

# Progress Update

Trevor Towstego  
UofT Neutrino/DM Meeting  
July 10, 2017

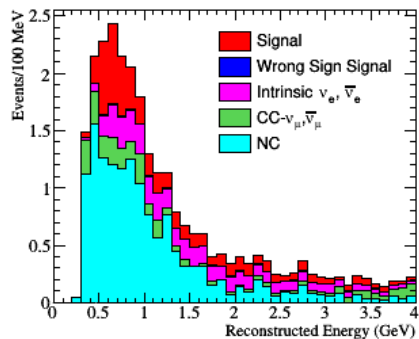
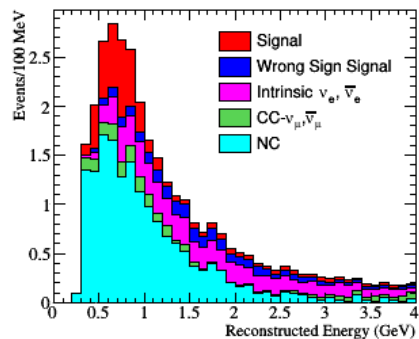
# Aluminum Pipe for mPMT Prototypes

- Heard back from some companies about ordering a small amount of 20" OD aluminum pipe
- Shandong Modern International Trade Co.
  - 6061 aluminum
  - 10 pieces minimum
  - \$410 / piece
  - \$4,100 total
  - OD 20" (+2.40/-0.80 mm)
  - Thickness 1" (+/- 10%)
- Foshan Kaiya Aluminum Co.
  - Getting quote tomorrow
- Ningbo City Beilun Fayi Metal Product Co.
  - Say they can do less than 10 pieces
  - In communications, but haven't heard back in a week (sent a reminder this morning)

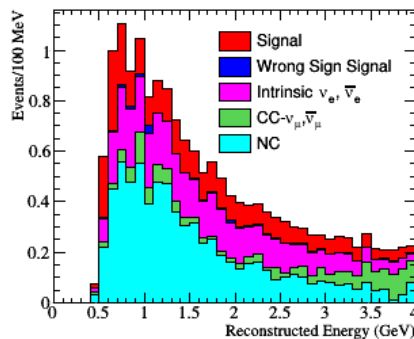
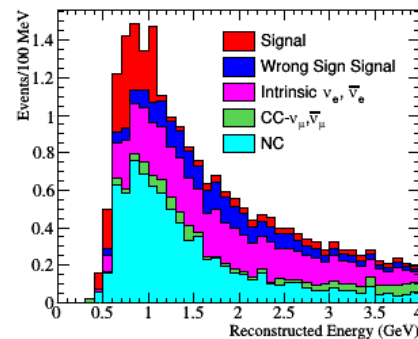
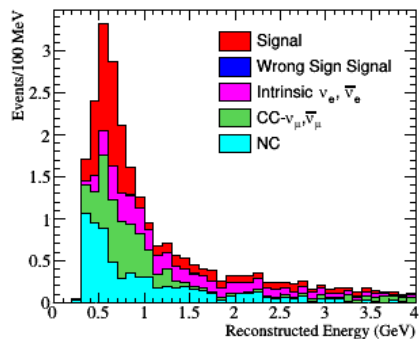
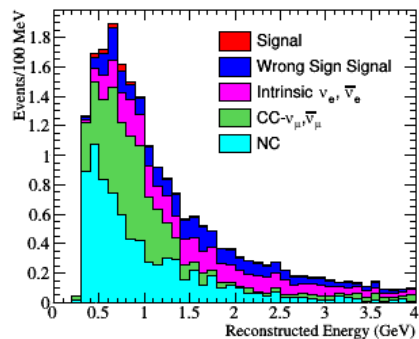
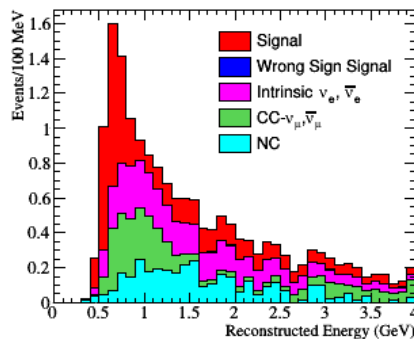
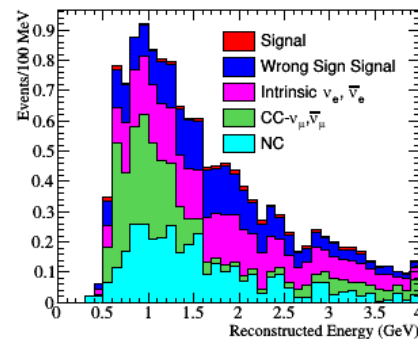
# $\nu_e$ CC1 $\pi^+$ Studies

$$\nu_e + p/n \rightarrow e^- + \pi^+ + p/n$$

- Still see conflicts between T2HKK selection with T2K MC vs atm MC
  - T2K MC gives larger NC contribution < 0.5 GeV in 2R selections
  - T2K MC gives larger  $\nu_\mu/\bar{\nu}_\mu$  CC contribution < 1 GeV in 1R1de selection
  - Discrepancies in number of events passing selection

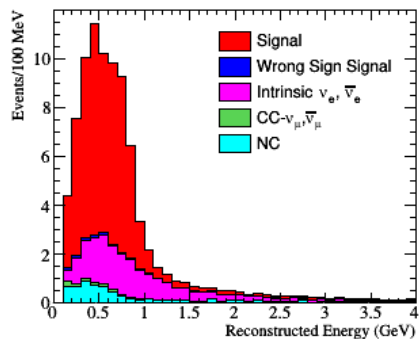
2Re $\pi$ 0de, FHC, OAA=2.5°, 6.75E21 POT2Re $\pi$ 0de, RHC, OAA=2.5°, 20.25E21 POT

T2K MC

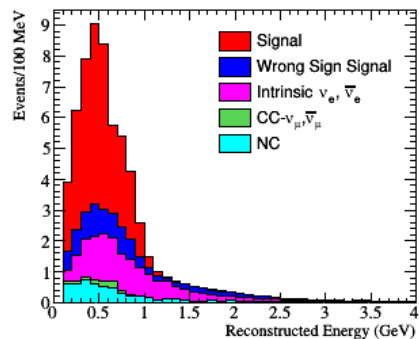
2Re $\pi$ 0de, FHC, L=1100km, OAA=2.5°2Re $\pi$ 0de, RHC, L=1100km, OAA=2.5°2Re $\pi$ 1de, FHC, OAA=2.5°, 6.75E21 POT2Re $\pi$ 1de, RHC, OAA=2.5°, 20.25E21 POT2Re $\pi$ 1de, FHC, L=1100km, OAA=2.5°2Re $\pi$ 1de, RHC, L=1100km, OAA=2.5°

