Reference Dose Coefficients for Occupational External Exposure

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Conversion Coefficients (c.c.) for use in Radiological Protection against External Radiation

Previously appeared in *Publication 74* (1996) / ICRU57, based on ICRP recommendations of *Publication* 60 (1991)

The new recommendations of *Publication* 103 (2007) made re-computation of c. c. necessary:

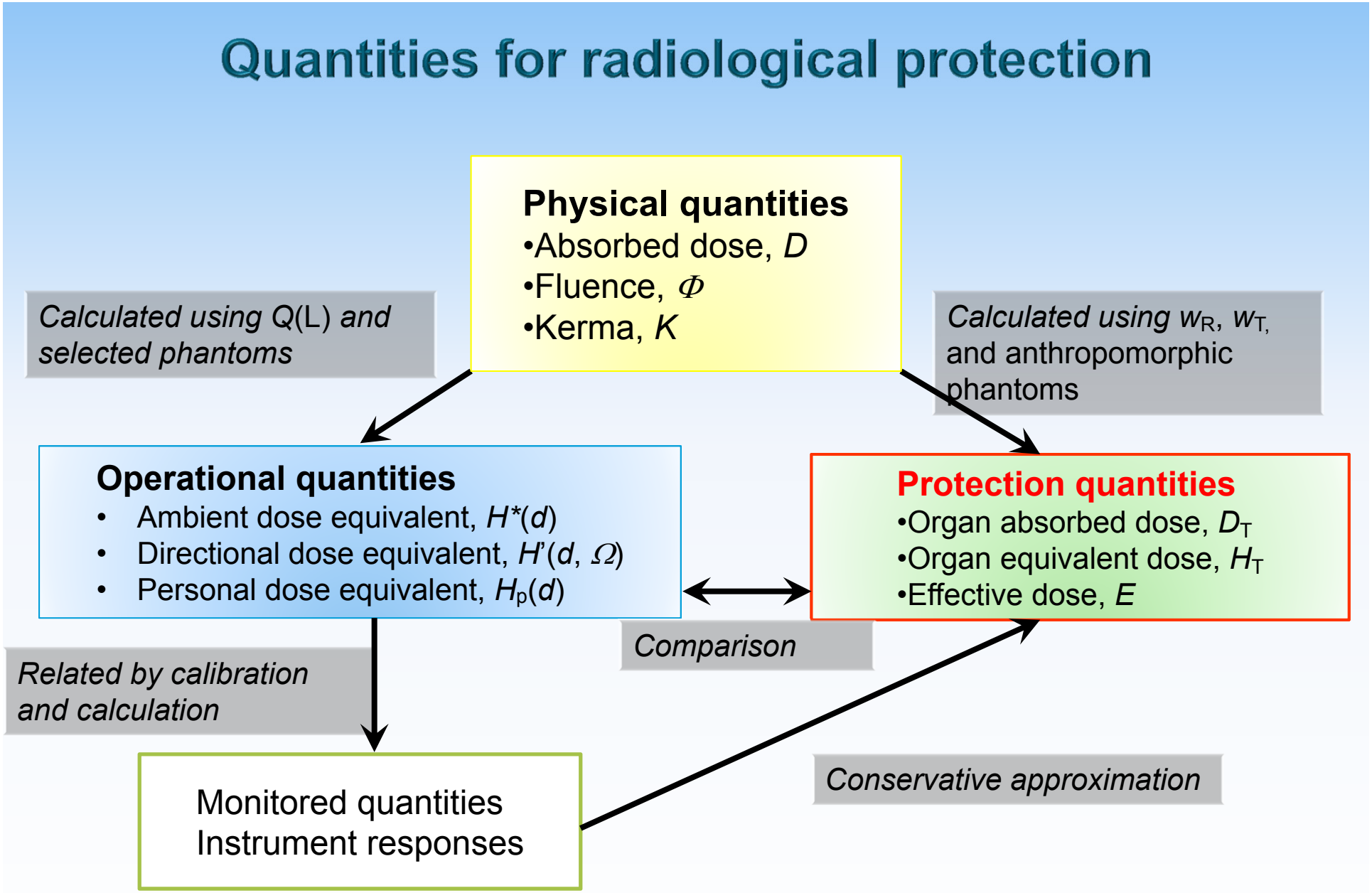
Revision of Publication 74 (1996):

Publication 116 (2010)

Radiation protection monitoring

- The practical implementation of the radiation protection requires appropriate methods and instruments for **monitoring radiation exposure**
- Exposure limits, reference levels and dose constraints are given in effective dose, E
- E is not a measurable quantity
- For external radiation, ICRU has therefore introduced operational quantities which are used for the calibration of instruments for ambient and individual monitoring, in particular for occupational exposure (ICRU 1985 and ICRU 1988)

Quantities for radiological protection



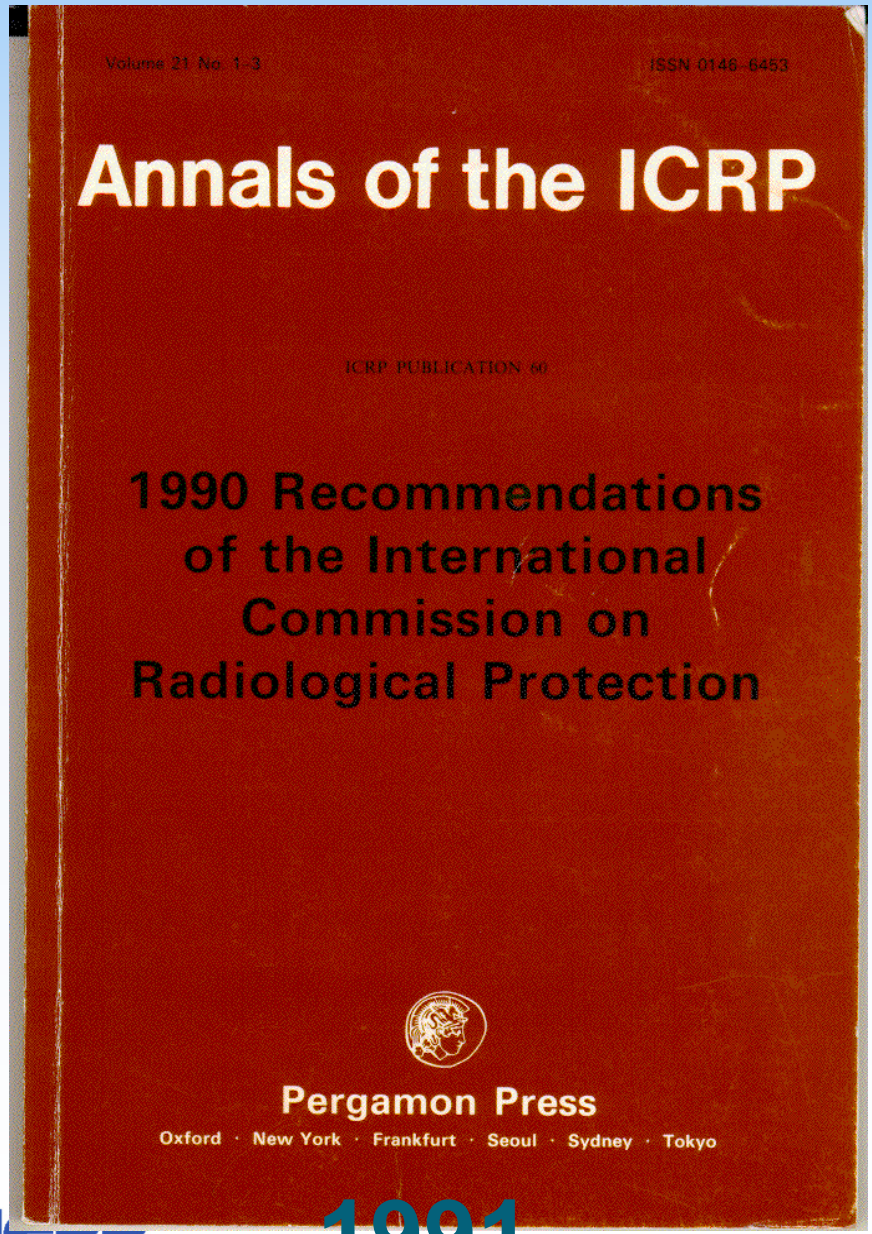
ICRP dose (conversion) coefficients for external occupational exposures

