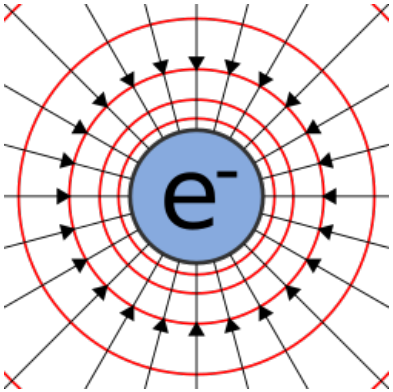
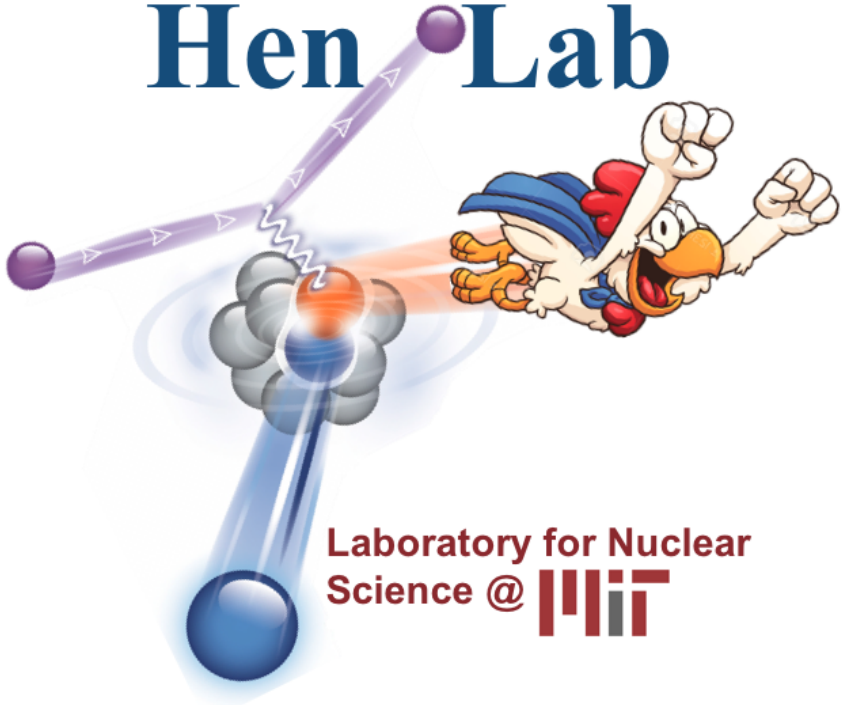
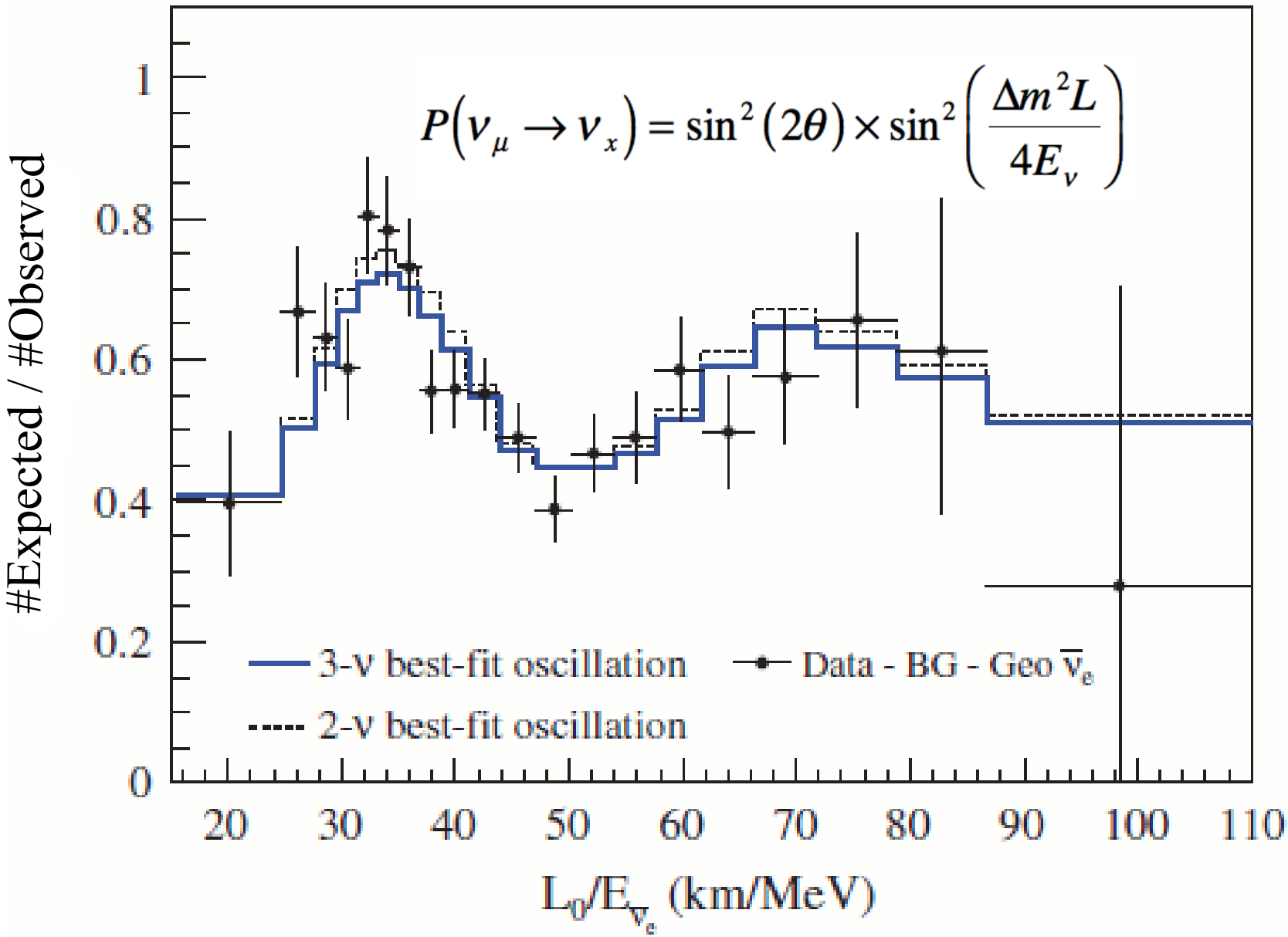
Electrons for Neutrinos





