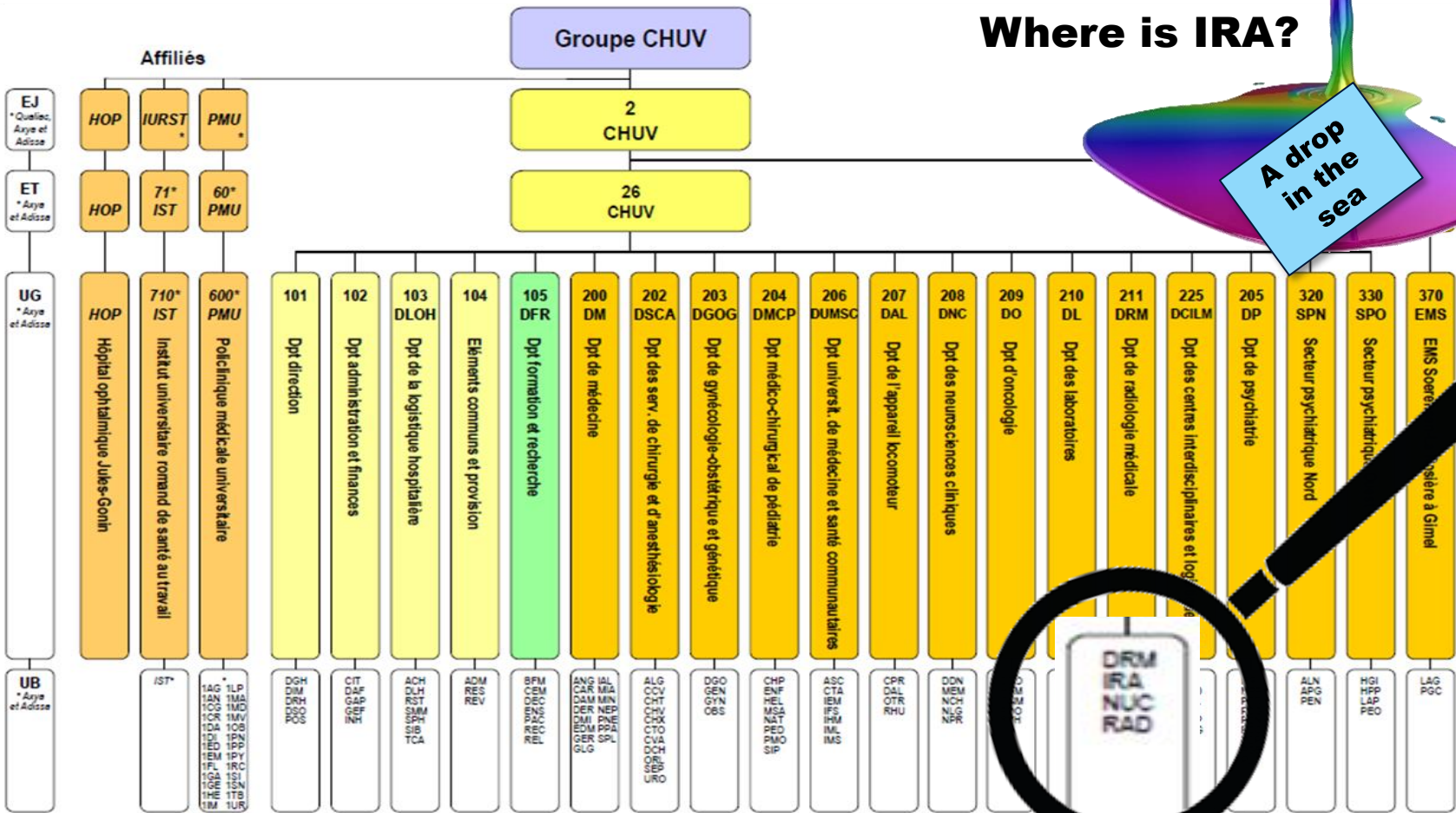
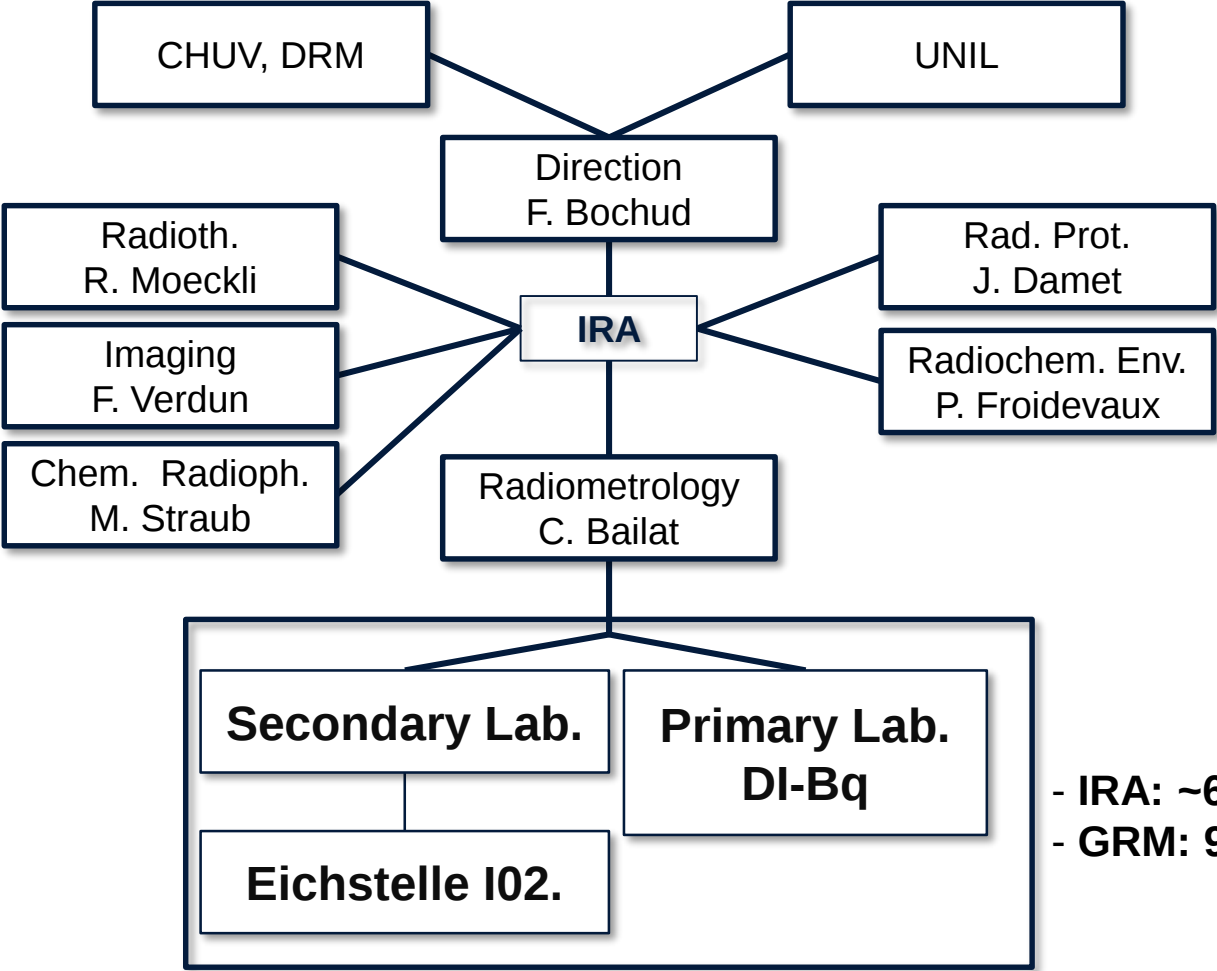


