Jet Energy Resolution for CEPC Exotic Higgs Decay Status

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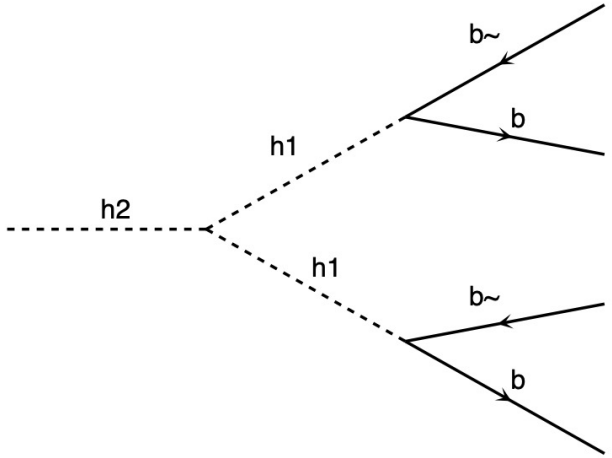
Physics Motivation

J. Kozaczuk, M. J. Ramsey-Musolf, and J. Shelton *Phys. Rev. D* **101**, 115035 (2020).

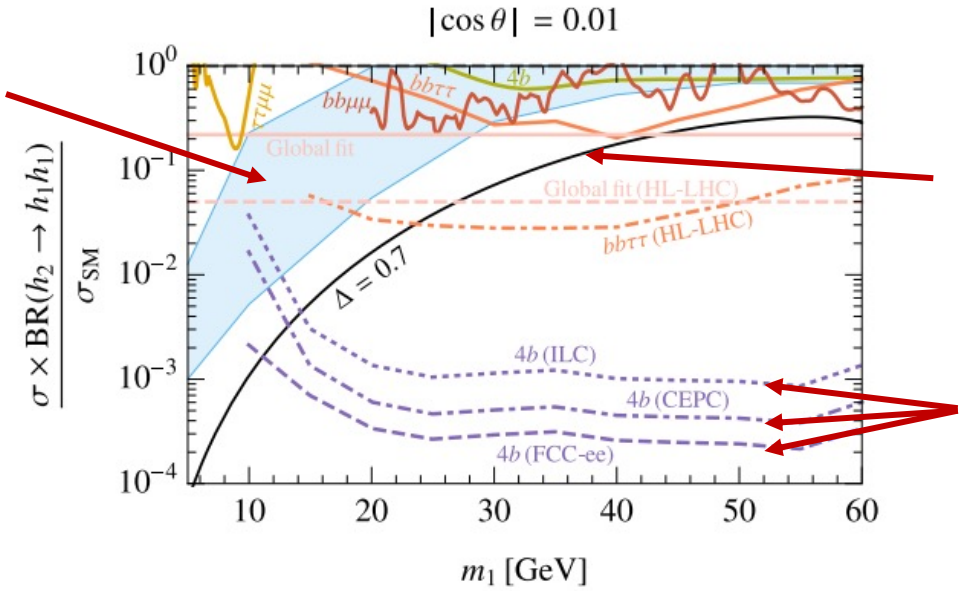
- We are interested in the strong first-order electroweak phase transition in the "SM Higgs + Light Real Singlet Scalar" model:

$$V = -\mu^2|H|^2 + \lambda|H|^4 + \frac{1}{2}a_1|H|^2 S + \frac{1}{2}a_2|H|^2 S^2 + b_1 S + \frac{1}{2}b_2 S^2 + \frac{1}{3}b_3 S^3 + \frac{1}{4}b_4 S^4$$

- Mass eigenstates: $h_1 = h\cos\theta + s\sin\theta \quad (h_1 : \text{singlet-like})$
  $h_2 = -h\sin\theta + s\cos\theta \quad (h_2 : \text{SM-like Higgs})$



