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Radon-222 measurement by detection of alpha- radioluminescence of air with a triple-to-double coincidence ratio (TDCR) counter

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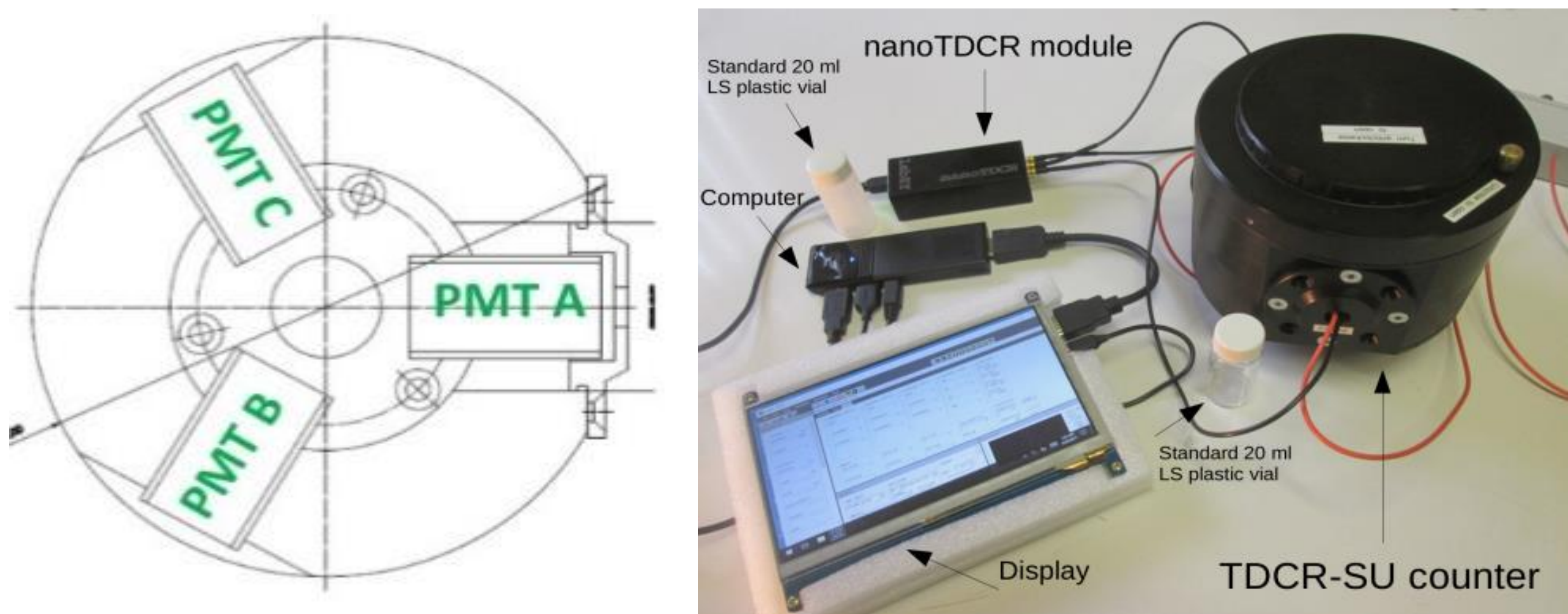
1. Introduction

The alpha radioluminescence of air has been proposed as a suitable method for indirect remote detection and imaging of alpha particle sources [1]. Further developments of this idea had led to the development of systems for optical detection of radon decay in air [2] and systems for imaging of alpha emitters in the environment [3,4].

In this work we show that the radioluminescence of air can be applied with a well-established metrological instrument for the purpose of monitoring and measurement of ²²²Rn activity concentration during radon calibrations. We propose the triple-to-double coincidence ratio (TDCR) counter as a detector for the light emitted by the radioluminescence of air induced by the alpha particles of ²²²Rn and its short-lived progeny. We demonstrate by comparison to a reference radon measurement device that this approach is feasible and very suitable for monitoring of radon concentrations in calibration experiments.

