Impact of Project X on LBNE

Neutrino Working Group Mtg, Oct 14 2011, FNAL

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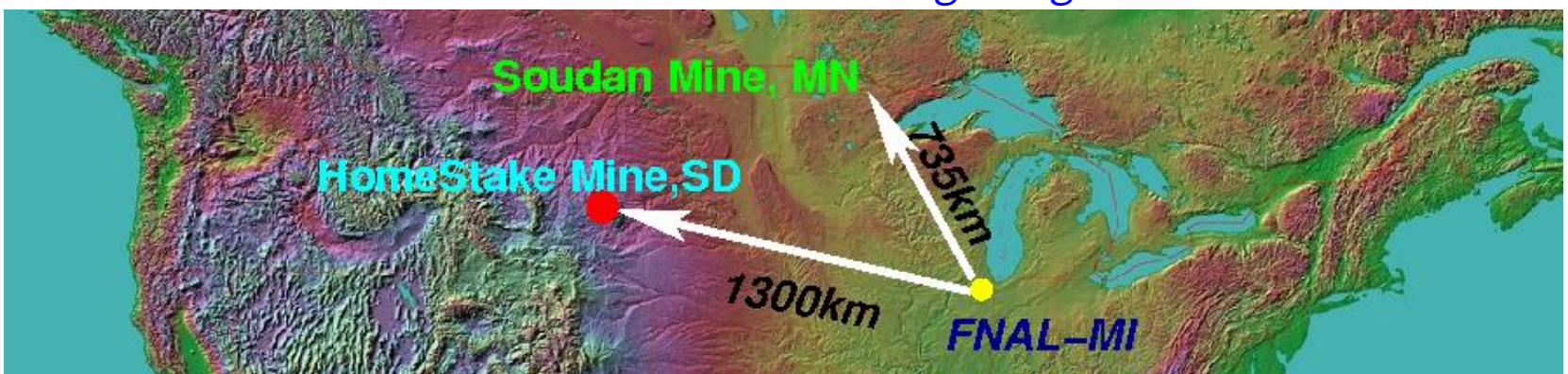
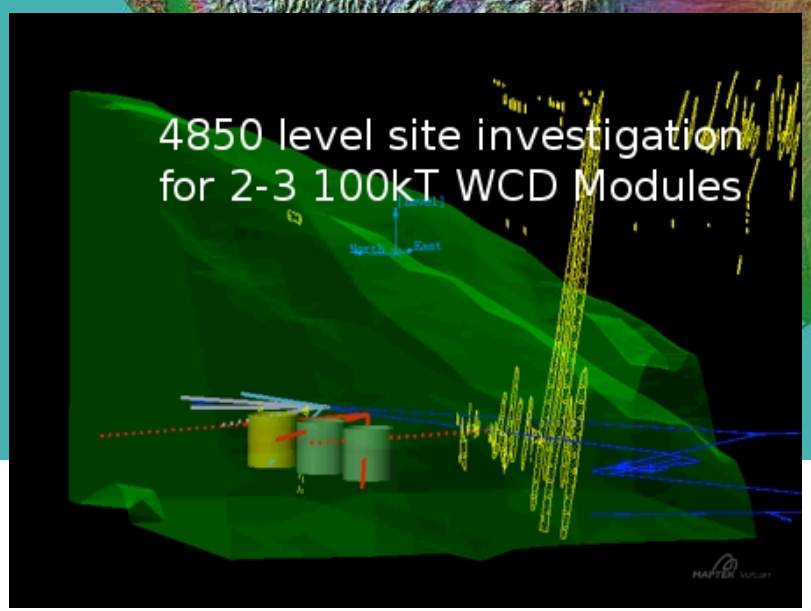
Brookhaven National Laboratory

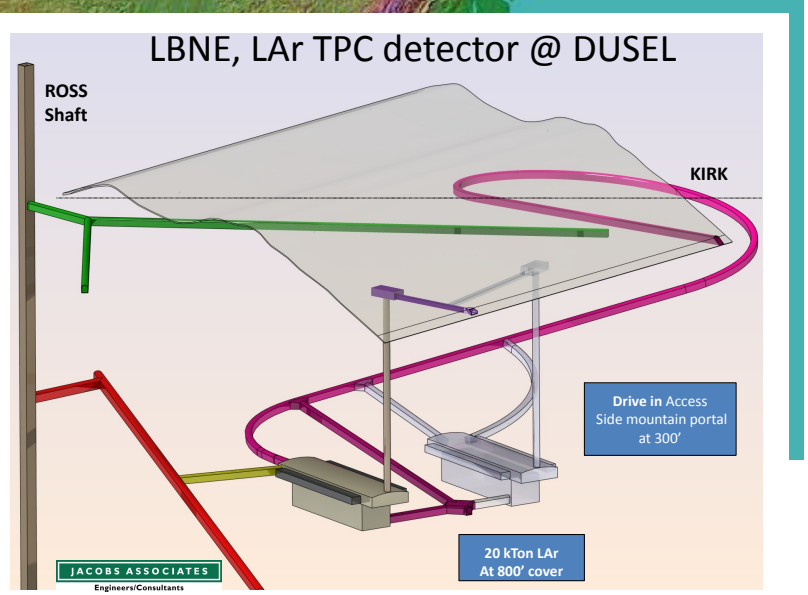
October 24, 2011

The Long Baseline Neutrino Experiment

A Long Baseline Neutrino Experiment (LBNE) from Fermilab to large scale neutrino detectors at Homestake is now being designed. CDR late 2011.



