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10 minutes talk at the Denver Conference.

DETAILED ANALYSIS OF JET SHOWERS OBSERVED BY EMULSION CHAMBERS WITH PRODUCING LAYER

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To investigate super high energy interaction, systematic studies and hunting of X particles are continued on jet showers observed in emulsion chambers exposed at balloon and aeroplane altitudes.

In parallel to the continuation of experiment we are also making reanalysis of old events.

In the beginning of this year we have got letters from Prof.David Ritson and Prof.Jere Lord imforming us that Kaplon, Peters and Ritson observed a very similar event to ours in their brass emulsion chamber exposed to balloon altitude about 23 years ago. That is so called "T star" and the first slide shows a sketch of this event.

They observed two π^0 mesons with much higher energy than others, 2.4TeV and 1.6TeV, which decayed into two γ rays at the point 7cm and 2.5cm respectively from the origin of the event with primary energy about 20TeV. They have reported in their paper that they found delayed decay of π^0 mesons of the order of 10^{-14} second.

We tried to reanalyse this event on the assumption that these

π^0 mesons are the daughter of X particle. We assumed 2 cases, one is two body decay of X^0 particle into two π^0 mesons, and the other is pair production of X particles each decaying into π^0 meson and her sister.

In both cases, the answer for mass value and or life time of assumed X particle seem not inconsistent with those we have reported at the last conference. It is exceedingly impressive that since the very first occasion of application of emulsion chamber to the study of super high energy phenomena they already observed such event very similar to ours.

Another old jet shower "ST-2" which was observed also in the first balloon experiment of Japanese Emulsion Chamber Group about 17 years ago was reanalysed by one of us. The primary energy of this event is estimated as $\sim$25TeV and n_s value is larger than 51. A sketch of the central part of this event is shown in the next slide.

One of cascade showers with the highest energy, 1TeV, one order higher than others shows a double core structure. This shower is carefully analysed and pointed out the possibility to be a π^0 meson produced at the distance 8.4cm from the origin of this jet shower. If we assume two body decay of X particle with mass value of $2\sim3$GeV, we get the maximum life time as $6\sim8\cdot10^{-13}$ second.

One of secondary charged particles "t" suffered a large angle scattering, about 1.87×10^{-2} radian, at the point 7.63cm from the origin. From this point two γ rays are emitted which are possible to couple into η^0 meson. Three dimensional analysis tells us that there must be, at least, one more neutral particle emitted from this point. Assuming quasi three body decay of X particle, we got probable sets of mass and life time as $\sim$3GeV and several times 10^{-12} seconds.

Turning to the second series of exposure, 14 emulsion chambers were exposed for about 500hrs at aeroplane altitude. In the course of analysis of observed events, we intended to apply relative

scattering method for determination of momentum of charged particles in order to study high energy jet showers in full detail.

Calibration of this method was done by means of emulsion chamber consists of 20 layers of 1mm lead plates and emulsion films, which was exposed to protons with energy of 205GeV/c at the National Accelerator Laboratory.

Following 2 slides shows the design of chamber and the results of calibration. We got the momentum value as ∿210GeV/c for incident protons, if we take longer cell length than 5mm Pb.

We applied this method to secondary particles of jet shower observed by new exposure. Next slide shows a lgtg θ distribution of this event whose primary energy is estimated as ∿20TeV and observed n_s larger than 70 and n_γ larger than 35.

The results of momentum measurement on 37 charged particles are shown in the next slide. Transverse momentum of these particles are consistent with those expected from the analysis on γ rays.

We also precisely analysed behaviour of charged particles and high energy part of γ rays of this event. Next slide shows the results of along the track scanning for secondary interactions. Following tracks of 26 charged particles over a length of one fourth of nuclear interaction mean free path we got 6 interactions. This is just equal to the expected nember.

Beside these secondary interactions we find complicated feature in the central region of this event a sketch of which is shown in the next slide.

At first, two high energy π^0 mesons with energy 3TeV and 0.6TeV were observed decaying respectively at the points of 6.14cm and 1.1cm from the origin. This remarkable feature is just like as in the "T star" which I've mentioned at the beginning of my talk.

We also observed the fact that one of charged particle was suffered double large angle scattering of the order of 2.0×10^{-3} and 1.9×10^{-3} radians respectively inside the producer layer.

Applying relative scattering measurement on this track after double scattering, we got the momentum value of 450 ± 200GeV/c

and high P_T value to the initial direction DE as 840 ± 390MeV/c. Assuming two body decay of X particle at the point E into one charged particle and other neutral particle, we get the minimum mass and maximum life time of X particle connecting D and E as 2GeV and 0.5×10^{-14} seconds. Perhaps we are possibly observing a new type of cascade decay of X' particle produced at the origin of this event.

Beside these, we observed two more γ rays. One is 55GeV and emitted from the scattering point of charged particle "1" inside the producer, and the other is 1.2TeV which cannot be produced directly from the origin of this event because of the three dimensional analysis. Further two more charged particles were suffured relatively large angle scattering, but in the upper part of the lead chamber.

Following several slides show the results of detailed three dimensional analysis on these particles.

Till now, we have not yet fixed our interpretation on this complicated phenomena.

Summarizing my talk, I would like to show you a list of events we are concerned and a table of possible X particles observed in these events.

Up to now, no new example of clear X particle was found, but several of dirty candidates. Considering other indirect information together, however, possibility of the existence of particles with life time around 10^{-13} second seems to be increased.

Thank you.

Reinterpretation of "T star"
reported in Physical Review 85, 900, 1952.

Case 1. $X^{\circ} \rightarrow \pi^{\circ}_{AA'} + \pi^{\circ}_{BB'}$

Case 2. $X_{AA'} \rightarrow \pi^{\circ}_{AA'} + ?$

$X_{BB'} \rightarrow \pi^{\circ}_{BB'} + ?$

Estimated values of mass and life time of X particle are attached on the figures in the next page.

