LIMITS ON STERILE NEUTRINO MIXING FROM DAYA BAY EXPERIMENT

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Introduction

The LSND experiment [1] has detected a 3.8σ excess of the expected number of $\overline{\nu}_e$ events in a $\overline{\nu}_\mu$ beam. Similar effects were observed by the MiniBooNE [2]: a 4.7σ excess in a total number of ν_e and $\overline{\nu}_e$ events.

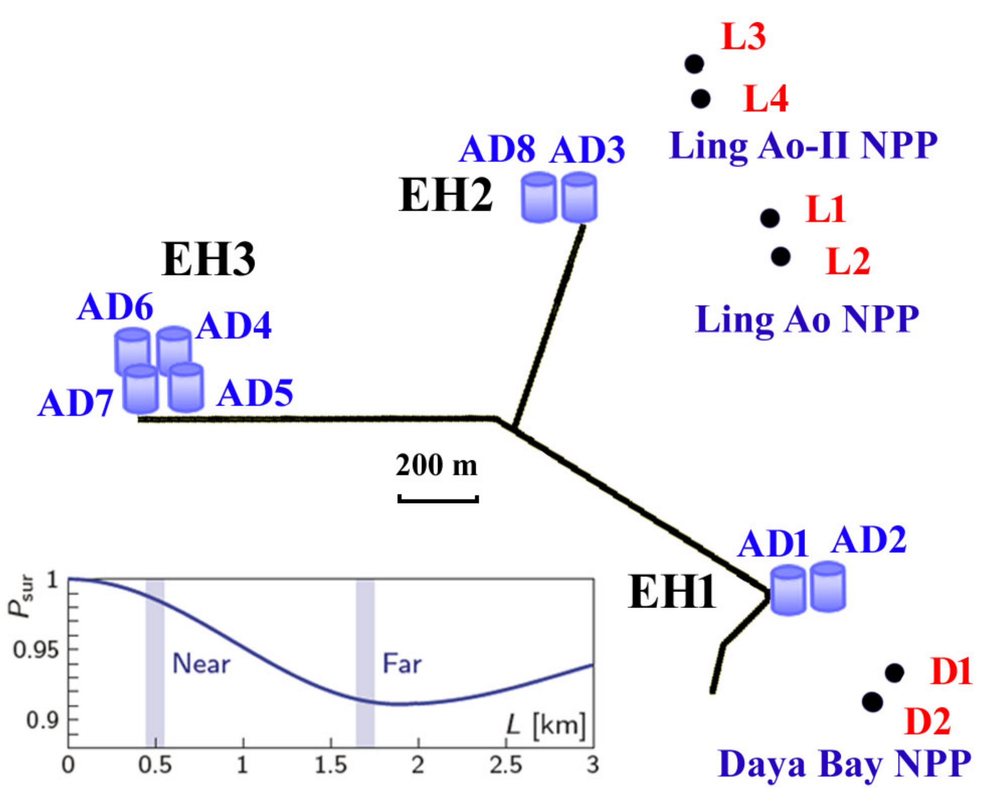
These excess could be explained with one or more sterile neutrinos, which interact only gravitationally.

The Daya Bay Experiment

A reactor antineutrino experiment [3]

