UNIVERSITY OF TORONTO

ν_e CCQE/CC1π^+ Selection Studies

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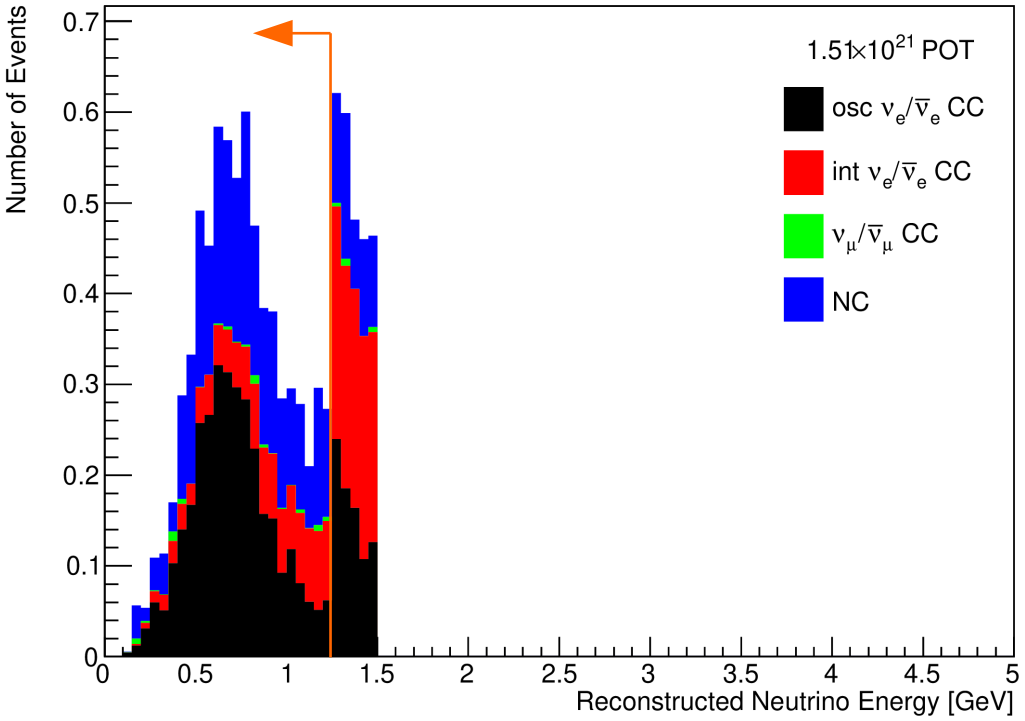
ν_e CCQE/CC1π^+ Meeting

October 31, 2019

E_{rec} Cut

- Investigated potential of changing E_{rec} cut from 1.5 GeV to 1.25 GeV
  - to be consistent with existing samples
- See how many oscillated ν_e CC events would be lost if making this change

Recovered ν_e CCQE



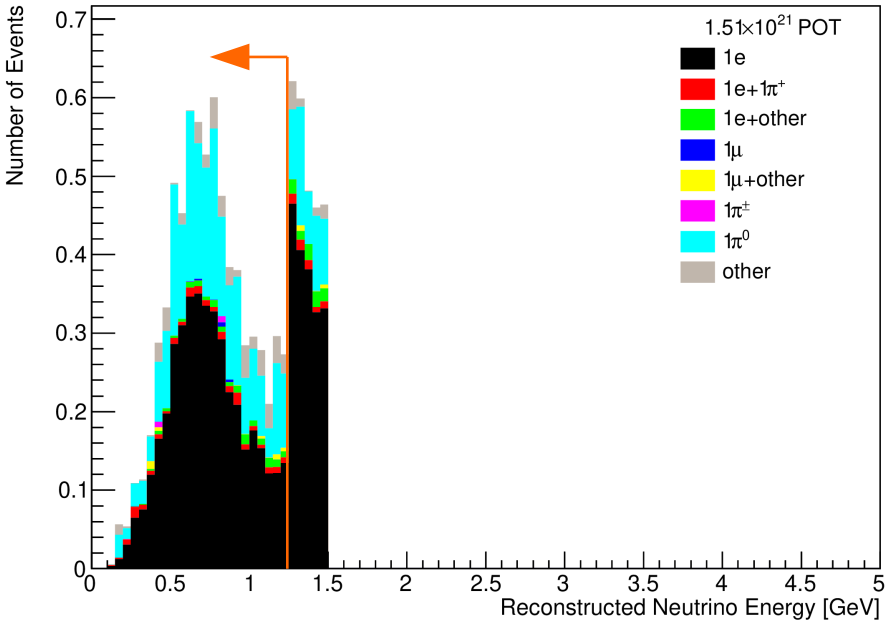
$$\mathrm{FOM} = \frac{N_{\mathrm{osc}\,\nu_e\mathrm{CC}}}{\sqrt{\left(N_{\mathrm{osc}\,\nu_e\mathrm{CC}} + N_{\mathrm{other}}\right)}}$$

- E_{rec} distribution of final sample is shown
  - with E_{rec} < 1.5 GeV
- Arrow indicates cut at E_{rec} < 1.25 GeV
- Although purity is better with more aggressive cut, FOM is reduced due to large efficiency loss

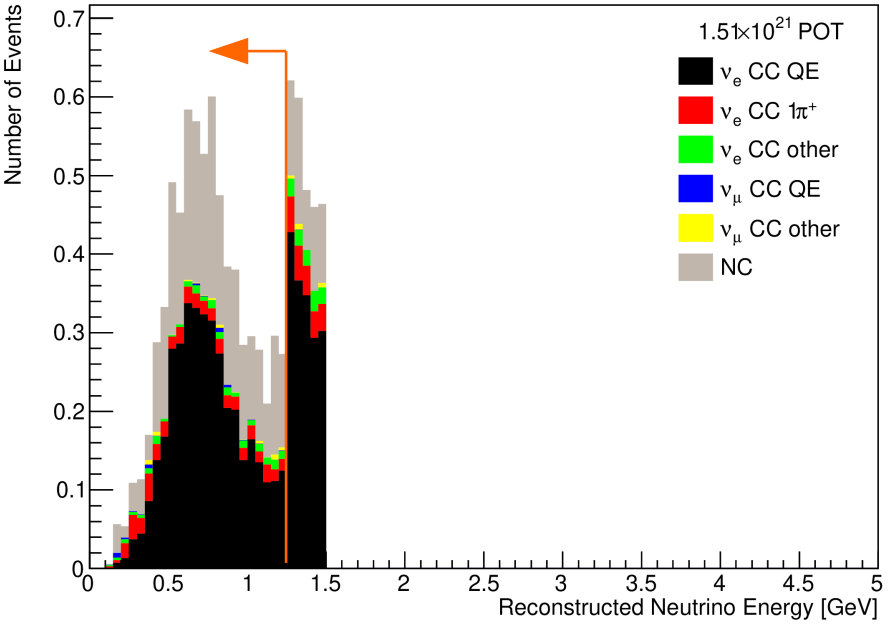
E_{rec} cut comparison		
	1.5 GeV	**1.25 GeV**
osc. ν_e CC	4.133	3.311
other	5.723	3.920
purity	0.419	0.458
FOM	1.317	1.231

