

Z pole $ee \rightarrow bb$ forward-backward asymmetry at CEPC

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1 IHEP

Introduction

- The CEPC data at Z pole energy allow high precision electroweak measurements of the Z boson properties, such as the forward-backward charge asymmetry (AFB) as a function of the effective weak mixing angle.

- The $ee \rightarrow bb$ is the only channel needs jet charge tagging from JOI

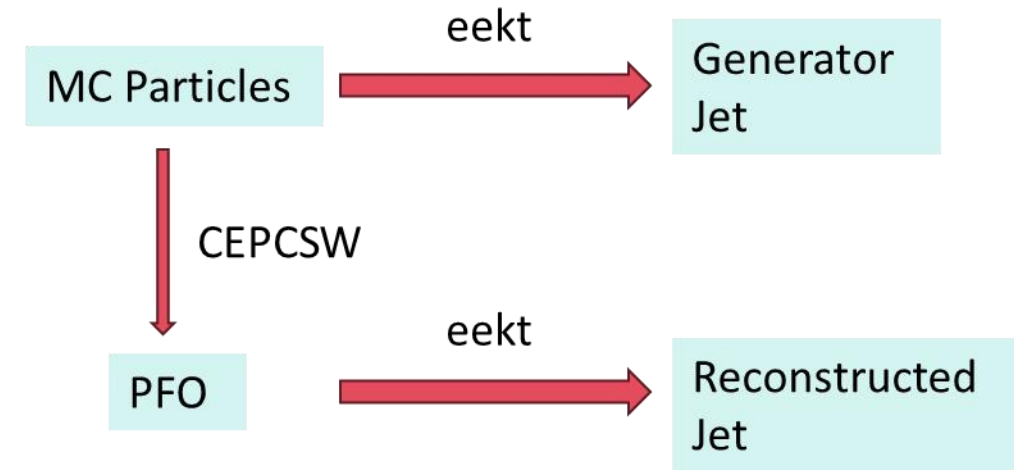
- LEP measured $AFB(b) = 0.1015 \pm 0.0064$ (stat.) ± 0.0035 (sys.). FCC-ee result is estimated to be 0.1010 ± 0.0001 .

- It verifies the performance of jet reconstruction and charge tagging.

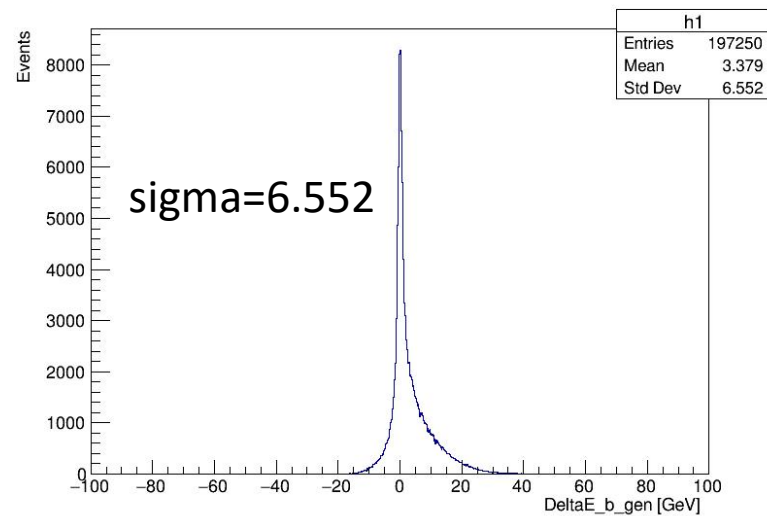
CEPC Ref-TDR					H \rightarrow qq, 125 GeV						
Truth	b	\bar{b}	c	\bar{c}	s	\bar{s}	u	\bar{u}	d	\bar{d}	g
	0.811	0.132	0.019	0.016	0.002	0.001	0.001	0.002	0.002	0.001	0.013
	0.124	0.819	0.017	0.018	0.001	0.002	0.002	0.001	0.001	0.002	0.014
	0.009	0.012	0.798	0.042	0.019	0.027	0.027	0.006	0.007	0.017	0.035
	0.013	0.011	0.049	0.790	0.027	0.022	0.006	0.026	0.016	0.007	0.033
	0.002	0.001	0.016	0.019	0.488	0.095	0.028	0.119	0.093	0.053	0.084
	0.001	0.002	0.020	0.015	0.084	0.508	0.124	0.024	0.049	0.091	0.082
	0.001	0.002	0.021	0.008	0.035	0.146	0.413	0.037	0.068	0.178	0.092
	0.002	0.001	0.008	0.021	0.139	0.040	0.045	0.391	0.189	0.070	0.093
	0.002	0.001	0.011	0.019	0.124	0.088	0.066	0.218	0.296	0.080	0.096
	0.001	0.002	0.020	0.009	0.078	0.132	0.239	0.059	0.076	0.289	0.095
	0.011	0.012	0.029	0.029	0.074	0.077	0.072	0.066	0.057	0.057	0.514
					Predicted						
TDR											

