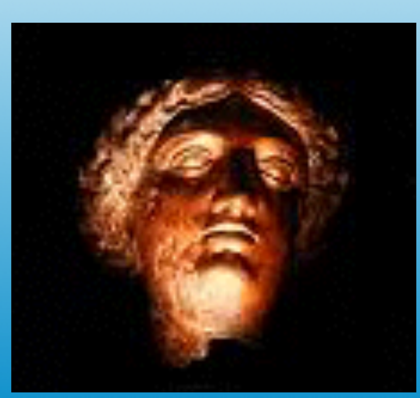


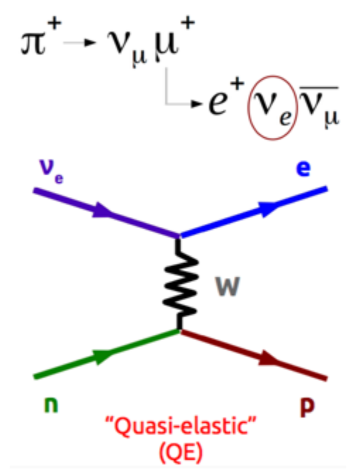
Electron neutrino quasi elastic scattering in MINERνA

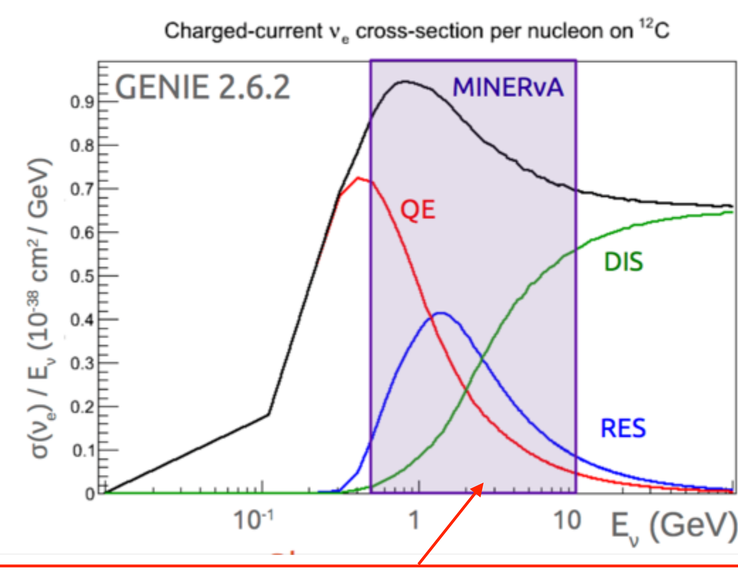
Jiyeon Han, University of Pittsburgh
on behalf of MINERνA collaboration

Electron neutrino quasi elastic scattering

Electron neutrino quasi elastic (QE) scattering

The process comes from the secondary decay from ν_μ process





Minerva covers E_ν = 0.5 ~ 10 GeV
QE fraction of the total decreases rapidly in E_ν > 0.5 GeV

ν_e QE differential cross section

- Measurement is important to ν_e appearance measurement
- Q^2 dependence of $\frac{\nu_e}{\nu_\mu}(CCQE)$ constrains cross section difference
- **Present the published result of cross section in LE and prospect for ME data**

Event selection

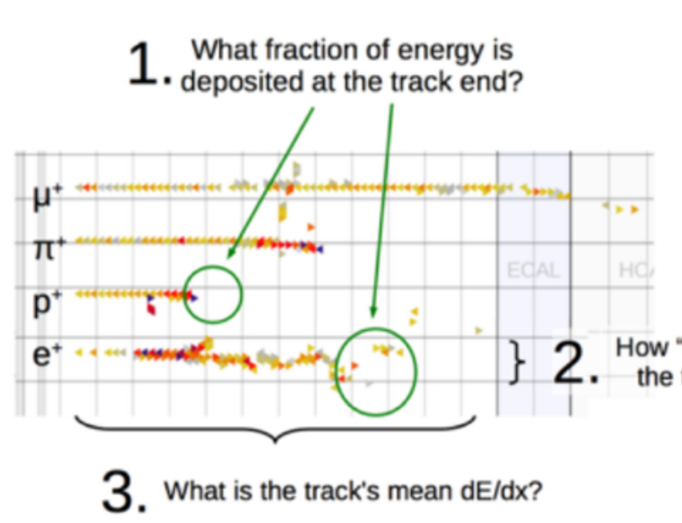
Signal definition of ν_e QE-like process :

