Institute of radiation physics

Préparation de solutions radioactives étalons par un laboratoire primaire

Claude Bailat, Thierry Buchillier

Frédéric Juget, Teresa Duran, Youcef Nedjadi, Corinne Moratal, Sandrine Zufferey

Let’s step back from the end certificate to the primary measurement….

Institut de radiophysique
Rue du Grand-Pré 1
CH-1007 Lausanne

Fiche descriptive

Echantillons 1407-1, 1407-2, 1407-3 et 1407-4

Délivré à :
LABOR SPIEZ
~~Austrasse~~
~~CH-3700 SPIEZ~~

Eckert & Ziegler
Isotope Products

24937 Avenue Tibbitts
Valencia, California 91355

Tel 661•309•1010
Fax 661•257•8303

CERTIFICATE OF CALIBRATION
GAMMA STANDARD SOLUTION

Radionuclide: Pb-210
Half-life: 22.3 ± 0.2 years
Catalog No.: MISC-STD
Source No.: 1369-91

Customer: ECKERT & ZIEGLER ISOTOPE PRODUCTS GMBH
P.O. No.: 37388
Reference Date: 15-Jun-09 12:00 PST
Contained Radioactivity: 9.458 μCi 349.9 kBq

Physical Description:
A. Mass of solution: 1.08654 g in 1 mL V-Vial
B. Chemical form: $Pb(NO_3)_2$ in 1M HNO_3
C. Carrier content: 10 μg Pb/mL of solution
D. Density: 1.0318 g/mL @ 20°C

Radioimpurities:
None detected

Radionuclide Concentration: 8.705 μCi/g, 322.1 kBq/g

Method of Calibration:
This source was prepared from a weighed aliquot of solution whose activity in μCi/g was determined using gamma ray spectrometry.
Peak energy used for integration: 46.5 keV
Branching ratio used: 0.0418 gammas per decay

Uncertainty of Measurement:
A. Type A (random) uncertainty: ± 0.3 %
B. Type B (systematic) uncertainty: ± 7.0 %
C. Uncertainty in aliquot weighing: ± 0.0 %
D. Total uncertainty at the 99% confidence level: ± 7.0 %

Notes:
- See reverse side for leak test(s) performed on this source.
- EZIP participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (as in NRC Regulatory Guide 4.15).
- Nuclear data was taken from NCRP Report No. 58, 1985.
- This solution has a working life of 5 years.

Quality Control

22-Jul-09
Date

EZIP Ref. No.: 1369-91

ISO 9001 CERTIFIED

Medical Imaging Laboratory
24937 Avenue Tibbitts Valencia, California 91355

Industrial Gauging Laboratory
1800 North Keystone Street Burbank, California 91504

Institut universitaire de radiophysique appliquée

Mandaté par l'Office fédéral de métrologie METAS pour la détermination et la diffusion de l'unité légale d'activité

Certificat d'étalonnage

No 0808-12.0311

Délivré à AAA Advanced Accelerator Applications
Technoparc
20, Rue Diesel
01630 – Saint Genis Pouilly
France

Objet **1 source radioactive de F-18**

Forme chimique Fluoro-Deoxy-Glucose FDG

Identification BP-FG-080826-B-01

Impuretés radioactives Aucun radionucléide émetteur gamma de longue période n'a été mesuré dans la source. (LD< 0.01%)

Activité Par unité de masse **(607.28 ± 4.69 [1]) MBq/g**

Date de référence 26 août 2008 à 07 h 15 TU [2]

Le responsable de la mesure Institut de Radiophysique Appliquée

Dr Yvan Calfari

Dr. Claude Bailat
Chef du groupe de Radiométrologie

Lausanne le 1er septembre 2008

[1] Le nombre qui suit le symbole ± est l'incertitude élargie. (voir page 2)
[2] Correspond à 9:15 Heure CET. (Heure locale Genève, horaire d'été)

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sé, de la procédure ilonné. Il n'a pas été é.

dations internationales[1], l'incertitude et en

, ISBN 92-67-20188-3.

Institut universitaire de Radiophysique Appliquée Grand-Pré 1 CH-1007 Lausanne
La publication ou la reproduction de ce certificat n'est autorisée que dans sa forme intégrale

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Czech Metrology Institute

Okružní 31, 638 00 Brno
Phone: +420 545 555 111, Fax: +420 545 222 728, www.cmi.cz

Workplace: Regional Branch Prague, Radiová 1136/3, 102 00 Praha 10
Ionizing Radiation Building, Radiová 1288/1a
Phone: +420 266 020 497, Fax: +420 266 020 466

CERTIFICATE

Certificate No.: 1035 - SE - 40293-15 Type: CBSS 2 Serial No: 030215-1503033

Radionuclide	Half life, days	Activity, kBq	Combined standard uncertainty, %
Am-241	157800	1,033	1,1
Cd-109	462,6	4,383	1,5
Ce-139	137,5	0,2436	1,2
Co-57	271,26	0,2202	1,1
Co-60	1925,4	0,6277	1,1
Cs-137	11019	0,5707	1,3
Sn-113	115,1	1,742	2,2
Sr-85	64,78	2,195	1,2
Y-88	106,6	2,188	1,5
Pb-210	8108	10,66	1,5

Mass: 539,0 g Density: 0,98 ± 0,01 g/cm^3 Volume: 550,0 ± 5,5 cm^3
Radionuclide impurities: gamma < 0,1 %
Reference date: 1.5.2015 Homogeneity better than: 1 %

Description:
Radioactive material is homogeneously dispersed in silicone resin. Composition of the matrix: C - 0,324 H - 0,0816 O - 0,216 Si - 0,379 (mass ratio).

Measuring method:
Preparation issues from standard ER solutions whose activities were determined by suitable absolute method. Final control is based on gamma spectrometry on HPGe detector.

Note:
As the criterion of homogeneity standard deviation of the activity value of 1 cm^3 element was chosen (n=10). The volume is calculated from the mass and the density. Pb-210 is in the radioactive equilibrium with Po-210.

Date of the certificate issue: 10.4.2015 Certificate validity 3 years

Customer:
Office fédéral de la santé publique OFSP

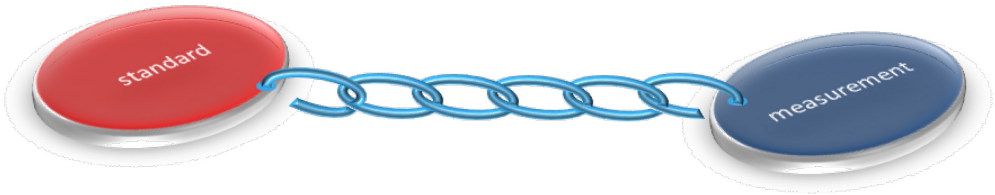
3003 Bern
SWITZERLAND

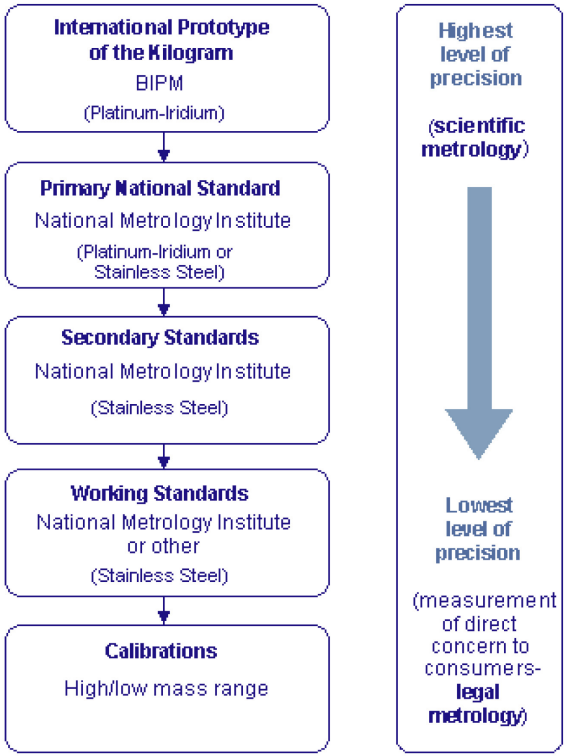
Control: Ing. Vlasta Zdychová, RNDr. Pavel Dryák, CSc.

