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Benefits of using a stable radioisotope for quality control and calibration of friskers, sample changers and beta/gamma CAMs

Las Vegas, NV

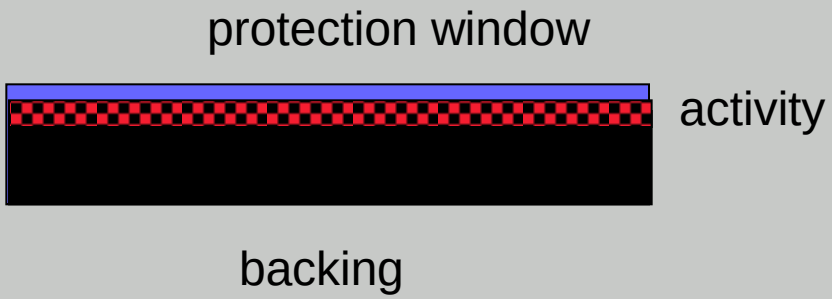
May 6, 2010

Activity versus emission rate in conventional sources

- Physical / legal performance: 4 Pi efficiency
  (cps / Bq; cpm / dpm)
- Detector performance: 2 Pi efficiency
  (cps / s^{-1})

Unfortuntely the ratio between both numbers depends on the source design and individual specimen:

- Backscattering
- Selfabsorption
- Non-uniformity



Bulk Material consisting Primordial Isotopes

Psychological, practical, legal and scientific advantages:

- ⇒ Non man-made
- ⇒ No decay correction
- ⇒ Low specific activity
- ⇒ Low total activity
- ⇒ Inherently 100 % reproducible
- ⇒ Inherently homogeneous activity concentration
- ⇒ Inherently homogeneous surface emission rate
- ⇒ Inherently traceable

Key Candidates:
K-40 & Lu-176

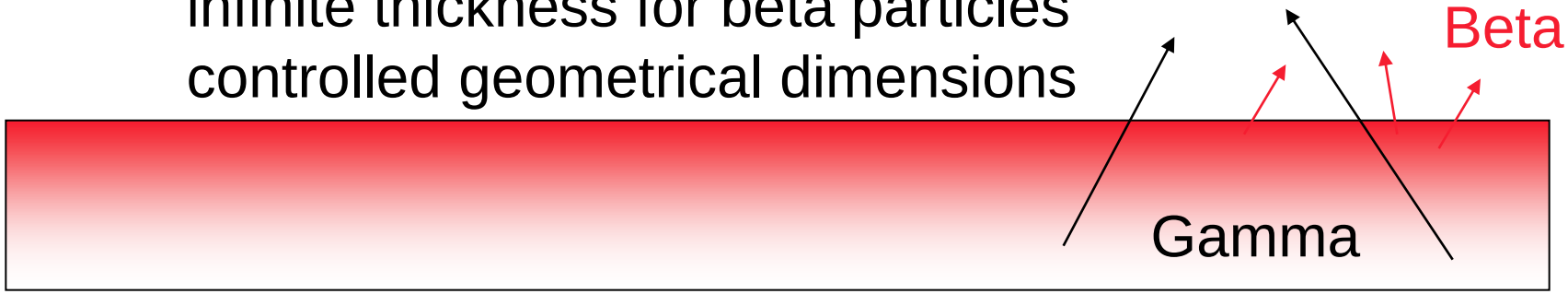
Man-Made and Primordial Isotopes

Nuclide	Half-life	Specific activity of isotope (Bq/g)	Natural abundance	Specific activity in natural element	Max beta energy	Gamma & X-rays > 50 keV
Co-60	5,27 a	4,19E+13	NA	NA	318 keV (100%)	1,17 MeV (100 %) 1,33 MeV (100 %)
Cs-137	30 a	3,22E+12	NA	NA	512 keV (95%) 1173 keV (5%)	662 keV (89 %)
K-40	1,28 E+09 a	2,59E+05	0,01%	31 Bq/g	1312 keV (89%)	1,46 MeV (11 %)
Lu-176	3,6 E+10 a	2,09E+03	2,59%	54 Bq/g	589 keV (99%)	55 keV (26 %) 63 keV (6,9 %) 88 keV (13 %) 202 keV (84 %) 307 keV (93 %)
Rb-87	4,8 E+10 a	3,17E+03	27,9%	883 Bq/g	273 keV (100%)	-
La-138	1,05 E+11 a	9,13E+02	0,09%	0,8 Bq/g	253 keV (33%)	788 keV (33 %) 1436 keV (67 %)

Lu_2O_3 Beta/Gamma Source

-Beta Emitter: 589 keV (99 %)

