UNIVERSITY OF TORONTO

ν_e CCQE/CC1π^+ Selection Studies

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ν_e CCQE/CC1π^+ Meeting

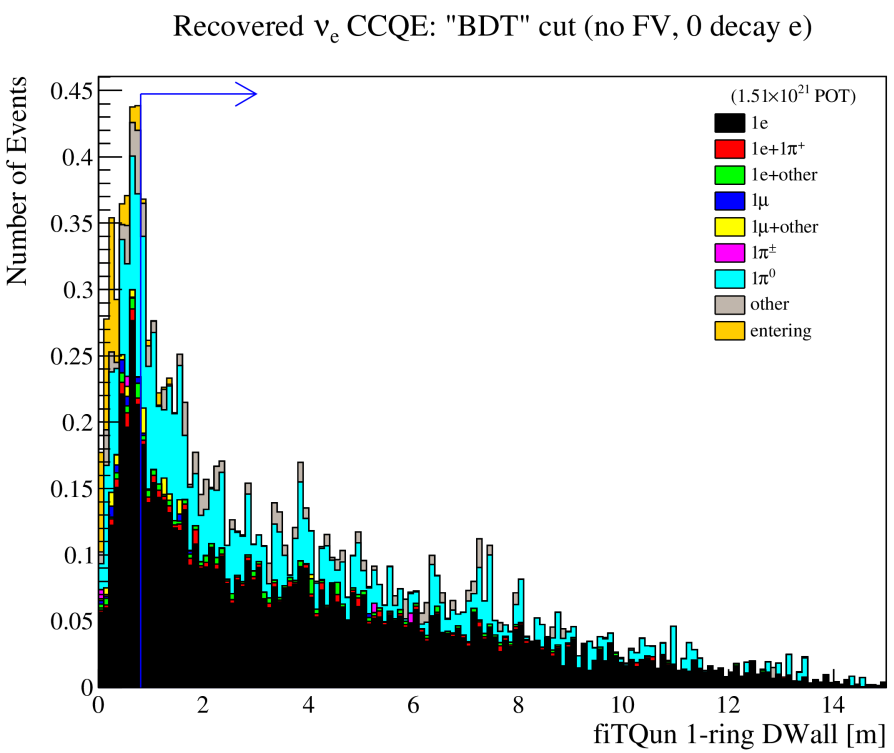
October 10, 2019

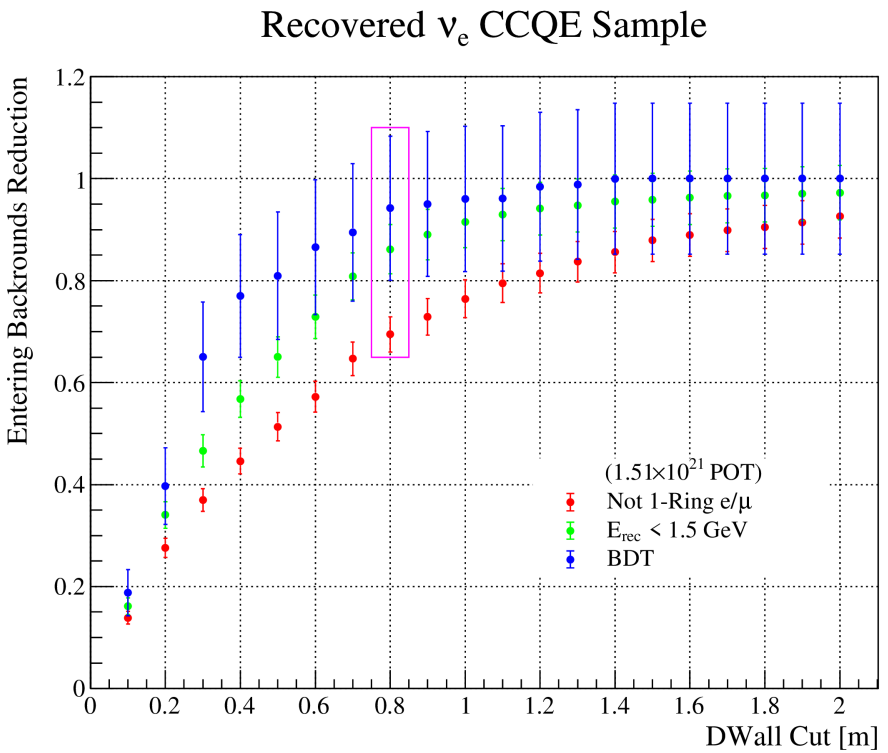
Fiducial Volume Cuts

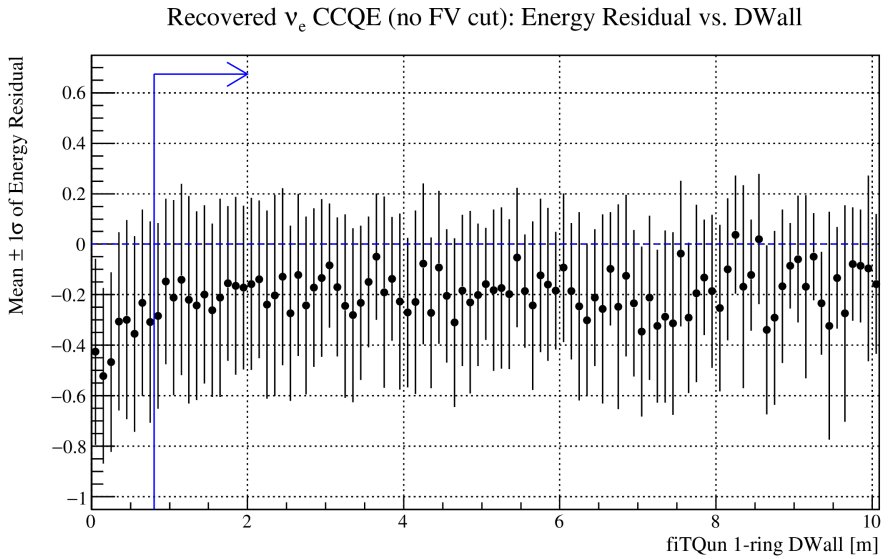
- No objections raised to FV cuts – now finalised
- Recovered ν_e CCQE
  - wall > 80 cm
  - towall > 170 cm

