Can we separate the ZZ and WW events with 4-jets full hadronic final state ?

Performance study of the 4-jet final state event reconstruction at the CEPC Baseline

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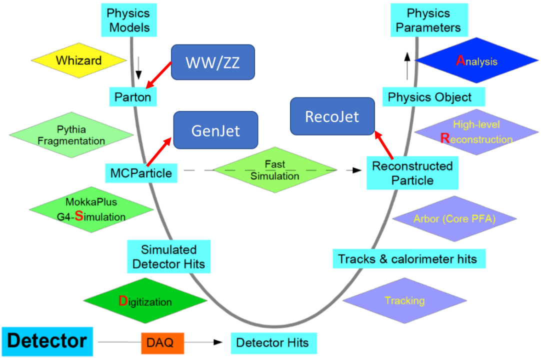
Introduction

At CEPC :

- $ZH \rightarrow$4-jet : $\sim$50%
- $WW \rightarrow$4-jet : $\sim$50%
- $ZZ \rightarrow$4-jet : $\sim$50%
- EW(Triplet Gauge Boson Coupling), and Higgs measurements.
- So jet is important

Sample



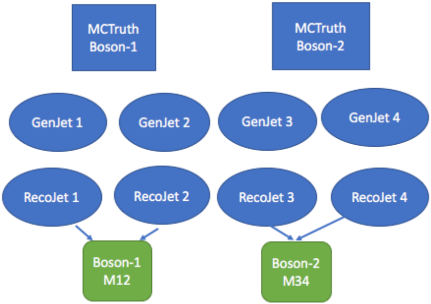
Inclusive sample :

- 38k $WW \to$ 4-jet
- 38k $ZZ \to$ 4-jet

Light sample :

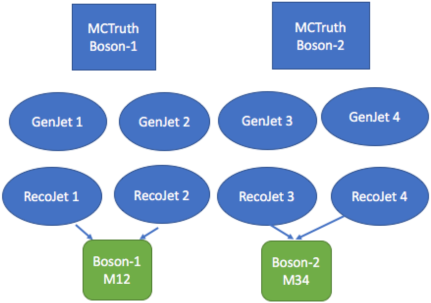
- 40k $WW \to$ uusd
- 40k$ZZ \to$uuuu

Pairing 4 jets



M12, M34, M13, M24, M14 and M23

Pairing 4 jets

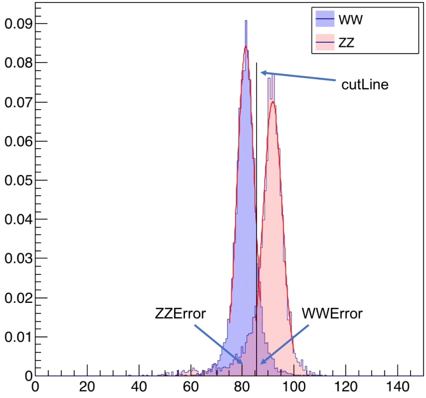


M12, M34, M13, M24, M14 and M23

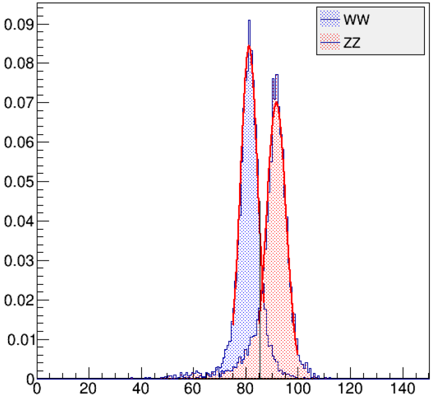
$$\begin{cases} distance\_Z1 = (M12 - mass_Z)^2 + (M34 - mass_Z)^2 \\ distance\_Z2 = (M13 - mass_Z)^2 + (M24 - mass_Z)^2 \\ distance\_Z3 = (M14 - mass_Z)^2 + (M23 - mass_Z)^2 \\ \ldots \end{cases}$$

Separation performance

0.5×(M12 + M34)



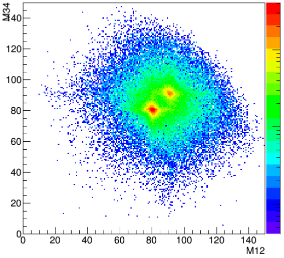
separation performance :
ZZError + WWError

