연세대학교
YONSEI UNIVERSITY

GEANT4
A SIMULATION TOOLKIT

2024 Geant4 Collaboration Meeting in Catania
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Potential Contributions to G4 Advanced Examples for ICRP Reference Phantoms

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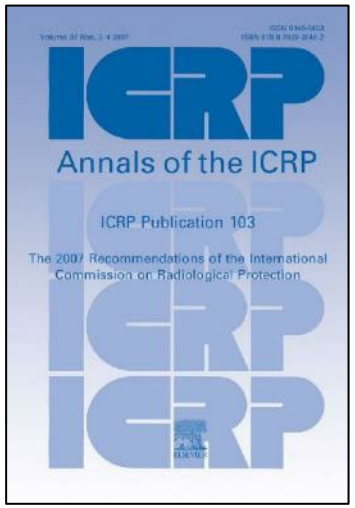
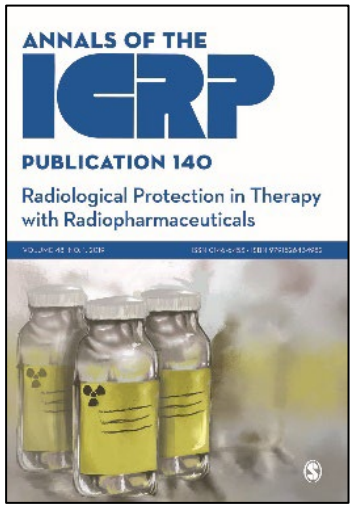
International Commission on Radiological Protection (ICRP)

- Founded in 1928
- Provides independent recommendations and guidance on radiological protection for the public benefit
- ~400 volunteer members from 53 countries: Main Commission, 4 Committees, 30 Task Groups, and Mentees (selected on the basis of recognized competence and experience)





ICRP Dosimetry System for Radiation Protection

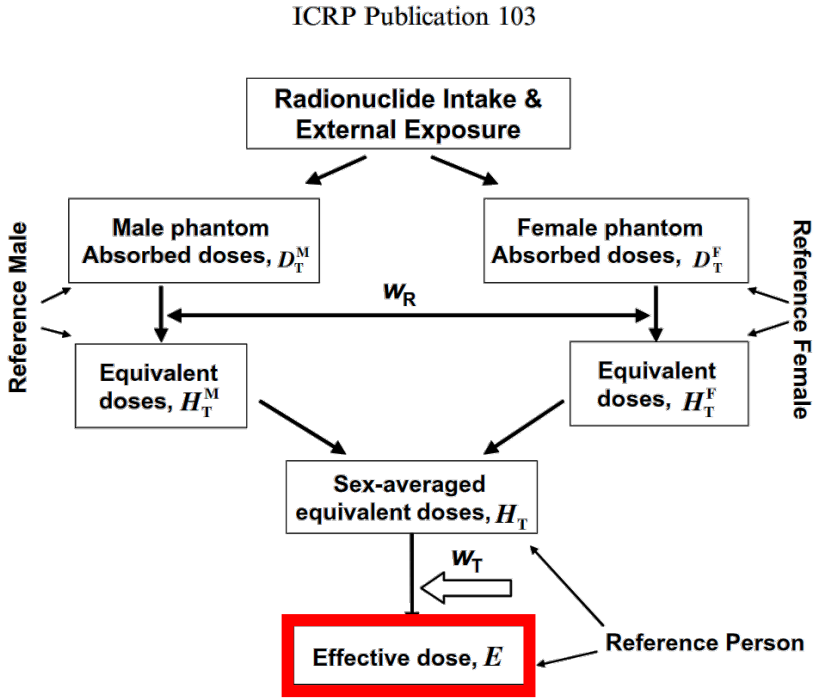
- **Effective dose** (Sv) defined by ICRP is the **most fundamental quantity** for radiation protection (e.g., annual dose limits).

- **Effective dose** defined for ***Reference Person***, not specific individuals.

- **Effective dose** is not measurable, which is calculated by performing Monte Carlo simulations using ***the ICRP reference computational phantoms*** (representing Reference Person).