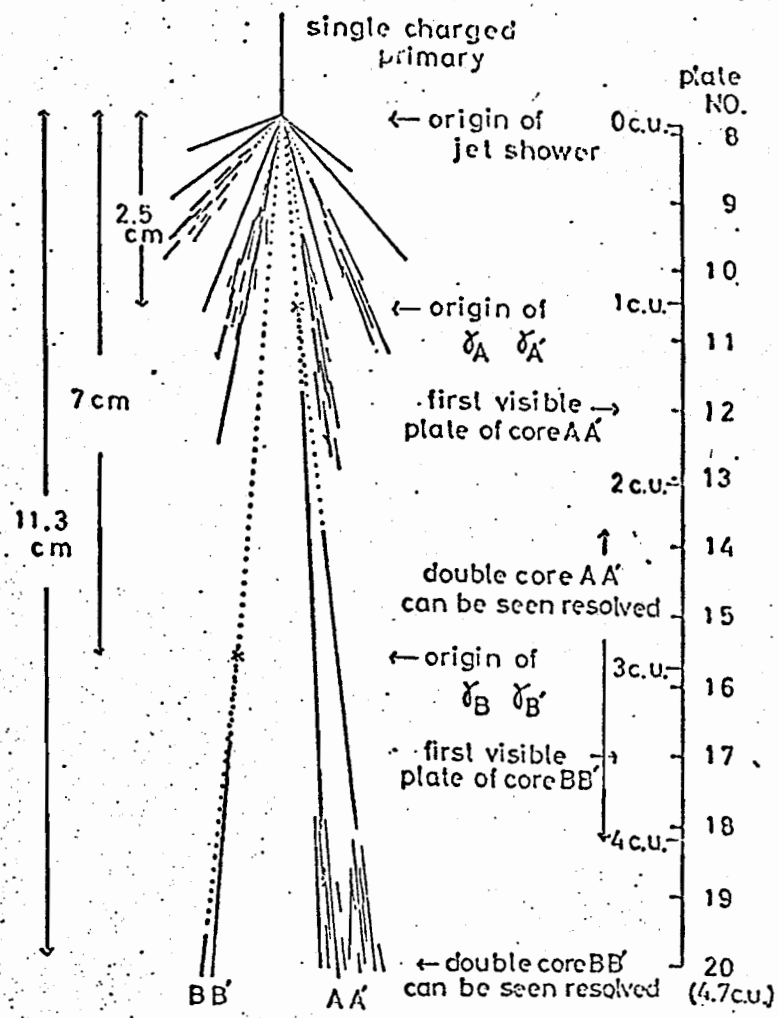
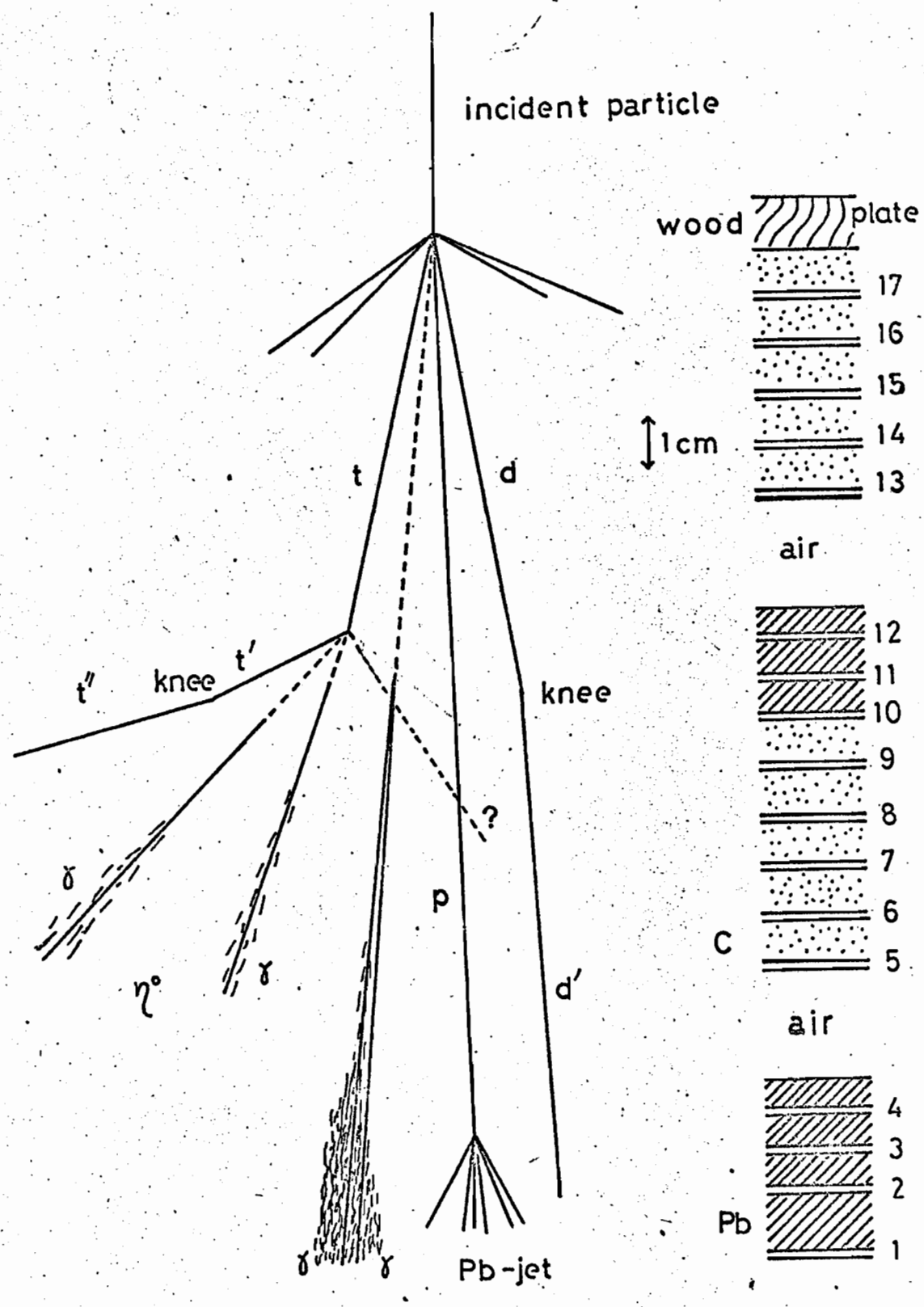
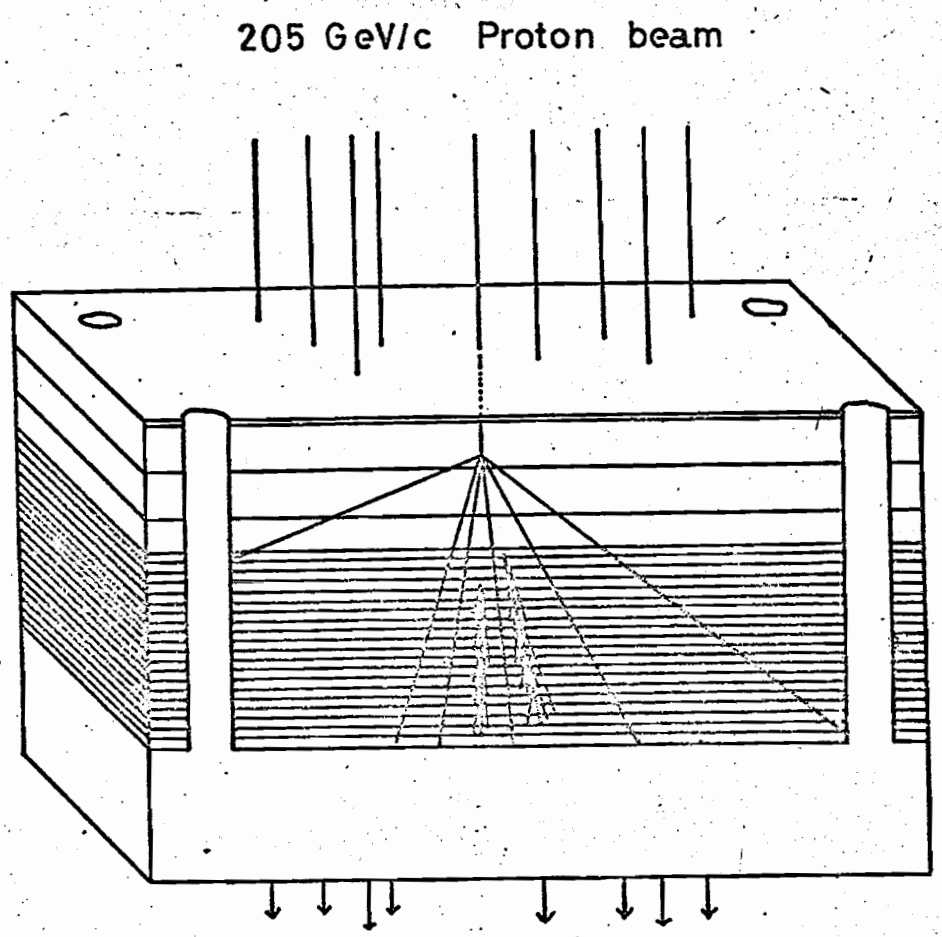


