Baselines and Oscillation Nodes

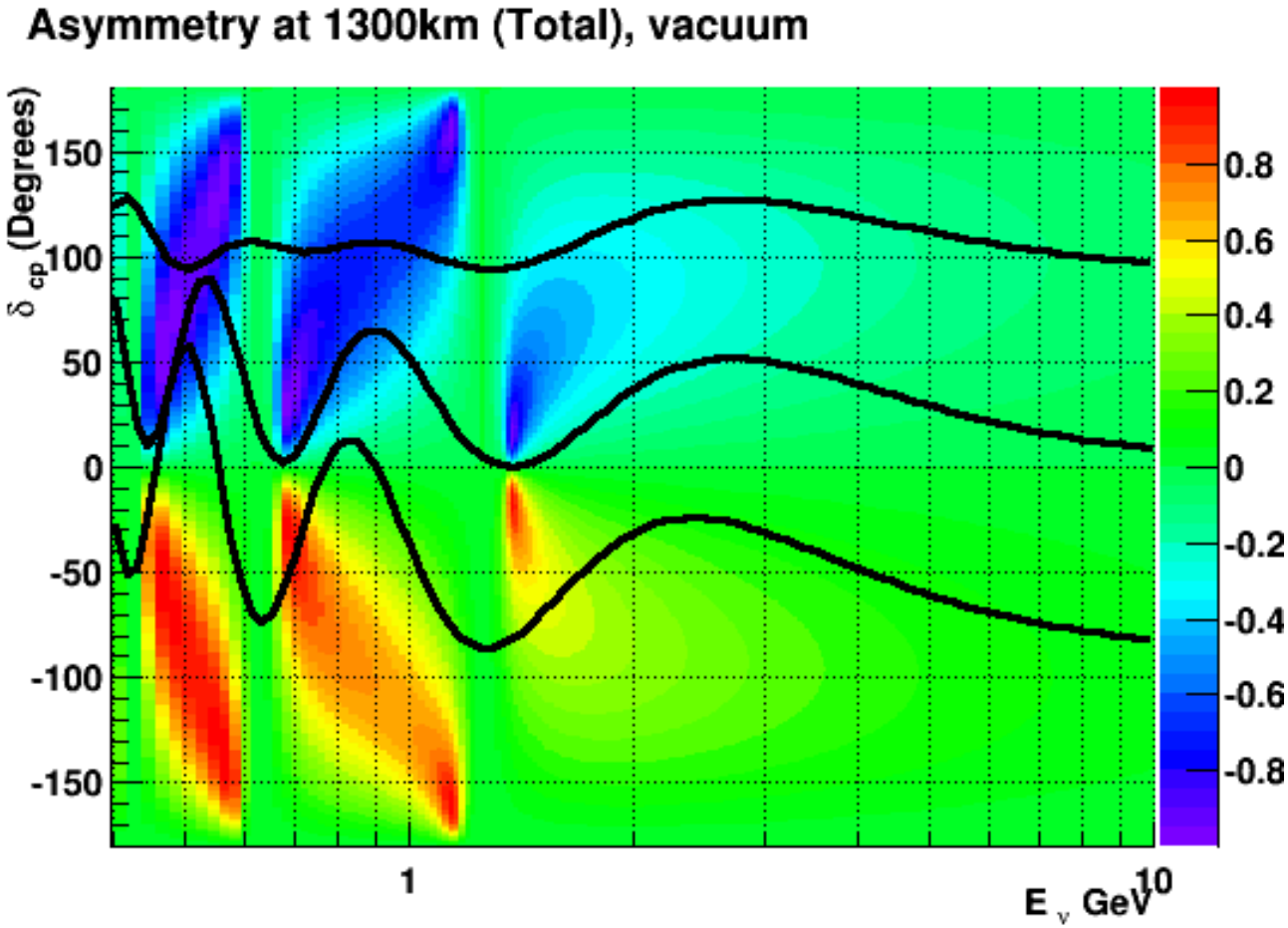
LBPWG, 08/08/2013

Mary Bishai

August 20, 2014

Outline

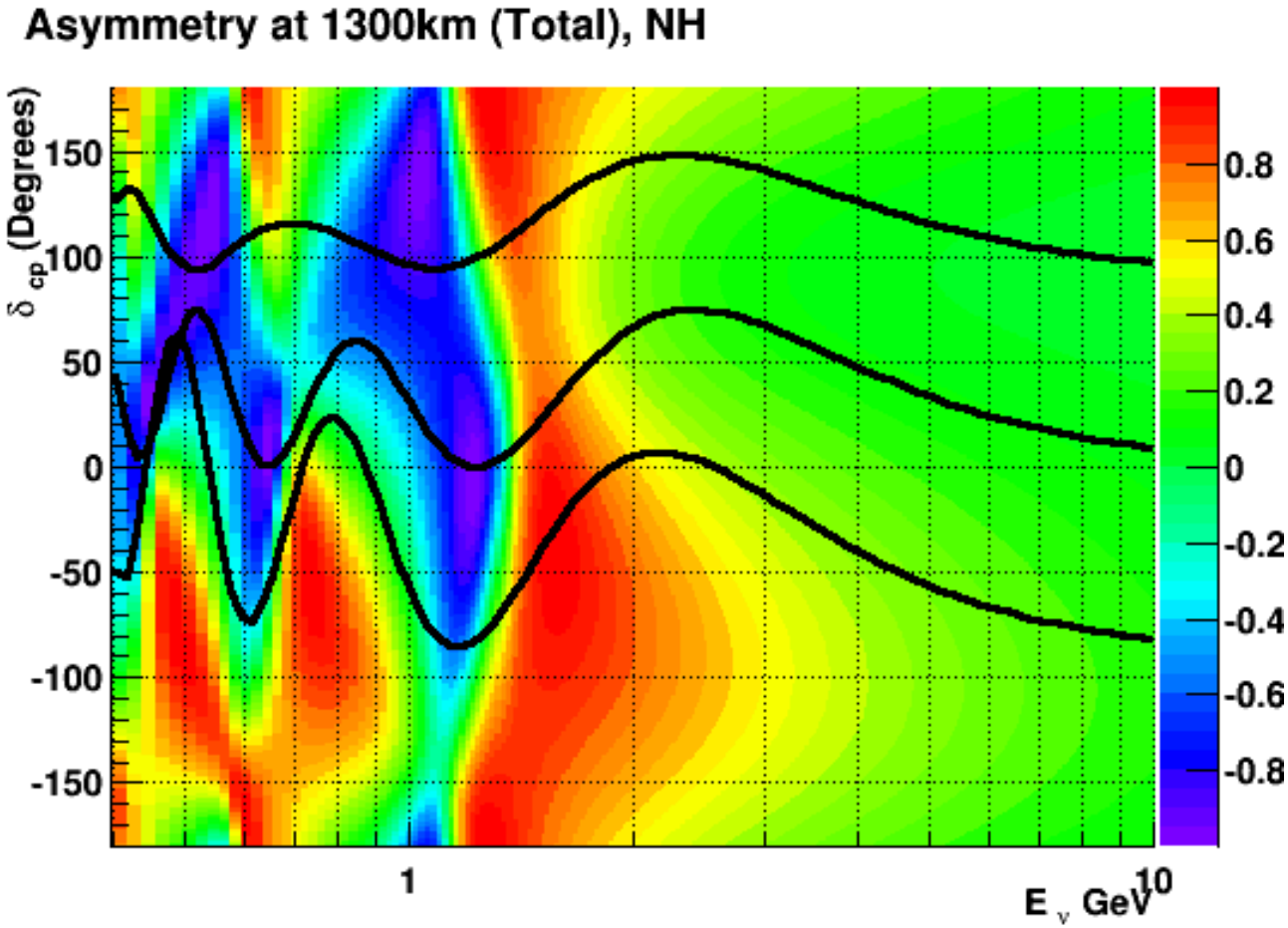
CP Asymmetry vs E_ν and δ_{cp}



Asymmetries are larger near minima

BUT, events appear at the maxima!

CP Asymmetry vs $\mathbf{E}_\nu$ and $\delta_{\mathbf{cp}}$



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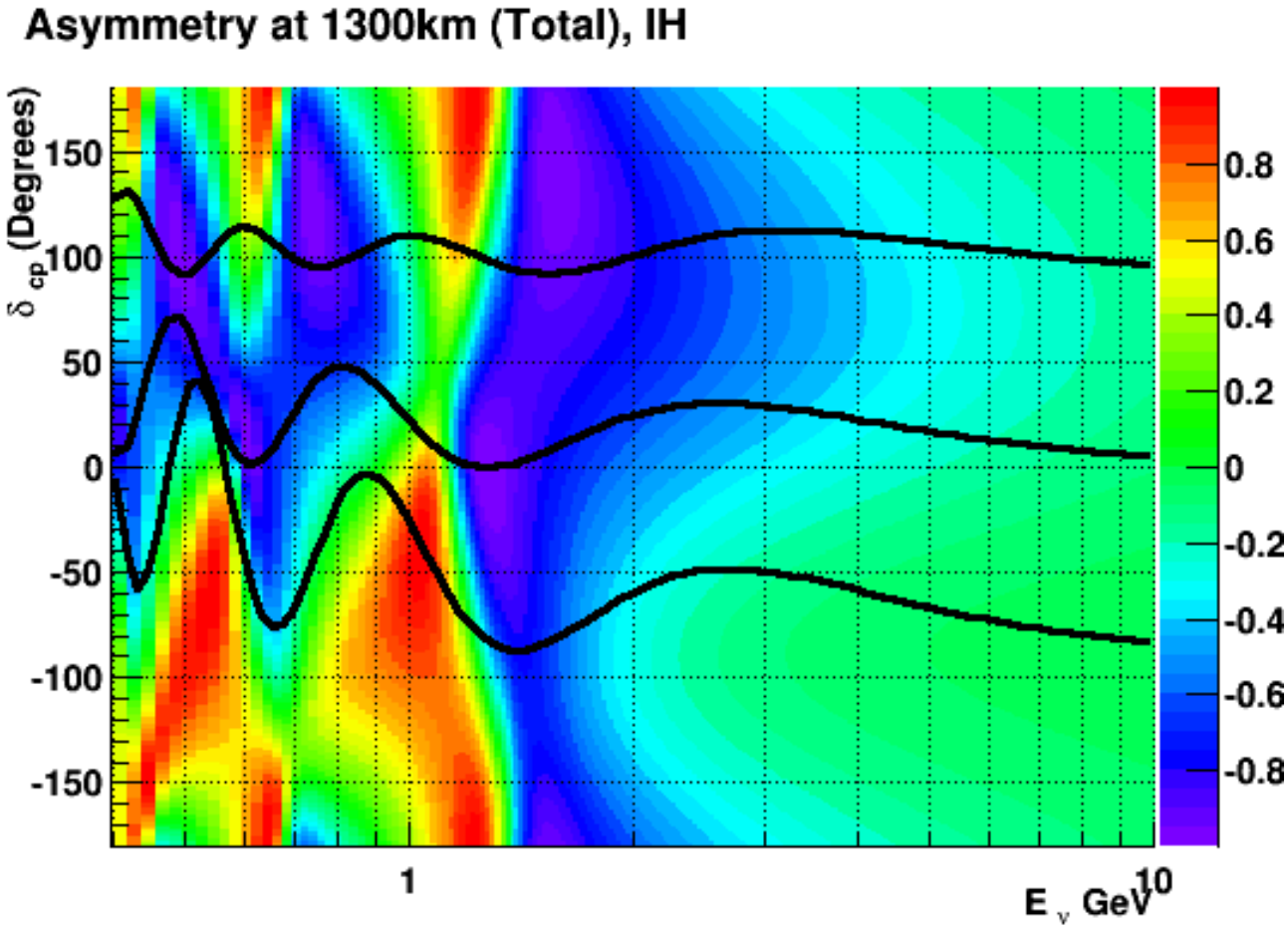

