

ABSTRACT

This work, a collaboration between **LNMRI/IRD/CNEN**, **BIPM** and **IPEN/CNEN**, describes the objectives of the SIRTI comparison, the standardized radionuclides, preparation of the ampoules for measurements, the dilution homogeneity tests, the results of the calibrations, SIRTI's adjustments and preliminary results of the key comparison, since the finalization of the comparison by the BIPM is in progress.

INTRODUCTION

Short half-life radionuclides are essential for Nuclear Medicine. These radionuclides are usually linked to a more complex molecular or cellular structure. This set is called a "radioactive tracer". Radioactive tracers with pharmacological characteristics, such as apyrogenicity, toxicity and sterility, are called "radiopharmaceuticals" and have been applied in Nuclear Medicine for the diagnosis and therapy of diseases.

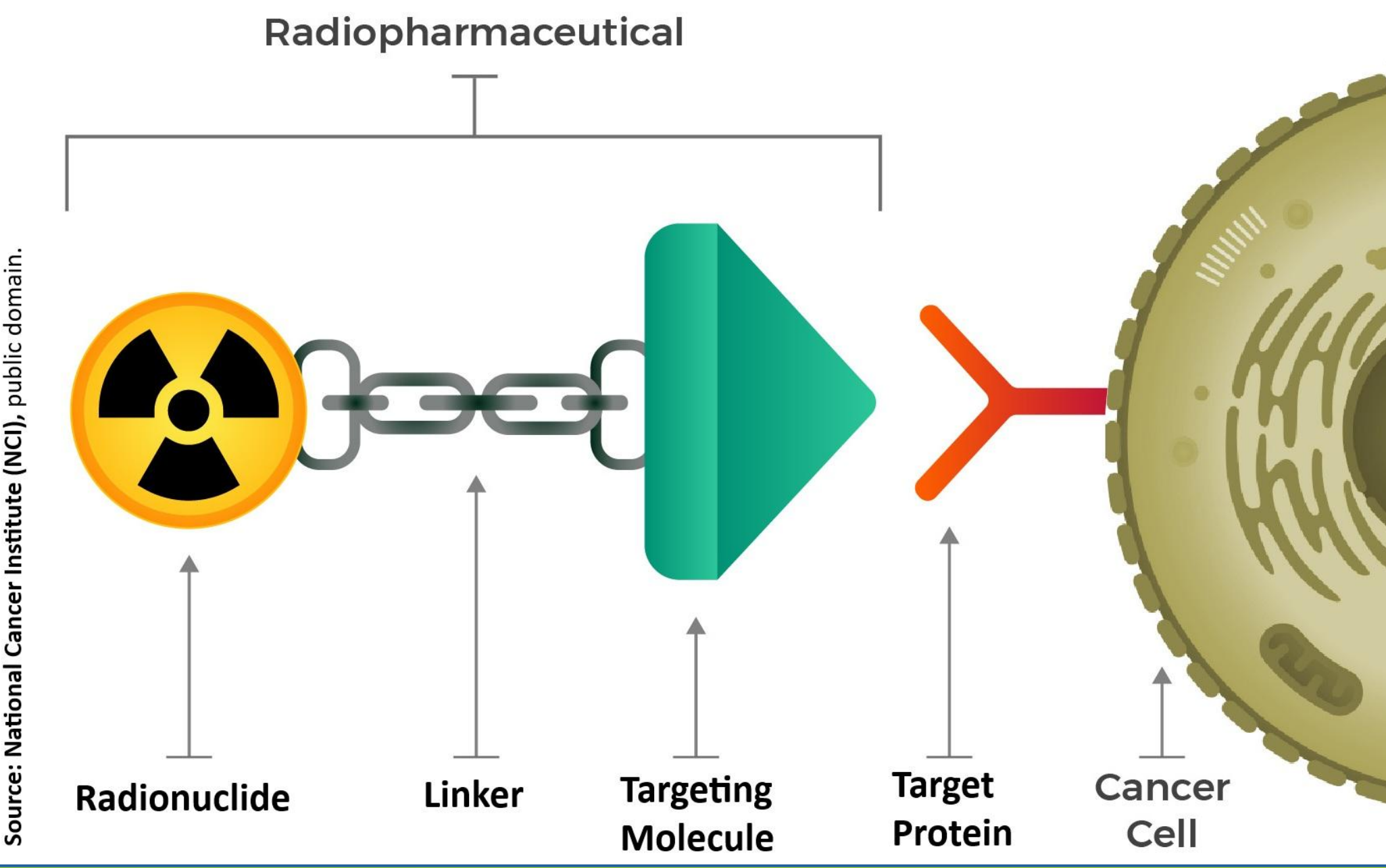


Figure 1: Diagram of a radiopharmaceutical.

Nuclear Medicine is expanding as these radionuclides become accessible and this places new requirements on National Metrology Institutes (NMIs). However, because of their short half-lives, less than 7 days, the submission of ampoules containing this radioactive material to the BIPM for measurement of the activity of gamma-emitting radionuclides in the International Reference System (SIR) is only possible for NMIs based in Europe.

To extend the use of SIR and allow other NMIs to participate, a transportable transfer instrument, SIR Transfer Instrument, known as SIRTl, was developed at BIPM following a request from CCRI(II) in 2005 and with the support of the Advisory Committee on Ionizing Radiation Transfer Instrument Working Group.

The SIRTl was in Rio de Janeiro, Brazil, at LNMRI/IRD/CNEN from October 23, 2023 to March 15, 2024. During this period, standardizations were carried out for the short half-life radionuclides ¹⁸F, ¹²³I and ¹⁵³Sm, of interest to nuclear medicine in Brazil.



Figure 2: Left to right: Regio, Ronaldo, Carlos, José (Bira), Romain, Carine, Alfredo, Johnny, Estela and Mônica.

The BIPM's researchers Carine Michotte and Romain Coulon stay in Rio from October 23rd until 1st December 2023, in this time measure ¹⁸F and training LNMRI/IRD/CNEN technician how to adjust and operate the SIRTl for ¹²³I and ¹⁵³Sm measurements.

SOURCES PREPARATION AND MEASUREMENTS AT LNMRI/IRD/CNEN SYSTEMS

The sources, received from radiopharmacies R2 PHARMA Group and IPEN/CNEN, were prepared from the uncalibrated ¹⁸F, ¹²³I and ¹⁵³Sm stock solution by differential weighing using the pycnometer method. The dilution scheme can be seen below.