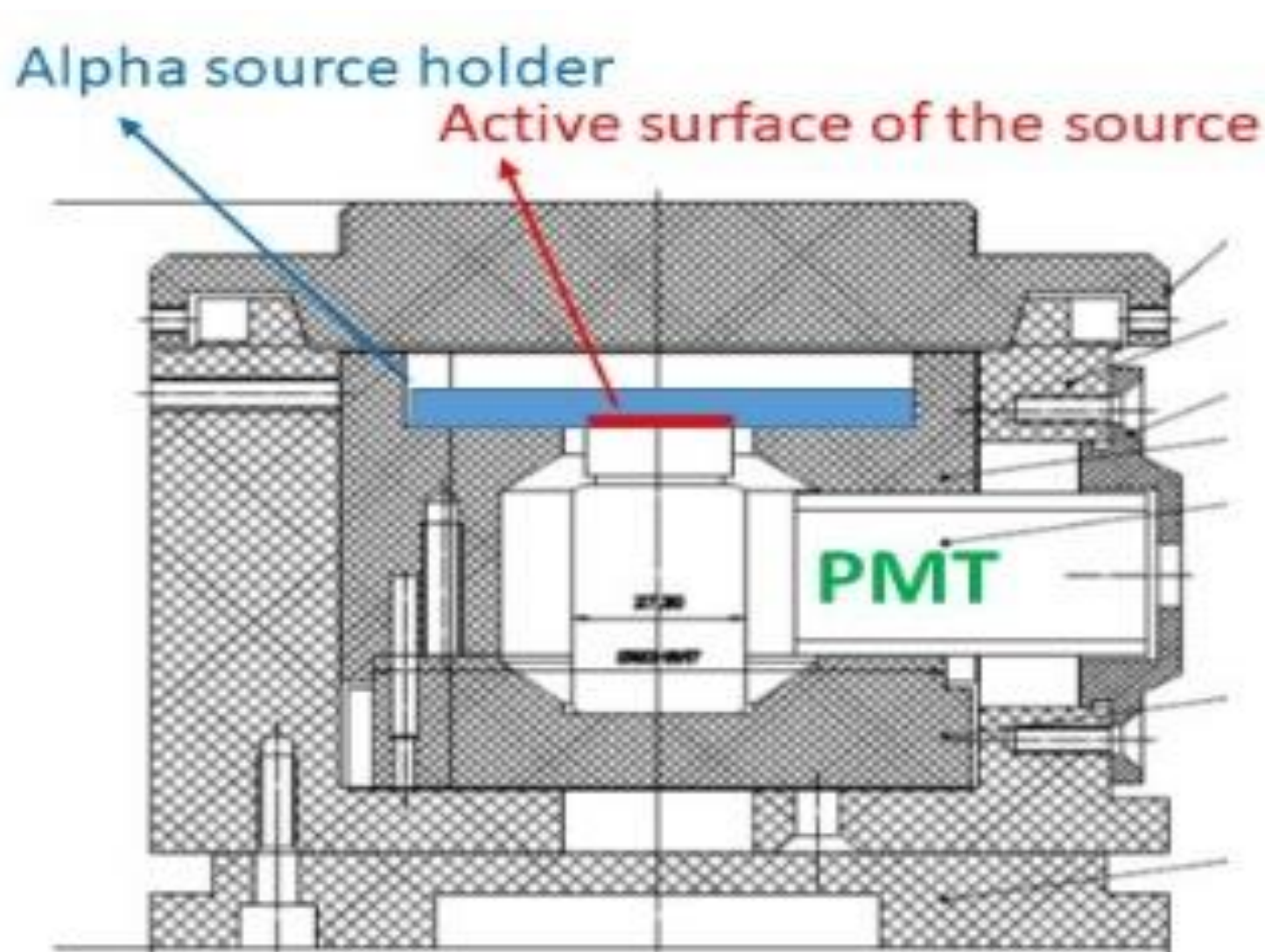
2. Methods and materials

In order to test the application of the alpha- radioluminescence of air for ²²²Rn-in-air monitoring we use a TDCR counter developed at Sofia University.

