CEPC Jets @ Clusters

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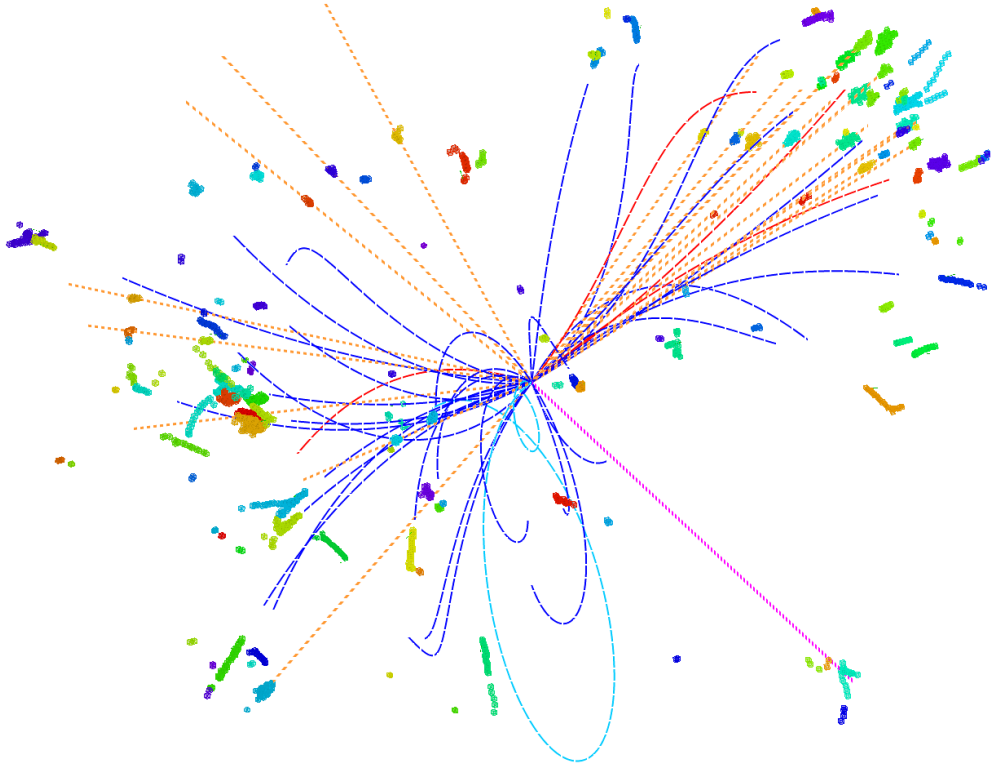
Outline

