Lab7(Ex1~8 Final) Result:

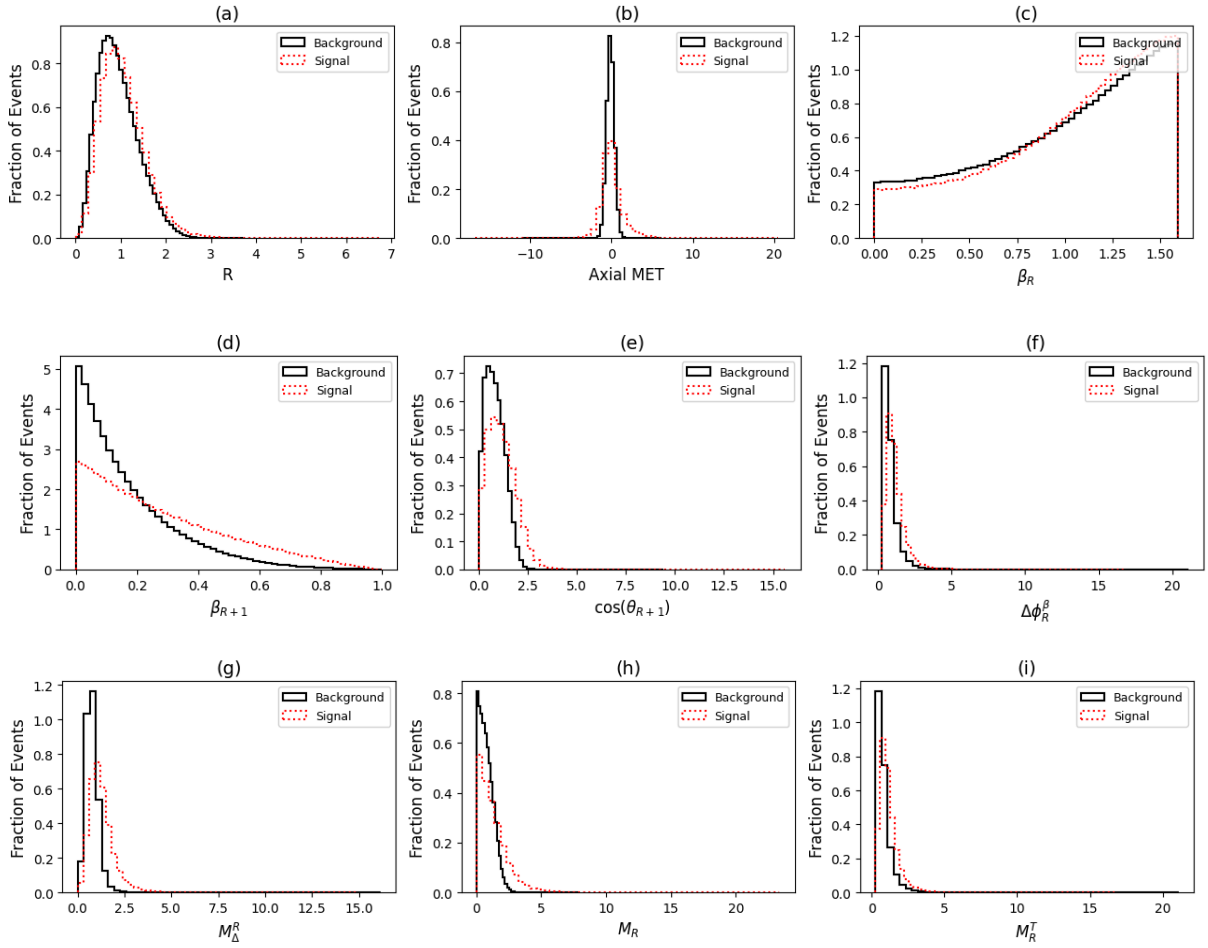
Exercise 1

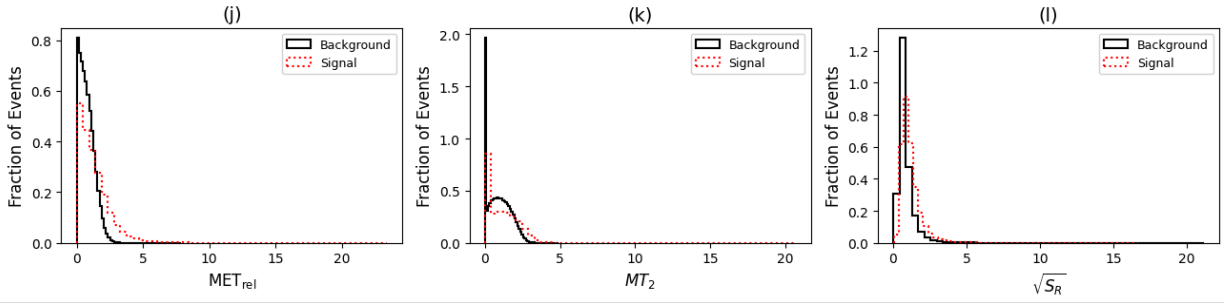
(Already exist)

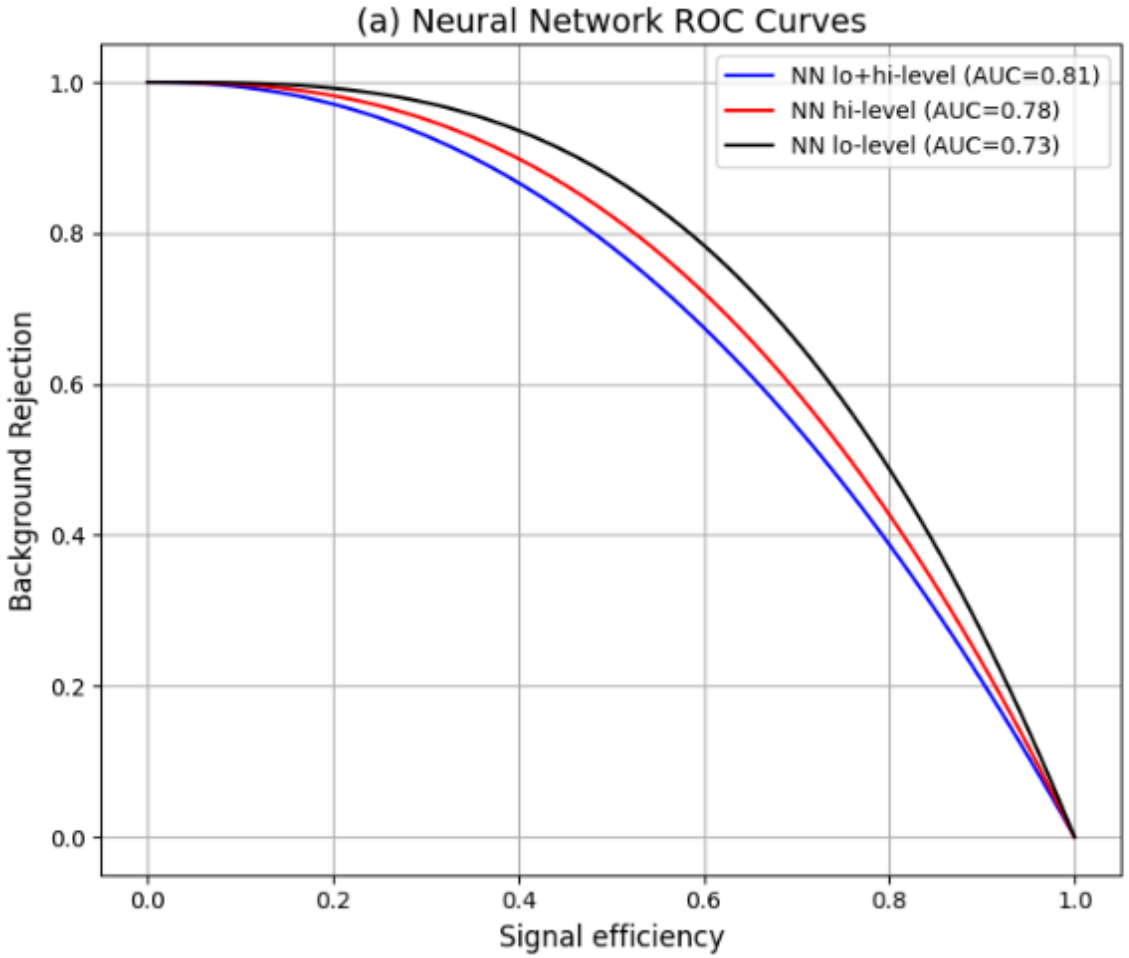
Exercise 2

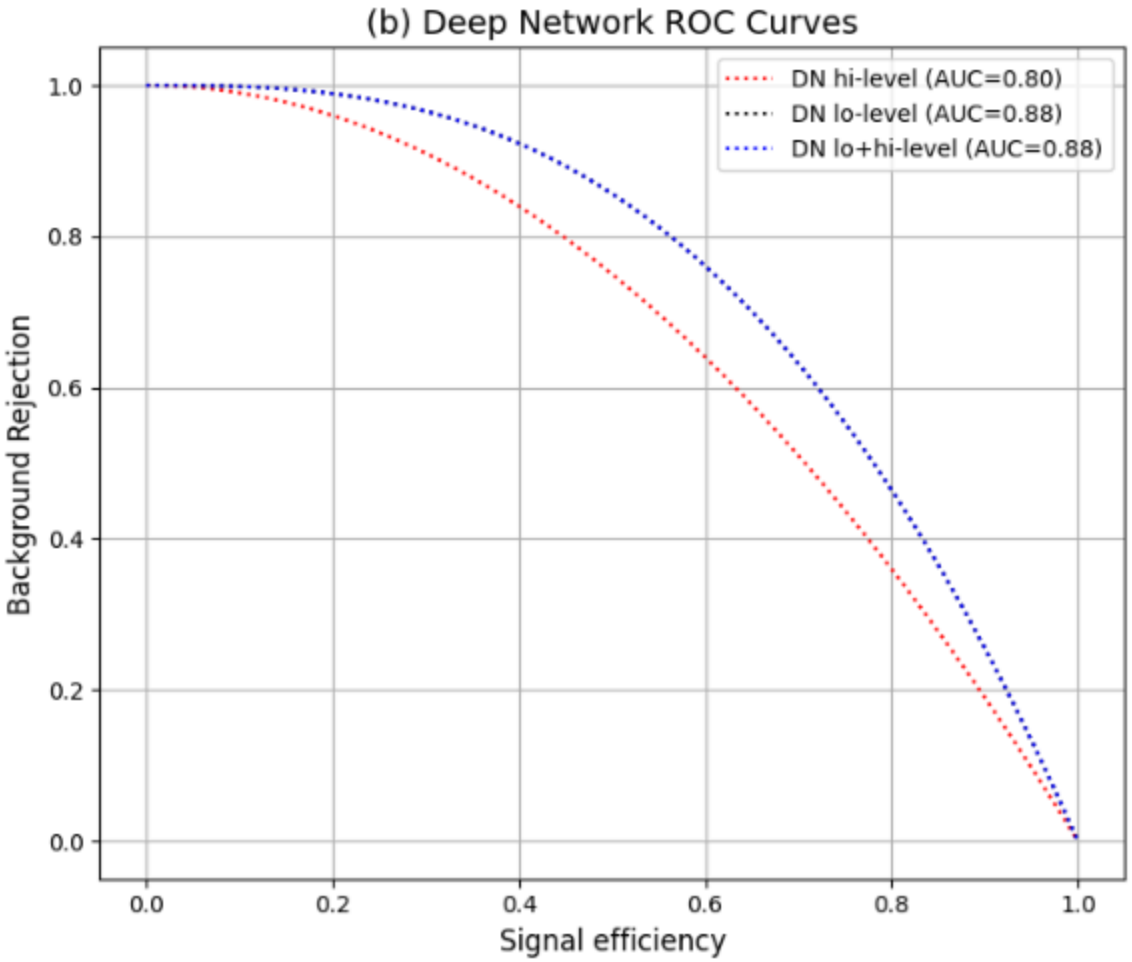
(Already exist)

Exercise 3

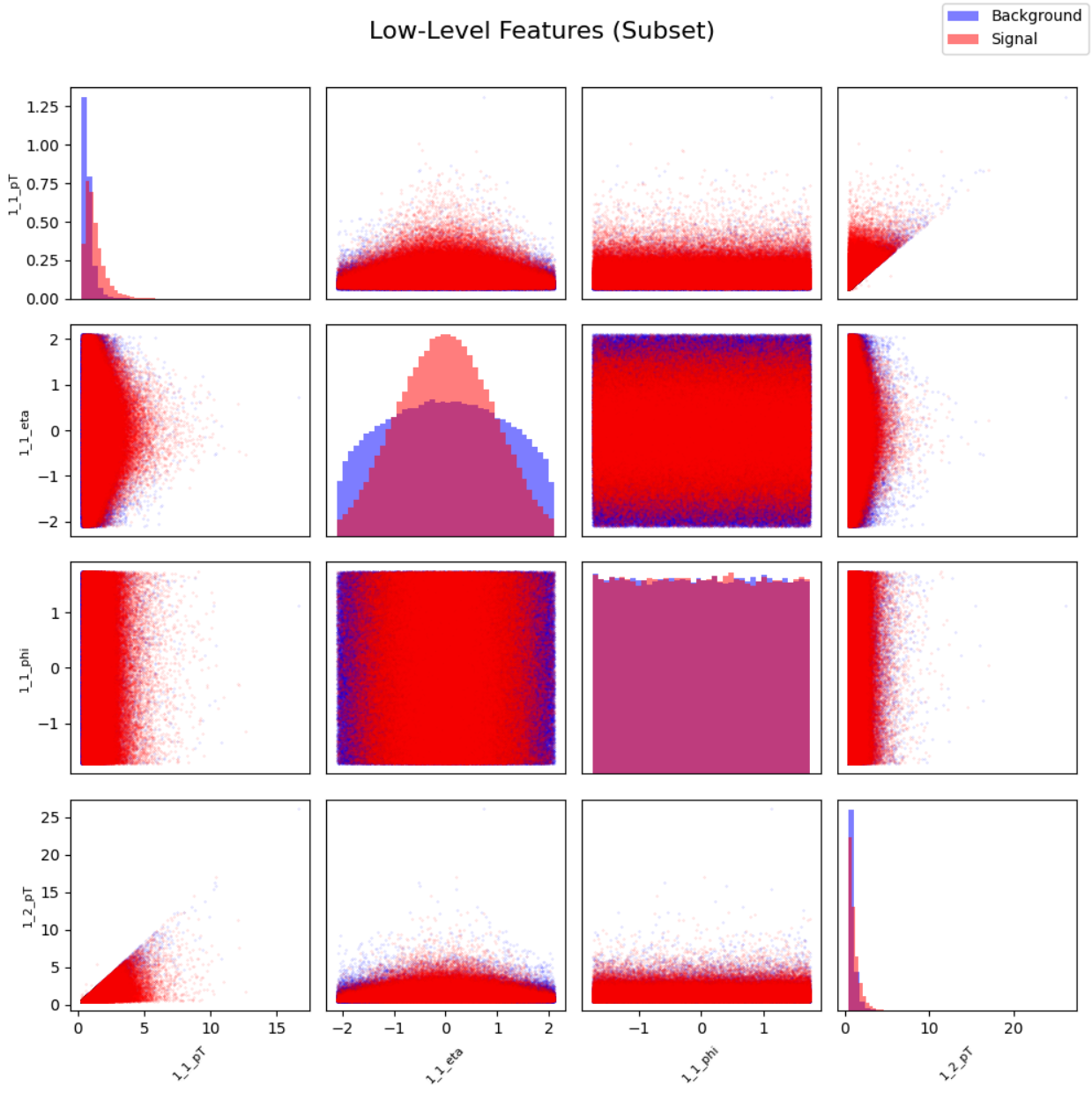


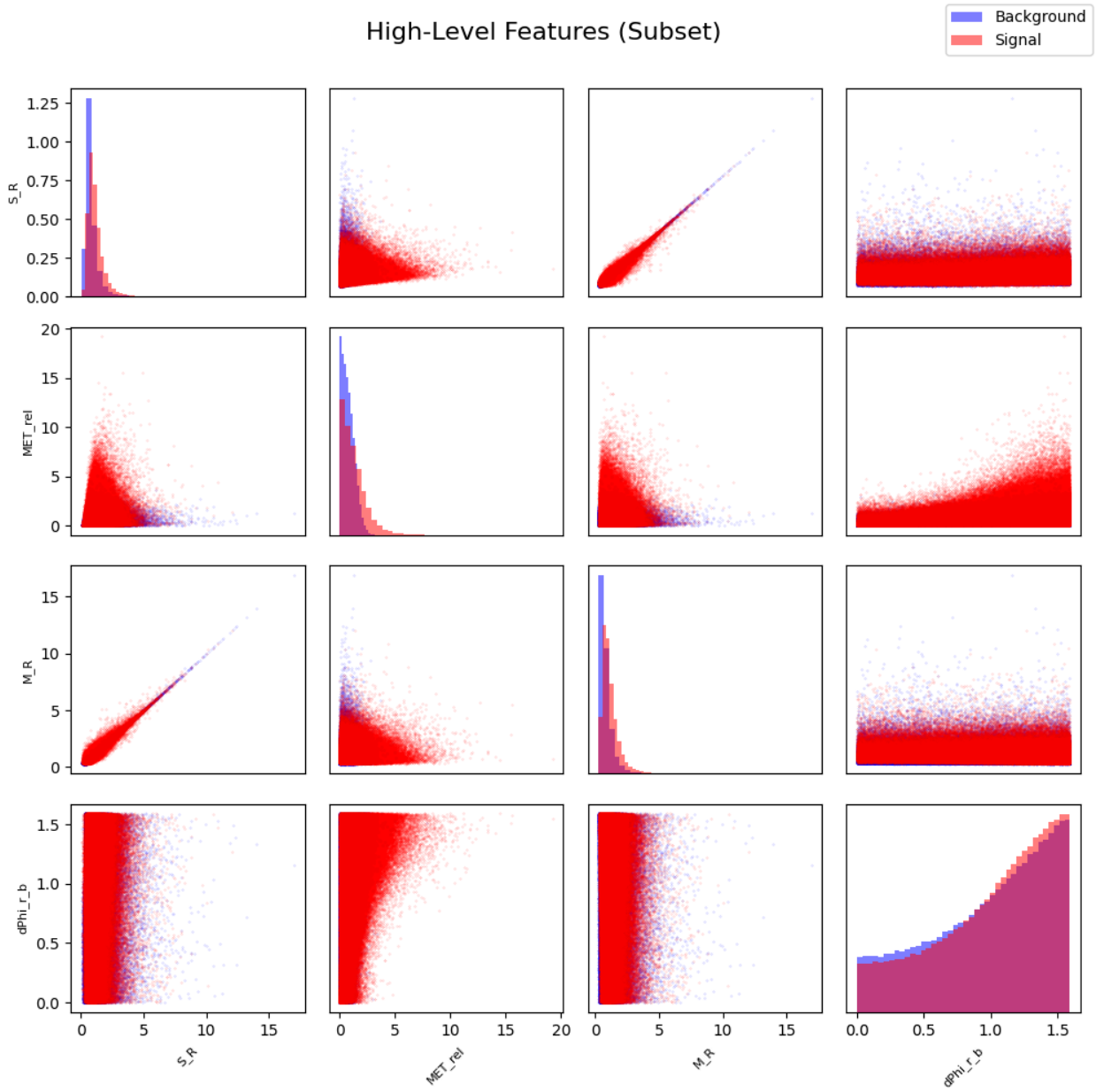

(j)
(k)
(l)
Background
Signal
Fraction of Events
$\mathrm{MET}_{\mathrm{rel}}$
MT_2
$\sqrt{S_R}$


(a) Neural Network ROC Curves
NN lo+hi-level (AUC=0.81)
NN hi-level (AUC=0.78)
NN lo-level (AUC=0.73)
Background Rejection
Signal efficiency