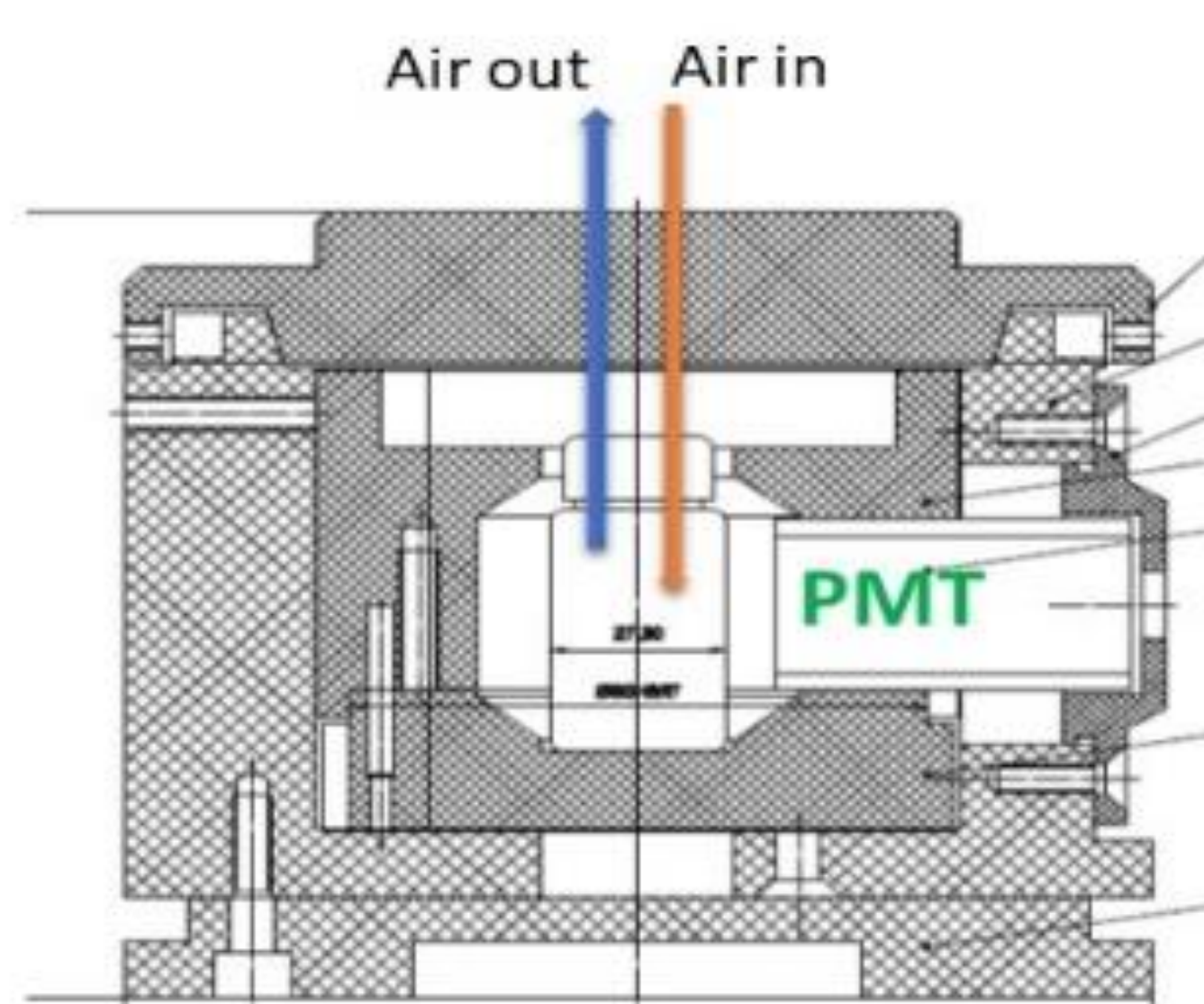


View of the TDCR counter developed at Sofia University

For the purpose of the experiments in this work the TDCR counter is equipped with a holder to allow testing of its response with alpha sources of different activities and with a special glass vial which allows ²²²Rn circulation.

