Radon Dosimetry: Current Status

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Centre for Radiation, Chemical and Environmental Hazards
Radiation Protection Division
formerly the National Radiological Protection Board

Radon Dosimetry: Current Status

Structure

1. Introduction
2. Dosimetric Approach
3. Epidemiological Approach
4. Are the Two Approaches Compatible
5. Current Developments

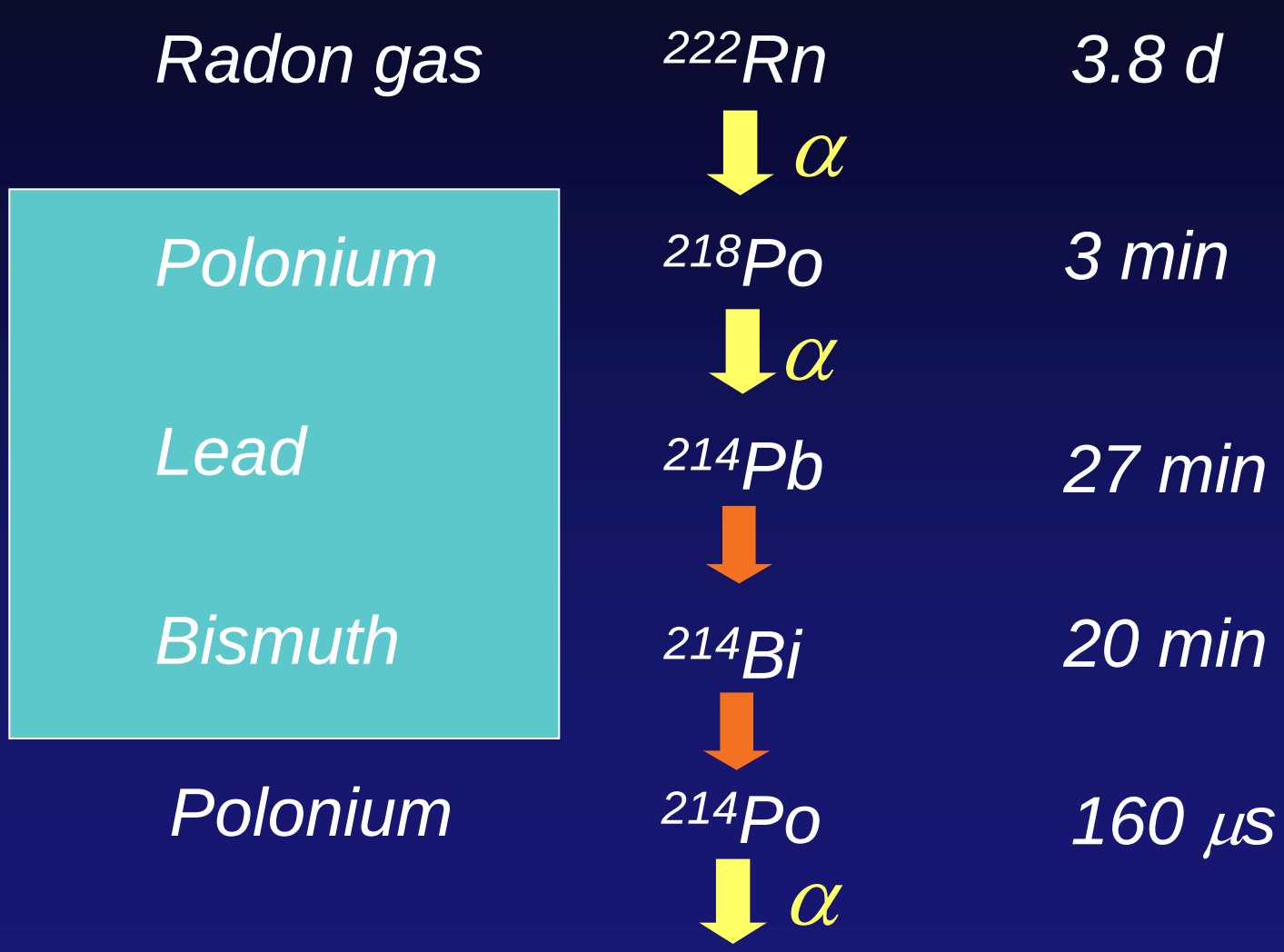
1. Introduction

What is radon?

- Radioactive noble gas
- From uranium-238 decay chain
- 3.82 day half-life
- Traces of uranium in all rocks and soils
- May diffuse several metres from where it is formed
- Emerges into open air or into houses