- For practical use, ICRP produces **dose conversion coefficients** to convert ***measurable quantity (e.g., fluence or kerma) to effective dose.***

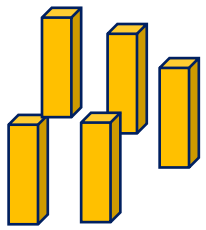
ICRP103 Recommendations	Worker	Public
Annual limit on effective dose	20 mSv	1 mSv



ICRP Reference Voxel Phantoms for Current ICRP Dosimetry System

- **Adults (2)** – male/female (ICRP 110, 2009) – ICRP110_HumanPhantom in G4 Advanced Examples
- **Children (10)** – 0, 1, 5, 10, 15 yr male/female (ICRP 143, 2020) – Not yet in G4 Advanced Examples

Male phantoms shown for illustration



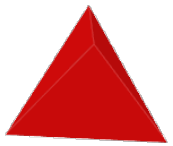
Voxel

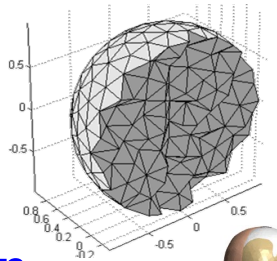
0mVRCP 1mVRCP 5mVRCP 10mVRCP 15mVRCP 15fVRCP amVRCP afVRCP

ICRP Reference Mesh Phantoms for Next ICRP Dosimetry System

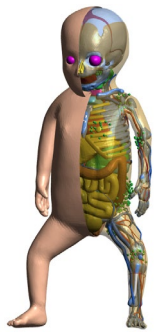
- **Adults (2)** – male/female (ICRP 145, 2020) – ICRP145_HumanPhantom in G4 Advanced Examples
- **Children (10)** – 0, 1, 5, 10, 15 yr male/female (ICRP 156, in press) – Not yet in G4 Advanced Examples

