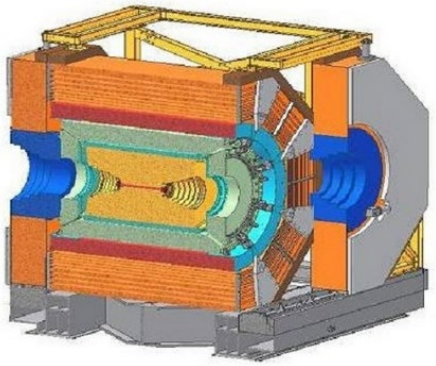


国家自然科学基金委重大项目-研究进展

《北京谱仪BESIII实验上粲夸克衰变中标准模型的精确检验》之课题二

粲强子的强子末态衰变机制研究

董燎原

中国科学院高能物理研究所

承担单位： 中国科学院高能物理研究所

合作单位： 南华大学

2026年BESIII粲强子物理研讨会，成都，**2026/10/17**

Hadronic decays of charmed hadrons

Measurements of the BFs

→ Are important component of heavy-flavor physics program.

→ Probe and calibrate non-perturbative QCD

→ Understand SU(3) flavor symmetry and its breaking effect

→ Test theoretical calculations of BFs and improve theoretical predictions of *CP* violation

Amplitude analysis of multi-body decays

→ Comprehensive measurement of intermediate two-body decay modes:
$D \to VP, PP, SP, SV, VV, AP, AV, TP$ ...

→ $D \to \phi X$: provide new insight into $\phi(1020)$ decays

→ $D \to a_0(980)X, f_0(980)X$: quantify long-range effects, probe intrinsic structure

→ $D \to K_S^0 X, K_L^0 X$: $K_S^0 - K_L^0$ asymmetry provides sensitivity to CKM dynamics

→ $D \to VV, AV$: polarization provides insights into the FSI dynamics

→ $D \to AP, AV$: probe axial-vector meson ($K_1(1270)$, $K_1(1400)$, …) properties

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

Goal: Build a comprehensive picture of exclusive hadronic decays of charmed hadrons

BF of Λ_c^+ hadronic decays

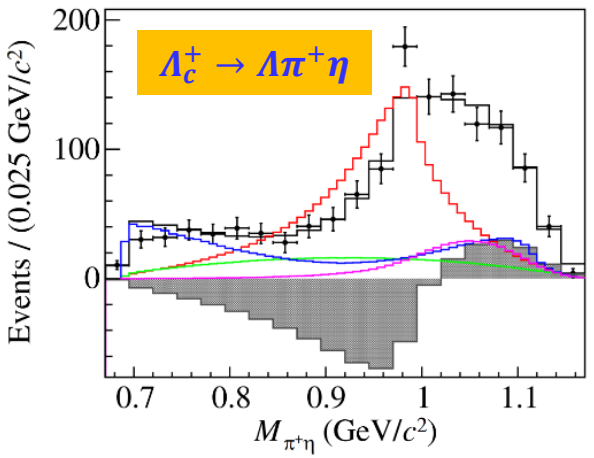
BF Measurement of Λ_c^+ hadronic decays

JHEP06(2026)269 4.5 fb^{-1}@4.599 – 4.699GeV

Signal mode	Global fit (%)	PDG (%)
pK_S^0	$1.696 \pm 0.033 \pm 0.048$	1.61 ± 0.07
$pK^-\pi^+$	$6.61 \pm 0.11 \pm 0.12$	6.35 ± 0.25
$pK_S^0\pi^0$	$2.186 \pm 0.057 \pm 0.048$	1.99 ± 0.12
$pK_S^0\pi^+\pi^-$	$1.883 \pm 0.040 \pm 0.070$	1.62 ± 0.11
$pK^-\pi^+\pi^0$	$4.89 \pm 0.10 \pm 0.11$	4.52 ± 0.28
$\Lambda\pi^+$	$1.322 \pm 0.027 \pm 0.026$	1.31 ± 0.05
$\Lambda\pi^+\pi^0$	$6.67 \pm 0.13 \pm 0.10$	7.10 ± 0.34
$\Lambda\pi^+\pi^-\pi^+$	$4.092 \pm 0.091 \pm 0.096$	3.67 ± 0.26
$\Sigma^0\pi^+$	$1.449 \pm 0.034 \pm 0.025$	1.29 ± 0.05
$\Sigma^+\pi^0$	$1.374 \pm 0.044 \pm 0.032$	1.26 ± 0.10
$\Sigma^+\pi^+\pi^-$	$4.58 \pm 0.10 \pm 0.10$	4.54 ± 0.20
$p\pi^+\pi^-$	$0.499 \pm 0.016 \pm 0.010$	0.47 ± 0.02

