EXPERIMENTAL MEASUREMENT OF BETA RAY SCATTERING IN AIR

D. P. Bhanti and S. K. Dua
Health Physics Division
Bhabha Atomic Research Centre
Bombay 400085

Presented at the First Annual Conference of the Indian Association for Radiation Protection (IARP) held at Bombay (India) 12-14 April, 1973.

EXPERIMENTAL MEASUREMENT OF BETA RAY SCATTERING IN AIR

INTRODUCTION

The scattering of the electrons by thin foils has been studied extensively by several workers (1-7). In these studies mostly monoenergetic beams and thin targets are used and the distributions of scattered electrons are determined. The scattering of beta rays in air is a complex phenomenon due to the fact that a spectrum of energy is involved and also the air is an extended scatterer. In the present work experimental studies have been carried out on the scattering of beta rays in air due to (i) collimated beams and (ii) an open point source.

(i) STUDIES WITH COLLIMATED BEAMS

A perspex chamber with inner dimensions of 6.5 x 6.5 x 10.2 cm (10.2 cm being the height) and of wall thickness 1 cm was used for the experiments with collimated beams. A point source was kept inside the chamber. The collimation was obtained by using two circular apertures (0.32 cm dia) - one in a perspex block (6.5 x 6.5 x 1 cm) placed at a distance of 2 cm above the source and the other in the top face of the chamber. The latter was covered with a mica film (1.1 mg/cm^2) to make the chamber air-tight.

The following experiments were done with the collimated beams:

(a) To see the effect of Air - Density on Beta Scattering:

An end window G.M. counter with the window facing the radiation from the apertures was placed on the beam-outlet in contact. The chamber was maintained at various negative pressures and countrates were registered. Fig.1 shows that the intensity of radiation emerging from the apertures falls much faster than as expected due to mere absorption in air. It is seen that the absorption of beta rays is insignificant as compared to scattering in air. This effect is more pronounced at low energies.

(b) Distribution of Direct and Scattered Components:

The components due to direct and scattered radiations were determined at various distances from the upper aperture. The detector was placed at known heights from chamber top facing the direct beam and then moved laterally to various positions in plane perpendicular to the primary radiations. The countrates were noted at these positions. Fig.2 gives the observed countrates at various lateral positions for two known heights from the chamber. As expected the scattered beta radiations are distributed symmetrically around the primary beam. From the data so obtained, the direct and the integrated scattered countrates are obtained and presented in Table 1. The scattered component increases rapidly with the vertical distance from the aperture and at 20 cm it is about 9 times the direct part of the beam.

(ii) STUDIES WITH AN OPEN SOURCE

A point source (3mm dia) of ^{32}P deposited on V.Y.N.S. film was mounted on a stand 1 meter above the ground. An end-window G.M. counter was placed facing the source at a distance of 1 meter above it. Aluminium absorbers of proper dimensions were interposed between source and the

detector.......

detector at various heights in order to shield the direct beam. Radiations reaching the detector at various absorber's positions were measured in terms of countrates. The results are presented in Fig.3. The countrates seen by the detector are mainly (about 99%) contributed by the scattered radiations. The rise at the beginning and the fall at the end of the curve can be explained from the geometrical considerations.

CONCLUSIONS

A collimated beam of beta radiations does not remain as a fine beam while passing through air but gets scattered quite significantly. The scattered component increases with the distance, the beam traverses through the air. The scattering is more pronounced in case of low energy betas. The knowledge obtained from these studies is found useful in controlling the exposures due to scattered beta radiations. The further work proposed in this field is to determine the energy spectrum in view of fact that the low energy betas possess higher value of quality factor (QF) and therefore the scattered beta particles are of greater importance.

REFERENCES

1. MOTT, N.F., "The Collission Between Two Electrons", Proc. Roy. Soc. (London) A 126, 259-67 (1930).
2. CHAMPION, F.C., "The Scattering of Fast Beta Particles by Electrons", Proc. Roy. Soc. (London) A 137, 688-95 (1932).
3. WILLIUMS, E.J., "Concerning the Scattering of Fast Electrons and of Cosmic-Ray Particles", Proc. Roy. Soc. (London) A 169, 531-71 (1939).

4. GOUDSMIT, G. and SAUNDERSON, J.L., "Multiple Scattering of Electrons", Phy. Rev. 57, 24 (1940)

5. VIOLET, CHARLES E., "Interactions of Fast Electrons and Positions with Matter (THESIS)", UCRL-2163 (1953).

6. DICKINSON, W.C. and DODDER, D.C. "Evaluation of particle loss due to Multiple Scattering in Foils", Rev. Sci, Instr. 24, 428-31 (1953).

