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Title: Neutron Operational and Protection Quantity Conversion Coefficients Under ICRP-26, ICRP-60, and ICRP-103

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Neutron Operational and Protection Quantity Conversion Coefficients Under ICRP-26, ICRP-60, and ICRP-103

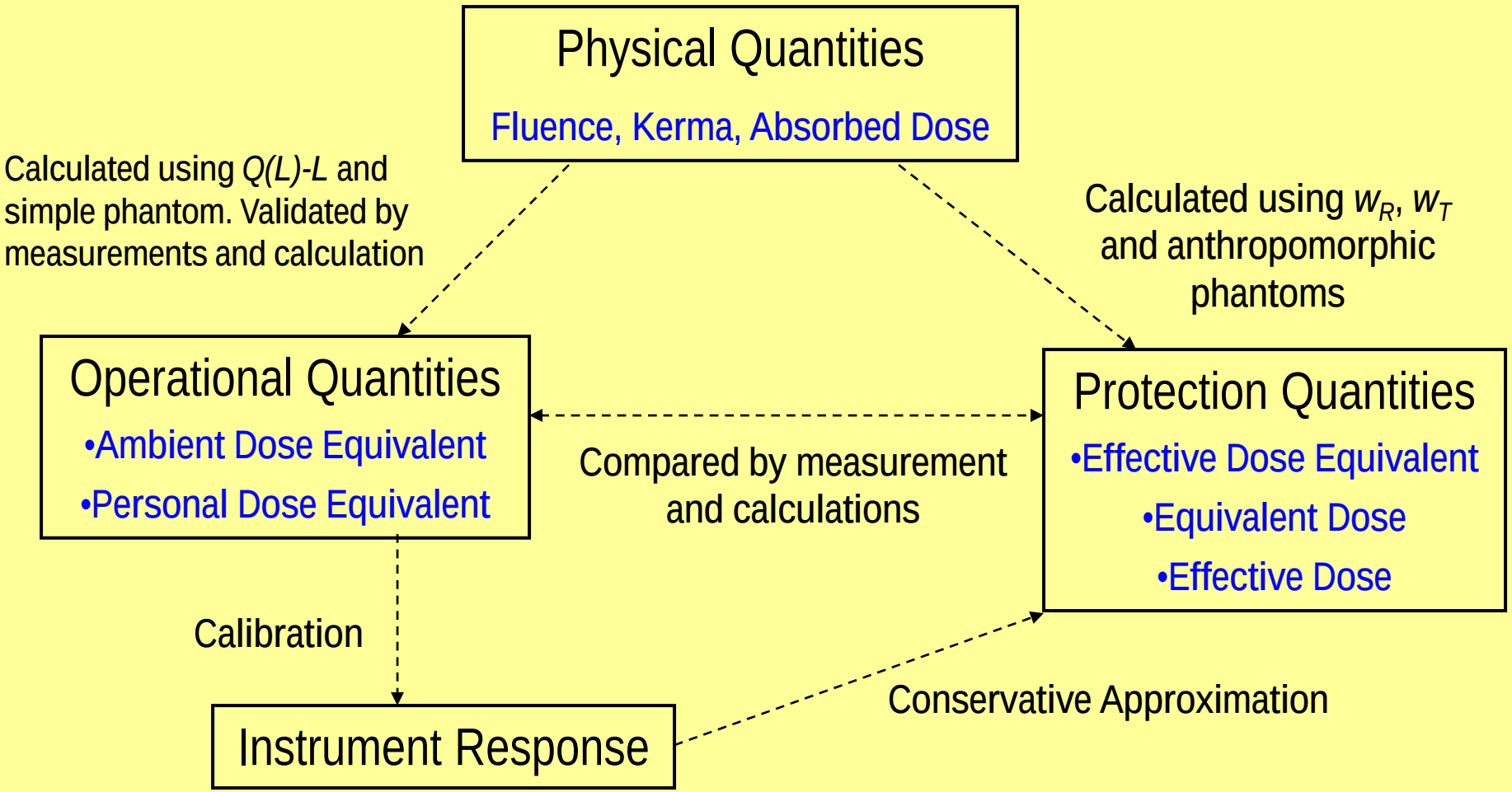
K.G. Veinot

Y-12 National Security Complex

Evolution of Recommendations

- Three major revisions to ICRP recommendations
- 1977 – ICRP-26
- 1991 – ICRP-60
- 2007 – ICRP-103
- All are risk-based approaches
- All use organ/tissue risk factors

System of Radiation Protection



ICRP-26

- “Dose Equivalent” – organs/tissues
- Organ/Tissue weighting factors (w_T)
- Effective Dose Equivalent (H_E)
- Dose modifier = quality factor (Q)
- Q based on LET in water (keV/μm)
- Q based on spectrum in organ/tissue
- Mathematical phantom
- Remainder organs
- Non-additive

ICRP-60

- “Equivalent Dose” – organs/tissues
- Organ/Tissue weighting factors (w_T)
- Effective Dose (E)
- Dose modifier = radiation weighting factor (w_R)
- w_R based on spectrum incident on phantom
- Mathematical phantom
- Remainder organs
- Non-additive