Fig. 3. sketch of the so-called T-star.



SKetch of ST-2

Fig.



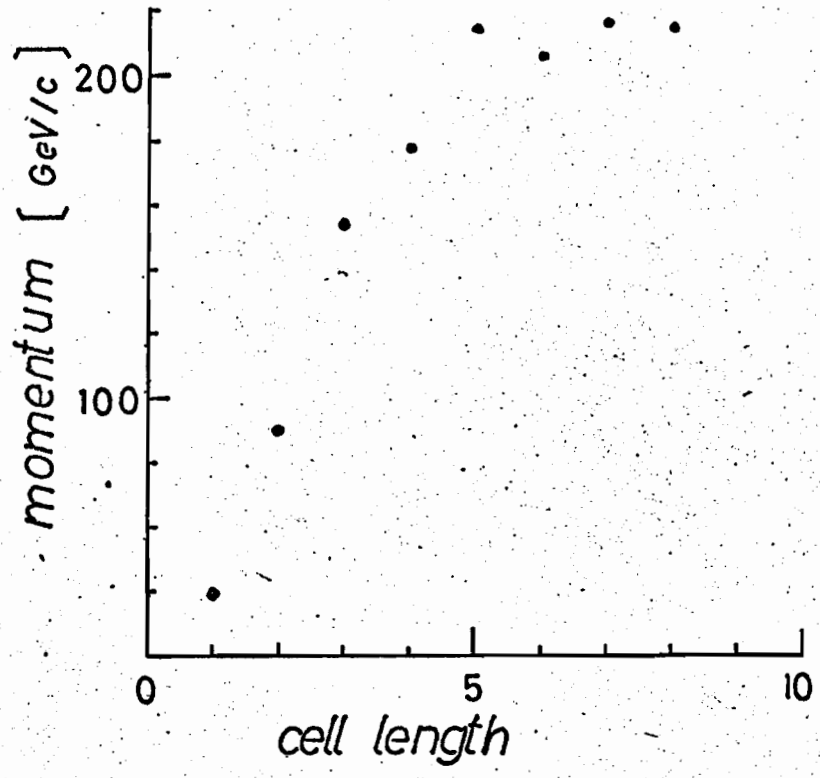
Producing layer

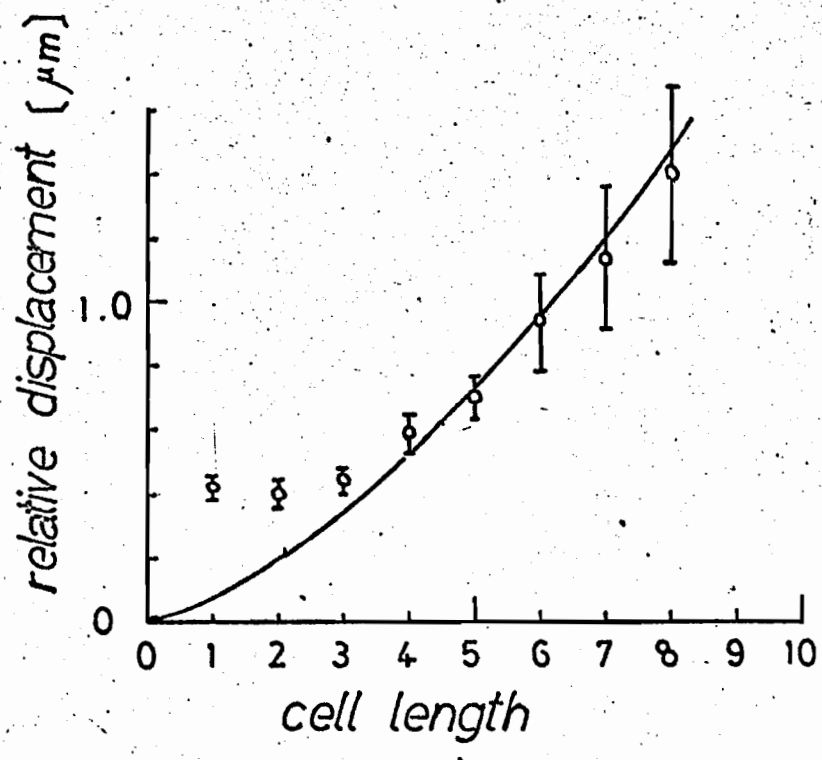
E.C.C.

