# CEPC

Jets, samples and Wednesday working meeting

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- Yuexin’s 1-1 report
- Fcc-ee status
- CEPC JOI RecoID in Zpole

# Fcc-ee Status

- Third Annual US Higgs Factory Future Circular Collider Workshop
- arXiv:2505.00272 Future Circular Collider Feasibility Study Report
- arXiv:2504.11103 Impact of tracker- and calorimeter-detector performance on jet flavor identification and Higgs physics analyses
- https://repository.cern/communities/fcc-ped-sub/records
  - CDS Record for Fcc physics. Recommended to read for analyzers.
  - Hinclusive Z(qq, comb): https://repository.cern/records/c5dn3-c0s73
  - Hmass, inclusive Z(ll): https://repository.cern/records/e9wsh-tb178
  - H(bb,cc,gg): https://repository.cern/records/3jjdh-6fz97
  - Hinvisible: https://repository.cern/records/9b128-qqc43/

# Fcc-ee: Current setup in analysis

| | |
|---|---|
| Fcc-ee: | 10.8iab@ZH240, 3.1iab@ttbar |
| CEPC refTDR: | 20iab@ZH240, 1iab@ttbar |

- Generator: Whizard3.1.2+Pythia6
- Fast simulation: Delphes+IDEA detector
- Vertex resolution: 3um
- In concept, Fcc has better vertex and Hcal detector compared to CEPC.
- Most their analysis done in fast simulation.

**Table 1:** The baseline FCC-ee operation model with four interaction points, showing the centre-of-mass energies, design instantaneous luminosities for each IP, and integrated luminosity per year summed over 4 IPs. The integrated luminosity values correspond to 185 days of physics per year and a 75% operational efficiency (i.e., $1.2 \times 10^7$ seconds per year) [15], in the Z, WW, ZH, and $t\bar{t}$ baseline sequence. The last two rows indicate the total integrated luminosity and number of events expected to be produced in the four detectors. The number of WW events includes all $\sqrt{s}$ values from 157.5 GeV up.

| Working point | Z pole | WW thresh. | ZH | $t\bar{t}$ | |
|---|---|---|---|---|---|
| $\sqrt{s}$ (GeV) | 88, 91, 94 | 157, 163 | 240 | 340–350 | 365 |
| Lumi/IP ($10^{34}$ cm$^{-2}$s$^{-1}$) | 140 | 20 | 7.5 | 1.8 | 1.4 |
| Lumi/year (ab$^{-1}$) | 68 | 9.6 | 3.6 | 0.83 | 0.67 |
| Run time (year) | 4 | 2 | 3 | 1 | 4 |
| Integrated lumi. (ab$^{-1}$) | 205 | 19.2 | 10.8 | 0.42 | 2.70 |
| Number of events | $6 \times 10^{12}$ Z | $2.4 \times 10^8$ WW | $2.2 \times 10^6$ ZH + 65k WW $\to$ H | $2 \times 10^6$ $t\bar{t}$ + 370k ZH + 92k WW $\to$ H | |

The nominal energy resolution for the IDEA prototype calorimeters has been assumed from Ref. [30]. In the electromagnetic crystal calorimeter:

$$\sqrt{a^2E^2 + b^2E + c^2} \quad (1)$$

with $a = 0.005$, $b = 0.03$ and $c = 0.002$.

In the hadronic dual-readout calorimeter:

