CEPC Jet&Samples

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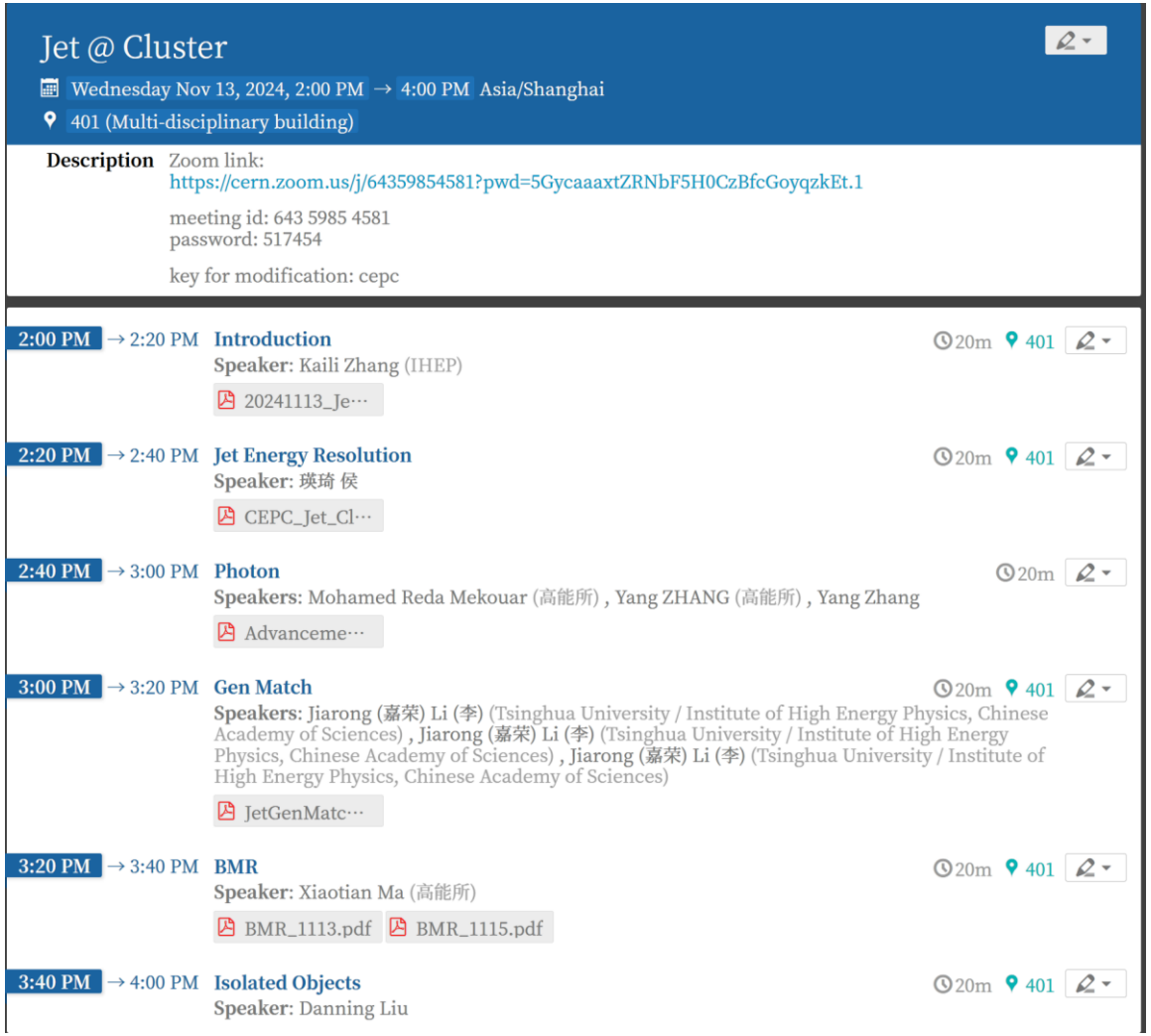
Outline

- Jet Contributions
- Jet Origin ID
- CEPC samples

Meeting Last week

https://indico.ihep.ac.cn/event/24116/
On each Wednesday, 2pm.
Welcome to participate!



Jet @ Cluster

Wednesday Nov 13, 2024, 2:00 PM → 4:00 PM Asia/Shanghai

401 (Multi-disciplinary building)

Description Zoom link:
https://cern.zoom.us/j/64359854581?pwd=5GycaaaxtZRNbF5H0CzBfcGoyqzkEt.1

meeting id: 643 5985 4581
password: 517454

key for modification: cepc

2:00 PM → 2:20 PM **Introduction** 20m 401
Speaker: Kaili Zhang (IHEP)
20241113_Je···

2:20 PM → 2:40 PM **Jet Energy Resolution** 20m 401
Speaker: 瑛琦 侯
CEPC_Jet_Cl···

2:40 PM → 3:00 PM **Photon** 20m
Speakers: Mohamed Reda Mekouar (高能所) , Yang ZHANG (高能所) , Yang Zhang
Advanceme···

3:00 PM → 3:20 PM **Gen Match** 20m 401
Speakers: Jiarong (嘉荣) Li (李) (Tsinghua University / Institute of High Energy Physics, Chinese Academy of Sciences) , Jiarong (嘉荣) Li (李) (Tsinghua University / Institute of High Energy Physics, Chinese Academy of Sciences) , Jiarong (嘉荣) Li (李) (Tsinghua University / Institute of High Energy Physics, Chinese Academy of Sciences)
JetGenMatc···

3:20 PM → 3:40 PM **BMR** 20m 401
Speaker: Xiaotian Ma (高能所)
BMR_1113.pdf BMR_1115.pdf

3:40 PM → 4:00 PM **Isolated Objects** 20m 401
Speaker: Danning Liu

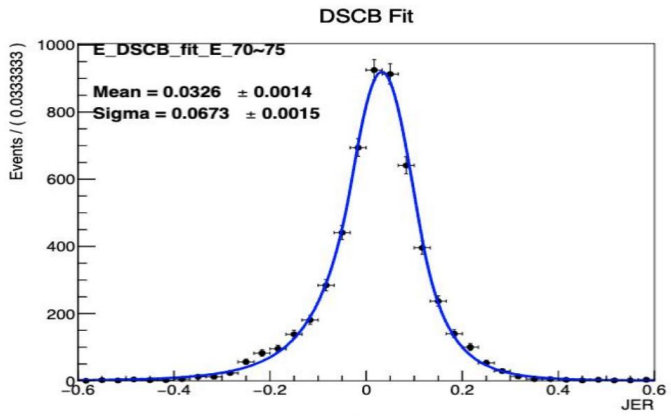
JER @Yingqi

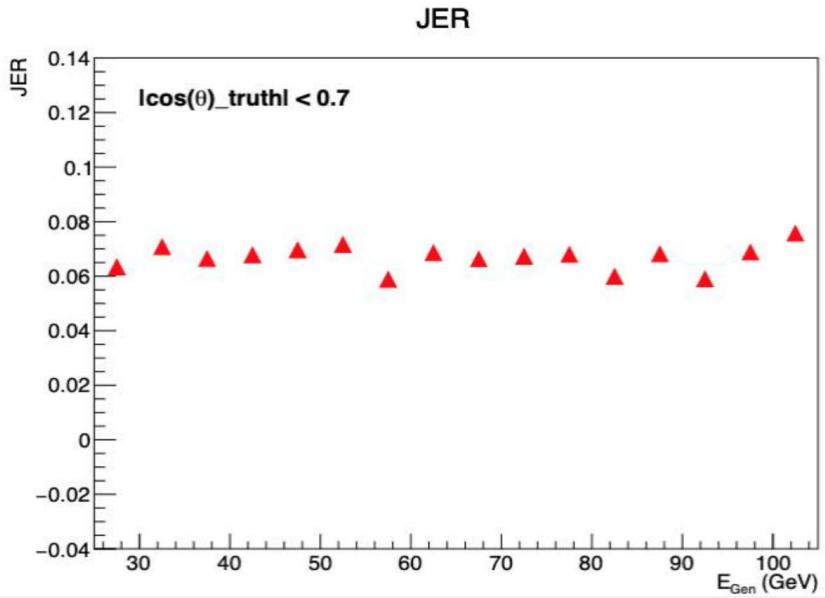
To repeat the jet behavior in Lai_2021_J._Inst._16_P07037.

