Jet Performance at CEPC

The 7th China LHC Physics Workshop

2021/11/25

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

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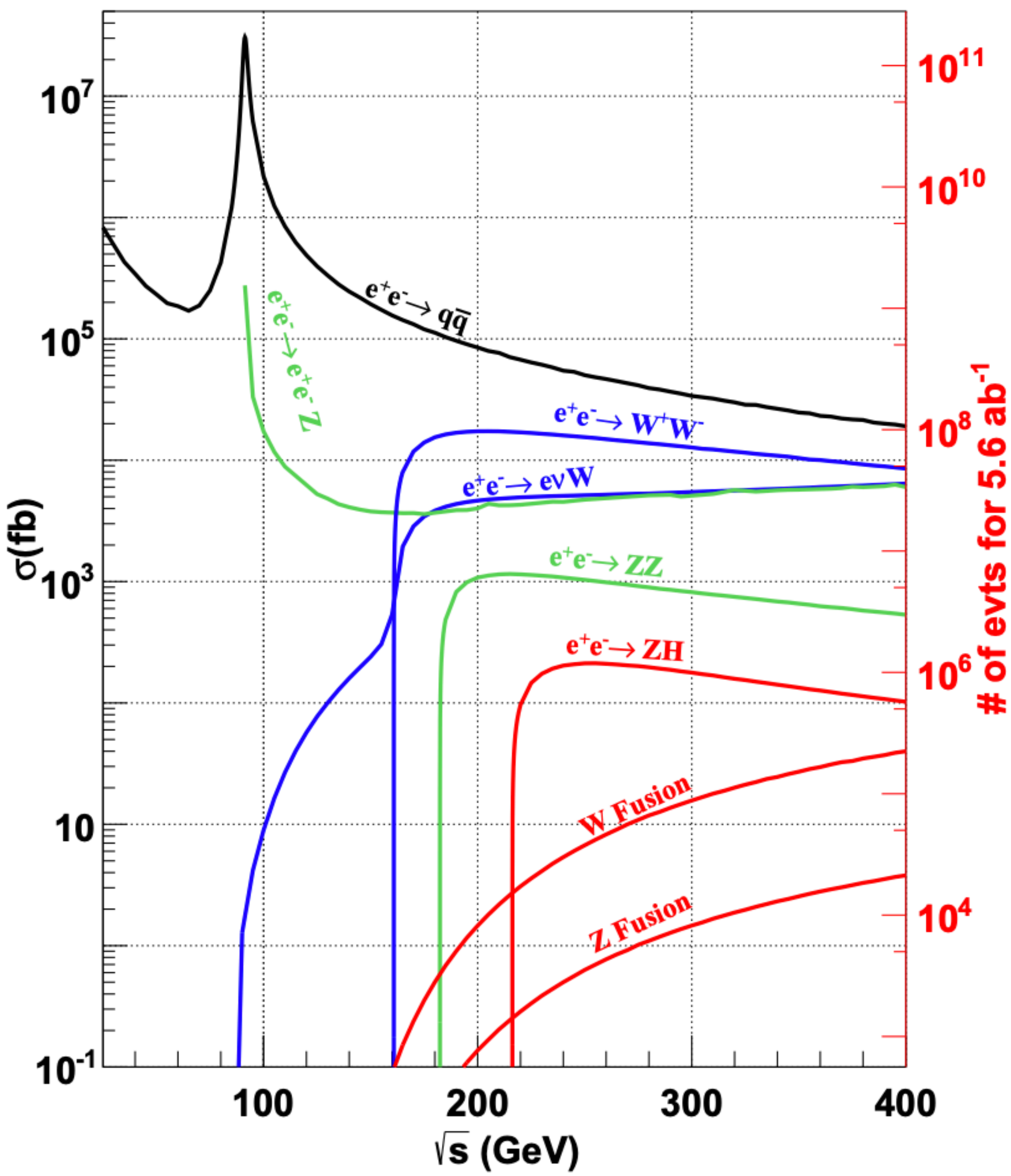
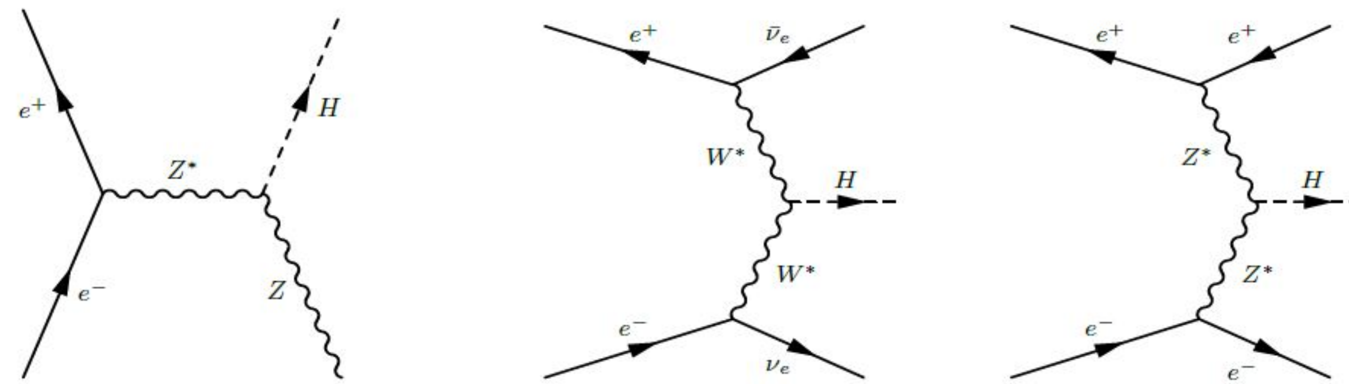
CEPC

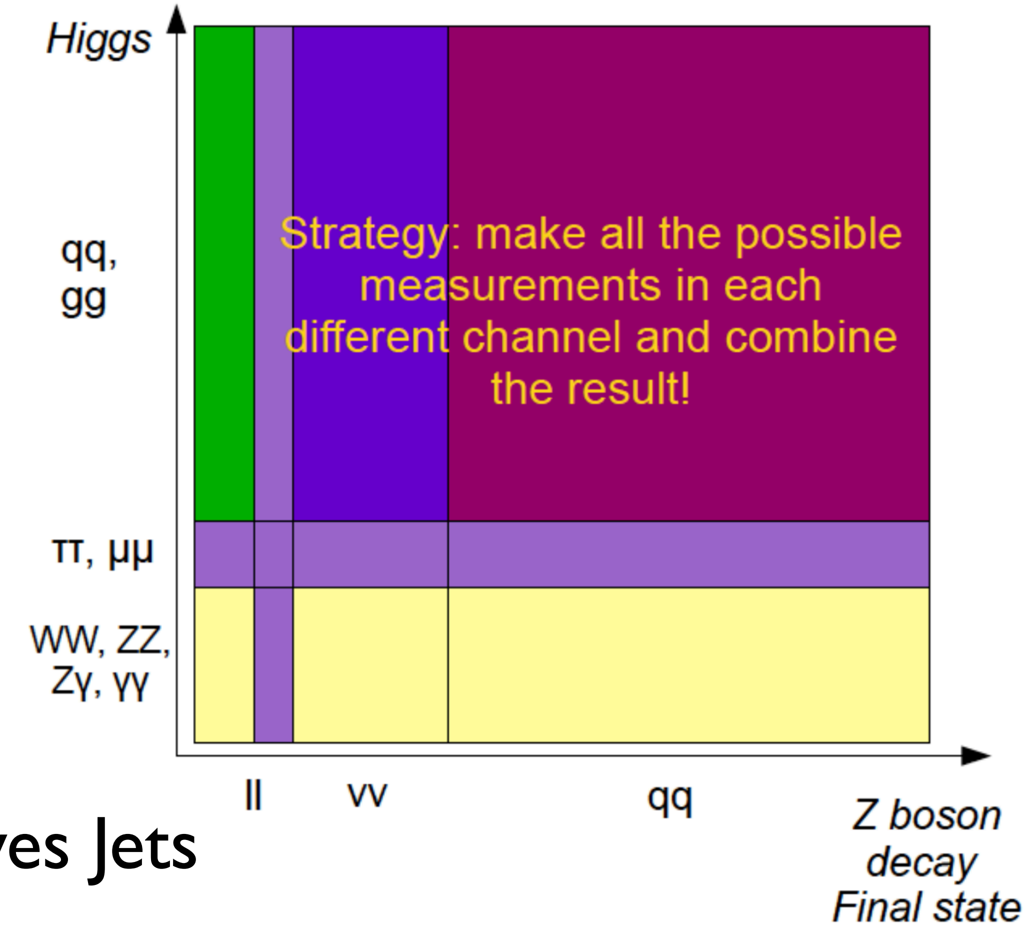




- Higgs factory: 240 GeV, 10^6 Higgs,
  - Advantage: Clean, Known initial states
  - Measurements: Higgs boson mass, cross section, decay modes, branching ratio
- Z factory: 91 GeV, 6×10^{11}
  - EW precision physics
- WW threshold runs, ~160GeV, 10^8
  - W mass/width measurement

