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A radionuclide calibrator based on Cherenkov counting for activity measurements of high-energy pure β^- -emitters

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Abstract

Due to their stability and reproducibility, re-entrant pressurized ionization chambers (also called radionuclide calibrators) are widely used for activity measurements in nuclear medicine services as well as in national metrology institutes to maintain reference standards. Generally, these secondary instruments yield accurate activity measurements for γ -emitting radionuclides. Ionization chambers are easy to use and thus well-adapted to guarantee the metrological traceability between national metrology institutes and end-users. However, the reproducibility of calibration factors can be significantly impaired when measuring high-energy pure β^- -emitters such as radiopharmaceuticals based on ^{90}Y . This is because the bremsstrahlung emission contributing to the instrument response is strongly dependent on the geometry of the components surrounding the radioactive solution. The present article describes a new design based on pulse counting to address this problem. It takes advantage of Cherenkov emission resulting from Compton scattering in transparent materials. The interest of Cherenkov counting is to obtain a low-sensitivity detector that enables direct measurements of high-activity solutions (at least up to 10 GBq for ^{90}Y -microspheres in aqueous suspensions used in nuclear medicine). A simple design based on a geometry close to an ionization chamber used at LNHB (Vinten 671 type) is described. The feasibility in terms of detection efficiencies (lower than 10^{-4} for ^{90}Y solutions) of the new radionuclide calibrator is investigated by Monte Carlo calculations using the Geant4 code.

Keywords

Ionization chambers; Radionuclide metrology; Metrological traceability; Cherenkov effect; High-energy pure β^- -emitters; Activity measurements.

1. Introduction

In the field of radionuclide metrology, re-entrant pressurized ionization chambers (also called radionuclide calibrators) are secondary instruments commonly used in national metrology institutes (NMIs) to maintain and to transfer reference standards of activity. These devices are also widely applied in nuclear medicine services for activity measurements of radiopharmaceuticals dedicated to diagnosis or therapeutic applications. Due to their stability and reproducibility, ionization chambers (ICs) represent a useful detection system to guarantee the metrological traceability of end-users' measurements to national activity standards (Zimmerman and Judge, 2007). At the international level, the Bureau des Poids et Mesures (BIPM) has in charge the equivalence of activity standards between NMIs through international comparisons. To this end, the Système International de Référence relies also on the use of a re-entrant IC since 1976 (Michotte, 2002, Ratel, 2007).

The IC principle remains unchanged since several decades (Schrader, 2007). The classical design consists in a gas-filled cylindrical vessel with a well at the centre of which containers (ampoules, vials, syringes, etc.) filled with radioactive solutions are placed to obtain measurements in quasi 4π geometry. The activity is determined by measuring an ionization current proportional to the energy

deposition rate of ionizing radiation in the gas medium. For that purpose, calibration factors need to be determined using radionuclide solutions traceable to primary standards in NMIs.

ICs are mostly sensitive to x or γ photon emission following radionuclide disintegrations. Thus, calibration factors with low uncertainties (less than 1%) and good reproducibility are currently obtained in NMIs for activity measurements of γ -emitters. But in the case of high-energy pure β^- -emitters such as ^{90}Y ($E_{\text{max}} \sim 2280 \text{ keV}$), the response of ICs predominantly relies on the detection of bremsstrahlung emitted along the track of beta particles in the container and its surroundings (e.g. source holder). The reproducibility of the measurements is then impaired by their higher sensitivity to variations in the geometrical characteristics of those components, e.g. container wall thickness.

In order to diminish the impact of such problems, the approach described in the present article is to implement pulse counting instead of measuring an ionization current. But then the possibility of counting saturation due to the high-activity of radioactive solutions must then be prevented (e.g. up to 10 GBq for ^{90}Y -microspheres in aqueous suspensions such as SIR-Spheres® (Sirtex, Australia)). In addition, it is intended to preserve most of the practical features of ICs: user-friendly instrument, use of the same containers for radioactive solutions (ampoules, vials, syringes, etc.), quasi 4π geometry. The solution presented here is to use a low-sensitivity detector based on Cherenkov light emission.

The paper first recalls the main characteristics of typical ICs applied as secondary instruments and the related problems when measuring high-energy pure β^- -emitters such as radiopharmaceuticals based on ^{90}Y . A description of the new design based on Cherenkov counting and the related advantages are exposed afterwards. Monte Carlo calculations using the Geant4 code (Agostinelli et al., 2003) are finally presented to give a first validation of the capability of the new radionuclide calibrator to measure the activity of ^{90}Y solutions up to 10 GBq with an appropriate low-detection efficiency.

