Radiation protection devices of the eye lens in medical staff

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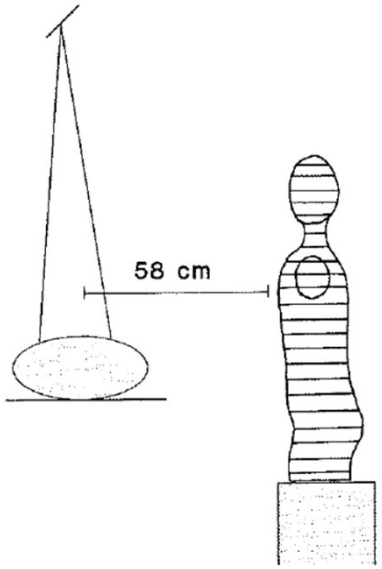
A brief, subjective and approximate history of radioprotective eyewear research

- 1200: Inuit's use snow googles to protect against ionizing radiations (UV)

https://wellcomecollection.org/works/hfbedump

- 1976: Richman et al. study glass transmission in direct angiography beam. Plastic, regular glass and lead glasses are studied.

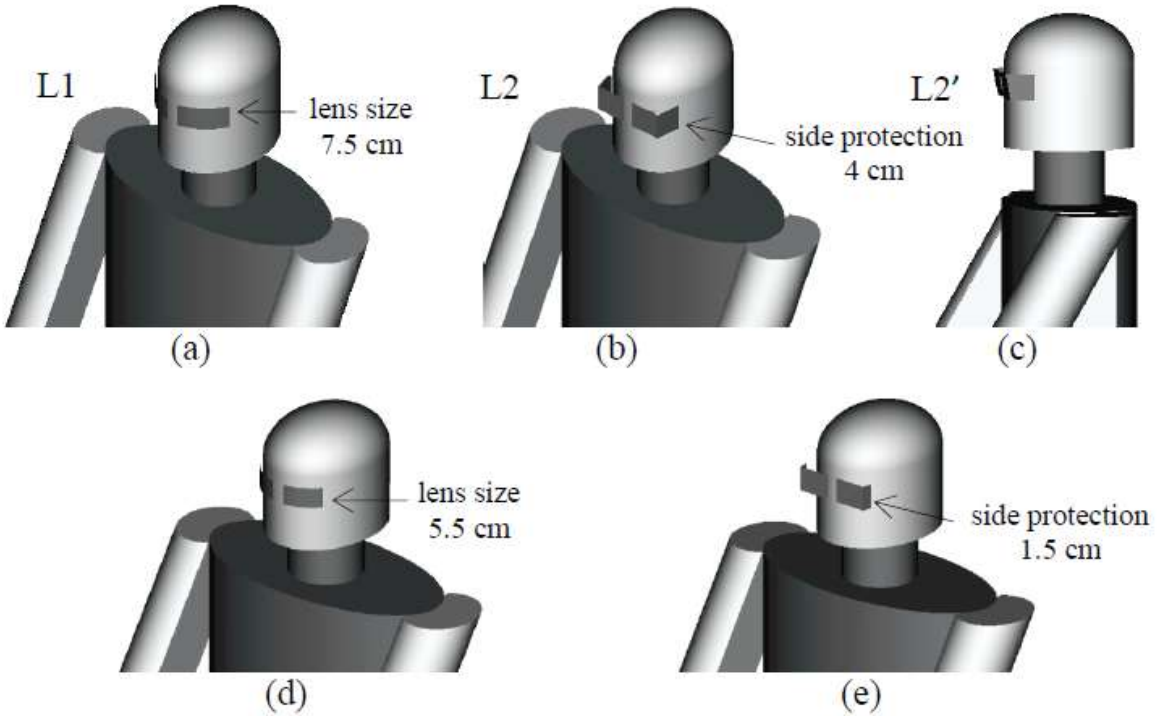


- 1980: Marshall et al. investigate protective eye wears **on an anthropomorphic phantom**. Photochromic glasses and lead-acrylic face mask are tested.

A brief, subjective and approximate history of radioprotective eyewear research

- 1981: Day and Forster publish measurements on efficiency of ordinary crown-glass eye wear **worn by hospital staff**.

- 2014: **Monte Carlo study** of parameters affecting lead glasses efficiency in interventional procedures (Koukorava et al.)



A brief, subjective and approximate history of radioprotective eyewear research

Three complementary type of efficiency studies:

- on phantom in clinical settings
  - → limited configurations
  - → dosimeter sensibility
- on staff in clinical settings
  - → ethical considerations…
  - → dosimeter sensibility
  - → dosimeter not actual organ dose
  - → combination of multiple parameters
- MC simulations
  - → models not completely realistic
  - → "discrete" configurations

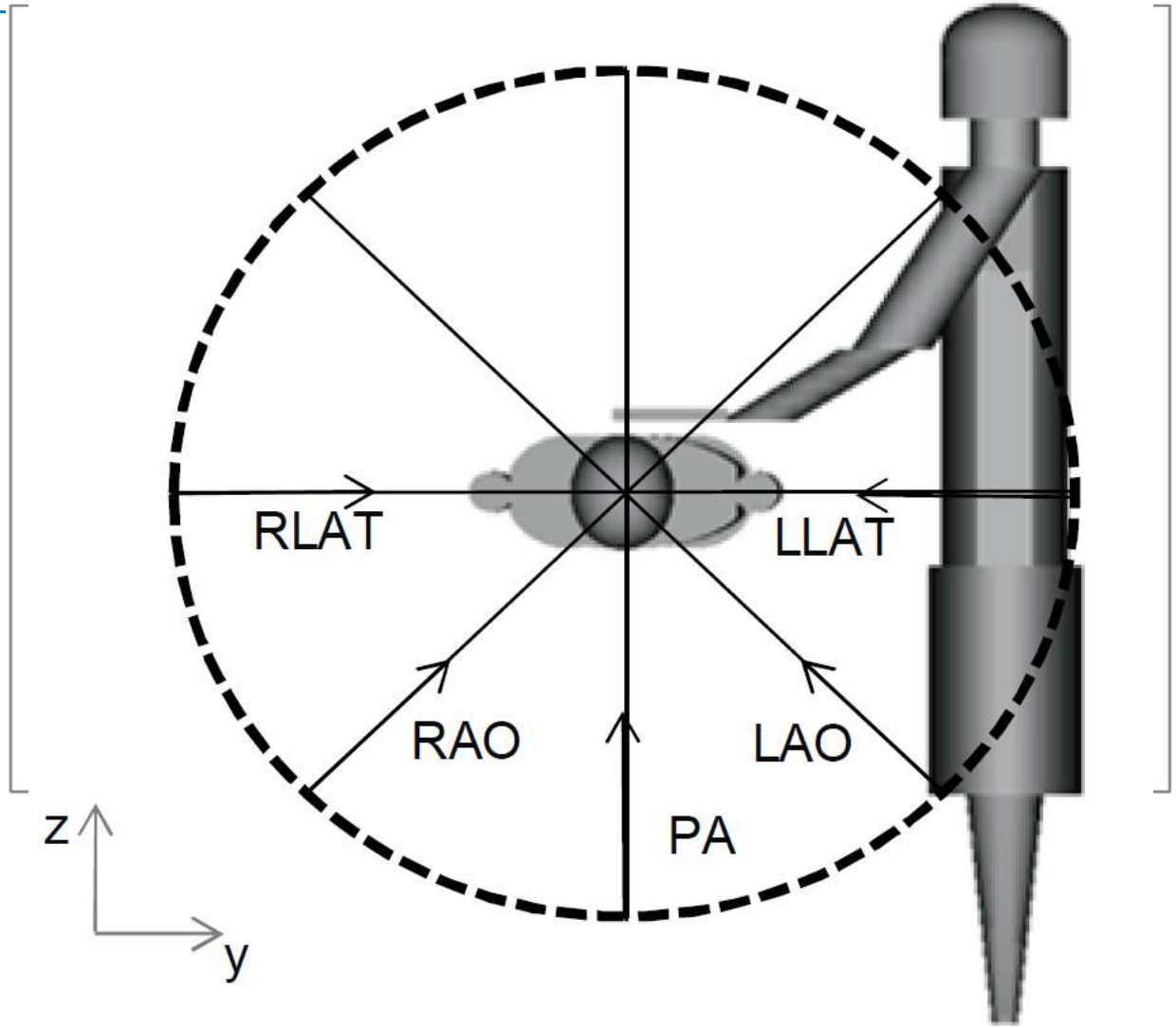
Lead glasses efficiency in interventional procedures
Strongly dependent on exposure conditions!

