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CALTECH - FERMILAB NEUTRAL CURRENT SEARCH*

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Abstract

Initial results of a neutral current search in the Caltech-Fermilab ν-experiment are discussed. Existence of the effect is confirmed at a level near that previously reported in other neutral current experiments.

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Within the past couple of years the search for heavy leptons and neutral currents has taken on new importance. The "Gauge Theories" which unify electromagnetic and weak forces <u>require</u> the existence of heavy leptons, neutral currents, or both. Even with the introduction of W-bosons, the reaction $\upsilon + \bar{\upsilon} \rightarrow W^+ + W^-$ still grows with energy and the introduction of either heavy leptons or neutral currents are necessary to bring about convergence in the theory.

A search for Gauge-type charged heavy leptons has been performed in the Caltech-Fermilab experiment by looking for the reaction

$$\upsilon_\mu + N \rightarrow Y^+ + \text{hadrons}$$
$$\hookrightarrow \mu^+ + \upsilon + \upsilon$$

The results of this experiment (PRL <u>32</u>, 1387 (1974)) show that $M_{Y^+} > 7.0$ GeV/c^2 unless the branching ratio for the Y^+ to decay into leptons is less than 10%. A search for the hadronic decay mode and also a search for neutral heavy leptons, Y^o, are now proceeding in the Caltech-Fermilab apparatus. However, thus far, there is <u>no</u> positive evidence for Gauge-type heavy leptons.

As we all know, the experimental indications pointing to the existence of non-strangeness changing neutral currents are more positive. The CERN-Gargamelle results, first presented last summer, indicated the presence of neutrino-like interactions without final state muons. The rate for these events was about five times that expected from neutron background in the beam. Confirmation of these observations have been reported by the Harvard-Penn-Wisconsin Group in a high energy neutrino experiment at Fermilab, and from the Argonne 12' bubble chamber for the single pion production channels.

Despite these results, it is still extremely difficult to make an absolutely convincing case for neutral currents. This is due to the simple experimental

fact that for neutral current reactions both the initial and final state neutrinos are non-observables. This means that the reaction is underconstrained and alternate mechanisms for the observations are possible. So, rather than actually "seeing" neutral current events, other explanations for events of this topology must be explained away.

For this reason, it is vital to look for neutral currents in as many experiments with different background problems as possible. I discuss here the initial results of a new experiment searching for neutral currents in the inclusive reactions $\nu(\bar{\nu}) + N \rightarrow \nu(\bar{\nu})$ + hadrons. The whole thrust of this initial experiment by our group was to concentrate on the question of existence/non-existence at or near the reported levels!

The primary experimental difficulty at high energies comes from not identifying the muon in the ordinary charged current inclusive reaction $\nu + N \rightarrow \mu^- +$ hadrons. Every attempt was made in our experiment both to minimize the level of undetected muons and determine experimentally the fraction of muons escaping detection.

The main features of the experiment are:

(1) An integrated Fe detector which is ~70 collision lengths longitudinally and 7.5 collision lengths from the center to the edges transversely.

(2) The dichromatic neutrino beam which separates ν and $\bar{\nu}$ by sign selecting a band of high energy hadrons (140 GeV); the beam has few low energy neutrinos. (Low energy neutrinos give slow, large angle muons which are difficult to identify).

(3) Muon identification by penetration inside the Fe detector with good acceptance for the muon.

The results of the experiment are summarized in the figures.

Figure 1 shows that the vertex of interaction is located to about ±5 cm in space. This vertex position is determined from the sparks in the chambers near the interaction point. It is important to determine the vertex with reasonable accuracy in order to make sure the events occurred well within the steel target. For events which are "neutral current candidates" (eg. no detected penetrating muon) the distributions in the transverse coordinates x and y and the longitudinal coordinate z are also shown. Note that the flat distribution over ~50 collision lengths in z indicates that these events cannot be neutron interactions. Also, the distributions in x and y show no noticeable peaking for events nearer the edges of the apparatus.

The apparatus was triggered on either detection of a penetrating muon <u>or</u> deposition of a few GeV of hadron energy in the calorimeter. To search for neutral currents, triggers of the second type with $E_h \geq 6$ GeV (where the detection efficiency is good) were used. The vertex was then required to be well inside the steel target, the hadron energy recorded, and information on penetration from the scintillation counters was used to identify muons. Figure 2 shows the distribution in penetration (P) for the <u>most penetrating particle</u> in the interaction. Note that a hadron cascade will typically penetrate about 10 collision lengths. The data, for both neutrinos and antineutrinos, show a peak for penetration typical of hadrons followed by a distribution for events with more penetration. The curves drawn for the expected charge current distributions come from fitting the differential distributions for events with a clearly identified muon ($P > 14$ C.L.).

