Impact of the new ICRP recommendations on external radiation protection dosimetry

How the changes to the dose quantities will affect the use of instruments and personal dosemeters in health physics applications

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Introduction

- ICRP published their previous major set of recommendations in 1991 – "1990 Recommendations of the International Commission on Radiological Protection" **ICRP 60**
- The current process began as a "10-yearly" review to be published around 2000
- Some false alarms along the way ("controllable dose")
- First draft of new recommendations distributed for consultation in 2005
- January 2007 – "final draft"
- March 2008 – "final final draft" approved in Essen by ICRP main Commission
- December 2007 – published as **ICRP 103**
- HPA response to be published within 9 months

ICRP 103

Recommendations of the ICRP: User's Edition

A International Commission on Radiological Protection title

By **International Commission on Radiological Protection**

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ICRP 103 – Table 1. Risk per Sv

Health Protection Agency

Detriment-adjusted nominal risk coefficients for stochastic effects after exposure at low dose rate

Exposed population	Cancer		Heritable effects		Total	
	ICRP103	ICRP60	ICRP103	ICRP60	ICRP103	ICRP60
Whole	5.5	6.0	0.2	1.3	5.7	7.3
Adult	4.1	4.8	0.1	0.8	4.2	5.6

“It is therefore the recommendation of the Commission that the approximated overall risk coefficient of **5% Sv^{-1}** on which current international radiation safety standards are based continues to be appropriate and should be retained for the purposes of radiological protection”

New ICRP recommendations - important features

- No changes to the operational quantities
- No changes to the dose limits
- "No change" to operational health physics (?)
- Changes to effective dose
  - Changes to w_R for neutrons and protons
  - Changes to w_T (tissue weighting factors – independent of radiation type)
  - Changes to the male/female specification
- Phantom specified explicitly
  - Voxel phantom adjusted to replicate reference man
  - Now specific to the calculation of conversion coefficients and SAF

New ICRP recommendations - operational implications

- Removed “practices” and “interventions”
- Retain justification and optimization
- Same source related principles to all controllable exposure situations:
  - planned
  - emergency
  - existing

Collective dose

ICRP103

- "The collective effective dose quantity is an instrument for optimisation … predominantly in the context of occupational exposure. **Collective effective dose is not intended as a tool for epidemiologic risk assessment**, and it is **inappropriate to use it in risk projections**. The aggregation of very low individual doses over extended time periods is inappropriate, and in particular, the calculation of the number of cancer deaths based on collective effective doses from trivial individual doses should be avoided."

ICRP60

- "If a measure of the radiation exposure in a population is desired, the collective effective dose can be calculated" (plus additional clauses)

w_T – new recommendations

Organ	ICRP26	ICRP60	ICRP103
Gonads	0.25	0.20	0.08
Bone marrow (red)	0.12	0.12	**0.12**
Lung	0.12	0.12	**0.12**
Breast	0.15	0.05	**0.12**
Thyroid	0.03	0.05	0.04
Bone surfaces	0.03	0.01	0.01
Remainder	0.30	0.05	**0.12**
Colon	-	0.12	**0.12**
Stomach	-	0.12	**0.12**
Bladder	-	0.05	0.04
Liver	-	0.05	0.04
Oesophagus	-	0.05	0.04
Skin	-	0.01	0.01
Salivary glands	-	-	0.01
Brain	-	-	0.01

Remainder

ICRP60: adrenals, brain, upper large intestine, small intestine, kidney, muscle, pancreas, spleen, thymus and uterus

ICRP103: adrenals, extrathoracic tissue, gall bladder, heart wall, kidneys, lymph nodes, muscle, oral mucosa, pancreas, prostate, small intestine, spleen, thymus, uterus/cervix

