Eye lens doses for medical staff performing interventional procedures

Lara Struelens
Radiation Protection Dosimetry and Calibration

Lara.struelens@sckcen.be

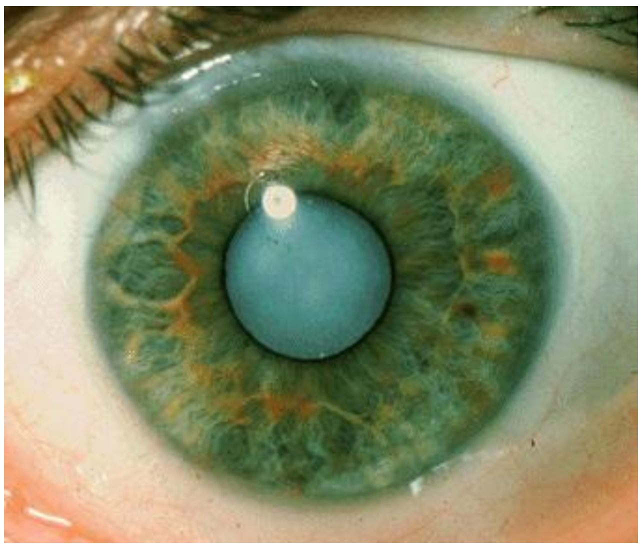
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

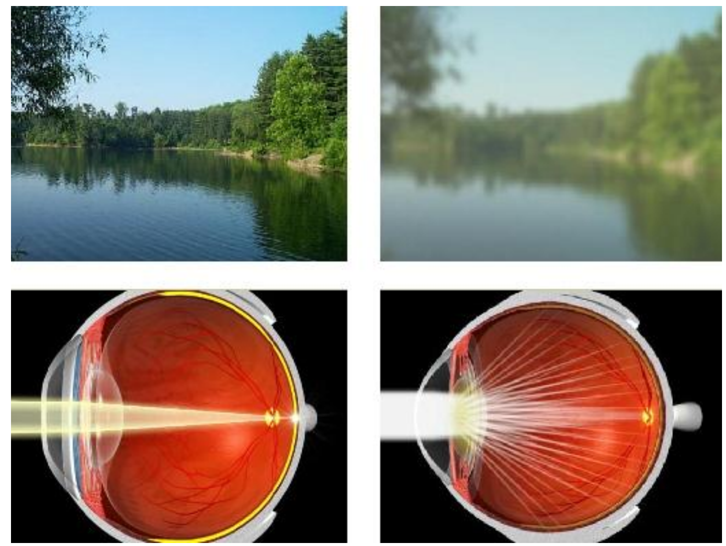
Overview

- Introduction
- Overview of eye lens doses for medical staff
- Radiation Protection of the eye
- Monitoring of eye lens doses
- Conclusion

Introduction

- Cataract: “loss of transparency of the eye lens”
  - Light not properly focused on the retina
  - Starts with lens opacities: no visual impact





  - Associated with aging and metabolic conditions, like diabetes
  - Also radiation-induced

Introduction

- Previous status radiation protection ICRP
  - Cataract induction = deterministic effect with definite threshold
    - Acute exposure: 0,5 – 2 Gy
    - Prolonged exposure: 5-6 Gy
  - Latency period that can last for decades
  - Dose limits
    - 150 mSv/year for occupational exposure

- Recent developments*: epidemiological studies
  - A-bomb survivors, Chernobyl clean-up workers, radiological technologists, …
  - High probability that threshold dose < 0,8 Gy
  - Not certain there is a threshold
  - Current limit is too high

* *Ainsbury EA, Bouffler SD, Dorr W, Graw J, Muirhead CR, Edwards AA, Cooper J. Radiation cataractogenesis: a review of recent studies. Radiat Res 2009; 172:1-9*

Introduction

- ICRP recommendations
  - **ICRP-103** (2007): recommends review of and evaluation of non-cancerous effects of ionising radiation on normal tissue
  - **ICRP-118** (2012): ICRP Statement on Tissue Reactions / Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context

