TAU CONTAMINATION AT THE NEUTRINO FACTORY

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In collaboration with:
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D. Meloni

arXiv: 1005.2275 [hep-ph]

THE GOLDEN CHANNEL

$\nu_e \longrightarrow \nu_\mu$

(θ_{13},δ)

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Wrong-sign muons

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Dominant backgrounds:

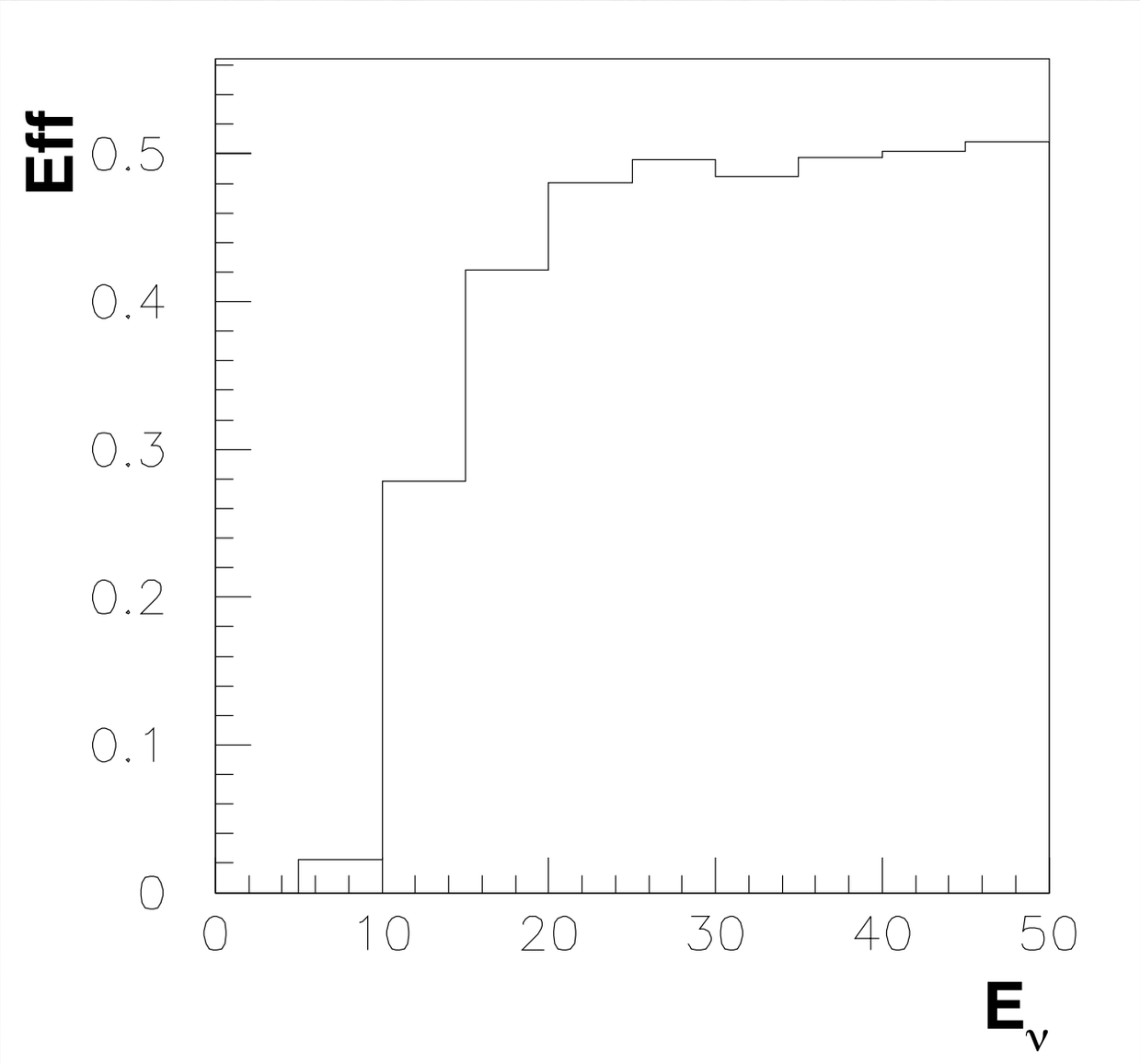
right-sign muons

CC with missed lepton + fake muon from hadrons

NC + fake muon from hadrons

OLD MIND EFFICIENCY

Tight kinematical cuts give a very low efficiency below 10 GeV and a very low background fraction



Cervera et al, hep-ph/0002108

CORR'S AND DEGENERACIES

- Correlations and Degeneracies (CaD) are a serious problem for the High-Energy (> 10 GeV) Neutrino Factory

- The oscillation signal is NOT on peak, and data below and above peak are needed to solve the problem

ISS Physics Rep., Bandyopadhyay et al, arXiv:0710.4947

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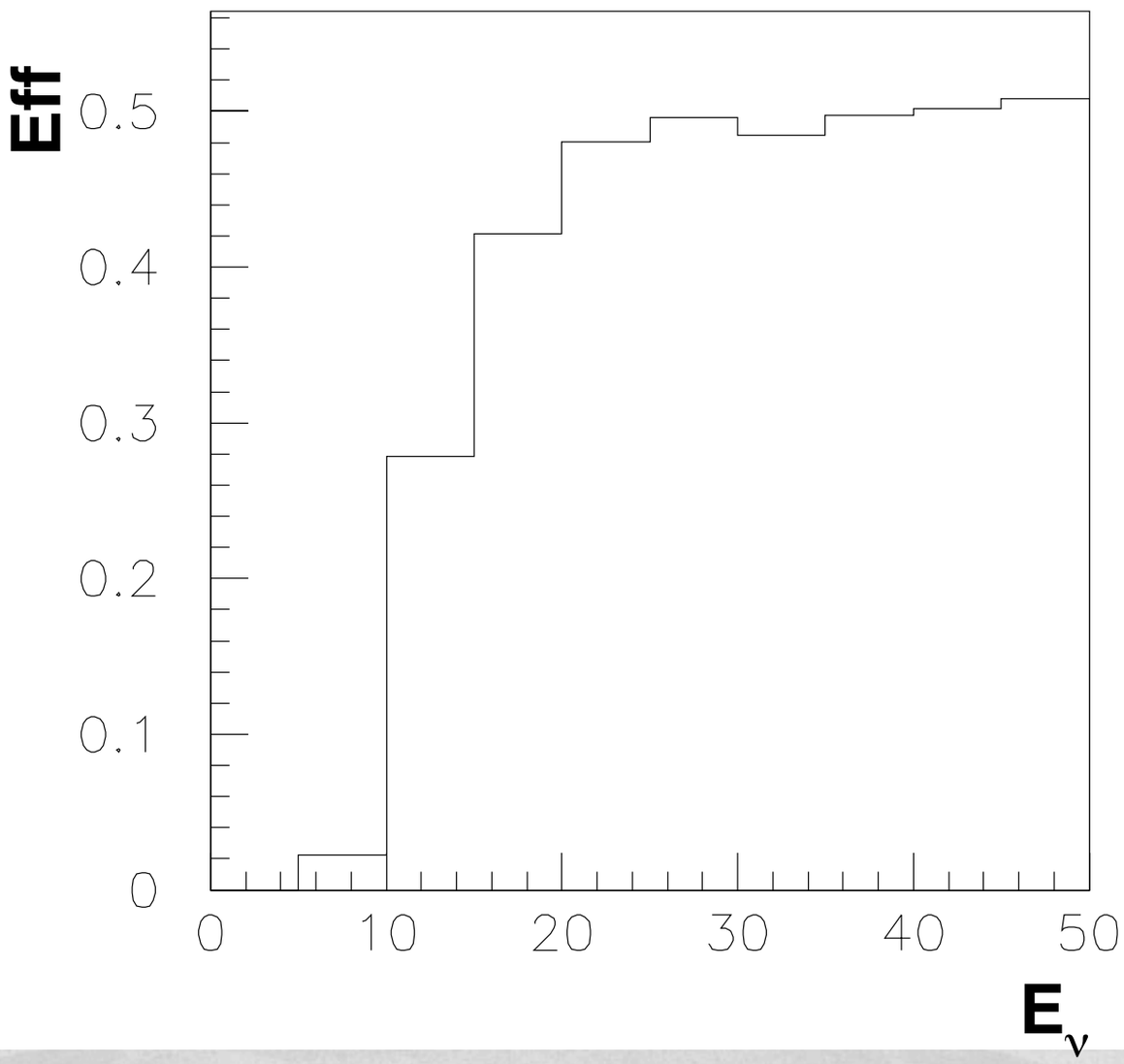

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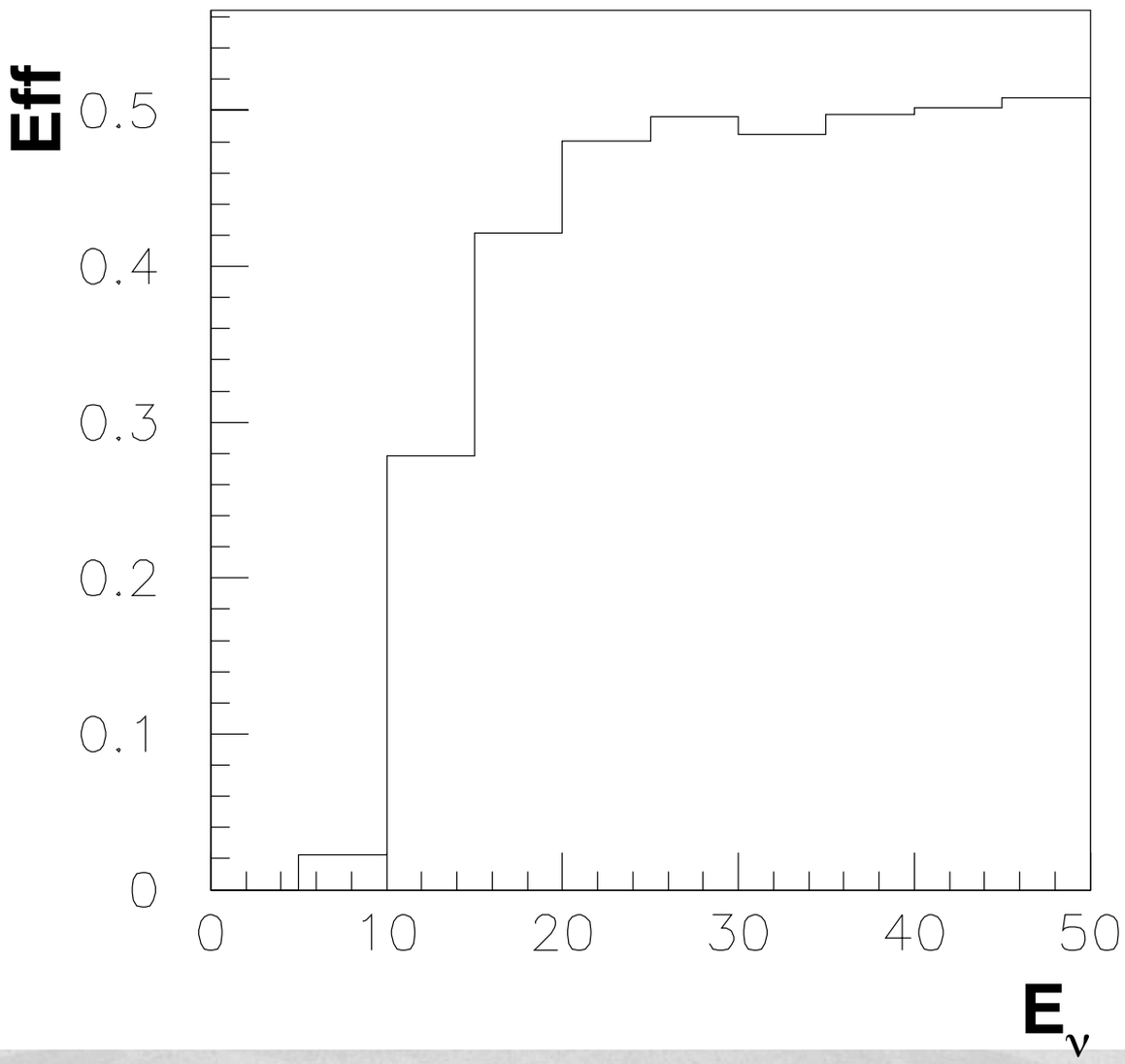

