



UNIVERSITY OF
TORONTO

ν_e CCQE/CC1 π^+ Selection Studies

Trevor Towstego
T2K-SK Meeting
May 13, 2019

Overview

- Investigated possibility of replacing the $2\text{Re}\pi^0\text{de}$ ($\nu_e \text{CC}1\pi^+$) selection with a $1\text{Re}\,0\text{de}$ ($\nu_e \text{CCQE}$) selection
 - Compare results of different selections
 - $2\text{Re}\pi^0\text{de}$ “exclusive” selection
 - $\nu_e \text{CC}$ “inclusive” selection
 - $1\text{Re}\,0\text{de}$ selection
 - Motivation to move forward with $1\text{Re}\,0\text{de}$ sample instead of $2\text{Re}\pi^0\text{de}$
- Hybrid sample progress

pre-BDT Cuts and BDT Training Variables

pre-BDT cuts		
Cut	0 decay e	1 decay e
FCFV		Wall > 50 cm
not 1Re	not 1Re-like (TN319, no FCFV requirement)	
0 decay e	1 sub-event	2 sub-events
E_{rec}		$E_{rec} < 1.5 \text{ GeV}$

BDT Training Variables	
<u>OLD: 2Reπ 0de / v_e CC 0de</u>	<u>NEW: 1Re 0de</u>
up to 3-ring -ln(L) ratios m_{π_0} 1R+2R fit momenta E_{rec} (CC1 π^+) ToWall e and π (2Re π) p_{low} (2Re π) $\cos(\theta_{e\pi})$ (2Re π)	up to 3-ring -ln(L) ratios m_{π_0} 1R+2R fit momenta E_{rec} (CCQE) Wall ToWall e (1Re) ToWall e ₁ and e ₂ (2Ree) p_{low} (2Ree) $\cos(\theta_{ee})$ (2Ree)

2Re π 0de Exclusive Selection

BDT training signal = 1e^{+/−}1 $\pi^{+/-}$

visible FSP:	1e1 $\pi^{+/-}$	1e	1e other	1 μ 1 $\pi^{+/-}$	1 μ	1 μ other	0l1 π^+	0l1 π^-	0l1 π^0	0IN π	0l other	1e ^{+/−} 1 $\pi^{+/-}$	other
	0.42	0.00	0.02	0.01	0.01	0.02	0.03	0.03	0.02	0.03	0.00	0.42	0.17
NEUT mode:	ν_e CC1 π^+	ν_e CCQE	ν_e CCN π	ν_e CCDIS	ν_e CCother	$\bar{\nu}_e$ CC	ν_μ CC	NC				$\nu_e/\bar{\nu}_e$ CC1 π^+	other
	0.38	0.01	0.02	0.00	0.01	0.02	0.04	0.10				0.38	0.21
v type:	osc ν_e CC	int ν_e CC	ν_μ CC	NC								osc $\nu_e/\bar{\nu}_e$ CC	other FOM
	0.31	0.14	0.04	0.10								0.31	0.28 0.41

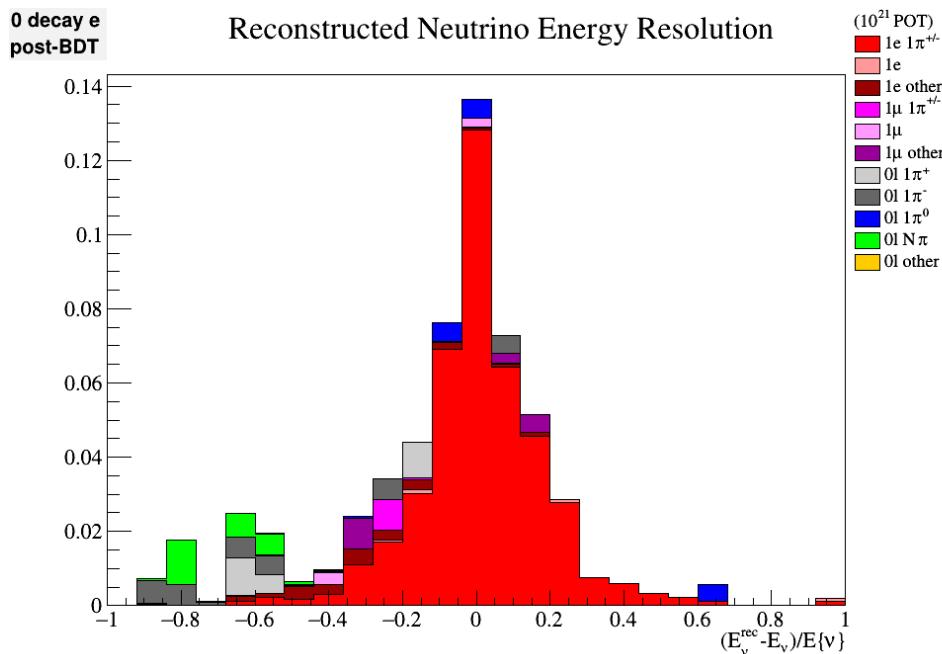
ν_e CC 0de Inclusive Selection

BDT training signal = $\nu_e/\bar{\nu}_e$ CC

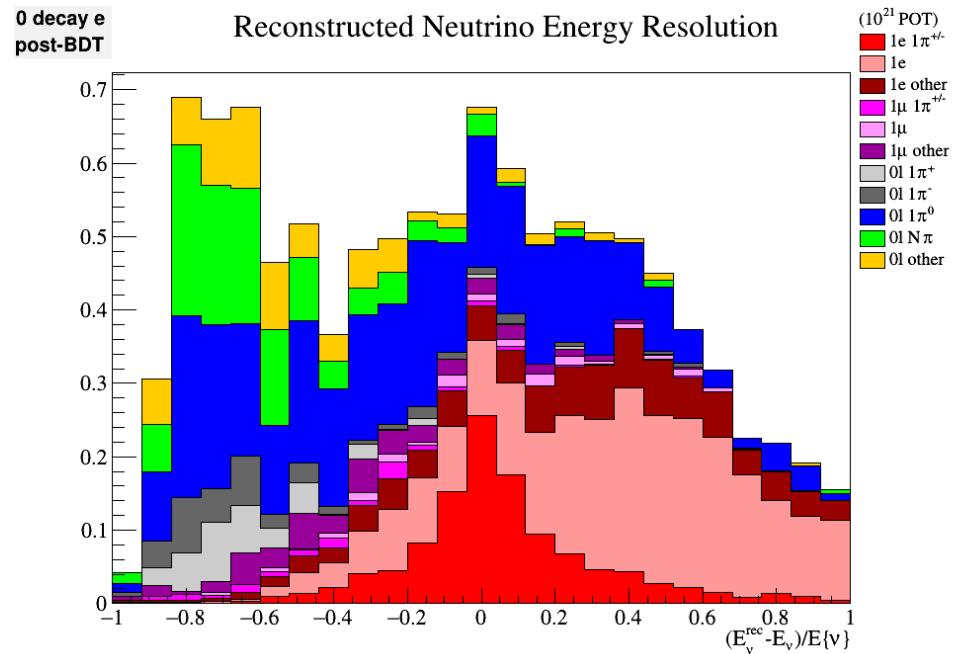
visible FSP:	1e1 $\pi^{+/-}$	1e	1e other	1 μ 1 $\pi^{+/-}$	1 μ	1 μ other	0l1 π^+	0l1 π^-	0l1 π^0	0IN π	0l other	1e all	other
	1.25	3.50	1.54	0.15	0.16	0.72	0.41	0.44	3.51	1.63	0.86	6.29	7.89
NEUT mode:	ν_e CC1 π^+	ν_e CCQE	ν_e CCN π	ν_e CCDIS	ν_e CCother	$\bar{\nu}_e$ CC	ν_μ CC	NC				$\nu_e/\bar{\nu}_e$ CC	other
	1.85	3.10	0.27	0.06	0.80	0.21	1.03	6.86				6.29	7.89
v type:	osc ν_e CC	int ν_e CC	ν_μ CC	NC								osc $\nu_e/\bar{\nu}_e$ CC	other FOM
	4.58	1.71	1.03	6.86								4.58	9.60 1.22

E_{rec} Resolution

2R π 0de Exclusive Selection



ν_e CC 0de Inclusive Selection



NOTE: E_{rec} calculated assuming CC1 π^+

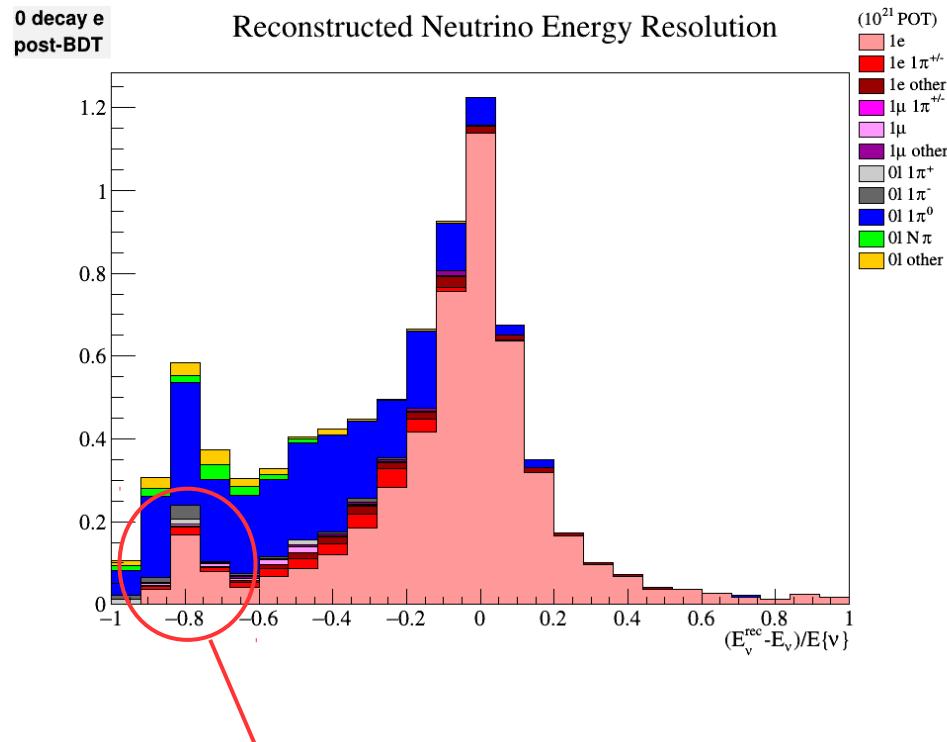
1Re 0de Selection

BDT training signal = $1e^{+/-}$

visible FSP:	$1e1\pi^{+/-}$	$1e$	$1e$ other	$1\mu 1\pi^{+/-}$	1μ	1μ other	$0l 1\pi^+$	$0l 1\pi^-$	$0l 1\pi^0$	$0l N\pi$	$0l$ other	$1e^{+/-}$	other	FOM	
	0.24	4.88	0.19	0.01	0.06	0.05	0.04	0.08	2.34	0.13	0.17		4.88	3.30	1.70
NEUT mode:	$v_e CC 1\pi^+$	$v_e CCQE$	$v_e CCN\pi$	$v_e CCDIS$	$v_e CCother$	$\bar{v}_e CC$	$v_\mu CC$	NC				$v_e/\bar{v}_e CCQE$	other	FOM	
	0.61	4.20	0.05	0.01	0.16	0.27	0.12	2.76					4.40	3.77	1.54
v type:	$osc v_e CC$	$int v_e CC$	$v_\mu CC$	NC								$osc v_e/\bar{v}_e CC$	other	FOM	
	3.58	1.72	0.12	2.76									3.58	4.60	1.25

E_{rec} Resolution

1Re Selection



2Re π 0de vs. 1Re 0de: Summary

		2Re π 0de Exclusive		ν_e CC 0de Inclusive		1Re 0de
Final State Particles	1e⁺⁻1π^{+-}	0.42	1e⁺⁻ all	6.29	1e⁺⁻	4.88
	other	0.17	other	7.89	other	3.30
NEUT Mode	$\nu_e/\bar{\nu}_e$ CC1 π^+	0.38	$\nu_e/\bar{\nu}_e$ CC	6.29	$\nu_e/\bar{\nu}_e$ CCQE	4.40
	other	0.21	other	7.89	other	3.77
Neutrino Type	osc $\nu_e/\bar{\nu}_e$ CC	0.31	osc $\nu_e/\bar{\nu}_e$ CC	4.58	osc $\nu_e/\bar{\nu}_e$ CC	3.58
	other	0.28	other	9.60	other	4.60
	FOM	0.41	FOM	1.22	FOM	1.25

Existing 1Re selections (TN319)

TN319 1-Ring Samples (10^{21} POT)				
Sample	$\text{osc } \nu_e$ CC	$\text{int } \nu_e$ CC	ν_μ CC	NC
ν_e CCQE	34.84	5.40	0.17	2.77
ν_e CC1 π^+	4.61	0.76	0.11	0.25

Proposed Samples Summary

pre-BDT cuts		
Cut	0 decay e	1 decay e
FCFV	Wall > 50 cm	
not 1Re	not 1Re-like (TN319, no FCFV requirement)	
0 decay e	1 sub-event	2 sub-events
E_{rec}	$E_{rec} < 1.5$ GeV	