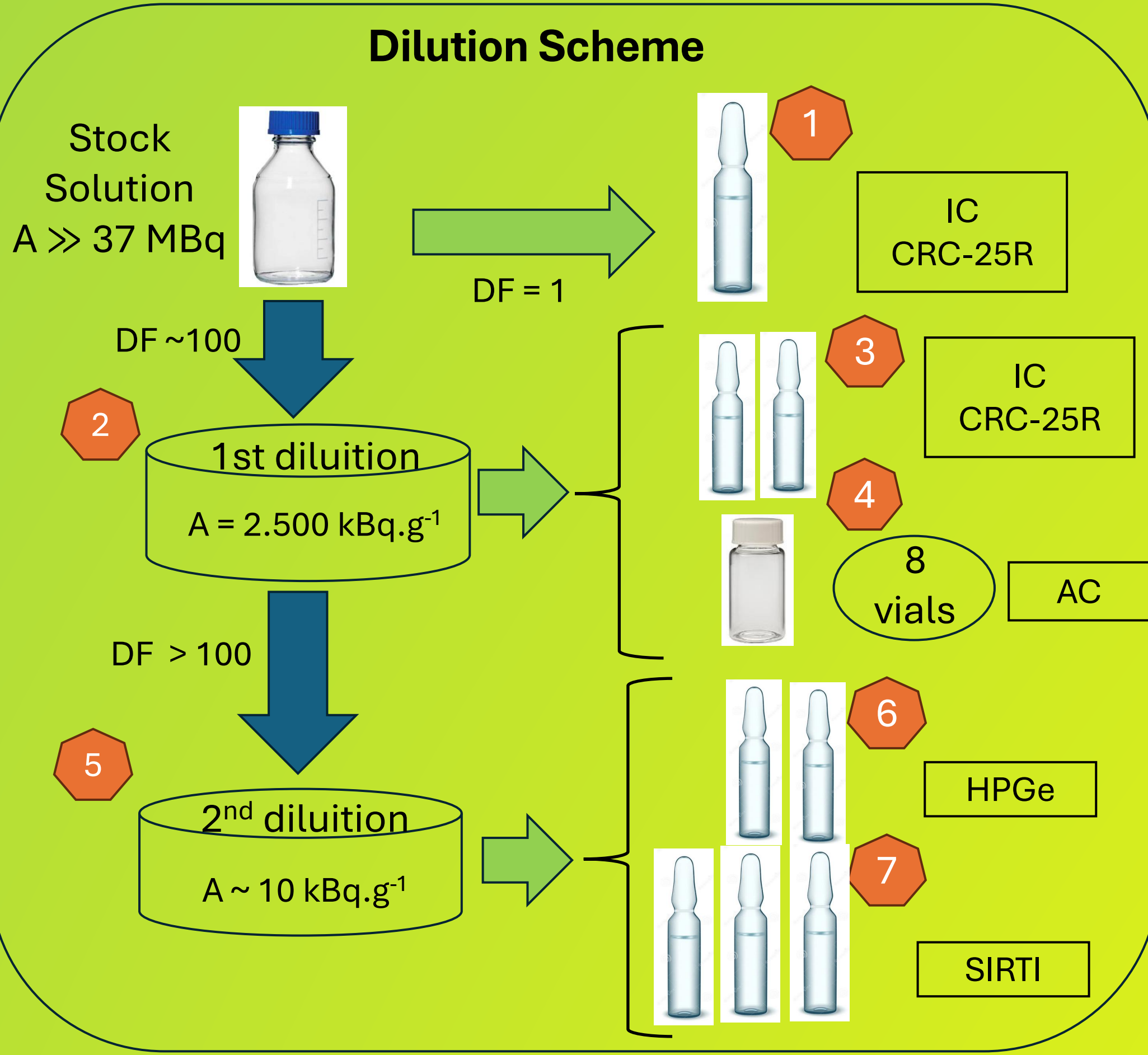


Figure 3: dilution scheme for source preparation.

Ampoule **1** was measured in the Ionization chamber system and Capintec CRC-25R to calibration the stock solution and the result was used to prepare the 1st dilution

The ampoules, set **3** from 1st dilution, were measured in the Ionization Chamber system and Activity Meter Capintec CRC-25R, the calibration results were used to check the homogeneity of the 1st dilution.

Eight liquid scintillation vials **4** prepared from the 1st dilution with ultima gold, were measured in the anticoincidence system, the calibration results were used to check the calibration factor of the ionization chambers.

The ampoules, set **6** from 2nd dilution, were measured in the HPGe detector, the calibration results were used to check the homogeneity and calibration of the 2nd dilution.

The ampoules, set **7** were for measurement in the SIRTl.

Table 1: Solution details.

Radionuclide	Solvent	Carriers	Density (g · cm ⁻³)
¹⁸ F	HCl 0.1 mol · dm ⁻³	none	1.020
¹²³ I		LiOH 53 µg · g ⁻¹ Na ₂ SO ₃ 37 µg · g ⁻¹ KI 37 µg · g ⁻¹	1.013
¹⁵³ Sm	HCl 0.1 mol · dm ⁻³	none	1.020

LNMRI/IRD/CNEN RESULTS

For ¹²³I, the difference between the activities measured in the ionization chamber of the two vials in set 3 yielded 0.0052 % and difference between the activities measured in the HPGe detector of the two vials in set 7 yielded 0.16 %. These results confirms the homogeneity of the first and second dilution of ¹²³I.

