



# CEPC

Jets, samples and Wednesday working meeting Kaili Zhang <u>zhangkl@ihep.ac.cn</u>

## Statistical uncertainty of JOI





- Each category 1M, in total 11M
- Training:Validation:Test 8:1:1
- Confusion Matrix from Test sample.(each ~100k).
- Use bootstrap method to estimate uncertainty
  - Times=1000, N\_sample=10k
  - Each time choose 10k sample from the total to estimate



#### B eff= 0.946±0.002 U eff= 0.458±0.005 D eff= 0.455±0.005

#### Error matrix

Lower error (nominal – 16%) Upper error (84% – nominal) - 0.005 0.005 o - 0.00213 0.00171 0.00061 0.00055 0.00051 0.00099 o - 0.00227 0.00169 0.00059 0.00055 0.00059 0.00091 0.00333 0.00213 0.00159 0.00143 0.00158 u = 0.00136 0.00347 0.00239 0.00161 0.00147 0.00152 υ - 0.00144 0.004 - 0.004 16%) nominal) σ - 0.00048 0.00169 0.00446 0.00318 0.00341 0.00209 ω - 0.00052 0.00181 0.00436 0.00302 0.00300 0.00221 - 0.003 (nominal \_ - 0.003 +Δ (84% 0.00057 0.00149 0.00335 0.00527 0.00459 0.00256 <u>-</u> - 0.00053 0.00141 0.00346 0.00485 0.00471 0.00246 < - 0.002 - 0.002 σ - 0.00045 0.00155 0.00393 0.00432 0.00478 0.00242  $\overline{v}$  - 0.00055 0.00147 0.00377 0.00450 0.00523 0.00248 - 0.001 - 0.001 ດ - 0.00154 0.00216 0.00364 0.00331 0.00322 0.00477 n - 0.00156 0.00226 0.00368 0.00341 0.00348 0.00444 d b С S u q b С S u d g

3

#### Gaussian shape test



Maximum deviation ~1% Average deviation ~0.2%



#### Stats uncertainty discussion



- Bootstrap derives uncertainty  $94.6\% \pm 0.2\%$  for b tagging
  - Bootstrap uncertainty can be made as small as desired.
  - 10x sample  $\propto$  sqrt(10) suppressing.
- Performance test to other samples under testing
  - Zpole, 2f, 4f, E360...
  - Downgrading performance is different with this stats.

### Class bias for s quark



ZH	Truth	Predict	Diff
b	186823	183901	-1.59%
С	185617	183967	-0.90%
d	187096	182944	-2.27%
S	185954	215191	13.59%
u	186815	173326	-7.78%
g	86597	79573	-8.83%

- Current model tends to predict more s quark.
  - Reweighting
    - (keep the bias model, but change output of M11)
  - Post-Recalibrating(let model output in certain ratio)
    - Also correlated to input and environment, like Higgs, Z.
  - Physics or just model-training artifact?
    - Trying to dig out with differential analysis.

## Application on Zpole Rb

CEPC

Unexpected behavior for c quark tagging. Under tuning with Hancen, Mohan.



#### Jet-Origin Identification Confusion Matrix (Merged)



# backups

#### **Current JOI**





CEPC TDR Jet Origin ID

Truth:	0.5936
Reco70:	0.5510
Nolep:	0.5494
Reco98:	0.5153
NoID:	0.4825





#### ParT\_RecoID98 - Baseline Difference 0 040 03

- م	0.04	0.05									
bar L	0.04	-0.04									
υ -		0.01	-0.06	0.03							
cbar	0.01	0.01	0.03	-0.06							
ω - ,			0.03	0.03	-0.16	0.01		0.05	0.02	0.01	
sbar			0.03	0.02		-0.14	0.04			0.02	
⊐ -			0.03	0.02		0.04	-0.08		-0.01	·	
ubar			0.02	0.03	0.03			-0.06	0.02	2	
σ-			0.02	0.03	0.03		-0.01	.0.02	-0.10	0.01	
dbaı			0.03	0.02		0.03				-0.08	
<u>ס</u> -			0.03	0.03					-0.01		-0.0
	b	bbar	- c	cbar	S	sbar	` u	ubar	d	dbar	ġ

