tth study
Lepton ID with BDT

2015/02/27

Yuji Sudo

training and test sample

signal : e, mu, tau(e), tau(mu), tau(1-prong), tau(3-prong)
training and test samples: tth→2l2nbbbb

background: mu, tau(e), tau(mu), tau(1-prong), tau(3-prong), b jet, lf jet
training and test samples: ttZ for light flavor jet
: tth→2l2nbbbb for the other background

- PFOs which can be traced to MC information are used to make samples.

BDTs:

Backgrounds

Signals

	e	mu	tau(e)	tau(mu)	tau 1-prong	tau 3-prong	bjet	lf jet
e	-	x	x	x	x	x	x	x
mu		-	x	x	x	x	x	x
tau(e)			-	x	x	x	x	x
tau(mu)				-	x	x	x	x
tau(1-prong)					-	x	x	x
tau(3-prong)						-	x	x

Input variables

Input variables are choseh from the following parameters

- hadOvEM: E_{hcal}/E_{ecal}
- calEovE: $(E_{hcal}+E_{ecal})/Epfo$
- coneE2woSeed: E_{cone2} without seed E_{PFO}
- isoCutOld: $6(E_{PFO}-15)^2 - (coneE2woSeed)^2$
- pfoR0 : $sqrt(trkD0^2+trkZ0^2)$
- coneE1OvConeE2: E_{cone1}/E_{cone2}
- coneMass1: reconstructed mass with PFOs in cone1
- coneMass3: reconstructed mass with PFOs in cone3
- clusterShape0: $\chi 2$ of fit
- clusterShape1: maximum deposited energy (GeV)
- clusterShape2: shower Max (mm)
- clusterShape3: transverse absorption length(mm)
- clusterShape5: shower Max/ Expected shower Max
- clusterShape16: xl20 (mm)
- yokuE: deposited energy in the yoku
- pfoe: PFO energy
- pt: Pt of PFO
- cone1E
- maxTrkEInCone13: Maximum energy of a PFO with track between cone1 and cone2
- nNeutralCone1: Number of PFOs with no track in cone1
- eNeutralCone1: Energy sum of PFOs with no track in cone1

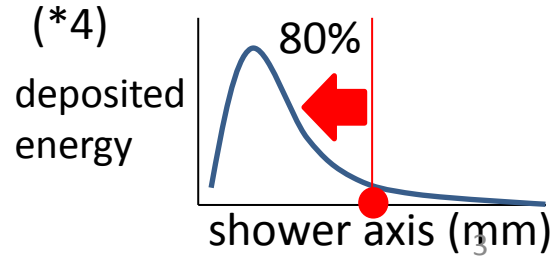
(*1) cone1: $\cos\theta>0.99$
cone2: $\cos\theta>0.98$
cone3: $\cos\theta>0.93$

(*2)cluster shape variables
- choose the highest energy cluster
- electron shower shaped is used to fit

(*3) transverse absorption length : distance btw shower center and location where cluster energy goes down to 1/e

(*4) xl20:length to the positon where the deposited energy reaches 80 % of total energy on shower axis

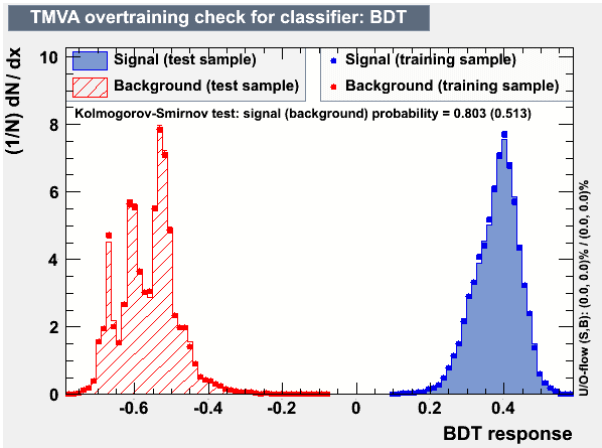
(*4)



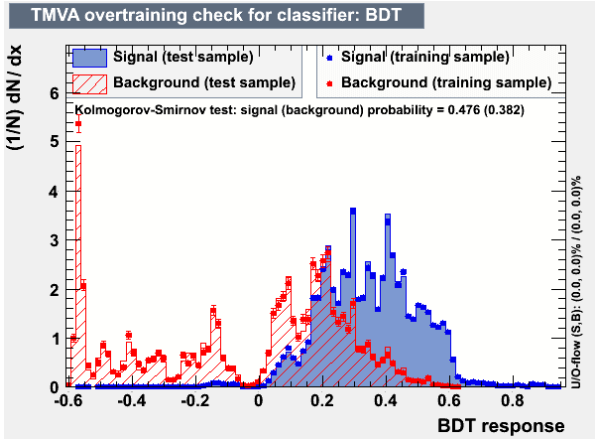
BDT Output, signal: electron

pre-cut : PFO energy > 2 GeV, PFO with track
additional pre-cut for electron or muon: PFO energy > 5 GeV

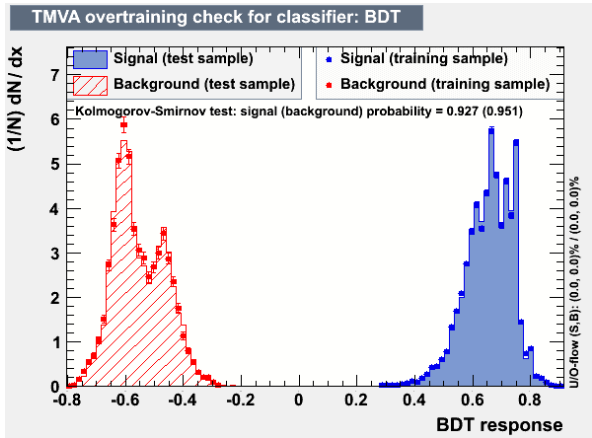
background: muon



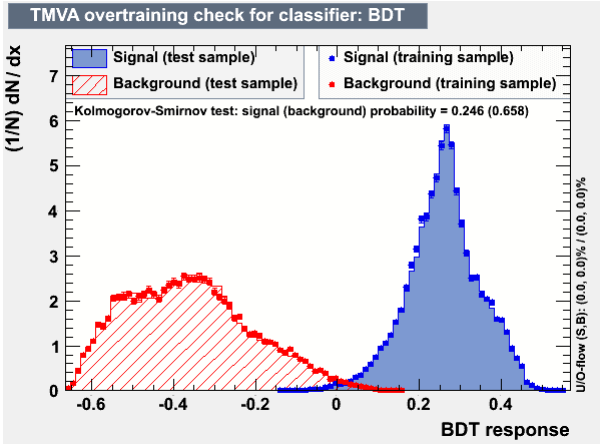
background: tau(e)



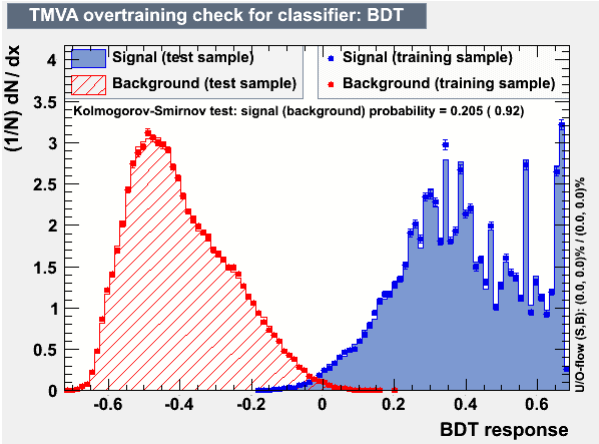
background: tau (μ)



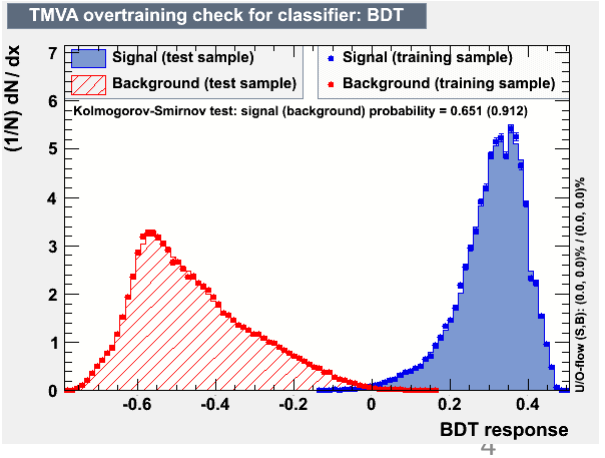
background: tau(h)



background: b jet



background: lf jet

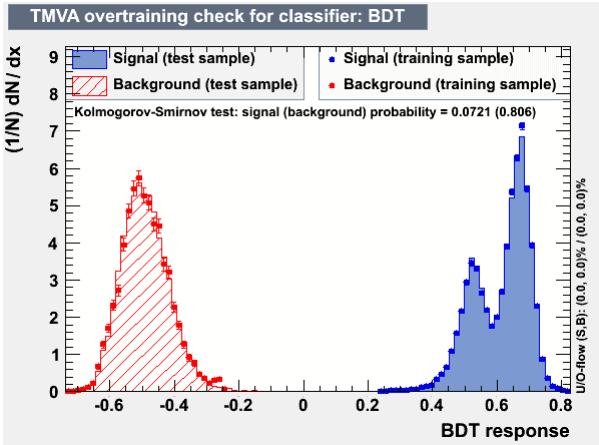


BDT Output, signal: muon

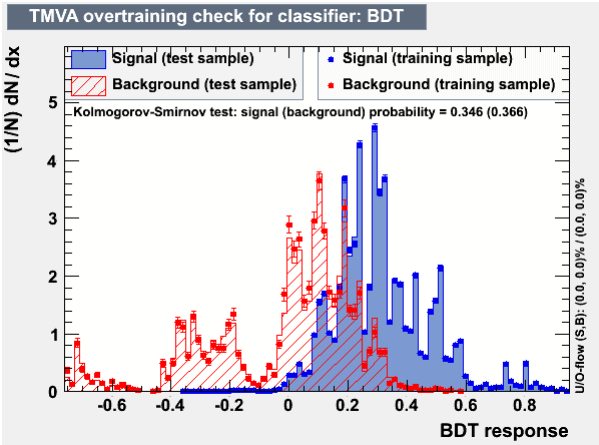
pre-cut : PFO energy > 2 GeV, PFO with track
additional pre-cut for electron or muon: PFO energy > 10 GeV

background: muon

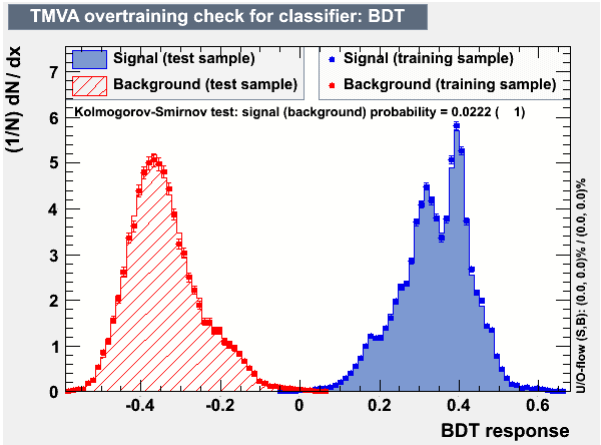
background: tau(e)



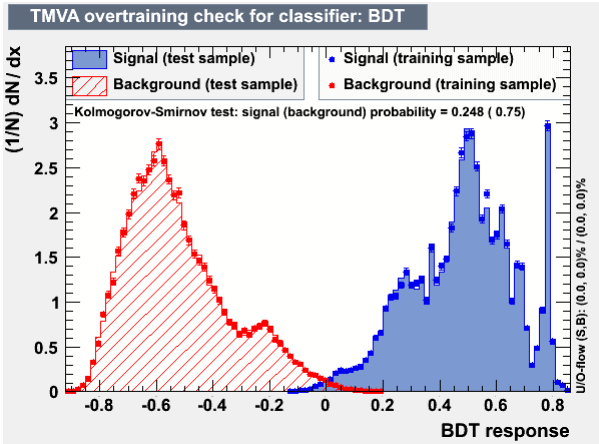
background: tau (μ)



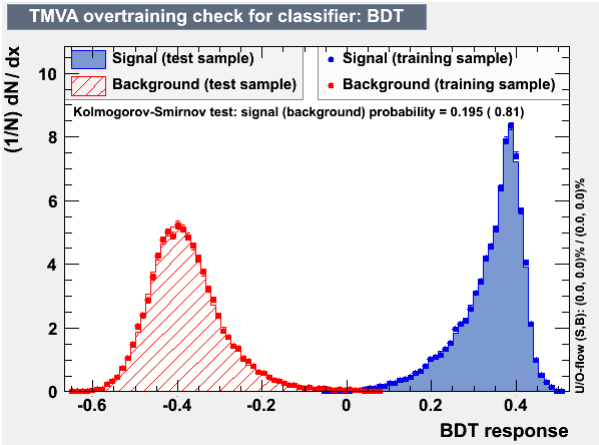
background: tau(h)



background: b jet



background: lf jet



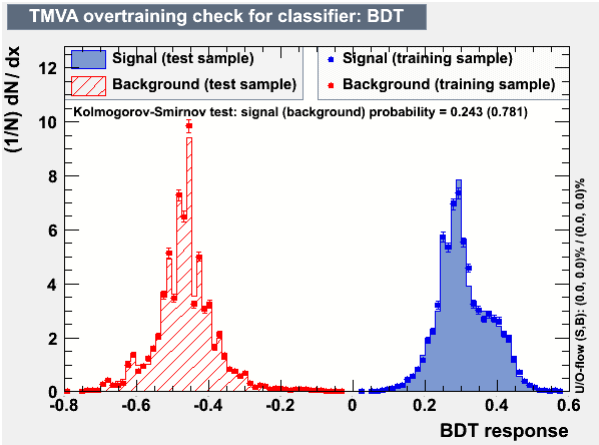
BDT Output, signal: tau(e)

pre-cut : PFO energy > 2 GeV, PFO with track

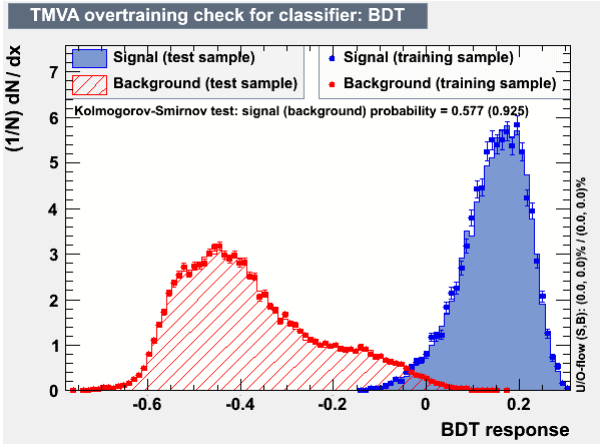
background: muon

background: tau(e)

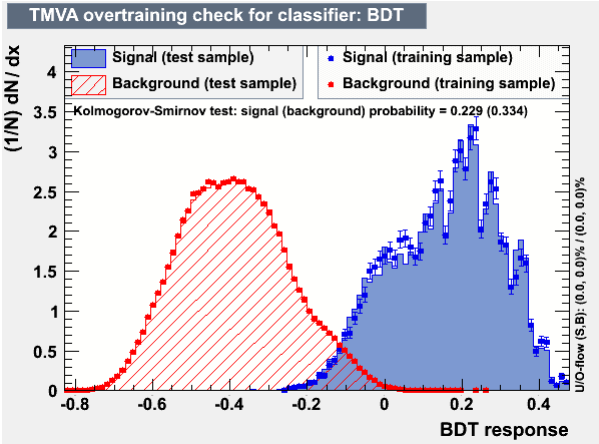
background: tau (μ)



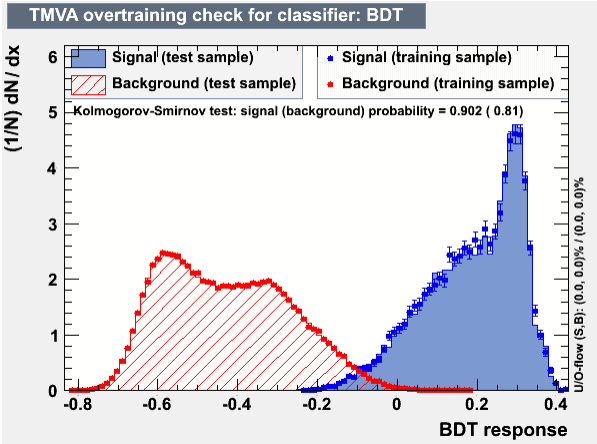
background: tau(h)



background: b jet



background: lf jet



BDT Output, signal: tau(m)

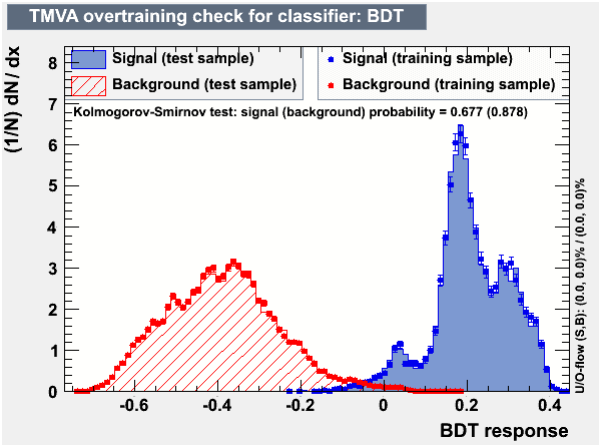
pre-cut : PFO energy > 2 GeV, PFO with track

background: muon

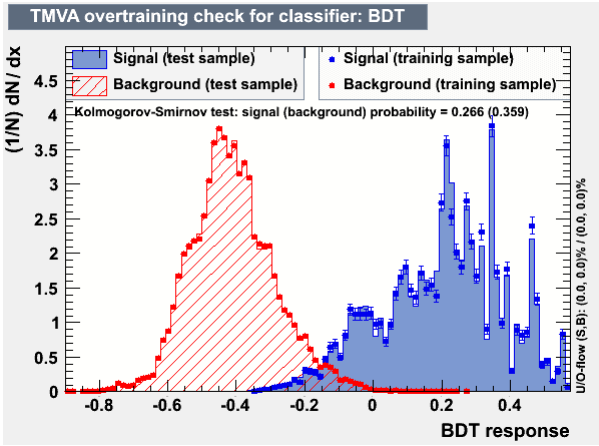
background: tau(e)

background: tau (μ)

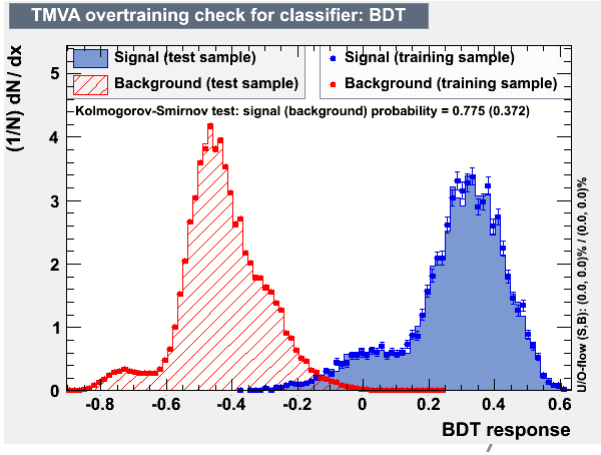
background: tau(h)



background: b jet



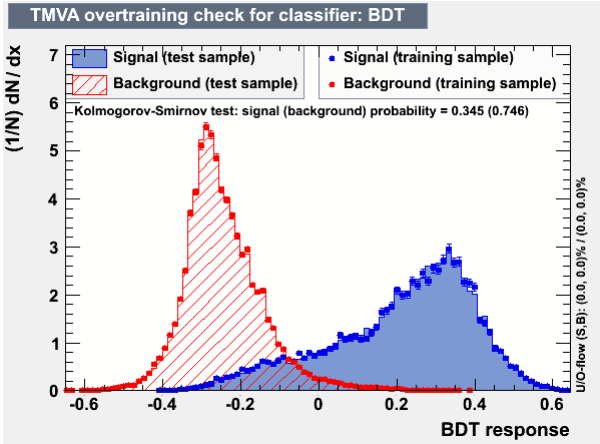
background: lf jet



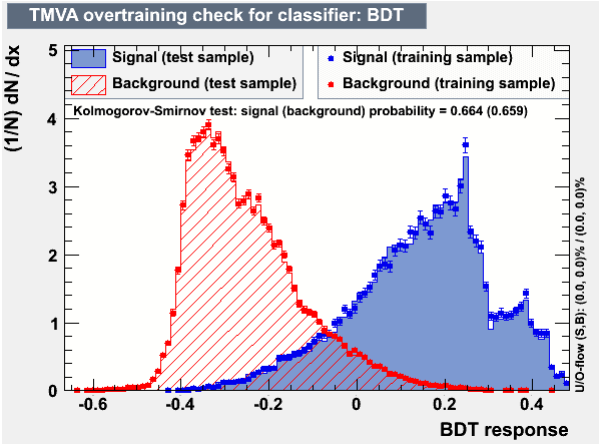
BDT Output, signal:
tau 1-prong (top), tau 3-prong (bottom)

pre-cut : PFO energy > 2 GeV, PFO with track

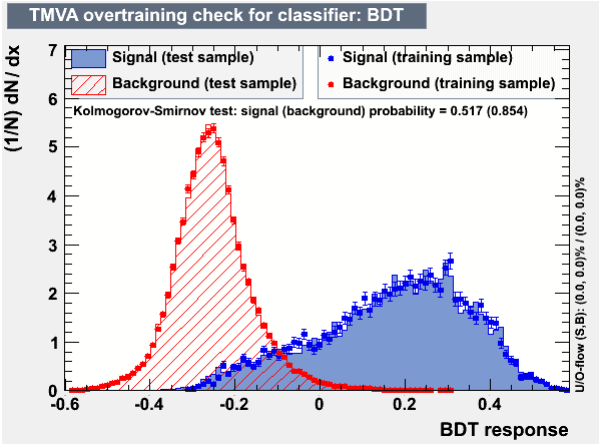
background: b jet



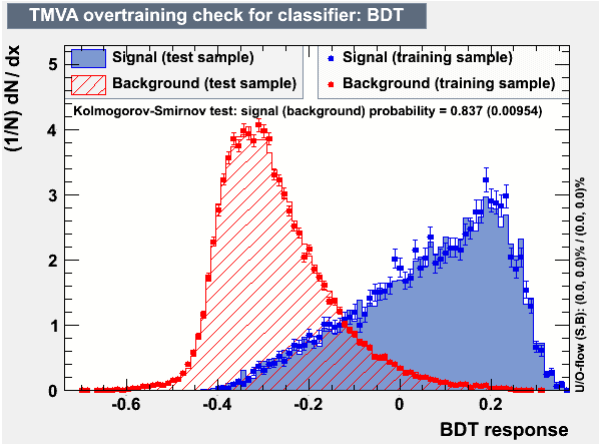
background: lf jet



background: b jet



background: lf jet



tth 2l2n

- Lepton ID efficiency with TMVA BDT (cut base) lepton selection

* in this table,
0 means less than 0.01%

particles

Selection

(%)	elec	muon	taue	taum	tauh1	tauh3	bjet	ljet
elec	92 (85.08)	0 (0)	43.42 (28.82)	0 (0)	0.42 (0.31)	0 (0.06)	0 (0)	N/A
muon	0 (0)	95.11 (92.14)	0 (0)	40.36 (18.19)	0.03 (0.01)	0 (0)	0 (0)	N/A
taue	0.94 (2.24)	0 (0)	29.32 (18.76)	0 (0)	0.33 (0.42)	0 (0)	0.04 (0.02)	N/A
taum	0 (0)	1.34 (2.66)	0 (0)	34.22 (35.07)	0.11 (0.09)	0 (0)	0.04 (0.03)	N/A
tauh1	0.28 (3.56)	0.06 (0.53)	0.71 (15.4)	0.04 (12.46)	55.64 (46.21)	0 (0)	0.04 (0.06)	N/A
tauh3	0 (0)	0 (0.01)	0.04 (0.08)	0 (0.04)	0 (0)	49.29 (38.74)	0.01 (0.04)	N/A
nonlep	6.76 (9.09)	3.47 (4.65)	26.49 (36.91)	25.37 (34.22)	43.44 (52.92)	50.7 (61.18)	99.84 (99.83)	N/A

ttZ

- Lepton ID efficiency with TMVA BDT (cut base) lepton selection

* in this table,
0 means less than 0.01%

particles

Selection

(%)	elec	muon	taue	taum	tauh1	tauh3	bjet	ljet
elec	90.92 (84.62)	0.01 (0.01)	44.3 (28.27)	0 (0)	0.15 (0.11)	0 (0.11)	0.01 (0.02)	0.01 (0.02)
muon	0 (0)	94.93 (92.23)	0 (0)	39.98 (18.28)	0 (0)	0.11 (0)	0.01 (0)	0 (0.01)
taue	1.16 (1.96)	0 (0.01)	28.08 (20.01)	0 (0)	0.34 (0.23)	0 (0)	0.02 (0.02)	0 (0)
taum	0 (0)	1.59 (2.93)	0 (0)	33.42 (36.28)	0.15 (0.07)	0 (0)	0.02 (0.03)	0 (0)
tauh1	0.31 (3.14)	0.05 (0.49)	0.56 (15.08)	0 (10.98)	54.97 (45.37)	0 (0)	0.01 (0.02)	0.38 (0.4)
tauh3	0.09 (0.05)	0 (0)	0 (0.08)	0 (0)	0 (0)	48.14 (37.99)	0 (0.02)	0.18 (0.2)
nonlep	7.5 (10.2)	3.39 (4.29)	27.03 (36.62)	26.59 (34.44)	44.36 (54.19)	51.73 (61.88)	99.89 (99.86)	99.4 (99.34)

BDT input variables table 1

	e-m	e-taue	e-taum	e-tauh	e-bjet	e-lfjet	m-taue	m-taum	m-tauh	m-bjet	m-lfjet
hadOvEM	✓		✓	✓	✓	✓	✓				
calEovE	✓	✓	✓			✓	✓		✓	✓	✓
coneE2woSeed		✓				✓		✓			
isoCutOld		✓	✓	✓		✓	✓		✓	✓	✓
pfoR0	✓	✓		✓	✓	✓		✓		✓	
coneE1OvConeE2					✓	✓	✓				
coneMass1	✓			✓	✓	✓	✓				✓
coneMass3		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
clusterShape0	✓	✓	✓	✓		✓	✓				✓
clusterShape1	✓		✓	✓	✓	✓	✓				✓
clusterShape2	✓		✓		✓	✓	✓				✓
clusterShape3	✓	✓	✓			✓		✓		✓	✓
clusterShape5	✓						✓				✓
clusterShape16	✓		✓	✓		✓	✓		✓		
yokuE	✓		✓					✓	✓		✓
pfoe			✓	✓	✓	✓	✓	✓	✓	✓	✓
pt							✓		✓	✓	✓
cone1E		✓			✓	✓					✓
nTrkInCone1		✓			✓	✓					
maxTrkEInCone13		✓		✓		✓					✓
nNeutralCone1				✓		✓			✓		✓
eNeutralCone1		✓		✓		✓			✓	✓	

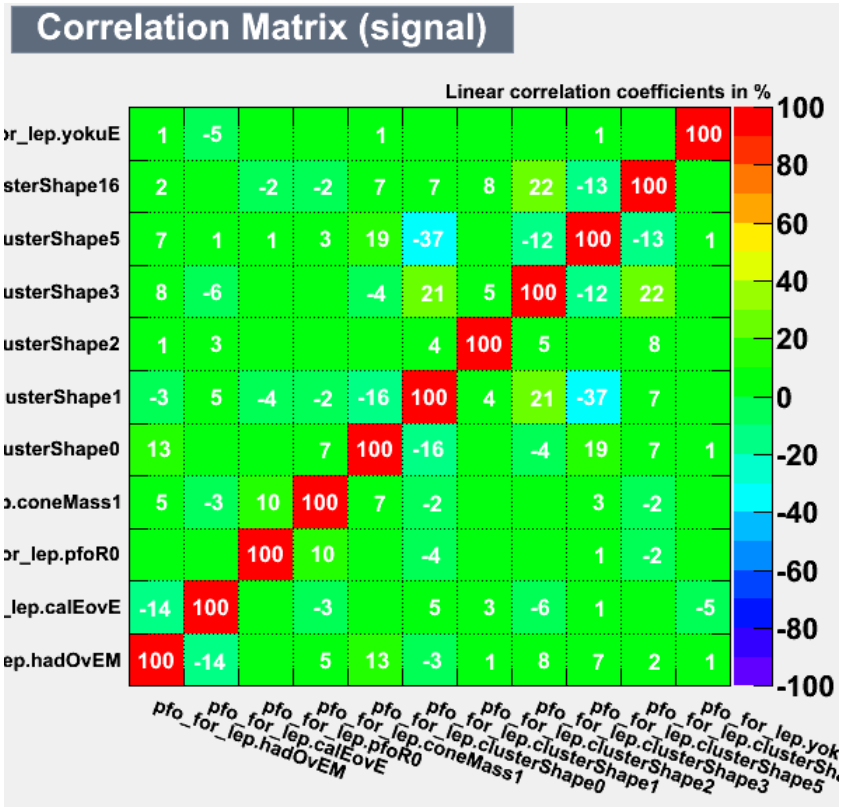
	taue-taum	taue-tauh	taue-bjet	taue-lfjet	taum-tauh	taum-bjet	taum-lfjet	tauh1-bjet	tauh1-lfjet	tauh3-bjet	tauh3-lfjet
hadOvEM	✓	✓	✓	✓	✓	✓	✓	✓			
calEovE		✓	✓	✓	✓	✓				✓	
coneE2woSeed		✓					✓	✓	✓	✓	
isoCutOld	✓	✓	✓	✓	✓	✓		✓		✓	
pfoR0		✓	✓	✓			✓	✓	✓	✓	✓
coneE1OvConeE2	✓	✓		✓	✓			✓	✓	✓	✓
coneMass1		✓						✓	✓	✓	✓
coneMass3		✓	✓	✓		✓	✓	✓	✓	✓	✓
clusterShape0	✓	✓	✓								
clusterShape1		✓	✓	✓			✓			✓	
clusterShape2			✓			✓				✓	
clusterShape3	✓	✓		✓	✓		✓	✓	✓	✓	✓
clusterShape5	✓	✓			✓						
clusterShape16	✓	✓	✓	✓							
yokuE					✓	✓	✓	✓		✓	
pfoe		✓	✓	✓	✓		✓		✓	✓	✓
pt									✓	✓	
cone1E		✓		✓	✓		✓	✓		✓	✓
nTrkInCone1		✓	✓	✓							
maxTrkEInCone13		✓	✓	✓				✓		✓	
nNeutralCone1								✓			
eNeutralCone1								✓		✓	

Input variables
and
Linear correlation matrix

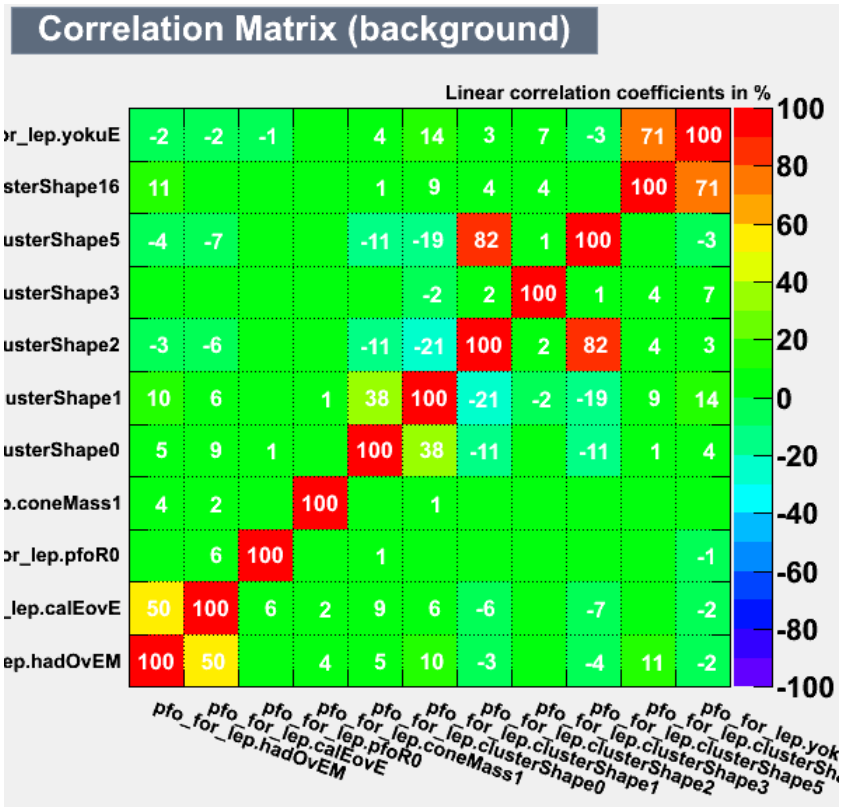
- input variables are chosen to maximize area of ROC curve

