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DRAFT

High-efficiency photon detection systems for accurate radioactivity measurements

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Abstract: High-efficiency gamma-ray detectors with (almost) 4π geometry, e.g. a large well-type NaI(Tl) detector or two NaI(Tl) detectors sandwiching the radioactive source, have turned out to be very powerful instruments, particularly for the metrology of gamma-radiation emitting radionuclides with complex decay schemes incorporating coincident photon transitions, due to the summing properties of such a detector. For a few coincident gamma rays the efficiency approaches nearly 100% and the uncertainty becomes very small and generally independent of a knowledge of the precise values of the decay-scheme parameters. This quasi-direct technique for activity measurements on suitable single radionuclides is reviewed and examples of performance are summarised. Further, a short overview on other 4π methods based on the same principles is presented and the so-called bi-4π method is given some thoughts.

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Preface

The method of using a photon detector with high intrinsic and geometrical efficiency - 4π-γ counting or almost-4π γ counting - is a time-effective, relatively simple and cheap, highly accurate quasi-direct technique for standardising a series of gamma-ray emitting radionuclides, in particular those with cascading gamma-transitions in complex decay schemes exhibiting no direct transition from the parent nucleus to the ground-state of the daughter nucleus. With these nuclides the accuracy achieved is comparable, if not superior, to that obtained when employing, e.g., 4π(PC)-γ counting with "thin" sources, and much less time consuming. Depending on the radionuclide, uncertainties can approach 0.1%, just by simple integral counting above a low and reproducible discrimination level. Moreover, dealing with the 4π-γ technique features not only the high culture of (almost) "mass-less" source standardisation, but also shows its value for applied purposes. Thicker and extended solid samples, typically of several tenths of a millimetre up to 2 mm thickness, and up to many millimetres in diameter, and other volume sources such as solutions can be readily standardised by the 4π-γ technique without much loss in accuracy (Pavlik and Winkler, 1983).

Therefore, it was recommended by the Consultative Committee for Ionizing Radiation, CCRI Section II, Measurement of Radionuclides (at the Bureau International des Poids et Mesures (BIPM), Sèvres/Paris, France) that the author who acted as co-ordinator of a related working group, should present a summary paper about this technique. It is largely based on his own experiences with this method.