

# **Implications of the new ICRP Recommendations for Air Crew Dosimetry**

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## Basic Recommendations of ICRP

1964/66	ICRP Publications 6 und 9 Recommendations of the International Commission on Radiological Protection
1974	ICRP Publication 26 Recommendations of the International Commission on Radiological Protection
1991	ICRP Publication 60 1990 Recommendations of the International Commission on Radiological Protection
2007	ICRP Publication 103 2007 Recommendations of the International Commission on Radiological Protection

The report was a result of about 9 years of discussions and drafting which includes phases of public consultations in 2004 and 2006.

## Additional Reports

*Low-dose extrapolation of radiation-related cancer risk*  
ICRP Publication 99 (2005)

*Assessing dose to the representative person*  
ICRP Publication 101, Part 1 (2006)

*Optimisation of radiological protection*  
ICRP Publication 101, Part 2 (2006)

*A framework for assessing the impact of ionising radiation on the environment*  
ICRP Publication 91 (2003)

**Annex A und B (2007, ICRP Publication 103):**

***Biological and Epidemiological Information on Health Risks Attributable to Ionising Radiation***

***Dosimetric Quantities used in Radiological Protection***

## 4. Quantities used in Radiological Protection

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### Individual monitoring of occupational exposure

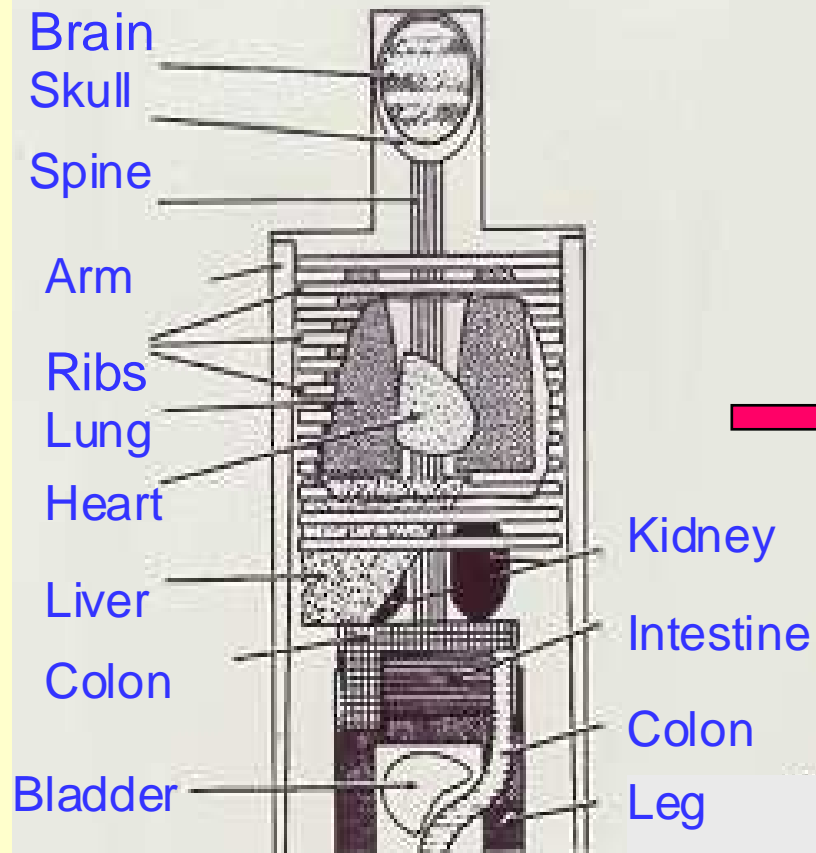
(149) *In certain situations where individual monitoring with personal dosimeters is not performed, such as exposure to aircrew, an assessment of effective dose may be obtained from values of the quantity ambient dose equivalent,  $H^*(10)$ . Effective dose is then calculated using appropriate factors derived from data on the radiation field or by calculating effective dose directly from these data.*

This procedure is already performed in air crew dosimetry since many years and obviously no general changes are recommended.

