

# Measurement of radioactivity in humans

Jussi Huikari

Laboratory of Environmental research  
Finnish Radiation and Nuclear Safety Authority  
(STUK)

# Radioactivity in humans

- Mostly  $^{40}\text{K}$ , also  $^{14}\text{C}$ , daughters of radon
- Artificial: civil population:  $^{137}\text{Cs}$   
workers:  $^{60}\text{Co}$ ,  $^{110\text{m}}\text{Ag}$ ,  $^{124}\text{Sb}$  etc...
- Internal dose can be estimated at the population level by using measurement results from food combined with diet information
- Internal dose of workers: air concentration measurements
- Individually: just measure directly, if you want be sure

# Internal and external dose

- external:
  - source is outside of the person
    - e.g. natural radioisotopes, x-ray examination, working with radioactive materials
- internal:
  - source is inside of the person
    - natural radioisotopes, inhaled or ingested radioactive materials during work
- both are measured in Sievert (Sv)
  - the health risk is the same if the dose is the same, conversion from Bq to Sv is different

# Whole body counters in STUK



iron room

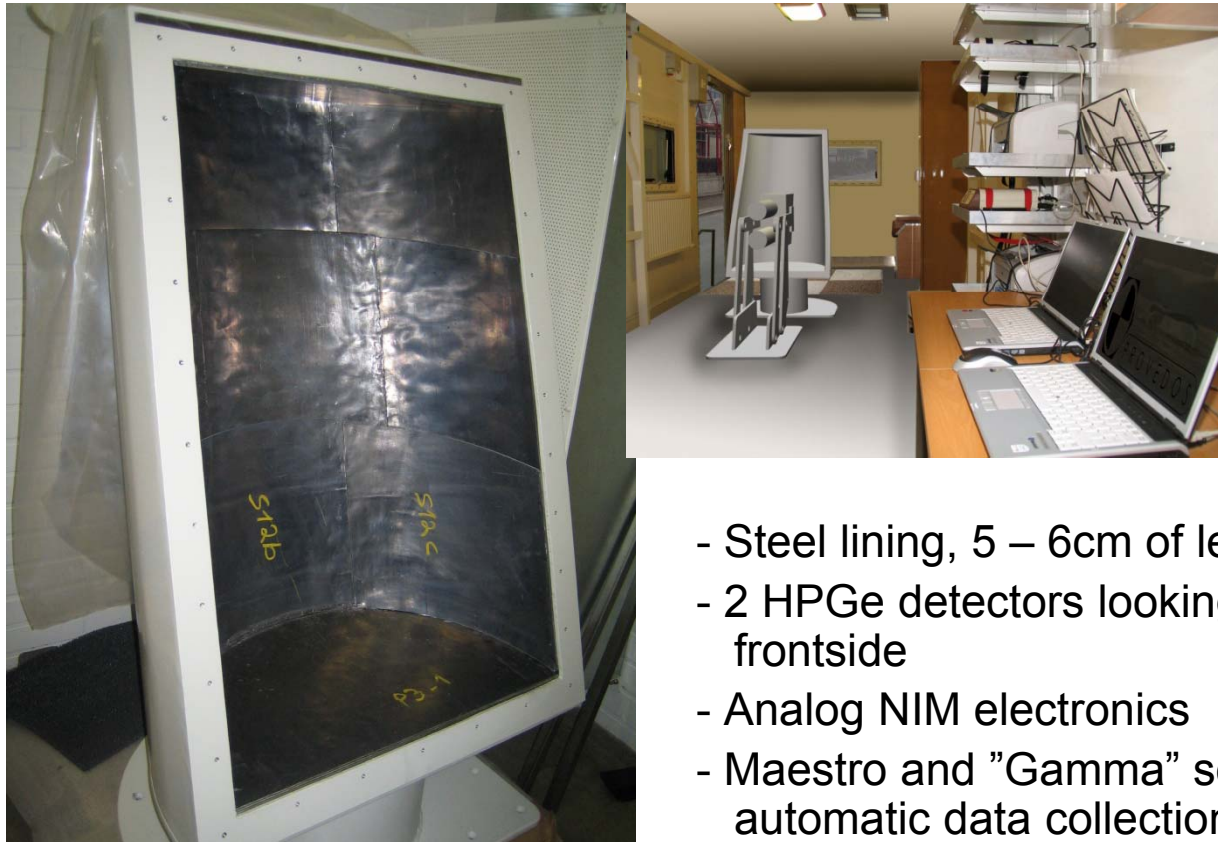


mobile unit

# Ironroom

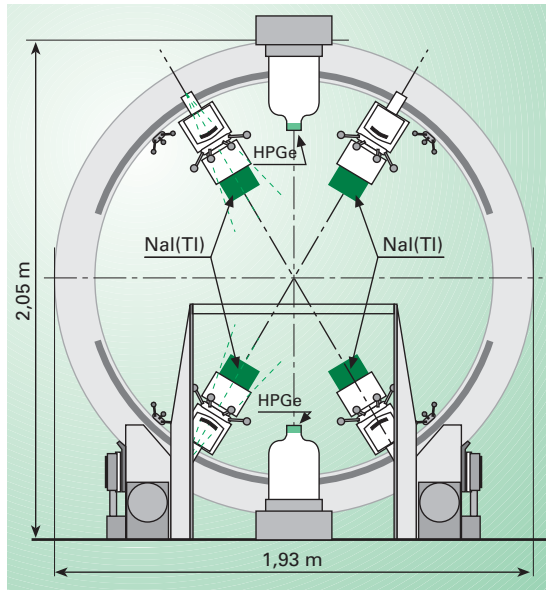
- 50 ton of old steel (from ocean liner built hundred years ago)
- 15 cm walls, lined with Pb and Cu ( both 3 mm)
  - Pb sheets reduces scattering from steel
  - Cu shields Pb X-rays
- 4 NaI + 3 HPGe
  - 1 HPGe is with Be window
- Analog electronics + Maestro + Gamma
- Geometry is scanning bed

# New shield for a mobile unit

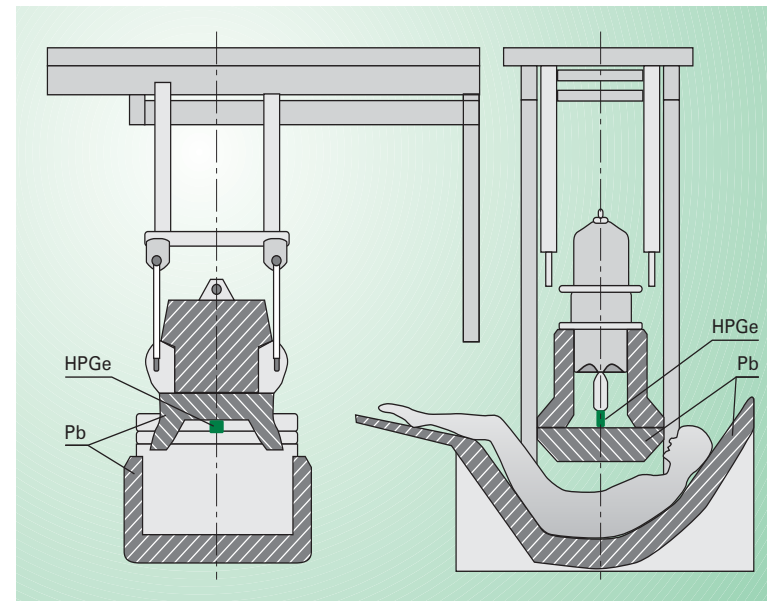


- Steel lining, 5 – 6cm of lead
- 2 HPGe detectors looking from frontside
- Analog NIM electronics
- Maestro and "Gamma" software for automatic data collection and spectrum analysis

