Accurate simulation of the radioluminescence induced in the air (resp. nitrogen) by an alpha-particle emitted from a planar, two-dimensional radionuclide-based sample applying a purely optical radiation-based device

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Basic Requirements:

1. Quasi-monochromatic optical sources emitting in the ultraviolet (UV) spectral range, the wavelength must match with one or more radioluminescence emission lines
2. Large area optical radiation source (to mimic the planar radioactive sample), with isotropic optical emitting properties ("Lambertian" emitter)
3. Variable optical output with a large dynamic range to simulate different radioactive decay activity levels

UV light-emitting diodes (LEDs) emitting at 260 nm and 340 nm were identified as optical radiation sources to fulfill requirement 1 (Figure 1).

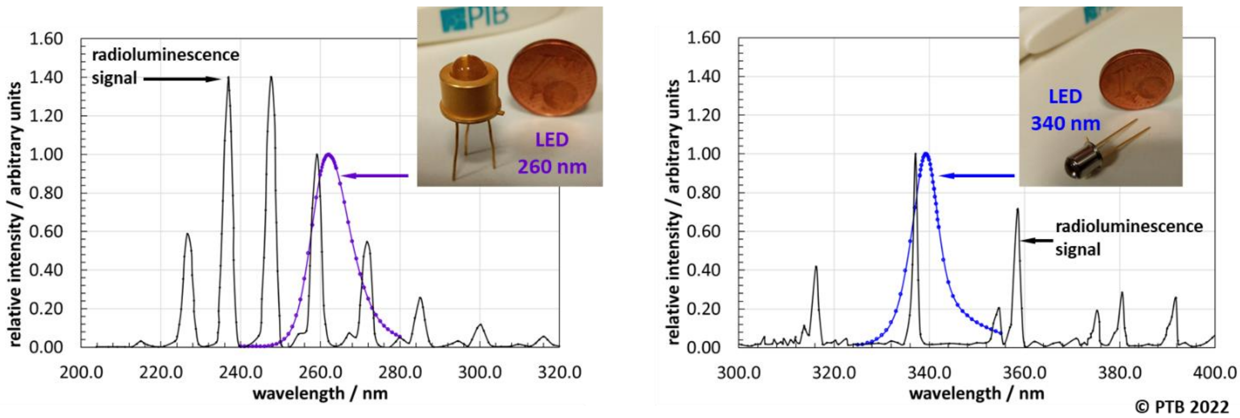

Figure 1: Radioluminescence optical radiation spectrum in the ultraviolet (UV) wavelength spectral range induced in the air by alpha-particles together with the emitted optical radiation by selected UV-LED radiation sources.

However, regarding requirement 2, the application of UV-LEDs is detrimental in terms of their geometrical radiation properties. The available UV-LEDs are point-like sources with a directional emitting pattern. Additionally, the adjustability of the LED optical output via the LED electrical current is possible only in a very limited range, hence requirement 3 becomes difficult to achieve.

One of the possible optical devices which can be used for the transformation of a point-like, directional radiation source into a large area uniform and diffuse optical emitter is an integrating sphere. In the most basic configuration, the integrating sphere has two ports. On port serves as input for the optical directional radiation (ex. the LED) whereas the second port is the output for the diffuse radiation (Figure 2).

To fulfill requirement 3, a first try option would be placing a variable aperture between the LED and the input port. As LEDs are point-like sources, this is not a feasible option in terms of reproducibility. Adding a 2nd integrating sphere to the setup and mounting a variable aperture in-between the output port resp. the input port of the two integrating spheres enables one to continuously and reproducible set the optical radiation output.

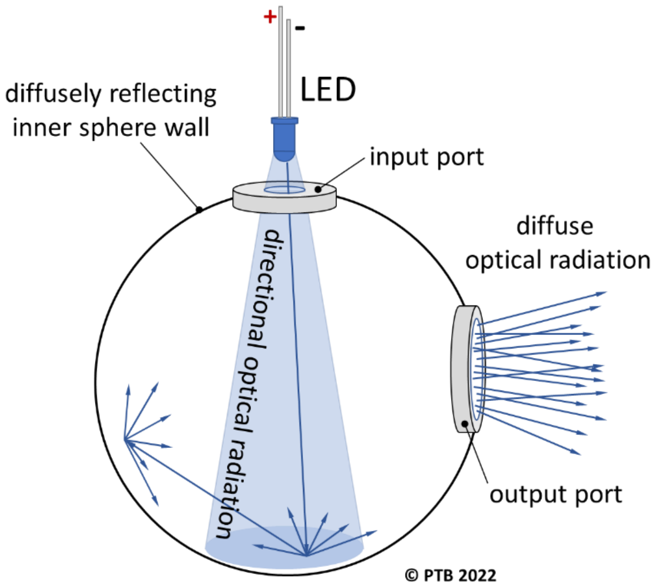

Figure 2: Integrating sphere: optical device for transforming a point-like, directionally emitting optical radiation source (e.g. an LED) into a large-area, diffuse, and homogenous emitting optical radiation source.

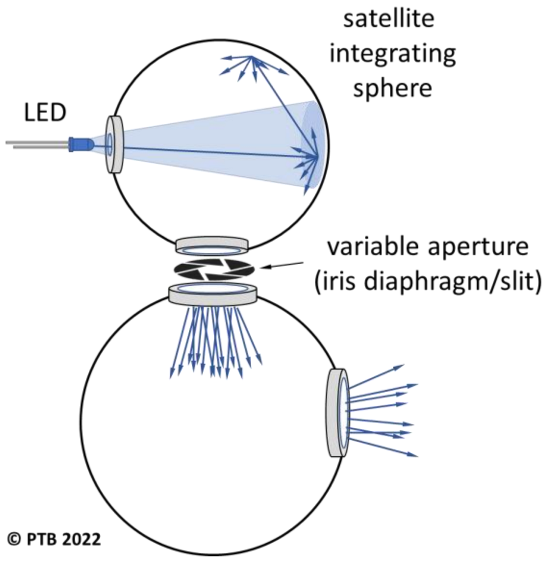

Figure 3: Combination of two integrating spheres with a variable aperture between the output port of the satellite integrating sphere and input port of the 2nd integrating sphere: method to obtain a reproducible, variable output optical radiation source