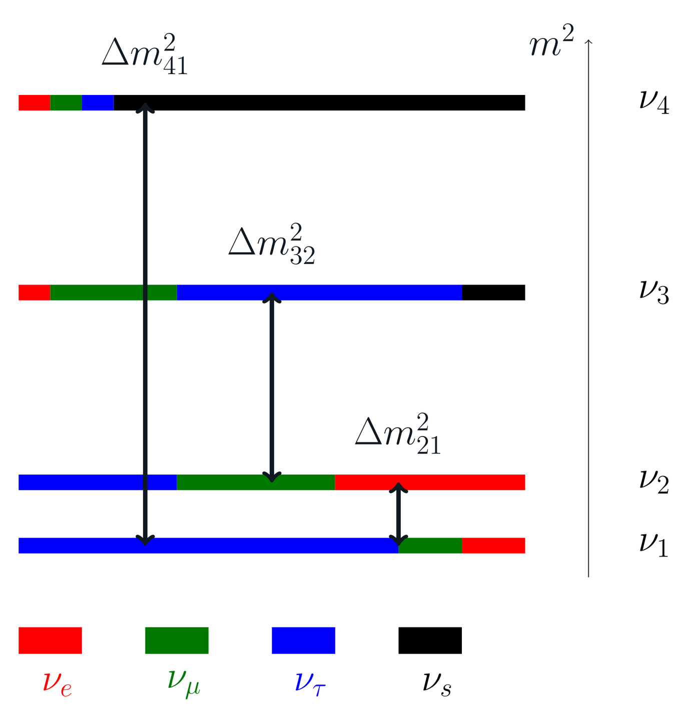
- Measures $\overline{\nu}_e$ disappearance from six reactors at multiple baselines from ~ 0.4 km (near halls) to ~ 1.7 km (far hall) baselines.
- Large statistics (more than $5 \cdot 10^6$ events).

	6AD	8AD	7AD
AD1	104.0	729.8	0
AD2	105.7	740.9	668.7
AD3	96.7	699.8	596.0
AD8	0	691.1	588.0
AD4	14.2	102.5	88.2
AD5	14.3	101.6	88.4
AD6	14.1	101.6	87.6
AD7	0	101.7	87.5



Neutrino oscillation

- Neutrino flavor eigenstates are superposition of mass eigenstates.
- Neutrino mixing can be parameterized by the Pontecorvo-Maki-Nakagawa-Sakata 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.
- A sterile state is one of the possible explanation of the reactor anomaly

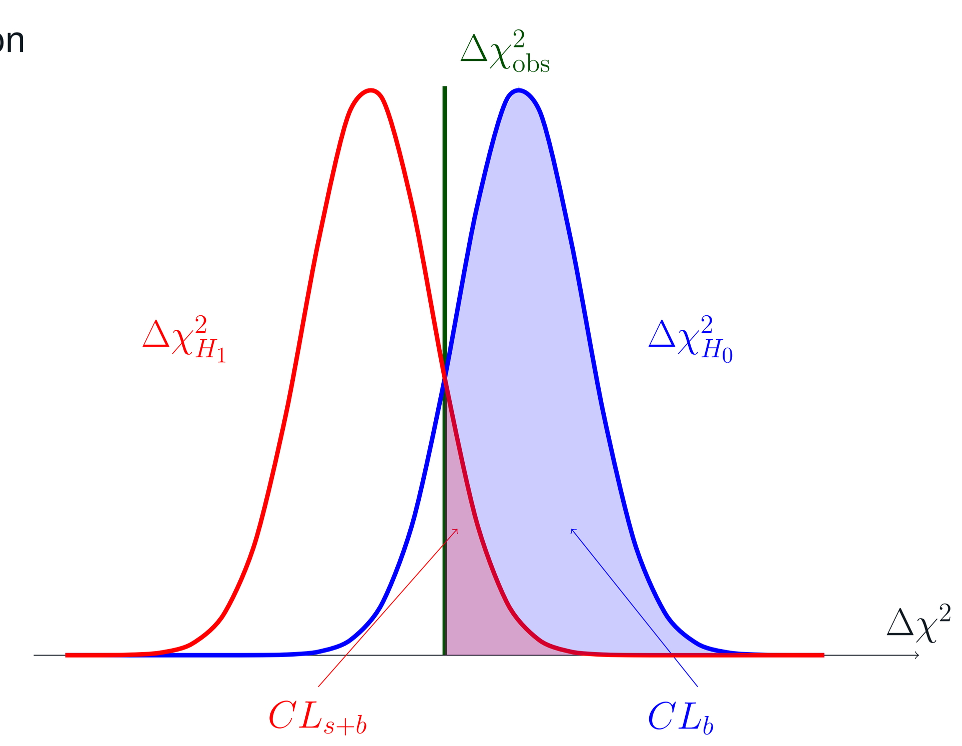


Analysis Method

CL_s method [4] was used to produce exclusion region:

- $H_0 : \sin^2 2\theta_{14} = 0$, three neutrino mixing
- $H_1 : \sin^2 2\theta_{14} \neq 0$, four neutrino mixing
- $\Delta\chi^2 = \chi^2_{H_1} - \chi^2_{H_0}$
- $CL_s = \frac{CL_{s+b}}{CL_b}$
- Exclusion rule: $CL_s < \alpha$
- $\Delta\chi^2$ has Gaussian approximation [5]

$$CL_s = \frac{1-p_1}{1-p_0} = \frac{1 - \left(\frac{\Delta\bar{\chi}^2_{H_1} - \Delta\chi^2(\mathbf{x})}{\sqrt{8\Delta\bar{\chi}^2_{H_1}}}\right)}{1 - \left(\frac{\Delta\bar{\chi}^2_{H_0} - \Delta\chi^2(\mathbf{x})}{\sqrt{8\Delta\bar{\chi}^2_{H_0}}}\right)}$$

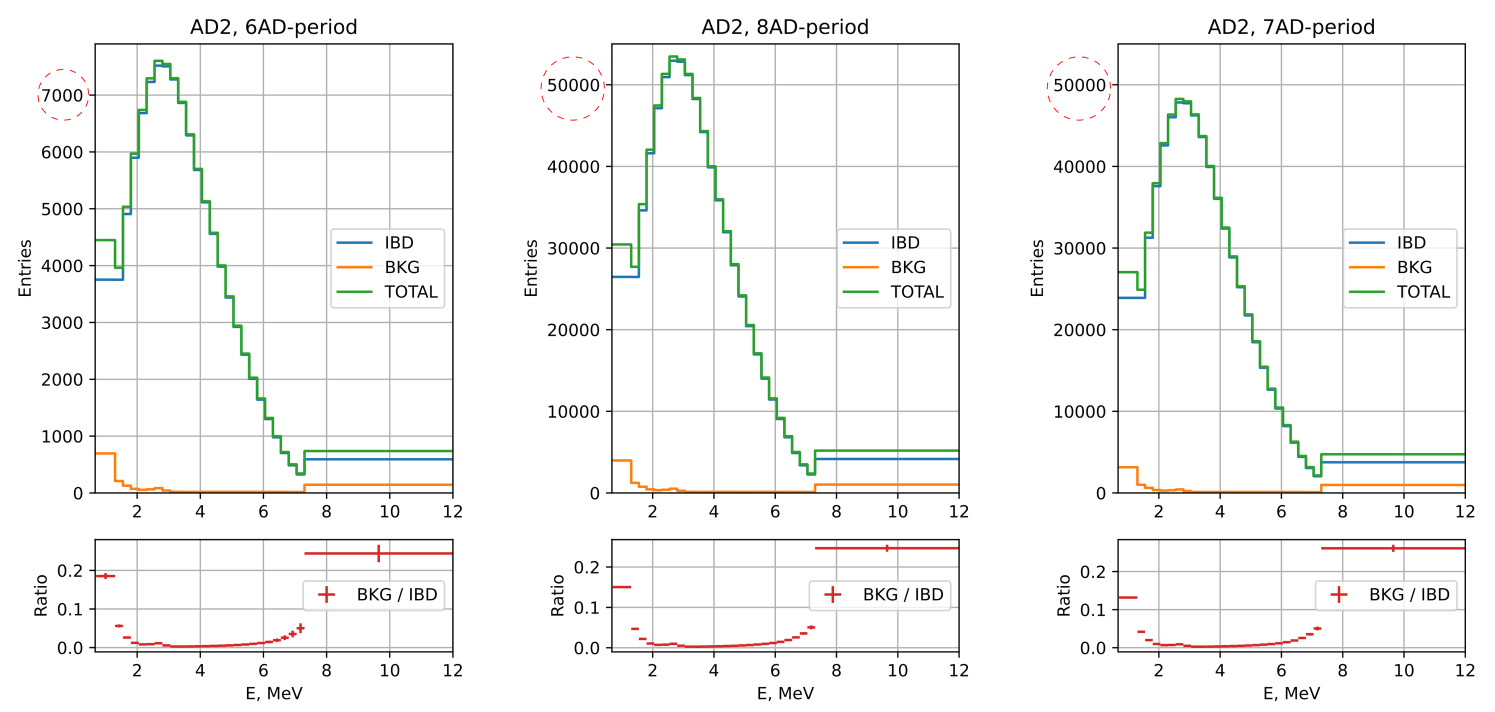


Daya Bay systematic and observation

