

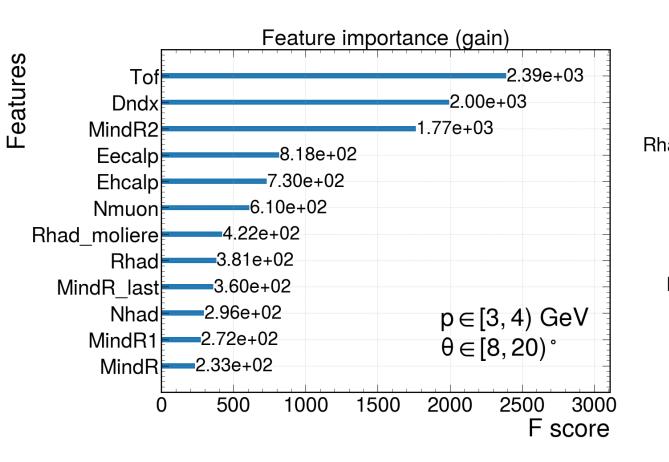


中國科學院為能物招酬完備 Institute of High Energy Physics Chinese Academy of Sciences

Updates on PID

Geliang Liu Apr. 16th, 2025

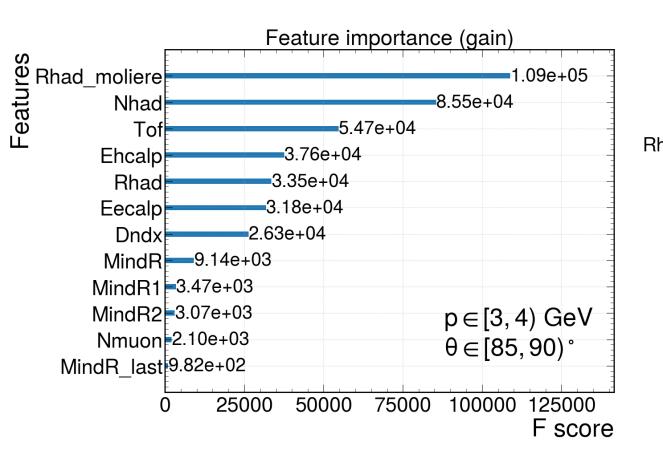
p = 3-4 GeV, θ = 8-20 °



$p \in [3, 4)$ GeV, $\theta \in [8, 20)^{\circ}$

$p \in [3, 4)$ GeV, $\theta \in [8, 20)^{\circ}$														1.0
Tof	1.00	0.15	0.06	0.08	-0.00	0.06	0.04	0.02	0.03	0.02	-0.03	0.05		1.0 xi
Dndx	0.15	1.00	0.03	0.12	0.03	0.09	0.06	0.03	0.07	0.09	-0.04	0.08	-	Feature Correlation Matrix
Eecalp	0.06	0.03	1.00	0.07	-0.17	0.07	0.07	0.07	0.05	-0.11	-0.04	-0.51		tion
Rhad	0.08	0.12	0.07	1.00	0.23	-0.04	-0.04	-0.04	-0.02	0.25	0.03	0.31	-	elat 9.0
nad_moliere	-0.00	0.03	-0.17	0.23	1.00	-0.04	-0.03	-0.02	-0.02	0.74	0.02	0.05	-	
MindR	0.06	0.09	0.07	-0.04	-0.04	1.00	0.63	0.45	0.52	-0.01	-0.37	-0.05		e e
MindR1	0.04	0.06	0.07	-0.04	-0.03	0.63	1.00	0.72	0.51	-0.00	-0.48	-0.05	_	atul atul
MindR2	0.02	0.03	0.07	-0.04	-0.02	0.45	0.72	1.00	0.54	0.01	-0.50	-0.04		
MindR_last	0.03	0.07	0.05	-0.02	-0.02	0.52	0.51	0.54	1.00	0.01	-0.30	-0.01		0.0
Nhad	0.02	0.09	-0.11	0.25	0.74	-0.01	-0.00	0.01	0.01	1.00	0.02	0.18	-	-0.2
Nmuon	-0.03	-0.04	-0.04	0.03	0.02	-0.37	-0.48	-0.50	-0.30	0.02	1.00	0.03		
Ehcalp	0.05	0.08	-0.51	0.31	0.05	-0.05	-0.05	-0.04	-0.01	0.18	0.03	1.00	-	-0.4
	Tof	Dndx	Eecalp	Rhad	Rhad_moliere	MindR	MindR1	MindR2	MindR_last	Nhad	Nmuon	Ehcalp		•

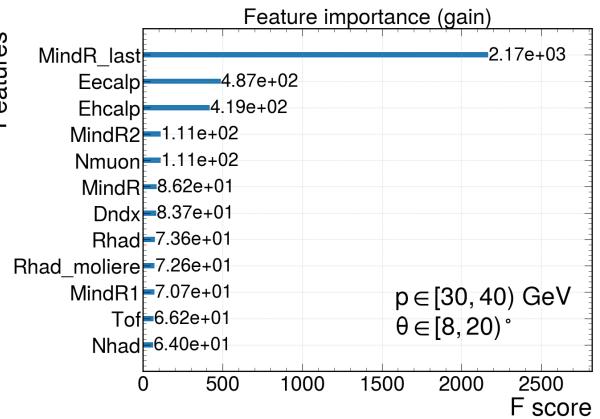
$p = 3-4 \text{ GeV}, \theta = 85-90^{\circ}$