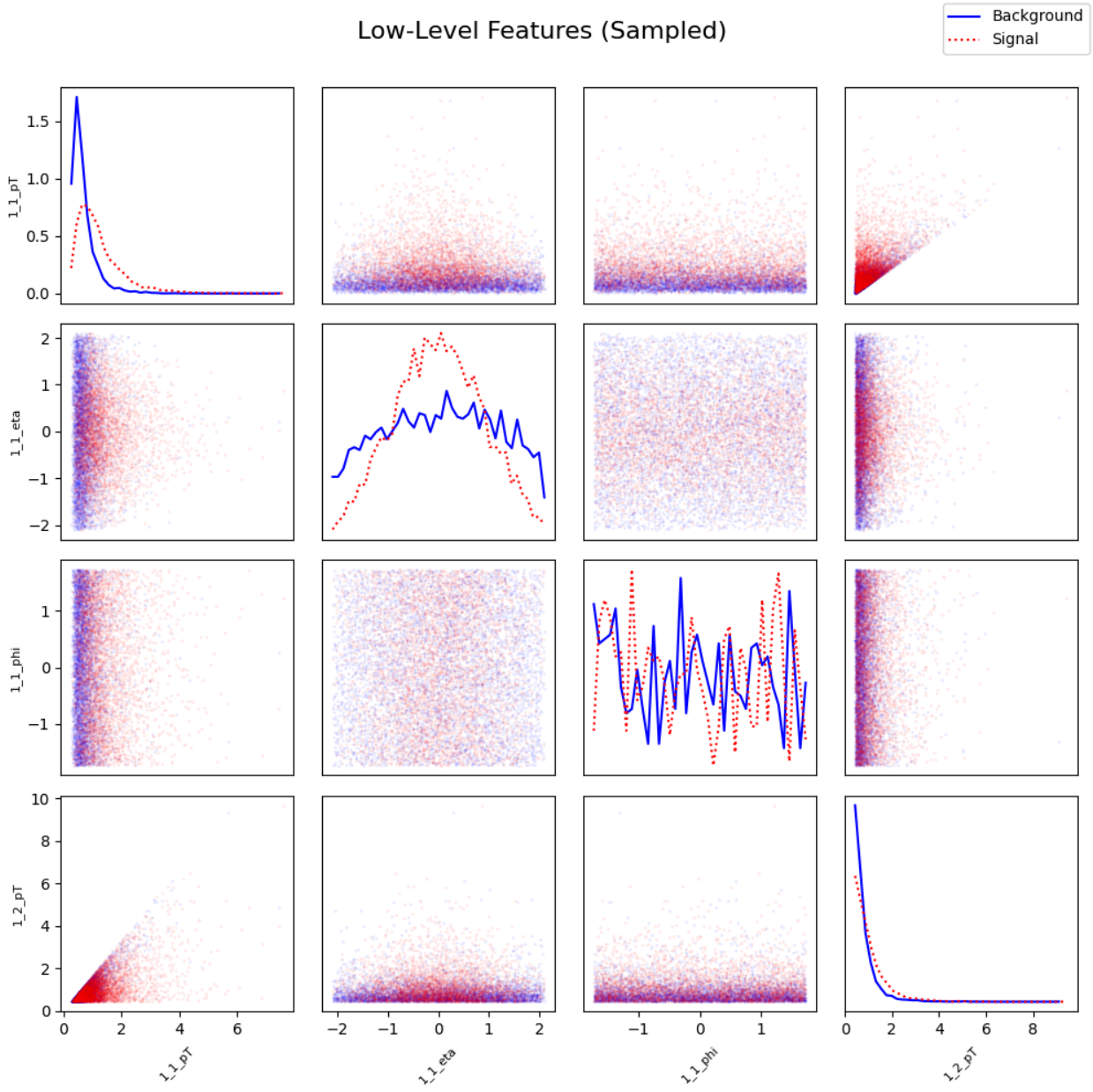

(b) Deep Network ROC Curves
DN hi-level (AUC=0.80)
DN lo-level (AUC=0.88)
DN lo+hi-level (AUC=0.88)
Background Rejection
Signal efficiency
0.0
0.2
0.4
0.6
0.8
1.0

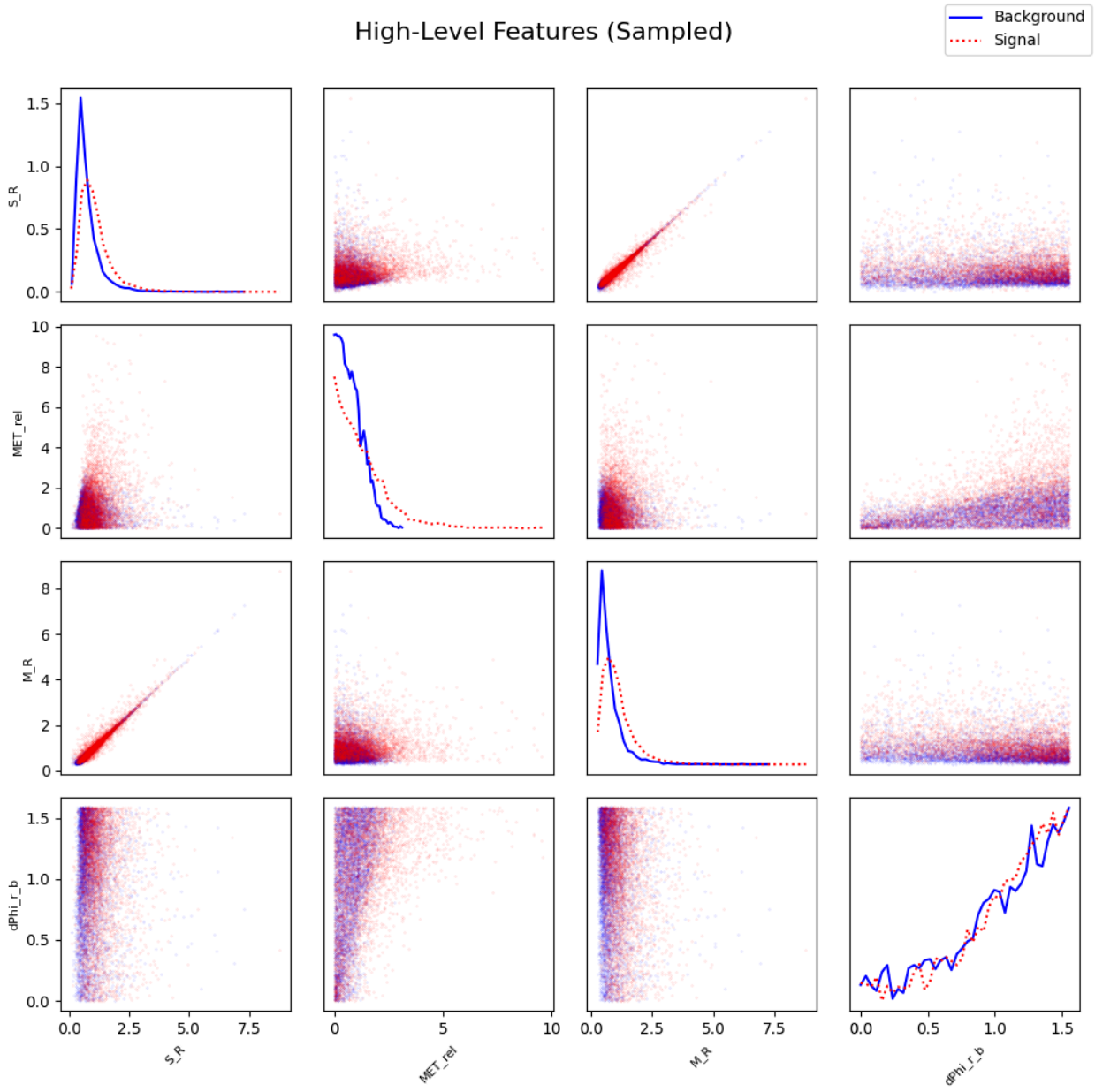
Exercise 4.1
(Part a)




High-Level Features (Subset)
Background
Signal
S_R
MET_rel
M_R
dPhi_r_b

(Exercise 4.1 Part b)




High-Level Features (Sampled)
Background
Signal
S_R
MET_rel
M_R
dPhi_r_b

(Exercise 4.1 part c)

```
Top 10 most discriminative variables based on mean difference:

MET          0.770480
1_1_pT       0.536629
MET_rel      0.505259
M_TR_2       0.496727
M_Delta_R    0.343099
M_R          0.339773
S_R          0.324697
1_2_pT       0.257438
axial_MET    0.159264
MT2          0.137493
dtype: float64
```

Exercise 4.2
(part a~c no need)

(part d)

Low-Level Features Covariance Matrix

	1_1_pT	1_1_eta	1_1_phi	1_2_pT	1_2_eta	1_2_phi	MET	MET_phi
1_1_pT	0.467	-0	0	0.305	-0	0.001	0.228	-0.001
1_1_eta	-0	1.004	-0.001	-0	0.408	-0.001	-0.002	-0.001
1_1_phi	0	-0.001	1.004	0.001	0	-0.267	0.001	-0.185
1_2_pT	0.305	-0	0.001	0.425	-0.001	0	0.079	-0.002
1_2_eta	-0	0.408	0	-0.001	1.006	0	0	-0
1_2_phi	0.001	-0.001	-0.267	0	0	1.004	-0	-0.035
MET	0.228	-0.002	0.001	0.079	0	-0	0.762	-0.003
MET_phi	-0.001	-0.001	-0.185	-0.002	-0	-0.035	-0.003	1.003

Low-Level Features Correlation Matrix

	1_1_pT	1_1_eta	1_1_phi	1_2_pT	1_2_eta	1_2_phi	MET	MET_phi
1_1_pT	1	-0.001	0	0.684	-0.001	0.001	0.383	-0.001
1_1_eta	-0.001	1	-0.001	-0	0.406	-0.001	-0.002	-0.001
1_1_phi	0	-0.001	1	0.002	0	-0.266	0.001	-0.184
1_2_pT	0.684	-0	0.002	1	-0.001	0	0.14	-0.002
1_2_eta	-0.001	0.406	0	-0.001	1	0	0	-0
1_2_phi	0.001	-0.001	-0.266	0	0	1	-0	-0.035
MET	0.383	-0.002	0.001	0.14	0	-0	1	-0.003
MET_phi	-0.001	-0.001	-0.184	-0.002	-0	-0.035	-0.003	1

High-Level Features Covariance Matrix

	cos_theta_r1	MET_rel	M_Delta_R	axial_MET	dPhi_r_b	M_R	MT2	S_R	M_TR_2	R
cos_theta_r1	0.039	0.055	0.039	-0.054	0.009	-0.014	0.045	-0.01	0.052	0.058
MET_rel	0.055	0.79	0.415	-0.12	0.146	0.044	0.409	0.082	0.302	0.249
M_Delta_R	0.039	0.415	0.389	-0.233	0.042	0.074	0.433	0.096	0.242	0.165
axial_MET	-0.054	-0.12	-0.233	1.005	-0.025	0.017	-0.461	-0.041	-0.185	-0.181
dPhi_r_b	0.009	0.146	0.042	-0.025	0.19	-0.029	0.021	-0.003	0.058	0.087
M_R	-0.014	0.044	0.074	0.017	-0.029	0.392	-0.037	0.38	0.21	-0.113
MT2	0.045	0.409	0.433	-0.461	0.021	-0.037	0.738	-0.011	0.189	0.232
S_R	-0.01	0.082	0.096	-0.041	-0.003	0.38	-0.011	0.382	0.228	-0.083
M_TR_2	0.052	0.302	0.242	-0.185	0.058	0.21	0.189	0.228	0.338	0.104
R	0.058	0.249	0.165	-0.181	0.087	-0.113	0.232	-0.083	0.104	0.222

High-Level Features Correlation Matrix

	cos_theta_r1	MET_rel	M_Delta_R	axial_MET	dPhi_r_b	M_R	MT2	S_R	M_TR_2	R
cos_theta_r1	1	0.316	0.319	-0.272	0.106	-0.116	0.264	-0.085	0.451	0.627
MET_rel	0.316	1	0.748	-0.134	0.378	0.078	0.535	0.15	0.584	0.595
M_Delta_R	0.319	0.748	1	-0.373	0.155	0.189	0.809	0.249	0.668	0.564
axial_MET	-0.272	-0.134	-0.373	1	-0.057	0.027	-0.535	-0.067	-0.317	-0.383
dPhi_r_b	0.106	0.378	0.155	-0.057	1	-0.106	0.056	-0.013	0.229	0.424
M_R	-0.116	0.078	0.189	0.027	-0.106	1	-0.068	0.981	0.577	-0.383
MT2	0.264	0.535	0.809	-0.535	0.056	-0.068	1	-0.021	0.379	0.574
S_R	-0.085	0.15	0.249	-0.067	-0.013	0.981	-0.021	1	0.635	-0.287
M_TR_2	0.451	0.584	0.668	-0.317	0.229	0.577	0.379	0.635	1	0.38
R	0.627	0.595	0.564	-0.383	0.424	-0.383	0.574	-0.287	0.38	1

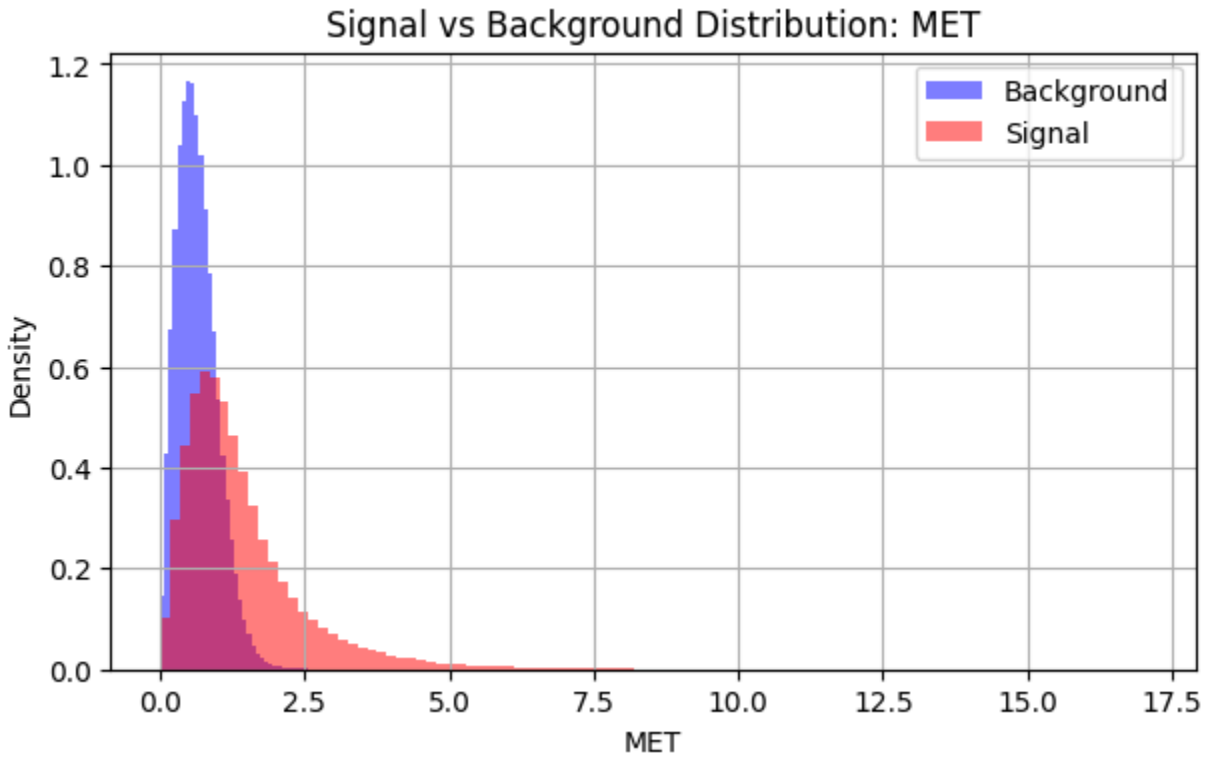
All Features Covariance Matrix

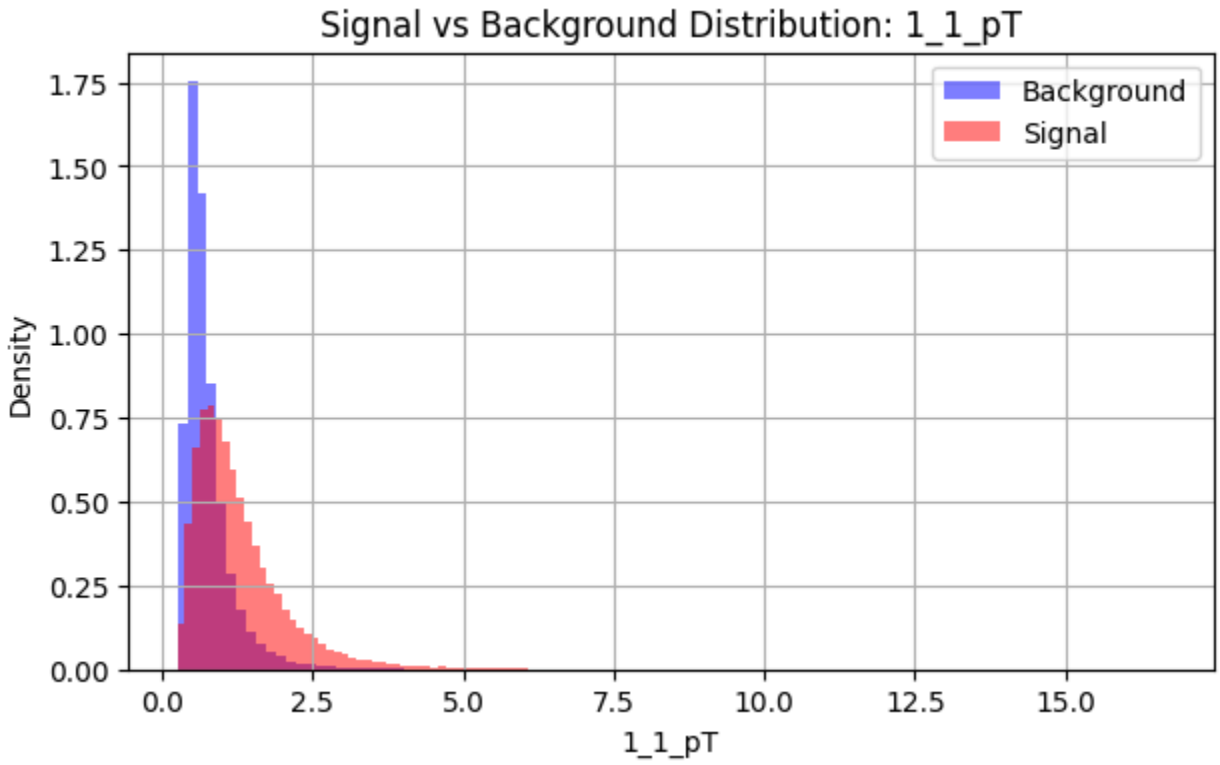
	1_1_pT	1_1_eta	1_1_phi	1_2_pT	1_2_eta	1_2_phi	MET	MET_phi	MET_rel	axial_MET	M_R	M_TR_2	R	MT2	S_R	M_Delta_R	dPhi_r_b	cos_theta_r1
1_1_pT	0.467	-0	0	0.305	-0	0.001	0.228	-0.001	0.098	-0.01	0.364	0.287	-0.06	-0.012	0.343	0.098	-0.047	0.022
1_1_eta	-0	1.004	-0.001	-0	0.408	-0.001	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	0	0	-0.001	-0.001	-0.001	0
1_1_phi	0	-0.001	1.004	0.001	0	-0.267	0.001	-0.185	0.001	-0.002	0.001	0.001	0	0.001	0.001	0.001	0.001	0
1_2_pT	0.305	-0	0.001	0.425	-0.001	0	0.079	-0.002	-0.001	0.051	0.325	0.163	-0.099	-0.069	0.322	0.006	-0.004	-0.028
1_2_eta	-0	0.408	0	-0.001	1.006	0	0	-0	0.001	-0.001	-0.001	0	0	0.001	-0.001	0.001	-0	0
1_2_phi	0.001	-0.001	-0.267	0	0	1.004	-0	-0.035	0.001	-0.002	0.001	0.001	0.001	0.002	0.001	0.001	-0	0
MET	0.228	-0.002	0.001	0.079	0	-0	0.762	-0.003	0.546	0.154	0.145	0.365	0.188	0.155	0.166	0.315	0.146	0.073
MET_phi	-0.001	-0.001	-0.185	-0.002	-0	-0.035	-0.003	1.003	-0.005	-0	-0.001	-0.001	-0	0	-0.002	-0.001	-0.002	0
MET_rel	0.098	-0.001	0.001	-0.001	0.001	0.001	0.546	-0.005	0.79	-0.12	0.044	0.302	0.249	0.409	0.082	0.415	0.146	0.055
axial_MET	-0.01	-0.001	-0.002	0.051	-0.001	-0.002	0.154	-0	-0.12	1.005	0.017	-0.185	-0.181	-0.461	-0.041	-0.233	-0.025	-0.054
M_R	0.364	-0.001	0.001	0.325	-0.001	0.001	0.145	-0.001	0.044	0.017	0.392	0.21	-0.113	-0.037	0.38	0.074	-0.029	-0.014
M_TR_2	0.287	-0.001	0.001	0.163	0	0.001	0.365	-0.001	0.302	-0.185	0.21	0.338	0.104	0.189	0.228	0.242	0.058	0.052
R	-0.06	0	0	-0.099	0	0.001	0.188	-0	0.249	-0.181	-0.113	0.104	0.222	0.232	-0.083	0.165	0.087	0.058
MT2	-0.012	0	0.001	-0.069	0.001	0.002	0.155	0	0.409	-0.461	-0.037	0.189	0.232	0.738	-0.011	0.433	0.021	0.045
S_R	0.343	-0.001	0.001	0.322	-0.001	0.001	0.166	-0.002	0.082	-0.041	0.38	0.228	-0.083	-0.011	0.382	0.096	-0.003	-0.01
M_Delta_R	0.098	-0.001	0.001	0.006	0.001	0.001	0.315	-0.001	0.415	-0.233	0.074	0.242	0.165	0.433	0.096	0.389	0.042	0.039
dPhi_r_b	-0.047	-0.001	0.001	-0.004	-0	-0	0.146	-0.002	0.146	-0.025	-0.029	0.058	0.087	0.021	-0.003	0.042	0.19	0.009
cos_theta_r1	0.022	0	0	-0.028	0	0	0.073	0	0.055	-0.054	-0.014	0.052	0.058	0.045	-0.01	0.039	0.009	0.039

