# Assessment of Scattering Contribution in Activity Measurements of $^{60}$Co Teletherapy Sources Using Geant4 and Garfield++

Mohammed Salim M[1],* T. M. Ashraf[2], Amalkrishna A M[1], and Adila J[1]
[1] *Department of Physics, TKM College of Arts and Science, Kollam-5, 691005, India and*
[2] *Regional Centre (RAPPCOF), Board of Radiation and Isotope Technology, Kota, Rajasthan, India*

## Introduction

High-intensity $^{60}$Co sealed sources are widely utilized in medical, agricultural, and industrial applications. The activity of $^{60}$Co Teletherapy Sources (CTS) measured inside a shielded environment known as a hot-cell. This facility is used for fabricating $^{60}$Co sealed sources from cobalt pellets and slugs.

A significant challenge in activity measurement is the contribution of scattered radiation, which can lead to an overestimation of the actual source activity. This study aims to quantify the scattering contribution from $^{60}$Co teletherapy sealed sources manufactured at BRIT's hot-cell. To address this, Geant4 [1] simulations, interfaced with Garfield++ [2], were employed to estimate the scattering contributions.

The primary objective of this study is to assess and quantify the impact of scattered radiation on activity measurements within the hot-cell environment, which may result in an overestimation of the source activity. The scattering contributions were measured experimentally and validated through simulations using Geant4 and Garfield++.

## Simulation and Methods:

The simulation setup for assessing scattering contributions in activity measurements of $^{60}$Co teletherapy sources utilized a hybrid approach integrating Geant4 and Garfield++. Geant4 was employed to simulate the primary interactions of gamma photons from the $^{60}$Co source, tracking their scattering behavior at the characteristic energies of 1.17 MeV and 1.33 MeV. For a detailed analysis of electron transport and charge collection, Garfield++ was used, focusing on ionization processes within a gas-filled detector. The experimental setup was designed to replicate real-world conditions, incorporating shielding materials and detectors to capture both direct and scattered photon interactions. The measurements were conducted within a hot cell specifically designed for handling radioactive materials, featuring dimensions of 2.4 m $\times$ 2.4 m $\times$ 4.8 m and fortified with 1.9 m thick high-density reinforced cement concrete walls. This robust shielding minimizes external radiation interference, ensuring precise data collection. .

Fig.1 shows the experimental setup and simulated particle trajectories in Geant4. Geant4 simulations were carried out in two distinct setups to assess scattering contributions. Initially, a beam of gamma radiation from the $^{60}$Co source was simulated to interact with the hot-cell environment, including its walls, floor, ceiling, and other objects. This setup allowed both primary and scattered radiation to reach a detector positioned 2545 mm away from the source, with the charge collected reflecting the combined effects of primary and scattered radiation. In the second setup, a 300 mm high lead cone was used to block the primary radiation while maintaining the same source-detector geometry. This configuration ensured that only scattered radiation reached the detector. The charge collected in this setup provided a measurement of the scattered radiation component. Data from these simulations were subsequently used to calculate the percentage of scattering contribution within the hot-cell environment.

*Electronic address: msalimvkd@tkmcas.ac.in

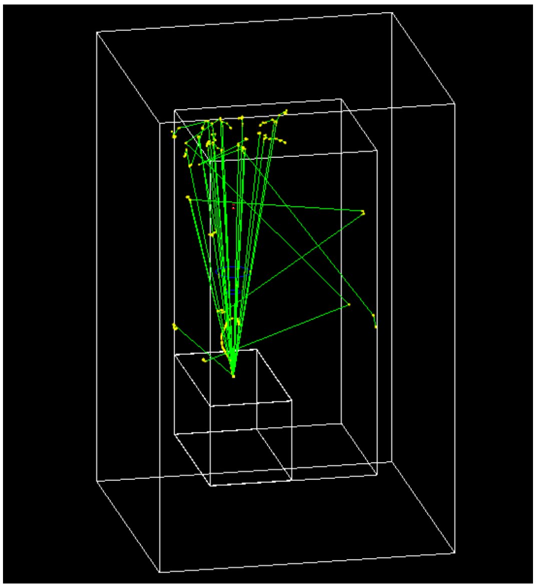

FIG. 1: Experimental setup and simulated particle trajectories in Geant4.

The combined Geant4 and Garfield++ approach enabled a comprehensive assessment of scattering effects, which is crucial for accurate activity measurements of high-energy gamma sources like $^{60}$Co .

## Results and Discussion

The simulation was conducted for three specific activities: 0.1 Curie, 0.2 Curie, and 0.25 Curie to assess the scattering contributions in activity measurements of $^{60}$Co sources. The simulated percentage scattering for these activities was 12.167%, 12.154%, and 11.97%, respectively, indicating that the percentage of scattering remains consistently around 12% across the tested activity levels. This finding aligns closely with experimental data collected under similar conditions. Additionally, results from Monte Carlo N-Particle (MCNP) simulations also corroborate this percentage scattering [3], further validating our observations. While the simulations successfully captured the scattering behavior, they were restricted to relatively low-activity sources due to computational limitations. By contrast, experiments conducted at the Board of Radiation and Isotope Technology (BRIT) involved $^{60}$Co sealed sources with much higher activities, ranging from 1 kilo Curie to 10 kilo Curie [3]. The strong agreement between our simulations, MCNP data, and experimental findings underscores the reliability of the Geant4-Garfield++ framework for predicting scattering behavior. However, the need to extend the simulation to accommodate higher activity levels remains a priority. Future work will focus on improving computational efficiency to simulate higher activity sources, allowing for more accurate assessments that are crucial for industrial and medical applications involving high-energy gamma sources such as $^{60}$Co.

## References


[1] GEANT4: “A simulation toolkit”, S. Agostinelli, and others. Nucl. Instrum. Meth., (2003), https://geant4.web.cern.ch/

[2] H. Schindler, R. Veenhof, Garfield++ “simulation of ionization based tracking detectors”, 2018, https://garfieldpp.web.cern.ch/garfieldpp/

[3] R. S. Vishwakarma et.al,“ESTIMATION OF PERCENTAGE SCATTERING CONTRIBUTION IN ACTIVITY MEASUREMENT OF $^{60}$Co TELETHERAPY SOURCES”,Journal of Medical Physics, Volume 42, Supplement 1, 2017