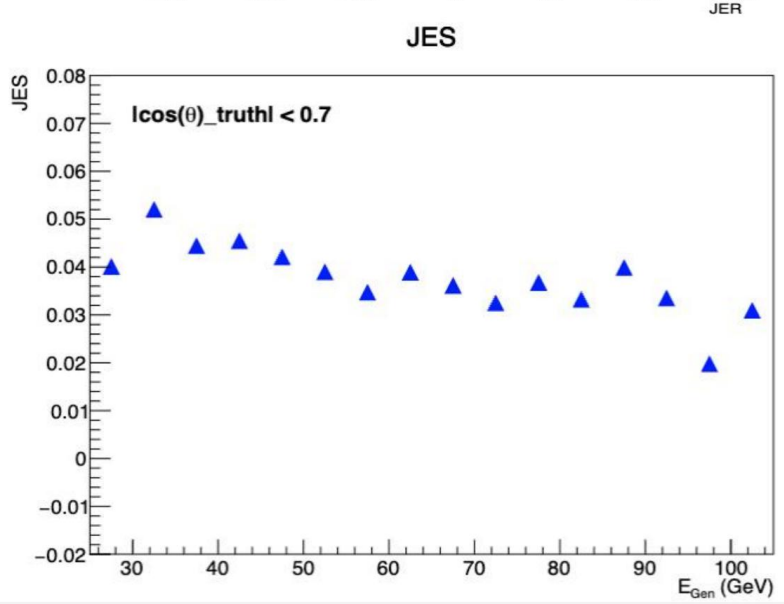
$$R_{R-G} = \frac{E_{RecoJet} - E_{GenJet}}{E_{GenJet}}$$

```
Jets_bins = [10, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 120]
```

- JER doesn't change significantly with the increase of energy.
- JES gradually decreases as energy increases.





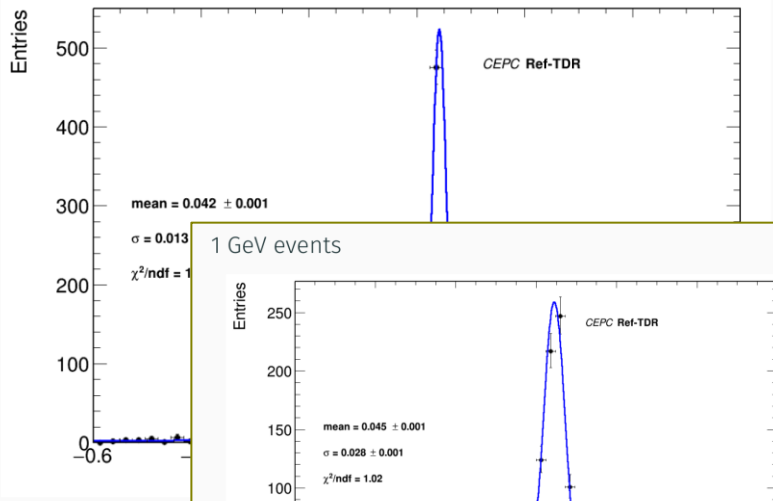


5

Photon Gun @Reda

To test the single photon response with detector.
PER ~1.3% consistent with Ecal performance.

5 GeV events



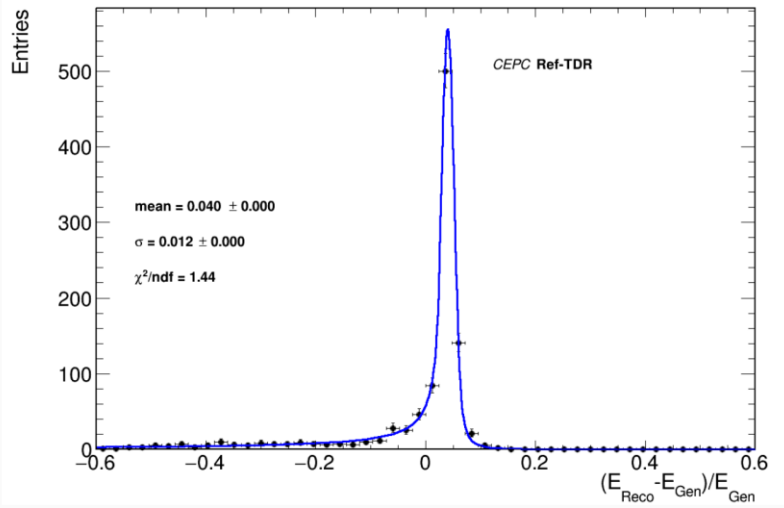
- PES = 4.2 %
- PER = 1.3 %
- Number of events < -0.1 = 131
- Number of events < -0.2 = 99

1 GeV events

Out of that, we get:

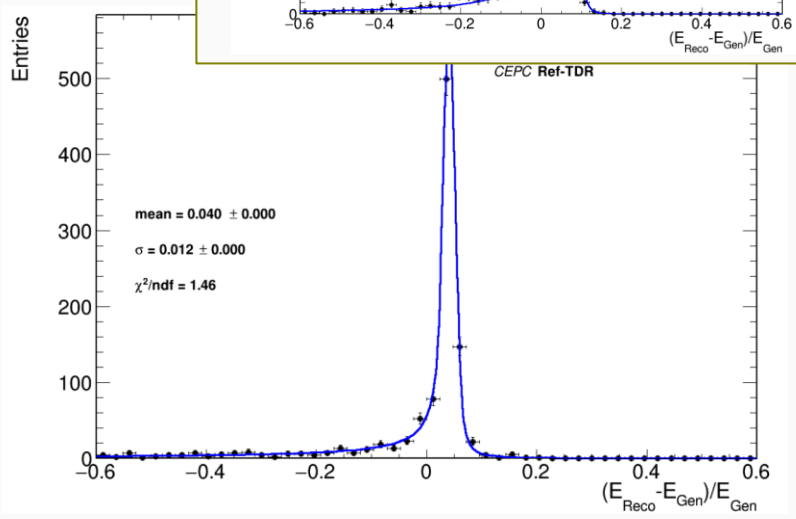
- **Photon Energy Scale:**
  Mean value shifted ($\bar{x}$)
  PES = 4.5 %
- **Photon Energy Resolution:**
  Standard deviation (σ)
  PER = 2.8 %
- Number of events < -0.1 = 145
- Number of events < -0.2 = 88

10 GeV events



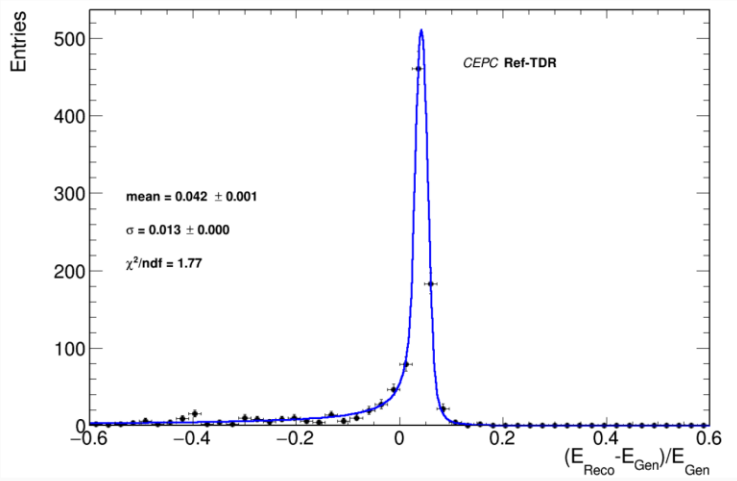
- PES = 4.0 %
- PER = 1.2 %
- Number of events < -0.1 = 131
- Number of events < -0.2 = 99

40 GeV events



- PES = 4.0 %
- PER = 1.2 %
- Number of events < -0.1 = 134
- Number of events < -0.2 = 97