atm MC

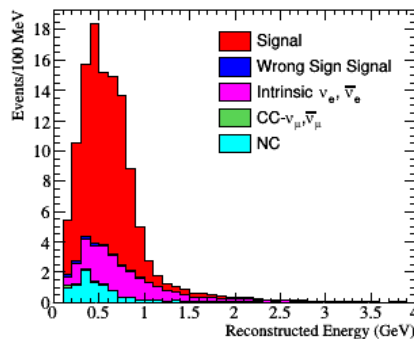
1Re0de, FHC, OAA=2.5°, 6.75E21 POT



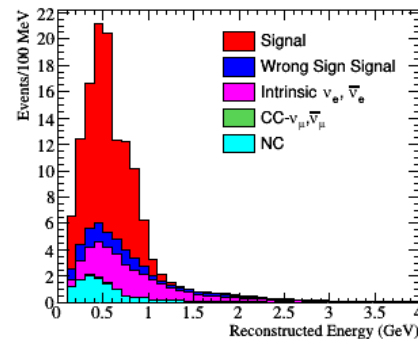
1Re0de, RHC, OAA=2.5°, 20.25E21 POT



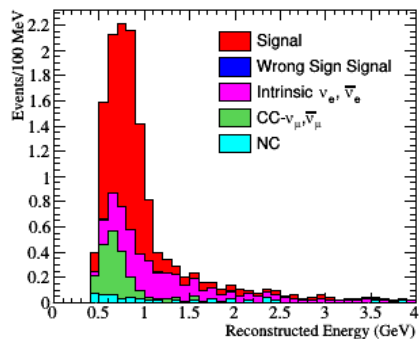
1Re0de, FHC, L=1100km, OAA=2.5°



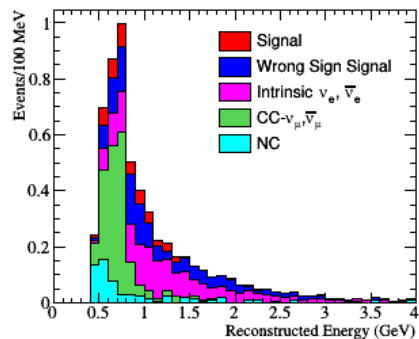
1Re0de, RHC, L=1100km, OAA=2.5°



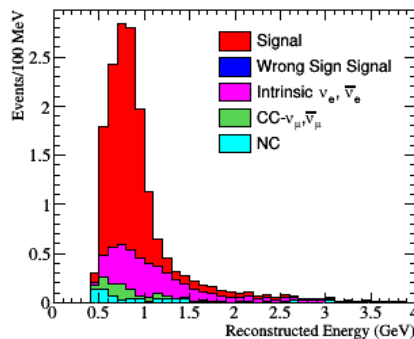
1Re1de, FHC, OAA=2.5°, 6.75E21 POT



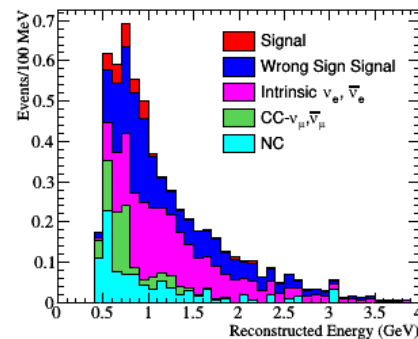
1Re1de, RHC, OAA=2.5°, 20.25E21 POT