2. Design of a new radionuclide calibrator based on Cherenkov counting

2.1. Problems related to activity measurements of high-energy pure β^- -emitters with ionization chambers

Typical re-entrant ICs (or radionuclide calibrators) operating in hospitals and in NMIs for activity measurements can be described as gas-filled vessels constructed with coaxial cylinders and equipped with a well at the centre of which radioactive solutions are placed. The dimensions of the detection system are generally chosen to obtain a quasi 4π detection geometry. For γ -emitting radionuclides, the mechanism of energy deposition leading to gas ionization is mostly due to the production of secondary electrons through Compton and photo-electric interactions in the gas and other elements (walls and electrodes). The voltage applied between the electrodes is set to reach a saturation current that minimizes the recombination of ion pairs and the effect of possible voltage fluctuations. As a result, the measured current is proportional to the radionuclide activity and the related calibration factor is determined by means of solutions of known activities of the same radionuclide, traceable to primary standards. These parameters are specific to the radionuclide calibrator used, and for a given instrument, to the geometry of the source. Accurate and reproducible activity measurements are usually achieved for γ -emitting radionuclides (associated uncertainties lower than 1%).

In the case of high-energy pure β^- -emitters, the ionization current results predominantly from the interaction of bremsstrahlung produced inside the container and its surroundings (e.g. source holder). The probability of direct interaction of beta particles in the gas medium is relatively low (depending on their energy). The variability of the energy deposition in the gas medium is thus mostly related the

possible variation of the parameters that influence the emission rate of bremsstrahlung photons and their energy distribution.

This issue has been largely discussed in the literature (Coursey et al., 1993, Santos et al., 2011, Fenwick et al., 2014). Recently, such a problem of reproducibility was observed for the IC calibration of ^{90}Y -labelled resin microspheres SIR-Spheres® developed for the treatment of liver tumors by radioembolization (~3 GBq injected to patients). Uncertainties up to 5% were reported on calibration factors due to the non-homogeneity of the vials provided by the manufacturer (Ferreira et al., 2016, Thiam et al., 2016).

2.2. Main characteristics of Cherenkov effect for its application in a radionuclide calibrator

As only a fraction of the deposited energy is needed to exceed a detection threshold, a pulse-mode counting can be implemented in the new transfer instrument to lower the variability of activity measurements for high-energy pure β^- -emitters. For instance, the pulse mode is applied at the BIPM for the SIR transfer instrument (SIRTI) to establish a link between the SIR and NMIs (Michotte et al., 2013) for short-lived radiopharmaceuticals ($^{99\text{m}}\text{Tc}$, ^{18}F). The SIRTI system is based on a well-type NaI(Tl) scintillation detector which is limited in terms of high-activity measurements due to its high sensitivity.

In order to allow high-activity measurements (up to 10 GBq for ^{90}Y solutions) using such a pulse-mode instrument, it is mandatory to have a low-sensitivity detector. As described in Fig. 1, the basic idea of the new design for a radionuclide calibrator is to replace the gas medium by a transparent dielectric material, and to measure Cherenkov photons which are produced in it by secondary electrons released following the interaction of bremsstrahlung.

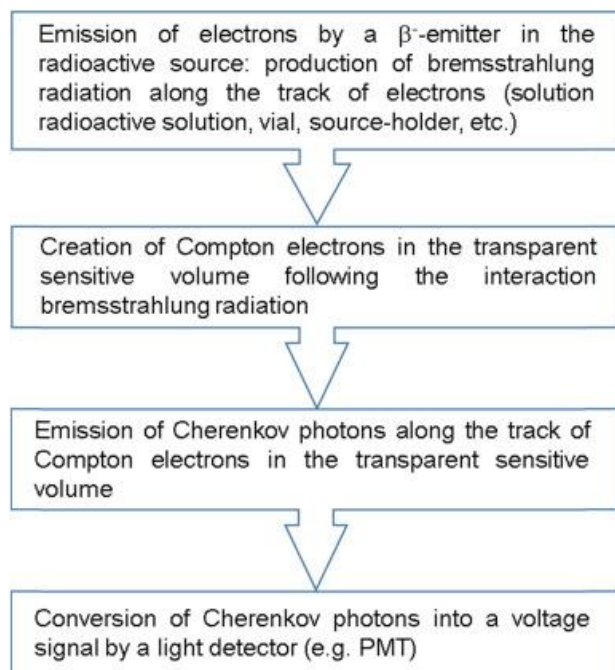


Fig. 1. Diagram describing the different interactions in the new design leading to the production of Cherenkov photons in a transparent material replacing the gas medium in ICs.