Institute of radiation physics

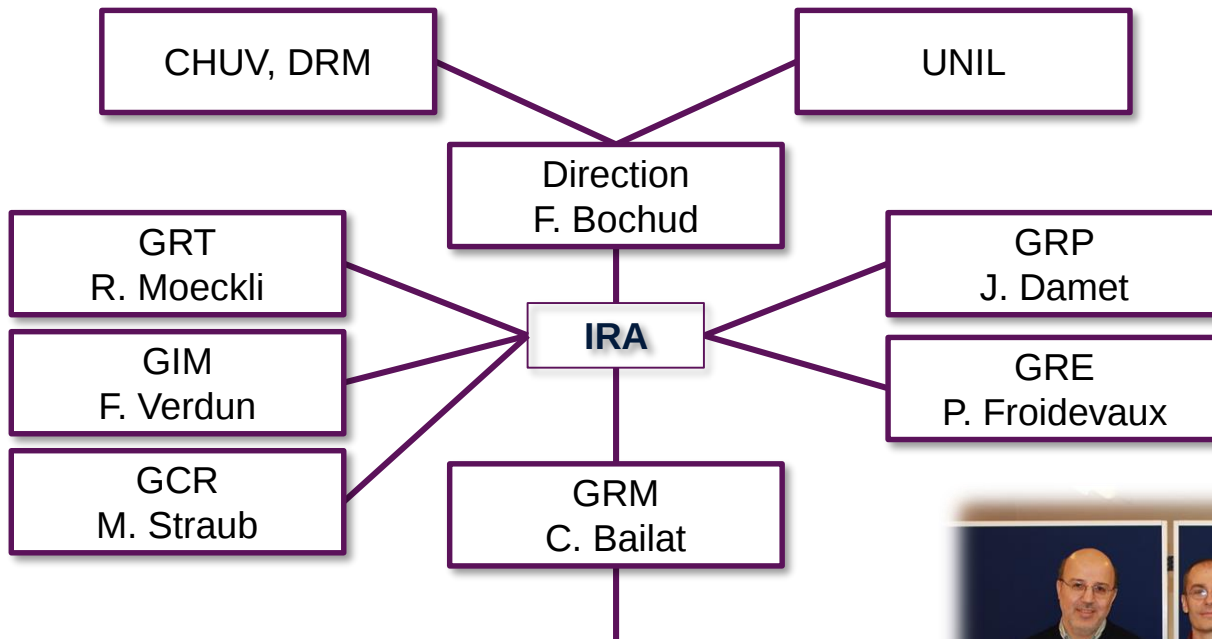
How do you produce reference solutions?

Where is IRA?





- IRA: ~60 Collaborators
- GRM: 9-10 Collaborators



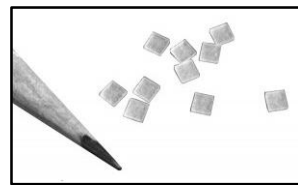
Frédéric Juget, Youcef Nedjadi, Teresa Duran

Thierry Buchillier, Corinne Moratal, Sandrine Zufferey, Patrik Jorge

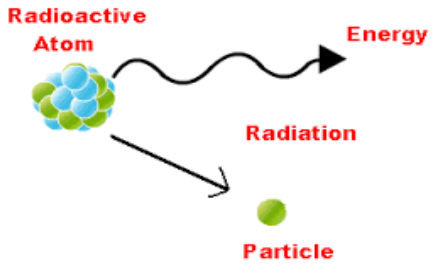
Damien Bühlmann, Manuel Santos



Radiometrology



Bq **Gy** **Sv**



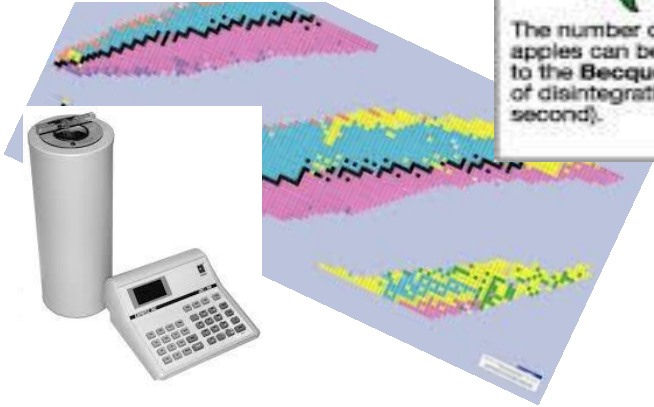
Units of measure for radioactivity

The number of falling apples can be compared to the **Becquerel** (number of disintegrations per second).

The number of apples that hit the sleeper can be compared to the **Gray** (absorbed dose).

The effect on the body, based on the size or weight of the apples, can be compared to the **Sievert** (effective dose).