Correlation plots

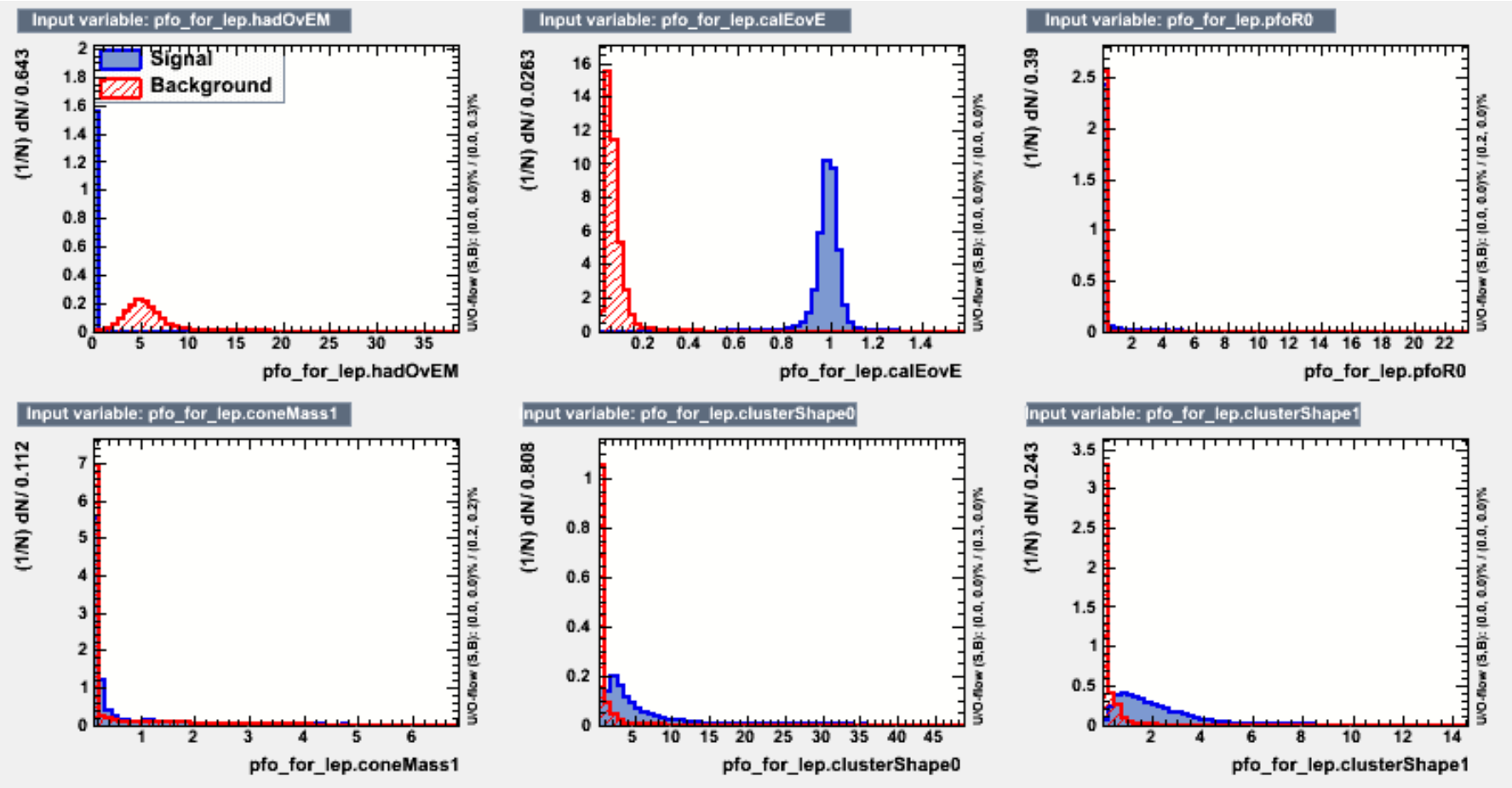
electron



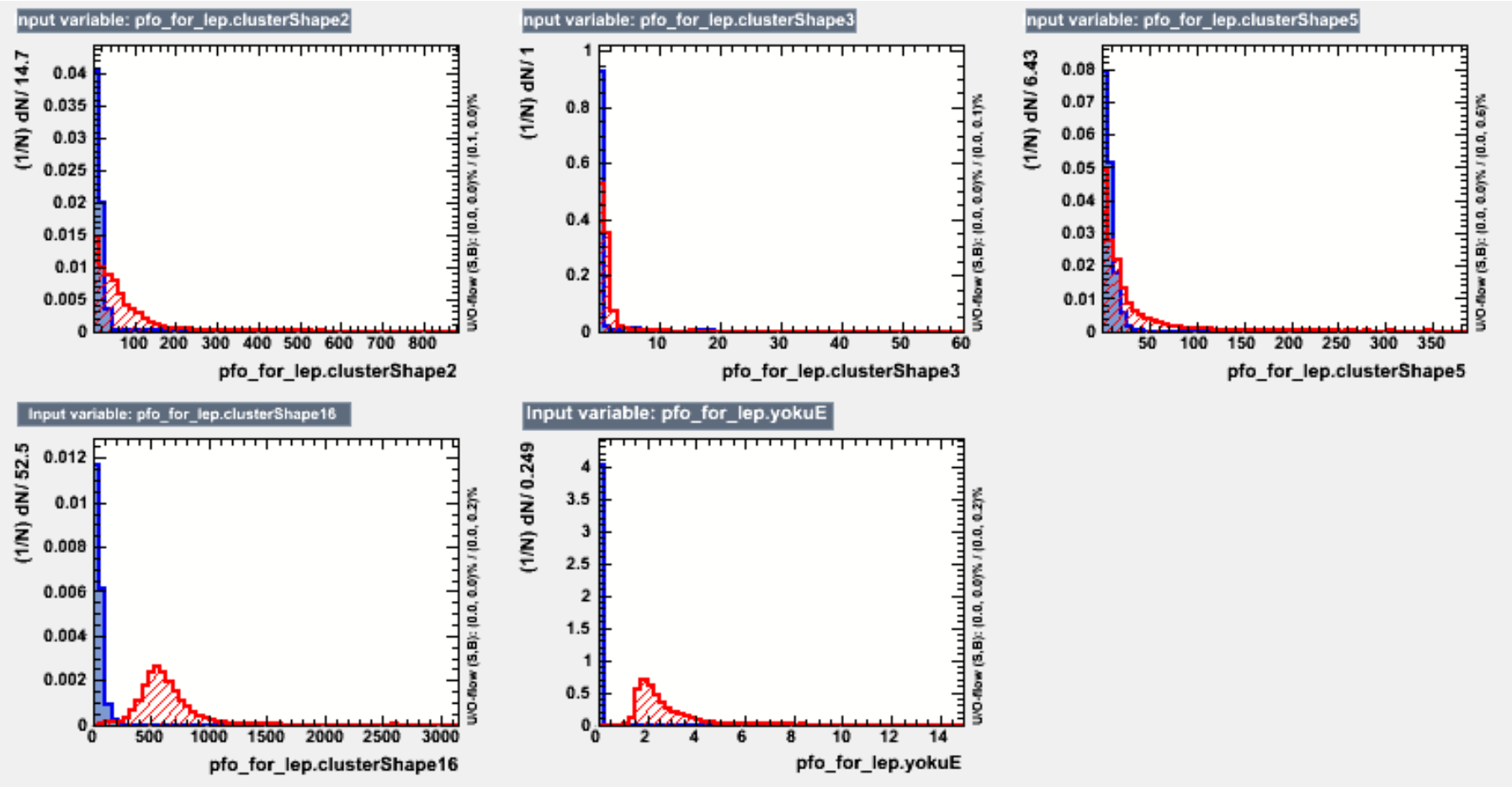
muon



BDT input variables e-mu 1

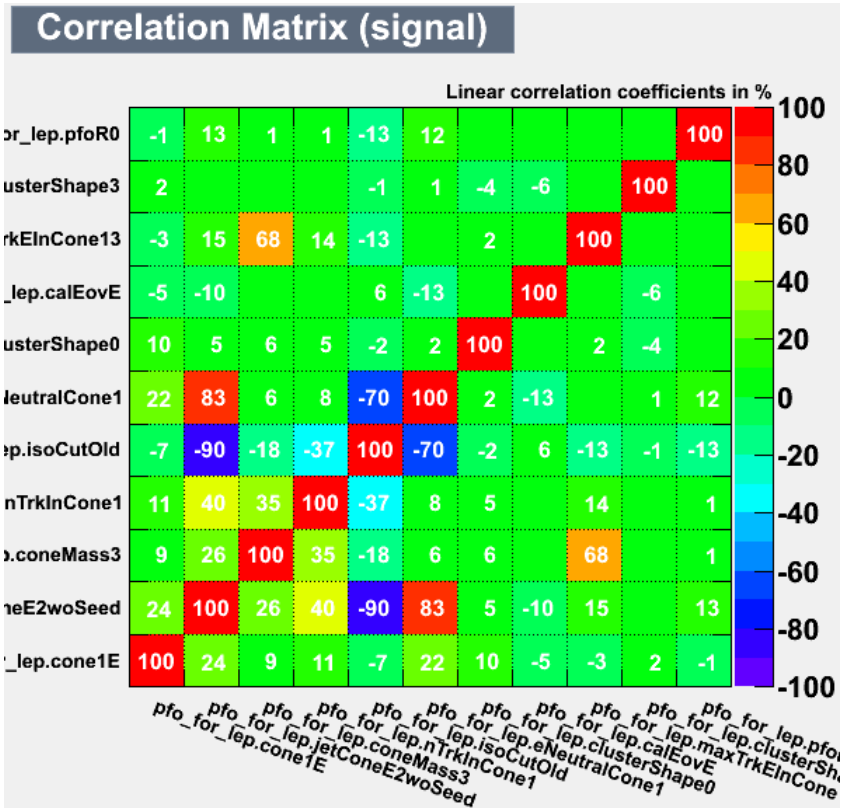


BDT input variables e-mu 2

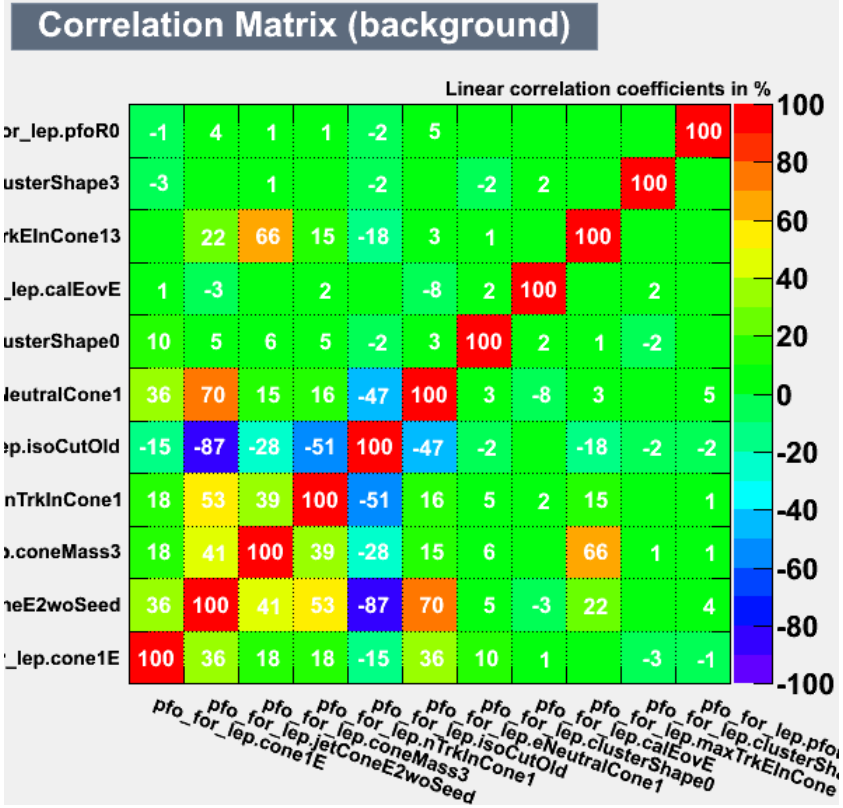


Correlation

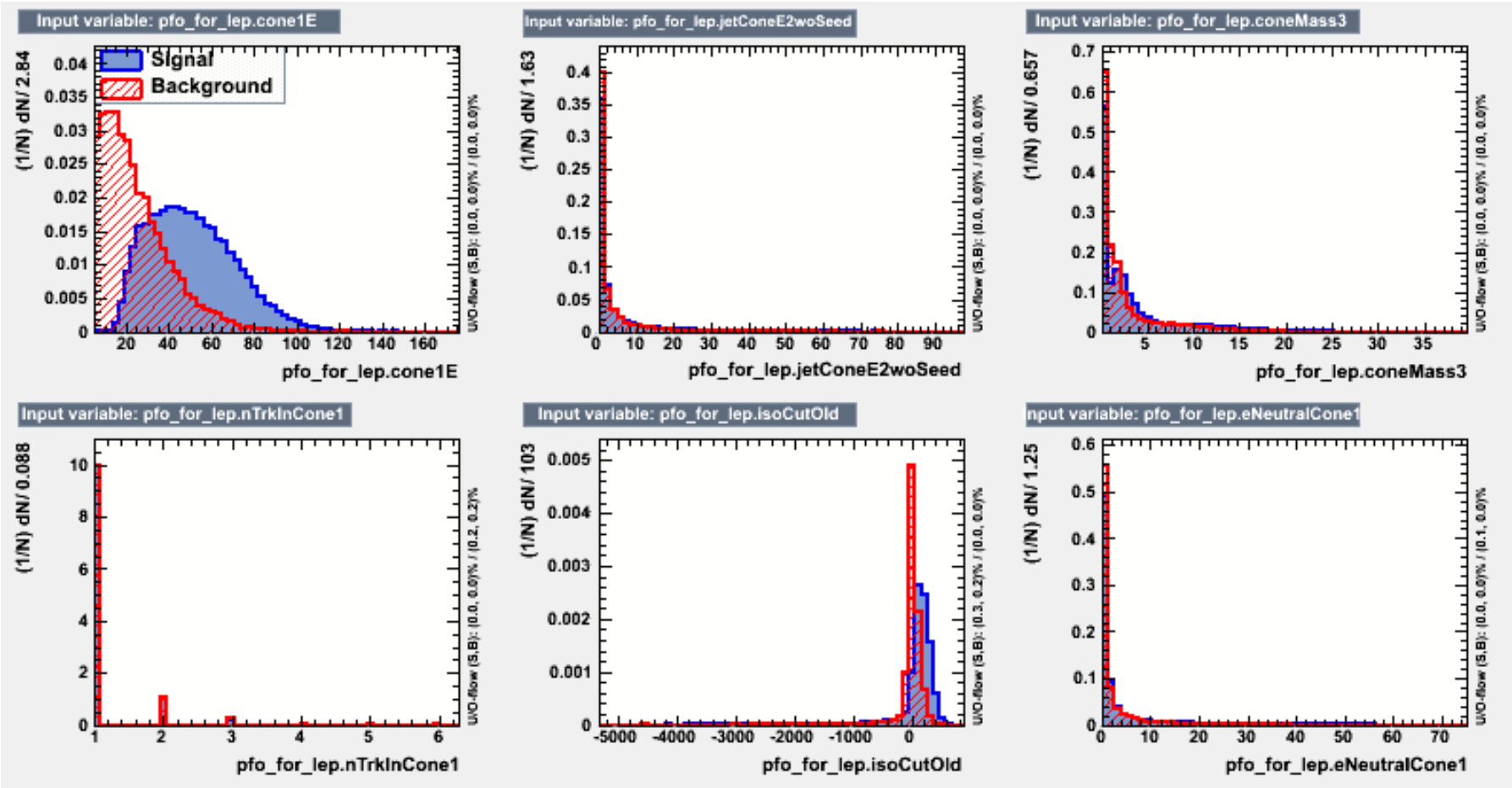
electron



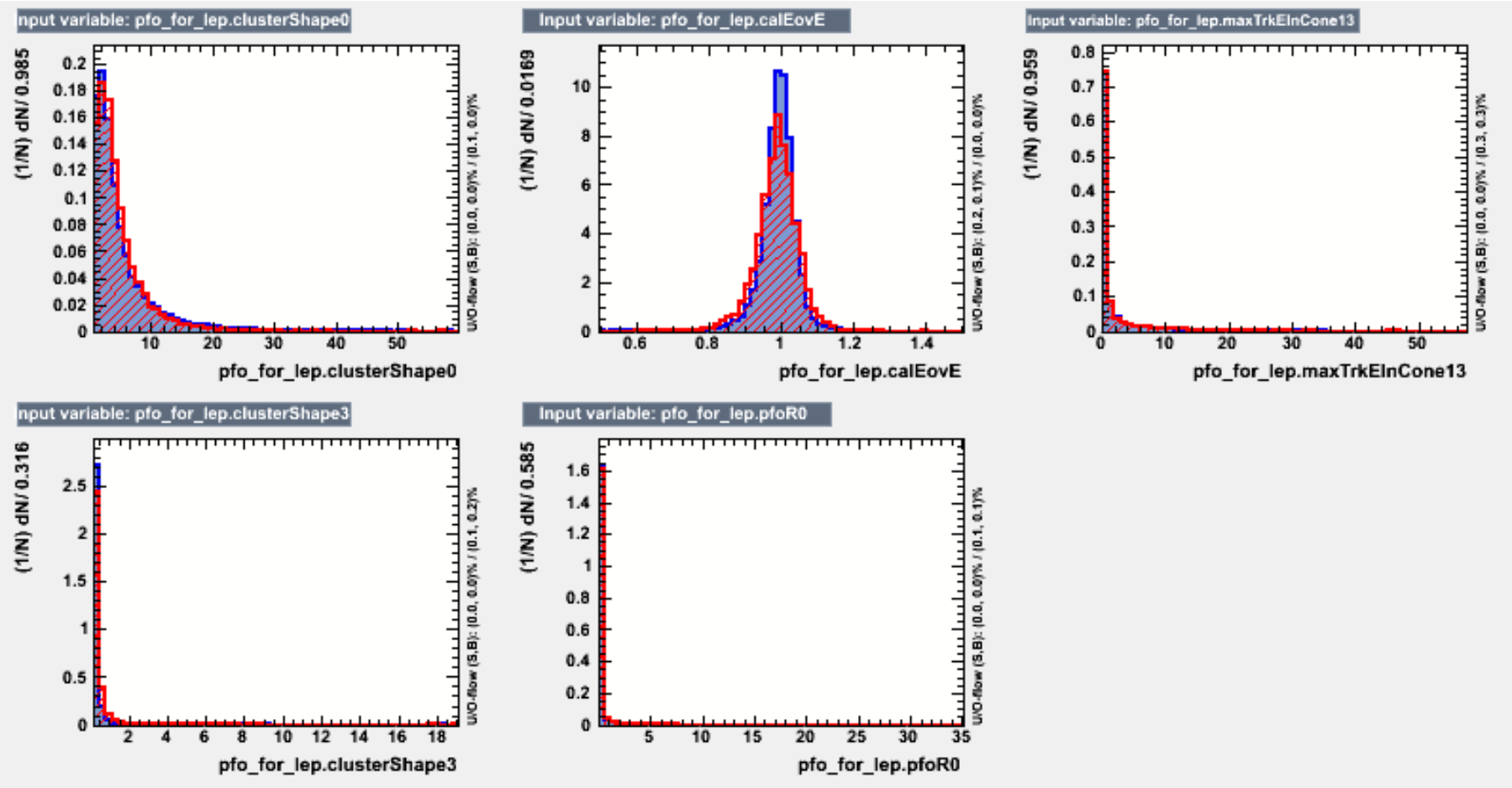
tau(e)



BDT input variables e-taue 1

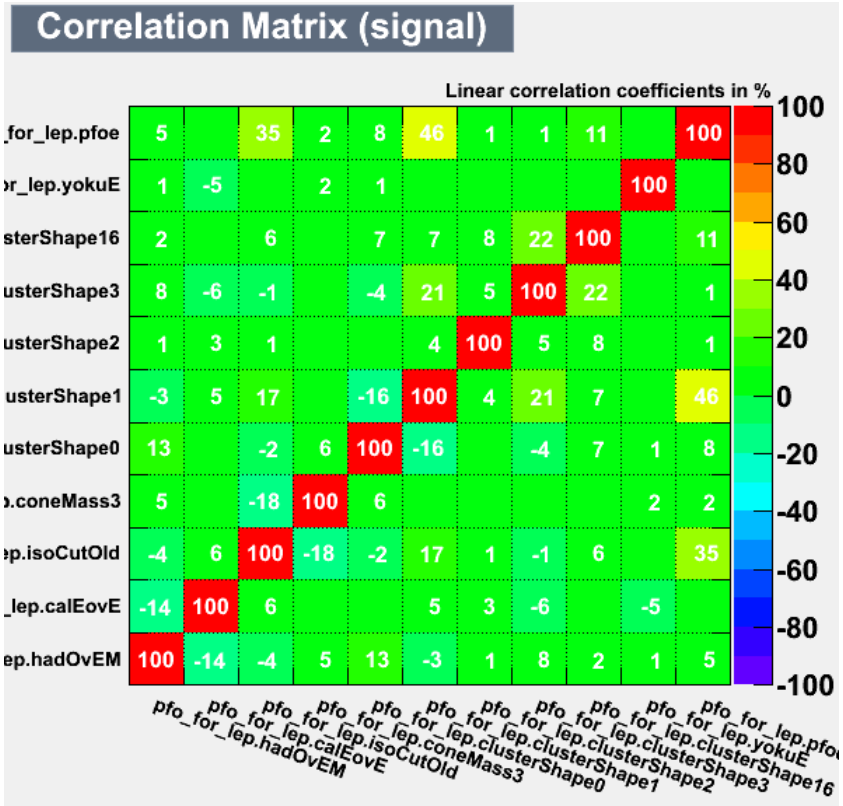


BDT input variables e-taue 2

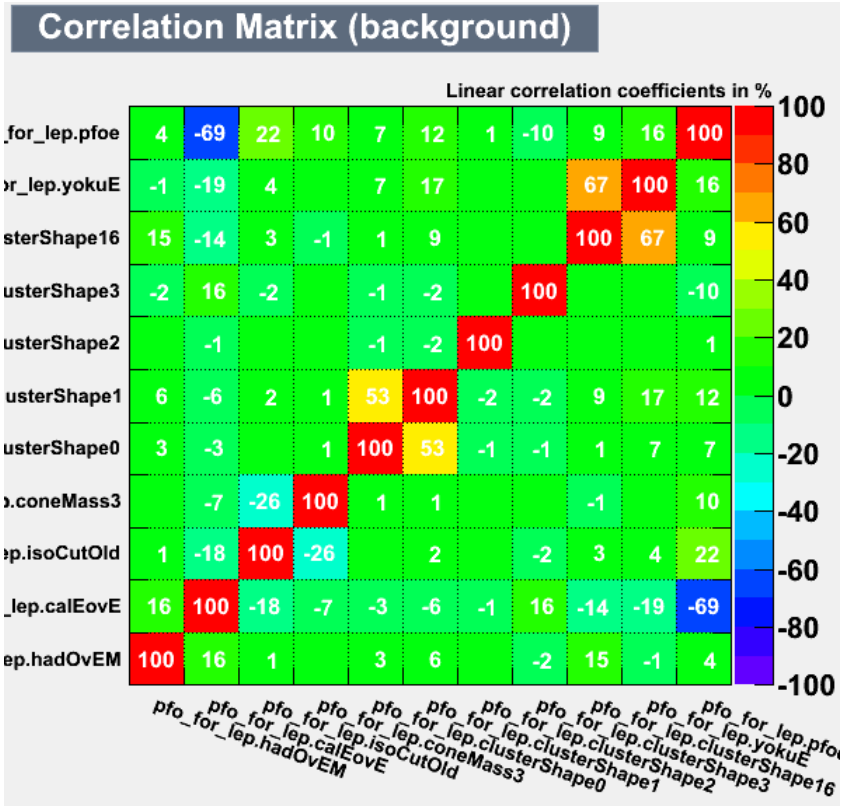


Correlation

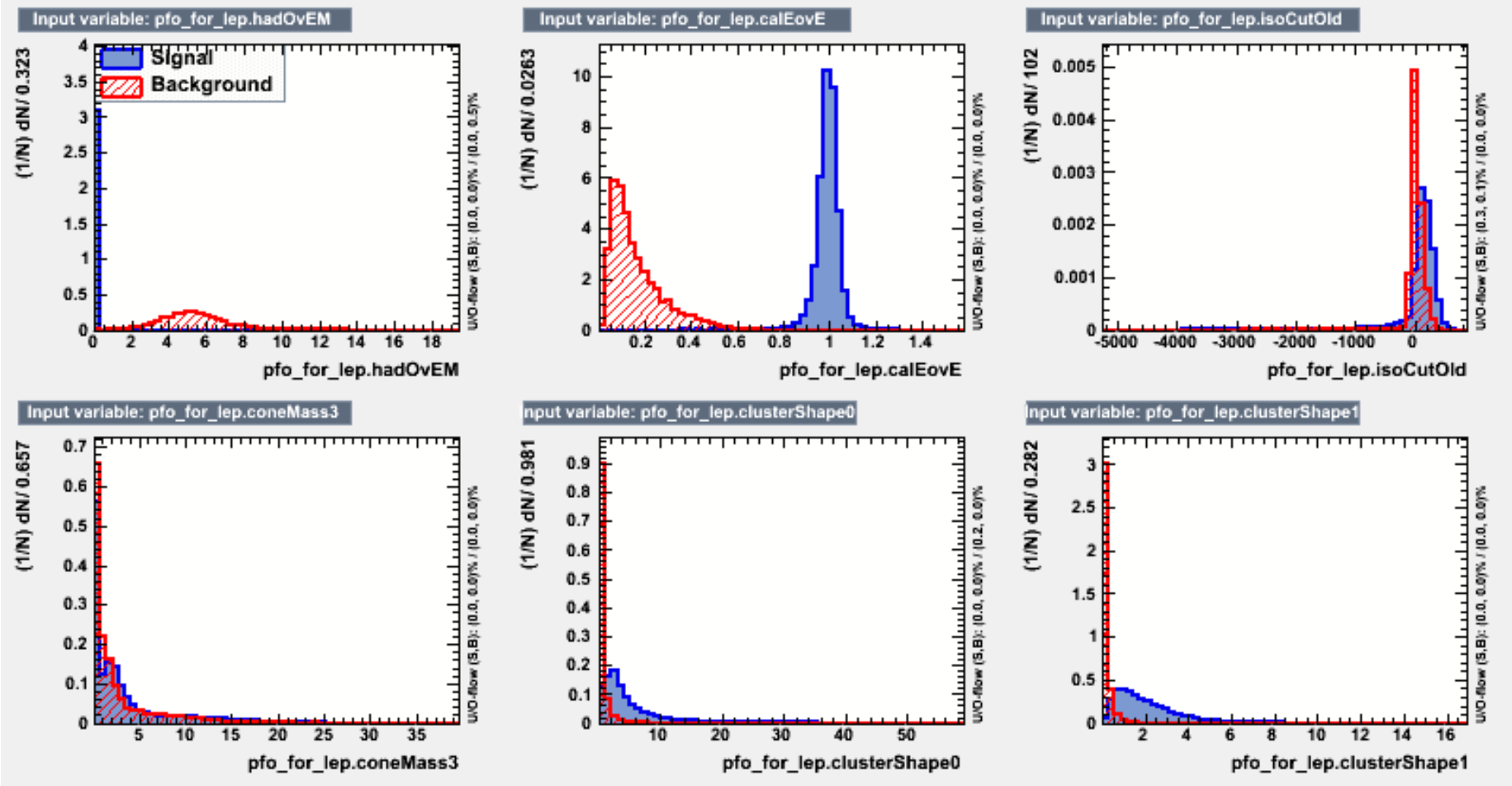
electron



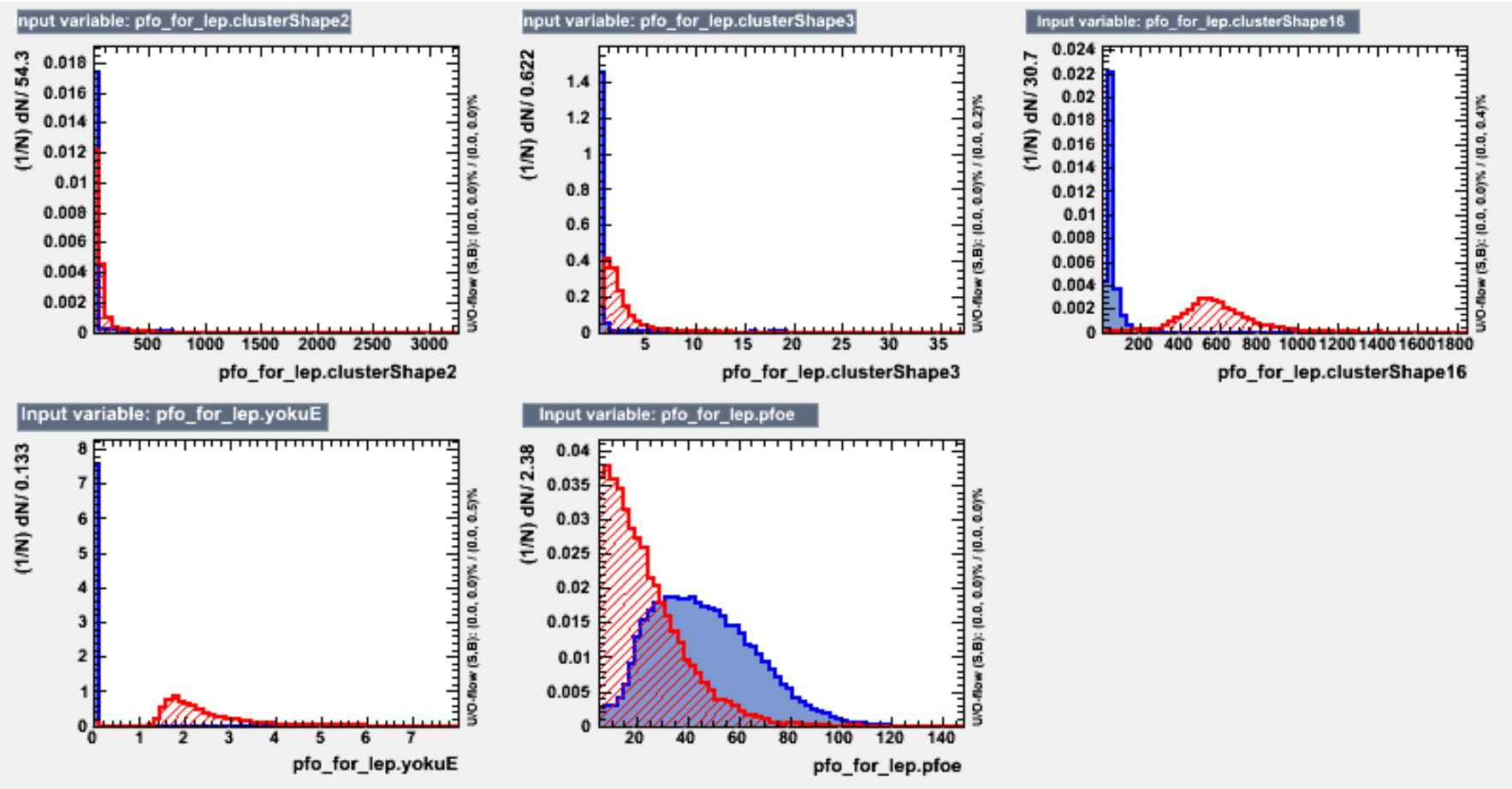
tau(m)



BDT input variables e-taum 1

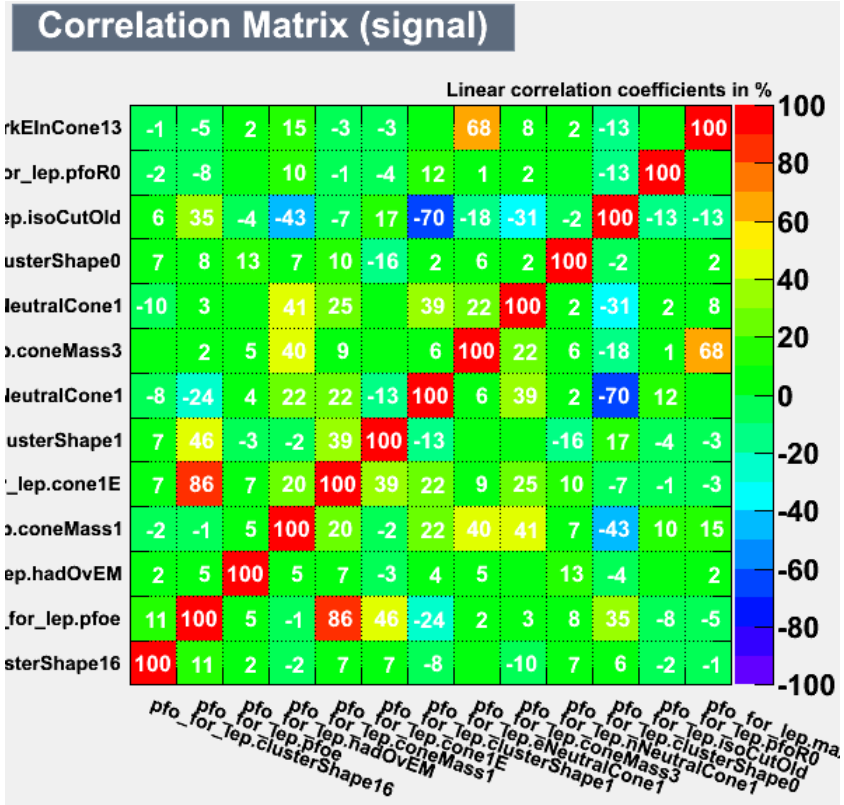


BDT input variables e-taum 2

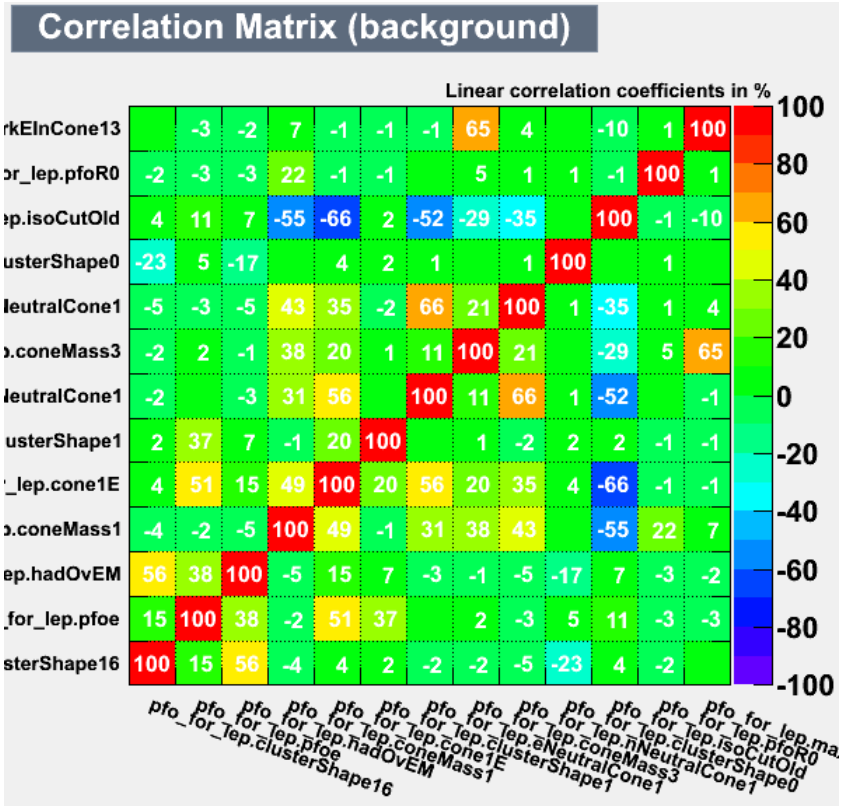


Correlation

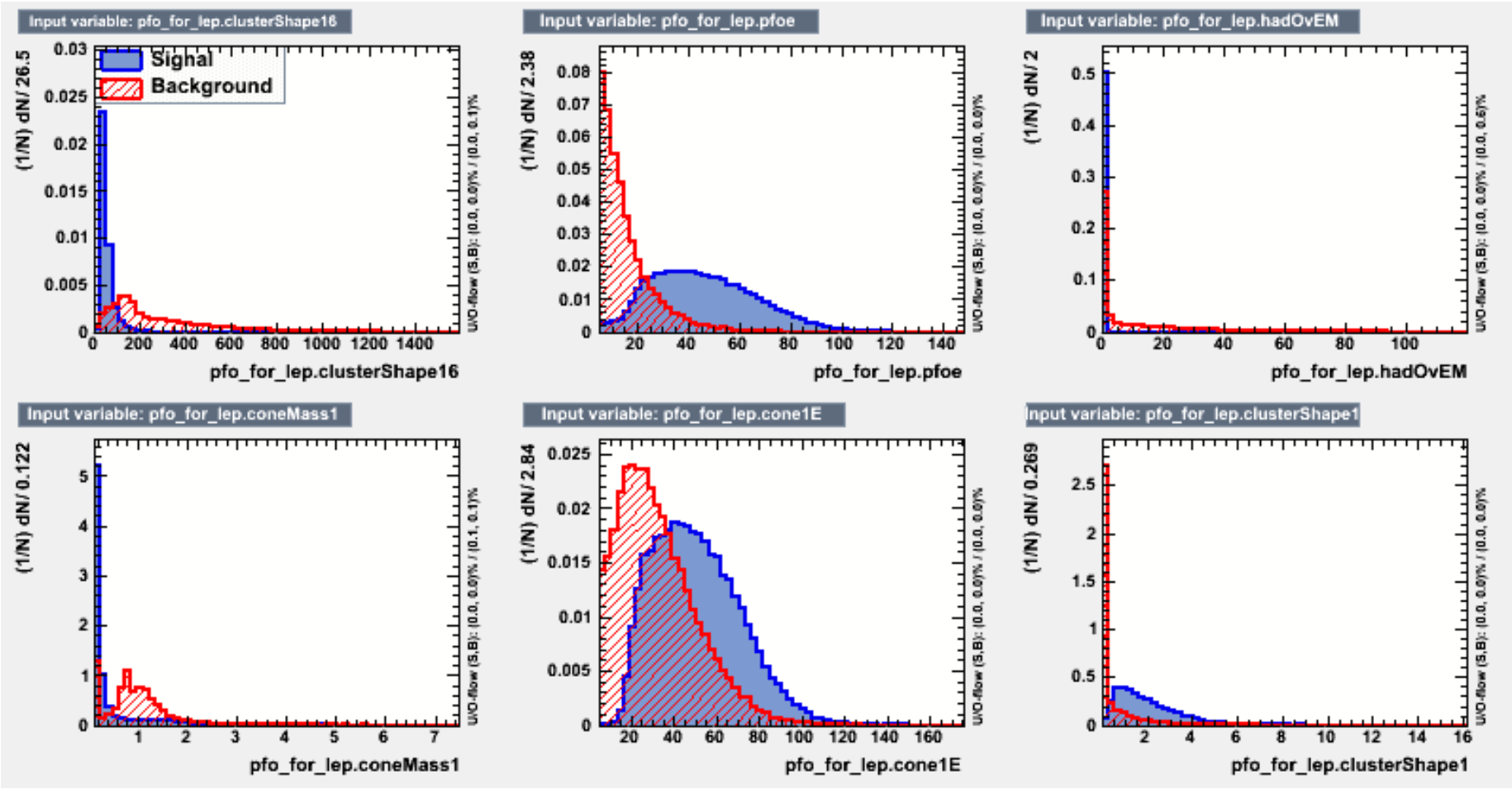
electron



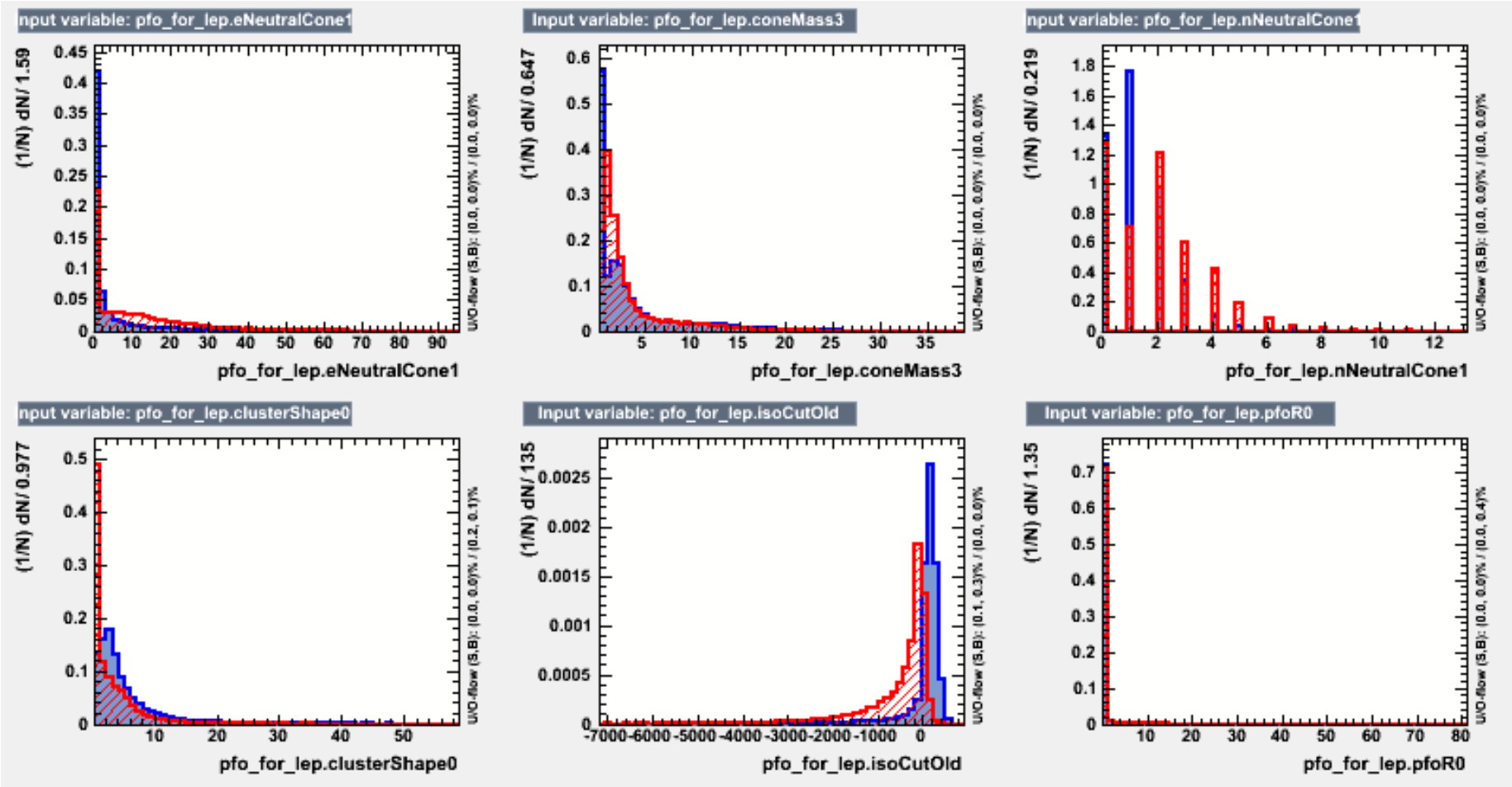
tau(h)



