



JOI comparison

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4-momentum usage in ParT

- Checked with Hideki:
 - **passing the 4-momenta is just a coding convenience to calculate pair-wise features.**
 - **4-momenta themselves are NOT USED IN THE TRAINING.**
 - They are inputs but not used in training.
- Information like $\log(E)$ is not overlapped.

interaction features, for this paper we only consider a specific scenario in which the interaction features are derived from the energy-momentum 4-vector, $p = (E, p_x, p_y, p_z)$, of each particle. This is the most general case for jet tagging, as the particle 4-vectors are available in every jet tagging task. Specifically, for a pair of particles a, b with 4-vectors p_a, p_b , we calculate the following 4 features:

$$\begin{aligned}
 \Delta &= \sqrt{(y_a - y_b)^2 + (\phi_a - \phi_b)^2}, \\
 k_T &= \min(p_{T,a}, p_{T,b}) \Delta, \\
 z &= \min(p_{T,a}, p_{T,b}) / (p_{T,a} + p_{T,b}), \\
 m^2 &= (E_a + E_b)^2 - \|\mathbf{p}_a + \mathbf{p}_b\|^2,
 \end{aligned} \tag{3}$$

where y_i is the rapidity, ϕ_i is the azimuthal angle, $p_{T,i} = (p_{x,i}^2 + p_{y,i}^2)^{1/2}$ is the transverse momentum, and $\mathbf{p}_i = (p_{x,i}, p_{y,i}, p_{z,i})$ is the momentum 3-vector and $\|\cdot\|$ is the norm, for $i = a, b$. Since these variables typically have a long-tail distribution, we take the logarithm and use $(\ln \Delta, \ln k_T, \ln z, \ln m^2)$ as the interaction features for each particle pair. The choice of this set of features is motivated by [Dreyer & Qu \(2021\)](#).

Ranking

/hpcfs/cepc/higgsgpu/zhangkl/part_ranking/ranking_compare.py

- For each variable:
 - Shuffle the variable
 - Set all to zero.
 - Set all to one random in (min, max)
 - Set each to random in (min, max)
- Baseline loss: 2.0535

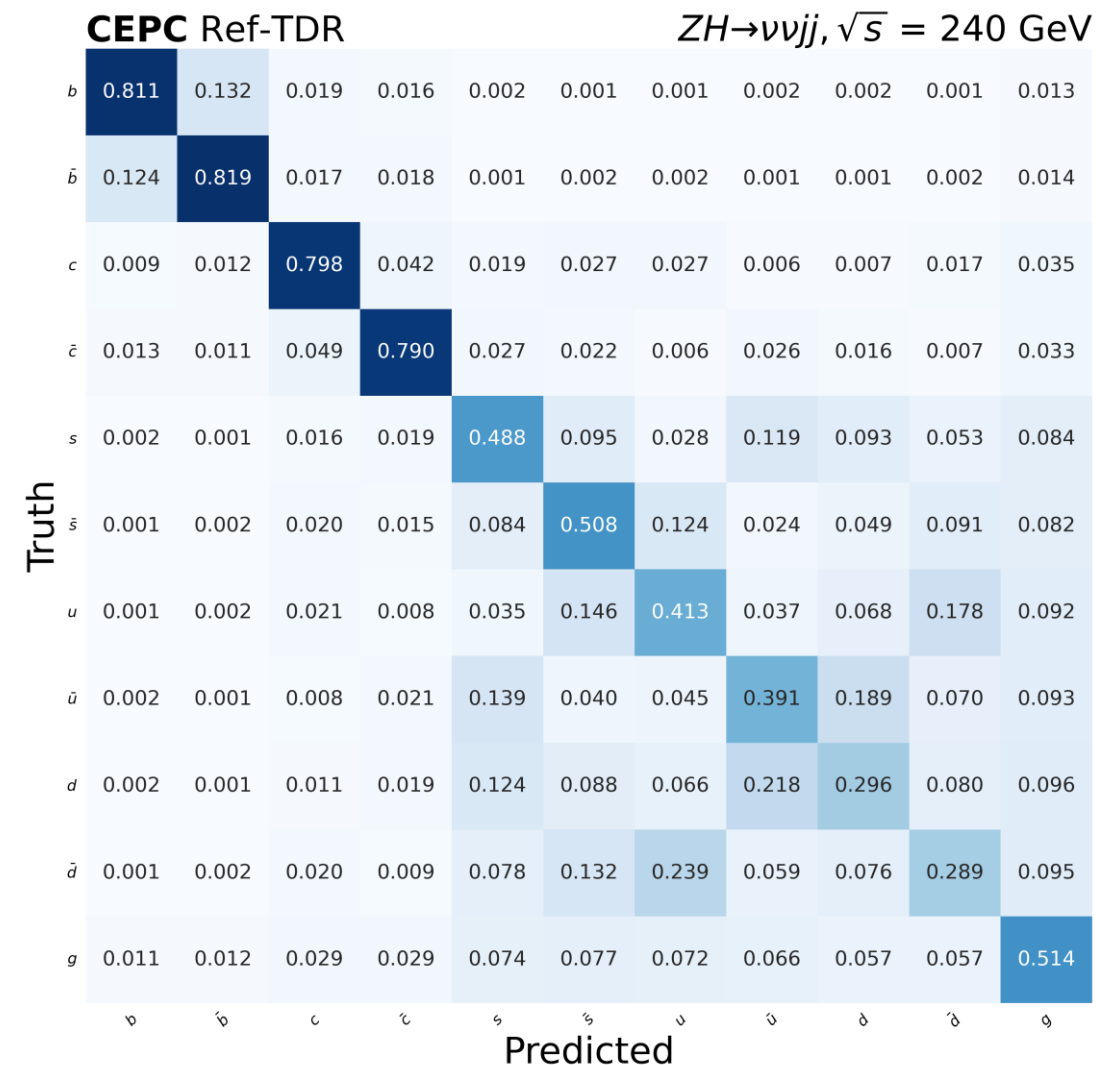
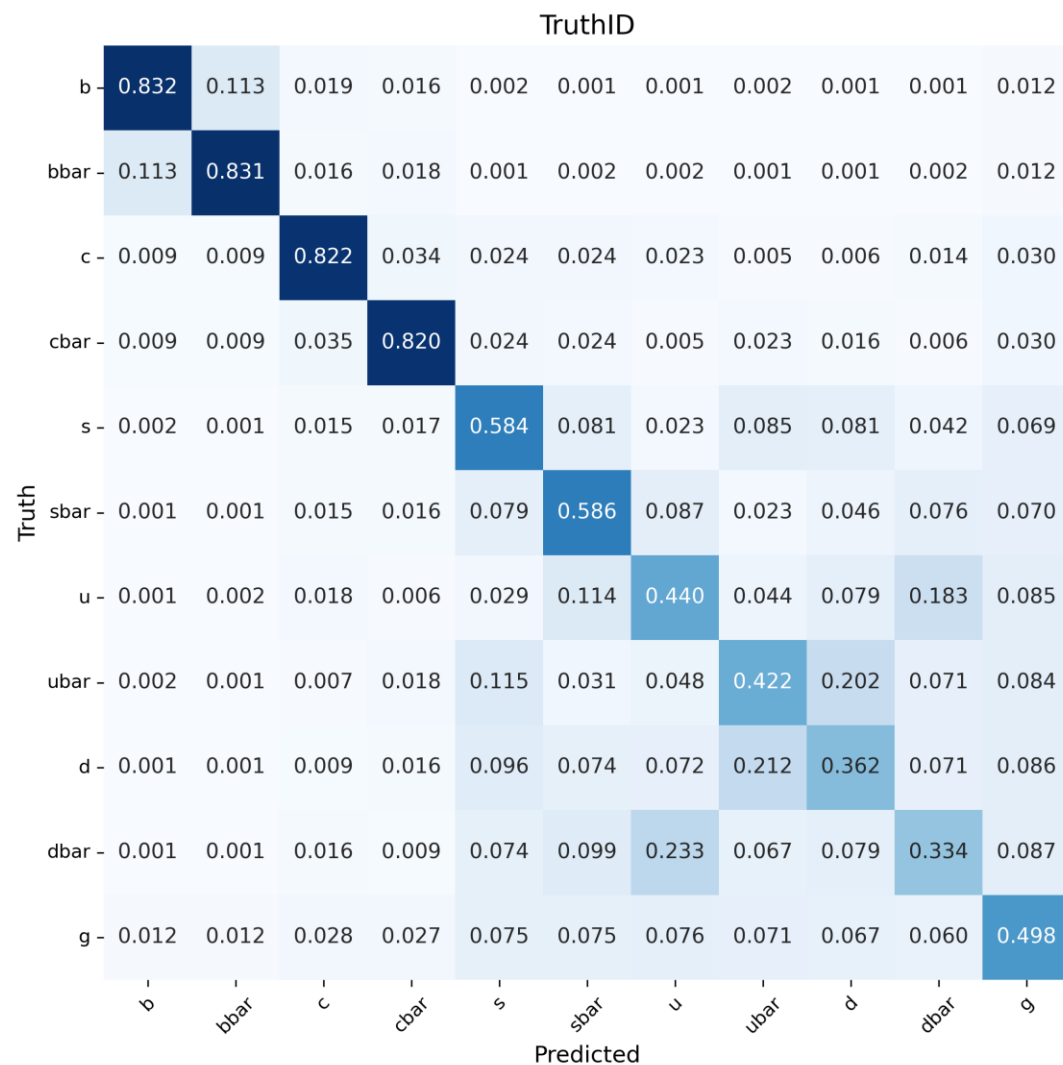
Rank	Feature Name	Shuffle	Set to Zero	Single Random	Random Noise
1	pfo_c_energy	0.2826	0.3521	0.2745	0.2994
2	pfo_c_pt	0.2108	0.2822	0.1929	0.2657
3	pfo_charge	0.1902	0.1780	0.2079	0.1775
4	pfo_c_rel_energy	0.1792	0.3491	0.2349	0.1841
5	pfo_Rbest_E	0.1775	0.1314	0.1617	0.1811
6	pfo_c_rel_pt	0.1702	0.2762	0.1397	0.1626
7	pfo_c_deltaR	0.1323	0.2431	0.1327	0.2203
8	pfo_px	0.1144	0.0894	0.1309	0.1593
9	pfo_py	0.1055	0.0872	0.1365	0.1698
10	pfo_Rbest_isPion	0.1042	0.1251	0.1168	0.0879
11	pfo_z0	0.0955	0.0738	0.3299	0.3365
12	pfo_d0	0.0952	0.0742	0.3151	0.3433
13	pfo_pz	0.0910	0.0630	0.1077	0.1618
14	pfo_dphi	0.0810	0.0525	0.1833	0.2034
15	pfo_deta	0.0727	0.0546	0.1774	0.2132
16	pfo_Rbest_isChargedKaon	0.0334	0.0347	0.0680	0.0787
17	pfo_z0err	0.0328	0.0108	0.2769	0.3107
18	pfo_d0err	0.0327	0.0209	0.2901	0.2823
19	pfo_Rbest_isProton	0.0270	0.0209	0.0455	0.0870
20	pfo_c_Ecal	0.0179	0.0204	0.0614	0.0461
21	pfo_c_Hcal	0.0099	0.0099	0.0845	0.0976
22	pfo_Rbest_isElectron	0.0086	0.0097	0.0765	0.1014
23	pfo_Rbest_isMuon	0.0068	0.0070	0.0340	0.0488
24	pfo_c_Eclusize	0.0061	0.0073	0.0152	0.0090
25	pfo_c_Hclusize	0.0042	0.0072	0.0660	0.0542
Take: 362.892255854 s					

