Fast Neutrino Oscillation in SB Reactor Antineutrino Experiments

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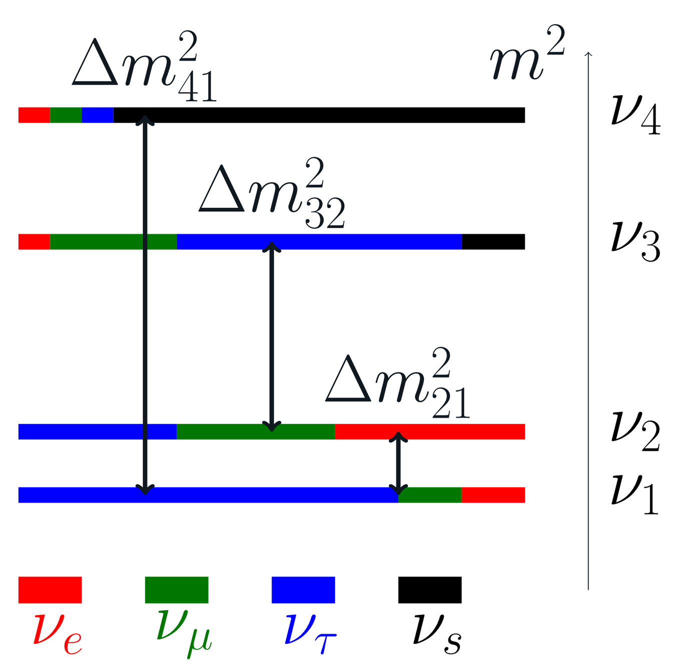
Introduction

Nuclear power plants usually used to determine properties of neutrinos. Nuclear reactor experiments could be divided by the oscillation base, distance between the nuclear core and the detector of $\overline{\nu}_e$. The short baseline (SB) experiments have oscillation base less then 100 m to be insensitive to neutrino oscillation effect.
In this work impact of the detector and reactor sizes is studied in a case of searching for sterile neutrinos parameters.

Neutrino oscillation

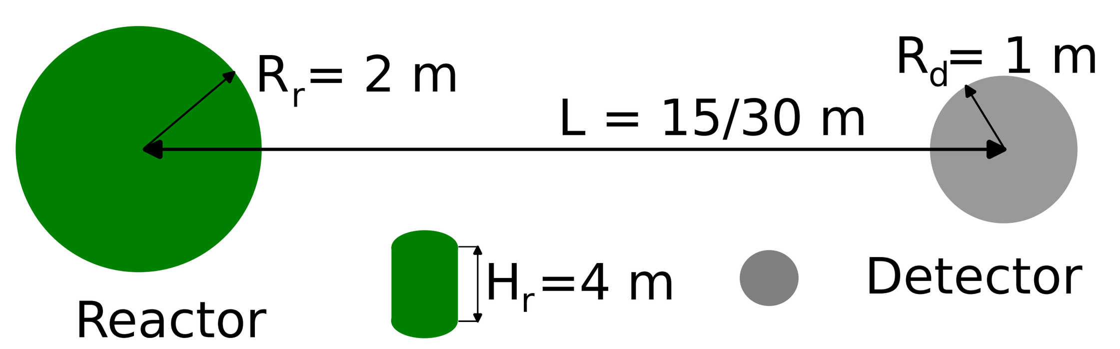
- Neutrino flavor eigenstates are a superposition of mass eigenstates.
- Neutrino mixing can be parameterized by the PMNS matrix.
- Commonly, neutrino oscillation is parameterized by three-neutrino mixing.