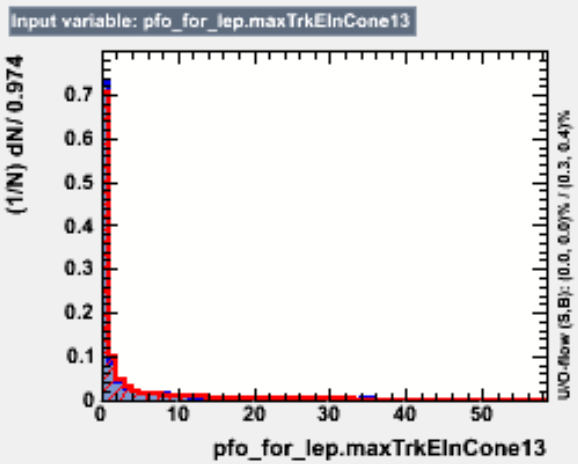
BDT input variables e-tauh 1



BDT input variables e-tauh 2

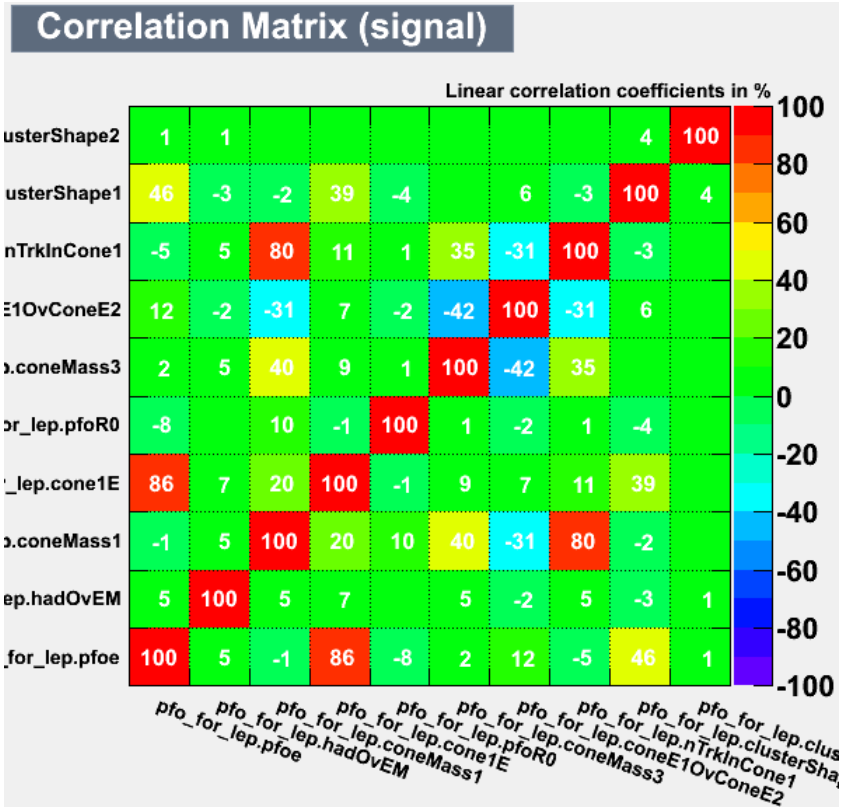


BDT input variables e-tauh 3

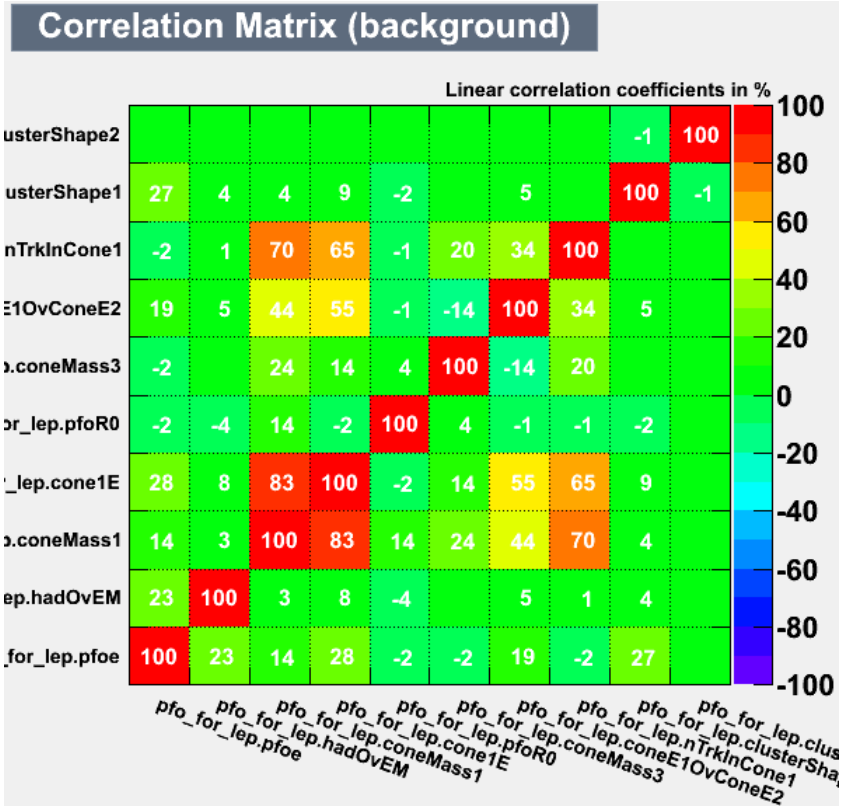


Correlation

electron



b jet



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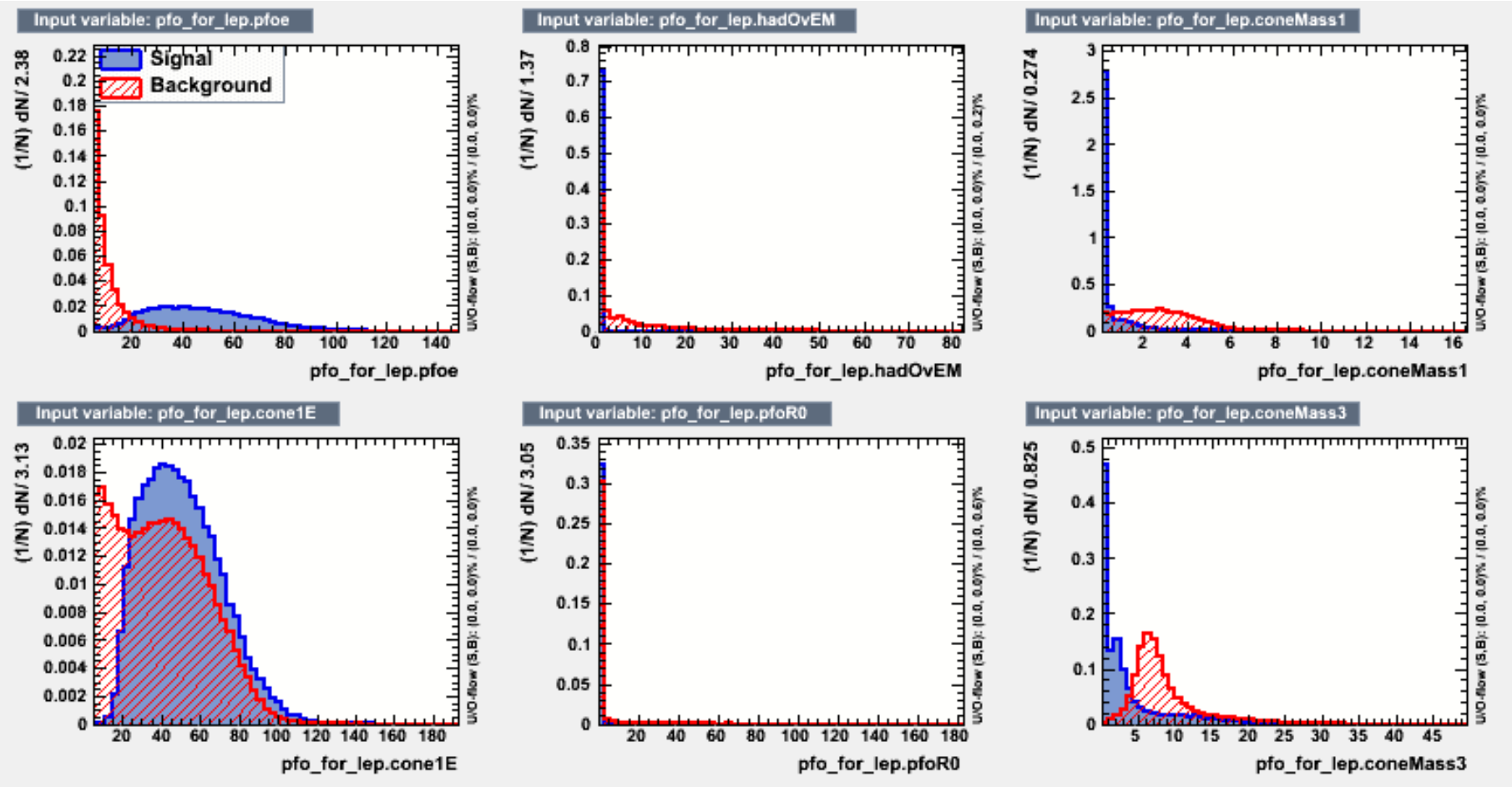

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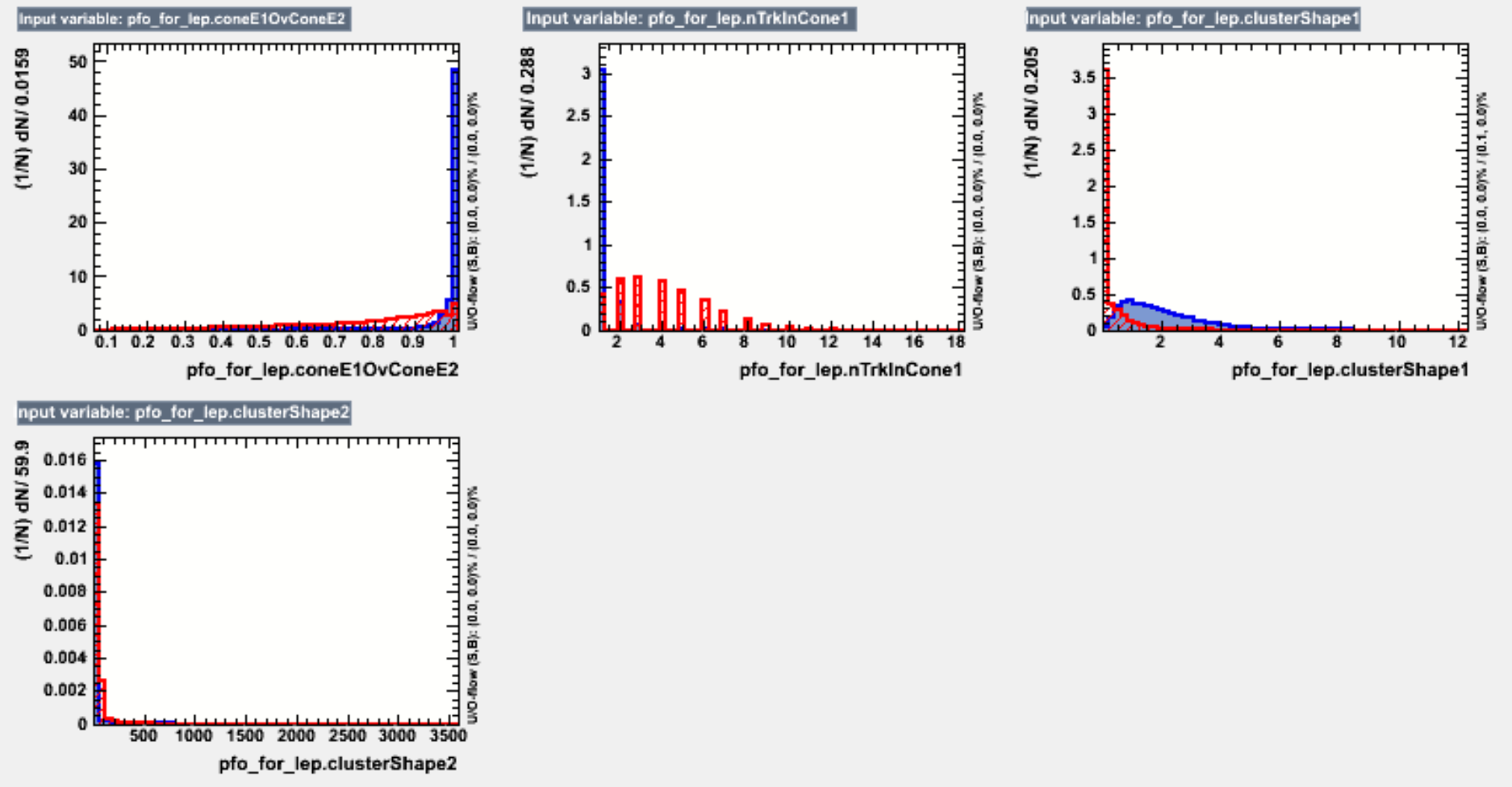
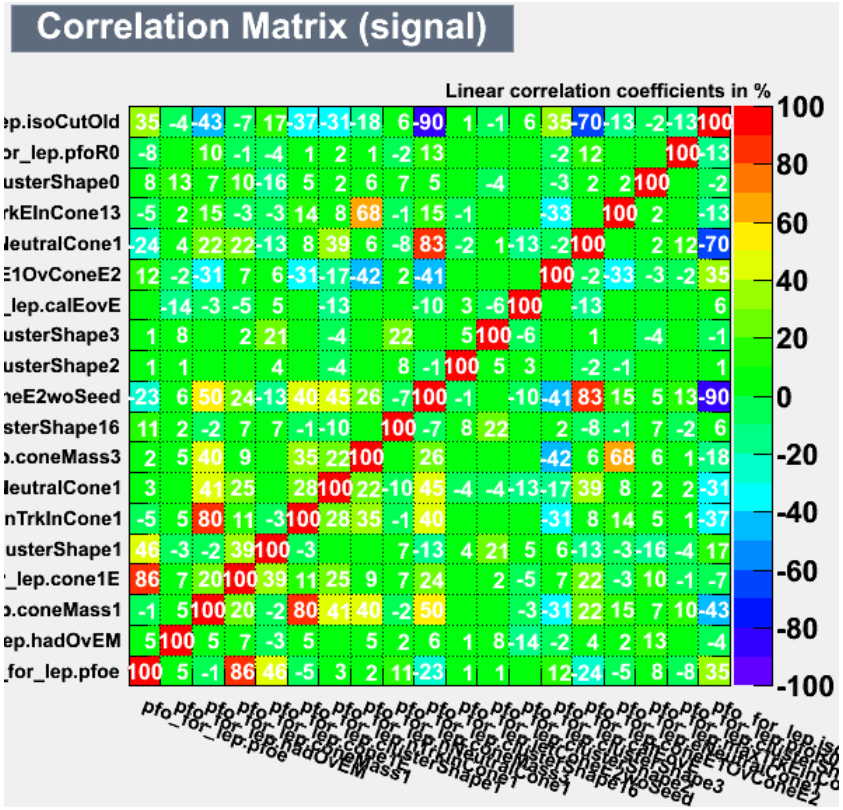
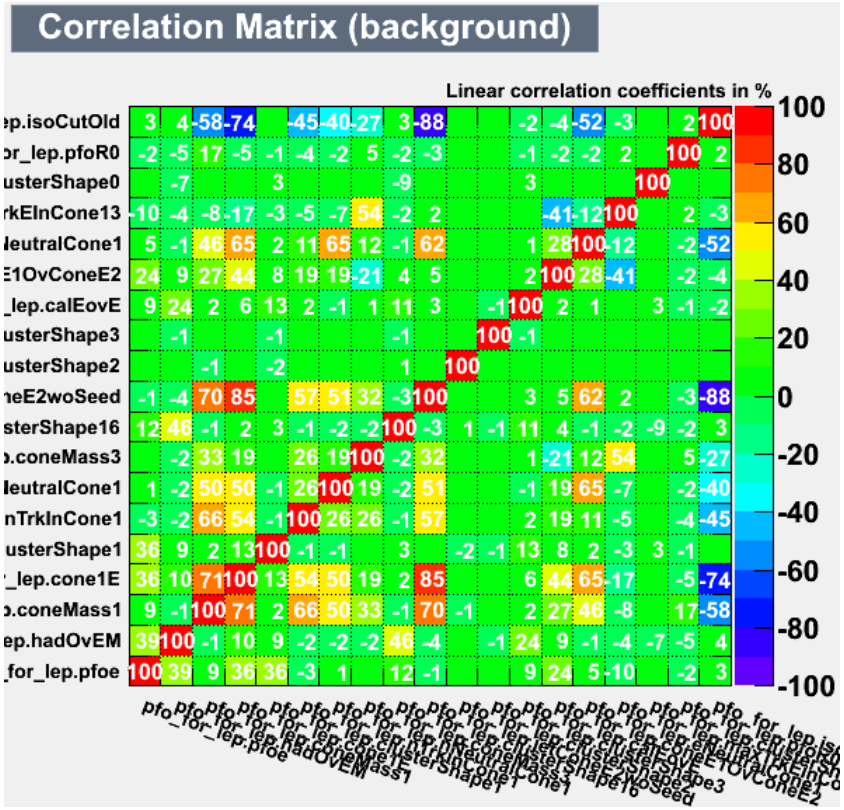


Correlation

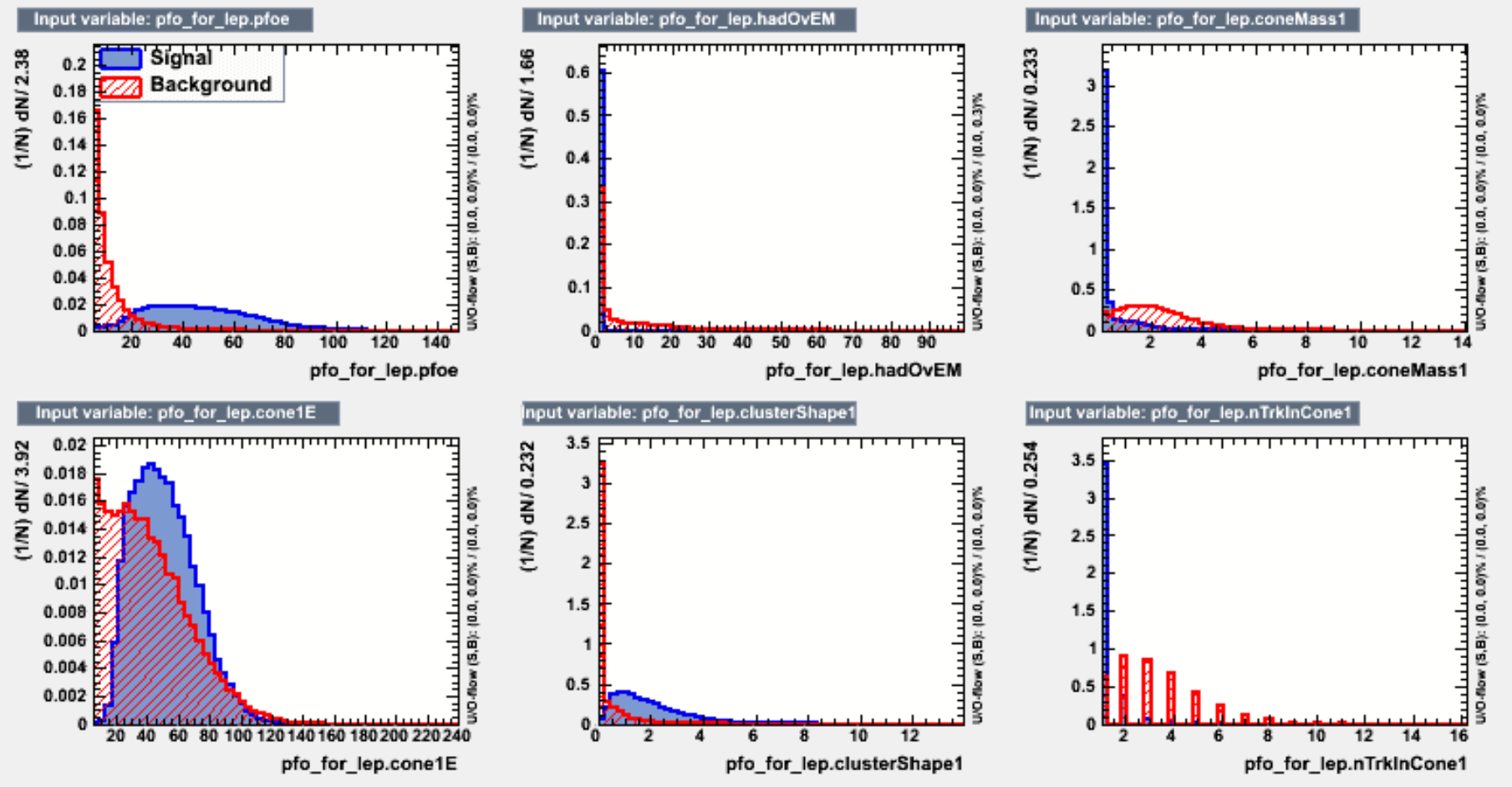
electron



lf jet



BDT input variables e-lfjet 1



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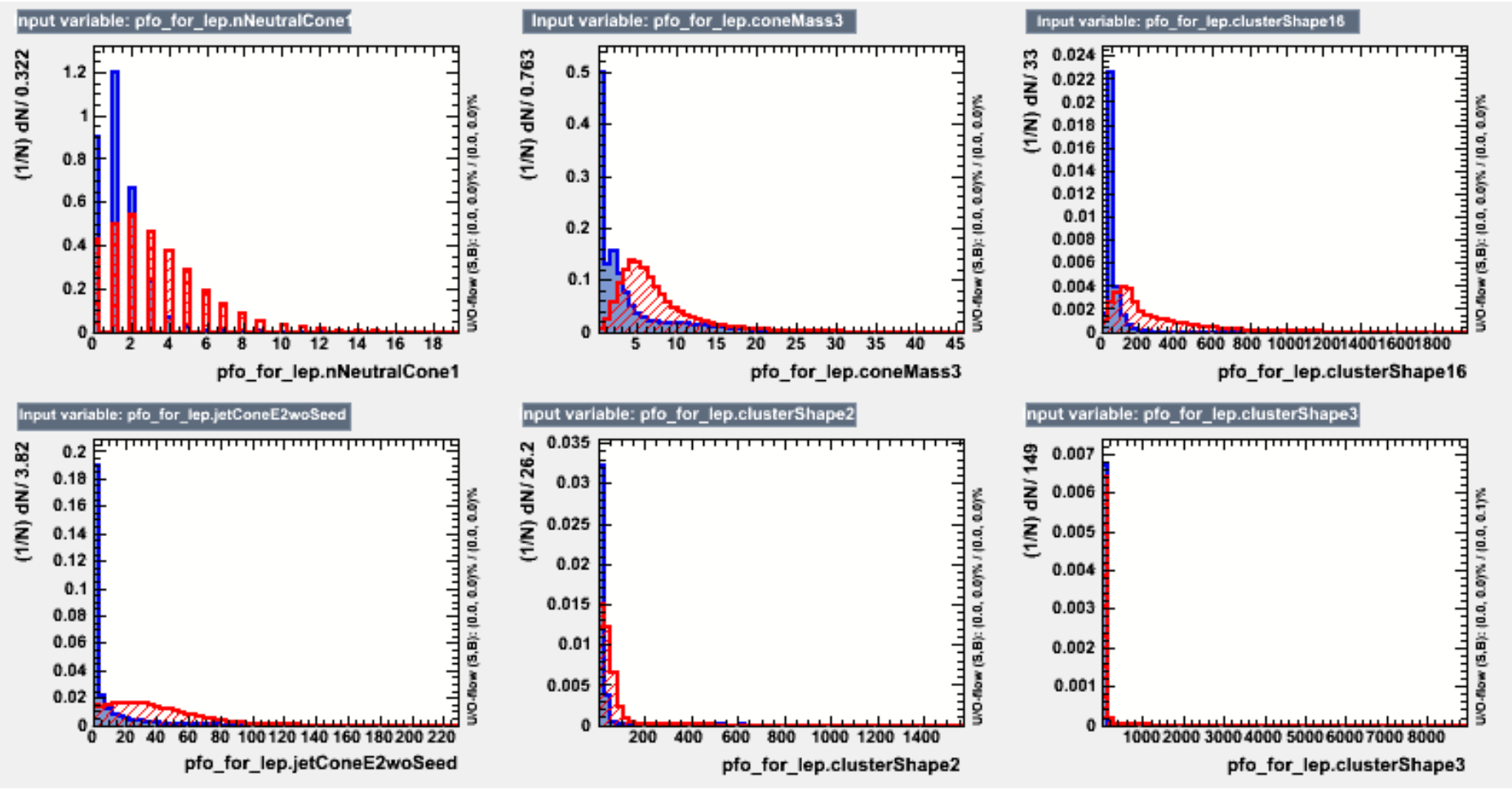

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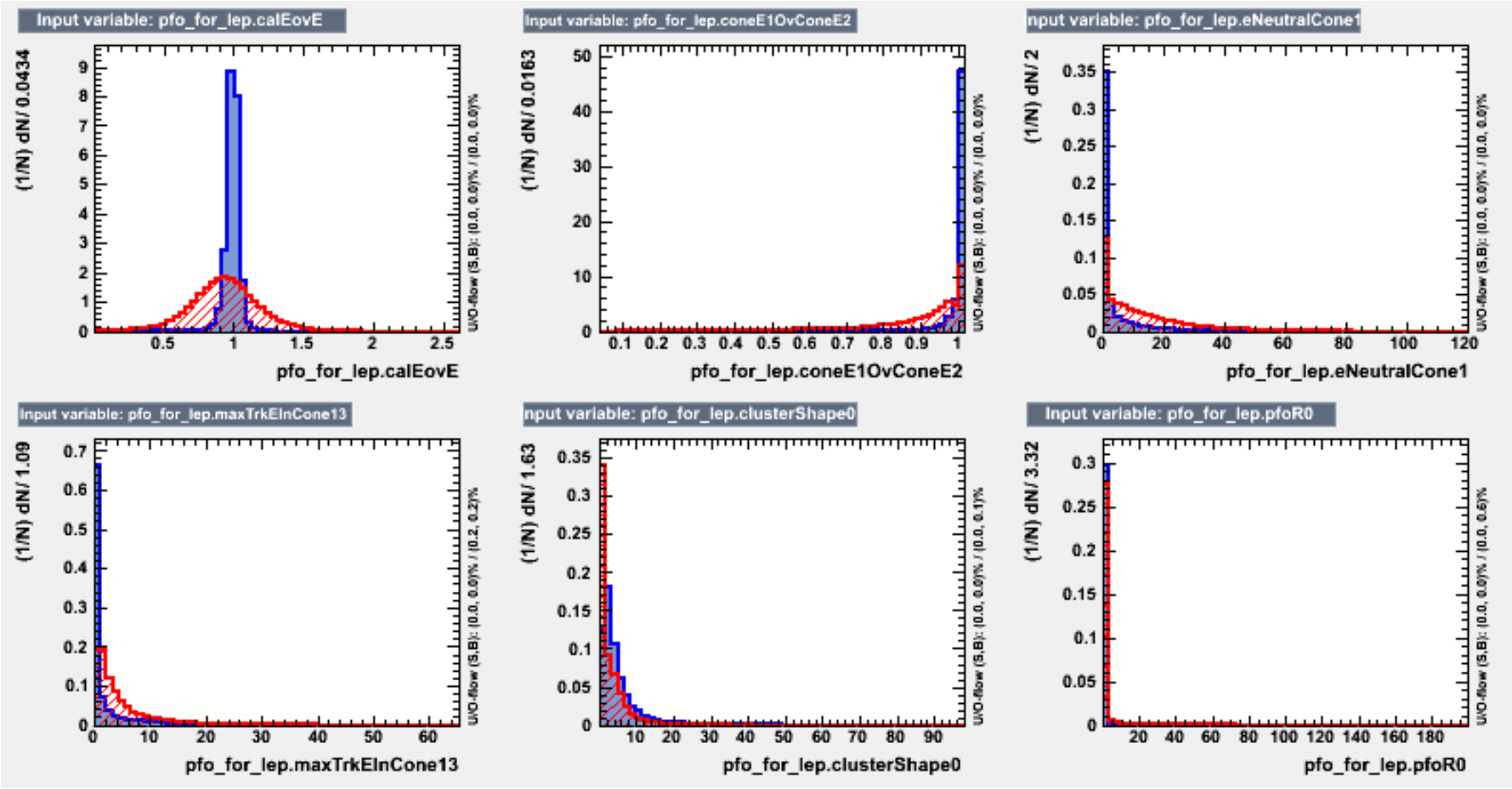
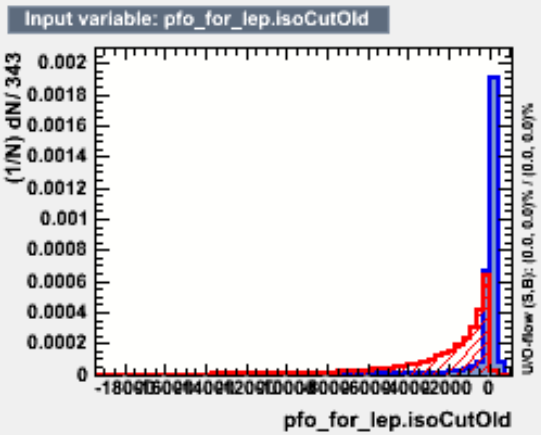
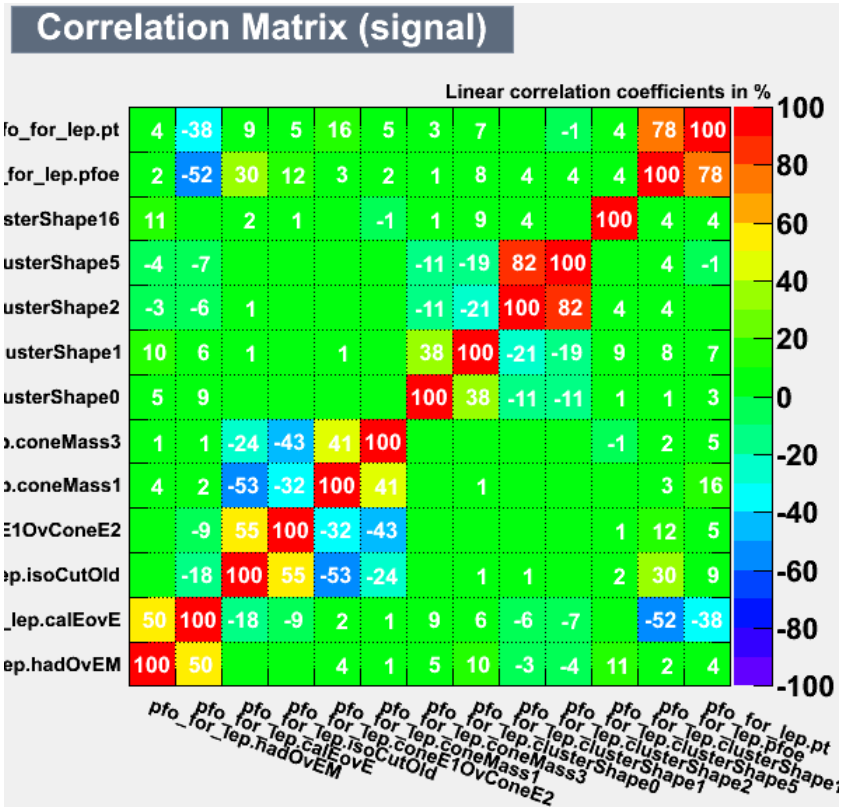