7. HESTER, DAVID H. and RAINWATER, J.R. WALTER J. "Coulombs Scattering in Aluminium without Atomic Excitation for 1 MeV Electrons", Phys. Rev. 138 A, A 12-14 (1965).

TABLE 1

RATIO OF INTEGRATED SCATTERED AND DIRECT COMPONENTS
AT VARIOUS DISTANCES FROM THE APERTURE

Distance between the aperture and detector (cm)	Integrated scattered component / Direct component
1.45	0.03
2.8	0.11
4.0	0.192
5.0	0.44
8.0	0.93
11.0	1.98
14.0	3.00
17.0	5.74
20.0	8.96

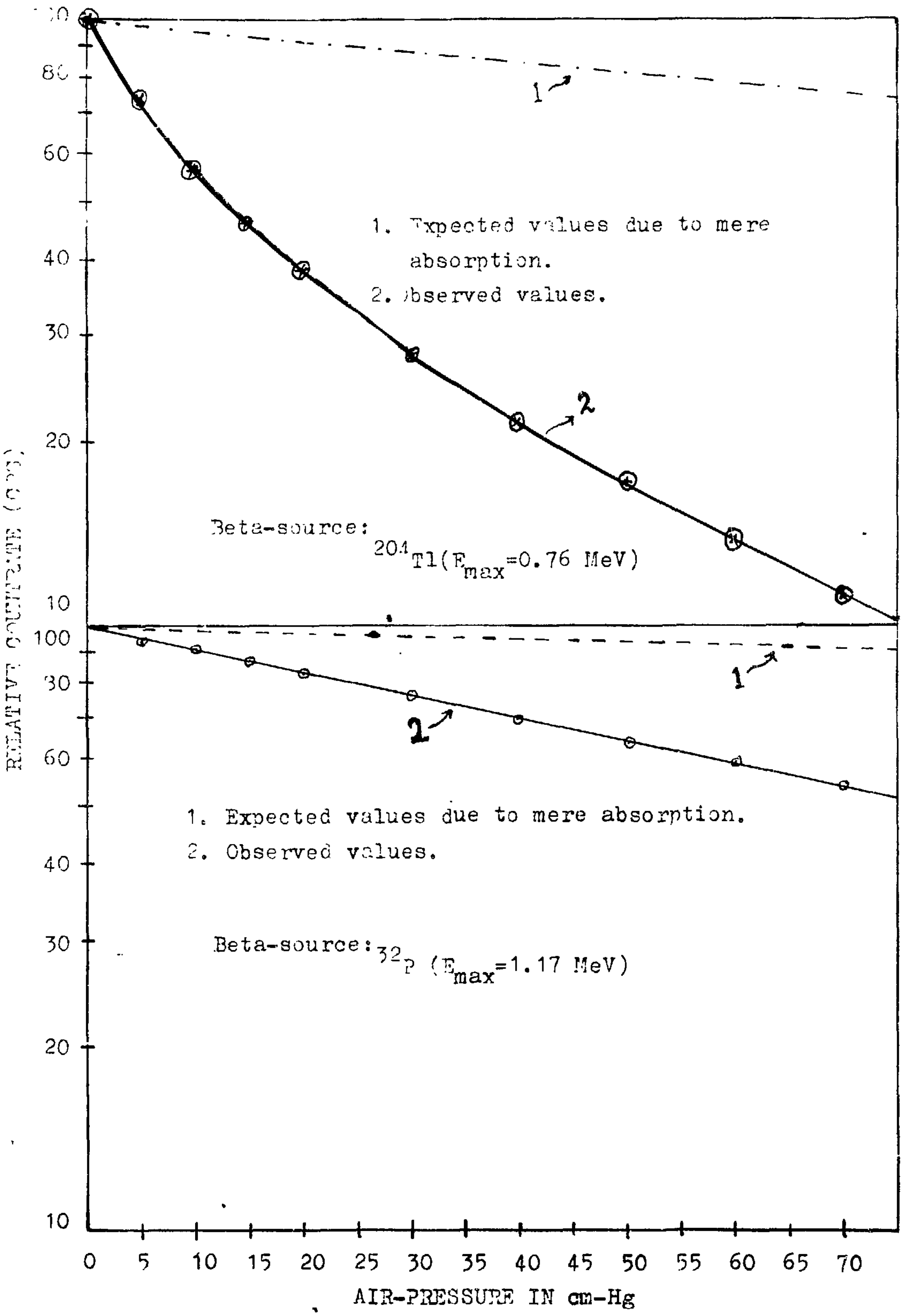

FIGURE 1: VARIATION IN COUNTRATE WITH AIR PRESSURE INSIDE THE CHAMBER.

