

The NOvA Experiment

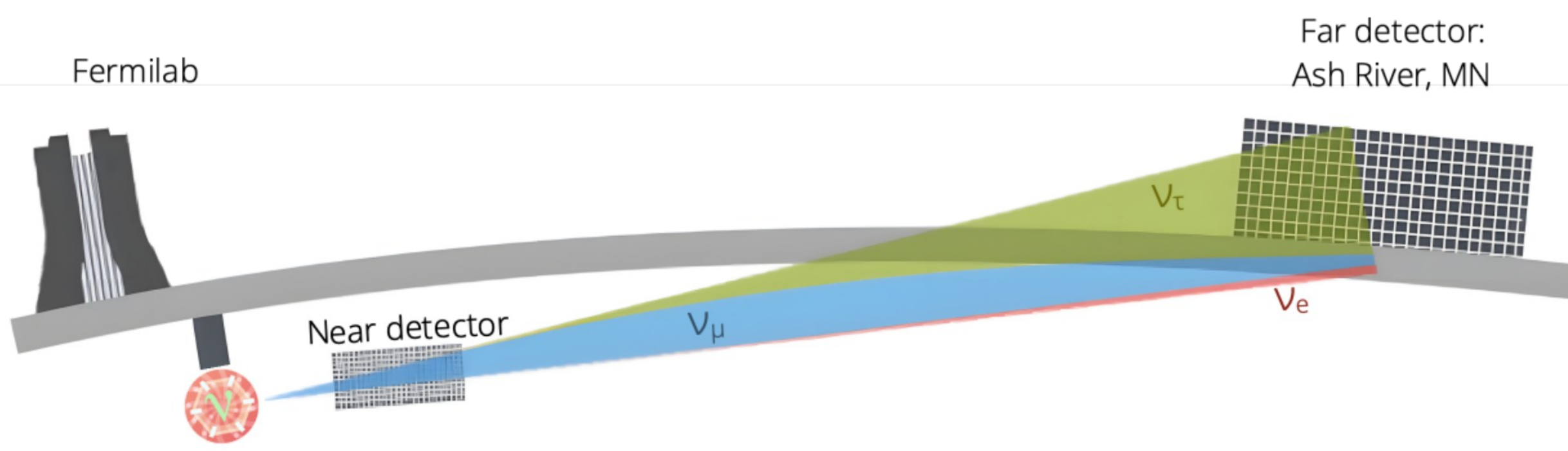
NOvA is a long-baseline neutrino oscillation experiment at Fermilab using the NuMI muon neutrino beam.

Detectors:

- Far Detector (FD): 14 kton; on the surface
- Near Detector (ND): 0.3 kton; underground
- Detectors are liquid scintillators

Goals

- Measurement of the oscillation parameters ($\Delta m_{32}^2, \theta_{23}, \delta_{CP}$)
- Determination of Neutrino Mass Ordering
- Physics Beyond the Standard Model



Neutrino Oscillations with Invisible Decay

We extend the standard 3-flavor neutrino oscillation framework by including the possibility that the mass eigenstates decay into **invisible particles** during propagation.

If the mass eigenstates can decay into invisible states with lifetime τ_i , the Hamiltonian acquires an additional imaginary term and becomes **non-Hermitian** [1]

$$\mathcal{H} = \left(\frac{1}{2E}\right) \left[U \begin{pmatrix} 0 & 0 & 0 \\ 0 & \Delta m_{21}^2 - i\alpha_2 & 0 \\ 0 & 0 & \Delta m_{31}^2 - i\alpha_3 \end{pmatrix} U^\dagger + \begin{pmatrix} A & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \right],$$

$$A = 2\sqrt{2}EG_F N_e, \quad G_F \text{ is the Fermi constant and } N_e \text{ is the electron number density in matter.}$$

$$\alpha_i = \frac{m_i}{\tau_i} \quad \alpha_i \text{ is the decay parameter of mass state } i, \text{ with } \tau_i \text{ the rest-frame lifetime into invisible states.}$$

Invisible decay modifies the total observable transition probability [2]

