A SEARCH FOR THE REACTION $\bar{\nu}_\mu + e^- \to e^- + \bar{\nu}_\mu$

(Paper 448)

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The amplitude of the weak neutral currents in neutrino interactions can be estimated via the study of neutrino scattering on electrons.

$$\nu_\mu + e^- \to e^- + \nu_\mu \qquad (1)$$

$$\bar{\nu}_\mu + e^- \to e^- + \bar{\nu}_\mu \qquad (2)$$

I shall present to day a status report of the search which is currently being made in Gargamelle for the reaction (2) which, as reaction (1), is forbidden at the first order in the V-A theory.

Last year, Hasert et al [1] reported a candidate for this reaction observed during the double scan of two lots of pictures taken with Gargamelle filled with CF_3Br and exposed at the CERN PS to beams of neutrinos (375.000 pictures) and antineutrinos (360.000 pictures). The event had been found in the $\bar{\nu}$ pictures where the background was estimated to be .03 ± .02 event.

Since that work, the Gargamelle Collaboration has now achieved the double scan of an additional lot of $\bar{\nu}$ pictures corresponding to an increase in statistics of about a factor 3 compared to the previous $\bar{\nu}$ sample. Most of these pictures were taken using the facilities offered by the installation of the new CERN PS injector. The experiment is still in progress and the results I am presenting concern the whole $\bar{\nu}$ data analyzed up to now, including those of Hasert et al.[1]

The characteristic signature for reaction (4) consists of an isolated electron track originating in the liquid at a small angle θ_e with respect to the antineutrino beam.

In the Gargamelle experiment a cut-off on E_e is imposed at 300 MeV to insure a reasonable scanning efficiency and to remove a possible background due to low energy γ rays. As a result of kinematics the angle θ_e should be less than about 3^o.

In a heavy liquid bubble chamber, the identification of electron tracks is almost straightforward from their characteristic spiral and the observation of bremsstralung effects. However, some experimental difficulties remain regarding (i) the determination of the sign of the electron charge above a given energy and (ii) the separation of energetic γ rays (zero opening angle) from single electrons. Table I summarizes the characteristics of all isolated electrons, positrons and γ rays of energy greater than 300 MeV and angle less than 5^o with respect to the neutrino beam detected after double scan in the Gargamelle experiment. It is seen that two unambiguously identified isolated electrons have been observed.

Different reactions induced by neutral particles which can simulate the signal have been carefully investigated by Hasert et al[1]. It was shown by these authors that the major source of background was due to the quasi elastic scattering of electronic neutrinos on nucleons

$$\nu_e + n \to e^- + p \qquad (3)$$

leading in the final state to a single electron emitted at small angle ($\theta_e < 5^o$), the proton being either of too low energy to be observed or remaining trapped in the parent nucleus without visible evaporation products.

The ν_e contamination present in the CERN ν_μ beam is known to be small (< 1%), preventing a meaningful study of the phenomenological characteristics of the ν_e-nucleon interactions to be done. To estimate the background due to reaction (3), Hasert et al[5] studied the more frequent reaction

$$\nu_\mu + n \rightarrow \mu^- + p \quad (4)$$

which at high energy is kinematically similar to reaction (3). They concluded that the probability of occurrence of the background configuration was 1.3 ± .7%. Using this value and the known ν_e flux in the $\bar{\nu}_\mu$ beam, the number of background events due to reaction (5) is estimated to be .12 ± .08. It should be stressed that no upper limit was put on the recoiling electron energy although it is expected that the electrons from the background reaction (3) should be on average more energetic than those from the reaction sought (2).

From Table I it is seen that at most 3 isolated electron-positron pairs of energy greater than 300 MeV and making an angle less than 5^o with respect to the beam direction have been observed. Using the appropriate ratio of Compton to pair production cross sections and the known energy distribution between the electron and the positron of a pair, γ rays could contribute at most .06 ± .03 background events.

As a result, the maximum contribution of the background is found to be .18 ± .12 events. This is to be compared with two unambiguous isolated electrons observed in the experiment. The probability that these two events could be due to the background is thus about 1.5%.

Inspection of Table I reveals that there exist two ambiguous isolated electrons. The $e^\pm$ candidate is of high energy as well as the three positrons which can be attributed to reaction

$$\bar{\nu}_e + p \rightarrow e^+ + n \quad (5)$$

It is known that the sign of the charge of an electron (positron) cannot be determined in about 50% of the cases at energies above 2 GeV[2]. The one $e^\pm$

Table I

Isolated electrons, positrons and γ-rays of energy greater than 300 MeV and angle with respect to the $\bar{\nu}$ beam less than 5° observed in the Gargamelle experiment

Event no	Type	Position in the chamber			Angle (degrees)	E (GeV)
		x	y	z		
1	e^-	-1647	69	139	$1.4^{+1.6}_{-1.4}$	.385 ± 100
2	e^-	374	157	-358	2 ± 2	.500 ± 120
3	e^- γ	-1090	-140	-260	2	1.9
4	γ	1723	-49	-148	4.8	1.8
5	γ	-1148	283	-561	3	2.3
6	$e^\pm$	-840	-120	400	3	4-5
7	e^+	-316	-43	533	3	2.3
8	e^+	-580	-490	130	4	~5
9	e^+	1458	328	280	5	~1.5