BDT input variables elfjet- 4

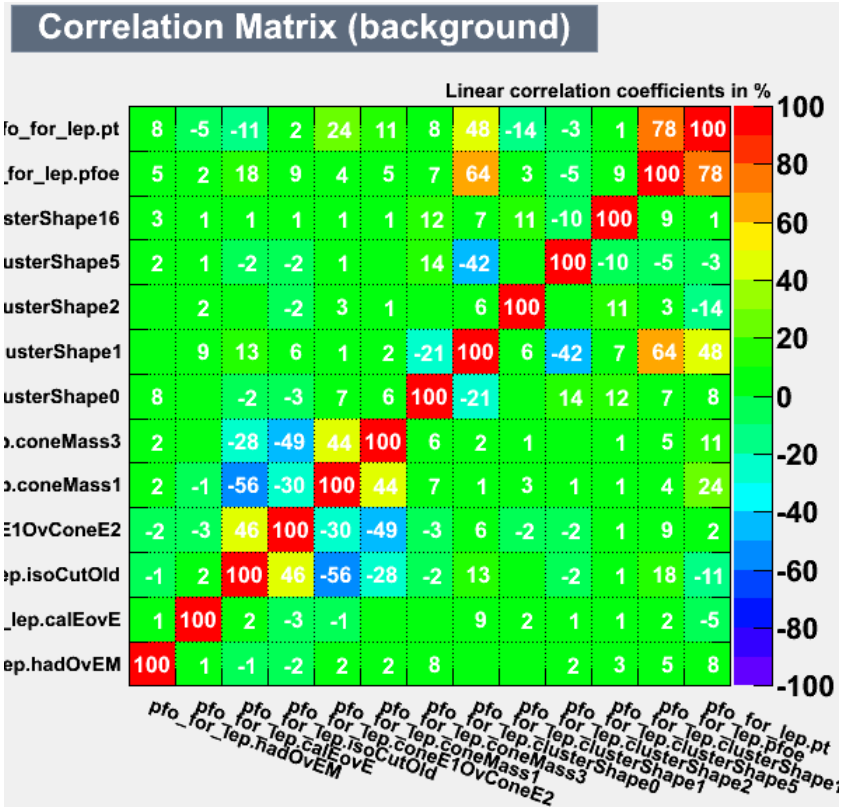


Correlation

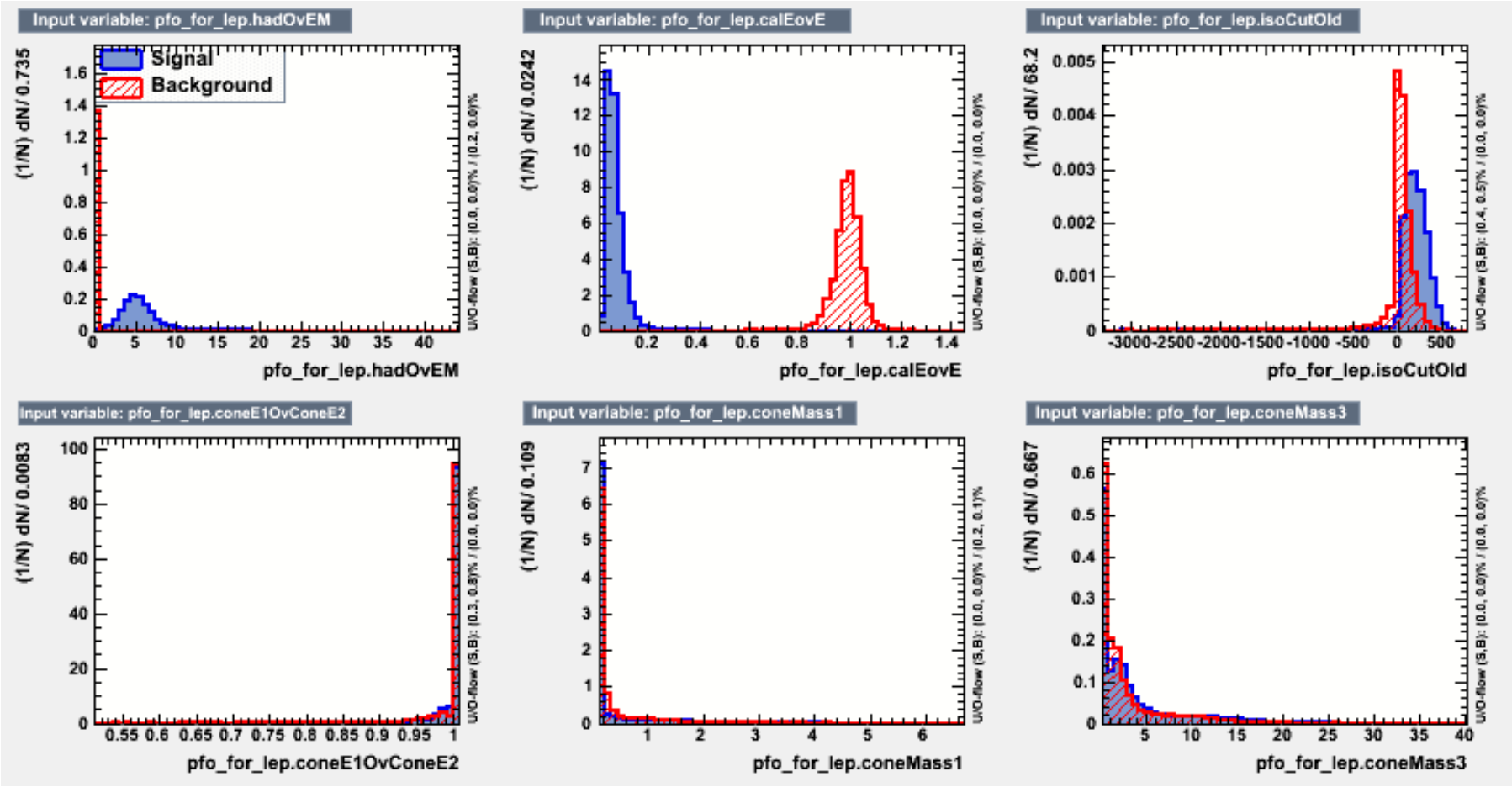
muon



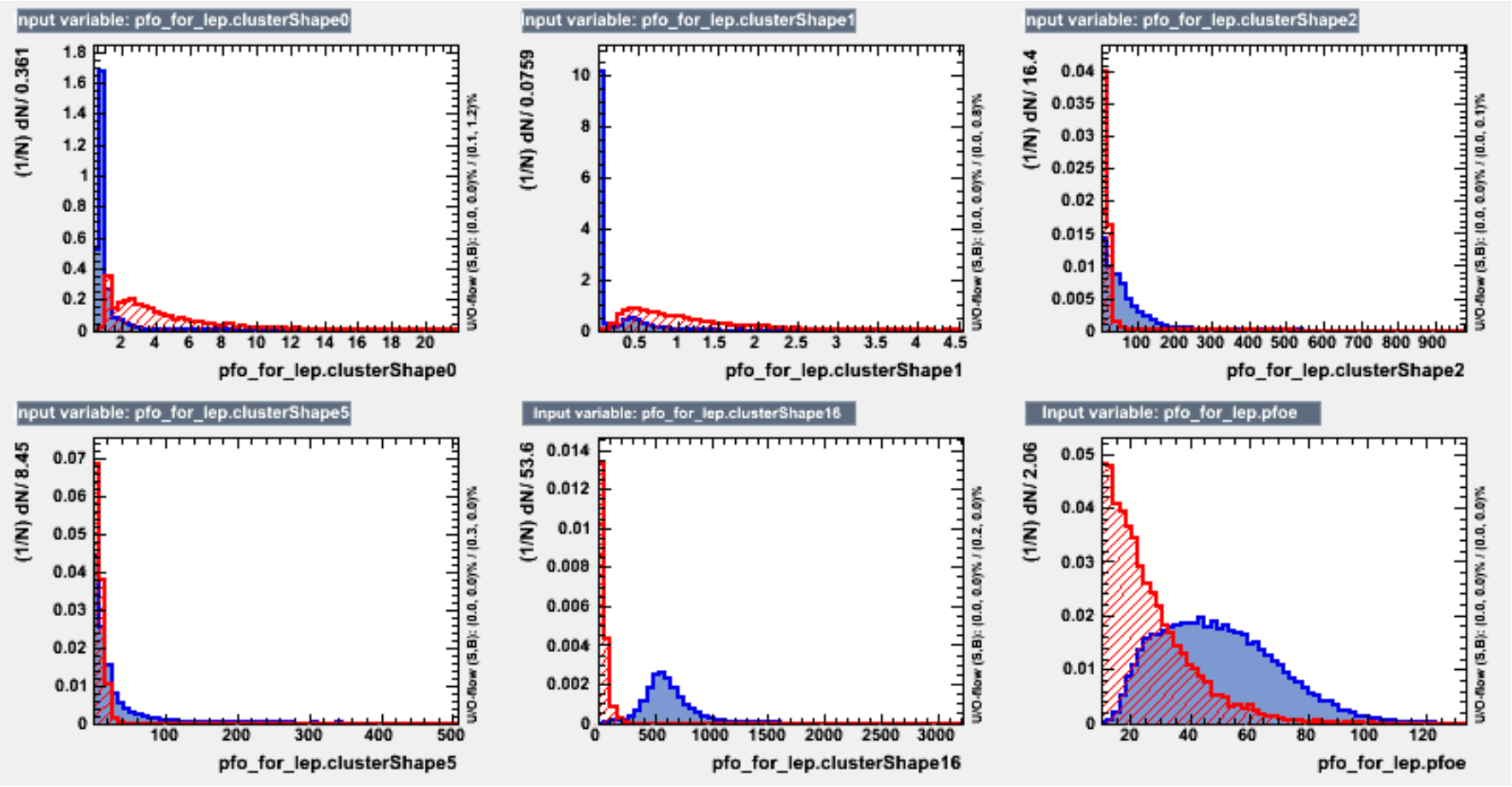
tau(e)



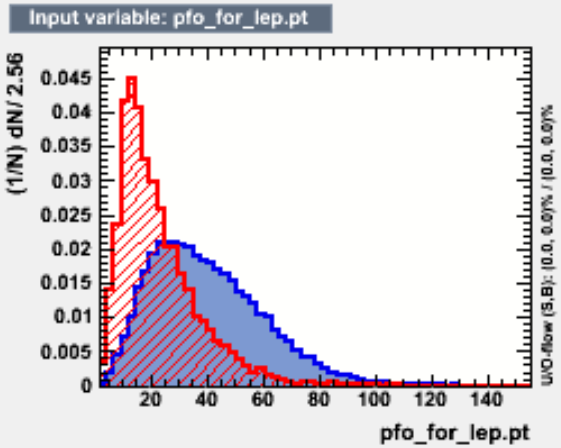
BDT input variables mu-taue 1



BDT input variables mu-taue 2

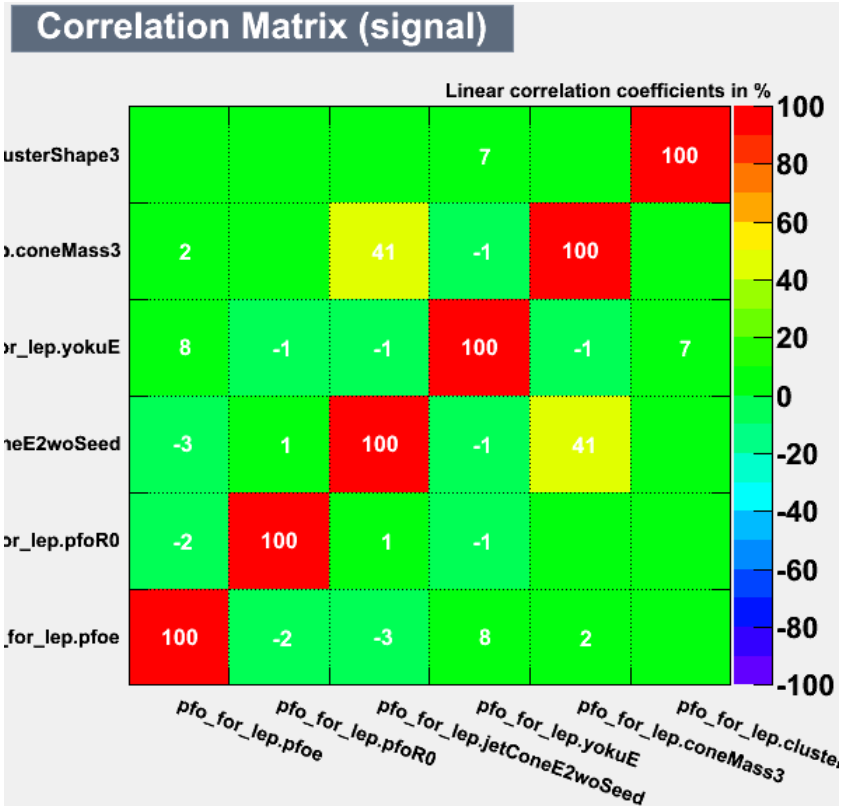


BDT input variables mu-taue 3

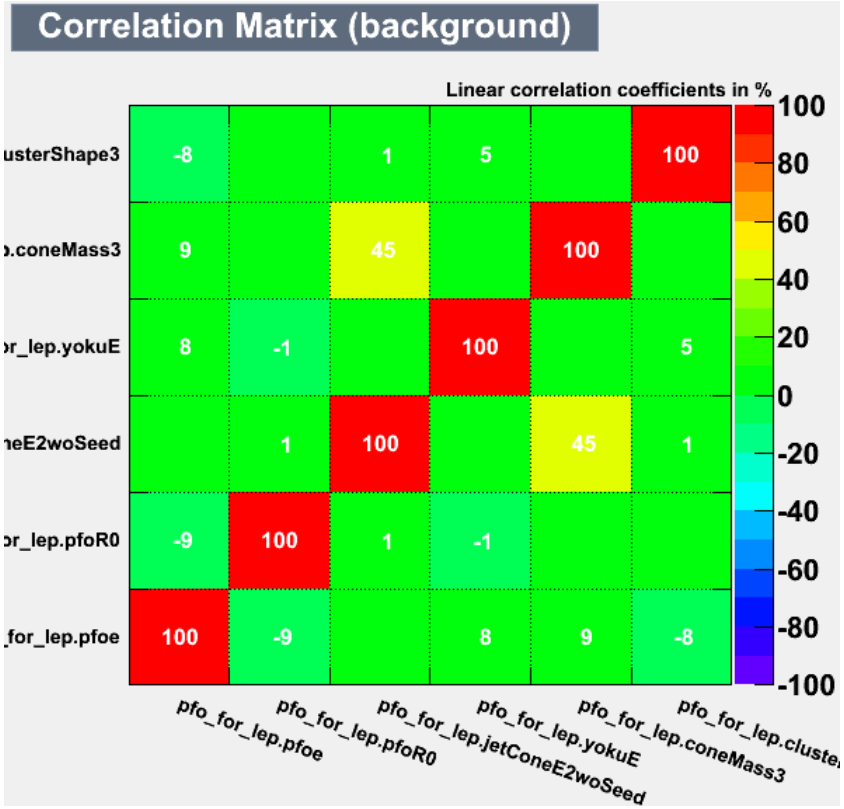


Correlation

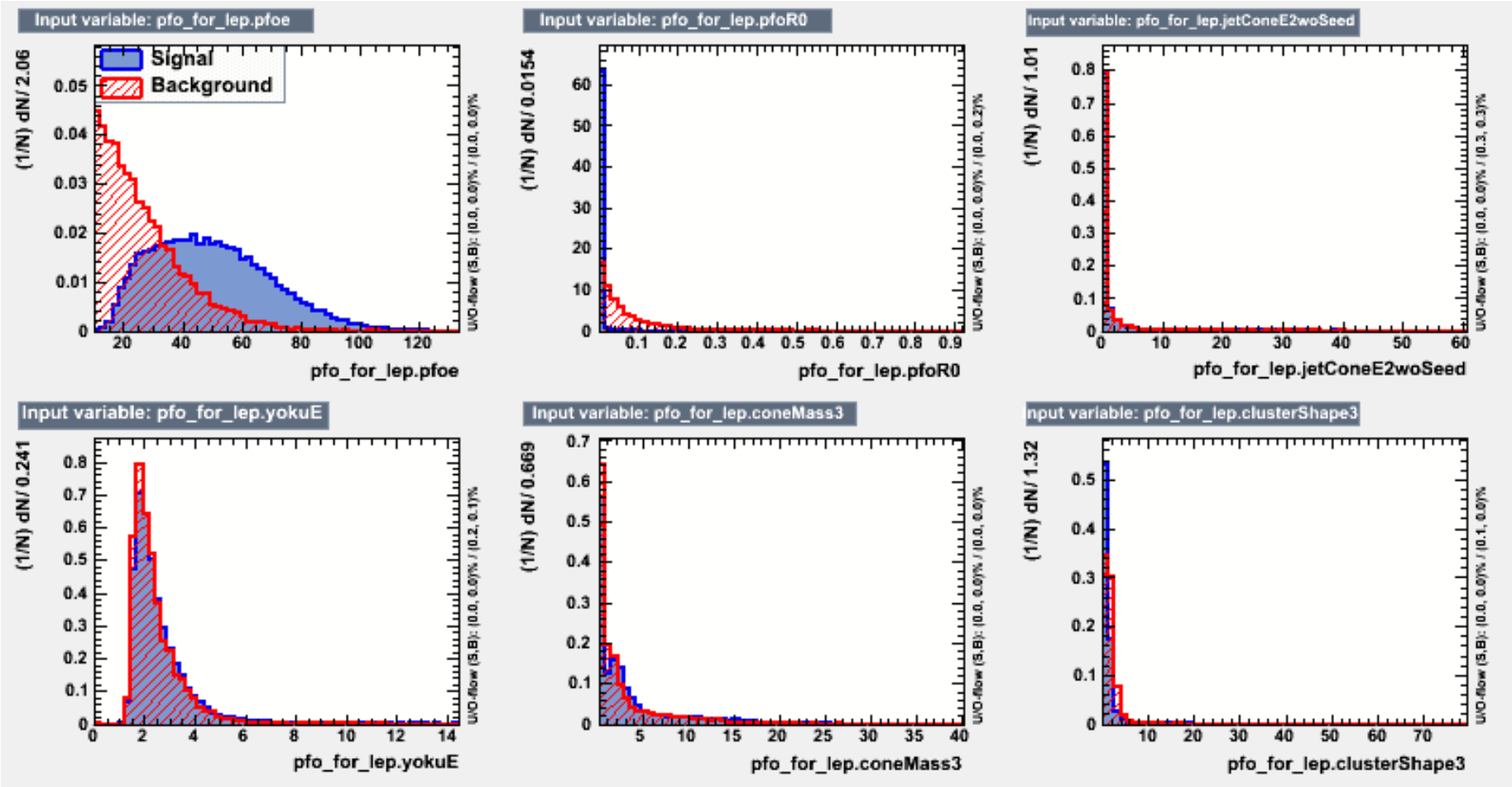
muon



tau(m)

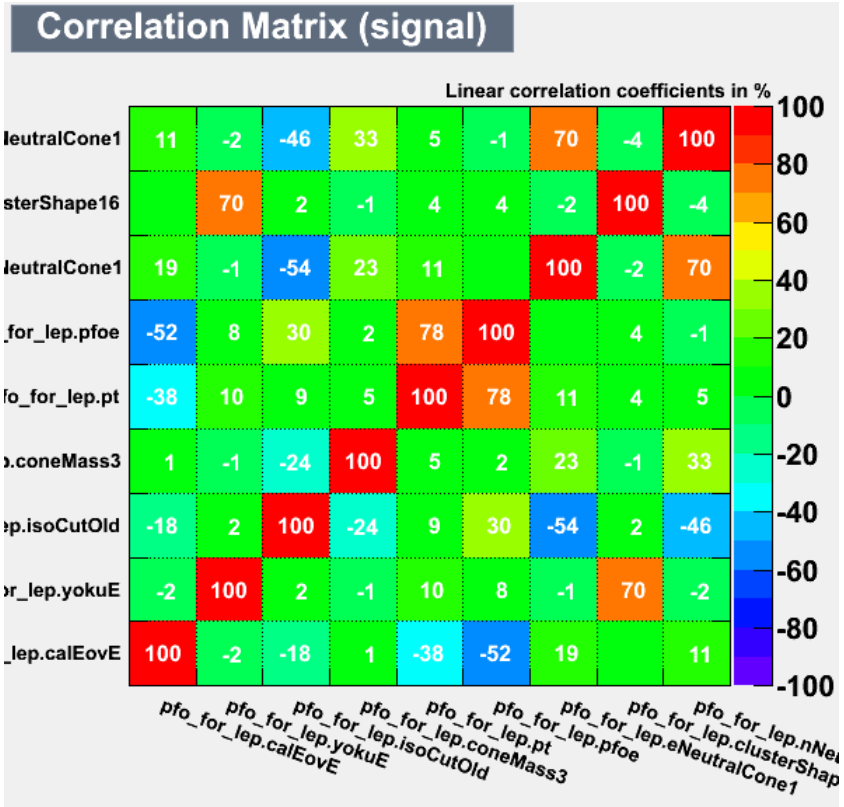


BDT input variables mu-taum 1

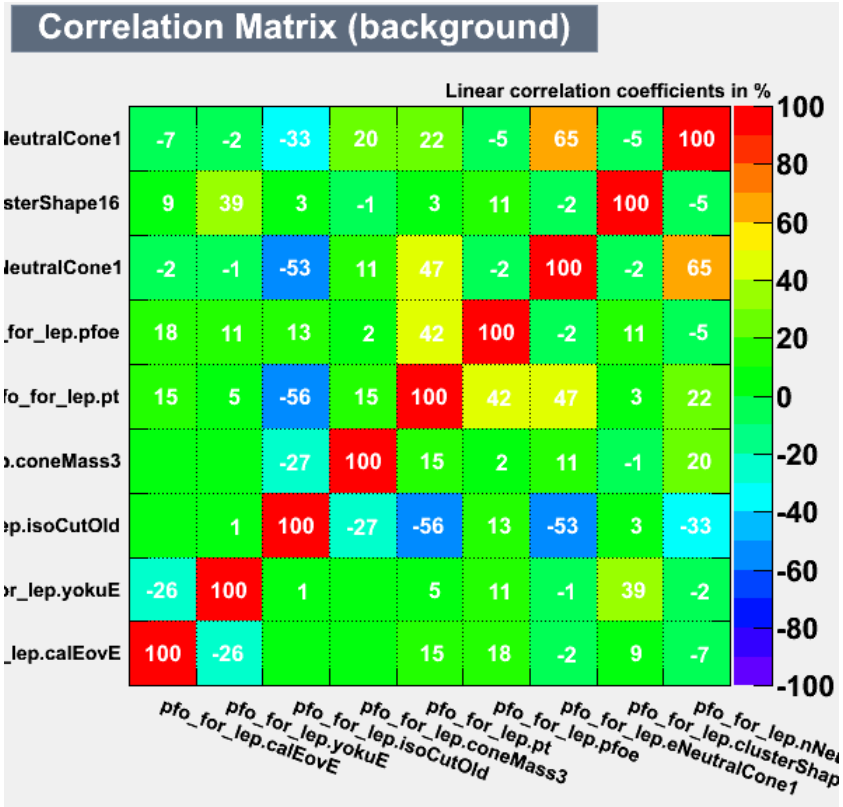


Correlation

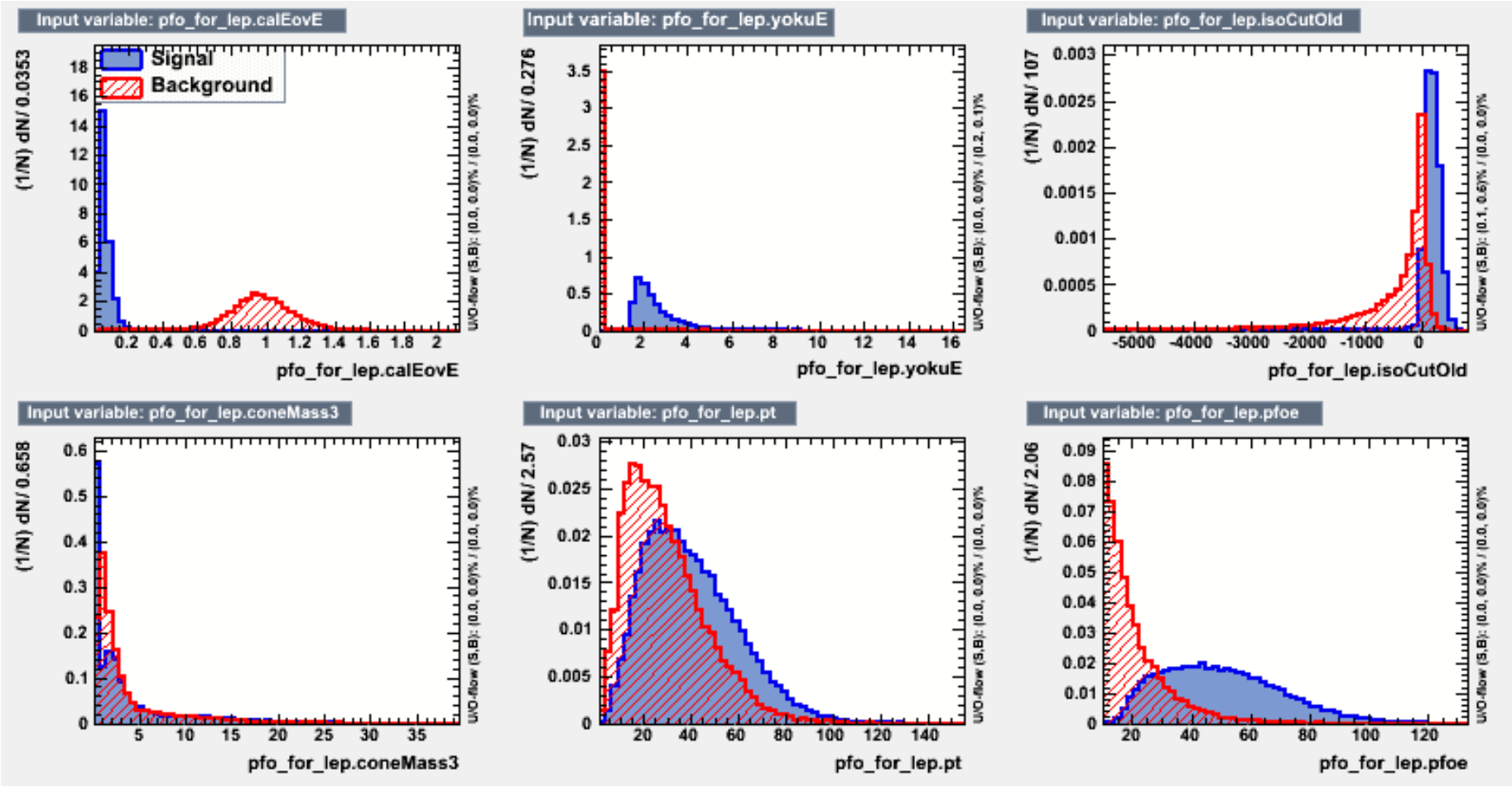
muon



tau(h)



BDT input variables mu-tauh 1



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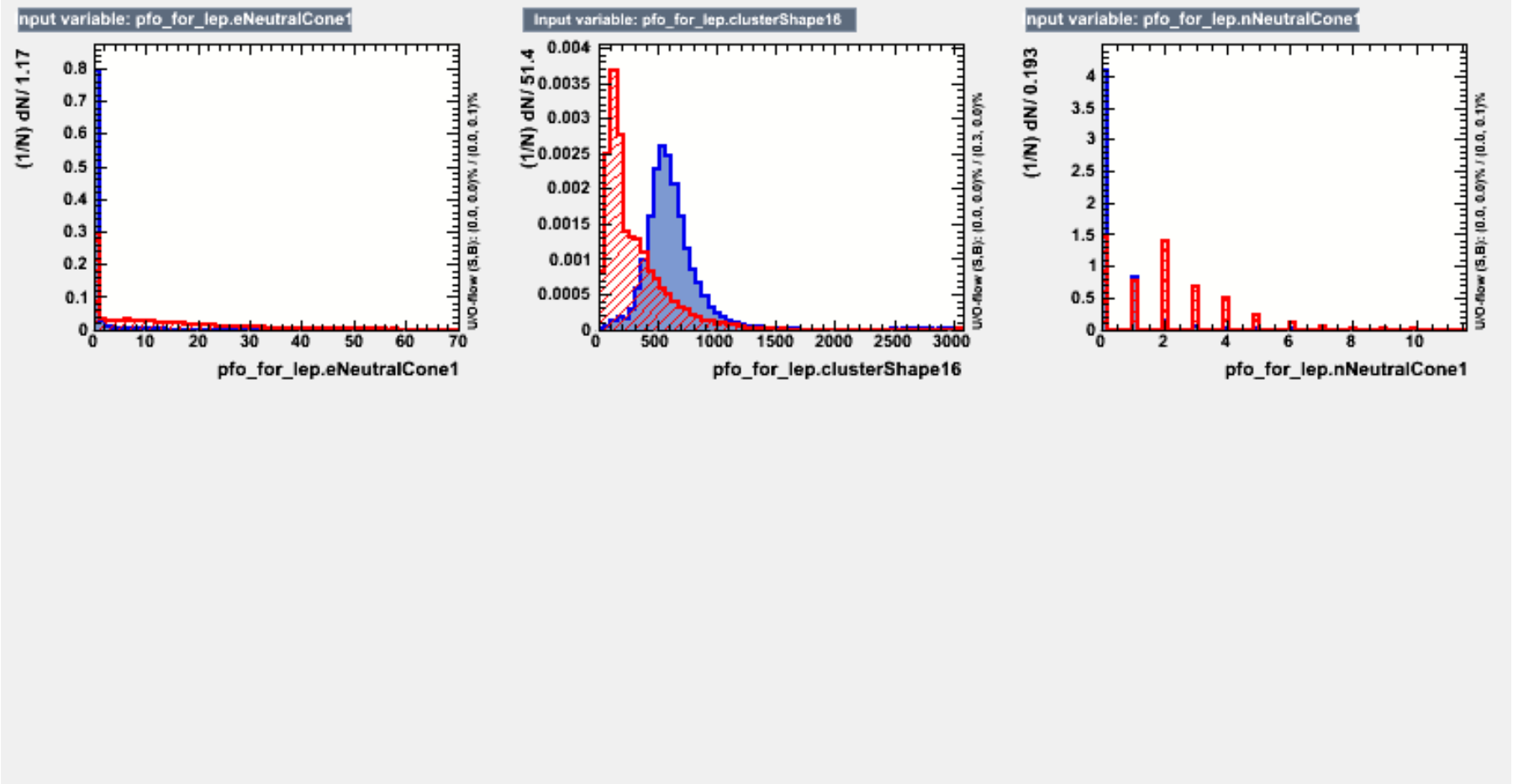
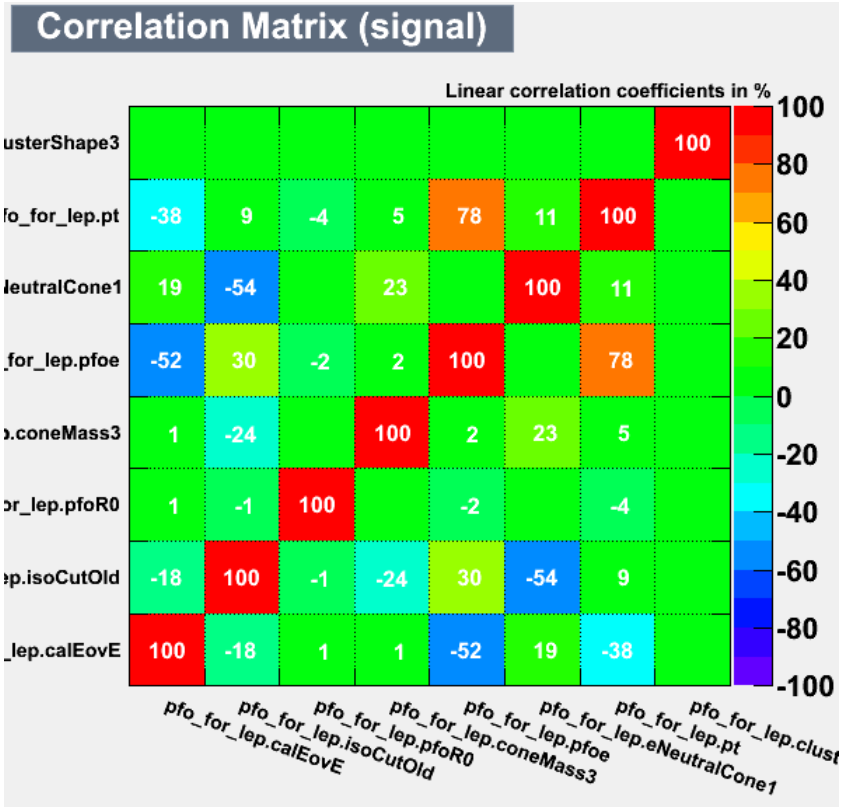
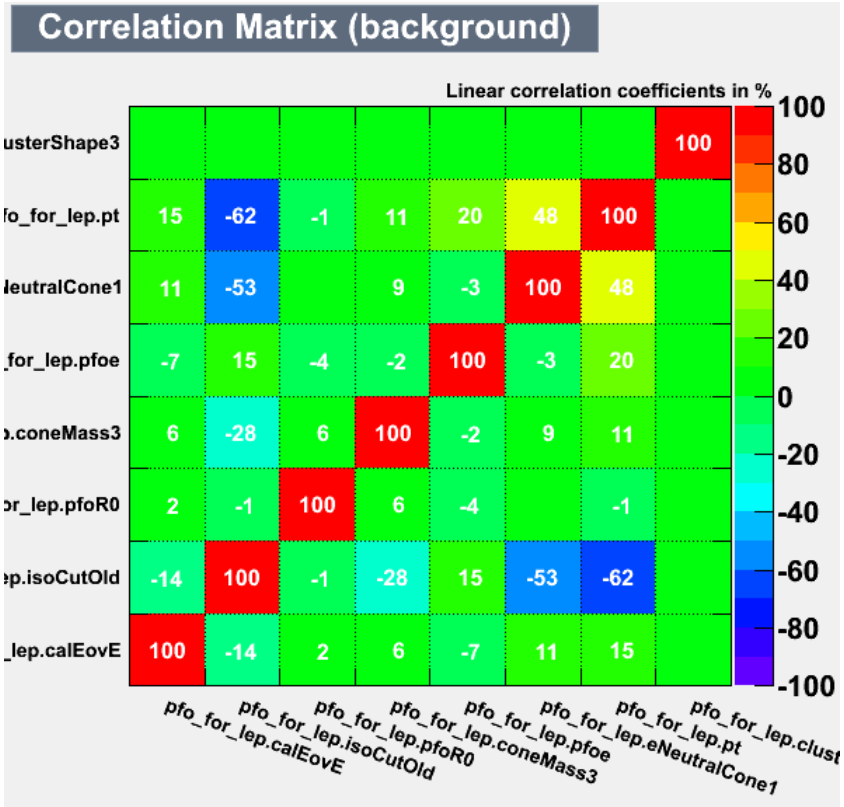


