Updates on Higgs boson invisible decay studies

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Kinematic selection

Following discussions on Wednesday, kinematic selections are tightened to help the XGBoost model work better.
Details on selection criteria are not given here.

Kinematic selection: 2mu

Cutflow

---------2mu channel----------

process	total	base eff	kinsel eff	selected
Z(2mu)H(inv)	1.435e+02	96.109 %	99.194 %	137
Z(2e)H(inv)	1.492e+02	0.000 %	0.000 %	0
Z(2q)H(inv)	2.900e+03	0.002 %	0.000 %	0
2mu+2v	5.678e+06	32.010 %	25.335 %	460478
2mu+2tau	3.730e+05	21.103 %	1.100 %	866
2mu+2q	4.471e+06	24.432 %	0.000 %	0
mu+tau+2v	8.073e+06	10.679 %	23.368 %	201471
2f	1.779e+09	2.348 %	4.530 %	1892732
hx	4.073e+06	2.547 %	0.569 %	590
others	3.658e+08	0.358 %	1.208 %	15804

---------2mu channel----------

process	total	base eff	kinsel eff	selected
Z(2mu)H(inv)	1.435e+02	96.109 %	97.971 %	135
Z(2e)H(inv)	1.492e+02	0.000 %	0.000 %	0
Z(2q)H(inv)	2.900e+03	0.002 %	0.000 %	0
2mu+2v	5.678e+06	32.010 %	19.776 %	359429
2mu+2tau	3.730e+05	21.103 %	0.819 %	645
2mu+2q	4.471e+06	24.432 %	0.000 %	0
mu+tau+2v	8.073e+06	10.679 %	19.065 %	164377
2f	1.779e+09	2.348 %	3.397 %	1419410
hx	4.073e+06	2.547 %	0.438 %	455
others	3.658e+08	0.358 %	0.957 %	12529

Kinematic selection: 2e

Cutflow

---------2e channel----------

process	total	base eff	kinsel eff	selected
Z(2mu)H(inv)	1.435e+02	0.000 %	0.000 %	0
Z(2e)H(inv)	1.492e+02	83.747 %	97.591 %	122
Z(2q)H(inv)	2.900e+03	0.000 %	0.000 %	0
2e+2v	5.568e+06	41.675 %	33.039 %	766710
2e+2tau	2.946e+06	15.539 %	7.520 %	34421
2e+2q	6.321e+06	29.459 %	0.013 %	239
e+tau+2v	8.719e+06	9.921 %	29.786 %	257635
2f	1.779e+09	1.031 %	5.742 %	1053087
hx	4.073e+06	1.960 %	2.479 %	1980
others	3.609e+08	0.795 %	7.024 %	201625

---------2e channel----------

process	total	base eff	kinsel eff	selected
Z(2mu)H(inv)	1.435e+02	0.000 %	0.000 %	0
Z(2e)H(inv)	1.492e+02	83.747 %	95.344 %	119
Z(2q)H(inv)	2.900e+03	0.000 %	0.000 %	0
2e+2v	5.568e+06	41.675 %	23.040 %	534665
2e+2tau	2.946e+06	15.539 %	4.911 %	22478
2e+2q	6.321e+06	29.459 %	0.008 %	156
e+tau+2v	8.719e+06	9.921 %	24.277 %	209985
2f	1.779e+09	1.031 %	3.345 %	613437
hx	4.073e+06	1.960 %	2.187 %	1746
others	3.609e+08	0.795 %	4.068 %	116773

