Physics potential of long baseline neutrino oscillation experiments

Joachim Kopp

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LAUNCH Workshop, Heidelberg, 23 March 2007

Outline

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On the way to physics beyond the Standard Model

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Understanding three-flavour neutrino oscillation parameters is crucial

Three-flavor oscillation probabilities

Expansion of “Golden Channel” probability in $\alpha = \frac{\Delta m_{21}^2}{\Delta m_{31}^2}$ and θ_{13}:

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Expansion of "Golden Channel" probability in $\alpha = \frac{\Delta m^2_{21}}{\Delta m^2_{31}}$ and θ_{13}:

$$P(\nu_e \to \nu_\mu) \simeq \sin^2 2\theta_{13} \sin^2 \theta_{23} \frac{\sin^2[(1-A)\Delta]}{(1-A)^2}$$
$$+ \alpha \sin 2\theta_{13} \sin \delta_{CP} \sin 2\theta_{12} \sin 2\theta_{23} \sin \Delta \frac{\sin A\Delta}{A} \frac{\sin[(1-A)\Delta]}{1-A}$$
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with $\Delta = \frac{\Delta m^2_{31} L}{4E}$ and $A = \frac{2\sqrt{2} G_F n_e E}{\Delta m^2_{31}}$.

Cervera et al. 2000, Akhmedov et al. 2004

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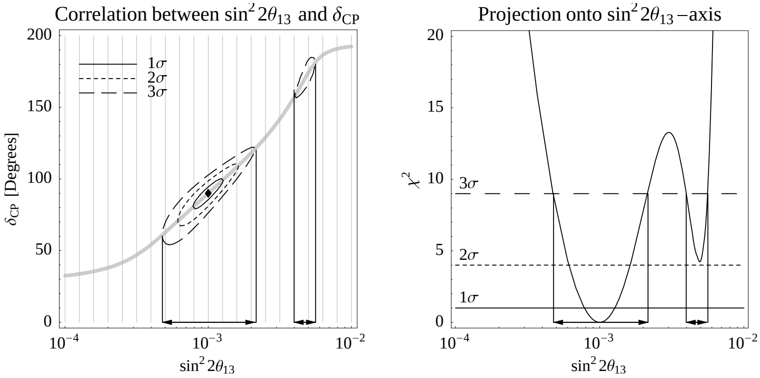

P. Huber, M. Lindner, W. Winter, hep-ph/0407333

Breaking correlations and degeneracies

→ Combine different oscillation channels

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$$P(\nu_e \to \nu_e) \simeq 1 - \sin^2 2\theta_{13} \frac{\sin^2[(1-A)\Delta]}{(1-A)^2} - \alpha^2 \sin^2 2\theta_{12} \frac{\sin^2 A\Delta}{A^2}$$

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- Exploit the “magic baseline”, for which $A\Delta = \pi$

Outline

1. Setting the stage: Three flavour neutrino oscillations
2. The actors and their performance: Long Baseline experiments
3. Conclusions

Simulating Long Baseline Experiments with GLoBES

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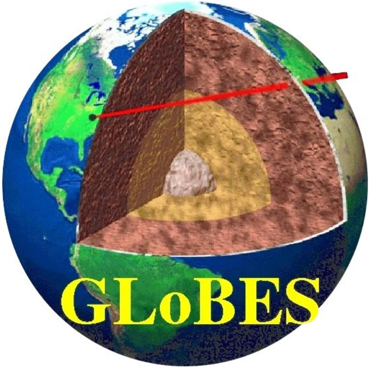

Huber, Lindner, Winter, hep-ph/0407333
Huber, JK, Lindner, Rolinec, Winter, hep-ph/0701187

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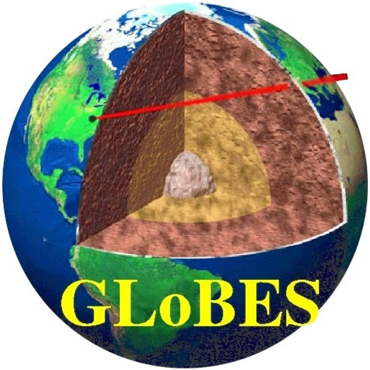

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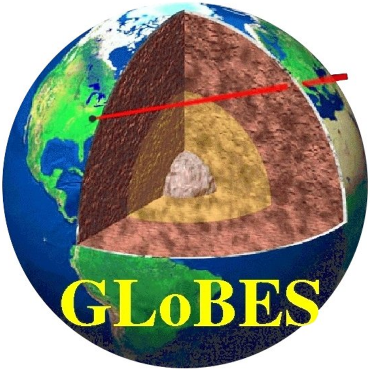