Ranking conclusion

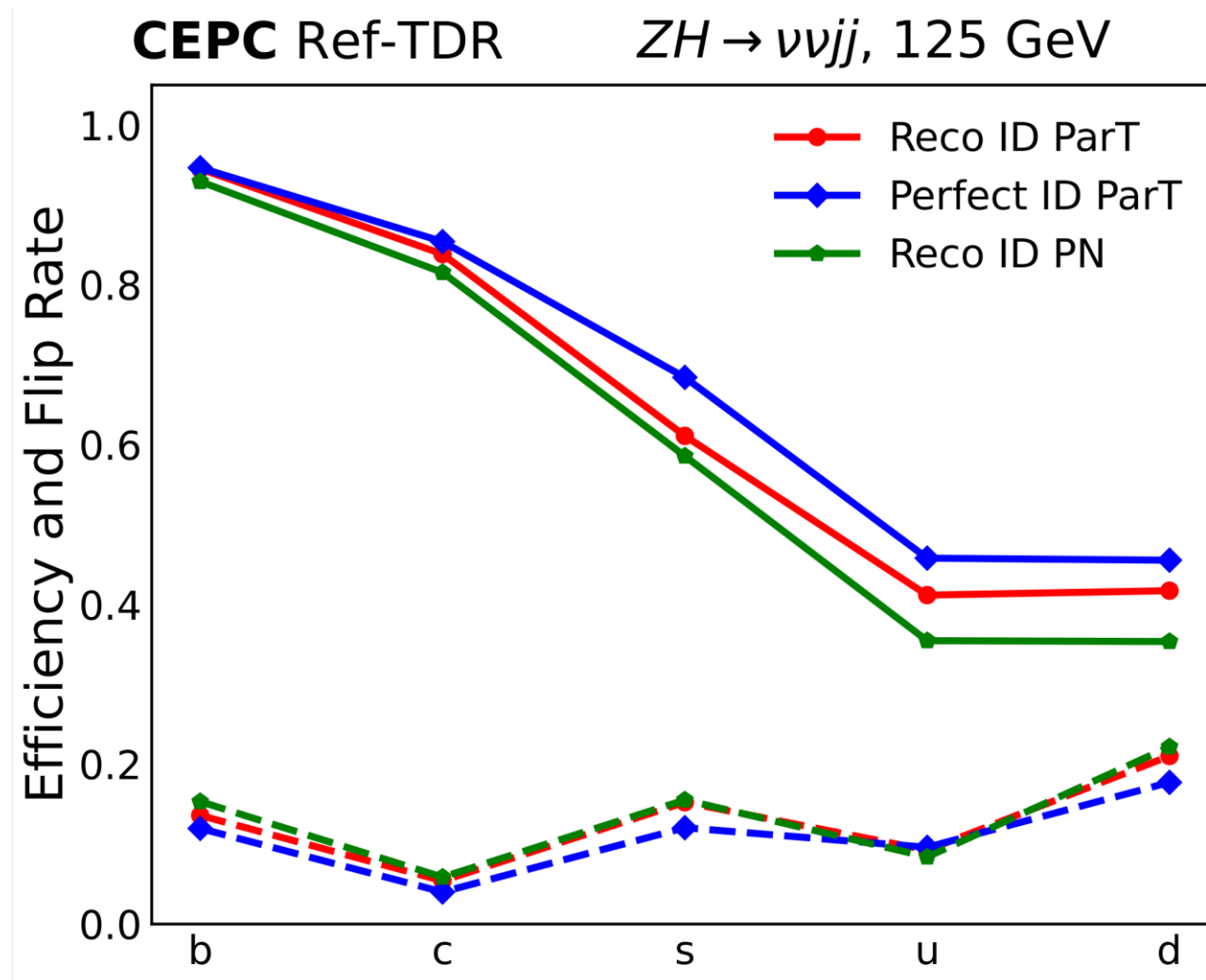
- Shuffle got smallest loss
 - Other method introduce extra loss
- If $D0/Z0/D0err/Z0err$ value is messed up, loss is largest (~ 0.3)
 - Consistent with Shap conclusion
- Taking Shap, Shuffle and Replace together:
 - Shuffle provide “unique” feature
 - Shap provide “decisive” feature
 - Replace provide “fragile” feature
 - showing extreme sensitivity for $d0/z0$.

Confusion Matrix

TruthID metric: 0.5936
 RecoID metric: 0.5562
 RecoID no logE metric: 0.5513
 Reco PN metric: 0.5356



10 points plot

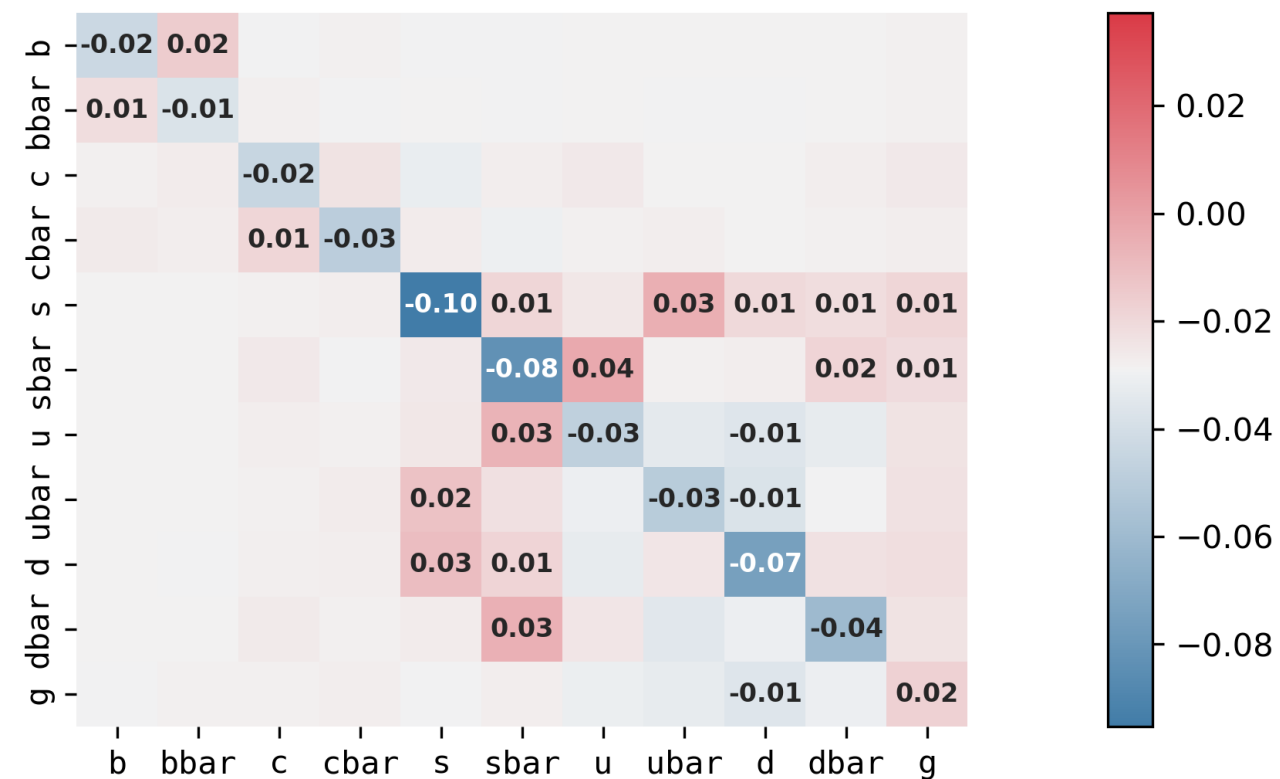


Transition matrix difference

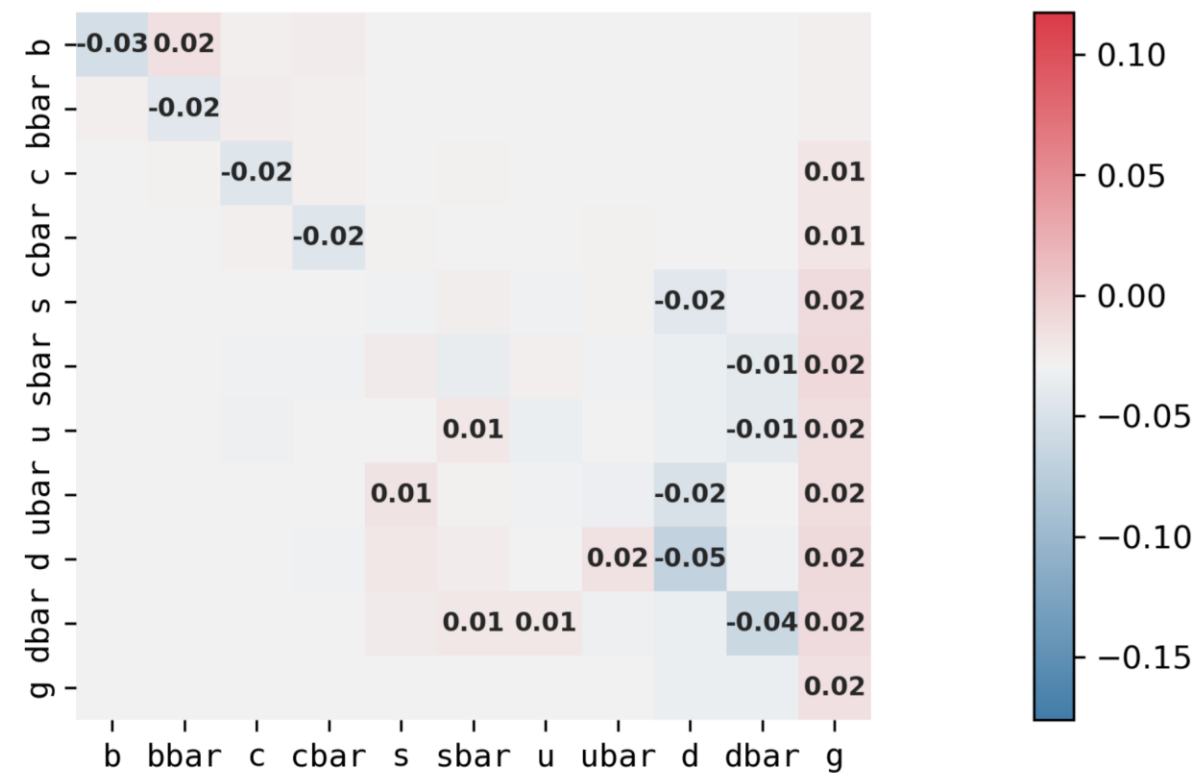
Truth ID ParT – Reco ID ParT.