- One electron or positron
- Any number of nucleons
- No other hadrons
- No photons with energies above 15MeV

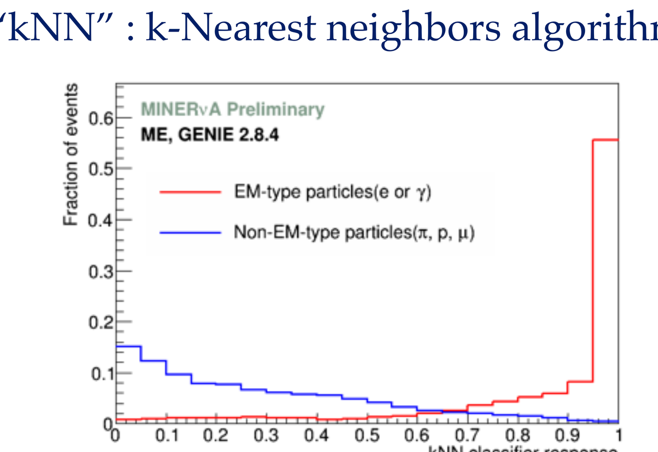
Good electron identification is important key of the measurement

Event selection for QE-like events :

- Fiducial and track quality cut
- Electron object selection : "kNN" method for electron identification

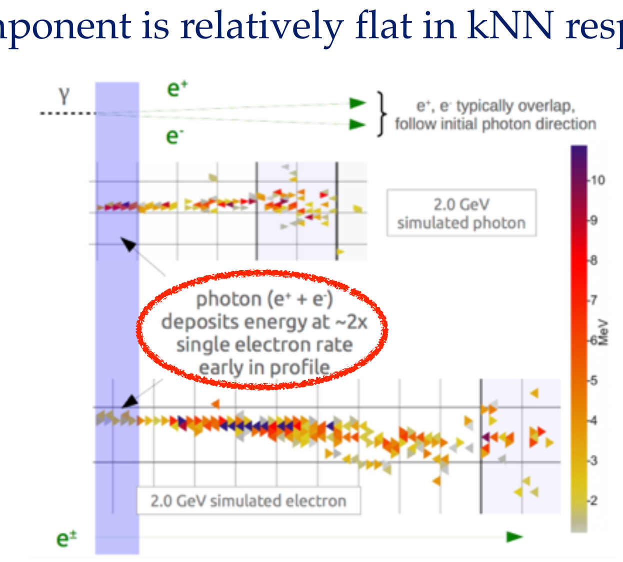


"kNN" : k-Nearest neighbors algorithm



π^0 component is relatively flat in kNN response

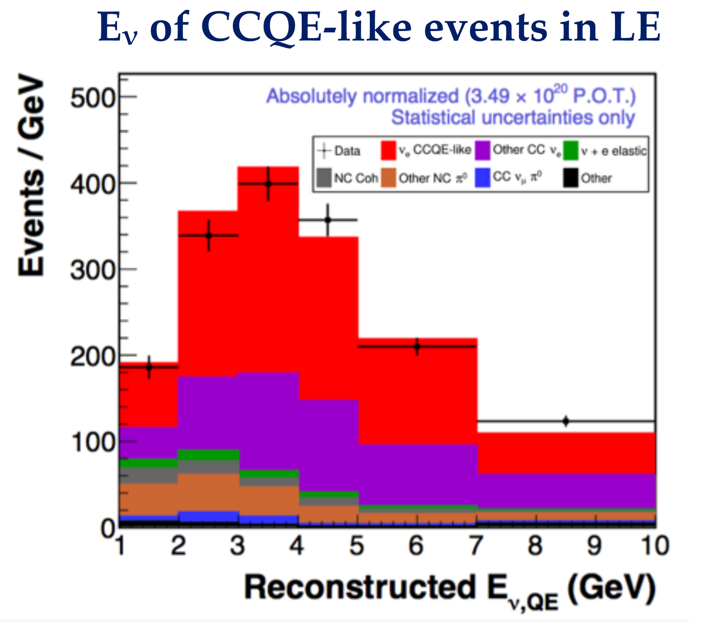
- Photon rejection :
  Energy deposition pattern early in track helps discriminate between $e^\pm$ vs. γ