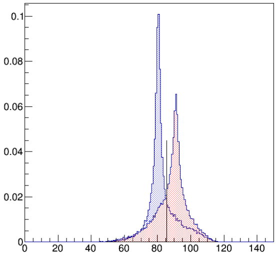


separation performance :

$$\frac{\Delta M}{\sqrt{\sigma_1^2+\sigma_2^2}}$$

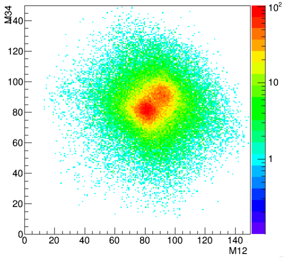
Separation performance

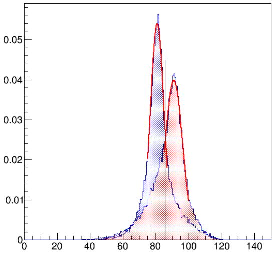




ee_genkt_algorithm :
R = 2, P = 1

GenJet separation performance : 57.24%

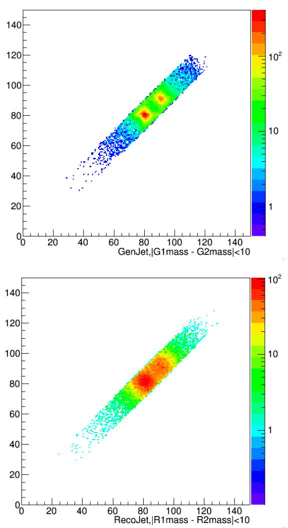




RecoJet separation performance : 62.71%

Separation performance

$|M12 - M34| < 10$



GenJet
WW selection ratio : 59.07%
ZZ selection ratio : 47.10%
separation performance : 32.37%

RecoJet
WW selection ratio : 54.01%
ZZ selection ratio : 43.8%
separation performance : 45.48%

ΔR

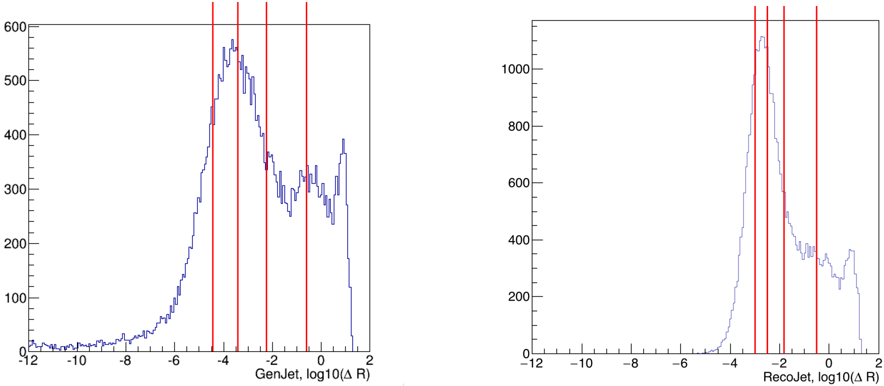
- MCTruth level($Boson_{tru}$)
- GenJet level($Boson_{gen}$)
- RecoJet level($Boson_{reco}$)

$$\Delta R = \Delta R_1 \times \Delta R_2$$

$$\Delta R_1 = \sqrt{(\theta_{boson1_{tru}} - \theta_{boson1_{reco/gen}})^2 + (\phi_{boson1_{tru}} - \phi_{boson1_{reco/gen}})^2}$$

$$\Delta R_2 = \sqrt{(\theta_{boson2_{tru}} - \theta_{boson2_{reco/gen}})^2 + (\phi_{boson2_{tru}} - \phi_{boson2_{reco/gen}})^2}$$

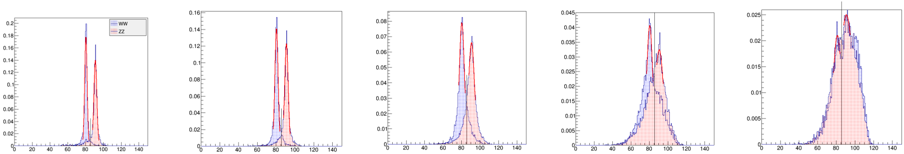
ΔR



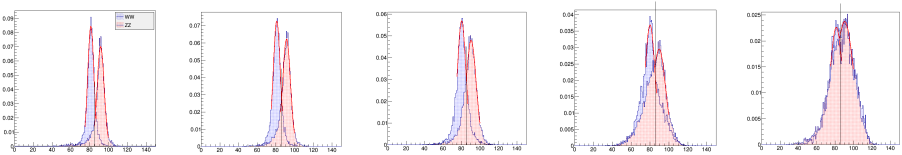
Characterize jet clustering performance into five sub-catalogues according to ΔR. Each catalogue contains 20% events.

