Use of TLD at CERN

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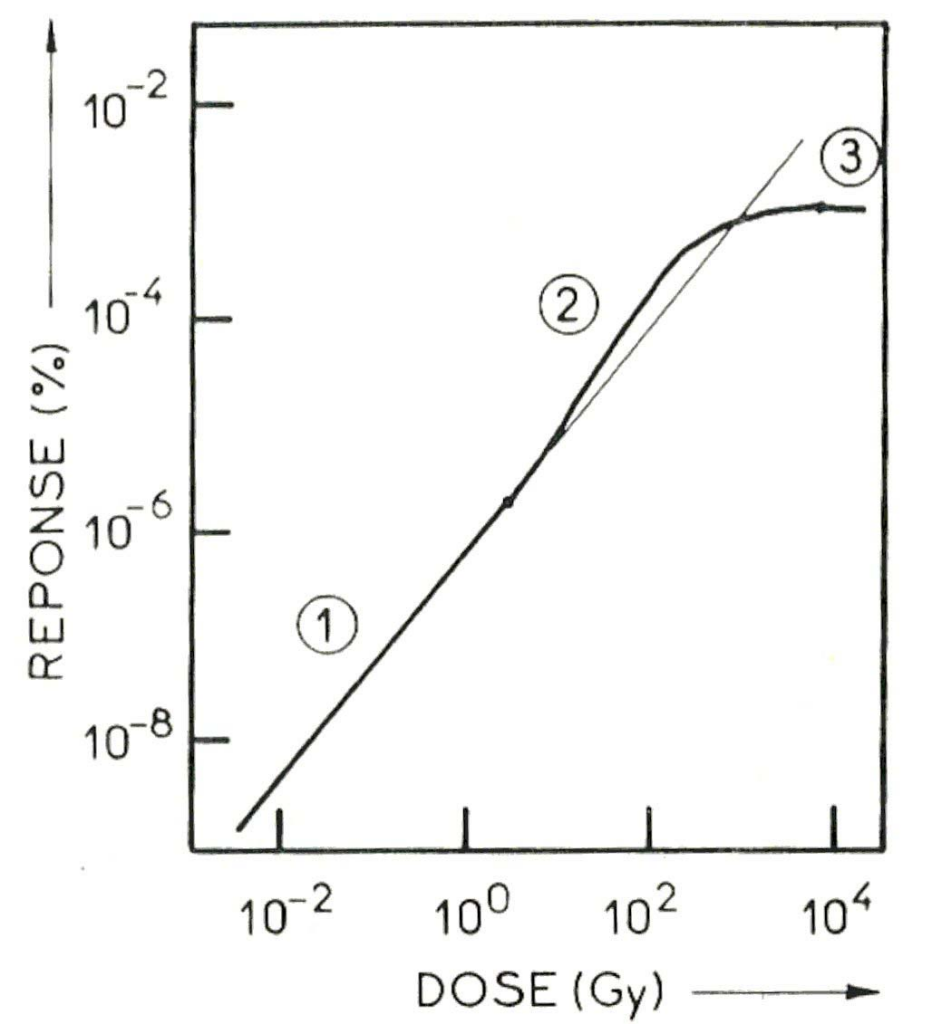
- TLD response versus dose
- Lithium Fluoride
- TLD response to gammas and neutrons
- Sensitivity
- The TLD service of the RP group
- Conclusions

Follow up of presentation given at RADMON meeting on 22 July 2004

TLD response vs dose



The response curve of a TLD material as a function of absorbed dose shows three regions:

1 a region in which the response is linear

2 a region of supralinearity, in which the sensibility increases (but the reliability decreases)

3 a saturation region (defines maximum detectable dose = 80% of saturation dose)

