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A Simulation of Primary Ionization for Different Gas Mixtures

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The primary ionization is an important part of study in nuclear and particle physics experiments. In high rate experiments [1], the primary ionization is helpful in deep understanding of the discharge formation and charge density studies. The primary ionization was obtained from the simulation of alpha source to estimate discharge probability using single and triple GEM configuration in argon gas mixture [2]. We present and focus here only on the simulation of primary ionization in different argon based gas mixtures [3] to obtain the number of primaries, spatial and energy information.
The simulation tools like geant4 [4] and heed [5] have applications in nuclear, particle, accelerator, medical and space sciences. The geant4 and heed were used to simulate the passage of particles through the matter. The advantage of geant4 toolkit is that it generates the particle information like energy deposition and position co-ordinates after each step. These steps are produced after each interactions that computes the cross-sections of physics processes that were considered for this simulation in a gas volume. The properties of primary ionization, as estimated by geant4 and heed have been compared.
We simulated a collimated beam of alpha particles with and without mylar sheet to compare the range of alpha particles. A bragg peak was obtained because the alpha particles deposit more energy towards the end of the trajectory in the gas volume. The energy loss of charged particles is inversely proportional to the square of their velocity which causes the bragg peak to occur. Thus, the number of primaries appear to be more near the bragg peak. The number of primaries generated with geant4 toolkit has been compared with the heed also. We simulated muons also in a similar manner to study primary ionization, though muons weakly interact with the gas volume for study.
A similar analysis has been done for Fe-55 source which is radioactive in nature. The Fe-55 captures electron and produce primary ionization along with Mn-55, ν e and gamma which are the secondaries in this reaction. The primary ionization have been compared with heed also.
We found that the response of alpha, muons and Fe-55 source in these Ar-based gas mixtures is found to be different due to their different properties.

References:
[1] F. Sauli, GEM: a new concept for electron amplification in gas detectors, NIMA 386 (1997) 531.
[2] P. K. Rout et al, Numerical estimation of discharge probability in GEM-based detectors, JINST 16 P09001 (2021).
[3] P. Gasik et al, Charge density as a driving factor of discharge formation in GEM-based detectors, NIM A 870 (2017), p. 116.
[4] S. Agostinelli et al, Geant4 - a simulation toolkit, NIM A 506.3 (2003), p. 250.
[5] I.B. Smirnov; “Interactions of particles with gases”; online at http://cern.ch/heed .

What is your experiment?

Particle Tracking

Primary author: Dr R., Kanishka (Saha Institute of Nuclear Physics, Kolkata 700064, India. Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai 400094, India.)

Co-authors: Prof. MUKHOPADHYAY, Supratik (Saha Institute of Nuclear Physics, Kolkata 700064, India. Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai 400094, India.); Prof. MAJUMDAR, Nayana (Saha Institute of Nuclear Physics, Kolkata 700064, India. Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai 400094, India.); Prof. SARKAR, Sandip (Saha Institute of Nuclear Physics, Kolkata 700064, India. Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai 400094, India.)

Presenter: Dr R., Kanishka (Saha Institute of Nuclear Physics, Kolkata 700064, India. Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai 400094, India.)

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