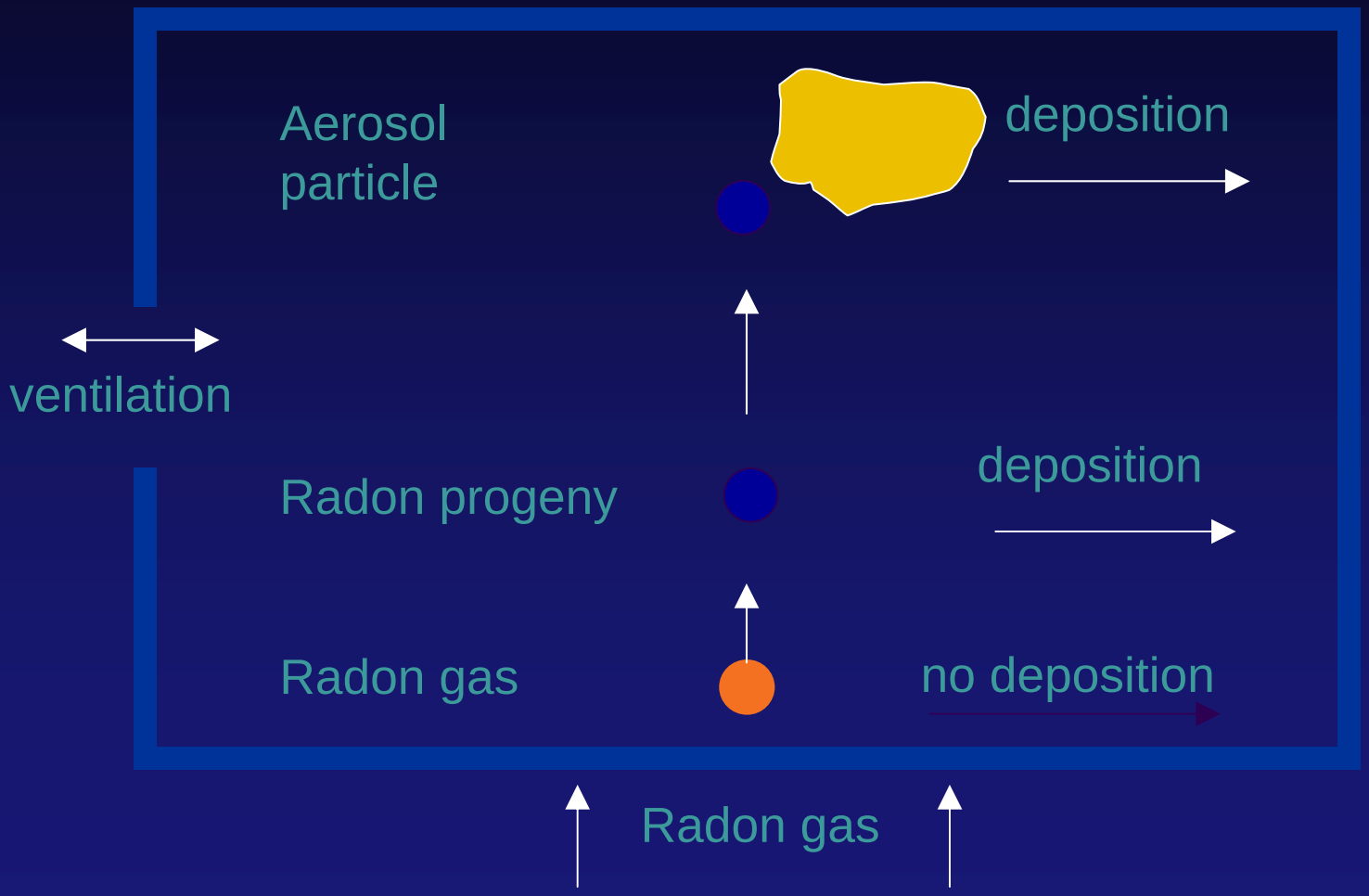
1. Introduction

What is radon?



1. Introduction

Formation of radon progeny



1. Introduction

Evidence for the risk from radon exposure

Miners in high-radon mines

Animals exposed to radon

People exposed at home

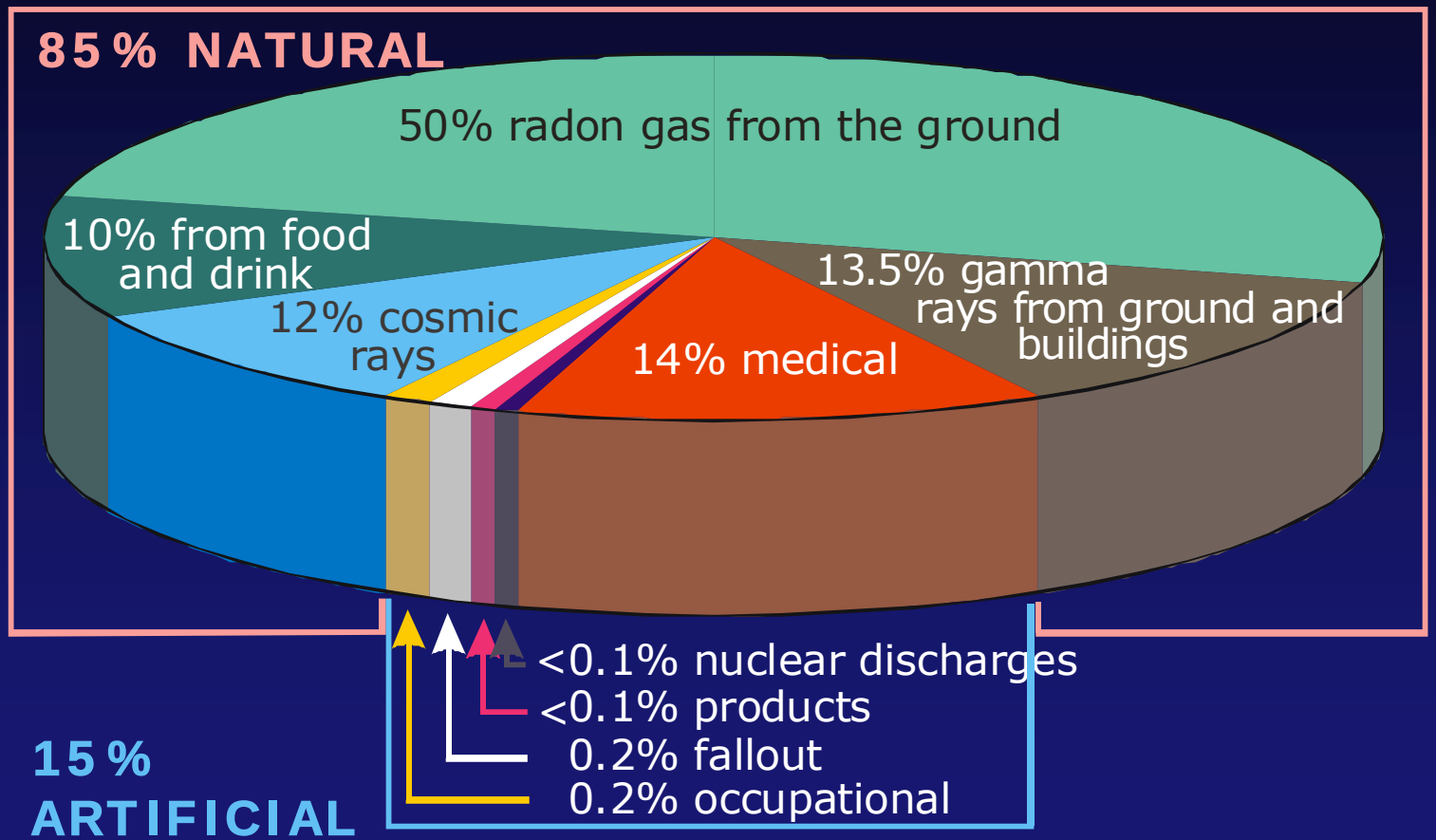
1. Introduction

Why is it important to estimate the risk?

- Radon is the number 1 cause of lung cancer among non smokers.
- Radon causes 100x more deaths than carbon monoxide poisoning
- Radon accounts for the largest component of naturally occurring background dose.

1. Introduction

Why is it important to estimate the risk?



1. Introduction

Why is it important to estimate the risk?

- ≈2500 deaths per year in UK
- ≈ 20,000 deaths per year in the US
- ≈ 0.5 million per year world-wide

"The biggest geological cause of deaths...
including earthquakes! "

1. Introduction

Units: concentration

Radon gas concentration

- pCi/L
- Bq m^{-3}

The PAEC associated with radon progeny in equilibrium with

100 pCi/L of radon gas is about

1WL

Potential Alpha Energy Concentration (PAEC)

1 Working Level (WL) is any combination of short lived decay products in 1 litre of air which will ultimately emit 1.3 10^5 MeV of alpha energy.

