Economizing the LBNE configuration with current experiments

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Based on: Ghosh, Goswami and Raut, 1412.1744

Introduction

- 3 flavour Neutrino oscillation:

  θ_{12}, θ_{23}, θ_{13}, δ_{CP}

  $\Delta_{21} : (m_2^2 - m_1^2)$, $|\Delta_{31}| : \pm(m_3^2 - m_1^2)$

- Unknowns:

  Hierarchy (NH: $m_3 > m_1$ or IH: $m_3 < m_1$)

  Octant of θ_{23} (LO: $\theta_{23} < 45$ or HO: $\theta_{23} < 45$)

  δ_{CP} (violation and precision)

Aim

- Find the minimum exposure for LBNE (recently renamed as DUNE) in conjunction with T2K, NOνA and ICAL for:

  Determination of hierarchy and octant with $\chi^2 = 25$

  To detect CP violation with $\chi^2 = 9$.

- Variable LBNE exposure: in units of MW-kt-yr

  Example:

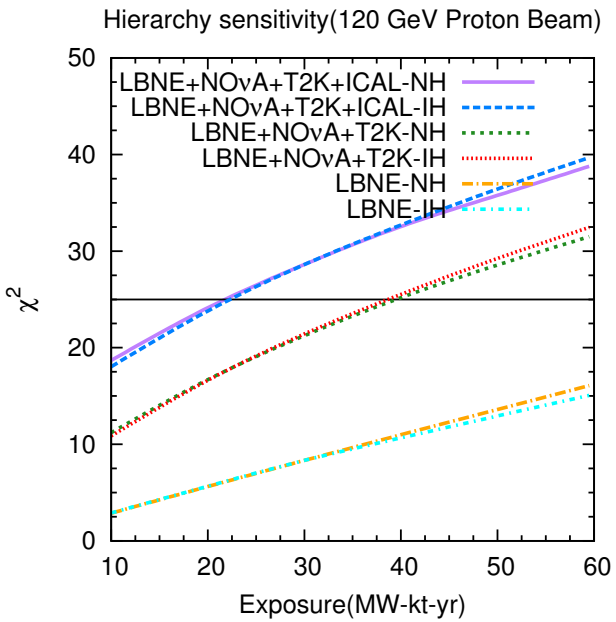
  20 MW-kt-yr = 1 MW beam , 10 kt detector, 2 year run time (in each, ν and $\bar{\nu}$ mode)

Details: T2K, NOνA, ICAL

- T2K (Japan): 22.5 kt water cerenkov detector with total 8×10^{21} POT in neutrino mode
- NOνA (Fermilab): 14 kt LAr detector running in (3+3) mode
- ICAL@INO (India): 50 kt iron calorimeter detector running for 10 years

Hierarchy Sensitivity

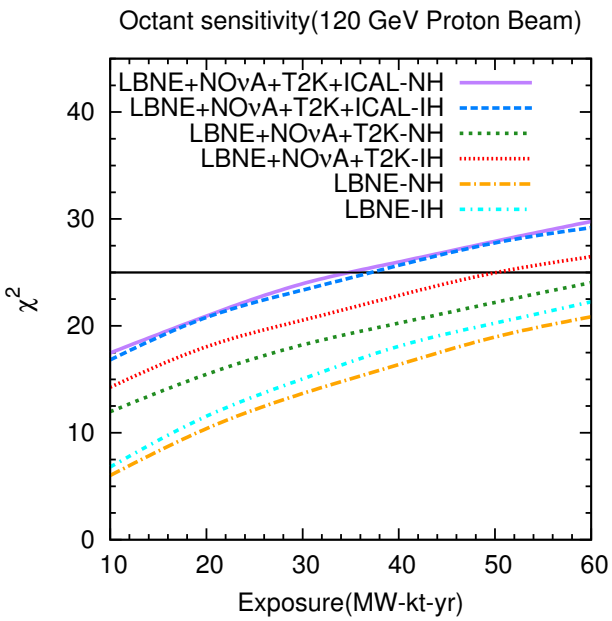
- χ^2 has been evaluated for true $\delta_{CP} = 0 - 2\pi$ and $\theta_{23} = 39^\circ$, 45°, 51° and taken the most conservative case
- Thus, hierarchy results correspond to: $\theta_{23} = 39^\circ$ and δ_{CP} around $+(-)90^\circ$ for NH(IH)
- For 1.2 MW beam and 10 kt detector:($\chi^2 = 25$)



- Only LBNE:
  95(106) $\Longrightarrow$ 7.9(8.8) yr
- LBNE+NOνA+T2K:
  39(39) $\Longrightarrow$ 3.25 yr
- LBNE+NOνA+T2K+INO:
  22(22) $\Longrightarrow$ 1.8 yr

Octant Sensitivity

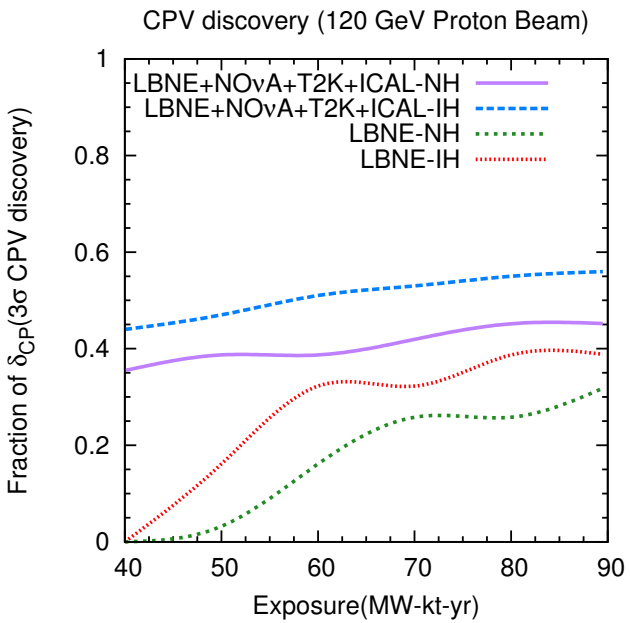
- χ^2 has been calculated for true $\delta_{CP} = 0 - 2\pi$ and $\theta_{23} = 39^\circ$, 51° and chosen the lower value
- This is not the most conservative case as one goes near maximal θ_{23}, octant sensitivity decreases.
- For 1.2 MW beam and 10 kt detector:($\chi^2 = 25$)