1Re1de, FHC, L=1100km, OAA=2.5°



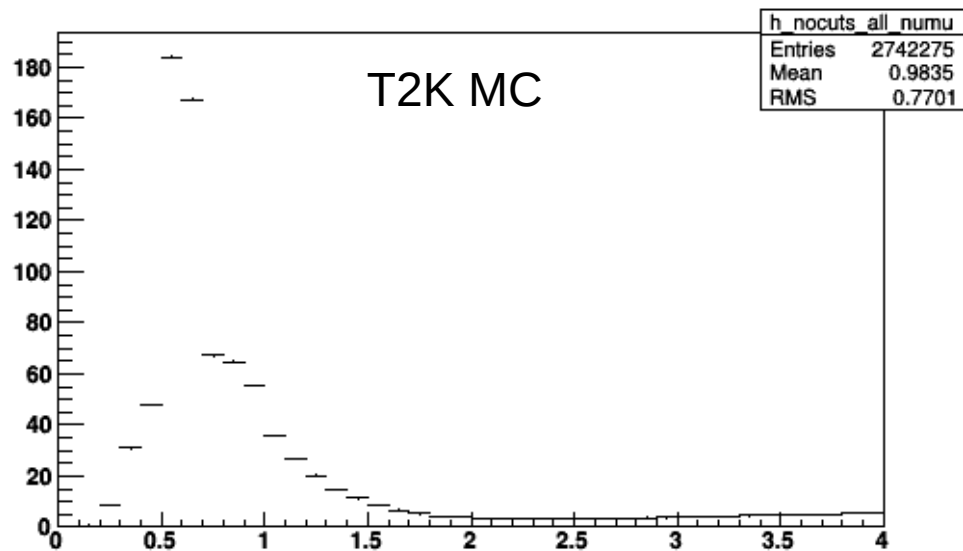
1Re1de, RHC, L=1100km, OAA=2.5°



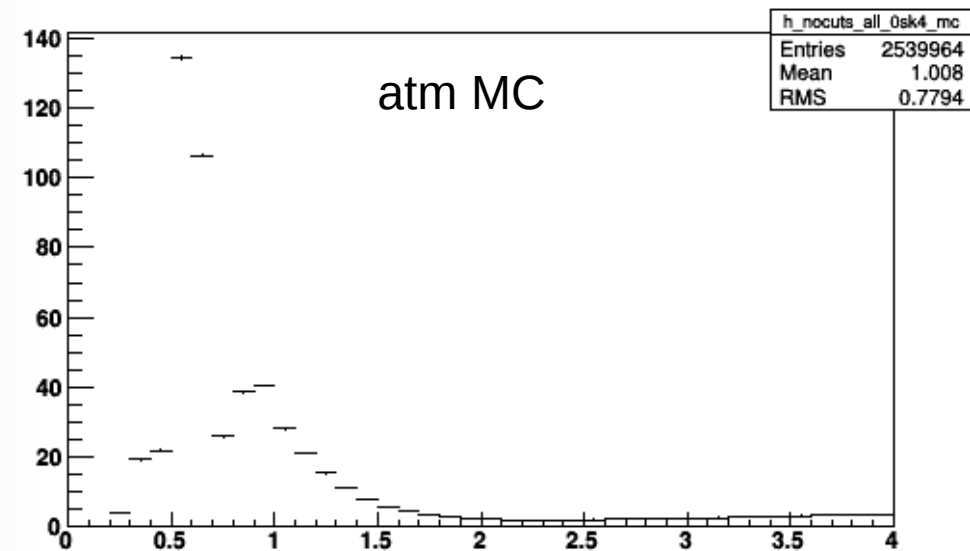
Neutrino/DM M

# Events before any cuts (reweighted)

All events



True neutrino energy

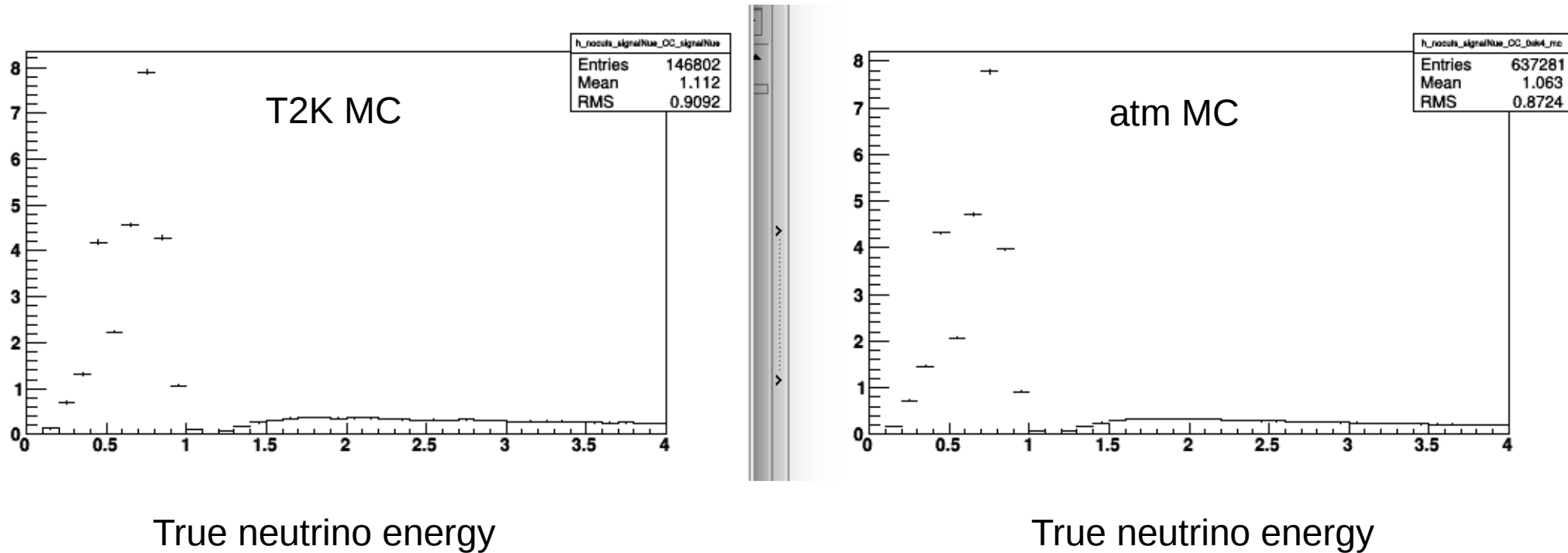


True neutrino energy

Number of events looks off... investigate different event categories

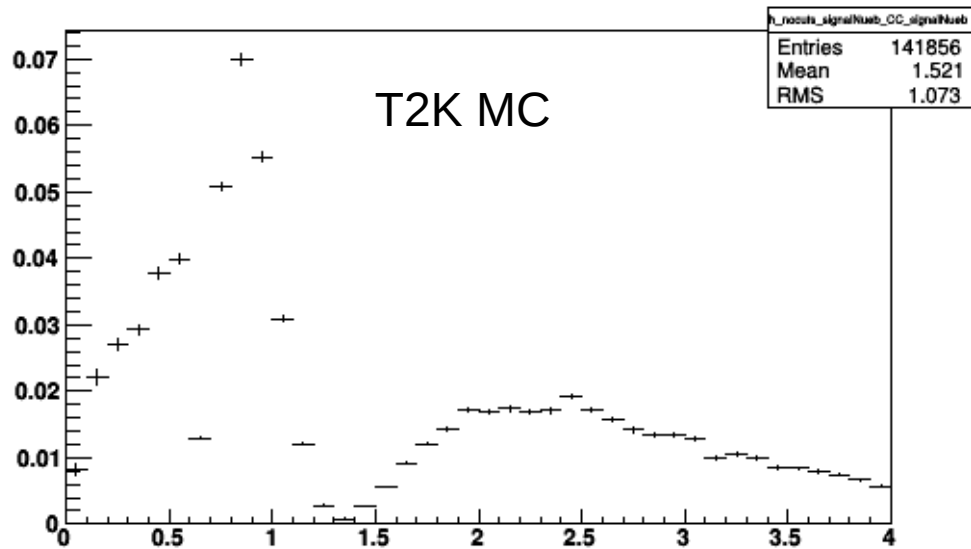
# Events before any cuts (reweighted)