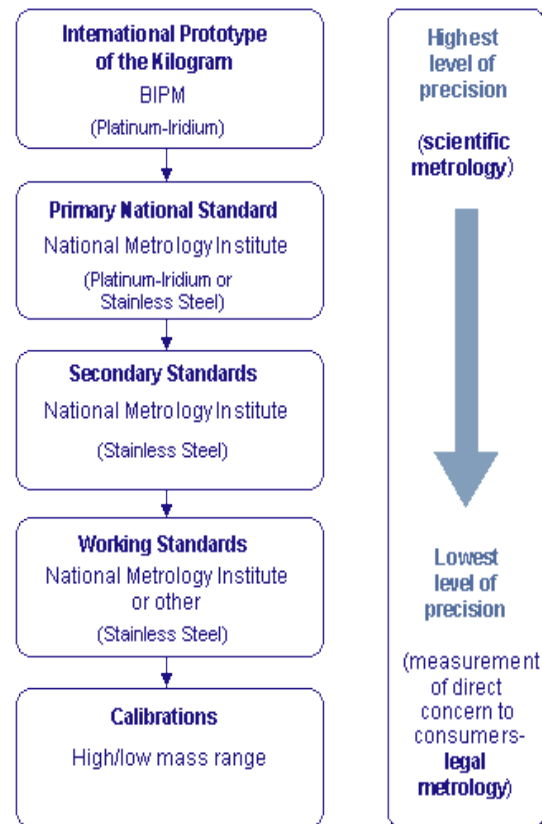
Source : C.E.A.



METROLOGY

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

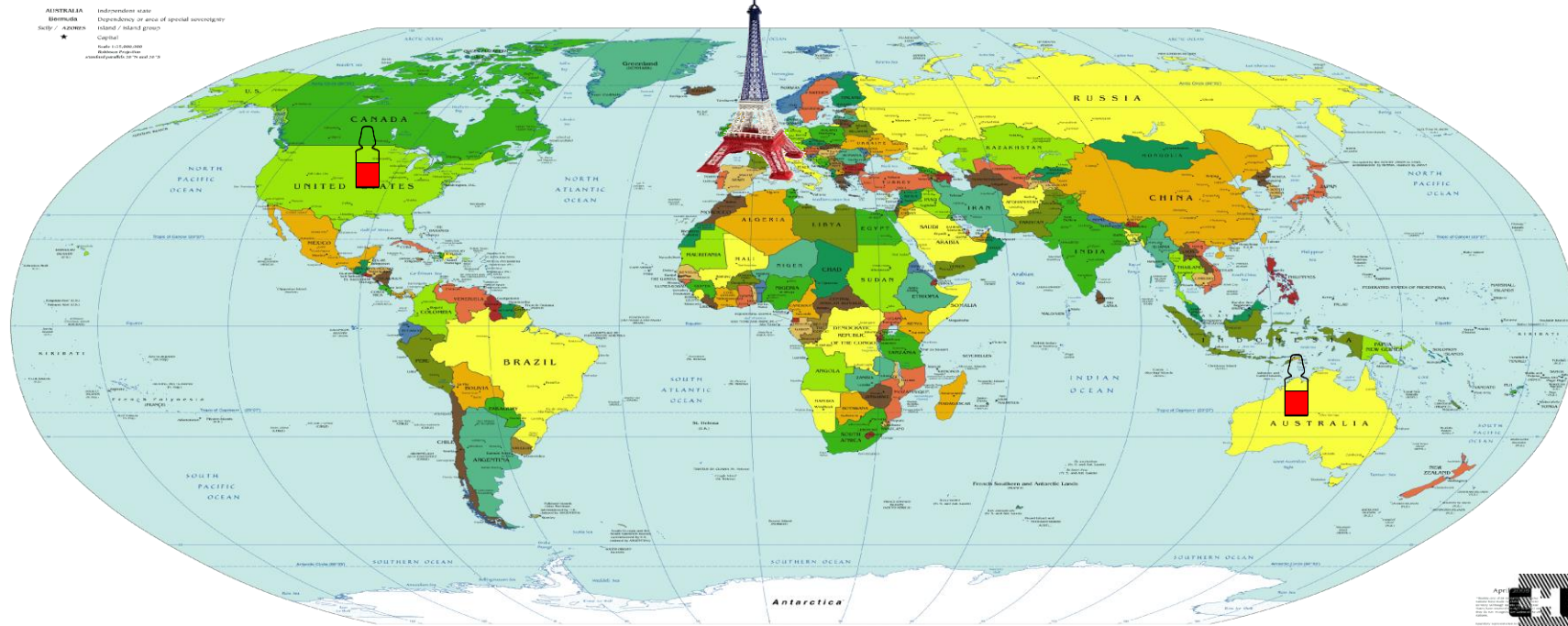
Calibration to a traceable standard can be used to determine an instrument's bias, or accuracy.



SIR: *Système International de Référence*

The gamma-ray emitters are sent to the BIPM where they are compared using pressurized ionization chambers.

