

Progress Update

Trevor Towstego
2-Ring ν_e CC1 π^+ Meeting
October 24, 2018

Using BDTs

- v1 Trial 8 – best grid search result shown on next slide
- v0 Trial 9 grid search interrupted by brief NEUT cluster shutdown at TRIUMF
 - Also was taking significantly longer than expected
 - Just one result from v0 Trial 9 shown using same BDT parameters as best v1 Trial 8 grid search result

Pre-BDT cuts	
v1	v0
<ul style="list-style-type: none"> - FCFV - not 1Re/1Re1de - possible 2Repi <ul style="list-style-type: none"> • <u>0 de</u>: 2Reπ, 2Rπe, and 3Re$\pi\pi$ sub-samples • <u>1 de</u>: 1Re, 2Ree, 2Reπ, 2Rπe, 2Rμe, and 3Re$\pi\pi$ sub-samples - 1/2 sub-events - $E_{rec}(1e,1\pi) < 1.5 \text{ GeV}$ 	<ul style="list-style-type: none"> - FCFV - not 1Re/1Re1de - 1/2 sub-events - $E_{rec}(1e,1\pi) < 1.5 \text{ GeV}$

	BDT variables								
	1R v 1R nll	1R v 2R nll	2R v 2R nll	2R v 3R nll	3R v 3R nll	3R v 4R nll	1R+2R kinematics	E_{rec} , towall e, towall π , p_{low} , $m_{\pi 0}$, ($d2se$)	1R+2R+3R fit indices
Trial 8	■	■	■	■	■		■	■	■
Trial 9	■	■	■	■	■	■	■	■	■

v1 (trial 8) BDT event breakdown

NTrees=10000, MaxDepth=7, MinNodeSize=0.05, NCuts=50
(best performing BDT architecture for both 0de and 1de)

0de											
	$1e1\pi^{+-}$	$1e$	$1e$ other	$1\mu1\pi^{+-}$	1μ	1μ other	$0l^{+-} 1\pi^+$	$0l^{+-} 1\pi^-$	$0l^{+-} 1\pi^0$	$0l^{+-} N\pi$	$0l^{+-}$ other
FCFV	5.08	46.83	6.66	11.13	47.24	24.92	7.53	10.63	83.37	16.81	17.60
BDT in	0.79	0.32	0.03	0.07	0.16	0.14	0.34	0.41	1.22	0.36	0.46
BDT out	0.60	0.03	0.01	0.01	0.00	0.03	0.05	0.05	0.07	0.10	0.03
1de											
	$1e1\pi^{+-}$	$1e$	$1e$ other	$1\mu1\pi^{+-}$	1μ	1μ other	$0l^{+-} 1\pi^+$	$0l^{+-} 1\pi^-$	$0l^{+-} 1\pi^0$	$0l^{+-} N\pi$	$0l^{+-}$ other
FCFV	7.48	5.24	2.68	38.78	148.00	60.21	10.26	3.33	4.58	15.24	6.31
BDT in	3.08	0.89	0.09	1.94	3.60	2.37	1.79	0.51	1.79	1.61	2.23
BDT out	2.15	0.19	0.02	0.06	0.02	0.24	0.04	0.02	0.08	0.13	0.09

0de				
	sig	bkg	FOM	δ FOM
FCFV	5.08	272.72		
BDT in	0.79	3.51		
BDT out	0.60	0.37	0.611	0.019

1de				
	sig	bkg	FOM	δ FOM
FCFV	7.48	294.57		
BDT in	3.08	16.82		
BDT out	2.15	0.90	1.230	0.019

v0 (trial 9) BDT event breakdown

NTrees=10000, MaxDepth=7, MinNodeSize=0.05, NCuts=50

0de											
	1e1 π^{+-}	1e	1e other	1 μ 1 π^{+-}	1 μ	1 μ other	0l $^{+-}$ 1 π^+	0l $^{+-}$ 1 π^-	0l $^{+-}$ 1 π^0	0l $^{+-}$ N π	0l $^{+-}$ other
FCFV	5.08	46.83	6.66	11.13	47.24	24.92	7.53	10.63	83.37	16.81	17.60
BDT in	1.90	5.45	1.79	2.85	24.13	3.42	5.91	9.04	63.70	6.57	13.41
BDT out	0.54	0.02	0.01	0.01	0.01	0.03	0.05	0.03	0.04	0.08	0.01
1de											
	1e1 π^{+-}	1e	1e other	1 μ 1 π^{+-}	1 μ	1 μ other	0l $^{+-}$ 1 π^+	0l $^{+-}$ 1 π^-	0l $^{+-}$ 1 π^0	0l $^{+-}$ N π	0l $^{+-}$ other
FCFV	7.48	5.24	2.68	38.78	148.00	60.21	10.26	3.33	4.58	15.23	6.31
BDT in	3.45	0.92	0.42	15.40	99.70	12.21	9.15	2.38	2.53	6.76	5.03
BDT out	2.08	0.16	0.02	0.09	0.02	0.22	0.07	0.02	0.08	0.15	0.11

0de				
	sig	bkg	FOM	δ FOM
FCFV	5.08	272.72		
BDT in	1.90	136.29		
BDT out	0.54	0.28	0.597	0.020

1de				
	sig	bkg	FOM	δ FOM
FCFV	7.48	294.57		
BDT in	3.45	154.50		
BDT out	2.08	0.94	1.199	0.019

Performance doesn't match that of v0 trial 8 (consistent with previous studies)

To Compare: “Improved Baseline” Selection

0de											
	1e1 π^{+-}	1e	1e other	1 μ 1 π^{+-}	1 μ	1 μ other	0l $^{+-}$ 1 π^+	0l $^{+-}$ 1 π^-	0l $^{+-}$ 1 π^0	0l $^{+-}$ N π	0l $^{+-}$ other
FCFV	13.08	52.30	10.20	90.54	216.44	136.26	19.53	15.01	88.74	39.20	25.13
e π -like	5.40	2.35	0.24	1.20	1.37	4.95	0.99	0.65	2.20	1.77	0.71
0 decay e	1.26	0.61	0.08	0.13	0.20	1.22	0.33	0.38	1.54	0.59	0.21
E _{rec} <1.5 GeV	0.70	0.24	0.02	0.05	0.09	0.11	0.18	0.20	1.07	0.23	0.13
1de											
	1e1 π^{+-}	1e	1e other	1 μ 1 π^{+-}	1 μ	1 μ other	0l $^{+-}$ 1 π^+	0l $^{+-}$ 1 π^-	0l $^{+-}$ 1 π^0	0l $^{+-}$ N π	0l $^{+-}$ other
FCFV	13.08	52.30	10.20	90.54	216.44	136.26	19.53	15.01	88.74	39.20	25.13
e π -like	5.40	2.35	0.24	1.20	1.37	4.95	0.99	0.65	2.20	1.77	0.71
1 decay e	4.14	1.74	0.16	1.05	1.17	3.71	0.66	0.27	0.66	1.17	0.50
E _{rec} <1.5 GeV	2.71	0.75	0.03	0.56	0.78	0.69	0.50	0.17	0.31	0.51	0.44

0de			
	sig	bkg	FOM
FCFV	13.08	693.36	
e π -like	5.40	16.43	
1 decay e	1.26	5.28	
E _{rec} <1.5 GeV	0.70	2.32	0.405

1de			
	sig	bkg	FOM
FCFV	13.08	693.36	
e π -like	5.40	16.43	
1 decay e	4.14	11.09	
E _{rec} <1.5 GeV	2.71	4.73	0.992

Approaching Systematics

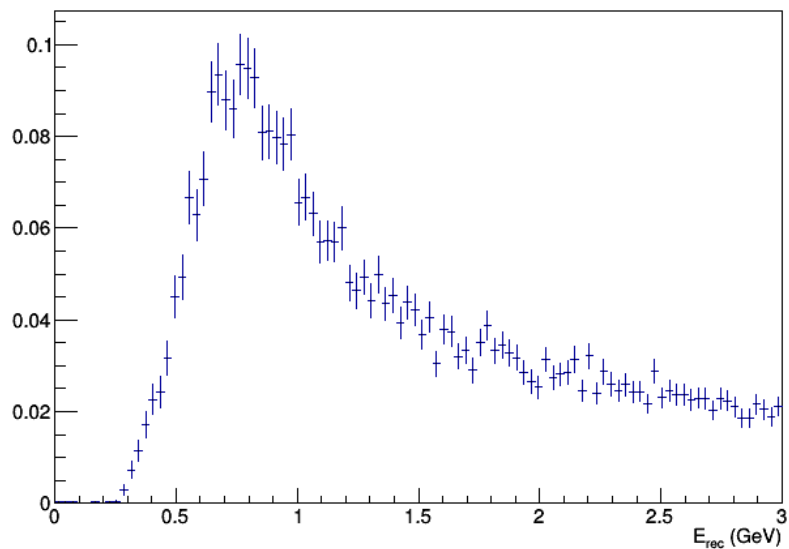
- Starting point: look at signal kinematic distributions before/after BDT
 - Understand which kinematic regions the selection is sensitive to
 - Neutrino interaction uncertainties
 - Explore other event generators (NUWRO, GENIE)
 - Single and multi-pion variations
 - BDT for re-weighting MC to different generators? (Cris)
 - Pion hadronic interactions (FSI and SI uncertainties)
 - TN325 (Elder) on tuning of the NEUT cascade model
 - Throws of possible FSI parameter set values using covariance matrix from TN325
 - Detector systematics
 - Try to develop hybrid samples for different backgrounds
- } Starting this week

