Development of portable Liquid Scintillation counters for on-site primary measurement of radionuclides using the Triple-to-Double Coincidence Ratio method

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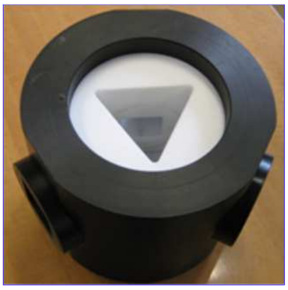
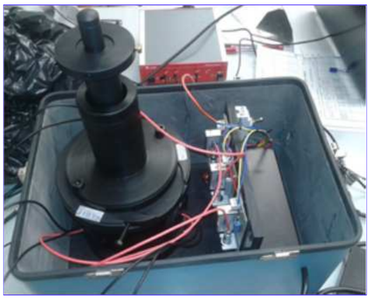
The Triple-to-Double Coincidence Ratio (TDCR) method in Liquid Scintillation counting is a primary radionuclide standardization method widely used in National Metrology Institutes (NMI). The scintillation light is detected by three photomultipliers tubes (PMT) and the detection efficiency is evaluated by using a model which uses the ratio of triple-to-double coincidences between the PMTs. In the framework of the European Metrofission project, a work package was dedicated to the realization of miniature self-calibrated primary TDCR systems, which are state-of-the-art, for use on-site. The challenge was to develop a versatile, portable, table-top designed instrument. Four prototypes of counters were built by the Metrofission partners ENEA (Italy), LNHB (France), NPL (UK) and PTB (Germany) using various technical approaches. These prototypes are described.

ENEA

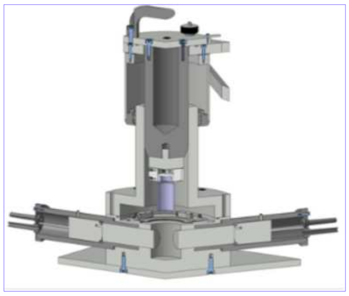


- Prismatic optical chamber (PTFE)
- Hamamatsu® R7600U-200 square miniature PMTs
- Piston-type sample loader
- Optical shutter

- Anode signals processed by CAEN® digitizer
- Amplitudes of pulses recorded in a file with timestamps
- Off-line processing by software
- Possibility to re-analyze the measurement with different parameters

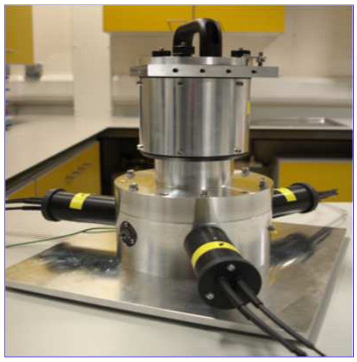


NPL

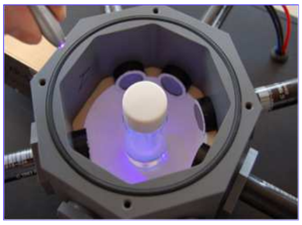


- Aluminium optical chamber coated with Spectraflect® reflective paint
- Hamamatsu® R6095 28 mm diameter PMTs
- Piston-type sample loader
- Optical shutter

- Anode signals amplified by Ortec® 474 fast amplifiers
- Coincidence and dead-time processing by the MAC3 coincidence unit (LNHB)
- External counters (PCI card)

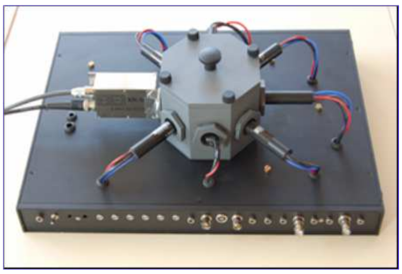


LNHB

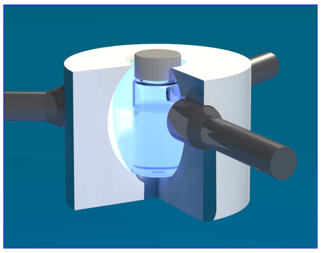


- Optical chamber coated with TiO_2 paint
- 6 Perkin-Elmer® channel PMTs
- Hamamatsu PMT (spectrometry)
- CdTe gamma detector and ^{241}Am source for Compton spectrometry

- FPGA-based coincidence module developed by LNHB
- On-line coincidence and dead-time processing
- Counters included for single, coincident and time signals
- USB link to PC



PTB



- Optical chamber made of highly reflective material (Gigahertz-Optik®)
- 3 Perkin-Elmer® channel PMTs
- Optical chamber and high-voltage modules installed in a compact box.

- FPGA-based coincidence module, 4KAM, developed by PTB with adjustable coincidence resolving time
- On-line processing
- Counters included for single, coincident and time signals
- Serial link to PC

Conclusion

Portable TDCR counters were developed at ENEA, LNHB, NPL and PTB, for in-situ measurements of low-energy beta emitters at a nuclear site. These systems will also be useful in other contexts, e.g. for the on-site measurement of short half-life radionuclides in production centers, or as a travelling metrological instrument for radionuclide activity intercomparisons. First validation measurements of these instruments show that they are adequate for the purpose and yield activity values similar to the ones obtained with primary measurement systems in use in NMIs. This action also gave the opportunity to extend the use of the TDCR method to more complicated decay-scheme radionuclides than pure beta emitters.

EMRP European Metrology Research Programme ▸ Programme of EURAMET

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