Pb 1 mm thick x 20

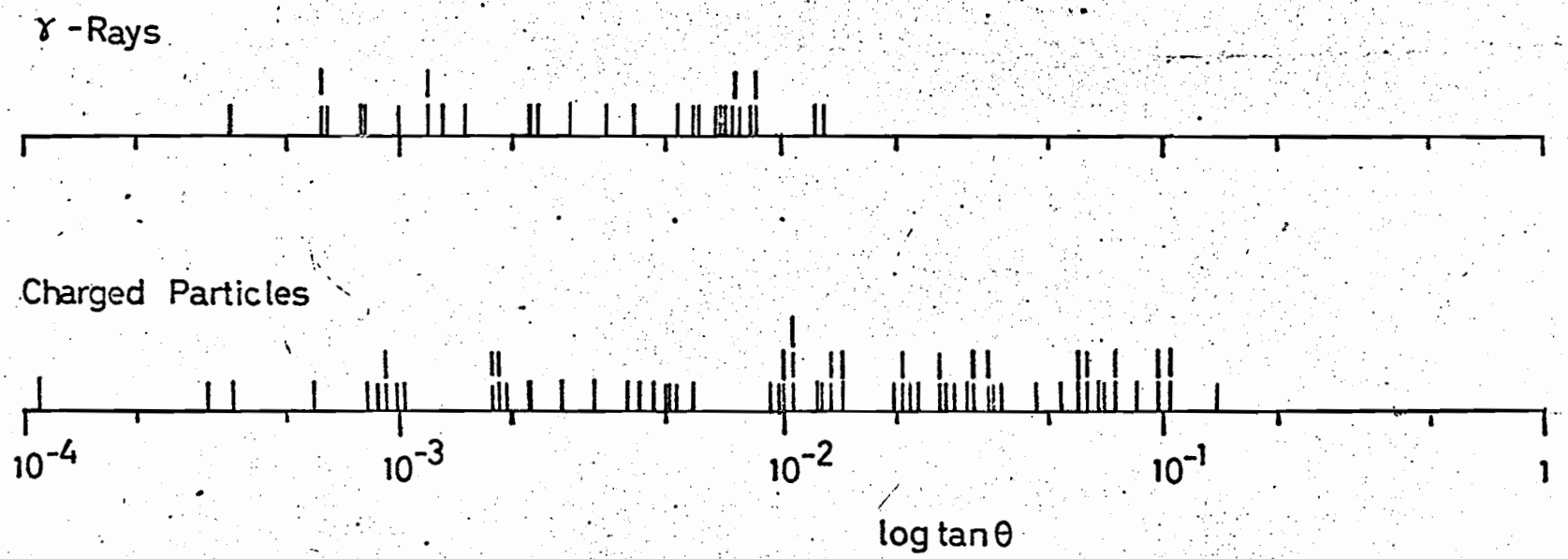
Film based emulsion x 20

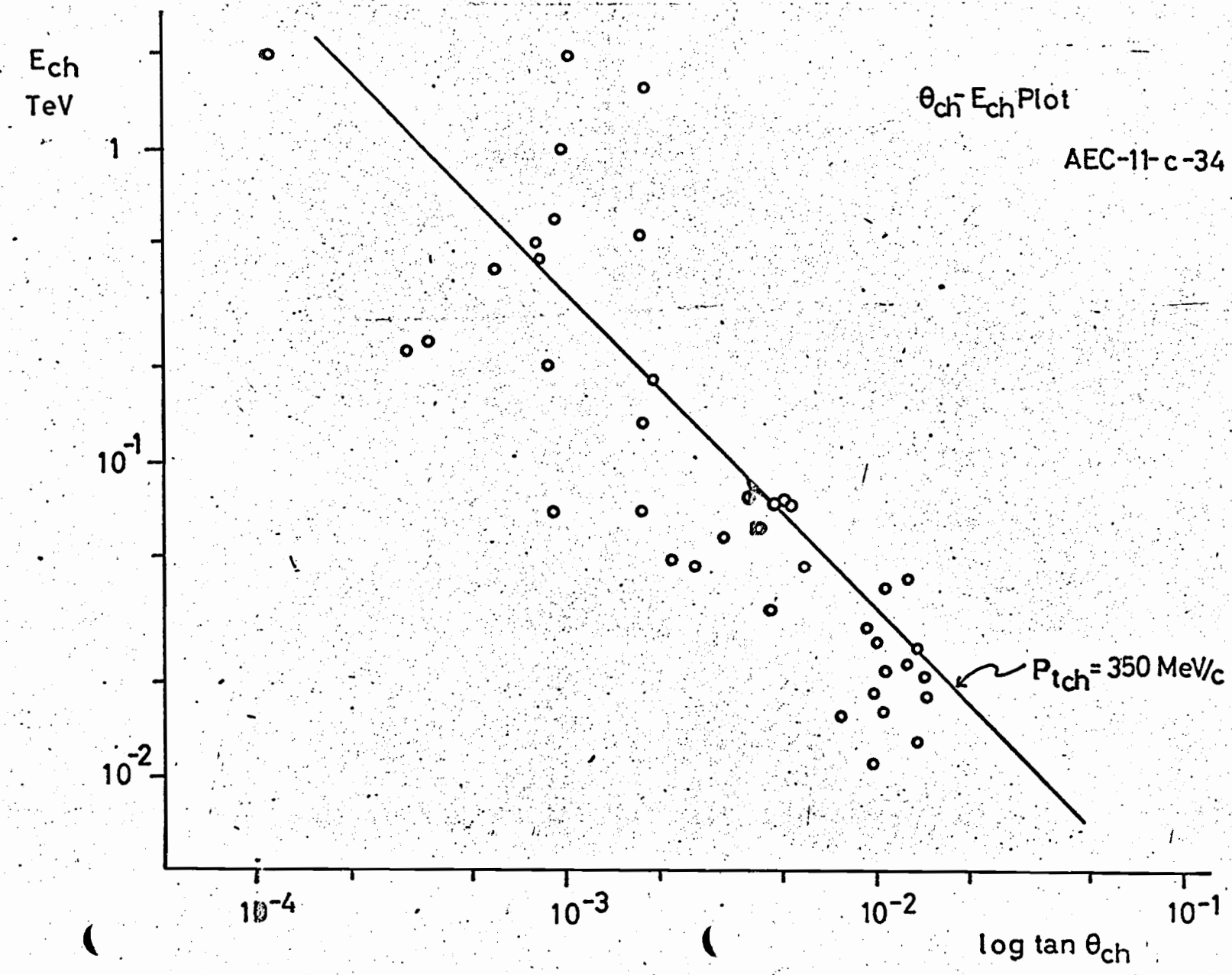
Base of meta-acrylic resin


momentum [GeV/c]
200
100
0
5
10
cell length


relative displacement [μm]
1.0
0
0 1 2 3 4 5 6 7 8 9 10
cell length

log tanθ Plot AEC-11-c-34




E_{ch}
TeV
1
10^{-1}
10^{-2}
θ_{ch}- E_{ch} Plot
AEC-11-c-34
P_{tch} = 350 MeV/c
10^{-4}
10^{-3}
10^{-2}
10^{-1}
log tan θ_{ch}

