# Staff shielding of the eye lens and brain

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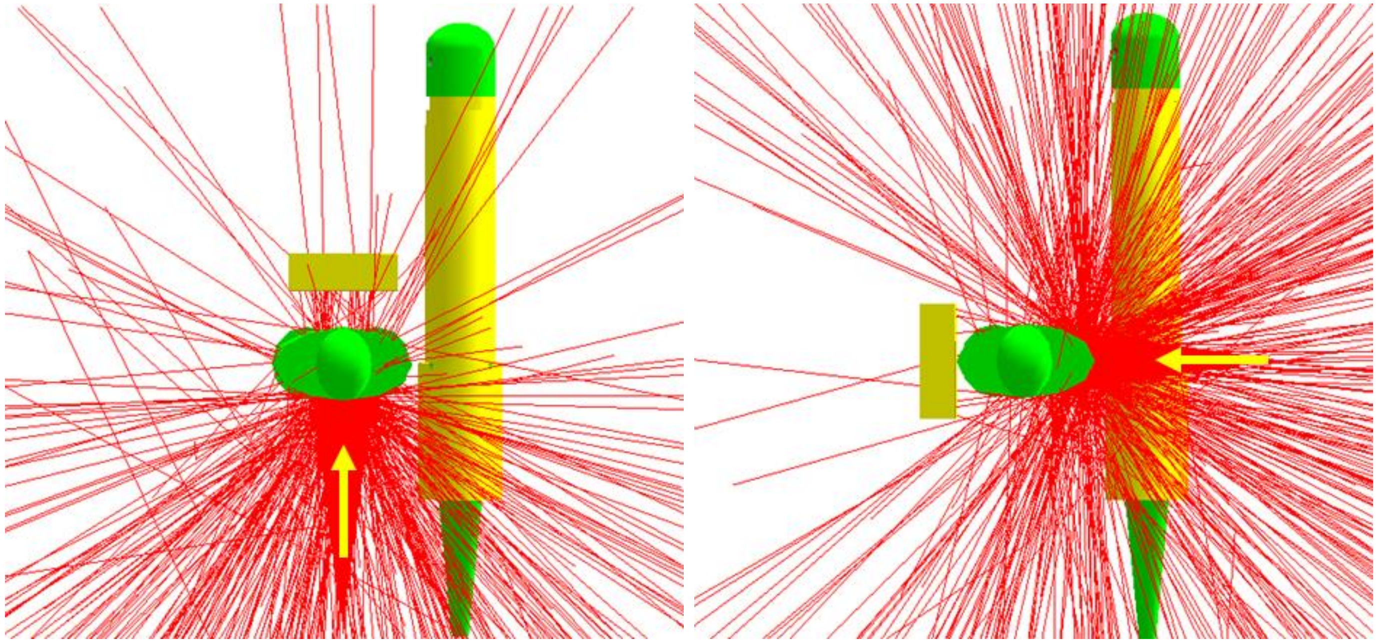
# Introduction



*Monte Carlo simulation of an interventional cardiology procedure. Red lines are particle tracks*

- Staff: radiation scattered by the patient
- Heterogeneous radiation field
- Head: mostly unshielded

- Eye lens: high radiosensitivity => cataracts
- Brain: still controversial; solid cancer risk? vascular risk?

# Introduction

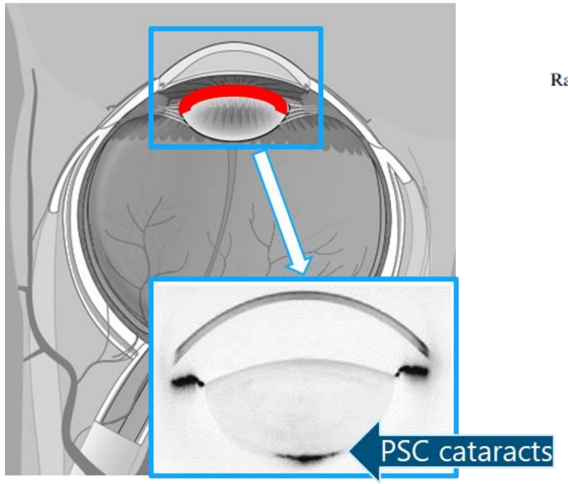



Table 1. Mean measured $H_p(3)$ per procedure ±1 s.d., number of procedures per year and estimated annual dose for physicians.

Radiation Protection Dosimetry (2015), Vol. 165, No. 1–4, pp. 289–293
doi:10.1093/rpd/ncv051

| | $<H_p(3)/\text{proc}>$ ±1 s.d. in µSv | No. proc $y^{-1}$ | $H_p(3)\ y^{-1}$ in mSv |
|---|---|---|---|
| Phys. 1 | 164 ± 129 | 369 | 61 ← |
| Phys. 2 | 42 ± 39 | 303 | 13 |
| Phys. 3 | 218 ± 163 | 149 | 32 ← |
| Phys. 4 | 62 ± 45 | 253 | 16 |
| Phys. 5 | 45 ± 42 | 182 | 8 |
| Phys. 6 | 49 ± 46 | 253 | 12 |
| Phys. 7 | 65 ± 53 | 325 | 21 ← |
| Phys. 8 | 251 ± 187 | 77 | 19 ← |
| Phys. 9 | 130 ± 102 | 385 | 50 ← |

*Dose limit: 20 mSv/year*

- Staff: radiation scattered by the patient
- Heterogeneous radiation field
- Head: mostly unshielded

- Eye lens: high radiosensitivity => cataracts
- Brain: still controversial; solid cancer risk? vascular risk?

