\( \nu_e \) Disappearance in Miniboone

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Torino - 17 December 2007
$R \equiv$ weighted average value of the ratio of measured and predicted $^{71}Ge$ production rates ($p$):

$$R \equiv \frac{p(\text{measured})}{p(\text{predicted})} = 0.88 \pm 0.05(1\sigma)$$

*Ga radioactive source exp. results may be interpreted as an indication of the disappearance of $\nu_e$ due to active-sterile oscillations!*

nucl-ex/0512041

hep-ph/0610352 Carlo Giunti & ML

arXiv:0711.4222 Mario A. Acero, Carlo Giunti & ML.
Miniboone data: Low Energy Excess or ...
Baic idea: a renormalization of the absolute event rate $\equiv \phi \otimes \sigma(M_A)$ by a constant factor $f$ with a simultaneous disappearance of the $\nu_e$ in the beam with a constant $P_{\nu_e \rightarrow \nu_e}$. This hypothesis is allowed by the large error on the absolute event rate.

N.B. constant $P_{\nu_e \rightarrow \nu_e} \leftrightarrow \Delta m^2 \gtrsim 20$ eV$^2$
<table>
<thead>
<tr>
<th>$j$</th>
<th>Energy Range [MeV]</th>
<th>$N_{\nu_e,j}^{\text{calc}}$</th>
<th>$N_{\nu_\mu,j}^{\text{calc}}$</th>
<th>$N_j^{\text{calc}}$</th>
<th>$N_j^{\text{meas}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200 − 300</td>
<td>26</td>
<td>258</td>
<td>284</td>
<td>375</td>
</tr>
<tr>
<td>2</td>
<td>300 − 375</td>
<td>30</td>
<td>117</td>
<td>147</td>
<td>199</td>
</tr>
<tr>
<td>3</td>
<td>375 − 475</td>
<td>37</td>
<td>90</td>
<td>127</td>
<td>170</td>
</tr>
<tr>
<td>4</td>
<td>475 − 550</td>
<td>32</td>
<td>39</td>
<td>71</td>
<td>83</td>
</tr>
<tr>
<td>5</td>
<td>550 − 675</td>
<td>49</td>
<td>33</td>
<td>82</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>675 − 800</td>
<td>41</td>
<td>21</td>
<td>62</td>
<td>64</td>
</tr>
<tr>
<td>7</td>
<td>800 − 950</td>
<td>41</td>
<td>20</td>
<td>61</td>
<td>59</td>
</tr>
<tr>
<td>8</td>
<td>950 − 1100</td>
<td>38</td>
<td>12</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>9</td>
<td>1100 − 1300</td>
<td>38</td>
<td>7</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>10</td>
<td>1300 − 1500</td>
<td>27</td>
<td>6</td>
<td>33</td>
<td>36</td>
</tr>
<tr>
<td>11</td>
<td>1500 − 3000</td>
<td>54</td>
<td>12</td>
<td>66</td>
<td>67</td>
</tr>
</tbody>
</table>

Table 1: $N_{\nu_e,j}^{\text{calc}}$: number of expected $\nu_e$-induced events; $N_{\nu_\mu,j}^{\text{calc}}$: number of expected $\nu_\mu$-induced events; $N_j^{\text{calc}}$: total number of expected events; $N_j^{\text{meas}}$: measured number of events.

Under this hypothesis, the theoretical number of events in the $j$th energy bin is given by

$$N_j^{\text{the}} = f \left( P_{\nu_e \rightarrow \nu_e} N_{\nu_e,j}^{\text{calc}} + P_{\nu_e \rightarrow \nu_\mu} N_{\nu_\mu,j}^{\text{calc}} \right),$$

We tested the $\nu_e$-disappearance hypothesis with the Pearson's chi-square

$$\chi^2_{\text{MB}} = \sum_{j=1}^{11} \frac{\left( N_j^{\text{the}} - N_j^{\text{meas}} \right)^2}{N_j^{\text{the}}},$$
\[ \chi^2_{MB} = 2.31/(9\ \text{dof}) \quad \text{gof} = 98.6\% \quad P_{\nu_e\rightarrow\nu_e} = 0.64^{+0.08}_{-0.07} \quad f = 1.41 \pm 0.06 \]
\[ \chi_{\text{MB+Ga}}^2 = 8.48 / (10 \text{ dof}) \quad \text{gof} = 58.2\% \quad P_{\nu_e \rightarrow \nu_e} = 0.82 \pm 0.04 \quad f = 1.31^{+0.04}_{-0.05} \]
Fit to Miniboone + Gallium + Beam Dump data

\[ \chi^2_{\text{MB+Ga+BD}} = 9.11/(11 \text{ dof}) \quad \text{gof} = 61.2\% \quad P_{\nu_e \rightarrow \nu_e} = 0.80^{+0.03}_{-0.04} \quad f = 1.32 \pm 0.04 \]
Possible Interpretations of the results

