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ABOUT SOME RESULTS OF THE BROOKHAVEN NEUTRINO EXPERIMENT

Jean-Marc Gaillard

In this report I would like to discuss some unpublished data especially relevant to the planning of the CERN experiment. I think it is unnecessary to review in detail the already published articles in Physical Review Letters and the proceedings of the CERN conference. I shall, however, use some of the data from these papers.

1. Total and Differential Cross Sections for "Elastic" Reactions

Reference is made to a new paper of Lapidus, who thinks he could explain the absence of electron events in the Brookhaven experiment by the existence of a specially strong pseudoscalar term. Unfortunately, this change will also give a cross section five times bigger for the reactions

$$\nu + n \rightarrow p + \mu^-$$
$$\bar{\nu} + p \rightarrow n + \mu^+$$

In our Brookhaven experiment, we have been using the measured fluxes of pions under the same conditions (angle and target position) to compute our neutrino fluxes. Measurements of kaons being rather poor, we have been forced to do some extrapolations in that case, but as the contribution of neutrinos due to kaons is only about 20%, as far as the "elastic" processes are concerned, I feel quite confident that the estimated error of 30% in our neutrino flux is correct. The only possibility to obtain more "elastic" events is to include into the counting the vertices events with only two prongs, and for which the presumed muon has a momentum greater than 300 Mev/c to fulfil our criteria. This will add a maximum of 6 events to the 29 already there. The rate for elastic events in that case becomes :

$$1.02 \pm 0.19 \text{ events}/10^{16} \text{ circulating protons}$$

to be compared with the rate computed from Lee and Yang cross sections

$$0.75 \pm \sim 0.23 \text{ events}/10^{16} \text{ circulating protons.}$$

These numbers seem to be incompatible with the Lapidus assumption.

A more serious question is the shape of the angular distribution as shown in Figure I; even with poor statistics it seems much more peaked forward than it should, if one believes the Yamaguchi computations. A good check would be to repete these calculations, using our limitations ($P\mu > 300$ Mev/c, $\Theta\mu < 60^{\circ}$) and our computed neutrino spectrum, shown in Figure 2. In such a computation, the Fermi momentum distribution and the Pauli principle should also be included. The shape of the angular distribution has a direct bearing upon the probability for a neutrino produced muon to stay inside the chamber with a long enough range: an important point to compare different set-up possibilities.

2. Vertices Events

Table I gives a complete list with as many relevant details as possible. What are those events? Theoretical estimates of the pion production have been made by Bell and Berman, Dennery, Dombey, introducing the $(^3/_2, ^3/_2)$ resonance, but no $\pi\pi$ interaction. The effect of the vector part should lead to cross sections $\sim 10^{-39} cm^2$. The axial part effect is more difficult to evaluate even in the case of very rough approximations.

For comparison, the mean elastic cross section for neutrinos and antineutrinos, with our spectrum, was about $3 \times 10^{-39} cm^2$. Even if the

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contribution of the $\pi\pi$ interaction will become important at high neutrino energies only, one could certainly expect the inelastic and the elastic cross sections to be of the same order of magnitude. Furthermore, there are not really 22 inelastic events for 29 elastic events, because no requirement like $P\mu > 300$ Mev/c has been put for the inelastic events. In fact, that particular condition eliminates in the Brookhaven case 30% of the elastic events, which will get the positions moved to :

41 elastic against 22 inelastic events.

It is rather difficult to say how many events among those vertices could in fact be elastic events with high momentum transfer to the nucleon. An upper limit is certainly to take all the events with two prongs only, and nothing else, to be elastic events; amounting to 8 events, of which as we have seen only 6 have $P\mu > 300$ Mev/c.

As far as the intermediate boson is concerned, it is difficult to say very much; the main argument is that the decay product of the W should take the maximum of the visible energy. This will in particular exclude all events but one (1 p + 1 Se). In the case of the decay $W \rightarrow \mu + \nu$, which would correspond to 2 visible muons, one must also require a small enough angle with the incoming neutrino of one of the muons, which must be the energetic one; two or three of the two prongs will be of the correct kind. In the four prong events we have got, the energy is mainly concentrated in the presumed muon, and only one event (22306) could be a case $W \rightarrow 3\pi$, associated with a muon. Finally, one extremely spectacular event (18891) with 1.5 Gev release in a charged pion + 2γ probably coming from a π^0 could be a good example of $W^{\mp} \rightarrow \pi^{\mp} + \pi^0$. These five or six events should consitute in a certain way an upper limit of the number of events which could be due to intermediate boson production in the Brookhaven experiment. The inelastic cross section will certainly increase by a factor 2 or 3 in the case of the CERN experiment; we should, therefore, consider very seriously the possibility that a good proportion of the inelastic events will simulate intermediate boson events, and we should find a way of identifying this last type of event in a completely unambiguous manner.

