Physics Performance at CEPC

CEPC Workshop 2020

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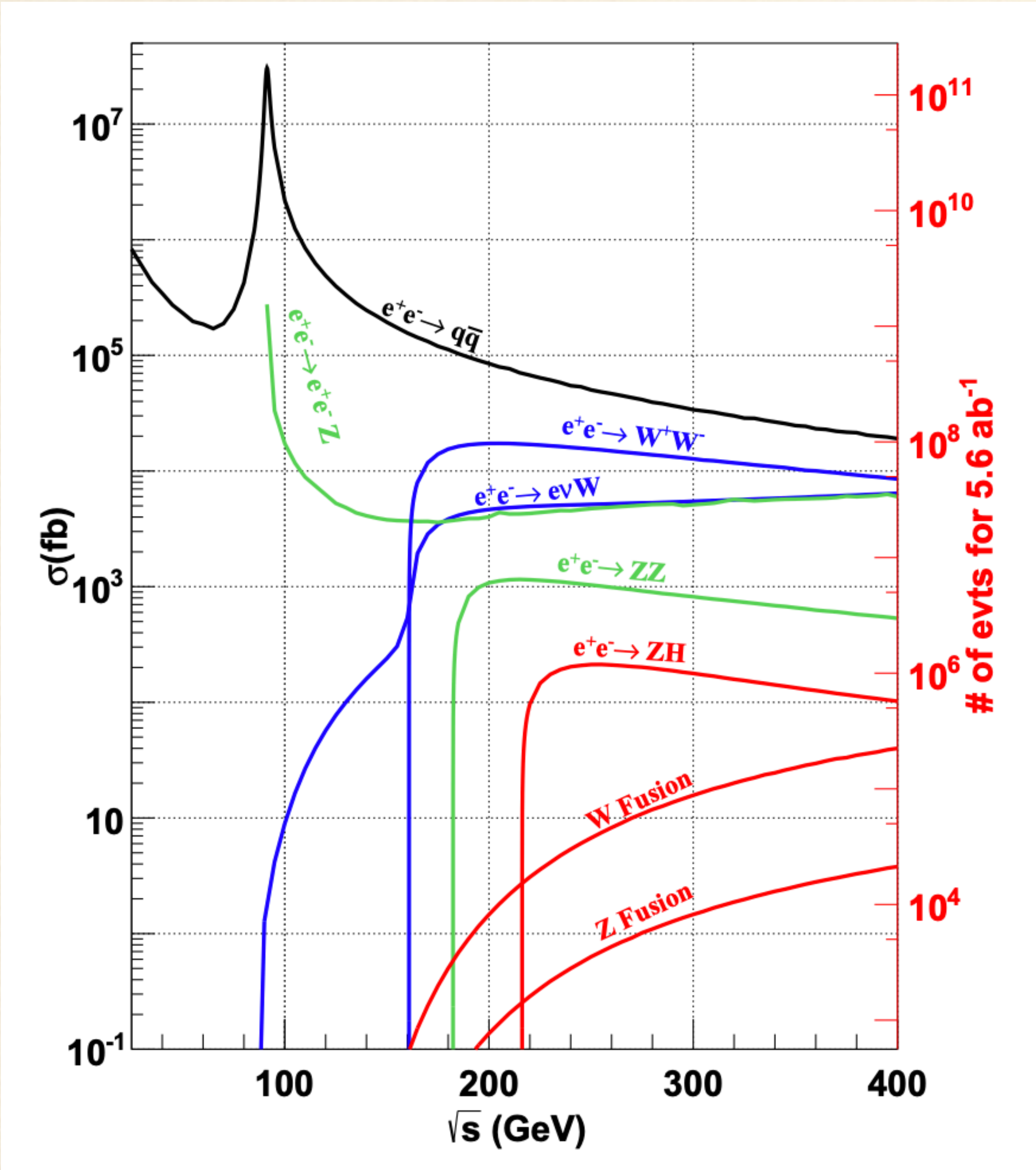
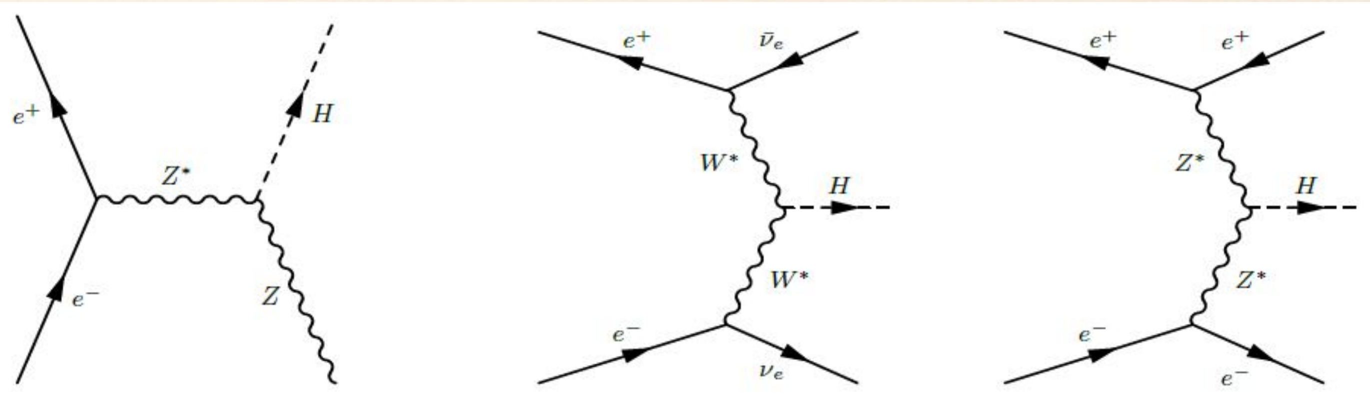
CEPC

Introduction to CEPC



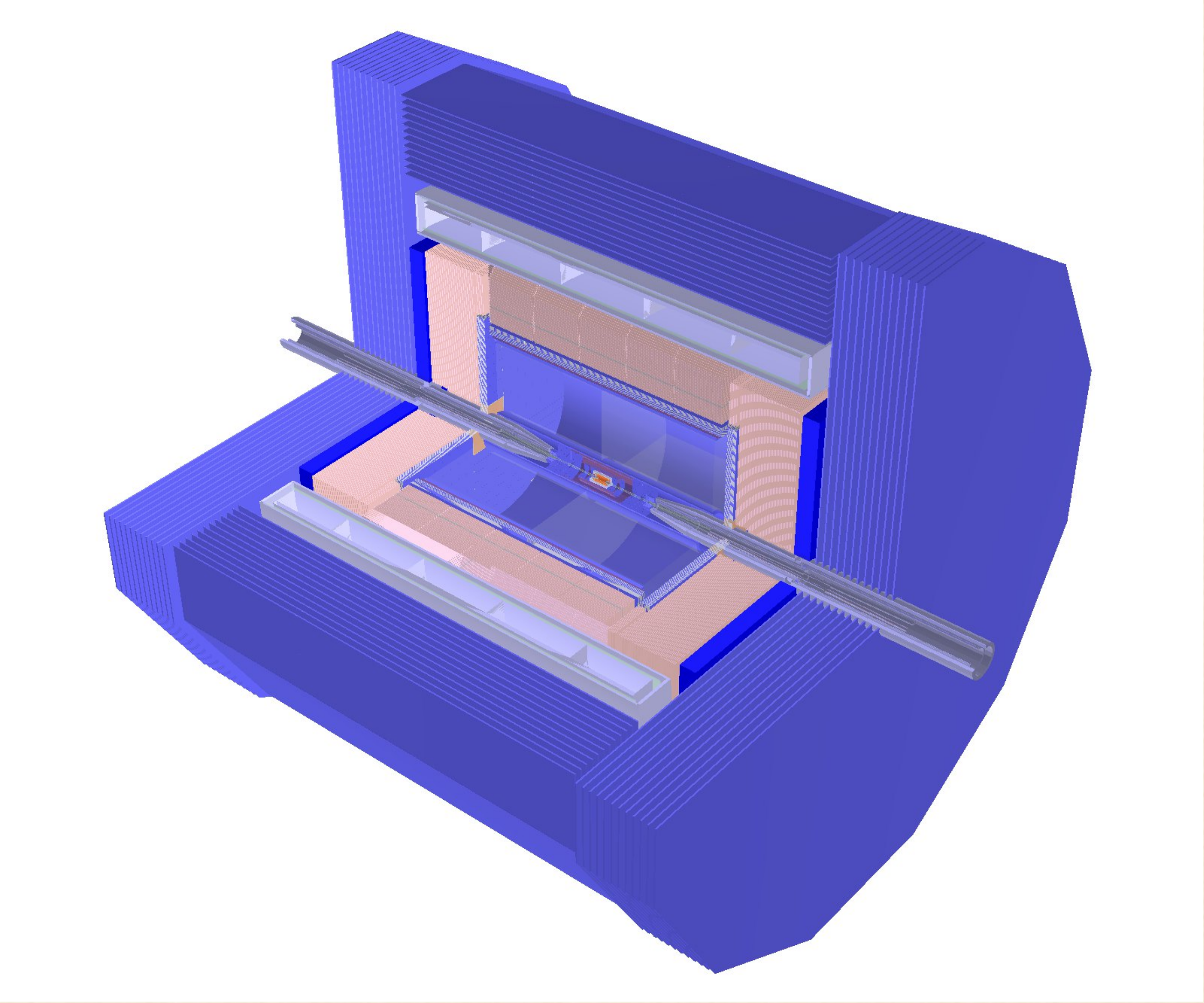


- Higgs factory: 240 GeV, 10^6 Higgs,
  - Advantage: Clean, Known initial states
  - Measurements: Higgs boson mass, cross section, decay modes, branching ratio
- Z factory: 91 GeV, 6×10^{11}
  - EW precision physics
- WW threshold runs, ~160GeV, 10^8
  - W mass/width measurement

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

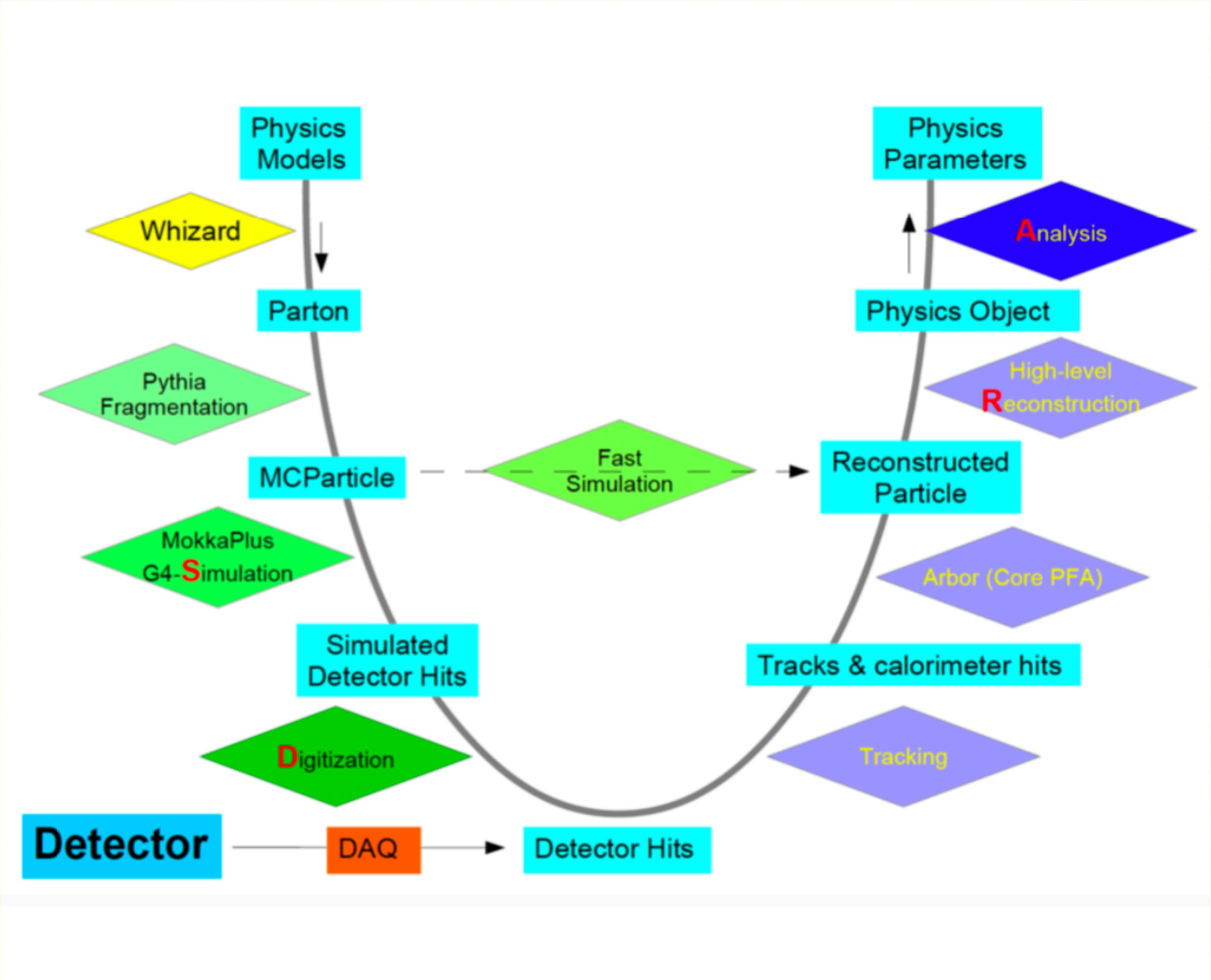
CEPC Detector Baseline

- PFA Oriented concept using High Granularity Calorimeter + TPC (*Option: full silicon tracker*)
- Alternative: Innovative Detector for Electron-positron Accelerator (IDEA)



