The Performance of Gaseous Electron Multiplier Preamplifiers (GEM) as a Neutron Sensitive Detector

Haitham Abdel Majid

Physics Department

APPROVED:

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Dr. Tony Forest, Chair, Ph.D.

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Chapter 1

Simulations and Analysis

Simulating the physical processes that occurs inside an operating detector is important for accurate performance analysis. The previous chapters of this work discussed a number of important theories that justify the physical processes that occurs in the detector's chamber, such as induced neutron fission, ionization, diffusion. Although, general solutions were mathematically derived without considering any specific approximations (constraints), the solutions are useful to reach more specific solutions by computer simulations. Using the solutions in Monte Carlo simulations and considering all the constraints that affect the process output, leads to accurately estimation for the output of a physical process, which can be used to assess data from a real experiment.

The fission chamber has more than one type of particles that may share in the detected signal by the QDC. When U-233 coating exists inside a gaseous chamber, alpha, beta or gamma particles may penetrate the drift region with a specific energy, as result of their energy loss in the medium, an ionization event may occur. In case of the exposure to a neutron flux, a fission fragment may pass through to create a signal inside detector by ionization as discussed in details in the previous chapters. The detected charge spectrum by the QDC may represent the ionization for either one or more than one particle. To analyze the charge spectrum, it is important to study the ionization simulation and the performed approximations to reach these results.

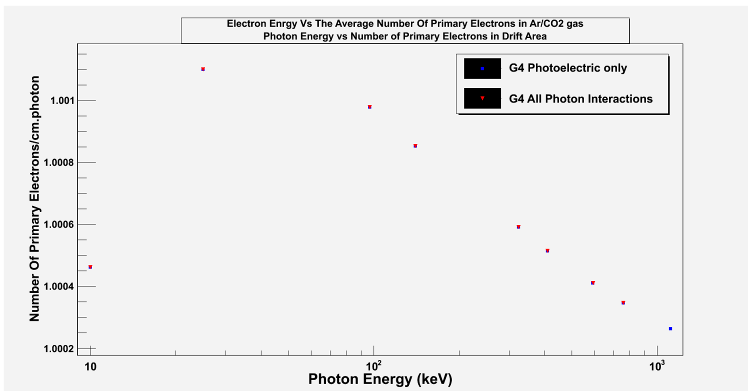
The aim of chapter is to present the simulation analysis that estimates the initial charge that appears when an ionizing particle or a fission fragment passes through the drift region and the effect of the detector's shutter on the magnitude of the charge in the drift region. According to the detector modified structure mentioned in section xx, a shutter is used to cover the area of U-233 coating, so it stop (partially stop0 all the positively charged ions, such as alpha particles and fission fragments, when it is closed, and to allow them to pass and ionize the gas when it is open. The next sections will discuss the analysis of the simulation results that study the effect of the shutter on the magnitude initial charge that emerges in the drift region by ionization; by a comparison for the simulated charge as the shutter is open and as it is close.

1.1 Photons and the fission chamber

Photons can interact with Ar/CO2 in the drift region. The fission chamber has sources for photons that may ionize the gas, the sources of these photons from the inside the detector that has U-233 coating, the coating is directly exposed to the drift region as in figure xxx. The detector may have photons from outside the chamber as it is operating in lineac or reactor hall; so it will be exposed to the neutrons and photons simultaneously.

GEANT4 has the ability to simulate the photon interactions in the fission chamber. GEANT4 gives the user a flexibility to simulate the photon interactions in the fission chamber, GEANT4 considers all the known interactions such photoabsorption, Compton scattering, and pair production. It has the ability to build an environment that has the same material and dimensions as in the real detector environment.

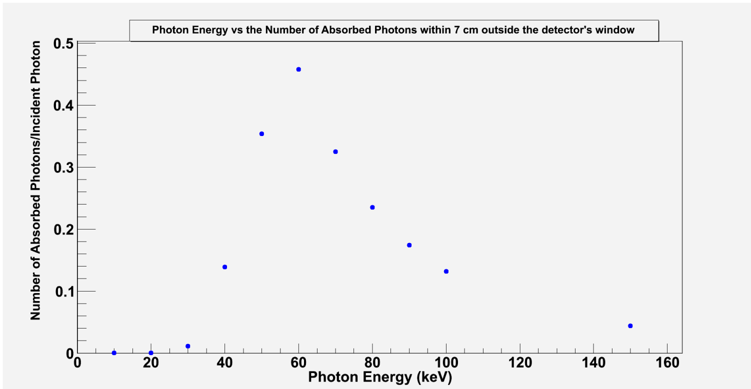
U-233 gamma particle has a negligible effect on the detector's drift region. gamma particles interactions simulation was established in 90/10 Ar/CO2; it showed the dominant interaction is photoabsorption, the number of absorbed photons is decreasing as the photon energy changes from 10 keV to 1 MeV, it shown a maximum number of absorbed photons by Ar/CO2 gas is when its energy is 20 keV.



The figures show the threshold energy for traveling photons in the detector and the number of the absorbed photons within the detector's drift area. Photons travel through the drift area and primarily interact by photoelectric effect with the gas's atoms and molecules; the emitted photon may have an energy up to 1.1 MeV and still the most probable interaction with the medium is the photoelectric effect. Figure xx1 shows the same numbers of primary electrons produced by an incident photon simulation by GEANT4; once when all photon's interactions are considered (red), and once when only the photoelectric effect only considered (blue). It also shows that all the photons are absorbed by Ar/CO2 gaseous medium. Since the incident photon energy varies from 10 keV up to 1.1 MeV, only the absorbed photons within a 1 cm will affect the detector signal. GEANT4 simulation shows that the dominant interaction is the photoelectric effect, even if the incident photon energy reaches 1.1 MeV. 25 percent of the photons will be absorbed that have energy of 25 keV, as the energy increases the number of photons decreases to reach 0.03 when the photon energy is 96.1 keV. As a result, gamma energy, emitted by U-233 or bremsstrahlung radiation that appears when the lineac is in operation, should have a maximum energy of 96.1 keV as it is in the detector's drift area, which maximizes the effect on the detector's signal.

7cm Outside the chamber

Photons may reach the detector's drift area and affect its signal when they pass through the kapton window or (less probably) through the ertalyte plastic. Normally, the detector structure is built from materials that prevent the photons of specific energies from causing ionization in the drift area. Figure xx3 shows the incident photon energy at a 7 cm distance from the kapton window and the number of photons absorbed in the drift area that cause ionization by photoelectric effect.



The figure shows a maximum number of absorbed photons; when the incident photon energy is 60 keV, 46 percent of the photons get absorbed by the drift region.

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