Recovered ν_e CCQE

Final State Particles



NEUT mode



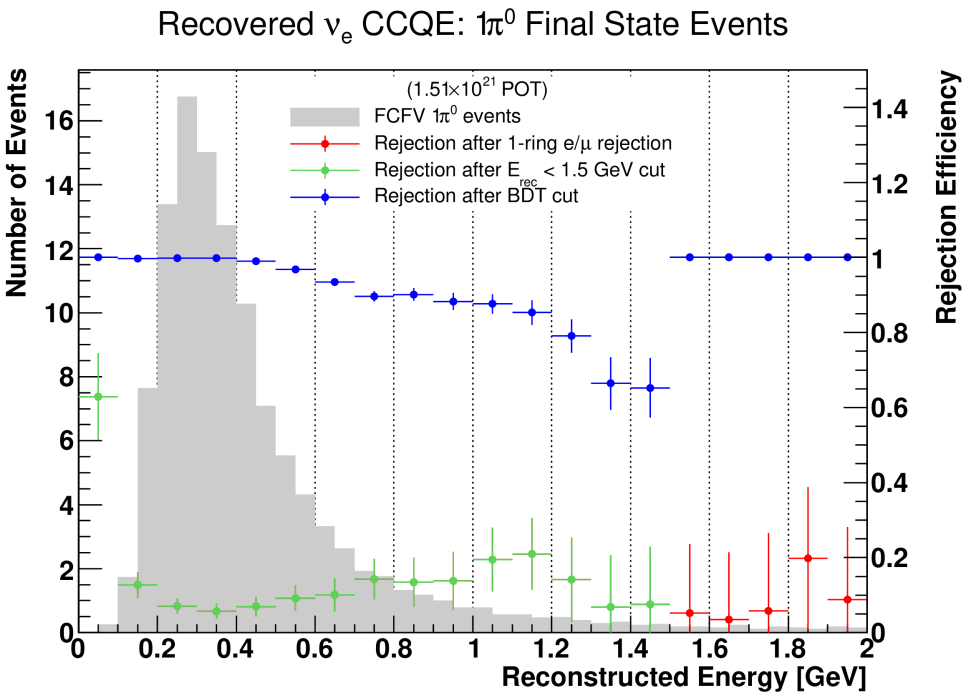
- E_{rec} distribution of final sample by final state particles (left) and NEUT mode (right)
- Arrows indicate cut at E_{rec} < 1.25 GeV

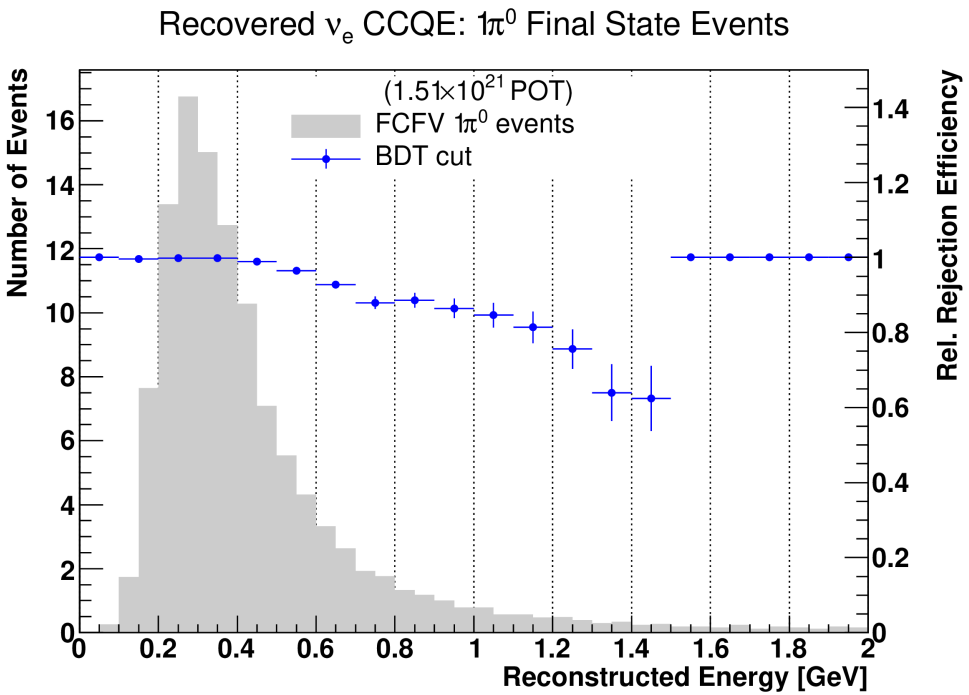
Comments from T2K-SK (2 weeks ago)

- At this point, I was leaning towards leaving E_{rec} cut at 1.5 GeV
- Some concerns from T2K-SK
  - E_{rec} plot looks strange
  - Systematics of events in that region?
    - Presumably these would have been rejected for a reason