ICRP-26 and ICRP-60 Protection Quantity Calculations

- ICRP-26 Effective Dose Equivalent, H_E

$$H_T = \frac{\int_m \int_L Q(L) D_L \, dL \, dm}{m}$$

$$H_E = \sum_T w_T H_T$$

- ICRP-60 Effective Dose, E

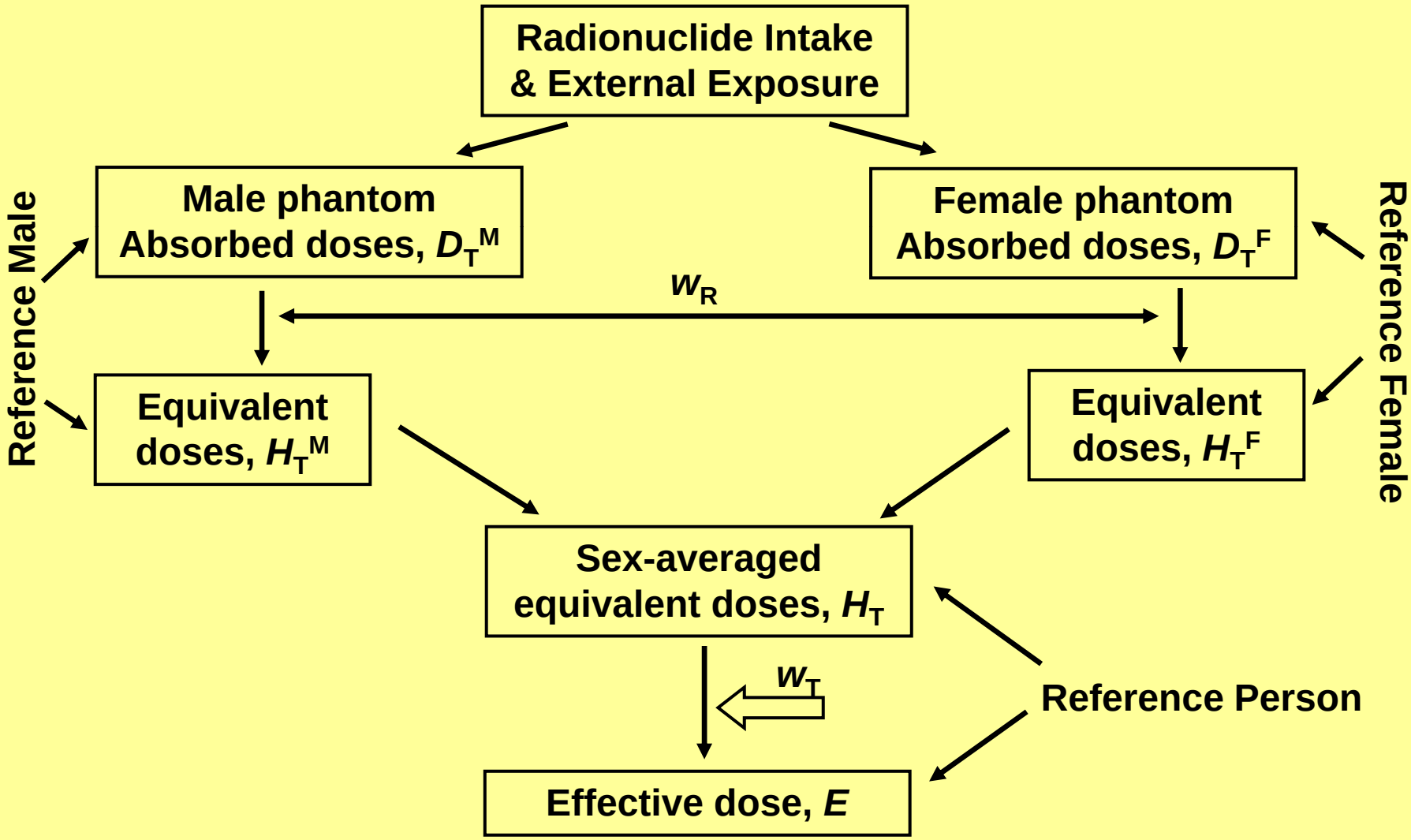
$$E = w_R * \sum_T D_T * w_T$$

(w_R based on spectrum incident on phantom. Single value for all organs)

ICRP-103

- “Equivalent Dose” – organs/tissues
- Organ/Tissue weighting factors (w_T)
- Effective Dose (E)
- Dose modifier = radiation weighting factor (w_R)
- w_R based on spectrum incident on phantom
- Voxel phantom (male and female) (ICRP-110)
- Remainder organs, but specified
- Sex averaging