Kinematic selection: 2q

Cutflow

---------2q channel----------

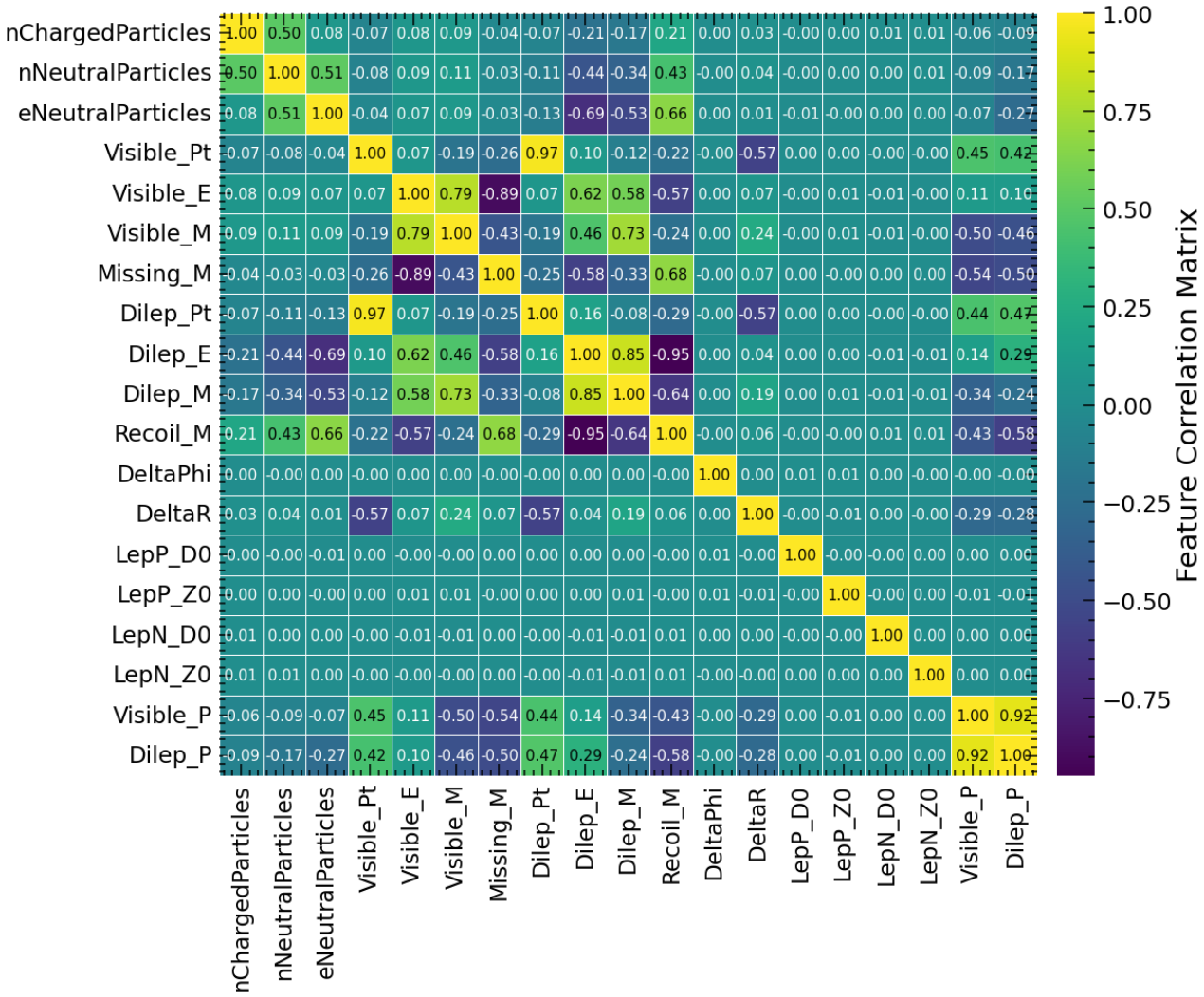
process	total	base eff	kinsel eff	selected
Z(2mu)H(inv)	1.435e+02	0.984 %	77.541 %	1
Z(2e)H(inv)	1.492e+02	10.146 %	69.929 %	11
Z(2q)H(inv)	2.900e+03	98.967 %	99.366 %	2852
2q+2v	7.394e+06	66.069 %	95.304 %	4655834
2tau+2v	4.707e+06	60.975 %	83.916 %	2408589
2q+tau+v	5.654e+07	25.990 %	55.474 %	8152441
2f	1.779e+09	9.236 %	84.399 %	138692035
hx	4.073e+06	19.758 %	55.287 %	444932
others	3.158e+08	4.403 %	61.924 %	8609893