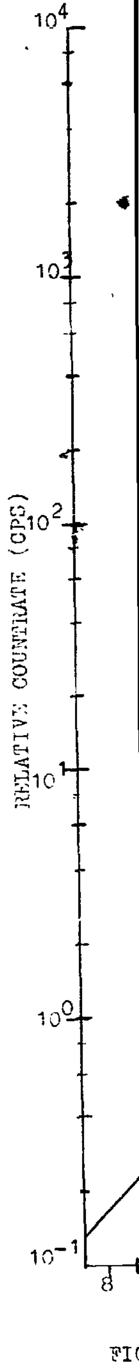

FIGURE.2: CURVE SHOWING COUNTRATE VS DISTANCE AT DIFFERENT HEIGHTS FROM THE CHAMBER.

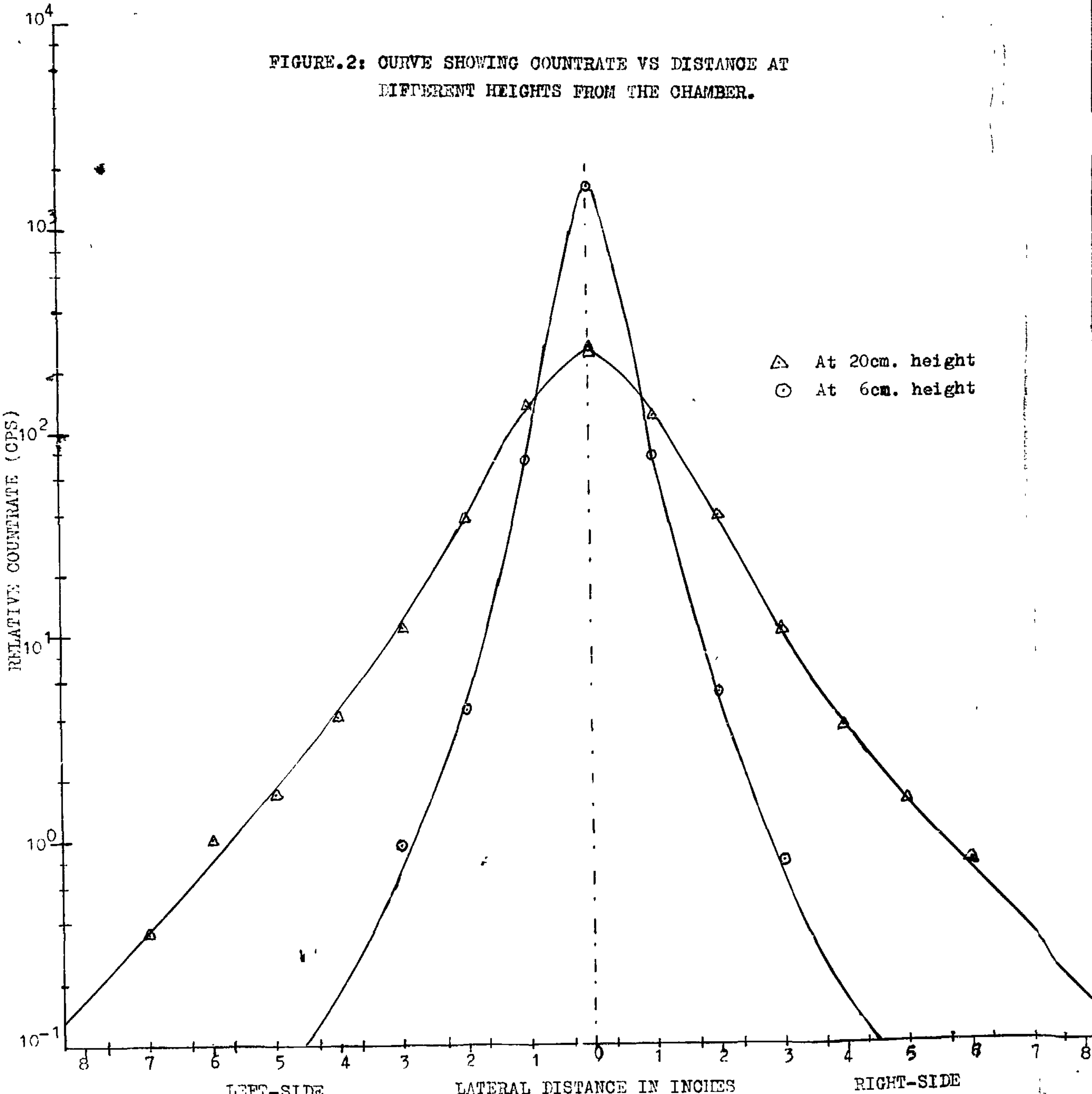

FIGURE 2:CURVE SHOWING COUNTRATE VS LATERAL DISTANCE AT