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SGMDA Software Guide

The SGMDA software (Fig. 1) is an open-source tool designed to simulate the behavior of non-portable Geiger-Mülle detectors. This first version was developed to evaluate the performance of these detectors based on various parameters and in the presence of radioactive sources emitting gamma radiation.

Future versions will also include the simulation of beta and alpha particle detection, enabling a more comprehensive modeling of detection phenomena.

The primary goal of SGMDA development is to provide an educational tool for studying gamma radiation attenuation in materials. Additionally, it aims to simulate the operation of Geiger-Müller detectors by varying several parameters, such as gas type, temperature, pressure, and other conditions affecting their performance.

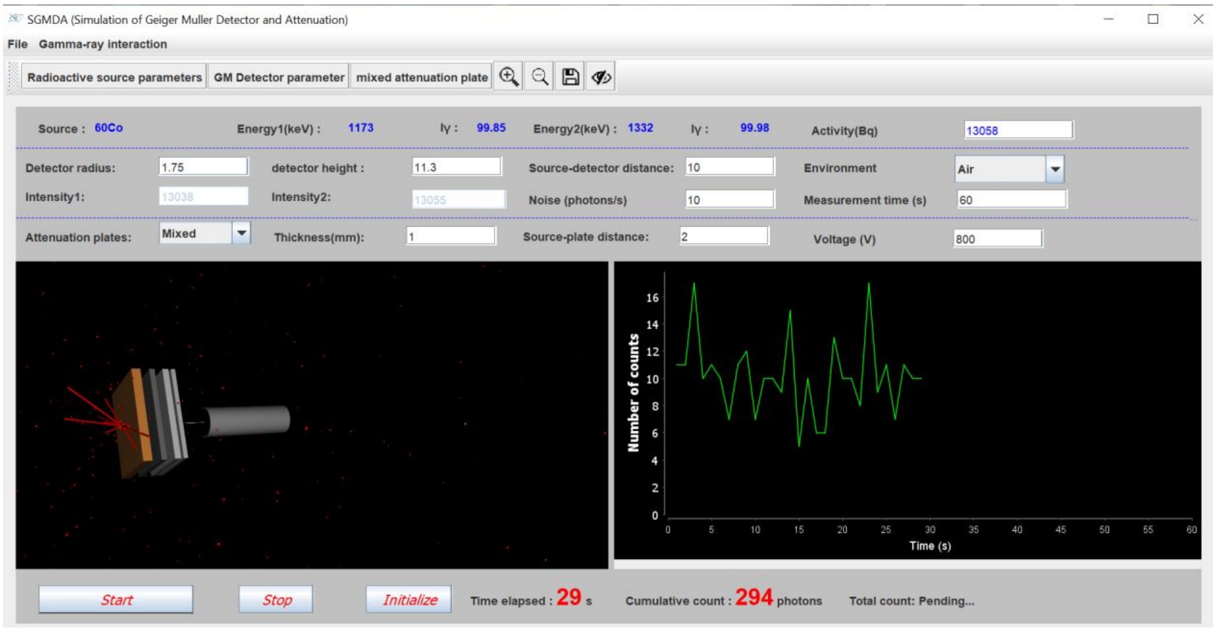

Fig. 1 The graphical interface of the SGMDA software

At the top of the software interface, there is the "File" menu (Fig. 2), which contains several submenus providing access to essential features.

- "**Radioactive sources parameters**": This submenu allows modifying or selecting all parameters related to the radioactive source used in the analysis.

- "**Detector (GM) parameters**": It includes all configurable parameters related to the Geiger-Müller detector, enabling adjustments according to specific needs.

- "**Mixed attenuation plate**": This submenu allows selecting the attenuation plates to be used for studying the absorption of gamma rays through different materials.

- "**Exit**": This option allows closing the software and safely exiting the application.