Kinematic Response Plots

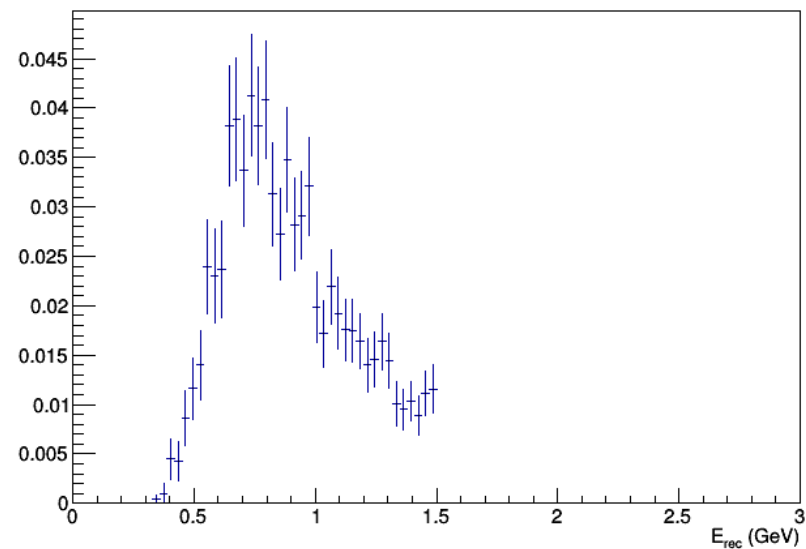
- Signal:
 - $E_{\text{rec}}, p_e^{\text{rec}}, p_{\pi}^{\text{rec}}, \cos(\theta_{e\pi}^{\text{rec}}), E_{\nu}, p_e^{\text{tru}}, p_{\pi}^{\text{tru}}, \cos(\theta_{e\pi}^{\text{tru}})$
- Background:
 - $E_{\text{rec}}, p_e^{\text{rec}}, p_{\pi}^{\text{rec}}, \cos(\theta_{e\pi}^{\text{rec}}), E_{\nu}$
 - not shown here, but plots are available
- 3 sets of plots:
 - FCFV cut
 - pre-BDT cuts
 - post-BDT

