UNIVERSITY OF TORONTO

ν_e CCQE/CC1π^+ Selection Studies

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ν_e CCQE/CC1π^+ Meeting

September 25, 2019

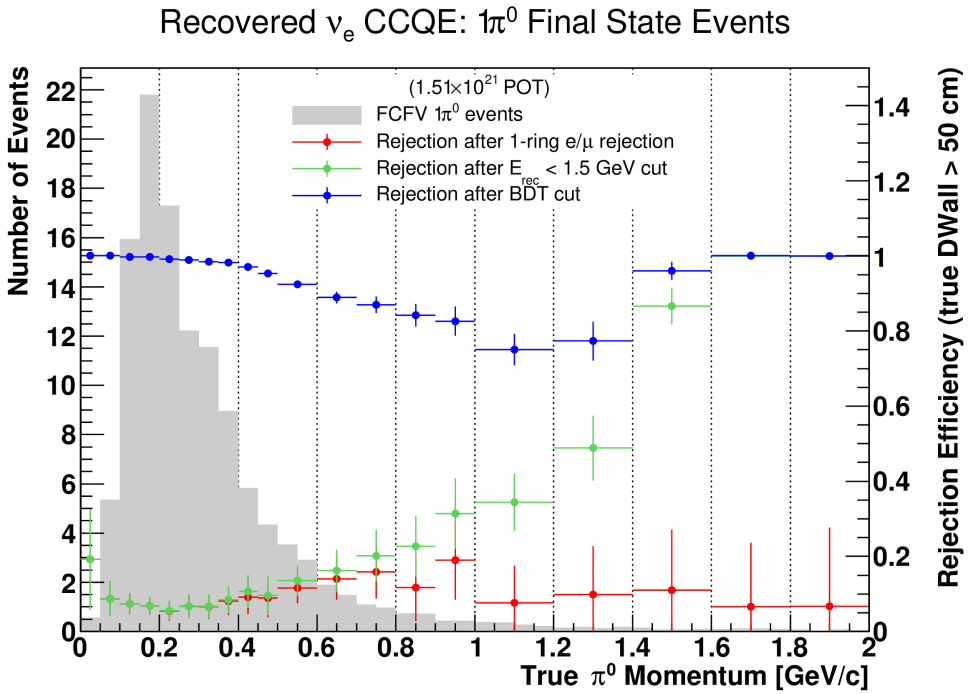
Selection Momentum Dependence

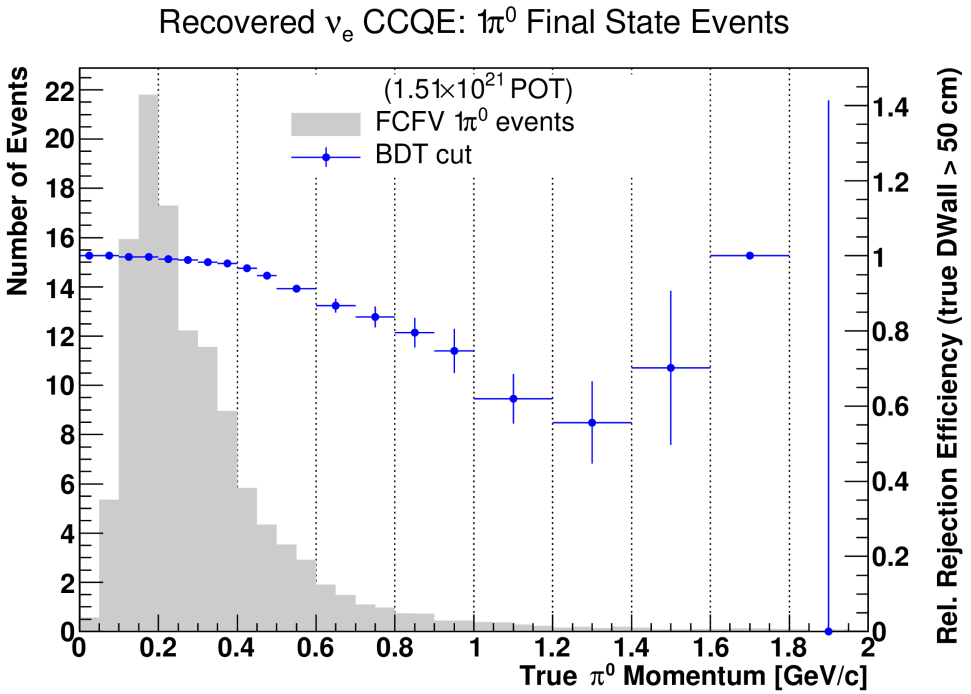
- 1π^0 Final State Events: Plot 1π^0 rejection efficiency vs. true π^0 momentum
  - recovered ν_e CCQE sample
- 1e Final State Events: Plot 1e selection efficiency vs. true e momentum
  - all ν_e samples
- 1e1$\pi^\pm$ Final State Events: Plot 1e1π^+ selection efficiency vs. true π^+ and e momentum
  - all ν_e samples

$1\pi^0$ Final State Events

Recovered ν_e CCQE Sample

$1\pi^0$ rejection vs. π^0 momentum



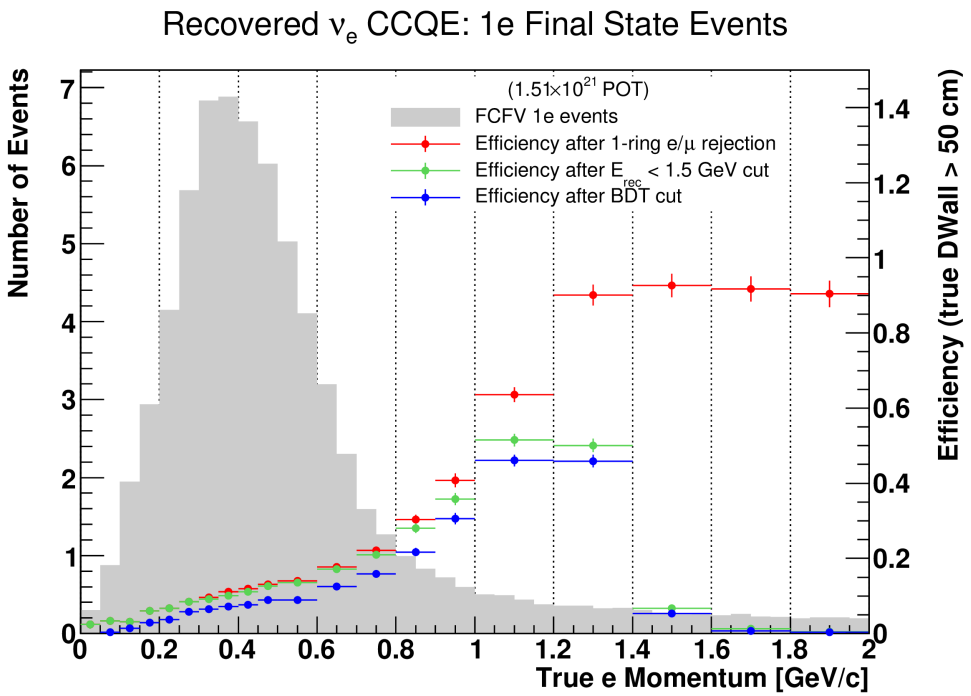


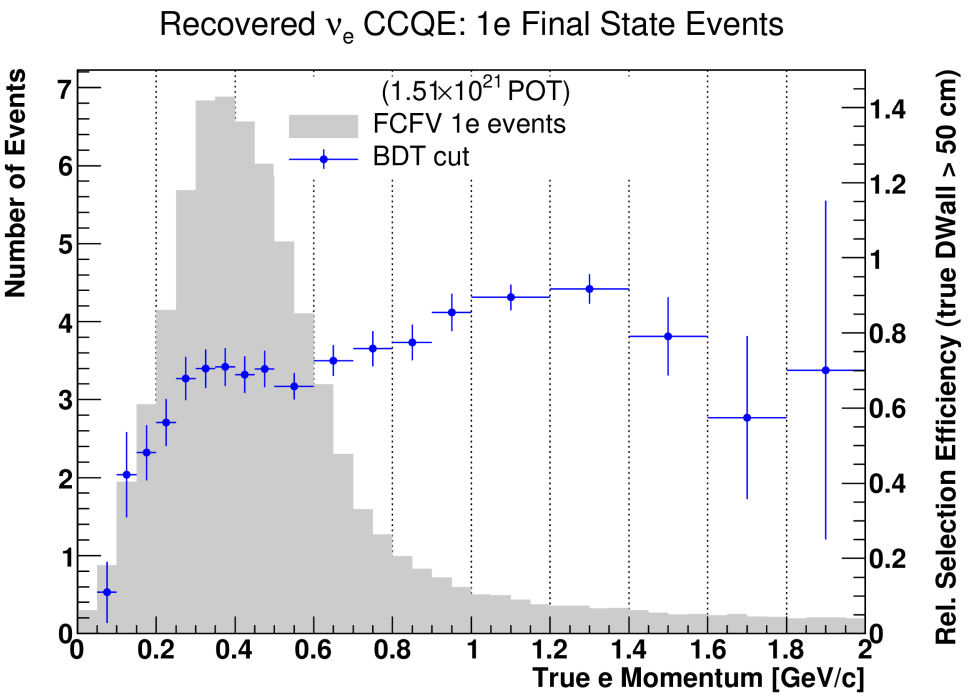
- Some true π^0 momentum dependence seen in π^0 rejection