Recovered ν_e CCQE

π^0 rejection efficiency vs. E_{rec}

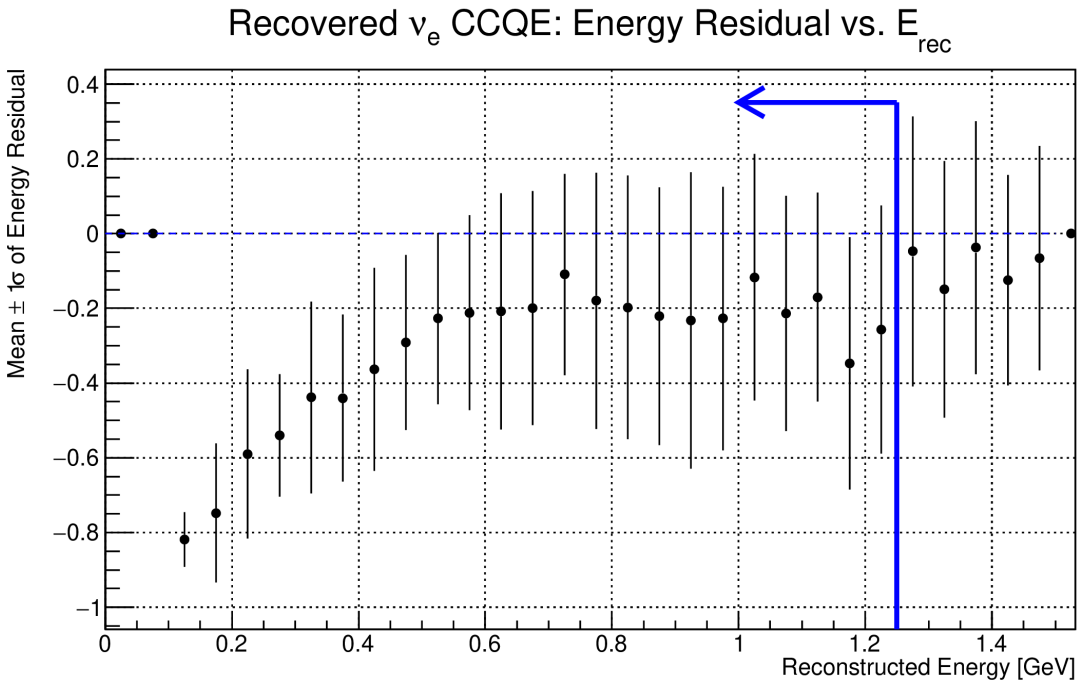




- Rejection efficiency drops off in 1.25 GeV < E_{rec} < 1.5 GeV region

Recovered ν_e CCQE

energy residual vs. E_{rec}



- Energy resolution actually seems better in 1.25 GeV < E_{rec} < 1.5 GeV region

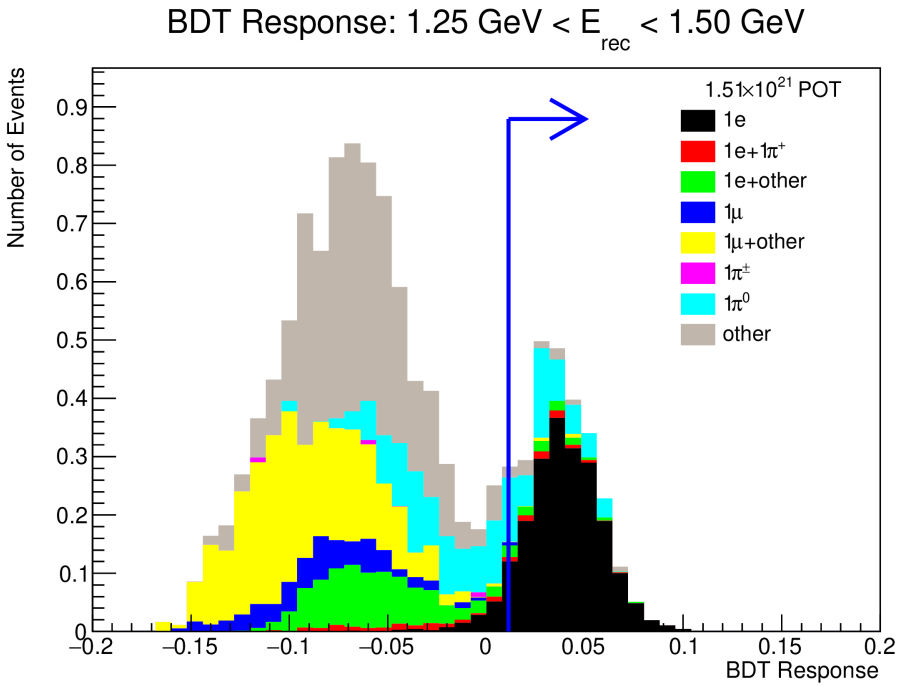
Comments from Hiro

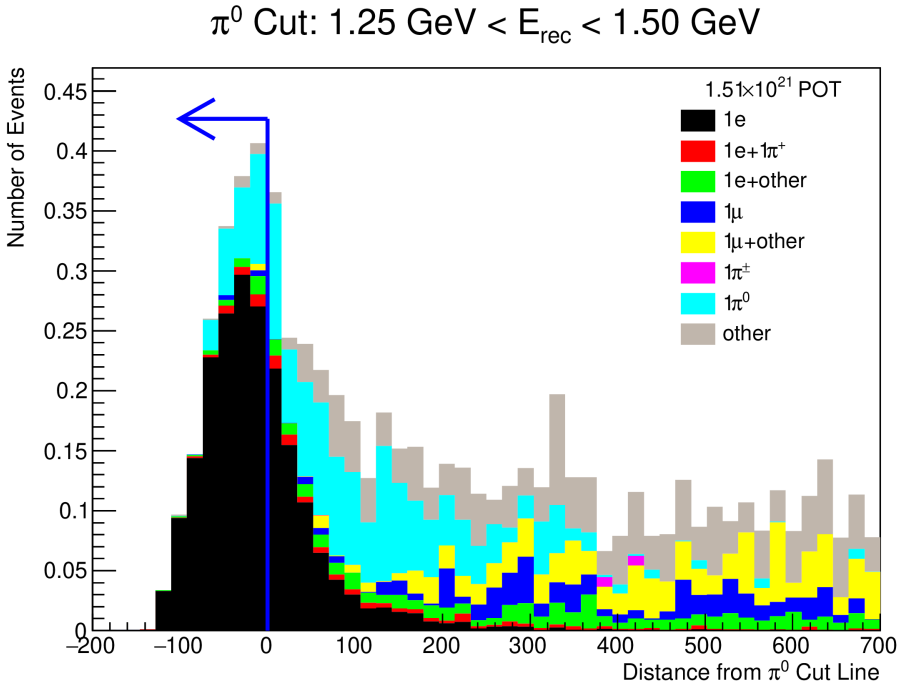
- Would be interesting to see how BDT distribution compares to π^0 cut from existing ν_e CCQE selection in 1.25 GeV < E_{rec} < 1.5 GeV region

