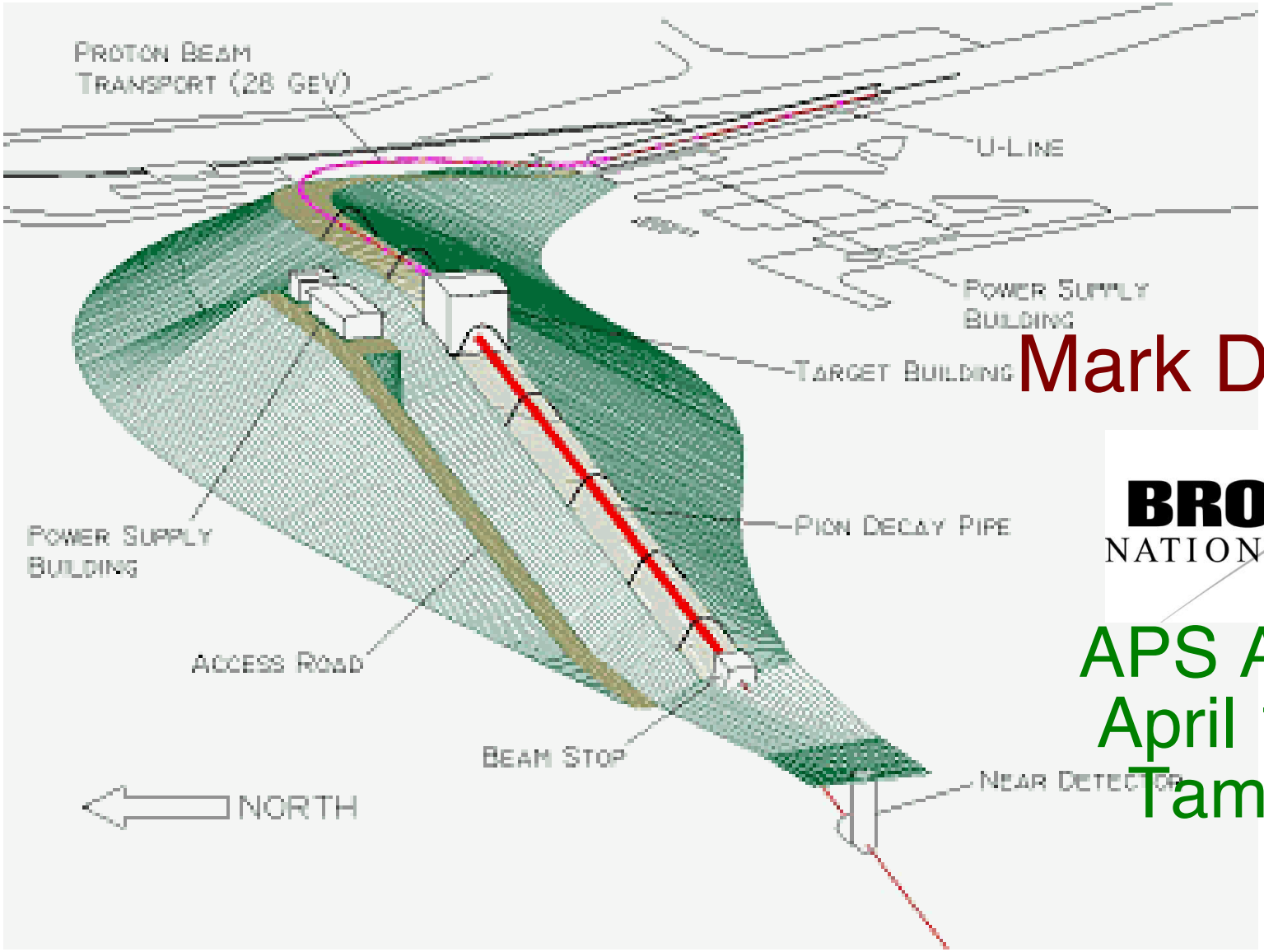
Very Long Baseline Neutrino Oscillation Experiment at Brookhaven National Laboratory