Correlation

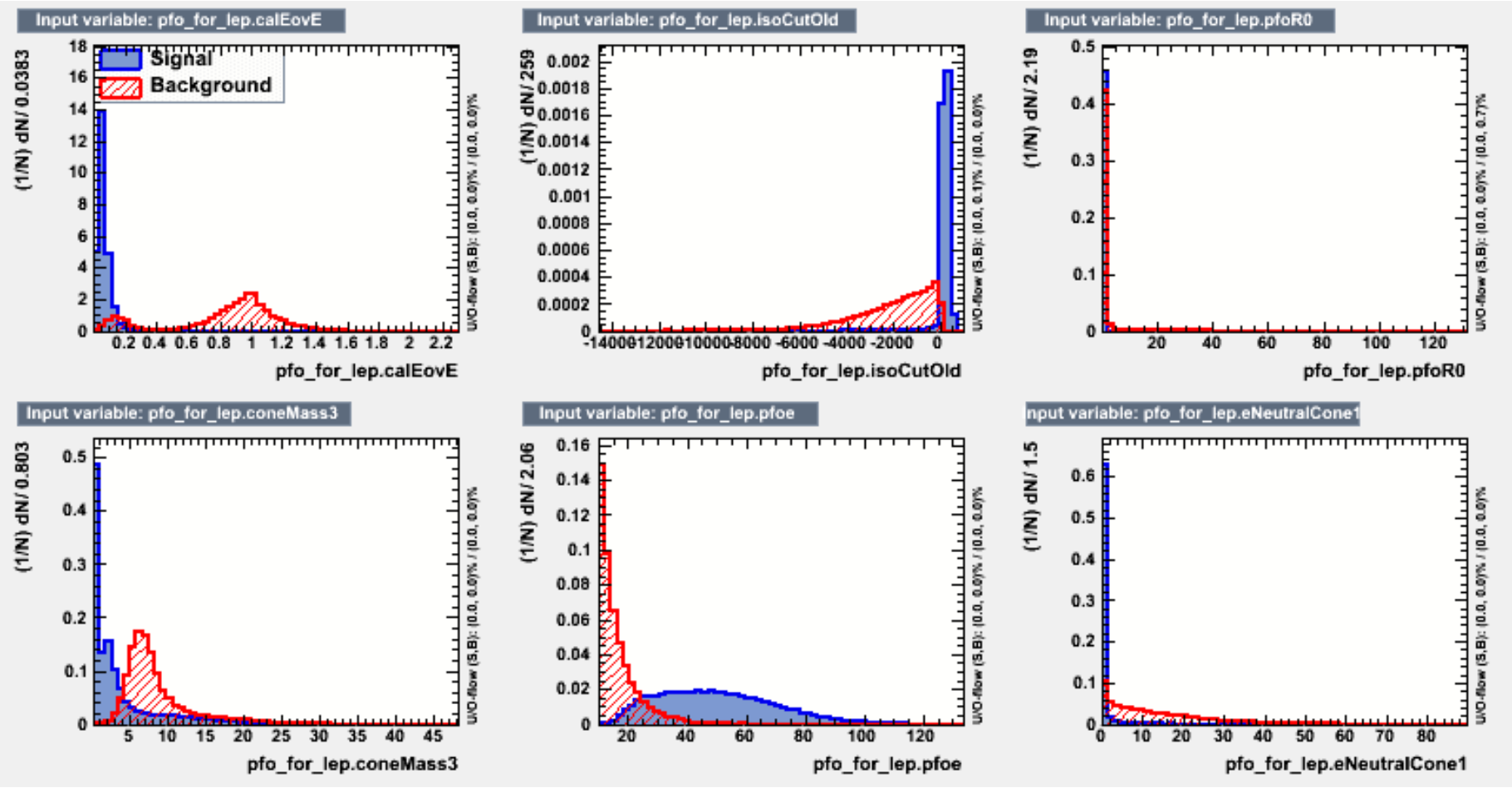
muon



b jet



BDT input variables mu-bjet 1



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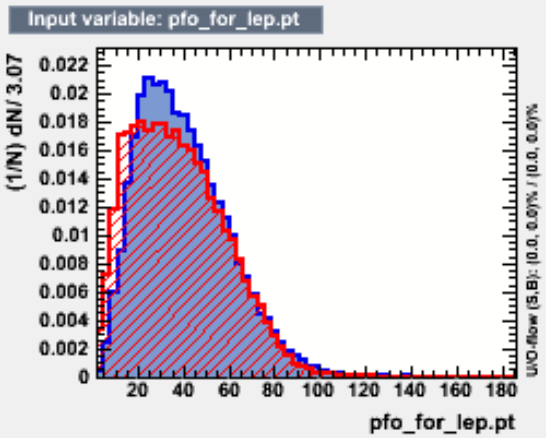
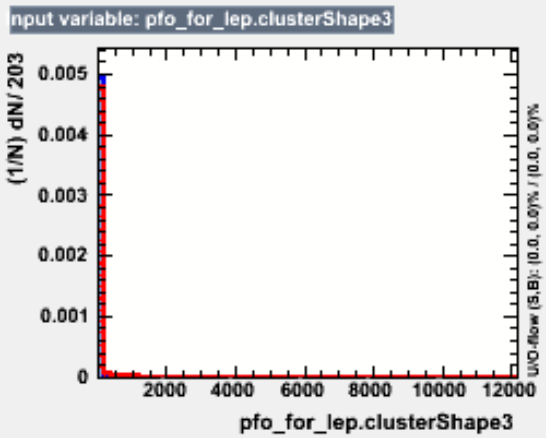
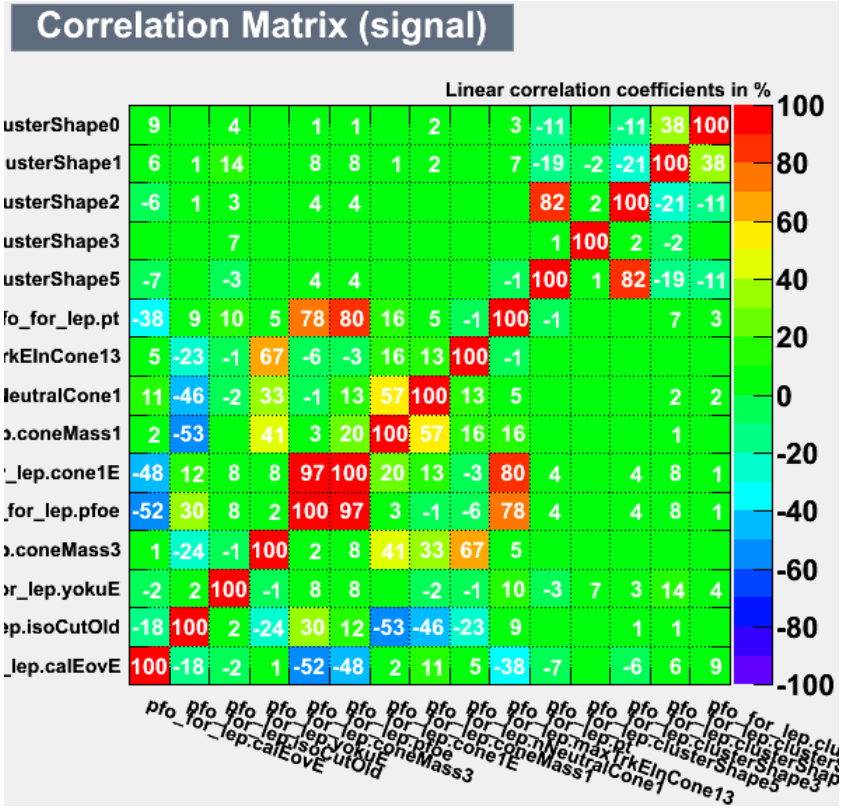


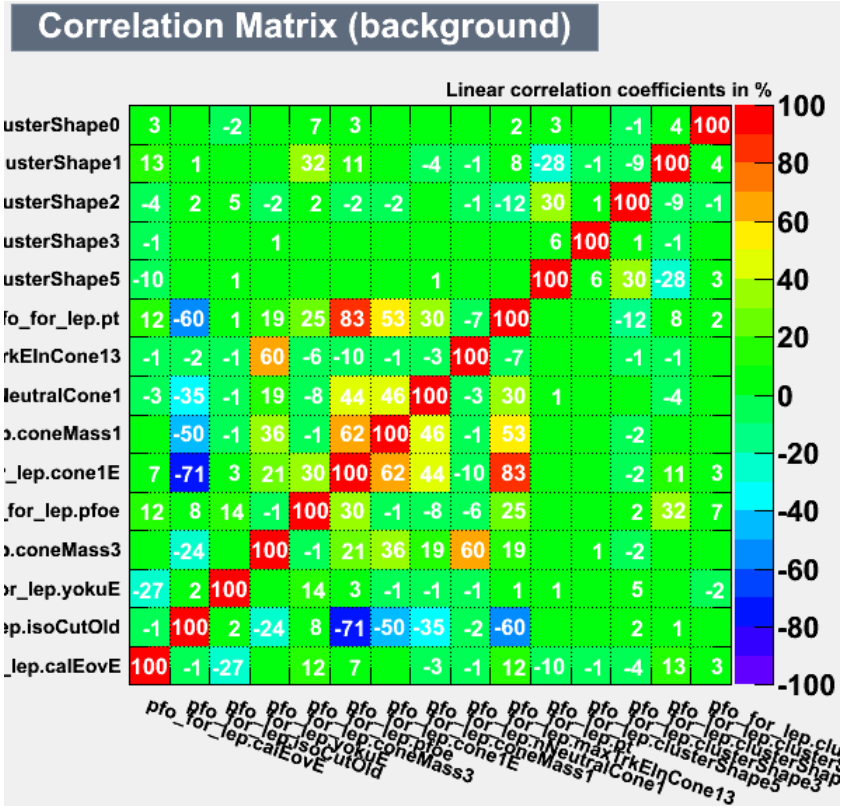


Correlation

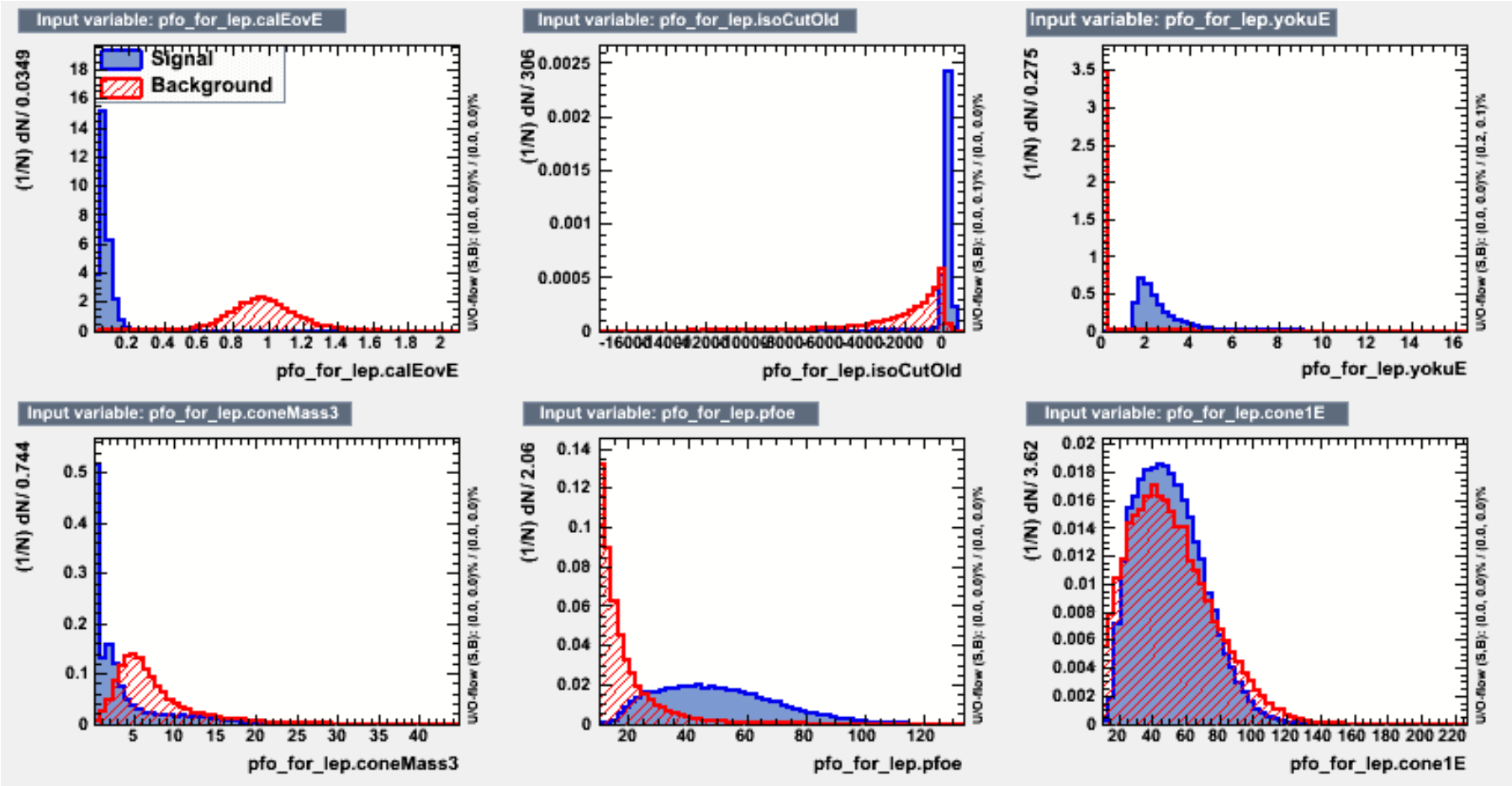
muon



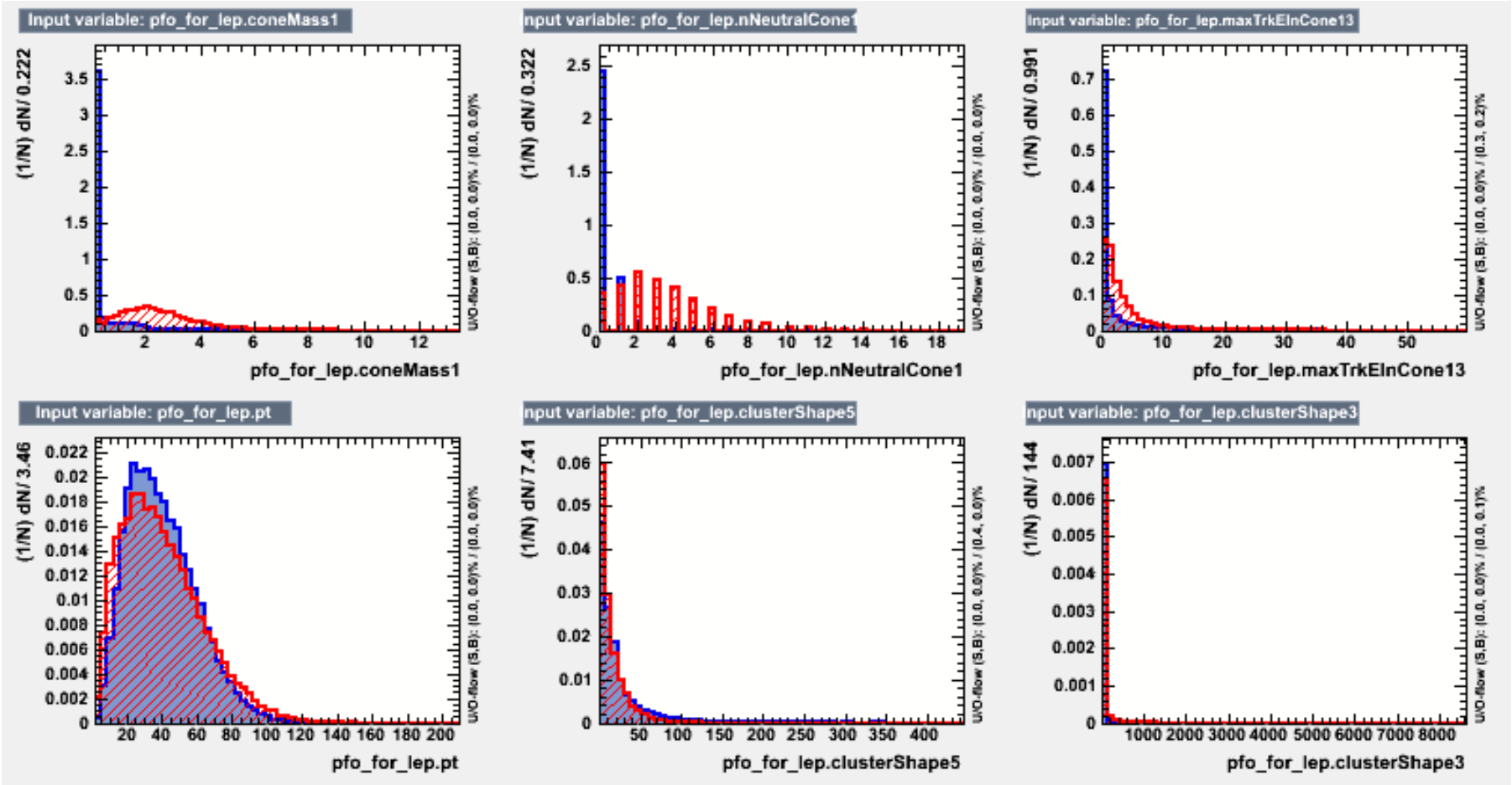
lf jet



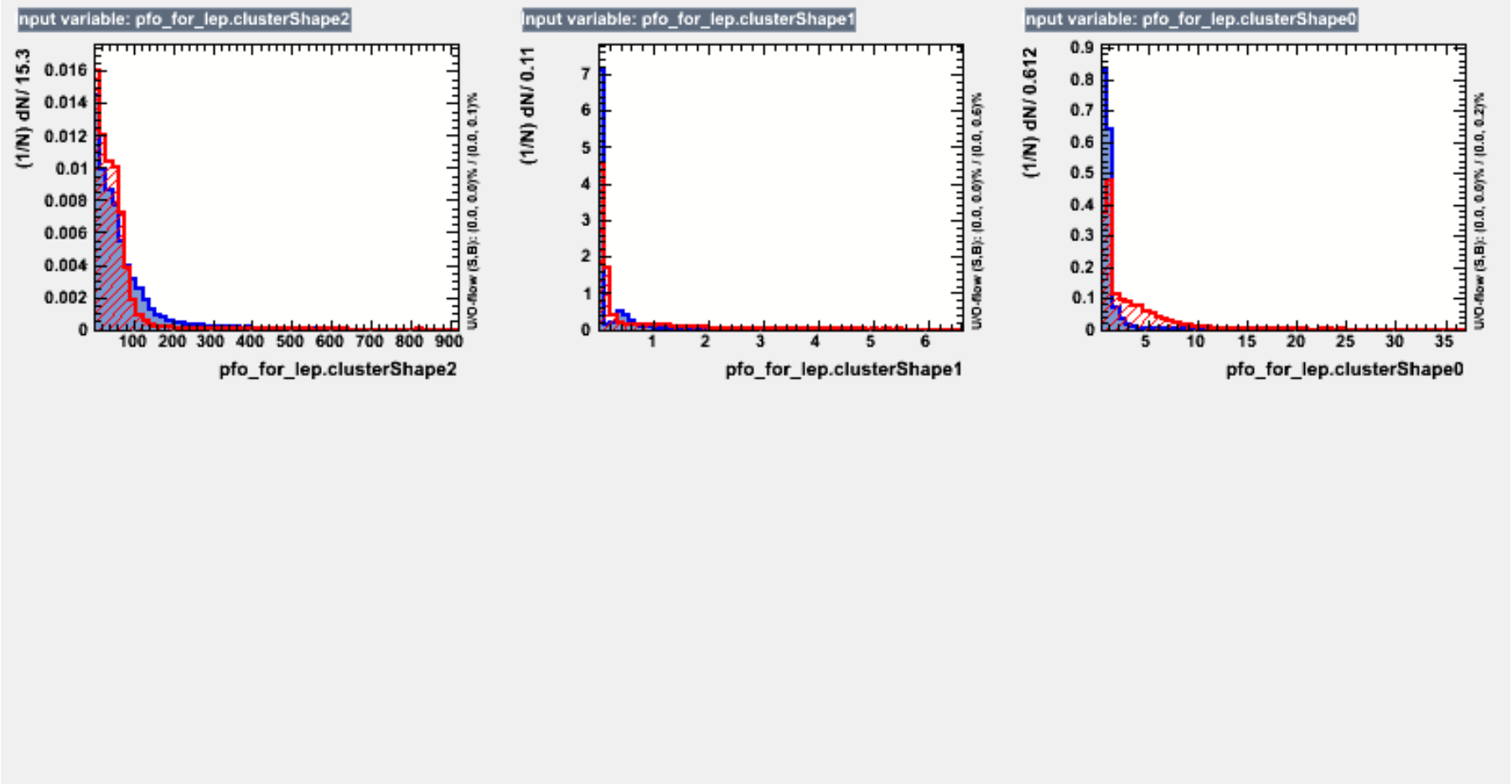
BDT input variables mu-lfjet 1



BDT input variables mu-lfjet 2

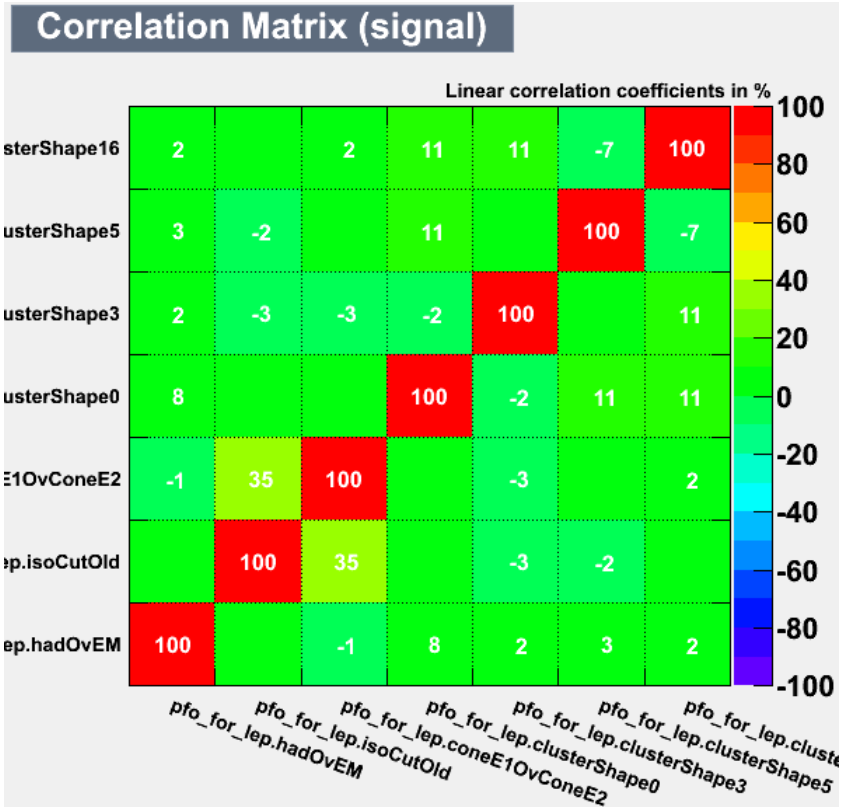


BDT input variables mu-lfjet 3

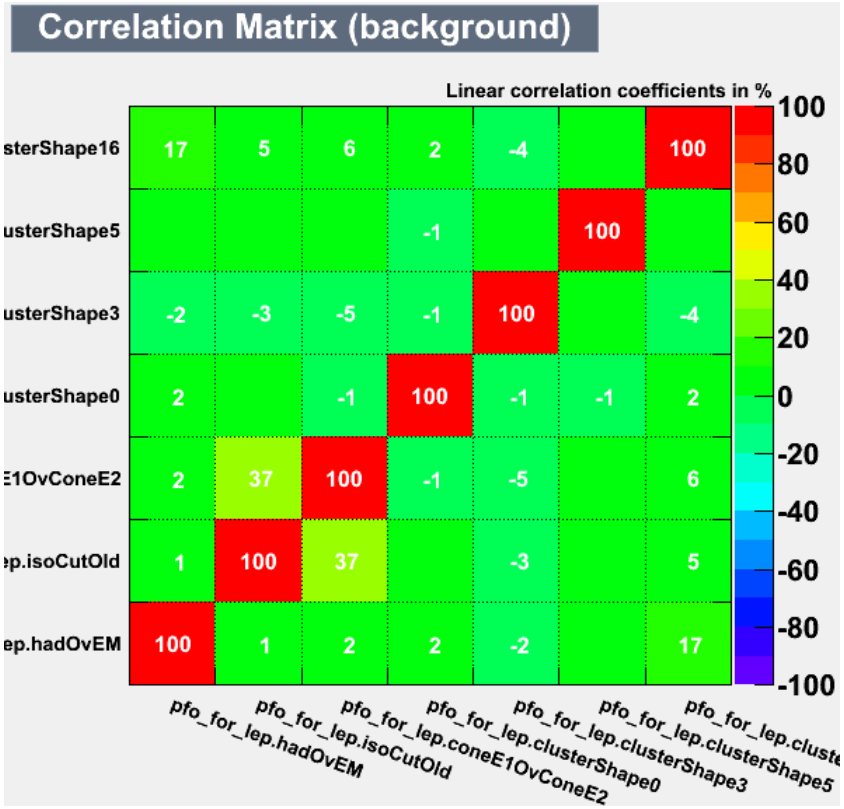


Correlation

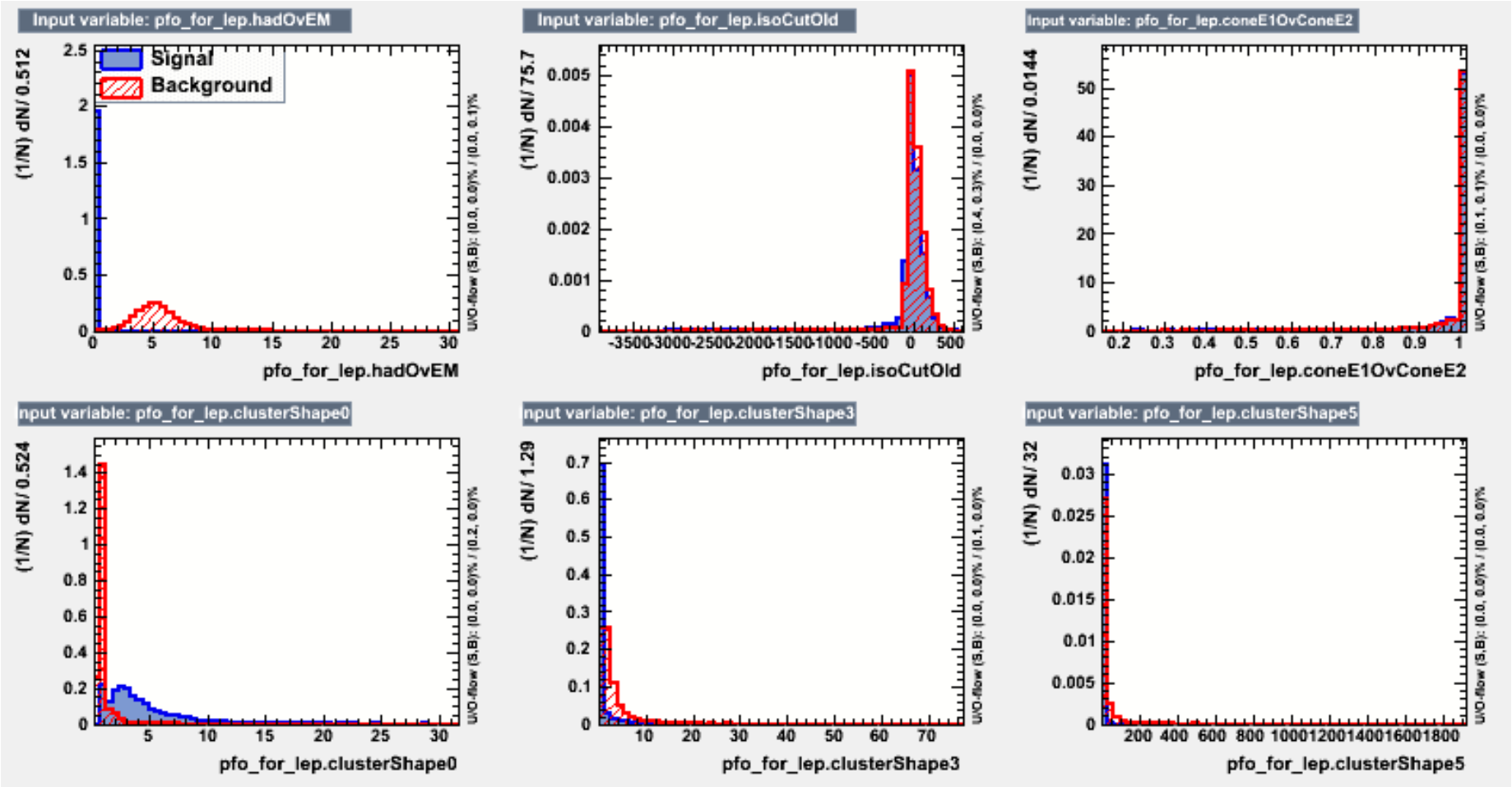
tau(e)



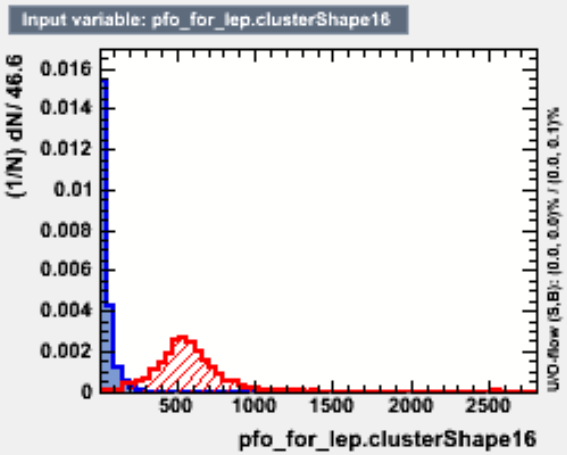
tau(m)



BDT input variables taue-taum 1

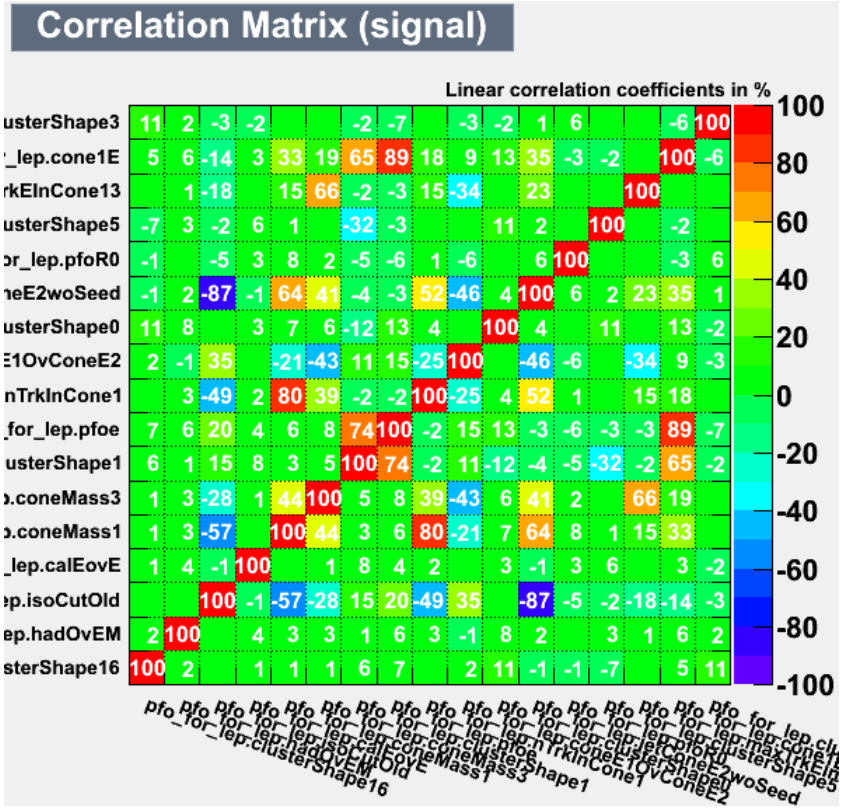


BDT input variables taue-taum 2

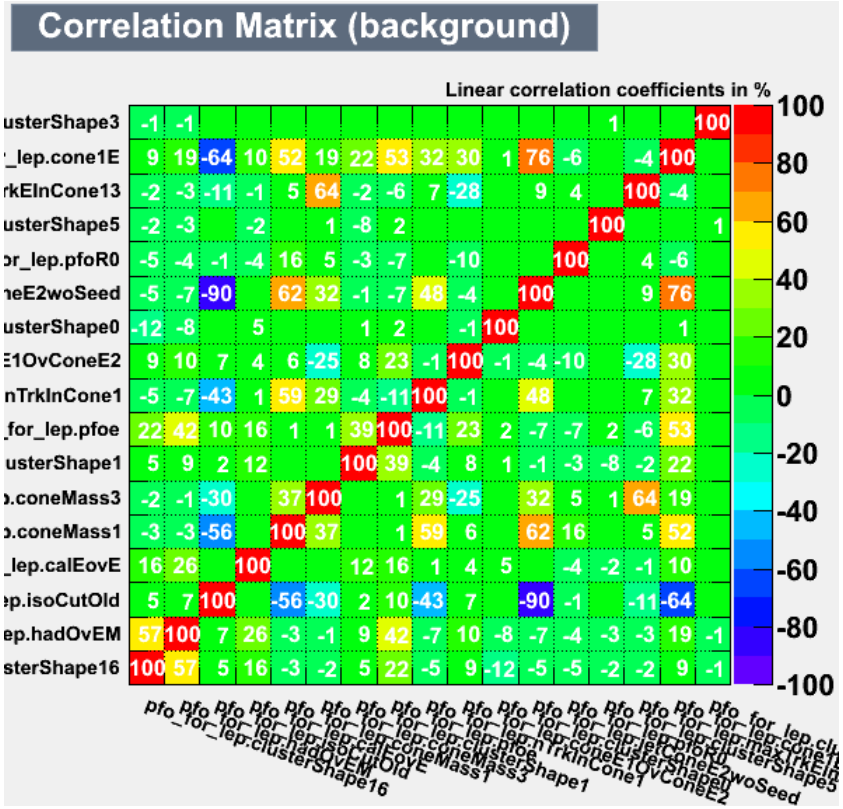


Correlation

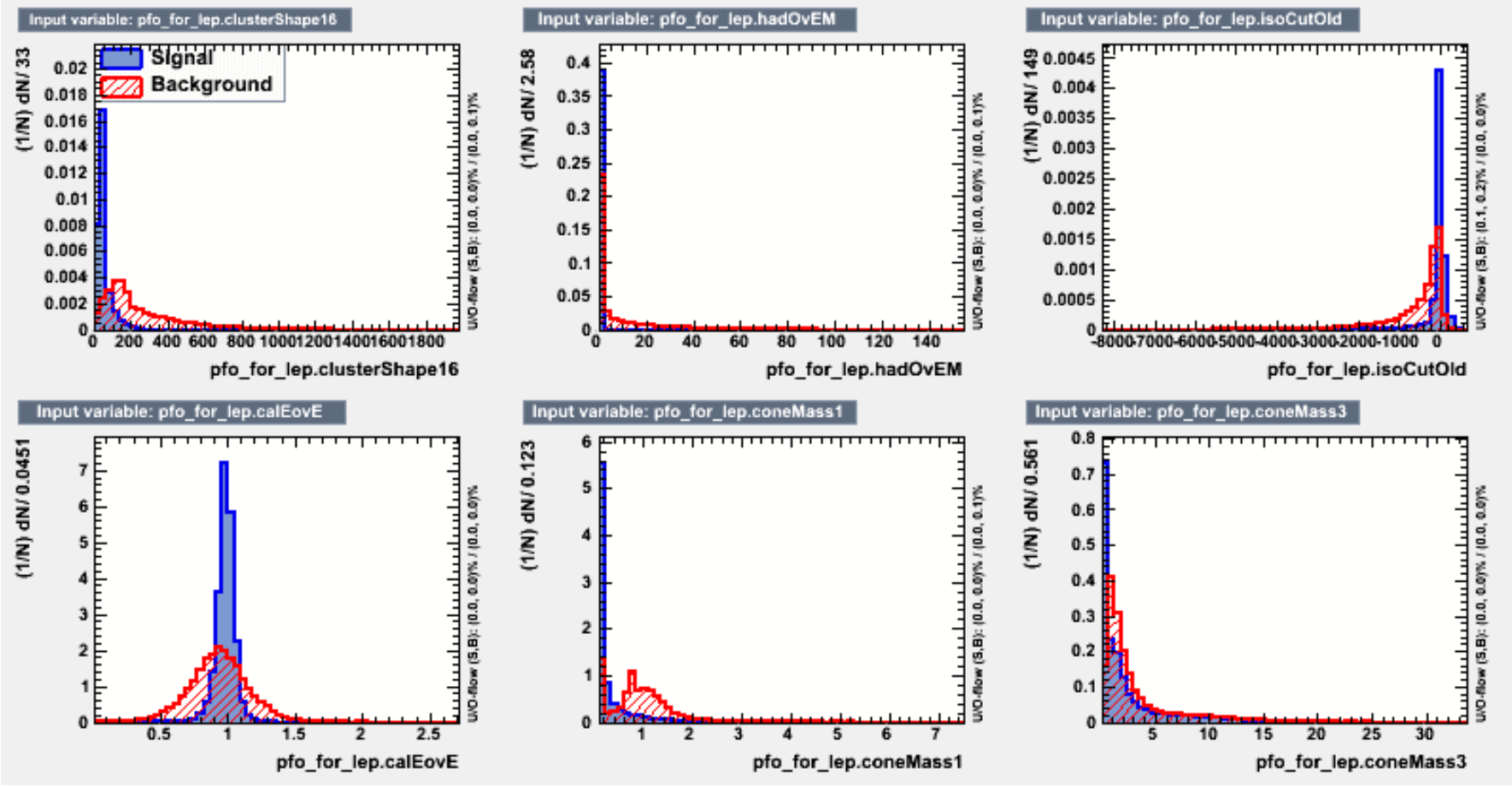
tau(e)



tau(h)