- >effect of projections
- > effect of design

→Gap and coverage

- > effect of head orientation
- < effect of mm eq Al

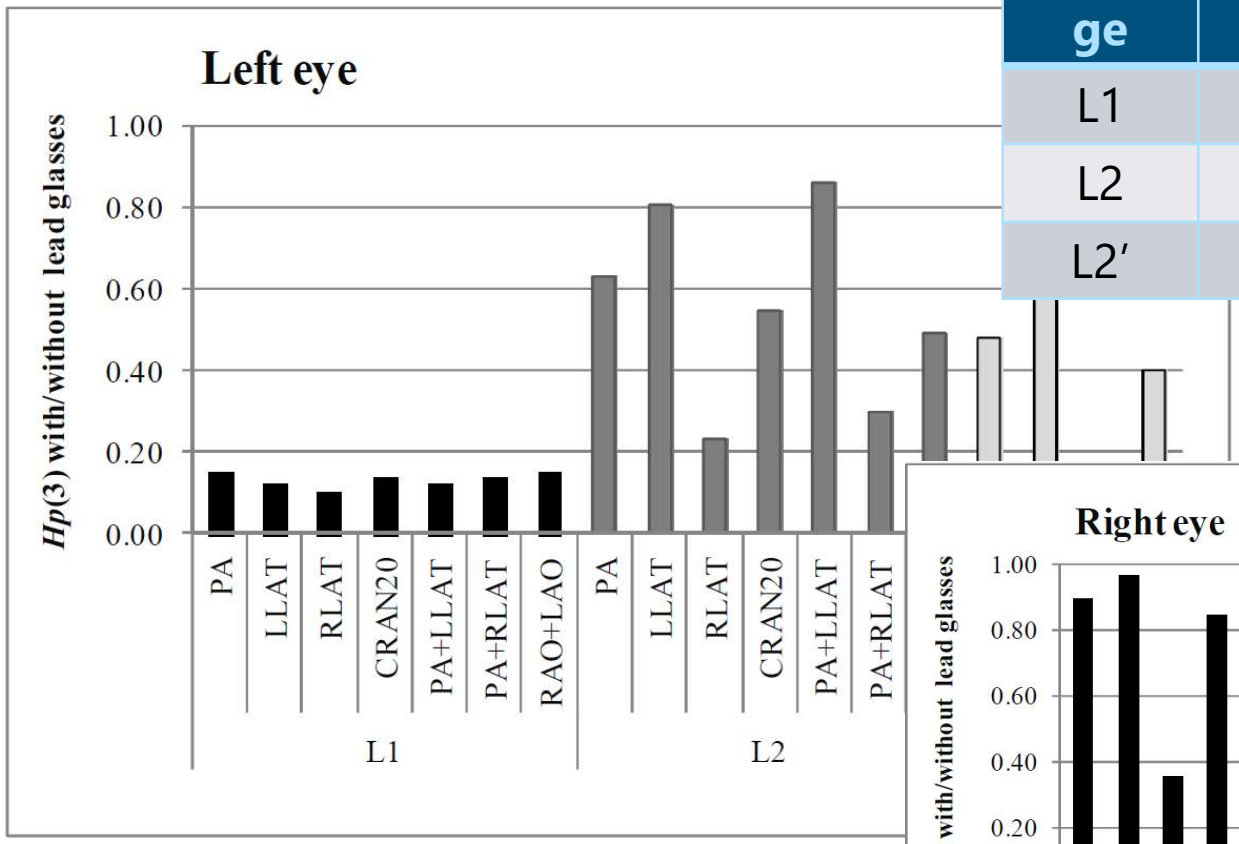
→ if >= 0,5

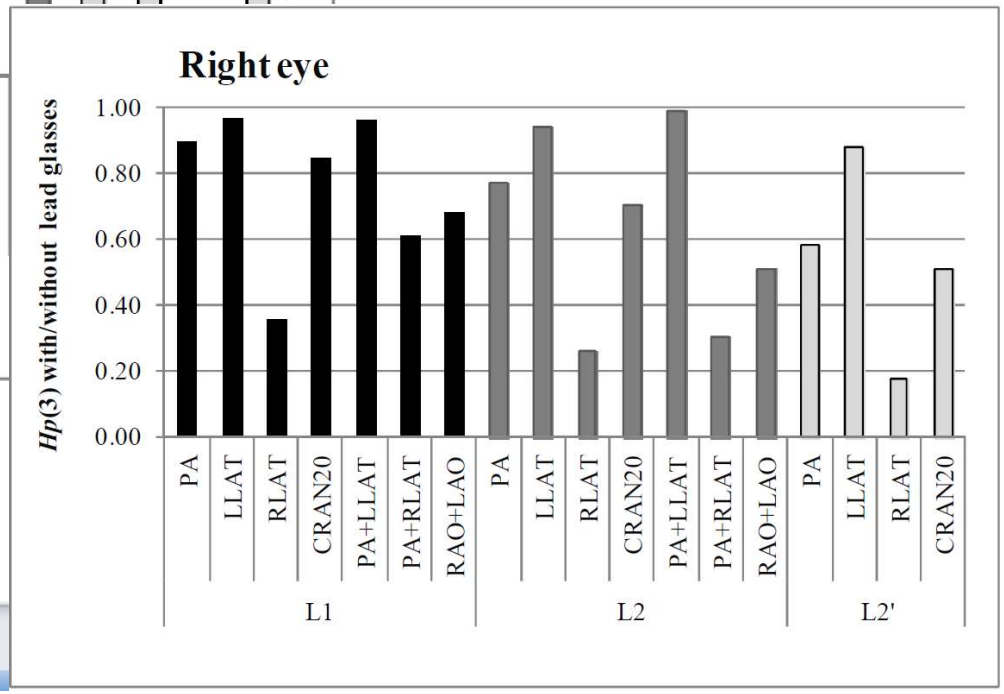


Koukorava et al 2011 Rad meas & 2014 JRP; also Mao, L., et al. (2019) Medical Physics

>> difference in efficiency between eyes

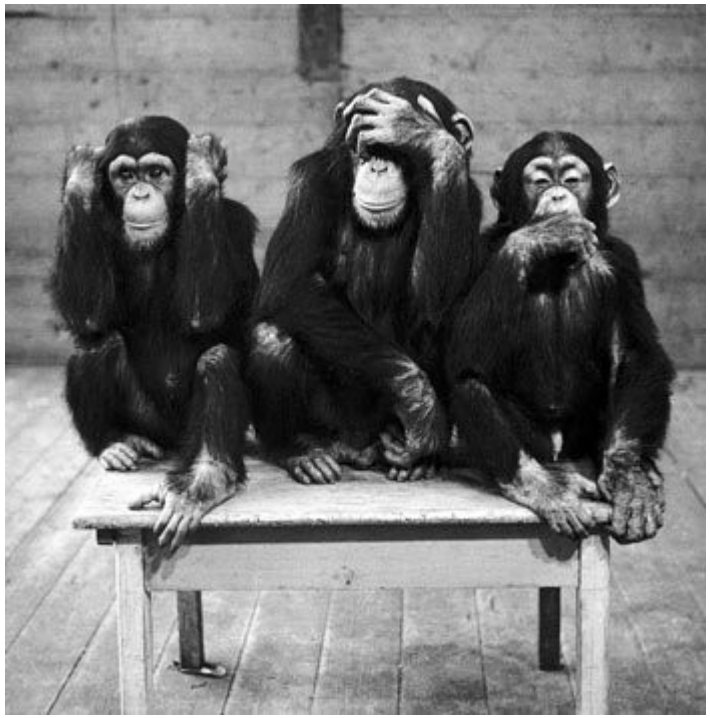
Average	Left eye	Right eye
L1	0,13	0,76
L2	0,56	0,64
L2′	0,43	0,54





Koukorava et al 2011 Rad meas & 2014 JRP

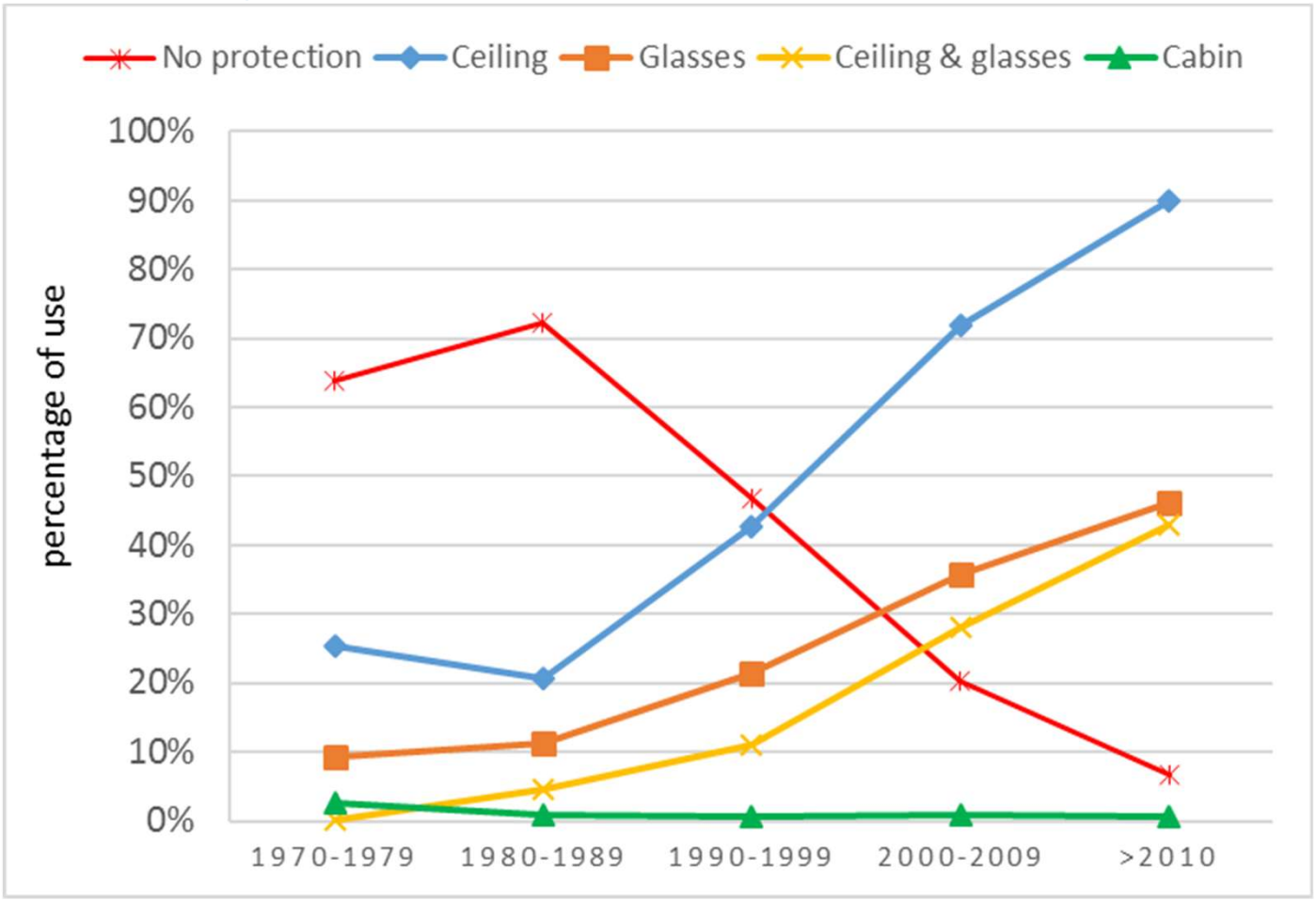
There is more than just eye wear



Euraloc
European epidemiological study on radiation-induced lens opacities among interventional cardiologists