$p \in [3, 4) \text{ GeV}, \theta \in [85, 90)^{\circ}$

		Р	= [ປ), 4	JG	ie v	, D	Εľ	OO_{1}	, 90	り			10
Tof	-1.00	0.64	0.13	0.22	-0.01	-0.01	-0.00	-0.01	-0.00	0.05	0.00	0.08		trix ^{0.1}
Dndx	0.64	1.00	0.19	0.25	-0.02	-0.02	-0.02	-0.02	-0.02	0.04	0.00	0.07	-	M 8.0
Eecalp	0.13	0.19	1.00	-0.10	-0.23	0.04	0.05	0.05	0.04	-0.15	-0.01	-0.65		0.0 Ition
Rhad	0.22	0.25	-0.10	1.00	0.17	-0.06	-0.06	-0.06	-0.06	0.19	0.02	0.24	-	elai
had_moliere	-0.01	-0.02	-0.23	0.17	1.00	-0.01	-0.00	-0.00	-0.01	0.74	-0.00	0.01	-	Feature Correlation Matrix
MindR	-0.01	-0.02	0.04	-0.06	-0.01	1.00	0.67	0.52	0.94	0.01	-0.32	-0.02	-	0.2 E
MindR1	-0.00	-0.02	0.05	-0.06	-0.00	0.67	1.00	0.77	0.66	0.02	-0.39	-0.02		atu
MindR2	-0.01	-0.02	0.05	-0.06	-0.00	0.52	0.77	1.00	0.53	0.02	-0.38	-0.02	-	0.0 Ŭ
MindR_last	-0.00	-0.02	0.04	-0.06	-0.01	0.94	0.66	0.53	1.00	0.01	-0.32	-0.02	_	-0.2
Nhad	0.05	0.04	-0.15	0.19	0.74	0.01	0.02	0.02	0.01	1.00	-0.01	0.07		
Nmuon	0.00	0.00	-0.01	0.02	-0.00	-0.32	-0.39	-0.38	-0.32	-0.01	1.00	0.01		-0.4
Ehcalp	0.08	0.07	-0.65	0.24	0.01	-0.02	-0.02	-0.02	-0.02	0.07	0.01	1.00	-	-0.6
	Tof	Dndx	Eecalp	Rhad	Rhad_moliere	MindR	MindR1	MindR2	MindR_last	Nhad	Nmuon	Ehcalp		
					È							2		

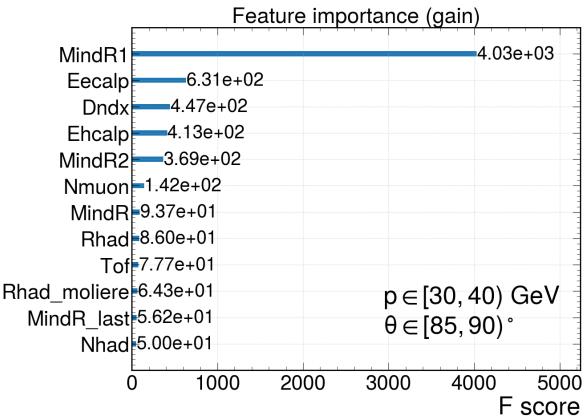
$p = 30-40 \text{ GeV}, \theta = 8-20^{\circ}$



$p \in [30, 40) \text{ GeV}, \theta \in [8, 20)^{\circ}$

		$p \in [00, \pm 0)$					$\Box \in V, \ U \in [0, 20)$							10
Tof	-1.00	0.21	-0.11	0.09	0.03	-0.18	-0.18	-0.18	-0.17	-0.09	0.07	0.04	-	Itrix ^{0.1}
Dndx	0.21	1.00	0.01	0.06	-0.00	-0.04	-0.04	-0.04	-0.03	-0.04	0.02	0.01	-	Ma 8.0
Eecalp	-0.11	0.01	1.00	-0.37	-0.36	0.76	0.74	0.72	0.71	-0.20	-0.26	-0.37	-	ion
Rhad	0.09	0.06	-0.37	1.00	0.19	-0.38	-0.37	-0.37	-0.36	0.14	0.15	0.17	-	elat
Rhad_moliere	0.03	-0.00	-0.36	0.19	1.00	-0.36	-0.38	-0.39	-0.40	0.32	0.07	-0.10	-	orr
MindR	-0.18	-0.04	0.76	-0.38	-0.36	1.00	0.93	0.89	0.88	-0.10	-0.34	-0.04	-	0.4 O Q
MindR1	-0.18	-0.04	0.74	-0.37	-0.38	0.93	1.00	0.96	0.92	-0.08	-0.35	0.06	-	Feature Correlation Matrix
MindR2	-0.18	-0.04	0.72	-0.37	-0.39	0.89	0.96	1.00	0.95	-0.07	-0.35	0.13	-	е ^{2.0} Ц
MindR_last	-0.17	-0.03	0.71	-0.36	-0.40	0.88	0.92	0.95	1.00	-0.06	-0.30	0.18	-	0.0
Nhad	-0.09	-0.04	-0.20	0.14	0.32	-0.10	-0.08	-0.07	-0.06	1.00	0.15	0.21		
Nmuon	0.07	0.02	-0.26	0.15	0.07	-0.34	-0.35	-0.35	-0.30	0.15	1.00	0.17	-	-0.2
Ehcalp	0.04	0.01	-0.37	0.17	-0.10	-0.04	0.06	0.13	0.18	0.21	0.17	1.00	-	0.4
	Tof	Dndx	Eecalp	Rhad	Rhad_moliere	MindR	MindR1	MindR2	MindR_last	Nhad	Nmuon	Ehcalp		-0.4

