Issues pertaining to Neutrino encodings

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Reminder

- Since the 2004 workshop, the “Neutrino Mixing” encoding assumes the three-neutrino paradigm (as do all papers that we encode without saying so.)
- If this turns out not to be the full story, all the encoding entries are either wrong, meaningless or just approximations
- As with any quantity in the PDG, multiple measurements are a test of the paradigm.
- There is still an “Other neutrino mixing” section to deal with measurements conceivably related to the alleged LSND signal.

What we encode

3 ν paradigm variables:

- Δm^2_{12} Δm^2_{21} Δm^2_{13} Δm^2_{23} Δm^2_{32} Δm^2_{31}
- $\sin^2 2\theta_{12}$ $\sin^2 2\theta_{23}$ $\sin^2 2\theta_{13}$
- δ_{CP}

Not (yet) encoded:

overall mass scale

Majorana phases

Sign of Δm^2_{32}

A problem that went away

- The CHOOZ limit, and now the reactor measurements, depend on Δm^2_{32}. In previous editions we had to change the limit on θ_{13} as the best value of Δm^2_{32} fluctuated. These fluctuations are now smaller and no longer important.

Conventions for Δm^2

Two problems:

1. We chose to encode $|\Delta m^2_{32}| \sim |\Delta m^2_{31}|$ but now $\delta(\Delta m^2_{32}) \sim |\Delta m^2_{21}|$
2. We encode $|\Delta m^2_{32}|$ but experiments measure Δm^2_{ee} and $\Delta m^2_{\mu\mu}$ and

$$\Delta m^2_{ee} = \Delta m^2_{\mu\mu} \pm \Delta m^2_{21}(\cos 2\theta_{12} - \cos\delta \sin\theta_{13} \sin 2\theta_{12} \tan\theta_{23})$$

- In the listings we say what each measurement is
- When we know the hierarchy → problem goes away.

Conventions for θ

- We originally chose to encode $\sin^2 2\theta_{ij}$

This is ok for θ_{12} and θ_{13}, but not now for θ_{23}. In the 2ν approximation (which is surprisingly good):

$P(\nu_\mu \rightarrow \nu_\mu) \propto \sin^2 2\theta_{23}$

[not sensitive to sign(θ_{23}-45°)]

But for ν_e appearance

$P(\nu_\mu \rightarrow \nu_e) \propto \sin^2\theta_{23} \sin^2 2\theta_{13}$

This is sensitive to whether θ_{23} is > or < 45° (called the octant).

A change for 2016

- We are in the process of switching from $\sin^2(2q_{ij})$ to $\sin^2(q_{ij})$ for 2016. This will involve re-encoding a small number of the θ_{23} entries and 3 new nodes.

$\sin^2\theta_{12}$	$0.304^{+0.012}_{-0.012}$
$\theta_{12}/^\circ$	$33.48^{+0.77}_{-0.74}$
$\sin^2\theta_{23}$	$[0.451^{+0.001}_{-0.001}] \oplus 0.577^{+0.027}_{-0.035}$
$\theta_{23}/^\circ$	$[42.2^{+0.1}_{-0.1}] \oplus 49.4^{+1.6}_{-2.0}$
$\sin^2\theta_{13}$	$0.0219^{+0.0010}_{-0.0011}$
$\theta_{13}/^\circ$	$8.52^{+0.20}_{-0.21}$
$\delta_{CP}/^\circ$	251^{+67}_{-59}
$\frac{\Delta m^2_{21}}{10^{-5}\ \mathrm{eV}^2}$	$7.50^{+0.19}_{-0.17}$
$\frac{\Delta m^2_{31}}{10^{-3}\ \mathrm{eV}^2}$ (N)	$[+2.458^{+0.002}_{-0.002}]$
$\frac{\Delta m^2_{32}}{10^{-3}\ \mathrm{eV}^2}$ (I)	$-2.448^{+0.047}_{-0.047}$

Global fit example (NuFIT 1.3)

Conventions for δ_{CP}

- New node in 2014 edition
- Choices: 0 to 2π, $-\pi$ to π, 0 to 360, -180 to 180
- All four are being used
- Polled several “experts”, nobody cared