TLD response vs dose

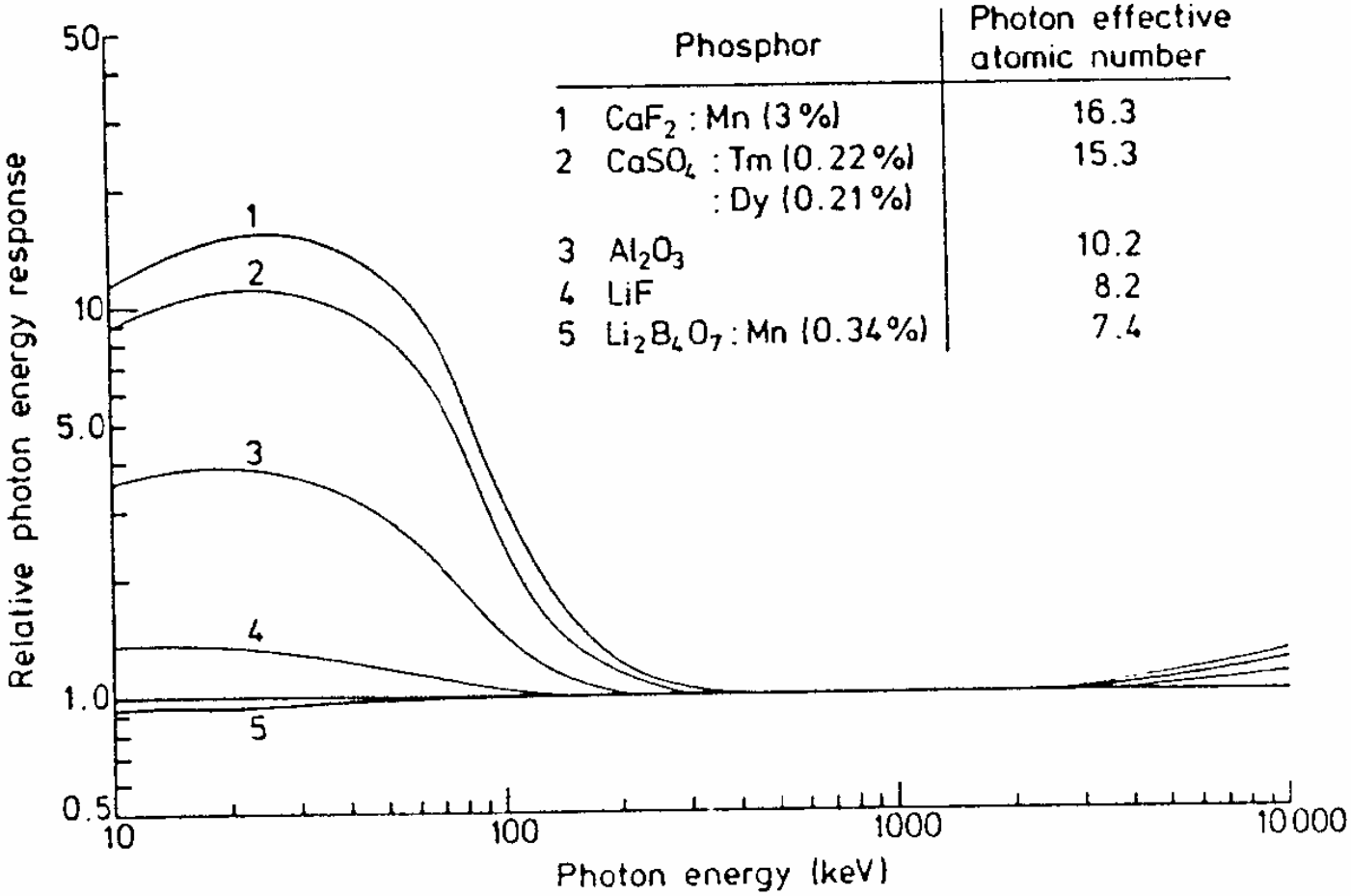
Theoretically, some types of TLDs are able to measure doses up to 100 Gy. However, with high doses there are 3 main problems:
1. "Rémanence": due to the elevated exposure not all of the traps are emptied with the first reading, and some information is lost. Moreover, to reset the TLD and assure the "reproducibility" of the results, a complete (and long) thermal treatment is needed.
2. Supralinearity: in this region the result need to be corrected with a risk of error. Moreover, the change in sensitivity remains after the reading. The material needs a complete thermal treatment.
3. Saturation: beyond a certain dose, there are no more traps to collect the information. At saturation the performance of the material is degraded and cannot be fully restored even with a complete thermal treatment.

For practical and economical reasons, TLDs are usually employed in their region of linearity.