A coefficient relating a dose quantity to a physical quantity. For external exposure, the physical quantity is the ‘fluence’ or ‘air kerma’

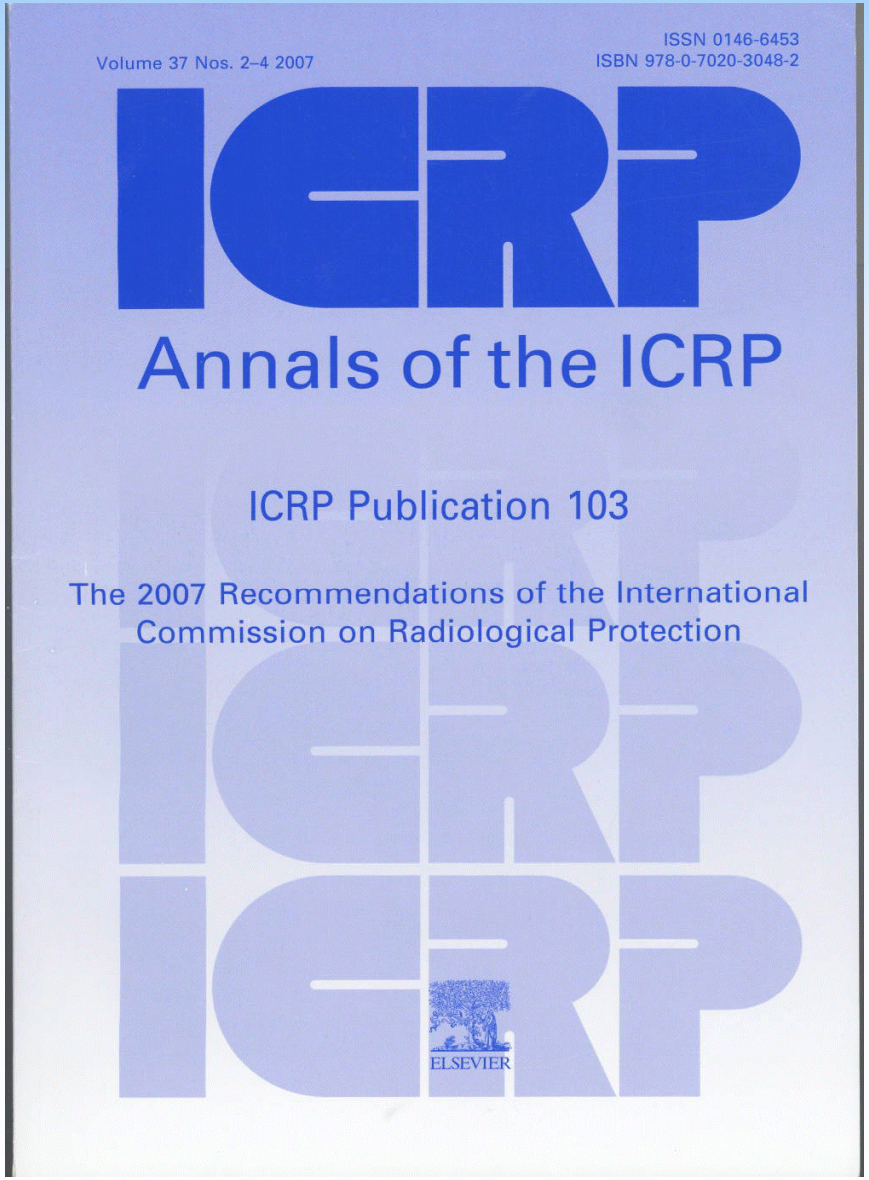
$$E_{Ref\ Person} = (ICRP\ Dose\ Coef)_{Ref\ Person} \times (\Phi\ or\ K_a)$$

Generally c.c. are calculated using radiation transport codes (Monte Carlo) and mathematical representations of the human body i.e. phantoms

ICRP 60 → ICRP 103: What did change that influences the dose coefficients?



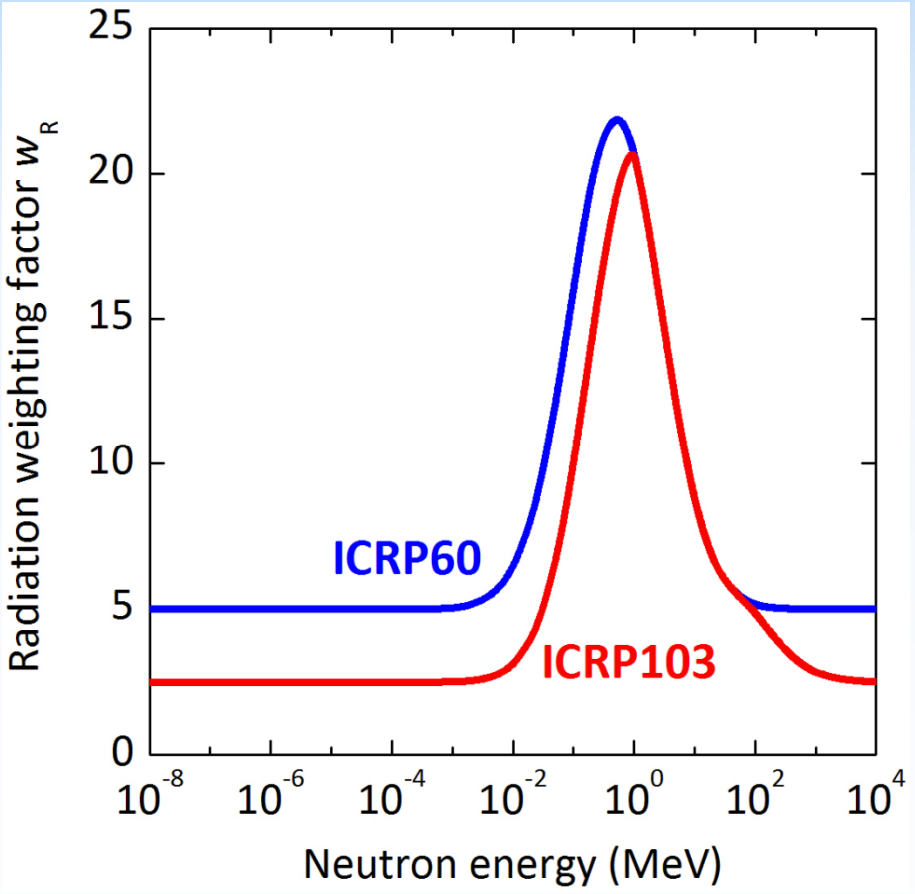
1991



2007

Radiation weighting factors, w_R

Radiation type	1990	2007
Photons	1	1
Electrons, muons	1	1
Protons	5	**2**
Charged pions	–	**2**
α particles, fission fragments, heavy ions	20	20
Neutrons	**Right figure**	



Tissue weighting factors W_T

Organ·tissue	1990	2007
Red bone marrow	0.12	0.12
Colon	0.12	0.12
Lung	0.12	0.12
Stomach	0.12	0.12
Breast	0.05	**0.12**
Gonads	0.20	**0.08**
Bladder	0.05	**0.04**
Oesophagus	0.05	**0.04**
Liver	0.05	**0.04**
Thyroid	0.05	**0.04**
Endosteum	0.01	0.01
Skin	0.01	0.01
Brain	–	**0.01**
Salivary glands	–	**0.01**
Remainder tissues	0.05	**0.12**

