PAUL SCHERRER INSTITUT

Implications of the ICRU 95 quantities for Swiss personal dosimetry services: a status quo (#106)

L. Bossin[1], C. Bailat[2], P. Carbonez[3], J. B. Christensen[1], M. Furlan[4], F. Fürholz[5], A. Pitzschke[2], E. G. Yukihara[1]

[1] Department of Radiation Safety and Security, Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

[2] Institute of Radiation Physics (IRA), University Hospital Center and University of Lausanne (CHUV), Lausanne, Switzerland

[3] CERN, Geneva, Switzerland

[4] Dosilab AG, Köniz, Switzerland

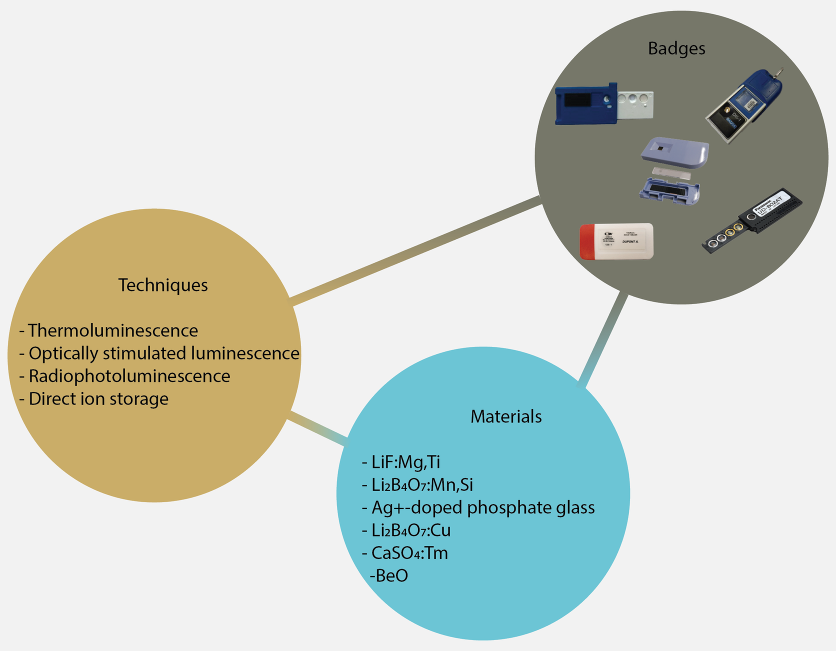
[5] Suva, Luzern, Switzerland

BACKGROUND

The ICRU Report 95 [1] introduced new quantities to be used in personal and ambient dose monitoring. The conversion coefficients to these new quantities were calculated on more realistic phantoms, thus giving a better approximation of the effective dose.

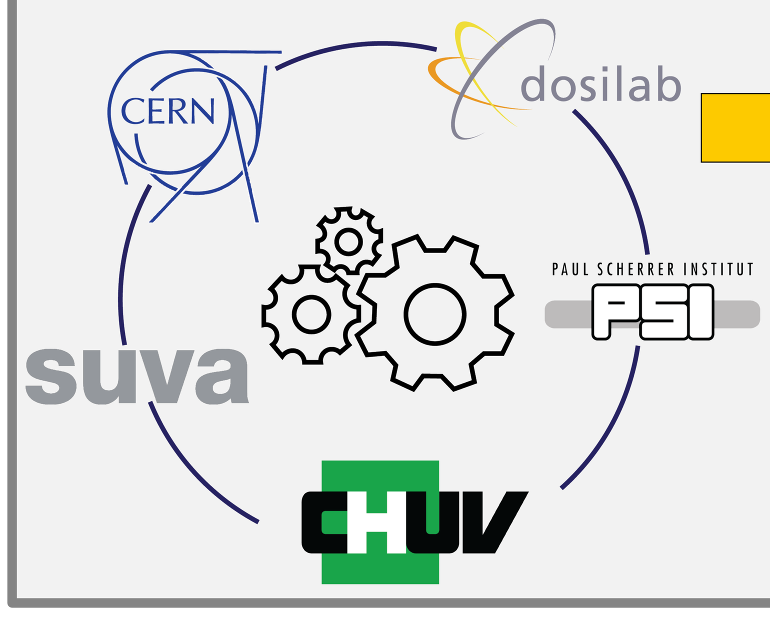
The objective of this work is to assess the photon response of the dosimetry systems used across Switzerland in terms of the operational quantities for external radiation exposure: personal dose, H_p, and personal absorbed dose in local skin, $D_{p,\text{local skin}}$, defined in the ICRU Report 95.