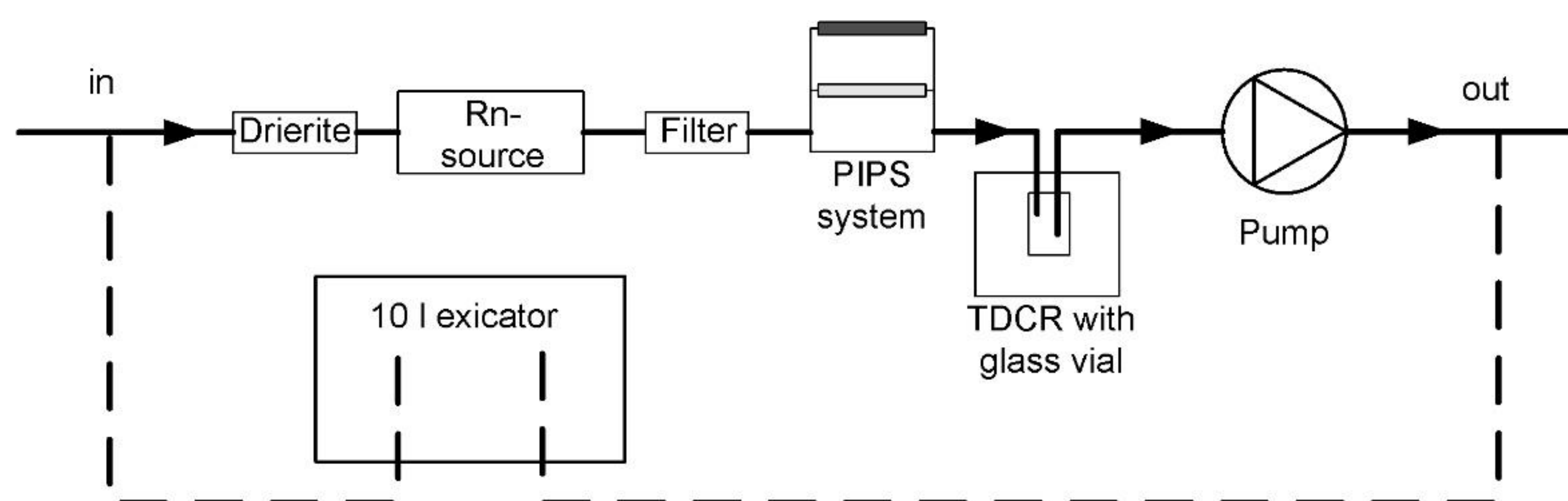


Modifications of the TDCR counter for linearity tests with alpha sources of different activities



