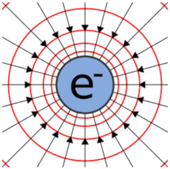
Electrons for Neutrinos Simulation



Hen Lab

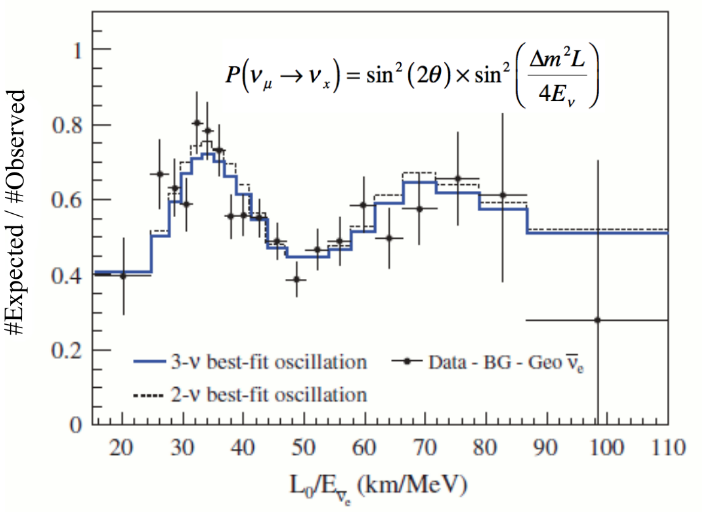
Laboratory for Nuclear Science @ MIT

Afroditi Papadopoulou

CLAS Summer Collaboration Meeting

July 12, 2018

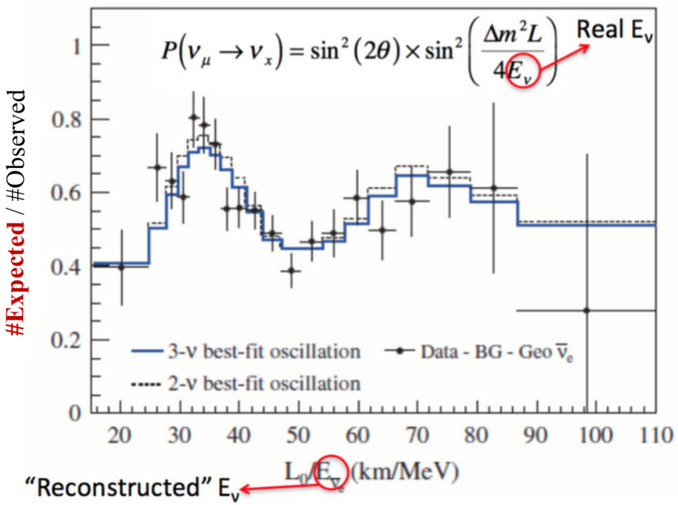
Neutrino Oscillation Analysis



KamLAND, PRL 100, 221803 (2008)

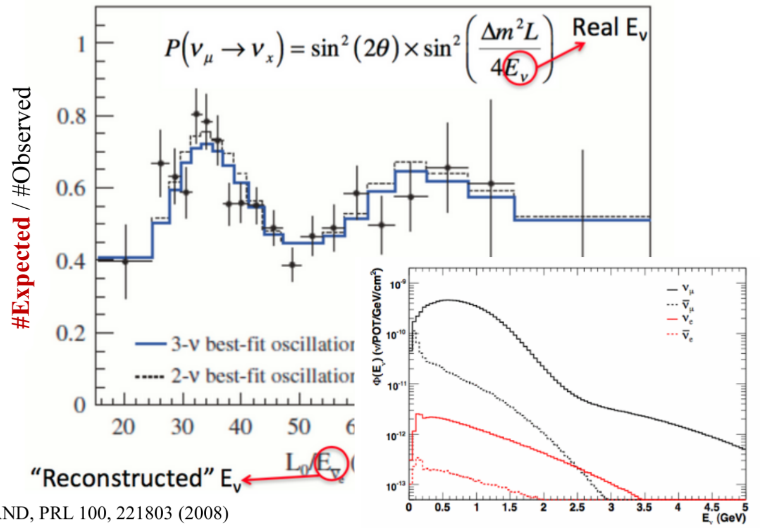
Motivation

Neutrino Oscillation Analysis



KamLAND, PRL 100, 221803 (2008)