Other radioprotective devices protecting the eye

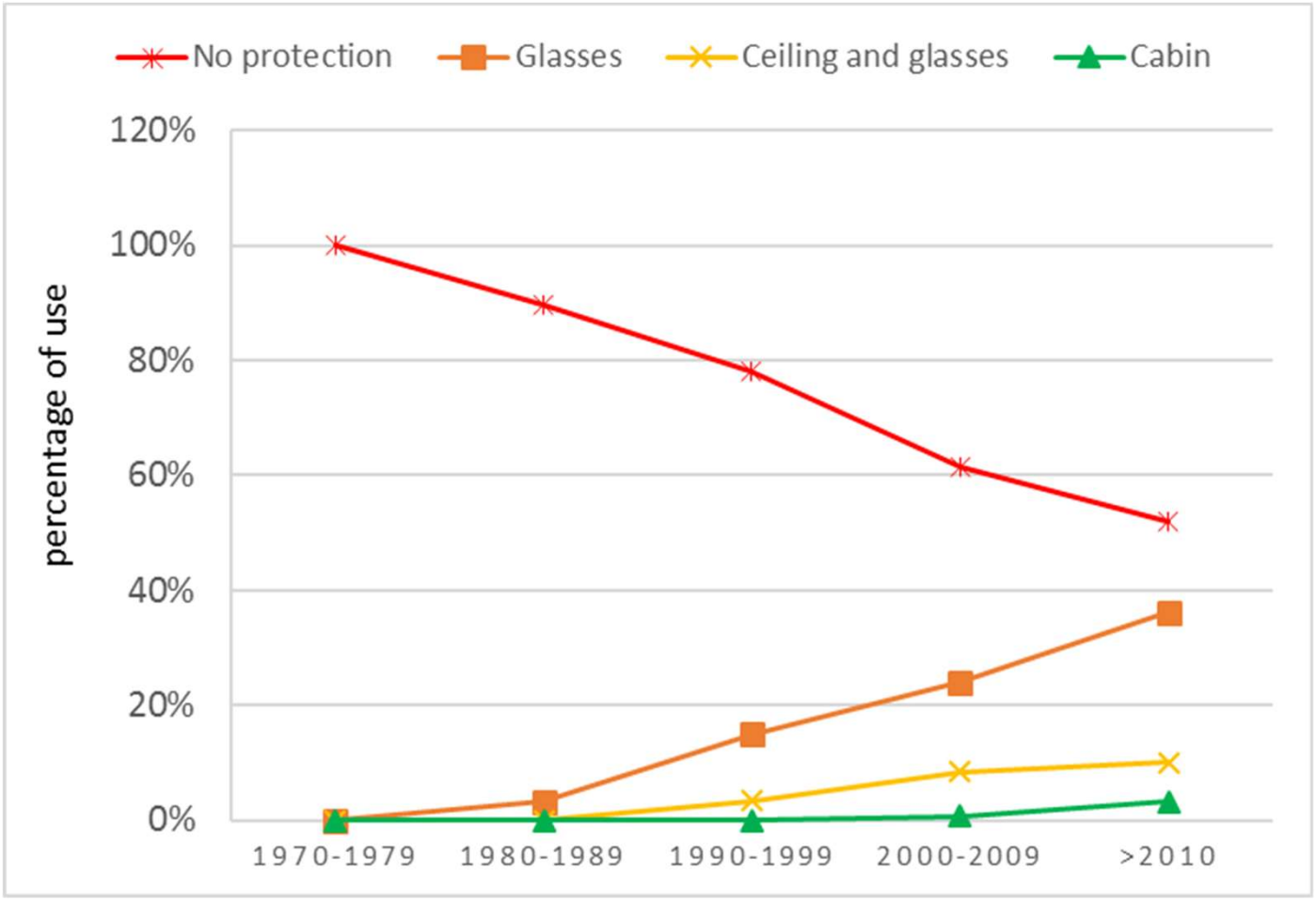
Haemodynamic procedures



Domienik et al, 2018, JRP

Other radioprotective devices protecting the eye

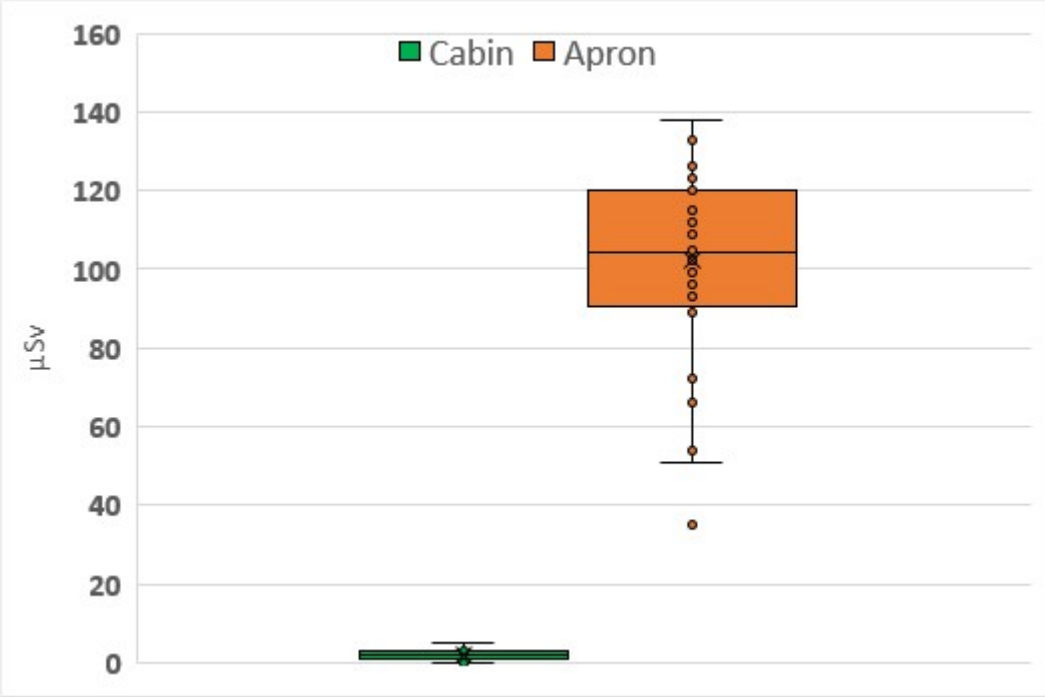
Pacemaker/ICD procedures



Domienik et al, 2018, JRP

Radioprotective cabins for haemodynamic procedures

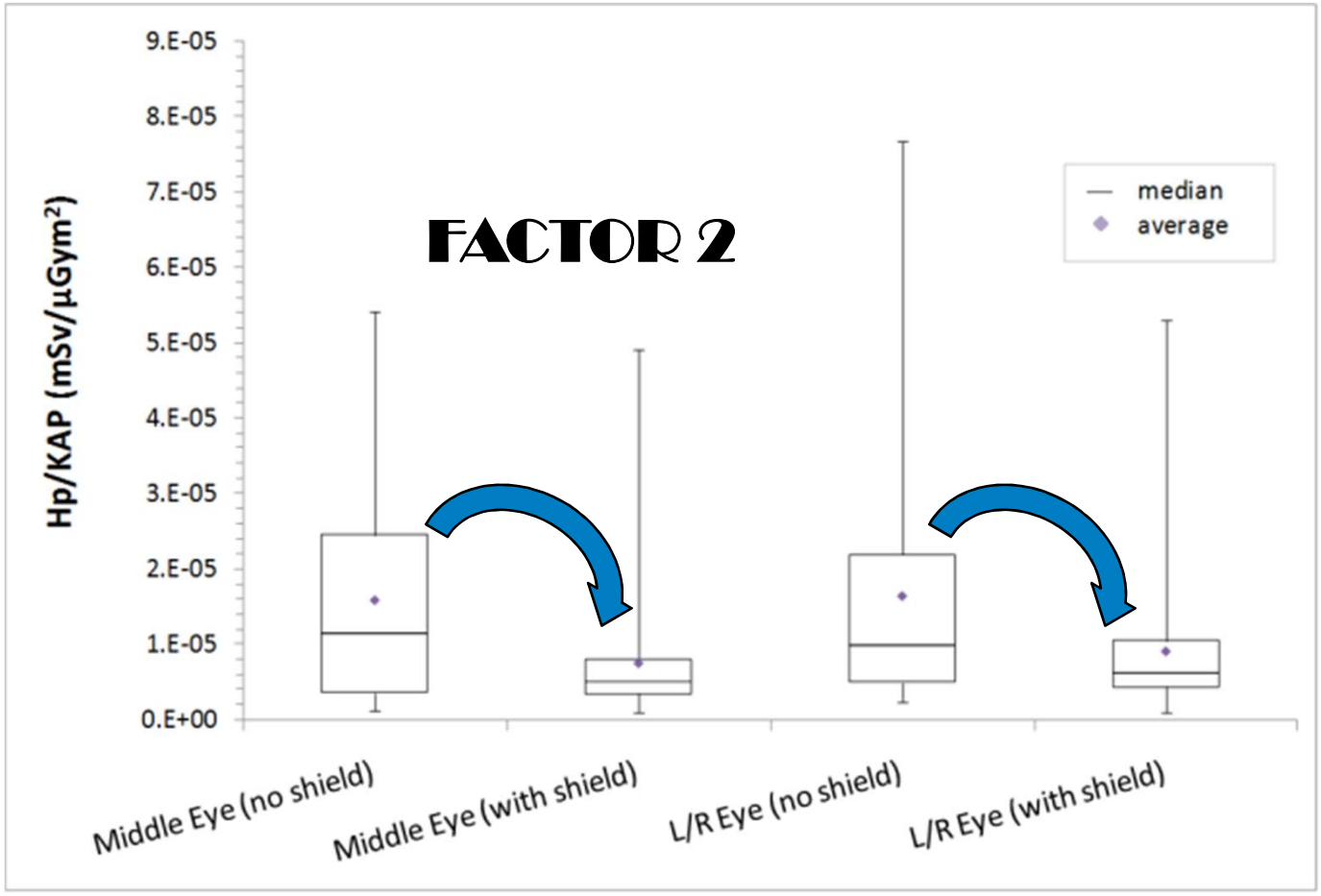
- "radiation doses within cabin = background levels irrespective of procedure and fluoroscopy duration"