Recovered ν_e CCQE

BDT vs. π^0 cut in 1.25 < E_{rec} < 1.5 GeV region

Final State Particles



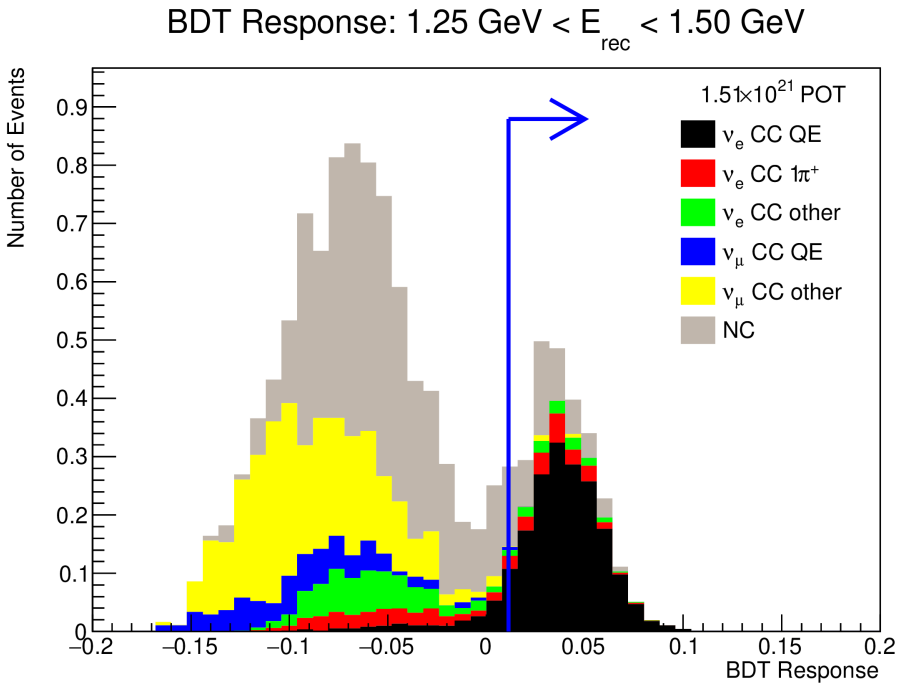


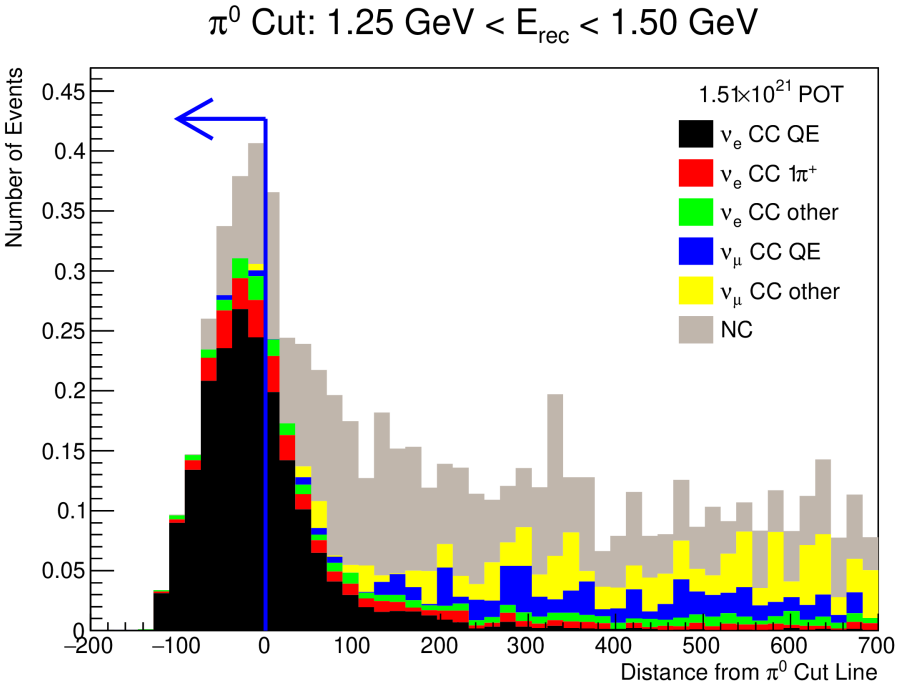
- These plots compare the BDT response (left) to the nominal π^0 cut in the 1.25 GeV – 1.5 GeV E_{rec} region

