



Radioactive Sources in Metrology: Applications and Alternative Technologies

CCRI(II) Measurement of Radionuclides

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CCRI webinar

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Science. Ingenuity. Sustainability.

The use of sources in Radionuclide Metrology

- Industries that rely on accurate and reliable radioactivity measurements
- The role of sources in development and maintenance of radionuclide standards
- International comparisons of radioactivity standards
- Dissemination of radioactivity standards

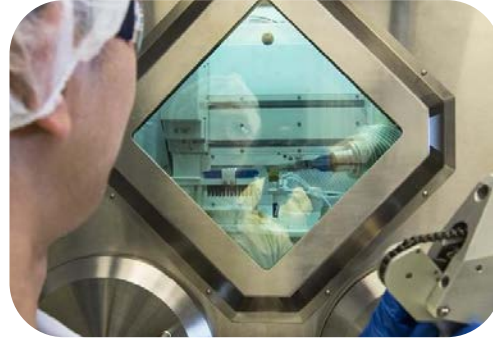
Accurate & reliable measurements to support health, trade, safety, environment



Diagnostic imaging
(PET-CT, SPECT)



Nuclear medicine
(therapy)



Radioisotope
production



Nuclear power



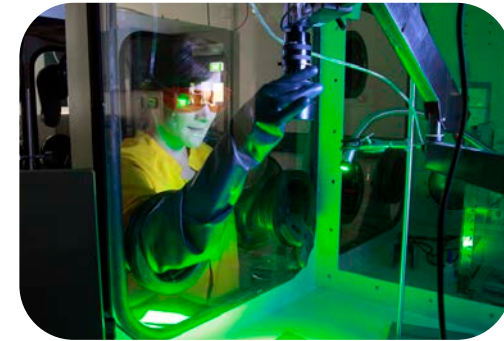
Radiation
protection



Environmental
monitoring



Nuclear
decommissioning



Nuclear forensics

The A-Z of radioactivity CMCs

Ag-110m	Be-7	Cm-242	Cu-64	Ge-68/ Ga-68	In-111	Na-22	Pu-238	Ru-103/ Rh-103m	Sr-85	Th-232	U-238
Am-241	Bi-207	Cm-243	Eu-152	H-3	In-113m	Na-24	Pu-239	Ru-106	Sr-87m	Tl-201	Xe-127
Am-243	Br-82	Cm-244	Eu-154	Hg-197	Ir-192	Nb-93m	Pu-240	S-35	Sr-89	Tl-202	Xe-131m
Ar-37	C-11	Co-56	Eu-155	Hg-203	K-40	Nb-95	Pu-241	Sb-124	Sr-90/ Y-90	Tl-204	Xe-133
Ar-41	C-14	Co-57	F-18	Ho-166m	K-42	Np-237/ Pa-233	Pu-242	Sb-125	Ta-182	Tm-170	Y-88
Au-195	Ca-47	Co-58	Fe-59	I-123	Kr-85	P-32	Ra-226	Sc-46	Tb-160	U-232	Y-90
Au-198	Cd-109	Co-60	Ga-67	I-124	Lu-177	P-33	Rb-86	Sc-47	Tc-99m	U-233	Yb-169
Au-199	Ce-139	Cr-51	Ga-68	I-125	Mn-54	Pa-233	Re-186	Se-75	Th-228	U-234	Zn-65
Ba-133	Ce-141	Cs-134	Gd-148	I-129	Mn-56	Pb-203	Re-188	Sm-153	Th-229	U-235	
Ba-140	Ce-144/ Pr-144	Cs-137	Gd-153	I-131	Mo-99/ Tc-99m	Po-210	Rn-222	Sn-113	Th-230		