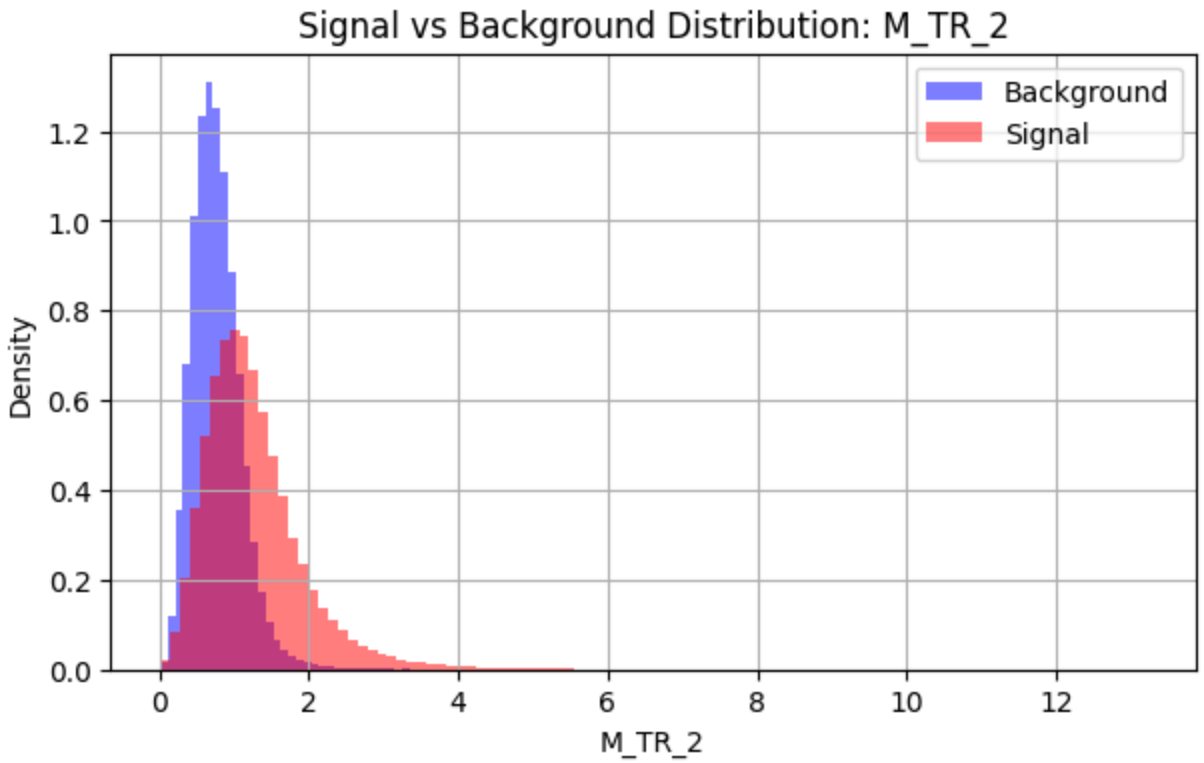
All Features Correlation Matrix

	1_1_pT	1_1_eta	1_1_phi	1_2_pT	1_2_eta	1_2_phi	MET	MET_phi	MET_rel	axial_MET	M_R	M_TR_2	R	MT2	S_R	M_Delta_R	dPhi_r_b	cos_theta_r1
1_1_pT	1	-0.001	0	0.684	-0.001	0.001	0.383	-0.001	0.16	-0.014	0.851	0.723	-0.186	-0.021	0.811	0.229	-0.157	0.165
1_1_eta	-0.001	1	-0.001	-0	0.406	-0.001	-0.002	-0.001	-0.002	-0.001	-0.001	-0.001	0.001	0	-0.001	-0.002	-0.002	0.002
1_1_phi	0	-0.001	1	0.002	0	-0.266	0.001	-0.184	0.001	-0.002	0.002	0.001	0	0.001	0.002	0.001	0.002	0.001
1_2_pT	0.684	-0	0.002	1	-0.001	0	0.14	-0.002	-0.001	0.078	0.797	0.43	-0.324	-0.123	0.799	0.014	-0.013	-0.217
1_2_eta	-0.001	0.406	0	-0.001	1	0	0	-0	0.001	-0.001	-0.001	0	0.001	0.002	-0.001	0.001	-0.001	0.001
1_2_phi	0.001	-0.001	-0.266	0	0	1	-0	-0.035	0.002	-0.002	0.001	0.001	0.001	0.003	0.001	0.002	-0.001	0
MET	0.383	-0.002	0.001	0.14	0	-0	1	-0.003	0.704	0.176	0.264	0.72	0.457	0.206	0.307	0.579	0.383	0.425
MET_phi	-0.001	-0.001	-0.184	-0.002	-0	-0.035	-0.003	1	-0.005	-0	-0.002	-0.002	-0	0	-0.003	-0.001	-0.004	0.001
MET_rel	0.16	-0.002	0.001	-0.001	0.001	0.002	0.704	-0.005	1	-0.134	0.078	0.584	0.595	0.535	0.15	0.748	0.378	0.316
axial_MET	-0.014	-0.001	-0.002	0.078	-0.001	-0.002	0.176	-0	-0.134	1	0.027	-0.317	-0.383	-0.535	-0.067	-0.373	-0.057	-0.272
M_R	0.851	-0.001	0.002	0.797	-0.001	0.001	0.264	-0.002	0.078	0.027	1	0.577	-0.383	-0.068	0.981	0.189	-0.106	-0.116
M_TR_2	0.723	-0.001	0.001	0.43	0	0.001	0.72	-0.002	0.584	-0.317	0.577	1	0.38	0.379	0.635	0.668	0.229	0.451
R	-0.186	0.001	0	-0.324	0.001	0.001	0.457	-0	0.595	-0.383	-0.383	0.38	1	0.574	-0.287	0.564	0.424	0.627
MT2	-0.021	0	0.001	-0.123	0.002	0.003	0.206	0	0.535	-0.535	-0.068	0.379	0.574	1	-0.021	0.809	0.056	0.264
S_R	0.811	-0.001	0.002	0.799	-0.001	0.001	0.307	-0.003	0.15	-0.067	0.981	0.635	-0.287	-0.021	1	0.249	-0.013	-0.085
M_Delta_R	0.229	-0.002	0.001	0.014	0.001	0.002	0.579	-0.001	0.748	-0.373	0.189	0.668	0.564	0.809	0.249	1	0.155	0.319
dPhi_r_b	-0.157	-0.002	0.002	-0.013	-0.001	-0.001	0.383	-0.004	0.378	-0.057	-0.106	0.229	0.424	0.056	-0.013	0.155	1	0.106
cos_theta_r1	0.165	0.002	0.001	-0.217	0.001	0	0.425	0.001	0.316	-0.272	-0.116	0.451	0.627	0.264	-0.085	0.319	0.106	1

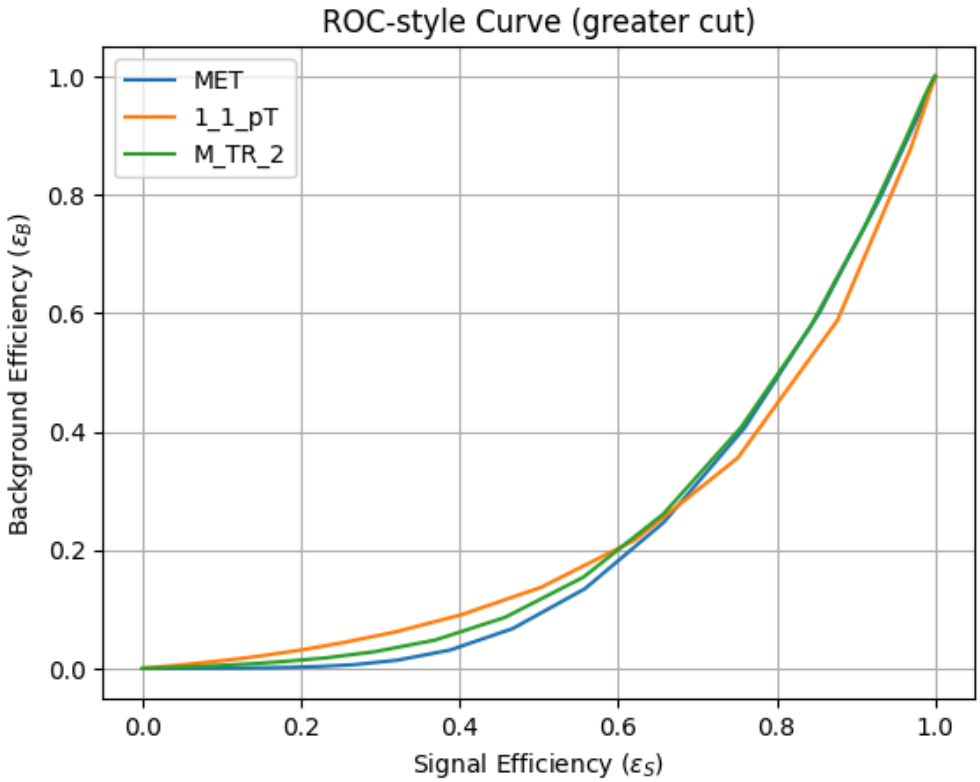
Exercise 5.1


Signal vs Background Distribution: MET
Background
Signal
Density
MET
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5

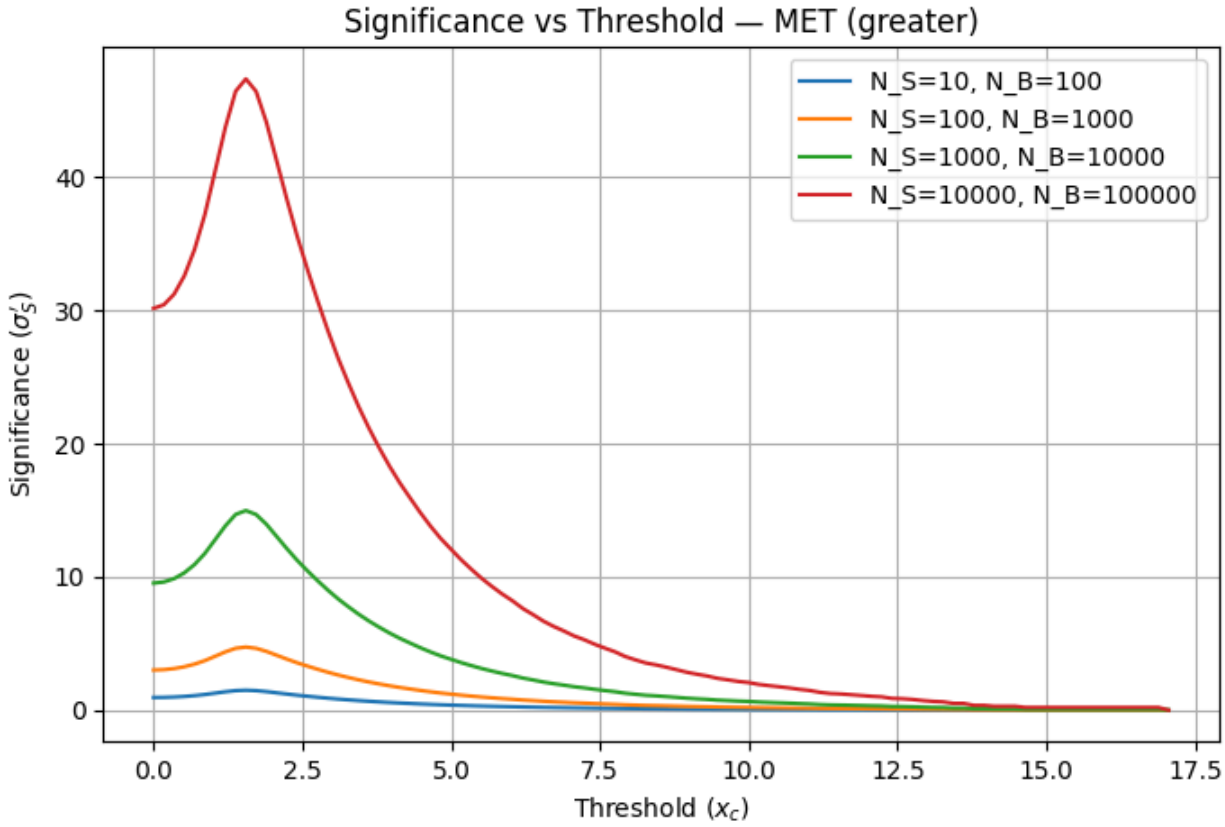

Signal vs Background Distribution: 1_1_pT
Background
Signal
Density
1_1_pT
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
0.0
2.5
5.0
7.5
10.0
12.5
15.0

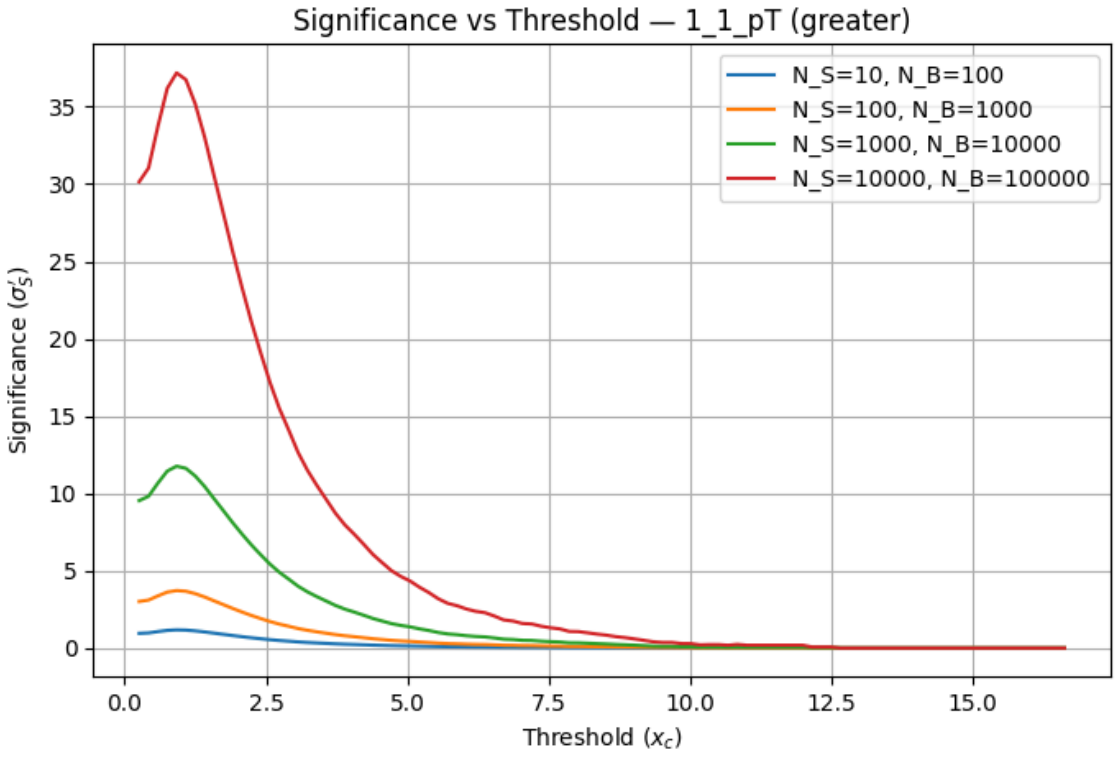

Signal vs Background Distribution: M_TR_2
Background
Signal
Density
M_TR_2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
2
4
6
8
10
12

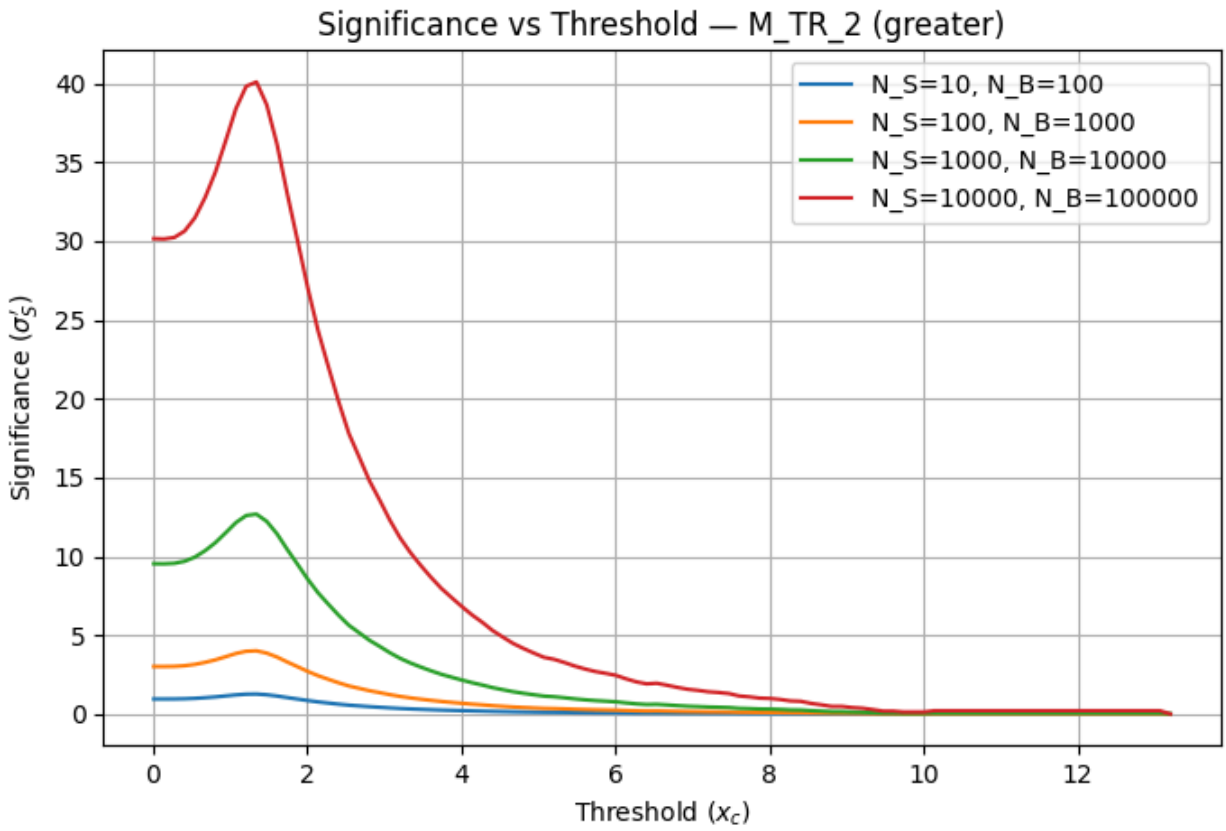
Exercise 5.2


ROC-style Curve (greater cut)
MET
1_1_pT
M_TR_2
Background Efficiency (ε_B)
Signal Efficiency (ε_S)
0.0
0.2
0.4
0.6
0.8
1.0

Exercise 5.3


Significance vs Threshold — MET (greater)
N_S=10, N_B=100
N_S=100, N_B=1000
N_S=1000, N_B=10000
N_S=10000, N_B=100000
Significance (σ'_S)
Threshold (x_c)
0
10
20
30
40
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5


Significance vs Threshold — 1_1_pT (greater)
N_S=10, N_B=100
N_S=100, N_B=1000
N_S=1000, N_B=10000
N_S=10000, N_B=100000
Significance (σ'_S)
Threshold (x_c)
0
5
10
15
20
25
30
35
0.0
2.5
5.0
7.5
10.0
12.5
15.0



Exercise 6.1

```
Optimal thresholds: {'MET': np.float64(0.3452432534405773), '1_1_pT':
np.float64(0.5863523684968852), 'M_TR_2': np.float64(0.5424982333612262)}
```

Exercise 6.2

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
MET > 0.345	0.931	0.7963	930	7963	9.8718
1_1_pT > 0.586	0.8196	0.4725	819	4725	11.0072
M_TR_2 > 0.542	0.7935	0.4555	793	4554	10.8501

Exercise 6.3

```
Cut order: ('MET', '1_1_pT', 'M_TR_2')

Scenario: N_S=10, N_B=100
```

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
MET > 0.345	0.931	0.7963	9	79	0.9872
1_1_pT > 0.586	0.8196	0.4725	8	47	1.1007
M_TR_2 > 0.542	0.7935	0.4555	7	45	1.085

Scenario: N_S=100, N_B=1000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
MET > 0.345	0.931	0.7963	93	796	3.1217
1_1_pT > 0.586	0.8196	0.4725	81	472	3.4808
M_TR_2 > 0.542	0.7935	0.4555	79	455	3.4311

Scenario: N_S=1000, N_B=10000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
MET > 0.345	0.931	0.7963	930	7963	9.8718
1_1_pT > 0.586	0.8196	0.4725	819	4725	11.0072
M_TR_2 > 0.542	0.7935	0.4555	793	4554	10.8501

Scenario: N_S=10000, N_B=100000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
MET > 0.345	0.931	0.7963	9309	79631	31.2172
1_1_pT > 0.586	0.8196	0.4725	8196	47250	34.8078
M_TR_2 > 0.542	0.7935	0.4555	7935	45548	34.3112

Cut order: ('MET', 'M_TR_2', '1_1_pT')

Scenario: N_S=10, N_B=100

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
MET > 0.345	0.931	0.7963	9	79	0.9872
M_TR_2 > 0.542	0.8873	0.7124	8	71	0.9914
1_1_pT > 0.586	0.7935	0.4555	7	45	1.085

Scenario: N_S=100, N_B=1000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
MET > 0.345	0.931	0.7963	93	796	3.1217
M_TR_2 > 0.542	0.8873	0.7124	88	712	3.135
1_1_pT > 0.586	0.7935	0.4555	79	455	3.4311

Scenario: N_S=1000, N_B=10000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
MET > 0.345	0.931	0.7963	930	7963	9.8718
M_TR_2 > 0.542	0.8873	0.7124	887	7123	9.9137
1_1_pT > 0.586	0.7935	0.4555	793	4554	10.8501

