Hadronic decays of charmed mesons at BESIII

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On behalf of the BESIII Collaboration

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@Marseille, France

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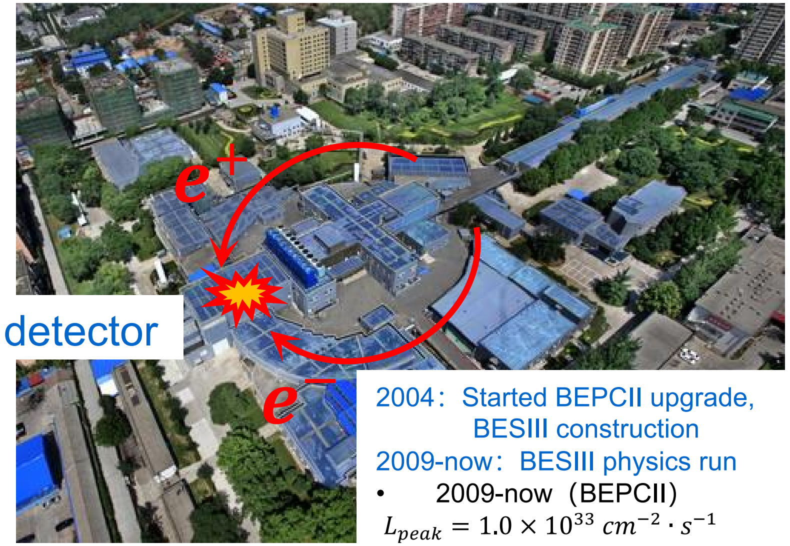
BESIII charm dataset

Beijing Electron Positron Collider II(BEPCII)

Beijing Spectrometer(BESIII)

BESIII detector

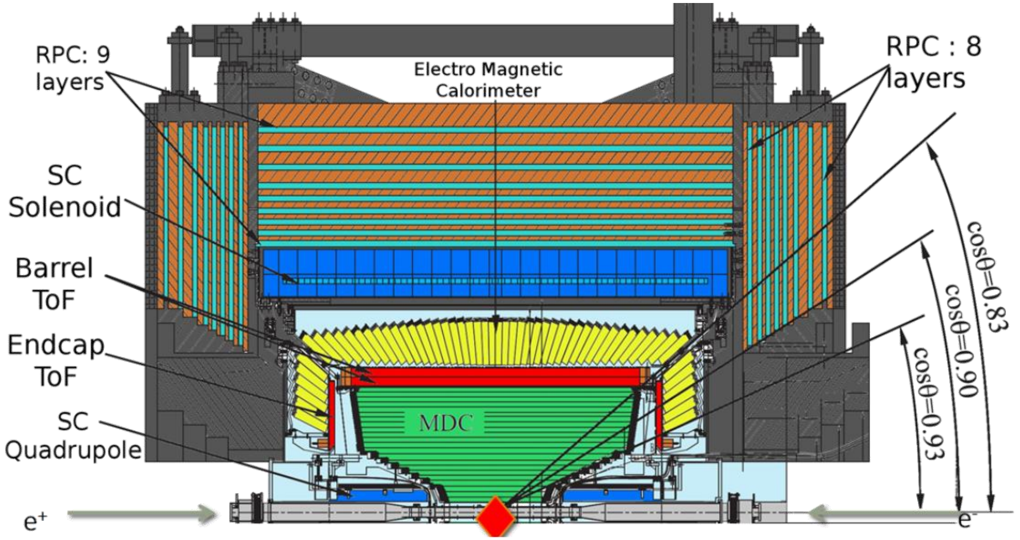


2004: Started BEPCII upgrade, BESIII construction

2009-now: BESIII physics run

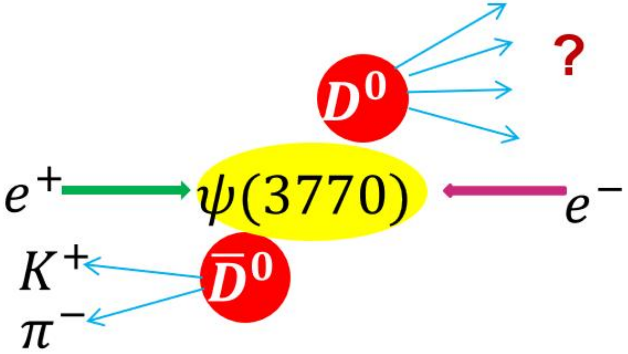
- 2009-now (BEPCII)

$L_{peak} = 1.0 \times 10^{33}\ cm^{-2} \cdot s^{-1}$



$D^{\pm,0}$: 20.3 fb^{-1} @E_{cm}=3.773 GeV: $e^+e^- \to \psi(3770) \to D\bar{D}$

$D_s^{\pm}$: 7.33 fb^{-1} @E_{cm}=4.128 − 4.226GeV: $e^+e^- \to D_sD_s^* \to XD_sD_s$



Production of charm hadron pair

↓

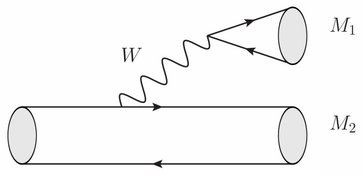
Tag one side
to study another side

Clean samples → Hadronic decays

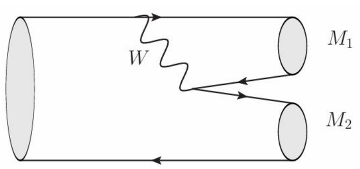
Absolute branching fraction
Amplitude analysis
etc.

Why hadronic decays of charmed mesons?

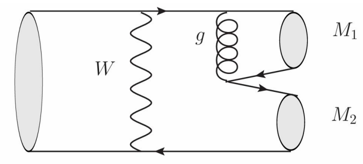
- Topological Diagram Approach



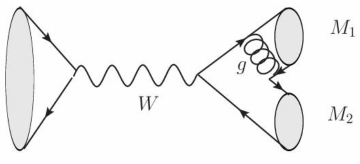
Color-allowed tree (T)



Color-suppressed tree (C)



W-exchange E



W-annihilation A

Mode	Amplitude
$D^0 \to K^+\pi^-$	$\lambda_{ds}(1.23T + E)$
$D^0 \to K^0\pi^0$	$\frac{1}{\sqrt{2}}\lambda_{ds}(C - E)$
$D^0 \to K^0\eta$	$\lambda_{ds}\left[\frac{1}{\sqrt{2}}(C+E)\cos\phi - E\sin\phi\right]$
$D^0 \to K^0\eta'$	$\lambda_{ds}\left[\frac{1}{\sqrt{2}}(C+E)\sin\phi + E\cos\phi\right]$
$D^+ \to K^0\pi^+$	$\lambda_{ds}(C + 0.71A)$
$D^+ \to K^+\pi^0$	$\frac{1}{\sqrt{2}}\lambda_{ds}(1.23T - 0.71A)$
$D^+ \to K^+\eta$	$\lambda_{ds}\left[\frac{1}{\sqrt{2}}(1.05T + A)\cos\phi - 0.81A\sin\phi\right]$
$D^+ \to K^+\eta'$	$\lambda_{ds}\left[\frac{1}{\sqrt{2}}(1.05T + A)\sin\phi + 0.81A\cos\phi\right]$
$D_s^+ \to K^0K^+$	$\lambda_{ds}(1.27T + 1.03C)$

- $D \to PP$ $\Longrightarrow$ high efficiency, low background, (usually) high precision, no interference. Good for A_{cp}, η - η' mixing etc..
- $D \to SP, D \to SV$, $(D \to SS)$ $\Longrightarrow$ Understand the nature of light scalar mesons, $a_0(980)$, $f_0(980)$, $K(700)$, $f_0(500)$ etc..
- $D \to VP$ $\Longrightarrow$ Clarifying the non-perturbative mechanism. Well defined quark content of V. Better than the PP and VV, due to the multiple-amplitude composition of PP and the polarization in VV.
- $D \to VV$ $\Longrightarrow$ Polarization in charmed decays.
- $D \to AP$ $\Longrightarrow$ Study axial-vector mesons, $a_1(1260)$, $K_1(1400)$etc..

P: pseudo-scalar
V: vector
S: scalar
A: axial-vector

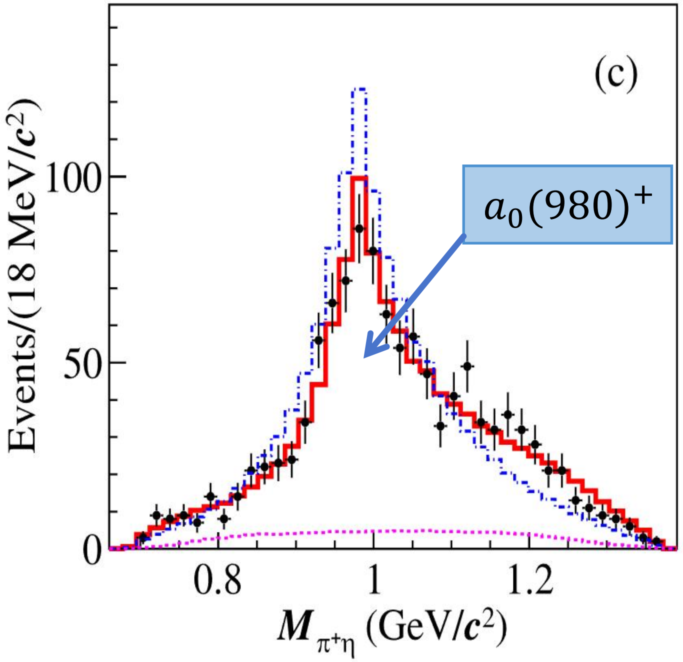
Amplitude analysis of $D^+ \to K_S^0 \pi^+ \eta$

Among $D \to a_0(980)^+ P$, $D^+ \to a_0(980)^+ K_S^0$ is the only decay free of weak-annihilation contributions.

