Dose conversion coefficients for photon exposure of the human eye lens

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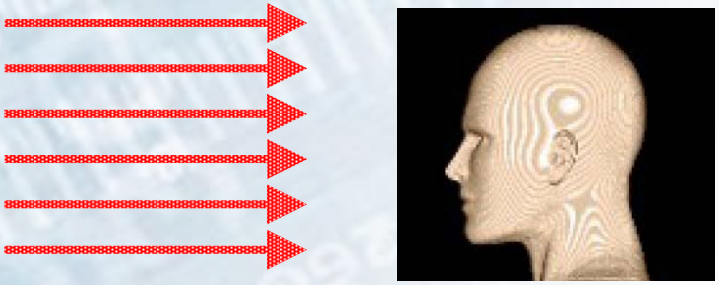
- **Introduction**
- **Geometry**
- **Results**
- **W/o Kerma approximation (KA): pros and cons**

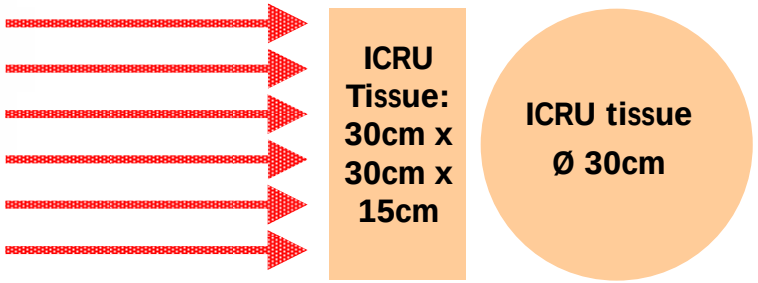
Introduction

Protection quantities: Organ dose H_T



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

Operational quantities: $H(d)$



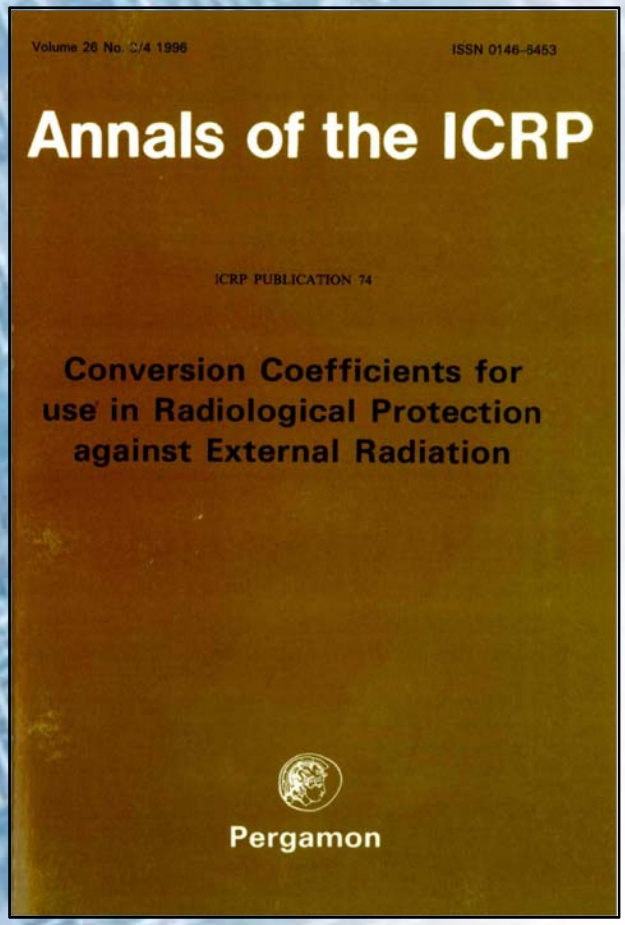
- **Calculated in hypothetical phantoms**
  ➔ estimate of dose in a person
- **Can be measured**
- **Dose limits are supervised**

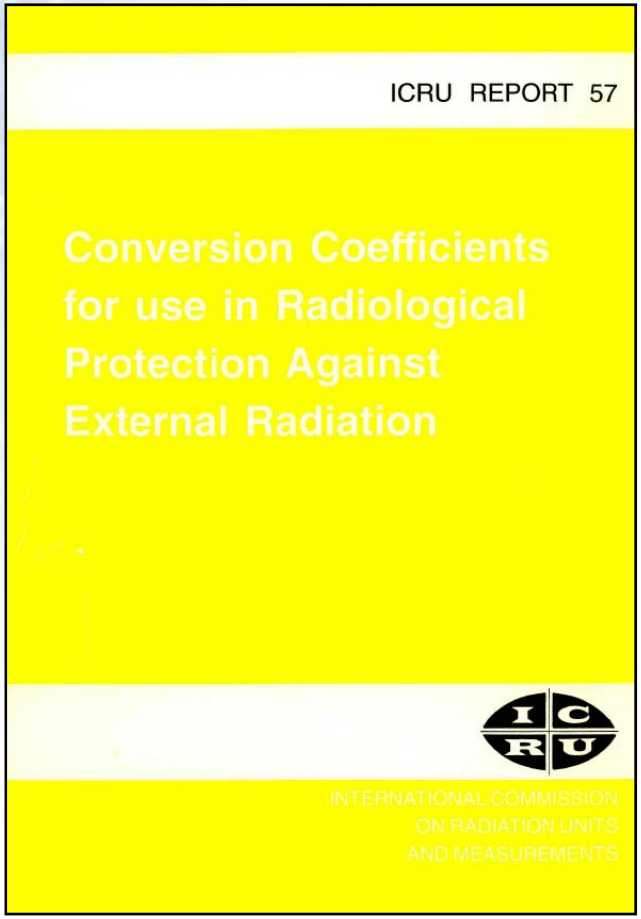
Limits are only kept in case

$\{H_T / \Phi\}$, e.g. $\{H_{eye} / \Phi\}$ **<** $\{H_p(d) / \Phi\}$, $\{H'(d) / \Phi\}$, $\{H^*(10) / \Phi\}$
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:** *Phys. Med. Biol. 54 (2009) 4069-4087 and Corrigendum: Phys. Med. Biol. 55 (2010) 3937-3945*