Scenario: N_S=10000, N_B=100000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
MET > 0.345	0.931	0.7963	9309	79631	31.2172
M_TR_2 > 0.542	0.8873	0.7124	8873	71236	31.3497
1_1_pT > 0.586	0.7935	0.4555	7935	45548	34.3112

Cut order: ('1_1_pT', 'MET', 'M_TR_2')

Scenario: N_S=10, N_B=100

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
1_1_pT > 0.586	0.8766	0.5876	8	58	1.0667
MET > 0.345	0.8196	0.4725	8	47	1.1007
M_TR_2 > 0.542	0.7935	0.4555	7	45	1.085

Scenario: N_S=100, N_B=1000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
1_1_pT > 0.586	0.8766	0.5876	87	587	3.3733
MET > 0.345	0.8196	0.4725	81	472	3.4808
M_TR_2 > 0.542	0.7935	0.4555	79	455	3.4311

Scenario: N_S=1000, N_B=10000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
1_1_pT > 0.586	0.8766	0.5876	876	5875	10.6673
MET > 0.345	0.8196	0.4725	819	4725	11.0072
M_TR_2 > 0.542	0.7935	0.4555	793	4554	10.8501

Scenario: N_S=10000, N_B=100000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
1_1_pT > 0.586	0.8766	0.5876	8765	58756	33.733
MET > 0.345	0.8196	0.4725	8196	47250	34.8078
M_TR_2 > 0.542	0.7935	0.4555	7935	45548	34.3112

Cut order: ('1_1_pT', 'M_TR_2', 'MET')

Scenario: N_S=10, N_B=100

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
1_1_pT > 0.586	0.8766	0.5876	8	58	1.0667
M_TR_2 > 0.542	0.8175	0.4891	8	48	1.082
MET > 0.345	0.7935	0.4555	7	45	1.085

Scenario: N_S=100, N_B=1000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
1_1_pT > 0.586	0.8766	0.5876	87	587	3.3733
M_TR_2 > 0.542	0.8175	0.4891	81	489	3.4216
MET > 0.345	0.7935	0.4555	79	455	3.4311

Scenario: N_S=1000, N_B=10000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
1_1_pT > 0.586	0.8766	0.5876	876	5875	10.6673
M_TR_2 > 0.542	0.8175	0.4891	817	4891	10.82
MET > 0.345	0.7935	0.4555	793	4554	10.8501

Scenario: N_S=10000, N_B=100000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
1_1_pT > 0.586	0.8766	0.5876	8765	58756	33.733
M_TR_2 > 0.542	0.8175	0.4891	8175	48911	34.2159
MET > 0.345	0.7935	0.4555	7935	45548	34.3112

Cut order: ('M_TR_2', 'MET', '1_1_pT')

Scenario: N_S=10, N_B=100

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
M_TR_2 > 0.542	0.9117	0.7478	9	74	0.9953
MET > 0.345	0.8873	0.7124	8	71	0.9914
1_1_pT > 0.586	0.7935	0.4555	7	45	1.085

Scenario: N_S=100, N_B=1000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
M_TR_2 > 0.542	0.9117	0.7478	91	747	3.1476
MET > 0.345	0.8873	0.7124	88	712	3.135
1_1_pT > 0.586	0.7935	0.4555	79	455	3.4311

Scenario: N_S=1000, N_B=10000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
M_TR_2 > 0.542	0.9117	0.7478	911	7478	9.9534
MET > 0.345	0.8873	0.7124	887	7123	9.9137
1_1_pT > 0.586	0.7935	0.4555	793	4554	10.8501

Scenario: N_S=10000, N_B=100000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'

M_TR_2 > 0.542	0.9117	0.7478	9117	74783	31.4755
MET > 0.345	0.8873	0.7124	8873	71236	31.3497
1_1_pT > 0.586	0.7935	0.4555	7935	45548	34.3112

Cut order: ('M_TR_2', '1_1_pT', 'MET')

Scenario: N_S=10, N_B=100

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
M_TR_2 > 0.542	0.9117	0.7478	9	74	0.9953
1_1_pT > 0.586	0.8175	0.4891	8	48	1.082
MET > 0.345	0.7935	0.4555	7	45	1.085

Scenario: N_S=100, N_B=1000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
M_TR_2 > 0.542	0.9117	0.7478	91	747	3.1476
1_1_pT > 0.586	0.8175	0.4891	81	489	3.4216
MET > 0.345	0.7935	0.4555	79	455	3.4311

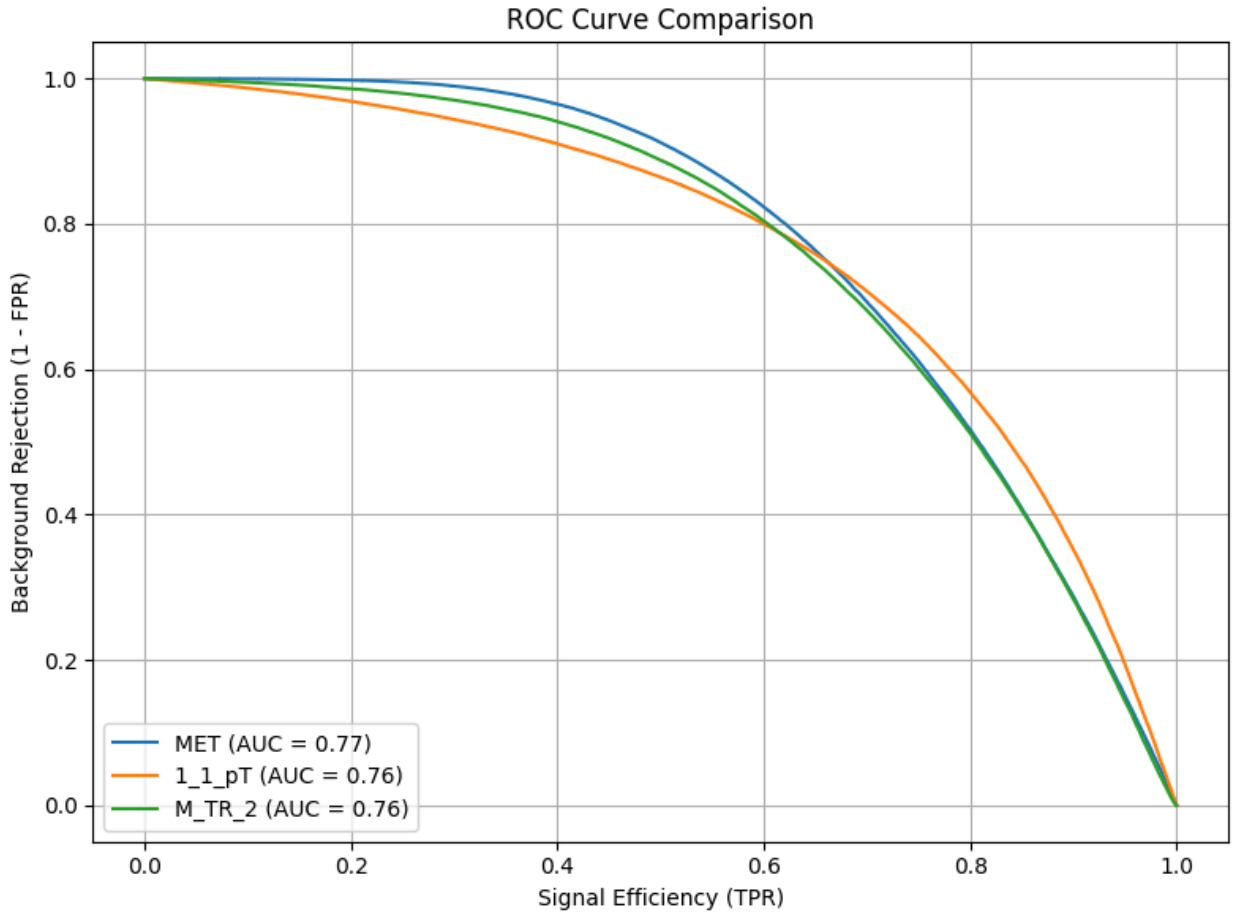
Scenario: N_S=1000, N_B=10000

cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
M_TR_2 > 0.542	0.9117	0.7478	911	7478	9.9534
1_1_pT > 0.586	0.8175	0.4891	817	4891	10.82
MET > 0.345	0.7935	0.4555	793	4554	10.8501

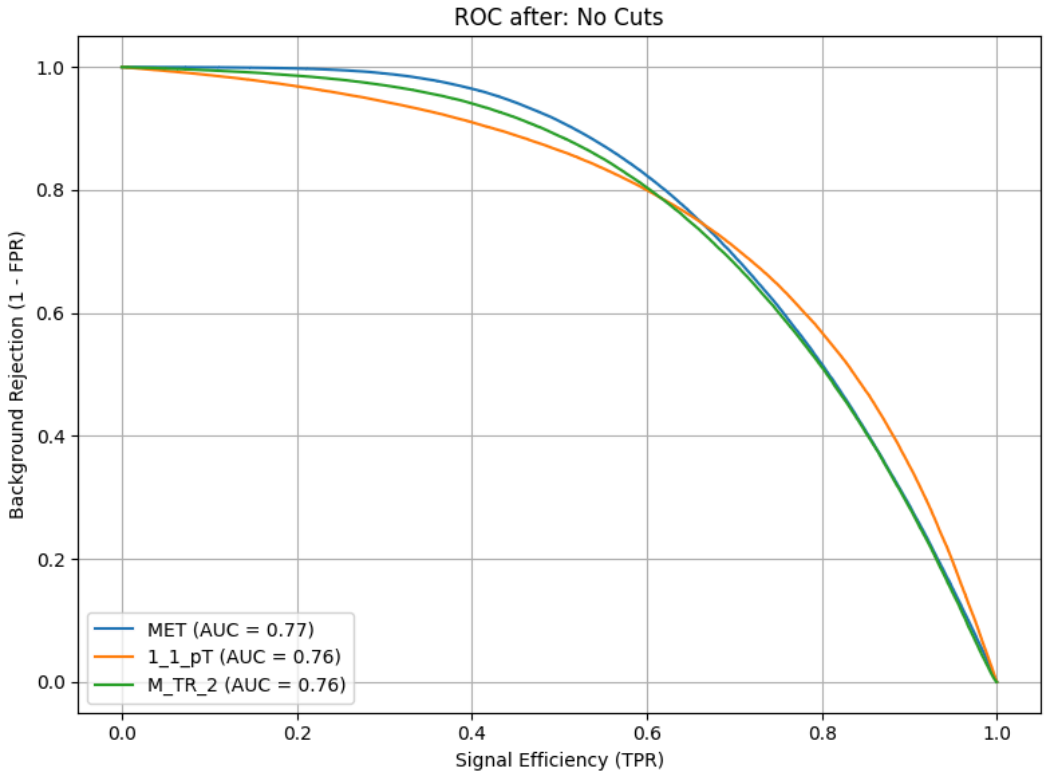
Scenario: N_S=10000, N_B=100000

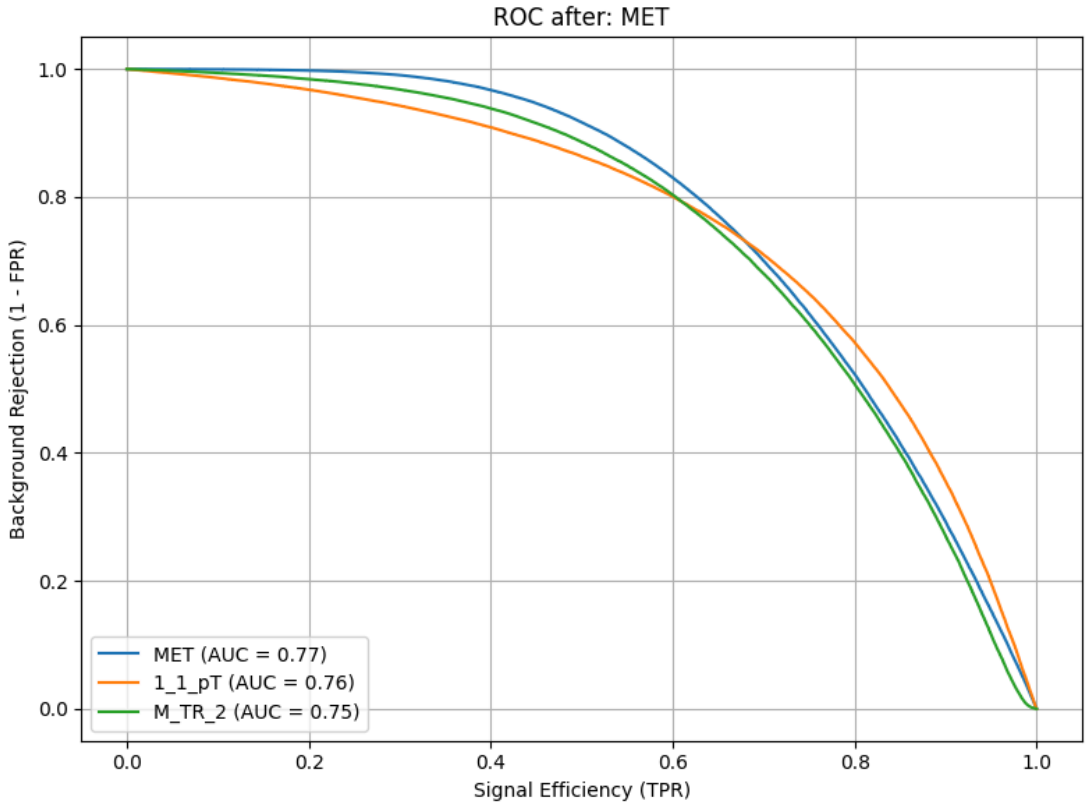
cut	epsilon_s	epsilon_b	N'_s	N'_b	sigma_s'
M_TR_2 > 0.542	0.9117	0.7478	9117	74783	31.4755
1_1_pT > 0.586	0.8175	0.4891	8175	48911	34.2159
MET > 0.345	0.7935	0.4555	7935	45548	34.3112

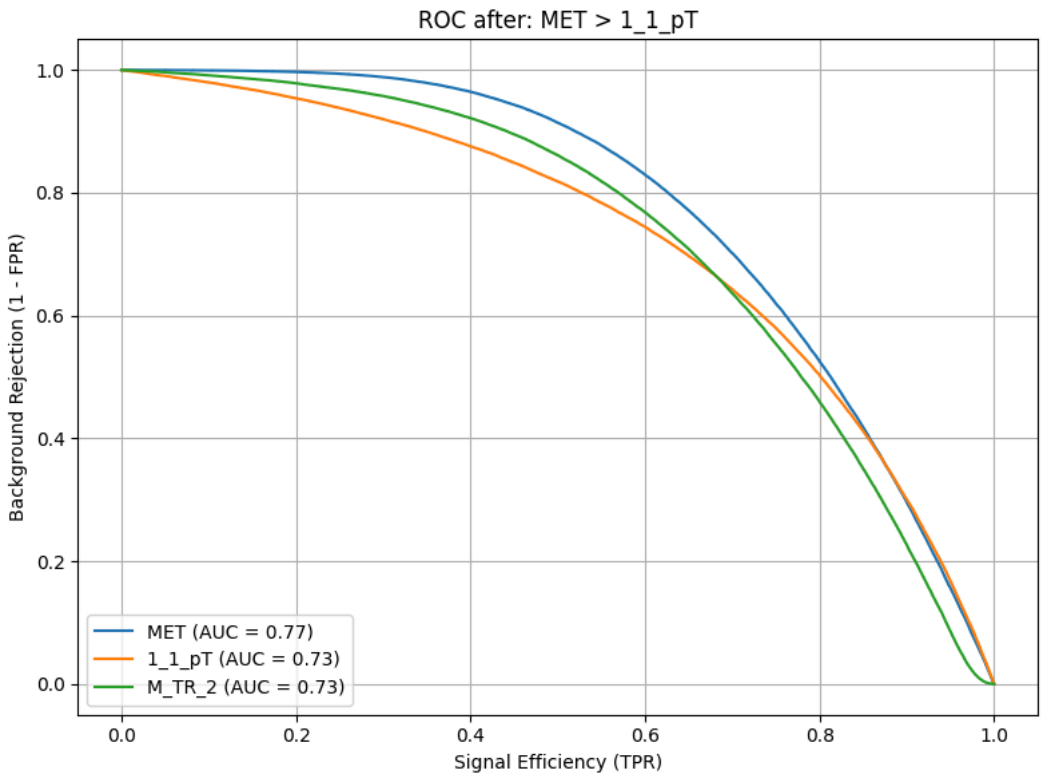
Exercise 7.1 & 7.2

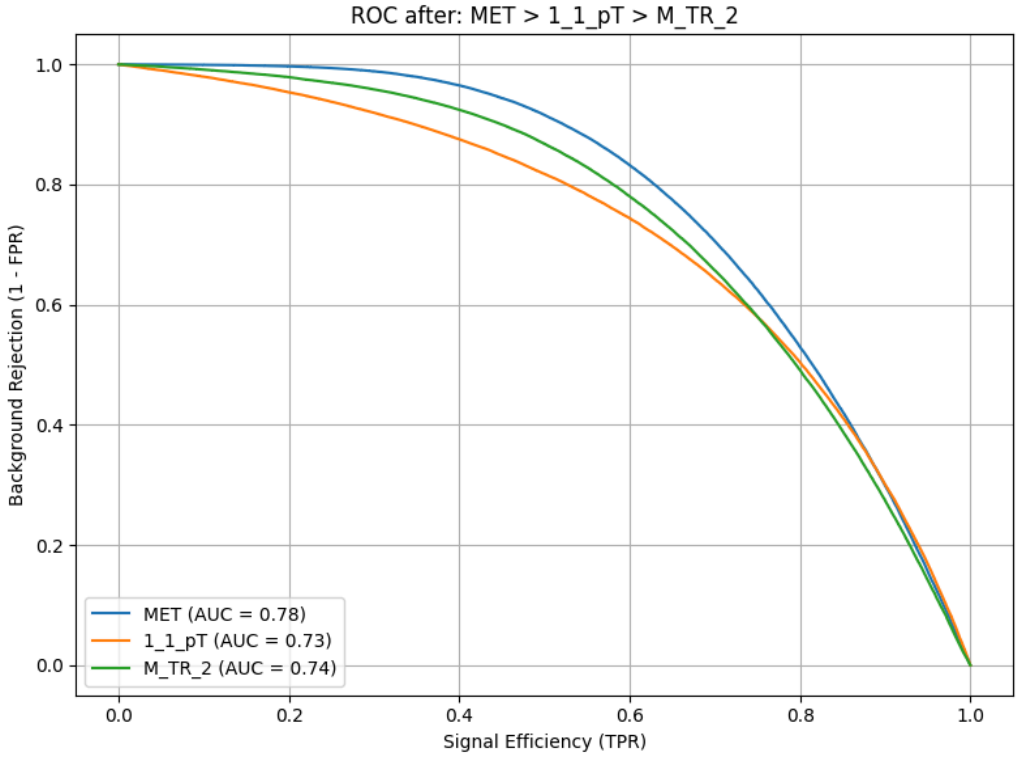


Exercise 7.3


ROC after: No Cuts
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
MET (AUC = 0.77)
1_1_pT (AUC = 0.76)
M_TR_2 (AUC = 0.76)

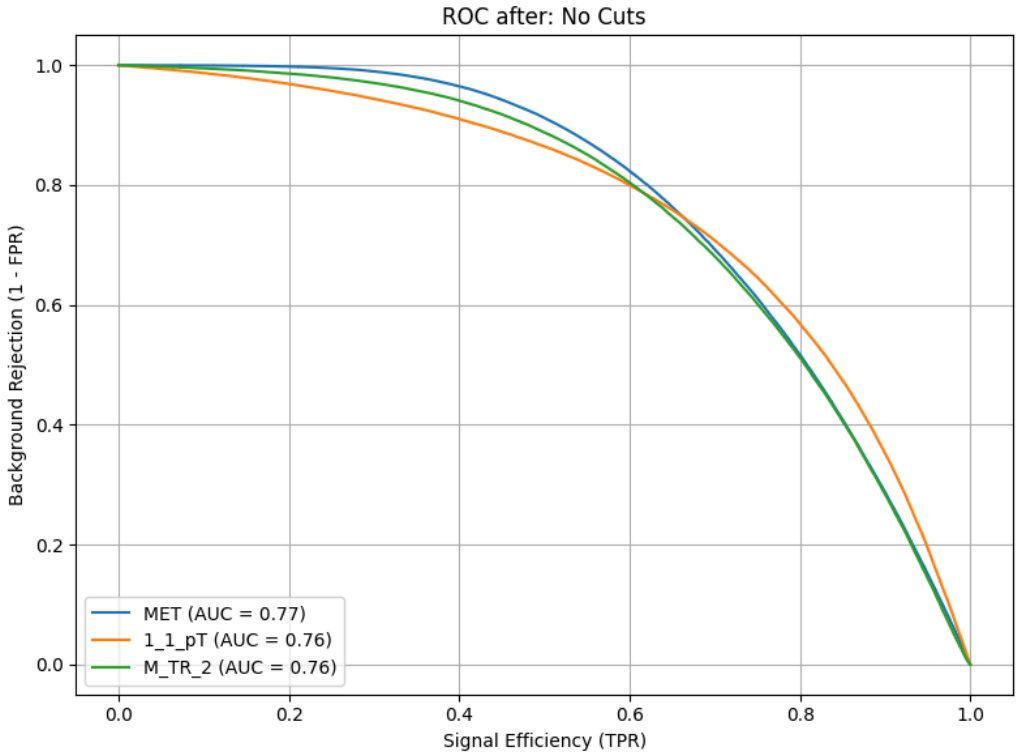

ROC after: MET
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
MET (AUC = 0.77)
1_1_pT (AUC = 0.76)
M_TR_2 (AUC = 0.75)