p = 30-40 GeV, θ = 85-90 °



$p \in [30, 40) \text{ GeV}, \theta \in [85, 90)^{\circ}$

$p \in [30, 40]$ GeV, $\theta \in [65, 90]$														1.0 ×
Tof	1.00	0.09	0.01	0.01	-0.00	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	-	itrix
Dndx	0.09	1.00	0.14	0.05	-0.04	-0.09	-0.09	-0.09	-0.09	-0.10	0.02	-0.04	-	⊠ 8.0
Eecalp	0.01	0.14	1.00	-0.62	-0.32	0.73	0.71	0.69	0.72	-0.12	-0.22	-0.37	-	Feature Correlation Matrix
Rhad	0.01	0.05	-0.62	1.00	0.22	-0.62	-0.61	-0.59	-0.61	0.07	0.21	0.13	-	elat elat
Rhad_moliere	-0.00	-0.04	-0.32	0.22	1.00	-0.35	-0.36	-0.36	-0.35	0.19	0.08	-0.13	-	0.4 0
MindR	-0.01	-0.09	0.73	-0.62	-0.35	1.00	0.95	0.90	0.99	-0.02	-0.31	0.11	-	e o o
MindR1	-0.01	-0.09	0.71	-0.61	-0.36	0.95	1.00	0.95	0.95	-0.00	-0.32	0.19	-	atu
MindR2	-0.01	-0.09	0.69	-0.59	-0.36	0.90	0.95	1.00	0.90	0.01	-0.32	0.22	-	Ө Ц 0.0
MindR_last	-0.01	-0.09	0.72	-0.61	-0.35	0.99	0.95	0.90	1.00	-0.02	-0.31	0.12	-	-0.2
Nhad	-0.01	-0.10	-0.12	0.07	0.19	-0.02	-0.00	0.01	-0.02	1.00	0.13	0.19	-	-0.2
Nmuon	0.00	0.02	-0.22	0.21	0.08	-0.31	-0.32	-0.32	-0.31	0.13	1.00	0.09	-	-0.4
Ehcalp	0.00	-0.04	-0.37	0.13	-0.13	0.11	0.19	0.22	0.12	0.19	0.09	1.00	-	-0.6
	Tof	Dndx	Eecalp	Rhad	Rhad_moliere	MindR	MindR1	MindR2	MindR_last	Nhad	Nmuon	Ehcalp		0.0

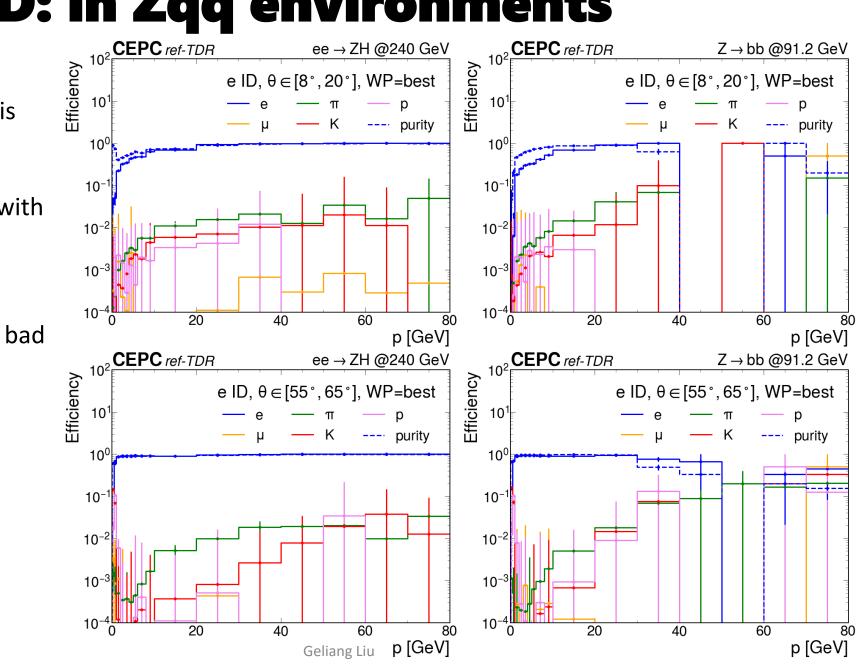
Features

For now, only E91.2_Zbb is checked.

XGBoost models trained with E240_ZH and applied to E91.2_Zbb.

0-1 GeV also trained, but bad performance.