2.93fb^{-1}@E_{cm}=3.773 GeV
1113 candidates with 98.2% purity

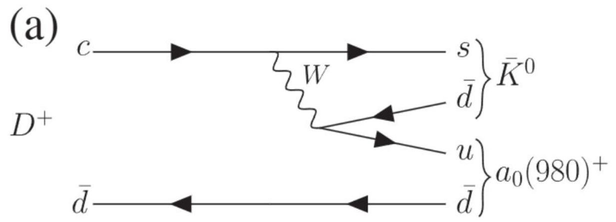
PRL 132, 131903 (2024)

Decay	Amplitude
$D^+ \to f_0 \pi^+$	$\frac{1}{\sqrt{2}} \alpha V_{cd}^* V_{ud}(T + C' + A + A') + \beta V_{cs}^* V_{us} C'$
$\to f_0 K^+$	$V_{cd}^* V_{us}[\frac{1}{\sqrt{2}} \alpha (T + A') + \beta A]$
$\to a_0^+ \bar{K}^0$	$V_{cs}^* V_{ud}(T' + C)$
$\to a_0^0 \pi^+$	$\frac{1}{\sqrt{2}} V_{cd}^* V_{ud}(-T - C' - A + A')$
$\to \sigma \pi^+$	$\frac{1}{\sqrt{2}} \beta V_{cd}^* V_{ud}(T + C' + A + A') - \alpha V_{cs}^* V_{us} C'$
$\to \bar{\kappa}^0 \pi^+$	$V_{cs}^* V_{ud}(T + C')$
$\to \bar{\kappa}^0 K^+$	$V_{cs}^* V_{us} T + V_{cd}^* V_{ud} A$
$D^0 \to f_0 \pi^0$	$\frac{1}{2} \alpha V_{cd}^* V_{ud}(-C + C' - E - E') + \frac{1}{\sqrt{2}} \beta V_{cs}^* V_{us} C'$
$\to f_0 \bar{K}^0$	$V_{cs}^* V_{ud}[\frac{1}{\sqrt{2}} \alpha (C + E) + \beta E']$
$\to a_0^+ \pi^-$	$V_{cd}^* V_{ud}(T' + E)$
$\to a_0^- \pi^+$	$V_{cd}^* V_{ud}(T + E')$
$\to a_0^+ K^-$	$V_{cs}^* V_{ud}(T' + E)$
$\to a_0^0 \bar{K}^0$	$V_{cs}^* V_{ud}(C - E)/\sqrt{2}$
$\to a_0^- K^+$	$V_{cd}^* V_{us}(T + E')$
$\to \sigma \pi^0$	$\frac{1}{2} V_{cd}^* V_{ud} \beta (-C + C' - E - E') - \frac{1}{\sqrt{2}} \alpha V_{cs}^* V_{us} C'$

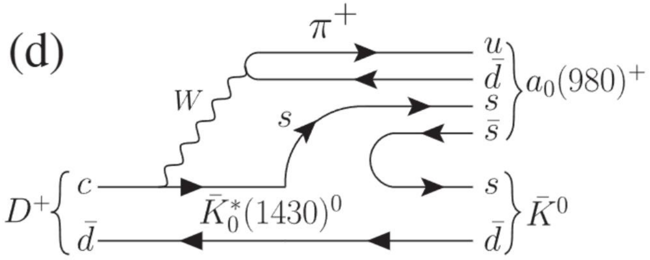


Hypothesis:

two-quark state-internal W-emission



tetraquark state-rescattering
$\bar{K}_0^*(1430)^0 \pi^+ \to K_S^0 a_0(980)^+$
external W-emission



✓ **Observation of W-annihilation-free decay $D^+ \to K_S^0 a_0(980)^+$**

- $\mathcal{B}(D^+ \to K_S^0 a_0(980)^+, a_0(980)^+ \to \pi^+ \eta) = (1.33 \pm 0.05_{stat} \pm 0.04_{syst})\%$
- **Provide sensitive constraints in the extraction of contributions from external and internal W-emission diagrams of $D \to SP$**
- Understand the inconsistency between theory and experiment of the $D \to a_0(980)^+ P$[1-3].

[1]Phys. Rev. D 105, 033006 (2022). [2]Phys. Rev. D 67, 034024 (2003). [3] Phys. Rev. D 81, 074031 (2010)

Amplitude analysis of $D^0 \to \pi^+\pi^-\eta$, $D^+ \to \pi^+\pi^0\eta$

7.9fb^{-1}@E_{cm}=3.773 GeV

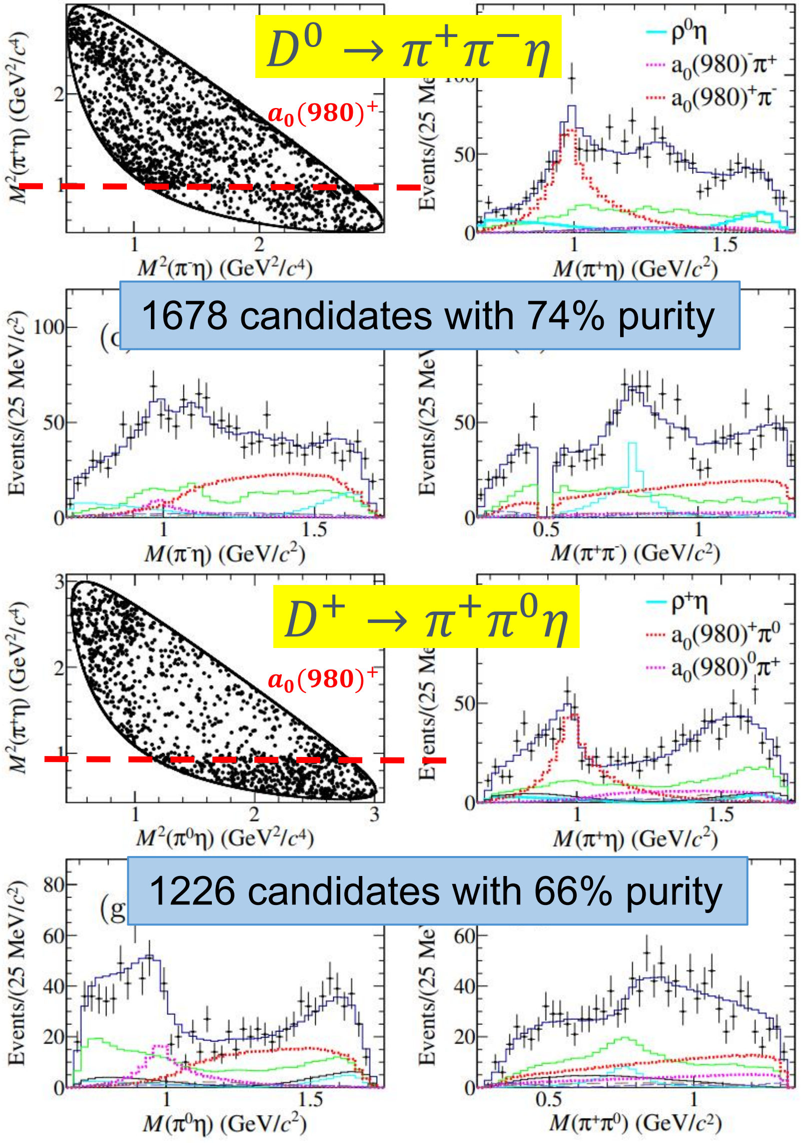
PRD 110, L111102

✓ **Observation of $D \to a_0(980)\pi$**

$\mathcal{B}(D^0 \to \pi^+\pi^-\eta) = (1.24 \pm 0.04 \pm 0.03)\%$

$\mathcal{B}(D^+ \to \pi^+\pi^0\eta) = (2.18 \pm 0.12 \pm 0.03)\%$

Amplitude	Phase (in unit rad)	BF ($\times 10^{-3}$)
$D^0 \to \rho^0\eta$	0 (fixed)	$0.19 \pm 0.02 \pm 0.01$
$D^0 \to a_0(980)^-\pi^+$	$0.06 \pm 0.16 \pm 0.12$	$0.07 \pm 0.02 \pm 0.01$
$D^0 \to a_0(980)^+\pi^-$	$-1.06 \pm 0.12 \pm 0.10$	$0.55 \pm 0.05 \pm 0.07$
$D^0 \to a_2(1320)^+\pi^-$	$-1.16 \pm 0.25 \pm 0.23$	$0.03 \pm 0.01 \pm 0.01$
$D^0 \to a_2(1700)^+\pi^-$	$0.08 \pm 0.17 \pm 0.23$	$0.07 \pm 0.02 \pm 0.03$
$D^0 \to (\pi^+\pi^-)_{S-\text{wave}}\eta$	$-0.92 \pm 0.29 \pm 0.14$	$0.05 \pm 0.02 \pm 0.03$
$D^+ \to \rho^+\eta$	$-4.03 \pm 0.19 \pm 0.13$	$0.20 \pm 0.07 \pm 0.05$
$D^+ \to (\pi^+\pi^0)_V\eta$	$-0.64 \pm 0.22 \pm 0.19$	$0.34 \pm 0.11 \pm 0.11$
$D^+ \to a_0(980)^+\pi^0$	0 (fixed)	$0.95 \pm 0.12 \pm 0.05$
$D^+ \to a_0(980)^0\pi^+$	$2.44 \pm 0.20 \pm 0.10$	$0.37 \pm 0.10 \pm 0.04$
$D^+ \to a_2(1700)^+\pi^0$	$0.92 \pm 0.20 \pm 0.14$	$0.09 \pm 0.05 \pm 0.02$
$D^+ \to a_0(1450)^+\pi^0$	$0.63 \pm 0.41 \pm 0.30$	$0.15 \pm 0.06 \pm 0.02$



BF ratios:

$$\mathcal{B}(D^0 \to a_0(980)^+\pi^-)/\mathcal{B}(D^0 \to a_0(980)^-\pi^+) = 7.5\,^{+2.5}_{-0.8}{}_{\text{stat}} \pm 1.7_{\text{syst}}$$

$$\mathcal{B}(D^+ \to a_0(980)^+\pi^0)/\mathcal{B}(D^+ \to a_0(980)^0\pi^+) = 2.6 \pm 0.6_{stat} \pm 0.3_{\text{syst}}$$

$\Longrightarrow$ Disagrees with theoretical predictions by orders of magnitude

In the diquark scenario, the external W-emission dominates the $D \to a_0(980)\pi$ decays contrary to expectations of its negligible contribution due to the very small $a_0(980)$ decay constant[1]. New mechanism needed?