0de: E_{rec}

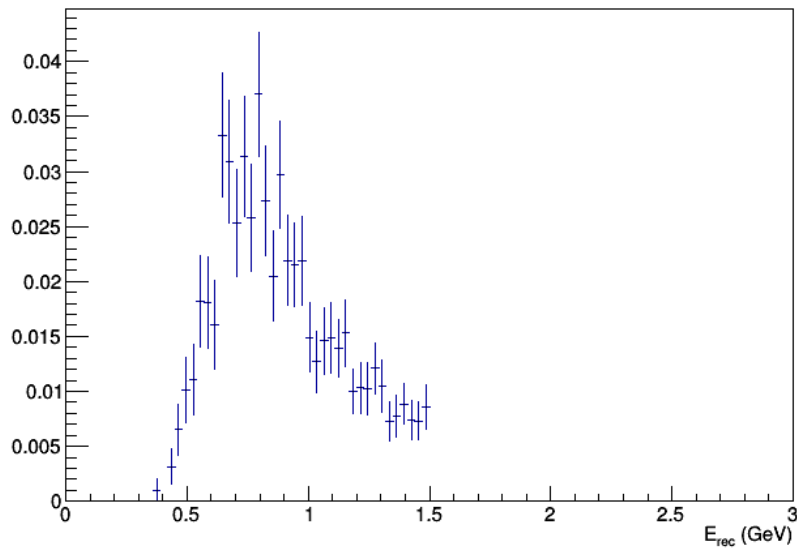
Sig E_{rec} FCFV events



Sig E_{rec} before BDT

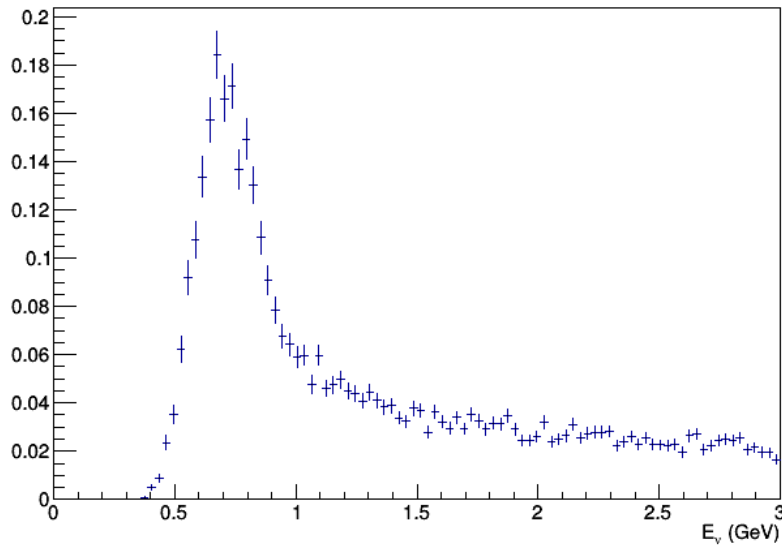


Sig E_{rec} after BDT

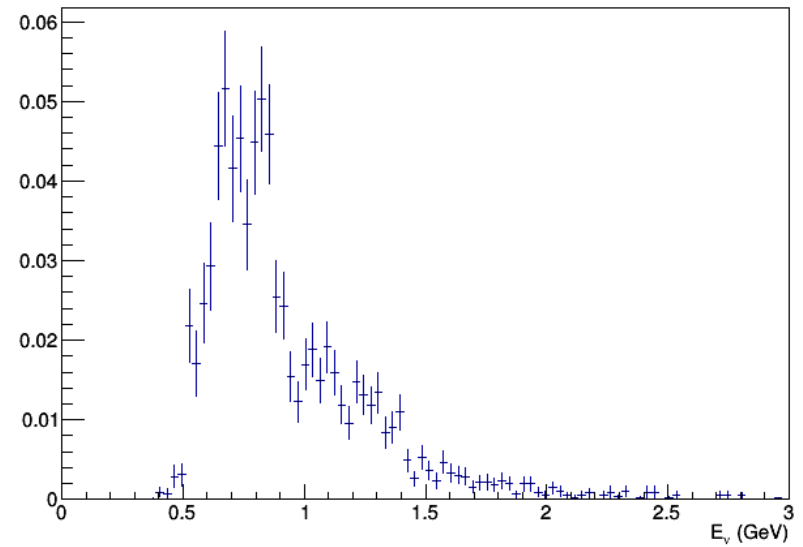


Ode: E_ν

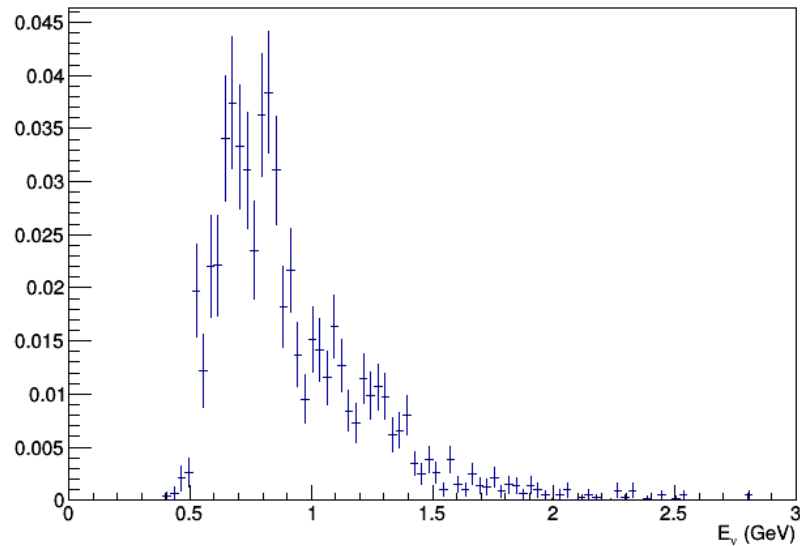
Sig E_ν FCFV events



Sig E_ν before BDT

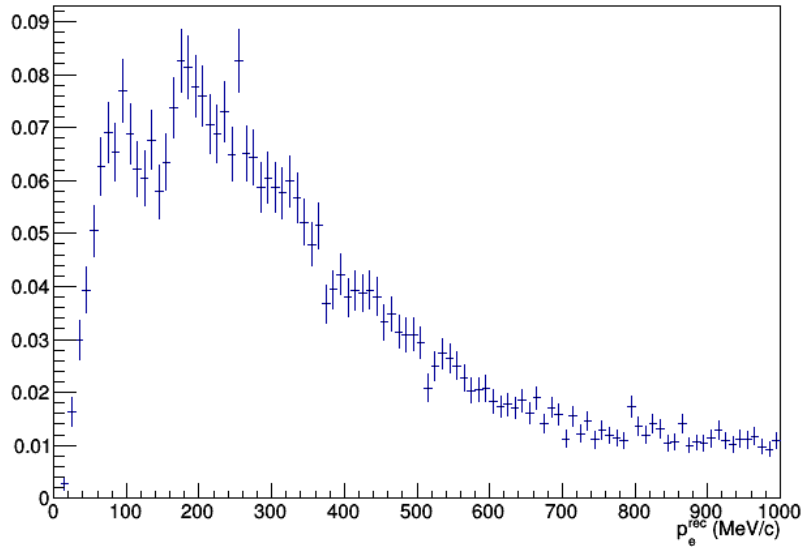


Sig E_ν after BDT

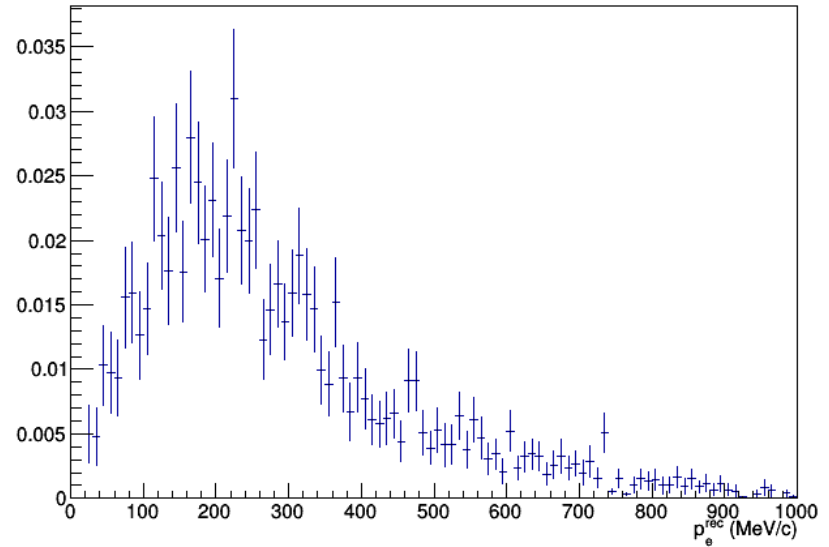


0de: p_e^{rec}

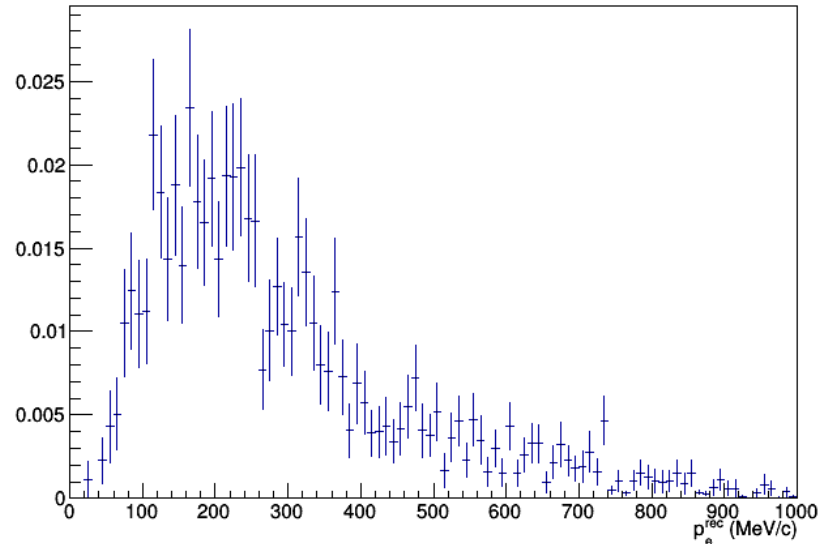
Sig p_e^{rec} FCFV events



Sig p_e^{rec} before BDT

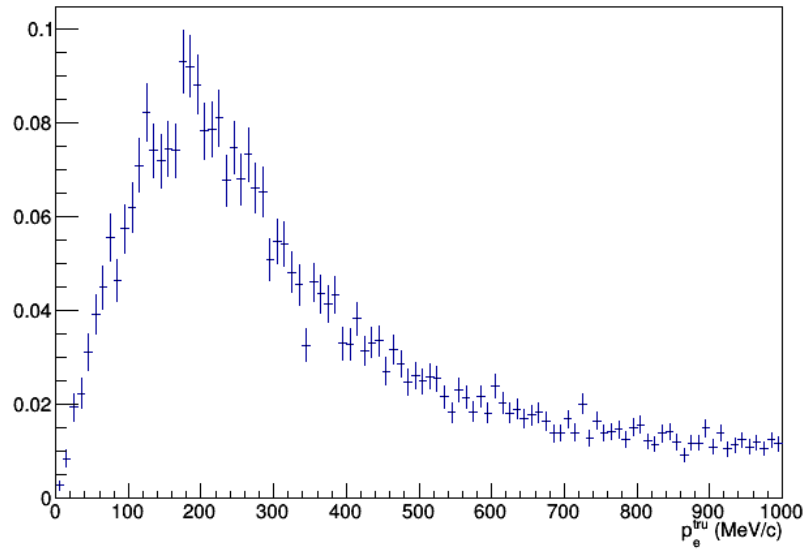


Sig p_e^{rec} after BDT

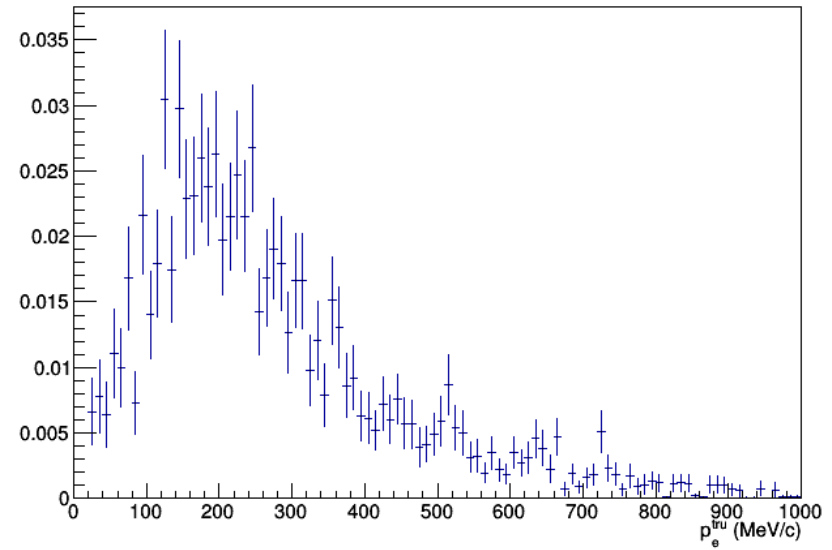


0de: p_e^{tru}

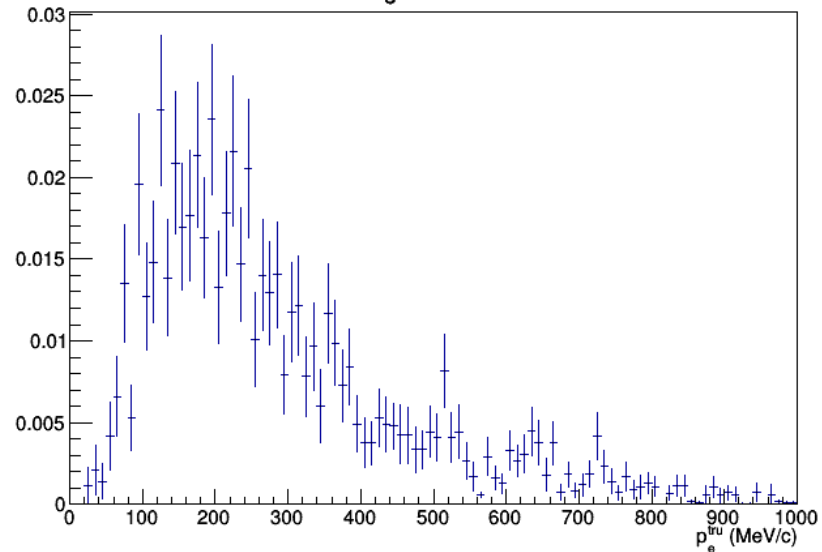
Sig p_e^{tru} FCFV events



