

L15f Validation of whole body counter measurements



IAEA

International Atomic Energy Agency

Validation planning

Validation of direct internal monitoring by whole body counting can be done by:

- Calibration of the measurement instrument (using standard reference materials or phantoms)
- Performance Testing
- Laboratory Intercomparisons

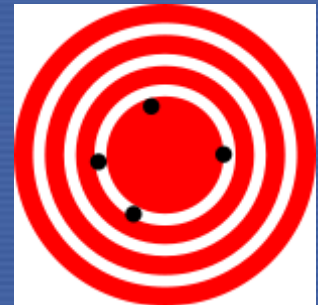
Performance criteria

The performance criteria are recommended by ANSI N13.30-1996.

For measurements at the Minimum Testing Level:

➤ **Accuracy** – 25% to + 50%

➤ **Precision** < 40 %



Minimum Testing Level (MTL)

The MTL should preferably be 5, but may be 10 times the Minimum Detectable Amount (MDA) as defined by:

$$MDA = \frac{4.65 \text{ sb} + 3}{K T e^{-\lambda \Delta t}}$$

- Where
- **sb** is the standard deviation of the total blank count
- **K** is the calibration constant
- **T** is the counting time
- **λ** is the radiological decay constant
- **Δt** is the elapsed time between an establish reference date and the analysis date.

MTL examples

Measurement Category	Type	Radionuclide	MTL
Fission and activation products	Total body	All of: Cs134 Cs137 Co60 Mn54	3 kBq
Radionuclides in the thyroid	Thyroid	I 131 or I 125	3 kBq

MTL examples

Measurement Category	Type	Radionuclide	MTL
Transuranium elements via L x-rays	Lung	Pu238	9 kBq
241Am	Lung	Am241	0.1 kBq
Th234	Lung	Th234 in equilibrium with its parent U238	0.5 kBq
U235	Lung	U235	30 Bq
Fission and activation products	Lung	Mn54 Co58 Co60	3 kBq
		Ce144	30 kBq
		Cs134 Cs137	3 kBq

Validation planning

- Start with method selection
- Define acceptable performance criteria
- Plan measurements to cover the performance criteria
- Do the measurements
- Evaluate the resulting spectra
- Assess the performance criteria
- Issue validation statement

Calibration with BOMAB phantom

The phantom is prepared by homogeneous dispersion of a mixture of gamma emitters (Cs137 , Ba133 and Co60) in Uralite Polyurethane Elastomer.

- Volume 91535 ml
- Density 1.026 g/ml
- Energy range:
- 250 – 1332 keV



JAERI lung phantom

The phantom was designed for calibration by the Japan Atomic Energy Research Institute.

Polyurethane and epoxy resin were used to simulate major body tissues, including lung. The density of the foamed polyurethane is 0.24 – 0.31 g/ml.



Calibration with JAERI lung phantom

The torso phantom has the following lung sets:

- Natural Uranium
- 3% Enriched Uranium
- Pu-238
- Am-241
- Th-232
- Energy range 15 – 300 keV (Th-232 to 2.6 MeV)

Performance testing

- Detector stability control with point sources of Co-60, Cs-137, and Am-241 for high energy range and the JAERI lung phantom containing Am241 for low energy range changing the chest wall thickness.
- Bias and precision were calculated

Intercomparison

IAEA organized from 2001 – 2007 an intercomparison for direct measurement of radionuclides in simulated organs.