Pai	rT_P	lecc	DD_	NoL	.ept	on -	Ba	seli	ne [	Diffe	eren	ice
- م	-0.03	0.02										
obar '	0.02	-0.03										
υ -			-0.03	0.01								
cbar			0.01	-0.04								
ა - ა					-0.08	0.01		0.03		0.01	0.01	
sbar					0.01	-0.09	0.04			0.01	0.01	
⊐ -					0.01	0.04	-0.04		-0.01			
ubar					0.04			-0.03	0.03			
-σ					0.04	0.01		0.02	-0.08			
dbar					0.02	0.03				-0.05		
ъ-									-0.01		0.01	
	- I	- I	- I	1	1	1			1	1	1	

#### b bbar c cbar s sbar u ubar d dbar g

#### ParT\_NoID - Baseline Difference <del>\_0.040.04</del> -<mark>0.03-0.04</mark> -0.060.04 0.01

υ -

cbar

S

sbar

ubar

σ

dbar

<del>ں</del> -

	0.00				0.01				
(	0.04	0.07	,			0.01			0.01
			-0.22	0.03	0.01	0.11	0.02		0.04
			0.02	-0.21	0.12	0.01		0.02	0.04
			0.01	0.06	-0.03		-0.02	-0.05	0.02
			0.05	0.01		-0.02	-0.06	0.02	0.02
			0.08		-0.01	0.06	-0.18		0.03
				0.08	0.05	-0.01		-0.16	0.03
							-0.03	-0.02	0.05
	1	1	1	1	1	1	- 1	1	

#### b bbar c cbar s sbar u ubar d dbar g

- 0.10

- 0.05

- 0.00

-0.05

-0.10

- -0.15

- -0.20

### Tagging Eff & Charge Flip rate



TruthID	Efficiency	Flip Rate	Reco70	Efficiency	Flip Rate	Reco98	Efficiency	Flip Rate	NoID	Efficiency	Flip Rate
b	0.95	0.12	b	0.94	0.14	b	0.94	0.16	b	0.94	0.16
С	0.85	0.04	С	0.84	0.06	С	0.83	0.08	С	0.83	0.09
S	0.68	0.12	S	0.62	0.15	S	0.54	0.17	S	0.49	0.23
u	0.46	0.10	u	0.40	0.09	u	0.37	0.10	u	0.40	0.09
d	0.46	0.18	d	0.40	0.22	d	0.40	0.25	d	0.34	0.30
g	0.44		g	0.46		g	0.41		g	0.47	
Metric	0.5936			0.5510			0.5153			0.5030	

### Overtraining:



#### TensorBoard convergence analysis confirms stable training convergence across all models.



Loss

Loss/eval (epoch) tag: Loss/eval (epoch)



	<b>NEI/IIIVE</b>
Apr15 06-24-56 apu013 ibep ac cn.let ParT0415NoID bigas full ParT 0 4945 0.5026 29 Tue Apr 15 23:13:3	1 16h 14m 52s
$\square$ Apr15_06_34_40 apu026 iben ac cn let ParT0415TruthID bigas full ParT 0.585 0.5935 29 Tue Apr 15 20:51:0	$0  13h \ 47m \ 43s$
Apr15 10-30-36 anu017 iben ac cn let ParT0415CNoID bigas full ParT $0.4749 = 0.4812 \cdot 29$ Wed Apr 16, 200747	15h 4/m 40s
$ = \frac{1}{2} \sqrt{10} \sqrt{10}$	12 18h 40m 5c



#### **Confusion Matrix**





# Matrix Difference

- Largest impact in S-Sbar tagging.
- Truth-label–wise normalization ensures row conservation

22% more truth s quarks are not tagged as s quark.11% more truth s quarks are tagged as ubar quark.



With/wo PID, b/c quark do not mix with udsg. (but better separation b and bbar).

With RecoID98(higher lepton rate), uds are likely to be tagged as c quark; While in NoID it disappeared. -> tagged as gluon.



