Reference Dose Coefficients for Environmental Exposure

ICRP Symposium on Radiological Protection Dosimetry

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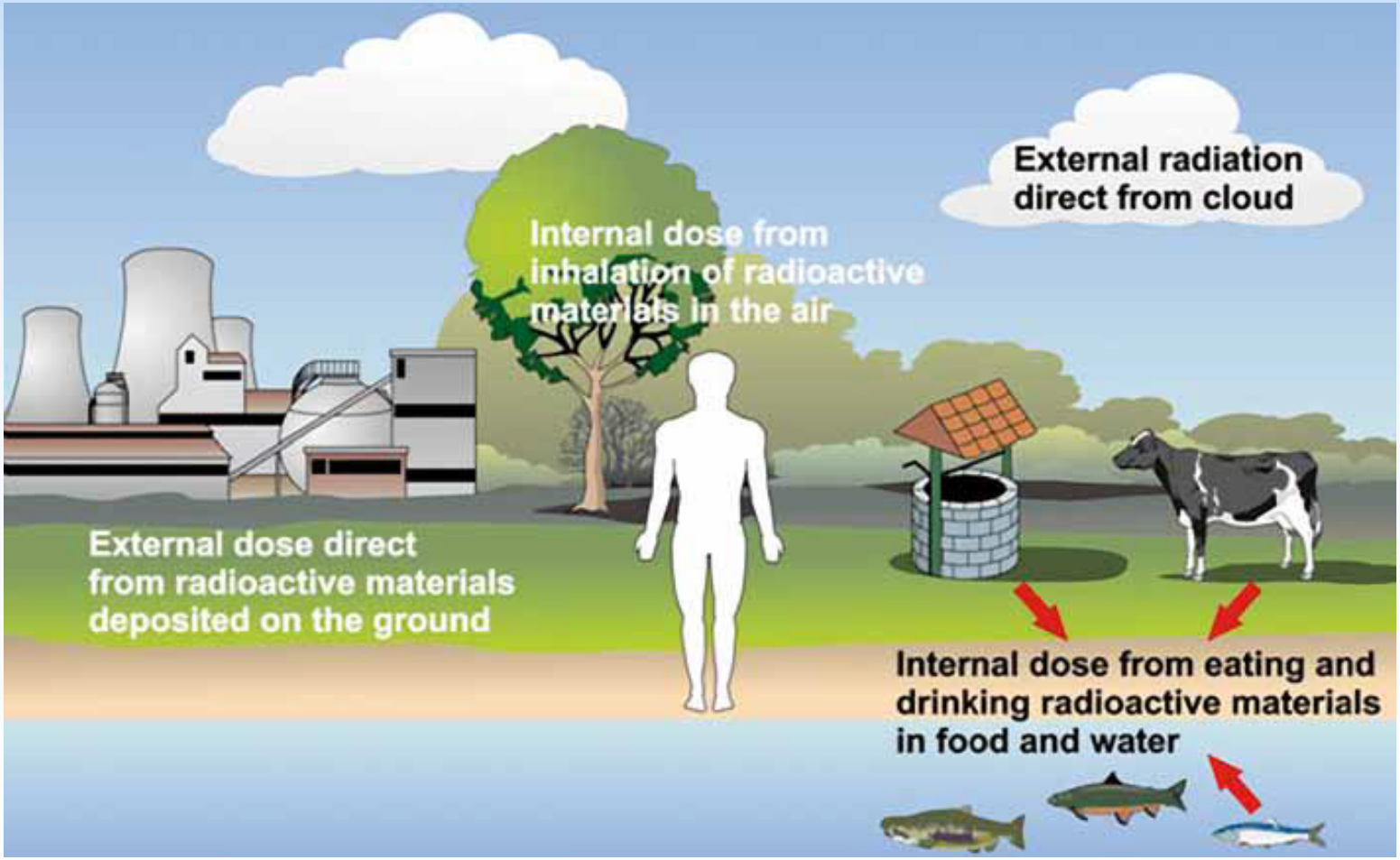
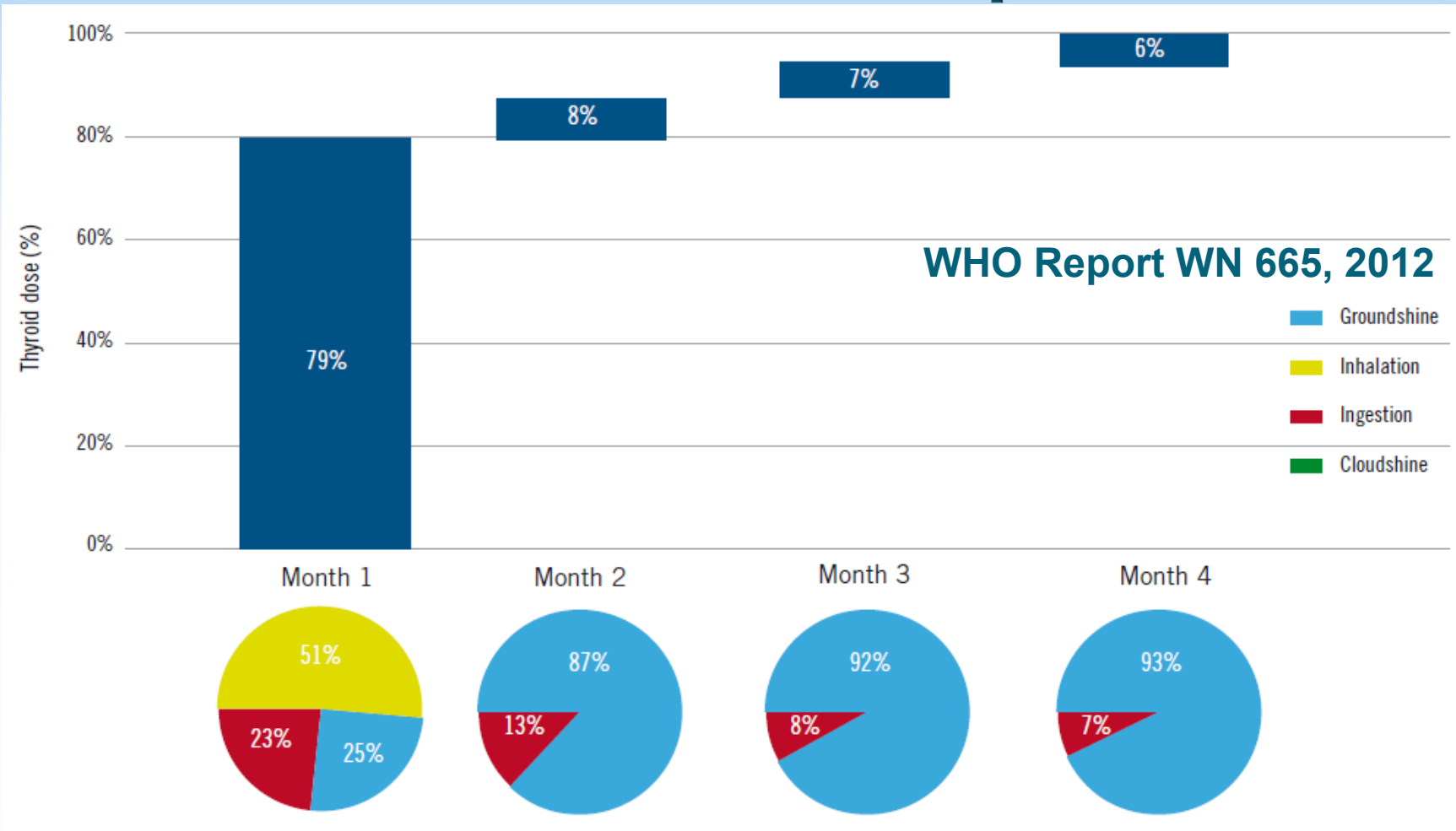
Helmut Schlattl[1], Daiki Satoh[2]
[1]Helmholtz Zentrum Muenchen, Neuherberg, Germany
[2]Nuclear Science and Engineering Center, Japan Atomic Energy Agency, Ibaraki, Japan