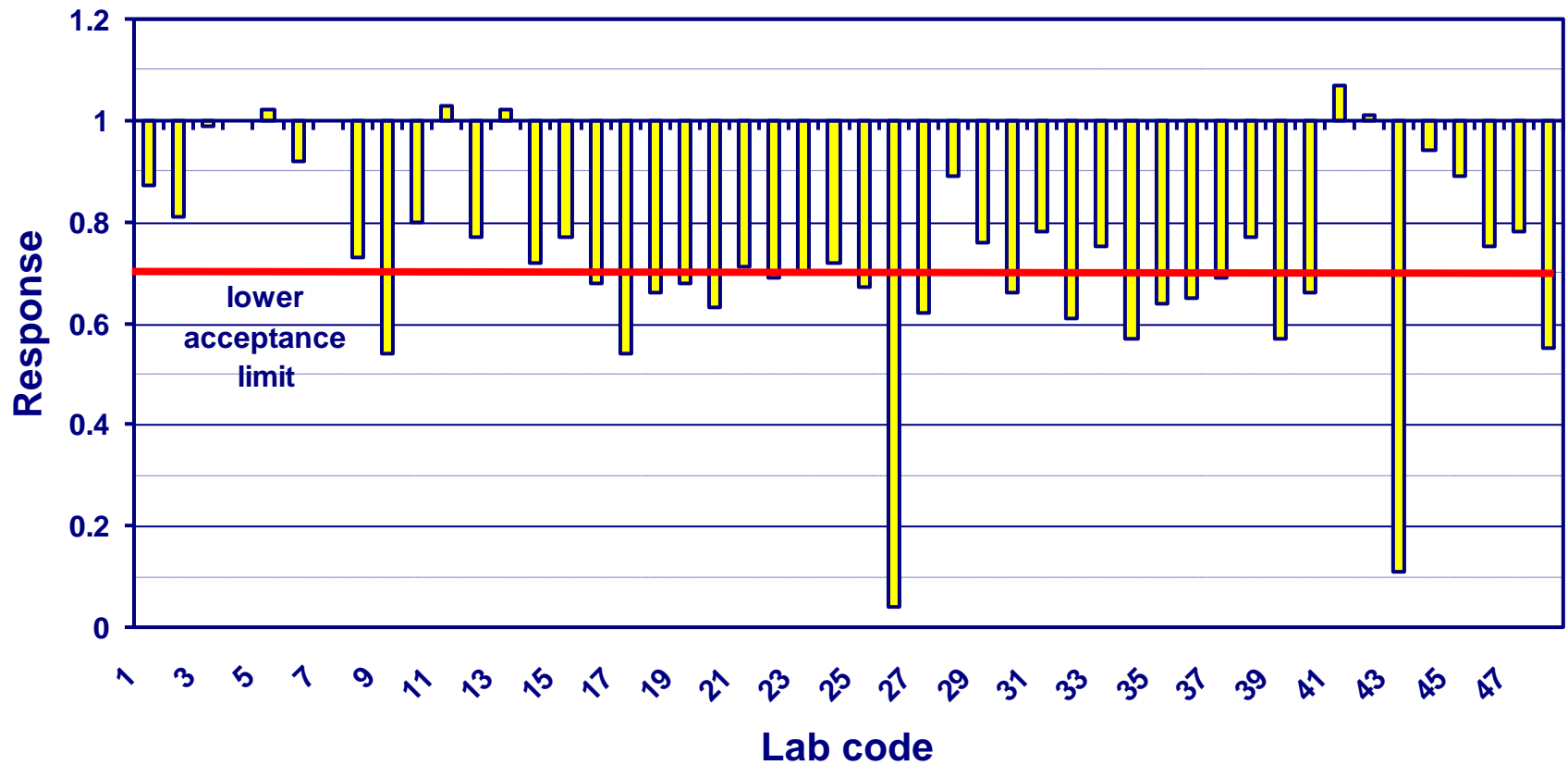
Phantoms used:

- Whole body (BOMAB)
- Thyroid
- Lung (JAERI)
- Bone



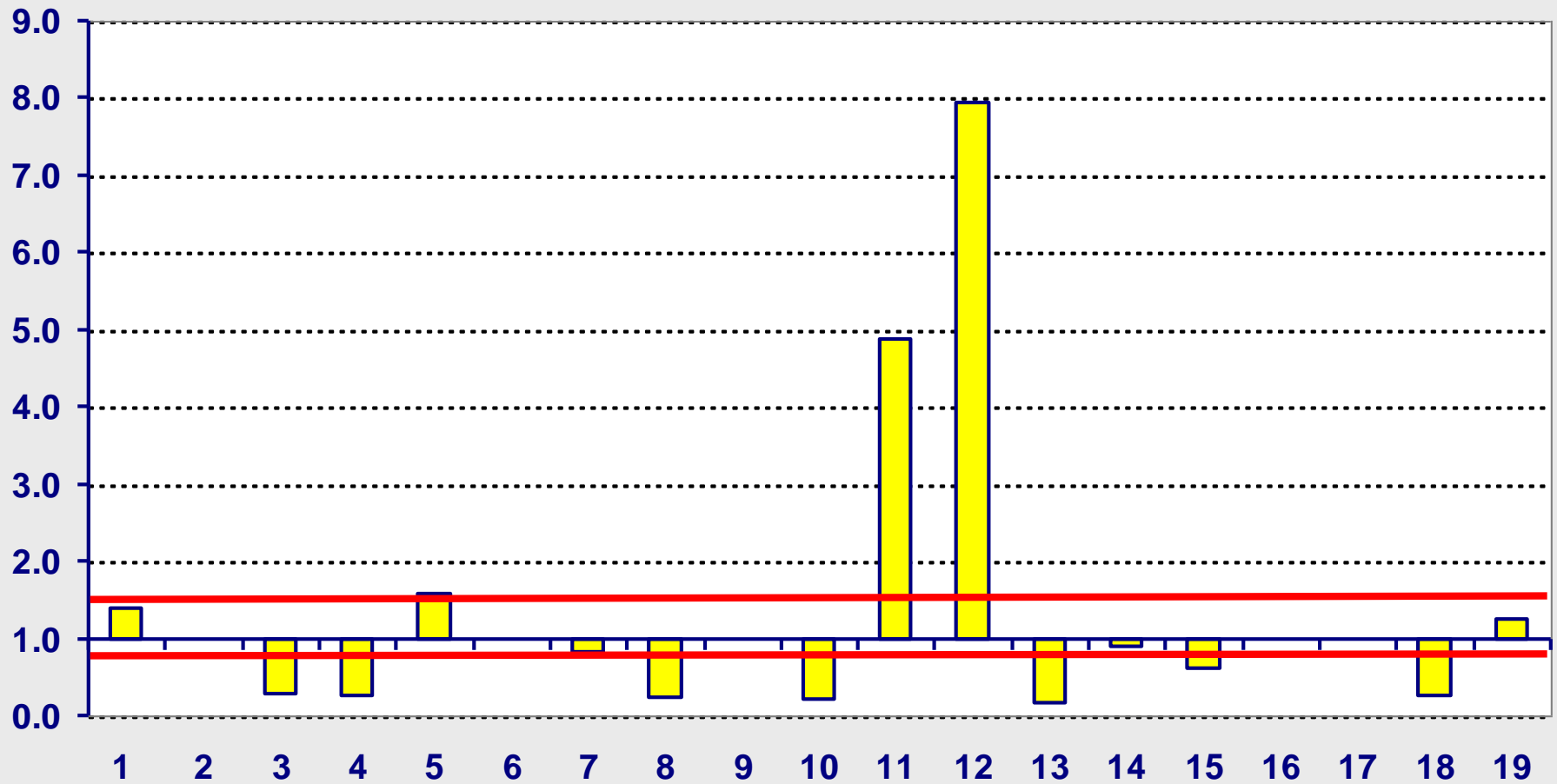
Intercomparison results

BOMAB measurement Cs137



