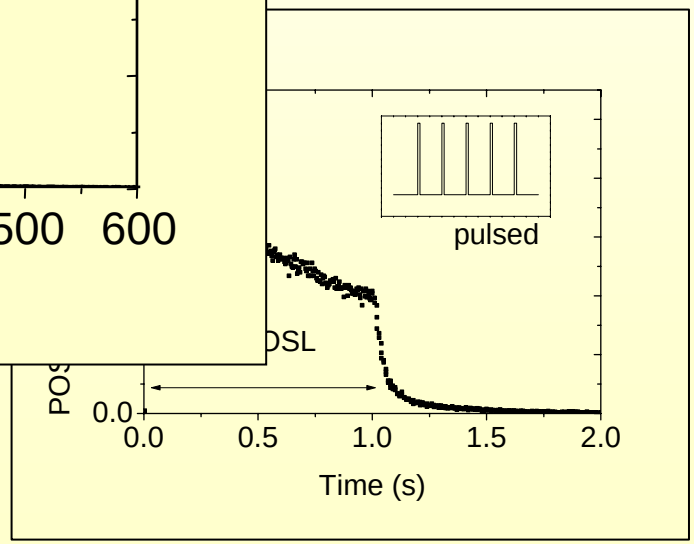
TL



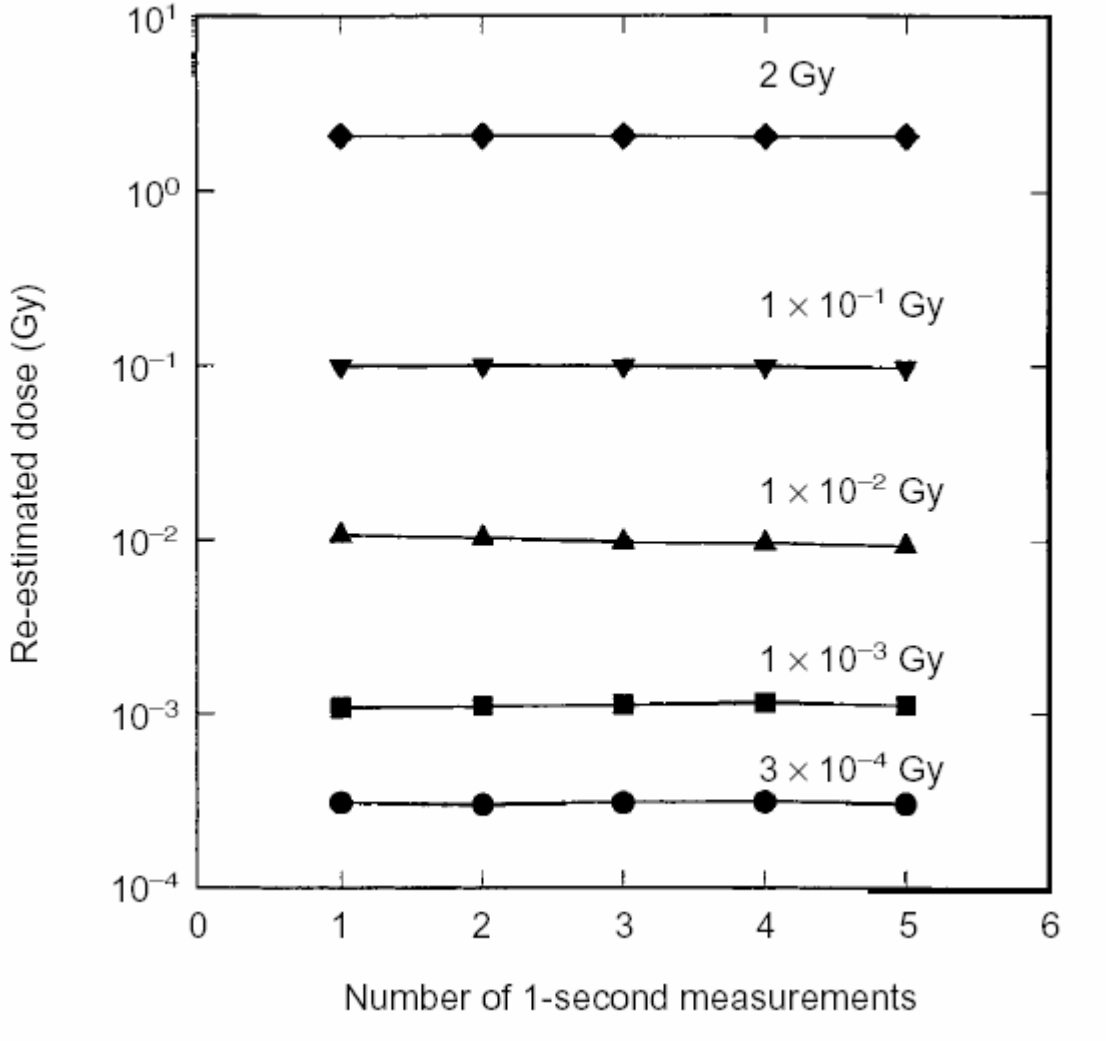
CW-OSL



POSL



Possibility of Re-estimation of doses



Can re-read the OSL signal, if the signal is strong enough. (No need to deplete the signal in order to measure it.)

Akselrod and McKeever, Radiat. Prot. Dosim. 81, 167-176 (1999)

Why develop OSL fro astronaut dosimetry?

