LBNE Physics and Beam Designs

INT 2010 Workshop, Seattle, WA 8/10/10

Mary Bishai, Brookhaven National Lab

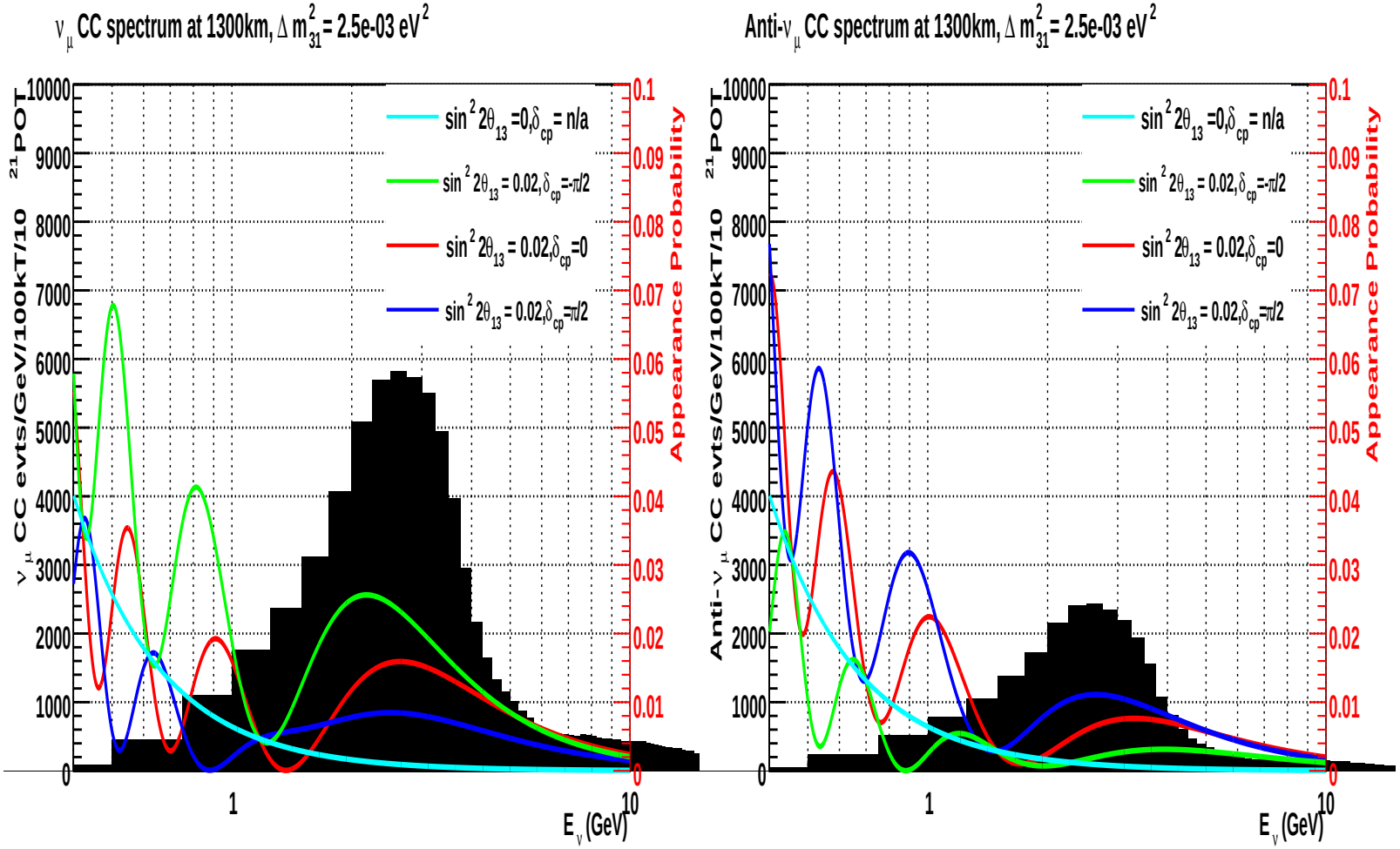
August 10, 2010

Outline

1. Physics with $\nu_\mu \longrightarrow \nu_e$ at 1300km
2. Physics with $\nu_\mu \longrightarrow \nu_\tau$

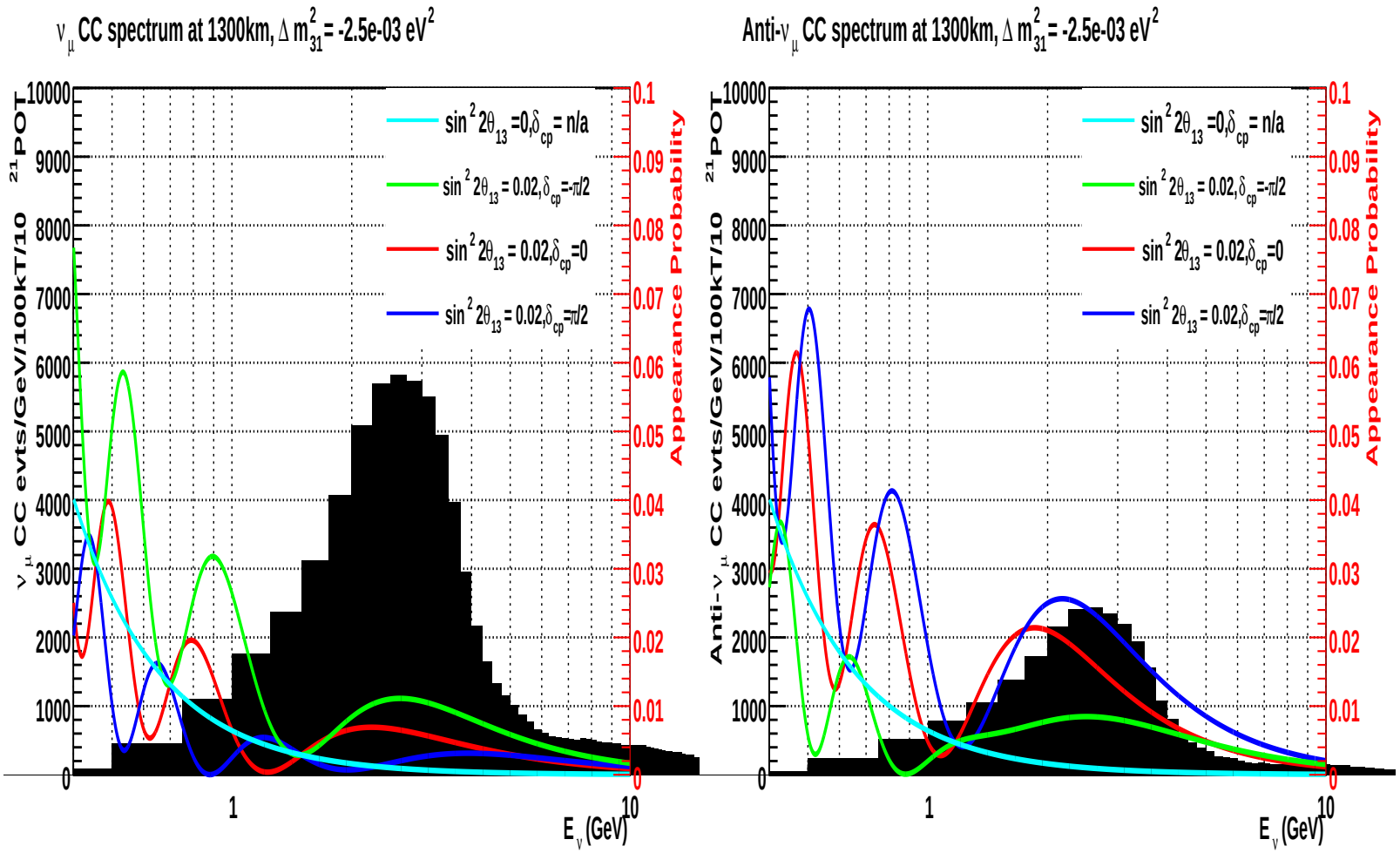
Oscillation and Beam Spectra