  } same as existing ν_e CCQE sample
- 2-ring ν_e CC1π^+
  - wall > 50 cm → same as 1-ring ν_e CC1π^+ sample
  - $towall_e$ > 150 cm
  - $towall_\pi$ > 150 cm
- Updated cut flow event breakdowns with these FV cuts can be found in backup slides

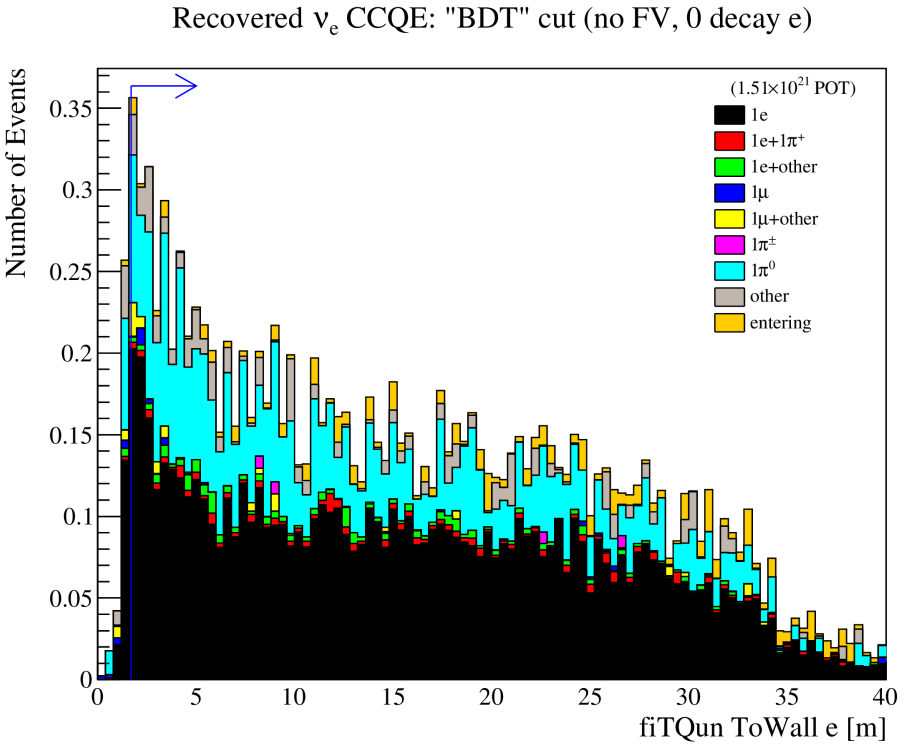
