中山大學
SUN YAT-SEN UNIVERSITY

Update of AFB measurement with Z--> qqbar

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Outline

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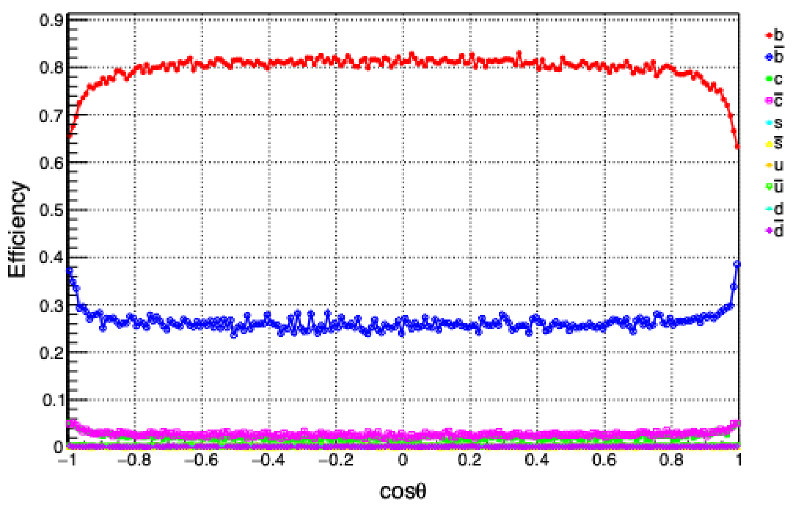
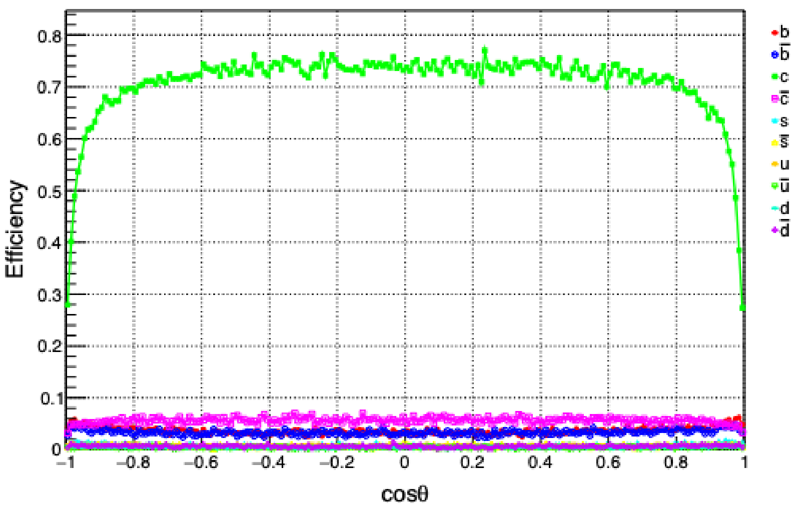
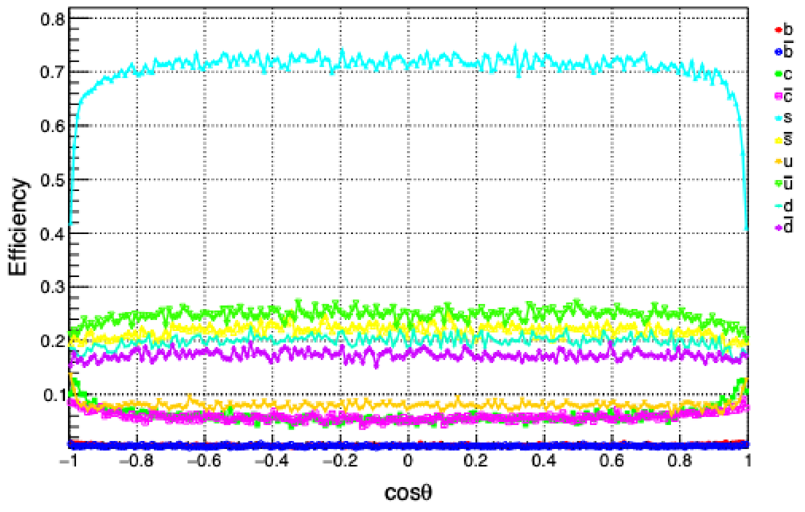
- ➢Review of Prior Report
- ➢Update
- ➢Summary