Cherenkov light is generated when a charged particle travels through a transparent dielectric medium with a speed greater than the phase velocity of light in that medium. The threshold condition of Cherenkov effect is given by the relation $n\beta > 1$ (where n is the refractive index of the medium; β is

the ratio of the velocity of the charged particle to the speed of light in vacuum). Cherenkov photons are emitted from the surface of a cone at an angle θ with respect to the path direction of the charged particle. The angle is defined by the following expression $\cos \theta = (n\beta)^{-1}$.

The minimum energy of electrons E_{th} (in keV) for Cherenkov emission depends on the refractive index of the medium and is obtained from special relativity:

$$E_{th} = 511 \cdot \left[\left(1 - \frac{1}{n^2} \right)^{-1/2} - 1 \right]$$

Refractive indices depend on the materials used as well as on photon wavelengths. In the case of fused silica, n is equal to 1.47 at the wavelength of 400 nm and yields a Cherenkov threshold of about 186 keV; at 200 nm, n is equal to 1.55, thus leading to a lower threshold (158 keV). Higher detection thresholds can be achieved with materials such as silica aerogels (Cantin et al., 1974) having refractive indices lower than 1.1 (corresponding to a Cherenkov threshold greater than 700 keV). Due to the continuous spectral bandwidth of the Cherenkov emission (predominant in the ultraviolet region and decreasing for visible wavelengths), the optical transmittance of the transparent material used has also an influence on the energy threshold. It is worth mentioning that the Cherenkov threshold can also be useful to prevent the counting of electrons emitted by decaying radionuclides and interacting directly with the sensitive part of the detector.

Here the aim is to take advantage of this Cherenkov threshold to obtain a low-sensitivity detector in order to prevent counting saturation for high-activity sources. In the case of pure β^- -emitters, other physical factors contribute to lower the detection efficiency: the low emission probability of bremsstrahlung, the radiative loss of energy representing a small fraction of the total energy loss of beta particles in matter; and the shape of the bremsstrahlung energy spectrum whose amplitude decreases continuously with increasing energy down to the end point.

It is worth noting here that the secondary electrons which are at the origin of Cherenkov emission are essentially produced by Compton interactions. Bremsstrahlung also interacts in the material by photo-electric effect, thus releasing photo-electrons. But if this effect is predominant at low energies, it becomes minor and even negligible at higher energies, in particular at energies above the Cherenkov threshold (typically around 200 keV). Therefore, compared to Compton electrons, photo-electrons have a negligible contribution to the production of Cherenkov photons.

2.3. Specifications for a radionuclide calibrator based on Cherenkov counting

Several parameters of the new design have an impact on the detection efficiency of the new system: geometry, refractive index and spectral transmittance of the transparent material that replaces the gas medium. The general specifications of the new detection system are to keep a geometry close to classical ICs used in NMIs and hospitals to enable activity measurements with the same containers, and to be as user-friendly as ICs for activity measurements. A simplified schematic of the new design is displayed in Fig. 2. A tube-shaped transparent material (glass, silica aerogels, etc.) is coated with a reflecting material and enclosed in a housing for protection against external parasitic light. The container filled with the radioactive solution installed in a source holder, is placed at the centre of the well. The source holder can be designed to maximise the attenuation of electrons moving out of the container so that only the bremsstrahlung created in the container and its surroundings can reach the sensitive volume (transparent material).