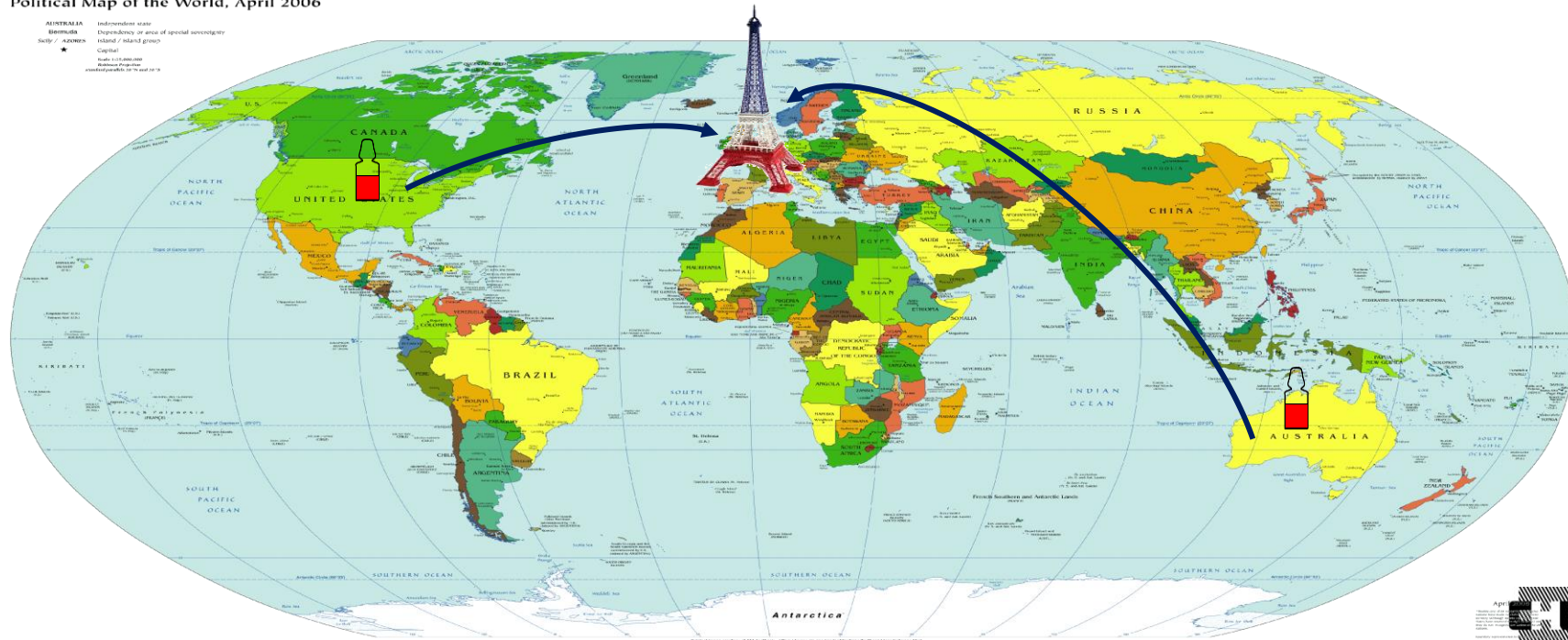
Political Map of the World, April 2006



SIR: Système International de Référence

The gamma-ray emitters are sent to the BIPM where they are compared using pressurized ionization chambers.

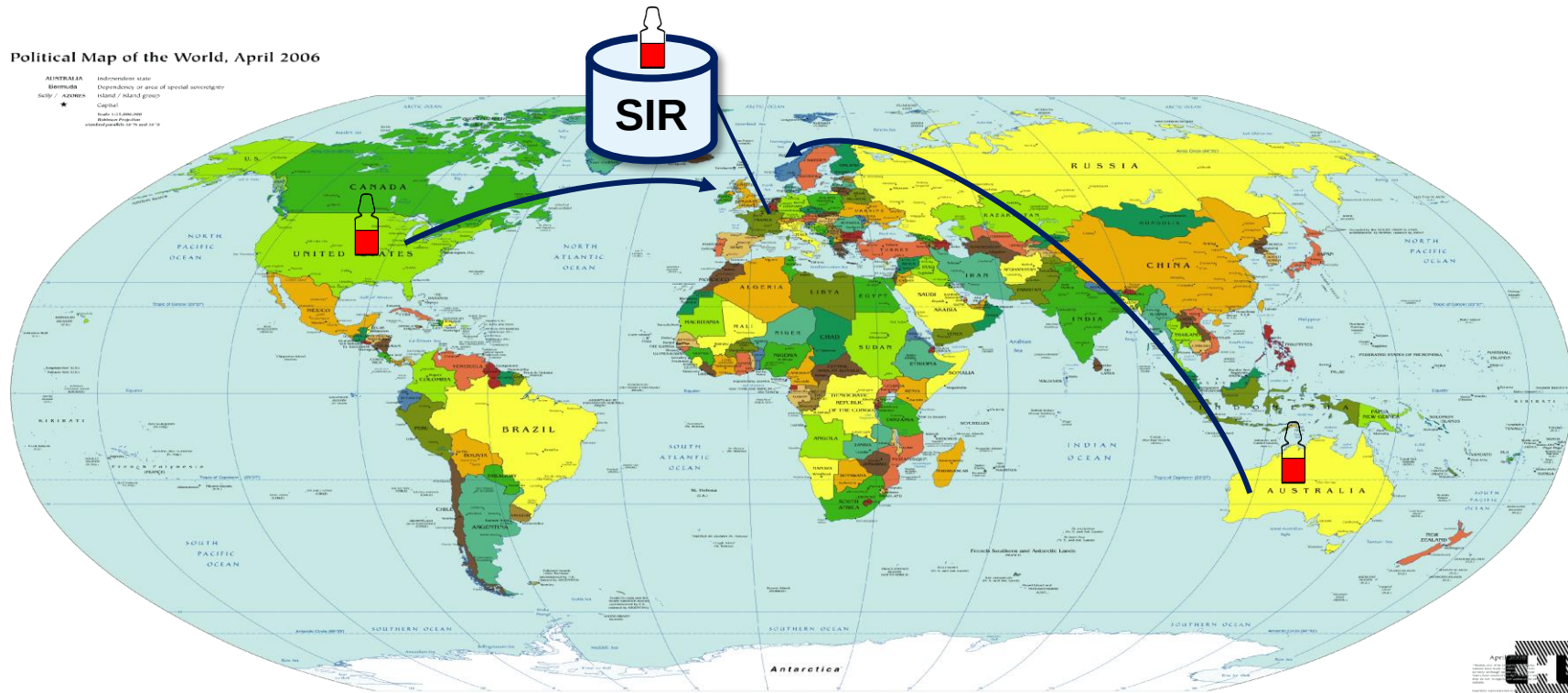
Political Map of the World, April 2006



SIR: Système International de Référence

The gamma-ray emitters are sent to the BIPM where they are compared using pressurized ionization chambers.

Political Map of the World, April 2006



SIR: Système International de Référence

The gamma-ray emitters are sent to the BIPM where they are compared using pressurized ionization chambers.