Cataract:
- **Threshold dose of 0,5 Gy** irrespective of the rate of dose delivery
- Dose limits: **20 mSv/year for occupational exposure**
  (averaged over 5 years, with not more than 50 mSv/year)

- Potentially serious implications for some health care professionals
  - medical staff performing interventional procedures

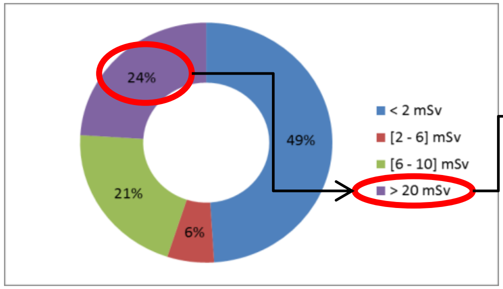
Eye lens doses for medical staff

- EU funded ORAMED project (2008-2011)
  *" **O**ptimization of **RA**diation protection for **MED**ical staff "*

- Overview of eye lens dose measurements
  - Interventional radiologists and cardiologists (>1300 interventional procedures)
  - 6 different countries

- Eye lens doses from **10 µSv to 4 mSv per procedure** (median value of 60 µSv)
- Cumulative **annual eye lens doses from < 1 mSv to 150 mSv**

- Considerable number **(24%)** exceed the annual dose limit of 20 mSv



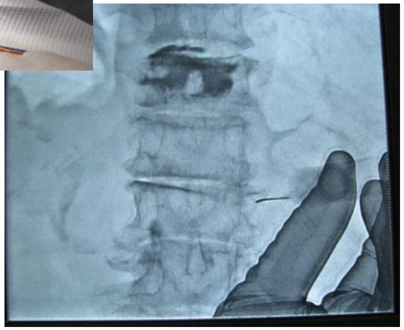
Exceeding the annual limit

Eye lens doses for medical staff

- Belgian ExDos project (2008-2011): financed by FANC

  "Overview of extremity doses and eye lens doses
  for interventional procedures and nuclear medicine in Belgium "

- Overview of eye lens dose measurements
  - 2 Belgian partners: SCK•CEN and UZ-Brussel
  - Belgian extension of ORAMED
    - Extension of measurements from 3 hospitals to 10 hospitals
    - Extra procedure: spine procedures (vertebroplasty and kyphoplasty)



- Eye lens doses from **10 μSv to 836 μSv per procedure** (median value of 34 μSv)
- Cumulative **annual eye lens doses from < 1 mSv to 61 mSv**

Eye lens doses for medical staff

- Recent epidemiological studies
  - French O'CLOC study*
    - 106 Interventional cardiologists and 99 unexposed individuals
    - Posterior subcapsular lens opacities: **17% vs. 5%, p<0.05**

** Jacob S, Boveda S, Bar O, Brézin A, Maccia C, Laurier D, Bernier MO. Interventional cardiologists and risk of radiation-induced cataract: Results of a French multicenter observational study. Int J Cardiol. 2012 May 17*

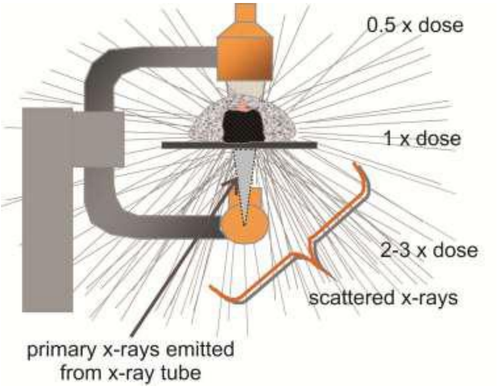
  - Finnish study
    - 16 interventional cardiologists + 20 interventional radiologists
    - **Cortical and PSC lens opacities**
  - IAEA study**: survey at cardiology conference
    - 58 cardiologists, 69 technicians
    - Posterior subcapsular lens changes:
      - **50% vs <10% (cardiologists) and 41% vs <10% (technicians)**