The systems investigated encompasses a range of techniques and materials and are, therefore, a good representation of the problems to be faced worldwide.



METHODOLOGY

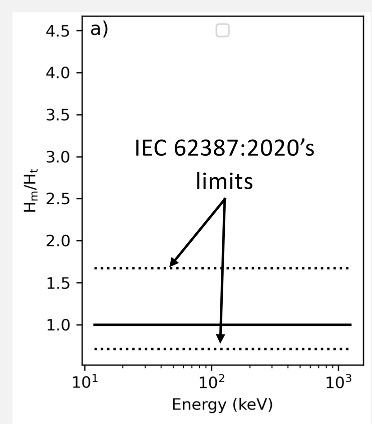
STEP 1: Gather energy and angle response data for $H_p(10)$ and $H_p(0.07)$ from the Swiss personal dosimetry services (CERN, Dosilab, CHUV, PSI, SUVA).



STEP 2: Calculate angle and energy response to H_p and $D_{p,\text{local skin}}$ using conversion coefficients.

$$R_{\text{new}} = R_{\text{old}} \cdot \frac{h_{\text{old}}}{h_{\text{new}}}$$

STEP 3: Assess performances against limits set for $H_p(10)$ and $H_p(0.07)$ in the IEC 62387:2020 [2].



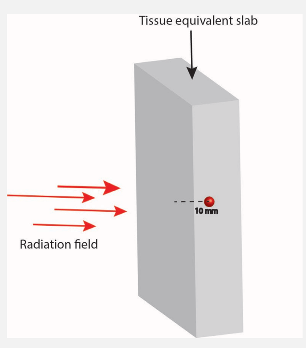
RESULTS: STATUS QUO

Redefinition

Whole-body monitoring

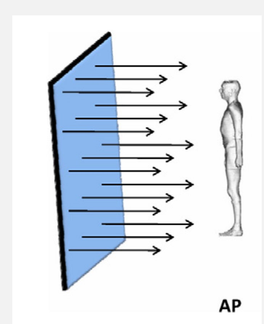
$H_p(10) \rightarrow H_p$

ICRU Report 51 = $H_p(10)$
Personal dose equivalent [Sv]



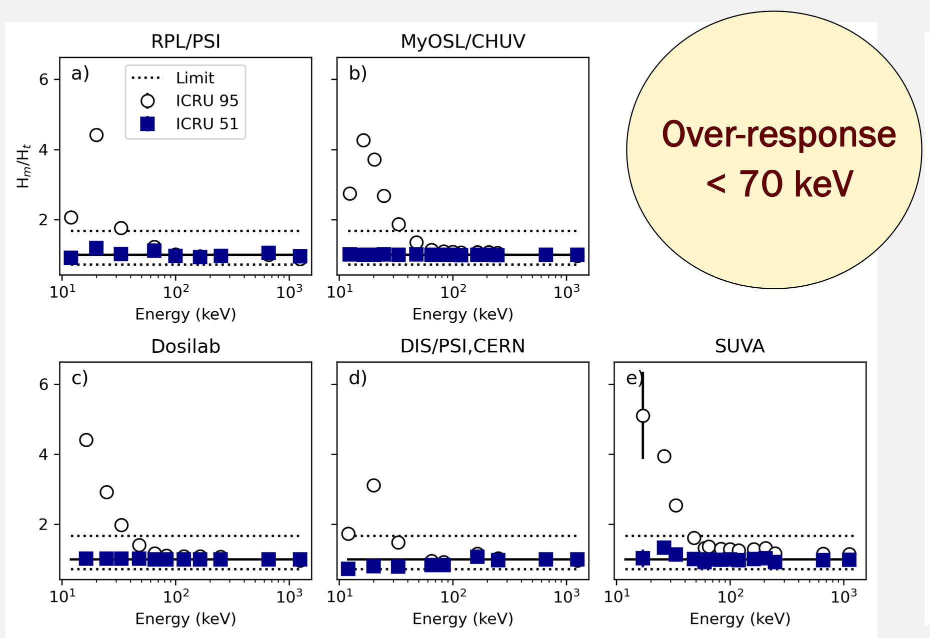
$H_p(10) = Q \times D(d = 10\text{ mm})$

