Federal Office for Radiation Protection

EURADOS

# Exercises related to the ICRP/ICRU Adult Reference Computational Phantoms

**EURADOS Intercomparison on the Usage of the ICRP/ICRU Reference Computational Phantoms**

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EURADOS WG6 Webinar

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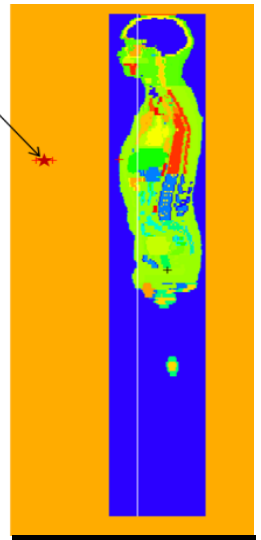
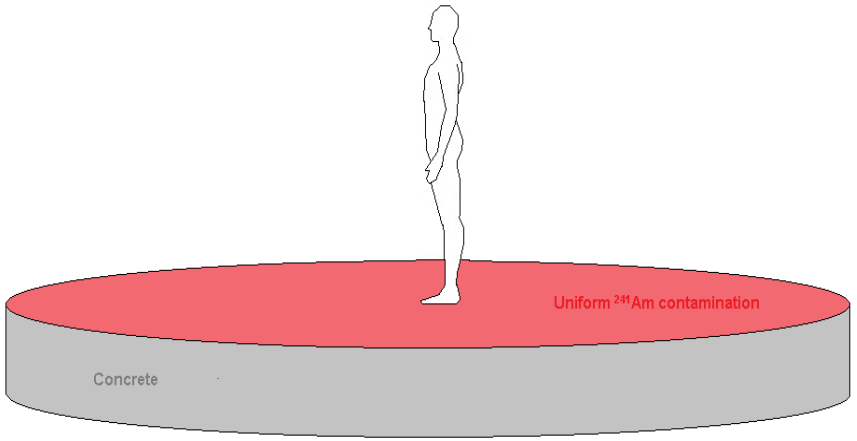
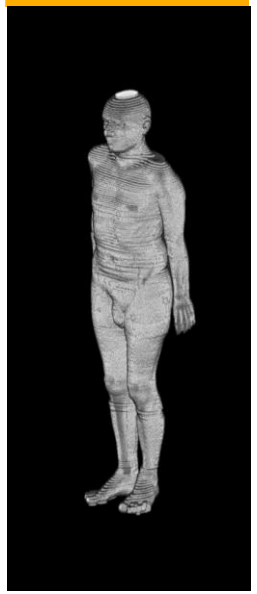
# EURADOS intercomparison exercise

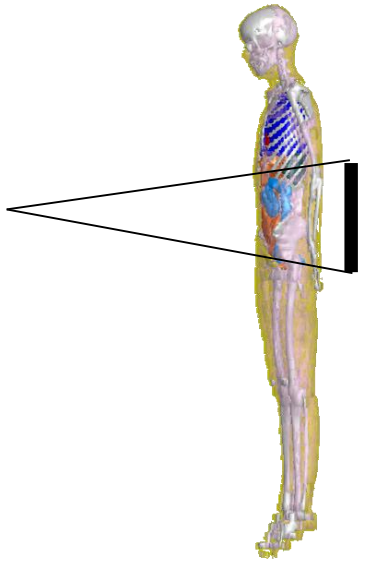
## 6 different exposure situations (tasks)

- Co-60 point source AP
- 10 keV neutron point source AP
- Ground contamination with Am-241
- Exposure in a cloud of N-16
- X-ray examinations
  - Chest PA
  - Abdomen AP
- Internal dosimetry
  - Monoenergetic photons
  - Monoenergetic electrons
  - Two specific radionuclides





