Status of Physics Performance

- CEPCSW TDR**25.03.6** release on March 14

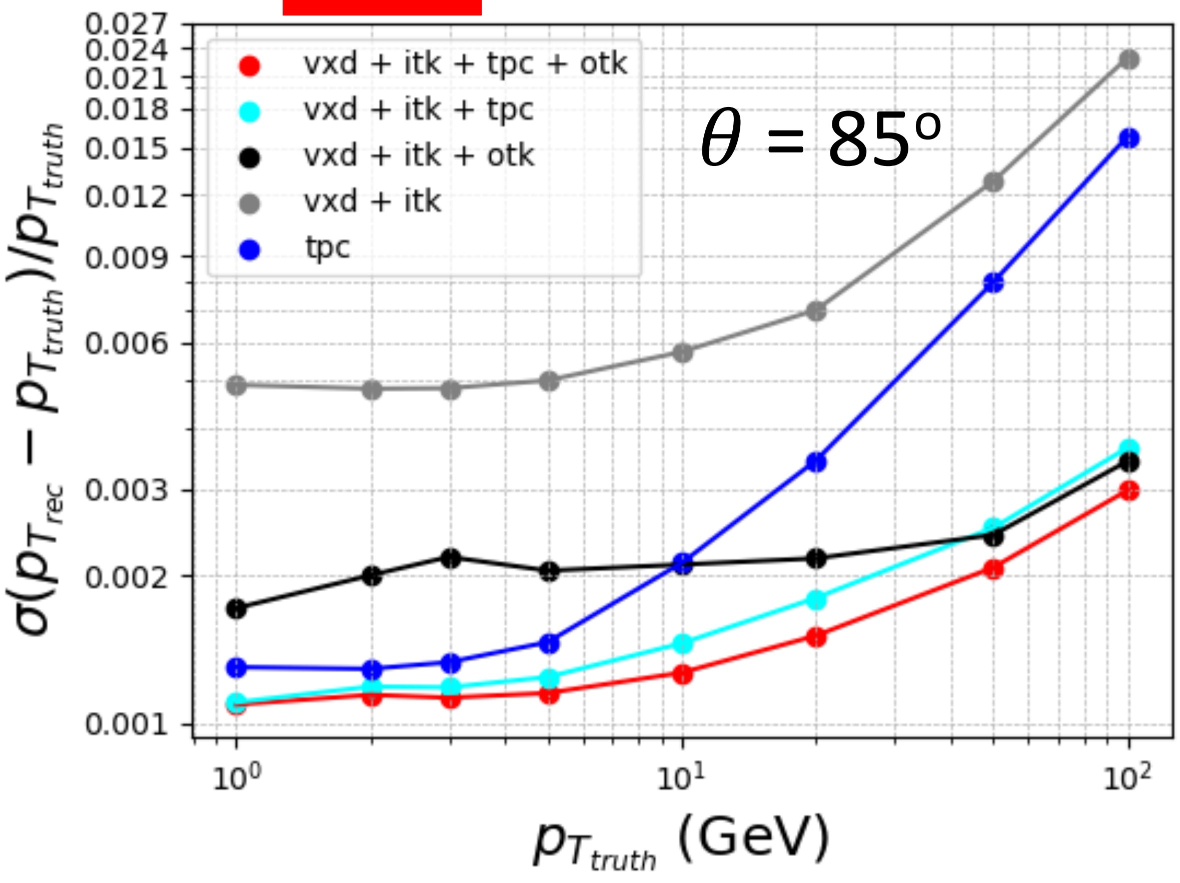
  (Several bug fixes since 25.03.0 release on March 3)
  - Switched to 15mm x 15mm Crystal Bar
  - Much improved PFO algorithm for ECal/HCal clustering
    - number of PFOs now very close to the number of MC particles
    - small issue observed – missing H/E information
  - Hits in muon chambers reconstructed
    - but magnetic field set to be 0 in return yoke due to time constraint
    - still working on track propagation through calorimeters to match muon hits
      - muon ID inside jets, important for flavor physics and jet flavor tagging
  - Event mixing not ready
    - Agree to evaluate only performance degradation at object level later: Tracking, TPC, etc.
  - PID package being worked out
- Mass production of TDR samples started since March 14
  - CPU/evt in good control, while some memory issues cause inefficiency of CPU usage – small number of nodes with large memory
    - simulation + digi + tracking -> ~24 s/evt, 4.x GB memory for job with 200 evts
    - rec -> ~6 s/evt, 6 GB for job with 200 evts