80 GeV events

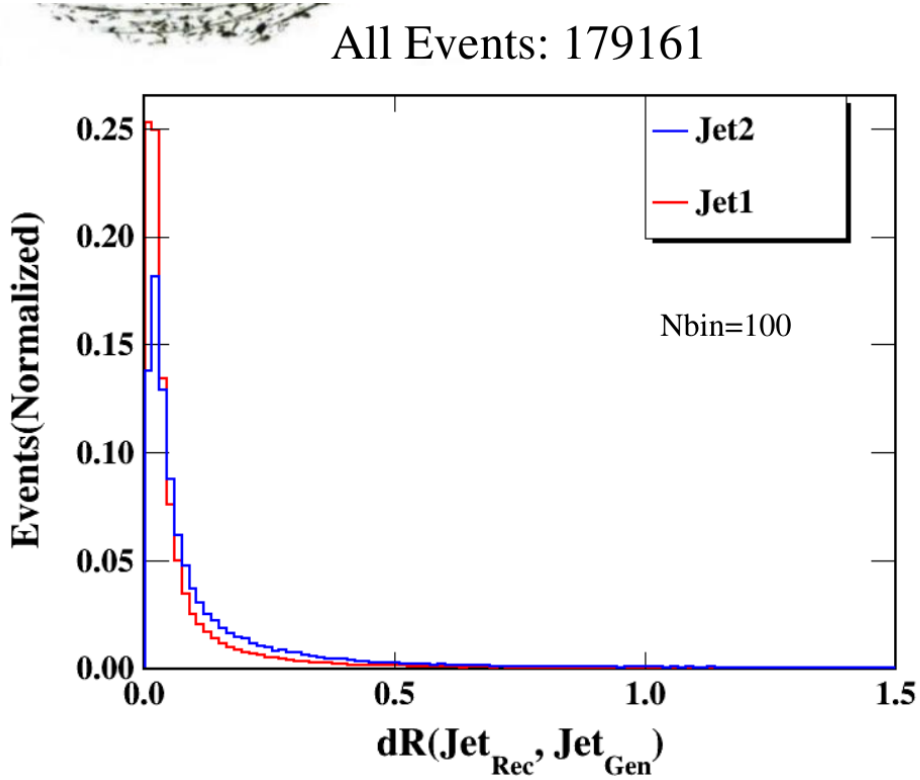


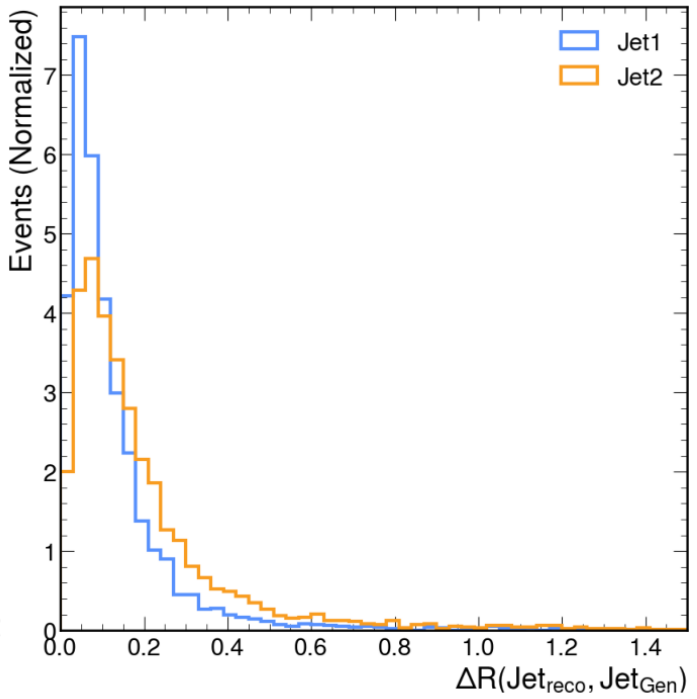
- PES = 4.2 %
- PER = 1.3 %
- Number of events < -0.1 = 143
- Number of events < -0.2 = 113

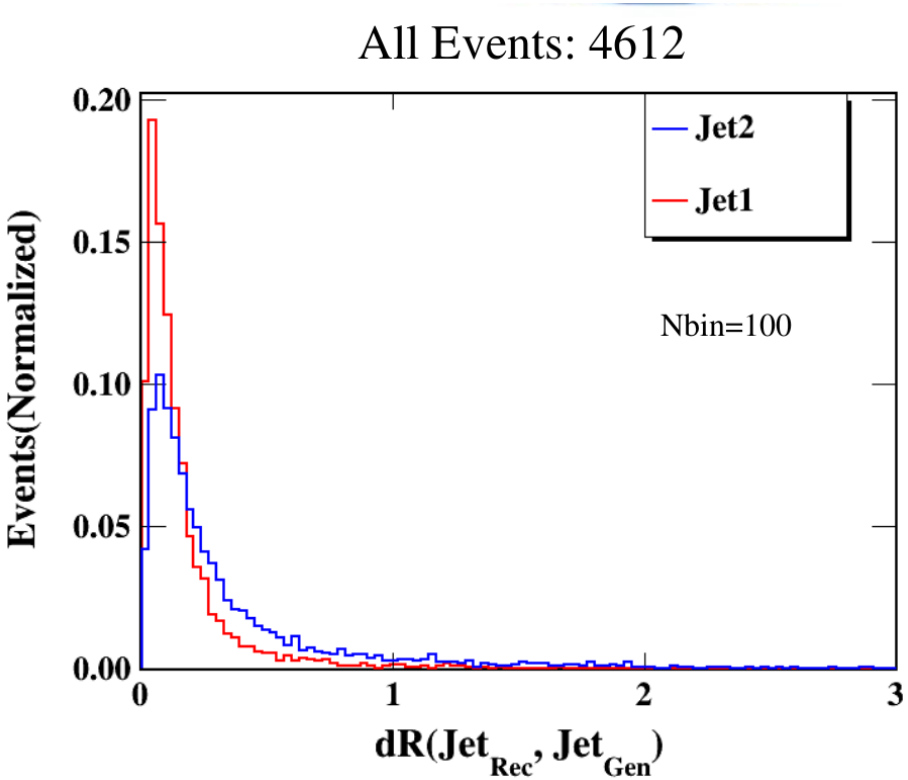
In average we have 9.44 % of events with relative energy difference < -0.2 and 13.34 % < -0.1

GenMatch @Jiarong

From 24.9.1 to 24.10.0, GenMatch performance improved a bit.
(Could be from P4 momentum from IP)







/cefs/higgs/zhangkl/Production/

tdr24.10.0

/publicfs/cms/user/wangzebing/CEPC/**CEPCSW_tdr24.9.1**/CEPCSW/FullSim_samples/Rec_TDR_o1_v01_E240_nnh_gg.root

ee → nnHgg 240 GeV

Jiarong aims to mimic the discrepancy from truth to reco.