- All-optical method lends itself to multiple configurations and devices
- High sensitivity
- Stable signal (no fading)
- Re-read of OSL signal (period dose plus total dose)
- Re-setting of signal by bleaching
- High reproducibility within a batch (e.g. Luxel^{TM})
- Thin dosimeters (e.g. Luxel^{TM}) for ease of use
- Fast readout
- Low (electrical) power
- High reliability of components
- Various on-board readout configurations
- Can combine with TLD/PNTD badges, and readers

Space & Ground-Based Experiments

Ground-based Experiments

- HIMAC-NIRS
- ICCHIBAN 2nd, 4th, 6th
- Peletron-UNAM
  (low-E *p*, *He*, *C, O*)
- Loma Linda (proton ICCHIBAN)
- NSRL-BNL

Space-based Experiments

- STS - several
- Soyuz/ISS (*MATROSHKA I & II*)
- Soyuz (*MESSAGE*; MOBILIZATION)
- Soyuz/ISS (*BRADOS*)
- Antarctica Balloon flight (TRACER)

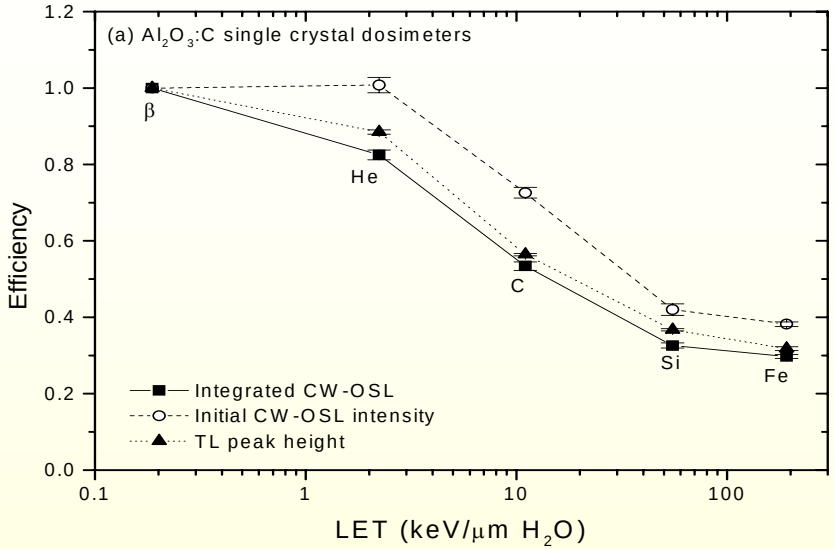
Multiple collaborators

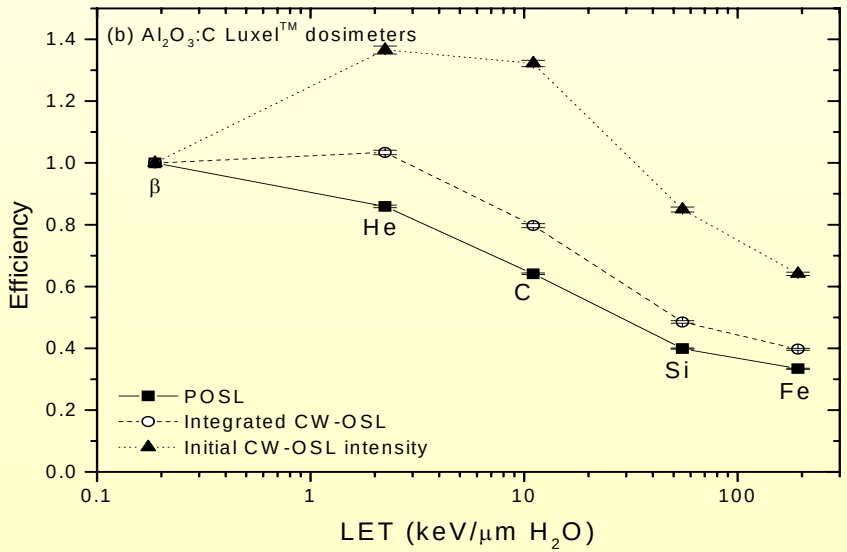
Summary of Major Properties

(1) OSL from Al_2O_3 shows sensitivity to HCP of LET > 10 keV/μm (up to 290MeV/n Xe; 1047 keV/μm)

(2) Sensitivity & precision depend on method of OSL readout

(3) Sensitivity & precision depend on material type (chip, Luxel)