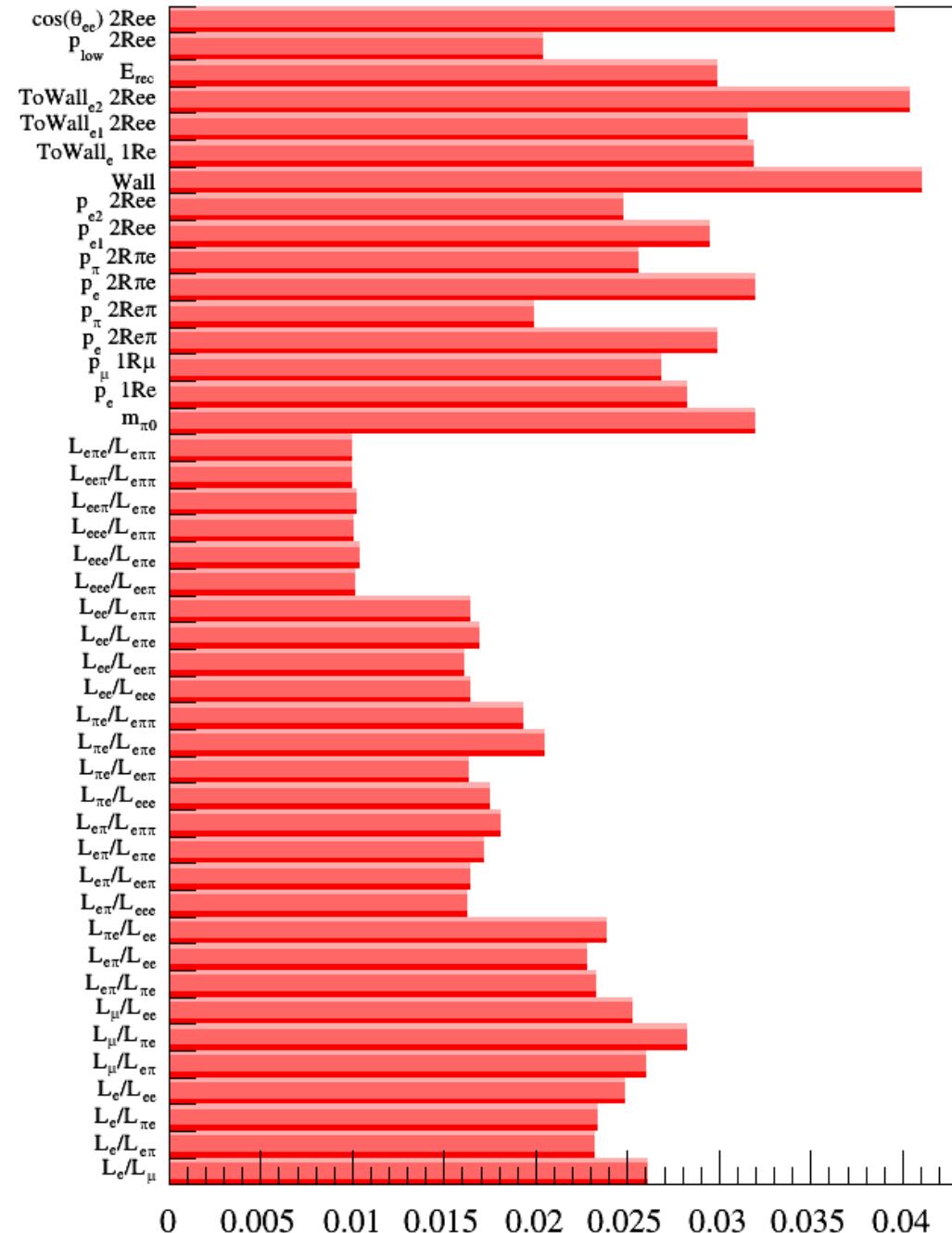
BDT Training Variables	
1Re 0de	2Re π 1de
up to 3-ring -ln(L) ratios m_{π_0}	up to 3-ring -ln(L) ratios m_{π_0}
1R+2R fit momenta E_{rec} (CCQE) Wall	1R+2R fit momenta E_{rec} (CC1 π^+) Wall
ToWall e (1Re) ToWall e ₁ and e ₂ (2Ree) p_{low} (2Ree) $\cos(\theta_{ee})$ (2Ree)	ToWall e and π (2Re π) d_{2se} p_{low} (2Re π) $\cos(\theta_{e\pi})$ (2Re π)

	1Re 0de		2Re π 1de	
Final State Particles	1e ⁺⁻	other	4.88	1e ⁺⁻ 1 π^{+-}
NEUT Mode	v_e/\bar{v}_e CCQE		4.40	v_e/\bar{v}_e CC1 π^+
	other		3.77	other
Neutrino Type	$osc v_e/\bar{v}_e$ CC		3.58	$osc v_e/\bar{v}_e$ CC
	other		4.60	other
	FOM		1.25	FOM

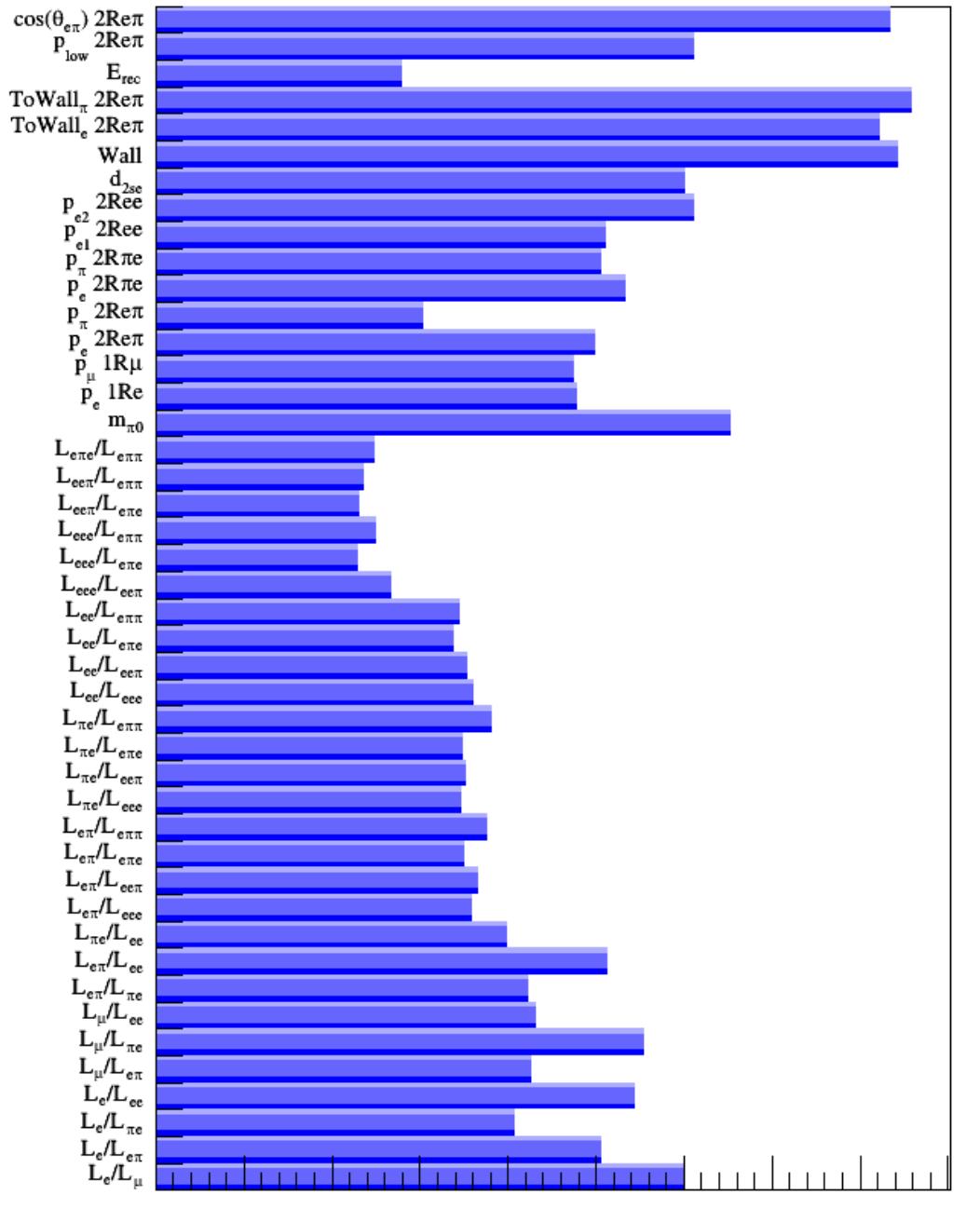
	Sample Summary (Existing + New)				
	Sample	$osc v_e$ CC	$int v_e$ CC	v_μ CC	NC
TN319	v_e CCQE	34.84	5.40	0.17	2.77
	v_e CC1 π^+	4.61	0.76	0.11	0.25
New	1Re 0de	3.58	1.72	0.12	2.76
	2Re π 1de	1.63	0.53	0.39	0.42

BDT Variable Importance

From 1Re Ode Training



From 2Reπ 1de Training



Hybrid Sample

- Started working on adapting Yoshida-san's hybrid $\mu\pi^+$ sample code towards an $e\pi^+$ sample
- First few steps went relatively smoothly
 - Generate list of 1-ring e-like events from atm data and from MC
 - Equalize MC to data
 - Extract e-like events from zbs files (data and MC)
- Now modifying code for next step
 - Extract all $e\pi^+$ events containing from T2K MC

Backup

Selection Tables

- The following slides show the event breakdowns at three points in the selection process:
 - FCFV: After the FCFV cut is made
 - pre-BDT: After the the pre-BDT cuts are made (see slide 3)
 - post-BDT: After the BDT is trained and tested
- Three different event breakdowns are shown:
 - visible FSP: by visible final-state particle topology
 - (visible = above Cherenkov threshold + 30 MeV/c momentum)
 - NEUT mode: by true NEUT mode
 - ν type: by neutrino type
 - oscillated $\nu_e/\bar{\nu}_e$ CC, intrinsic $\nu_e/\bar{\nu}_e$ CC, $\nu_\mu/\bar{\nu}_\mu$ CC, and NC

2Re π 0de (Exclusive) Selection

BDT training signal = 1e^{+/−}1 $\pi^{+/−}$

visible FSP:	1e1 $\pi^{+/−}$	1e	1e other	1 μ 1 $\pi^{+/−}$	1 μ	1 μ other	0l1 π^+	0l1 π^-	0l1 π^0	0lN π	0l other	1e1 $\pi^{+/−}$	other		
FCFV	4.63	45.01	8.93	8.96	41.60	32.68	7.69	12.16	83.11	17.28	15.76		4.63	273.17	
pre-BDT	1.78	4.11	2.24	2.43	22.39	5.03	6.00	10.13	63.13	6.87	11.79		1.78	134.11	
post-BDT	0.42	0.00	0.02	0.01	0.01	0.02	0.03	0.03	0.02	0.03	0.00		0.42	0.17	
NEUT mode:	v _e CC1 π^+	v _e CCQE	v _e CCN π	v _e CCDIS	v _e CCother	\bar{v}_e CC	v _{μ} CC	NC				v _e CC1 π^+	other		
FCFV	9.04	39.19	2.29	1.12	4.10	2.82	83.29	135.95					9.04	268.76	
pre-BDT	2.64	3.54	0.37	0.09	1.21	0.26	29.89	97.87					2.64	133.25	
post-BDT	0.38	0.01	0.02	0.00	0.01	0.02	0.04	0.10					0.38	0.21	
v type:	osc v _e CC	int v _e CC	v _{μ} CC	NC								osc v _e \bar{v}_e CC	other	FOM	
FCFV	38.06	20.50	83.29	135.95									38.06	239.69	2.28
pre-BDT	5.95	2.17	29.89	97.87									5.95	129.94	0.51
post-BDT	0.31	0.14	0.04	0.10									0.31	0.28	0.41

ν_e CC 0de (Inclusive) Selection

BDT training signal = $\nu_e/\bar{\nu}_e$ CC

visible FSP:	1e1 $\pi^{+/-}$	1e	1e other	1 μ 1 $\pi^{+/-}$	1 μ	1 μ other	0l1 π^+	0l1 π^-	0l1 π^0	0lN π	0l other	1e1 $\pi^{+/-}$	other		
FCFV	4.63	45.01	8.93	8.96	41.60	32.68	7.69	12.16	83.11	17.28	15.76		4.63	272.98	
pre-BDT	1.78	4.11	2.24	2.43	22.39	5.03	6.00	10.13	63.13	6.87	11.79		1.78	134.12	
post-BDT	1.25	3.50	1.54	0.15	0.16	0.72	0.41	0.44	3.51	1.63	0.86		1.25	12.93	
NEUT mode:	ν_e CC1 π^+	ν_e CCQE	ν_e CCN π	ν_e CCDIS	ν_e CCother	$\bar{\nu}_e$ CC	ν_μ CC	NC				ν_e CC1 π^+	other		
FCFV	9.04	39.19	2.29	1.12	4.10	2.82	83.29	135.95					9.04	268.58	
pre-BDT	2.64	3.54	0.37	0.09	1.21	0.26	29.89	97.87					2.64	133.26	
post-BDT	1.85	3.10	0.27	0.06	0.80	0.21	1.03	6.86					1.85	12.33	
v type:	osc ν_e CC	int ν_e CC	ν_μ CC	NC								osc $\nu_e/\bar{\nu}_e$ CC	other	FOM	
FCFV	38.06	20.50	83.29	135.95									38.06	239.74	2.28
pre-BDT	5.95	2.17	29.89	97.87									5.95	129.95	0.51
post-BDT	4.58	1.71	1.03	6.86									4.58	9.60	1.22

