

High Sensitive X-Ray Films to Detect Electron Showers in 100 GeV Region

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ABSTRACT

Non-screen type X-ray films have been used in emulsion chamber experiments to detect high energy showers in cosmic rays. Ranges of the detection threshold is from about 1 to 2 TeV as depending on the exposure conditions. In order to improve this threshold, we have tested different types of X-ray films and sheets i.e. high sensitive screen type X-ray films (Fuji G8-RXO) and luminescence sheets (Fuji 'Imaging Plate'). For these, the threshold of the shower detection is found to be about 200 GeV, which is much lower than that of non-screen type X-ray films. These films are useful to detect showers in the medium energy range, a few hundred GeV, of the cosmic ray electrons¹⁾.

1. Introduction.

In emulsion chamber experiments, the detection of high energy electron showers is usually carried out by naked eye scanning on X-ray films. This reduces a lot of labour for microscope scanning of high energy showers. The detection threshold, if we use non-screen type films such as the Sakura N-type, is about 1 to 2 TeV as depending on the exposure conditions. In order to improve this threshold, we tested other types of X-ray films and sheets i.e. the screen type X-ray films (Fuji G8-RXO), and the luminescence sheets (Fuji 'Imaging Plate').

These photographic materials have been irradiated to the INS electron synchrotron beams to obtain the characteristic curves for the particle densities²⁾. The net optical density, D_n , of the RXO at the electron density of $10^6/\text{cm}^2$ has been confirmed to be about 10 times higher than that of the N-type. This result suggests that the detection threshold for G8-RXO is by a factor of 10 less than that of N-type. For 'Imaging Plate', the computer-aided laser beam scanning was performed for the measurements of D_n ³⁾.

These films and sheets have been also tested to detect electron showers in the emulsion chamber exposed at balloon altitude. By track counting of the observed showers in nuclear emulsions, the detection threshold of G8-RXO has been found to be around 200 GeV, which is consistent with results of the accelerator experiment.

2. Characteristic Curve of X-Ray Films and 'Imaging Plate'.

Several types of X-ray films (Sakura N type, Fuji #200 type and G8-RXO) and 'Imaging Plate' have been irradiated vertically to the 760 MeV electron beams. The setup of these materials is shown in Figure 1. The electron beam densities in this irradiation are covering from 6.7×10^4 to 2.7×10^6 /cm² at the center of the beams.

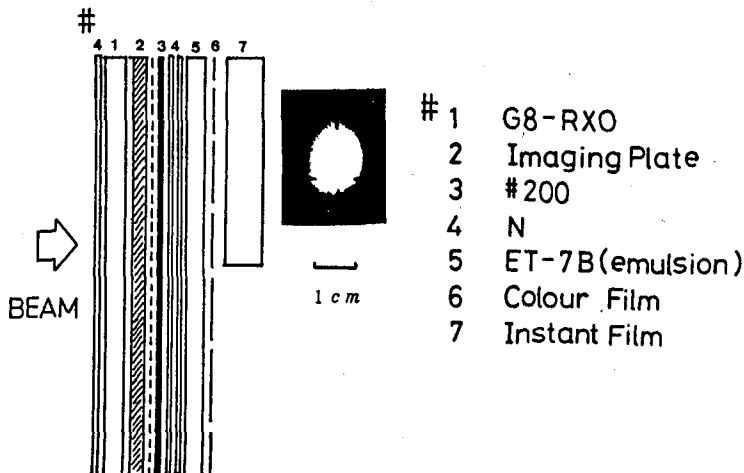


Fig.1 Setup of photographic materials.

The development times were 15 min., 20 min. and 25 min. for N-type and #200, and 10 min., 12 min., and 15 min. for RXO respectively, under the condition that Konidol developer was used at 20°C. After the development, the optical densities, D , on the films were measured with the microphotometer with the slit size of $200 \times 200 \mu\text{m}^2$. The electron densities were determined by the track counting in the emulsion plates. Figure 2 shows examples of the beam profiles on these films.

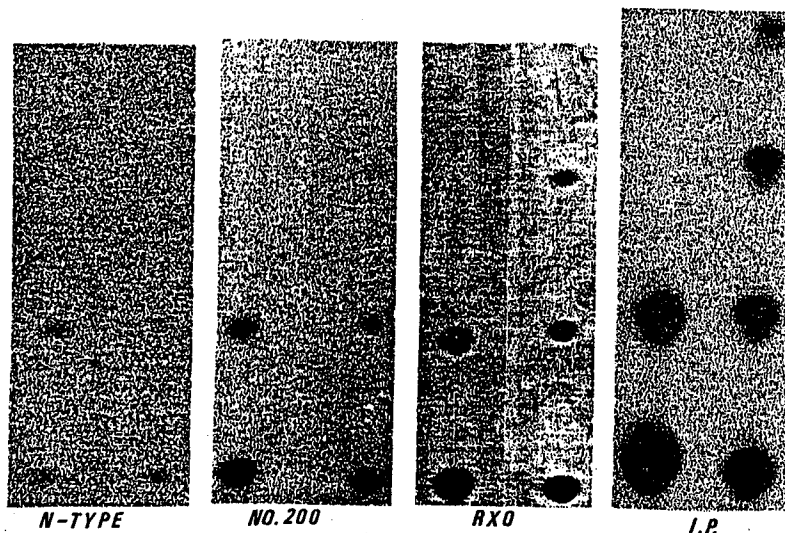


Fig.2 Beam profiles on different types of films are shown for comparison. Each black spot at the same relative position on a film corresponds to the same intensity of beam.