➔**ICRP asked for corres-ponding values for photons**

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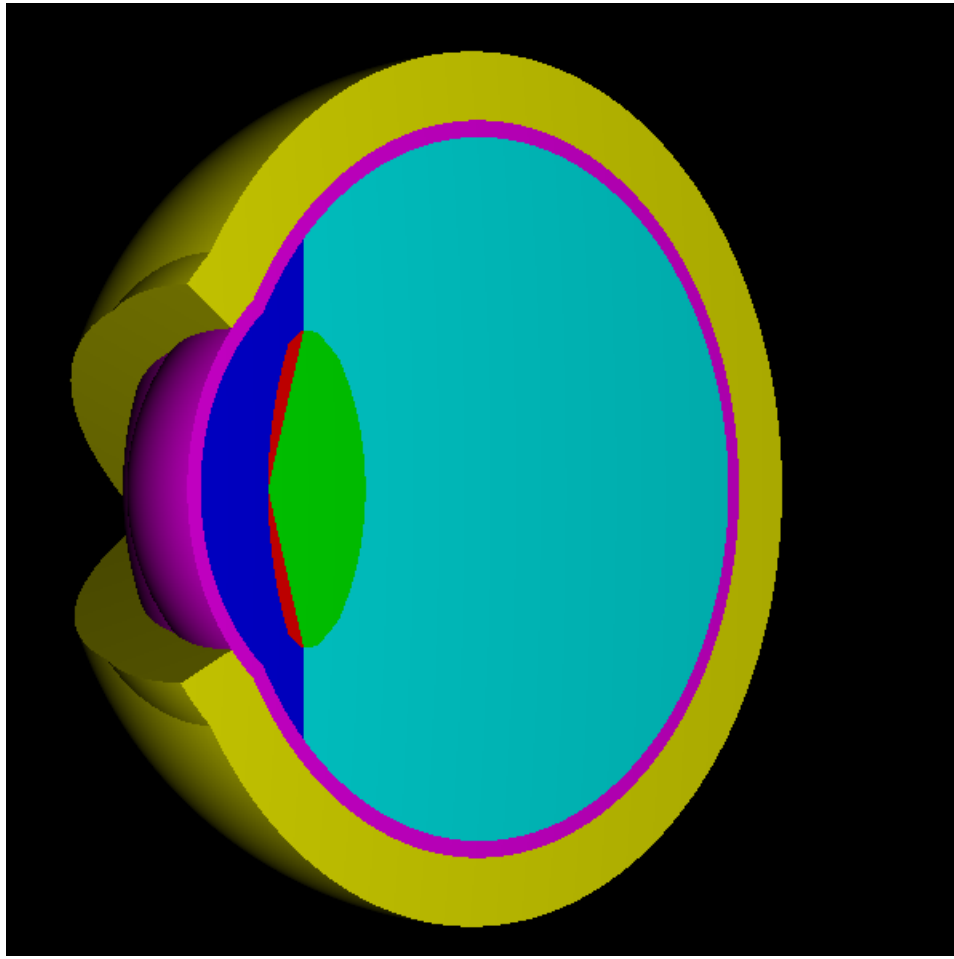
Geometry: Eye

Mathematical model

➔ small volumes can be modelled

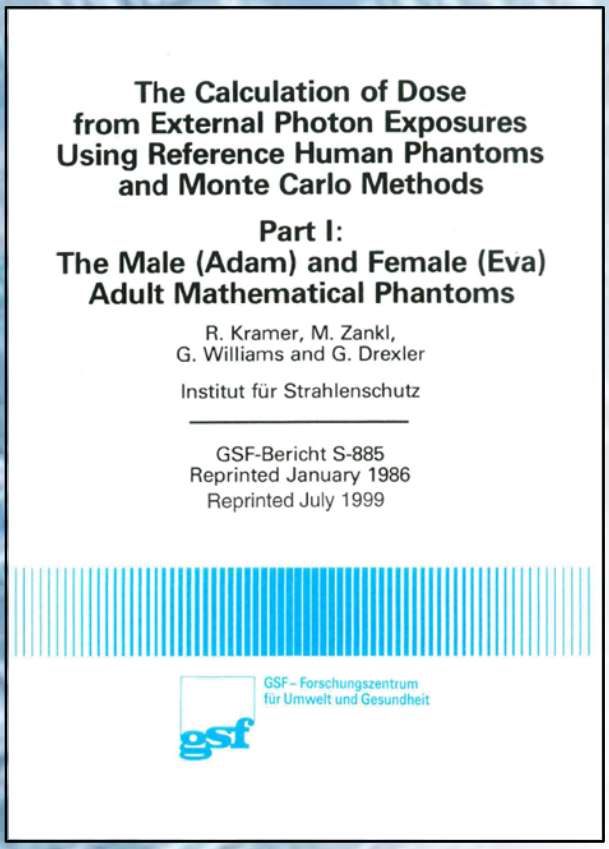
➔ no problems with finite voxel size

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)


The Calculation of Dose
from External Photon Exposures
Using Reference Human Phantoms
and Monte Carlo Methods

Part I:
The Male (Adam) and Female (Eva)
Adult Mathematical Phantoms

R. Kramer, M. Zankl,
G. Williams and G. Drexler

Institut für Strahlenschutz

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GSF – Forschungszentrum
für Umwelt und Gesundheit

