CEPC WORKSHOP 2026

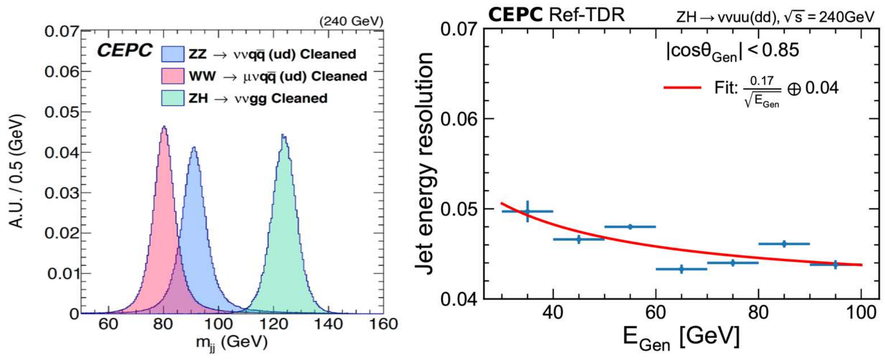
Improved Jet Energy Reconstruction with XGBoost for the CEPC

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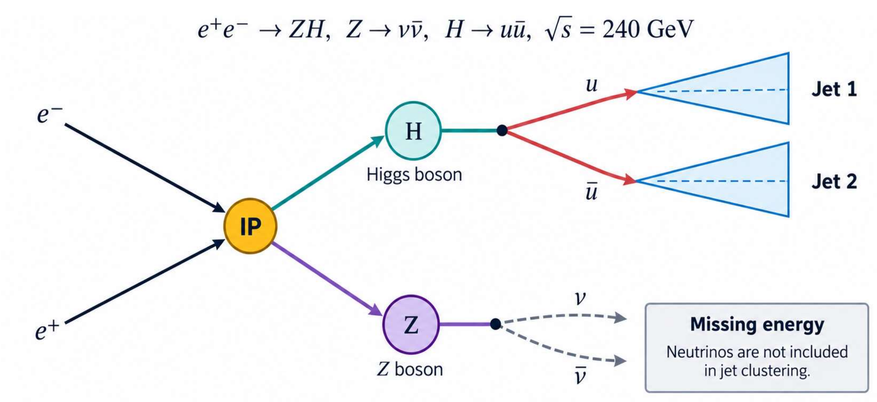
Physics Goal

- Separating hadronic W, Z, Higgs decays motivates jet-energy resolution of **~3-4% at 100 GeV**
- CEPC Ref-TDR reports light-quark JER of 4.5% and $H \to gg$ BMR of 3.87%



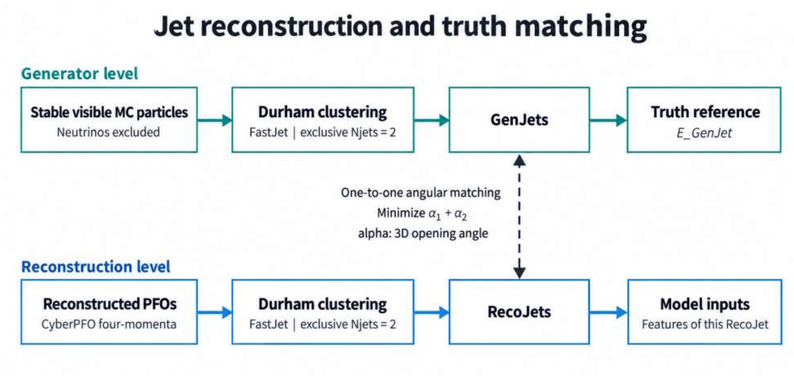
Sample

- Process: $e^+e^- \to ZH \to \nu\bar{\nu}u\bar{u}$, at $\sqrt{s} = 240$ GeV
- Simulation and Reconstruction: CEPCSW 25.3.7
- Nominal Sample: 1M events, 2M jets before selection
- Input: Reconstructed CyberPFO objects, detector info and truth particle



Jet Reconstruction and Selection

- **RecoJet**: cluster CyberPFO four-momenta
- **GenJets**: stable truth particles, excluding υ
- Both collections use **FastJet exclusive $e^+e^-k_t$ clustering (Durham)** with $N_{jets} = 2$
- **RecoJets and GenJets** are matched one-to-one by minimizing the **sum of their opening angles**



- **Energy range:** $30 \leq E_{GenJet} < 100$ GeV
- **Barrel acceptance:** $|cos\theta_{GenJet}| < 0.85$
- **Matching requirement:** $\alpha < 0.2$ rad

60% train / 20% validation / 20% test

The split is performed by source files, keeping jets from the same event in the same dataset. All compared methods use the same selected test jets