Ing. Jiří Šuráň, MBA
Deputy director of BB Prague

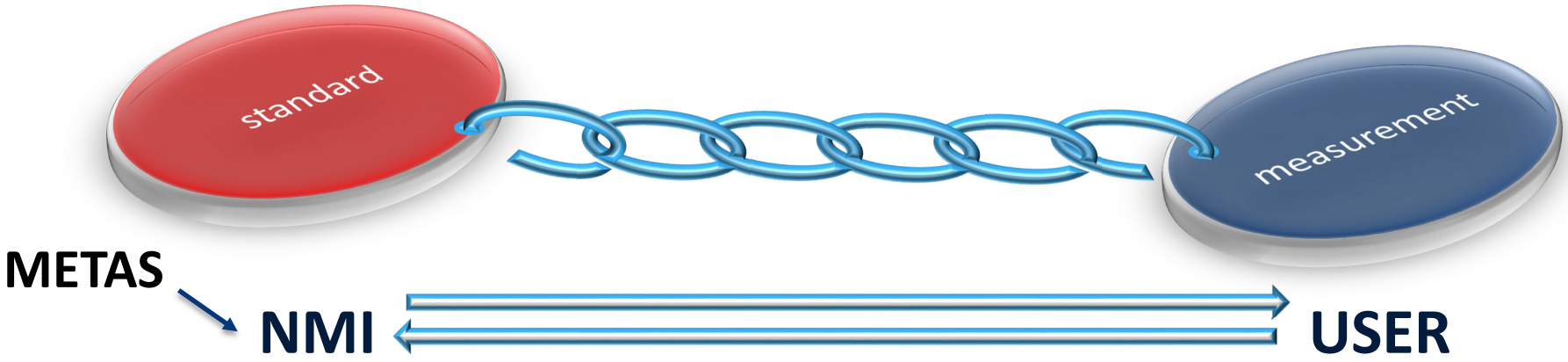
METROLOGY

Traceability refers to an unbroken chain of comparisons relating an instrument's measurements to a known standard.





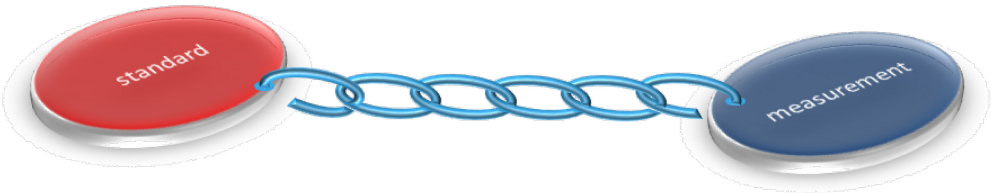
Calibration to a traceable standard can be used to determine an instrument's bias, or accuracy.

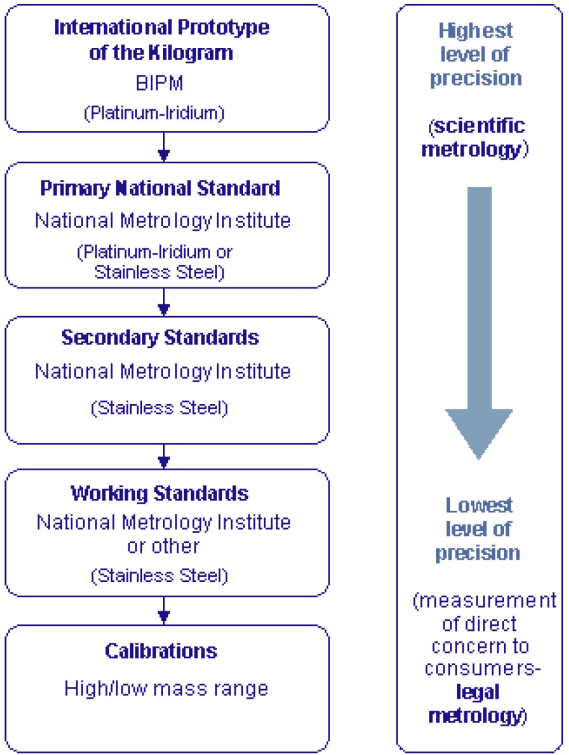


In many countries, national standards are maintained by a National Metrology Institute (NMI) → highest level of standards for the calibration / measurement traceability infrastructure in that country.

METROLOGY + RADIO = IONISING RADIATION

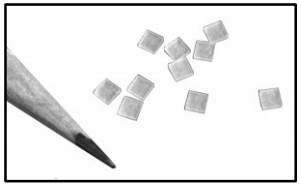
Traceability refers to an unbroken chain of comparisons relating an instrument's measurements to a known standard.

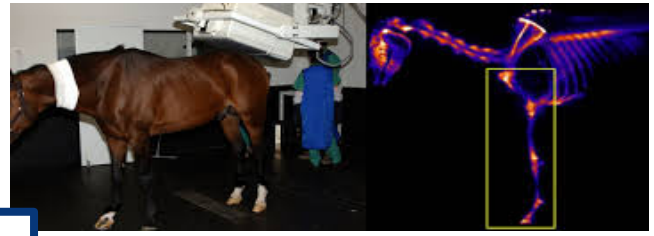




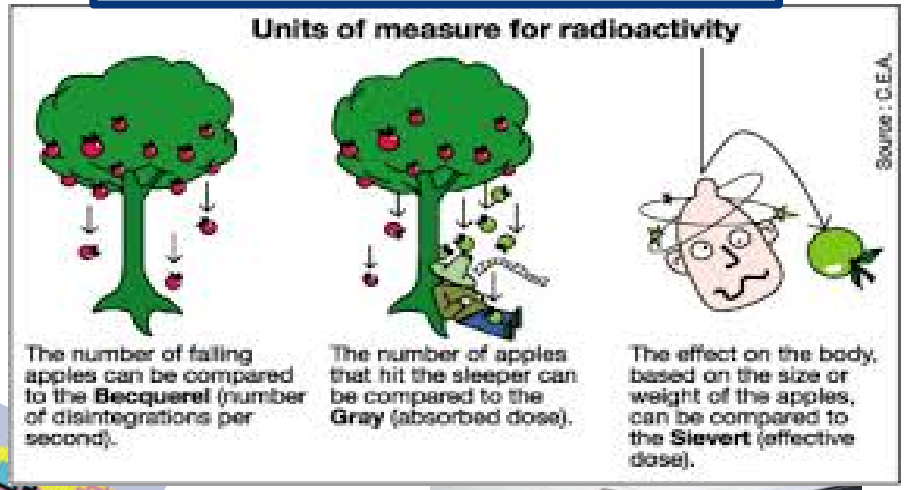
Calibration to a traceable standard can be used to determine an instrument's bias, or accuracy.