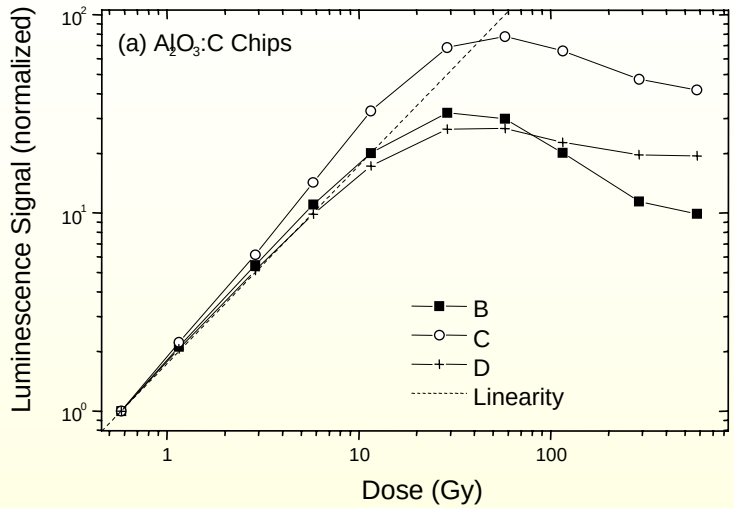


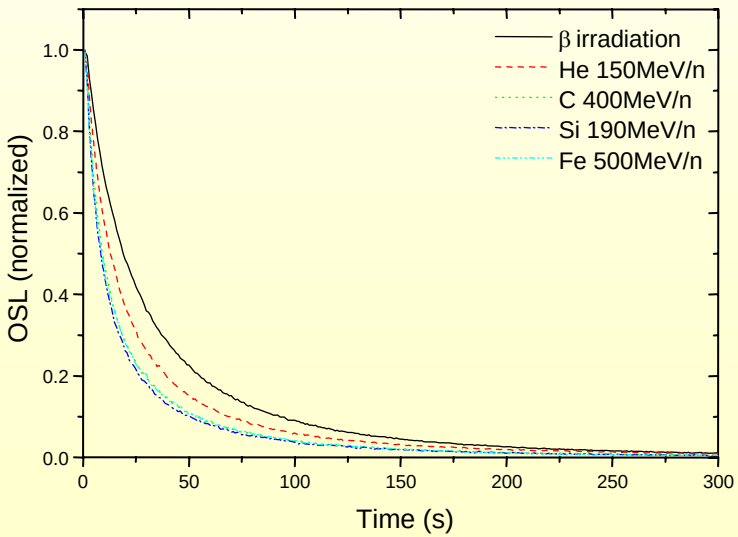


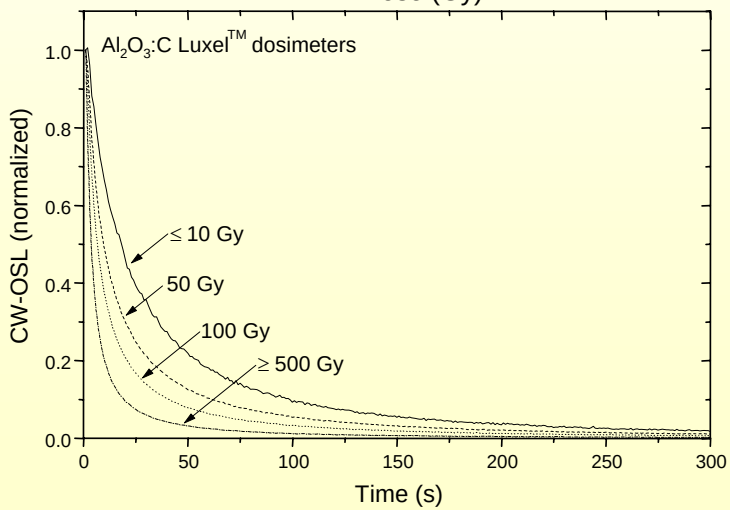
Summary of Major Properties

(4) Sensitivity decrease with LET due to loss of sensitivity at high doses

(5) OSL decay rate depends on (a) dose, (b) LET





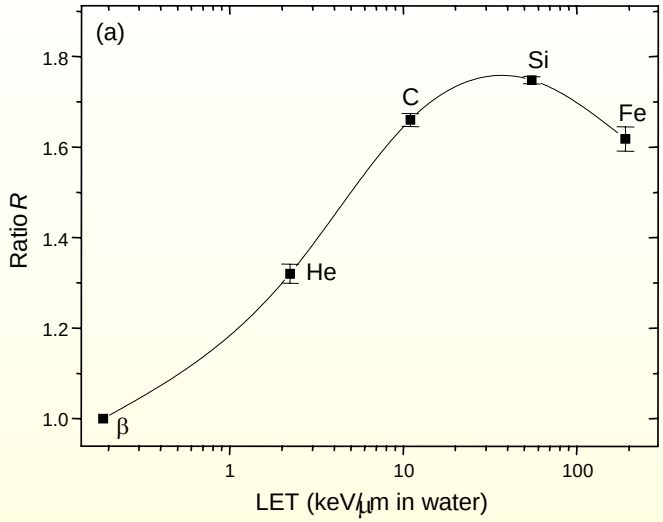


Summary of Major Properties

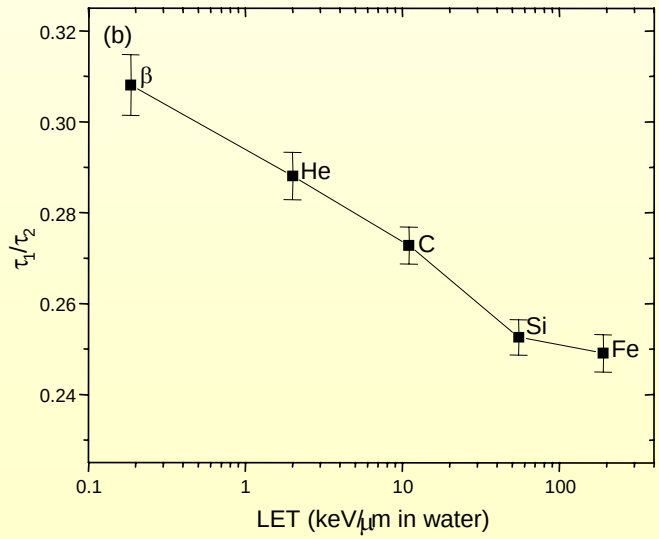
(6) Possibility of LET information from OSL decay curves

