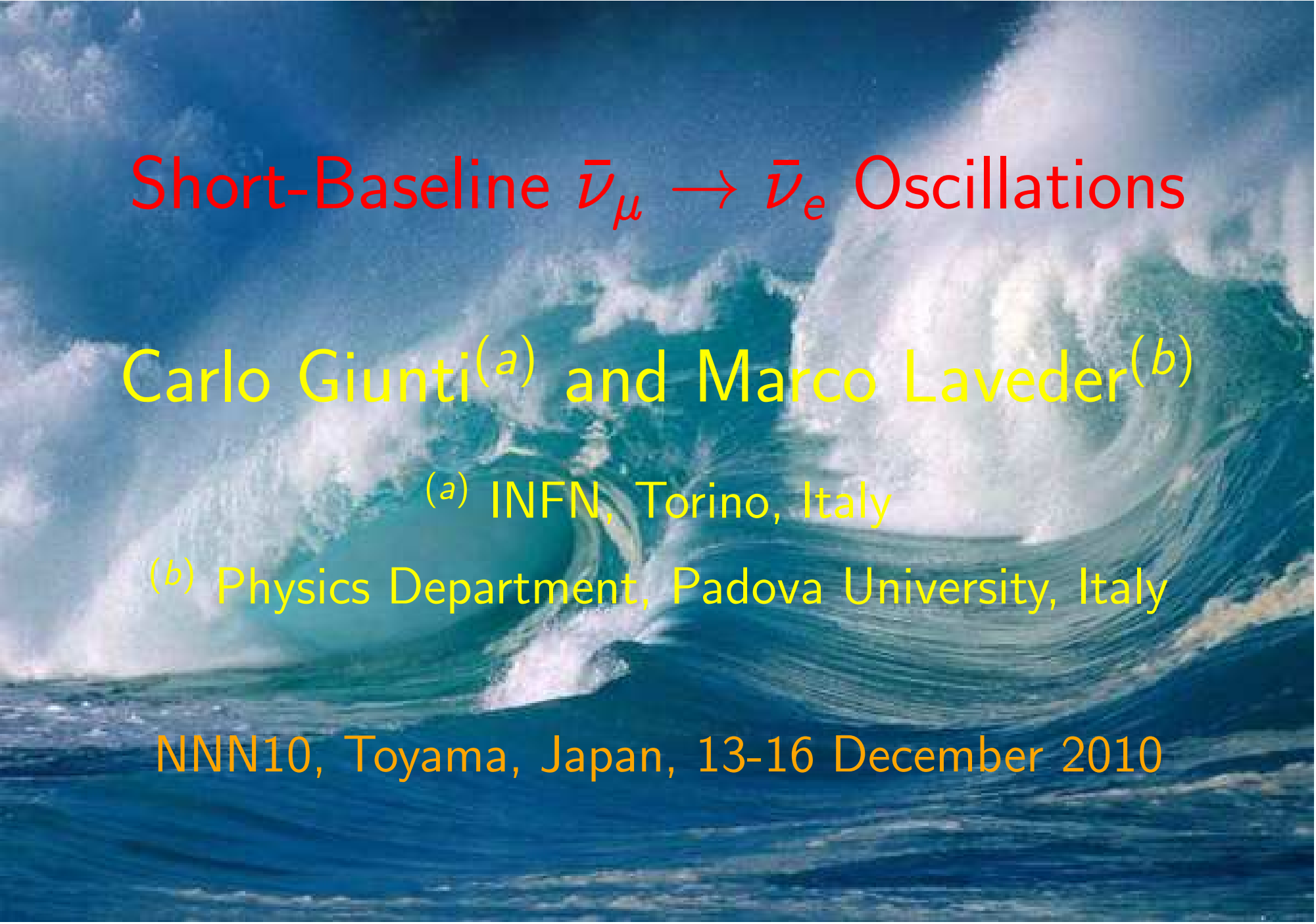


Short-Baseline $\bar{\nu}_\mu \to \bar{\nu}_e$ Oscillations

Carlo Giunti[(a)] and Marco Laveder[(b)]