1Re 0de Selection

BDT training signal = $1e^{+/-}$

visible FSP:	$1e1\pi^{+/-}$	$1e$	$1e$ other	$1\mu 1\pi^{+/-}$	1μ	1μ other	$0l1\pi^+$	$0l1\pi^-$	$0l1\pi^0$	$0lN\pi$	$0l$ other	$1e^{+/-}$	other		
FCFV	4.63	45.01	8.93	8.96	41.60	32.68	7.69	12.16	83.11	17.28	15.76		45.01	232.78	
pre-BDT	2.45	6.92	3.88	3.22	25.21	7.20	7.07	11.41	75.78	10.43	13.91		6.92	160.56	
post-BDT	0.24	4.88	0.19	0.01	0.06	0.05	0.04	0.08	2.34	0.13	0.17		4.88	3.30	
NEUT mode:	$v_e CC1\pi^+$	$v_e CCQE$	$v_e CCN\pi$	$v_e CCDIS$	$v_e CCother$	$\bar{v}_e CC$	$v_\mu CC$	NC				$v_e/\bar{v}_e CCQE$	other		
FCFV	9.04	39.19	2.29	1.12	4.10	2.82	83.28	135.95					40.68	237.13	
pre-BDT	3.77	5.98	0.68	0.13	2.13	0.57	35.67	118.57					6.23	161.24	
post-BDT	0.61	4.20	0.05	0.01	0.16	0.27	0.12	2.76					4.40	3.77	
v type:	osc $v_e CC$	int $v_e CC$	$v_\mu CC$	NC								$osc v_e/\bar{v}_e CC$	other	FOM	
FCFV	38.06	20.50	83.28	135.95									38.06	239.76	2.28
pre-BDT	8.79	4.46	35.67	118.57									8.79	158.68	0.68
post-BDT	3.58	1.72	0.12	2.76									3.58	4.60	1.25

2Re π 1de Selection

BDT training signal = 1e⁺⁻1 π^{+-}

visible FSP:	1e1 π^{+-}	1e	1e other	1 μ 1 π^{+-}	1 μ	1 μ other	0l1 π^+	0l1 π^-	0l1 π^0	0lN π	0l other	1e ⁺⁻ 1 π^{+-}	other		
FCFV	6.95	4.64	3.81	32.01	132.51	82.41	11.12	3.61	4.65	15.28	5.14		6.95	295.10	
pre-BDT	3.24	0.65	0.67	13.62	93.68	19.37	9.77	2.63	2.70	6.82	4.05		3.24	153.95	
post-BDT	1.95	0.13	0.08	0.09	0.02	0.28	0.08	0.04	0.06	0.13	0.11		1.95	1.02	
NEUT mode:	v _e CC1 π^+	v _e CCQE	v _e CCN π	v _e CCDIS	v _e CCother	\bar{v}_e CC	v _{μ} CC	NC				v _e / \bar{v}_e CC1 π^+	other		
FCFV	10.57	0.52	2.31	1.21	0.54	0.26	246.94	39.72					10.62	291.44	
pre-BDT	3.71	0.09	0.47	0.14	0.13	0.03	126.72	25.92					3.72	153.47	
post-BDT	2.01	0.02	0.08	0.00	0.03	0.01	0.39	0.42					2.02	0.95	
v type:	osc v _e CC	int v _e CC	v _{μ} CC	NC								osc v _e / \bar{v}_e CC	other	FOM	
FCFV	7.86	7.54	246.94	39.72									7.86	294.20	0.45
pre-BDT	3.06	1.50	126.72	25.92									3.06	154.13	0.24
post-BDT	1.63	0.53	0.39	0.42									1.63	1.34	0.95

1Re Ode Selection Plots

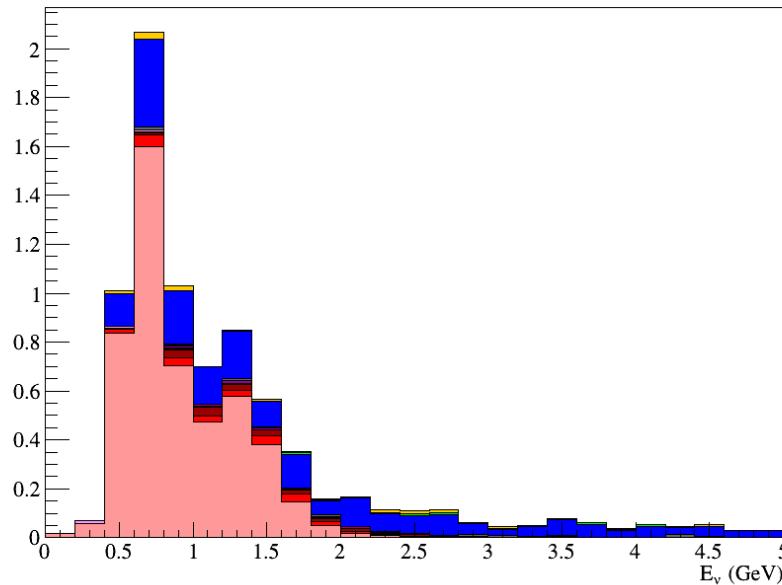
- The following slides contain plots of the 1Re Ode selection

0 decay e
post-BDT

True Neutrino Energy

(10^{21} POT)

- 1e
- 1e $1\pi^{\pm}$
- 1e other
- 1 μ $1\pi^{\pm}$
- 1 μ
- 1 μ other
- 0l $1\pi^+$
- 0l $1\pi^-$
- 0l $1\pi^0$
- 0l N π
- 0l other

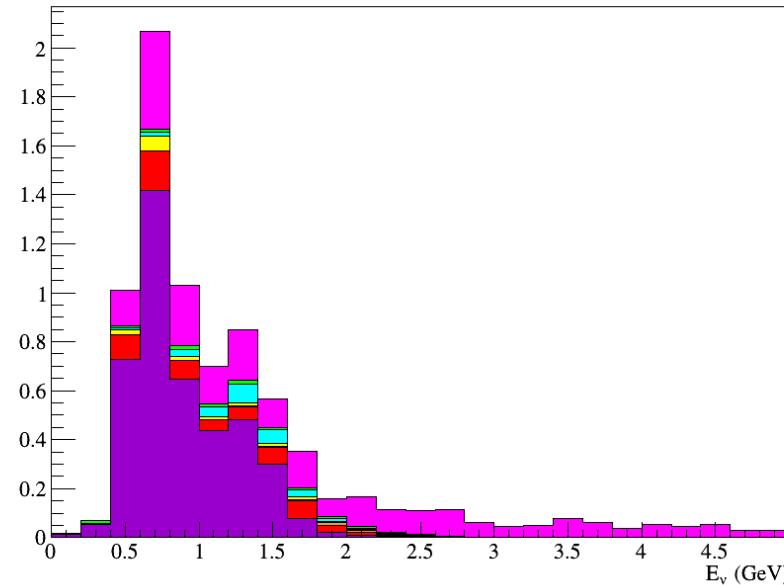


0 decay e
post-BDT

True Neutrino Energy

(10^{21} POT)

- ν_e CC QE
- ν_e CC $1\pi^+$
- ν_e CC $N\pi$
- ν_e CC DIS
- ν_e CC other
- $\bar{\nu}_e$ CC
- ν_μ CC
- NC

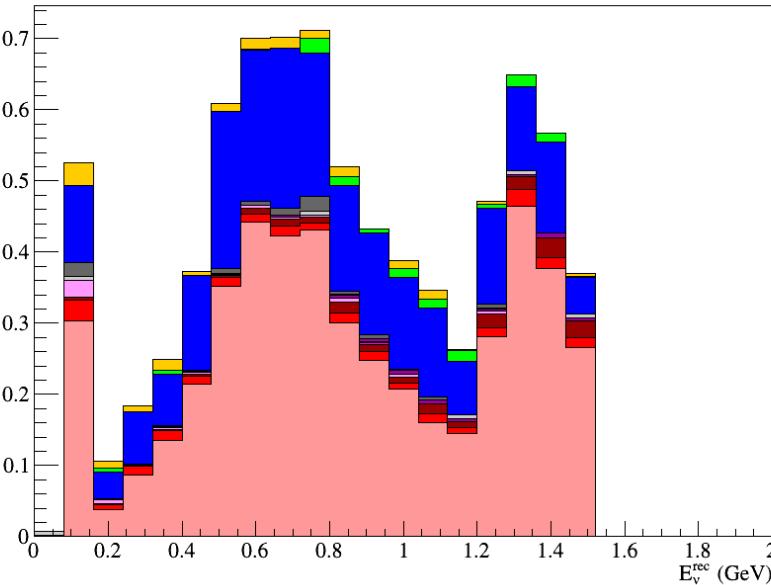


0 decay e
post-BDT

Reconstructed Neutrino Energy

(10^{21} POT)

- 1e
- 1e $1\pi^{\pm}$
- 1e other
- 1 μ $1\pi^{\pm}$
- 1 μ
- 1 μ other
- 0l $1\pi^+$
- 0l $1\pi^-$
- 0l $1\pi^0$
- 0l N π
- 0l other

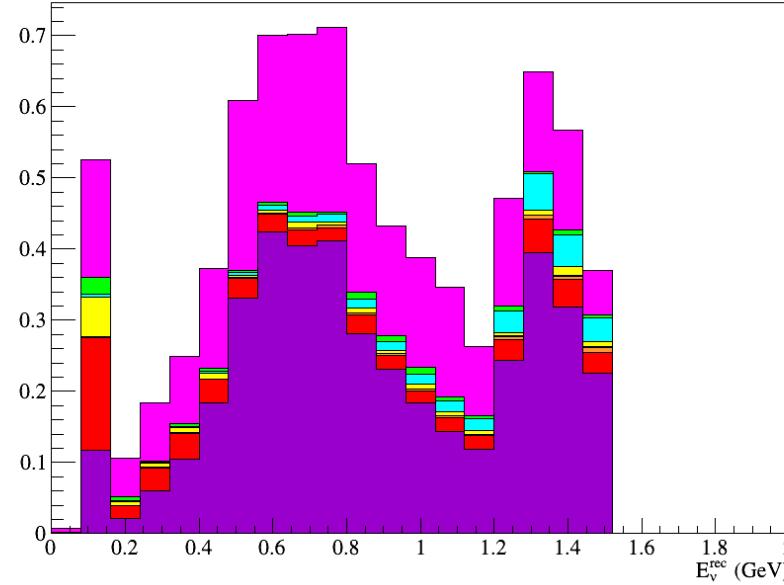


0 decay e
post-BDT

Reconstructed Neutrino Energy

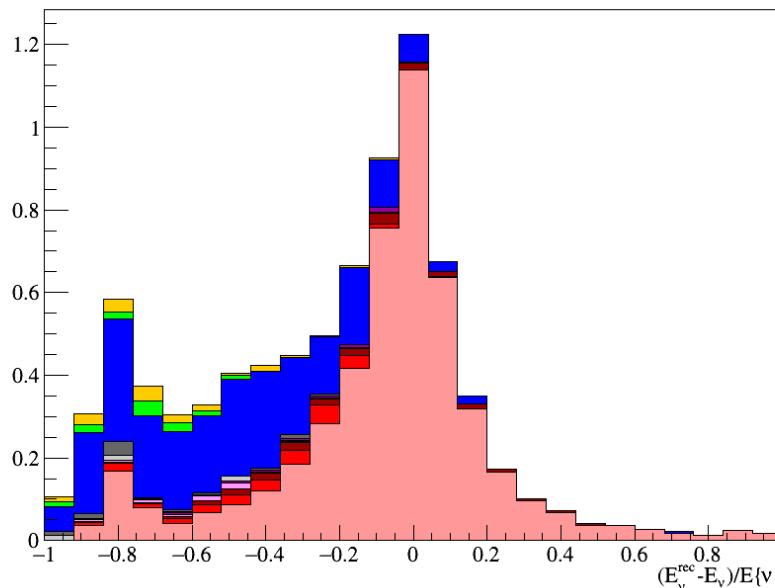
(10^{21} POT)

- ν_e CC QE
- ν_e CC $1\pi^+$
- ν_e CC $N\pi$
- ν_e CC DIS
- ν_e CC other
- $\bar{\nu}_e$ CC
- ν_μ CC
- NC



0 decay e
post-BDT

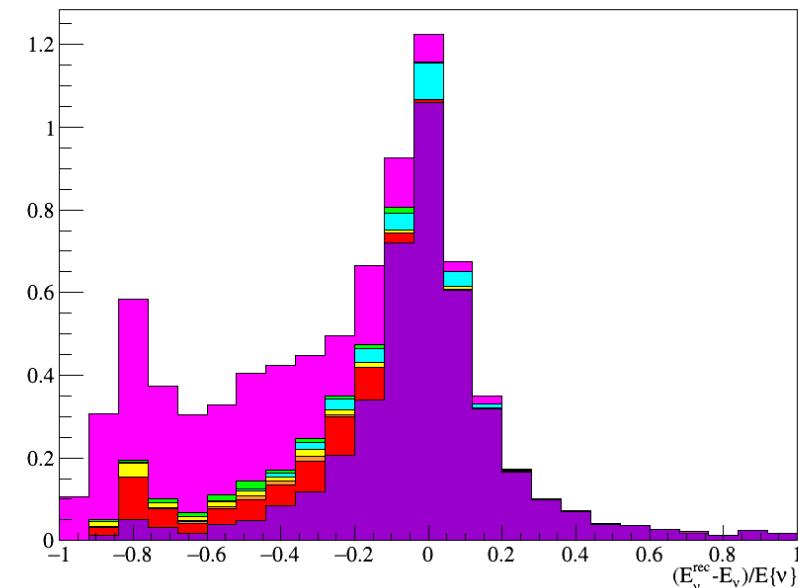
Reconstructed Neutrino Energy Resolution



(10^{21} POT)
1e
1e $1\pi^+$
1e other
1 μ $1\pi^+$
1 μ other
0l $1\pi^+$
0l $1\pi^-$
0l $1\pi^0$
0l N π
0l other

