

Neutrino Masses and See-Saw Mechanism

2004-02-24

At Fujiwara Seminar

M. Koshiha

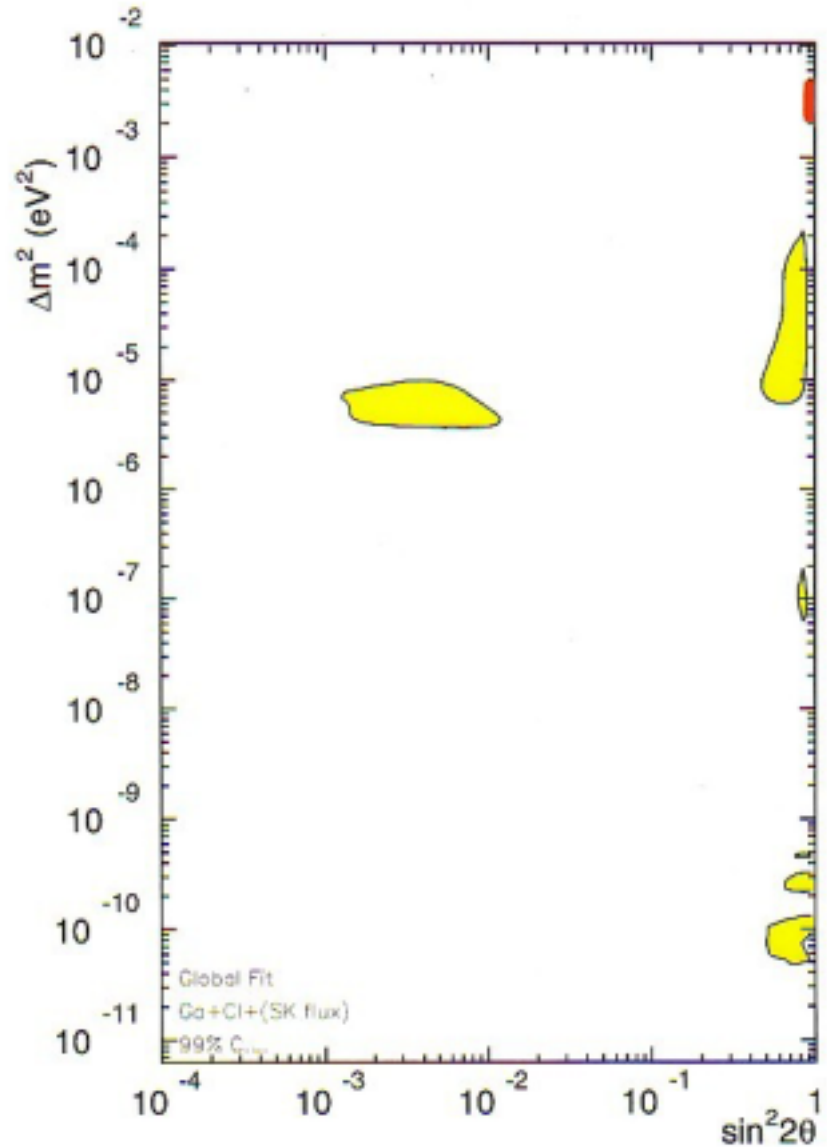
Good Old days of late '90s

- When the atmospheric neutrino oscillation was just established and the solar neutrino oscillation parameters were getting constrained.
- The next slide shows the situation.

Permissible regions
of neutrino-oscillation.