$$\sqrt{d^2E^2 + e^2E + f^2} \quad (2)$$

# Fcc-ee: Higgs mass

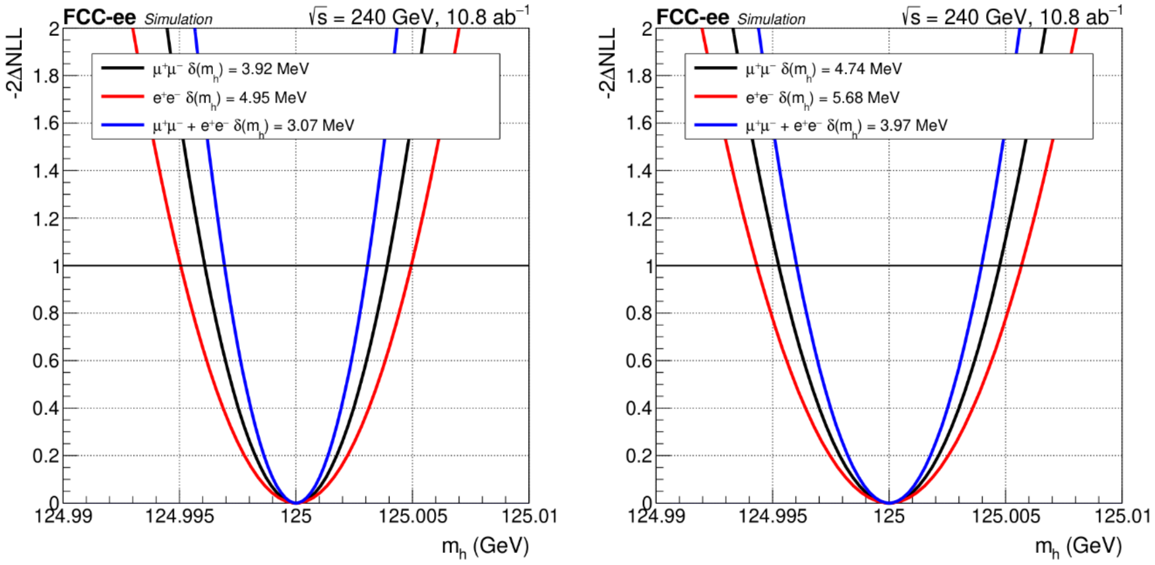



**Fig. 23** Likelihood scan statistical-only (left) and statistical+systematics (right).

**Table 5** Statistical (stat+syst) uncertainty on the Higgs mass (MeV) for various fit configurations. Fits are performed using the nominal categorization unless stated otherwise. The values in brackets represent the statistical+systematic uncertainties. Values are normalized to an integrated luminosity of 10.8 ab$^{-1}$.

| **Fit configuration** | $\mu^+\mu^-$ channel | $e^+e^-$ channel | combination |
|---|---|---|---|
| Nominal | 3.92 (4.74) | 4.95 (5.68) | 3.07 (3.97) |
| Degradation electron resolution | 3.92 (4.74) | 5.79 (6.33) | 3.24 (4.12) |
| Magnetic field 3T | 3.22 (4.14) | 4.11 (4.83) | 2.54 (3.52) |
| CLD 2T (silicon tracker) | 5.11 (5.73) | 5.89 (6.42) | 3.86 (4.55) |
| BES 6% uncertainty | 3.92 (4.79) | 4.95 (5.92) | 3.07 (3.98) |
| No beam energy spread | 2.11 (3.31) | 2.93 (3.88) | 1.71 (2.92) |
| Ideal resolution | 3.12 (3.95) | 3.58 (4.52) | 2.42 (3.40) |
| Freeze backgrounds | 3.91 (4.74) | 4.95 (5.67) | 3.07 (3.96) |
| Remove backgrounds | 3.08 (4.13) | 3.51 (4.58) | 2.31 (3.45) |

# Hadronic decays:

**Table 23**: Expected Precision (%) for the $\sigma(ZH) \times \text{BR}(H \to jj)$ at 68 % CL

| | $H \to b\bar{b}$ | $H \to c\bar{c}$ | $H \to gg$ | $H \to s\bar{s}$ | $H \to \tau\tau$ | $H \to ZZ$ | $H \to WW$ |
|---|---|---|---|---|---|---|---|
| $Z \to ll$ ($l = \mu, e$) | 0.60 | 3.47 | 1.93 | 220 | 2.54 | 7.65 | 1.49 |
| $Z \to qq$ | 0.32 | 3.52 | 3.07 | 410 | 110 | 50 | 8.74 |
| $Z \to \nu\bar{\nu}$ (I) | 0.35 | 2.06 | 1.01 | 100 | 10.6 | 11.4 | 1.28 |
| $Z \to \nu\bar{\nu}$ (II) | 0.33 | 2.27 | 0.94 | 140 | 21.8 | 19.8 | 1.89 |
| Combined ($Z \to \nu\nu$ (I)) | 0.21 | 1.56 | 0.85 | 89 | 2.46 | 6.24 | 0.95 |
| Combined ($Z \to \nu\nu$ (II)) | 0.21 | 1.66 | 0.80 | 105 | 3.97 | 10.1 | 1.16 |