1e Final State Events
vs.
True e Momentum

Recovered ν_e CCQE Sample

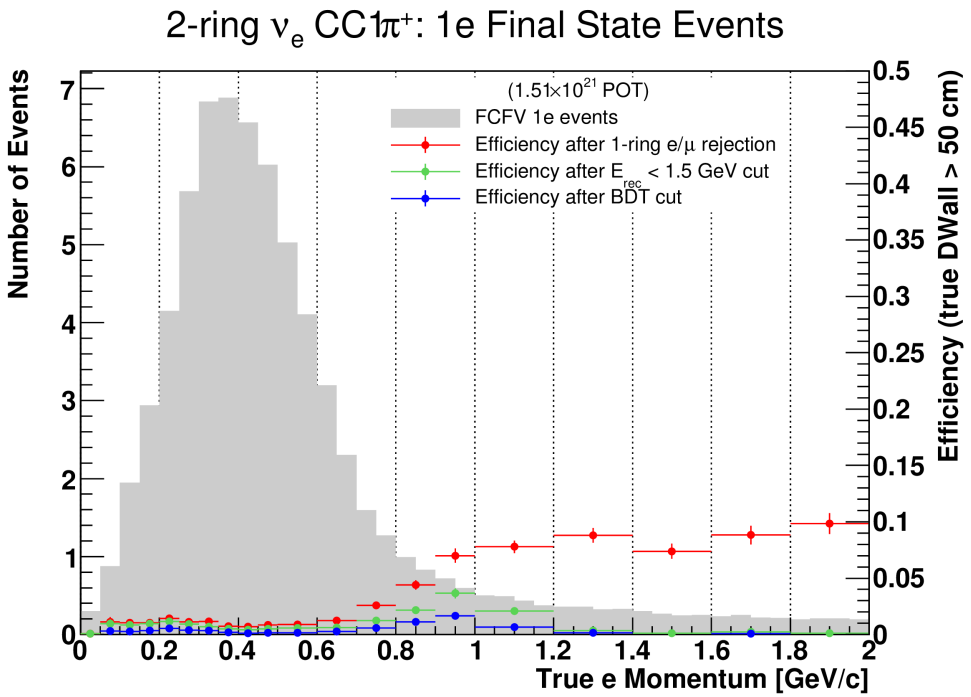
1e efficiency vs. e momentum

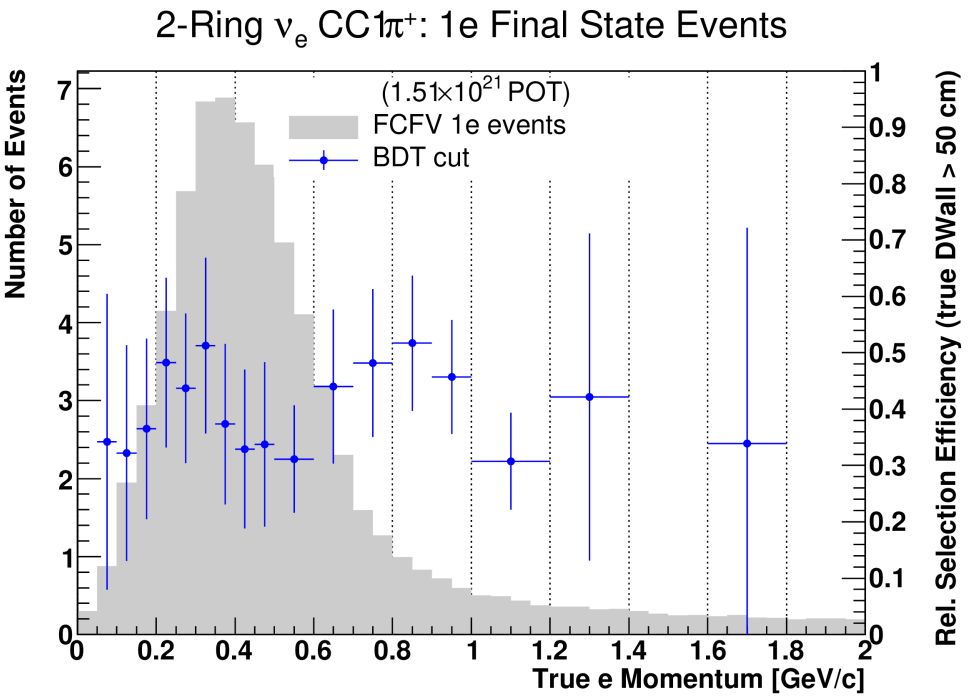


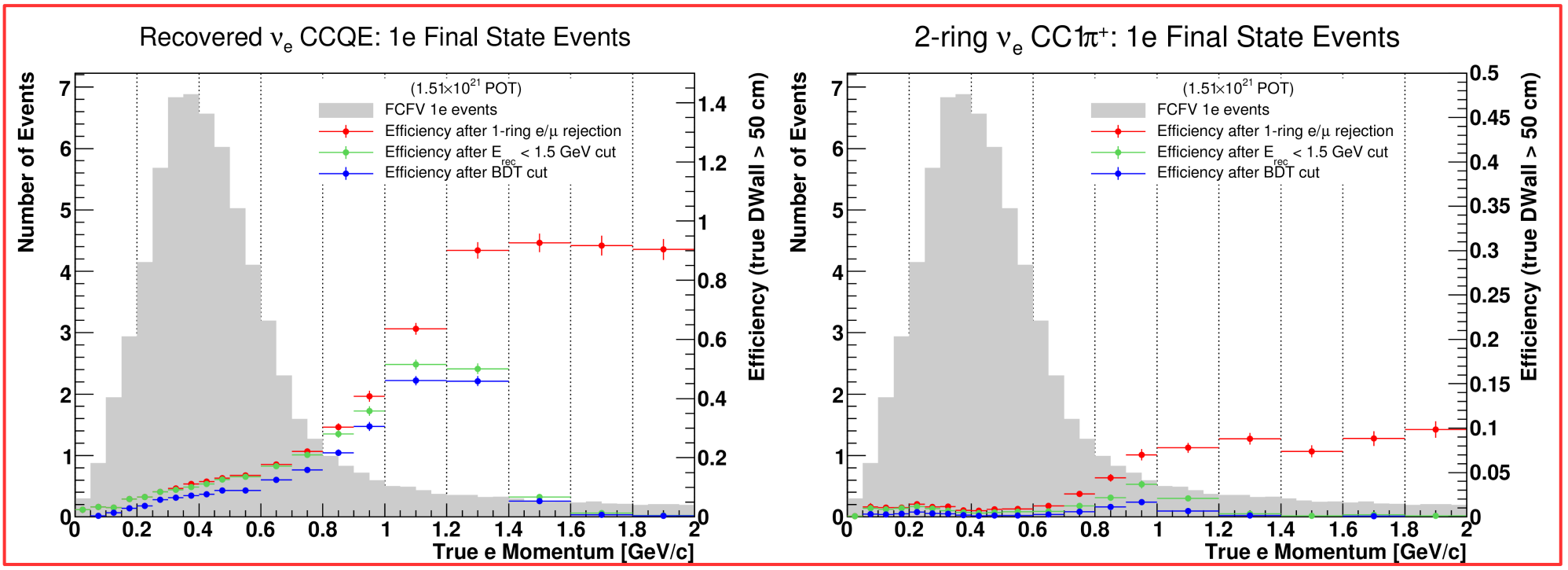


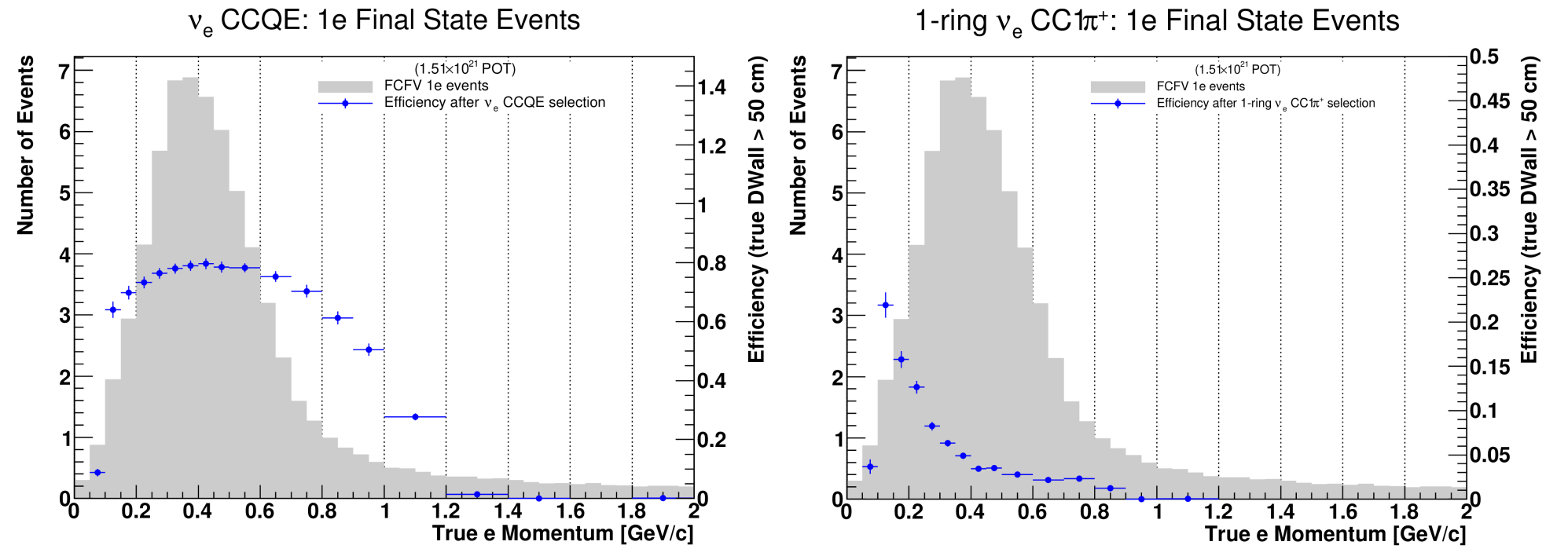
2-Ring ν_e CC1π^+ Sample

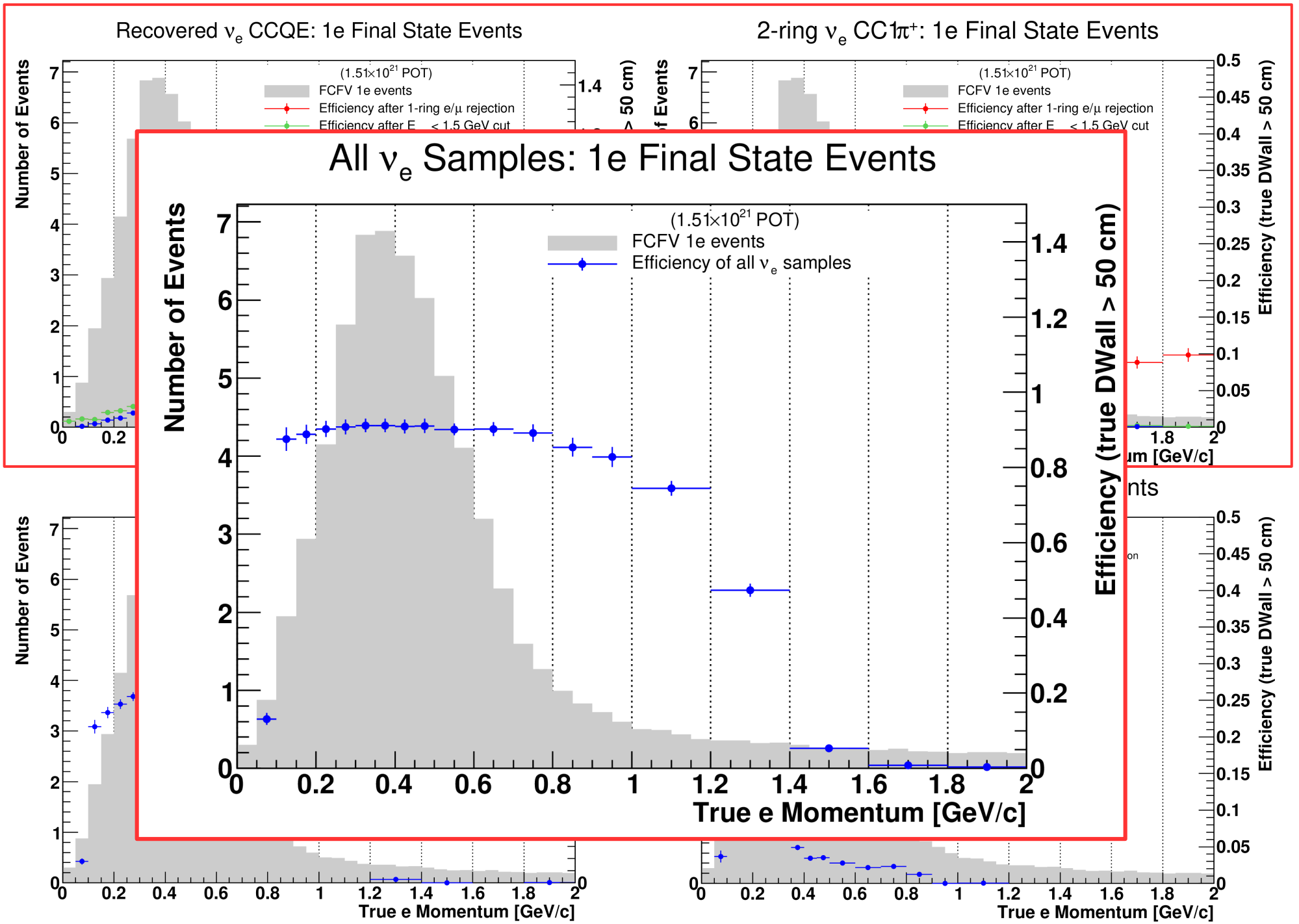
1e efficiency vs. e momentum





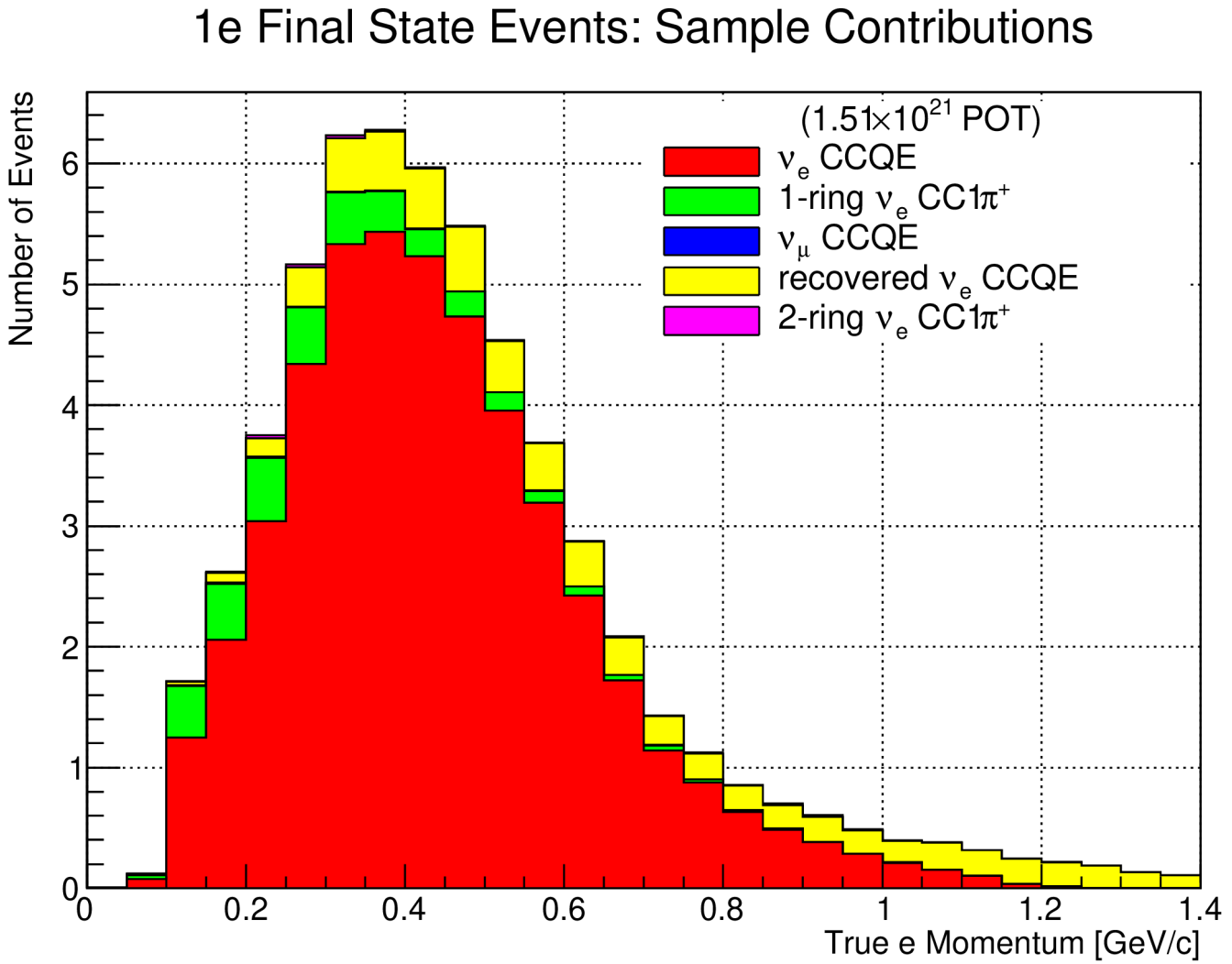

Recovered ν_e CCQE: 1e Final State Events
(1.51×10^21 POT)
FCFV 1e events
Efficiency after 1-ring e/μ rejection
Efficiency after $E_{rec.}$ < 1.5 GeV cut
Efficiency after BDT cut
Number of Events
Efficiency (true DWall > 50 cm)
True e Momentum [GeV/c]
2-ring ν_e CC1π^+: 1e Final State Events
(1.51×10^21 POT)
FCFV 1e events
Efficiency after 1-ring e/μ rejection
Efficiency after $E_{rec.}$ < 1.5 GeV cut
Efficiency after BDT cut
Number of Events
Efficiency (true DWall > 50 cm)
True e Momentum [GeV/c]