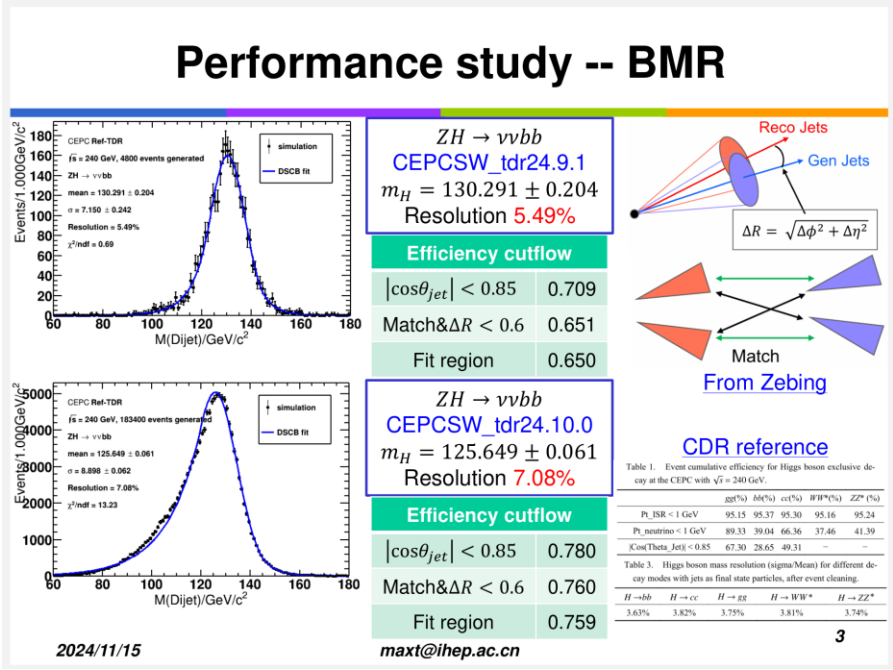
BMR @Xiaotian

- Comparisons between tdr24.9.1 and tdr24.10.0 Also apply truthmatch cut

Release	BMR/Efficiency	$ZH \to \nu\nu gg$	$ZH \to \nu\nu bb$	$ZH \to \nu\nu cc$	$ZH \to \nu\nu uu$	$ZH \to \nu\nu dd$	$ZH \to \nu\nu ss$
CEPCSW _tdr24.9.1	$\lvert\cos\theta_{jet}\rvert < 0.85$	5.43%/0.65	5.49%/0.65	5.46%/0.65	5.68%/0.71	5.15%/0.70	5.79%/0.70
	$\lvert\cos\theta_{jet}\rvert < 0.7$	5.28%/0.50	5.34%/0.50	5.28%/0.50	5.39%/0.54	4.93%/0.51	5.45%/0.52
CEPCSW _tdr24.10.0	$\lvert\cos\theta_{jet}\rvert < 0.85$	5.27%/0.76	7.08%/0.76	6.09%/0.76	5.13%/0.76	5.28%/0.76	5.92%/0.75
	$\lvert\cos\theta_{jet}\rvert < 0.7$	4.98%/0.57	6.49%/0.56	5.64%/0.57	4.86%/0.57	4.94%/0.57	5.57%/0.56

From $|\cos\theta|$ 0.85-0.7: ↑
From 24.9.1-24.10.0: Mainly ↑

bb's weird long tail under study.



Isolated Objects @Danning

Working with Hengne;

```
                                    Muon        Electron
E_ecal  / E_total                   <0.5            >0.6
E_total / P_track                   <0.3            >0.9

Muon, elctron:  Charged+.
Photon:         No track; No Charge; Only Ecal deposit.

Energy threshold: ~10GeV.

Overlap Removal. (Muon in Jet)

- 实现简单的PID.  e/mu /gamma separation.
- isolated lepton/photon处理方式。参考ATLAS: dr0.4椎体内 其他objects 能量小于(0.1E+1) (0.022E+7) (yy->E, lepton->P) 数值待测试。
- FixedCutLoose

Sample like: Z->mm H->inclusive
```

JOI

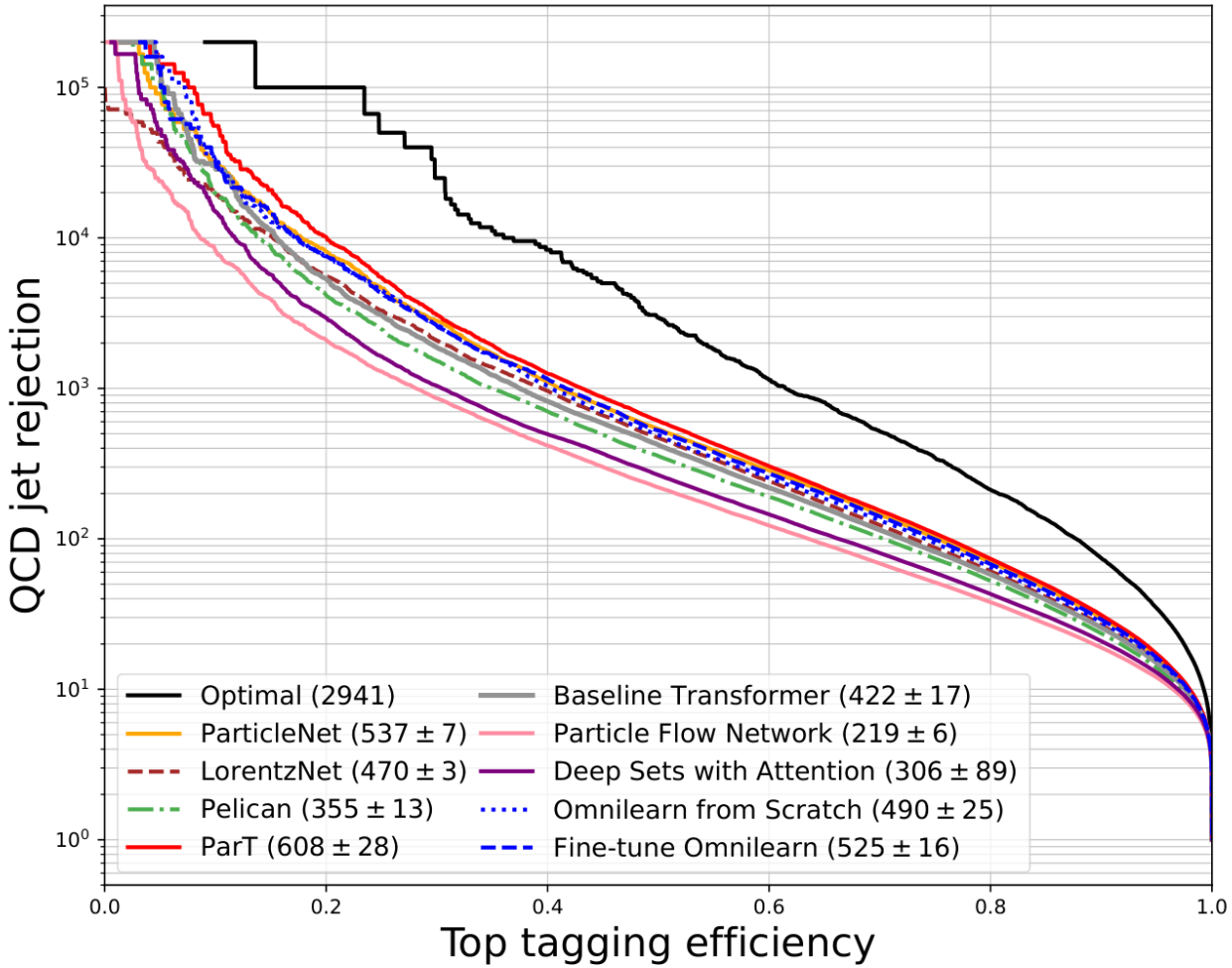
Following https://github.com/ZHUYFgit/CEPC-Jet-Origin-Identification
The script and samples for Particle transformer are ready.

```
_outputTree->Branch("part_rdphi",     &part_rdphi);
_outputTree->Branch("part_rdtheta",     &part_rdtheta);
_outputTree->Branch("part_rdlon",     &part_rdlon);
_outputTree->Branch("part_mom", &part_mom);


_outputTree->Branch("part_px",     &part_px);
_outputTree->Branch("part_py",     &part_py);
_outputTree->Branch("part_pz",     &part_pz);
_outputTree->Branch("part_energy", &part_energy);
_outputTree->Branch("part_pt",     &part_pt);
_outputTree->Branch("part_deta",   &part_deta);
_outputTree->Branch("part_dphi",   &part_dphi);
_outputTree->Branch("part_d0val",  &part_d0val);
_outputTree->Branch("part_d0err",  &part_d0err);
_outputTree->Branch("part_dzval",  &part_dzval);
_outputTree->Branch("part_dzerr",  &part_dzerr);
_outputTree->Branch("part_charge", &part_charge);
```

```
inputs:
  pf_features:
    ###   - [part_d0, null]
    ###   - [part_d0err, 0, 1, 0, 1]
    ###   - [part_dz, null]
    ###   - [part_dzerr, 0, 1, 0, 1]
    ###   - [part_deta, null]
    ###   - [part_dphi, null]


      - [part_pt_log, -1.5, 1.0]
      - [part_e_log, -0.687, 1.0]
      - [part_logptrel, -4.7, 1.0]
      - [part_logerel, -4.473, 1.0]
      - [part_deltaR, 2.1, 2.3]
      - [part_charge, null]
    ###  - [part_isChargedHadron, null]
      - [part_isChargedKaon, null]
      - [part_isPion, null]
      - [part_isProton, null]
      - [part_isElectron, null]
      - [part_isMuon, null]
      - [part_isNeutralHadron, null]
      - [part_isPhoton, null]
    ###  - [part_isNeutron, null]
    ###  - [part_isAntiNeutron, null]
    ###  - [part_isLambda, null]

    ###  - [part_BHad, null]
    ###  - [part_isPi0, null]
    ###  - [part_isKLong, null]
    ###  - [part_isKShort, null]
      - [part_d0, null]
    ###  - [part_d0e, 0, 1, 0, 1]
      - [part_dz, null]
    ###  - [part_dze, 0, 1, 0, 1]
      - [part_deta, null]
      - [part_dphi, null]


  pf_vectors:
    length: 50
    pad_mode: wrap
    vars:
      - [part_px, null]
      - [part_py, null]
      - [part_pz, null]
      - [part_energy, null]
```

State of the art: Jet Machine Learning

2411.02628



Among all the ML tools, Particle Transformer has the best performance.
But there is still a gap from the ideal situation.