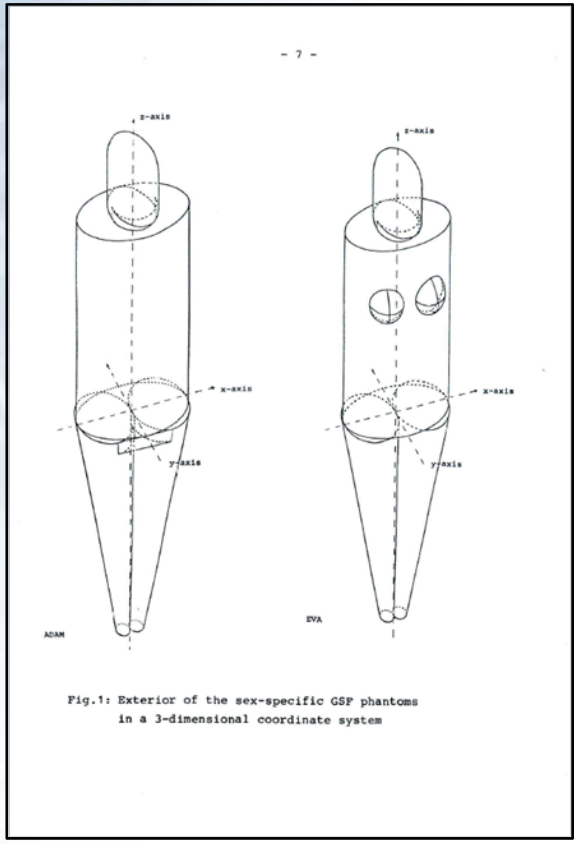
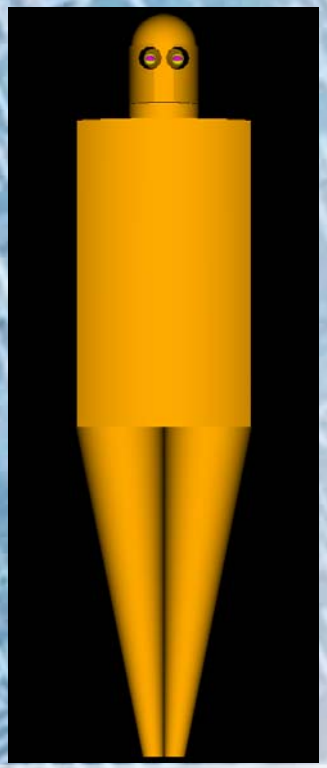
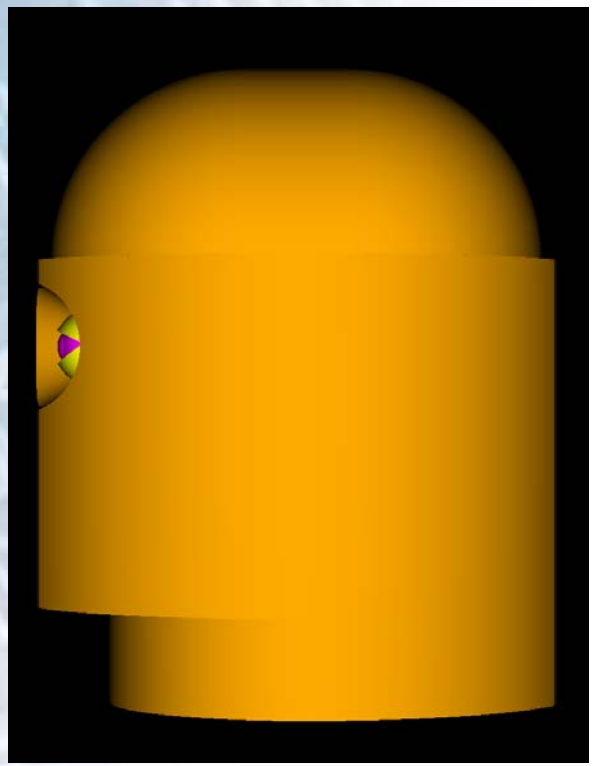


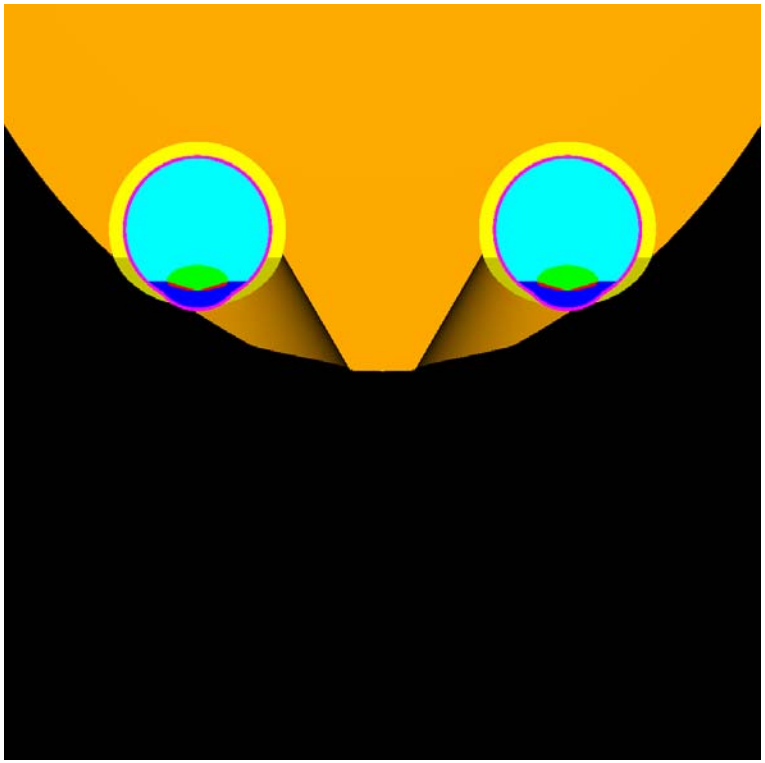
Fig.1: Exterior of the sex-specific GSF phantoms in a 3-dimensional coordinate system