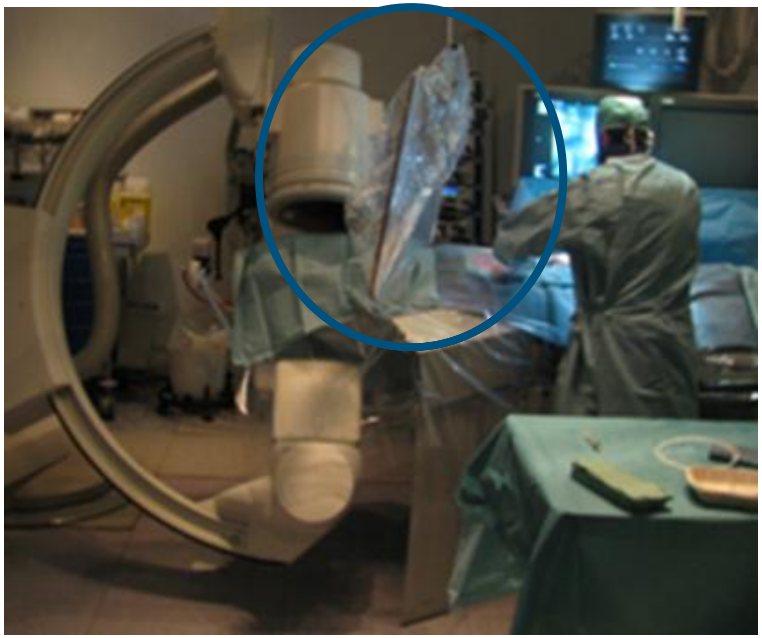
*** Vano E, Kleiman NJ, Duran A, Romano-Miller M and Rehani MM. Radiation-associated Lens Opacities in Catherization Personnel: Results of a Survey and Direct Assessments. J Vasc Interv Radiol 2013; 24:197-204*

Radiation protection of the eye

- Medical staff exposed by scattered radiation from the patient

- Protect the eye with
  - lead ceiling-mounted screens





www.oramed-fp7.eu

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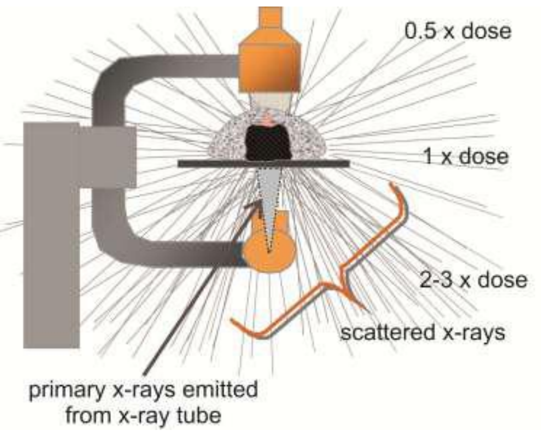

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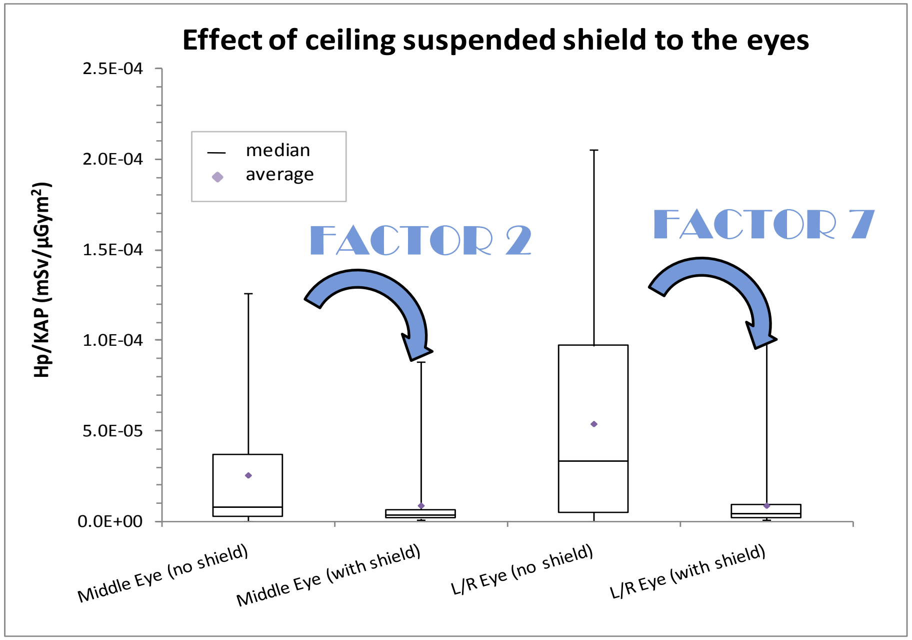

