FOURTEENTH INTERNATIONAL CONFERENCE ON RADIATION, NATURAL SCIENCE, MEDICINE, ENGINEERING, TECHNOLOGY AND ECOLOGY
RAD CONFERENCE
JUNE 15-19, 2026
HUNGUEST HOTEL SUN RESORT, HERCEG NOVI, MONTENEGRO

Performance of the TDCR system from IFIN-HH

George Pață*,**, Ioana Lalău*, Mastaneh Zadehrafi*, Aurelian Luca*, Mihail-Răzvan Ioan*

* *Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH), Romania, Magurele 077125*
** *University of Bucharest, Faculty of Physics, Magurele 077125, Romania*

ABSTRACT

The triple to double coincidence ratio (TDCR) method for liquid scintillation measurement is used in national metrology institutes (NMIs) and designated institutes (DI) as a primary technique to standardize pure beta emitters. The TDCR system from IFIN-HH has been developed and commonly used for the last two decades with its associated electronics to measure different radionuclides. IFIN-HH has participated in several international comparisons for activity measurements of the following radionuclides - ^{3}H, ^{55}Fe, ^{89}Sr, ^{68}Ge, ^{222}Rn, ^{99}Tc - obtaining very good results using the TDCR method. The PMTs threshold values are very important for achieving low noise and high detection efficiency. In this paper, we will present the TDCR liquid scintillation measurement system along with the performance of the device obtained for few radionuclides.

MOTIVATION

- Liquid scintillation counting based on the Triple-to-Double Coincidence Ratio (TDCR) method is one of the most important primary standardization techniques used by National Metrology Institutes (NMIs) especially for pure beta-emitting radionuclides.
- The TDCR system developed at IFIN-HH has been continuously improved and routinely used for radionuclide standardization and international comparisons over the last two decades [1-3]. Since 2013, the TDCR system is included in the Romanian National Standard of the becquerel – the measurement unit of the quantity Activity (of a radionuclide).
- The objective of this work is to present the TDCR system from IFIN-HH and to evaluate its performance through several international key comparisons and routine measurements.

EXPERIMENTAL SETUP

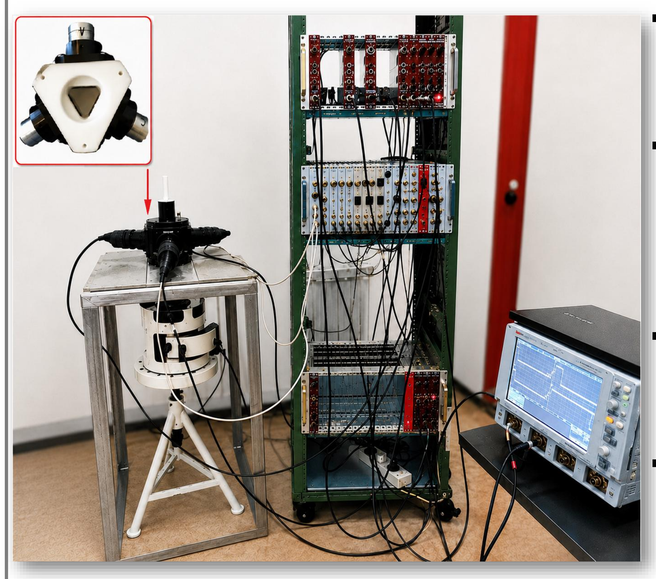

Fig. 1. The TDCR system from IFIN-HH.

- The TDCR system from IFIN-HH consists of three photomultiplier tubes (PMTs) positioned symmetrically around a liquid scintillation vial.
- The detection efficiency is determined using the Triple-to-Double Coincidence Ratio method, which allows activity determination without the need for external calibration sources.
- Special attention was given to the optimization of PMT discriminator thresholds in order to achieve low background counting rates while maintaining high detection efficiency.
- The performance of the system was evaluated through activity measurements of liquid sources containing different radionuclides and participation in many international CIPM-CCRI(II) key comparisons [4].