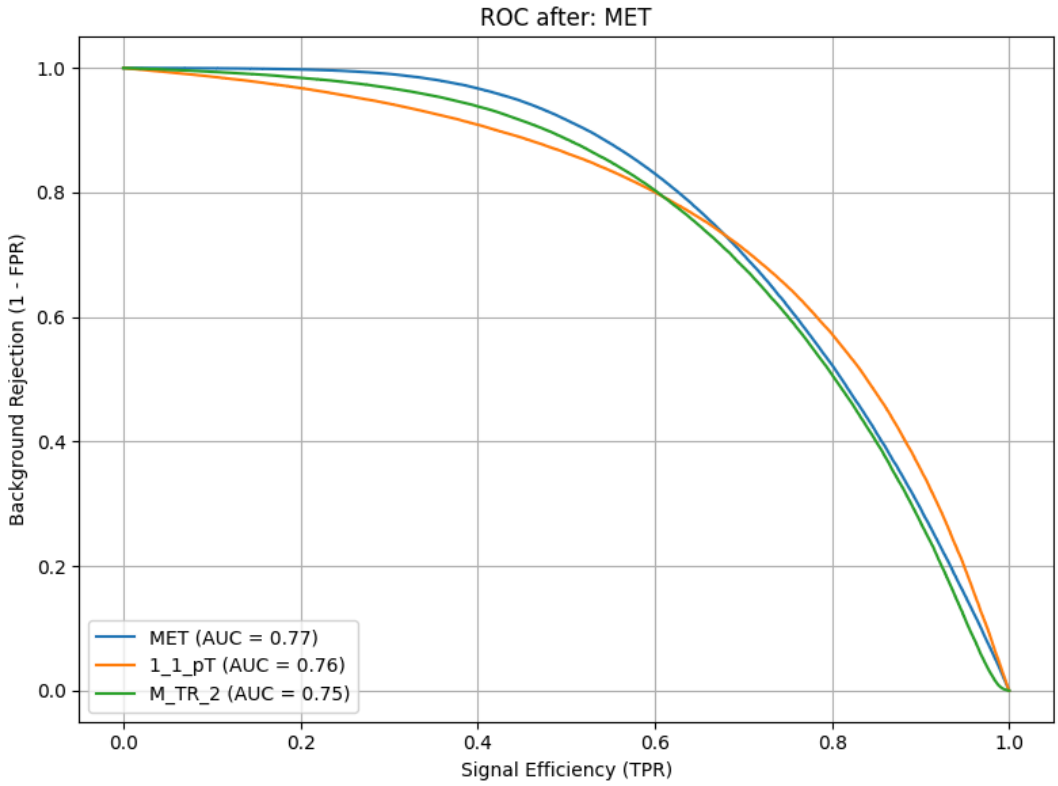

ROC after: MET > 1_1_pT
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
MET (AUC = 0.77)
1_1_pT (AUC = 0.73)
M_TR_2 (AUC = 0.73)
0.0
0.2
0.4
0.6
0.8
1.0

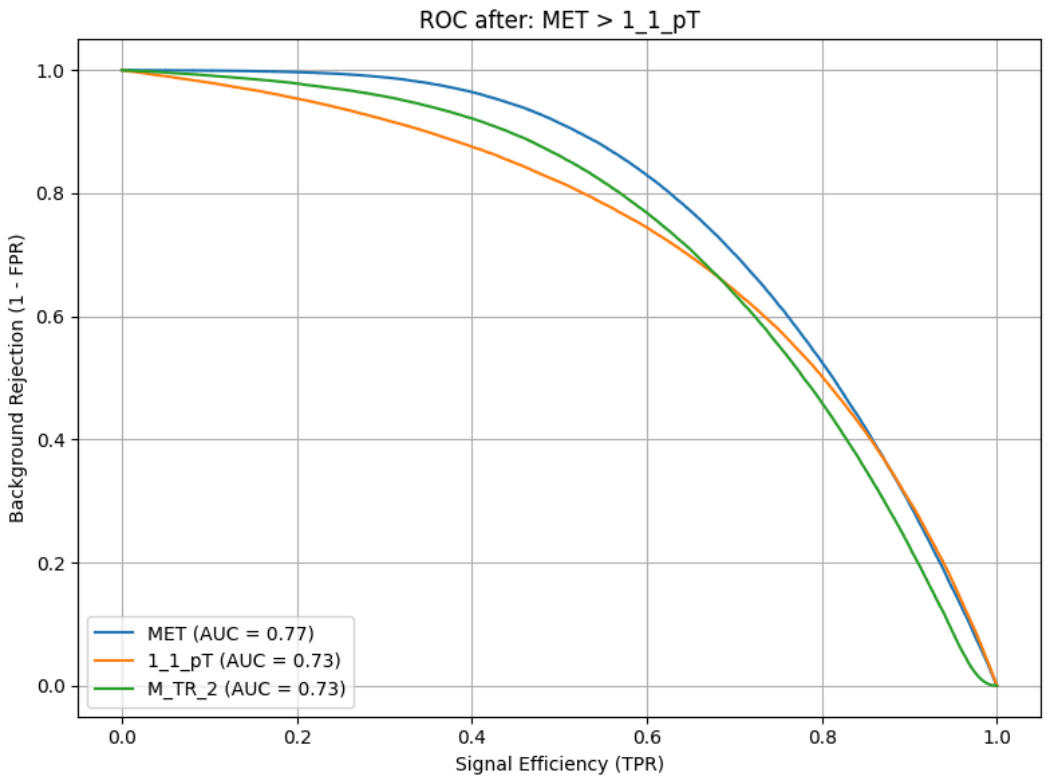

ROC after: MET > 1_1_pT > M_TR_2
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
MET (AUC = 0.78)
1_1_pT (AUC = 0.73)
M_TR_2 (AUC = 0.74)
0.0
0.2
0.4
0.6
0.8
1.0

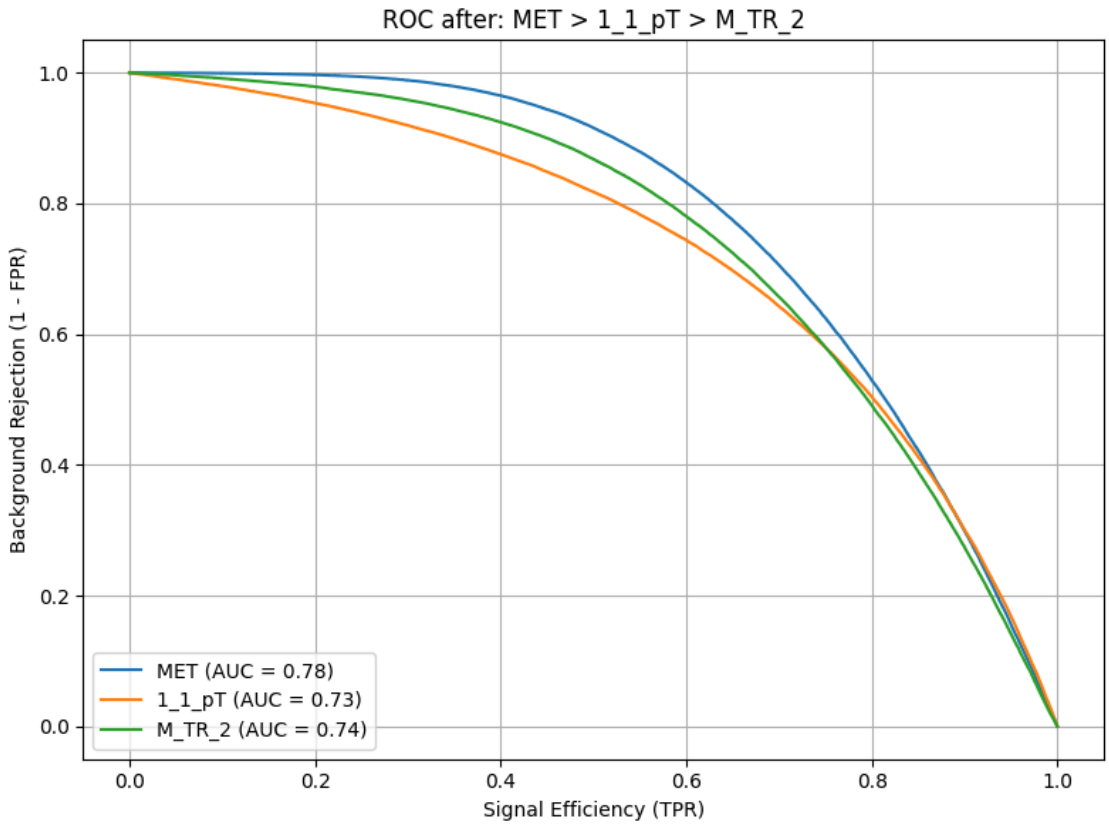
Exercise 7.4

(`Cut Order: ('MET', '1_1_pT', 'M_TR_2'))`

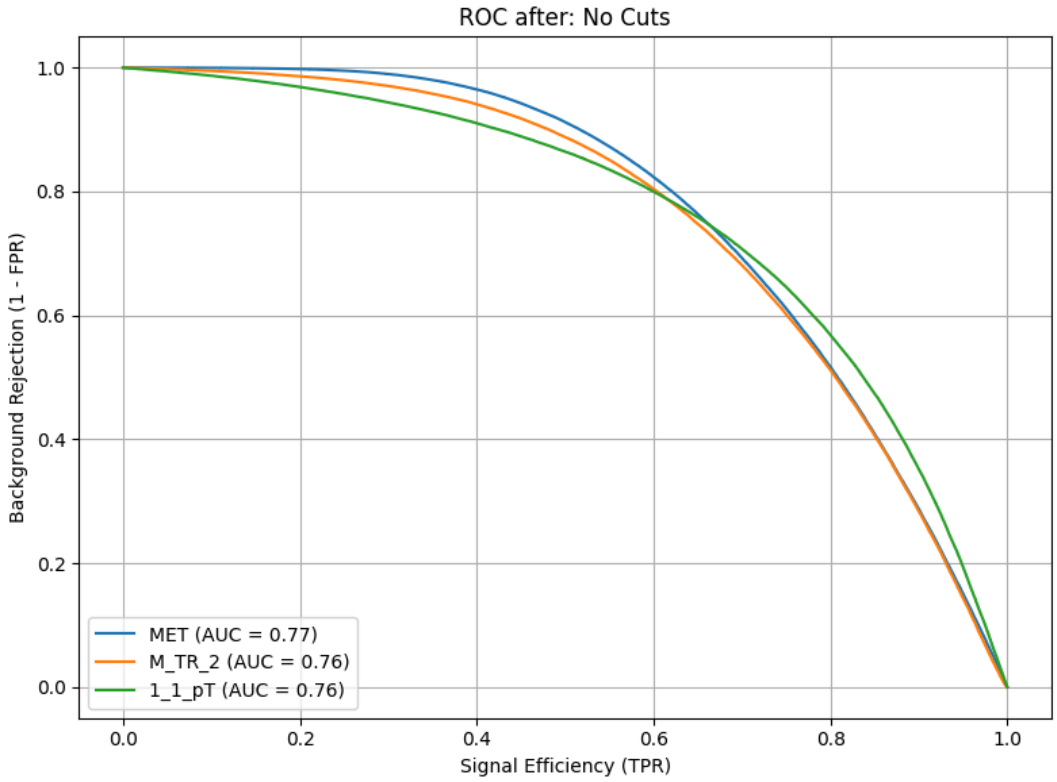


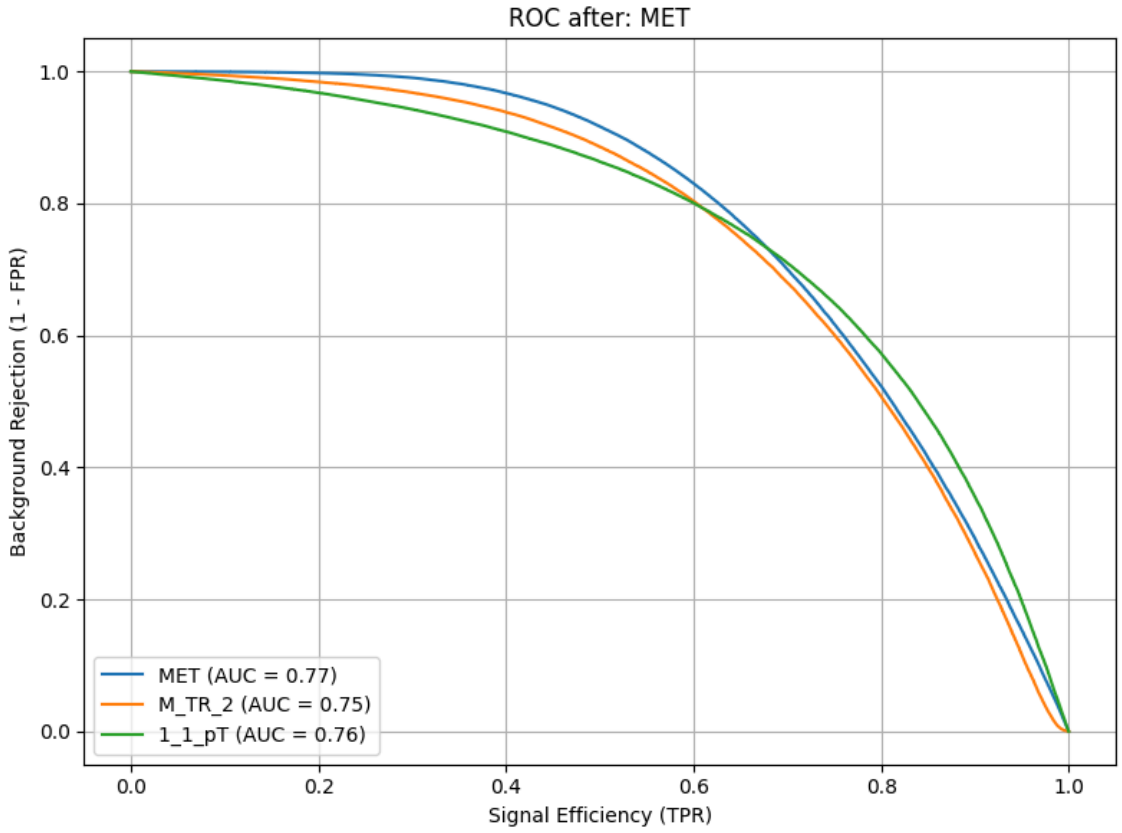


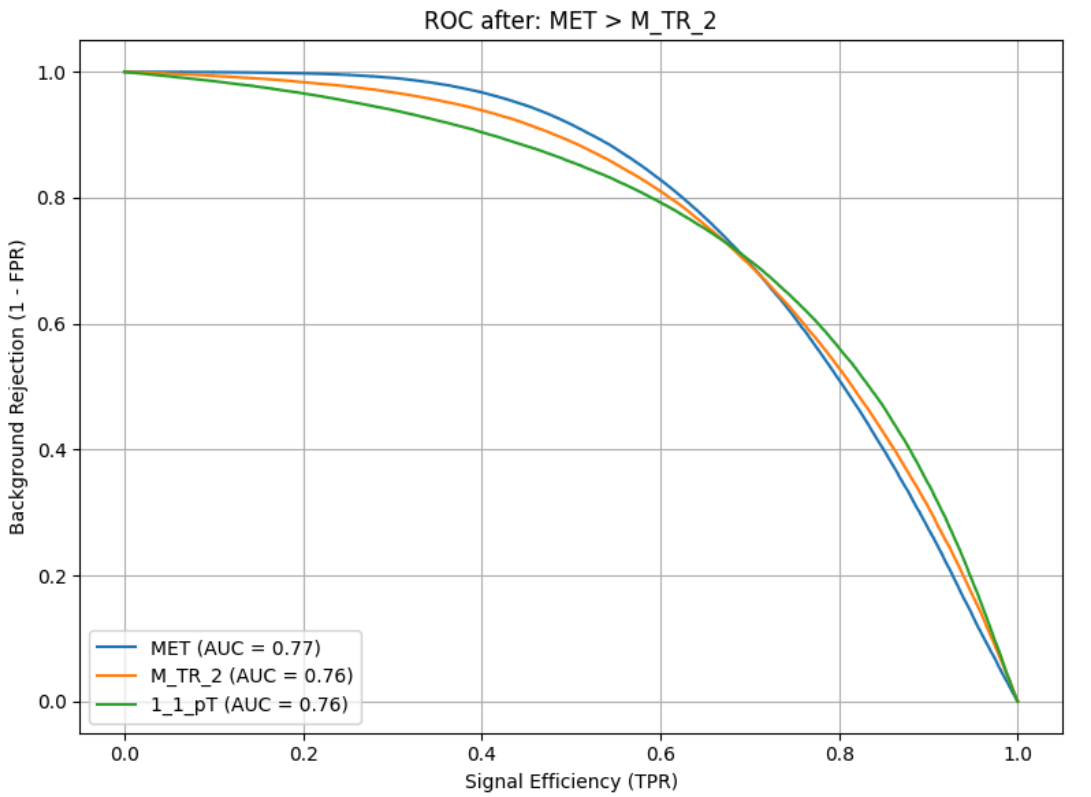

ROC after: MET > 1_1_pT
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
MET (AUC = 0.77)
1_1_pT (AUC = 0.73)
M_TR_2 (AUC = 0.73)
0.0
0.2
0.4
0.6
0.8
1.0

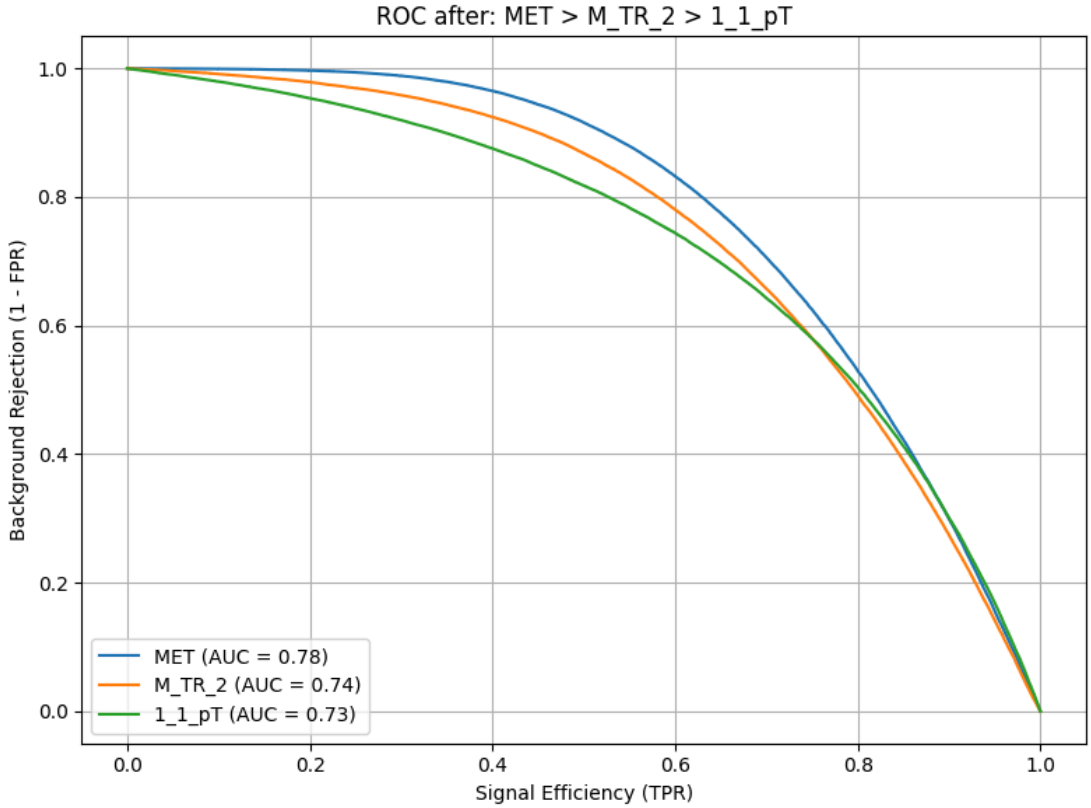

ROC after: MET > 1_1_pT > M_TR_2
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
MET (AUC = 0.78)
1_1_pT (AUC = 0.73)
M_TR_2 (AUC = 0.74)
0.0
0.2
0.4
0.6
0.8
1.0

(Cut Order: ('MET', 'M_TR_2', '1_1_pT'))

