# Recombination process of the ionization chamber at a low dose rate

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## 1. Introduction

An ionization chamber was developed as the detector for a radiation monitoring system (RMS). The ionization chamber is for the gamma monitoring detector for the RMS. When measuring the dose rate with an ionization chamber, the observed current is always lower than the saturation current due to an ion recombination. There are three different processes in the ion recombination. These are the initial recombination, the general recombination and the diffusion loss. One has to know which process is the dominant one in the ion recombination, if the dose rate is to be determined accurately. Since our ionization chamber will be operated at a low dose rate, we studied the recombination process of the ionization chamber at a low dose rate.

## 2. Experiment and Analysis

The ionization chamber was designed and fabricated. Saturation curves of the ionization chamber were measured, and the fraction of the initial recombination was determined in various dose rate.

### *2.1 Experiment*

We designed the ionization chamber with a cylindrical geometry. The collecting electrode and the outside electrode were made of polyethylene. Carbon was coated on one side of them to provide an electric conductivity. Guard electrode was placed between the collecting electrode and the outside electrode. The BNC and SHV connectors were used to obtain a signal from the collecting electrode and bias the voltage on the outside electrode. Argon gas was filled inside the chamber.

$^{137}$Cs with an activity of 2 mCi. was beamed onto the ionization chamber. A lead aperture with a diameter of 1 cm, and the thickness of 10 cm was placed in front of the ionization chamber. The ionization current from the chamber was measured with a high-precision Keithley 6517A electrometer, and the outside wall was biased with on ORTEC 673 high voltage supply. Various dose rate from 6.5 to 42 μSv/h were obtained by changing the source-to-chamber distance.

### *2.2 Analysis*

The fractional recombination loss at voltage *V*, *p(V)*, is defined by

$$p(V) = \frac{i_{sat} - i}{i_{sat}} .$$

Here $i$ is the measured current, and $i_{sat}$ is the saturation current at a given dose. It can be assumed that

$$p(V) = f(V) + g(V) ,$$

where *f(V)* represents the general recombination, and *g(V)* represents the initial recombination. If $i_0$ and $i$ are the ionization currents obtained at $V_0$ and $V$ respectively, then

$$p(V) - p(V_0) = (f(V) - f(V)) + (g(V) - g(V_0)) .$$

*f(V)* is linearly dependent on $i/V^2$, and *g(V)* is proportional to *1/V*. Then,

$$\frac{i_0 - i}{i_{sat}} = \left(\frac{b}{V} - \frac{b}{V_0}\right) + a\left(\frac{i}{V^2} - \frac{i_0}{V_0^2}\right),$$

where $a$ and $b$ are the proportional constants. If $i_0$ is the ionization current for the highest collecting potential, $i_0$ is assumed as $i_{sat}$.

We plot $(i_0-i)/i_0$ as a function of $(i/V^2-i_0/V_0^2)$, where we set $i$ as a variable and $V$ as a fixed parameter. The ordinate at $(i/V^2-i_0/V_0^2)=0$ gives the initial recombination component.

The initial recombination component was plotted as a function of *1/V*, and it showed almost a linear function of *1/V*.

From the above process, we can determine the parameters of $a$ and $b$, and the ratio of the initial recombination to the total recombination can be obtained from the parameters. Figure 1 shows the ratio of the initial recombination to the total recombination as a function of the dose rate. It was measured at a bias voltage of 120 V.

## 3. Conclusion

We designed and fabricated an ionization chamber with a collecting volume of 10 *l*. Since the collecting volume is large, it can be operated at a low dose rate. The initial recombination can be a dominant process when the general recombination is reduced at a low dose rate. We obtained the fraction of the initial recombination process at a low dose rate.

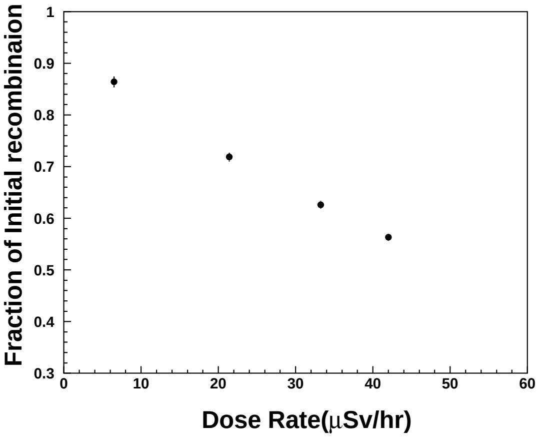


Fig. 1 The fraction of the initial recombination as a function of the dose rate

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