# Reference computational phantoms – ICRP Publication 110

Male
176 cm, 73 kg
1.9 million voxels
Voxel size: 36.5 $mm^3$

## 140 Organ identification numbers

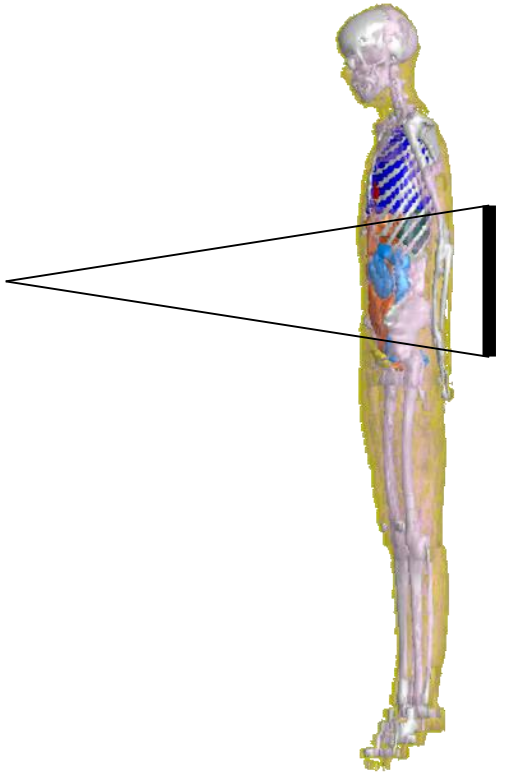
To be downloaded from
https://journals.sagepub.com/doi/suppl/10.1177/ANIB_39_2

Female
163 cm, 60 kg
3.9 million voxels
Voxel size: 15.2 $mm^3$

# Example: Abdomen AP x-ray examination

## Specification:

- Divergent rectangular energy-spectral x-ray source (point source) placed in front of the phantom and directed towards it (energy spectrum provided)
- Imaginary rectangular image receptor behind the phantom
- Focus-to-detector distance: 115 cm
- Skin-to-detector distance: 10 cm
- Field size at detector: 35 cm (width) x 45 cm (height)
- Source: centred between
  - Top of liver and bottom of pelvic bone
  - Left- and right-most extensions of the pelvic bone



## Task:

- Calculate organ absorbed doses normalised to
  - Entrance air kerma free in air, $K_a$
  - Kerma-area product, KAP