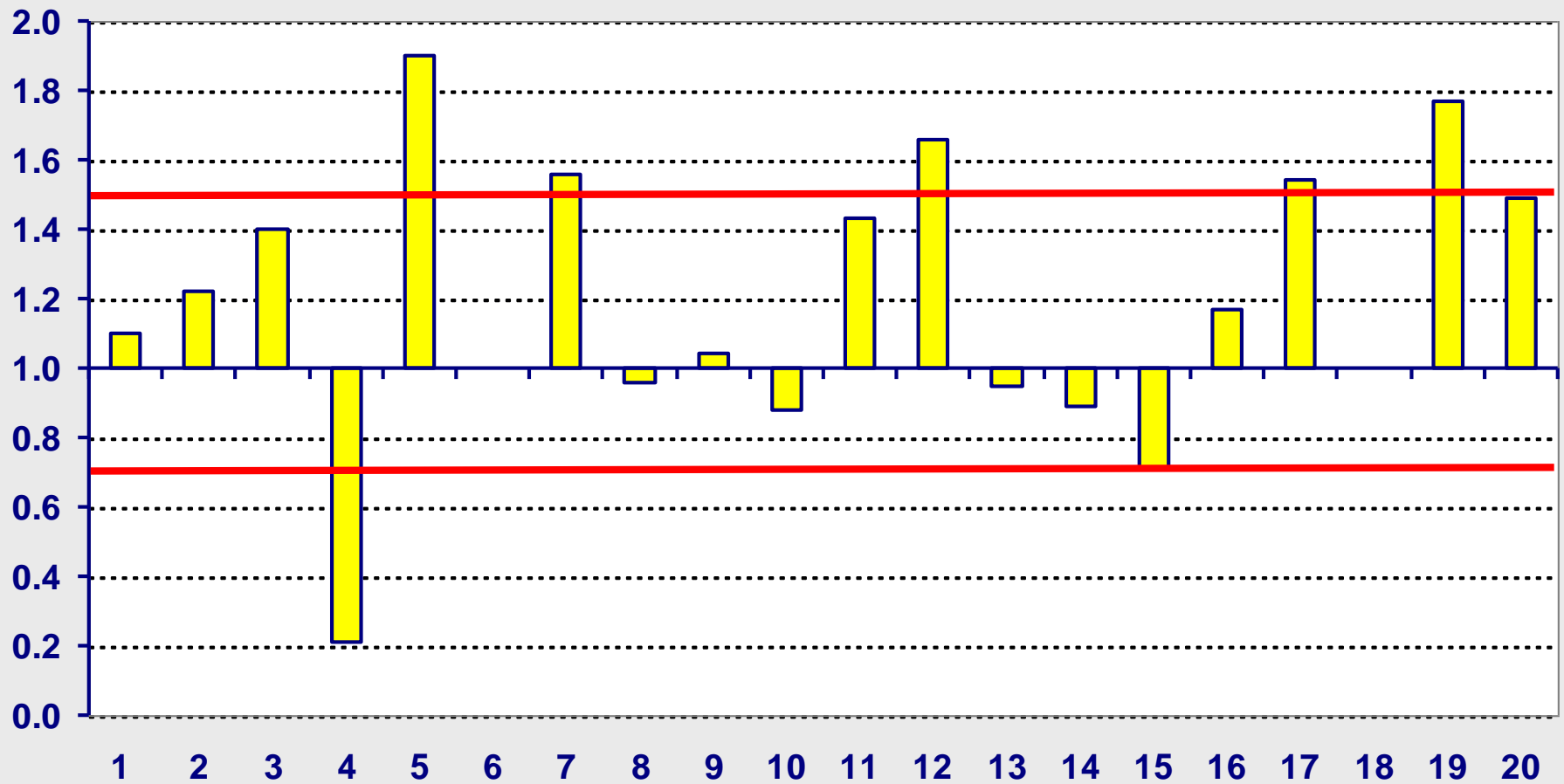
Intercomparison results

U (3% enr) ^{238}Pu bias for torso phantom



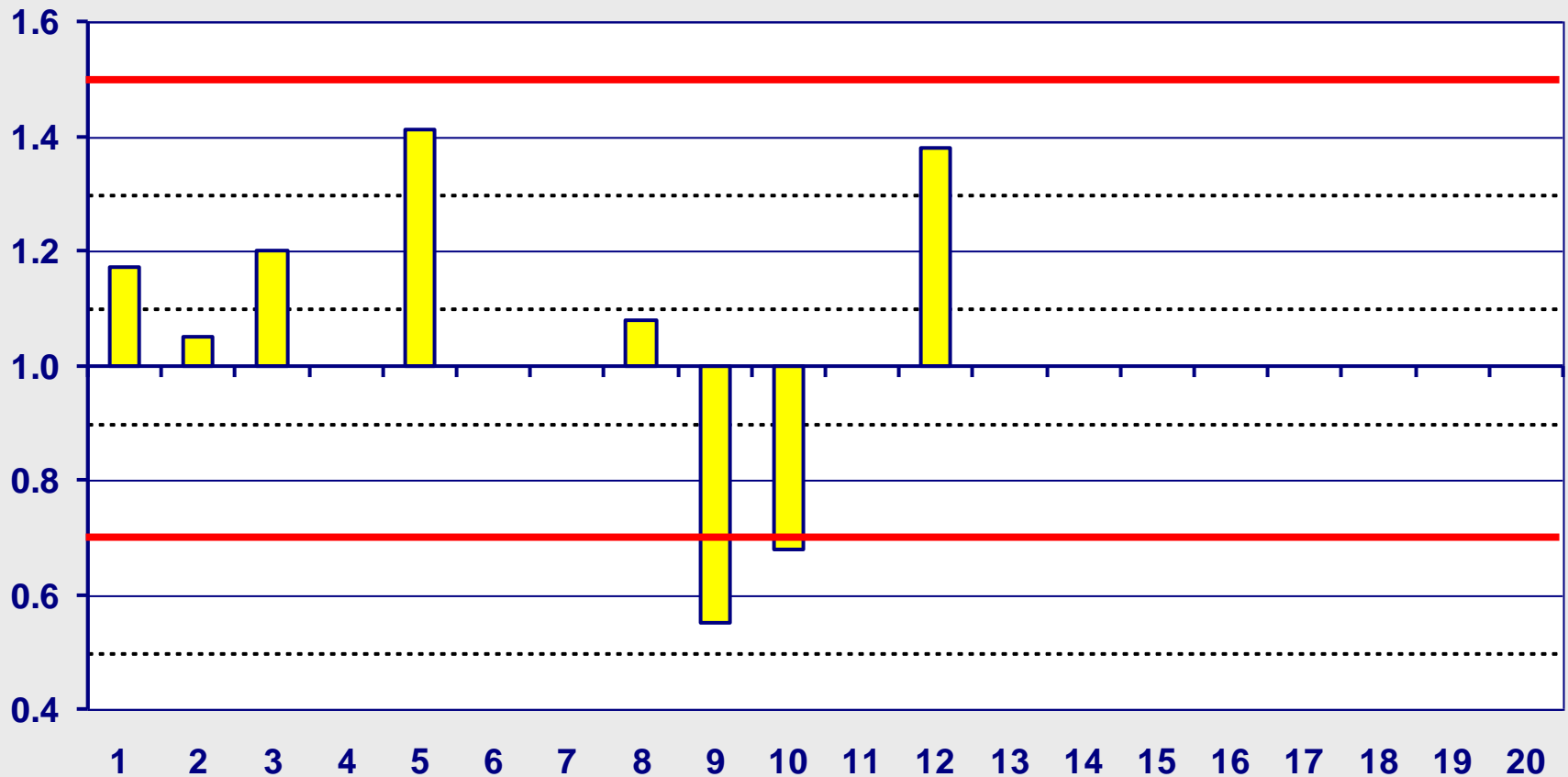