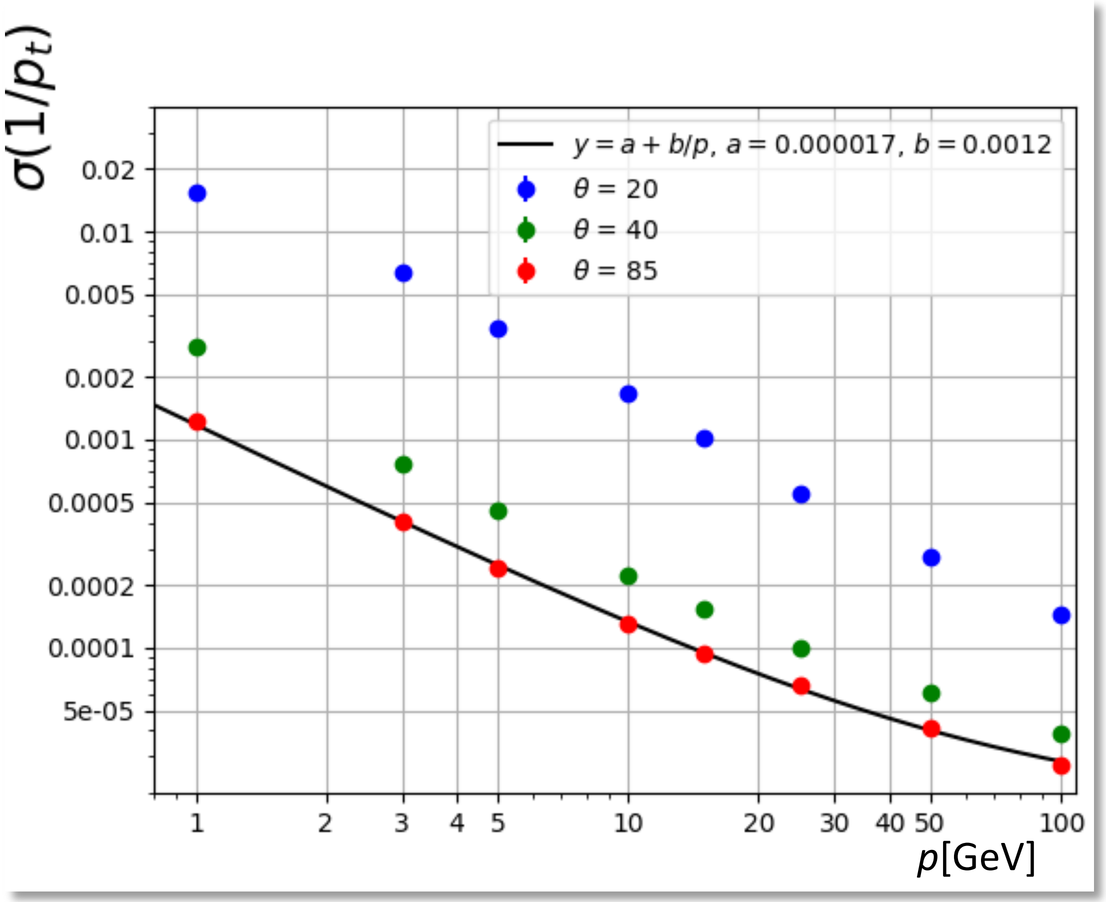
Tracking

Tracking momentum resolution

Chenguan Zhang, Hao Zhu

25.3.0





Few outliers will be fixed with better fits
NO BIG ISSUES observed

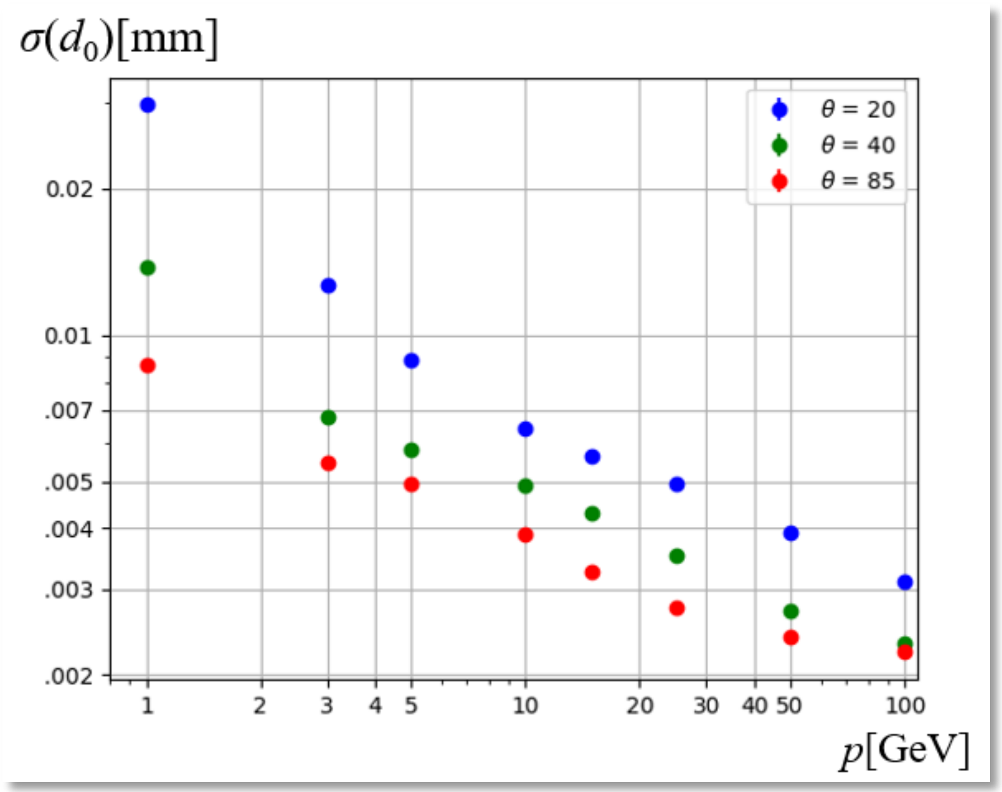
Curve of $1.7\times10^{-5} \oplus 1.2\times10^{-3}/(p\cdot\sin\theta)$ shown for illustration