---------2q channel----------

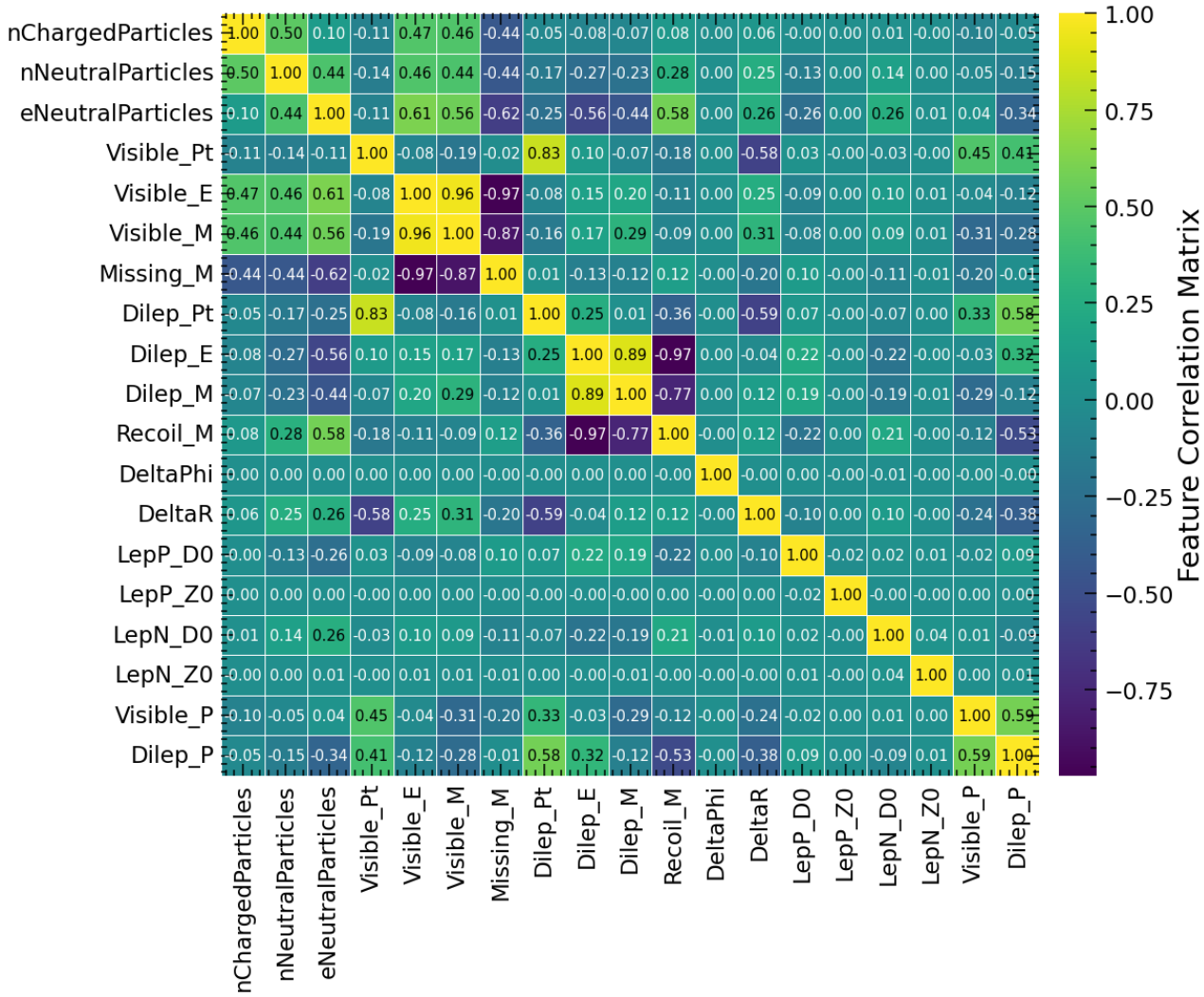
process	total	base eff	kinsel eff	selected
Z(2mu)H(inv)	1.435e+02	0.984 %	0.000 %	0
Z(2e)H(inv)	1.492e+02	10.146 %	0.019 %	0
Z(2q)H(inv)	2.900e+03	98.967 %	95.408 %	2739
2q+2v	7.394e+06	66.069 %	38.052 %	1858960
2tau+2v	4.707e+06	60.975 %	2.522 %	72396
2q+tau+v	5.654e+07	25.990 %	17.341 %	2548376
2f	1.779e+09	9.236 %	37.289 %	61276060
hx	4.073e+06	19.758 %	37.819 %	304355
others	3.158e+08	4.403 %	10.288 %	1430407