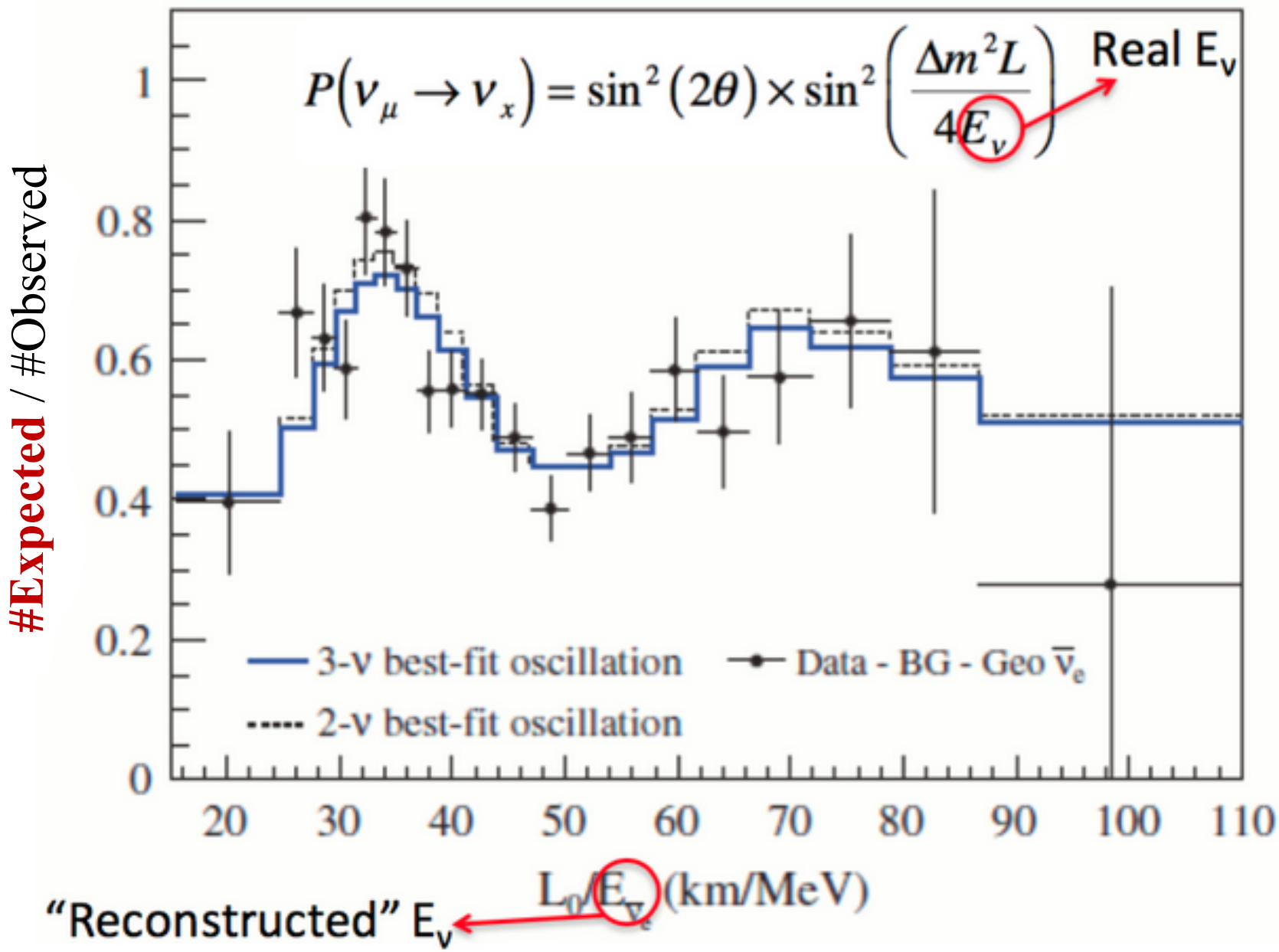
Afroditi Papadopoulou
New Perspectives 2018
Fermilab, IL
6/18/18

Neutrino Oscillations



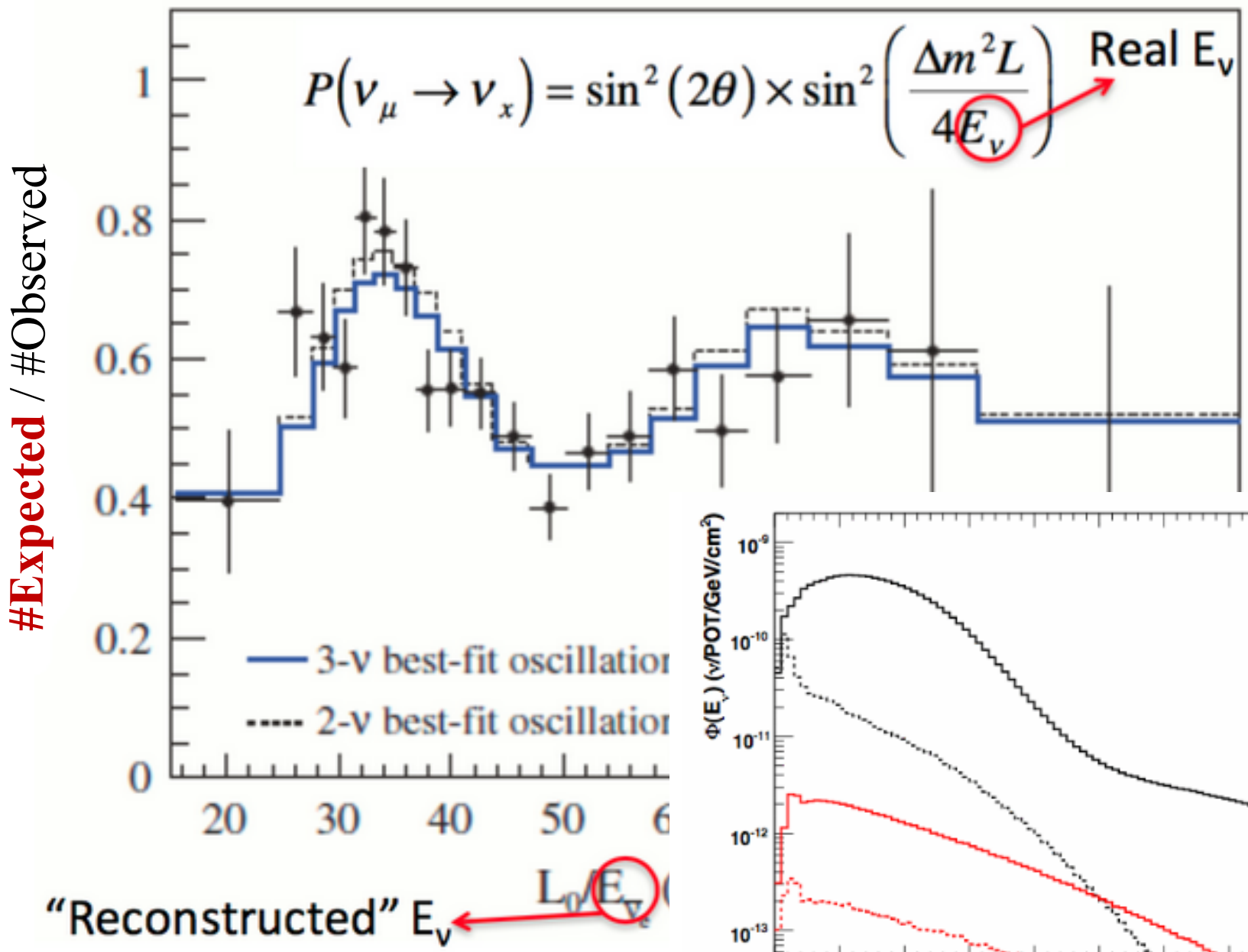
KamLAND, PRL 100, 221803 (2008)