#### JOI with charged only tracks



---- ParT\_TruthID\_Charged 1.0 ---- ParT\_RecolD70\_Charged ParT\_RecoID98\_Charged 0.9 ParT\_NoID\_Charged 0.8 0.7 Rate Efficiency and Flip R 5.0 9.0 7.0 9.0 0.3 0.2 0.1 0.0 0.2 Residuals A-Baseline 0.1 -----0.0 -0.1-0.2d b С s u

CEPC TDR Jet Origin ID

#### **Charged Confusion Matrix**



Truth:	0.5661
Reco70:	0.5281
Reco98:	0.5142
NoID:	0.4825

ParT_RecolD70_Charged											
b -	0.797	0.134	0.022	0.025	0.003	0.001	0.001	0.002	0.002	0.001	0.012
bbar -	0.135	0.793	0.026	0.022	0.002	0.003	0.002	0.001	0.001	0.001	0.013
c -	0.011	0.014	0.768	0.049	0.023	0.031	0.031	0.007	0.008	0.020	0.039
cbar -	0.015	0.011	0.050	0.767	0.031	0.022	0.006	0.033	0.020	0.008	0.037
s -	0.002	0.002	0.018	0.023	0.467	0.088	0.027	0.136	0.090	0.056	0.092
- røds Truth	0.001	0.002	0.022	0.017	0.087	0.471	0.134	0.027	0.055	0.091	0.092
u -	0.001	0.002	0.024	0.010	0.043	0.165	0.377	0.037	0.067	0.173	0.101
ubar -	0.002	0.001	0.010	0.025	0.162	0.042	0.037	0.383	0.170	0.066	0.102
d -	0.002	0.001	0.012	0.024	0.142	0.092	0.055	0.236	0.247	0.082	0.107
dbar -	0.001	0.002	0.024	0.012	0.089	0.144	0.230	0.058	0.080	0.252	0.106
g -	0.012	0.013	0.032	0.032	0.081	0.083	0.072	0.075	0.056	0.057	0.487
	\$	bbar	ċ	doar	5	spar	\$	JIDBY	8	dipar	\$
						and the second					
					F ParT_N	Predicted	d narged				
b -	0.778	0.147	0.021	0.031	F ParT_N 0.002	Predicted	anarged	0.003	0.001	0.001	0.014
b - bbar -	0.778	0.147	0.021	0.031	F ParT_N 0.002 0.001	Predicted IOID_CH 0.001 0.002	d narged 0.001 0.003	0.003	0.001	0.001	0.014
b - bbar - c -	0.778	0.147 0.774 0.016	0.021 0.031 0.731	0.031 0.021 0.074	F ParT_N 0.002 0.001 0.015	Predicted IOID_CP 0.001 0.002 0.034	0.001 0.003 0.041	0.003 0.001 0.009	0.001 0.001 0.009	0.001 0.001 0.017	0.014 0.014 0.044
b - bbar - c - cbar -	0.778 0.151 0.009 0.017	0.147 0.774 0.016 0.009	0.021 0.031 0.731 0.073	0.031 0.021 0.074 0.734	F ParT_N 0.002 0.001 0.015 0.034	Predicted IOID_CI 0.001 0.002 0.034 0.014	d o.oo1 0.003 0.041 0.008	0.003 0.001 0.009 0.042	0.001 0.001 0.009 0.017	0.001 0.001 0.017 0.009	0.014 0.014 0.044 0.042
b - bbar - c - cbar - s -	0.778 0.151 0.009 0.017 0.002	0.147 0.774 0.016 0.009 0.001	0.021 0.031 0.731 0.073 0.014	0.031 0.021 0.074 0.734	F ParT_N 0.002 0.001 0.015 0.034 0.313	Predicted IOID_CH 0.001 0.002 0.034 0.014 0.099	anarged 0.001 0.003 0.041 0.008 0.036	0.003 0.001 0.009 0.042 0.237	0.001 0.001 0.009 0.017 0.100	0.001 0.001 0.017 0.009 0.057	0.014 0.014 0.044 0.042 0.115
- d - rodd - c- - cbar - - s-	0.778 0.151 0.009 0.017 0.002 0.001	0.147 0.774 0.016 0.009 0.001	0.021 0.031 0.731 0.073 0.014 0.024	0.031 0.021 0.074 0.734 0.026	F ParT_N 0.002 0.001 0.015 0.034 0.313 0.098	Predicted 0.001 0.002 0.034 0.014 0.099 0.318	0.001 0.003 0.041 0.008 0.036	0.003 0.001 0.009 0.042 0.237 0.035	0.001 0.001 0.009 0.017 0.100 0.059	0.001 0.001 0.017 0.009 0.057 0.100	0.014 0.014 0.044 0.042 0.115 0.114