- Material maps used in sim and rec are now simplified and consistent

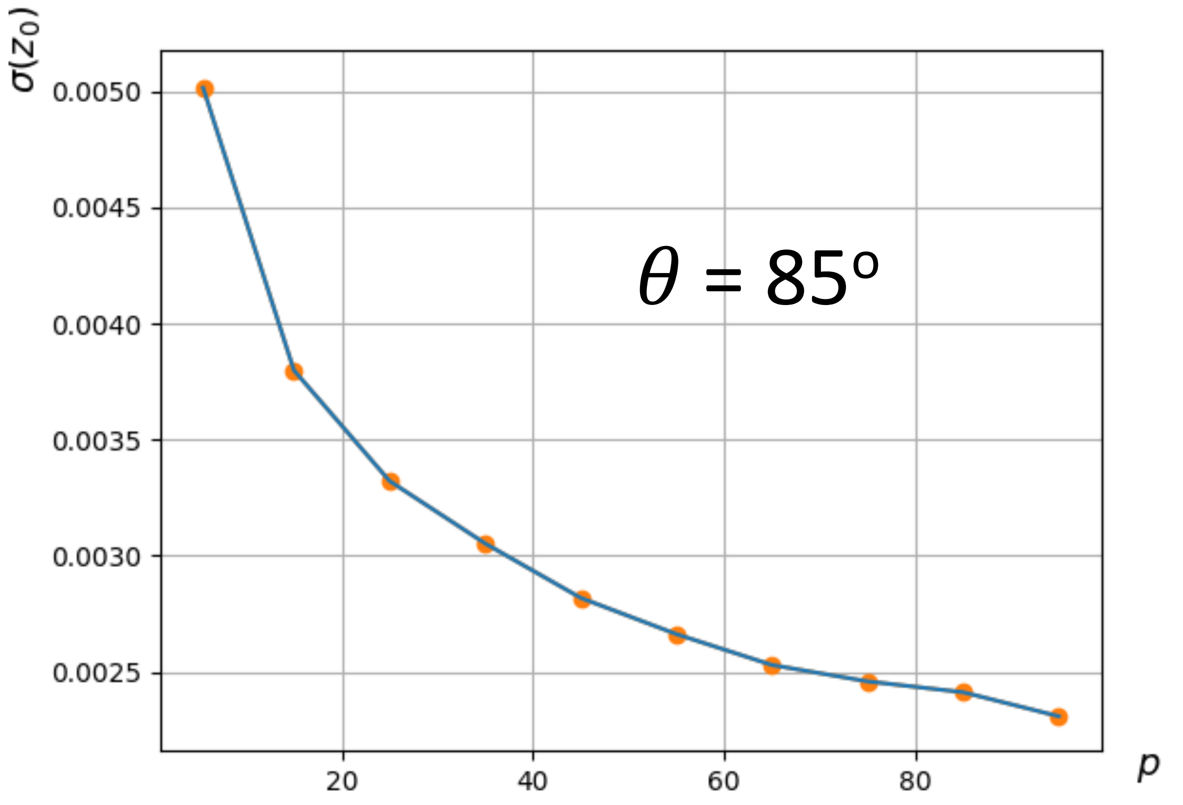
Impact parameter resolution

Tdr25.1.0

Chenguan Zhang, Hao Zhu

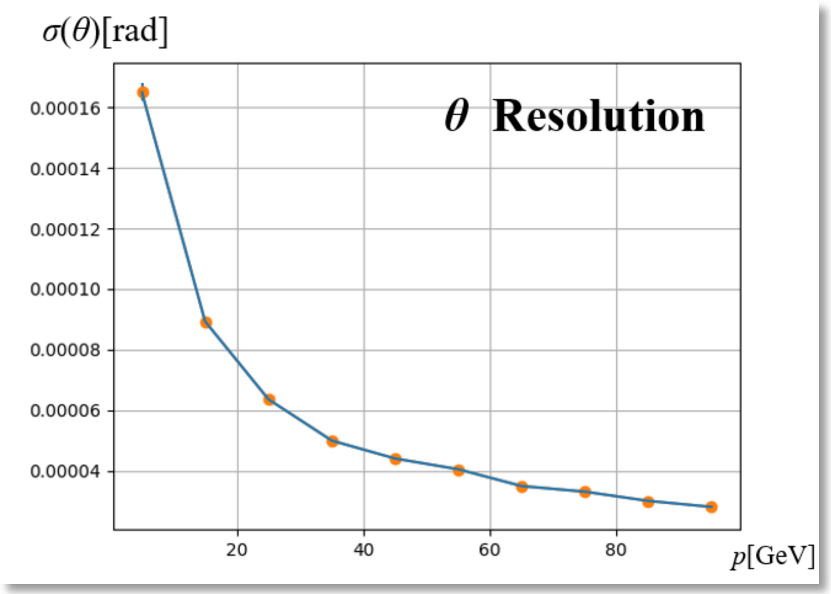


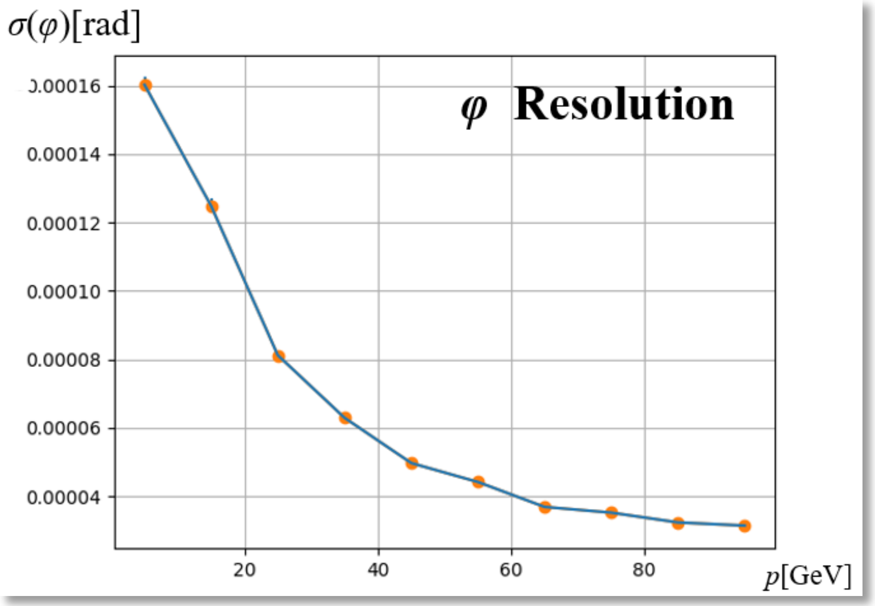
(mm)