Latest tool: L-GATr

Lorentz-Equivariant Geometric Algebra Transformer: 2411.00446
We are applying ParT and keep an close eye on latest evolution.

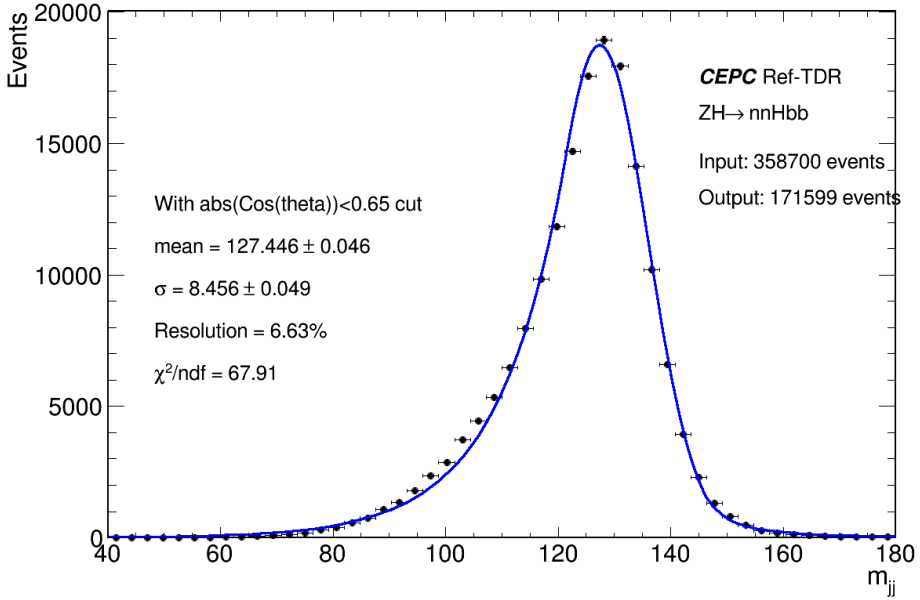
Network	Accuracy	AUC	$1/\epsilon_B$ ($\epsilon_S = 0.5$)	$1/\epsilon_B$ ($\epsilon_S = 0.3$)
TopoDNN [52]	0.916	0.972	–	295 ± 5
LoLa [9]	0.929	0.980	–	722 ± 17
N-subjettiness [53]	0.929	0.981	–	867 ± 15
PFN [54]	0.932	0.9819	247 ± 3	888 ± 17
TreeNiN [55]	0.933	0.982	–	1025 ± 11
ParticleNet [56]	0.940	0.9858	397 ± 7	1615 ± 93
ParT [57]	0.940	0.9858	413 ± 16	1602 ± 81
MIParT [58]	0.942	0.9868	505 ± 8	2010 ± 97
LorentzNet* [10]	0.942	0.9868	498 ± 18	2195 ± 173
CGENN* [12]	0.942	0.9869	500	2172
PELICAN* [40]	0.9426 ± 0.0002	0.9870 ± 0.0001	–	2250 ± 75
L-GATr* [33]	0.9423 ± 0.0002	0.9870 ± 0.0001	540 ± 20	2240 ± 70
ParticleNet-f.t. [58]	0.942	0.9866	487 ± 9	1771 ± 80
ParT-f.t. [58]	0.944	0.9877	691 ± 15	2766 ± 130
MIParT-f.t. [58]	0.944	0.9878	640 ± 10	2789 ± 133
L-GATr-f.t.* (new)	0.9442 ± 0.0002	0.98792 ± 0.00004	661 ± 24	3005 ± 186

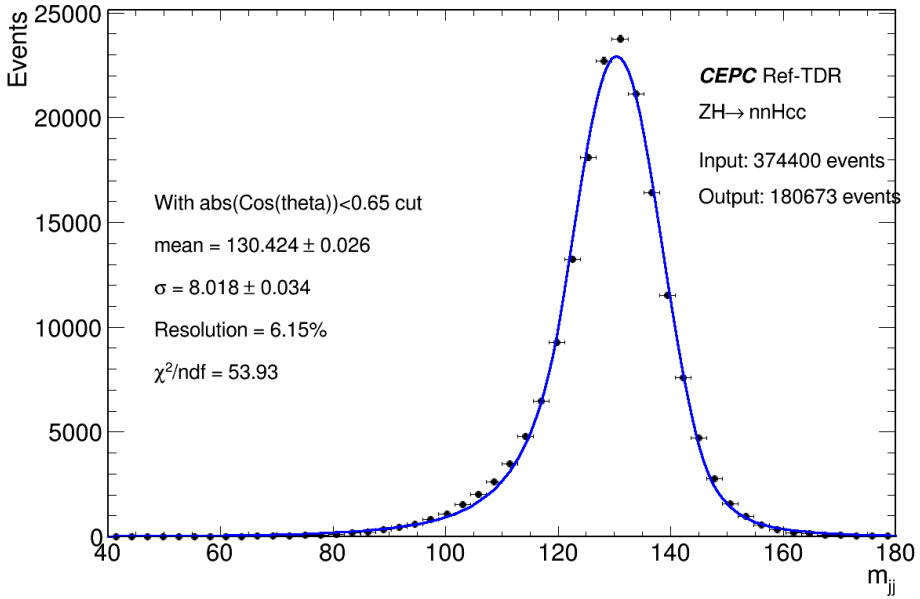
Samples

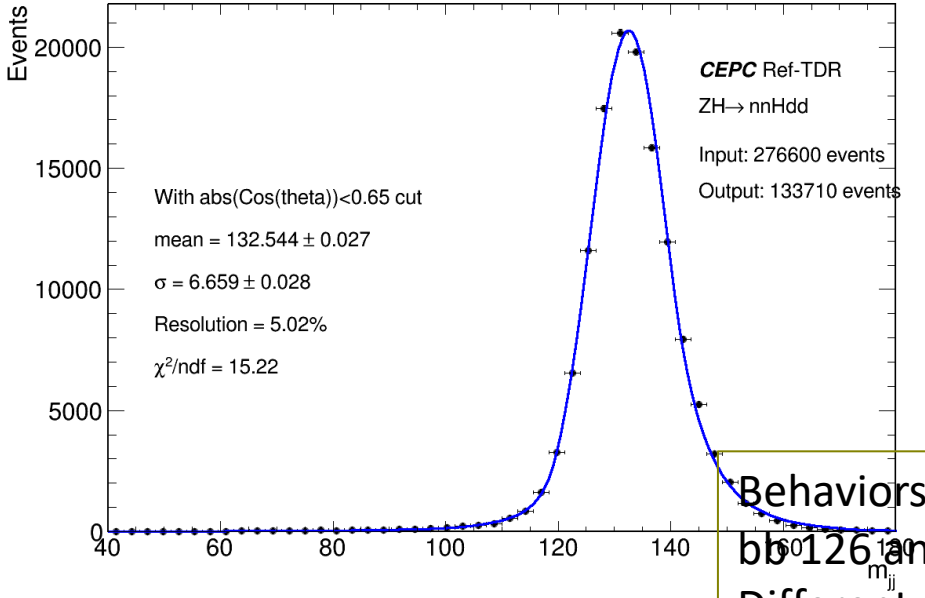
- Samples under /cefs/higgs/zhangkl/Production
  - ~40k for each.
  - ~400k for vvHbb/cc/gg/uu/dd/ss.
  - Under tdr 24.10.0.
    - Endcap Calo still missing.
  - Let me know if further requirement.