Normal hierarchy

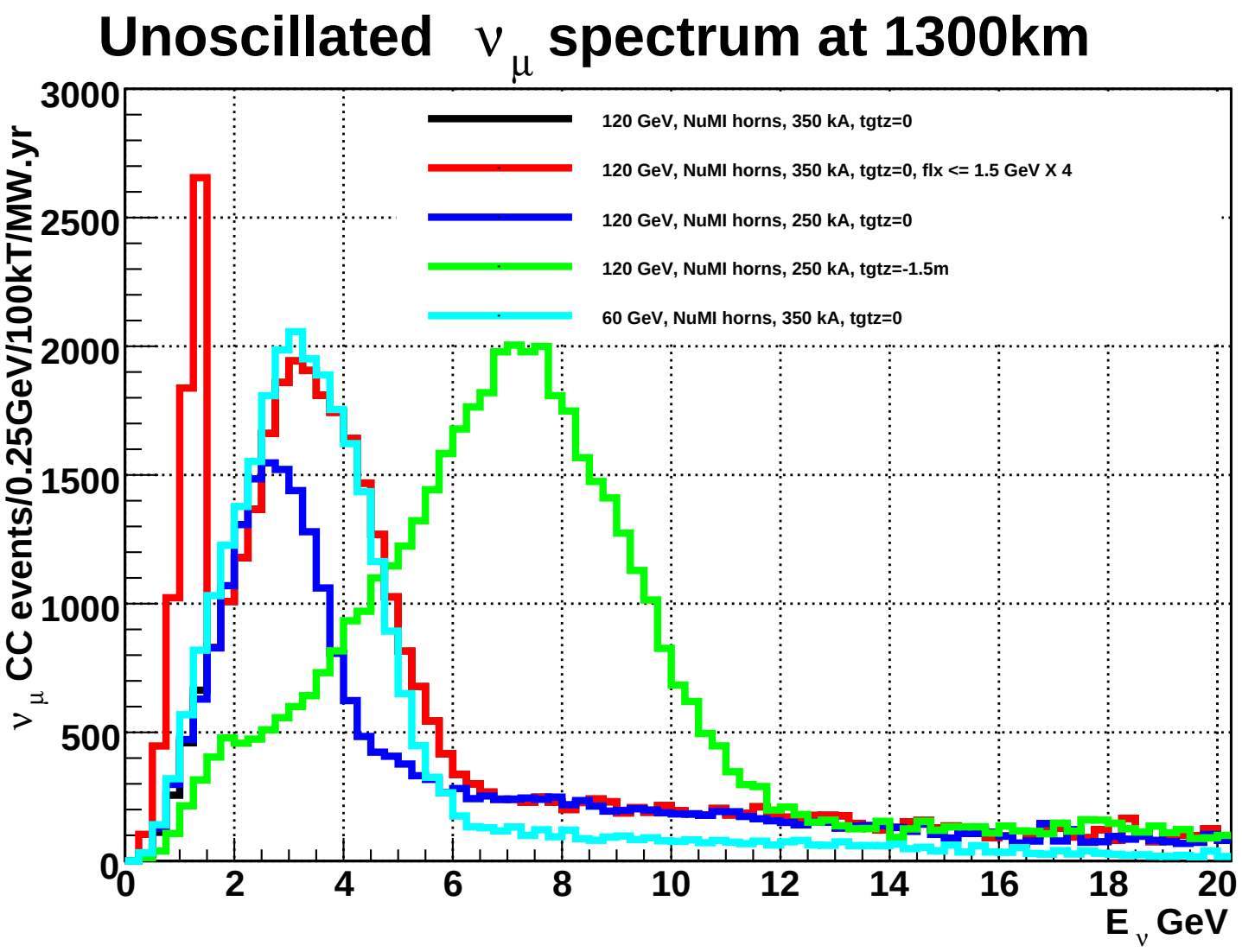


Oscillation and Beam Spectra

Reverse hierarchy



Different Beam Spectra Studied



Measurement of $\sin^2 2\theta_{13}$ and δ_{cp}

$\nu : \bar{\nu}$ 1:1

Using a fit to the appearance spectrum with NO DETECTOR EFFECTS we can access the intrinsic physics capababilities of different beams:

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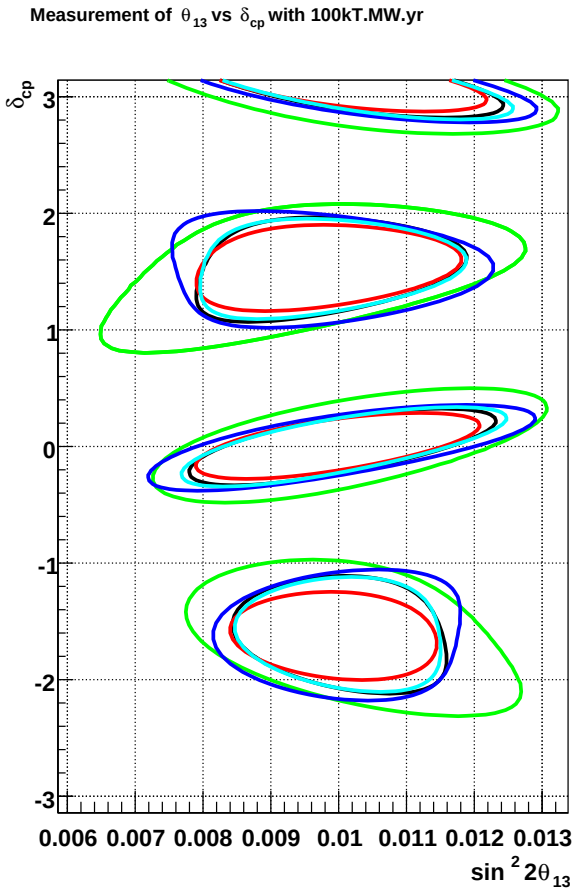
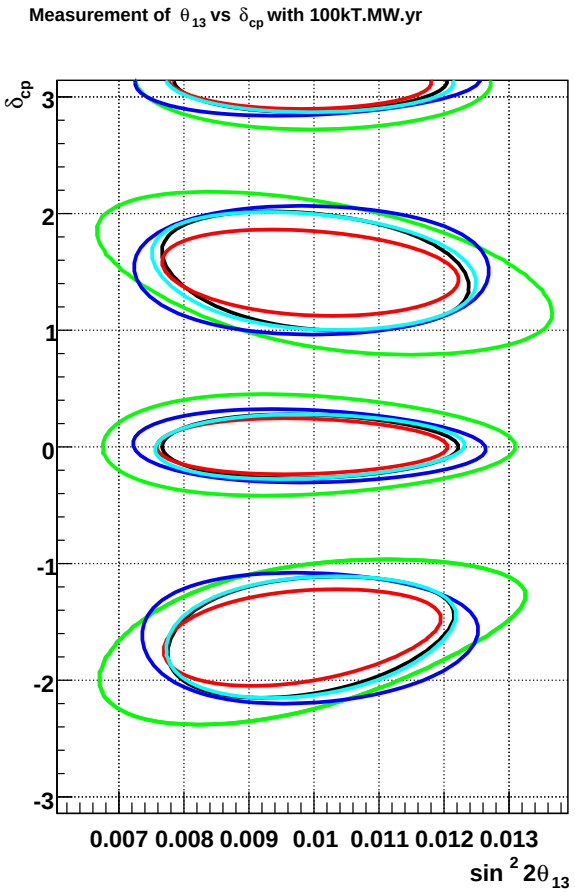
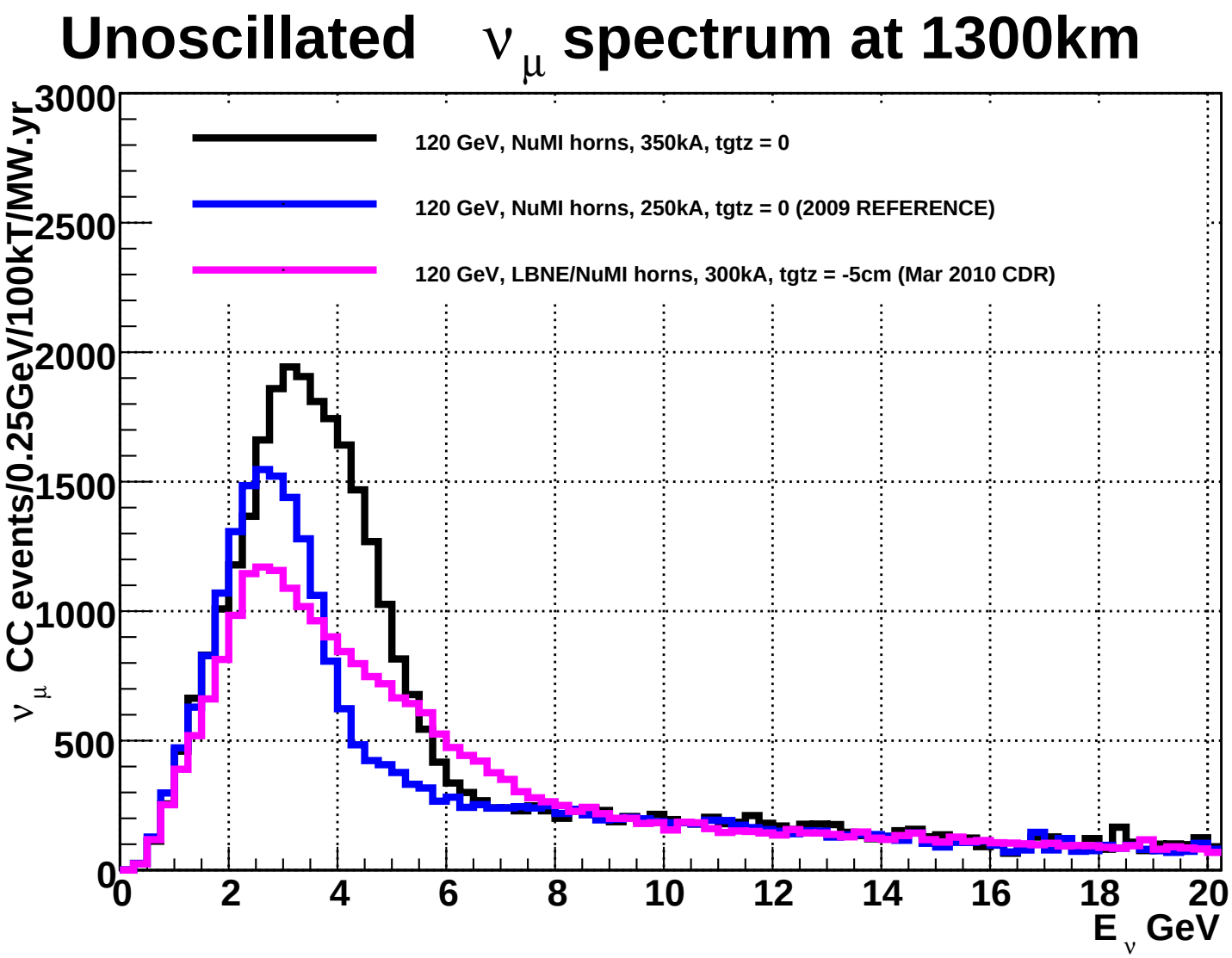


