First measurements of muon anti-neutrino disappearance by the T2K experiment

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Introduction

- First measurements of \overline{v}_{μ} disappearance in the T2K experiment
- search for new physics by comparing

 v_{μ} disappearance and v_{μ} disappearance

- treat (θ_{23} , Δm_{23}^2) and ($\overline{\theta}_{23}$, $\Delta \overline{m}_{23}^2$) as independent parameters
- ✓ neutrino oscillation probabilities :

 $P(v_{\mu} \rightarrow v_{\mu}) \approx 1 - \sin^{2}(2\theta_{23}) \sin^{2}(\Delta m_{23}^{2}L/E) \quad L : \text{baseline length}$ $P(\overline{v}_{\mu} \rightarrow \overline{v}_{\mu}) \approx 1 - \sin^{2}(2\overline{\theta}_{23}) \sin^{2}(\Delta \overline{m}_{23}^{2}L/E) \quad E : \text{neutrino energy}$

All the oscillation parameters except for $\overline{\Theta}_{23}$ and $\Delta \overline{m}_{23}^2$ are fixed use T2K neutrino result and PDG 2014 values

The T2K (Tokai to Kamioka) experiment

Protons on target (POT)

1.000n

295km

Vear Detecto

Neutrino Bean

- Long-baseline (295km) neutrino oscillation experiment
- Purpose : measure neutrino mixing parameters
- shift beam direction by 2.5° (off-axis method)
 narrower energy peak, lower background
- ✓ analyzed $\overline{\nu}$ data corresponding to 2.315 × 10²⁰

Mt.Noguchi-Goro Dake

Super-Kamiokande

Mt.Ikenoyama 1,360m





Analysis overview



Systematic uncertainties

• 44 systematic parameters in total





Fractional error on number-of-event prediction		w/o ND measurement	w/ ND measurement
v flux and cross section	flux	7.1%	3.5 %
	cross section common to ND	5.8%	1.4 %
	(flux) ×(cross section common to ND)	9.2%	3.4 %
	cross section (SK specific)	10.0 %	
	total	13.0%	10.1%
Final or Secondary Hadronic Interaction		2.1%	
Super-K detector		3.8%	
total		14.4%	11.6%

- Uncertainties are decreased due to ND280 constraint
- Dominant uncertainties come from the interaction difference of material between carbon and oxygen
- especially CC multinucleon interaction model uncertainty
- Systematic uncertainties will be decreased by analyzing
- different μ kinematics than CCQE neutrino-oxygen interaction data in ND (ongoing)

CC C Isos

• $17 v_{\mu}$ and \overline{v}_{μ} events are observed

- expected 60 without oscillation
- Data show clear disappearance
- v and v results are consistent
- v contour is much larger than v contour
- smaller $\overline{\theta}_{23}$ compared to MINOS
- statistics dominated
- \checkmark × 2 statistics by this summer



T2K has set a best limit on the $\overline{\theta}_{23}$ parameter. More results are coming soon!