Research and Application of Radionuclides Metrology at NIM

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Ionizing Radioation Division
Organization

- National Institute of Metrology (NIM) is established in 1955
- Two Sites in Beijing: He Ping Li and Changping
Organization

Director

The Scientific and Technological Committee of NIM

Administrative Departments
- Executive Office for Administration
- Department of R&D Management
- Department of Quality System Management
- Department of Human Resources
- Department of Finance
- Department of Infrastructural Renovation and Management
- Department of Public Relations
- Department of Retired Staff Management

Research Divisions
- Div. of Metrology in Length and Precision Engineering
- Div. of Thermophysics and Process Measurements
- Div. of Mechanics and Acoustics
- Div. of Electricity and Magnetism
- Div. of Electronic and Information Technology
- Div. of Optics
- **Div. of Ionizing Radiation**
- Div. of Time and Frequency
- Div. of Nano Merology and Materials Measurement
- Div. of Chemical Metrology and Analytical Science
- Div. of Energy and Environmental Measurement
- Div. of Medical and Biological Measurement
- Div. of Engineering Metrology and Testing Technology
- Div. of Strategy Development

Supporting Departments
- Department of Operation Management of Changping Campus
- Logistic Service Center
- China National Metrology Technology Development Corporation
- Department of Information and Facilities Management

The 5th ARADOS Annual Meeting
Organisation

- **Three section**: Radioactivity, Dosimetry, Accelerator and Neutron
- **Staff**: 27 Employees, 3 postdocs, 26 graduated students
- **Becoming the PSDL (Primary standard Dosimetry Laboratory) of IAEA SSDL network in 2016**

![Ionizing radiation building in He Ping Li](image1)

![Building for electron accelerator for high-dose dosimetry](image2)

![New Building for LINAC, CT and monoenergetic X-rays](image3)
Organisation

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Ionizing radiation building in He Ping Li

Building for electron accelerator for high-dose dosimetry

New Building for LINAC, CT and monoenergetic X-rays
Radioactivity group

- **Realize the Système International (SI) units for activity (the becquerel)**
- **Maintain and develope radionuclides metrology facility.**
  *Continuously improve national radionuclides metrology infrastructure.*
- Provide the **national standards of radionuclides** used in environmental protection, occupational health monitoring, nuclear energy safety etc.
- Provide calibration **service and radioactive reference material**.
- Develop **test specifications and norms** for calibration or verification.
**Radionuclide Metrology facilities**

- $4\pi X(e) - \gamma$ coincidence
- $4\pi\beta - \gamma$ coincidence
- $4\pi(LS) - \gamma$ coincidence
- $4\pi(LS)$ counter
- $2\pi\alpha, \beta$ emission rate
- $\alpha, \beta$ Low background
Radionuclide Metrology facilities

γ spectrometry
Radon Chamber
4πγ ionization Chamber
α/β counter
DSA for Radon activity
α Spectrometry
Radioactive Reference Sources and material

- Standardized Radioactive solution, alpha & beta emitting plane sources, gamma nuclides mixed sources were developed and disseminated as traceability standards of radioactivity, monitoring, testing and comparison sources.

- More than 40 kinds of reference sources and material were provided to support the metrology requirements from nuclear power plants, environmental protection agencies, and disease prevention agencies in China.

Partial photos of references sources and material
Intercomparison

2. BIPM.RI(II)-K4.Tc-99m (2012)
3. APMP.RI(II)-K2.Fe-59 (2014)
5. CCRI(II)-K2.Ge-68 (2016)
6. CCRI(II)-S12 (2016)

BIPM.RI(II)-K4 Tc-99m (2012)

The Standardization and Comparison Plan for Medicine Radionuclides

- Standardization of medical nuclide F-18, C-11, Cu-64 etc. and plan to take part in the comparison using the SIRTI, piloted by BIPM (estimate in 2019~2020)

Primary standard for radionuclides measurement

SIRTI used in the comparison for short-lived nuclides
Medical radionuclides used for diagnosis and treatment