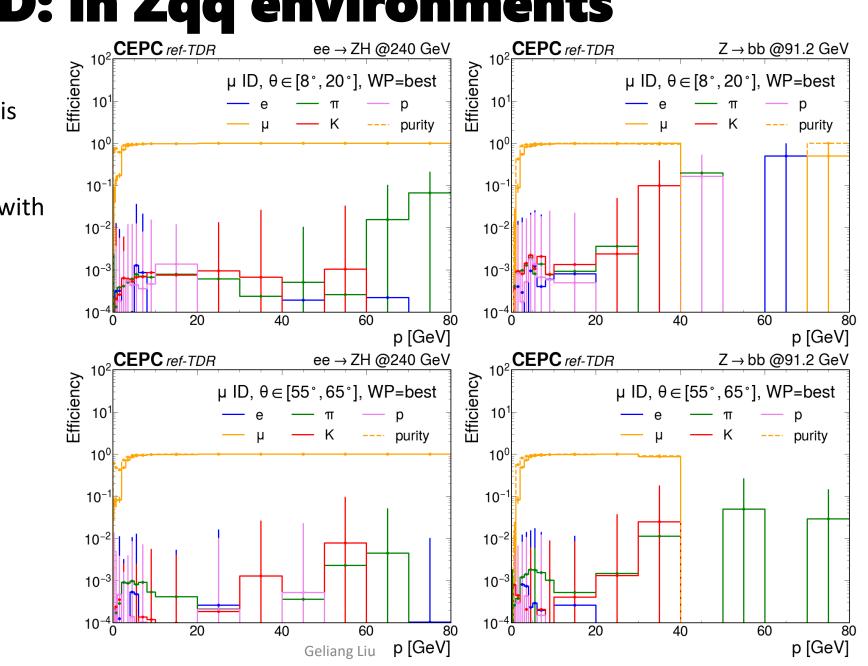
Electron ID comparison.



For now, only E91.2_Zbb is checked.

XGBoost models trained with E240_ZH and applied to E91.2_Zbb.

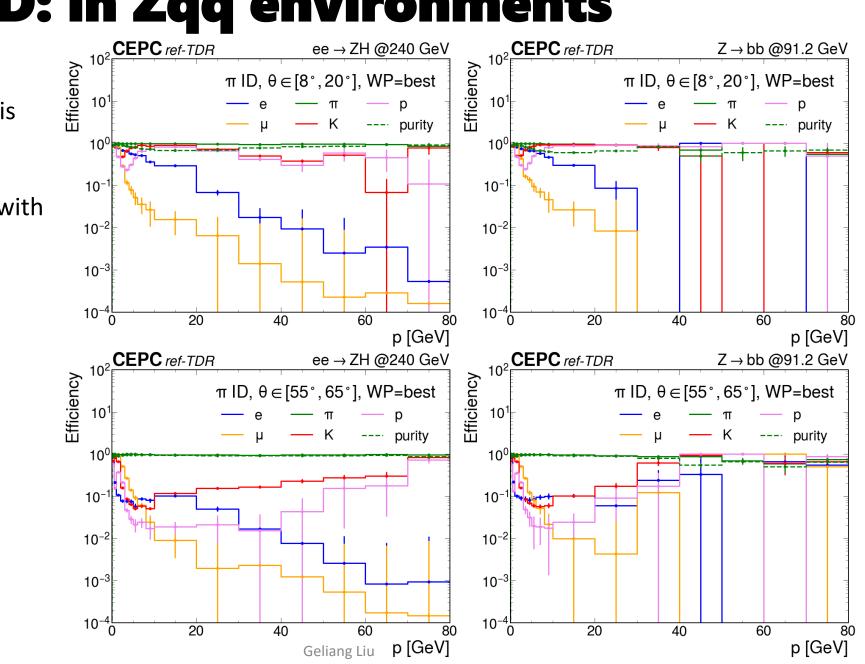
Muon ID comparison.



For now, only E91.2_Zbb is checked.

XGBoost models trained with E240_ZH and applied to E91.2_Zbb.

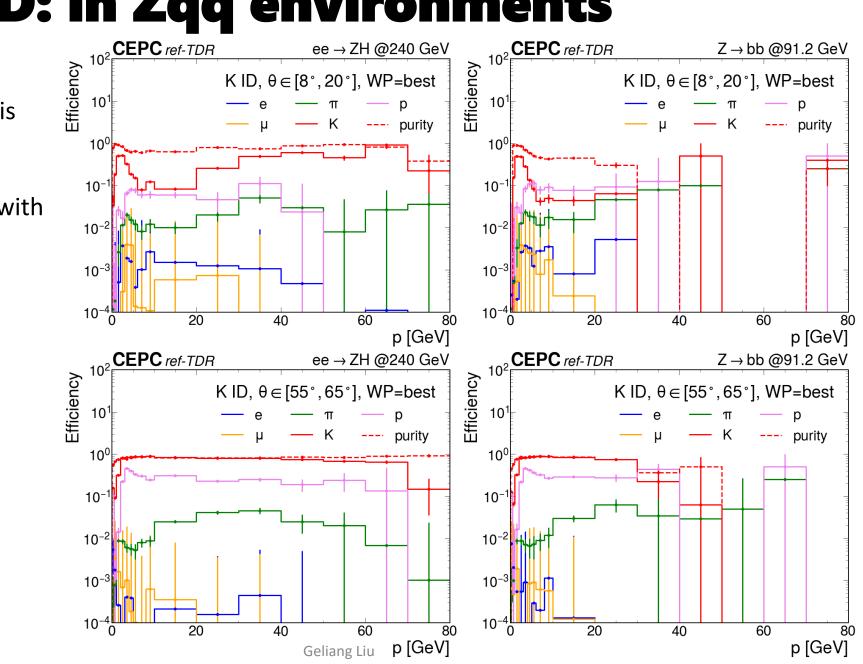
Pion ID comparison.



