Neutrino Experiments

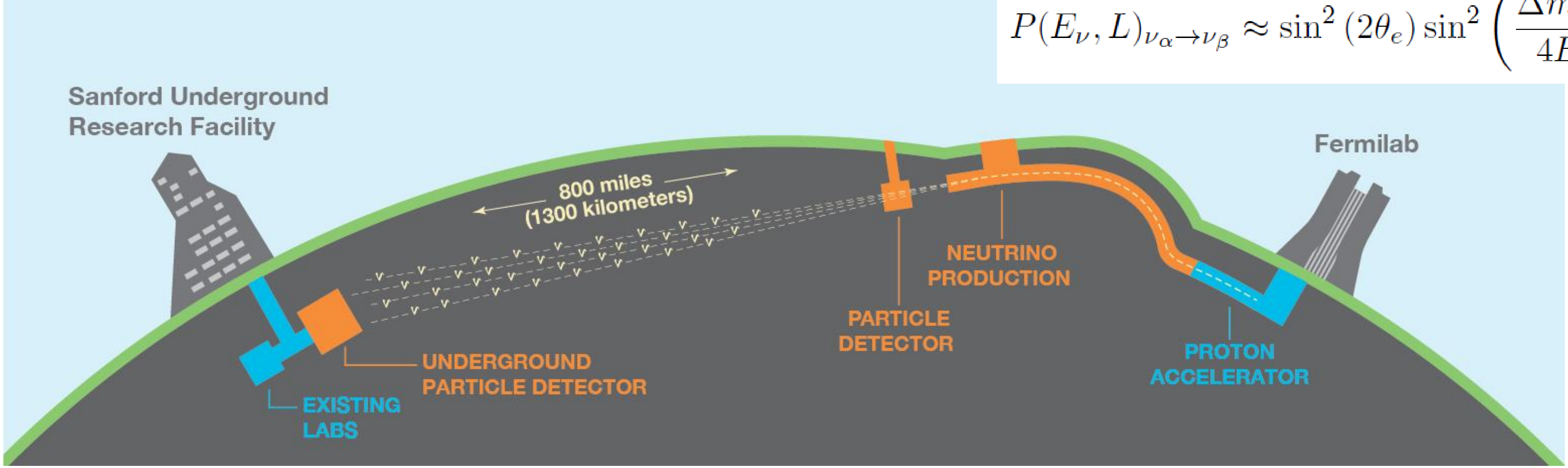
$$\begin{pmatrix} |\nu_e\rangle \\ |\nu_\mu\rangle \\ |\nu_\tau\rangle \end{pmatrix} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix} \begin{pmatrix} |\nu_1\rangle \\ |\nu_2\rangle \\ |\nu_3\rangle \end{pmatrix}$$

Long-baseline (LBL) neutrino experiments: e.g., DUNE (US), HyperK (Japan)

- observe and detect neutrino oscillations, near & far detector
- nuclear effects are main component of the systematic error

[DUNE, Fermilab]

$$P(E_\nu, L)_{\nu_\alpha \to \nu_\beta} \approx \sin^2(2\theta_e)\sin^2\left(\frac{\Delta m^2 L}{4E_\nu}\right)$$



Why using electrons for neutrino physics?

- Similar properties:

$$\left(\frac{d^2\sigma}{d\Omega d\omega}\right)_e = \sigma_M \left[A_L R_L + A_T R_T \right]$$

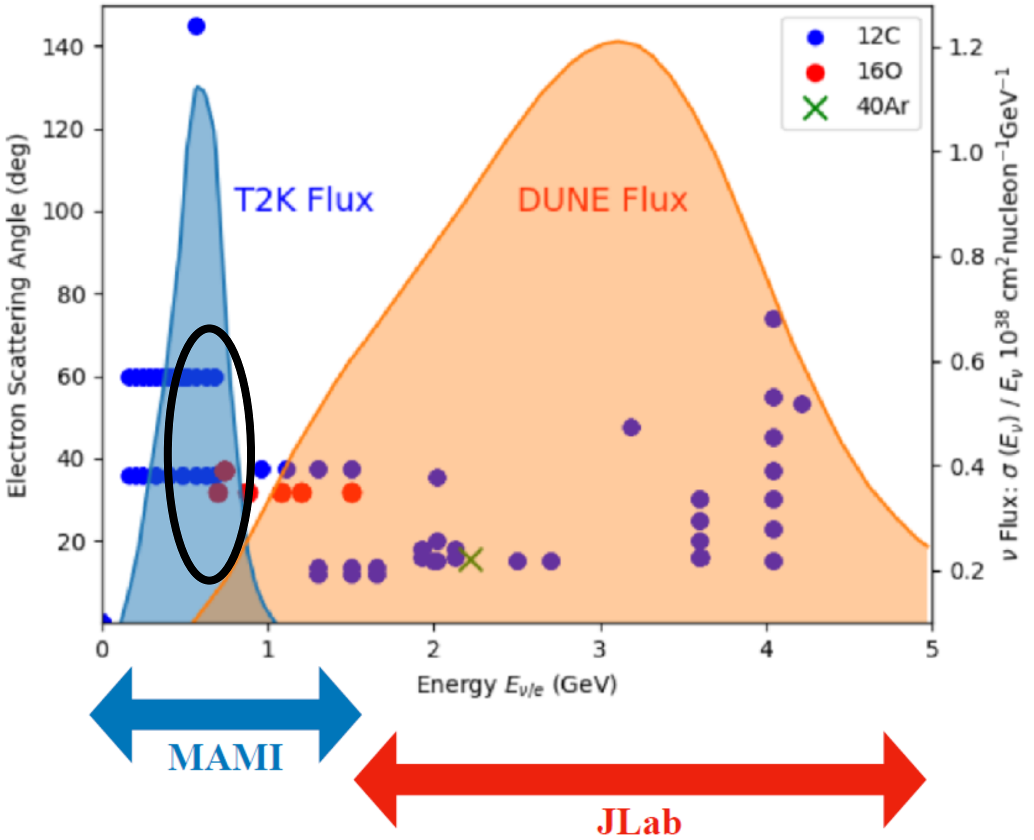
$$\left(\frac{d^2\sigma}{d\Omega d\omega}\right)_{\nu/\bar{\nu}} = \sigma_0 \left[A_{CC} R_{CC} + A_{CL} R_{CL} + A_{LL} R_{LL} + A_T R_T \pm A_{T'} R_{T'} \right]$$

- Useful to constrain model uncertainties
- Electrons have precisely known energies
  → Test incoming energy reconstruction methods

Target nuclei used in LBL experiments:

- ^{12}C, ^{16}O, and ^{40}Ar

Existing inclusive data for relevant 'electrons for neutrinos' - target nuclei



Experiments in Mainz @ A1

A1 setup is an unique tool for electron for neutrino experiments:

- covers a broad range of scattering angles
- beam energies from 50 MeV to 1.6 GeV

→ possible to investigate different nuclear effects

- We have already data for different kinematics of carbon and argon
- And measured oxygen (not analyzed yet)

If you want to see the results, come to my poster!!