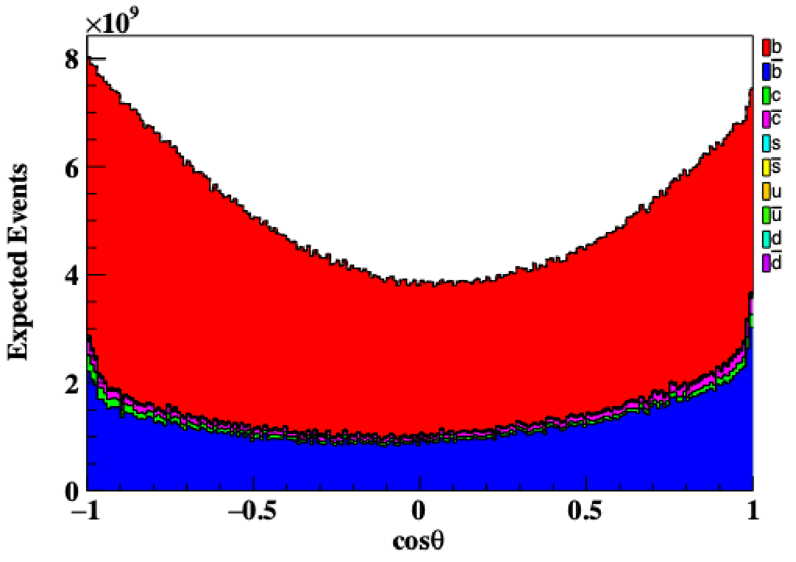
Efficiency curves

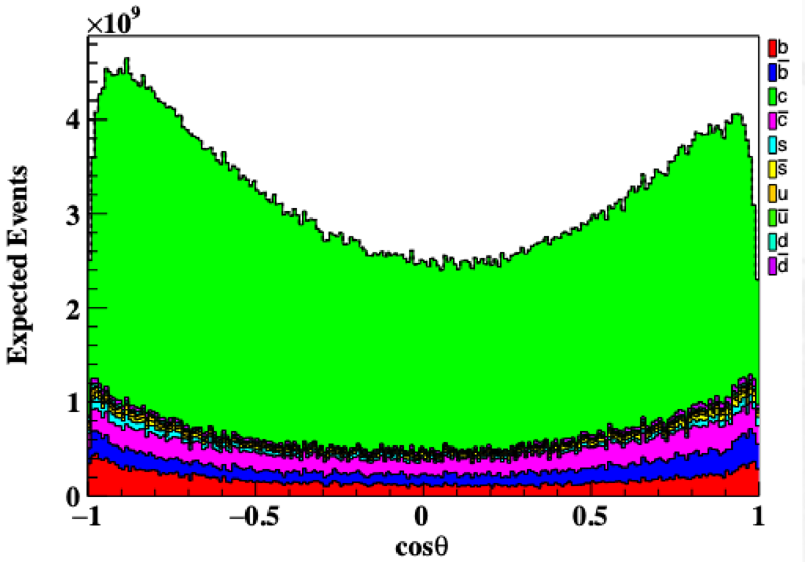
Event selection -> Jet clustering -> ParticleNet -> Working point determination -> Efficiency curves

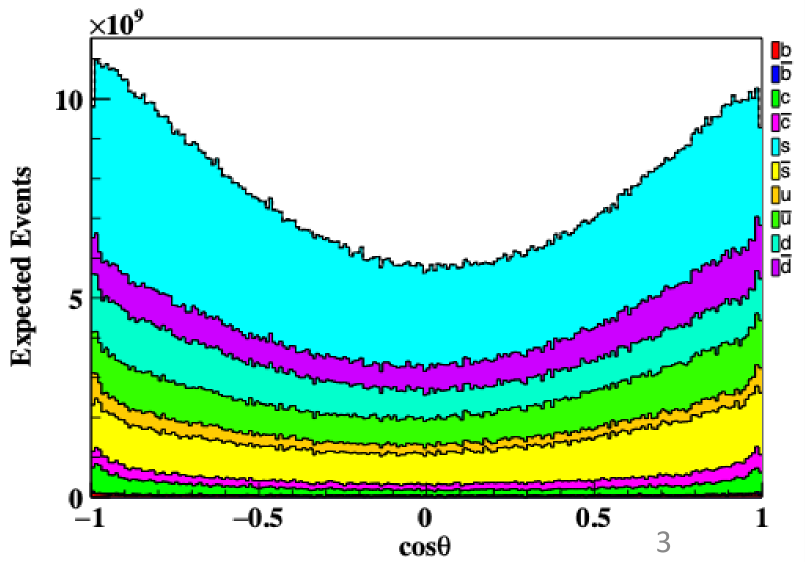












Measurement of A_{FB}

- The expected number of events for reconstructed flavor j (5 flavor) in bin i (200) is:

$$N_{i,j}^{\text{exp}} = \mathcal{L} \sum_k \sigma_{i,j} \epsilon_{i,j,k},$$

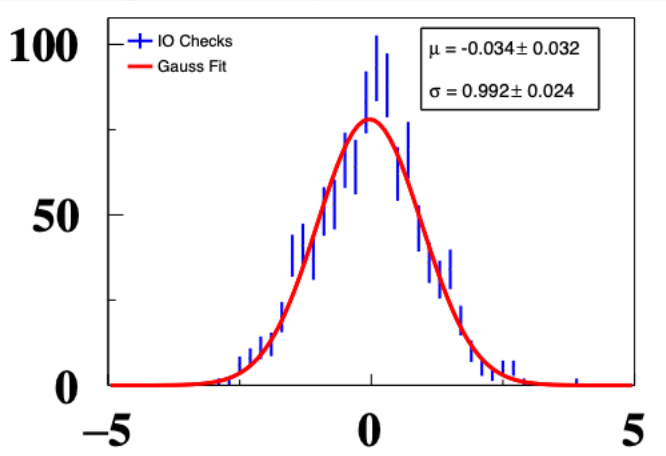
$$\sigma_{i,j} = (1 + \cos^2\theta_i + \frac{8}{3} A_{FB,j} \cos\theta_i)\Delta,$$