Maintenance of radionuclide standards

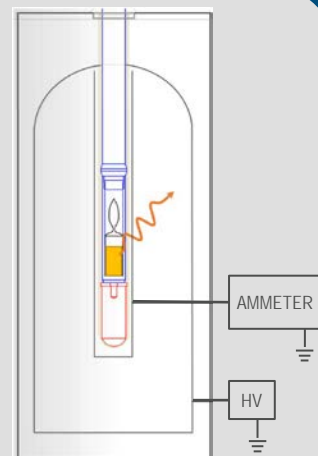
Source dispensing



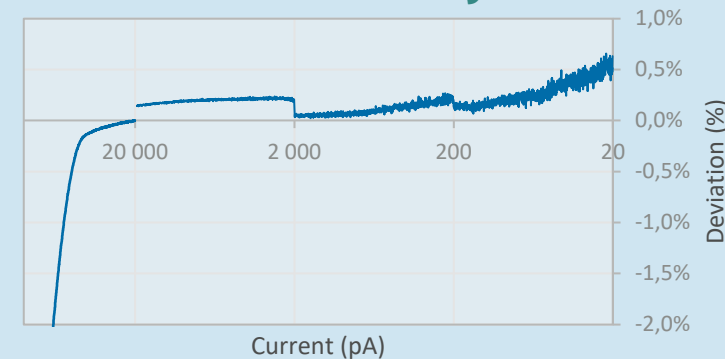
Prepare counting sources for primary standardisation, calibration of secondary equipment & for customers

Secondary standard Ionisation chamber

- Standards “saved” as radionuclide-specific calibration factors (pA/MBq)
- Accuracy, reproducibility & stability < 0.1%



Keithley 6517A electrometer with SSIC ^{99m}Tc linearity



Primary standardisation

- Source activity determined from first principles
- Independent of prior calibration of detectors
- Bq/mg



^{226}Ra sealed sources to account for



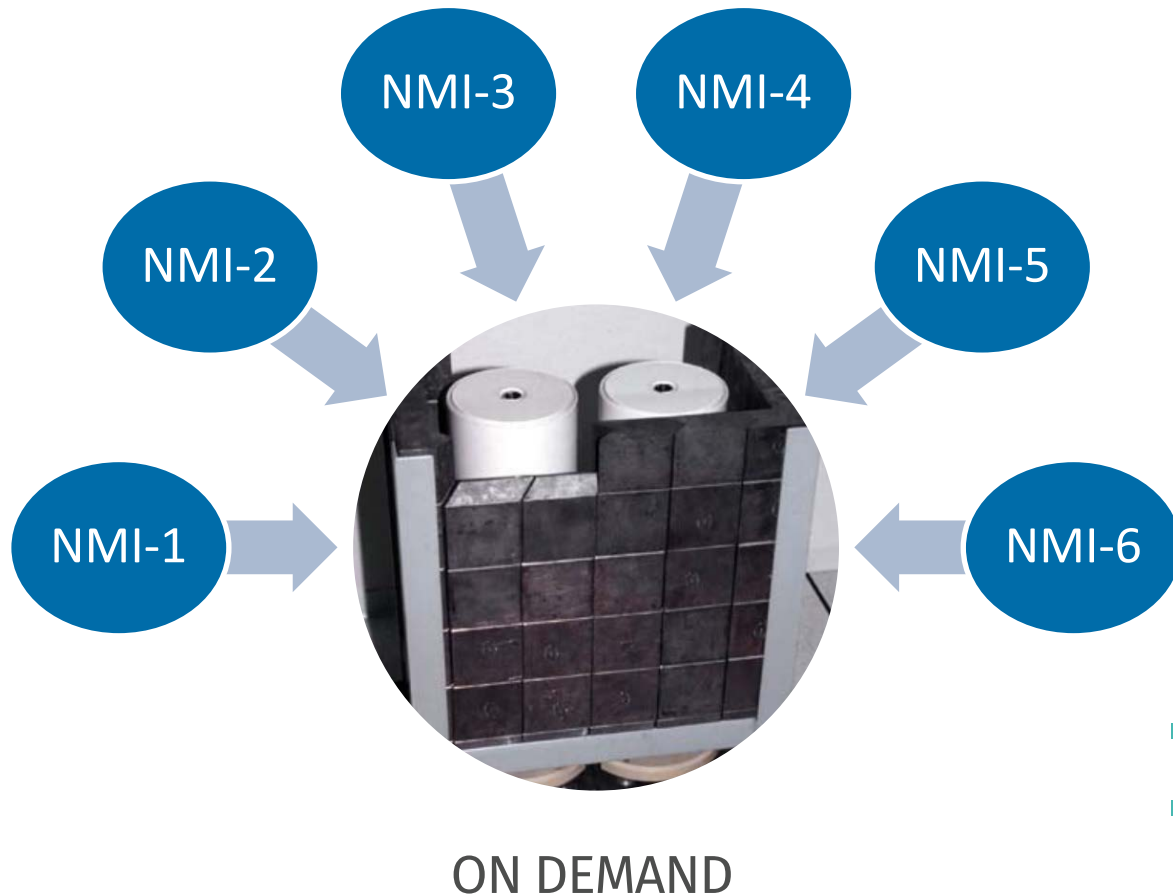
- Non-linearity between capacitor ranges
- Instability due to temperature fluctuations & gas leaks from pressurised IC, drifts in electronics