[(a)] INFN, Torino, Italy

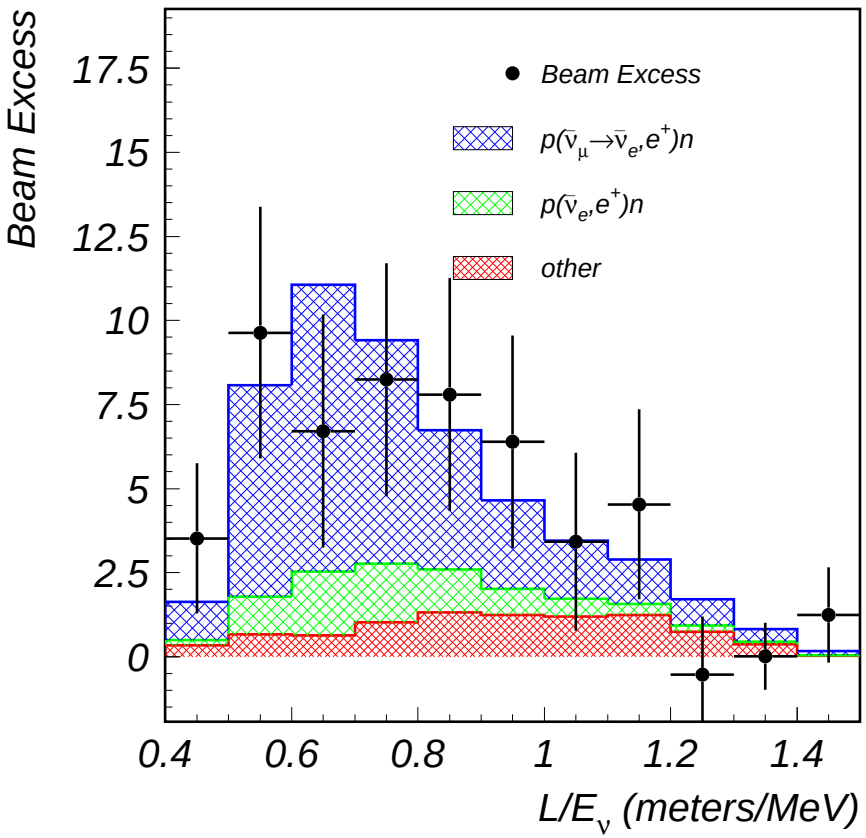
[(b)] Physics Department, Padova University, Italy

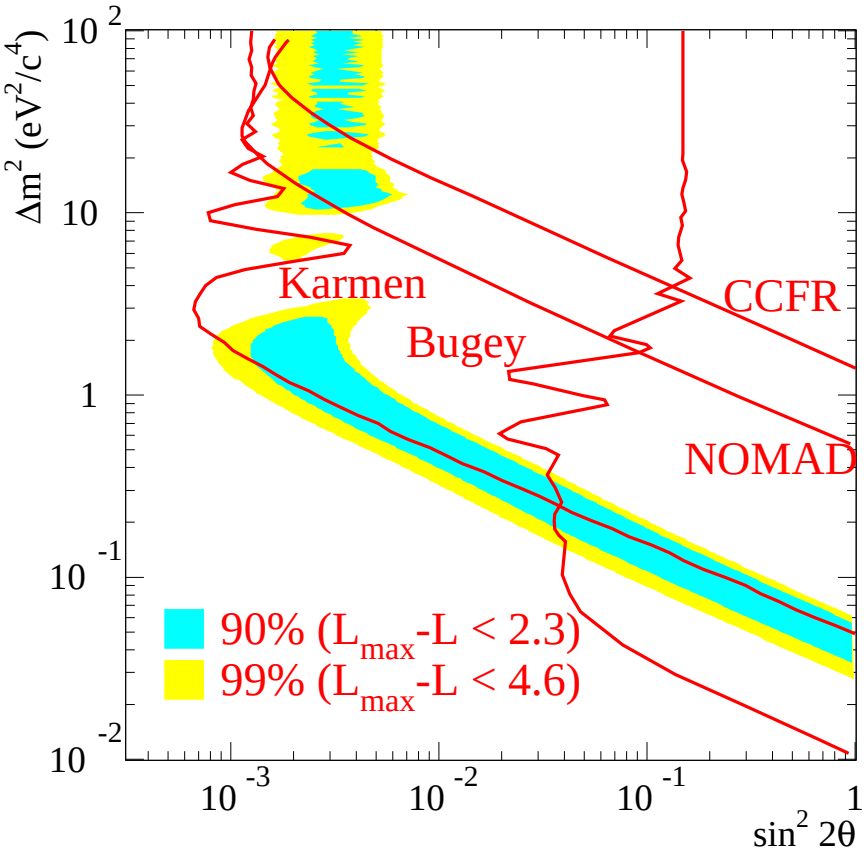
NNN10, Toyama, Japan, 13-16 December 2010

LSND

[LSND, PRL 75 (1995) 2650; PRC 54 (1996) 2685; PRL 77 (1996) 3082; PRD 64 (2001) 112007]

$\bar{\nu}_\mu \to \bar{\nu}_e$ $\quad L \simeq 30\,\text{m}$ $\quad 20\,\text{MeV} \leq E \leq 200\,\text{MeV}$