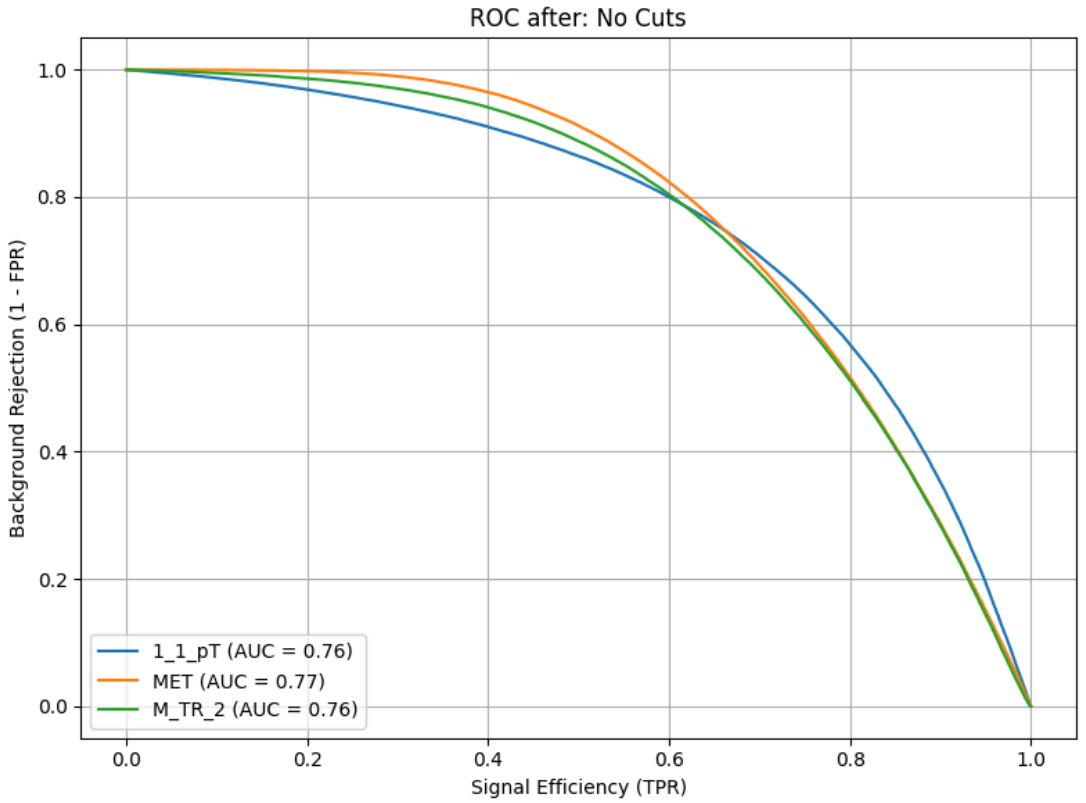


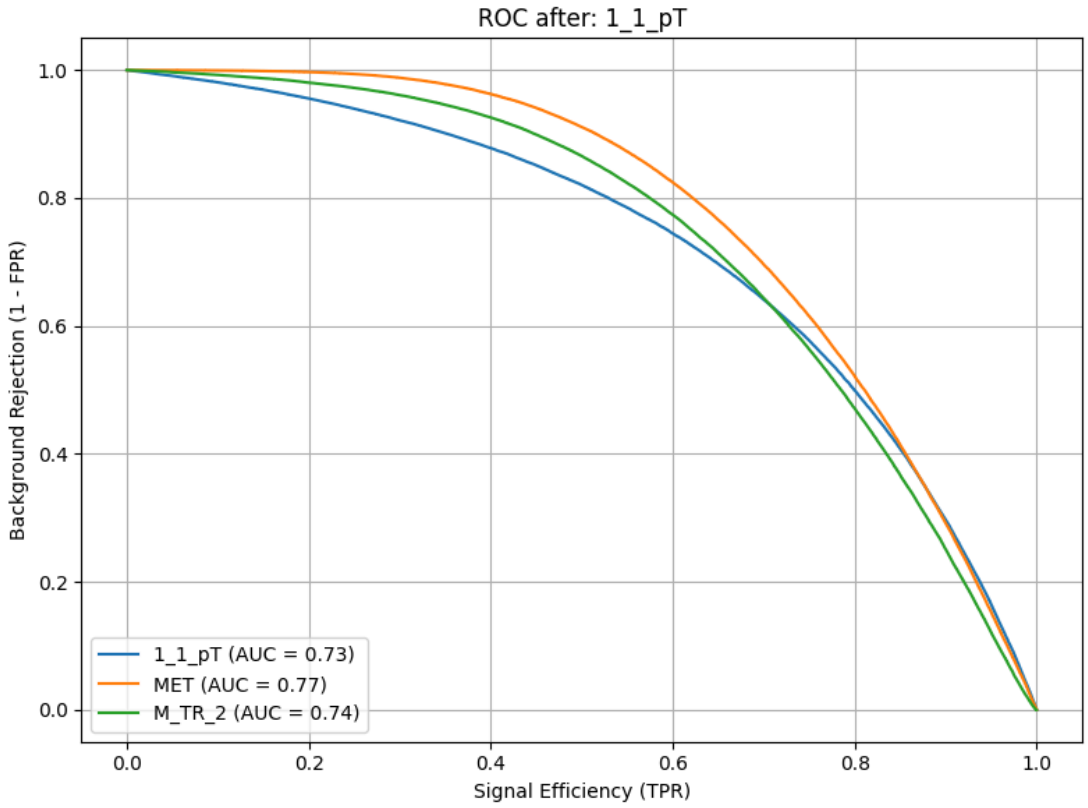


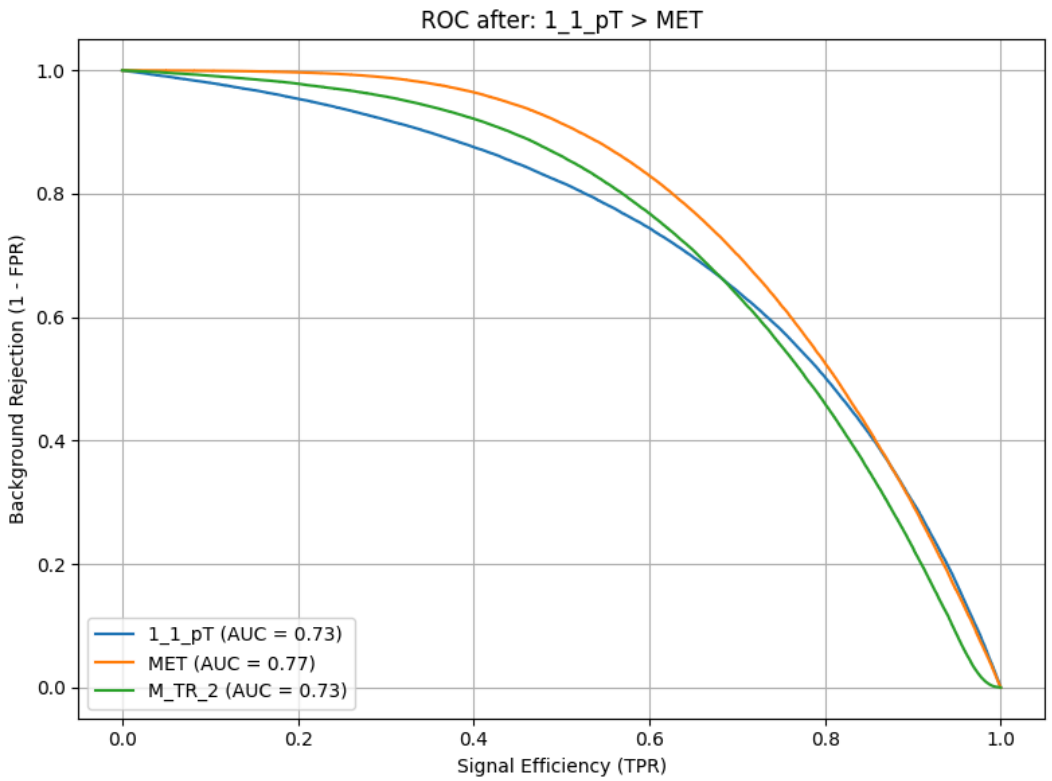

ROC after: MET > M_TR_2
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
MET (AUC = 0.77)
M_TR_2 (AUC = 0.76)
1_1_pT (AUC = 0.76)
0.0
0.2
0.4
0.6
0.8
1.0

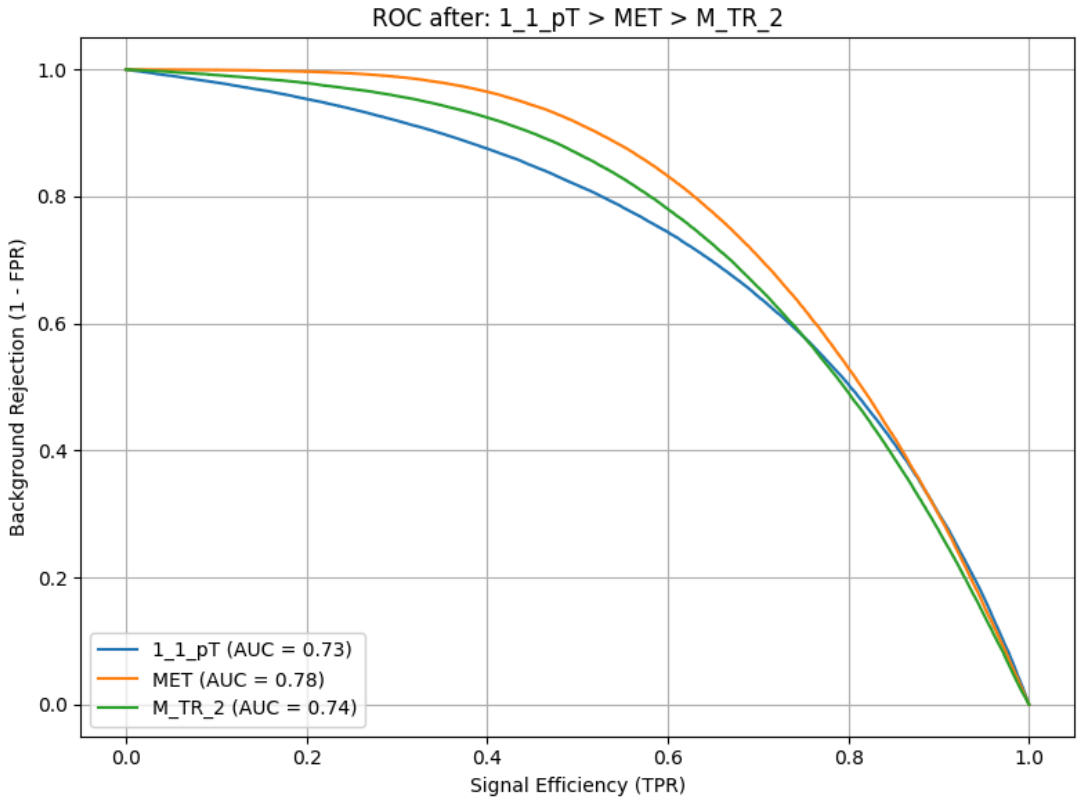

ROC after: MET > M_TR_2 > 1_1_pT
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
MET (AUC = 0.78)
M_TR_2 (AUC = 0.74)
1_1_pT (AUC = 0.73)
0.0
0.2
0.4
0.6
0.8
1.0

(Cut Order: ('1_1_pT', 'MET', 'M_TR_2'))

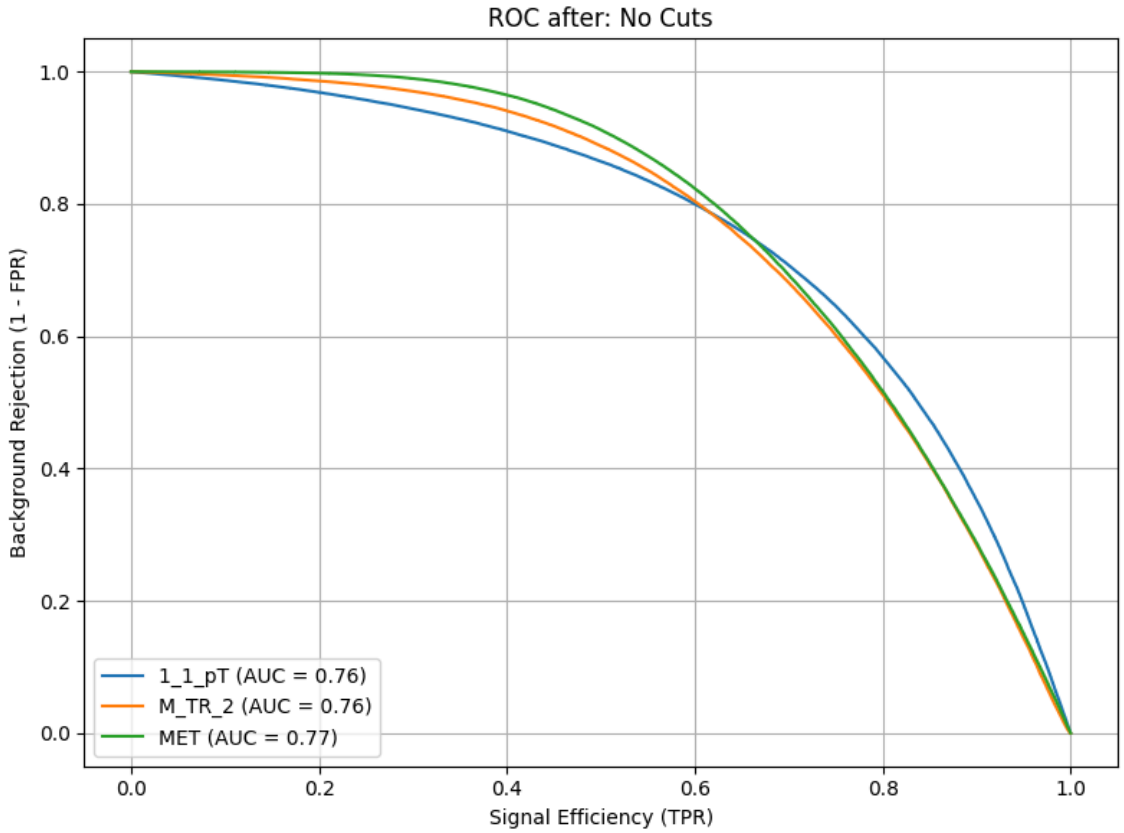


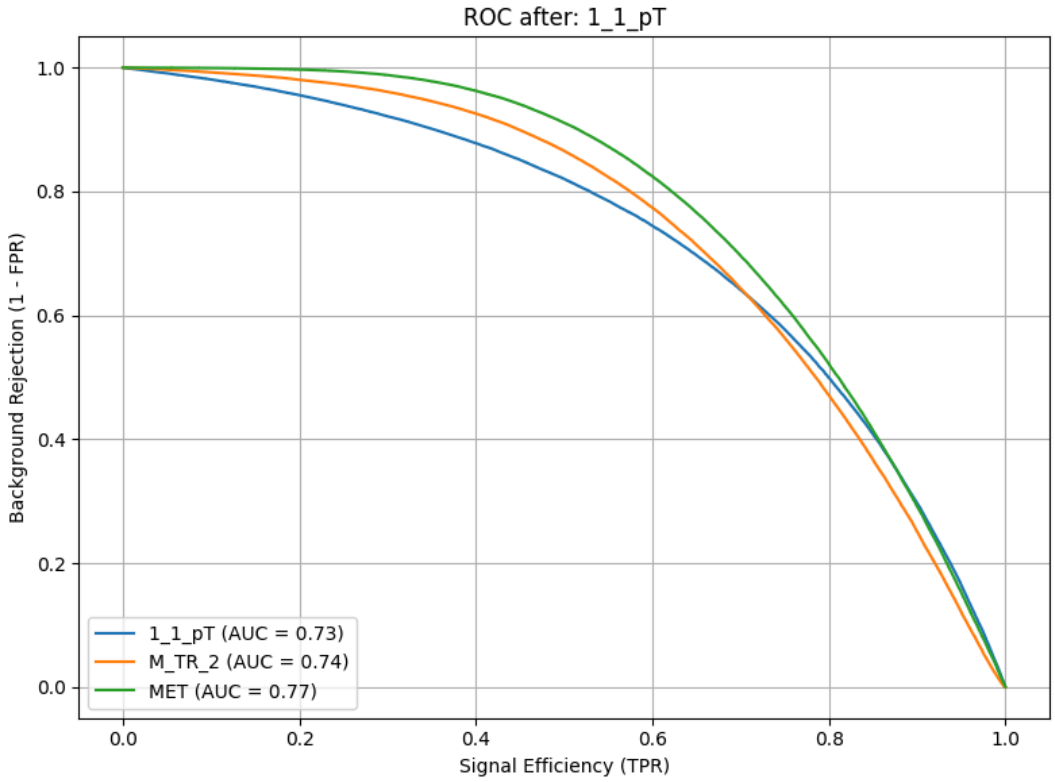


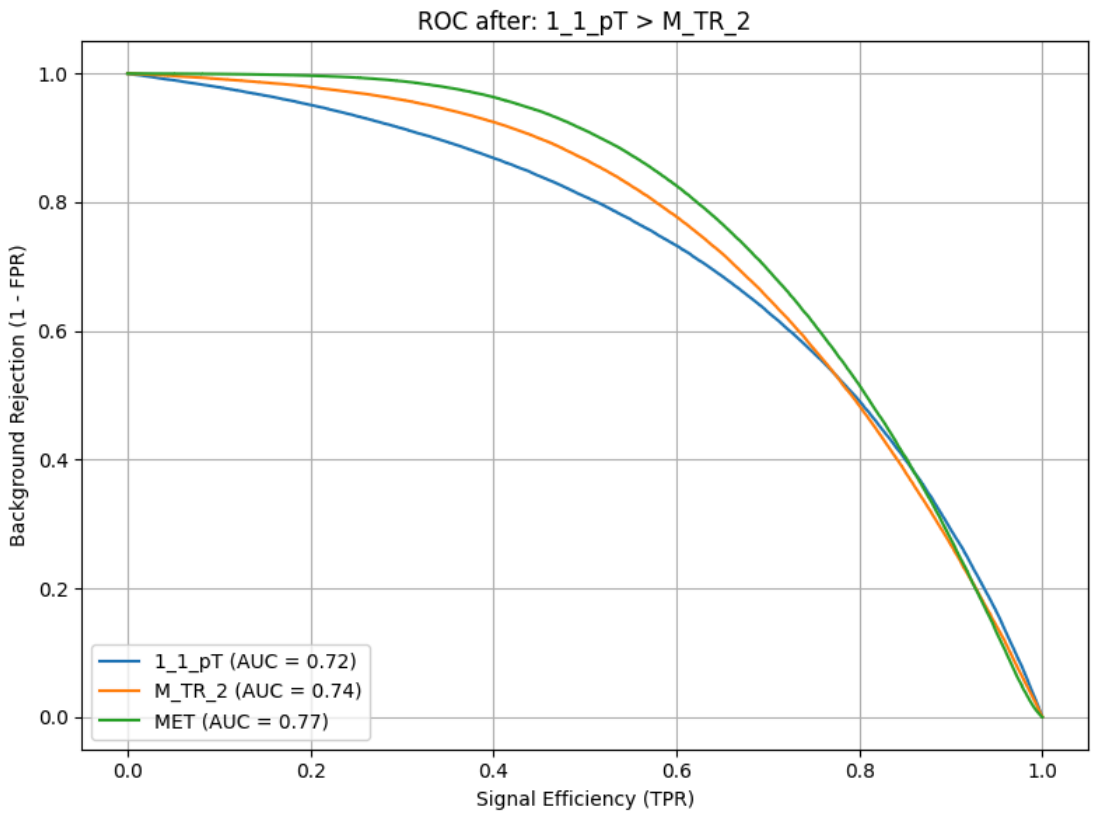

ROC after: 1_1_pT > MET
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
1_1_pT (AUC = 0.73)
MET (AUC = 0.77)
M_TR_2 (AUC = 0.73)
0.0
0.2
0.4
0.6
0.8
1.0

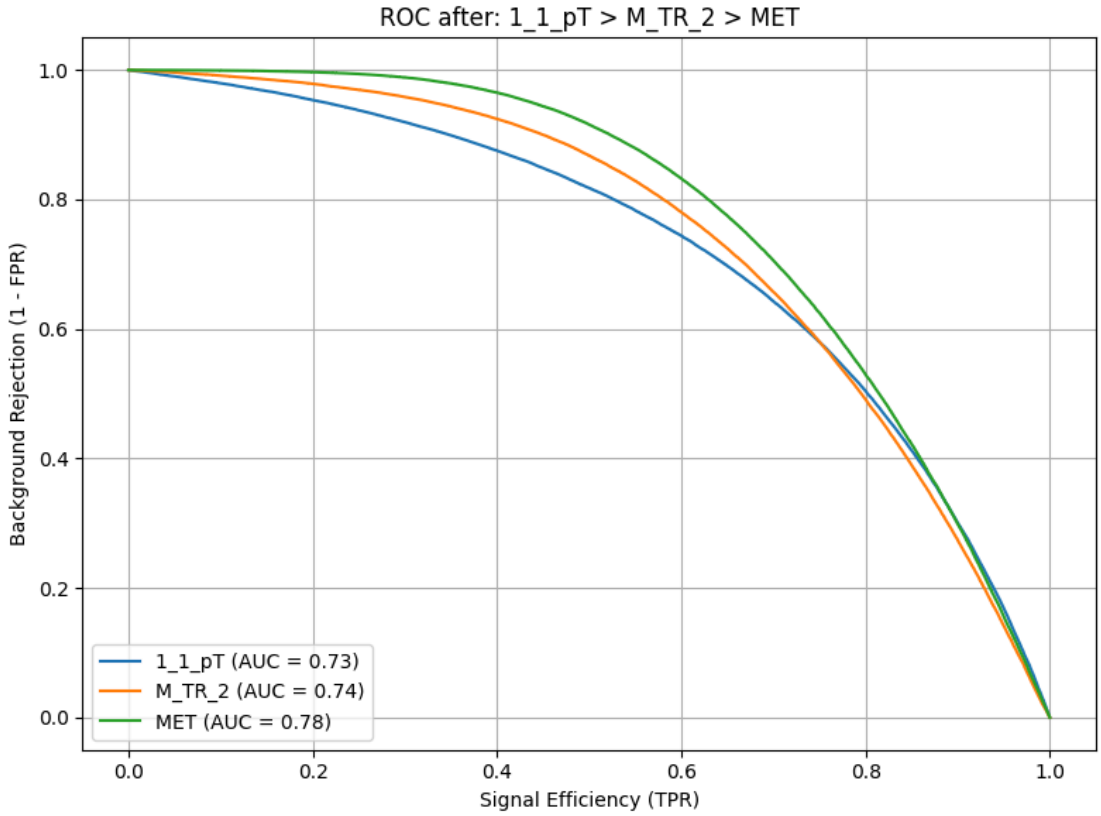

ROC after: 1_1_pT > MET > M_TR_2
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
1_1_pT (AUC = 0.73)
MET (AUC = 0.78)
M_TR_2 (AUC = 0.74)
0.0
0.2
0.4
0.6
0.8
1.0