Reco ID ParT – Reco ID PN.

Reco ID - Baseline Difference



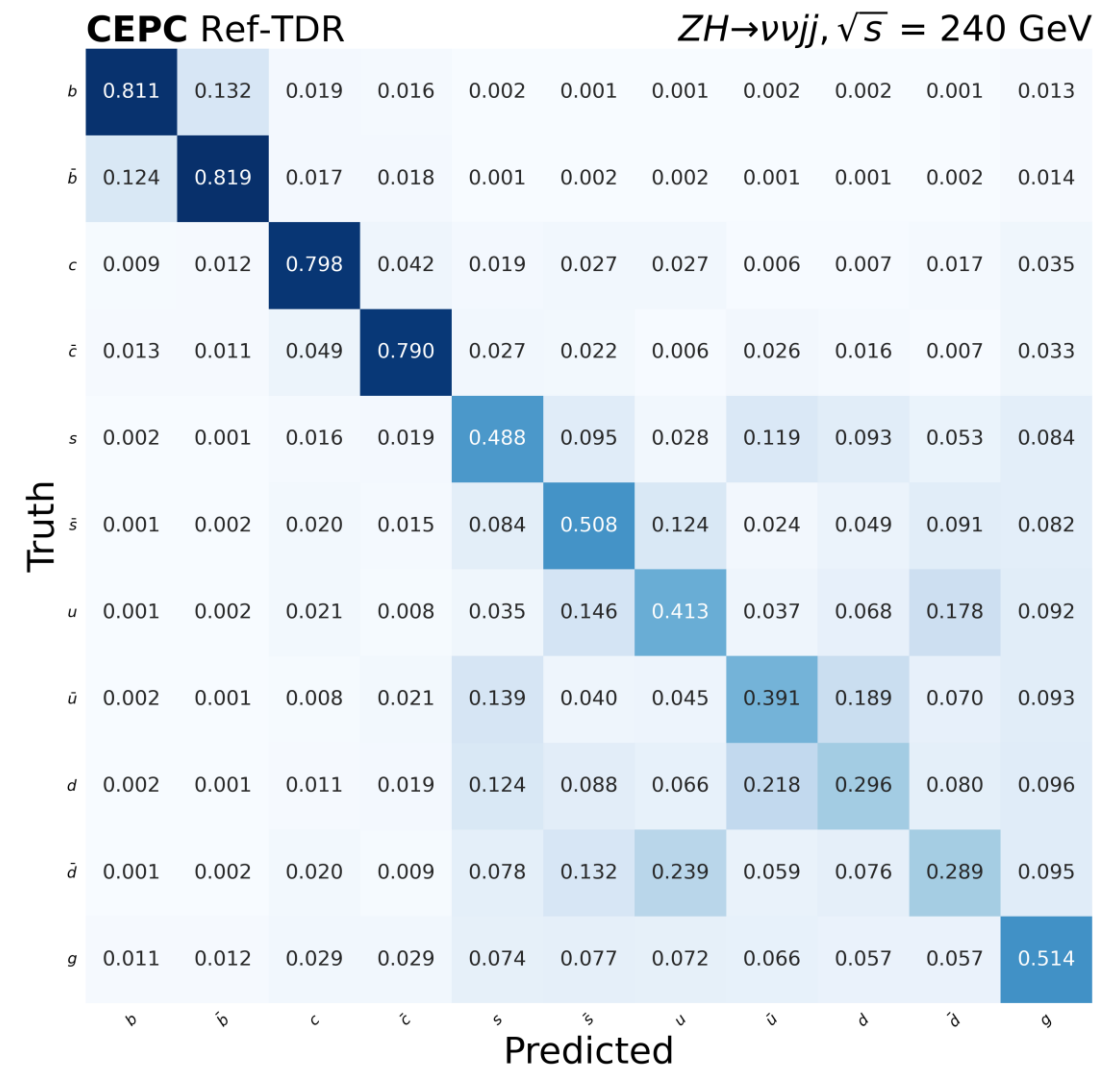
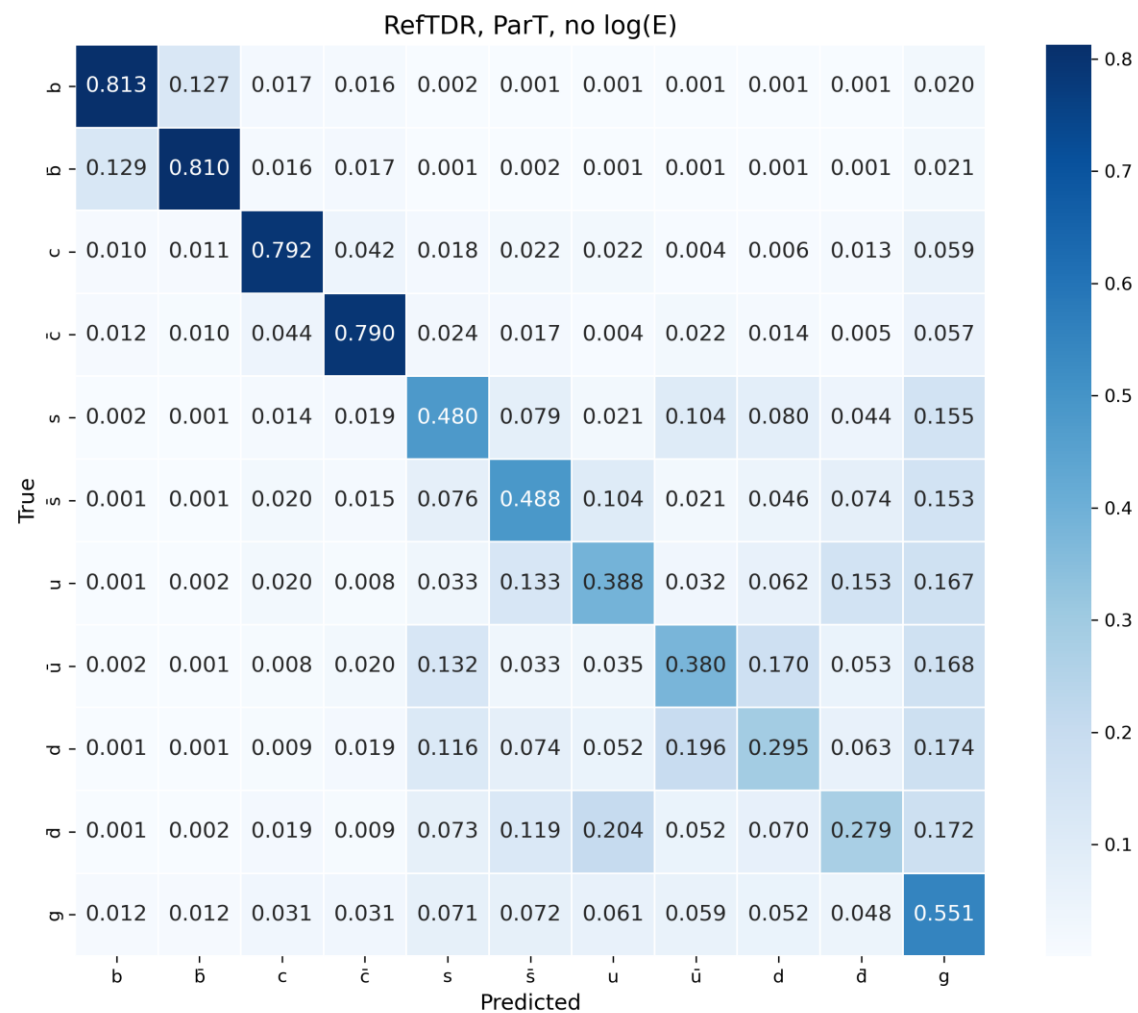
Reco ID PN - Baseline Difference