- Exact efficiency difficult to quantify!
- But does it matter?
- Limited to femoral access because of cabin size

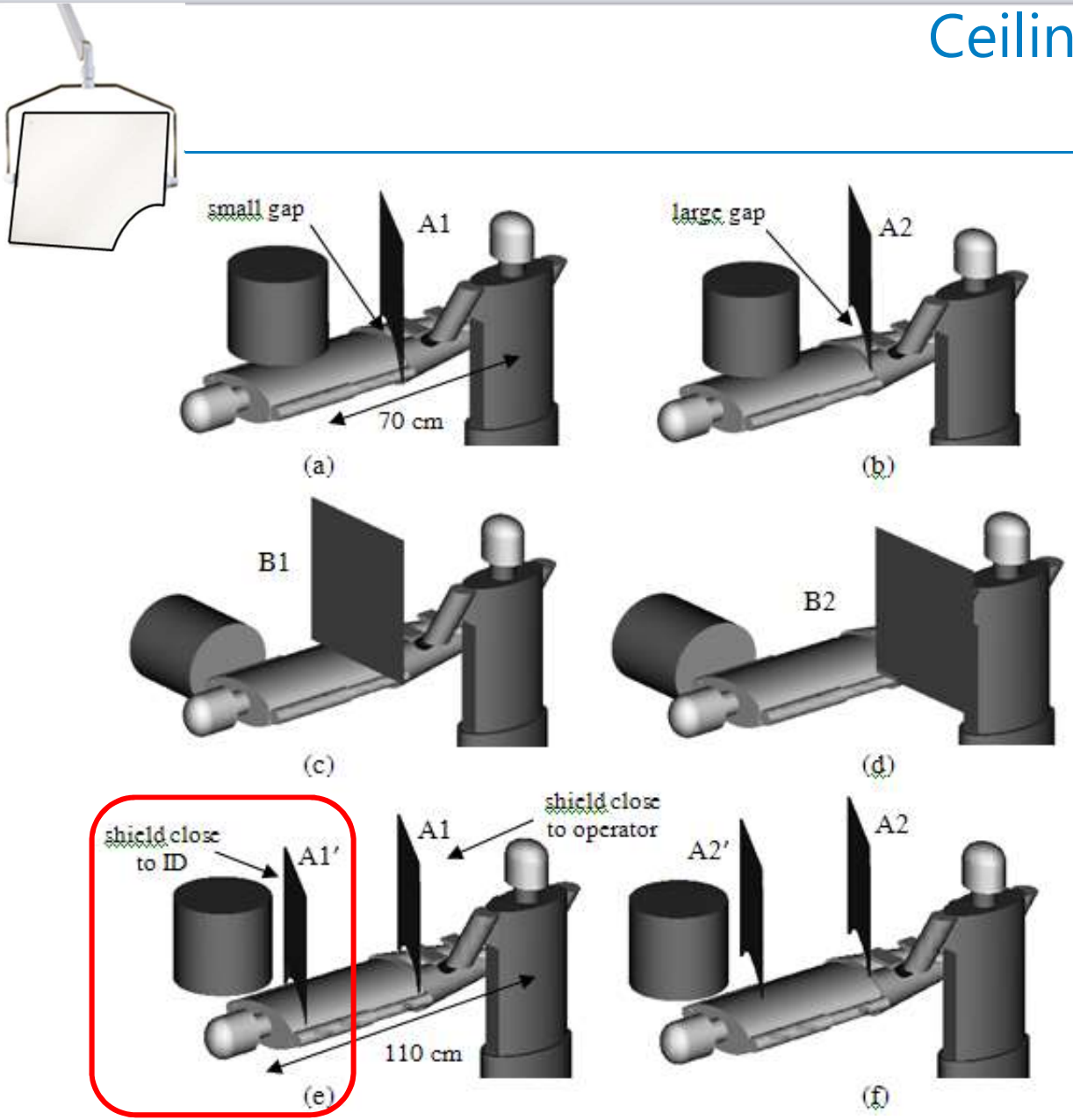
Dragusin et al. 2007 Eur Hart J

Ceiling suspended screen
Clinical measurement



Vanhavere et al. 2012, Oramed final report

Ceiling suspended screen MC simulations

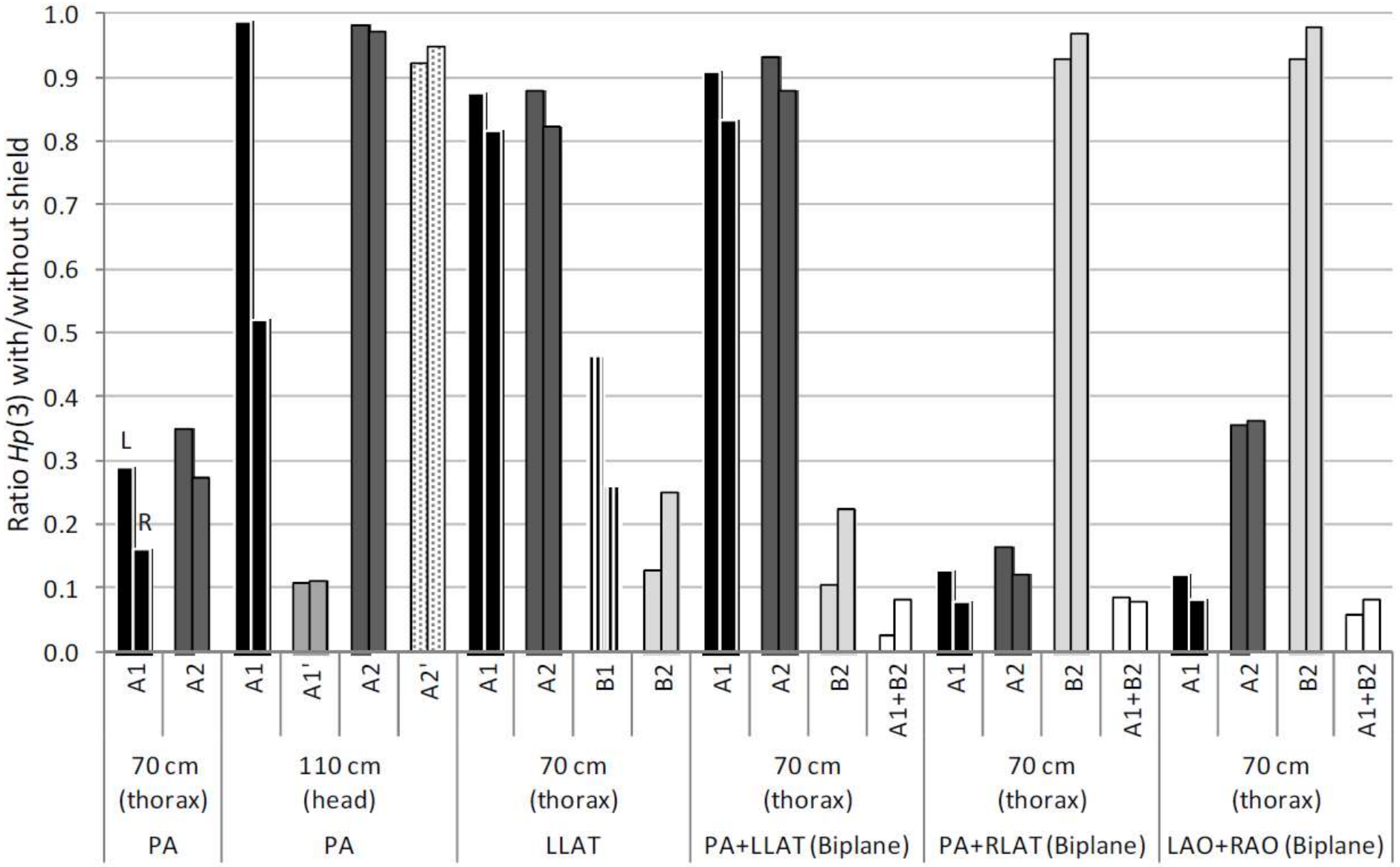


On average ~50% efficiency

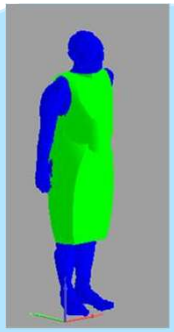
Importance of position

- Close to patient
- Close to x-ray field

Koukorava et al 2014 JRP

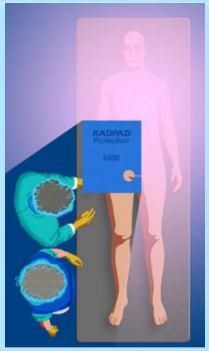

Ratio Hp(3) with/without shield
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
L
R
A1
A2
A1
A1'
A2
A2'
A1
A2
B1
B2
A1
A2
B2
A1+B2
A1
A2
B2
A1+B2
A1
A2
B2
A1+B2
70 cm (thorax) PA
110 cm (head) PA
70 cm (thorax) LLAT
70 cm (thorax) PA+LLAT (Biplane)
70 cm (thorax) PA+RLAT (Biplane)
70 cm (thorax) LAO+RAO (Biplane)