ICRU Report 95 = H_p
Personal dose [Sv]

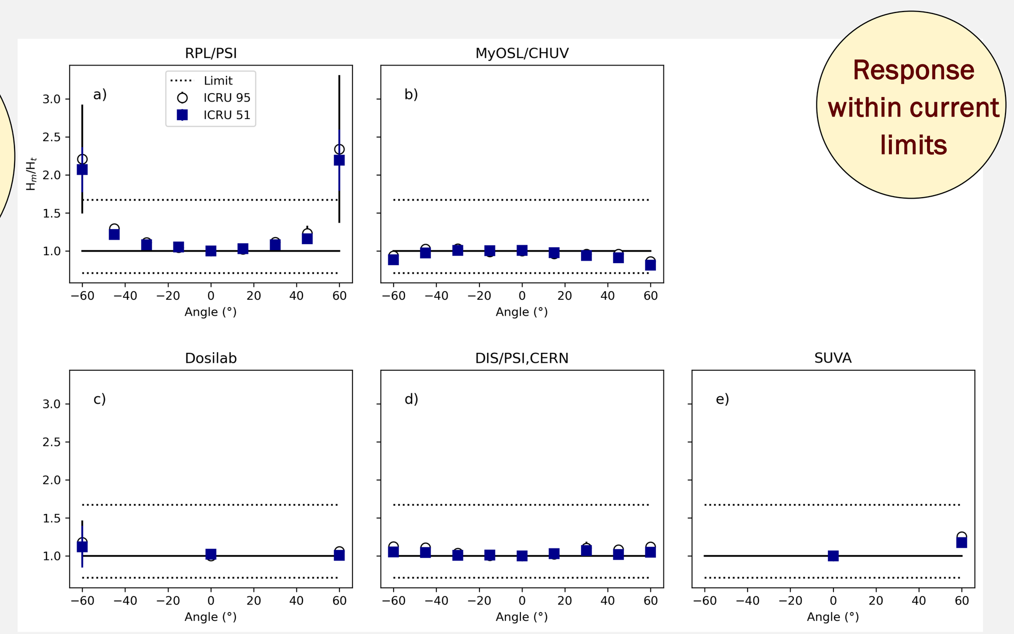


$H_p = \Phi\, h_\varphi\,, \quad h_E = \frac{E}{\Phi}$

Energy response



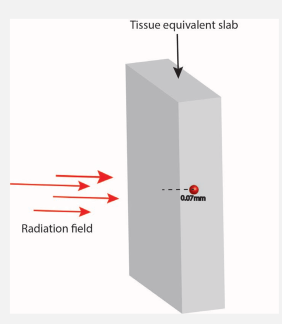
Angle response (33 keV)



Skin monitoring

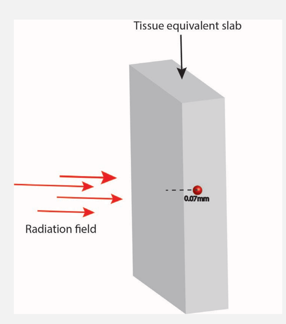
$H_p(0.07) \rightarrow D_{p,\text{ local skin}}$

ICRU Report 51 = $H_p(0.07)$
Personal dose equivalent [Sv]