Radiation protection of the eye

- Medical staff exposed by scattered radiation from the patient

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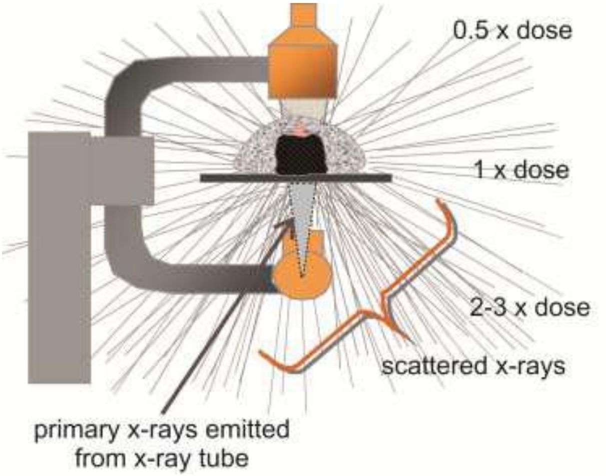
  - lead glasses



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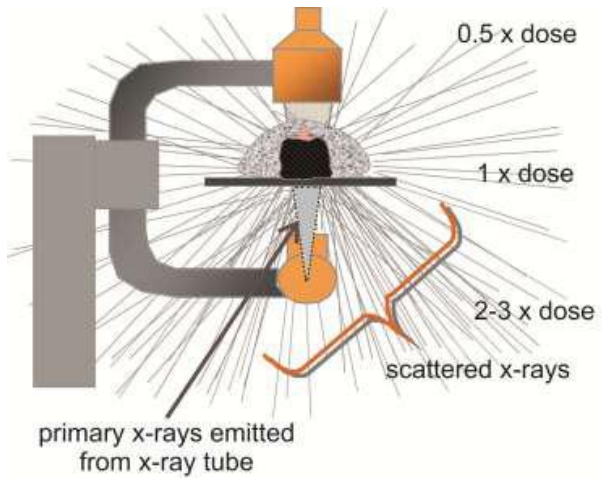

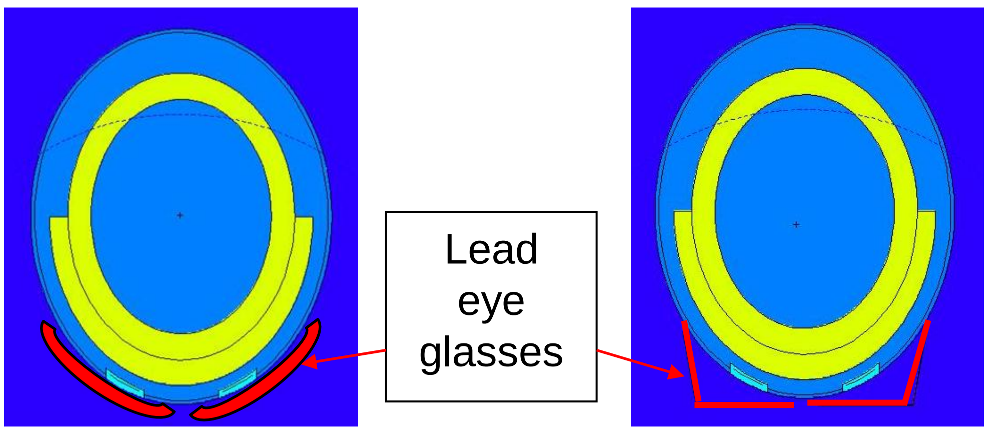

<u>Result:</u>
Ratio with/without lead glasses for any interventional procedure and tube configuration