Recovered ν_e CCQE

BDT vs. π^0 cut in 1.25 < E_{rec} < 1.5 GeV region

NEUT mode



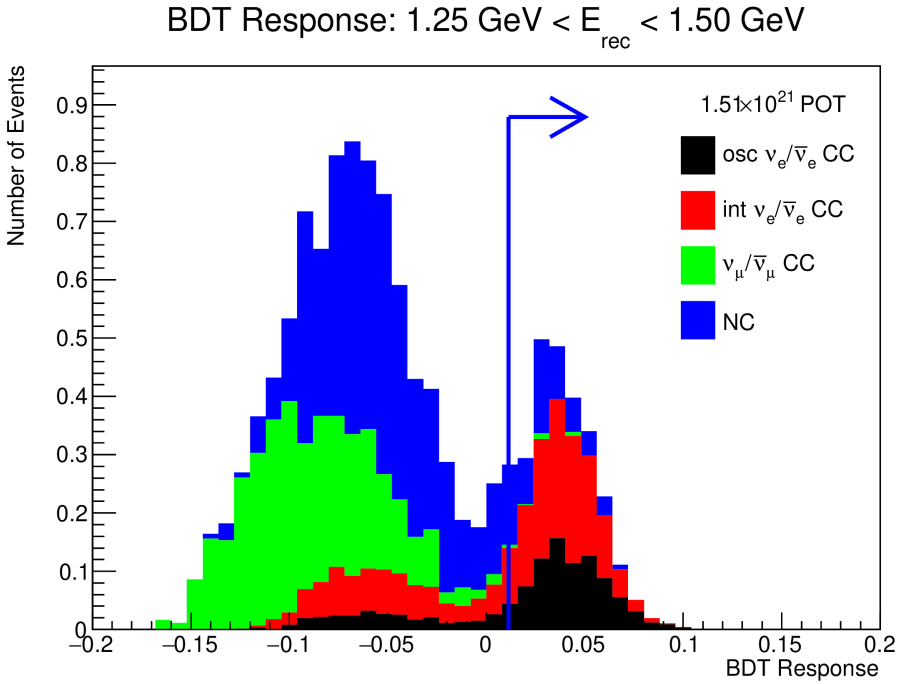


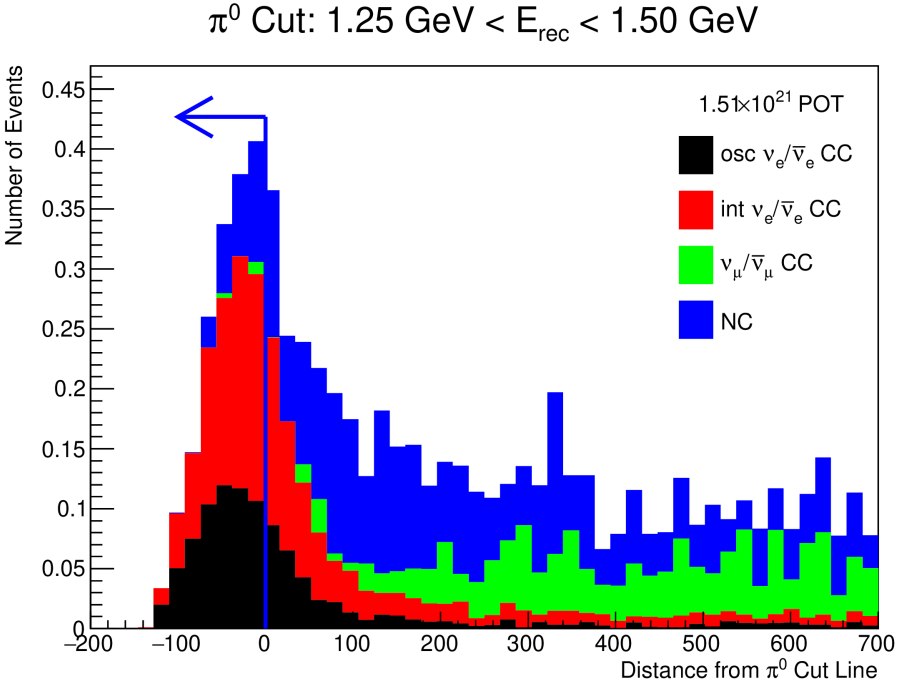
- These plots compare the BDT response (left) to the nominal π^0 cut in the 1.25 GeV – 1.5 GeV E_{rec} region

Recovered ν_e CCQE

BDT vs. π^0 cut in 1.25 < E_{rec} < 1.5 GeV region

neutrino type

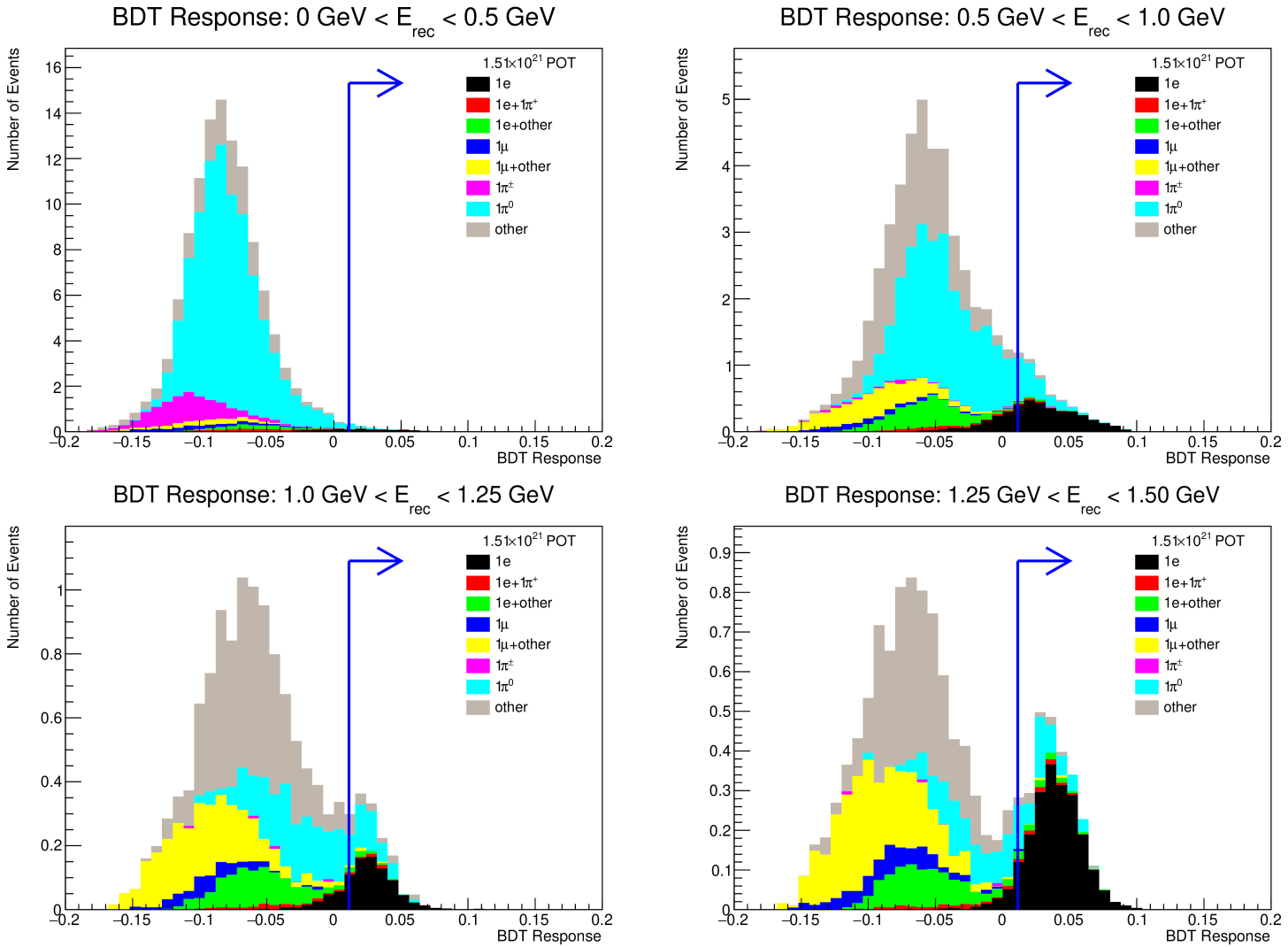




- These plots compare the BDT response (left) to the nominal π^0 cut in the 1.25 GeV – 1.5 GeV E_{rec} region