CEPC CDR (released 2018): arxiv:1811.10545 White Paper: arxiv:1810.09037

Jets in CEPC



- Detector reconstruct all the physics objects
- Higgs:
  - 97% of the SM Higgsstrahlung Signal involves Jets
  - 4jets/6jets ~ 66%, need color-singlet identification: grouping the hadronic final sate particles into color-singlets (Z, H, W, gamma, ...)
- Other:
  - Semi-leptonic from WW or Single W/Z: W mass, aTGC, etc.
  - Full hadronic from WW/ZZ: Boson separation
  - Top pairs, WWZ, VBS, …
- Jet clustering is essential for any measurements concerning jet direction

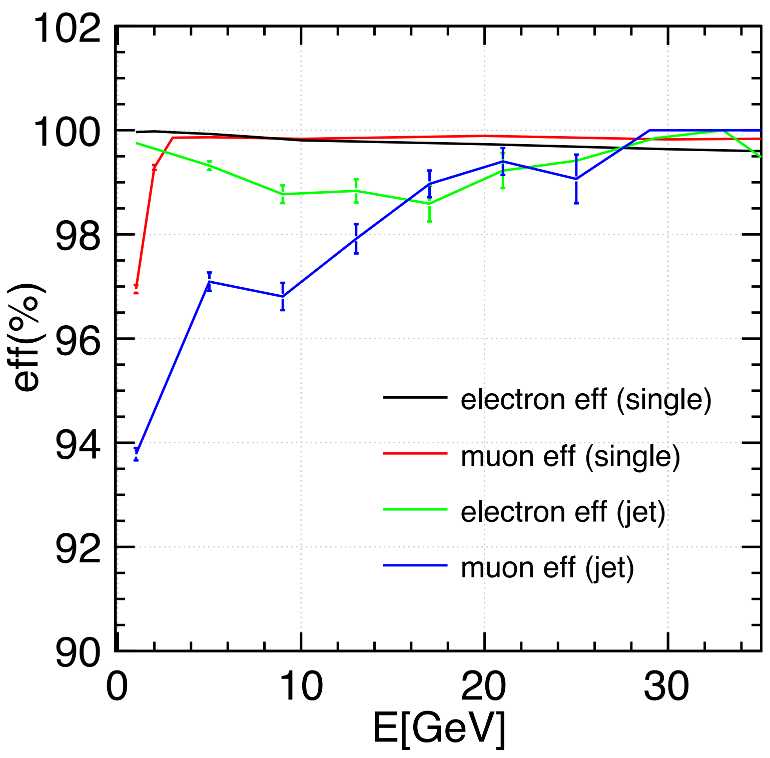
Performances for Physics objects

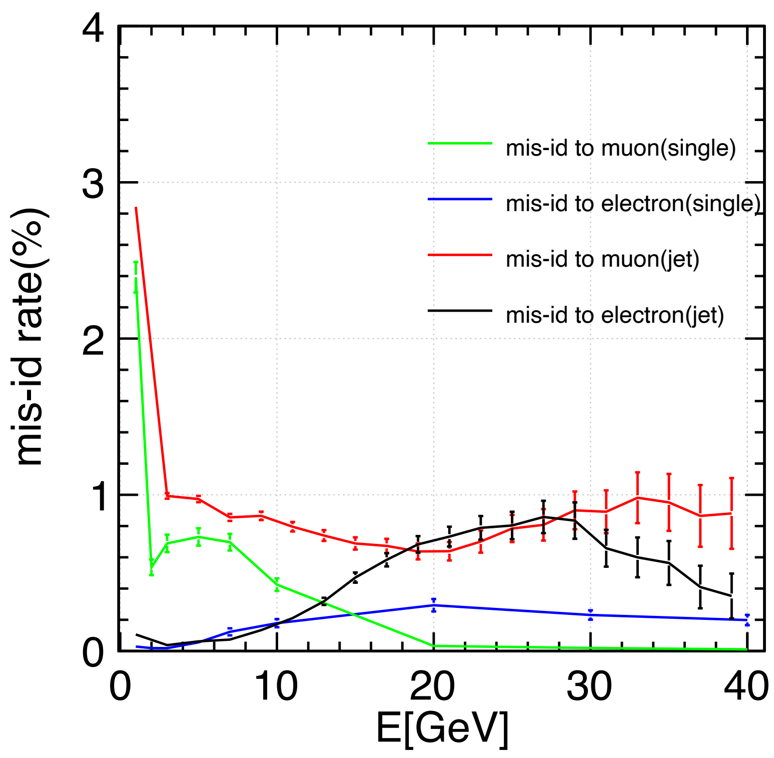
- Acceptance: $|\cos(\theta)| < 099$
- Tracks:
  - Pt threshold, ~ 100 MeV
  - $\delta p/p \sim o(0.1\%)$
- Photons:
  - Energy threshold, ~ 100 MeV
  - $\delta E/E$: 3 – 15%/sqrt(E)
- Pi-Kaon separation: 3-sigma
- Pi-0: rec. eff*purity @ $Z \to qq$ > 60% @ 5GeV

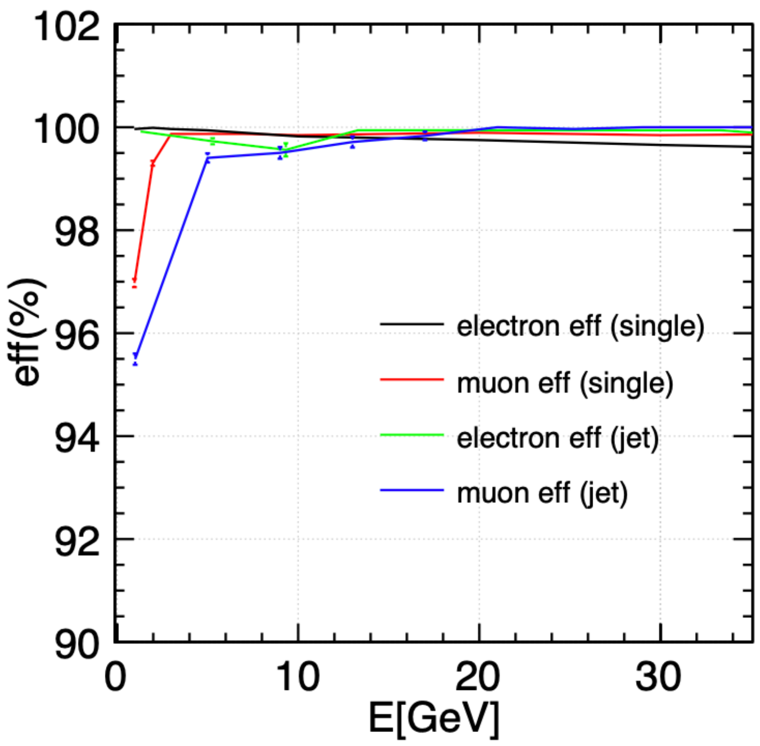
- Reconstruction of simple combinations: Ks/Lambda/D with all tracks @ $Z \to qq$: 60/75 – 80/85%
- Missing Energy: Consistent with BMR
- BMR: 3.7%
- Jet charge: eff*(1-2ω)2 ~ 15%/30% @$Z \to bb/cc$
- B-tagging: eff*purity @ $Z \to qq$: 70%
- C-tagging: eff*purity @ $Z \to qq$: 40%
- Lepton inside jets: eff*purity @ $Z \to qq$ ~ 90% (energy > 3 GeV)
- Tau: eff*purity @ $WW \to$ tauvqq: 70%, mis id from jet fragments ~ o(1%)