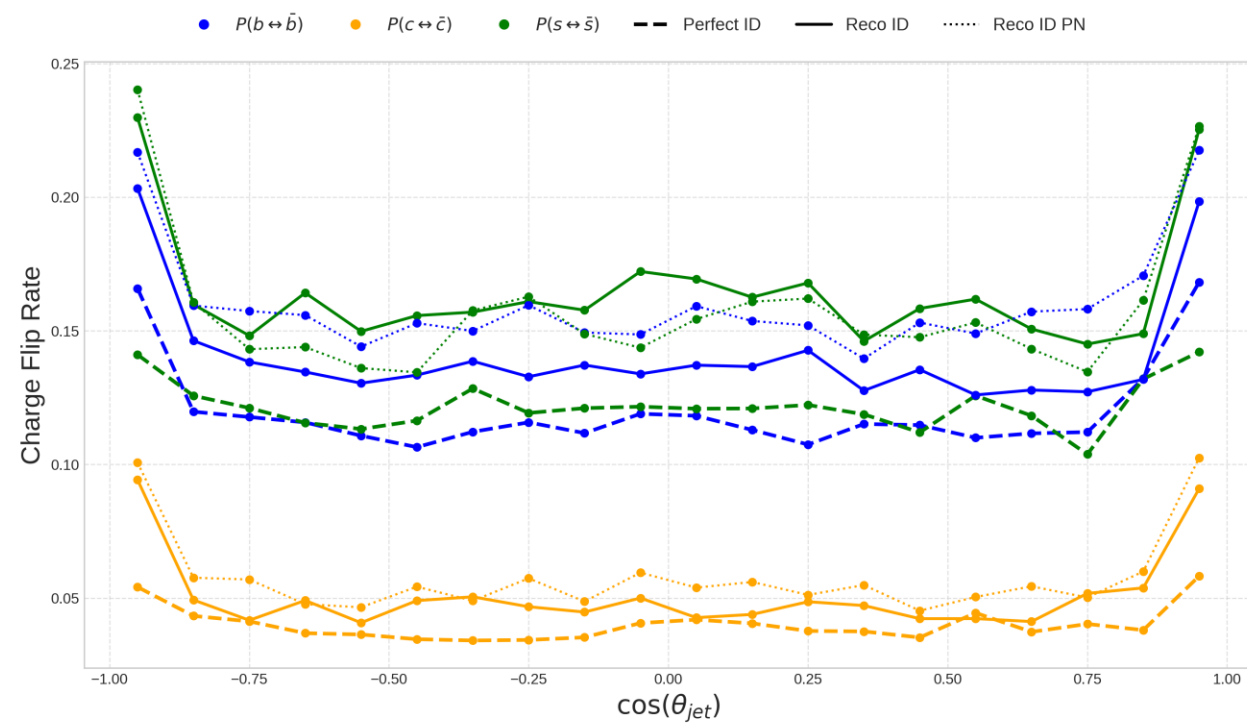
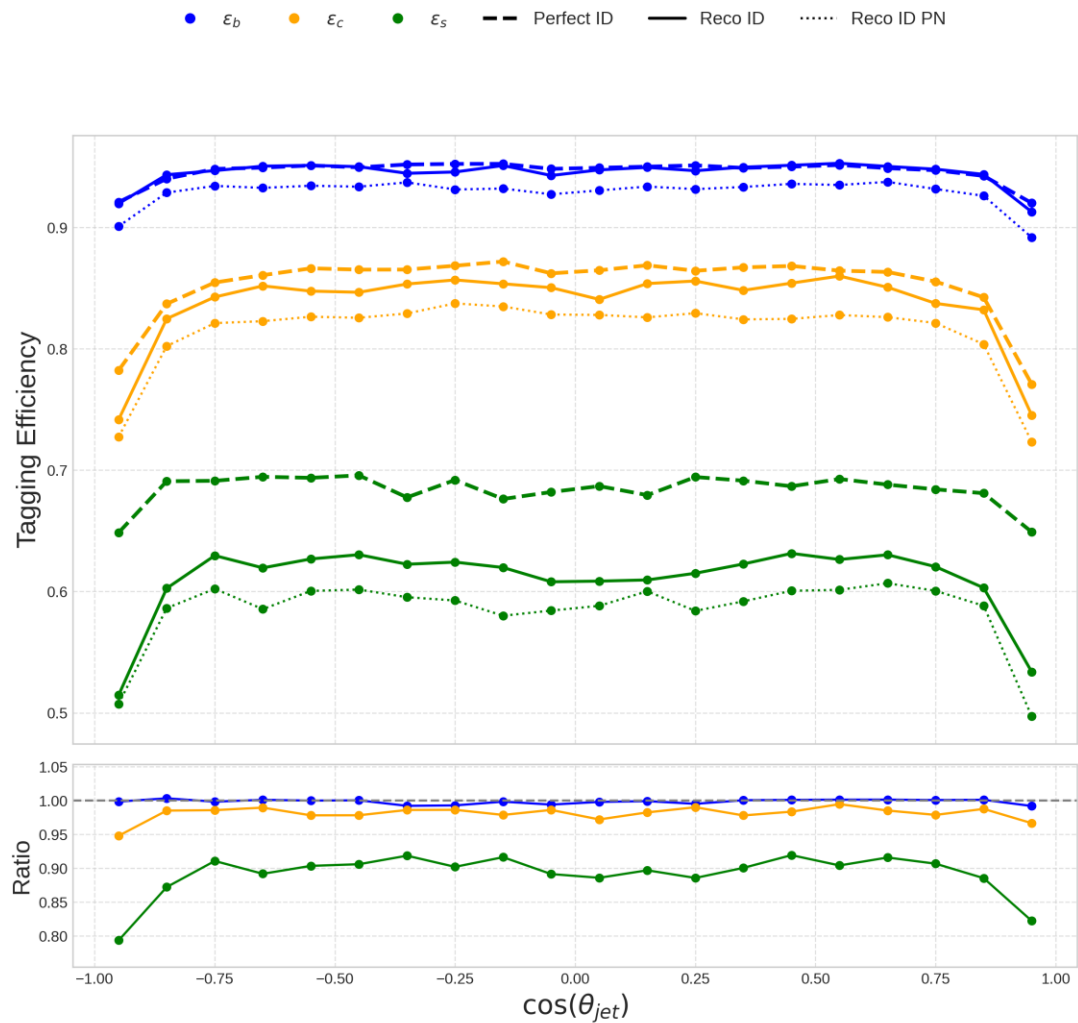
Impact of no log(E)



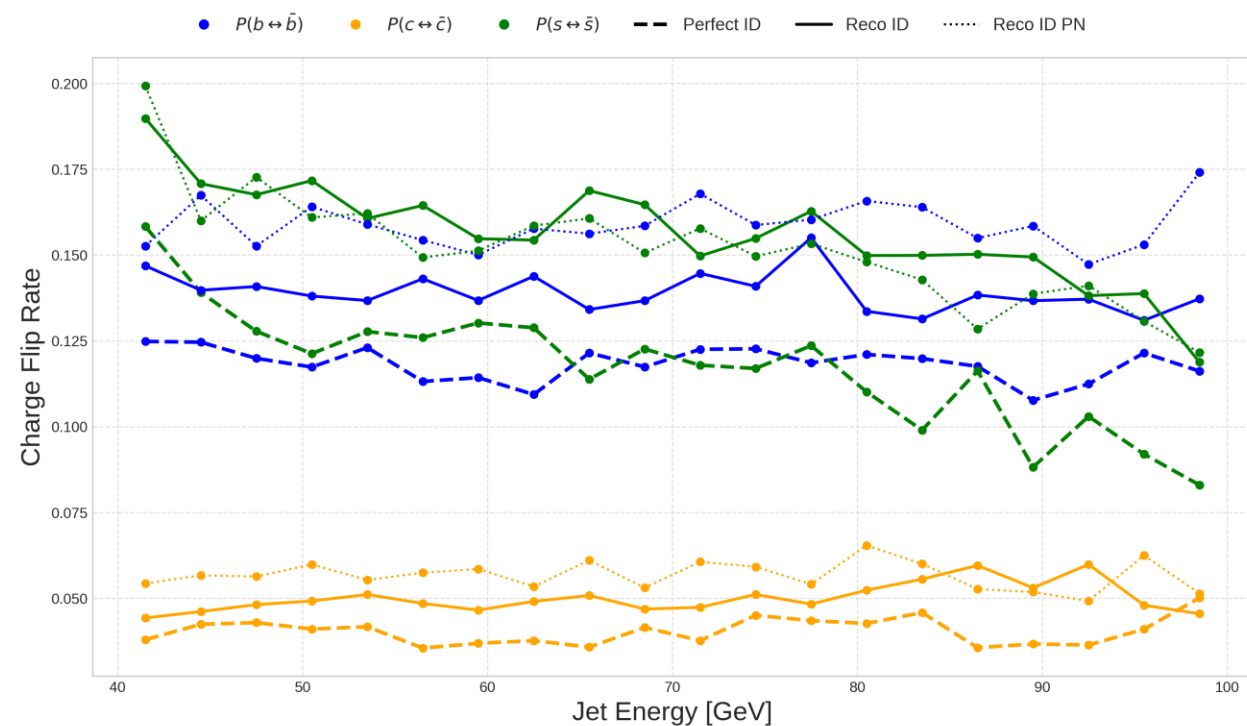
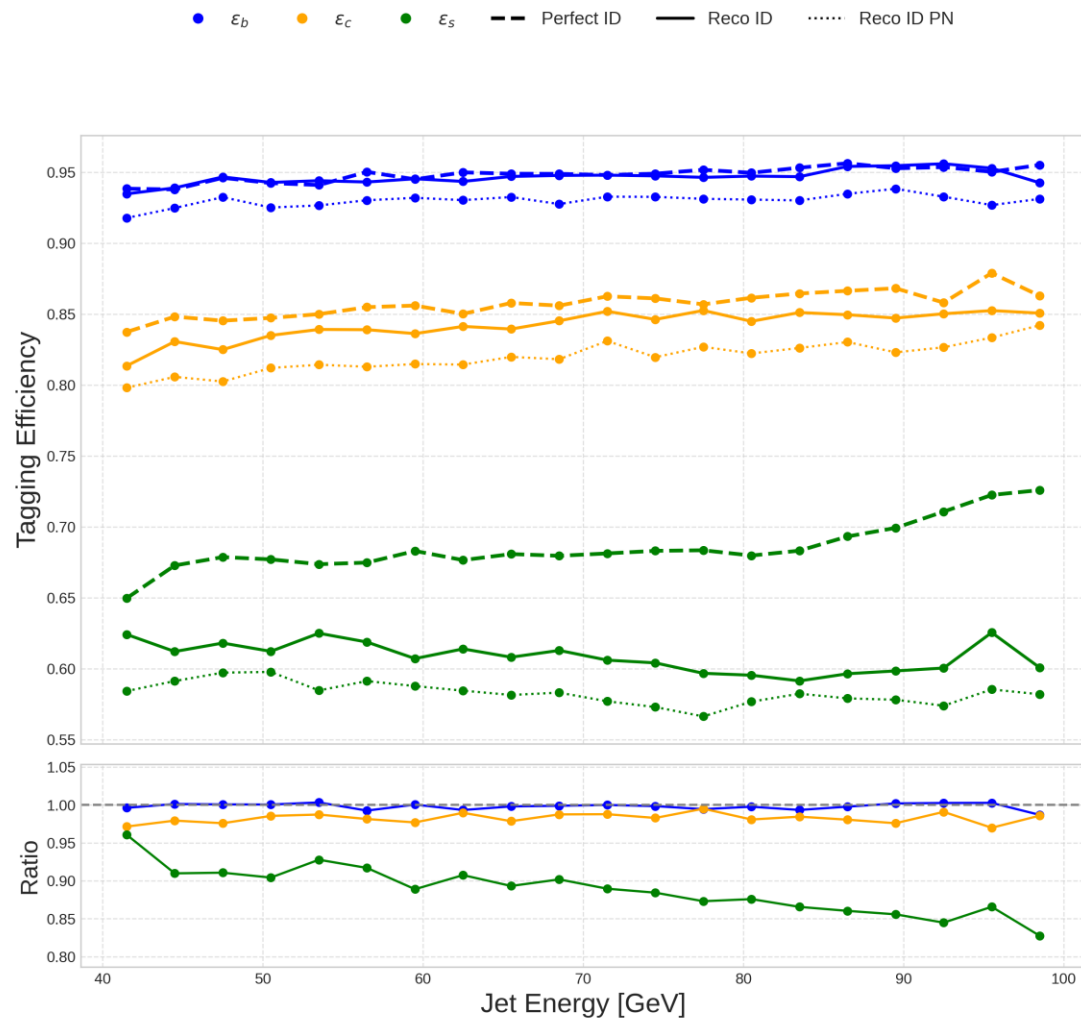
RecoID metric: 0.5562
 RecoID no logE metric: 0.5513
 Worse uds performance;