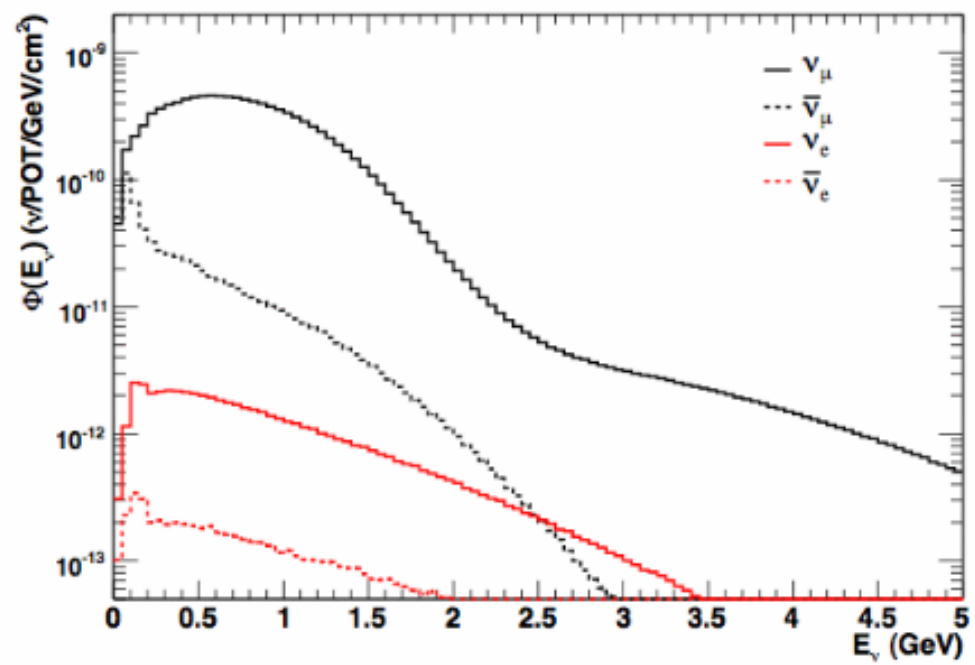
Neutrino Oscillations



KamLAND, PRL 100, 221803 (2008)

Neutrino Oscillations





KamLAND, PRL 100, 221803 (2008)

New Strategy

New Strategy

Electrons for Neutrinos!

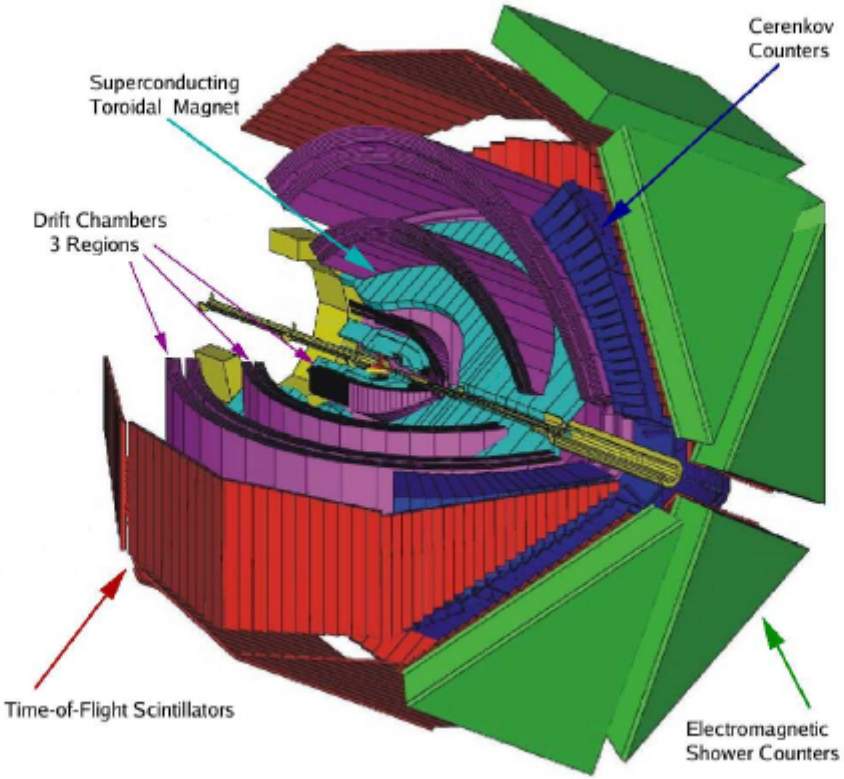
- Use e-scattering data to constraint ν-data.

Why ?

- *e and ν share many common aspects of the interaction (isovector part).*
- *Beam energy and EM interaction well known.*
- *CLAS@JLab: Large number of e-scattering data in a wide phase-space.*

Beam energy (# triggers)			
Target	1.161 GeV	2.261 GeV	4.461 GeV
^{3}He	141	217	186
^{4}He	-	333	445
^{12}C	62	238	310
^{56}Fe	-	23	30
CH2	10	35	21
Empty cell	19	69	33

e2a Data Analysis Strategy



- *Select QE-like (e,e'p) events.*
- *Reweight by e-N / ν -N cross-section ratio.*
- *Analyze them as "neutrino data".*
- *Study kinematic quantities and beam energy reconstruction methods.*
- *Compare to Neutrino Event Generator predictions.*
- *Identify parts in phase-space with good agreement.*

GENIE is a Universal Neutrino Event Generator

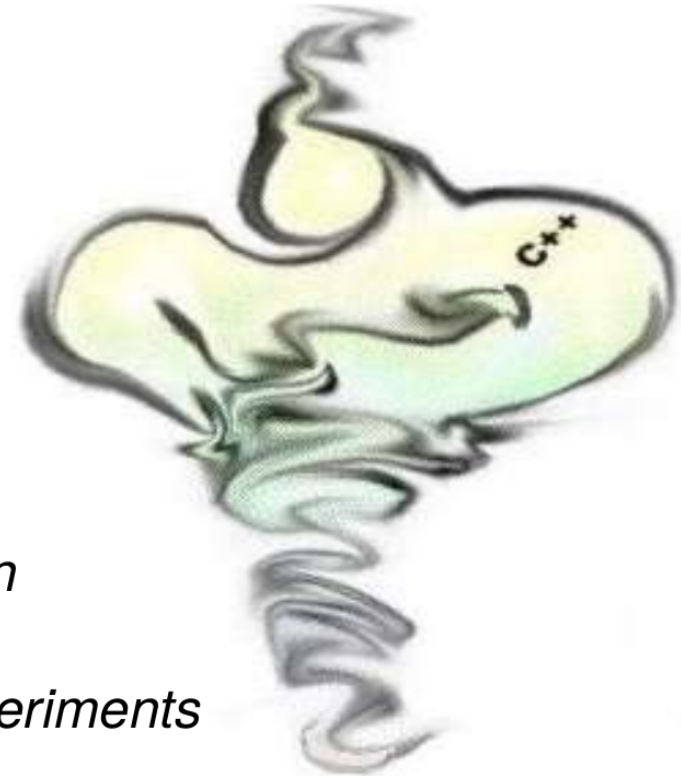
Generates

Events for

Neutrino

Interaction

Experiments



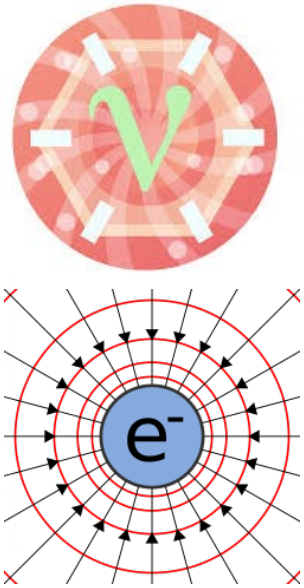
Includes:

- *Flux Drivers.*
- *Detector Geometry Analysers for standard detector descriptions.*
- *Interfaces with GEANT for feeding it with GENIE events.*

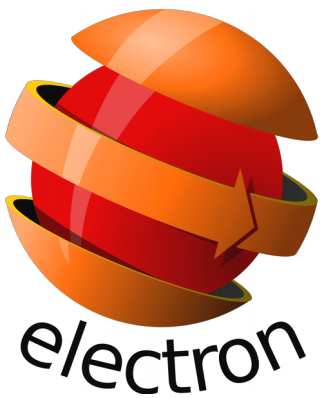
Event Selection

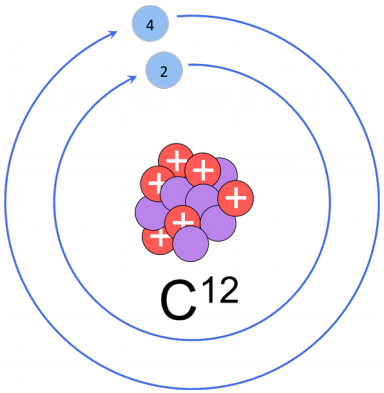
Analysis on ^{12}C @ E = 2.261 GeV

- 1 proton with $p_p > 300$ MeV/c.
- Fiducial cuts.
- π^0 corrections.
- 2-proton & charged pion corrections.
- $Q^2 \geq 0.5$ GeV^2/c^2
- $W < 2$ GeV/c^2
- $|x_B - 1| < 0.2$
- Simulation: Only QE & MEC events.