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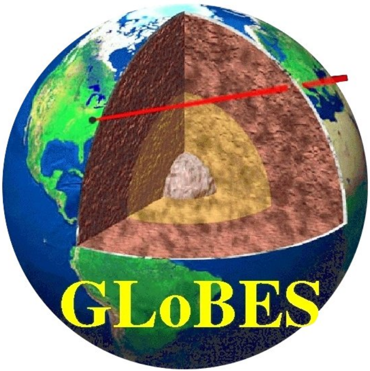

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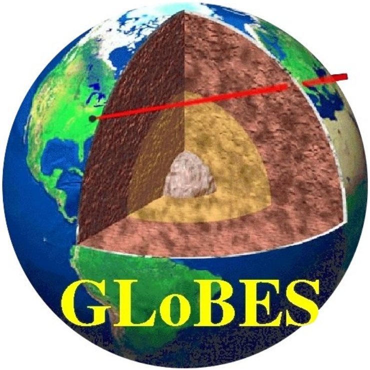

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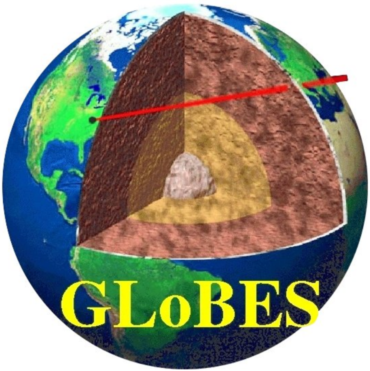

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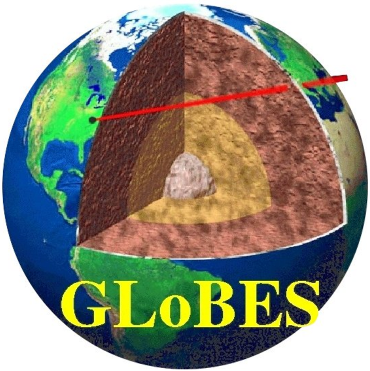

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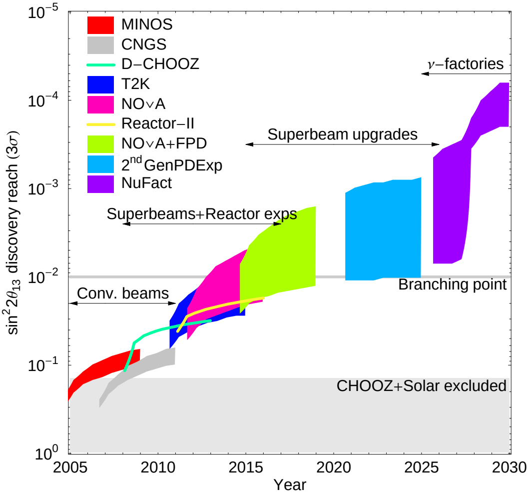
A possible evolution of the θ_{13} discovery reach



M.G. Albrow, . . . , W. Winter, et al., hep-ex/0509019

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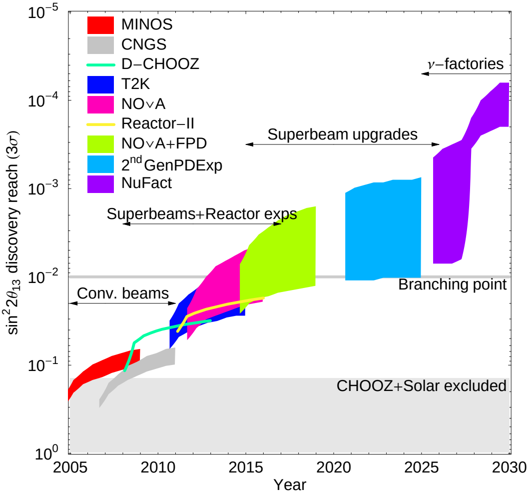

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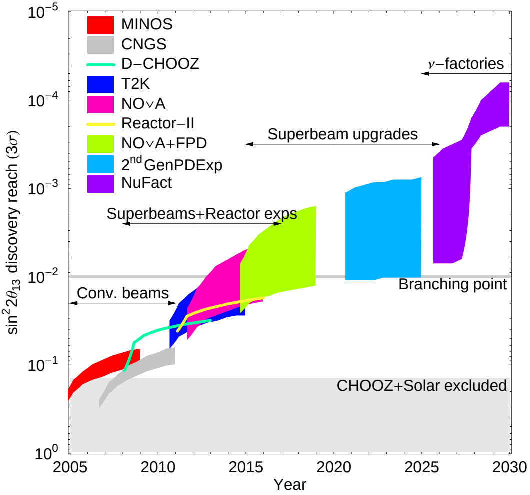