There are more recent radioprotective devices

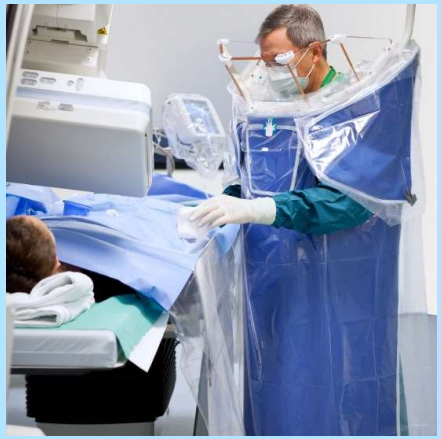


Lead and Leadfree apron

Saldarriaga Vargas et al. *RPD* 2018



http://www.radpad.com/portfolio/femoral-entry-angiography-shield/



https://www.biotronik.com/en-de/products/zero-gravity

Efficiency of more recent staff radioprotective tools Investigated in the frame of Medirad with focus on eye lens and brain

Efficiency of more recent staff radioprotective tools

Subtask 2.2.3: Evaluation of efficiency and effectiveness of staff radioprotective tools

Objectives

- Assessing **efficiency and effectiveness** of available **shielding devices** on **staff** exposure
- Providing valuable **novel information** on decrease in operators doses, including **brain and eye lens** doses
- Making **recommendations**

Partners

- **SCK•CEN**, IRSN, NIOM

MEDIRAD: Implications of Medical Low Dose Radiation Exposure

Objectives

- *Improving organ dose estimation and registration*
  - *To optimise doses, and support clinical-epidemiological studies*
- *Evaluating the effects of low to moderate doses of radiation*
  - *on cardiovascular diseases and long-term effects from RT in breast cancer treatment*
  - *on cancer risk from CT in children*
- *Developing science-based consensus policy recommendations for the effective protection of patients, workers and the general public.*

Partners

- *About 34 Partners from 14 countries*
- *Coordinator: European Institute for Biomedical Imaging Research (EIBIR), Austria*

Duration

- 57 Months ; Start June 2017

Funding

- This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 755523

Radioprotective drapes on the patient

- Lead or lead free material
- Many clinical studies in literature (>20) but little about eye lens
- Mostly evidence of dose reduction (from a few % to 50%)

Musallam, A., et al. 2015 CCI; Dabin et al 2017 RPD

- But not always

Grabowizc et al 2017 JRP

MEDIRAD

Radioprotective drapes on the patient

Already some measurements

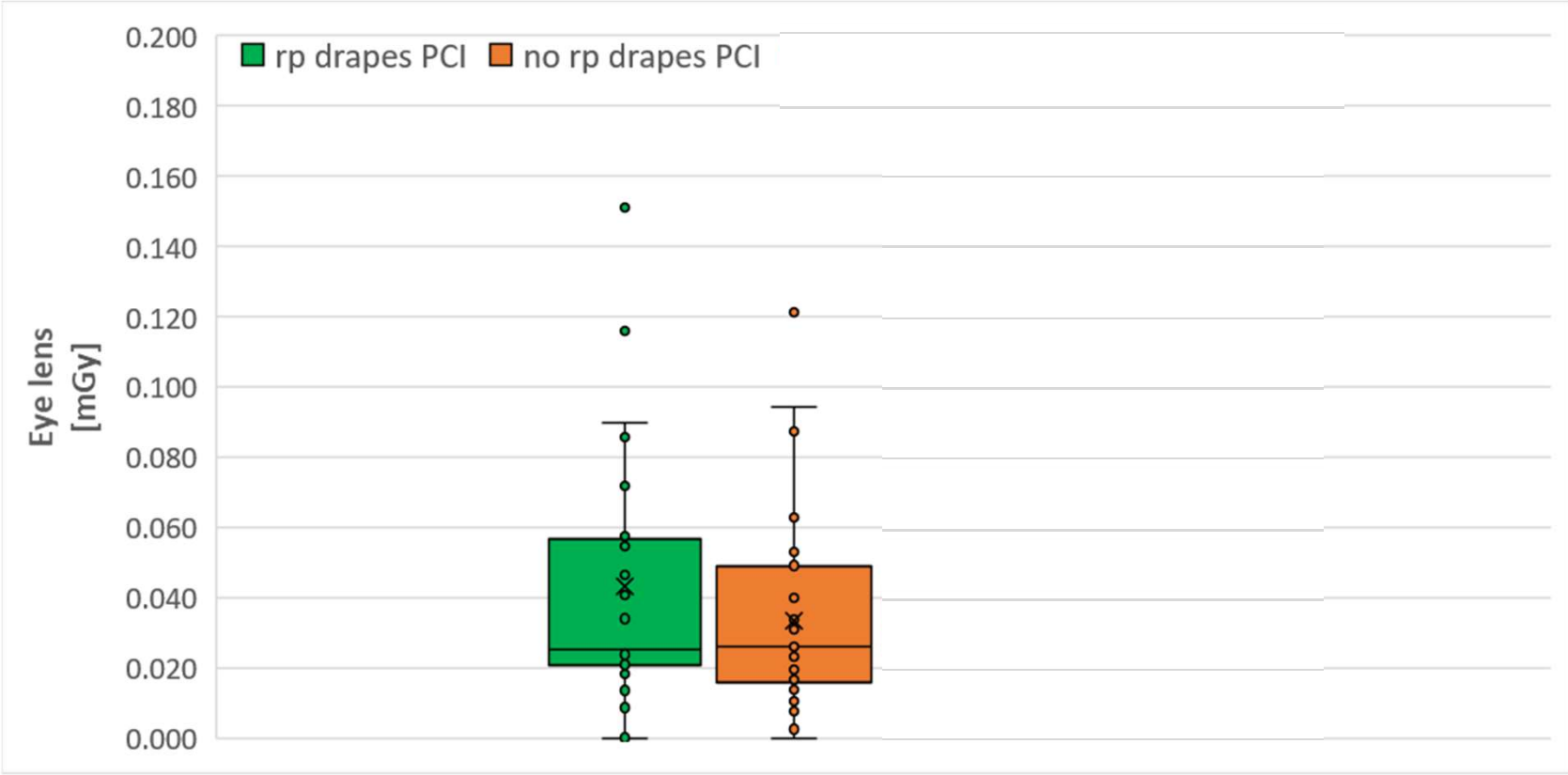
~130 procedures monitored so far

- 71 CTO: 36 No; 35 Yes
- 63 PCI: 35 No; 28 Yes

→No significant difference for PCIs

→Clear difference for CTOs

→**Difference in procedure exposure?**



MEDIRAD

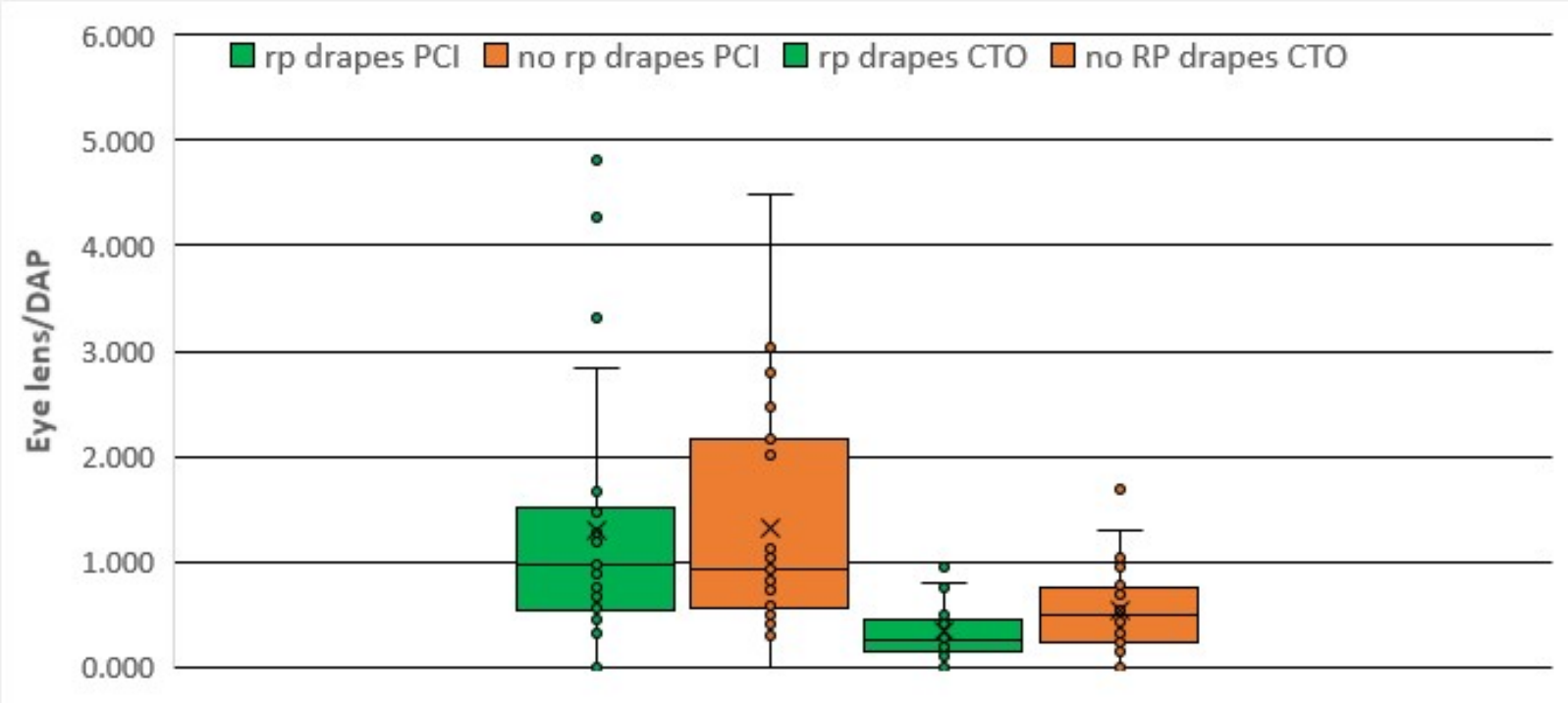
Maybe using normalized doses?