Recovered ν_e CCQE

BDT distribution in all E_{rec} regions



Observations

- E_{rec} dependence in π^0 rejection is observed in 1.25 GeV – 1.5 GeV region
- Energy resolution seems to improve in this E_{rec} region
- Likely safer to change E_{rec} cut to 1.25 GeV
  - However, may continue working for now with 1.5 GeV cut
  - Would be straightforward to change cut in the future as systematic studies progress

Comments from T2K-SK (last week)

- E_{rec} cut of 1.25 GeV was originally used because of an observed data/MC discrepancy in the π^0 cut distribution for higher E_{rec} regions
- Discussion evolved into a suggestion that I look at *replacing* the existing ν_e CCQE sample with a single BDT, rather than having two independent samples
  - Results shown on following slides

New ν_e CCQE Sample

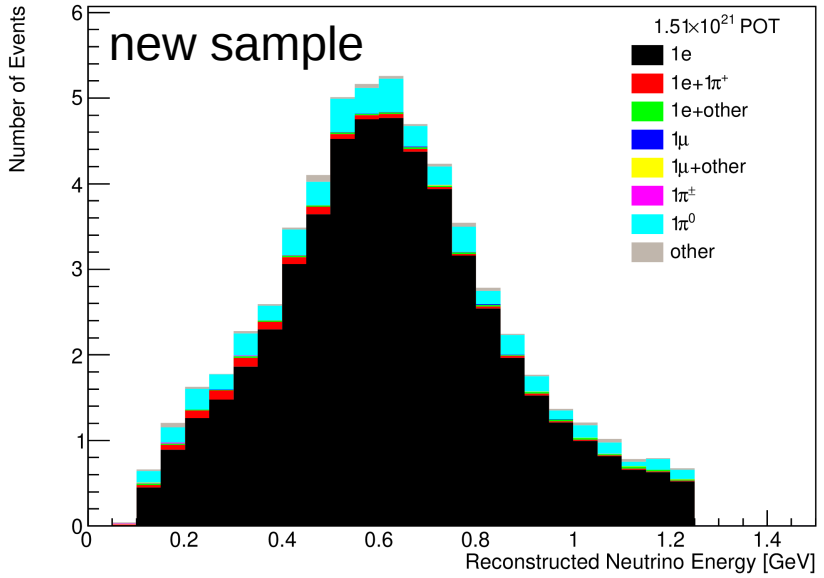
- Trained new BDT to select for all 1e final state events
- Used E_{rec} cut of 1.25 GeV to better compare with existing ν_e CCQE sample

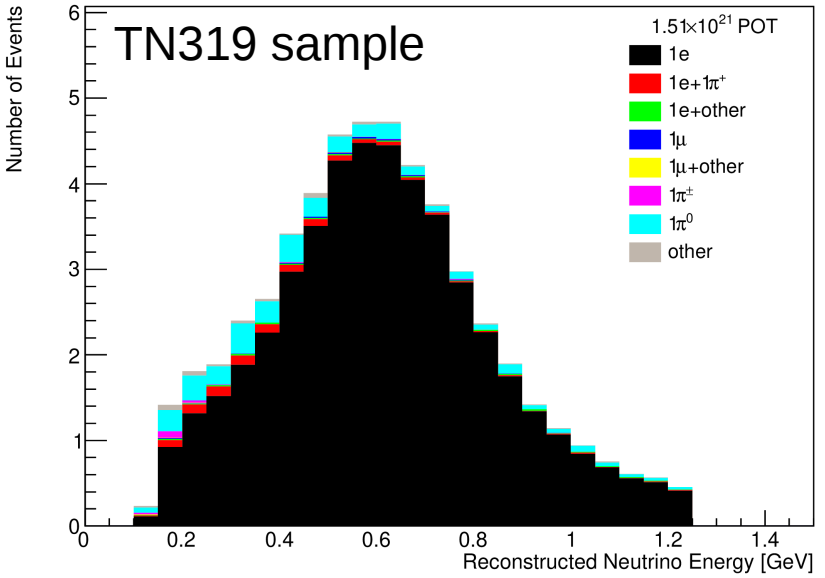
Cuts
Fully Contained (evclass==1 && nhitac<16)
E_{vis} > 30 MeV
Fiducial Volume (Wall > 80 cm && ToWall > 170 cm)
Not 1-ring μ-like (reject ν_μ CCQE sample)
0 decay e
E_{rec} < 1.25 GeV
BDT cut