For ¹⁵³Sm, the difference between the activities measured in the ionization chamber of the two vials in set 3 yielded 0.083 % and difference between the activities measured in the HPGe detector of the two vials in set 7 yielded 0.12 %. These results confirms the homogeneity of the first and second dilution of ¹⁵³Sm.

For ¹⁸F, it was not possible to perform the homogeneity test of the first and second dilution due to some technical problems.

Standardizations performed at LNMRI/IRD were consistent, within the measurement uncertainties, whose maximum value is 1.5%.

No significant impurities of gamma-emitting radionuclides were detected in the solutions of the three radionuclides.

Table 2: Measurements results of ¹⁸F.

Radionuclide: ¹⁸ F			
Reference date: 11/28/2023 15:00 (UTC)			
Measurement System	A (kBq/g)	U (%)	Δ (%)
Anticoincidence	without measurement		
Ionization Chamber	5.413	0.70	-
HPGe Detector	5.572	0.86	2.94

Table 3: Measurements results of ¹²³I.

Radionuclide: ¹²³ I			
Reference date: 02/08/2024 15:00 (UTC)			
Measurement System	A (kBq/g)	U (%)	Δ (%)
Anticoincidence	8.323	0.47	-
Ionization Chamber	8.434	1.4	1.33
HPGe Detector	8.681	0.88	4.30

Table 4: Measurements results of ¹⁵³Sm.

Radionuclide: ¹⁵³ Sm			
Reference date: 03/06/2024 15:00 (UTC)			
Measurement System	A (kBq/g)	U (%)	Δ (%)
Anticoincidence	22.393	0.66	-
Ionization Chamber	22.250	0.82	-0.64
HPGe Detector	22.415	1.5	0.10

SIRTl ADJUSTS AND MEASUREMENTS

The detector is a well-type 3" × 3" NaI(Tl) crystal from Saint-Gobain Crystals (France). The well designed to hold the SIR-type ampoule is 5 cm deep and 2 cm in diameter. The crystal is coupled with an ETL 9305 photomultiplier.