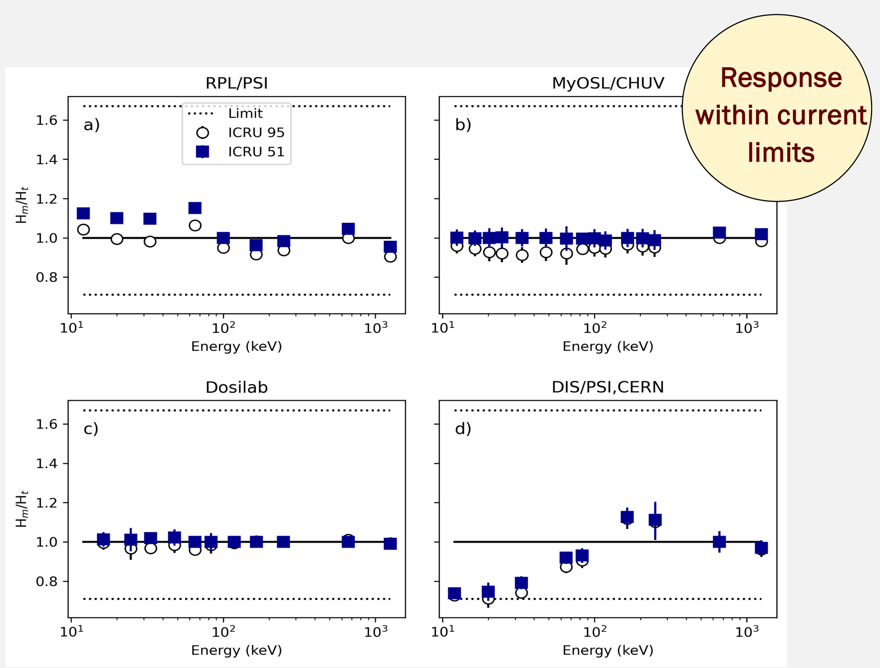


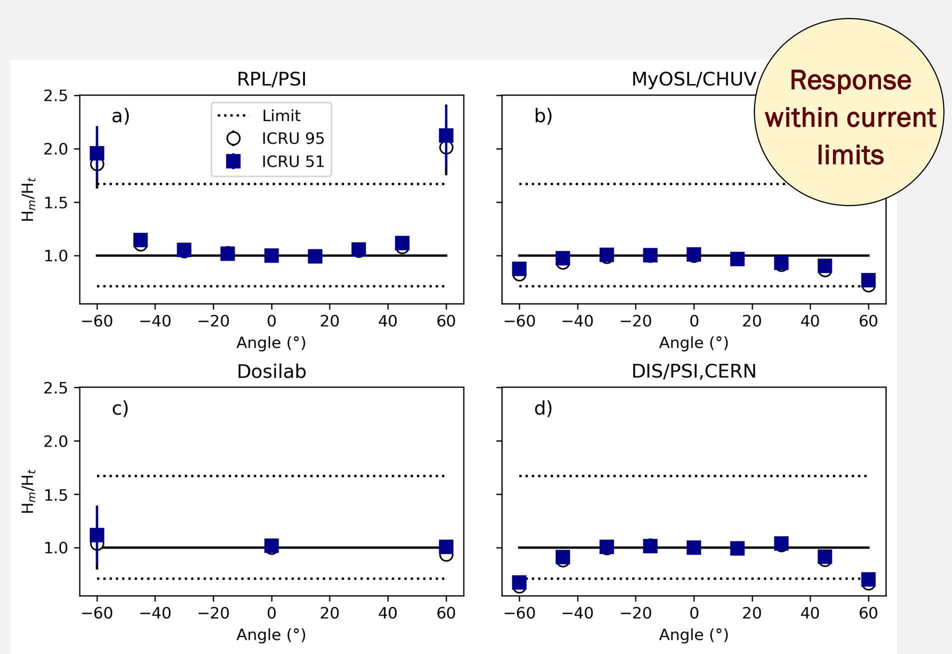
$H_p(0.07) = Q \times D(d = 0.07\text{ mm})$

ICRU Report 95 = $D_{p\text{ local skin}}$
Personal absorbed dose in local skin [Gy]



$D_{p\text{ local skin}} = D(d = 0.07\text{ mm})$





a) Radiophotoluminescence dosimeters used at the Paul Scherrer Institute. Ag+-doped phosphate RPL glass detectors of type FD-7 (AGC TECHNO GLASS CO., LTD.,96 Shizuoka, Japan), dosimeter badges of the type GBFJ-01, reader FDG-660, and dose calculation software CDEC-Easy (CHIYODA TECHNOL CORP., Tokyo, Japan).

b) OSL dosimeters used at the CHUV. BeO OSL detectors (MyOSL 4.0, RadPro International).