Left eye = 0.13 (20%)

Right eye = 0.84 (15%)

- www.oramed-fp7.eu
- European ELDO project

Monitoring of eye lens doses

- Need to follow up the eye lens dose
  - for medical staff at risk to exceed annual eye lens dose limit

- ORAMED: development and validation of eye lens dosemeter “EYE-D”
  - Measuring in terms of Hp(3) dose quantity

RADCARD, Poland

Monitoring of eye lens doses

- Need to follow up the eye lens dose
  - for medical staff at risk to exceed annual eye lens dose limit

- ORAMED: development and validation of eye lens dosemeter "EYE-D"
  - Measuring in terms of Hp(3) dose quantity

  - Practical problems: ergonomics of the system
  - Difficult to use in combination with lead glasses

  - Increase of number of dosemeters per person
  - Risk of exceeding dose limit, depend on medical speciality

  - **Alternative method to assess eye lens dose??**

Monitoring of eye lens doses

- European ELDO project (funded by DoReMi network)

"Correlation between eye lens dose and whole body dose"

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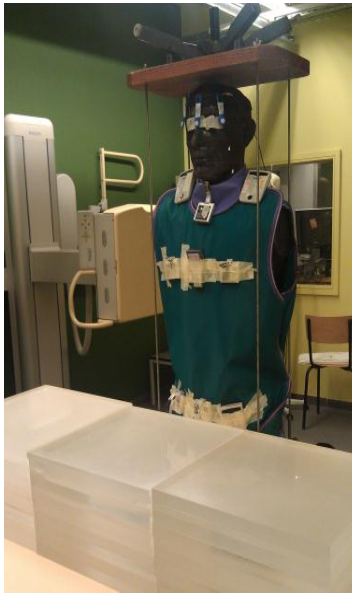
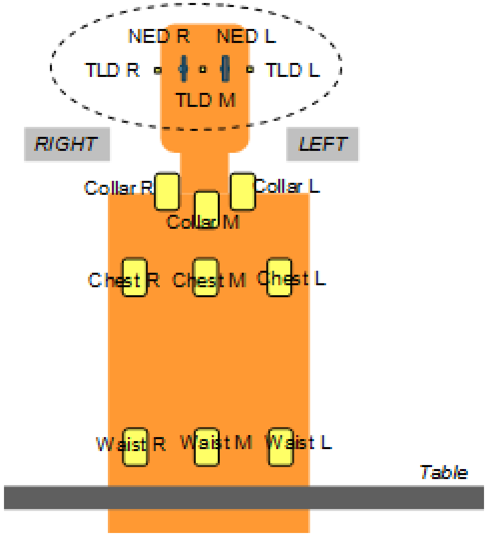
STUK
Bundesamt für Strahlenschutz

- Measurement of eye lens doses and whole body doses in clinical conditions
  - Operator: Rando-Alderson phantom
  - Patient: PMMA plates
  - Passive and active dosemeters
  - Measurements above the lead apron
    - Eye level
    - Collar level
    - Chest level
    - Waist level
    - Left – middle – right side