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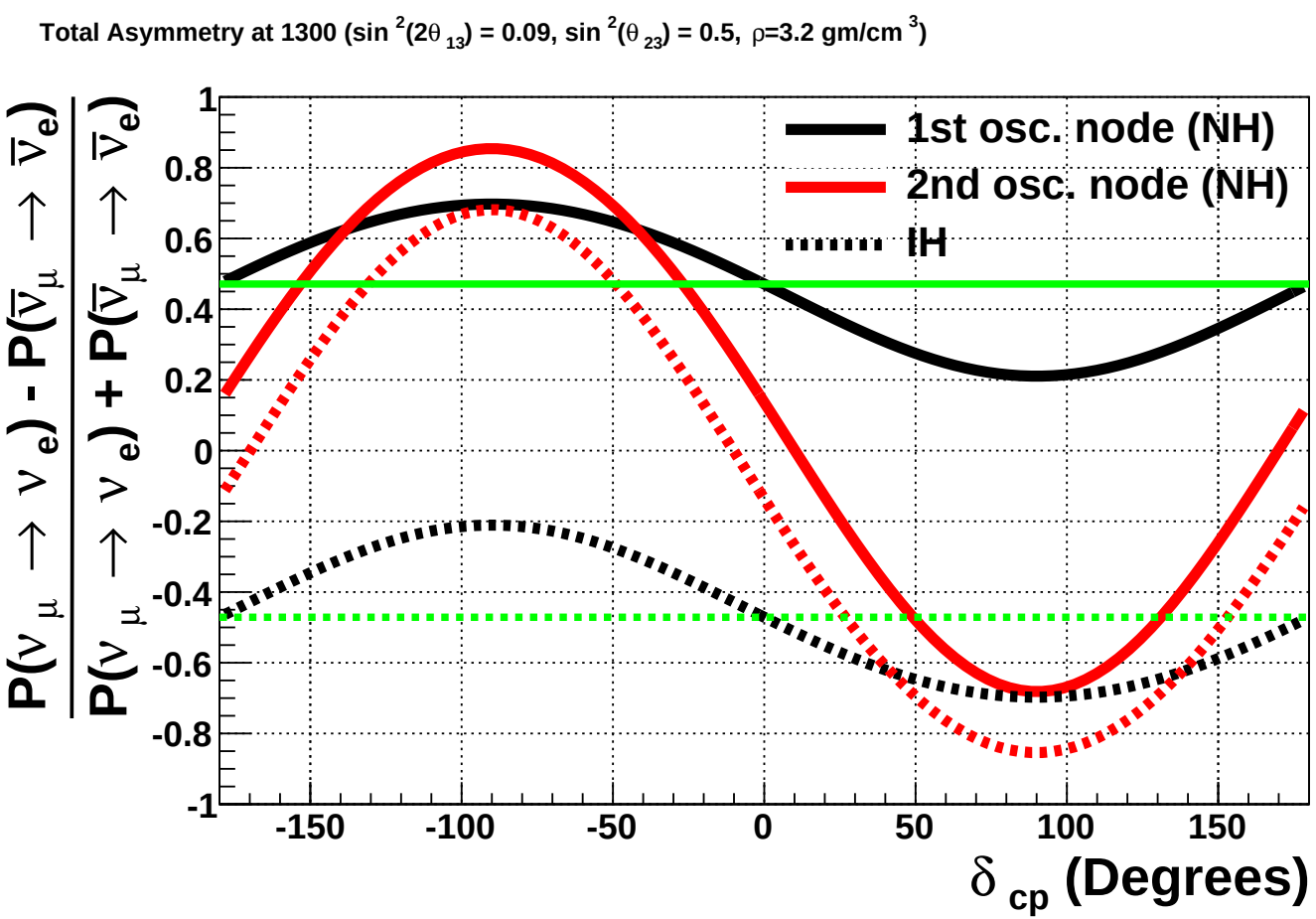
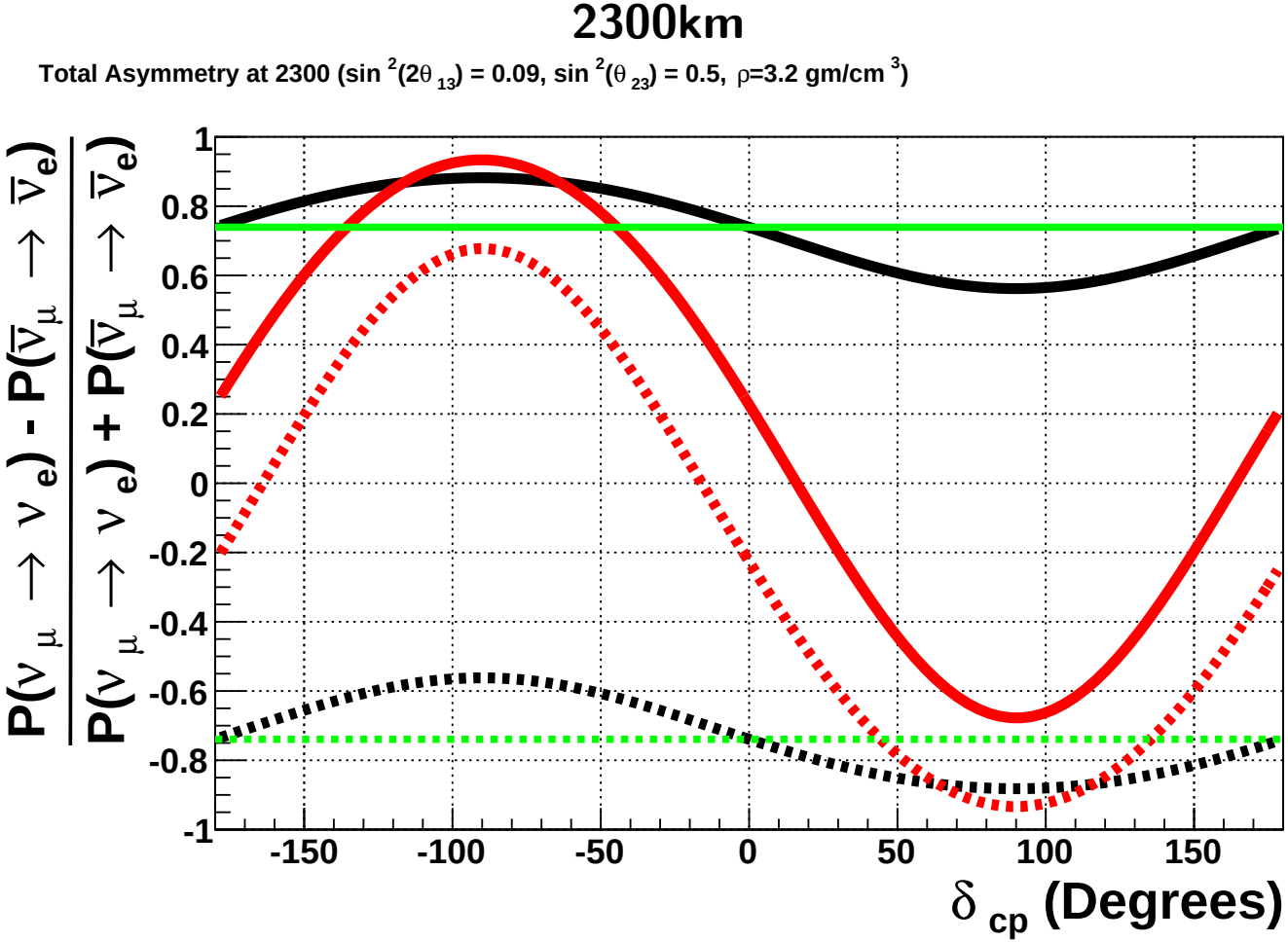
Matter and CP Asymmetries at Maxima



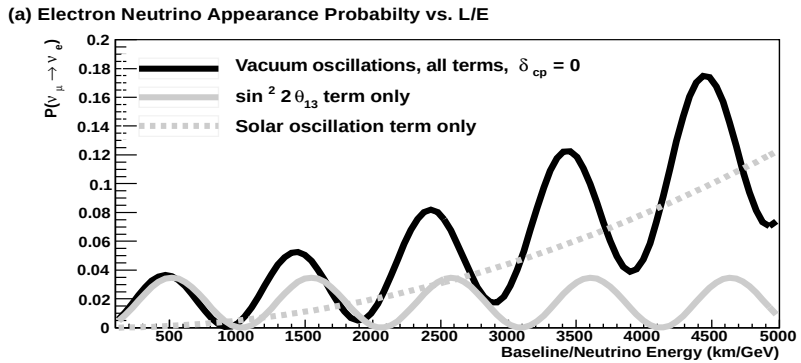
$$\mathcal{A}^1_{\text{matter}} = 0.5,\ \mathcal{A}^1_{\text{CP}} = 0.2$$
$$\mathcal{A}^2_{\text{matter}} = 0.1,\ \mathcal{A}^2_{\text{CP}} = 0.7$$

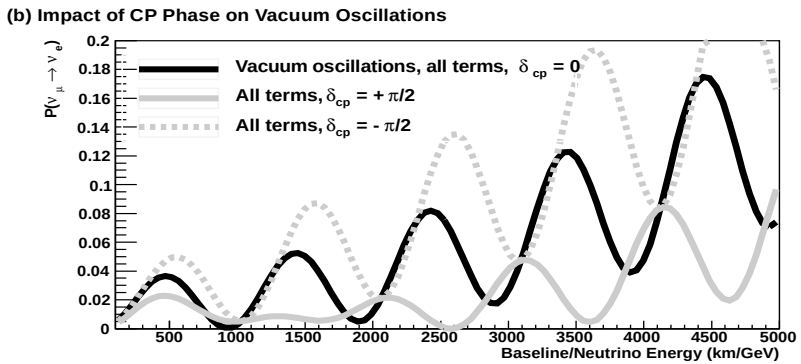
Matter and CP Asymmetries at Maxima

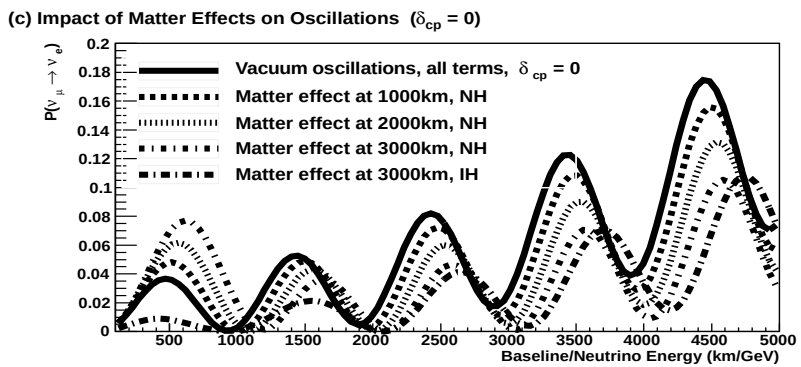


$$\mathcal{A}^1_{\text{matter}} = 0.75,\ \mathcal{A}^1_{\text{CP}} = 0.2$$
$$\mathcal{A}^2_{\text{matter}} = 0.2,\ \mathcal{A}^2_{\text{CP}} = 0.7$$

Osc. vs L/E







1st oscillation node is from $L/E \sim 100\mathrm{km/GeV}$ to 1000 km/GeV

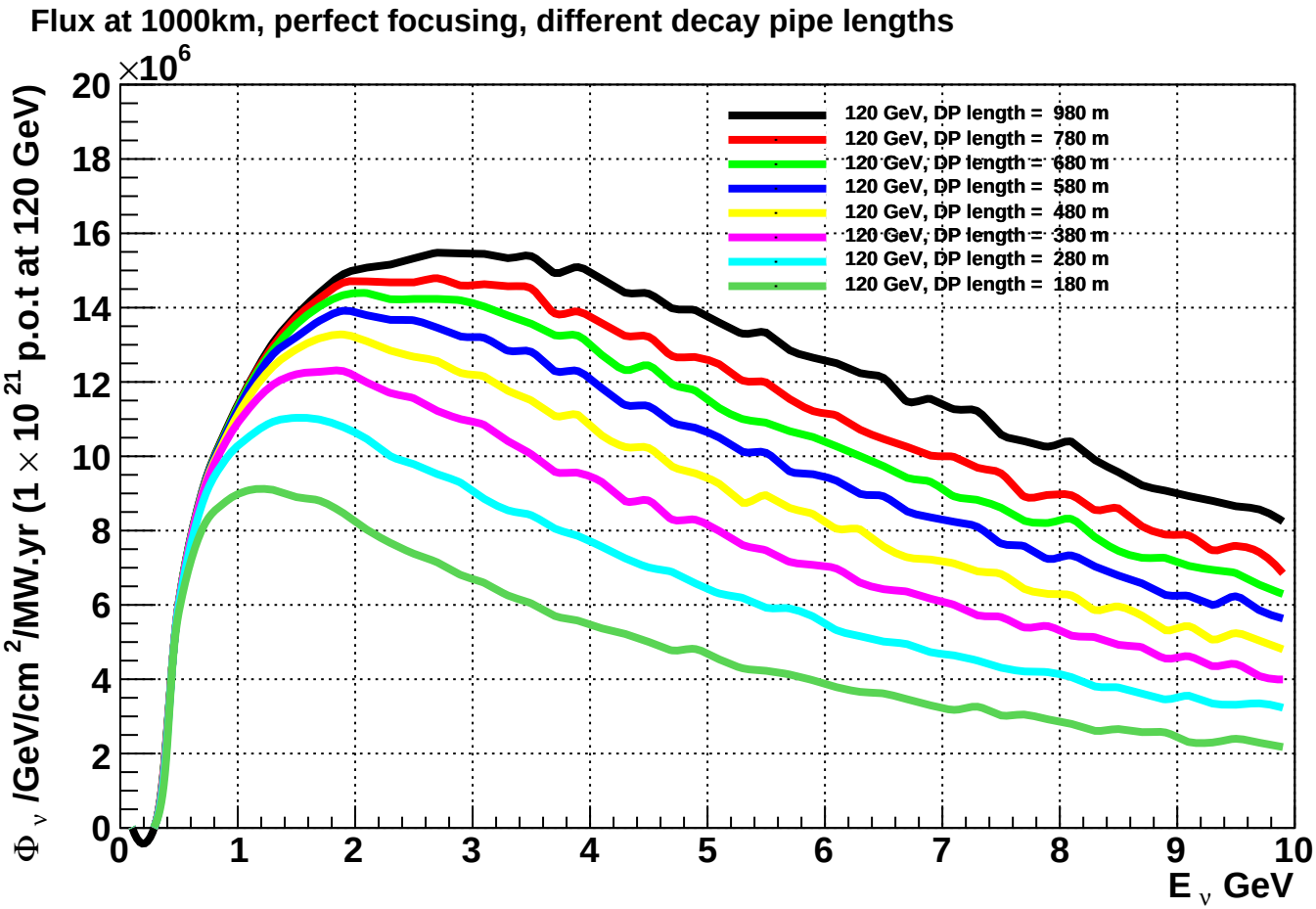
2nd oscillation node is from $L/E \sim 1000\mathrm{km/GeV}$ to 2000 km/GeV

Assuming flat flux and $\sigma^2_\nu/\sigma^1_\nu = 0.4$, integrated event rates in vacuum over 1st and 2nd oscillation nodes are:

$$\frac{R^2}{R^1} = \frac{(1/1000 - 1/2000)}{(1/100 - 1/1000)} \times \frac{0.05}{0.035} \times 0.4 = 3\%$$

