Prog. Theor. Phys. Vol. 53 (1975), May

A New Particle Observed in High Energy Cosmic Ray Interactions

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February 1, 1975

An emulsion chamber with producing layers was floated from Sanriku Balloon Center at an altitude of 10 g/cm^2 for the studies of nuclear interactions at energies above 10 TeV. Among the secondary charged particles of a jet produced in this chamber, two particles are considered to have decayed; one into a charged particle and η-meson and the other into a charged particle and π^0-meson with lifetimes of about 10^{-12} seconds. These particles are very similar to the X-particle reported by Niu et al.[1] In this letter, some details of this event are reported.

The schematic views of the chamber and of the event are shown in Fig. 1. The prong no. 2 in the forward cone scatters about 3.8×10^{-3} radians in the acrylics base of emulsion plate at the point of 30.4 mm

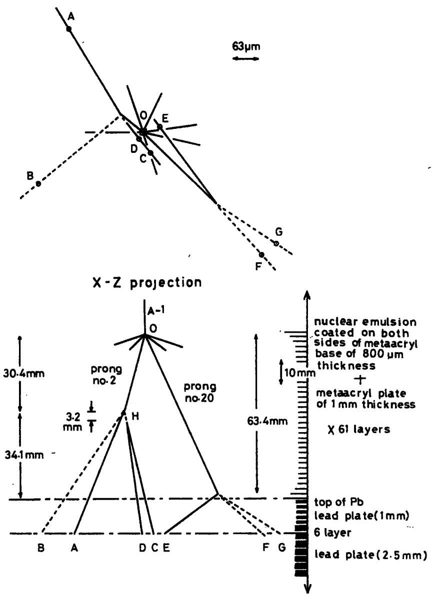

Fig. 1. A-1 $27ns+17\gamma$; $E_0=18.4$ TeV; X-Y projection.

from the origin of the A-1 jet. The area of radius 1.0 mm near the scattered point was scanned very carefully on both sides of the emulsion plate and there are no other charged particles associated with the scattered point. In the nearly opposite direction of the scattered particle A, a pair of electrons C and D which are produced from a γ-ray H, appear at the point of 3.2

mm from the scattered point. The pair of electrons clearly converges to the scattered point of the charged particle. Another γ-ray, B, was observed at the 6th layer of the lower chamber. The convergency of this γ-ray to the scattered point was examined by measuring the relative distances between an electron pair of this γ-ray and secondary charged particles produced from the jet. It is concluded from the convergent point distribution that this γ-ray converges to the scattered point of the prong no. 2 with one standard deviation of 16.2 mm, where the distance between the scattered point and the origin of jet is 30.4 mm. The prong no. 20 in the middle cone scatters in the acrylics base about 1.5×10^{-2} radians at the point of 63.4 mm from the origin. In the opposite direction, two pairs of electrons F and G appear at the points of 4.1 mm and of 8.2 mm from the scattered point, respectively. They also converge clearly to the scattered point of the prong no. 20.

The energies of the scattered charged particles A and E were measured by the relative scattering method in the lead plates. The energies of γ-rays B, F and G were estimated by counting of cascade electrons.[2] The energies of two electrons from γ-ray C and D were estimated by three methods; electron counting method, the opening angle method and the relative scattering method in acrylics plate as well as in the lead plates. The energies esti- mated by those three methods are consistent with each other within an error of 35%.

The coplanarities of the charged particle A and a pair of γ-rays $B+H$ and of E and $F+G$ are confirmed within the limit of the errors in the energy estimations.

The transverse momenta of charged particle A and a pair of γ-rays $B+H$ from the axis of the respective parent particles are (0.61 ± 0.21) GeV/c and (0.62 ± 0.11) GeV/c, and those of E and $F+G$ are (0.75 ± 0.15) GeV/c and (0.80 ± 0.24) GeV/c, respectively.

Table I. Invariant mass.

		$A+(B+H)$	$B+(F+G)$
Mass (GeV)	P	1.98 ± 0.50	2.10 ± 0.53
	K	1.66 ± 0.42	1.74 ± 0.44
	π	1.55 ± 0.38	1.59 ± 0.40

Invariant masses of two γ-rays, $B+H$ and $F+G$, are estimated to be (0.51 ± 0.15) GeV and (0.12 ± 0.04) GeV. They are most likely to be η-meson and π^0-meson, respectively. Invariant mass of the scattered charged particle and a pair of γ-rays in each prong, $A+B+H$ and $E+F+G$, is estimated by assuming that the scattered charged particle is proton, kaon and pion, respectively. As is shown in Table I, the prongs no. 2 and no. 20 have the nearly same mass value as about 2.0 GeV for proton, 1.7 GeV for kaon and 1.55 GeV for pion.*)

The probability that these events are due to the nuclear interactions, such as diffractive or charge exchange process, is very small. It is estimated to be smaller than 10^{-6}, considering the large transverse momentum of these particles, the coplanarity and the momentum balance described above. Therefore, it is quite possible to attribute these phenomena to the two-body decays with lifetimes of 6×10^{-13} seconds for the prong no. 2 and 4×10^{-12} seconds for the prong no. 20. It is very similar to the X-particle reported by Niu et al.[1]

As to the features of these particles, their lifetimes are too short for weak decay

*) There is another method to calculate invariant mass from the geometry of the event, assuming the coplanarity and the momentum balance described above and the true mass values of η or π^0-meson instead of the estimated values. The invariant masses $(A+\eta)$ and $(E+\pi^0)$ estimated by this method are 1.75 GeV and 1.9 GeV, assuming the scattered particle to be kaon.

and too long for strong decay. They may be explained by the weak decay of a new type of particle which has a larger Q-value than the ordinary particles. The phenomena could be interpreted as the pair production of baryonic or mesonic particles with the same mass value, which decay into $(P^{\pm}(K^{\pm})+\eta$ and $P^{\pm}(K^{\pm})+\pi^0$ through the weak interaction with lifetimes of about 10^{-12} seconds.

On the other hand, it is interesting to note that invariant mass of the prongs no. 2 and no. 20 is estimated to be 4.1 GeV and 3.8 GeV, assuming the scattered particles to be kaon and pion, respectively. It might be the same particle as the vector particle J with mass 4.1 GeV or 3.7 GeV observed by Abrams et al.[3)]

More details of the analysis of this event will be reported in a future publication.[4)]

The authors are grateful to Professors J. Nishimura and K. Niu for useful discussions, and also to the members of Sanriku Balloon Center for successful flight.

1) K. Niu et al., Prog. Theor. Phys. **46** (1971), 1644.
2) J. Nishimura, Prog. Theor. Phys. Suppl. No. 32 (1964), 72.
3) G. S. Abrams et al., Phys. Rev. Letters **24** (1974), 1453.
4) CKJ-Report-18, Cosmic Ray Laboratory publication, University of Tokyo.