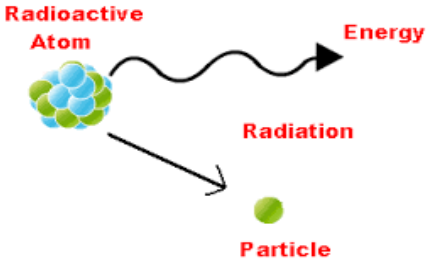
Radiometrology

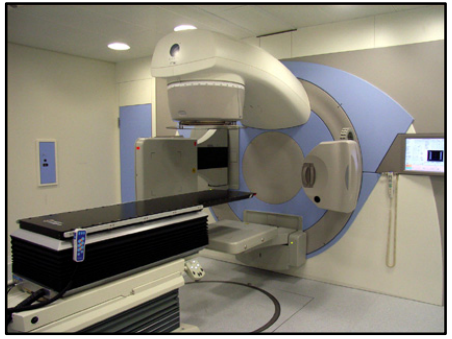


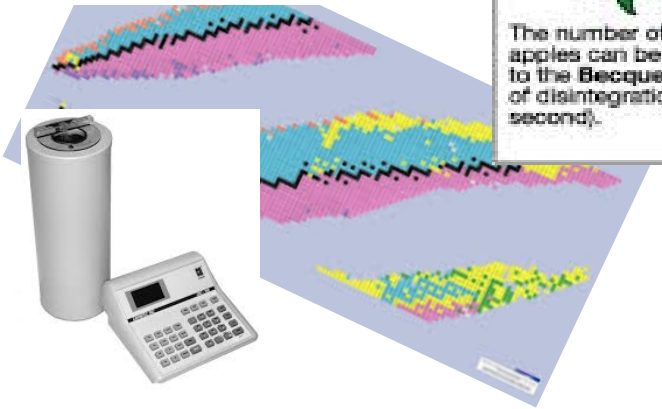


Bq **Gy** **Sv**

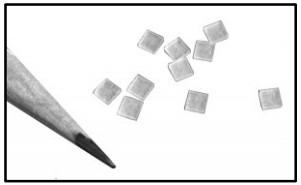


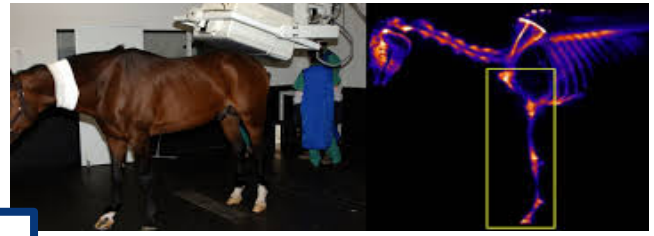




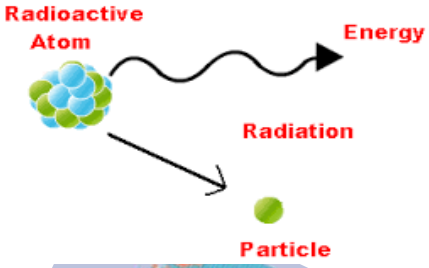


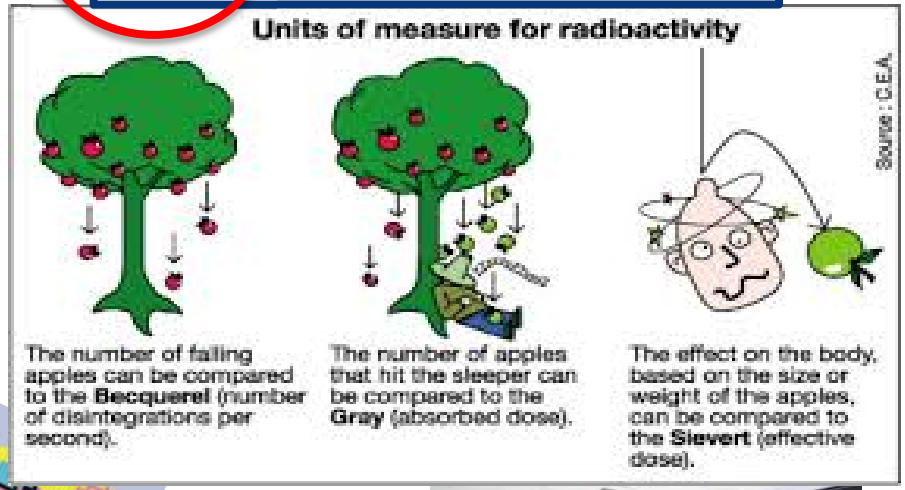
Radiometrology

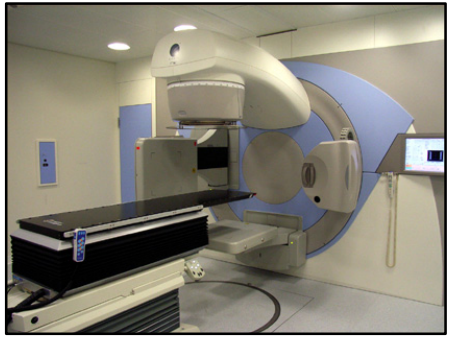


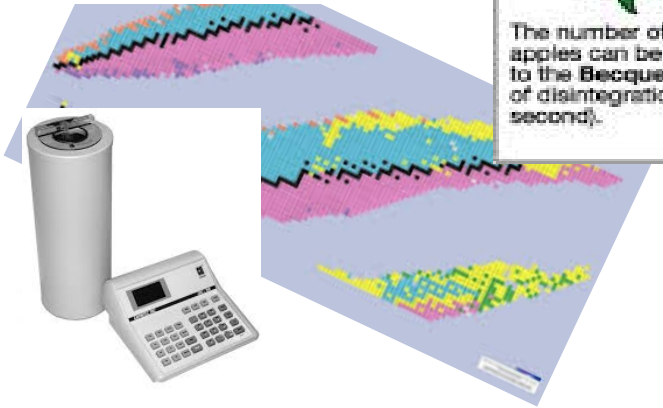


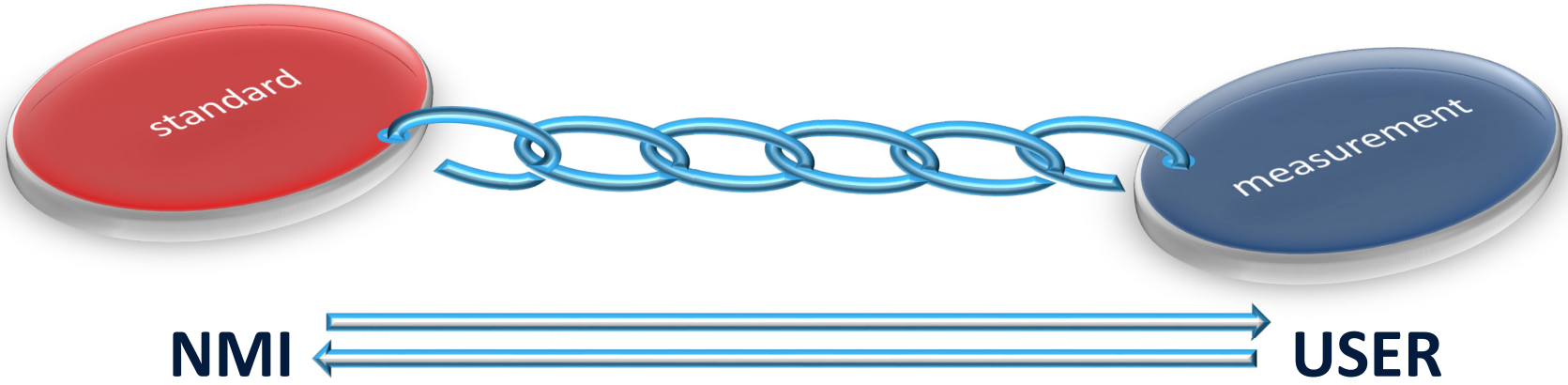
Bq **Gy** **Sv**







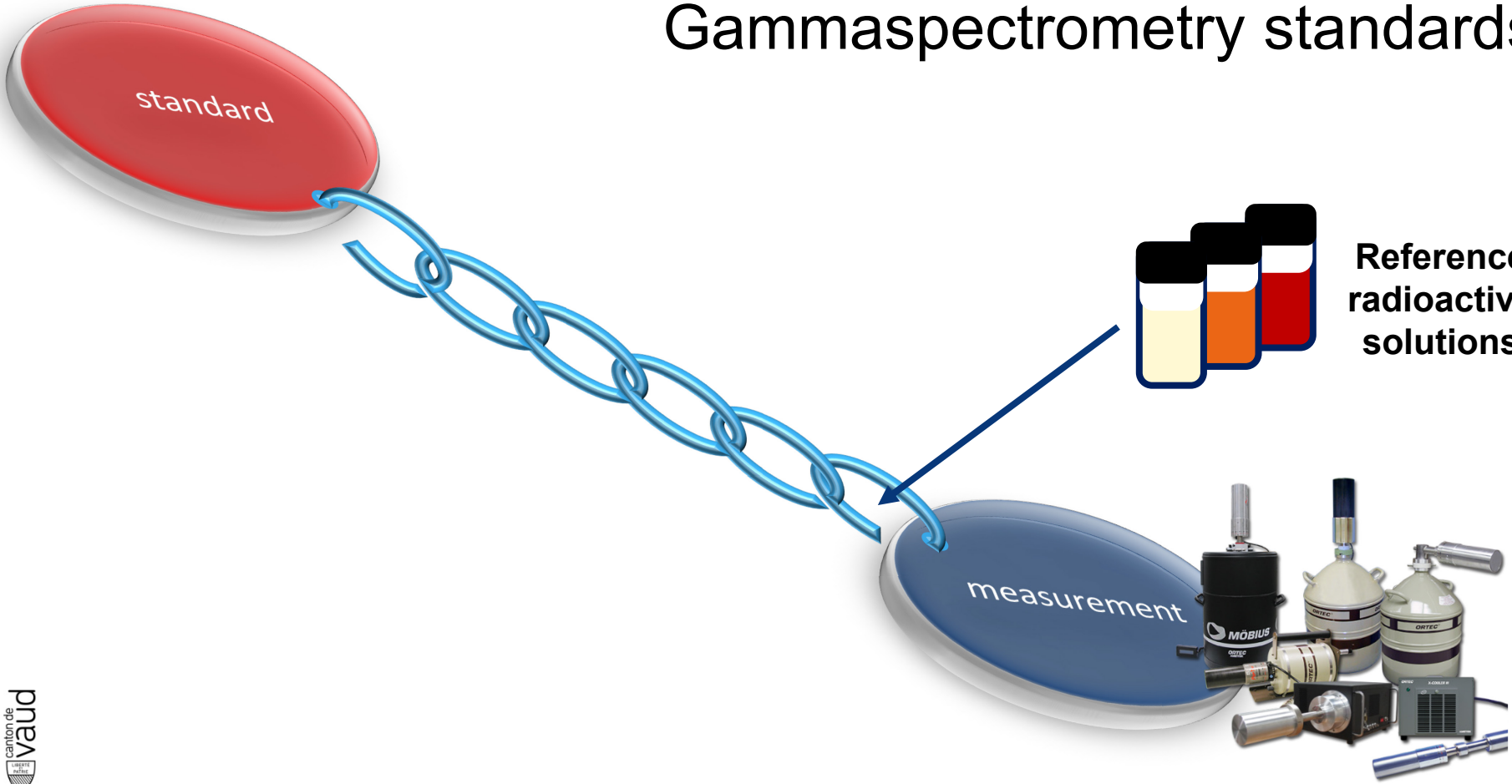




In many countries, national standards for IR are maintained by a designated institute.