Neutrino fluxes with perfect focusing

120 GeV, decay channel lengths from 200m to 1km



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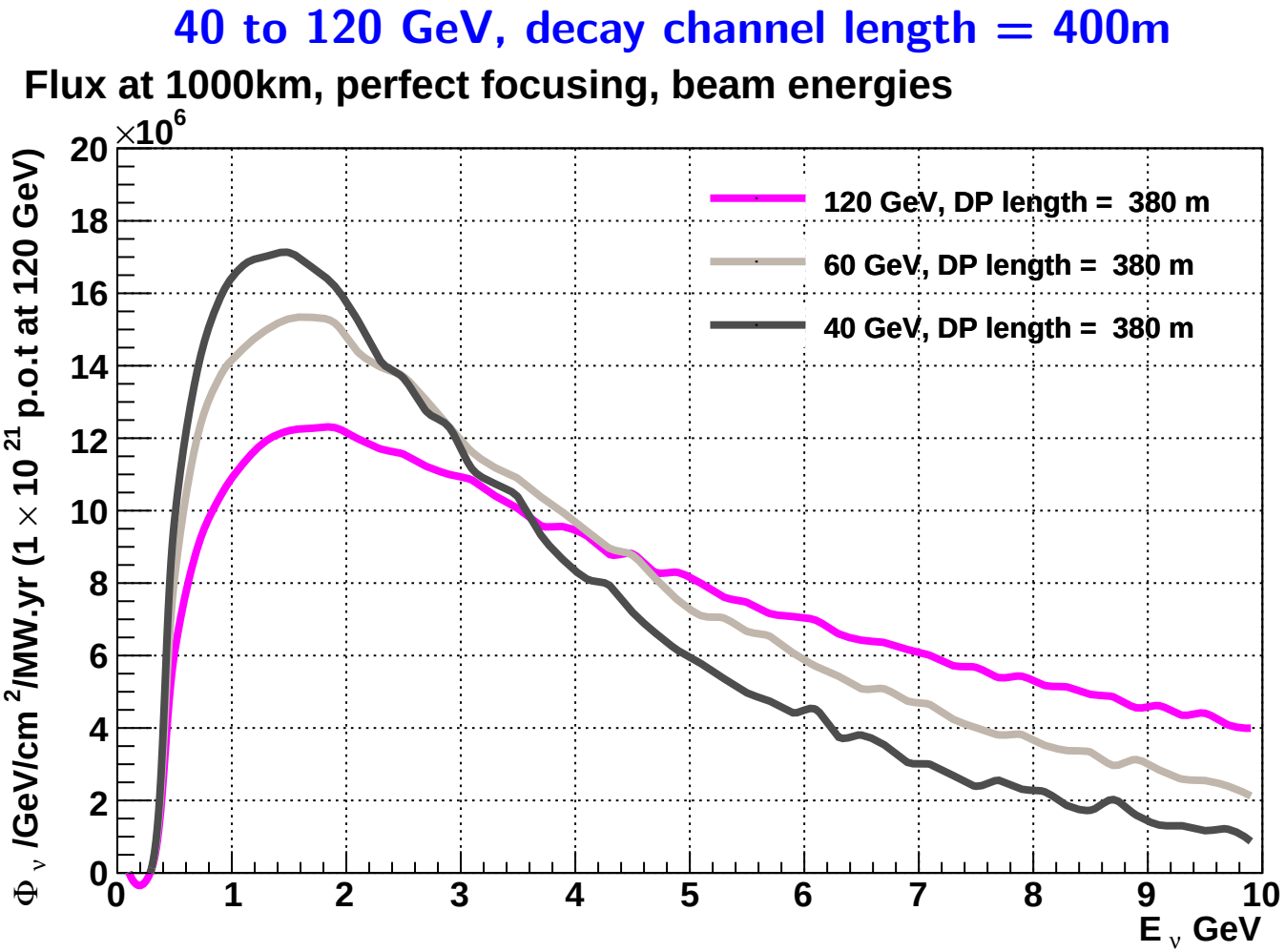

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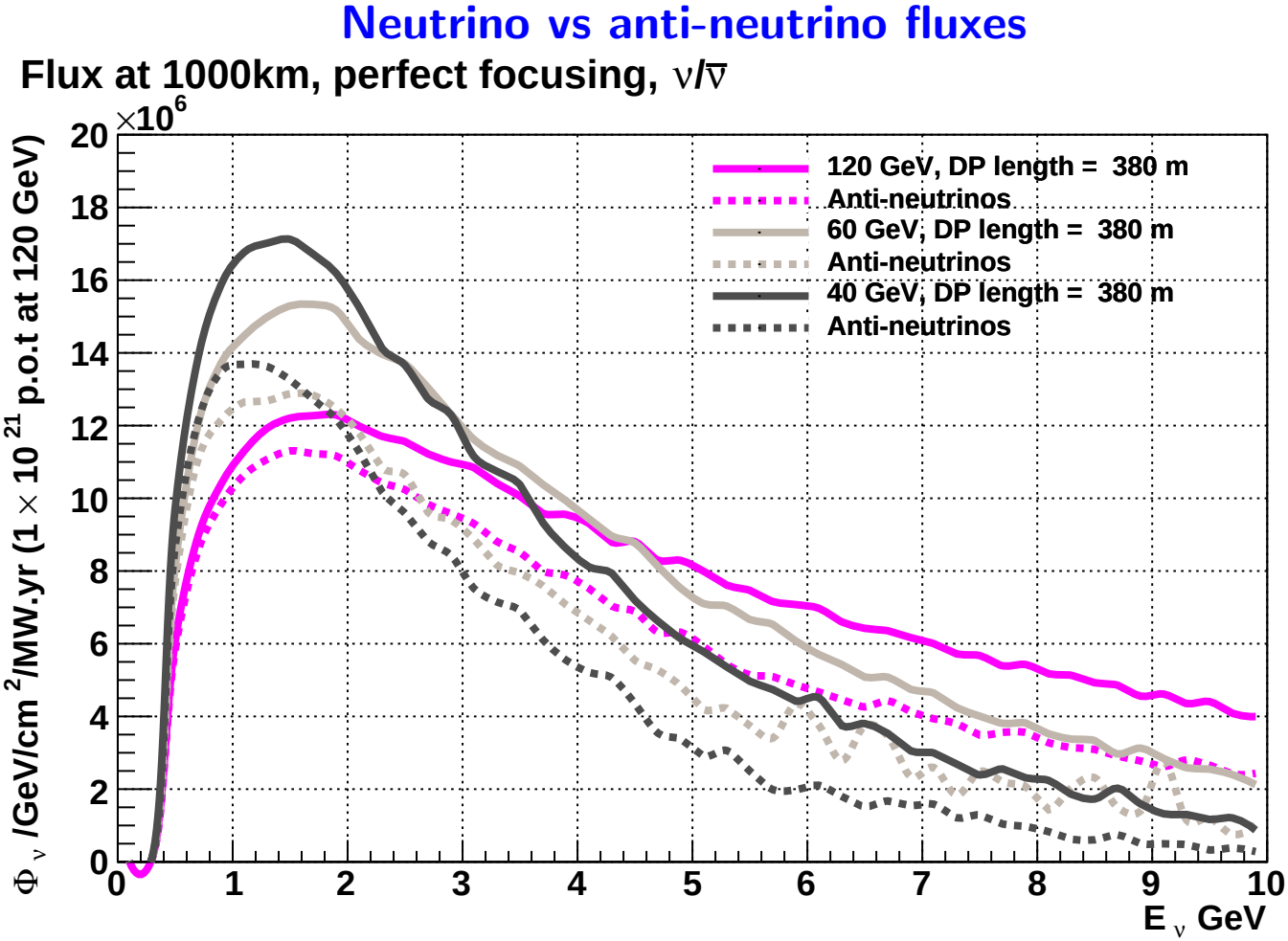

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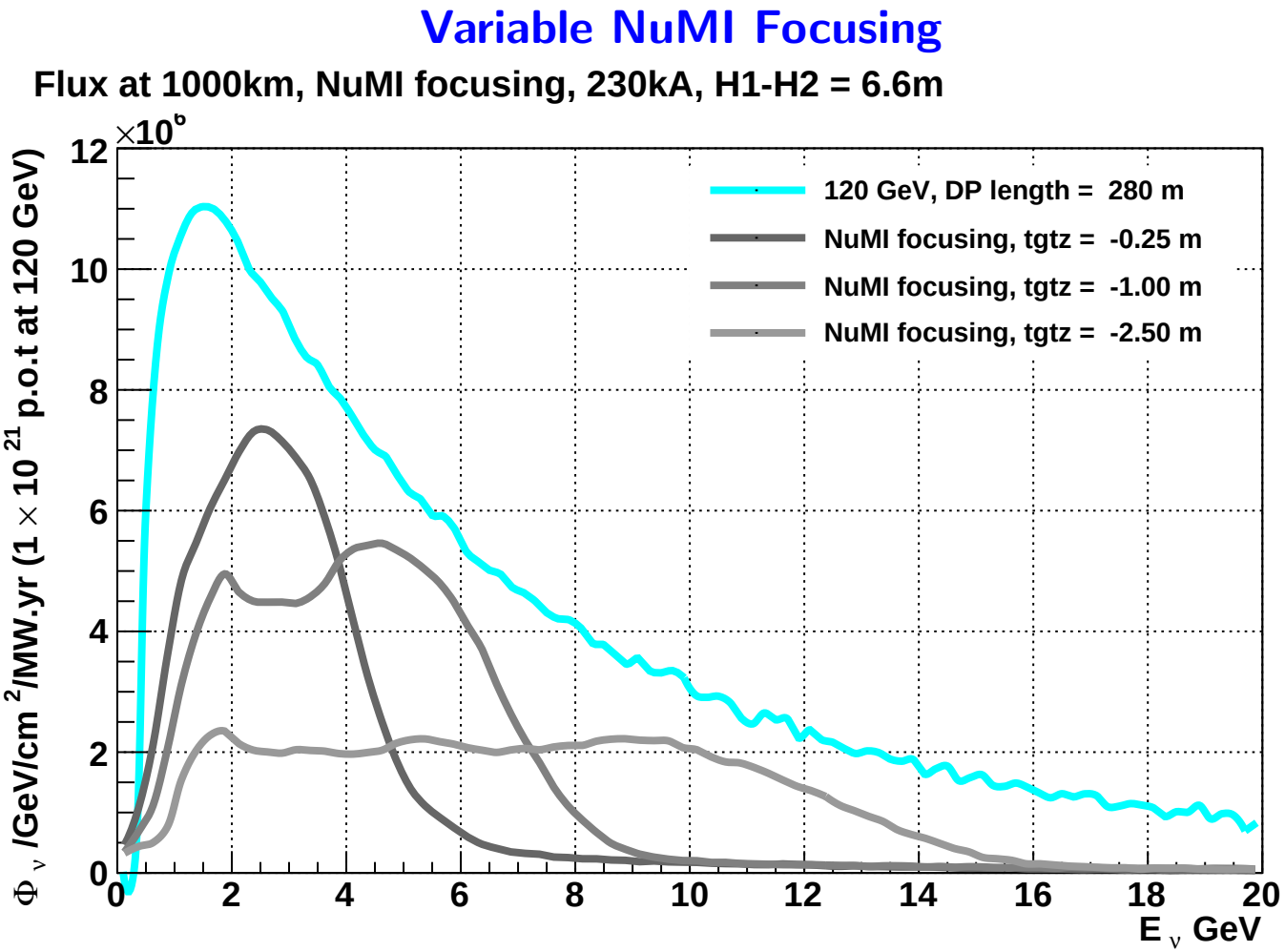


Event Rates vs. Baseline

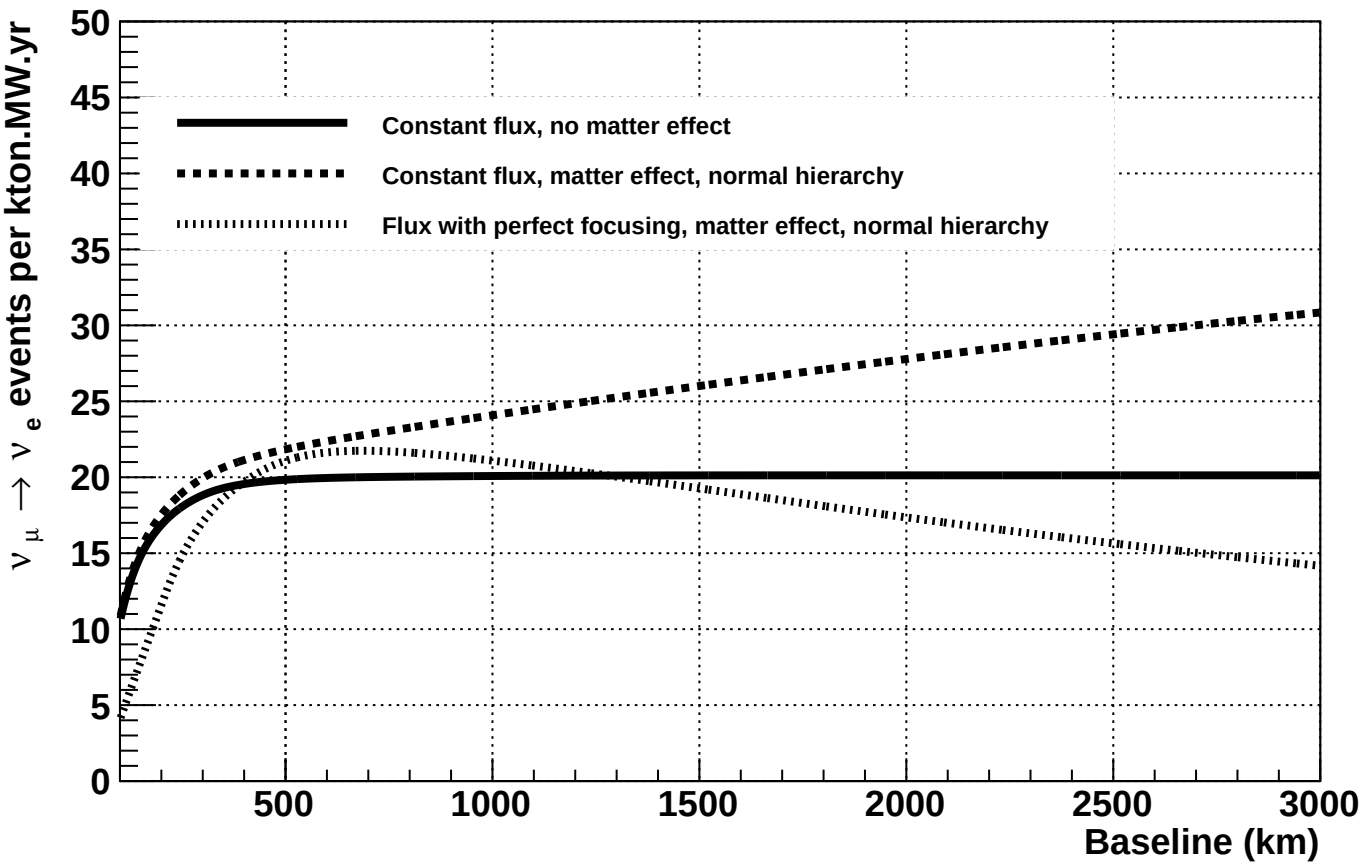
$$\mathcal{R} = \int \Phi^{\nu_\mu}_{\text{perfect}}(E_\nu) \times \sigma(E_\nu) \times P(\nu_\mu \rightarrow \nu_e)\, dE_\nu$$