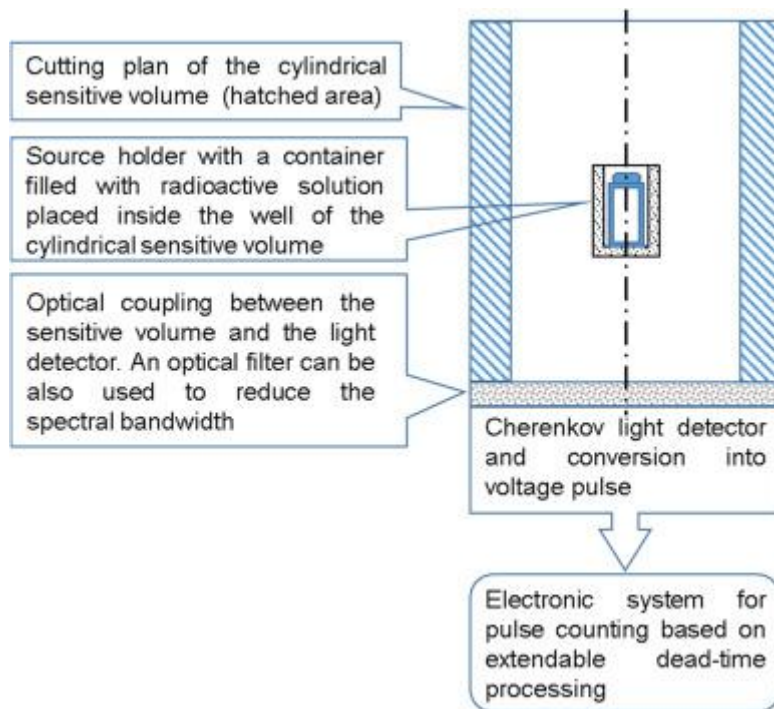


Fig. 2. Simple schematic of the new calibrator design based on Cherenkov counting.

Pulse counting can be implemented by collecting the Cherenkov photons converted into voltage pulses by means of a light detector (e.g. a photomultiplier tube (PMT)). The optical coupling with the light detector is used to optimize the collection of Cherenkov photons created in the tube-shaped sensitive volume. This part can also be used as an optical filter to reduce the spectral bandwidth of Cherenkov photons or as a wavelength shifter to match the spectral bandwidth to the spectral sensitivity of the light detector (e.g. PMT). This detector is coupled to a dedicated preamplifier whose shaping time is set according to the expected operating mode (spectrometry or timing). The associated electronic readout has to be designed to accept high counting rates (higher than $500 \text{ kcounts s}^{-1}$) with a good counting uncertainty ($\sim 0.1\%$). This specification can be fulfilled with pulse-processing systems operating with extendable dead-times incorporating the live-time technique such as those developed at LNH for primary measurements (Bouchard, 2000). This pulse processing can also be implemented using digital systems fed directly with the preamplifier stage (Bobin et al., 2014). The counting and dead-time processing is triggered by means of a detection threshold set above the noise level. Two PMTs set in timing mode can also be used for coincidence counting (for instance using a detection threshold set below the single photoelectron emission).

The duration of a measurement is directly related to the expected uncertainty, and then to the cumulated detected counts which depend on the counting rate in the Cherenkov detector and the dead-time length. According to Poisson statistics, 10^6 counts are at least required to reach a counting standard uncertainty equal to 0.1% . In the case of activity measurements of SIR-Spheres® ($\sim 3 \text{ GBq}$ before injection to the patient) using a Cherenkov detector with a detection efficiency of 10^{-4} and a dead-time length of $5 \mu\text{s}$, the minimum measurement duration is about 15 s. It is worth mentioning that corrections have to be considered for the combined effects of radioactive decay and live-time measurement in the case of short-lived radionuclides (Fitzgerald, 2016).

3. Monte Carlo calculations with the Geant4 code

The feasibility of the new design was validated (in particular in terms of expected detection efficiencies) by means of Monte Carlo calculations using the Geant4 simulation toolkit (Agostinelli et al., 2003) which provides all the packages useful for the transport of all particles mentioned in the diagram displayed in Fig. 1: the creation of bremsstrahlung by electrons in the container (solution and container wall) and its surroundings (source holder, housing), the diffusion of bremsstrahlung photons in the whole detector and their interactions in the sensitive transparent material by Compton scattering, creation of Cherenkov photons along the track of Compton electrons and their propagation towards a light detector (e.g. PMT) for subsequent counting. The transport of Cherenkov photons is made possible by defining the optical properties attached to each transparent element of the geometry modelling. The simulation construction results from the experience acquired during the studies related to TDCR-Cherenkov (Triple-to-Double Coincidence Ratio) measurements at LNHB (Thiam et al., 2010, Bobin et al., 2010). The modelling of the new design was investigated using common materials with known optical properties. The sensitive transparent element consists of a fused silica tube with dimensions similar to the Vinten 671 type IC (Thiam et al., 2016) used at LNHB (height: 360 mm; inner diameter: 102 mm; outer diameter: 122 mm). As depicted in the geometry modelling in Fig. 3, this part is enclosed in a black plastic housing made of Delrin® (polyoxymethylene, thickness: 15 mm). In order to optimize the collection of Cherenkov photons for pulse counting, a reflective Teflon® layer (thickness: 1 mm) is placed between the black housing and the glass tube. A fused silica disc (thickness: 15 mm) is placed at the bottom of the glass tube to ensure the optical coupling with a PMT window (diameter: 76 mm). For the present study, the optical properties of the XP2020Q PMT were attached to the PMT window including the photoemissive bialkali layer. The implementation of refraction and reflection processes at medium boundaries is based on the UNIFIED model (Levin and Moisan, 1996) using refractive indices defined according to photon wavelengths. No length attenuations are considered in fused silica but the optical bandwidth was taken into account in the Geant4 modelling. The low-wavelength cut-off at 160 nm is defined by fused silica properties and the limit for higher wavelengths is due to the sensitivity of the PMT photoemissive layer.