- $\mathrm{A_{FB}}$ could be extracted via a binned maximum likelihood fit

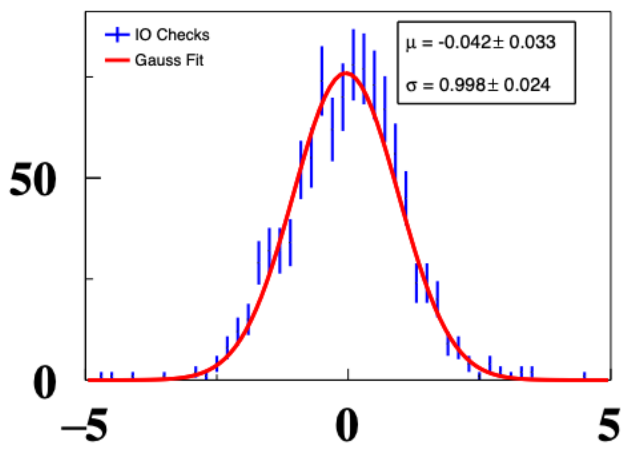
$$\mathcal{L}(A_{FB,j}, N_j^{\text{prod}}) = \prod_i \frac{\mu_{i,j}^{n_{i,j}} e^{-\mu_{i,j}}}{n_{i,j}!},$$

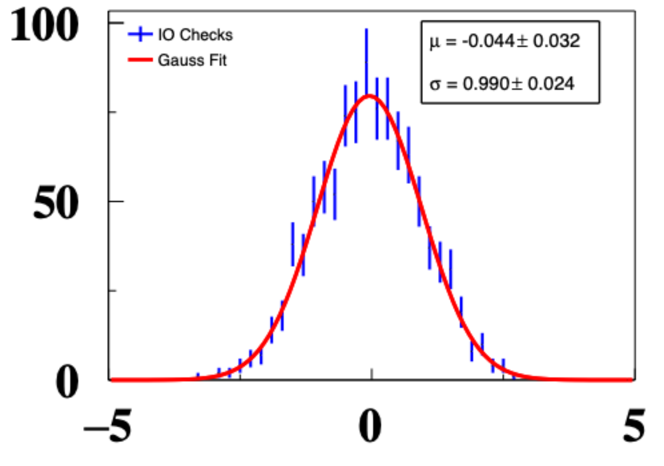
- To estimate the statistical precision, and joint flavor and charge identification
  - Generate 1000 toy Monte Carlo samples.
- The results are listed below:

	This work (10^{-3})	PDG values(10^{-3})
ΔA_{FB}^b	0.013	16
ΔA_{FB}^c	0.021	50
ΔA_{FB}^s	0.018	148



Pull = (O - I) / error





Measurement of $\sin^2\theta_W^{eff}$

- The published sensitivities of $\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$ are at the 10^{-3} level
  - The sensitivity obtained from $A_{FB}^{0,b}$ is better than that from $A_{FB}^{0,l}$, because the cross section for quark final states is larger than that for leptonic decays.

	$\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$	$\Delta\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$ (10^{-3})
LEP, $A_{FB}^{0,b}$	0.23221±0.00029	1.3
LEP, $A_{FB}^{0,l}$	0.23099±0.00053	2.3
SLC, A_{LR}	0.23098±0.00026	1.2
LEP+SLC	0.23153±0.00016	0.70

- To extract $\sin^2\theta_W^{\mathrm{eff}}$ from the simulated CEPC data, a similar binned extended maximum likelihood is performed
- 1000 toy Monte Carlo samples, pull distributions are also standard
- The results (10^{-6}) are listed
  - Improvements in both statistical precision and analysis methods

	b	c	s
$\Delta\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$	1.0	1.5	1.4

Extension to polarization scenario

- The expected bin-by-bin number of left(right)-handed events

$$N^{\text{exp}}_{L(R),i,j} = \mathcal{L}\Delta \sum_k \sigma_{L(R),i,j}\epsilon_{i,j,k},$$

- $\sin^2\theta_W^{\text{eff}}$ could be extracted via a binned maximum likelihood fit

$$\mathcal{L}(\sin^2\theta_W^{\text{eff}}, N^{\text{prod}}_{L,j}, N^{\text{prod}}_{R,j}) = \prod_i \frac{\mu_{L,i,j}^{n_{L,i,j}} e^{-\mu_{L,i,j}}}{n_{L,i,j}!} \times \frac{\mu_{R,i,j}^{n_{R,i,j}} e^{-\mu_{R,i,j}}}{n_{R,i,j}!},$$

- 1000 toy Monte Carlo samples, pull distributions are also standard
- The results (10^{-6}) are listed