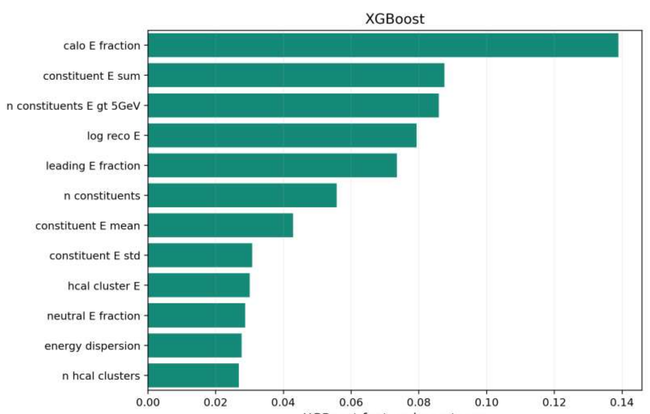
XGBoost

Reconstructed Jet Variables	No of Variables
Jet kinematics	7
Multiplicities and charge	11
Constituent energy distribution	8
Energy composition	4
Calorimeter information	6
Angular shape	7

- Regression function comparison

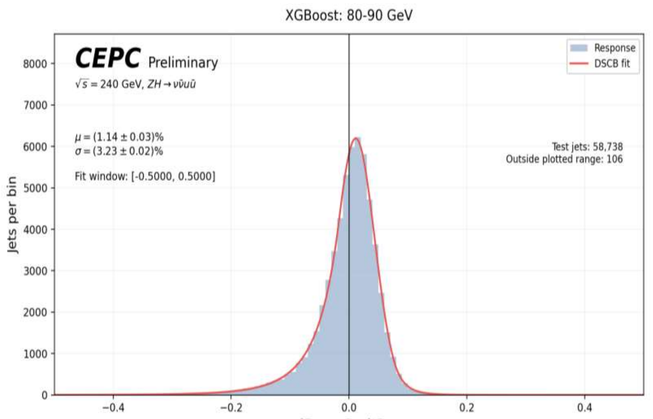
Regression Function	RMSE [GeV]	Mean bias [%]
$ln(E_{GenJet}/E_{RecoJet})$	**4.54**	**0.19**
$E_{GenJet}/E_{RecoJet}$	4.57	0.39
$E_{GenJet} - E_{RecoJet}$	4.52	0.38