~130 procedures monitored so far

- 71 CTO: 36 No; 35 Yes
- 63 PCI: 35 No; 28 Yes

→No significant difference for PCIs

→Clear decrease for CTOs: 40%



MEDIRAD

How to explain such differences?

Caused by different:

→projections?

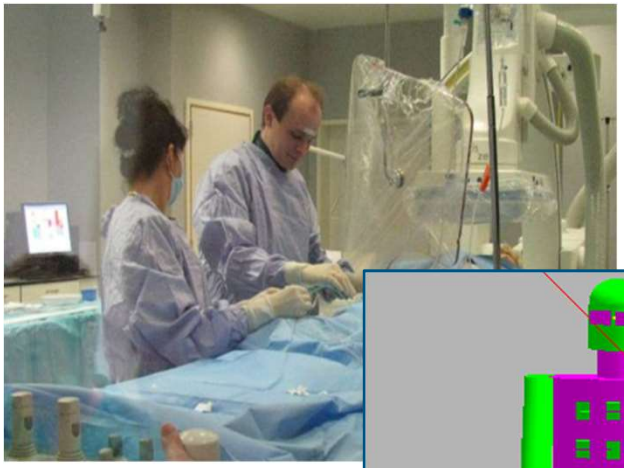
→physician positions?

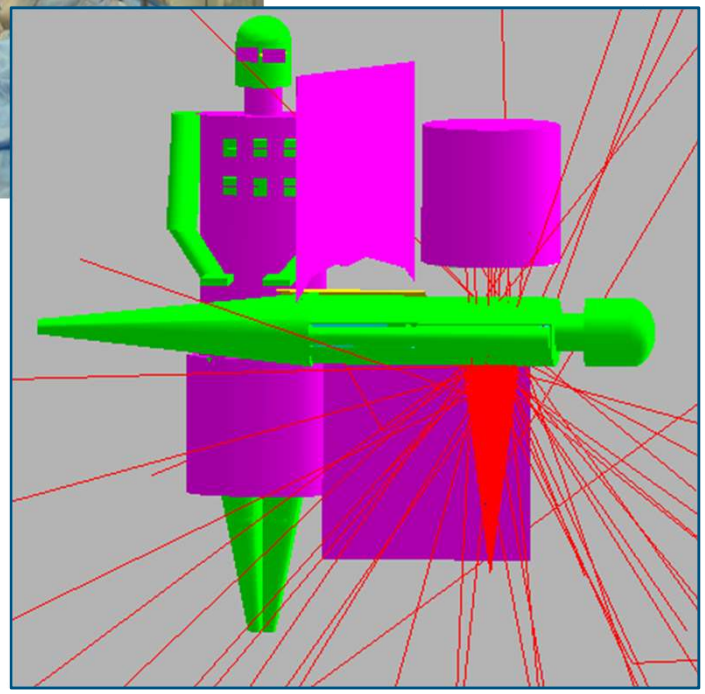
→Head orientation?

→beam energies?

→Access?

→Drape position?



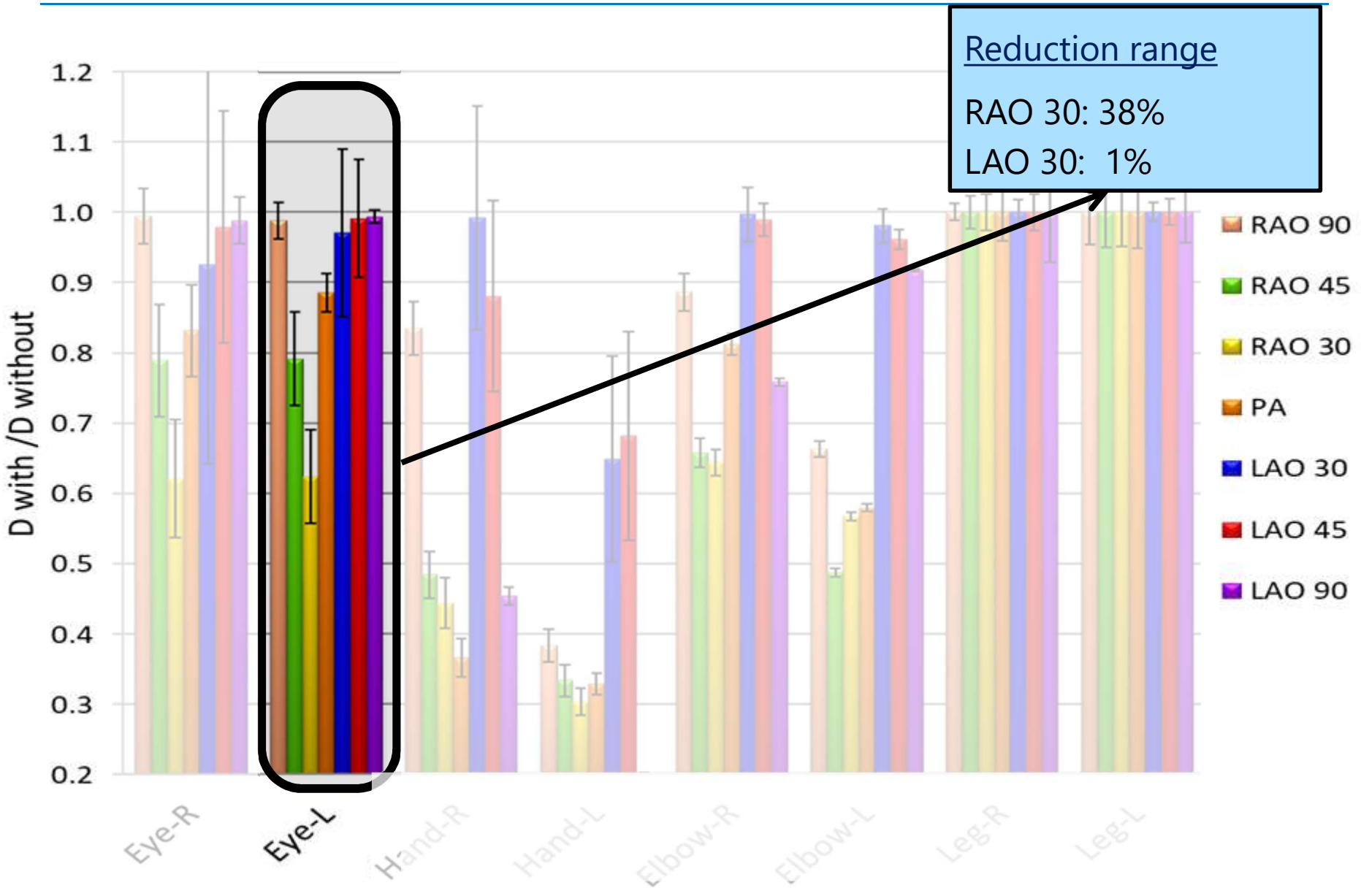


- MC simulations:
  - Mathematical phantom

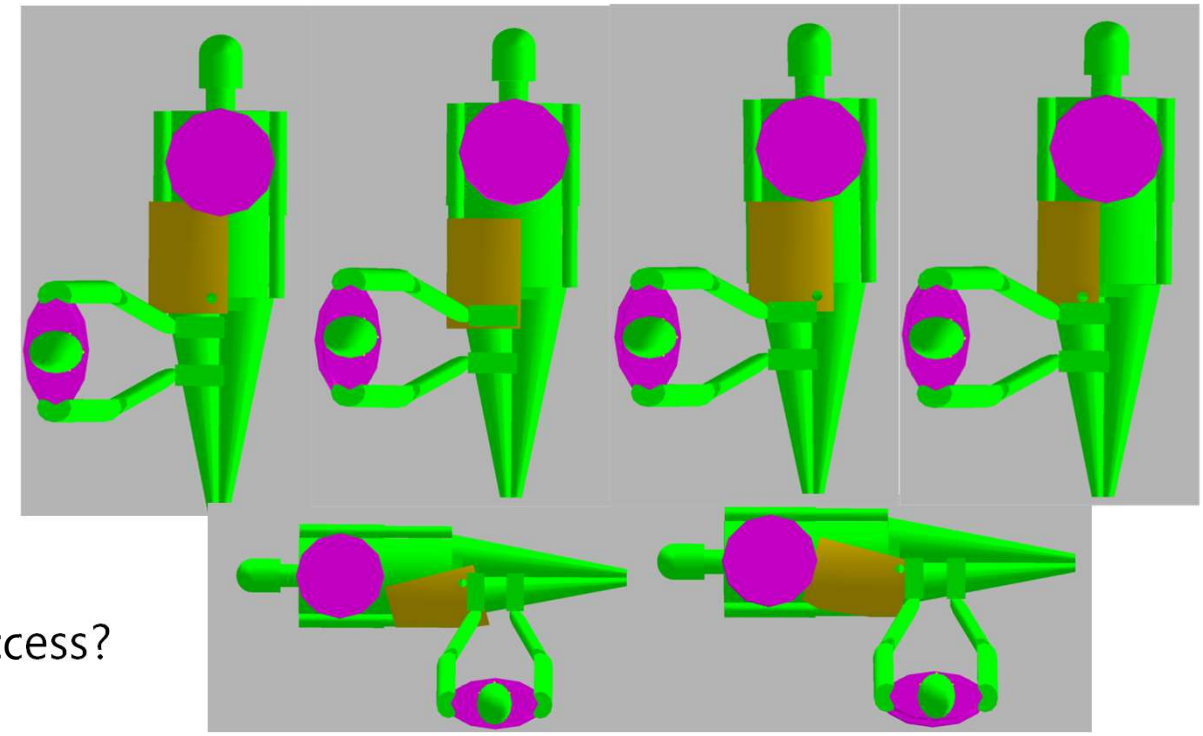
    (modified anthropomorphic ORNL-MIRD phantom)
  - MCNP-X
  - Several projections
  - Physician position, orientation

MC simulation results

Red Radpad, Radial access, no ceiling shield



How to explain such differences?