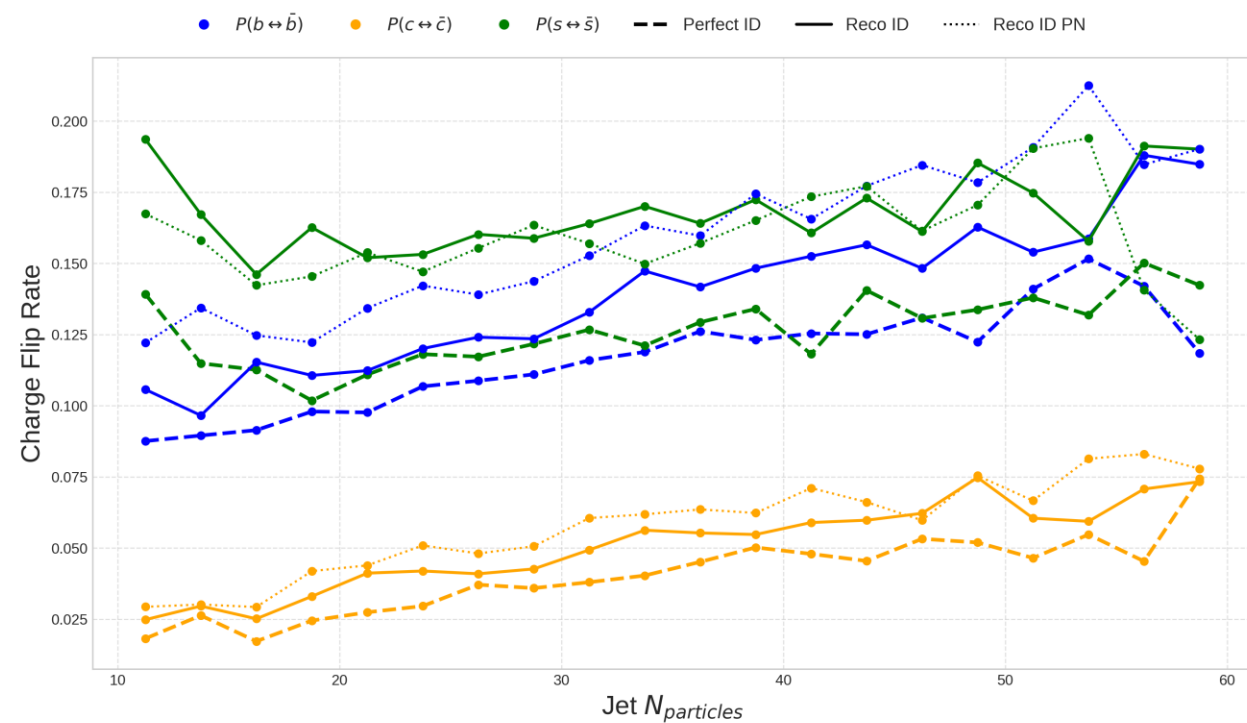
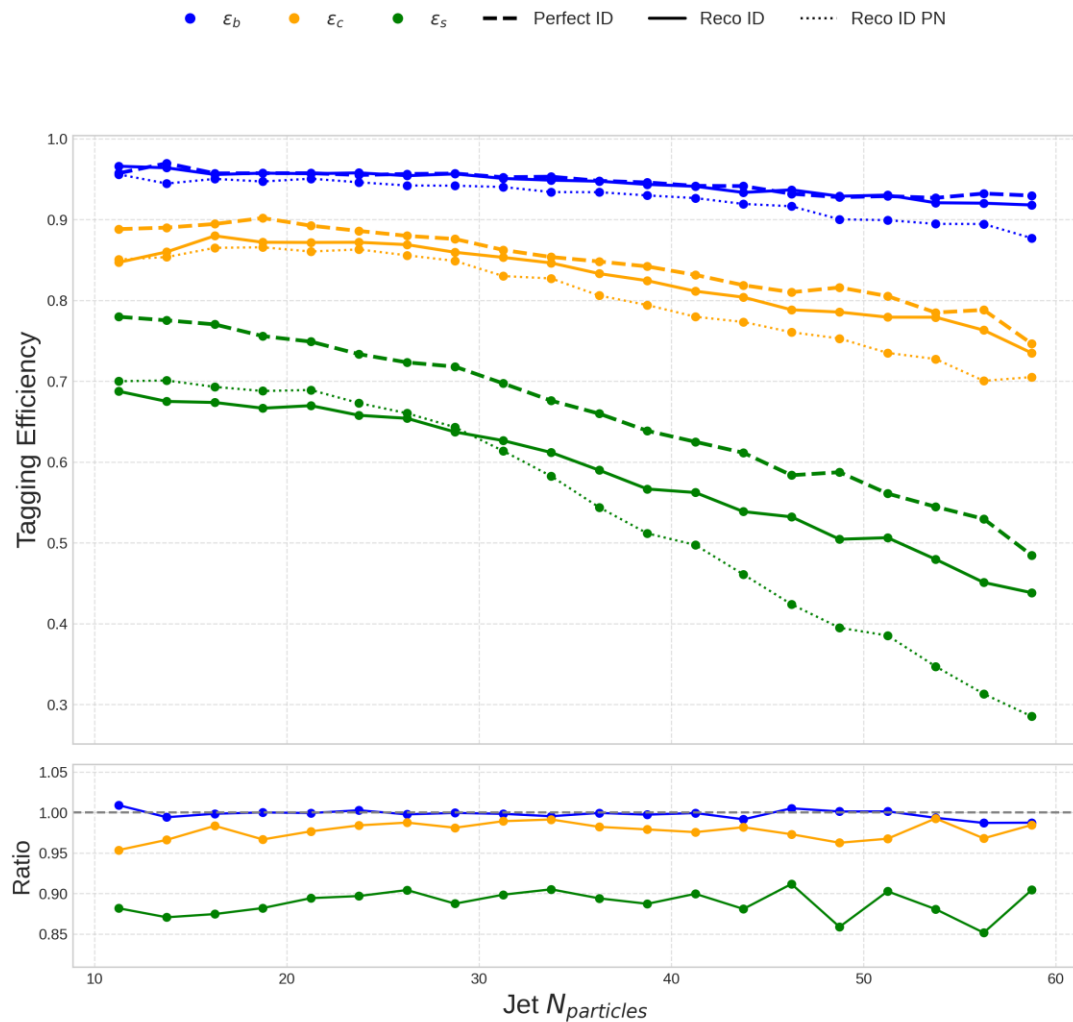
Jet Eff-Flip rate-Costheta



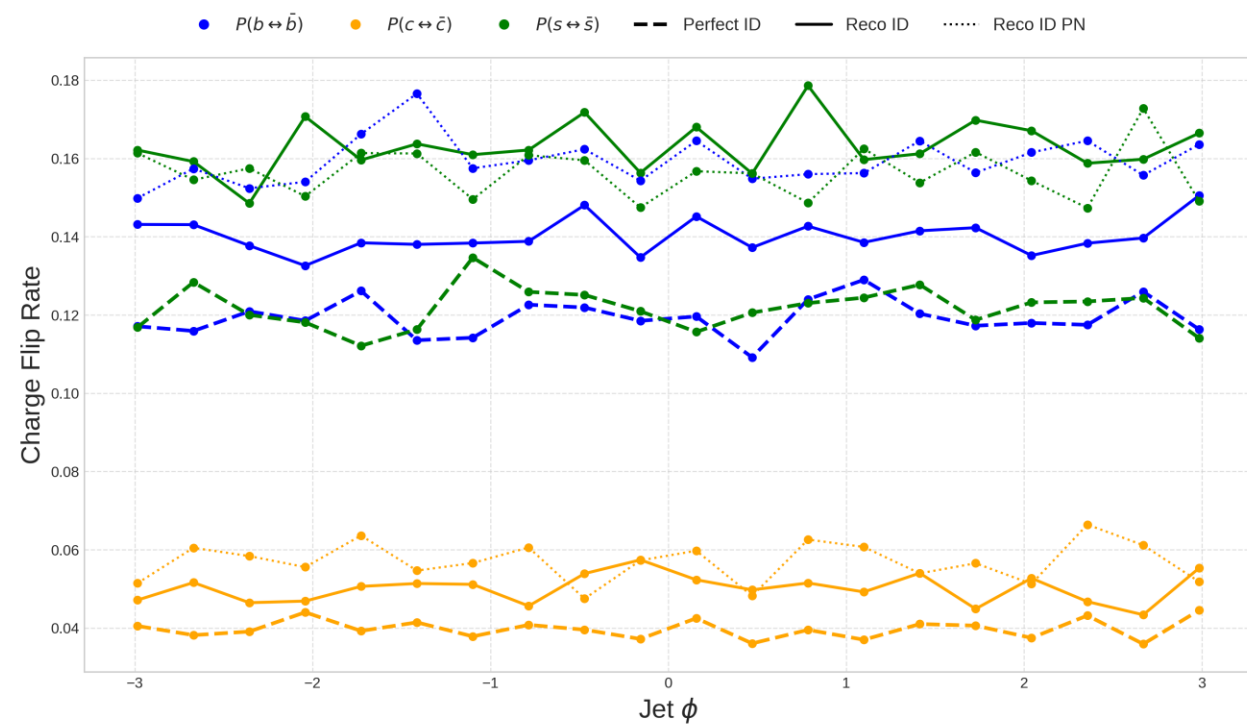
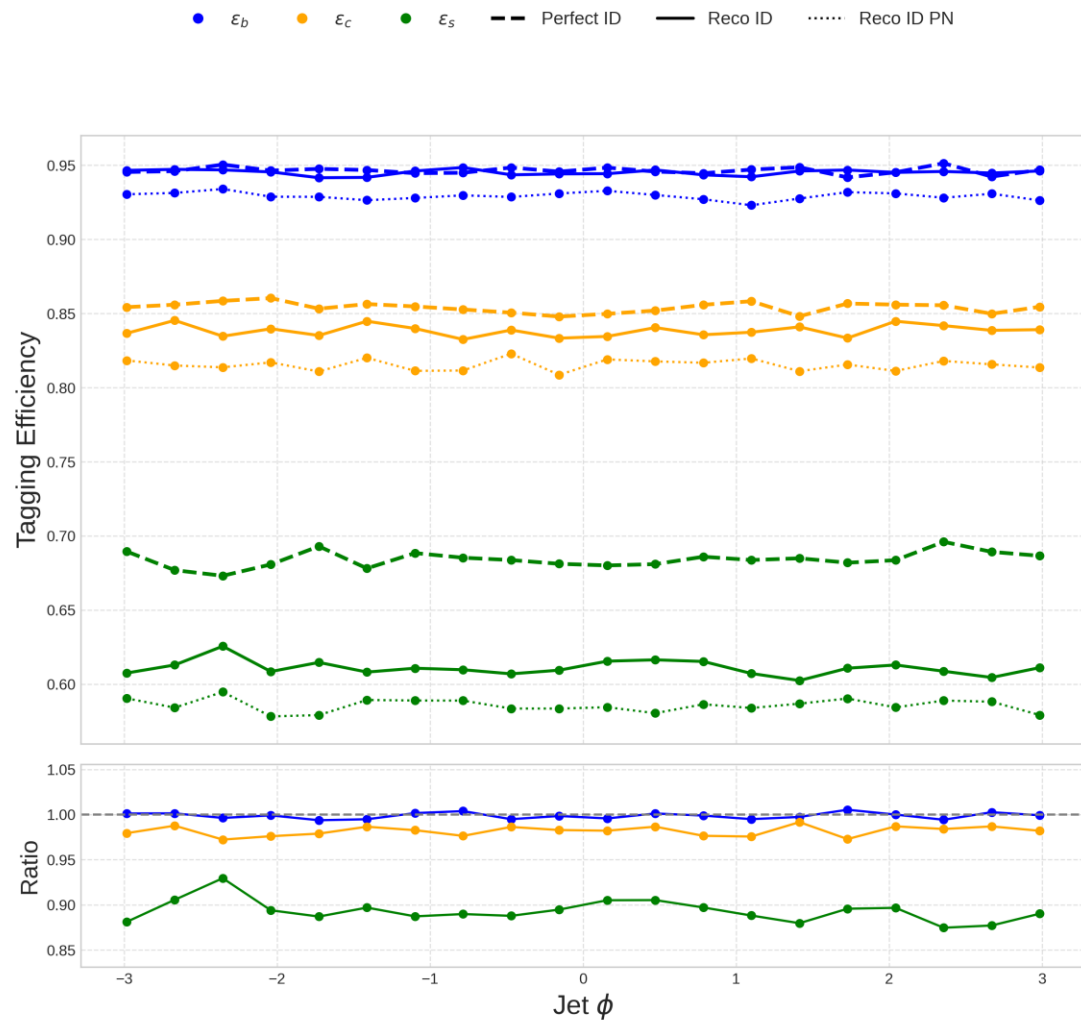
Jet Eff-Flip rate- Jet Energy