Sources of radiation doses in contaminated environment



Cumulative thyroid dose of a 10 year old child in Fukushima prefecture



→ External irradiation is main source of radiation dose a few months after accident

Historical overview

- Dillman, Health Physics 1974:
  Dose-depth values for reference adult (MIRD-type) in radioactive cloud
- US Department of Energy, DOE/EH-0070 1988 (ORNL):
  Organ dose conversion factors for adults
  (refined in FGR-12 report 1993)
- JAERI/HMGU (e.g., Saito et al., J. Nuc. Sci. Technol. 1991):
  Organ dose coefficients for children and baby (voxel models)

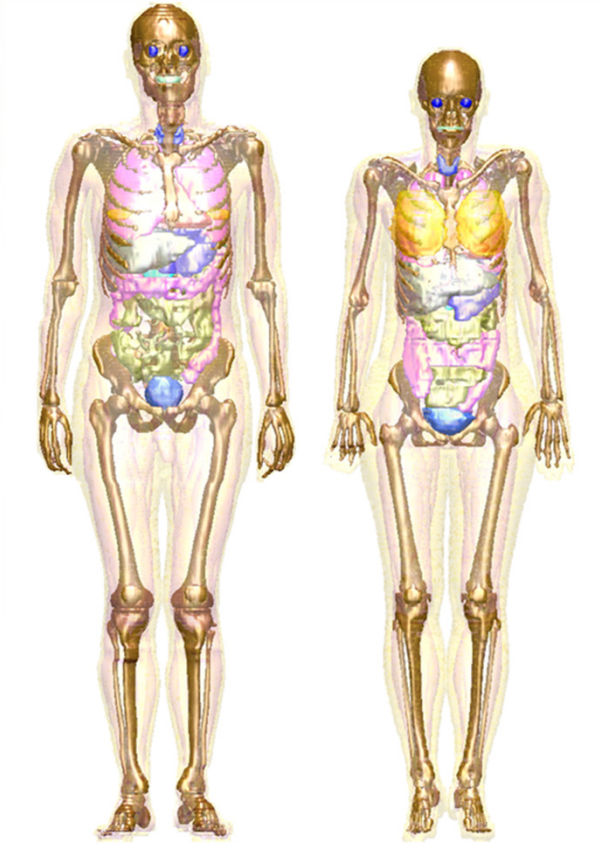
ICRP task group: establishment of reference dose coefficients

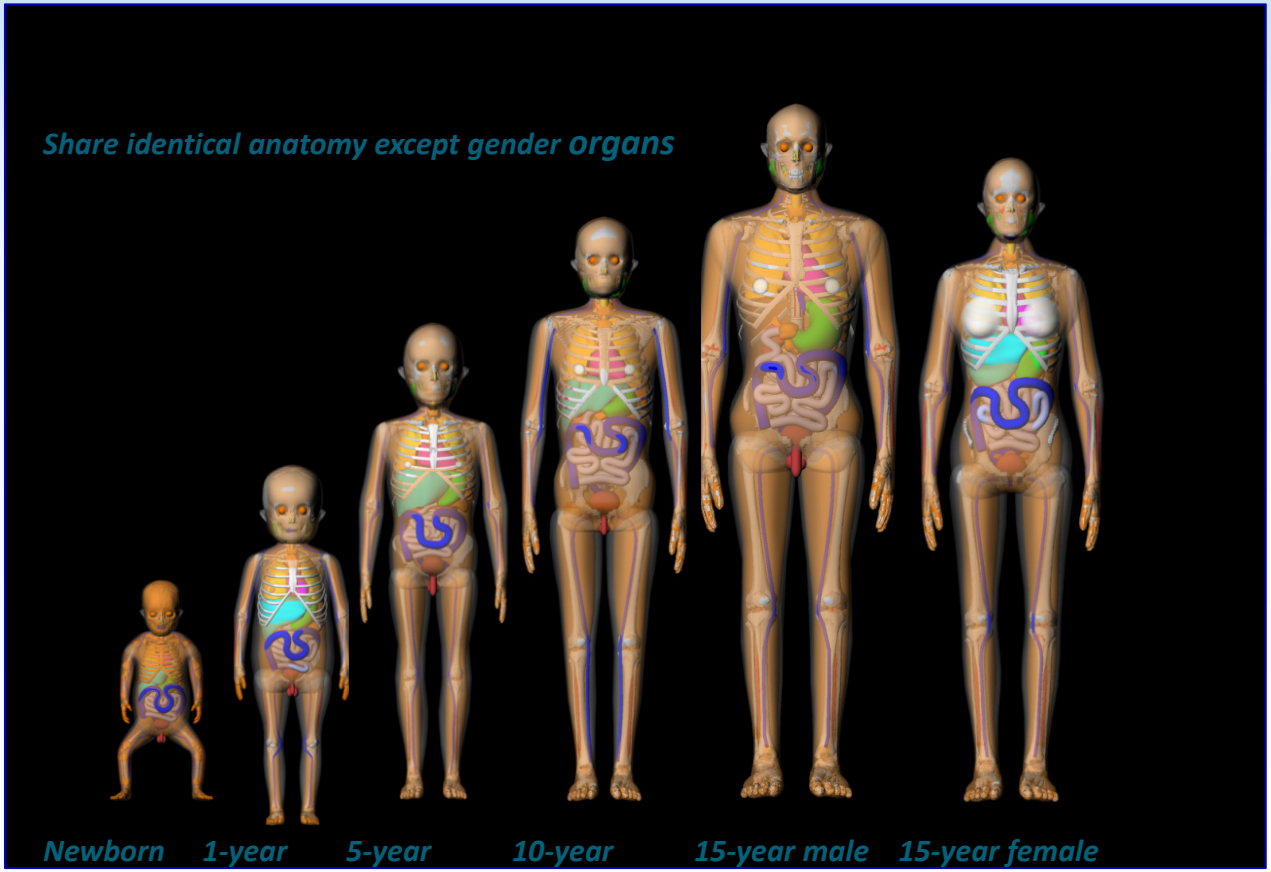
- Conversion coefficients:

  measured activity → organ and effective dose rate

- Three different scenarios
  - Air submersion
  - Ground contamination
  - Water immersion
- ICRP reference human models
  - Reference adults (ICRP 110)
  - Upcoming reference paediatric models
- For gamma and beta emitters