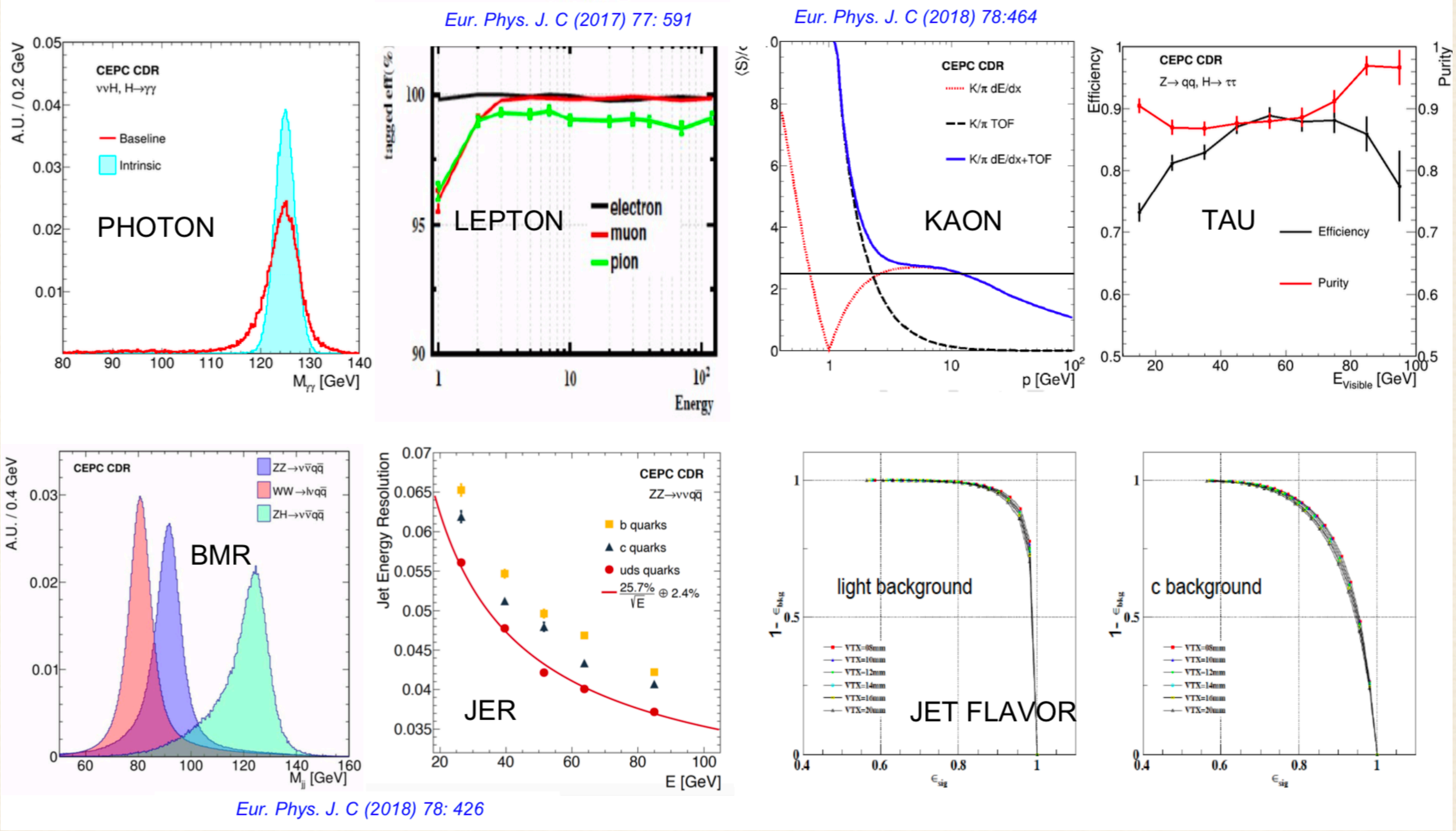
CEPC Full Simulation

- Software chain
- CDR Samples:
  - Full simulated Higgs signal
  - small cross-section(<20 fb): simulated to a minimal statistic of 100k
  - 4 fermion background Full simulated
  - 2 fermion background: 20% simulated



PFA - Objects

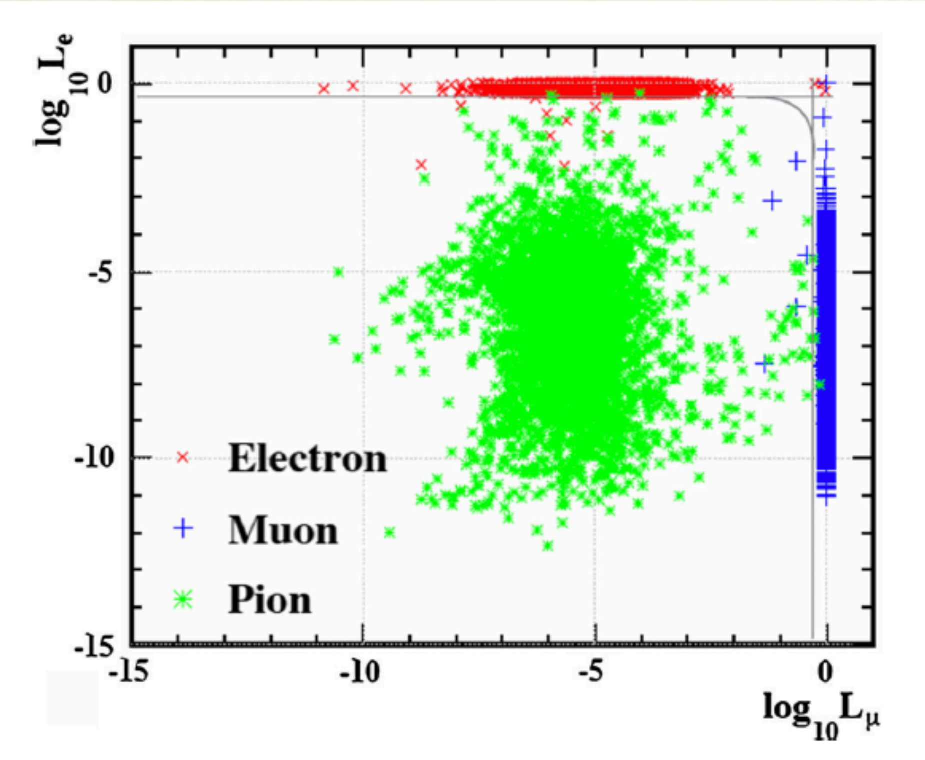
- ZH final states: (ll,νν,qq)×(γγ,ZZ/WW,ll,νν,qq/gg)
  Make all the possible measurement in different channel and combine the result

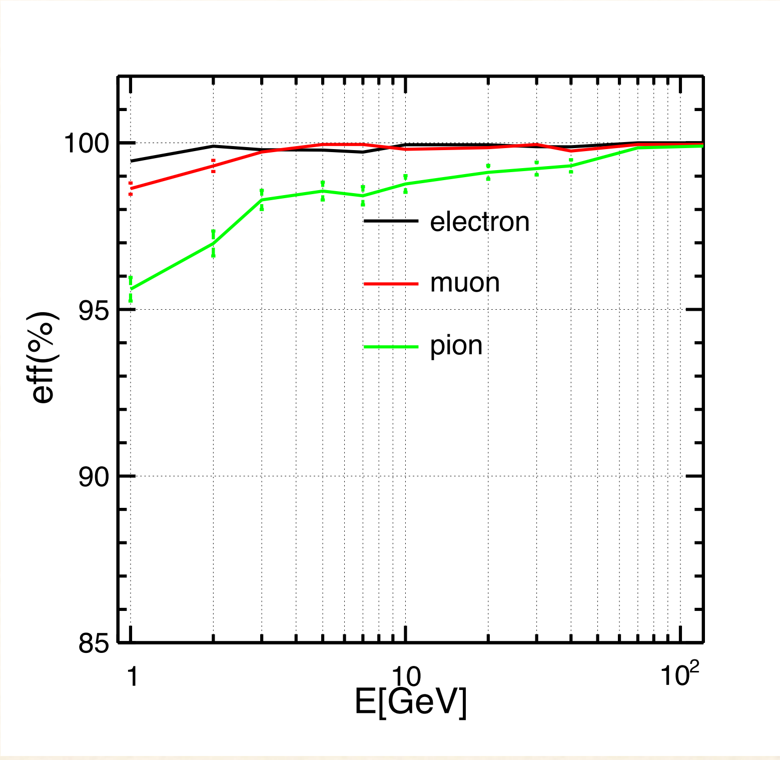


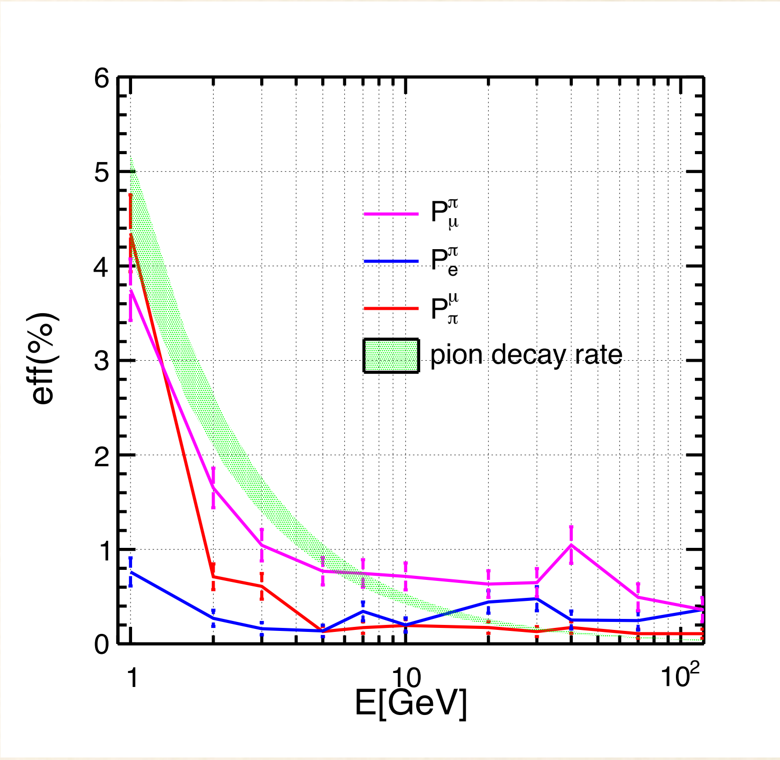
Lepton ID: Isolate Leptons

by Dan YU

- LICH uses TMVA methods to summarize 24 input variables into two likelihoods, corresponding to electrons and muons.
- The efficiency for electron and muon is higher than 99.5% (E>2 GeV). Pion efficiency ~ 98%.







Migration Matrix at 40GeV (LICH)

Type	e^- *like*	μ^- *like*	π^+ *like*
e^-	99.71 ± 0.08	< 0.07	0.21 ± 0.07
μ^-	< 0.07	99.87 ± 0.08	0.05 ± 0.05
π^+	0.14 ± 0.05	0.35 ± 0.08	99.26 ± 0.12

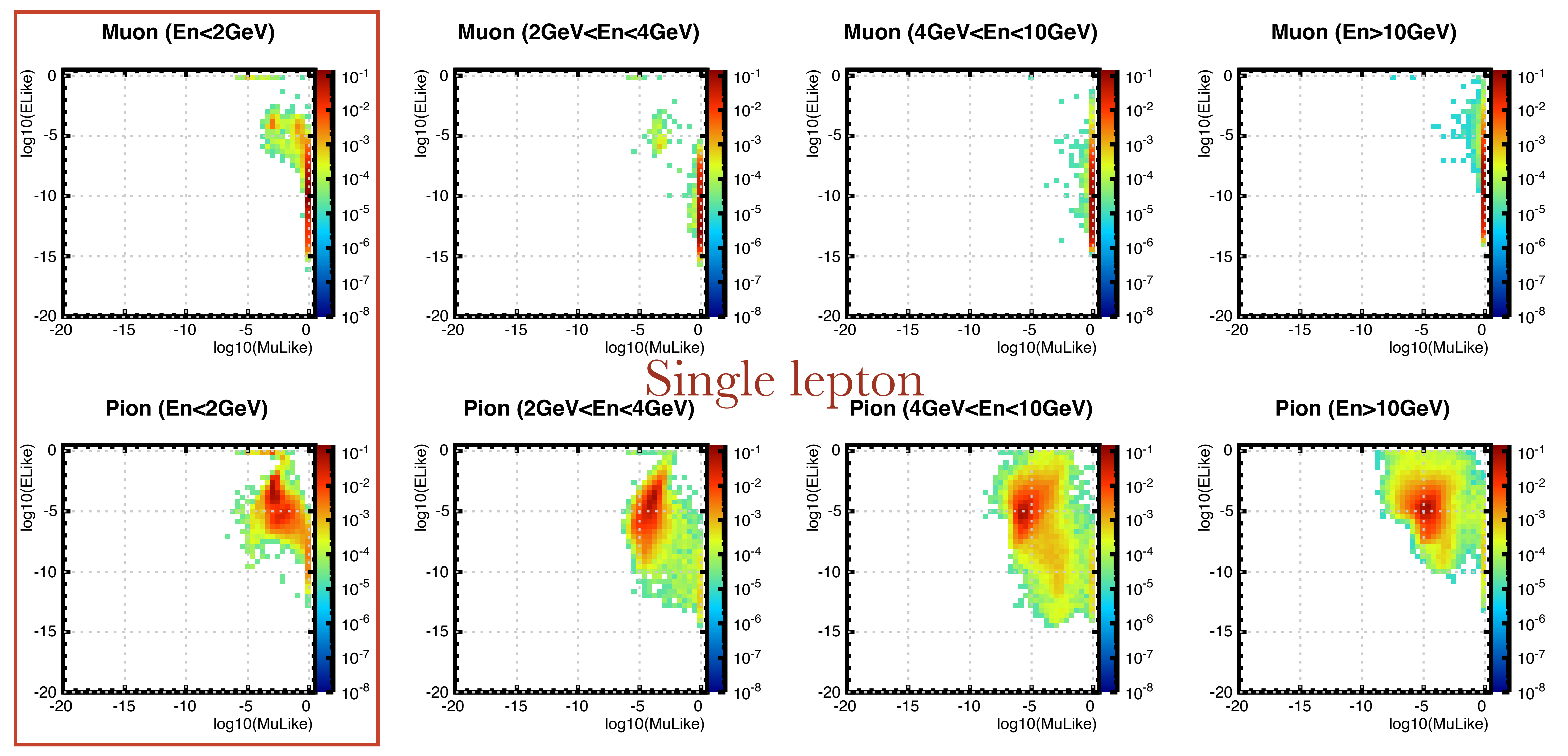
Migration Matrix for ALEPH PID ($> 2GeV$)(*Eur.Phys.J.C20:401-430,2001*)

Type	e^- *like*	μ^- *like*	π^+ *like*	undefined
e^-	99.57 ± 0.07	< 0.01	0.32 ± 0.0	0.09 ± 0.04
μ^-	< 0.01	99.11 ± 0.08	0.88 ± 0.08	0.01 ± 0.01
π^+	0.71 ± 0.04	0.72 ± 0.04	98.45 ± 0.06	0.12 ± 0.03

Eur. Phys. J. C (2017) 77: 591

Likelihood vs Energy

- For higher energy, still nice separation
- For lower energy, pion mixed with muon