EWPT viable: numerical

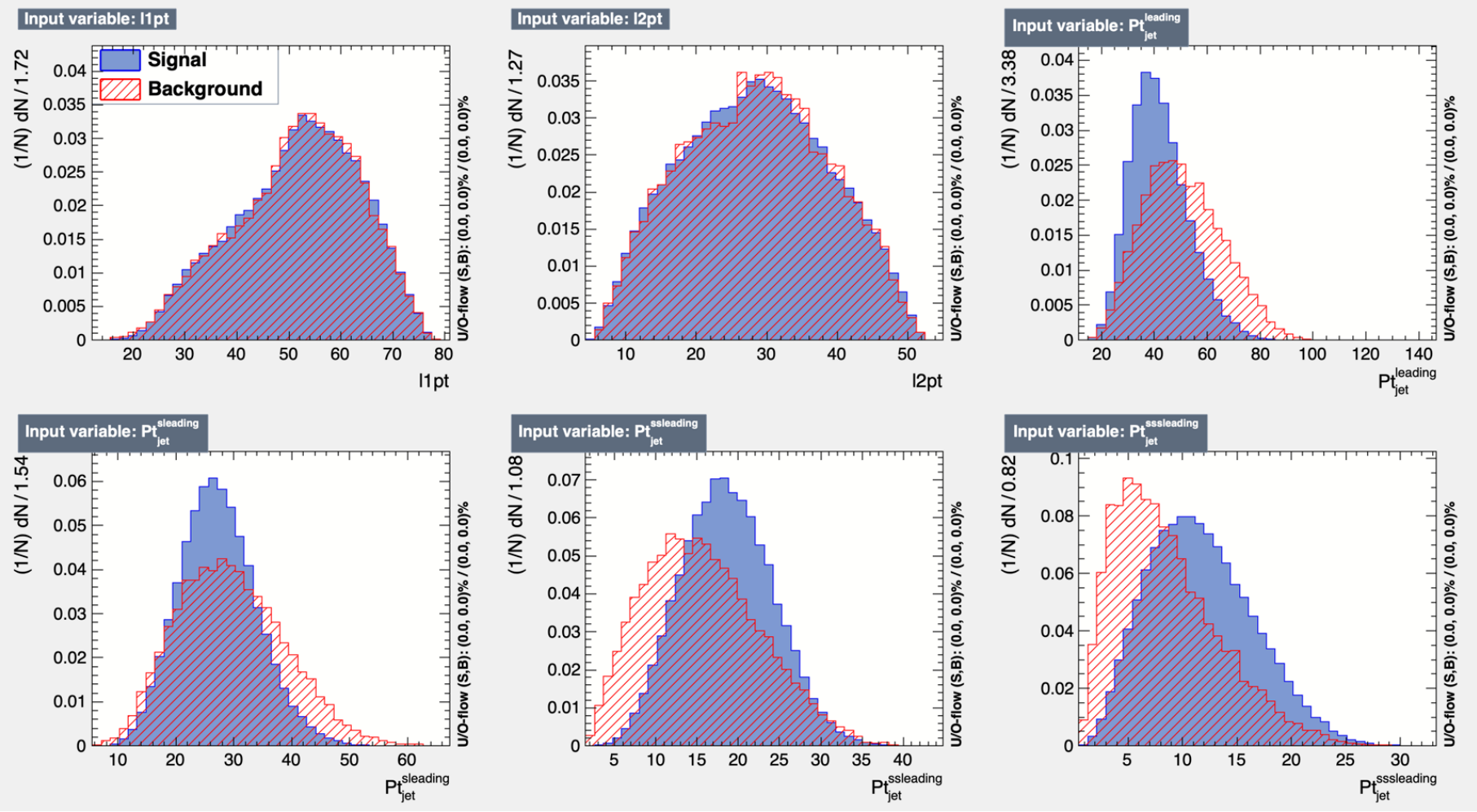


EWPT viable: semi analytic

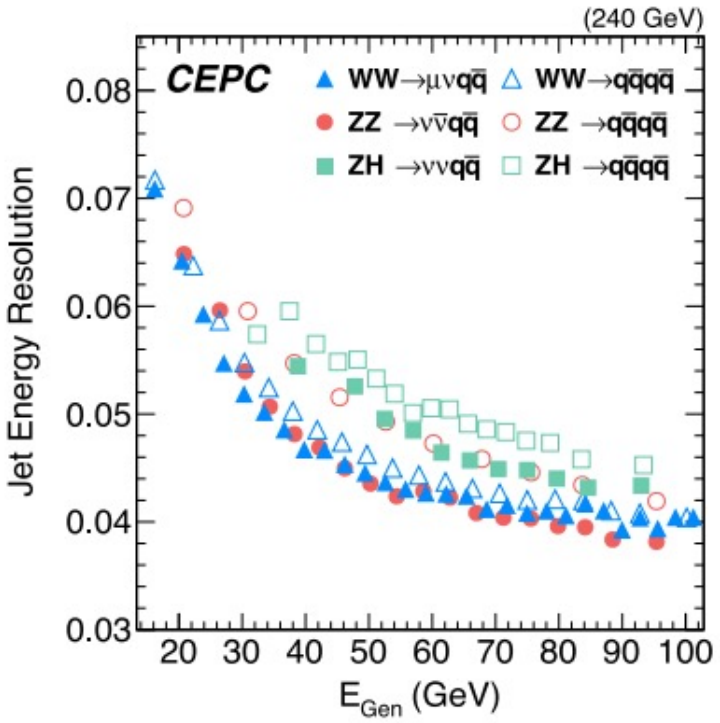
Future e^+e^-

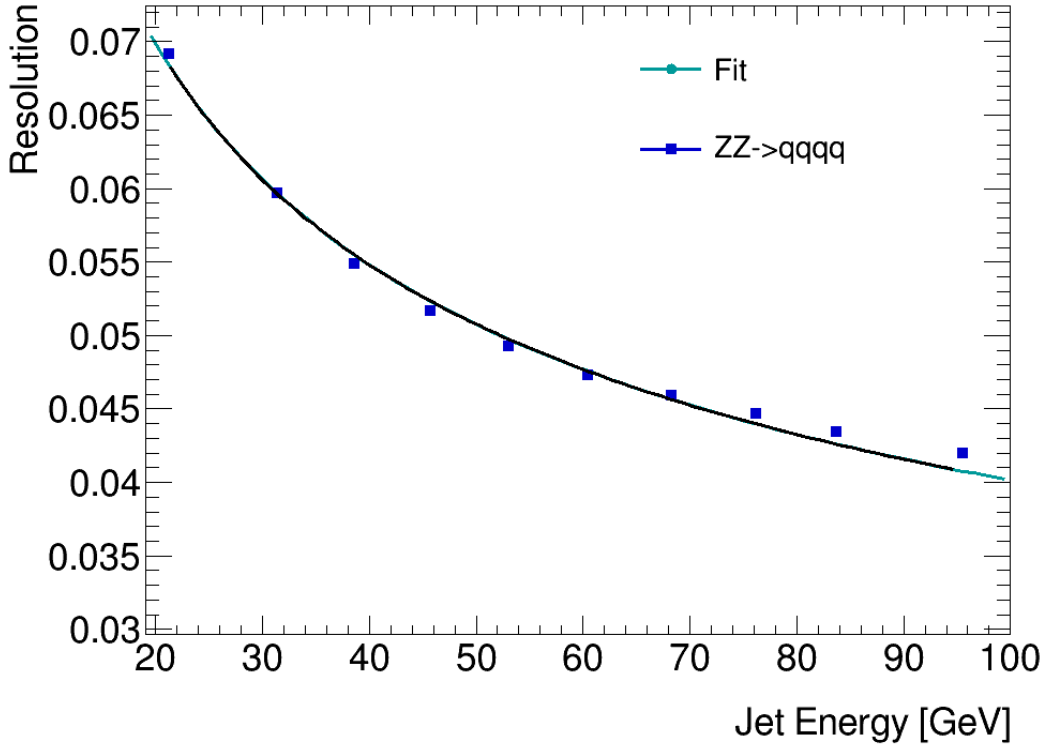
J. Kozaczuk, M. J. Ramsey-Musolf, and J. Shelton *Phys. Rev. D* **101**, 115035 (2020).
Z. Liu *et al.*, *Chinese Phys. C* **41**, 063102 (2017).

