Progress Update

Trevor Towstego

2-Ring ν_e CC1π^+ Meeting

April 3, 2019

Overview

- Summary of current BDT results
  - v0 pre-BDT cuts, trial 10 variables
    - fiTQun index not used at all
  - Small changes made to 1-ring e-like rejection in pre-BDT selection
    - Removed FCFV requirement from these cuts
- Thoughts on systematics approach
- Plan going foward

Optical Devices

- John and I packaged these items in a box:
  - Deuterium lamp
    - With power supply and cables
  - Monochromator
  - Picoammeter
- I will ship these items out this week
  - Any particular address to use?
- Software was used to control monochromator
  - Don’t remember how this was acquired... disk or download?

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)	
0 decay e	1 sub-event	2 sub-events
E_{rec}*	$E_{rec}(p_e,p_\pi) < 1.5$ GeV	

BDT training variables
1R v 1R -ln(L) 1R v 2R -ln(L) 2R v 2R -ln(L) 2R v 3R -ln(L) 3R v 3R -ln(L) 1R+2R fit kinematics E_{rec}*, towall e*, towall π*, p_{low}*, $m_{\pi 0}$

* Event reconstruction done using fiTQun's 2Reπ-like fit

0 decay e: $1e^{\pm}1\pi^{\pm}$ Training

visible FSP:	**$1e1\pi^{+/-}$**	**1e**	**1e other**	**$1\mu1\pi^{+/-}$**	**1μ**	**1μ other**	**$0l1\pi^{+}$**	**$0l1\pi^{-}$**	**$0l1\pi^{0}$**	**$0lN\pi$**	**0l other**		**$1e1\pi^{+/-}$**	**other**	**FOM**
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	0.28
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	0.15
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	0.55
NEUT mode:	**ν_e CC1π^+**	**ν_e CCQE**	**ν_e CCNπ**	**ν_e CCDIS**	**ν_e CCother**	**$\bar{\nu}_e$ CC**	**ν_μ CC**	**NC**					**ν_e CC1π^+**	**other**	**FOM**
FCFV	9.04	39.19	2.29	1.12	4.10	2.82	83.29	135.95					9.04	268.76	0.54
pre-BDT	2.64	3.54	0.37	0.09	1.21	0.26	29.89	97.87					2.64	133.25	0.23
post-BDT	0.38	0.01	0.02	0.00	0.01	0.02	0.04	0.10					0.38	0.21	0.50
ν type:	**osc ν_e CC**	**int ν_e CC**	**ν_μ CC**	**NC**									**osc ν_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

0 decay e: $\nu_e/\bar{\nu}_e$ CC1$\pi^{\pm}$ Training

visible FSP:	1e1$\pi^{+/-}$	1e	1e other	1μ1$\pi^{+/-}$	1μ	1μ other	0l1π^{+}	0l1π^{-}	0l1π^{0}	0lNπ	0l other		1e1$\pi^{+/-}$	other	FOM
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	273.16	0.28
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	0.15
post-BDT	0.74	0.30	0.34	0.03	0.03	0.15	0.13	0.12	0.45	0.37	0.14		0.74	2.06	0.44
NEUT mode:	**ν_e CC1π^{+}**	**ν_e CCQE**	**ν_e CCNπ**	**ν_e CCDIS**	**ν_e CCother**	**$\bar{\nu}_e$ CC**	**ν_μ CC**	**NC**					**ν_e CC1π^{+}**	**other**	**FOM**
FCFV	9.04	39.19	2.29	1.12	4.10	2.82	83.29	135.95					9.04	268.76	0.54
pre-BDT	2.64	3.54	0.37	0.09	1.21	0.26	29.89	97.87					2.64	133.25	0.23
post-BDT	0.85	0.21	0.06	0.01	0.20	0.06	0.21	1.21					0.85	1.95	0.51
ν type:	**osc ν_e CC**	**int ν_e CC**	**ν_μ CC**	**NC**									**osc ν_e CC**	**other**	**FOM**
FCFV	38.06	20.50	83.29	135.95									38.06	239.70	2.28
pre-BDT	5.95	2.17	29.89	97.87									5.95	129.94	0.51
post-BDT	0.99	0.40	0.21	1.21									0.99	1.82	0.59