Agree with PDG, with precision improved by 2–3 ×

Observation of $\Lambda_c^+ \to \Lambda a_0(980)^+$



PRL 134 (2025) 021901,
6.1 fb^{-1}@4.6 – 4.843GeV

$$\mathcal{B}(\Lambda_c^+ \to \Lambda a_0(980)^+, a_0(980)^+ \to \pi^+\eta) = \left(1.05 \pm 0.16_{\text{stat}} \pm 0.05_{\text{syst}} \pm 0.07_{\text{ext}}\right)\%$$

6 Amplitude analyses: published/to be submitted

$\Lambda_c^+ \to \Lambda\pi^+\pi^0$	JHEP **12** (2022) 033
$\Lambda_c^+ \to \Lambda\pi^+\eta$	Phys. Rev. Lett. **134** (2025) 021901
$\Lambda_c^+ \to \pi^+K^+K^-$	Phys. Rev. D **114** (2026) 032008
$\Lambda_c^+ \to pK_S^0\pi^0$	to be submitted to JHEP
$\Lambda_c^+ \to nK_S^0\pi^0$	to be submitted to JHEP
$\Lambda_c^+ \to p\pi^+\pi^-$	to be submitted to PRL

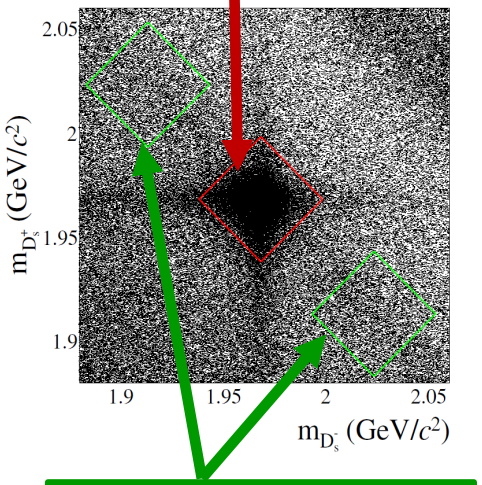
BF of D_s^+ hadronic decays

BF Measurement of D_s^+ hadronic decays

JHEP05(2024)335, 7.33fb^{-1}@4.178 – 4.226GeV

17 Amplitude analyses published

42965 events in signal region



14728 events in combined sideband

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

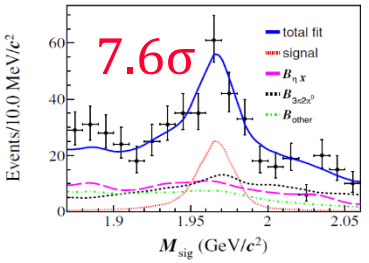
Agree with PDG with much improved precision