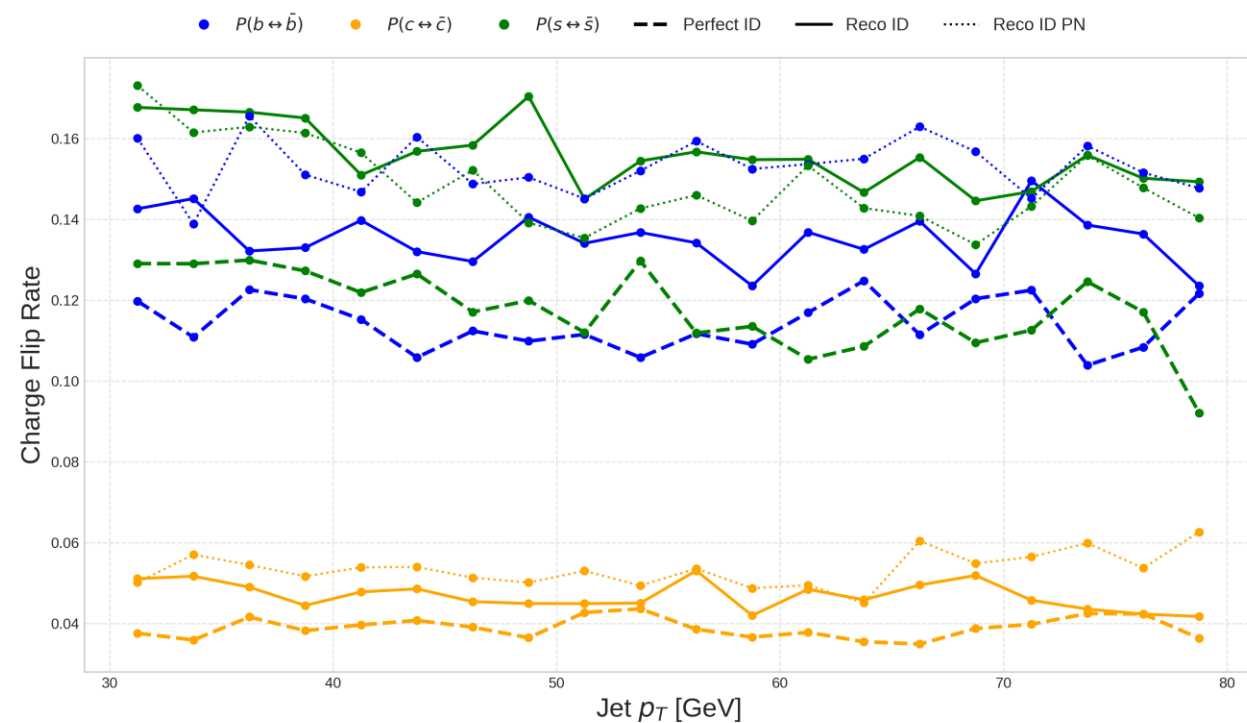
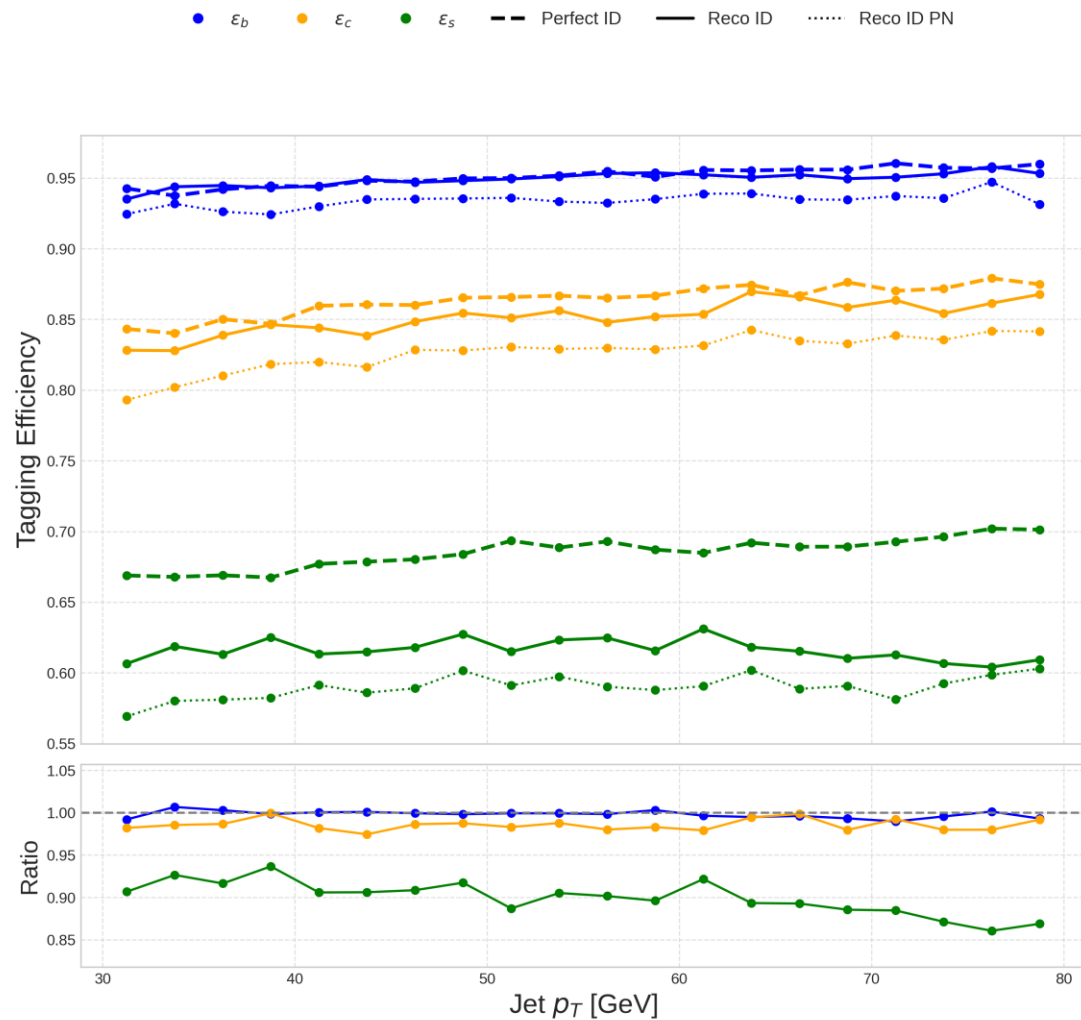
Jet Eff-Flip rate- Jet NPFOs