## Is brain cancer an occupational disease of cardiologists?

Finkelstein MM[1]

The Canadian Journal of Cardiology, 01 Nov 1998, 14(11):1385-1388
PMID: 9854520

**Objective**

To assess the plausibility of radiation as a cause of the statistically unusual event of two cardiologists in Toronto, Ontario who were diagnosed with brain tumours in 1997.

**Conclusions**

Initiation of brain tumours during cardiac fluoroscopic procedures is plausible. Physicians are reminded to practise radiation safety methods during fluoroscopic procedures. The diagnosis of two additional brain tumours in Canadian interventional cardiologists during the past 10 years would confirm the occupational causation theory. The author invites physicians to report knowledge of the diagnosis of brain tumours in Canadian cardiologists to the author or to the editors.

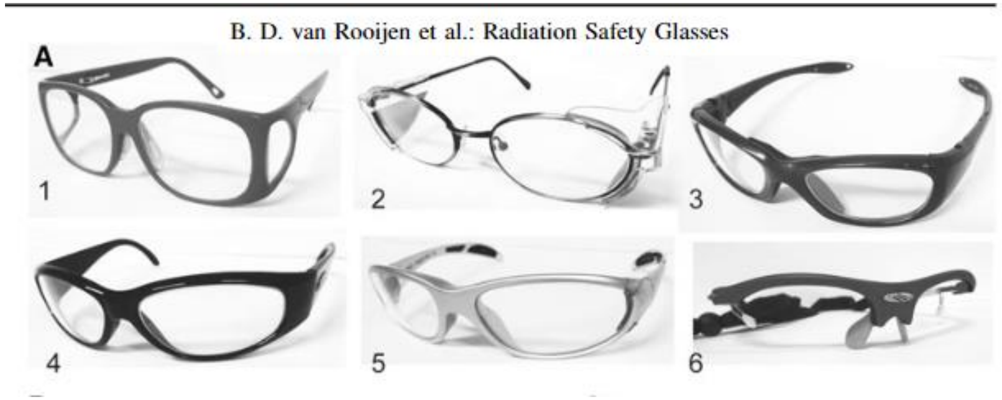
Data suggest that the vasculature in the brain *may* show damage at doses as low as 150 mSv (or 150,000 µSv).

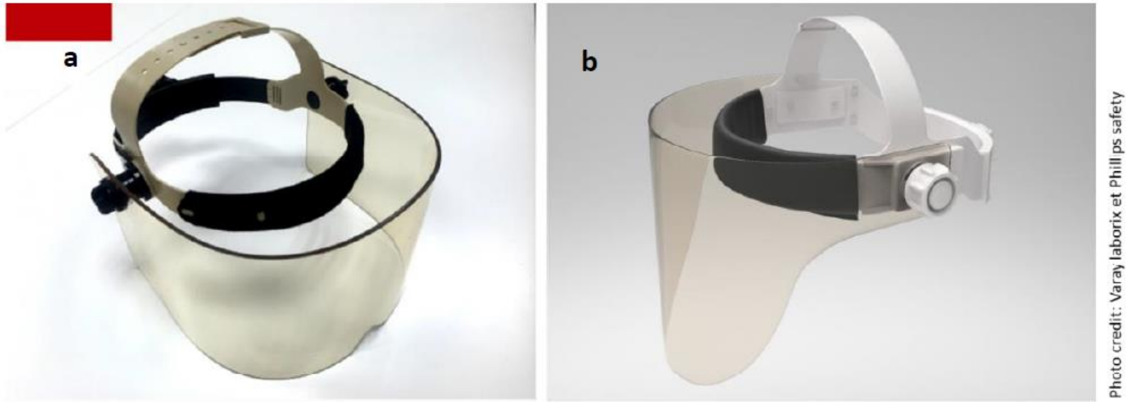
JACC: CARDIOVASCULAR INTERVENTIONS VOL. 9, NO. 3, 2016
FEBRUARY 8, 2016:299-304 Letters to the Editor

# Introduction

Radiation Protection of the head: eye lens and brain

- Lead glasses
- Masks
- (Caps)



# Eye lens protection

- Different models of lead glasses available
- Models from before the ICRP dose reduction
- Efficiency assessed with phantoms, dosemeters over the eye surface
- Dose Reduction Factor: ~ 1 - 10