- **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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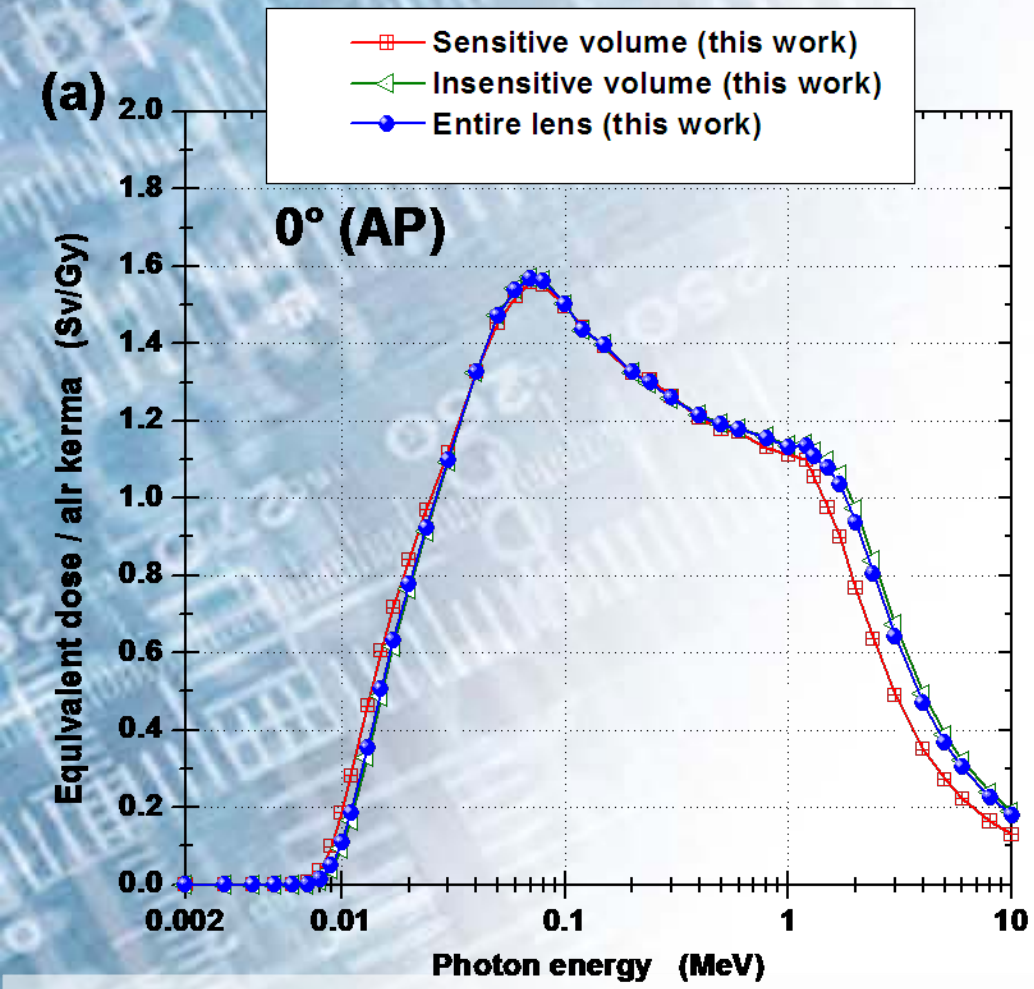
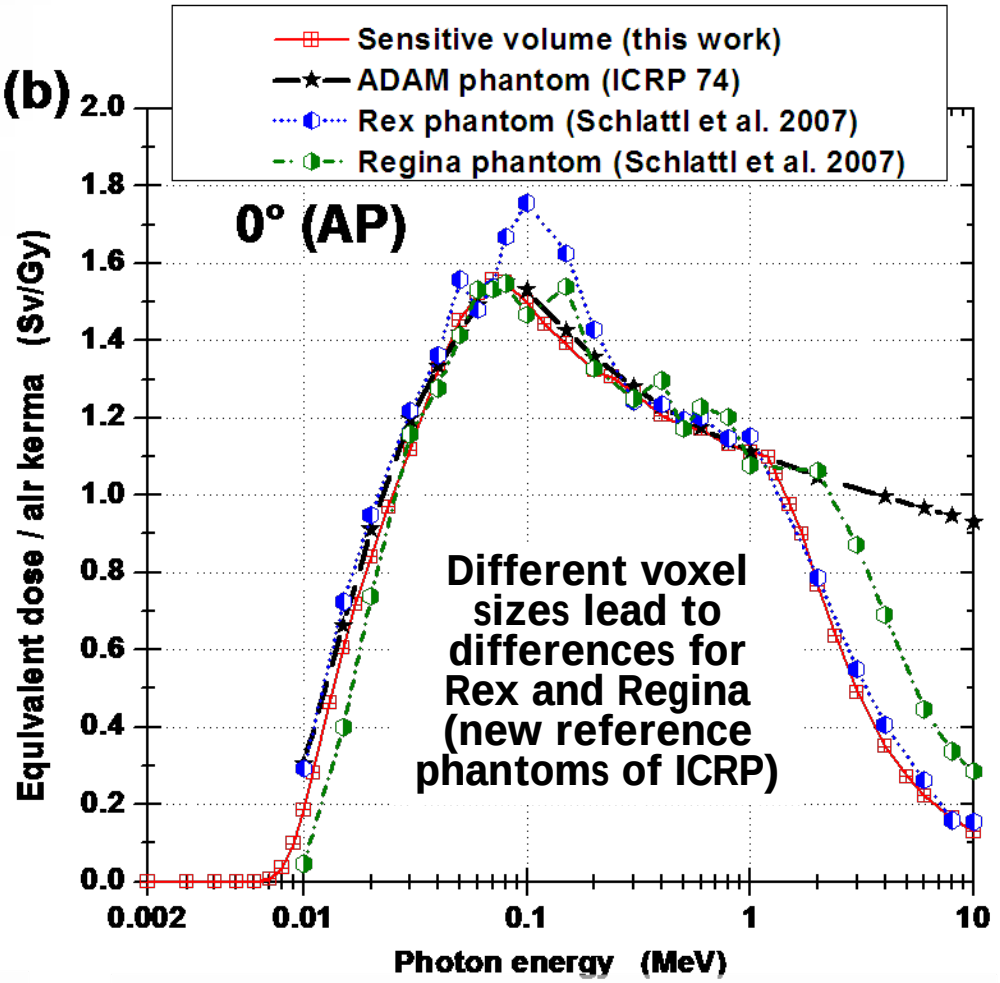
Results (mean value of both eyes)