Cuts are relaxed to increase the efficiency at low energy

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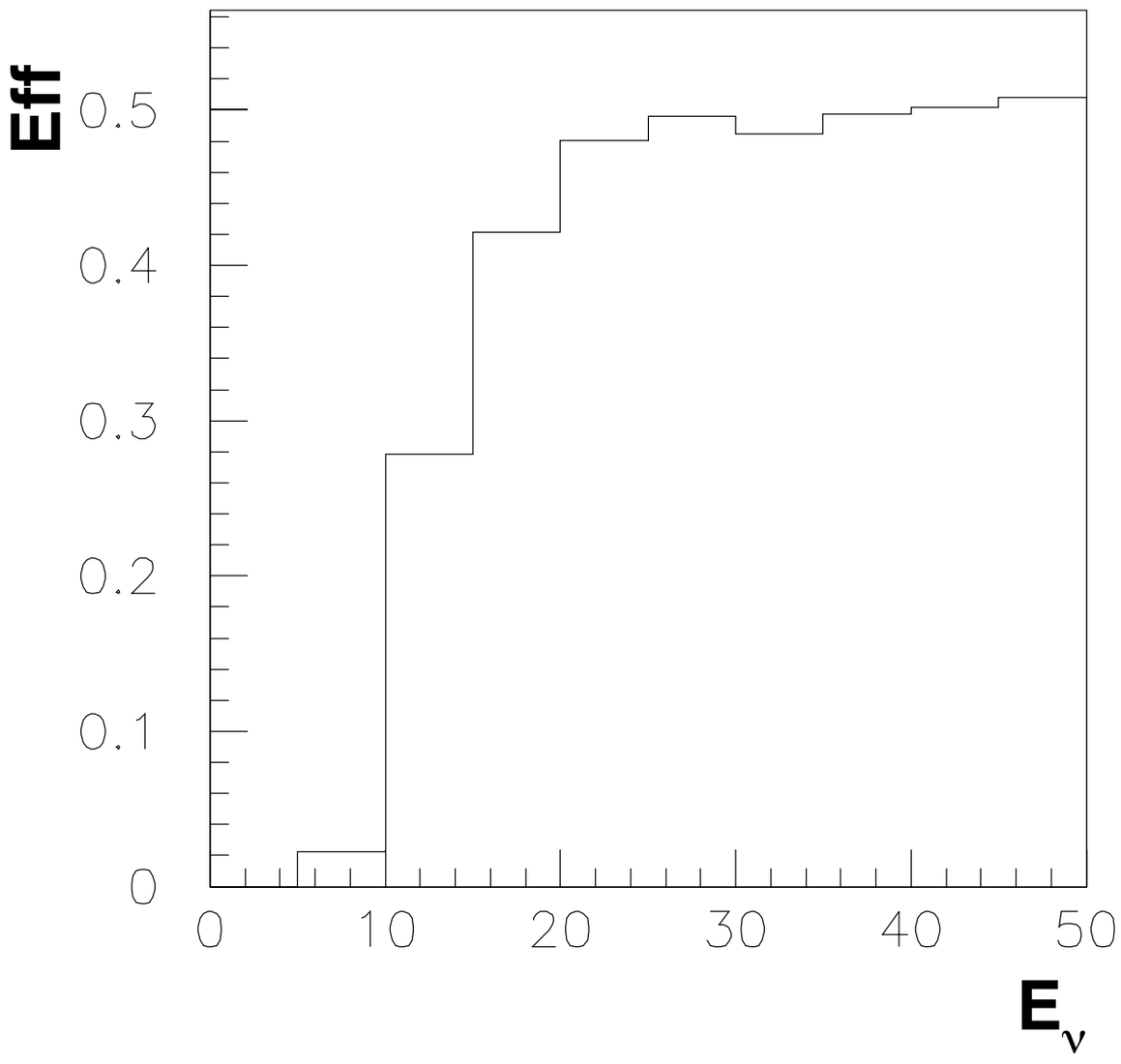

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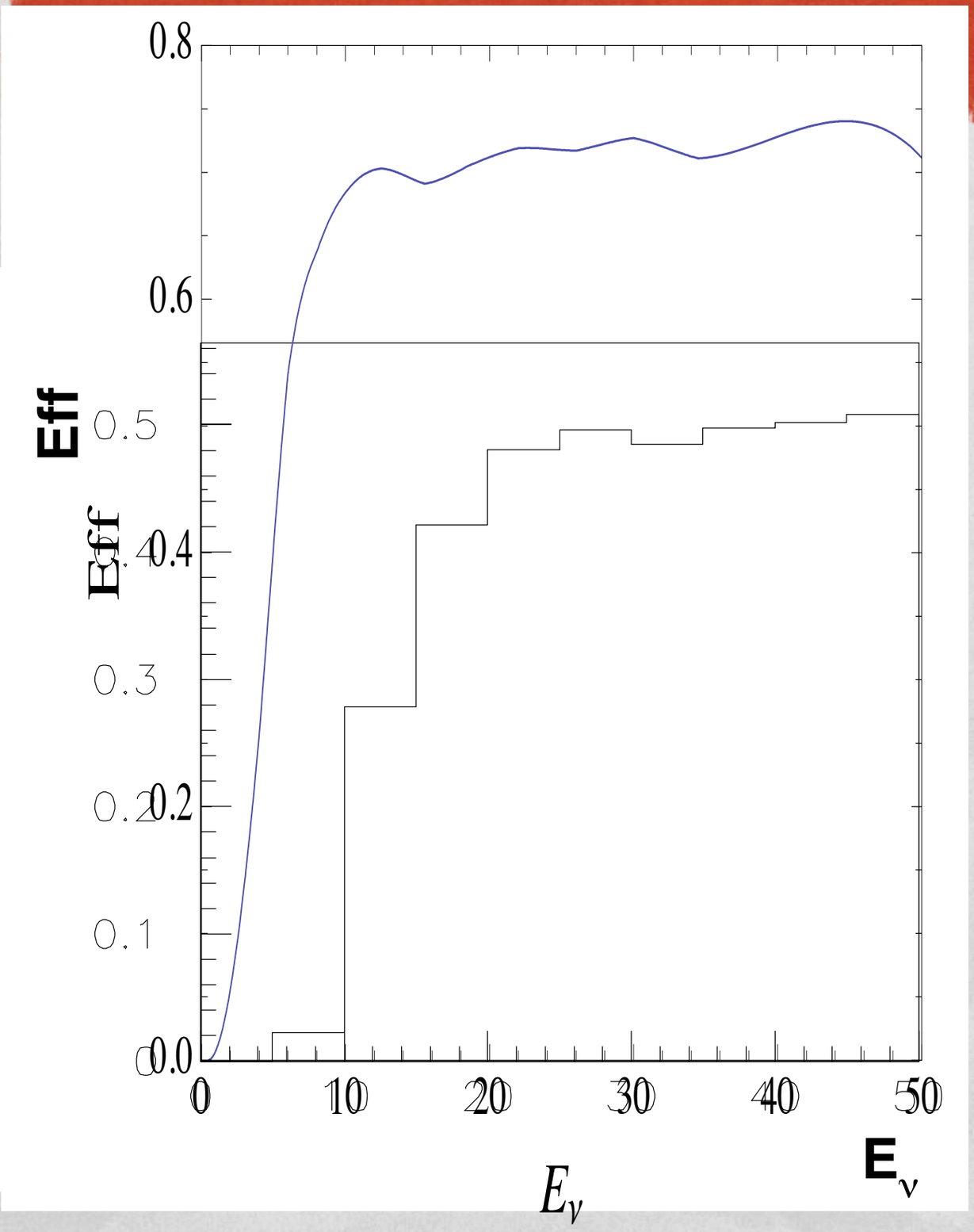

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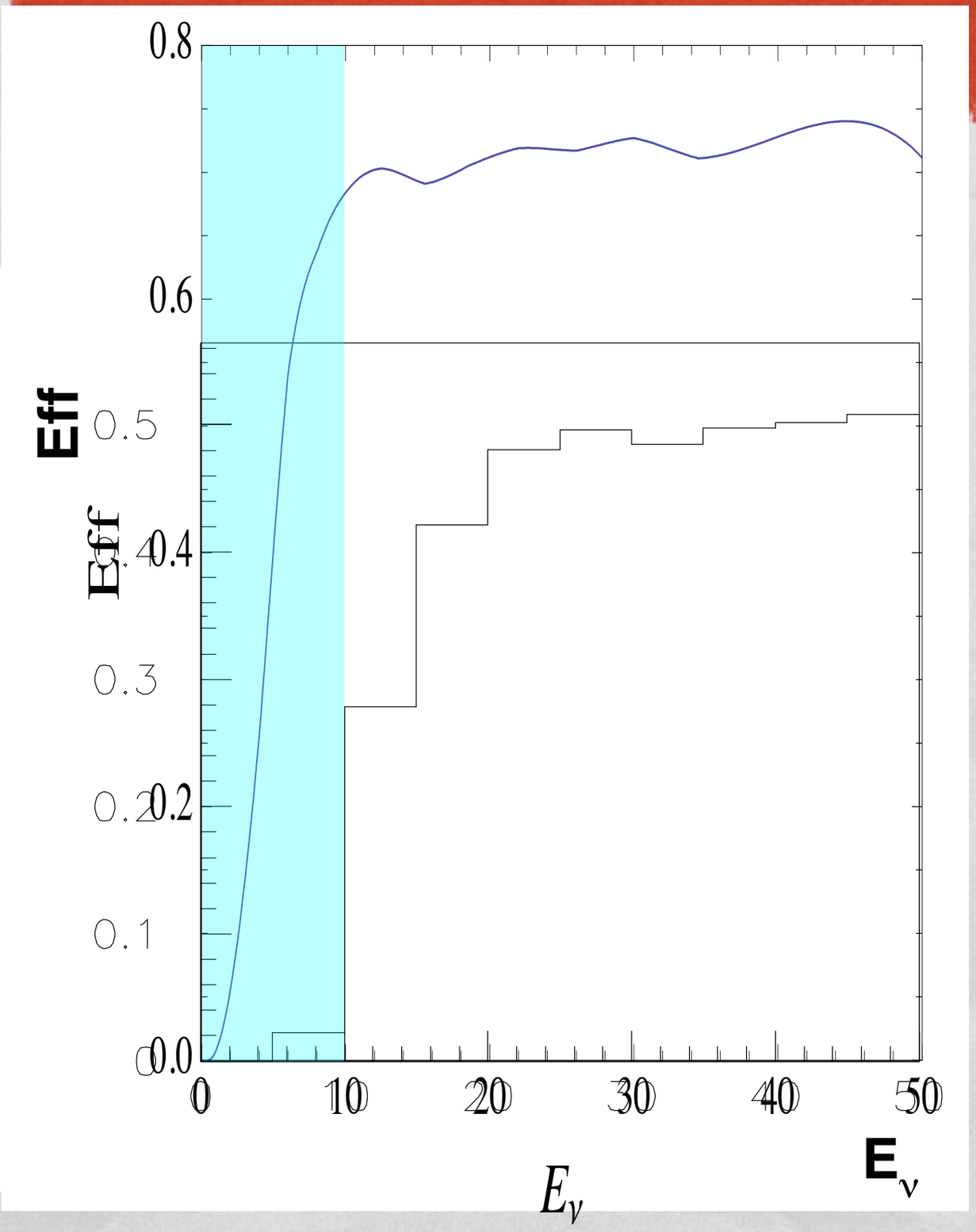