1. Introduction

Units: exposure

Radon gas concentration

- Bq m^{-3} h

Annual exposure of radon gas in a home of 230 Bqm^{-3}

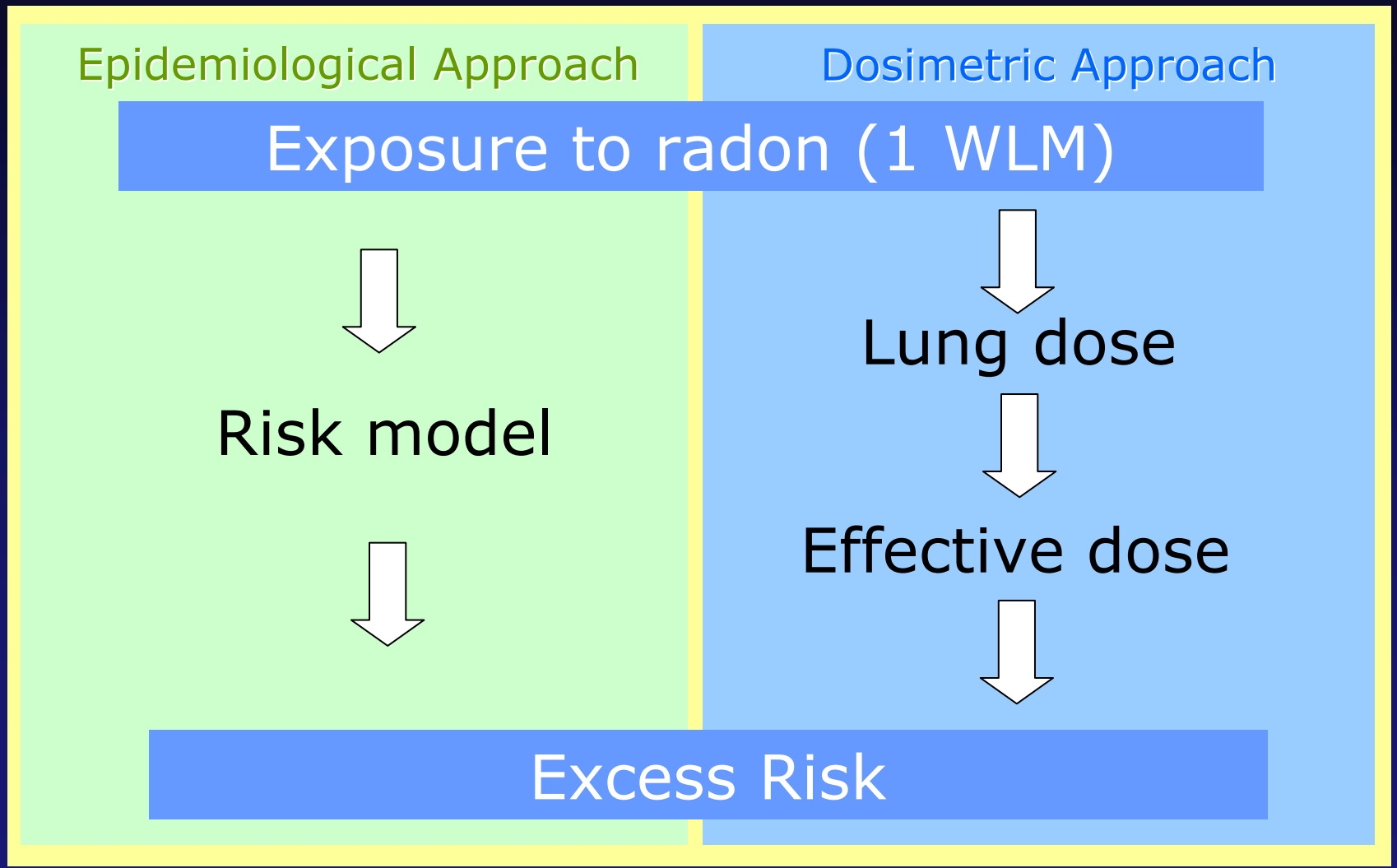
= 1WLM

Potential Alpha Energy Concentration (PAEC)

1 Working Level (WLM) is an exposure to 1 WL for 1 month (170 h).

1. Introduction

How can the risks from radon be assessed?

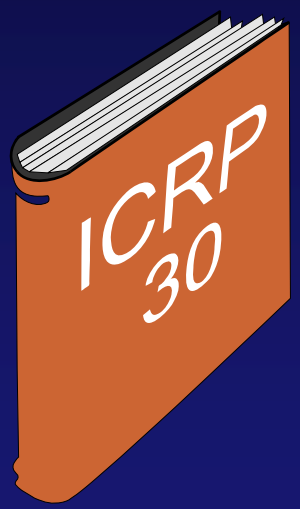


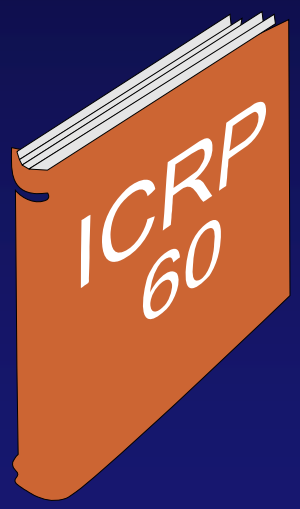
1. Introduction

Dosimetric approach

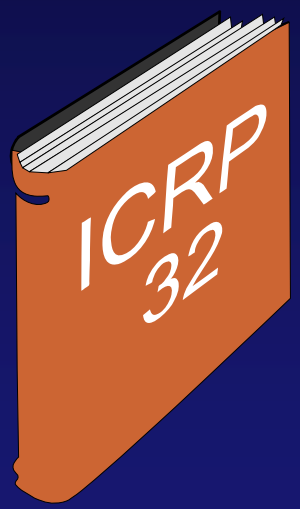
Radon has always had its own publications

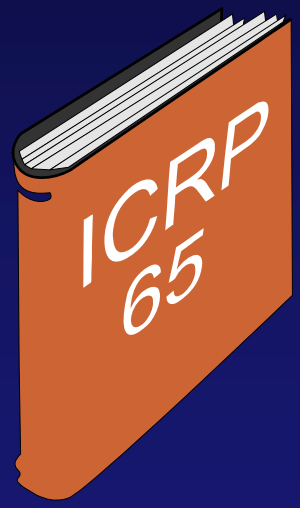
All radionuclides (except radon)