oscillated  $\nu_{\mu e}$  CC events

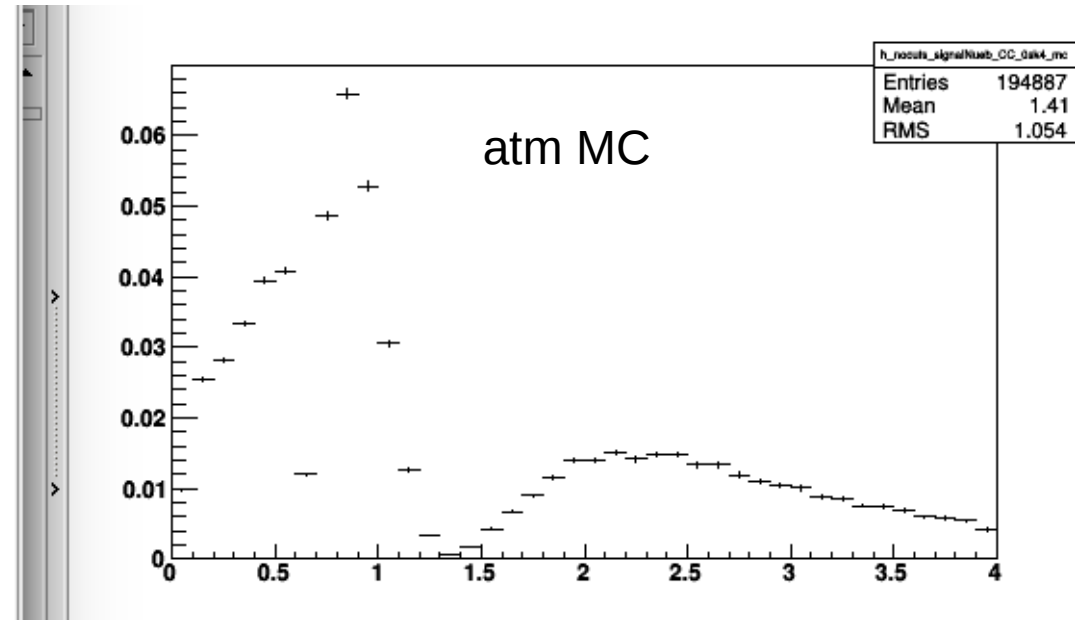


# Events before any cuts (reweighted)

oscillated nuebar CC events



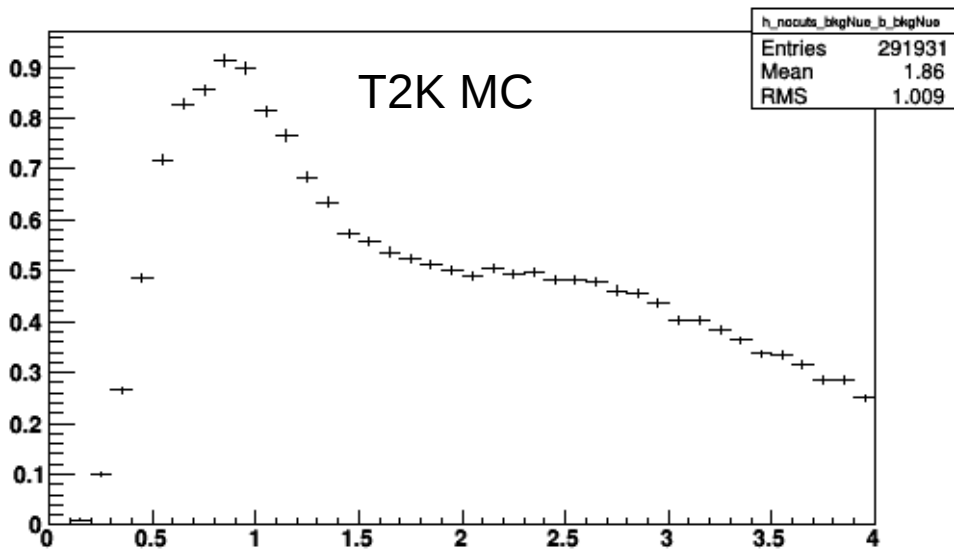
True neutrino energy



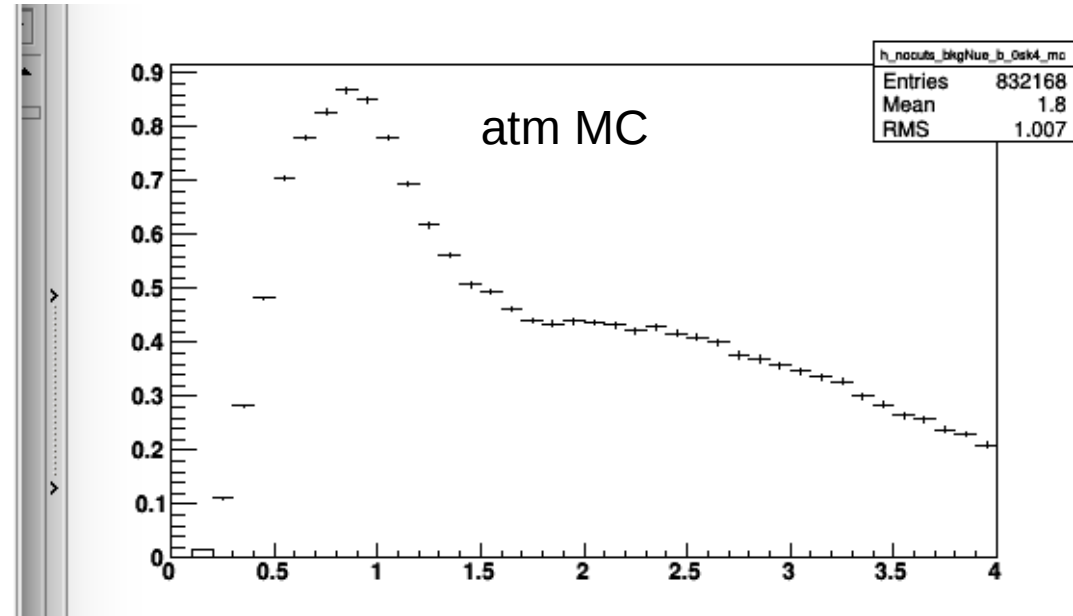
True neutrino energy

# Events before any cuts (reweighted)

intrinsic nue CC events



True neutrino energy

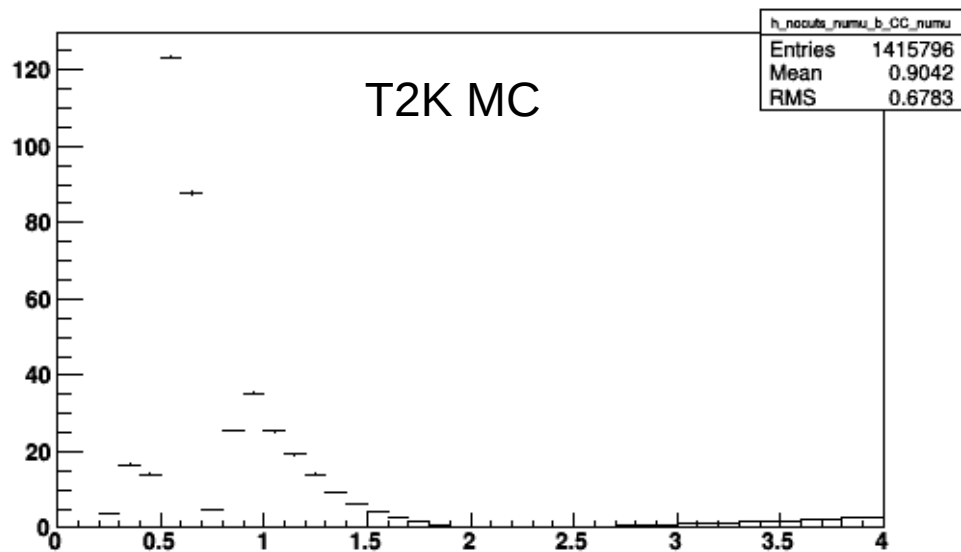


True neutrino energy