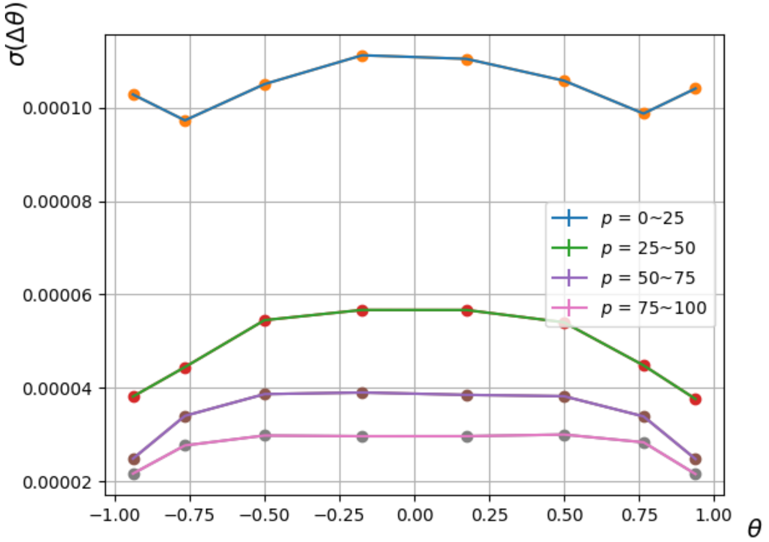


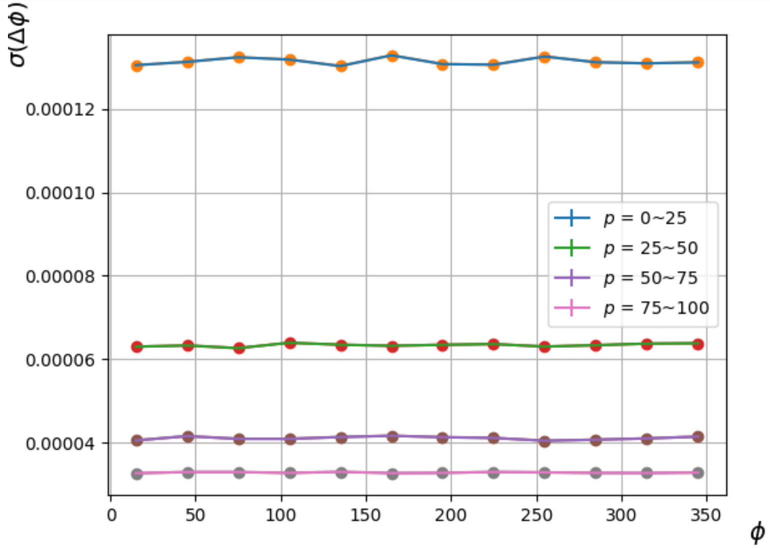
Tracking angular resolution

Chenguan Zhang, Hao Zhu







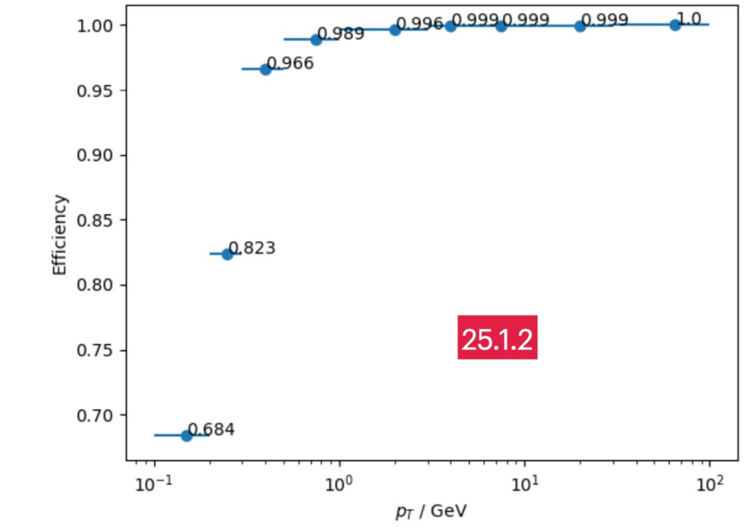


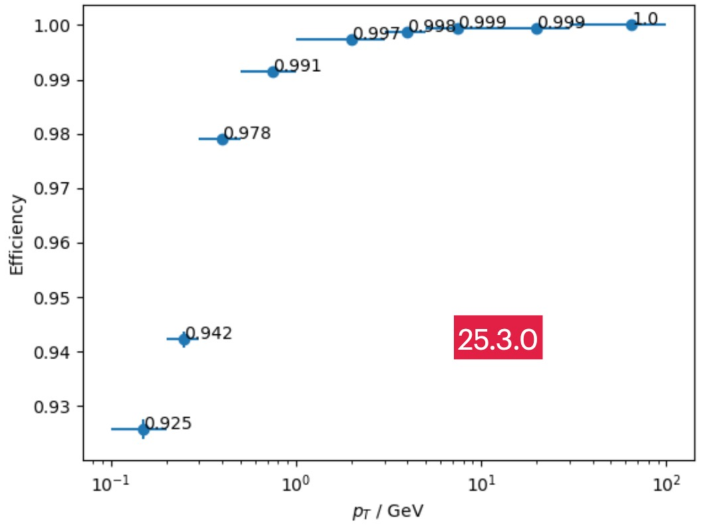
Tracking efficiencies

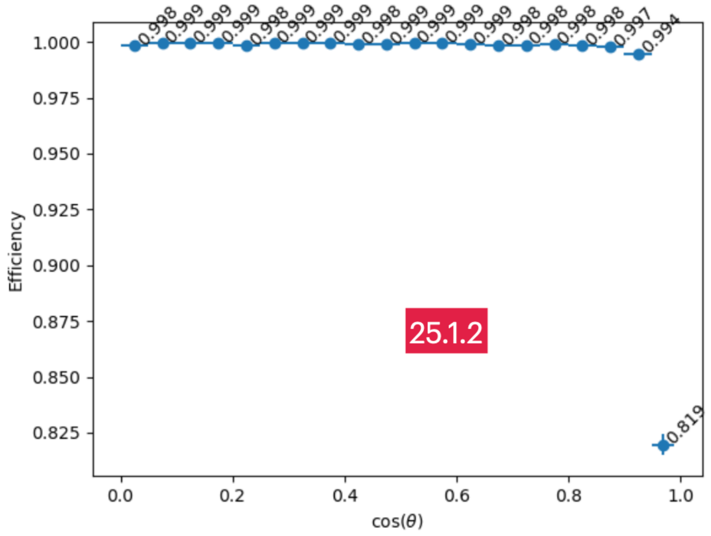
- **Sample: E124_nnHbb**

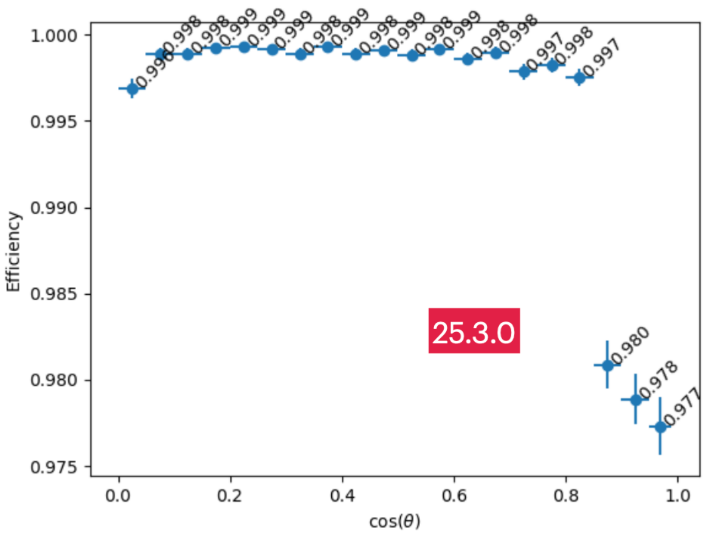
Chenguan Zhang

Improved tracking efficiency in new release

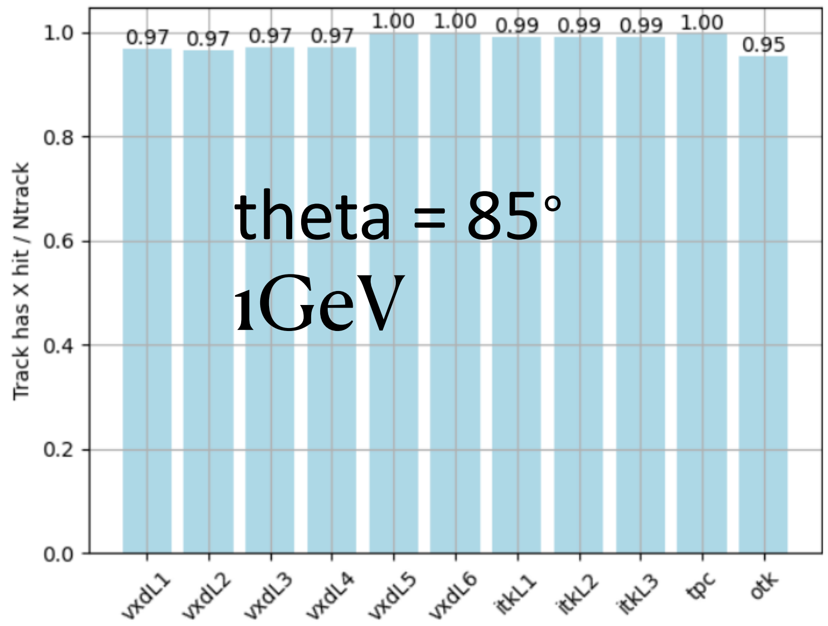








Hit efficiency recovered in 25.3.0



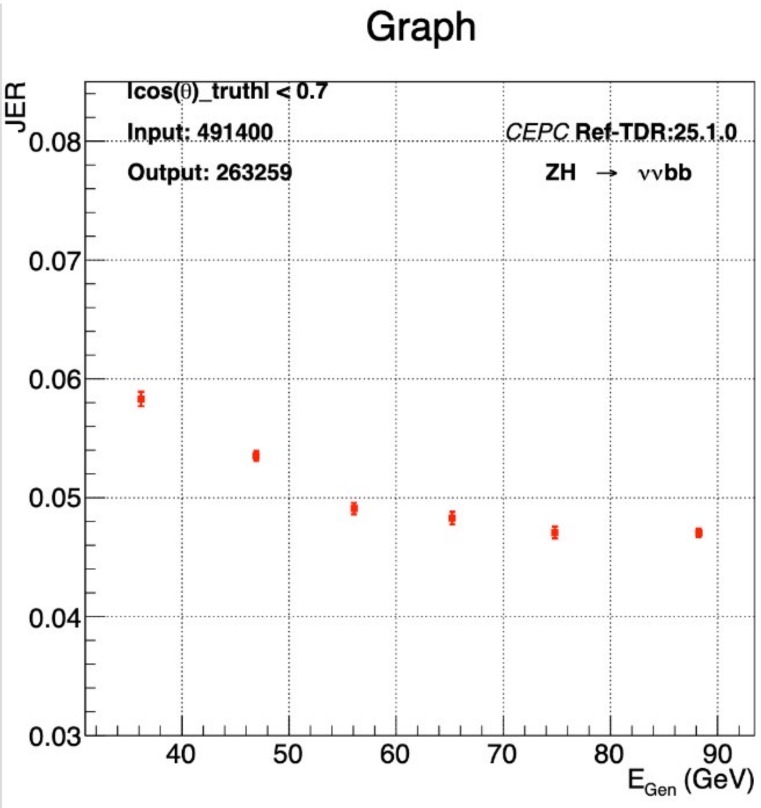
Performance update of PID (charge hadron, lepton, photon) and vertexing in 25.3.6 will be shown in next meeting