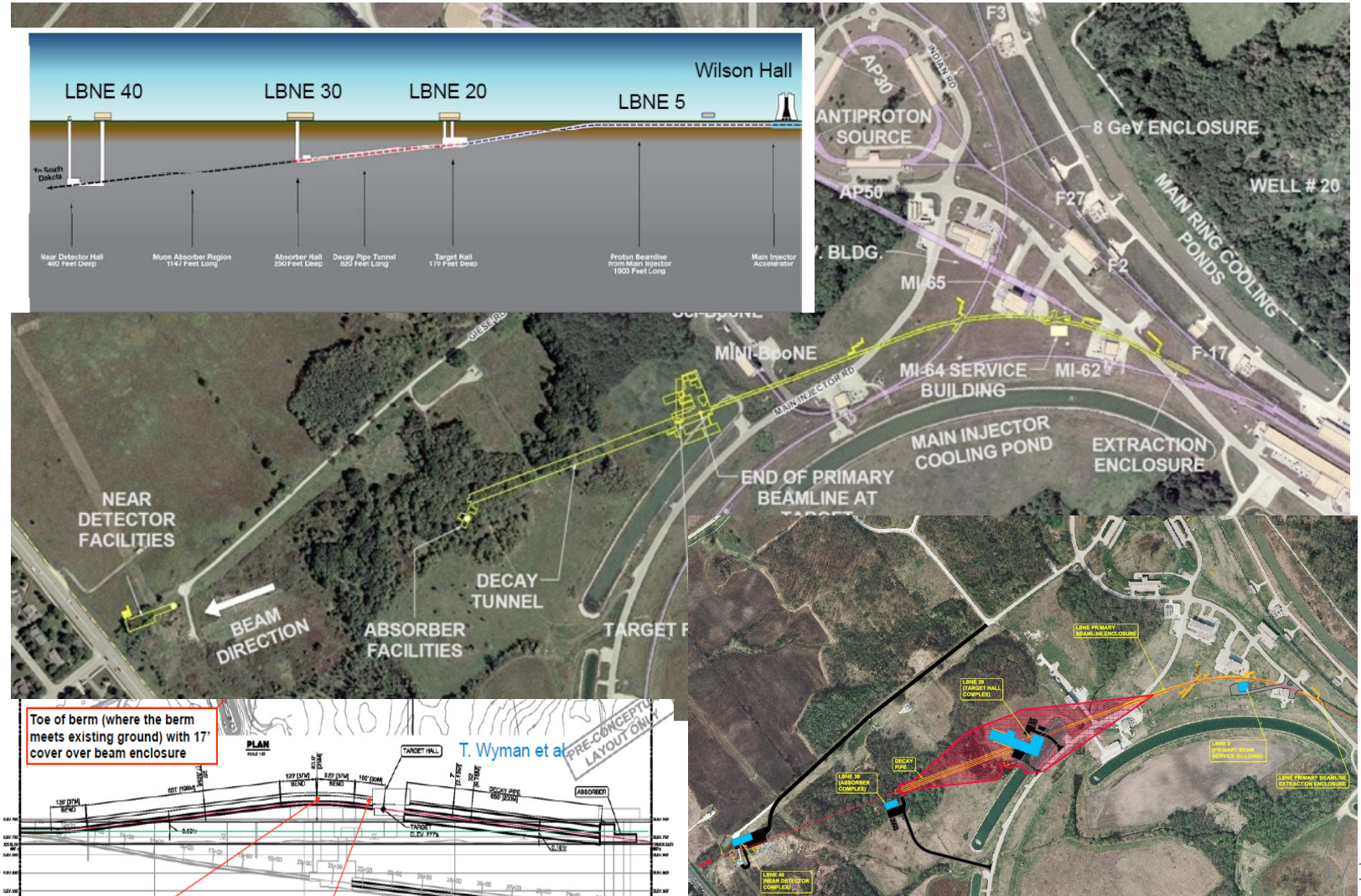




The LBNE Beamline at Fermilab

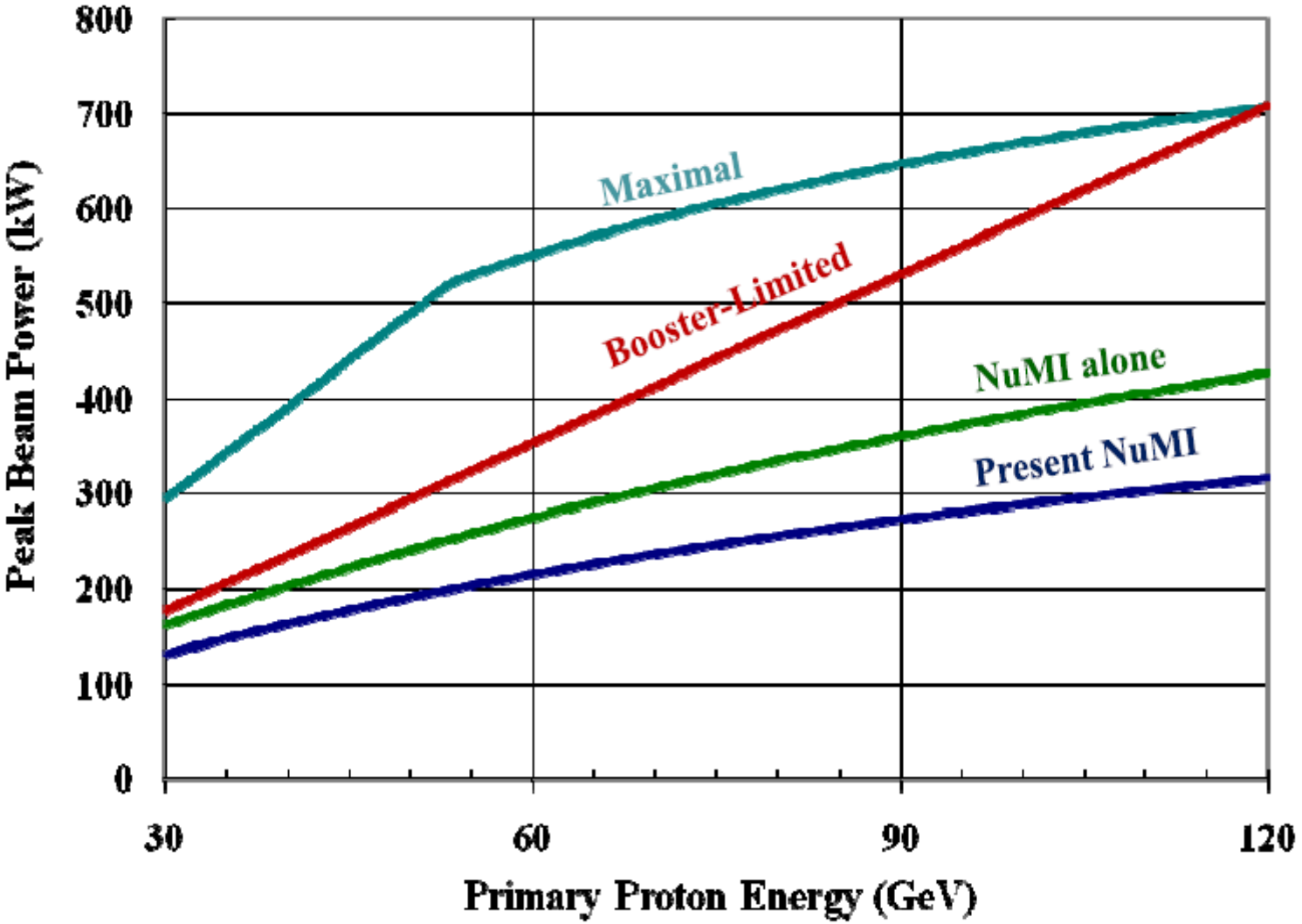
The LBNE project will start with a 700kW beam with 80-120 GeV p