The simulated events

- $ee \rightarrow bb$ events are simulated with Whizard1.95 at Z pole energy.
 - The W and Z boson mass (width) values are set precisely to 80.377 (2.085) GeV and 91.1876 (2.4952) GeV.
 - Include ISR and FSR.
- The AFB(b) at Z pole is 0.14665 ± 0.00222 (Counting) by simulating 200000 events.
 - **Not Compatible with LEP result at Z pole, investigating**
- Reconstruction with CEPC software(CEPCSW).
- Use eekt algorithm for jet-reconstruction.
 - by MissingET Package written by Geliang Liu.
 - Jet truth match with ΔR .

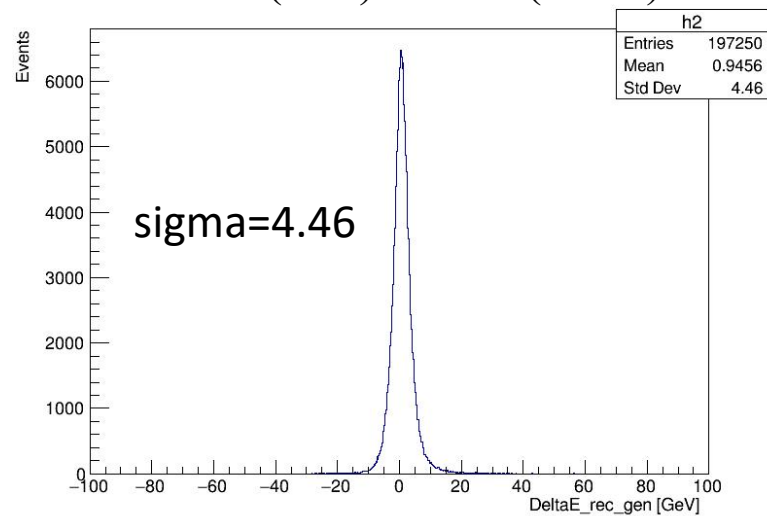
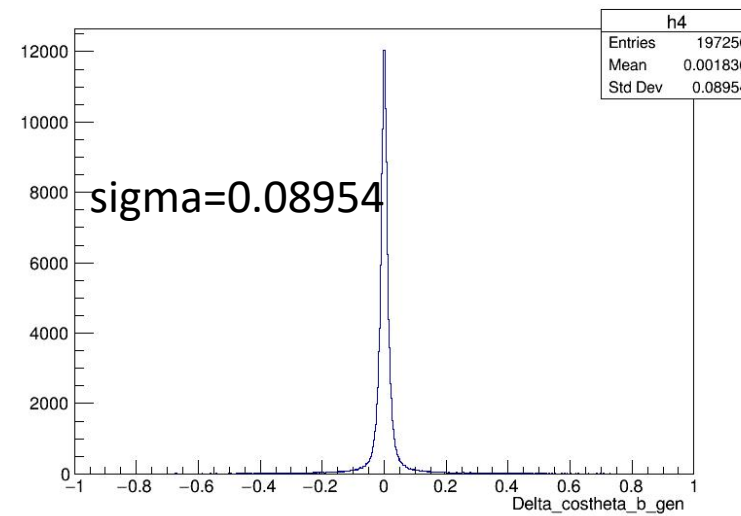