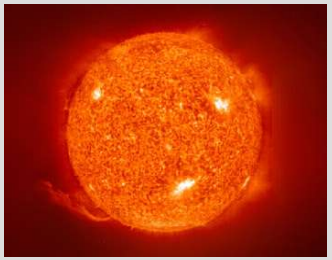


Mark Dierckxsens

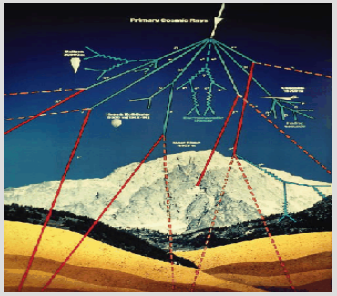
BROOKHAVEN NATIONAL LABORATORY

APS April Meeting
April 16-19, 2005
Tampa, Florida

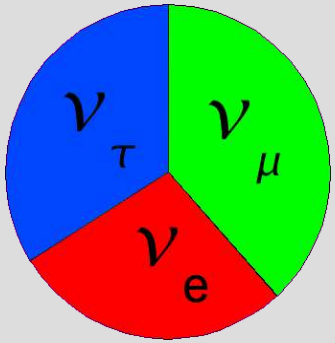
Neutrino Oscillations Results



$$\Delta m^2_{21} = (8.0 \pm 0.3) 10^{-5} eV^2$$
$$\sin^2 2\theta_{12} = 0.86 \pm 0.04$$



$$|\Delta m^2_{32}| = (2.5 \pm 0.3) 10^{-3} eV^2 \quad \text{sign?}$$
$$\sin^2 2\theta_{23} = 1.02 \pm 0.04 \quad \text{degeneracy?}$$



$$\sin^2 2\theta_{13} < 0.12 \quad \text{(99\% C.L.)}$$
$$\delta_{CP} = ???$$

Values from: A. Strumia & F Vissani
hep-ph/0503246 - ifup-th/2005-06

Next Generation Experiments

- increase sensitivity $\sin^2 2\theta_{13}$ & δ_{CP} significantly
- precision measurements of Δm^2_{32} & $\sin^2 2\theta_{23}$
- resolve mass hierarchy (sign of Δm^2_{32})
- sensitive to new physics

Brookhaven idea:

- O(MW) broadband neutrino beam
- O(Mt) detector
- O(Mm) distance

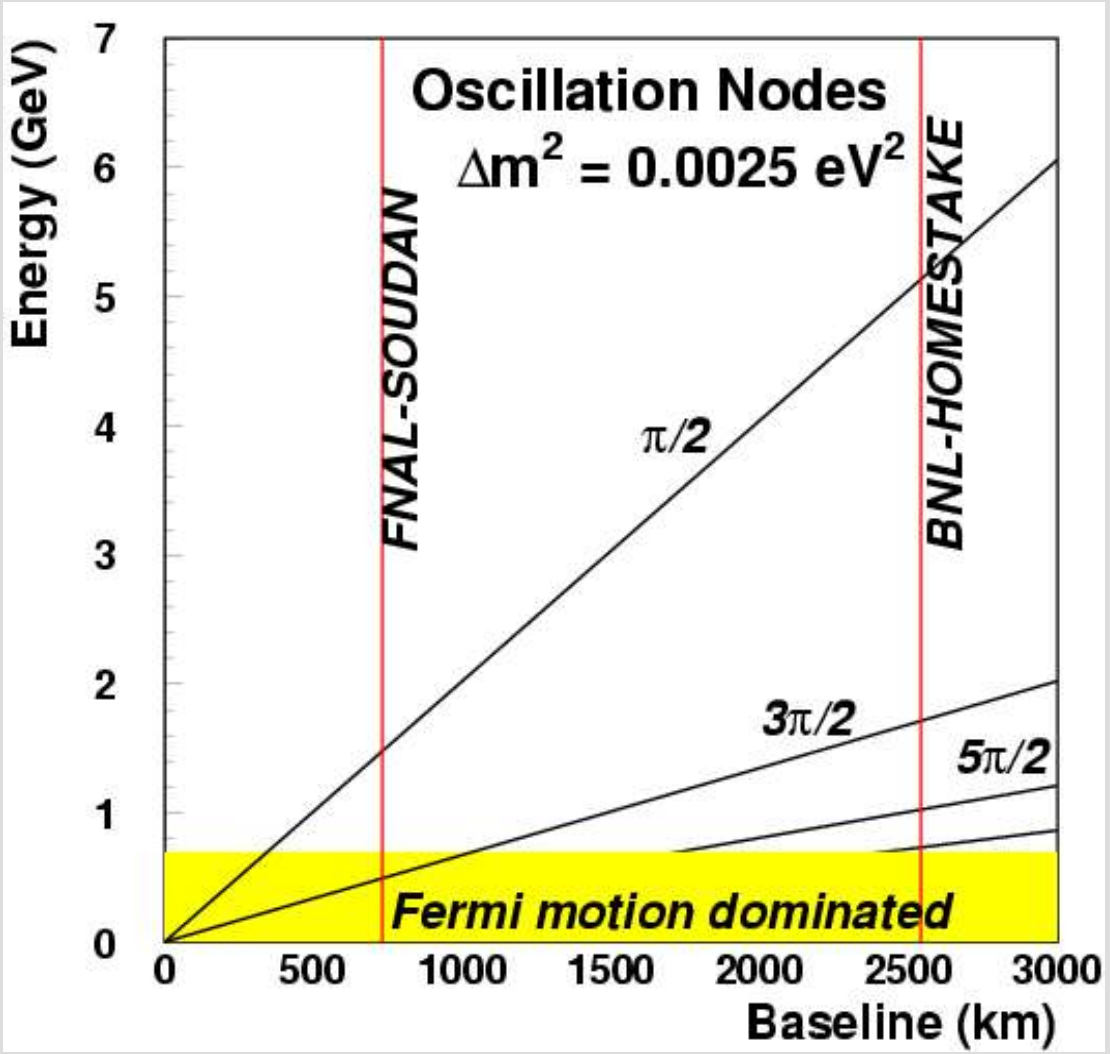
Why Very Long Baseline?

observe multiple nodes in oscillation pattern

☞ less dependent on flux normalization

neutrino travels larger distance through earth

larger matter effects



flux ~ L^{-2}: lower statistics

but: CP asymmetry ~ L

sensitivity to δ_{CP} independent of distance!

better S:B

(Marciano hep-ph/0108181)

Why Broadband Beam?

observe multiple nodes extraction of oscillating signal from background.