[1] Phys. Rev. D 105, 033006(2022).

Amplitude analysis of $D^+ \to \pi^+\eta\eta$

20.3fb^{-1}@E_{cm}=3.773 GeV 1624 candidates with 85% purity

arXiv: 2505.12086

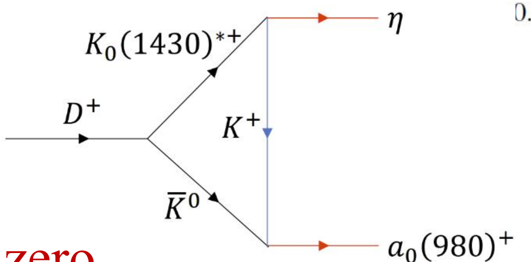
✓ **First observation of an altered $a_0(980)$ line-shape**

(due to triangle loop rescattering)

Fit1: $P_{a_0(980)}$ three-channel coupled Flatte formula,

the fitted pole position is inconsistent with previous measurement.

To consider the rescattering process $D^+ \to \bar{K}_0^*(1430)^0 K^+ \to a_0(980)^+\eta$, we perform Fit2 and Fit3

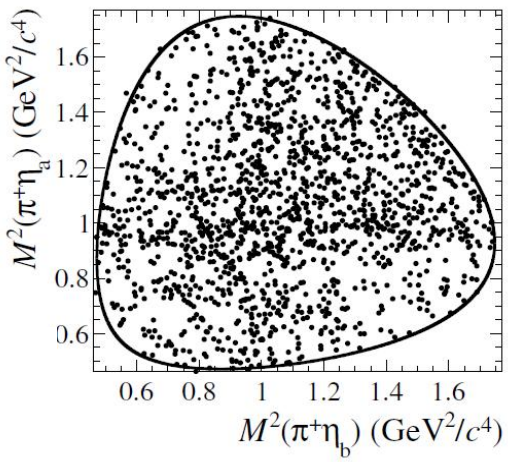


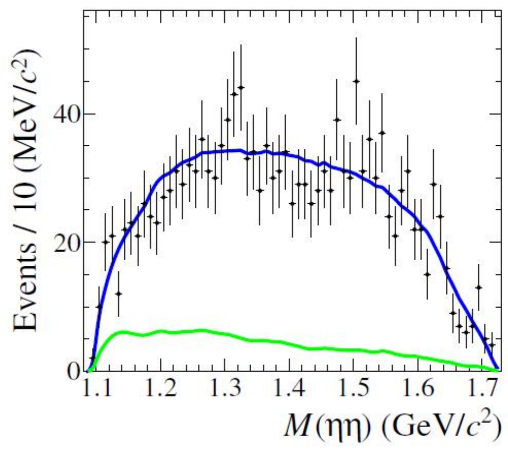
Fit2: $(1 + |C|e^{i\phi_C}A_{\rm loop})P_{a_0(980)}$

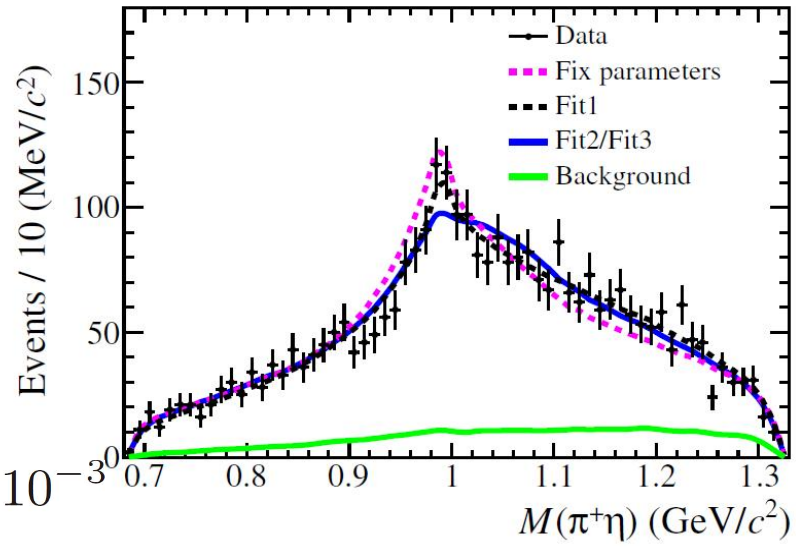
Fit3: $(1 + |C|A_{\rm loop})P_{a_0(980)}$ with ϕ_C fixed to zero.

$$|C| = 0.113 \pm 0.015_{\rm stat.} \pm 0.048_{\rm syst.}$$

Fit2 and Fit3 give good descriptions of the altered $a_0(980)$ line-shape.







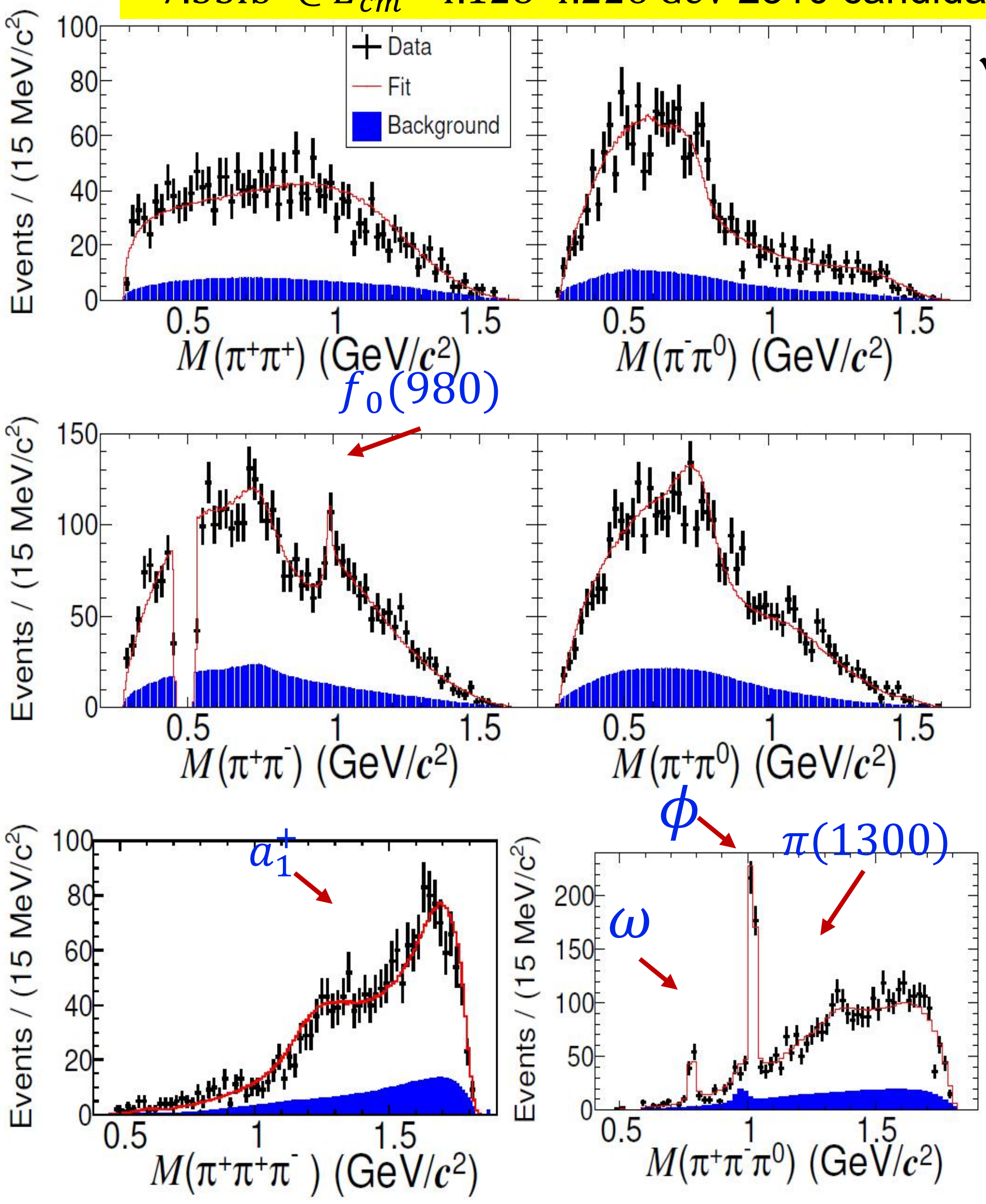
✓ **BF measurement**

$$\left.\begin{array}{r}\mathcal{B}(D^+ \to \pi^+\eta\eta) \\ \mathcal{B}(D^+ \to a_0(980)^+\eta)\ \mathcal{B}(a_0(980)^+ \to \pi^+\eta)\end{array}\right\} = (3.67 \pm 0.12_{\rm stat.} \pm 0.06_{\rm syst.}) \times 10^{-3}$$