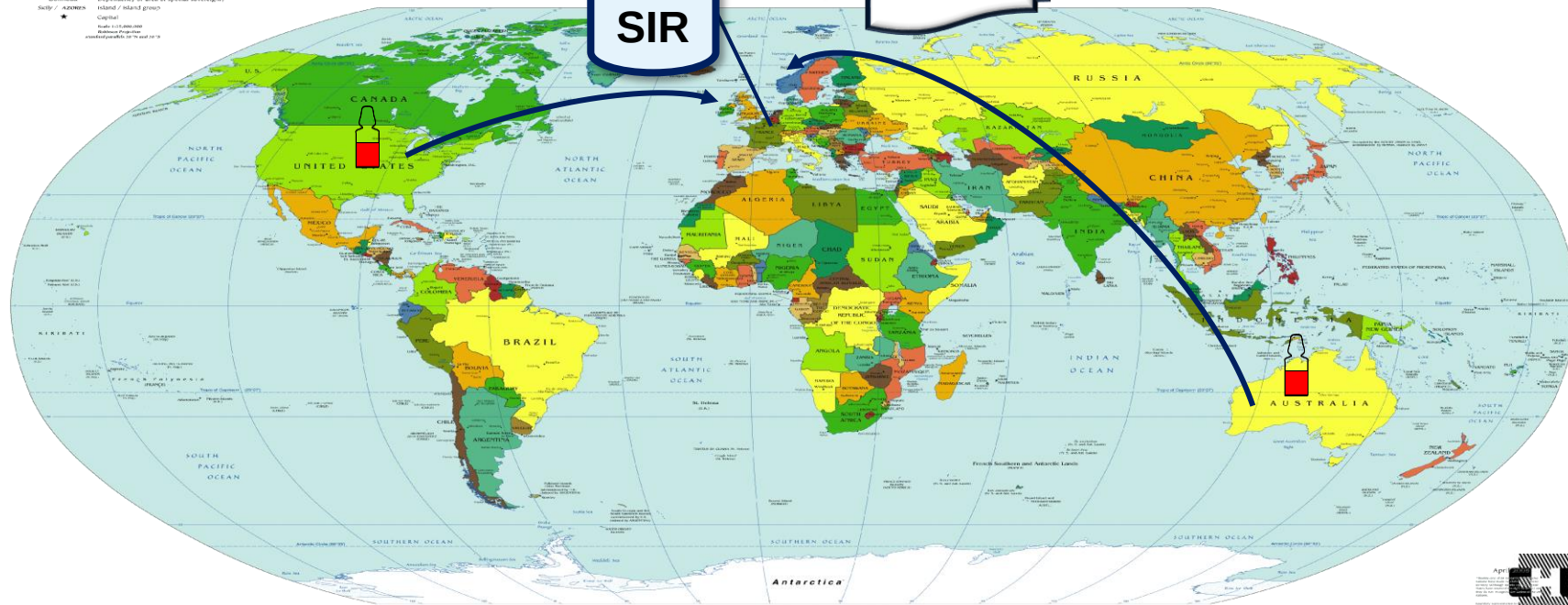
Political Map of the World, April 2006

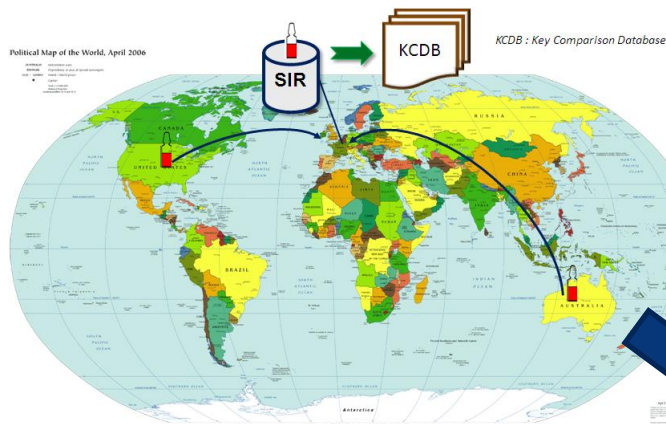
AUSTRALIA
independent state
EUROPE
Dependency or area of special sovereignty
SOLY / AZORES
Capital
Main cities (pop. 100,000)
Population (millions)
Standardized population (10% and 100%)



KCDB

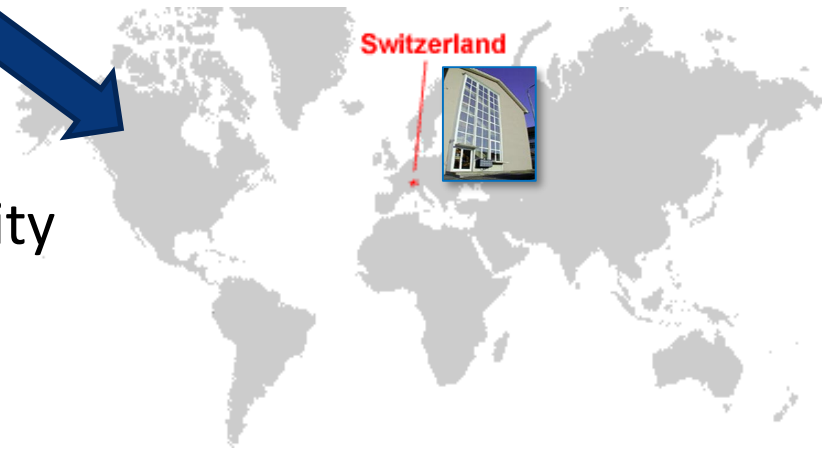
KCDB : Key Comparison Database



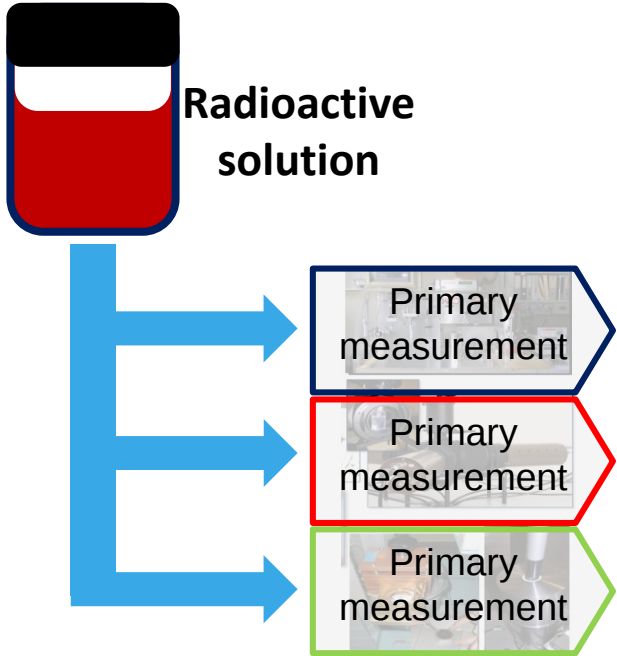


Primary laboratory missions

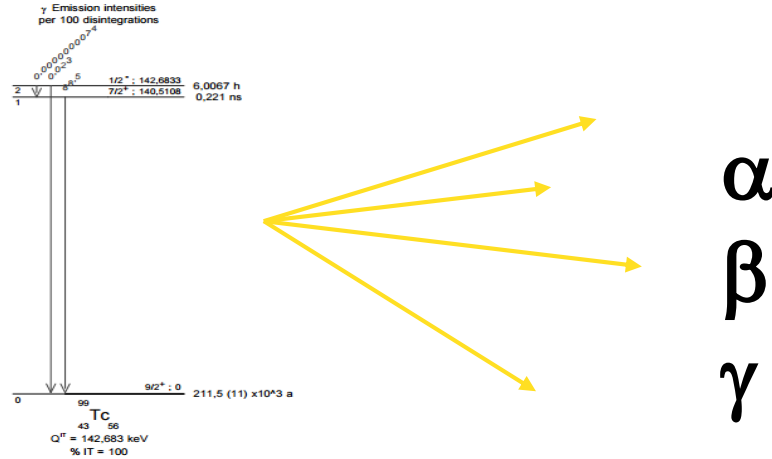
- Realization of the physical quantity
- Conservation
- Dissemination



