

Experimental study of decoherence effects in neutrino oscillations in Daya Bay

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- ▶ Treatment of flavor states as a superposition of mass states with different momenta, **wave packets**, resolves inconsistencies of plane wave approach and leads to **new effects** (Gaussian form factor for wave packet is assumed):
 - ▶ **Loss of coherence** due to different group velocities of wave packets and **spatial localization of production/detection regions**.
 - ▶ **Partial restoration of coherence** due to wave packet spatial broadening.

$$P_{\alpha\beta}(L) = \sum_{k,j=1}^3 \frac{V_{k\beta} V_{\alpha k}^* V_{j\alpha} V_{\beta j}^*}{\sqrt{4 + (L/L_{kj}^d)^2}} \exp \left[-\frac{(L/L_{kj}^{\text{coh}})^2}{1 + (L/L_{kj}^d)^2} - D_{kj}^2 \right] e^{-i(\varphi_{kj} + \varphi_{kj}^d)}$$

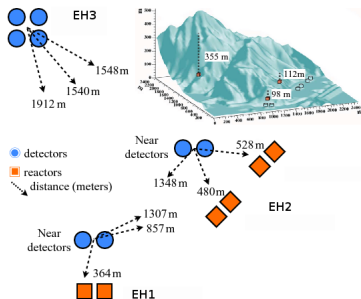
- ▶ Multiple reactor-detector baselines allow to constrain relative momentum dispersion of wave packets σ_{rel} in Daya Bay.

- ▶ 8 detectors and 6 reactors.
- ▶ $\bar{\nu}_e$ detection through inverse beta-decay
 $\bar{\nu}_e + p \rightarrow e^+ + n$
- ▶ Use coincidence of prompt and delayed signals in time to select $\bar{\nu}_e$ events.

- ▶ Rich event sample $\bar{\nu}_e \sim 10^6$:

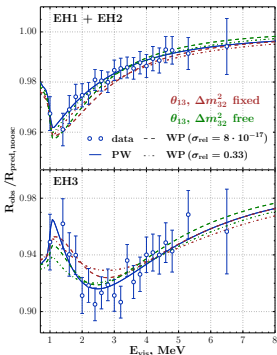
	EH1	EH2	EH3
Events	613813	477144	150255

- ▶ Energy resolution $\sim 8\%$ at 1 MeV.



- Statistical analysis based on **fixed-level $\Delta\chi^2$** (systematics propagated with covariance matrix) and **Feldman-Cousins** approach with free σ_{rel} , $\sin^2 2\theta_{13}$, Δm_{32}^2 , flux normalization N shows 3 distinct regions:

- $\sigma_{\text{rel}} < 10^{-16}$ – oscillations are suppressed by D^2 (spatial size of reactor cores).
- $10^{-16} < \sigma_{\text{rel}} < 0.1$ – no impact on oscillations.
- $\sigma_{\text{rel}} > 0.1$ – loss of coherence due to spatial separation L^{coh} and dispersion L^{d} .



- Allowed region for σ_{rel} at 95% C.L.:

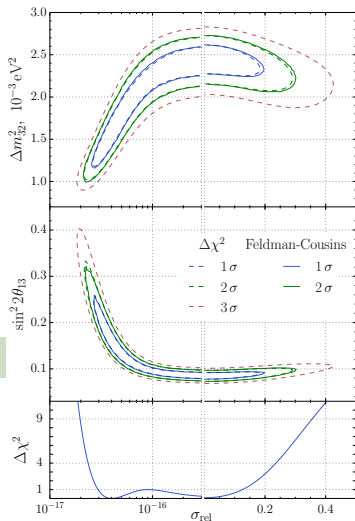
$$2.38 \cdot 10^{-17} < \sigma_{\text{rel}} < 0.232$$

- First experimental limits on spatial size of wave packet are:

$$10^{-11} \text{ cm} \lesssim \sigma_x \lesssim 2 \text{ m}$$

- Upper limit on σ_{rel} is:

$$\sigma_{\text{rel}} < 0.2 \text{ at } 95\% \text{ C.L.}$$



- The **insignificance** of decoherence effect ensures **unbiased measurement** of oscillation parameters in Daya Bay.