High-energy particle detectors on the basis of x-ray transition radiation (XTR) as explored till now possess low efficiency of particle registration and small relative aperture. The particle detector described below takes advantage of the detection of energy released in the bulk of a gas by the absorption of XTR-quantas, as well as the ionization of the gas by the high-energy primary particle. High registration efficiency of ultra high-energy particles could be achieved using XTR techniques, the relative aperture being rather high.

This method, first proposed in 1961, was experimentally investigated only recently. The philosophy of the method consists in registration by a single detector of x-ray quanta both the charged particle and the transition radiation generated by the particle in a laminar medium. The yield of the detector will be proportional to total energy released due to the absorption of XTR and the ionization losses of a particle in the same detector. While the intensity of XTR depends strongly on \( \gamma = E/mc^2 \), the ionization losses of ultrarelativistic particles are practically independent of \( \gamma \); the yield of detector for small values of \( \gamma \) is defined, consequently, by ionization losses and for large \( \gamma \) basically by the absorption of XTR.

The detection of radiation and particles in high-energy particle detectors under examination was by means of gaseous xenon scintillator enclosed in an aluminum container with round 100\( \mu \) thick mylar windows of 6 cm in diameter through which the radiation and registered particles passed. (See Fig. 1.) The photomultiplier, with its photocathode right in the gaseous medium, was inserted from the side of the container, the thickness of the scintillator being 4 cm of xenon at the pressure of 1.6 atm.

As the wavelengths of the light emitted in a gaseous scintillator are in the far ultraviolet, the coating of the inner side of the container and the photocathode by a spectrum-shifter was provided to match the radiation spectrum and the spectral characteristic of the photomultiplier. Special attention was given to gas cleaning, as the impurities cause the sharp reduction of scintillation intensity. With that end in view, the scintillation gas has been continuously purged in a 600\( ^\circ \) C hot calcium chip by means of natural circulation.

The energy resolution of the xenon gaseous scintillator, at xenon pressure of 1.6 atm and the energy of quanta ~24 keV was 70 per cent; i.e., the light yield of such a scintillator equals that of NaI(Tl) crystal.

The high-energy particle detector assembly, consisting of a laminar medium followed by the xenon gaseous scintillator, was exposed to 31-GeV electrons of the Serpukhov proton accelerator. The electron beam was separated by an array of scintillation counters. The laminar medium was composed of 1000, 10\( \mu \)-thick mylar films 0.7-mm distant from each other. The measurements were carried out with and without the laminar medium to check the contribution of background events. The xenon scintillator output signals were transmitted through a pulse stretcher and a
scintillation array controlled linear gate to a 128-channel pulse-height analyzer.

In Fig. 2 the energy distribution of events in xenon measured with the laminar medium (crosses) and without it (points) is given. In the first case, the maximum number of events, i.e., the most probable value of energy released in xenon due to the absorption of XTR-quantas and the ionization losses corresponds to 125 keV. The calculations of the probable value of ionization losses in xenon give the figure of 48 keV. Hence, 77 keV can be attributed to the absorption of XTR.

The ratio of the total number of events in an interval of energy release of 75-200 keV to the number of electrons traversing the laminar medium, i.e., the efficiency of electron registration by transition radiation, was 0.865 ± 0.095. The particle registration probability as measured in the absence of the laminar medium was 0.116 ± 0.013. A part of these events is due to the tail of the Landau distribution; another part is due to electron bremsstrahlung in a 12.5 g/cm² liquid hydrogen target used in another experiment and installed in front of the laminar medium.

The energy distributions in xenon due to XTR and the ionization losses of 31 GeV electrons, as well as that due to the ionization losses only, were calculated for our detection instrument by the Monte-Carlo technique. The Monte-Carlo calculations are in good agreement with the experimental results.

These data indicate that XTR detection by a xenon scintillator allows identification of ultrahigh-energy particles in the region of $\gamma \approx 10^3 - 10^4$.

In conclusion the authors wish to express their gratitude to G. Ts. Avakian and M. S. Kocharian for the help in detector assembly development, to A. S. Belousov and N. Boedanov of Lebedev Physical Institute for their assistance during the run, and also to the staff of the IHEP accelerator.

References

Fig. 1. Schematic of gaseous xenon scintillator. 1-photomultiplier, 2-magnetic shield, 3-teflon O-ring, 4-container.

Fig. 2. The distribution of the energy release with the laminar medium (crosses) and without it (points).