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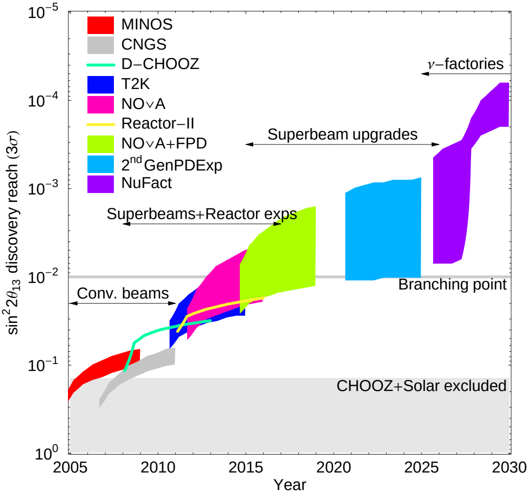

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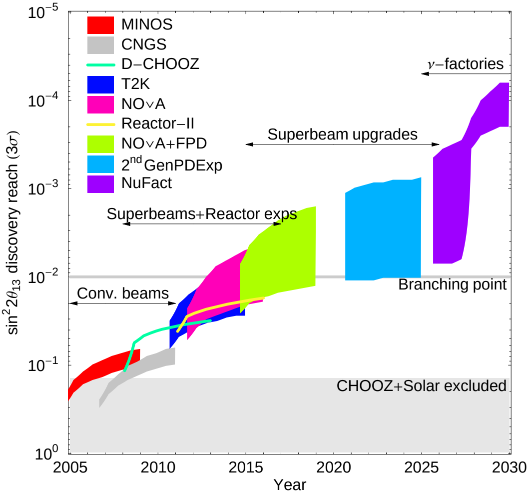

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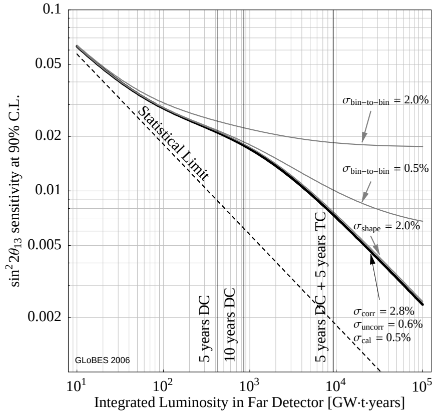
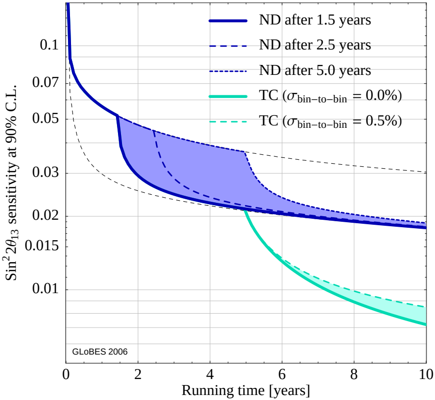
Towards the branching point: Reactor experiments





P. Huber, JK, M. Lindner, M. Rolinec, W. Winter, hep-ph/0601266

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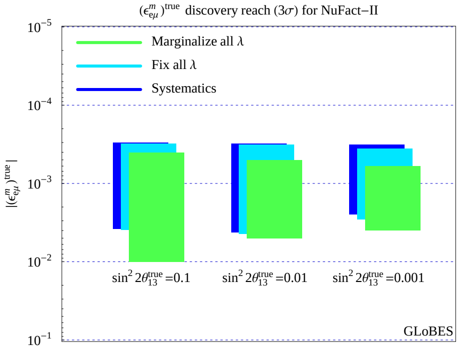

JK, M. Lindner, T. Ota, hep-ph/0702269

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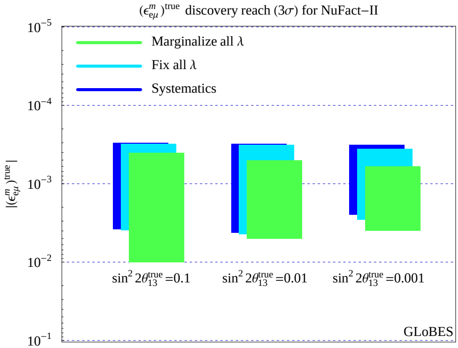

JK, M. Lindner, T. Ota, hep-ph/0702269
Talk by T. Ota this afternoon

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- Main challenge: Disentangle parameter correlations and degenerate solutions
- Branching point for choosing the ultimate technology in neutrino physics at $\sin^2 2\theta_{13} \sim 0.02$
- Neutrino oscillation experiments can also be used to directly detect physics beyond the standard model, such as non-standard interactions.