ν_e CCQE: 1e Final State Events
(1.51×10^21 POT)
FCFV 1e events
Efficiency after ν_e CCQE selection
Number of Events
Efficiency (true DWall > 50 cm)
True e Momentum [GeV/c]
1-ring ν_e CC1π^+: 1e Final State Events
(1.51×10^21 POT)
FCFV 1e events
Efficiency after 1-ring ν_e CC1π^+ selection
Number of Events
Efficiency (true DWall > 50 cm)
True e Momentum [GeV/c]


Recovered ν_e CCQE: 1e Final State Events
2-ring ν_e CC1π^+: 1e Final State Events
All ν_e Samples: 1e Final State Events
$(1.51\times10^{21}$ POT)
FCFV 1e events
Efficiency of all ν_e samples
Efficiency after 1-ring e/μ rejection
Number of Events
Efficiency (true DWall > 50 cm)
True e Momentum [GeV/c]

Absolute Sample Contributions

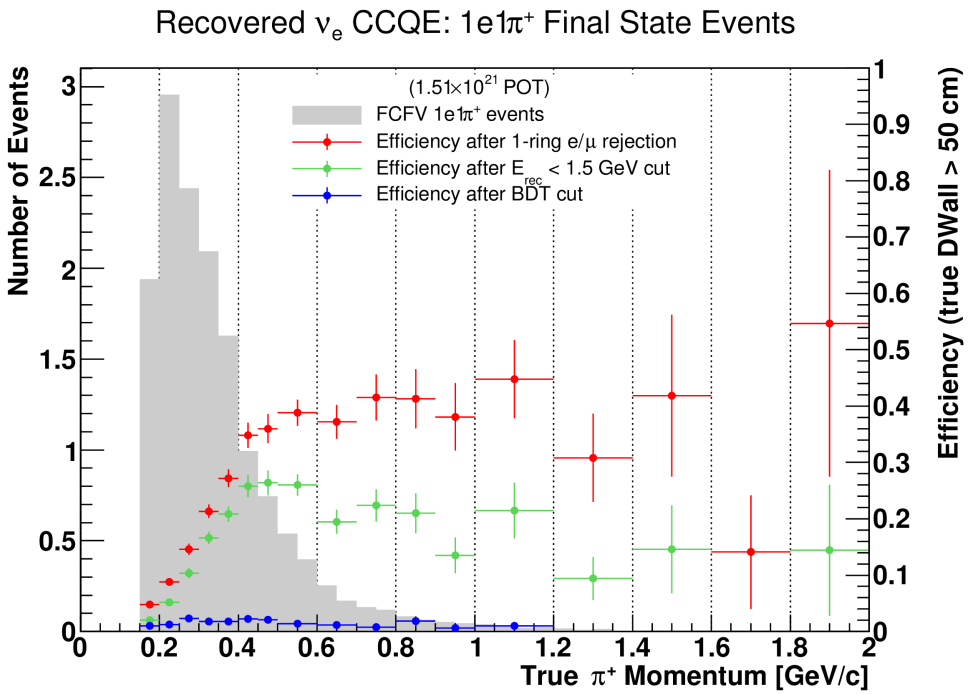
1e Final State Events

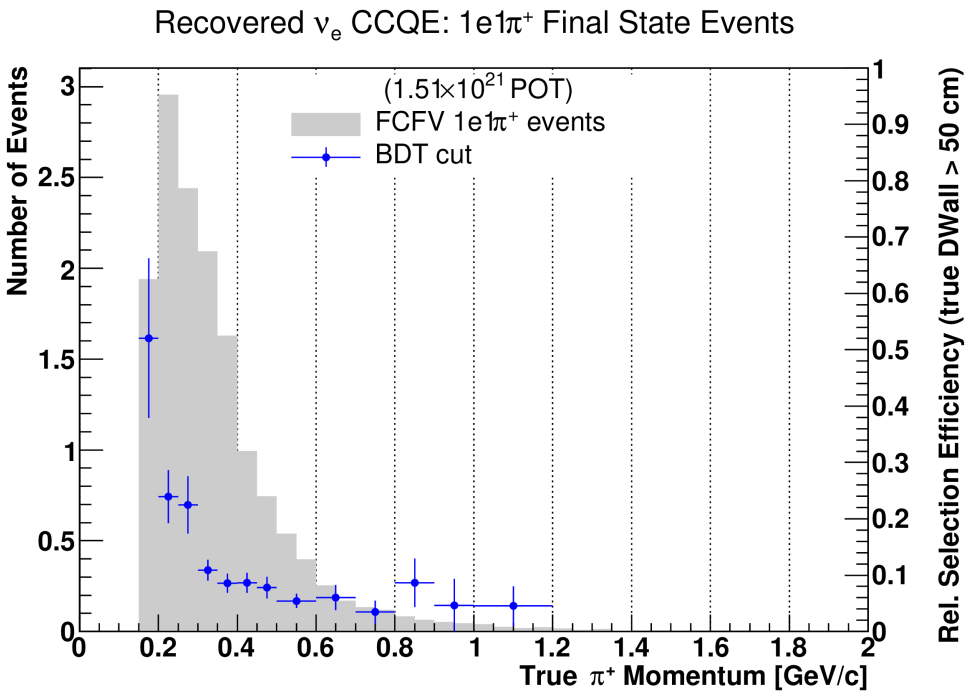


1e1π^+ Final State Events
vs.
True π^+ Momentum

Recovered ν_e CCQE Sample

1e1π⁺ efficiency vs. π⁺ momentum

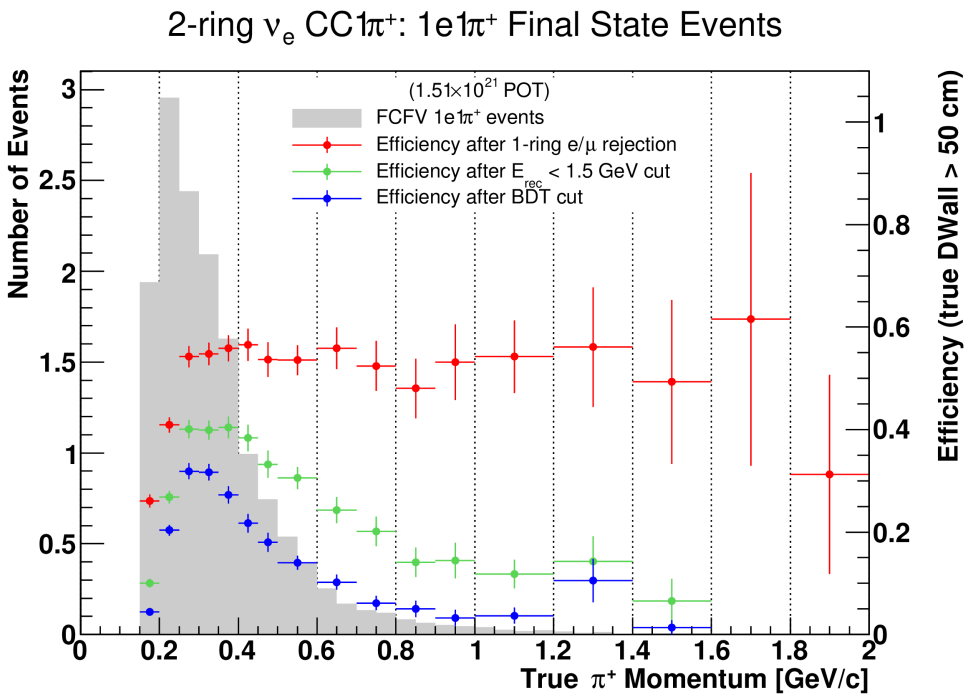


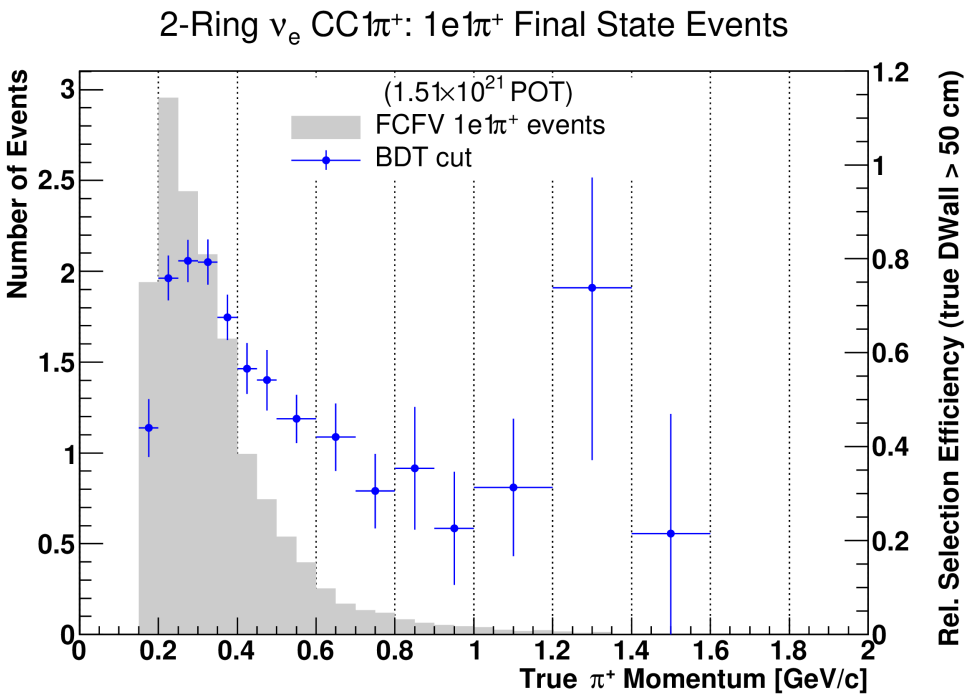


- Relative efficiency peak at low π⁺ momentum would be expected
  - With π⁺ near threshold, more likely to be mistaken for a 1e event