Female phantoms shown for illustration

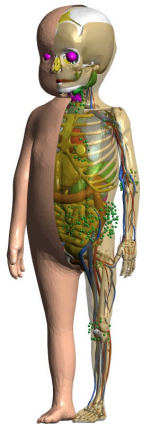




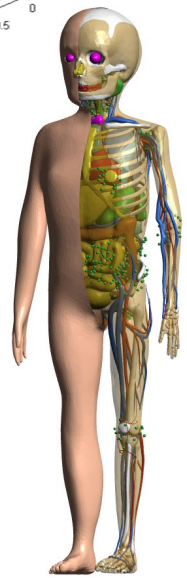
Tetrahedron



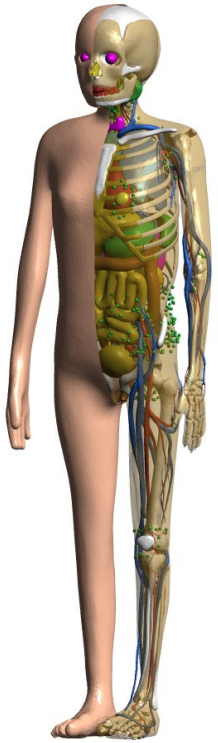
0fMRCP



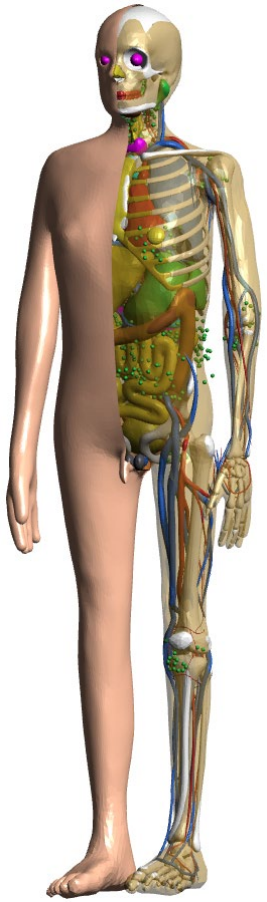
1fMRCP



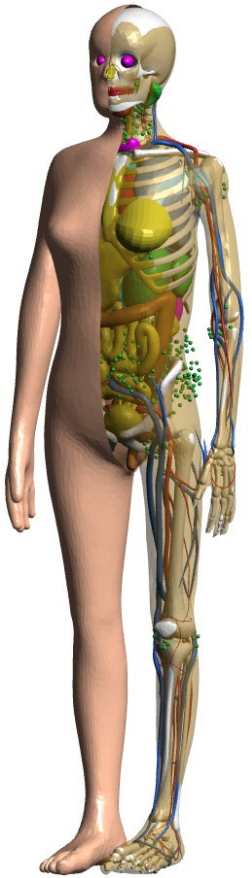
5fMRCP



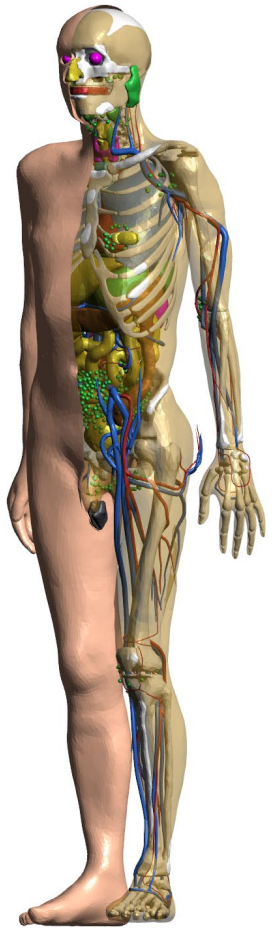
10fMRCP



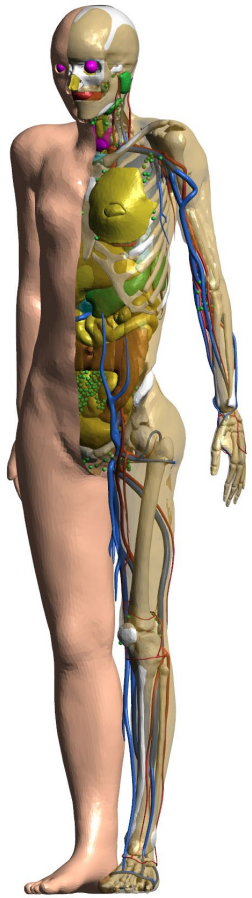
15mMRCP



15fMRCP



amMRCP

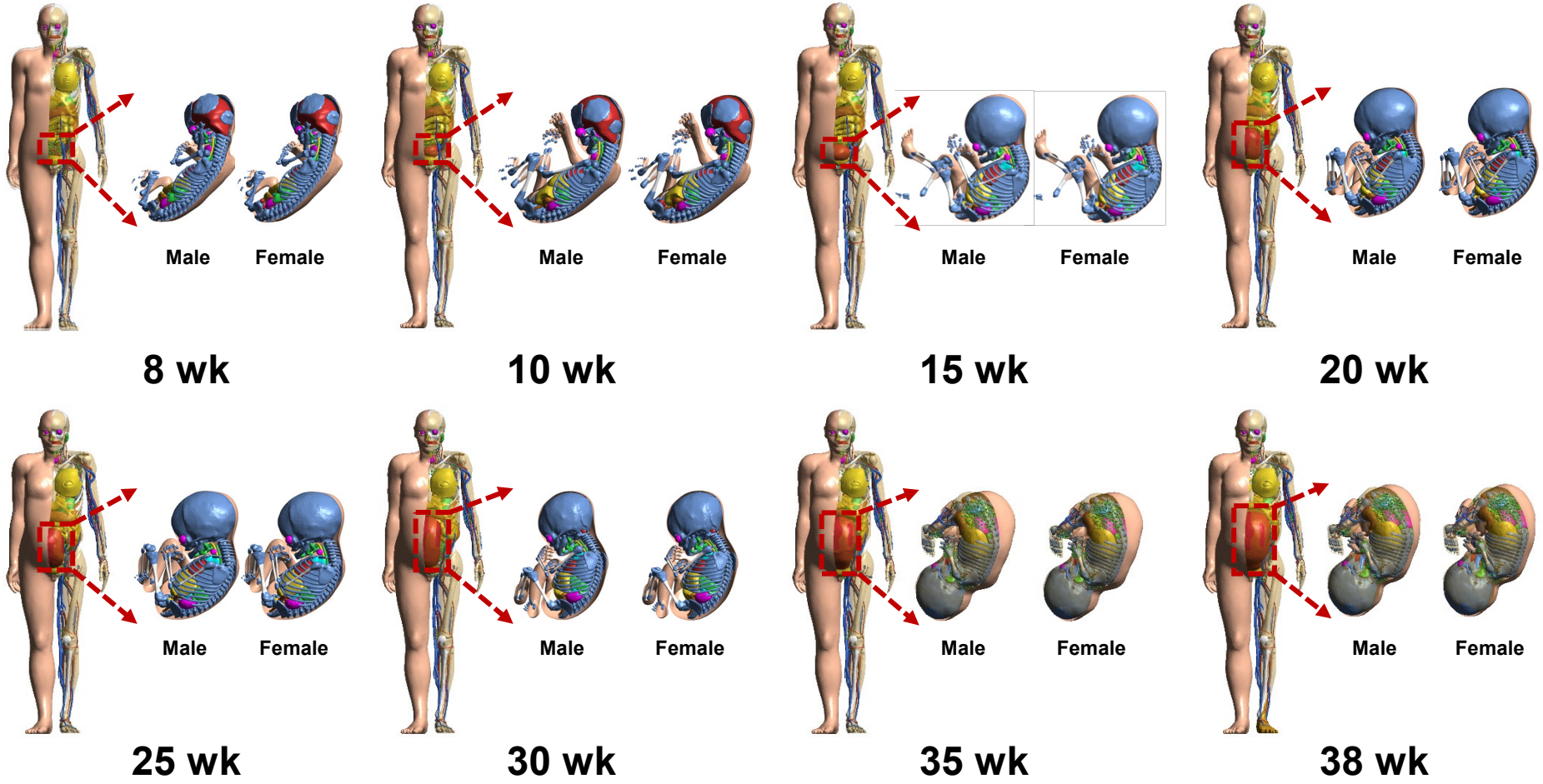


afMRCP

ICRP Reference Mesh Phantoms for Next ICRP Dosimetry System

- **Mother phantoms (8)** – 8, 10, 15, 20, 25, 30, 35, 38 wk (fetal age)
- **Fetal phantoms (16)** – 8, 10, 15, 20, 25, 30, 35, 38 wk (fetal age) male/female
- **Draft report under review** (publication expected in late 2025 or early 2026)

Tetrahedron



Potential Contributions to G4 Advanced Examples

- **Extension of the existing G4 Advanced Examples to include all ICRP phantoms**
  - ICRP_VoxelPhantom ← ICRP110_HumanPhantom
    - ✓ ICRP110 adult voxel phantoms (existing)
    - ✓ **ICRP143 pediatric voxel phantoms (new)**
  - ICRP_MeshPhantom ← ICRP145_HumanPhantom
    - ✓ ICRP145 adult mesh phantoms (existing)
    - ✓ **ICRP156 pediatric mesh phantoms (new)**
    - ✓ **ICRPxxx pregnant-female mesh phantoms (new)**

- **Upgrades of the G4 Advanced Examples for the ICRP phantoms**
  - New scoring class to improve skeletal dosimetry using the fluence-to-skeletal dose response functions (DRFs) derived from micro-CT images of bones
  - New scoring class to apply radiation/tissue weighting factors for effective dose calculations
  - New GPS to simulate various external exposures (idealized beam fields, environmental contaminations (soil, air, water), cosmic rays in space or atmosphere, etc.)
  - New GPS to emit particles within specific organs/tissues for internal dosimetry (e.g., SAF)

Thanks for your attention