Reverse hierarchy



The CDR design vs 2009 NuMI-like reference beam



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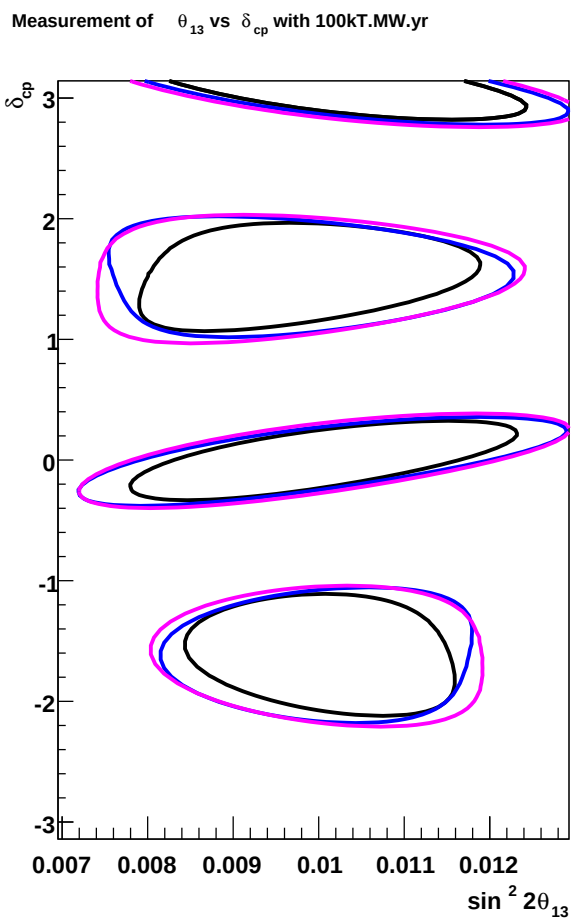
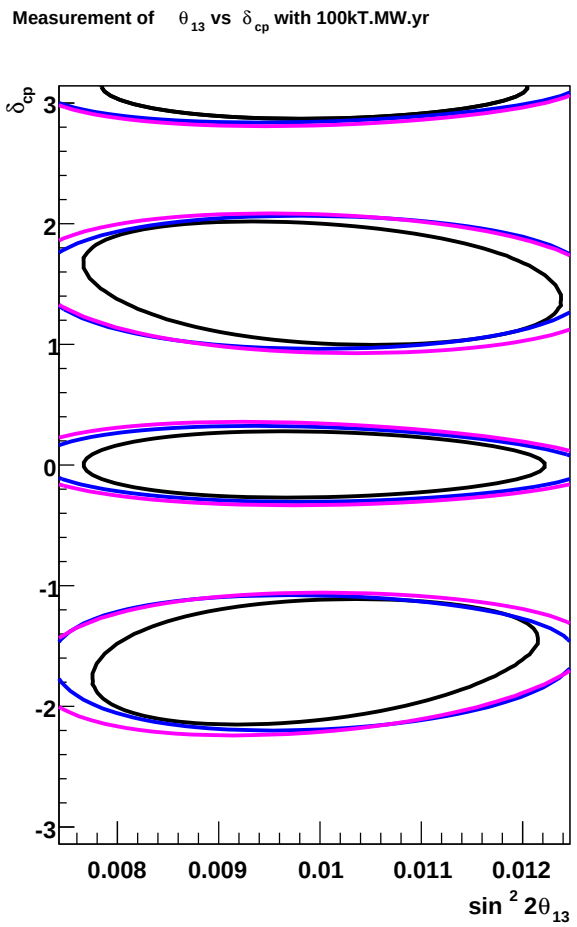
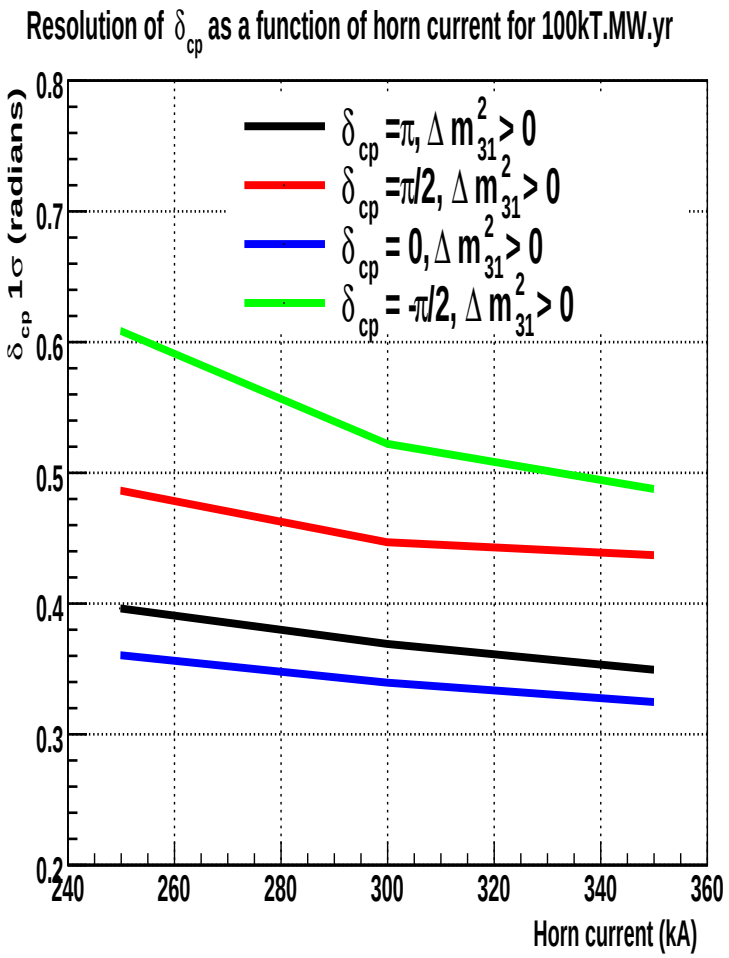