ICRP-103 Protection Quantity Calculations

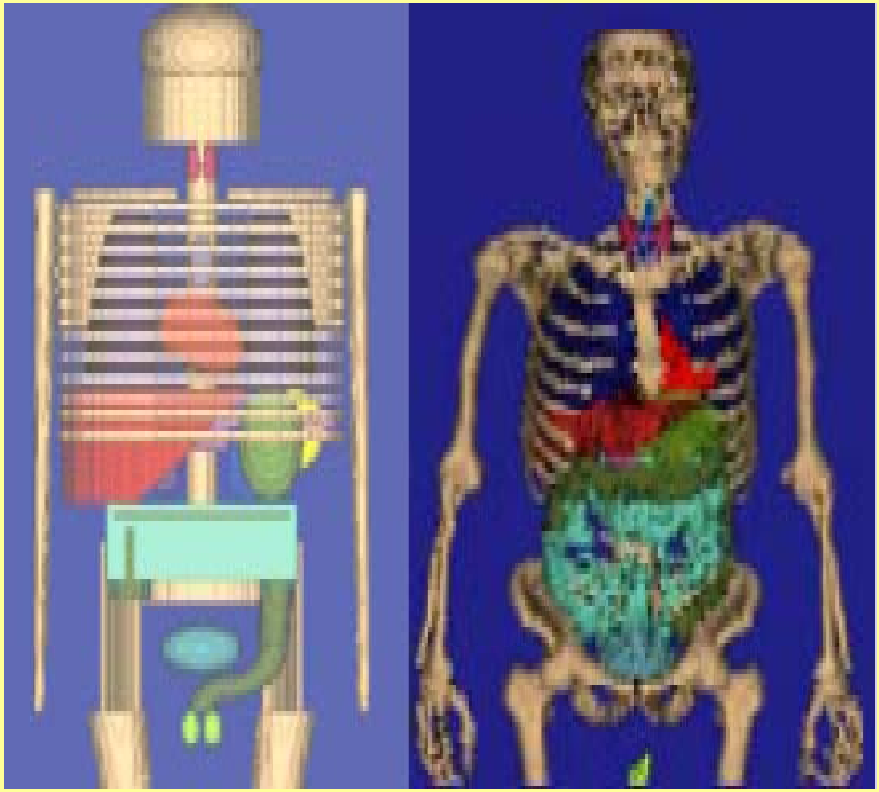


Calculations

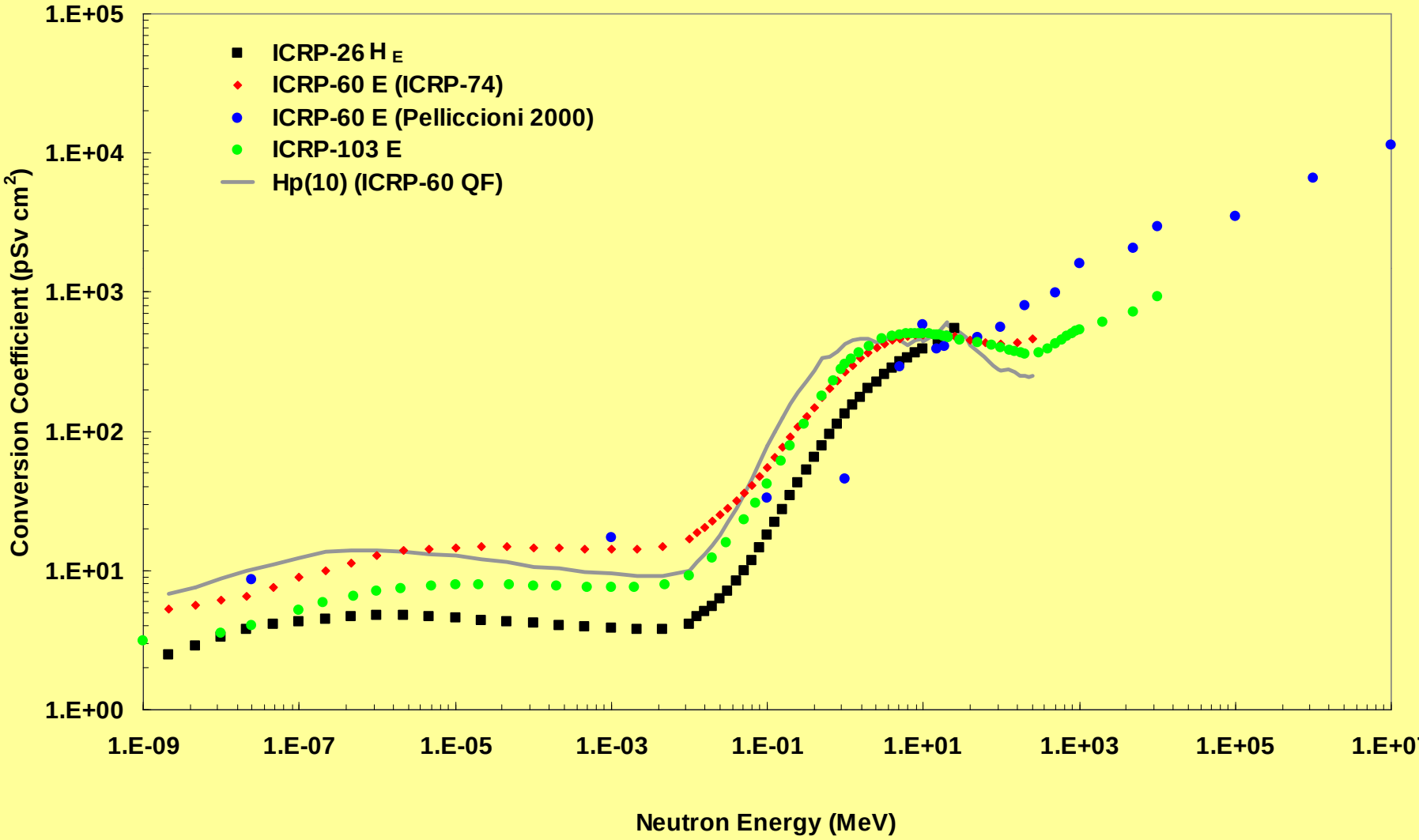
- Monte Carlo
- Various geometries (AP, PA, LLAT, RLAT, ISO, ROT)
- Absorbed dose in organs
- Modifier (QF or w_R)
- Remainder organs
- Weighted sum