Compare the bias of eekt and PFO on Energy and Costheta



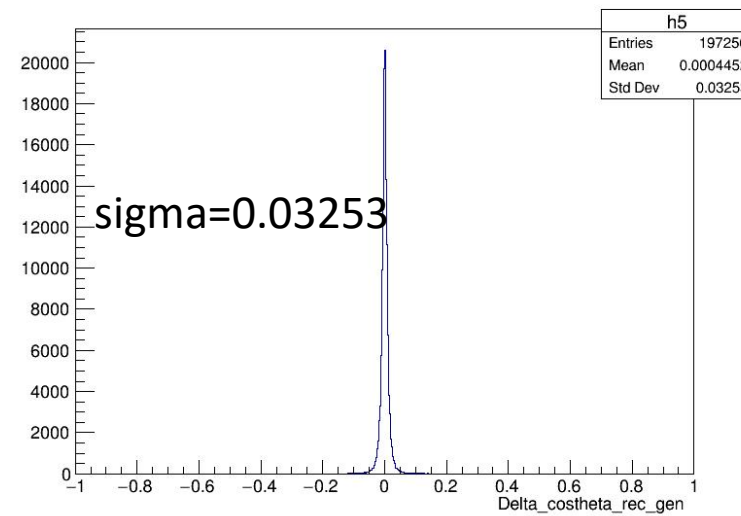
$$\Delta E(\text{bias}) = E(\text{Truth}) - E(\text{GenJet})$$

$$\Delta \cos\theta(\text{bias}) = \cos\theta(\text{Truth}) - \cos\theta(\text{GenJet})$$

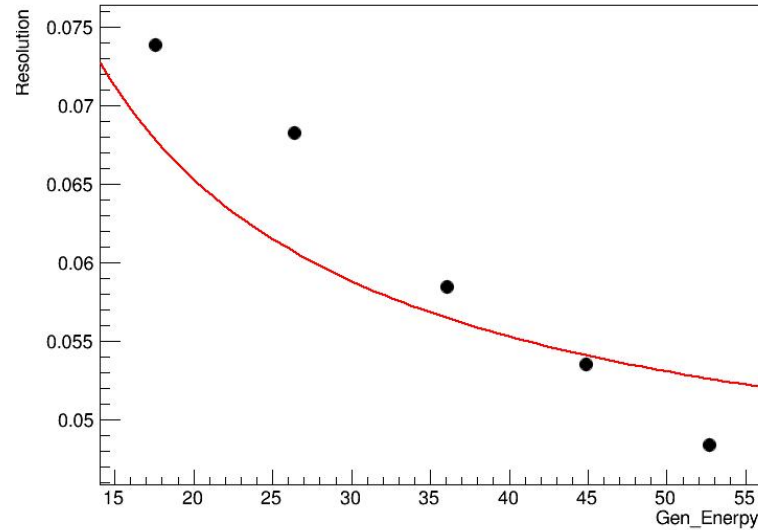


$$\Delta E(\text{Resolution}) = E(\text{RecoJet}) - E(\text{GenJet})$$

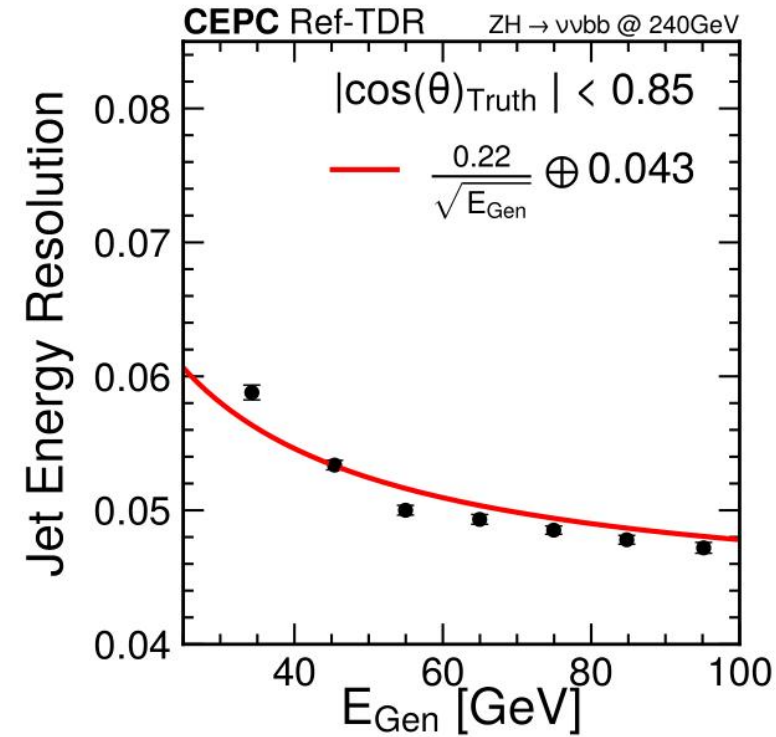
$$\Delta \cos\theta(\text{Resolution}) = \cos\theta(\text{RecoJet}) - \cos\theta(\text{GenJet})$$



Compare the bias of eekt and PFO on Energy and Costheta



Jet Resolution at different generator energy.
Similar to the plots given by TDR.