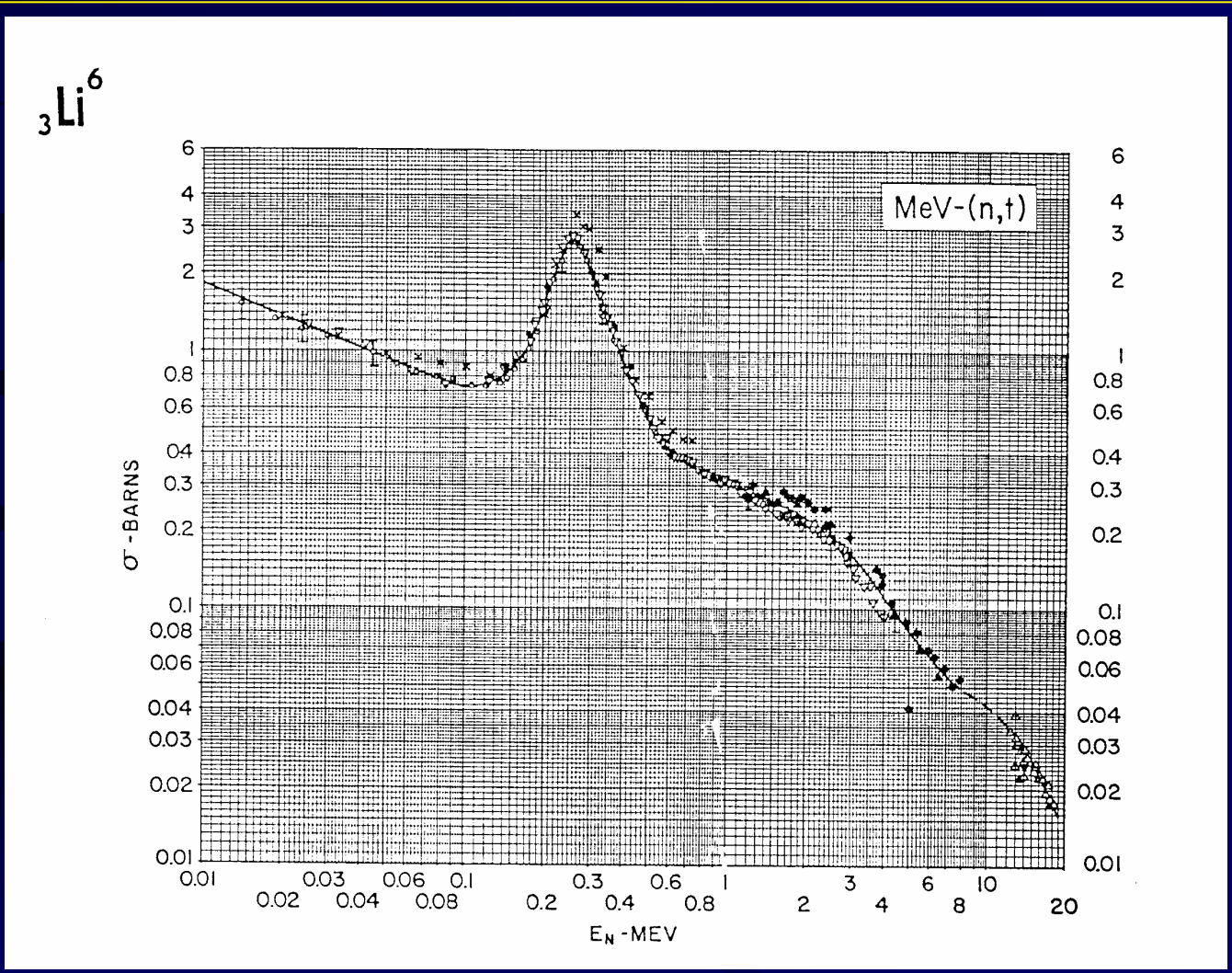
Lithium Fluoride

- Almost negligible fading at room temperature
- Low atomic number, which does not differ much from that of air or tissue → energy deposited in LiF is correlated to gamma dose
- Constant response over a wide range of photon energies
- Because natural lithium contains 7.4% Li-6, LiF dosimeters are sensitive to slow neutrons via (n,α) reaction
- The response to neutrons can be enhanced by using lithium enriched in Li-6, or suppressed by using lithium consisting entirely of Li-7