XGBoost models: correlations

2mu

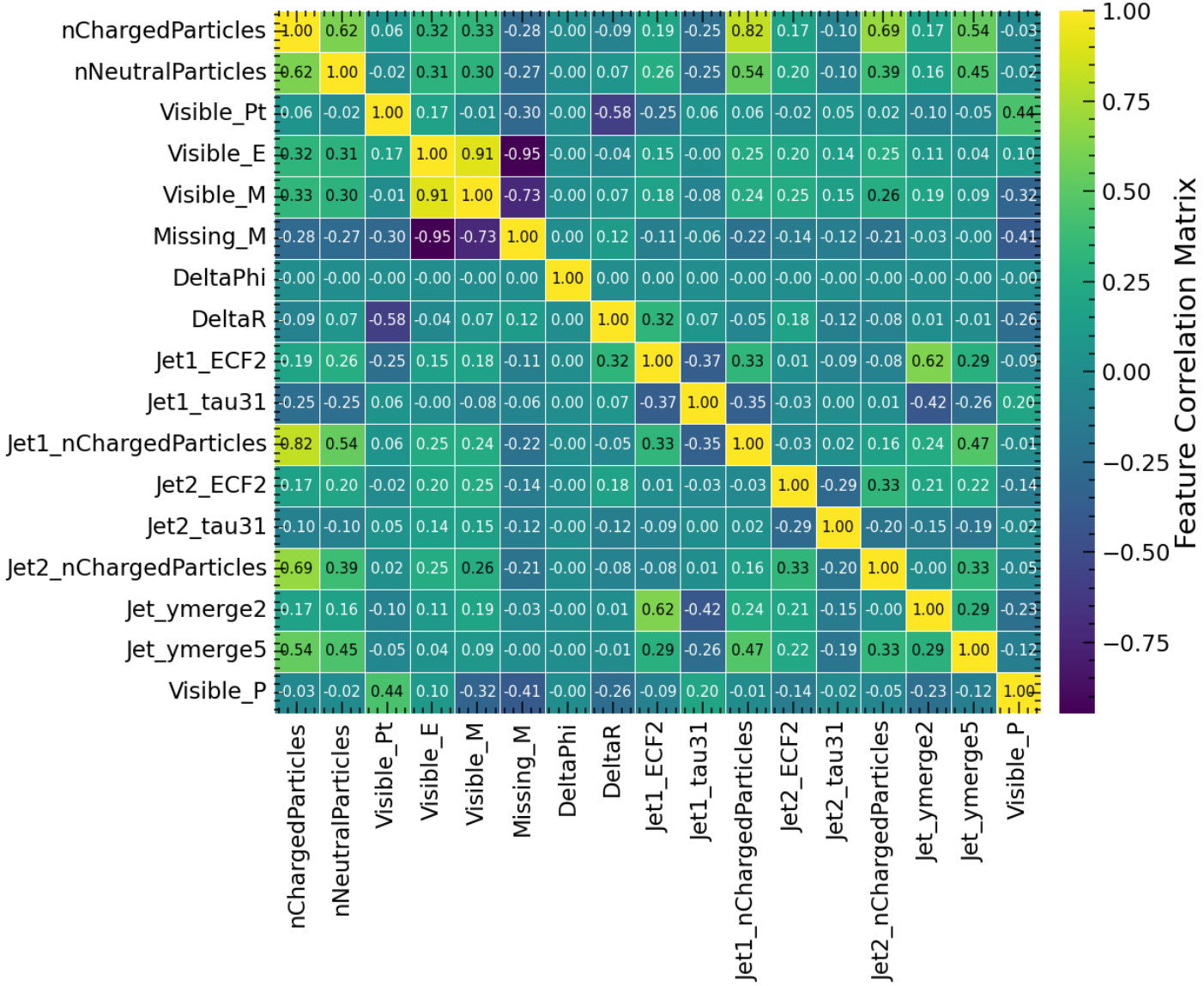


2e

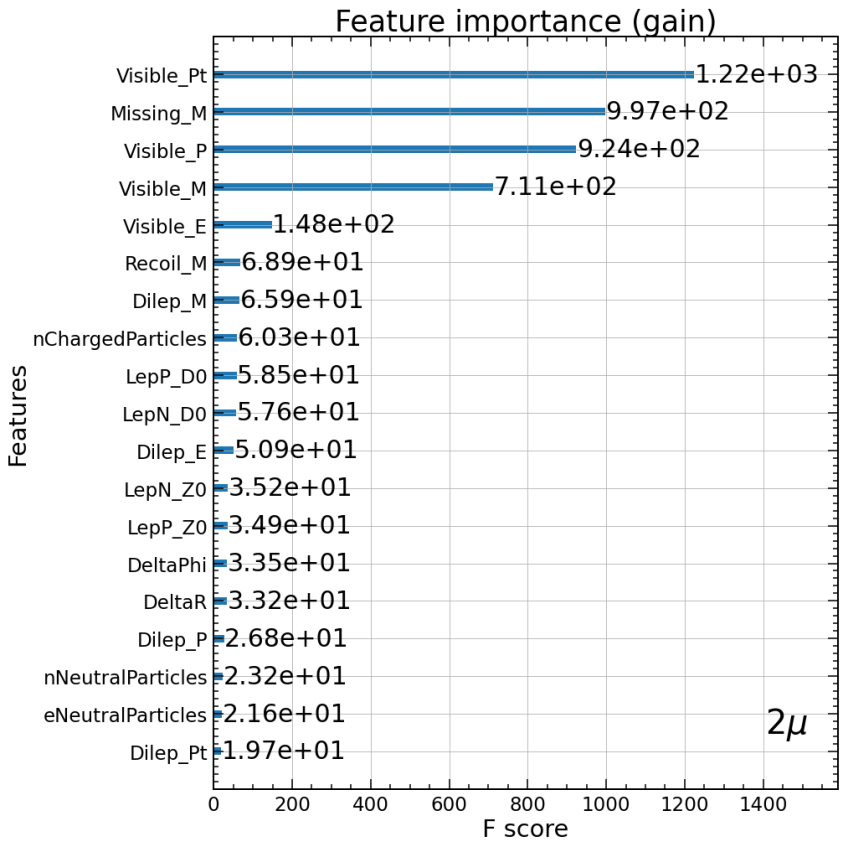


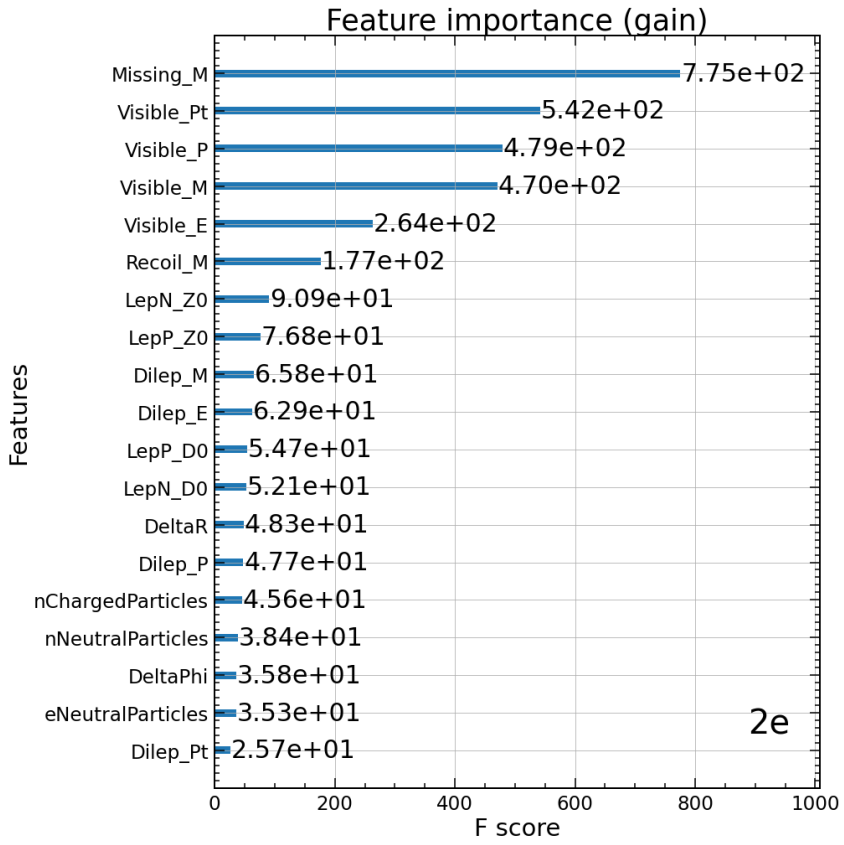