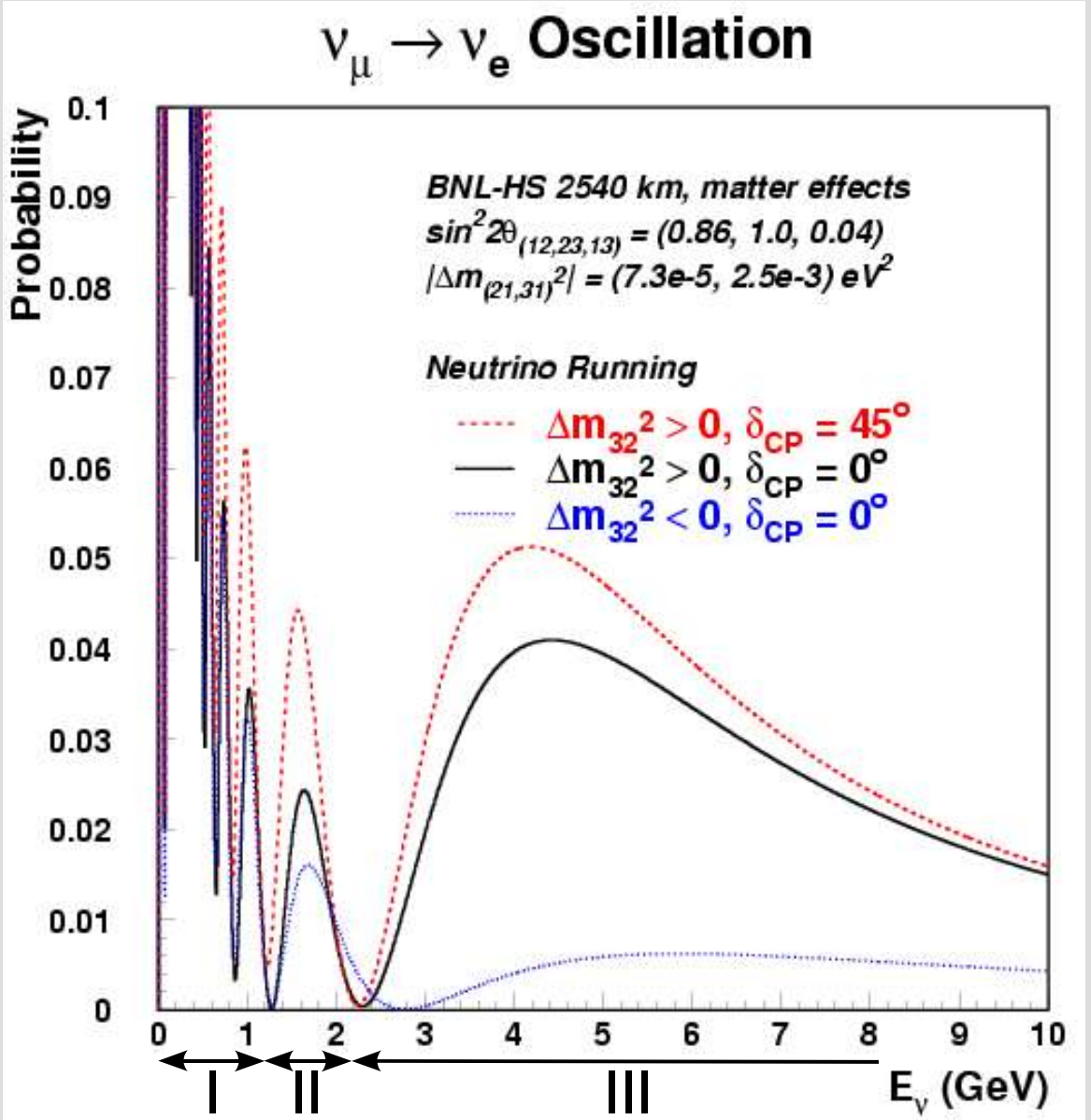
larger energies

larger cross sections

less running time for anti-neutrinos

Sensitive to different parameters in different energy regions:

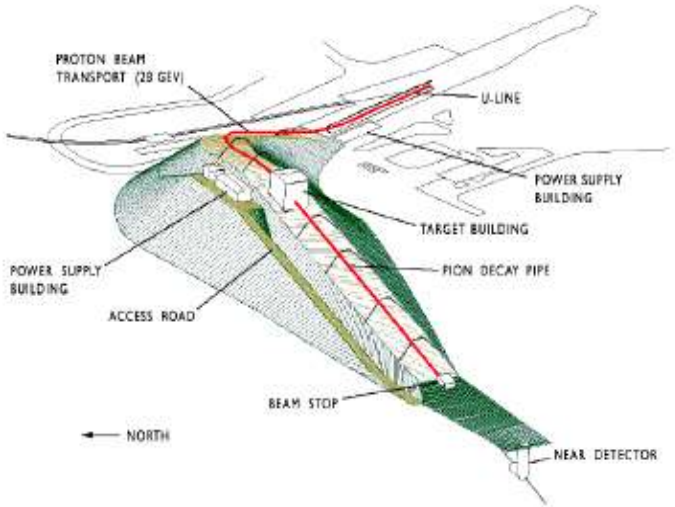
	I	II	III
$\sin^2 2\theta_{13}$	+	+	+
sign(Δm^2_{32})	0	0	++
δ_{CP}	+	++	+
solar	++	+	+