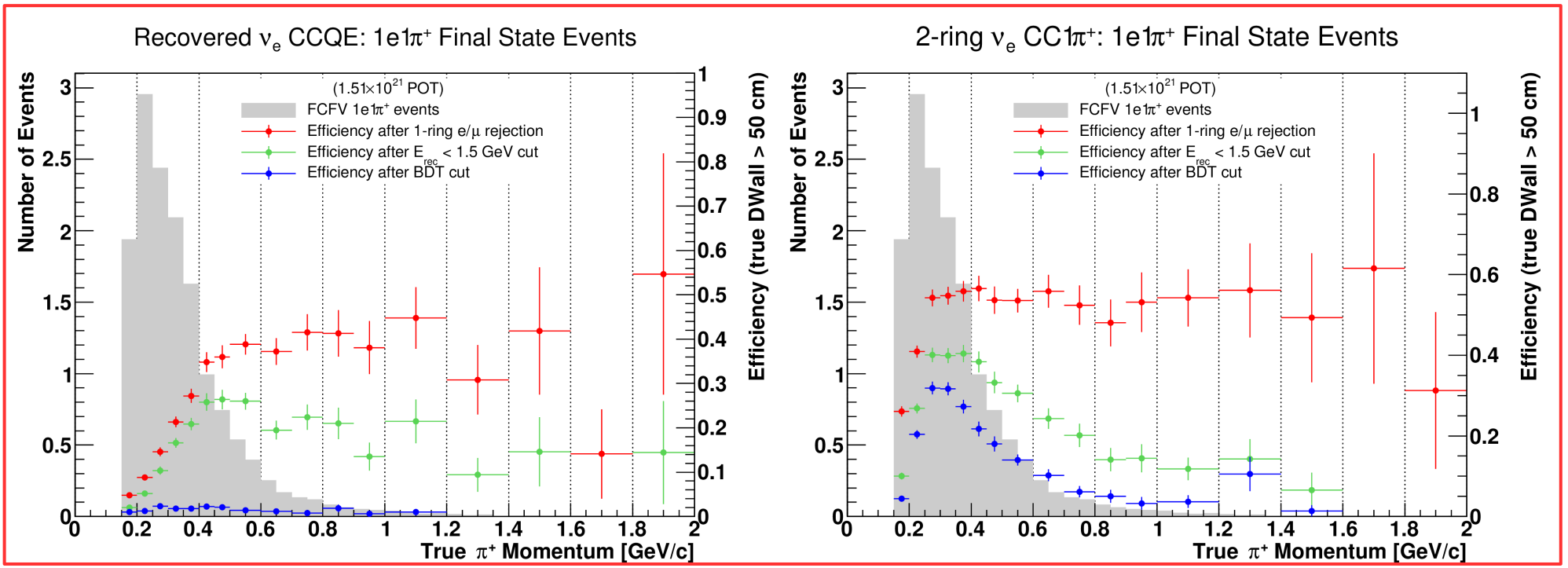
2-ring ν_e CC1π^+ Sample

1e1π^+ efficiency vs. π^+ momentum





- Fair amount of true π^+ momentum dependence observed


Recovered ν_e CCQE: 1e1π⁺ Final State Events
(1.51×10²¹ POT)
FCFV 1e1π⁺ events
Efficiency after 1-ring e/μ rejection
Efficiency after E_{rec} < 1.5 GeV cut
Efficiency after BDT cut
Number of Events
Efficiency (true DWall > 50 cm)
True π⁺ Momentum [GeV/c]
2-ring ν_e CC1π⁺: 1e1π⁺ Final State Events
(1.51×10²¹ POT)
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Efficiency after ν_e CCQE selection
Number of Events
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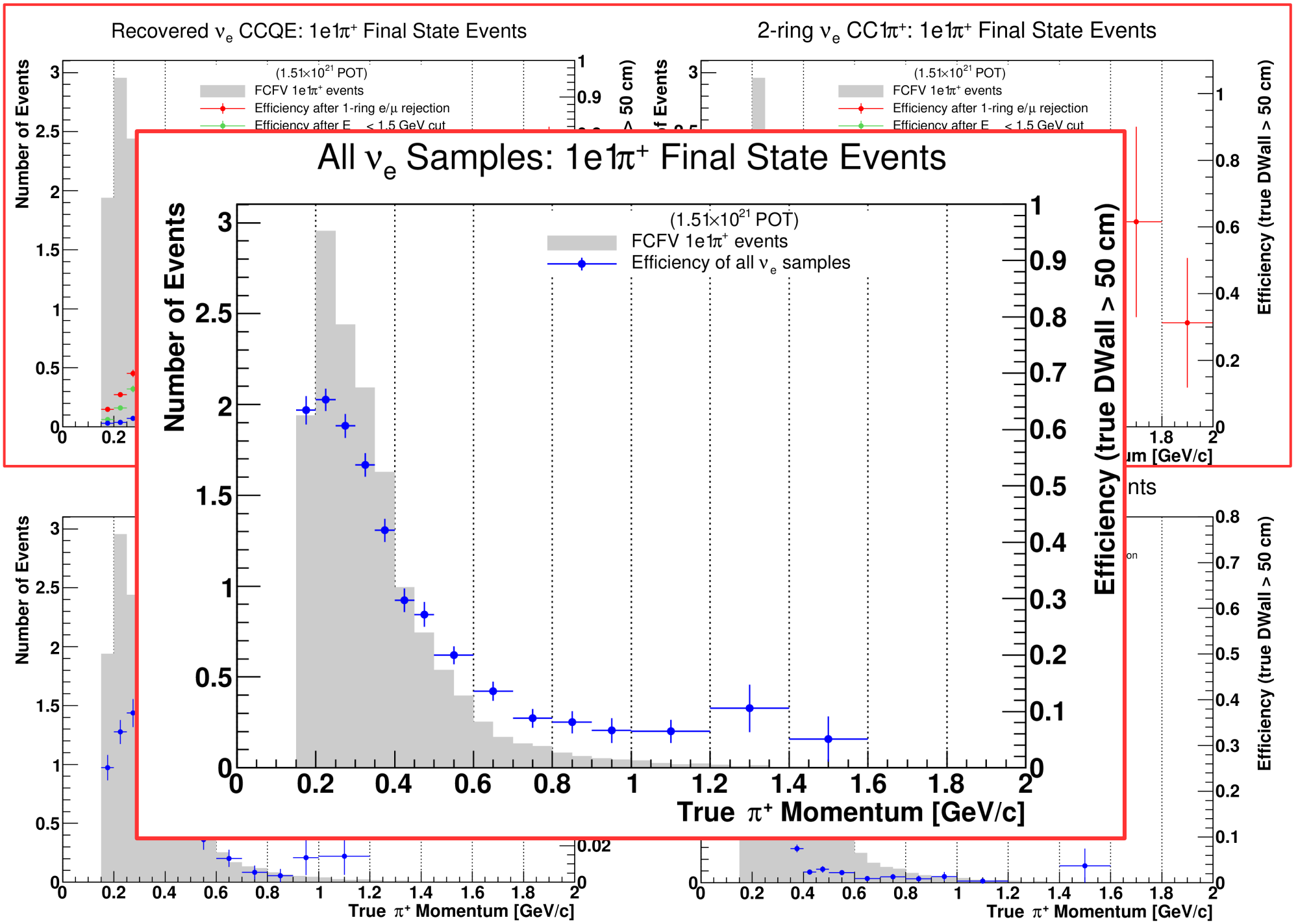
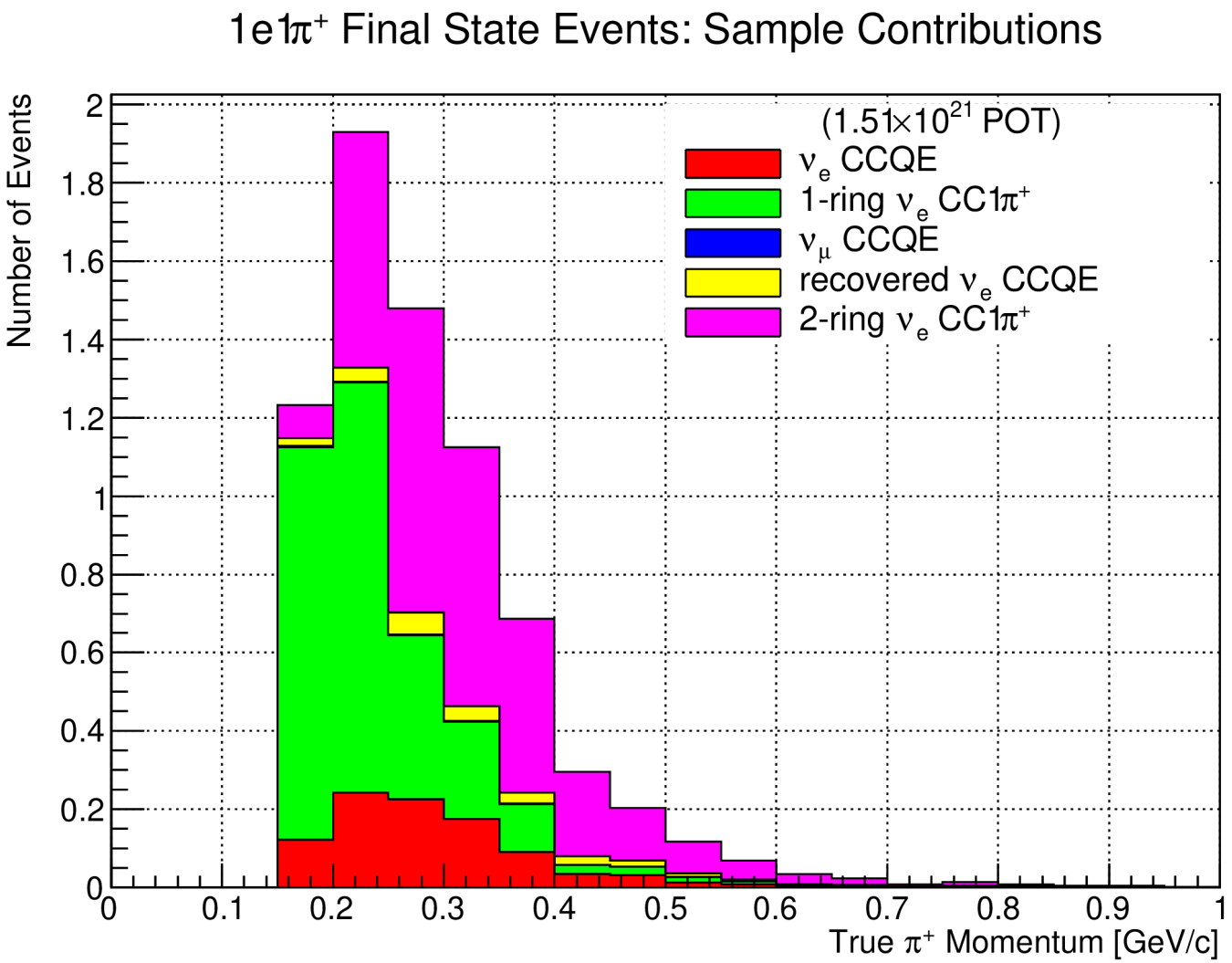
True π⁺ Momentum [GeV/c]
1-ring ν_e CC1π⁺: 1e1π⁺ Final State Events
(1.51×10²¹ POT)
FCFV 1e1π⁺ events
Efficiency after 1-ring ν_e CC1π⁺ selection
Number of Events
Efficiency (true DWall > 50 cm)
True π⁺ Momentum [GeV/c]


Recovered ν_e CCQE: 1e1π^+ Final State Events
2-ring ν_e CC1π^+: 1e1π^+ Final State Events
All ν_e Samples: 1e1π^+ Final State Events
(1.51×10^{21} POT)
FCFV 1e1π^+ events
Efficiency after 1-ring e/μ rejection
Efficiency of all ν_e samples
Number of Events
Efficiency (true DWall > 50 cm)
True π^+ Momentum [GeV/c]