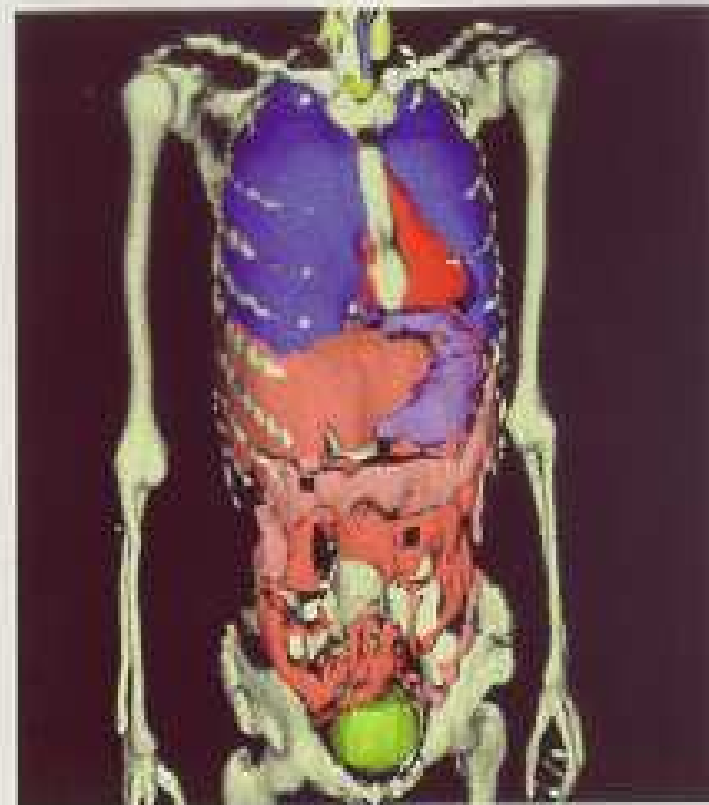
## 4. Quantities used in Radiological Protection

- Reference voxel phantoms
- Effective dose and tissue weighting factors
- Radiation weighting factors
- Implications on air crew doses

# Phantoms



MIRD phantom



Reference voxel phantoms  
(male and female)