Phantom Models

- Through ICRP-60 mathematical models used. ICRP-103 uses volumized pixel (voxel) phantoms developed from high-res scans.



Protection Quantity DCFs

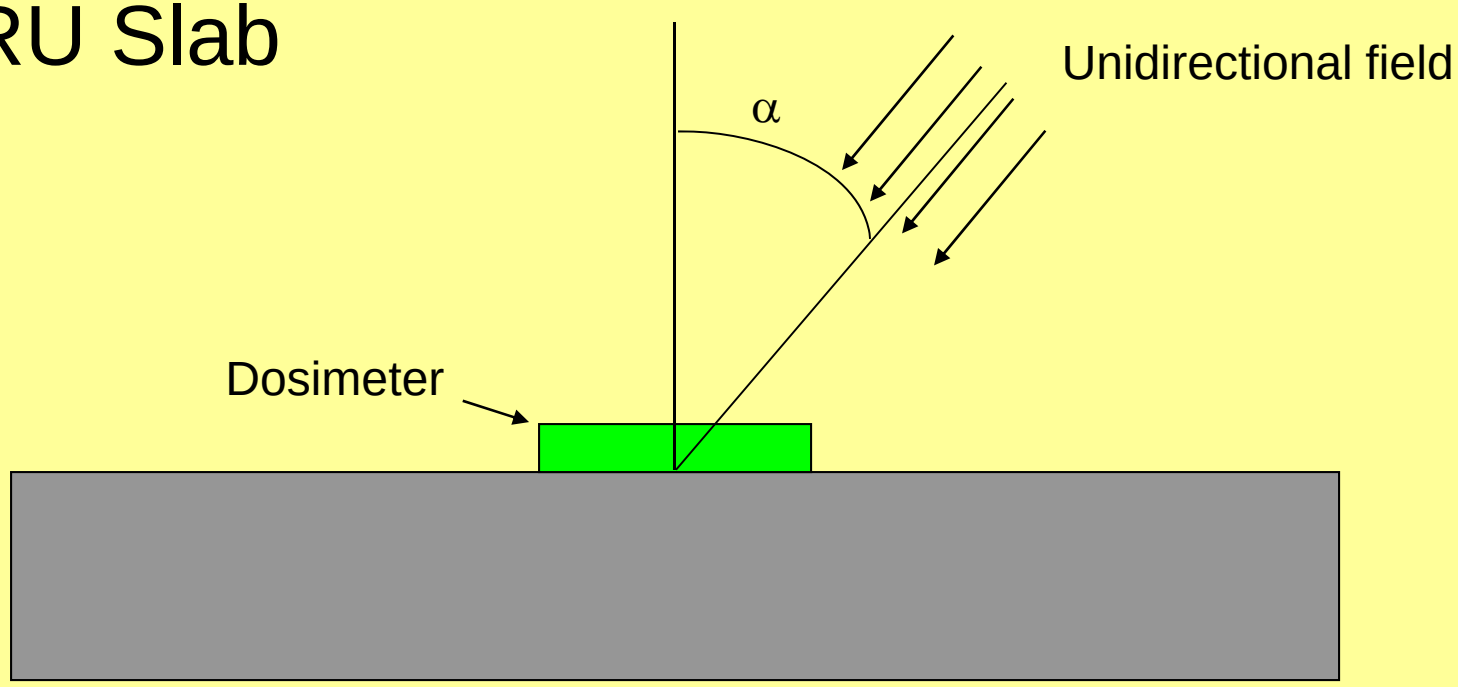


Operational Quantities

- Defined by ICRU
- Intended to be measurable (and calculable)
- Based on simple phantom designs
- Based on standard (but unattainable conditions)
- Should conservatively approximate protection quantities