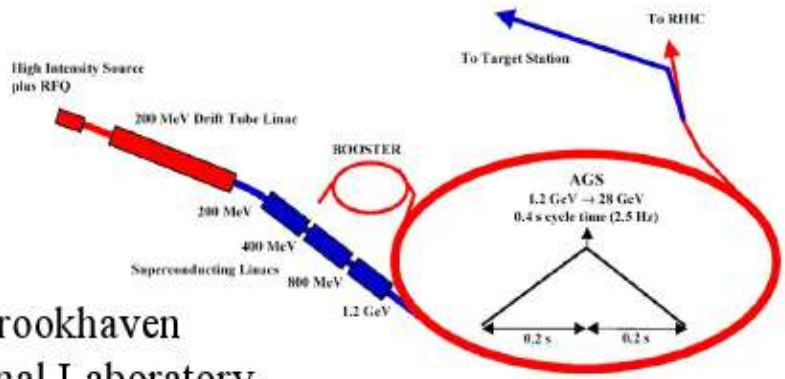


AGS Conceptual Design Report

BNL-73210-2004-IR

The AGS-Based Super Neutrino Beam Facility
Conceptual Design Report





Brookhaven
National Laboratory
Upton, NY 11973
8 October 2004

October 8, 2004 BNL-73210-2004-IR

The AGS-Based Super Neutrino Beam Facility
Conceptual Design Report

Editors: W. T. Weng, M. Diwan, and D. Raparia

Contributors and Participants

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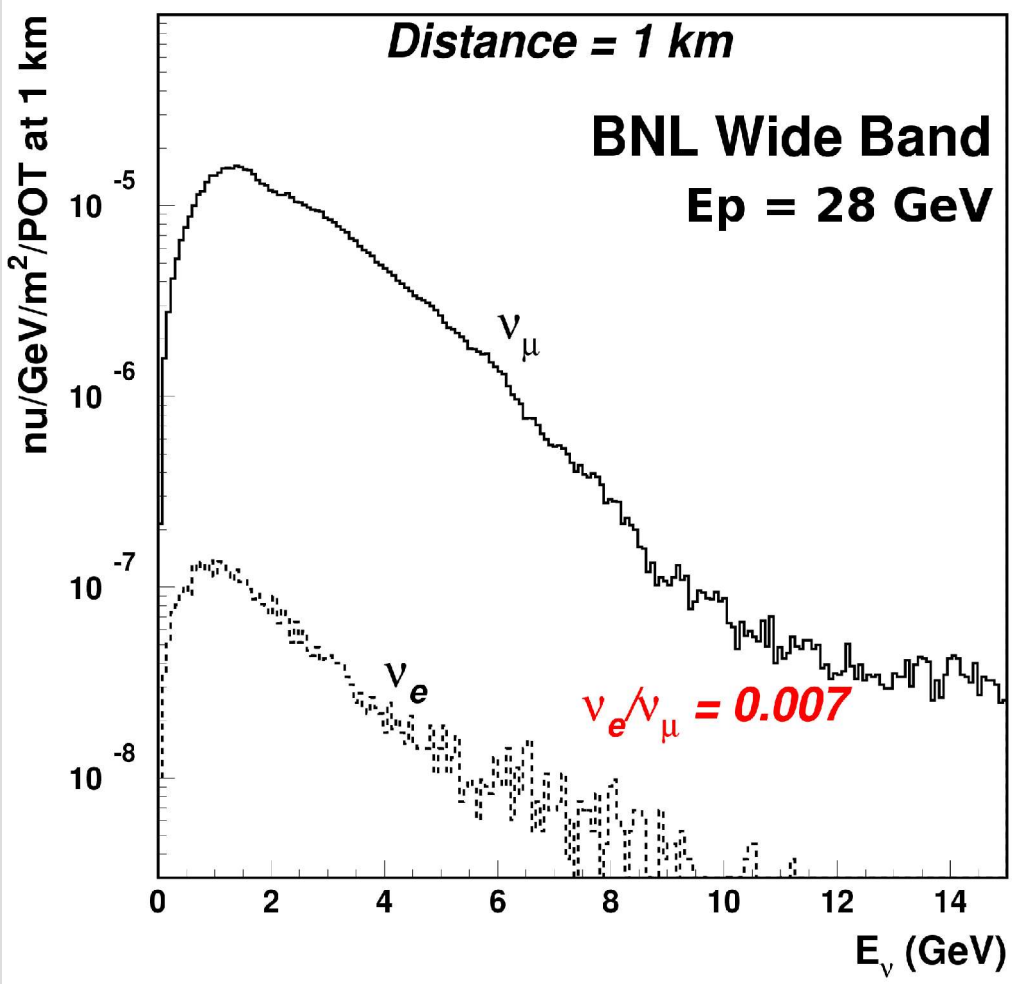
http://raparia.sns.bnl.gov/nwg_ad/agsnbcdr1.pdf