New ICRP recommendations - effective dose

$$E = w_{\text{breast}} H_{\text{breast,female}} + \sum_{T \neq \text{breast}} w_T \left[\frac{H_T^M + H_T^F}{2} \right] \qquad \text{(ICRP74)}$$

$$H_T^M = \sum_T w_R D_{T,R} \qquad \text{(male only)}$$

$$H_T^F = \sum_T w_R D_{T,R} \qquad \text{(female only)}$$

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

$$= \sum_T w_T \left[\frac{\sum_{T_{male}} w_R D_{T,R} + \sum_{T_{female}} w_R D_{T,R}}{2} \right]$$

Effective dose – remainder organs

ICRP 60

If any single organ of the remained has an equivalent dose greater than any of the twelve specified organs, then that organ and the rest of the remainder should each receive a tissue weighting factor of 0.025

ICRP 103

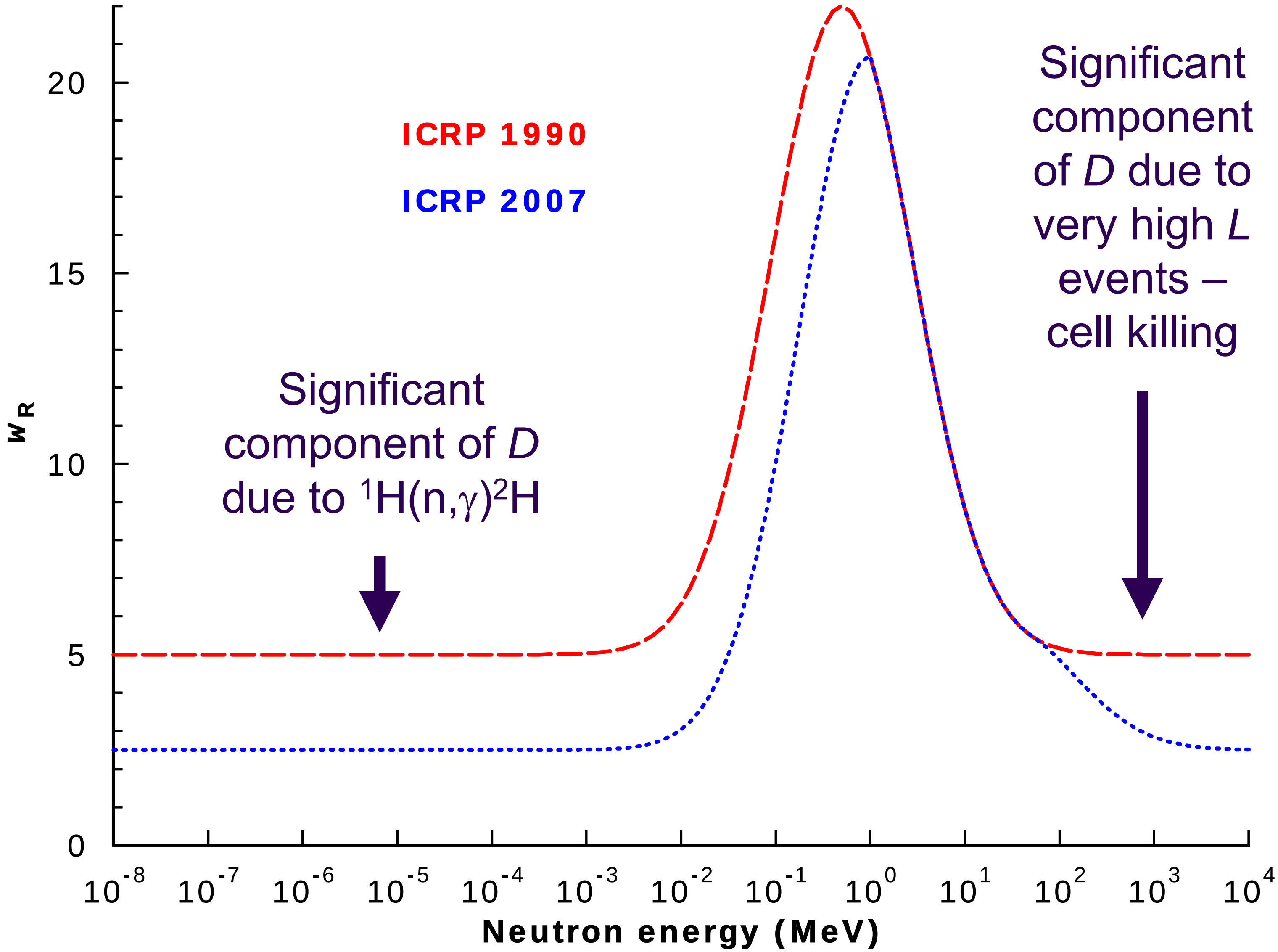
$$H_{\text{Rem}}^{M} = \frac{1}{13}\sum_{T} H_{T}^{M} \qquad \text{(male only)}$$