**Table 24**: Relative Uncertainty (%) for the $\sigma_{ZH} \times \mathcal{B}(H \to XX)$ and $\sigma_{\nu_e\bar{\nu}_e} \times \mathcal{B}(H \to XX)$ at 68 % CL

| $\sqrt{s}$ | 240 GeV | | 365 GeV | |
|---|---|---|---|---|
| Integrated luminosity | 10.8 ab$^{-1}$ | | 3.0 ab$^{-1}$ | |
| Channel | $ZH$ | $\nu_e\bar{\nu}_e H$ | $ZH$ | $\nu_e\bar{\nu}_e H$ |
| $H \to b\bar{b}$ | ±0.21 | ±1.89 | ±0.41 | ±0.67 |
| $H \to c\bar{c}$ | ±1.61 | ±19.4 | ±3.13 | ±3.49 |
| $H \to s\bar{s}$ | ±120 | ±990 | ±360 | ±290 |
| $H \to gg$ | ±0.80 | ±5.50 | ±2.21 | ±2.66 |
| $H \to WW$ | ±1.17 | ±15.6 | ±3.18 | ±5.36 |
| $H \to ZZ$ | ±9.94 | ±130 | ±26.0 | ±37.1 |
| $H \to \tau^+\tau^-$ | ±3.67 | $\infty$ | ±11.0 | ±24.2 |

# Hinclusive:

**Presented path to model-independent ZH cross-section at center-of-mass energy of 240(365) GeV**

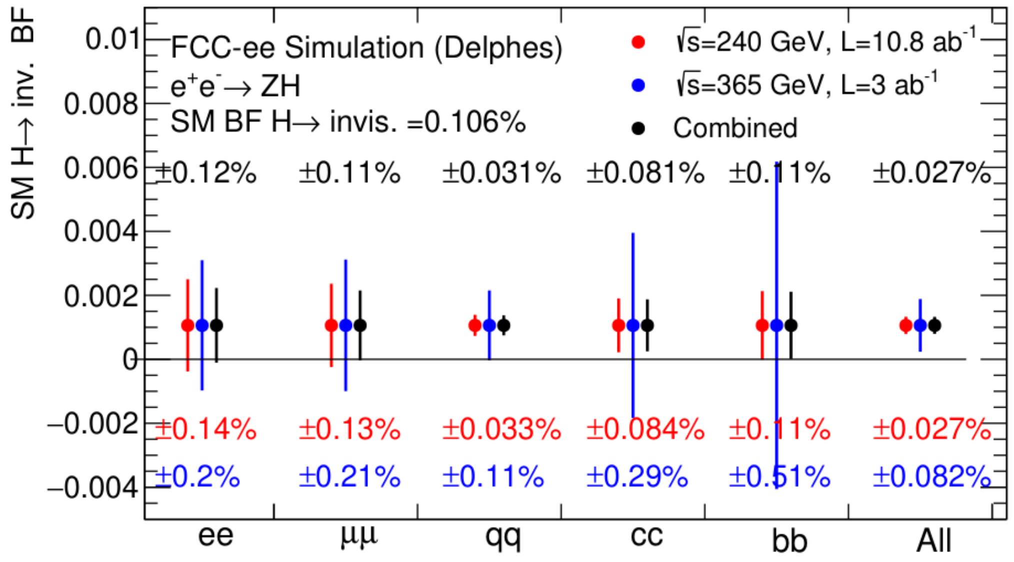
- Hadronic channel 0.38(0.57)%
- Hadronic+leptonic combined uncertainty of 0.31(0.53)%
- Proven to be model-independent within quoted uncertainties

| Channel | Accelerator | Lumi ($fb^{-1}$) | ZH uncertainty (%) | Scaled to FCC (10.8 $ab^{-1}$) |
|---|---|---|---|---|
| Hadronic | CLIC [1] | 500 | 3.65 | 0.79 |
| | ILC [2] | 250 | 2.6/2.4 (+/–) | 0.40/0.37 |
| | FCC (this work) | 10800 | 0.41 | 0.41 |
| Leptonic | ILC [3] | 250 | 2.5/2.9 (+/–) | 0.38/0.44 |
| | FCC (this work) | 10800 | 0.52 | 0.52 |
| Total ZH | ILC/CLIC [4] | 250 | 2.0/2.0 (+/–) | 0.30 |
| | FCC CDR | 5000 | 0.50 | 0.34 |
| | FCC (this work) | 10800 | 0.32 | 0.32 |



Full paper ready with systematic study.