Recovered ν_e CCQE: DWall > 80 cm

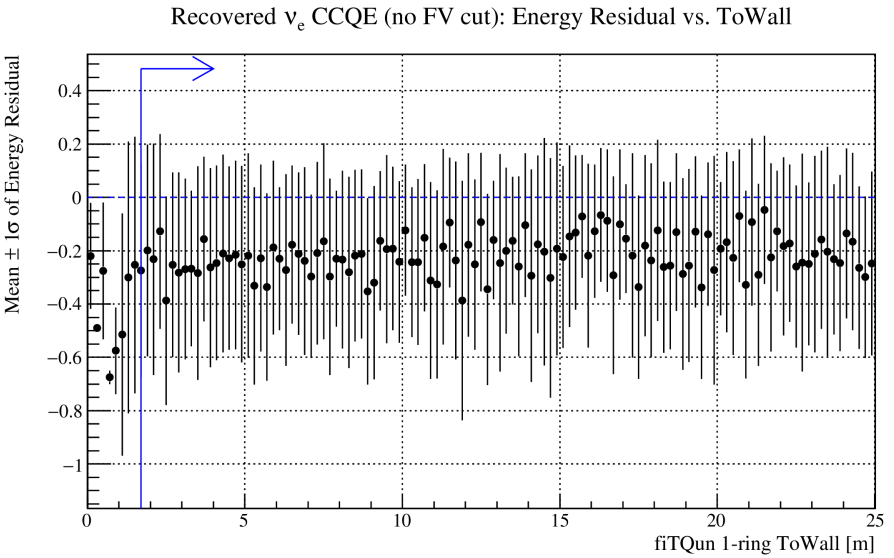




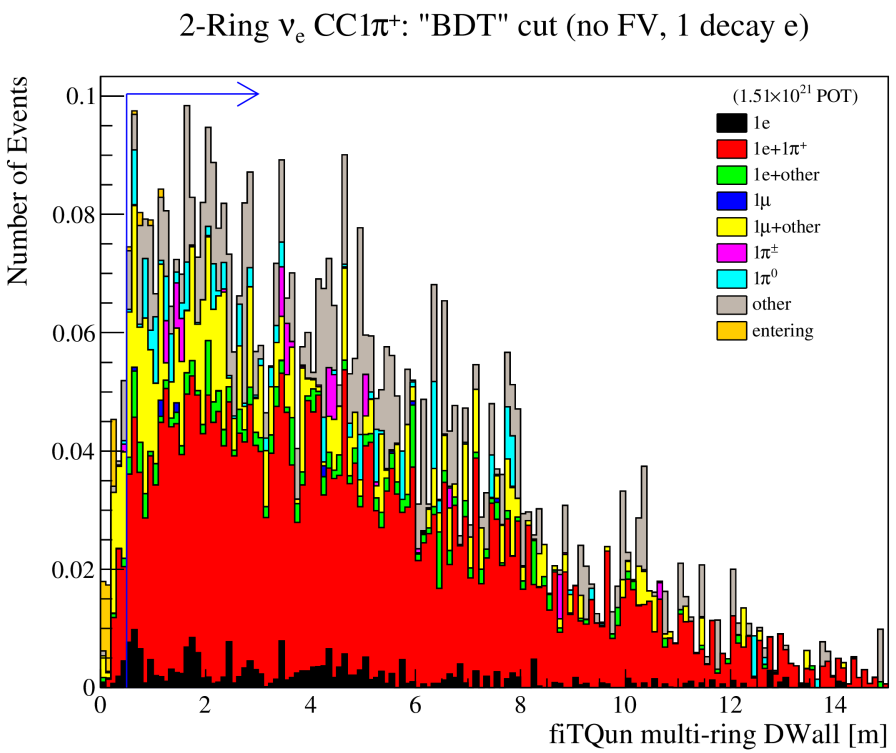


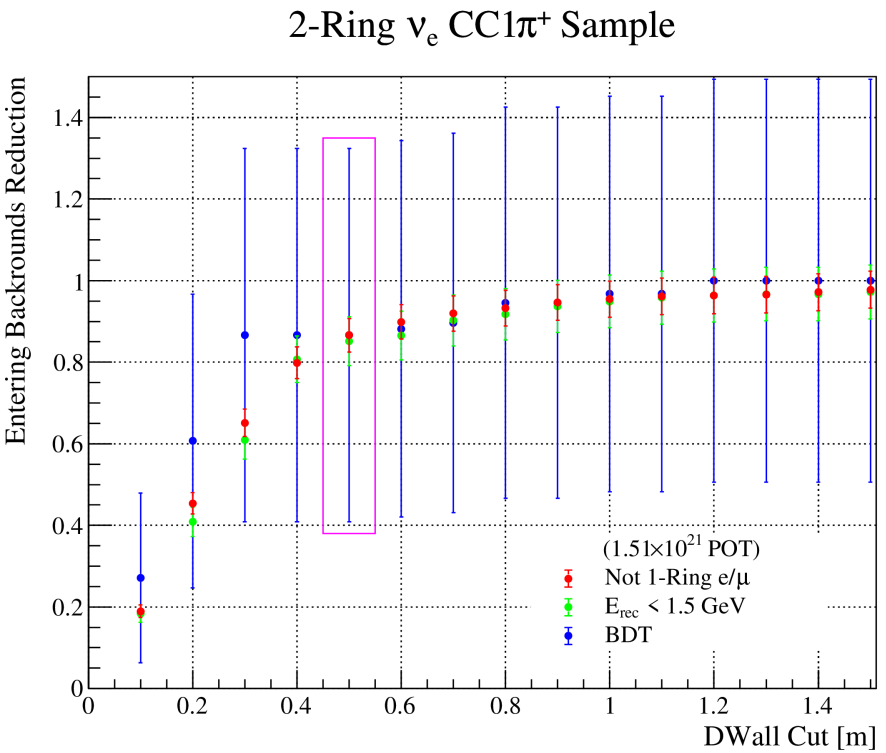
Recovered ν_e CCQE: ToWall > 170 cm

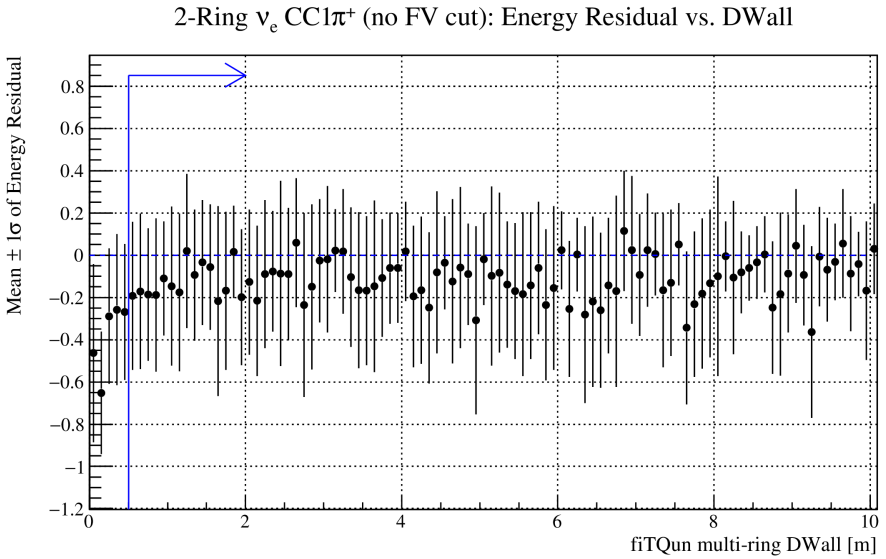




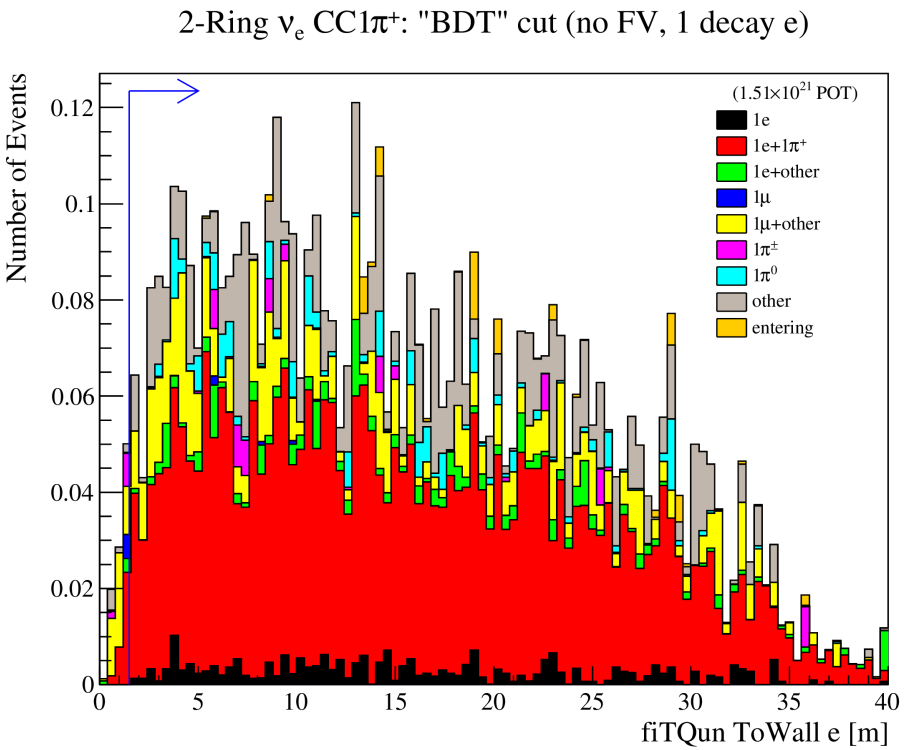