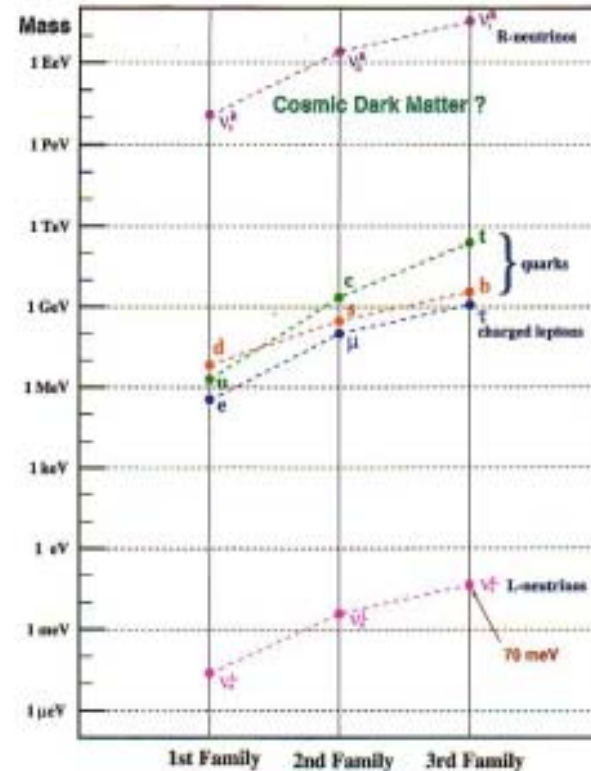
Red: ν_μ vs. ν_τ

Yellow: ν_e vs. ν_μ



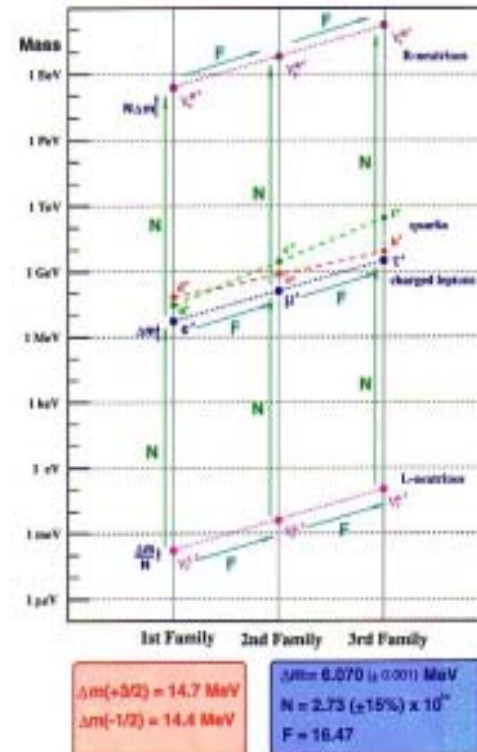
Mass Spectrum 1

- A possible mass spectrum consistent with the observations.
- See-Saw mechanism with the leptons as the Dirac particles in it.



Mass Spectrum 2

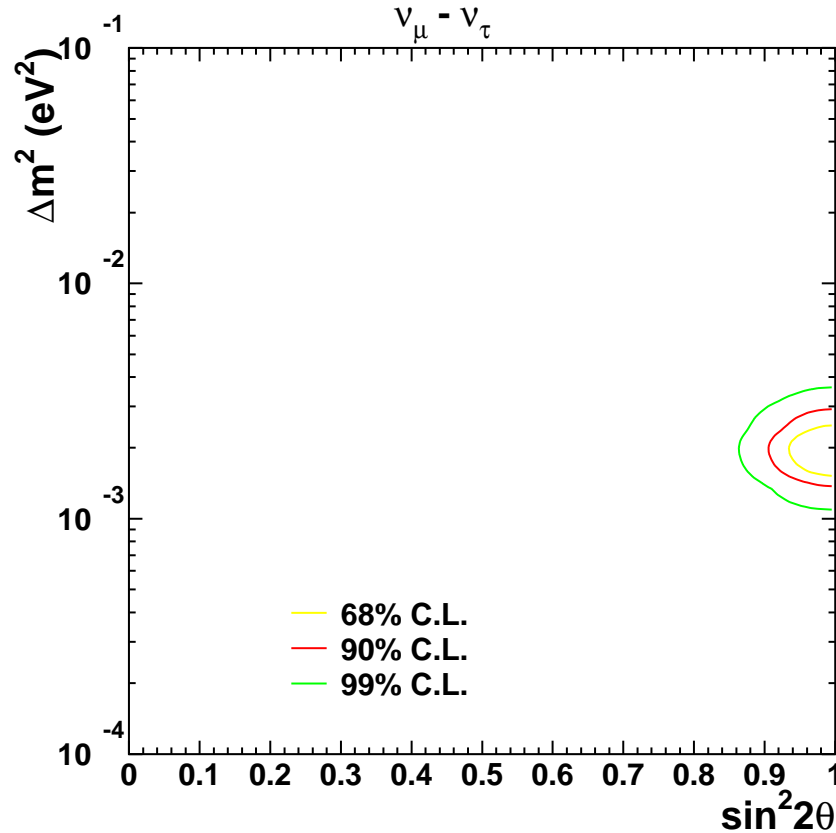
- A slight mass shift of charged particles make the regularity more apparent.
- This is for your fun.