Effective dose in *Publication* 103: sex averaged

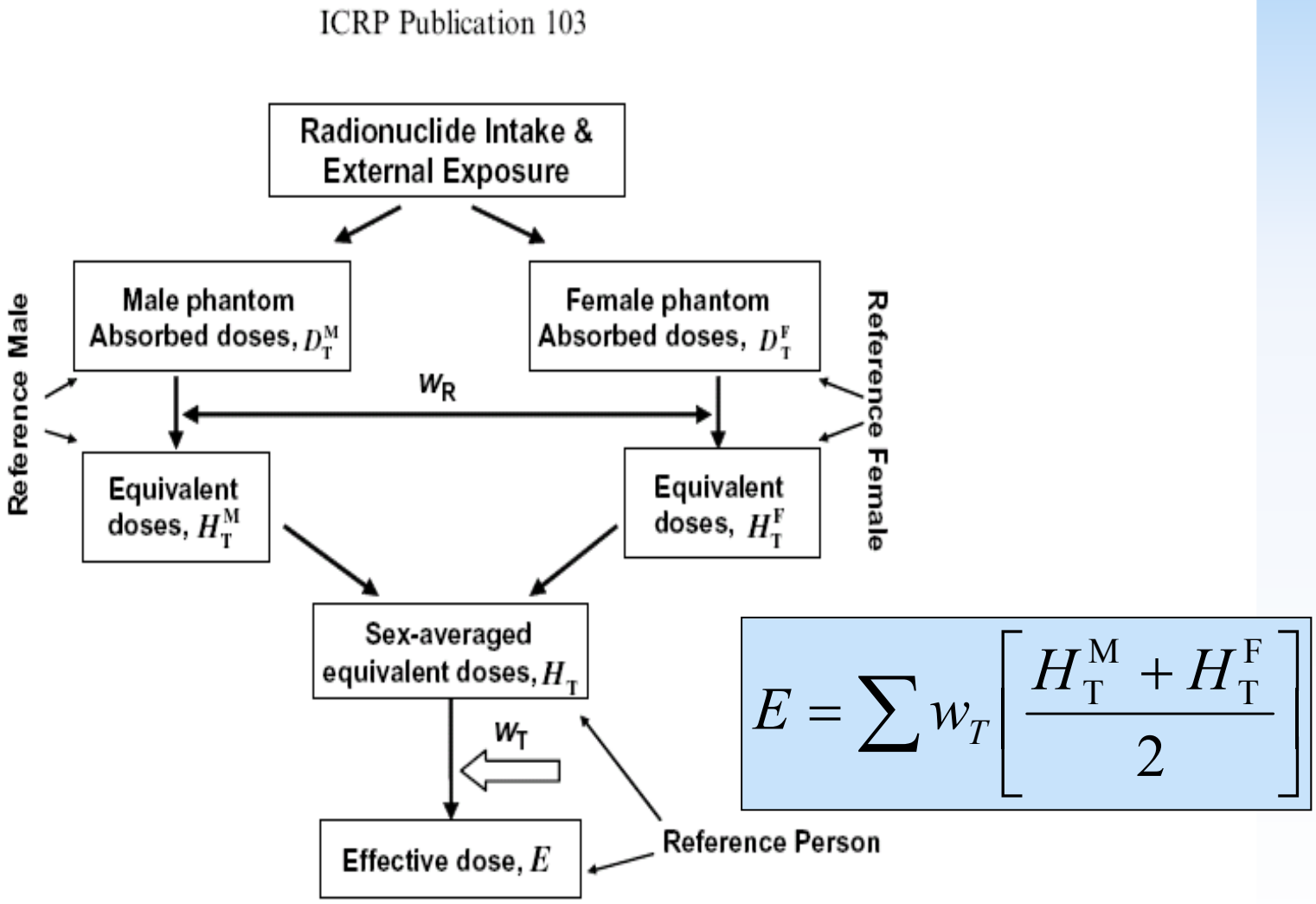
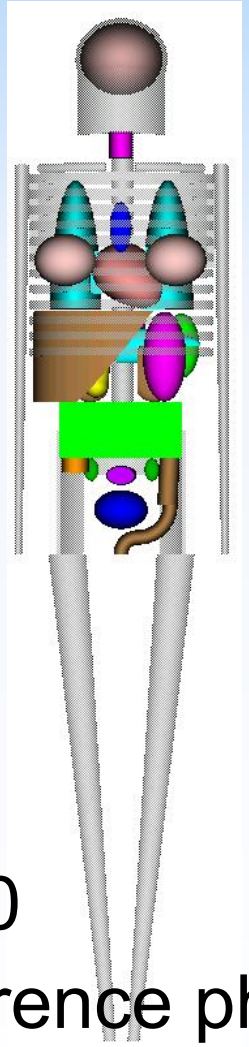


Fig. 2. Sex averaging to obtain the effective dose.

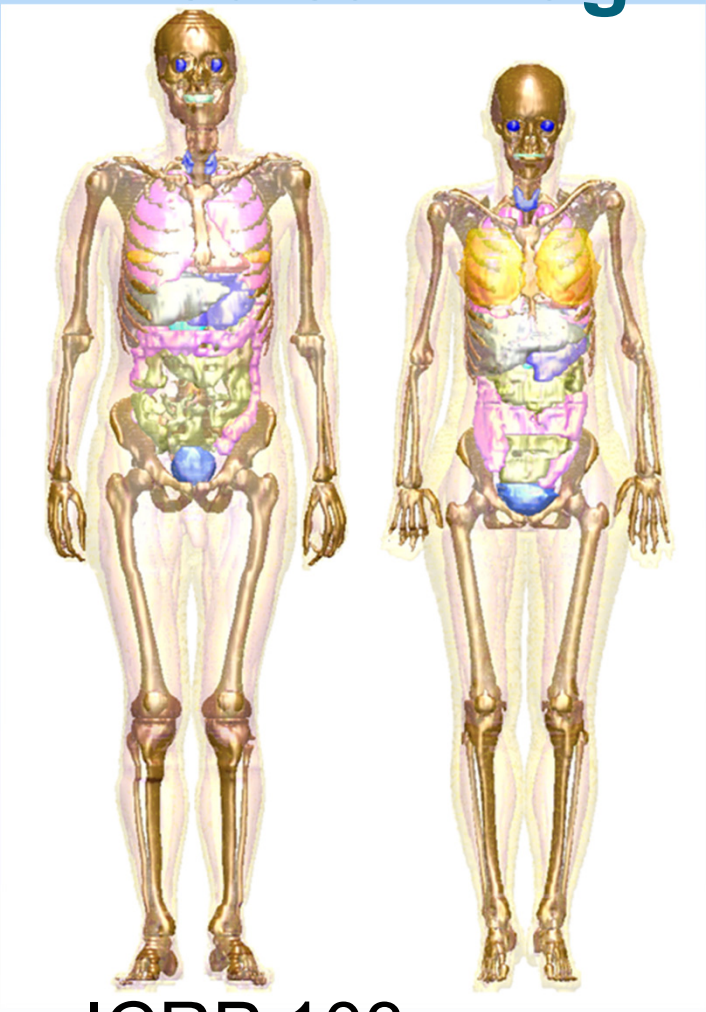
MIRD stylized phantoms



ICRP 60

No reference phantoms

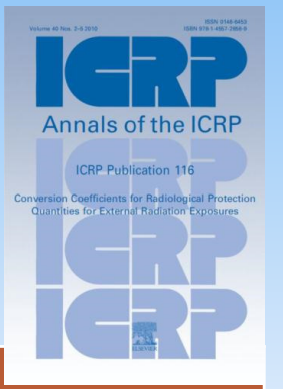
Voxel phantoms based on medical imaging



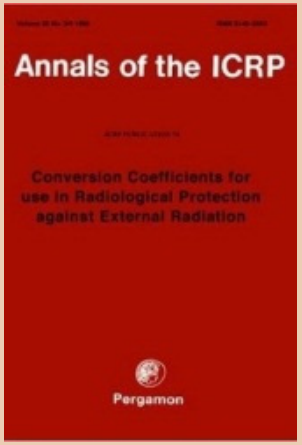
ICRP 103

reference phantoms

ICRP Publication 116
Conversion Coefficients for Radiological Protection Quantities for External Radiation Exposures