b - bbar - c- cbar - s - s - sbar - u -	0.778 0.151 0.009 0.017 0.002 0.001	0.147 0.774 0.016 0.009 0.001 0.002	0.021 0.031 0.731 0.073 0.014 0.024	0.031 0.021 0.074 0.734 0.026 0.014	F ParT_N 0.002 0.001 0.015 0.034 0.313 0.098	Predicted IOID_CP 0.001 0.002 0.034 0.014 0.099 0.318 0.162		0.003 0.001 0.009 0.042 0.237 0.035	0.001 0.001 0.009 0.017 0.100 0.059	0.001 0.001 0.017 0.009 0.057 0.100	0.014 0.014 0.044 0.042 0.115 0.114
 bbar -       -  - - -	0.778 0.151 0.009 0.017 0.002 0.001 0.001	0.147 0.774 0.016 0.009 0.001 0.002 0.002	0.021 0.031 0.731 0.073 0.014 0.024 0.025	0.031 0.021 0.074 0.734 0.026 0.014 0.010	F ParT_N 0.002 0.001 0.015 0.034 0.313 0.098 0.044 0.161	<pre>Predicted IDD_CF 0.001 0.002 0.034 0.014 0.009 0.318 0.162 0.045</pre>		0.003 0.001 0.009 0.042 0.237 0.035 0.035	0.001 0.001 0.009 0.017 0.059 0.059 0.059	0.001 0.001 0.017 0.009 0.057 0.100 0.133	0.014 0.014 0.044 0.042 0.115 0.114 0.121
b - bbar - cbar - s - t <u>p</u> sbar - u - ubar - d -	0.778 0.151 0.009 0.017 0.002 0.001 0.001 0.002	0.147 0.774 0.016 0.009 0.001 0.002 0.002 0.001	0.021 0.031 0.731 0.073 0.014 0.024 0.024 0.010	0.031 0.021 0.074 0.026 0.014 0.026	FParT_N 0.0001 0.015 0.034 0.034 0.098 0.044 0.161	redicter loID_Cf 0.001 0.002 0.034 0.014 0.099 0.162 0.045 0.080	d arged 0.001 0.003 0.041 0.008 0.036 0.036 0.054	0.003 0.001 0.009 0.042 0.237 0.035 0.035 0.0413 0.288	0.001 0.001 0.009 0.017 0.010 0.059 0.130 0.157	0.001 0.001 0.017 0.009 0.057 0.100 0.133 0.056 0.081	0.014 0.014 0.044 0.042 0.115 0.114 0.121 0.120
b - bbar - c - cbar - s - s s - s bar - ubar - d - dbar -	0.778 0.151 0.009 0.017 0.002 0.001 0.002 0.002	0.147 0.774 0.016 0.009 0.001 0.002 0.001 0.001	0.021 0.031 0.731 0.073 0.014 0.025 0.010 0.010	0.031 0.021 0.074 0.074 0.026 0.010 0.026 0.025 0.014	FParT_N 0.002 0.001 0.015 0.034 0.034 0.098 0.044 0.161 0.161 0.172	redicter loID_Cf 0.001 0.002 0.034 0.034 0.045 0.045 0.045 0.080	d narged 0.001 0.003 0.041 0.036 0.234 0.036 0.036 0.036	0.003 0.001 0.009 0.042 0.237 0.035 0.413 0.288	0.001 0.001 0.009 0.009 0.100 0.059 0.059 0.130 0.130	0.001 0.001 0.017 0.009 0.057 0.100 0.133 0.056 0.081 0.162	0.014 0.014 0.044 0.115 0.115 0.114 0.121 0.120 0.128
b - c c ccbar - scbar - u - u d - d - d - g - g -	0.778 0.151 0.009 0.017 0.002 0.001 0.002 0.002 0.002	0.147 0.774 0.016 0.009 0.001 0.002 0.001 0.001 0.001	0.021 0.031 0.731 0.073 0.014 0.024 0.010 0.013 0.024	0.031 0.021 0.734 0.734 0.026 0.014 0.026 0.025 0.014	F FAT_N ParT_N 0.002 0.001 0.034 0.313 0.098 0.044 0.161 0.172 0.081 0.081	Predicted           IoID_CF           0.001           0.002           0.034           0.014           0.099           0.318           0.162           0.045           0.080           0.174           0.066	d arged 0.001 0.003 0.041 0.008 0.036 0.036 0.036 0.054 0.281 0.085	0.003 0.001 0.009 0.042 0.237 0.035 0.035 0.288 0.055 0.088	0.001 0.001 0.017 0.017 0.100 0.059 0.130 0.130 0.137	0.001 0.001 0.009 0.009 0.057 0.100 0.133 0.056 0.081 0.081	0.014 0.014 0.044 0.115 0.114 0.121 0.120 0.128 0.125 0.522