ICRP Reference virtual human models





Adults

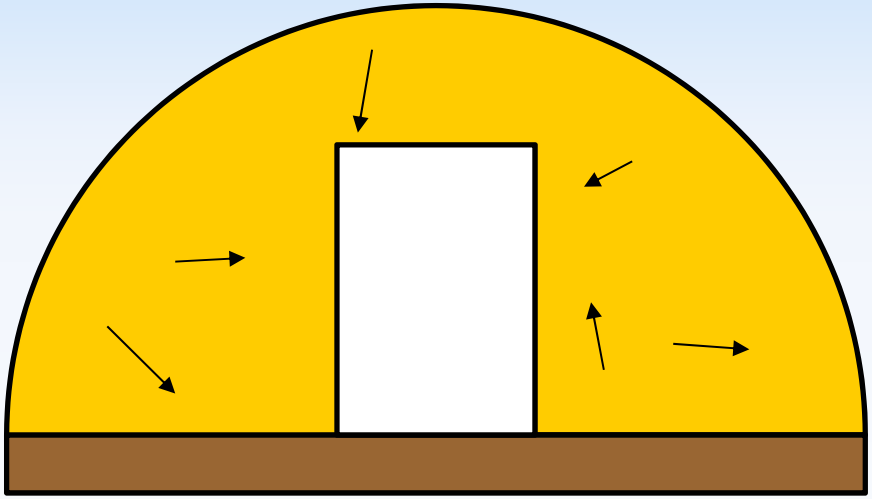
Paediatric

Quality assurance

- Primary calculations by JAEA
- Spot checks by ICRP task group 90 members
- Comparison with previous calculations for photons in air and soil
- Comparison with draft “Federal Guidance Report 15” of the US Environmental Protection Agency

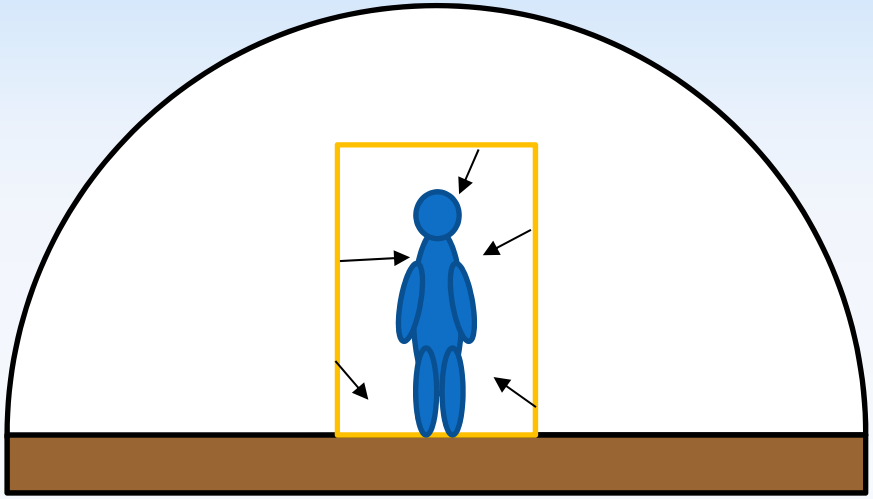
Simulation setup (air)

Step 1: Scoring at coupling cylinder



Semi-sphere:
Radius = 5.0 mean free paths
(e.g. 656m for 1 MeV photon)
Soil thickness = 100 cm

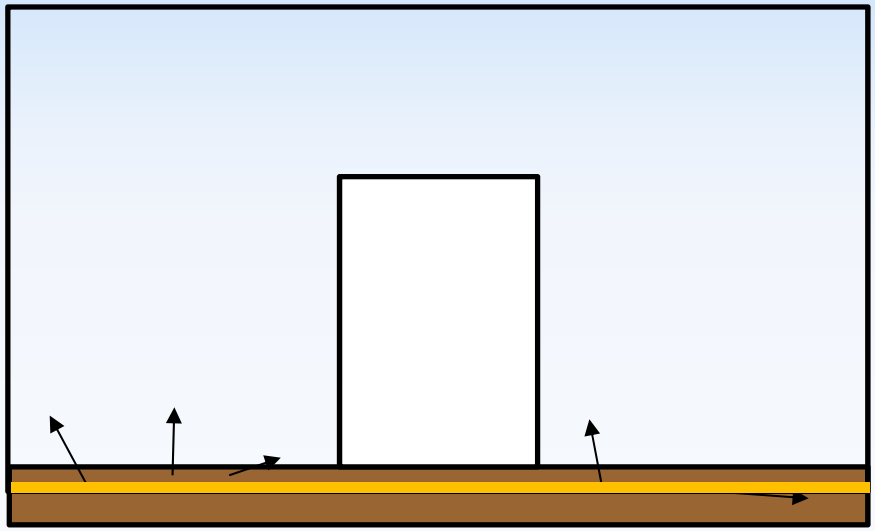
Step 2: Organ DC calculation



Coupling cylinder:
diameter= 60 cm,
height 200cm

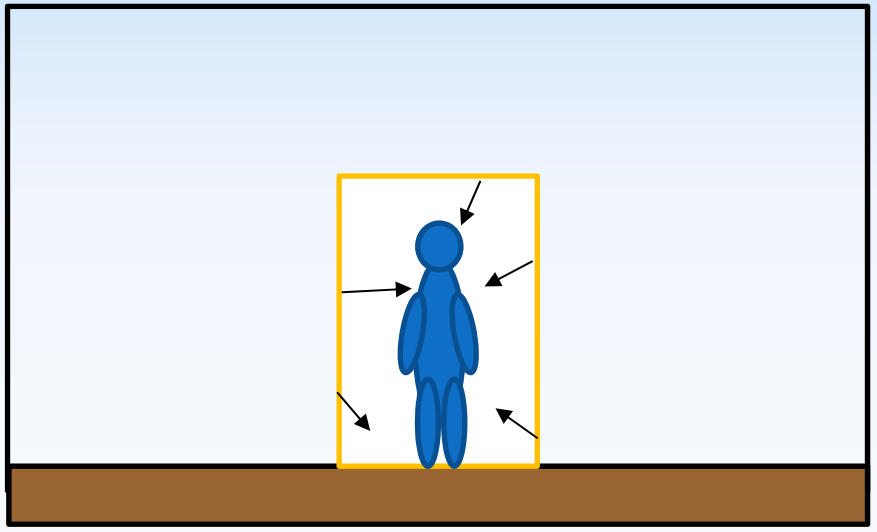
Simulation setup (ground)

Step 1: Scoring at coupling cylinder



Semi-sphere:
Radius: 5 mean free paths (MFP)
Height: 3 mean free paths
Soil thickness between 2 and 5 MFP

Step 2: Organ DC calculation



Coupling cylinder:
diameter= 60 cm,
height 200cm

5 source depths:

0, 0.2, 1., 2.5 and 4 mean free paths

Volumetric ground sources

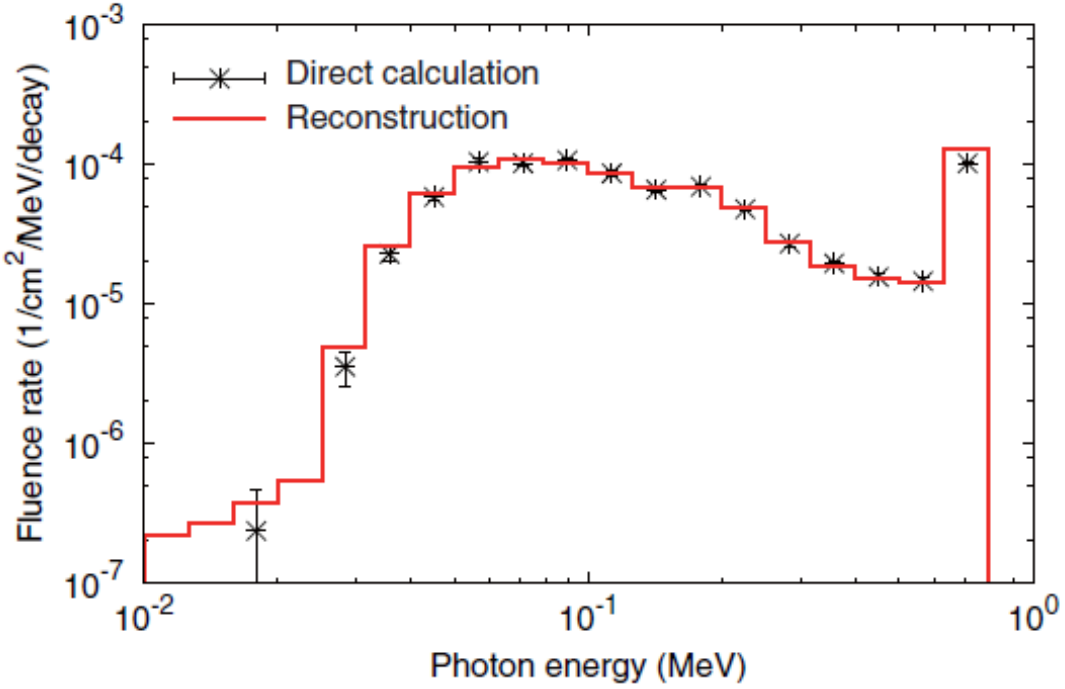
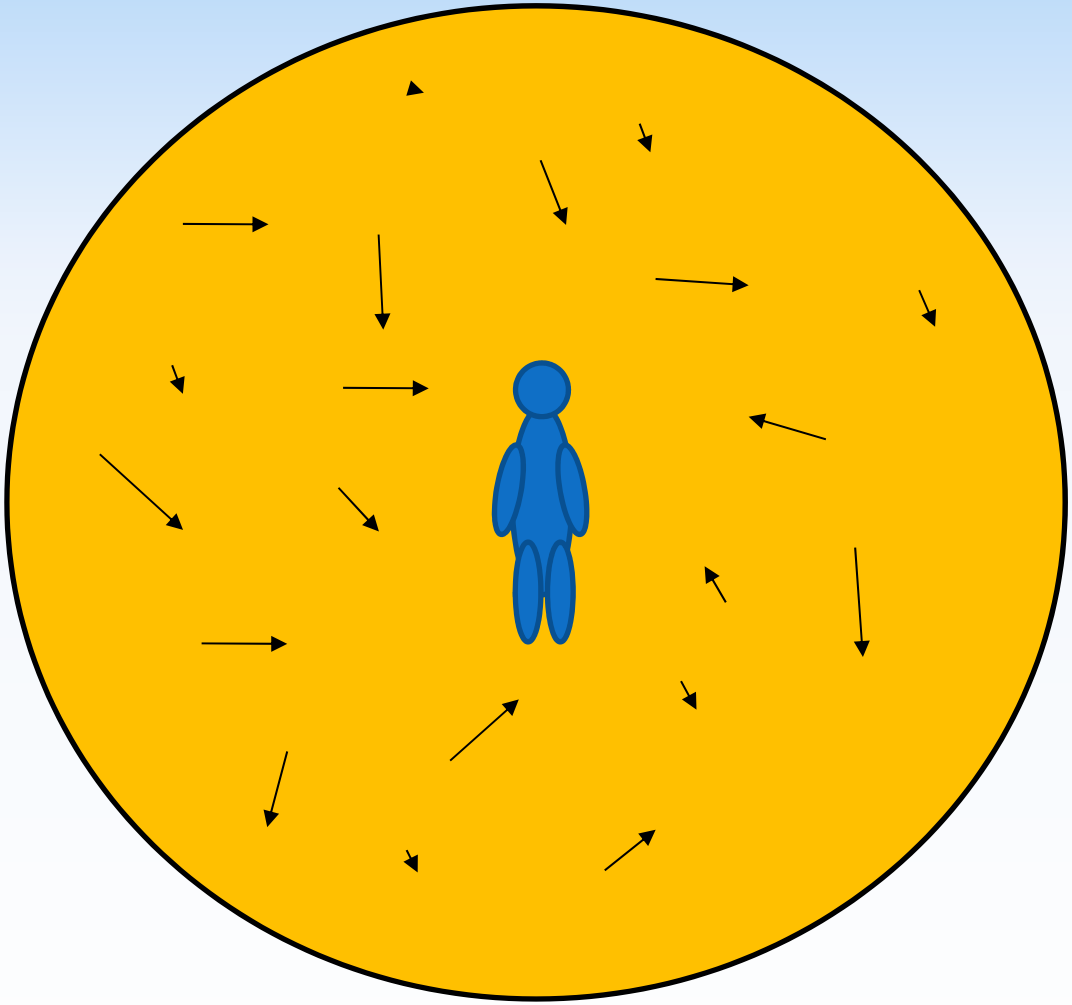


Figure 8. Energy spectra for environmental photons from volumetric source of ^{137}Cs with exponential distribution with $\beta = 1.0$.
Note: Stars represent the results calculated directly by PHITS from the volumetric source, and line indicates the results reconstructed by using data for planar sources.

D. Satoh et al., J. Nuc. Sci. Technol., 53, 69-81, 2016.

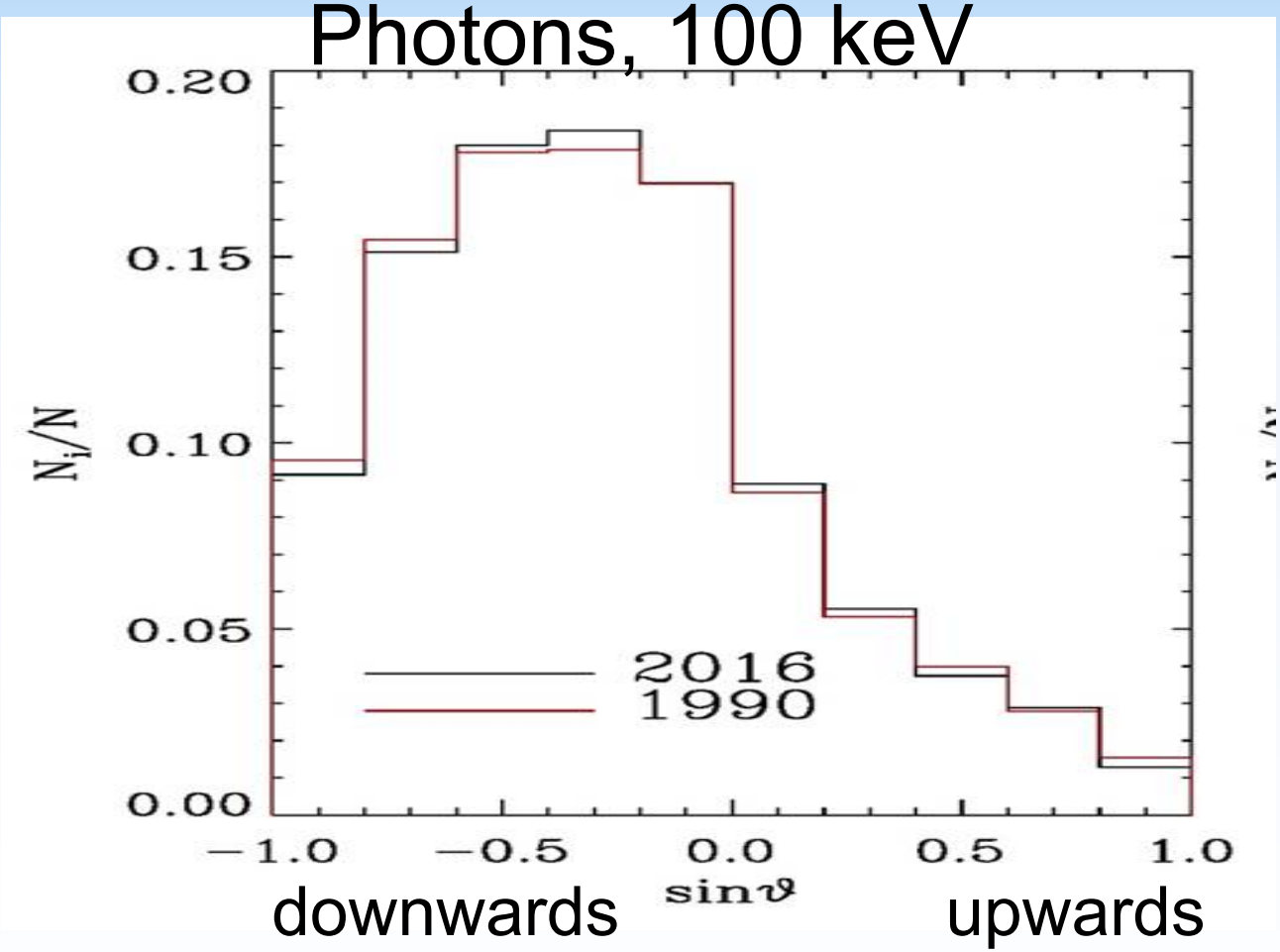
Simulation setup (water)