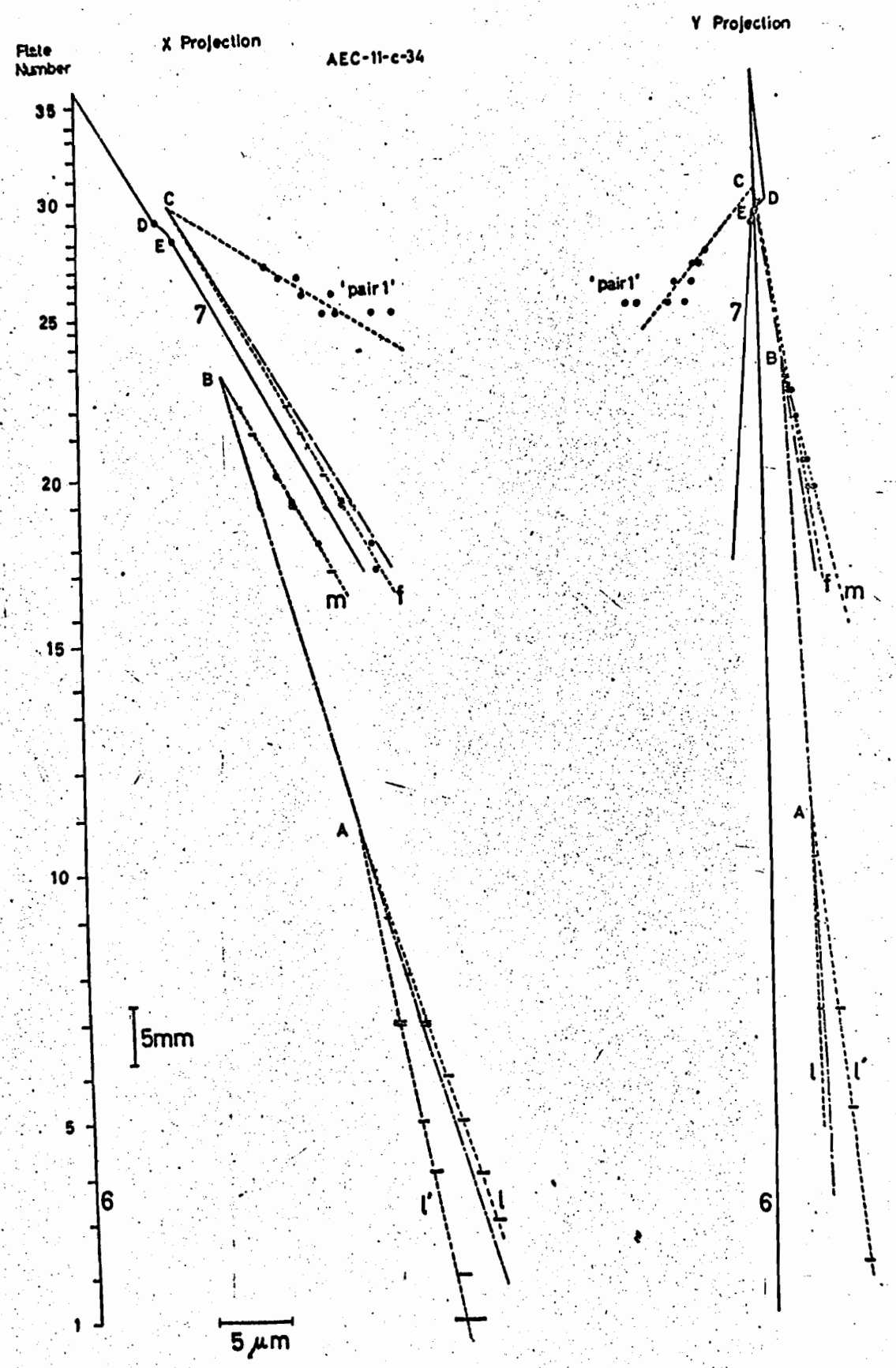
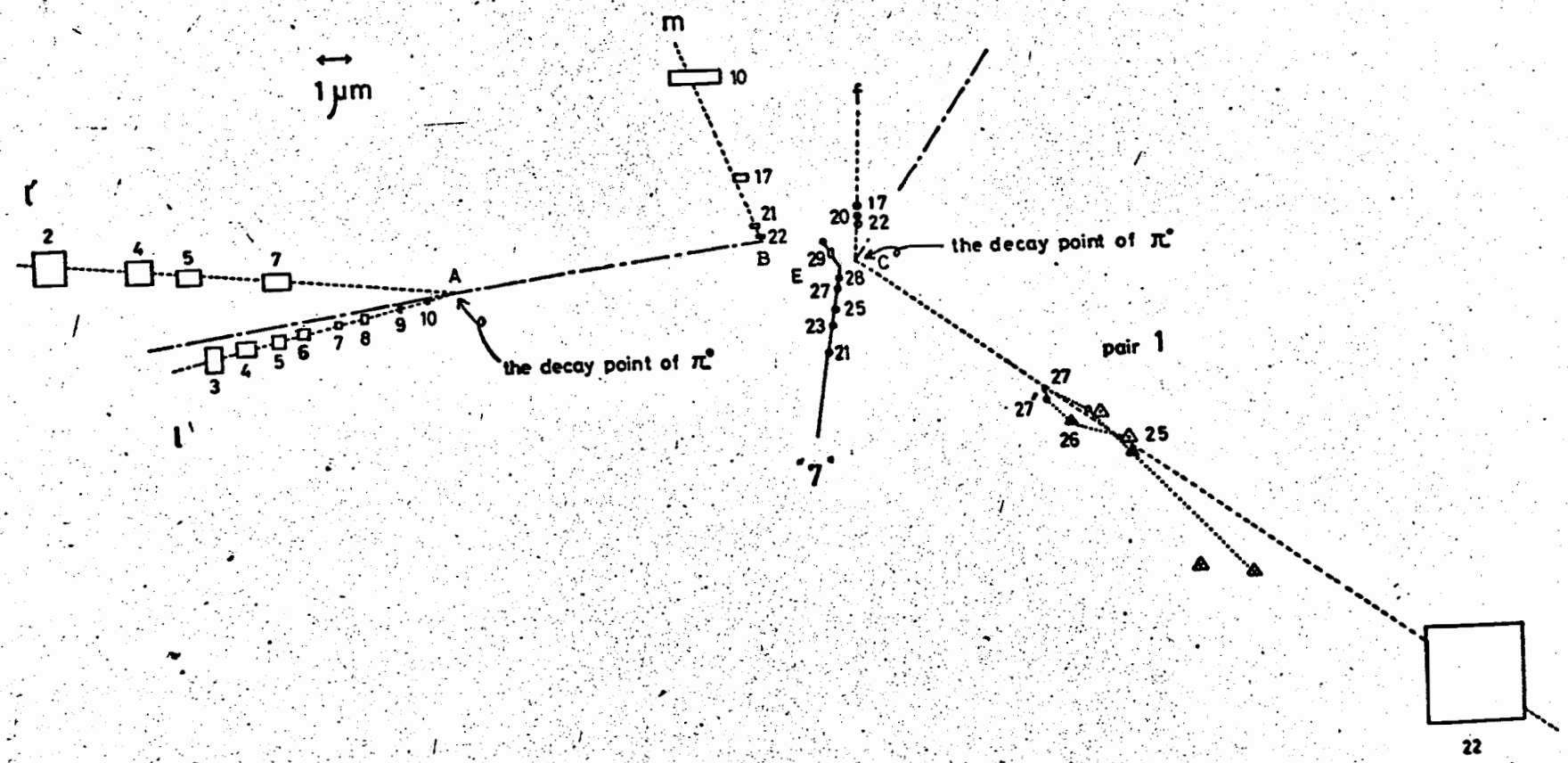