AGS 1MW proton beam

Upgrade AGS (28 GeV protons)

intensity: 7.10^{13} → 9.10^{13} ppp

rep. rate: ~0.3Hz → 2.5Hz



1) ramp time: ~1.2s → 0.2s
   repl. power supply, rf, ...

2) filling time: 0.6s → 1ms
   replace booster:
   extend warm linac 200 MeV
   new SC linac 1 GeV

3) Work continues to goto 1.5 or 2 MW.

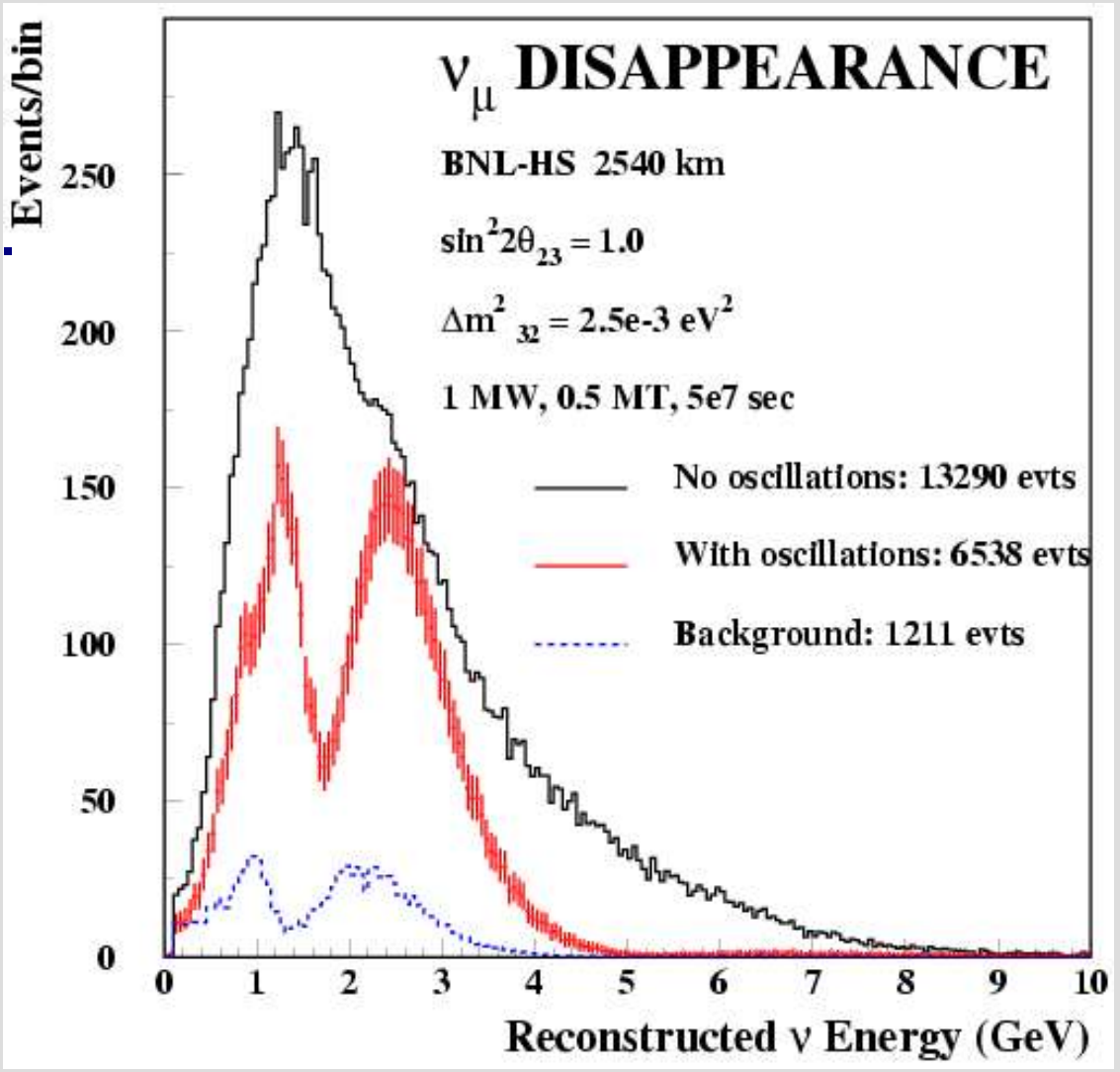
4) Experimental work on 1 MW carbon-carbon target.