Sphere:
Radius: 200 cm

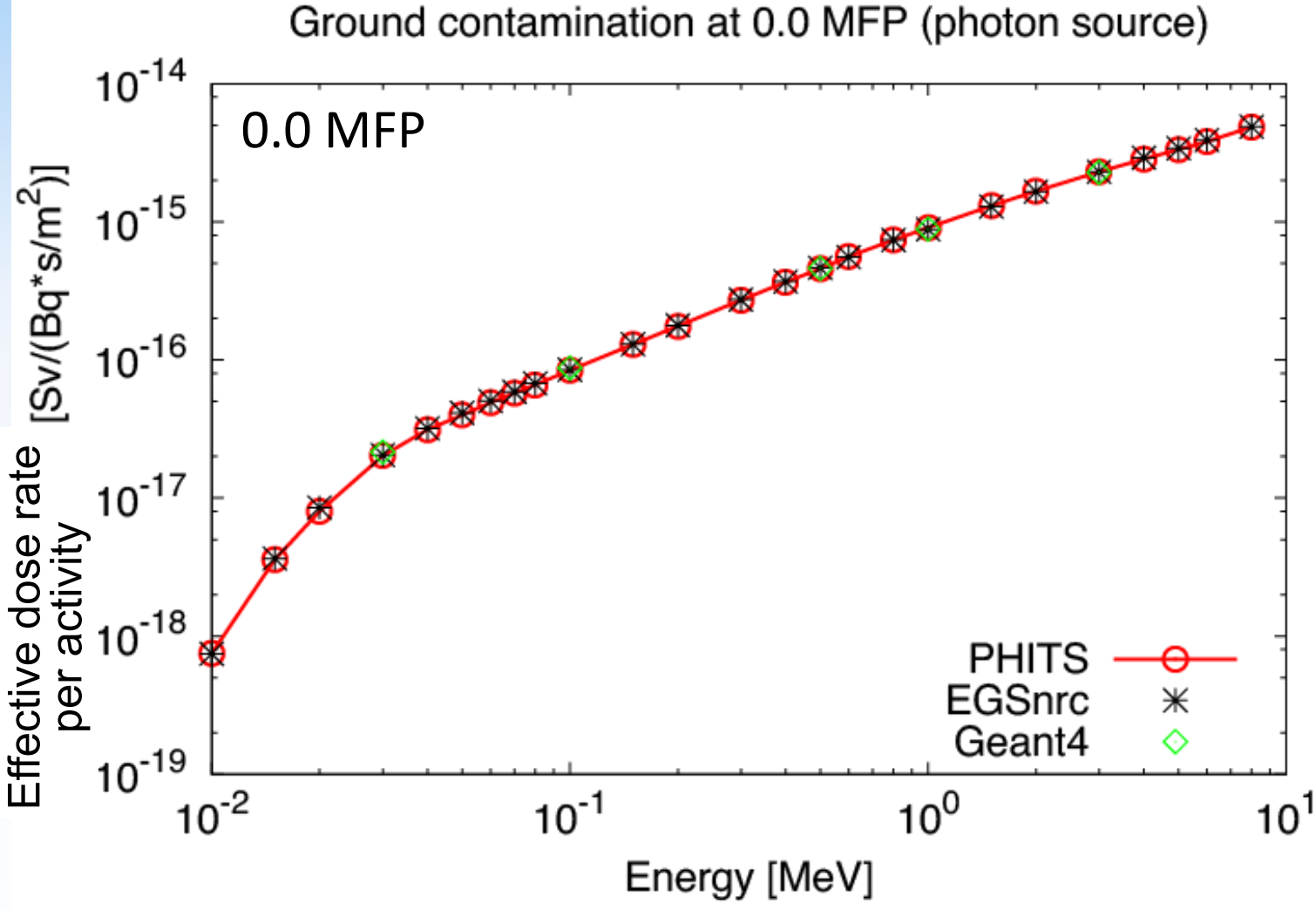
Air submersion: angular field

Photons, 100 keV



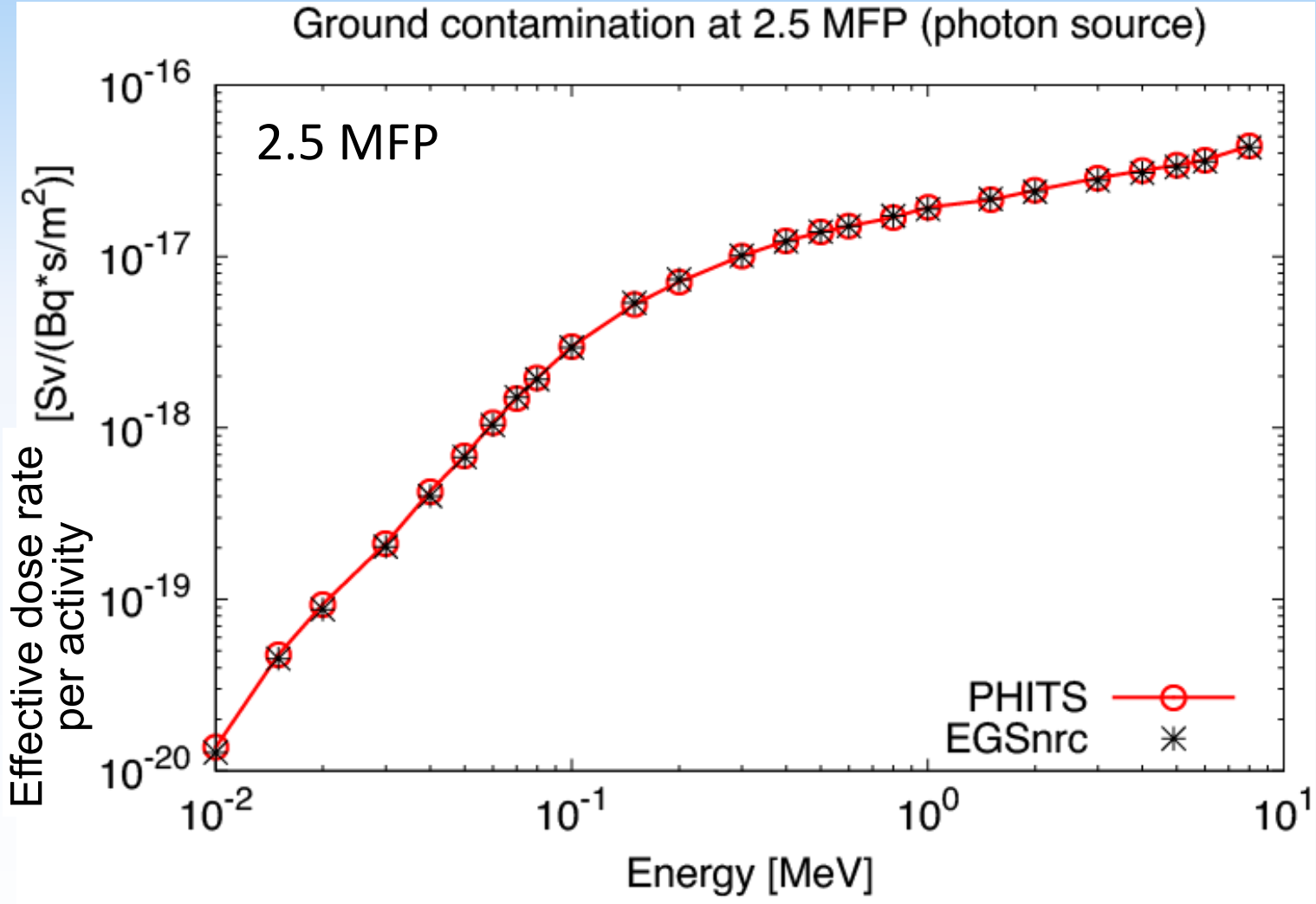
downwards upwards

Results: soil contamination



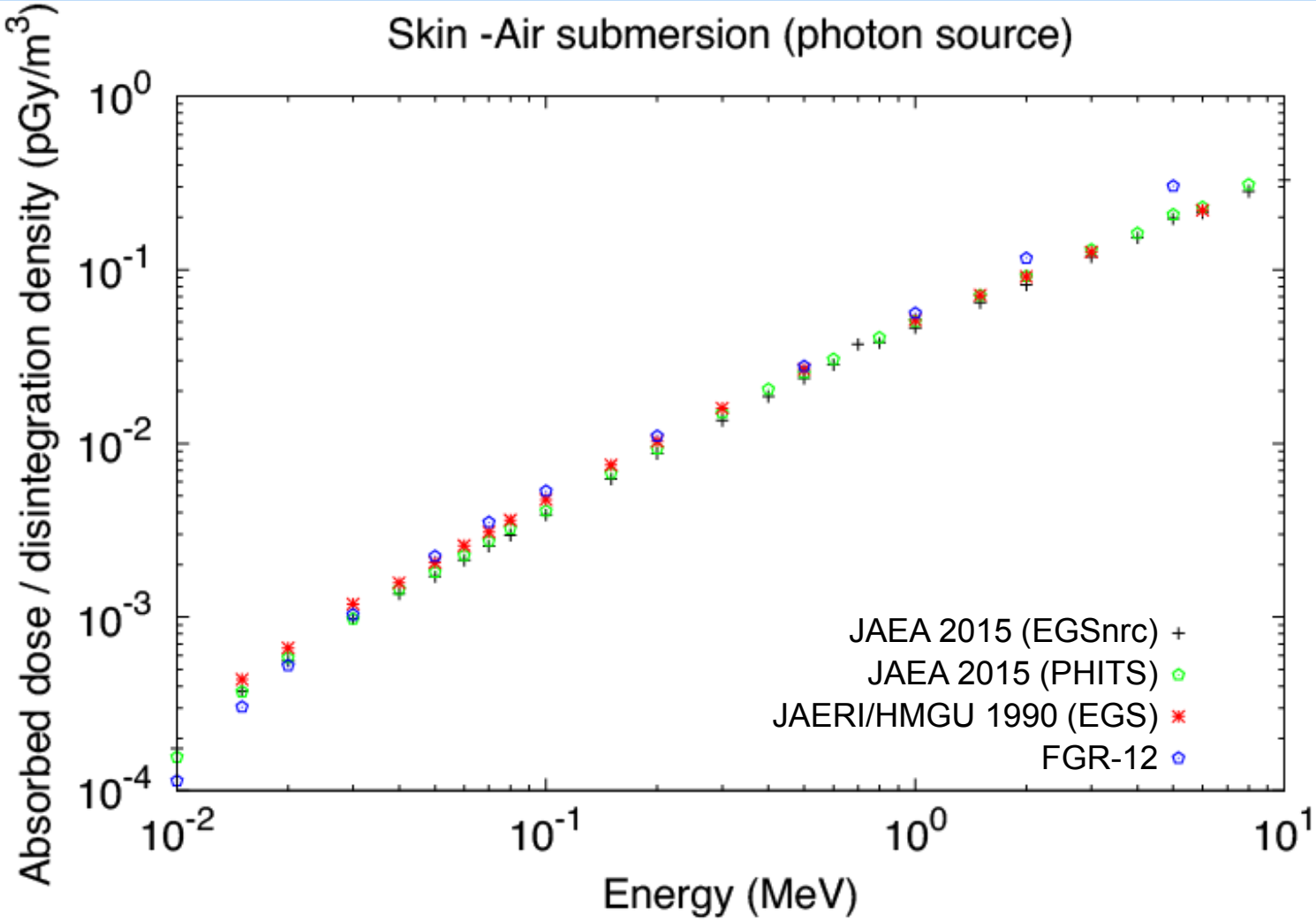
Effective dose rates per activity (Adult)