BDT input variables taue-tauh 1



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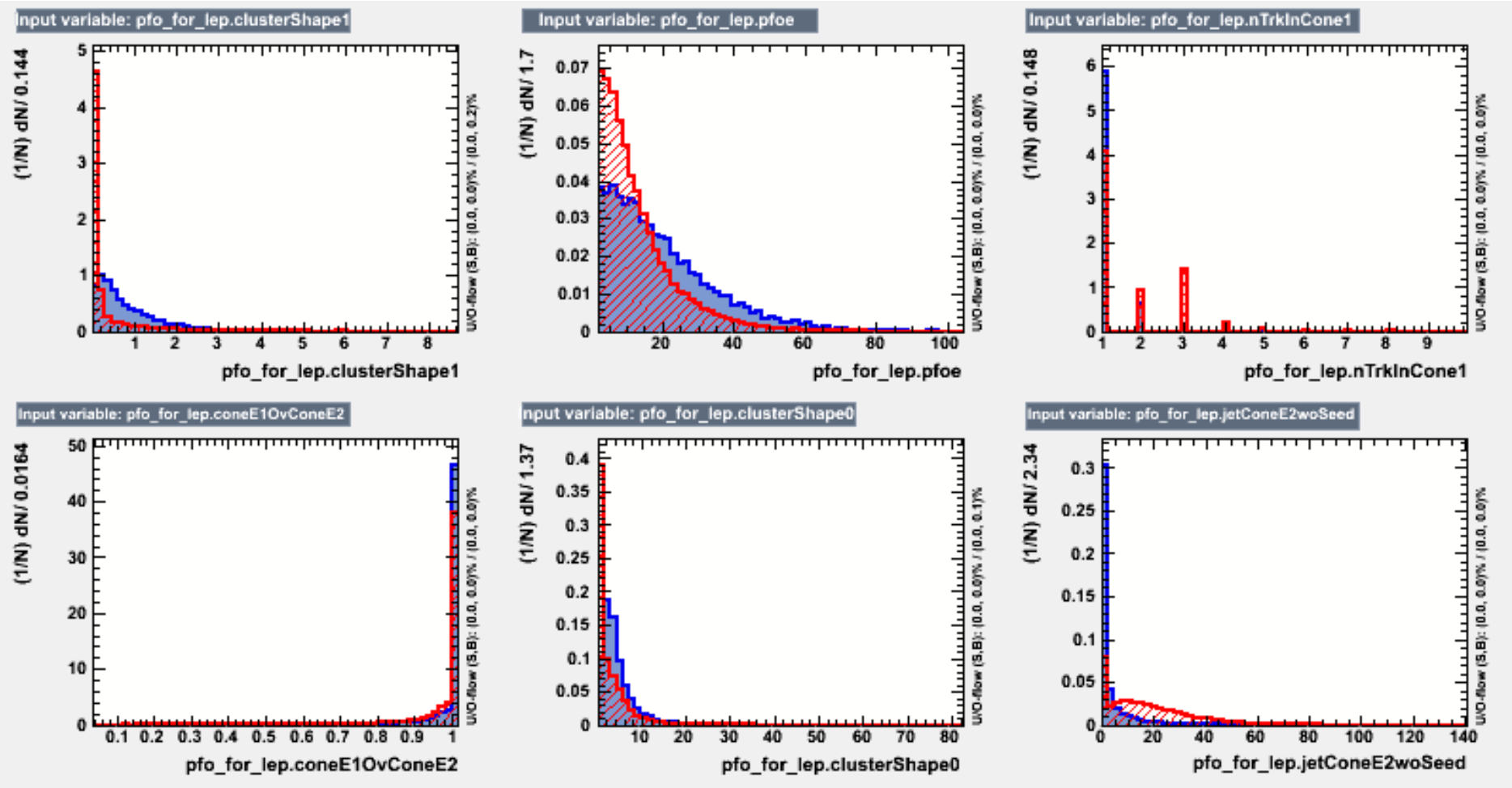
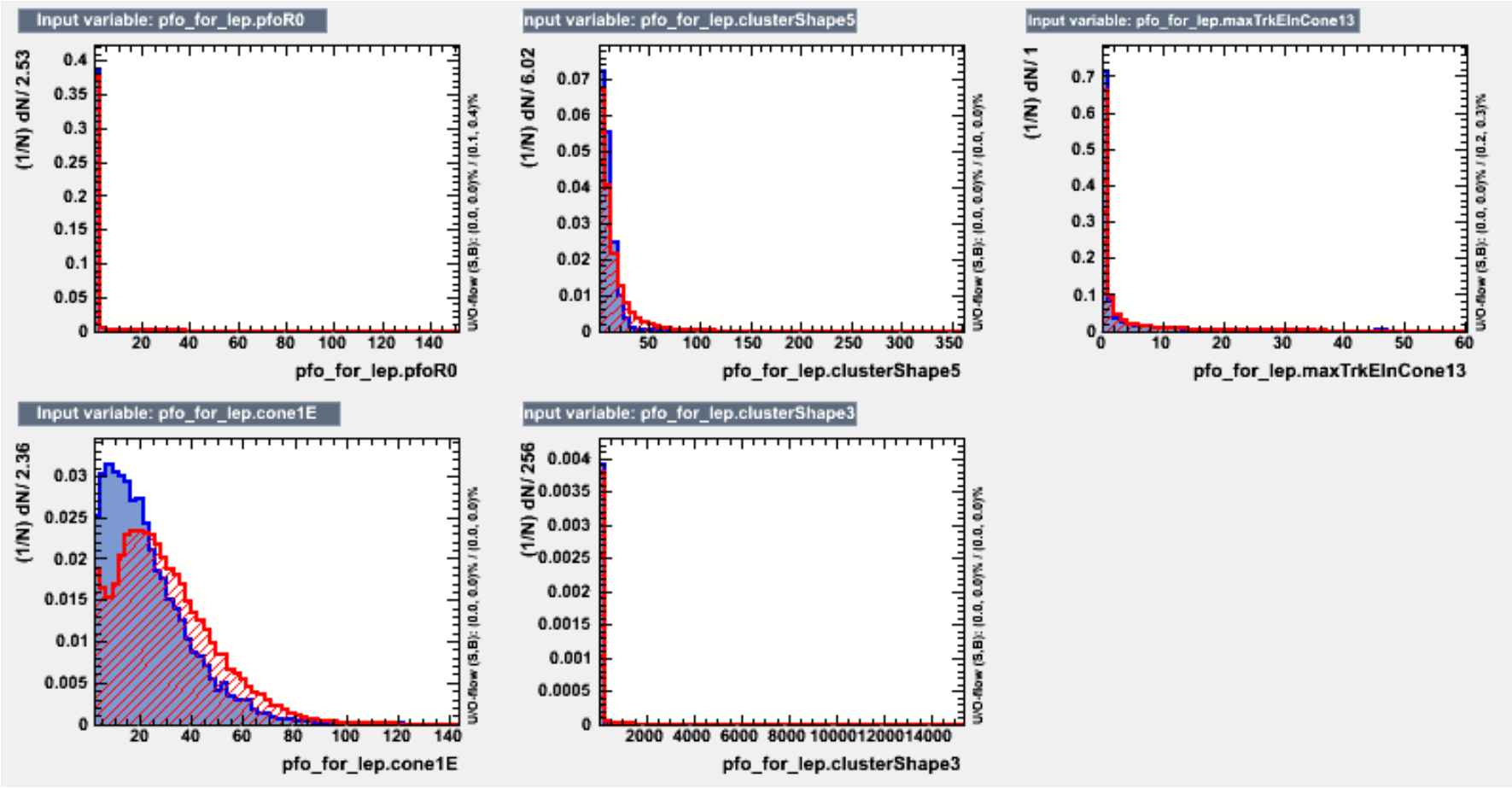
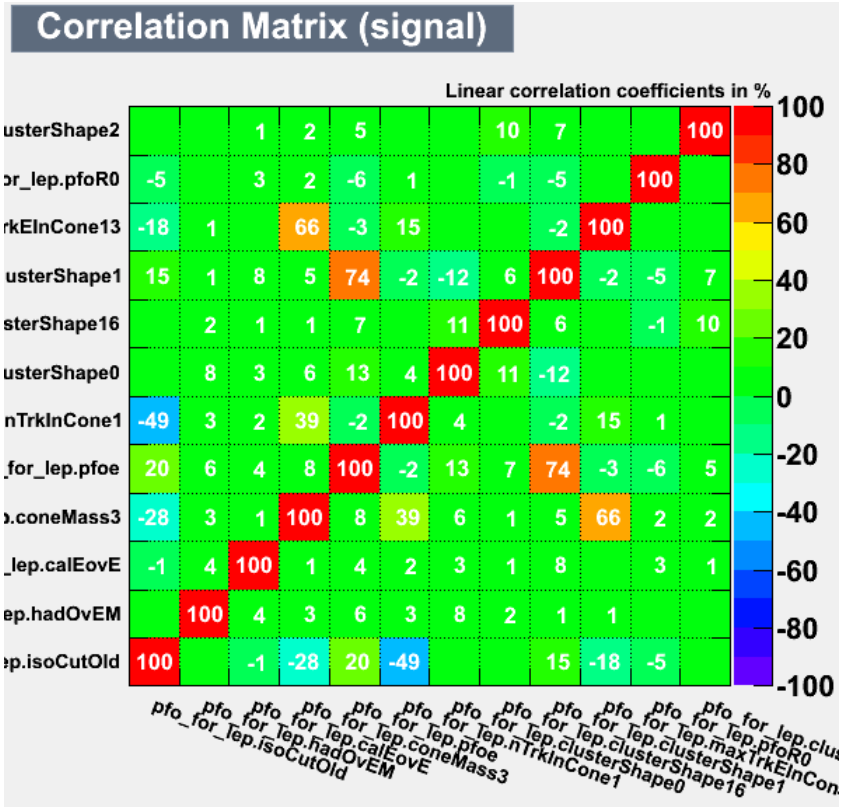


BDT input variables taue-tauh 3

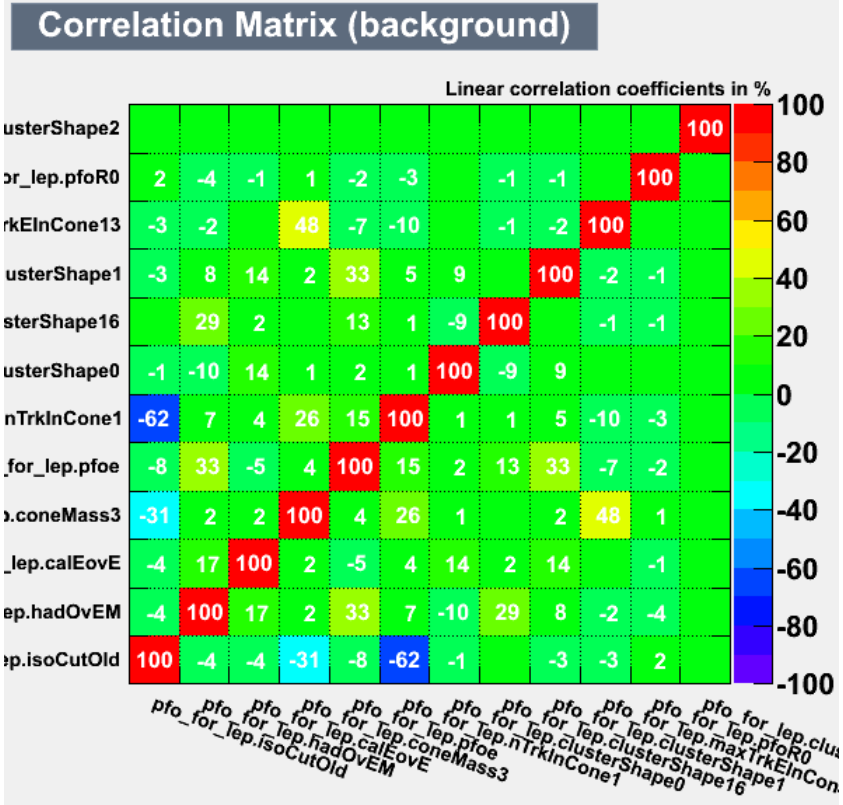


Correlation

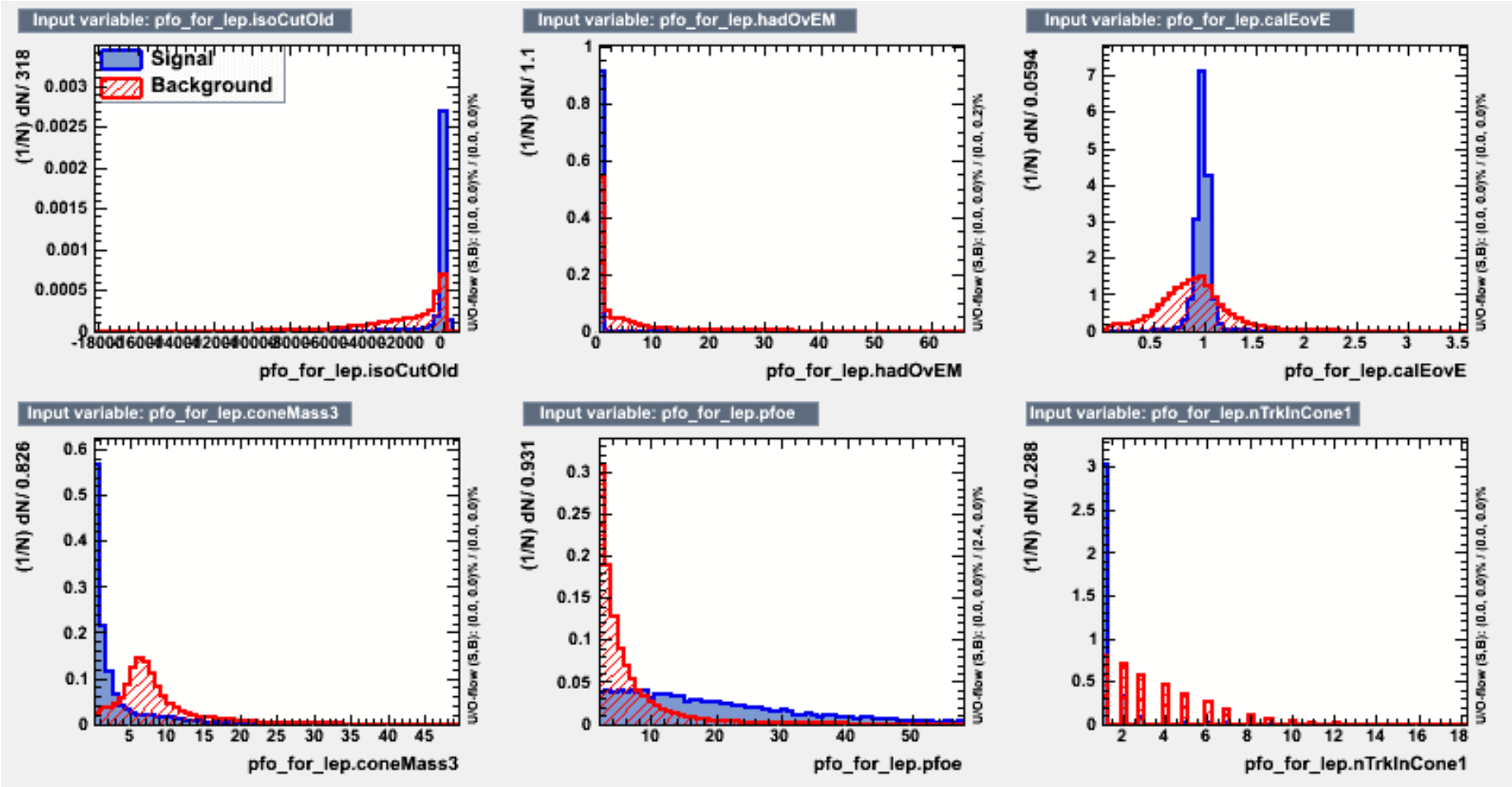
tau(e)



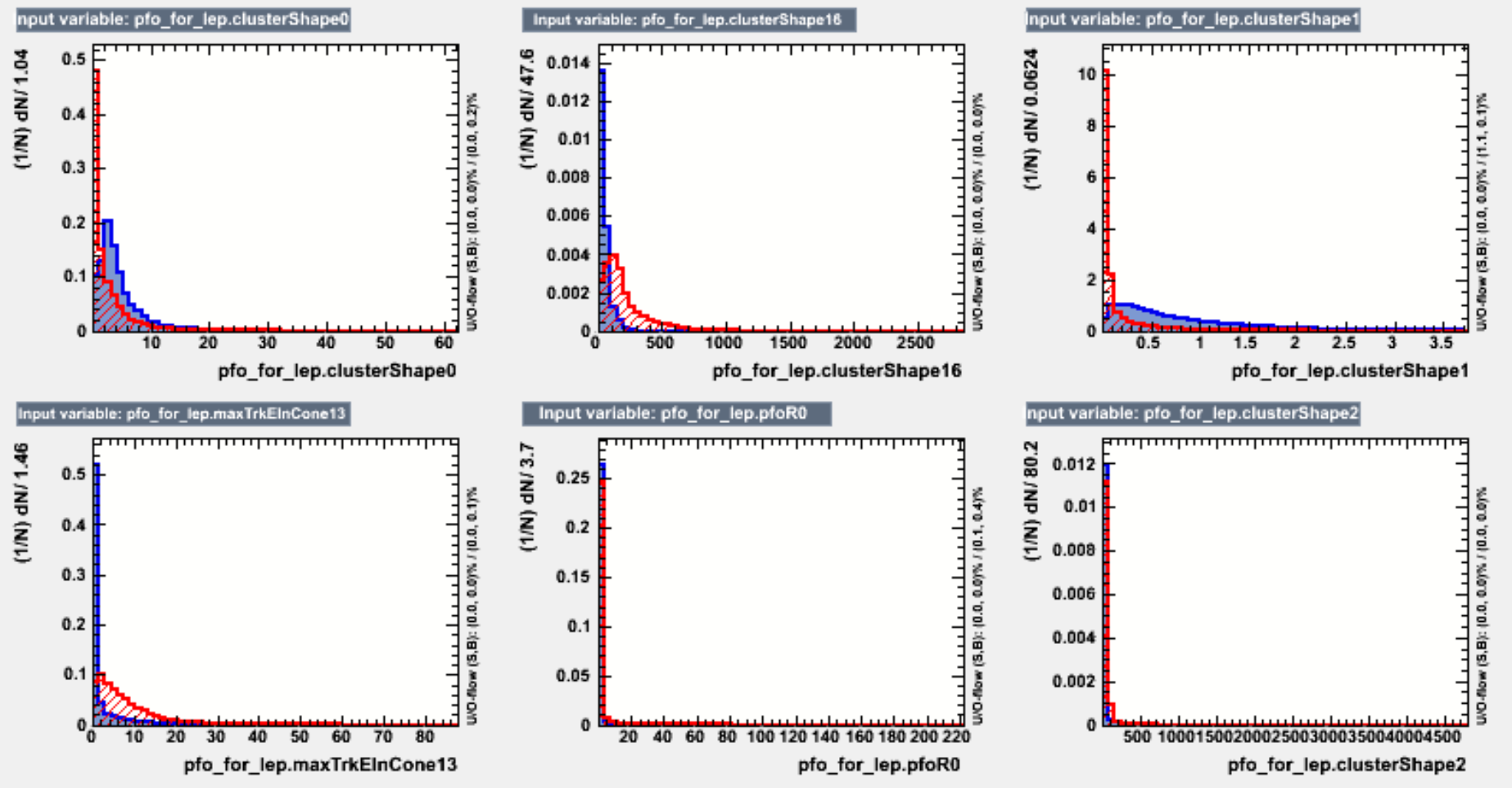
b jet



BDT input variables taue-bjet 1

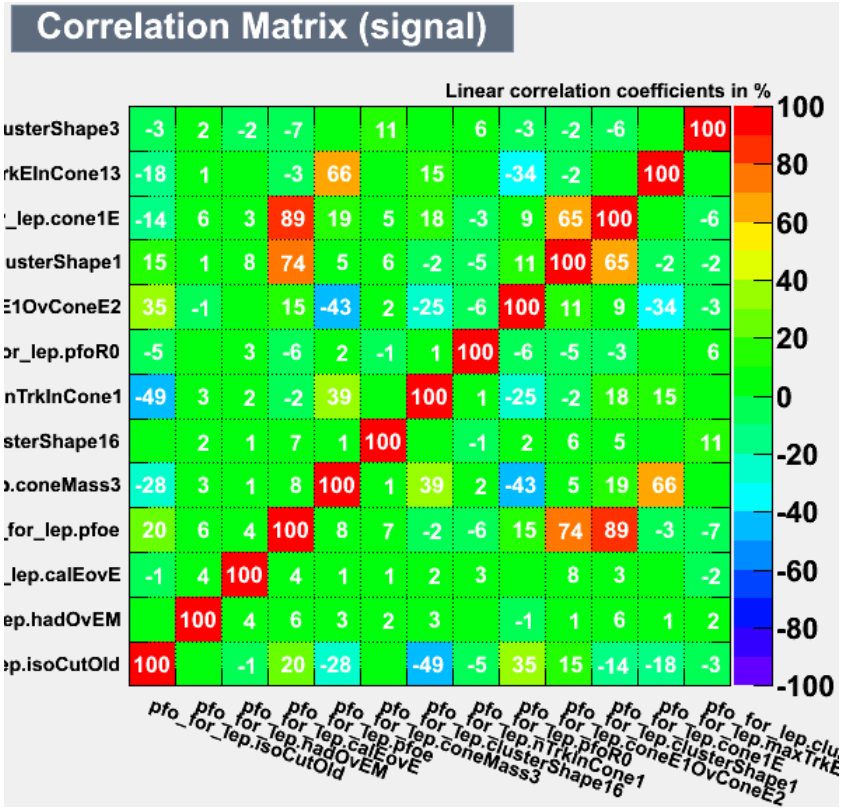


BDT input variables taue-bjet 2

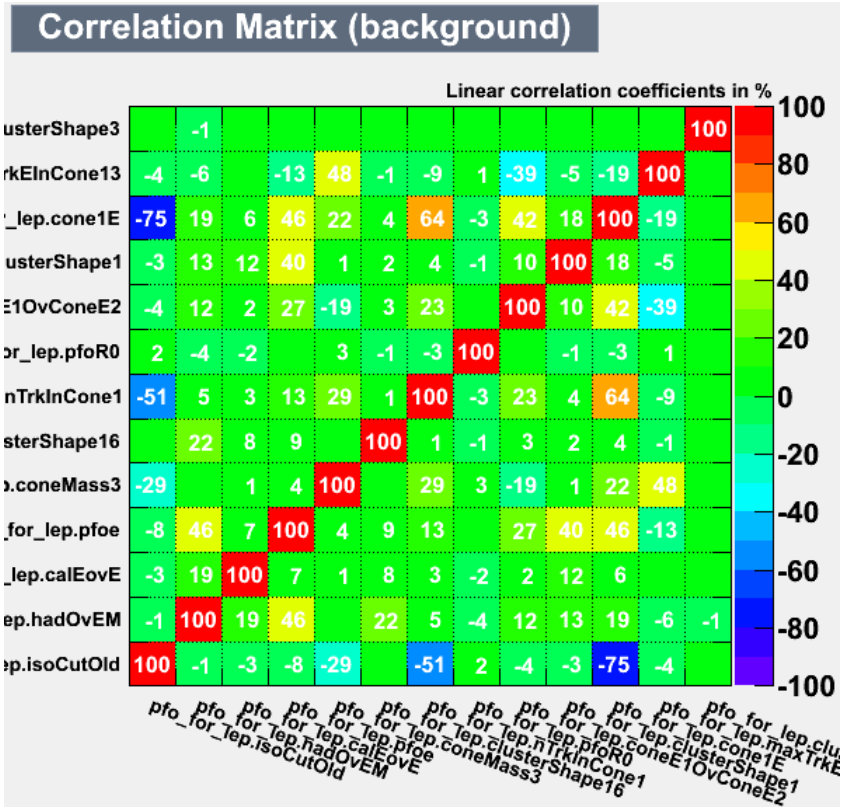


Correlation

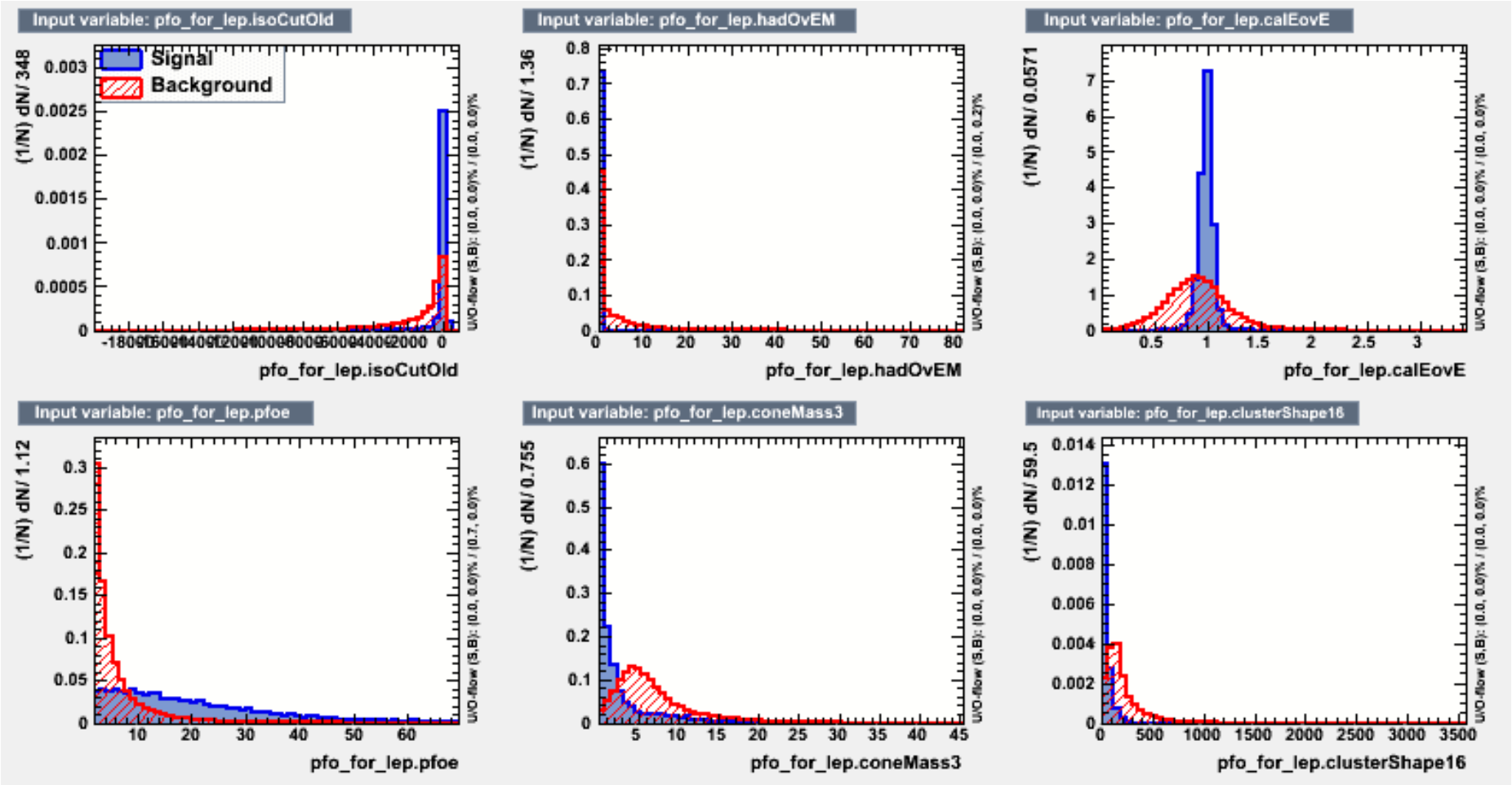
tau(e)



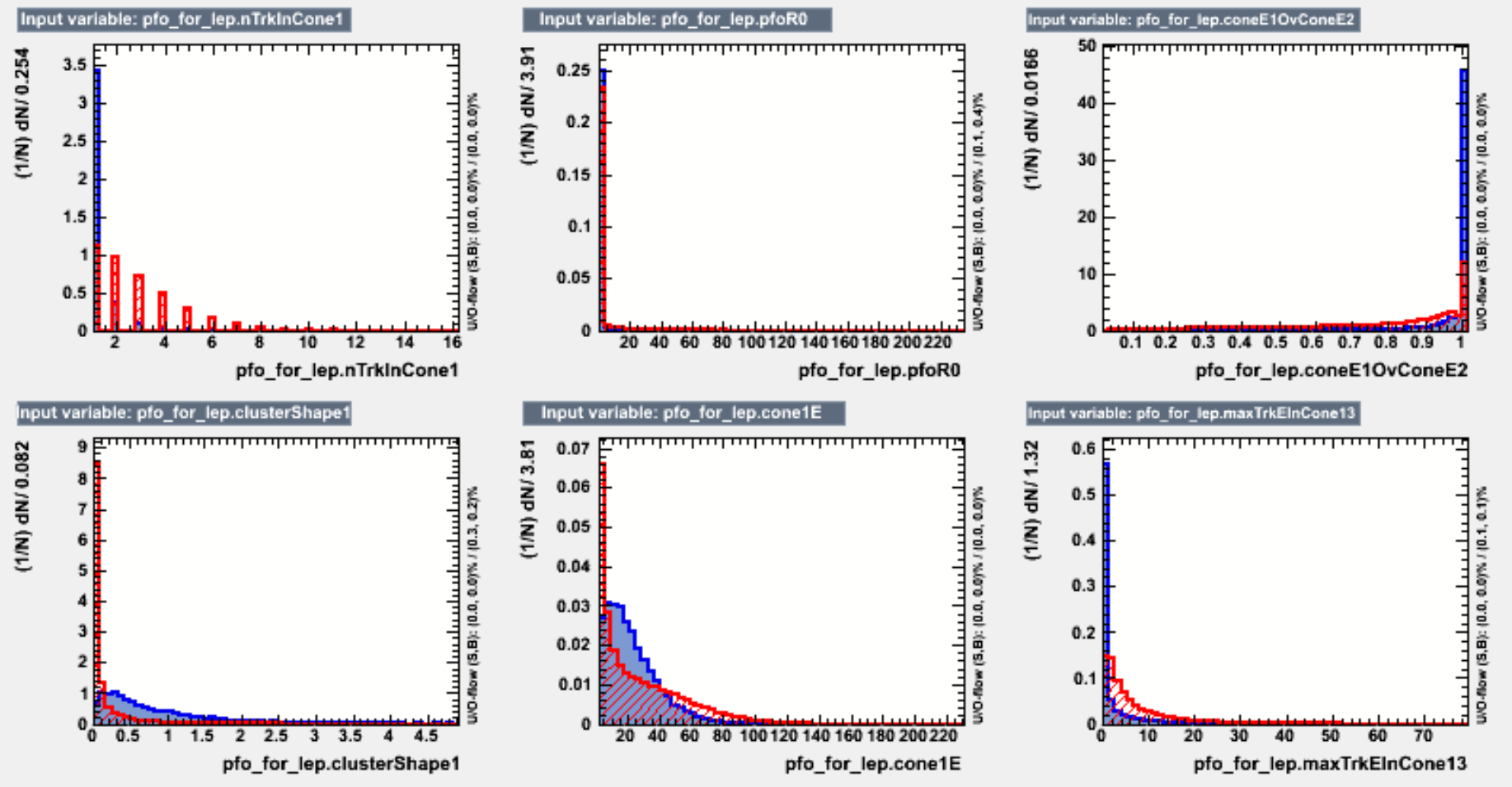
lf jet



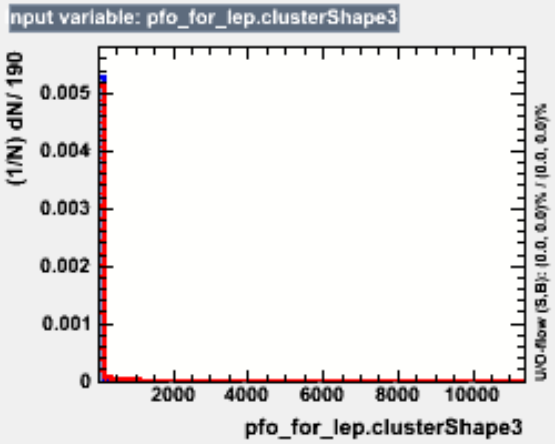
BDT input variables taue-lfjet 1



BDT input variables taue-lfjet 2

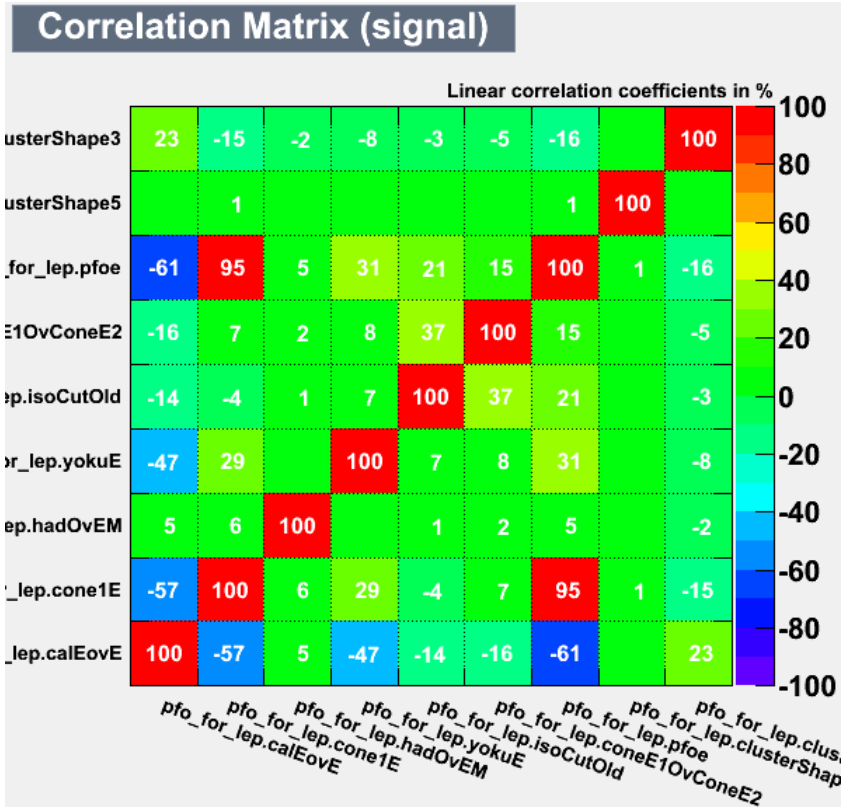


BDT input variables taue-lfjet 3

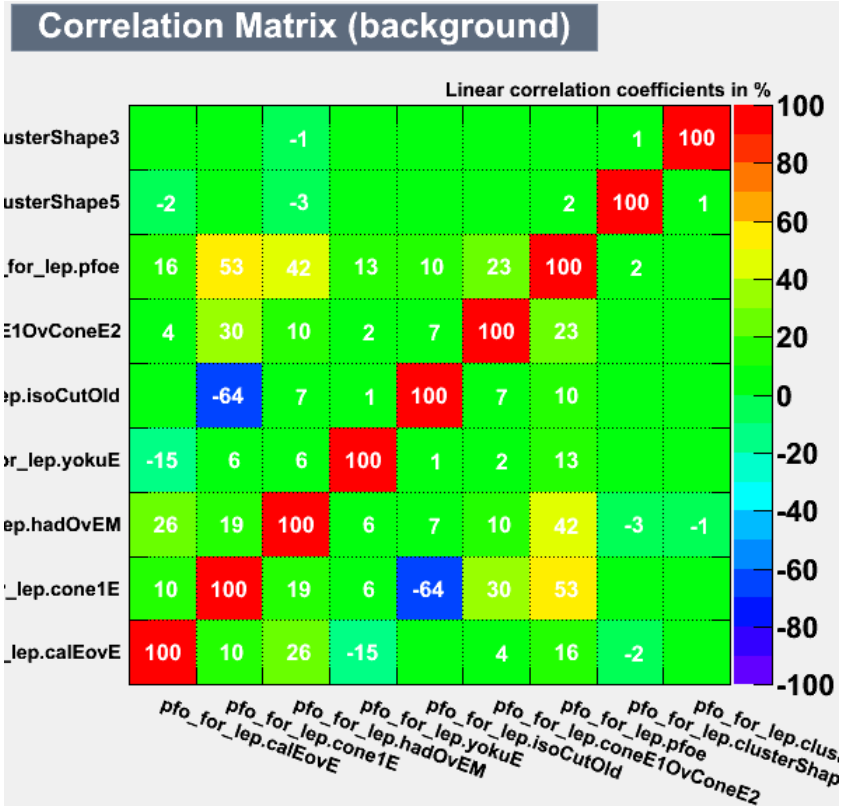


Correlation

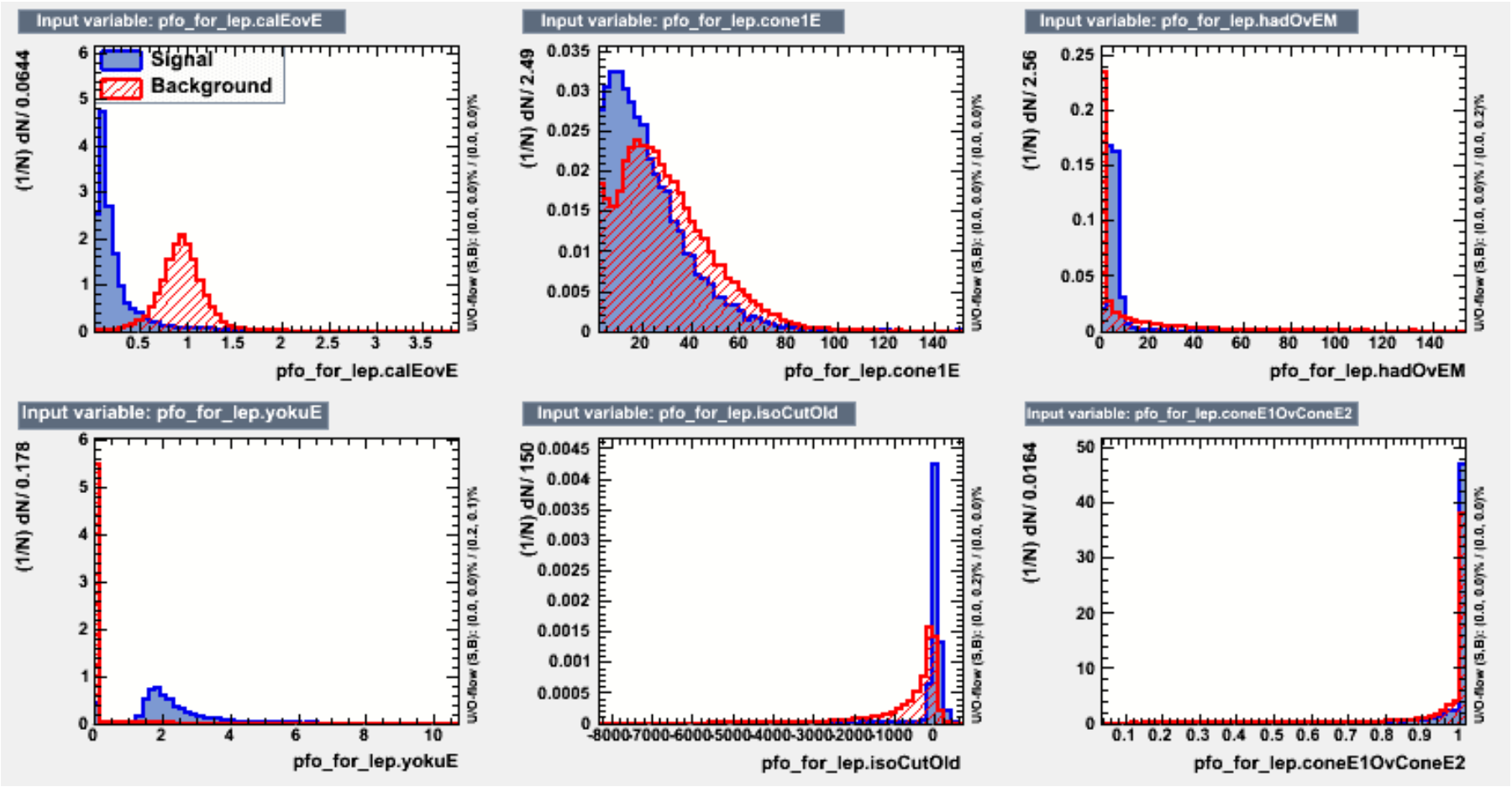
tau(m)