Amplitude analysis of $D_s^+ \to \pi^+\pi^+\pi^-\pi^0$

7.33fb^{-1}@E_{cm}=4.128-4.226 GeV 2310 candidates with >78% purity

PRL 134, 011904 (2025)

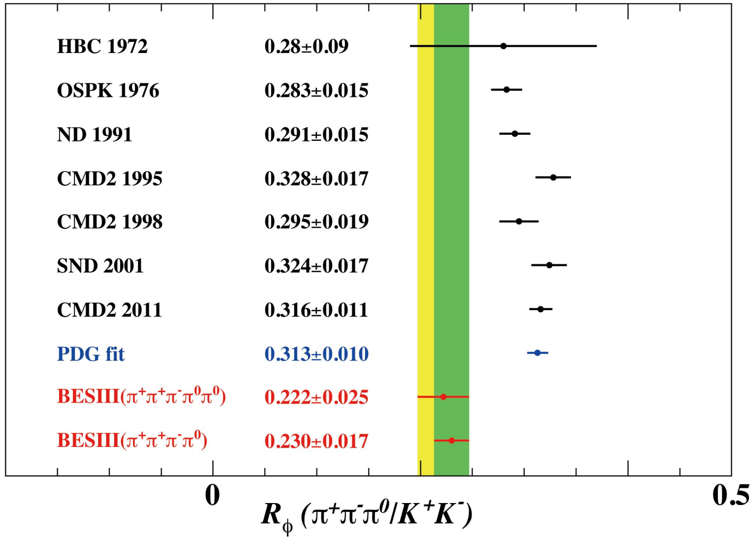


✓ **Observation of $D_s^+ \to f_0(980)\rho(770)^+$** (Mainly involves W-external-emission diagram)

Component	Phase (rad)	BF (10^{-3})
$f_0(1370)\rho^+$	0.0(fixed)	$5.08 \pm 0.80 \pm 0.43$
$f_0(980)\rho^+$	$3.99 \pm 0.13 \pm 0.07$	$2.57 \pm 0.44 \pm 0.20$
$f_2(1270)\rho^+$	$1.11 \pm 0.10 \pm 0.10$	$1.94 \pm 0.36 \pm 0.12$
$(\rho^+\rho^0)_S$	$1.10 \pm 0.18 \pm 0.10$	$0.71 \pm 0.25 \pm 0.12$
$(\rho(1450)^+\rho^0)_S$	$0.43 \pm 0.18 \pm 0.17$	$0.94 \pm 0.27 \pm 0.16$
$(\rho^+\rho(1450)^0)_P$	$4.58 \pm 0.16 \pm 0.09$	$1.75 \pm 0.27 \pm 0.08$
$\phi((\rho\pi) \to \pi^+\pi^-\pi^0)\pi^+$	$2.90 \pm 0.15 \pm 0.18$	$5.08 \pm 0.32 \pm 0.10$
$\omega((\rho\pi) \to \pi^+\pi^-\pi^0)\pi^+$	$3.22 \pm 0.21 \pm 0.09$	$1.41 \pm 0.17 \pm 0.06$
$a_1^+(\rho^0\pi^+)_S\pi^0$	$3.78 \pm 0.16 \pm 0.12$	$2.55 \pm 0.34 \pm 0.20$
$a_1^0((\rho\pi)_S \to \pi^+\pi^-\pi^0)\pi^+$	$4.82 \pm 0.15 \pm 0.12$	$1.29 \pm 0.39 \pm 0.24$
$\pi(1300)^0((\rho\pi)_P \to \pi^+\pi^-\pi^0)\pi^+$	$2.22 \pm 0.14 \pm 0.08$	$2.39 \pm 0.48 \pm 0.45$

- $\mathcal{B}(D_s^+ \to \pi^+\pi^+\pi^-\pi^0) = (2.04 \pm 0.08 \pm 0.05)\%$

✓ **Measurement of ϕ**



- $\mathcal{B}(D_s^+ \to \phi\pi^+, \phi \to \pi^+\pi^-\pi^0) = (5.08 \pm 0.32 \pm 0.10) \times 10^{-3}$
- $\mathcal{B}(D_s^+ \to \phi\pi^+, \phi \to K^+K^-) = (2.21 \pm 0.05 \pm 0.07)\%$

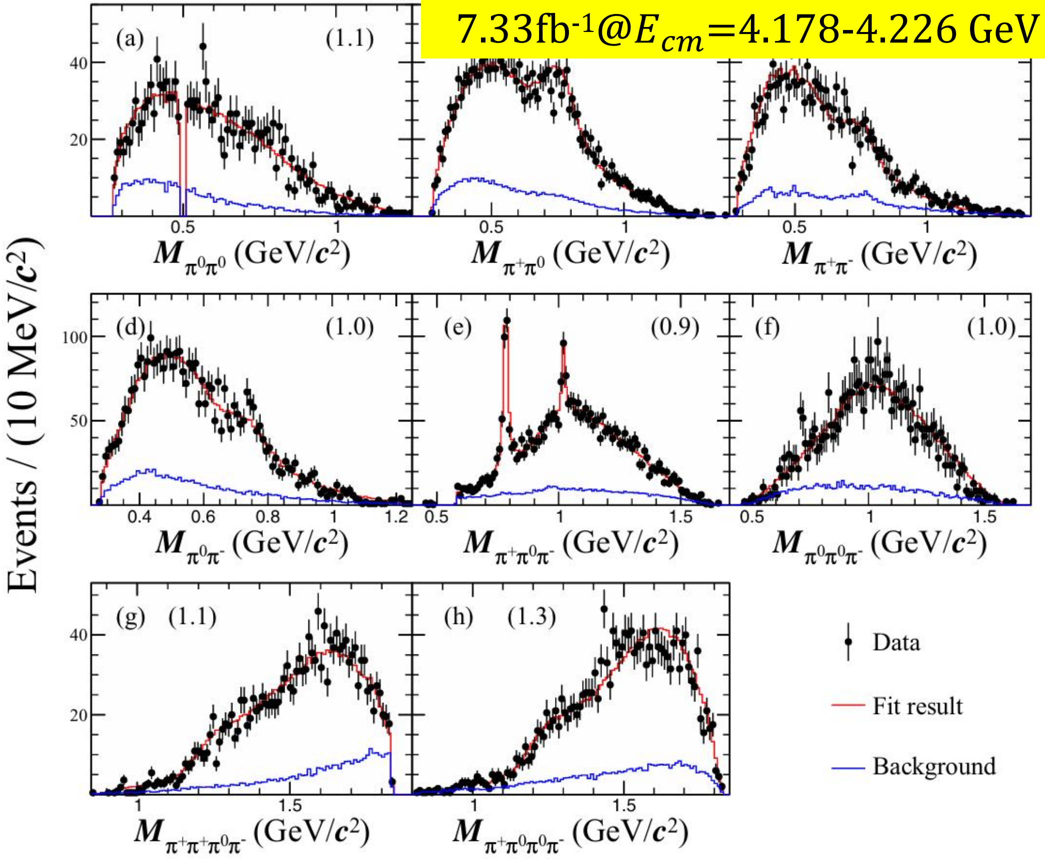
Taking from $D_s^+ \to K^+K^-\pi^+$ PRD 104, 012016

$\frac{\mathcal{B}(\phi\to\pi^+\pi^-\pi^0)}{\mathcal{B}(\phi\to K^+K^-)} = 0.230 \pm 0.014_{stat} \pm 0.010_{syst}$
deviates from PDG value(0.313 ± 0.010) by $> 4\sigma$.

Amplitude analysis of $D_s^+ \to \pi^+\pi^+\pi^-\pi^0\pi^0$

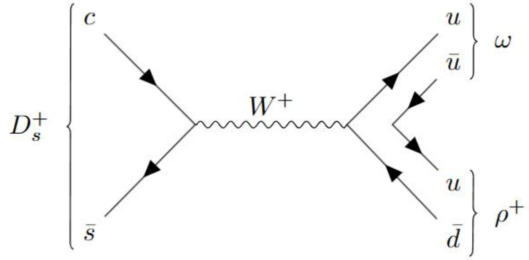
7.33fb^{-1}@E_{cm}=4.178-4.226 GeV 1888 candidates with >79% purity

PRL 134, 201902 (2025)