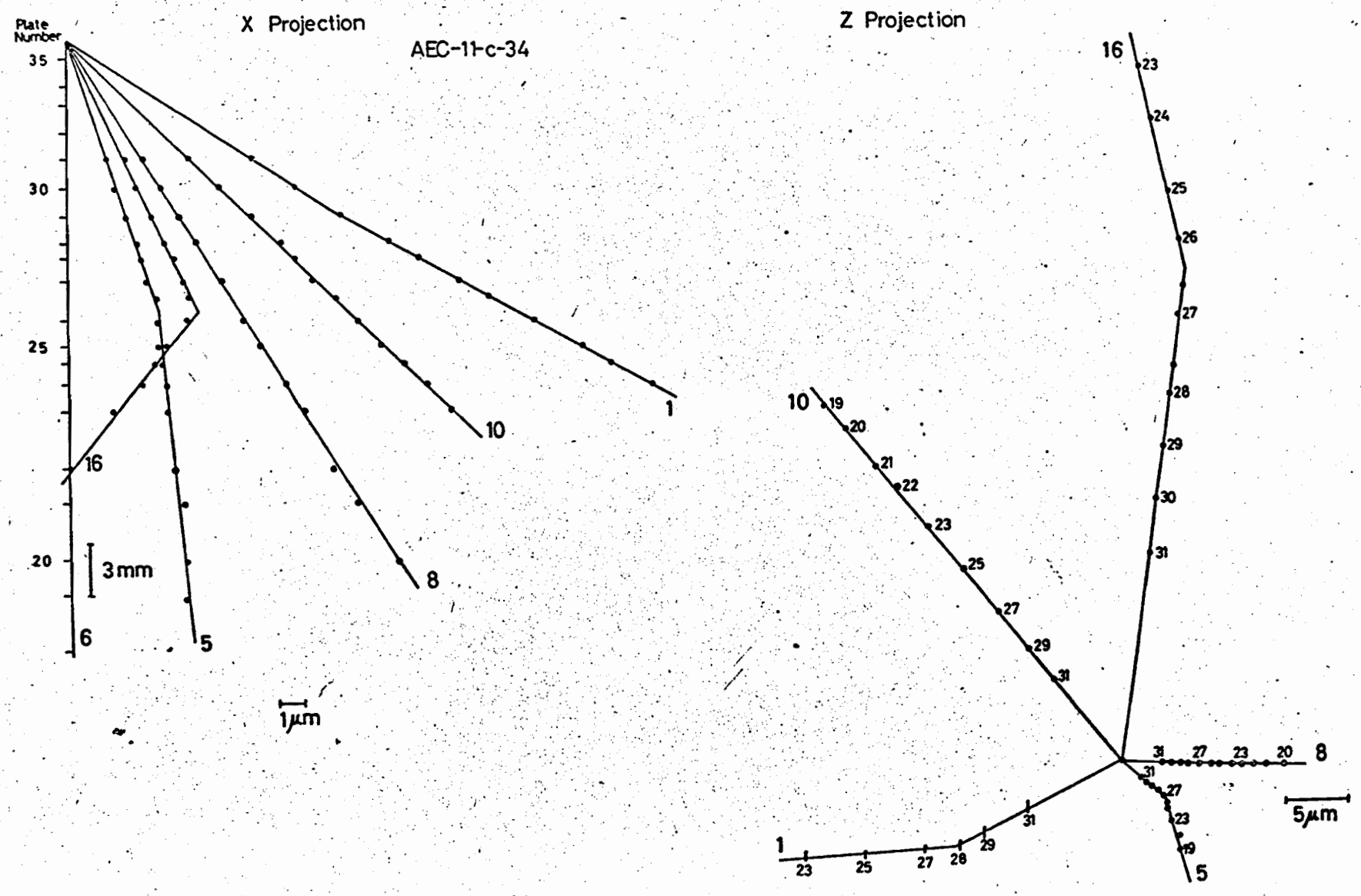