(a) Ratio of area to initial intensity

(b) Ratio of decay constants

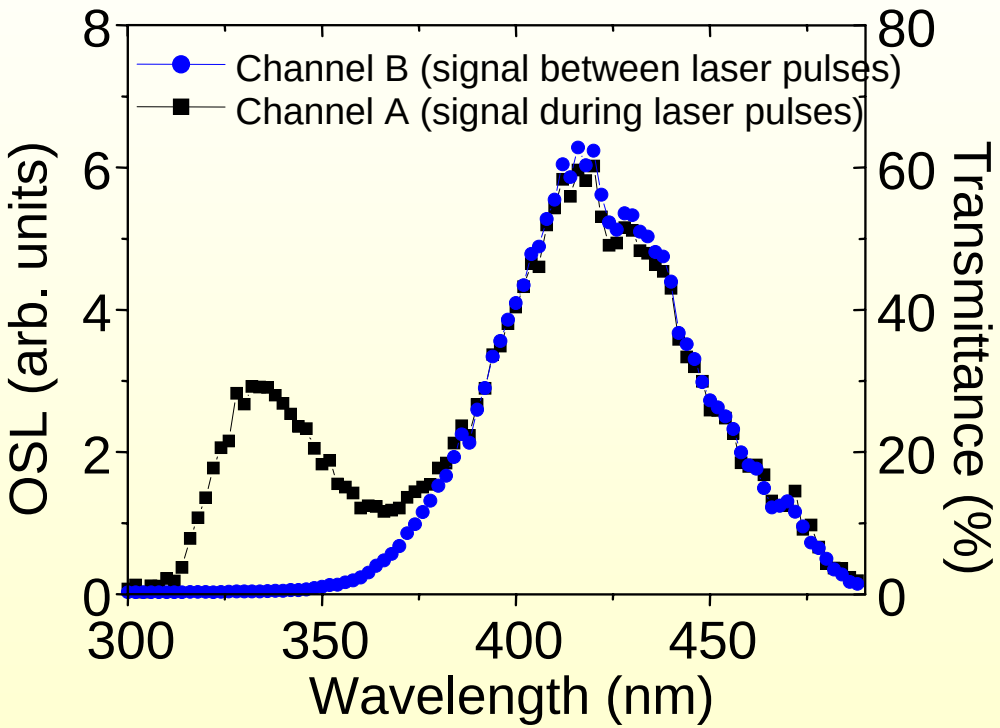


(7) Possibility of LET information from emission spectra

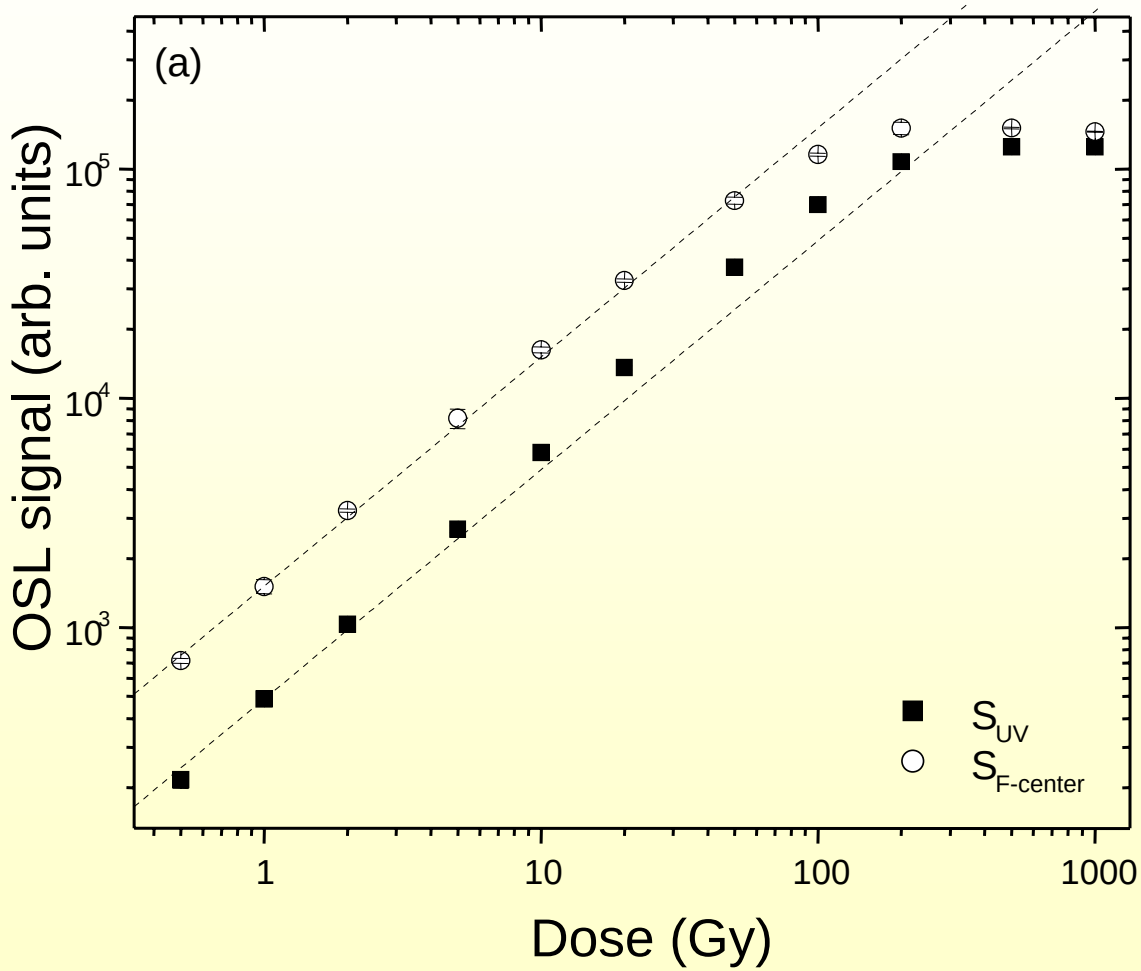


OSL from Al_2O_3:C: emission bands

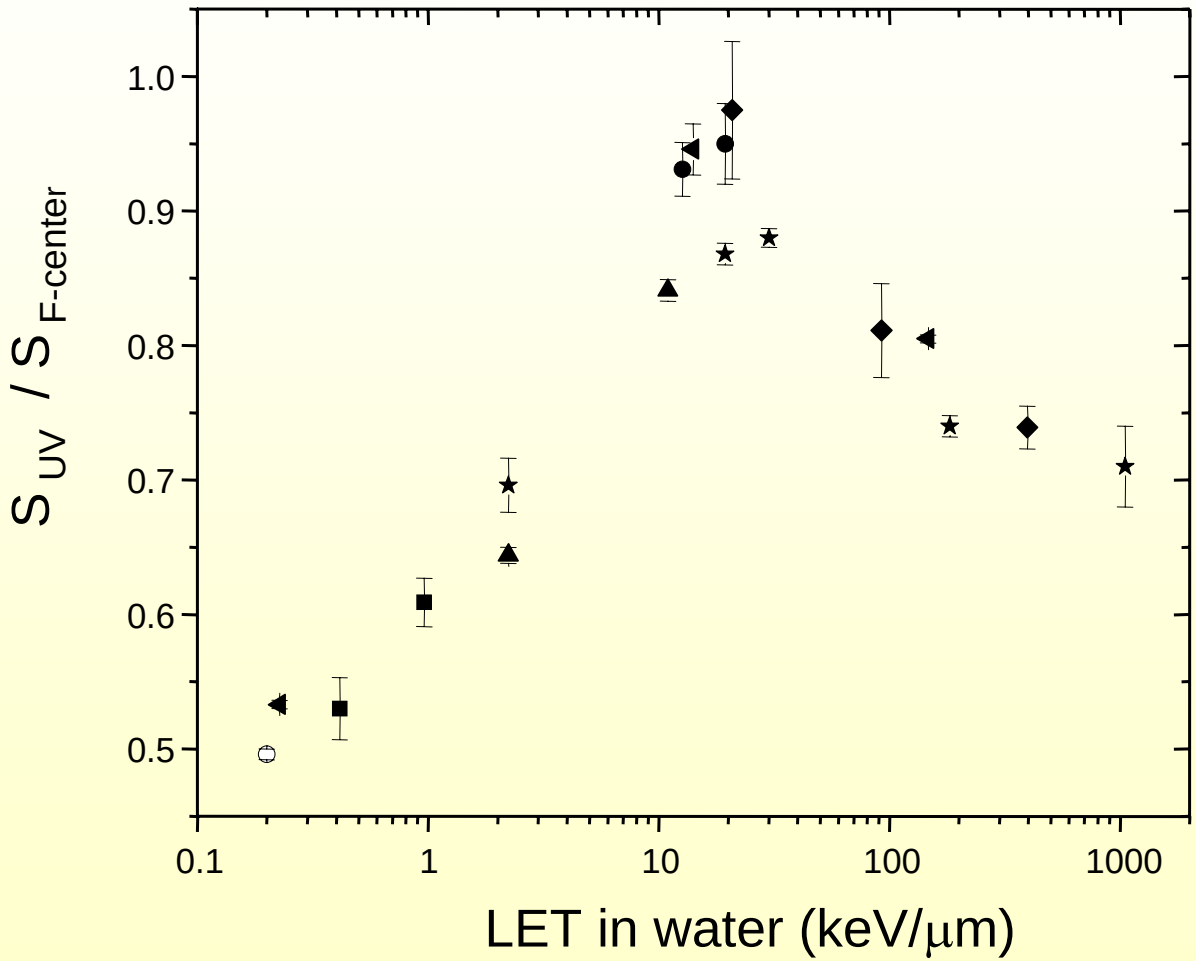