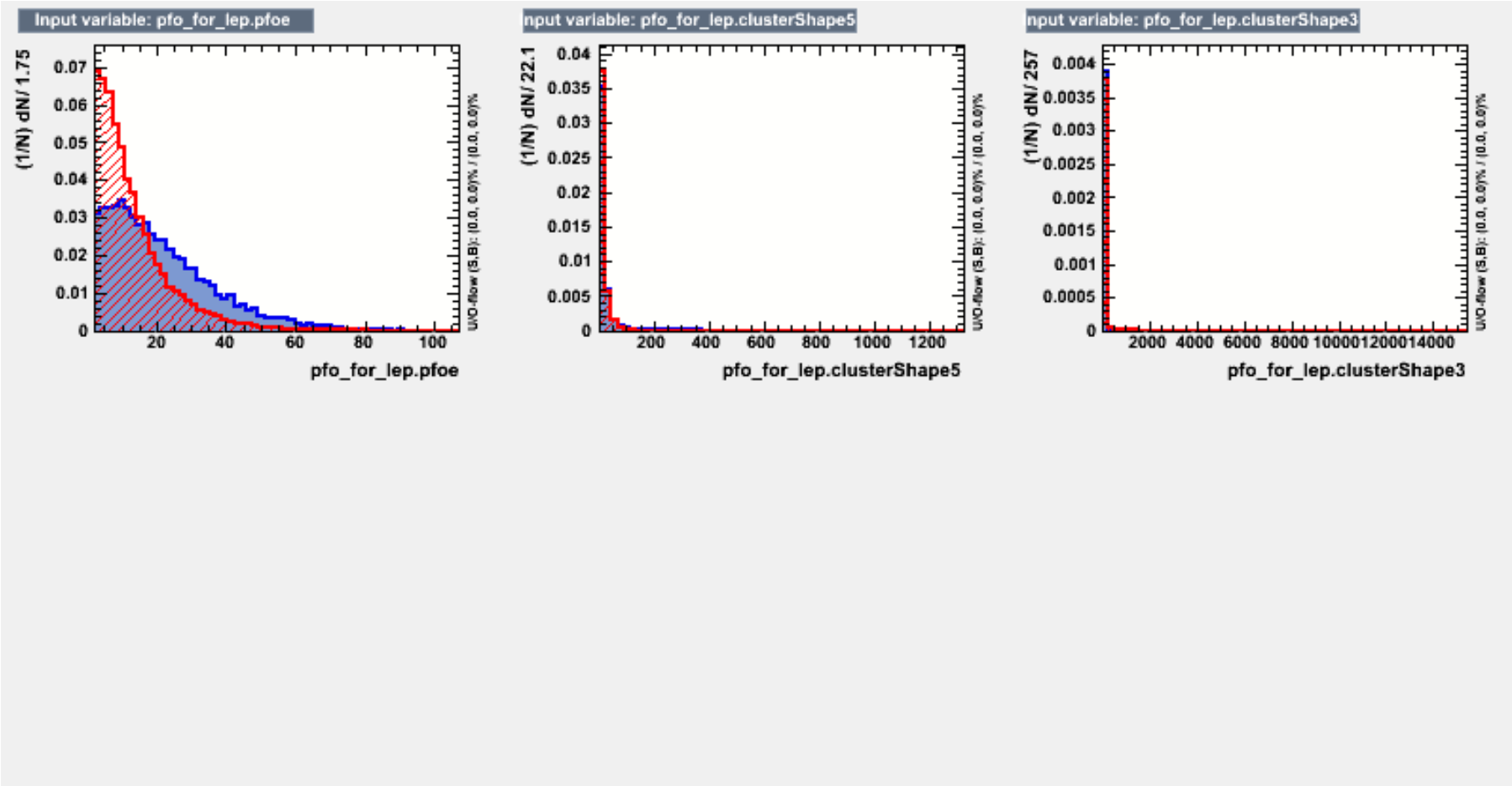
tau(h)



BDT input variables taum-tauh 1

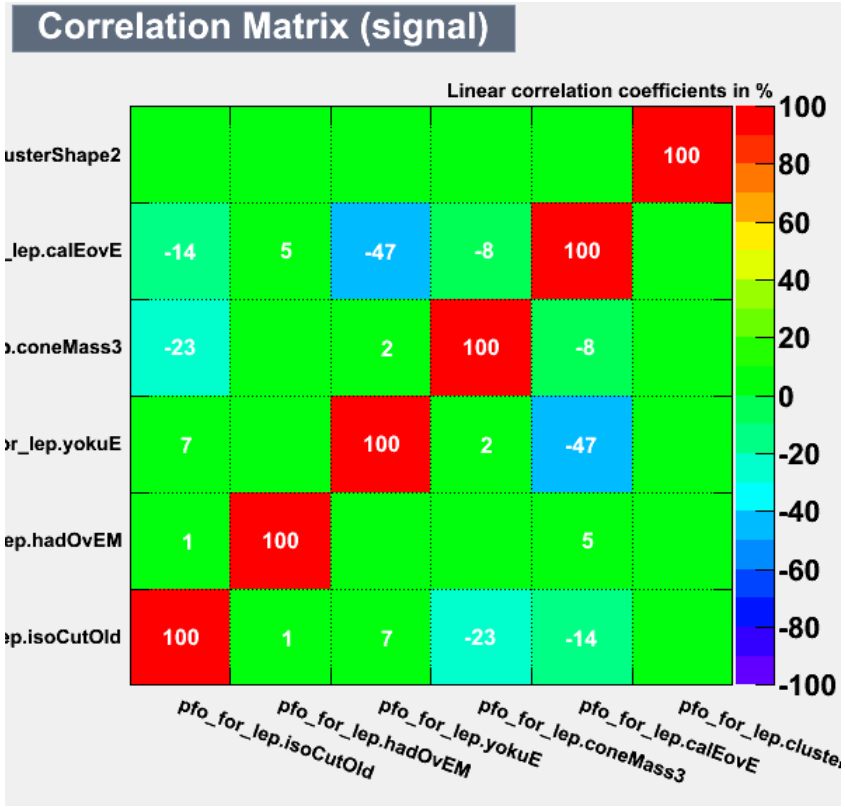


BDT input variables taum-tauh 2

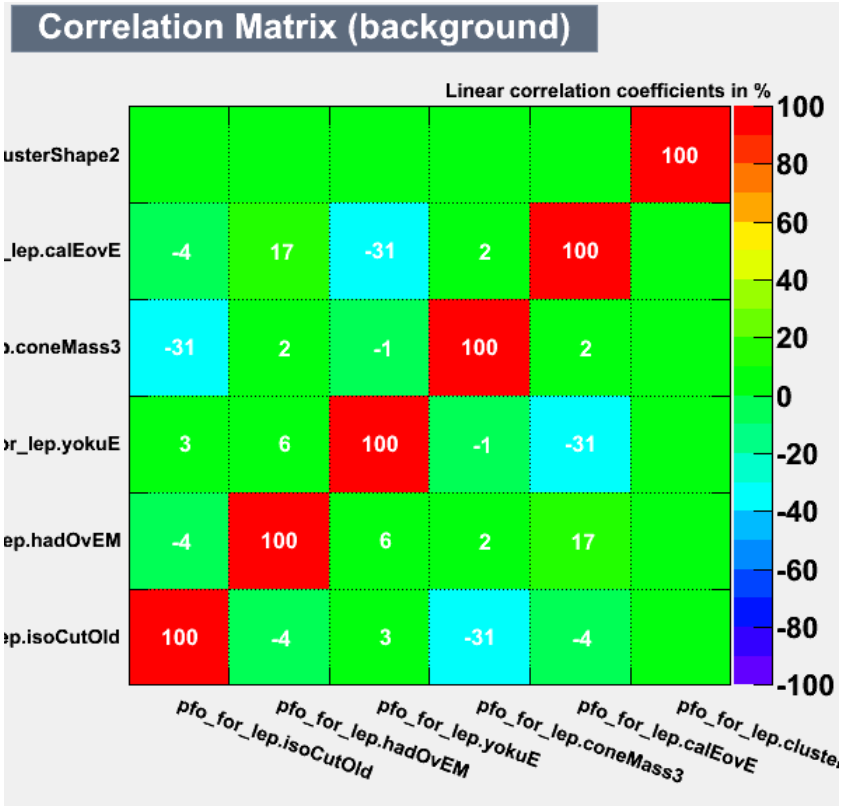


Correlation

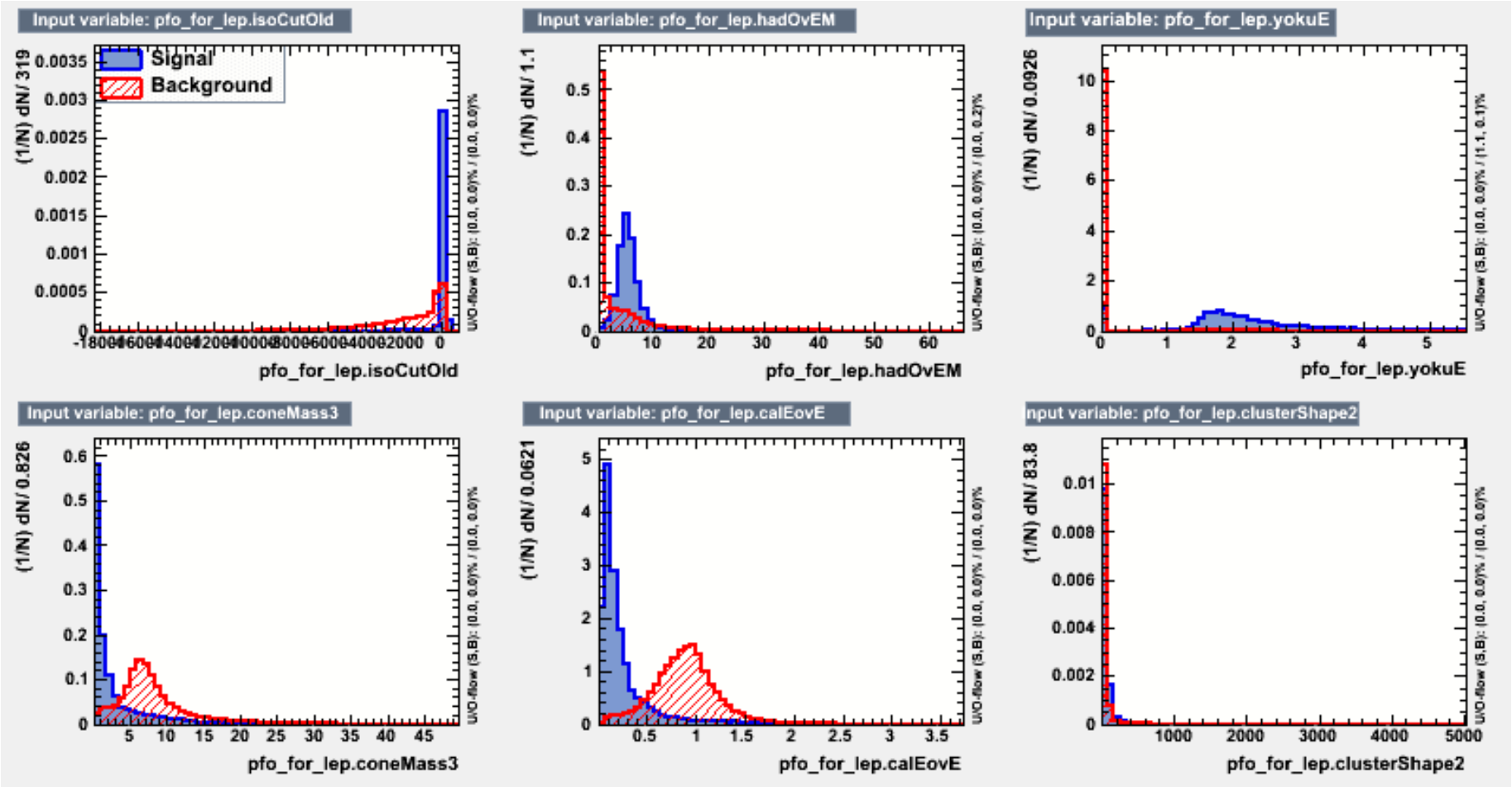
tau(m)



b jet

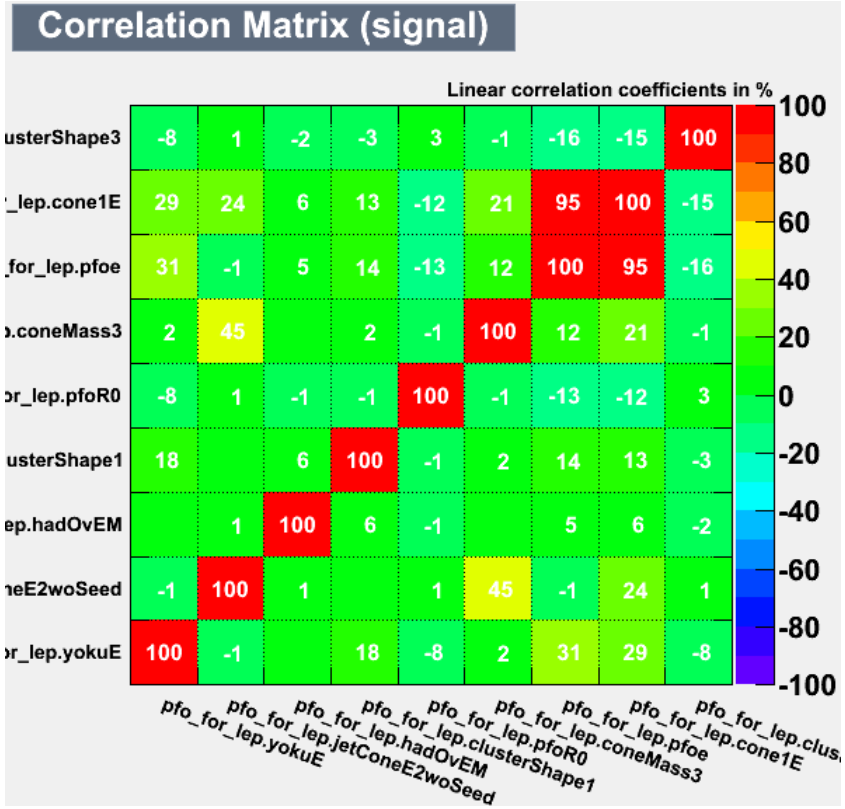


BDT input variables taum-bjet 1

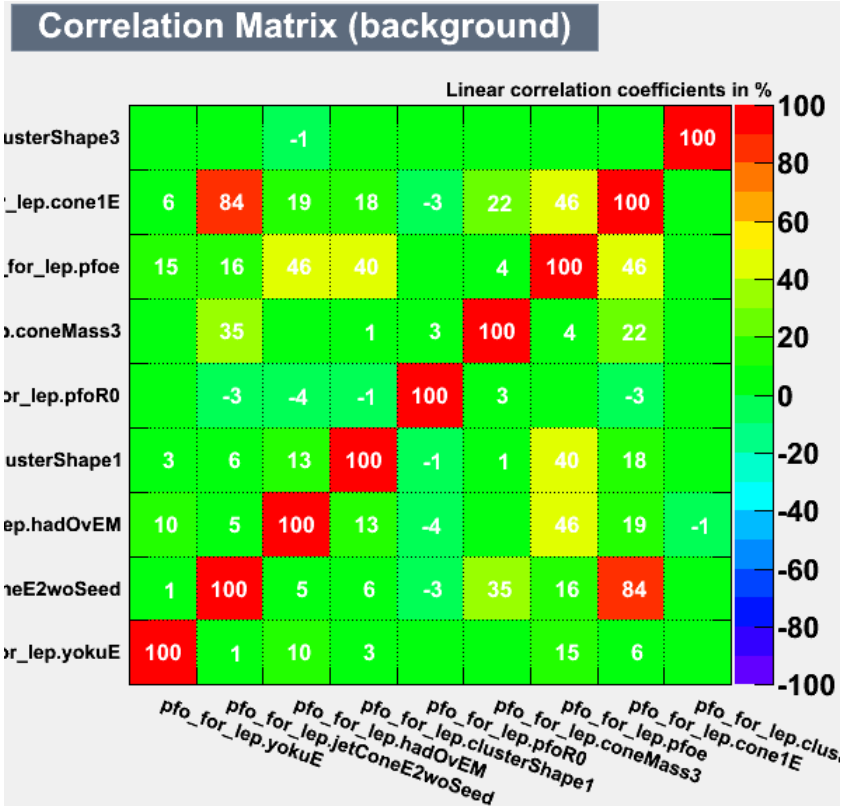


Correlation plots

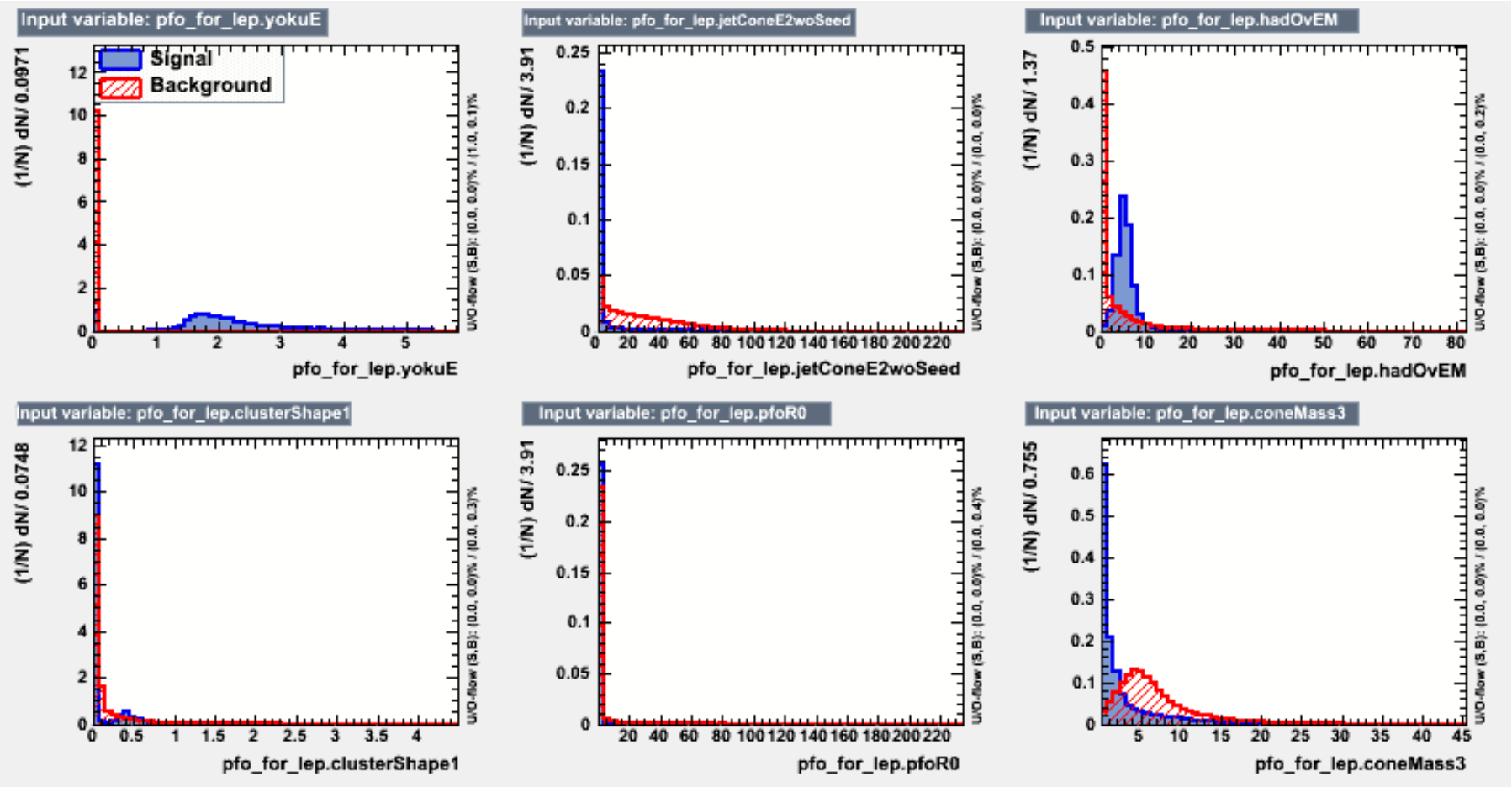
tau(m)



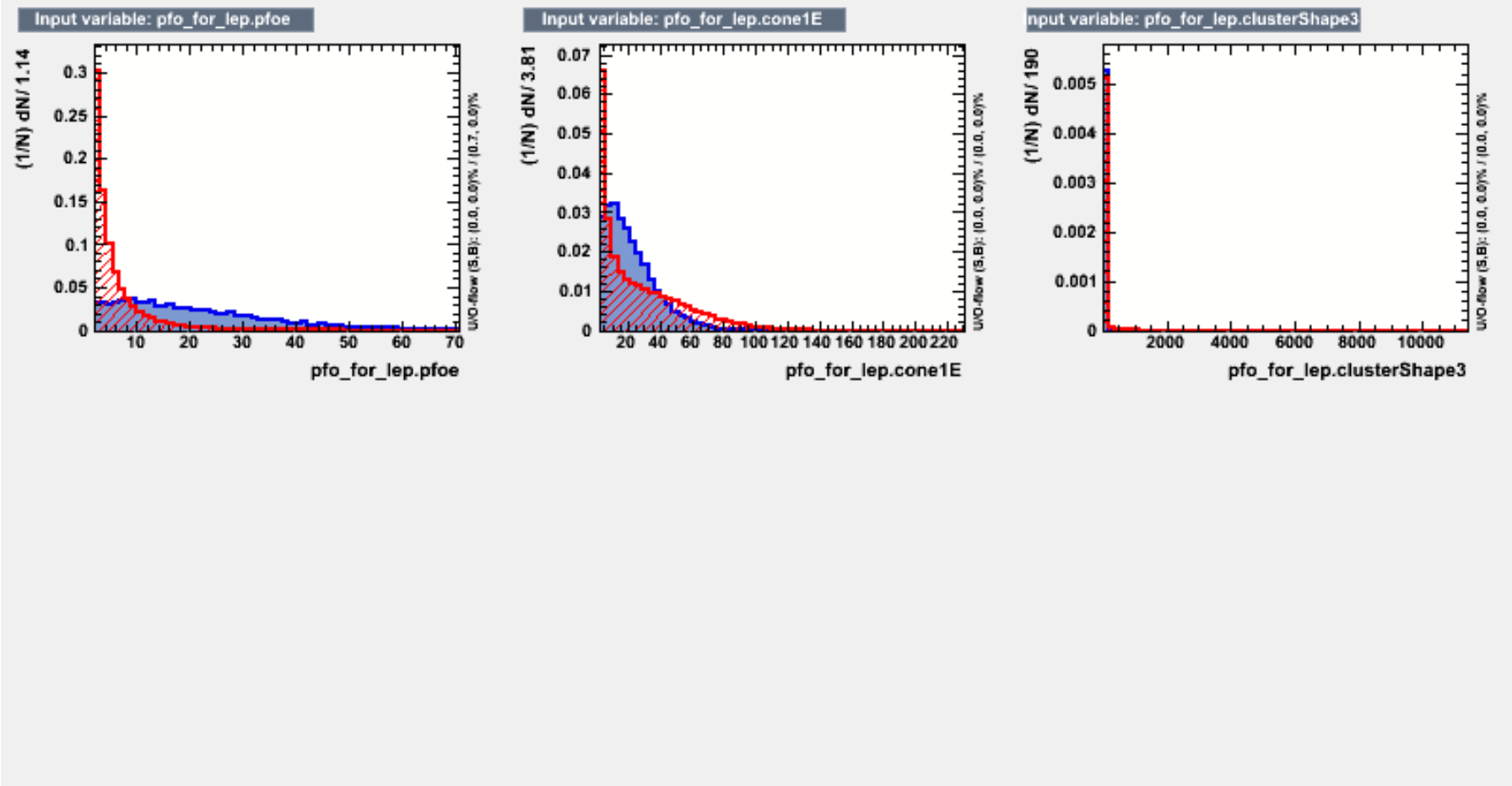
lf jet



BDT input variables taum-lfjet 1

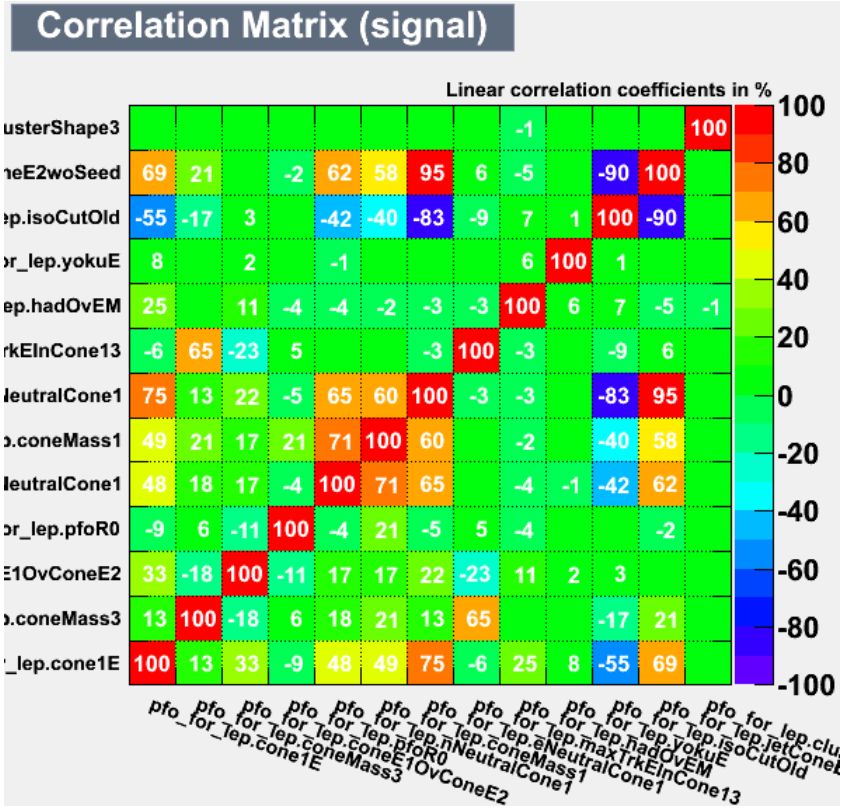


BDT input variables taum-lfjet 2

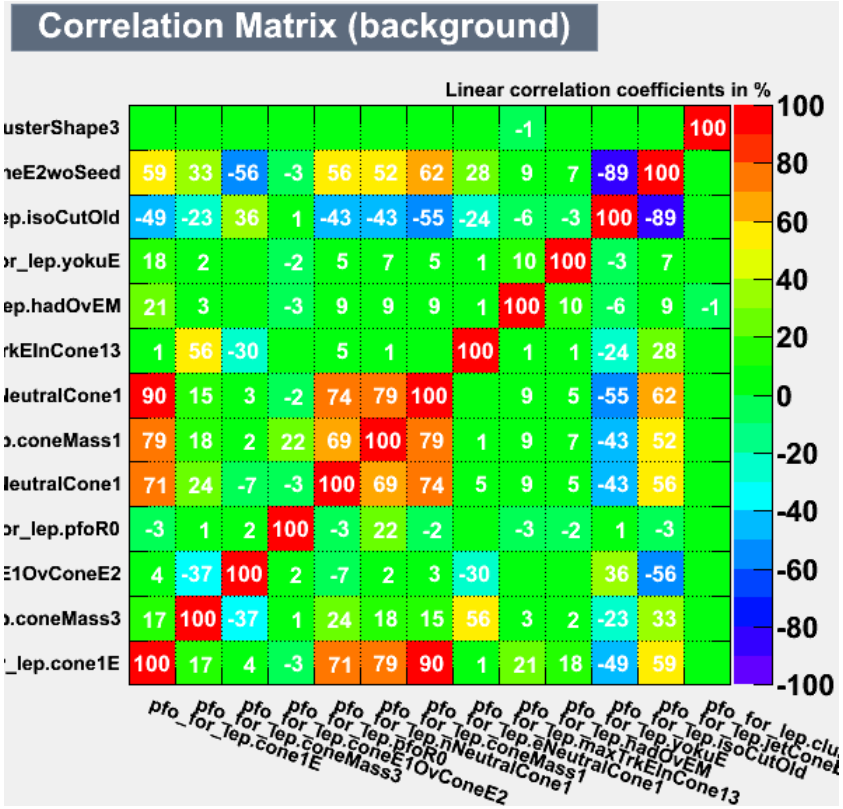


Correlation

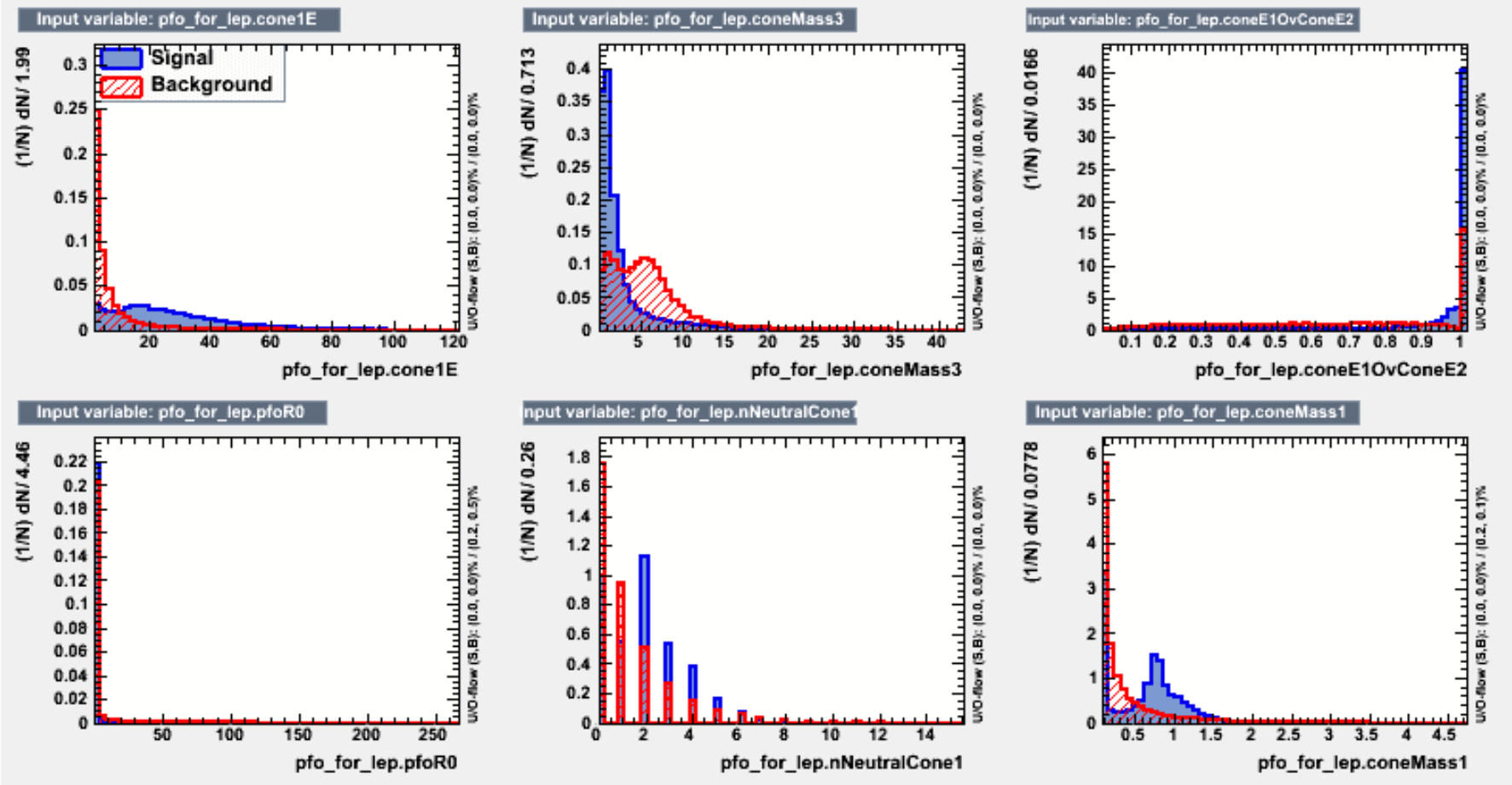
tau(1-prong)



