Dose conversion coefficients for photon exposure of the human eye lens

*Rolf Behrens*
Contents

- Introduction
- Geometry
- Results
- W/o Kerma approximation (KA): pros and cons
Operational quantities: $H(d)$

- Calculated in hypothetical phantoms
  - realistic dose in a person
- Can be measured
- Dose limits are supervised

Protection quantities: Organ dose $H_T$

- Calculated in human phantoms
  - realistic dose in a person
- Cannot be measured
- Dose limits are fixed

Limits are only kept in case

\[ \{ H_T / \Phi \}, \text{ e.g. } \{ H_{\text{eye}} / \Phi \} < \{ H_p(d) / \Phi \}, \{ H'(d) / \Phi \}, \{ H^*(10) / \Phi \} \]

- e.g. $\{ H_p(3) / \Phi \}$

⇒ Reliable values for $\{ H_T / \Phi \}$ are required
Introduction

• ICRP74 (=ICRU57) is under revision

• New values for electrons are available:
  and Corrigendum:

➔ ICRP asked for corresponding values for photons
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Geometry: Eye

Mathematical model

→ small volumes can be modelled

→ no problems with finite voxel size

Further details:
PMB 54 (2009) 4069-4087
and Corrigendum:
PMB 55 (2010) 3937-3945

Radiation sensitive part of the lens
Geometry: Body
(scattering and absorption)

- **Shape:** ADAM and EVA phantoms as used in ICRP74 and ICRU57
- **Size:** Mean value of ADAM and EVA phantoms
- **Cone for every eye socket cut out of head to represent the nose**
Geometry: Body (scat. + absorp.)

- Parallel beam; Vacuum; Monoenergetic photons: 5 keV - 10 MeV
- Secondary electrons are transported (w/o kerma approximation) (as usual for revision of ICRP74) ➔ Boundary effects realistic
- Monte Carlo transport simulation: EGSnrc using EGSpp
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Results (mean value of both eyes)

- Less absorption at front part of lens
- Less dose build-up at front part of lens

Conversion coefficients for the eye lens
Dr. Rolf Behrens  Physikalisch-Technische Bundesanstalt
Results (mean value of both eyes)

- Absorption in the head

Conversion coefficients for the eye lens
Dr. Rolf Behrens     Physikalisch-Technische Bundesanstalt
Results

- Absorption in the head: Stronger for the eye opposite the radiation source
Results (mean value of both eyes)

• All angles: Similar to values of ICRP 74, except above 1 MeV (kerma approxim.)
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W/o KA: pros and cons

- **Pro:** Doses at interfaces inside the body are correct.
- **Con:** Doses near the surface of the body may be too small, because:
  - Material between the source and the person may produce secondary electrons, e.g. glasses in front of the eyes.
  - The calculated eye lens dose may be too small!
  - An operational quantity may seem to be conservative although it is not!
W/o KA: pros and cons

- Results with kerma approximation lead to similar values as in ICRP74
## W/o KA: pros and cons

### Recommendation to assess realistic dose values from fluence spectra

<table>
<thead>
<tr>
<th>Contribution of secondary electrons produced outside the body</th>
<th>Approximate method A</th>
<th>Approximate method B</th>
<th>Accurate method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values recommended for use</td>
<td>negligible</td>
<td>significant</td>
<td>arbitrary</td>
</tr>
<tr>
<td>For photons: Values of this work</td>
<td></td>
<td></td>
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<tr>
<td>For $E_{ph} &lt; 1$ MeV: Values of this work</td>
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<tr>
<td>For $E_{ph} &gt; 1$ MeV: Values of ICRP 74</td>
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<tr>
<td>Add up both contributions</td>
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</tbody>
</table>

For photons: Values of this work

For electrons: Values of this eye model (Behrens et al. 2009 and Corrigendum)
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Questions?