For now, only E91.2_Zbb is checked.

XGBoost models trained with E240_ZH and applied to E91.2_Zbb.

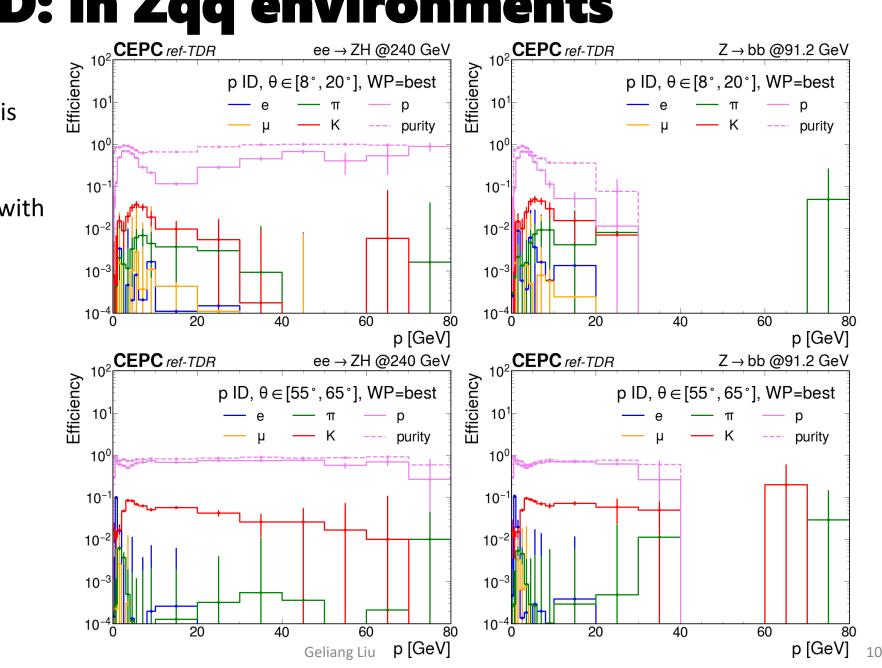
Kion ID comparison.



For now, only E91.2_Zbb is checked.

XGBoost models trained with E240_ZH and applied to E91.2_Zbb.

Proton ID comparison.



Photon ID with XGBoost

Input features

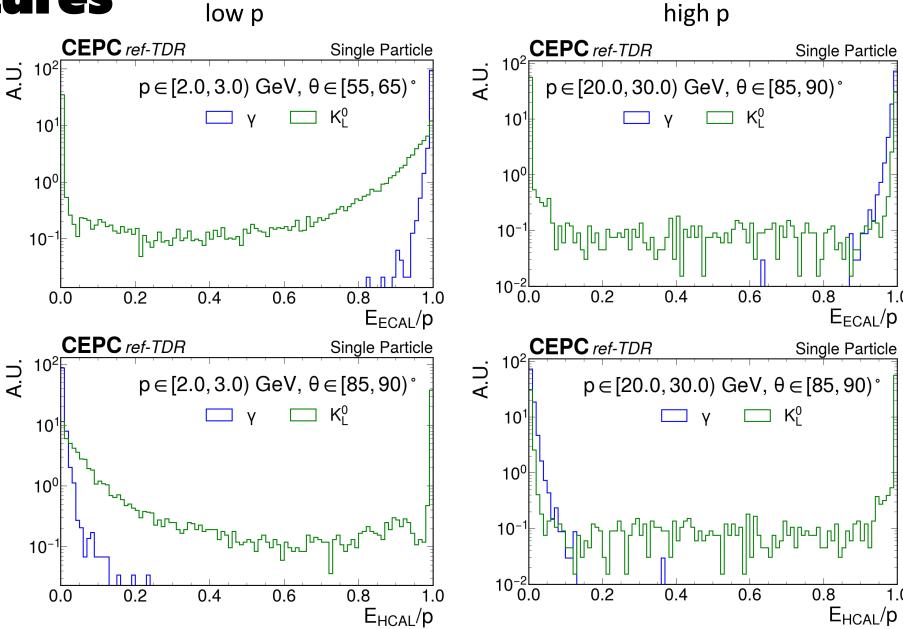
- E_{ECAL}/p , l_{ECAL} , R_{ECAL}^{90} , W_{ECAL}^{η} , W_{ECAL}^{ϕ}
- E_{HCAL}/p , l_{HCAL} , R_{HCAL}^{90} , W_{HCAL}^{η} , W_{HCAL}^{φ} , $N_{hadClus}$

Samples

- Single particle gun samples of γ and K_L^0 with $p \in [1, 80]$ GeV and $\theta \in [8, 172]^\circ$
- /cms/user/liugeliang/CEPC/202503/Production/ParticleGun/gamma*
- /cms/user/liugeliang/CEPC/202503/Production/ParticleGun/K_L0_*

Input features

A.U.



