

LBNE Physics Working Group

Mel Shochet

Working Group Members

- **Mary Bishai – BNL**
- **Ed Blucher – Chicago**
- **Steve Brice - FNAL**
- **Milind Diwan – BNL**
- **Bonnie Fleming - Yale**
- **Gil Gilchriese – LBNL**
- **Bill Marciano – BNL**
- **Mark Messier – Indiana**
- **Stephen Parke – FNAL**
- **Gina Rameika – FNAL**
- **Kate Scholberg – Duke**
- **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, $\overline{\nu}_\mu$, μ 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 subject 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

$$\theta_{12} = 0.593 \pm 0.018$$

$$\theta_{23} = 0.705 \pm 0.078$$

$$\theta_{13} = 0.154 \pm 0.005^*$$

$$\Delta m_{21}^2 = (7.58 \pm 0.23) \times 10^{-5} \text{ eV}^2$$

$$|\Delta m_{31}^2| = (2.35 \pm 0.12) \times 10^{-3} \text{ eV}^2 (\Delta m_{31} > 0 \text{ NH}, < 0 \text{ IH})$$

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 .**
- **Issues that come up in the workshop**