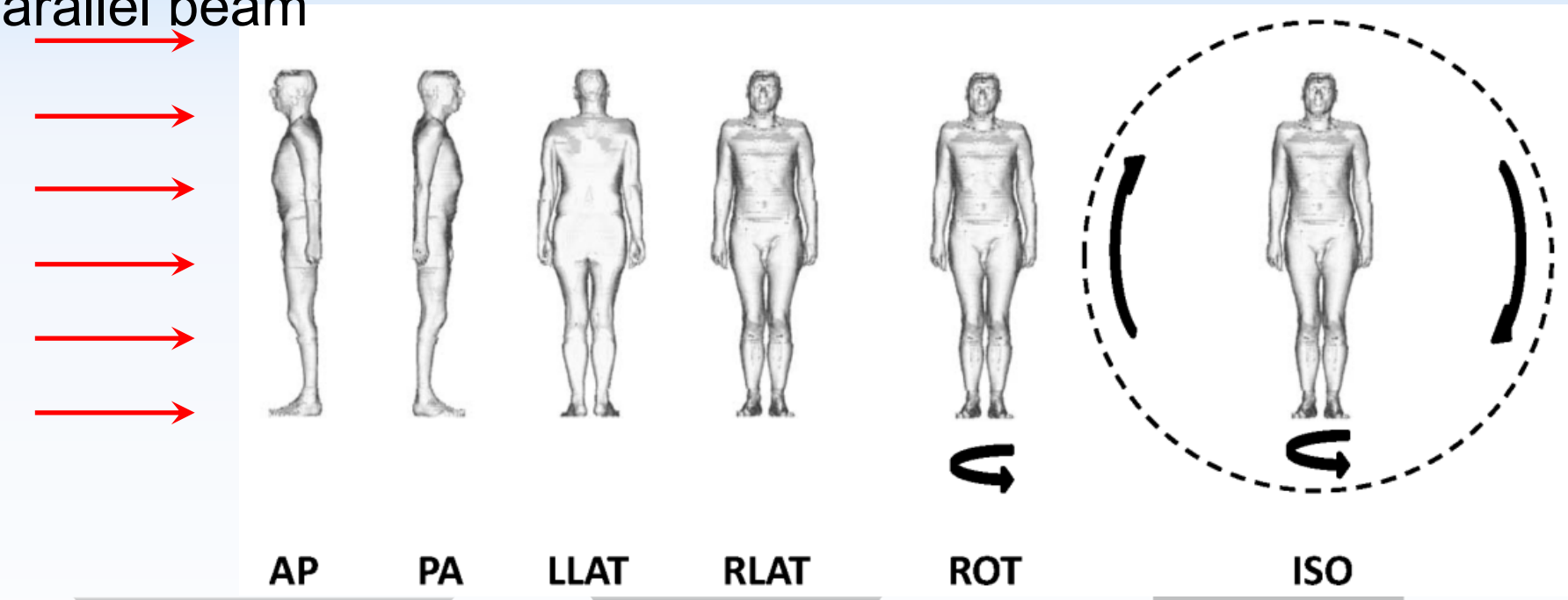


ICRP74 / ICRU57	ICRP116
● Photons: 10 keV – 10 MeV ● Neutrons: 0.001 eV – 180 MeV ● Electrons: 100 keV – 10 MeV ● Operational quantities for the above radiations	● Photons: 10 keV – 10 GeV ● Neutrons: 0.001 eV – 10 GeV ● Electrons/Positrons: 50 keV – 10 GeV ● Protons: 1 MeV – 10 GeV ● Muons±: 1 MeV – 200 GeV ● Pions±: 1 MeV – 10 GeV ● He ions: 1 MeV/u – 100 GeV/u ● Skeletal dose response functions ● DCC for the lens of the eye ● DCC for skin ● DCC for semi-ISO geometry ● Data CD and download (ASCII & Excel)



Dose coefficients are evaluated using Monte Carlo simulations of radiation transport in the reference phantoms for idealized radiation fields