Neutrino Oscillation Analysis



KamLAND, PRL 100, 221803 (2008)

New Strategy

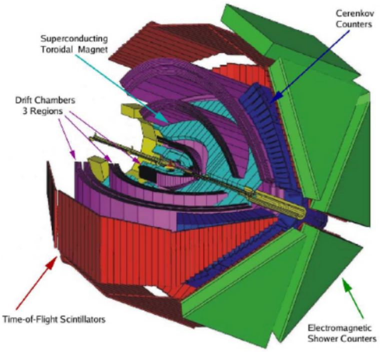
Electrons for Neutrinos!

Why?

↪ e and ν share many common aspects (isovector part).
↪ Well known beam energy.
↪ Large number of e-scattering data in a wide phase-space.

*CLAS@JLab **Millions of 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".
↪ Compare to event generator predictions.
↪ Identify parts in phase-space with good agreement.

Simulation Event Selection

$C^{12}(e, e'p)@E = 2.261GeV$

$\hookrightarrow$ *Only 1 proton*

$\hookrightarrow$ *No charged or neutral pions*

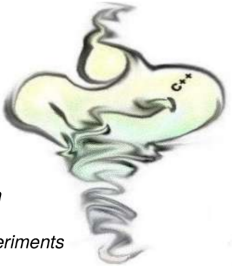
$\hookrightarrow Q^2 > 0.5GeV$

$\hookrightarrow$ *W < 2 GeV*

$\hookrightarrow |x_B - 1| < 0.2$

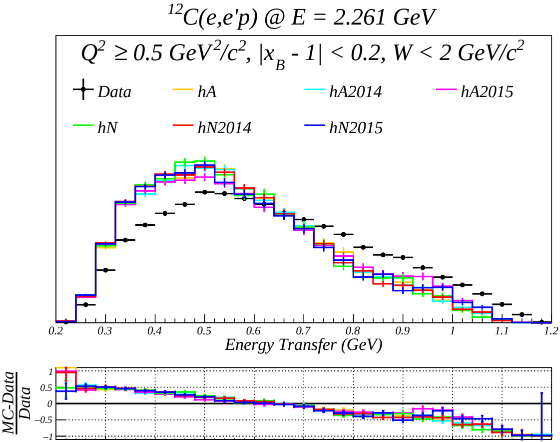
$\hookrightarrow$ *Division by the Mott cross-section*

Generates
Events for
Neutrino
Interaction
Experiments



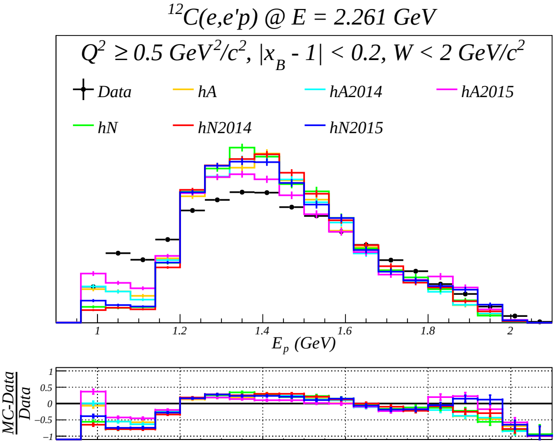
Significant differences

Even around the QE peak.