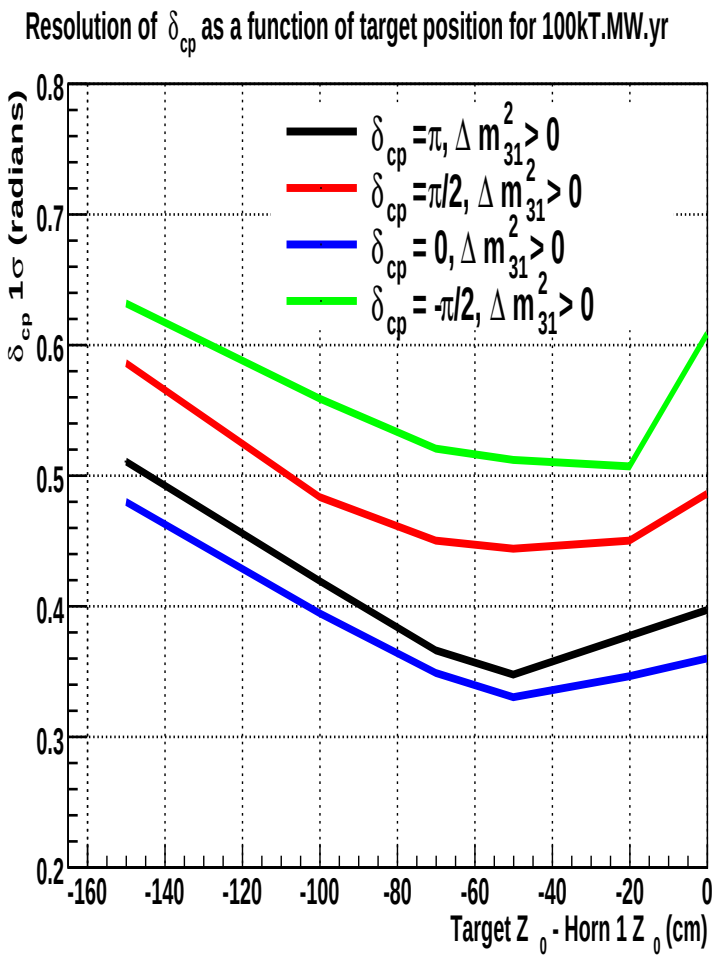
Reverse hierarchy



A New Paradigm for Optimizing Beam Designs

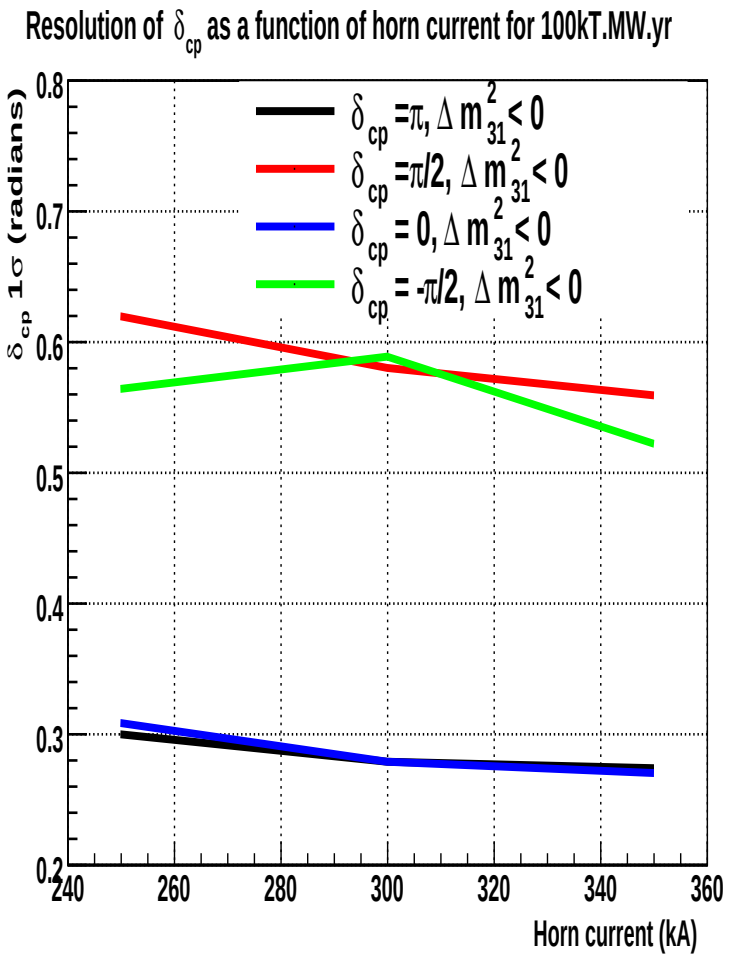
Normal Hierarchy

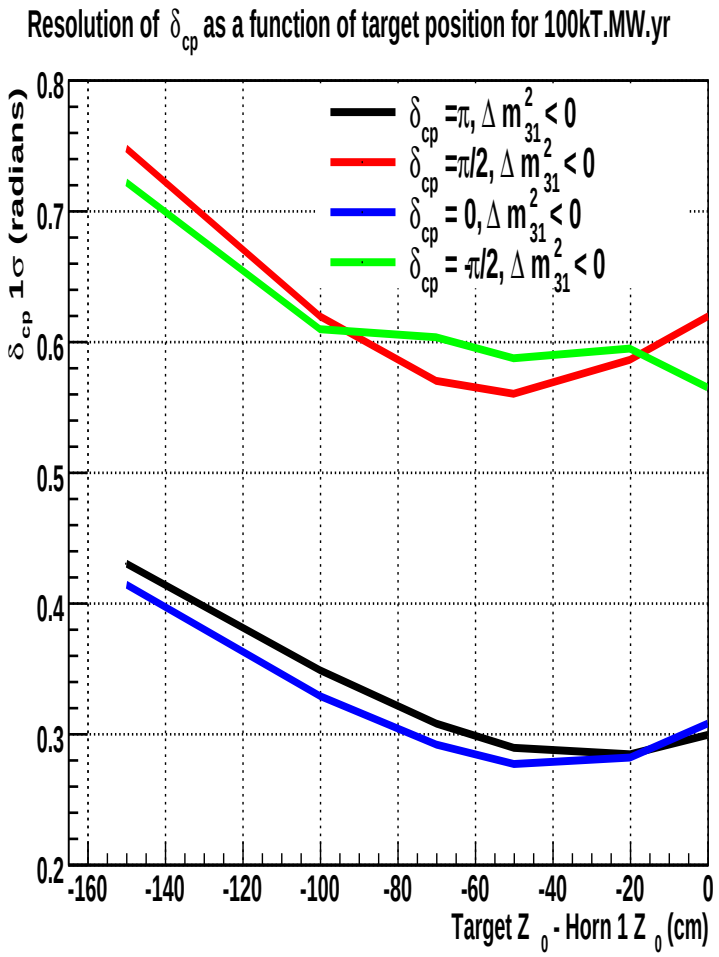




A New Paradigm for Optimizing Beam Designs

Inverted Hierarchy