Cut Order: ('1_1_pT', 'M_TR_2', 'MET')

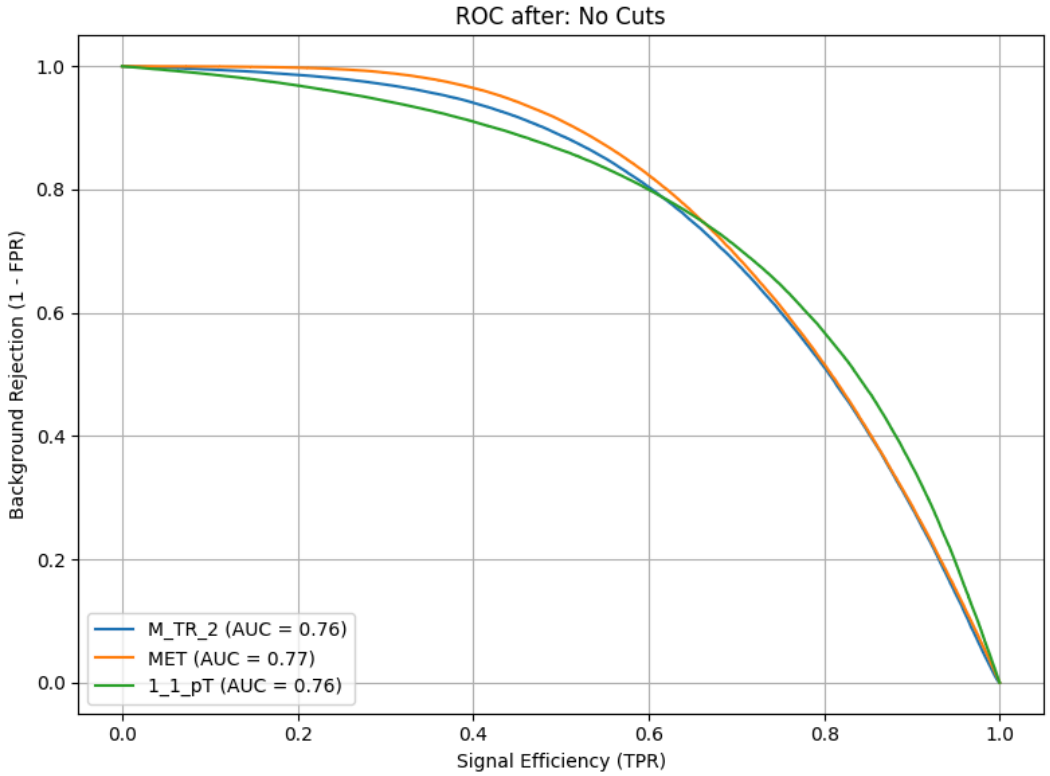


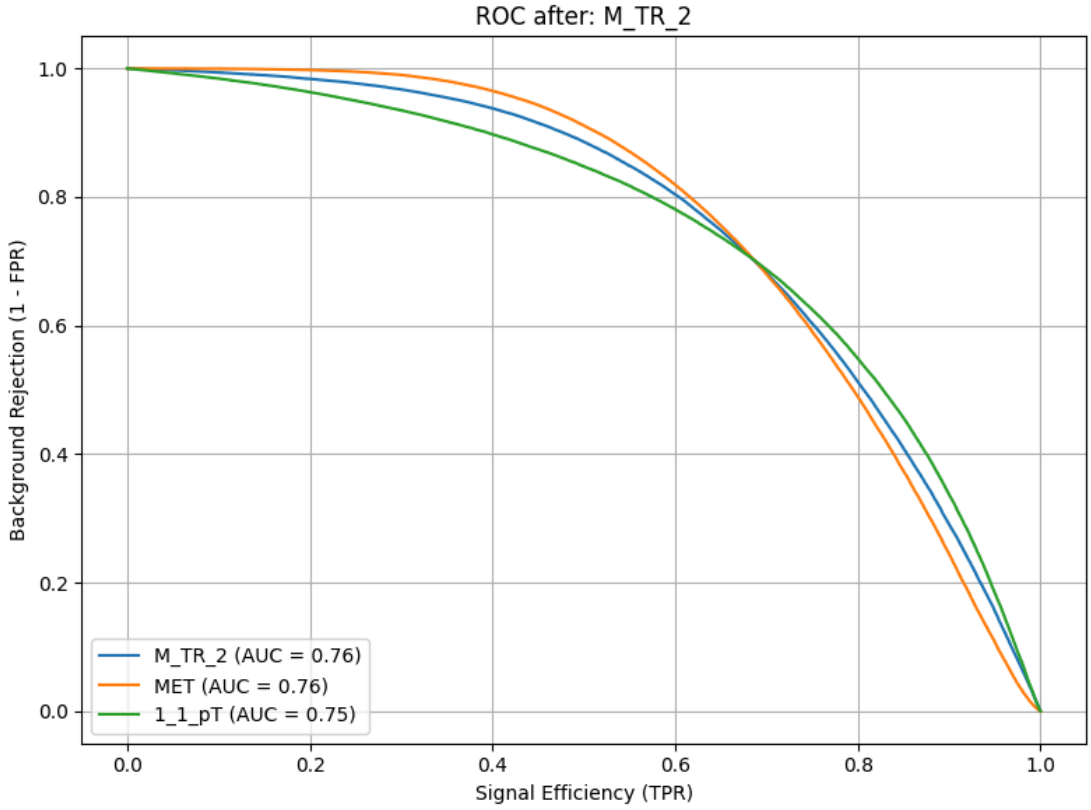


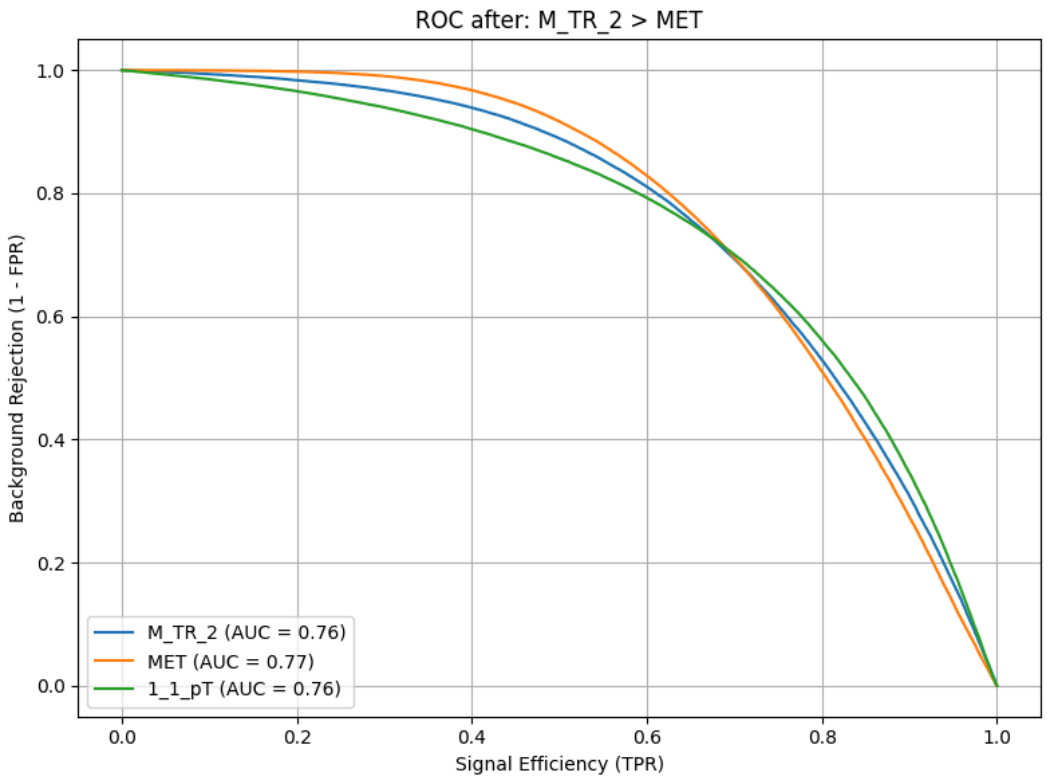

ROC after: 1_1_pT > M_TR_2
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
1_1_pT (AUC = 0.72)
M_TR_2 (AUC = 0.74)
MET (AUC = 0.77)
0.0
0.2
0.4
0.6
0.8
1.0

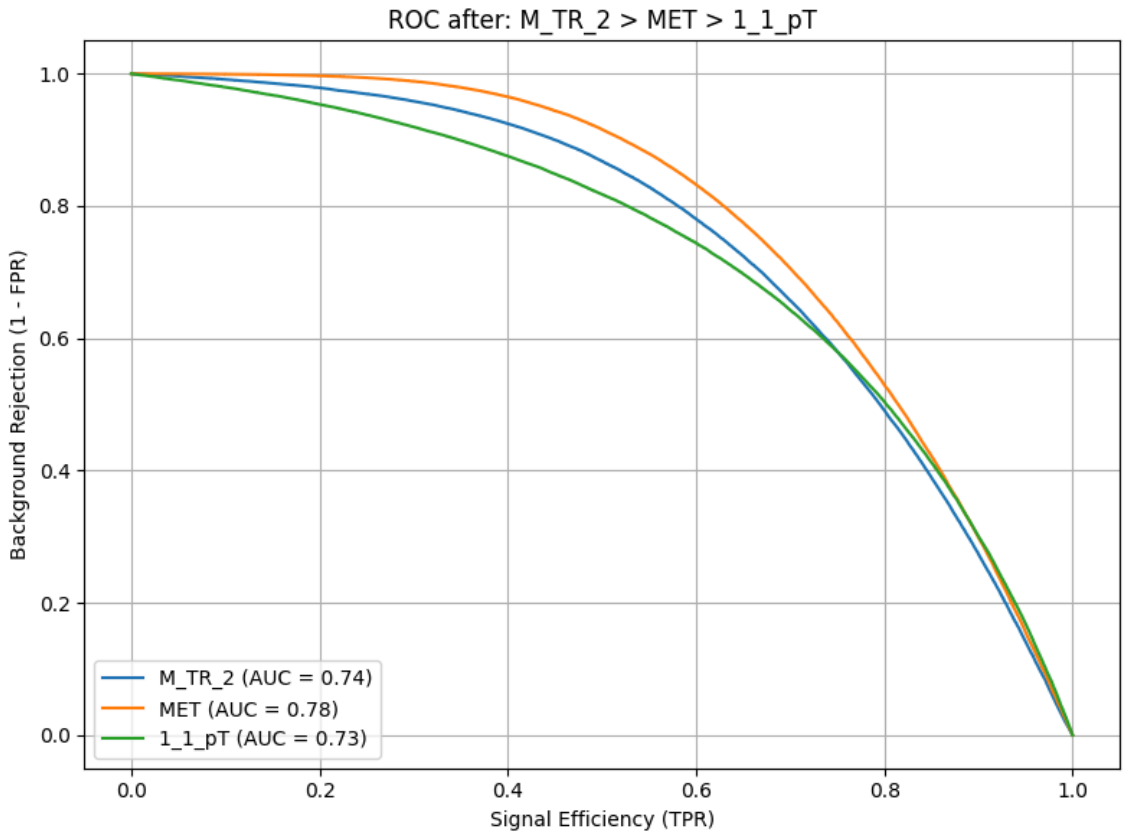

ROC after: 1_1_pT > M_TR_2 > MET
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
1_1_pT (AUC = 0.73)
M_TR_2 (AUC = 0.74)
MET (AUC = 0.78)
0.0
0.2
0.4
0.6
0.8
1.0

Cut Order: ('M_TR_2', 'MET', '1_1_pT')

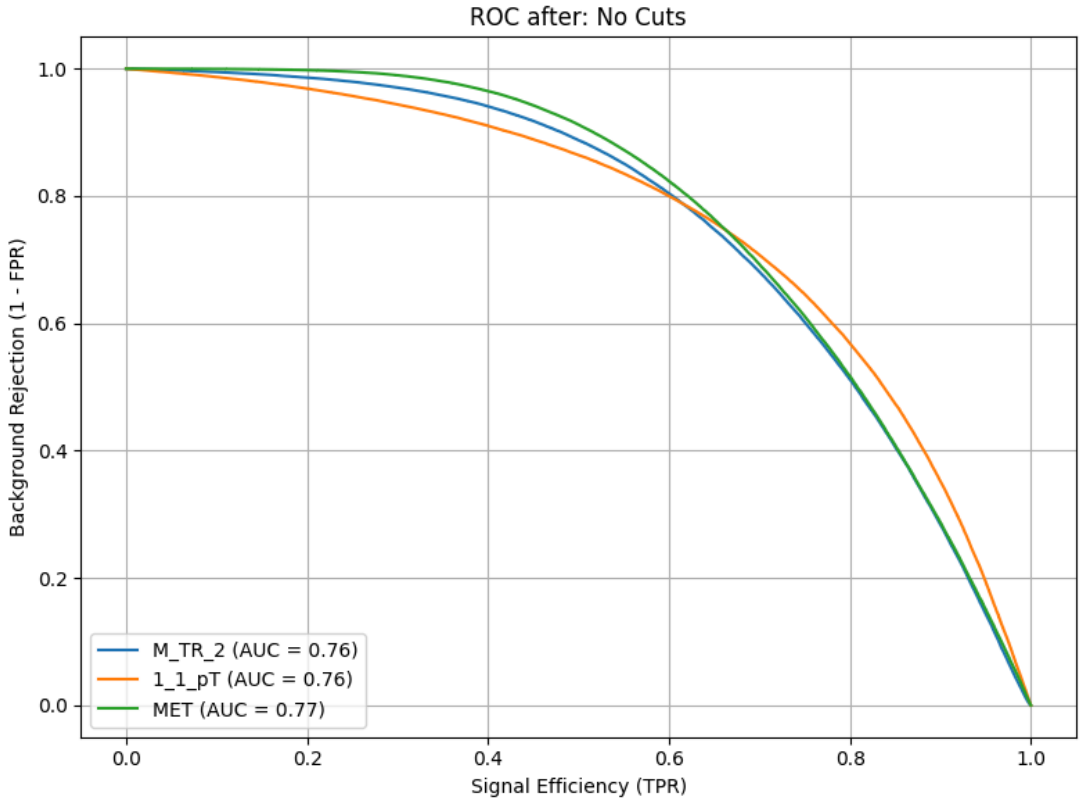


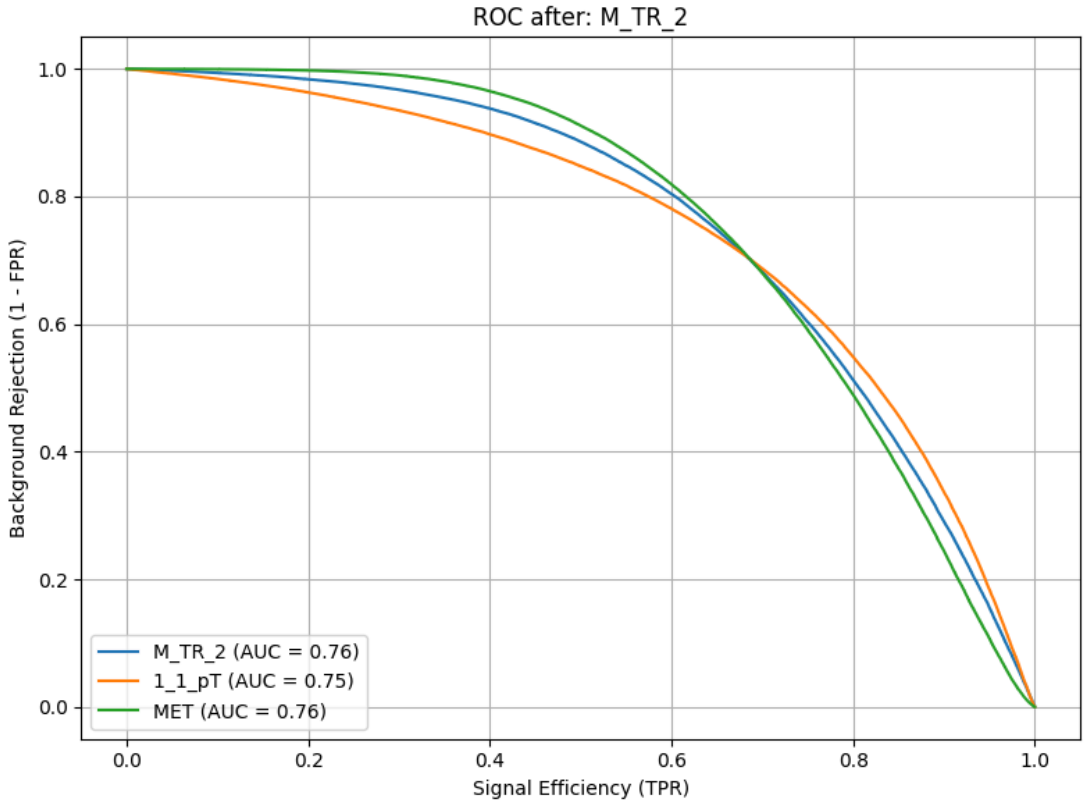


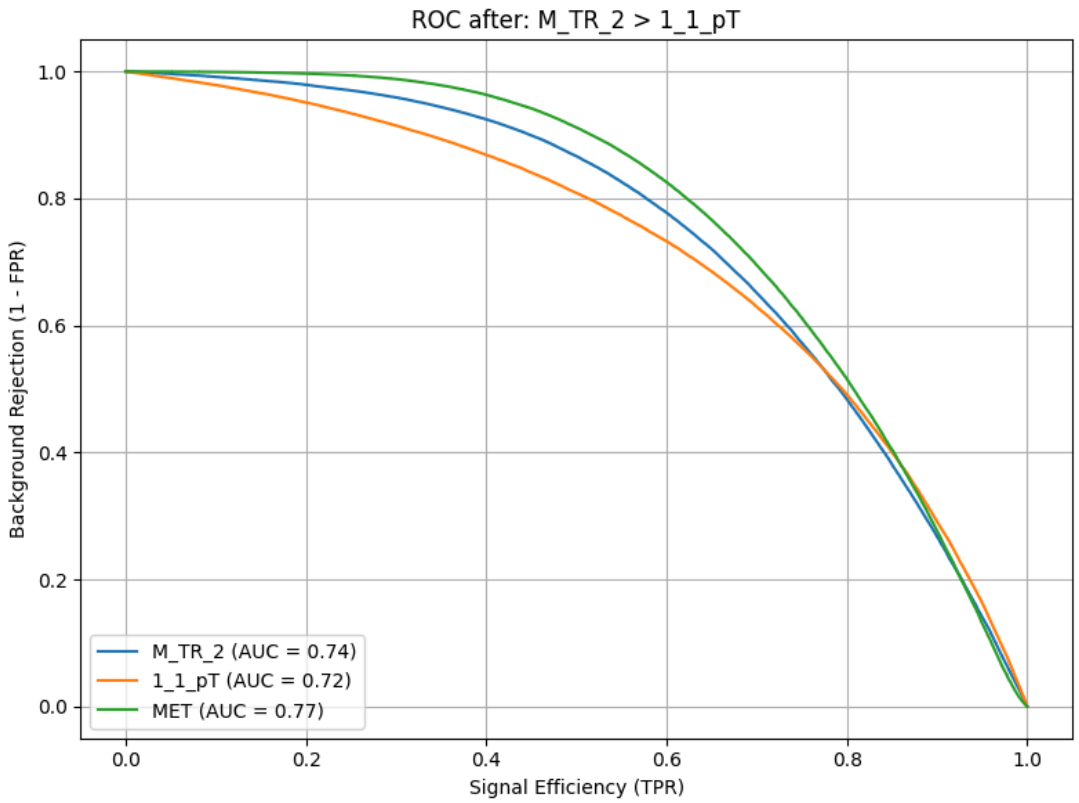

ROC after: M_TR_2 > MET
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
M_TR_2 (AUC = 0.76)
MET (AUC = 0.77)
1_1_pT (AUC = 0.76)
0.0
0.2
0.4
0.6
0.8
1.0