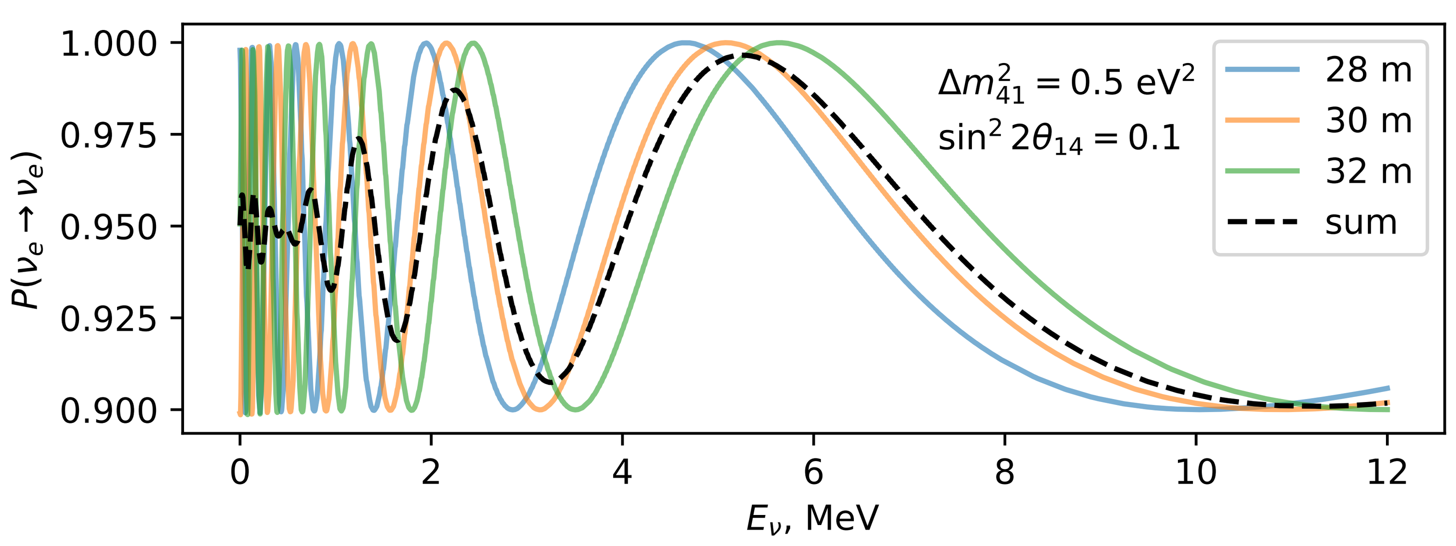
- An additional state (sterile) that does not interact through weak interaction but it could mix with active states.

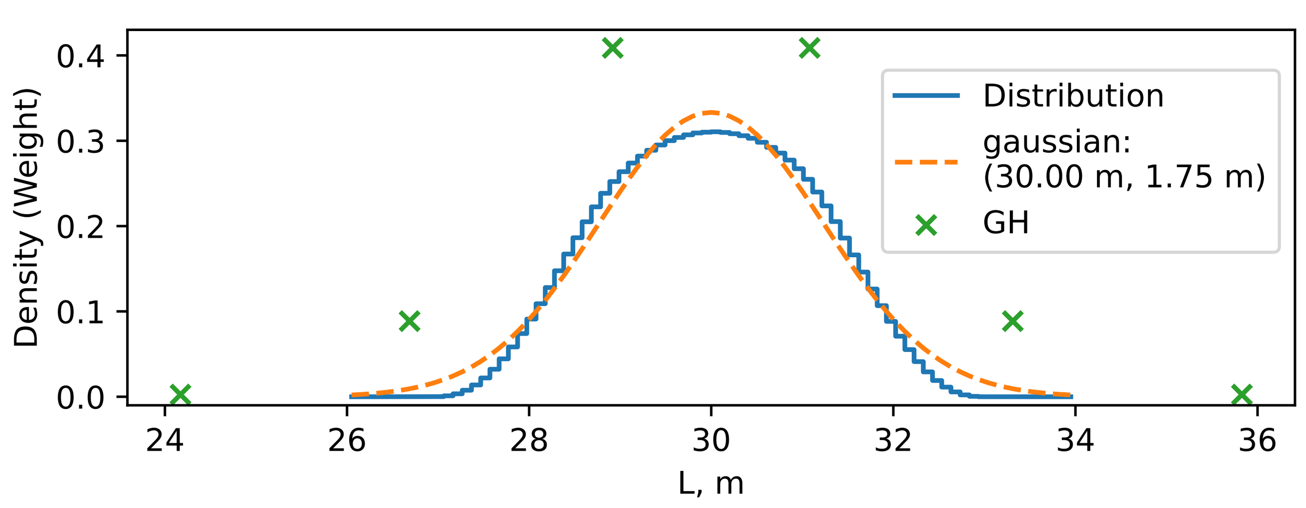
$$P(\overline{\nu}_\alpha \to \overline{\nu}_\alpha) = 1 - 4\sum_{k<j}^{N_\nu} |U_{\alpha j}|^2 |U_{\alpha k}|^2 \exp\left(-i\frac{\Delta m^2_{jk}}{4E}L\right)$$

Vertex Distribution



Usually, the reactor and detector considered to be point-based. However, sterile oscillation changes rapidly on small distance from reactor for the large values of Δm^2_{41}.
Gauss-Hermitian (GH) quadrature is used for the numerical averaging of fast oscillation. Two figures above demonstrate the distance distribution (distance passed by $\overline{\nu}_e$ between reactor and detector) and integration of it.