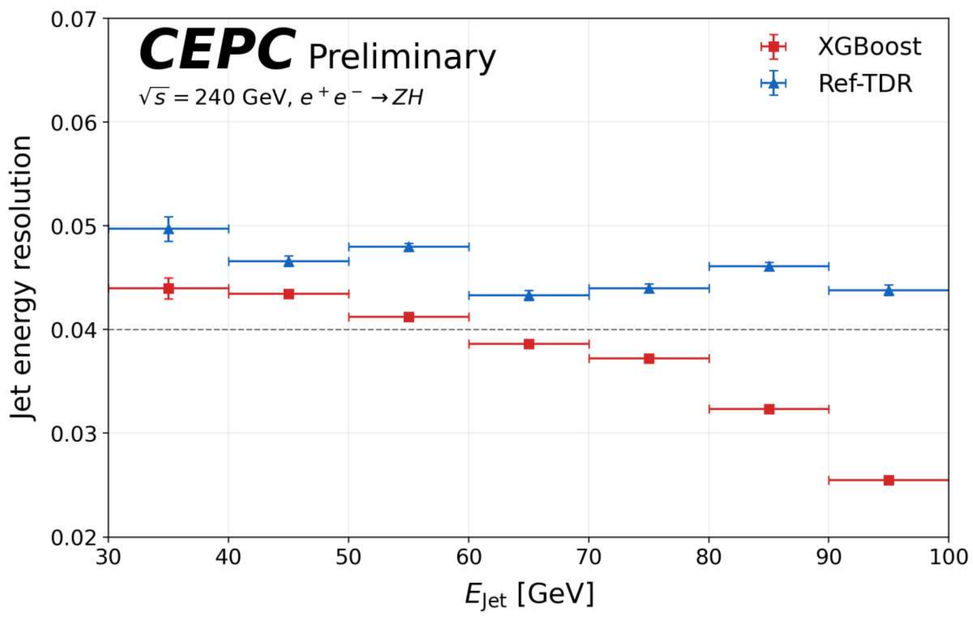
- Importance of input variables



Jet Energy Resolution

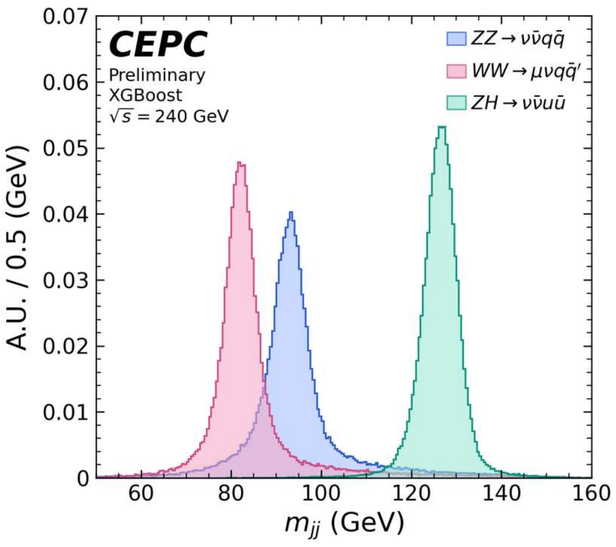
- 80-90 GeV Result



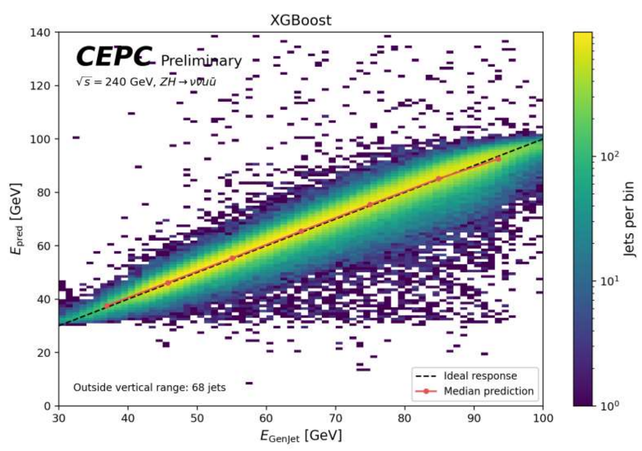


- The XGBoost model trained on $H \to u\bar{u}$ improves dijet mass resolution for all three bosons, without retraining.
- $BMR = \sigma_{core}/\mu$

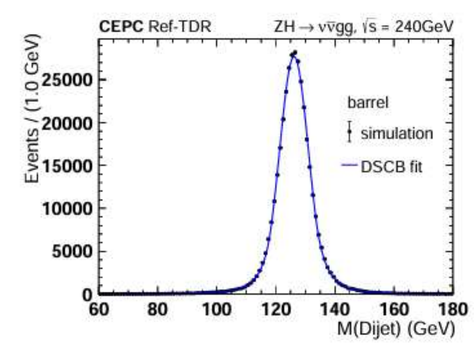
BMR	Ref-TDR	XGBoost	Improvement
H	3.87%	**2.80%**	**27.6%**
W	5.01%	**3.70%**	**26.1%**
Z	5.20%	**3.96%**	**24.0%**

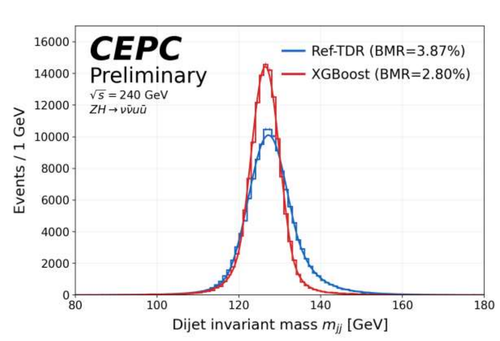


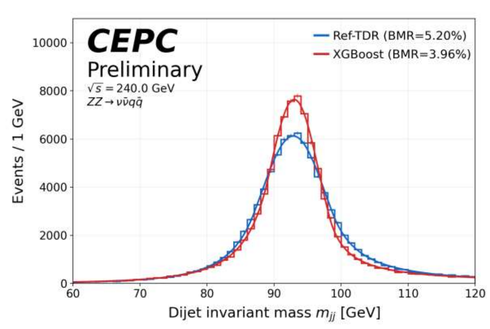
- **JER (Ref-TDR → XGBoost):**
  4.5% → 3.0% (improvement 33%)
- **JER (XGBoost) reaches**
  2.6% at 90-100 GeV

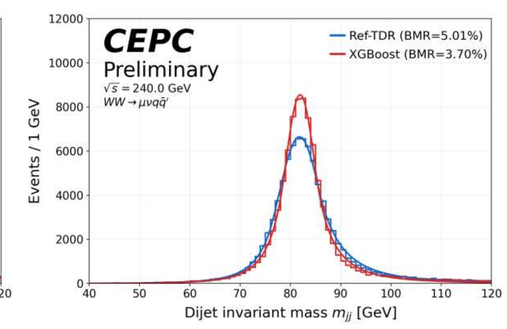


Boson Mass Resolution









Conclusions and outlook

- XGBoost significantly improves JER and BMR of Higgs, Z and W by 20-30%
- Next: extend to other Higgs, W and Z decay flavours and estimate its physics impact

[1] CEPC Study Group, CEPC Technical Design Report: Reference Detector (2025), arXiv:2510.05260, Sec. 15.1.7.