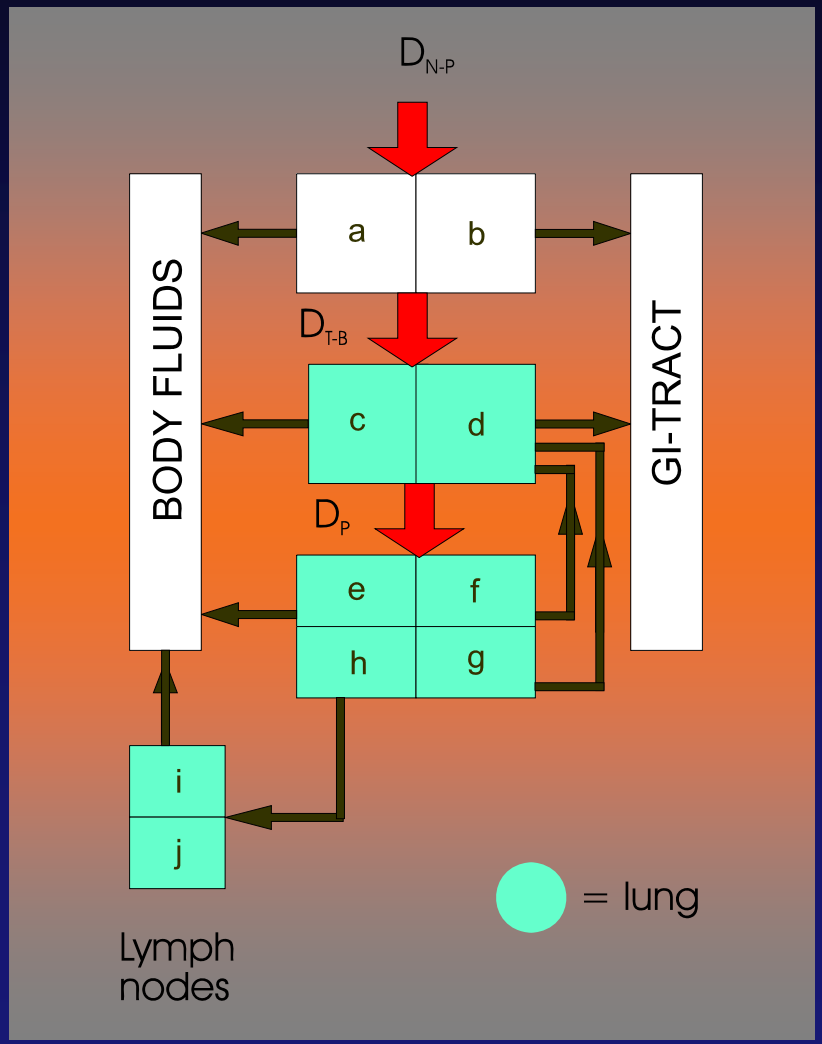
Radon





1. Introduction

Dosimetric approach



The ICRP 30 lung model was never really designed for short lived nuclides

The ICRP-66 model was an attempt to rectify this situation, and bring radon in line with other radionuclides.

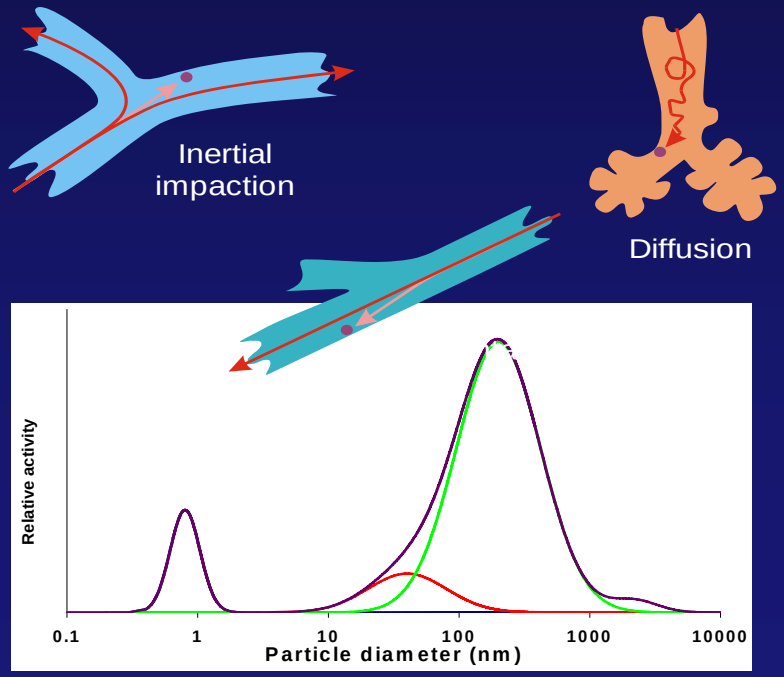
2. The Dosimetric Approach

Dosimetric approach

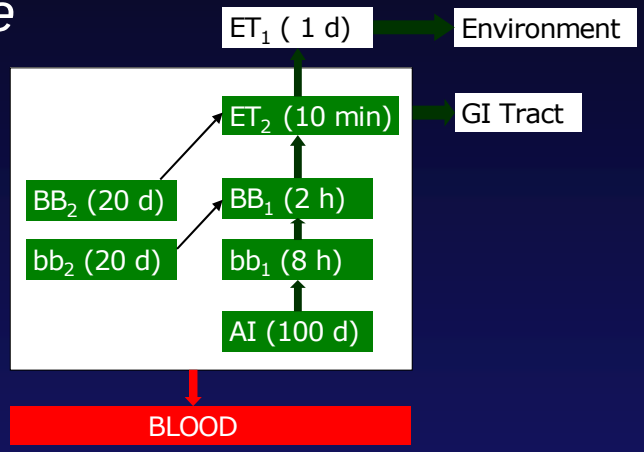
ICRP 66 was designed to deal with short lived radionuclides, so does this change things?

Deposition

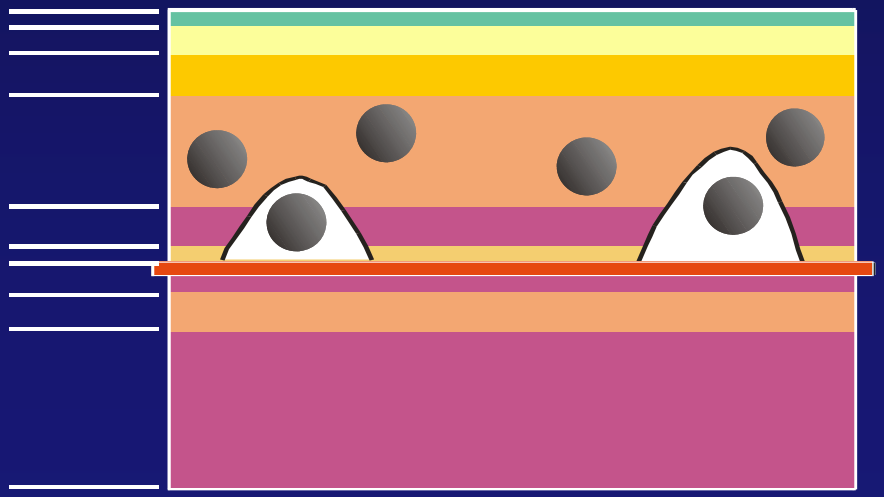
Particle Deposition in Respiratory Tract