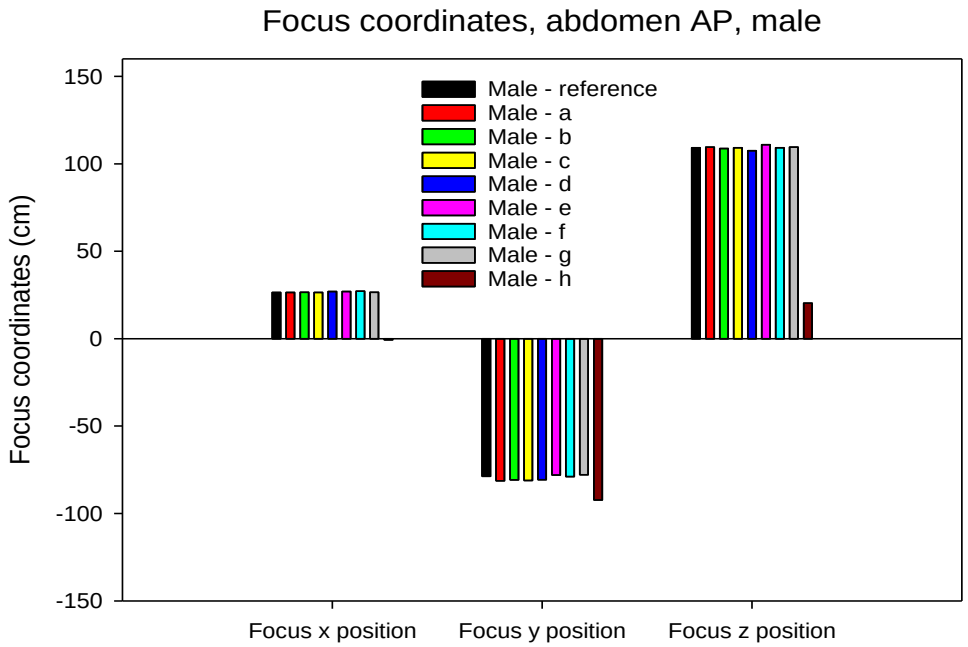
# Abdomen AP x-ray examination

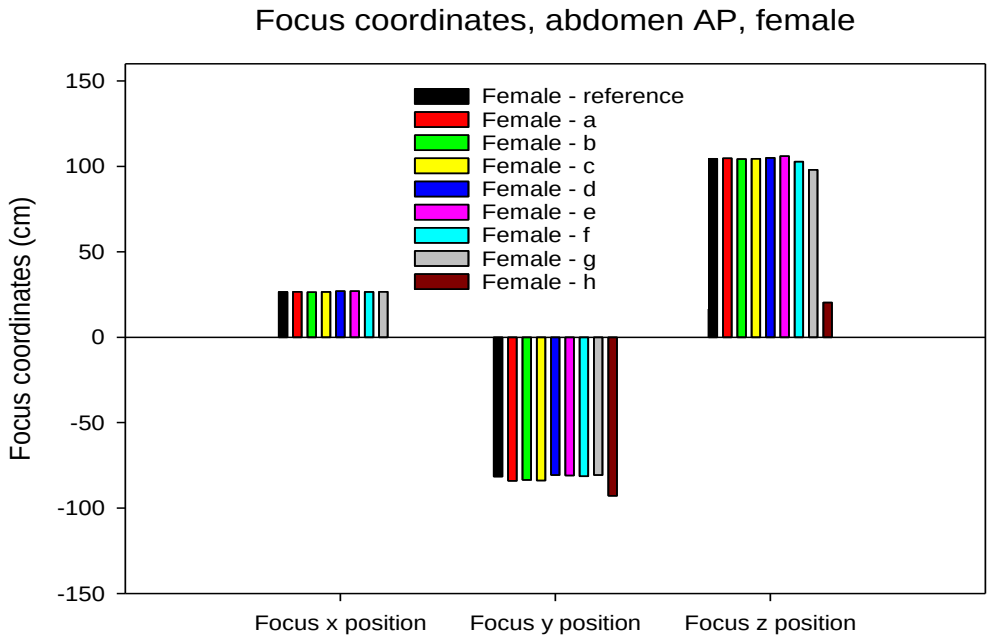
Part of the task: determine location of the source point

- Height extensions of liver and pelvic bone
  → source z coordinate