0 decay e
post-BDT

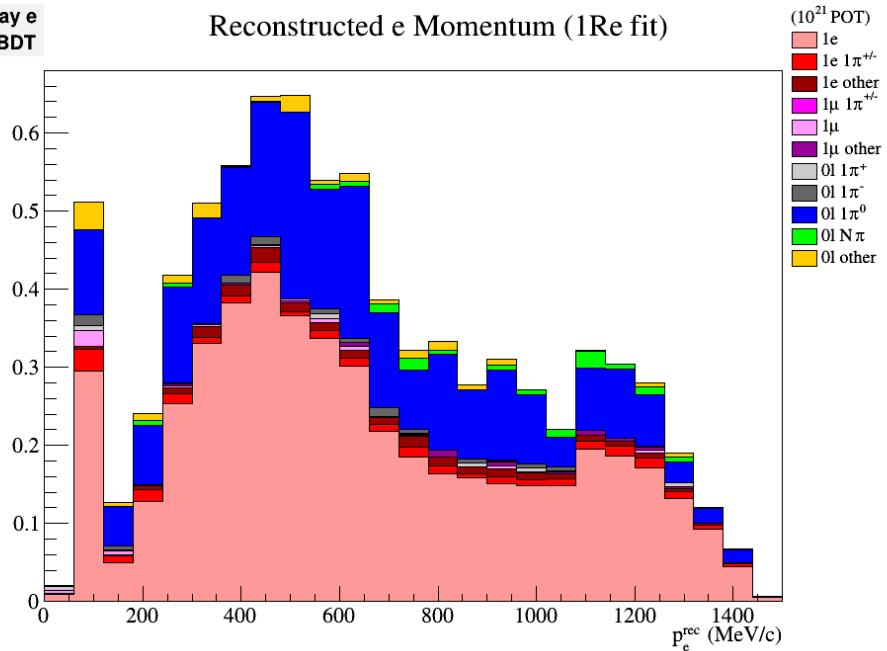
Reconstructed Neutrino Energy Resolution



(10^{21} POT)
 ν_e CC QE
 ν_e CC $1\pi^+$
 ν_e CC N π
 ν_e CC DIS
 ν_e CC other
 $\bar{\nu}_e$ CC
 ν_μ CC
NC

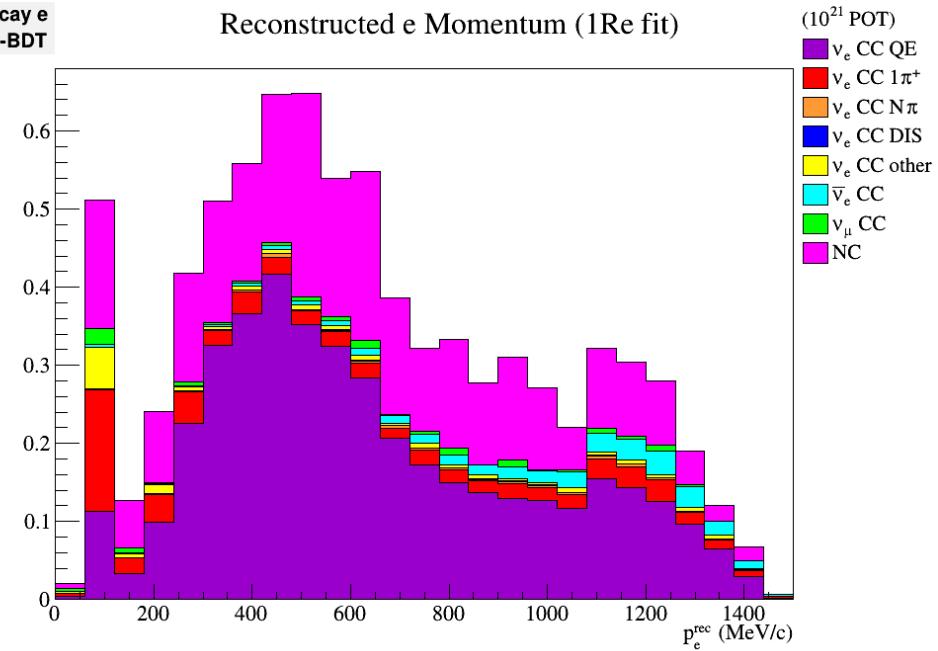
0 decay e
post-BDT

Reconstructed e Momentum (1Re fit)



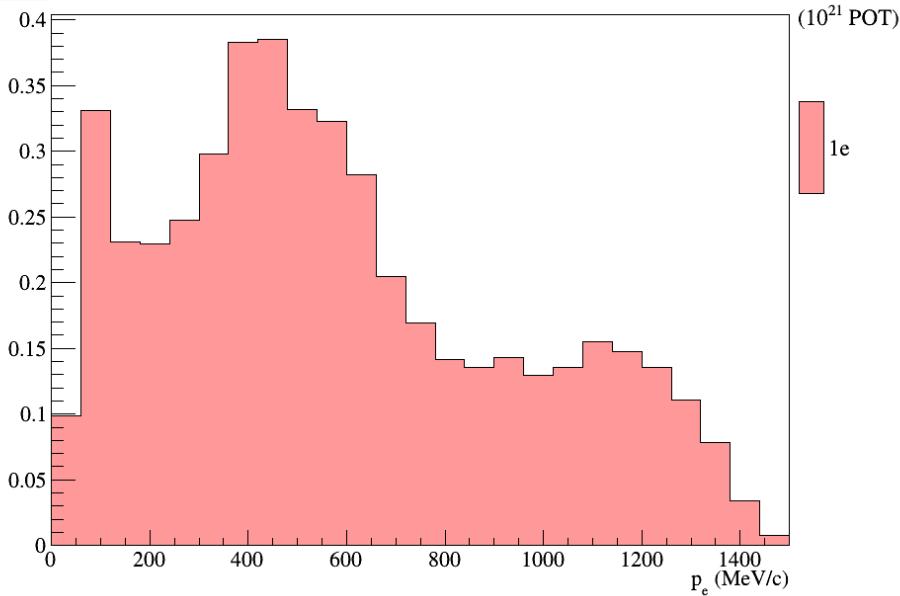
0 decay e
post-BDT

Reconstructed e Momentum (1Re fit)



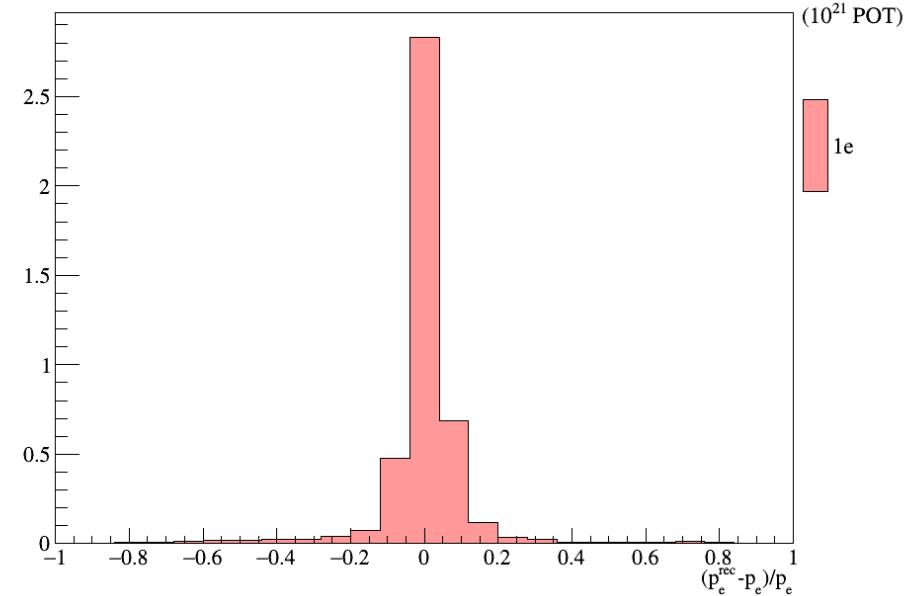
0 decay e
post-BDT

True e Momentum



0 decay e
post-BDT

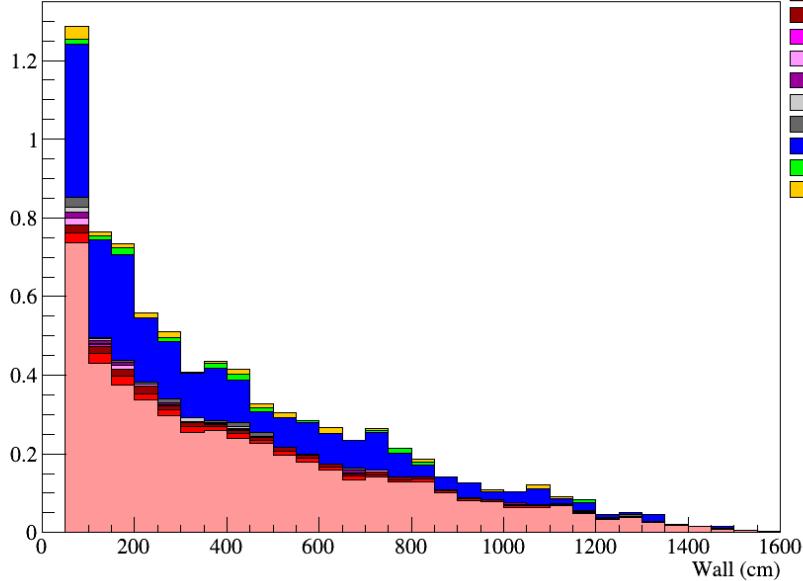
Reconstructed e Momentum Resolution



0 decay e
post-BDT

Wall

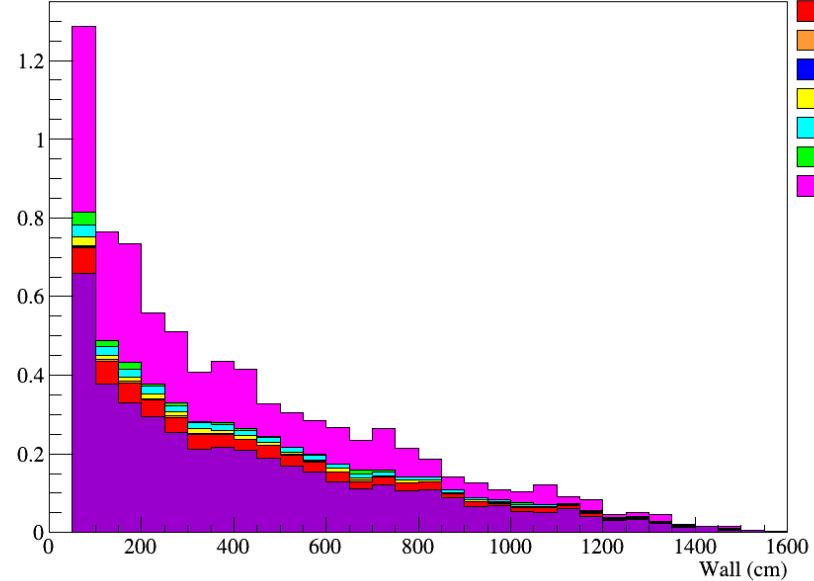
(10^{21} POT)
1e
1e 1 $\pi^{+/-}$
1e other
1 μ 1 $\pi^{+/-}$
1 μ
1 μ other
0l 1 π^+
0l 1 π^-
0l 1 π^0
0l N π
0l other



0 decay e
post-BDT

Wall

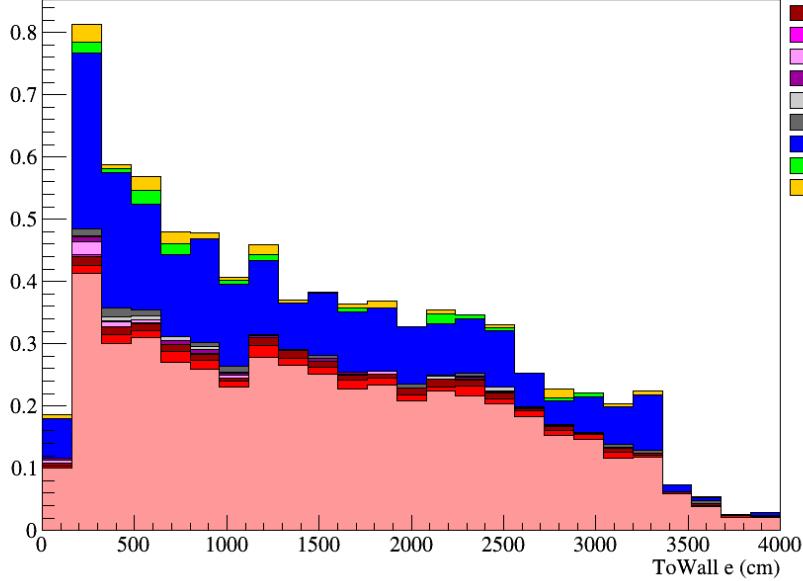
(10^{21} POT)
 ν_e CC QE
 ν_e CC 1 π^+
 ν_e CC N π
 ν_e CC DIS
 ν_e CC other
 $\bar{\nu}_e$ CC
 ν_μ CC
NC



0 decay e
post-BDT

ToWall e (1Re fit)

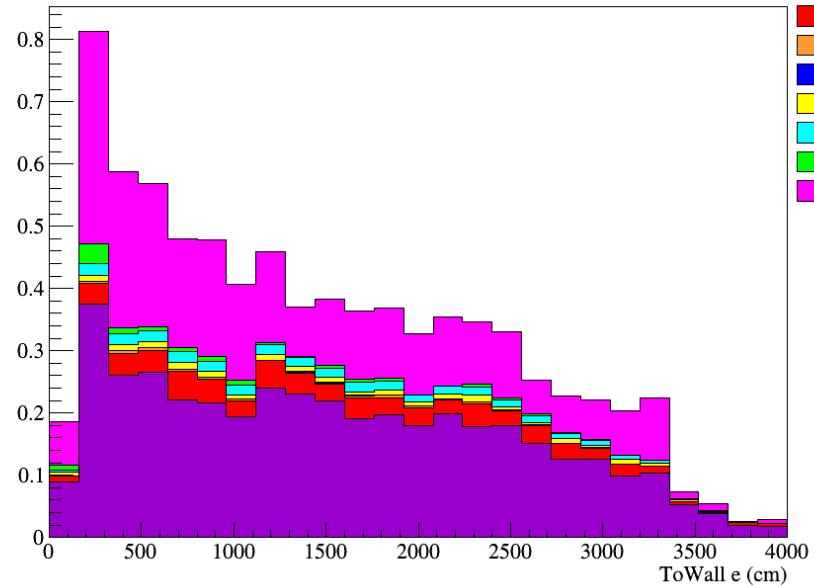
(10^{21} POT)
1e
1e 1 $\pi^{+/-}$
1e other
1 μ 1 $\pi^{+/-}$
1 μ
1 μ other
0l 1 π^+
0l 1 π^-
0l 1 π^0
0l N π
0l other