Jet Resolution for ZH \rightarrow $\nu\nu b\bar{b}$ process given by TDR.

AFB Calculation

• Two ways to calculate AFB:

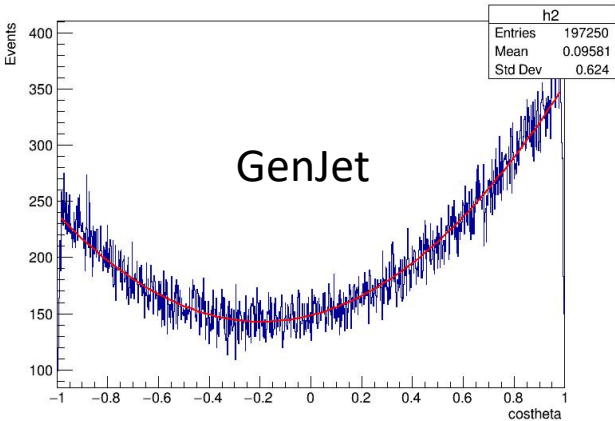
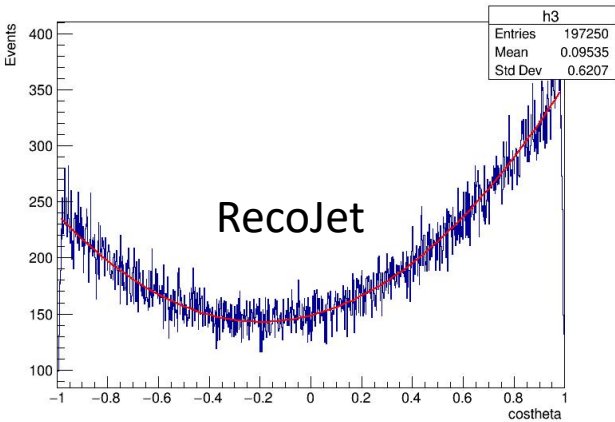
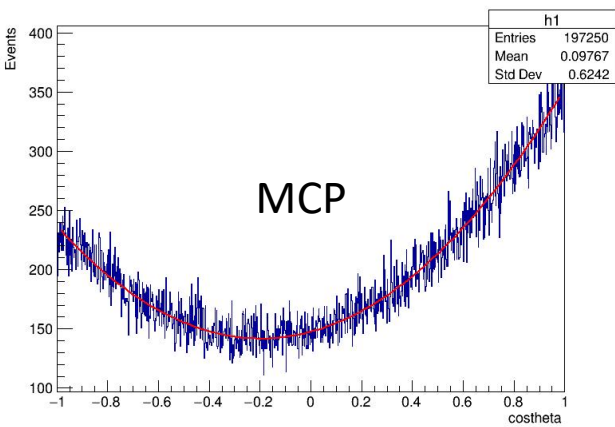
○ Counting AFB: (forward – backward)/ (forward + backward). $A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$

○ Fitting AFB: Fitting the Costheta distribution. $\frac{d\sigma}{d\cos\theta} = \sigma_{bb}^{\text{tot}} \left[\frac{3}{8}(1 + \cos^2\theta) + A_{FB}^b \cos\theta \right]$

We calculate AFB without any cut.

	MC Particle	Generator Jet	Reconstructed Jet
Counting AFB	0.14641 ± 0.00223	0.14324 ± 0.00223	0.14303 ± 0.00223
Fitted AFB	0.14691 ± 0.00210	0.14428 ± 0.00210	0.14511 ± 0.00209

- AFB of Generator Jet is smaller than MC Particle. Missing energy taken by neutrinos can't be reconstructed using eekt.
- CEPCSW reconstruction don't affect AFB in general.



Summary

- Simulate ee to bb channel and compared the AFB results from MC particles, Gen jets and Reco jets.
 - Consistency among three AFB results shows the good performance of eekt and CEPCSW on reconstruction.
 - eekt algorithm should solve missing energy problem from neutrinos.
- Next Step.
 - Include background sample and consider selections.
 - Use machine learning based jet origin identification (JOI) for jet flavor tagging.

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