2-ring ν_e CC1π^+: DWall > 50 cm

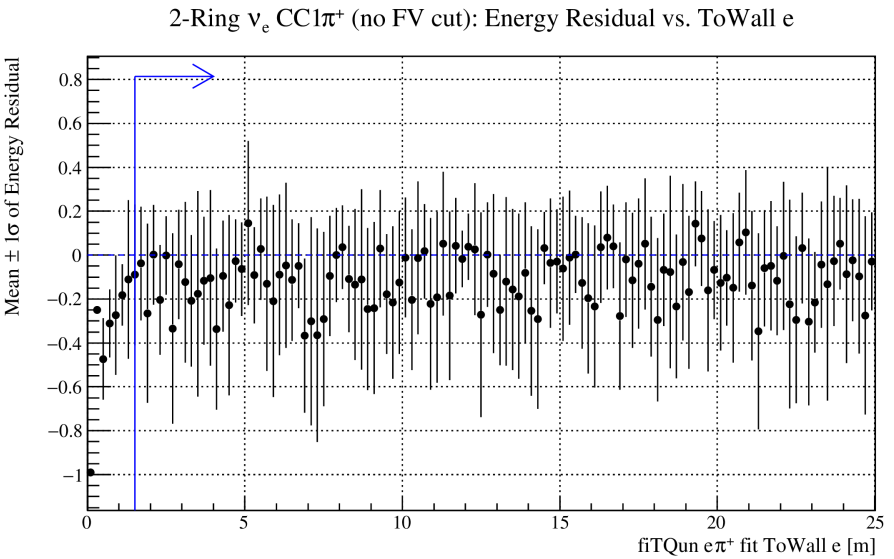




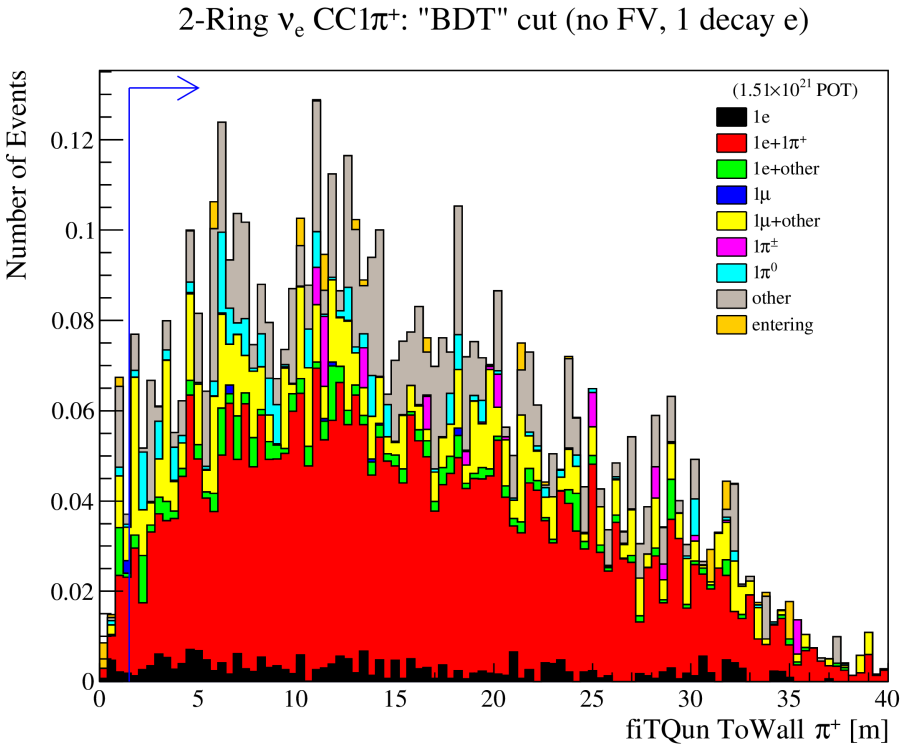


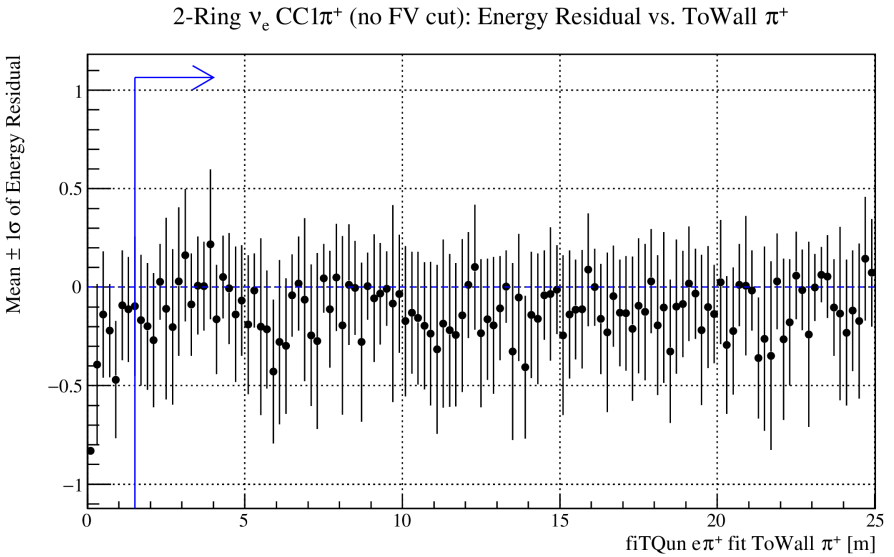
2-ring ν_e CC1π^+: ToWall e > 150 cm





2-ring ν_e CC1π^+: ToWall π^+ > 150 cm