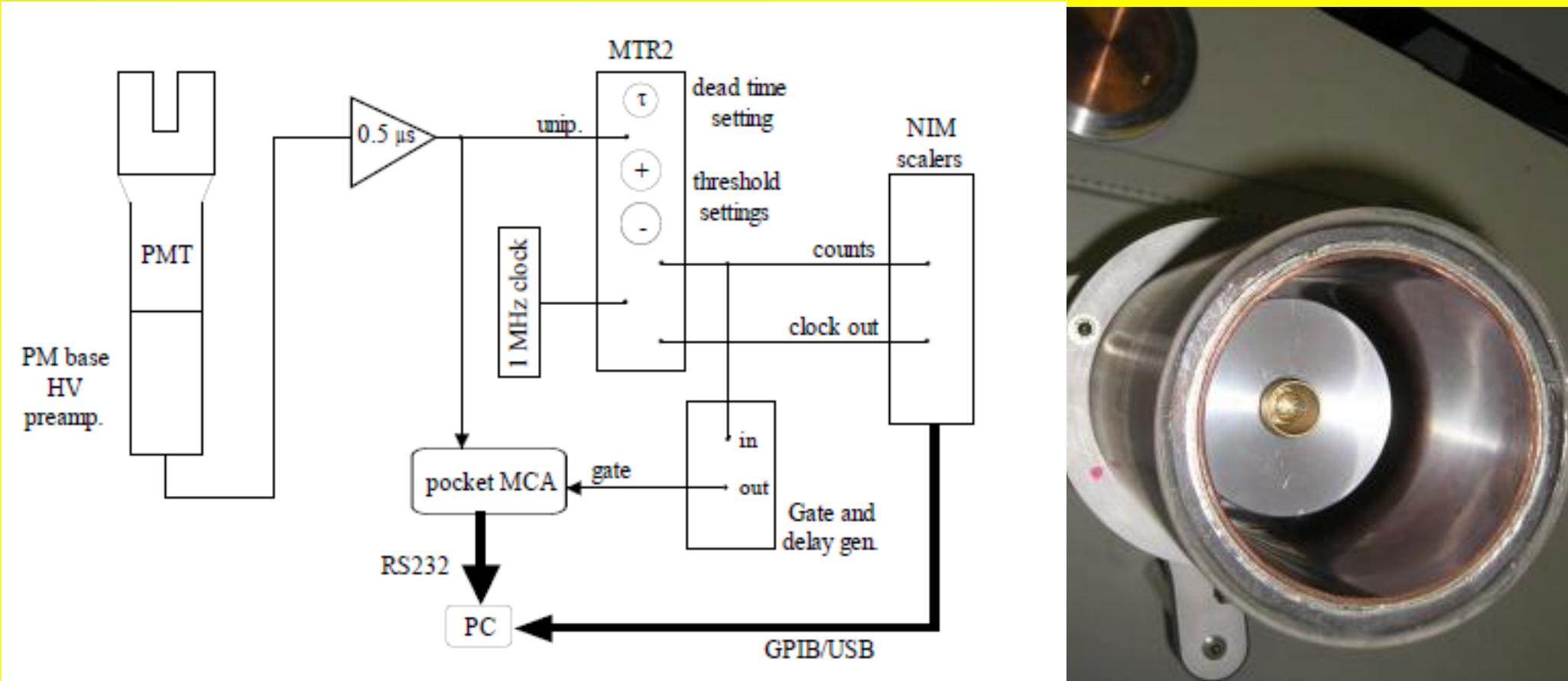


Figure 4: Block diagram and SIRTl detector (source: BIPM).

Before starting the radionuclide measurement, some adjustments and tests must be made to the SIRTl instrument. In the following we will only describe the MTR2 adjustment of the SIRTl.

MTR2 ADJUSTMENT

The threshold of the MTR2 was adjust with the Niobium source in the detector well. The adjustment consists of identify the channel number Cp that best divides the X-ray peak into two symmetrical parts. After that the positive threshold of MTR2 must be increased until the MCA spectrum is cut at the position of the Cp peak, that is, the position of half the height of the remaining peak is in the Cp channel, see figures 5.