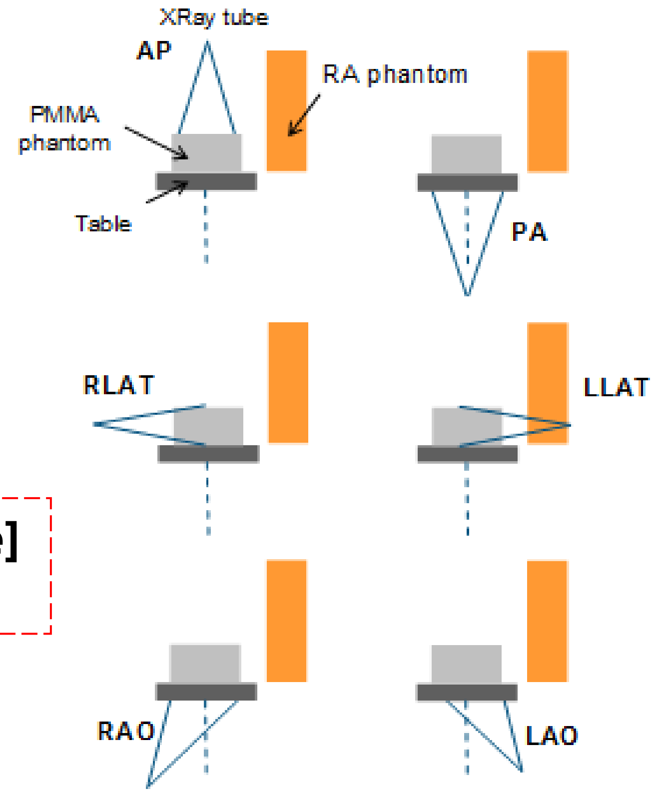


Monitoring of eye lens doses

- European ELDO project (funded by DoReMi network)

  "Correlation between eye lens dose and whole body dose"

- Clinical conditions
  - Different x-ray beam projections
  - Different operator positions with respect to the x-ray field
  - Different x-ray beam energies
  - Mono-plane and bi-plane x-ray systems



Result = ratio [eye lens dose/whole body dose] and associated uncertainty

  - Without protection equipment (lead glasses and ceiling-mounted screen)

Monitoring of eye lens doses

- All measurement configurations together (48 cases)

Ratio of average **left eye** lens dose and whole body dose measured at different locations, considering **all projections and operator positions**.

	Collar L	Collar M	Collar R	Chest L	Chest M	Chest R	Waist L	Waist M	Waist R
Ratio	3.3	2.1	11.5	0.8	1.2	2.5	1.5	1.8	8.0
Standard deviation	**42%**	48%	81%	90%	73%	100%	159%	143%	147%

Best correlation

Ratio of average **right eye** lens dose and whole body dose measured at different locations, considering **all projections and operator positions**.

	Collar L	Collar M	Collar R	Chest L	Chest M	Chest R	Waist L	Waist M	Waist R
Ratio	2.7	1.7	8.6	0.7	0.9	1.8	1.3	1.6	6.2
Standard deviation	**42%**	45%	73%	90%	58%	101%	164%	153%	155%

Monitoring of eye lens doses

- Measurement per type of procedure

Ratio of average **left eye** lens dose and whole body dose measured at different locations, considering projections and operator positions for **CA&PTCA** and **RF ablations**.

	Collar L	Collar M	Collar R	Chest L	Chest M	Chest R	Waist L	Waist M	Waist R
Ratio	4.0	2.6	12.8	0.7	1.0	1.9	0.5	0.7	3.7
Standard deviation	**41%**	40%	56%	52%	56%	50%	46%	64%	101%

Reduced uncertainties

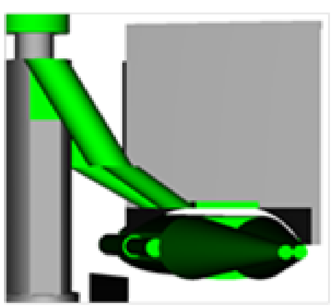
Ratio of average **left eye** lens dose and whole body dose measured at different locations, considering projections and operator positions for **pacemaker procedures**.

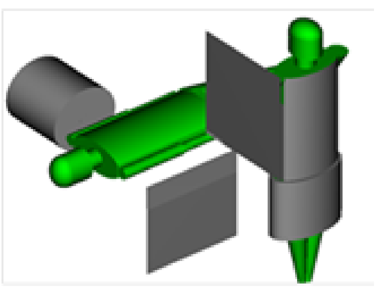
	Collar L	Collar M	Collar R	Chest L	Chest M	Chest R	Waist L	Waist M	Waist R
Ratio	3.4	2.4	8.2	0.7	0.9	1.7	0.5	0.7	2. 7
Standard deviation	36%	52%	70%	**23%**	41%	35%	40%	52%	87%