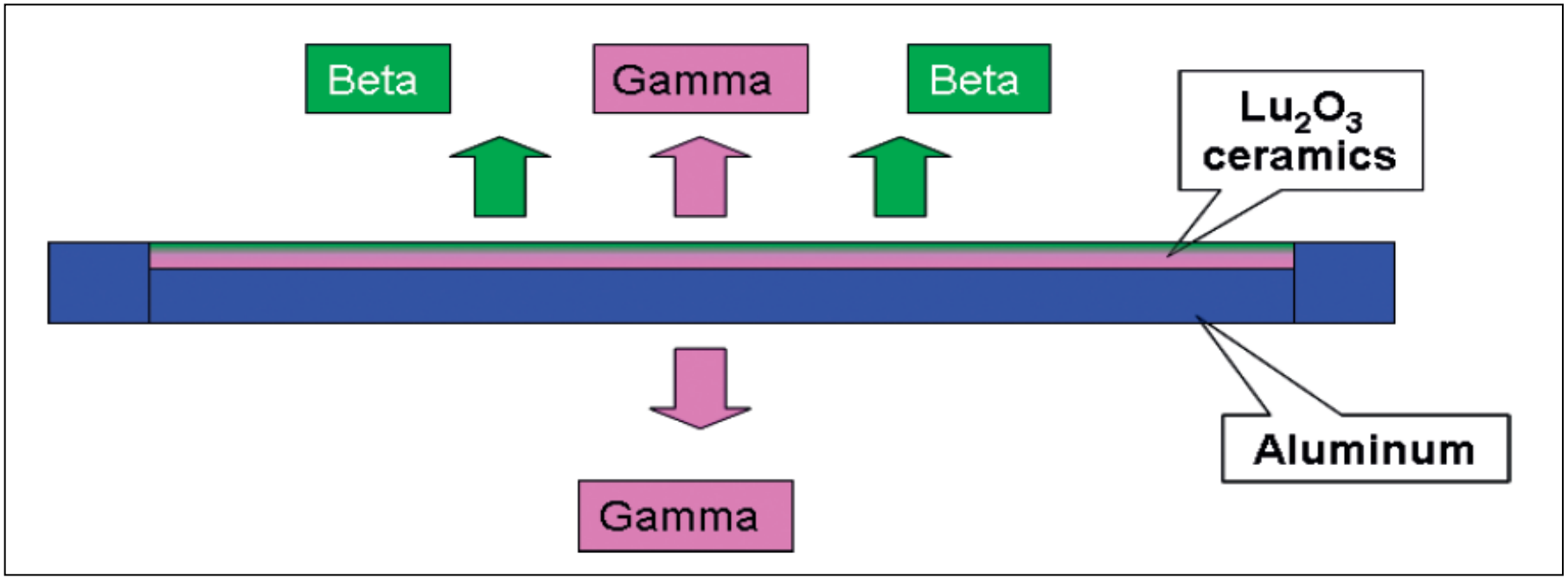
- Surface emission rate is **totally** constant & reproducible:
  - constant natural abundance of Lu-176
  - chemically pure (99,99 %) Lu_2O_3
  - infinite thickness for beta particles
  - controlled geometrical dimensions



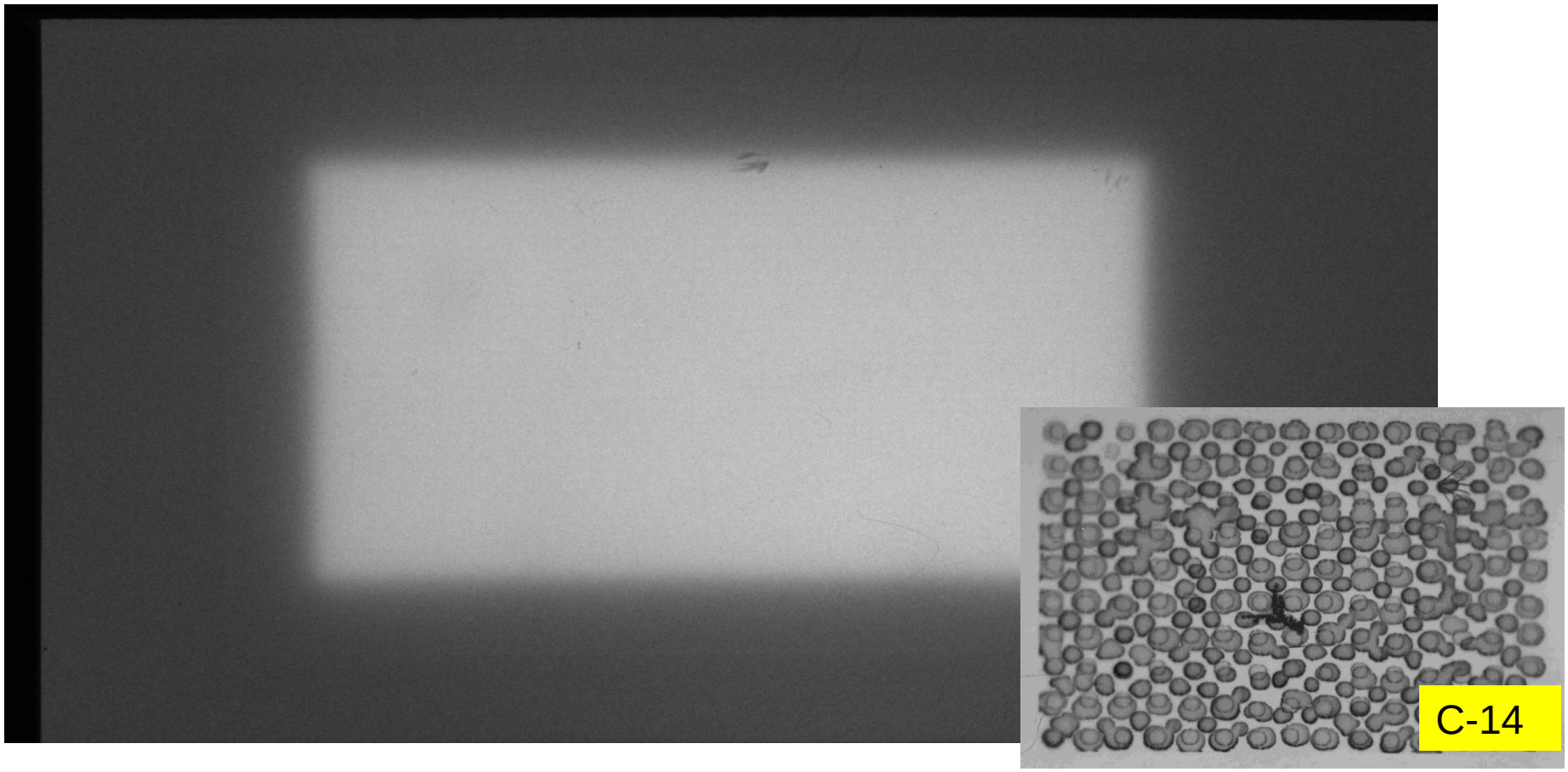
Specific beta surface emission rate is about 0,8 s^{-1}/cm^2

