



### Search for Sterile Neutrinos at the SBN Program

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#### The SBN Program

- 3 LArTPC detectors at baselines ranging from 110 600m.
- Located along the Booster neutrino beam at Fermilab.
- Main goal is to search for light sterile neutrinos.
- Motivated by the LSND, MiniBooNE, Gallium & Reactor anomalies.
- Excess or deficit of observed events may be explained by oscillations with an eV scale neutrino.



# **Oscillation Probability**

- PMNS mixing matrix  $\begin{pmatrix}
  \nu_{e} \\
  \nu_{\mu} \\
  \nu_{\tau} \\
  \nu_{s}
  \end{pmatrix} = \begin{pmatrix}
  U_{e1} & U_{e2} & U_{e3} & U_{e4} \\
  U_{\mu 1} & U_{\mu 2} & U_{\mu 3} & U_{\mu 4} \\
  U_{\tau 1} & U_{\tau 2} & U_{\tau 3} & U_{\tau 4} \\
  U_{s 1} & U_{s 2} & U_{s 3} & U_{s 4}
  \end{pmatrix} \begin{pmatrix}
  \nu_{1} \\
  \nu_{2} \\
  \nu_{3} \\
  \nu_{4}
  \end{pmatrix}$ 
  - For the case  $\Delta m^2_{41} \gg |\Delta m^2_{31}|, \Delta m^2_{21},$  short baseline oscillations are approximated by

$$P_{\mu \to \mu} = 1 - 4|U_{\mu 4}|^2 (1 - |U_{\mu 4}|^2) \sin^2\left(\frac{\Delta m_{41}^2 L}{4E}\right)$$

$$P_{\mu \to e} = 4|U_{\mu 4}|^2|U_{e4}|^2 sin^2 \left(\frac{\Delta m_{41}^2 L}{4E}\right)$$

•  $u_e$  appearance and  $u_\mu$  disappearance are complementary.

# Analysis

- Produce a fit by combining oscillation physics + the cross-section, flux and detector uncertainties.
- Combine data to produce a single SBN fit.



# Sensitivities

- Sensitivities produced using the VALOR SBN analysis framework.
- Obtain a sensitivity for the entire SBN program (combine all three detectors).



• Expressing  $U_{\mu 4}$  and  $U_{e 4}$  in terms of mixing angles  $sin^2 2\theta_{\mu e} = 4|U_{\mu 4}|^2|U_{e 4}|^2$   $sin^2 2\theta_{\mu \mu} = 4|U_{\mu 4}|^2(1-|U_{\mu 4}|^2)$ 

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#### Conclusion

- Three LArTPC's investigating multiple oscillation channels.
- Goal is to perform a joint analysis of the different oscillation channels.
- As the near detector, SBND will be the main contributor in reducing uncertainties.

- Previous individual results in favour of sterile neutrinos only at the  $3\sigma$   $4\sigma$  level.
- SBN will provide a definitive test at the  $5\sigma$  level.