Plate Number
X Projection
AEC-11-c-34
Y Projection
35
30
25
20
15
10
5
1
C
D
E
B
A
7
6
'pair 1'
m
f
l
l'
5mm
5 μm

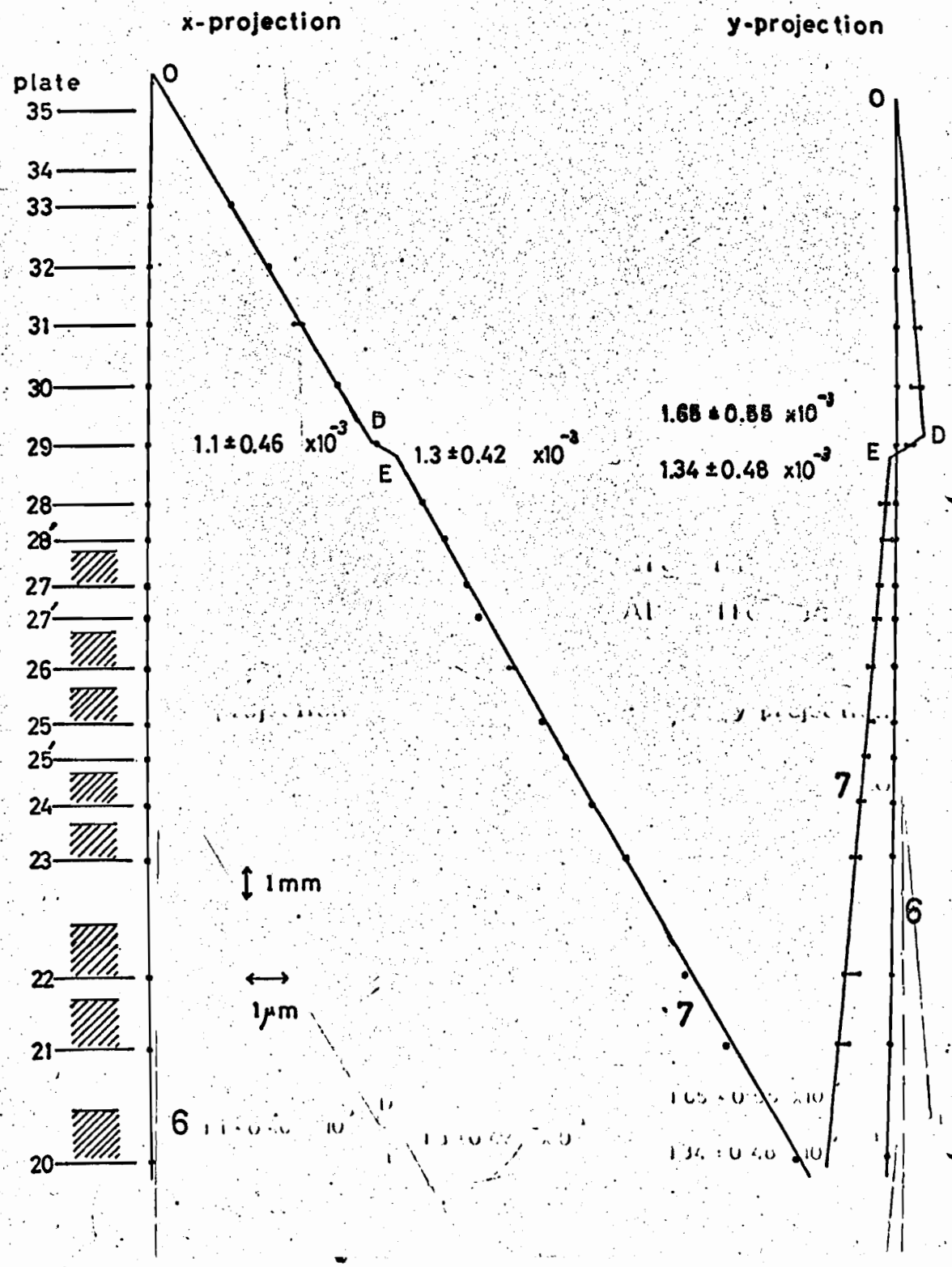
Z-Projection AEC -11c -34



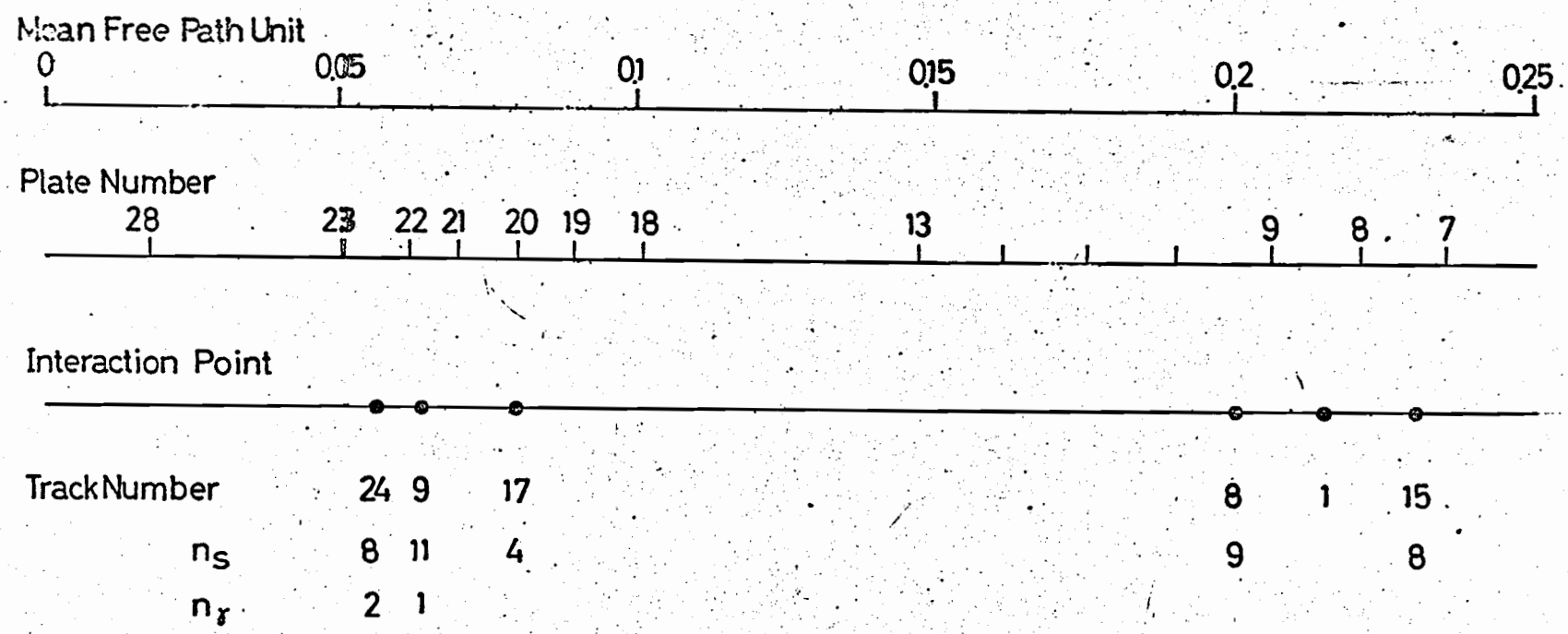

X Projection
AEC-11-c-34
Plate Number
35
30
25
20
3mm
1μm
1
10
8
16
6
5
Z Projection
16
10
8
1
5
5μm