$D_s^+ \to K^+ K^- \pi^+$	Phys. Rev. D **104** (2021) 012016
$D_s^+ \to K_S^0 K^+ \pi^0$	Phys. Rev. Lett. **129** (2022) 182001
$D_s^+ \to \pi^+ \pi^+ \pi^-$	Phys. Rev. D **106** (2022) 112006
$D_s^+ \to \pi^+ \pi^+ \pi^- \eta$	Phys. Rev. D **104** (2021) L071101
$D_s^+ \to \pi^+ \pi^0 \eta'$	**JHEP 04** (2022) 058
$D_s^+ \to \pi^+ \pi^0 \pi^0$	**JHEP 01** (2022) 052
$D_s^+ \to K^+ \pi^+ \pi^-$	**JHEP 08** (2022) 196
$D_s^+ \to K^+ \pi^+ \pi^- \pi^0$	**JHEP 09** (2022) 242
$D_s^+ \to K_S^0 K_S^0 \pi^+$	Phys. Rev. D **105** (2022) L051103
$D_s^+ \to K_S^0 K^- \pi^+ \pi^+$	Phys. Rev. D **103** (2021) 092006
$D_s^+ \to K^+ K^- \pi^+ \pi^0$	Phys. Rev. D **104** (2021) 032011
$D_s^+ \to K^+ K^- \pi^+ \pi^+ \pi^-$	**JHEP 07** (2022) 051
$D_s^+ \to K_S^0 \pi^+ \pi^0$	**JHEP 06** (2021) 181
$D_s^+ \to \pi^+ \pi^0 \eta$	Phys. Rev. Lett. **123** (2019) 112001
$D_s^+ \to \pi^+ \pi^+ \pi^- \pi^0$	Phys. Rev. Lett. **134** (2025) 011904
$D_s^+ \to \pi^+ \pi^+ \pi^- \pi^0 \pi^0$	Phys. Rev. Lett. **134** (2025) 201902
$D_s^+ \to K_S^0 K_L^0 \pi^+$	Phys. Rev. Lett. **135** (2025) 161902
$D_s^+ \to \pi^+ \pi^0 \pi^0 \eta$	arXiv:2603.18521

Observation of $D_s^+ \to \omega \pi^+ \eta$

PRD 107, 052010 (2023), 7.33fb^{-1}@4.178 – 4.226GeV

$$\mathcal{B}(D_s^+ \to \omega \pi^+ \eta) = (0.54 \pm 0.12 \pm 0.04)\%$$



分支比测量和振幅分析为理解D_s^+介子强子衰变机制提供了完整的实验信息

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

7.33fb^{-1} @ 4.178 – 4.226GeV , PRL 134, 011904 (2025)

1552 candidates with >75% purity

Observation of $D_s^+ \to f_0(980)\rho(770)^+$

(Mainly involves W-external-emission diagram)

$$\mathcal{B}(D_s^+ \to \pi^+\pi^+\pi^-\pi^0|_{\text{non}-\eta}) = (2.04 \pm 0.08_{\text{stat.}} \pm 0.05_{\text{syst.}})\%$$

$$\mathcal{B}(D_s^+ \to \eta\pi^+) = (1.56 \pm 0.09_{\text{stat.}} \pm 0.04_{\text{syst.}})\%$$