	$P_e = 0.5$	$P_e = 0.6$	$P_e = 0.7$	$P_e = 0.8$
b	0.55	0.54	0.52	0.51
c	0.71	0.69	0.68	0.65
s	0.83	0.82	0.81	0.79

Discussion of systematic uncertainties

- Detector modeling
- Flavor-tagging calibration
- Beam energy and polarization
- QCD and hadronization modeling
- Background contamination
- Beamstrahlung effects

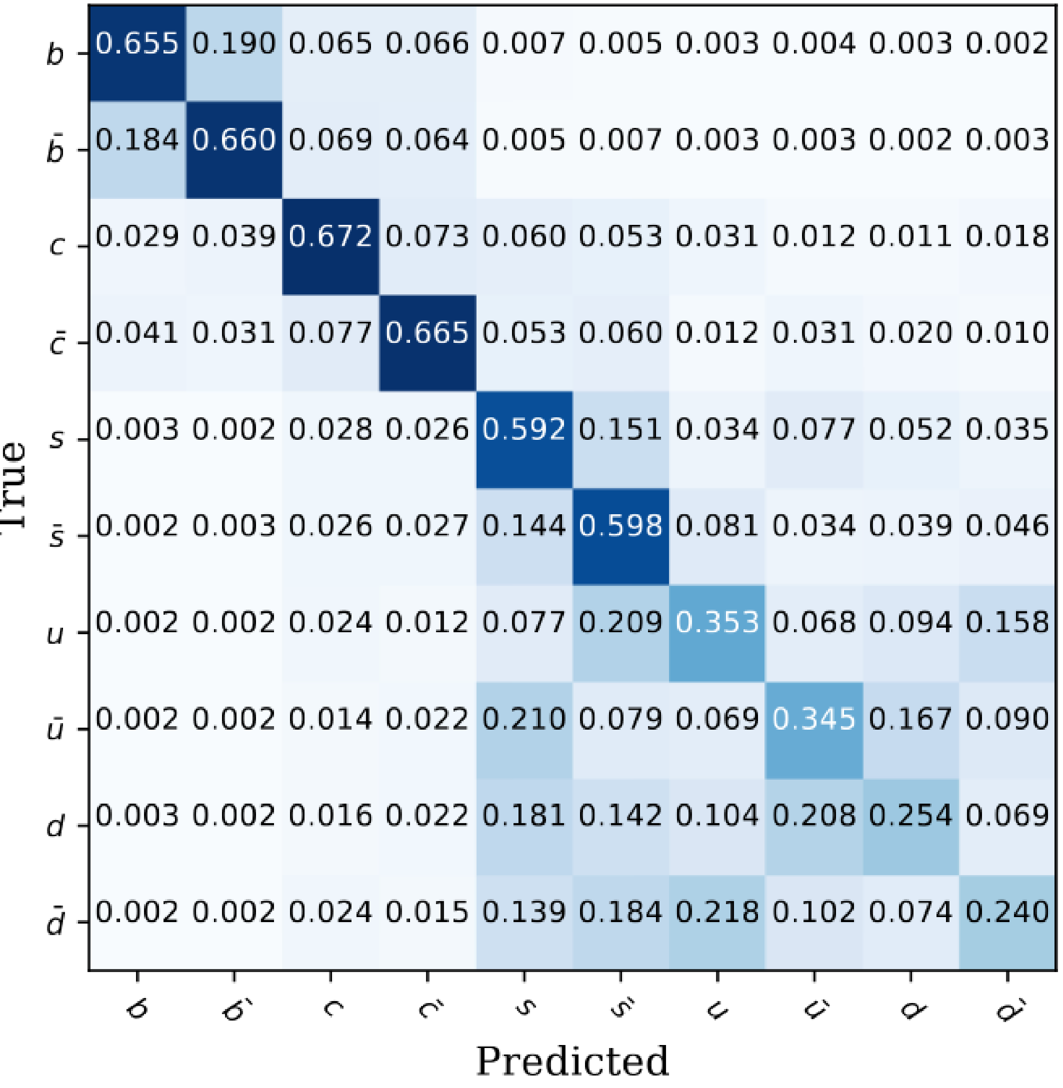
Table 8. Summary of key systematic uncertainties.

Source	A_{FB}	$\sin^2\theta_W^{\mathrm{eff}}$
Beam energy	1.7×10^{-6}	1.0×10^{-6}
Luminosity	1.8×10^{-6}	3.4×10^{-7}
Polarization	-	1.7×10^{-5}
QCD corrections	10^{-4}	10^{-4}