- Jet Basics
- Previous Jet@CEPC
- Tasks

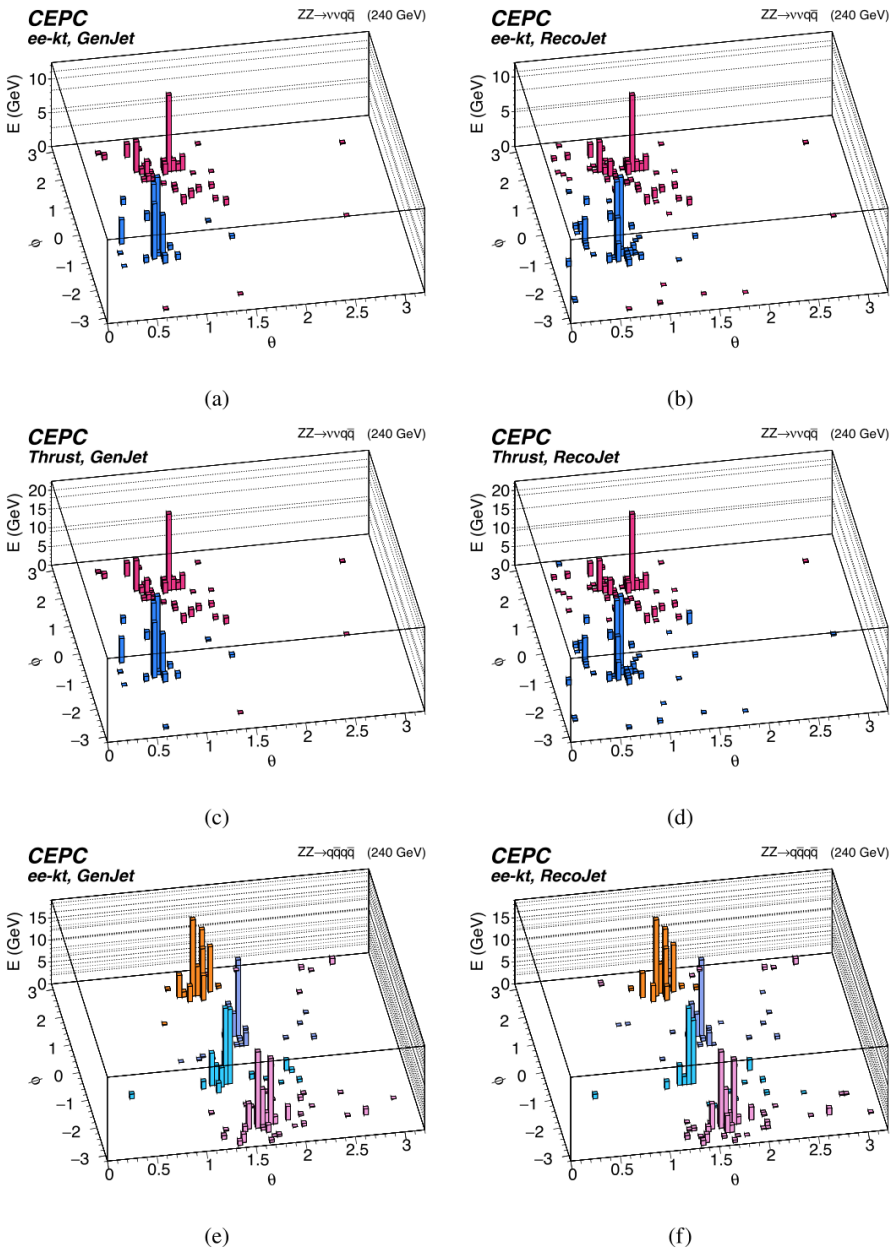
Jets 喷注



- Including varied components
- CEPC uses FastJet package to do jet clustering.
- Now, ee-kt/Durham algorithm used.
  - You need and only need to specify N_jets for Fastjet.
  - Generally, for all kt algos, 2 parameter: R and P can be adjusted.
  - ee-kt no R setting, so all clusters will be clustered.

$$d_{ij} = \min(E_i^{2p}, E_j^{2p}) \frac{(1-\cos\theta_{ij})}{(1-\cos R)},$$
$$d_{iB} = E_i^{2p},$$

Jet event display



Jet @ CEPCSW

```
JetDefinition jet_def(ee_kt_algorithm);

ClusterSequence clust_seq(input_particles, jet_def);

vector<PseudoJet> jets = sorted_by_pt(clust_seq.exclusive_jets(nJets));
```