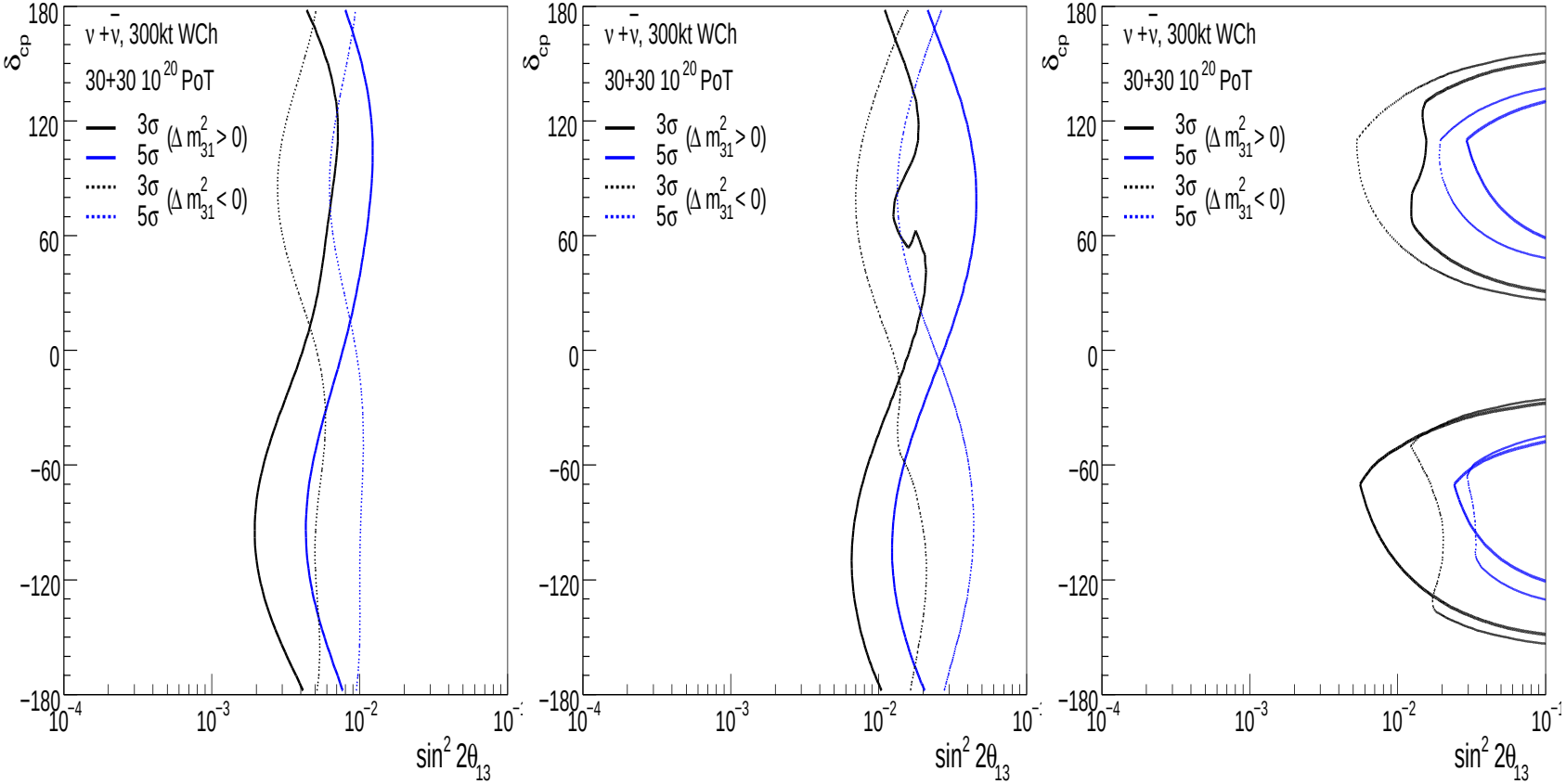


Is Optimal Beam + Detector = Best Expt?

WCe 2009 beam designs

Mark Dierckxsens

$\sin^2 2\theta_{13} \neq 0$ **mass hierarchy** **$\delta_{cp} \neq 0, \pi$**



Default: 120 GeV, 250kA, no plug, 3+3 MW.yr