- Lateral extension of pelvic bone→ source x coordinate
- Exit coordinate of the beam
  - → image receptor y coordinate (10 cm away)
  - → source y coordinate (115 cm in opposite direction)

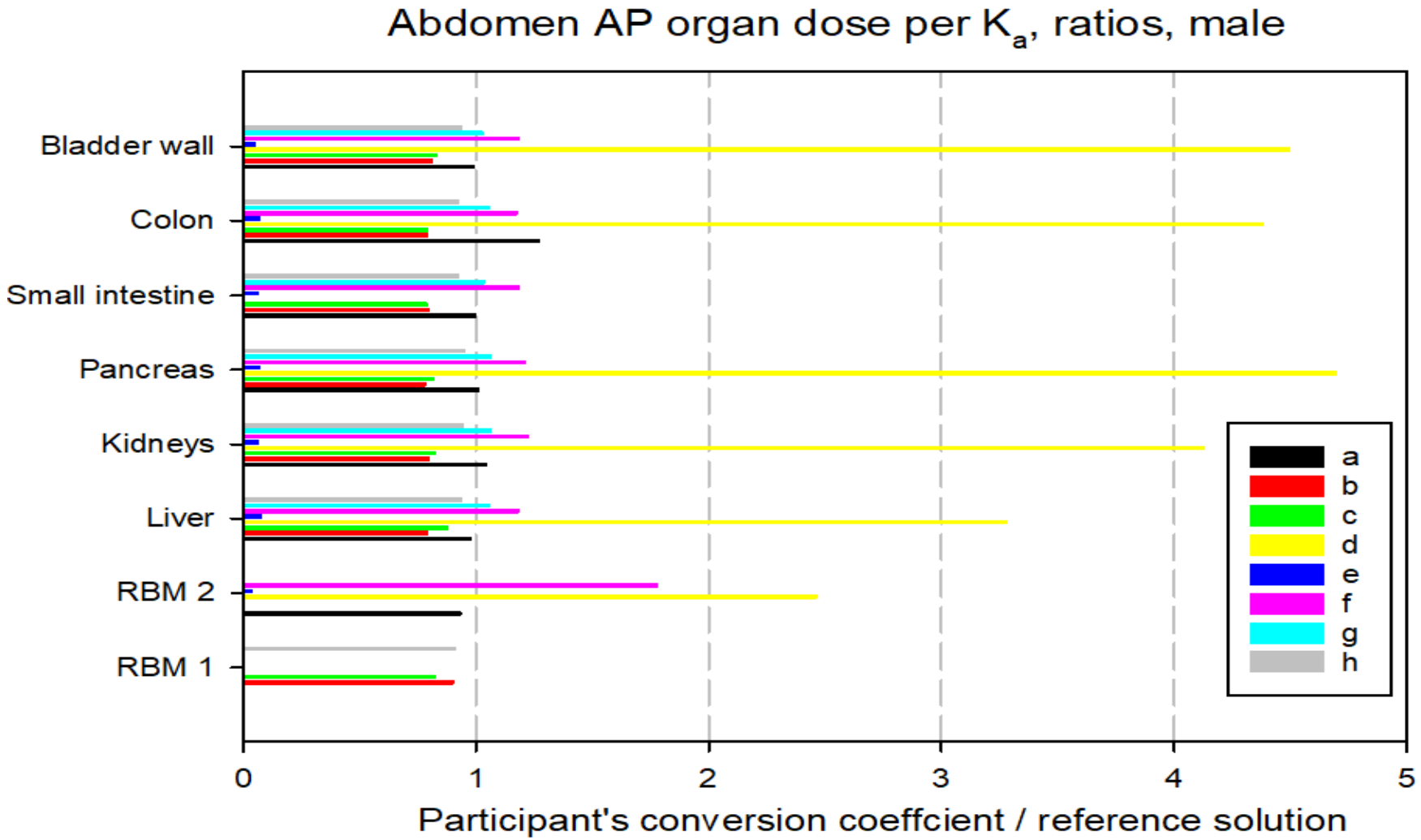
Findings:

- Most participants‘ coordinates similar to reference, but still slightly different
- Participant „h“ used a different coordinate system (origin in centre of phantom array)



# Abdomen AP x-ray examination: participants‘ initial solutions



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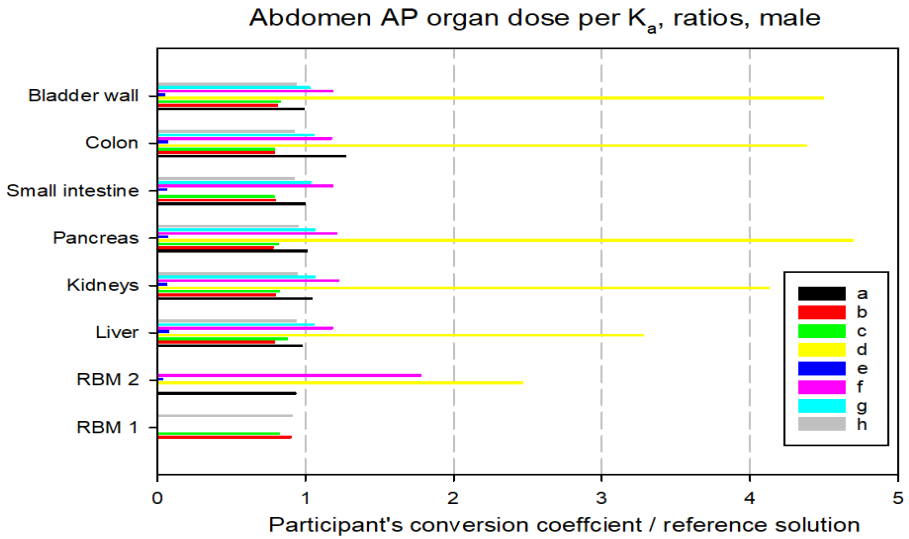