Specific gamma surface emission rate is about 30 s^{-1}/cm^2

2 Side Measurement for Gamma Compensation

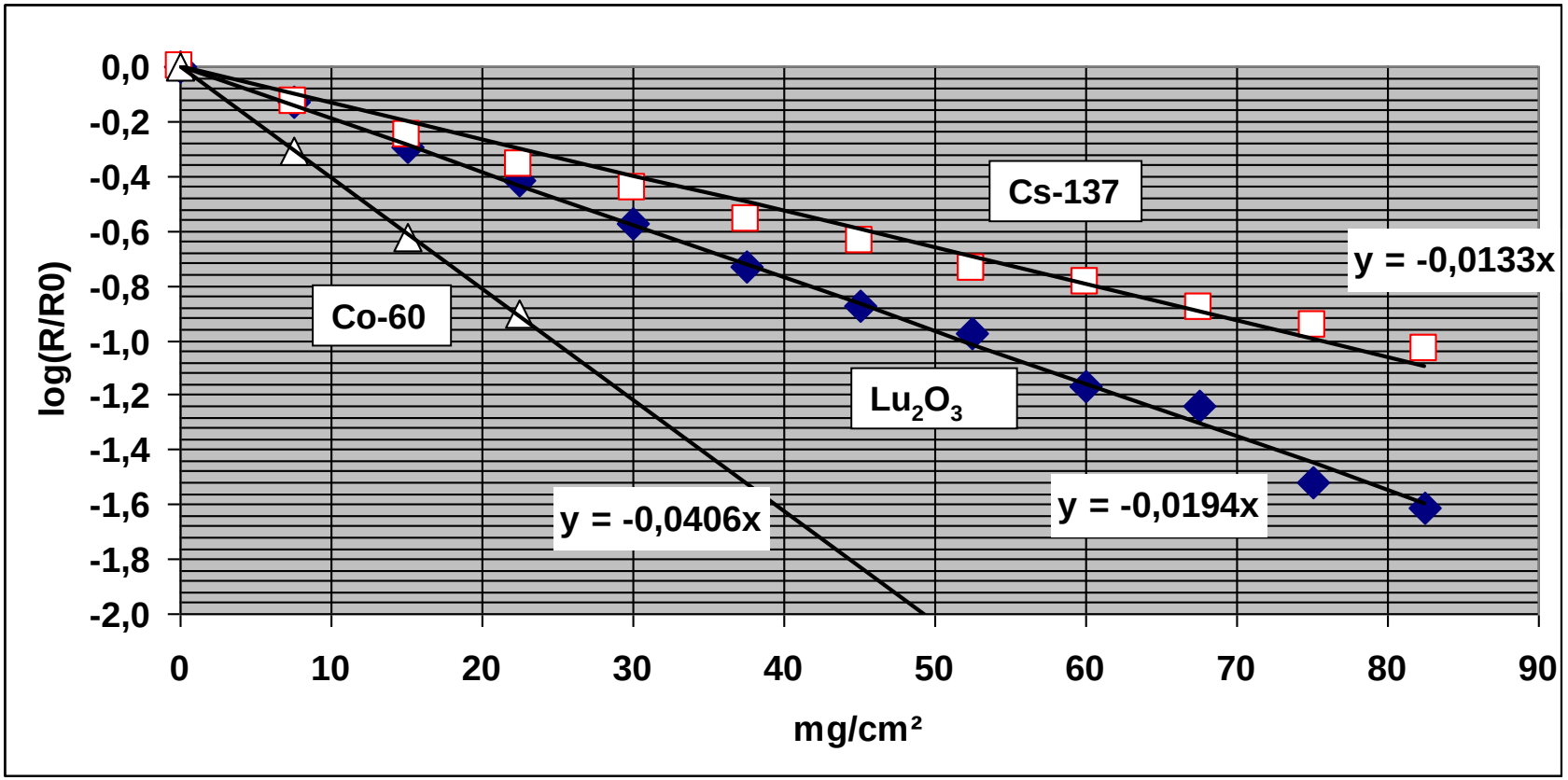


Auto-Radiography of Lu_2O_3 110 cm²