Intercomparison results

Am 241 bias for torso phantom



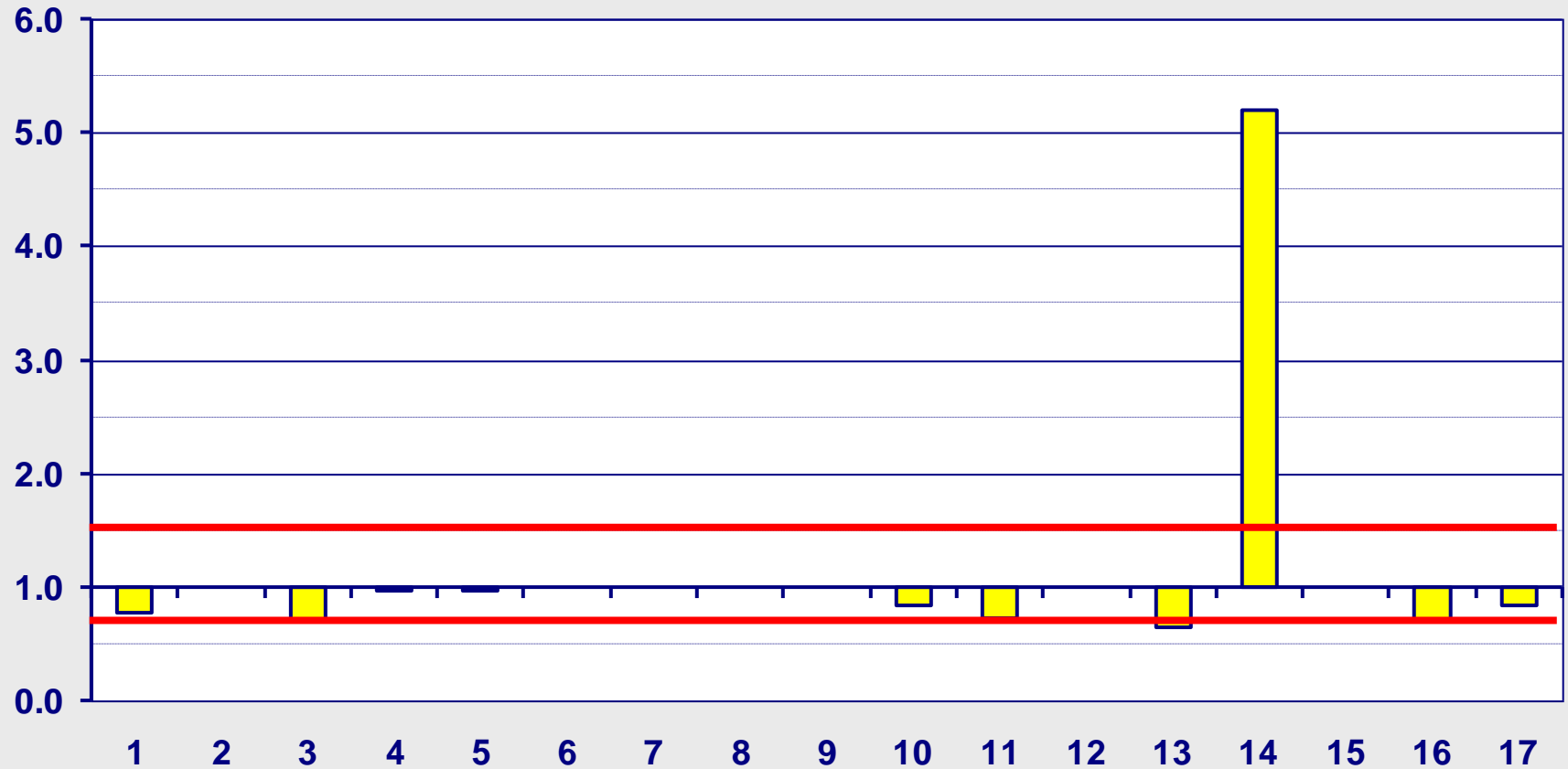
Intercomparison results

Pu238 bias for torso phantom



Intercomparison results

Pu238 bias for lung phantom



Validation statement

- Issue validation statement accordingly