Clearance



Dosimetry



2. The Dosimetric Approach

Dosimetric approach

Exposure 1 WLM

Lung model parameters

Ab Dose to bb, BB, AI

A_i = 0.333, w_R = 20

Eq Lung Dose 125 mSv

w_T = 0.12

Effective Dose 15 mSv

Risk=0.112/Sv, DDREF=2

RISK 8.4×10^{-4}

Unattached fract 1%

Eq'm factor, F=0.4

Unattached size .0011 m

Attached size 0.25 m

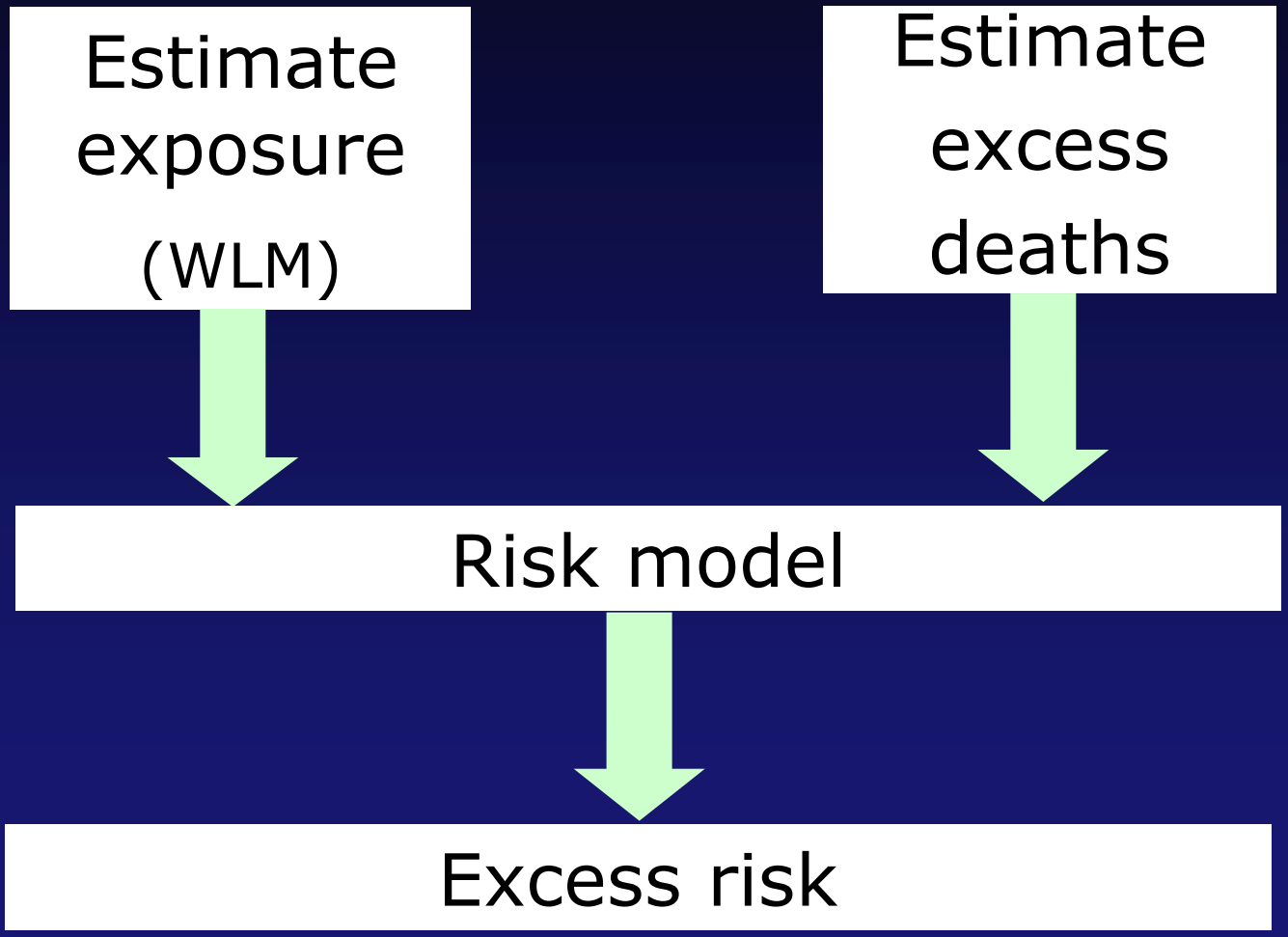
Breathing rate 1.2 m^3h^{-1}

Absorption $t_{1/2}$ 10 h

Morphometry ICRP 66

3. The Epidemiological Approach

Need a risk model



3. The Epidemiological Approach

Need a risk model

Exposure 1 WLM

Data from amalgamated underground minor cohorts

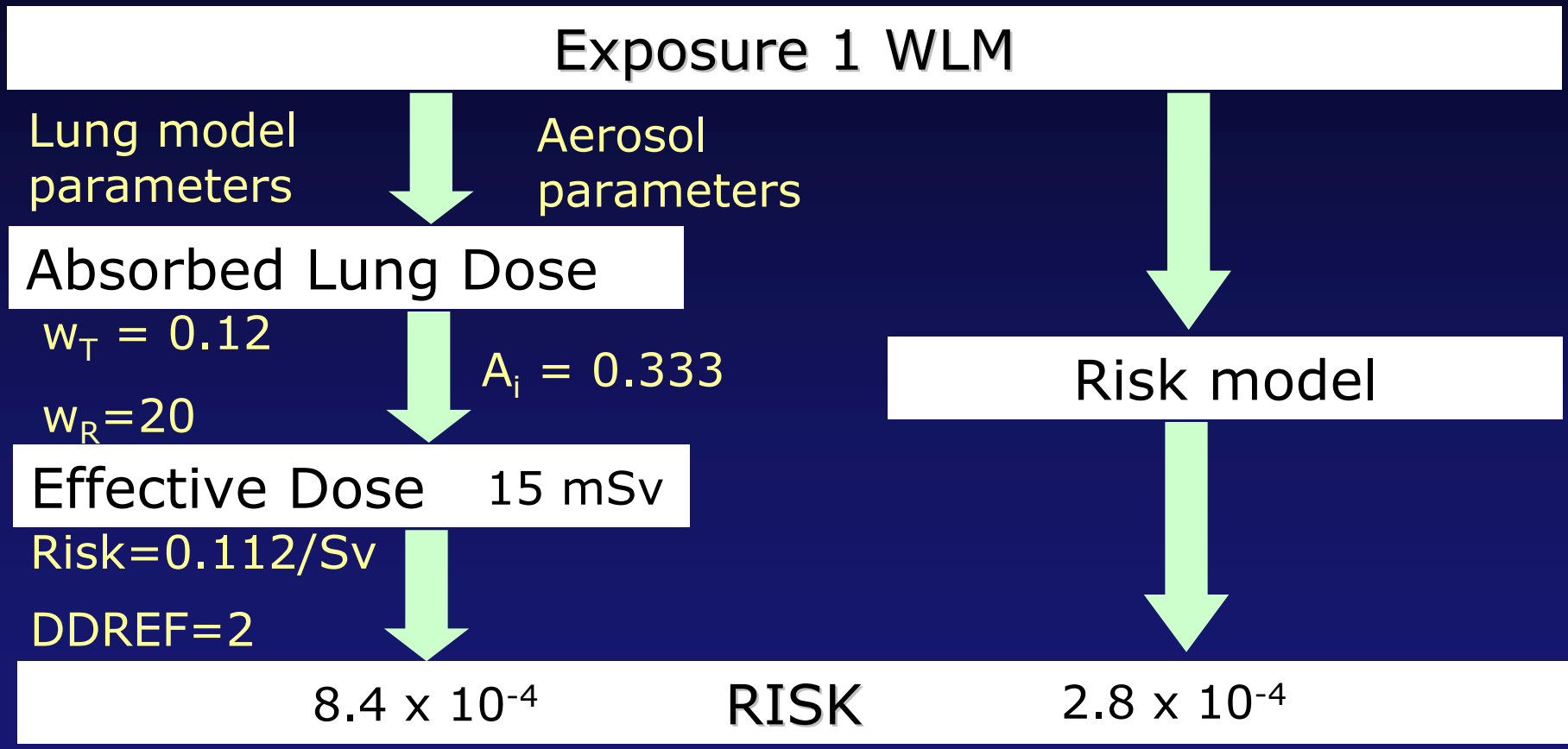
Multiplicative relative risk model with a reduction for time since exposure (ICRP 65)