Lepton in jets

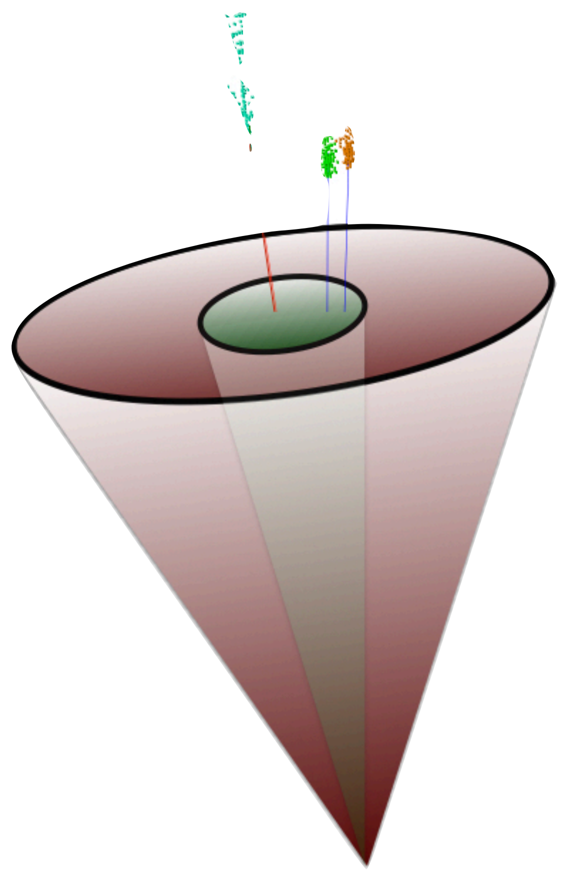
- The performance for lepton in jets degrades 1-2% comparing to the single particle results
- This degrading reduced without clustering confusion
- Application: Bc→τν (arxiv:2007.08234 by Taifan ZHENG)
- Further: more flavor physics such as lepton flavor universality, etc.



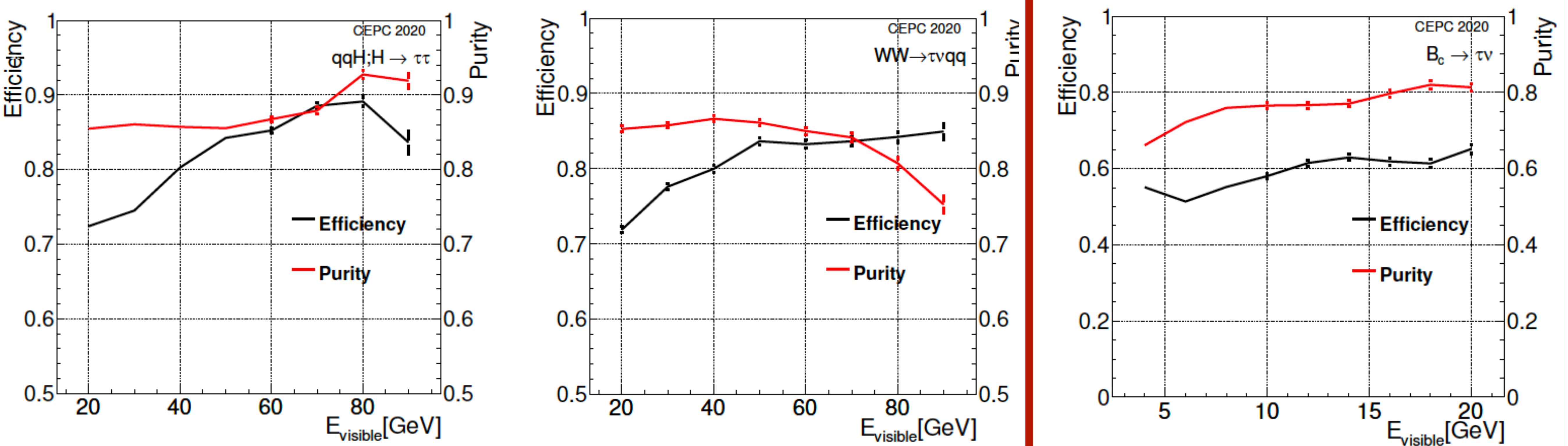




Tau



- Double cone based algorithm
- Use the multiplicity, energy ratio between two cones, invariant mass for τ tagging
- H→ττ has been analyzed, accuracy ~ 0.8%
- For tau in jets, efficiency ~ 60%, purity ~ 80% (adjustable for different physics purpose)



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Boson Mass Resolution

- BMR: relative mass resolution of the hadronic system, especially for the hadronically decayed massive Bosons (W, Z, H)

- • BMR < 4%: to separate qqH signal from qqX background with recoil mass

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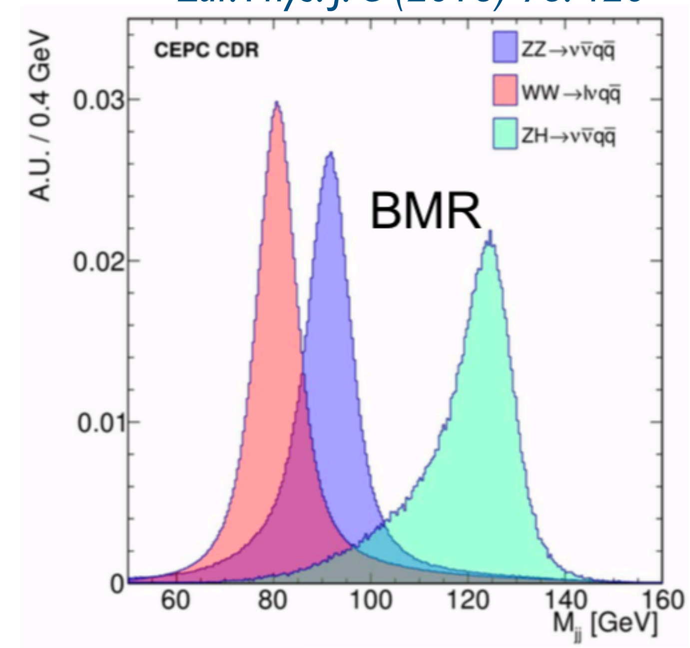