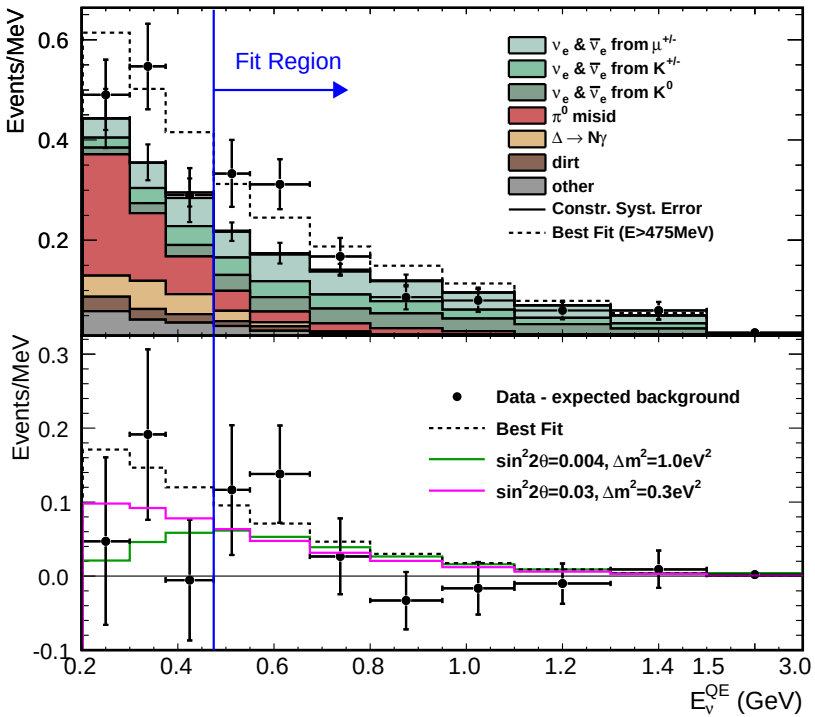


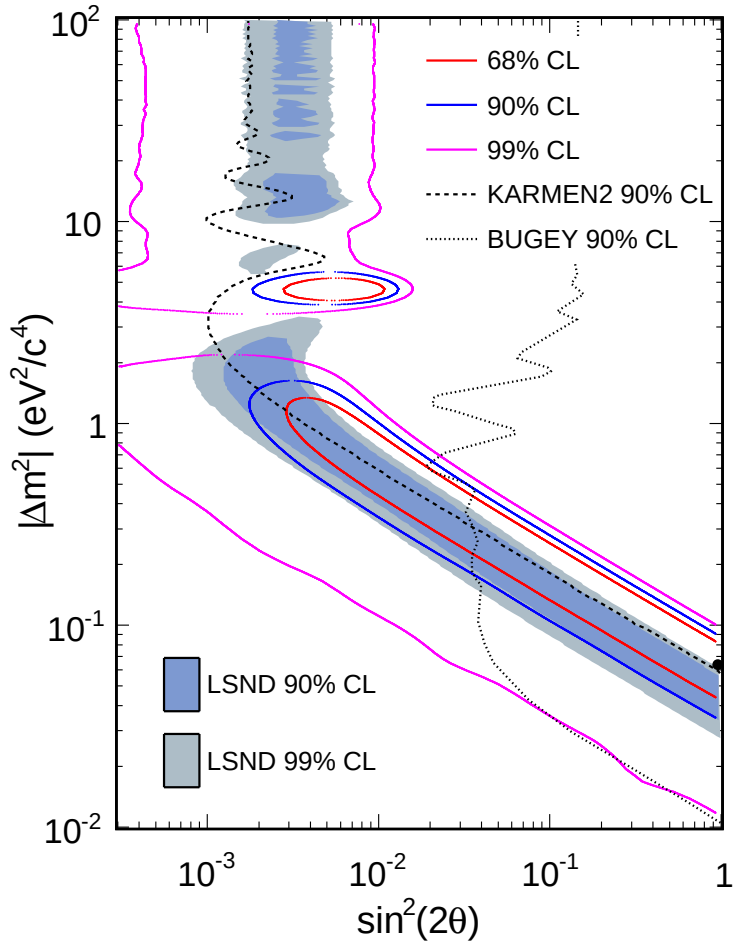
$\Delta m^2_{\text{LSND}} \gtrsim 0.2\,\text{eV}^2 \quad (\gg \Delta m^2_{\text{ATM}} \gg \Delta m^2_{\text{SOL}})$

MiniBooNE Antineutrinos

[MiniBooNE, PRL 105 (2010) 181801, arXiv:1007.1150]

$\bar{\nu}_\mu \to \bar{\nu}_e$ $\quad L \simeq 541\,\text{m}$ $\quad 475\,\text{MeV} \leq E \lesssim 3\,\text{GeV}$