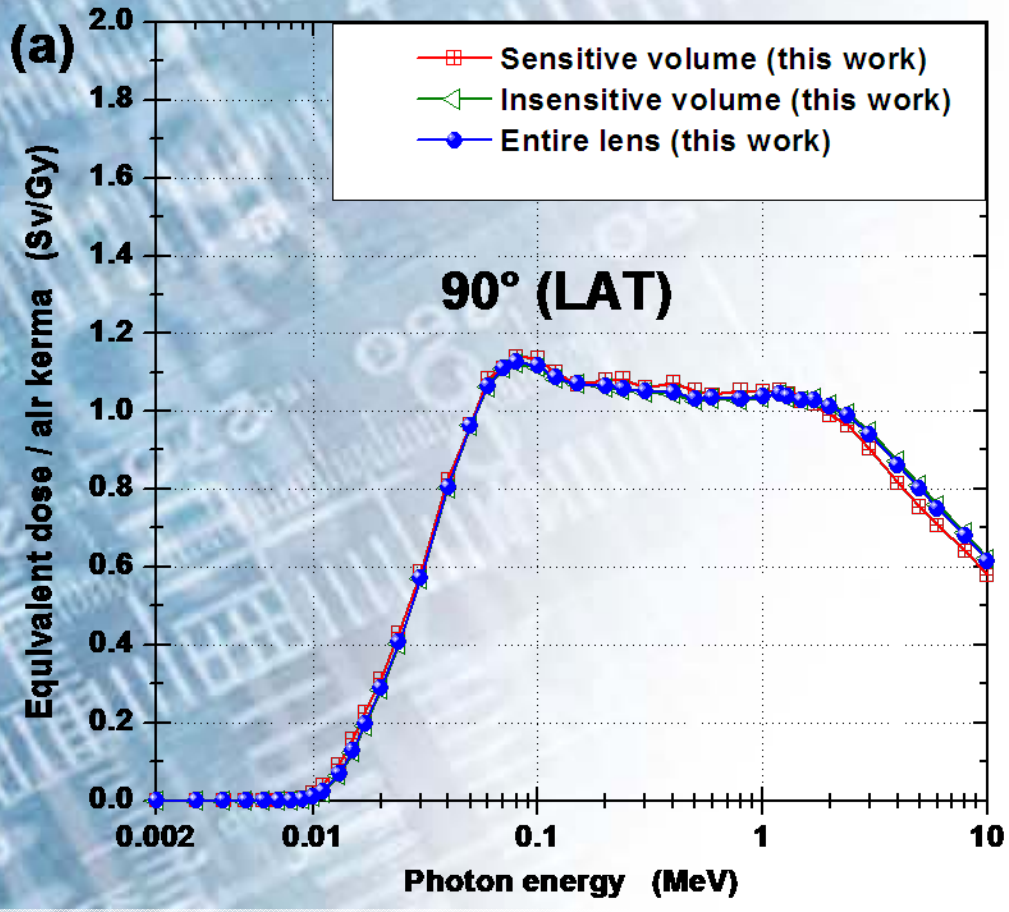


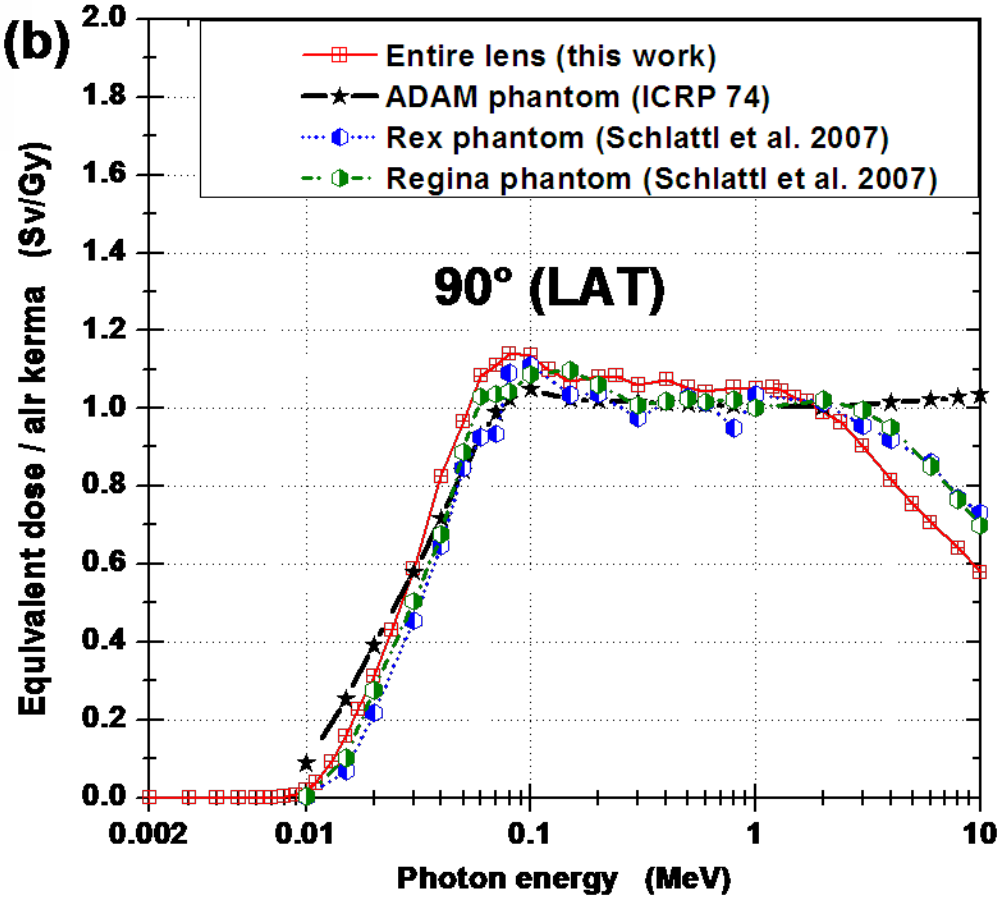


- **Less absorption at front part of lens**
- **Less dose build-up at front part of lens**

- **Dose build-up not calculated in ICRP74 (kerma approximation)**

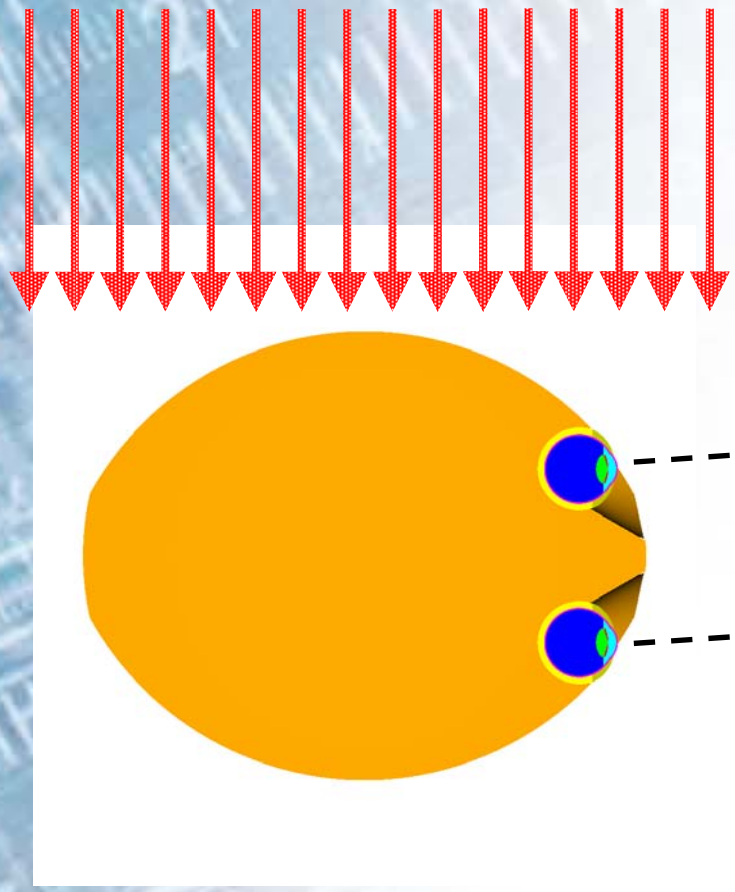
Results (mean value of both eyes)