Gamma spectroscopy



- Calibrate gamma spec systems
- Identify & quantify radionuclides & impurities

International Reference System (SIR)

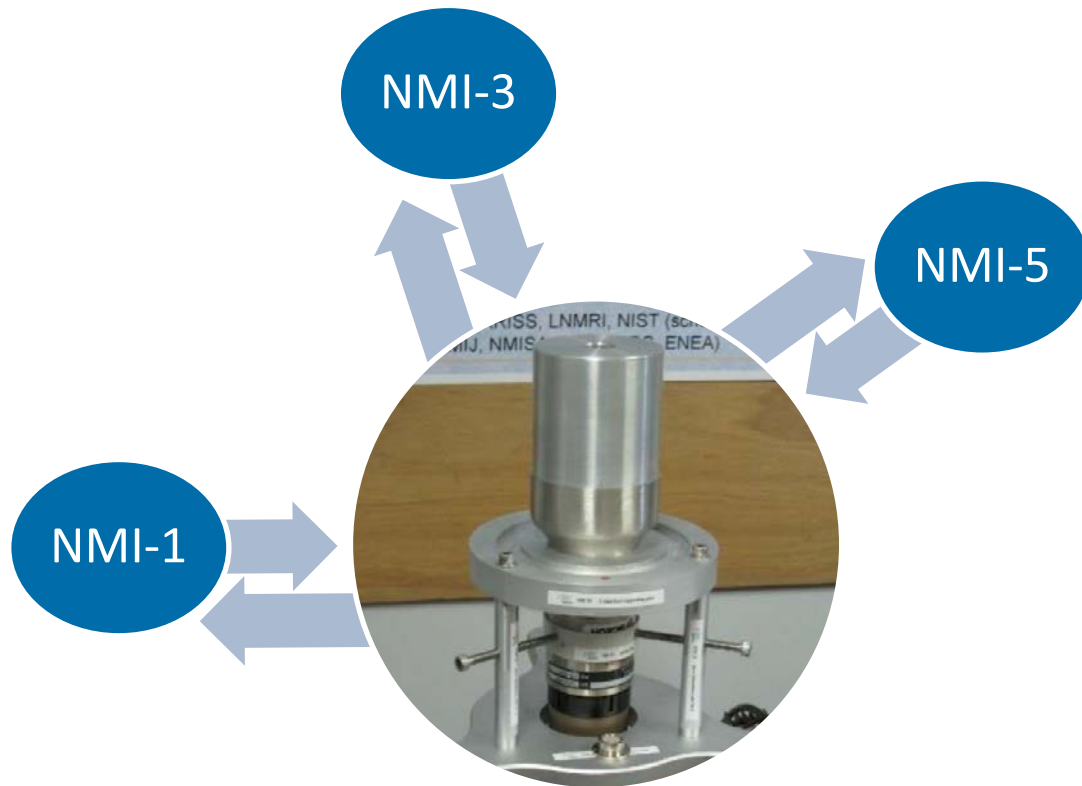


- Established by BIPM in 1976 to compare national standards of γ -emitting radionuclides
- Pressurised ionization chamber in lead shielding
- Participants send standardised ampoules to BIPM
- Current produced by ampoule compared to that produced by one of five reference ^{226}Ra sources
- SIR provided 776 independent results for 72 different radionuclides

- Operation relies on sealed ^{226}Ra reference sources
- Sources are aging and indefinite use is not allowed by the regulator

- Solutions:
- Fewer sources: New technology for improved current measurement linearity
- Different radionuclide: $^{166\text{m}}\text{Ho}$