Cuts are relaxed to increase the efficiency at low energy

ISS Detector Rep., Abe et al, JINST 4 (2009) T05001

SILVER CHANNEL AT MIND

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(θ_{13}, δ)

SILVER CHANNEL AT MIND

$\nu_e \longrightarrow \nu_\tau \longrightarrow \tau^-$

(θ_{13},δ) $\sigma_{\tau N}$

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In MIND, this signal adds to the golden muon sample

FINAL MUON ENERGY

- Fitting in the Final Muon Energy:
  - add the two samples: more signal
  - no hadronic calorimeter info: more background

Indumati and Sinha, arXiv:0910.2020 (right-sign muons)

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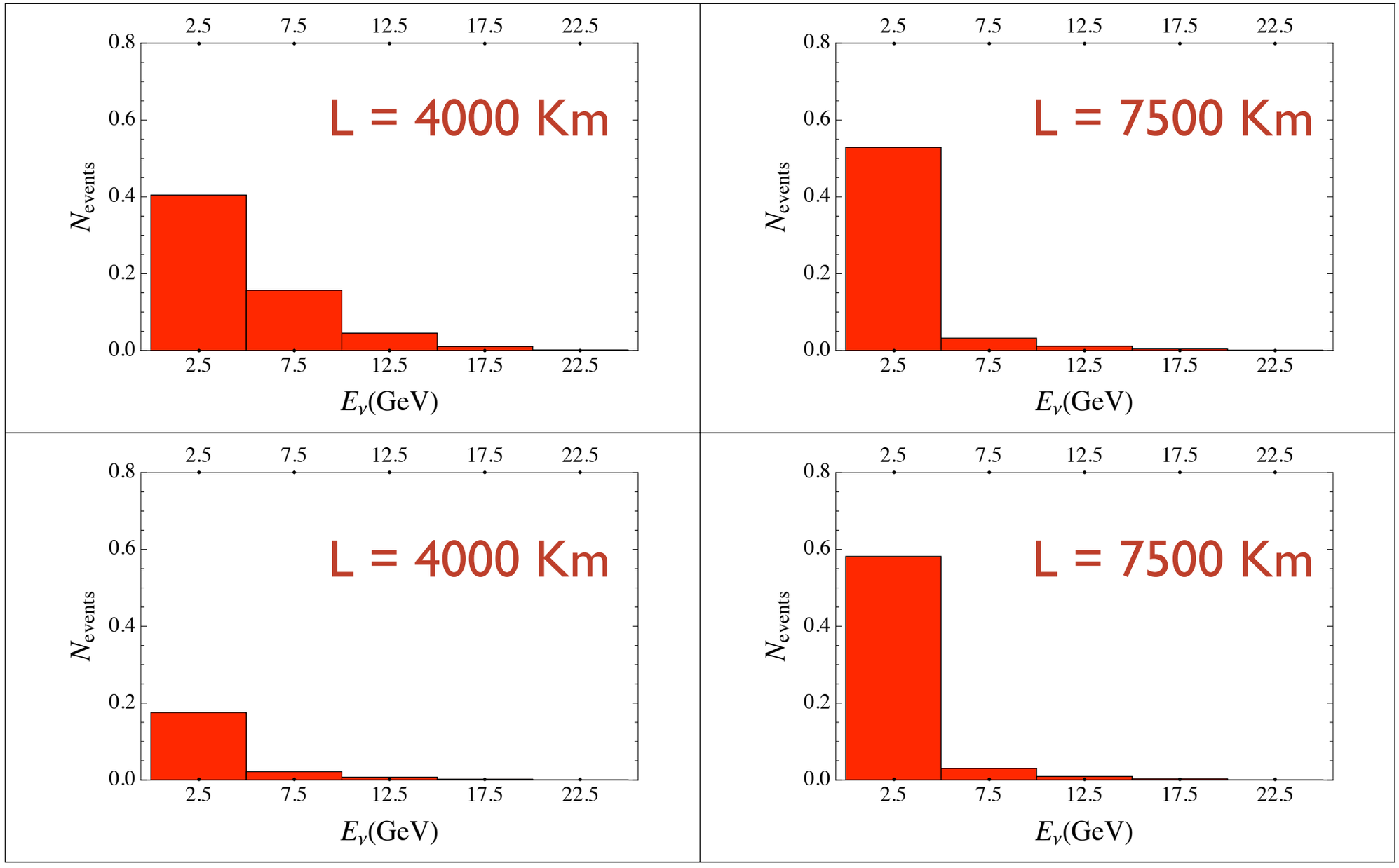
The neutrino energy is wrongly reconstructed!

This is what we call τ-contamination!

TAU CONTAMINATION

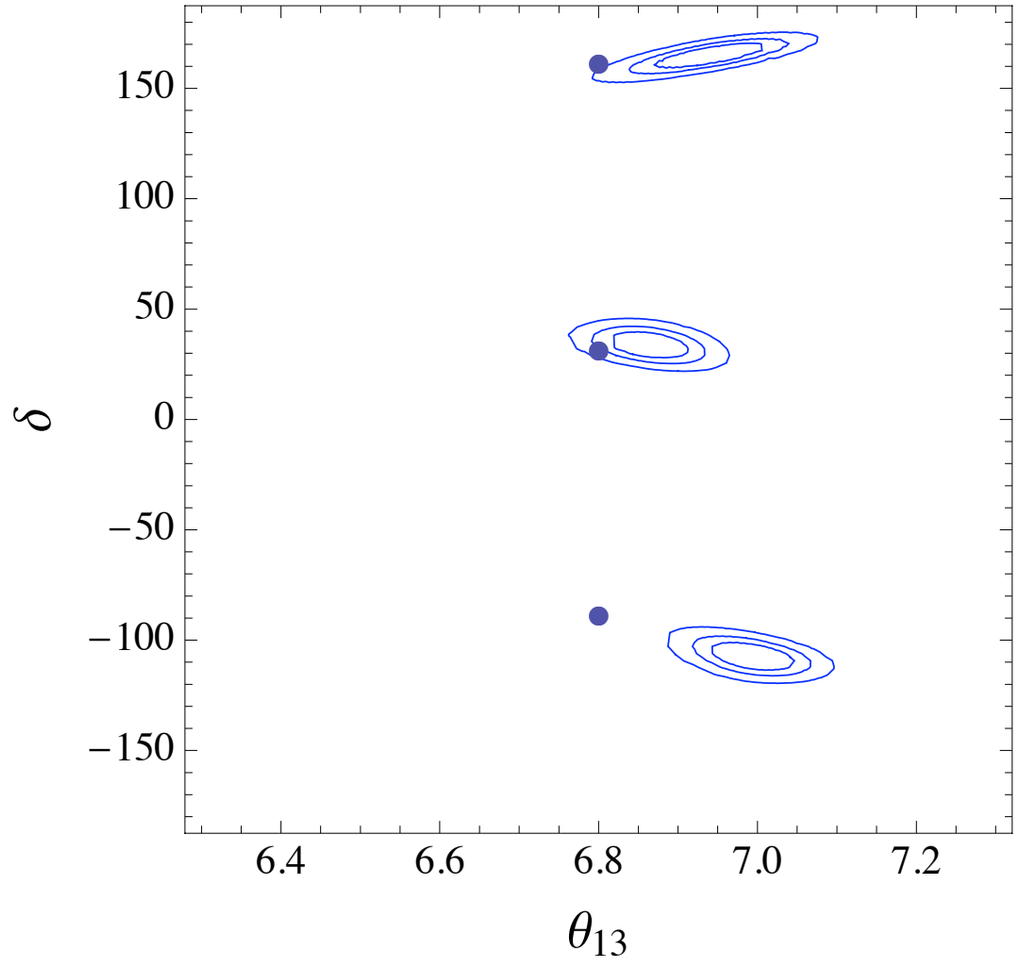


25 GeV NF

WRONG TREATMENT

- Fitting tau-contaminated data with the golden muon distribution, only

- $\theta_{13} = 6.8°$
  $\delta = 160°, 30°, -90°$

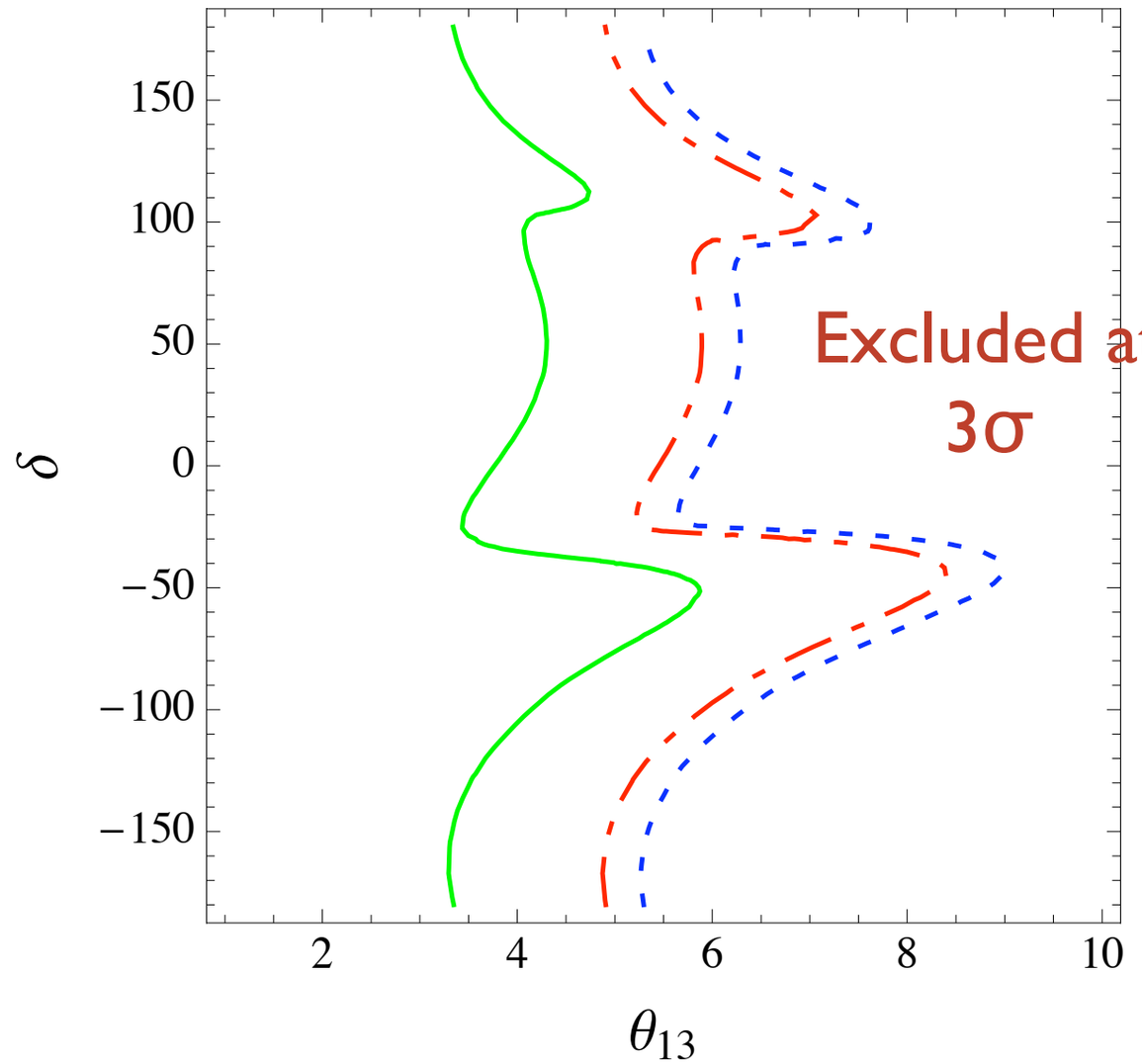


Gonzalez-Garcia, Maltoni, Salvado, arXiv:1001.4524

HYPOTHESIS TEST

- How good is the hypothesis that tau-contaminated data can be fitted with the golden muon distribution, only?

