Scientific Reach of Future Neutrino Oscillations Exps.

Parameter	T2K	T2HK	Reactor	Nova	Nova2	VLBNO
Δm_{32}^2	✓	✓	-	✓	✓	✓
$\sin^2(2\theta_{23})$	✓	✓	-	✓	✓	✓
$\sin^2(2\theta_{13})$ [a]	✓	✓	✓	✓	✓	✓
$\Delta m_{21}^2 \sin(2\theta_{12})$ [b]	-	-	-	-	-	12%
sign of (Δm_{32}^2) [c]	Nova	-	-	T2K	T2K	yes
measure δ_{CP} [d]	-	Nova	-	-	T2HK	±13°
N-decay improv.	x1	x20	-	-	-	x10
Detector (KTons)	50	1000	20	30	30	400
Beam Power (MW)	0.74	4.0	14000	0.65	2.0	1.5
Baseline (km)	295 [e]	295 [e]	1	810 [e]	810 [e]	>2500
Detector Cost ($M)	exists	~$$$	20	165	+ ???	$$
Beam Cost ($M)	exists	$$	exists	$	$$$	400

Combined measurement

[a] **detection of $\nu_\mu \rightarrow \nu_e$, upper limit on or determination of $\sin^2(2\theta_{13})$**

[b] **detection of $\nu_\mu \rightarrow \nu_e$ appearance, even if $\sin^2(2\theta_{13}) = 0$; determine θ_{23} angle ambiguity**

[c] **detection of the matter enhancement effect over the entire δ_{CP} angle range**

[d] **measure the CP-violation phase δ_{CP} in the lepton sector; Nova2 depends on T2HK**

[e] **beam is 'off-axis' from 0-degree target direction**

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Comments on Neutrino Oscillations Experiments

- ***All*** **parameters of neutrino oscillation can be measured in *one* experiment**
  - **a Very Long Baseline Neutrino Oscillation (VLBNO) at >2000 km**
  - **the cost of VLBNO is comparable to (or less than) competing proposals**
  - **the mass of the VLBNO target enables a powerful *Nucleon Decay* search**
- **Use of a *broadband neutrino beam* at *very long distances* is the key**
- Focus on CP because **The CP-violation parameter is the most difficult parameter to determine**
  - **matter effects interact with CP-violation effects**
  - **the CP-violation phase δ_{CP} has distinct effects over the full 360º range**
- **Off-axis beam method requires multiple distances and detectors**
  - **all experiments will require of order 10 Snomass years of running**
- **All measured oscillation parameters will be limited to ~1% precision by systematic errors except $\sin^2(2\theta_{23})$**