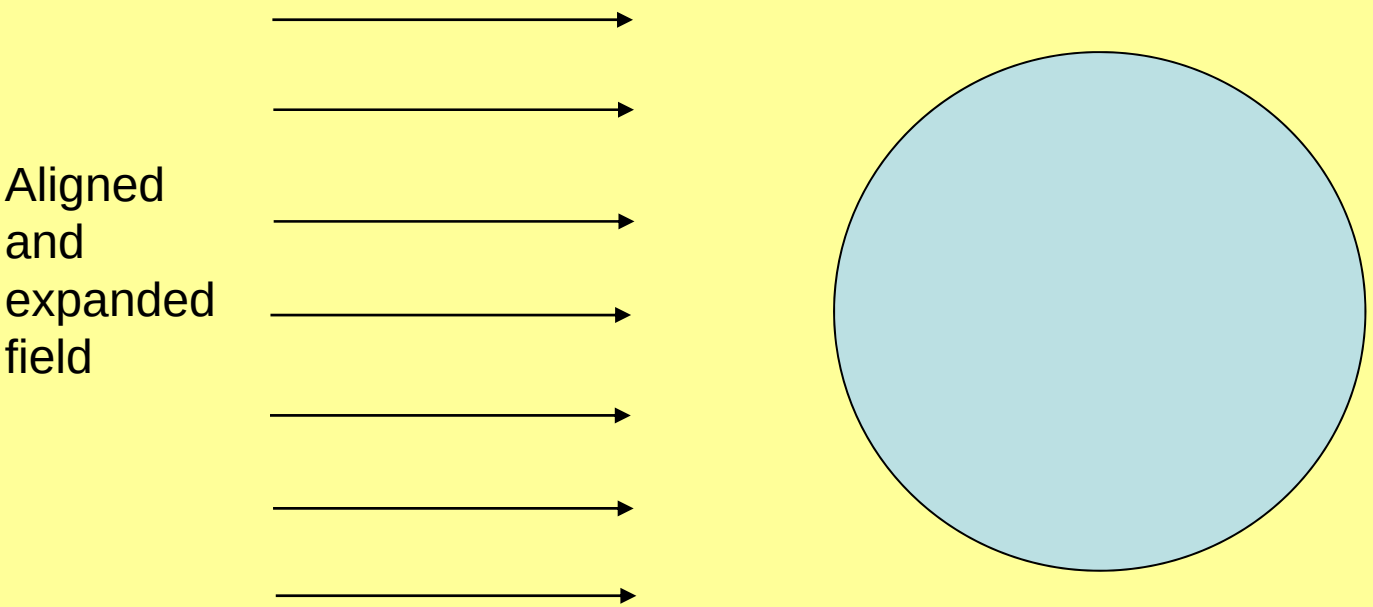
Personal Dose Equivalent

- Monitoring for individuals
- Defined in the body – multi-valued quantity
- Usually the trunk = 30 cm X 30 cm X 15 ICRU Slab



Ambient Dose Equivalent

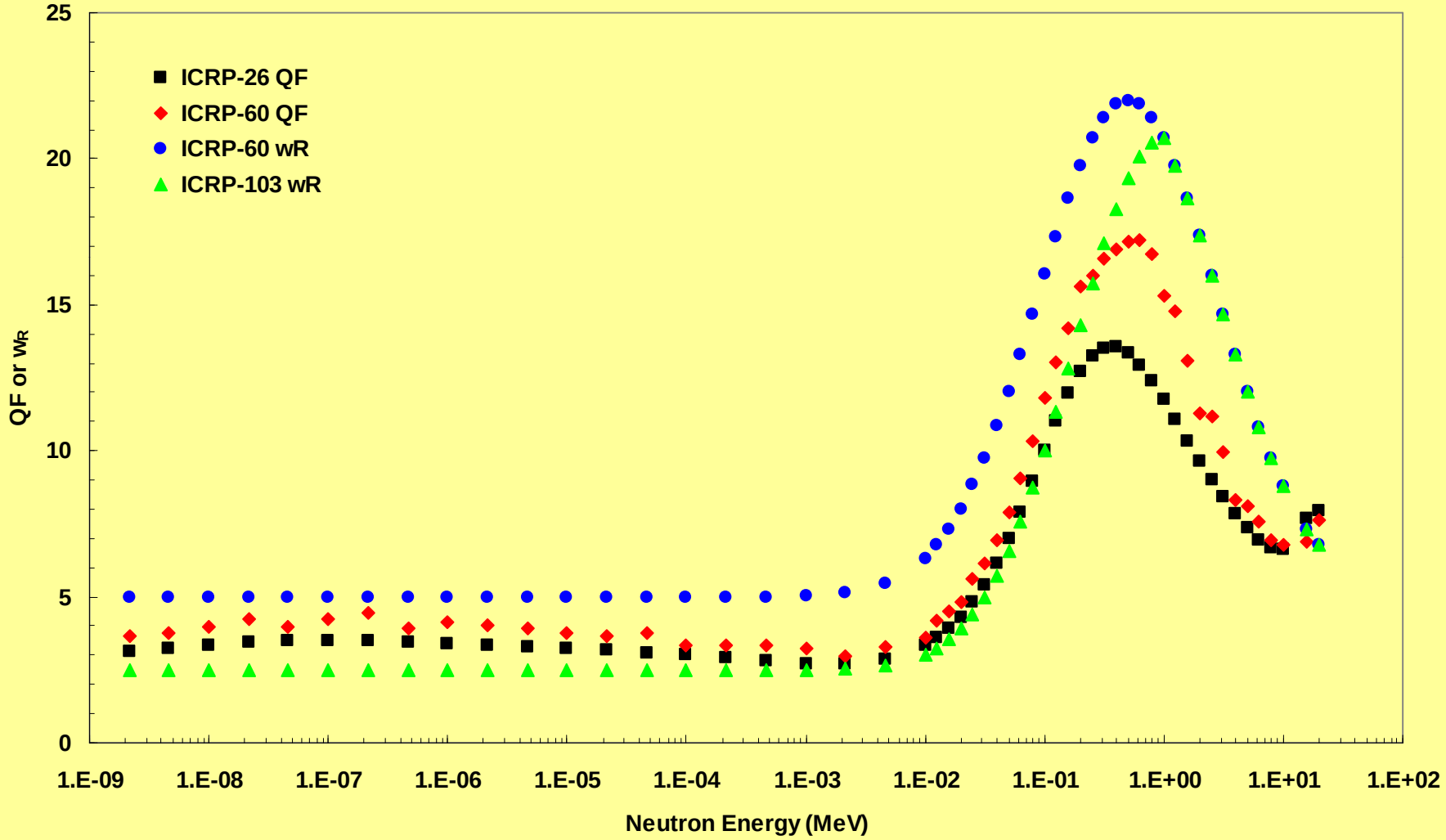
- Area monitoring
- Defined in the ICRU sphere (15 cm radius)
- Instrument calibrations