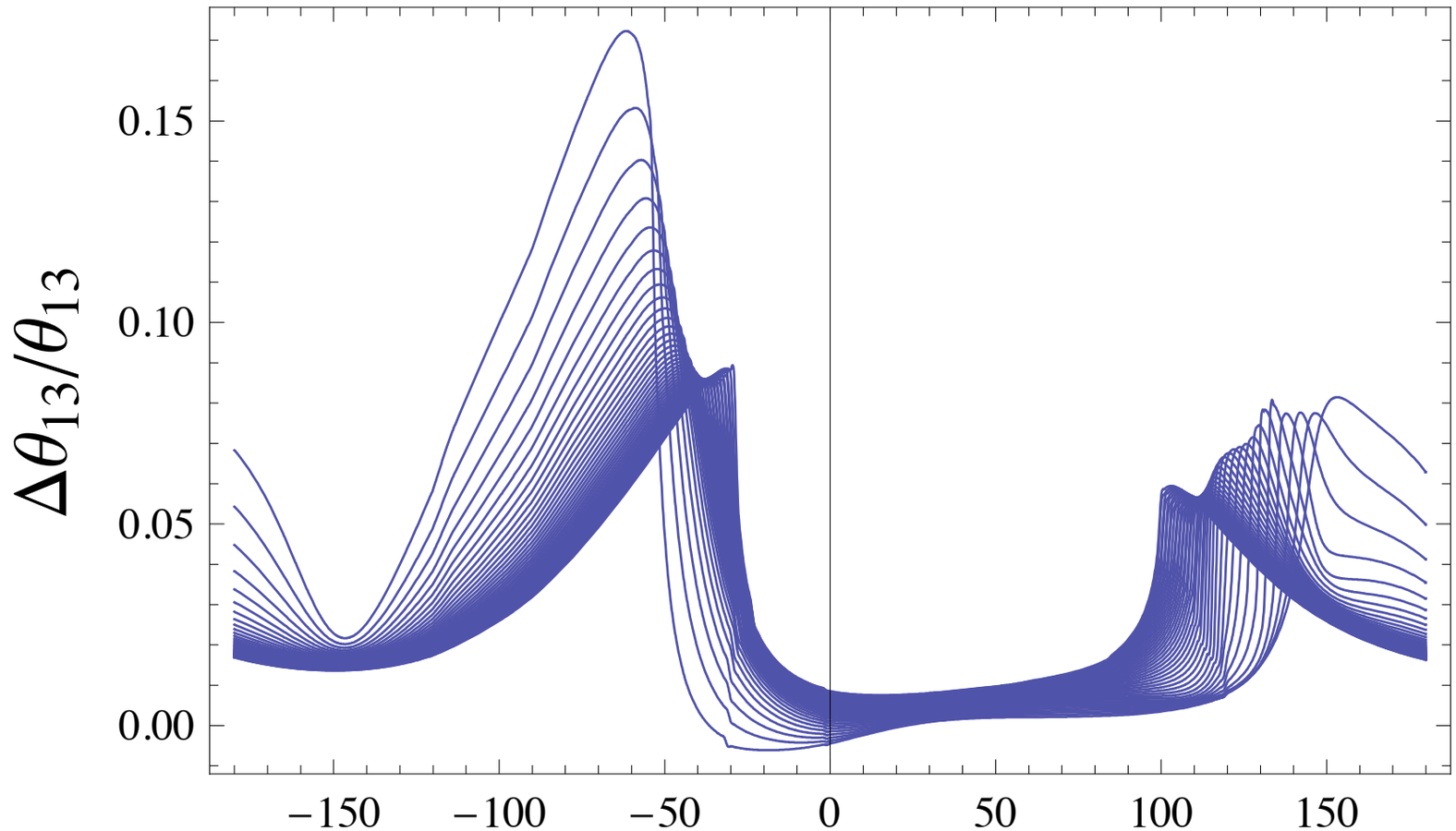
- The answer is: VERY POOR!!!!!!



L = 4000 Km

FITTED PARAMETERS, I

Relative error in the best-fit value for θ_{13}



True $\theta_{13} \in [1°,5°]$

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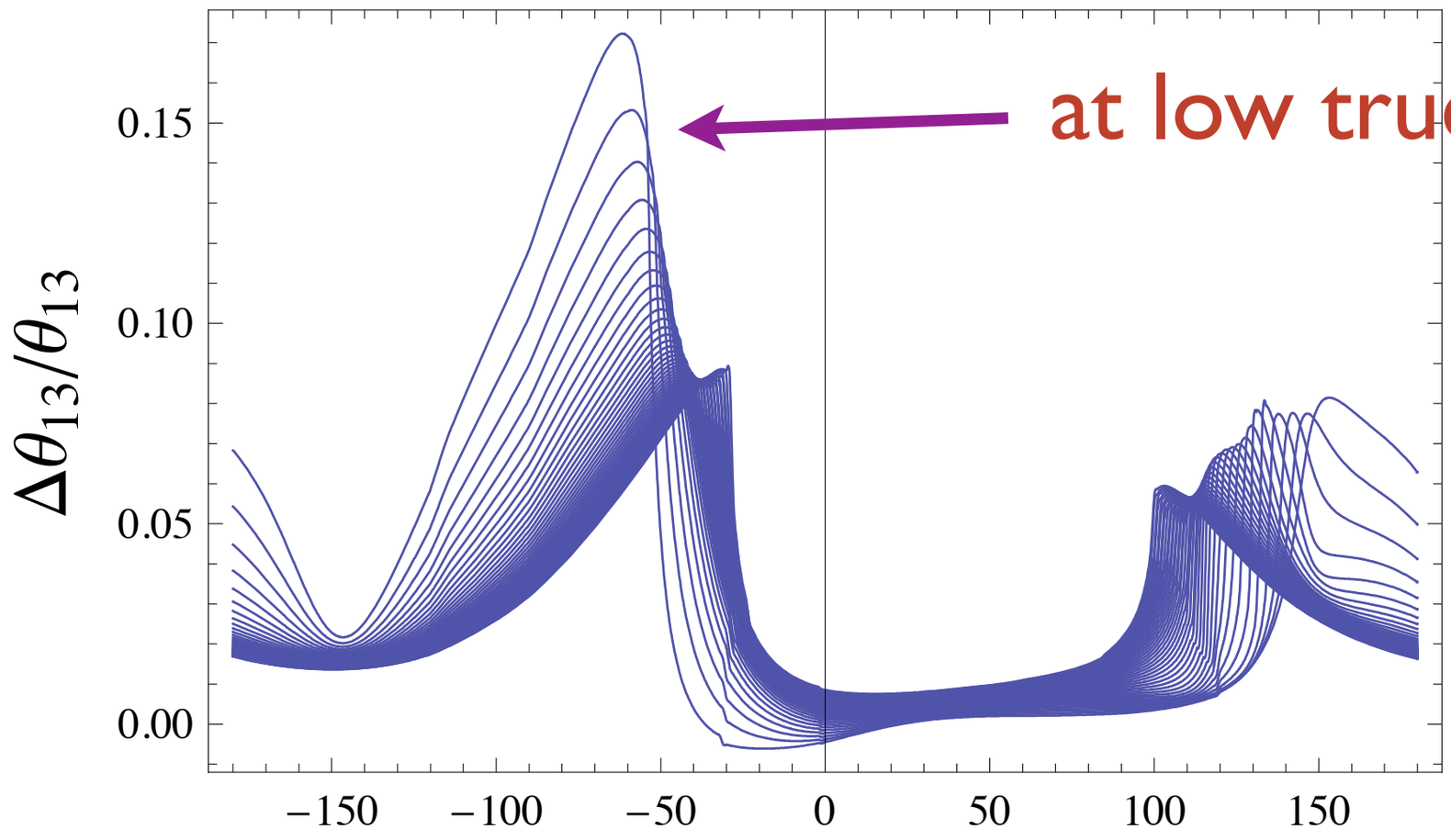

at low true θ_{13}

True $\theta_{13} \in [1°,5°]$

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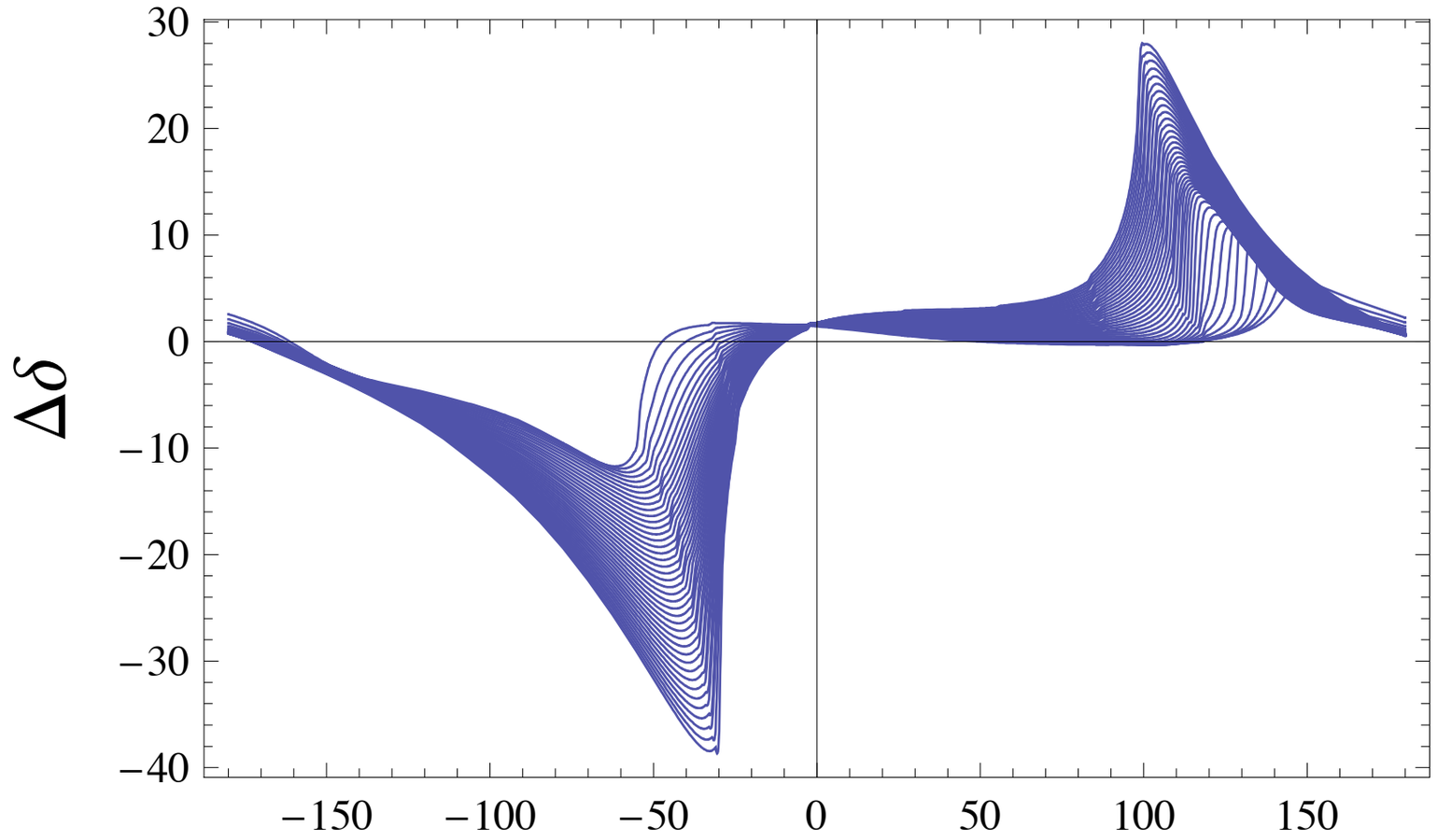
FITTED PARAMETERS, 2