B. D. van Rooijen et al.: Radiation Safety Glasses


J. Radiol. Prot. **40** (2020) R46 Review

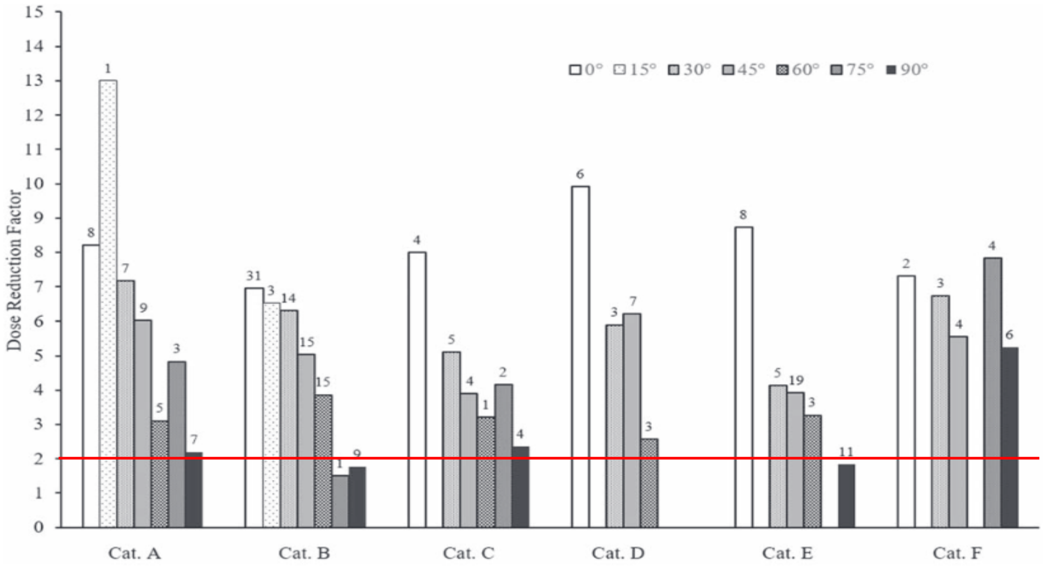
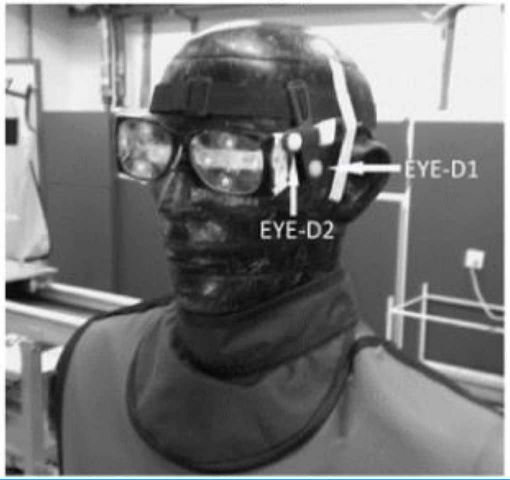



**Figure 2.** Mean of the *DRF* estimates aggregated by horizontal scatter incidence angle $\alpha_h$ and eyewear category. The numbers on the top of the columns represent the sample size for each group.

J. Radiol. Prot. **36** (2016) N19




S McVey *et al*

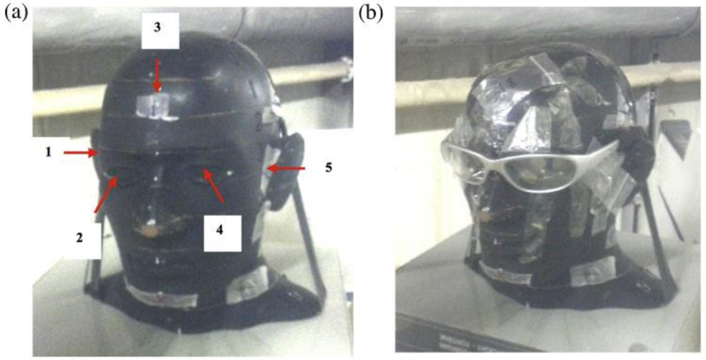



**Figure 2.** (a) Rando head phantom showing TLD positions 1–5. 1: RHS, 2: Right eye, 3: forehead, 4: left eye, 5: LHS. (b) Rando head phantom measurements with protective lead glasses.

J. Radiol. Prot. **33** (2013) 647–659

# Eye lens protection

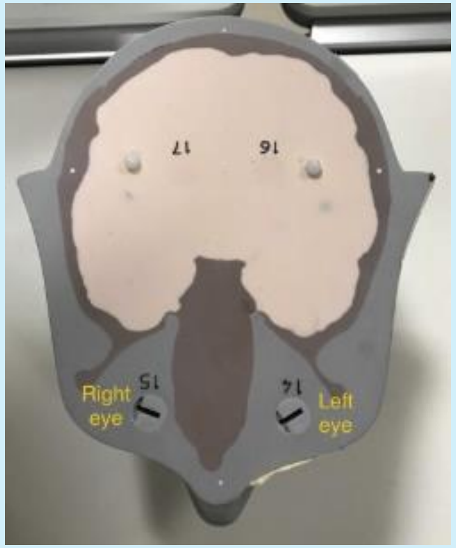
| Radiation direction | Dose transmission factor (%) for eight models of eyewear | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Below, left lens | 72 | 43 | 78 | 85 | 86 | 22 | 35 | 70 |

Figure 4. Head phantom

Figure 6. Polyethylene disc, used in the head phantom, with holes to fit TLDs.

T. Geber et al. / Radiation Measurements 46 (2011) 1248–1251

| Eyewear | Left lens |
|---|---|
| Standard eyewear | 99% ± 4% |
| Eyewear with side shield | 96% ± 5% |




J Vasc Surg. 2020 Dec;72(6):2139-2144.