Realization



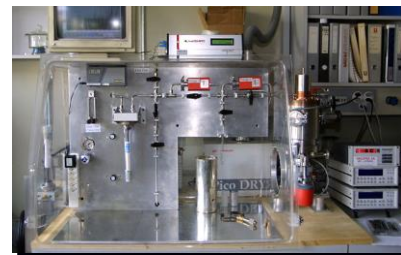
The measurement technique depends on the radionuclide (its decay scheme).



Standardization $\rightarrow$ activity concentration [Bq/g] and associated uncertainty

Defined solid angle alpha counting

Rn-222



LSC

F-18, Y-90, H-3, C-14, Ni-63, Mn-54, Ra-223,
Fe-55



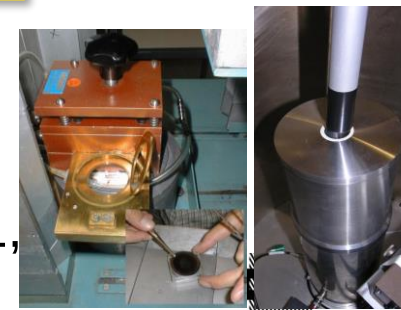
$4\pi\gamma$ -counting

F-18, I-123, Ho-166m, Tc-99m, Eu-152



Coincidence counting

F-18, Cs-134, Ba-133, Ho-166m, Co-57, I-123, I-125, I-131,
Tc-99m, Mn-54, Ho-166m, Cs-134, Eu-152



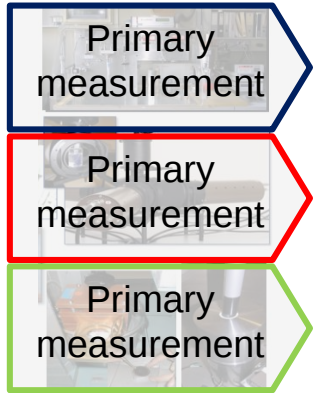
Realization



Conservation



Radioactive
solution



$C_{A, \text{mes}}$

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



Realization



Conservation



Radioactive
solution

Primary
measurement

Primary
measurement

Primary
measurement



$C_{A, \text{mes}}$

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



SIR

Political Map of the World, April 2006



Realization



Conservation



Radioactive
solution

Primary
measurement

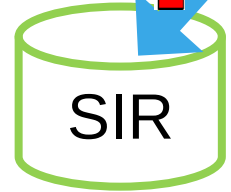
Primary
measurement

Primary
measurement



$C_{A, \text{mes}}$

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



Political Map of the World, April 2006



Up to now, **30** international comparisons of radionuclides, of which 17 are now CCRI(II) key comparisons → **CMC**

Realization



Conservation



Radioactive



A CMC is a calibration and measurement capability available to customers under normal conditions:

(a) as published in the BIPM key comparison database (KCDB) of the CIPM MRA; or

(b) as described in the laboratory's scope of accreditation granted by a signatory to the ILAC Arrangement. "

Up to now, **30** international comparisons of radionuclides, of which 17 are now CCRI(II) key comparisons → **CMC**

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		NMI Internal Service Identifier	Comments
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum value	Maximum value	Units	Parameter	Specifications	Value	Units	Coverage factor	Level of Confidence	Is the expanded uncertainty a relative one?	Reference standard	Source of traceability		