# Hinvisible:



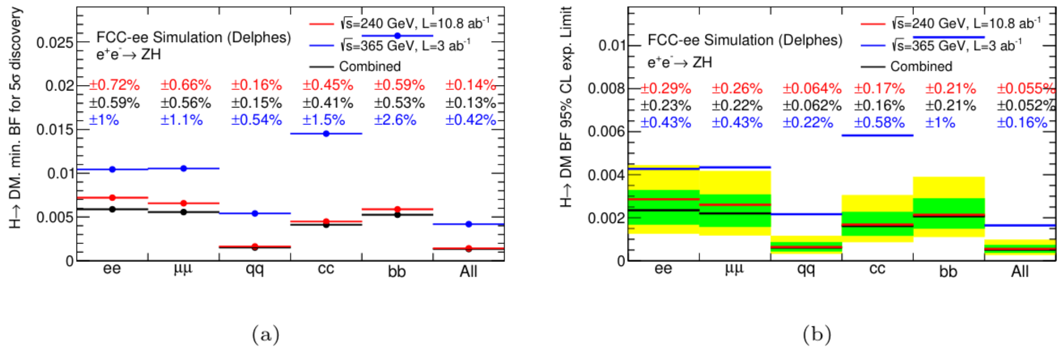



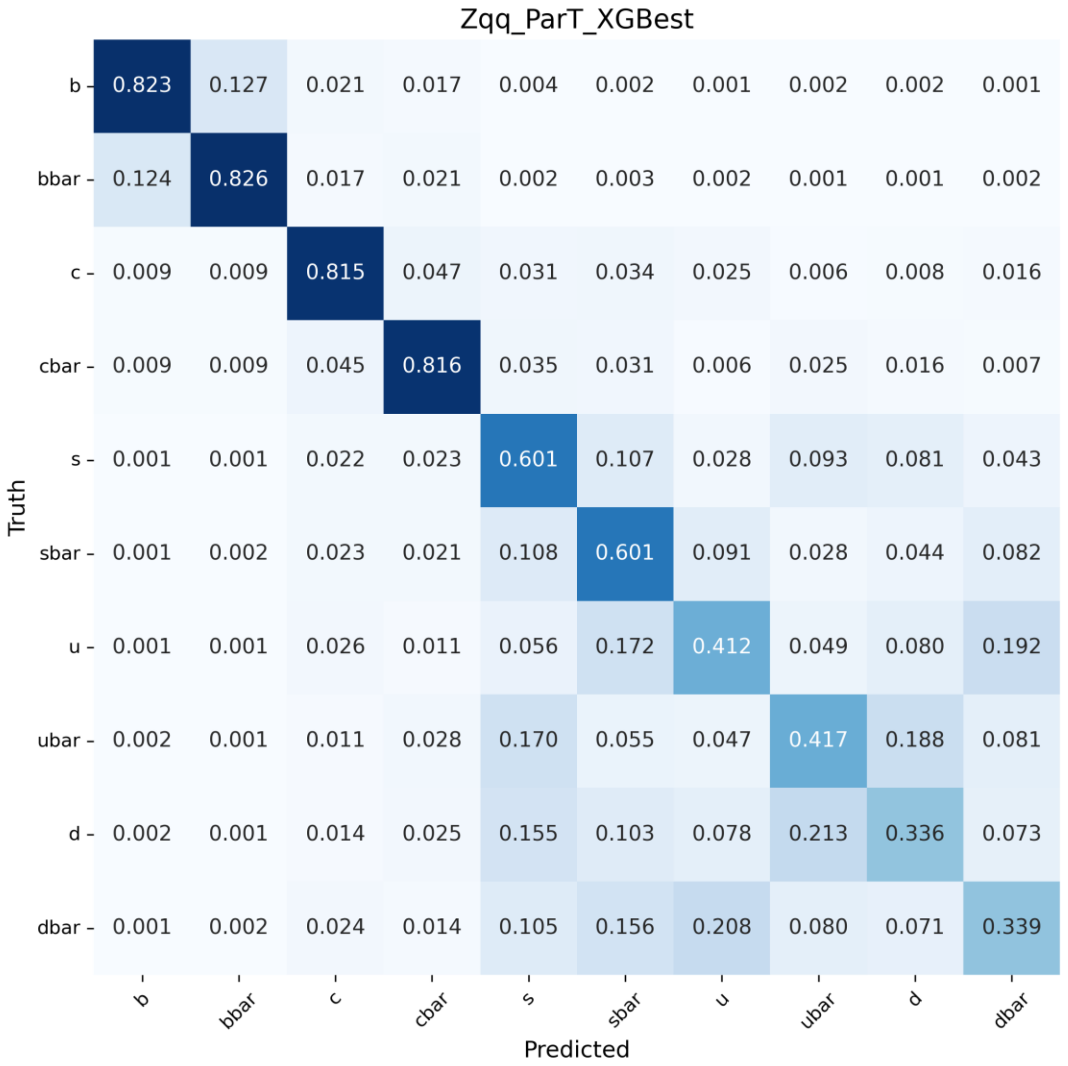

**Fig. 11**: (a) The minimum for a $5\sigma$ discovery and (b) the limit at 95% confidence level on the branching fraction of the Higgs boson to new invisible particles for the individual channels and all channels combined. Results shown are for the data at $\sqrt{s} = 240$ GeV and $\sqrt{s} = 