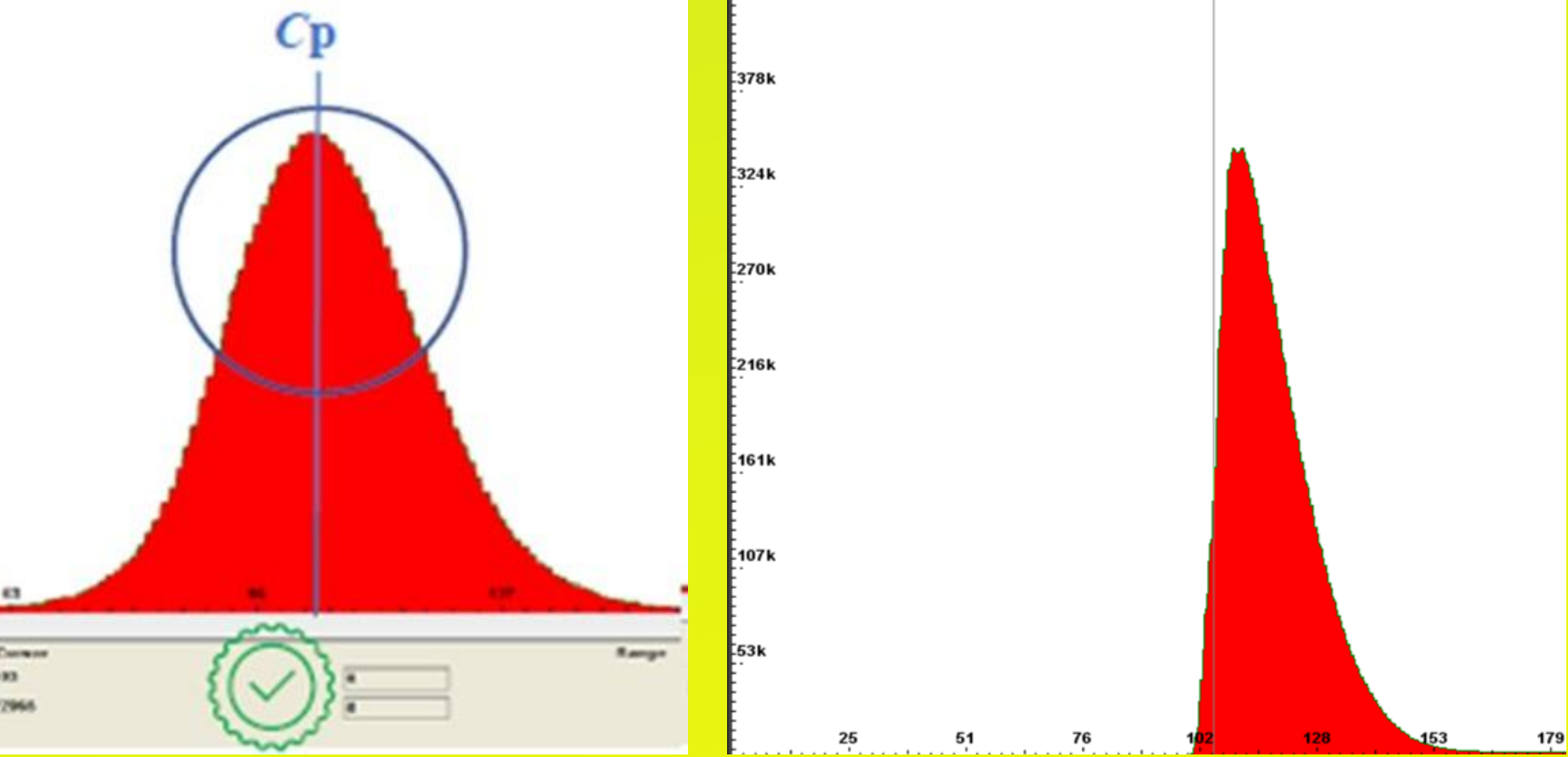