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Physics with $\nu_\mu \longrightarrow \nu_e$ at 1300km

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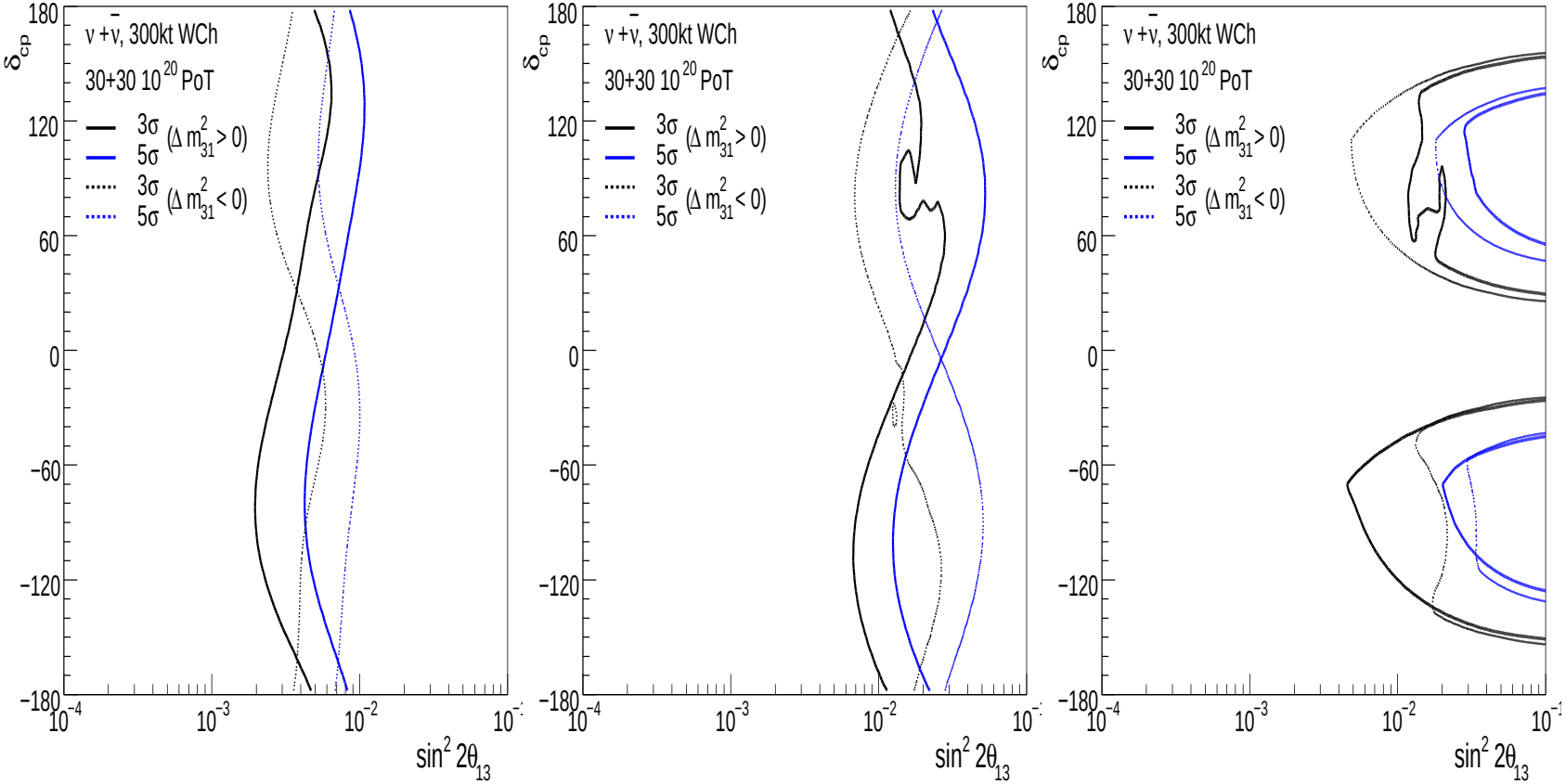
$\sin^2 2\theta_{13} \neq 0$ **mass hierarchy** **$\delta_{cp} \neq 0, \pi$**