- Only LBNE:
  84(76) $\Longrightarrow$ 7(6.3) yr
- LBNE+NOνA+T2K:
  65(50) $\Longrightarrow$ 5.4(4.1) yr
- LBNE+NOνA+T2K+INO:
  35(37) $\Longrightarrow$ 2.9(3) yr

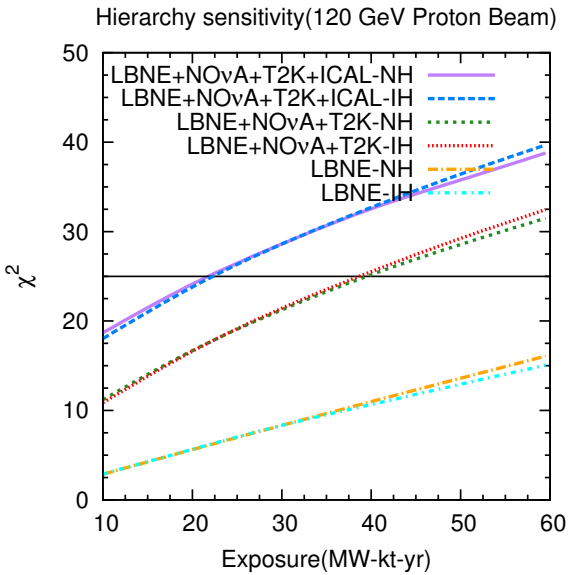
Detecting CP violation(40% CP coverage)

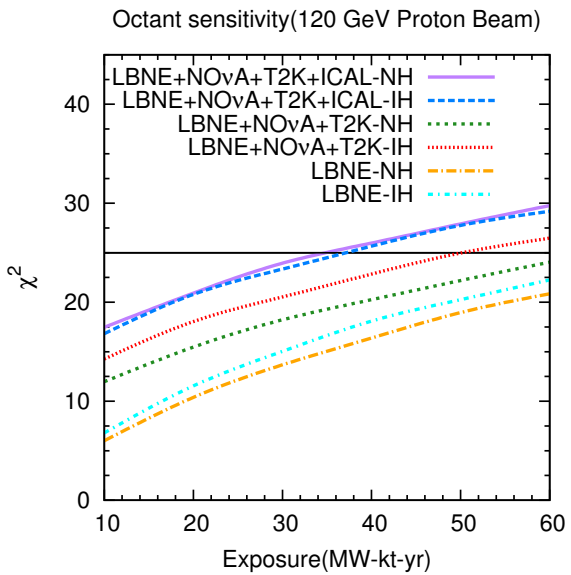
- CPV detection ability of an experiment is its ability to distinguish the true value of δ_{CP} in nature from 0° and 180°.
- We have chosen the smallest fraction over $\theta_{23} = 39^\circ$, 45° and 51°, to get a conservative estimate.
- For 1.2 MW beam and 10 kt detector:($\chi^2 = 9$)

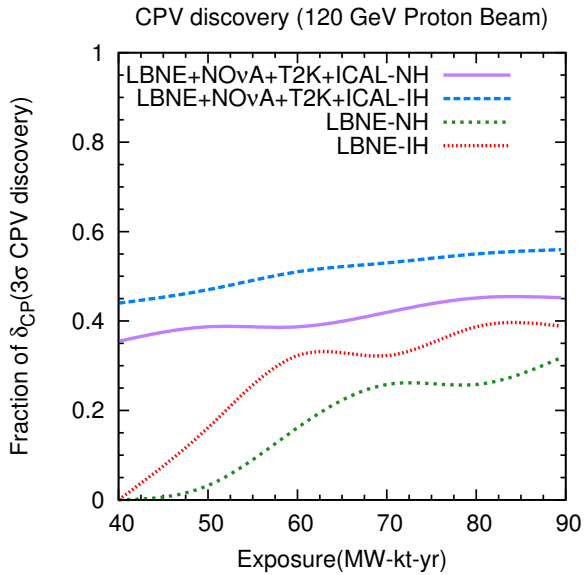


- Only LBNE:
  $114(90) \implies 9.5(7.5)$ yr
- LBNE+NOνA+T2K:
  $65(36) \implies 5.4(3)$ yr
- LBNE+NOνA+T2K+INO:
  $65(36) \implies 5.4(3)$ yr

Summary







Sensitivity	LBNE+NOνA+T2K+ICAL	LBNE+NOνA+T2K	LBNE
Hierarchy($\chi^2 = 25$)	22(22)	39(39)	95(106)
Octant($\chi^2 = 25$)	35(37)	65(50)	84(76)
CP(40% at $\chi^2 = 9$)	65(36)	65(36)	114(90)

We also study the role of near detector, 2nd oscillation maxima and anti-neutrinos in this context. These results are presented in the poster.