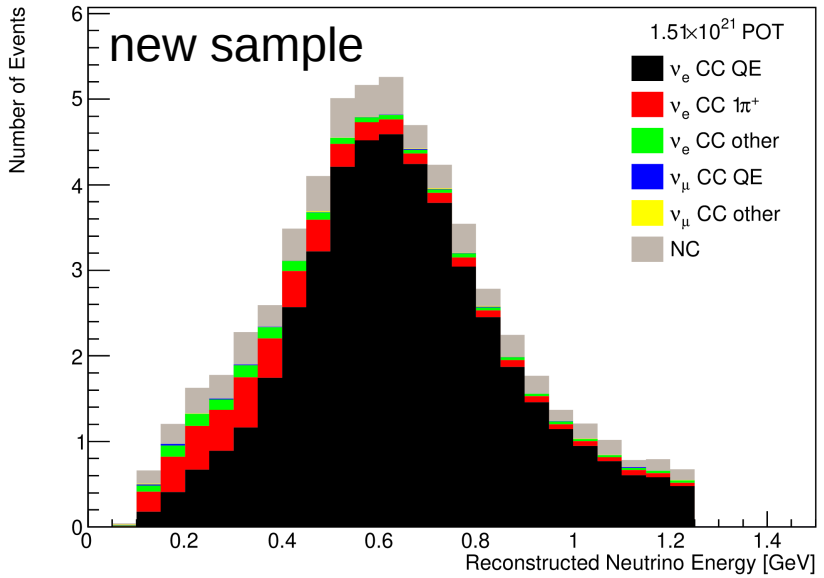
ν_e CCQE Samples Comparison

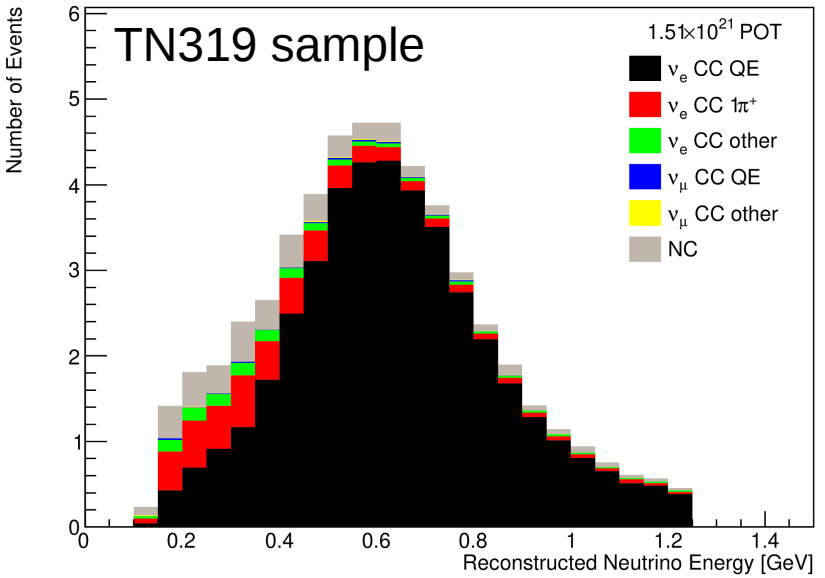
	New ν_e CCQE	TN319 ν_e CCQE	+ Recovered ν_e CCQE (E_{rec} < 1.25 GeV)	+ Recovered ν_e CCQE (E_{rec} < 1.5 GeV)
1e	51.30	47.65		54.18
other	7.01	5.19		10.38
FOM	6.72	6.55		6.74
ν_e CCQE	45.53	42.24		48.21
other	12.78	10.60		16.36
FOM	5.96	5.81		6.00
osc. ν_e CC	43.00	40.17	43.48	44.67
other	15.31	12.67	16.59	19.89
FOM	5.63	5.53	5.61	5.56