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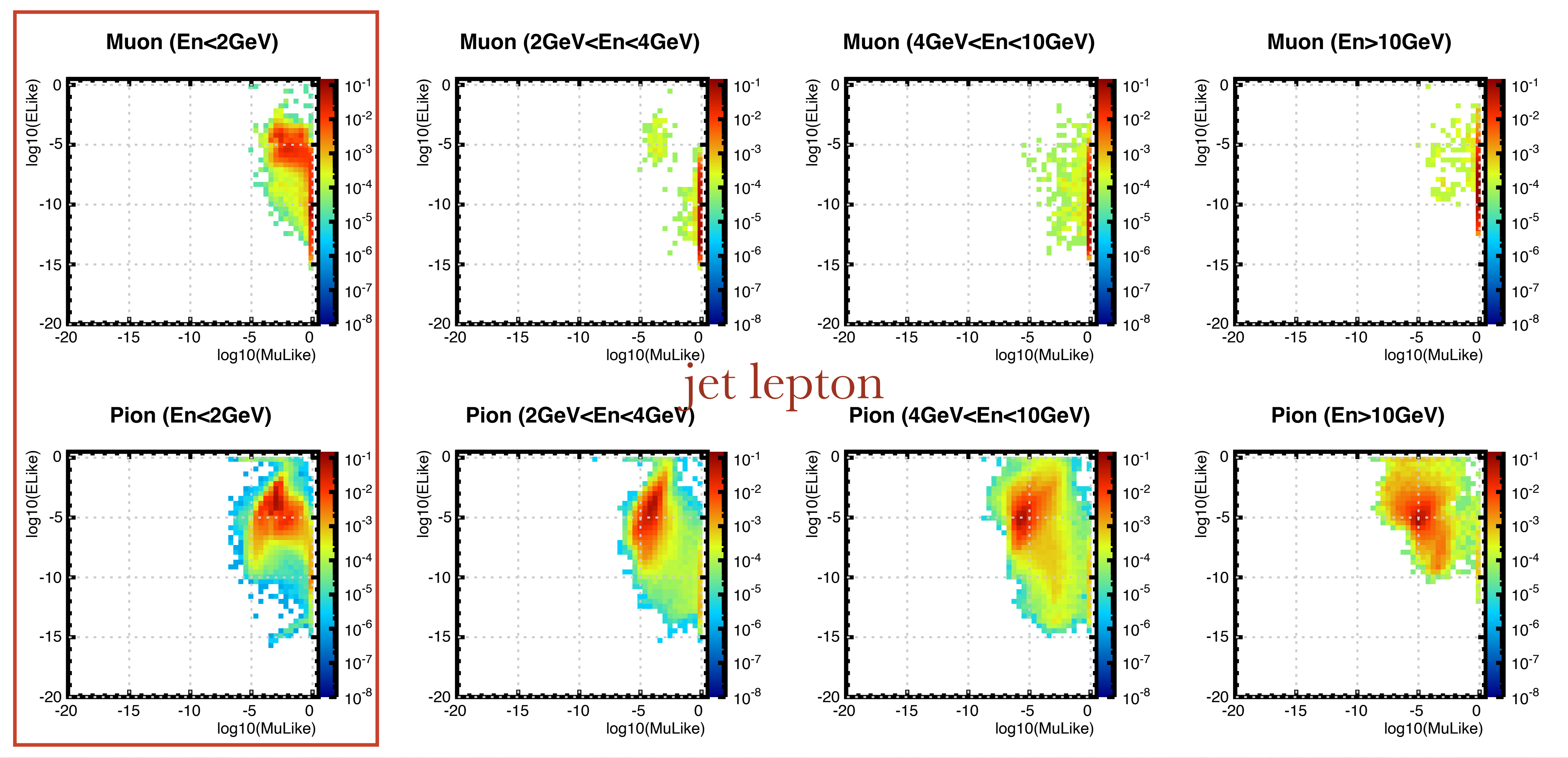
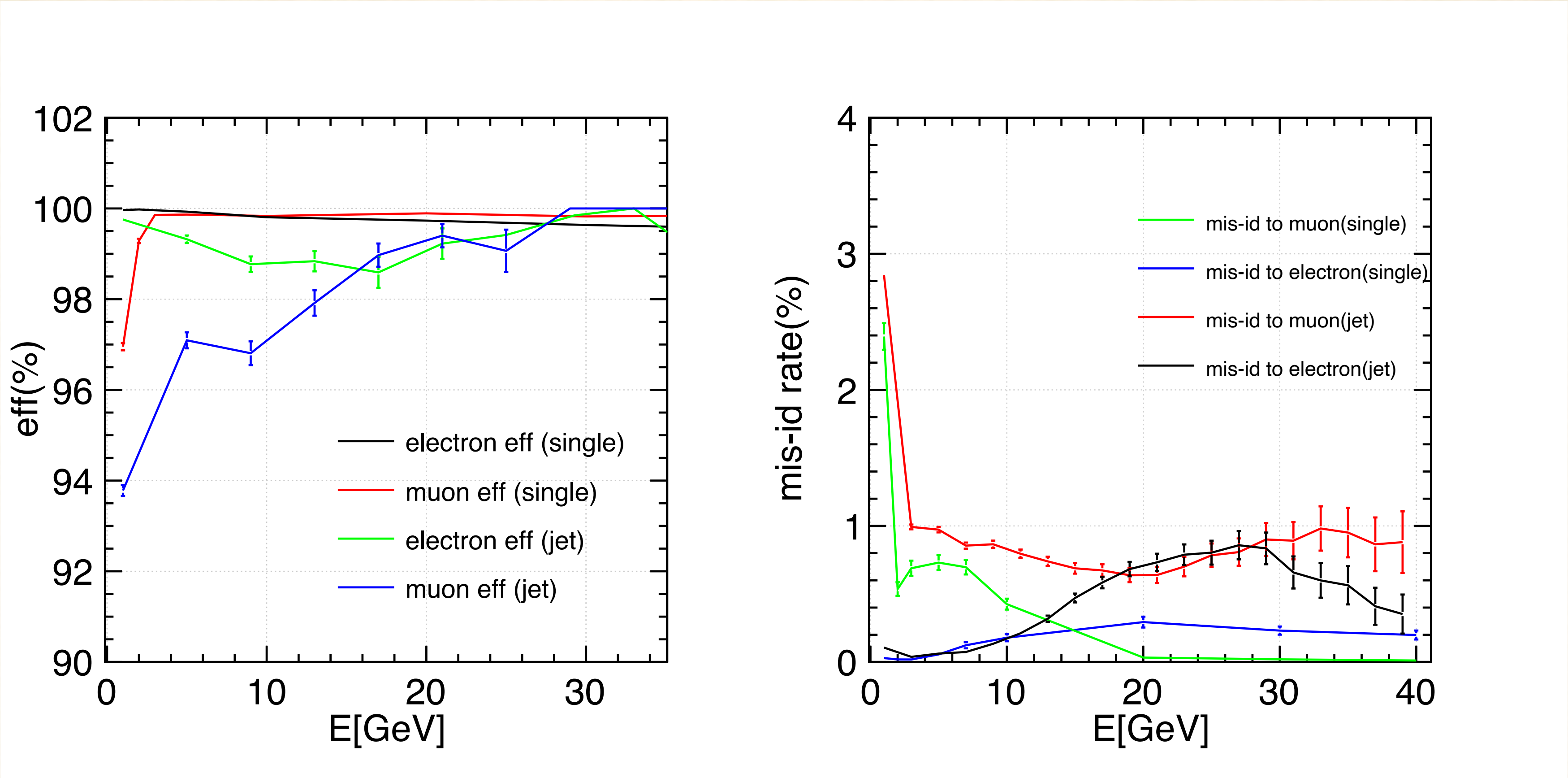


Lepton in jets

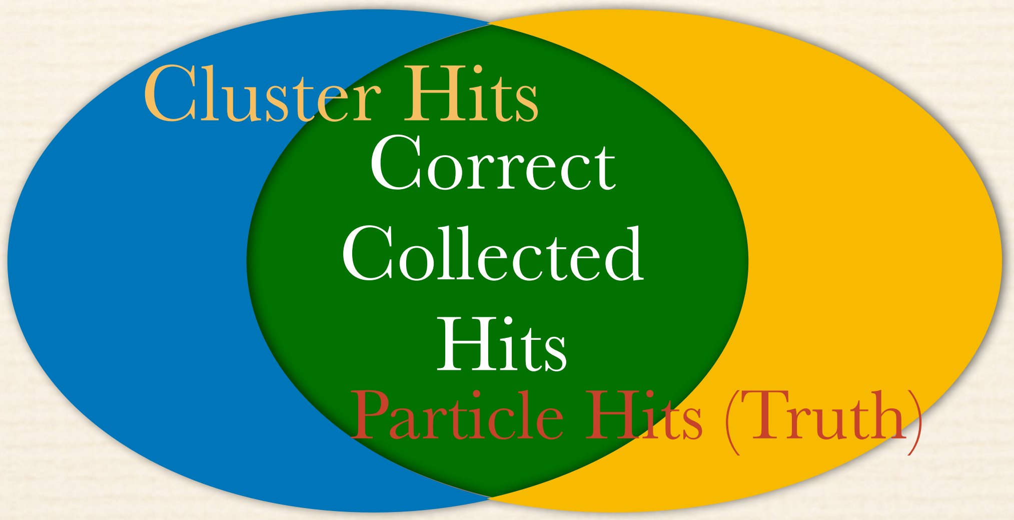
- The performance for lepton in jets degrades comparing to the single particle results
- Application: Bc→τν (arxiv:2007.08234 by Taifan ZHENG)
- Further: more flavor physics such as lepton flavor universality, etc.



Clustering Performance

- Use clustering
  - efficiency (correct collected hits/particle hits)
  - purity (correct collected hits/cluster hits)