# Computational Reference Phantoms

## Voxel phantoms

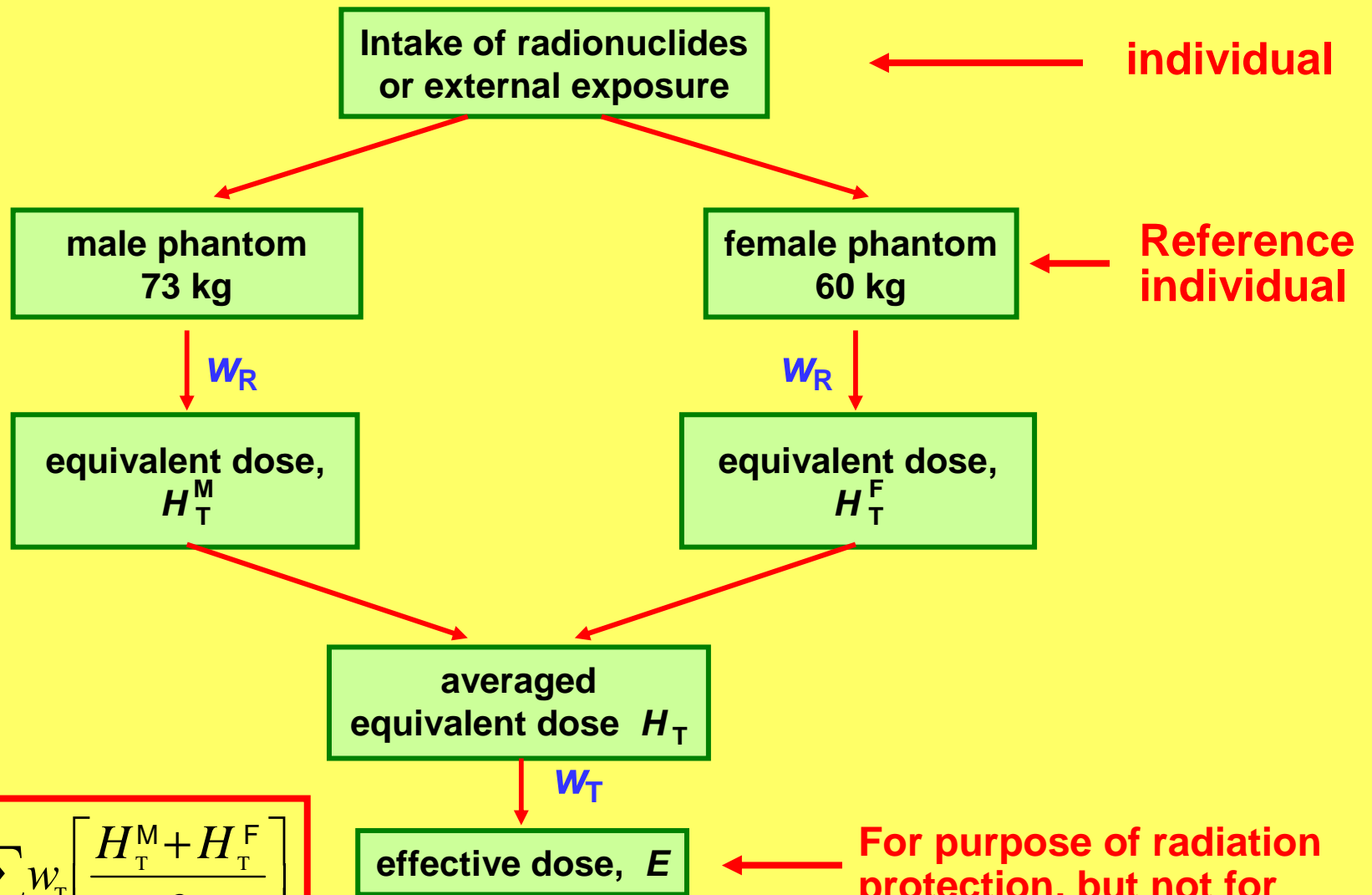
Adult reference male

Adult reference female

Anatomical and physiological characteristics of reference male and female specified in ICRP Publication 89 (2002)

- For external exposure with high energy photons or neutrons, the change from mathematical models (MIRD, ADAM, EVA etc.) to voxel phantoms only results in moderate changes in conversion coefficients for equivalent doses,  $H_T$ .
- For internal emitters and charged particles with limited ranges the changes in size and position of organs and tissues in a voxel phantoms may result in more pronounced changes in conversion coefficients for equivalent doses,  $H_T$ .

## Calculation of effective dose



$$E = \sum_T W_T \left[ \frac{H_T^M + H_T^F}{2} \right]$$

**For purpose of radiation protection, but not for individual risk assessment**

# Effective Dose

$$E = \sum_T w_T \left[ \frac{H_T^M + H_T^F}{2} \right]$$

In a given exposure situation, the value of effective dose is not related to an individual person but to a reference person given by averaging the equivalent doses to a male and female phantom (sex averaging).

Tissue weighting factors,  $w_T$ , are also sex- and age-averaged.

Gender-specific detriments for ages 18-64 years at exposure (in  $10^{-4}/\text{Sv}$ ) and  $w_T$  values for all ages

Tissue	Detriment for adult		Relative detriment for adult		$w_T$ both gender all ages
	Male	Female	Male	Female	
Stomach	44.5	60.7	0.122	0.119	0.12
Colon	62.0	27.7	0.170	0.054	0.12
Liver	28.5	14.7	0.078	0.029	0.04
Lung	80.0	165.4	0.219	0.325	0.12 ←
Breast	0.0	76.6	0.000	0.150	0.12
Ovary	0.0	15.7	0.000	0.031	0.08 <sup>(2)</sup>
Thyroid	1.6	7.0	0.004	0.014	0.04 ←
6 organs/tissues <sup>(1)</sup>	78.0	76.4	0.213	0.150	0,22
Other solids(Rem)	70.1	65.1	0.192	0.128	0.14
Total	365	509	1.00	1.00	1.00

(1) Oesophagus, Bone surface, Skin, Bladder, Bone marrow, Gonads(hereditary)