Outline

- Update

Joint flavor and charge identification



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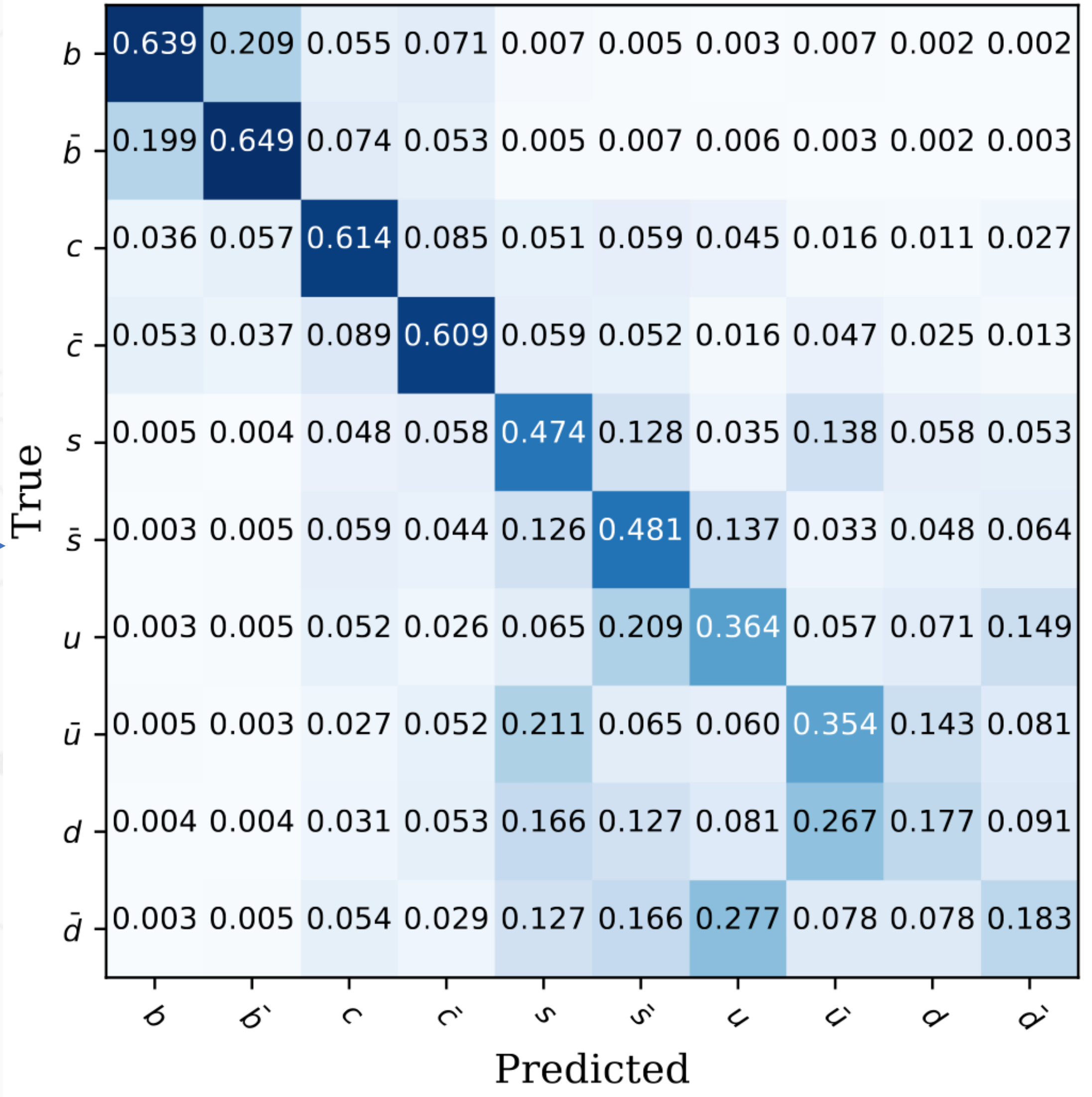
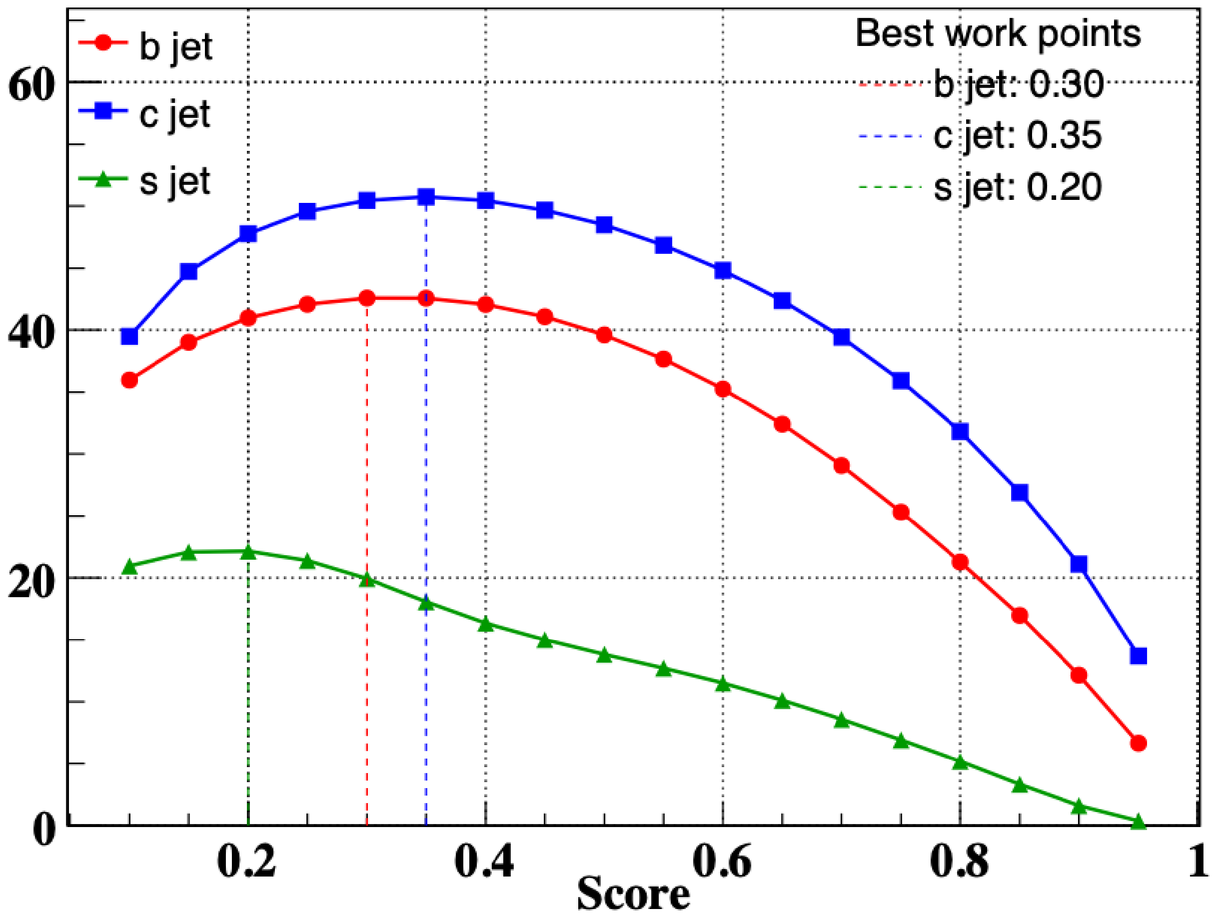
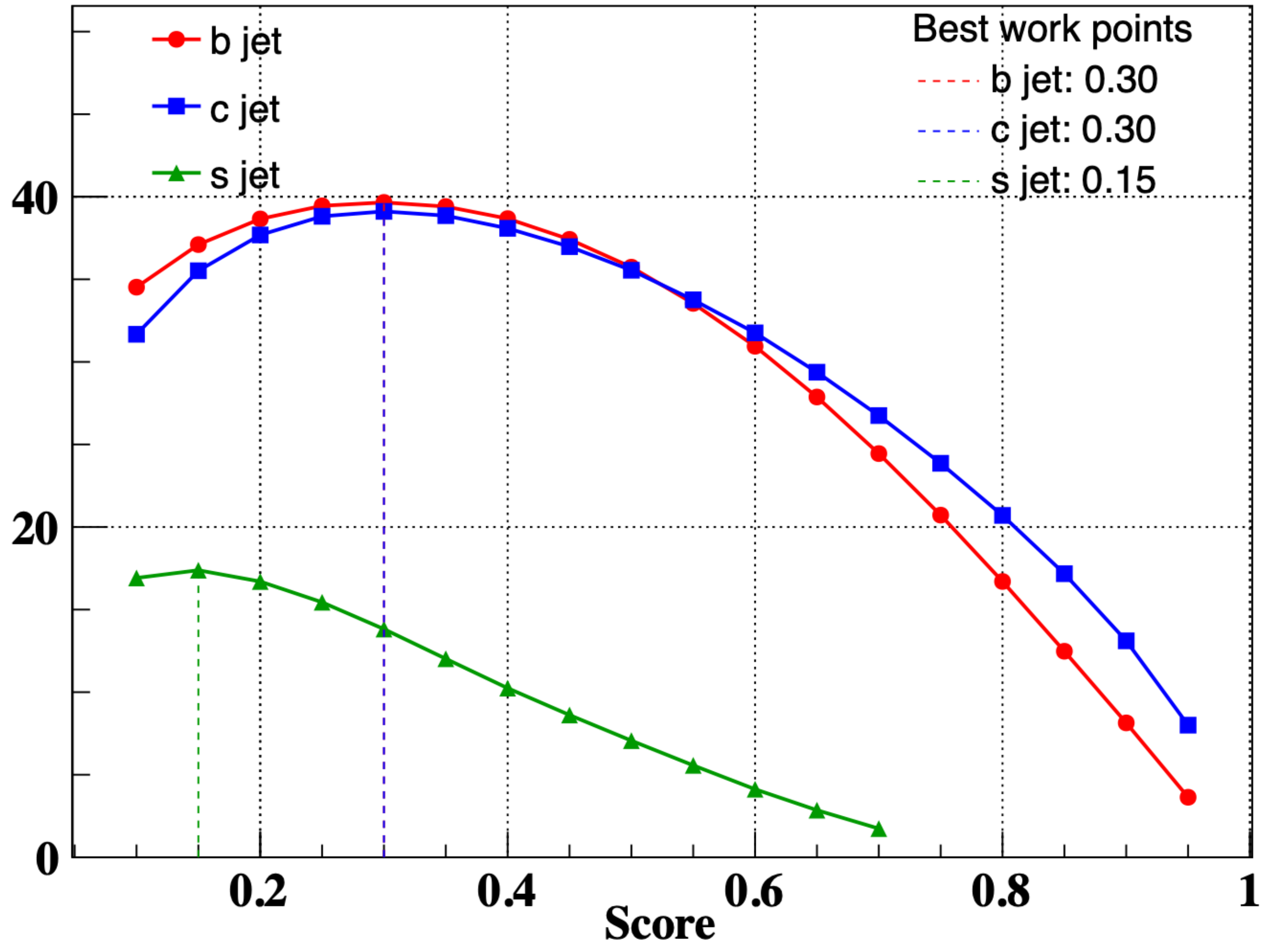