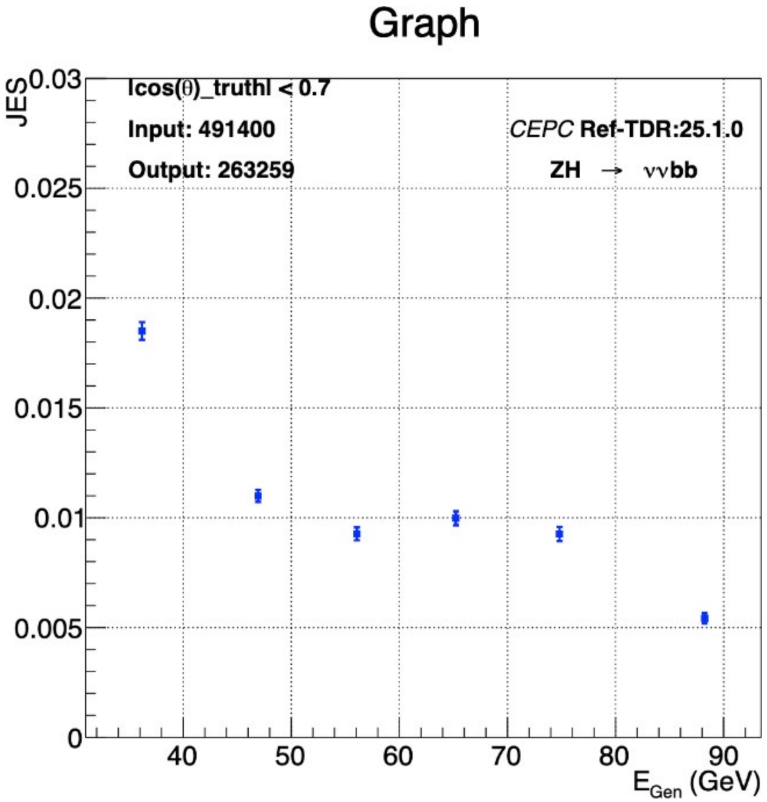
Jets

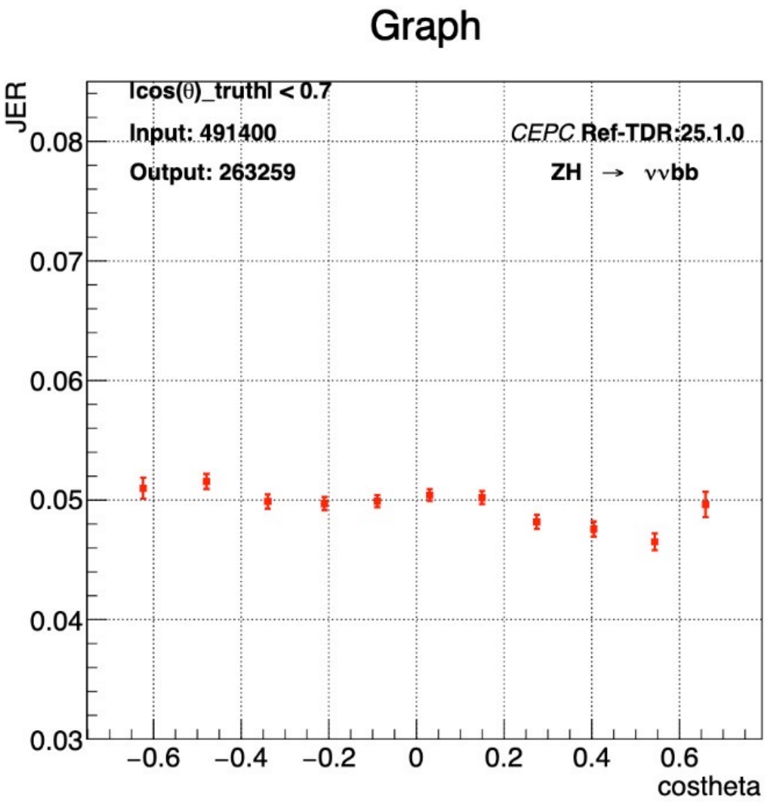
JER

Yingqi Hou, Kaili Zhang, et. al.

- ZH->$\nu\nu$bb sample







JER vs E

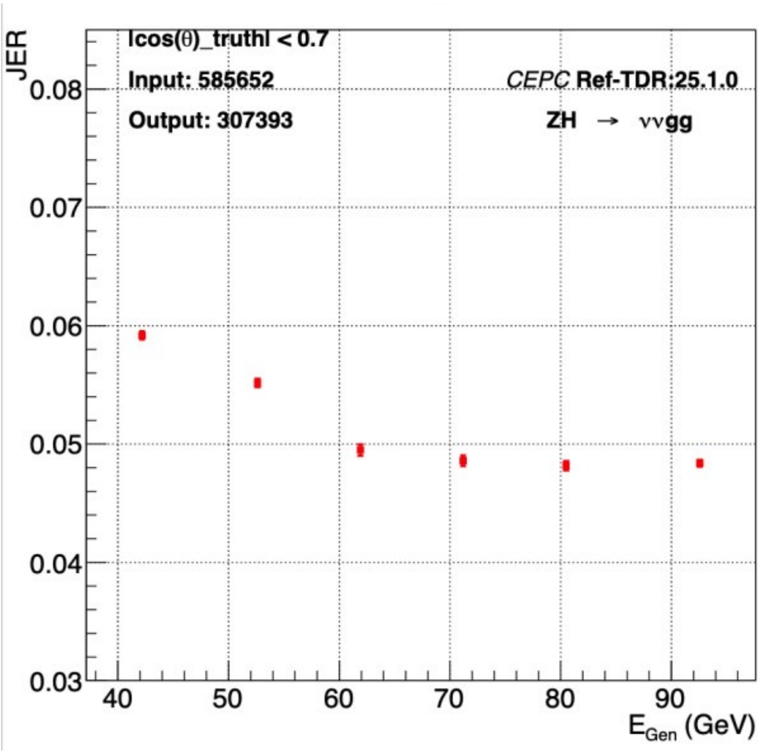
JES vs E

JER vs cos$\boldsymbol{\theta}$

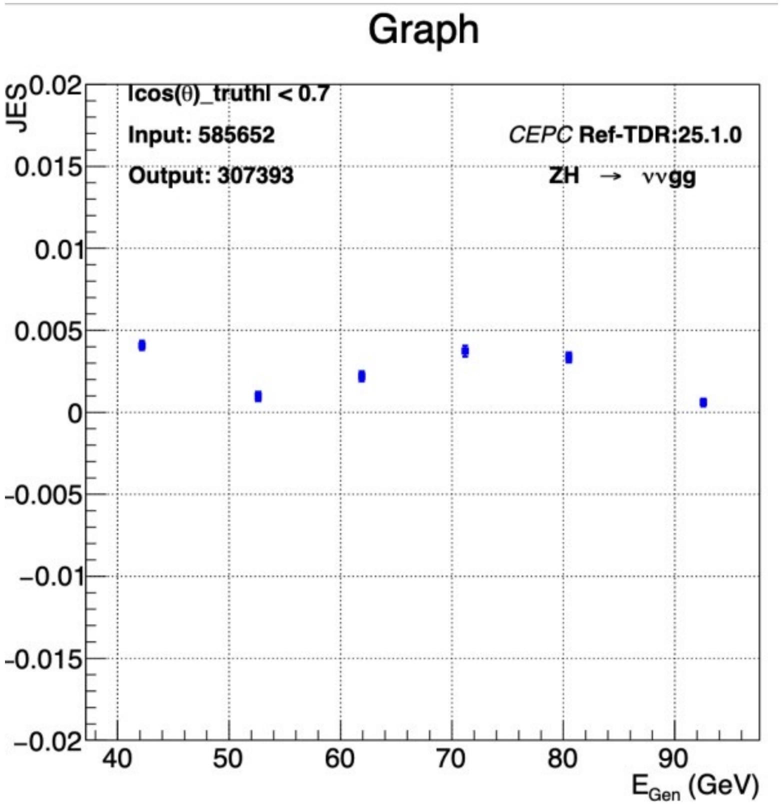
JER

Yingqi Hou, Kaili Zhang, et. al.

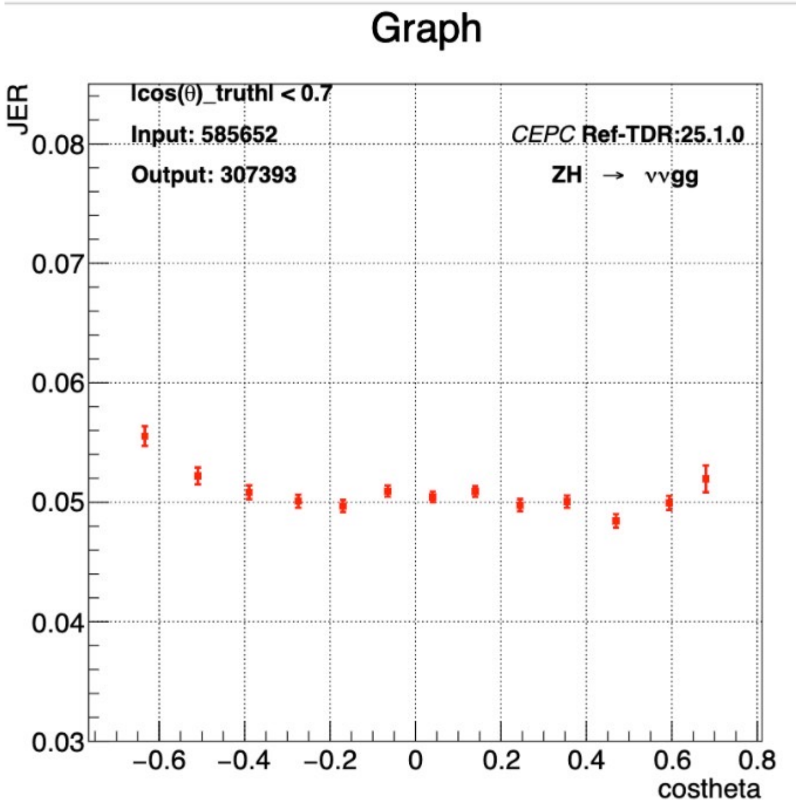
- ZH->*νν*gg sample



JER vs E



JES vs E



JER vs cos$\boldsymbol{\theta}$

Physics level: without event cleaning
Detector level: with event cleaning |Pt_isr|,|Pt_v|<1GeV.
|cos_theta|<0.85 in the table.