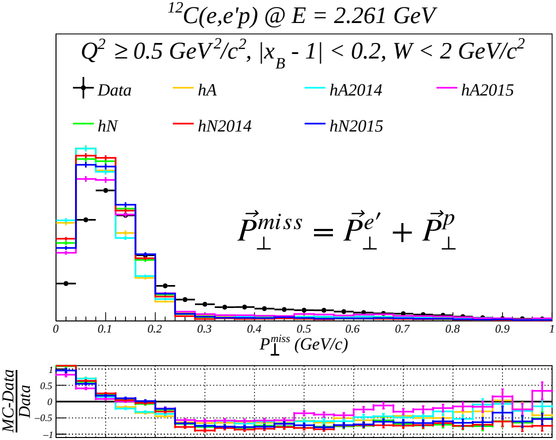
Significant differences

In the low energy regime.



Transverse Missing Momentum

Underestimation in the high $P_{\perp}^{miss}$ regime.



Energy Reconstruction

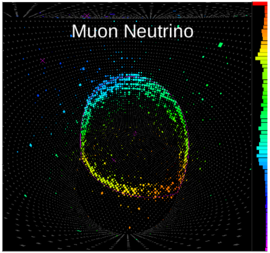
Energy Reconstruction Methods

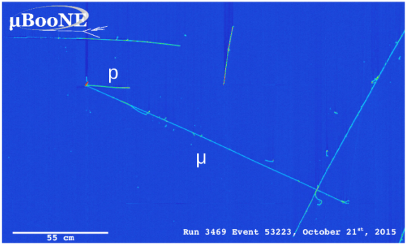
Leptonic Method

Only scattered lepton assuming QE scattering.

Calorimetric Method

Using all the particles in the final state.





Cherenkov Detectors

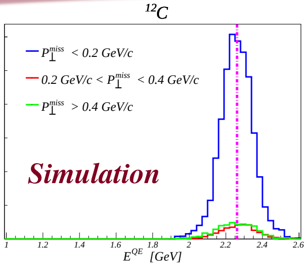
Electrons & Pions.
No protons or neutrons.

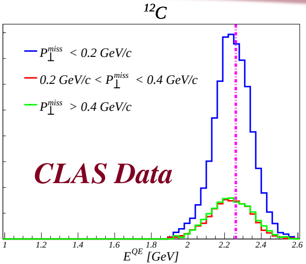
Tracking Detectors

Charged Particles & π^0.
Progress towards neutrons (ANNIE).

Only Final State Lepton

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





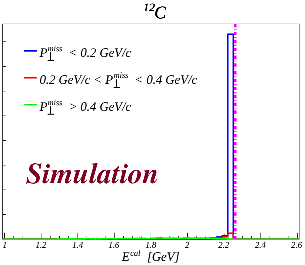
Simulation vs CLAS Data

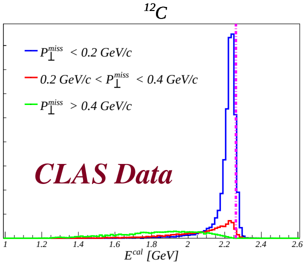
Significantly smaller contribution from higher $P_\perp^{miss}$ slices in our simulation.

Calorimetric Energy Reconstruction

All Final State Particles

$$E_{cal} = E_l + \Sigma T_p + \epsilon + \Sigma E_\pi$$



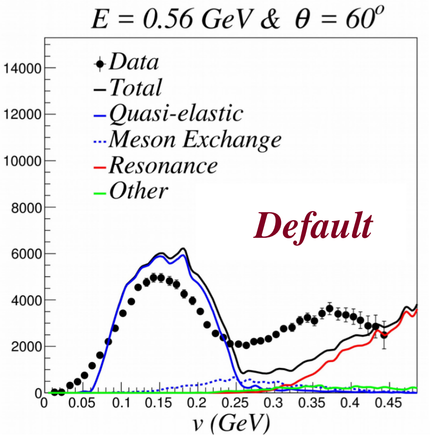


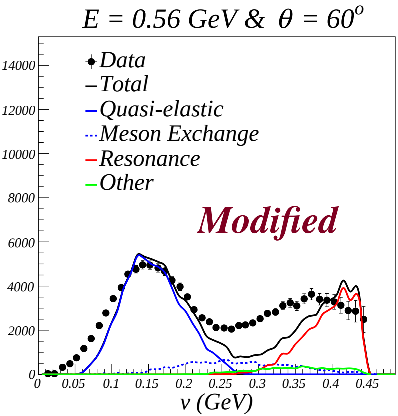
Simulation vs CLAS Data

Much broader distributions from CLAS Data.