- Most Signal ssleading jets are very soft (pT < 15 GeV) .
- Signal: Z->ee/mumu, H->ss->4b
- leading/sleading/ssleading/sssleading jets are sorted by larger pT.



Extrapolating jet energy resolution





Temporarily, we are using the extrapolated JER for our analysis. We extracted the points in the figure at got a fitted line.

Vary each jet's energy with a Gaussian distribution with the corresponding resolution

Getting jet energy resolution by MC

- Pei-Zhu Lai, et al., Jet performance at the Circular electron-positron Collider

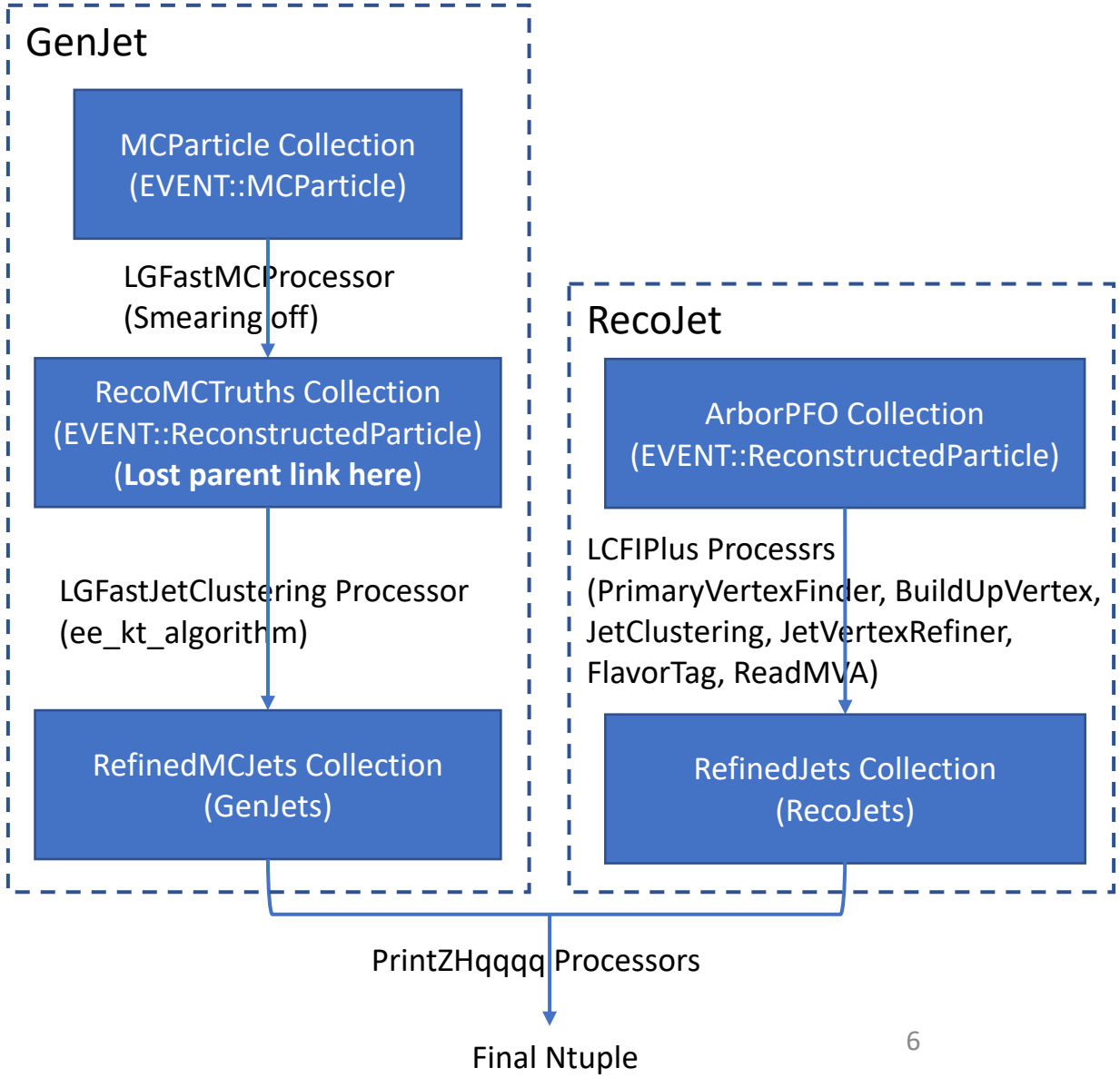
  - "GenJets" are the clustered true-level Monte Carlo (MC) particles that were produced from the hadronization of the partons, simulated by Pythia [30], including the subsequent decay products such as photons, leptons, or other lighter hadrons. Neutrinos are excluded in the clustering, while only the decay products of hadrons with $c\tau > 1$ cm are included.