In the 21st century, the situation changed.

- The atmospheric neutrino oscillation parameter, $\Delta(m^2)$, moved down.
- The solar neutrino's Small Mixing Angle solution was deleted.
- These two changes made the neutrino masses impossible to be proportional to the corresponding lepton masses.

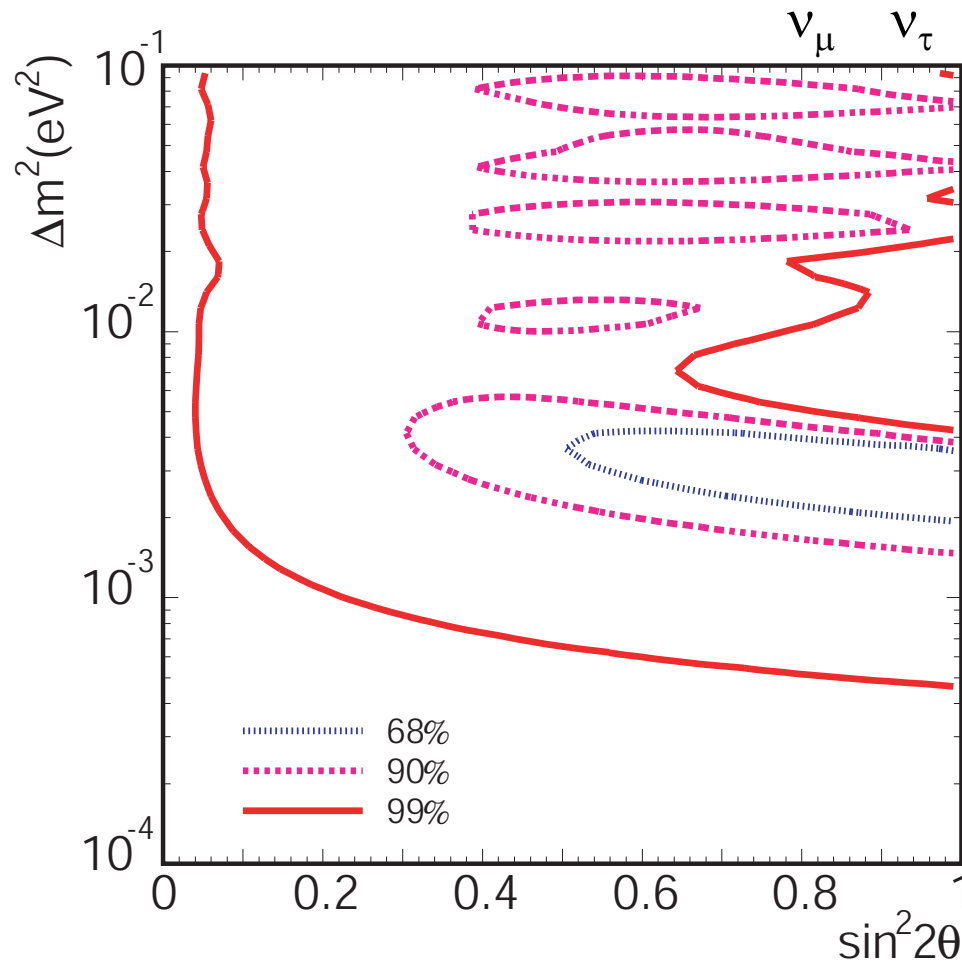
Allowed parameter region (Super-K atmospheric)