$(\sin^2 2\theta_{13} = 0.09, \sin^2\theta_{23} = 0.5, \delta_{cp} = 0, |\Delta m^2_{31}| = 2.4 \times 10^{-3})$

Flux: 120 GeV, perfect focusing, $\sim$ 400m decay channel, on-axis

Normal Hierarchy

Appearance rates versus baseline



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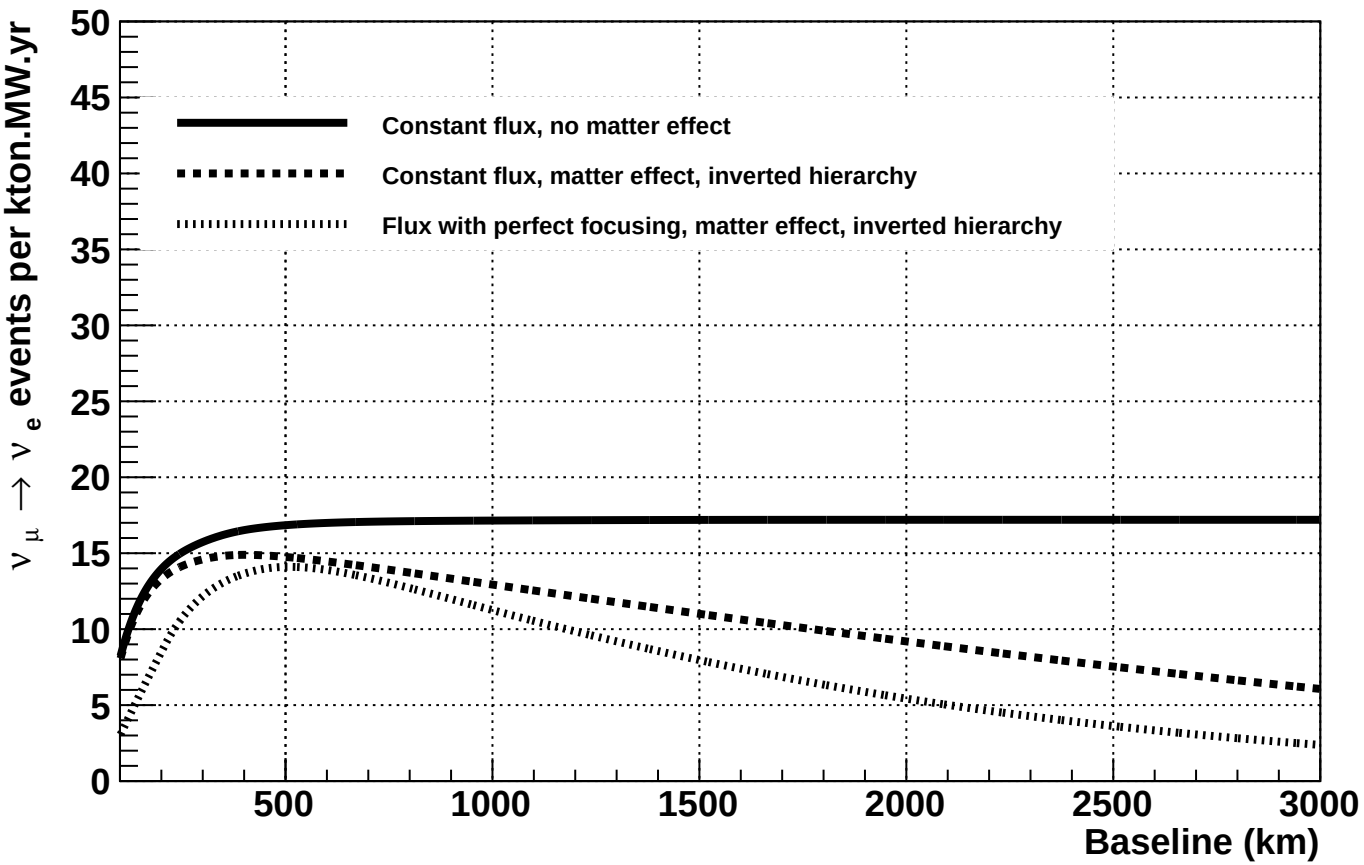

Event Rates vs. Baseline at 1st and 2nd Osc. Nodes

1^{st} osc. node from $E_1 = 1.267|\Delta m^2_{31}|L/\pi$ to $10 \times E_1$

2^{nd} osc node from $E_2 = 1.267|\Delta m^2_{31}|L/(2\pi)$ to E_1

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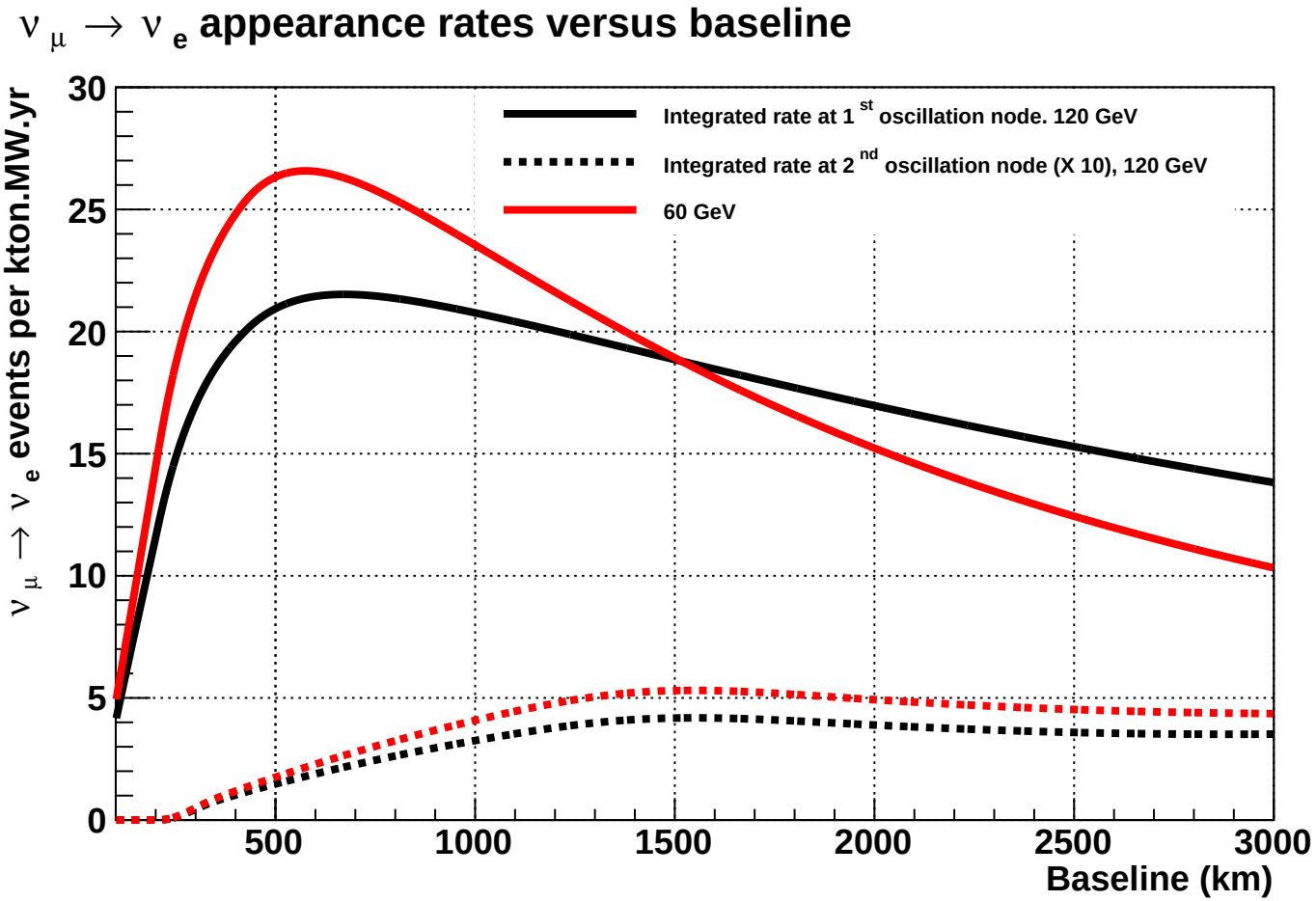

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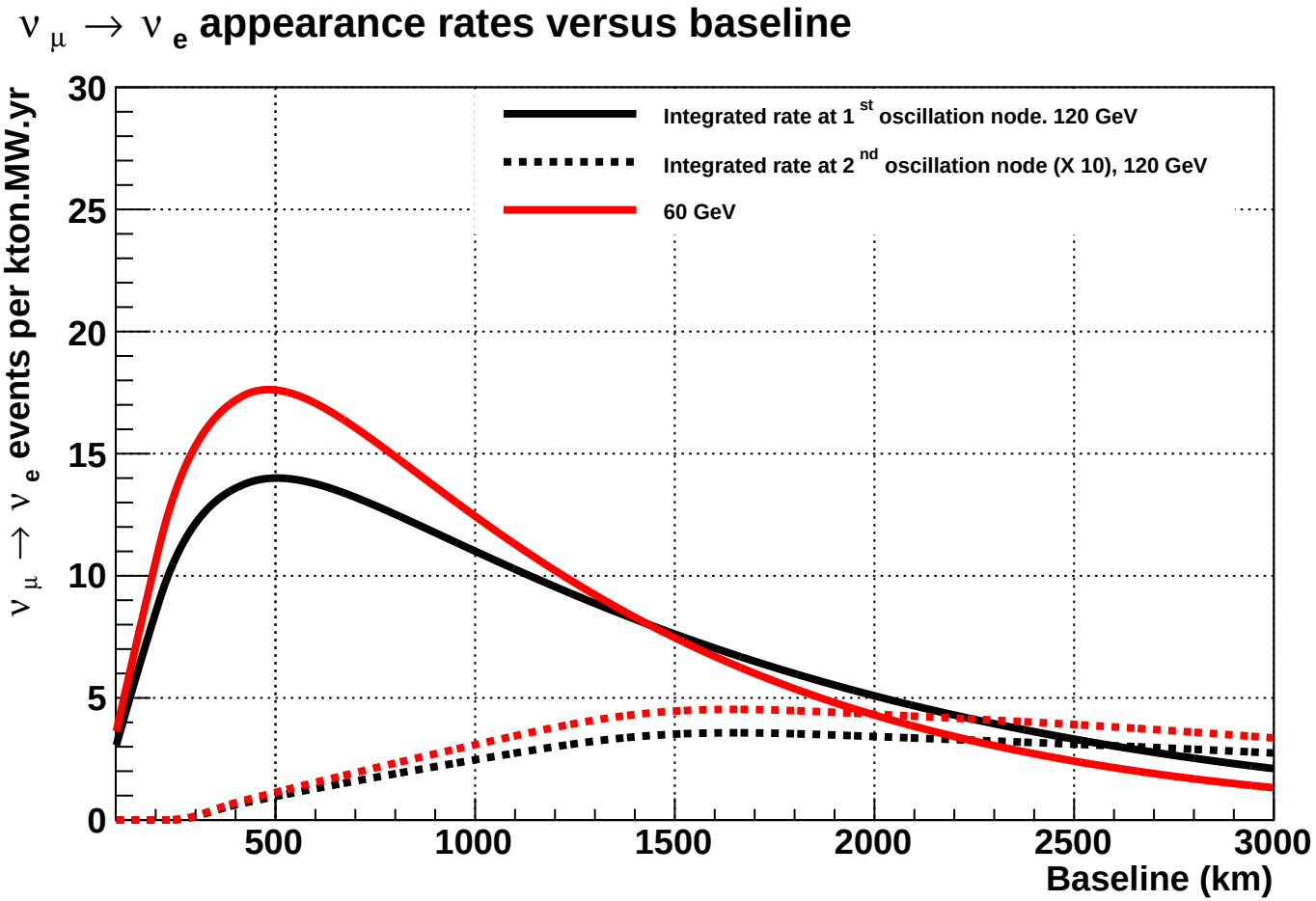

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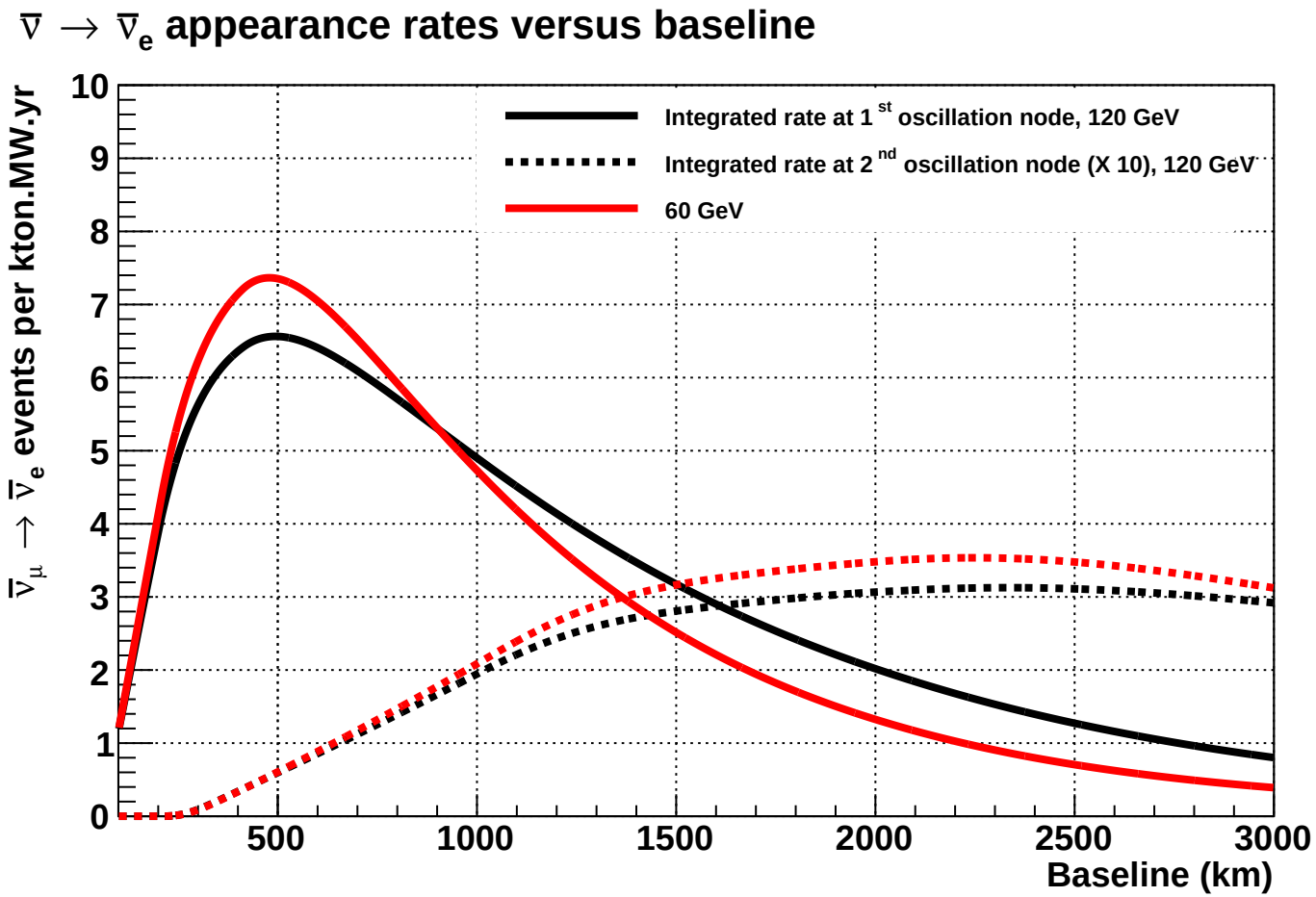