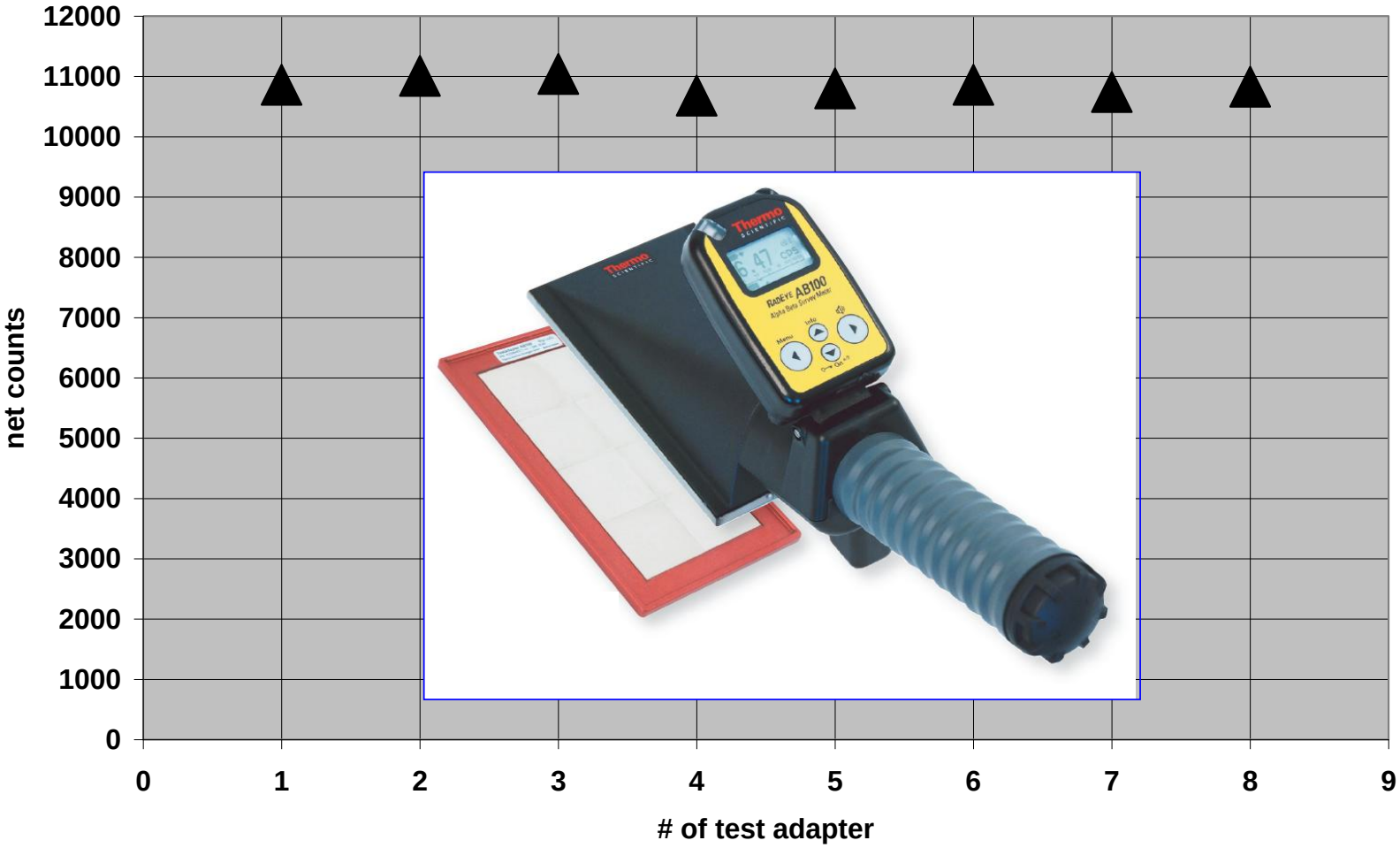
Homogeneous “calibration sources” can be manufactured to practically any (rectangular) size, assembled from 37 mm x 37 mm tiles.