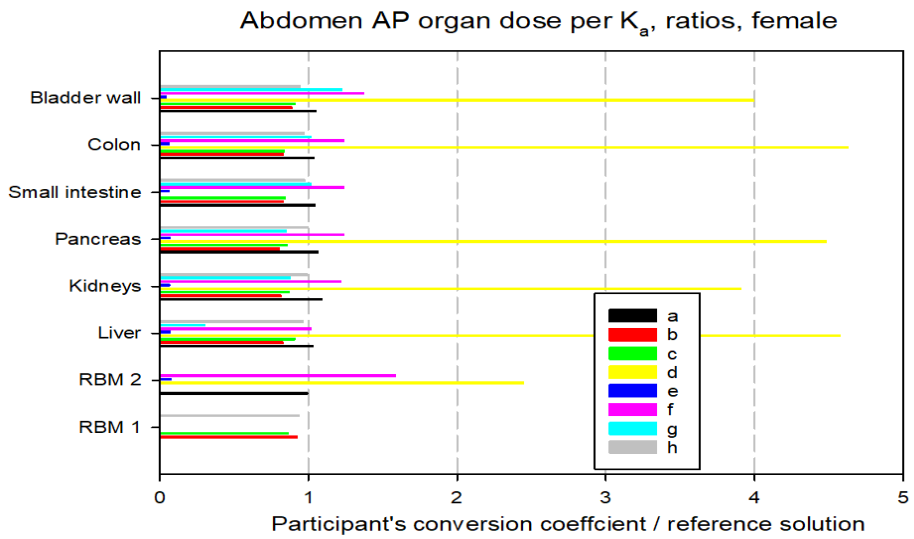


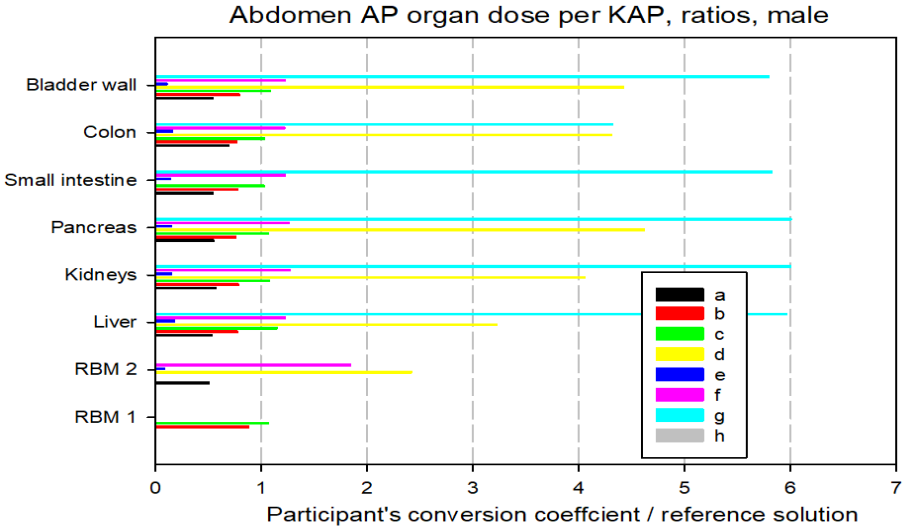


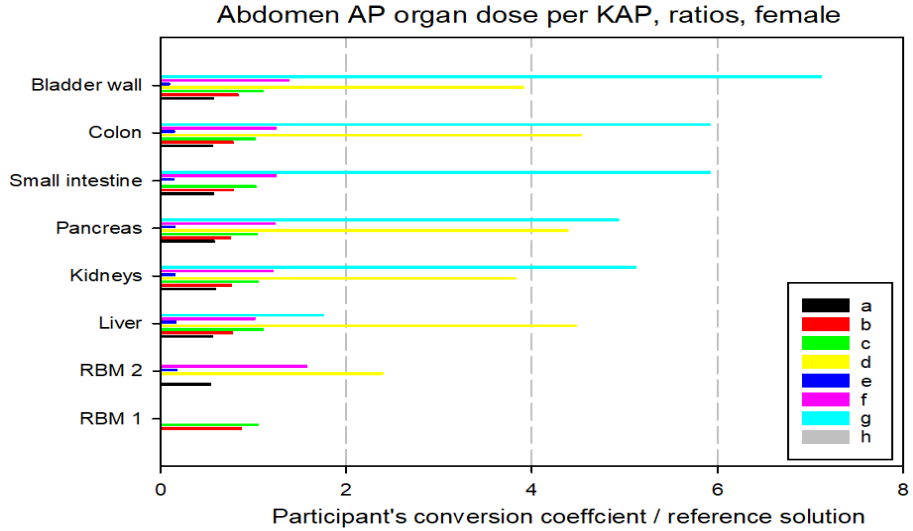

# Reasons of discrepancies between participants’ and master solutions

- Selected cases where individual organs differed more than the others:
  - Wrong tissue material assignment to individual organs
  - Selection of wrong organ identification number (i.e. selection of a different organ)
  - Typing errors