  - "RecoJets" are clustered from the reconstructed final-state particles by the $e^+e^-k_t$ algorithm in the same way as the "GenJet".

The relative difference between the Parton and the GenJet represents the theoretical uncertainties of a given jet clustering algorithm, while the relative difference between the GenJet and RecoJet characterizes the detector performance. The GenJet and RecoJet are mapped to each other with the combination that minimizes the sum of angles between the GenJet-RecoJet pairs. For a given pair, the relative difference is then expressed in terms of the jet energy resolution (JER), the jet energy scale (JES), the jet angular resolution (JAR), and the jet angular scale (JAS). A more detailed

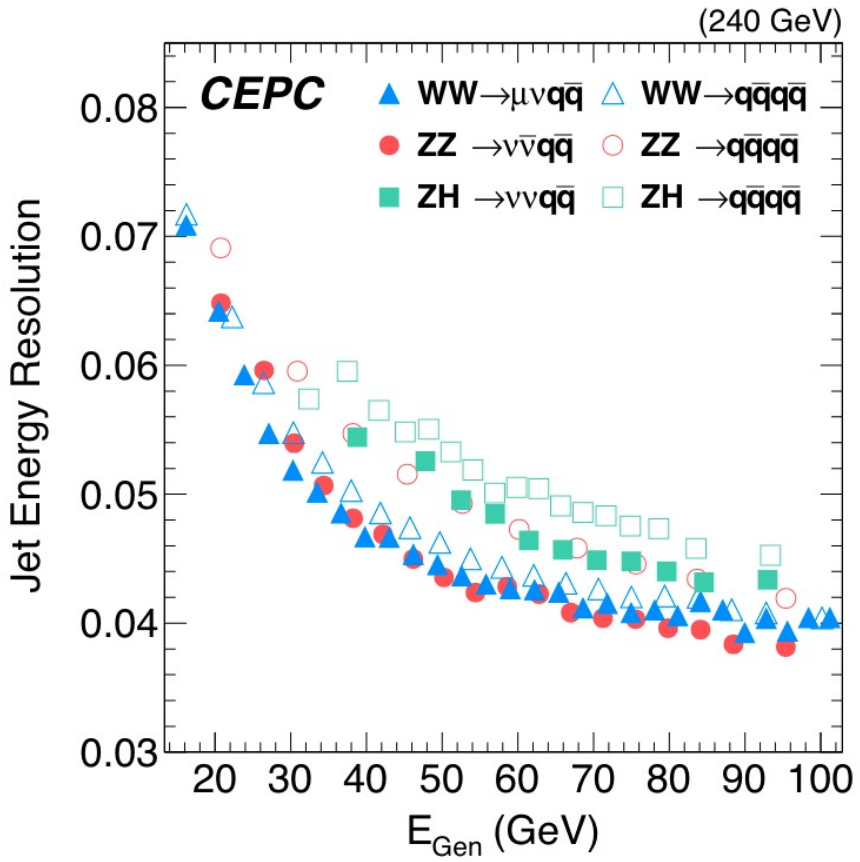
Getting jet energy resolution by MC

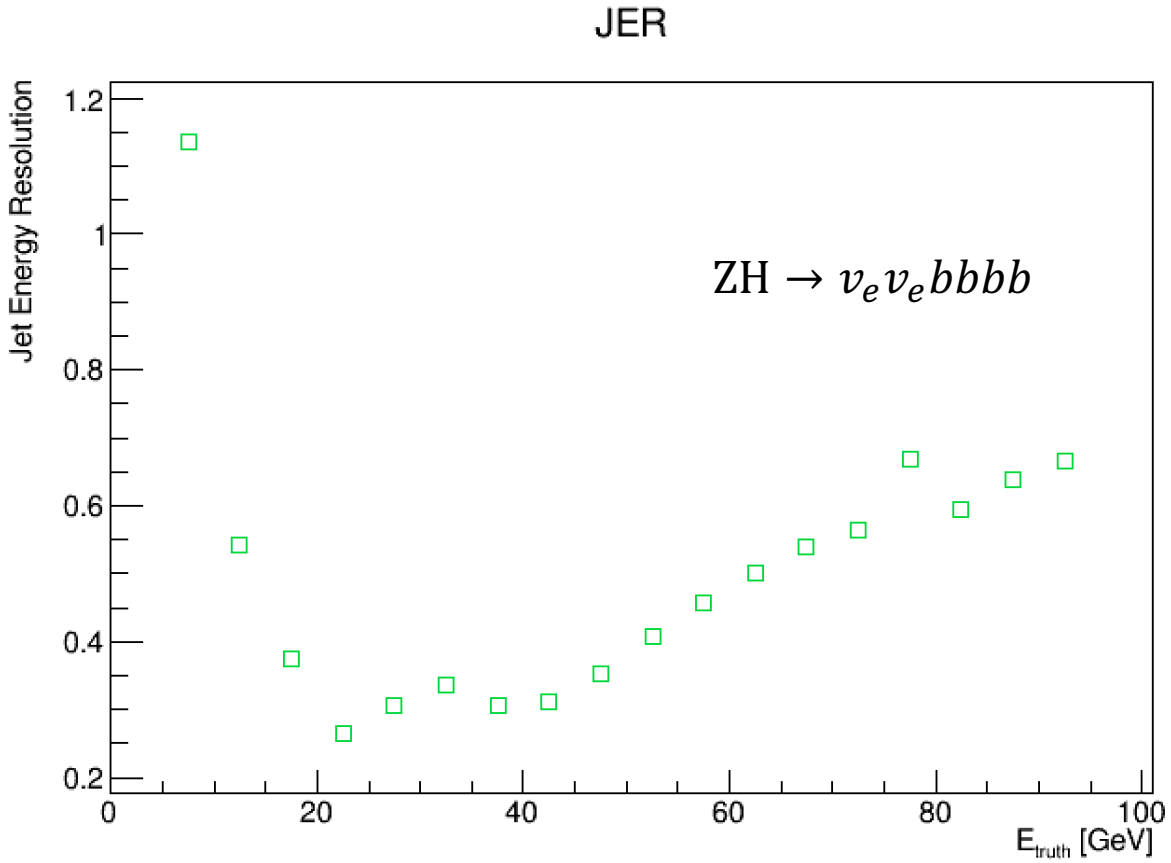
- Samples: $Z(\boldsymbol{\nu\bar{\nu}}) + H \rightarrow ss \rightarrow b\bar{b}b\bar{b}$
- Generator: MG5+Py8->hepmc
- Simu&Reco: CEPCSoft v0.1.1
- Method (an attemp):
  - Get **GenJet** by **LGFastJetClustering** Processor
  - Get **RecoJet** by **LCFIPlus** Processor (NJets = 4)
  - Match GenJet and RecoJet by angle.
- **Question**: How to get the correct GenJet?



Getting jet energy resolution by MC

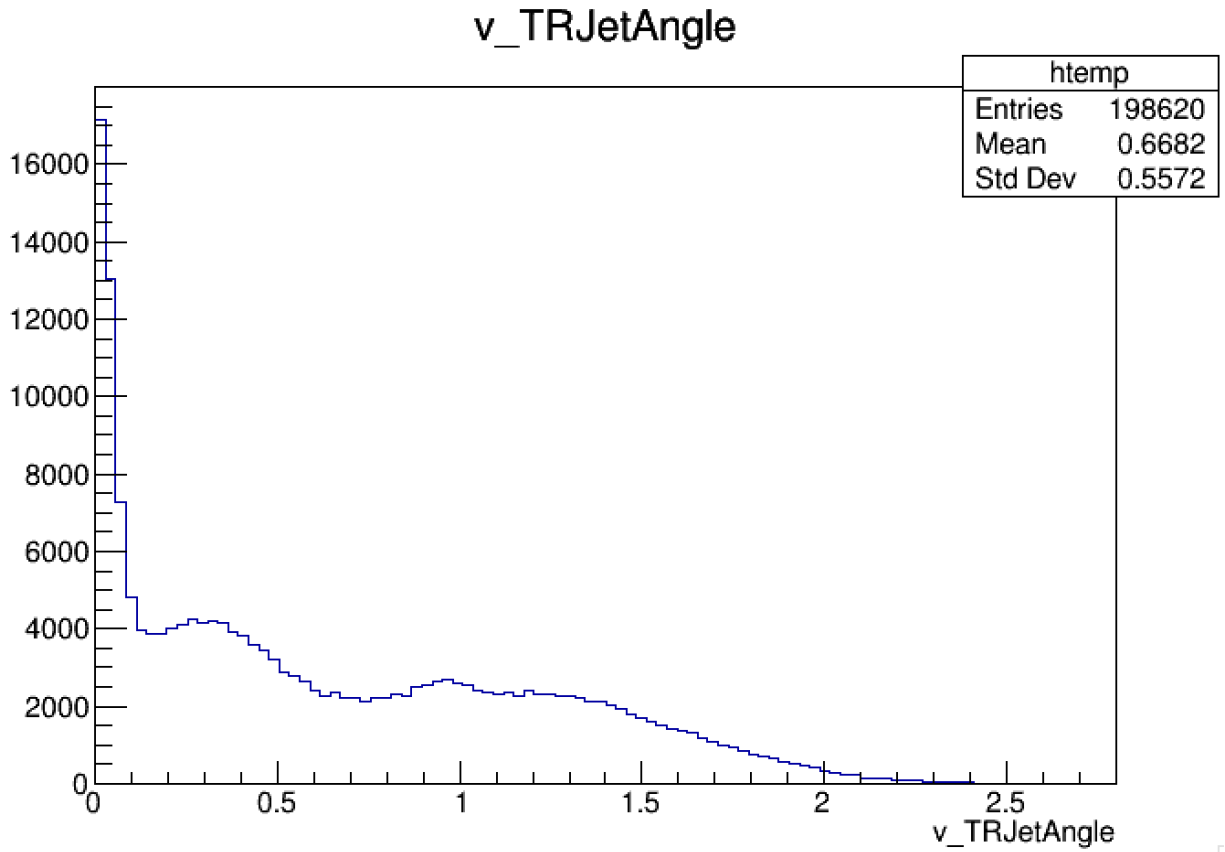
Peizhu Lai (arXiv:2104.05029)