# Eye lens protection

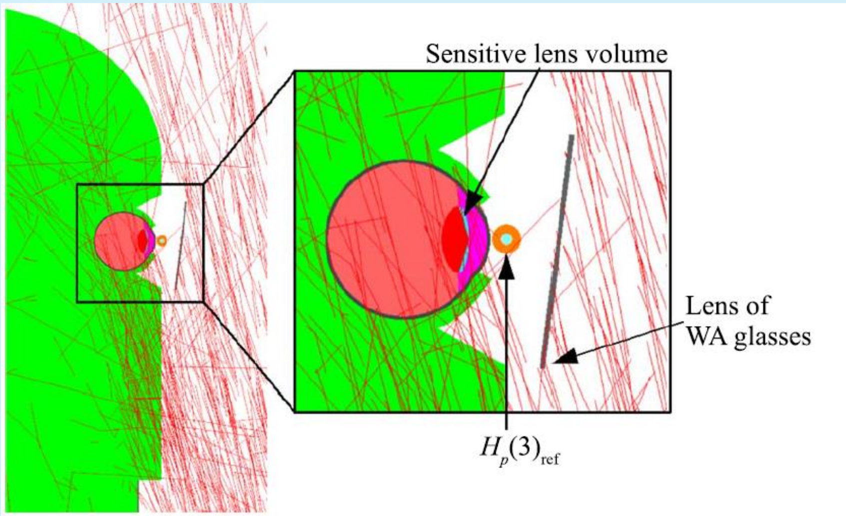
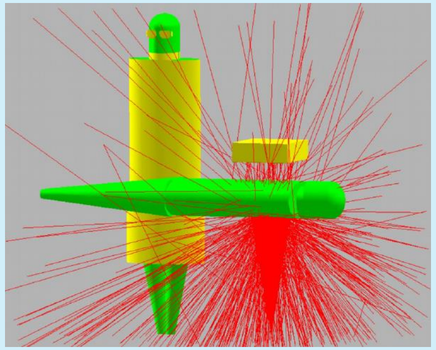



**Figure 4.** Shielding provided by the lead glasses to $H_p(3)_{ref}$ and to the eye lens. Lines represent x-ray photon tracks, simulated with MCNPX.

J. Radiol. Prot. **40** (2020) 215

$$\frac{H_p(3)_{ref}}{H_{lens,sensitive}} = 0.6$$



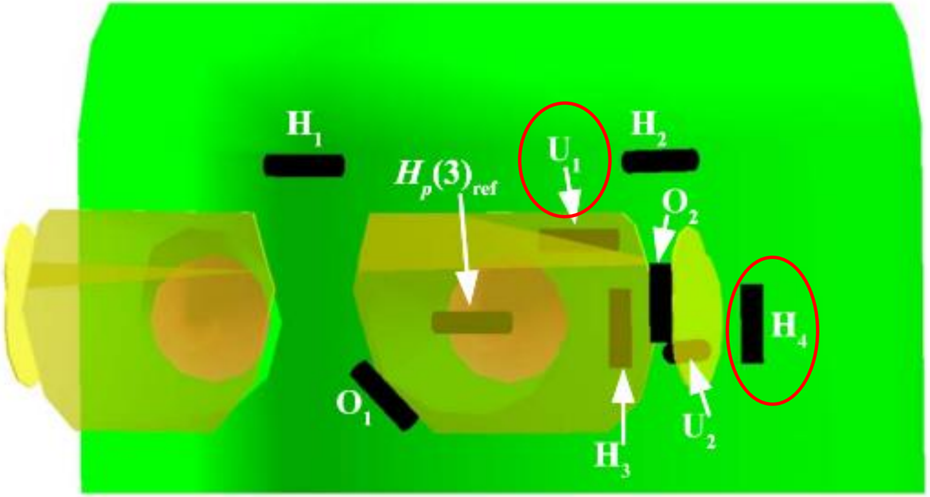



**Figure 3.** Positions of dosemeters modelled in the simulations. The dosemeters are shown as black where viewed directly and the colour modified where they are overlaid by shields.

| Position | $R_{H_{lens}}$ |
|---|---|
| $H_1$ | 1.3 |
| $H_2$ | 1.0 |
| $H_3$ | 1.6 |
| $H_4$ | 1.5 |
| $O_1$ | 1.6 |
| $O_2$ | 1.5 |
| $U_1$ | 0.2 |
| $U_2$ | 0.4 |
| $H_p(3)_{ref}$ | 0.6 |