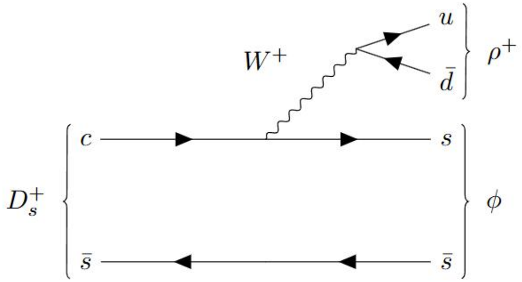
Amplitude	Phase ϕ (rad)	FF (%)	BF (%)
$D_s^+[S] \to \omega\rho^+$	0.0 (fixed)	$6.12 \pm 1.34\,^{+0.44}_{-0.52}$	$0.30 \pm 0.07\,^{+0.02}_{-0.03}$
$D_s^+[P] \to \omega\rho^+$	D>S>P	$5.05 \pm 0.86\,^{+0.83}_{-0.79}$	$0.25 \pm 0.04\,^{+0.04}_{-0.04}$
$D_s^+[D] \to \omega\rho^+$	$4.91 \pm 0.09\,^{+0.04}_{-0.09}$	$10.36 \pm 1.26\,^{+0.70}_{-1.45}$	$0.52 \pm 0.07\,^{+0.04}_{-0.07}$
$D_s^+ \to \omega\rho^+$	...	$19.98 \pm 1.40\,^{+0.92}_{-1.20}$	$0.99 \pm 0.08\,^{+0.05}_{-0.07}$
$D_s^+[S] \to \phi\rho^+$	[illegible]	$11.62 \pm 0.94\,^{+0.46}_{-0.39}$	$3.32 \pm 0.29\,^{+0.19}_{-0.17}$
$D_s^+[P] \to \phi\rho^+$	S>P>D	$2.22 \pm 0.42\,^{+0.15}_{-0.15}$	$0.63 \pm 0.12\,^{+0.05}_{-0.06}$
$D_s^+ \to \phi\rho^+$	...	$13.86 \pm 1.03\,^{+0.47}_{-0.35}$	$3.98 \pm 0.33\,^{+0.21}_{-0.19}$

✓ **Observation of the pure W-annihilation decay $D_s^+ \to \omega\rho^+$**



pure W-annihilation
doninated by D-wave(50%)

- $\mathcal{B}(D_s^+ \to \omega\rho^+) = (0.99 \pm 0.08_{\rm stat}{}^{+0.05}_{-0.07\,\rm syst})\%$



pure external W emission
doninated by S-wave

- $\mathcal{B}(D_s^+ \to \phi\rho^+) = (3.98 \pm 0.33_{stat} \pm 0.021_{syst})\%$,

✓ **Measurement of ϕ**

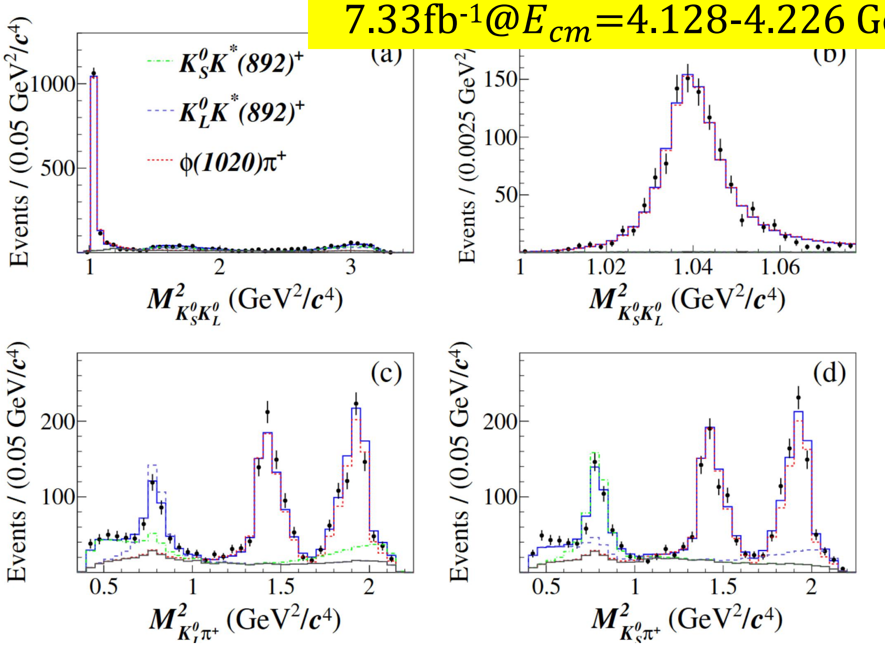
$$\frac{\mathcal{B}(\phi\to\pi^+\pi^-\pi^0)}{\mathcal{B}(\phi\to K^+K^-)} = 0.222 \pm 0.019_{\rm stat} \pm 0.016_{\rm syst}$$

deviates from PDG value(0.313 ± 0.010) by $> 3\sigma$.

Amplitude analysis of $D_s^+ \to K_S^0 K_L^0 \pi^+$

arXiv:2503.11383

7.33fb^{-1}@E_{cm}=4.128-4.226 GeV 1552 candidates with >75% purity



Amplitude	Phase (rad)	FF (%)	BF (%)
$D_s^+ \to \phi\pi^+$	0.0(fixed)	$70.9 \pm 1.3 \pm 1.5$	$1.32 \pm 0.05 \pm 0.04$
$D_s^+ \to K_L^0 K^*(892)^+$	$0.68 \pm 0.17 \pm 0.21$	$22.8 \pm 1.3 \pm 1.5$	$0.42 \pm 0.03 \pm 0.03$
$D_s^+ \to K_S^0 K^*(892)^+$	$-2.40 \pm 0.18 \pm 0.31$	$17.4 \pm 1.2 \pm 0.9$	$0.31 \pm 0.02 \pm 0.02$

✓ **Observation of the $K_S^0 - K_L^0$ asymmetry in the $D \to K_{S/L}^0 V$**

(Interference of CF and DCS decays)

- $$\frac{\mathcal{B}(D_s^+ \to K_S^0K^*(892)^+)-\mathcal{B}(D_s^+ \to K_L^0K^*(892)^+)}{\mathcal{B}(D_s^+ \to K_S^0K^*(892)^+)+\mathcal{B}(D_s^+ \to K_L^0K^*(892)^+)} = -0.134 \pm 0.05_{stat.} + 0.034_{syst.}$$

Model	DAT(F4)	DAT(F1′)
$D_s^+ \to \bar{K}^0 K^{*+}$	-0.164 ± 0.032	-0.159 ± 0.028

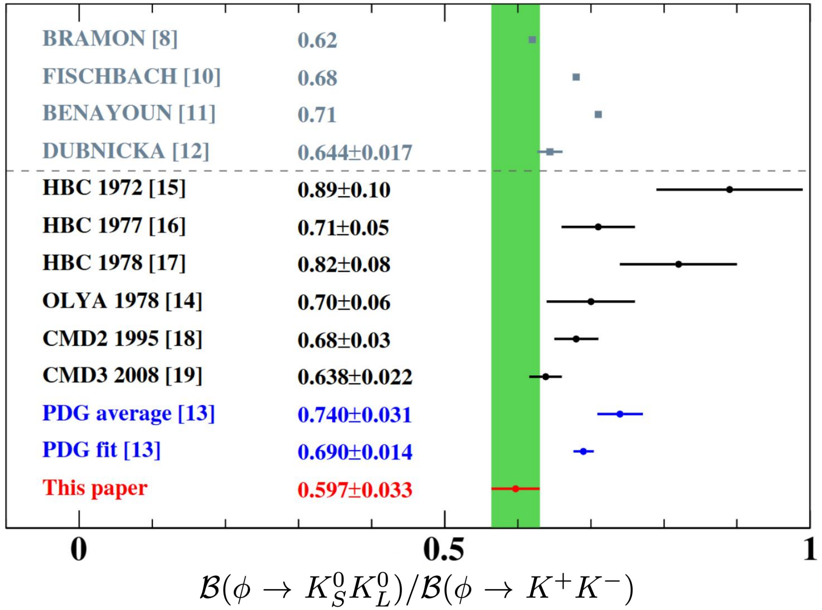
Predictions by H. Y. Cheng *et al.*, PRD109, 073008

✓ **Measurement of ϕ**

$$\frac{\mathcal{B}(\phi\to K_S^0K_L^0)}{\mathcal{B}(\phi\to K^+K^-)} = 0.597 \pm 0.023_{\rm stat} \pm 0.024_{\rm syst}$$

deviates from PDG value(0.740 ± 0.033) by $> 3\sigma$.

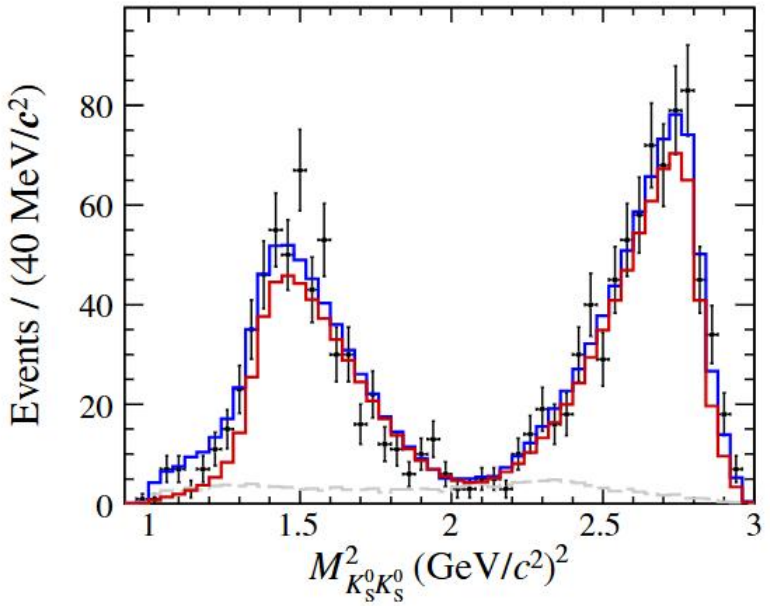
- New effects may be needed in theory?
- Sum of ϕ branching ratios < 100%? possibly indicating new decays or recalibration of $\phi \to K^+K^-$?