BMR

Xiaotian Ma, et. al.

25.1.0

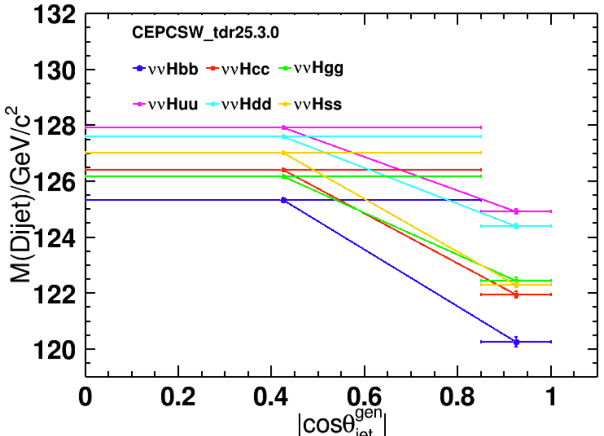
Case	process	$ZH \to \nu\nu gg$	$ZH \to \nu\nu bb$	$ZH \to \nu\nu cc$	$ZH \to \nu\nu uu$	$ZH \to \nu\nu dd$	$ZH \to \nu\nu ss$
Physical level	BMR/%	4.00 ± 0.01	4.36 ± 0.03	4.16 ± 0.03	3.79 ± 0.01	3.97 ± 0.01	4.44 ± 0.01
	Efficiency/%	73.3	73.7	74.0	74.2	74.1	74.1
Detector level	BMR/%	3.95 ± 0.01	3.74 ± 0.02	4.01 ± 0.01	3.77 ± 0.01	3.95 ± 0.01	4.40 ± 0.01
	Efficiency/%	65.7	28.1	48.6	70.3	70.1	70.2

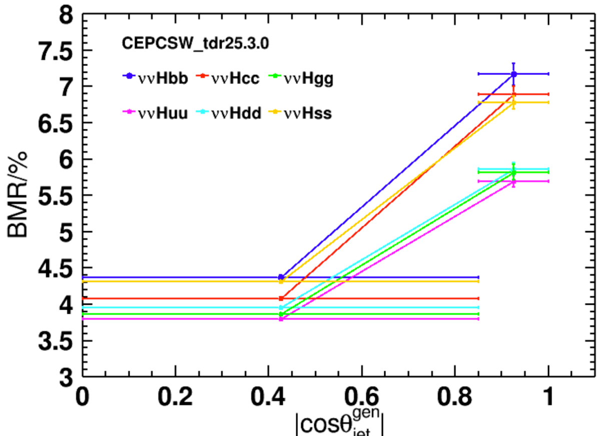
25.3.0

Case	process	$ZH \to \nu\nu gg$	$ZH \to \nu\nu bb$	$ZH \to \nu\nu cc$	$ZH \to \nu\nu uu$	$ZH \to \nu\nu dd$	$ZH \to \nu\nu ss$
Physical level	BMR/%	3.87 ± 0.01	4.37 ± 0.03	4.09 ± 0.02	3.82 ± 0.01	3.97 ± 0.01	4.33 ± 0.01
	Efficiency/%	74.4	74.5	74.8	74.9	74.8	74.8
Detector level	BMR/%	3.82 ± 0.01	3.70 ± 0.01	3.92 ± 0.01	3.80 ± 0.01	3.94 ± 0.01	4.30 ± 0.01
	Efficiency/%	66.7	28.4	49.1	71.2	70.8	70.9

Observation:
better BMR in 25.3.0 with 15mm x 15mm crystal bar geometry than 10x10 in 25.1