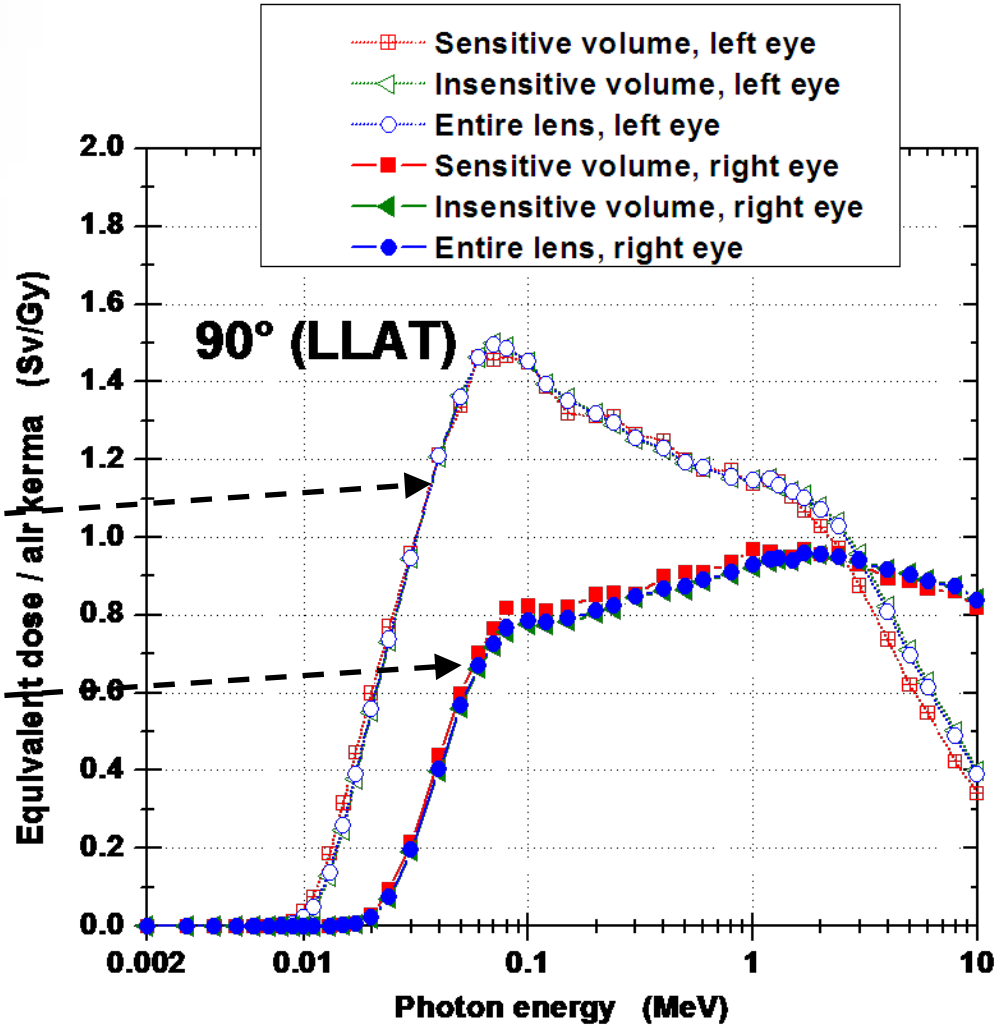




- **Absorption in the head**

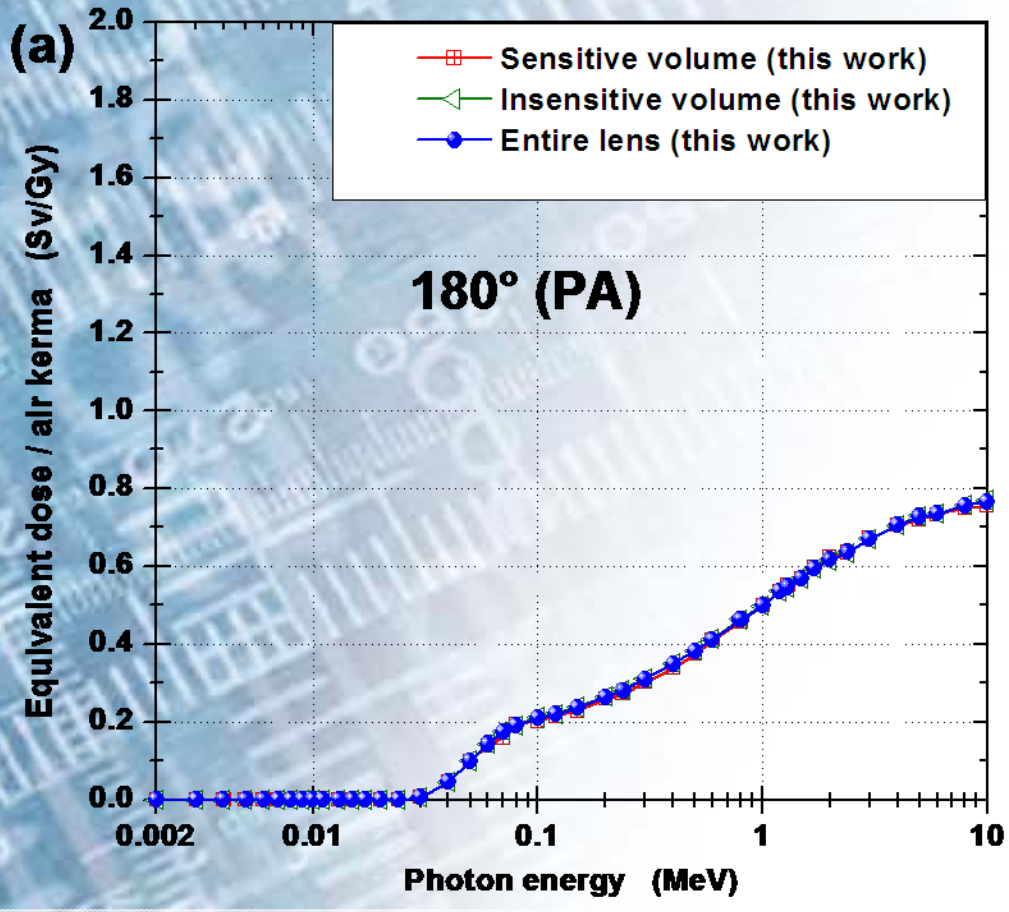
Results

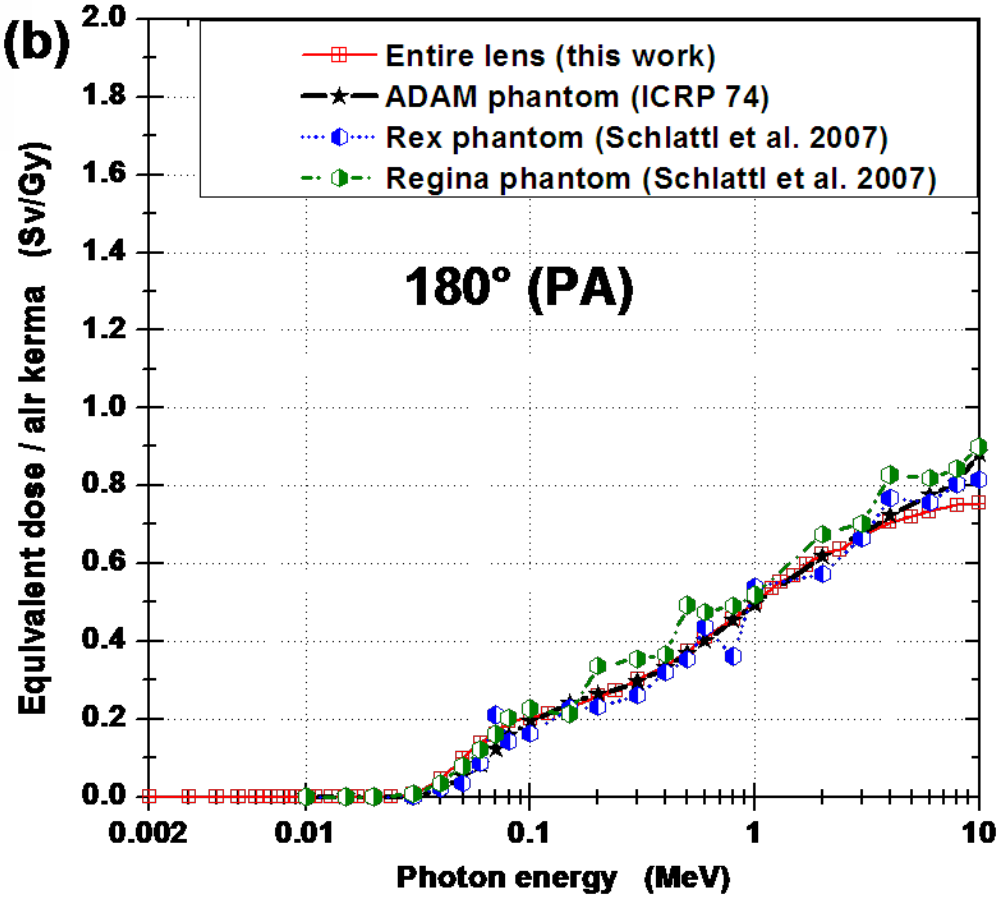




- **Absorption in the head: Stronger for the eye opposite the radiation source**