Reference population J,PR,US,UK,CH (ICRP-60)

Risk 2.8×10^{-4}

4. Are the two approaches compatible?

A comparison



4. Are the two approaches compatible?

Uncertainties

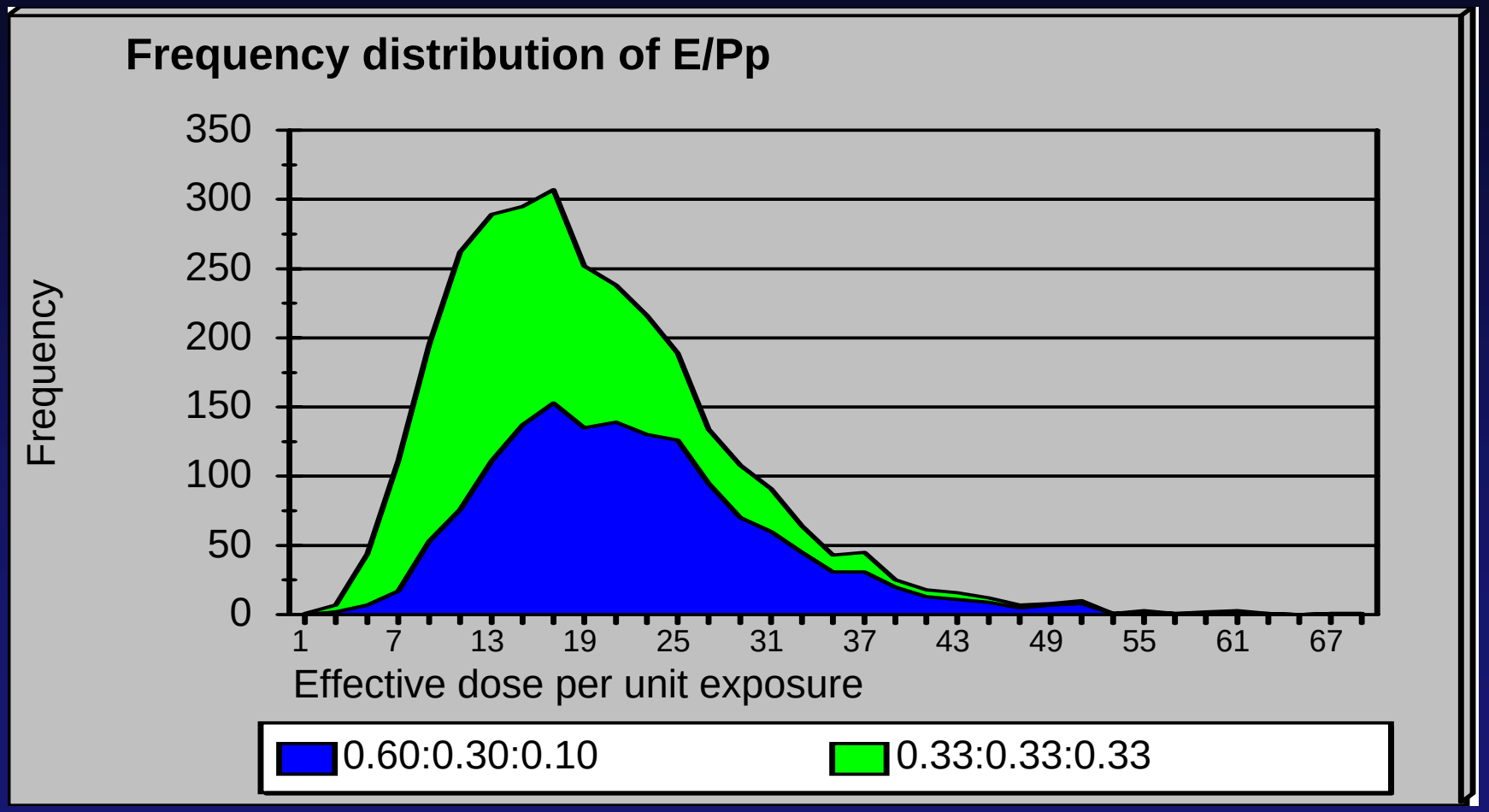
Sarah Darby and Sir Richard Doll

Radiation Protection in Australia 8 (4) (1990)

" .... current estimates about the size of the risk associated with exposure in houses of the order of 20 Bq m^{-1} may be too high or they may be too low by a factor of two"