Obviously, there is an apparent excess of events for shorter penetrations. Since this is the extrapolated part of the curve for charged currents it is possible that these distributions are due to anamolous charged current distributions in this region. In order to investigate this possibility we have compared the hadron energy distritutions in figure 3 for $P \leq 13$ CL (neutral currents?)

$P > 14$ C.L. (charged currents), and $18 \leq P \leq 26$. Characteristically, as one looks at shorter penetration for the muon the muon has less energy. This means that E_{had} approaches E_{ν}. By looking at the total charged current distribution and a subset for shorter penetration this effect is apparent in the figure. The expected E_{had} distribution for charged currents with $P \leq 13$ C.L. is also shown. Note that the measured E_{had} distribution is characteristically different from that expected from an excess of charged current events at large Y. The peak in P is also not explainable from ν_e interactions, cosmic rays, etc.

The raw level of the excess is $\frac{\sigma(\text{excess})}{\sigma(\text{charge current})} = 0.22$ and 0.33 for neutrinos and antineutrinos, approximately the same level reported in previous experiments. The actual magnitude of this effect depends on the y-distribution of these short penetration events, detection efficiency vs E_{had}, etc. At this point we believe the magnitude is within a factor of two of these <u>RAW</u> numbers, however, more measurements are necessary to quote accurate rates and distributions. We are pursuing these goals in a new run.

In conclusion, we have evidence for neutrino-like interactions with no muon in the final state. Our results are consistent with previous results and seem to point toward the existence of neutral currents as an explanation.