$$H_{\text{Rem}}^{F} = \frac{1}{13}\sum_{T} H_{T}^{F} \qquad \text{(female only)}$$

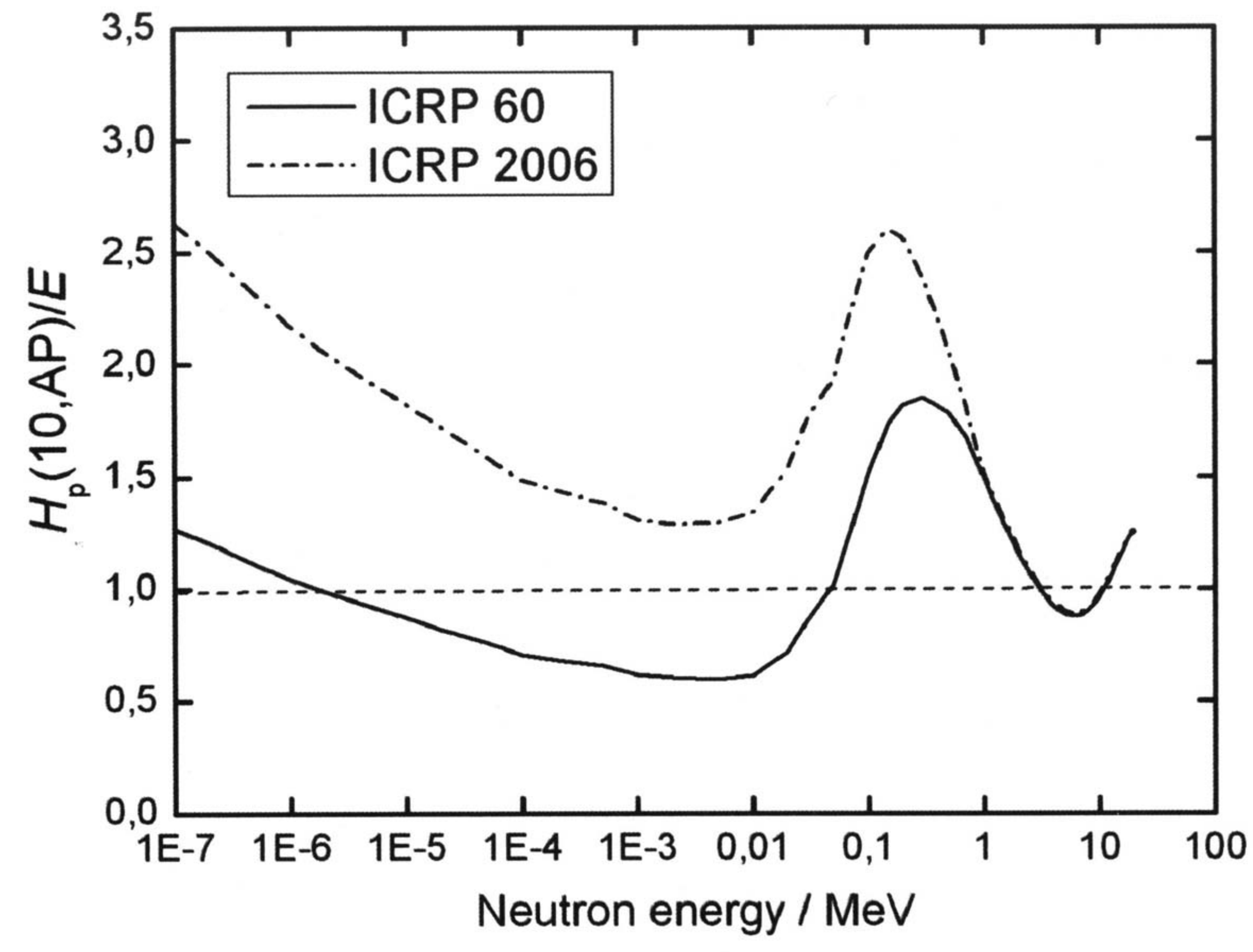
Radiation weighting factor - w_R

Radiation	w_R – ICRP 103	w_R – ICRP60
γ, e, μ	1	1
n (< 1 MeV)	$w_R = 2.5 + 18.2\exp\left[-\frac{(\ln(E))^2}{6}\right]$	