# Eye lens protection

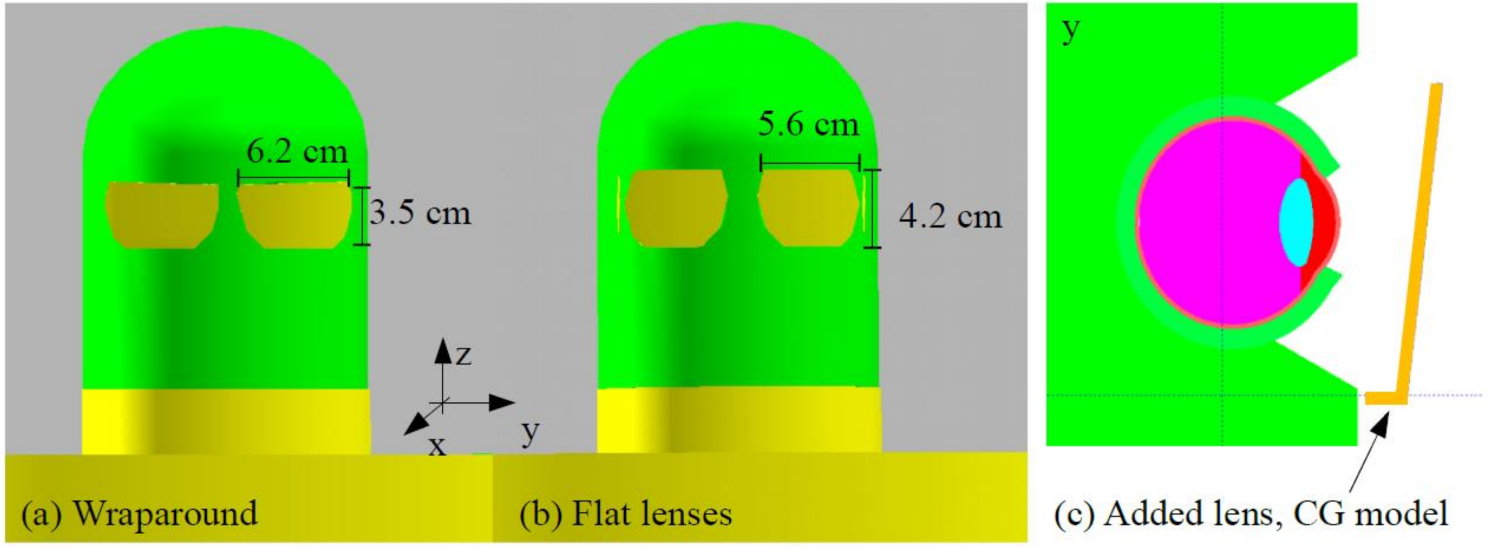
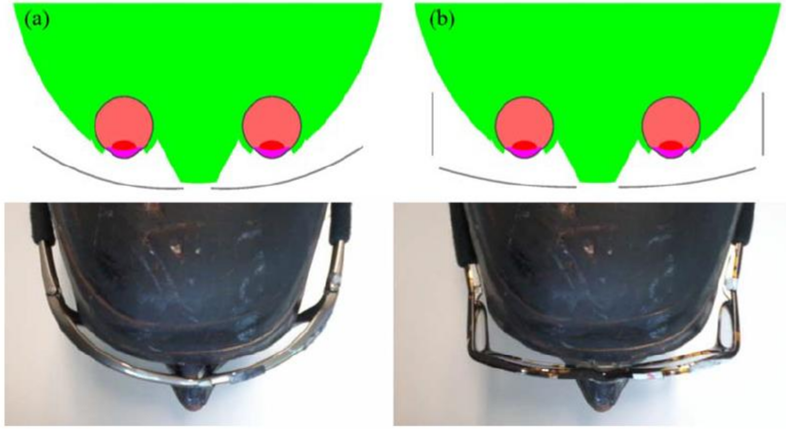