# Measurement geometries



iron room

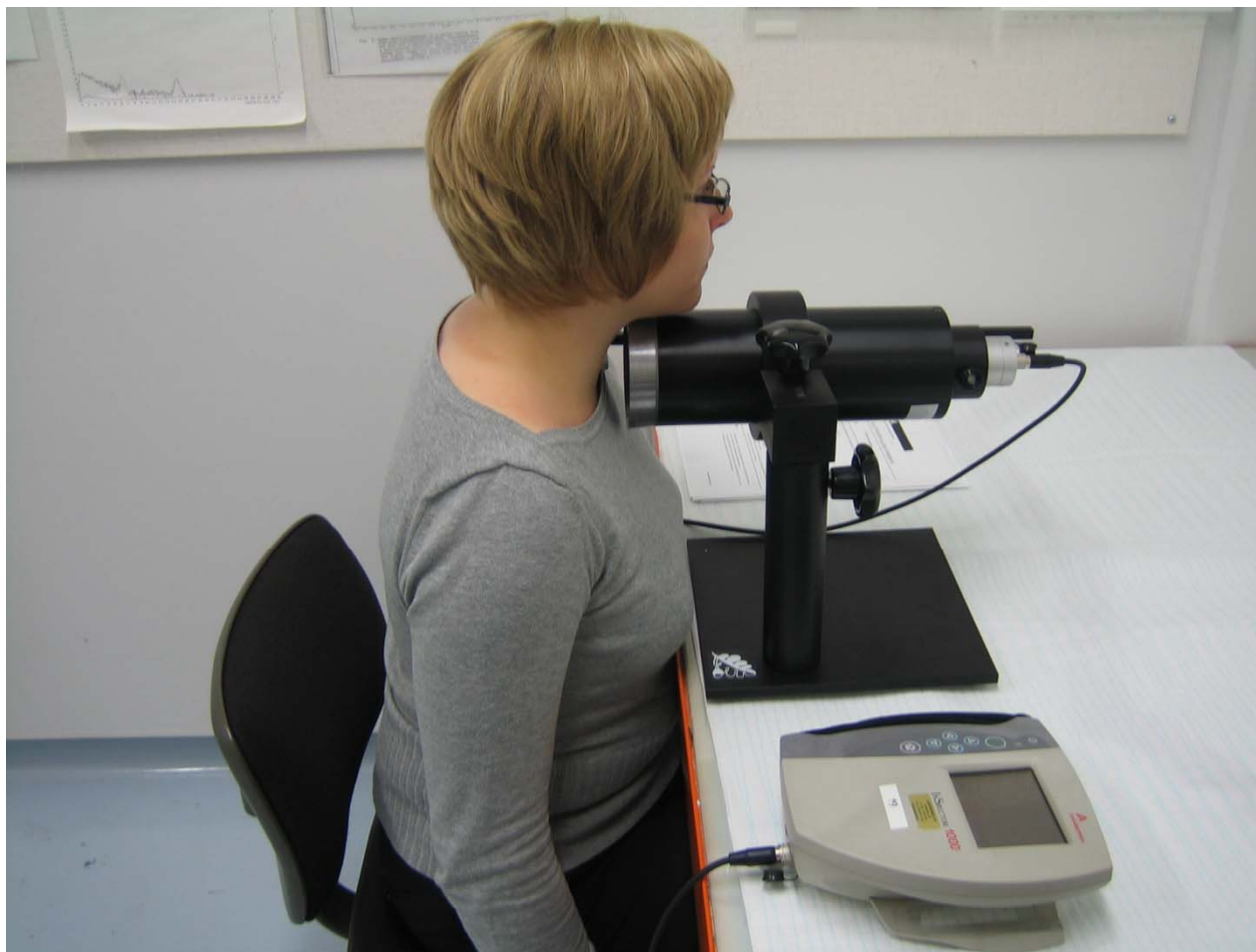


mobile unit

# Thyroid monitor Atomtex

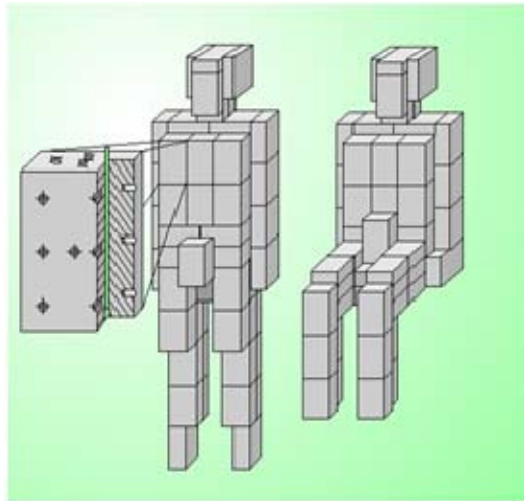