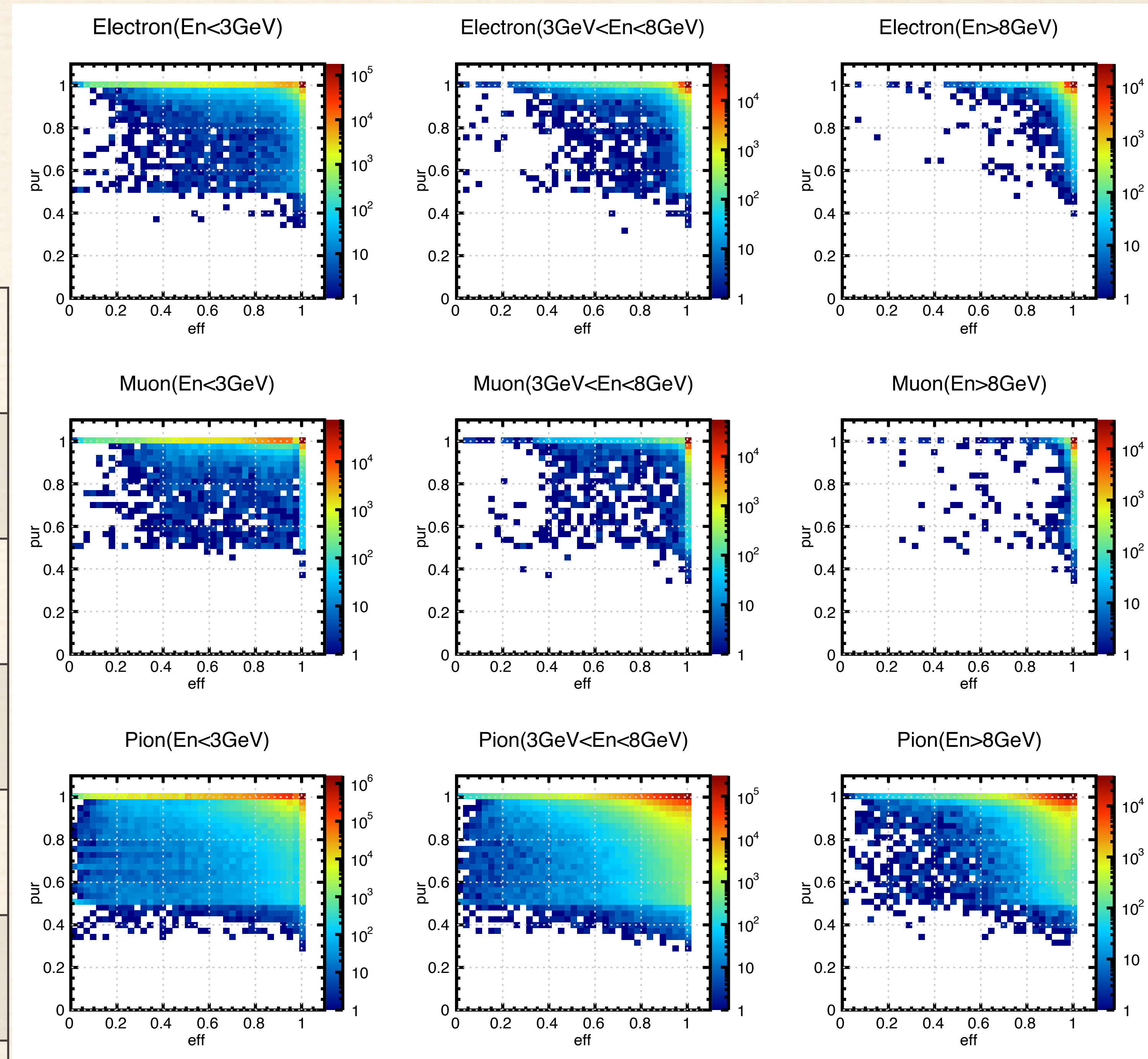
to characterize clustering performance



Clustering Performance

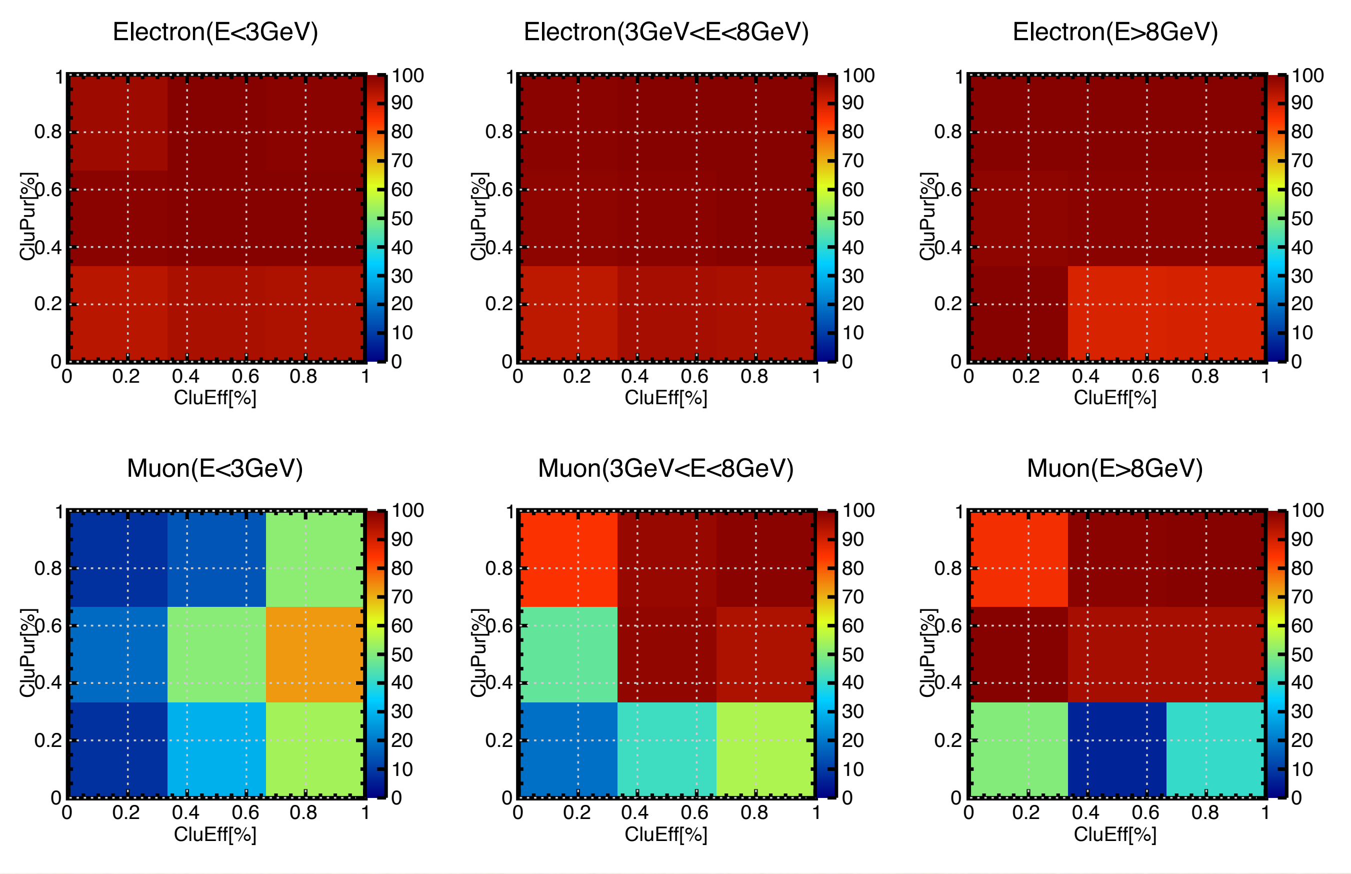
- Higher energy, better clustering performance

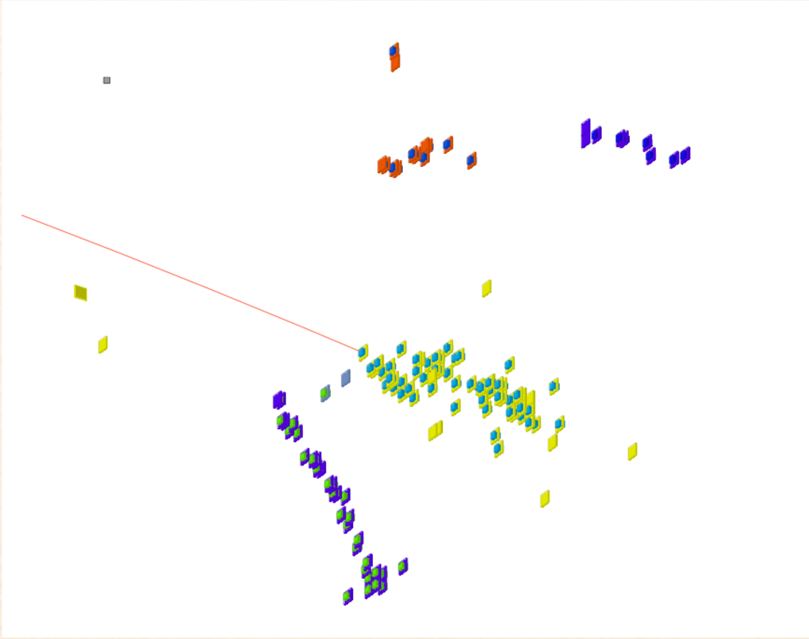
ratio(%)		<3GeV	3-8GeV	>8GeV
e	1	71.06	65.16	50.85
	<0.9	18.87	9.84	6.64
μ	1	54.55	81.68	82.53
	<0.9	31.45	5.75	3.55
π	1	52.84	24.75	13.45
	<0.9	26.77	32.68	30.52



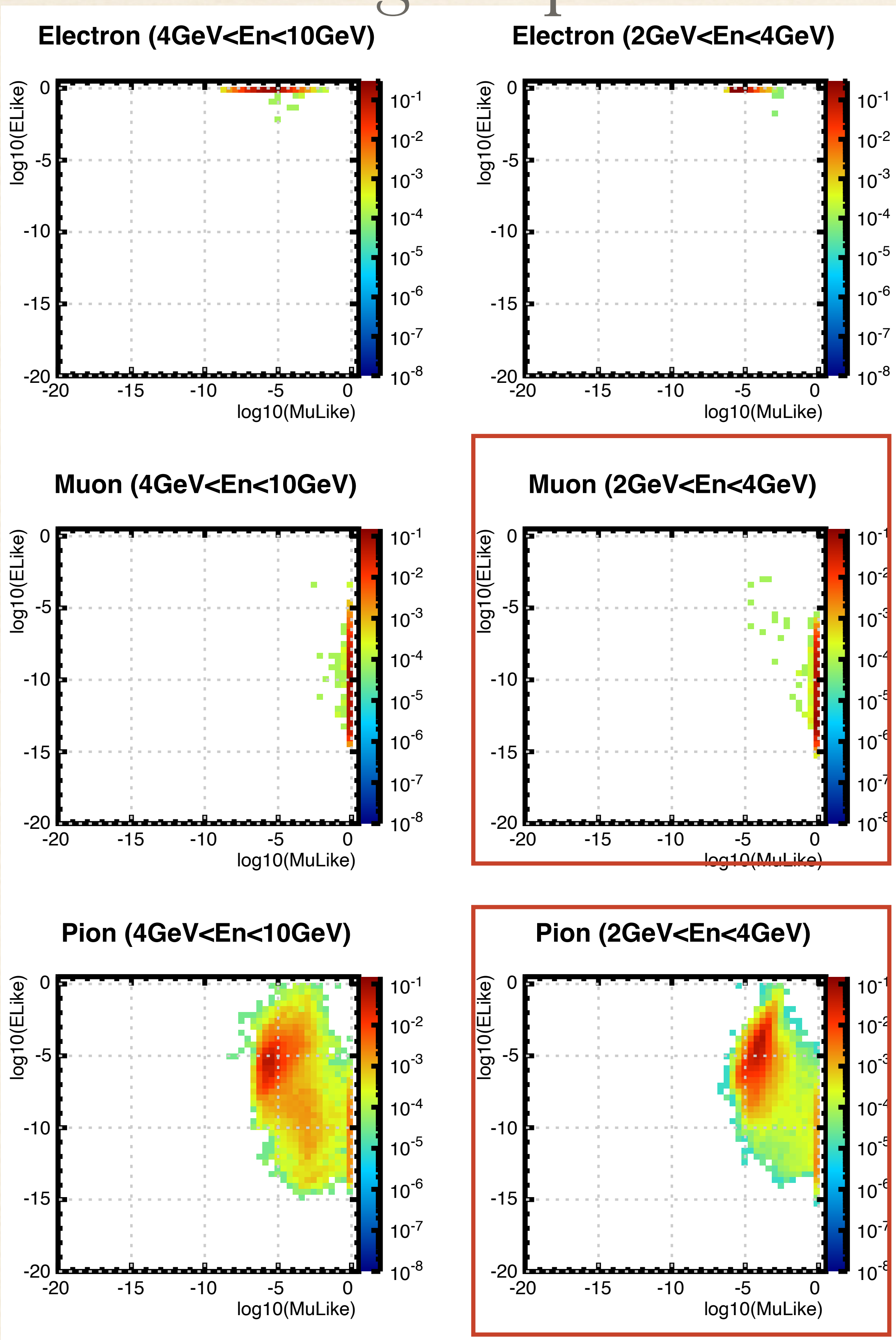
Clustering vs PID

- Electrons:
  - low energy: dE/dx dominate
  - clusters are compact, the splitting clusters still electron-like
- Muon:
  - cluster is not MIP-like if mixed with other hits
  - muon likeliness is lost when the muon cluster splits into small pieces
- Pion:
  - likely to be a EM cluster with some branches
  - more likely to be mis-identified as an electron for lower clustering efficiency