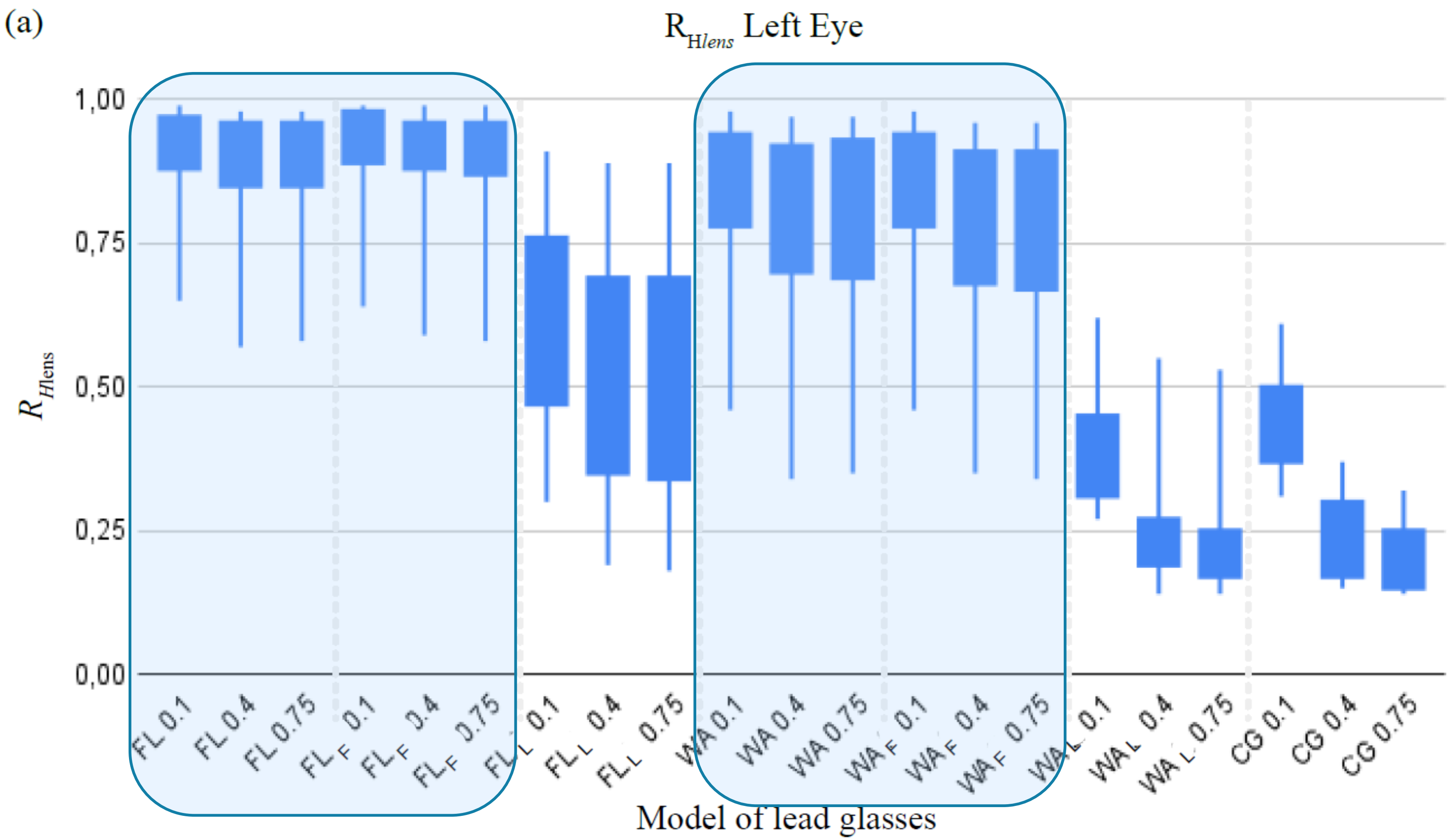

Figure 1: Dimensions of the two standard models of lead glasses: a) Wraparound (WA) and b) flat frontal lenses with side shielding (FL). c) Added lead rims towards the face in the CG model, transverse view.

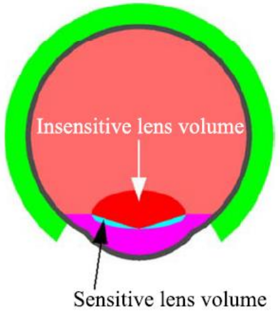
- Variation in the design of lead glasses
  - Lead thickness
  - Presence of Pb in the frames
  - Lens length
  - Extra horizontal lens



# Eye lens protection

(a)