Parallel beam



Antero-Posterior

Posterior-Anterior

Left Lateral

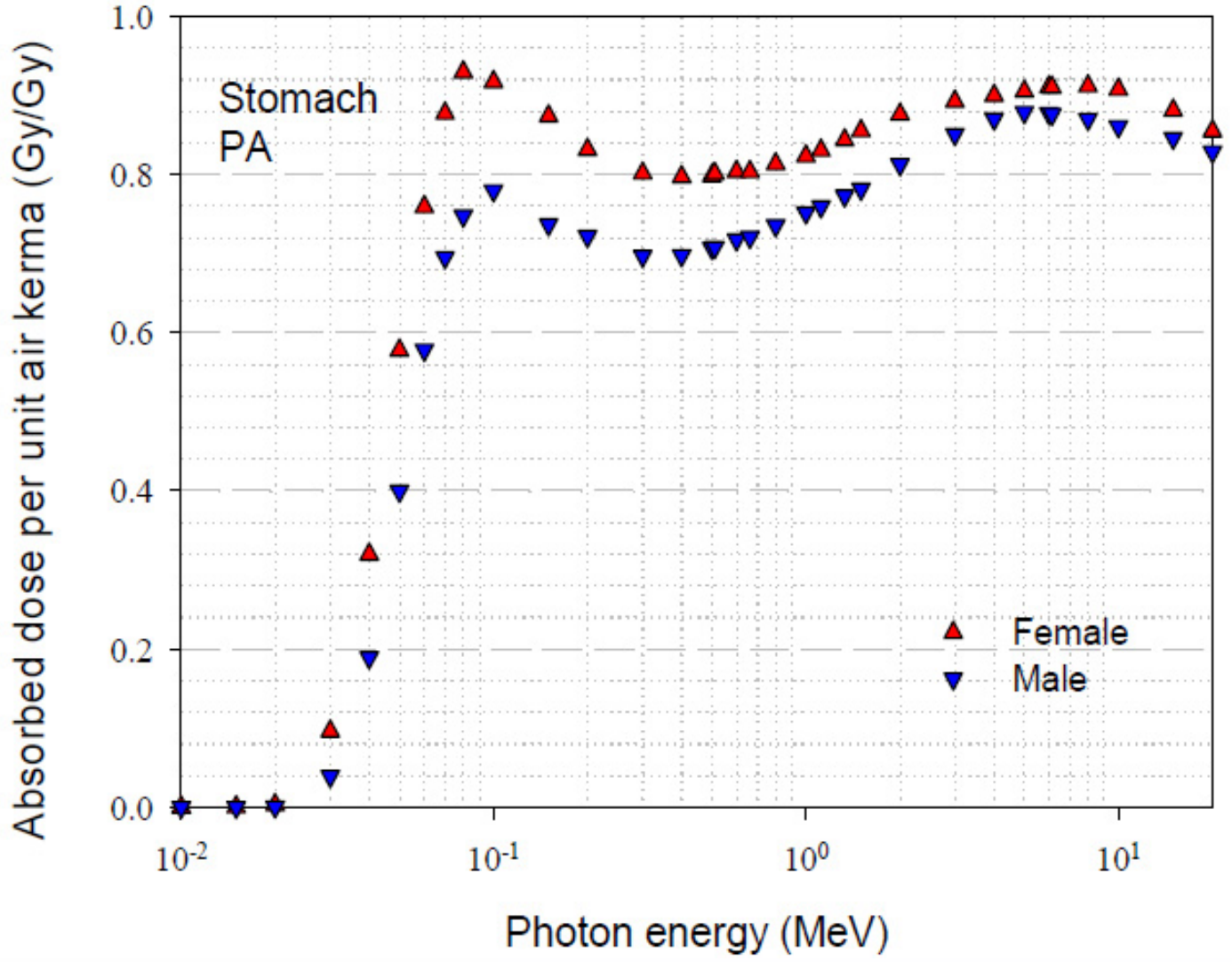
Right Lateral

Rotational

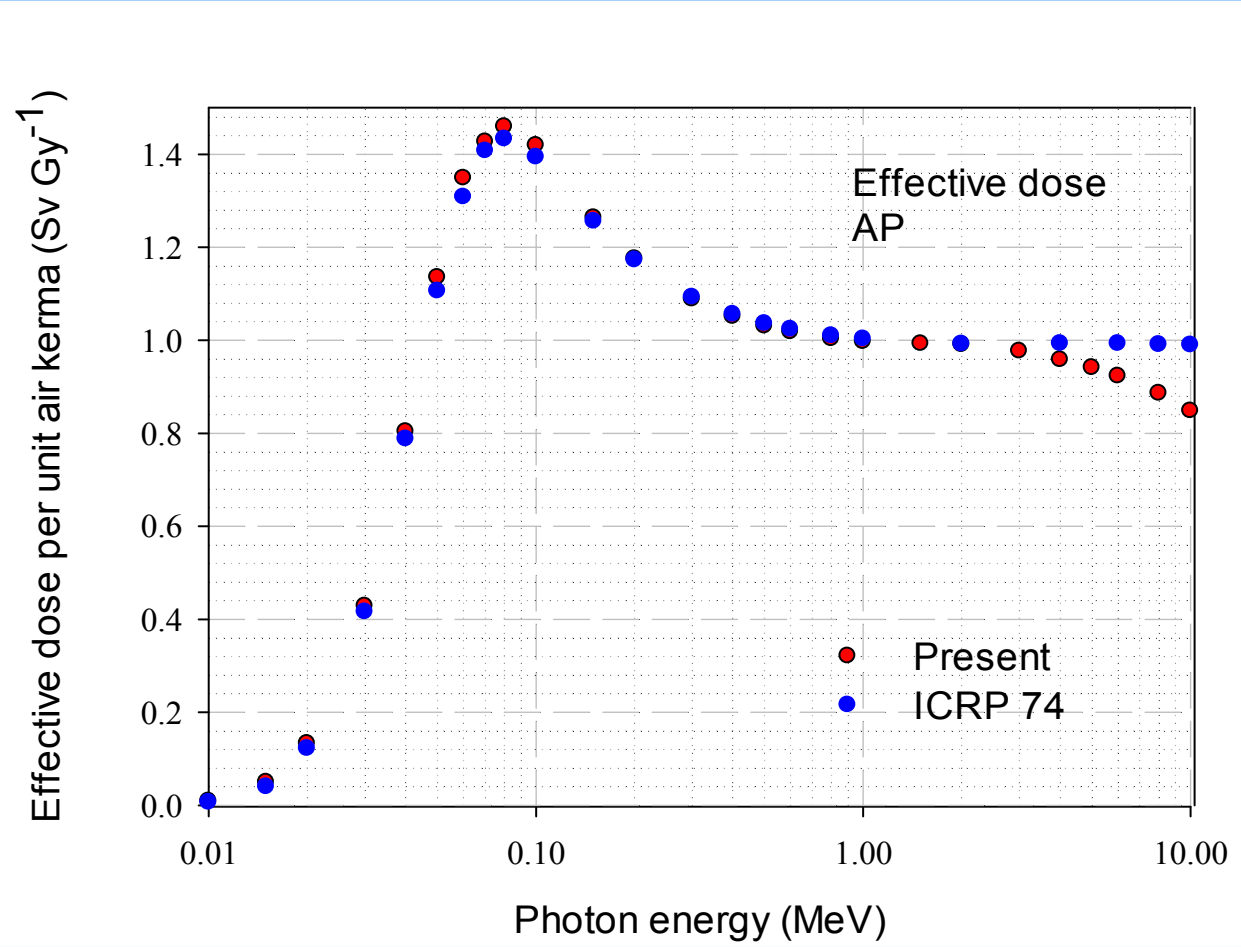
Isotropic

Semi Isotropic

Photons: There are sex differences

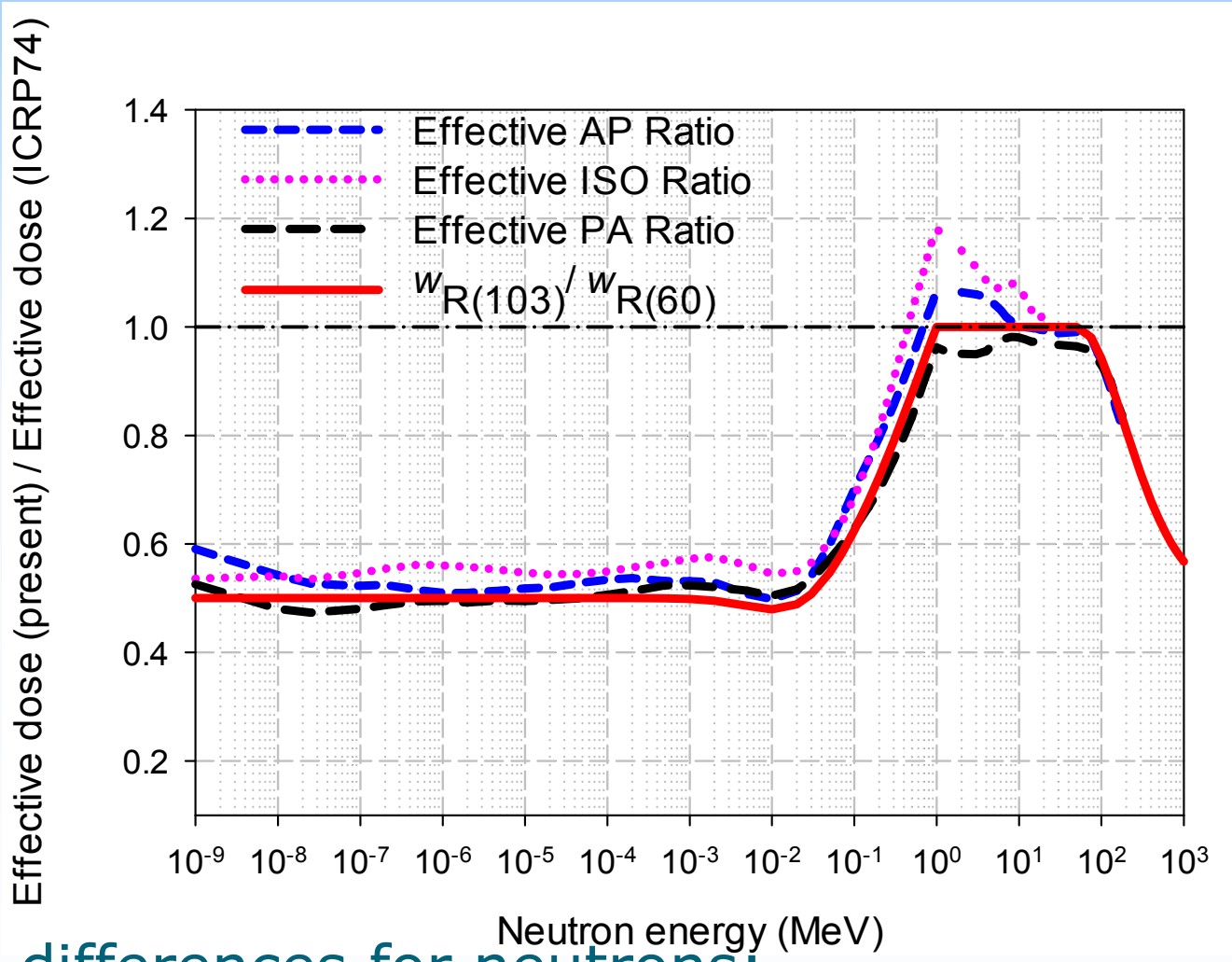


Comparison: effective dose (ICRP116 vs. ICRP74)