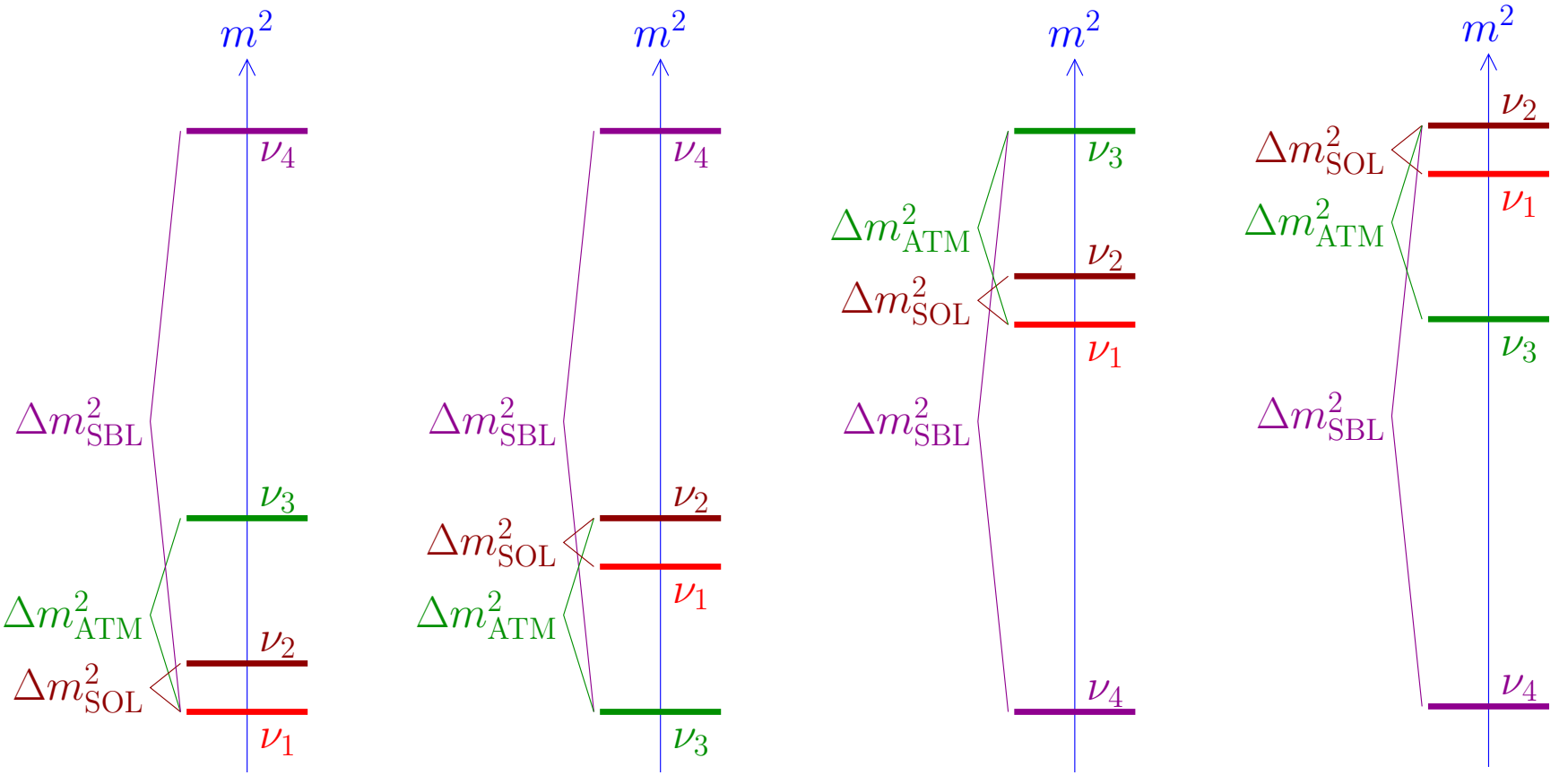




Agreement with LSND $\bar{\nu}_\mu \to \bar{\nu}_e$ signal!

Similar L/E but different L and $E \Longrightarrow$ Oscillations!

3+1 Four-Neutrino Schemes



Perturbation of 3-ν Mixing

$$|U_{e4}|^2 \ll 1 \qquad |U_{\mu 4}|^2 \ll 1 \qquad |U_{\tau 4}|^2 \ll 1 \qquad |U_{s4}|^2 \simeq 1$$

SBL Oscillation Probabilities in 3+1 Schemes

$$P_{\nu_\alpha \to \nu_\beta} = \sin^2 2\vartheta_{\alpha\beta} \sin^2\left(\frac{\Delta m^2 L}{4E}\right)$$

$$\sin^2 2\vartheta_{\alpha\beta} = 4|U_{\alpha 4}|^2 |U_{\beta 4}|^2$$

No CP Violation!

$$P_{\nu_\alpha \to \nu_\alpha} = 1 - \sin^2 2\vartheta_{\alpha\alpha} \sin^2\left(\frac{\Delta m^2 L}{4E}\right)$$

$$\sin^2 2\vartheta_{\alpha\alpha} = 4|U_{\alpha 4}|^2 \left(1 - |U_{\alpha 4}|^2\right)$$

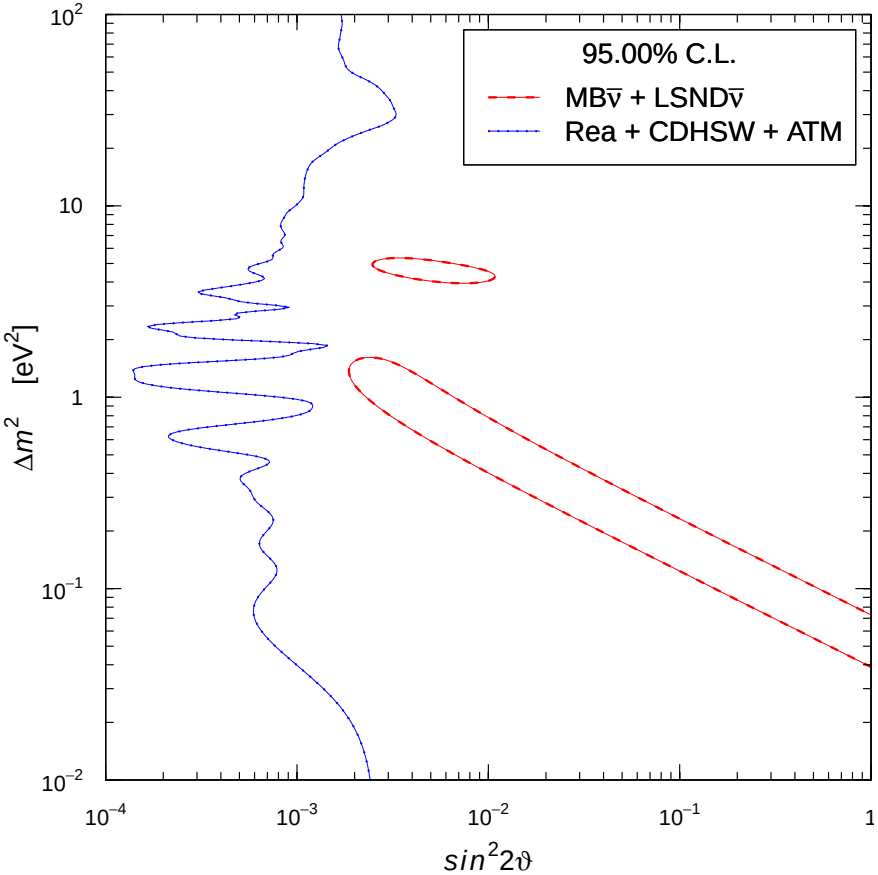
$$U = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} & U_{e4} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} & U_{\mu 4} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} & U_{\tau 4} \\ U_{s1} & U_{s2} & U_{s3} & U_{s4} \end{pmatrix}$$