In CH, DI = IRA

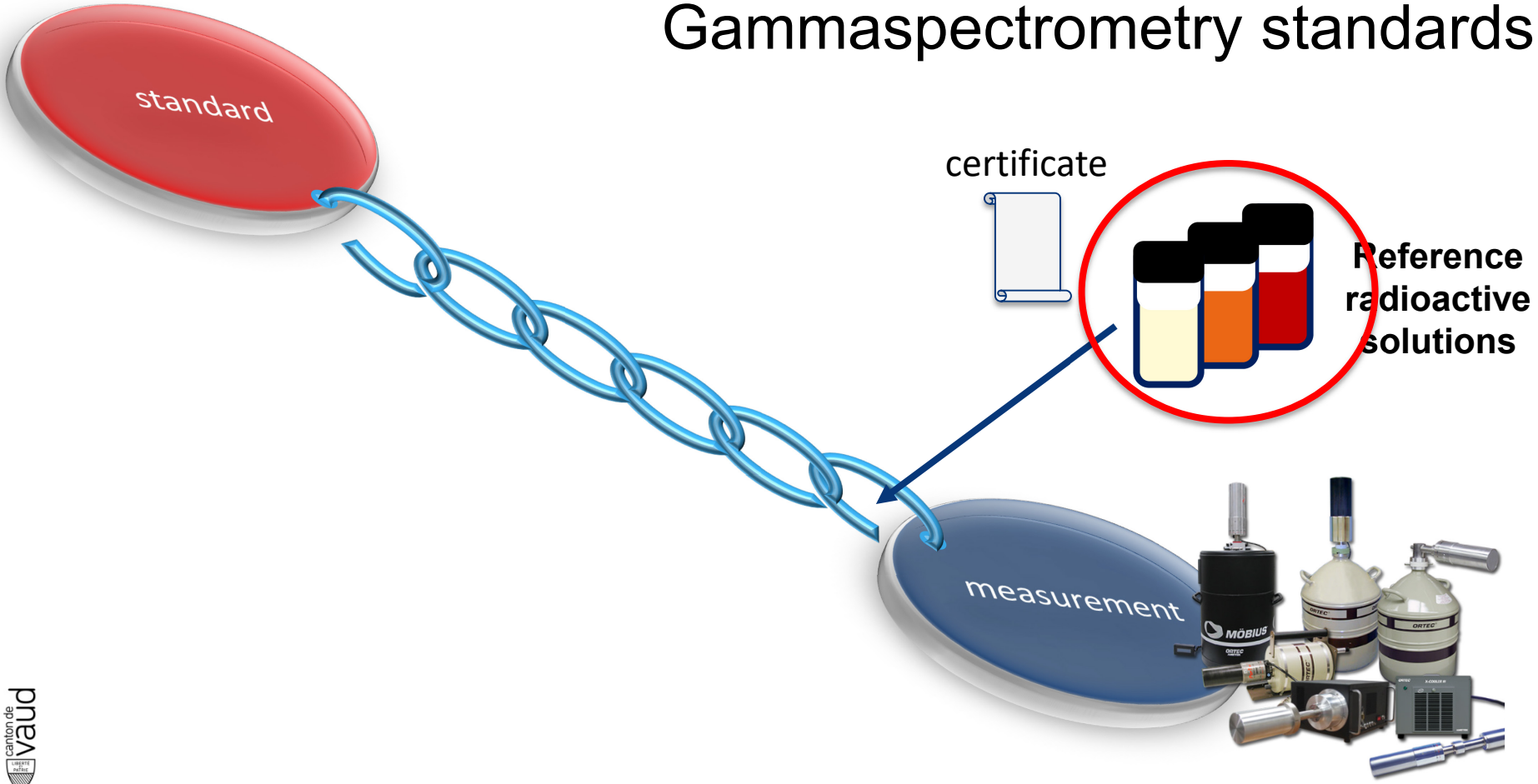
Gammaspectrometry standards



Reference radioactive solutions

canton de vaud

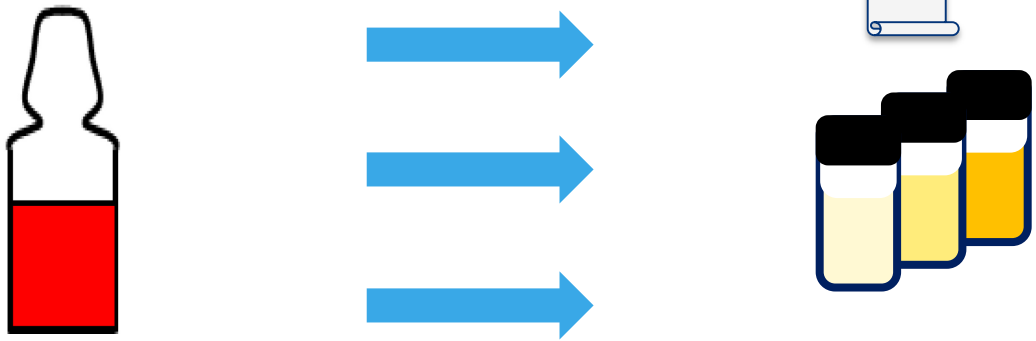
Gammaspectrometry standards



canton de vaud

Mother/master solution

Standards



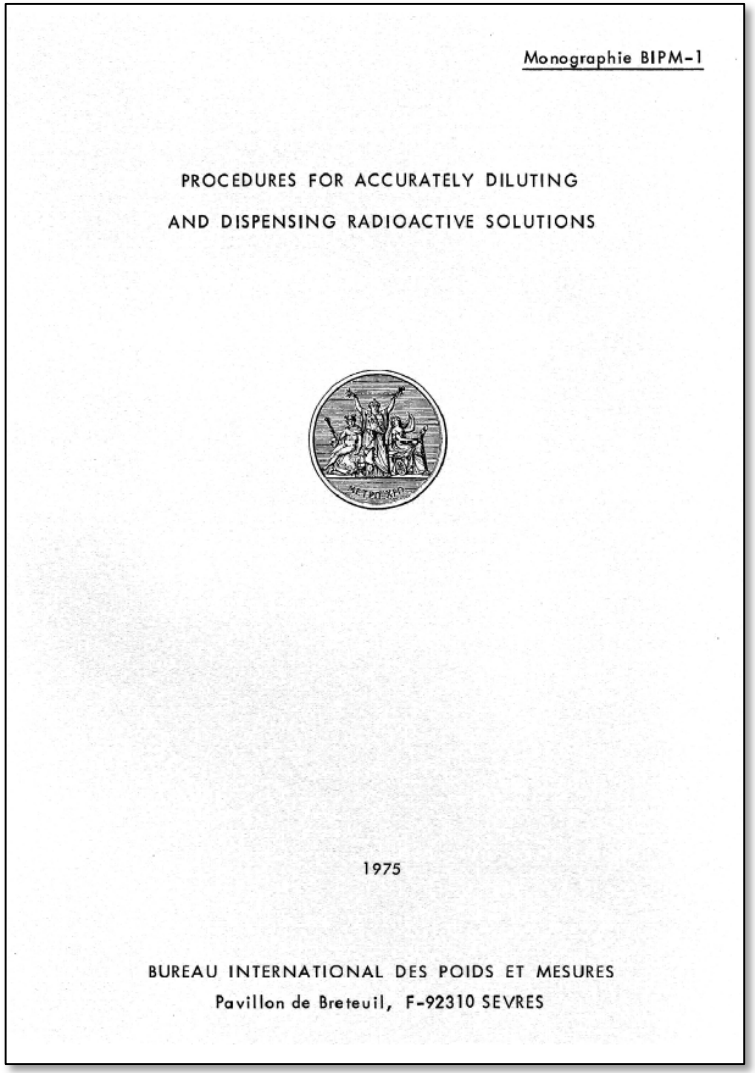
Gravimetric dilutions

Gravimetric procedures for radionuclide metrology are described in a monographie of the BIPM (1975)

→ It is maybe old, but nothing change in chemical interactions.

→ Detailed description of precautions (chemistry, physics, …)

→ One important recommendation is that the dilution factor must be < 50 and preferably > 30.


Monographie BIPM-1

PROCEDURES FOR ACCURATELY DILUTING
AND DISPENSING RADIOACTIVE SOLUTIONS

1975

BUREAU INTERNATIONAL DES POIDS ET MESURES
Pavillon de Breteuil, F-92310 SEVRES

Example: procedure to produce Co-57 standard

Goal of the manipulation:

Realize three vials of Co-57 with an activity of around 200 MBq (concentration 40 MBq/g) from a mother sample at high concentration (4 GBq/g)

Use of several samples to obtain an accurate measurement of the activity:

Traceable measurement of the activity concentration using a sealed ampoule (using the CIR)

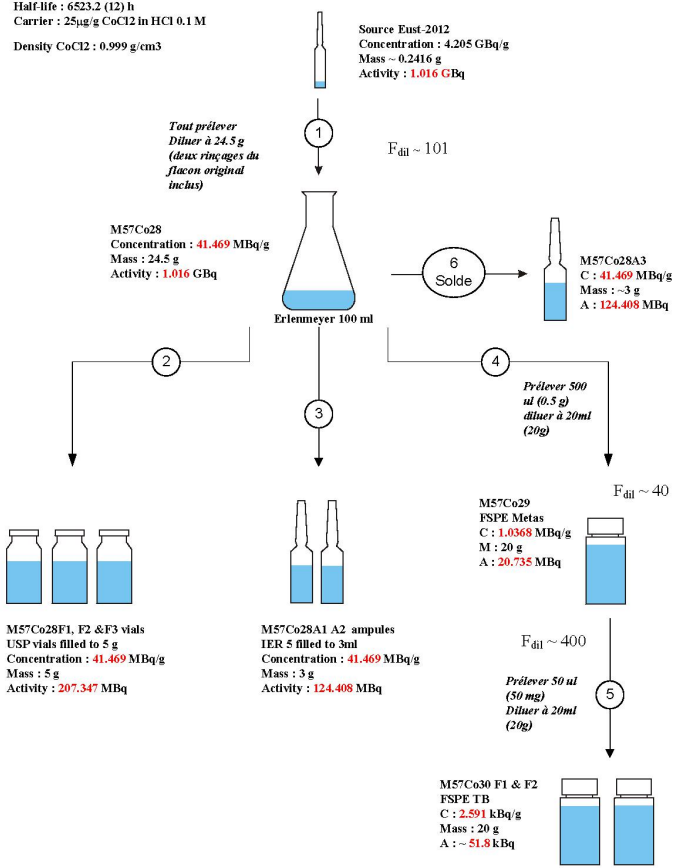
Control the presence of impurities (Co-58, Co-56…) by gamma spectrometry