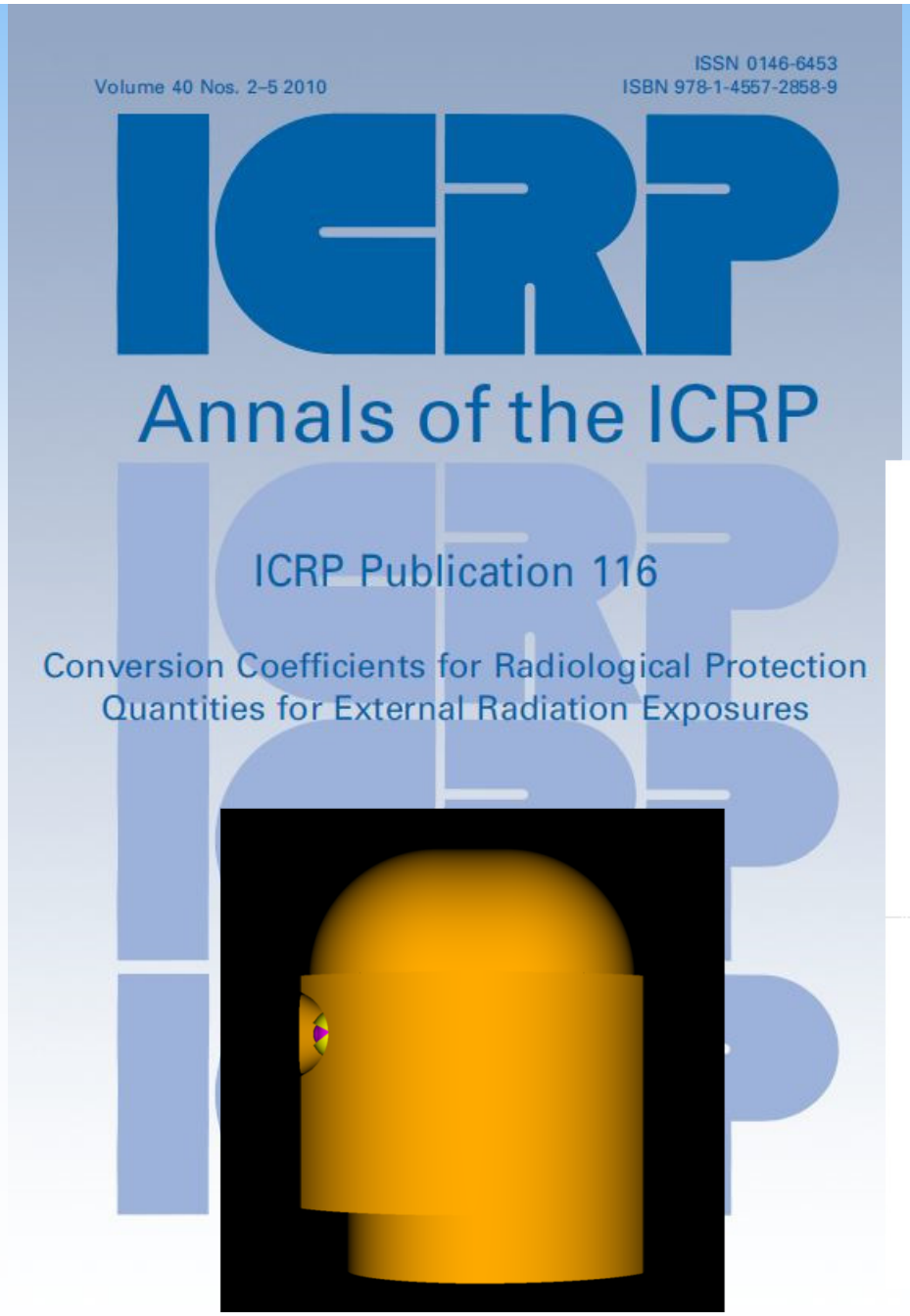


Not much difference for photons; old values calculated with kerma approximation → overestimation for superficial organs and energies above 500 keV

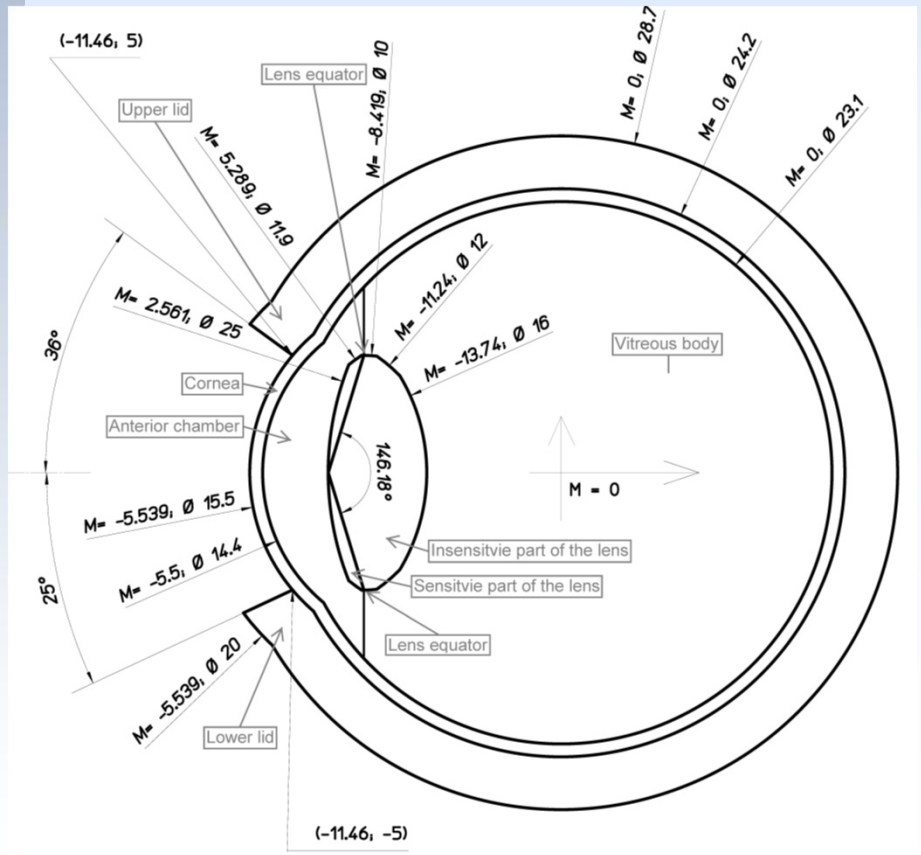
Comparison: effective dose (ICRP116 vs. ICRP74)



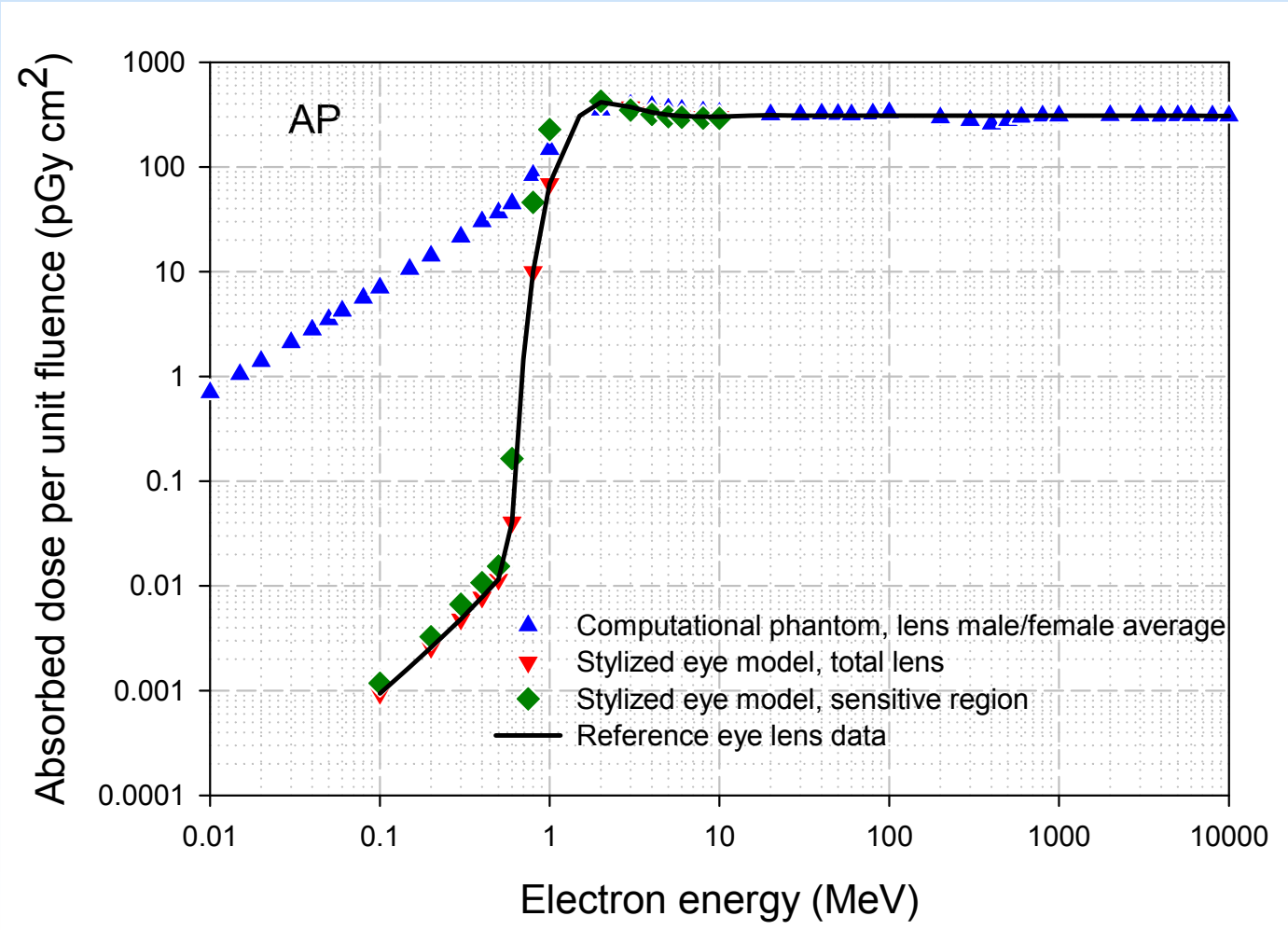
Larger differences for neutrons;
Largest contribution to the difference stems from the change of W_R