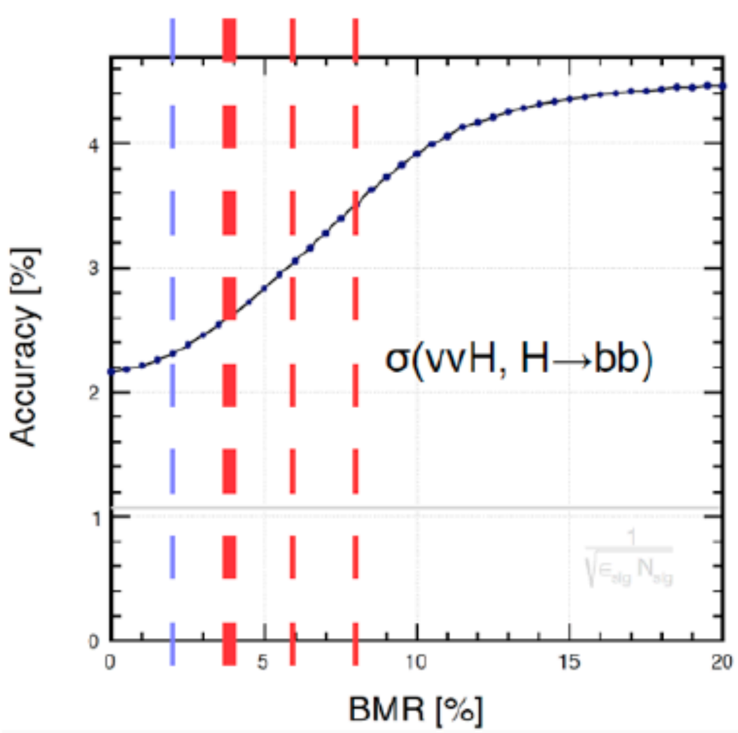

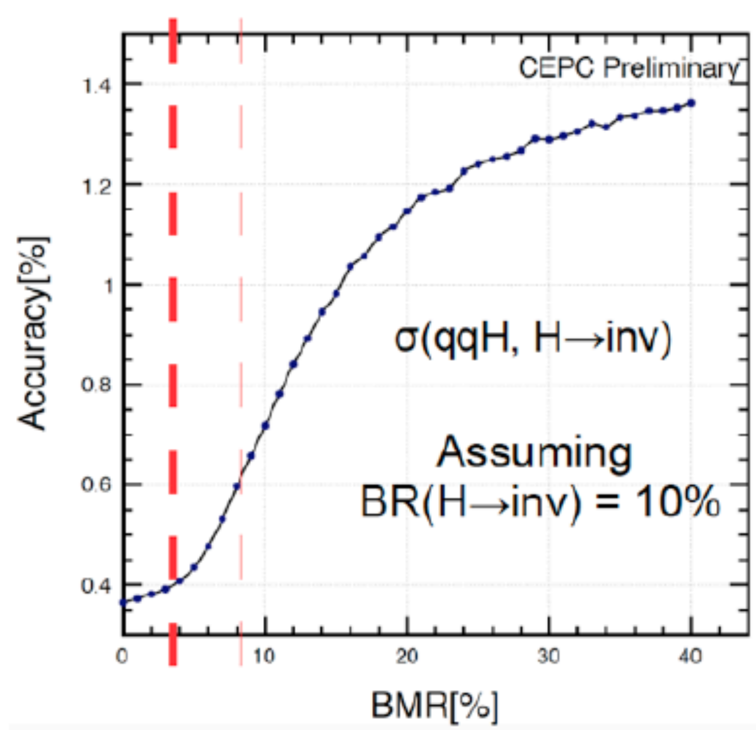

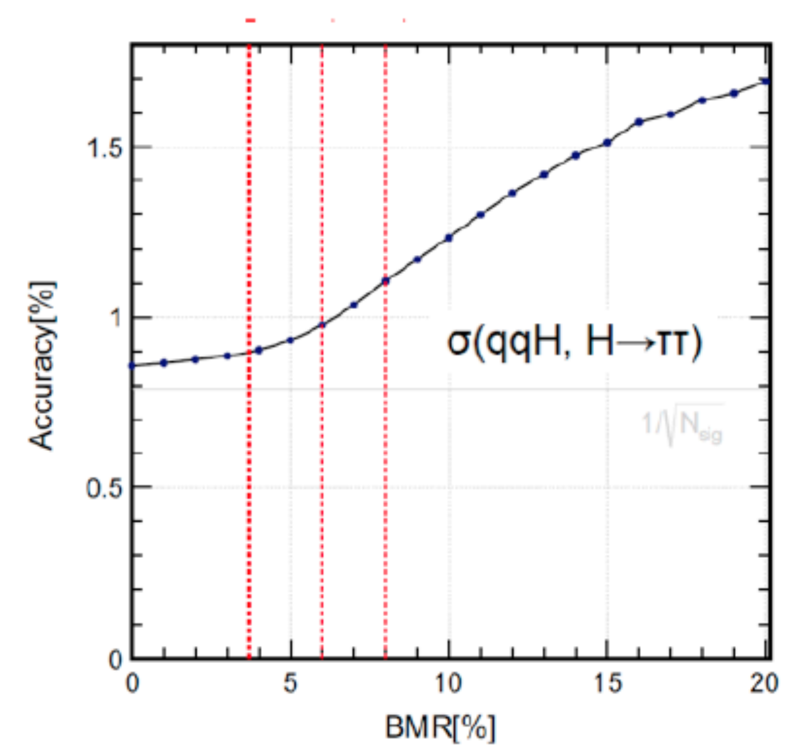