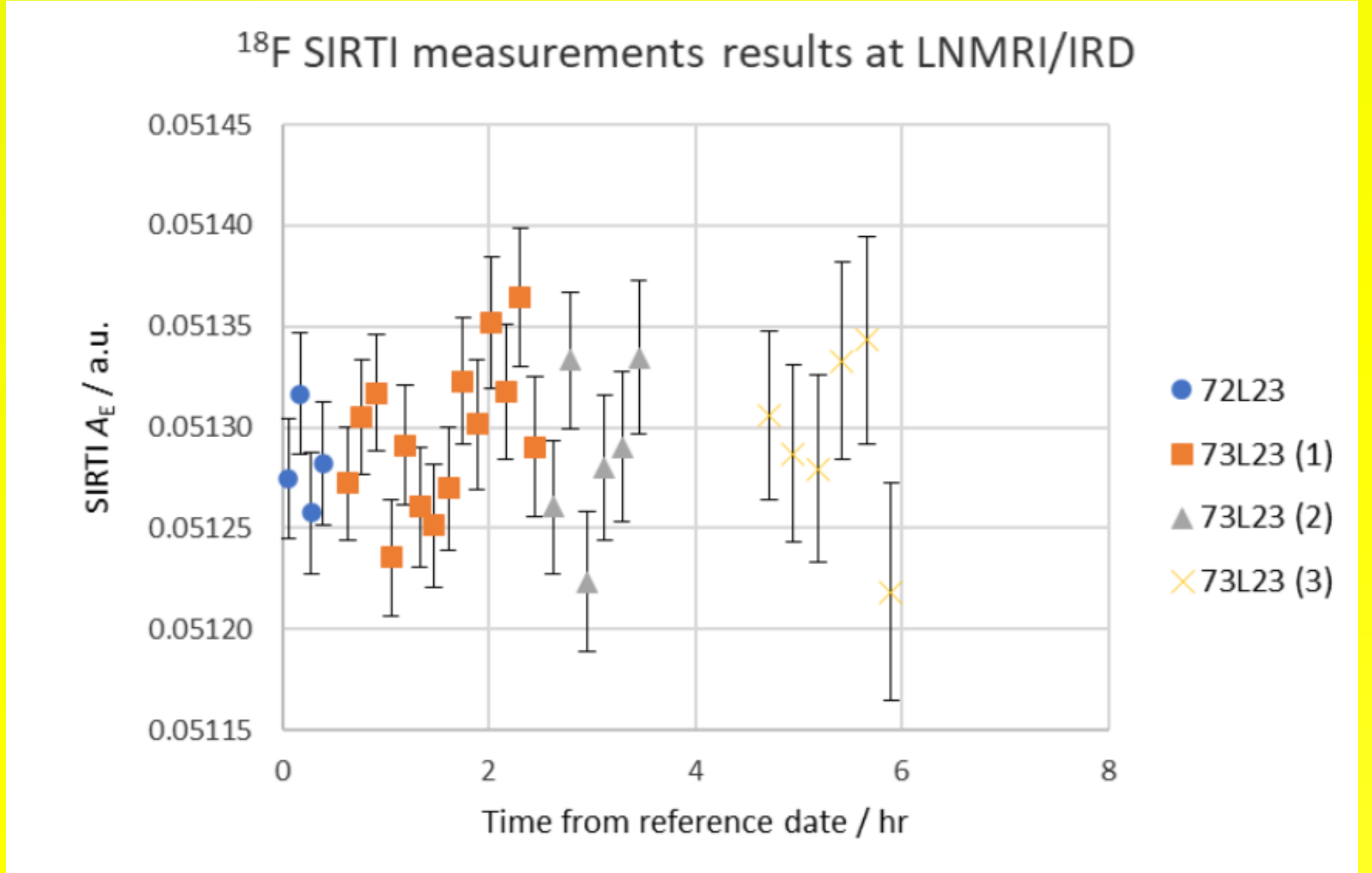