Exploitation de la source de Co-57 Eust-2012 pour la fabrication de sources de référence

Reference date : 12 mars 2012 **Source preparation date : 13 mars 2012**

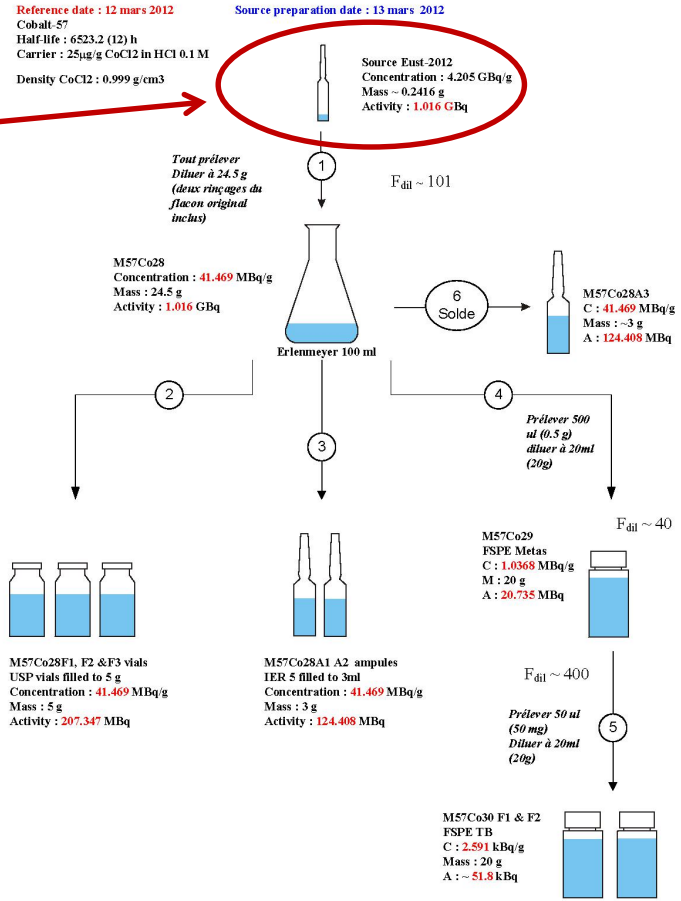
Cobalt-57
Half-life : 6523.2 (12) h
Carrier : 25µg/g CoCl2 in HCl 0.1 M

Density CoCl2 : 0.999 g/cm3

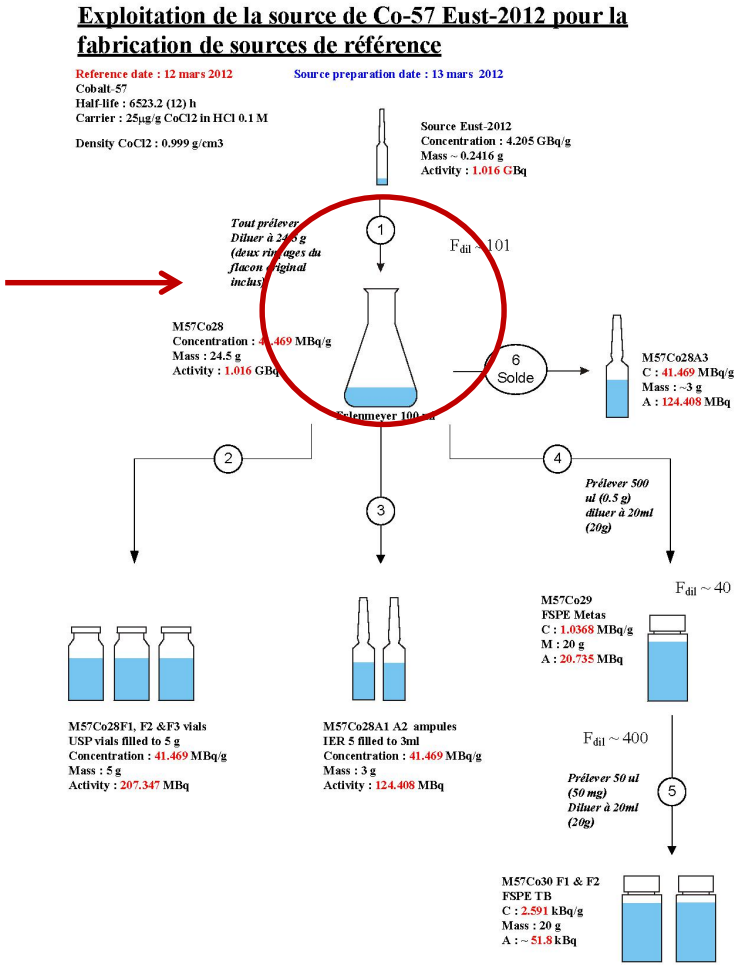


Mother solution in 2ml ampoule

Exploitation de la source de Co-57 Eust-2012 pour la fabrication de sources de référence

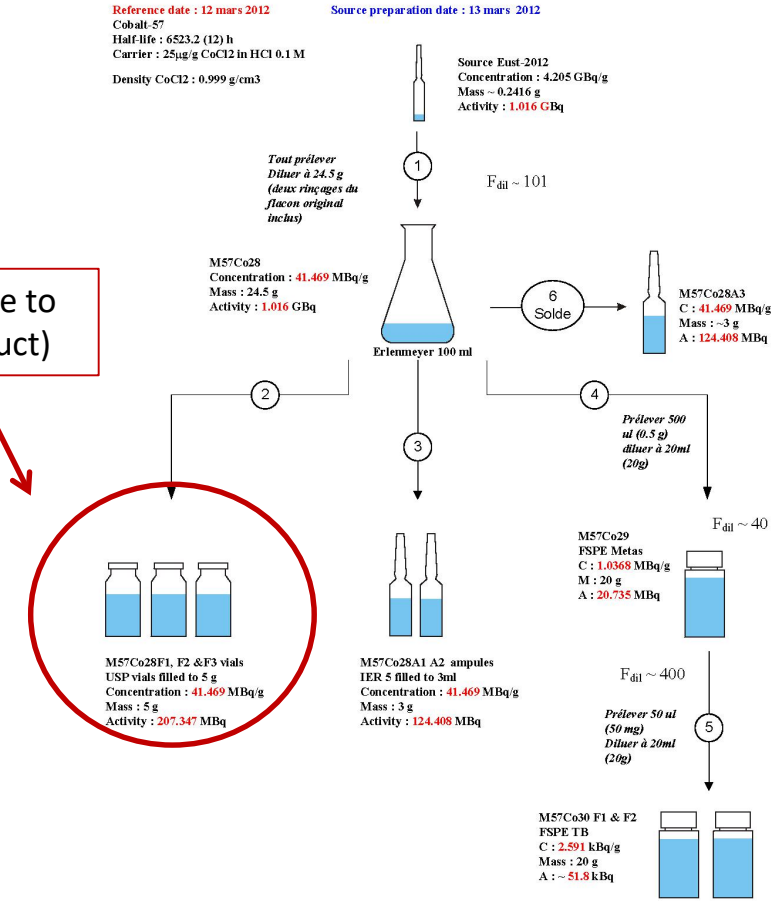


Multiple dilutions to reach a factor 100 using carrier $CoCl_2$ dans HCl 0.1 M

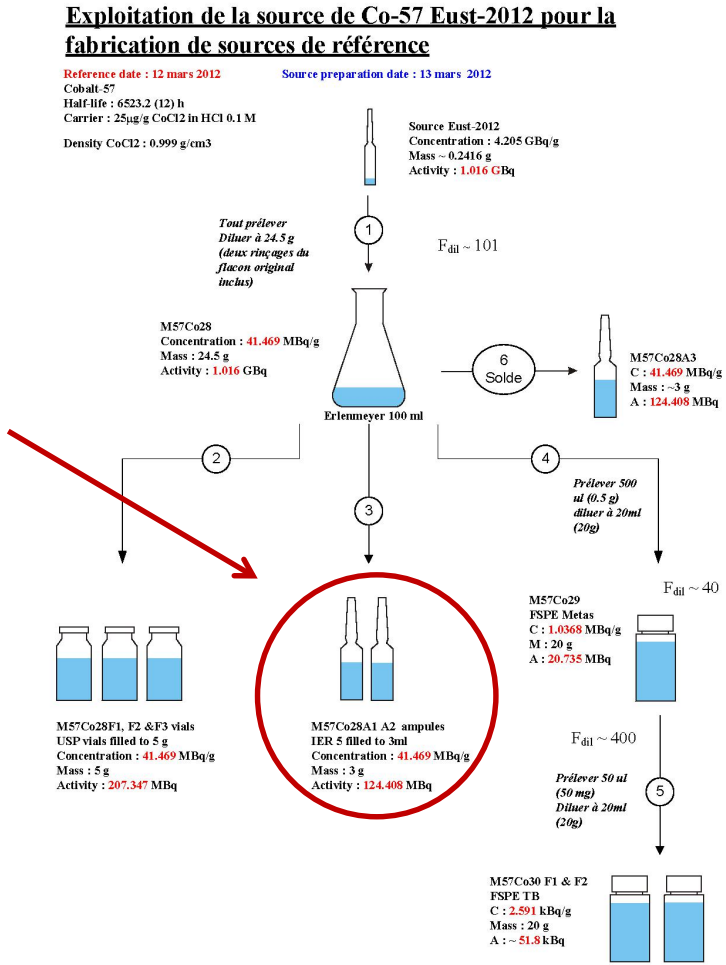


Exploitation de la source de Co-57 Eust-2012 pour la fabrication de sources de référence