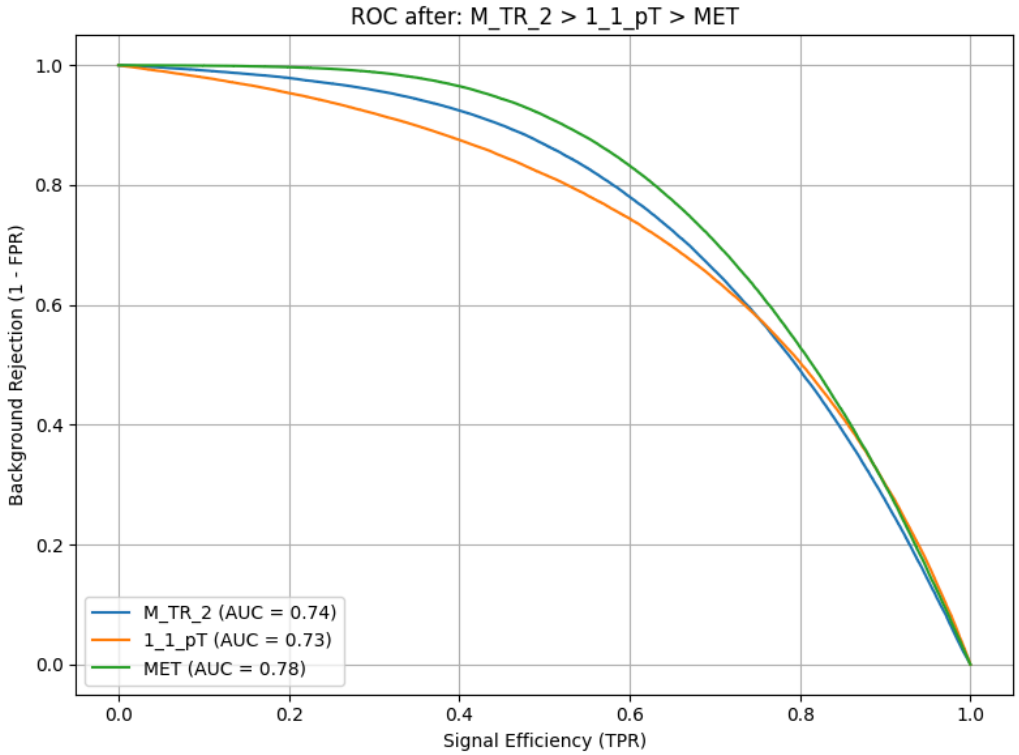

ROC after: M_TR_2 > MET > 1_1_pT
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
M_TR_2 (AUC = 0.74)
MET (AUC = 0.78)
1_1_pT (AUC = 0.73)
0.0
0.2
0.4
0.6
0.8
1.0

Cut Order: ('M_TR_2', '1_1_pT', 'MET')



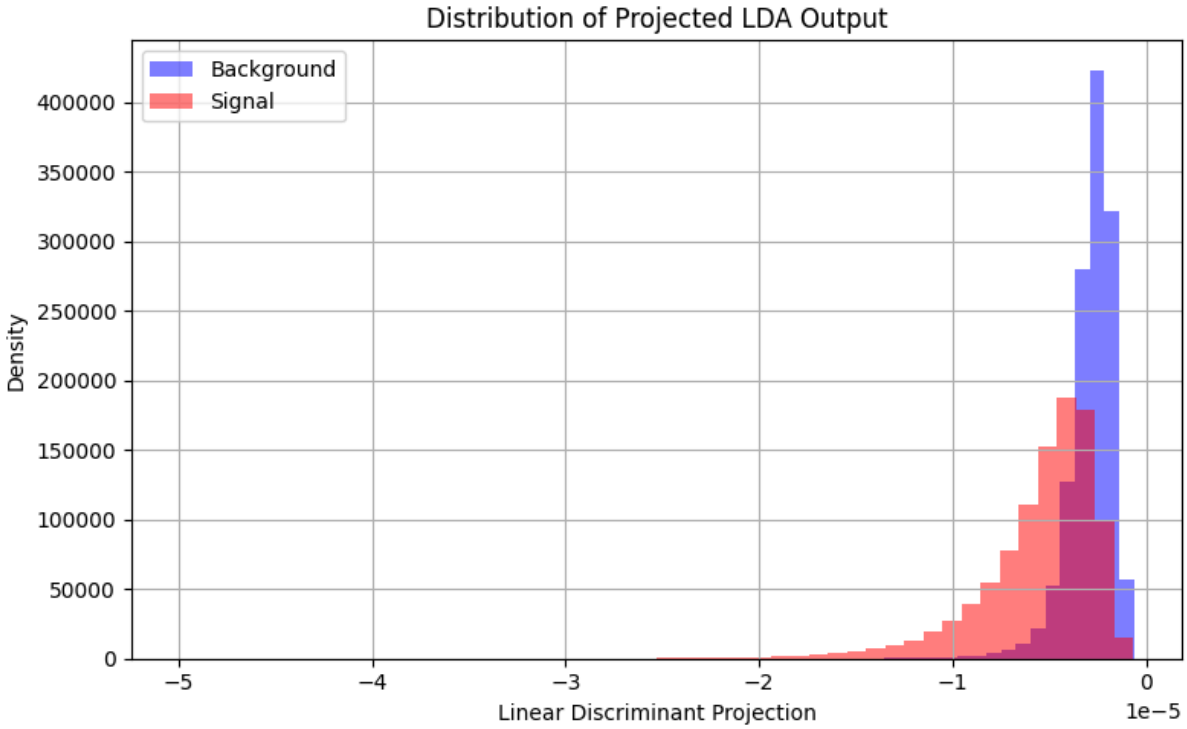



ROC after: M_TR_2 > 1_1_pT
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
M_TR_2 (AUC = 0.74)
1_1_pT (AUC = 0.72)
MET (AUC = 0.77)
0.0
0.2
0.4
0.6
0.8
1.0

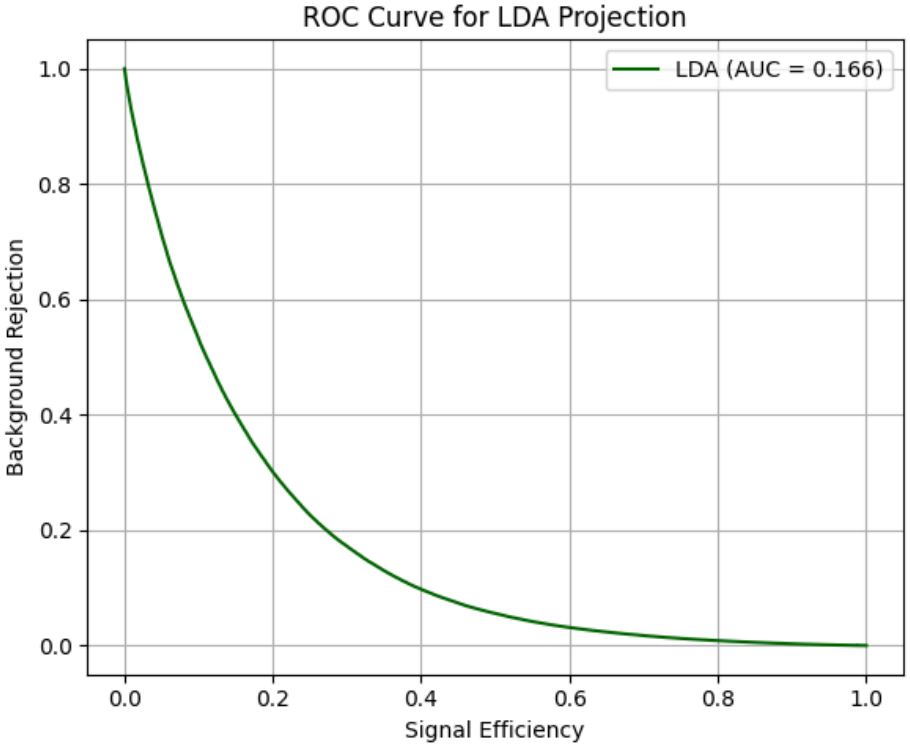

ROC after: M_TR_2 > 1_1_pT > MET
Background Rejection (1 - FPR)
Signal Efficiency (TPR)
M_TR_2 (AUC = 0.74)
1_1_pT (AUC = 0.73)
MET (AUC = 0.78)
0.0
0.2
0.4
0.6
0.8
1.0

Exercise 8.1-a (No needed)

Exercise 8.1-b



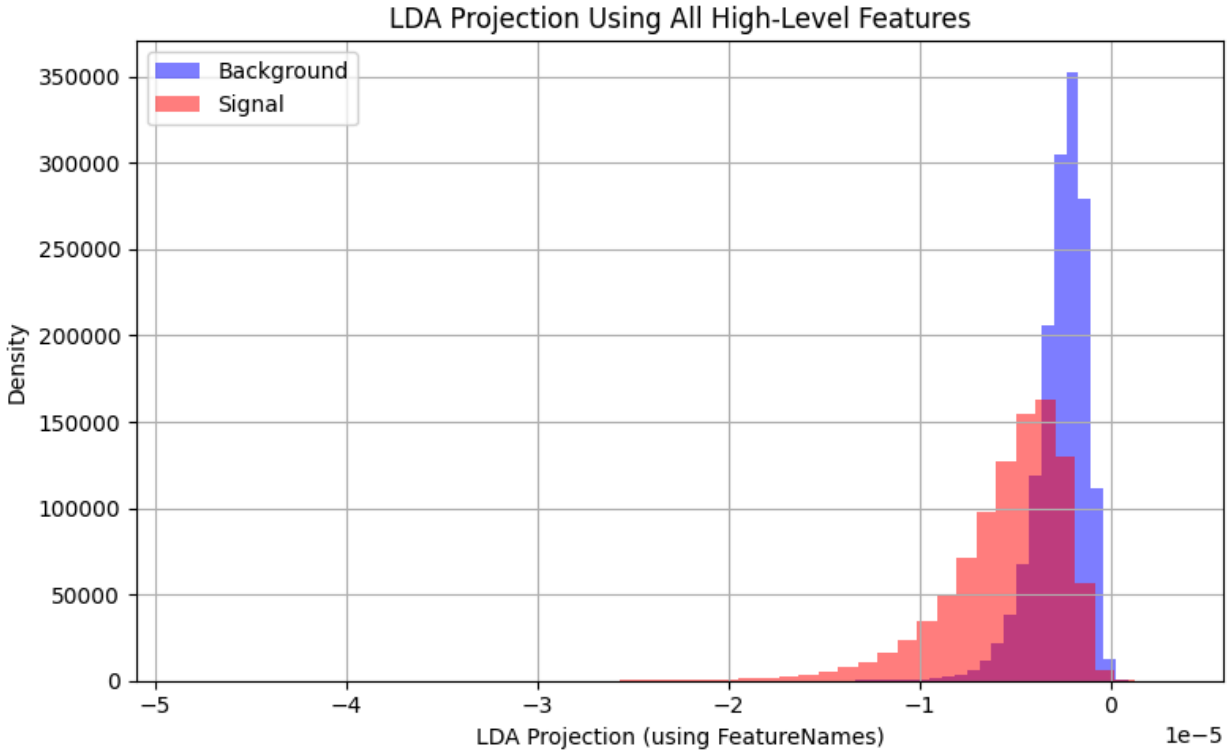
Exercise 8.1-c

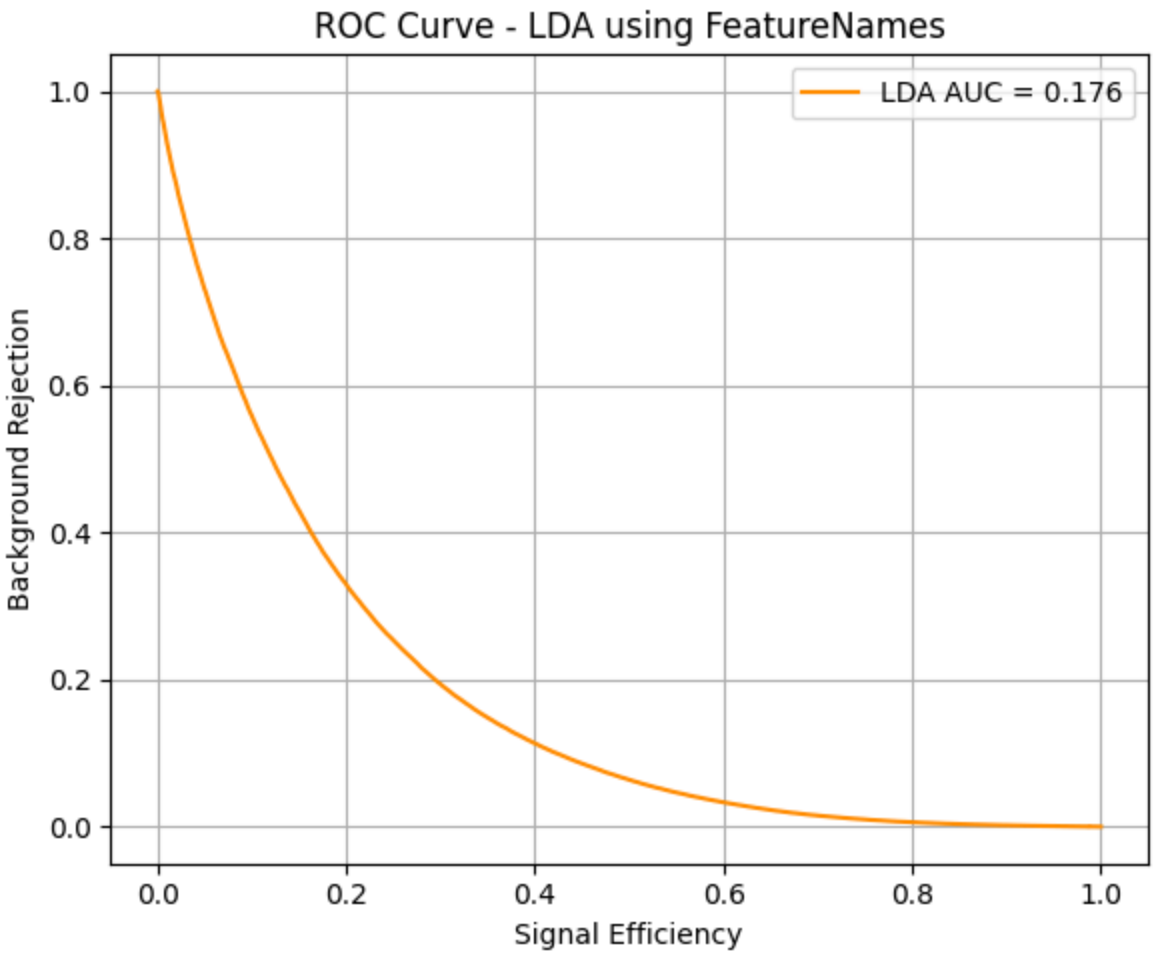


Exercise 8.1-d

```
Scenario N_S=10, N_B=100 → max σ_s' = nan
Scenario N_S=100, N_B=1000 → max σ_s' = nan
Scenario N_S=1000, N_B=10000 → max σ_s' = nan
Scenario N_S=10000, N_B=100000 → max σ_s' = nan
<ipython-input-75-984adde85638>:13: RuntimeWarning: invalid value encountered in divide
  sigma_s = N_s_prime / np.sqrt(N_s_prime + N_b_prime)
```

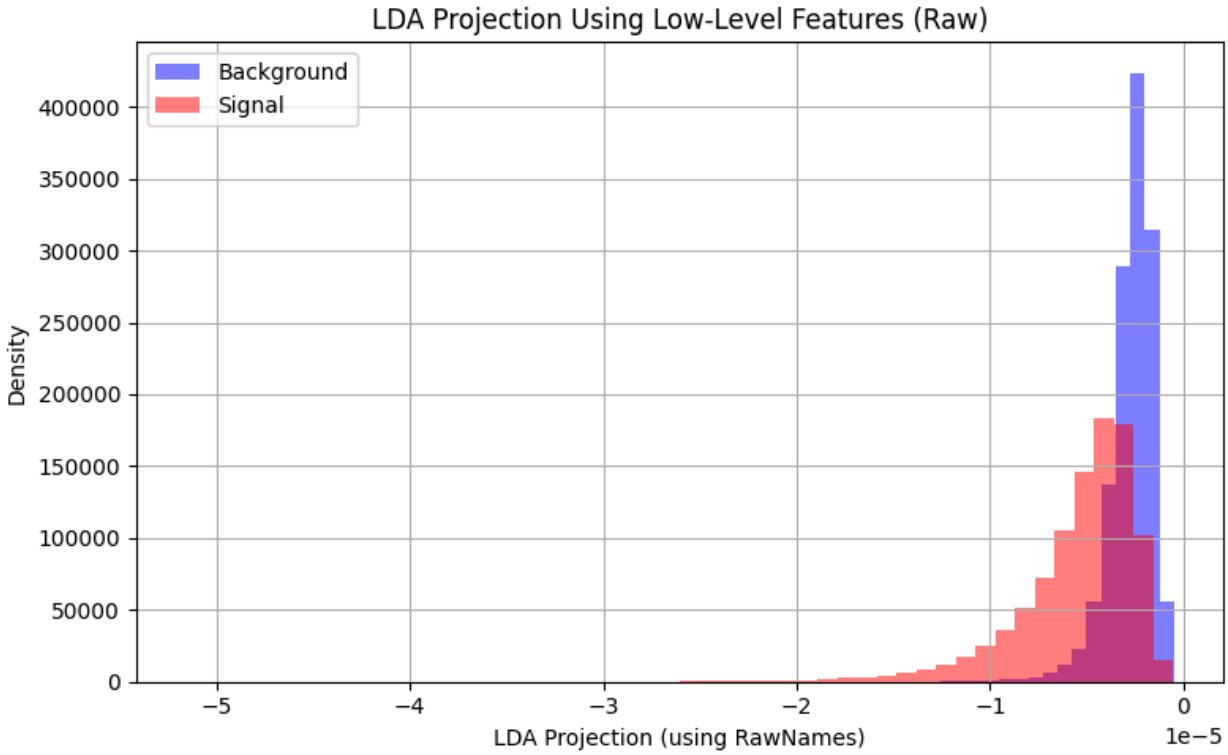
The Rest of FeatureNames

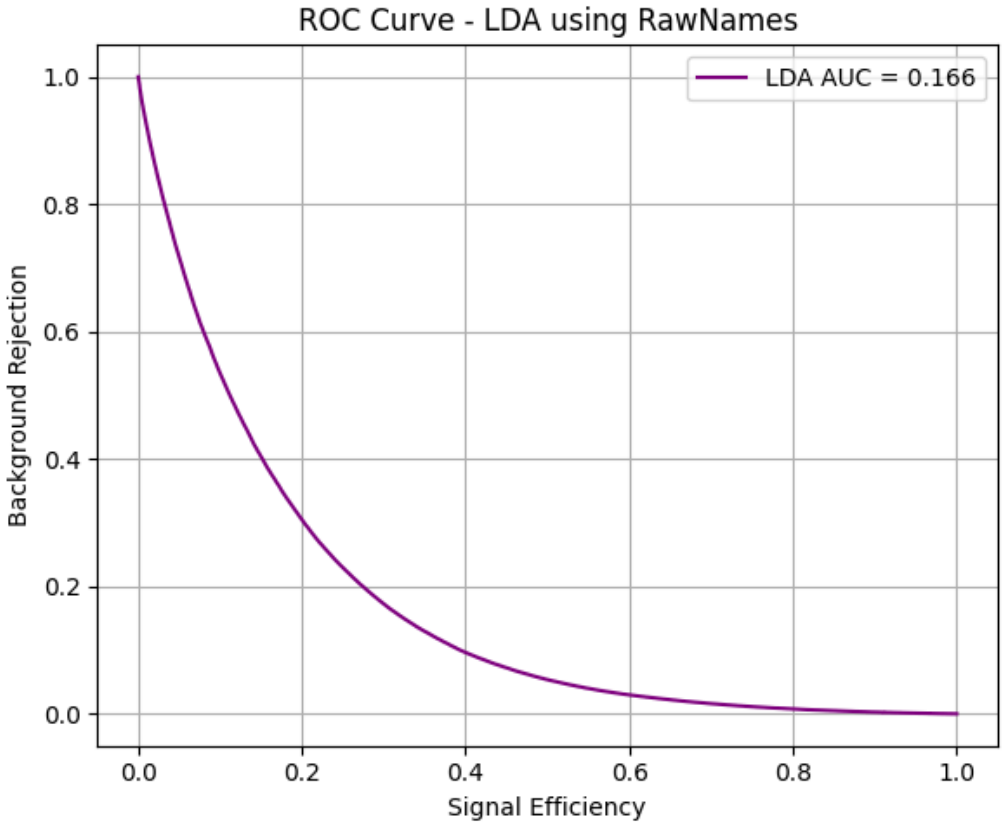





```
Scenario N_S=10, N_B=100 → max σ_s' = nan
Scenario N_S=100, N_B=1000 → max σ_s' = nan
Scenario N_S=1000, N_B=10000 → max σ_s' = nan
Scenario N_S=10000, N_B=100000 → max σ_s' = nan
<ipython-input-85-adcaeb850e3c>:63: RuntimeWarning: invalid value encountered in divide
  sigma_s = N_s_prime / np.sqrt(N_s_prime + N_b_prime)
```

The Rest of RawNames





```
Scenario N_S=10, N_B=100 → max σ_s' = nan
Scenario N_S=100, N_B=1000 → max σ_s' = nan
Scenario N_S=1000, N_B=10000 → max σ_s' = nan
Scenario N_S=10000, N_B=100000 → max σ_s' = nan
<ipython-input-86-ce6485e5efd3>:64: RuntimeWarning: invalid value encountered in divide
  sigma_s_raw = N_s_prime_raw / np.sqrt(N_s_prime_raw + N_b_prime_raw)
```