Absolute Sample Contributions

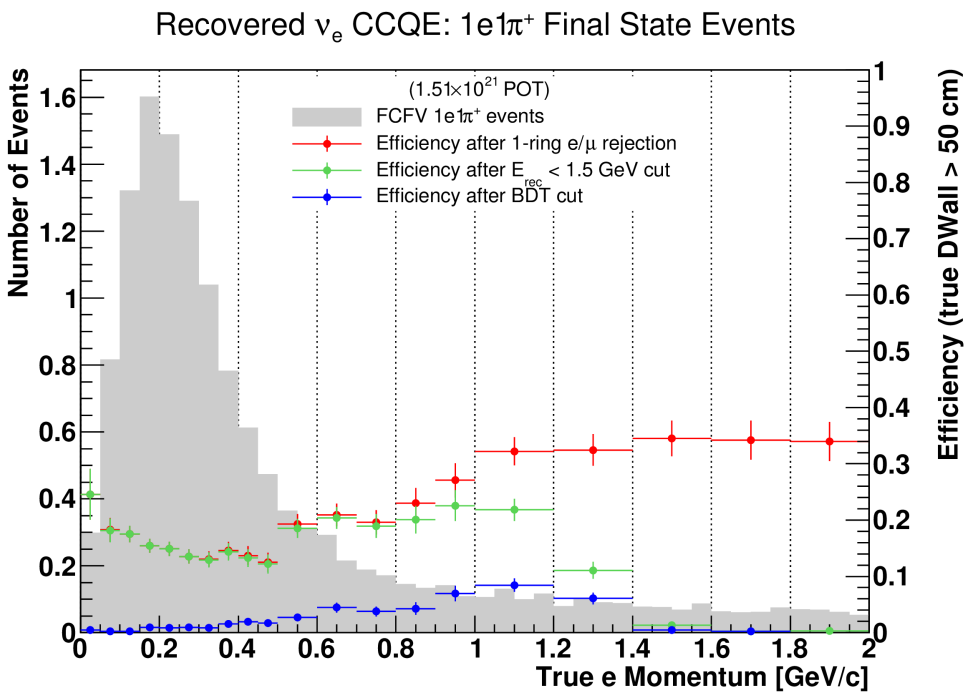
1e1π⁺ Final State Events

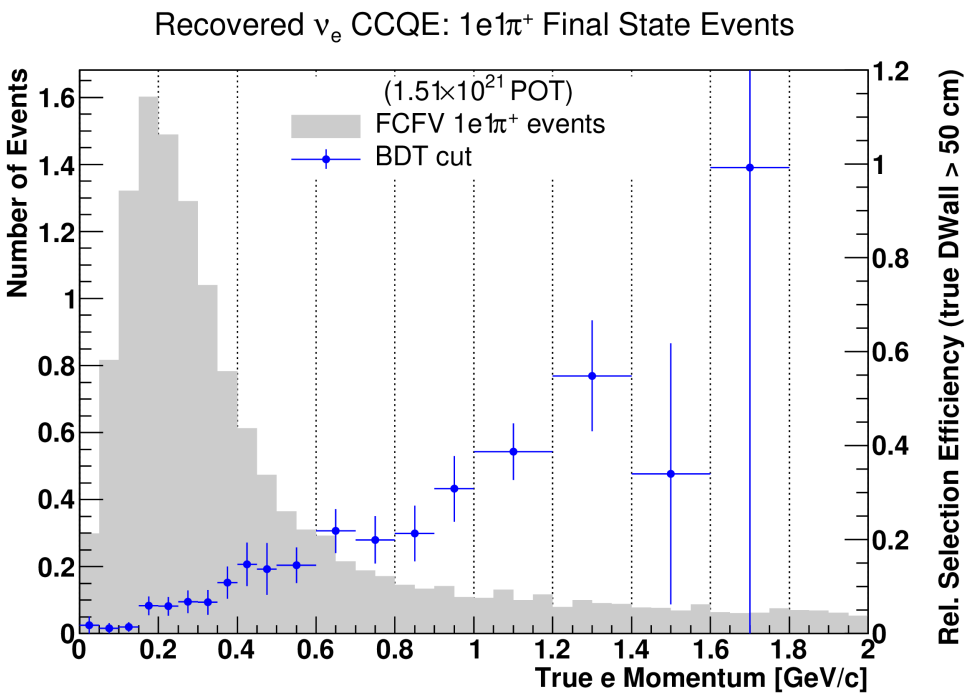


1e1π^+ Final State Events
vs.
True e Momentum

Recovered ν_e CCQE Sample

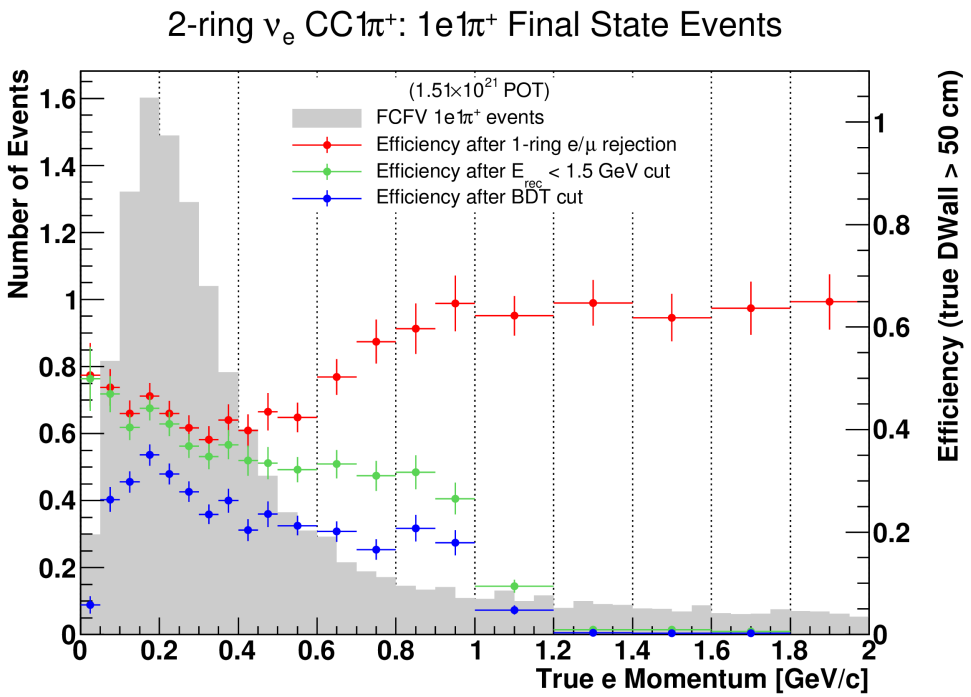
1e1π⁺ efficiency vs. e momentum

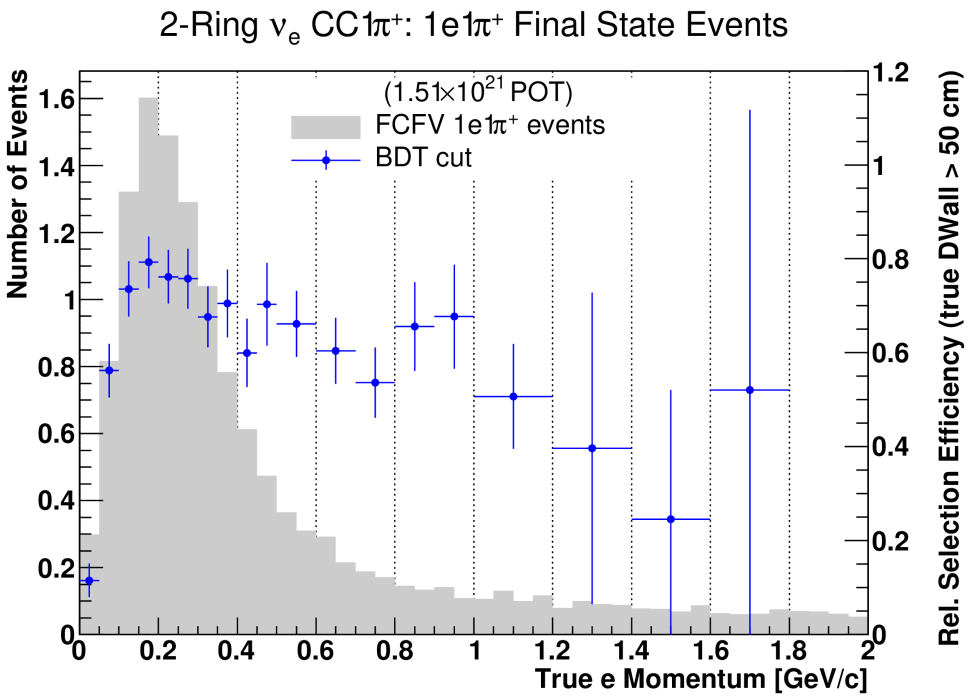




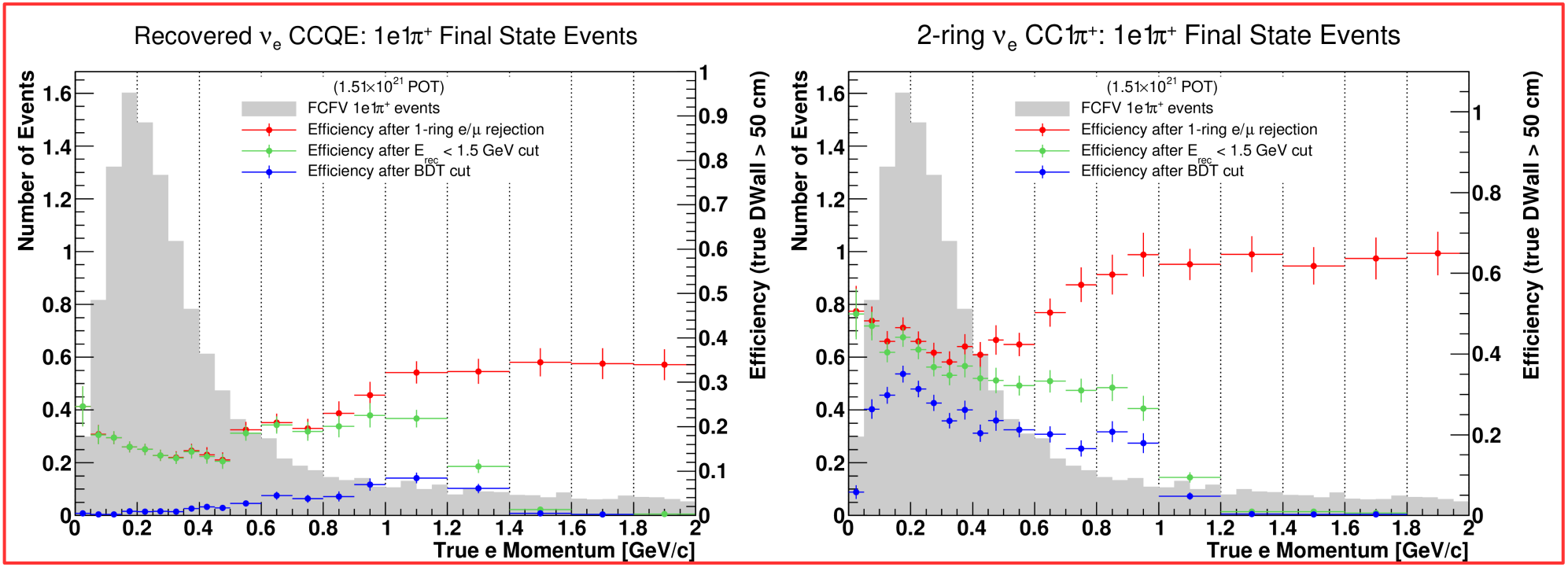
2-ring ν_e CC1π^+ Sample

1e1π^+ efficiency vs. π^+ momentum





- Less true e momentum dependence is observed compared to π^+


Recovered ν_e CCQE: 1e1π⁺ Final State Events
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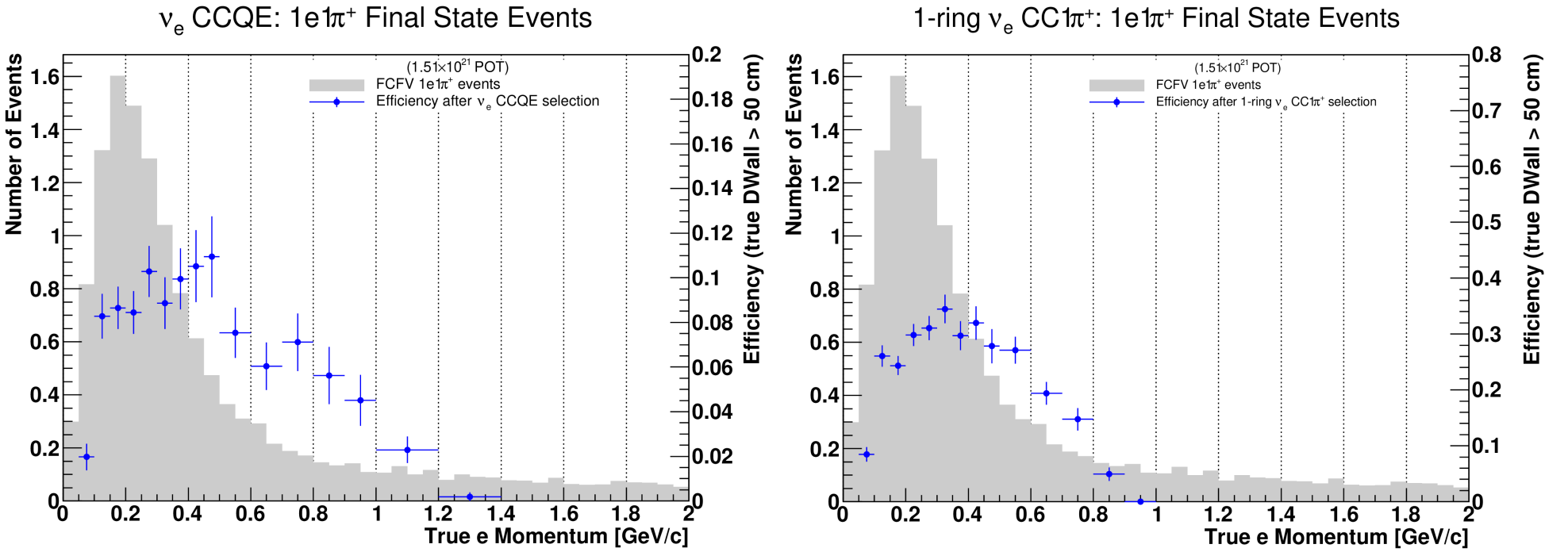
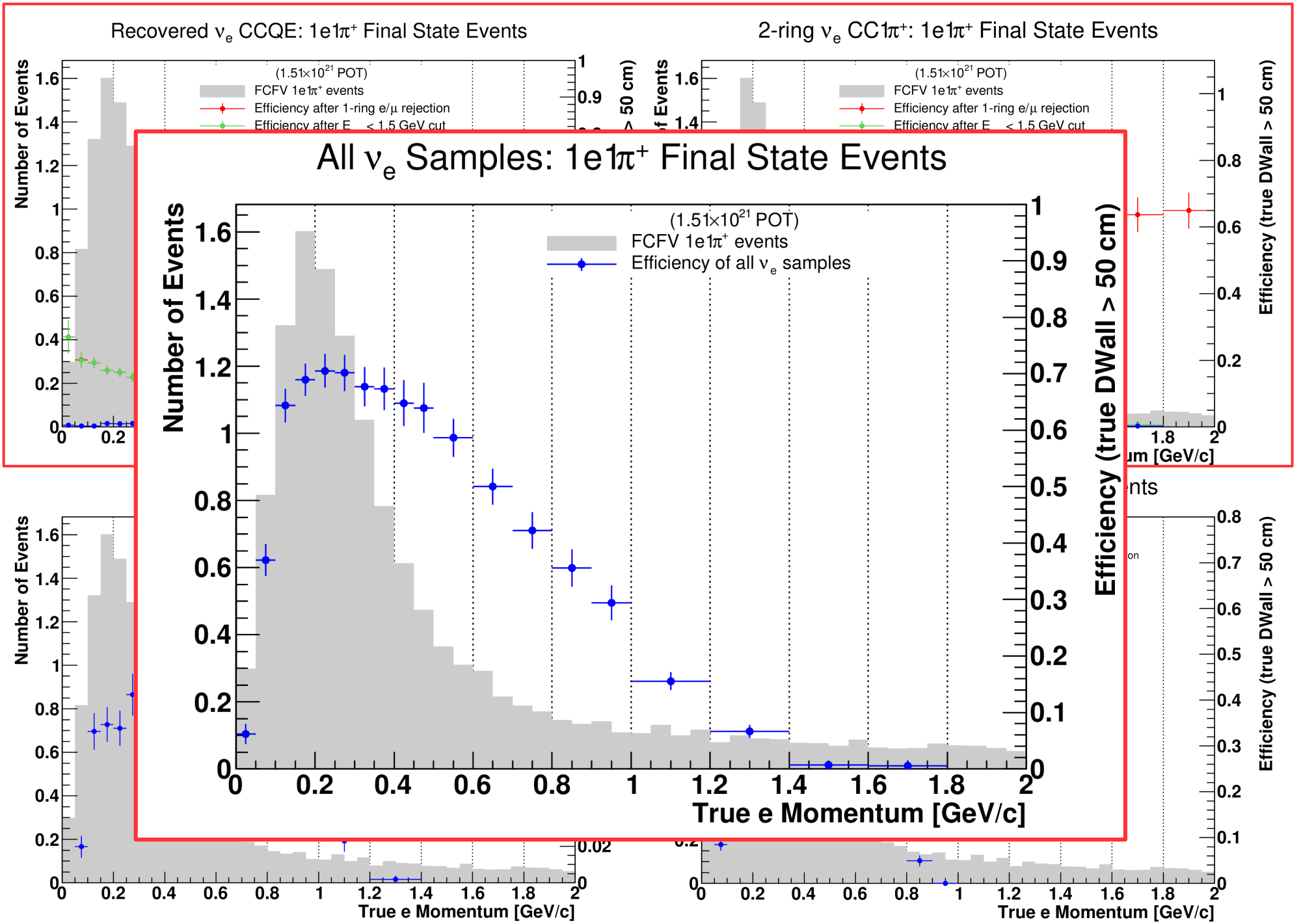
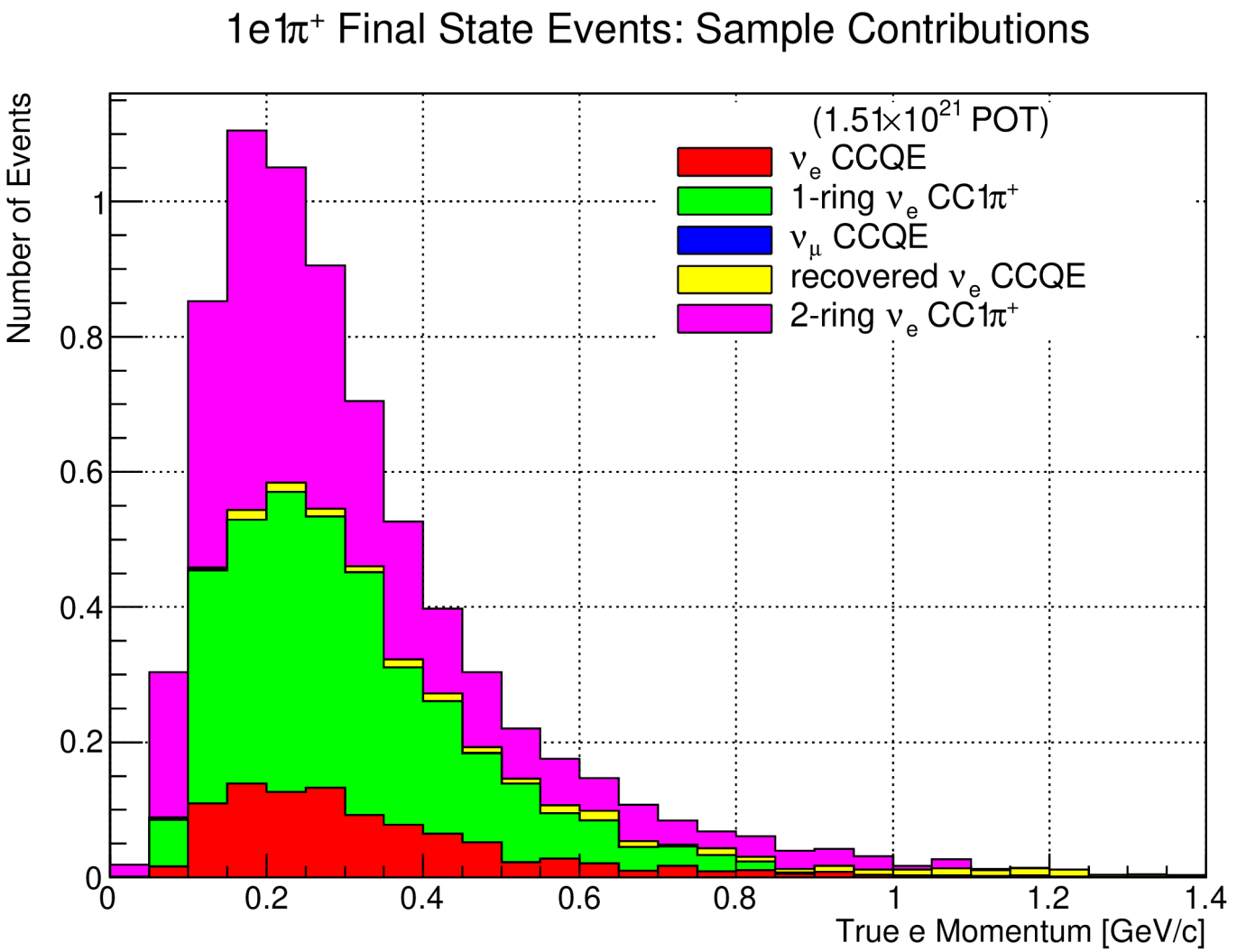

ν_e CCQE: 1e1π⁺ Final State Events
(1.51×10²¹ POT)
FCFV 1e1π⁺ events
Efficiency after ν_e CCQE selection
Number of Events
Efficiency (true DWall > 50 cm)
True e Momentum [GeV/c]
1-ring ν_e CC1π⁺: 1e1π⁺ Final State Events