We have considered here an old indication in favor of $\nu_e$ disappearance found from the analysis of the results of Beam-Dump (BD) experiments: $\sin^2 2\theta = 0.48 \pm 0.10 \pm 0.05$ for the large squared-mass difference $\Delta m^2 = 377 \pm 27 \pm 7 \text{ eV}^2$ [G. Conforto Nuovo Cim. A103 (1990) 751]. In this case, the average $\nu_e$ survival probability is

$$P_{\nu_e\to\nu_e}^{\text{BD}} = 0.76 \pm 0.06. \quad (1)$$

The large disappearance of $\nu_e$ found in this study may be due to oscillations into sterile neutrinos $\nu_e \to \nu_s$ with $\Delta m^2 \gtrsim 20 \text{ eV}^2$, since

- $\nu_e \to \nu_\mu$ transitions are restricted by the results of CCFR, KARMEN, NOMAD and MINIBOONE;
- $\nu_e \to \nu_\tau$ transitions are limited by the results of CHORUS and NOMAD.
Comparison with SBL reactor limits : Bugey 2 detectors

2 detectors Bugey 90 % C.L. (raster scan) limits do not exclude active-sterile mixing with 
$\delta m^2 > 5 \text{ eV}^2$
Bugey 90% C.L. high $\delta m^2$ (raster scan) limit do not exclude active-sterile mixing with $\sin^2 2\theta \lesssim 0.15$ if the neutrino flux is known with 2.8% error.
### Reactors Exp. : Errors on the Normalization

<table>
<thead>
<tr>
<th></th>
<th>KAMLAND</th>
<th>CHOOZ</th>
<th>BUGEY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total reactor related</td>
<td>3.43 %</td>
<td>0.94 %</td>
<td>2.8 %</td>
</tr>
<tr>
<td>Cross section</td>
<td>0.20 %</td>
<td>1.90 %</td>
<td>0.20 %</td>
</tr>
<tr>
<td>Total detector related</td>
<td>2.24 %</td>
<td>1.67 %</td>
<td>4.14 %</td>
</tr>
<tr>
<td>Combined</td>
<td>4.10 %</td>
<td>2.70 %</td>
<td>5.00 %</td>
</tr>
</tbody>
</table>
CHOOZ high $\delta m^2$ limits

90% C.L. limit: $\sin^2 2\theta < 0.1$

FC limit: $\sin^2 2\theta < 0.16$

hep-ex/0301017
Taken the Bugey error as a reference value (5% error on $P_{\bar{\nu}_e \rightarrow \nu_e}$) we face 2 possibilities (3% is the error on $P_{\nu_e \rightarrow \nu_e}^{MB+Ga+BD}$):

- The error in $\bar{\nu}_e$ data may be $> 5\%$ and therefore
  \[
  (P_{\nu_e \rightarrow \nu_e}^{MB+Ga+BD} - P_{\bar{\nu}_e \rightarrow \bar{\nu}_e}) < 4\sigma .
  \]

- The error in $\bar{\nu}_e$ data is $< 5\%$ and therefore
  \[
  (P_{\nu_e \rightarrow \nu_e}^{MB+Ga+BD} - P_{\bar{\nu}_e \rightarrow \bar{\nu}_e}) > 4\sigma .
  \]

This possibility seems to need new physics that violates CPT.

In hep-th/0610252 R.Casalbuoni showed as the infinite component wave Majorana equation [E.Majorana Nuovo Cimento 9 (1932) 335], were no negative energy solutions are presents, violates CPT !!!
Abstracts
A new method of quantization is proposed which allows Dirac’s theory of the positron to be built up in such a form that there is complete symmetry between the positive and negative charge throughout the formalism of the theory, while in Dirac’s original form this symmetry applied only to the results of the theory, which had to be obtained by using ambiguous mathematical operations such as subtraction of infinities. It is also claimed that the new method of quantization is capable of describing a neutral particle without states of negative kinetic energy and without introducing a "mirror image" like the positron.

Future SBL Beta-Beam experiments [P. Zucchelli PLB 532 (2002) 166] with a pure $\nu_e$ or $\bar{\nu}_e$ beam from nuclear decay of accelerated ions have the potentiality to check the possible SBL disappearance of $\nu_e$ and $\bar{\nu}_e$ with high accuracy.
... if they are roses they’ll flower...

... GOOD LUCK to Majorana $\nu$ physics !!!
Backup slides
Before $[z_{VTX} > 184 \text{ cm}]$ cut: observed = 7969; predicted = 8329

(4% absolute normalization error) $\Rightarrow 1\sigma$ deficit

hep-ex/0306037
NUTEV $\nu_e$, $\bar{\nu}_e$ measurements

\[ \Delta m^2 = 1000 \text{ eV}^2, \, 90\% \, \text{CL} \, \sin^2 2\alpha \]

\[ \Delta m^2 = 100 \text{ eV}^2, \, \sin^2 2\alpha = 0.01 \]

\[ \Delta m^2 = 1000 \text{ eV}^2, \, \sin^2 2\alpha = 0.01 \]

hep-ex/0203018