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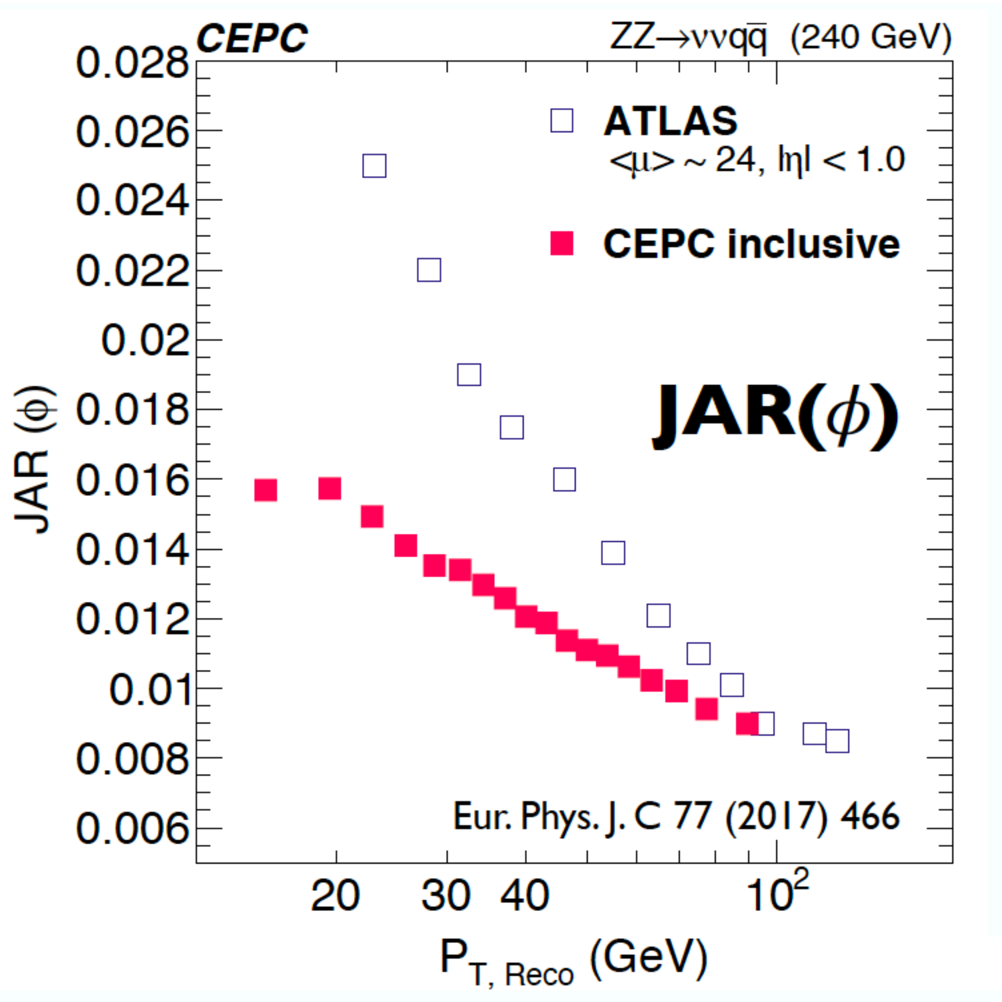
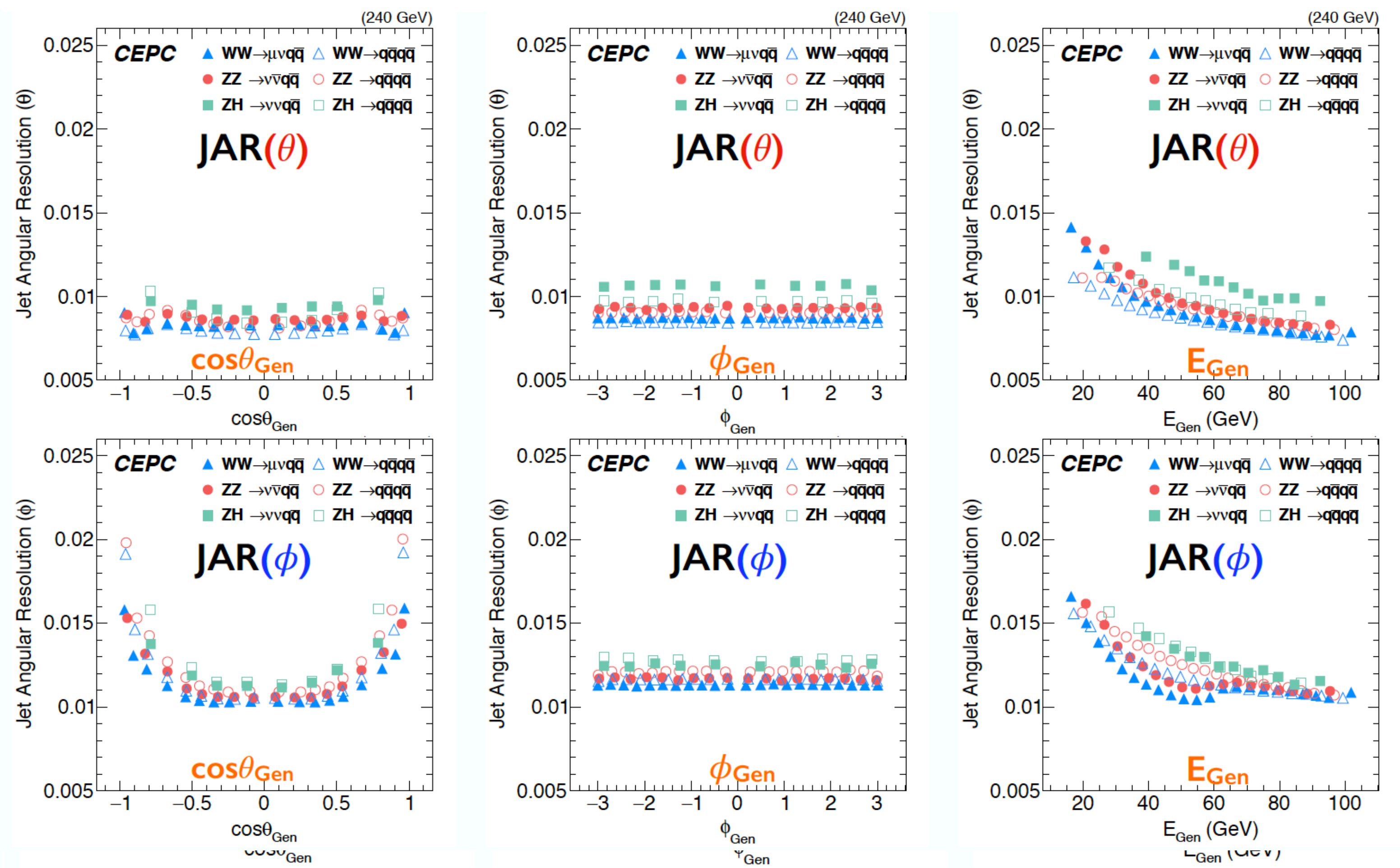
Jet Energy Resolution & Scale