In the future will profit from the 2.3 MW Project X beam



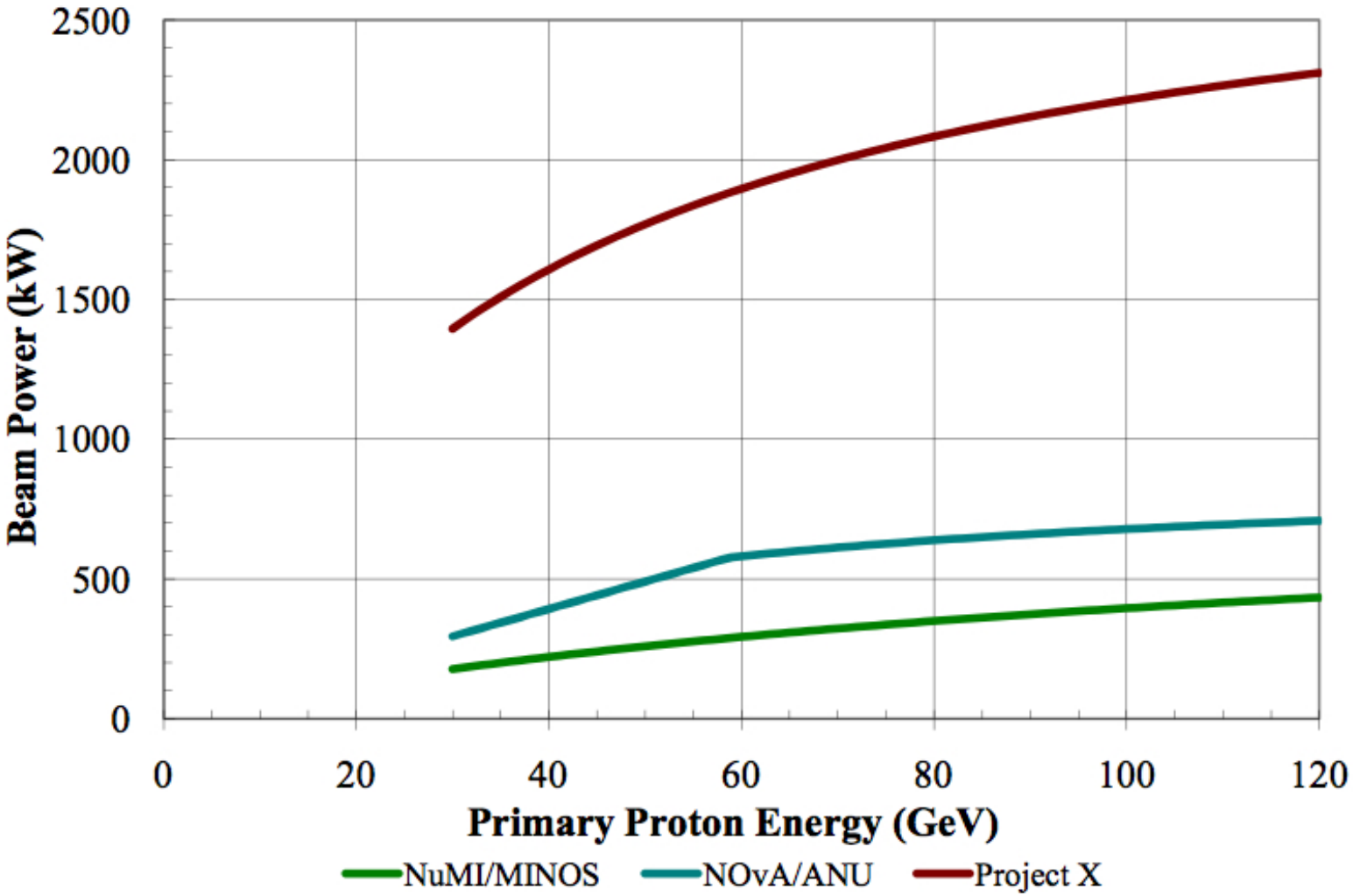
Main Injector Primary Proton Beam Power (R. Zwaska)

With only 700kW (NoVA/ANU) :



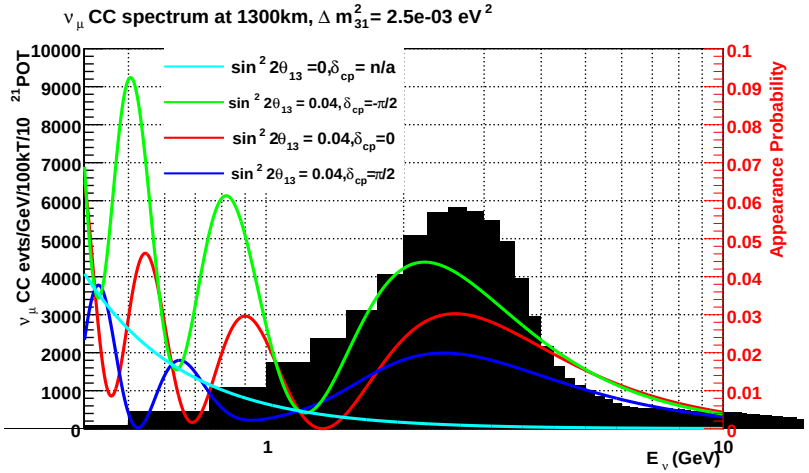
Main Injector Primary Proton Beam Power (R. Zwaska)

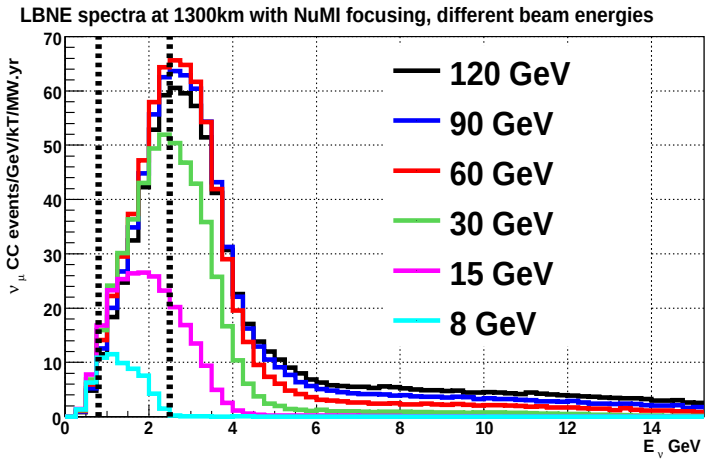
With Project X:



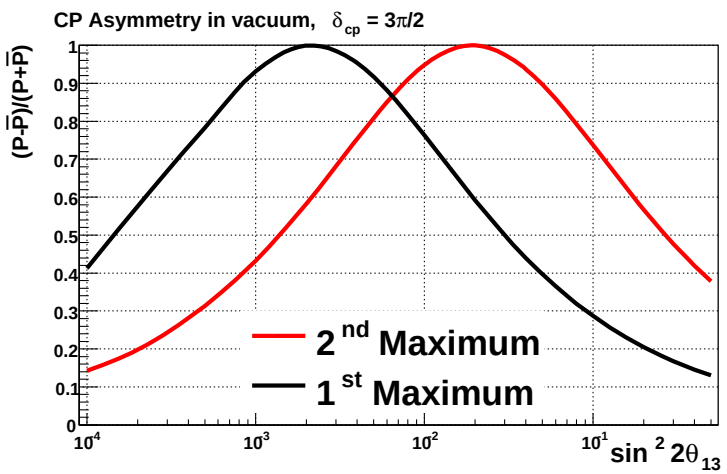
LBNE Neutrino Beam

Wide-band beam to cover BOTH oscillation maxima for best CP Violation/Mass Hierarchy sensitivity

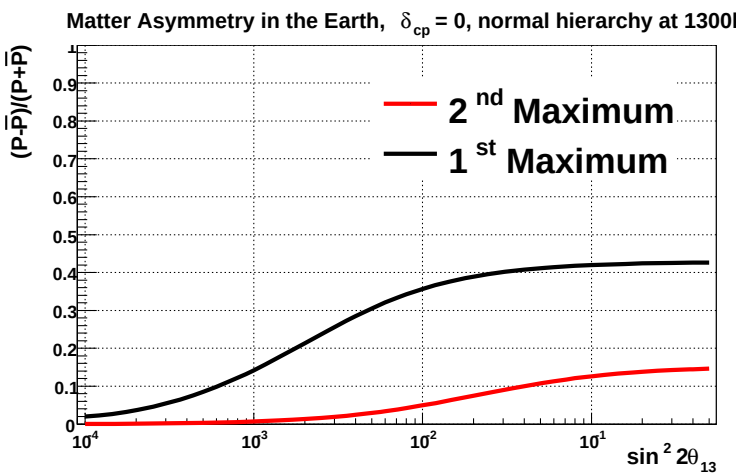




CP Asymmetry (vacuum)



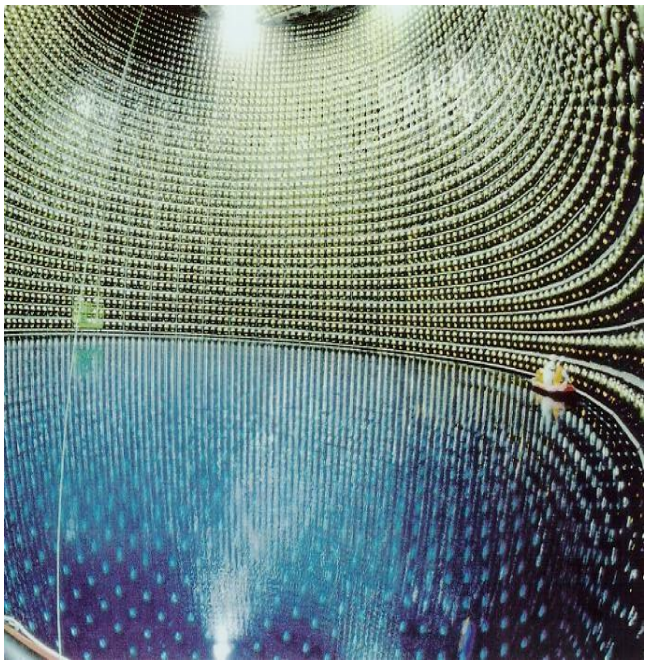
Matter Asymmetry (no CPV)



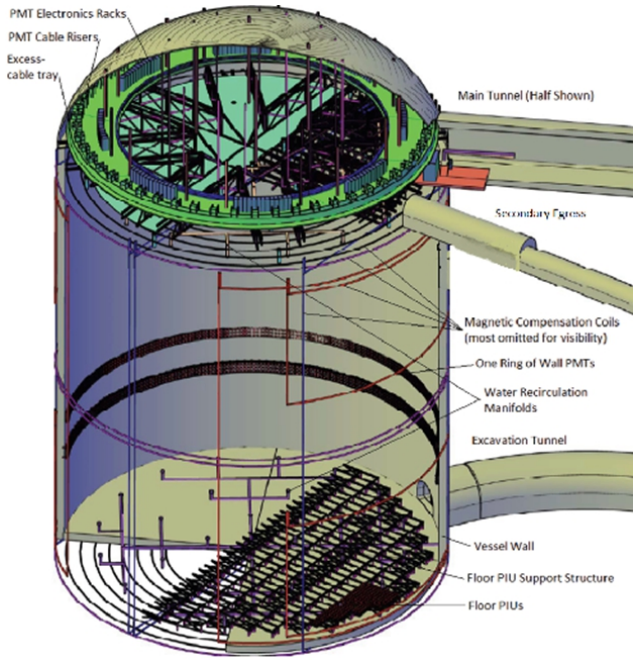
LBNE Detectors: Water Cerenkov

(R. Wilsons talk)

SuperKamiokande : 50kt



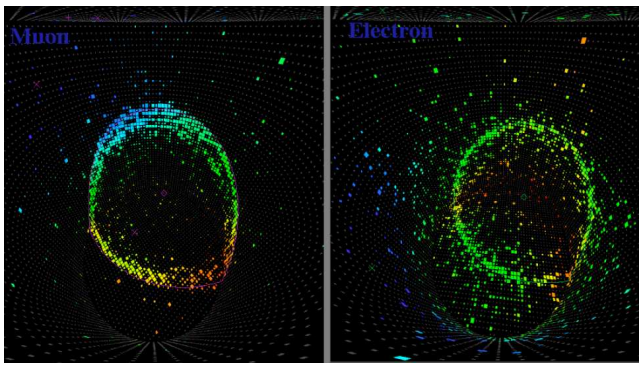
LBNE WCD ∼ 230 kt



200kt (fiducial), ≈ 55m diameter, ≈ 60m height, 30K 10-12" HQE PMTs (15% coverage)

Known technology ∼ 4× SuperK

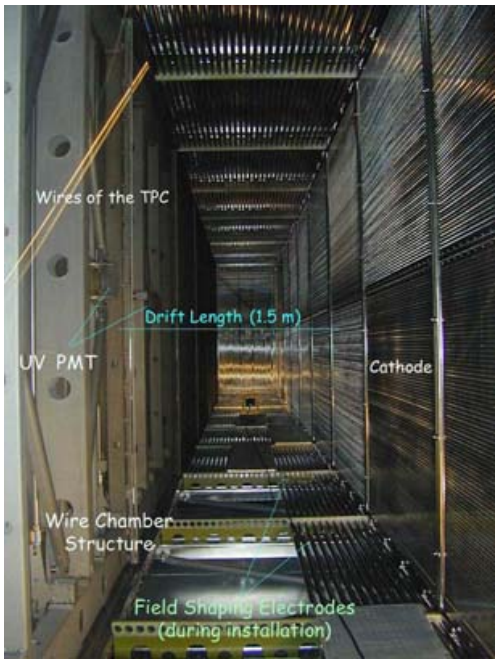
Large NC π^0 backgrounds, low eff.