POSL measurements



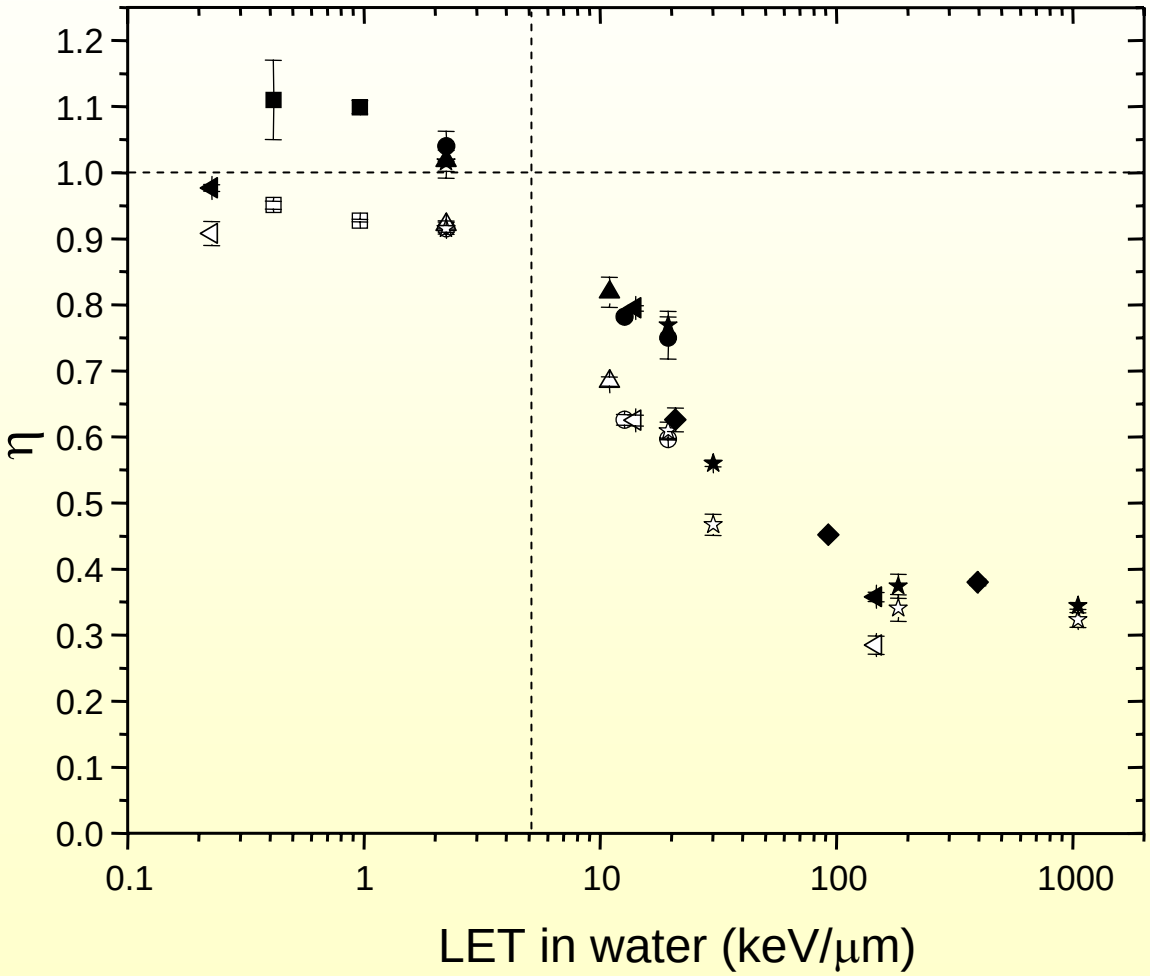
CW-OSL from Al_2O_3:C: dose dependence



CW-OSL from Al_2O_3:C: LET dependence



CW-OSL from Al_2O_3:C: relative efficiency



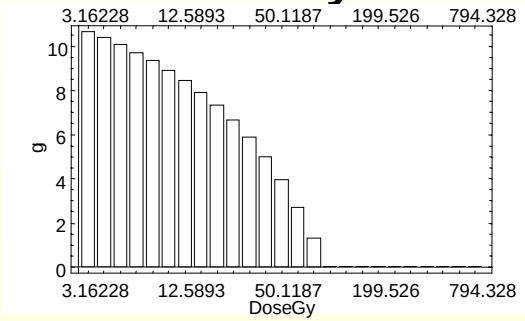
Closed symbols: UV
Open symbols: F-center

