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ABSTRACT

We have observed 5 events of the reaction $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$ in a sample of $\sim$50,000 charged current neutrino interactions in a heavy neon-hydrogen mixture in the 15 foot bubble chamber at Fermilab. This result is in rough agreement with the prediction of the Weinberg-Salam model with the currently favored value of the mixing angle, $\sin^2\theta \sim 1/4$.

The reaction $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$ can proceed only via the neutral current weak interactions. It is a purely leptonic process and is, therefore, free of any uncertainties introduced by hadrons in comparing experimental measurements with theoretical predictions. Experimentally, the observation of this process is very difficult. The cross section expected from the Weinberg-Salam model is of the order of $1\frac{1}{2} \times 10^{-42}\ E_\nu\ \mathrm{cm}^2$! This means about $\sim$1 such event in 10^4 charged current ν_μ interactions.

Our search for this process was carried out at the Fermi National Accelerator Laboratory using the two horn focused wideband neutrino beam with an average of 10^{13} 400 GeV protons per pulse hitting the neutrino target. The neutrino spectrum extends from a few GeV up to beyond 100 GeV, peaking near 30 GeV. The neutrino detector was the 15 foot bubble chamber filled with a 64 atomic percent neon-hydrogen mixture with a radiation length of 40 cm and a hadronic interaction length of 125 cm. In this detector, single fast forward electrons, which are the signal for this reaction, can be identified with high efficiency by bremmstrahlung and spiralization at the end of the track. Single electrons, positrons, and photons converting to an e^+e^- pair can be distinguished from each other in the 30 kgauss magnetic field of the chamber.

We present here preliminary results based on a scan of 87,000 photographs (slightly more than one half of the available data). In this sample there are approximately 50,000 charged current ν_μ interactions. We have found so far 5 single e^- events, with no other tracks coming from the vertex, with the following energies and angles with respect to the incident ν beam direction:

Event	E(GeV)	θ(Degrees)
1	4 ± 2	0.6 ± 0.3
2	7 ± 2	0.5 ± 0.3
3	9 ± 1	0.5 ± 0.3
4	28 ± 9	0.5 ± 0.3
5	35 ± 4	0.2 ± 0.2

The energies and angles of these 5 single electrons agree with the kinematics of the process $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$, as shown on Fig. 1.

We have considered the following background processes:

a) $\nu_e + u \rightarrow e^- + p$ where the proton is not visible. From the measured number of these events where the proton is visible, we estimate that this background is $\sim$0.5 events or $\sim$10% of the signal.

b) Photons that Compton scatter or convert to asymmetric e^+e^- pairs such that the e^+ is too slow to be seen. From the observed number of $\gamma \rightarrow e^+e^-$ pairs where both the e^+ and the e^- are visible, we conclude that the background from this source is neglibible.

c) The process $\nu_e + e^- \rightarrow \nu_e + e^-$ is experimentally indistinquishable from $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$, so that strictly speaking our signal of 5 events is the sum of these processes (as well as those initiated by $\bar{\nu}_\mu$ and $\bar{\nu}_e$). However the flux of ν_e (and $\bar{\nu}_\mu$ and $\bar{\nu}_e$) in our beam is a few percent or less, and thus, the contribution due to neutrinos other than ν_μ is most likely neglibible.

We thus interpret the 5 single electron events as $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$, with a total background of $\sim$0.5 events. A signal of 5 events in a sample of 50,000 charged current ν_μ interactions is roughly consistent with the prediction of the Weinberg-Salam model with the currently favored value of the mixing angle of $\sin^2\theta \approx 1/4$. However, we have not yet completed a good measurement of the scanning efficiency for these events so that we can not give a cross section for this process at the present time.

In the recent Gargamelle experiment at the CERN SPS, 10 single electrons were found in a sample of 24,000 charged current ν_μ interactions, with a cross section for this process that is considerably higher than the prediction of the Weinberg-Salam model with $\sin^2\theta = 0.25$. At the present time we do not wish to imply a disagreement between our result and Gargamelle. We should be able to make a definite statement in the near future when we have scanned the remainder of our film (containing a total of about 100,000 charged current ν_μ interactions) and have done enough double scanning to determine our scanning efficiency.