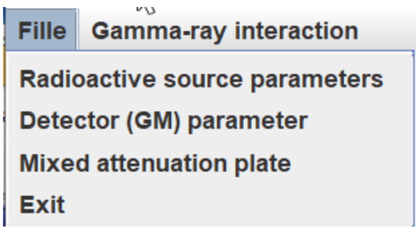

Fig. 2 The File Menu and its submenus

Another menu called "**Gamma-ray interaction**" is present in the software interface (Fig. 3) but is not yet functional in this version.

The next version of the software will be fully operational and will allow the study of gamma spectroscopy, this time using an HPGe semiconductor detector for more precise and detailed analysis.

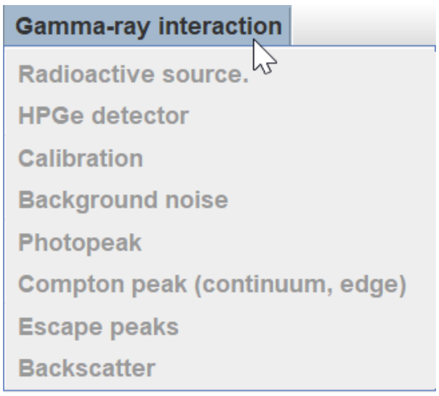

Fig. 3 Gamma-ray Interaction Menu

To simplify the use of the SGMDA software, the submenus of the "File" Menu are presented in the form of shortcut buttons (Fig. 4). These buttons allow quick access to the main features without having to navigate through dropdown menus.

In addition to these shortcuts, the interface also includes buttons for common actions such as zooming and unzooming, thus offering better visualization of the 3D graphs.

Other essential features are also accessible through specific buttons, including saving and printing the results.

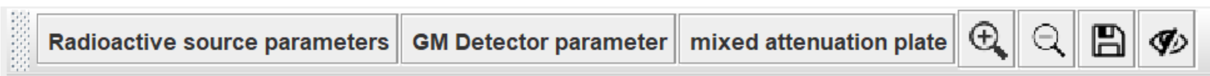

Fig. 4 The submenus of the File menu in the form of buttons

A single click on the "Radioactive sources parameters" button will display a window containing the parameters of the radioactive source (Fig. 5). This window allows the user to manipulate the chosen radioactive source for studying the Geiger-Müller detector and also for studying the attenuation of gamma radiation.

The interface of this window is designed to easily manage the different parameters of the source, thus facilitating the study of interactions between the radiation and the detector. Additionally, it provides tools to adjust the parameters according to the analysis needs.

However, it is important to note that this first version of the software does not function properly when beta or alpha particles are involved, limiting the study in these specific configurations.