0 decay e: $\nu_e/\bar{\nu}_e$ CC Training

visible FSP:	$1e1\pi^{+/-}$	1e	1e other	$1\mu1\pi^{+/-}$	1μ	1μ other	$0l1\pi^{+}$	$0l1\pi^{-}$	$0l1\pi^{0}$	$0lN\pi$	0l other		$1e1\pi^{+/-}$	other	FOM
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	0.28
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	0.15
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	0.33
NEUT mode:	ν_e $CC1\pi^{+}$	ν_e CCQE	ν_e $CCN\pi$	ν_e CCDIS	ν_e CCother	$\bar{\nu}_e$ CC	ν_μ CC	NC					ν_e $CC1\pi^{+}$	other	FOM
FCFV	9.04	39.19	2.29	1.12	4.10	2.82	83.29	135.95					9.04	268.58	0.54
pre-BDT	2.64	3.54	0.37	0.09	1.21	0.26	29.89	97.87					2.64	133.26	0.23
post-BDT	1.85	3.10	0.27	0.06	0.80	0.21	1.03	6.86					1.85	12.33	0.49
ν type:	osc ν_e CC	int ν_e CC	ν_μ CC	NC									osc ν_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

1 decay e: $1e^{\pm}1\pi^{\pm}$ Training

visible FSP:	$1e1\pi^{+/-}$	1e	1e other	$1\mu1\pi^{+/-}$	1μ	1μ other	$0l1\pi^{+}$	$0l1\pi^{-}$	$0l1\pi^{0}$	$0lN\pi$	0l other		$1e1\pi^{+/-}$	other	FOM
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	0.40
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	0.26
post-BDT	2.11	0.17	0.09	0.11	0.02	0.35	0.09	0.05	0.07	0.17	0.10		2.11	1.22	1.16
NEUT mode:	**ν_e CC1π^+**	**ν_e CCQE**	**ν_e CCNπ**	**ν_e CCDIS**	**ν_e CCother**	**$\bar{\nu}_e$ CC**	**ν_μ CC**	**NC**					**ν_e CC1π^+**	**other**	**FOM**
FCFV	10.57	0.52	2.31	1.21	0.54	0.26	246.94	39.72					10.57	291.49	0.61
pre-BDT	3.71	0.09	0.47	0.14	0.13	0.03	126.72	25.92					3.71	153.48	0.30
post-BDT	2.21	0.03	0.09	0.01	0.03	0.01	0.48	0.48					2.21	1.11	1.21
ν type:	**osc ν_e CC**	**int ν_e CC**	**ν_μ CC**	**NC**									**osc ν_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	1.79	0.58	0.48	0.48									1.79	1.53	0.98

1 decay e: $\nu_e/\bar{\nu}_e$ CC1$\pi^{\pm}$ Training

visible FSP:	1e1$\pi^{+/-}$	1e	1e other	1μ1$\pi^{+/-}$	1μ	1μ other	0l1π^{+}	0l1π^{-}	0l1π^{0}	0lNπ	0l other		1e1$\pi^{+/-}$	other	FOM
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	295.15	0.40
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	0.26
post-BDT	2.21	0.46	0.10	0.09	0.04	0.30	0.08	0.06	0.10	0.18	0.11		2.21	1.52	1.14
NEUT mode:	**ν_e CC1π^{+}**	**ν_e CCQE**	**ν_e CCNπ**	**ν_e CCDIS**	**ν_e CCother**	**$\bar{\nu}_e$ CC**	**ν_μ CC**	**NC**					**ν_e CC1π^{+}**	**other**	**FOM**
FCFV	10.57	0.52	2.31	1.21	0.54	0.26	246.94	39.72					10.57	291.52	0.61
pre-BDT	3.71	0.09	0.47	0.14	0.13	0.03	126.71	25.92					3.71	153.48	0.30
post-BDT	2.55	0.04	0.11	0.01	0.05	0.01	0.43	0.53					2.55	1.18	1.32
ν type:	**osc ν_e CC**	**int ν_e CC**	**ν_μ CC**	**NC**									**osc ν_e CC**	**other**	**FOM**
FCFV	7.86	7.54	246.94	39.72									7.86	294.24	0.45
pre-BDT	3.06	1.50	126.71	25.92									3.06	154.12	0.24
post-BDT	2.07	0.69	0.43	0.53									2.07	1.66	1.07