- Specify PFO container and njets.
- Not stored in final ntuple.
- In Zebing’s Genmatch
  - Many variable stored.
  - Find jet_ntuple to extract informations

```
StatusCode GenMatch::initialize(){

  // Create a new TTree
  _file = TFile::Open(m_outputFile.value().c_str(), "RECREATE");
  _tree = new TTree("jets", "jets");
  _tree->Branch("jet1_px", &jet1_px, "jet1_px/D");
  _tree->Branch("jet1_py", &jet1_py, "jet1_py/D");
  _tree->Branch("jet1_pz", &jet1_pz, "jet1_pz/D");
  _tree->Branch("jet1_E", &jet1_E, "jet1_E/D");
  _tree->Branch("jet1_costheta", &jet1_costheta, "jet1_costheta/D");
  _tree->Branch("jet1_phi", &jet1_phi, "jet1_phi/D");
  _tree->Branch("jet1_pt", &jet1_pt, "jet1_pt/D");
  _tree->Branch("jet1_nconstituents", &jet1_nconstituents, "jet1_nconstituents/I");
  _tree->Branch("jet2_px", &jet2_px, "jet2_px/D");
  _tree->Branch("jet2_py", &jet2_py, "jet2_py/D");
  _tree->Branch("jet2_pz", &jet2_pz, "jet2_pz/D");
  _tree->Branch("jet2_E", &jet2_E, "jet2_E/D");
  _tree->Branch("jet2_costheta", &jet2_costheta, "jet2_costheta/D");
  _tree->Branch("jet2_phi", &jet2_phi, "jet2_phi/D");
  _tree->Branch("jet2_pt", &jet2_pt, "jet2_pt/D");
  _tree->Branch("jet2_nconstituents", &jet2_nconstituents, "jet2_nconstituents/I");
  _tree->Branch("constituents_E1tot", &constituents_E1tot, "constituents_E1tot/D");
  _tree->Branch("constituents_E2tot", &constituents_E2tot, "constituents_E2tot/D");
  _tree->Branch("mass", &mass, "mass/D");
  _tree->Branch("ymerge", ymerge, "ymerge[6]/D");
  _tree->Branch("nparticles", &nparticles, "nparticles/I");
  _tree->Branch("jet1_GENMatch_id", &jet1_GENMatch_id, "jet1_GENMatch_id/I");
  _tree->Branch("jet2_GENMatch_id", &jet2_GENMatch_id, "jet2_GENMatch_id/I");
  _tree->Branch("jet1_GENMatch_mindR", &jet1_GENMatch_mindR, "jet1_GENMatch_mindR/D");
  _tree->Branch("jet2_GENMatch_mindR", &jet2_GENMatch_mindR, "jet2_GENMatch_mindR/D");

  _tree->Branch("PFO_Energy_muon", &PFO_Energy_muon);
  _tree->Branch("PFO_Energy_muon_GENMatch_dR", &PFO_Energy_muon_GENMatch_dR);
  _tree->Branch("PFO_Energy_muon_GENMatch_ID", &PFO_Energy_muon_GENMatch_ID);
  _tree->Branch("PFO_Energy_muon_GENMatch_E", &PFO_Energy_muon_GENMatch_E);
  _tree->Branch("PFO_Energy_Charge", &PFO_Energy_Charge);
  _tree->Branch("PFO_Energy_Charge_Ecal", &PFO_Energy_Charge_Ecal);
  _tree->Branch("PFO_Energy_Charge_Hcal", &PFO_Energy_Charge_Hcal);
  _tree->Branch("PFO_Energy_Charge_GENMatch_dR", &PFO_Energy_Charge_GENMatch_dR);
  _tree->Branch("PFO_Energy_Charge_GENMatch_ID", &PFO_Energy_Charge_GENMatch_ID);
  _tree->Branch("PFO_Energy_Charge_GENMatch_E", &PFO_Energy_Charge_GENMatch_E);
  _tree->Branch("PFO_Hits_Charge_E", &PFO_Hits_Charge_E);
  _tree->Branch("PFO_Hits_Charge_R", &PFO_Hits_Charge_R);
  _tree->Branch("PFO_Hits_Charge_theta", &PFO_Hits_Charge_theta);
  _tree->Branch("PFO_Hits_Charge_phi", &PFO_Hits_Charge_phi);

  _tree->Branch("PFO_Energy_Neutral", &PFO_Energy_Neutral);
  _tree->Branch("PFO_Energy_Neutral_singleCluster", &PFO_Energy_Neutral_singleCluster);
  _tree->Branch("PFO_Energy_Neutral_singleCluster_R", &PFO_Energy_Neutral_singleCluster_R);
  _tree->Branch("PFO_Hits_Neutral_E", &PFO_Hits_Neutral_E);
  _tree->Branch("PFO_Hits_Neutral_R", &PFO_Hits_Neutral_R);
  _tree->Branch("PFO_Hits_Neutral_theta", &PFO_Hits_Neutral_theta);
  _tree->Branch("PFO_Hits_Neutral_phi", &PFO_Hits_Neutral_phi);
```