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

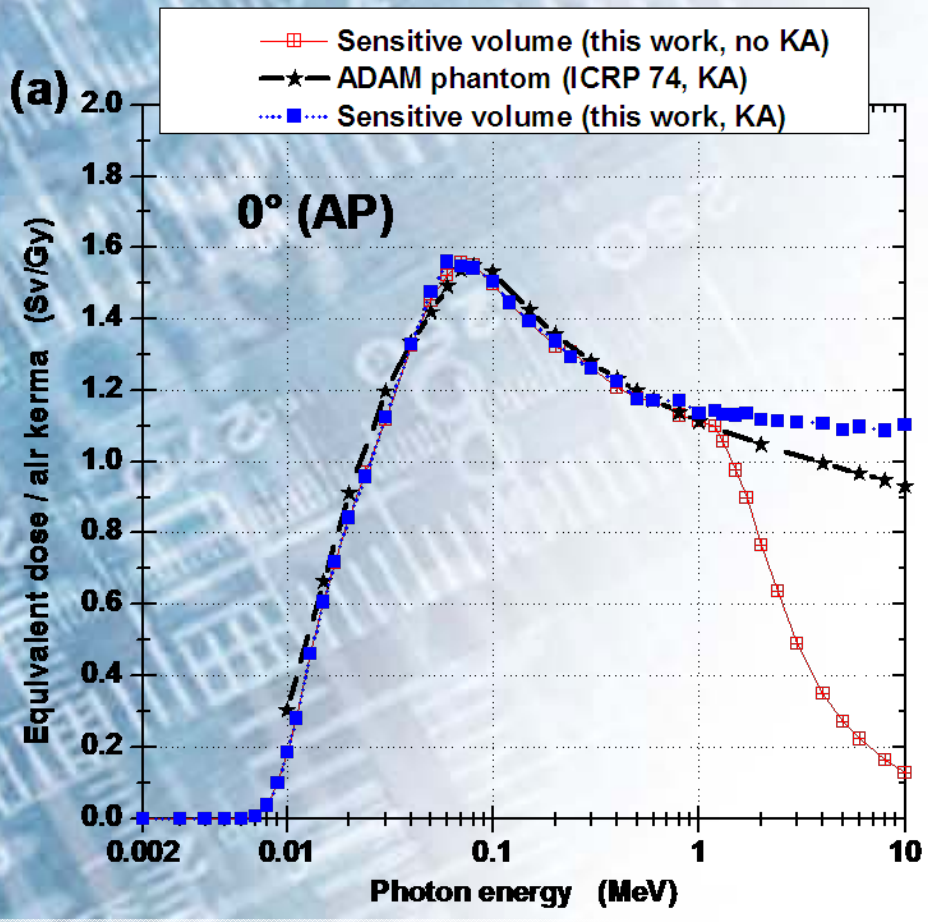
- **Pro:** **Doses at interfaces inside the body are correct.**
- **Con:** **Doses near the surface of the body may be too small, because:**

