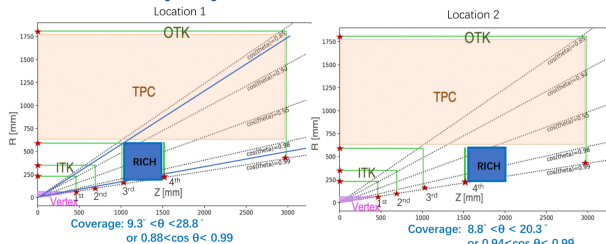


Flavor-physics impact of RICH at AGORA

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RICH biweekly meeting
11 September 2026

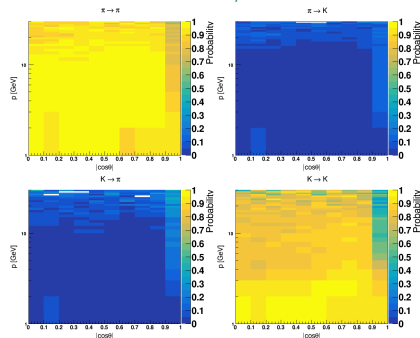
Two proposed RICH locations



Two RICH locations are proposed to extend PID at small angles.

More PID coverage may improve flavor-physics sensitivity.

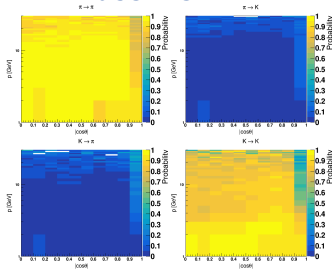
Baseline π/K PID



Baseline PID becomes inefficient near $|\cos \theta| \rightarrow 1$.

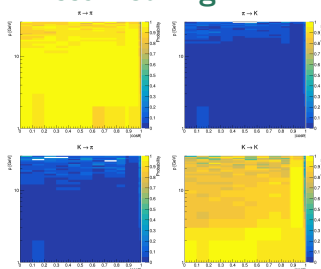
Assumed RICH extension of π/K PID

Baseline PID



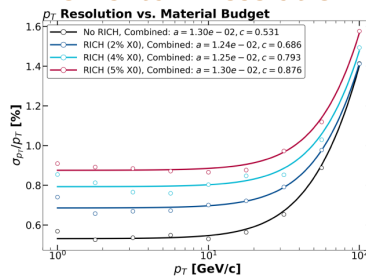
CEPCSW π/K PID

Assumed high PID



97% correct π/K ID in the RICH

Momentum resolution



Analysis assumption: 2% X_0 RICH material

Baseline PID is retained outside the RICH acceptance.

Samples

CEPCSW full simulation at the Z pole

$$e^+e^- \rightarrow Z \rightarrow b\bar{b},$$

$$e^+e^- \rightarrow Z \rightarrow c\bar{c}.$$

$eecc$: 1,597,828 events

$eebb$: 1,596,648 events

Truth information

Particle species, decay chains and kinematics

Physics studies

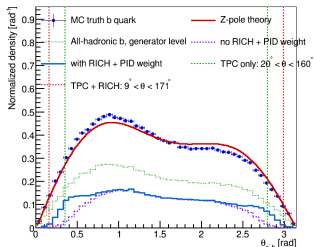
- ▶ Inclusive heavy-flavor yields
- ▶ Charm ΔA_{CP} precision
- ▶ Truth-level CKM γ sensitivity

Baseline PID and assumed RICH PID

Possible gains from additional small-angle PID

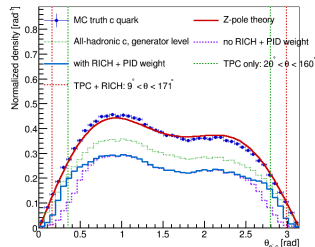
RICH increases inclusive heavy-flavor yields