Jet performance parameters

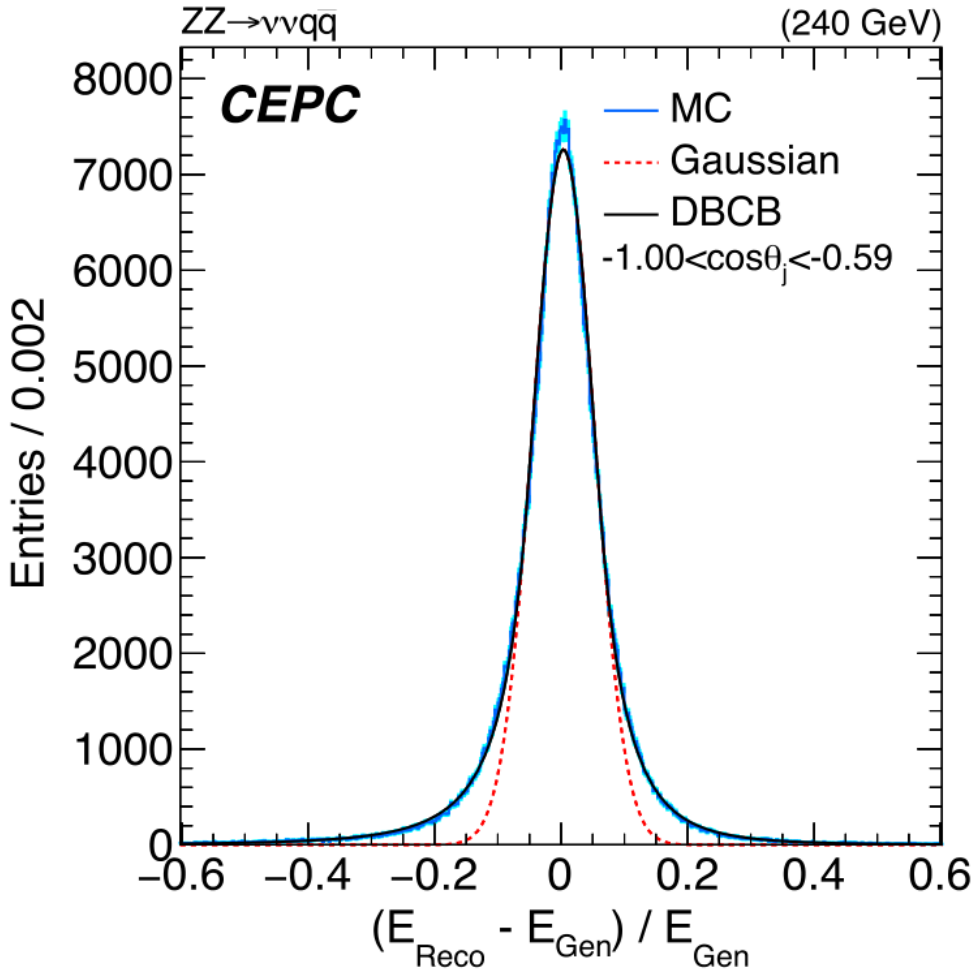
Peizhu, JINST

$$R_{R-G} = \frac{E_{RecoJet} - E_{GenJet}}{E_{GenJet}}$$

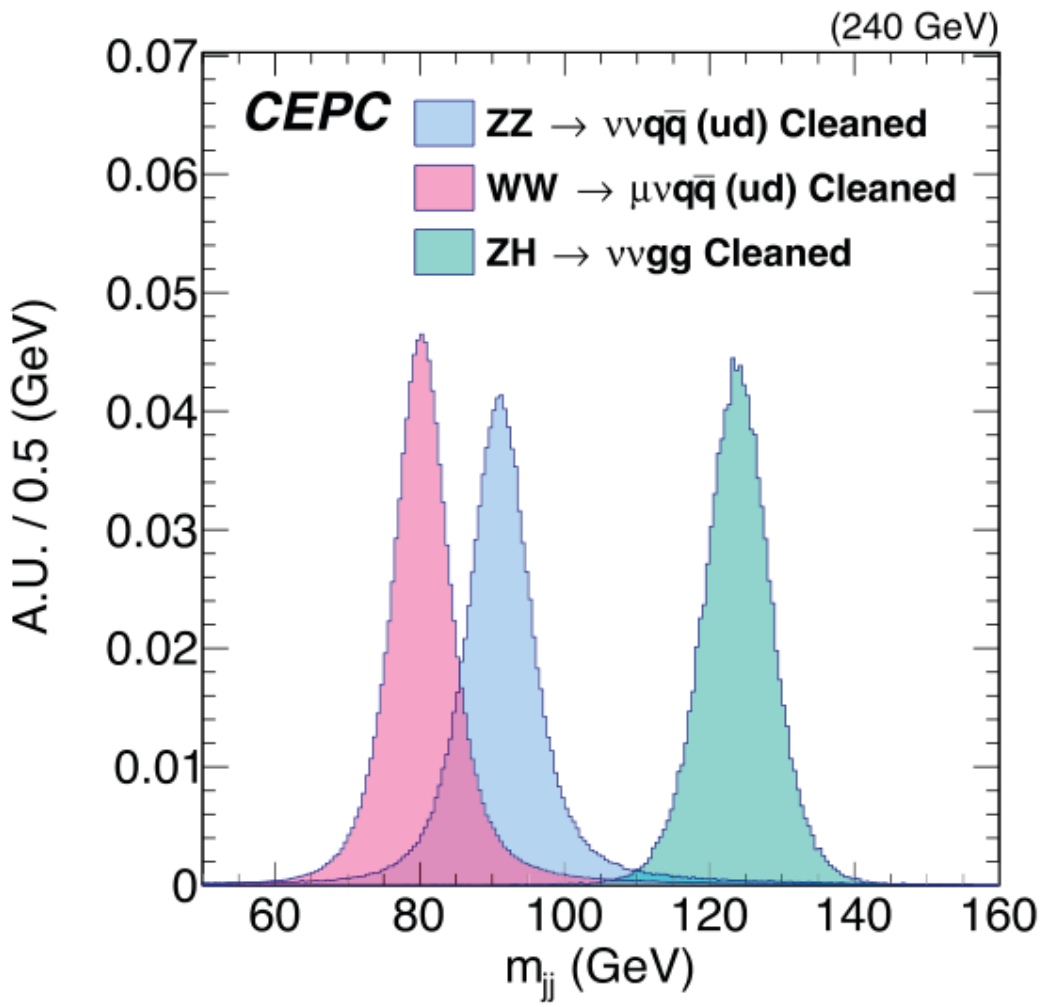
- After Reco-Gen matching,

In this difference plot (DSCB fit)

- JES Jet energy scale
  - Mean value shifted ($\bar{x}$)
- JER Jet energy resolution
  - Standard deviation (σ)



Jet performance parameters



- BMR(Boson mass resolution).
- ~Jet energy resolution.
- In CDR, when calculating BMR:
  - Veto total ISR components Pt > 1GeV;