Results: soil contamination

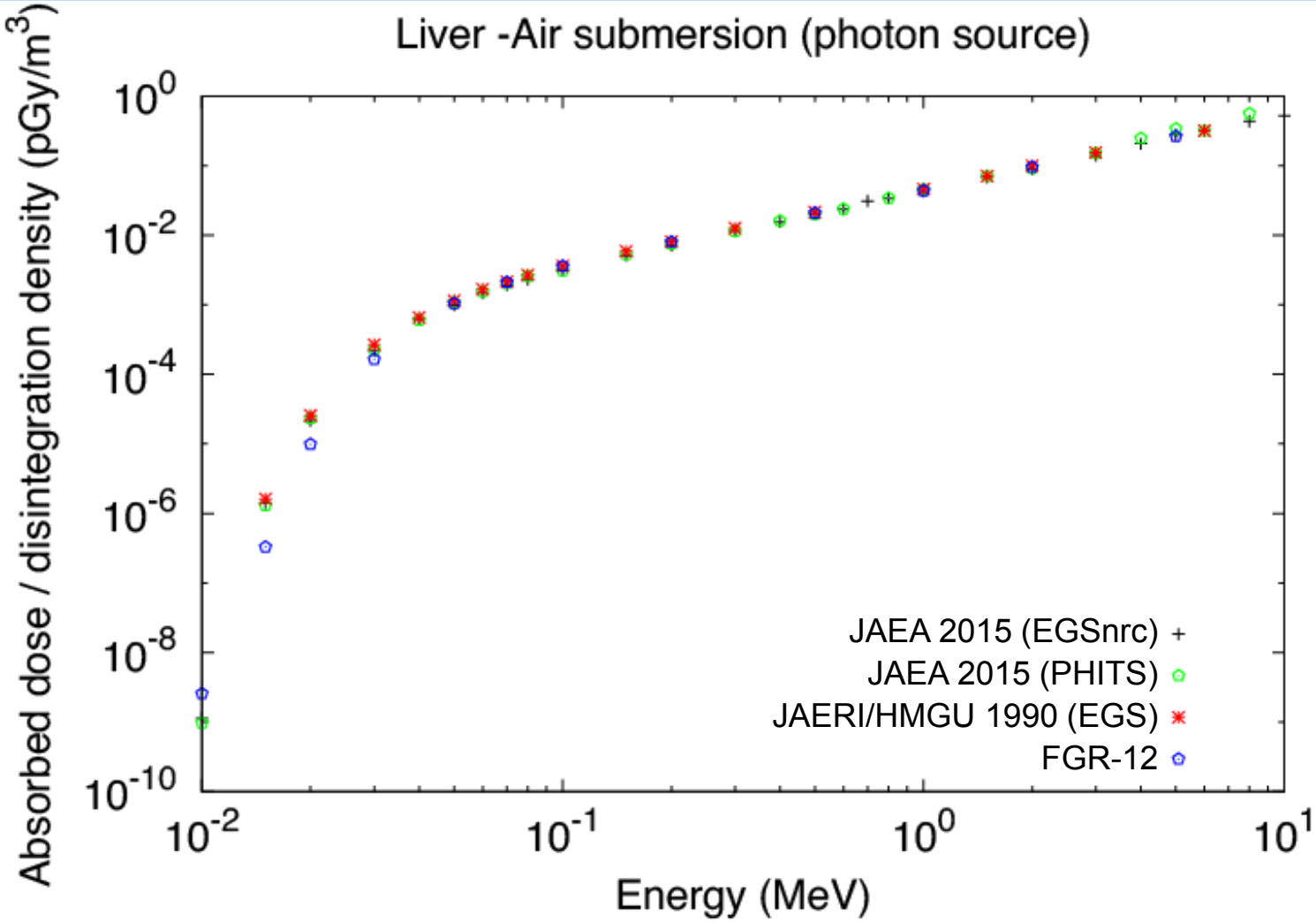


Effective dose rates per activity (Adult)