Should be due to the improved PFA clustering



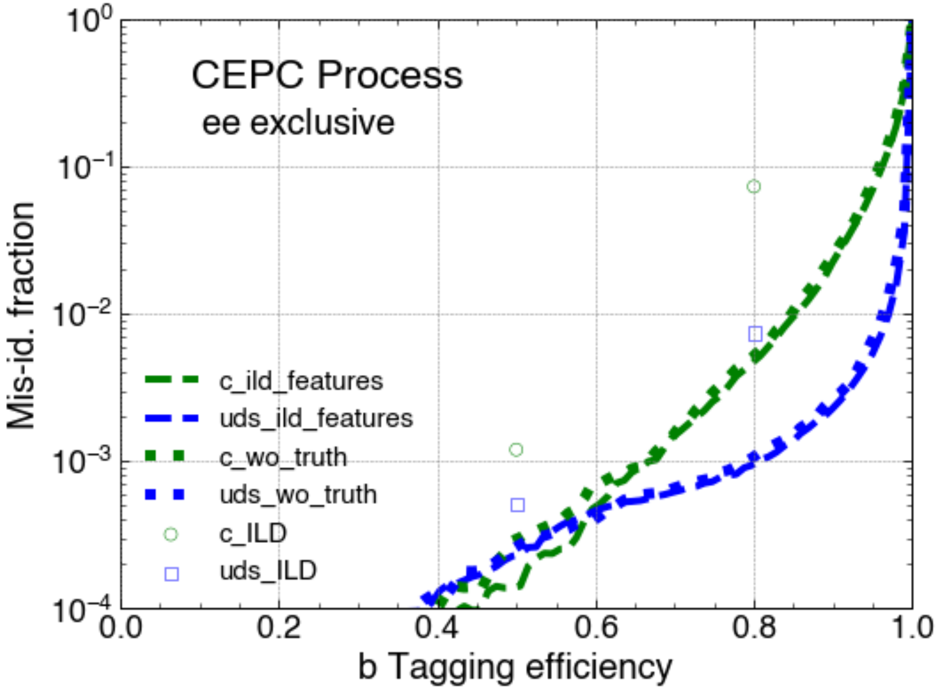


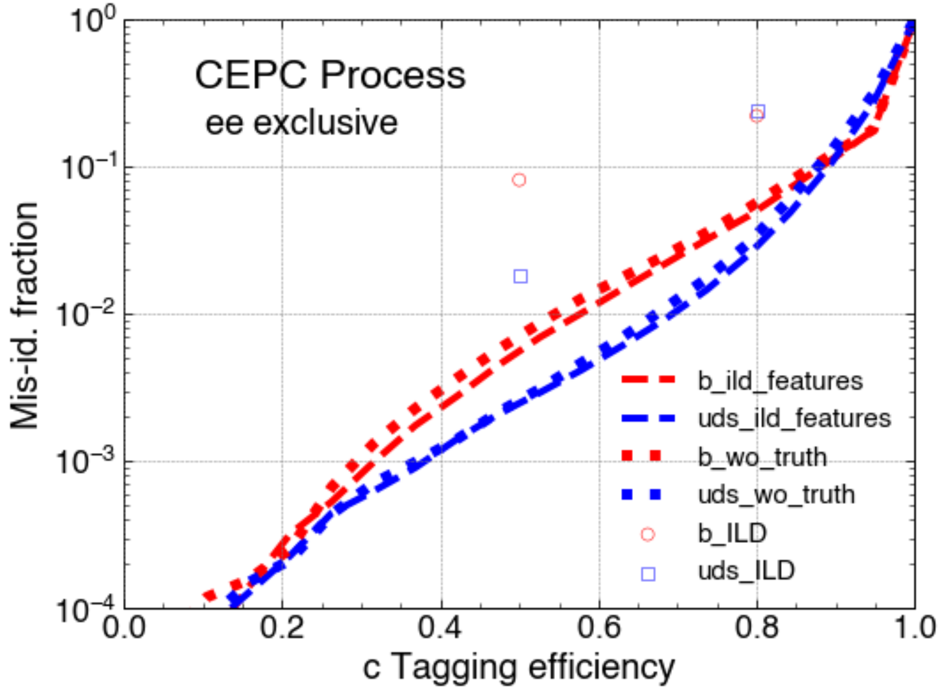
Dijet mass and BMR of barrel and endcap

Much worse resolution in endcap as expected

Jet Flavor Tagging with BDT

- With similar set of variables as ILD (ILD paper arXiv:1506.08371)
- Much better performance compared to ILD
  - caveat: missing beam background, electronic noise in RefTDR



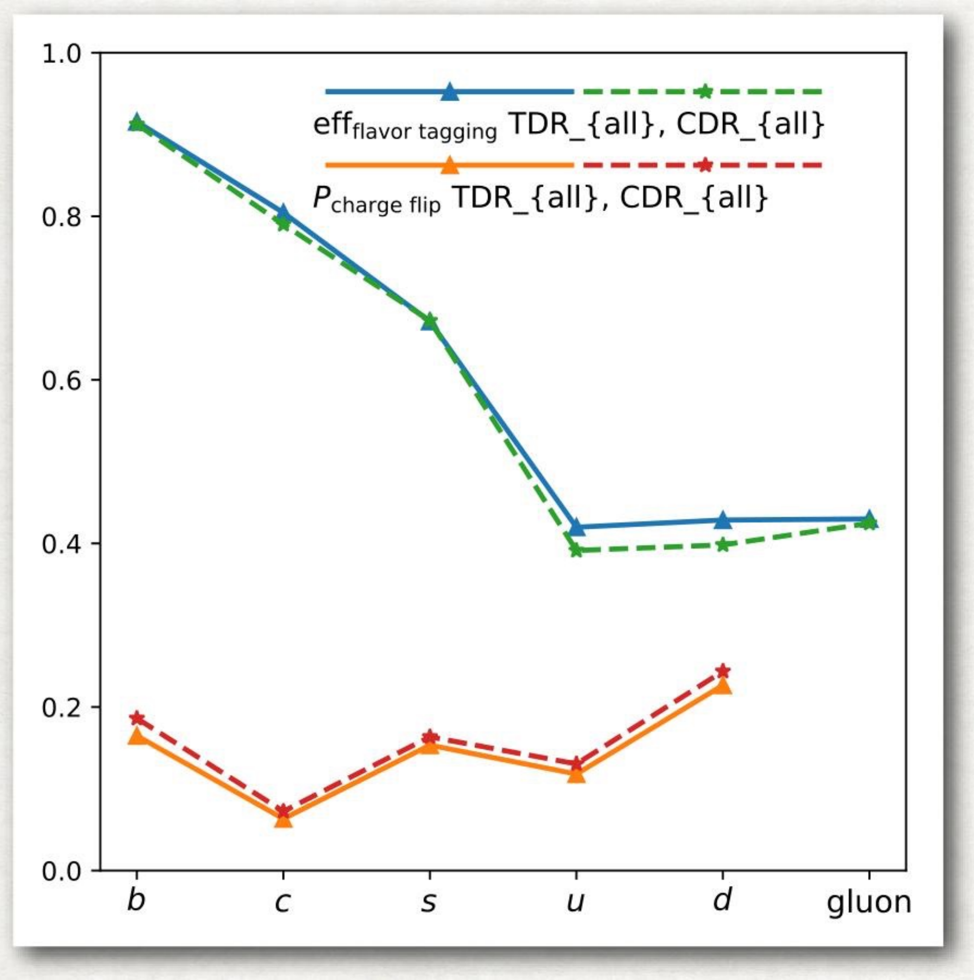


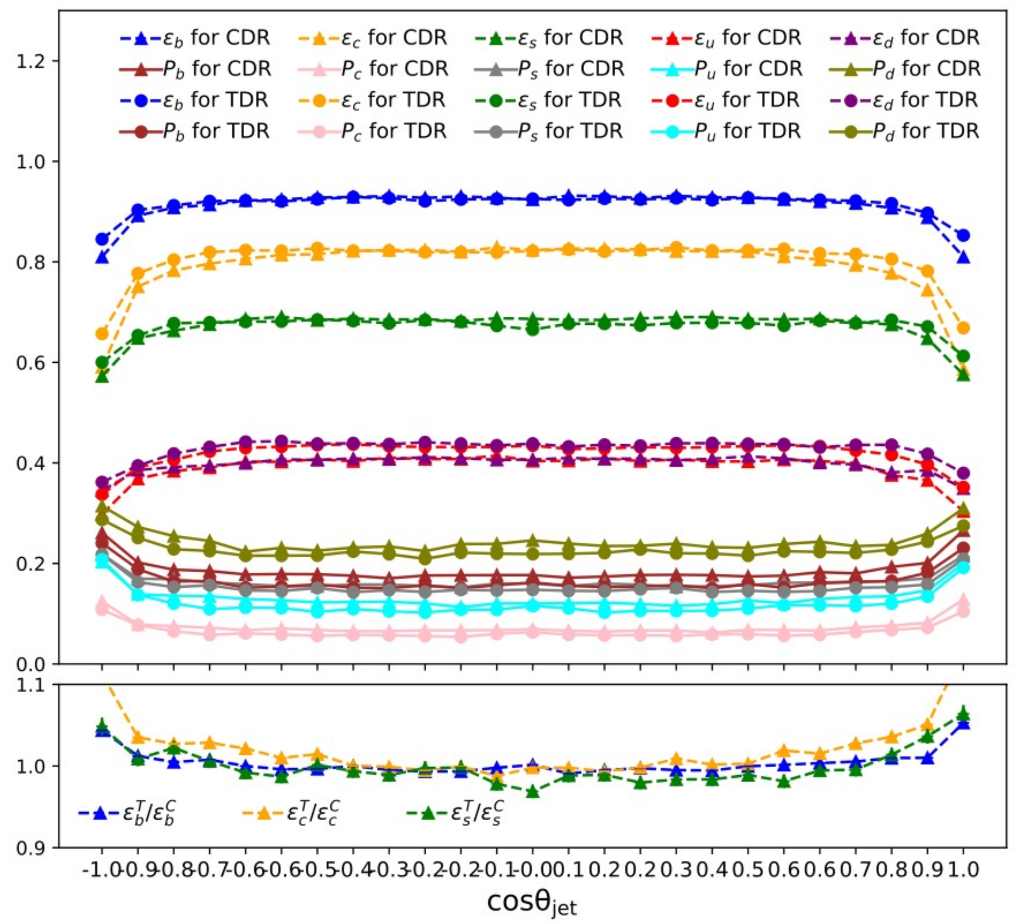
More details in Minlin Wu's talk

Jet Origin ID (JOI)

