Tackling DIS Region Using Spectral Function Formalism

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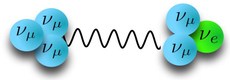
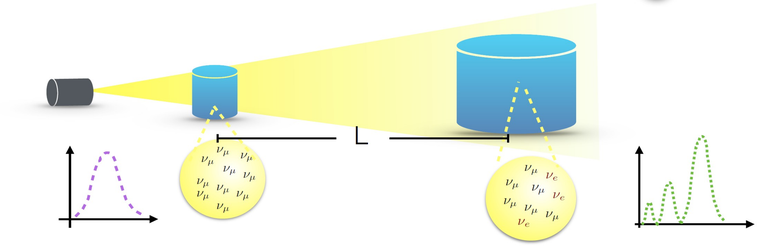
Mysteries of Neutrino Physics

Neutrinos are very elusive particles. Understanding their properties will give us information on the universe and its formation and potentially clarify open questions (e.g. baryon asymmetry).

$$P_{\nu_\mu \to \nu_e}(E, L) \sim \sin^2 2\theta \sin^2\left(\frac{\Delta m^2 L}{4E}\right) \to \Phi_e(E, L)/\Phi_\mu(E, 0)$$





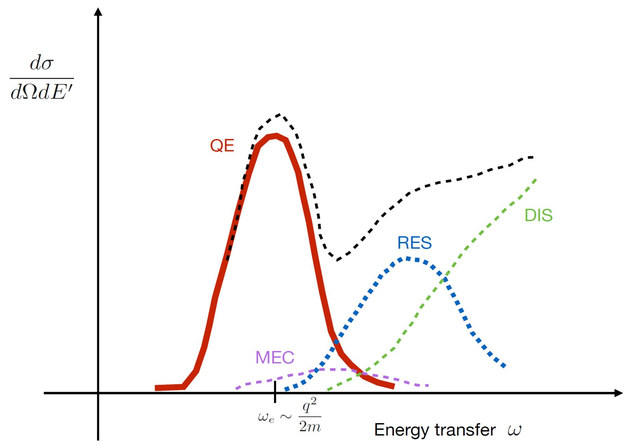
→ Fig. 1
Depiction of ν_μ oscillation.

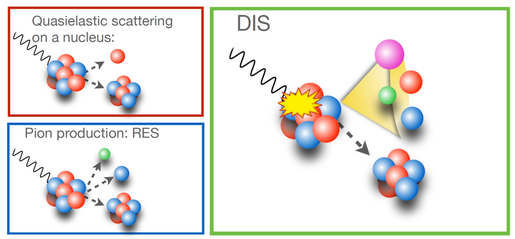
Detectors measure neutrino interaction rate: a quantitative knowledge of σ(E) and $f_\sigma(E)$ is crucial to precisely extract ν oscillation parameters.

$$N_e(E_{\text{rec}}, L) \propto \sum_i \Phi_e(E, L)\sigma_i(E) f_{\sigma_i}(E, E_{\text{rec}})dE$$

Reconstructed ν energy — Cross Section — Smearing matrix

← Fig. 2
Event count relation to σ as a function of reaction mechanism.





Different reaction mechanisms contributing to lepton-nucleus cross section—fixed value of the beam energy (monochromatic). In neutrino experiments these contributions are not nicely separated.

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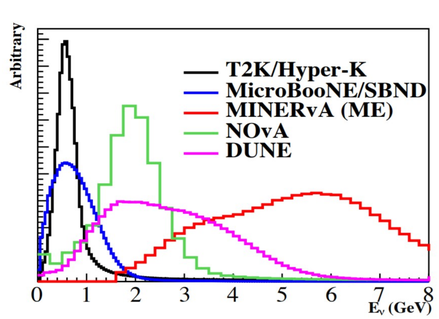
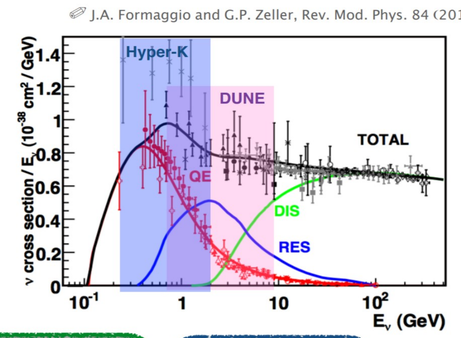
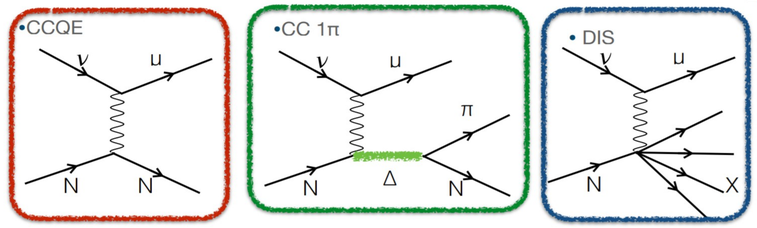
Prediction of ν cross-section for Deep Inelastic Scattering (DIS)

Interpretation of signals relevant to ongoing and future experiments at higher ν energies (MINERνA, NOνA, DUNE) require accurate predictions of nuclear cross-sections in inelastic channels.





← Fig. 3
Experimental flux given ν energy.



→ Fig. 4
Reaction mechanisms for ν-nucleon collisions.

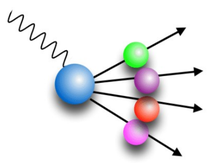
The intrinsic properties of the nucleus are described by the Spectral Function → effective field theory and nuclear many-body methods.

$$d\sigma_A = \int dE\, d^3k\, d\sigma_N P(\mathbf{k}, E) \qquad d\sigma_N \propto W_2(\omega, q^2)cos^2\frac{\theta}{2} + 2W_1(\omega, q^2)sin^2\frac{\theta}{2}$$

$$Q^2 \to \infty,\ \omega \to \infty$$

$$\omega W_2(\omega, q^2) \to F_2(x) = \sum_i e_i^2 x f_i(x)$$

$$mW_1(\omega, q^2) \to F_1(x) = \frac{1}{2x}F_2(x)$$



← Fig. 5
Nucleon structure functions can be written in terms of parton distribution functions in the limit of $Q^2 \to \infty$ and $\omega \to \infty$.

We utilize different sets of parton distribution functions (PDFs) using the LHAPDF library and compare with nuclear nCTEQ PDFs, allowing for an accurate prediction of DIS values needed to extract further oscillation parameters.