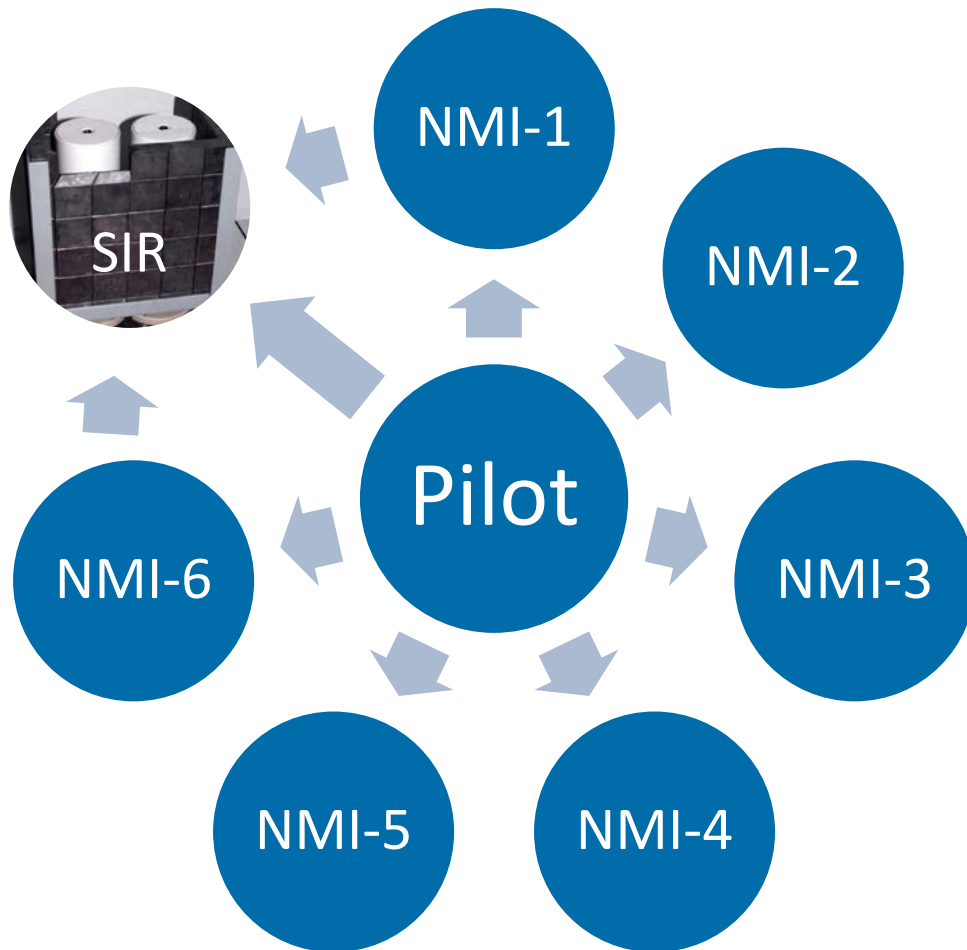
SIR Transfer Instrument (SIRTI)



- Established in 2013 to compare national standards of short-lived γ -emitting radionuclides
- Calibrated against SIR for 5 radionuclides
- Well-characterised NaI(Tl) well detector with data acquisition system
- Stability monitored by ^{94}Nb reference source
- Low-energy threshold set using $^{93\text{m}}\text{Nb}$ X-ray peak

- SIRTI and reference source shipped to NMI
- Measurements taken by BIPM staff (or remotely)
- Limited to 2 participants per year

Large scale K2 key comparisons



- Aliquots of the same master solution distributed to participants by pilot laboratory
- Some participants submit standardised ampoules of the solution to the BIPM to provide a link to the SIR

- Intercomparisons rely on:
 - Shipping of sources around the world
 - Regulatory compliance
 - Time-bound shipping and customs clearance of short-lived radionuclides

Activity standards disseminated as certified sources

- Solutions in ampoules, vials, bottles
- Gases in ampoules, pressurized canisters
- Point sources
- Solid sources in various matrices
- Sources in natural matrices
- Sealed sources
- Large area sources

- Proficiency tests
- Onsite traceability measurements



Representative images were taken from the catalogues of a few NMIs. Please refer to the KCDB for details on radioactivity CMCs for all NMIs.

<http://www.lnhb.fr/services-en/> <https://www.eurostandard.cz/nuclides.html>

<https://www.ptb.de/cms/en/ptb/fachabteilungen/abt6/measurement-and-calibration-capabilities/radioactivity/activity-standards.html>

Activity standards disseminated through measurements

- Sources submitted by users and certified by NMI by primary or secondary measurement
- Calibration of radionuclide calibrators using certified reference sources
- Certification of short-lived radionuclide sources at production sites by:
 - portable primary standardisation system, or
 - using a transfer instrument with traceability to national standard