XGBoost models: correlations

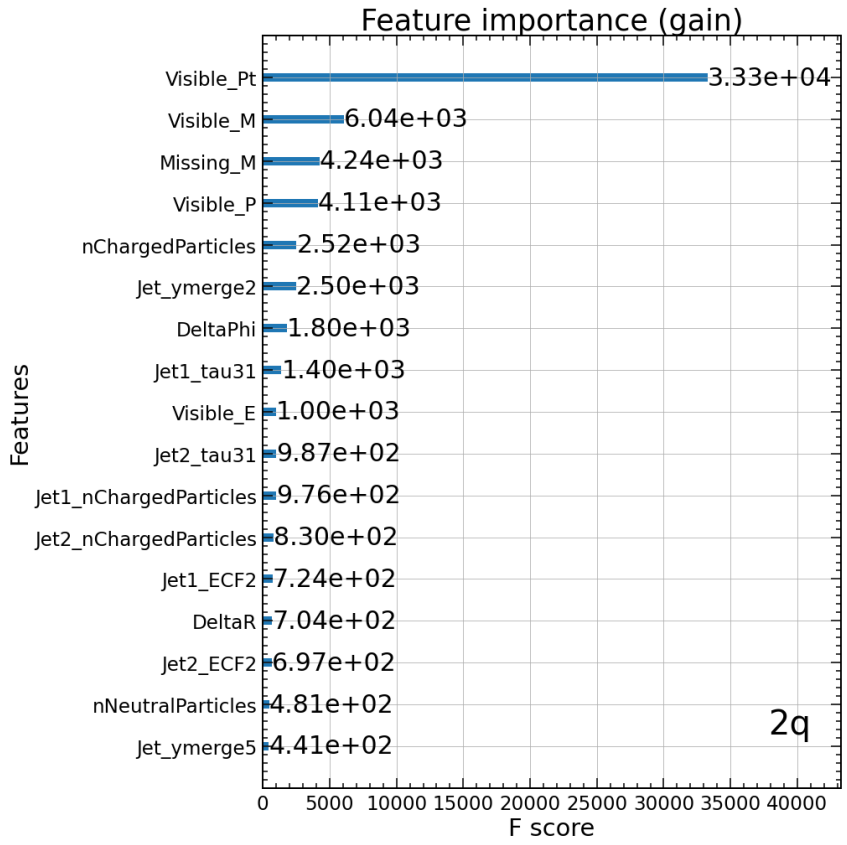
2q



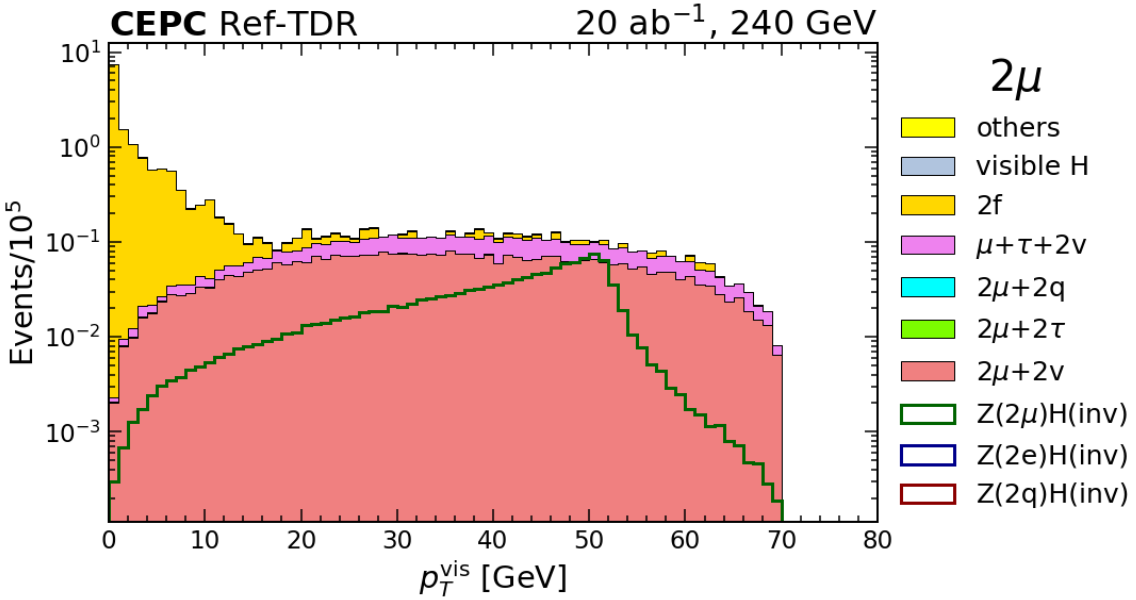
XGBoost models: importance