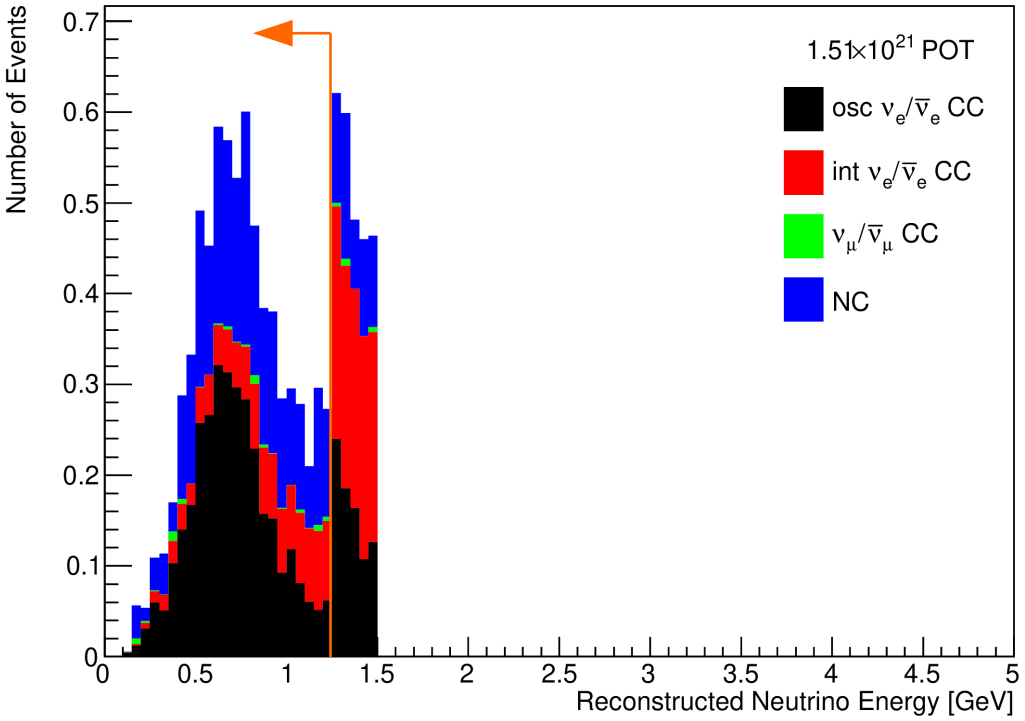




E_{rec} Cut

- 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



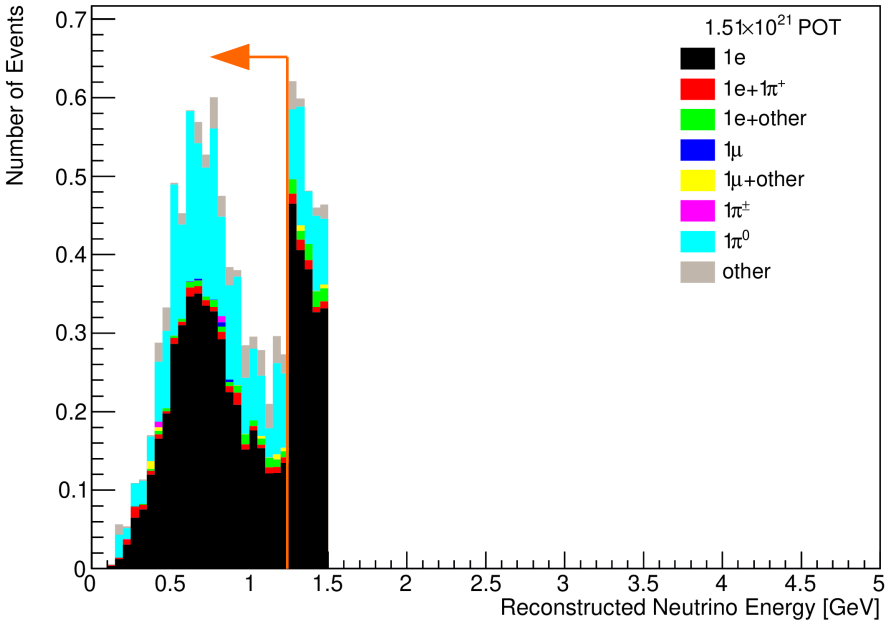
$$\mathrm{FOM} = \frac{N_{\mathrm{osc}\,\nu_e\mathrm{CC}}}{\sqrt{\left(N_{\mathrm{osc}\,\nu_e\mathrm{CC}} + N_{\mathrm{other}}\right)}}$$