  - Veto total neutrino Pt > 1GeV;
    - ISR and neutrino from single jet from Higgs.
  - Require Costheta_Jet;
- Current CEPCSW no endcap calo;
  - Require Costheta_Jet<0.65 (under tuning)

Table 1. Event cumulative efficiency for Higgs boson exclusive decay at the CEPC with $\sqrt{s} = 240$ GeV.

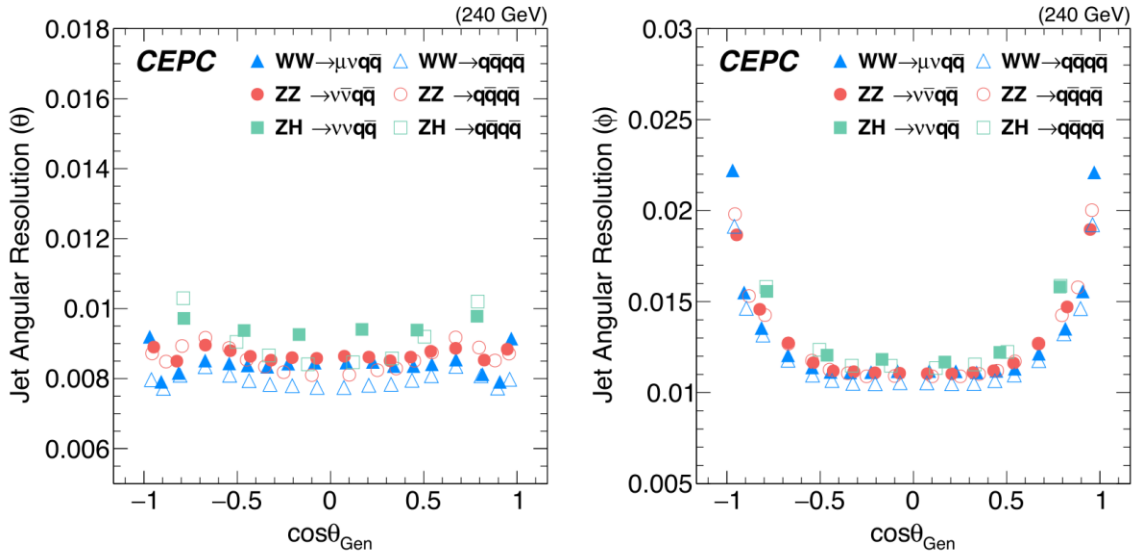
	gg(%)	bb(%)	cc(%)	WW^*(%)	ZZ^* (%)
Pt_ISR < 1 GeV	95.15	95.37	95.30	95.16	95.24
Pt_neutrino < 1 GeV	89.33	39.04	66.36	37.46	41.39
|Cos(Theta_Jet)| < 0.85	67.30	28.65	49.31	–	–