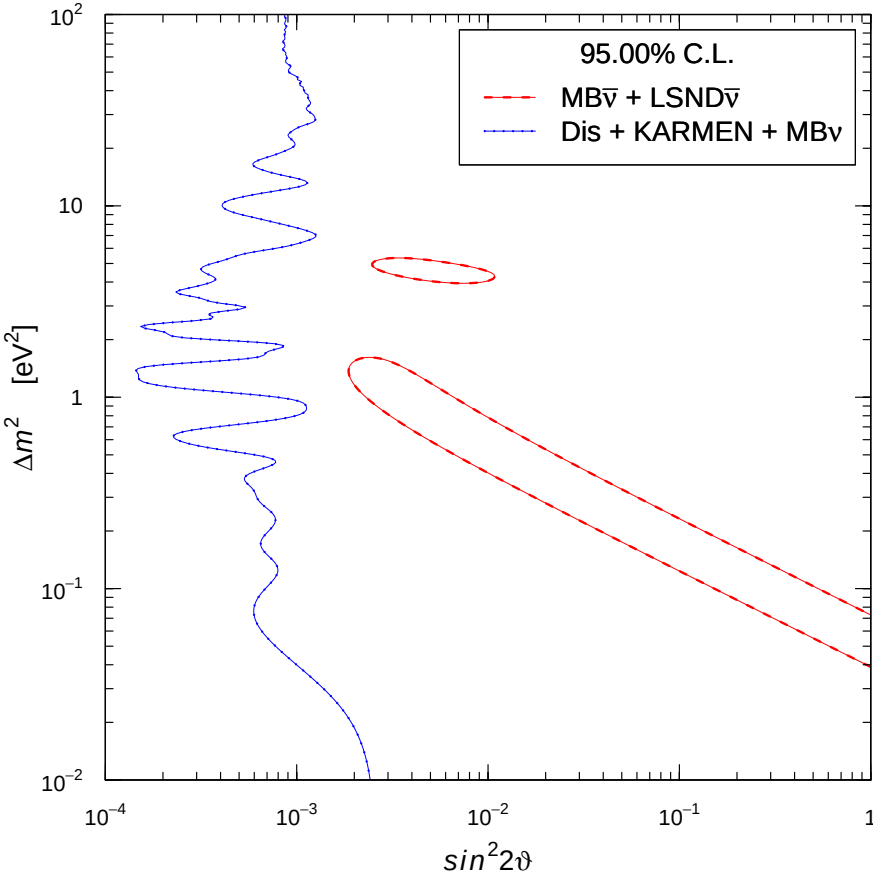
SBL

$$\sin^2 2\vartheta_{\alpha\alpha} \ll 1$$

$$\Downarrow$$

$$|U_{\alpha 4}|^2 \simeq \frac{\sin^2 2\vartheta_{\alpha\alpha}}{4}$$



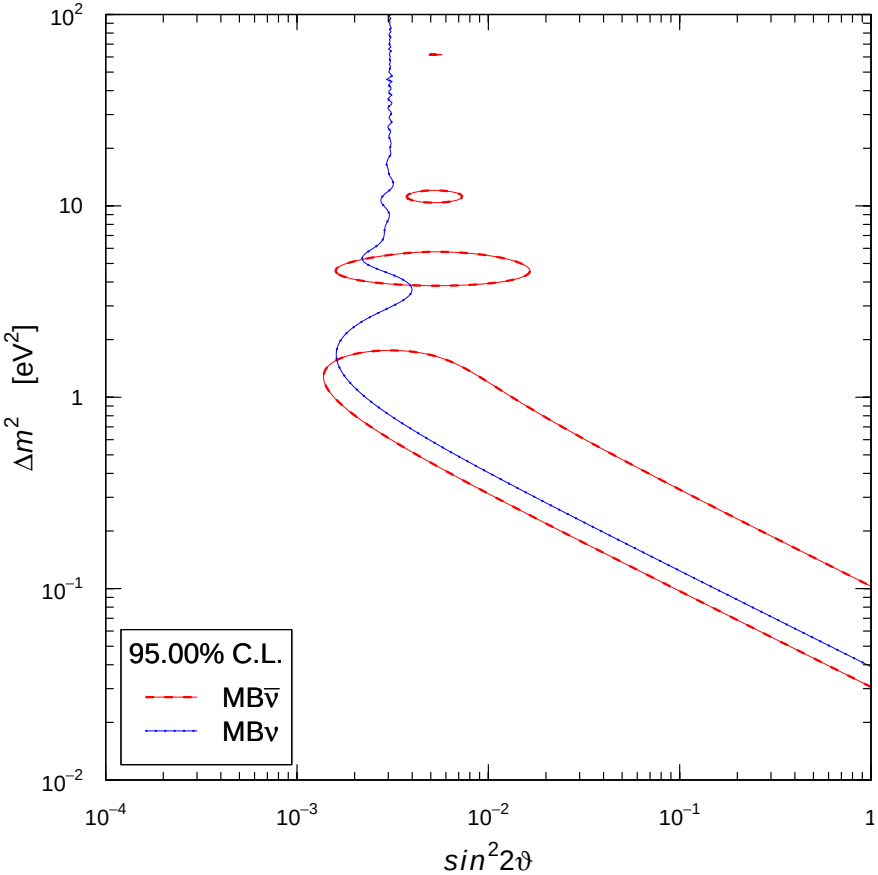


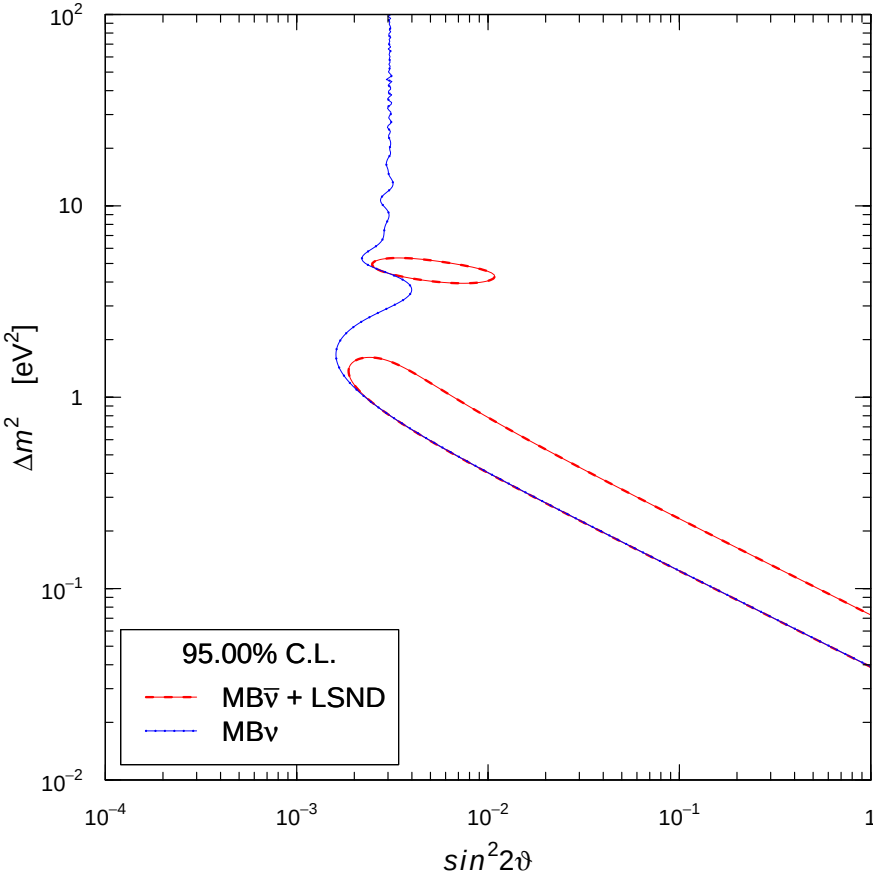
PGoF $= 0.11\%$ PGoF $= 0.0095\%$

3+1 Four-Neutrino Schemes

Strong tension between LSND and MiniBooNE $\bar{\nu}_\mu \to \bar{\nu}_e$ and

- $\bar{\nu}_e$ (Bugey) $+ \overset{(-)}{\nu}_\mu$ (CDHSW+ATM) disappearance limits
- KARMEN $\bar{\nu}_\mu \to \bar{\nu}_e$ and MiniBooNE $\nu_\mu \to \nu_e$