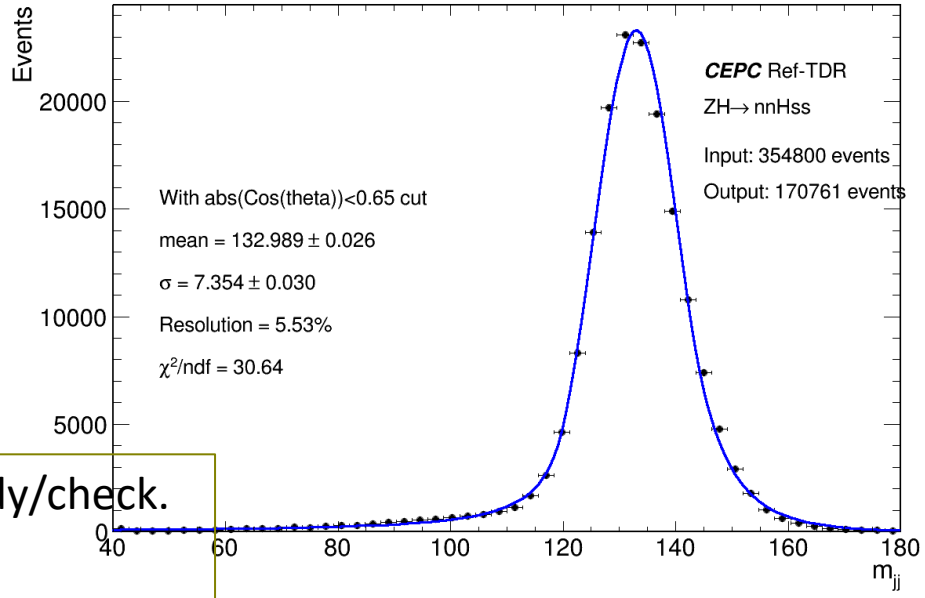
```
E240_2f_ll
E240_2f_qq
E240_4f_ww_h
E240_eeHbb
E240_eeHcc
E240_eeHdd
E240_eeHgg
E240_eeHinclusive
E240_eeHss
E240_mmHbb
E240_mmHcc
E240_mmHdd
E240_mmHgg
E240_mmHinclusive
E240_mmHss
E240_nnHbb
E240_nnHbb_1101
E240_nnHbb_1105
E240_nnHbb_1105v2
E240_nnHcc
E240_nnHdd
E240_nnHddv2
E240_nnHgg
E240_nnHinclusive
E240_nnHss
E240_nnHtautau
E240_nnHuu
E240_nnHyy
E240_qqHbb
E240_qqHinclusive
E240_qqHmm
```