Largest signal: 120 GeV, 350kA, no plug, 3+3 MW.yr

Sensitivities for ν vs $\bar{\nu}$ running

WCe 200kT

Lisa Whitehead

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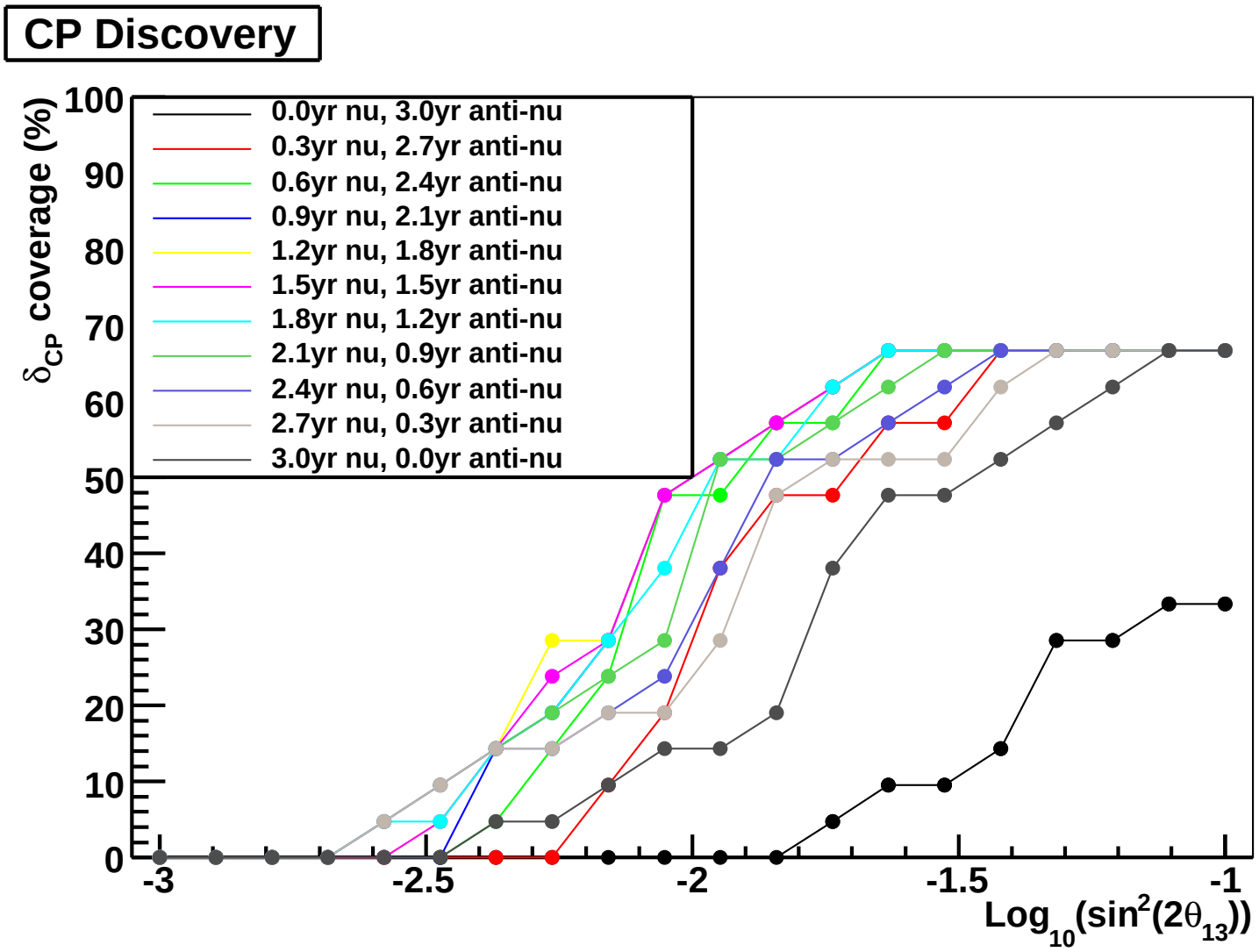

ν_τ appearance rates

Off-axis	ν_μ CC	ν_μ CC osc	ν_e CC beam	NC-1π^0	$\nu_\mu \rightarrow \nu_e$ CC	$\nu_\mu \rightarrow \nu_\tau$ CC
LBNE 120 GeV LE tune at 1300 km						
0km	103.555	38.6494	1.11656	1.97985	2.02658	0.516844
12km	78.2479	33.3195	0.848907	1.47473	1.40496	0.432345
23km	37.3308	20.4992	0.535284	0.726417	0.534162	0.177616
57km	4.84188	2.44314	0.112944	0.0621709	0.0977932	0.0154812
LBNE 120 GeV HE1 tune at 1300 km						
0km	221.975	141.334	1.62529	2.73066	2.41004	3.17395
12km	70.6879	31.0312	1.04706	1.16763	1.22622	0.444722
23km	24.1803	12.5287	0.482609	0.425847	0.368477	0.163741
57km	2.9185	1.42326	0.0813795	0.0459469	0.054992	0.0111908
LBNE 120 GeV HE2 tune at 1300 km						
0km	233.221	174.689	1.37975	2.32893	1.72884	3.98009
12km	50.8549	24.4061	0.891302	0.803728	0.814372	0.378541
23km	18.8327	9.72962	0.389099	0.310801	0.28574	0.143066
57km	2.22623	1.08523	0.0673788	0.0409784	0.0407686	0.010099

Conclusions

- **We need to reconsider the optimal LBNE beam spectrum with an emphasis on δ_{cp} measurement.**
- **High energy beam tunes in principal could also be used to measure δ_{cp} and θ_{13}, with slightly worse resolution, but would open up possibilities for other physics searches.**
- **We need to add new physics sensitivity calculations with a high energy beam options.**
- **How do we produce a low energy neutrino beam? We can use this beam to observe ν_e appearance conclusively at 1300km - large CP effects. DAEDLUS?.**
- **How do we better interact with the beam project at FNAL?**