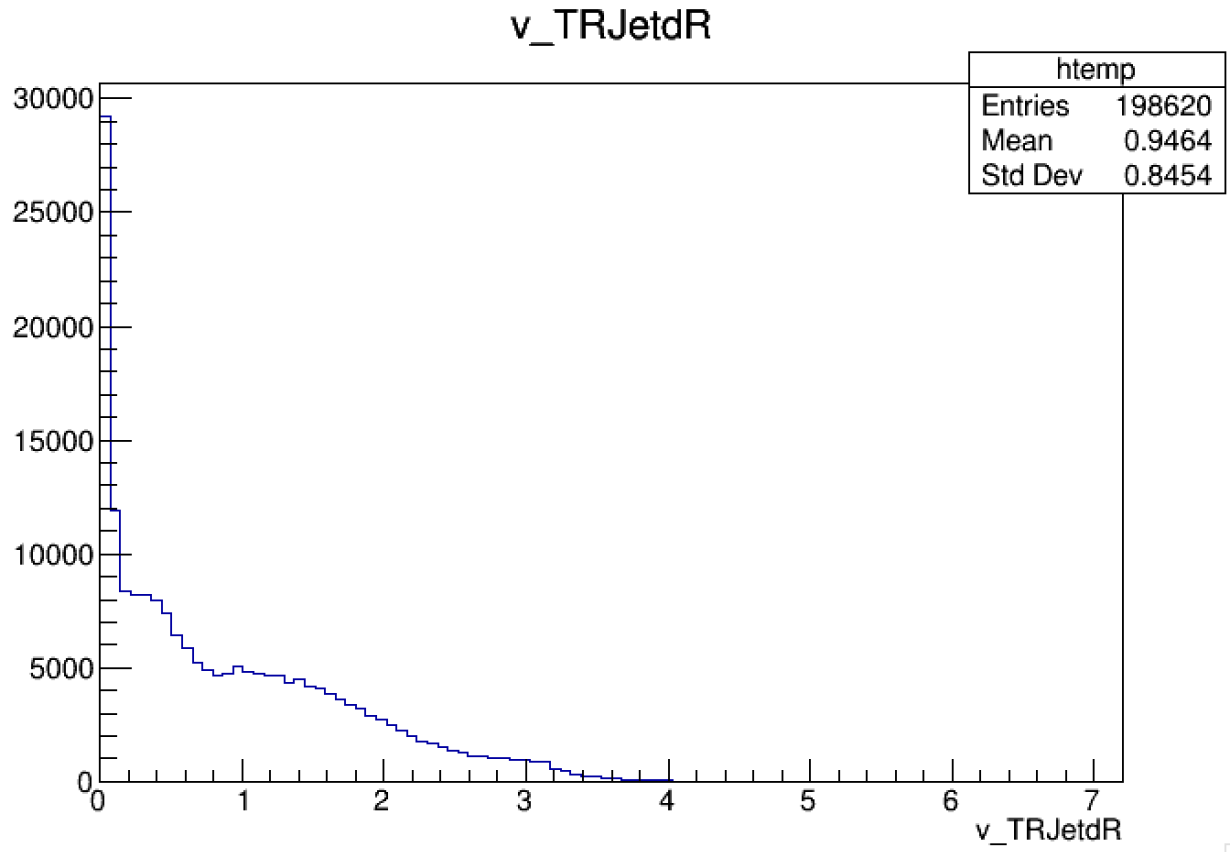




Reco-Truth Jet Matching

- 74% RecoJets failed to match with GenJet. (delta angle > 10°)