Sig p_e^{tru} before BDT

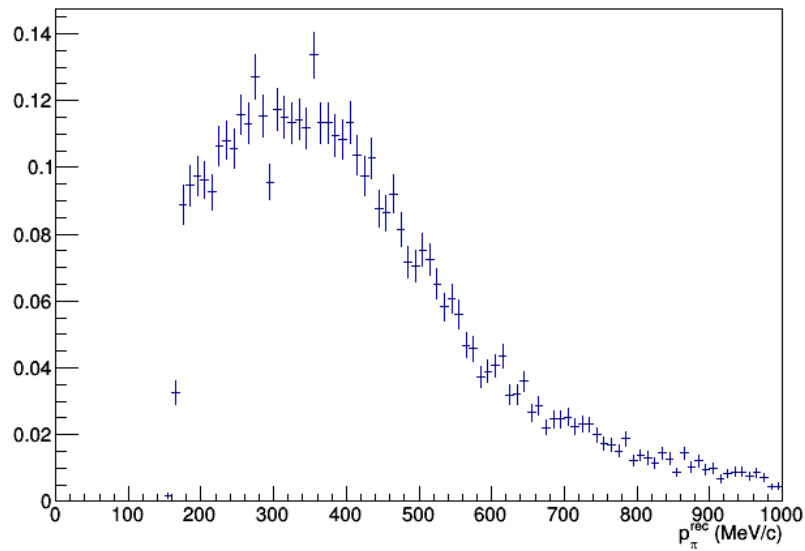


Sig p_e^{tru} after BDT

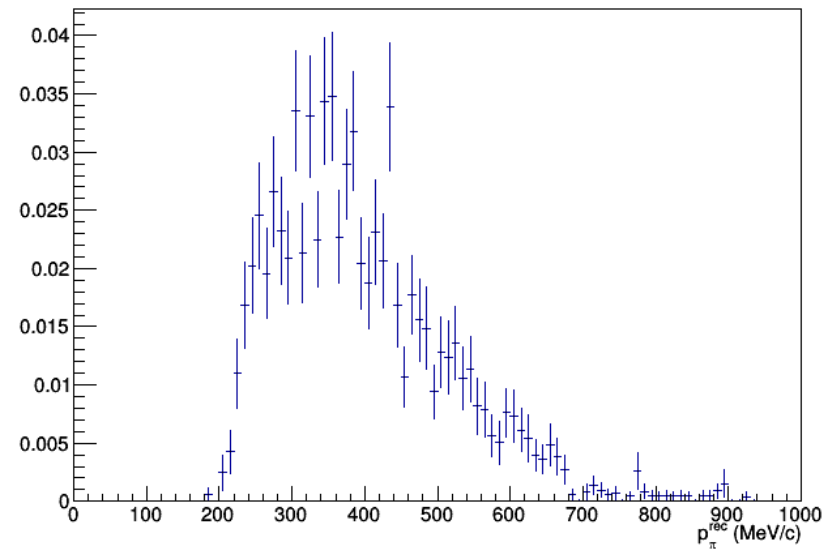


0de: p_{π}^{rec}

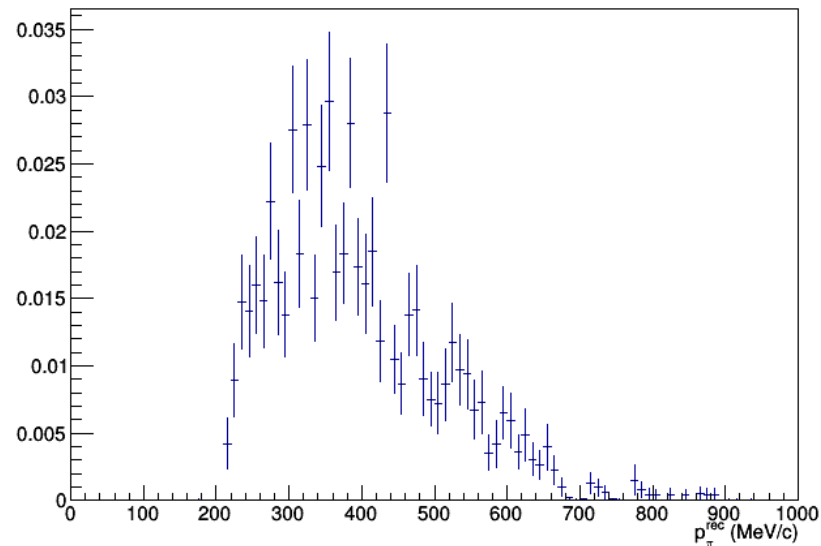
Sig p_{π}^{rec} FCFV events



Sig p_{π}^{rec} before BDT

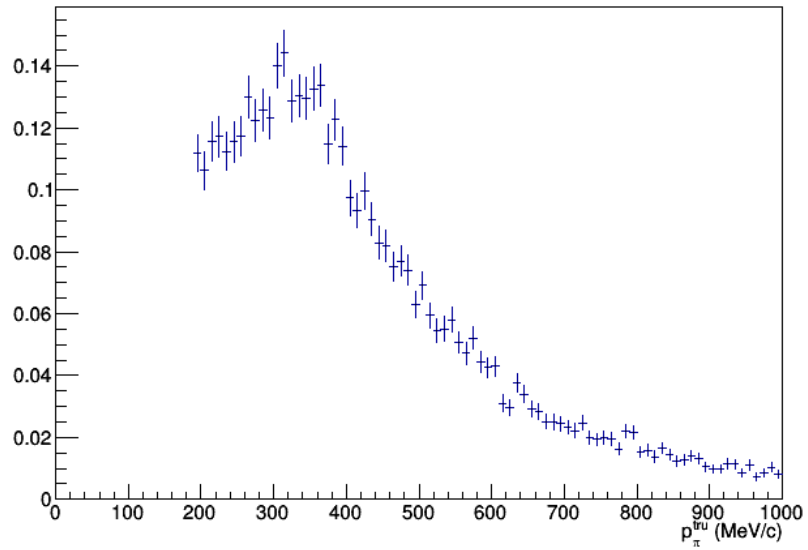


Sig p_{π}^{rec} after BDT

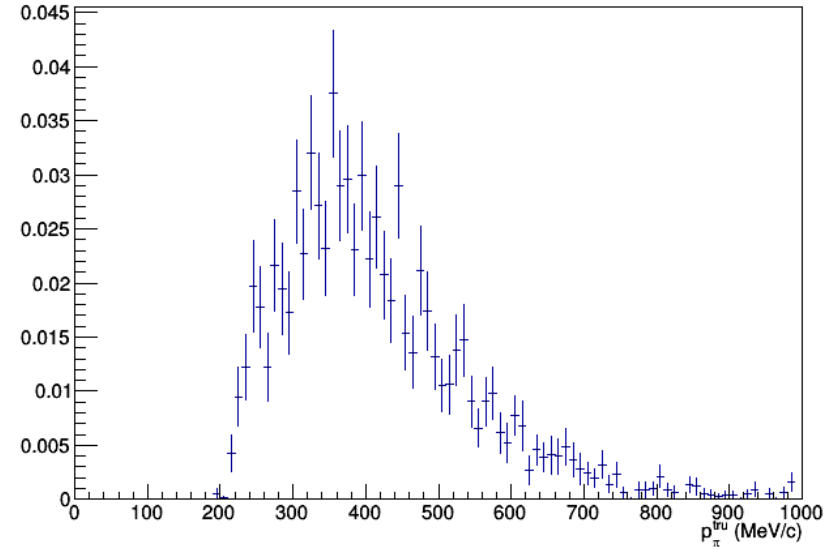


0de: p_{π}^{tru}

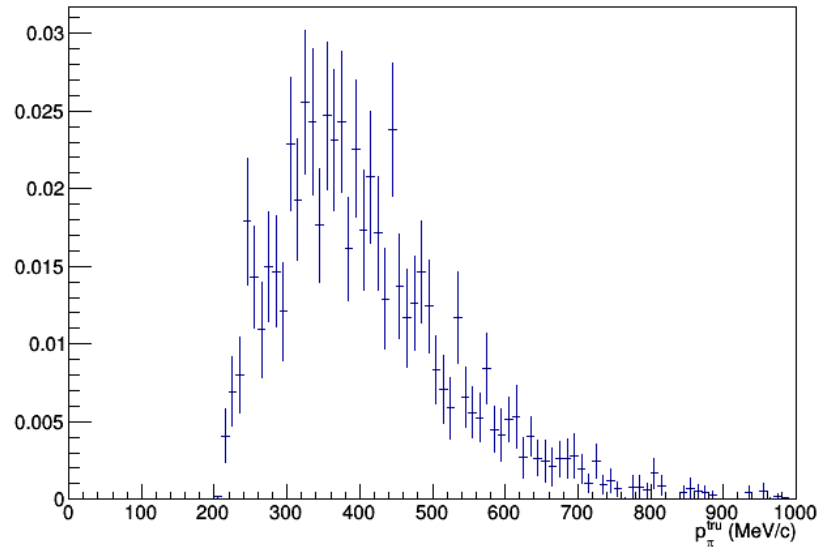
Sig p_{π}^{tru} FCFV events



Sig p_{π}^{tru} before BDT

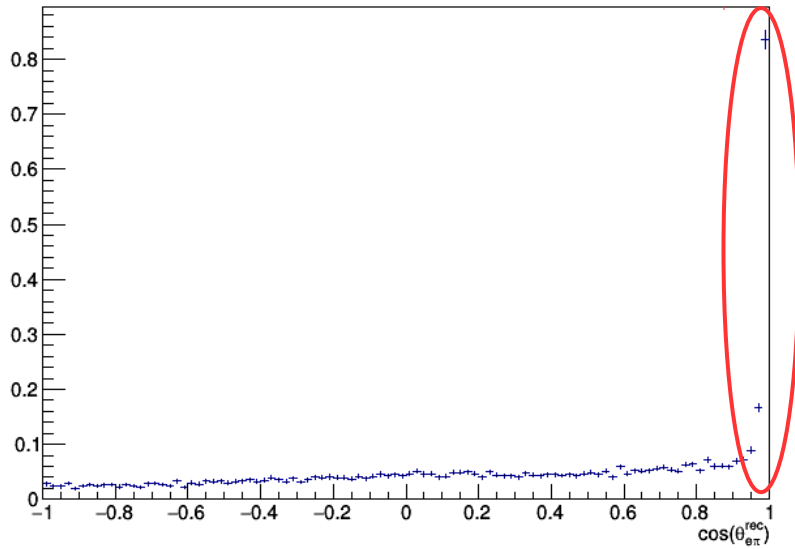


Sig p_{π}^{tru} after BDT

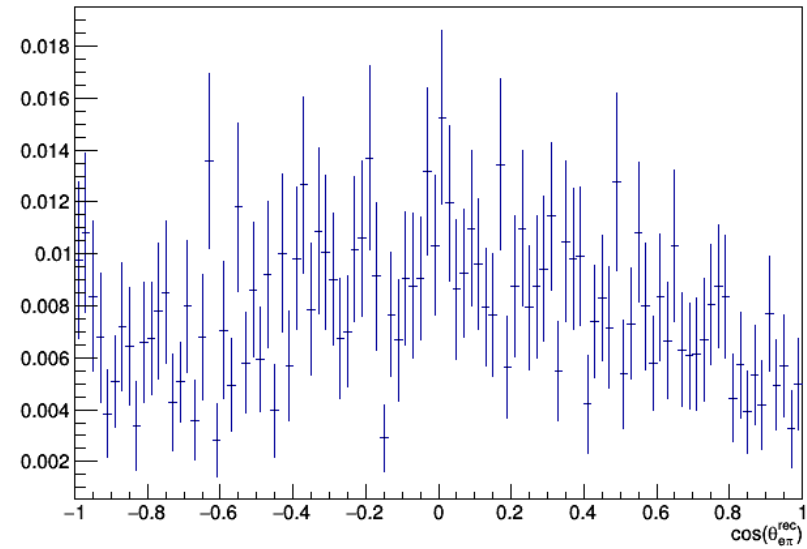


0de: $\cos(\theta_{e\pi}^{\text{rec}})$

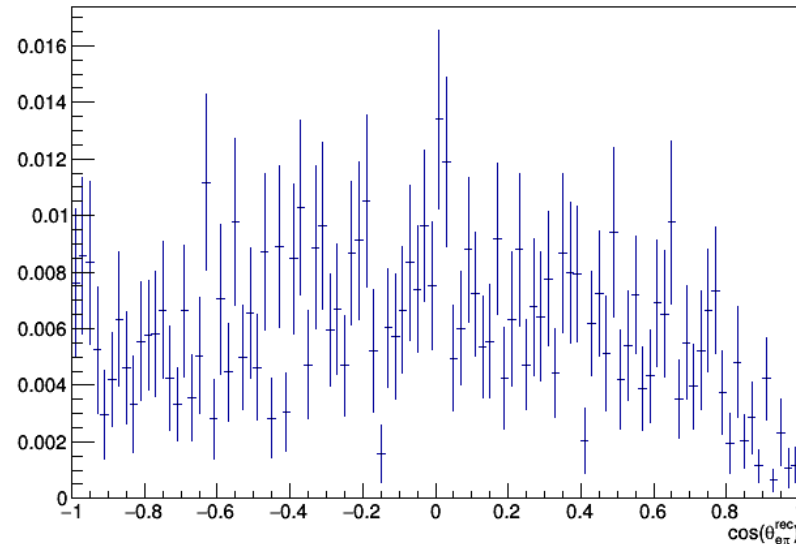
Sig $\cos(\theta_{e\pi}^{\text{rec}})$ FCFV events