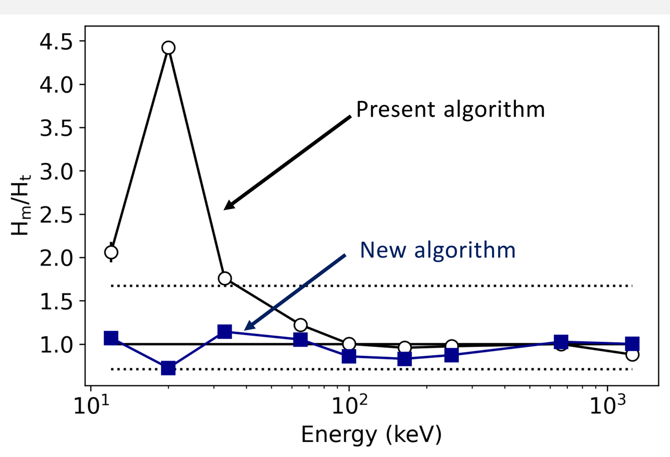
c) Thermoluminescence dosimeters used at Dosilab. $CaSO_4$:Tm and $Li_2B_4O_7$:Cu (Panasonic TLD System), dosimeter badges UD-802 and UD-807 (Panasonic, Japan).

d) Direct ion storage dosimeters used at the CERN and Paul Scherrer Institute. DIS-1, Mirion.

e) Thermoluminescence dosimeters used by the SUVA. $Li_2B_4O_7$:Mn,Si TL detectors (Firma Rados, FIN-20101 Turku).

SOLUTIONS

To reduce H_p's over-response < 70 keV



Photon energy response in terms of Personal dose, H_p, of the RPL detectors used at PSI, under the present dose calculation algorithm, and using a dose calculation algorithm specifically designed for the ICRU 95 quantity H_p [3].

1. Change to the dose calculation algorithm, for dosimeters with multiple filters available. Use of an algorithm with spectral capabilities, capable of estimating the mean energy of the incident particle, coupled with conversion factors for H_p.

2. Changes to the filter combination [4].

CONCLUSION AND OUTLOOK

Conclusion: All personal dosimetry systems used across Switzerland, designed to estimate $H_p(10)$, will show an over-response at photon energies < 70 keV for H_p, if no changes are implemented. This is a result of the re-definition of the quantity H_p. The angle response at 33 keV photon energy of H_p, and $D_{p,\text{ local skin}}$ are similar to that of $H_p(10)$ and $H_p(0.07)$, respectively. The energy response of $D_{p,\text{ local skin}}$ differs little from $H_p(0.07)$'s energy response.

Outlook: An affordable improvement to the H_p over-response would consist in a change of the dose calculation algorithm. However, this relies on a number of filters with differing energy response being present within the badge. Any physical modification to the dosimeters would have to be fully evaluated.

These results will be communicated to stakeholders within Switzerland, to support the dialog in designing the legislative framework for dosimetry for the ICRU Report 95 quantities (e.g., requirements for the accreditation of dosimetry services).

REFERENCES

[1] ICRU, 2020. ICRU Report 95. Operational Quantities for External Radiation Exposure. ICRU.

[2] IEC, 2020. International Standard IEC 62387:2020. Radiation Protection Instrumentation - Passive Integrating Dosimetry Systems for Personal and Environmental Monitoring of Photon and Beta Radiation. International Electrotechnical Commission.

[3] Bossin, Lily, et al. "Performance of radiophotoluminescence personal dosimeters in terms of the ICRU Report 95's operational quantities." *Radiation Measurements* 156 (2022).

[4] Eakins, J. S., and R. J. Tanner. "The effects of revised operational dose quantities on the response characteristics of a beta/gamma personal dosemeter." *Journal of Radiological Protection* 39.2 (2019): 399.