NAL PROPOSAL No. 156

Scientific Spokesman:
K. Niu
Institute for Nuclear Study
University of Tokyo
Tanashi, Tokyo

Study of Secondary Particles Produced by 200 and 500 GeV Protons in Emulsion Chambers

K. Niu

Institute of Nuclear Study, University of Tokyo

August 1971

NAL PROPOSAL

Study of Secondary Particles Produced by 200 and 500 GeV Protons in Emulsion Chambers

K. Niu

Institute of Nuclear Study, University of Tokyo

OBJECTIVES

1. Comparison between the beam energy and the primary energy as determined by properties of secondary particles, in order to check the method currently used in cosmic ray experiments.

2. The distribution of energy given to γ-rays and the distribution of elasticity of collisions.

3. Search for short-lived particles as found by the author in an emulsion chamber exposed to cosmic rays (see, a copy of our paper attached).

INSTRUMENTATION

Emulsion chambers consisting of nuclear emulsions and thin low Z materials. Each chamber has a depth of about 0.1 interaction mean free paths. The beam intensity shall be about 10^3 - 10^4 protons/cm^2, so that about 10^4 - 10^5 interactions are expected in each chamber. This is compared with about 10^3 interactions obtained in an equivalent energy range in the emulsion chambers recently exposed to cosmic rays.

The beam intensity required is smaller by a factor of ten than that by Kusumoto et al, since secondary particles, in particular γ-rays developing into cascade showers, shall be measured separately from each other. Apart from this point, all other requirements are the same as Kusumoto's. Therefore, the exposure; that is, Kusumoto's and ours shall be regarded as two parts of one experiment.

to be published in Letter of Progress of Theoretical Physics.

A Possible Decay in Flight of New Type Particle

K. NIU and E. MIKUMO
Institute for Nuclear Study, University of Tokyo
Y. MAEDA
Yokohama National University

Among secondary particles produced in a high energy jet shower observed by emulsion chambers exposed to cosmic rays, a possible decay in flight of new type particle was found.

A new type of emulsion chamber[1] with local producing layer of jet shower was developped in order to investigate super high energy jet showers in full detail combining informations about secondary charged particles at or near an origin of jet shower as well as γ rays. Exposure of new type chambers about 500 hours at about 260 gr/cm^2 was performed using a Jet Cargo Aeroplane of Japan Air Lines.

One of jet shower observed in this type of chamber, Event "6B-23", was fortunately produced in the emulsion of lower surface of a plate in the middle of the producing layer which is a pile of 49 nuclear emulsion plates with a 50 μm coating on both sides of meta-acryl base with a thickness of 800 μm. Therefore, type of this jet shower was observed as (70+19)n. Schematical view of this jet shower is shown in Fig. 1.

In Fig. 2 is shown the relation of energy to lg.tgθ for γ -rays with lg.tgθ distribution of charged secondary particles.

The most impressive fearture of this jet shower is that 2 γ rays with energy nearly one order higher than others are emitted very closely in the center region of shower. The total sum of their energy is estimated as 3.2 $\pm$ 0.4 TeV, and relative distance between them is 3.4 μm at the target plane 5.14 cm down from jet shower origin. Coupling them into a π^0 meson, the estimated production hight is 3.8 $\pm$ 0.5 cm above the target plane, and it dosen't reach to the jet shower origin.

There emitted 4 charged particles very near to these γ rays. We drew precise target diagramm of tracks of these 4 particles A,B, C and D at each emulsion surface in the producing layer, and then reconstructed three dimensional view of tracks of these particles and π^0 meson. X,Y and Z prjections of these tracks are shown in Fig. 3a, b and c. We adopted Z axis parallel to the emitted direction of track B.

As you can see from X and Y projections, tracks B and C have knees at 1.38 cm and 4.88 cm respectively from the origin of jet shower. Angles of direction change of tracks are 1.07×10^{-3} radian and 1.50×10^{-3} radian respectively.

Looking at the Z projection, you can easily recognize that the two cascade cores from the π^0 meson appear in just the opposite direction of track B' and particles B, B' and the π^0 meson satisfy the coplanarity condition. The emission angle of the π^0 meson from the point of direction change of track B is 1.96×10^{-4} radian.

We followed down the tracks B' and C' to the bottum of lower chamber the thickness of which is 7 cascade units, and found nothing associated with tracks B' and C' before thier leaving the chamber. Therefore, tracks B' and C' might be produced by hadronic particles. Inspecting near arround the point of direction change of tracks B' and C' no track associated with those points was found.

Basing on the features descrived above, it is possible to attribute the phenomenon including tracks B, B' and the π^0 meson to a two body decay of X particle into a π^0 meson and a charged hadron. Transverse momentum of the π^0 meson to the initial direction of X particle is estimated as 627 ± 90 MeV/c and this value is also applied for that of particle B' in the case of two body decay. From this the momentum of particle B' turns out to be 0.59 TeV/c. Assuming $\pi^\pm$ meson or proton as a partner of the π^0 meson, mass and proper life time of X particle are got as shown in Table 1.

Table 1

Assumed decay mode	M_X GeV	T_X sec.
$X \rightarrow \pi^0 + \pi^\pm$	1.78	2.2×10^{-14}
$X \rightarrow \pi^0 + p$	2.95	3.6×10^{-14}

As for the characteristics of X particle, the transverse momentum of daughter π^0 meson, 627 ± 90 MeV/c, is much higher than maximum momentum of decay products of existing strange particles. The proper life time of X particle is several times 10^{-14} seconds, and this is extremely longer than those of resonance particles.