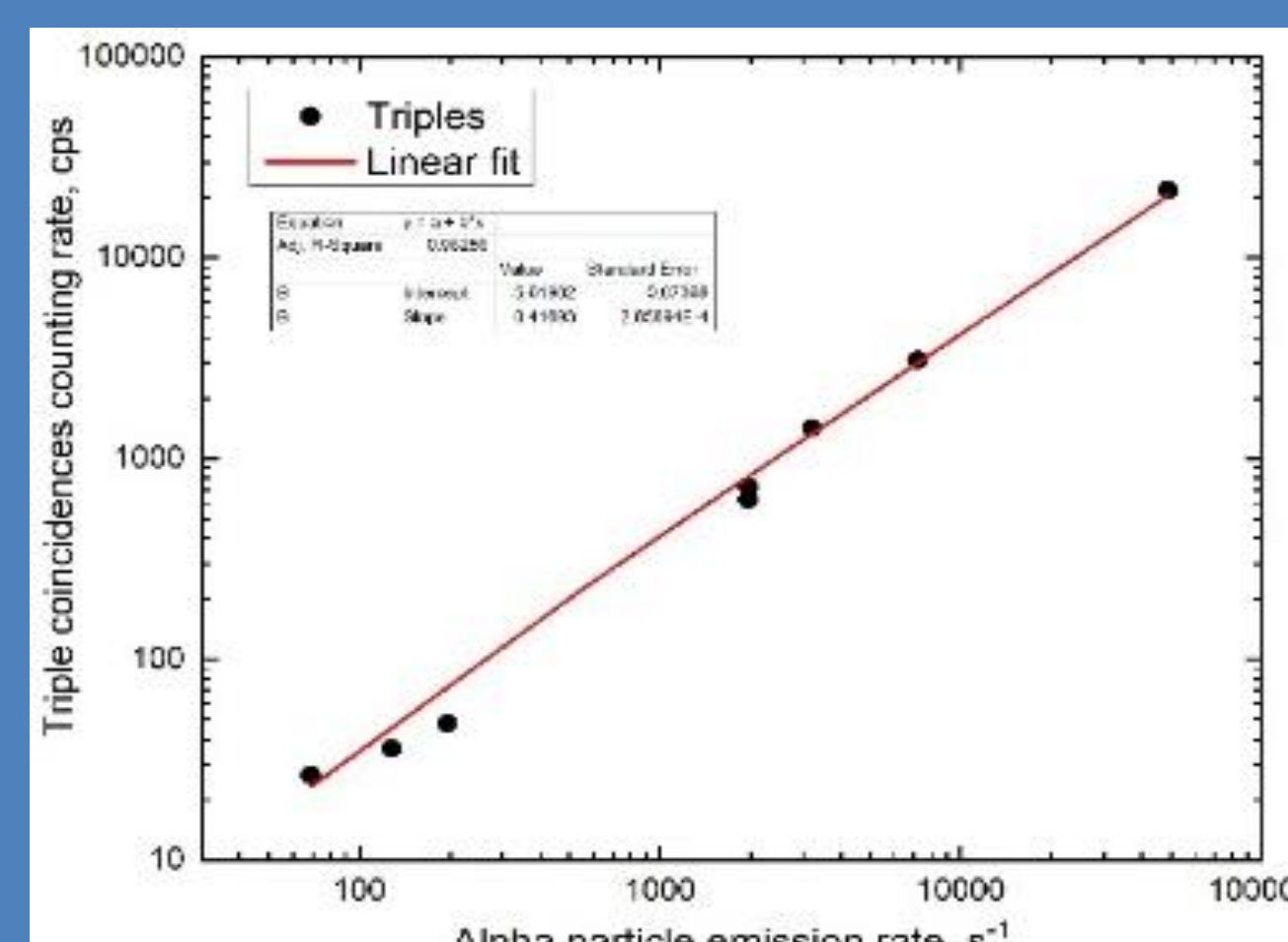
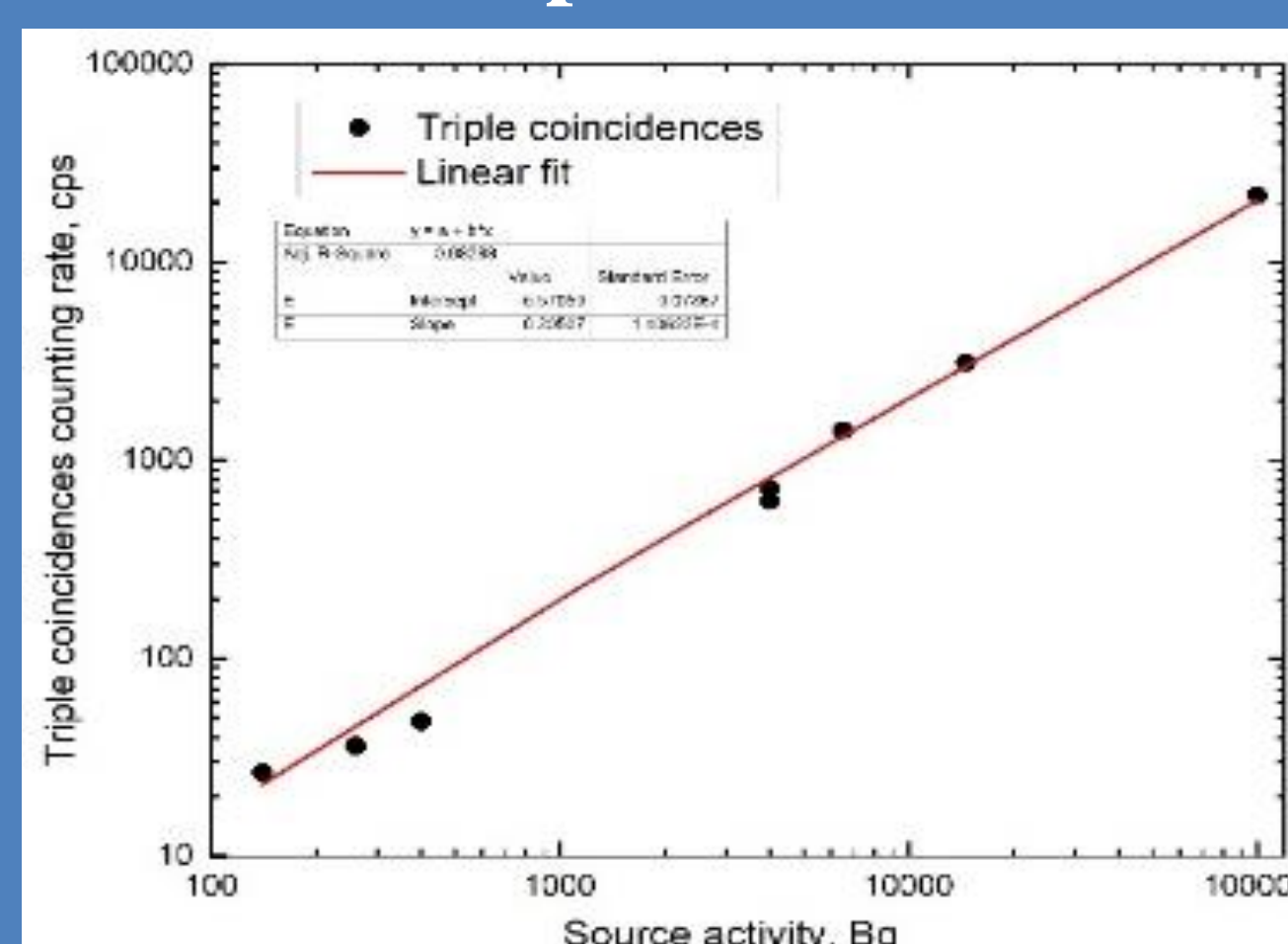
Modifications of the TDCR counter for the ²²²Rn-in-air tests.