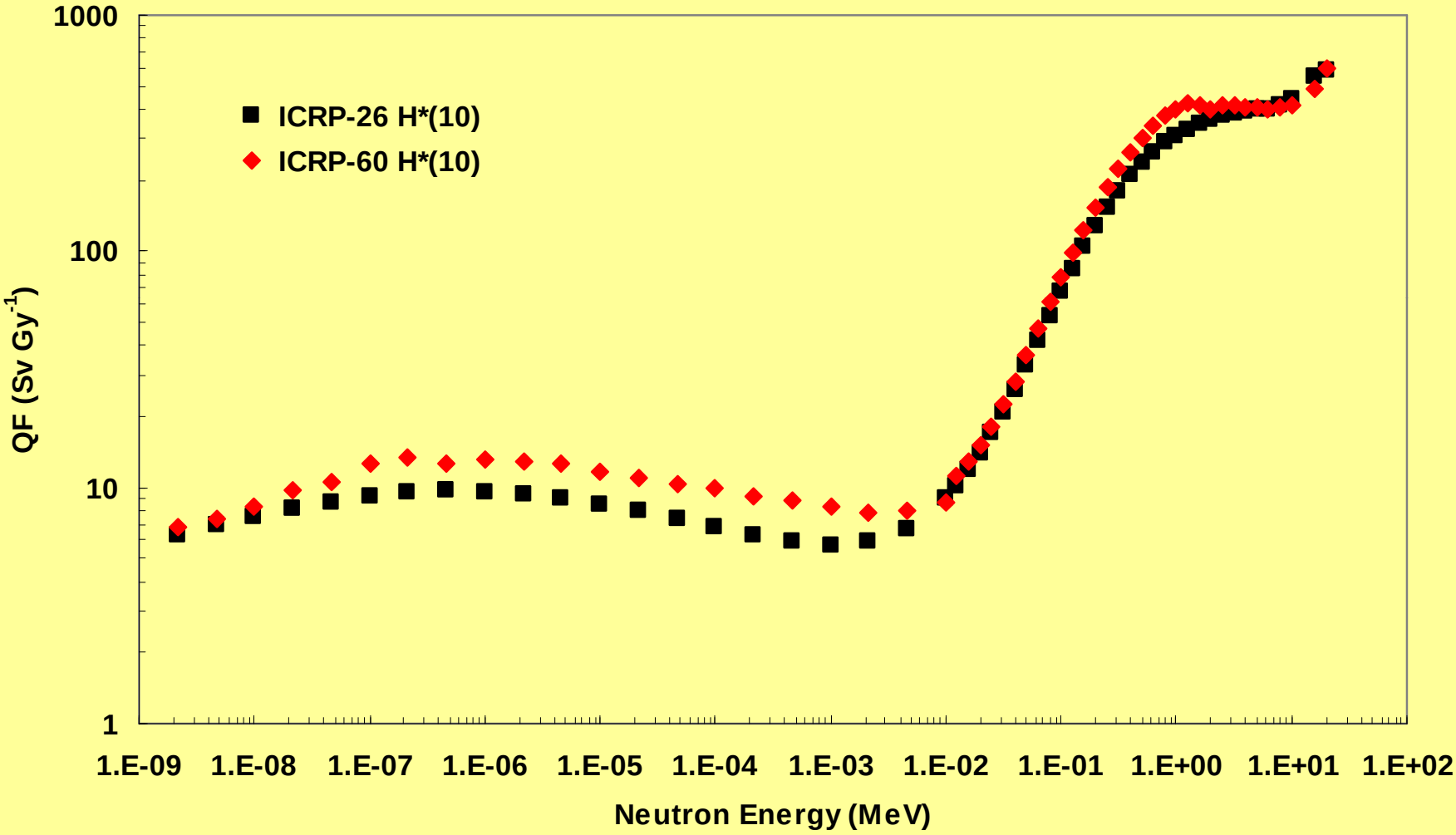
ICRP/ICRU DCFs

- ICRP-74
- ICRP revising ICRP-74 now (to include ICRP-103)
- Includes ICRP-103 DCFs
- ICRU to update operational quantities
- No changes to Q(L)-L, so QF same
- Higher energies