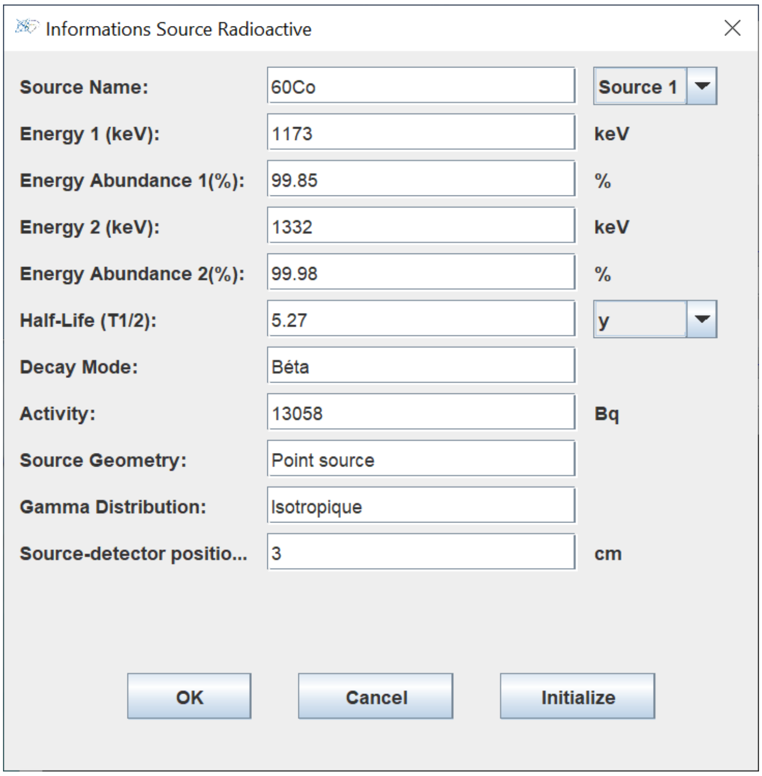

Fig. 5 Window of the radioactive source parameters to be used

The software already offers three examples of radioactive sources to use, providing a base for initial analyses. These sources include 137Cs, 60Co, and 133Ba (Fig. 6), each with specific characteristics that allow the study of various interactions with the detector and attenuation materials.

These examples are pre-configured in the software, making it easier for the user to quickly start simulations without manually entering the radioactive source parameters. The inclusion of these commonly used sources in gamma analyses also simplifies the calibration and testing phase of the detector.

The software also provides the user with the option to use other radioactive sources by modifying fields such as energy, abundance, activity, etc. This offers great flexibility in choosing sources for analyses tailored to specific conditions or more complex studies.

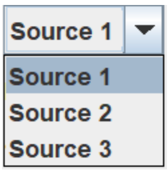

Fig. 6 Radioactive sources suggested by the software

Regarding the second button "Detector (GM) parameters", a single click will display a window specifically dedicated to the Geiger-Müller detector parameters (Fig. 7). This window gathers a wide range of parameters, from the detector length to the dead time, allowing full management of the detector's characteristics.

The user has the ability to modify all these parameters, providing great flexibility to observe their effects on the counting rate. For example, modifying the detector length can influence its ability to detect radiation, while the dead time affects the detector's response to fast pulses.

With this feature, the user can explore different configurations and better understand how adjustments to the detector parameters impact the accuracy and sensitivity of the measurements.