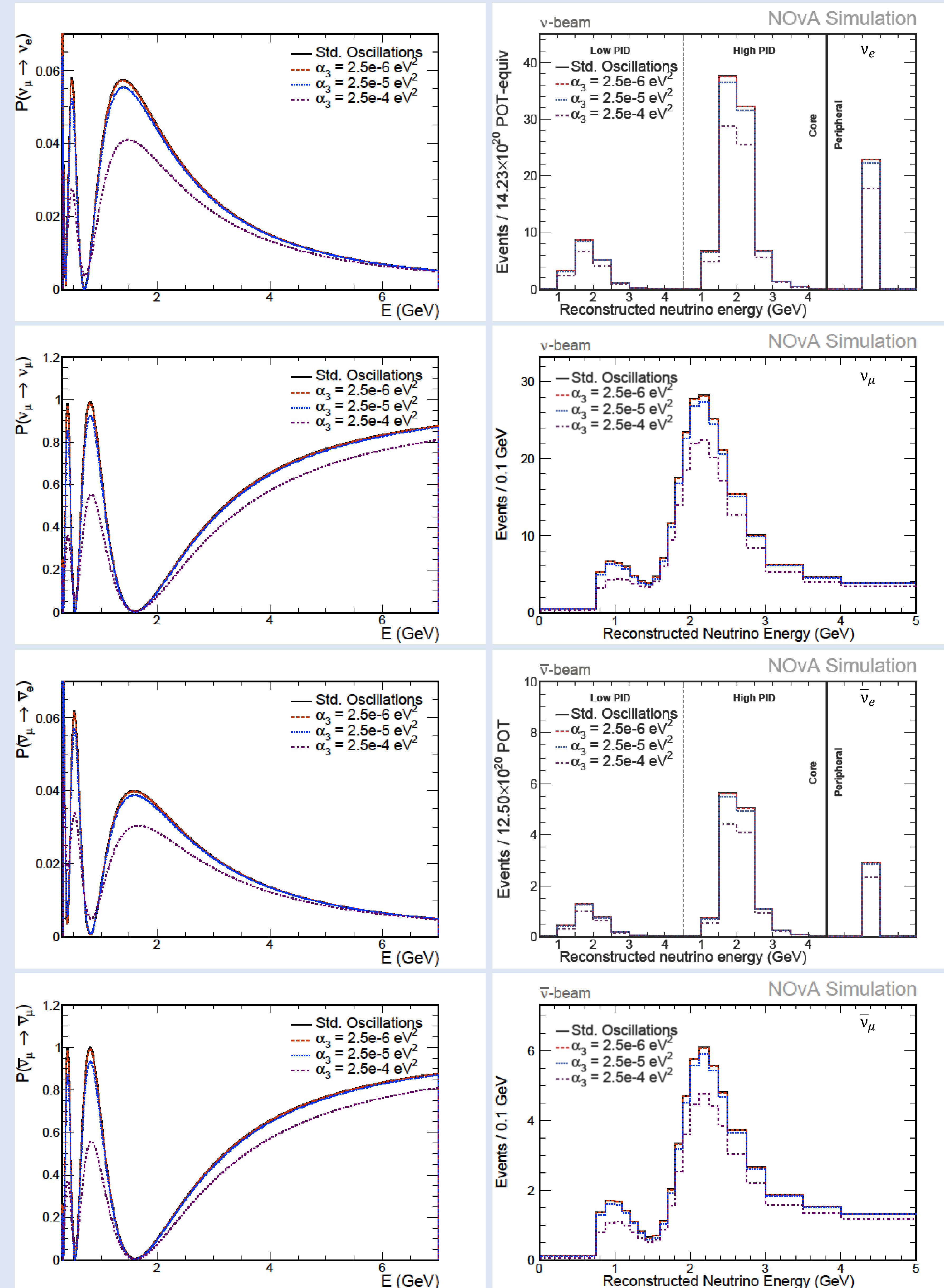
$$P_{\beta e} + P_{\beta \mu} + P_{\beta \tau} = 1 - P_D(\beta),$$

where $P_D(\beta)$ is the neutrino decay probability for a flavor $\beta = e, \mu, \tau$.

Effects of Neutrino Decay on Oscillation

Probabilities and Event Spectra

Neutrinos



Anti-Neutrinos

Observations

- The effect of invisible neutrino decay becomes more pronounced as the decay parameter increases
- Changes observed in oscillation probabilities are reflected in the event predictions
- Since the amplitude of the oscillations is mainly affected by the presence of the decay parameter, it could be said that this study would give information about the parameters that govern the oscillation.

These results were obtained using the best-fit values of oscillation parameters from the NOvA experiment [3].

Our results motivate dedicated sensitivity studies to quantify the potential of NOvA to probe invisible decay

Ongoing work

- Sensitivity and limits to decay parameter from NOvA data
- Correlation between decay parameters and standard oscillation parameters

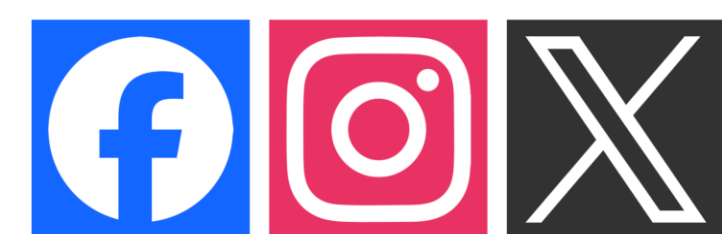
References

- [1] KM3NeT/ORCA Collaboration. *Journal of High Energy Physics* 04 (2025) 105.
- [2] Gomes, R. A., Gomes, A. L. G., Peres, O. L. G. *Physics Letters B*, 740 (2015) 345-352.
- [3] NOvA Collaboration. *Physical Review D* 106 (2022) 032004.

Acknowledgments

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