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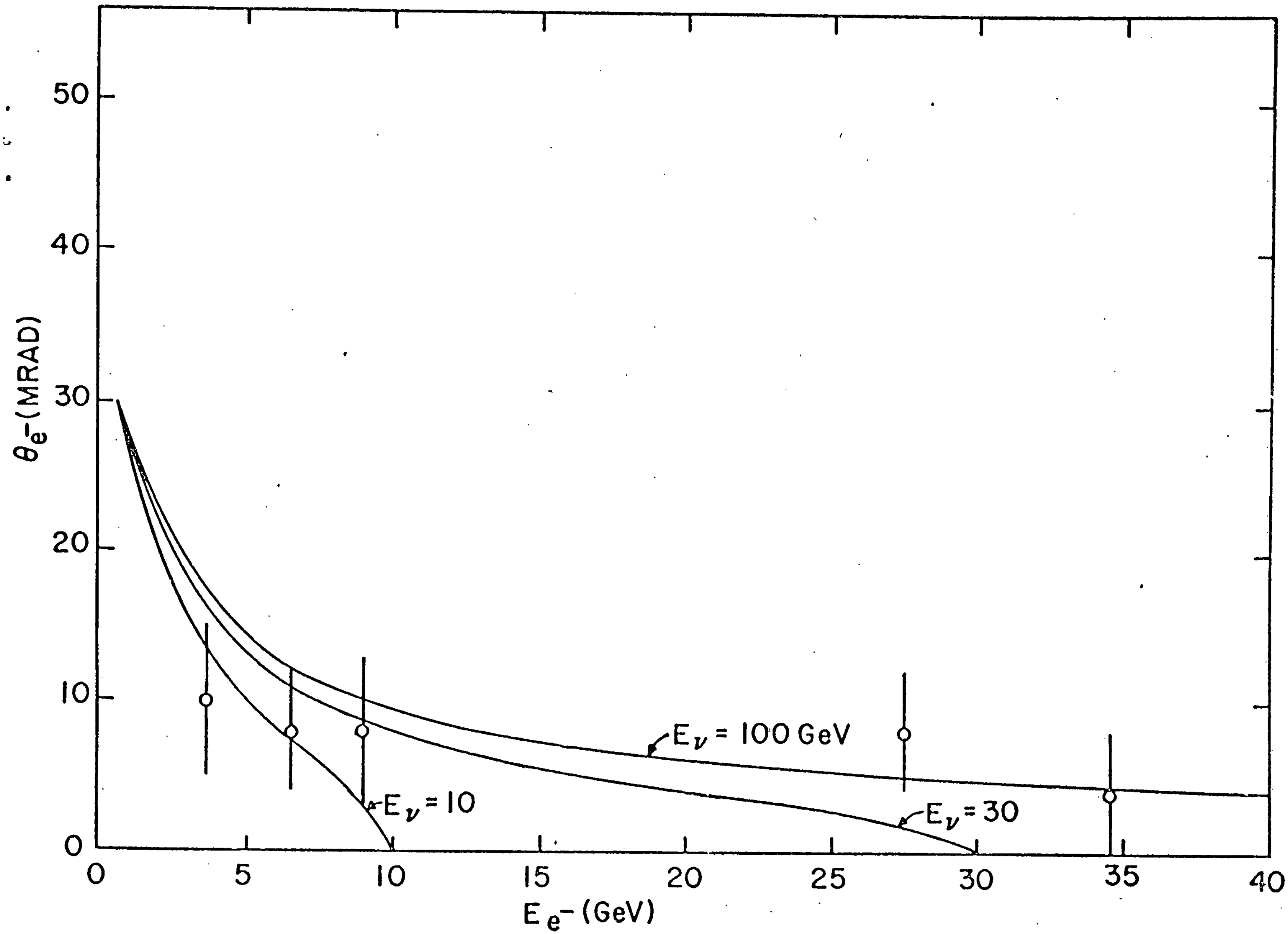

Fig. 1. The lab angle θ_{e^-} vs. the lab energy E_{e^-} for the 5 observed single electrons, compared with the kinematics of the reaction $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$ for various incident neutrino energies.