Absolute error in the best-fit value for δ



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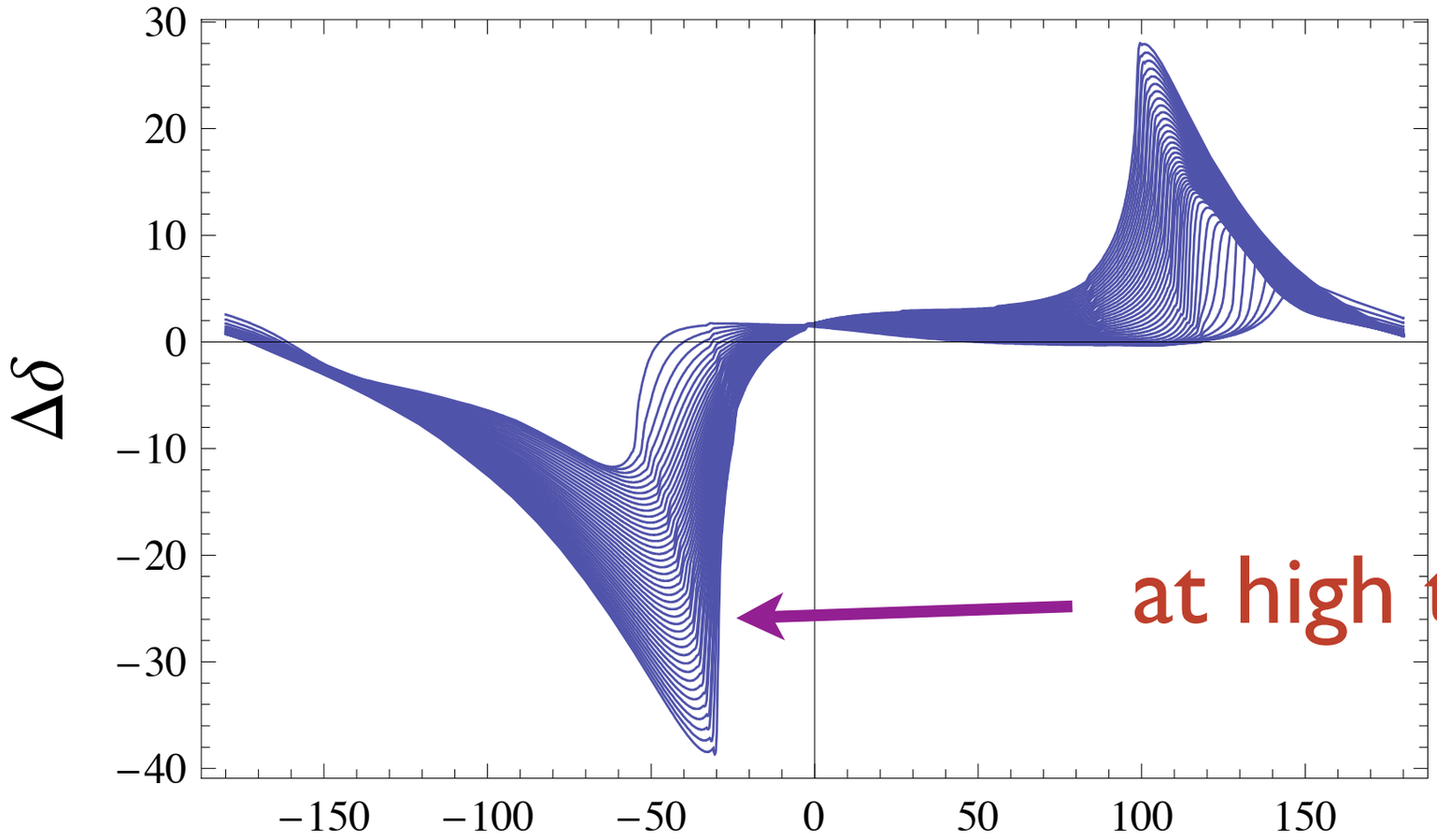

at high true θ_{13}

True $\theta_{13} \in [1°,5°]$

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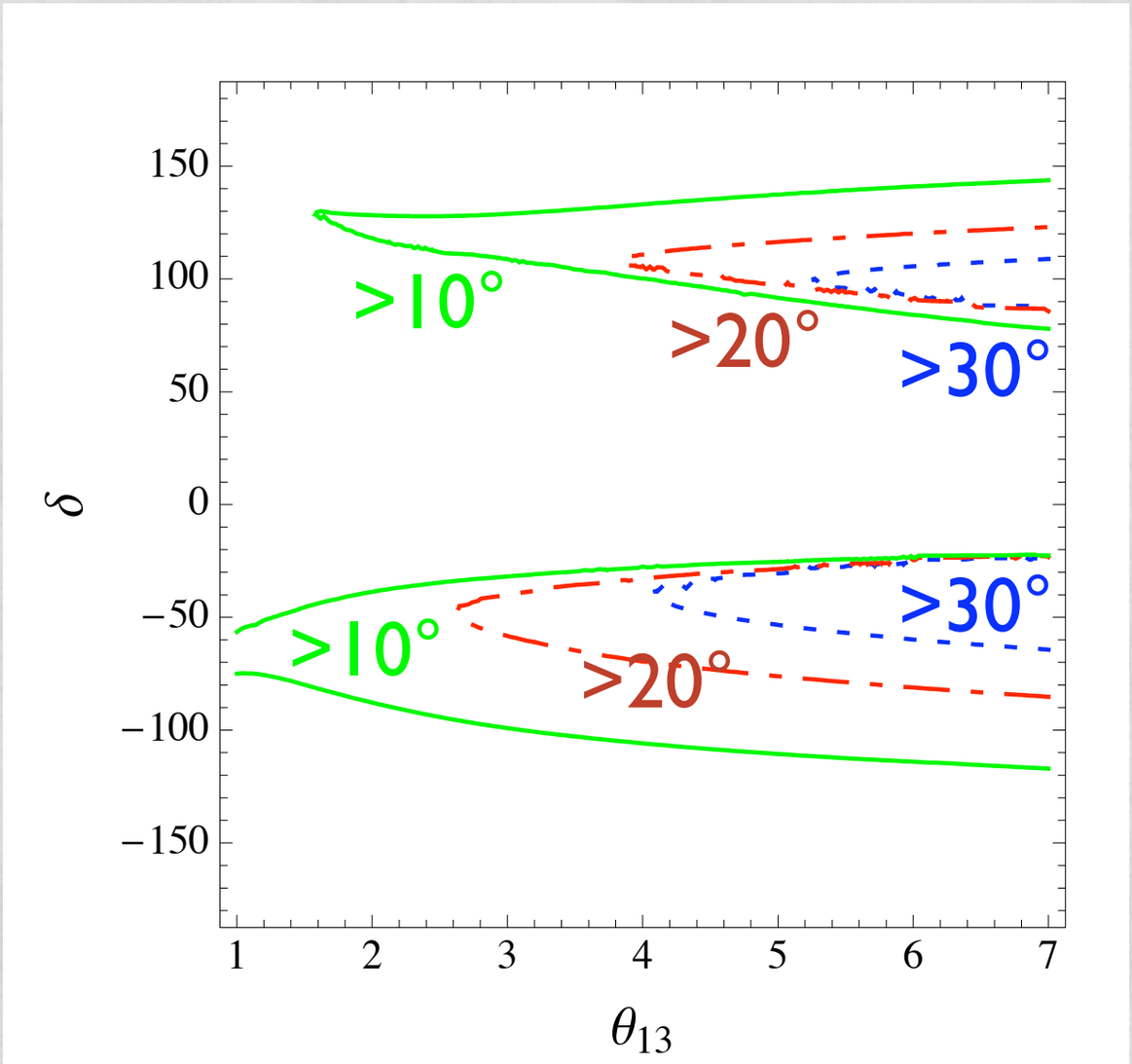
ABSOLUTE ERROR IN δ



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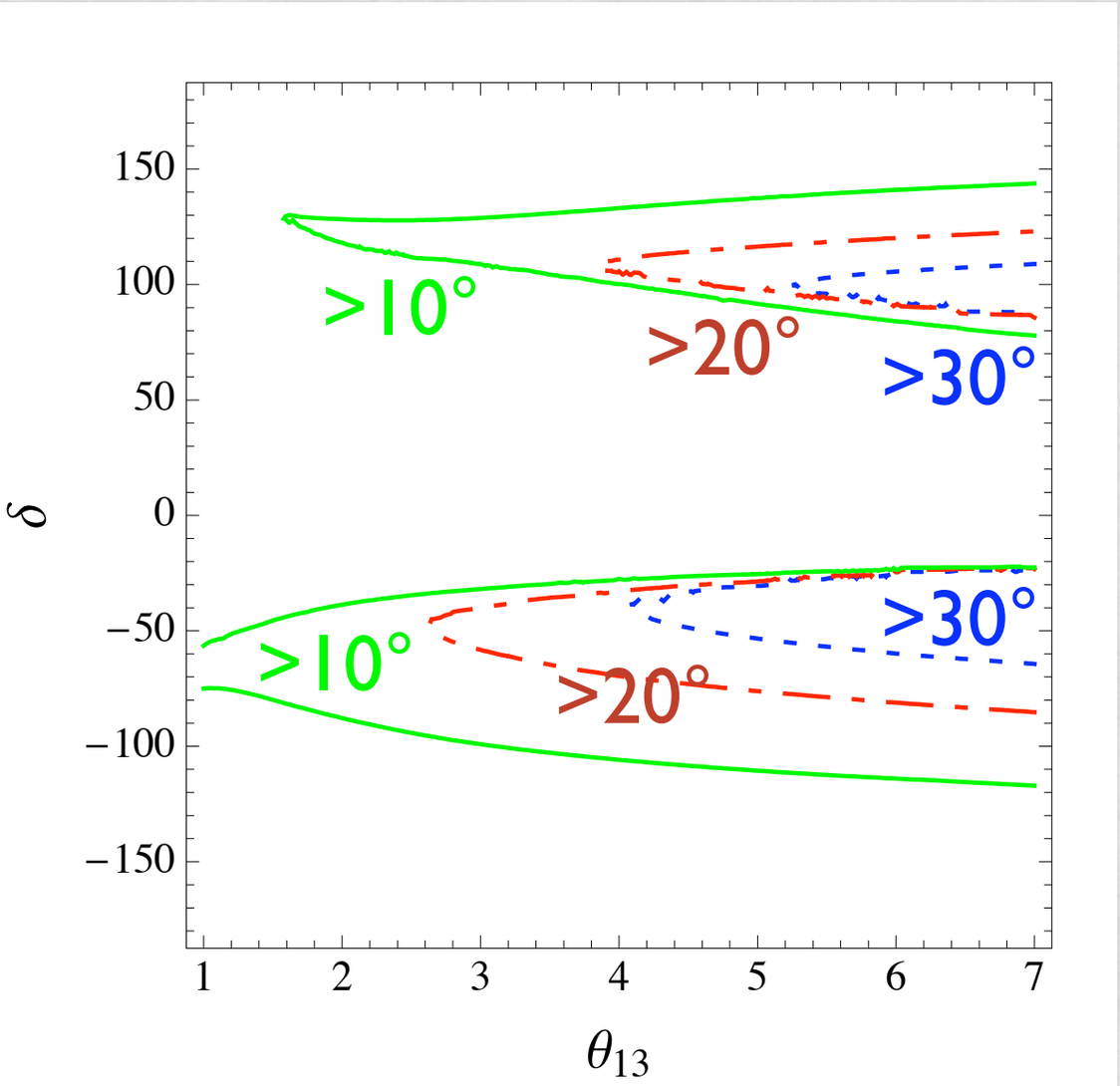