Sig $\cos(\theta_{e\pi}^{\text{rec}})$ before BDT

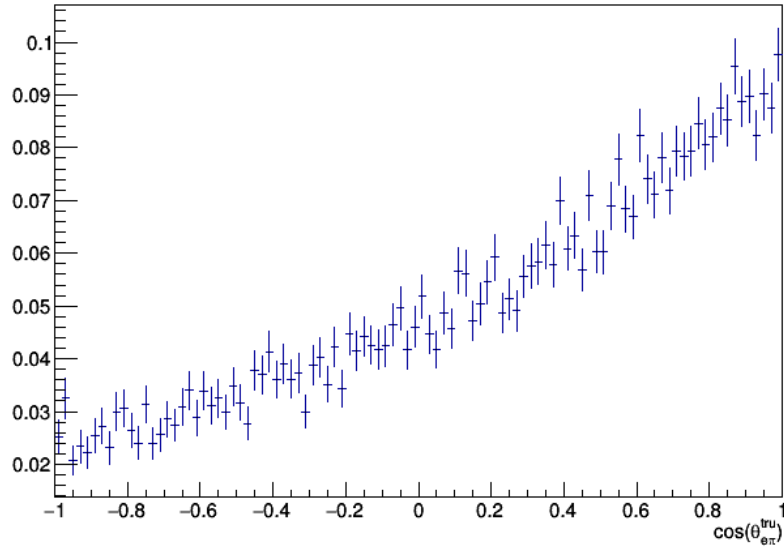


Sig $\cos(\theta_{e\pi}^{\text{rec}})$ after BDT

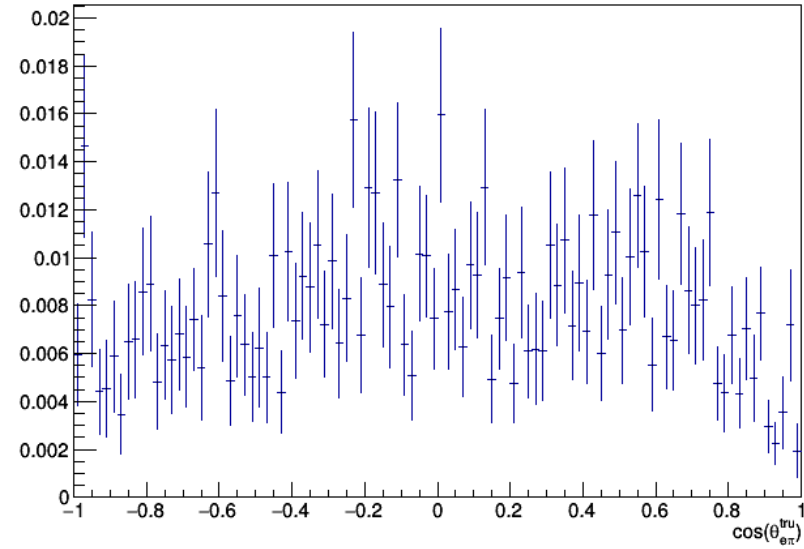


Ode: $\cos(\theta_{e\pi}^{\text{tru}})$

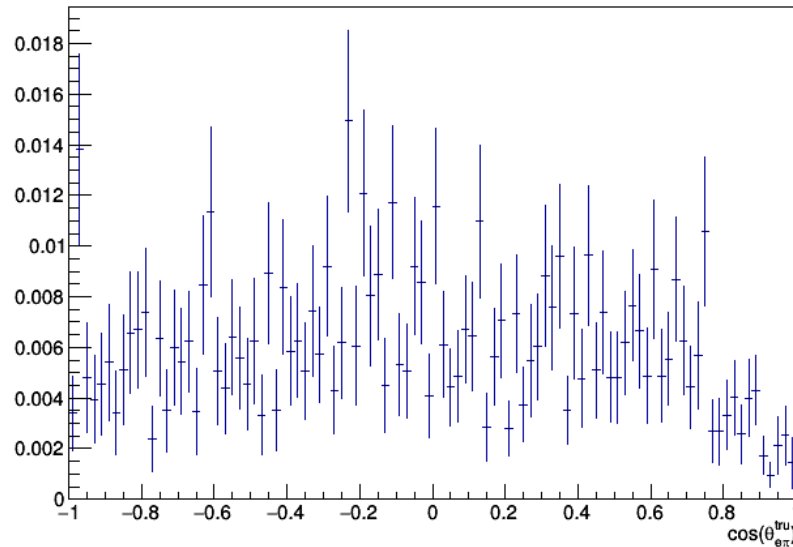
Sig $\cos(\theta_{e\pi}^{\text{tru}})$ FCFV events