- 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

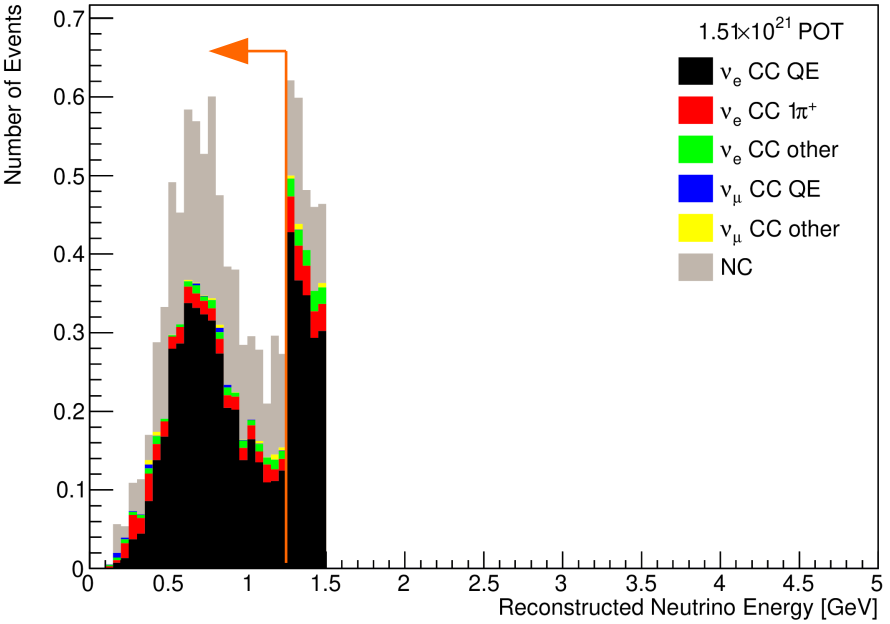
E_{rec} cut comparison		
	1.5 GeV	**1.25 GeV**
osc. ν_e CC	4.133	3.311
other	5.723	3.920
purity	0.419	0.458
FOM	1.317	1.231

Recovered ν_e CCQE

Final State Particles



NEUT mode



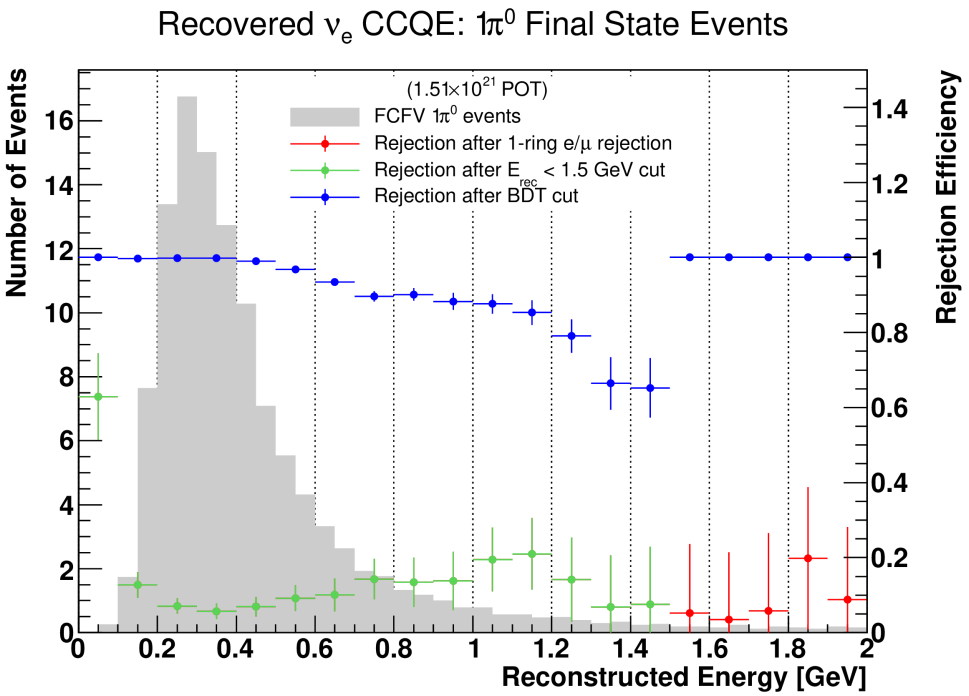
- E_{rec} distribution of final sample by final state particles (left) and NEUT mode (right)
- Arrows indicate cut at E_{rec} < 1.25 GeV

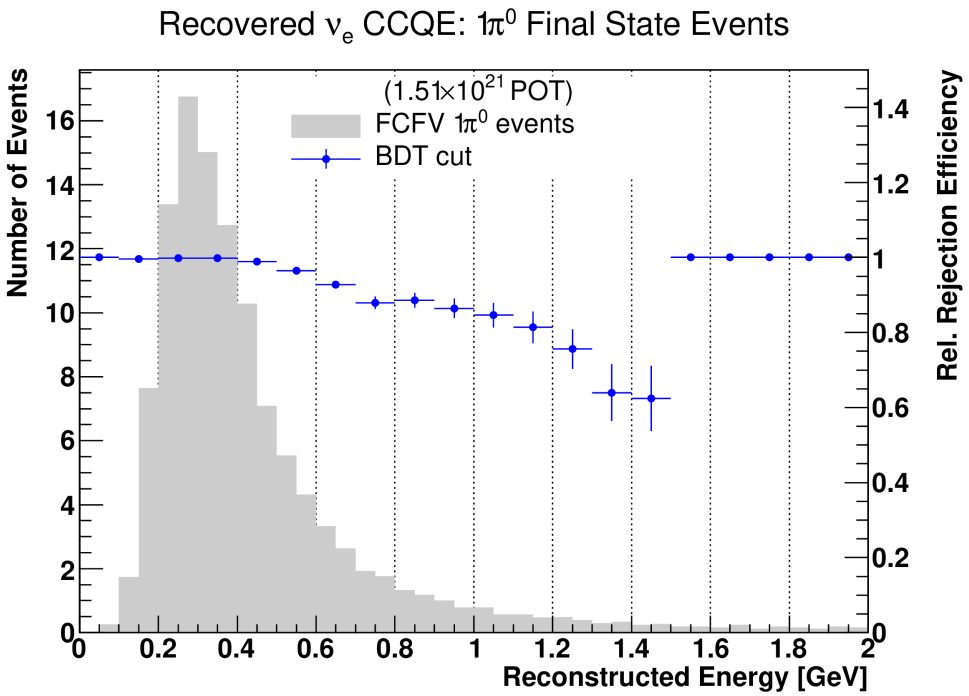
Comments from T2K-SK

- Some concerns regarding recovered ν_e CCQE sample
  - 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}