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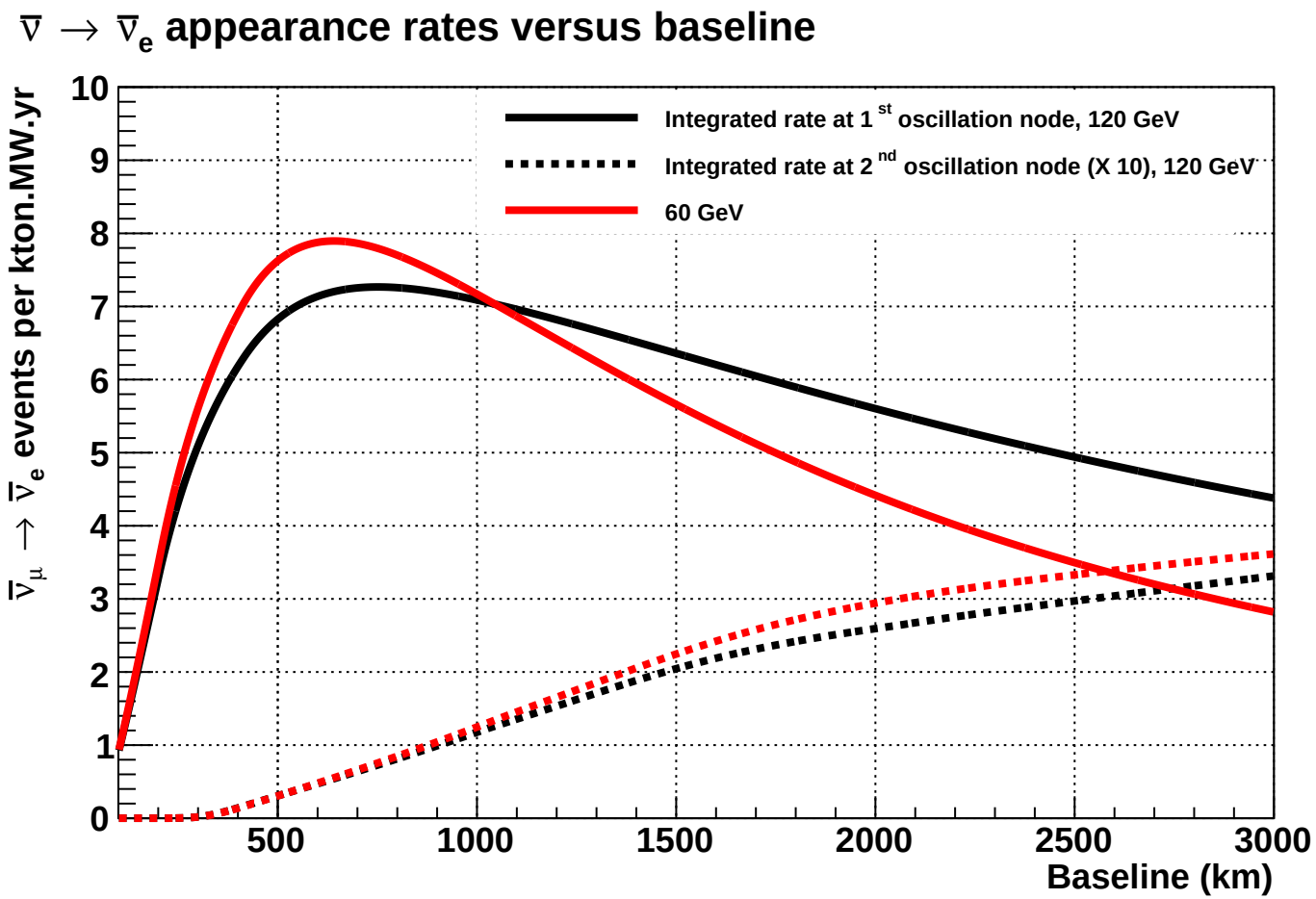

Integrated Rate Asymmetries w/ Perfect Focusing

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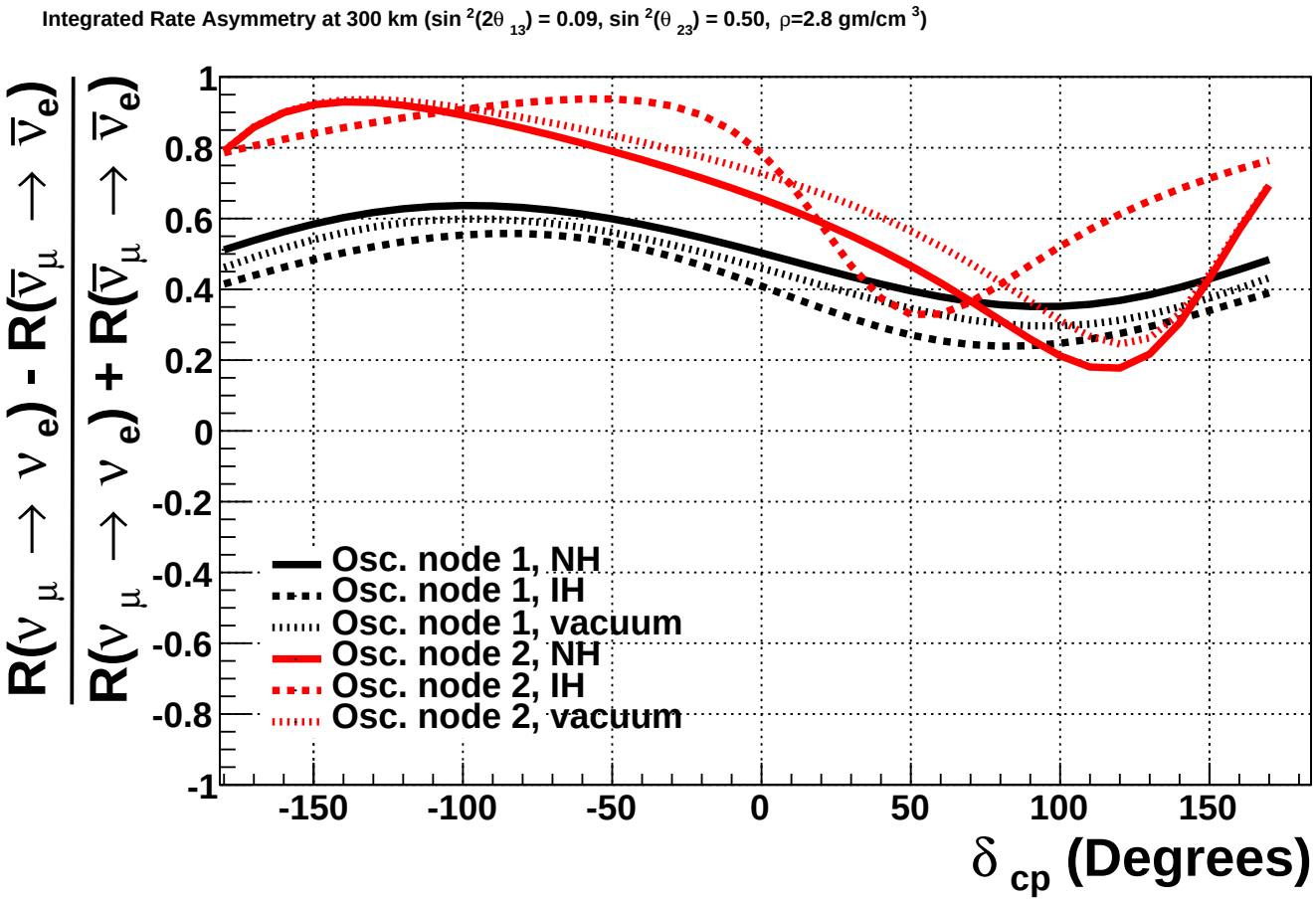
300 km



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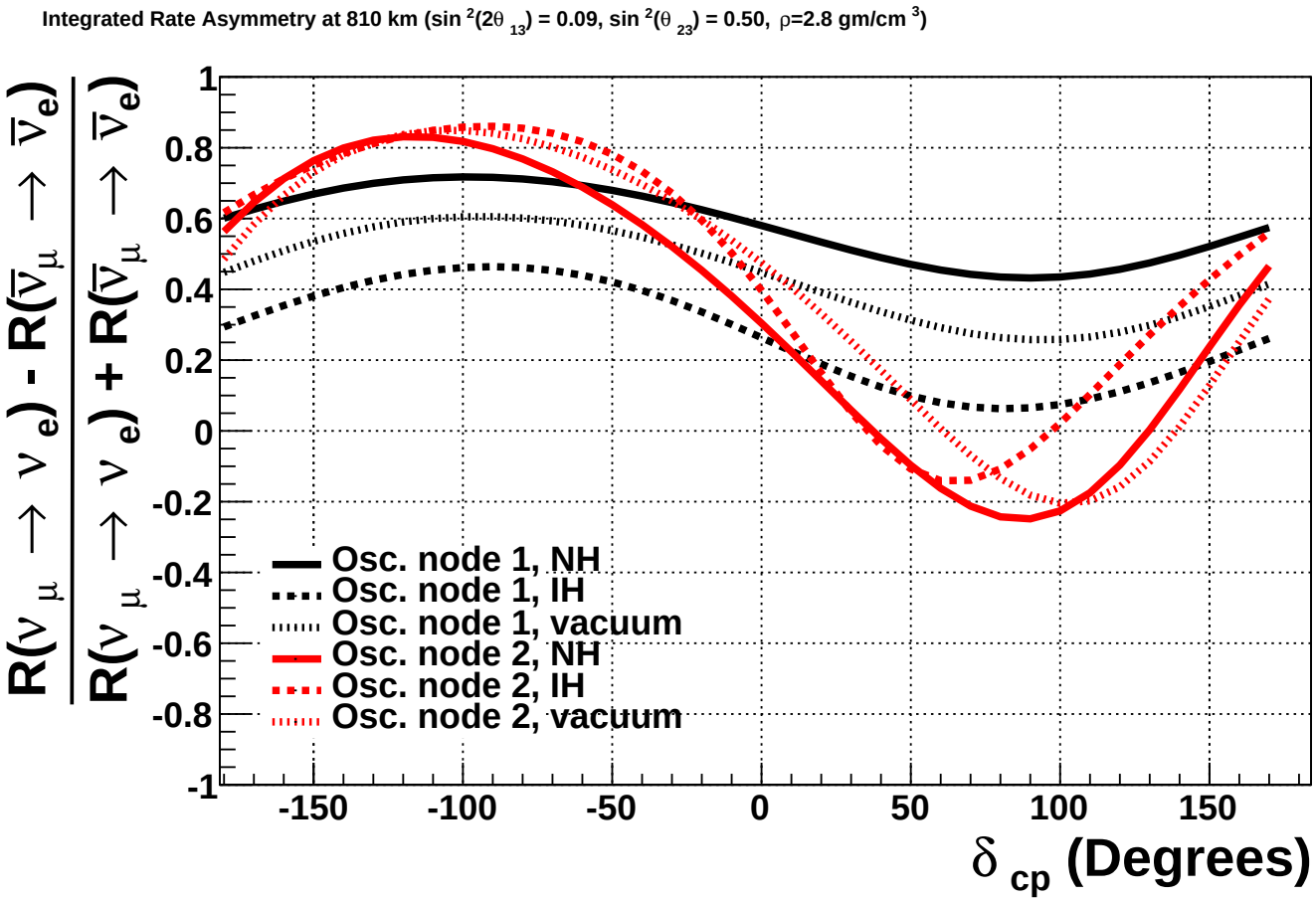
810 km