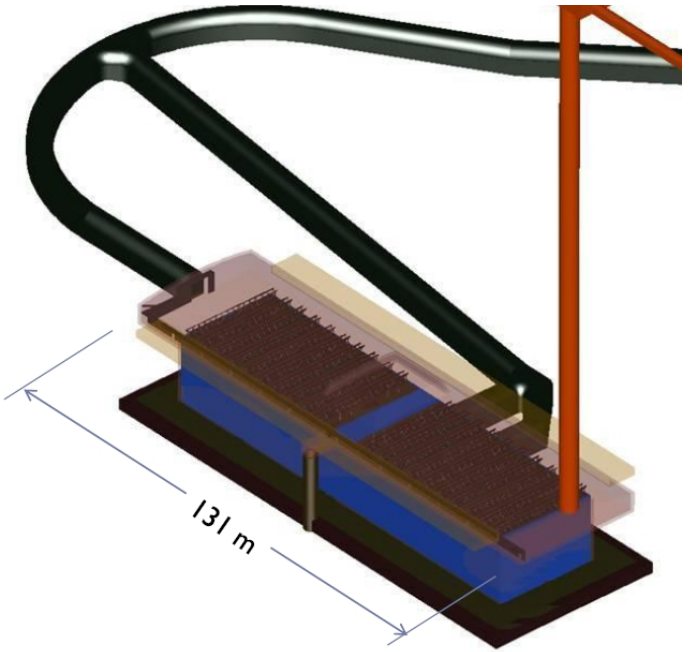
LBNE Detectors: Liquid Argon TPC

(R. Wilsons talk)

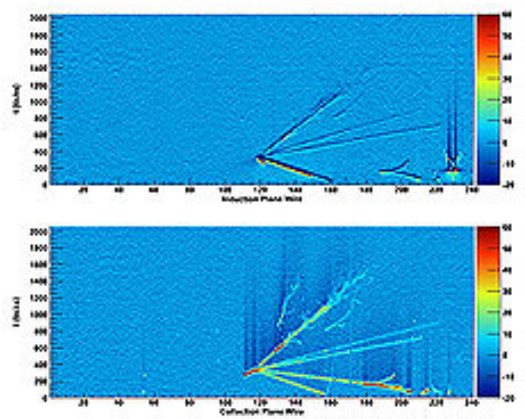
ICARUS : 0.6kt



LBNE LAr : 17kt module X 2



ArgoNeuT (175 litre) prototype in the NuMI beam →



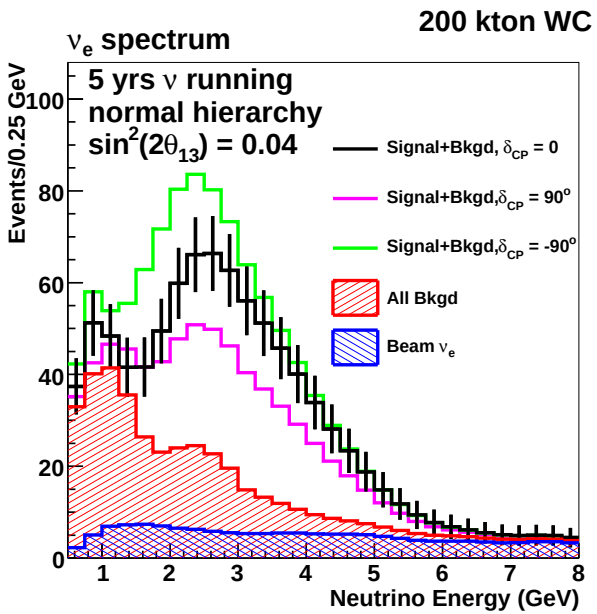
High efficiency and purity

Requires 30× scale-up - challenging.

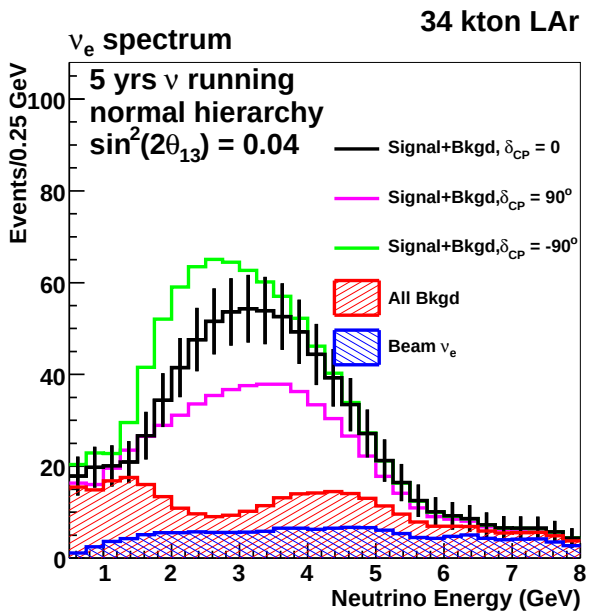
LBNE spectra and event rates

On-axis wide-band beam (NuMI focusing). Water Cerenkov response is based on the SuperK MC. LAr is modeled as a near-perfect detector. *Exposure is 3.5 MW. yr ν with* $\sin^2 2\theta_{13} = 0.04$*:*