Sig $\cos(\theta_{e\pi}^{\text{tru}})$ before BDT

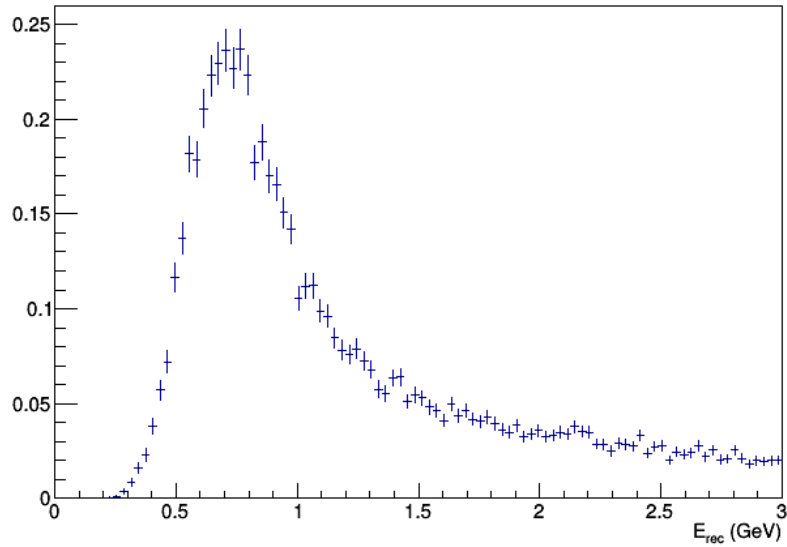


Sig $\cos(\theta_{e\pi}^{\text{tru}})$ after BDT

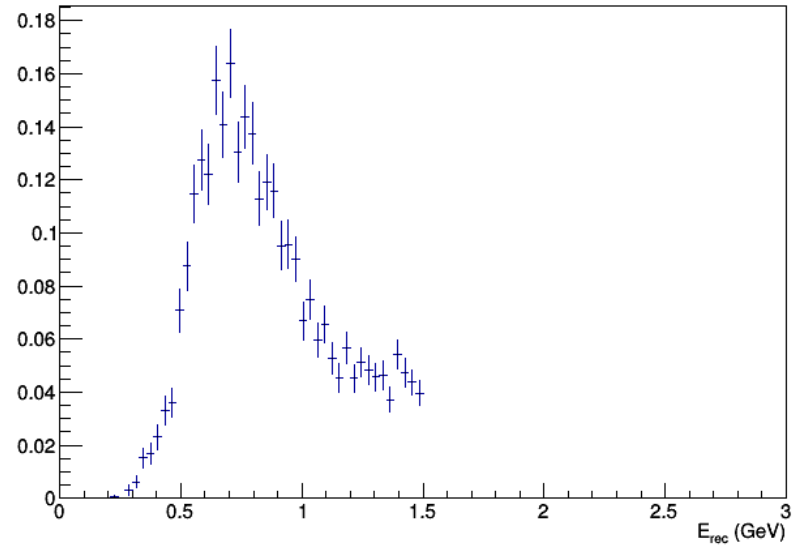


1de: E_{rec}

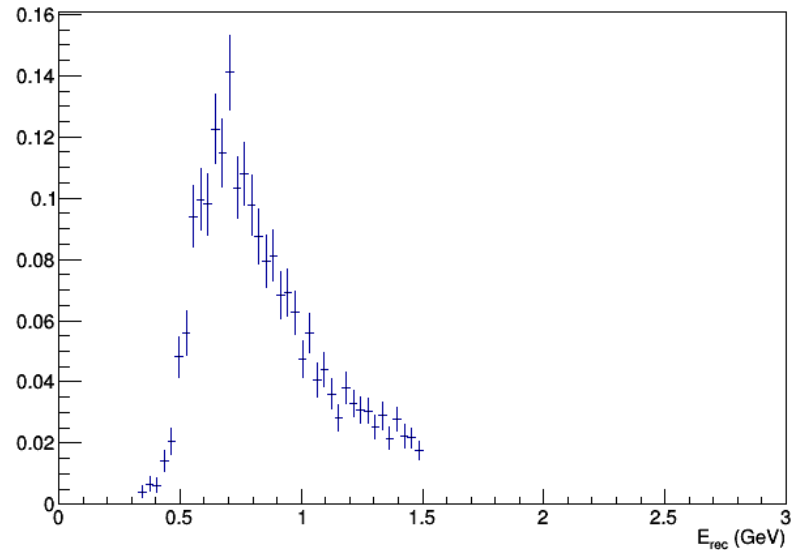
Sig E_{rec} FCFV events



Sig E_{rec} before BDT

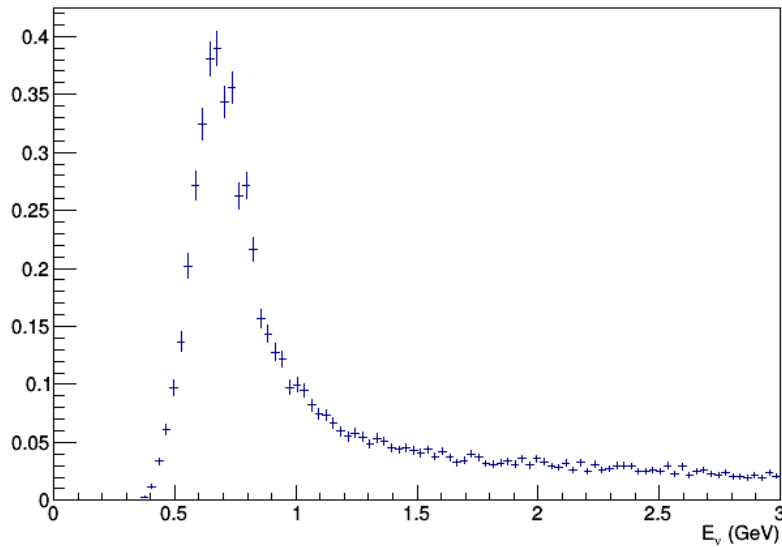


Sig E_{rec} after BDT

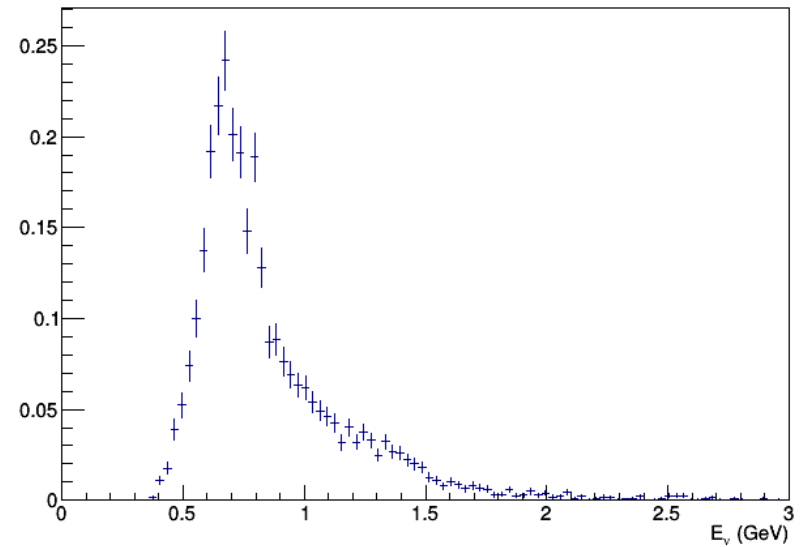


1de: E_ν

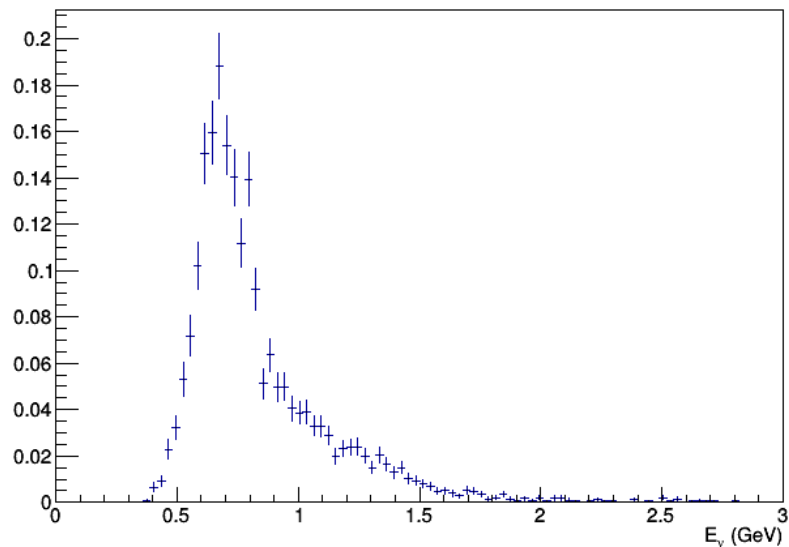
Sig E_ν FCFV events



Sig E_ν before BDT

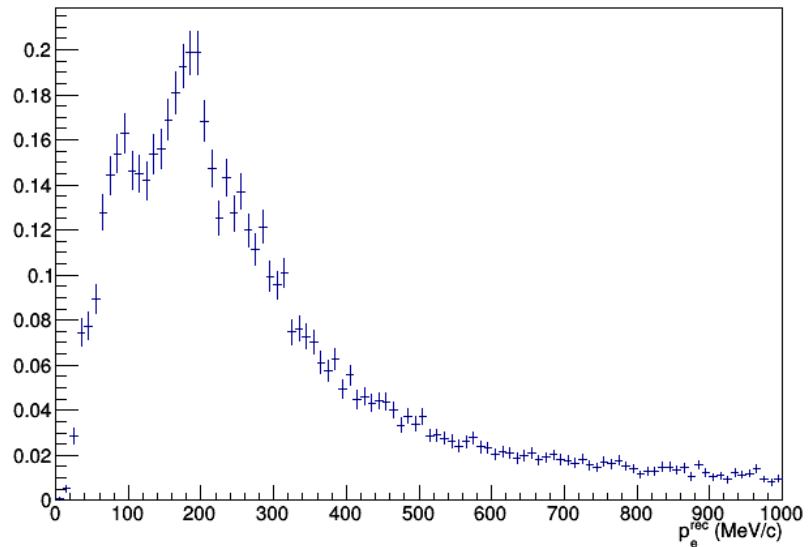


Sig E_ν after BDT

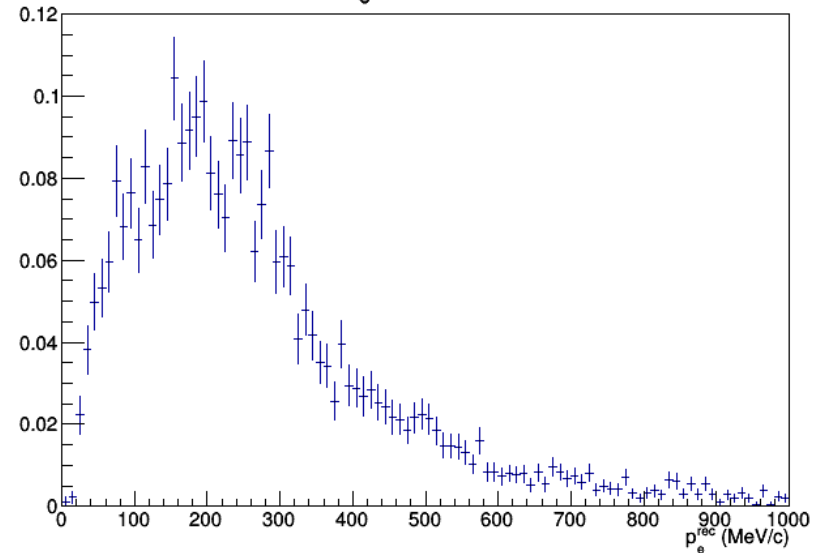


1de: p_e^{rec}

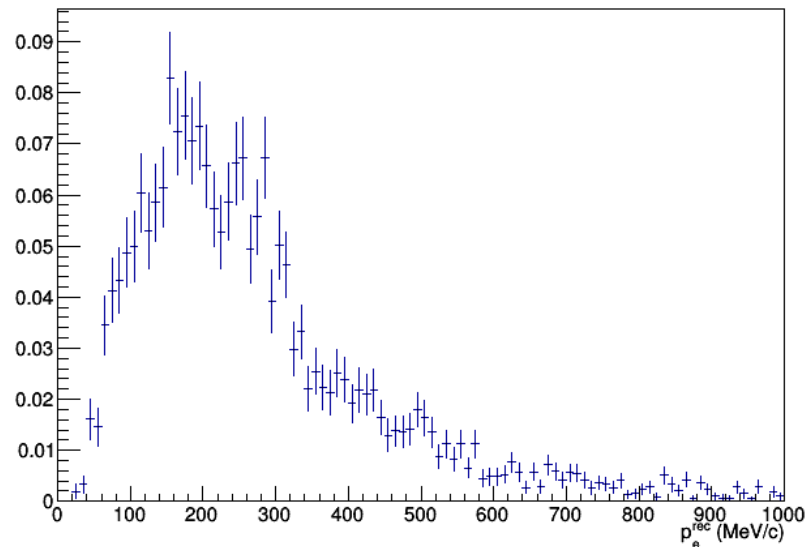
Sig p_e^{rec} FCFV events



Sig p_e^{rec} before BDT

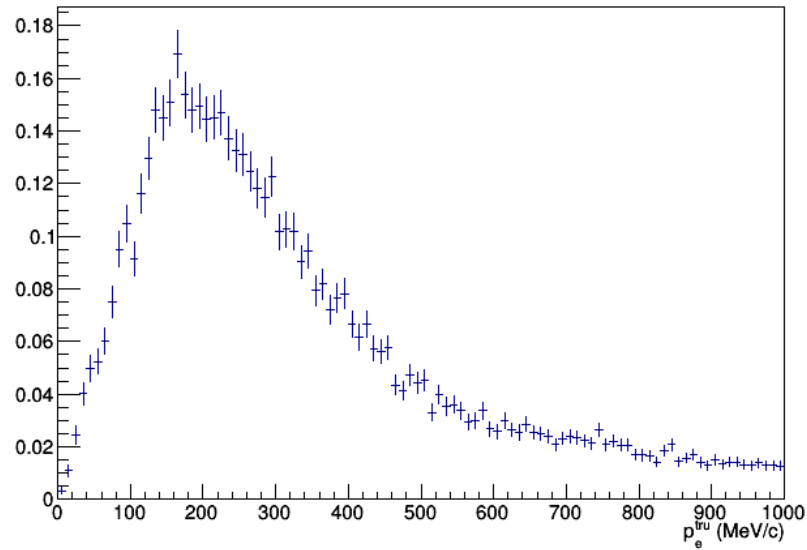