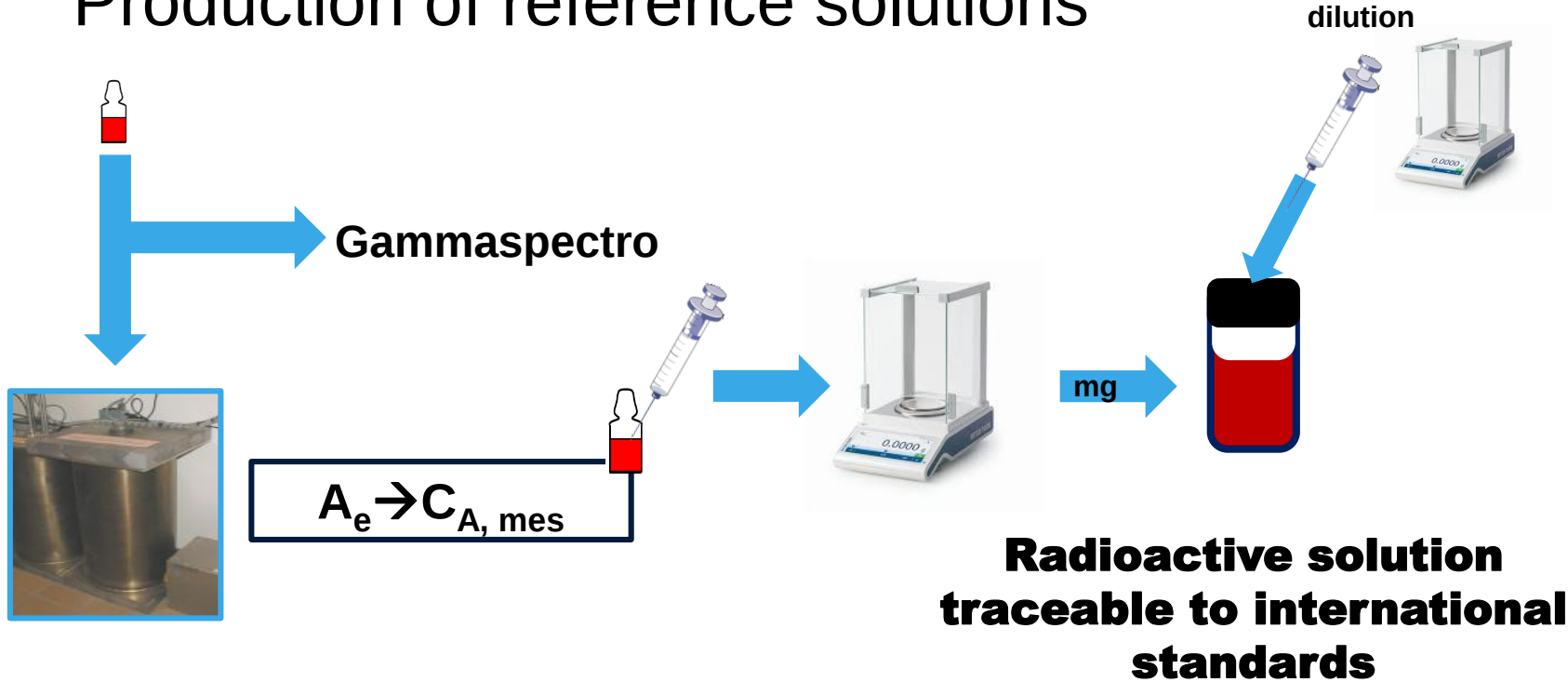
RADIOACTIVITY

Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	2.00E+04	1.50E+07	Bq g ⁻¹	F-18	no further specifications	0.8	%	2	~95%	Yes	4 π NaI counting, LS counting (efficiency tracing), standard weighting set	IRAMETAS	EUR-RAD-IRA-2001	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	1.00E+04	7.00E+06	Bq g ⁻¹	Na-22	no further specifications	0.8	%	2	~95%	Yes	4 π γ coincidence counting, standard weighting set	BIPMMETAS	EUR-RAD-IRA-2002	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	3.00E+04	2.00E+07	Bq g ⁻¹	Mn-54	no further specifications	0.3	%	2	~95%	Yes	4 π (PC) γ coincidence counting, 4 π NaI counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2003	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	1.00E+05	6.00E+07	Bq g ⁻¹	Co-57	no further specifications	0.7	%	2	~95%	Yes	4 π (PC) coincidence counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2004	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	1.00E+04	7.00E+06	Bq g ⁻¹	Co-60	no further specifications	0.3	%	2	~95%	Yes	4 π γ coincidence counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2005	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	4.00E+04	3.00E+07	Bq g ⁻¹	Se-75	no further specifications	1	%	2	~95%	Yes	4 π (PC) γ coincidence counting, 4 π NaI counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2006	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	1.00E+04	7.00E+06	Bq g ⁻¹	Y-88	no further specifications	0.9	%	2	~95%	Yes	4 π (PC) coincidence counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2007	

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		NMI Internal Service Identifier	Comments
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum value	Maximum value	Units	Parameter	Specifications	Value	Units	Coverage factor	Level of Confidence	Is the expanded uncertainty a relative one?	Reference standard	Source of traceability		
Activity per unit mass	Single nuclide solution	LS spectrometer, balance	5.00E+02	5.00E+05	Bq g ⁻¹	Sr-90/Y-90	no further specifications	1	%	2	~95%	Yes	LS counting (efficiency tracing), standard weighting set	IRAMETAS	EUR-RAD IRA-2008	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	1.00E+05	7.00E+07	Bq g ⁻¹	Tc-99m	no further specifications	1.4	%	2	~95%	Yes	4 π (PC) γ coincidence counting, 4 π NaI counting, standard weighting set	IRAMETAS	EUR-RAD IRA-2009	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	3.00E+06	1.60E+08	Bq g ⁻¹	Cd-109	no further specifications	1.3	%	2	~95%	Yes	4 π (PC) γ coincidence counting, standard weighting set	IRAMETAS	EUR-RAD IRA-2010	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	1.00E+05	7.00E+07	Bq g ⁻¹	I-123	no further specifications	1.1	%	2	~95%	Yes	4 π (PC) γ coincidence counting, 4 π NaI counting, standard weighting set	IRAMETAS	EUR-RAD IRA-2011	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	1.00E+07	8.00E+09	Bq g ⁻¹	I-125	no further specifications	1.8	%	2	~95%	Yes	X- γ coincidence counting, standard weighting set	IRAMETAS	EUR-RAD IRA-2012	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	6.00E+04	4.00E+07	Bq g ⁻¹	I-131	no further specifications	1	%	2	~95%	Yes	4 π (β γ) coincidence counting, standard weighting set	IRAMETAS	EUR-RAD IRA-2013	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	5.00E+04	3.00E+07	Bq g ⁻¹	Ba-133	no further specifications	0.6	%	2	~95%	Yes	4 π (PC) γ coincidence counting, standard weighting set	IRAMETAS	EUR-RAD IRA-2014	

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		NMI Internal Service Identifier	Comments
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum value	Maximum value	Units	Parameter	Specifications	Value	Units	Coverage factor	Level of Confidence	Is the expanded uncertainty a relative one?	Reference standard	Source of traceability		
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	1.50E+04	1.00E+07	Bq g ⁻¹	Cs-134	no further specifications	1	%	2	~95%	Yes	4 π $\beta\gamma$ coincidence counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2015	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	4.00E+04	3.00E+07	Bq g ⁻¹	Cs-137	no further specifications	0.4	%	2	~95%	Yes	4 π $\beta\gamma$ efficiency tracing, standard weighting set	IRAMETAS	EUR-RAD-IRA-2016	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	1.00E+05	7.00E+07	Bq g ⁻¹	Ce-139	no further specifications	0.6	%	2	~95%	Yes	4 π (PC) γ coincidence counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2017	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	2.00E+04	1.30E+07	Bq g ⁻¹	Eu-152	no further specifications	0.6	%	2	~95%	Yes	4 π (PC) γ coincidence counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2018	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	4.00E+04	2.50E+07	Bq g ⁻¹	Yb-169	no further specifications	0.5	%	2	~95%	Yes	4 π (PC) γ coincidence counting, 4 $\pi\gamma$ NaI counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2019	
Activity per unit mass	Single nuclide solution	Secondary standard ionization chamber, balance	2.50E+04	1.50E+07	Bq g ⁻¹	Ir-192	no further specifications	0.5	%	2	~95%	Yes	4 π (PC) γ coincidence counting, 4 $\pi\gamma$ NaI counting, standard weighting set	IRAMETAS	EUR-RAD-IRA-2020	
Activity per unit mass	Single nuclide solution	LS spectrometer, balance	1.00E+03	1.00E+06	Bq g ⁻¹	Tl-204	no further specifications	5.5	%	2	~95%	Yes	LS counting (CIEMAT-NIST), standard weighting set	IRAMETAS	EUR-RAD-IRA-2021	

Production of reference solutions



*(activity concentration + uncertainty +
impurities)*

Merci de votre attention

Danke für Ihre Aufmerksamkeit

Thanks you.....