Geliang Liu

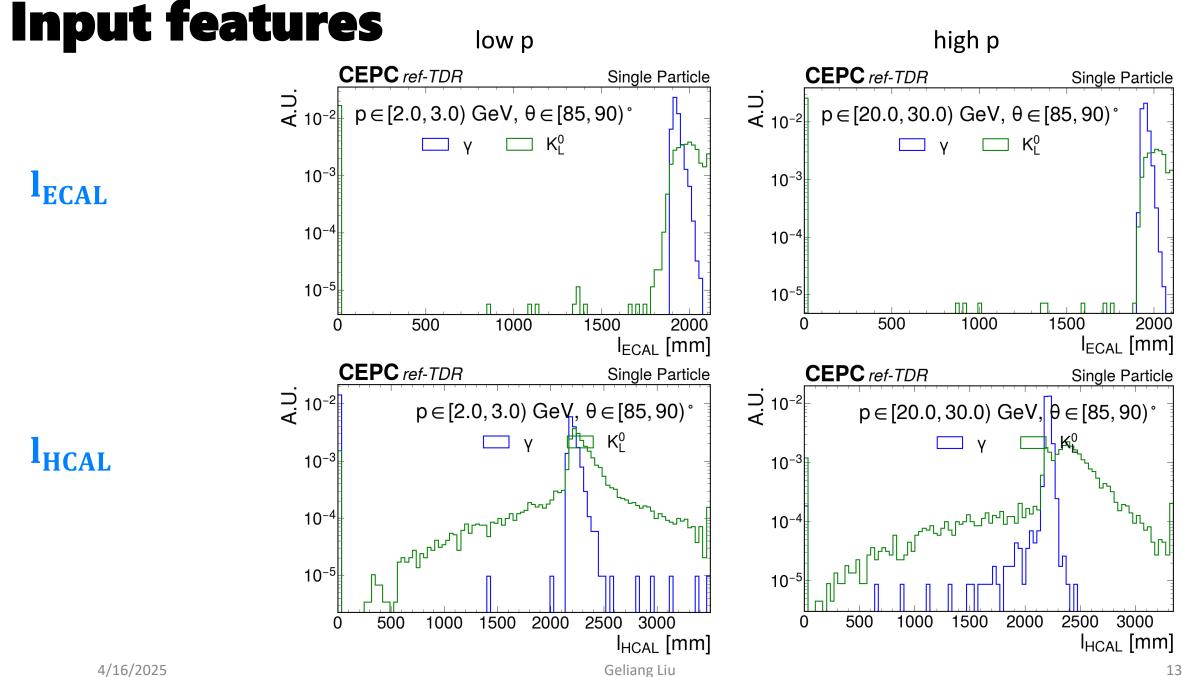
 E_{HCAL}/p

 E_{ECAL}/p

12

1.0

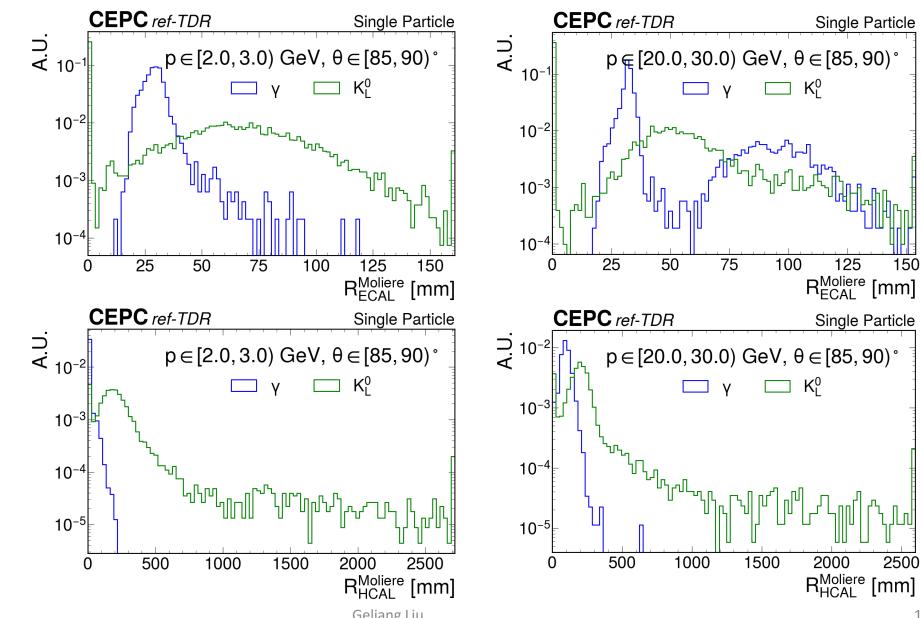
1.0



Input features

low p

high p

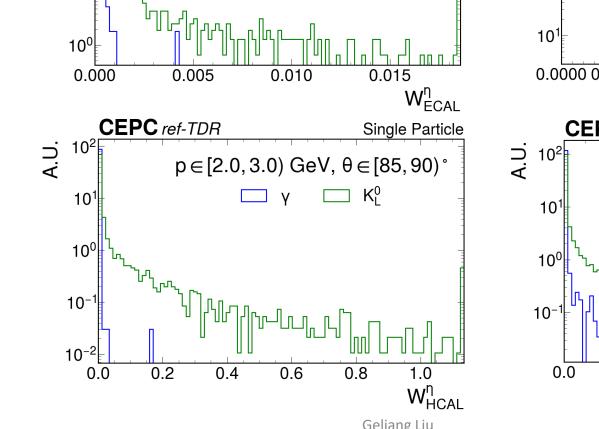


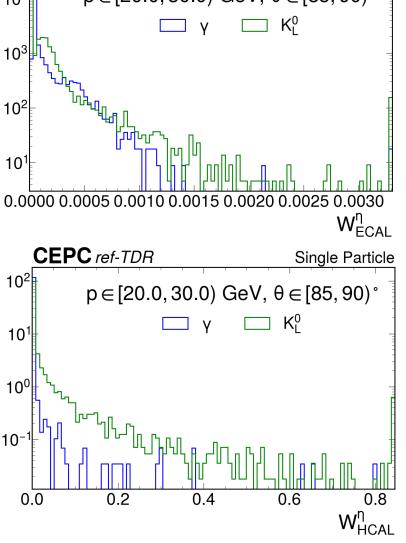
R⁹⁰_{HCAL}

R⁹⁰ ECAL

Input features low p high p CEPC ref-TDR **CEPC** ref-TDR Single Particle **Single Particle** A.U. $p \in [2.0, 3.0) \text{ GeV}, \theta \in [85, 90)^{\circ}$ $p \in [20.0, 30.0) \text{ GeV}, \theta \in [85, 90)^{\circ}$ 10³ K^0_L K_{I}^{0} W_{ECAL}^{η} 10³ 10² 10² 10¹ 10¹