Sig p_e^{rec} after BDT

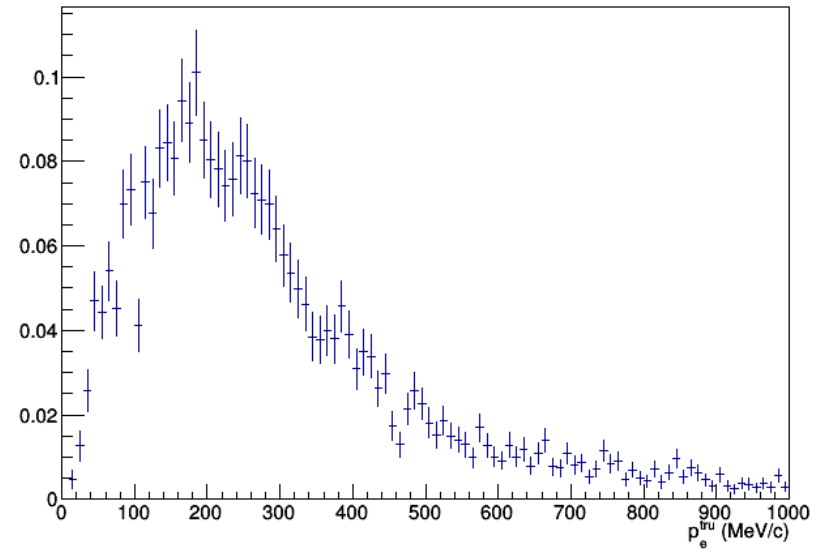


1de: p_e^{tru}

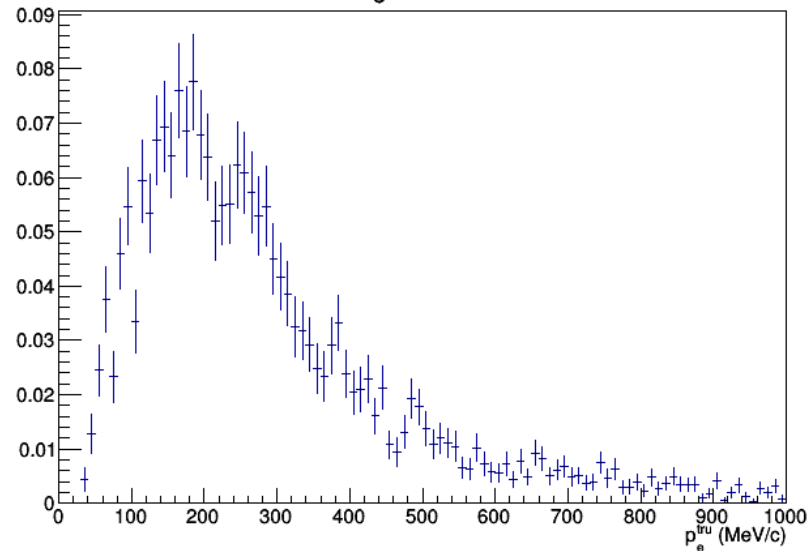
Sig p_e^{tru} FCFV events



Sig p_e^{tru} before BDT

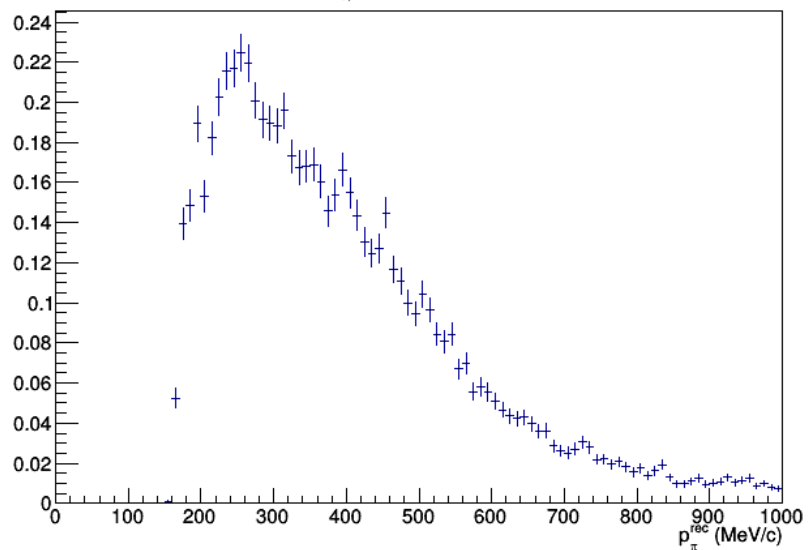


Sig p_e^{tru} after BDT

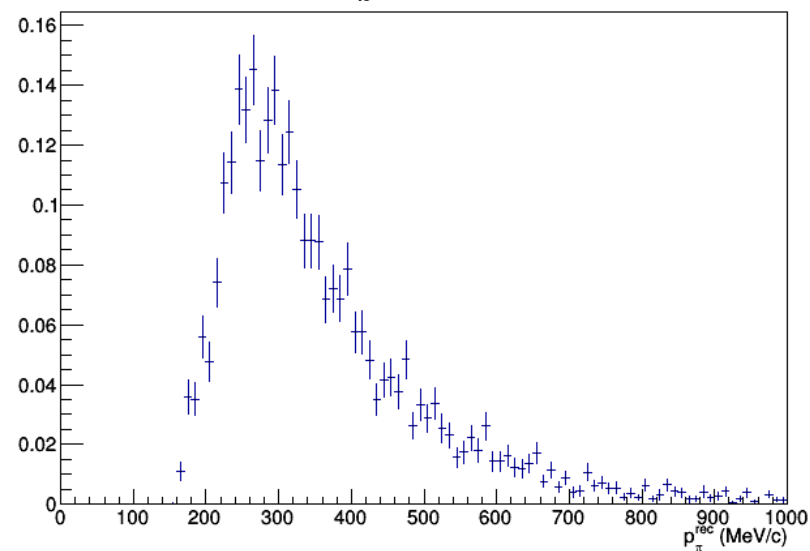


1de: p_{π}^{rec}

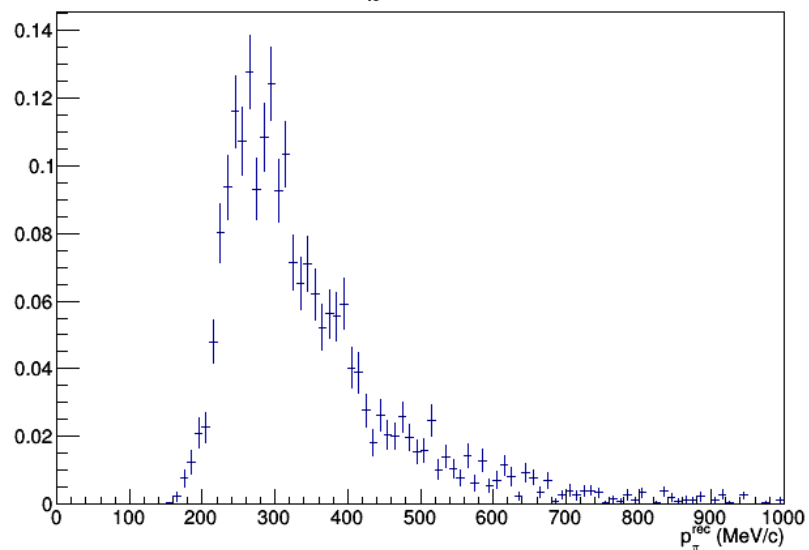
Sig p_{π}^{rec} FCFV events



Sig p_{π}^{rec} before BDT

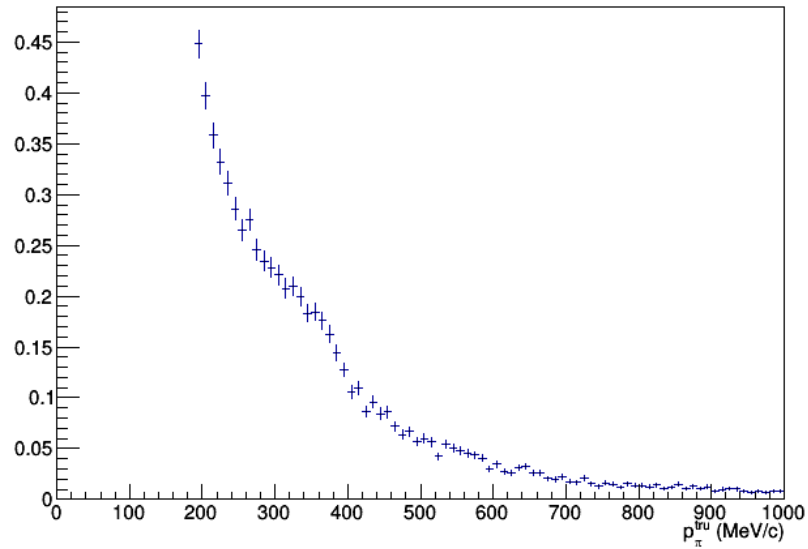


Sig p_{π}^{rec} after BDT

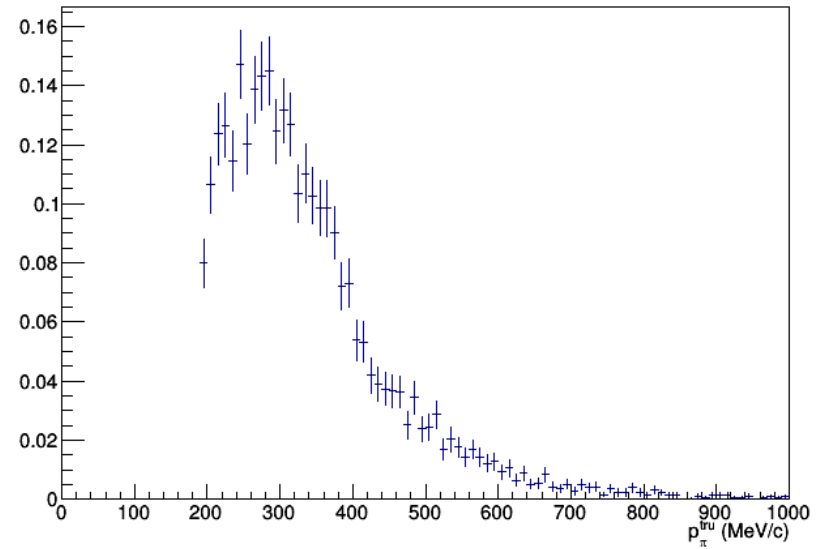


1de: p_{π}^{tru}

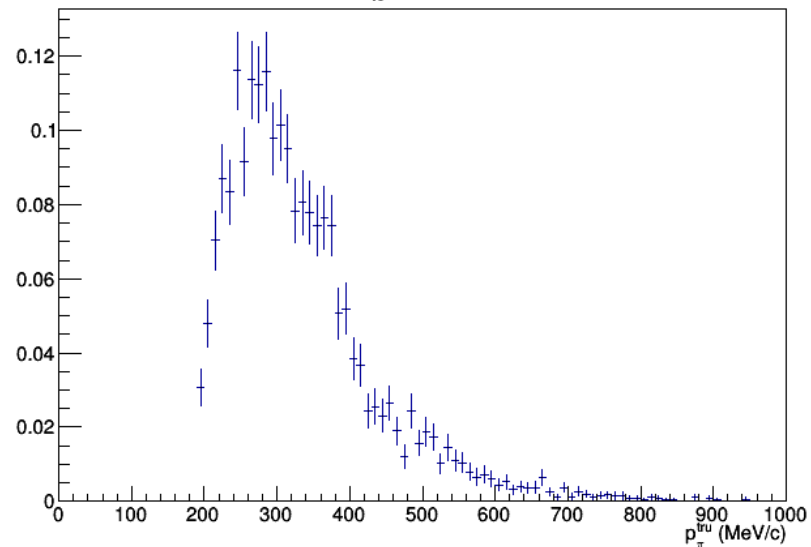
Sig p_{π}^{tru} FCFV events



Sig p_{π}^{tru} before BDT

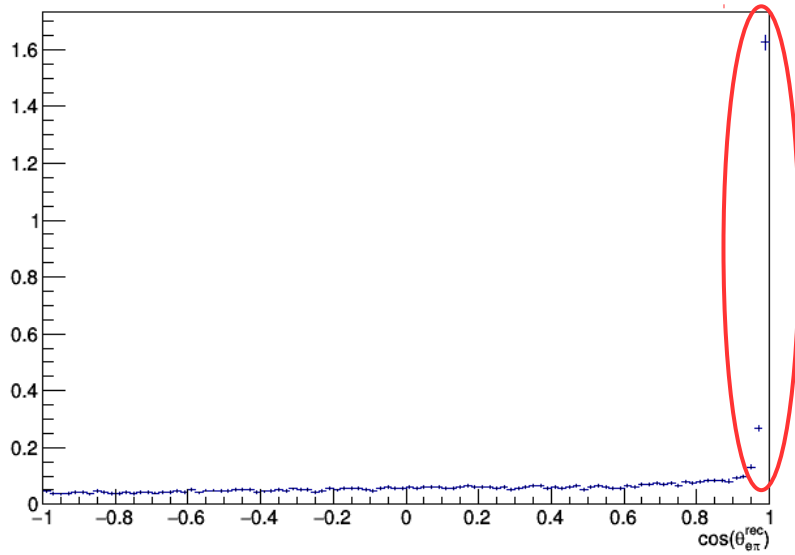


Sig p_{π}^{tru} after BDT

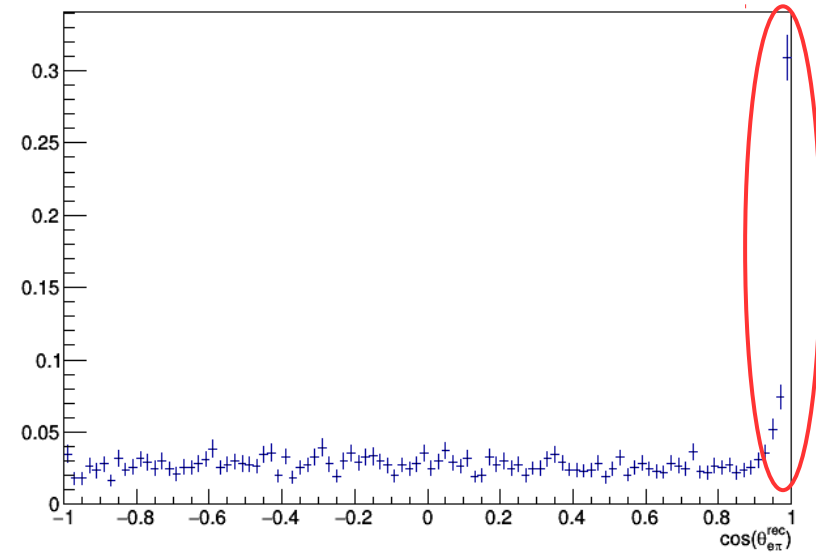


1de: $\cos(\theta_{e\pi}^{\text{rec}})$