(2) including hereditary effects from gonads

## Tissue-Weightingfactor, $w_T$

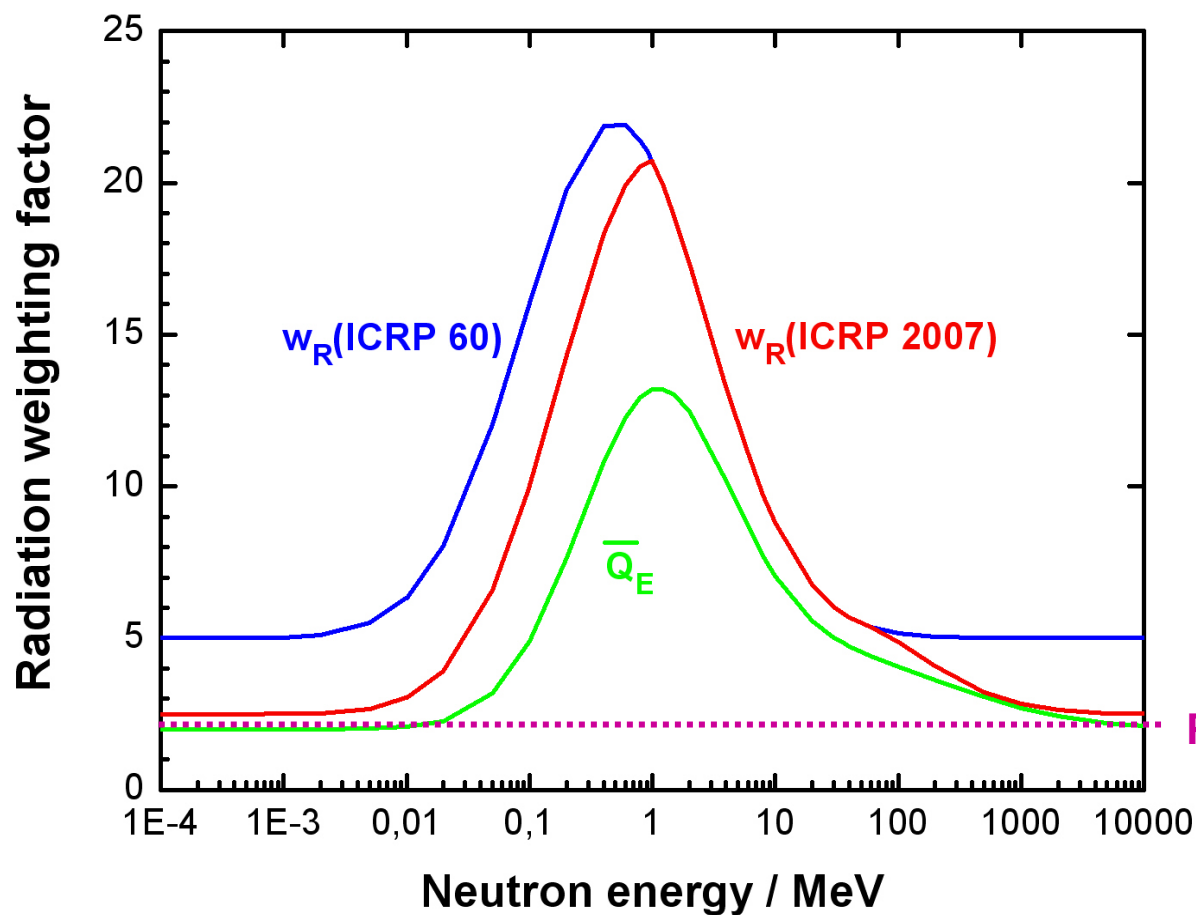
<u>Organ or tissue T</u>	<u>ICRP 60</u>	<u>ICRP 103</u>
Bone marrow (red)	0.12	0.12
Colon	0.12	0.12
Lung	0.12	0.12
Stomach	0.12	0.12
Remainder	0.05	→ <b>0.12</b>
Breast	0.05	→ <b>0.12</b>
Gonads	0.20	→ <b>0.08</b>
Bladder	0.05	→ 0.04
Liver	0.05	→ 0.04
Oesophagus	0.05	→ 0.04
Thyroid	0.05	→ 0.04
Bone surface	0.01	0.01
Skin	0.01	0.01
Brain	Rem.	→ <b>0.01</b>
Salivary glands		→ <b>0.01</b>

## Radiation weighting factors (ICRP 2007)

<u>Radiation</u>		$w_R$
Photons		<b>1</b>
Electrons and muons		<b>1</b>
Neutrons		<b>continuous function</b>
Protons and charged pions	<b>5</b> →	<b>2</b>
Alpha particles, heavy ions and fission products		<b>20</b>