Comparison of Absorption Curves



Effective maximum beta energy:
480 keV from Lu_2O_3 surface

Variation between different Adapters



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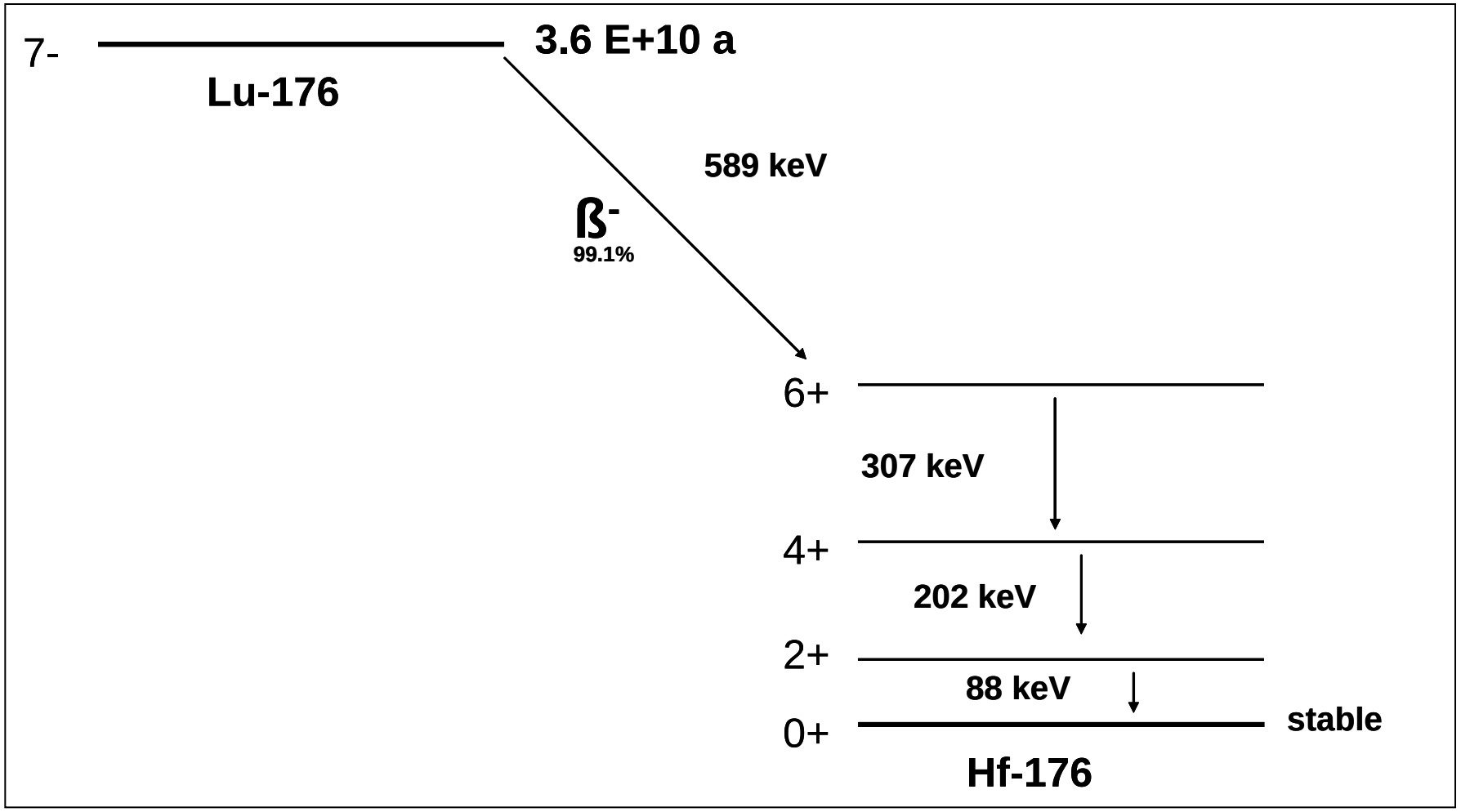
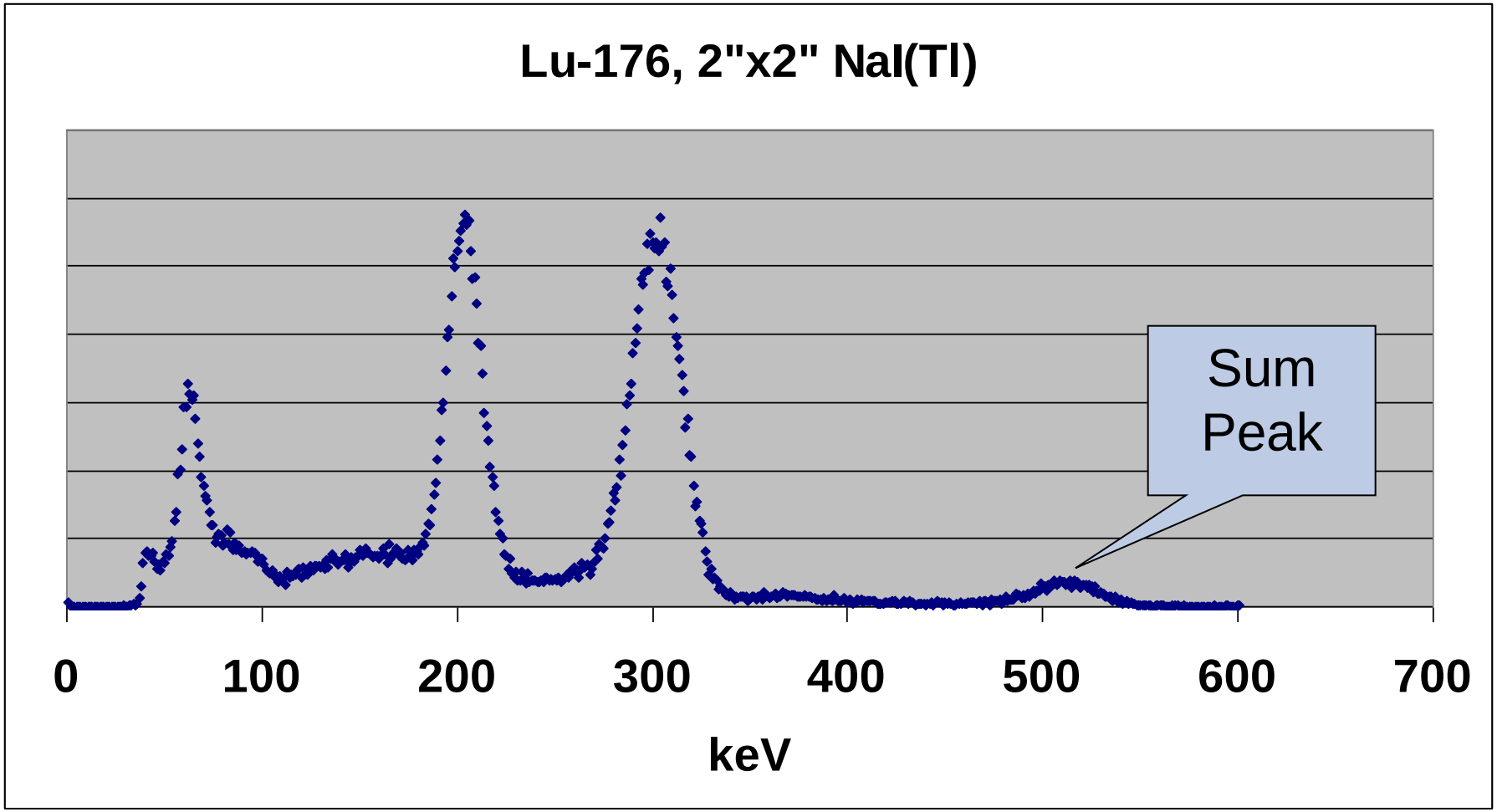
Performance Verification of RadEye B20

