SHIELDING OF EXTERNAL 12 GeV PROTON BEAM LINE AT KEK

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Several shielding experiments were performed at the slow extracted beam line from 12 GeV PS at KEK. The side view of the beam line around the "K3 target" is shown in Fig. 1. Measurements were done on the overhead shield. It is made of heavy concrete and its density is 3.65 g/cm^3. The reaction $^{12}C(n,2n)^{11}C$ was utilized for the measurement of neutrons with a threshold of $E \geq 20$ MeV and an Andersson-Braun type "rem counter" (Studsvik 2202D) was used to measure neutron dose equivalent (D.E.) at the energy below about 20 MeV. Thermoluminescent dosimeters were also used to measure radiation due to gamma-rays and other charged particles.

When the source is small and thin (that is, no build-up occurs in it), according to the "Moyer model" the D.E. rates on the lateral shield are expressed as follows;

$$H = H_0 \exp(-b\theta) \exp(-d \operatorname{cosec}\theta/\lambda_{att})/r^2 ;$$

where r is the distance from the source, d is the thickness of the lateral shield and θ is the angle from the beam direction. H_0, b and λ_{att} are coefficients to be determined experimentally.

Shields made of paraffin, heavy concrete and iron were added on the overhead shield, respectively. And D.E. was measured on them. First attenuation lengths (λ_{att}) were obtained for these materials as follows;

λ_{att} =	133 ± 16 g/cm^2	for paraffin
	167 ± 7	for heavy concrete (ρ=3.65)
	188 ± 12	for iron

The relation between these attenuation lengths and inelastic mean free paths (λ_{inel}) is shown in Fig. 2. The former is about 1.4 times larger than the latter.

Next, D.E. was measured along the beam line on the overhead shield. And the relaxation parameter (b) was obtained as follows;

$$b = 2.5 \pm 0.2 \text{ /sr} \qquad (60° < \theta < 100°)$$

When concrete was used on the outer surface of the shield, effective source parameter (H_0) was obtained as follows;

$$H_0 = 3.2 \pm 1.0 \times 10^{-8} \quad (\text{rem/h})\cdot\text{m}^2 \ / \ (\text{GeV/sec})$$

It is normalized per unit "beam loss" GeV/sec.

If iron is used on the outer surface of the shield and hydrogenous materials is not put on it, H_0 becomes about 2.7 times larger because low energy neutrons are not removed.

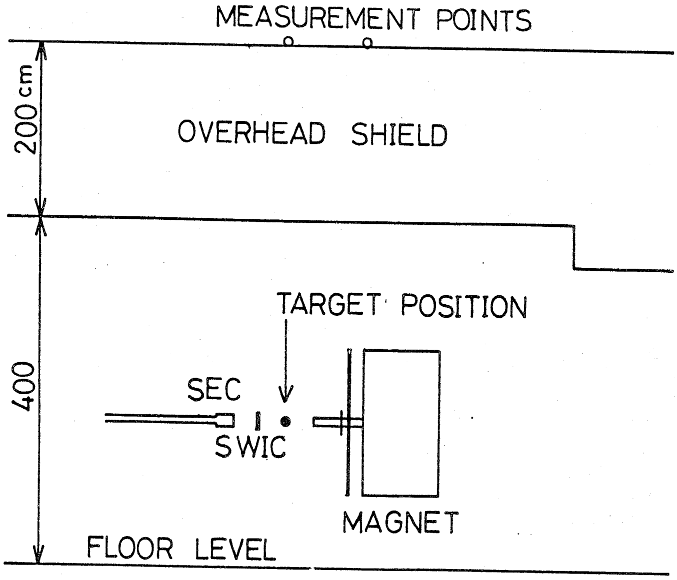

Fig. 1. Side view of the K3 beam line around the target.

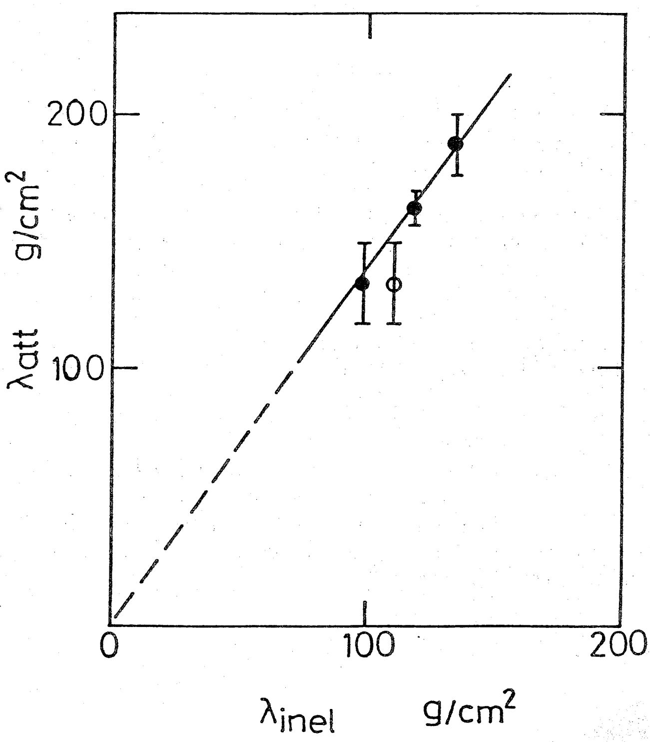

Fig. 2. Attenuation length VS inelastic mean free path.

Open circle denotes the inelastic mean free path of paraffin where inelastic cross section of hydrogen nuclei is ignored.