1 decay e: $\nu_e/\bar{\nu}_e$ CC Training

visible FSP:	$1e1\pi^{+/-}$	1e	1e other	$1\mu1\pi^{+/-}$	1μ	1μ other	$0l1\pi^{+}$	$0l1\pi^{-}$	$0l1\pi^{0}$	0lNπ	0l other		$1e1\pi^{+/-}$	other	FOM
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	295.06	0.40
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	153.94	0.26
post-BDT	2.29	0.46	0.23	0.13	0.05	0.67	0.16	0.08	0.20	0.42	0.12		2.29	2.52	1.04
NEUT mode:	**ν_e CC1π⁺**	**ν_e CCQE**	**ν_e CCNπ**	**ν_e CCDIS**	**ν_e CCother**	**$\bar{\nu}_e$ CC**	**ν_μ CC**	**NC**					**ν_e CC1π⁺**	**other**	**FOM**
FCFV	10.57	0.52	2.31	1.21	0.54	0.26	246.97	39.72					10.57	291.49	0.61
pre-BDT	3.71	0.09	0.47	0.14	0.13	0.03	126.72	25.92					3.71	153.49	0.30
post-BDT	2.61	0.07	0.18	0.05	0.07	0.02	0.85	0.98					2.61	2.20	1.19
ν type:	**osc ν_e CC**	**int ν_e CC**	**ν_μ CC**	**NC**									**osc ν_e CC**	**other**	**FOM**
FCFV	7.86	7.54	246.97	39.72									7.86	294.16	0.45
pre-BDT	3.06	1.50	126.72	25.92									3.06	154.12	0.24
post-BDT	2.12	0.86	0.85	0.98									2.12	2.69	0.97

Thoughts

- FCFV will likely not be optimized
  - Propose to change to 100 cm...? Would 200 cm be too conservative?
- Discussion with Mark Scott regarding use of reconstructed kinematics in training
  - Concerns regarding systematics since pions are poorly understood
  - Will see how this plays out when studying other event generators

Systematics

- Mike suggested using Xiaoyue's systematics framework, and it seems Yoshida-san is going this route with the ν_μ CC1π^+ sample
- My current understanding of systematics:
  - <u>BANFF (beam flux + cross section) systematics</u>
    - Covariance matrix already exists
    - Xiaoyue re-weights using polynomial response functions for the cross section "shape" parameters, generated event-by-event
  - <u>FSI/SI (NEUT cascade model) systematics</u>
    - Covariance matrix already exists
    - Xiaoyue re-weights using 5th order polynomials for each parameter, generated event-by-event
  - <u>SK detector systematics</u>
    - Use hybrid samples for signal, and atmospheric samples (data/MC comparison) for background?
      - Depends on which backgrounds are most significant
      - What if atmospheric samples don't exist for backgrounds? (ex. 1μ^-1π^+ final state – have to use hybrid here as well?)
    - Xiaoyue parameterizes as a smearing and bias of the fiTQun reconstructed quantities:

      $$L^i_{jk} \rightarrow \alpha^i_{jk} L^i_{jk} + \beta^i_{jk}$$

      where L^i are the relevant fiTQun parameters (ex. ring-counting, e/μ PID, etc.), j is the event topology index, and k is the visible energy bin index
      - L^i's are chosen because the event selection is based on them – what would I choose for my L^i's?
      - Hybrid samples would be used to assign prior constraints on α and β for the corresponding L^i's
        - ex. hybrid π^0 samples used to assign constraints on α and β for e/π^0 PID parameter in the 1π^0 category
  - <u>Other systematics</u> – neutrino interaction (**generator comparisons**), energy scale, fiducial volume, decay e tagging efficiency

Bigger Picture

- Discussion with Roger:
  - Seems to favour exclusive ν_e CC1π^+ selection
  - Strong motivation for including new samples in 2020 oscillation analysis
    - From T2K-SK + OA meeting
  - This will mean sample and systematics will have to be completed by end of this year
    - Consistent with my plan towards graduation
- Before moving forward, I would like to have a clear plan
  - Clearly lay out plan for systematics with a better understanding than before
    - Use Xiaoyue's framework or previous approach (TN326)?
    - What exactly needs to be done by end of this year
      - i.e. what exactly will I be "handing off" to the OA group? A few covariance matrices and the final BDTs?