n (1 MeV → 50 MeV)	$w_R = 5 + 17\exp\left[-\frac{(\ln(2E))^2}{6}\right]$	$w_R = 5 + 17\exp\left[-\frac{(\ln(2E))^2}{6}\right]$
n (> 50 MeV)	$w_R = 2.5 + 3.25\exp\left[-\frac{(\ln(0.04E))^2}{6}\right]$	
p (> 2 MeV - not recoil), charged π	2	5 (not π)
α, fission fragments, heavy nuclei	20	20

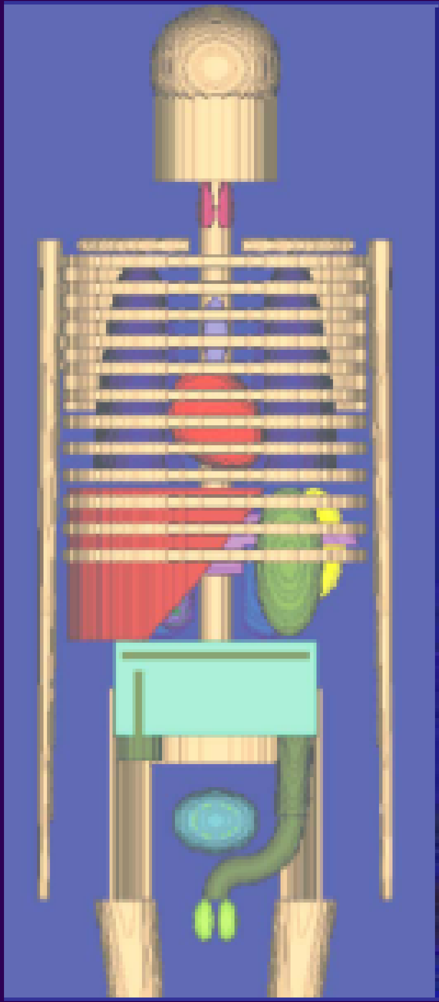
Neutron radiation weighting factor - w_R