Special considerations to the eye lens dose



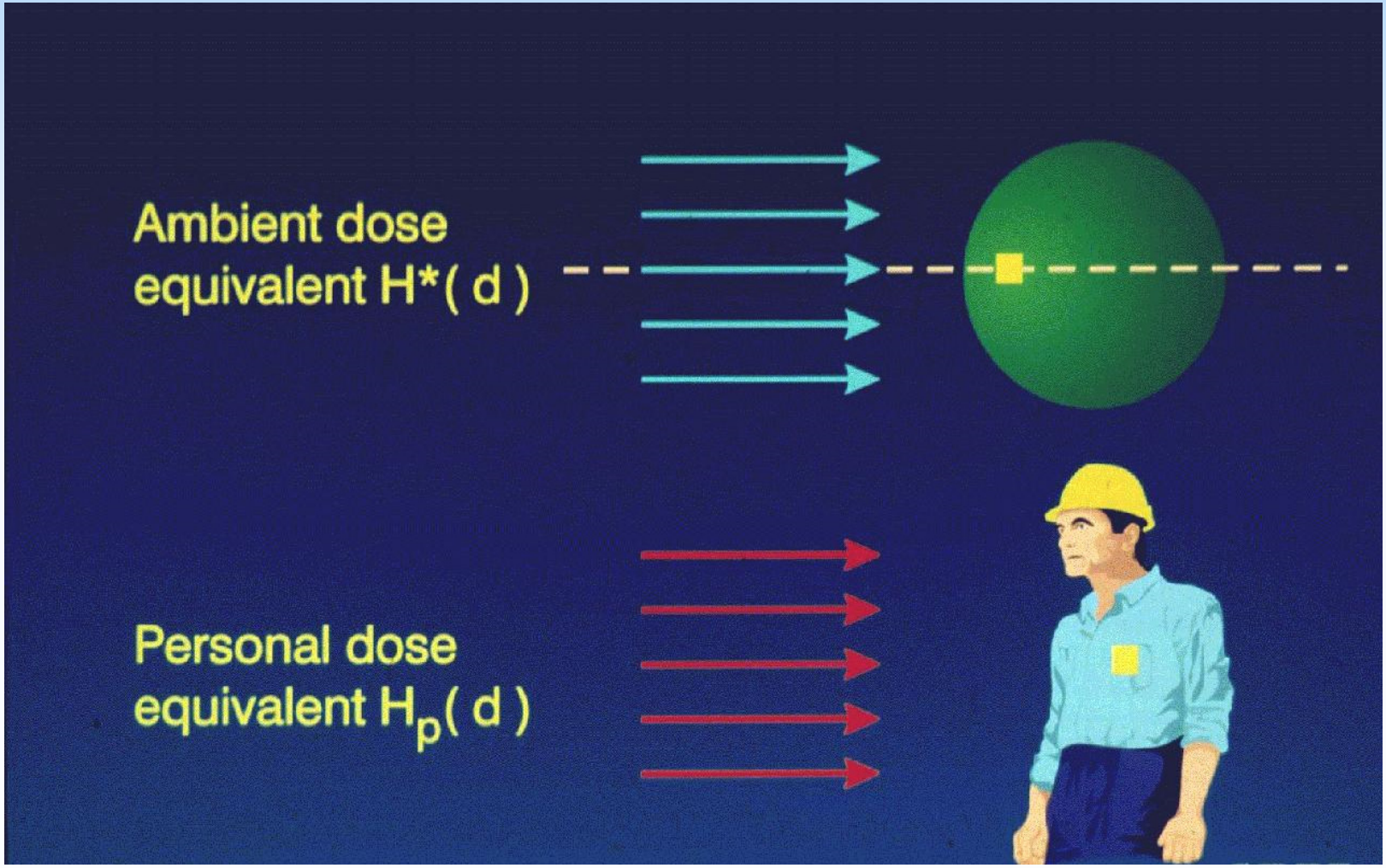
Electrons, AP: Eye lens absorbed doses as calculated with the reference phantoms and the stylised model. The coefficients evaluated with the reference phantoms present an overestimation for low electron energies



Operational quantities

- Used to provide a reasonable estimate of the protection quantities to assess and demonstrate compliance with the limits
- Ambient Dose Equivalent
- Directional Dose Equivalent
- Personal Dose Equivalent
- **Measurable**

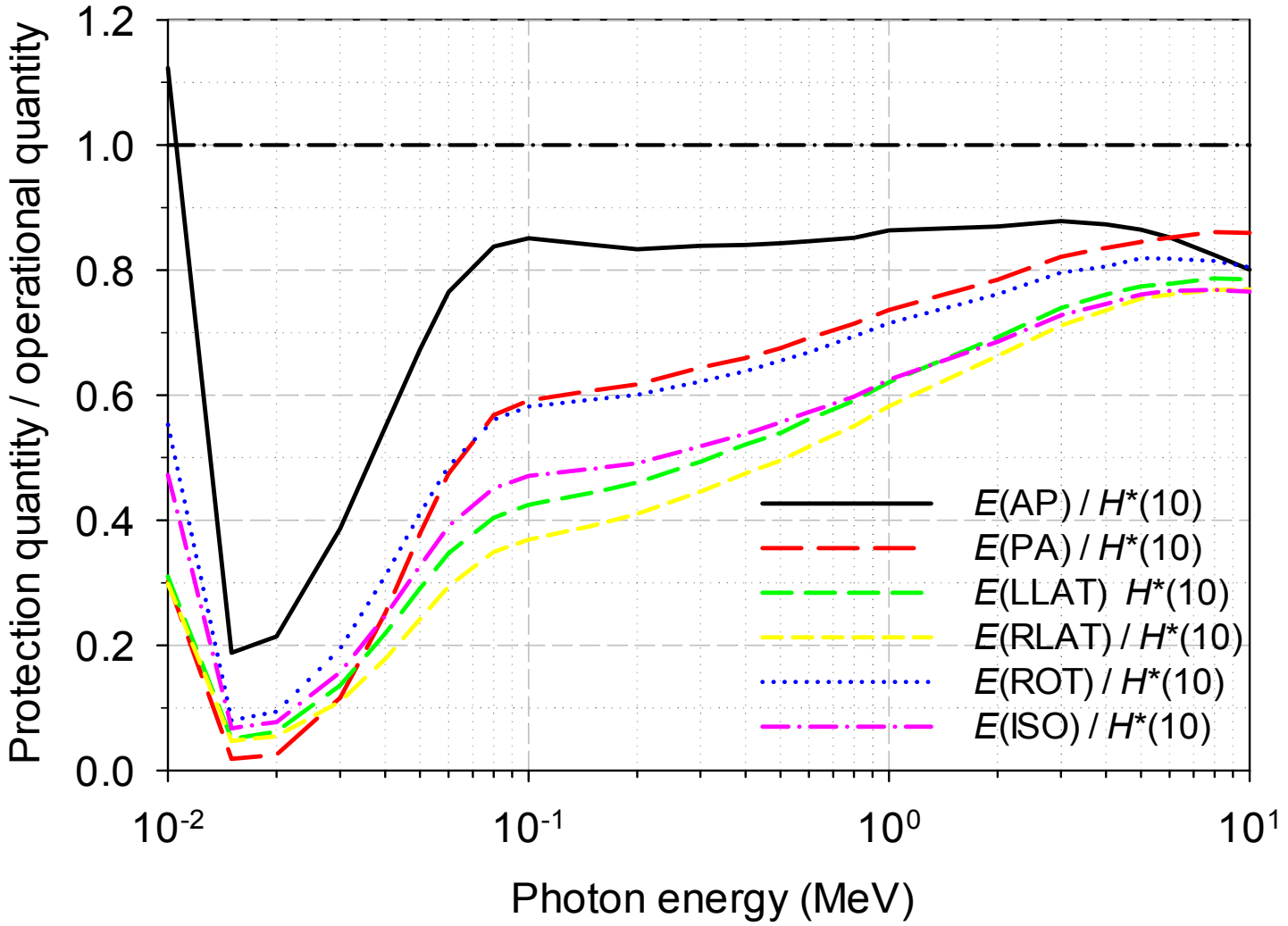
Operational quantities for external radiation