Super-Kamiokande collaboration, draft in preparation

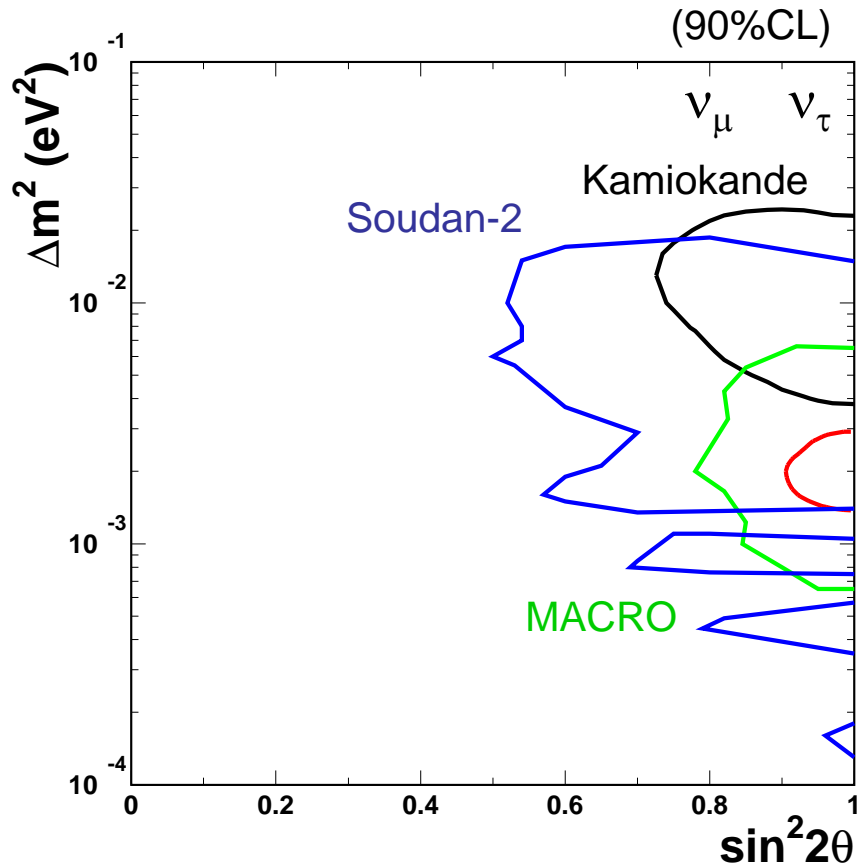
Y.Hayato, for the Super-Kamiokande and K2K collaborations, talk presented at the EPS2003 conference, Aachen, Germany, July 2003.

Allowed parameter region (K2K)



M.H.Ahn et al. (K2K collaboration), Phys. Rev. Lett. **90**, 171302 (2003)

Allowed parameter region (atmospheric neutrino experiments, 2003)