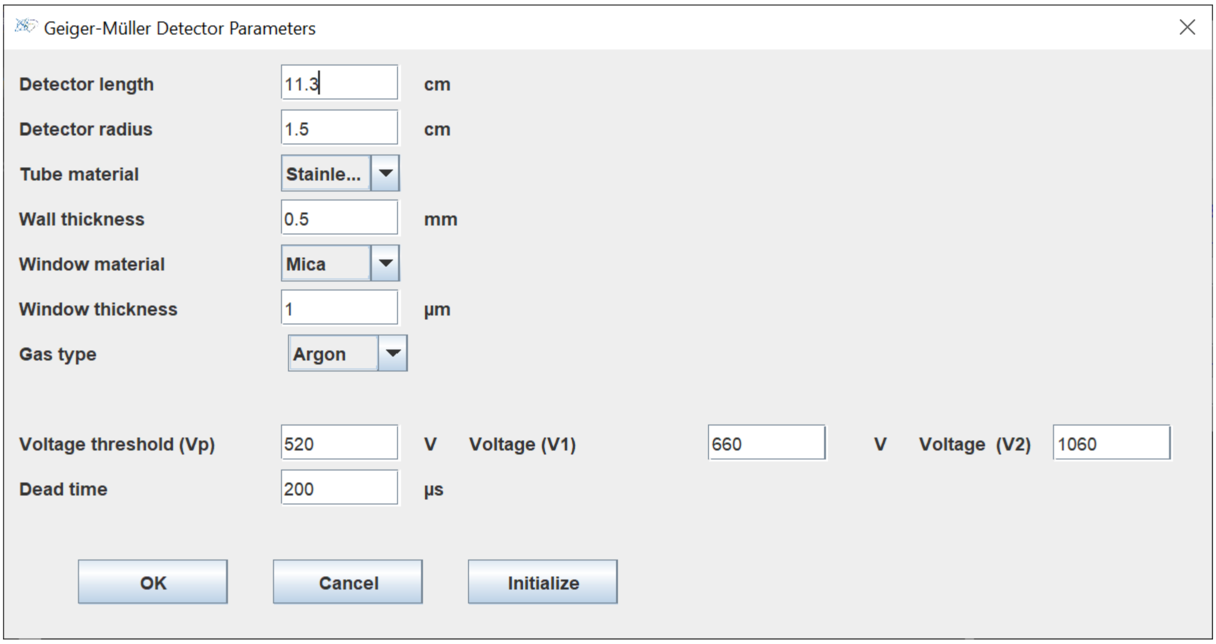

Fig. 7 Window designed for Geiger-Müller detector parameters

Currently, two detector tube materials are available to the user: "Glass" and "Stainless Steel" (Fig. 8). These materials have been chosen based on their specific properties that influence the performance and sensitivity of the detector.

Glass is a commonly used material for its transparency and low cost characteristics, making it suitable for general applications. It is particularly used for low to medium energy detectors, offering good radiation response while being relatively lightweight.

On the other hand, stainless steel is a more robust and resistant material, often preferred for applications requiring better durability and increased protection against harsh environmental conditions. It is generally used in environments where higher radiation levels are present, as it offers better protection and longer detector life.

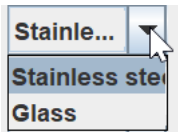

Fig. 8 Geiger-Müller detector tube material

At the detector entrance, the user has the option to choose between "Mica" or "Glass"(Fig. 9) based on their specific needs, and to select the desired thickness for each material. This option allows for customization of the detector according to the experiment requirements and the type of radiation to be measured.

Mica is a material often used for its low mass and transparency to radiation, making it an ideal choice for detectors where measurement accuracy is crucial. It provides a fast response to low-energy radiation while offering excellent efficiency for specific detection ranges.

Glass, on the other hand, offers better mechanical strength and is used in applications requiring greater durability. Depending on the chosen thickness, glass can be adjusted to optimize radiation absorption and the detector's lifespan. This flexibility allows the user to adapt to various types of experiments while ensuring optimal performance.

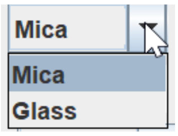

Fig. 9 Select the type of material at the detector entrance.

Regarding the detector gas, the software offers six types of gases to choose from: "Xenon", "Argon", "Neon", "Helium", and finally "Krypton" (Fig. 10). These gases are the most commonly used and recognized in Geiger-Müller detectors for their specific properties that influence detection performance.

Xenon, for example, is a noble gas that provides excellent response to ionizing radiation, particularly for high-energy radiation. It is often used in applications requiring high sensitivity and fast response to charged particles.

Argon and Neon are also noble gases, used in specific configurations to offer better detection efficiency while minimizing interference from other types of radiation. **Helium**, on the other hand, is a light gas used in situations where a rapid response is crucial, especially for detecting low levels of radiation.

Krypton is also included for its properties that offer a good balance between sensitivity and stability of measurements under various experimental conditions. These gases are selected based on the specific requirements of the detector and the type of radiation to be measured, providing the user with a wide range of options to optimize the performance of their detection device.

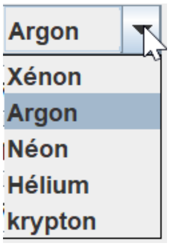

Fig. 10 The gases to be used in the detector tube

The third button is also dedicated to the study of gamma-ray attenuation in certain materials. This module of the software allows the user to simulate the attenuation of gamma radiation in six different materials: "Lead", "Aluminum", "Copper", "Iron", "Barium" and "Cadmium" (Fig. 11). These materials have been selected for their specific radiation absorption properties, making them particularly useful in gamma detection experiments.