- JER: 2-4 times better than CMS @ 0 PU
- JAR: 1.0-1.6 times better
- JES: 0.1%/1% level with/without polar angle dependent calibration

By Pei-zhu Lai





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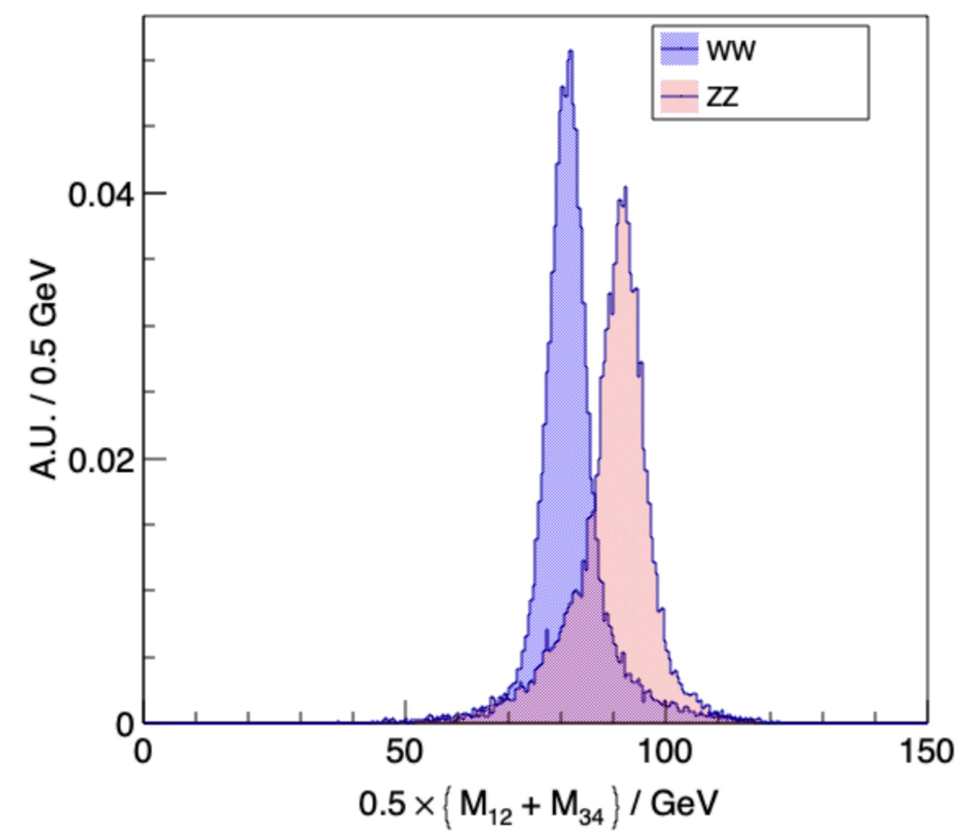
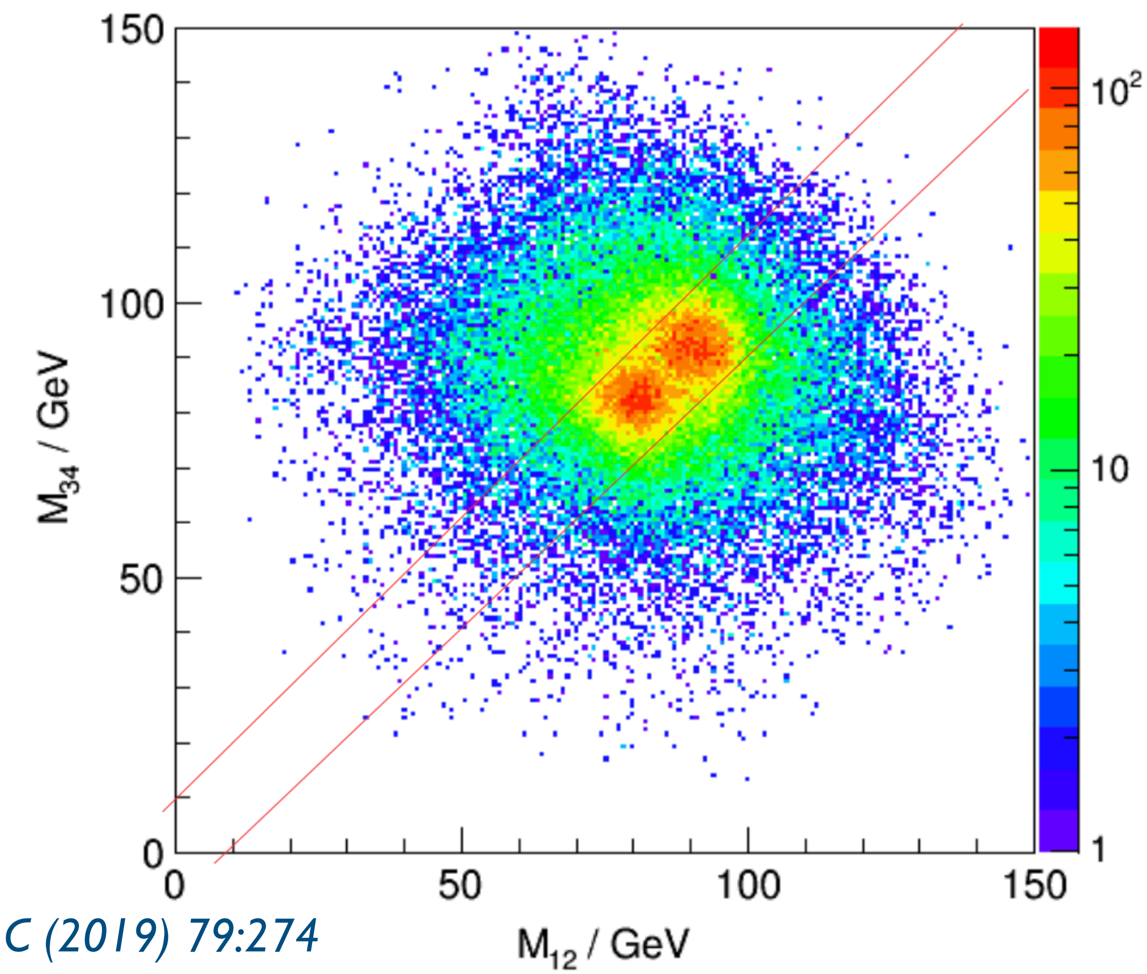
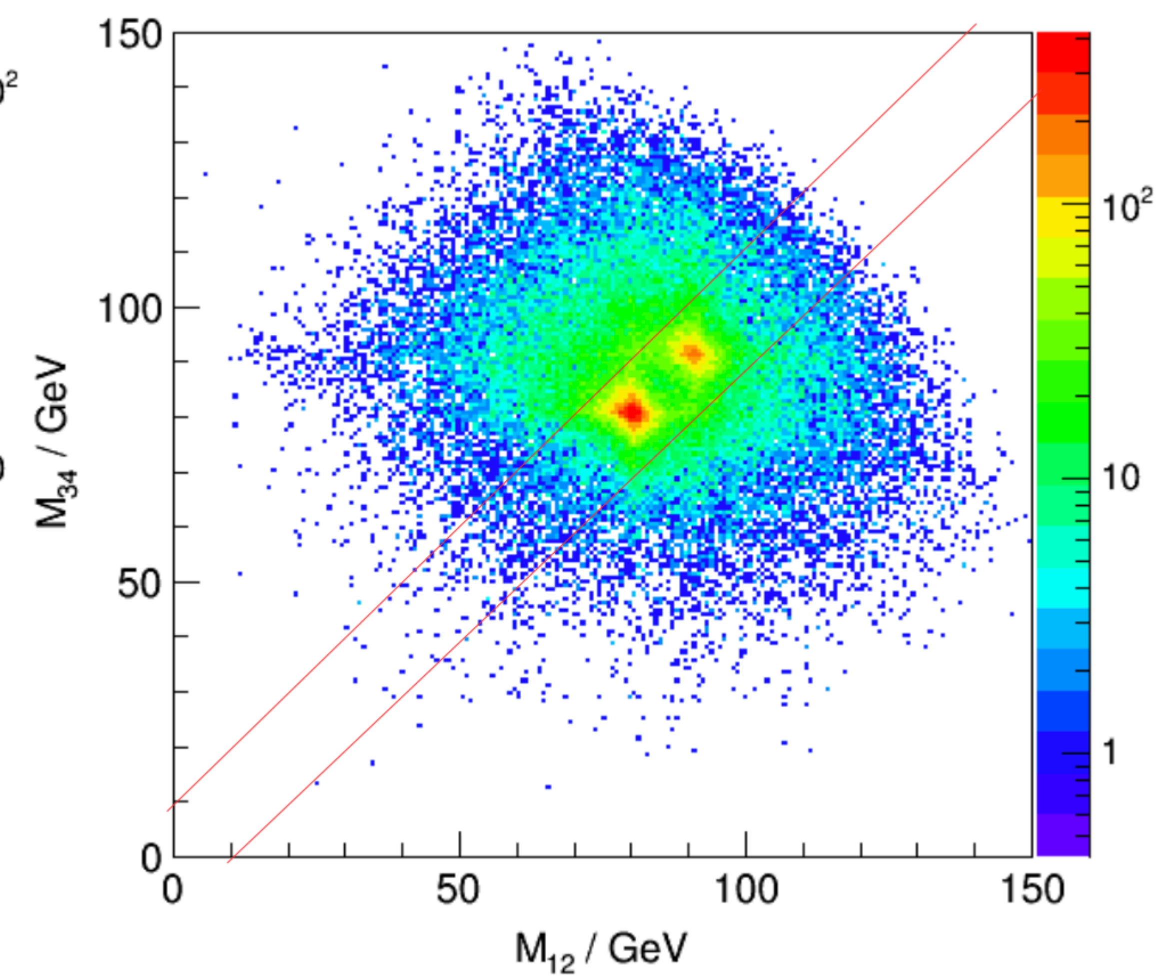
WW-ZZ separation

By Yongfeng Zhu

- Overlap ratio:
  - Genjet (Jet confusion): 53%
  - Recojet (Detector response): 58%
- |M12 – M34| < 10 GeV: half the statistic sacraficed, the overlapping ratio reduced from 58%/53% to 40%/27% fo the Reco/Genjet