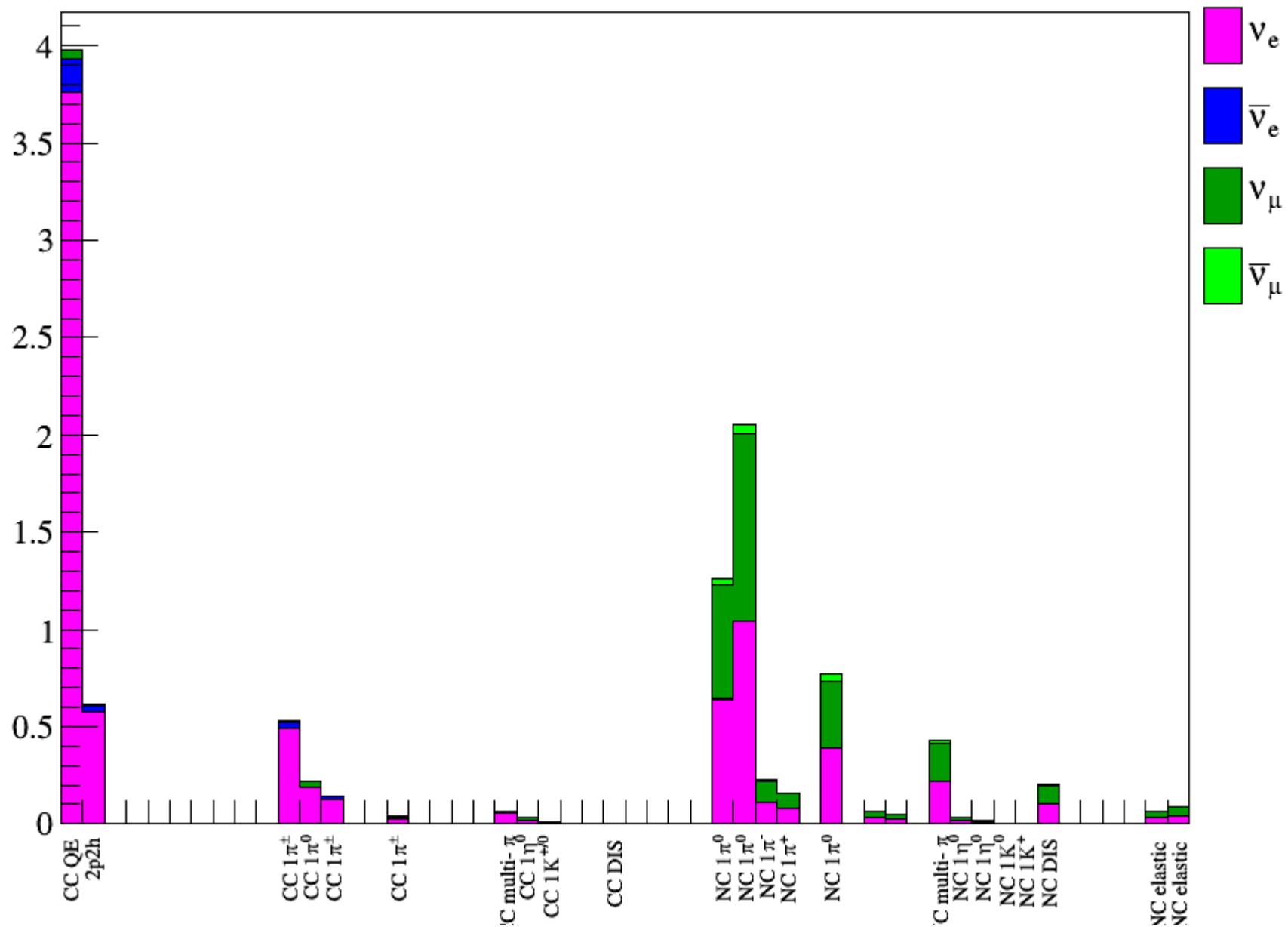
0 decay e
post-BDT

ToWall e (1Re fit)

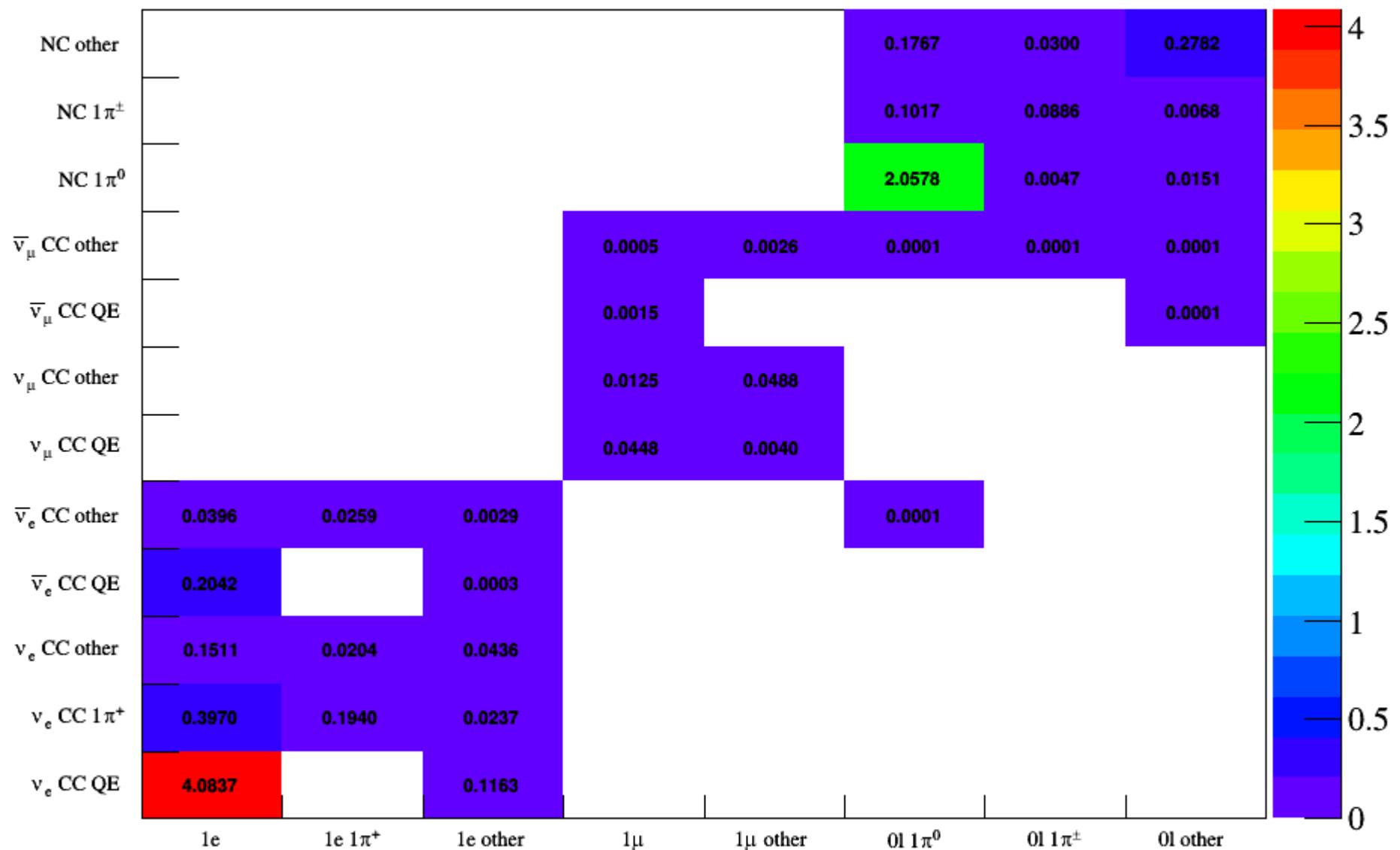
(10^{21} POT)
 ν_e CC QE
 ν_e CC 1 π^+
 ν_e CC N π
 ν_e CC DIS
 ν_e CC other
 $\bar{\nu}_e$ CC
 ν_μ CC
NC



Neutrino Interaction Mode (NEUT)

 (10^{21} POT) 