(1.51×10²¹ POT)
FCFV 1e1π⁺ events
Efficiency after 1-ring ν_e CC1π⁺ selection
Number of Events
Efficiency (true DWall > 50 cm)
True e Momentum [GeV/c]


Recovered ν_e CCQE: 1e1π⁺ Final State Events
2-ring ν_e CC1π⁺: 1e1π⁺ Final State Events
All ν_e Samples: 1e1π⁺ Final State Events
(1.51×10²¹ POT)
FCFV 1e1π⁺ events
Efficiency after 1-ring e/μ rejection
Efficiency of all ν_e samples
Number of Events
Efficiency (true DWall > 50 cm)
True e Momentum [GeV/c]

Absolute Sample Contributions

1e1π⁺ Final State Events



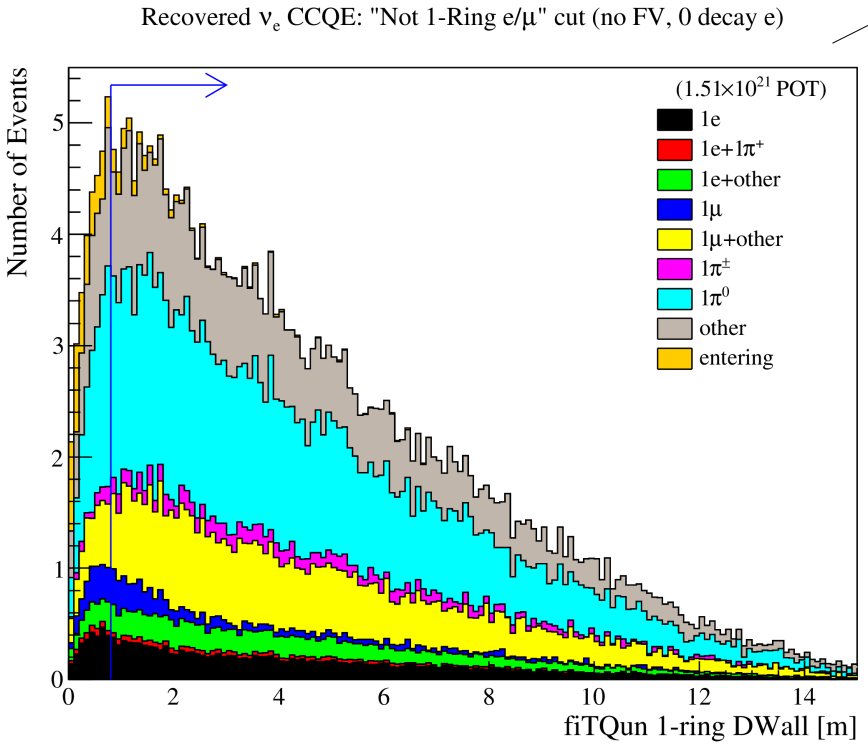
Thoughts

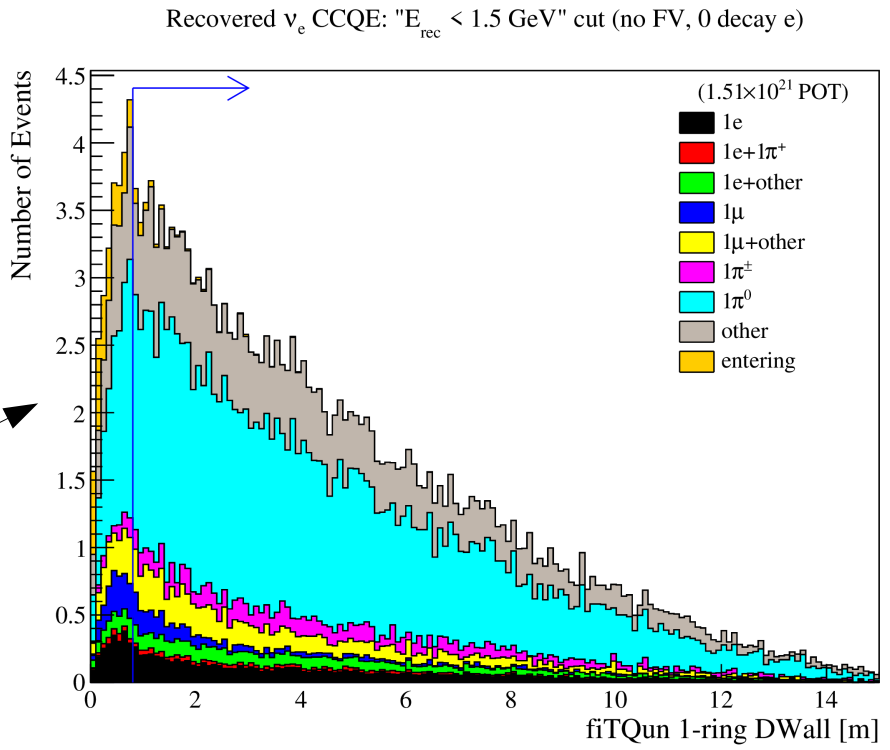
- Significant π^0 momentum dependence in ν_e CCQE selection
- Significant π^+ momentum dependence in 2-ring ν_e CC1π^+ selection
  - 1e1π^+ efficiency seems to lose π^+ momentum dependence at threshold when considering *all* ν_e samples
  - Also making 2D plots of efficiency: true e momentum vs. true π^+ momentum