All systematic effects and uncertainties of the Daya Bay experiment can be devided into three groups:

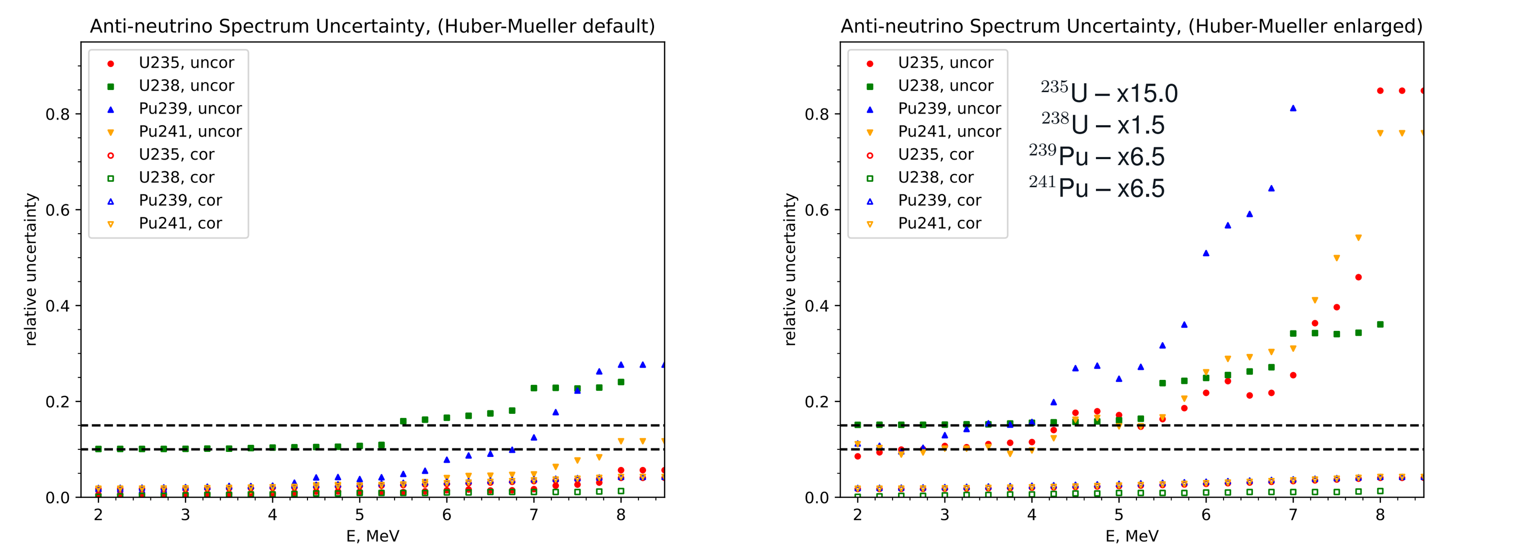
- Background: $\omega^{\rm Li}$, $N^{\rm bkg}({\rm Li/He})$, $N^{\rm bkg}({\rm AmC})$, $N^{\rm bkg}(C(\alpha,n))$, N^{acc}, $N^{\rm bkg}(\text{fast } n)$, $S(\text{fast } n)$
- Reactor: $E^{fission}$, W_{th}, fission fractions (f), off-equilibrium, SNF (spent nuclear fuel), spectrum uncertainties (Huber-Mueller model)
- Energy: σ_E, IAV (inner acryl vassel), LSNL (liquid scinitillator non-linearity), E_{scale}, ϵ

The examples of signal and background events for the detector AD2 in three different periods you may find below. Pay attention to the y-axes scale.