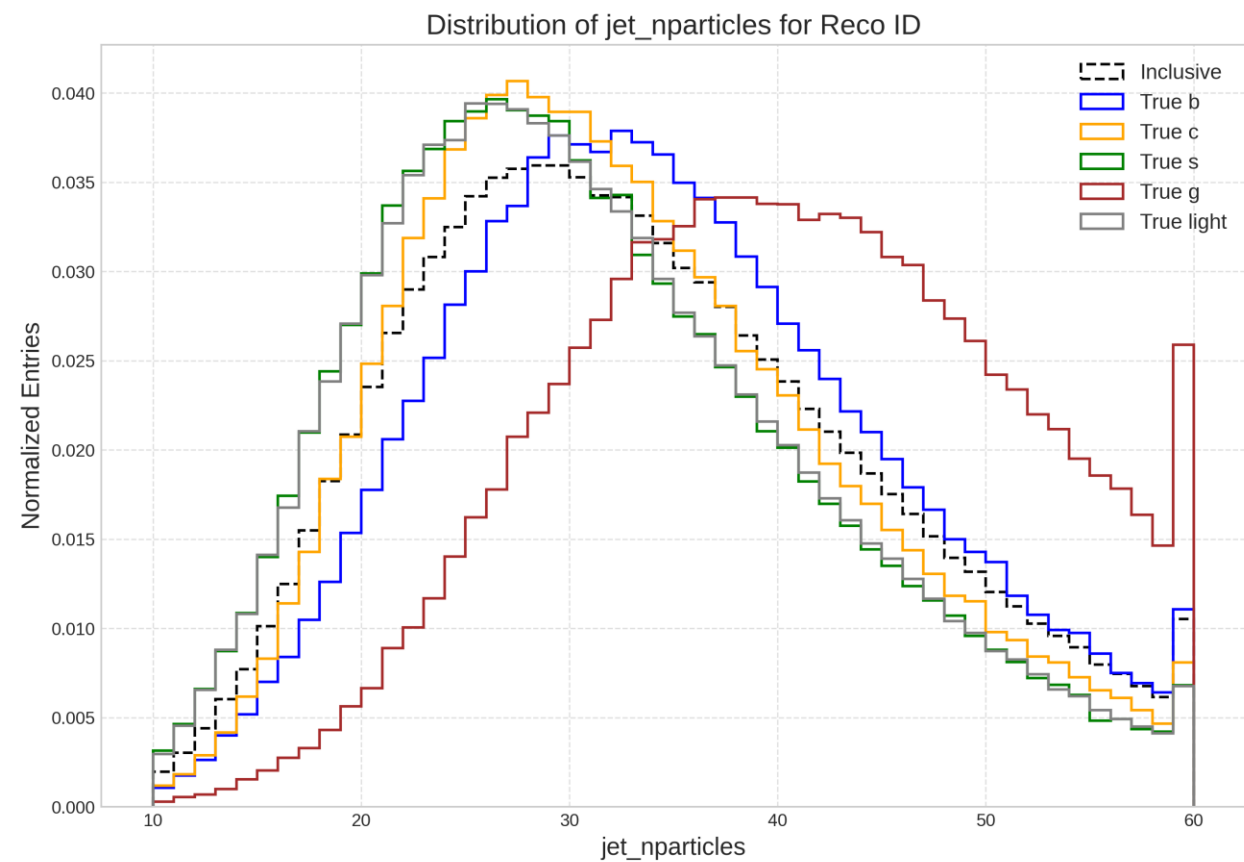
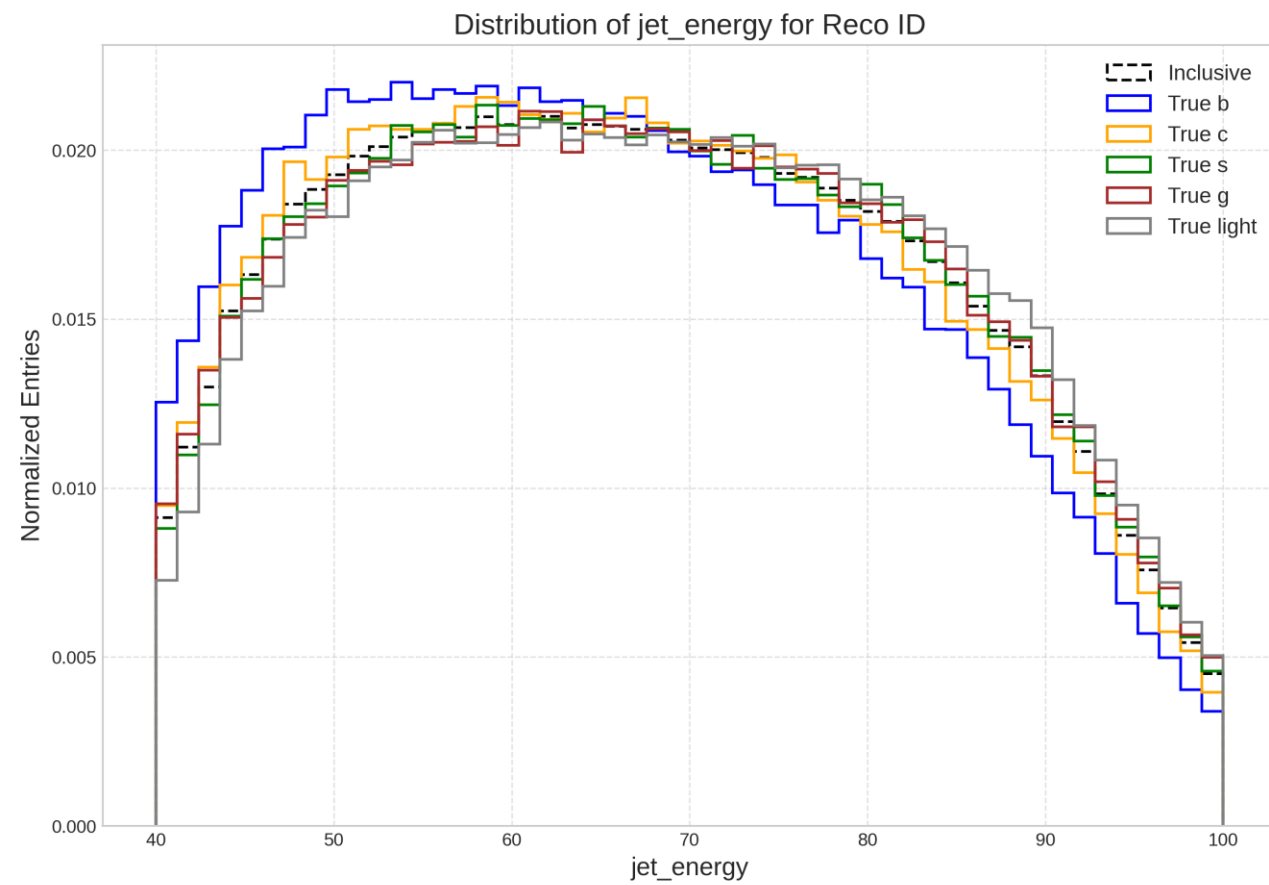
Jet Eff-Flip rate- Jet Phi



Jet Eff-Flip rate- Jet Pt



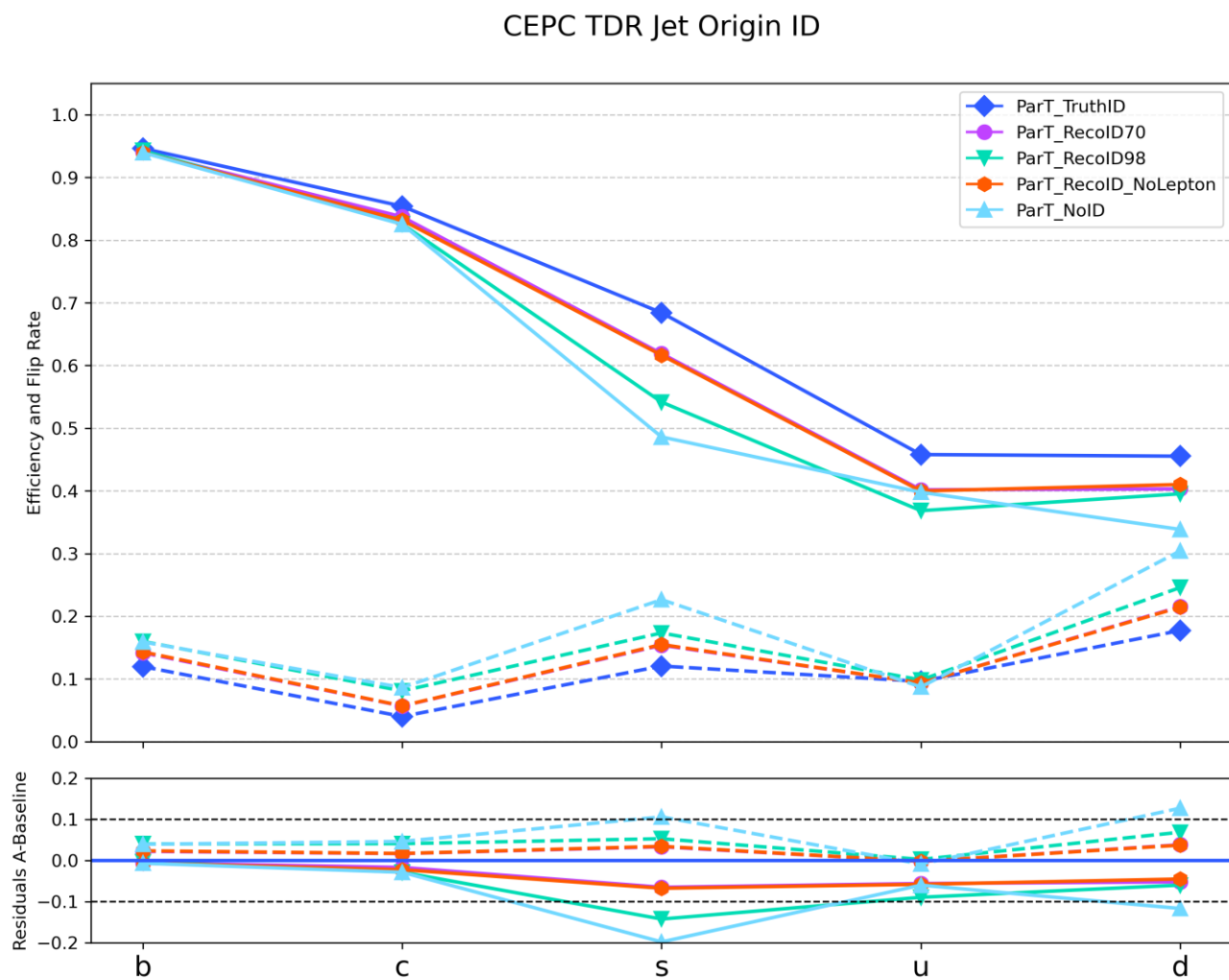
Kinematics sanity check:



Comparisons done before

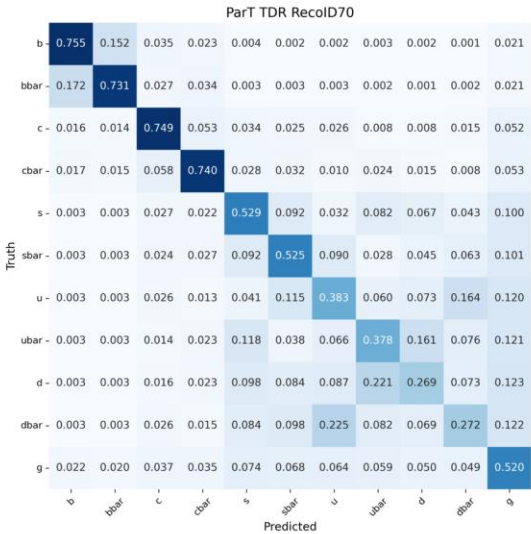


Truth: 0.5936
Reco70: 0.5510
Nolep: 0.5494
Reco98: 0.5153
NoID: 0.4825



Results from YF

Results from YF

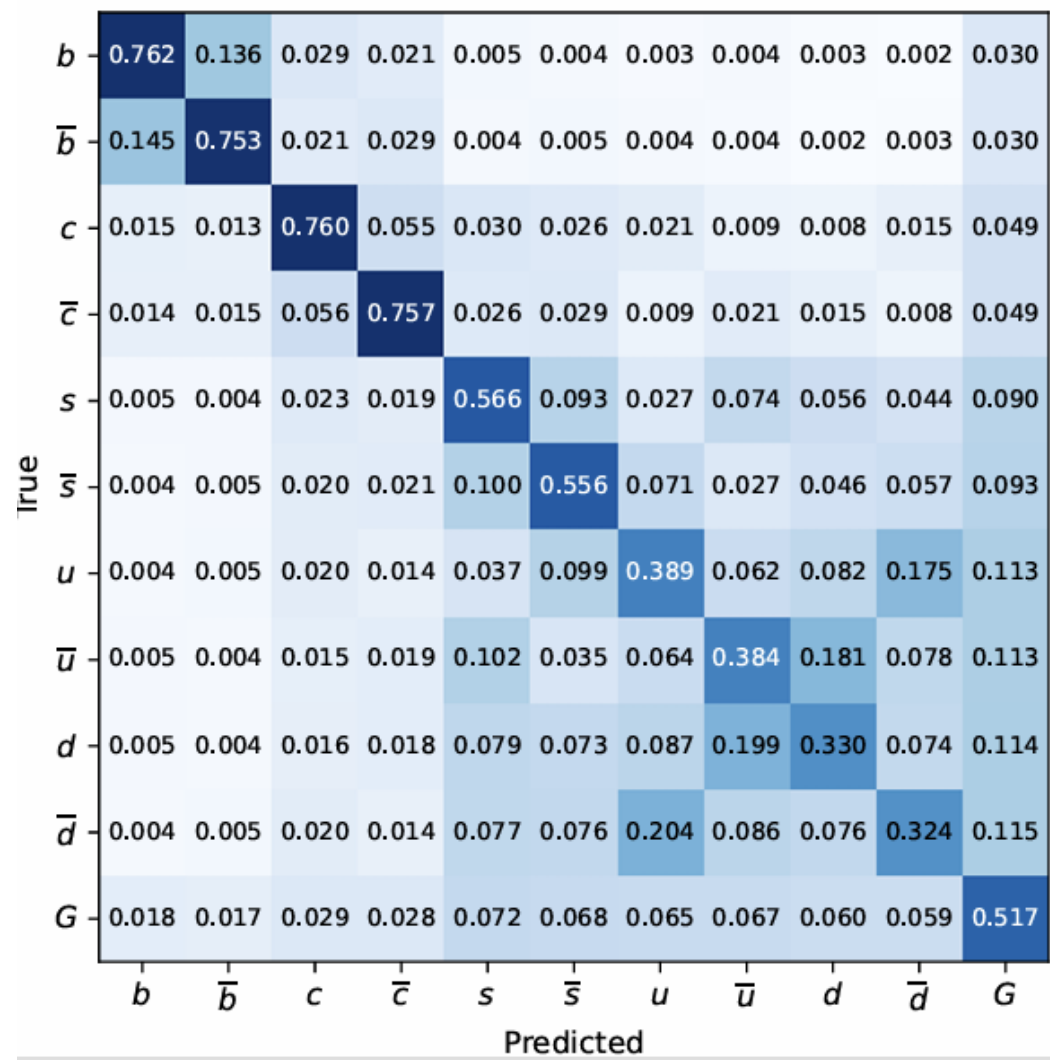


- ParT TDR RecoID70: 0.5319
- PN TDR TruthID: 0.5486
- PN TDR RecoID70: 0.5075
- PN TDR RecoID70Charged: 0.4952
- PN CDR TruthID: 0.5285

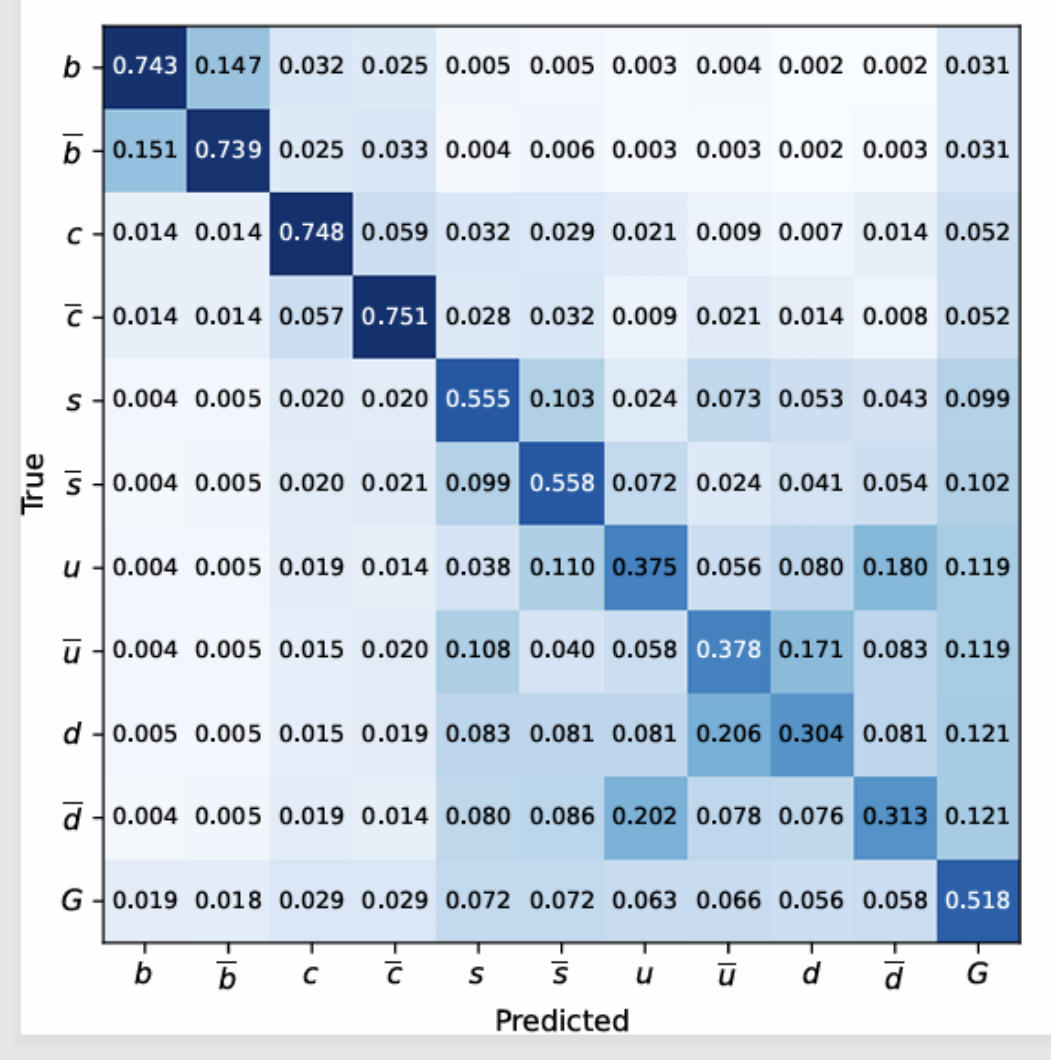
- Input variables slightly different with my result;
- But difference between processes can be a cross check.

Results from Jialin, CDR fast

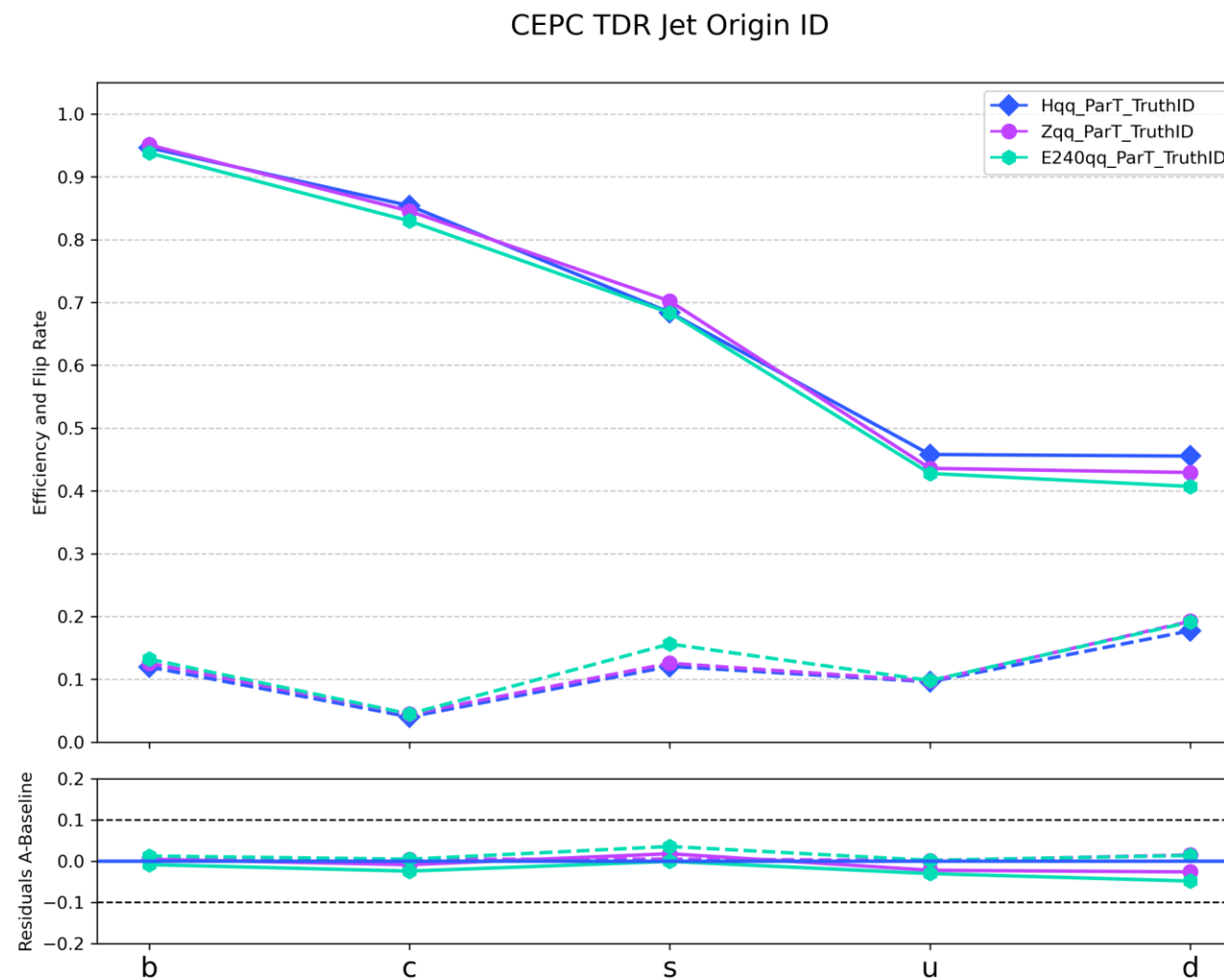
CDR, fast, truth ID, ParT



CDR, fast, truth ID, PN



Extrapolation to different process



Check items



- Full & Fast
- TDR & CDR
- PN/ParT/MIParT/ParT-ee
- Truth/Reco PID
- MC Generator(Whizard, Madgraph)
- Data scaling...