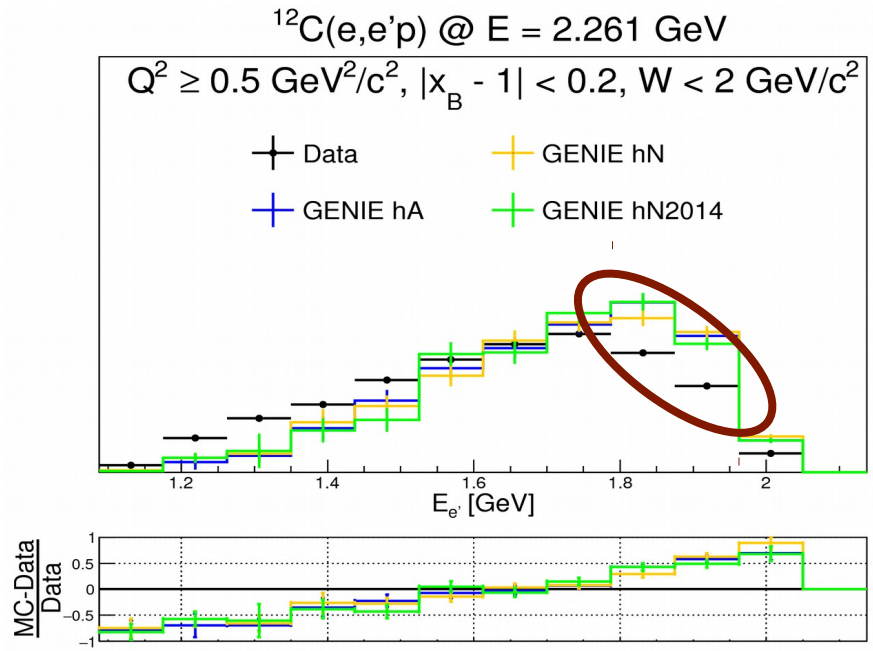


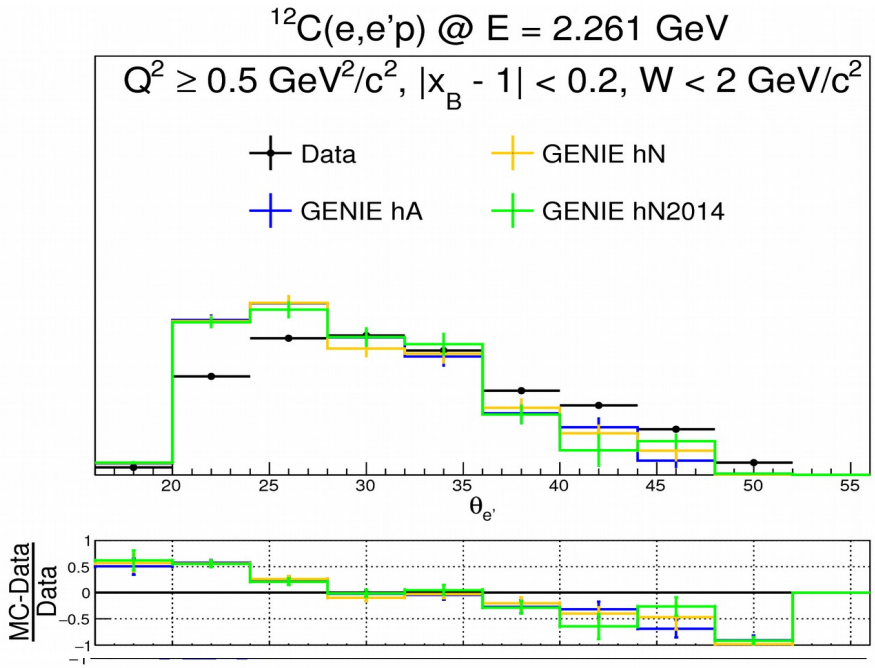
Phase Space

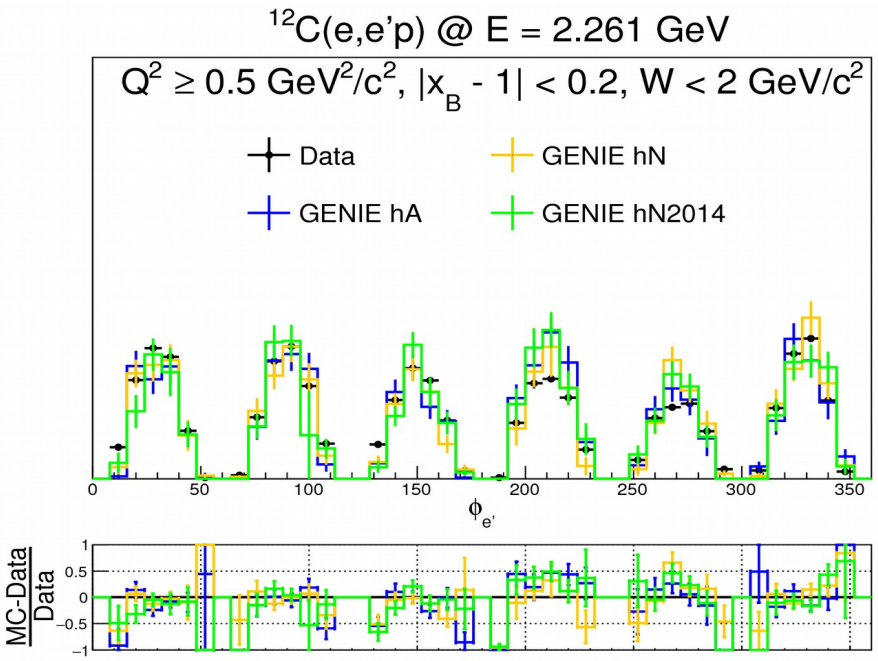




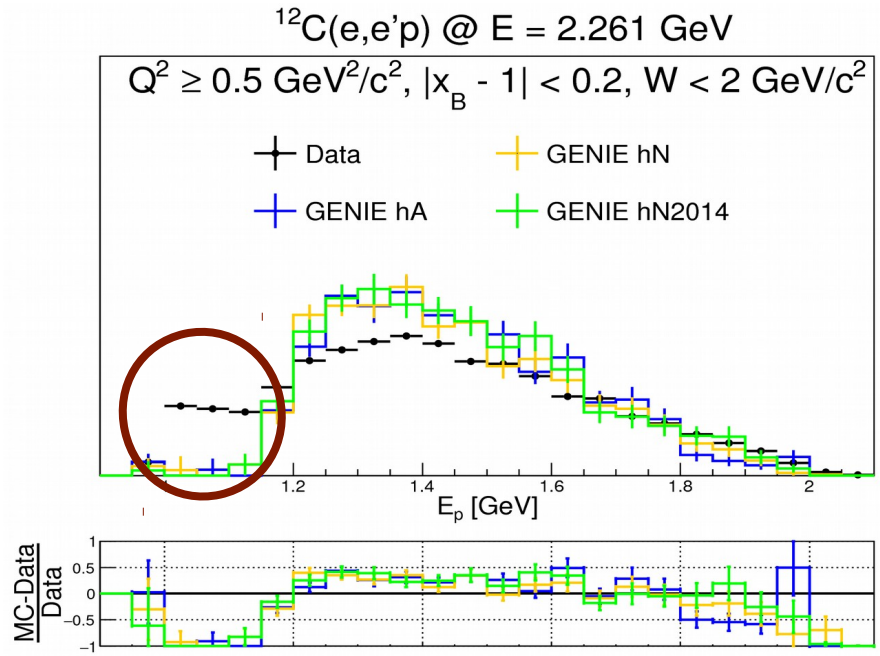
Electron Phase Space

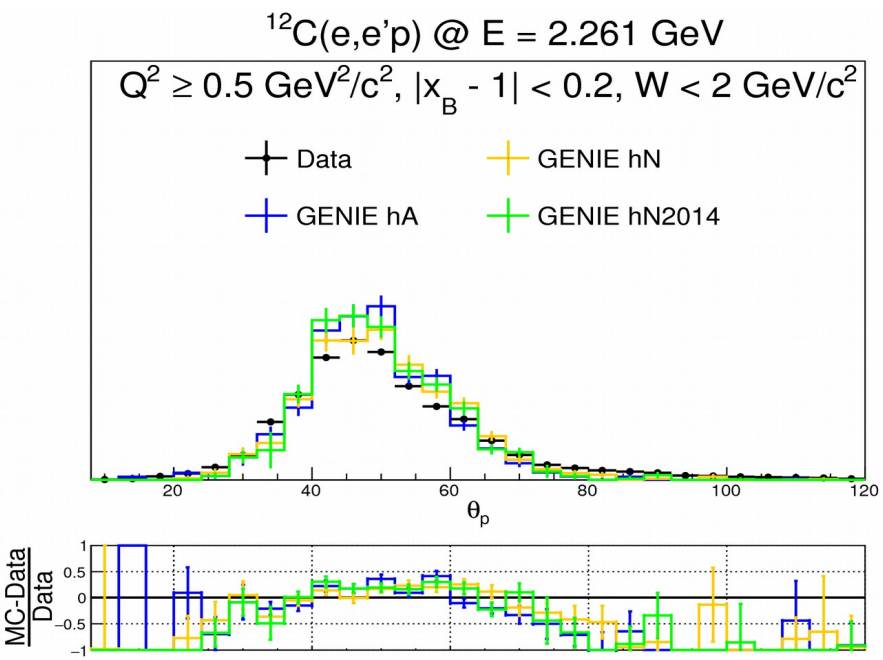


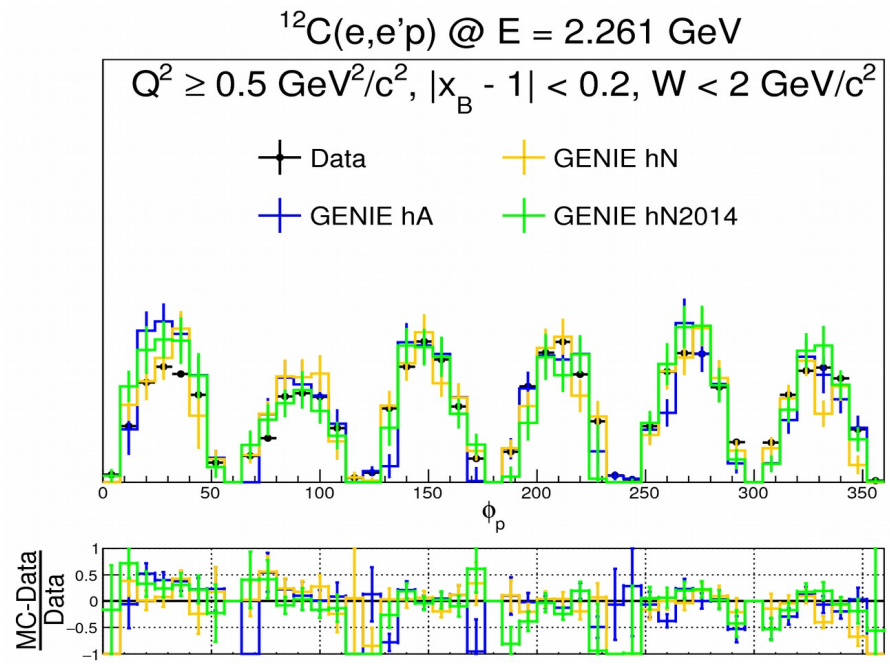




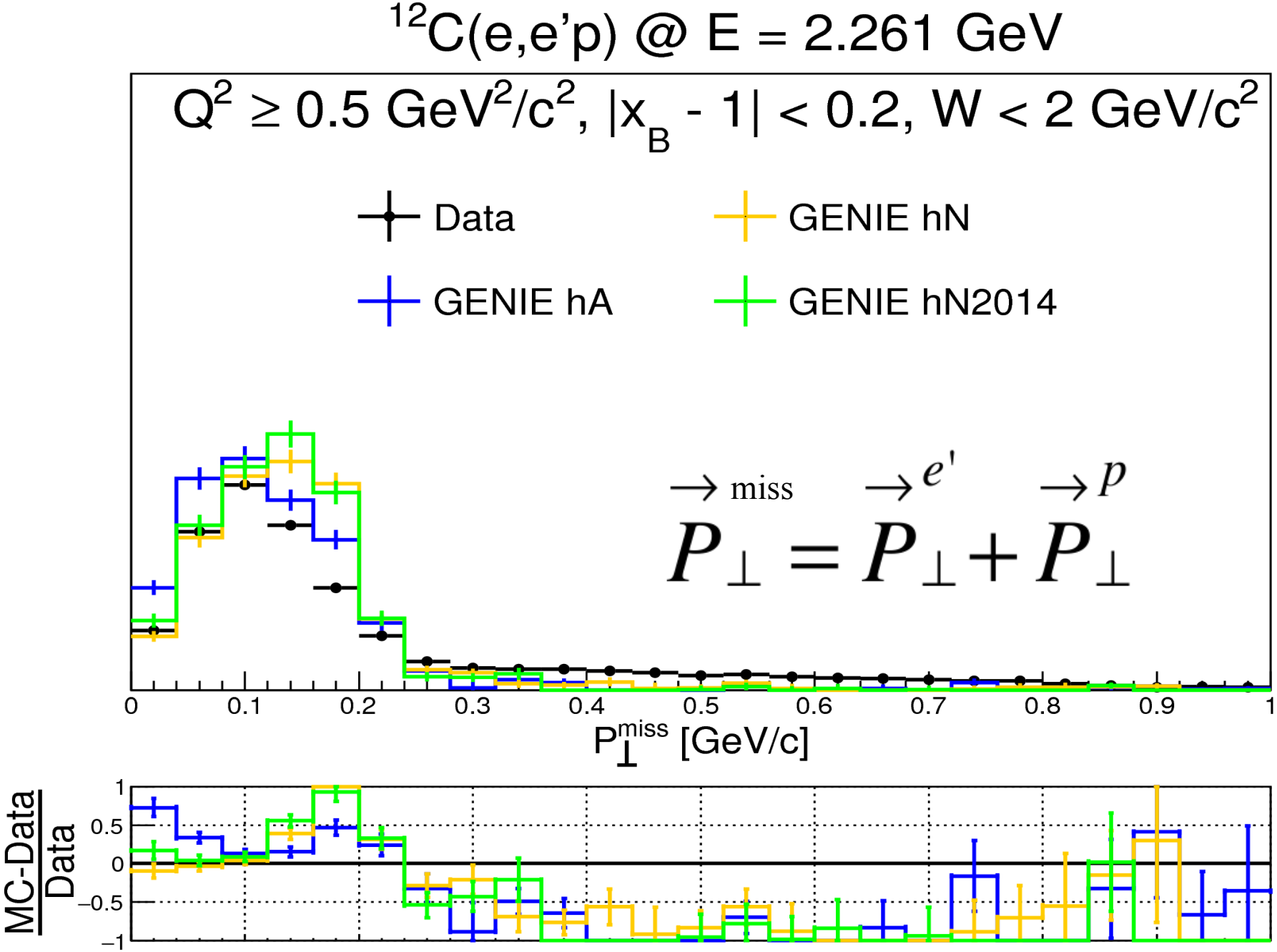
Proton Phase Space



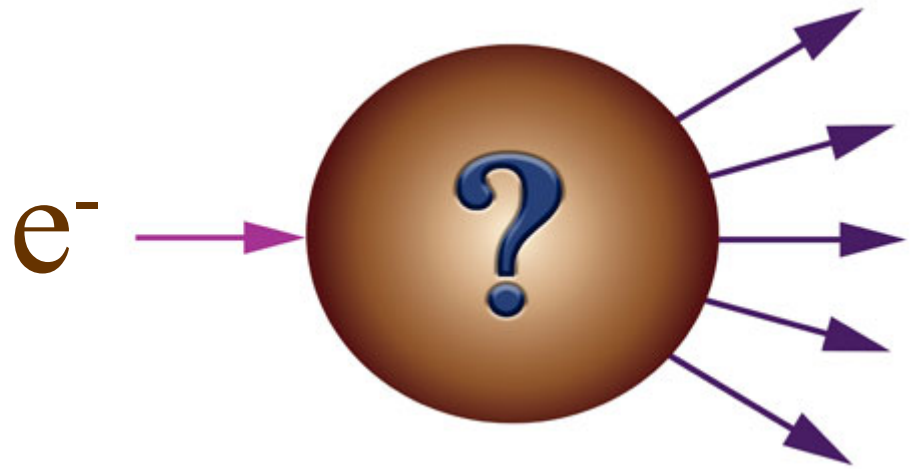