A dedicated experimental system (schematic view below) was developed in order to create controllable ²²²Rn concentrations in the LS vial in the TDCR counter. The opened system (solid lines) is used to create low ²²²Rn concentrations, while the closed (dash lines) for high ²²²Rn concentrations. The PIPS ²²²Rn measurement system, developed previously at LNHB [5] was used as a reference ²²²Rn detector.

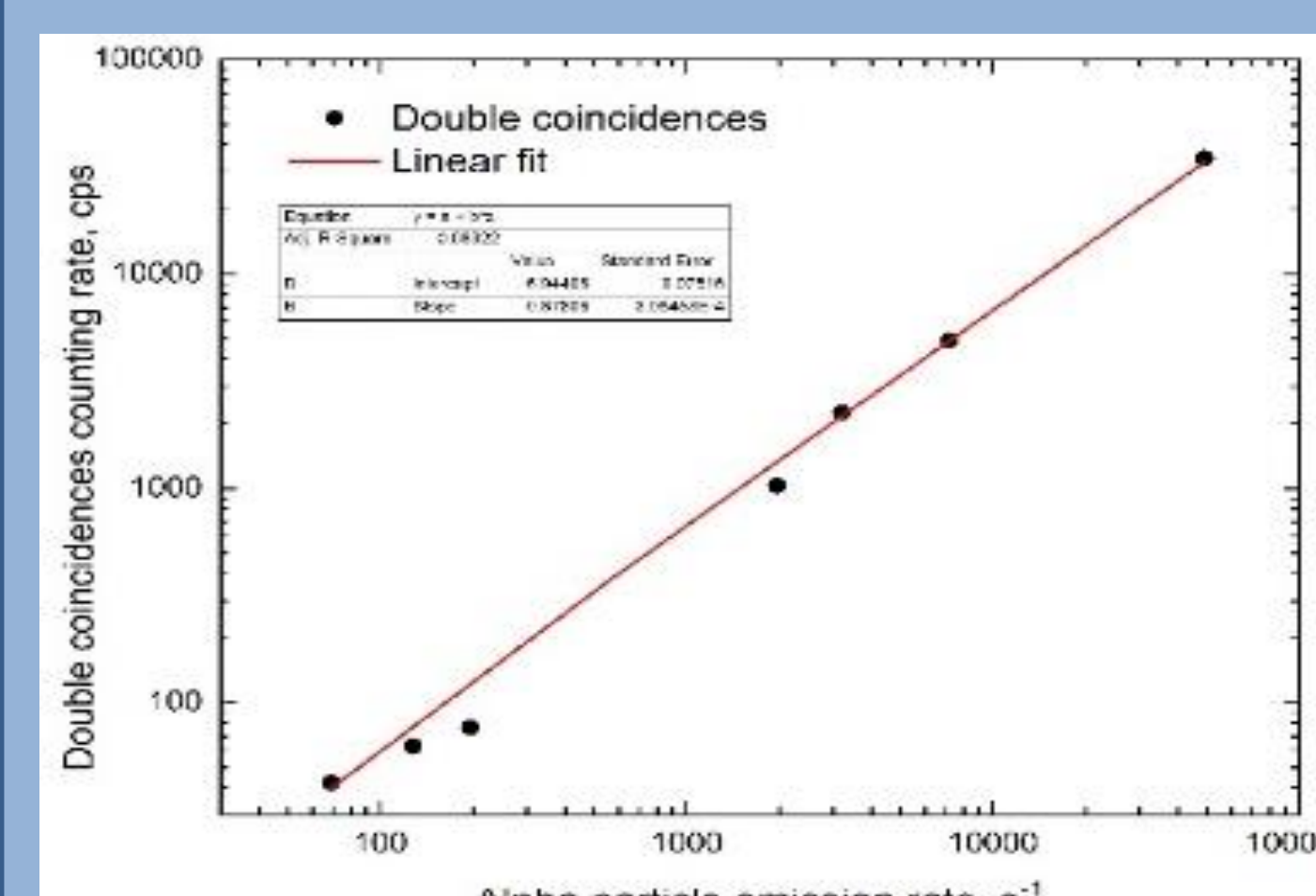
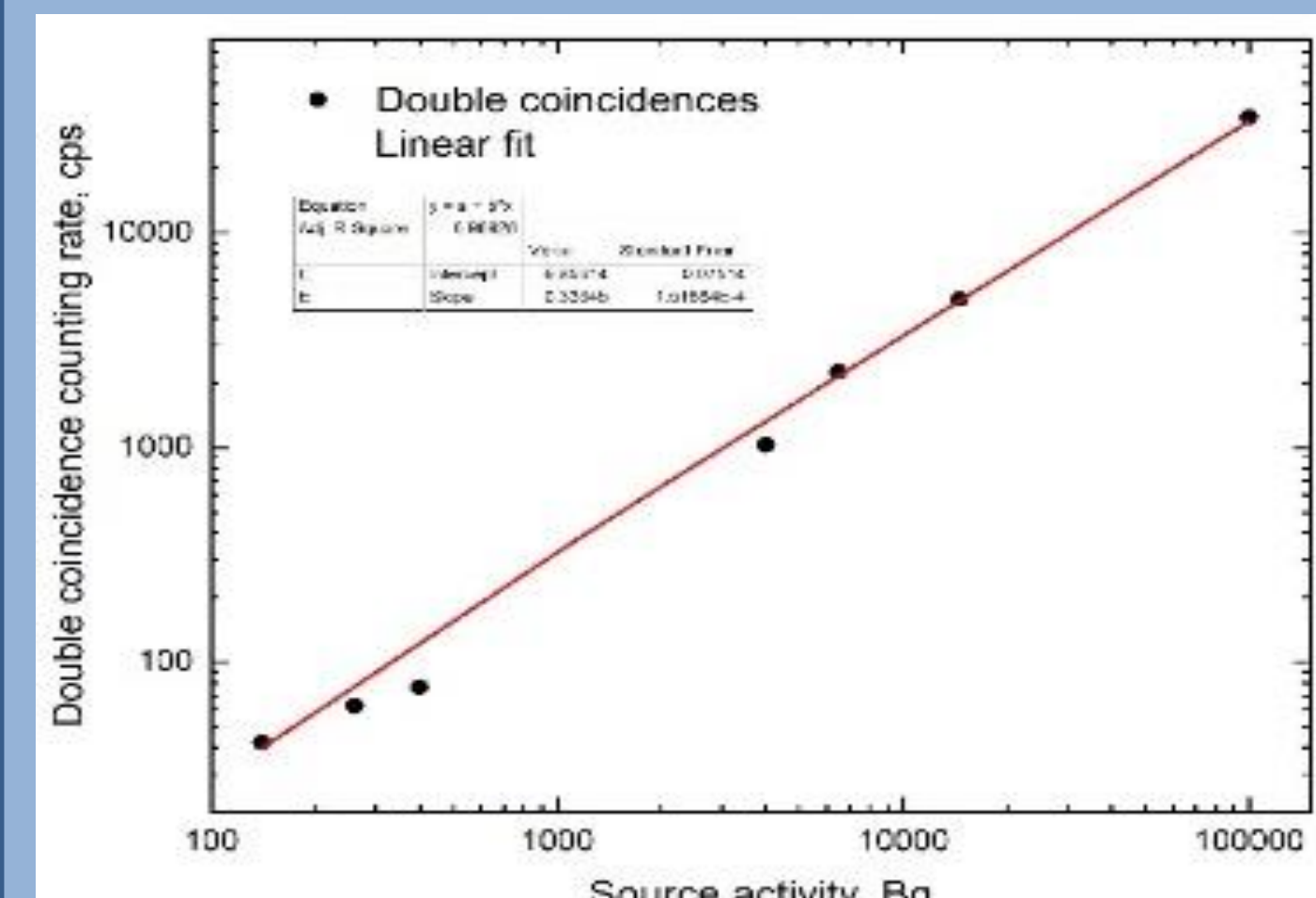