The user has the option to study each material individually, allowing them to observe in detail how each material influences gamma-ray attenuation based on the chosen thickness and the frequency of radiation. This offers an in-depth understanding of the behavior of radiation interacting with different materials.

Additionally, the software also allows the user to position these materials in sequence to simulate complex environments where multiple layers of materials can be used to study the cumulative attenuation of gamma radiation. This can be particularly useful in applications where multiple materials are involved, such as radiation shielding studies or industrial environments where material combinations are used to control radiation exposure.

This module thus provides the user with the flexibility to explore various configurations and better understand the effectiveness of each material in gamma-ray attenuation.

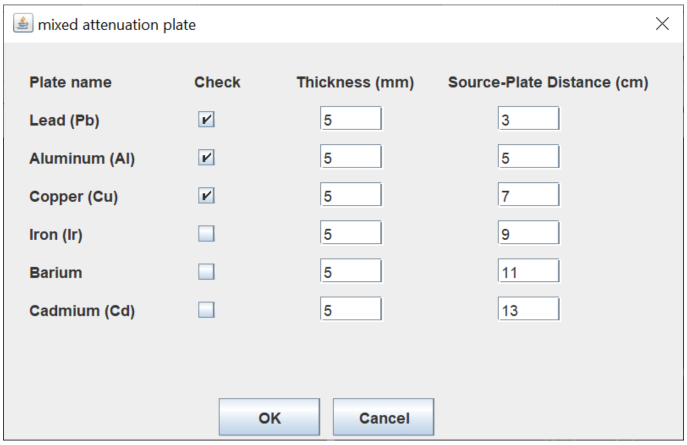

Fig. 11 Window to simulate the attenuation of gamma radiation in certain materials

The software operation requires first selecting the radioactive source via the first button and then choosing the detector through the second button. These steps are essential for the software to begin the measurements correctly. Once these parameters are set, the software can start the simulation and provide accurate results. Fig. 12 shows part of the graphical interface dedicated to displaying certain information, such as the selected radioactive source, its energies, abundances, activity, and other relevant parameters related to the detector.

This section of the interface allows the user to view essential information in one place, without needing to navigate through the source, detector, or plate parameter windows. The user can track real-time changes and adjustments to the parameters, which greatly simplifies the software's use. Additionally, options are provided for the user to modify certain parameters directly from this interface without having to return to the dedicated windows, offering better fluidity and efficiency in managing simulations and measurements. This helps save time and optimize the analysis process.

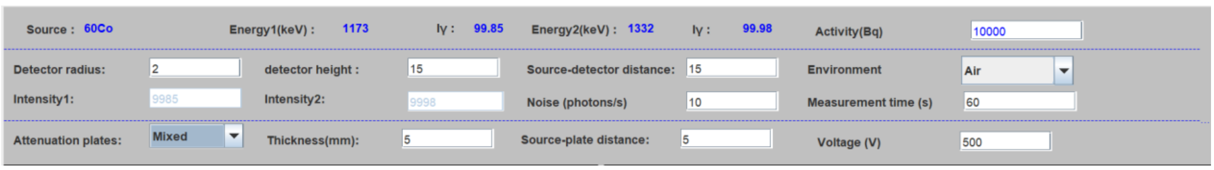

Fig. 12 Section reserved for certain information and parameter modifications.

The previous section also includes options to select the voltage and measurement time. These settings are crucial for ensuring the accuracy of the measurements and adapting to the specific conditions of the experiment. The user also has the option to select the background noise or choose to perform the measurement without background noise, depending on the requirements of the study. This allows for simulating different experimental conditions and adjusting the parameters to obtain more specific and reliable results. Fig. 13 illustrates this feature, highlighting the available choices for adjusting these settings.