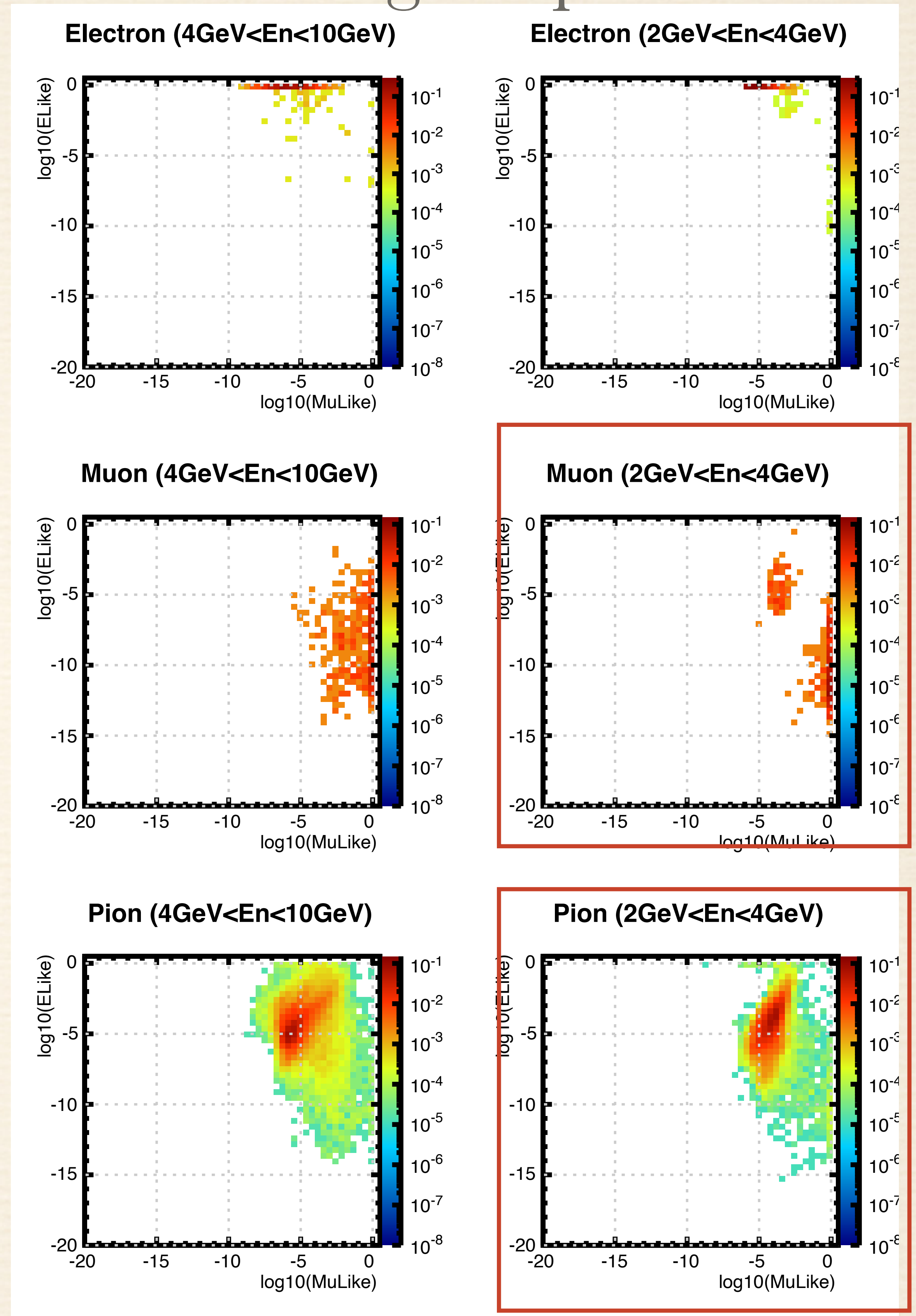




Clustering eff*pur=1

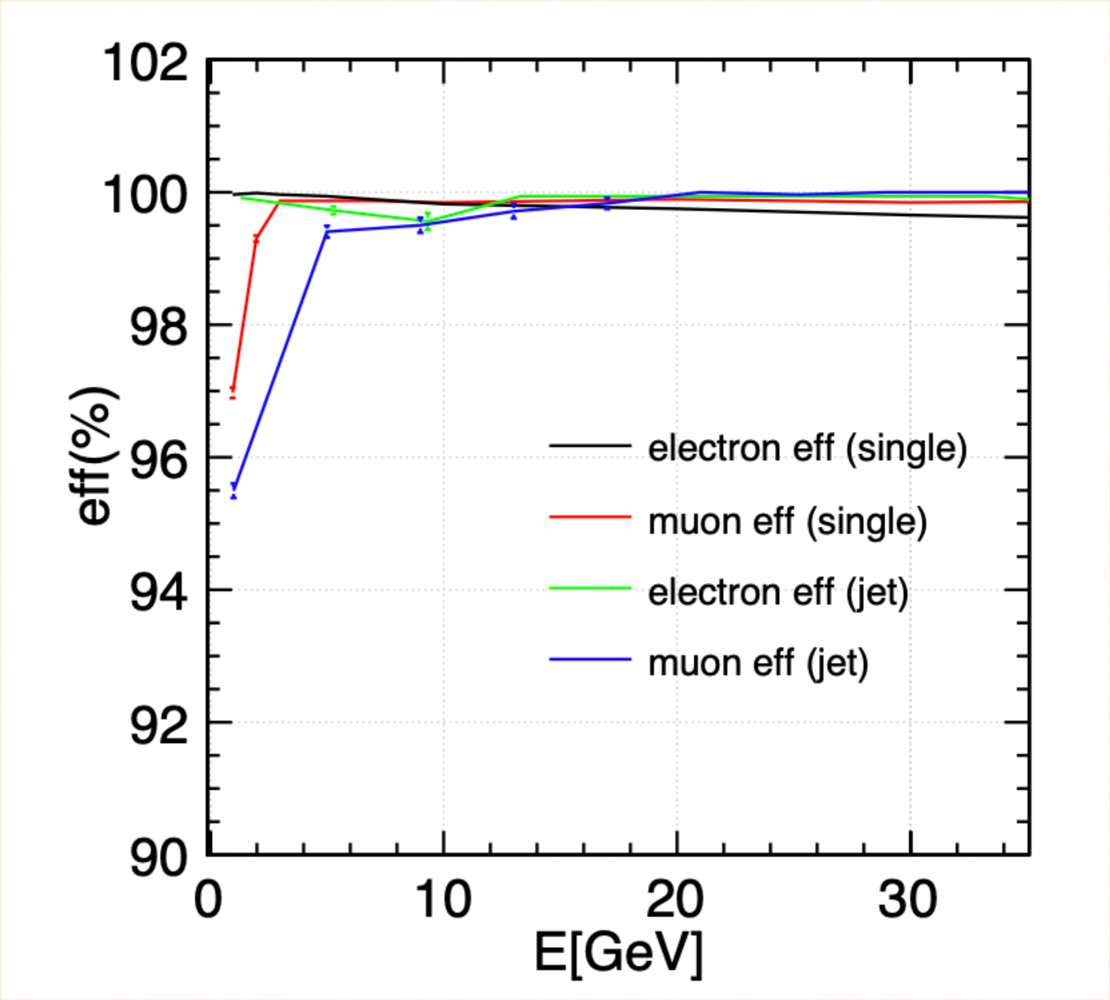


Clustering eff*pur<0.9

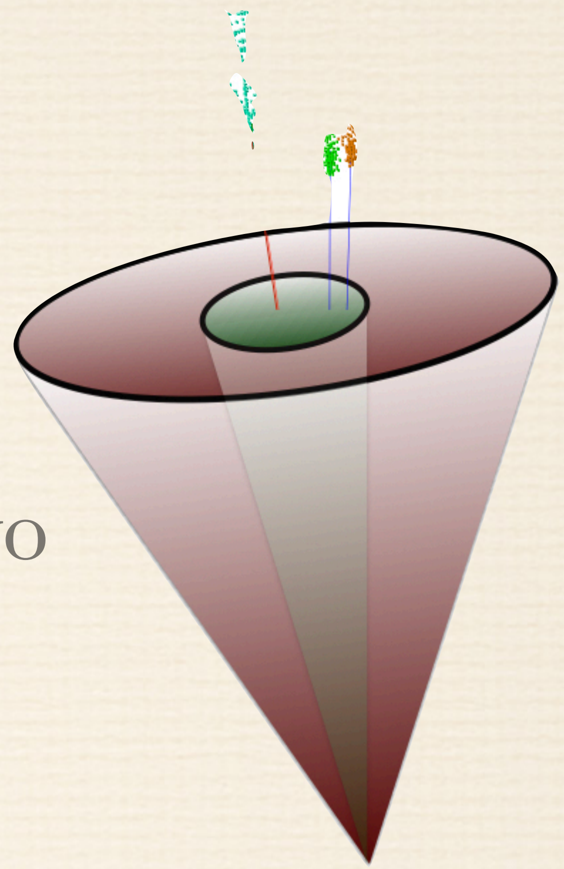


Comparison

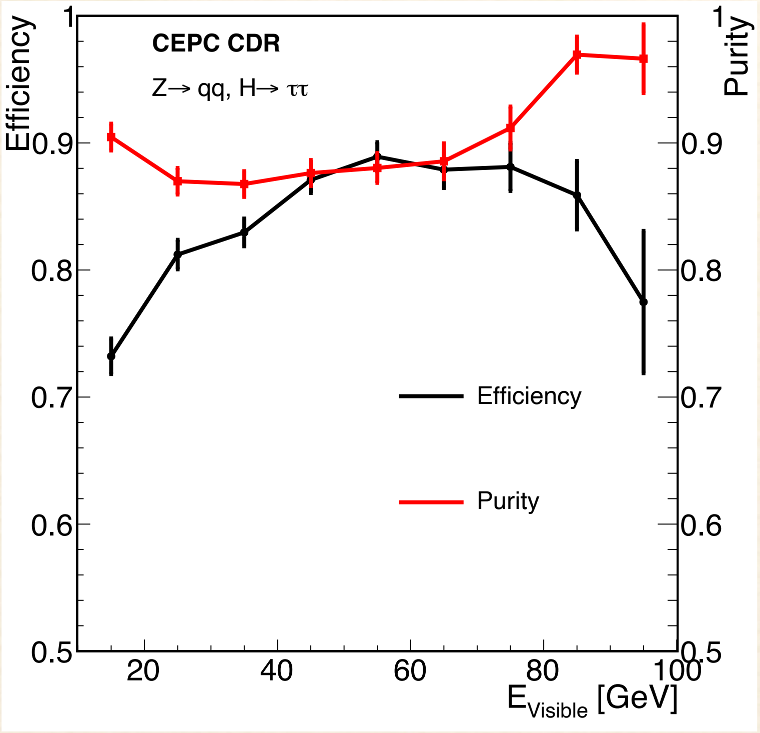
- Comparison of lepton identification performance for perfect clusters and the performance of single particle

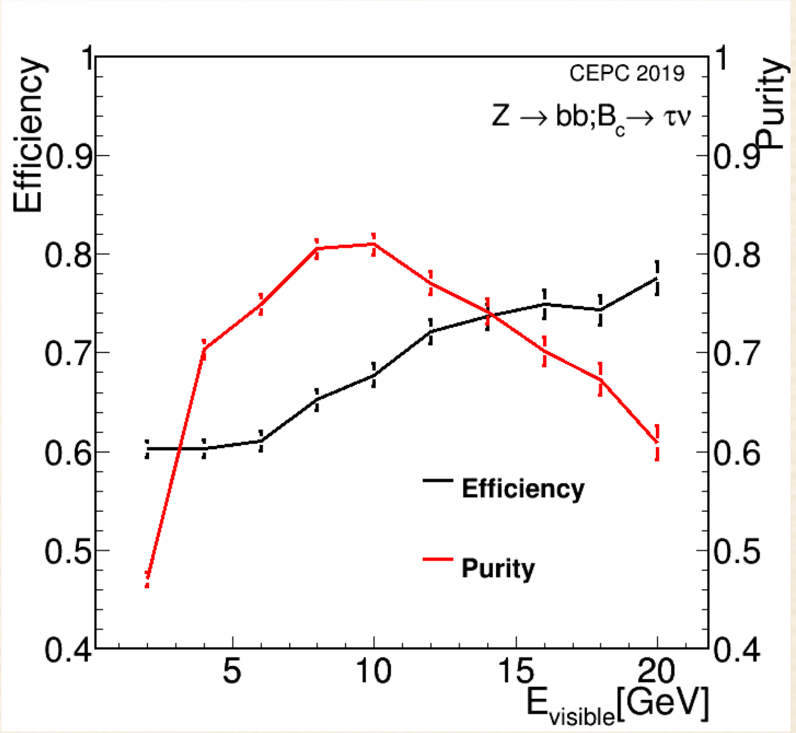


Taurus



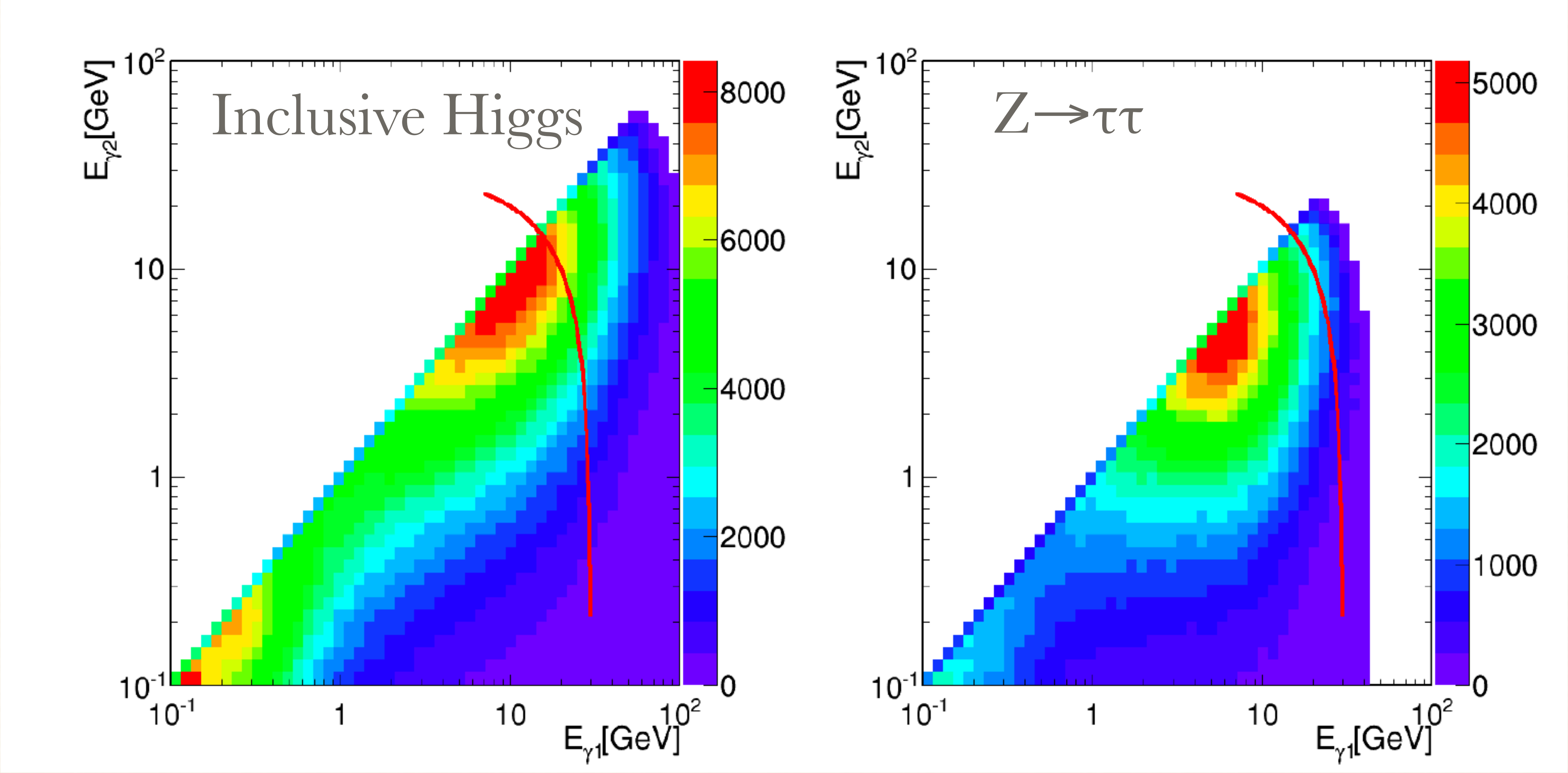
- Double cone based algorithm
  - Use the multiplicity, energy ratio between two cones, invariant mass for τ tagging
- H→ττ has been analyzed





π0 Reconstruction in Physics Events

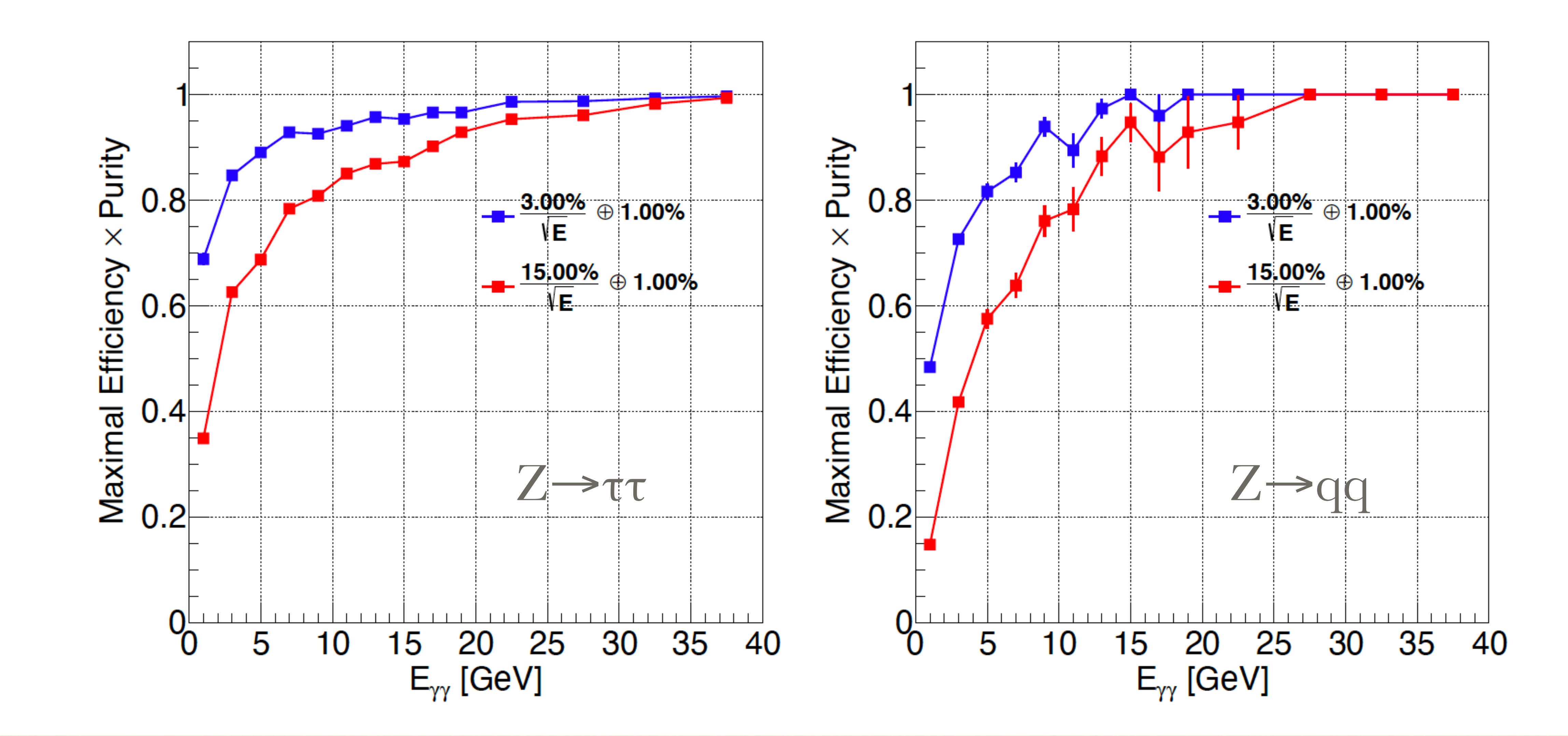
- π0 important in τ, flavor, energy reconstruction…
- Energy distribution of photon decayed from π0