3. Results of the linearity tests

Triple coincidences counting rate vs. activity or emission rate of the alpha sources

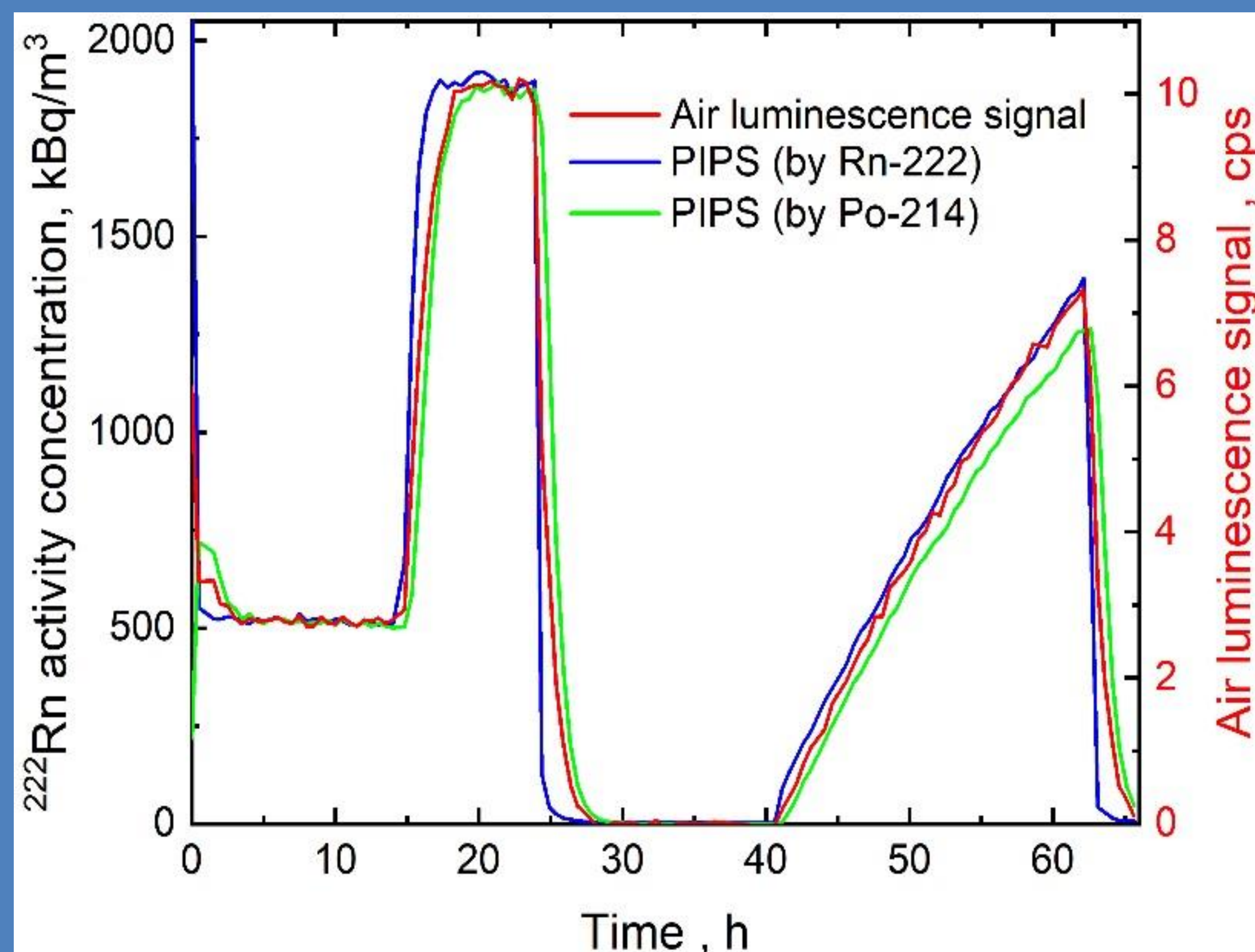


Double coincidences counting rate vs. activity or emission rate of the alpha sources



4. Results of the tests with ²²²Rn-in-air

The Figure below shows the comparison between the signal measured with the TDCR counter (net triple coincidence counting rates, red line) and the ²²²Rn (blue line) and ²¹⁴Po (green line) activity concentrations measured with the Passivated Implanted Planar Silicon (PIPS) system. The duration of each measurement for the two systems is 30 minutes. The results indicate very coherent response of the TDCR detector even in the regions of sharp changes of ²²²Rn concentrations (either sharp increase or sharp decrease). The constant and varying ²²²Rn concentrations were created deliberately in the system in order to study the temporal response of the TDCR counter. We observe excellent agreement and good temporal response of the TDCR detector, governed by the activities of ²²²Rn, ²¹⁸Po and ²¹⁴Po in the system.



Summary

- A TDCR counter can be used as a detector of the radioluminescence light produced by the alpha particles in air;
- A good linearity of response in terms of measured triple and double counting rates versus the alpha particle fluxes is demonstrated.
- An excellent agreement between the TDCR signal and reference ²²²Rn measurements by a PIPS detector system is observed.

References

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 [5]. B. Sabot et al., Appl. Radiat. Isotopes 109 (2016) 205 - 209