NEUT Mode vs. Visible Final State Particles

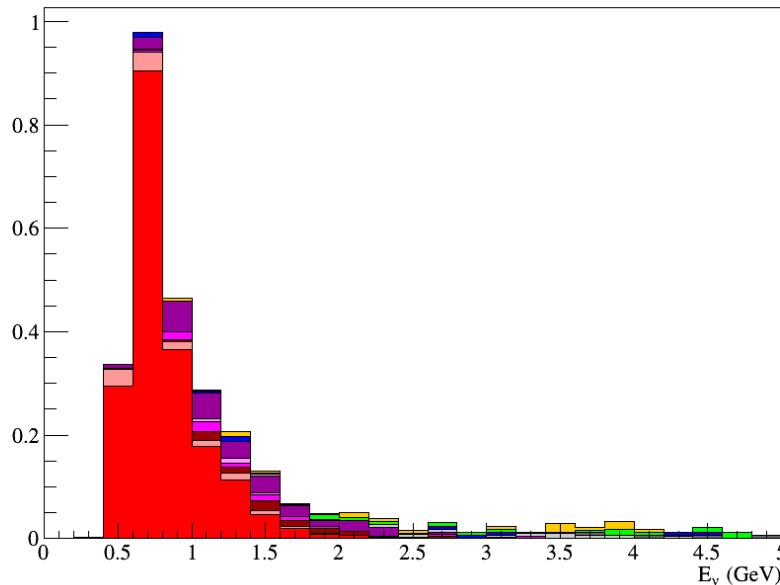


2Re π 1de Selection

- The following slides contain plots of the 2Re π 1de selection

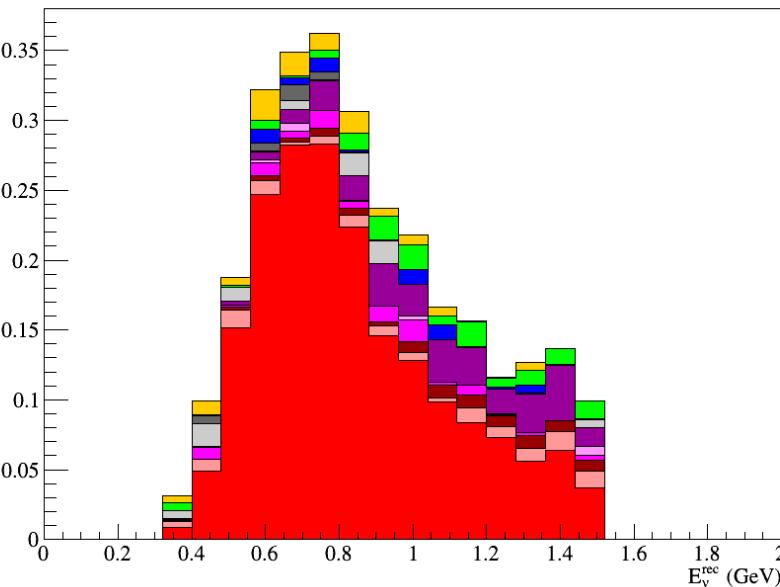
1 decay e
post-BDT

True Neutrino Energy



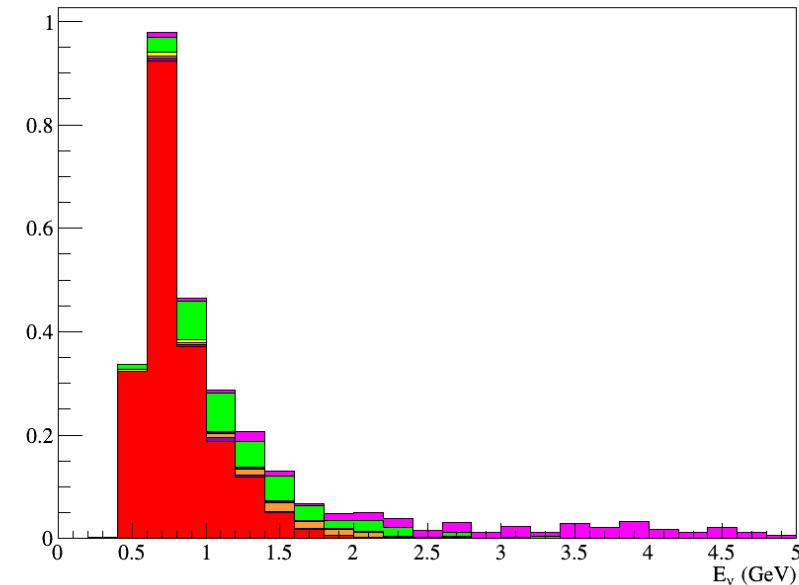
1 decay e
post-BDT

Reconstructed Neutrino Energy



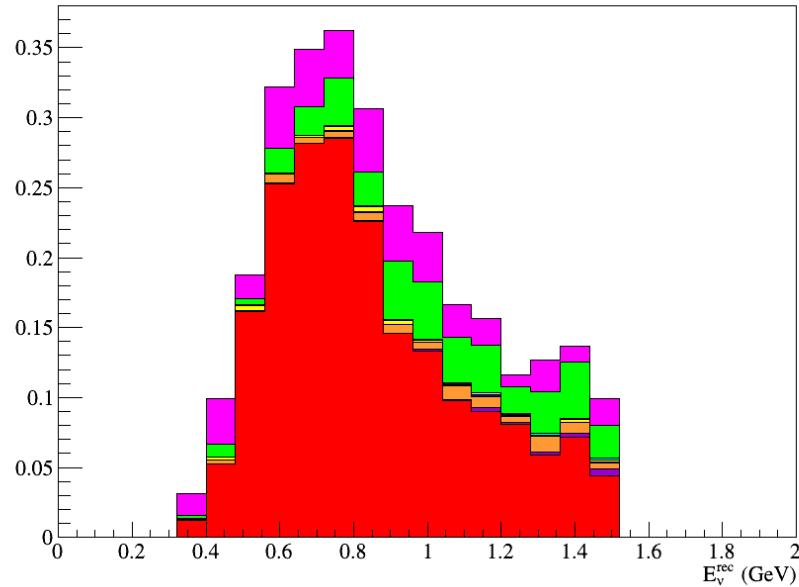
1 decay e
post-BDT

True Neutrino Energy



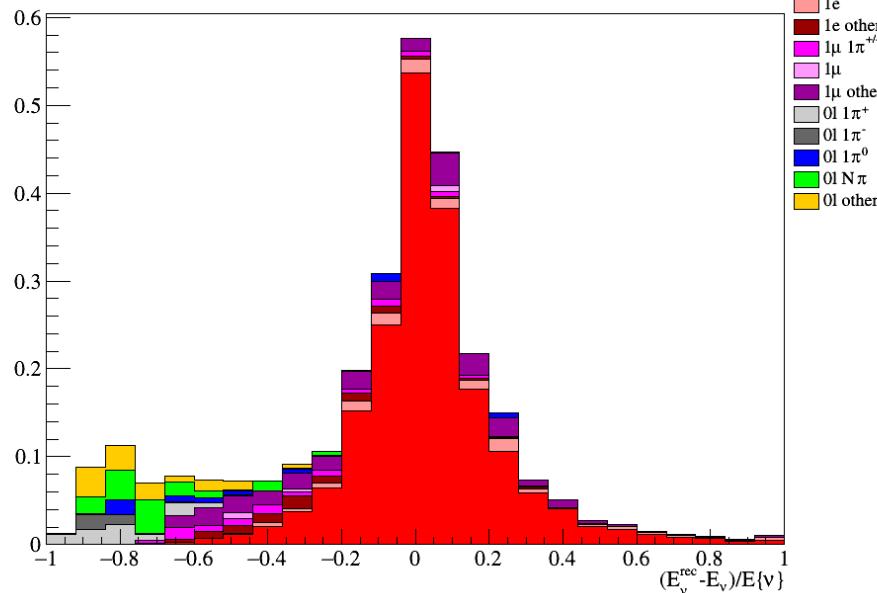
1 decay e
post-BDT

Reconstructed Neutrino Energy



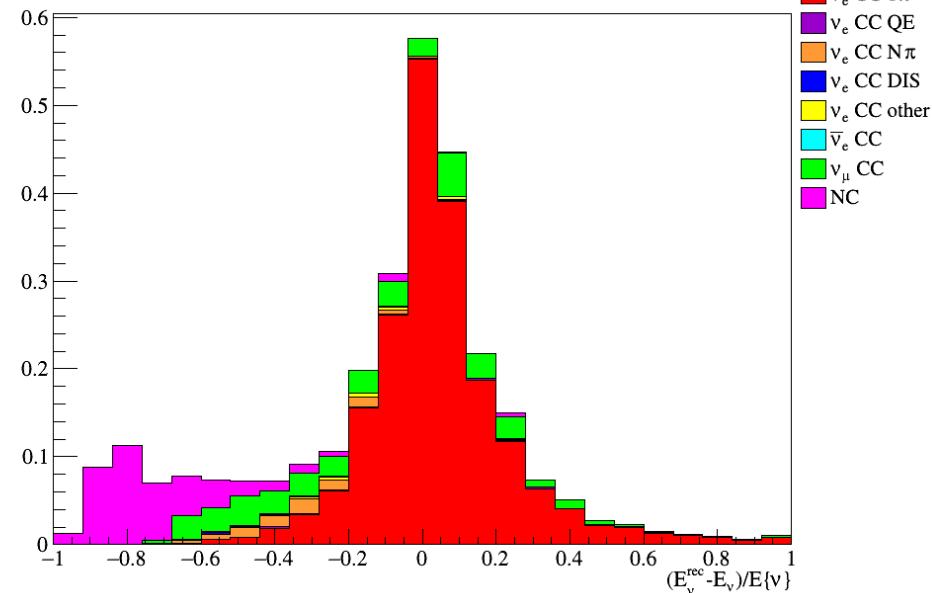
1 decay e
post-BDT

Reconstructed Neutrino Energy Resolution



1 decay e
post-BDT

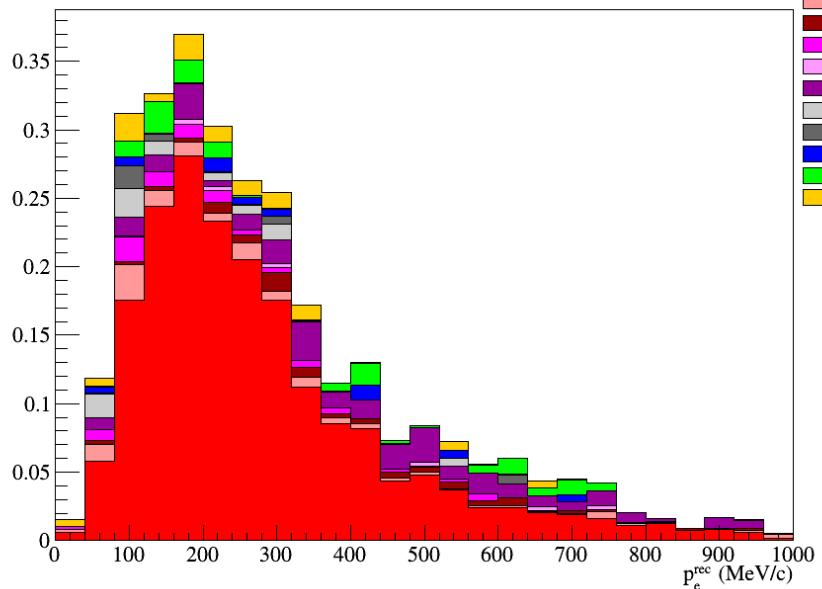
Reconstructed Neutrino Energy Resolution



1 decay e
post-BDT

Reconstructed e Momentum (2Re π fit)

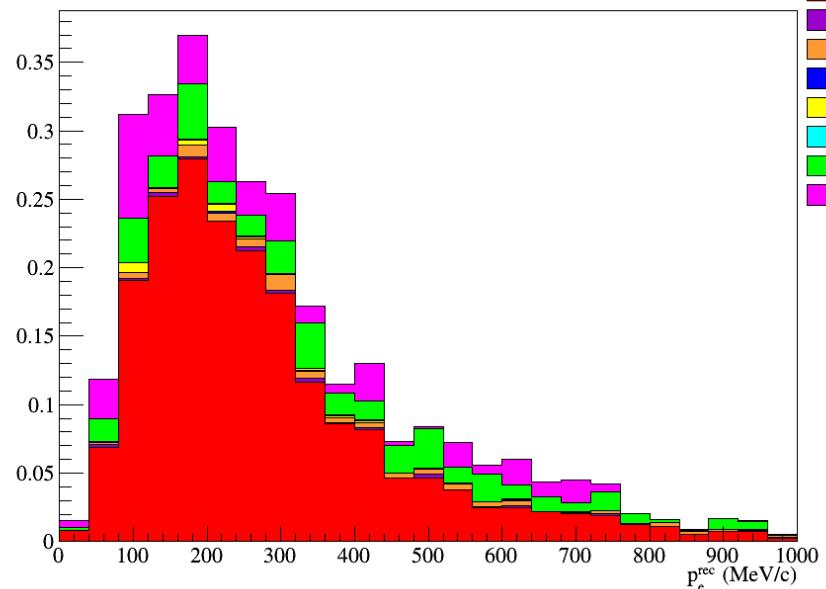
(10²¹ POT)
1e 1 $\pi^{+/-}$
1e
1e other
1 μ 1 $\pi^{+/-}$
1 μ
1 μ other
0l 1 π^+
0l 1 π^-
0l 1 π^0
0l N π
0l other



1 decay e
post-BDT

Reconstructed e Momentum (2Re π fit)

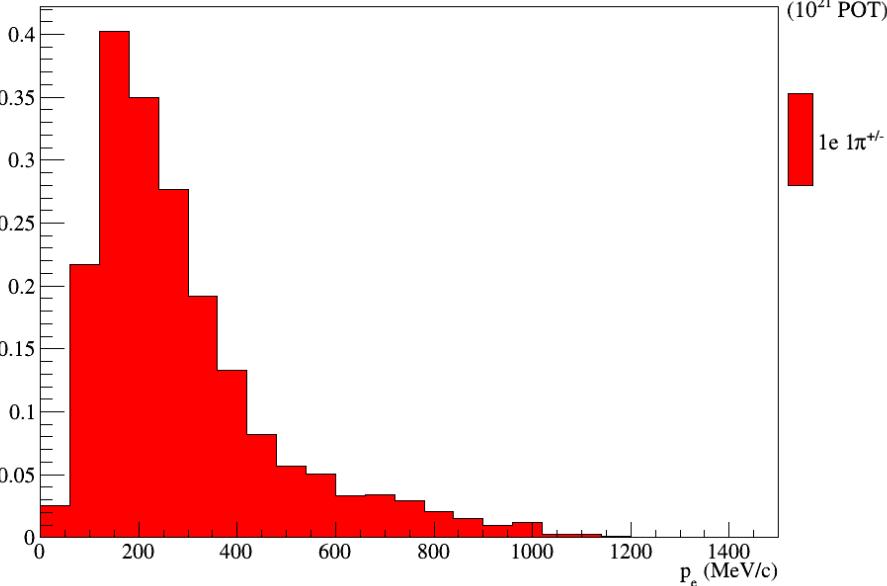
(10²¹ POT)
v_e CC 1 π^+
v_e CC QE
v_e CC N π
v_e CC DIS
v_e CC other
v_e CC
v_μ CC
NC



1 decay e
post-BDT

True e Momentum

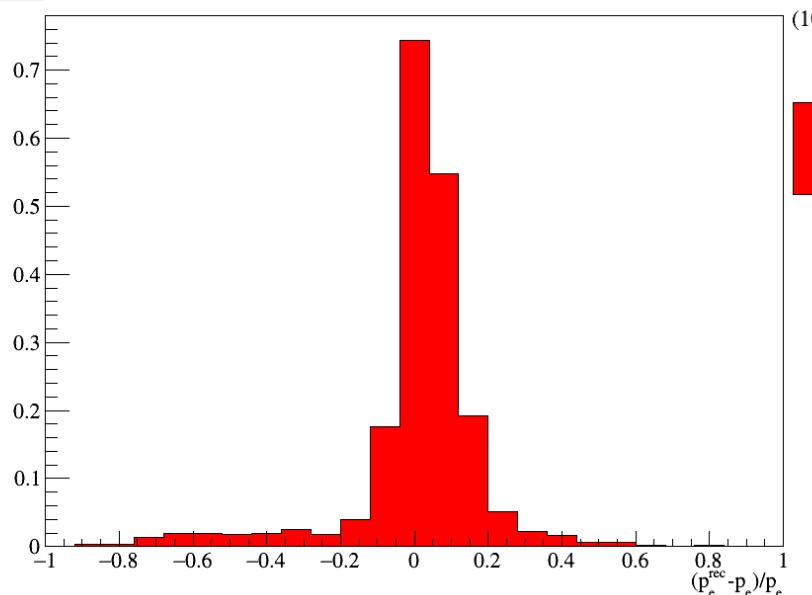
(10²¹ POT)



1 decay e
post-BDT

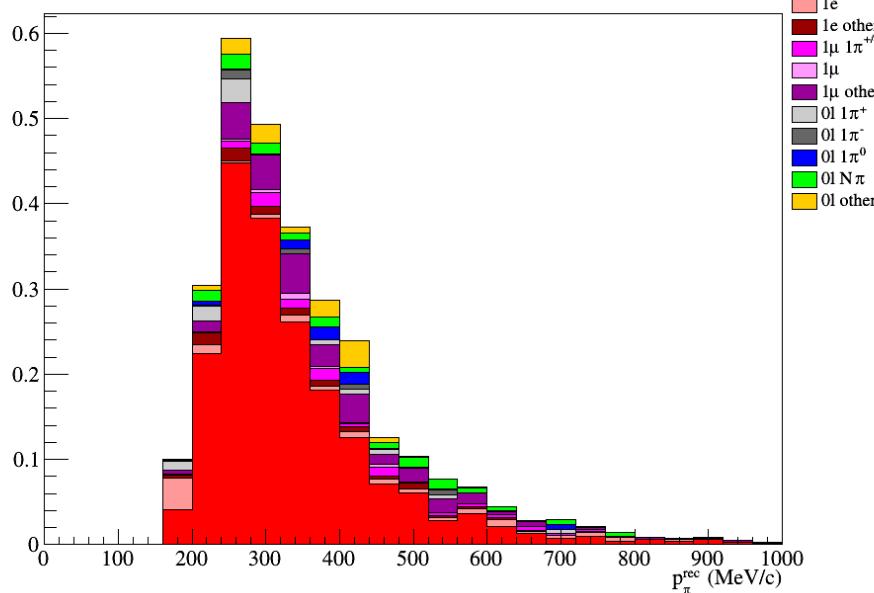
Reconstructed e Momentum Resolution

(10²¹ POT)