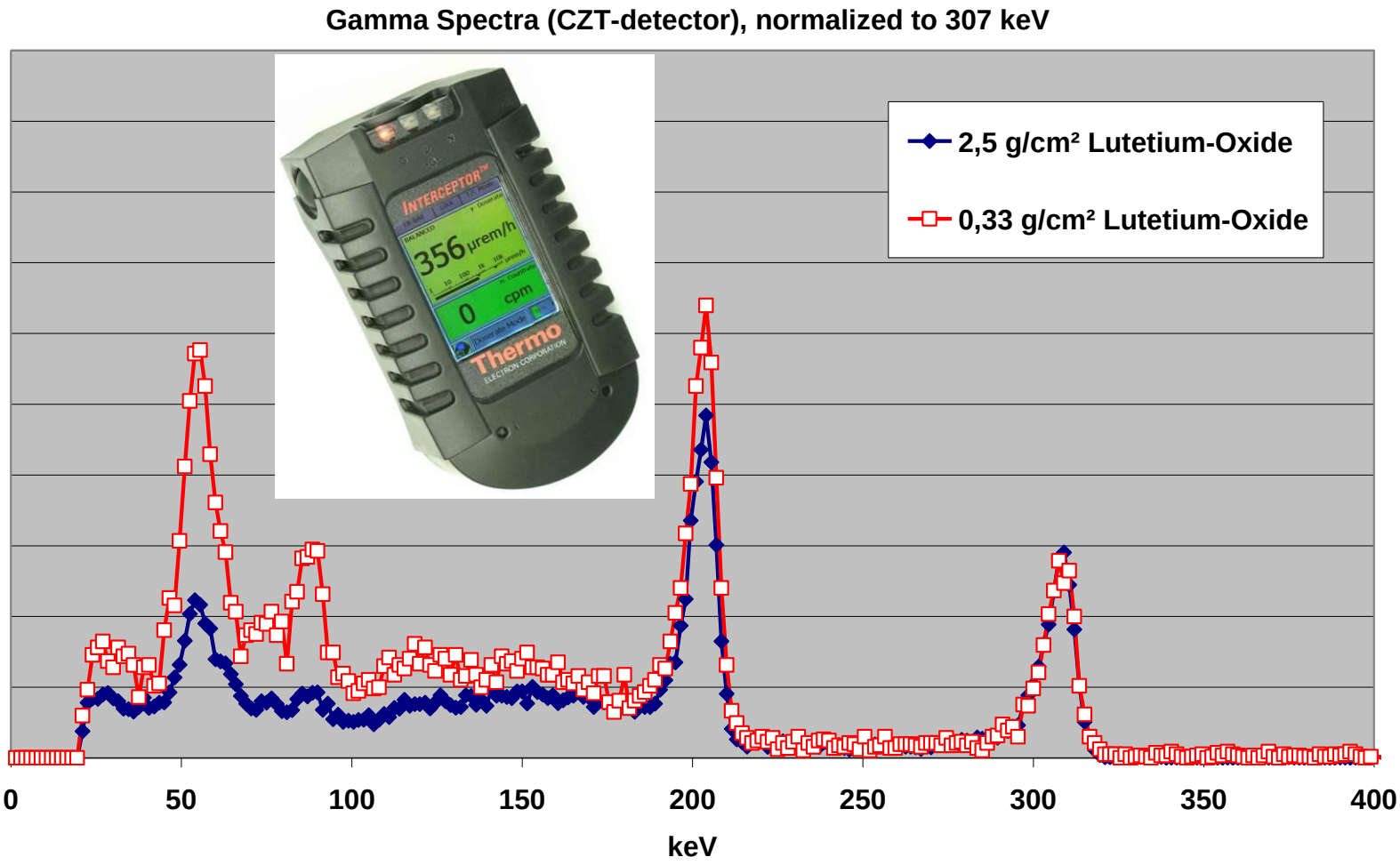
Decay Scheme of Lu-176



Energy Spectrum Lu-176



Energy Spectrum Lu-176



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Peak stabilization of I-131 monitor

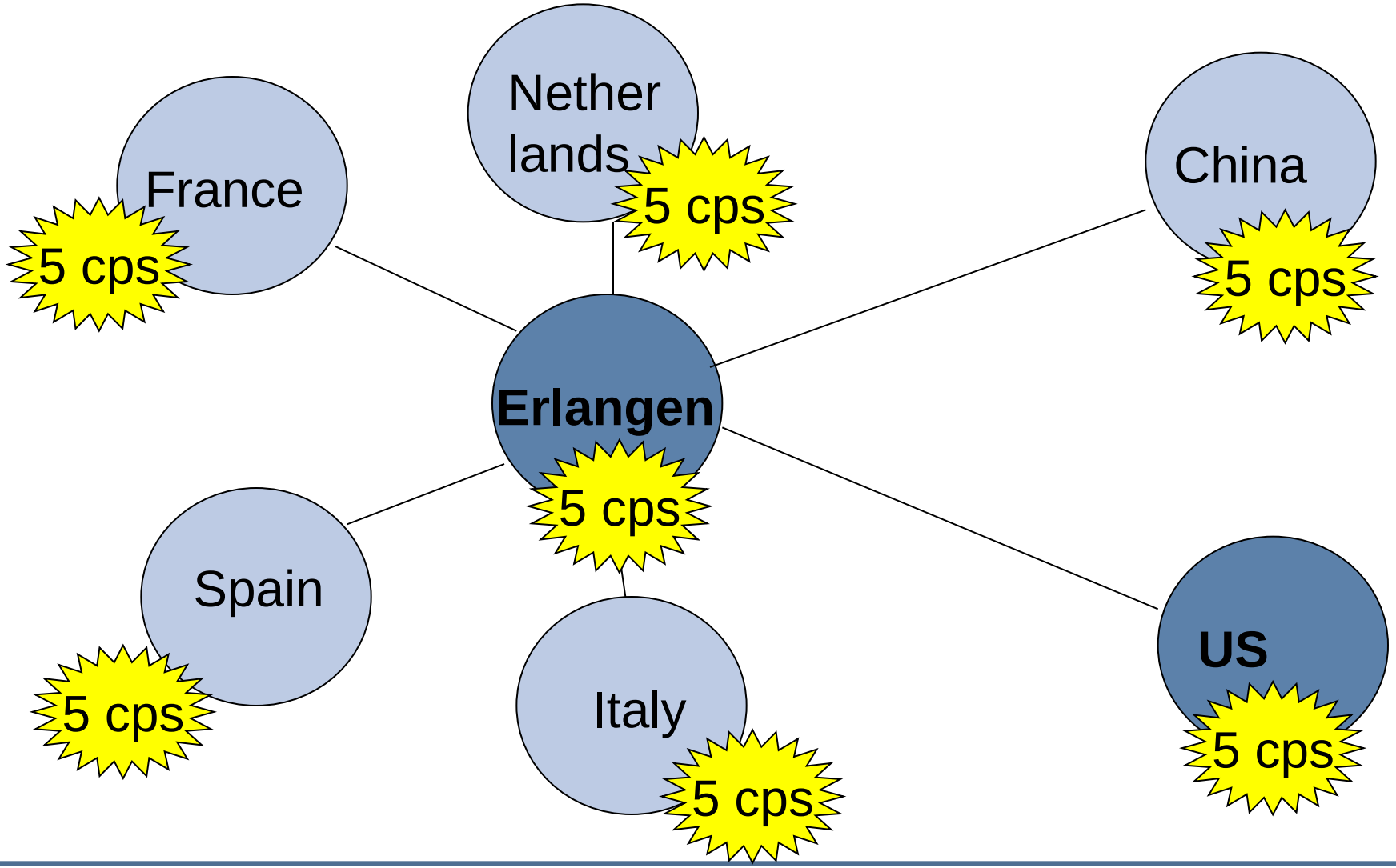
High Voltage adjustment with a built-in Lu-176-source

RadEye PRD Test Adapter (36 g Lu_2O_3)