PGoF = 2.0%

PGoF = 0.27%

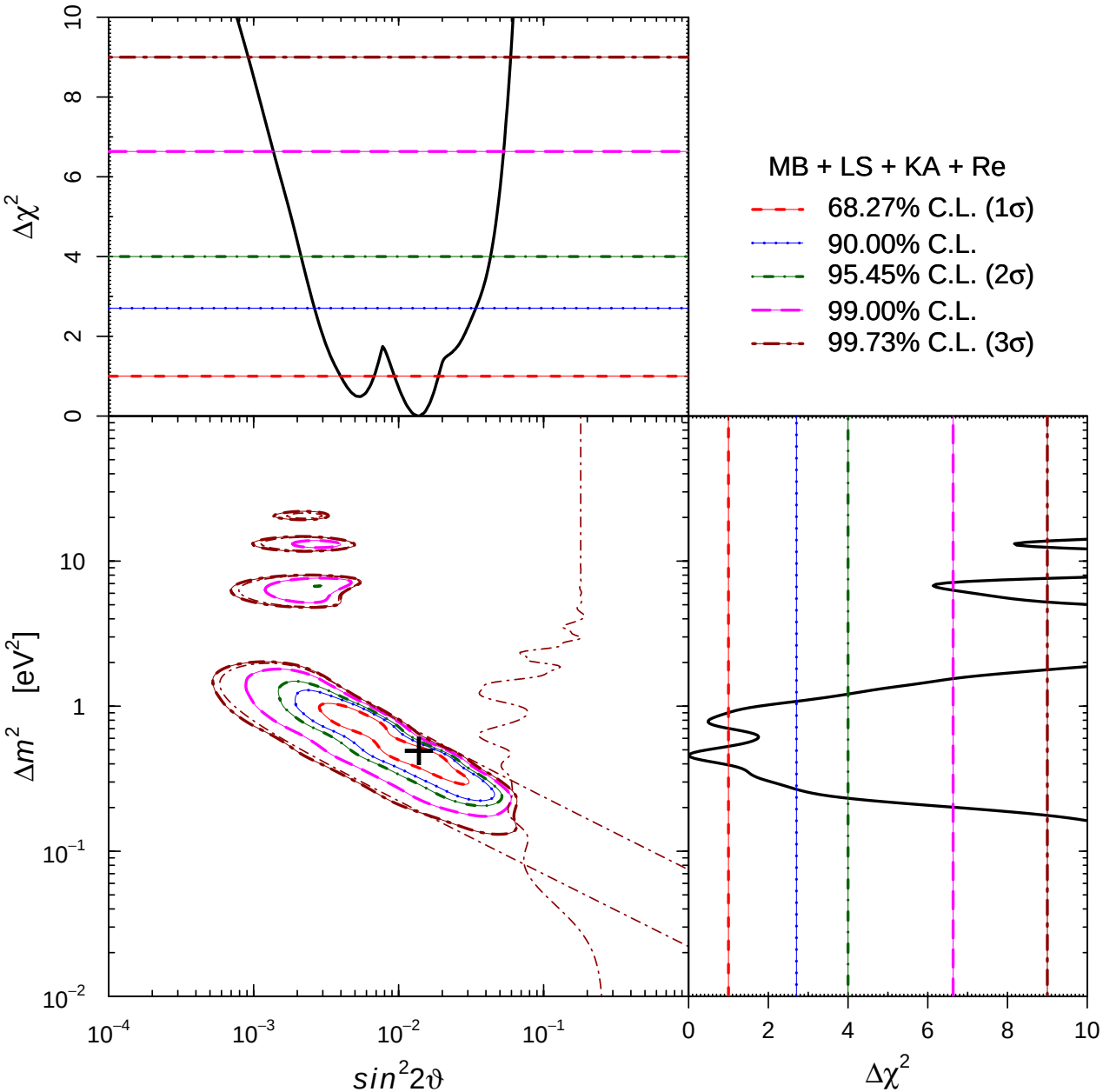
3+1 Four-Neutrino Schemes: Strong tension between

- LSND and MiniBooNE $\bar{\nu}_\mu \to \bar{\nu}_e$
- MiniBooNE $\nu_\mu \to \nu_e$

CPT Violation?

[Barger, Marfatia, Whisnant, PLB 576 (2003) 303]