Catalogue

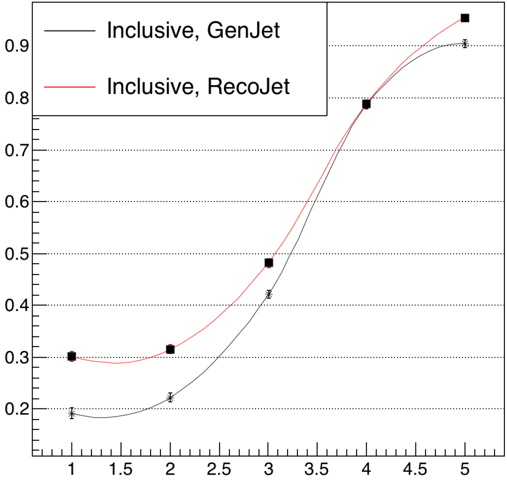
At GenJet level :



At RecoJet level :



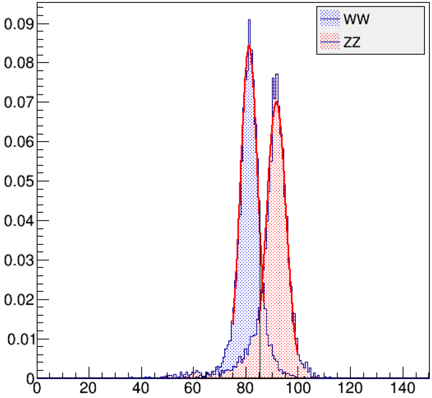
Catalogue

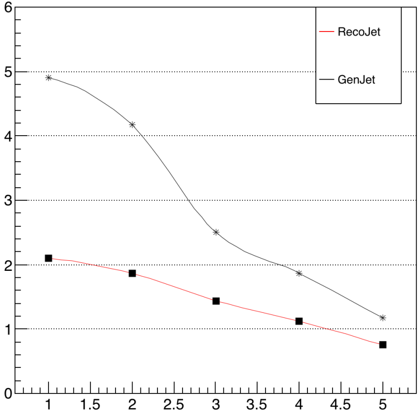


The separation performance variates with the jet clustering performance.

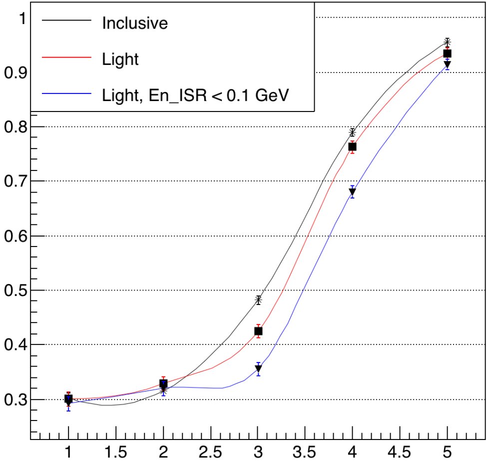
Catalogue

$$\text{separation performance} = \frac{\Delta M}{\sqrt{\sigma_1^2 + \sigma_2^2}}$$





Impact factor



- neutrinos in heavy-flavor quarks decay
- initial state radiation (ISR)

jet clustering algorithm

$$ee\_genkt\_algorithm : \begin{cases} d_{ij} = min(E_i^{2p}, E_j^{2p}) \times \dfrac{1 - cos\theta_{ij}}{1 - cosR} \\ d_{iB} = E_i^{2p} \end{cases}$$

- R : jet radius
- P = 1 : prefers to cluster soft particles first
- P = -1 : prefers to cluster hard particles first
- P = 0 : both of the distance variables are independent of energy

P = ? R = ? if WW/ZZ→4 quarks

	P = -1	P = 0	P = 1	P = 2	P = 3
$R = 2.5$	88.60%	84.57%	62.71%	65.04%	68.28%
$R = 2$	89.03%	84.57%	62.71%	65.04%	68.28%
$R = 1$	100.00%	96.44%	66.85%	69.24%	73.67%

Answer : R = 2 or larger, P = 1 $\longrightarrow$ *ee_kt_algorithm*

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(v) Neutrinos in heavy flavor decay and initial state radiation have impact on separation performance.

Thanks !