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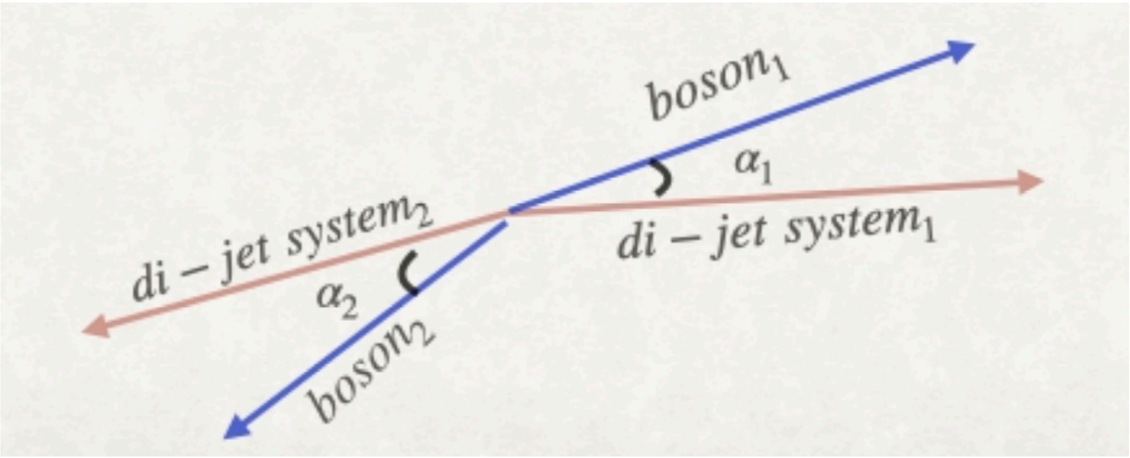
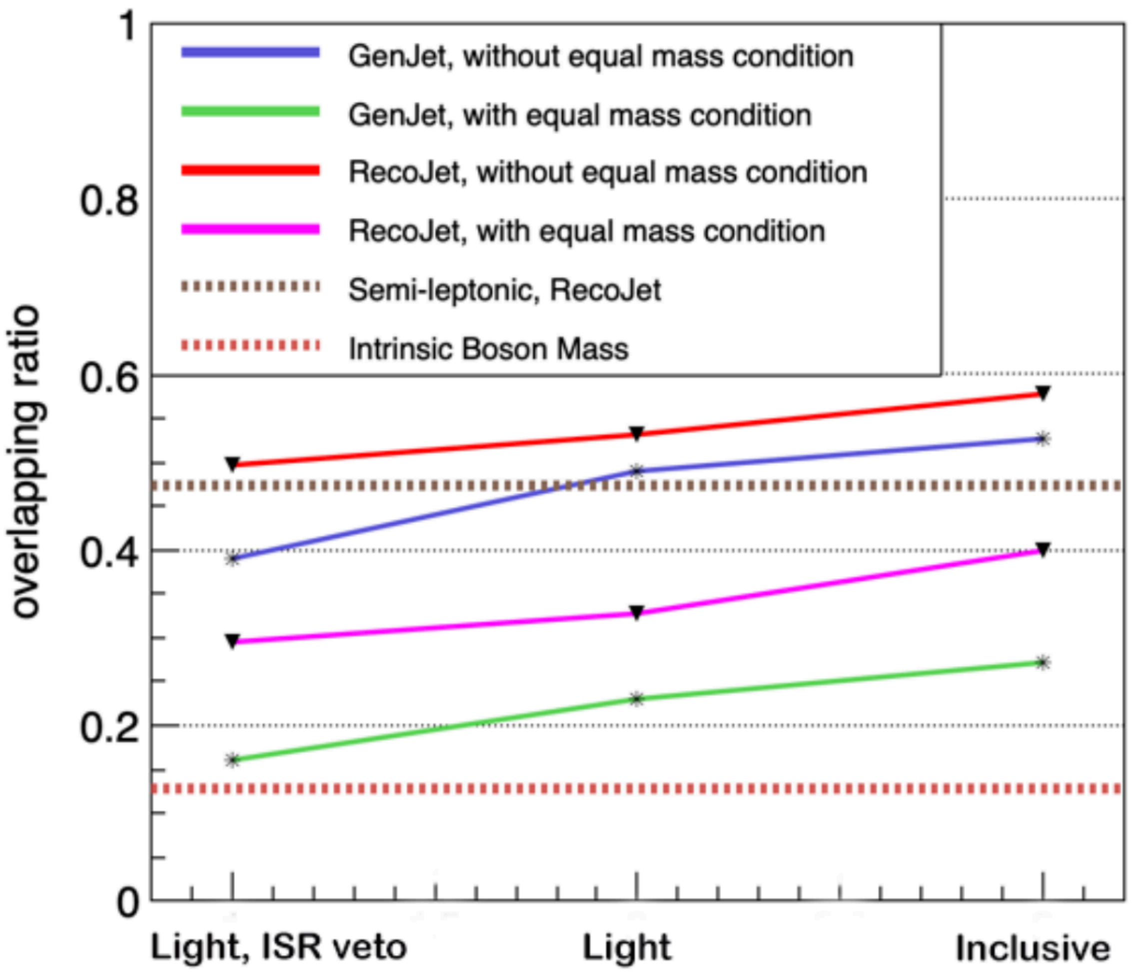
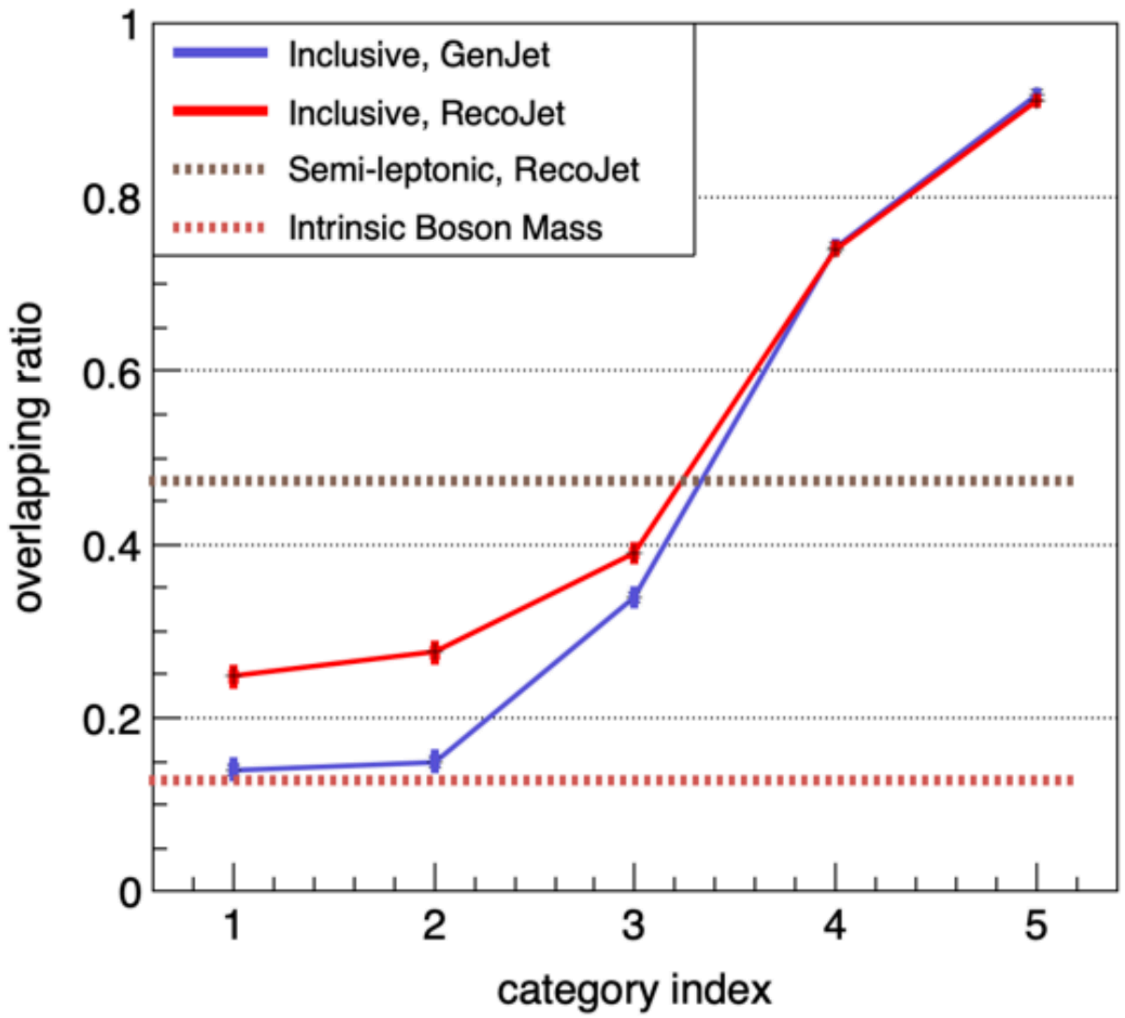
Jet confusion

- The CEPC Baseline could separate efficiently the WW-ZZ with full hadronic final state
- Jet confusion can be quantified by angles between truth/reco level bosons
- The overlapping ratios increase monotonically with the jet confusion