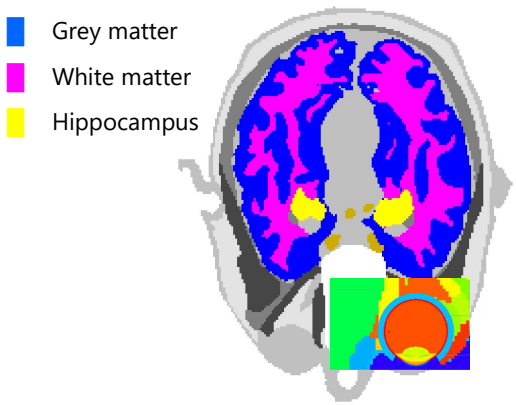


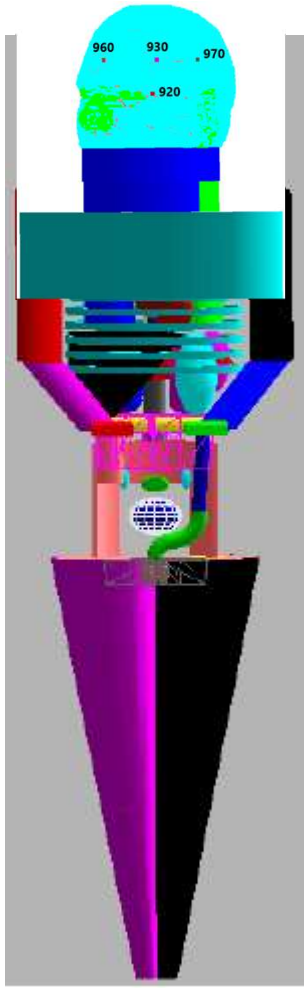
Caused by different:

- projections? Possible
- physician positions/ access? Not likely
- beam energies? Not likely
- Drape position? limited

Radioprotective mask

Not really new but little evidence in literature





- No information in the literature

Phantom adapted to regions of interest

- **Body**: Mathematical ORNL phantom
- **Head**: Zubal head
- **Eye: :** Behrens model

Zubal et al. *Med Phys* 1994. Behrens et al

MEDIRAD

Radioprotective mask
No clear message, sorry!

- Far from field
  - On average **66% dose reduction to eye lens dosim!**
  - No significant dose reduction to eye lens
  - Little effect of head orientation
- Closer to field
  - No significant dose reduction to eye lens or dosim

- Far from field
  - On average **80% dose reduction to eye lens dosim!**
  - Comparable decrease to eye lens
  - Big effect of head orientation (<< protection)!
- Closer to field
  - A bit smaller but significant dose reduction to eye lens or dosim

A Hébré Rapport de stage 2018

Zero Gravity ceiling-suspended system

Limited but significant evidence!

- On staff: about 50% dose decrease to eye lens (Haussen et al, 2017, Neuroimaging)
- On phantom: 45-fold decrease (Marichal et al, 2011, J Vasc Interv Radiol)

- And MC simulations?

→ let's look at the future

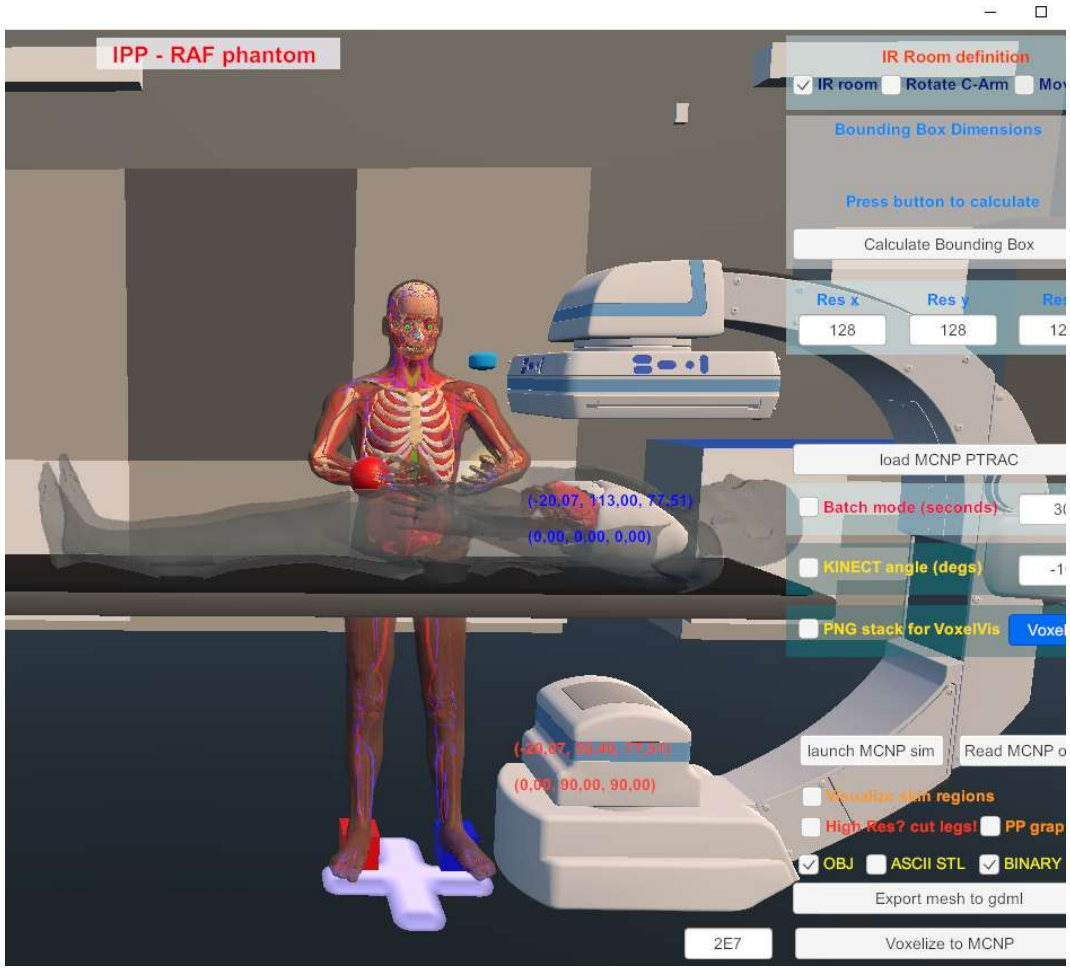
PODIUM
Personal Online Dosimetry
Using computational Methods

What the future of MC simul could be…

No more complex phantom modeling! Just playful interfaces!