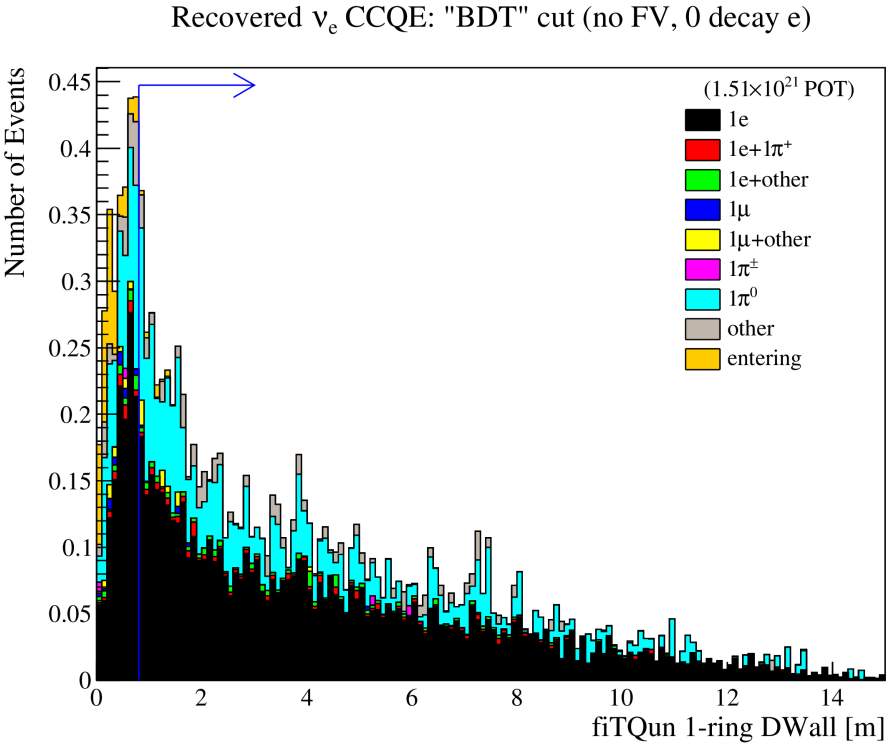
Fiducial Volume Studies

- Plot DWall distribution including entering backgrounds
- Plot reconstructed energy residuals vs. DWall
  - look for reconstructed energy bias at low DWall
- Plot reconstructed energy residuals vs. ToWall
  - look for reconstructed energy bias at low ToWall

Recovered ν_e CCQE: DWall

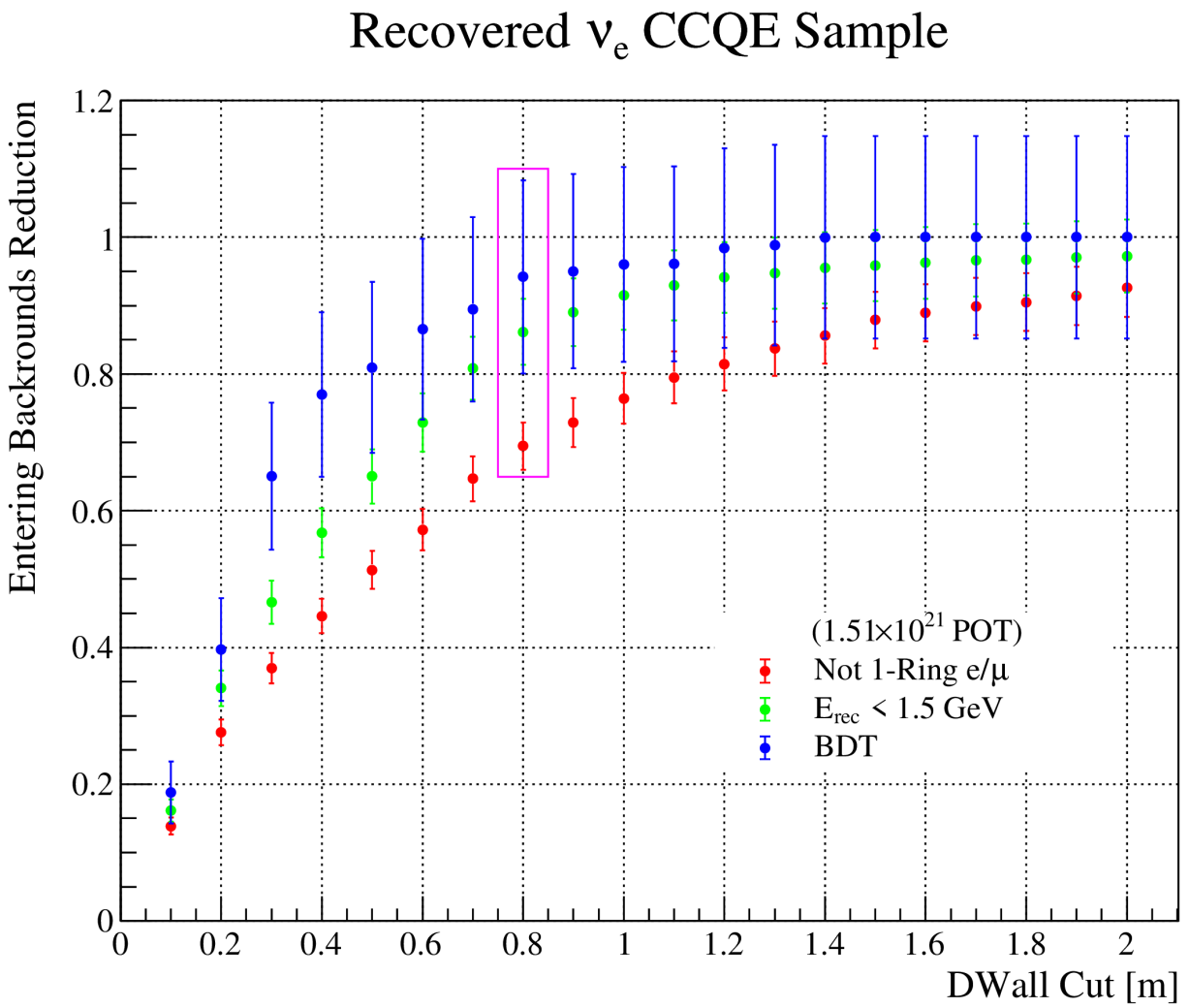




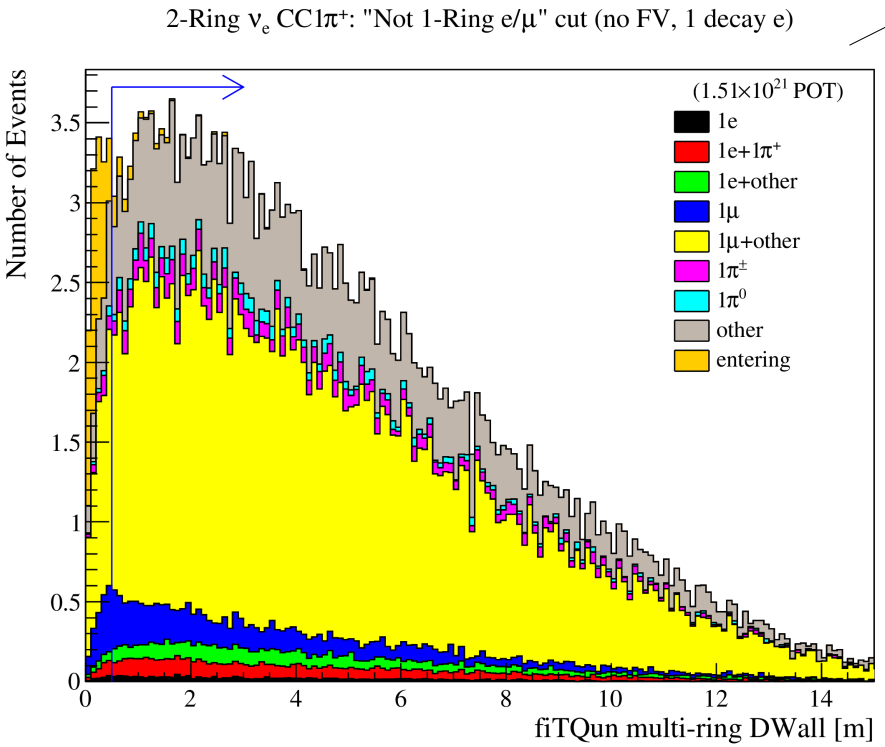


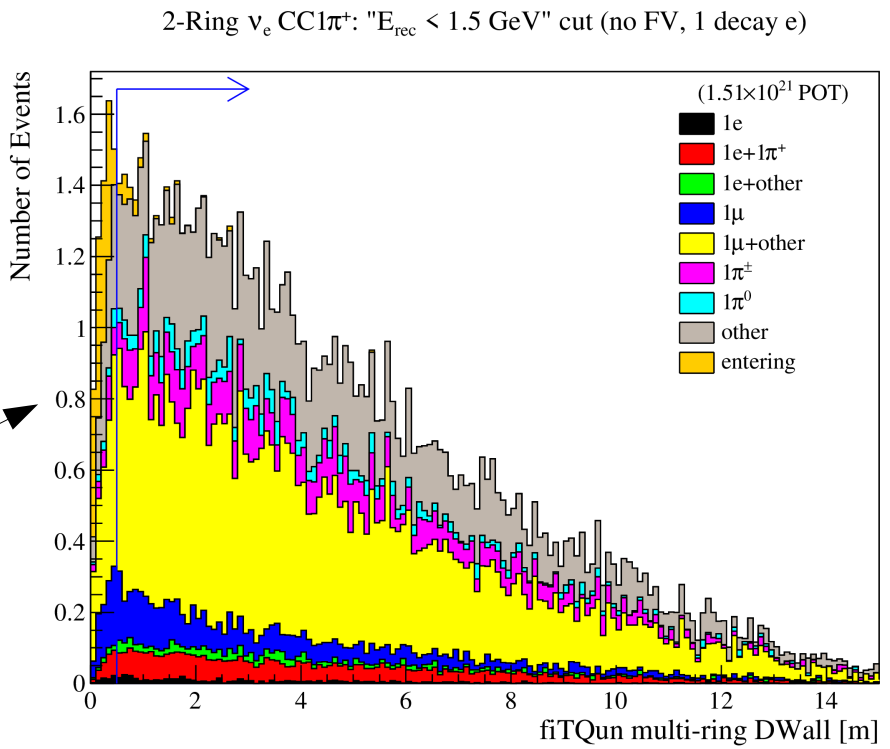
- DWall cut of 80 cm being considered

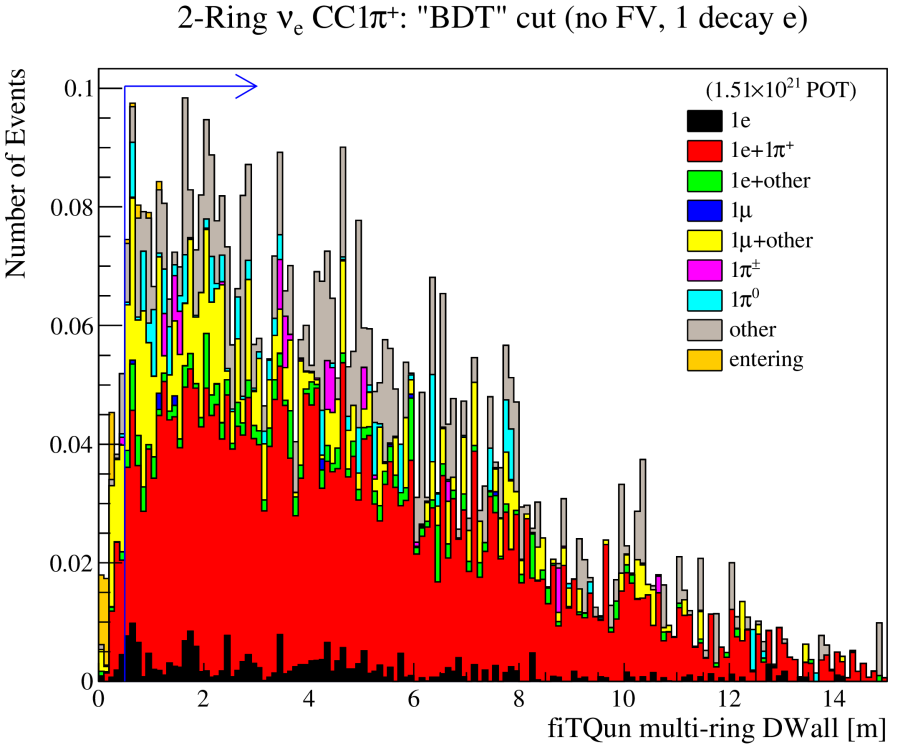
Entering Backgrounds % Reduction vs. DWall Cut