Predicted

## **Charged Matrix Difference**



Similar performance corresponds to FullPFOs. Nertral PFO contributions are global and not for any specified flavor.





ParT NoID Charged - Baseline Difference

-0.05

-0.10

-0.15

-0.20

### Residual: only charged tracks



CEPC TDR Jet Origin ID



#### Consistent Analysis: TDR ParT vs PN Truth ID

CEPC TDR Jet Origin ID



0.5936: 0.5579

### Matrix Difference



ParT with better metric, while PN has better gluon separation. The improvement is believed from TLorentz vector information.



PN\_TruthID - Baseline Difference

#### Consistent Analysis: ParT\_Reco70

1.0

0.9

0.8

0.3

0.2

0.1



0.5510: 0.5319





#### Matrix Difference



Under check for input variables and traing hyper parameter.



RecolD70\_YF - Baseline Difference

#### Consistent Analysis: PN\_TruthID



0.5579: 0.5486





### Matrix Difference

#### Similar performance while migration from u/dbar.





#### PN\_TruthID\_YF - Baseline Difference

### TDR/CDR, PN, truth ID:



0.5486: 0.5285



CEPC TDR Jet Origin ID

### Matrix Difference



TDR improved from CDR in 2%.



PN\_CDR\_TruthID - Baseline Difference

#### To dos



- Further check inputs/outputs for consistence, like costheta
- After sanity check, applications:
  - b/c/g/s tagging, H->bb/cc/gg/ss analysis
  - Ability for genializing: JOI to Zpole, to E240 ZZ/WW/qq
  - Package for users

• ...

#### **Results from YF**



					ParT T	DR Red	olD70				
b	- 0.755	0.152	0.035	0.023	0.004	0.002	0.002	0.003	0.002	0.001	0.021
bbar	- 0.172	0.731	0.027	0.034	0.003	0.003	0.003	0.002	0.001	0.002	0.021
с	- 0.016	0.014	0.749	0.053	0.034	0.025	0.026	0.008	0.008	0.015	0.052
cbar	- 0.017	0.015	0.058	0.740	0.028	0.032	0.010	0.024	0.015	0.008	0.053
S	- 0.003	0.003	0.027	0.022	0.529	0.092	0.032	0.082	0.067	0.043	0.100
Truth spar	- 0.003	0.003	0.024	0.027	0.092	0.525	0.090	0.028	0.045	0.063	0.101
u	- 0.003	0.003	0.026	0.013	0.041	0.115	0.383	0.060	0.073	0.164	0.120
ubar	- 0.003	0.003	0.014	0.023	0.118	0.038	0.066	0.378	0.161	0.076	0.121
d	- 0.003	0.003	0.016	0.023	0.098	0.084	0.087	0.221	0.269	0.073	0.123
dbar	- 0.003	0.003	0.026	0.015	0.084	0.098	0.225	0.082	0.069	0.272	0.122
g	- 0.022	0.020	0.037	0.035	0.074	0.068	0.064	0.059	0.050	0.049	0.520
	\$	boat	L C	char	- 5	so <sup>at</sup>	ہ ک ط	Jpar	ò	apar	\$

- ParT TDR RecolD70: 0.5319
- PN TDR TruthID: 0.5486
- PN TDR RecolD70: 0.5075
- PN TDR RecoID70Charged: 0.4952
- PN CDR TruthID: 0.5285

#### **Results from YF**



