Impact on flavor physics with RICH detector

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RICH extends PID coverage into the forward and backward regions.

Forward/backward RICH coverage

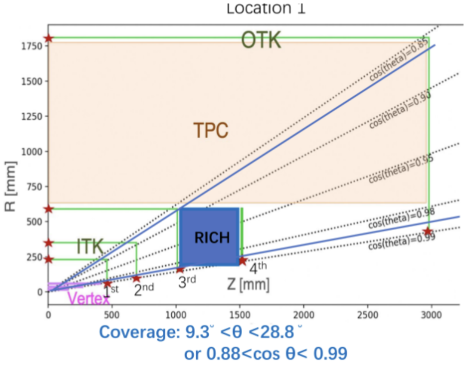
$\Downarrow$

Higher K/π PID efficiency

$\Downarrow$

Larger usable B/D samples

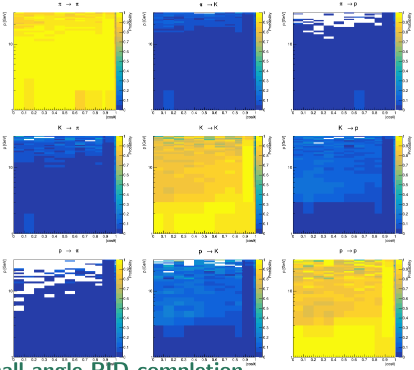
Reliable K/π identification is essential for heavy-flavor physics.



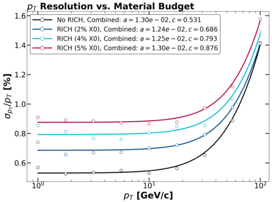
Candidate Location 1 geometry and its angular coverage.

Samples: truth-level information from fully simulated CEPC $e^+e^- \to Z \to b\bar{b}$ and $e^+e^- \to Z \to c\bar{c}$ samples at the Z pole.

Nominal 3×3 PID response map



Momentum resolution



Parameters fitted at $\theta = 15^\circ$; nominal RICH material: 2% X_0.

$$\frac{\sigma_{p_T}}{p_T} = ap_T \oplus \frac{b}{\beta\sqrt{\sin\theta}} \simeq ap_T \oplus c(\theta), r = 10^{-2}\sqrt{(ap_T)^2 + c^2(\theta)},$$

$$\delta \sim Gaussian(0, r), \qquad \vec{p}_{\mathrm{smeared}} = (1+\delta)\vec{p}_{\mathrm{truth}}.$$

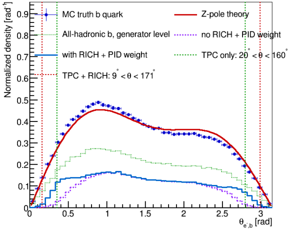
Small-angle PID completion

$$P_{\mathrm{RICH}}(h \to h) = 97\%, \qquad h \in \{\pi, K, p\}.$$

For tracks crossing RICH in $3 < p < 20$ GeV, the missing small-angle PID response is completed with the assumed RICH performance.

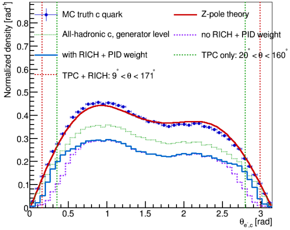
RICH increases inclusive b- and c-quark yields

b quark: $+19.7\%$ yield



$b \to B^{0,\pm}, B_s^0, B_c^{\pm}, \Lambda_b^0, \Xi_b^{0,\pm}, \Omega_b^{\pm}$
$\to p/\bar{p}, K^{\pm}, \pi^{\pm}$

c quark: $+10.7\%$ yield



$c \to D^{0,\pm}, D_s^{\pm}, \Lambda_c^{\pm}, \Xi_c^{0,\pm}, \Omega_c^0$
$\to p/\bar{p}, K^{\pm}, \pi^{\pm}$

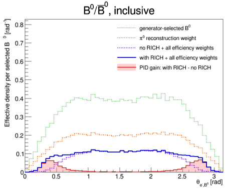
	b quark			c quark		
Selection layer	no RICH	with RICH	gain	no RICH	with RICH	gain
Generator-level all-hadronic fraction	56.47%		–	77.95%		–
All daughter tracks accepted	41.08%	45.97%	11.92%	71.43%	74.46%	4.25%
All-track PID-weighted efficiency	28.04%	**33.57%**	**19.72%**	57.67%	**63.84%**	**10.71%**

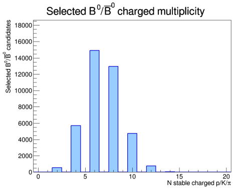
RICH gain in B^0 and D^0 decays with π^0

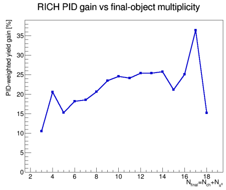
Truth-level treatment: stable charged daughters are restricted to $p/K/\pi^{\pm}$, while reconstructible π^0 candidates are included with a fixed $\epsilon_{\pi^0} = 0.8$;

$$N_{\text{total}} = N_{\text{ch}} + N_{\pi^0}.$$

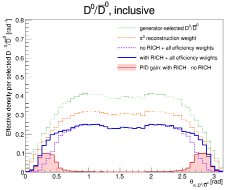
$B^0/\bar{B}^0$

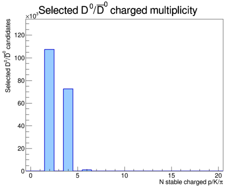


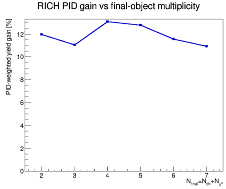




$D^0/\bar{D}^0$







Conclusion within this model: the inclusive RICH yield gain is 22.3% for $B^0/\bar{B}^0$ and 12.3% for $D^0/\bar{D}^0$.

Summary: RICH boosts B^0 and D^0 yields

For the neutral samples shown above, stable charged daughters are restricted to $p/K/\pi^{\pm}$; reconstructible π^0 candidates are included with $\epsilon_{\pi^0} = 0.8$.

Decay sample	N_{selected}	$Y_{\text{no RICH}}$	$Y_{\text{with RICH}}$	Yield gain
$B^0/\bar{B}^0$	39 668	8 784.9	10 741.3	**22.3%**
$D^0/\bar{D}^0$	180 787	97 597.0	109 641.7	**12.3%**

- Modes containing π^0 account for about 97% of the selected $B^0/\bar{B}^0$ sample and 74% of the $D^0/\bar{D}^0$ sample.
- The RICH raises the inclusive yield by **22.3%** for $B^0/\bar{B}^0$ and **12.3%** for $D^0/\bar{D}^0$.
- The RICH provides a robust yield gain across multiplicities, with a larger enhancement for $B^0/\bar{B}^0$ than for $D^0/\bar{D}^0$.

Next step: $B^{\pm} \to DK^{\pm}$ sensitivity to γ

Physics target

$$B^{\pm} \to DK^{\pm}, \qquad D \to K_s\pi\pi$$

Interference between the D^0 and $\bar{D}^0$ decay paths to a common final state provides sensitivity to the CKM angle γ.

Where RICH can help

- Improve K/π separation for the bachelor track and D daughters.
- Suppress $B^{\pm} \to D\pi^{\pm}$ cross-feed into the DK sample.

Key question

Does the RICH deliver a measurable improvement in the precision on γ?

Current status: Initial MC samples for the $B^{\pm} \to DK^{\pm}$ study have been generated; reconstruction and sensitivity evaluation are the next step.