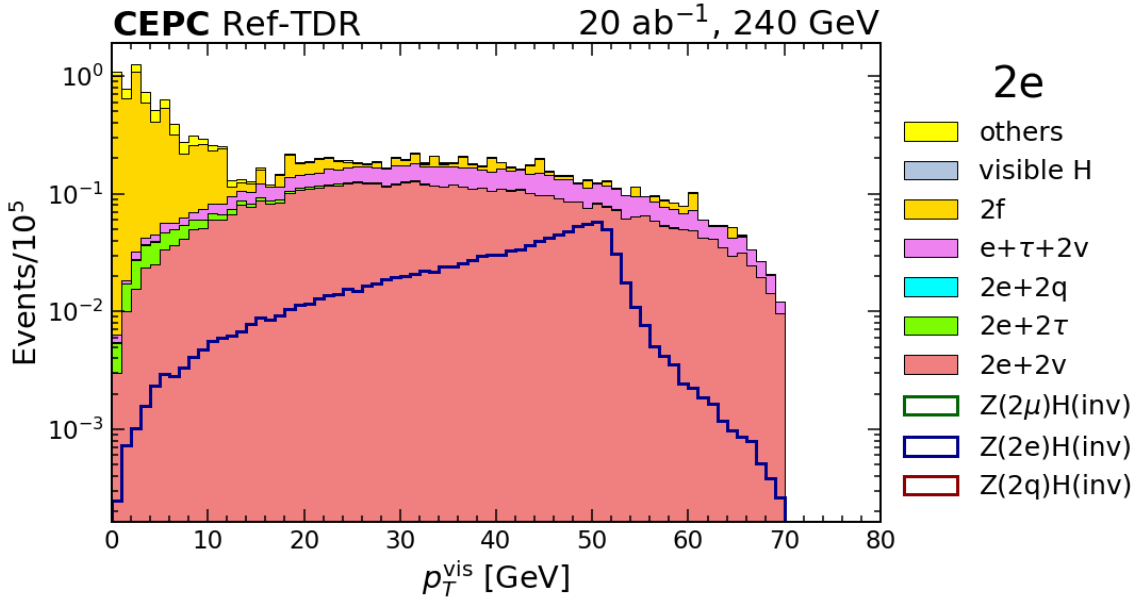


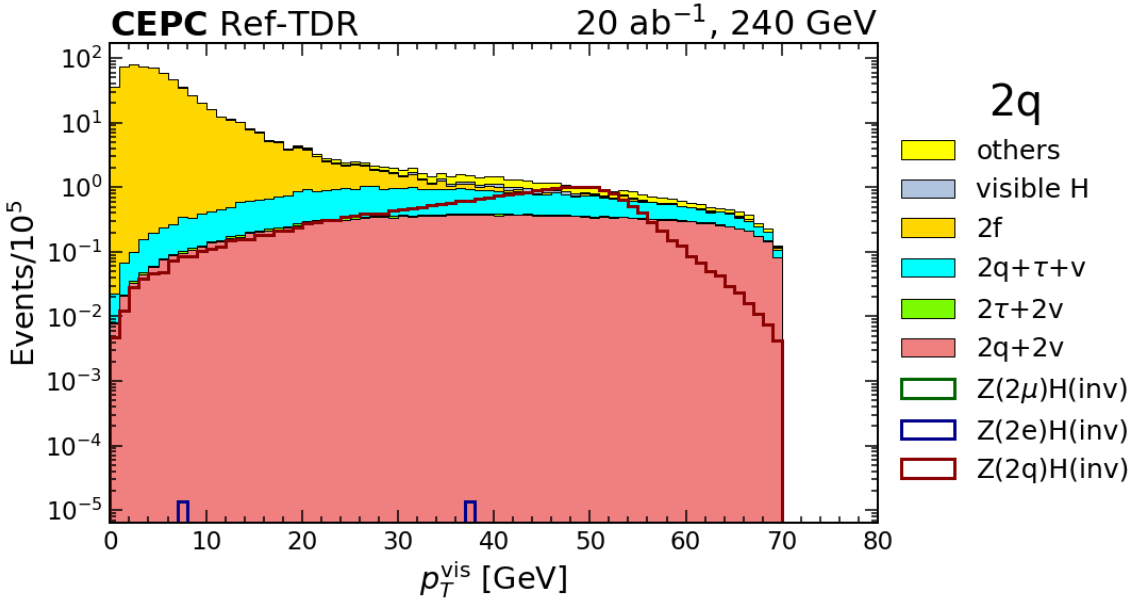




XGBoost models: visible pt

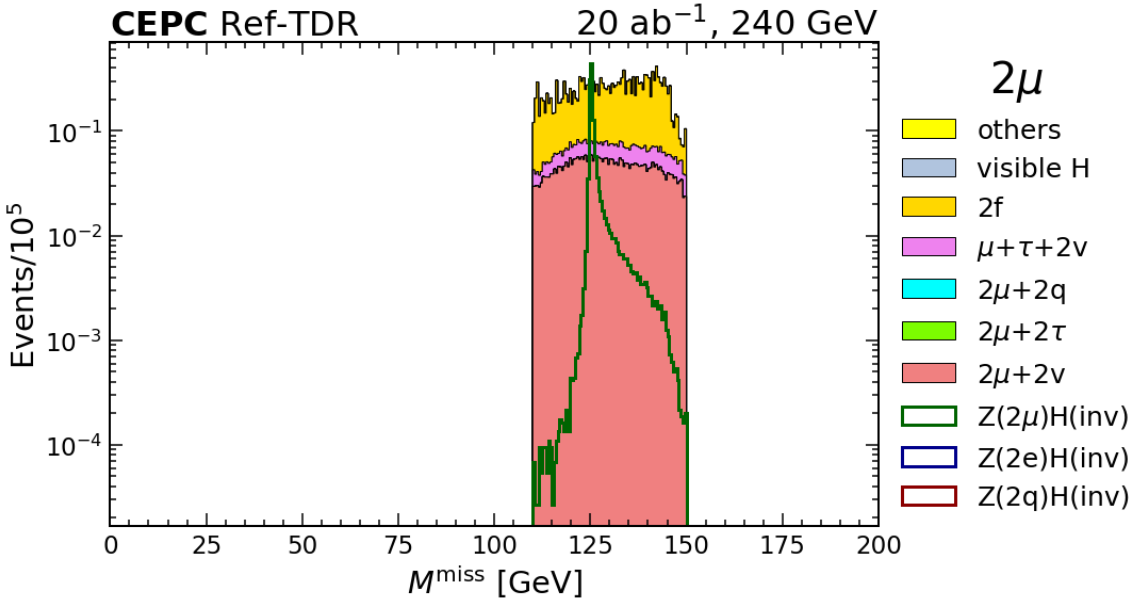