(124) ..... The selection of a single  $w_R$  value of 20 for all types and energies of heavy charged particles is a conservative estimate and is recommended as sufficient for general application in radiological protection. *For applications in space, where these particles contribute significantly to the total dose in the human body, a more realistic approach may be used.*

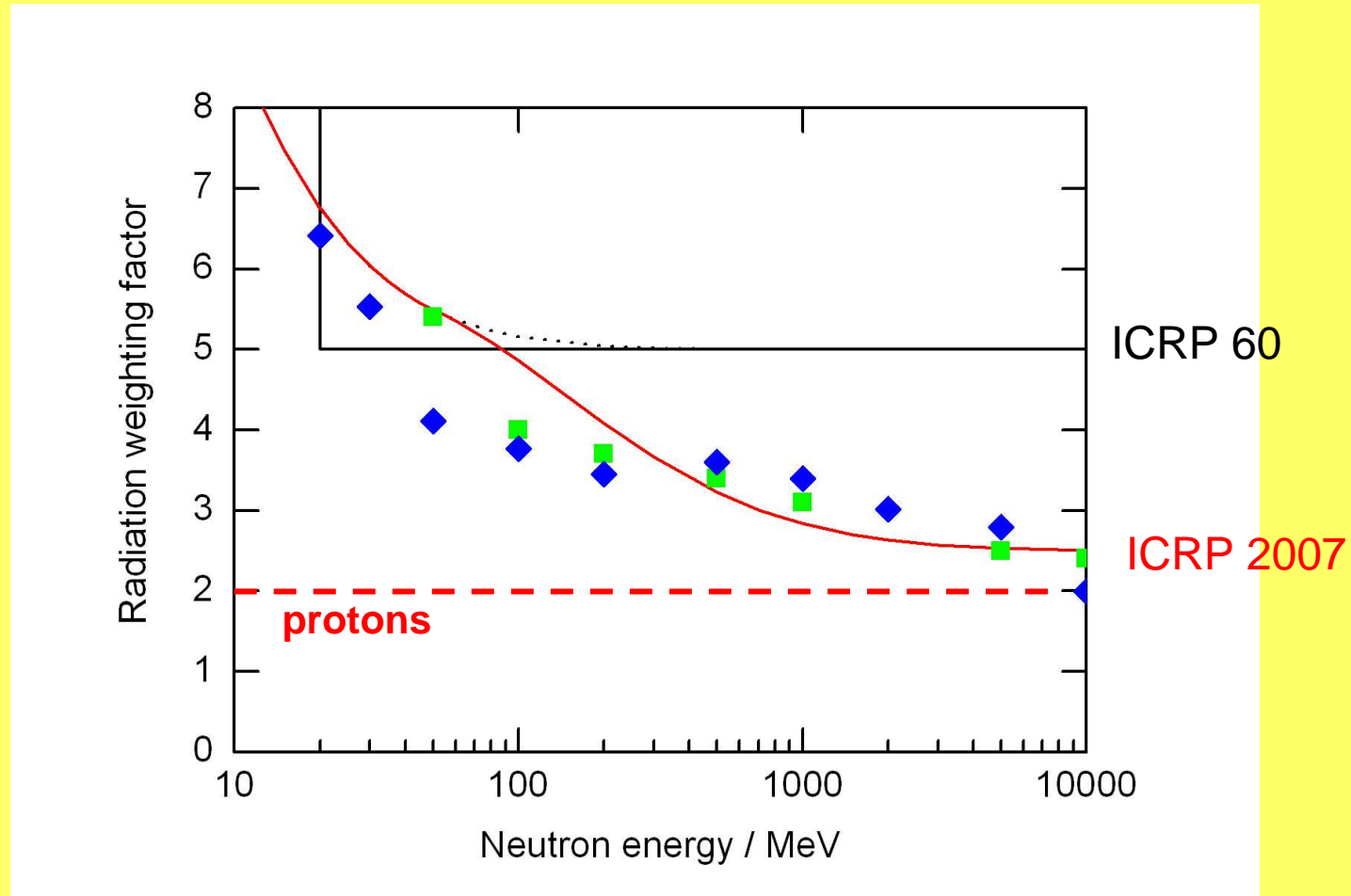
## Radiation weighting factor for neutrons