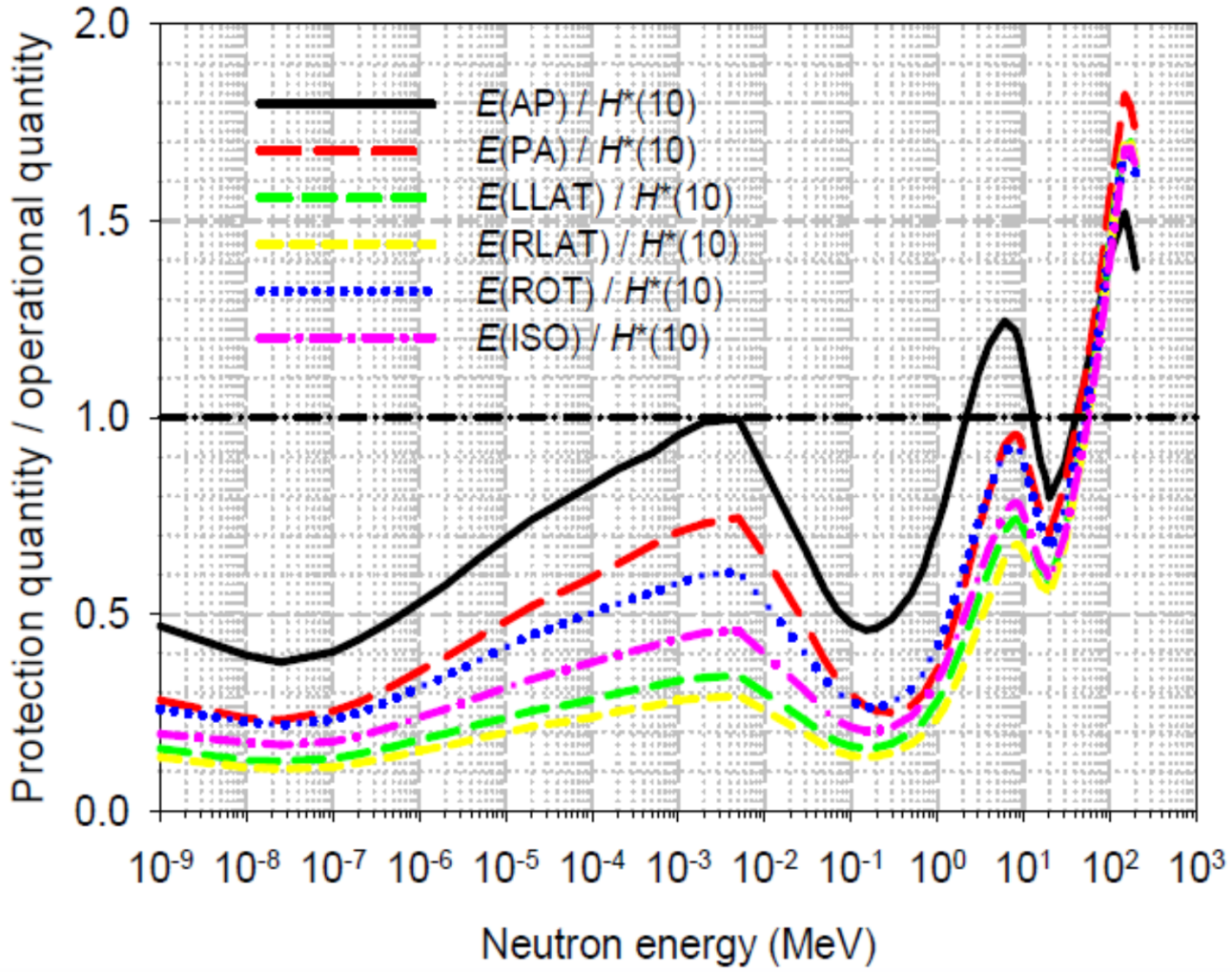
Are the operational quantities still good approximations of the protection quantities?

- Ambient and Personal Dose Equivalent were not addressed in the revision
- Earlier definitions still valid but challenged
- How do they compare?

Comparison: effective dose *vs.* ambient dose equivalent
Photons



Photons and neutrons: the operational quantity continues to be a reasonably conservative estimate of the protection quantity in the energy ranges that have been considered in ICRP 74



Conclusions: how different are the new Dose Conversion Coefficients?

- **Photons:** The differences of effective dose conversion coefficients are lower than 10% for energies above 30 keV
- **Neutrons:** Generally lower (up to a factor of 2) than the ICRP 74/ICRU 57 due to the reduced w_R differences
- **Electrons:** New values are higher than earlier ones due to the difference of phantom representation
- **Protons:** Generally lower than earlier ones due to the reduced w_R
- For some geometries greater differences are observed due to increased value of w_T for the breast

Operational Quantities: conclusions

- The operational quantities for photons, neutrons and electrons continue to provide a good approximation for the energy ranges considered in ICRP Publication 74, but not at the higher energies considered in ICRP Publication 116
- When adopting the new ICRP recommendations and related dose coefficients, there are no consequences for the practical radiation monitoring of external radiation in most occupational exposures, except at very high energies

Task Group (DOCAL) under ICRP C2

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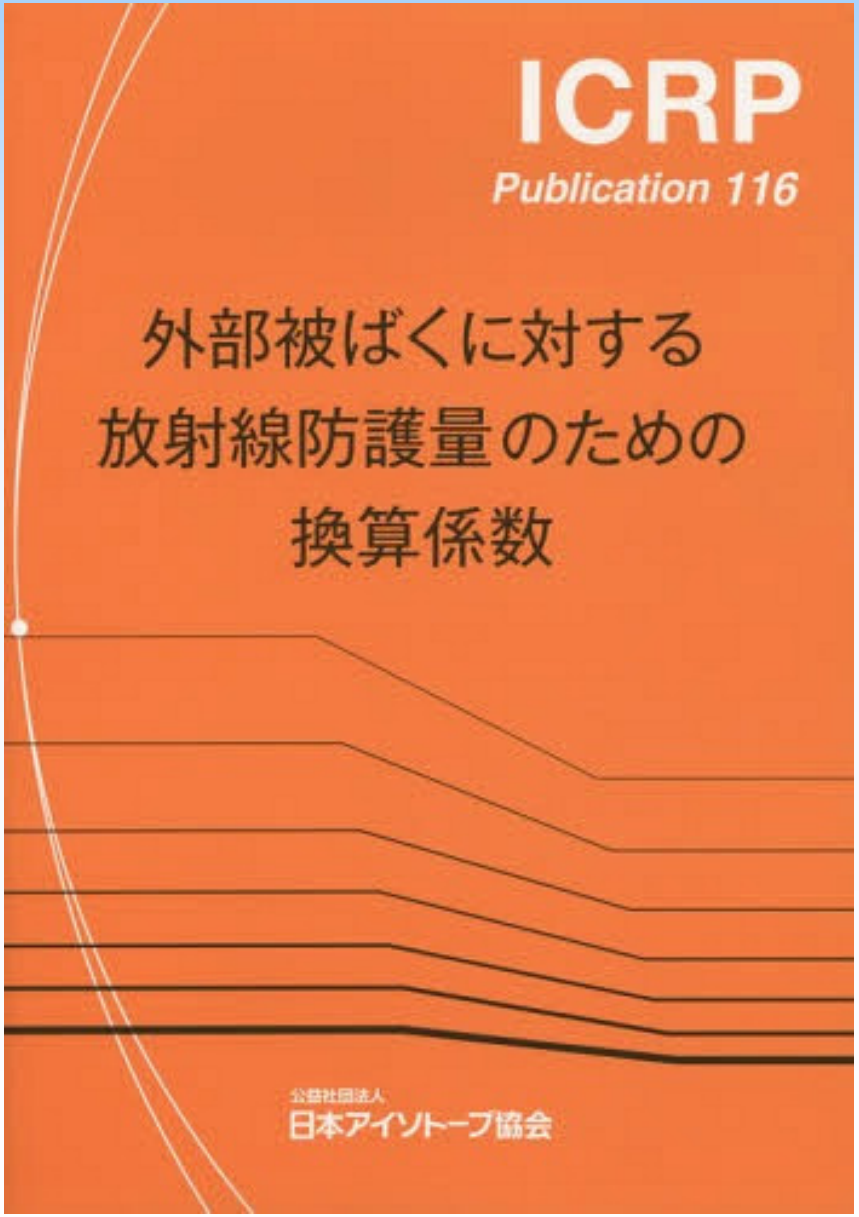

Thank you for your attention!

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