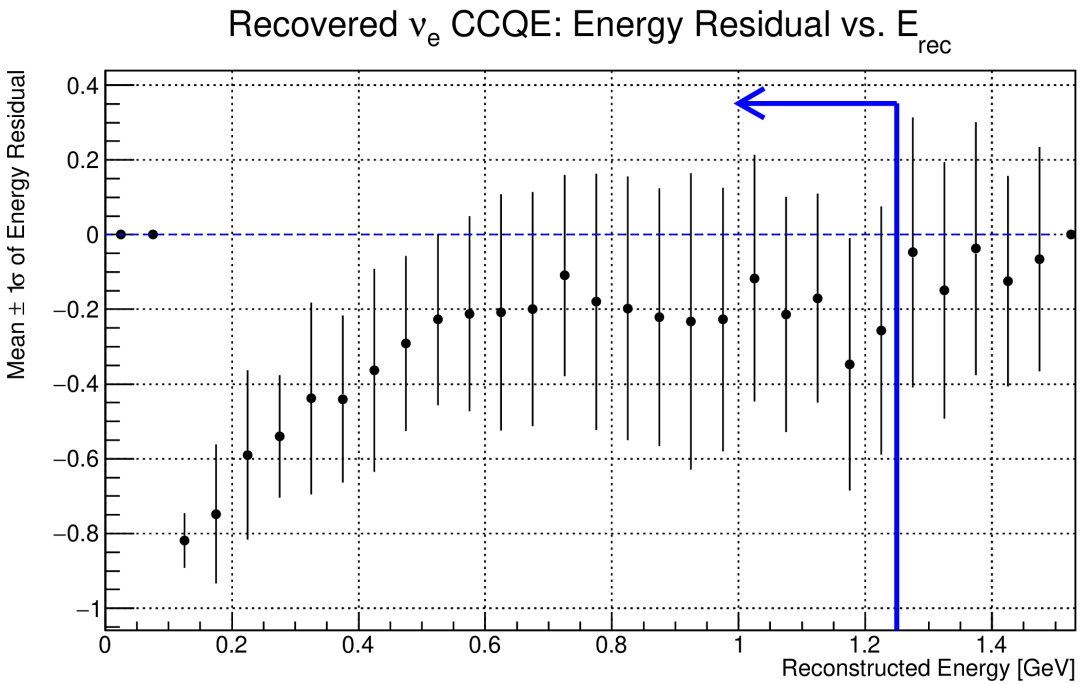




- Rejection efficiency drops off in 1.25 GeV < E_{rec} < 1.5 GeV region

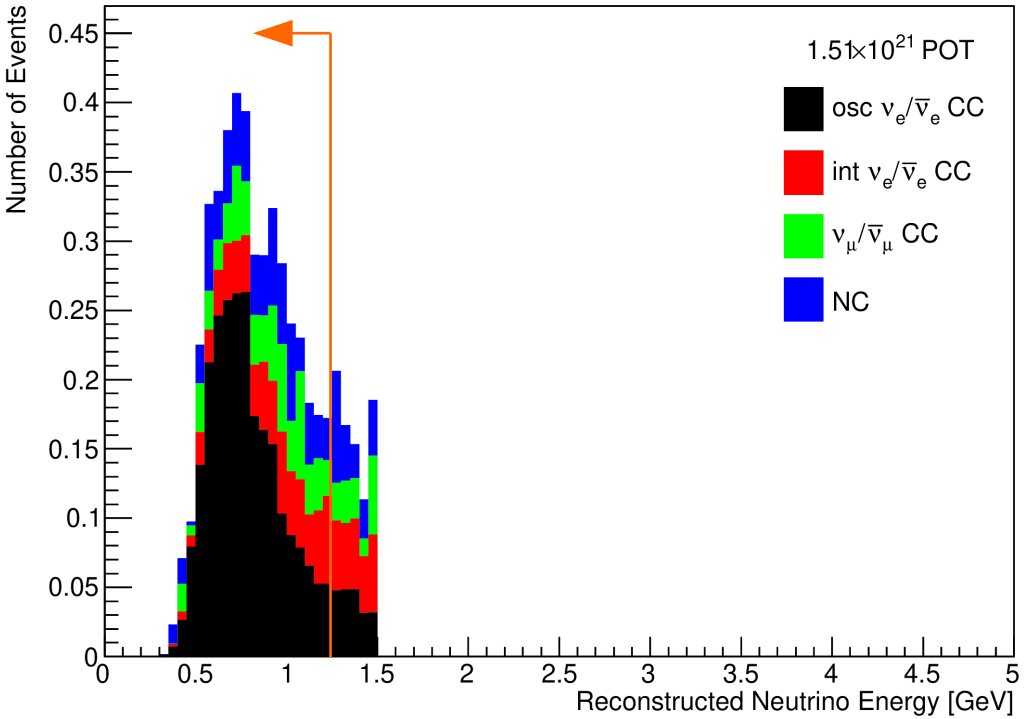
Recovered ν_e CCQE

energy residual vs. E_{rec}



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

2-ring ν_e CC1π^+



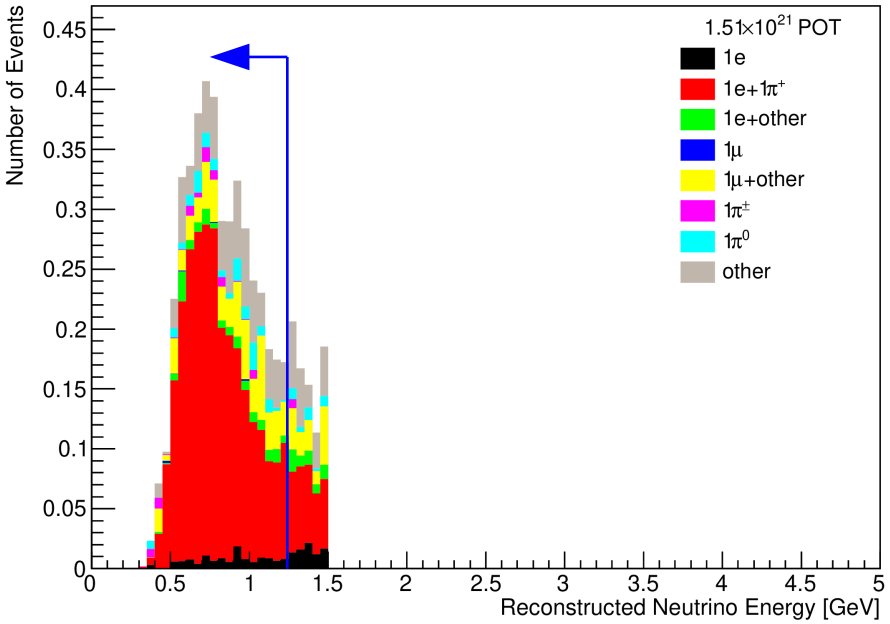
$$\mathrm{FOM} = \frac{N_{\mathrm{osc}\,\nu_e\mathrm{CC}}}{\sqrt{\left(N_{\mathrm{osc}\,\nu_e\mathrm{CC}} + N_{\mathrm{other}}\right)}}$$

- E_{rec} distribution of final sample is shown
  - with E_{rec} < 1.5 GeV
- Arrow indicates cut at E_{rec} < 1.25 GeV
- More aggressive E_{rec} cut may benefit selection

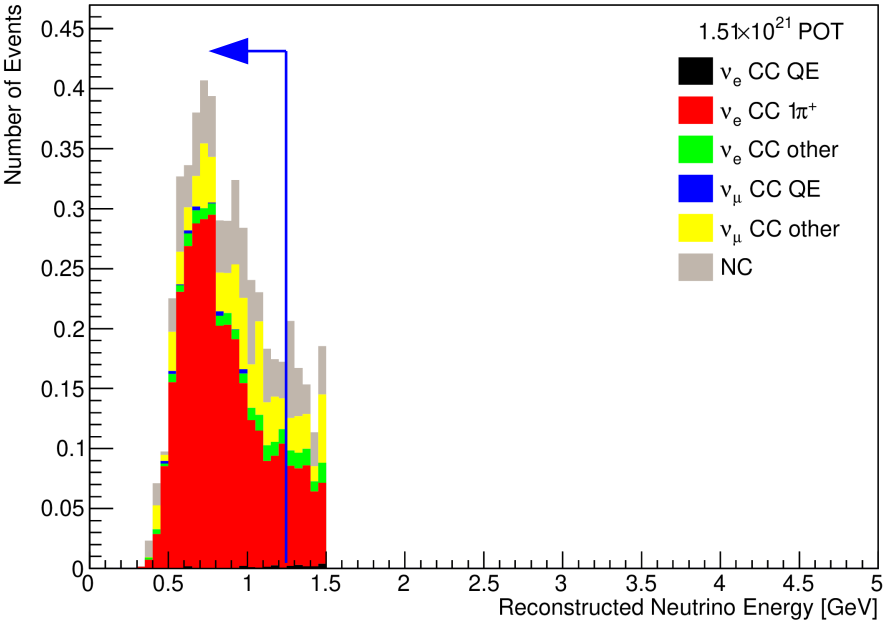
E_{rec} cut comparison		
	1.5 GeV	**1.25 GeV**
osc. ν_e CC	2.635	2.426
other	2.643	2.026
purity	0.499	0.545
FOM	1.147	1.150

2-ring ν_e CC1π^+

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

E_{rec} Cut Summary

- Recovered ν_e CCQE
  - Lowering E_{rec} cut from 1.5 GeV to 1.25 GeV improves purity of oscillated ν_e CC events, but with significant efficiency loss
    - FOM decreases significantly
  - However, some concerns from T2K-SK suggest that 1.25 GeV may be preferred
- 2-ring ν_e CC1$\pi^{\pm}$
  - Lowering E_{rec} cut from 1.5 GeV to 1.25 GeV improves purity with a small efficiency loss
    - FOM is approximately unchanged