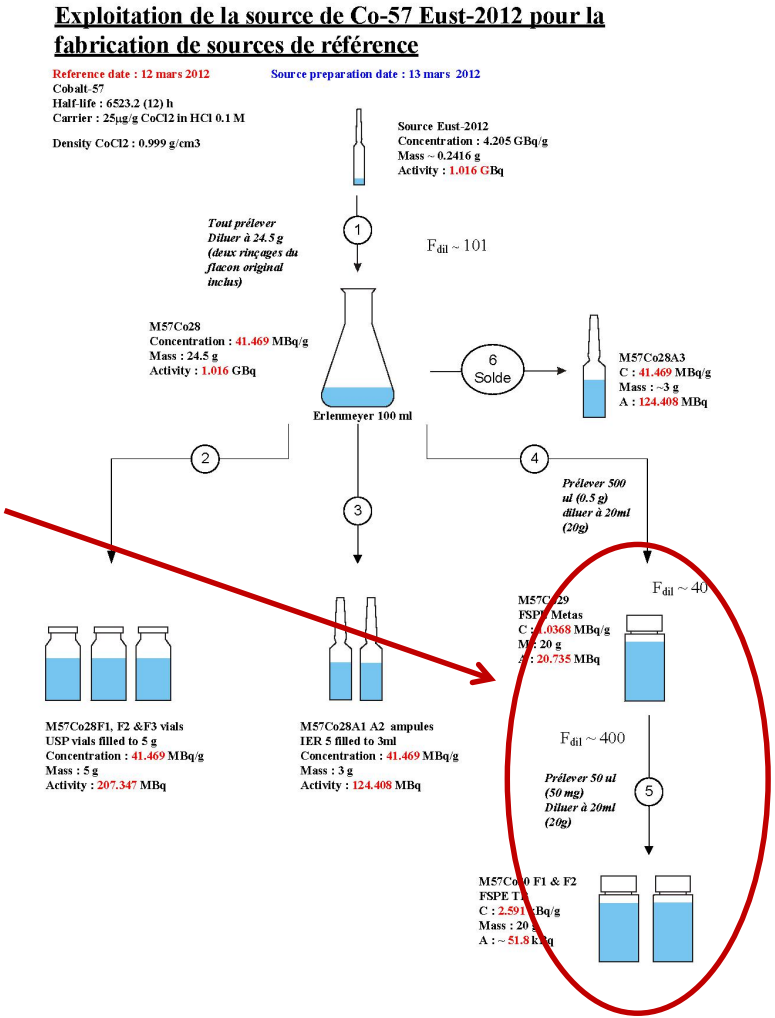
Taking 3 x 5 g with syringe to produce 3 vials (endproduct)



Taking 2 x 3 g with syringe to produce 2 ampoules for CIR measurement
→ check of dilution factor



Taking 0.5 g with pipette and complete at 20 g with carrier to perform gamma spectrometry
→ Check for impurities



Glassware preparation

- *Treated with deconnex (detergent) during 24h*
- *Rinsed and bathed with distilled water during 24h*
- *Rinsed and bathed with carrier during 24h*
- *Rinse and streamed during 8h*
- *Each container is referred and covered with parafilm*

Preparation of accessories

- *2 syringes 1ml, 1 syringe 5ml, 1 syringe 10 ml; 100 ml of carrier; 2 pipettes 500ml et 50ml + laboratory material, shielding and contamination monitor.*
- *Each syringe is refered*

Weighing room is climatised 24 h before use

At each dilution step the containers are weighed to know the mass content and to estimate the waste (leftovers in containers, syringes ...)

The weighing values are automatically saved in an Excel file and recorded by hands

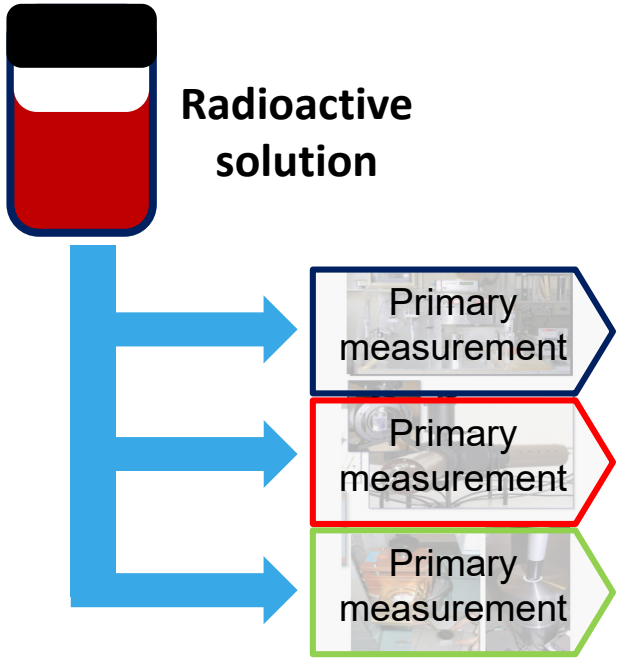
The continuous mass recording is essential to know precisely the mass of the solution of each container

The final uncertainty on mass is < 0.01%

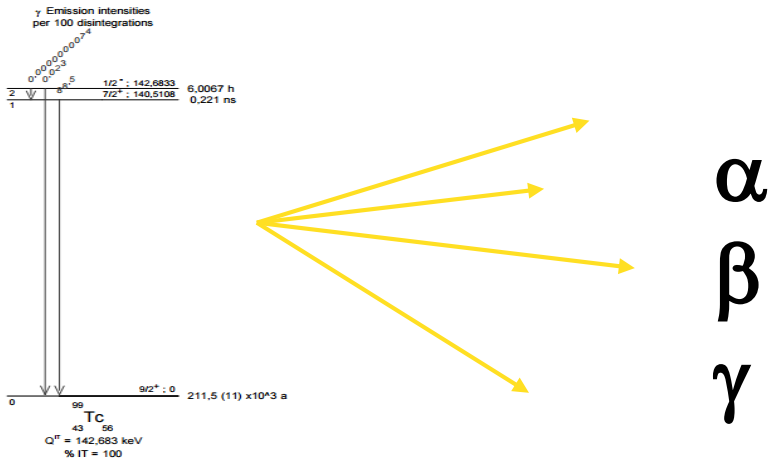
But how do we make/get the mother/master solution?

→ Magic of the realization of the unit Bq

Realization

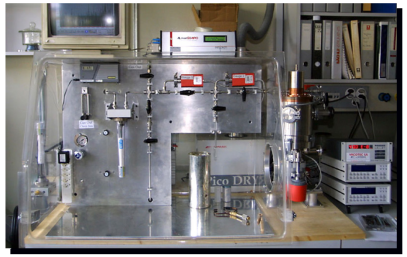


The measurement technique depends on the radionuclide (its decay scheme).

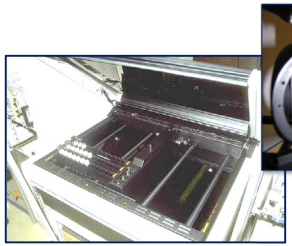


Standardization → activity concentration [Bq/g] and associated uncertainty

Defined solid angle alpha counting (Rn-222)



LSC (F-18, Y-90, beta), Triple to Double Coincidence Ratio (TDCR) (H-3, C-14, Ni-63, Fe-55…)



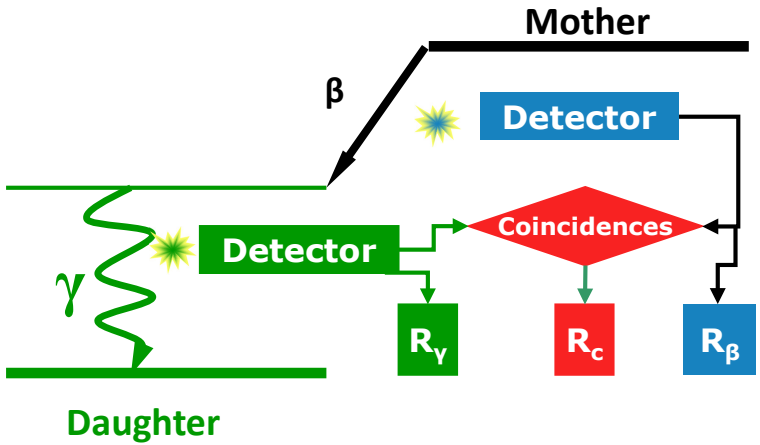
4πγ-counting (F-18, I-123, Tc-99m)