Jet angular performance

$$D_{R-G} = \theta_{RecoJet} - \theta_{GenJet} \quad \text{or} \quad \phi_{RecoJet} - \phi_{GenJet}$$

- JAR(θ, ϕ): Standard deviation (σ)
- JAS(θ, ϕ): Mean value shifted ($\bar{x}$)

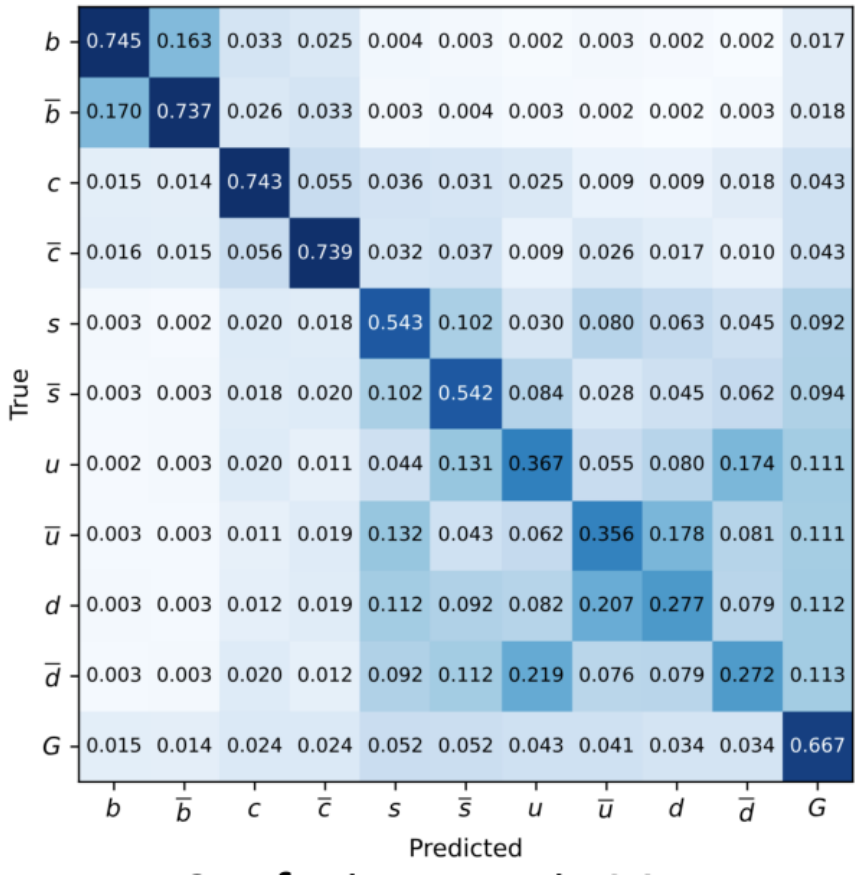
Most of the plots and performance need re-check under current CEPC ref-TDR.
Both for performance study and sanity check.



(a) (b)

Flavor information

- Use traditional LCFIplus package, or ML training like ParticleTransformer, jet flavor information can be tagged.
- ML shows better performance
- Need migration.



Sample preparing

Dijets:

- ZH, Z->vv, H->uu, dd, ss, bb, cc, gg — each 100k;
- ZZ, ZZ->vvqq; — 100k;
- WW, WW->mvqq — 100k;
  - Need muon removal.

4jets: each 100k?

- ZH, Z->vv, H->ZZ->qqqq
- ZH, Z->vv, H->WW->qqqq
- ZZ, ZZ->qqqq
- WW, WW->qqqq

6jets(?)

- ZH->ZZZ(ZWW)->qqqqqq.

Need to verify after binning if the stats are enough.

Tasks to do

- Remove isolated lepton/photon in PFO then jet clustering.
    - Need a quick PID
- Jet Sample Production
- Jet Event display
- Jet Gen Match
- JE related plots
- JA related plots
- BMR plots
- Neutral jet superclusters
- Particle gun one-type particle response
- Repeat Ecal/Hcal performance+

Tasks sub priority

- Validation ee-kt algorithm with others.
- Validation generator Whizard with others.
- Flavors/JOI
- Endcap jet performance