$P^{miss}_{\perp}$ Plot

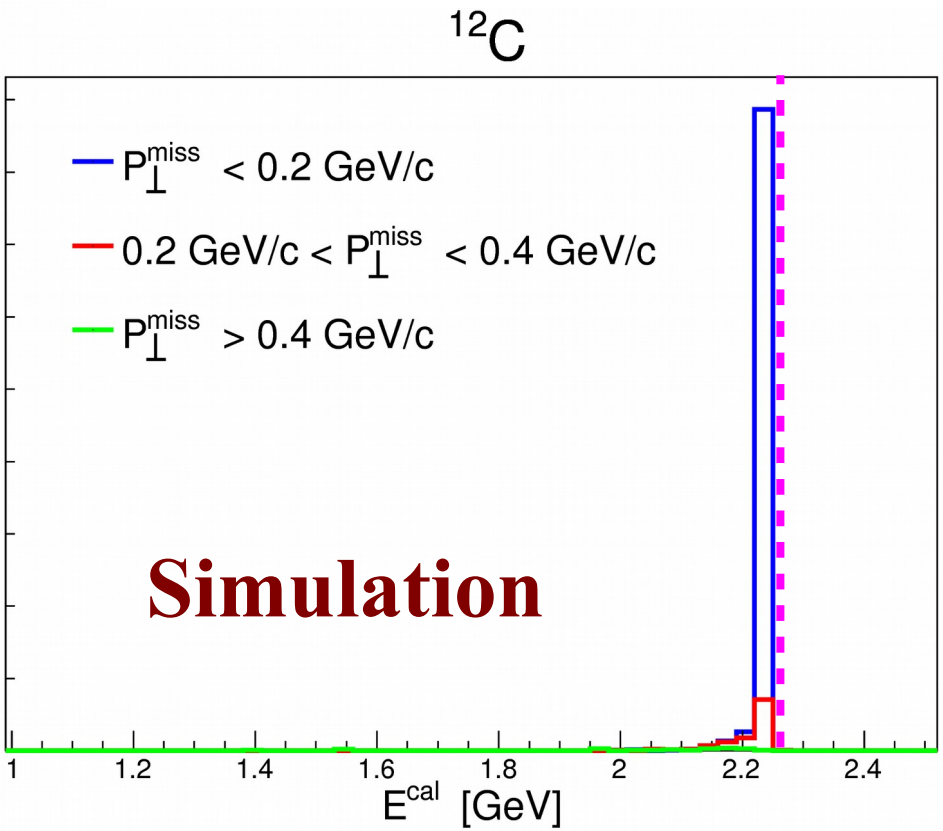


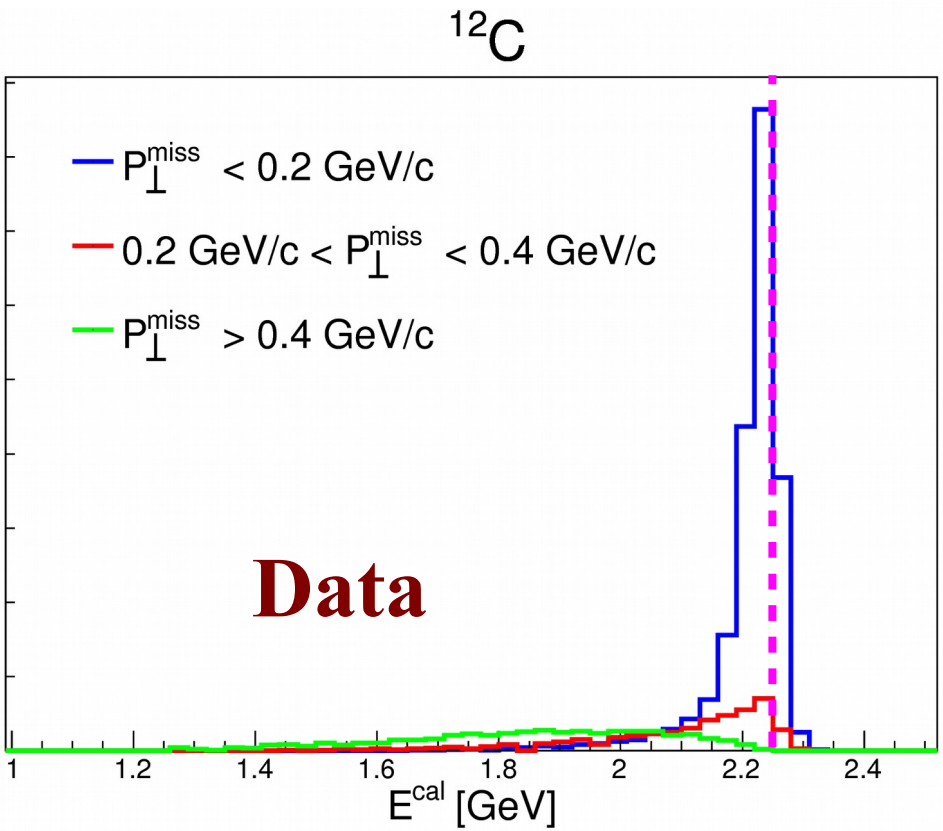
Energy Reconstruction



Calorimetric Energy Reconstruction

$Q^2 \geq 0.5\ GeV^2/c^2,\ |x_B - 1| < 0.2,\ W < 2\ GeV/c^2$





Calorimetric Reconstruction

(sum over all particles)

$$E_\nu^{cal} = T_h + E_l + BE$$

Future Plans