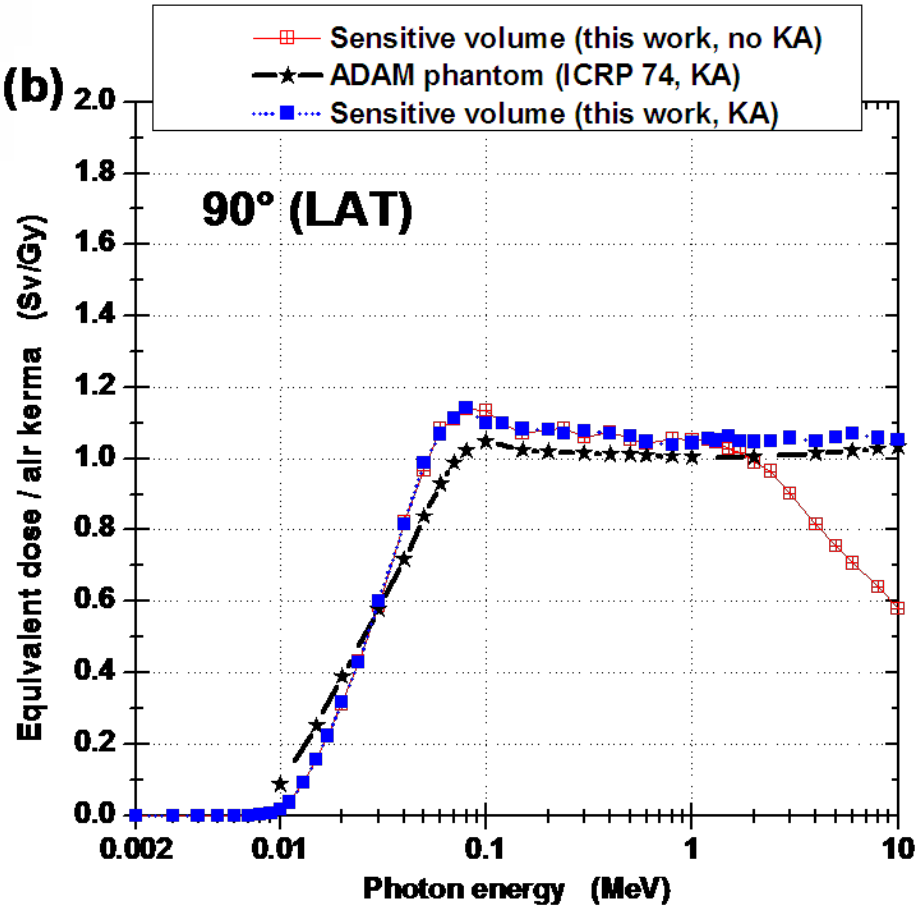
  Material between the source and the person may produce secondary electrons, e.g. glasses in front of the eyes.

  ➔ 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



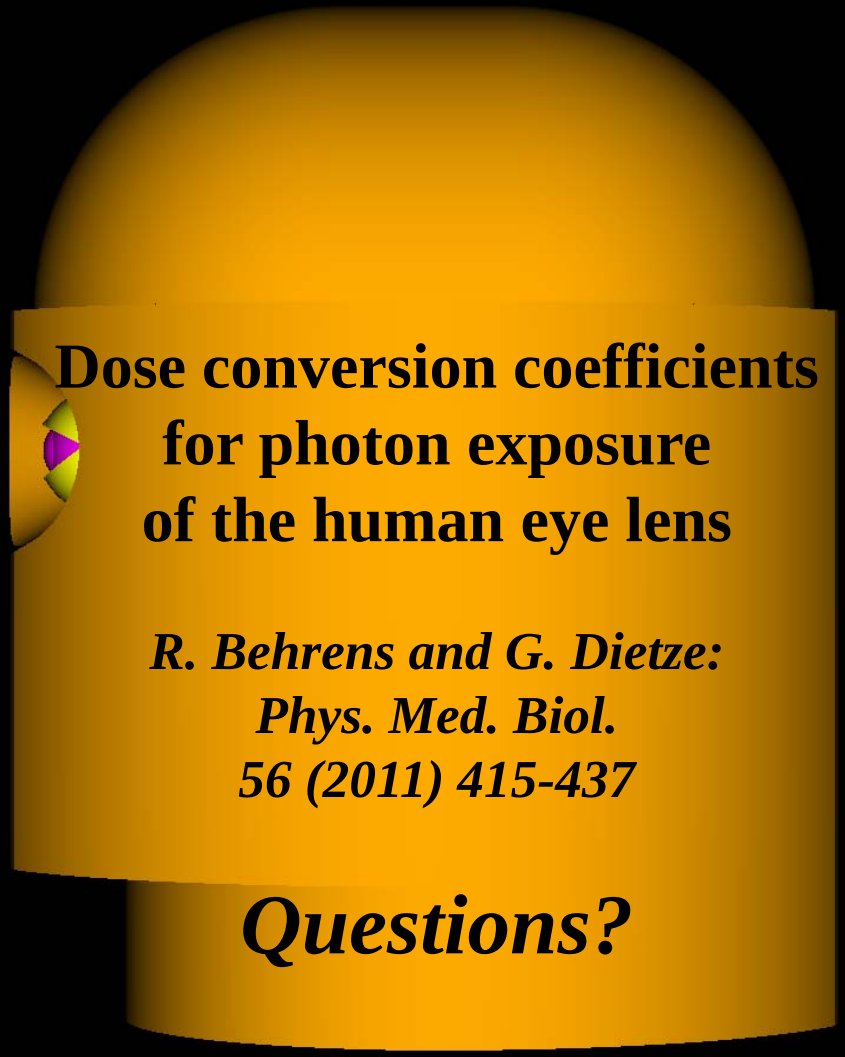


- **Results with kerma approximation lead to similar values as in ICRP74**

W/o KA: pros and cons

Recommendation to assess realistic dose values from fluence spectra

	Approximate method A	*Approximate method B*	*Accurate method*
Contribution of secondary electrons produced outside the body	**negligible**	**significant**	**arbitrary**
Values recommended for use	**For photons: Values of this work**	**For E_{ph} < 1 MeV: Values of this work** **For E_{ph} > 1 MeV: Values of ICRP 74**	**For photons: Values of this work** **For electrons: Values of this eye model (Behrens et al. 2009 and Corrigendum)** **Add up both contributions**



Dose conversion coefficients for photon exposure of the human eye lens

R. Behrens and G. Dietze:
Phys. Med. Biol.
56 (2011) 415-437

Questions?