PODIUM
Personal Online Dosimetry
Using computational Methods

Different protections available

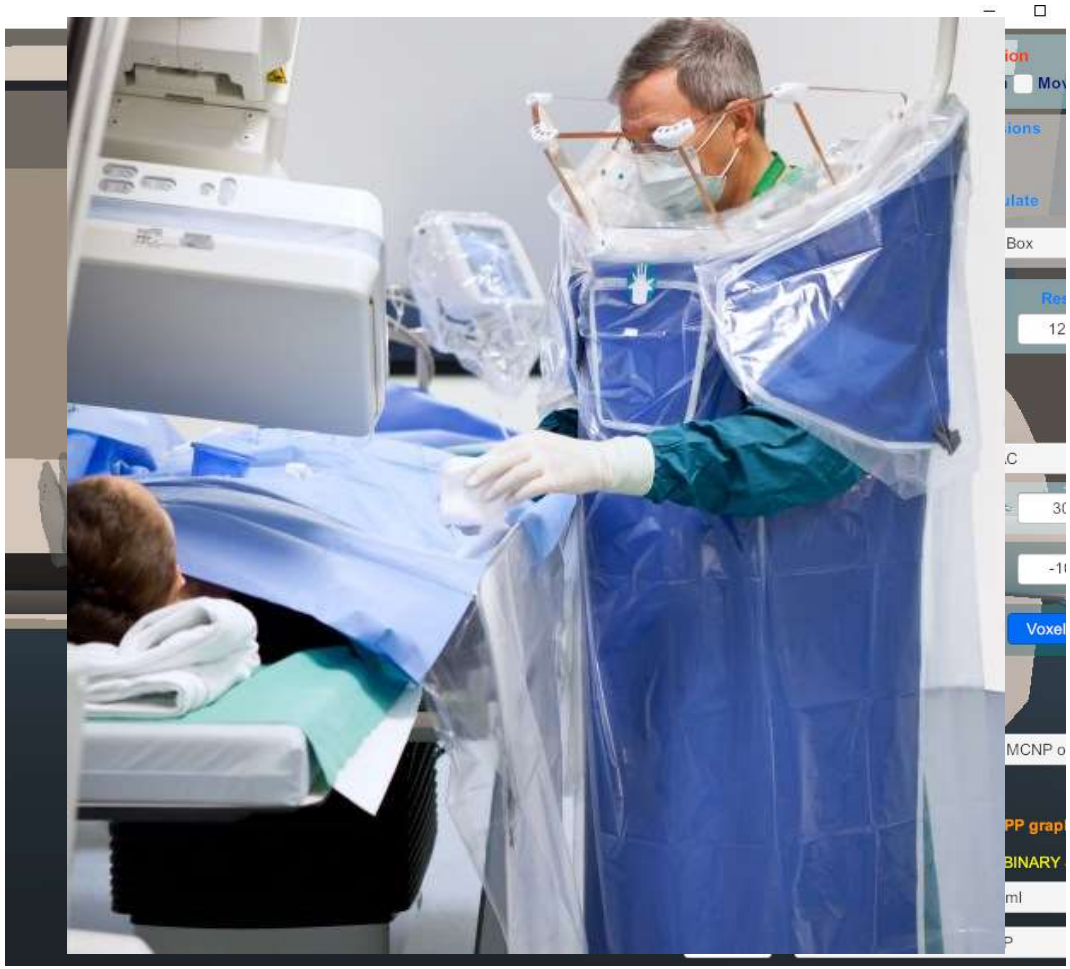


PODIUM
Personal Online Dosimetry
Using computational Methods

Different protections available

PODIUM
Personal Online DosImetry
Using computational Methods

Including Zero Gravity



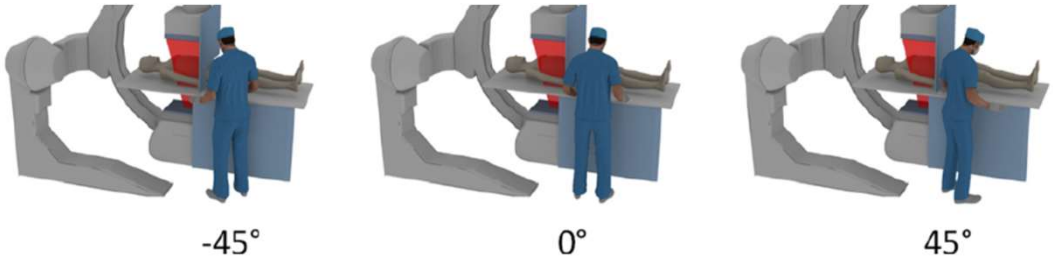
Zero Gravity suspended ceiling system Biotronik.com

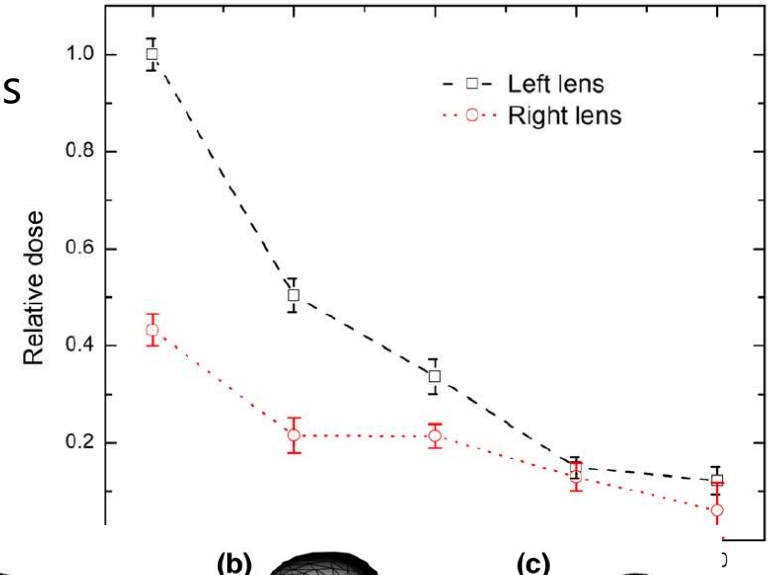
Still some limitations

"limited" number of configurations to be created and simulated

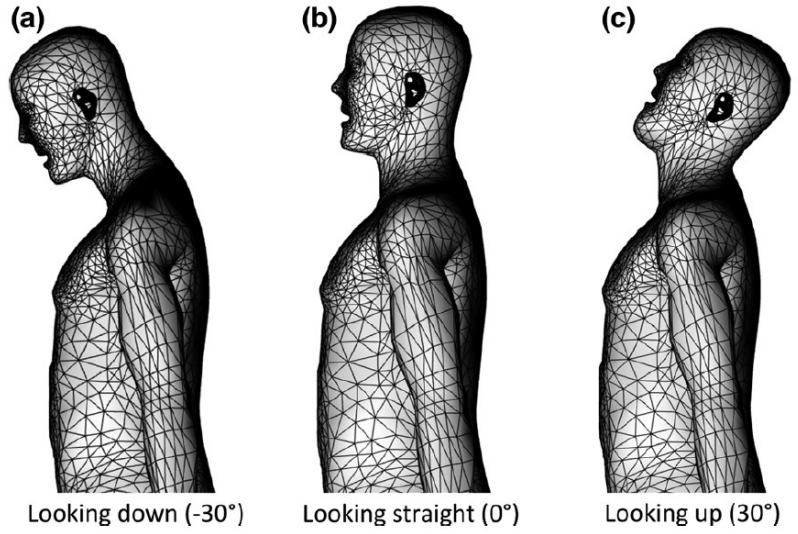
VS

Infinite number of postures in real clinical procedures





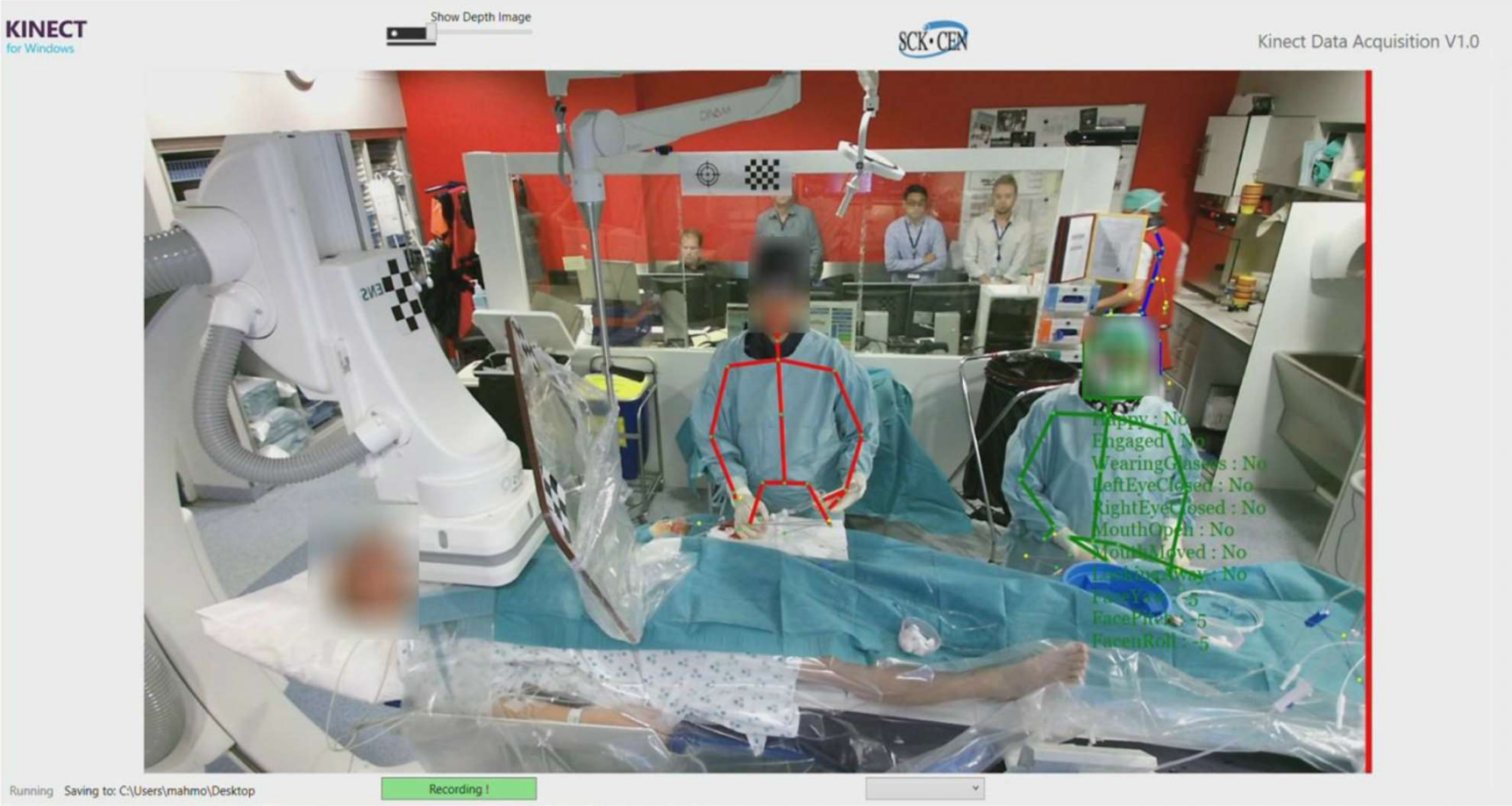
- Never ending opportunity for research!
- Ex: Koukorava et al 2014 JRP, Principi, S., et al. 2016 Phys Med and Mao, L., et al. 2019 Medical Physics; Meas on phantom: Dorey, S., et al. 2019 Radiography



The PODIUM approach

Personal OnlineDosImetryUsing CoMputationalMethods

PODIUM
Personal Online DosImetry
Using computational Methods



Animated phantom coupled with staff tracking system
→ Infinite number of postures in real clinical procedures

There is more than interventional cardiology

Nuclear Medicine

- Electron exposure (Behrens et al 2009; Bruchmann et al 2016):
  - E < 1.5 MeV: Close the eyes / laboratory glasses
  - E < 3.5 MeV: 13 mm thick PMMA or 6 mm thick glass

- Gamma exposure (Cho et al 2016, Bruchmann et al 2016)):
  - eyewear protectors give dose-reduction effect for lower energy sources (123I, 201Tl and 99mTc)
  - lower efficiency for 18F, 111In and 67Ga.

There is more than interventional cardiology

Veterinary medicine

- Same as for human medicine

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