Comparing the T2K and NOvA interaction model

Clarence Wret
Jeremy Wolcott

c.wret@rochester.edu

NOvA-T2K Workshop, FNAL
26 Feb 2019
Overview

- One of the large challenges of the joint fit is unifying systematics
- Interaction systematics have a large impact on the error budget at both experiments
- The interaction systematics should be largely correlated
  - Neutrino interactions, e.g. CC0/1π, 2p2h, FSI models...
  - Secondary interactions of pions or nucleons
  - Wrong evaluation → Bias in central value and/or uncertainty
- Crucial to study these for success of joint fit!

- Current plan: isolate of systematics that are important and need correlations
Comparing T2K and NOvA tunes

- Looked at some GENIE with NOvA tune and NEUT with T2K tune, scratched our heads and discussed

- e.g. CCQE cross-section larger at T2K, 2p2h cross-section larger at NOvA
What interaction parameters matter?

- What have we done this afternoon:
  - Informal discussion led to $2p2h/\text{MEC}$, resonant/$1\pi$ and $\nu_e/\nu_\mu$ differences

<table>
<thead>
<tr>
<th>Interaction model</th>
<th>Critical to both</th>
<th>Critical to one or the other</th>
</tr>
</thead>
<tbody>
<tr>
<td>2p2h normalization, nu and nubar</td>
<td>yes, T2K and NOvA</td>
<td>JW: Enushape knob on NOvA effectively does it; totally separate nu and nubar</td>
</tr>
<tr>
<td>2p2h shape, C, O, T2K: Modify strength into QE-like vs. Delta-like, interference terms scaled</td>
<td>yes, T2K and NOvA MEC shape. Identified in Oct 2017 workshop</td>
<td>Need to understand assumed and reasonable energy scaling and how hadronic system may be interlinked to leptonic system.</td>
</tr>
<tr>
<td>nue/numu and nuebar/numubar differences: Second class currents</td>
<td>yes, T2K. Unclear/small? NOvA.</td>
<td>LP: Mass effects differnet in NEUT and GENIE for resonant model CW: resonant doesn't take mass effect in $1p1h$ same, $2p2h$ -- how does it handle lepton mass effects?</td>
</tr>
<tr>
<td>nue/numu and nuebar/numubar differences: radiative corrections</td>
<td>yes, T2K. Unclear/small? NOvA.</td>
<td>yes.</td>
</tr>
<tr>
<td>Pion final state interactions (FSI)</td>
<td>yes, T2K and NOvA MEC shape.</td>
<td>KSM: We have to look at this by looking at a space where the models can be compared. generate pions at the center. JW: Model selection is hA and hN in GENIE-- we could be similar with hN. Dials don't work for hN-- and how to weight it. KSM: Decide how to compare and correlate, not same model</td>
</tr>
</tbody>
</table>

- Study effects using raw GENIE or NEUT passed through acceptance map, applying the tunes

Clarence Wret
Thanks