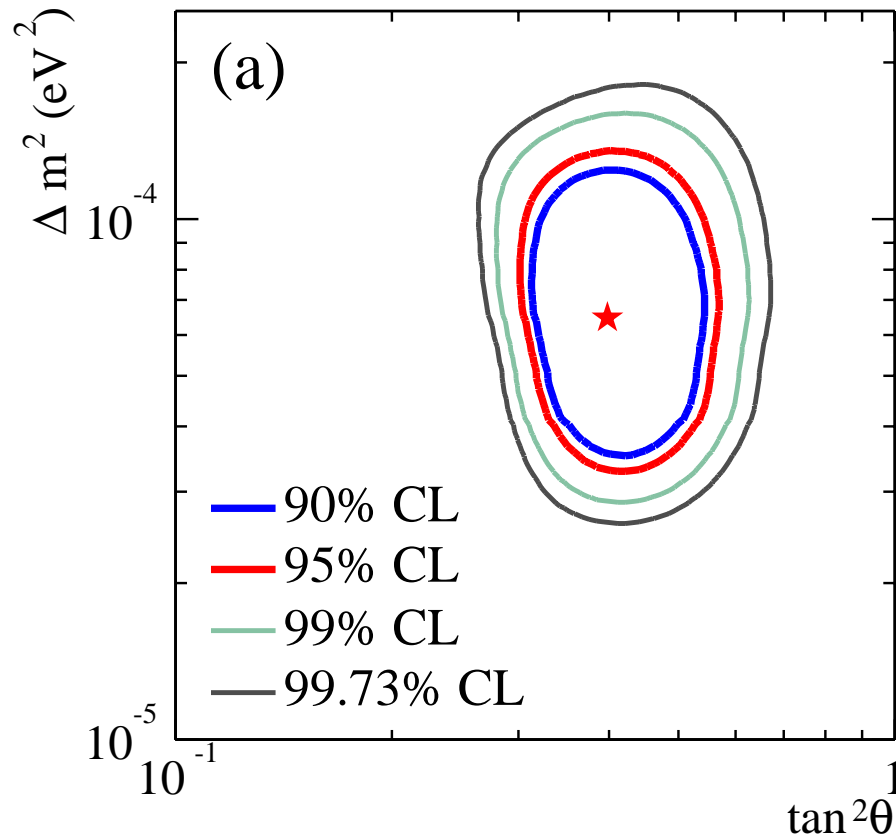


S. Hatakeyama et al.
(Kamiokande
collaboration), Phys. Rev.
Lett. **81**, 2016 (1998)

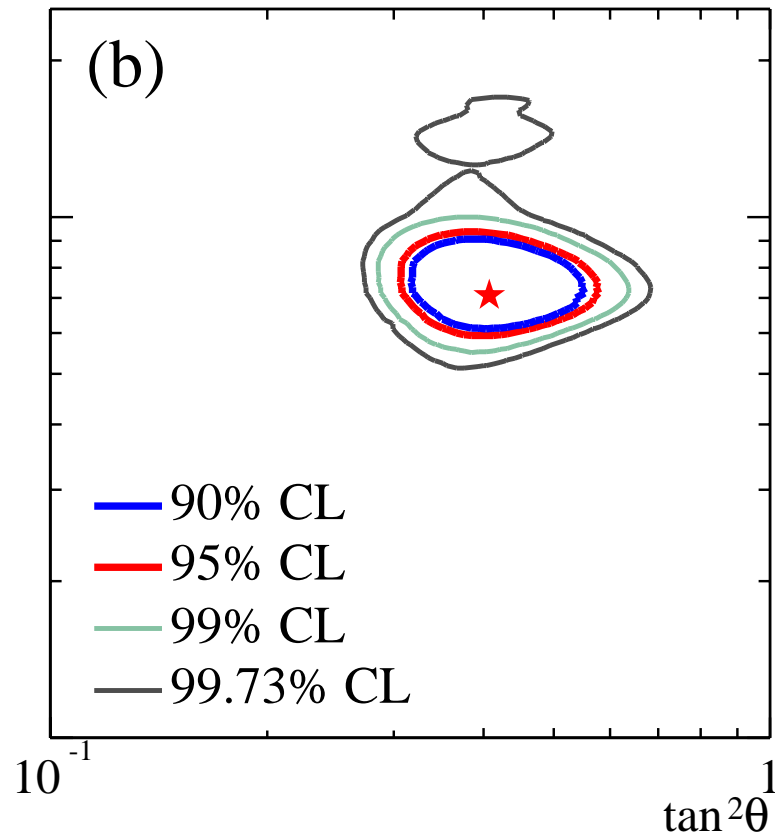
M. Ambrosio et al.
(MACRO collaboration),
Phys. Lett. B **566**, 35
(2003)

