Calculation of Electric Field Distortion Rate due to Potential Difference between Guard Electrode and Collection Electrode using Simulator in Parallel Plate Ionization Chamber

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1. Introduction

Ionization chamber is still widely used in radiation detection field because that gives absolute dose, hardness for radiation damage and simplicity of operation in somewhat. Parallel plate ionization chamber for proton beam calibration was designed and fabricated in KAERI. Fabricated ionization chamber includes guard electrode that may cause distortion of electric field due to potential difference between guard electrode and collection electrode. To calculate this distortion rate Maxwell and Garfield simulator was incorporated.

2. Fabricated ionization chamber

Fabricated parallel plate ionization chamber for proton beam calibration is show in Fig. 1. This consists of a guard electrode and subassemblies that are represented by windows, pad-quads and electrodes. Guard electrode is for intercepting current flowing from potential electrode to collecting electrode [1, 2]. Material of windows and electrodes used in ionization chamber was chosen to minimize the beam loss in magnitude because proton beams must pass through them without any loss of energy. Active area and collecting volume of fabricated ionization chamber were 471 mm^2, 371.1 cc respectively.

Fig.1 Fabricated parallel plate ionization chamber had double BNC connectors, SHV connectors and gas quick connectors.

And preliminary test was performed like saturation current, aging test and leakage current with and without Am-241 standard gamma-ray source. To determine the optimal operating voltage two-voltage method was incorporated [3].

3. Simulations

Simulation was performed using Maxwell and Garfield program. [4] Former is commonly used to solve the electric vector and equipotential line using finite element method (FEM) that is based on the Maxwell equation. Chamber shapes, chamber materials and boundary/source condition were firstly set and solved by FEM. Solved electric field vector and equipotential line were imported to Garfield to visualize the electron drift lines. Magboltz which informs the characteristics of filling gases was incorporated to trace the electron drift lines in filling gases. In case of air linear extrapolation of longitudinal and transversal difference was 70,728 V/cm, 36,714 V/cm respectively for negative electron.

Guard electrode is for intercepting current flowing from potential electrode to collecting electrode. In high precision measurement, potential of collecting electrode may higher or lower than guard electrode. And electric field is changed due to the shape and geometry of guard electrode. So distortion of electric field may affect the active volume that is defined as the volume of gas from which ions are drawn to the collecting electrode. Simulated electron drift lines of ionization chamber were shown in Fig.2 when potential of guard electrode was 30V.

When the potential of the collecting electrode falls below that of the guard electrode, the active volume of the chamber is increased. While the potential of the collecting electrode rises above that of the guard electrode, the active volume is diminished.

Potential electrode and collecting electrode was set at -1500V and 0V respectively. And potential of guard electrode was changed -30V ~ 30V. Filling gas was air. Conditions of air were atmospheric pressure and room temperature. Monte Carlo algorithm was used for integration technique to see the electron drift behavior. Through the simulation space charge that is another cause of electric field distortion wasn't considered because to consider the effect of only guard electrode [5]. Electric field distortion rate was calculated by variation rate of active volume in ionization chamber. 500 particles were equally generated inside of ionization chamber and used to calculate the active volume. Different guard electrode geometries were simulated a way of above mentioned and compared the electric field distortion rate.

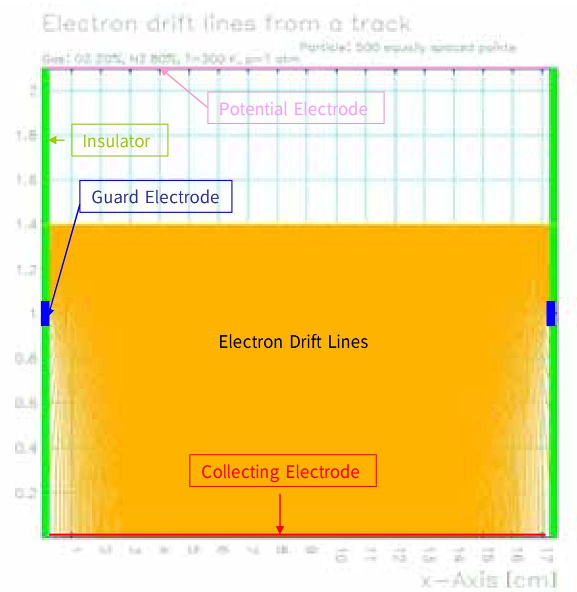

Fig.2 Electron drift lines inside of ionization chamber. 500 equal particles were generated at the line of (0.001 1.4, 16.99 1.4) coordinate system and drawn to collecting electrode and guard electrode.

3. Conclusion

Parallel plate ionization chamber having guard electrode structure was fabricated. Guard electrode controls the electric field and defines the active volume inside of ionization chamber. But electric field can be distorted by potential difference between guard electrode and collecting electrode. Thus through the Maxwell and Garfield program different guard geometries can be simulated to determine the optimal guard structure.

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