Summary of Major Properties

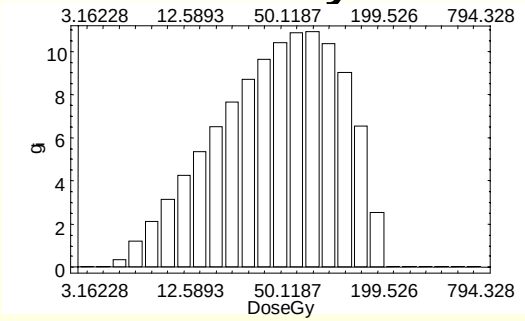
(8) Possibility of extracting dose due to low LET from dose due to high LET

Dose distributions extracted from deconvolutions of OSL decay curves

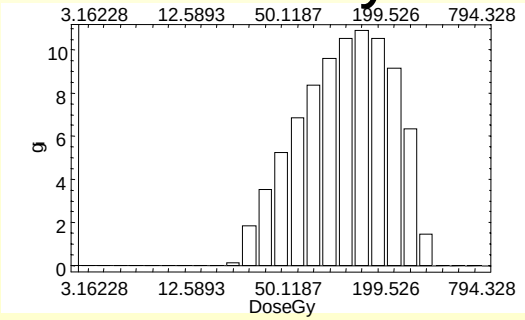
100 mGy beta



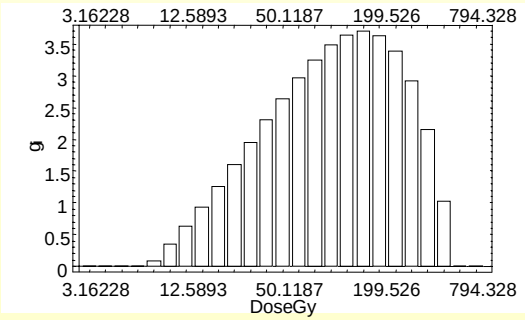
100 mGy He



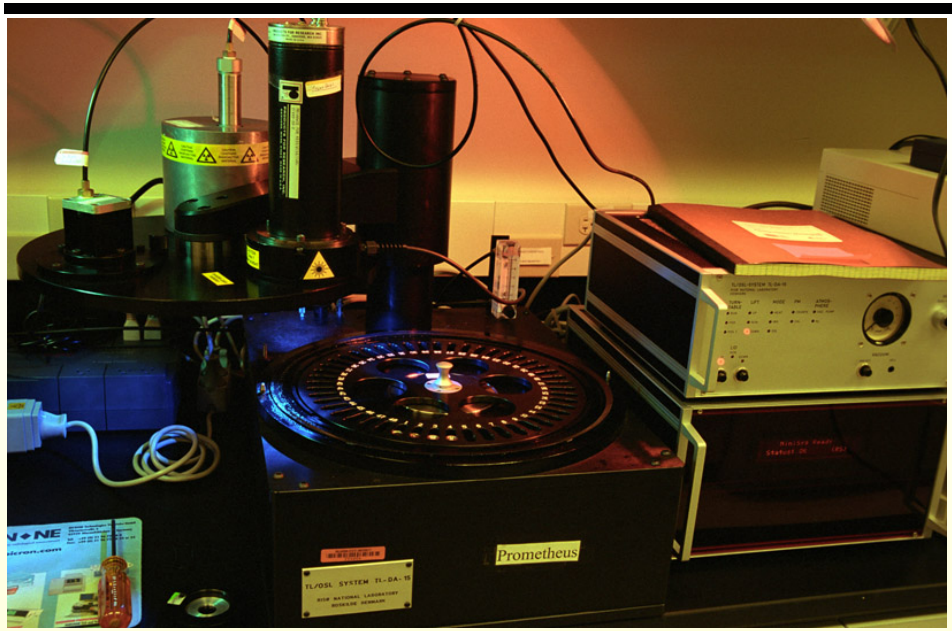