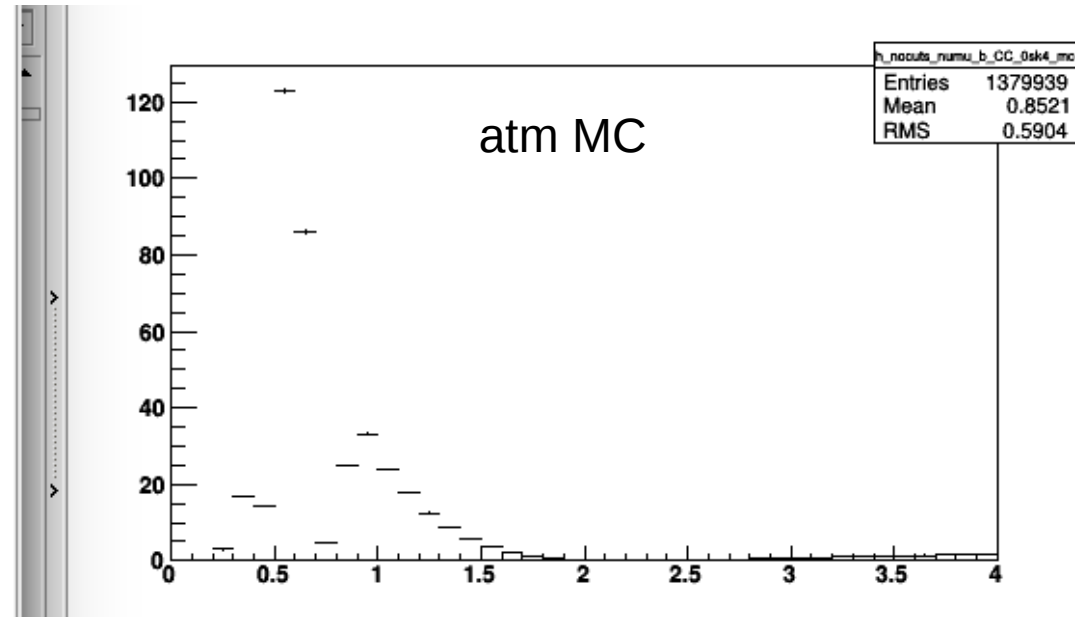


# Events before any cuts (reweighted)

numu + numubar CC events



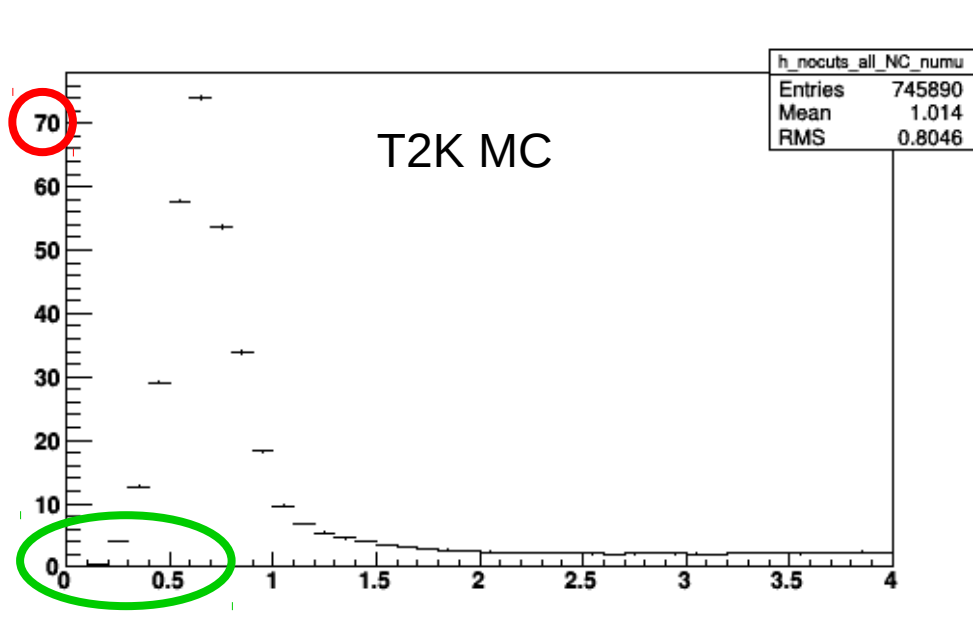
True neutrino energy



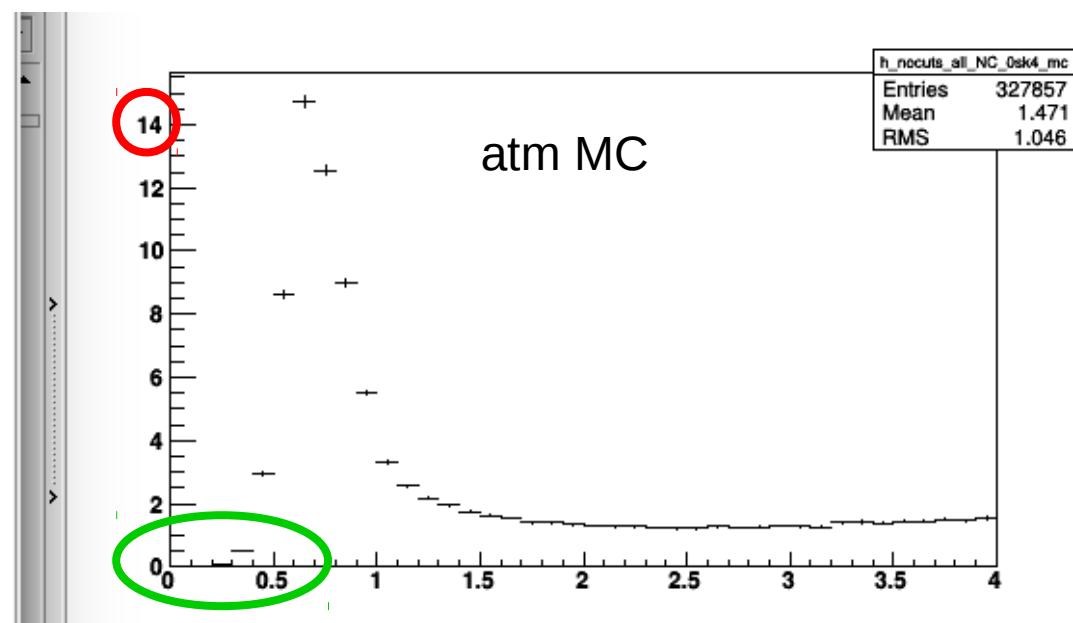
True neutrino energy

# Events before any cuts (reweighted)

NC events



True neutrino energy



True neutrino energy

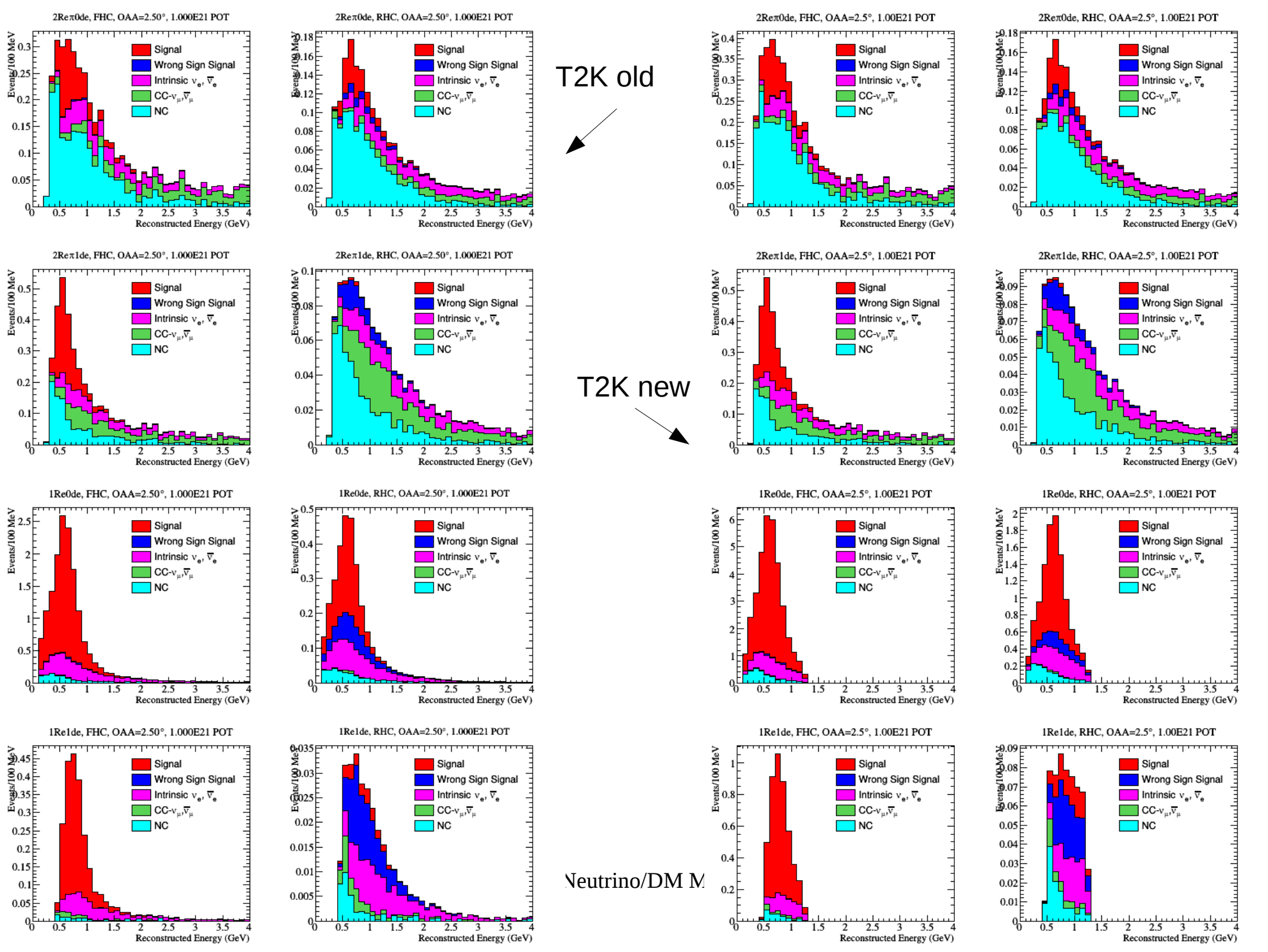
Something still clearly wrong with NC reweighting