25.01

Based on Particle Transformer





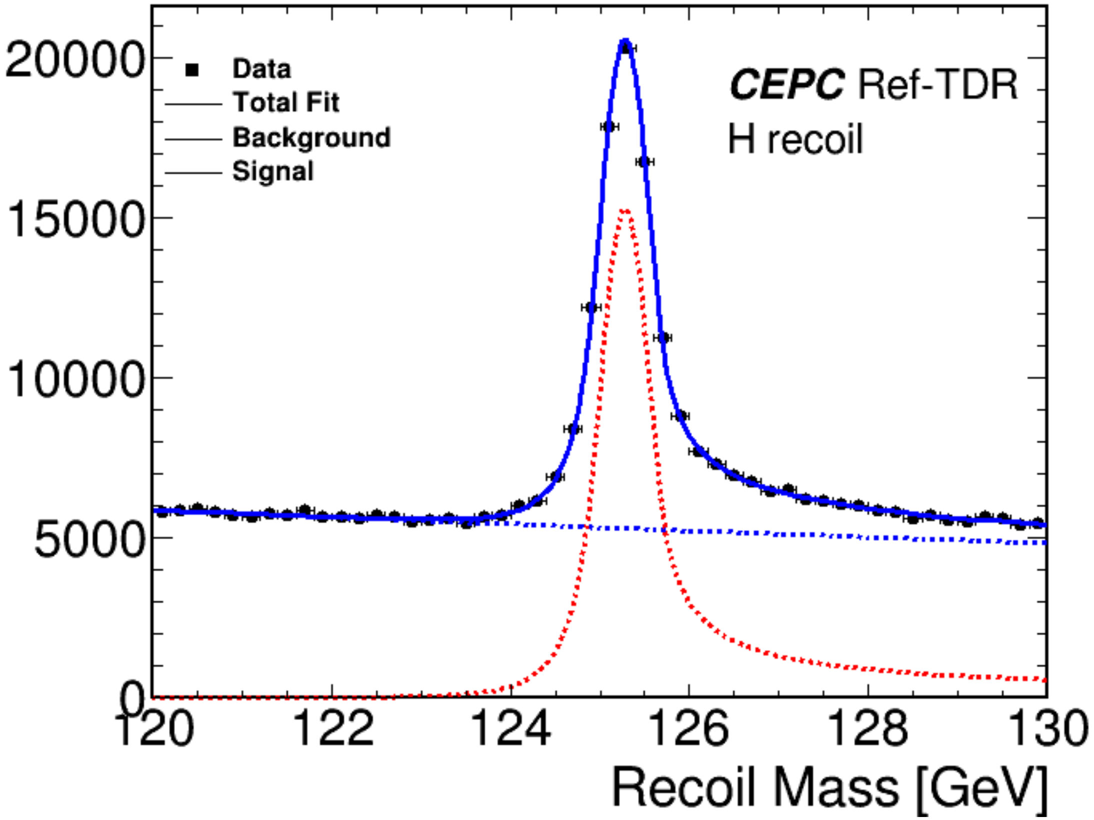
No vertex used, but learn from track impact parameters

- JOI implemented with TDR simulations
- In general slightly better performance observed than CDR (both with truth PID)
  - Could be due to better VTX, and ???
- Will be repeated in 25.03.6 with reco PID

First look at benchmarks

mH through recoil mass

25.01



Fitted by exponential & TwosidedCB
mH=125.281 GeV, Stat unc. = 2.4 MeV

- Currently only barrel muons considered
  - cos(theta)<0.85, and truth muon ID
  - Reasonable STAT unc. on mH ~ 2.4 MeV with 20/ab
- Might have 2 or 3 categories in TDR
  - barrel-barrel, barrel-endcap, endcap-endcap
  - Stat unc. will be further improved
- Systematic uncertainties to be be investigated
  - Beam energy spread, muon pT resolution/scale, etc.
  - Syst. unc. in endcap could be larger

Search for Higgs invisible

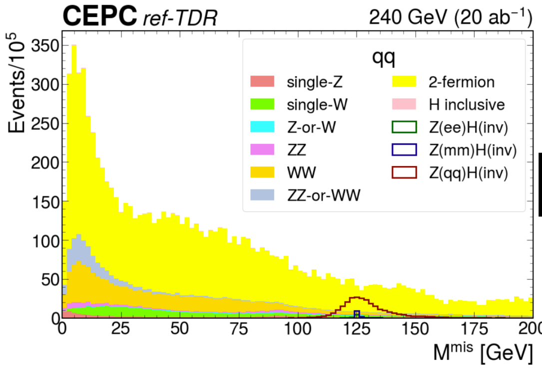
25.01

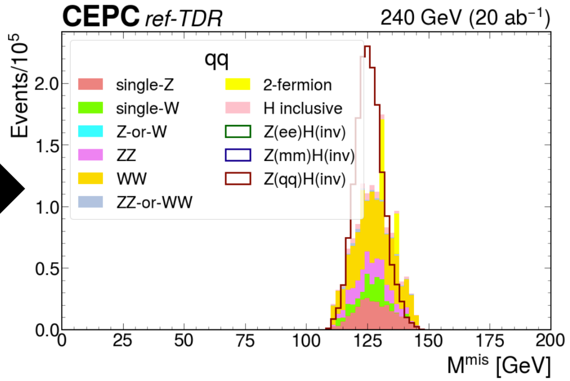
Kinematic selection

Copy the selection criteria from Chinese Phys. C 44 123001

➢ **qq final state**

Process	eeH	mmH	qqH	sz	sw	szw	zz	ww	zzww	2f	Hincl	All bkg
Total yield	140800	135400	2736200	32403400	69705000	4989600	22819400	181522200	73003000	1082137200	4073200	140800
Kin sel	23	0	1626945	244397	128022	0	182434	601706	20246	97783	55033	23
eff (%)	0.0163	0.000	59.460	0.754	0.184	0.000	0.800	0.332	0.028	0.009	1.351	0.0163
eff CDR (%)	-	-	60.81	0.66	0.06	0.00	0.64	0.21	0.02	0.00	0.97	0.03





missing mass in Zqq final state for 240 GeV run

- With 5.6 ab-1 or 20 ab-1
- 3 Z final states considered, sensitivity dominated by Zqq as expected
- Fit Mmis
- No systematic uncertainties yet
- Compute **expected** BR(H⟶invisible)
  - SM BR(H⟶invisible)≈0.1%

Final state	Uncertainty	Upper limit	Upper limit (CDR)
ee	$(1.00^{+4.68}_{-1.00})\cdot 0.1\%$	0.921%	1.08%
μμ	$(1.00^{+2.53}_{-1.00})\cdot 0.1\%$	0.495%	0.55%
qq	$(1.00^{+1.21}_{-1.00})\cdot 0.1\%$	0.237%	0.27%
All	$(1.00^{+1.05}_{-0.92})\cdot 0.1\%$	0.202%	0.26%

5.6 ab-1

Final state	Uncertainty	Upper limit
ee	$(1.00^{+2.46}_{-1.00})\cdot 0.1\%$	0.483%
μμ	$(1.00^{+1.28}_{-0.86})\cdot 0.1\%$	0.234%
qq	$(1.00^{+0.64}_{-0.64})\cdot 0.1\%$	0.125%
All	$(1.00^{+0.55}_{-0.53})\cdot 0.1\%$	0.102%

20 ab-1

Summary

- Studies on physics object performance through full simulation shown
  - Tracking pT resolution $1.7\times10^{-5} \oplus 1.2\times10^{-3}/(p\cdot\sin\theta)$ for polar angle at 85^{o}
  - PID (TPC+TOF)~ 3**σ** separation power for 3-10 GeV pi-K
  - BMR reaches the design goal: ~ 3.82% in TDR vs. 3.75% in CDR for Hgg
  - Excellent vertex performance as expected
  - Preliminary results show very promising jet flavor tagging and JOI performance
- Moving to physics benchmark studies with 25.03.6 release
  - Mass production started on March 14
  - Though still some developments ongoing
  - Hopefully final results ready in 2 weeks