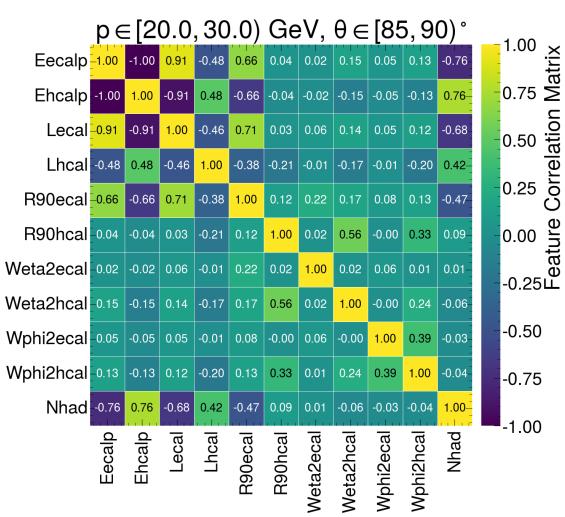
4/16/2025

Correlations

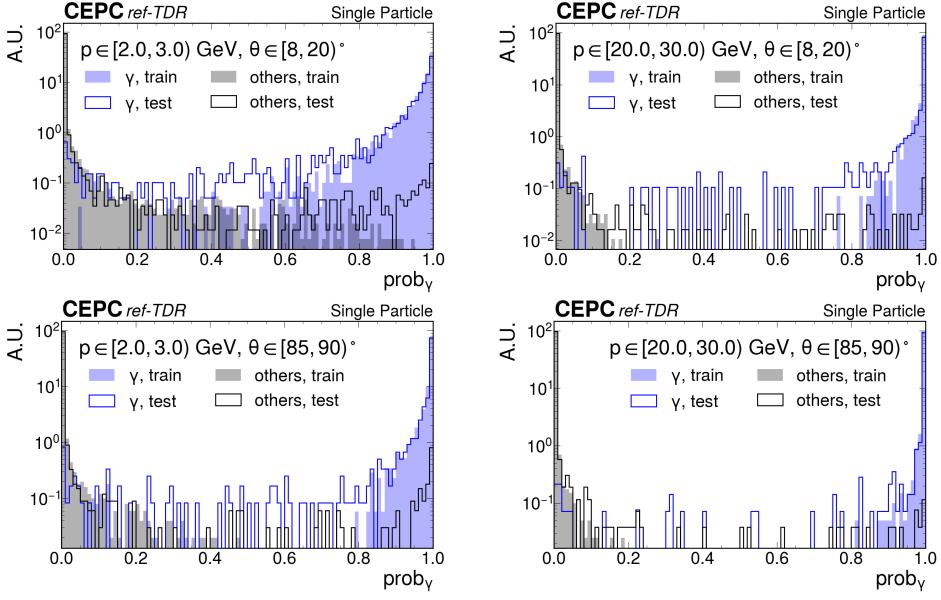
low p

$p \in [2.0, 3.0) \text{ GeV}, \theta \in [85, 90)^{\circ}$													
Eecalp	-1.00	-1.00	0.84	-0.50	0.55	-0.02	-0.03	0.14	0.03	0.09	-0.73	-	atrix ^{00.1}
Ehcalp	-1.00	1.00	-0.84	0.50	-0.55	0.02	0.03	-0.14	-0.03	-0.09	0.73	-	Matr
Lecal	-0.84	-0.84	1.00	-0.39	0.60	0.01	0.04	0.11	0.05	0.09	-0.55	-	Correlation
Lhcal	-0.50	0.50	-0.39	1.00	-0.10	0.07	0.02	-0.01	-0.01	-0.03	0.49	-	rrela
R90ecal	_0.55	-0.55	0.60	-0.10	1.00	0.21	0.06	0.21	0.11	0.18	-0.22	-	0.25 ō Ö
R90hcal	-0.02	0.02	0.01	0.07	0.21	1.00	0.01	0.49	0.01	0.42	0.26	-	ature
Weta2ecal	-0.03	0.03	0.04	0.02	0.06	0.01	1.00	0.01	0.13	0.00	0.06	-	ര് ല -0.25ഥ
Weta2hcal	-0.14	-0.14	0.11	-0.01	0.21	0.49	0.01	1.00	0.02	0.29	0.01	-	0.20