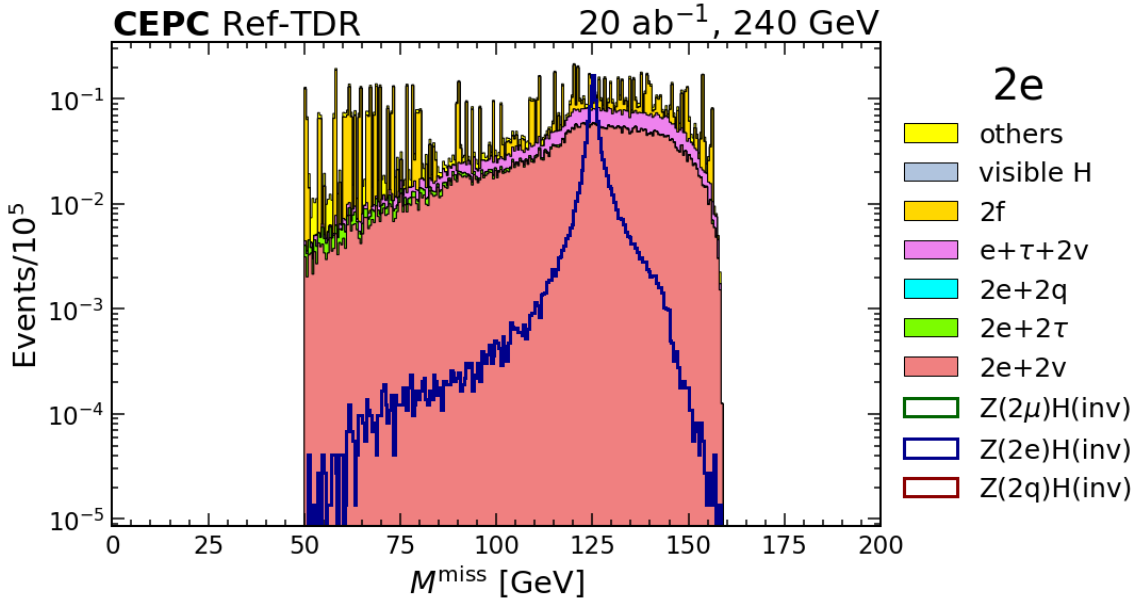


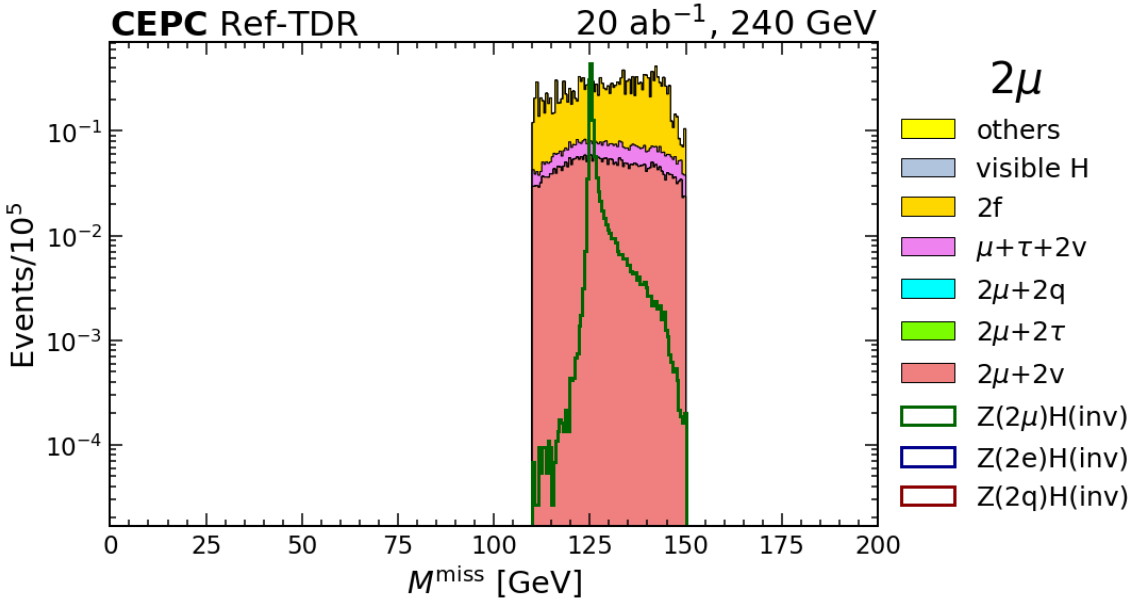


High importance mostly due to rejection of 2f backgrounds.