The characteristic curves for these films and sheets are shown in Figure 3. The data on N-type and #200 are those for the development time of 15 min. The D_n 's of N-type and #200 increase with development times, but the ratio of sensitivities of #200 to N-type remains constant, keeping the value of ~ 2.5 . The D_n of RXO, however, does not change with the development time. As shown in Figure 3, the characteristic curve for RXO shows a non-linear dependence on the electron density. This is due to the characteristics of the screen type X-ray films. As to 'Imaging Plate', the characteristic curve is derived after the computer processing. We can choose the most appropriate condition which is suitable for detecting the electron shower.

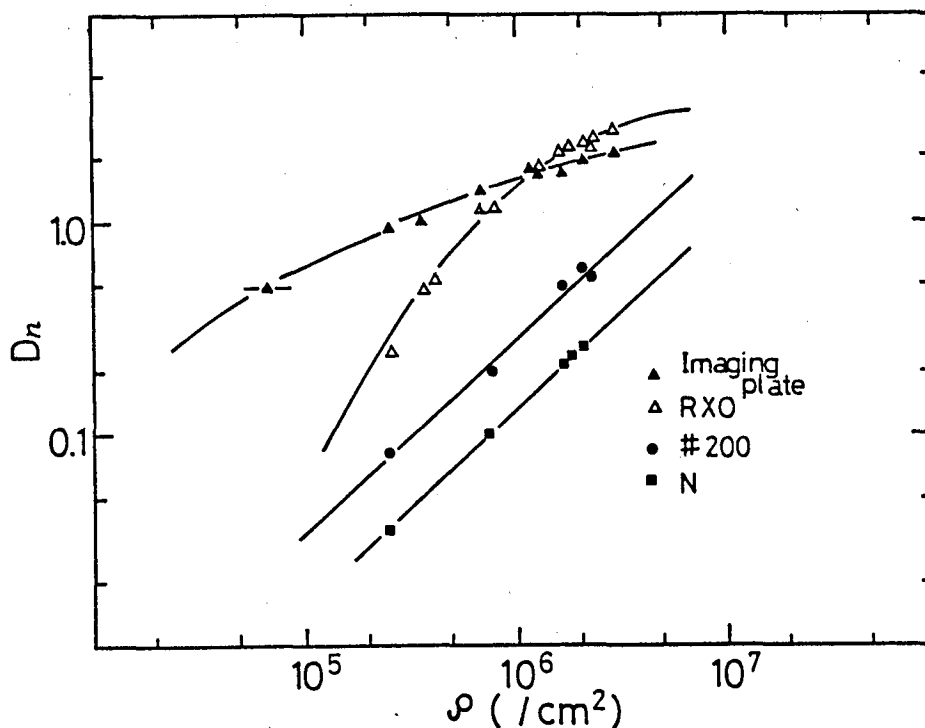


Fig.3 Characteristic curves of different types of films.

3. Discussion.

From the characteristic curves, we observe that the ratios of the sensitivities from N-type via, #200 and G8-RXO to 'Imaging Plate' are of 1:2.5:8:80 at the D_n of 0.1. This seems to indicate that the ratios of the detection threshold of electron showers are of 1:0.4:0.13:0.013 with respect to the foregoing ratios.

In actual case, however, the threshold is determined not only by sensitivity of the film, but also the signal to noise ratio of D , the noise in which is produced by the background tracks and chemical fogs. Fluctuations of the D due to background tracks depend on the number of grains developed by these tracks, and depend on the sensitivities and grain sizes of the films. Grain size in non-screen type X-ray films are larger than that in screen type X-ray films. The average area of grains in N-type and RXO are $16.5 \mu\text{m}^2$ and $4.8 \mu\text{m}^2$ respectively.

The sensitivity of each grain in N-type is high, and almost of all grains are developed when thin tracks penetrate through the grains. The sensitivity remains almost unchanged even for slow protons or electrons contained in the background tracks. This is the reason why non-screen type X-ray films have been used in the shower detection for long exposure experiment.

The screen type X-ray films have quite different characteristics. The sensitivity is almost proportional to the ionization loss of the penetrating particles. Thus screen type X-ray films and 'Imaging Plate' could be thought as the most effective in detecting showers for short exposure experiment such as the balloon's. Referring to these fact, we exposed the emulsion chamber with G8-RXO and 'Imaging Plate' at balloon altitude in September, 1984. The experiment was to observe the cosmic ray electrons at medium energy range of a few hundred GeV.

The detection threshold in this exposure has been made clear to be around 200 GeV. Detailed analysis has also been made for the fluctuations of the background D , and confirmed the detection threshold energy is around 200 GeV for this exposure by considering the signal to noise ratio of D . 'Imaging Plate' is much more sensitive than RXO, but as seen from the signal to noise ratio consideration, the threshold energy in this experiment is a little lower than the RXO's. We are now trying to find the most favorable condition for the computer-aided process of 'Imaging Plate' to get a lower threshold for the detection of electron showers.

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