4. Are the two approaches compatible?

Uncertainties



4. Are the two approaches compatible?

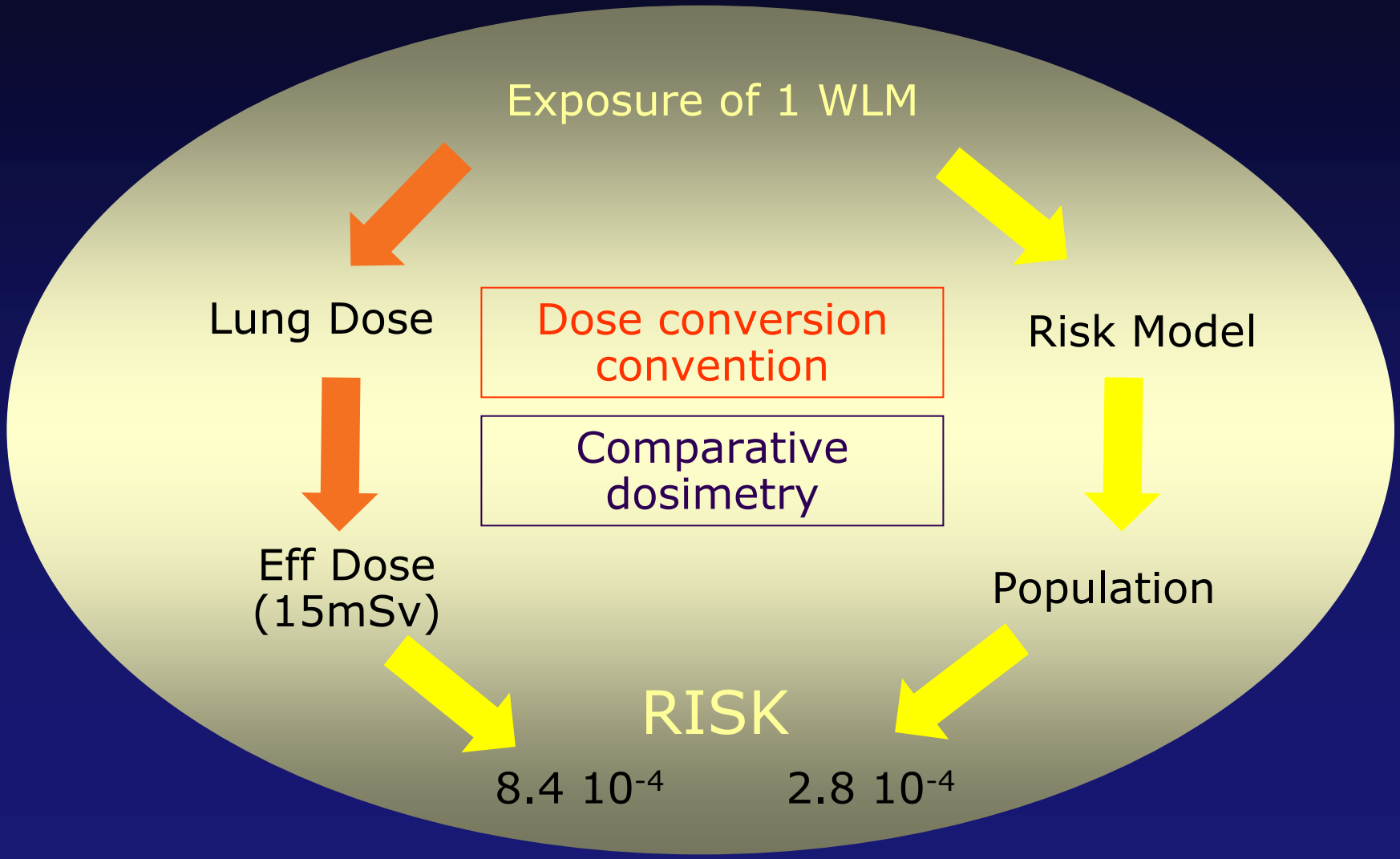
The ICRP resolution

ICRP 66 (p101, para 356)

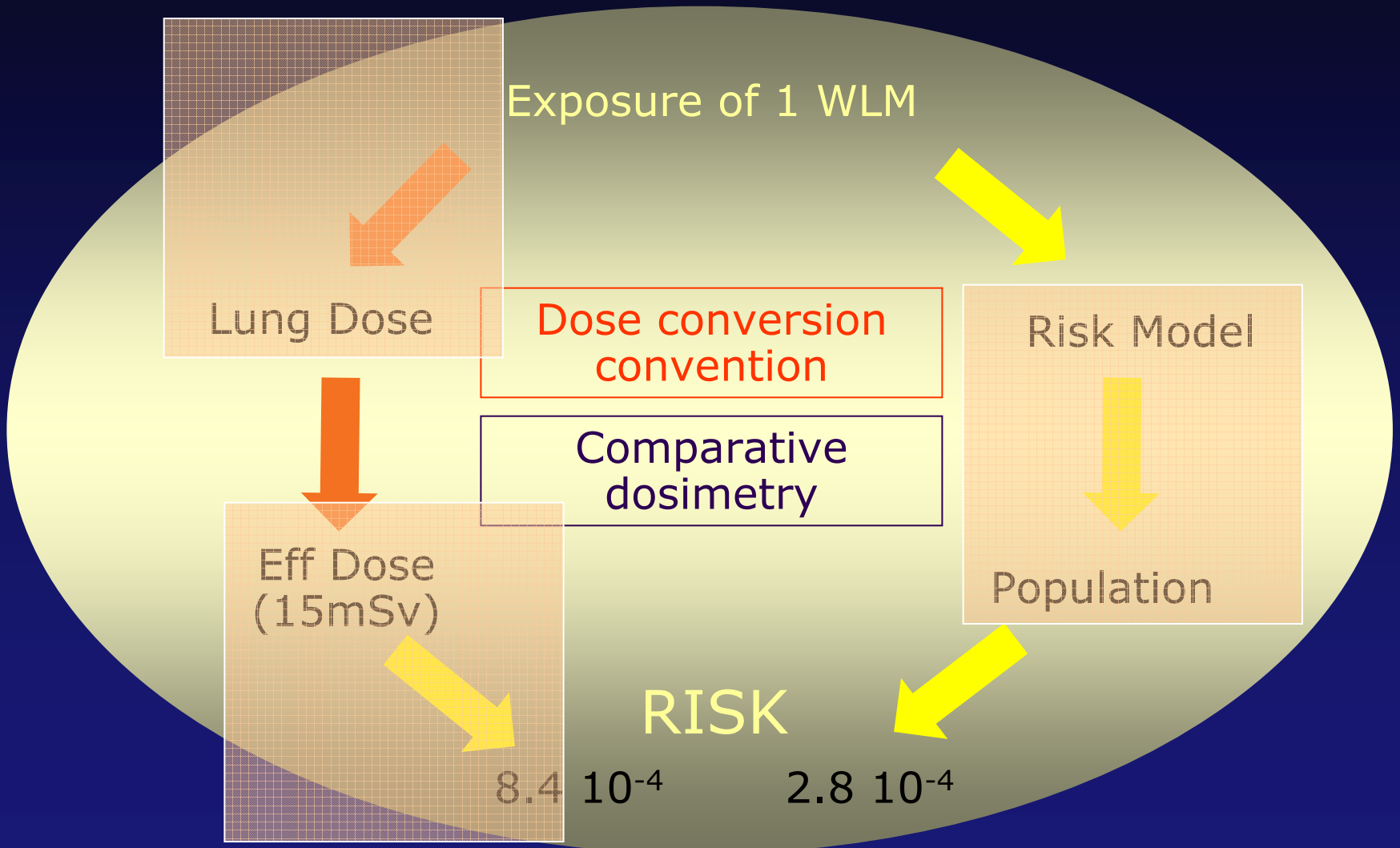
"In the case of exposure to radon progeny, since estimates of lung cancer risk for workers (and members of the public) can be made reliably from epidemiologic studies relating lung cancer in miners to radon exposure, the Commission does not recommend the ... [dosimetric approach]"