Coincidence counting:

- 4πβ-4πγ-counting (F-18, Cs-134, Ba-133,…)
- 4πβγ-counting (Co-57, I-123, I-125, I-131, Tc-99m)

β-γ coincidence counting

For a radionuclide which emits a beta (β) followed by a gamma (γ) particle, one can write :



$$R_\beta = R_0 \times \varepsilon_\beta$$

$$R_\gamma = R_0 \times \varepsilon_\gamma$$

$$R_c = R_0 \times \varepsilon_\beta \times \varepsilon_\gamma$$

$$\Rightarrow \quad R_0 = \frac{R_\beta R_\gamma}{R_c}$$

Realization → Conservation

Radioactive solution

Primary measurement

Primary measurement

Primary measurement

$C_{A,\,mes}$

$C_{A,\,mes} \leftrightarrow A_e$

Realization → Conservation

Radioactive solution

Primary measurement

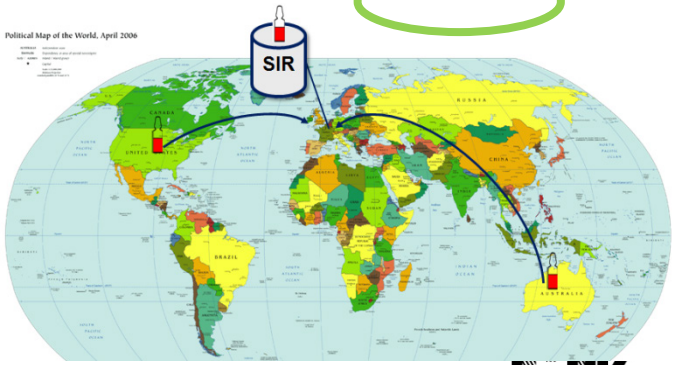
Primary measurement

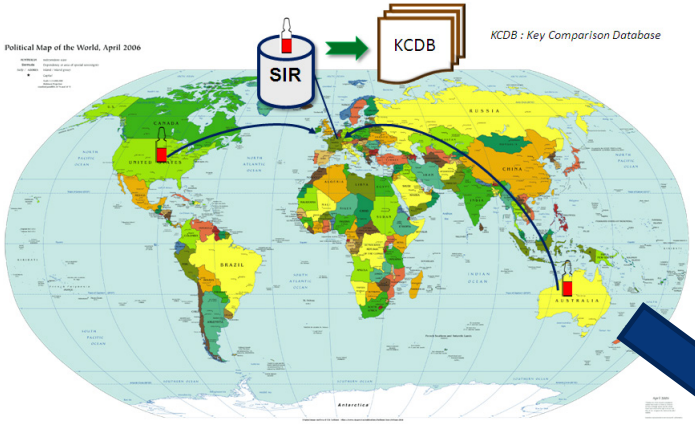
Primary measurement

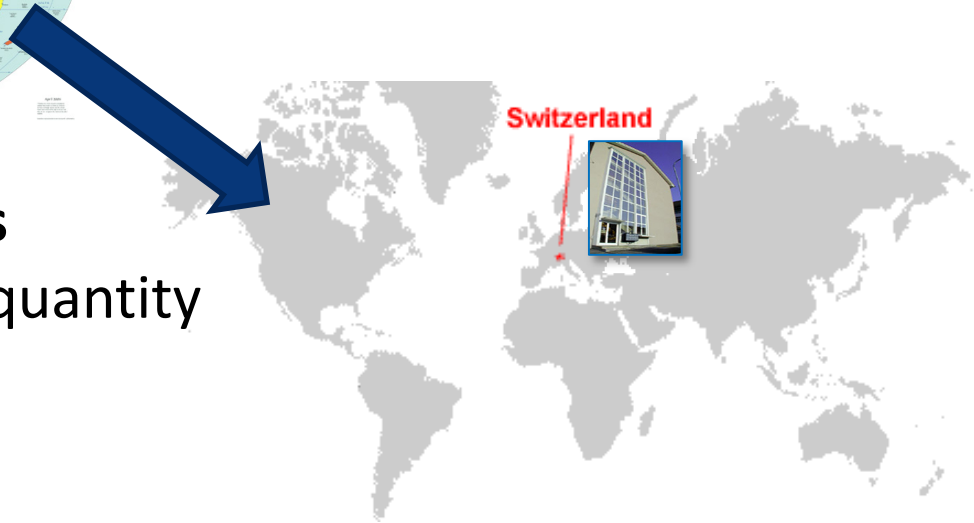
$C_{A,\,mes}$

$C_{A,\,mes} \leftrightarrow A_e$

SIR







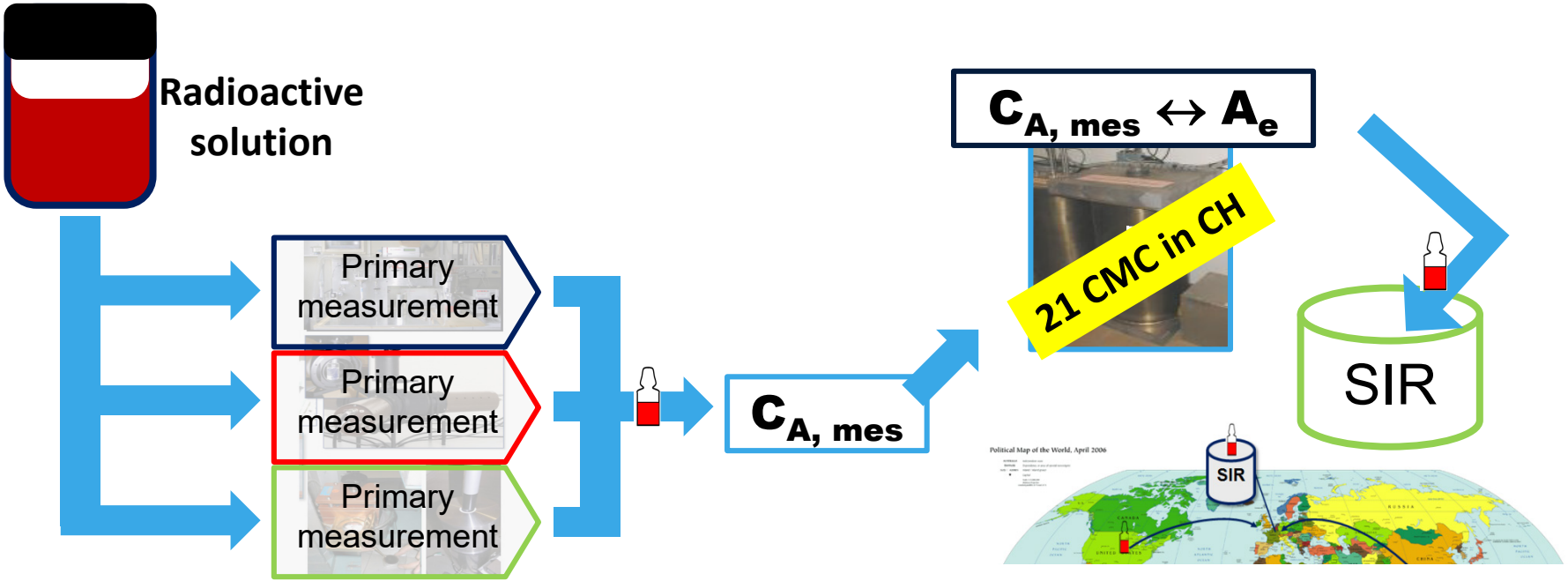
Primary laboratory missions

- Realization of the physical quantity

- Conservation

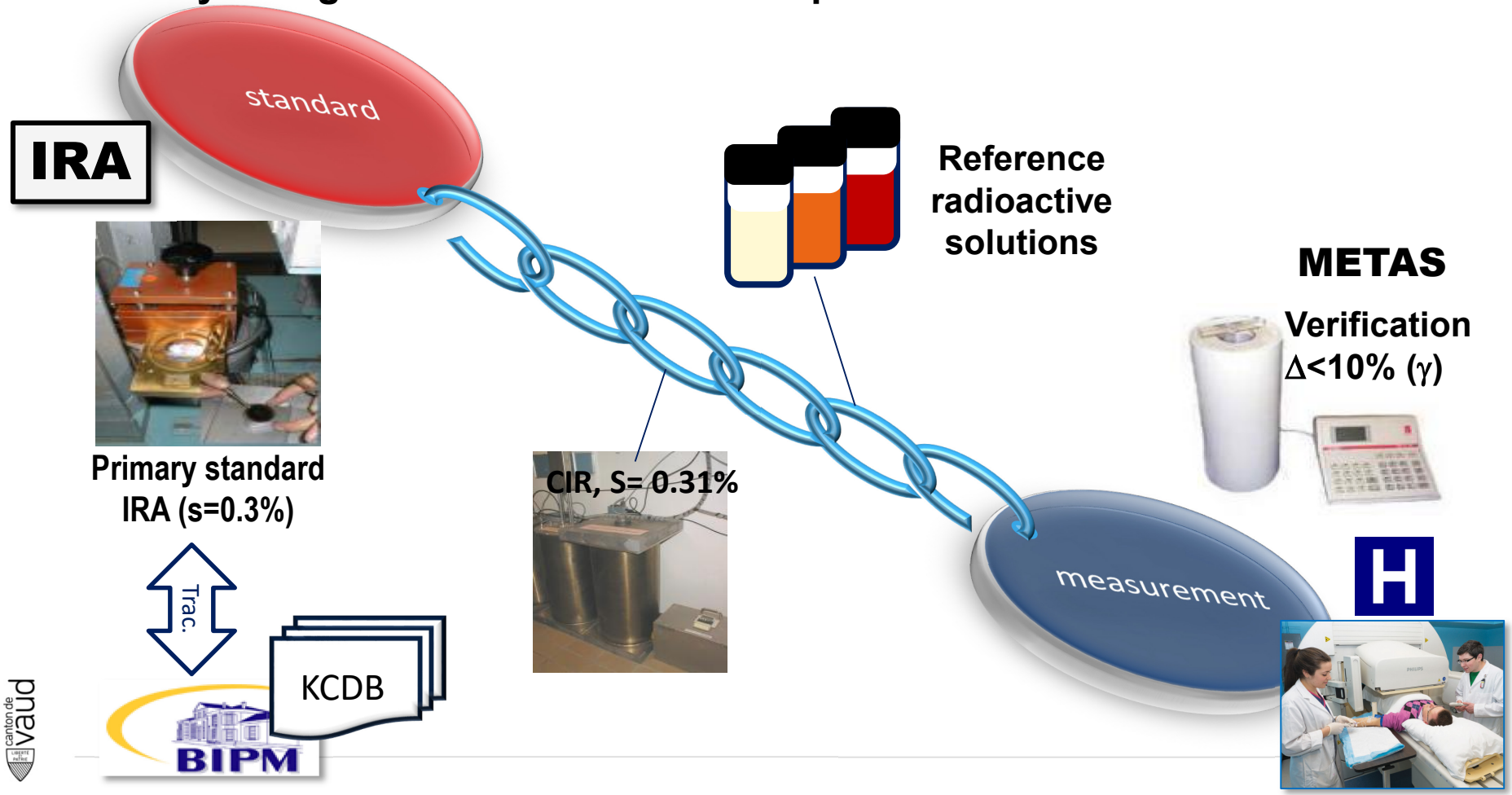
- Dissemination

Realization → Conservation

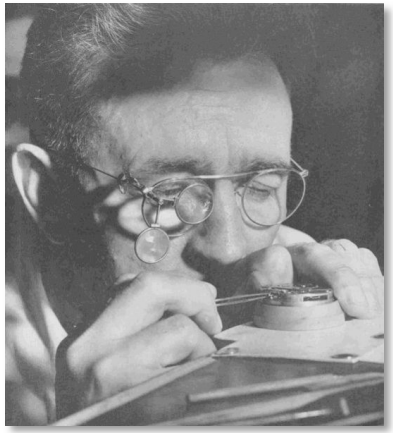


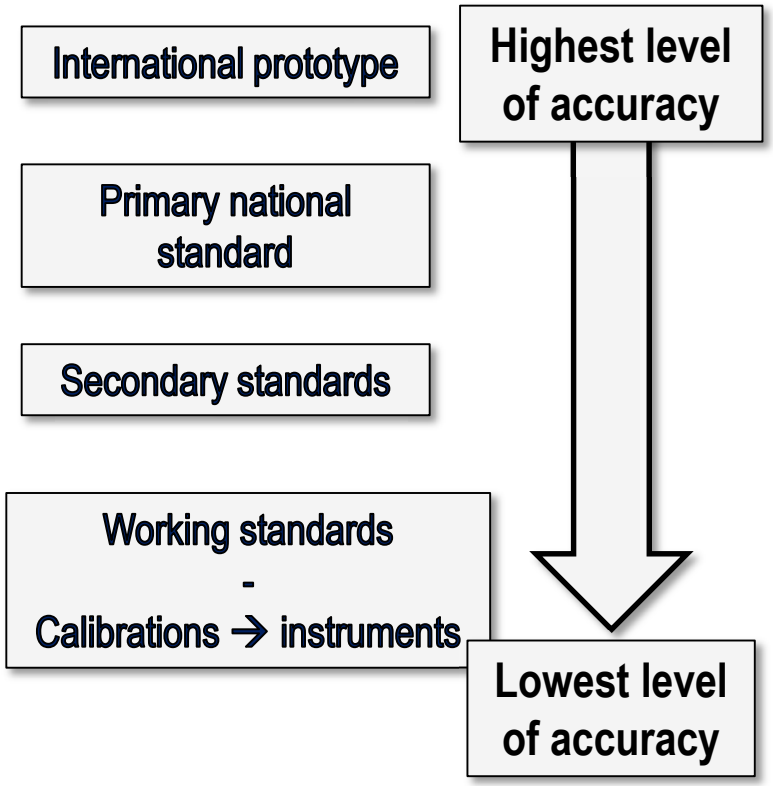