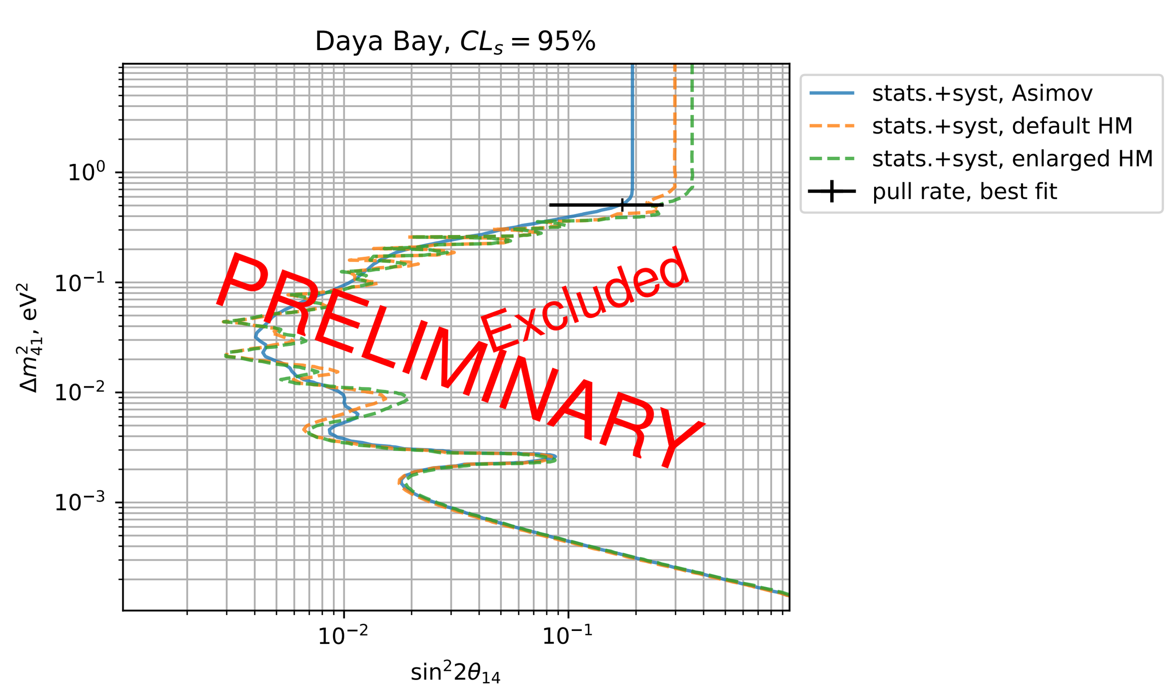


Nominal and enlarged Huber-Mueller uncertainties

- The Huber-Mueller model of $\overline{\nu}_e$ energy spectrum [6], [7] is used to produce results.
- Spectral uncertainties are enlarged to be more independent of $\overline{\nu}_e$ model



Daya Bay sensitivity and exclusion



- Daya Bay exclusion region based on 3158 days of data taken.
- No evidence of light sterile neutrino is observed.
- Stringent limits are obtained on the $\sin^2 2\theta_{14}$ in the region

$$10^{-4}\ \text{eV}^2 < \Delta m^2_{41} < 0.3\ \text{eV}^2.$$

Conclusion

- No evidence of sterile neutrino is found.
- Analysis based on full dataset was produced.
- Influence of spectral uncertainties has been verified.
- Best fit value is in the insensitive region.

References

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