Additionally, the section presents an option where the user can select the plates used to simulate the attenuation of gamma rays in the material. This choice is essential for studying the impact of specific materials on gamma radiation attenuation, based on the thickness and type of material used. The ability to simulate measurements with or without plates allows the user to test different configurations, examining how the presence or absence of plates influences the results. Fig. 14 shows this option, giving the user the flexibility to perform plate simulations, incorporating or excluding materials for gamma-ray attenuation.

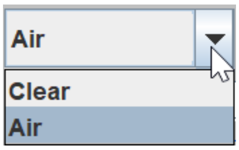

Fig. 13 Option to choose measurement with or without background noise.

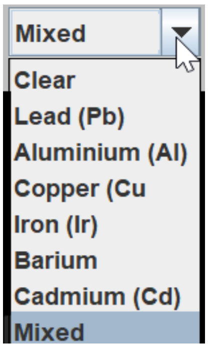

Fig. 14 Option to select or deselect material plates.

Fig. 15 illustrates the 3D graphical representation of the entire setup, including the radioactive source, the plates to be studied, and the Geiger Muller detector. This graph allows the user to visualize the interaction between these elements in a 3D environment, providing a clear and detailed perspective of the arrangement of components. The red points in the graph represent the energies emitted by the radioactive source, helping to visualize the radiation emitted into the surrounding space. The green points, on the other hand, represent the background noise, an important factor to consider when analyzing the accuracy of the measurements taken by the detector.

This graph was specifically designed to clarify and facilitate the understanding of the parameters used in the simulation. It allows distinguishing the different sources of information, whether they come from the radioactive source, the material plates being studied, or the detector. With this 3D representation, the user can better understand the interactions between these elements and adjust the parameters accordingly to refine the results.

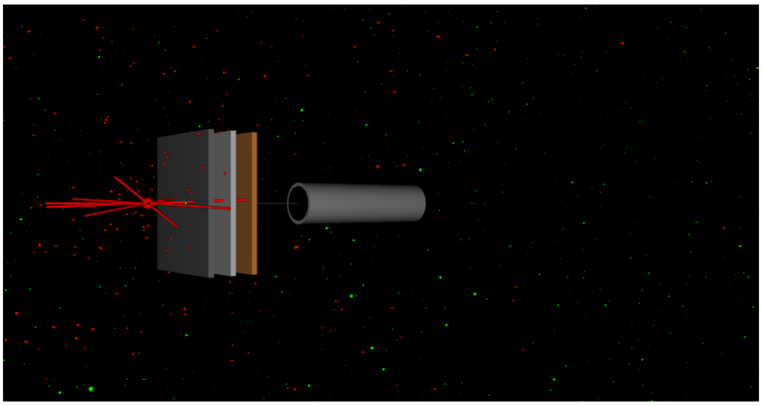

Fig. 15 3D graph to visualize the entire equipment setup.

Fig. 16 represents a graph depicting real-time counting, where the user can dynamically track the variation in the counting rate and gain a clear visual representation of the counting process. This graph is designed to provide a continuous view of the detector's activity, allowing the user to see fluctuations in the counts over time as the data is acquired. This real-time visualization is crucial for quickly assessing the detector's performance and for adjusting parameters as needed to optimize measurements.

The graph clearly and intuitively displays the variations in the counting rate, allowing the user to easily interpret the data collected. By showing this information continuously, the user can observe trends and potential anomalies, providing direct control over the ongoing experiment. This also allows for real-time decision-making to enhance measurement accuracy or adjust experimental conditions as necessary.

This graph is an essential tool for effective monitoring of the counting process, offering the user a transparent view of the detector's performance during data acquisition. It ensures precise, real-time management of experimental parameters, which is vital for reliable and reproducible results.