Average $R_{Hlens}$: 0,77 – 0,92

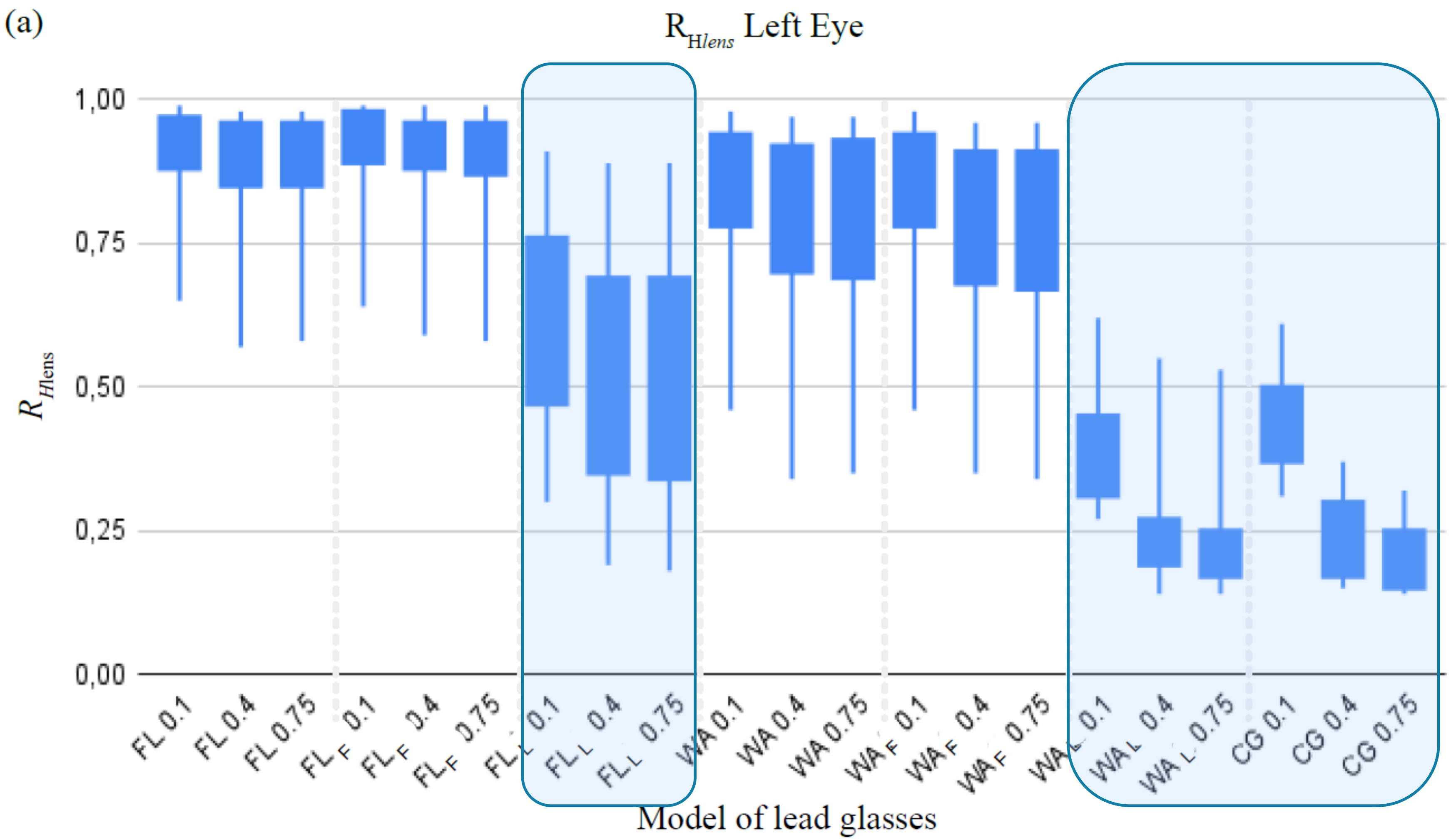
Lens thickness:
0,1 mmPb to 0,75 mmPb

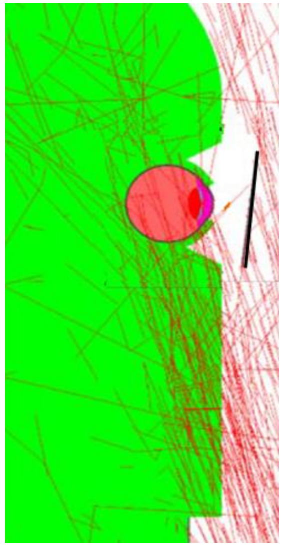
Presence or absence of Pb
In the frames

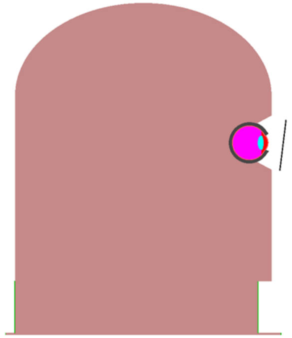
Average $R_{Hlens}$: 0,20 – 0,62

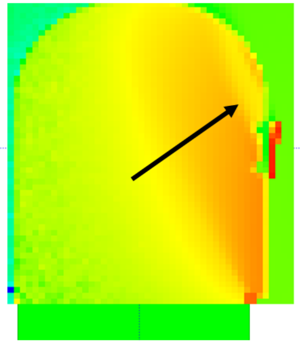
Longer frontal lens: 1 to 2 cm, depending on the model of LG