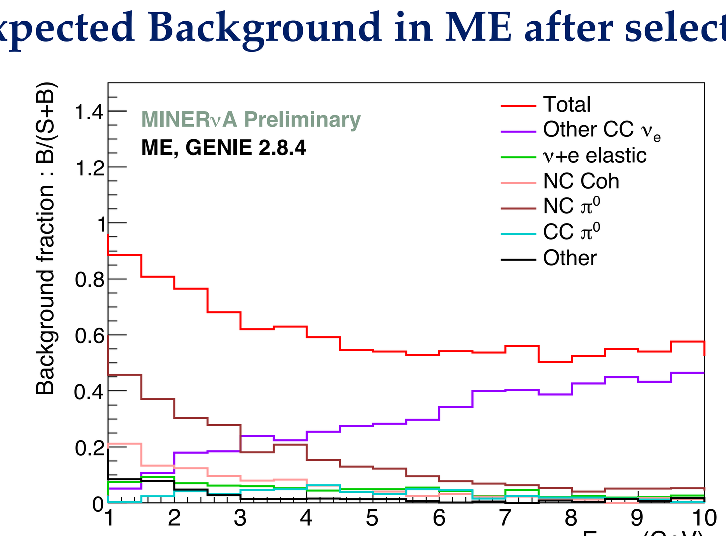
- CCQE-like event selection :
  Signal is an isolated process
  Require not much activity outside $e^\pm$ cone or near event vertex region

Background prediction

E_ν of CCQE-like events in LE



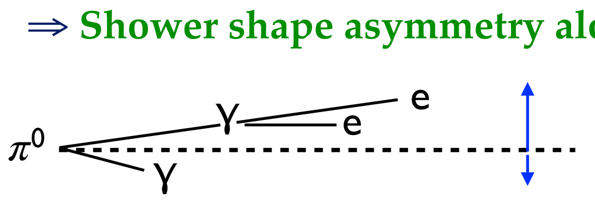
Expected Background in ME after selection



Background fraction in Q^2 is flat

Leading background is non-QE charged-current process (Resonance, DIS)
Neutral-current π^0 background is larger in ME (~50% more than LE)

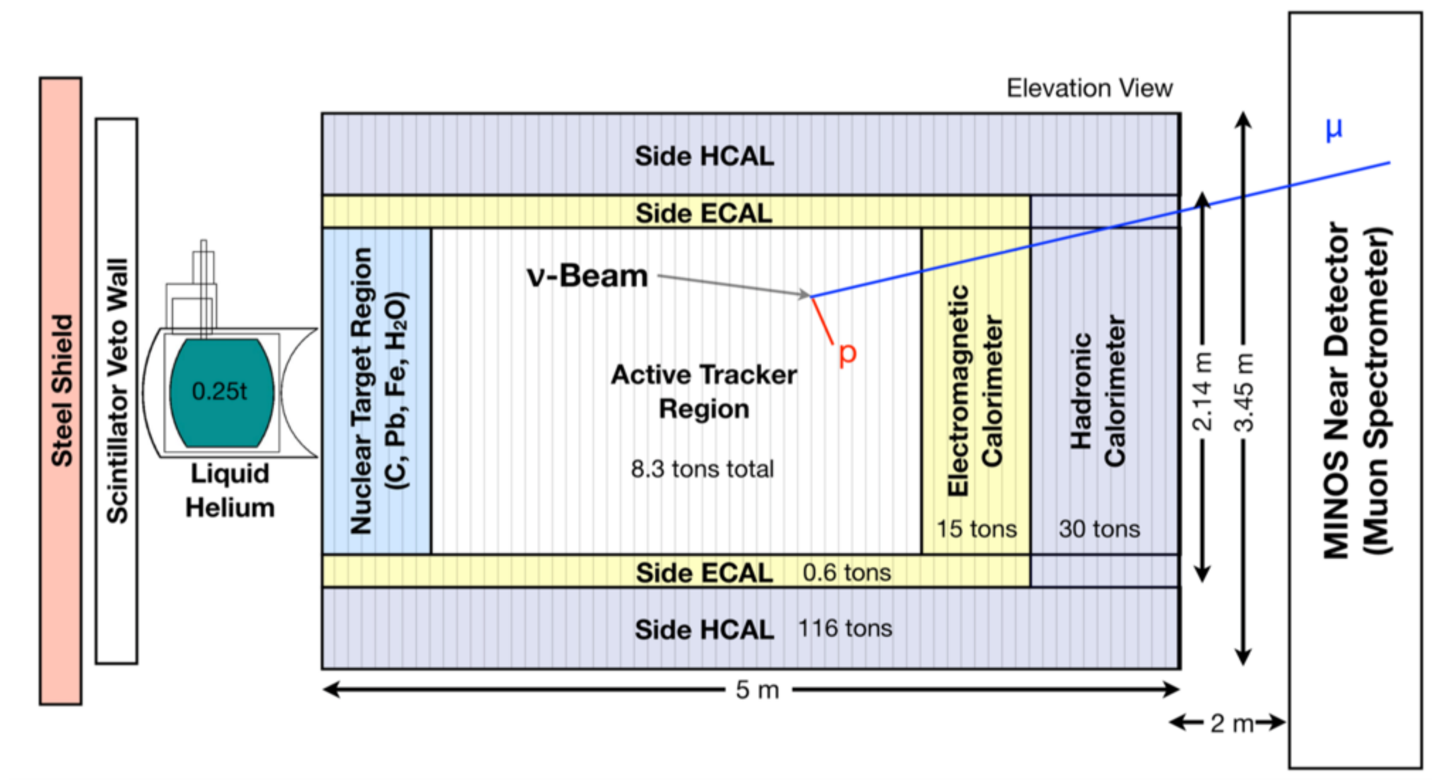
⇒ **Shower shape asymmetry along particle axis improves to discriminate π^0 from e**



