Exotic contributions to atmospheric neutrino oscillations

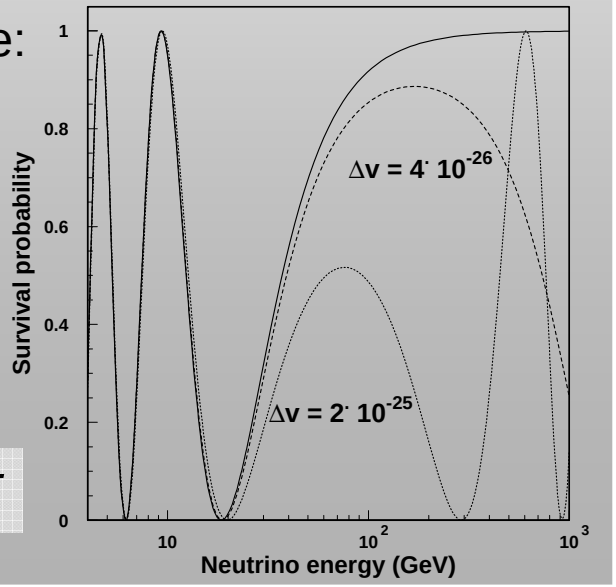
(M. Sioli, Workshop on "Perspectives in neutrino physics and astrophysics", Bologna, June 17th, 2005)

- Atmospheric neutrinos offer a unique possibility to test the Lorentz Invariance - and/or the Equivalence Principle - to an unprecedented level (atmospheric neutrinos are ultrarelativistic: $\gamma = E/m \approx 10^{12}$!)
- New features in a VLI scenario:
  - 3 different asymptotic velocities $v_1 \neq v_2 \neq v_3 \neq c$ → Δv_{12}, Δv_{23}, Δv_{13}
  - A new "velocity" basis, besides the "mass" and "flavor" basis → general mixing
- VLI (and VEP) could induce neutrino flavor oscillations, in competition with "standard" mass-induced oscillations → mixed scenario
- Formally, they are similar to the mass-induced case alone:

$$P\left(\nu_\mu \rightarrow \nu_\mu\right) = 1 - \sin^2 2\Theta \sin^2 \Omega$$

- The term Ω depends on:
  - Δm^2 and L/E ratio → mass-induced oscillations
  - Δv and $L \cdot E$ product → VLI-induced oscillations

→ VLI effects are emphasized at large L and large E

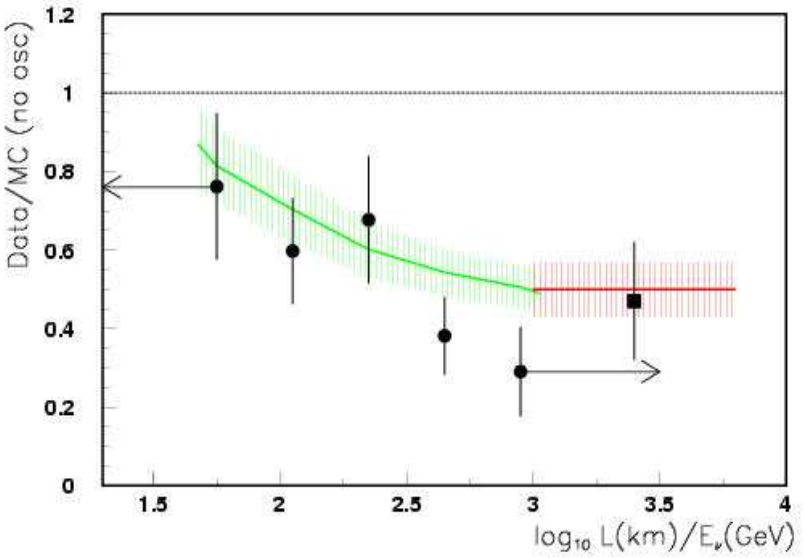


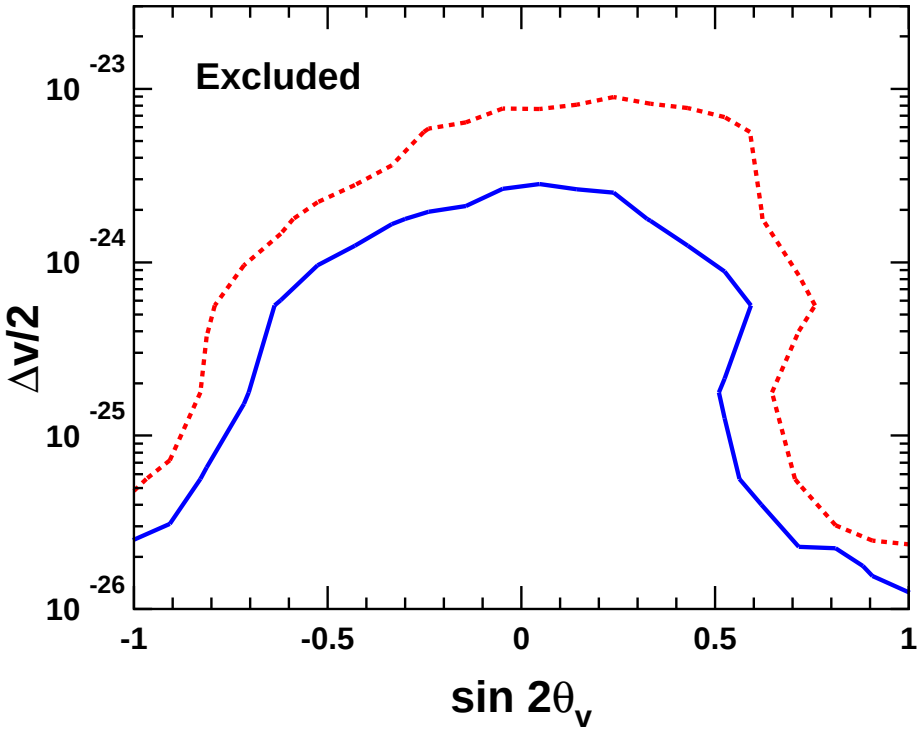
Recently, we estimated the energy of about 300 events of MACRO upgoing neutrino-induced muons using MCS information in the rock absorbers of the detector **[PLB 566 (2003) 35]**

This are "golden" events for VLI studies:

$\langle E_\nu \rangle \approx 50$ GeV

$\langle L \rangle \approx 10000$ km





The analysis is based on the ratio of high and low energy samples:

LOW ≡ $E_\nu < 28$ GeV

HIGH ≡ $E_\nu > 142$ GeV

A second analysis (MLH) confirms these results

[Details are in PLB 615 (2005) 14]

When all the parameters all left free:

$$|\Delta v| < 3 \cdot 10^{-25}$$