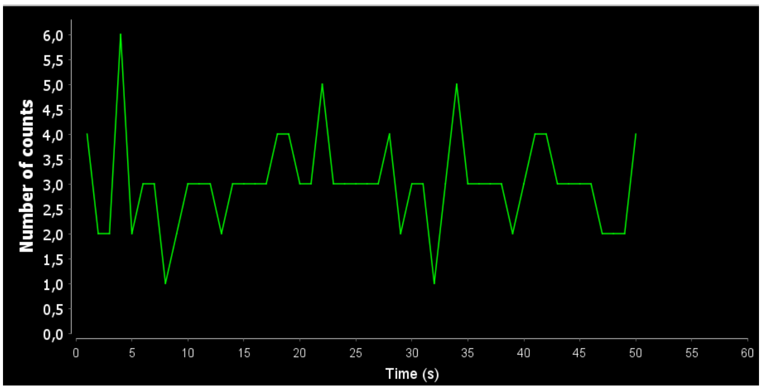

Fig. 16 Real-time counting variation graph.

When the user right-clicks on the graph (Fig. 17), several options appear. These allow adjusting the graph, saving it in different formats, printing it, or changing its colors.

The zoom and dezoom functions are also available. Additionally, the user can select a part of the graph directly with the mouse.

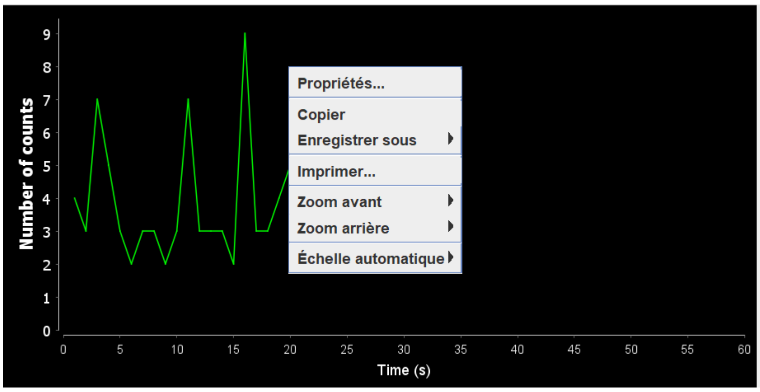

Fig. 17: Options to adjust the graph.

At the bottom of the software, the user has a red "Start" button to begin the measurement (Fig. 18). Once the button is pressed, the software starts the measurement process, and the user can track the elapsed time and real-time measurement results. The time elapsed and the measurement results are continuously updated and displayed during the process. This allows the user to monitor the progress of the measurement accurately and in real-time. The information is presented clearly and concisely for easy understanding.

The "Stop" button allows the user to stop the measurement at any time, enabling them to restart it with different parameters without waiting for the allocated time to end. This way, they can save time and perform multiple other measurements with different parameters.

When the measurement time is complete, the counting results are immediately displayed in two distinct places on the interface. The first display of the results appears at the bottom right of the software, providing a quick view of the final count. The second display appears in a window that automatically pops up as soon as the measurement time ends (Fig. 19), ensuring that the results are visible and easily accessible to the user. This simultaneous display guarantees that the user can view the results immediately after the measurement is finished.

The software also offers an "Initialize" button to reset the results to zero. However, the user is not required to reset the results manually, as the software automatically does this after each measurement, ensuring continuous tracking of new data without any additional intervention. This simplifies the user experience, allowing each new measurement to begin with fresh data without the need for manual resetting.

Fig. 18 Section for starting, tracking, and displaying results.

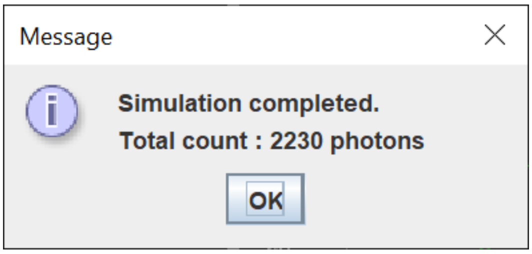

Fig. 19 Measurement result display window.