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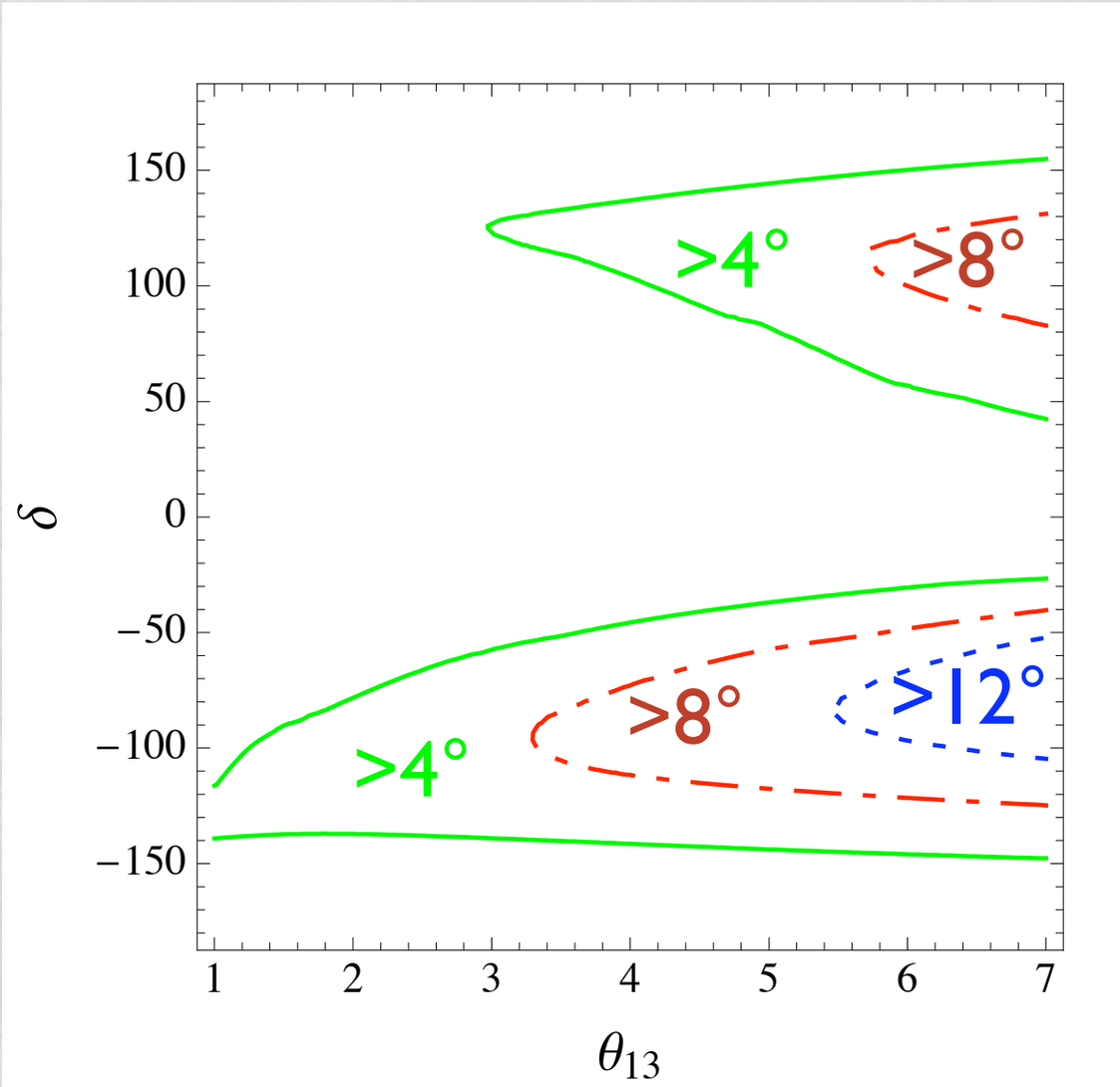
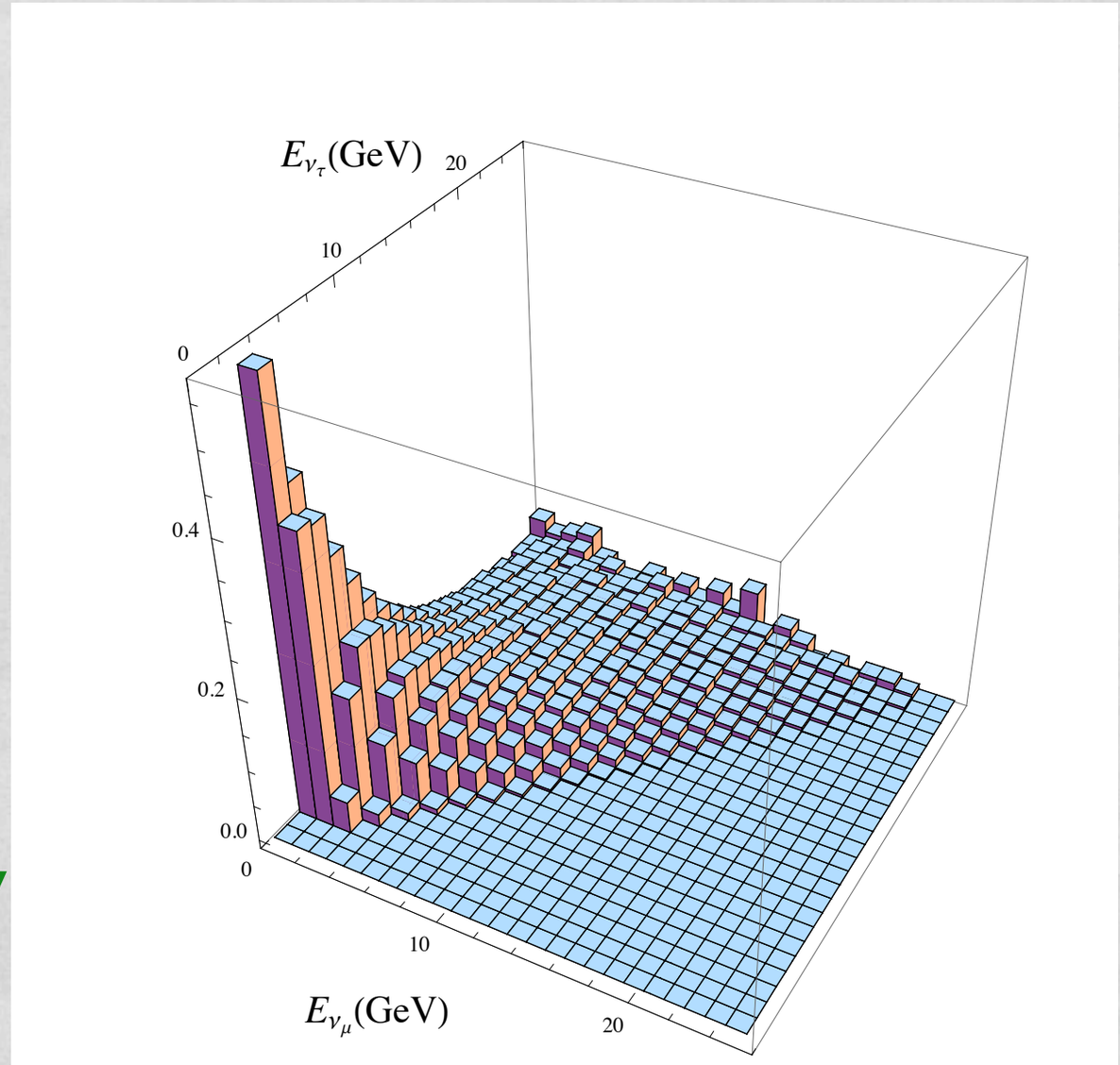


L = 4000 + 7500 Km

THE MIGRATION MATRIX M_{IJ}

- 10^6 ν_τ per energy bin
- Cross-section and differential decay width $\tau \rightarrow \mu\ \nu_\mu\ \nu_\tau$ with GENIE