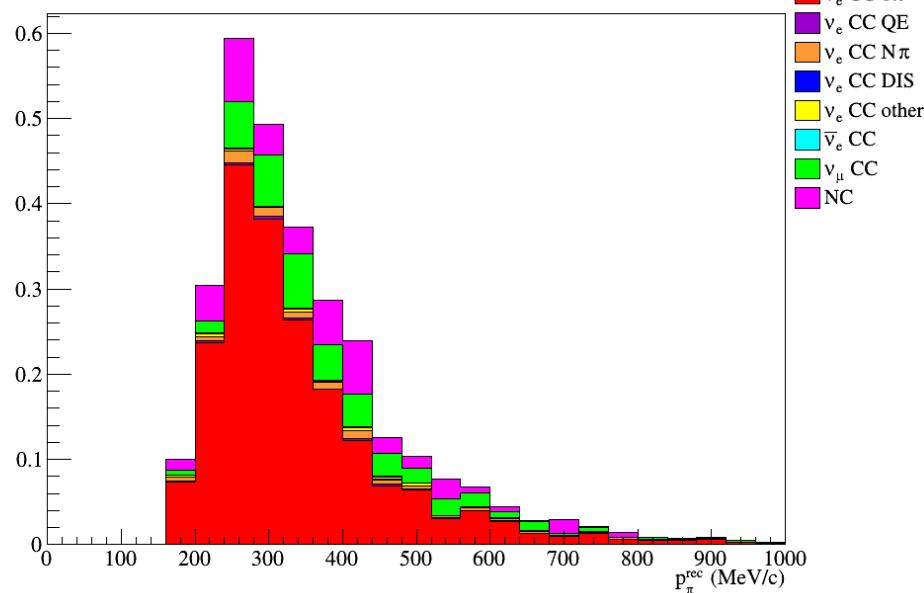
1 decay e
post-BDT

Reconstructed π Momentum (2Re π fit)



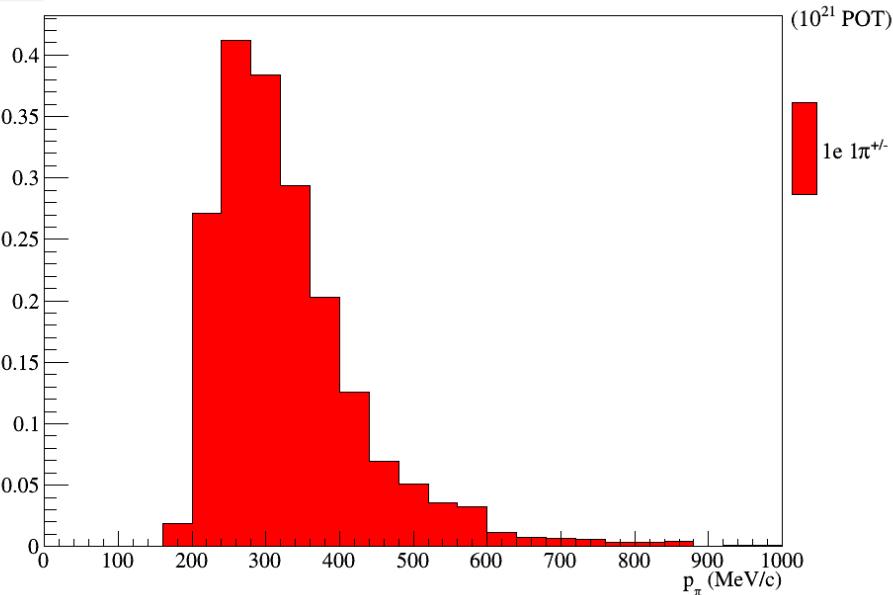
1 decay e
post-BDT

Reconstructed π Momentum (2Re π fit)



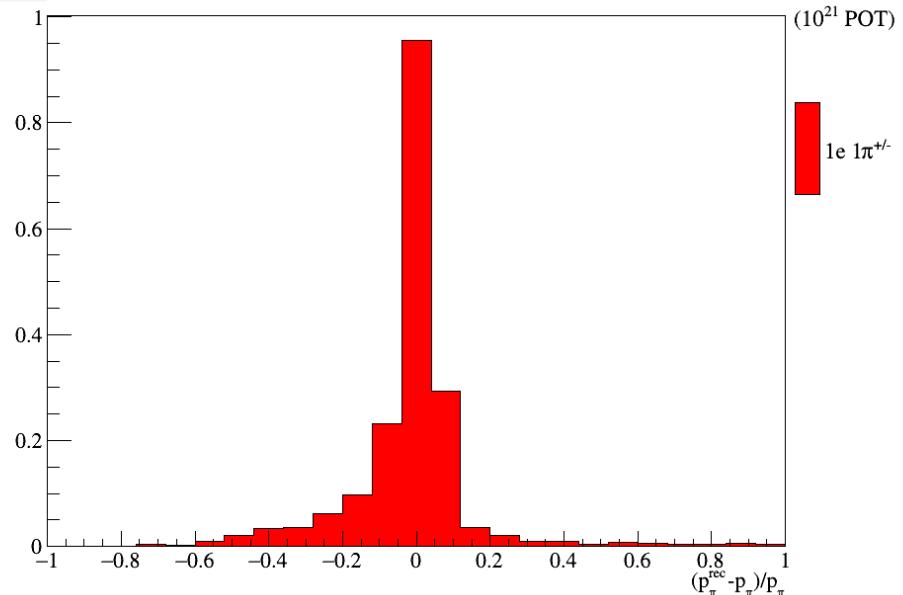
1 decay e
post-BDT

True π Momentum



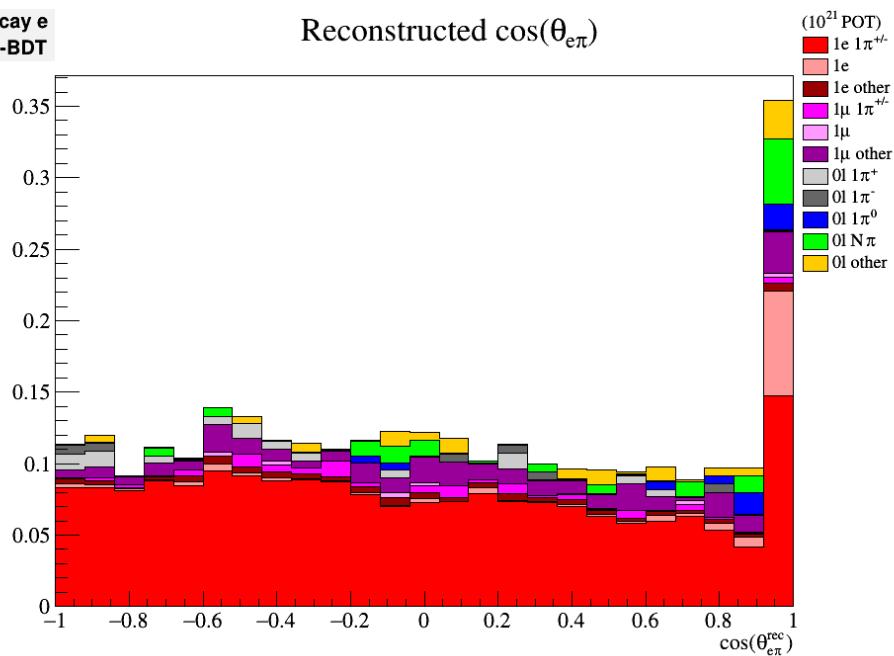
1 decay e
post-BDT

Reconstructed π Momentum Resolution



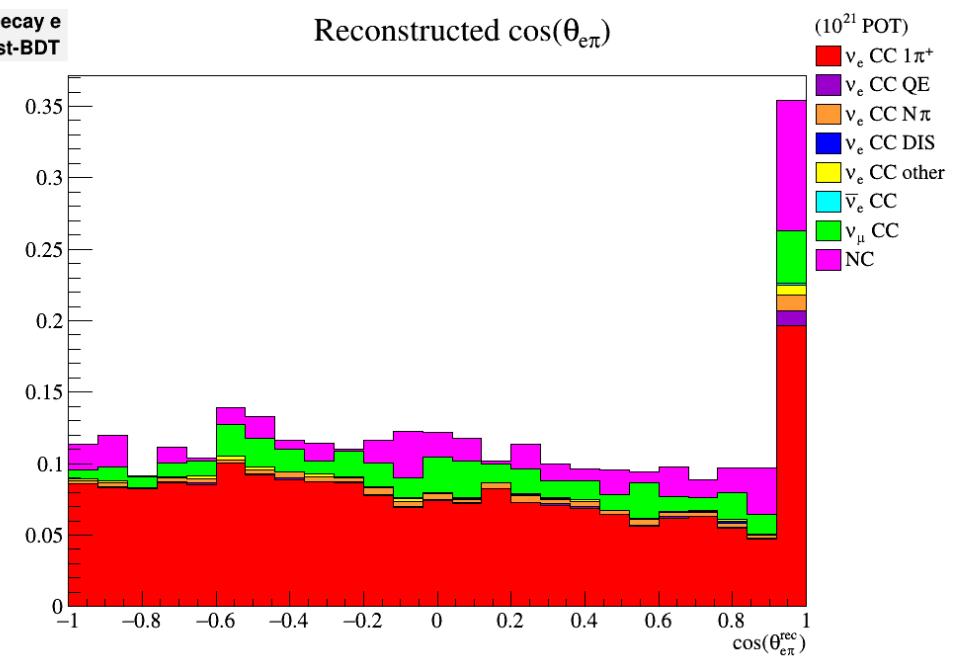
1 decay e
post-BDT

Reconstructed $\cos(\theta_{e\pi})$



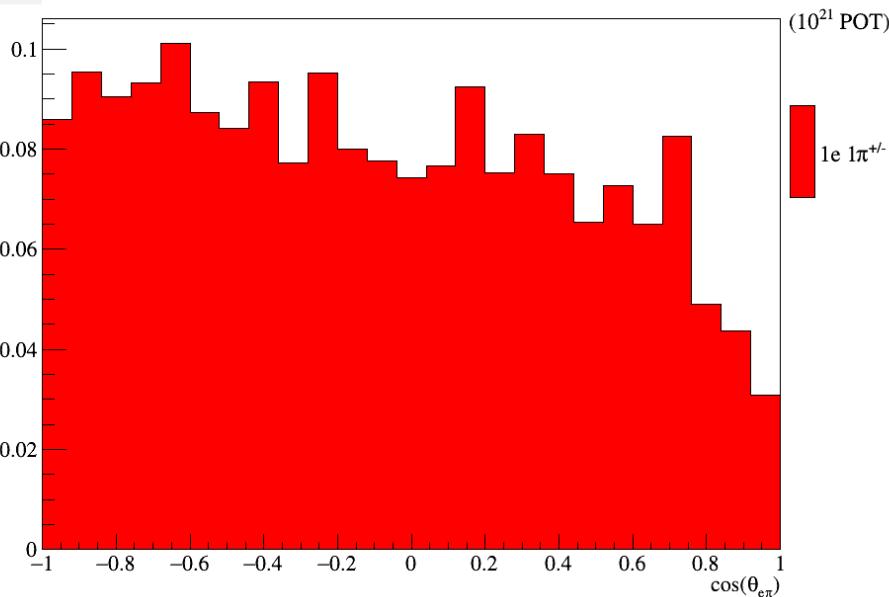
1 decay e
post-BDT

Reconstructed $\cos(\theta_{e\pi})$



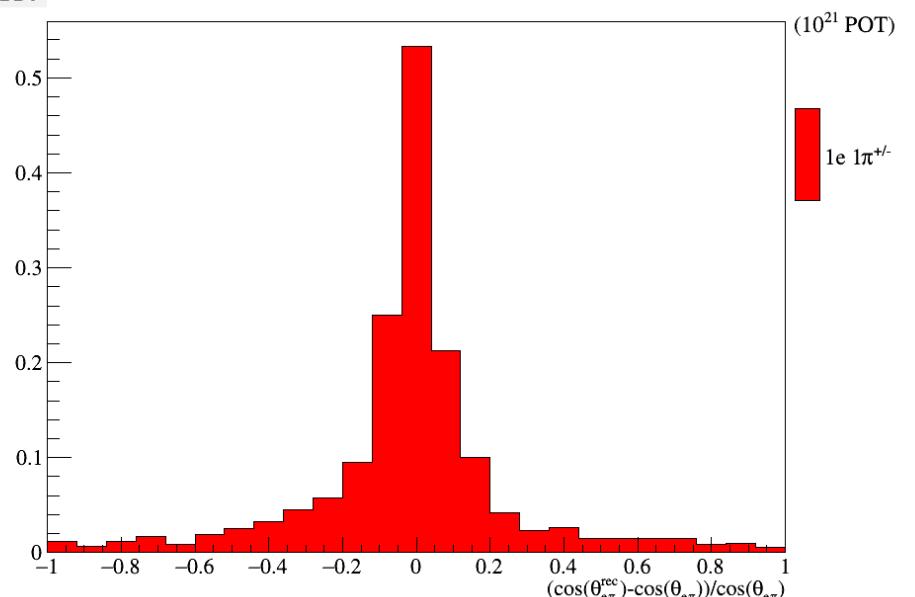
1 decay e
post-BDT

True $\cos(\theta_{e\pi})$



1 decay e
post-BDT

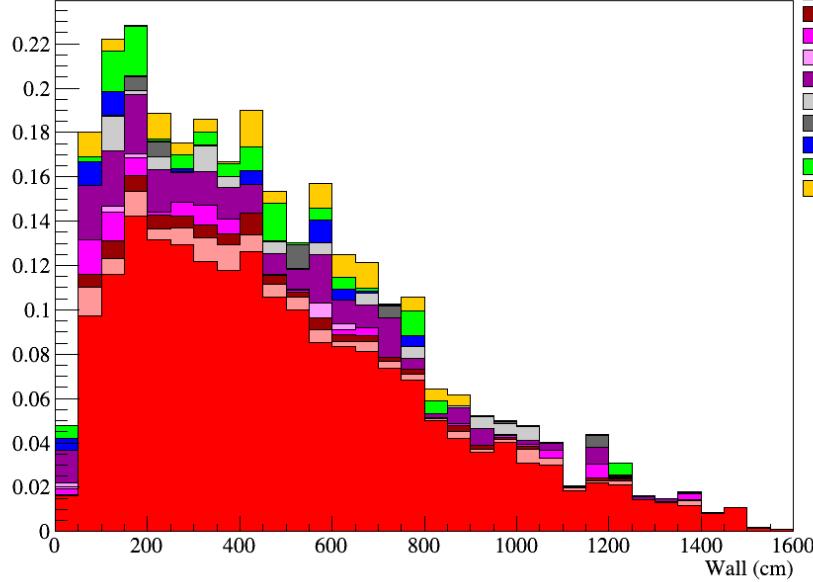
Reconstructed $\cos(\theta_{e\pi})$ Resolution