b sample: +19.72%



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

c sample: +10.71%

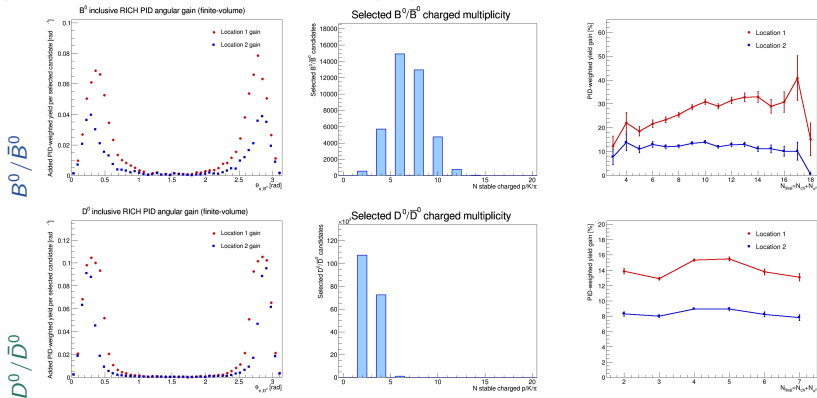


$$c \rightarrow D^{0,\pm}, D_s^\pm, \Lambda_c^\pm, \Xi_c^{0,\pm}, \Omega_c^0 \\ \rightarrow p/\bar{p}, K^\pm, \pi^\pm$$

Selection layer	<i>b</i> sample			<i>c</i> sample		
	baseline	RICH	gain	baseline	RICH	gain
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%

Location 1 captures the larger neutral-hadron gain

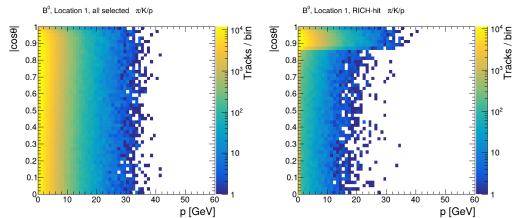
B/D mesons which decay into $p/K/\pi$ and π^0 candidates use $\epsilon_{\pi^0} = 0.8$.



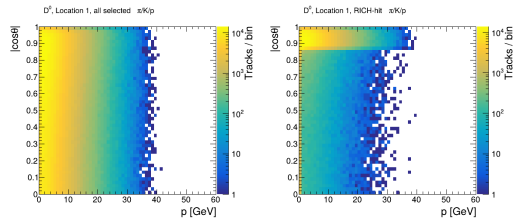
Study	$B^0/\bar{B}^0$ gain	$D^0/\bar{D}^0$ gain
Location 1	27.5%	14.5%
Location 2	12.7%	8.6%

RICH-hit tracks occupy the forward low-momentum region

$B^0/\bar{B}^0$, Location 1

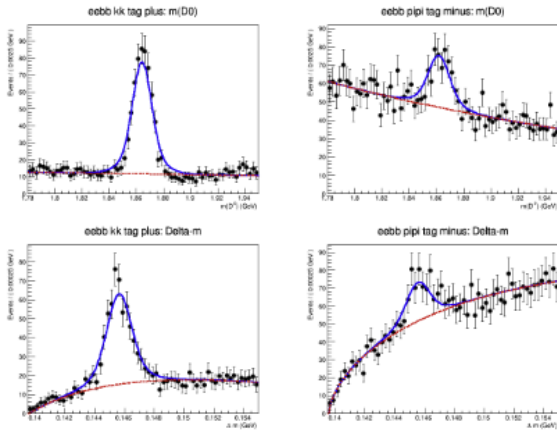


$D^0/\bar{D}^0$, Location 1



Scenario	B^0 RICH-hit fraction	D^0 RICH-hit fraction	RICH hits below 20 GeV, B^0/D^0
Location 1	16.6%	17.0%	99.67% / 98.15%
Location 2	8.6%	8.5%	99.71% / 98.16%

ΔA_{CP} benchmark



Representative $e^+e^- \rightarrow b\bar{b}$, $D^0 \rightarrow K^+K^-$, $D^0 \rightarrow \pi^+\pi^-$,
baseline PID fit.

$$D^{*\pm} \rightarrow D^0 \pi_s^\pm, \pi \text{ tag } D \text{ flavor}$$

$$D^0 \rightarrow K^+K^-, \pi^+\pi^-.$$

$$\Delta A_{CP} = A_{\text{raw}}(KK) - A_{\text{raw}}(\pi\pi).$$

The simultaneous fit uses $m(D^0)$,
 $\Delta m = m(D^*) - m(D^0)$, and

$$\mu = N_S S + N_P P + N_C C + N_X X,$$

with signal, real- D^0 plus random- π_s ,
combinatorial and cross-feed
components.

Why RICH gives little gain for ΔA_{CP}

$D^0 \rightarrow h^+ h^-$: two charged daughter tracks

Only a small fraction enters the Location 1 RICH:

	KK	$\pi\pi$
$eecc$	3.1%	2.8%
$eebb$	2.7%	3.9%

Few tracks receive additional PID information, so the precision gain is limited.