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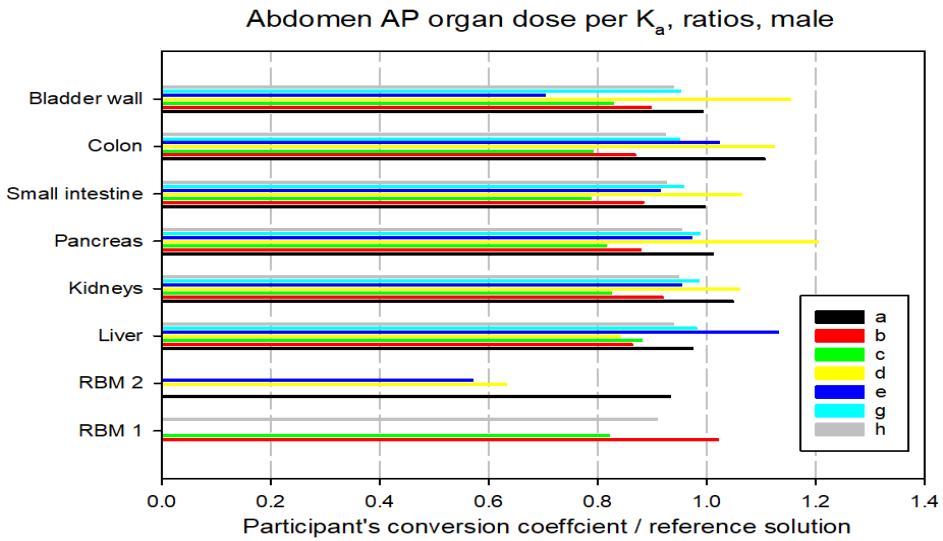
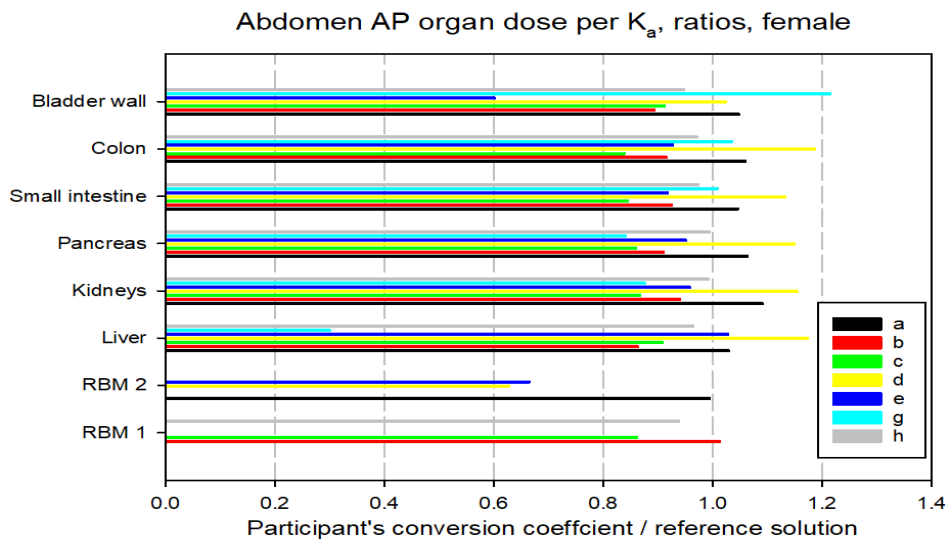
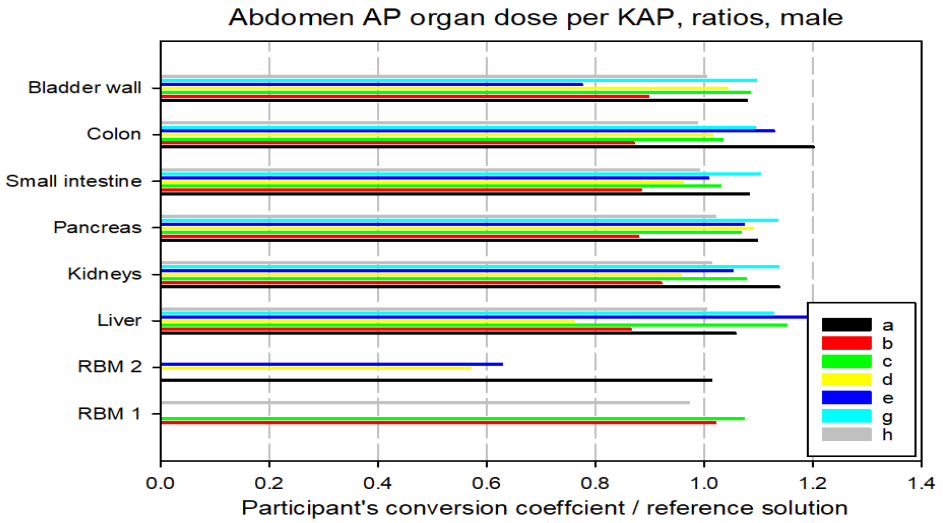
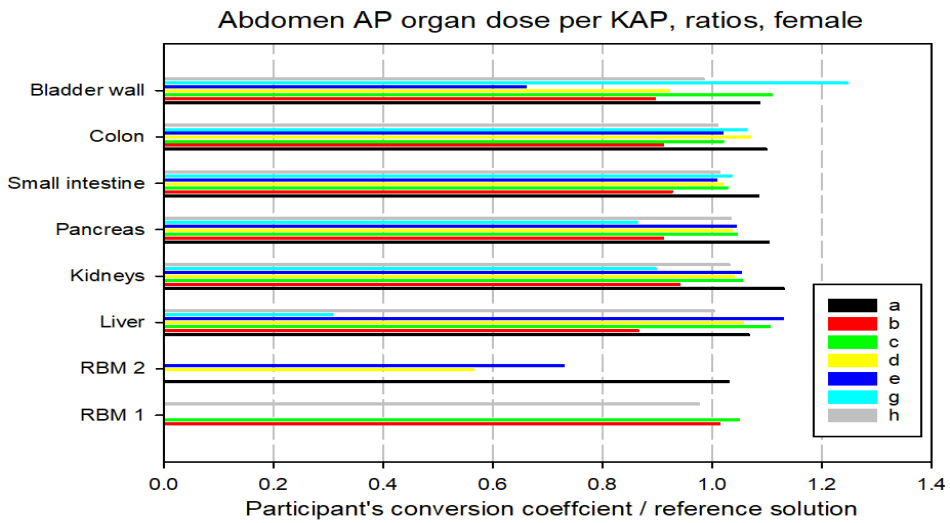
  - Air kerma free-in-air at 1 metre from the source instead at focus-to-skin distance
- Difficulties with understanding the normalisation quantity “kerma-area product”
  - Large number of solutions in better agreement for normalisation per air kerma than per kerma-area product
  - Only two (for Chest PA) and three (for Abdomen AP) participants had the conversion between the two normalisation quantities approximately right

# Abdomen AP x-ray examination: participants‘ revised solutions



# General problems with participants’ solutions

- Omitted quality assurance of results
  - Plausibilty considerations
    - Homogeneous exposure conditions result in similar magnitudes of organ doses
    - Value for single intermediate energy unlikely entirely outside the range of values for other energies
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  - Comparison with literature values for similar exposure conditions
- Changes applied for revision of results not disclosed
  - Appropriateness cannot be judged
  - Reasons for initially erroneous solution remain unclear
    - No additional insights can be gained into possible similar errors to be expected in future similar exercises
    - No insights can be gained that might help other participants

# Summary and Conclusions

- EURADOS intercomparison exercise: tasks of practical interest in
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  - ability to combine the ICRP/ICRU reference computational phantoms correctly with radiation transport codes
- Sometimes: lack of awareness of the necessity to quality assure computational results
  - plausibility checks
  - comparison with literature data for similar exposure conditions
- We believe that such studies are beneficial to the field of computational dosimetry:
  - Direct training of participants via feedback with the task organisers
  - Availability of representative dose values for various exposure conditions that may aid future novice users in the quality assurance of their methods

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