Wphi2ecal	-0.03	-0.03	0.05	-0.01	0.11	0.01	0.13	0.02	1.00	0.22	-0.00	-	-0.50
Wphi2hcal	-0.09	-0.09	0.09	-0.03	0.18	0.42	0.00	0.29	0.22	1.00	0.04	-	-0.75
Nhad	-0.73	0.73	-0.55	0.49	-0.22	0.26	0.06	0.01	-0.00	0.04	1.00-	-	1 00
	Eecalp	Ehcalp	Lecal	Lhcal	R90ecal	R90hcal	Weta2ecal	Weta2hcal	Wphi2ecal	Wphi2hcal	Nhad		-1.00

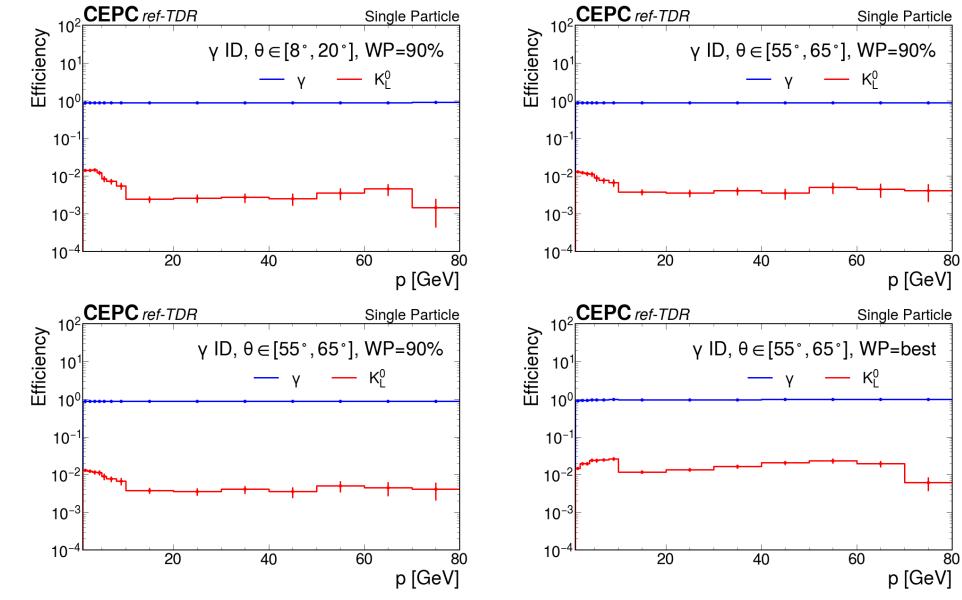
high p



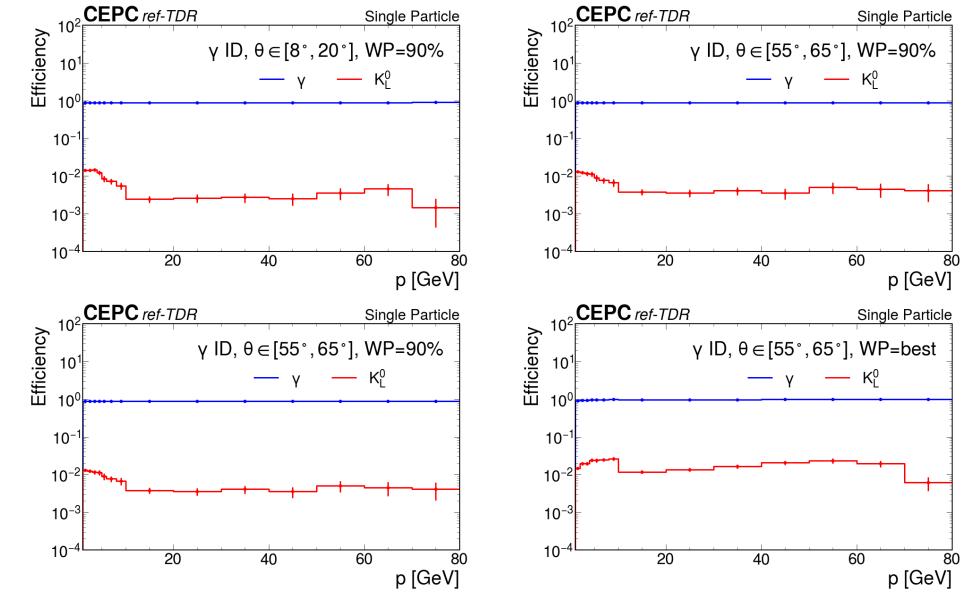
Train v.s. test



Efficiency



Efficiency



To be tested in ZH environments

Challenges

- Not only to distinguish photons from neutral hadrons, but also from clusters induced by charged hadrons
- A quick look shows that the large fraction of neutral PFOs are matched to charged hadrons.
- Even for those matched to neutral hadrons, the signatures are different from particle gun samples (still have large fraction of energy in ECAL).
- Need further checks.