# Thoughts

- I thought I fixed NC issue in atm MC T2HKK selection
  - basically just reweighting events for the T2HKK flux / atmospheric MC flux without performing oscillations
- Currently looking into splitting NC into different neut modes to better identify issue
- Also looking at alternative approach: verify T2K MC selection by duplicating 1Re and 1Re1de selections from TN319

# T2K selection using standard 1R selections

- Used 1Re and 1Re1de selections from TN319
- Applied 2R selections only on events excluded by 1Re and 1Re1de selections
- Saw large improvement in 1Re and 1Re1de selection efficiencies
- I think this will make a good starting point for future improvements to 2R selection

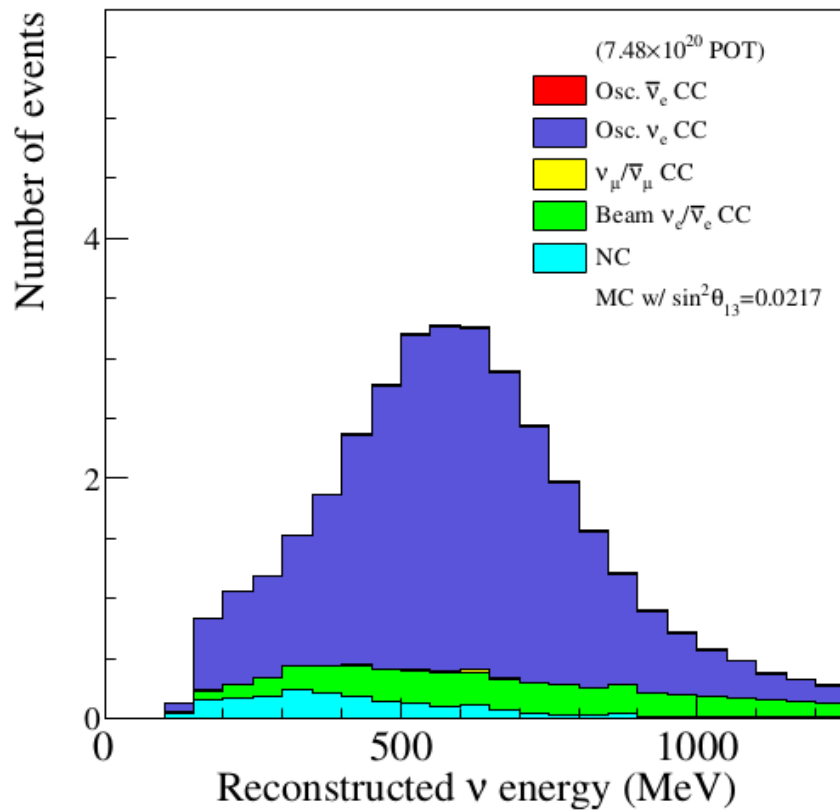


# Compare 1R samples to TN319

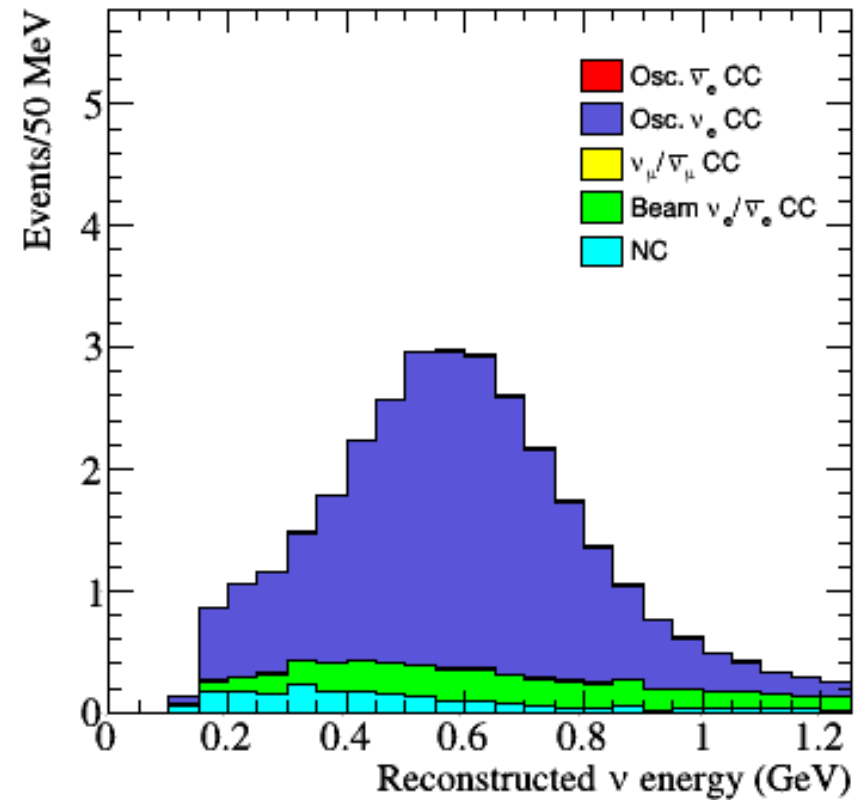
- Ran selection on T2K 14c MC using the same parameters as TN319
  - ensured oscillation parameters and POT were the same
  - used the same cuts
  - ensured wall, towall, and Erec calculations were the same

# 1Re $\nu_e$ Selection

$\nu_e$  sample,  $7.48 \times 10^{20}$  POT



TN319



My Selection

# 1Re $\nu_e$ Selection

	fitQun			
	$\nu_\mu + \bar{\nu}_\mu$	beam $\nu_e + \bar{\nu}_e$	signal $\nu_e + \bar{\nu}_e$	
	CC			
FCFV	330.957	21.771	42.830	
1ring	143.778	11.108	35.820	
e-like	4.305	11.103	35.779	
evis> 100MeV	1.617	11.023	35.080	
0 Michel	0.439	9.383	31.696	
Erec< 1.25GeV	0.278	4.953	30.560	
not $\pi^0$	0.135	4.403	28.658	
	NC			
FCFV	118.810	3.441	signal	
1ring	21.349	0.621	28.66	
e-like	12.842	0.534	background	
evis> 100MeV	8.592	0.388	6.65	
0 Michel	7.590	0.210	purity	
Erec< 1.25GeV	5.687	0.143	81.18%	
not $\pi^0$	2.059	0.048		