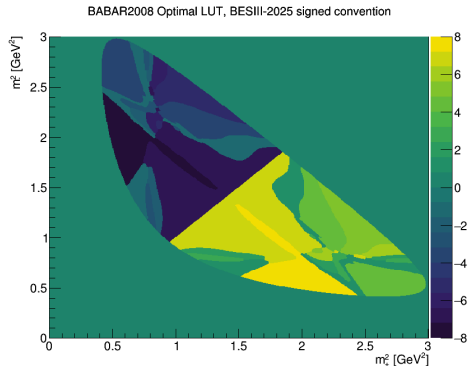
Extrapolation to $10^{12} Z$

$$\sigma_{10^{12}Z}^{(q)} = \sigma_{MC}^{(q)} \sqrt{\frac{N_{MC}^{(q)}}{10^{12} \mathcal{B}(Z \rightarrow q\bar{q})}}.$$

Sample	baseline	RICH	improvement
$eecc$	2.18×10^{-4}	2.18×10^{-4}	0.28%
$eebb$	2.69×10^{-4}	2.68×10^{-4}	0.53%
Combined	1.70×10^{-4}	1.69×10^{-4}	0.38%

Combined precision gain: $\sim 0.4\%$

CKM γ benchmark and likelihood fit



Sixteen signed Optimal bins with the BESIII-2025 convention.

$$B^\pm \rightarrow DK^\pm, \quad D \rightarrow K_S^0 \pi^+ \pi^-.$$

$$S_i^\pm = h_B [F_{\pm i} + r_B^2 F_{\mp i} + 2r_B \sqrt{F_i F_{-i}} Q_i^\pm],$$

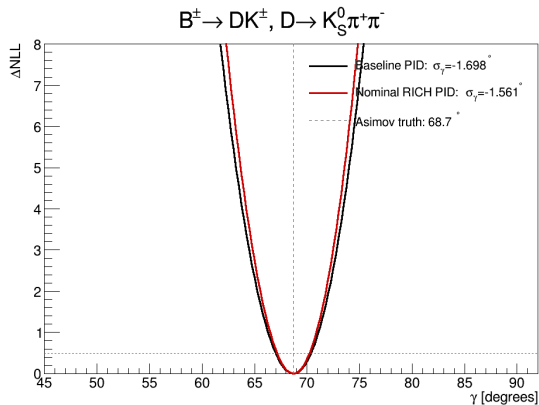
$$\mu_i^\pm = S_i^\pm + B_i^{D\pi, \pm}.$$

Likelihood fit

$$-2 \ln \mathcal{L} = 2 \sum_{i, \pm} \left[\mu_i^\pm - n_i^\pm + n_i^\pm \ln \frac{n_i^\pm}{\mu_i^\pm} \right] + \Delta \mathbf{z}^T V_{C, s}^{-1} \Delta \mathbf{z}.$$

1. Apply PID weights to signal and $D\pi$ cross-feed.
2. Build B^+ and B^- yields in the signed bins.
3. Constrain $F_i, (c_i, s_i)$ with the BESIII covariance.
4. Profile γ over r_B, δ_B and normalizations.

Five-track PID gives an 8.07% γ gain



Normalization: yields are projected to $N_Z = 1.0 \times 10^{12}$ before the likelihood fit.

Five charged tracks

$$K_{\text{bach}}^\pm + 4\pi$$

More tracks give more chances to enter the RICH acceptance.

DK Signal +9.0%

$$278,823 \rightarrow 304,014$$

$D\pi$ cross-feed -15.0%

$$228,761 \rightarrow 194,369$$

$$\sigma_\gamma : 1.698^\circ \rightarrow 1.561^\circ$$

8.07% better precision

Summary

Inclusive flavor gain

- ▶ Additional forward/backward PID increases usable heavy-flavor yields.

b : +**19.7%**

c : +**10.7%**

for all hadronic final state.

Location comparison

	$B^0/\bar{B}^0$	$D^0/\bar{D}^0$
Loc. 1	+ 27.5%	+ 14.5%
Loc. 2	+12.7%	+8.6%

Location 1 has a larger overlap with the forward heavy-flavor track population and gives a larger PID gain.

Physics benchmarks

- ▶ $D^0 \rightarrow KK, \pi\pi$ ΔA_{CP} :

$\sim$ **0.4%**

improvement in statistical precision.

- ▶ CKM γ
 $B \rightarrow D(k_S \pi \pi) K$:

$1.698^\circ \rightarrow 1.561^\circ$

+**8.07%**

improvement in σ_γ .

Precision gain depends on final-state topology and selection.