- **Conclusion:**
  - Do not change E_{rec} cut for 2-ring ν_e CC1π^+ sample
  - Still unsure what to do with recovered ν_e CCQE sample

Backup

Detailed Cutflow: Recovered 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 1Re/μ	15.79	16.71	18.54	34.61	378.41	242.67
0 decay e	15.21	7.69	10.93	10.28	58.45	175.76
E_{rec} < 1.5 GeV	7.72	4.78	4.28	4.86	12.64	156.02
BDT cut	5.57	0.61	0.27	0.03	0.05	3.34

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 1Re/μ	17.77	9.86	24.20	36.60	342.01	21.48	112.61	142.19
0 decay e	16.05	2.84	15.26	7.28	55.85	10.24	107.58	63.19
E_{rec} < 1.5 GeV	8.24	1.90	6.97	3.73	12.14	10.21	103.60	43.51
BDT cut	6.12	0.21	0.21	0.01	0.04	0.02	2.75	0.49

Detailed Cutflow: 2-ring ν_e CC1π^+

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	61.18	29.32	21.38	237.01	422.48	281.06
Not 1Re/μ	16.69	17.37	19.41	32.27	376.28	253.88
0 decay e	0.57	8.94	5.90	18.42	154.61	51.76
E_{rec} < 1.5 GeV	0.14	5.11	1.07	7.10	40.34	32.01
BDT cut	0.04	3.32	0.23	0.02	0.81	0.98

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	73.12	14.50	25.79	265.06	355.83	35.10	122.17	160.85
Not 1Re/μ	18.77	10.19	25.34	33.75	340.02	21.40	117.59	148.85
0 decay e	1.66	6.98	6.93	11.55	147.80	8.76	4.86	51.67
E_{rec} < 1.5 GeV	0.53	4.45	1.46	5.14	38.96	8.44	3.40	23.38
BDT cut	0.22	3.08	0.21	0.01	0.69	0.08	0.20	0.92