# Thyroid monitor Canberra

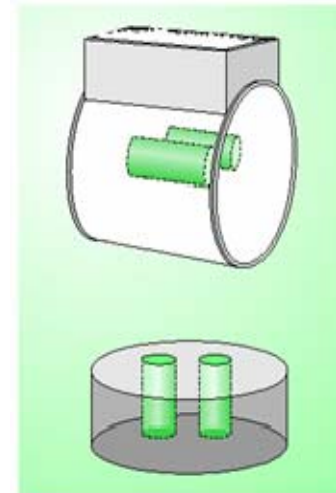


# Calibration phantoms

polyethylene tiles: gamma ray attenuation close to human tissue

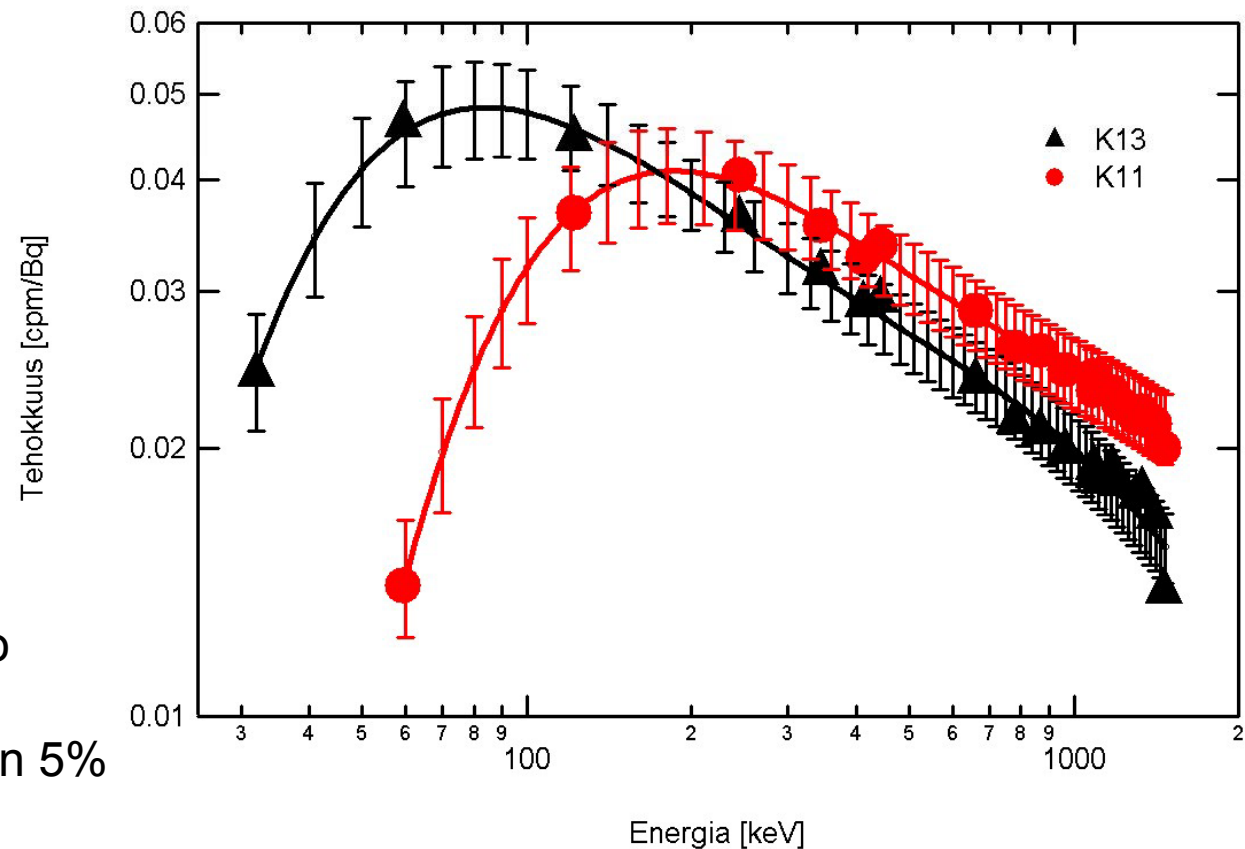


Whole body



Thyroid