M. Sanchez, et al.
(Soudan-2 collaboration),
hep-ex/0307069

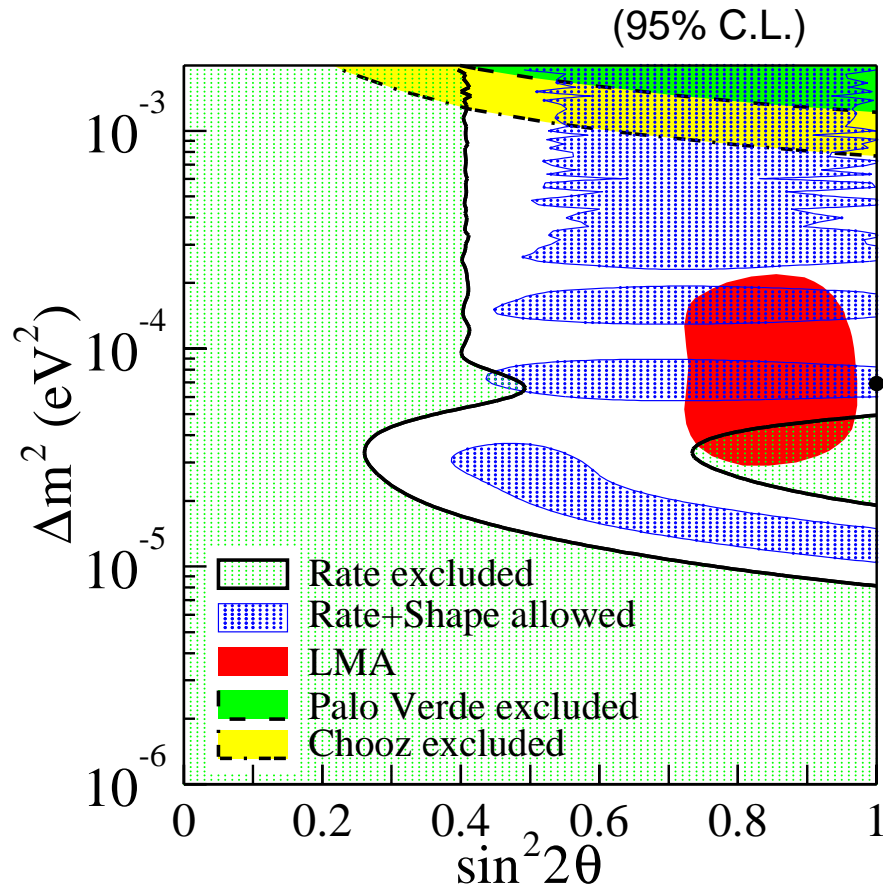
Allowed parameter region (solar neutrino experiments only, SNO salt data included)



Allowed parameter region (solar neutrino + KamLAND experiments, 2003)



Allowed region from KamLAND



K.Eguchi et al. (KamLAND collaboration), Phys. Rev. Lett. **90**, 021802 (2003)

What then can be expected?

- The straight-forward application of the See-Saw model will give the following picture.
- The largest permissible mass ratio $m_{\nu\tau}/m_{\nu\mu}$ is 5.5. Suppose this ratio applies to $m_{\nu\mu}/m_{\nu e}$.
- Then the mass of the right handed heavy Neutrino of the First Family will be around

160 TeV.

What will you do, then?

Thank you for the patience.

M. Koshiha