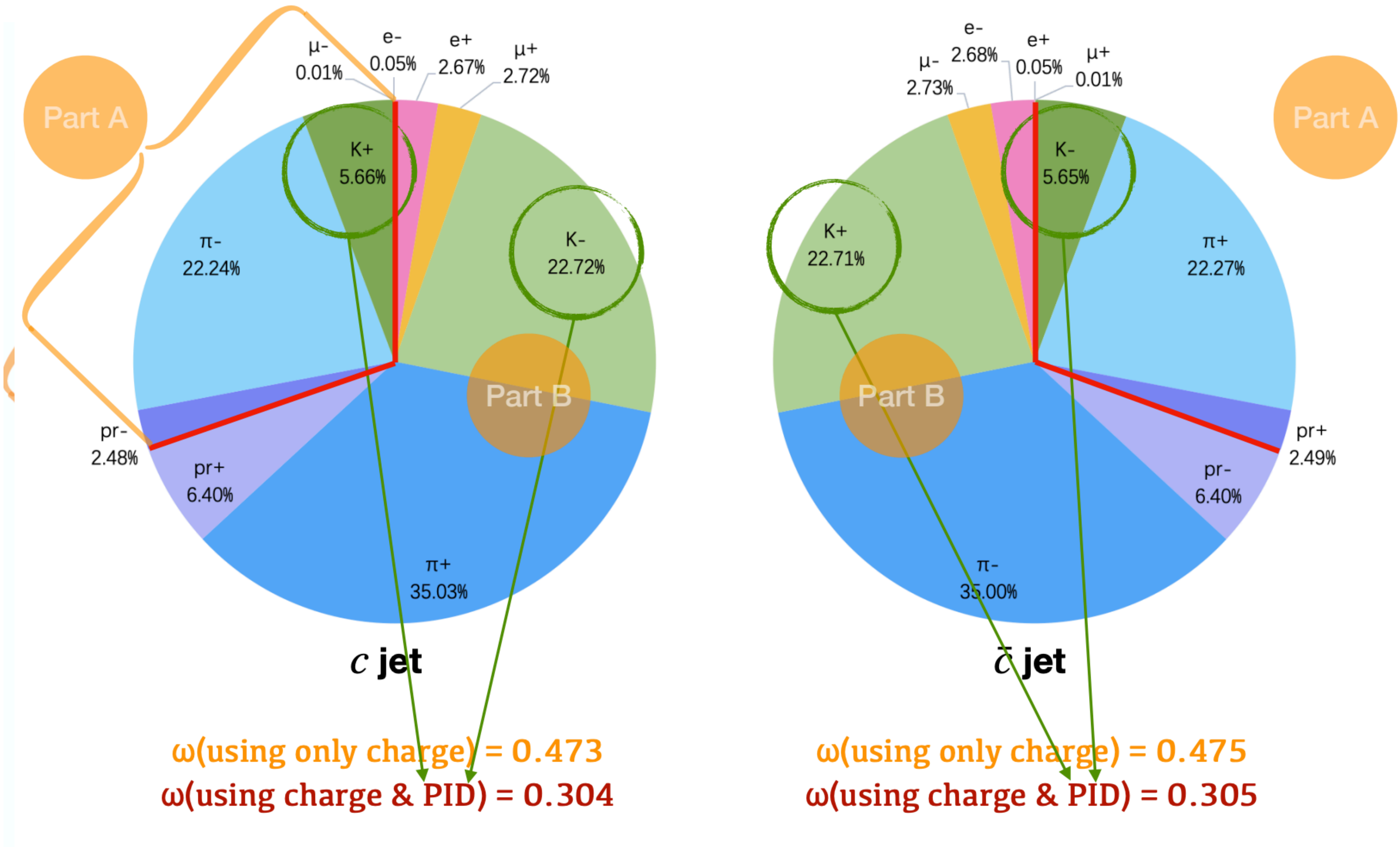






jet confusion order calculated from angles between truth/reco bosons

Jet Charge Measurement

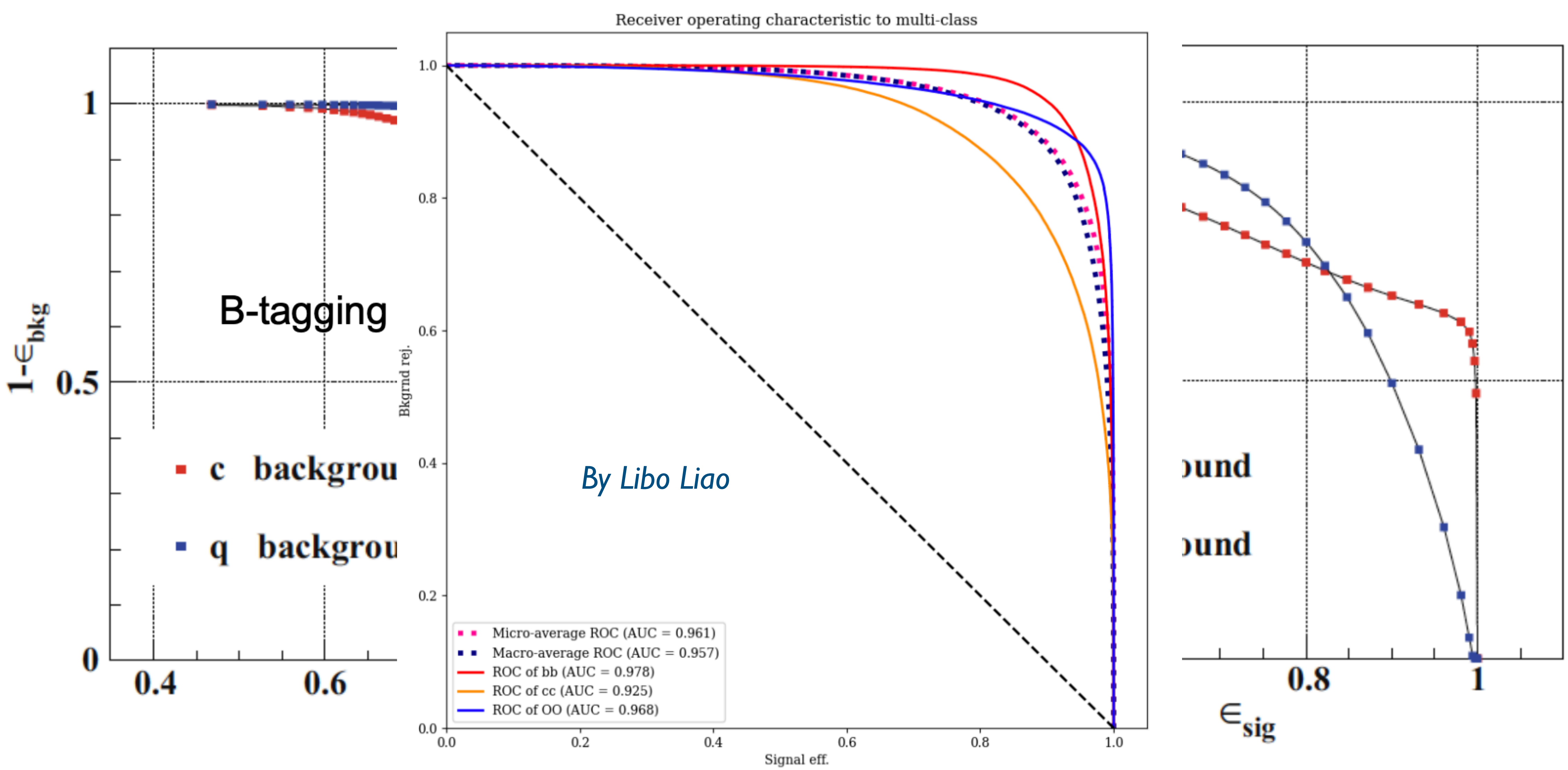


- Effective tagging power: take misjudgment rate ω and efficiency into account
  - Z→bb/cc: 0.090/0.200(single jet) → 0.137/0.301(double jets)

By Hanhua Cui

Jet Flavor Tagging

- B-tagging: eff*purity @ Z→qq: 70% • C-tagging: eff*purity @ Z→qq: 40%
- Preliminary result with ParticleFlow Network (arXiv:1810.05165)



Summary

- Objects in jets are reconstructed in CEPC, and can be used for further analysis
- Boson Mass Resolution: better than 4% is critical, Baseline reaches 3.8%
- Jet energy scale & Jet energy resolution
  - JER 2-4 times better than LHC. However, dependence to the jet clustering & matching need caution.
- Color Singlet Identification
  - Bottleneck for measurements with more than 4-jets. Requires innovative developments/theoretical studies
- Jet Flavor Tagging, critical for g(Hcc), g(Hbb), g(Hgg) measurements
  - Reasonable performance at CDR/baseline, preliminary result with PFN shows improvement.
- Jet Charge Reconstruction using straight forward algorithm
  - Effective tagging power of 14%/30% @ $Z \rightarrow bb/cc$
- Future: more benchmarks, especially differential analyses...

Thank you!

Effective tagging power

- Lepton and Kaon can deliver better misjudgment rate ω than pion and proton
- Other dependences: B/C hadrons type, source of leading particle

bbar jet → b jet ↓	e,μ,K	π,proton
e,μ,K	13.75% $\omega = 0.117$	23.34% $\omega = 0.231$
π,proton	23.34% $\omega = 0.231$	39.56% $\omega = 0.404$

cbar jet → c jet ↓	e,μ,K	π,proton
e,μ,K	11.46% $\omega = 0.040$	22.38% $\omega = 0.109$
π,proton	22.38% $\omega = 0.109$	43.77% $\omega = 0.263$