1 decay e
post-BDT

Wall

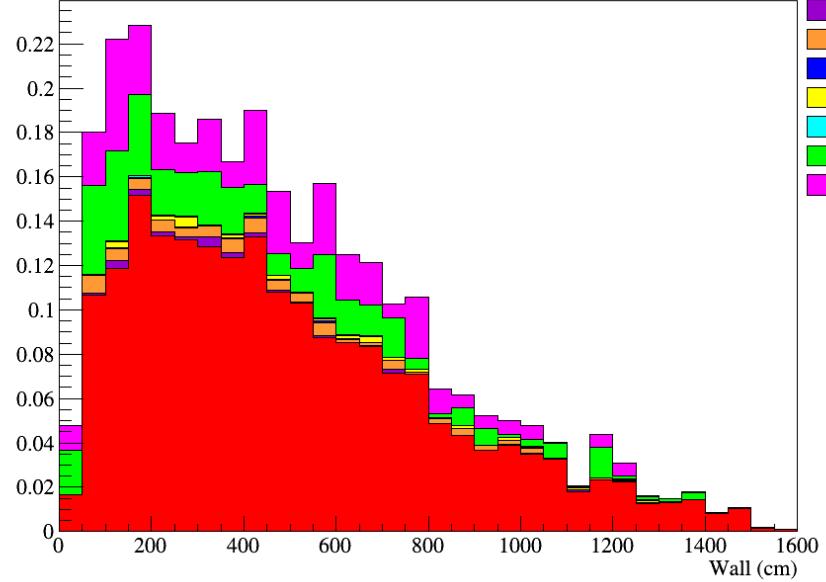
(10^{21} POT)
1e $1\pi^{+/-}$
1e
1e other
 1μ $1\pi^{+/-}$
 1μ
 1μ other
0l $1\pi^+$
0l $1\pi^-$
0l $1\pi^0$
0l $N\pi$
0l other



1 decay e
post-BDT

Wall

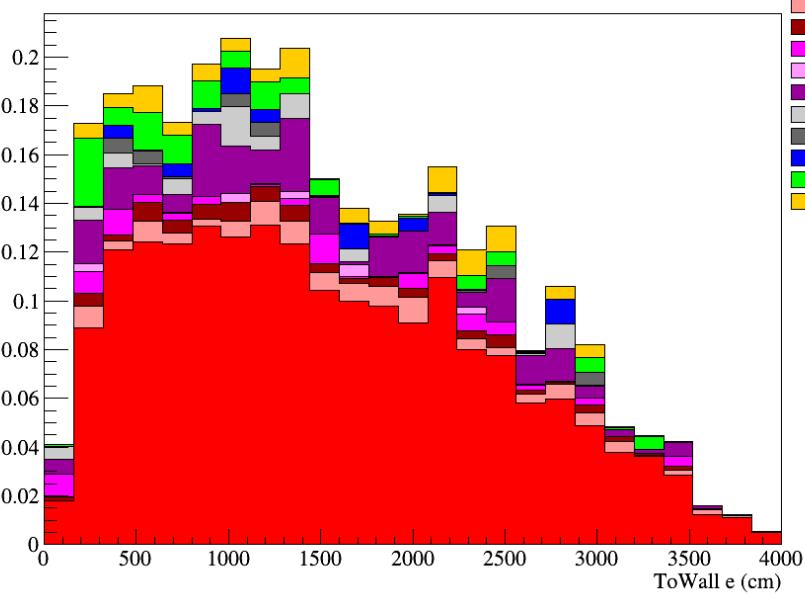
(10^{21} POT)
 ν_e CC $1\pi^+$
 ν_e CC QE
 ν_e CC $N\pi$
 ν_e CC DIS
 ν_e CC other
 $\bar{\nu}_e$ CC
 ν_μ CC
NC



1 decay e
post-BDT

ToWall e (2Re π fit)

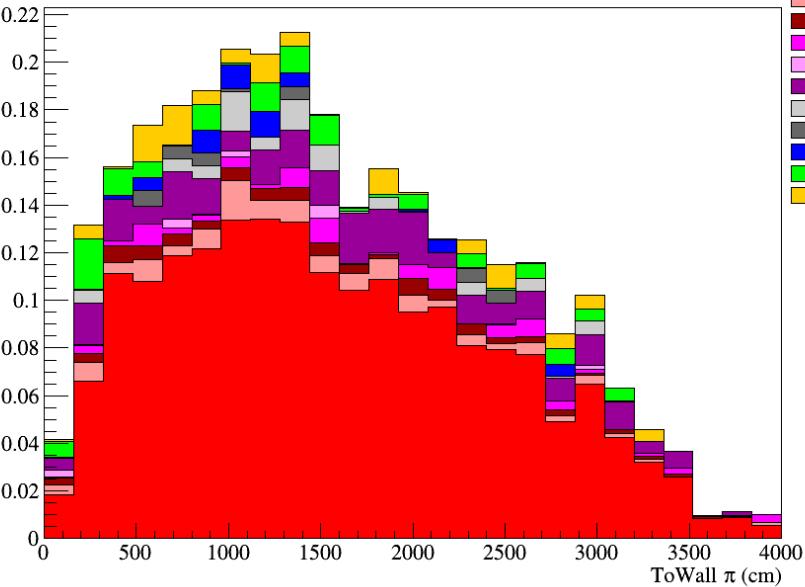
(10^{21} POT)
le 1 $\pi^{\prime\prime}$
le
le other
l μ 1 $\pi^{+/-}$
l μ
l μ other
0l 1 π^+
0l 1 π^-
0l 1 π^0
0l N π
0l other



1 decay e
post-BDT

ToWall π (2Re π fit)

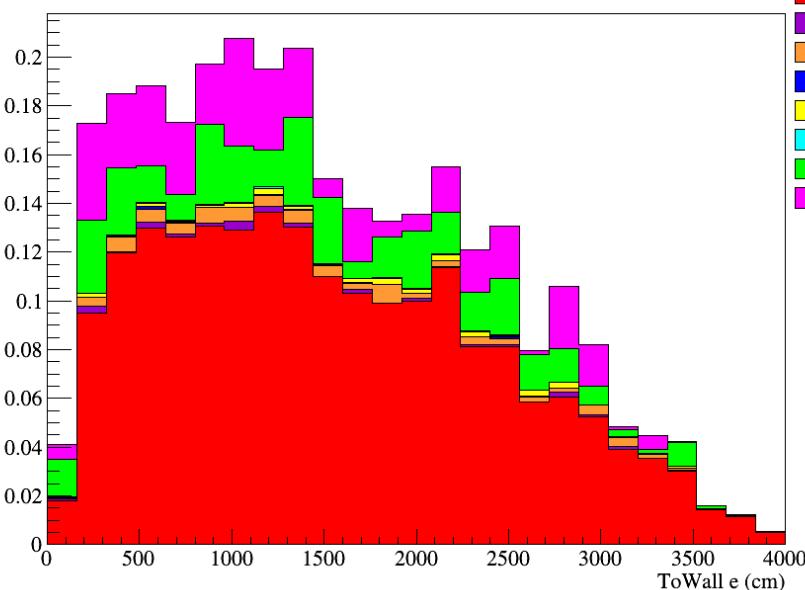
(10^{21} POT)
le 1 $\pi^{\prime\prime}$
le
le other
l μ 1 $\pi^{+/-}$
l μ
l μ other
0l 1 π^+
0l 1 π^-
0l 1 π^0
0l N π
0l other



1 decay e
post-BDT

ToWall e (2Re π fit)

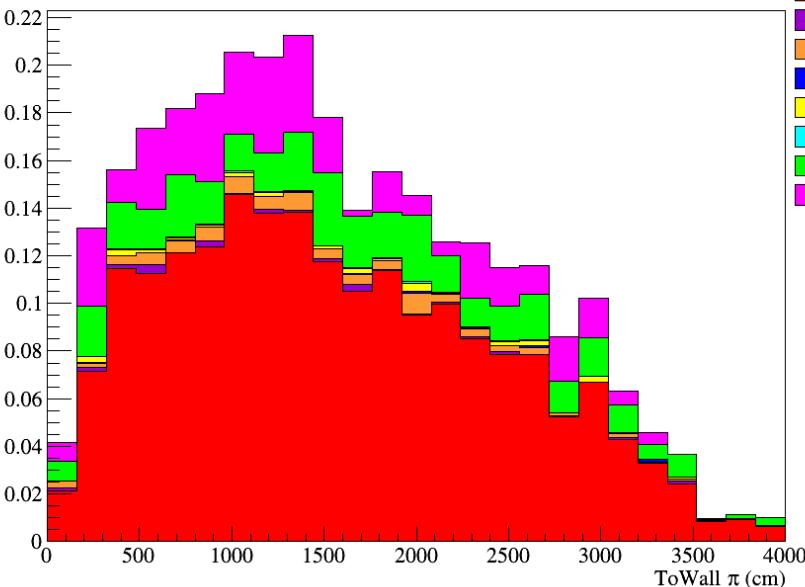
(10^{21} POT)
v_e CC 1 π^+
v_e CC QE
v_e CC N π
v_e CC DIS
v_e CC other
 \bar{v}_e CC
v _{μ} CC
NC



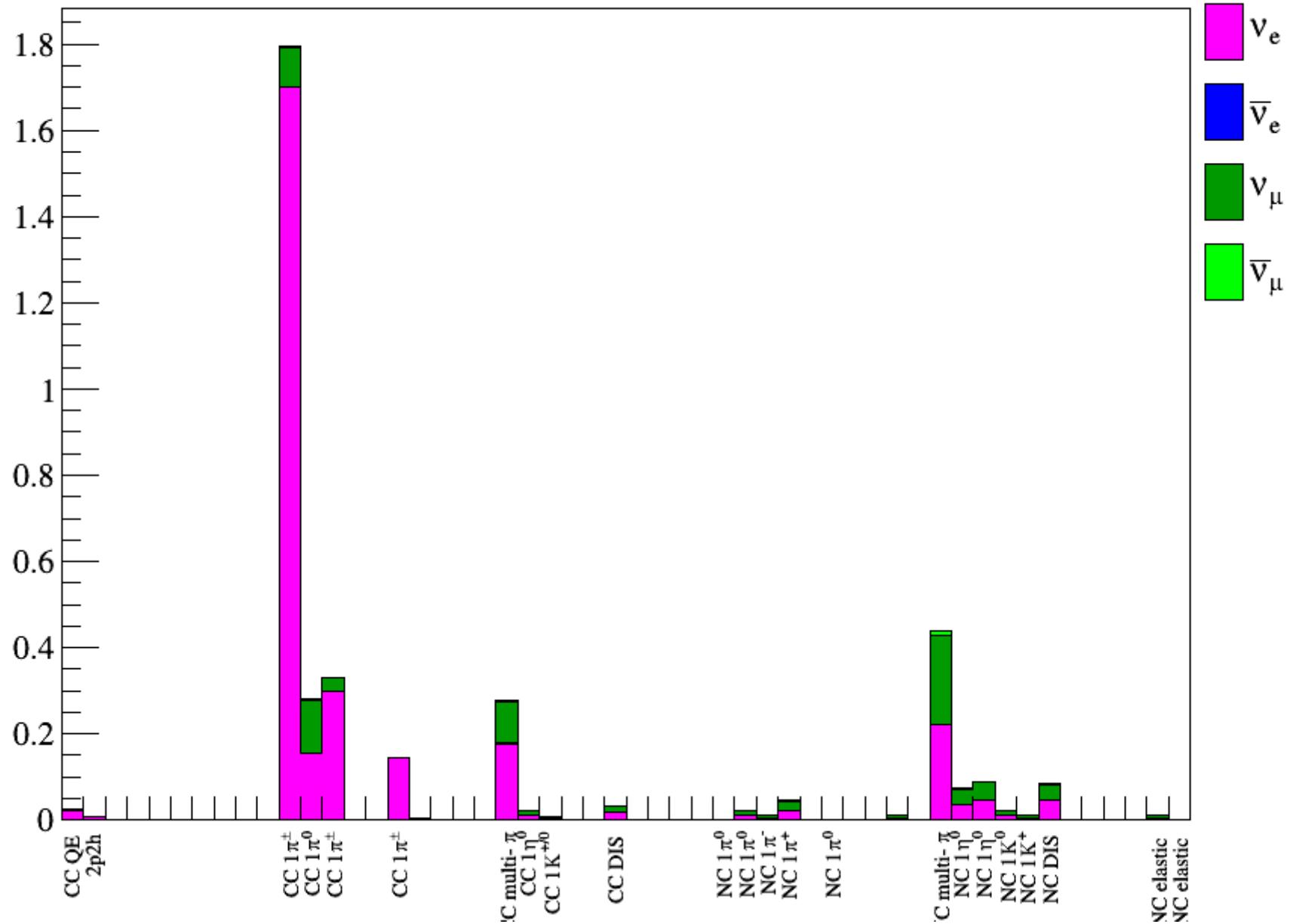
1 decay e
post-BDT

ToWall π (2Re π fit)

(10^{21} POT)
v_e CC 1 π^+
v_e CC QE
v_e CC N π
v_e CC DIS
v_e CC other
 \bar{v}_e CC
v _{μ} CC
NC



Neutrino Interaction Mode (NEUT)

 (10^{21} POT) 

NEUT Mode vs. Visible Final State Particles