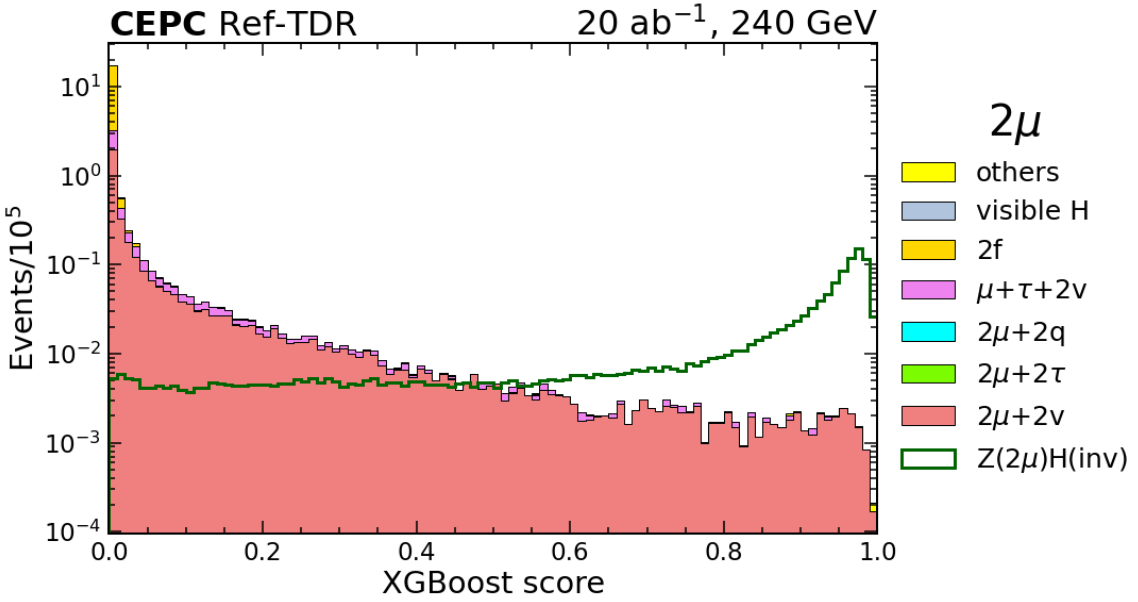
XGBoost models: missing mass

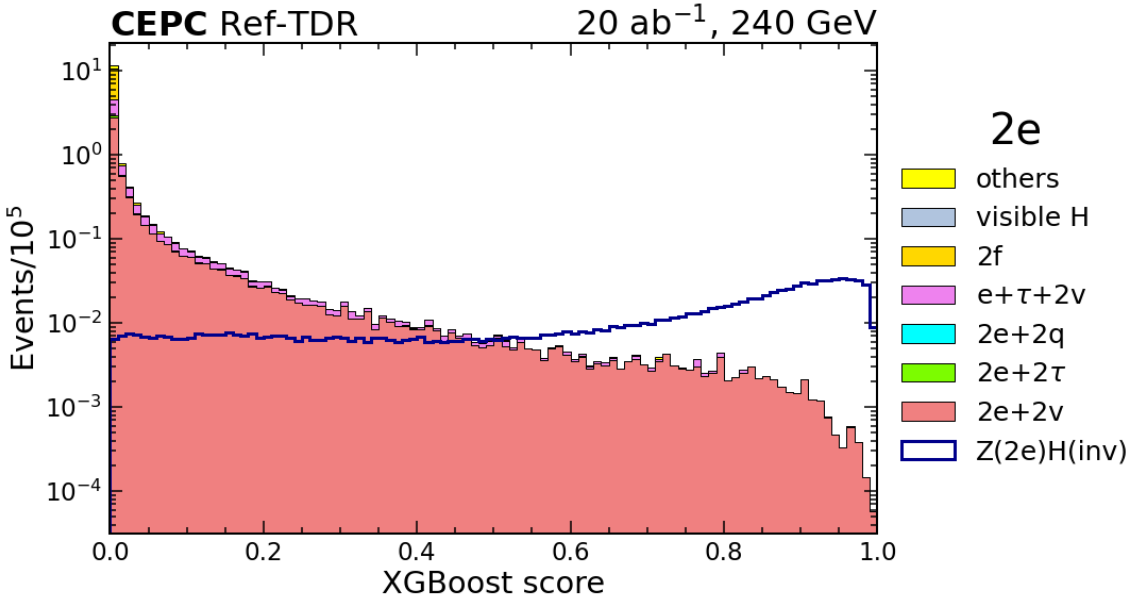


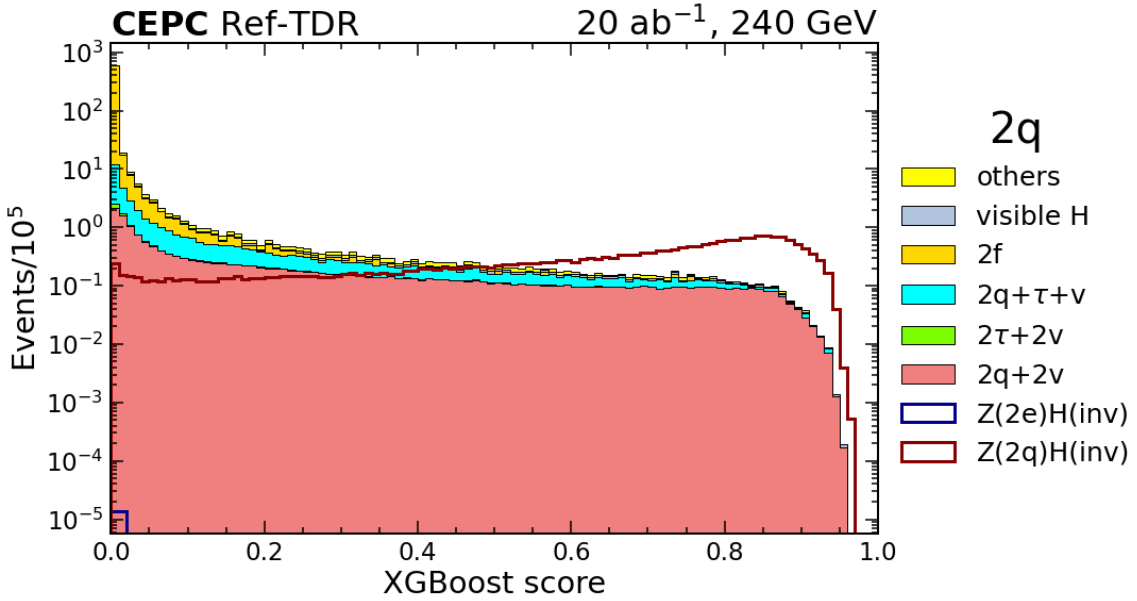




XGBoost score







Shape is similar to the results shown last Wednesday, but the amplitude should be lower since we rejected more backgrounds in the kinematic selection.

New results

For results on Wednesday

- Performance is underestimated: I smoothened the histogram, which seems to flatten the distribution, making the background higher in the high XGBoost score region.
- This affects all channels.
- No longer smoothen the histogram: there may be some fluctuations, but they should not affect the result very much.

New results

Much better sensitivities in all channels!!!

	5.6 ab^{-1}				20 ab^{-1}		
channel	unc	CEPC-v4	significance	UL (%)	unc	significance	UL (%)
2μ	$^{+84.3\%}_{-80.4\%}$	222%	1.25 σ	0.179%	$^{+44.1\%}_{-43.1\%}$	2.36 σ	0.093%
$2e$	$^{+124.4\%}_{-100.0\%}$	428%	0.86 σ	0.266%	$^{+64.9\%}_{-62.6\%}$	1.62 σ	0.137%
$2q$	$^{+57.8\%}_{-57.6\%}$	90%	1.74 σ	0.121%	$^{+30.6\%}_{-30.5\%}$	3.28 σ	0.064%
combine	$^{+44.3\%}_{-43.7\%}$	82%	2.31 σ	0.092%	$^{+23.4\%}_{-23.2\%}$	4.36 σ	0.049%

Can we make a discovery?