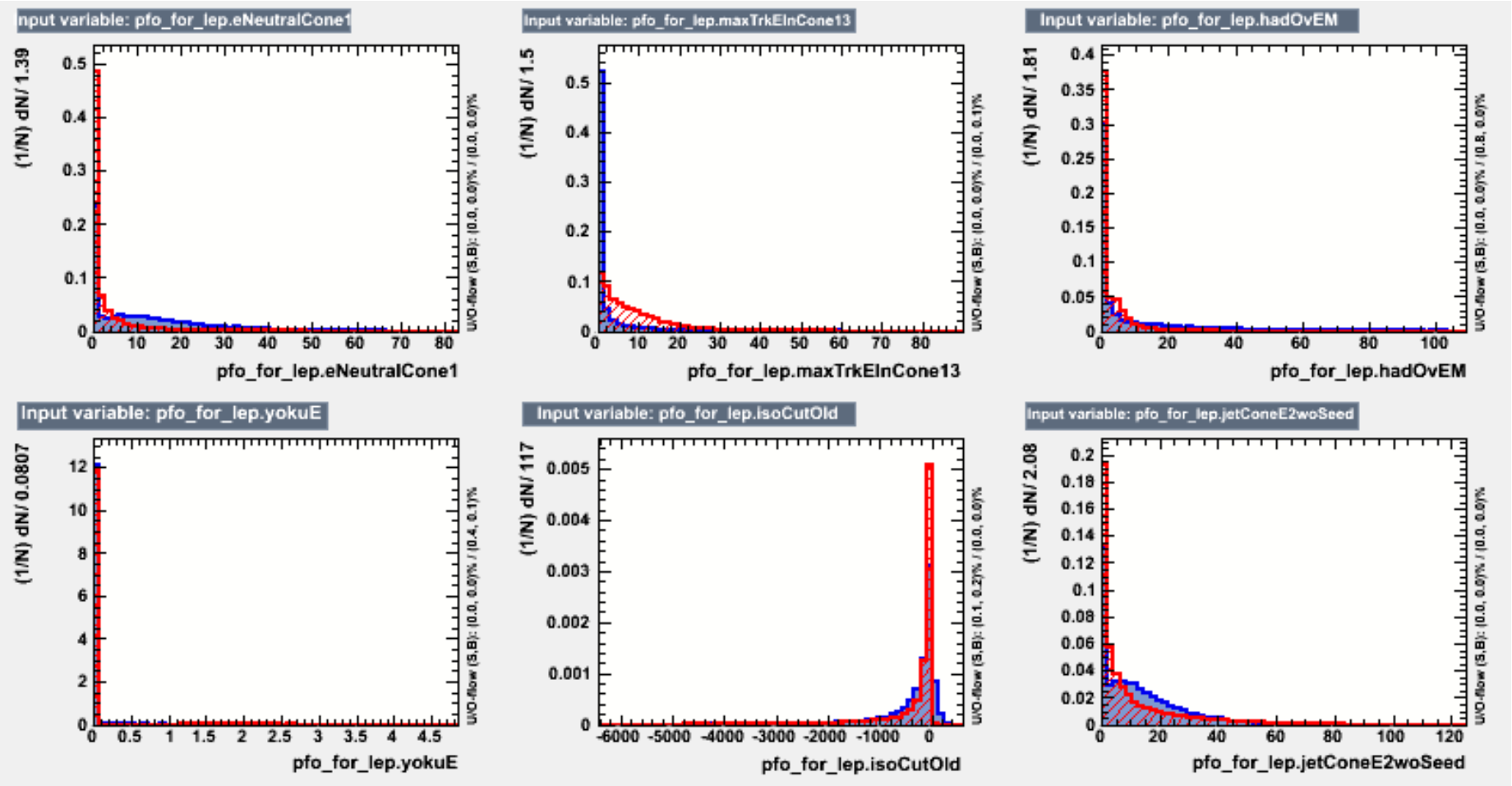
b jet



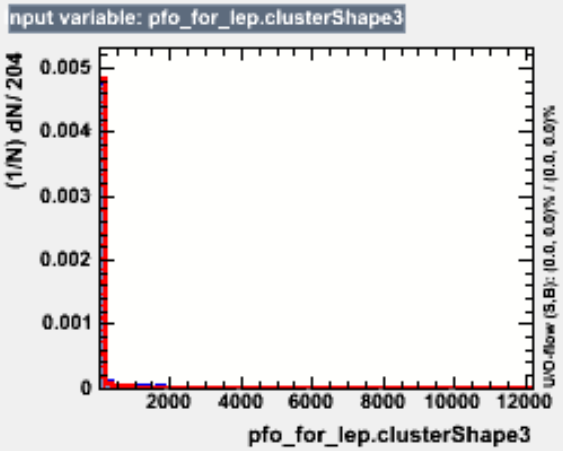
BDT input variables tauh1-bjet 1



BDT input variables tauh1-bjet 2

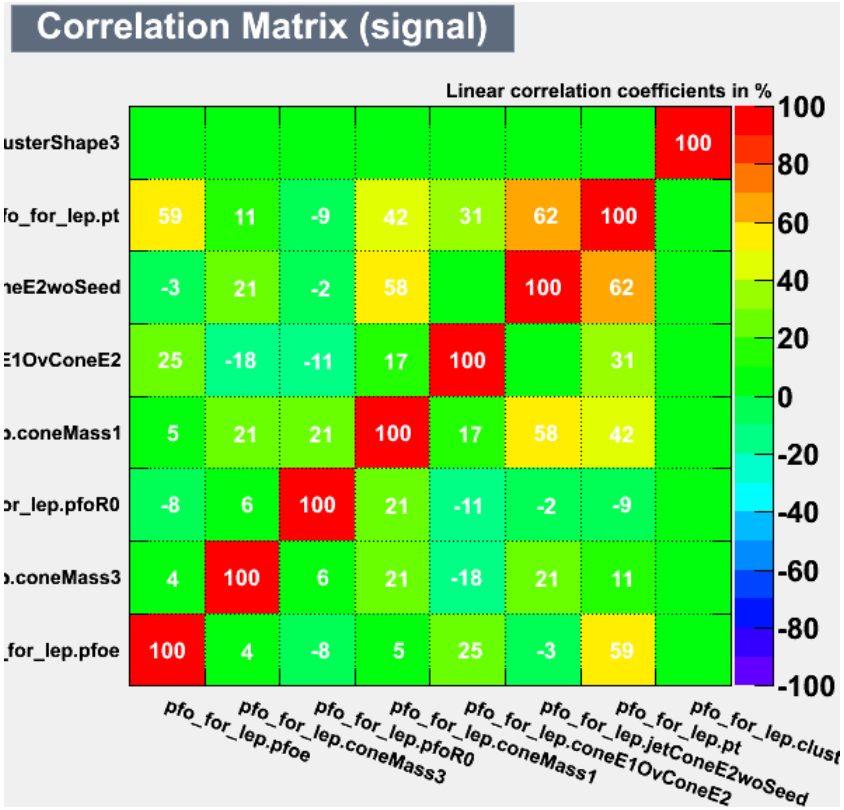


BDT input variables tauh1-bjet 3

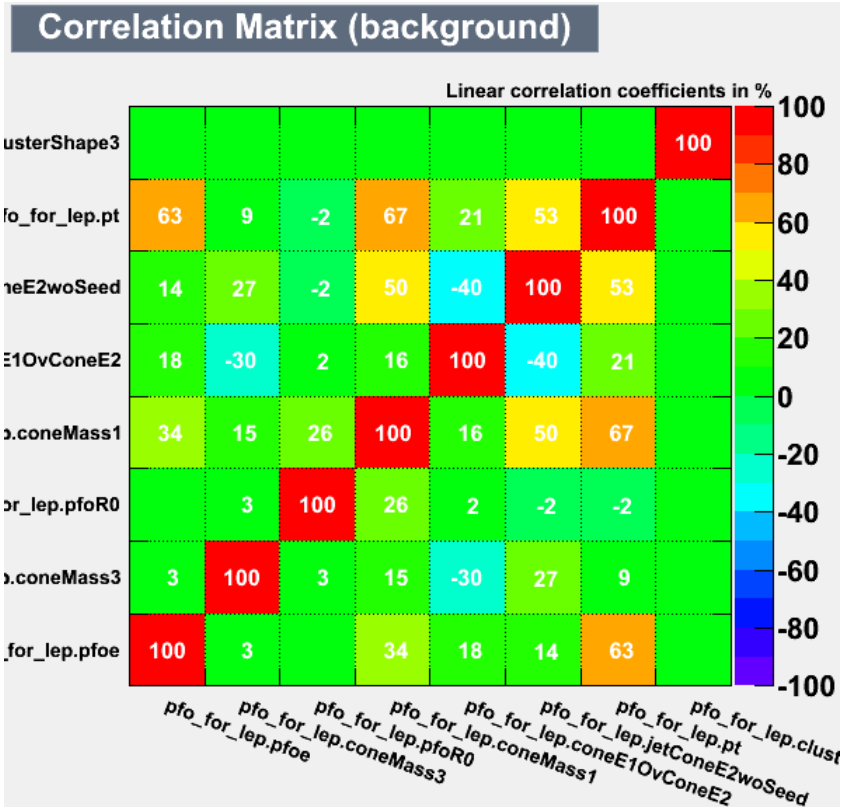


Correlation

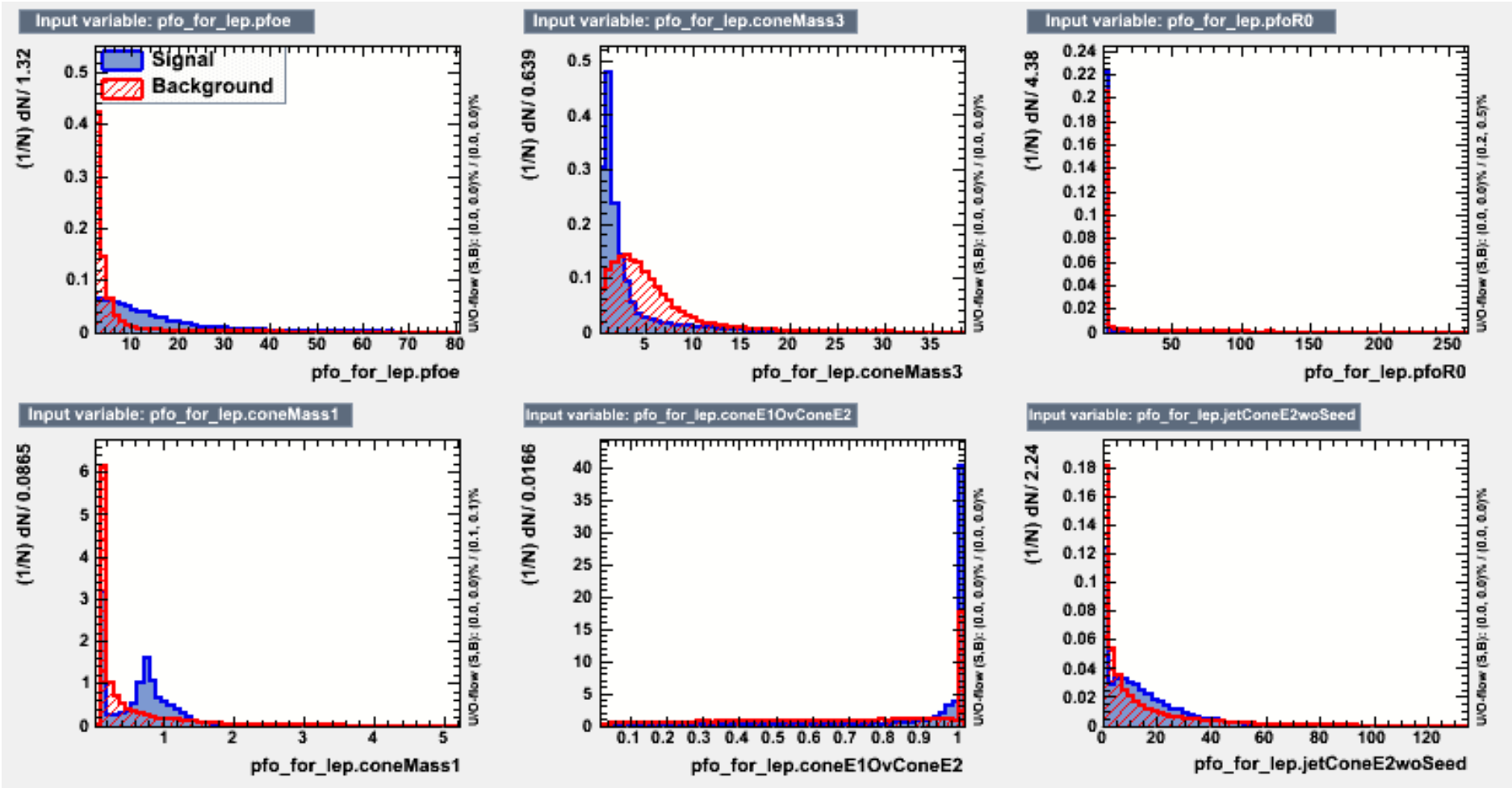
tau(1-prong)



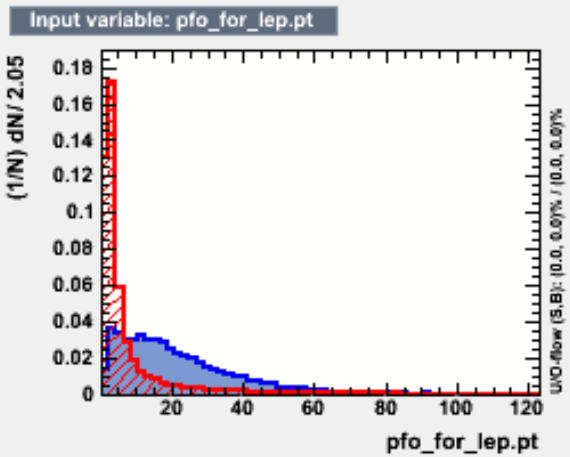
lf jet

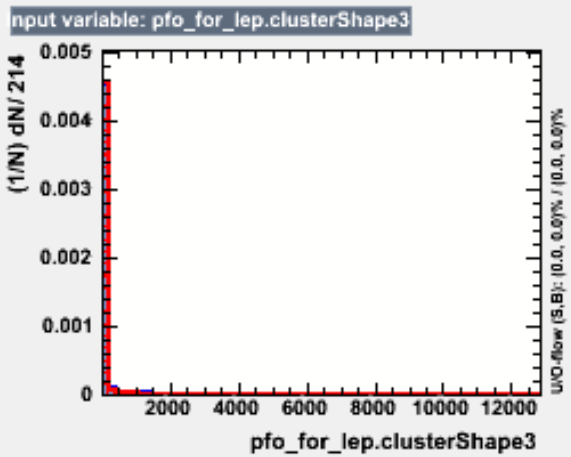


BDT input variables tauh1-lfjet 1



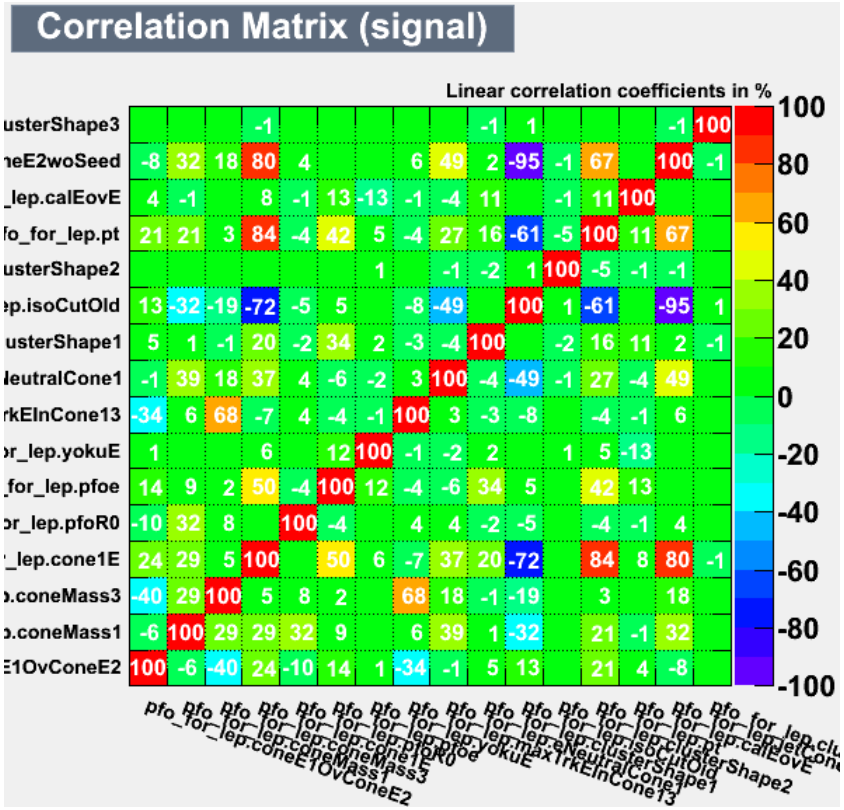
BDT input variables tauh1- 2



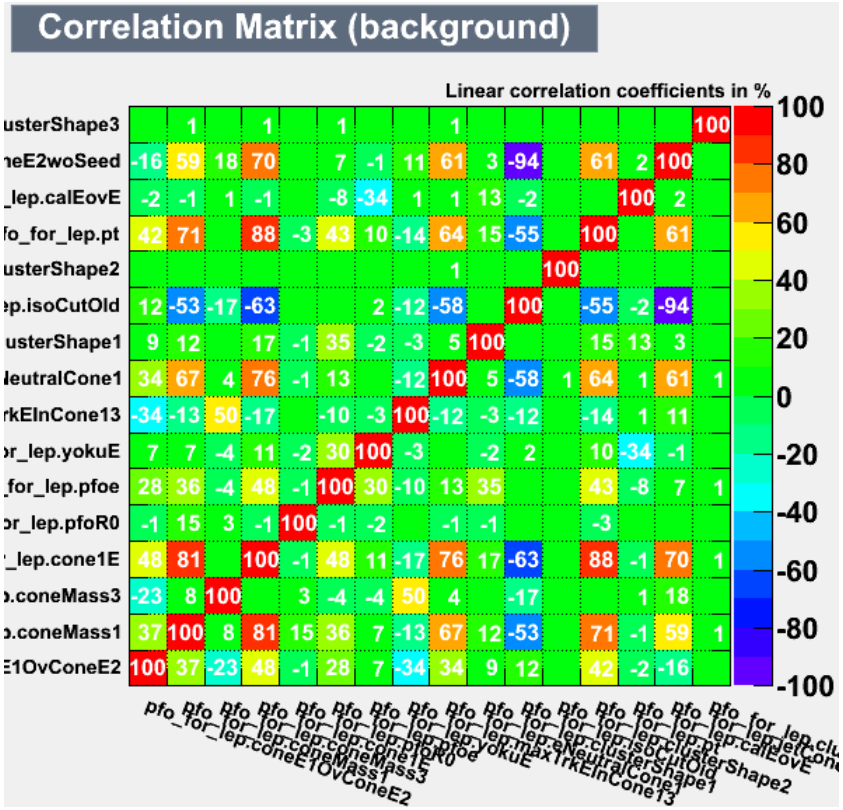


Correlation

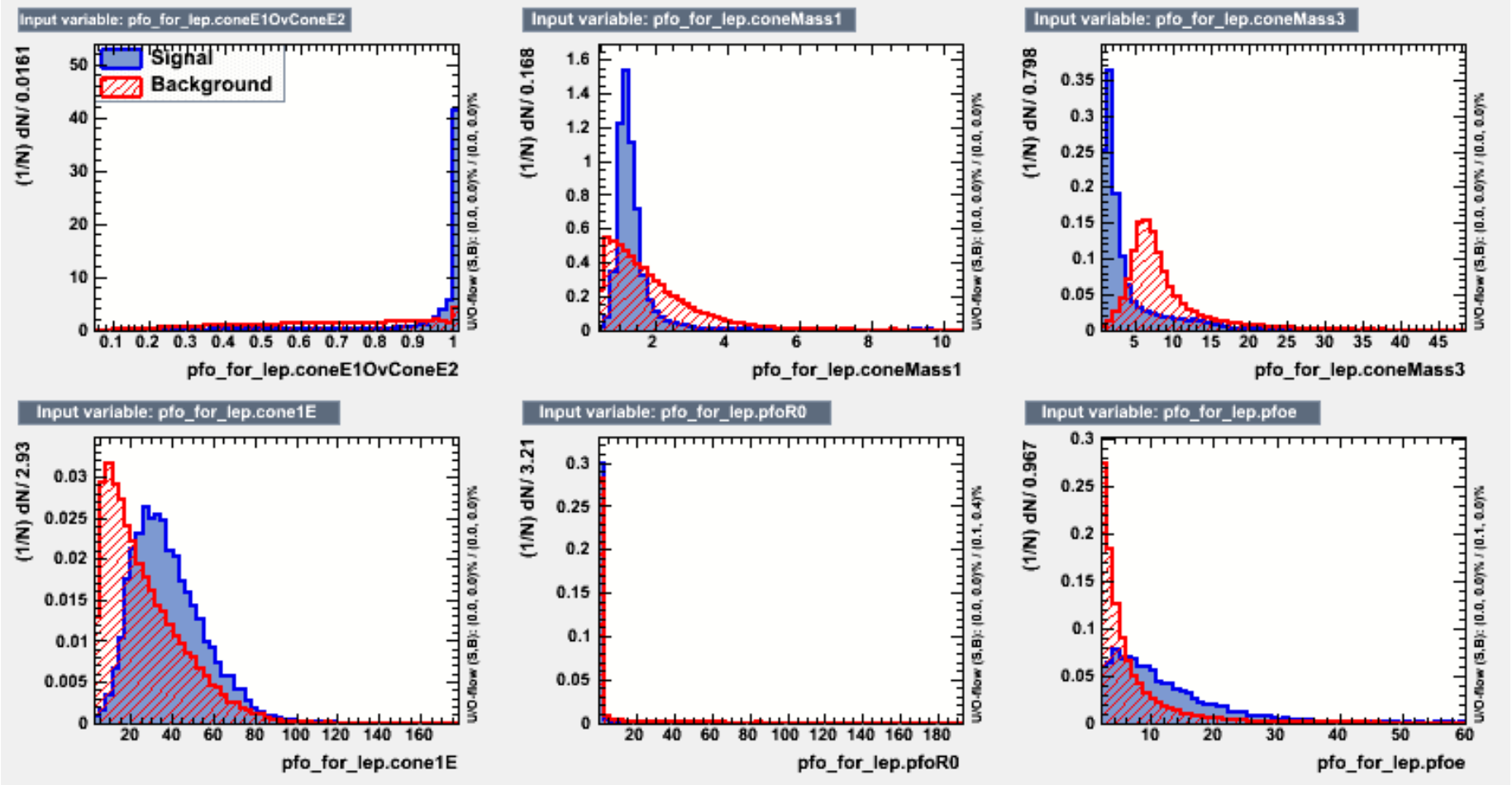
tau(3-prong)



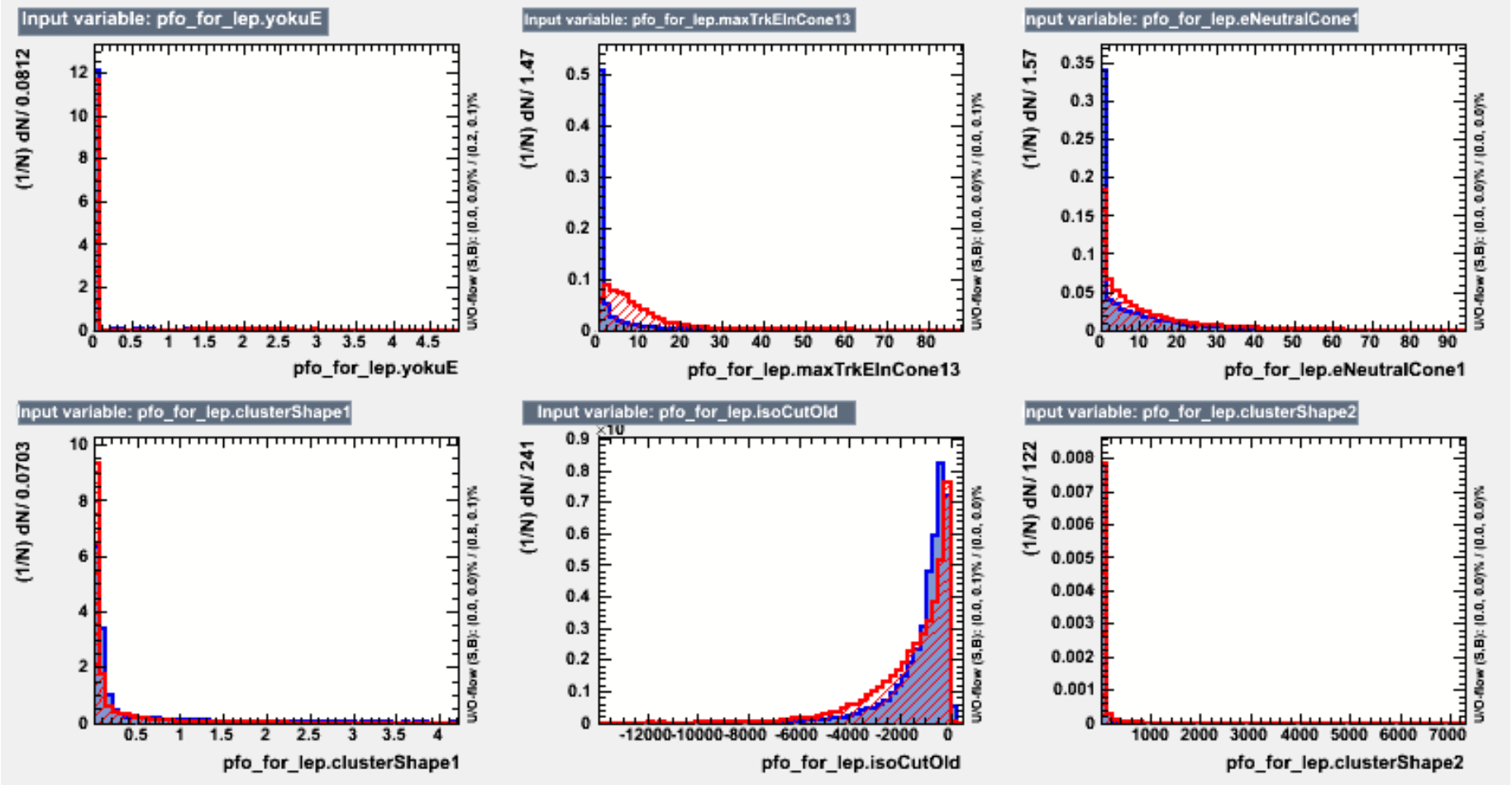
b jet



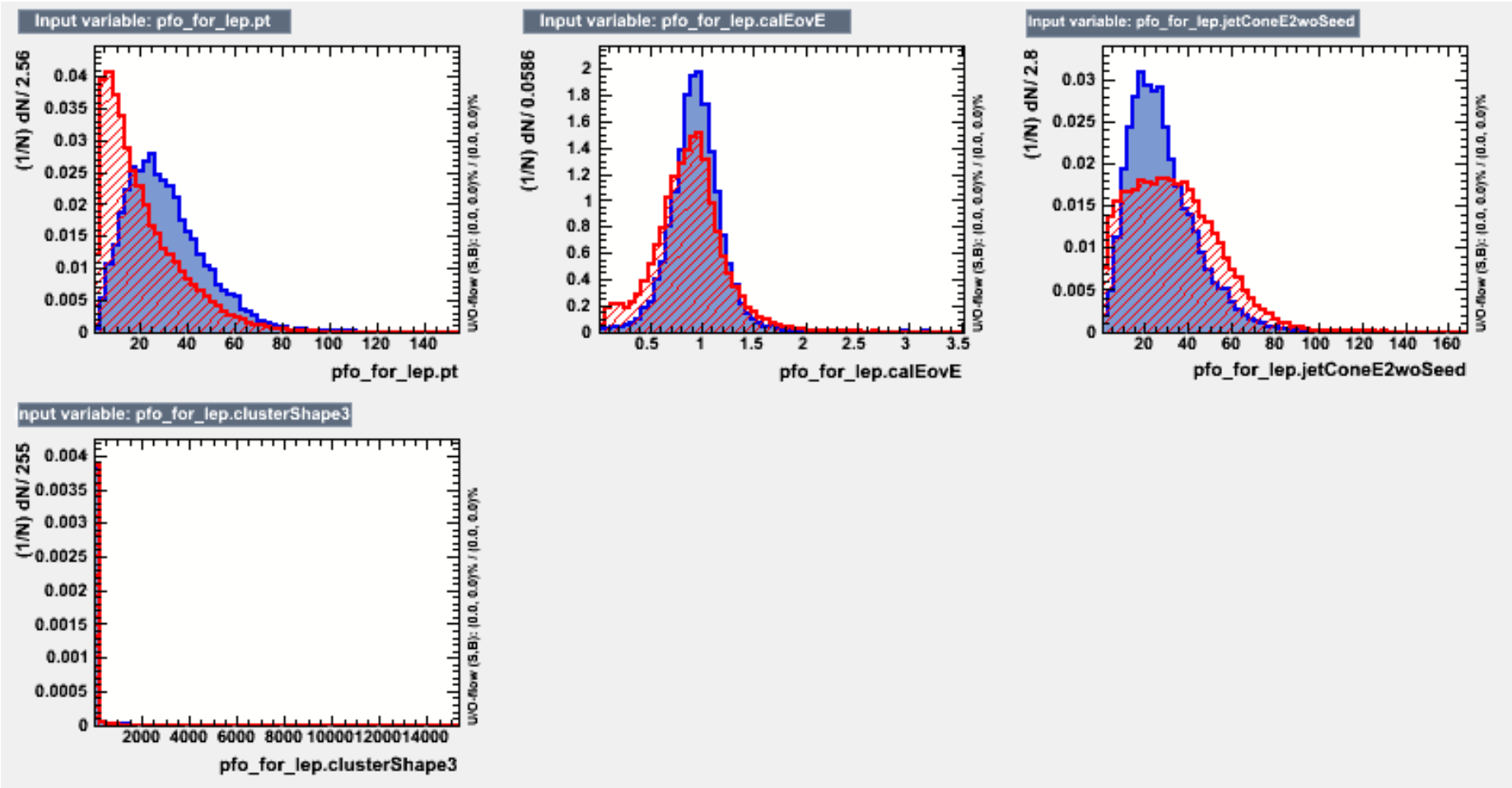
BDT input variables tauh3-bjet 1



BDT input variables tauh3-bjet 2

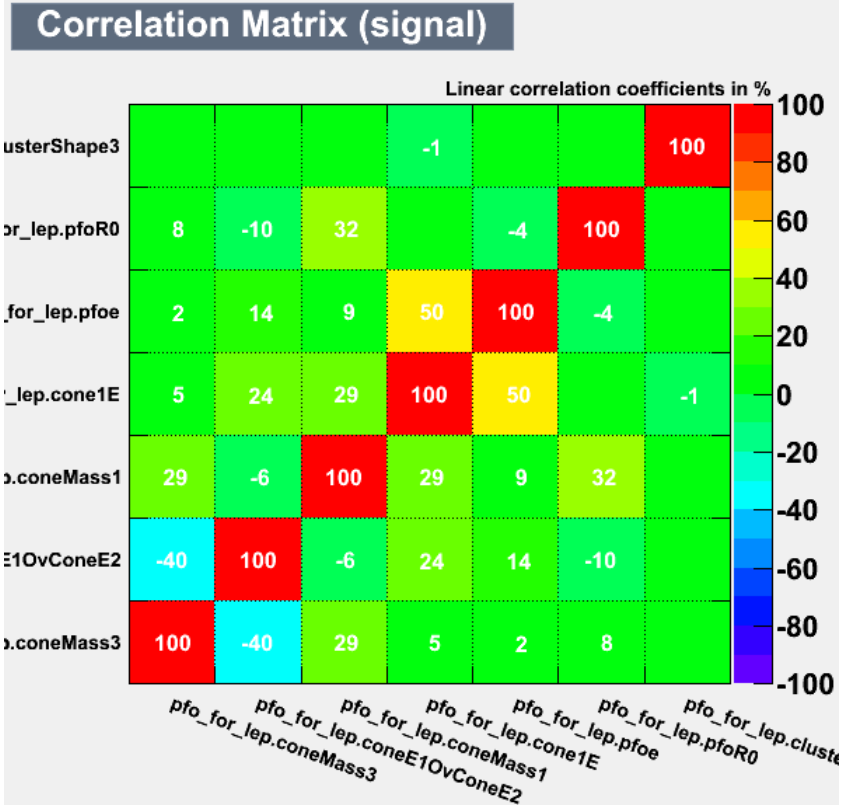


BDT input variables tauh3-bjet 3

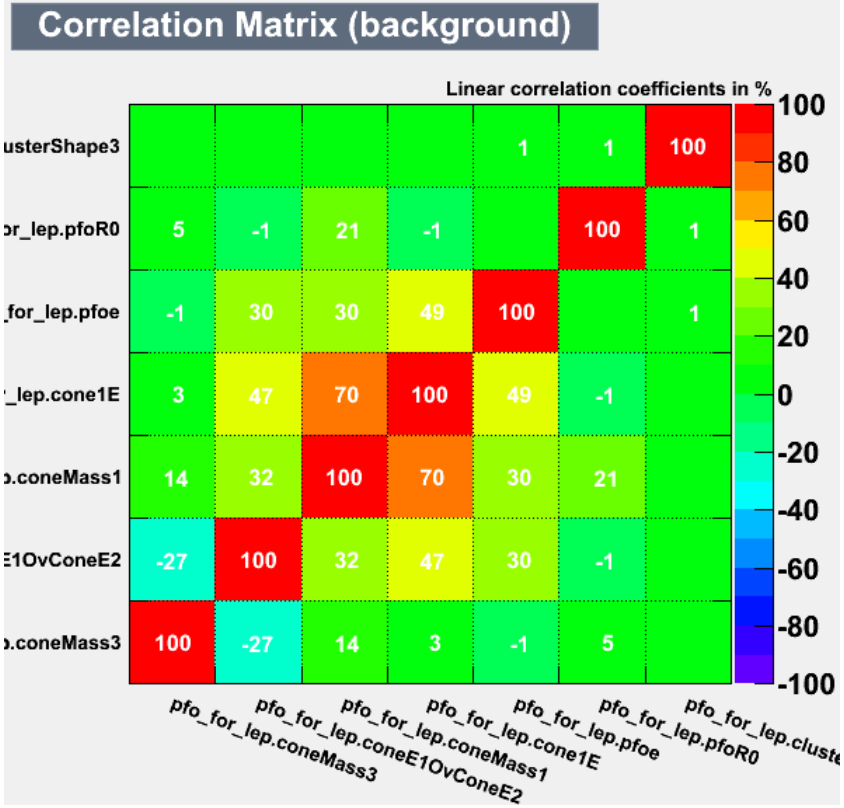


Correlation

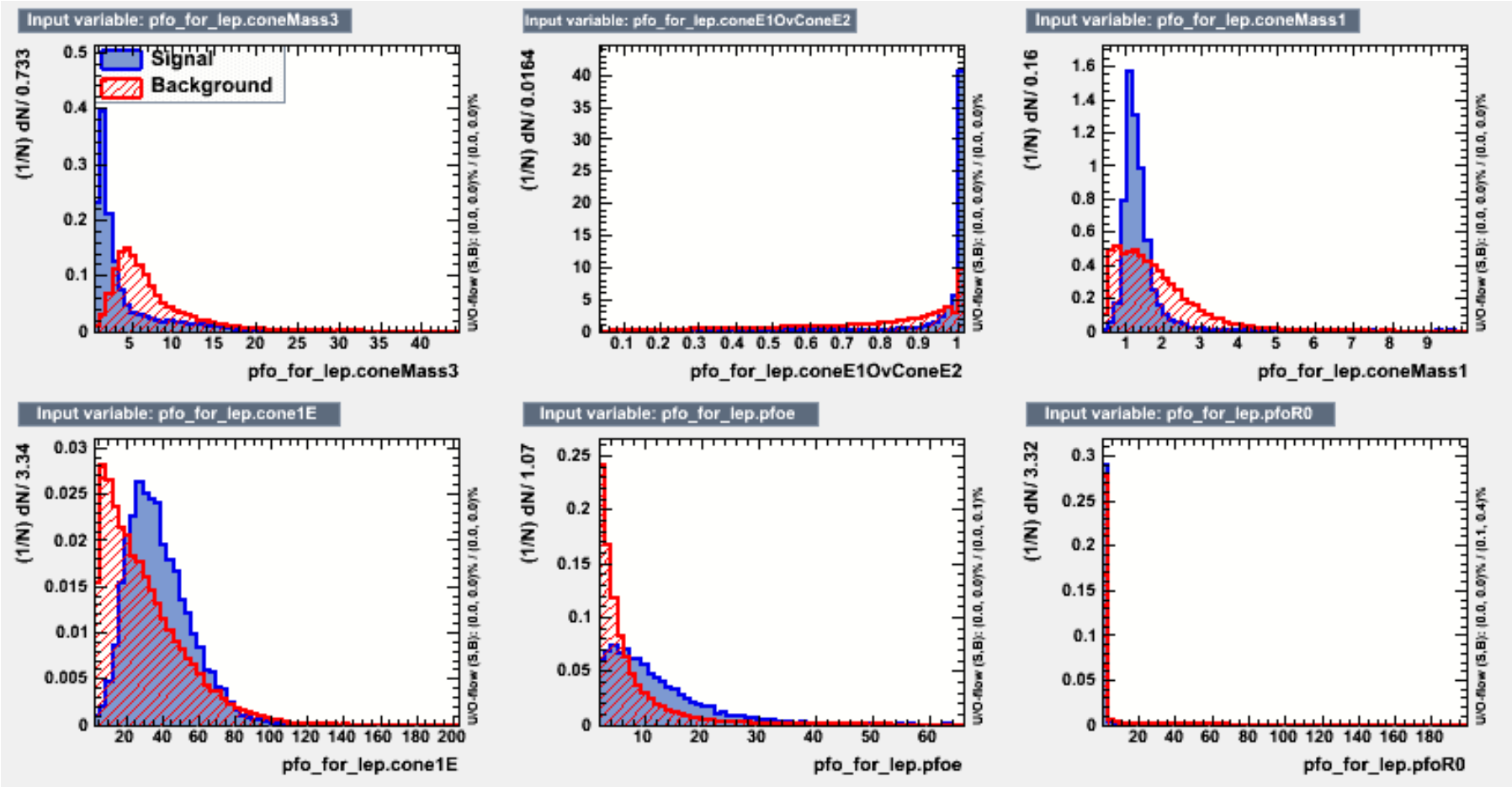
tau(3-prong)



lf jet



BDT input variables tauh3-lfjet 1



BDT input variables tauh3-lfjet 2