RESULTS

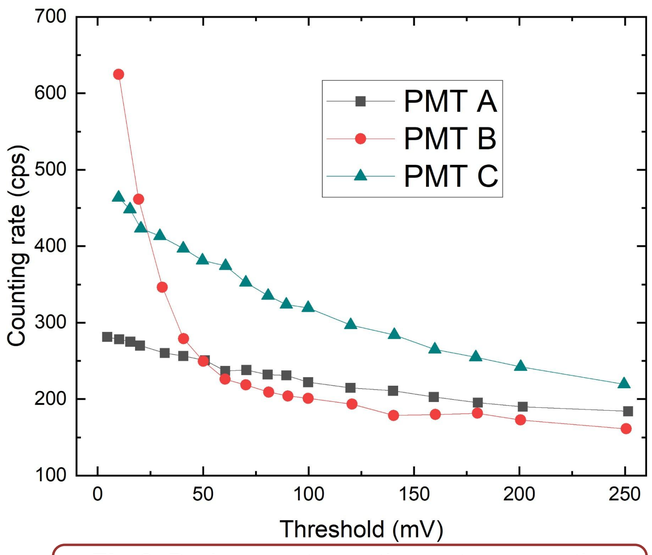

Fig.2. Dark current counting rate versus the discriminator level (A, B, and C) for PMTs.

✓ The results obtained during the CCRI(II) key comparisons are in good agreement with the Key Comparison Reference Values (KCRVs), confirming the reliability of the TDCR system for radionuclides activity standardization and its important role in the assurance of the metrological traceability for the activity measurements in Romania.

✓ The agreement observed for radionuclides such as ^{3}H, ^{55}Fe, ^{89}Sr, ^{99}Tc, ^{68}(Ge+Ga) and ^{222}Rn (in secular equilibrium with its daughters) demonstrates the robustness of the IFIN-HH TDCR methodology.

Radionuclide	Comparison	IFIN-HH - reported value ($a_{IFIN} \pm u_c$) kBq/g	KCRV Comparison reference value ($a_{comb} \pm u_c$) kBq/g	Difference (IFIN-HH – KCRV): D_i, kBq/g U_i (k=2), kBq/g
^{3}H	CCRI(II)-K2.H-3	36.49 ± 0.32	37.10 ± 0.18	D_i = 0.62, U_i =0.73
^{55}Fe	CCRI(II)-K2.Fe-55	514.9 ± 3.8	516.8 ± 2.9	D_i = -1.9, U_i =9.6
^{89}Sr	CCRI(II)-K2.Sr-89	26.09 ± 0.21	26.33 ± 0.05	D_i = - 0.24, U_i =0.86
^{99}Tc	CCRI(II)-K2.Tc-99	56.43 ± 0.23	56.45 ± 0.13	D_i = - 0.02, U_i = 0.50
^{68}Ge	CCRI(II)-K2.Ge-68	601.6 ± 6.6	621.7 ± 1.1	D_i = - 20.1, U_i =13.4
^{222}Rn	CCRI(II)-K2.Rn-222	73680 ± 1300	71500 ± 1500	D_i = 2180, U_i =3970

✓ The dark current measurements show that the discriminator threshold can be adjusted to significantly reduce electronic noise while preserving counting efficiency.