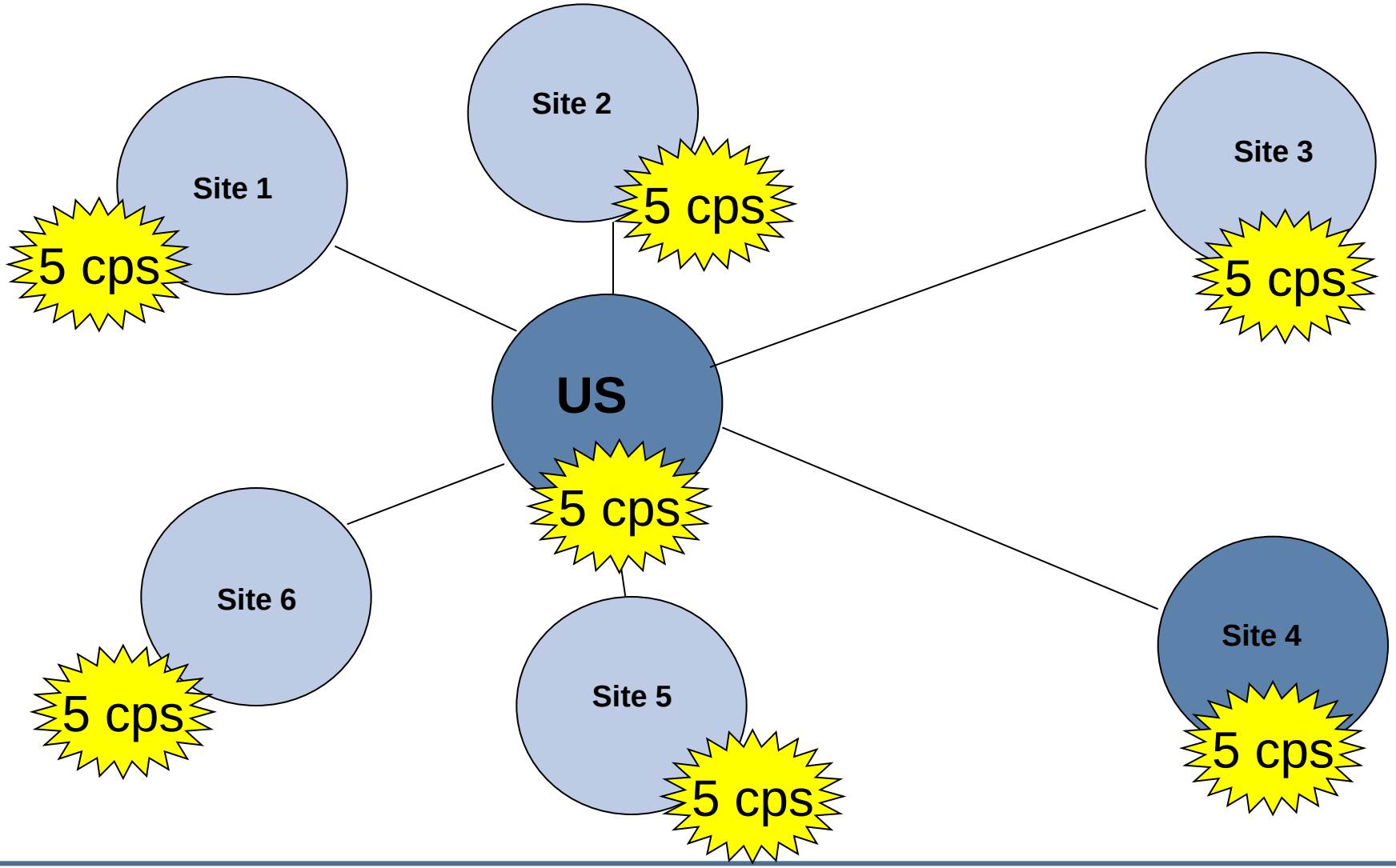
- **Special shape minimizes distance to detector**
- **Lu_2O_3 compressed to 9 g/cm³**
- **High Response to Lu-176 energies = 100 cps**

Performance Check: 5 s
HV-Adjustment: 2 min

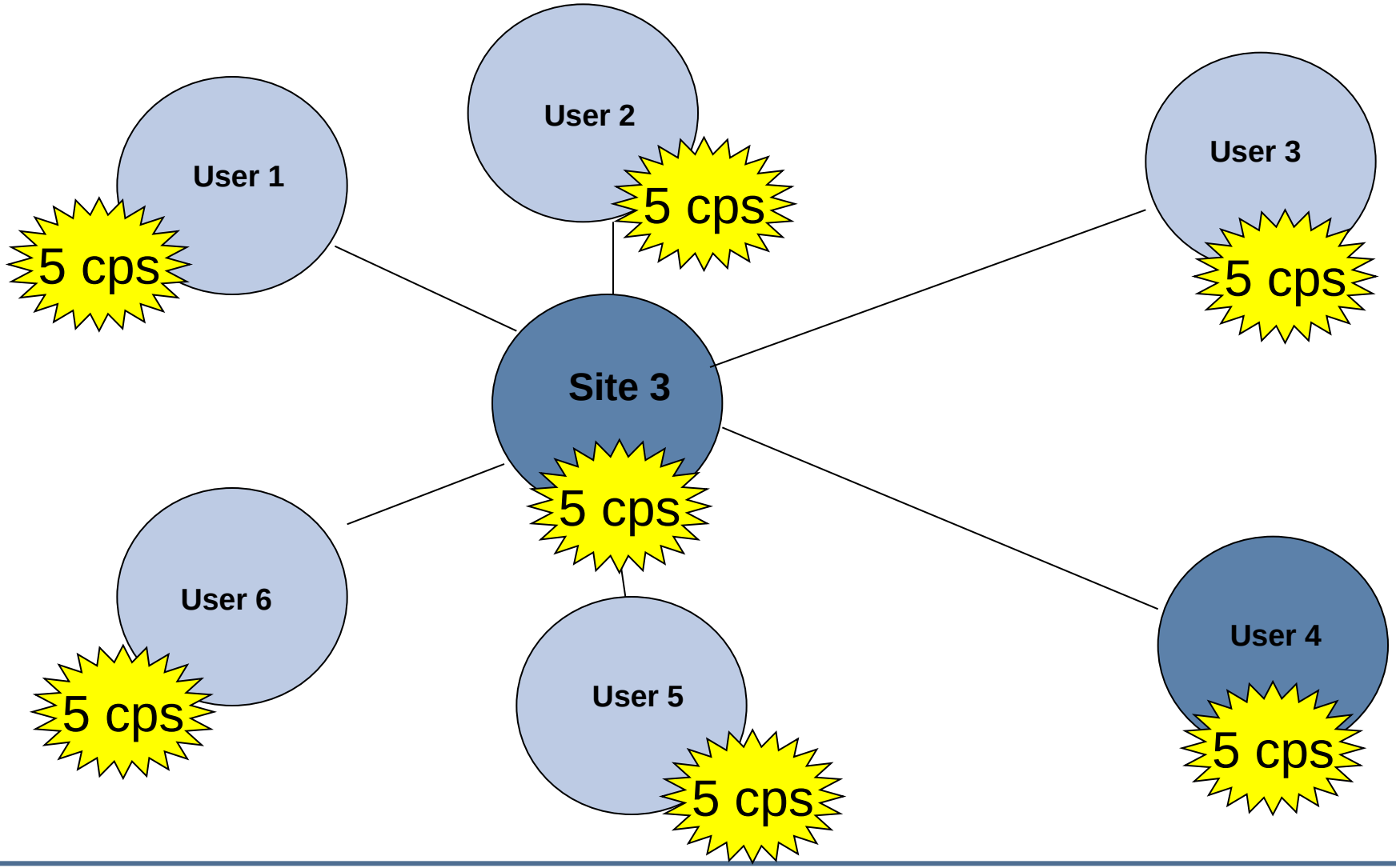
Lutetium Test-Adapter Clones (Top Level)