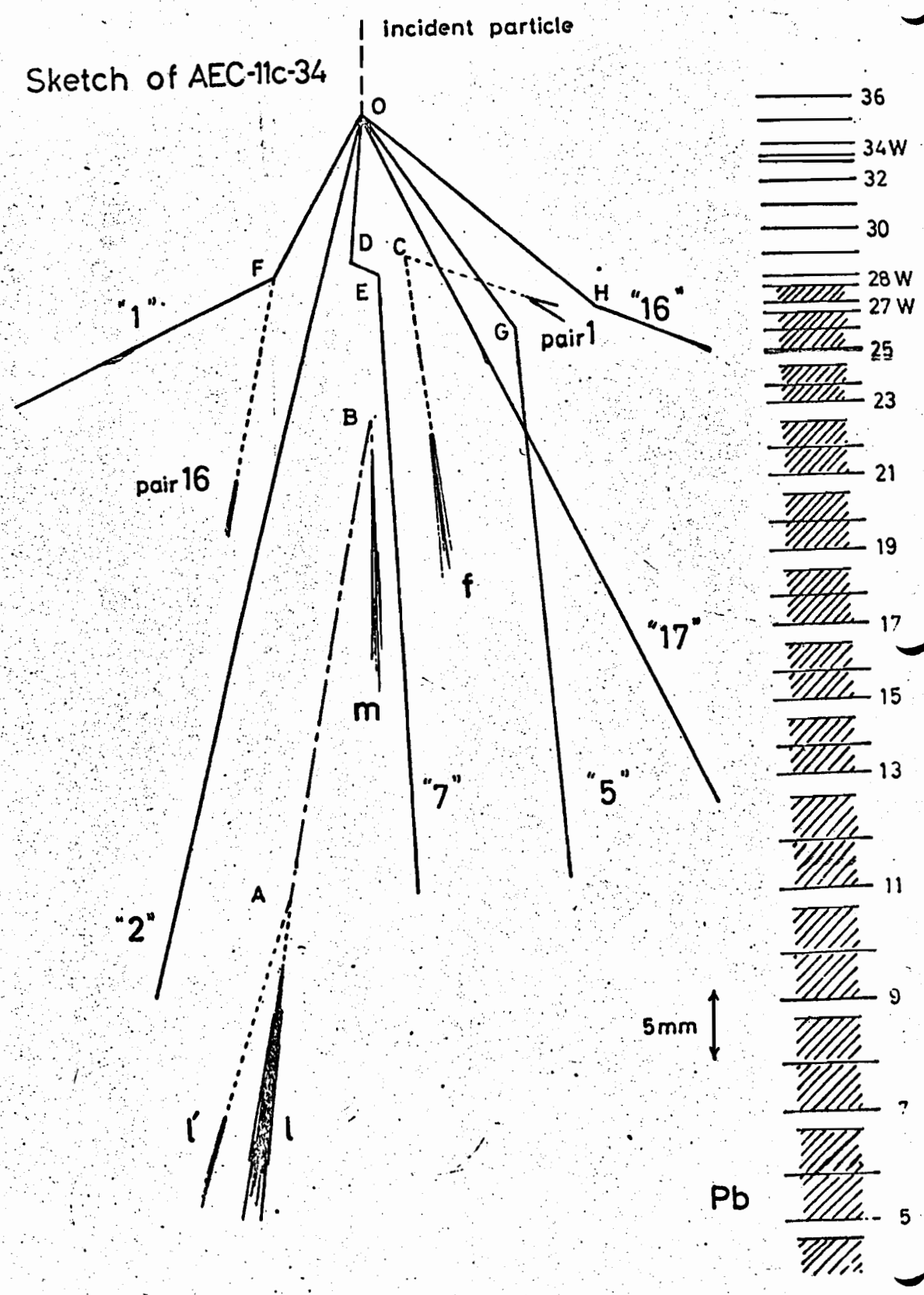
X-and Y- Projections of the Charged Particle "7"

AEC -11c - 34

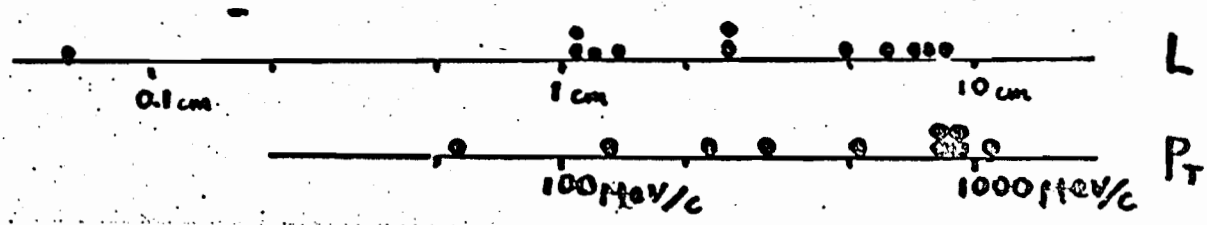


Secondary Interaction AEC-11-c-34




Sketch of AEC-11c-34
incident particle
O
"1"
F
D
C
E
H
"16"
G
pair 1
B
pair 16
f
"17"
m
"7"
"5"
A
"2"
5mm
l'
l
Pb
36
34W
32
30
28 W
27 W
25
23
21
19
17
15
13
11
9
7
5

	Ch of 1ry ptl.	$E_{0\,TeV}$	n_S	ΣE_γ	E_{π^0} or γ TeV
6B-23	0	~10	70	~4.5	3.2
T	±1	~20	36	6	2.4, 1.6
ST-2	?	~25	>51	2.1	1.0
11C-34	0	~20	>70	8	3.0, 0.6, 1.2

(High n_S) (Torpedo type)

		$M_{X\,GeV}$	$\tau_{X\,sec}$	L_{cm}	P_T MeV/c	
6B-23	$X^\pm \to \pi^0 + \pi^\pm$	1.78	$2.2\cdot10^{-14}$			
	or p	2.95	$3.6\cdot10^{-14}$	1.38	627	pair production ?
	or Σ^+	3.5	$4.2\cdot10^{-14}$			
	$X^\pm \to \chi^\pm + \chi^0$	>1	$<7.7\cdot10^{-13}$	4.88	315	
T	$X^0 \to \pi^0 + \pi^0$	2.56	$3.2\cdot10^{-14}$	2.5	1100	
	or $X \to \pi^0 + \chi$	(2~5)	$<3\cdot10^{-13}$	7.3		
	$X \to \pi^0 + \chi$		$<5\cdot10^{-13}$	2.5		
ST-2	$X^\pm \to \eta^0 + \chi^\pm + \chi^0$	(~3)	$<4\cdot10^{-12}$	7.63	229 815	
	$X^0 \to \pi^0 + \chi^0$	(2~3)	$6\sim8\cdot10^{-13}$	8.4		
11C-34	$X_2^\pm \to X_1^\pm + \chi^0$			1.1	>900	Cascad decay ?
	$X_1^\pm \to \chi^\pm + \chi^0$	>2	$<5\cdot10^{-15}$	0.063	840	
	$X^0 \to \pi^0 + \chi^0$	>1	$<6.1\times10^{-14}$	1.1	130	
	$X^0 \to \pi^0 + \chi^0$	>2	$<1.4\cdot10^{-13}$	6.14	900	
	$X^\pm \to \chi^\pm + \gamma + \cdots$			1.18	55	
	=