$\bar{\nu}_\mu \to \bar{\nu}_e$ and $\bar{\nu}_e \to \bar{\nu}_e$



$\chi^2_{\text{min}} = 77.3$

NdF $= 82$

GoF $= 63\%$

$\sin^2 2\vartheta = 0.014$

$\Delta m^2 = 0.46\,\text{eV}^2$

Parameter Goodness-of-Fit

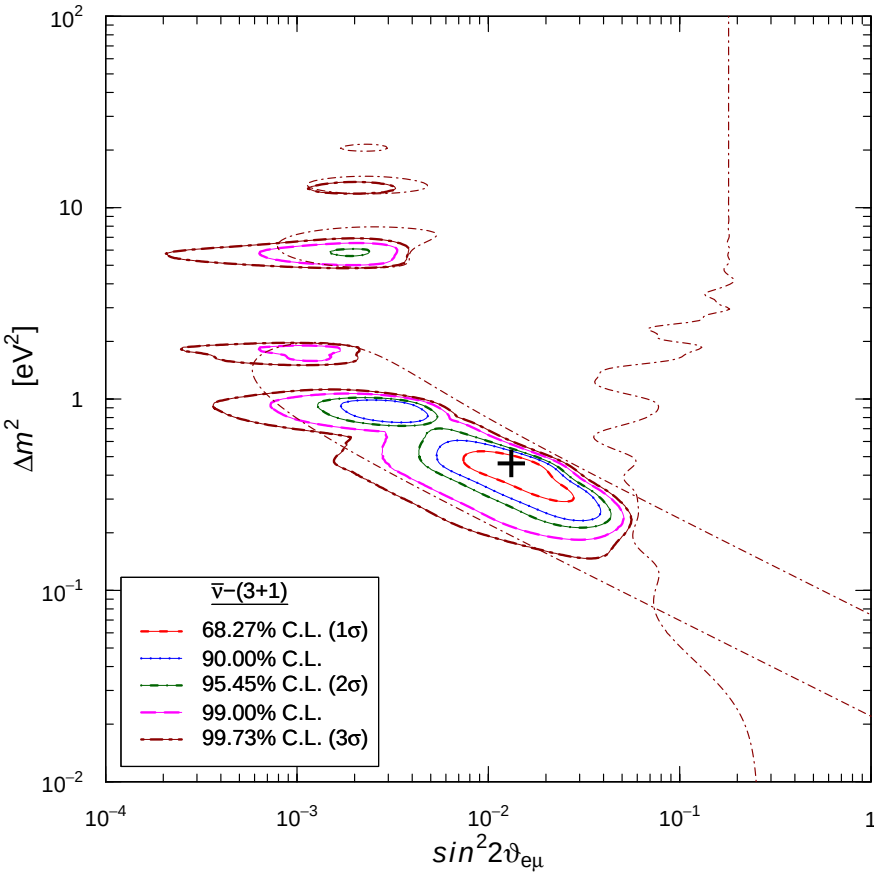
$\Delta\chi^2_{\text{min}} = 3.0$

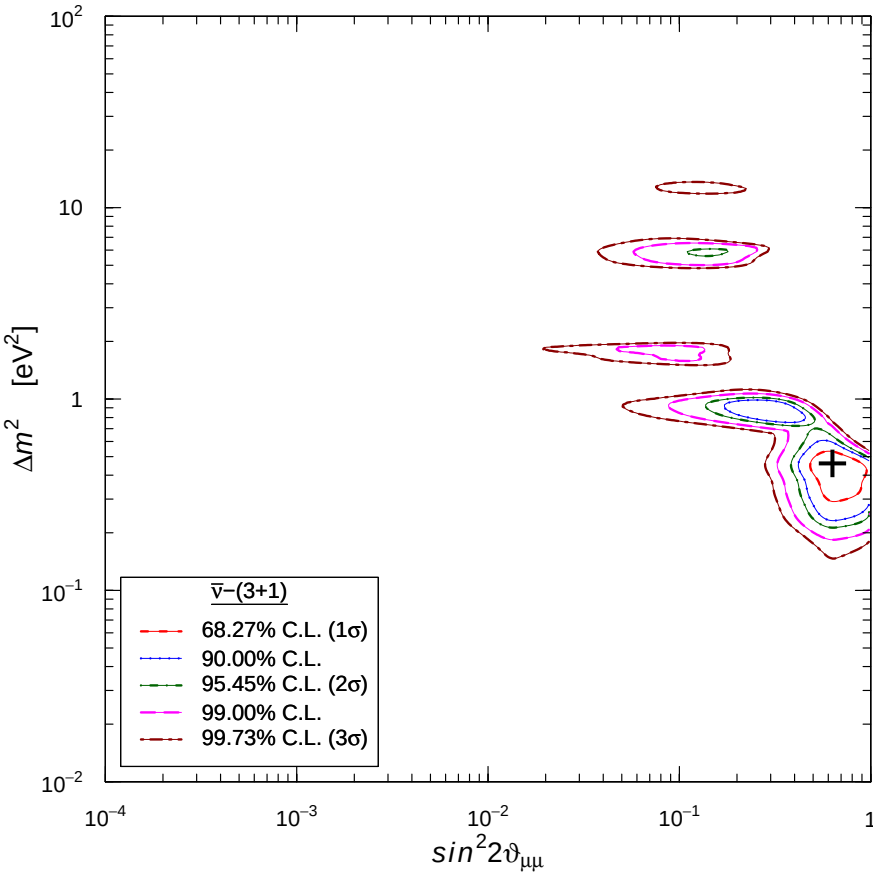
NdF $= 2$

GoF $= 22\%$

[Giunti, Laveder, PRD 82 (2010) 093016, arXiv:1010.1395]

Antineutrino Oscillations in 3+1 Schemes





$$\chi^2_{\text{min}} = 77.5 \qquad \text{NdF} = 82 \qquad \text{GoF} = 62\%$$

$$\Delta m^2 = 0.43\,\text{eV}^2 \quad \sin^2 2\vartheta_{e\mu} = 0.013 \quad \sin^2 2\vartheta_{ee} = 0.017 \quad \sin^2 2\vartheta_{\mu\mu} = 0.63$$

Prediction: large SBL $\bar{\nu}_\mu$ disappearance at $0.1 \lesssim \Delta m^2 \lesssim 1\,\text{eV}^2$

[Giunti, Laveder, arXiv:1012.0267]

Conclusions

- Impressive LSND and MiniBooNE agreement on $\bar{\nu}_\mu \to \bar{\nu}_e$ signal
- Two experimental tensions:
  - LSND and MiniBooNE $\bar{\nu}_\mu \to \bar{\nu}_e$ vs MiniBooNE $\nu_\mu \to \nu_e$
  - LSND and MiniBooNE $\bar{\nu}_\mu \to \bar{\nu}_e$ vs $\bar{\nu}_e$ and ν_μ disappearance limits
- CPT-invariant 3+1 Four-Neutrino Mixing is strongly disfavored
- CPT-violating 3+1 Mixing $\Longrightarrow$ large SBL $\bar{\nu}_\mu$ disappearance