GENIE Event Generator Development

Standard Candle → Inclusive Analysis On ^{12}C





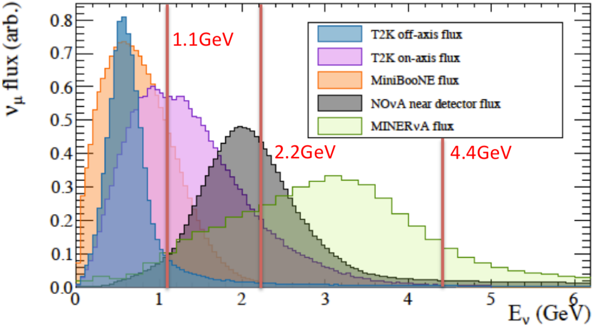
Future Plans

Available Nuclei

^{3}He, ^{4}He, ^{12}C, ^{56}Fe

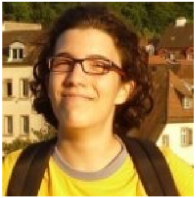
Available Energies

1.1 GeV, 2.261 GeV, 4.461 GeV



Thank you!

Mariana Khachatryan (ODU@JLab)



Afroditi Papadopoulou (MIT@FNAL)

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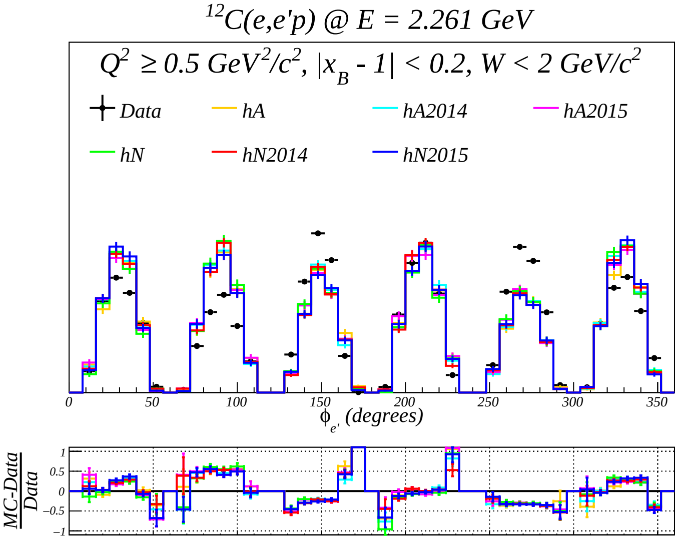
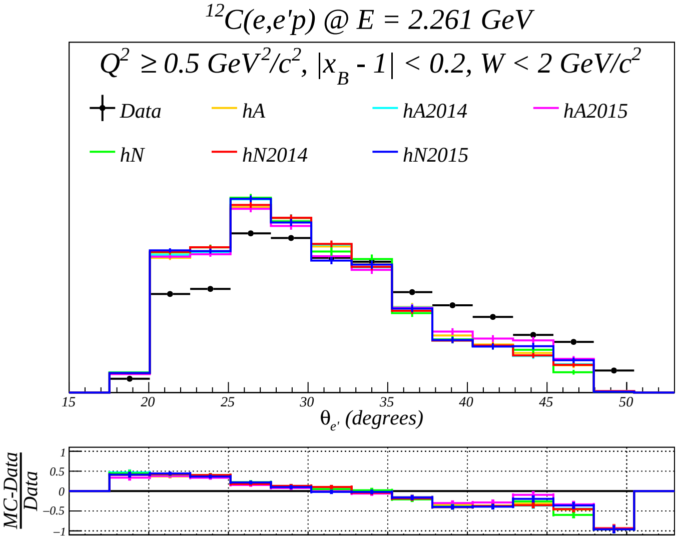
Backup Slides