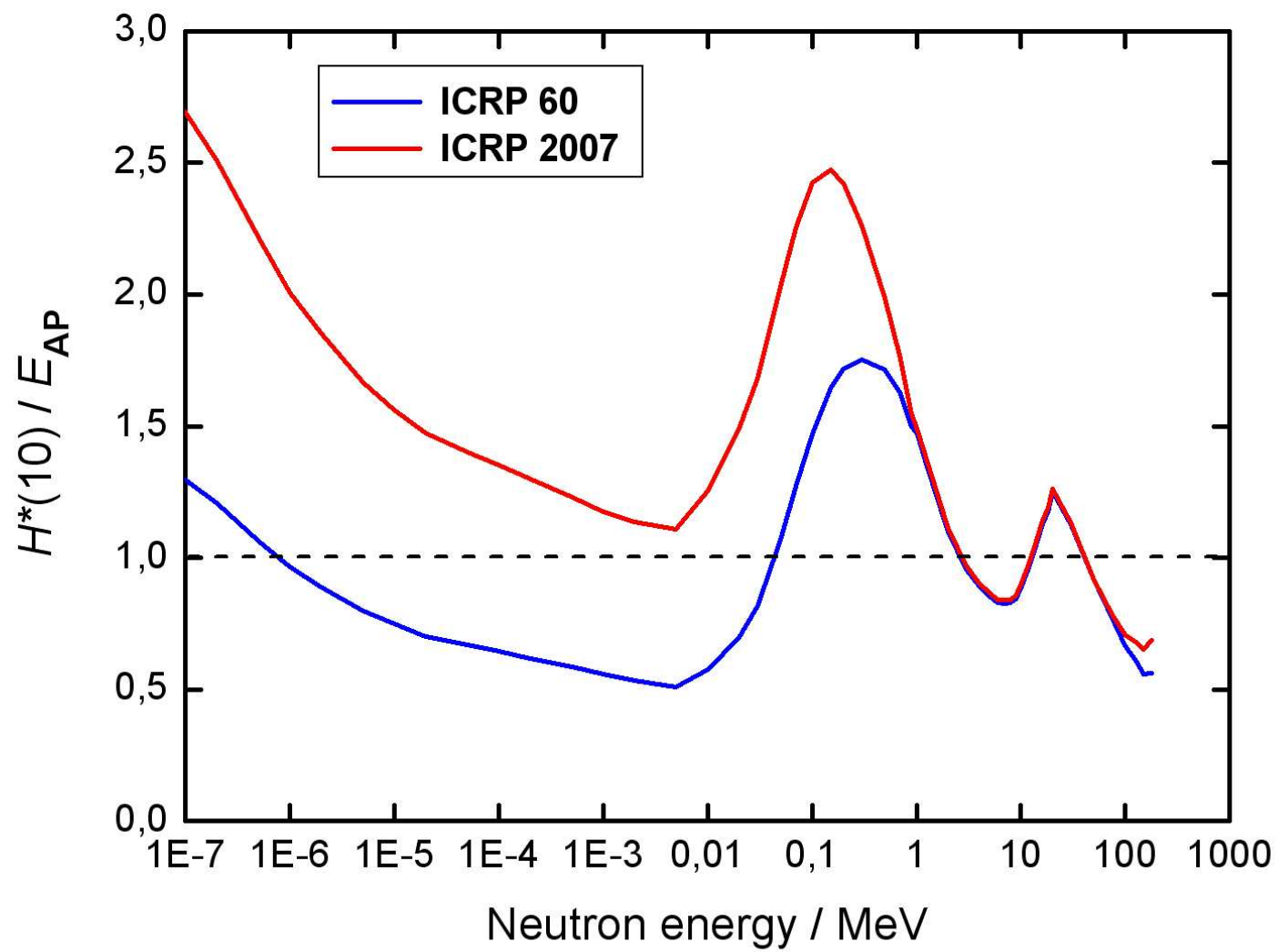
$$\bar{Q}_E = \frac{H_E}{\sum w_T D_T}$$

Protons, pions

# Radiation weighting factor, $w_R$ , for neutrons



$\overline{Q}_E$ :    ◆ Pelliccioni (1998, 2004)    ■ Yoshizawa (1998)



**Thank you for your attention**