DIFFERENT HEIGHTS FROM THE CHAMBE

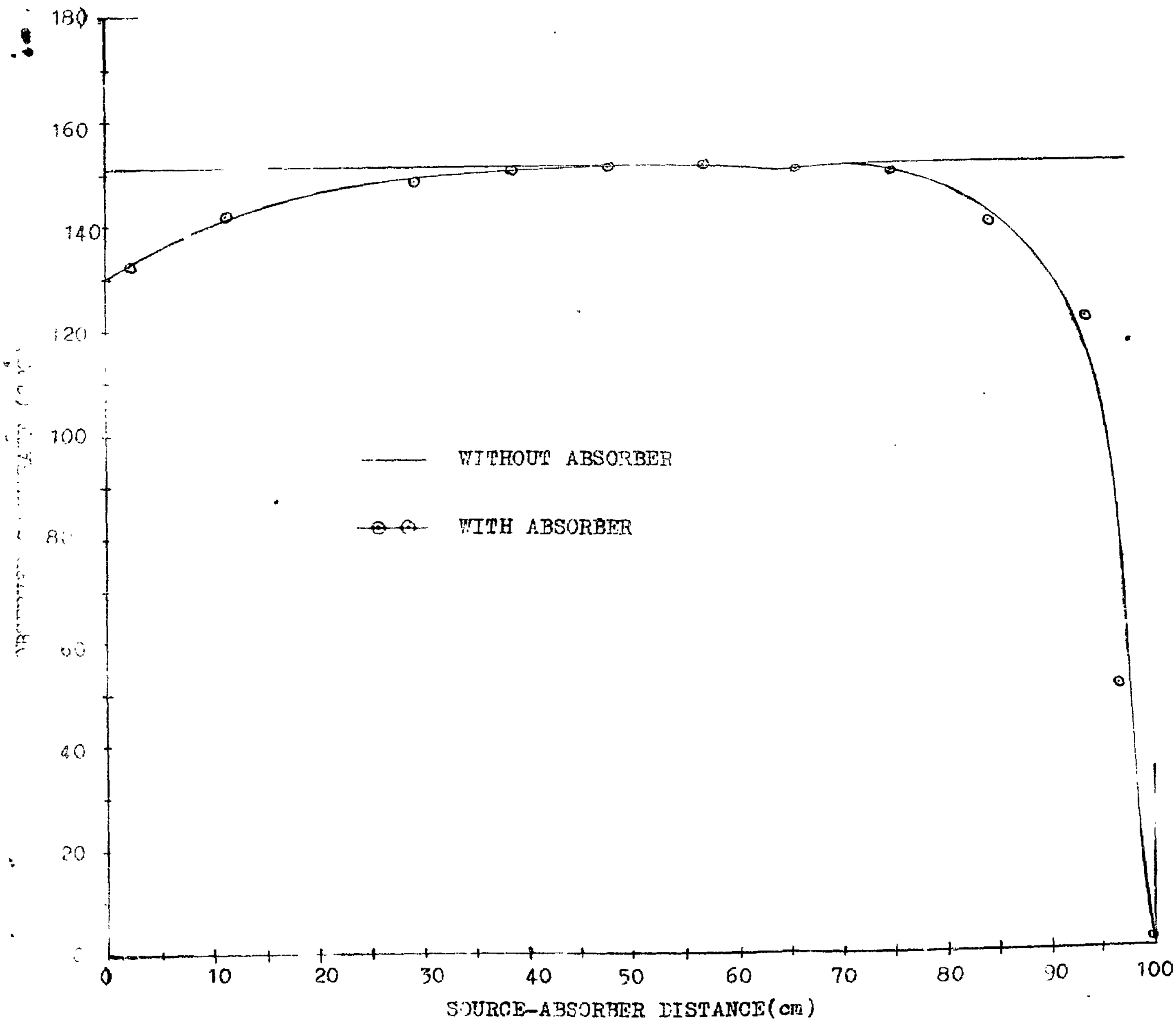

FIGURE 3 : OBSERVED COUNTRATE PLOTTED AGAINST VARIOUS ABSORBERS POSITIONS

FIGURE. 3: OBSERVED COUNTRATE PLOTTED AGAINST VARIOUS ABSORBERS POSITIONS.