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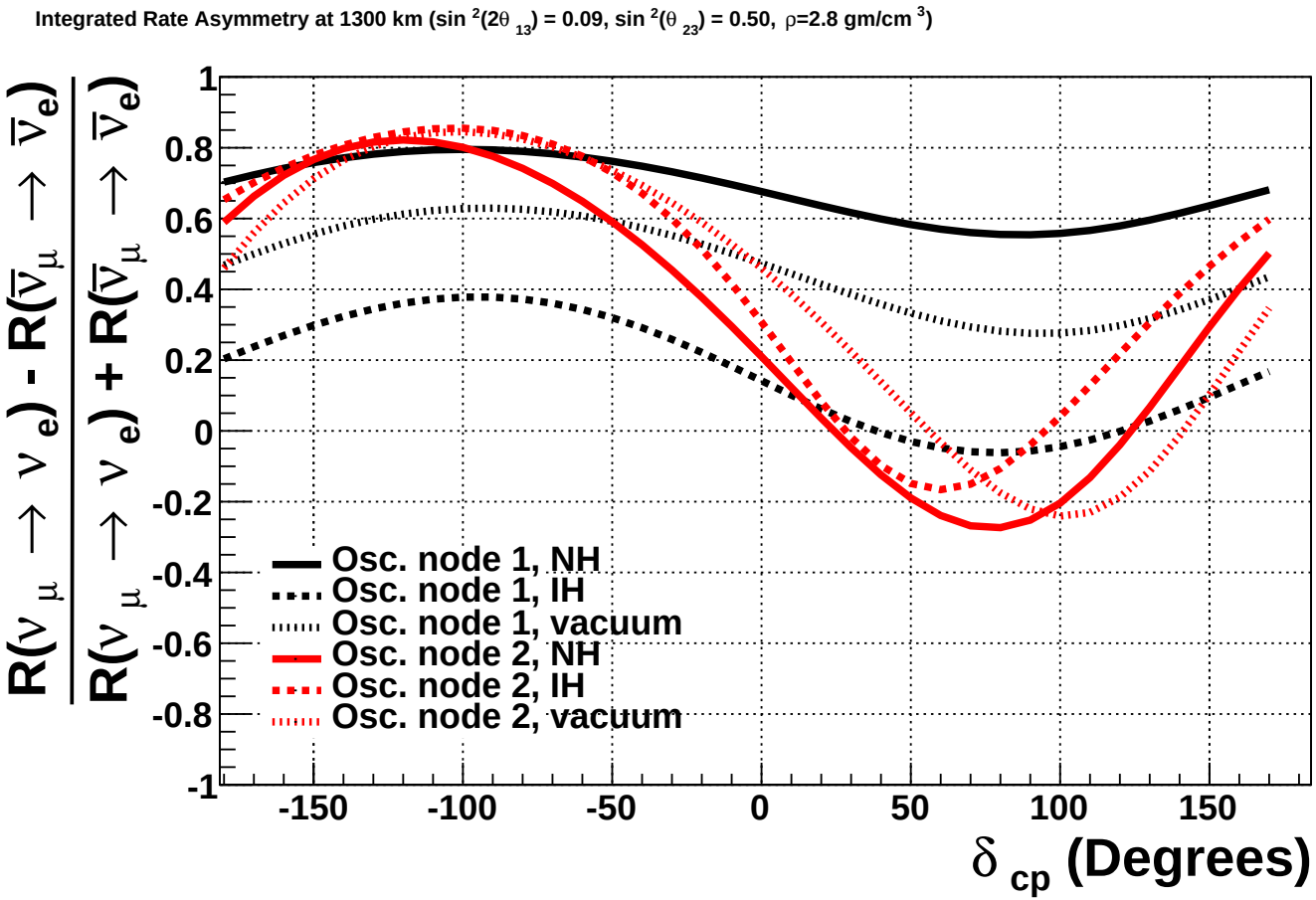
1300 km



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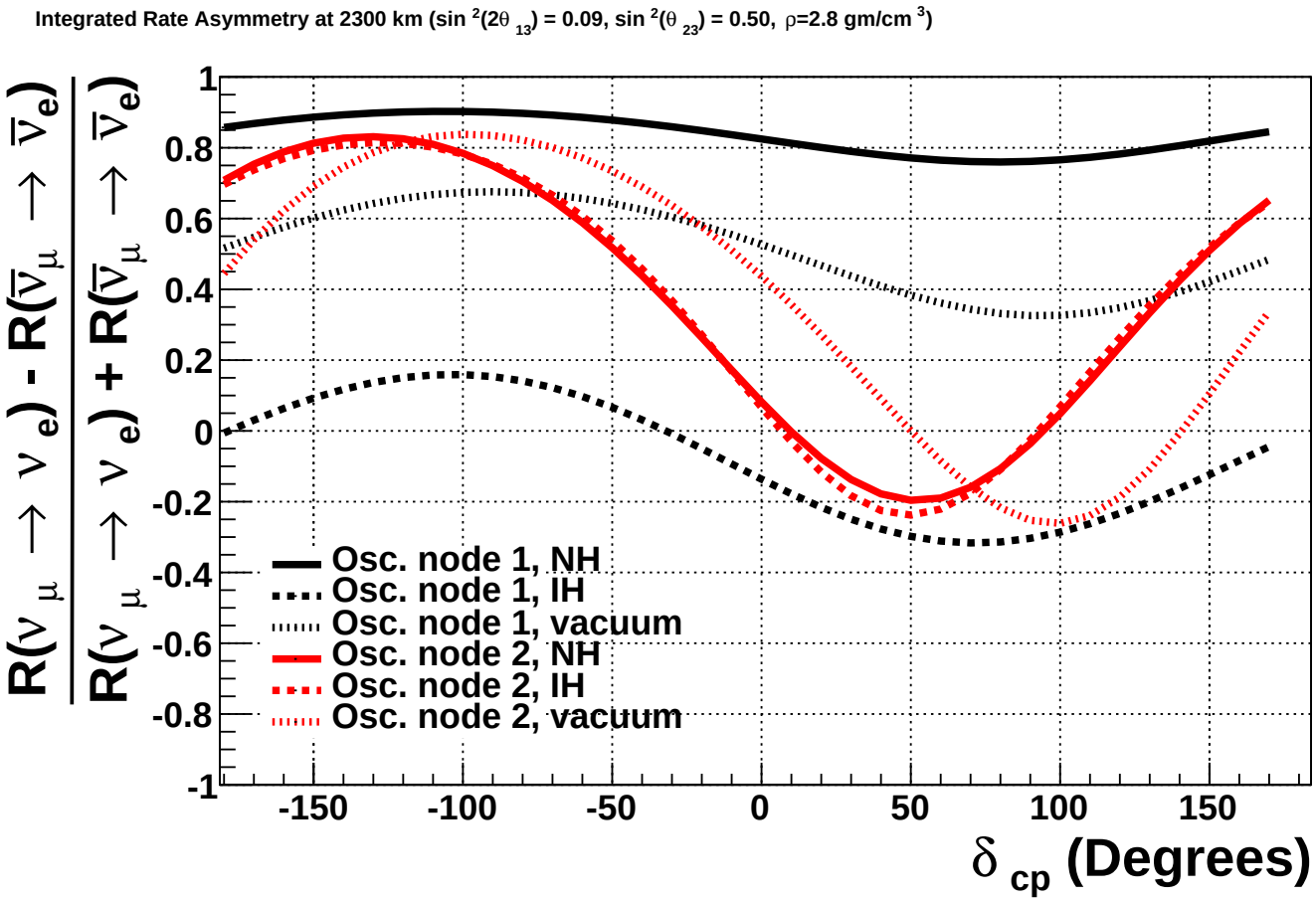
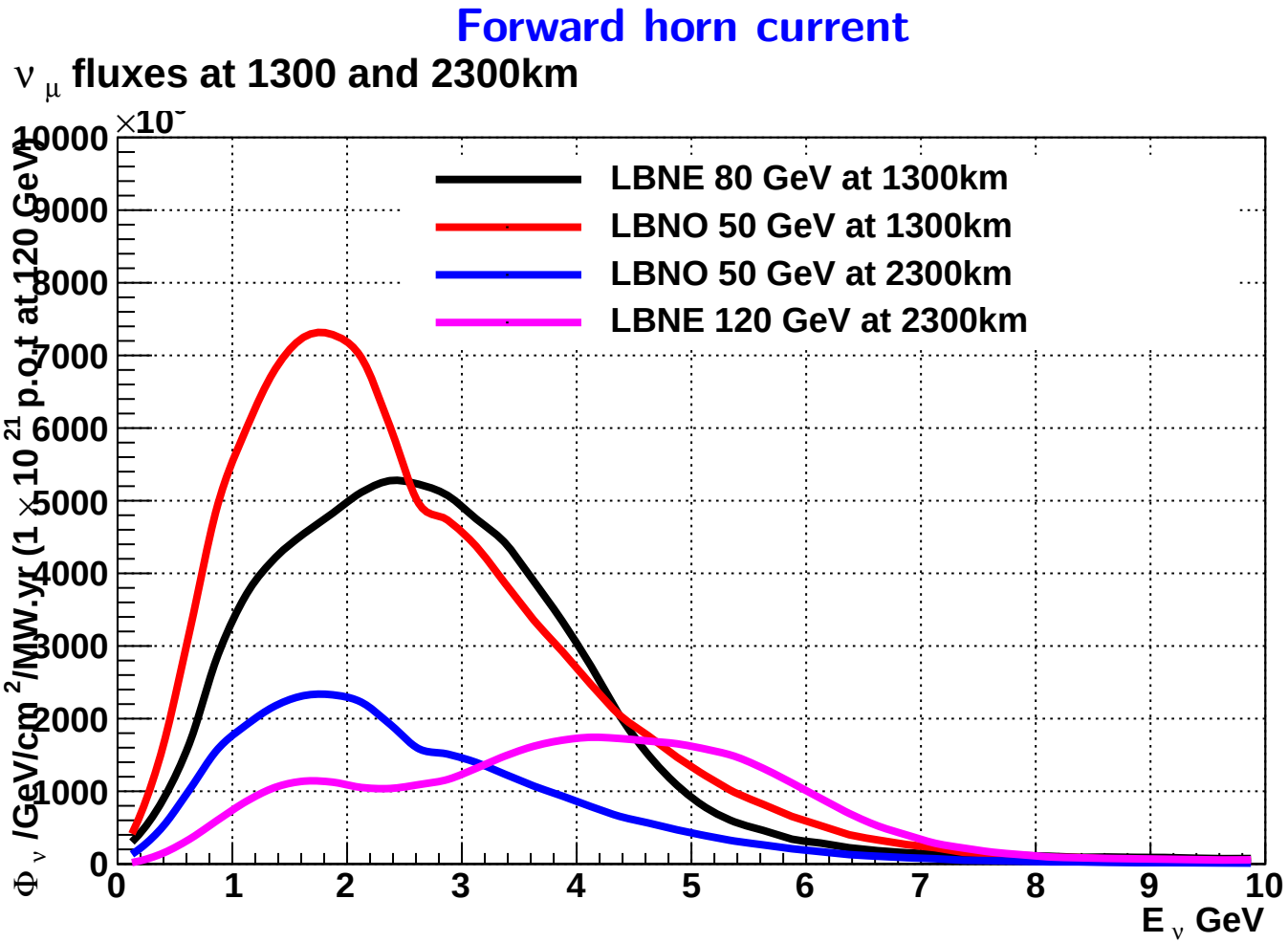
2300 km



LBNO/LBNO fluxes



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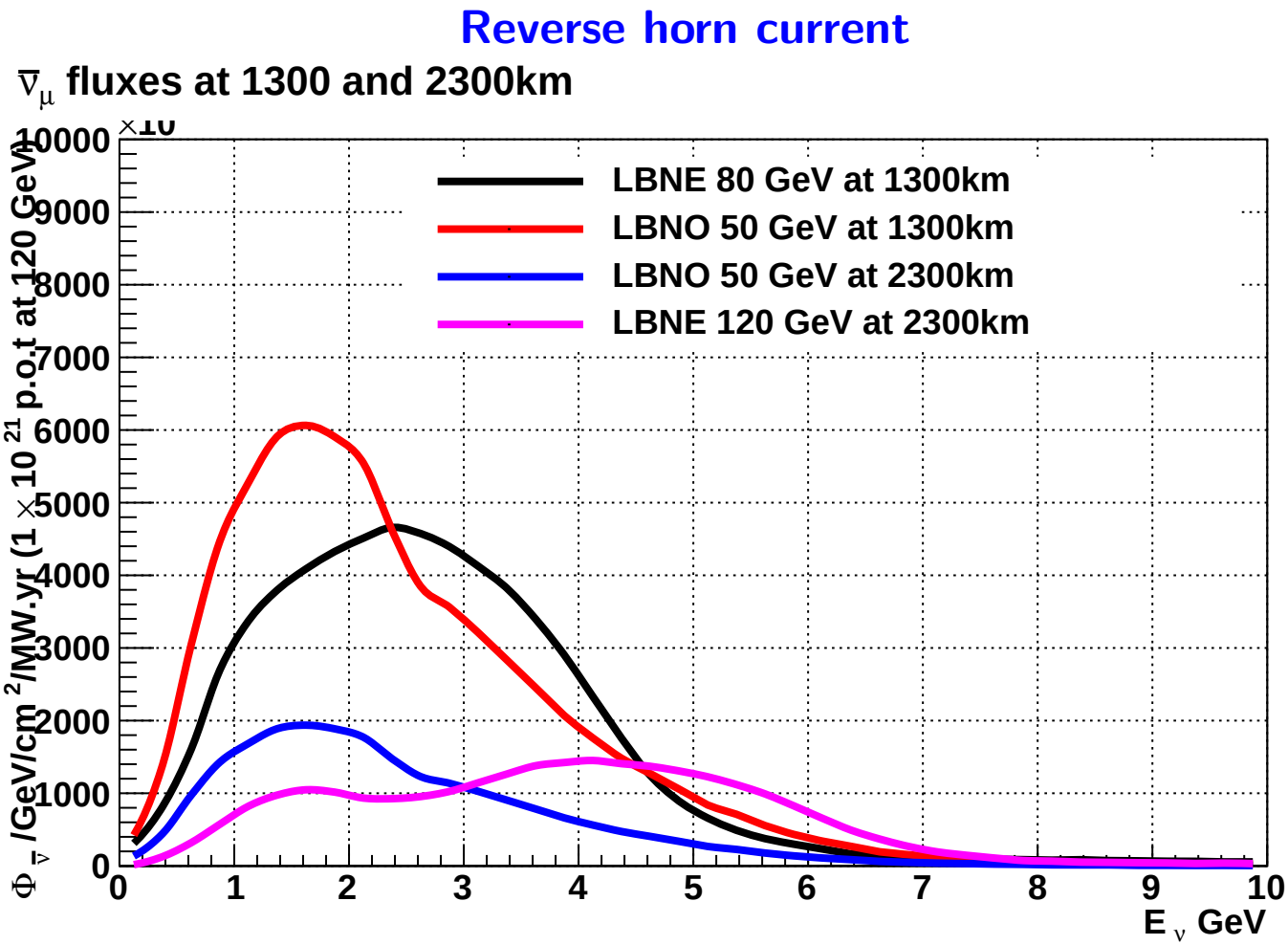
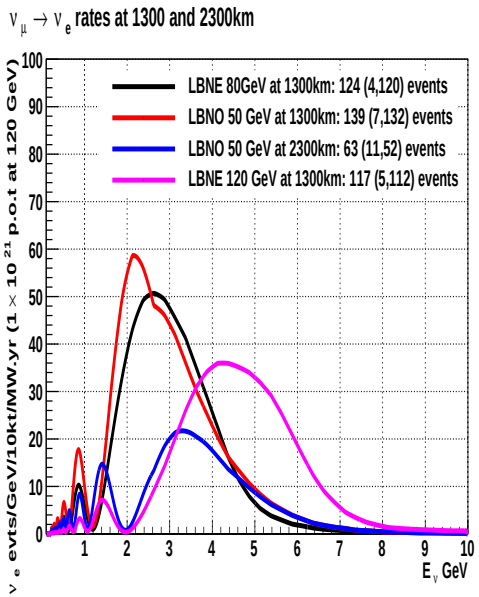
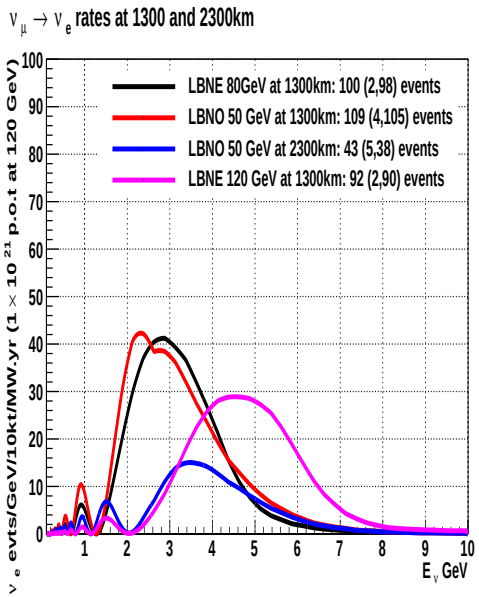
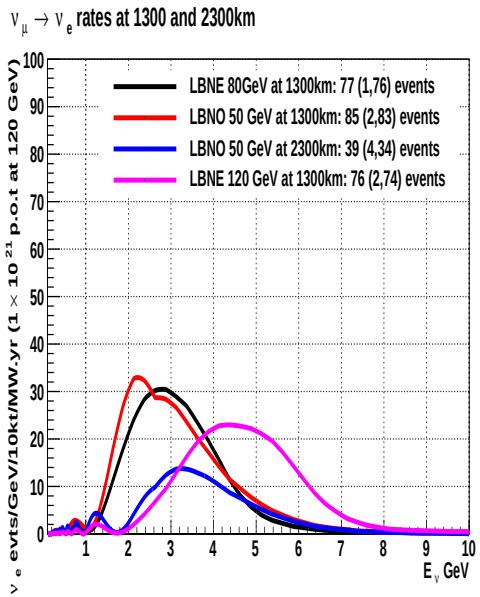