Jet with flavor



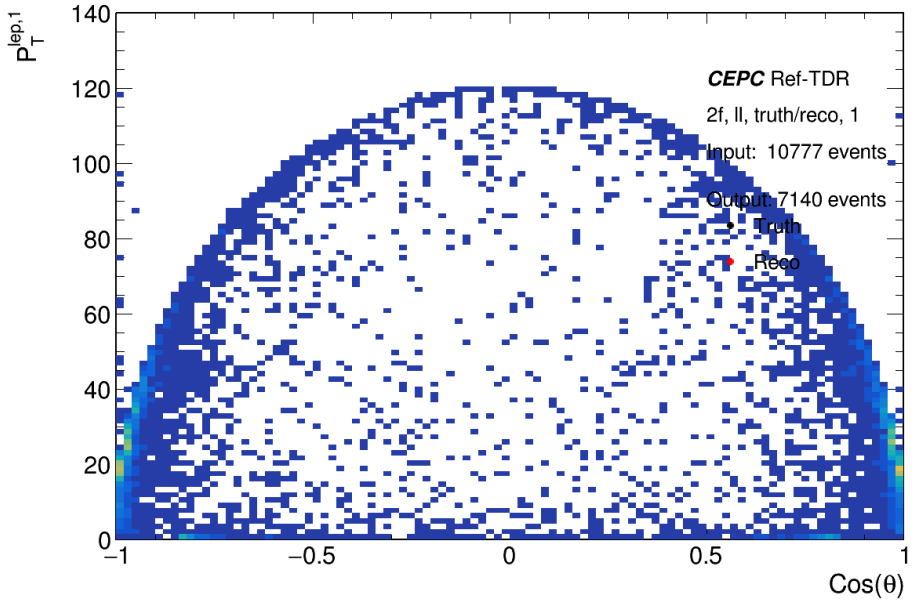


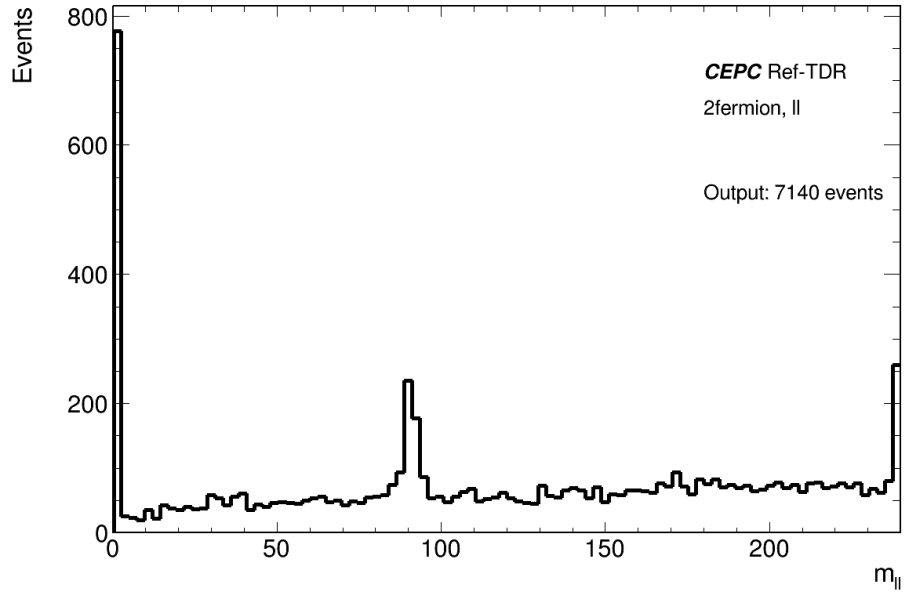


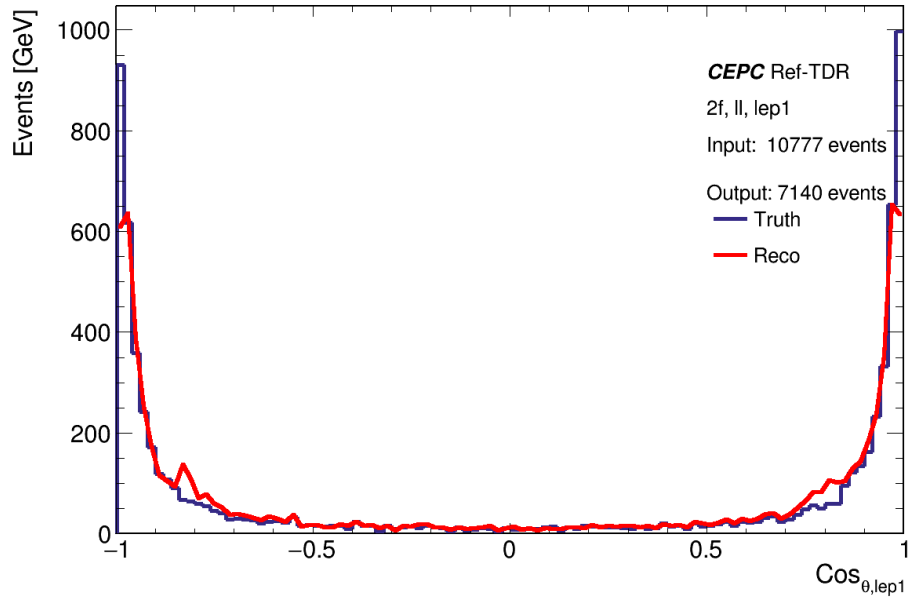


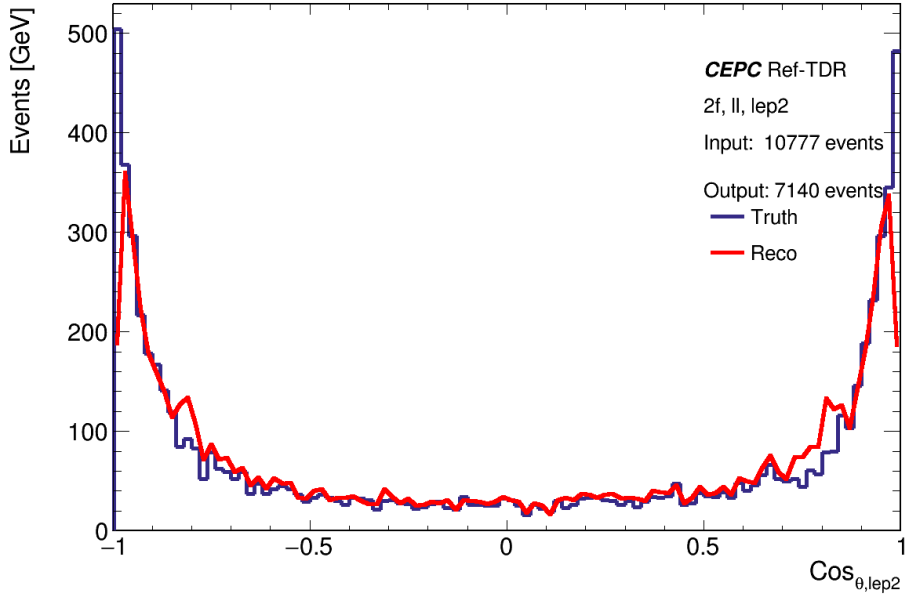
Behaviors need further study/check.
bb 126 and other ~130;
Different resolution…

2f, ee->ll

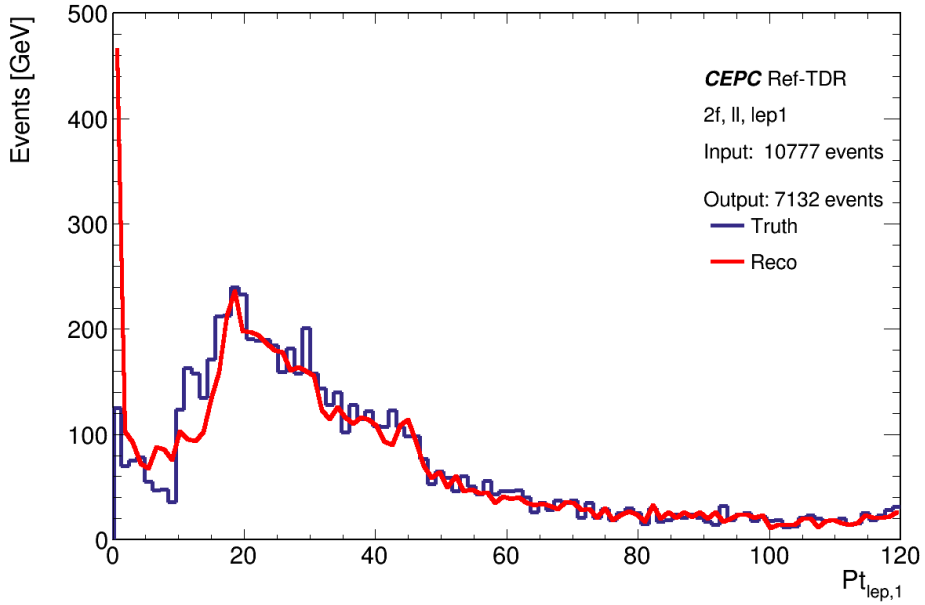

$P_T^{lep,1}$
CEPC Ref-TDR
2f, ll, truth/reco, 1
Input: 10777 events
Output: 7140 events
Truth
Reco
Cos(θ)

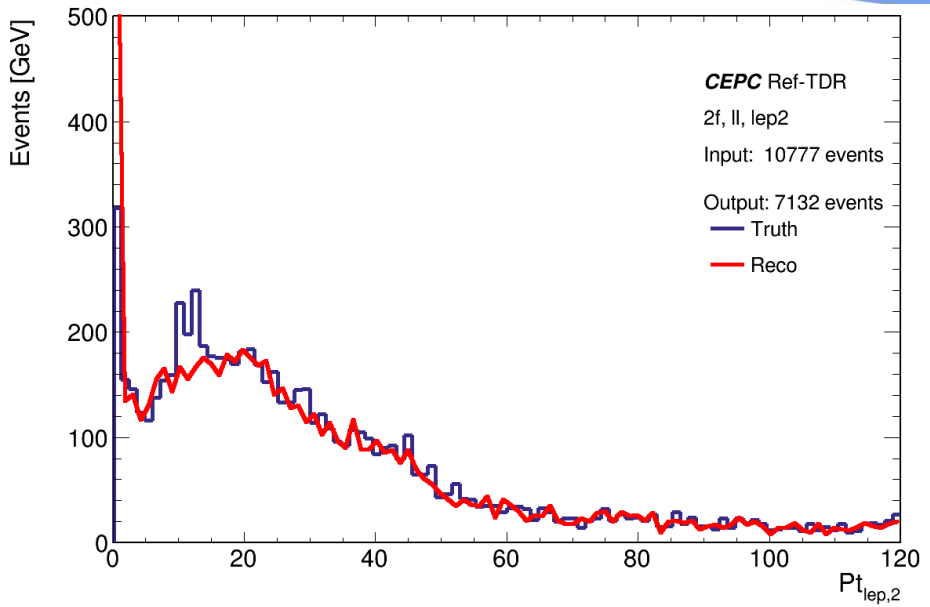

Events
CEPC Ref-TDR
2fermion, ll
Output: 7140 events
m_{ll}

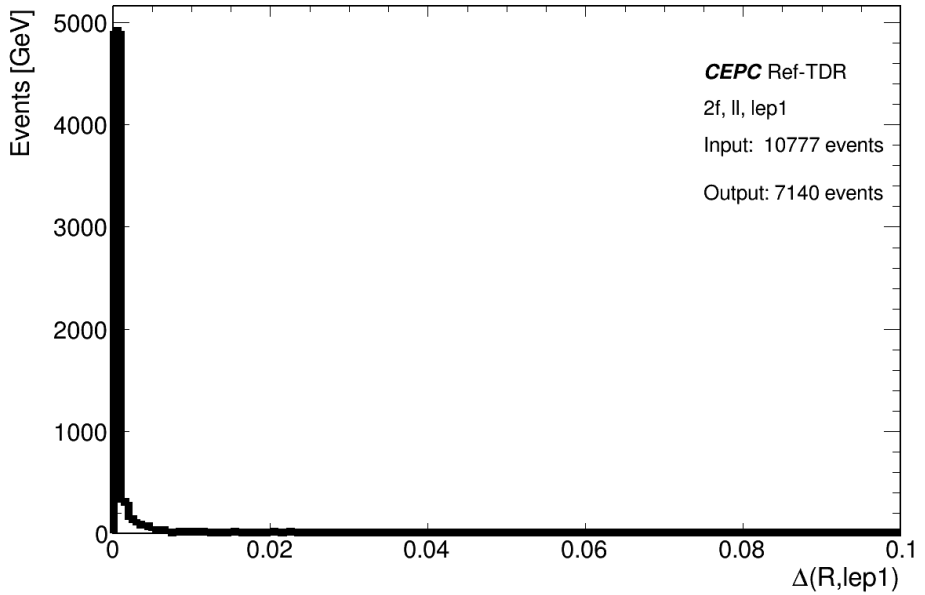

Events [GeV]
CEPC Ref-TDR
2f, ll, lep1
Input: 10777 events
Output: 7140 events
Truth
Reco
$Cos_{\theta,lep1}$