Shower shape of π^0 is not symmetric along the particle axis

MINERνA detector

Minerva is a dedicated on-axis neutrino-nucleus scattering experiment running at FNAL in NuMI beam



Cross section measurement of Q^2

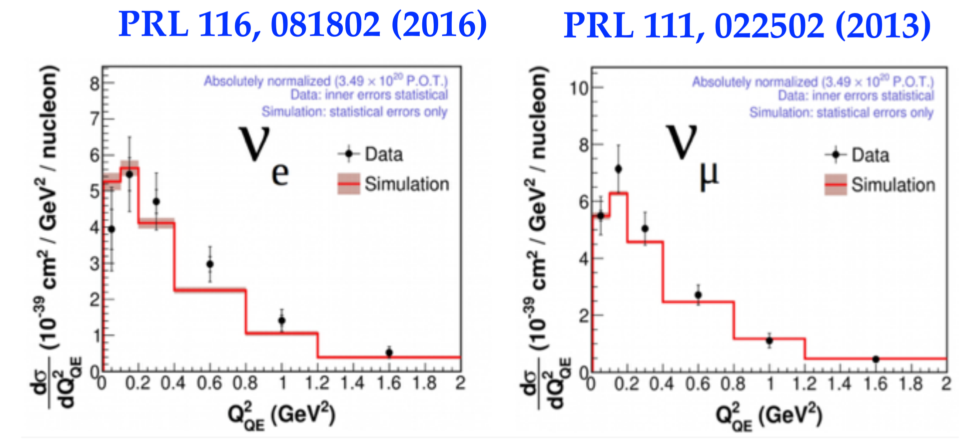
$$\left(\frac{d\sigma}{d\xi}\right)_i = \frac{1}{\Phi} \times \frac{1}{T_n} \times \frac{1}{(\Delta\xi)_i} \times \frac{\sum_j U_{ij}(N_j^{obs} - N_j^{bkg})}{\epsilon_i}$$

Flux, *Number of targets*, *Bin width*, *Unsmearing matrix*, *Selected sample*, *Background*, *Efficiency*

four-momentum energy transfer (Q^2) ⇒ $Q^2 = -m_e^2 + 2E_\nu(E_e - \sqrt{E_e^2 - m_e^2}\cos\theta_e)$

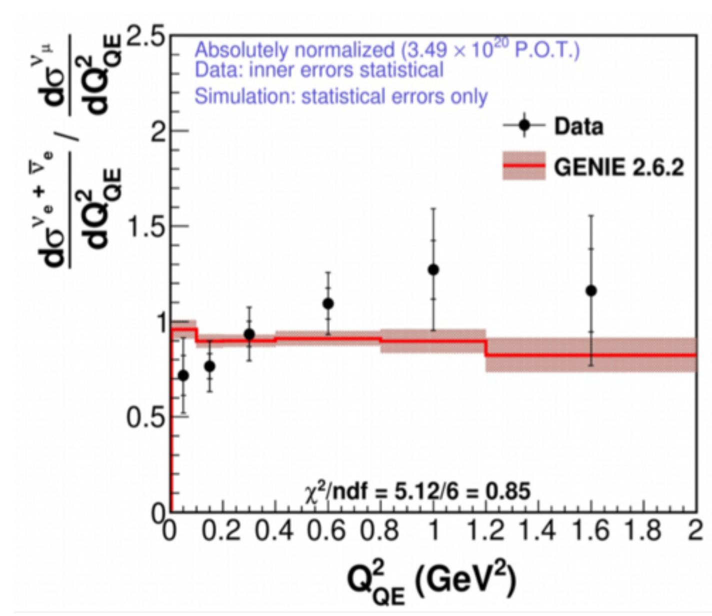
ν_e vs. ν_μ comparison

PRL 116, 081802 (2016) PRL 111, 022502 (2013)



