LBNE Physics Working Group

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Working Group Members

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- **Milind Diwan – BNL**
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- **Mel Shochet – Chicago (chair)**
- **Jenny Thomas – UCL**
- **Charlie Young – SLAC**
- **Sam Zeller – FNAL**
- **Jeff Appel – FNAL (scientific secretary)**

Our Charge: evaluate specific options

(reach for mass hierarchy, $\not{CP}$, p decay, supernova ν's) as a function of detector mass for physics, cost analysis

- **Homestake:** LAr detector at 4800′ or at the surface
- **Soudan:** LAr detector at 2300′ or at the surface
- **Ash River:** LAr detector at the surface
- **Split the mass between Soudan and Ash River**

To assess the maximum physics that can be extracted from a choice that will be severely limited by available funds, we are to include the results from T2K & NOvA and, for the Minnesota options, continued running of NOvA. This is particularly important for determining the mass hierarchy.

Detector Assumptions

- **LBNE**
  - **LAr TPC of varying fiducial masses (2 kton-34 kton)**
  - **L = 1300 km (Homestake), 735 km (Soudan), 810 km (Ash River)**
  - **700 kW beam = 6×10^{20} POT/year**
  - **detector performance from arXiv: 1110.6249 [hep-ex]**
- **NOvA**
  - **15 kton liquid scintillator detector**
  - **L = 810 km**
  - **700 kW beam = 6×10^{20} POT/year**
  - **detector performance from GLoBES**
    (http://www.mpi-hd.mpg.de/personalhomes/globes/glb/0709-nova.glb)
- **T2K**
  - **22.5 kton water Cerenkov detector**
  - **L = 295 km**
  - **expected exposure provided by Japan (see next slide)**
  - **detector performance from GLoBES**
    (http://www.mpi-hd.mpg.de/personalhomes/globes/glb/0709-t2k.glb)

T2K Expected Exposure

Period	Integ. No. of Proton on Target	Beam Power (kW)	
-Jun.2012	3.1E+20	170	
-Jun.2013	7.8E+20	200	
-Jun.2014	1.2E+21	250	*2
-Jun.2015	1.8E+21	250	
-Jun.2016	2.5E+21	300	
-Jun.2017	3.2E+21	300	
-Jun.2018	3.9E+21	300	
-Jun.2019	5.5E+21	700	*1
-Jun.2020	7.1E+21	700	
-Jun.2021	8.8E+21	700	

*1 Completion time of MR upgrade (assumed to be 2018) is suject to change, depending on economical situation, readiness and so on.

*2 LINAC upgrade completed

* Beam Energy 30GeV

Gina will show results as a function of the total T2K exposure.

Assumed Neutrino Oscillation Parameters

$\theta_{12} = 0.593 \pm 0.018$
$\theta_{23} = 0.705 \pm 0.078$
$\theta_{13} = 0.154 \pm 0.005^{*}$
$\Delta m^2_{21} = (7.58 \pm 0.23) \times 10^{-5}\ eV^2$
$|\Delta m^2_{31}| = (2.35 \pm 0.12) \times 10^{-3}\ eV^2$ ($\Delta m_{31} > 0$ NH, < 0 IH)

from G.L. Fogli *et al.*, PRD 84, 053007 (2011)
*Daya Bay result with systematic error only, from arXiv:1203.1669 [hep-ex]

Some issues to be considered post-workshop

- **Impact of the near-detector performance.**
- **Running off-axis to Homestake.**
- **Changing assumed ν oscillation parameters by 1 or 2 σ.**