E_{rec} Comparison

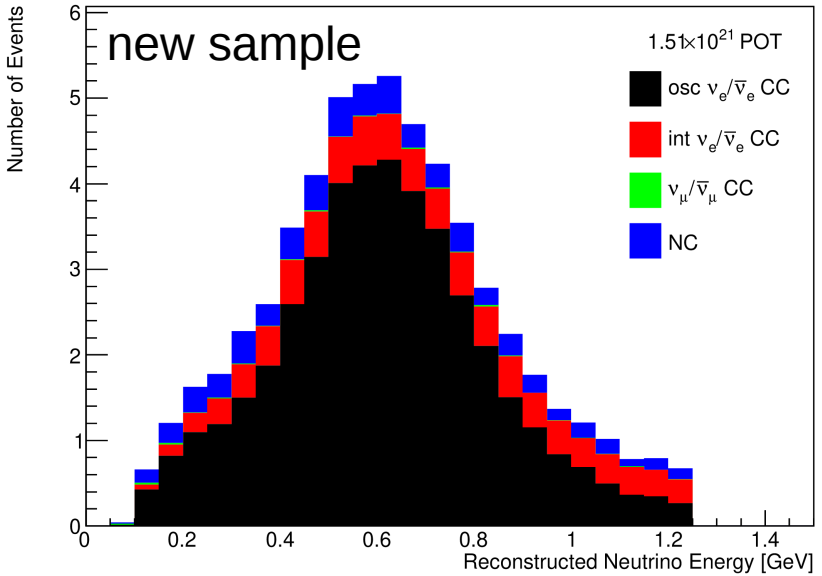


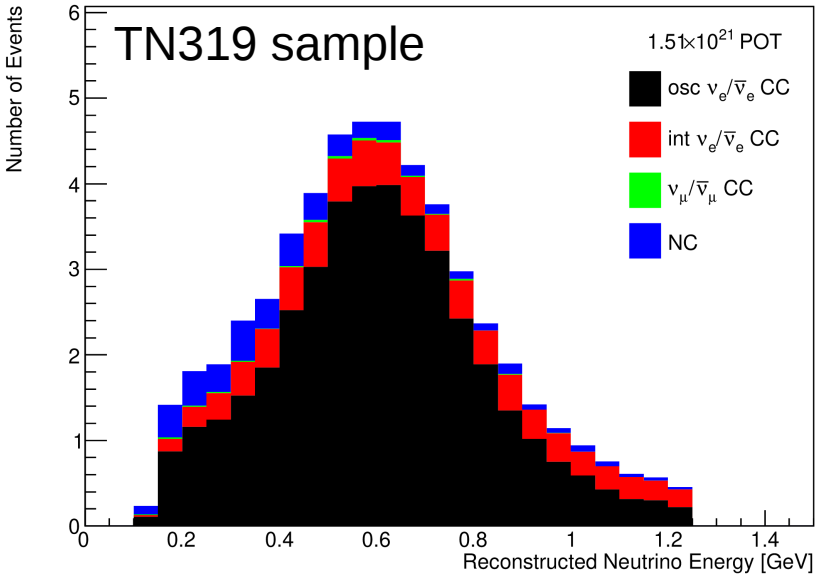






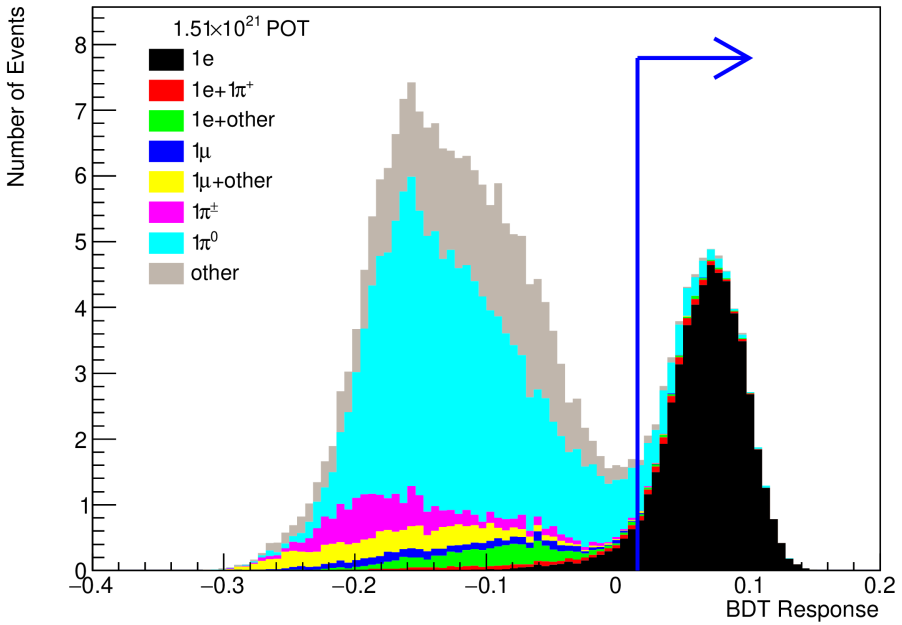
E_{rec} Comparison

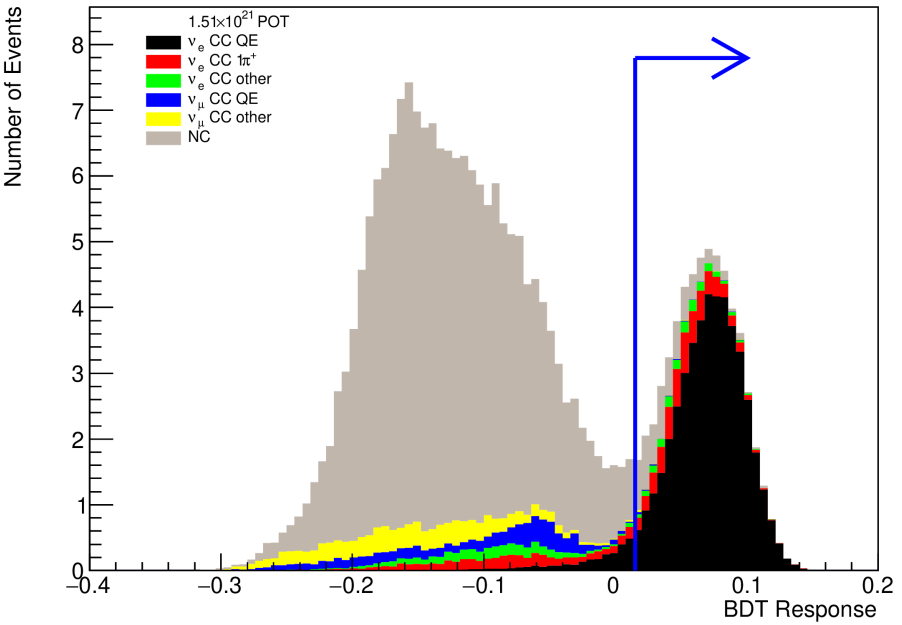




- BDT seems to allow more NC $1\pi^0$ events at higher E_{rec}, but with better signal efficiency

BDT Response





Thoughts

- Still hesitant to change the sample I'm working on at this point
  - Not entirely sure how much extra work it will entail
- Welcome thoughts/comments on whether it would be better to pursue this new sample vs. just pursuing the recovered sample
  - Both in terms of the physics and in terms of my plan towards graduation
- Plan to look at RHC as well
  - T2K-SK 14c ntuples with additional fiTQun information need to be filled

Backup

Detailed Cutflow: New ν_e CCQE

NEUT Mode

1.51×10²¹ POT	$\nu_e/\bar{\nu}_e$ CC QE	$\nu_e/\bar{\nu}_e$ CC 1$\pi^{\pm}$	$\nu_e/\bar{\nu}_e$ CC other	$\nu_\mu/\bar{\nu}_\mu$ CC QE	$\nu_\mu/\bar{\nu}_\mu$ CC other	NC
All	74.53	36.95	27.36	377.57	706.00	991.26
OD Hits < 16	67.90	32.69	23.43	274.99	465.00	348.72
E_{vis} > 30 MeV	67.67	32.54	23.39	268.99	462.18	309.86
Fiducial Volume	58.57	28.19	20.42	249.58	428.98	268.88
Not 1Rμ	58.54	28.15	20.42	38.57	379.96	255.41
0 decay e	57.71	12.79	12.41	13.77	59.06	186.71
E_{rec} < 1.25 GeV	48.27	9.39	5.04	7.67	10.40	161.98
BDT cut	45.53	5.01	1.50	0.12	0.09	6.05

Final State

1.51×10²¹ POT	1e	1e+1π^+	1e+other	1μ	1μ+other	1$\pi^{\pm}$	1π^0	other
All	89.05	17.68	32.36	420.74	587.88	63.65	146.50	855.79
OD Hits < 16	81.26	16.24	28.18	306.17	388.44	46.41	134.76	211.28
E_{vis} > 30 MeV	80.90	16.19	28.16	301.28	387.78	39.36	134.17	176.80
Fiducial Volume	70.05	14.00	24.61	279.92	360.47	35.25	116.35	153.96
Not 1Rμ	70.00	13.98	24.61	38.14	342.27	24.31	116.31	151.43
0 decay e	64.45	3.86	15.55	8.18	55.91	12.02	111.18	71.31
E_{rec} < 1.25 GeV	54.58	2.76	6.27	4.04	9.49	11.96	105.78	47.86
BDT cut	51.30	1.02	0.35	0.06	0.05	0.03	4.81	0.69