Determination of working points

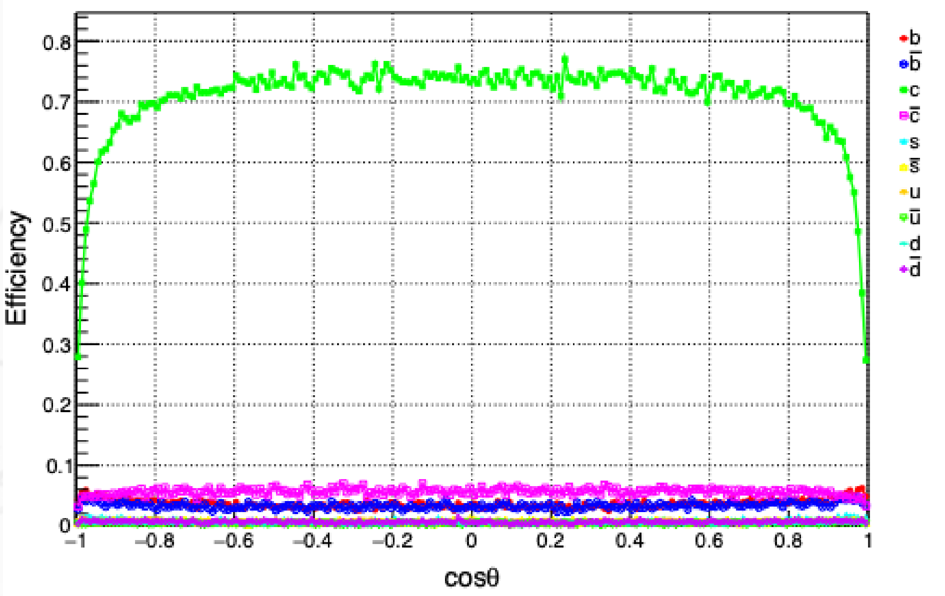
$$\mathrm{FoM} = \sum_i \sigma_i \times \epsilon_i \times \rho_i \times \left(\frac{1}{\sigma_i}\frac{\partial\sigma_i}{\partial A_{\mathrm{FB}}}\right)^2$$
$$= \sum_i \epsilon_i \times \rho_i \times \frac{1}{\sigma_i}\left(\frac{8}{3}\cos\theta_i\right)^2,$$

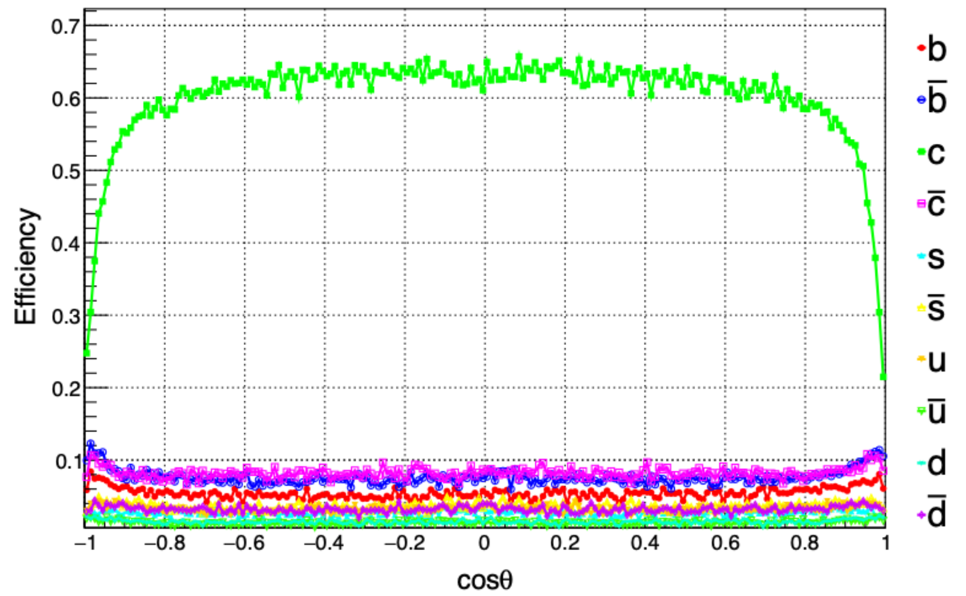
fast/full





Efficiency curves (c, s, as example)