Model

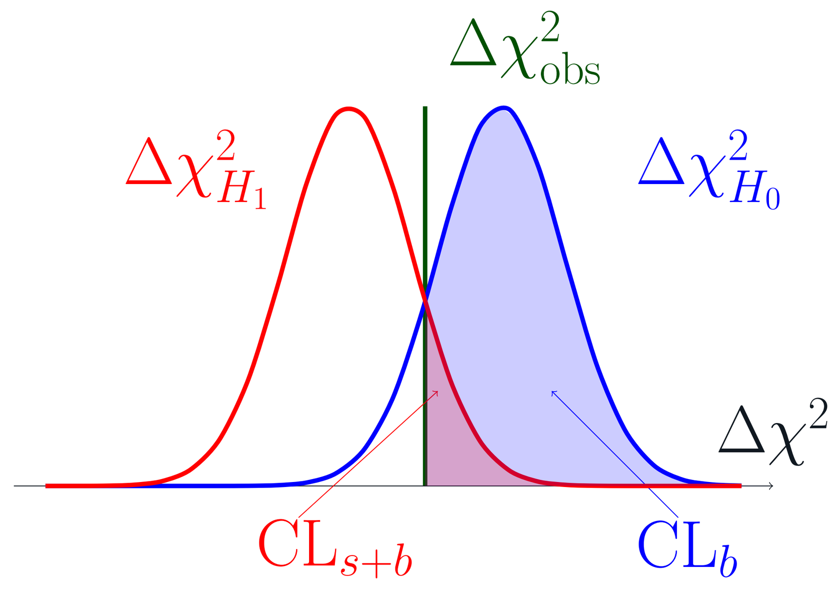
The following model was used in this study:

- The reactor has $H = 4$ m, $R = 2$ m, the detector is sphere which $R = 1$ m;
- Energy resolution $\sigma = 17\%$;
- Working time of the detector is 1 year;
- Nominal thermal power of reactor is 3 GW.

Gaussian CL_s

CL_s method [1] was used to produce sensitivity region:

- $H_0 : \sin^2 2\theta_{14} = 0$, 3ν mixing
- $H_1 : \sin^2 2\theta_{14} \neq 0$, 4ν mixing
- $\Delta\chi^2 = \chi^2_{H_1} - \chi^2_{H_0}$
- $CL_s = \frac{\mathrm{CL}_{s+b}}{\mathrm{CL}_b}$
- Exclusion rule: $\mathrm{CL}_s < \alpha$