4. Are the two approaches compatible?

The ICRP resolution



4. Recent Developments



5. Recent Developments

Dosimetry

Marsh J W, Birchall A and Davis K. *Comparative dosimetry in homes and mines: estimation of K-factors*. Presented at the 7th Internatiuonal Symposium on the Natural Radiation Environment (NRE-VII), 20-24 May, 2002, Rhodes, Greece

- Best estimate of all the latest aerosol parameters
- Best estimate of all the latest lung model parameters

→ 12.5 mSv/WLM

5. Recent Developments

Risk per Sv

ICRP Publication 60 (1991)			
	Cancer	Hereditary	Total Det(1)
Worker	4.8	0.8	5.6
Public	6.0	1.3	7.3
ICRP Publication 103 (2007)			
	Cancer	Hereditary	Total Det(1)
Worker	4.1	0.1	4.2
Public	5.5	0.2	5.7

(1) Percent risk per Sv

5. Recent Developments

Epidemiology

Before 2000			
Reference	Risk Model	Population[1]	Risk / WLM
BEIR IV (1988)	BEIR IV	US	$3.5\ 10^{-4}$
ICRP-65 (1993)	ICRP65(GSF)	ICRP-60	$2.8\ 10^{-4}$
After 2000			
EPA (1999)	BEIR VI[2]	US	5.1
EPA(2003)	BEIR VI[2 and 3]	US	$5.4\ 10^{-4}$
Tomasek(2008)	BEIR VI[2]	ICRP-103	$5.3\ 10^{-4}$
Tomasek(2008)	Czech/French	ICRP-103	$4.4\ 10^{-4}$

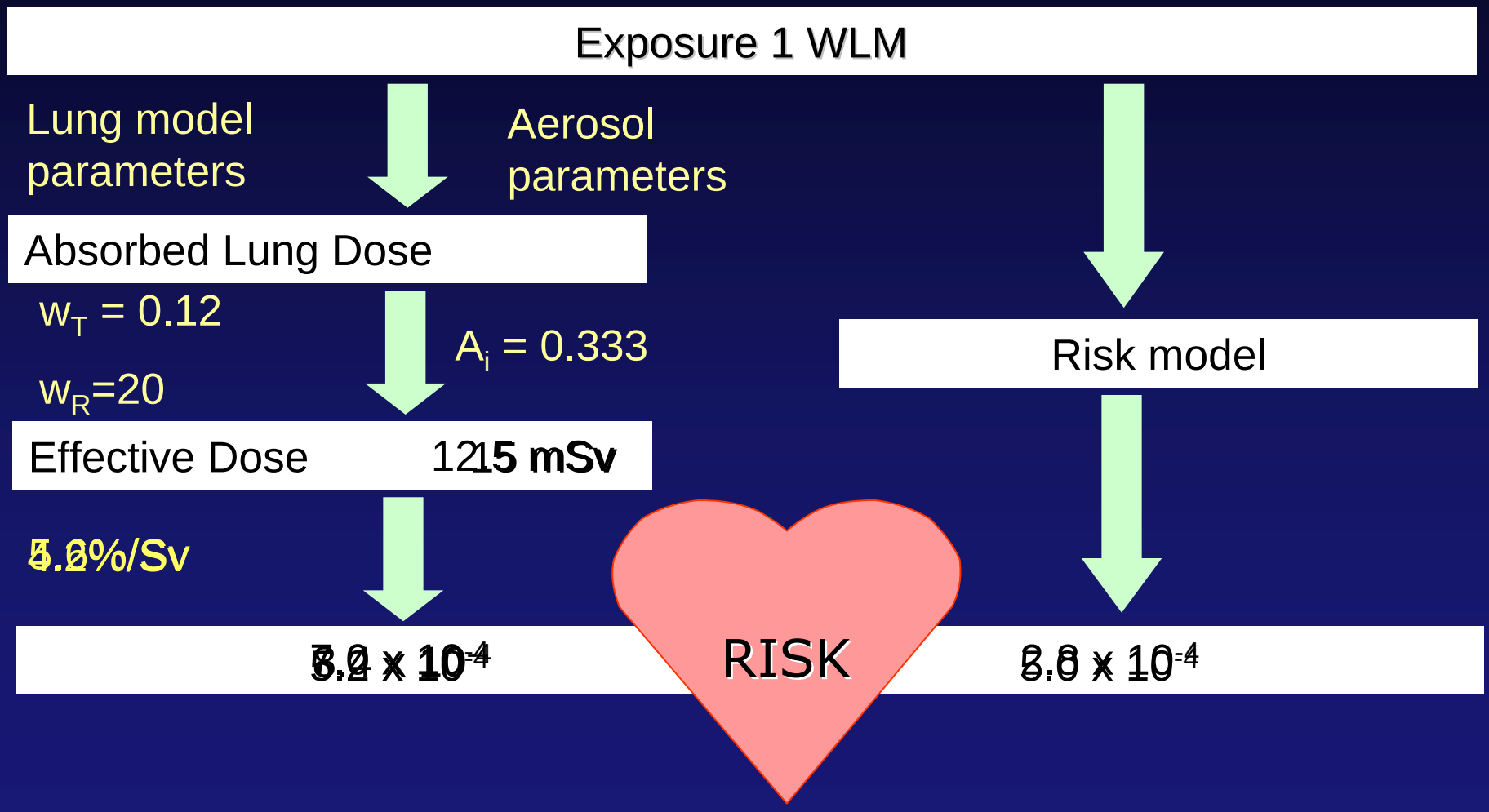
[1] males/females smokers/non-smokers

[2] exposure-age-concentration risk model

[3] exposure-age-duration risk model

In a recent statement, ICRP has recommended a value of $5.0\ 10^{-4}$ for radiation protection purposes.

5. Recent Developments



5. Recent Developments

Dose coefficients

ICRP

Using a revised value of 5×10^{-4} per WLM for the lung cancer risk…

and equating with total detriment from ICRP-103

Workers	4.2×10^{-2} Sv^{-1}	12 mSv WLM^{-1}
Public	5.7×10^{-2} Sv^{-1}	9 mSv WLM^{-1}

NCRP

NCRP SC-6-2 have recently updated NCRP Report 93 *"Ionizing Radiation Exposure of the United States Population". The new document, NCRP Report 160 recommends a value of* 10 mSv WLM^{-1} *for radon exposure*

5. Conclusion

- *For the first time in a long time we are seeing harmonisation in the way radon is treated, from a radiation protection viewpoint.*

- *This lends weight to the system of radiological protection for other radionuclides (especially airborne alpha emitters).*

THE END