# Whole body counter: gamma efficiency

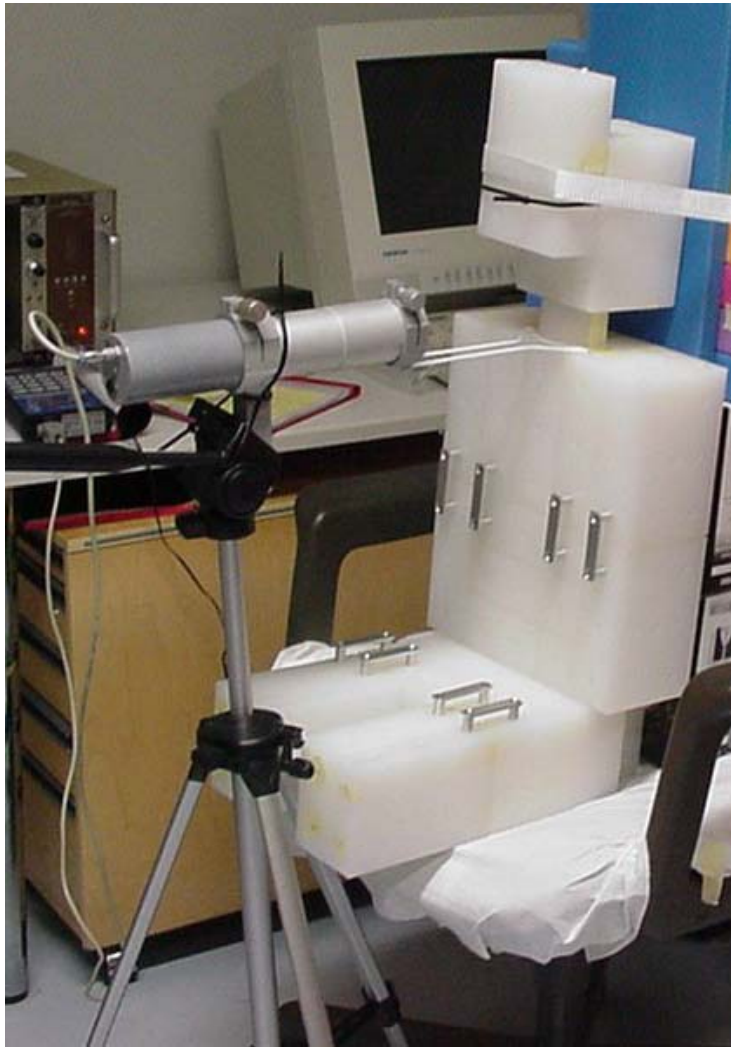


Two source rods per tile:  
 $^{152}\text{Eu}$ ,  $^{137}\text{Cs}$ ,  $^{40}\text{K}$ ,  $^{60}\text{Co}$