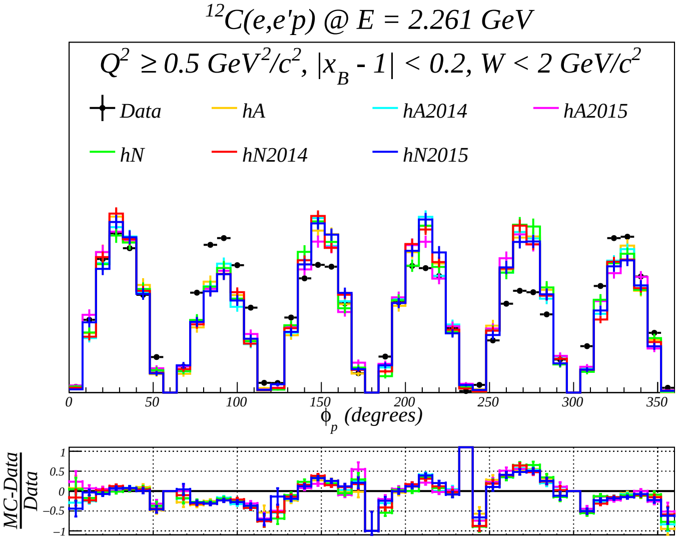
Electron Phase Space



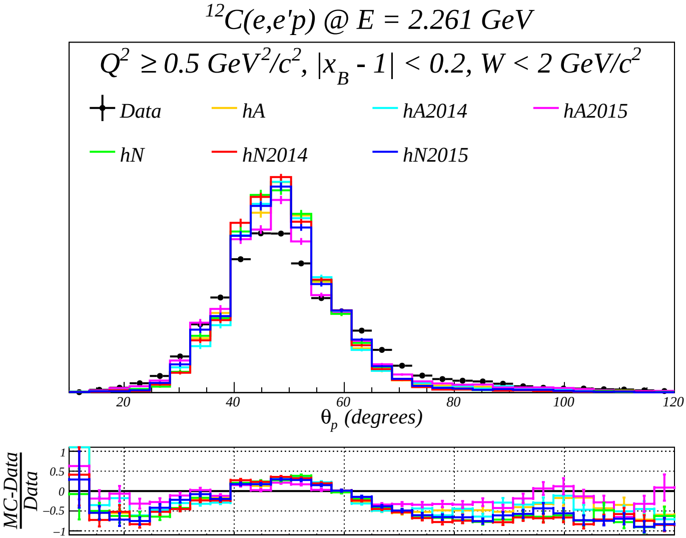
Electron Phase Space



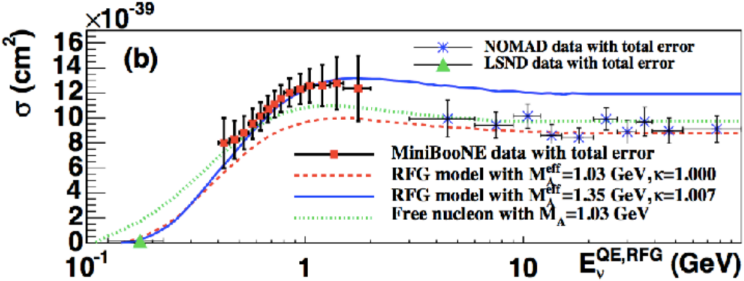
Proton Phase Space



Proton Phase Space



Reconstruction from the final state lepton



Incoming Energy Reconstruction

Highly model & parameter dependent.