Benchmarking the GENIE Neutrino Event Generator Against Electron Scattering Data

Ongoing Efforts

- *Implementation of the MEC, Resonance and DIS into GENIE.*
- *Expand to other generators / reactions / nuclei / energies.*
- *Study impact on bias in oscillation analyses.*

Thank you!

Mariana Khachatryan (ODU)

Afroditi Papadopoulou (MIT)

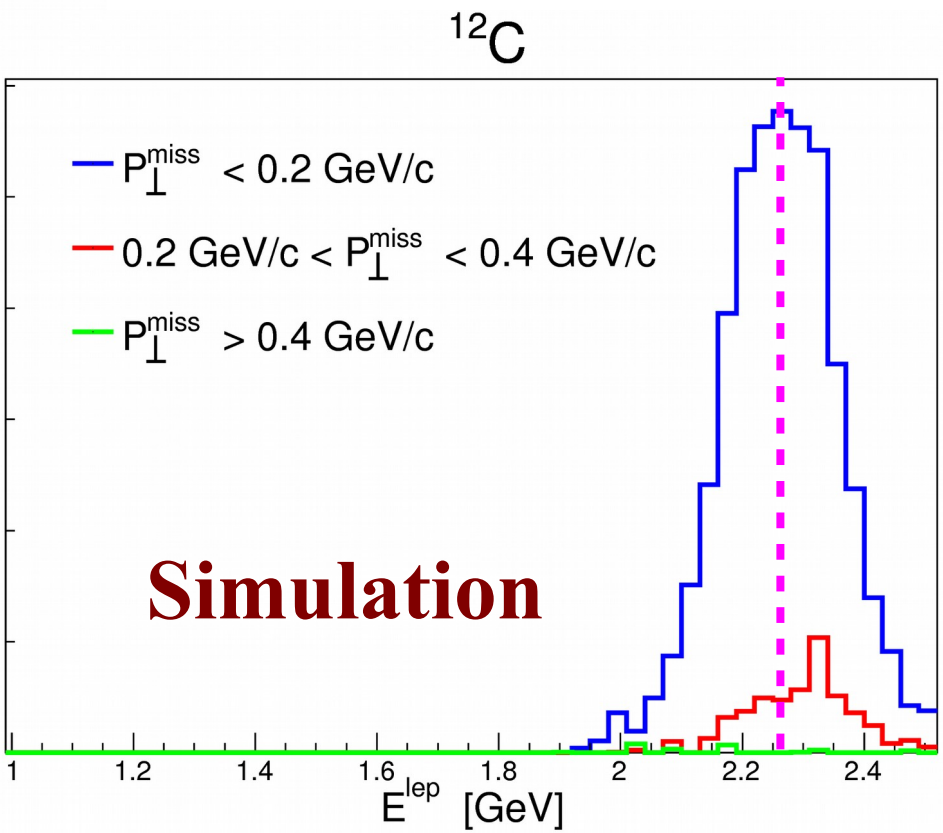
Adi Ashkenazi (MIT)