Andreopoulos et al, arXiv:0905.2517



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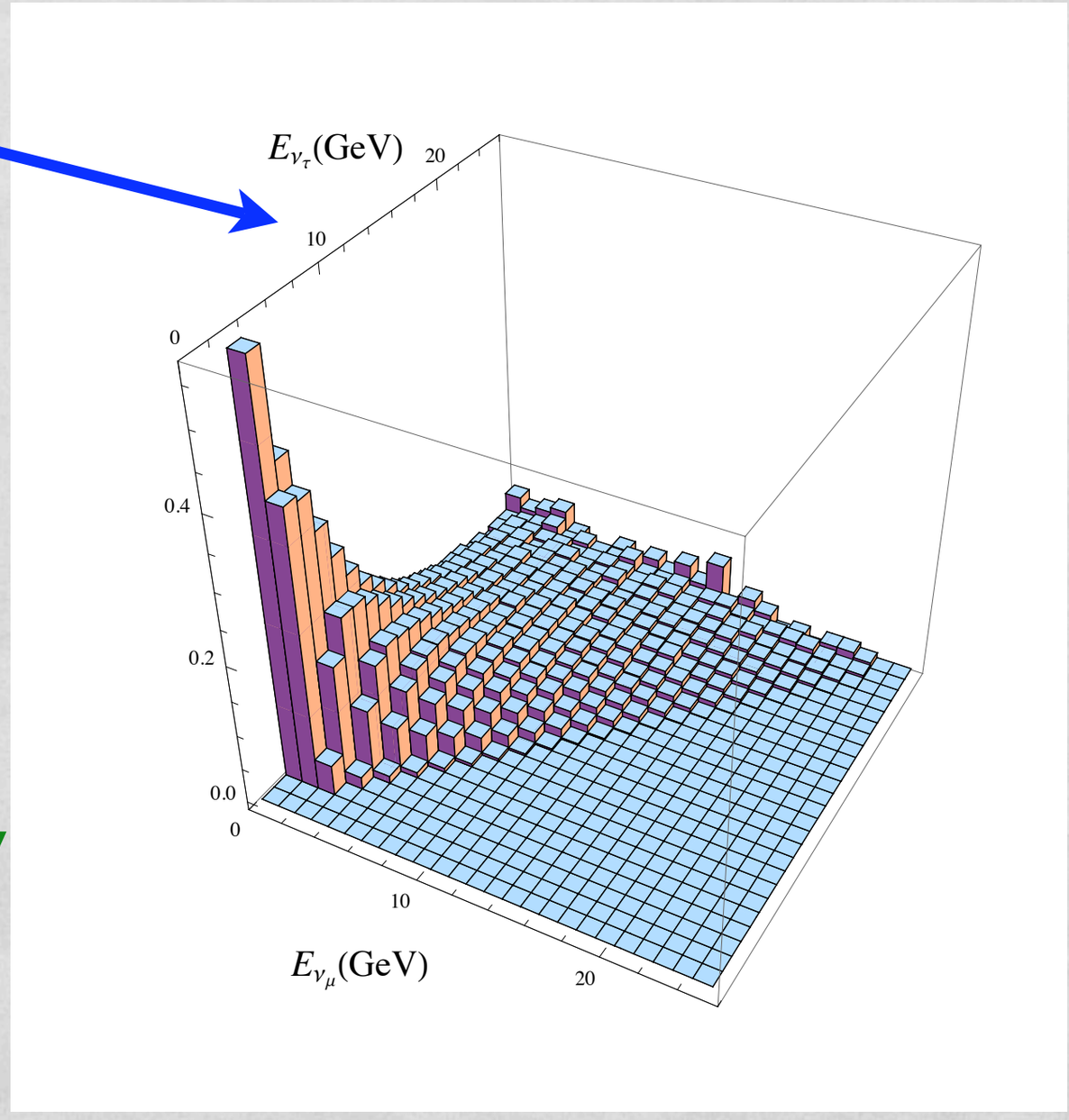

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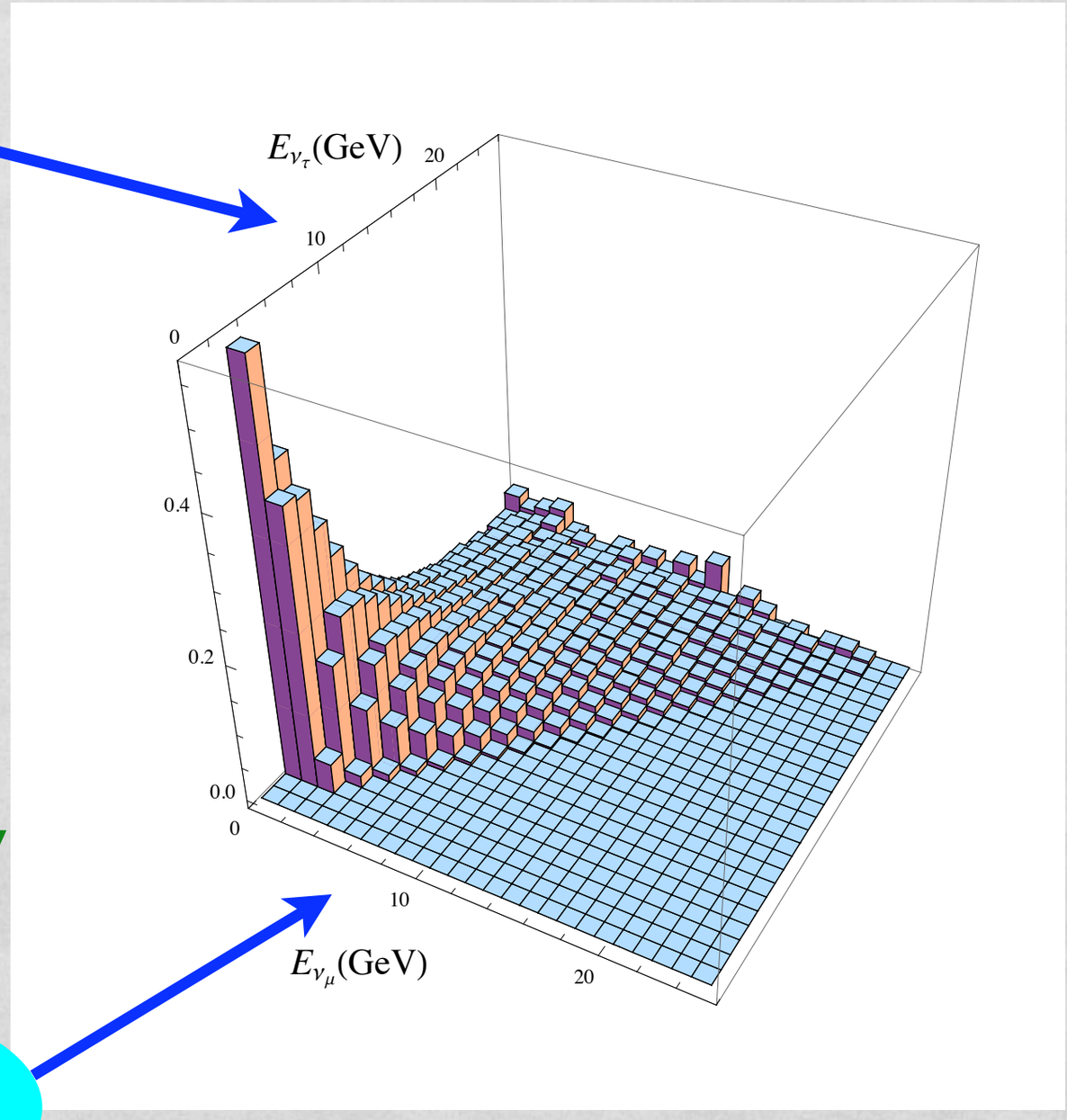

Fake E $\nu\mu$

THE COMPLETE SIGNAL

Once we have computed the migration matrix M_{ij}, we can compute theoretically the complete signal:

$$N^i_{obs} = N^i_{\mu} + \Sigma_j \, M_{ij} \, N^j_{\tau \to \mu}$$

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Migration Matrix

Silver muons

RIGHT TREATMENT

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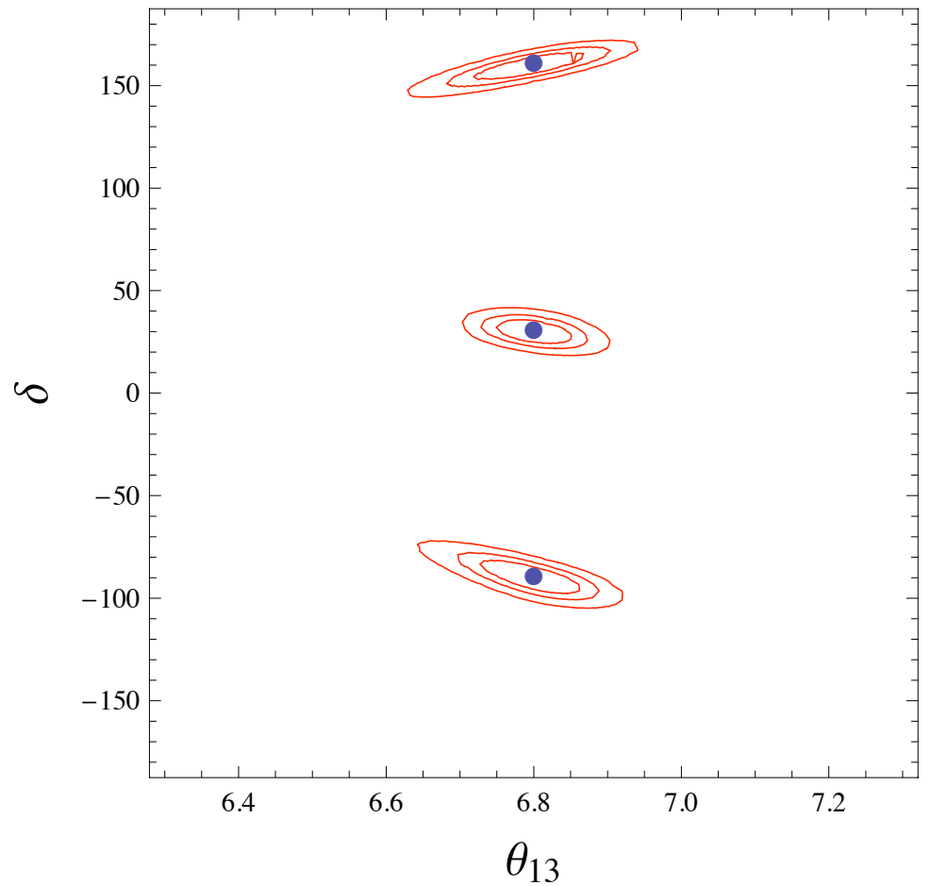

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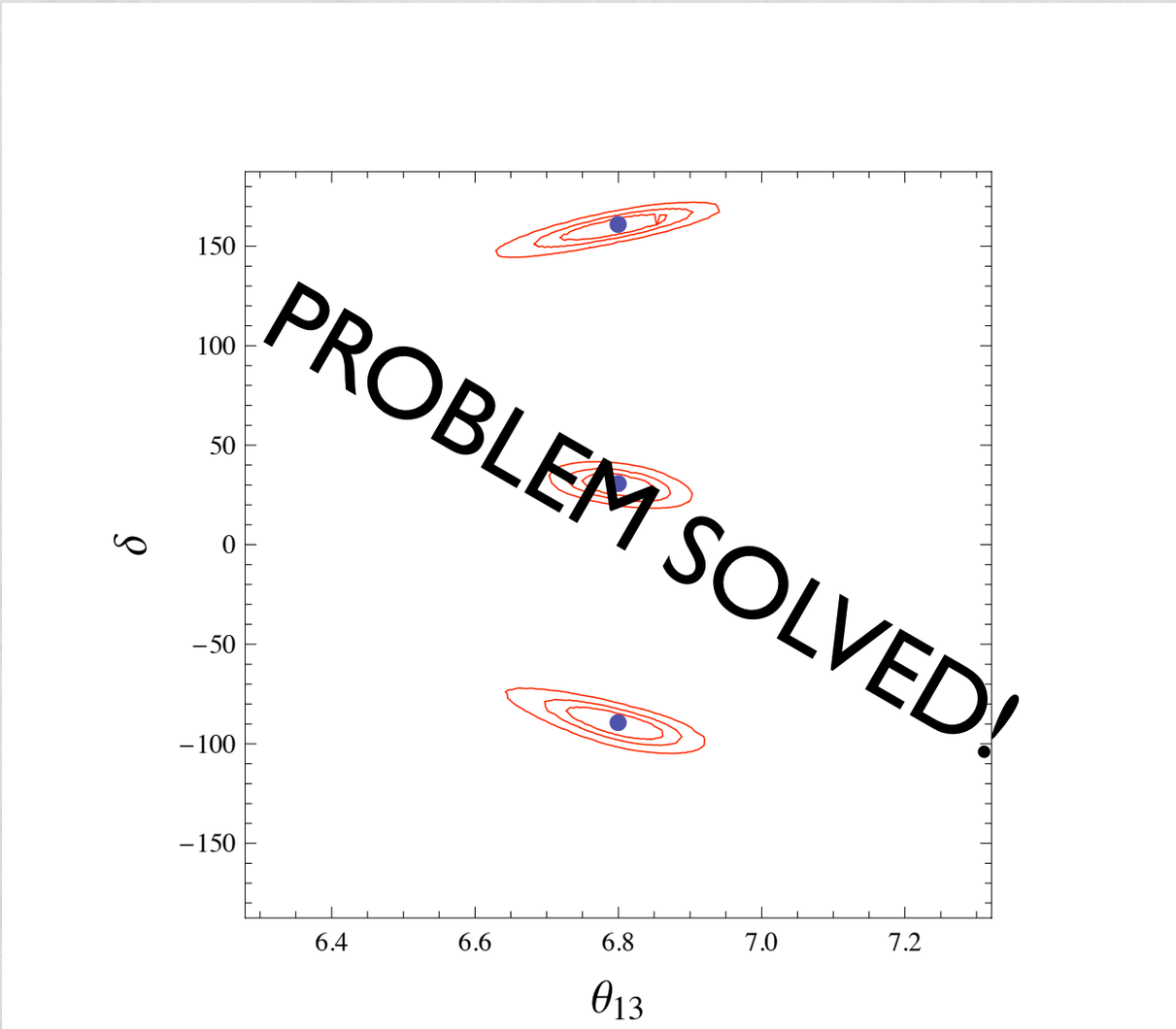