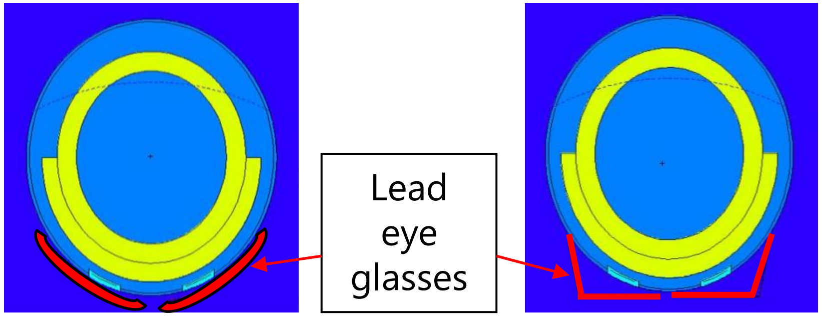
Monitoring of eye lens doses

- Influence of **the use of protection equipment** on these ratio's

- Monte Carlo calculations
  - Variation of eye lens dose and whole body dose with
    - Shape of lead glasses
    - Thickness of lead
    - Position and shape of ceiling-mounted lead screen
  - For all possible x-ray projections, operator positions and x-ray tube configurations







Result = correction coefficients considering effect of protection and associated uncertainty

Monitoring of eye lens doses

- Effect of ceiling shield (19 cases)

Ratio of dose **with/without ceiling-mounted lead screen**, considering all projections and operator positions.

	Eyes	Collar	Chest	Waist
Ratio	0.51	0.63	0.75	0.82
Standard deviation	70%	54%	34%	22%

- Effect of lead glasses (27 cases)

Ratio of dose **with/without lead glasses**, considering all projections and operator positions.

Large influence of glasses shape
- Rounded model: 0.17
- Squared model: 0.63

More calculations on-going !!!

	Left Eye	Right Eye
Ratio	0.13	0.84
Standard deviation	20%	15%

PRELIMINARY

Monitoring of eye lens doses

Summary

- The correlation between eye lens and whole body dose depends on
  - Type of procedure
  - The position of the whole body dosemeter (always ABOVE lead apron)
  - The working practice
    - position of operator
    - The use of protective equipment

- Assessing eye lens dose from whole body dose can introduce **large uncertainties**
  (40% to 160% without protection ; additional 15% to 70% for use of protection)
  - This method is first evaluation of eye lens dose
  - If assessed dose is high: specific person can benefit from wearing eye lens dosemeter routinely

- Useful for future retrospective epidemiological study of this population

Conclusion

- Medical staff performing interventional procedures is at risk of exceeding annual dose limit for the eye lens (20 mSv)
  - Measured eye lens doses are high, especially if no protection is used
  - Recent epidemiological studies show increased prevalence of lens opacities for this population
- Monitoring eye lens dose is crucial
  - First evaluation possible from whole body dose records (above the lead apron)
  - Lack of practical eye lens dosemeter
    - Also to be used in combination with lead glasses
- At least as important is the awareness from the medical staff of the risk and the implementation of protection tools
  - Eye lens doses can be significantly reduced if lead glasses and ceiling-mounted shields are **properly** used

Conclusion

- More research is continuously performed related to the dose-response of radiation-induced lens opacities in the low-dose range

- Currently preparing an **European** epidemiological study on radiation-induced cataract for interventional cardiologists
  - Several European countries are preparing the creation of a national cohort using the same protocols (ELDO project)
  - Joined analysis of the pooled European cohort
  - To elucidate further the reduction of the threshold for cataract (ICRP-118)
  - To confirm if there is a threshold

  - Belgium is also participating in this study and in preparation of creating a national cohort of interventional cardiologists
    - Retrospective assessment of eye lens doses
    - Performance of ophthalmological examinations

Questions?

Thank you for your attention !!!

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Centre d'Etude de l'Energie Nucléaire
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Fondation d'Utilité Publique
Foundation of Public Utility

Registered Office: Avenue Herrmann-Debrouxlaan 40 – BE-1160 BRUSSELS
Operational Office: Boeretang 200 – BE-2400 MOL

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