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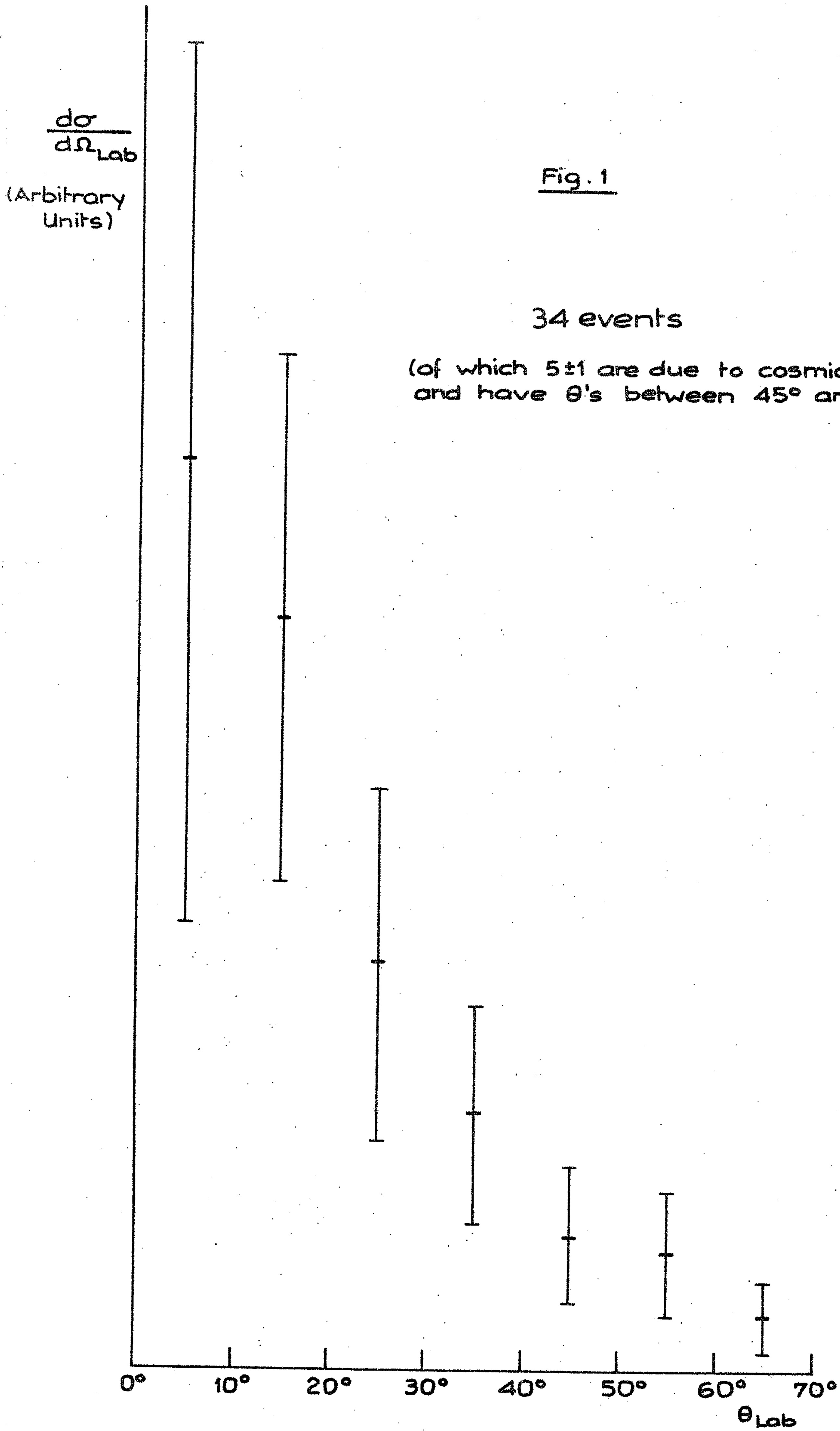
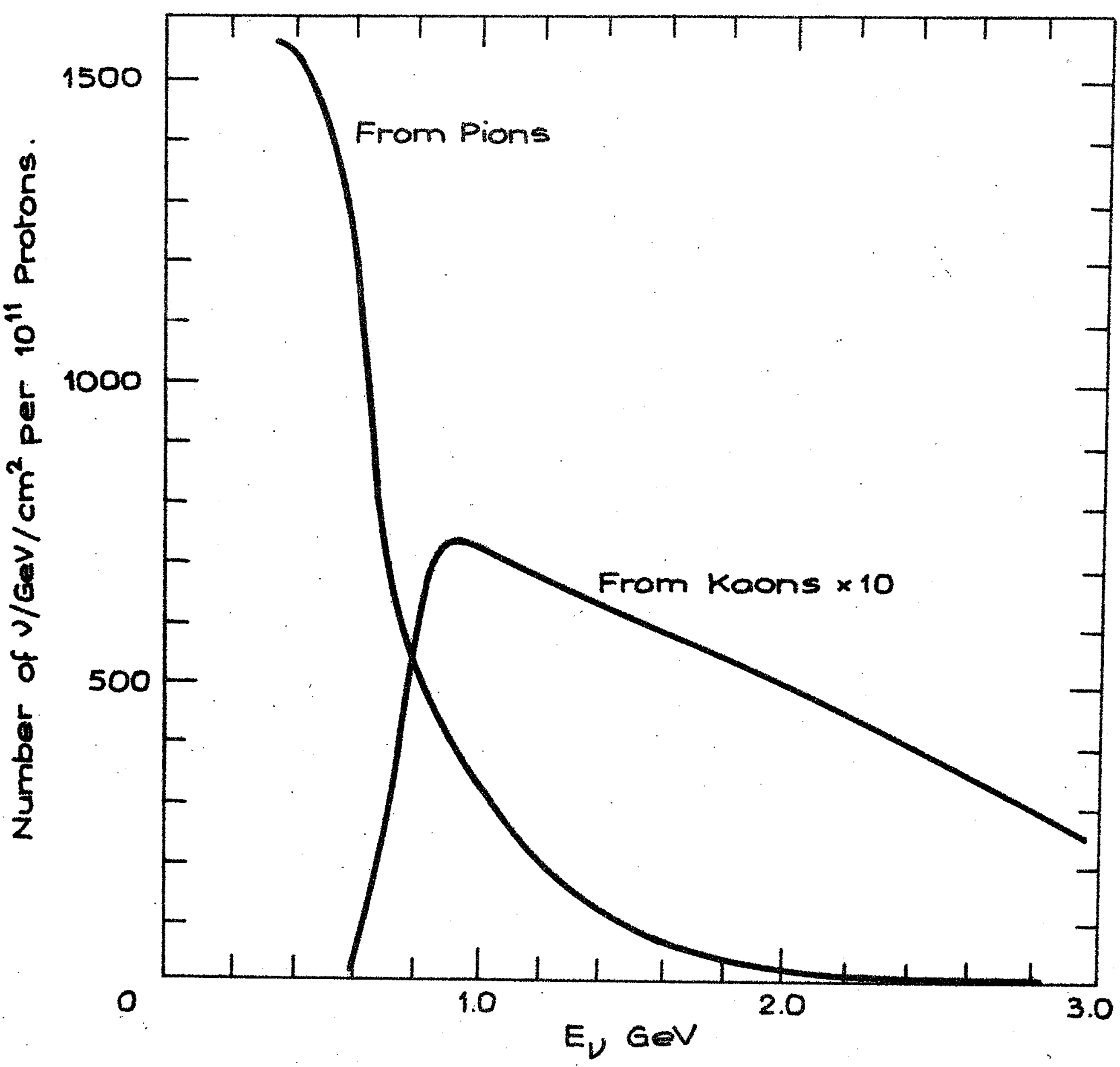
TABLE I