Lutetium Test-Adapter Clones (2nd Level)



Lutetium Test-Adapter Clones (3rd Level)



Take-Away

It is NOT the fact that Lu-176 is of natural origin (Ra-226 is natural as well)

Lutetium test adapters are "intrinsically safe sources" made of a "stable radioisotope" in its natural abundance

with "perfect" uniformity and reproducibility

Annual Limit of Intake for Cs-137 and Lu_2O_3

	ALI	ALI
Cs-137	**1,5 MBq**	**0,5 µg**
Lu-176	**11 MBq**	**220 kg (Lu_2O_3)**

Little Ingestion Risk

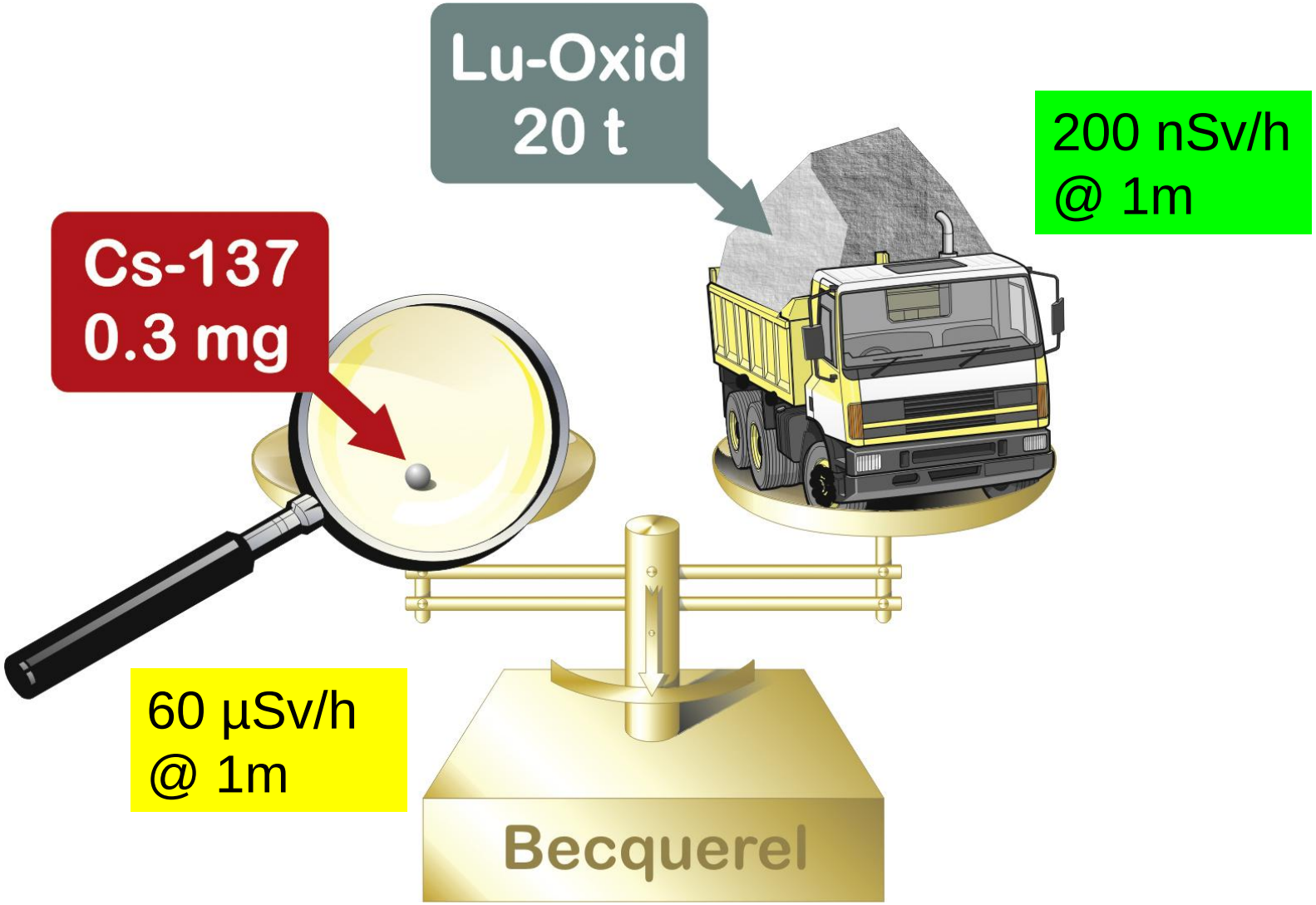
Publication:

Test Adapters Based on Natural Lutetium

IRPA, Argentina 2008

(and citations therein)

Cs-137 vs. Lu-176 – Same Activity (1 GBq)



Lutetium – a Long Term Investment

- 600 Mio Years | -500 Mio Years | -300 Mio Years | -100 Mio Years | -200,000 Years | 2000 Years

10 kBq »» **9.9 kBq**

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