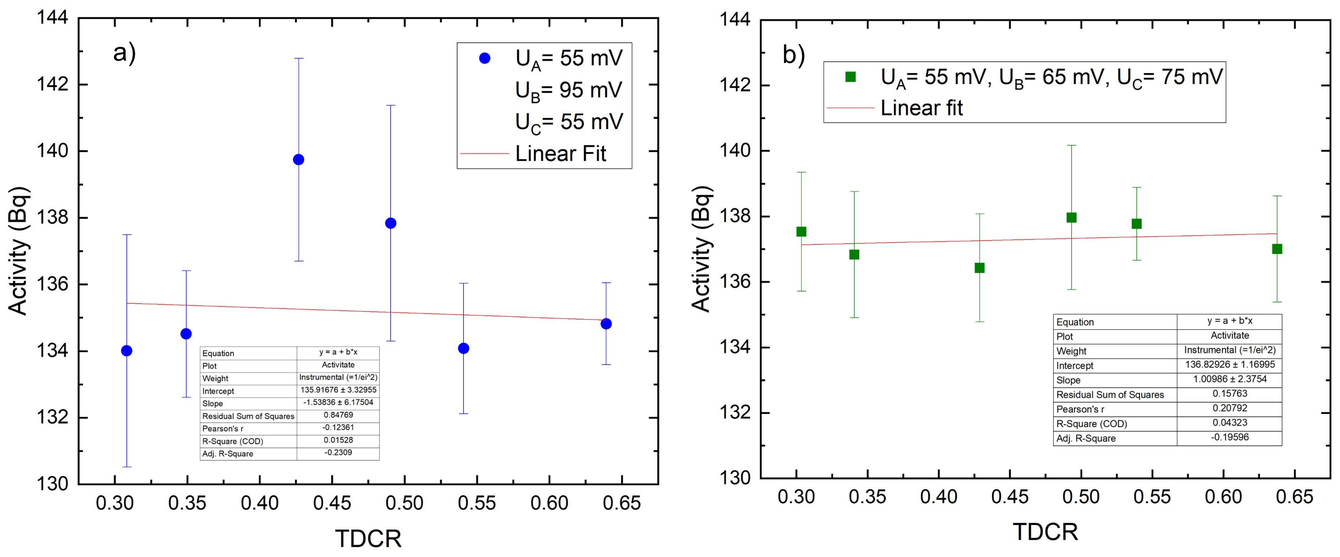

Fig.3. Results of measurement of the ^{3}H standard source (code S462) obtained with 2 discriminator levels: **a)** U_A= 55 mV, U_B= 95 mV, U_C= 55 mV; **b)** U_A= 55 mV, U_B= 65 mV, U_C= 75 mV. Counting efficiency was changed by using gray filters.

The stability measurements demonstrate a stable operation of the TDCR system over long measurement periods.

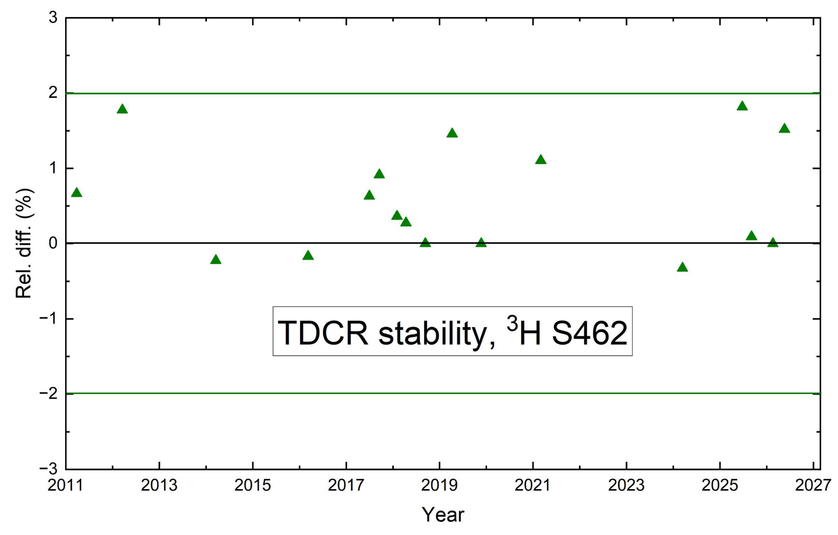

Fig. 4. Stability check of the TDCR system: relative difference between the measured and the certified activity values of a ^{3}H standard source (code S462).

CONCLUSIONS

- The TDCR system developed at IFIN-HH has demonstrated stable and reliable operation over more than two decades.
- Optimization of PMT discriminator thresholds allows low noise operation while maintaining high detection efficiency.
- Results obtained in international CIPM-CCRI(II) comparisons are consistent with the corresponding reference values.
- The TDCR method remains a robust primary standardization technique for pure beta-emitting radionuclides.
- The system is suitable for future radionuclide metrology applications and international comparison exercises.

ACKNOWLEDGEMENTS

This work was funded through Core Project PN: 23 21 02 03 and 134PED/2025.

The Core Project PN 23 21 02 03 has received funding from the National Research Authority - Romanian Ministry of Education and Research (MEC).

REFERENCES

1. Razdolescu, A. C., Broda, R., Cassette, P., Simpson, B. R. S., Van Wyngaardt, W. M., (2006) The IFIN-HH triple coincidence liquid scintillation counter, Applied Radiation and Isotopes 64 1510 – 1514\; 2. Broda, R., Cassette, P., Kossert, K., (2007) Radionuclide metrology using liquid scintillation counting, Metrologia 44 S36 – S52; 3. Antohe, A., Sahagia, M., Cassette, P., Luca, A., Ioan, M. –R, (2019) Tritium standardization by the LSC-TDCR method and participation at international comparisons, Romanian Reports in Physics 71, 209 ; 4. https://www.bipm.org/en/committees/cc/ccri/wg/ccri-ii-

CONTACT

Ioana Lalău, PhD
ioana.lalau@nipne.ro