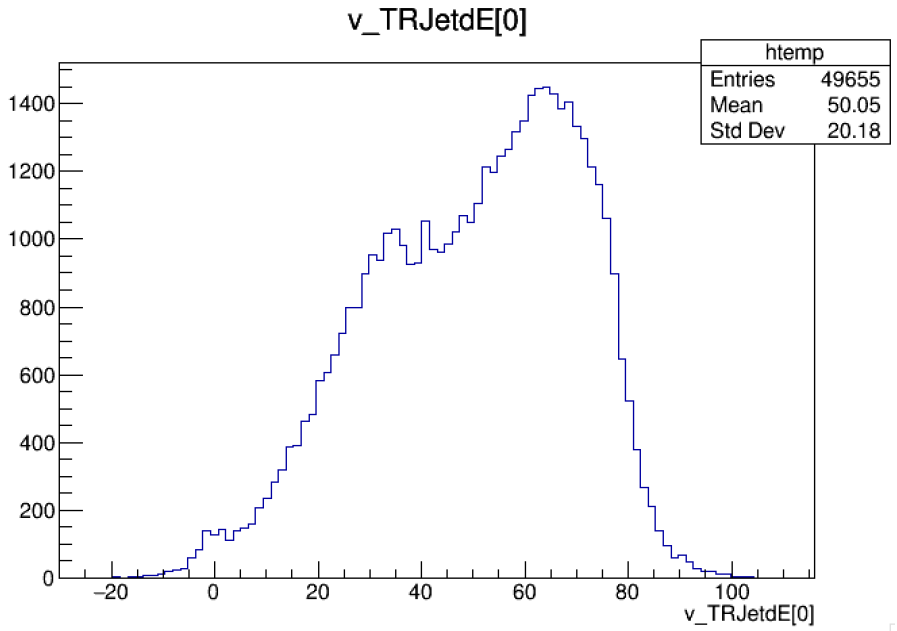


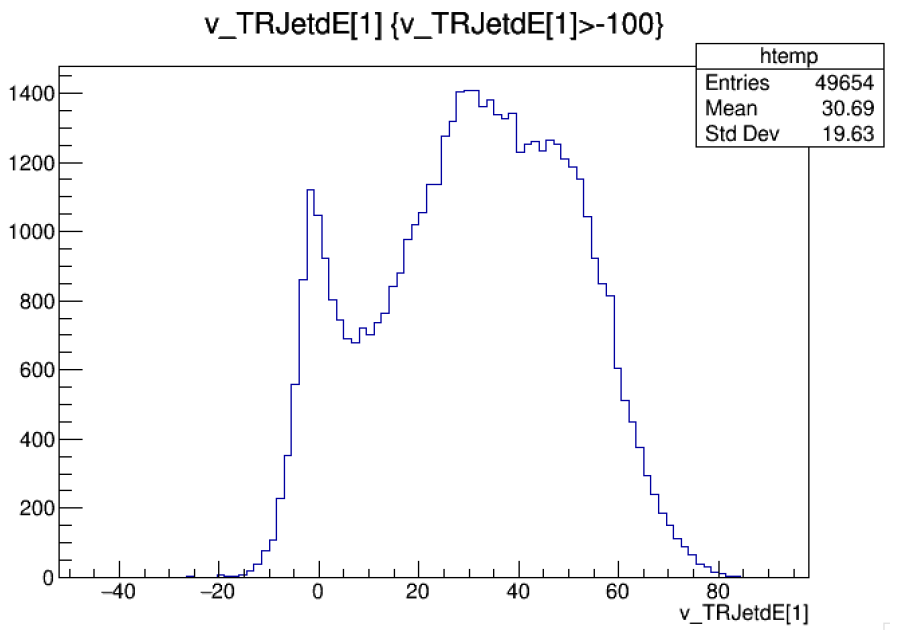
Getting jet energy resolution by MC

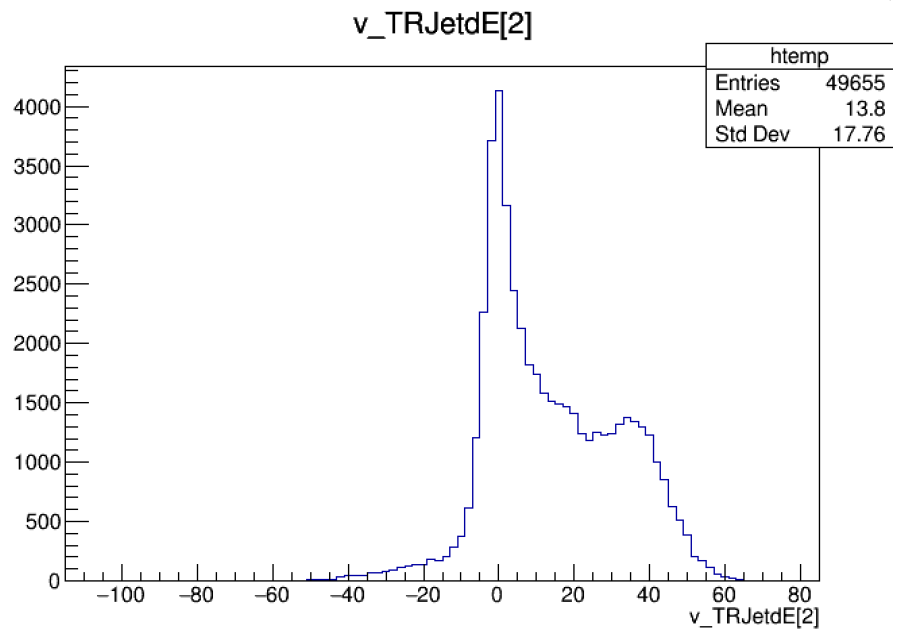
- CEPCSoft version: 0.1.1
- Geometry: CEPC_v4
- Mokka steer file:
  lxslc7:*/cefs/higgs/xuliang/lss/template_steer/simu.macro*
- Marlin steer file (Reco):
  lxslc7:*/cefs/higgs/xuliang/lss/template_steer/reco.xml*
- Marlin steer file (Ana):
  lxslc7:*/cefs/higgs/xuliang/lss/template_steer/ana_GenJet.xml*
- Processsors code: https://github.com/ykrsama/CEPC_JER
- samples:
  lxslc7:*/cefs/higgs/xuliang/lss/signal/E240.Pveveh_bbbb.e0.p0*