Figure 5: MTR2 adjustment of the SIRTl (source: BIPM).

PRELIMINARY RESULTS OF KEY COMPARISON

The graph 1 shows the perfect agreement between two SIR/BIPM ampoules and the stability of the SIRTl for the ¹⁸F.



Graph 1: ¹⁸F SIRTl measurements results at LNMRI/IRD/CNEN (source: BIPM).

The preliminary result of the comparison of ¹⁸F with SIRTl showed agreement with the international reference value (KCRV), within k=2.5.

For ¹²³I, the result is about 5 % of the SIR KCRV. ¹²³I is difficult to measure and there is a large scatter in the NMI results. This may be discussed in the KCWG(II) later. indicates a disagreement among the key comparison participants and will be the subject of study in the next ICRM.

For ¹⁵³Sm, the result is very good and agrees with the SIR KCRV within the standard uncertainty.

The finalization of the comparison by the BIPM is in progress.

ACKNOWLEDGEMENTS

We would like to thank the **R2 PHARMA Group**, whose unit **R2 - Soluções em Radiofarmácia Ltda** - Duque de Caxias, Rio de Janeiro, donated ¹⁸F (FDG) for this key comparison, and **radiofarmacie of IPEN/CNEN**, São Paulo, donated solutions of ¹²³I and ¹⁵³Sm.

Narration: IA FreeTTS.

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