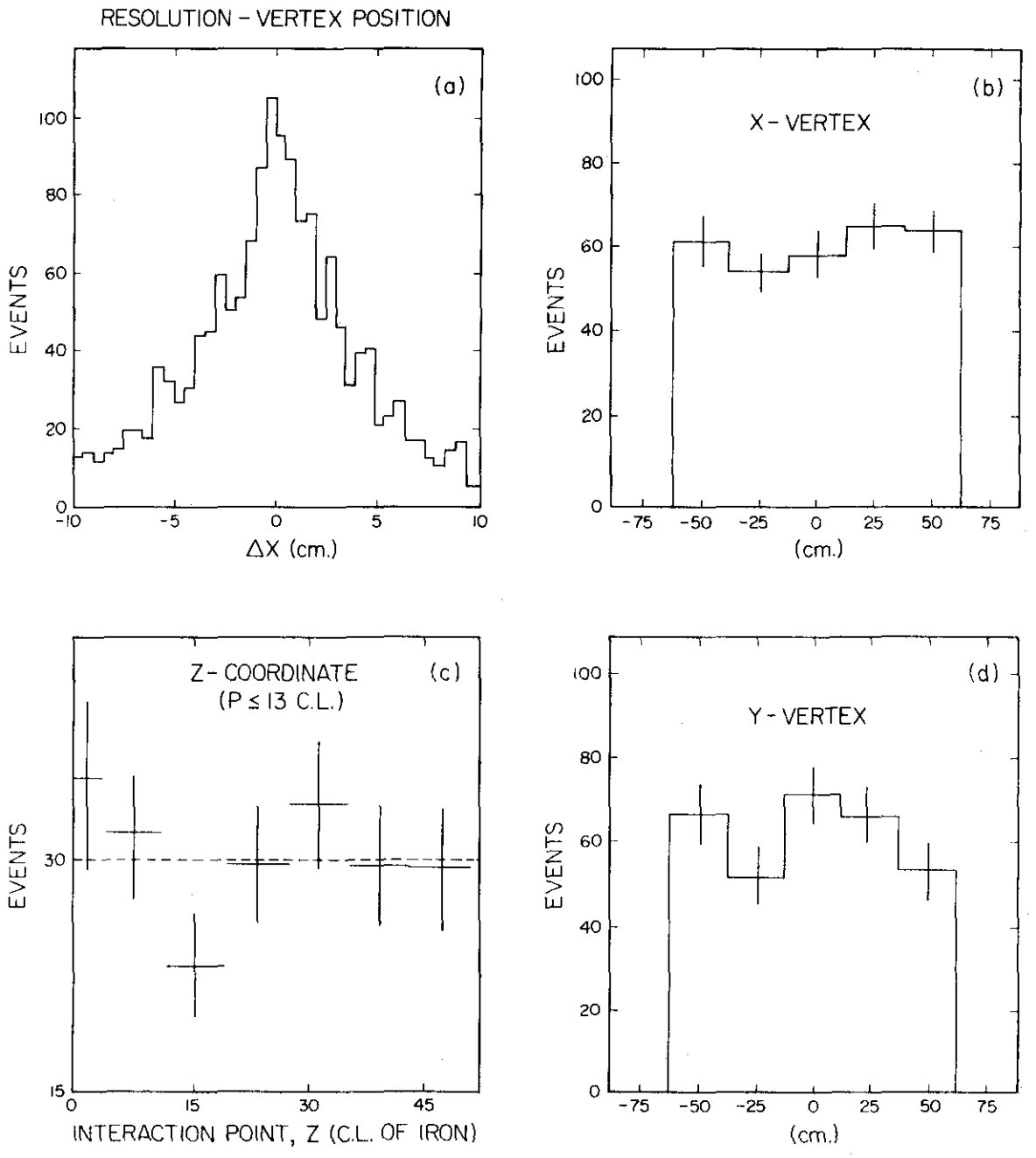

Fig. 1

Resolution of vertex location (1a), and longitudinal and transverse positions of vertex for neutral current candidates (1b, 1c, 1d) for ν induced interactions.

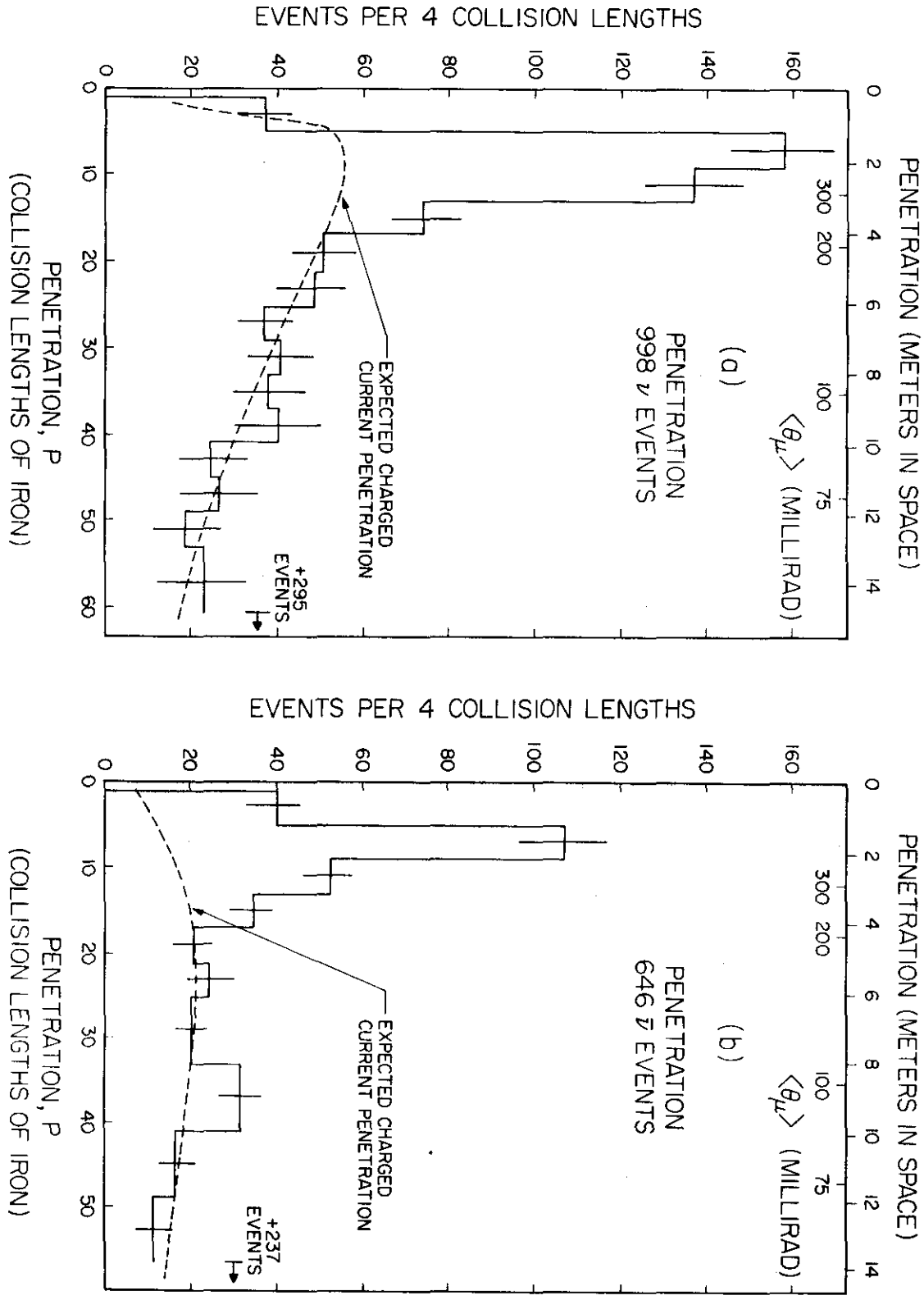

Fig. 2

Most penetrating particle distributions, P, for ν and $\bar{\nu}$ events.