Total activity known within 5%

Repeated measurements:  
- Stability of the electronics

# Thyroid calibration



- $^{133}\text{Ba}$  in neck phantom

-Distance 20cm

-three geometries:  
child, teenager, adult

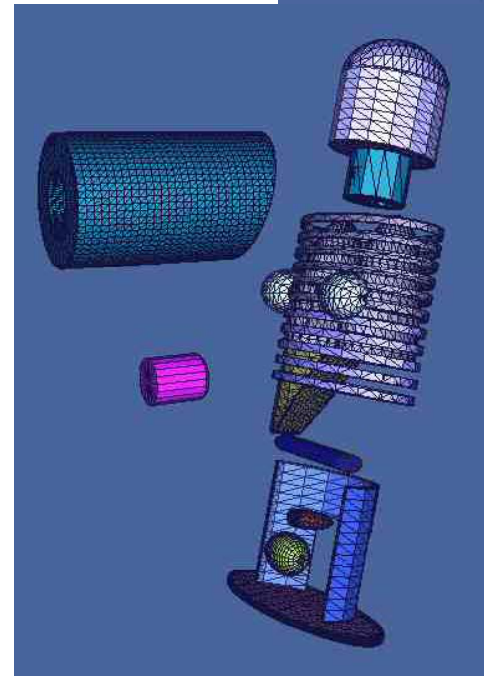
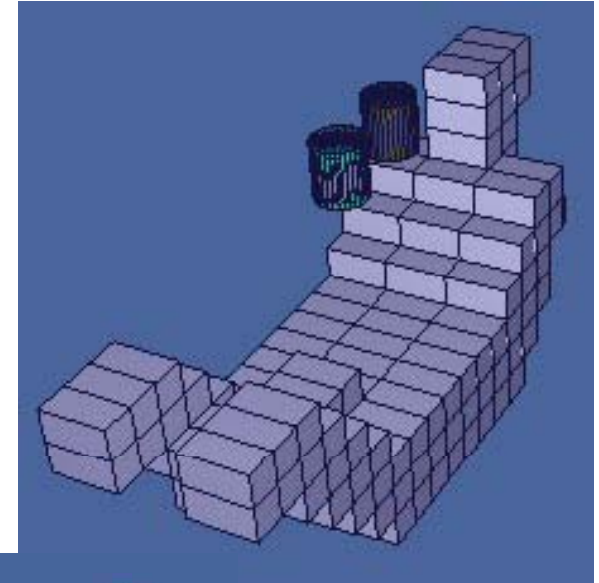
-detection limit  
2000 Bq ( $t=100\text{s}$ )  
760 Bq ( $t=600\text{s}$ )