200 kt WCD



34 kt LAr



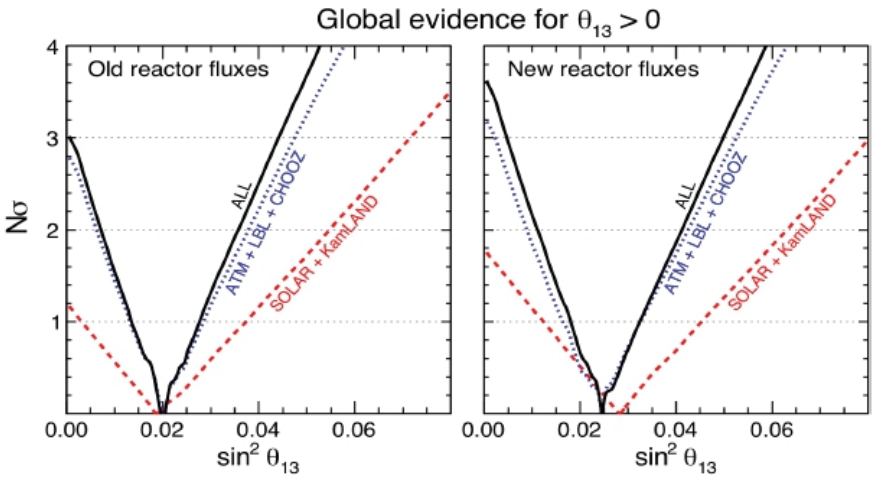
Interaction rates per 100kT.MW.yr

ν_μ CC	ν_μ CC osc	ν_e CC beam	$\nu_\mu \rightarrow \nu_e$ CC	$\nu_\mu \rightarrow \nu_\tau$ CC
20K	7.8K	220	400	100

Latest Global fit to $\sin^2\theta_{13}$

G. Fogli et. al.

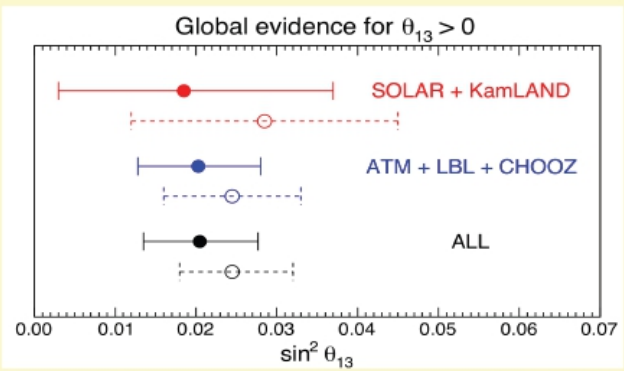
Our global results for $\sin^2\theta_{13}$ PRD 84, 053007 [arXiv:1106.6028]



Note:

ATM+LBL+CHOOZ now more significant that Solar+KamLAND

Astonishing conspiracy of the two totally independent sets of data



$\sin^2\theta_{13} = 0.021 \pm 0.007$ (old reactor fluxes)

$\sin^2\theta_{13} = 0.025 \pm 0.007$ (new reactor fluxes)

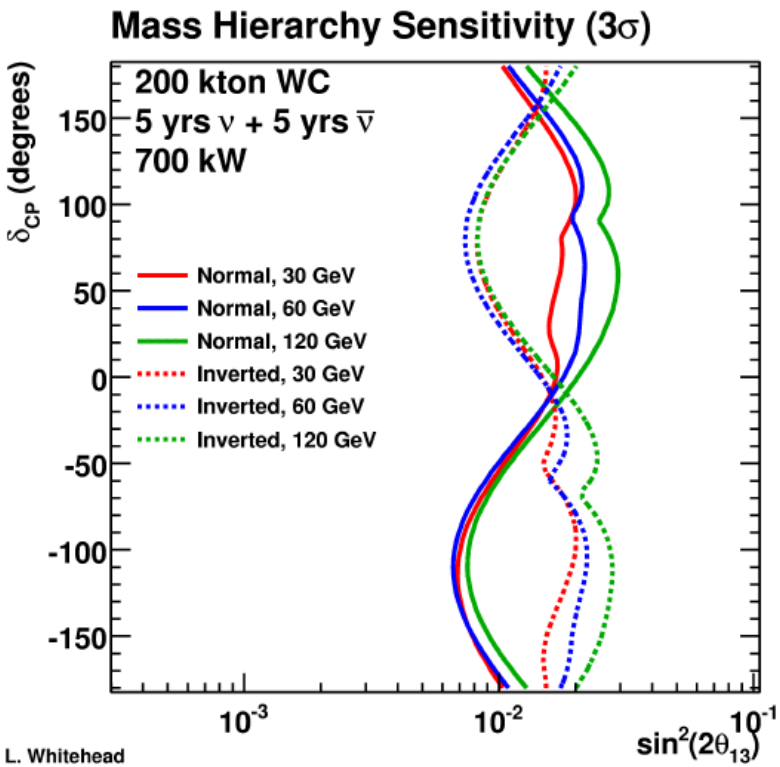
In conclusion, evidence for $\sin^2\theta_{13} > 0$ at $> 3\sigma$ (with small changes for new/old reactor fluxes assumed in the fit).

Measurements of CPV and MH in LBNE

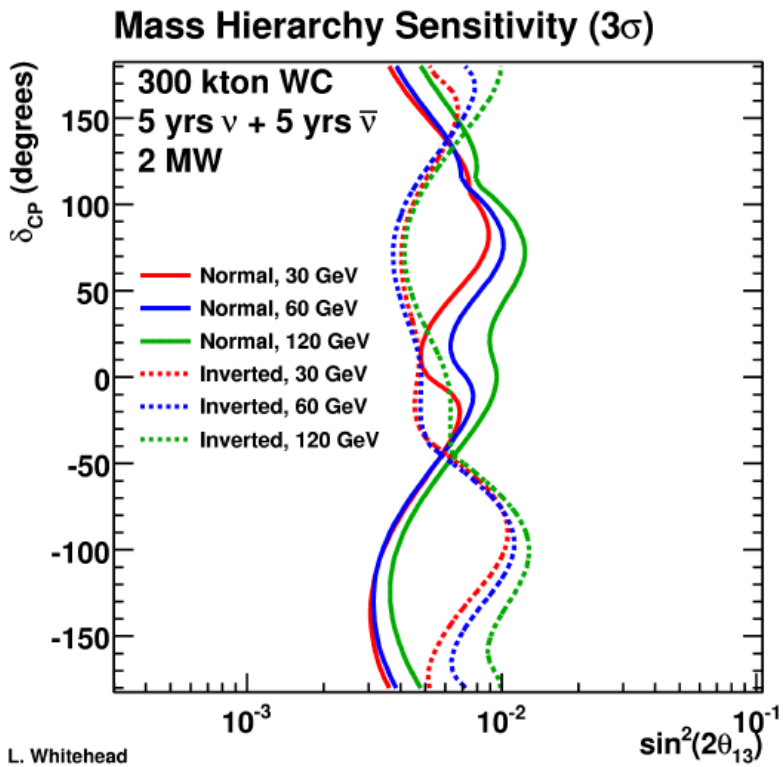
200-300 kt WCD detector and 5 yrs of ν + 5 yrs of $\bar{\nu}$ running:

Mass Hierarchy

700kW beam



2 MW beam



Sensitivity at δ=0, normal hierarchy

	30 GeV	60 GeV	120 GeV
200 kton, 700 kW	0.0158	0.0178	0.0200
300 kton, 2 MW	0.0050	0.0071	0.0100

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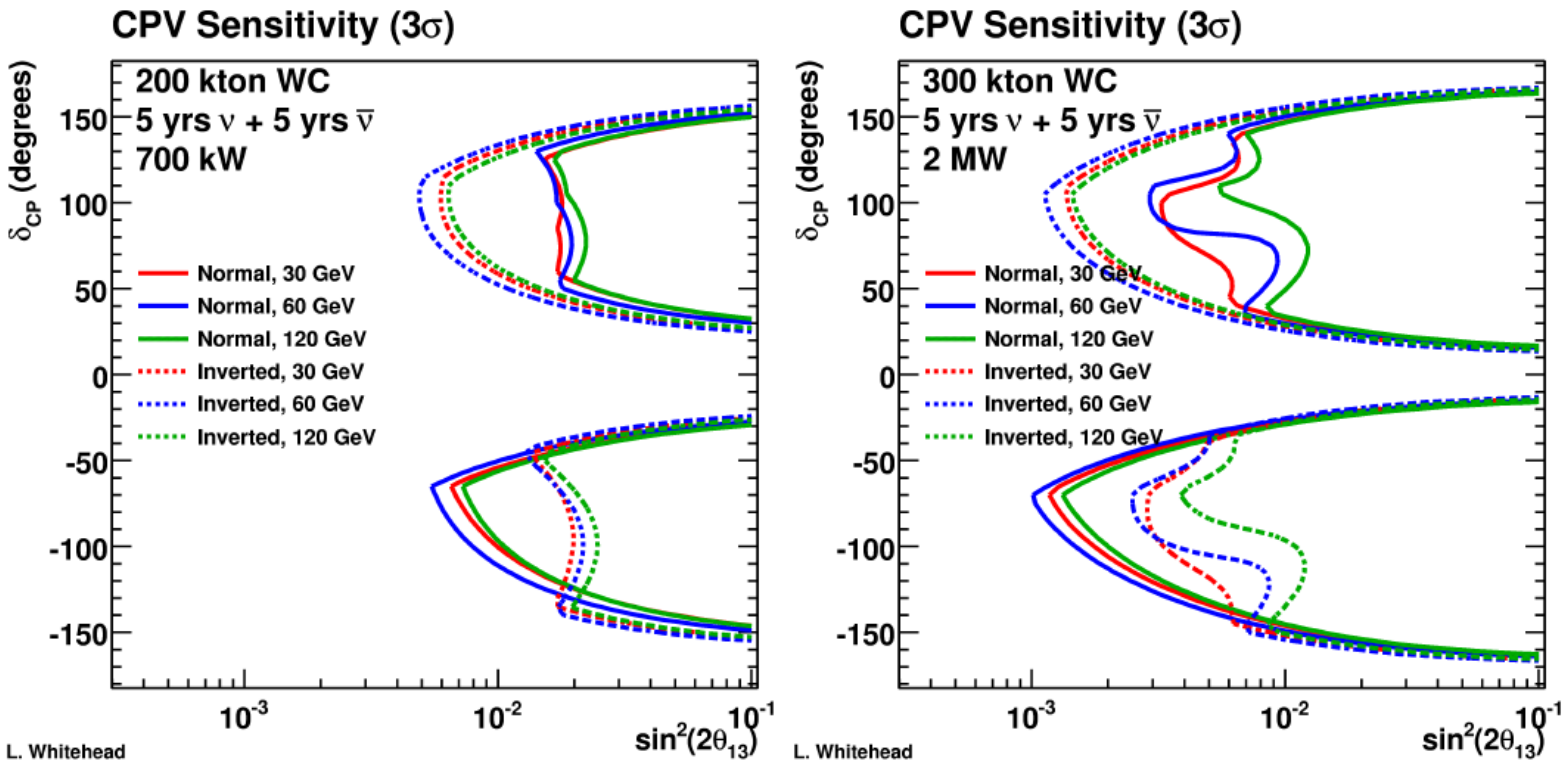
Measurements of CPV and MH in LBNE

200-300 kt WCD detector and 5 yrs of ν + 5 yrs of $\bar{\nu}$ running:

CP Violation

700kW beam **2 MW beam**



Maximum sensitivity, normal hierarchy

	30 GeV	60 GeV	120 GeV
200 kton, 700 kW	0.0063	0.0056	0.0071
300 kton, 2 MW	0.0013	0.0011	0.0014

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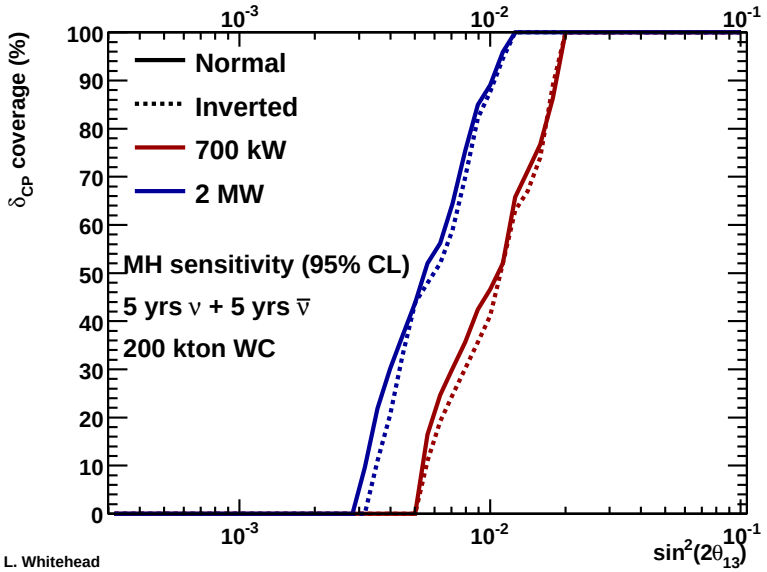
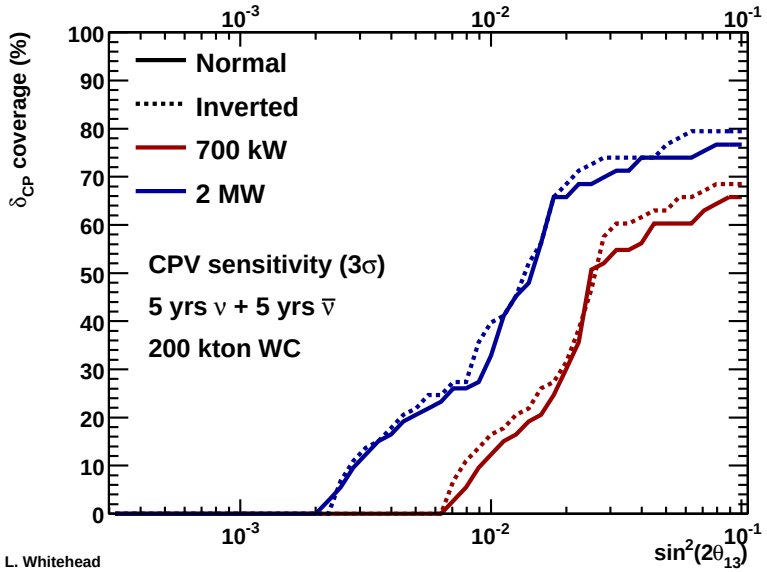
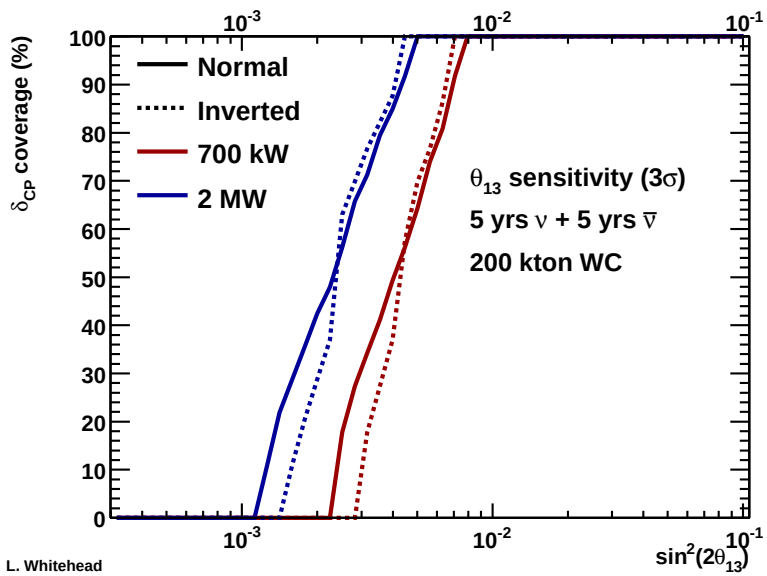
Fraction of δ_{cp} values with Project X (120 GeV)

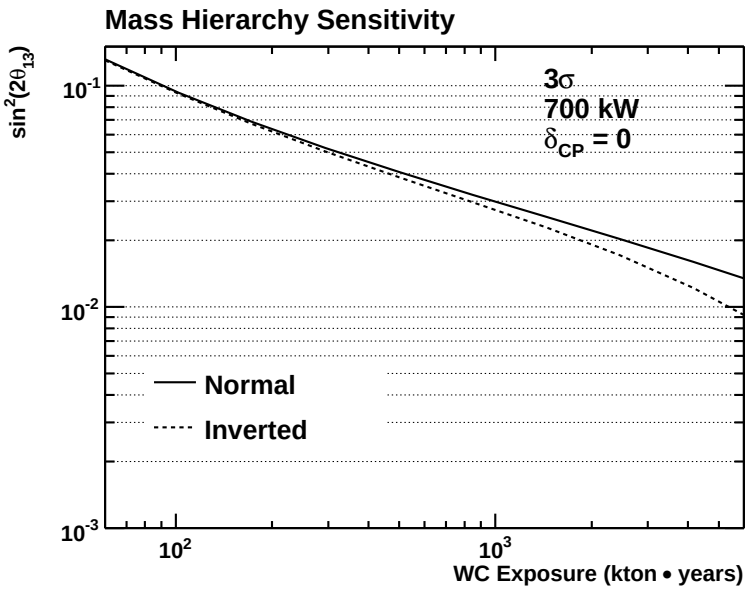




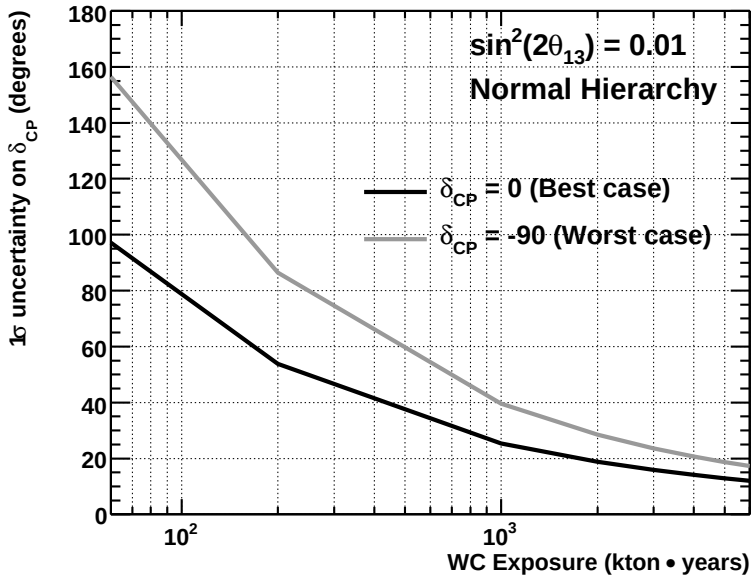


Ultimate ν Oscillation Sensitivities

MH Sensitivity at 3σ



Resolution of δ_{cp}



Sensitivity to MH at 3σ for all δ_{cp} for $\sin^2 2\theta_{13} \geq 0.01$

Precision measurement of δ_{cp} ($< 20^\circ$ resolution) for $\sin^2 2\theta_{13} \geq 0.01$

30yrs at 700kW $\equiv <$ 10yrs at 2.3 MW

$3\ \sigma$ 700 kW x 10 yrs $\approx 4.7\ \sigma$ 2.3 MW x 10 yrs

Summary and Conclusions

- **With Project X, LBNE can reach 3σ sensitivity to MH and CP Violation for values of $\sin^2 2\theta_{13} \sim 0.01$ in less than 10 yrs.**
- **For 95% of the global fit range of $\sin^2 2\theta_{13} = 0.097 \pm 0.027$: 5σ sensitivity for ν CP Violation with ProjectX.**
- **Sensitivity increases with Project X beyond beam power can be achieved using lower primary beam energies at $\sim$ 2MW.**