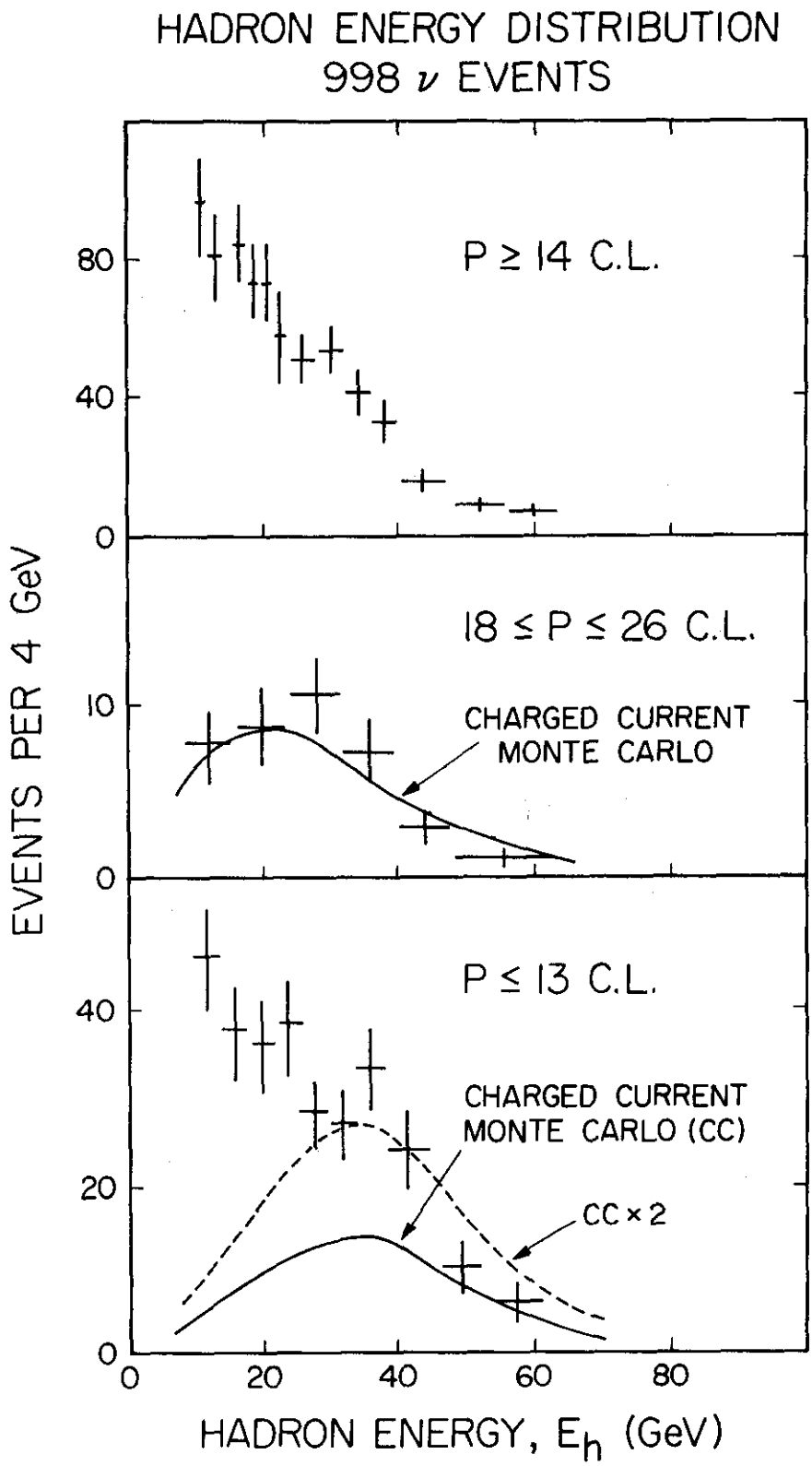

Fig. 3

Hadron Energy distributions for different values of penetration, P.