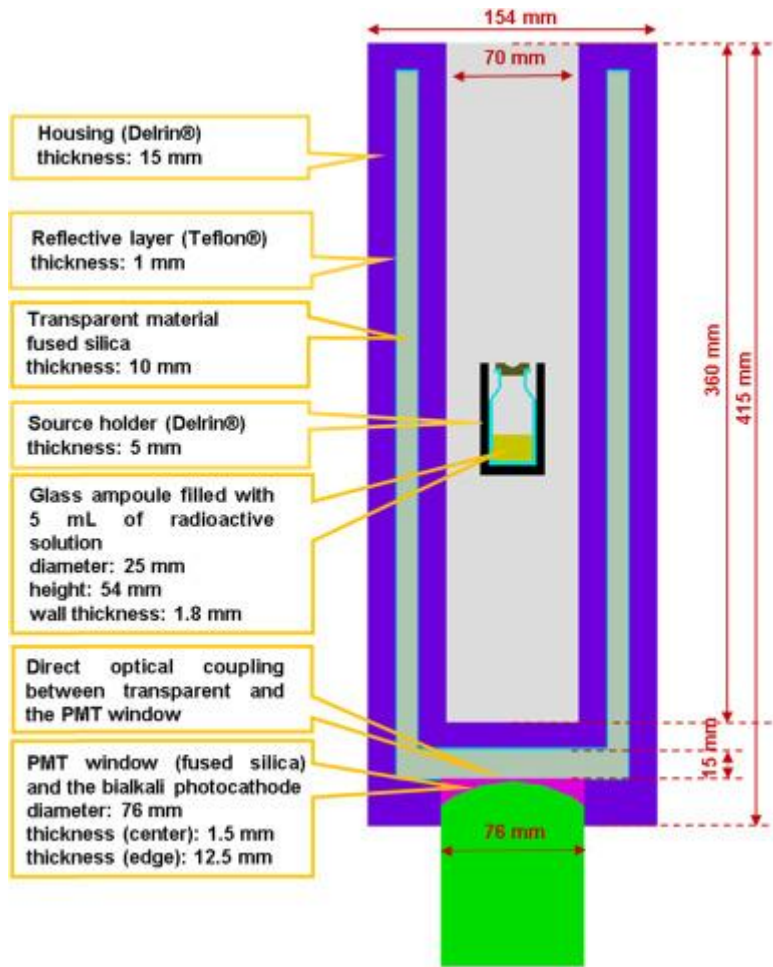


Fig. 3. Geometry modelling with a container (wall thickness: 1.8 mm) similar to the vials provided by Sirtex for SIR-Spheres®.

Using the UNIFIED model (Levin and Moisan, 1996), the surface of the fused silica element is defined as “polished” using a dispersive refractive index (1.47 at 400 nm). The interface between the fused silica and the Teflon® layer is modelled as a “dielectric-metal” boundary with a lambertian-type reflectivity of 95%. The PMT window (76 mm diameter) has the optical properties of fused silica. The bialkali photocathode is included in the simulation to calculate the number of Cherenkov photons refracted at the interface between the fused silica and the photoemissive layer. The associated physical properties are drawn from the literature: dispersive refractive index (Motta and Shönert, 2005; Harmer et al., 2006) and quantum efficiency as a function of wavelengths (Araújo et al., 1998).