TN319

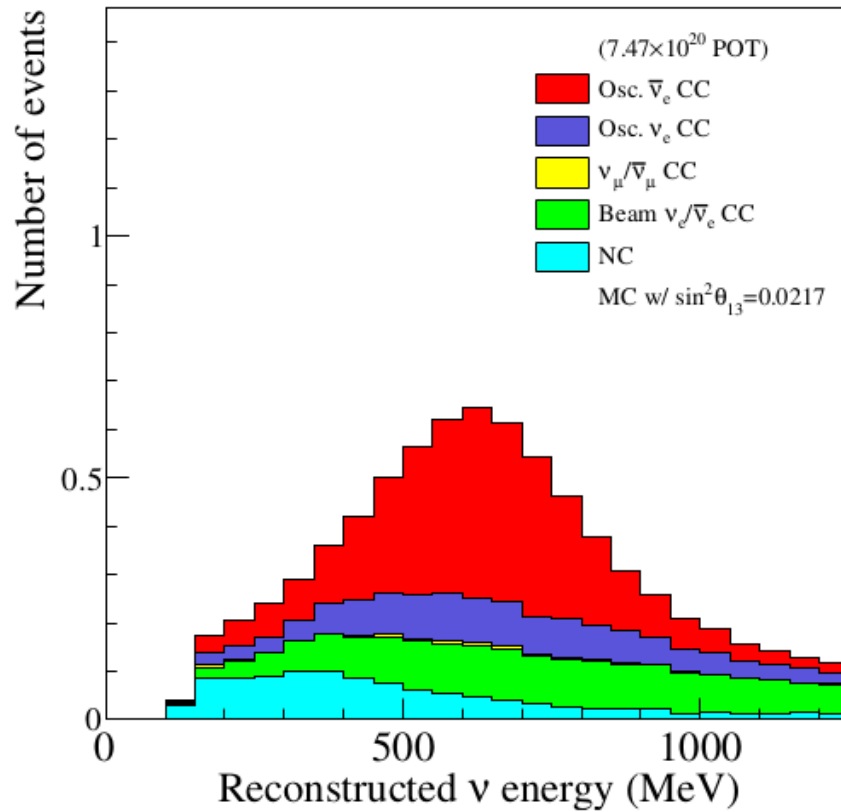
Table 9: nue sample			
	numu + numubar	beam nue + nuebar	signal nue + nuebar
	CC		
<b>FCFV</b>	331.185	20.819	41.104
<b>1ring</b>	144.857	10.594	33.744
<b>e-like</b>	4.444	10.586	33.698
<b>evis&gt;100MeV</b>	1.538	10.504	33.011
<b>0 Michel</b>	0.413	8.610	28.815
<b>Erec&lt;1.25GeV</b>	0.263	4.560	27.839
<b>not pi0</b>	0.126	4.041	26.067
	NC		
<b>FCFV</b>	126.461	3.584	<b>signal</b>
<b>1ring</b>	24.076	0.695	26.07
<b>e-like</b>	13.929	0.400	<b>background</b>
<b>evis&gt;100MeV</b>	9.453	0.282	6.24
<b>0 Michel</b>	8.130	0.233	<b>purity</b>
<b>Erec&lt;1.25GeV</b>	6.244	0.162	80.70%
<b>not pi0</b>	2.020	0.050	

My Selection

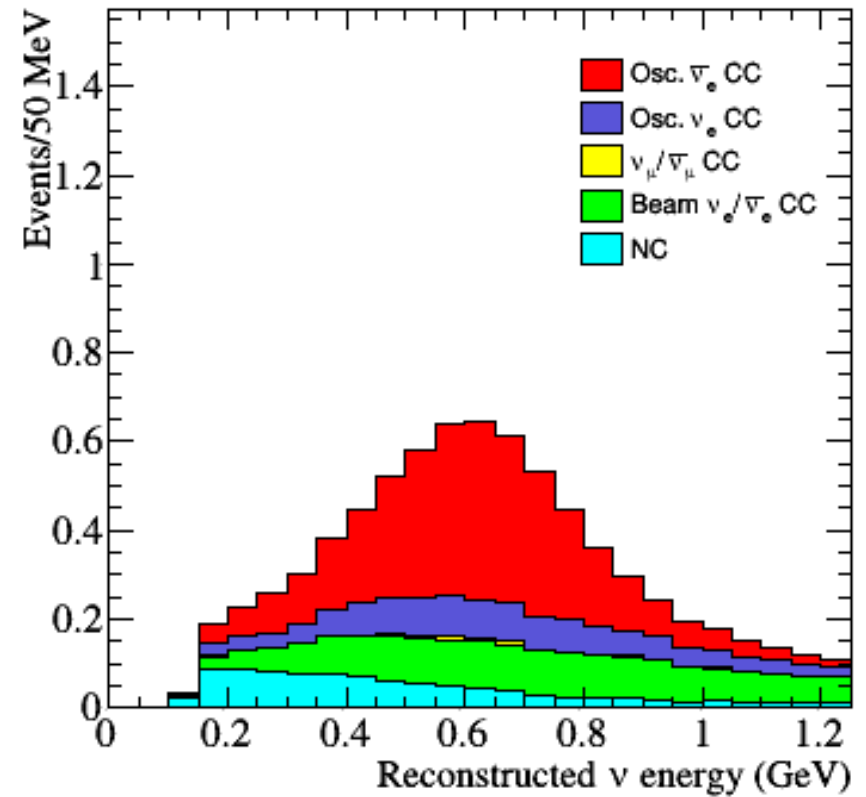


# 1Re $\bar{\nu}_e$ Selection

$\bar{\nu}_e$  sample,  $7.47 \times 10^{20}$  POT



TN319



My Selection

# 1Re $\bar{\nu}_e$ Selection

	fitQun			1
	$\nu_\mu + \bar{\nu}_\mu$	beam $\nu_e + \bar{\nu}_e$	signal $\nu_e + \bar{\nu}_e$	
	CC			
FCFV	140.554	10.221	7.473	
1ring	64.588	5.175	6.038	
e-like	1.329	5.171	6.033	
evis> 100MeV	0.679	5.152	5.983	
0 Michel	0.194	4.575	5.666	
Erec< 1.25GeV	0.131	2.026	5.158	
not $\pi^0$	0.062	1.759	4.684	
	NC			
FCFV	51.897	1.748	signal	
1ring	9.154	0.306	4.68	
e-like	5.706	0.184	background	
evis> 100MeV	4.179	0.134	2.87	
0 Michel	3.579	0.110	purity	
Erec< 1.25GeV	2.773	0.075	61.99%	
not $\pi^0$	1.022	0.029		