2-Ring ν_e CC1π^+: DWall

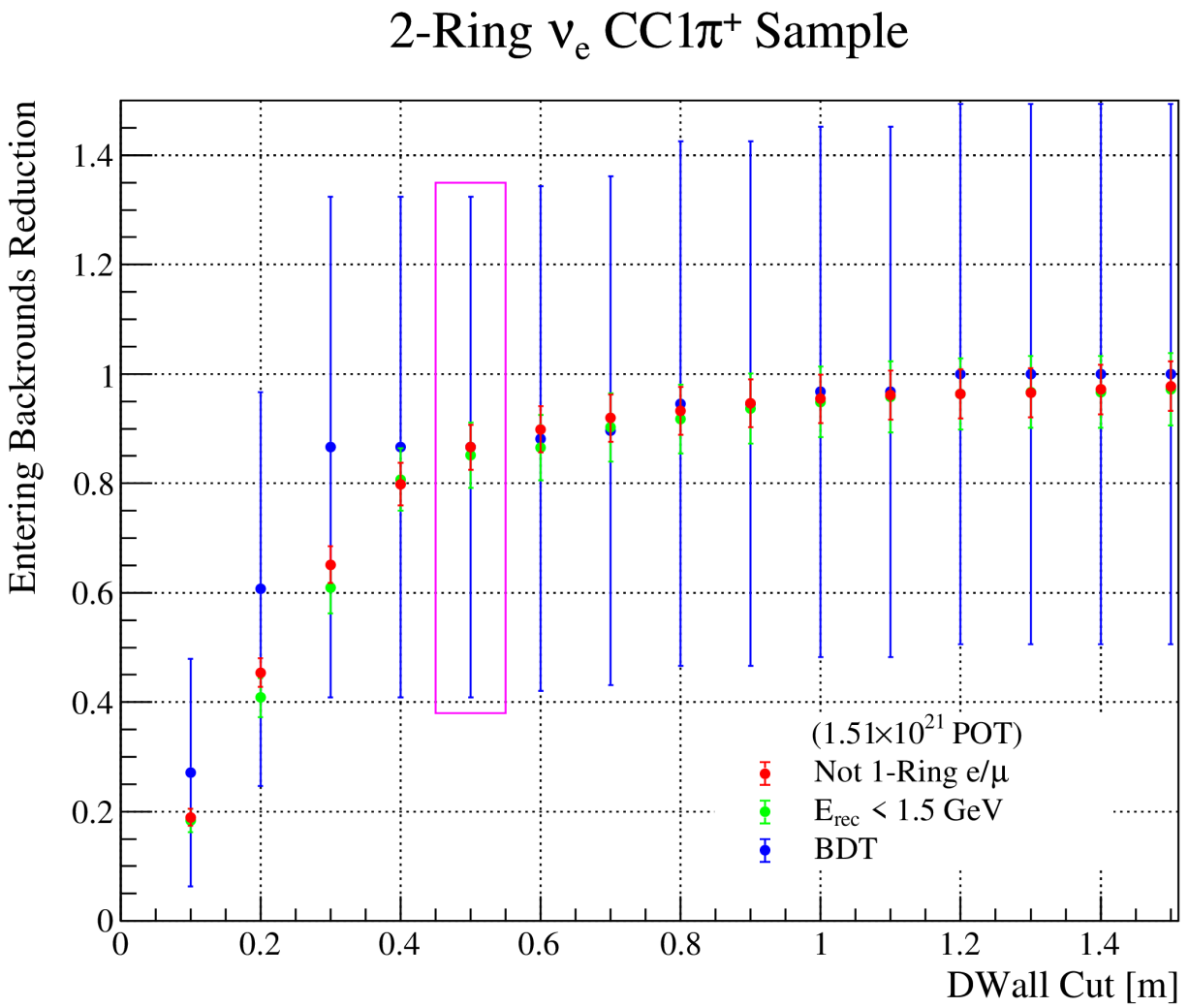




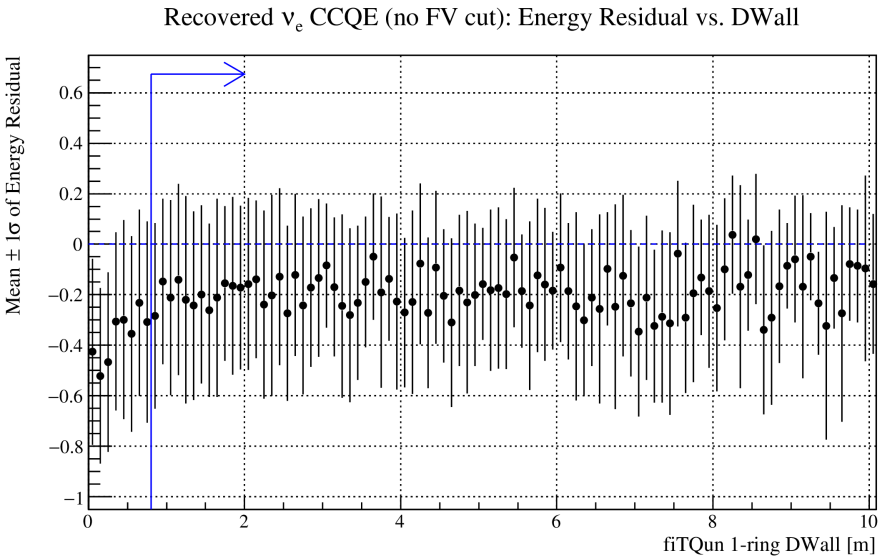


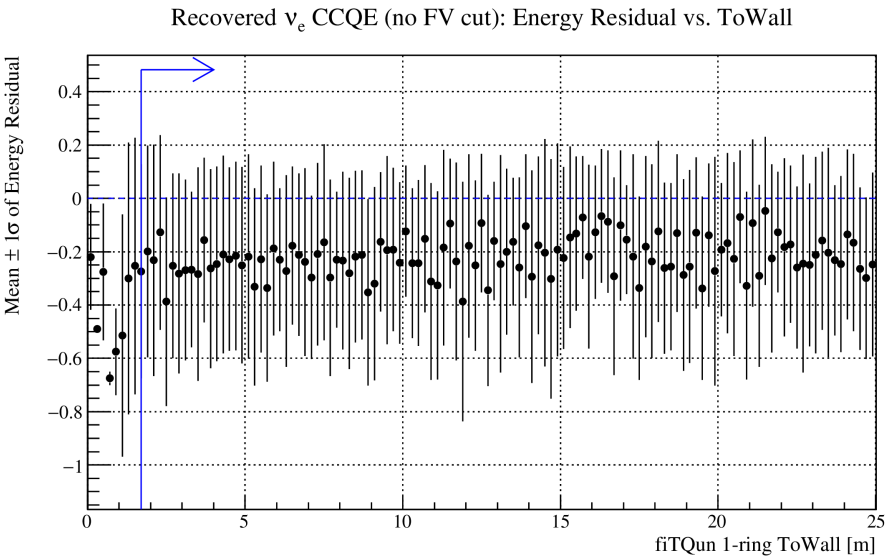
- DWall cut of 50 cm being considered

Entering Backgrounds % Reduction vs. DWall Cut



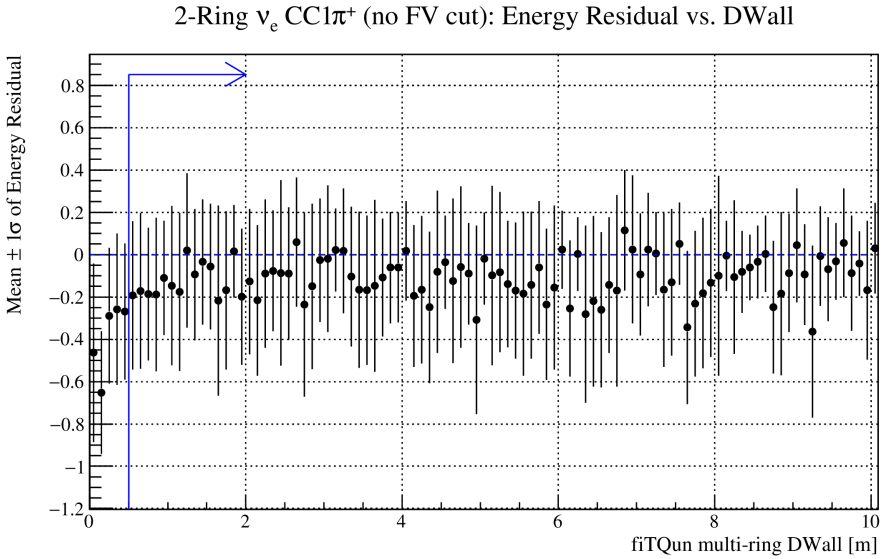
Recovered ν_e CCQE: Energy Residual

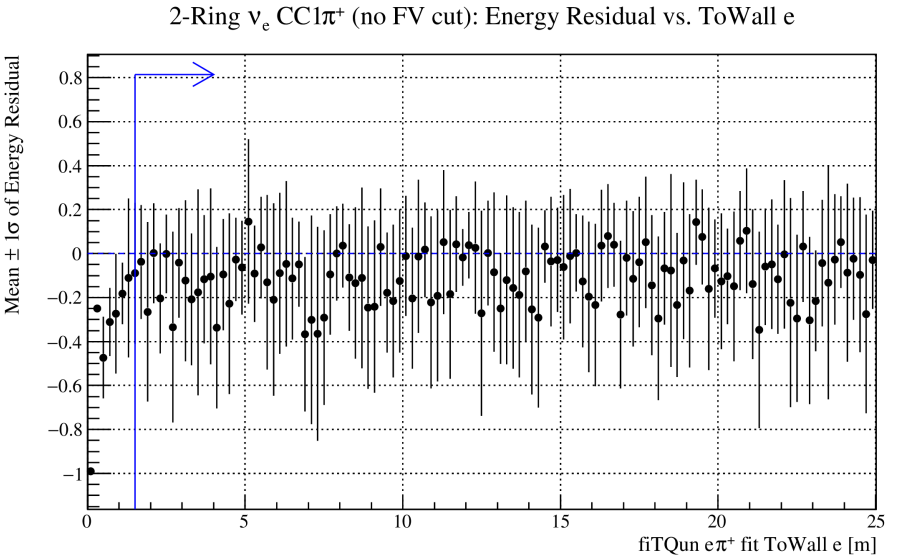


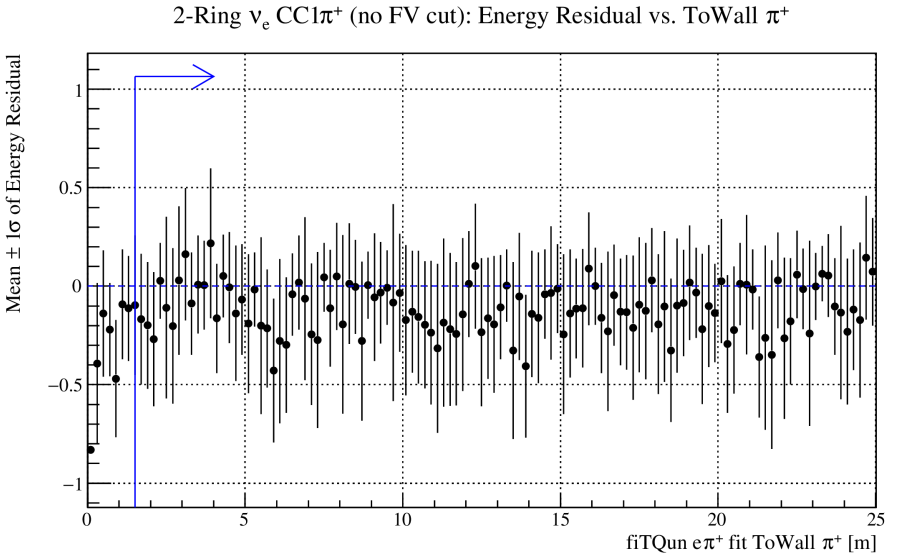


- DWall cut at 80 cm seems to work
- Considering ToWall cut at 170 cm
  - Partly to be consistent with existing ν_e CCQE sample

2-Ring ν_e CC1π^+: Energy Residual







- DWall cut at 50 cm looks okay
- Considering ToWall cut at 150 cm for both e- and π^+-like rings
  - Could maybe go lower, but worried about systematics that I can't see in these plots

Ongoing Work

- Some more efficiency plots
  - Isolate dominant background topology for 2-ring ν_e CC1π^+ sample and produce rejection efficiency plots
    - similar to 1π^0 rejection plots for recovered ν_e CCQE sample
  - 2D plots of 1e1π^+ efficiency for p_e vs. $p_{\pi+}$
- Swiftly move towards working on BANFF and FSI/SI systematics
  - Longer-term: detector systematics

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
Wall > 50 cm	62.28	29.88	21.34	262.16	443.85	285.85
Not 1Re/μ	17.28	17.64	19.33	37.31	390.96	255.75
0 decay e	16.67	8.12	11.45	11.56	60.98	185.50
E_{rec} < 1.5 GeV	8.86	5.12	4.57	5.98	14.11	164.98
BDT cut	6.33	0.67	0.30	0.04	0.09	3.88

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
Wall > 50 cm	74.54	14.86	25.66	293.94	372.41	37.86	123.78	162.30
Not 1Re/μ	19.45	10.42	25.21	39.81	352.85	22.57	118.77	149.19
0 decay e	17.60	3.03	15.98	8.64	58.10	10.76	113.54	66.63
E_{rec} < 1.5 GeV	9.47	2.05	7.41	4.90	13.43	10.72	109.40	46.23
BDT cut	6.95	0.24	0.24	0.03	0.07	0.02	3.14	0.63

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
Wall > 50 cm	62.39	30.09	21.84	248.69	430.81	289.56
Not 1Re/μ	17.38	17.86	19.82	34.18	382.75	259.78
0 decay e	0.58	9.19	6.02	19.16	157.15	53.04
E_{rec} < 1.5 GeV	0.14	5.27	1.11	7.52	41.65	32.91
BDT cut	0.04	3.37	0.23	0.02	0.86	1.00

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
Wall > 50 cm	74.65	14.94	26.31	278.22	361.81	37.26	125.21	164.98
Not 1Re/μ	19.56	10.51	25.85	36.04	345.38	22.21	120.21	152.02
0 decay e	1.71	7.17	7.08	12.30	150.06	9.10	4.96	52.77
E_{rec} < 1.5 GeV	0.55	4.59	1.51	5.63	40.10	8.76	3.49	23.97
BDT cut	0.23	3.13	0.22	0.01	0.73	0.08	0.20	0.93