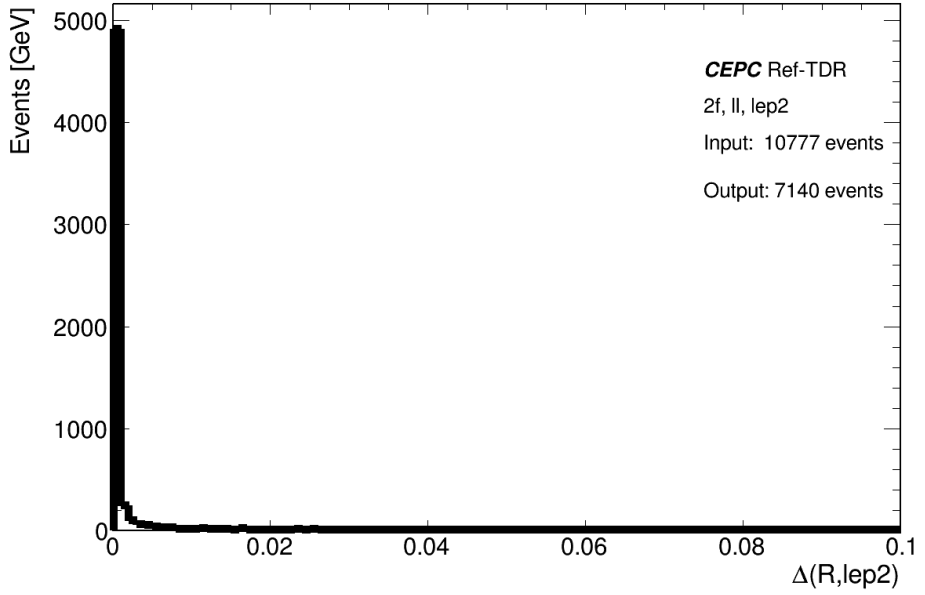

Events [GeV]
CEPC Ref-TDR
2f, ll, lep2
Input: 10777 events
Output: 7140 events
Truth
Reco
$Cos_{\theta,lep2}$

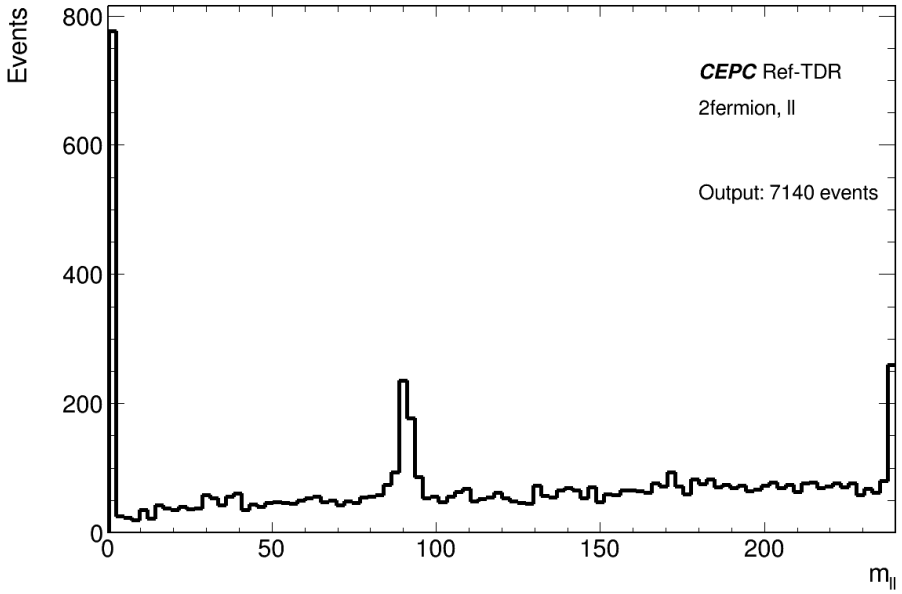
2f, ee->ll

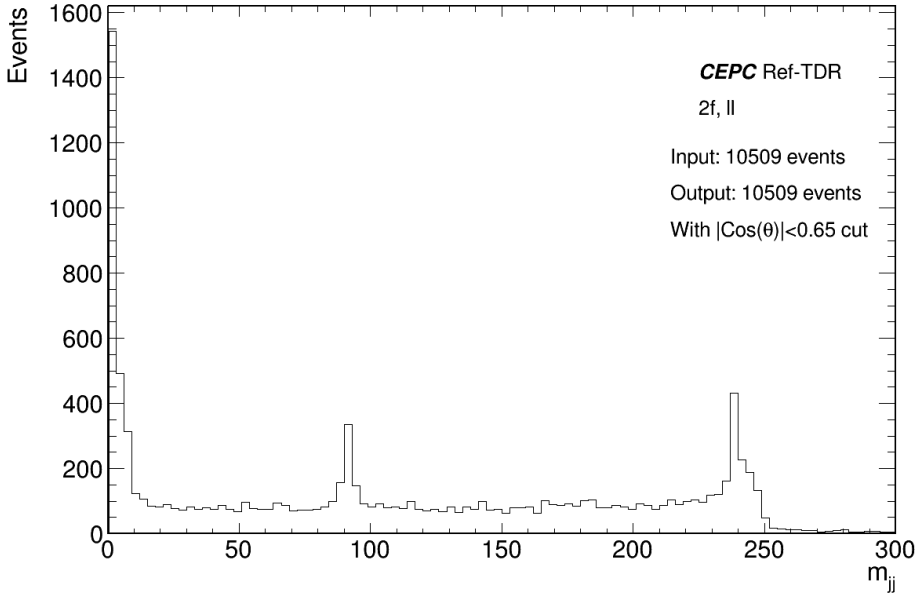

CEPC Ref-TDR
2f, ll, lep1
Input: 10777 events
Output: 7132 events
Truth
Reco
Events [GeV]
Pt_lep,1

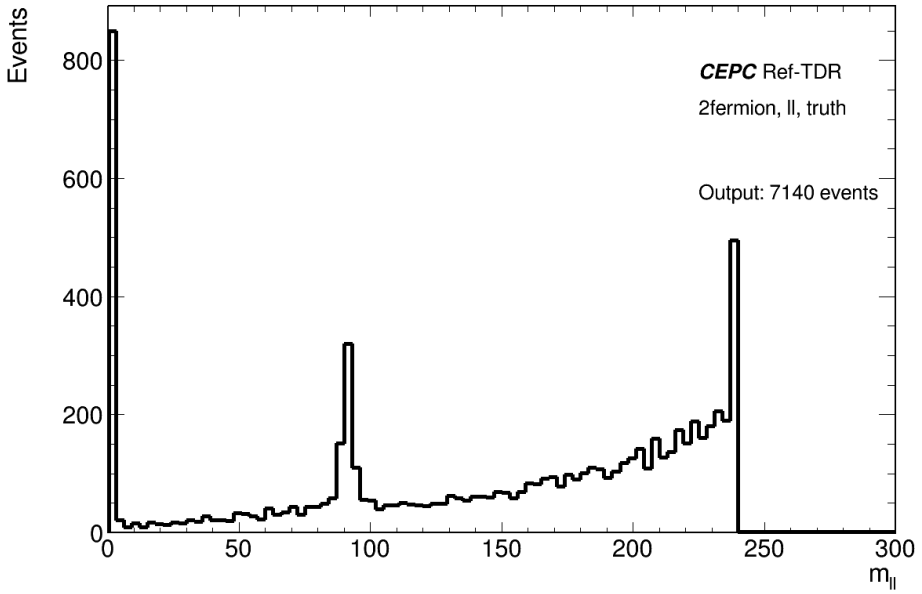

CEPC Ref-TDR
2f, ll, lep2
Input: 10777 events
Output: 7132 events
Truth
Reco
Events [GeV]
Pt_lep,2


CEPC Ref-TDR
2f, ll, lep1
Input: 10777 events
Output: 7140 events
Events [GeV]
Δ(R,lep1)


CEPC Ref-TDR
2f, ll, lep2
Input: 10777 events
Output: 7140 events
Events [GeV]
Δ(R,lep2)







- 2fermion sample has full angle cover.
- Can be use to replace particle gun.