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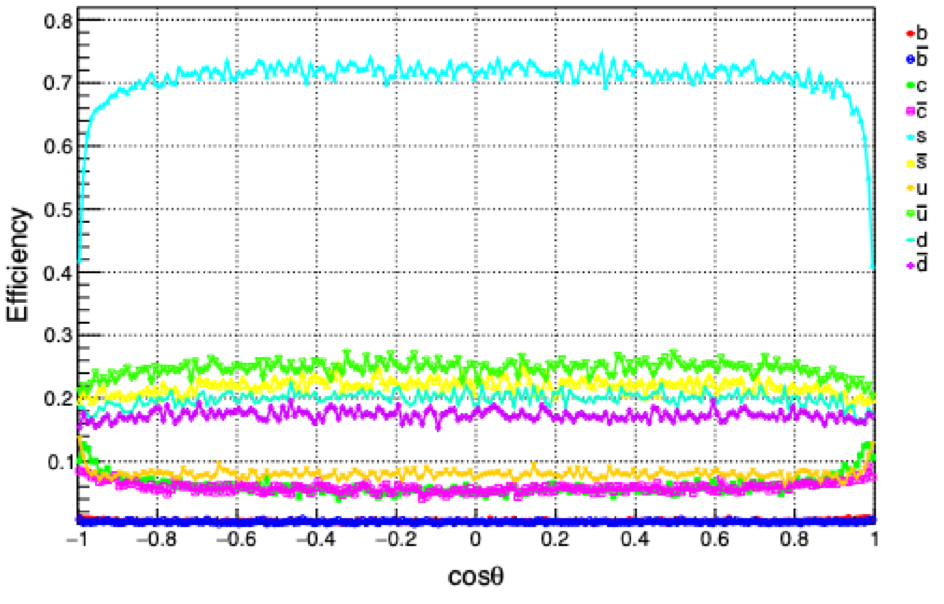

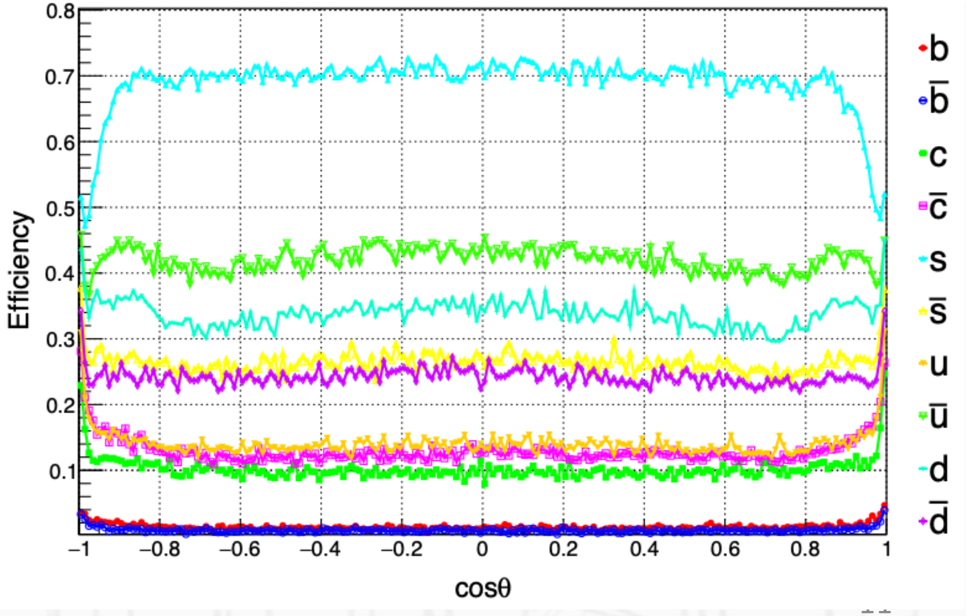

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- The results are listed below:

	This work (10^{-3})	PDG values(10^{-3})
ΔA_{FB}^b	0.013(**0.013**)	16
ΔA_{FB}^c	0.021(**0.026**)	50
ΔA_{FB}^s	0.018(**0.019**)	148

- More sensitive to the signal efficiency than to the background efficiency.

Measurement of $\sin^2\theta_W^{eff}$

- To extract $\sin^2\theta_W^{\text{eff}}$ from the simulated CEPC data, a similar binned extended maximum likelihood is performed
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	b	c	s
$\Delta\sin^2\theta_{\text{eff}}^{\text{lept}}$	1.0(**1.1**)	1.5(**1.9**)	1.4(**1.7**)

Extension to polarization scenario

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	$P_e = 0.5$	$P_e = 0.6$	$P_e = 0.7$	$P_e = 0.8$
b	0.55(**0.62**)	0.54(**0.58**)	0.52(**0.57**)	0.51(**0.55**)
c	0.71(**0.91**)	0.69(**0.89**)	0.68(**0.86**)	0.65(**0.84**)
s	0.83(**0.98**)	0.82(**0.97**)	0.81(**0.95**)	0.79(**0.93**)

Summary

- Fast simulation results are superseded by full simulation.
- The results are consistent with expected.

- The draft is ready, and we request to proceed to the next stage.