π0 Reconstruction - FastSim

by Yuexin Wang

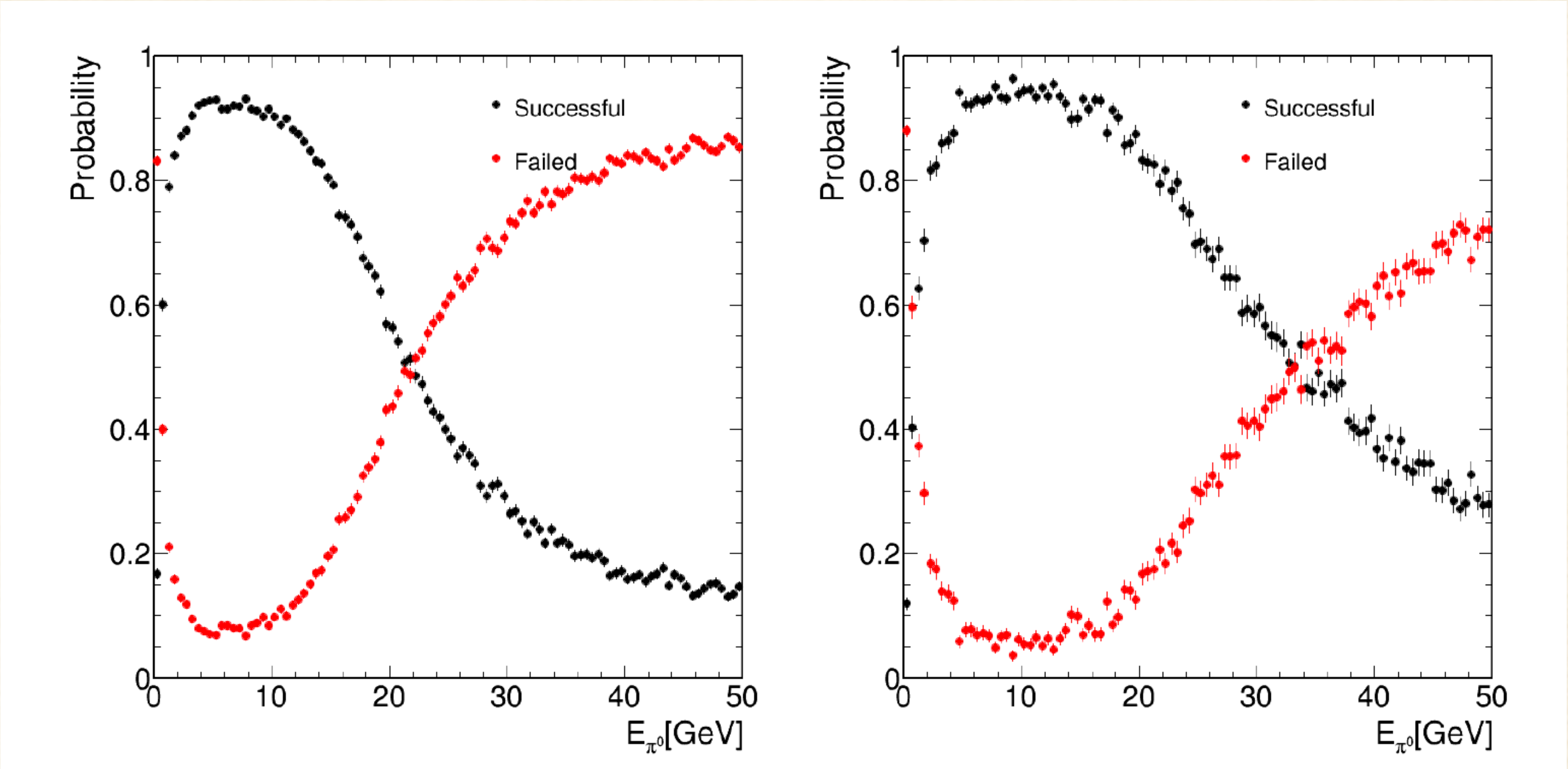
- Fast simulation analysis has been done to investigate the potential
- Perfect separation



π0 Reconstruction Rate

by Yuqiao Shen

- The probability of successfully reconstructing π0 in the barrel region and in the endcap region
- In the barrel region, 50% can be reconstructed when π0 energy lower than 22 GeV.
- In the endcap region, 50% can be reconstructed when π0 energy lower than 34 GeV.
- The lower energy degrading caused by photon identification and reconstruction.
- Most within the region with above 50% reconstruction rate

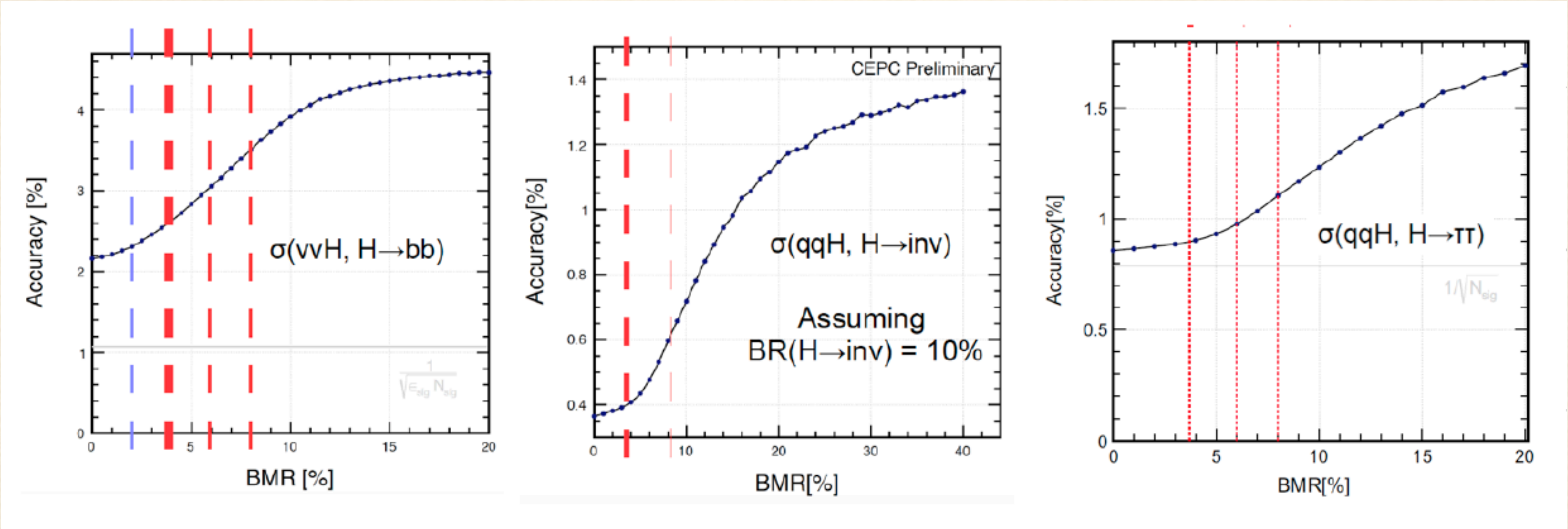


Jet Performance

- Jet performance: boson invariant mass resolution, jet energy and angular differential response, number of jets identification

Detector Optimization

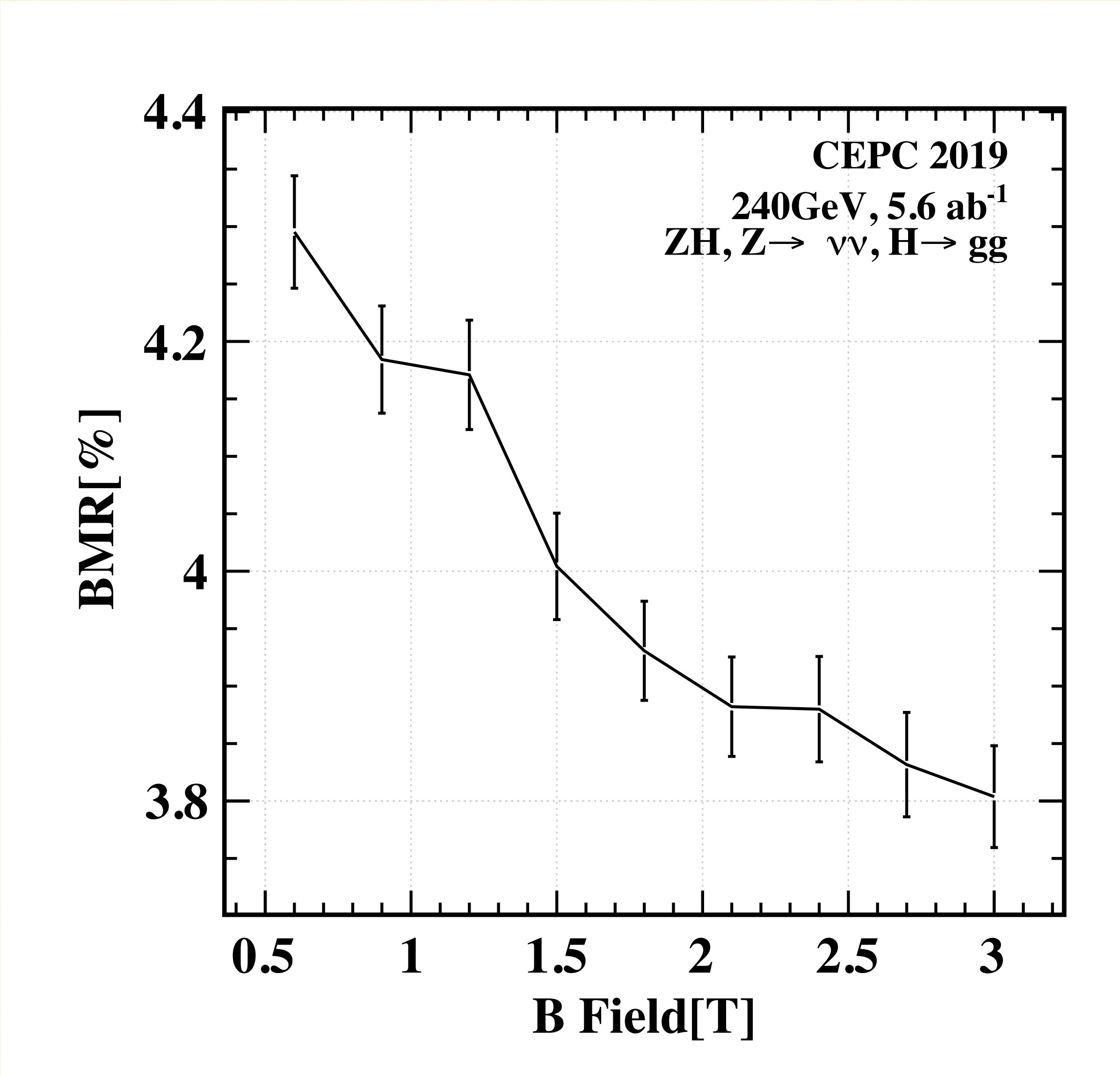
- BMR used for detector optimization
  - current: 3.7%
  - requirement: 4%
- Parameters for optimization: TPC size, B field, Ecal, Hcal, Solinoid, Detector acceptance



B Field

by Dan YU

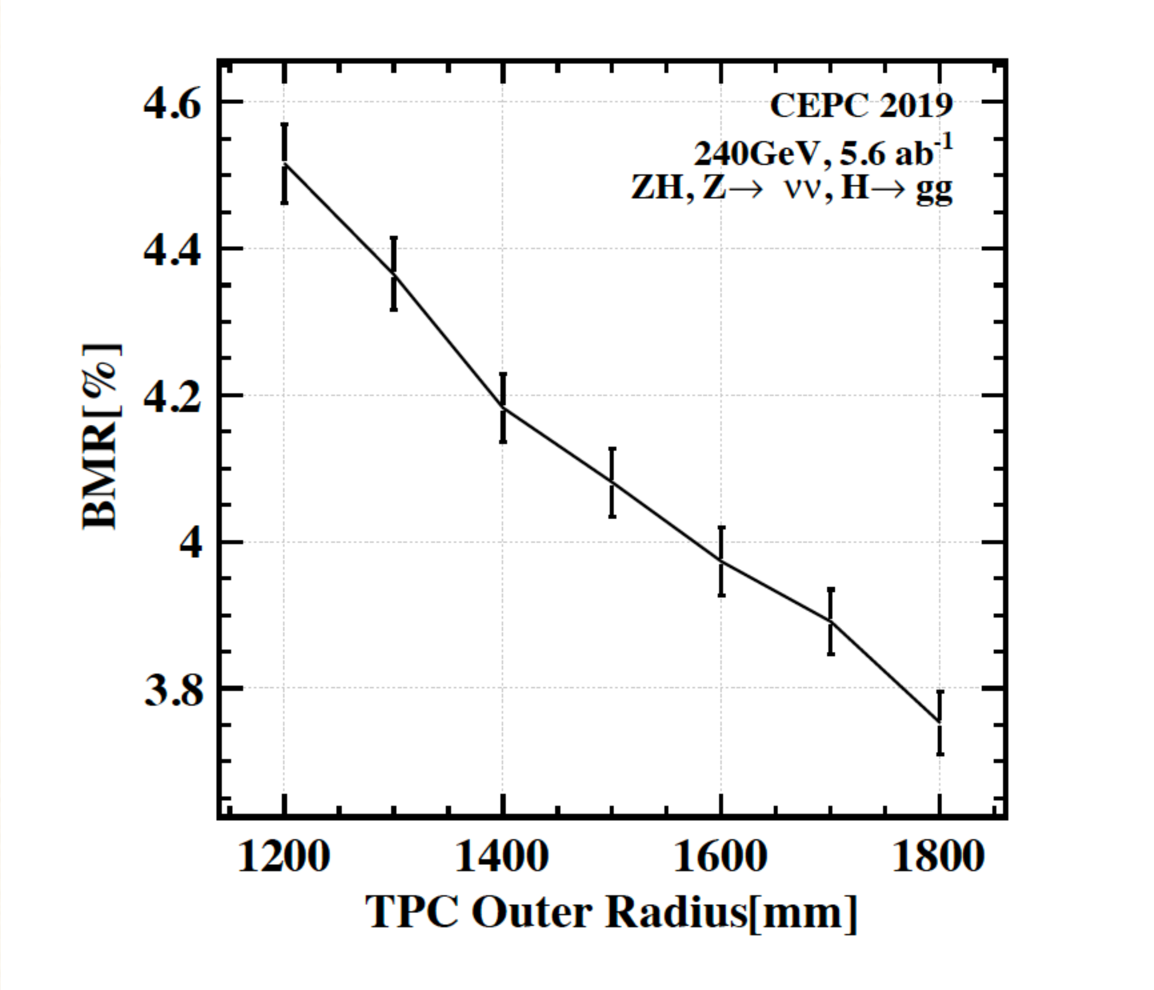
- B Field influence the separation of particles
- degrades by 13.16% at 0.6T
- 4% BMR: at least 1.5T