# Eye lens protection

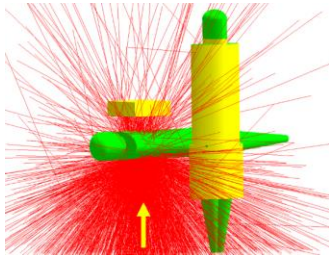


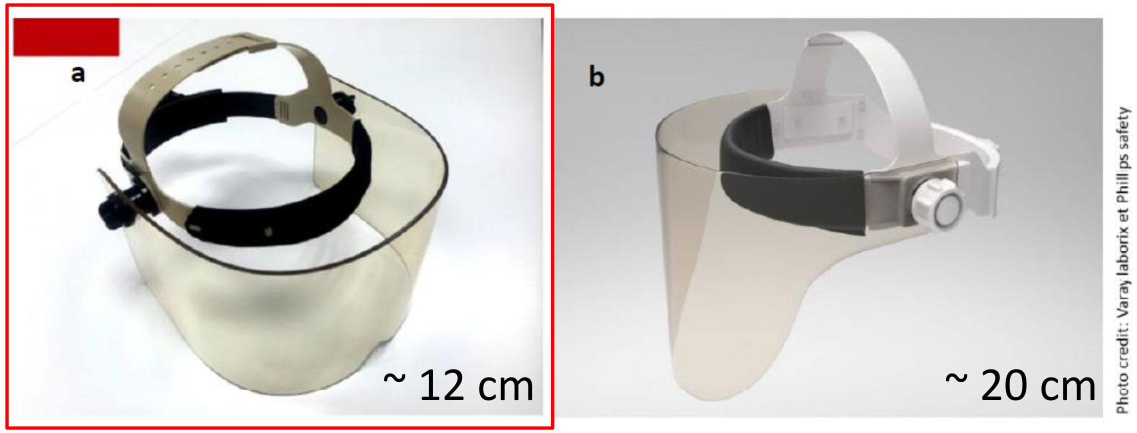




Doses: red > orange > yellow



# Eye lens and brain protection



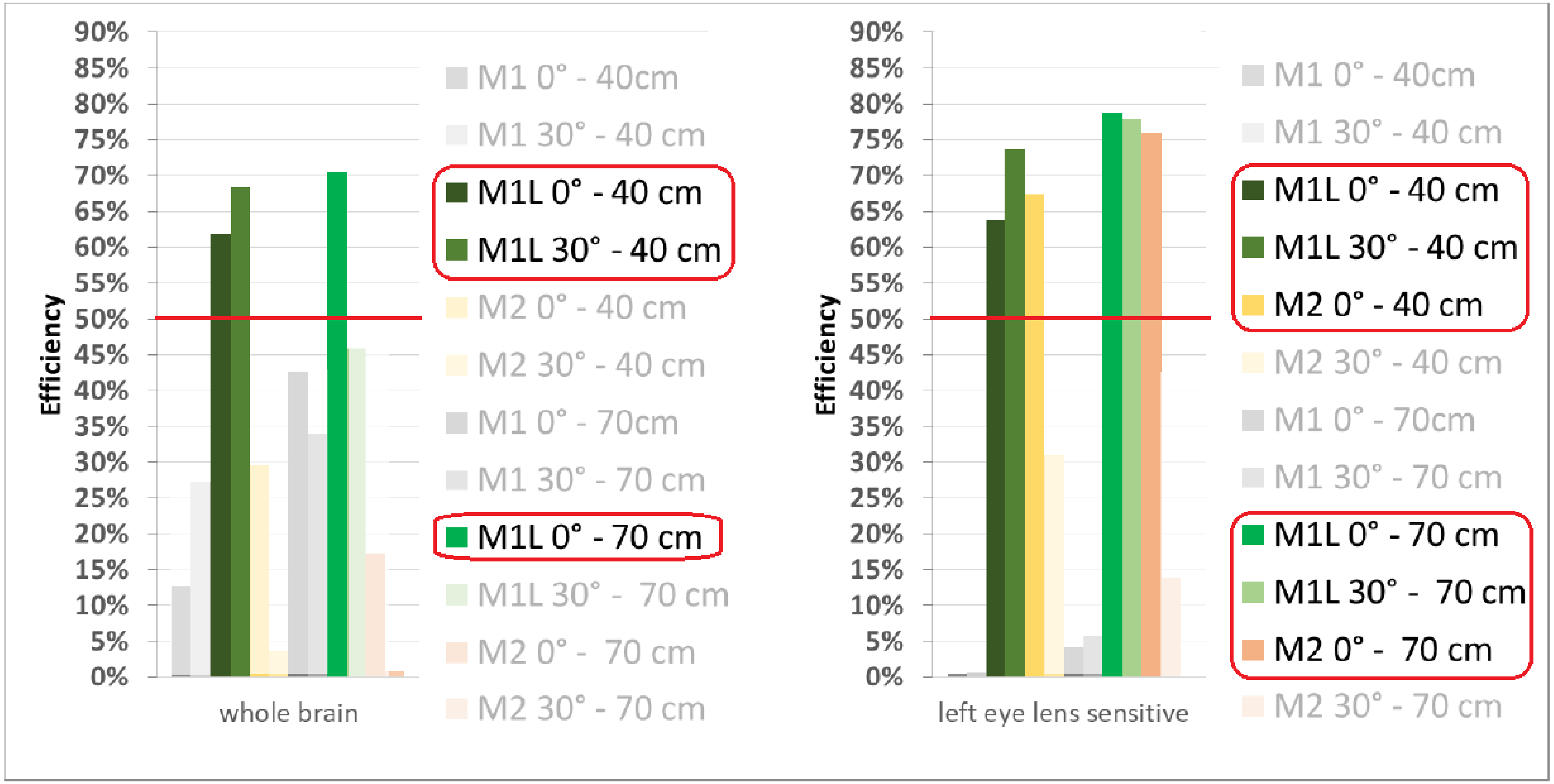

Attenuation (dosemeters on the mask)

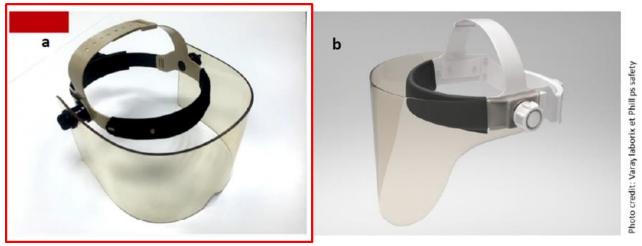
M1 (a) = 76% to 87%　　M2 (b) = 65% to 90%

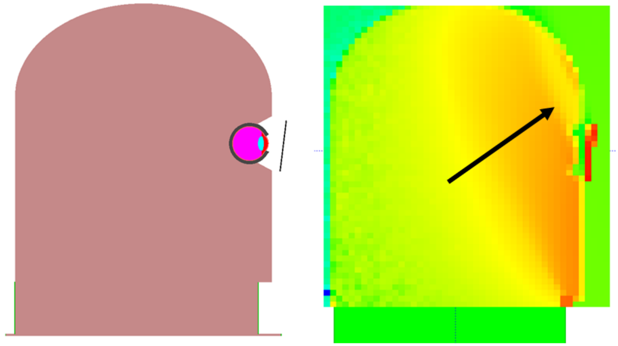
M1 efficiency for brain, eye lens
for PA projection and four operator positions (head at 0°)

| | Whole brain | Left eye lens |
|---|---|---|
| **PA –40 cm** | 11.6% | 0.1% |
| **PA–50 cm** | 20.3% | 1.2% |
| **PA – 60 cm** | 31.6% | 1.8% |
| **PA – 70 cm** | 39.2% | 1.9% |

# Eye lens and brain protection



Doses: red > orange > yellow

# Summary

Lead glasses:

- current models decrease the eye lens dose by only 20%
- Models with longer frontal lens, even of thinner Pb equivalency, are potentially more efficient (dose reduction > 50%)

Masks:

- Longer models provide better protection for eye lens and brain (dose reduction > 50%)
- Attenuation measured with dosemeters over/under the mask is not realistic of their efficiency (+65% vs 5% to 40%)

Caps:

- Provide some protection only to the brain, none to the eye lens
- Attenuation measured with dosemeters over/under the cap is not realistic of their efficiency (~80% vs < 40%)

Efficiency of RP devices *usually* increases further from the primary X-ray beam (femoral access)

# Take Home message

- Attenuation is **NOT** the same as dose reduction in the organ of interest

- Dose reduction assessment is **STRONGLY** influenced by the reference dose

- Radiation reaching the staff comes from **below**: minimizing spaces where radiation can leak through will likely increase protection

*There is still room for optimization of radiation protection devices!*

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