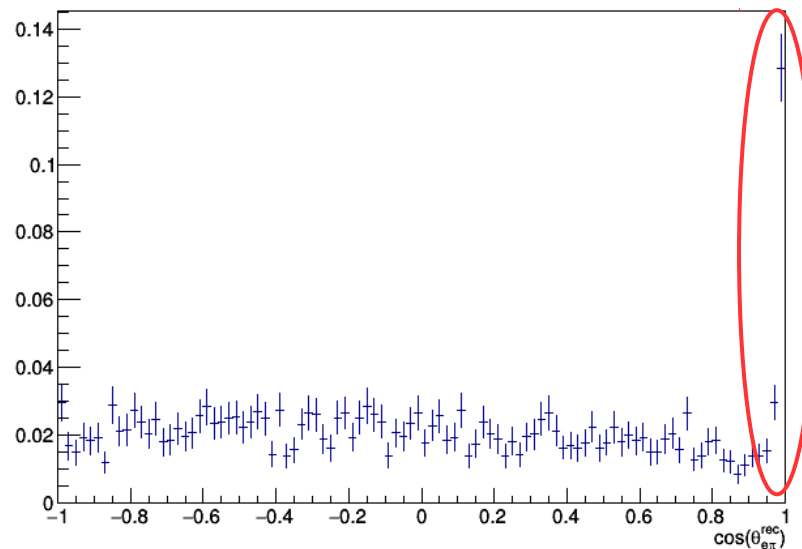
Sig $\cos(\theta_{e\pi}^{\text{rec}})$ FCFV events



Sig $\cos(\theta_{e\pi}^{\text{rec}})$ before BDT

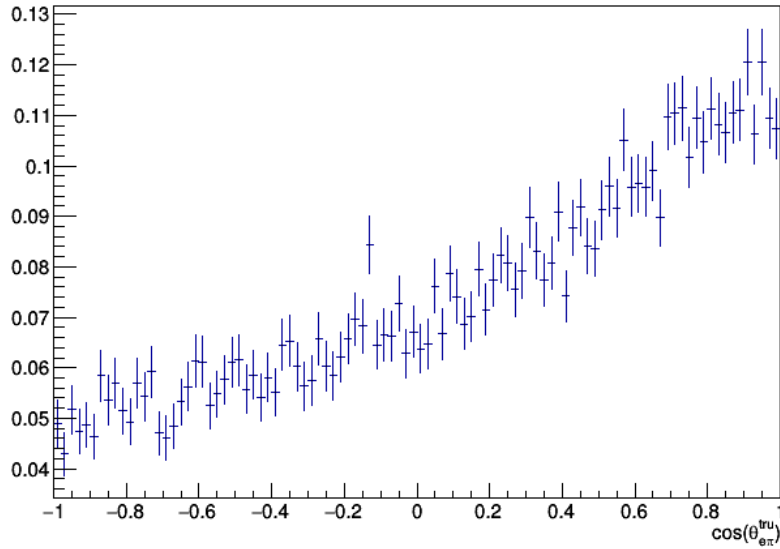


Sig $\cos(\theta_{e\pi}^{\text{rec}})$ after BDT

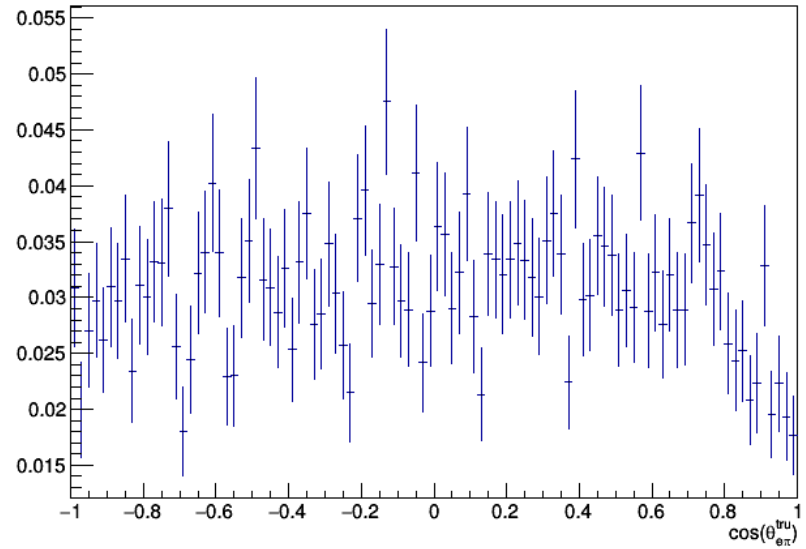


1de: $\cos(\theta_{e\pi}^{\text{tru}})$

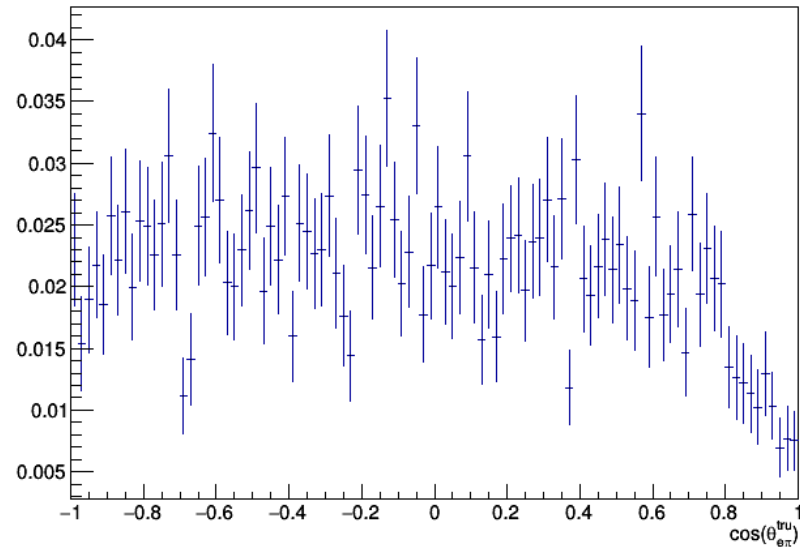
Sig $\cos(\theta_{e\pi}^{\text{tru}})$ FCFV events



Sig $\cos(\theta_{e\pi}^{\text{tru}})$ before BDT



Sig $\cos(\theta_{e\pi}^{\text{tru}})$ after BDT



Current/Future Work

- Starting to look at using other generators on NEUT cluster
 - GENIE, NUWRO, any others?
 - Study neutrino interaction uncertainties
 - Can also investigate BDT over-training with different test samples