# Detection limits

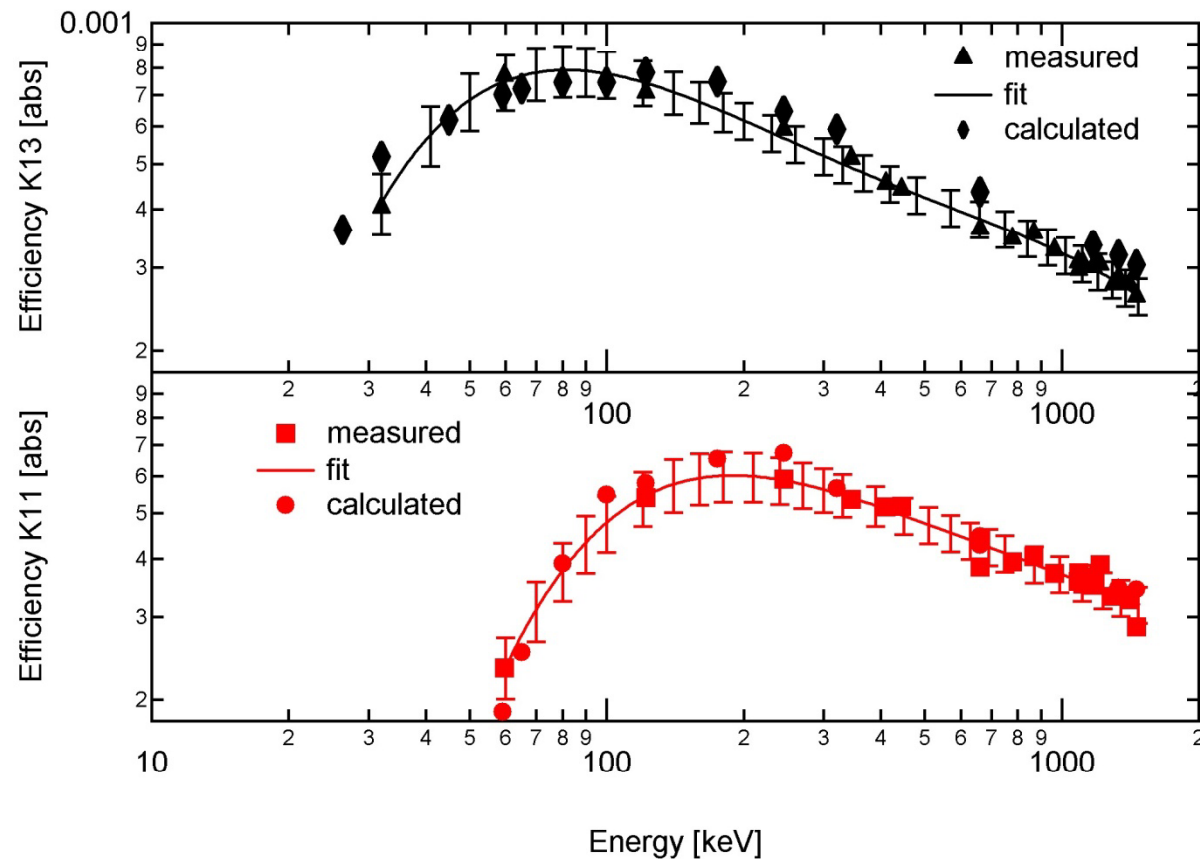
Isotope	Atomtex [Bq]	Mobile unit [Bq]	Ironroom [Bq]
$^{137}\text{Cs}$	200	80	30
$^{60}\text{Co}$	200	50	20
$^{131}\text{I}$	300	100	100

# Mathematical calibration

- You need calculation software
- Usage of that requires as input:
  - numerical phantom
  - source data
  - geometry of the set up
- We selected MCNPX (version 2.6f)
- Two phantoms, tiles and MIRD
- Simulated successfully present mobile unit
- Although simulations are good, cannot be the only calibration