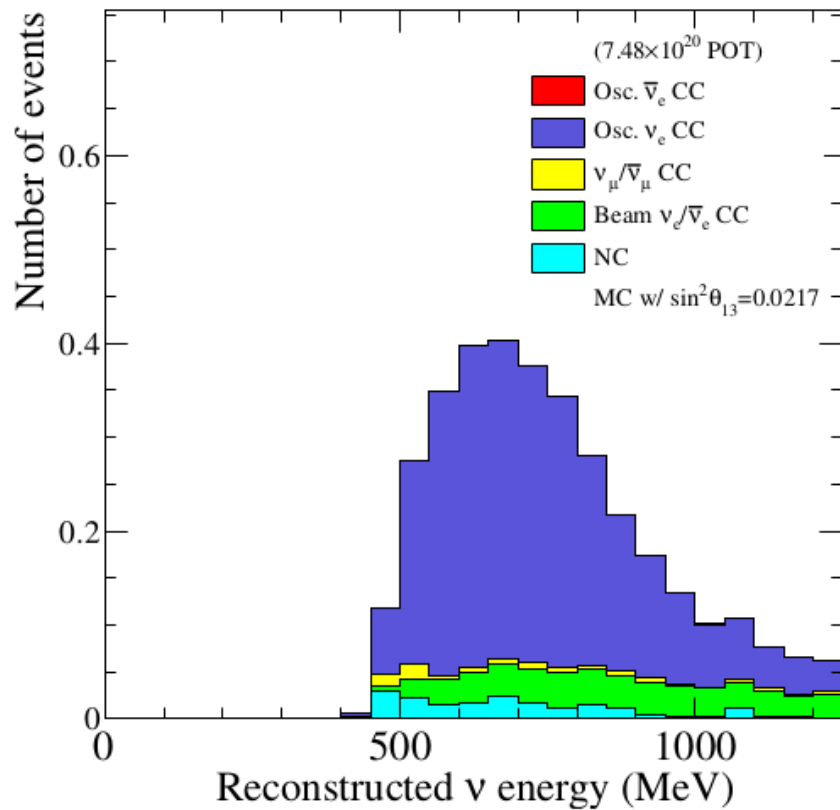
TN319

Table 10: nuebar sample			
	numu + numubar	beam nue + nuebar	signal nue + nuebar
CC			
<b>FCFV</b>	144.440	9.994	7.701
<b>1ring</b>	68.424	5.157	6.204
<b>e-like</b>	1.370	5.153	6.198
<b>evis&gt;100MeV</b>	0.648	5.130	6.141
<b>0 Michel</b>	0.188	4.491	5.776
<b>Erec&lt;1.25GeV</b>	0.129	2.044	5.308
<b>not pi0</b>	0.061	1.775	4.822
NC			
<b>FCFV</b>	53.565	1.824	<b>signal</b>
<b>1ring</b>	9.741	0.340	4.82
<b>e-like</b>	5.915	0.198	<b>background</b>
<b>evis&gt;100MeV</b>	4.200	0.142	2.79
<b>0 Michel</b>	3.631	0.118	<b>purity</b>
<b>Erec&lt;1.25GeV</b>	2.837	0.083	63.34%
<b>not pi0</b>	0.928	0.028	

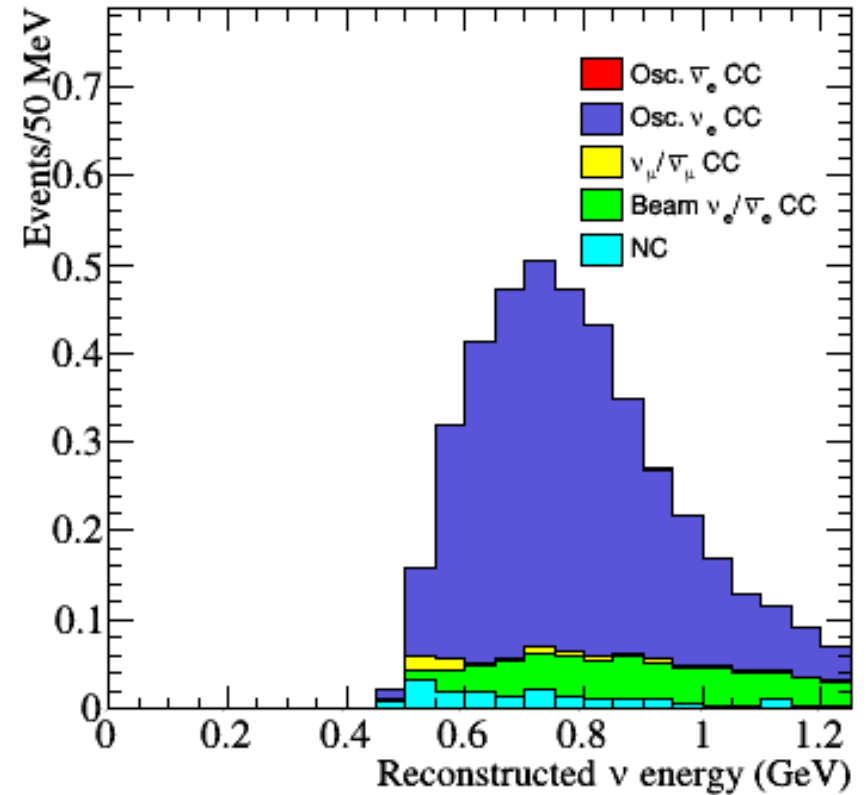
My Selection

# 1Re1de $\nu_e$ CC $1\pi^+$ Selection

1-ring  $\nu_e$ -CC  $1\pi^+$  sample,  $7.48 \times 10^{20}$  POT



TN319



My Selection

# 1Re1de $\nu_e$ CC1 $\pi^+$ Selection

	fitQun		
	$\nu_\mu + \bar{\nu}_\mu$	beam $\nu_e + \bar{\nu}_e$	signal $\nu_e + \bar{\nu}_e$
	CC		
FCFV	337.439	22.002	42.770
1ring	146.127	11.138	35.703
e-like	4.169	11.132	35.661
evis>100MeV	1.411	11.046	34.923
1 Michel	0.680	1.521	3.312
Erec< 1.25GeV	0.233	0.552	3.052
not $\pi^0$	0.083	0.466	2.747
	NC		
FCFV	119.862	3.473	signal
1ring	21.731	0.626	2.747
e-like	13.139	0.372	background
evis>100MeV	9.120	0.262	0.741
0 Michel	1.051	0.041	purity
Erec< 1.25GeV	0.490	0.021	78.75%
not $\pi^0$	0.186	0.007	

TN319

**Table 12:  $\nu_e$ -CC1pi sample**

	numu + numubar	beam nue + nuebar	signal nue + nuebar
	CC		
<b>FCFV</b>	333.862	21.194	41.175
<b>1ring</b>	143.079	10.628	33.632
<b>e-like</b>	4.303	10.620	33.592
<b>evis&gt;100MeV</b>	1.342	10.532	32.867
<b>1 Michel</b>	0.650	1.782	4.123
<b>Erec&lt;1.25GeV</b>	0.218	0.625	3.779
<b>not pi0</b>	0.078	0.534	3.406
	NC		
<b>FCFV</b>	129.280	3.661	<b>signal</b>
<b>1ring</b>	24.124	0.690	3.41
<b>e-like</b>	14.275	0.405	<b>background</b>
<b>evis&gt;100MeV</b>	9.627	0.282	0.80
<b>1 Michel</b>	1.001	0.038	<b>purity</b>
<b>Erec&lt;1.25GeV</b>	0.457	0.020	81.00%
<b>not pi0</b>	0.180	0.006	

My Selection

# Verifying T2HKK selection with T2K MC

- Compare Mark Hartz's 1Re selection in T2HKK with T2K MC (as was done with atm MC) to make sure numbers match
  - check to see if the scaling factor of 1.37 is the same
- Might need to re-produce sensitivity code inputs with scaling factor taken into account

# Final Thoughts

- If T2K MC selection is acceptably verified (for both T2K and T2HKK), move away from using atm MC
  - should more time be spent investigating NC issue in atm MC?