Frame	Type*)	Pμ(Mev/c)	Θμ	Comments
14993	1p + 1 Se	>250	27°	
15871	1p + 1 Sγ	>600	8.5°	shower = 500 Mev/c from calibration.
17204	1p + 1 Se	>500	18.5°	
17991	2p + 1 Se	=190	50°	
18891	2p + 2Sγ	>600	30°	apparently $\mu^{\pm} + \pi^{\mp} + \pi^{0}$ (2 γ's)-presumed charged pion scatters inside the chamber. $\pi^{0} \sim 1$ Gev KE.
19142	2p	>420 =280	26° 47°	could be 2 μ's.
21132	2p	>300	16°	could be elastic event with high momentum transfer (450 Mev/c).
21989	3p	>400	53°	
22306	4p	~250	0-20°	visible kinetic energy roughly 250 Mev per particle, could be an example of $W \to 3\pi$.
22516	1p + 1 Se	=200		
22892	2p	=270 =310	53° 62°	
23241	2p	>345 >215	33° 66°	could be two μ's.
23369	4p	>420	26°	3 other prongs quite short.
23405	2p	>350	10°	could be two μ's.
23451	2p + 1 Sγ	>440	55°	shower roughly 250 Mev/c.
23620	3p	=250	38°	
23661	2p	>150 =195	49° 21°	
24394	2p	>250 >320	36° 40°	
25498	1p + 1 Sγ			prong interacting could be $\pi + \gamma$.
25866	4p	>600	36°	3 other short tracks.
29086	1p + 2 Se	>420	60°	
29136	2p	>440	27°	

*) p = prong.
Se = shower starting from creation plate.
Sγ = shower not starting from vertex.



dσ/dΩ_Lab
(Arbitrary Units)
Fig. 1
34 events
(of which 5±1 are due to cosmic rays and have θ's between 45° and 65°)
0°
10°
20°
30°
40°
50°
60°
70°
θ_Lab



Number of ν/GeV/cm² per 10¹¹ Protons.
1500
1000
500
0
From Pions
From Kaons ×10
1.0
2.0
3.0
E$_\nu$ GeV

FIG. 2