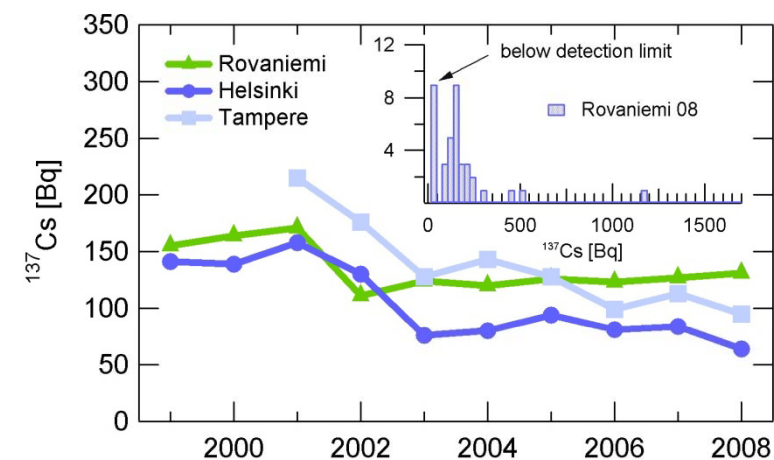
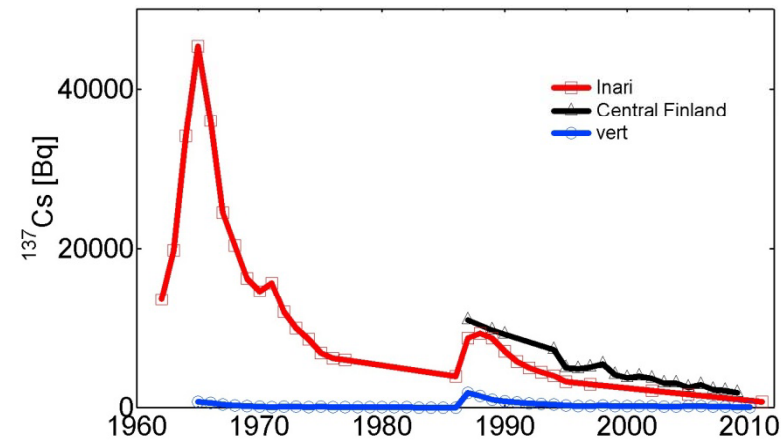
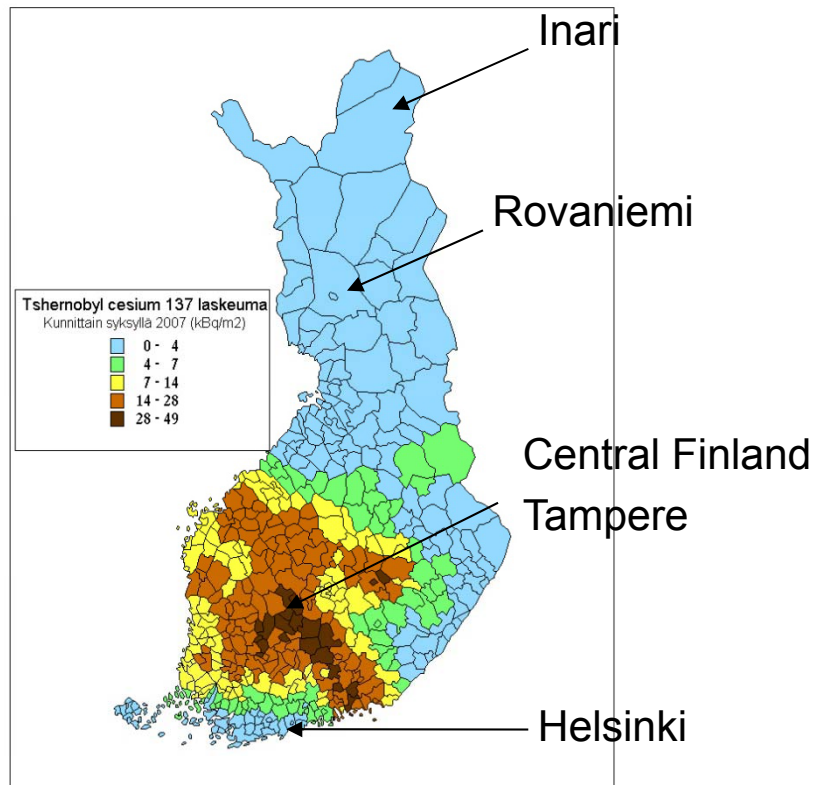
# Simulation results



# History

- Whole body gamma spectrometry started in early sixties:
  - fallout from nuclear weapon test in atmosphere
  - measurement mostly in northern Finland
  - first finn measured in 1961 in Stockholm
- Chernobyl accident:
  - more groups to be monitored
  - also in the south
- Presently about 500-700 measurements annually
  - number includes also monitoring of the radiation workers

# Environment surveillance: Human part



# Radiation workers

- While handling radioactive materials, machining activated components etc. workers inhale radioisotopes
- Companies have to make sure that internal doses are also under control
- Our whole body counters are the only nuclide specific ones in Finland
- Once we have the total body activity, a dose can be estimated
  - commercial software : IMBA pro (HPA,UK)
- need to know the time of intake
- several measurements if dose appears to be over 1 mSv (never needed so far)

## About results

- Typical radionuclides in radiation workers:  $^{60}\text{Co}$  ja  $^{110\text{m}}\text{Ag}$ .
- Activities detected are usually low, from <50 to 500 Bq.
- In most measurements, nothing unusual is detected.
  - The official detection limit for our equipment is about 100 Bq.
- Most Finns have  $^{137}\text{Cs}$ , average being between 100-200 Bq.
- As a conclusion, internal doses posses no significant health risk, to our best knowledge. Except radon!