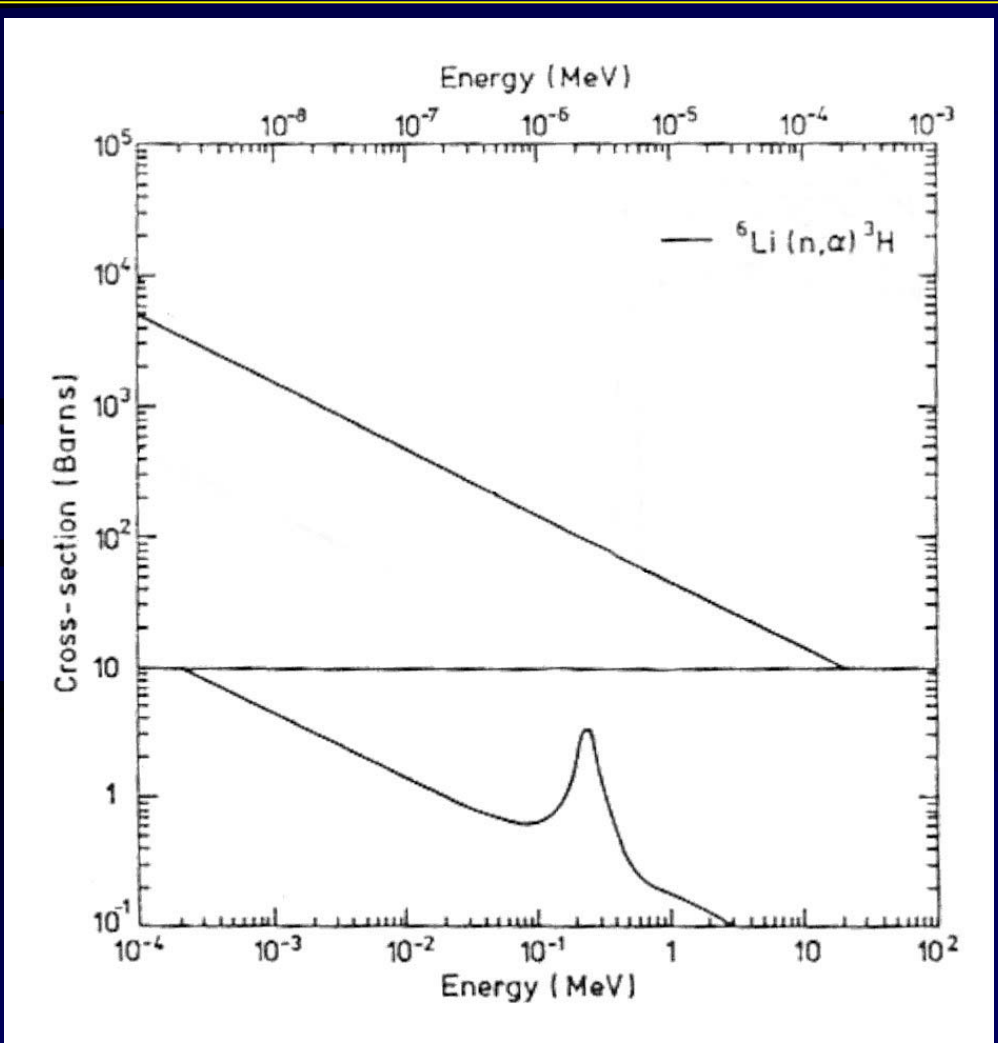
Energy response to photons



Energy response to intermediate and fast neutrons



Energy response to thermal neutrons



The main reaction of ^{6}Li TLD with neutrons is via radiative capture:

$^{6}Li(n,\alpha)^{3}H$.

The sensitivity of the TLD material to neutrons follows the cross section

^{6}Li: σ_{th} = 945 barn

^{7}Li: σ_{th} = 0.033 barn

Sensitivity as a function of particle type and energy

The sensitivity should be independent of energy for particles with a low Linear Energy Transfer (LET).

The response is well known for 'common' type of radiation like gammas, neutrons and beta particles (ambient and personal dosimetry).

We have no knowledge of the efficiency of TLDs in mixed radiation fields as those encountered around high-energy accelerators.

The TLD service of the RP group

At CERN we use Harshaw TLD 600 (95.6% Li-6) and TLD 700 (0.01% Li-6)

Size of the dosimeter:
3.1 mm x 3.1 mm x 0.9 mm
(23 mg)

Dose range: 10 µGy – 100 Gy
(in practice: 10 µGy – a few mGy)

The TLD service of the RP group

One automatic reader, ALNOR (10 µGy – 2 Gy)

One semi-automatic reader, HARSHAW, for high doses

Cross-calibration of TLDs with the environmental monitoring stations

Conclusions (1)

- The estimated number of annual TLD measurements in the LHC experimental areas (about 1800, information from the July RADMON meeting) is significant, i.e. about 20% of the present RP workload. In addition, it may be that most of the readings will have to be done in semi-automatic mode rather than automatic as for most of the routine environmental measurements.
- The required manpower and resources have to be addressed → need for one dedicated staff (part-time)
- Cost of material: about 10 CHF per dosimeter
- RP laboratory equipment: some upgrade is needed to the readers

Conclusions (2)

- To be used for high-level dosimetry, some investigation on their response to certain types of radiation (e.g., protons, muons, pions) is required
- For neutron monitoring in the environment, the TLDs are used within a polyethylene moderator, whilst in the LHC experiments it is likely they will have to be used bare → response only to thermal neutrons ?
- For the time being the RP group will maintain the TLD service