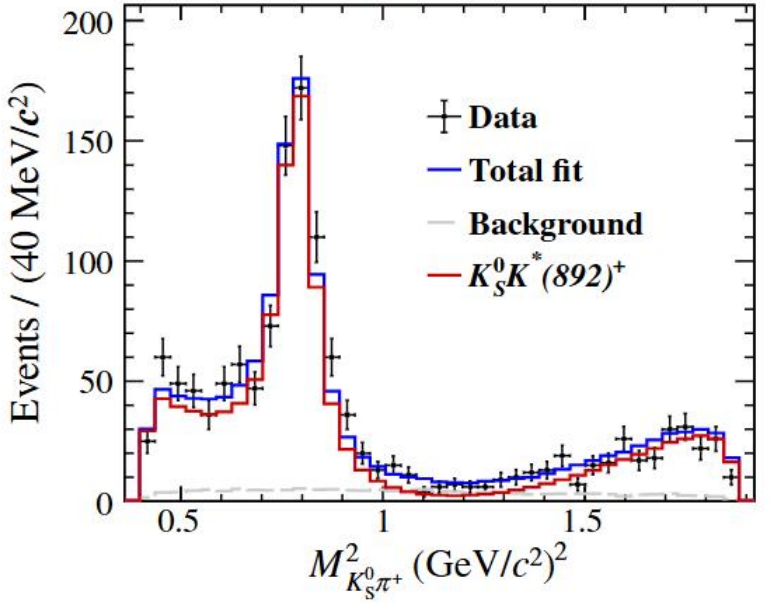


Amplitude analysis of $D^+ \to K_S^0 K_S^0 \pi^+$

7.93fb^{-1}@E_{cm}=3.773 GeV
1177 candidates with >89% purity

PRD 110.092006 (2024)





✓ **Precise measurement of $D^+ \to K_S^0 K^*(892)^+$**

$D \to VP$

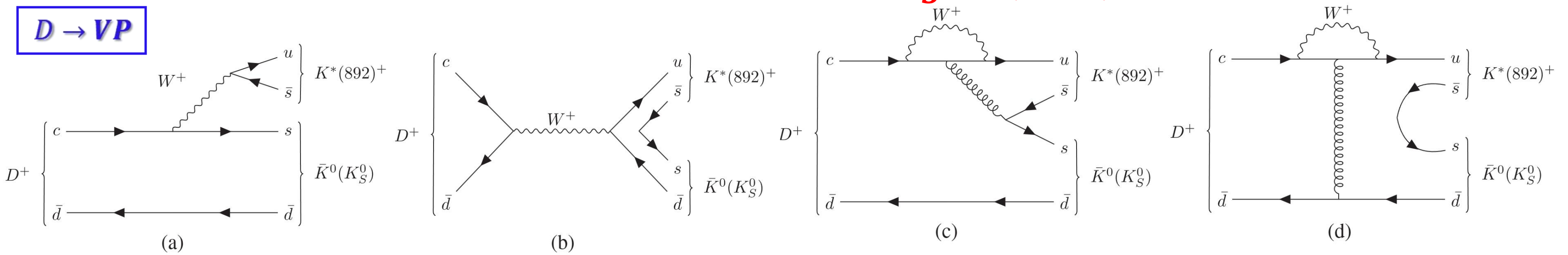


TABLE I. Theoretical predictions of $\mathcal{B}(D^+ \to K_S^0 K^*(892)^+)$ and the previous experimental measurement.

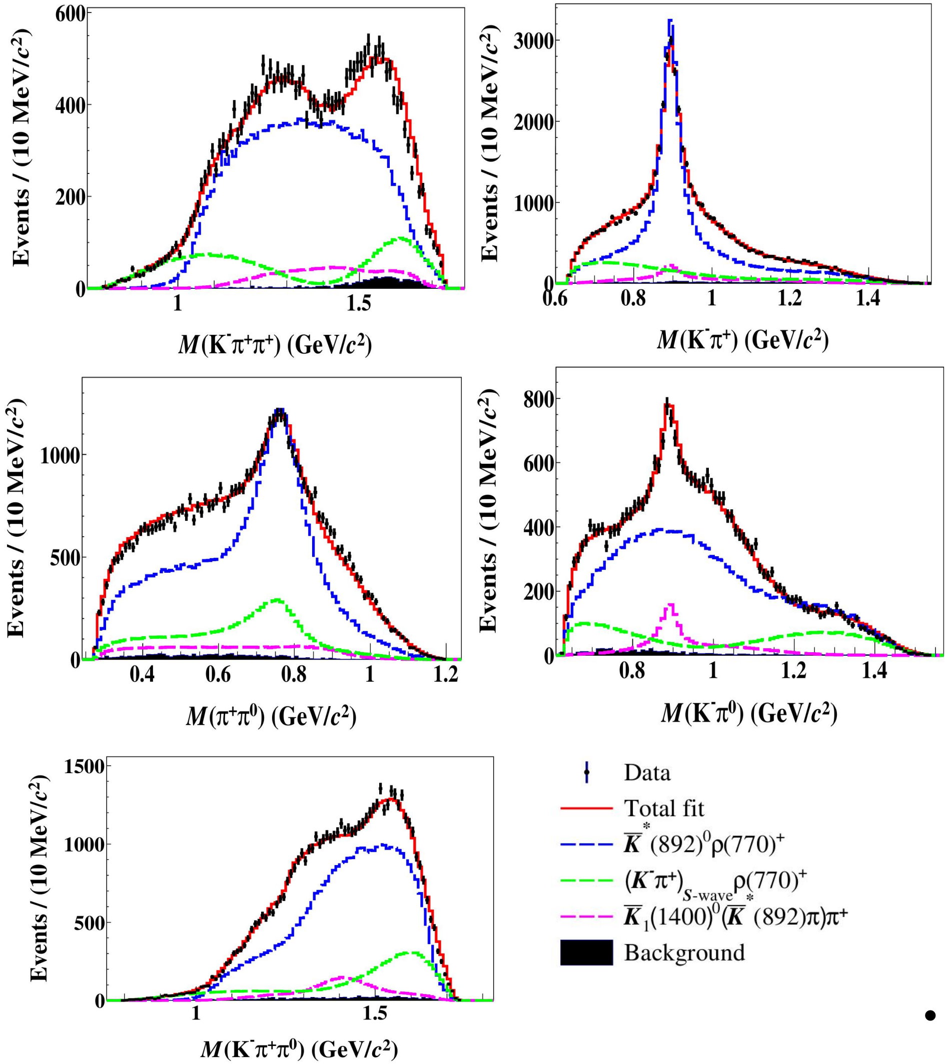
Model	$\mathcal{B}(D^+ \to K_S^0 K^*(892)^+)$ ($\times 10^{-3}$)
Pole [12]	6.2 ± 1.2
FAT (mix) [13]	5.5
TDA (tree) [1]	5.02 ± 1.31
TDA (QCD-penguin) [2]	4.90 ± 0.21
TDA [14]	7.90 ± 0.25
BESIII measurement [11]	$8.69 \pm 0.40_{\rm stat} \pm 0.64_{\rm syst} \pm 0.51_{\rm BF}$

$$\mathcal{B}(D^+ \to K_S^0 K^*(892)^+) = (8.72 \pm 0.28_{stat.} + 0.15_{syst.}) \times 10^{-3}$$

PRD 104, 012006

Consistent with the previous BESIII measrement but with improved precision

Amplitude analysis of $D^+ \to K^-\pi^+\pi^+\pi^0$



Decay channel and Collaboration	$\mathcal{B}(D^+ \to \bar{K}^*(892)^0\rho(770)^+)$ $(\times 10^{-2})$
$D^+ \to K^-\pi^+\pi^+\pi^0$, current analysis	$6.52 \pm 0.11 \pm 0.26$
$D^+ \to K^-\pi^+\pi^+\pi^0$, MARK-III [4]	$7.2 \pm 1.8 \pm 2.1$
$D^+ \to K^0_S\pi^+\pi^0\pi^0$, BESIII [21]	$5.82 \pm 0.49 \pm 0.29$

7.93fb^{-1}@E_{cm}=3.773 GeV
26709 candidates with >98% purity

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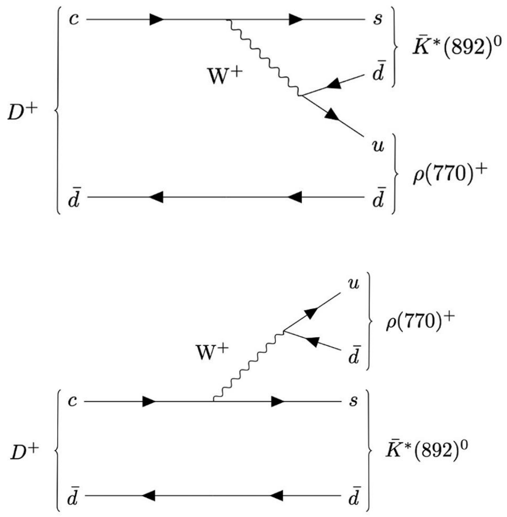
✓ **Measurement of $D^+ \to \bar{K}^{*0}\rho^+$**

$D \to VV$



(dominated by S-wave)