Two types of containers used at LNHB (filled with 5 mL of aqueous solution) were considered in the Monte Carlo calculations. The simulations were implemented with a vial having a geometry (wall thickness: 1.8 mm, height: 54 mm, diameter: 25 mm) close to those used for SIR-Spheres®. As depicted in Fig. 4, the other container with a thinner wall is similar to specific glass ampoules used at LNHB for activity measurements in ICs (wall thickness: 0.6 mm, height: 85 mm, diameter: 18 mm). The Monte Carlo calculations were performed with a radioactive solution of ^{90}Y ($E_{\text{max}} \sim 2280$ keV), a high-energy β^- -emitter commonly used in nuclear medicine services. The geometry of source holders (Delrin®) was adapted to the dimensions of both containers using a wall thickness of 5 mm to absorb most of high-energy electrons moving out from the vials.

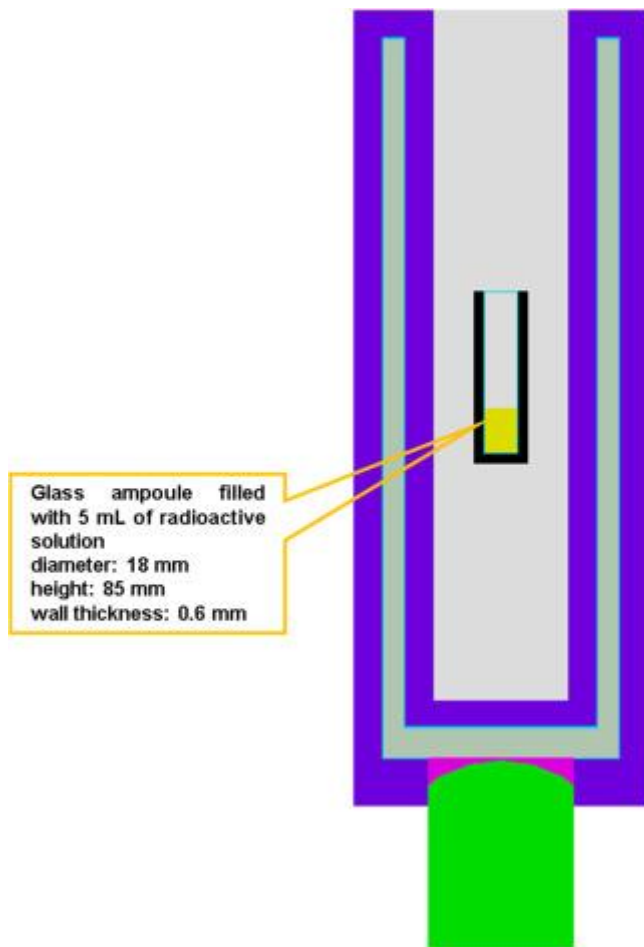


Fig. 4. Geometry modelling with a container (wall thickness: 0.6 mm) similar to the specific ampoules used at LNHB for activity measurement with ionization chambers.

Each simulated electron (with energies distributed according to the β -spectrum of ^{90}Y) is randomly generated in the 5-mL volume of aqueous solution. The transport of bremsstrahlung photons emitted along the electron track is considered in the different parts of the detector (radioactive solution, container, source holder). Cherenkov photons are emitted in the transparent materials along the path of Compton electrons resulting from the interactions of bremsstrahlung. The number of Cherenkov photons in a given spectral region is calculated from a Poisson distribution with a mean value determined from the Frank and Tamm (1937) theory. The simulation gives the number of photoelectrons calculated from the Cherenkov photons refracted at the bialkali photocathode using a binomial trial defined with the dispersive quantum efficiency given by Araújo et al. (1998) (~24% in the 300–400 nm region).

The Monte Carlo calculation results corresponding to the simulation of 10^8 primary electrons are presented in Table 1 for both containers.

Counting threshold (minimum number of PMT photoelectrons per counted pulse)	Detection efficiency	
	Container wall thickness: 1.8 mm	Container wall thickness: 0.6 mm
2	0.79×10^{-4}	0.79×10^{-4}
3	0.62×10^{-4}	0.61×10^{-4}
4	0.5×10^{-4}	0.49×10^{-4}
5	0.42×10^{-4}	0.41×10^{-4}
6	0.36×10^{-4}	0.35×10^{-4}
7	0.31×10^{-4}	0.3×10^{-4}
8	0.26×10^{-4}	0.26×10^{-4}
9	0.23×10^{-4}	0.23×10^{-4}
10	0.2×10^{-4}	0.2×10^{-4}

Table 1. Calculated detection efficiencies for two types of containers filled with 5 mL of ^{90}Y solution, expressed according to a counting threshold corresponding to the minimum number of PMT photoelectrons per counted pulse. The thickness of the source holder (Delrin®) is 5 mm.