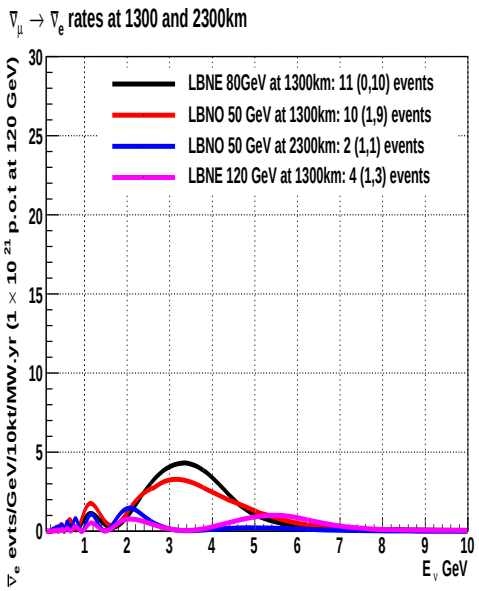
Appearance Spectra (no detector effects) NH

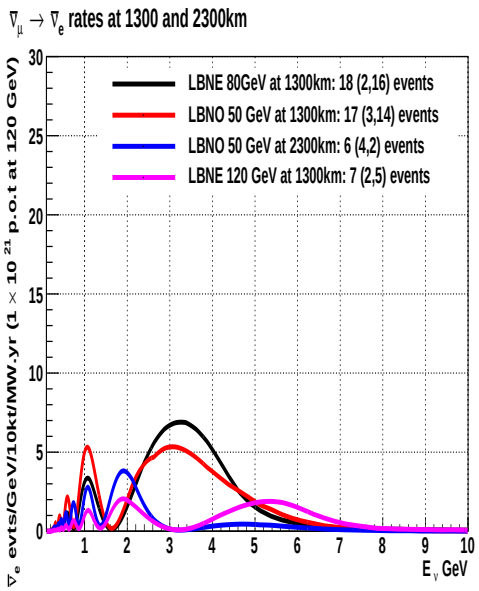
$\delta_{cp} = -\pi/2$ $\delta_{cp} = 0$ $\delta_{cp} = \pi/2$

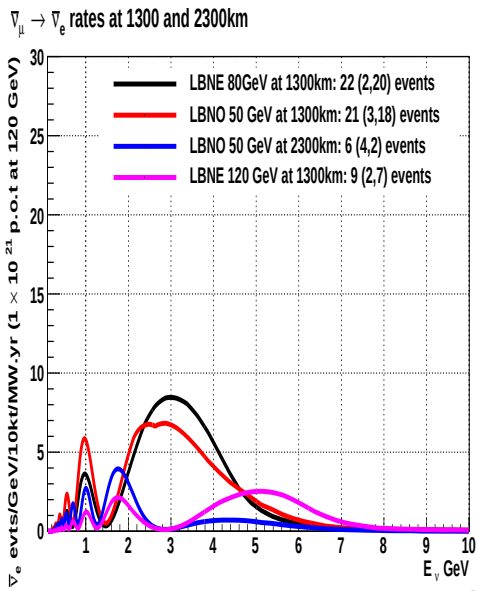












Appearance Spectra (no detector effects) IH

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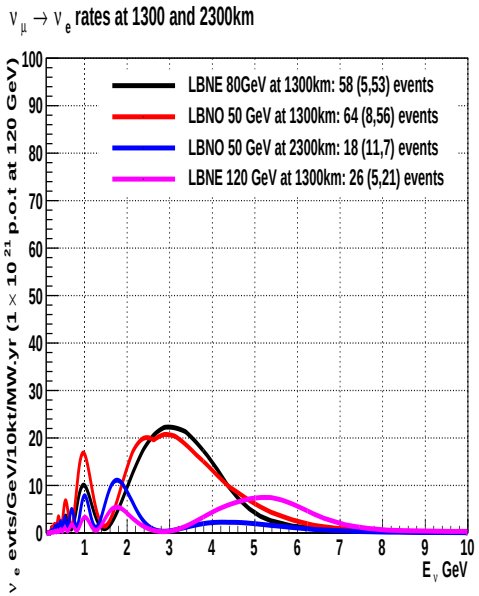

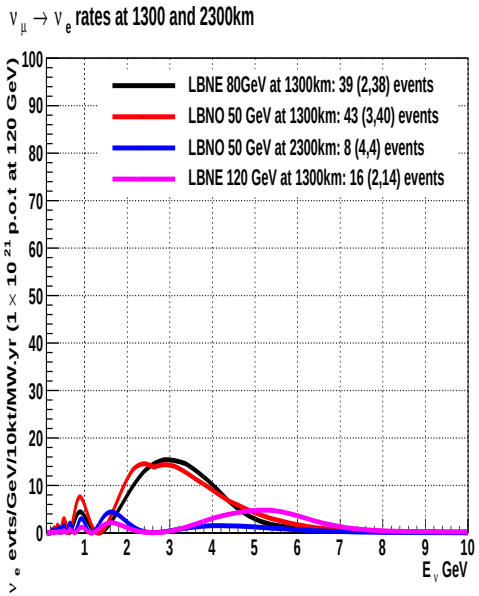

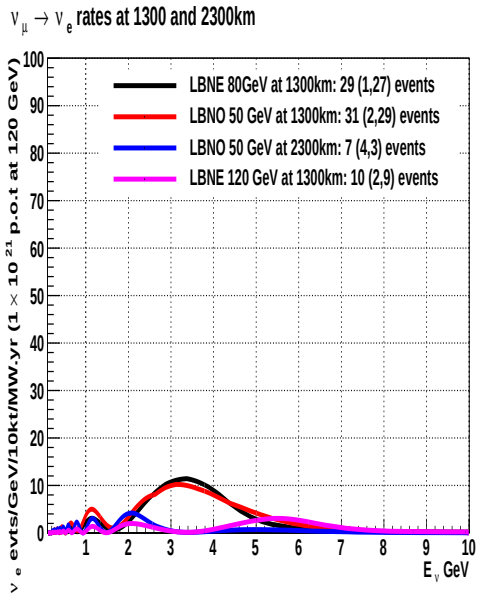

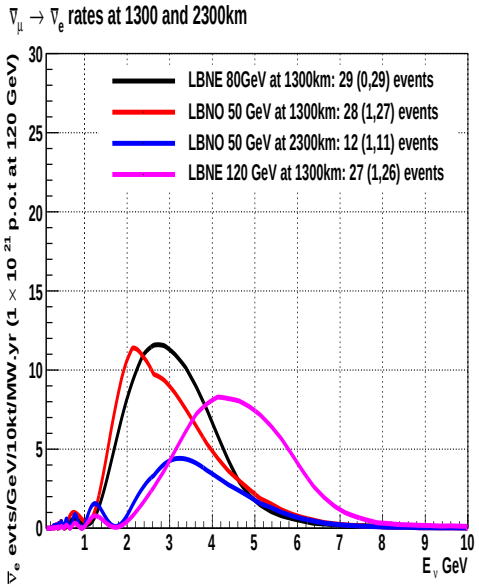

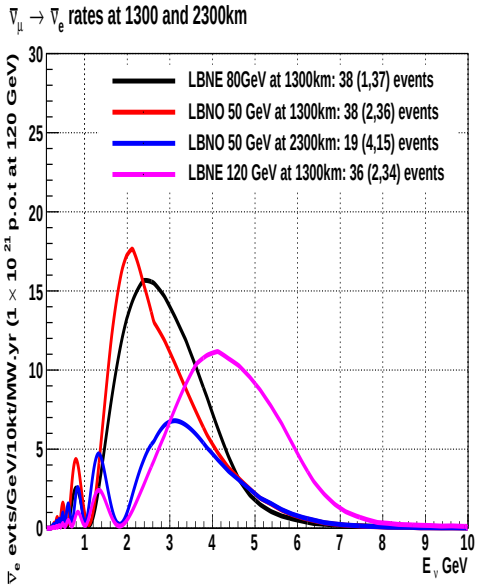

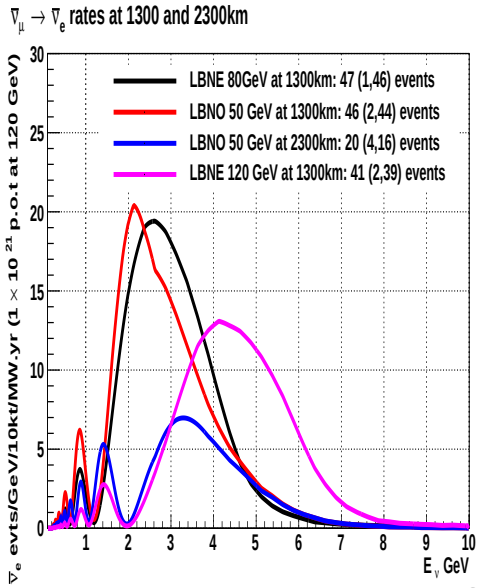

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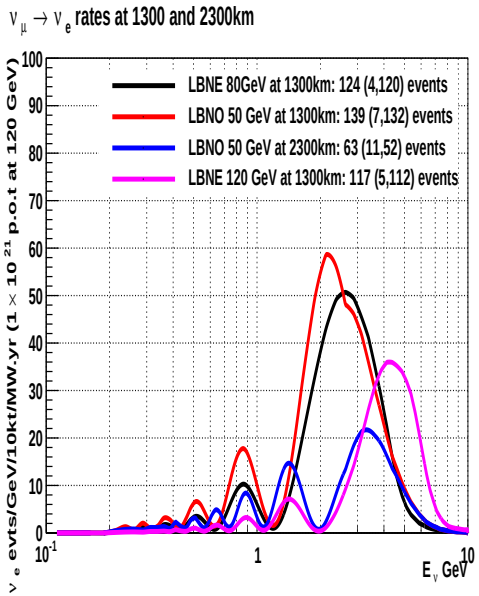