Up to now, **30** international comparisons of radionuclides, of which 17 are now CCRI(II) key comparisons → this is it for now!

Traceability brought to clinical site → Example of radionuclide calibrators

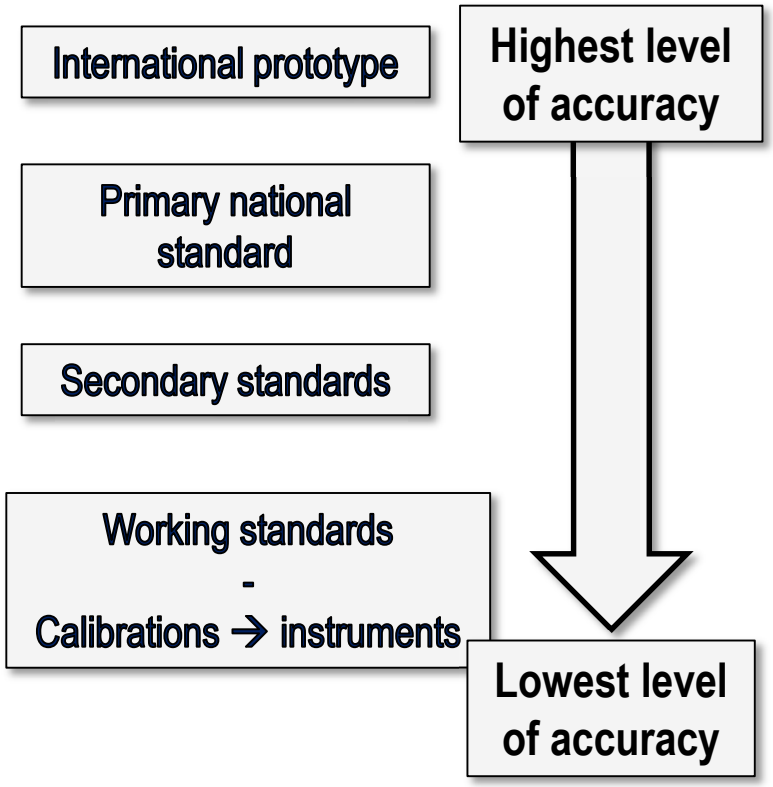


Building a chain of traceability





Building a chain of traceability



Must take into account:

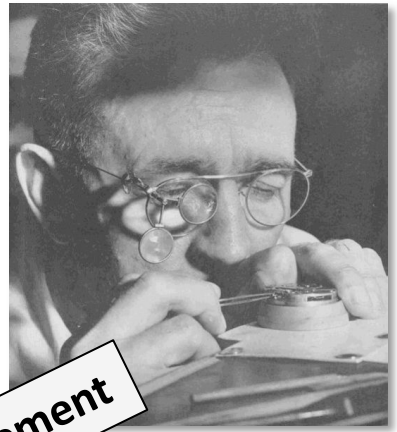
goal,

technical limitations,

financial limitations,

....

Building a chain of traceability



International prototype

Primary national standard

Secondary standards

Working standards
-
Calibrations → instruments

Highest level of accuracy

Lowest level of accuracy

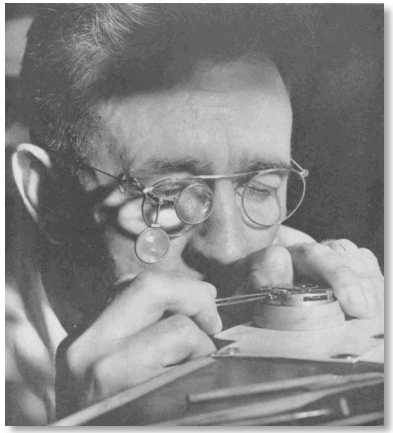
Minimal clinical requirement

u ~ 5 %

Radionuclide calibrators, Injectors, ..

HOSPITALS

Building a chain of traceability



International prototype

Primary national standard

Secondary standards

Working standards
-
Calibrations → instruments

Highest level of accuracy

Lowest level of accuracy

u ~ 0.5 %

u ~ 1 %

u ~ 5 %

SIR

IRA

METAS

Radionuclide calibrators, Injectors, ..

HOSPITALS

Merci de votre attention

Danke für Ihre Aufmersamkeit

Thanks you……

canton de vaud