100 mGy C

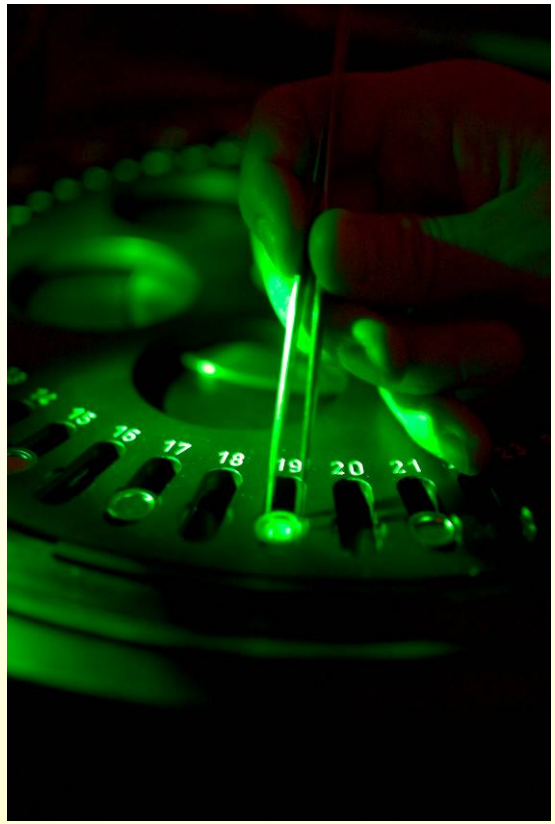


100 mGy Fe

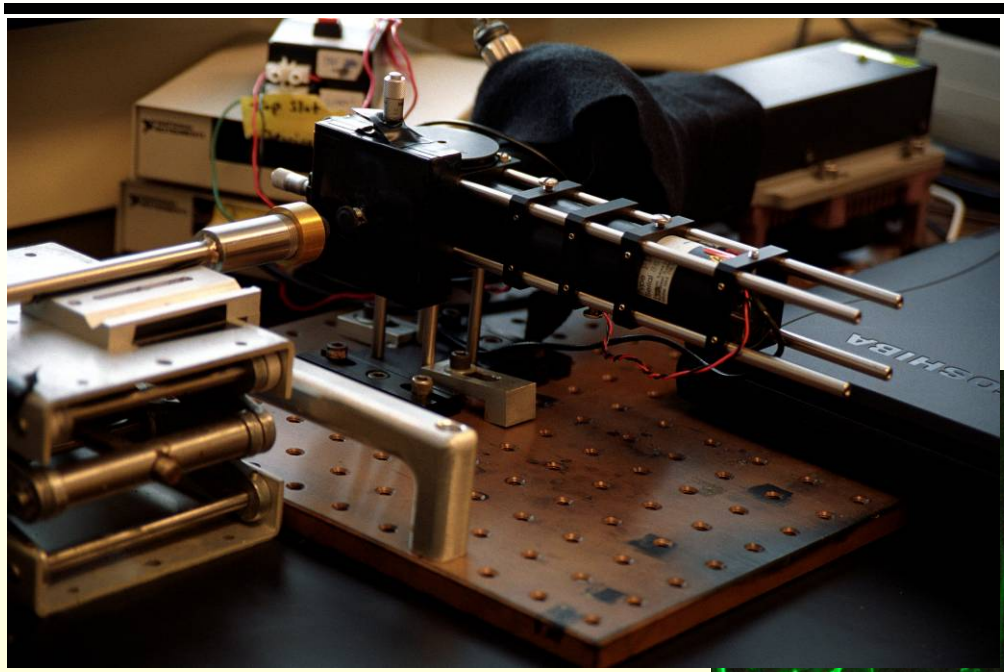


Risoe TL/OSL reader

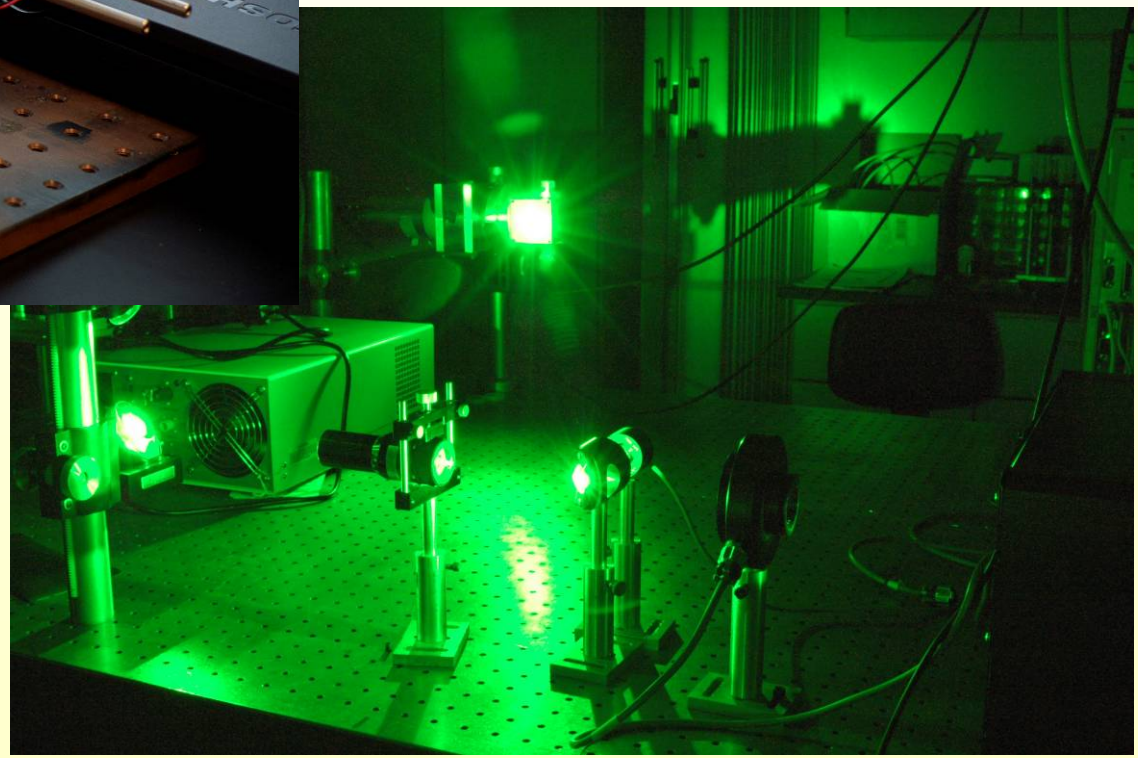




Experimental OSL readers



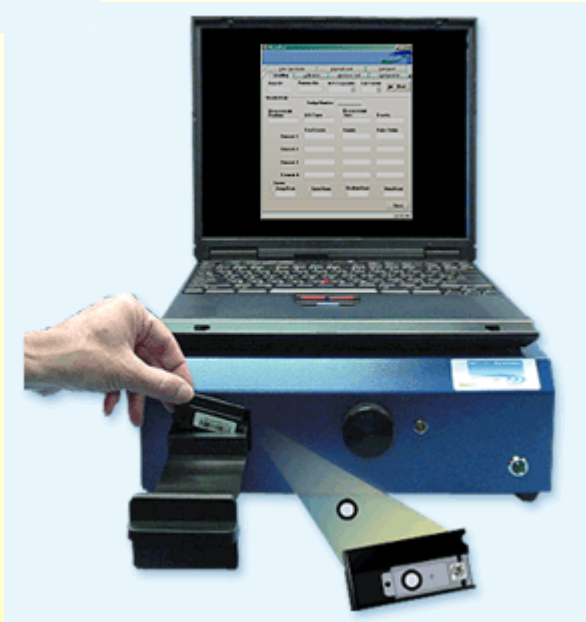
Portable POSL system



Laboratory POSL system

Experimental OSL readers

InLight™ (Landauer Inc.)