365$ GeV and at the two beam energies combined. The contribution from SM Higgs boson to neutrinos is treated as a background.

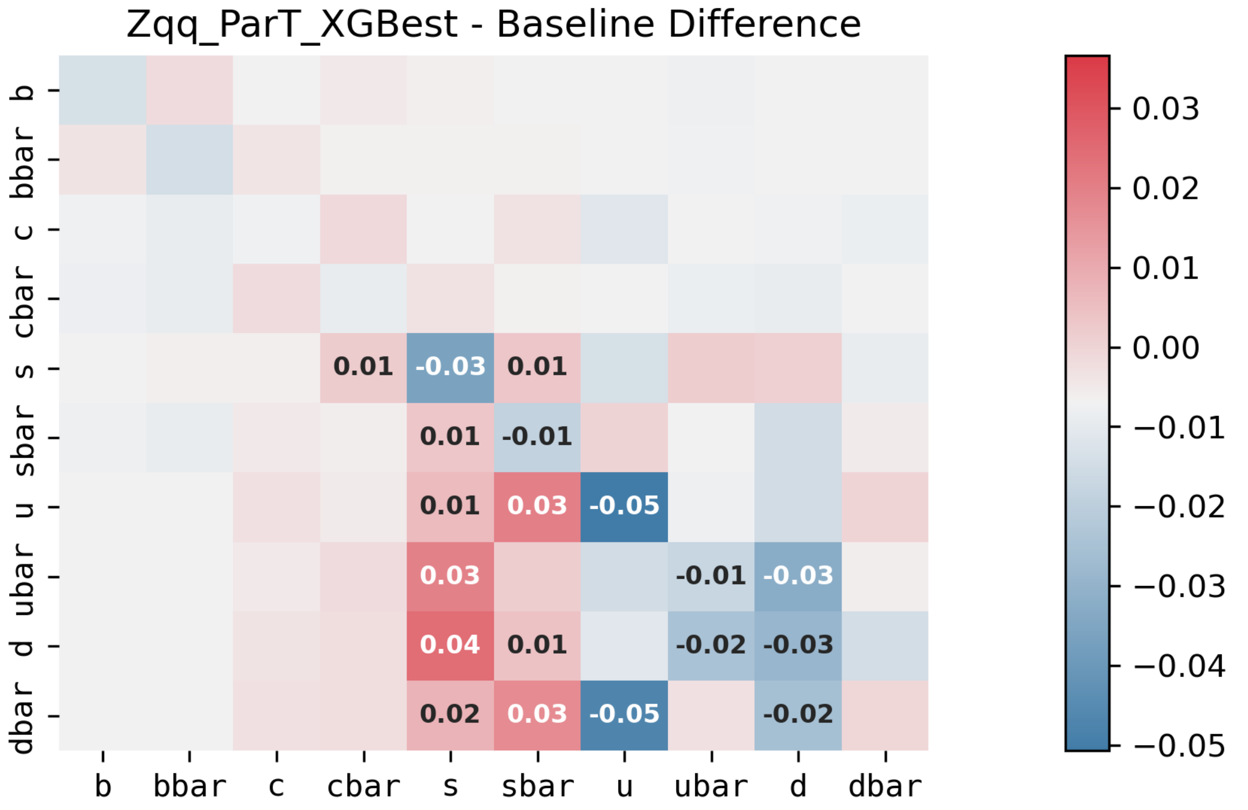
# Summary for Fcc status

- Similar hardware + methodology with CEPC.
    - ML-based method widely used like jet tagging.
- Some variation on different detection conditions studied.
- Analysis well prepared including systematics.