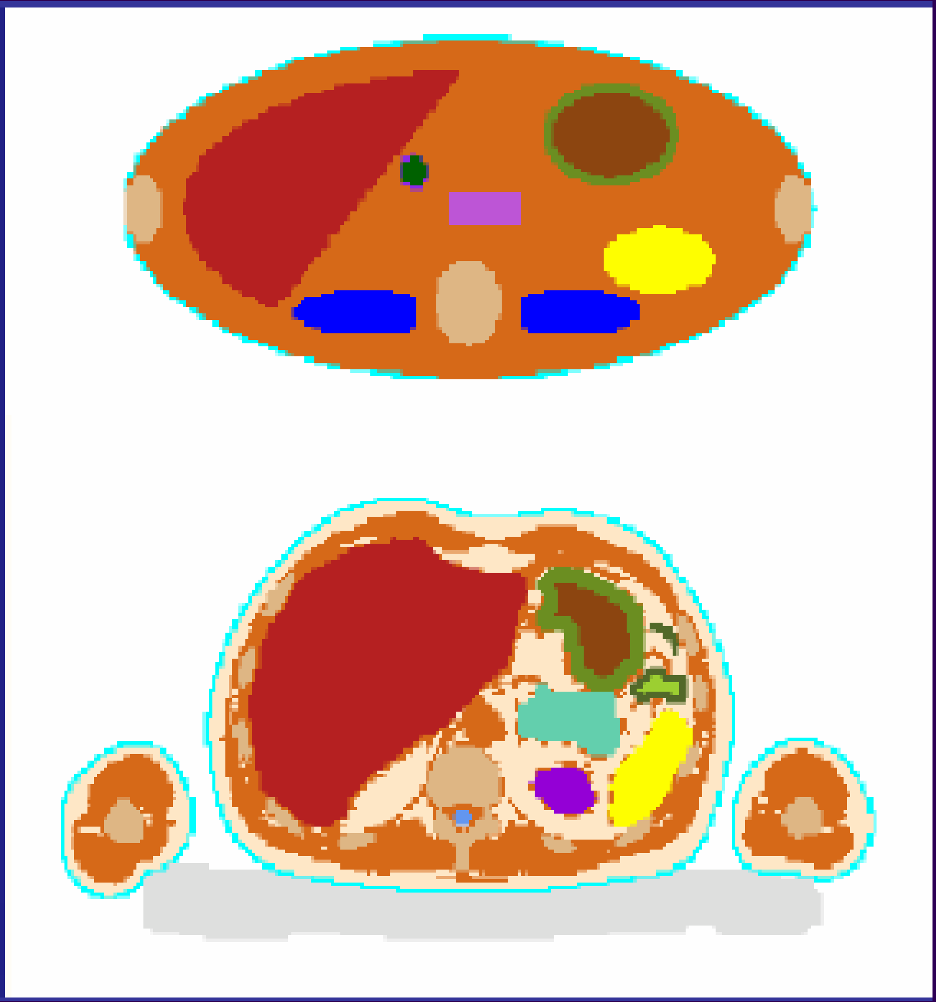


$H_p(10, 0°)$ vs E_{AP} (Dietze, PTB)



New voxel geometry (thanks to Maria Zankl, PTB)