Cross section differences arise from lepton mass terms and nuclear effects

Both ν_e and ν_μ cross sections agree with predictions within uncertainties

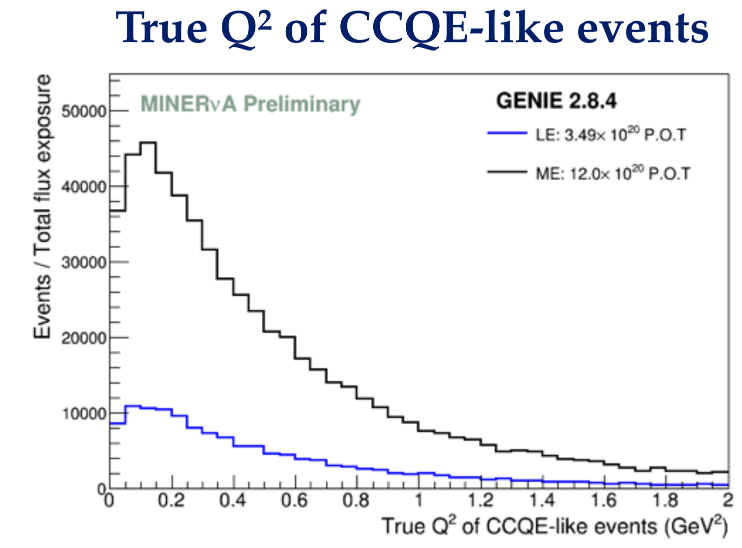


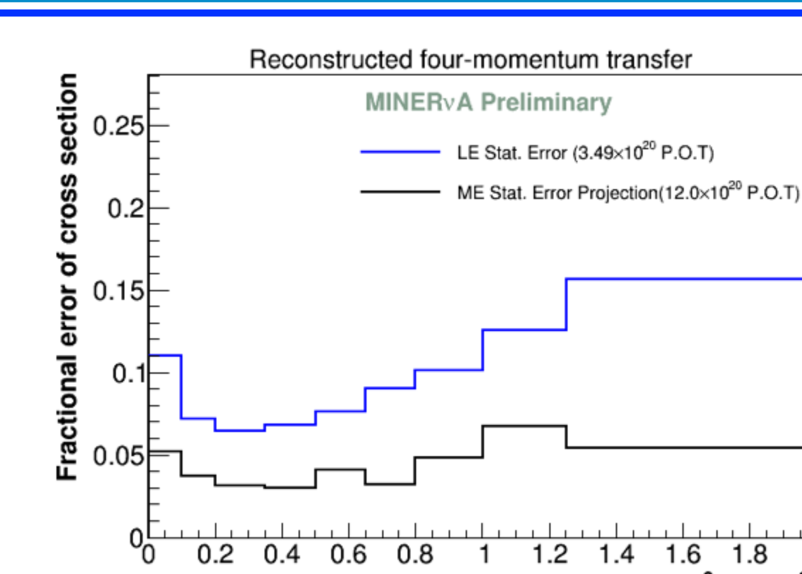
- Syst. errors partially cancel in ratio
- ν_e CCQE stat. errors dominant

⇒ *Goal is to further improve the precision of ν_e CCQE measurement*

Fractional uncertainty projection in ME

True Q^2 of CCQE-like events





- **Measurement precision improves from statistics increase ME**
- Systematic errors are expected to be improved in ME (Flux, Detector, Modeling)

Summary

- Cross section of electron neutrino quasi elastic is measured using LE data
- Cross section ratio of ν_e to ν_μ is compared and still agrees with prediction
- Measurement is expected to have better precision :
  - Reduce the stat. uncertainty by half, especially in high Q^2 region
  - Expect the reduction of syst. uncertainty from improvement of modeling

⇒ *Improve the sensitivity of cross section ratio (ν_e/ν_μ) measurement*