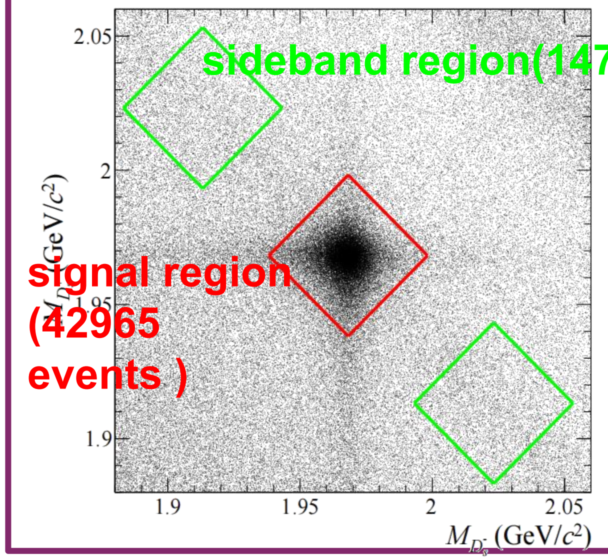
Intermediate process	BF (10^{-2})
$D^+ \to \bar{K}^*(892)^0\rho(770)^+, \bar{K}^*(892)^0 \to K^-\pi^+, \rho(770)^+ \to \pi^+\pi^0$	$4.35 \pm 0.07 \pm 0.17$
$D^+ \to K_1(1270)^0\pi^+, K_1(1270)^0 \to K^-\rho(770)^+, \rho(770)^+ \to \pi^+\pi^0$	$0.24 \pm 0.02 \pm 0.02$
$D^+ \to \bar{K}_1(1400)^0\pi^+, \bar{K}_1(1400)^0 \to \bar{K}^*(892)\pi, \bar{K}^*(892) \to K\pi$	$0.46 \pm 0.01 \pm 0.02$
$D^+ \to \bar{K}(1460)^0\pi^+, \bar{K}(1460)^0 \to \bar{K}^*(892)\pi, \bar{K}^*(892) \to K\pi$	$0.32 \pm 0.01 \pm 0.02$
$D^+ \to \bar{K}(1680)^{*0}\pi^+, \bar{K}(1680)^{*0} \to \bar{K}^*(892)\pi, \bar{K}^*(892) \to K\pi$	$0.25 \pm 0.02 \pm 0.05$
$D^+ \to (K^-\pi^+)_{S-\text{wave}}\rho(770)^+, \rho(770)^+ \to \pi^+\pi^0$	$1.16 \pm 0.04 \pm 0.05$
$D^+ \to \bar{K}(1460)^0\pi^+, \bar{K}(1460)^0 \to K^-(\pi^+\pi^0)_V$	$0.53 \pm 0.05 \pm 0.03$
$D^+ \to \bar{K}(1460)^0\pi^+, \bar{K}(1460)^0 \to (K^-\pi)_V\pi$	$0.22 \pm 0.03 \pm 0.02$
$D^+ \to (K^-\rho(770)^+)_A\pi^+, \rho(770)^+ \to \pi^+\pi^0$	$0.11 \pm 0.01 \pm 0.01$
$D^+ \to (\bar{K}^*(892)\pi)_A\pi^+, \bar{K}^*(892) \to K\pi$	$0.05 \pm 0.01 \pm 0.01$
$D^+ \to (\bar{K}^*(892)^0\pi^+)_A\pi^0, \bar{K}^*(892)^0 \to K^-\pi^+$	$0.05 \pm 0.01 \pm 0.02$
$D^+ \to (K^-\pi^+)_V\rho(770)^+, \rho(770)^+ \to \pi^+\pi^0$	$0.03 \pm 0.01 \pm 0.01$
$D^+ \to (K^-(\pi^+\pi^0)_V)_P\pi^+$	$0.05 \pm 0.01 \pm 0.01$

- $\mathcal{B}(D^+ \to K^-\pi^+\pi^+\pi^0) = (6.06 \pm 0.04 \pm 0.07)\%$
- $\mathcal{B}(D^+ \to \bar{K}^{*0}\rho^+)$ =$(6.52 \pm 0.11 \pm 0.26)\%$, consistent with the world average result.

Branching fractions of D_s^+ hadronic decays

7.33fb^{-1}@E_{cm}=4.178 - 4.226 GeV

JHEP 05(2024)335



Global fit to ST and DT yields

15 decay modes

Numbers of producted $D_s^+ D_s^-$ pairs:

$\sqrt{s}$ (GeV)	$N^{D_s^+ D_s^-}$ ($\times 10^5$)
4.128 and 4.157	6.29±0.06±0.01
4.178	31.79±0.24±0.06
4.189	5.51±0.05±0.01
4.199	4.92±0.05±0.01
4.209	5.07±0.05±0.01
4.219	4.32±0.04±0.01
4.226	6.82±0.07±0.02

Provides important input for the relative BF measurements of BESIII.

Mode	$\mathcal{B}$ (%)	$\mathcal{A}_{CP}$ (%)
$D_s^+ \to K_S^0 K^+$	$1.502 \pm 0.012 \pm 0.009$	$0.29 \pm 0.50 \pm 0.21$
$D_s^+ \to K^+ K^- \pi^+$	$5.49 \pm 0.04 \pm 0.07$	$0.48 \pm 0.26 \pm 0.24$
$D_s^+ \to K_S^0 K^+ \pi^0$	$1.47 \pm 0.02 \pm 0.02$	$-0.85 \pm 1.97 \pm 0.46$
$D_s^+ \to K_S^0 K_S^0 \pi^+$	$0.73 \pm 0.01 \pm 0.01$	$1.14 \pm 1.58 \pm 0.44$
$D_s^+ \to K^+ K^- \pi^+ \pi^0$	$5.50 \pm 0.05 \pm 0.11$	$-0.66 \pm 0.91 \pm 0.33$
$D_s^+ \to K_S^0 K^+ \pi^+ \pi^-$	$0.93 \pm 0.02 \pm 0.01$	$2.00 \pm 2.37 \pm 0.70$
$D_s^+ \to K_S^0 K^- \pi^+ \pi^+$	$1.56 \pm 0.02 \pm 0.02$	$-0.24 \pm 1.05 \pm 1.07$
$D_s^+ \to \pi^+ \pi^+ \pi^-$	$1.09 \pm 0.01 \pm 0.01$	$-0.88 \pm 1.17 \pm 0.38$
$D_s^+ \to \pi^+ \eta$	$1.69 \pm 0.02 \pm 0.02$	$-0.44 \pm 0.89 \pm 0.19$
$D_s^+ \to \pi^+ \pi^0 \eta$	$9.10 \pm 0.09 \pm 0.15$	$1.05 \pm 1.45 \pm 0.62$
$D_s^+ \to \pi^+ \pi^+ \pi^- \eta$	$3.08 \pm 0.06 \pm 0.05$	$2.42 \pm 2.85 \pm 0.78$
$D_s^+ \to \pi^+ \eta'$	$3.95 \pm 0.04 \pm 0.07$	$-0.59 \pm 0.76 \pm 0.20$
$D_s^+ \to \pi^+ \pi^0 \eta'$	$6.17 \pm 0.12 \pm 0.14$	$-1.60 \pm 2.57 \pm 0.64$
$D_s^+ \to K_S^0 \pi^+ \pi^0$	$0.51 \pm 0.02 \pm 0.01$	$-2.17 \pm 4.65 \pm 1.10$
$D_s^+ \to K^+ \pi^+ \pi^-$	$0.620 \pm 0.009 \pm 0.006$	$1.81 \pm 2.01 \pm 0.45$

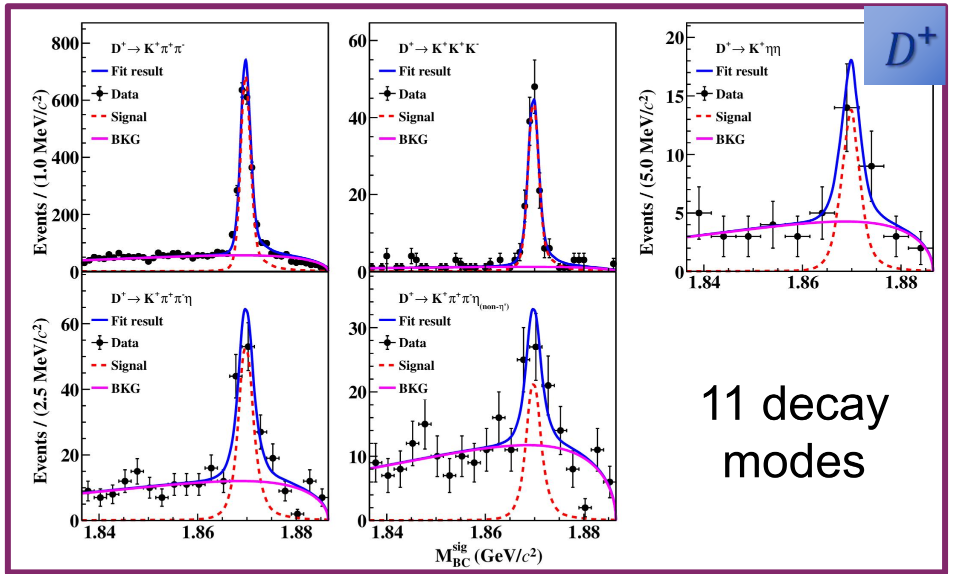
- Agree with PDG with much improved precision
- No significant asymmetries are observed.