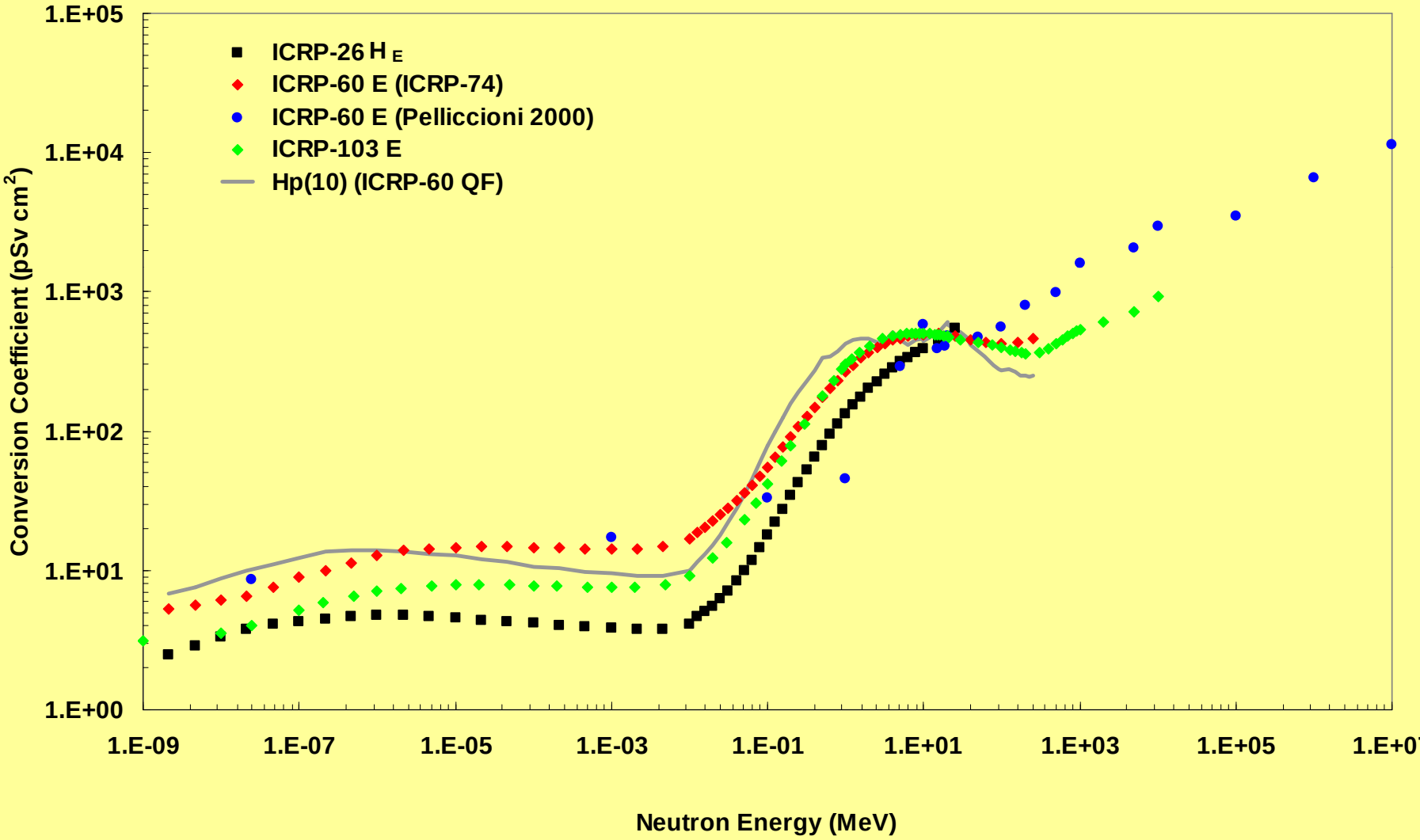
Quality and Radiation Weighting Factors



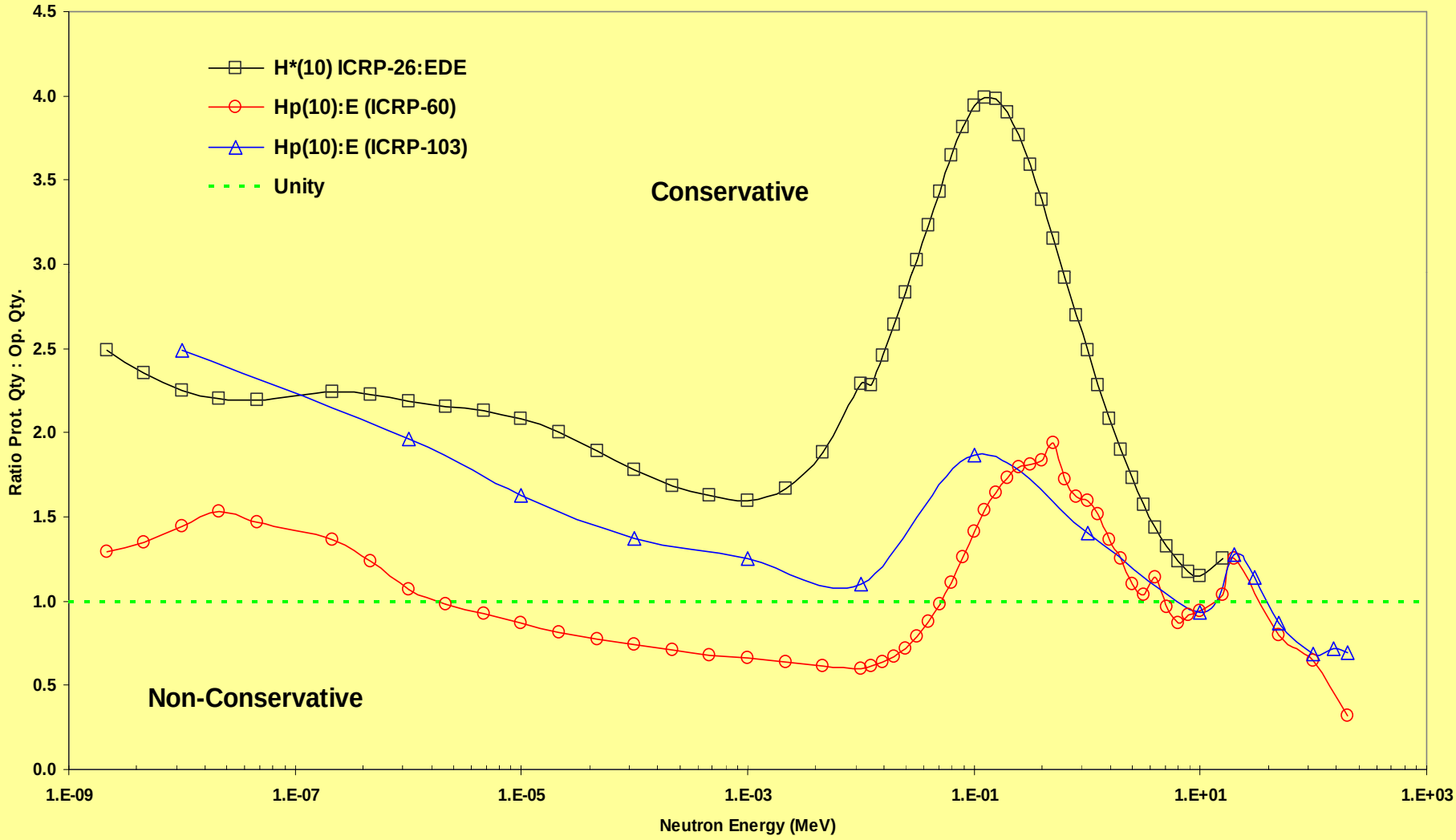
ICRP-26 and ICRP-60 *H**(*10*)



Protection/Operational Quantity DCFs



Conservative Approximation?



How Different are the New Dose Conversion Coefficients?

- **Photons**
  - The differences of effective dose conversion coefficients are lower than 10%.
- **Neutrons**
  - Generally lower (up to a factor of 2) than ICRU 57 / ICRP 74 due to the reduced w_R differences
- **Protons**
  - Generally lower than ICRU 57 / ICRP 74 due to the reduced w_R
- **For some geometries greater differences are observed due to increased value of w_T for the breast**
- More data available at higher energies

ICRP-26 Vs. ICRP-60 Source DCFs

	^{252}Cf	D_2O ^{252}Cf	Am-Be	Am-B	Poly. Mod. ^{252}Cf	Pu-F	Pu-Be
ICRP-26 *H*(10)* (pSv-cm^2)	333	93	373	378	218	333	291
ICRP-60 *H*(10)* (pSv-cm^2)	380	107	394	410	242	384	317
Rem Ball Response ICRP-26 Cal. (counts)	333	133	334	384	220	311	272
Rem Ball Response ICRP-60 Cal. (counts)	380	152	381	438	251	355	310

Data from HPJ Vol. 95, suppl. 2 August 2008

Conclusions

- Quality factors same in ICRP-60 and ICRP-103 (operational quantities don’t change)
- Q(L)-L differs from ICRP-26 to ICRP-60 (DOE impact)
- Protection quantities are generally lower
- Data to higher energies