The plots in Fig. 5 display the simulated energy distributions of the different types of ionizing radiation leading to the production of Cherenkov photons in fused silica: primary β -particles in the vial resulting from ^{90}Y disintegrations, bremsstrahlung and Compton electrons in the transparent material. This graph clearly shows that the energies of Compton electrons are largely distributed below the Cherenkov threshold (~ 140 keV). The calculated detection efficiencies are given according to the minimum number of photoelectrons produced at the photocathode which is considered as a detection threshold. The results clearly show that it is possible to obtain detection efficiencies lower than 10^{-4} making possible measurements of high-activity solutions up to 10 GBq in the case of ^{90}Y solutions. The detection efficiency can also be tuned by using a detection threshold adapted to the activity level in the container. It has to be pointed out that the detection efficiencies of both containers are very close. Conversely the response of the Vinten 671 type IC obtained with the LNHB ampoule is about 9 times higher than for a vial provided by Sirtex (Lourenço et al., 2015). The comparison of the Monte Carlo calculations obtained with both containers shows that the radionuclide calibrator based on Cherenkov counting is less sensitive to the wall thickness.

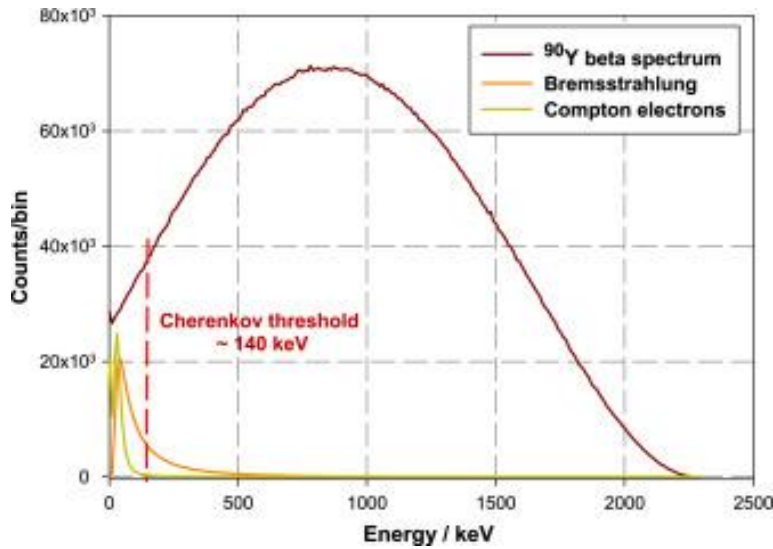


Fig. 5. Simulated energy distributions of the different types of ionization radiation leading to the creation of Cherenkov photons in the transparent material: primary β -particles (10^8 simulated events) in the vial (Sirtex), bremsstrahlung and Compton electrons in fused silica. The Cherenkov threshold is approximately equal to 140 keV.

The impact of the source-holder (Delrin®) was also investigated by reducing its thickness from 5 mm to 1 mm. As it can be observed in Table 2, this modification of the source-holder geometry has no significant impact on detection efficiencies.

Counting threshold (minimum number of PMT photoelectrons per counted pulse)	Detection efficiency	
	Container wall thickness: 1.8 mm	Container wall thickness: 0.6 mm
2	0.80×10^{-4}	0.80×10^{-4}
3	0.61×10^{-4}	0.62×10^{-4}
4	0.49×10^{-4}	0.51×10^{-4}
5	0.41×10^{-4}	0.43×10^{-4}
6	0.34×10^{-4}	0.36×10^{-4}
7	0.29×10^{-4}	0.31×10^{-4}

Table 2. Calculated detection efficiencies for two types of containers filled with 5 mL of ^{90}Y solution, expressed according to a counting threshold corresponding to the minimum number of PMT photoelectrons per counted pulse. The thickness of the source holder (Delrin®) is 1 mm.

The simulation results displayed in Table 3 correspond to a modified modelling in which fused silica was replaced by borosilicate (except the PMT window). In this configuration, the lower detection efficiencies (about 2 times compared with fused silica) are the result of the higher low-wavelength cut-off of borosilicate (~ 290 nm). Because refractive indices decrease according to photon wavelengths, the low-wavelength cut-off of borosilicate yields a higher Cherenkov threshold in the spectral bandwidth of the detection system.