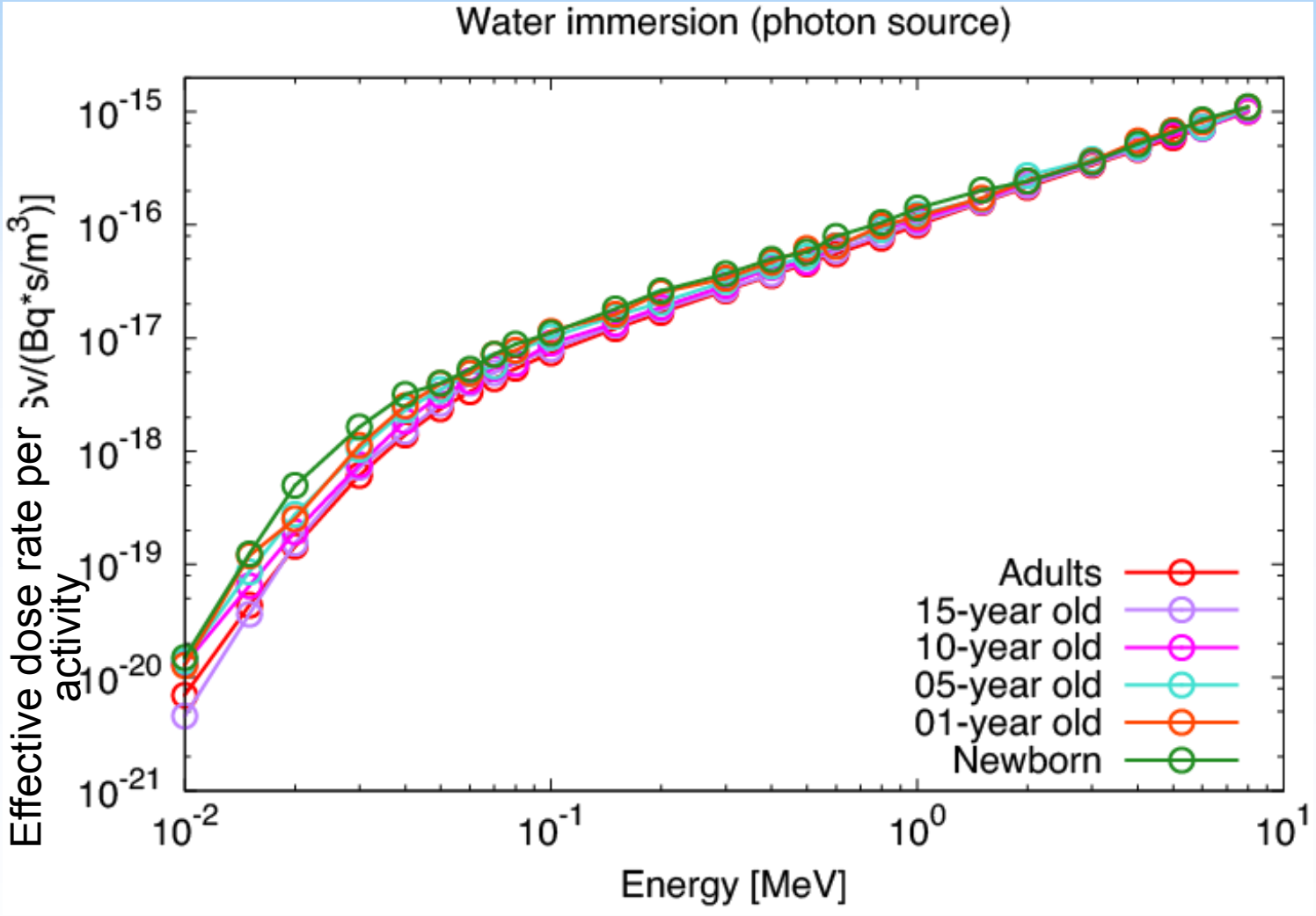
Results: air submersion



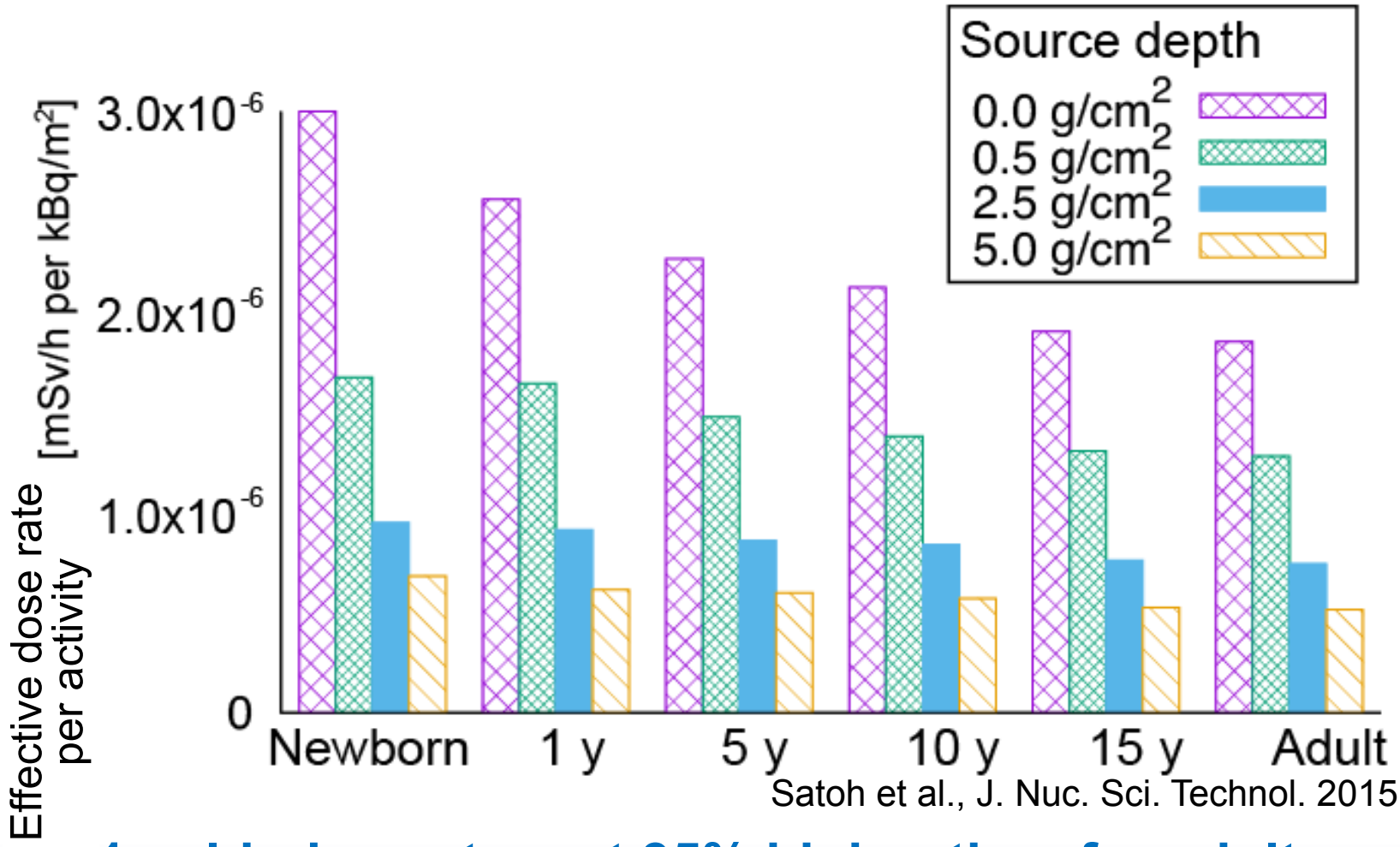
Results: air submersion



Results: water immersion



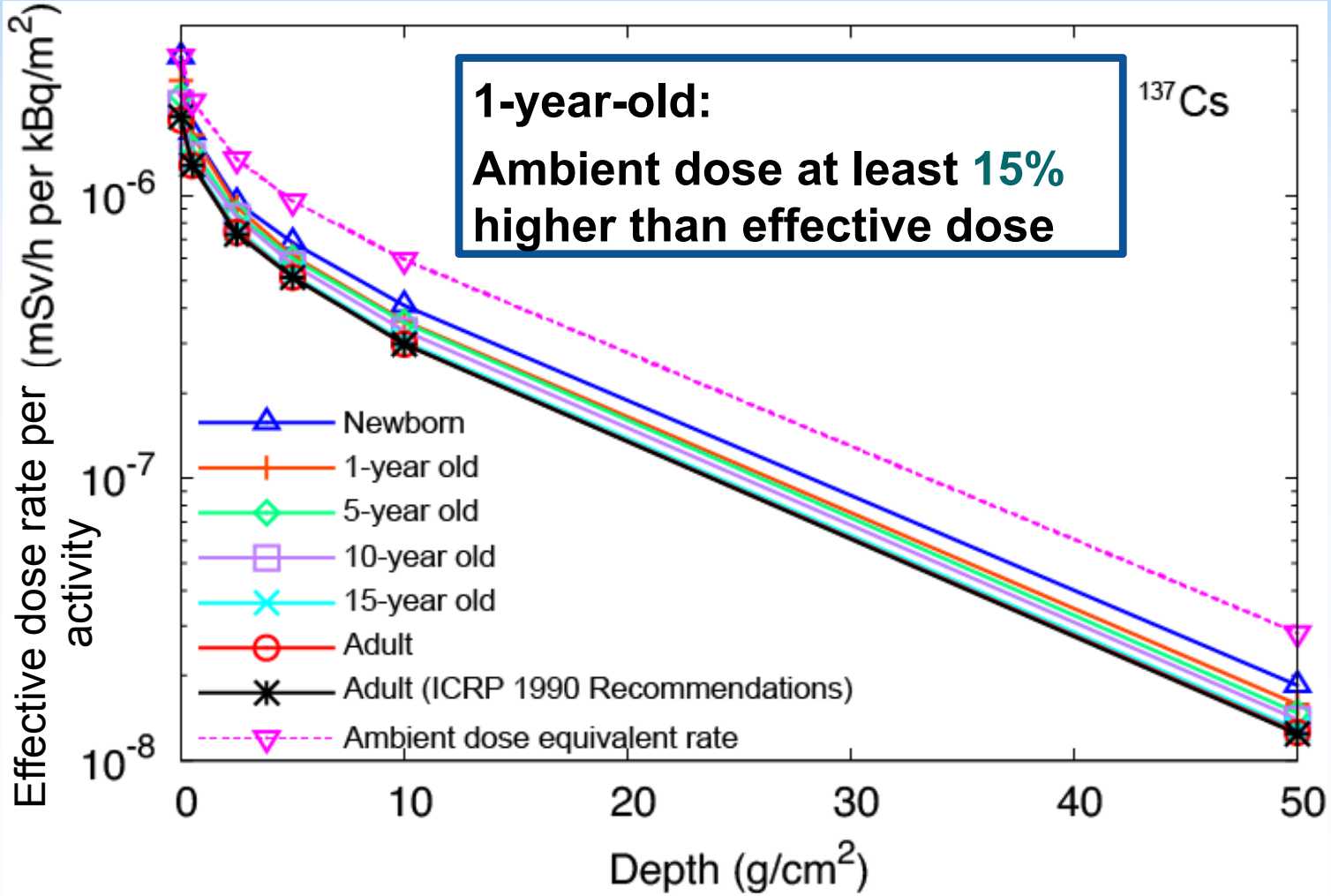
^{137}Cs source in ground



Satoh et al., J. Nuc. Sci. Technol. 2015

1y old: dose at most 35% higher than for adult

^{137}Cs source in ground



D. Satoh et al., J. Nuc. Sci. Technol., 53, 69-81, 2016.

Summary

- Establishment of reference dose coefficients for air submersion, ground contamination and water immersion
- Application of ICRP adult and paediatric reference models
- Quality control by international members of ICRP task group 90
- Ambient dose rate is conservative effective-dose rate estimator for adults, children and infants

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