ν_μ disappearance

neutrino running:

1MW beam
0.5Mt water Cerenkov det.
2540km distance
5e7s running time
~50000 tot CC events

determine Δm^2_{32}
& $\sin^2 2\theta_{23}$ to 1%
systematics dominated



anti-neutrino running:

same as ν but with
2MW beam

including anti-ν running:

- CPT test possible
- errors below 1% achievable

ν_e Appearance

backgrounds:

- beam ν_e
- NC ν_μ

neutrino running:

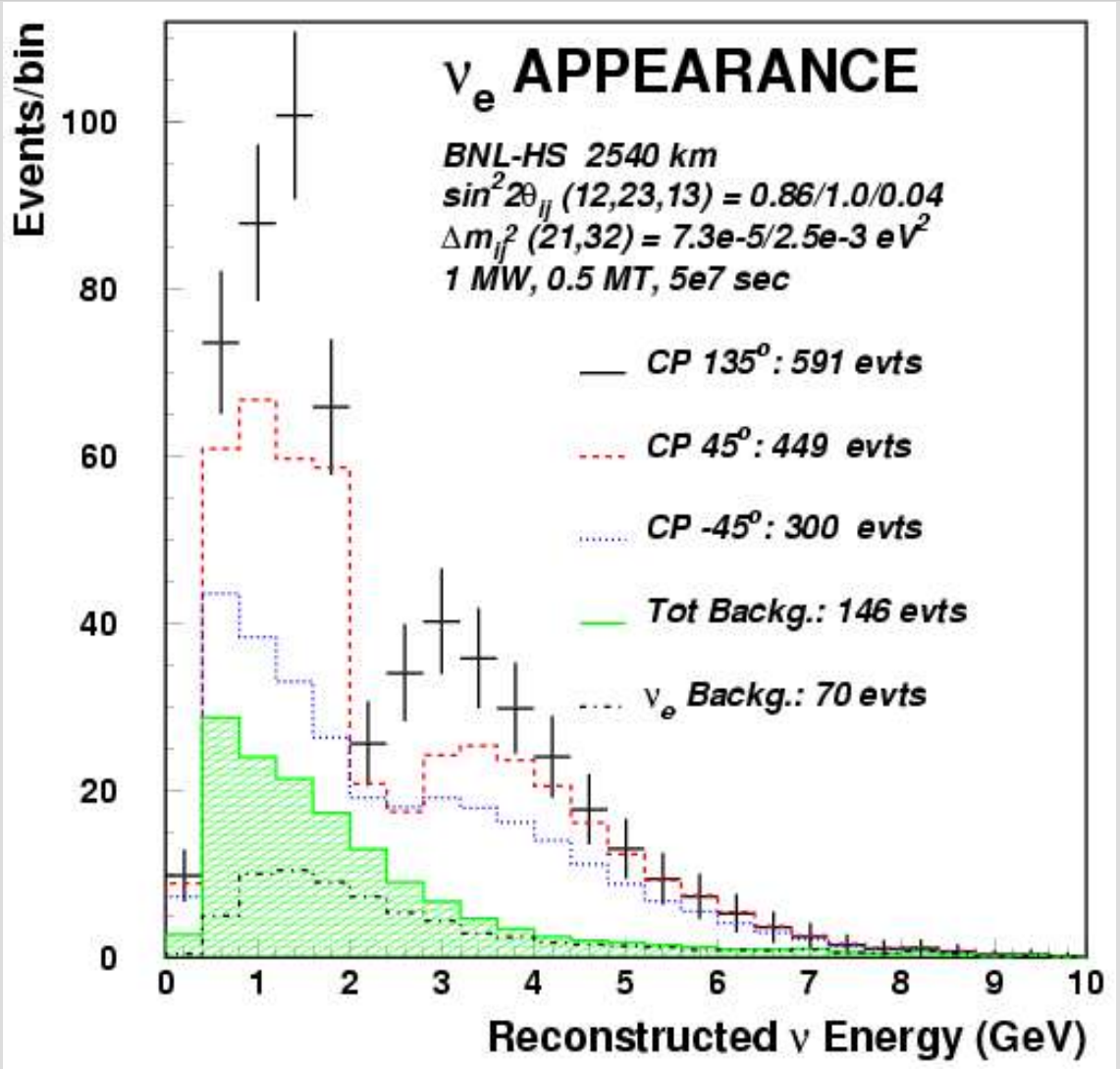
measure $\sin^2 2\theta_{13}$ and δ_{CP}

for $\sin^2 2\theta_{13} > 0.01$

resolve mass hierarchy

include anti-neutrino run:

exclude $\sin^2 2\theta_{13} > 0.003$



if $\sin^2 2\theta_{13}$ too small → δ_{CP} measurement not possible

observation ν_e appearance possible through solar term

Recent Studies

Results assume ν_μ NC background rejection to 1%
in water Cerenkov detector.

Preliminary studies prove this is achievable!

C. Yanagisawa (Stony Brook), 3rd BNL/UCLA workshop
http://www.physics.ucla.edu/hep/proton/proton2005.htm

Comparisons sensitivities for a 2540km and 1290km baseline.

M. Diwan, Proc. Heavy Quarks and Leptons, hep-ex/0407047

Δm^2_{32}, $\sin^2 2\theta_{23}$ & $\sin^2 2\theta_{13}$: shorter distance slightly better

due to statistics, but large systematic contrib.

sign(Δm^2_{32}) & δ_{CP}: longer baseline slightly better

larger matter and CP effects, better S:B
observation of ν_e appearance if θ_{13} too small

Conclusions

- Very long baseline concept developed at BNL:
  shoot 1MW ν beam to 0.5 Mt detector at 2500km
- From AGS CDR: a $273M upgrade is needed (direct cost)
- Precision measurement (% level) of Δm^2_{32} & $\sin^2 2\theta_{23}$
- δ_{CP} can be measured if $\sin^2 2\theta_{13} > 0.01$, and mass hierarchy can be resolved in neutrino running alone.
- Further improvements can be achieved with anti-ν running
- Longer baseline is favored due to smaller dependence on systematic errors and larger matter and CP effects
- Can be achieved with conventional, well known techniques