TPC Size

by Hanhua Cui

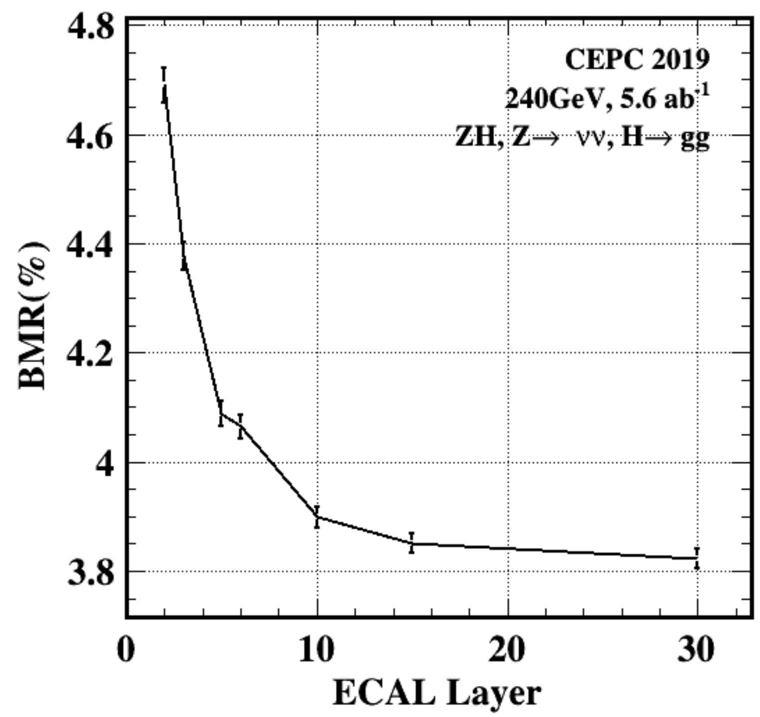
- Ratio R/Z fixed (already optimized)
- BMR degrades 20% when the radius of TPC reduces to 1200mm
- 4% BMR: R>1450mm Z>1600mm

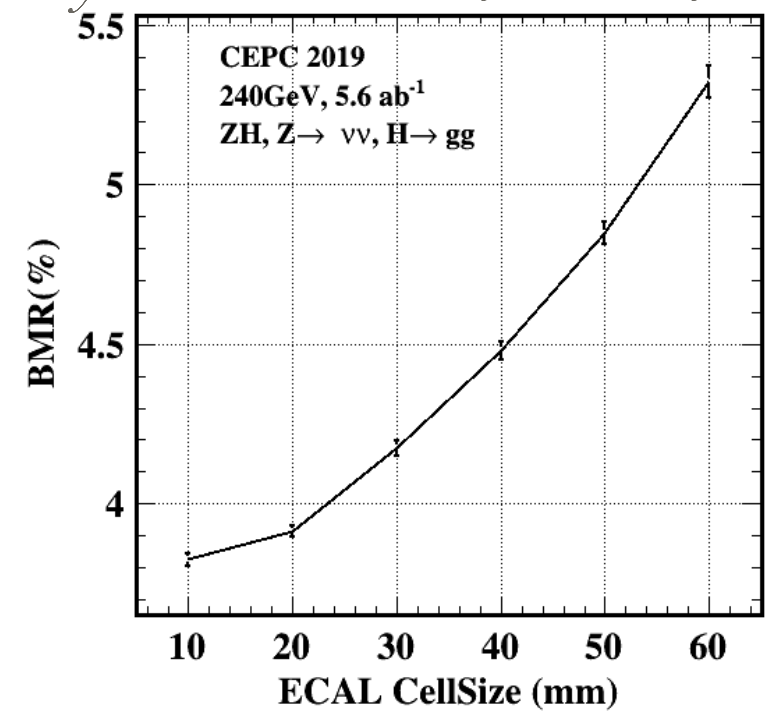


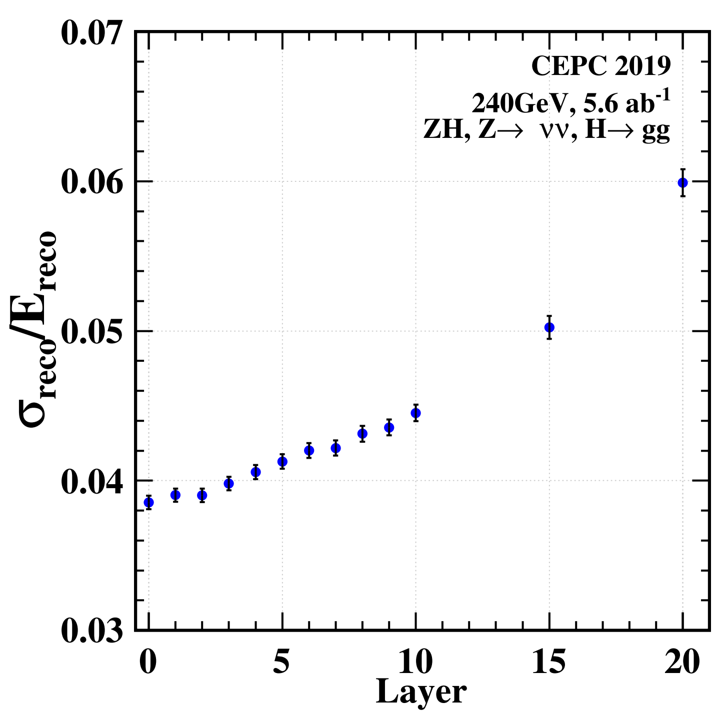
Calorimeters

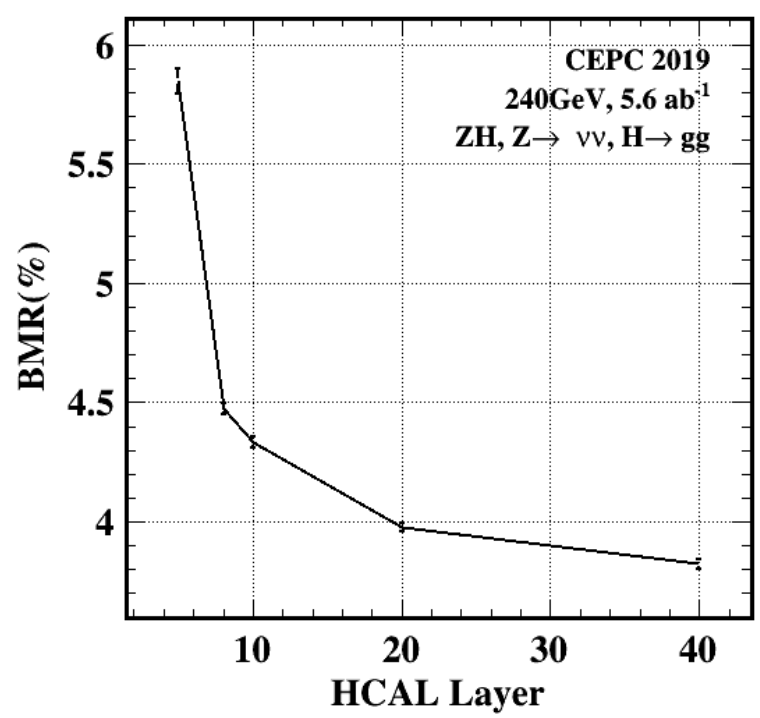
by Yukun Shi & Jeichen JIang

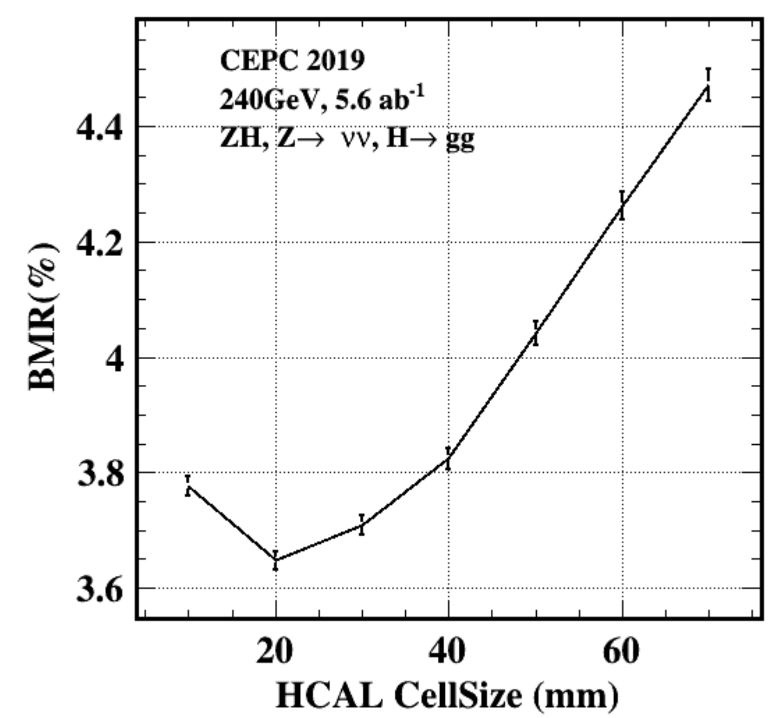
- The PFA needs high granularity to separate charged particles
- Longitudinal parameter limits resolution
- To reduce cost of detector, one consideration the solenoid between ECAL and HCAL