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CONCLUSIONS, I

- Wrong-sign muons from wrong-sign taus represent an unavoidable component of the signal at MIND

- Using the final muon energy: larger backgrounds

- Using the reconstructed neutrino energy, but not including this component, gives either

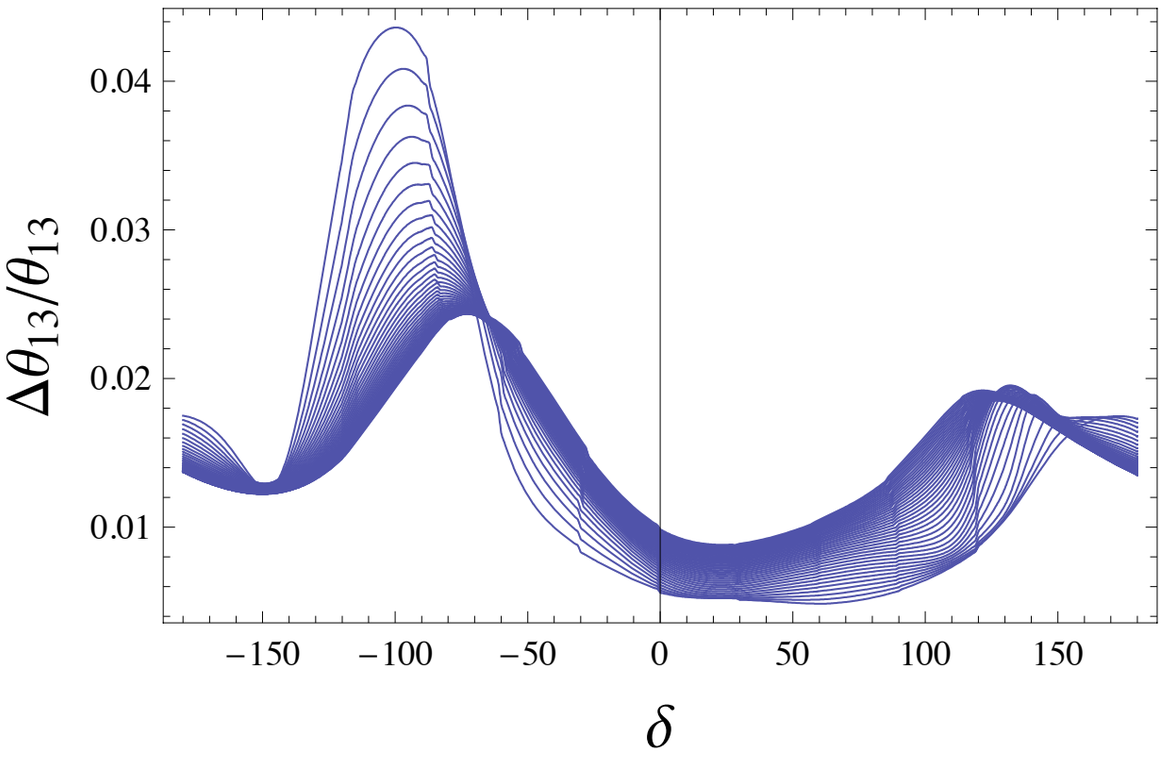
  - an awful fit (for $\theta_{13} > 5°$)

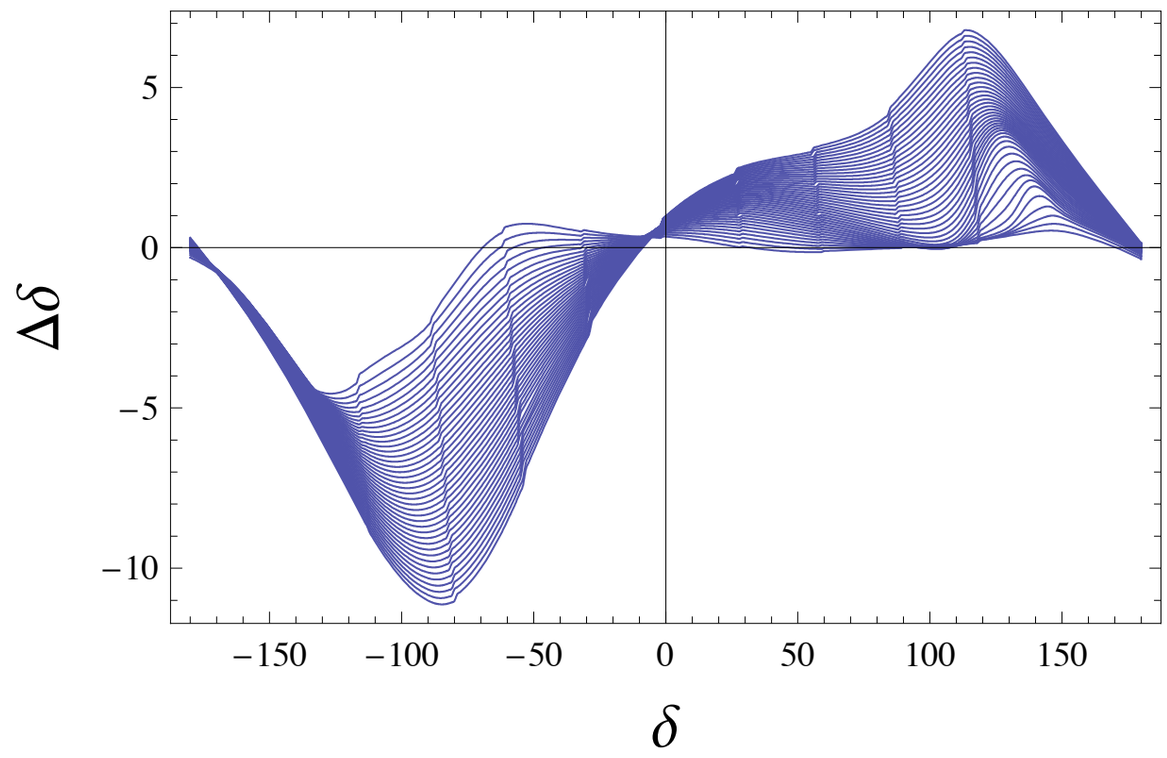
  - a wrong measurement of θ_{13} and δ (for $\theta_{13} \in [1°, 5°]$)

CONCLUSIONS,2

- We have statistically computed the migration matrix that assigns muon-from-tau events corresponding to a given $E_{\nu\tau}$ to bins in fake $E_{\nu\mu}$
- When the theoretical distribution of expected events take into account this component, the problem is solved
- We must include M_{ij} in Globes

OTHER PLOTS, I





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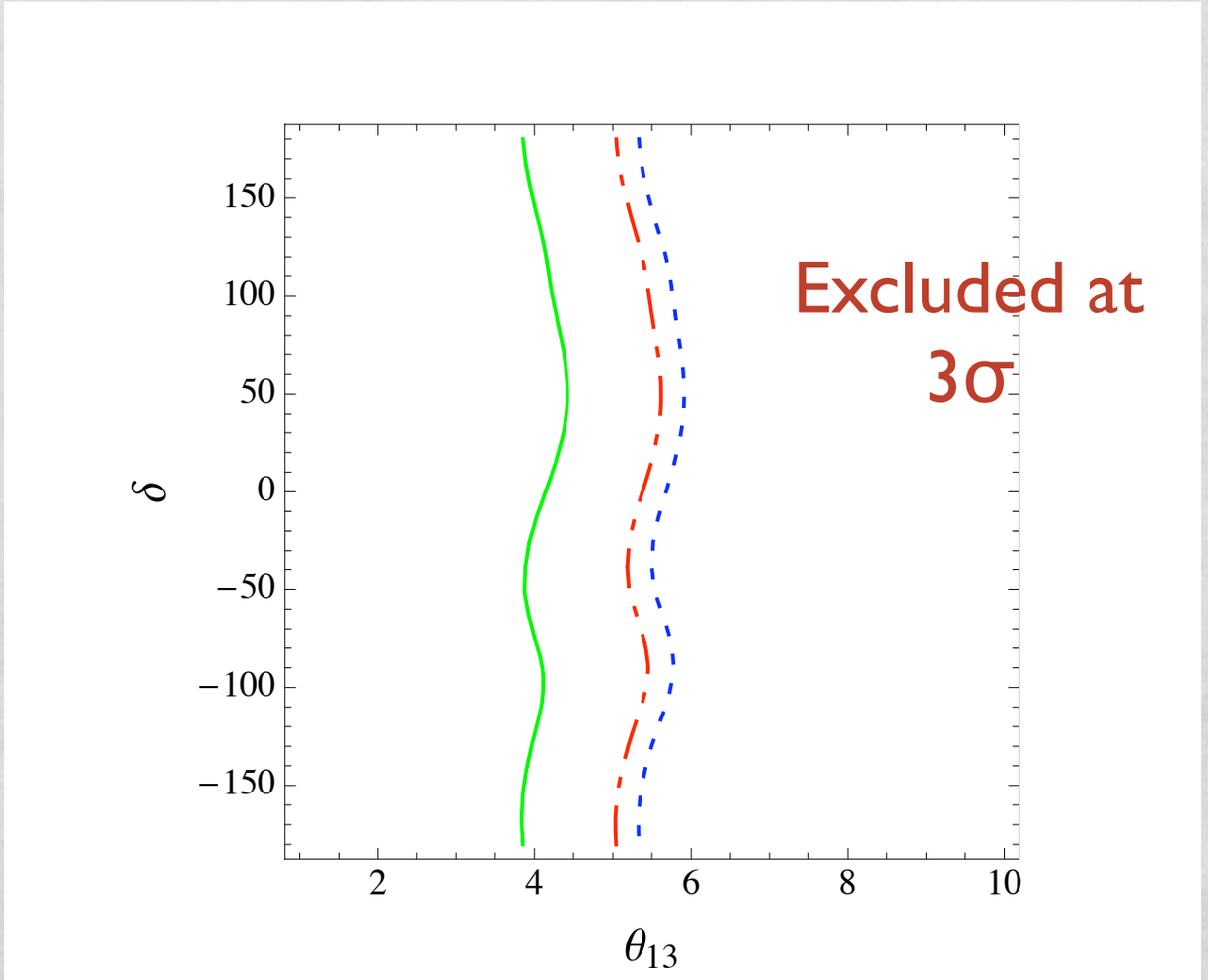

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