Traceability brought to clinical site → Example of radionuclide calibrators



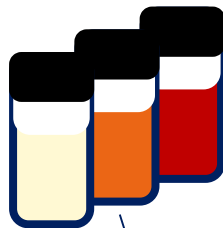
Traceability brought to clinical site → Example of radionuclide calibrators



IRA



Primary standard
IRA ($s=0.3\%$)



Reference
radioactive
solutions



CIR, $S=0.31\%$



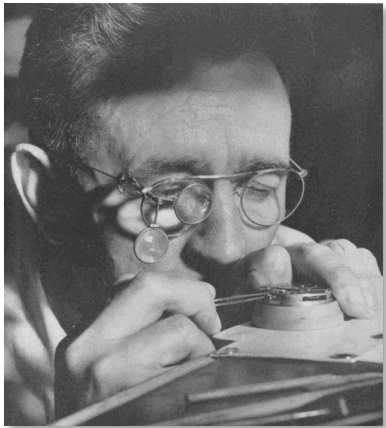
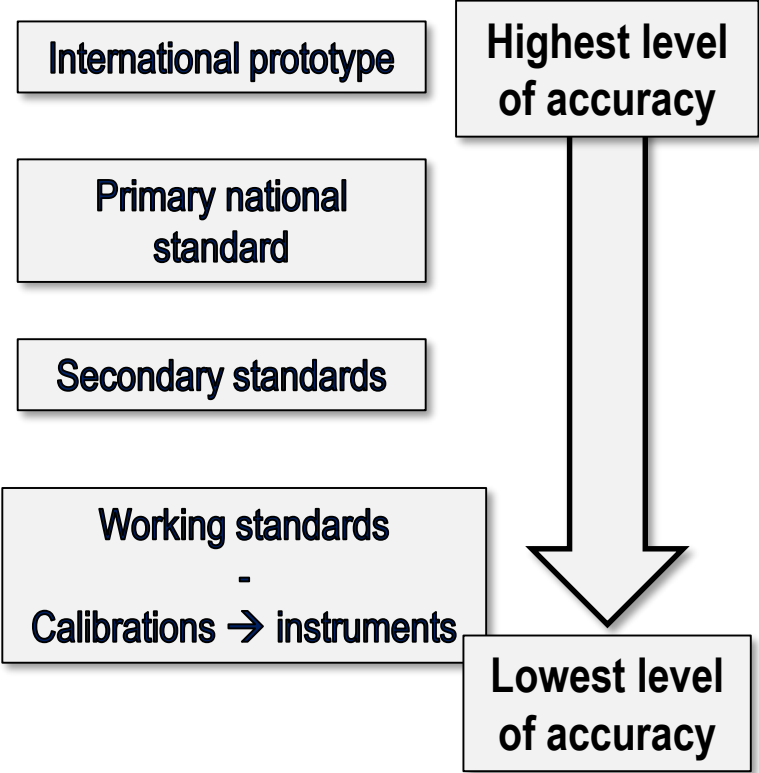
METAS
Verification
 $\Delta < 10\% (\gamma)$



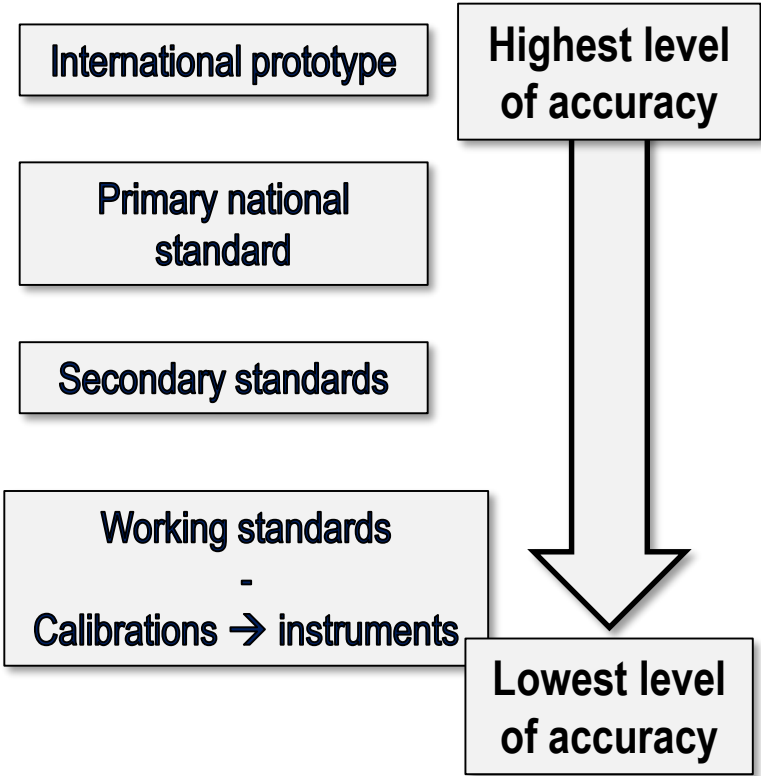
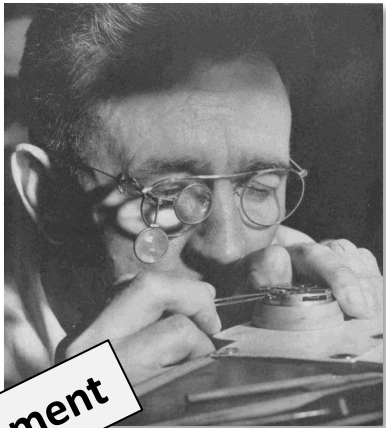
H



Building a chain of traceability



Building a chain of traceability



Minimal clinical requirement

$u \sim 5 \%$

Radionuclide
calibrators,
Injectors, ..

HOSPITALS

Building a chain of traceability