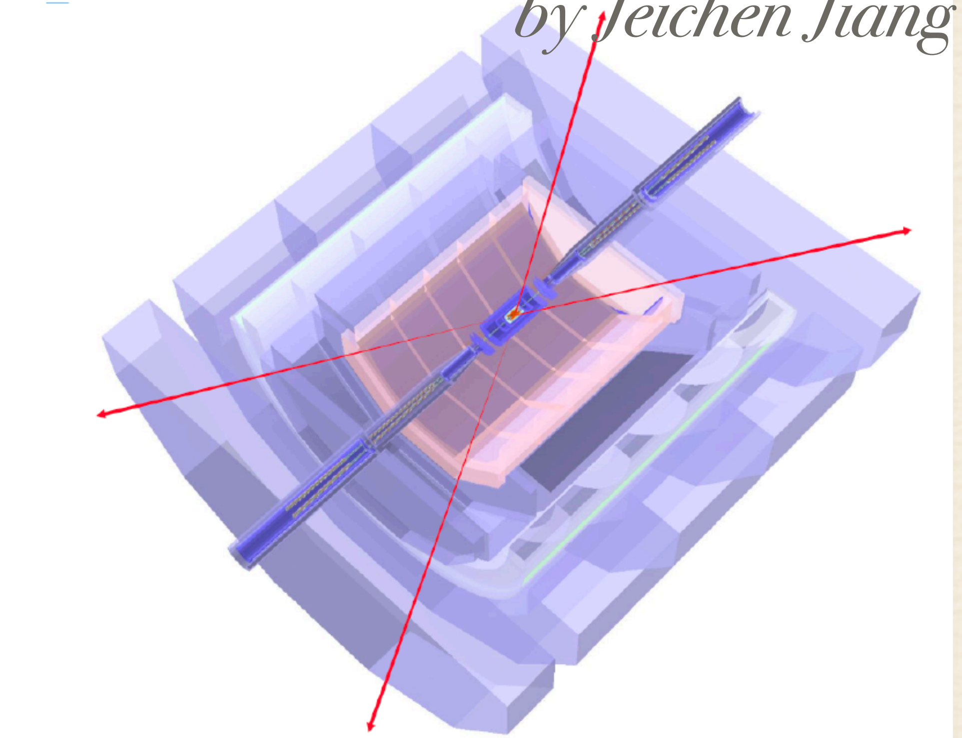




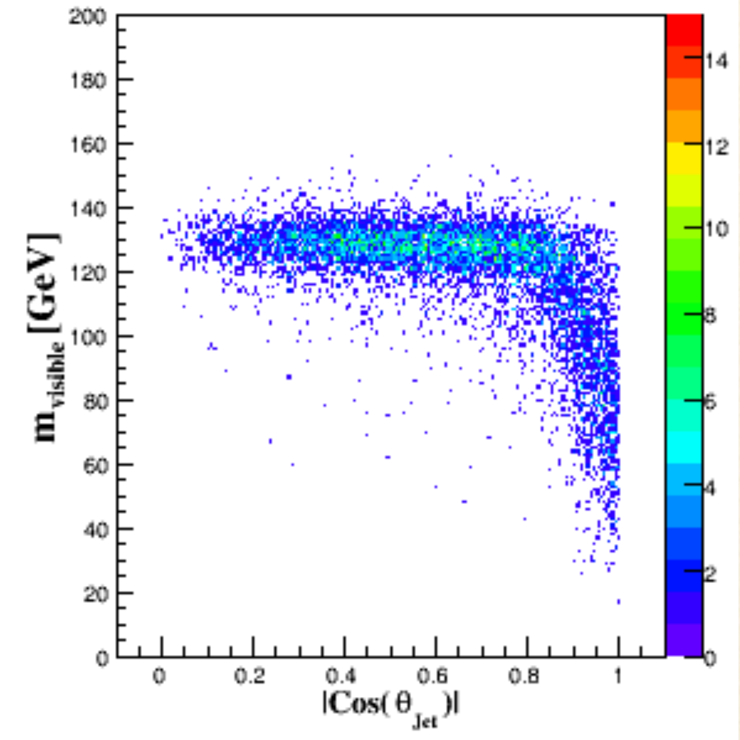
Detector Acceptance

- Acceptance limits the performance
- Mute hits above acceptance

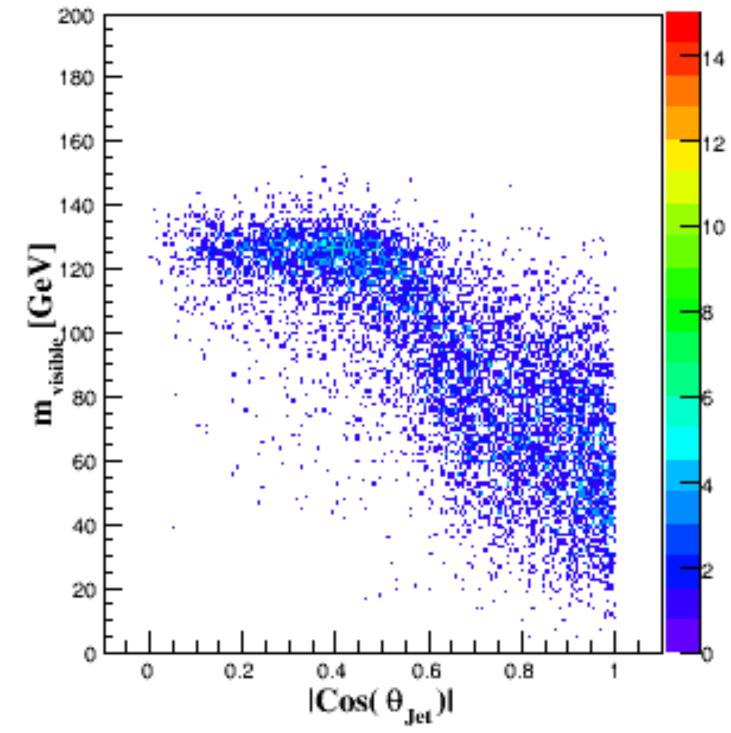
by Jeichen Jiang

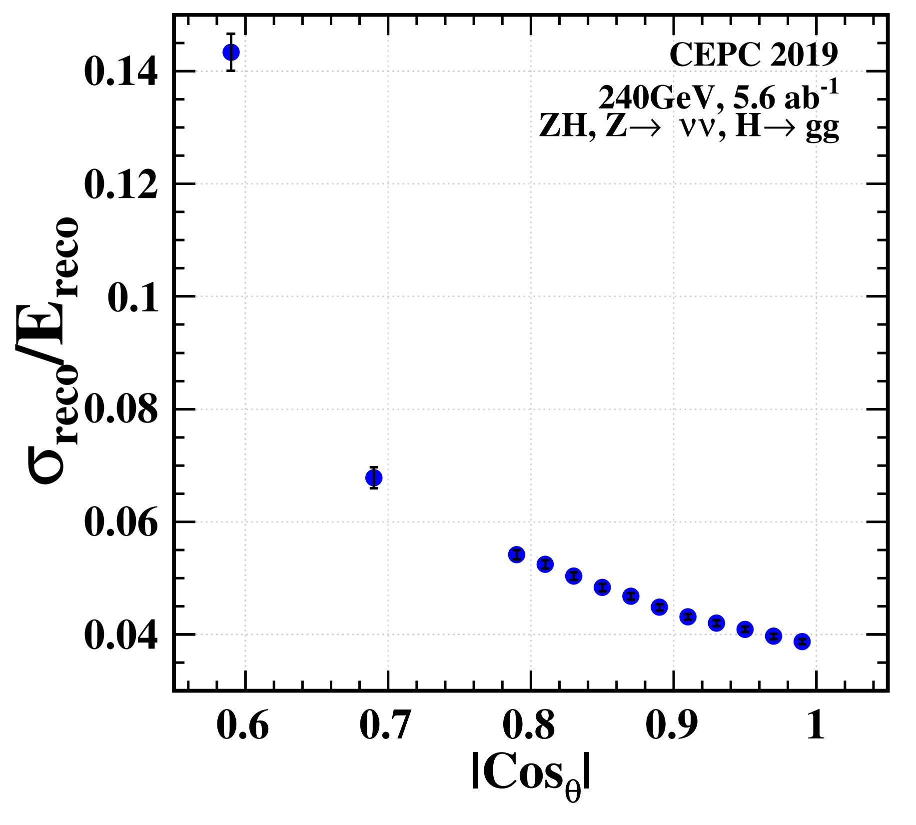


Acceptance θ = 5



Acceptance θ = 20

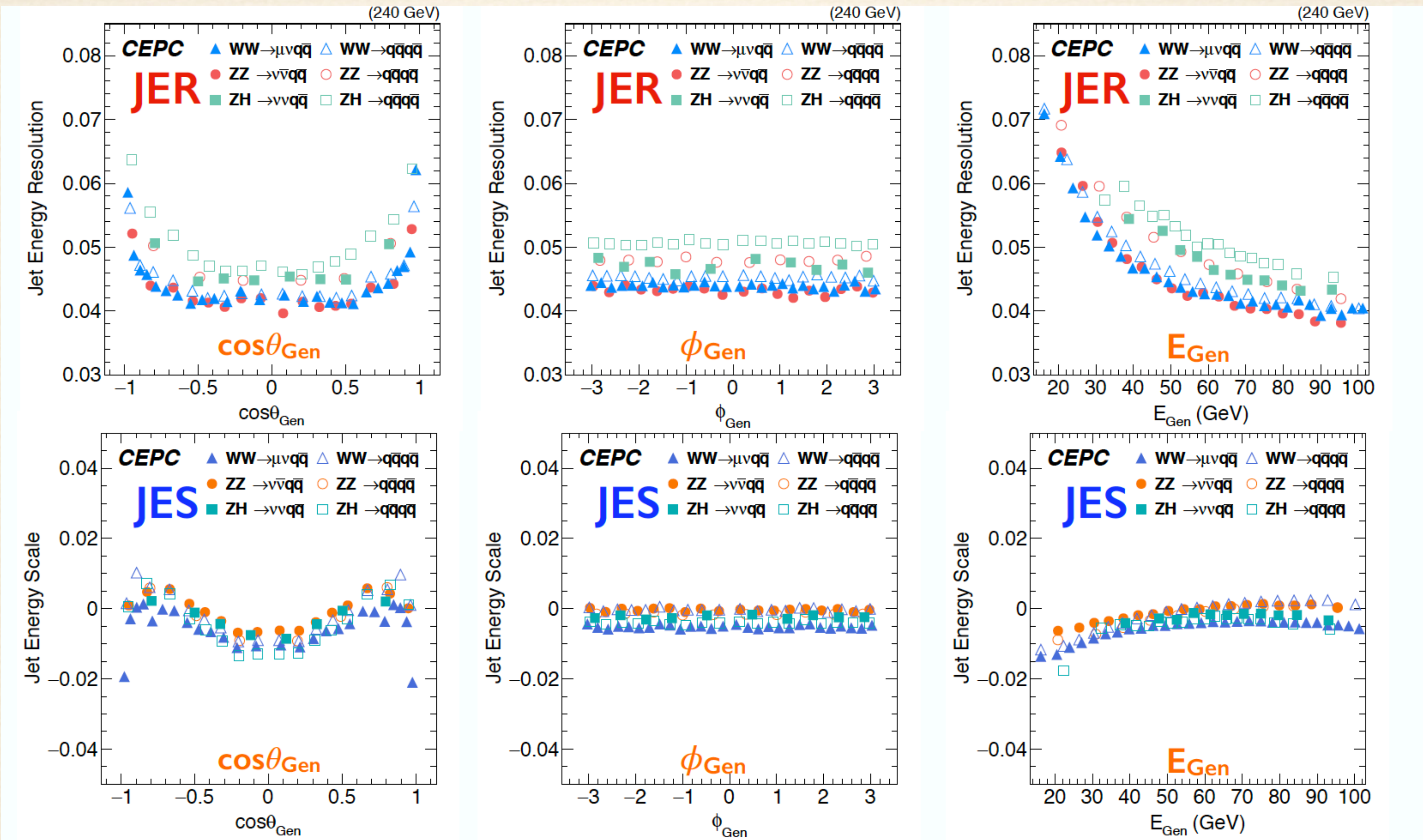




Jet Energy Resolution & Jet Energy Scale

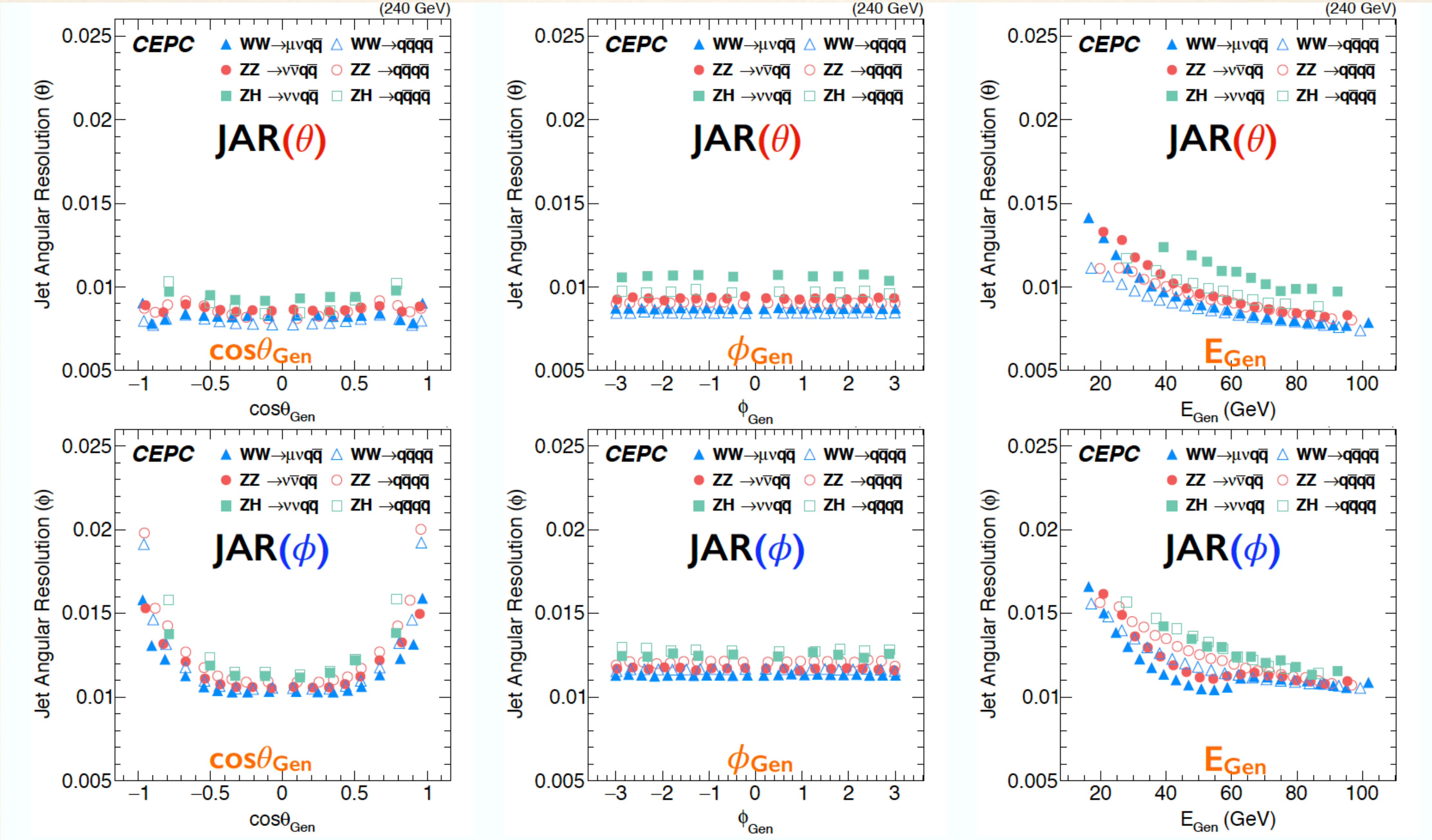
by Pei-Zhu Lai

- The difference between 2 and 4 jets final-state is controlled within 1% level



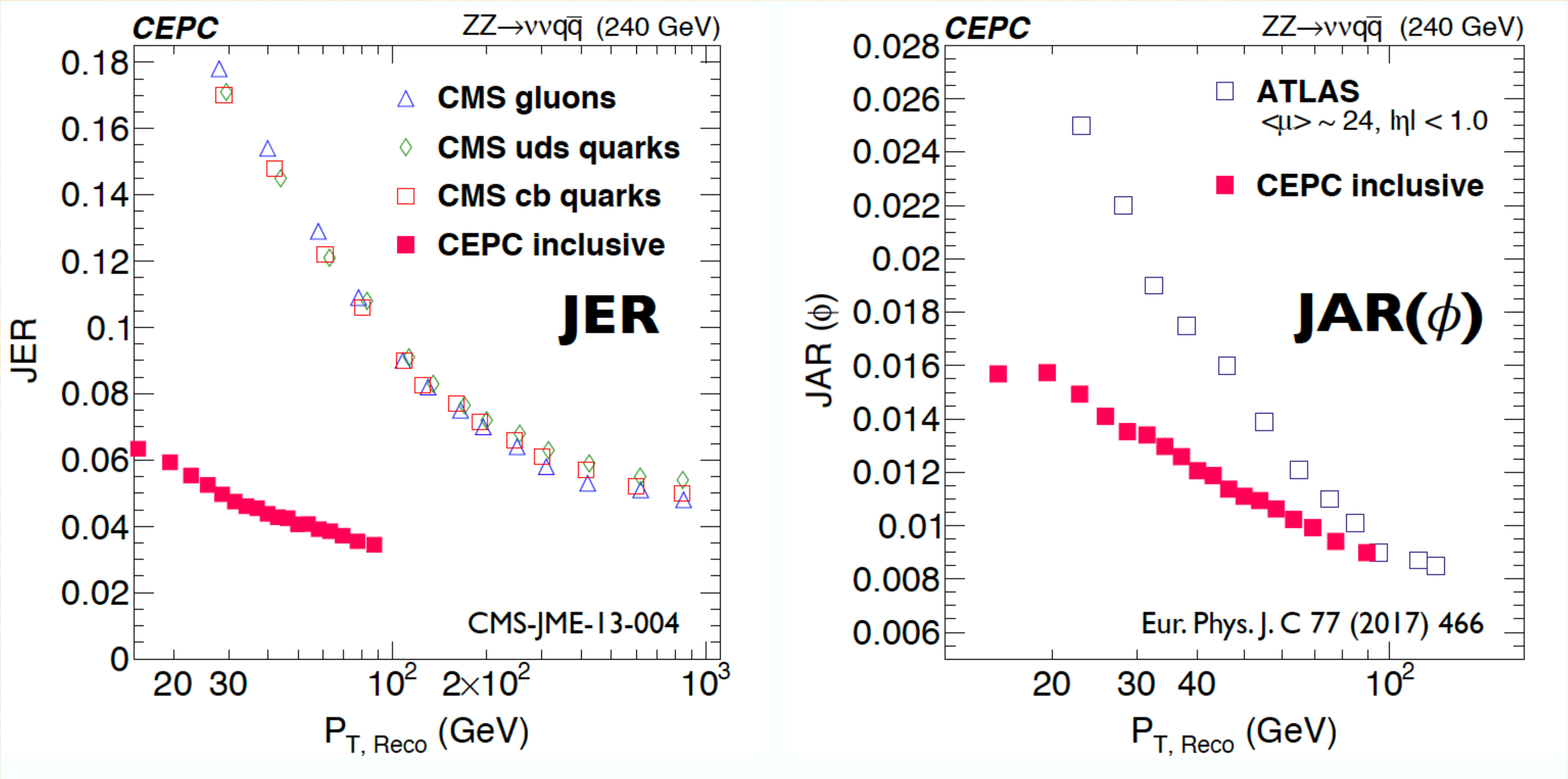
Jet Angular Resolution

- JAR is around 1% in barrel region



Compare to LHC

- JER: 3-4 times better
- JAR: 1.0-1.6 times
- W mass precision~ 10GeV



Summary

- The CEPC physics objects are various and performances have been studied for the baseline
- For lepton identification, the performance of jet leptons is slightly degraded (1-2%) compare to the isolate case, due to the clustering confusion
- $\pi0$ reconstruction analysis shows the CEPC baseline detector can reconstruct the $\pi0$ with energy as high as 20 - 30 GeV (About 97% of the $\pi0$ in $Z \to \tau\tau$ events)
- Jet
    - BMR used in the detector optimization, providing evidence for the detector design
    - CEPC baseline JER ~ 4%, JAR ~1%

Thank you!

Backup