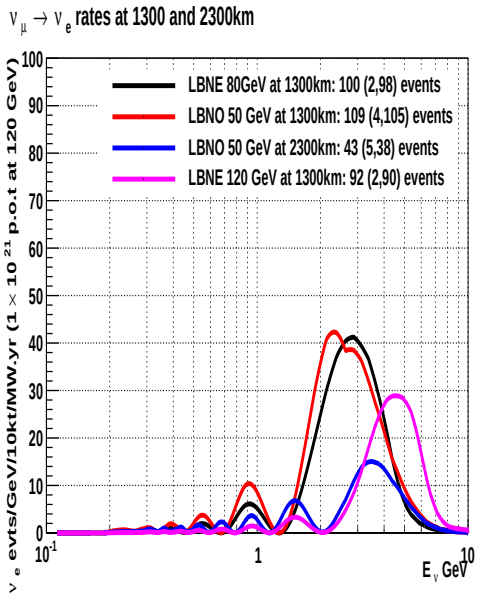

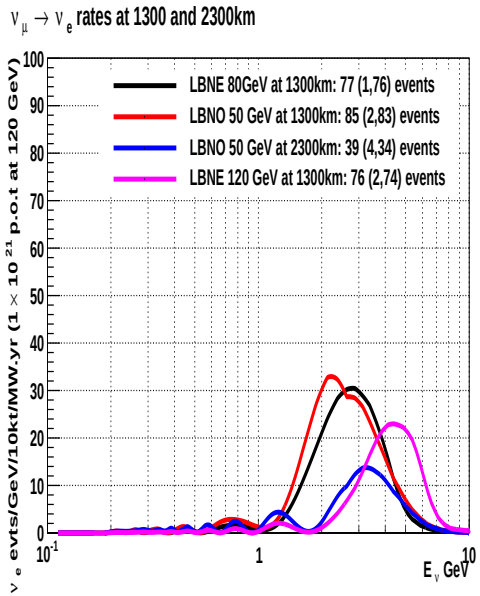

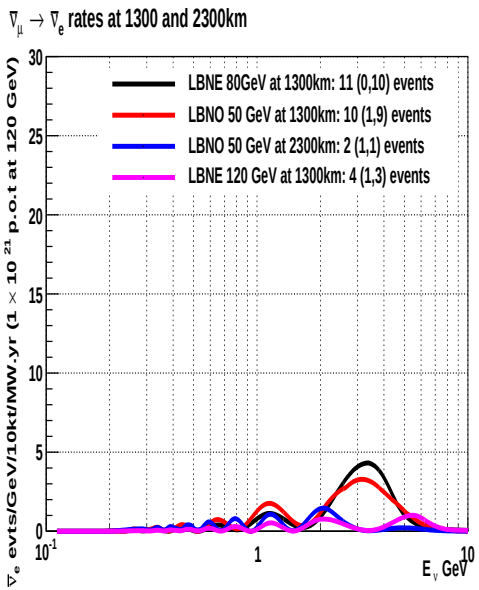

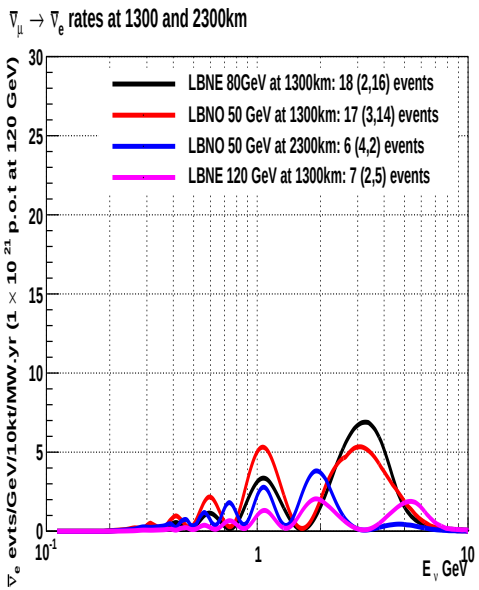

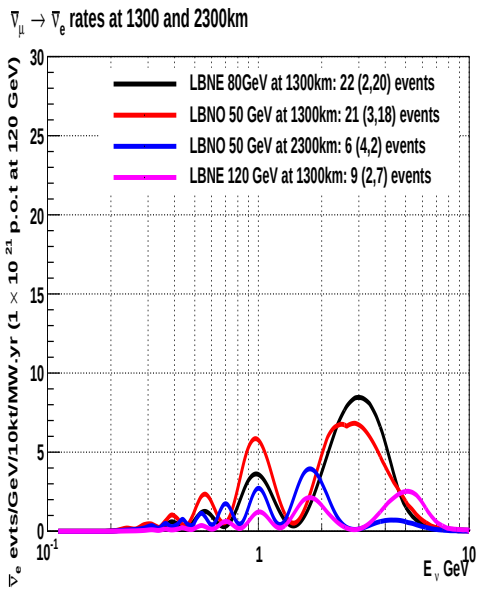

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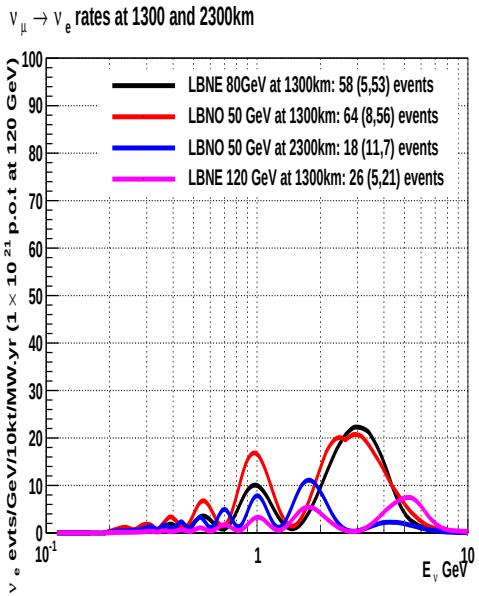
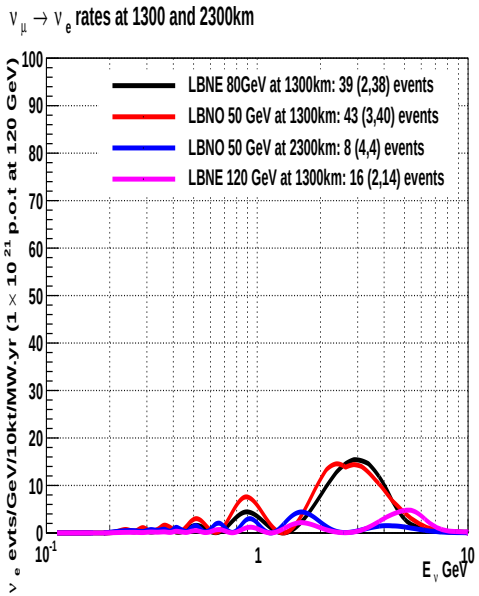
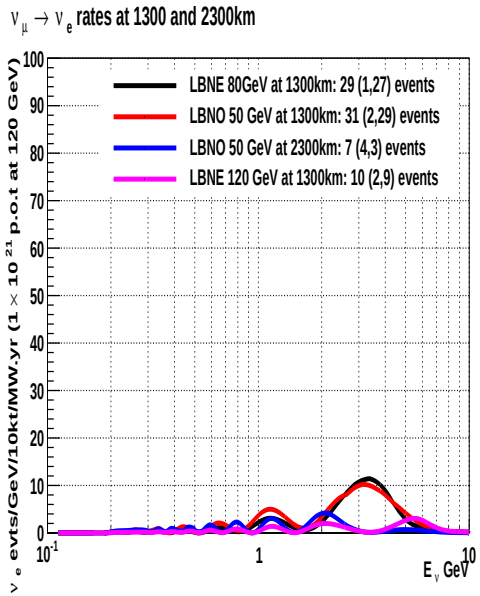
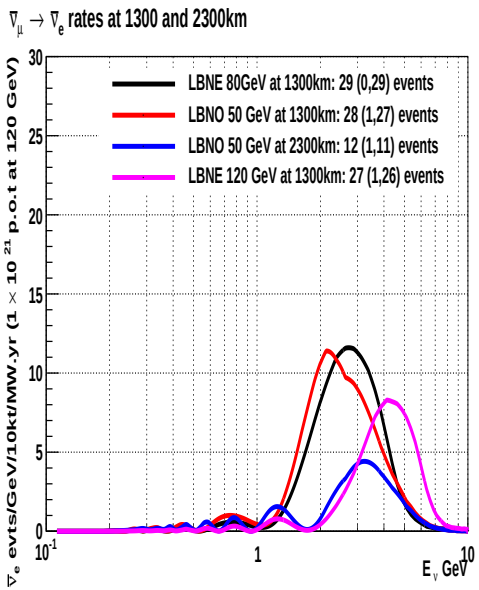
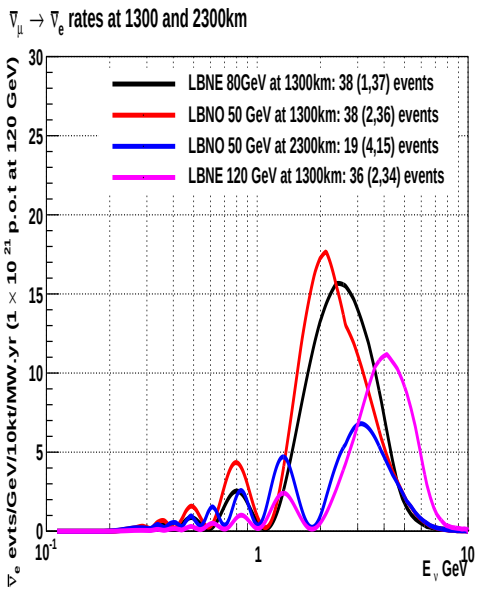
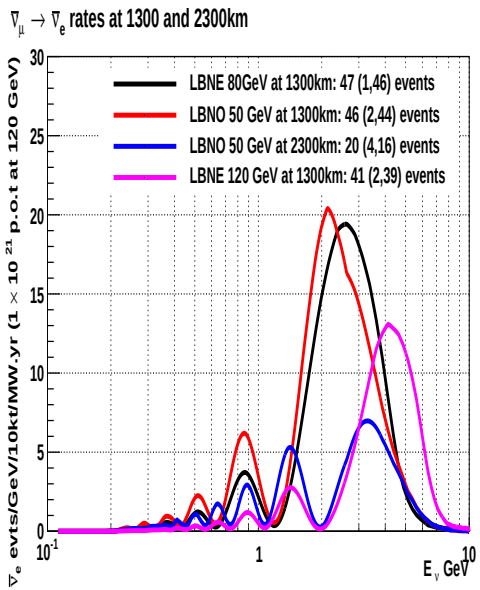










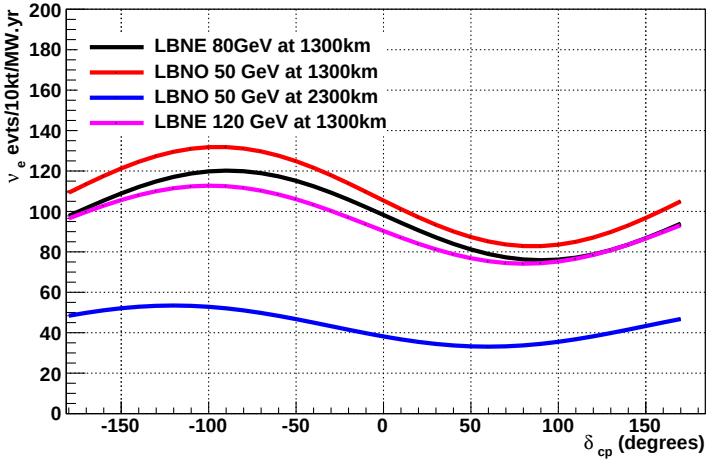


Appearance Rates vs. δcp (no detector effects)
1st Osc. Node $\geq$ 2nd Osc. Node

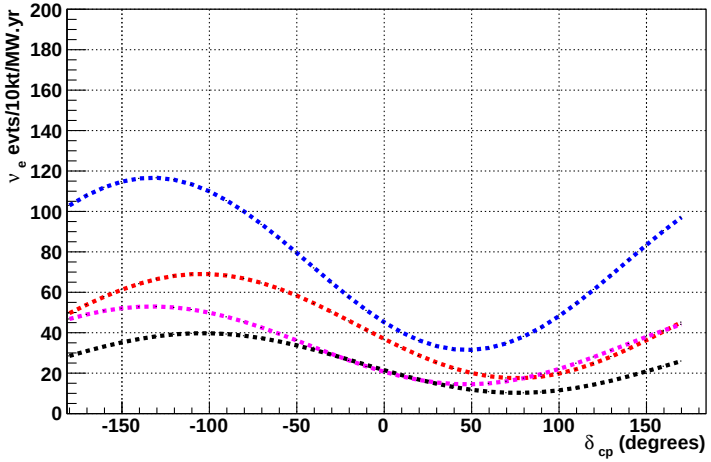
$(\sin^2 2\theta_{13} = 0.09, \sin^2\theta_{23} = 0.45, |\Delta m^2_{31}| = 2.5 \times 10^{-3}, \rho = 3.2\ \mathrm{gm/cm^3})$

Normal Hierarchy

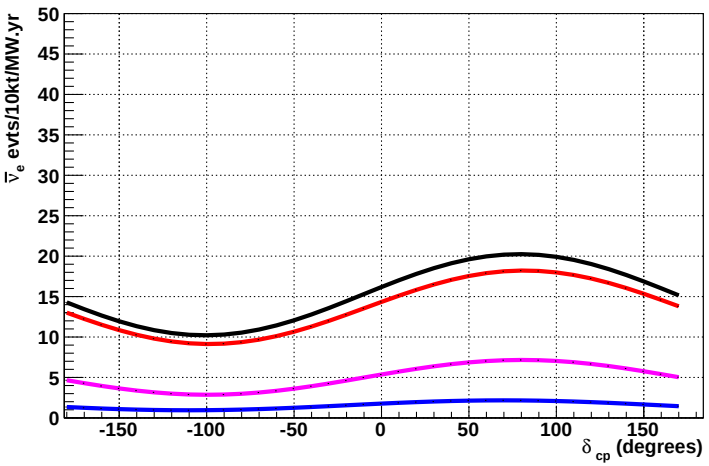
ν_e appearance rates 1st osc node, NH



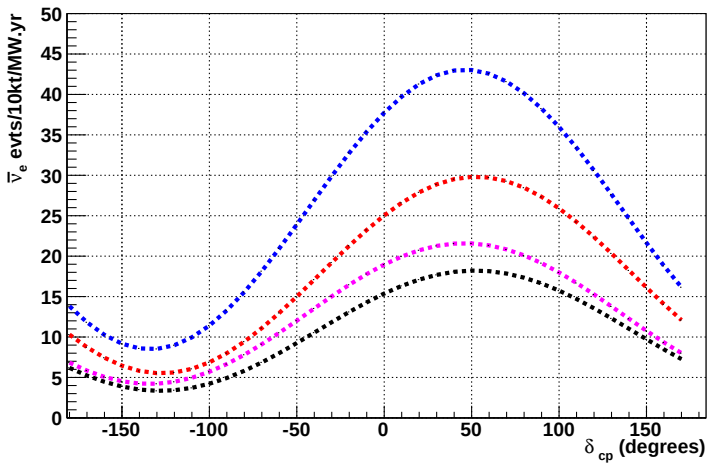
ν_e appearance rates at >= 2nd node (x10), NH



$\bar{\nu}_e$ appearance rates 1st osc node, NH



$\bar{\nu}_e$ appearance rates at >= 2nd node (x10), NH



Appearance Rates vs. δcp (no detector effects)
1st Osc. Node $\geq$ 2nd Osc. Node

$(\sin^2 2\theta_{13} = 0.09, \sin^2\theta_{23} = 0.45, |\Delta m^2_{31}| = 2.5 \times 10^{-3}, \rho = 3.2\ \mathrm{gm/cm^3})$

Inverted Hierarchy