MicroStar™ (Landauer Inc.)

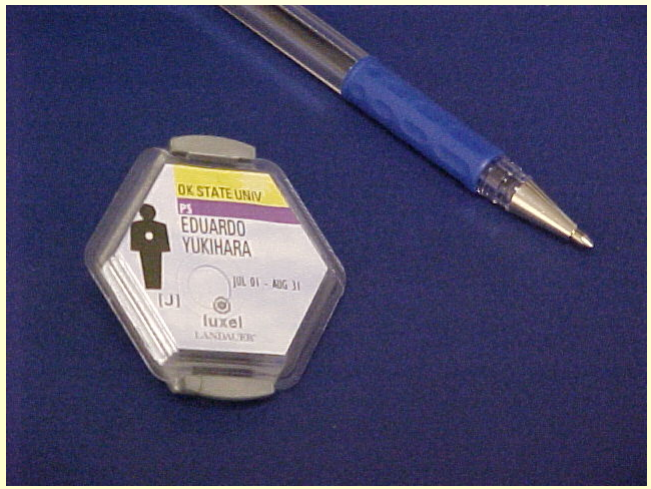
Current OSL applications

Personnel dosimetry of ionizing radiation (Landauer Inc.)
(Technology licensed from OSU)

60,000 costumers (1.4 million individuals)

Al_2O_3:C from Landauer Crystal Growth Division (Stillwater)

Luxel™ badge



Future projects: *The Citizens' Dosimeter*

- Project underway at the **Environmental Measurements Laboratory** (Gladys Klemic - gladys.klemic@dhs.gov)
- Credit card format dosimeter
- Strategically placed card readers
- Combine existing technology in new design

Requirements

- Sensitivity between 0.5mGy – 10 Gy
- Readout in <3s
- Signal loss <10% relative to previous readout

Future projects: *The Citizens' Dosimeter*

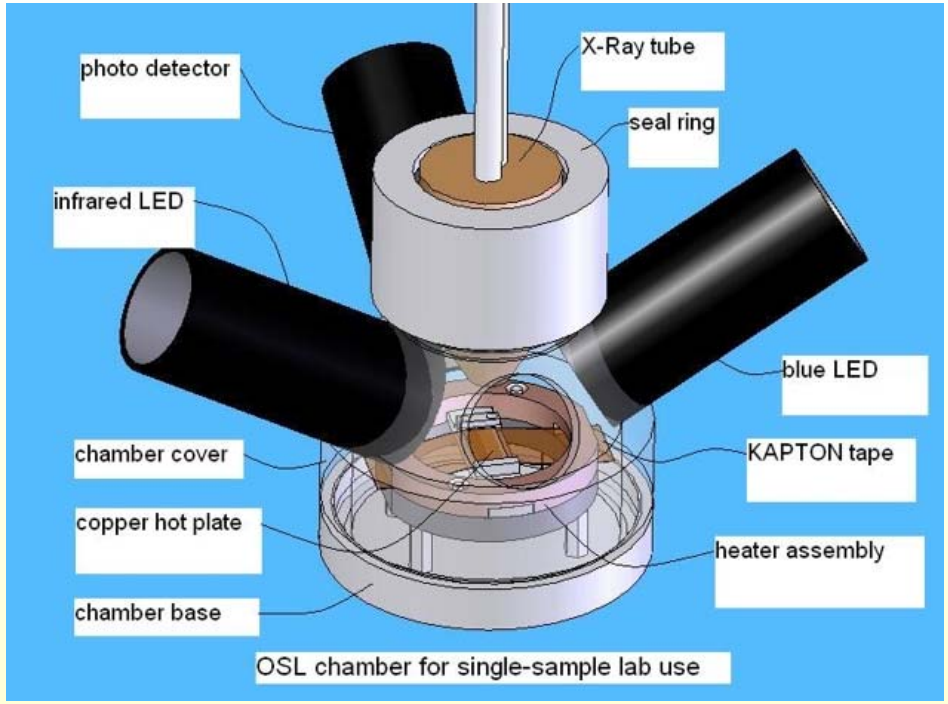
Objectives

- Design and build a functioning prototype OSL reader (light source, light transducer, associated electronics)
- Operational in a bench-top setting, but components chosen such that they could be incorporated into a rugged commercial version (that could be used in a sheltered outdoor environment).
- Design the coupling between a prototype card and the reader
- Design the prototype card

Mars Dating Instrument

Objectives

- Design and build a functioning prototype TL/OSL reader for luminescence dating of martian surface sediments.
- (light source, light transducer, associated electronics, radiation source)



Mars Dating Instrument

Space Dosimetry

Next step

- OSL personal dosimeter readout capability for long-duration missions (ISS, Moon, Mars)
- Design and build a functioning prototype OSL reader for on-board use (light source, light transducer, associated electronics, software)
- Design an astronaut personal dosimeter badge including capability for PNTD and TLD
- Design interface to the reader

Space Dosimetry

Requirements

- Sensitivity < 0.01 mGy
- Days to years of accumulated dose (up to 3 year missions)
- Fast and easy readout
- Dosimeter – easy to wear, use, handle, read
- Light-weight, low power, etc.

Conclusions:

- Fabrication of a small OSL reader will happen in the next few years due to the convergence of interests in homeland security, planetary exploration, luminescence dating, and space dosimetry.
- All elements for the reader are available. There is no critical obstacle: OSL readout is already realized, electronics is feasible.

Thank you!