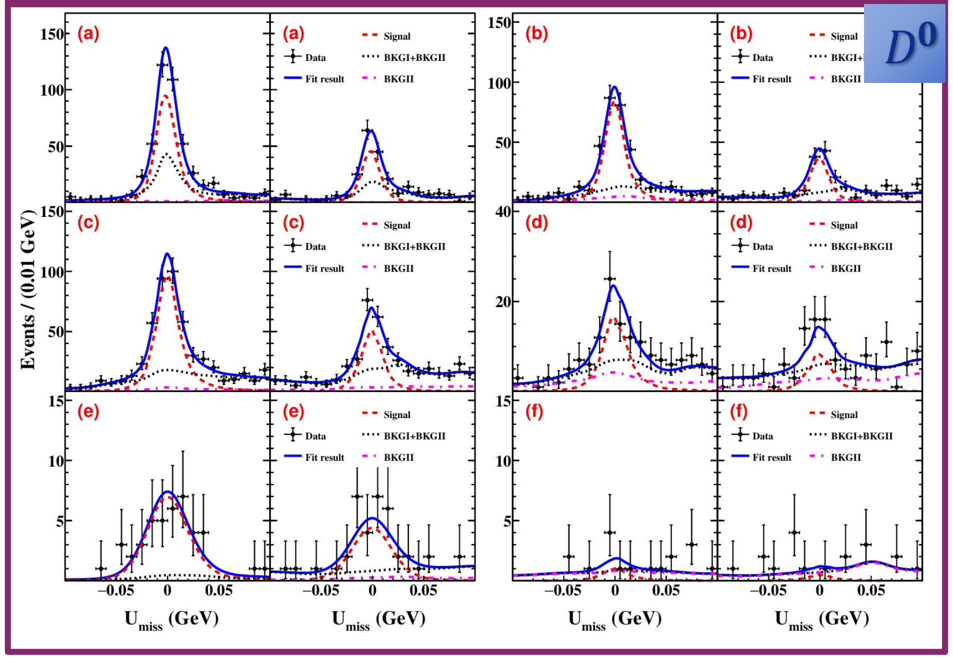
Branching fractions of D^+/D^0 hadronic decays

--Doubly Cabibbo-Suppressed (DCS) decays

20.3fb^{-1}@E_{cm}=3.773 GeV

JHEP06(2025)220





- Understanding of the decay dynamics of charm quarks.
- The BF of DCS decay is expected to be (0.5 - 2.0) tan⁴θ_C times CF. (θ_C is the Cabibbo mixing Angle)
- First observations of $D^0 \to K^+\pi^-\eta$, $D^0 \to K^+\pi^-\pi^0\eta$, $D^+ \to K^+\pi^+\pi^-\eta$ and $D^+ \to K^+\eta\eta$.

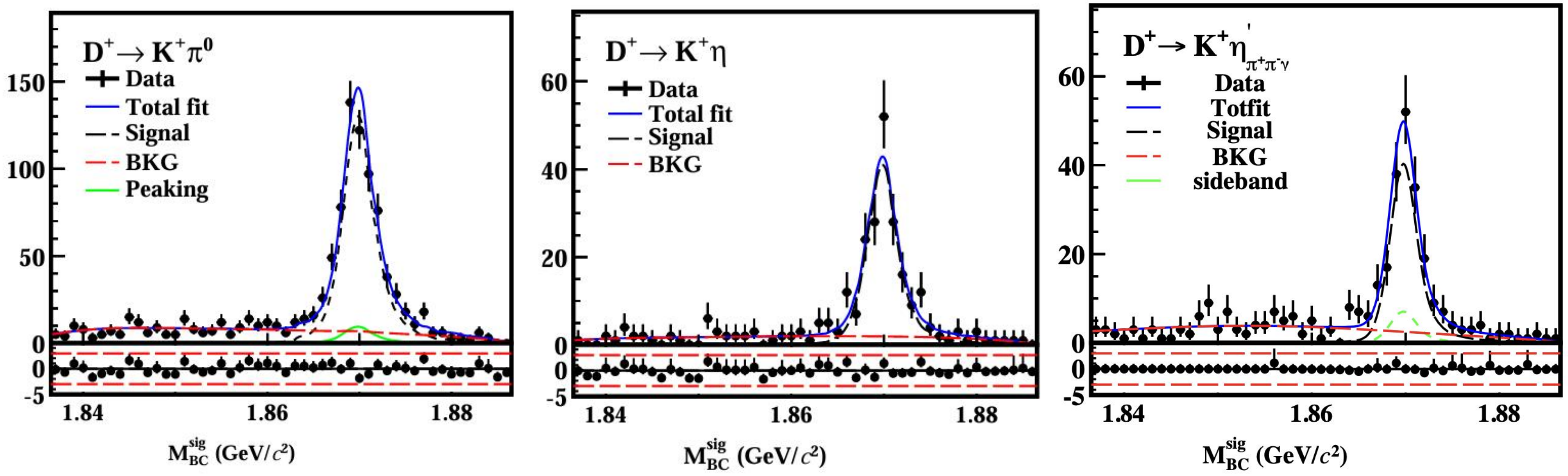
Signal decay	$\mathcal{B}_{\rm DCS}^{\rm This\ work}$ $(\times10^{-4})$	$\mathcal{B}_{\rm DCS}^{\rm PDG}$ $(\times10^{-4})$
$D^0 \to K^+\pi^-$	$1.30 \pm 0.09 \pm 0.04$	1.50 ± 0.07
$D^0 \to K^+\pi^-\pi^-\pi^+$	$2.38 \pm 0.19 \pm 0.12$	2.65 ± 0.06
$D^0 \to K^+\pi^-\pi^0$	$3.06 \pm 0.21 \pm 0.10$	3.06 ± 0.16
$D^0 \to K^+\pi^-\pi^0\pi^0$	$1.40 \pm 0.27 \pm 0.09$	< 3.6
$D^0 \to K^+\pi^-\eta$	$1.04 \pm 0.16 \pm 0.08$	–
$D^0 \to K^+\pi^-\pi^0\eta$	< 0.7	–
$D^+ \to K^+\pi^+\pi^-$	$4.50 \pm 0.12 \pm 0.35$	4.91 ± 0.09
$D^+ \to K^+\pi^+\pi^-\eta$	$1.56 \pm 0.22 \pm 0.04$	–
$D^+ \to K^+(\pi^+\pi^-\eta)_{\rm non-\eta'}$	$0.67 \pm 0.18 \pm 0.02$	–
$D^+ \to K^+K^+K^-$	$0.51 \pm 0.05 \pm 0.01$	0.614 ± 0.011
$D^+ \to K^+\eta\eta$	$0.59 \pm 0.23 \pm 0.02$	–

Branching fractions of $D^+ \to K^+\pi^0$, $K^+\eta$, $K^+\eta'$

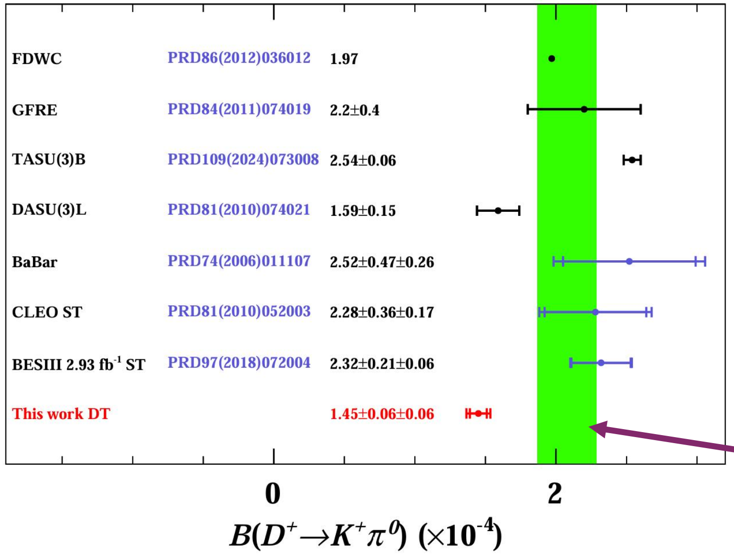
--Doubly Cabibbo-Suppressed (DCS) decays

20.3fb^{-1}@E_{cm}=3.773 GeV

arXiv:2506.15533



Signal decay	$D^+ \to K^+\pi^0$	$D^+ \to K^+\eta$	$D^+ \to K^+\eta'$
N_{DT}	629 ± 28	182 ± 15	214 ± 17
$\epsilon_{DT}/\epsilon_{ST}$ (%)	53.29 ± 0.36	19.20 ± 0.13	14.02 ± 0.11
$\mathcal{B}_{sig}$ ($\times 10^{-4}$)	1.45 ± 0.06	1.17 ± 0.10	1.88 ± 0.15



Smaller than all other experimental results and theoretical predictions

Signal decay	$D^+ \to K^+\pi^0$	$D^+ \to K^+\eta$	$D^+ \to K^+\eta'$
CLEO [12]	$2.28 \pm 0.36 \pm 0.17$	...	...
Belle [13]	...	$1.15 \pm 0.16 \pm 0.05$	$1.87 \pm 0.19 \pm 0.05$
BaBar [14]	$2.52 \pm 0.47 \pm 0.26$	...	...
BESIII [15]	$2.32 \pm 0.21 \pm 0.06$	$1.51 \pm 0.25 \pm 0.14$	$1.64 \pm 0.51 \pm 0.24$
PDG [16]	2.08 ± 0.21	1.25 ± 0.16	1.85 ± 0.20
DASU(3)L [1]	1.59 ± 0.15	0.98 ± 0.04	0.91 ± 0.17
TASU(3)B [2]	2.54 ± 0.06	1.04 ± 0.01	1.07 ± 0.01
GFRE [3]	2.2 ± 0.4	1.2 ± 0.2	1.0 ± 0.1
FDWC [4]	1.97	0.66	1.14
This work	$1.45 \pm 0.06 \pm 0.06$	$1.17 \pm 0.10 \pm 0.03$	$1.88 \pm 0.15 \pm 0.06$

Improved by a factor of two compared to the PDG

Summary & Outlook

- Charm hadronic decays are key labs to understand non-perturbative QCD

- The copious decay products also provide idea platform to investigate the natures of light mesons, such as $a_0(980)$, $f_0(980)$, $f_0(500)$, $a_1(1260)$, ϕ…

- More interesting results are coming using 20.3 fb^{-1} $\psi(3770)$ data.

- BEPCII-U will extend the lifetime of BESIII (will continue to run till ~2030). $3\times$ luminosity above 4 GeV & max energy to 5.6 GeV

Thanks for your attention!