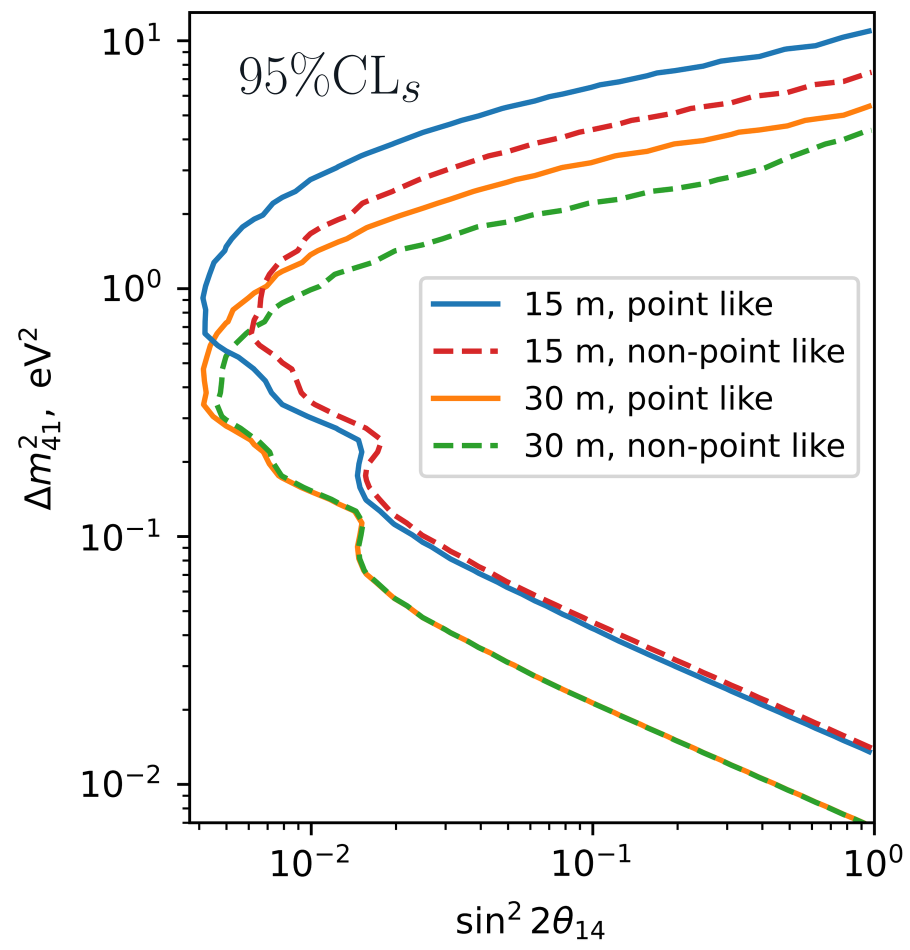


Could be speed up with Gaussian approximation [2].

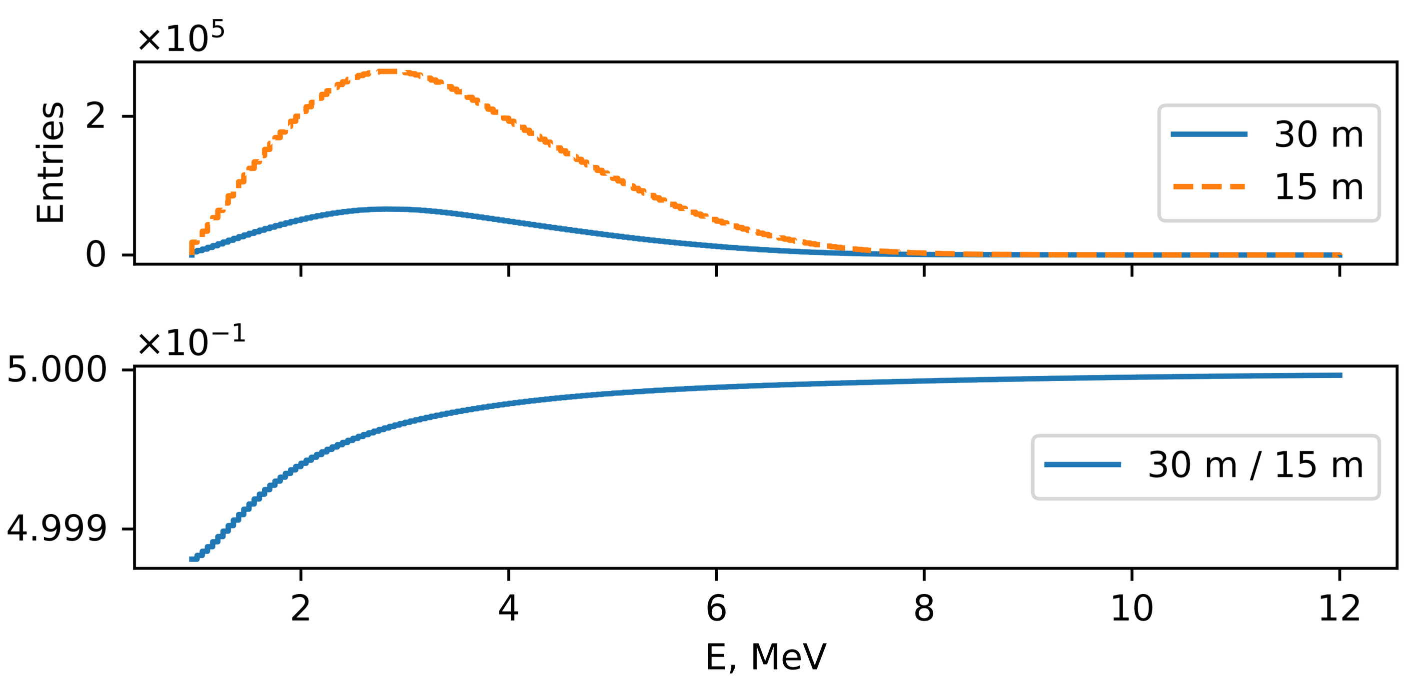
Results

Two oscillation bases were used: 15 m and 30 m.

- A closer detector to the reactor has a greater sensitivity to the large values of Δm^2_{41};
- Taking into account sizes of the reactor and the detector decreases sensitivity to the large Δm^2_{41}.



Observations for 15 m and 30 m and their ratio are demonstrated bellow (detector is non-point)



Acknowledgements

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References

[1] *J. Phys. G* **28** (2002) 2693-2704.
[2] *NIM-A* **827** (2016) 63-78.