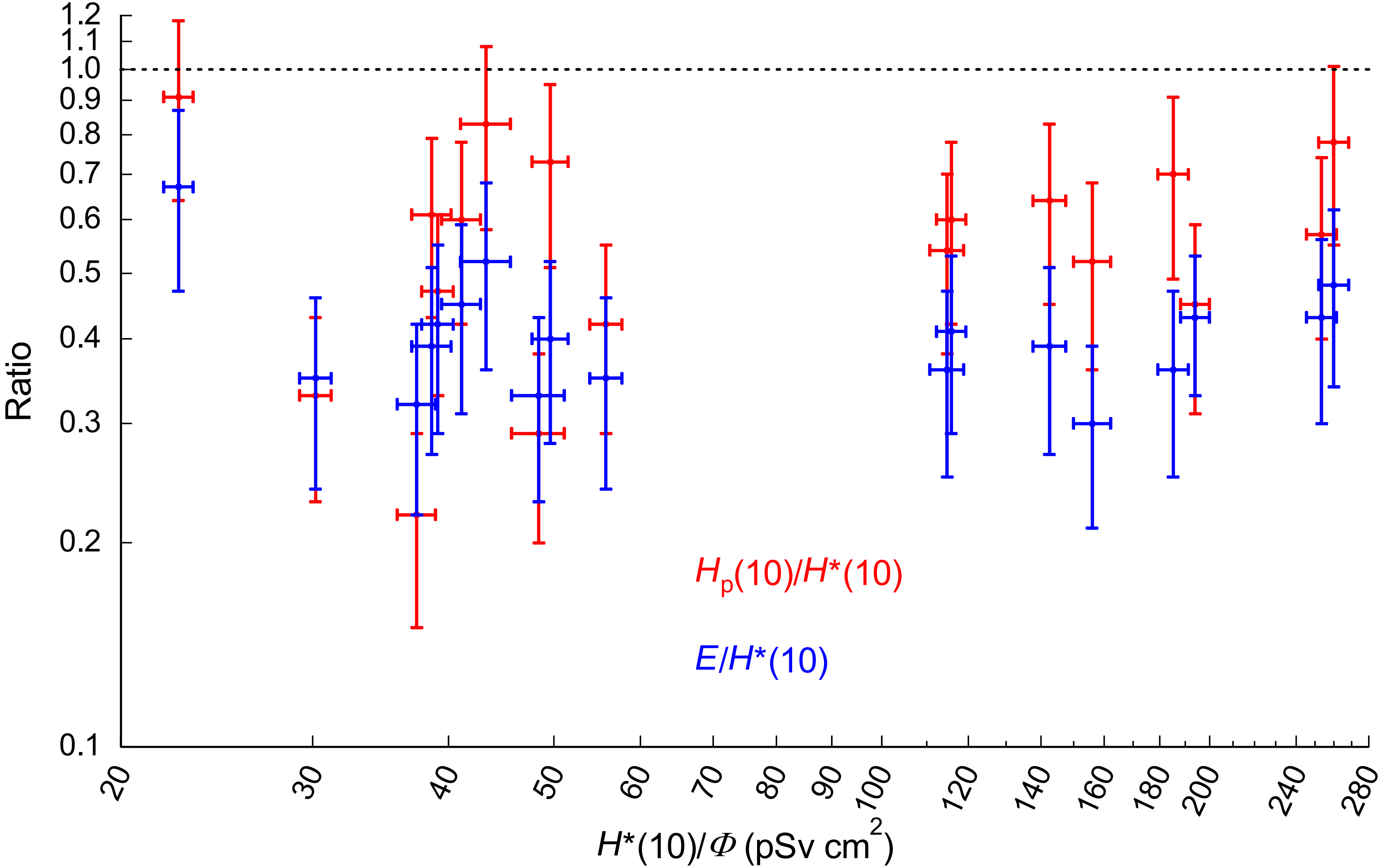
New voxel geometry - impact

- Organs now have realistic sizes, shapes and depths
- Organ shielding (or lack of) more realistic
- On average, organs located deeper in the body
- Some “organ doses” change by up to 30% for some irradiation situations
- Changes to effective dose < 10% (?)
- Higher absorbed dose per unit fluence for highly penetrating radiation?
- For some partial body exposures the changes will be very significant (example – medical applications with a lead apron)

New recommendations - impact

- For photons/electrons, the changes are simply due to the new phantoms
- For neutrons, for highly scattered fields, effective dose may fall significantly:
  - Lower w_R
  - Weaker penetration of the phantom
- A dosemeter worn on the front of the torso may be less adequate in some circumstances:
  - $H_p(10)$ will be lower, but E may not be
- Cosmic/accelerator radiation – lower effective dose
  - in space (~ 0.5)
  - aircraft altitudes (~ 0.75)

Neutron effective dose vs $H_p(10)$ and $H^*(10)$ from EVIDOS



Conversion coefficients

- Being calculated by DOCAL group set up by ICRP
- HPA has three “corresponding members” but no full member
- Meet annually in May
- Calculations held up by difficulties with bone dosimetry – some features are much smaller than 1 voxel, so dose deposition cannot be calculated in the voxel phantom
- DOCAL may agree new datasets in May 2008
- More likely to be May 2009
- Or May 2010…

New ICRP recommendations - conclusions

- No changes to the operational quantities (yet)
- Changes to effective dose
- New *E* conversion coefficients for all radiation types
- Effective dose conversion coefficients for photons and electrons not expected to change very significantly
- Effective dose conversion coefficients for neutrons will probably be lower if a significant component of the dose equivalent derives from neutrons with energies lower than 1 MeV or higher than 50 MeV
- **As yet, no conversion coefficients have been calculated for the new specification of effective dose with the new phantoms**