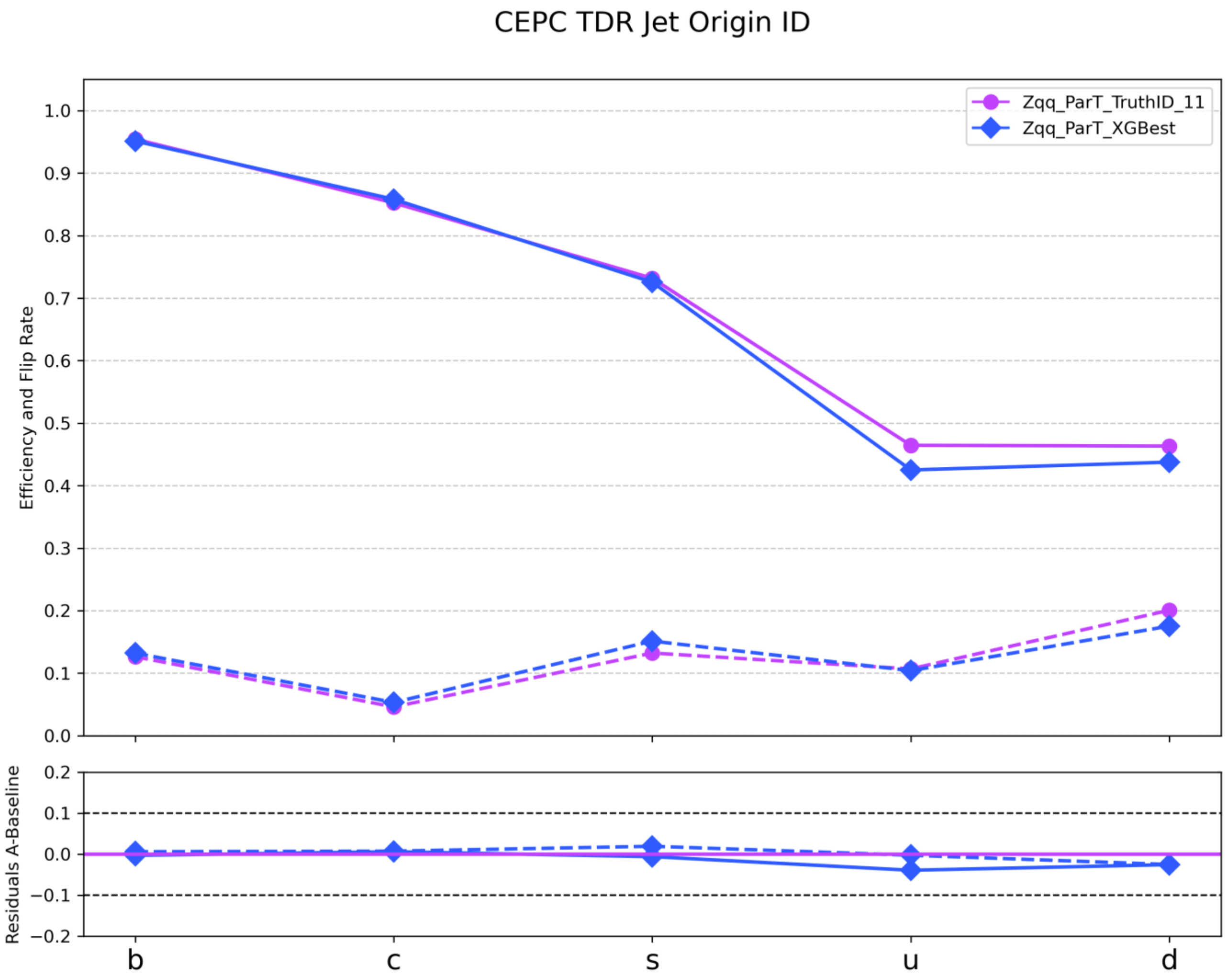
# XGBest @Zpole: JOI performance

M10: 0.6134-0.5986



# XGBest @Zpole: JOI performance




- However, the reco ID performance for b, c, s is almost kept.
- Good enough for Rb Rc Rs measurement.