CHAPTER I

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Back scattering of gamma rays is a subject of investigations since early fifties. Theoretical and experimental studies on the angular distribution of intensity and energy of the backscattered radiation (number and energy albedo) from shield materials are found to be intense in sixties. This spurt in activities is mainly due to the increased use of nuclear radiation in diverse field of applications. Accurate knowledge of number and energy albedo of backscattered photons is important in designing reactor shields and other shield calculations. The exact theoretical calculation of the angular distribution of intensity and energy other than primary or single scattering from a shield of finite thickness is not possible, and therefore, one has to depend either on the approximate theoretical calculations using Monte Carlo method or on the experimental measurements. This leads to the extensive Monte Carlo calculations [Hayward and Hubbell (1953, 1954A)]; Perkins (1955); Berger (1957); Berger and Raso (1958, 1960); Leimdörfer (1962); Raso (1963); Berger and Morris (1966); Preiss and Livnat (1973); Elias et al (1976) and Seda (1977)] and experimental measurements [Hayward and Hubbell (1954B); Bulatov and Garusov (1960); Hyodo and Shimizu (1961); Hyodo and
his group (1962, 1964, 1967); Clifford (1964); Barret and Waldman (1964); Haggmark et al (1965); Chilton (1967); Pozdneev (1967A, 1967B); Steyn and Andrews (1967); Baran et al (1969); Elias et al (1973); Sinha (1976); Biswas et al (1978, 1979A)] by various workers. The work of Hayward and Hubbell [1953, 1954A] seems to be the first to use the Monte Carlo calculation to the gamma ray albedo problem. The same authors [1954B] are also first to report the experimental investigations on backscattering of gamma rays using scintillation spectrometer. Later, intensive experimental investigations are taken by many group of workers such as Kyoto University group under the leadership of Hyodo; Gorki University group under the leadership of Podzneev. These investigations lead to the conclusion that the shield calculations for gamma rays require careful analysis. Moreover, the literature contains only the fragmentary knowledge on the albedos of gamma rays from shield materials of finite thickness. Recently, careful systematic analysis of backscattered radiation has been taken up in this laboratory as a part of its programme. Systematic investigations on the number albedo of backscattered photons have been carried out in this laboratory by Sinha [1976, 1978] and Biswas et al [1978, 1979A]. Presently this laboratory is engaged in the systematic investigations on the energy albedo of backscattered photons. The present dissertation is a few steps toward achieving this project.
Most of the measurements excepting those of Bulatov et al [1960] and Elias et al [1973] are carried out using thalium activated sodium iodide \([\text{NaI(Tl)}]\) as detector. The efficiency of the sodium iodide detector is found to vary markedly with the energy of the photon. As the backscattered gamma rays have a continuous distribution of energy, an elaborate computation is needed to take into account the variation of the detection efficiency of the detector with photon energy. In the case of measuring number albedo of backscattered photons, in which one is interested in the number of scattered photons irrespective of their energies, this tedious efficiency correction has been avoided by using an uniform response photon counter [Biswas et al 1979A]. The measurement of energy albedo requires the knowledge of both the scattered intensity and energy of the scattered photons. In fact, it requires the evaluation of the sum of the product of number of photons \([N_i]\) for each photon of energy \(E_i\), i.e. \(\sum_i N_i E_i\). Taking account of efficiency correction for a wide range of energies is not an easy job and requires elaborate computation. Moreover it can not be known with 100% certainty. Therefore, it is apparent that finding out a means by which the tedious efficiency correction can be avoided is the best solution. This is possible if a detector whose response is proportional to the energy of the photon is available. Only for such detector the integral counts observed is a direct measure of \(\sum_i N_i E_i\).
The present dissertation deals with the following objectives:

1. To study the theoretical feasibility of developing a proportional response photon counter. We are concerned here only with 2" thick NaI(Tl) detector. It has been found that it is possible to have such a detector whose response is proportional in the energy range of few keVs to 1.5 MeV.

2. To put such a detector developed from theoretical consideration to experimental test. It has been tested with six photon energies and the experimentally obtained efficiency values have been compared with theoretically predicted values.

3. To measure energy albedo of back scattered photons from shield materials using this new detector and to compare the values with theoretical and other experimental values.