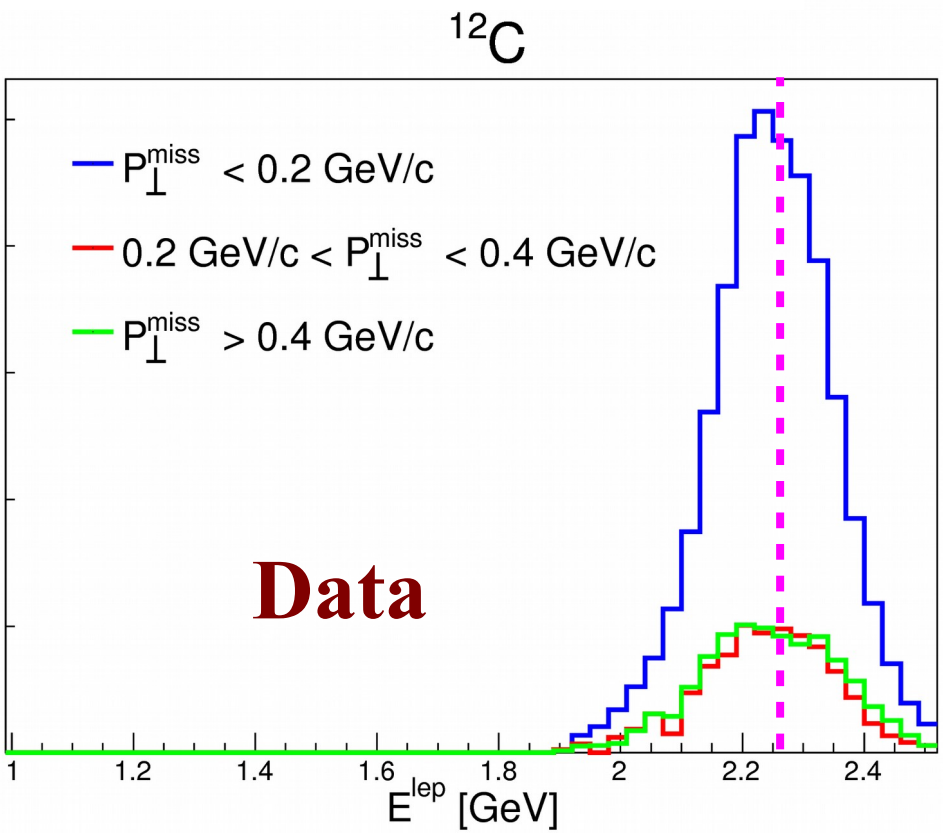
\+ Larry Weinstein (ODU), Or Hen, Adrian Silva (MIT), Kendall Mahn (MSU), Steve Dytman (Pitsburg), Eli Piasetzky, Erez Cohen (TAU) Minerba Betancourt (FNAL)

Backup Slides

Leptonic Energy Reconstruction

$Q^2 \geq 0.5\ GeV^2/c^2,\ |x_B - 1| < 0.2,\ W < 2\ GeV/c^2$

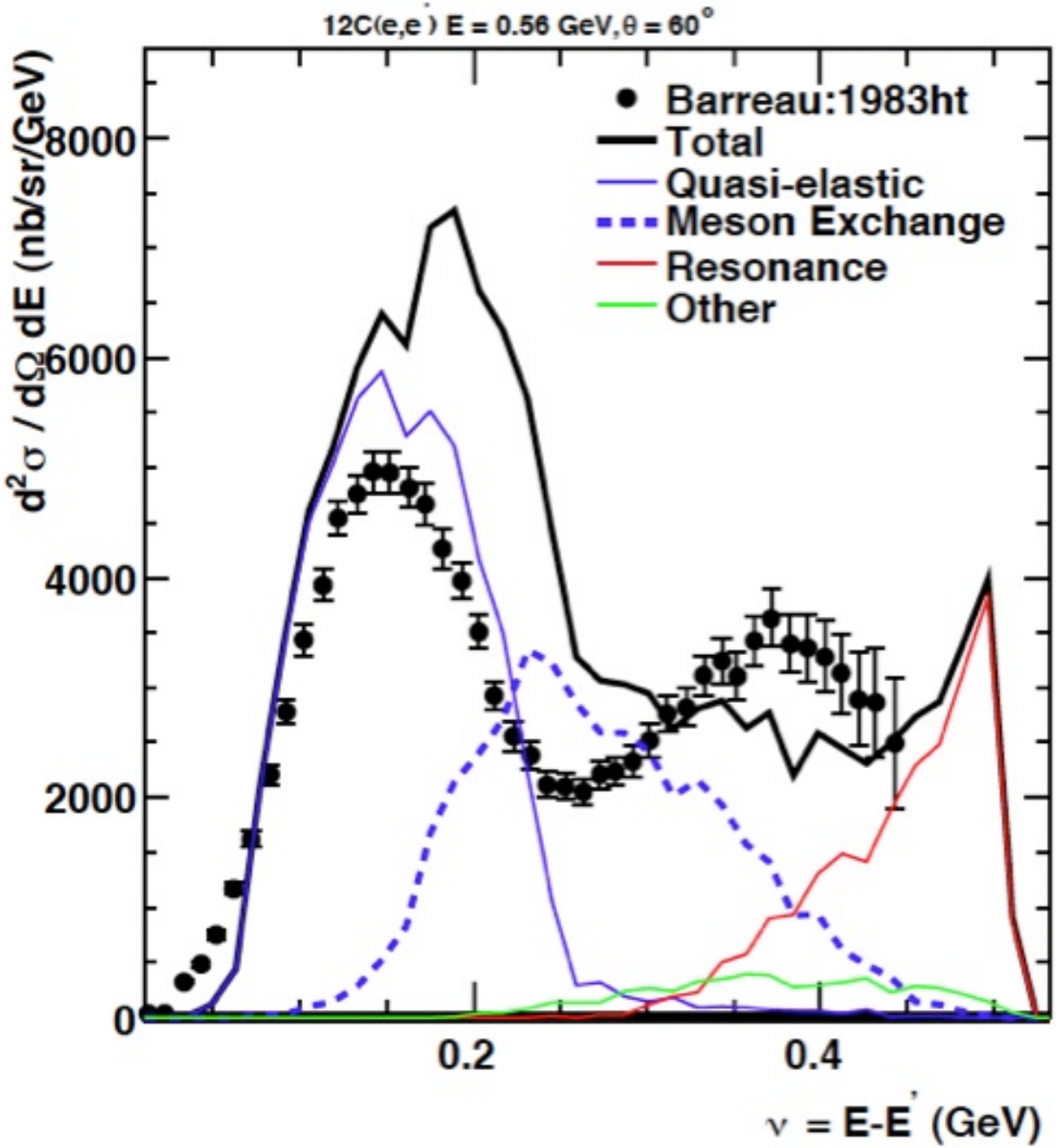




<u>Leptonic Reconstruction</u>

(only scattered lepton)

$$E_\nu^{kin} = \frac{2M\varepsilon + 2ME_l - m_l^2}{2(M - E_l + |k_l|\cos\theta)}$$


12C(e,e') E = 0.56 GeV, θ = 60°
Barreau:1983ht
Total
Quasi-elastic
Meson Exchange
Resonance
Other
d²σ / dΩ dE (nb/sr/GeV)
8000
6000
4000
2000
0
0.2
0.4
ν = E-E' (GeV)