Counting threshold (minimum number of PMT photoelectrons per counted pulse)	Detection efficiency	
	Container wall thickness: 1.8 mm	Container wall thickness: 0.6 mm
2	0.35×10^{-4}	0.34×10^{-4}
3	0.21×10^{-4}	0.21×10^{-4}
4	0.13×10^{-4}	0.14×10^{-4}
5	0.09×10^{-4}	0.1×10^{-4}
6	0.06×10^{-4}	0.07×10^{-4}
7	0.05×10^{-4}	0.05×10^{-4}

Table 3. Calculated detection efficiencies for two types of containers filled with 5 mL of ^{90}Y solution, expressed according to a counting threshold corresponding to the minimum number of PMT photoelectrons per counted pulse. Fused silica was replaced by borosilicate for the transparent material in the Cherenkov detector (except the PMT window). The thickness of the source holder (Delrin®) is 5 mm.

Monte Carlo calculations were also implemented with ^{18}F , a β^+ -emitter ($E_{\text{max}} \sim 634$ keV) applied in hospitals for PET imaging. The calculated detection efficiencies according to the minimum number of detected photoelectrons are presented in Table 4 (fused silica for the transparent material and source-holder thickness equal to 5 mm). Because of the emission of 511-keV photons due to electron-positron annihilation, the detection efficiencies are much higher than for the solution of ^{90}Y . Nevertheless, a detection threshold can be set to a level (for instance corresponding to at least 9 photoelectrons per pulse) that enables activity measurements of ^{18}F solutions with activities in the order of 1 GBq, corresponding to a value that complies with activities currently met in measurements for nuclear medicine applications.

Counting threshold (minimum number of PMT photoelectrons per counted pulse)	Detection efficiency	
	Container wall thickness: 1.8 mm	Container wall thickness: 0.6 mm
2	5.91×10^{-2}	6.1×10^{-2}
3	3.39×10^{-2}	3.51×10^{-2}
4	1.82×10^{-2}	1.88×10^{-2}
5	0.91×10^{-2}	0.95×10^{-2}
6	0.44×10^{-2}	0.46×10^{-2}
7	0.21×10^{-2}	0.22×10^{-2}
8	0.11×10^{-2}	0.12×10^{-2}
9	0.06×10^{-2}	0.07×10^{-2}
10	0.04×10^{-2}	0.04×10^{-2}

Table 4. Calculated detection efficiencies for two types of containers filled with 5 mL of ^{18}F solution, expressed according to a counting threshold corresponding to the minimum number of PMT photoelectrons per counted pulse. The thickness of the source holder (Delrin®) is 5 mm.

4. Conclusion

A new design of a radionuclide calibrator based on Cherenkov counting was presented as an alternative to ICs used in NMIs or hospitals. The objective is the development of a new detector dedicated to activity measurements of high-energy pure β^- -emitters (such as ^{90}Y radioactive solutions) that yields lower sensitivity to geometry dependence of bremsstrahlung radiation. To this end, the new detection system was designed to operate in pulse-mode counting using Cherenkov emission produced in a transparent material (replacing the gas medium in ICs). The aim is to take advantage of Cherenkov threshold to obtain a low-sensitivity detector in order to prevent counting saturation in the case high-activity measurements (greater than 1 GBq). The range of detection efficiencies is directly related to the optical properties of the transparent material where the Cherenkov emission is produced. A first validation of the feasibility was given by means of Monte Carlo calculations in the case of ^{90}Y solutions. For that purpose, a simple design was modelled using common glass materials (fused silica, borosilicate) in which Cherenkov effect takes place. The modelling geometry is close to the Vinten 671 type IC used at LNHB in order to enable activity measurements with usual containers (vials, ampoules, syringes, etc.). The results of Monte Carlo calculations have shown that a low-sensitivity detector based on Cherenkov counting can be built to enable activity measurements of ^{90}Y radioactive solutions up to 10 GBq. Moreover simulations performed with two types of containers (having two different wall thicknesses: 1.8 mm and 0.6 mm) have demonstrated that the new design is less sensitive the variation of wall thickness than the Vinten 671 type IC used at LNHB. Further work is underway to study the possible applications of this new design to other radionuclides and to realize and test a first prototype of this instrument. The measurement limitations for low activities will be studied. For instance, the counting rate related to background will be investigated to assess the total range of activities that can be measured with the new radionuclide calibrator. The linearity at high counting rates of the dead-time processing will also be tested for the reliability of high-activity measurements.

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