- **Tc-99m**, half life about 6h, widely applied for imaging in SPECT
  (Single-Photon Emission Computed Tomography)
- **F-18**, half life about 1.8h; **Ga-68**, half life about 67.8min used for imaging in PET (Positron Emission Tomography)
- ... for diseases diagnosis

- **I-131**, half life about 8d, applied for thyroid disease treatment
- **Ra-223**, half life about 11.4d; used for the treatment with castration-resistant prostate cancer, symptomatic bone metastases
- **Y-90**, half life about 2.67d widely applied for the treatment of liver cancer
- ... for diseases treatment
A new and more realistic TDCR model by Penelope (in cooperation with LNHB and BIPM)

With more detailed geometrical and material descriptions for optical chamber, chamber cap, photomultipliers

An example of the computed absorption spectrum for the interaction of γ ray with a liquid scintillator
Primary and Secondary Standards of Radioactive Gas Activity

- Establish the standards for gas radioactivity, based on internal gas counting techniques by applying length compensation method.

- Investigate the method to calibrate the radioactive gas monitor systems, such as in nuclear power plants (noble gas nuclides Kr-85, Xe-133 etc., particular H-3 in heavy water reactors).

- Participation at the Xe-133 comparison piloted by LNHB around 2020.

The structure scheme for traceability and usage of radioactive gas activity measurement.
Low-level Measurement Technique for γ Spectrometry

- Study and apply the anticoincidence counting technique to extend the lower limit for currently used γ-ray spectrometry
- Enhance the measurement capability for low-level samples in different matrix
- Participation at CCRI/ APMP/ other RMOs Supplementary comparisons

The detection and electrical units of the low-level apparatus

3D view of the low-level γ spectrum system
Orginizing the comparison of radon measurement apparatus

• Radon decay products measuring instruments are commonly used in mines or environmental monitoring.
• Stable and controlled radon decay products atmosphere will be used for comparison of various instruments.
• Due to the lack of mutual recognition of calibration and measurement capabilities (CMCs) of radon field between world-wide metrology laboratories, such comparisons will contribute to the reduction of systematic deviations.
Participants in this comparison

RHLH Technology Co.
北京瑞恒联合科技有限公司

Core ring(Beijing)Technology Co.

SARAD

TRACERLAB

中国测试技术研究院
National Institute of Measurement and Testing Technology

中国计量科学研究院
National Institute of Metrology, China

中国原子能科学院
China Institute of Atomic Energy

中国地质大学
CHINA UNIVERSITY OF GEOSCIENCES

清华大学
Tsinghua University

中国疾控中心
National Institute for Radiological Protection, China CDC

Science Laboratories Limited

新儀儀器有限公司

北京核地科技发展有限公司
Beijing Hedi Sci-Tech Development Co., Ltd.

赛普环仪（北京）科技有限公司

成都理工大学
Chengdu University of Technology
• Under three comparison conditions, 12 out of 20 laboratories have achieved comparison equivalence for radon concentration measurement. And 8 out of 16 laboratories achieved equivalence for radon decay products measurements.
• One or several of the following reasons are the main reasons for not obtaining equivalent results: (1) instruments' problem; (2) the evaluation of uncertainty of measurement results is seriously unreasonable; (3) the measurement method with errors or large defects. (4) instrument measurement is affected by environmental parameters (temperature, humidity or aerosol concentration).
Orginizing the comparison of nuclear safety labs

- Orginizing the comparison of radionuclide activity measurements closely related to safety, effluent and environmental protection monitoring of nuclear power plants, enhance the ability of radionuclide activity measurement
- Encourage relevant academic exchanges, improve the level of monitoring and analysis, and work together for more safe and efficient production of nuclear power.

Typical recent work
Medium and Long Term Development Planning of Radionuclides Activity Metrology

• Respond to national metrology demands, especially from nuclear medicine, environmental protection, nuclear safety and security, as well as disease prevention etc.
• Develop more robust national measurement infrastructure, more effective and efficient metrology capability.
• Promote more cooperation with other national metrology institutes for information sharing, knowledge transfer, training, visits of laboratories for learning and getting specific expertise and collaboration in projects, etc.

Cited From CCRI strategy document 2018-2028
Thank you for your attention