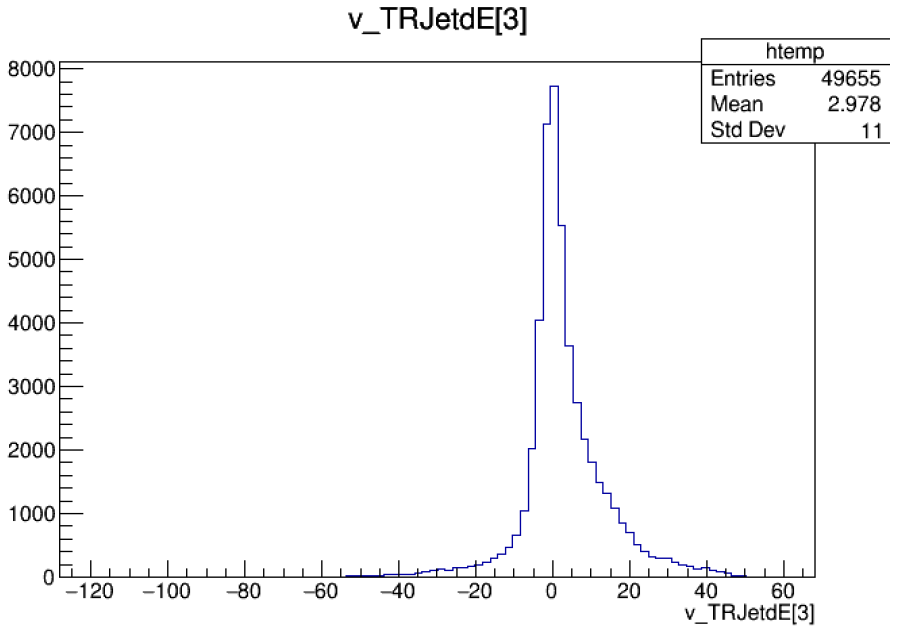
Backup

Histogram of $E_{GenJet} - E_{RecoJet}$

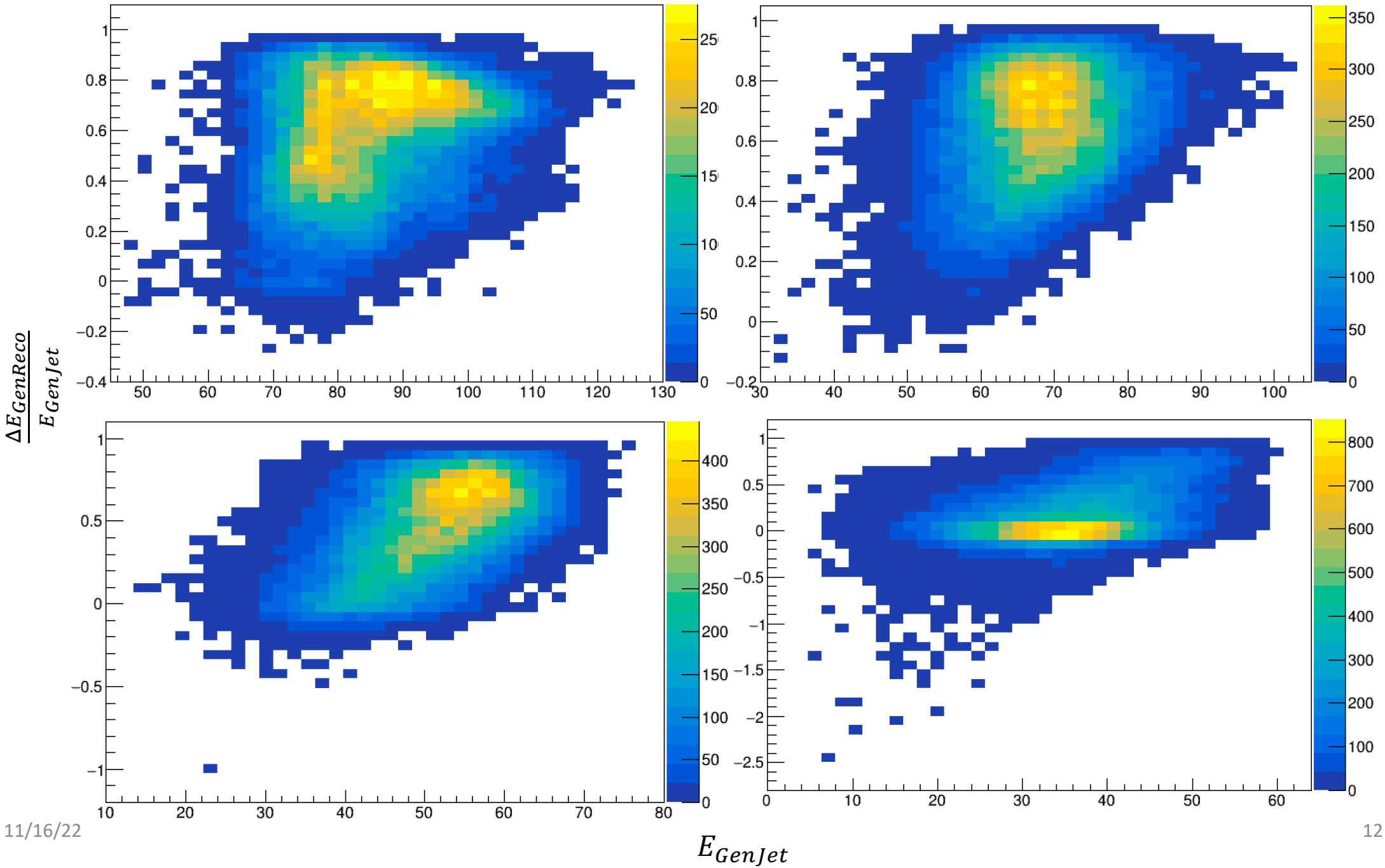








$E_{GenJet} - E_{RecoJet}$


$\frac{\Delta E_{GenReco}}{E_{GenJet}}$
E_{GenJet}

Comparision of matchd/unmatched GenJet Pt