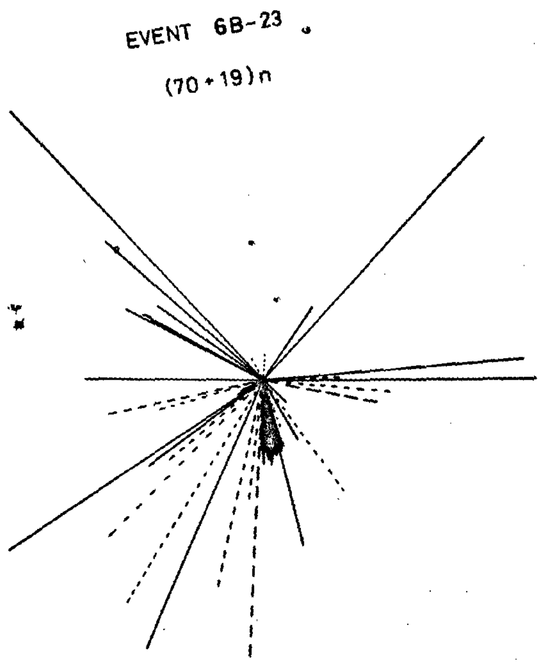
Therefore, our X particle could not be included neither in strange particle nor resonance particle.

If the direction change of track C at 4.88 cm from jet shower origin is attributed to a decay of particle C into a hadronic particle C' and a neutral hadronic particle, maybe we are observing a pair production of new type particles.

Full detail of analysis on this event and others will be published in another paper.

1) K. Niu et al., to be published in Proceedings of 12 th International Conference on Cosmic Rays, Hobert, Tasmania, Australia, 1971.

Fig. 1



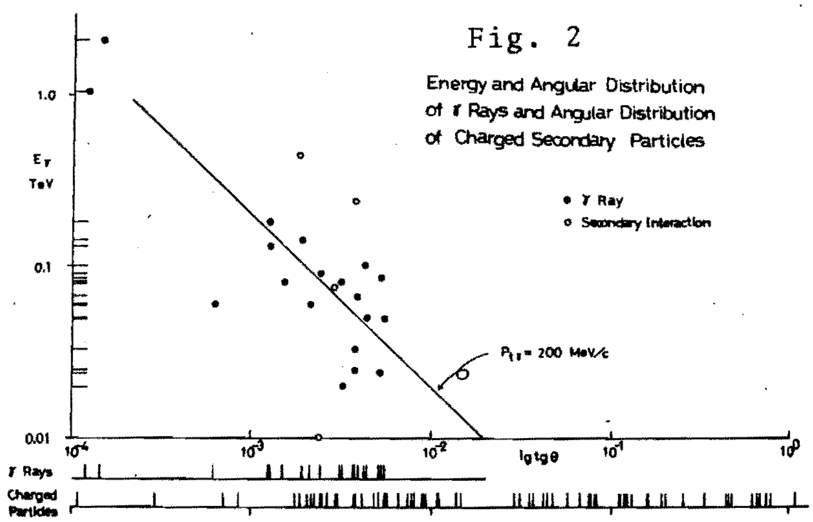


Fig. 2

Energy and Angular Distribution of γ Rays and Angular Distribution of Charged Secondary Particles

Fig. 3a Fig. 3b

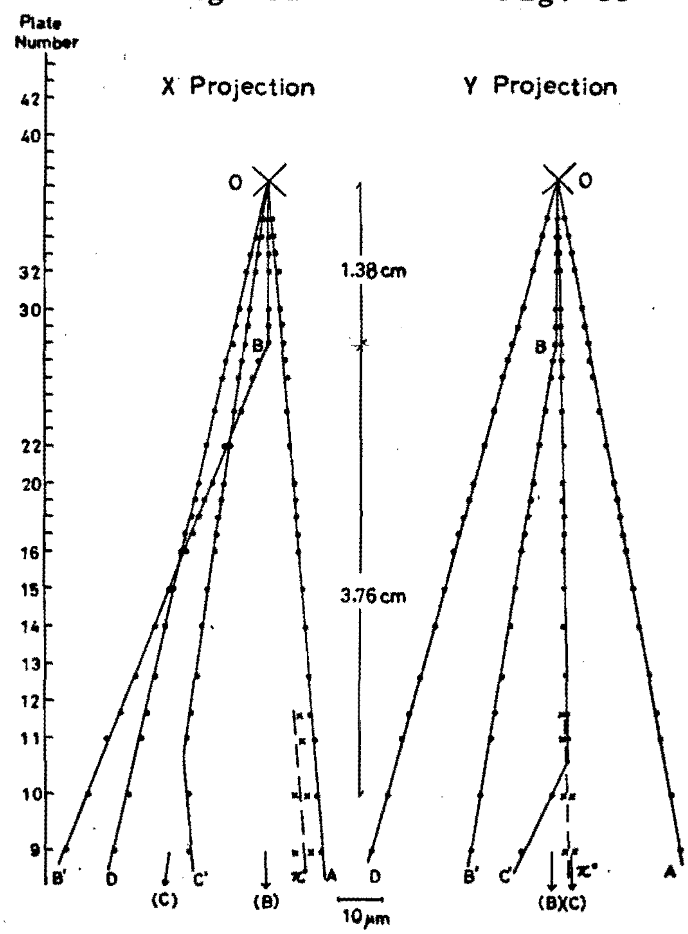


Plate Number
42
40
32
30
22
20
16
15
14
13
12
11
10
9
X Projection
Y Projection
O
B
1.38 cm
3.76 cm
B'
D
(C)
C'
(B)
π°
A
10 μm
(B)(C)

Fig. 3c   Z projection