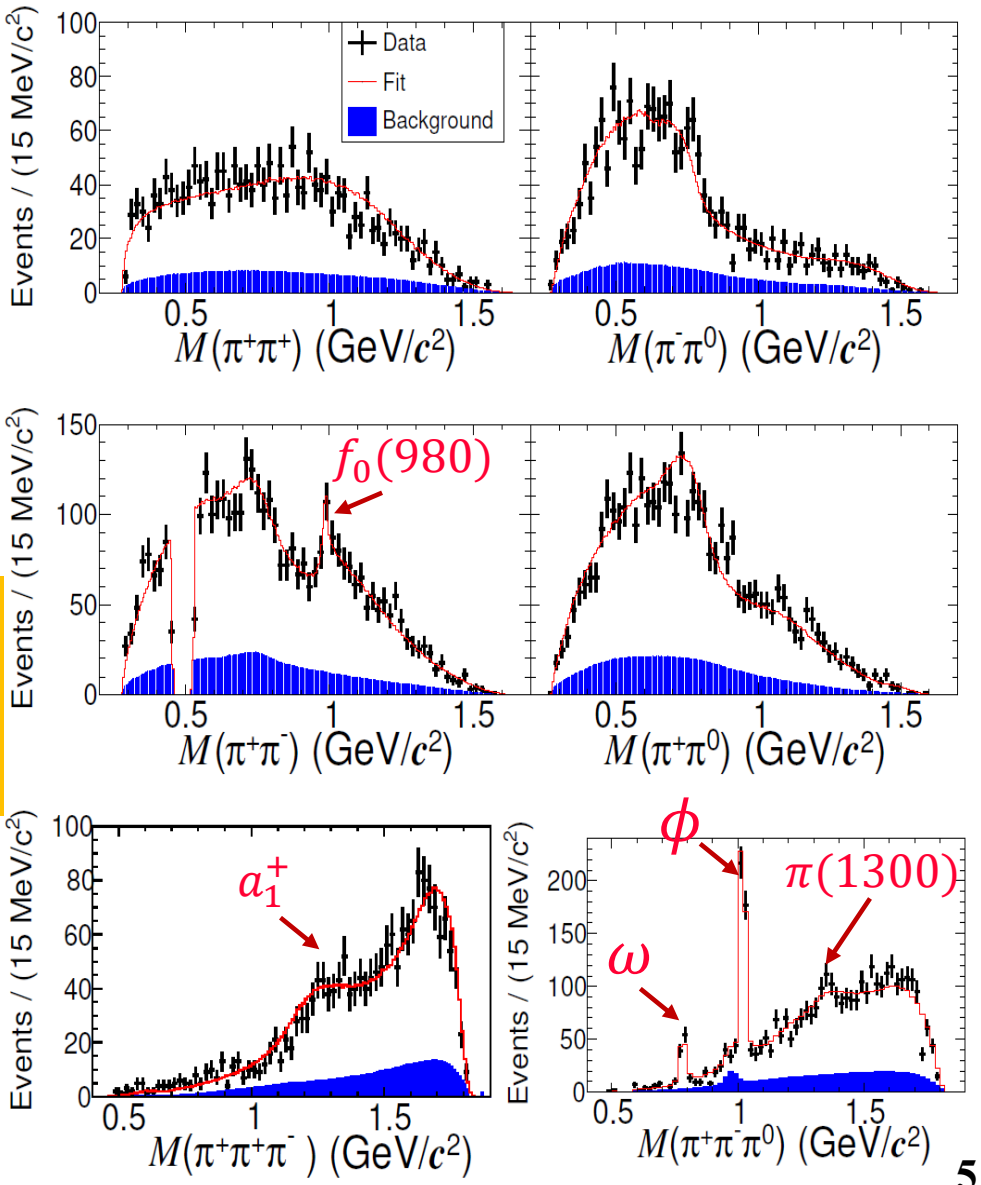
$$\frac{\mathcal{B}(\phi(1020) \to \pi^+\pi^-\pi^0)}{\mathcal{B}(\phi(1020) \to K^+K^-)} = 0.230 \pm 0.014_{\text{stat.}} \pm 0.010_{\text{syst.}}$$

Taking from $D_s^+ \to K^+K^-\pi^+$
BESIII, PRD 104, 012016 (2021)

Deviates from PDG value (0.313 ± 0.010) by $>4\sigma$

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

W-annihilation decay
$BF = (1.92 \pm 0.30) \times 10^{-3}$
(PDG)

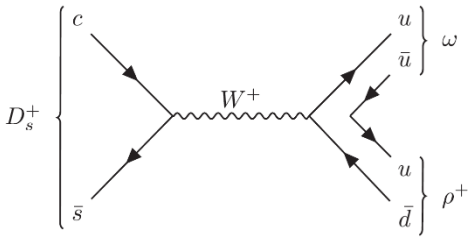


Amplitude analysis of $D_s^+ \to \pi^+\pi^+\pi^-\pi^0\pi^0$

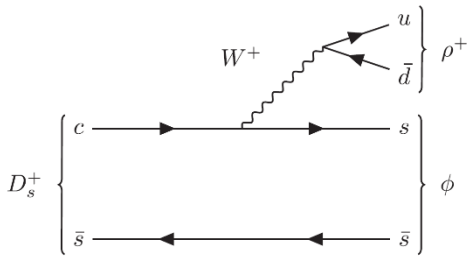
7.33fb^{-1} @ 4.178 – 4.226GeV , PRL 134, 201902 (2025)

1888 candidates with >79% purity

Observation of $D_s^+ \to \omega\rho(770)^+$



Pure W-annihilation



Pure W-external emission

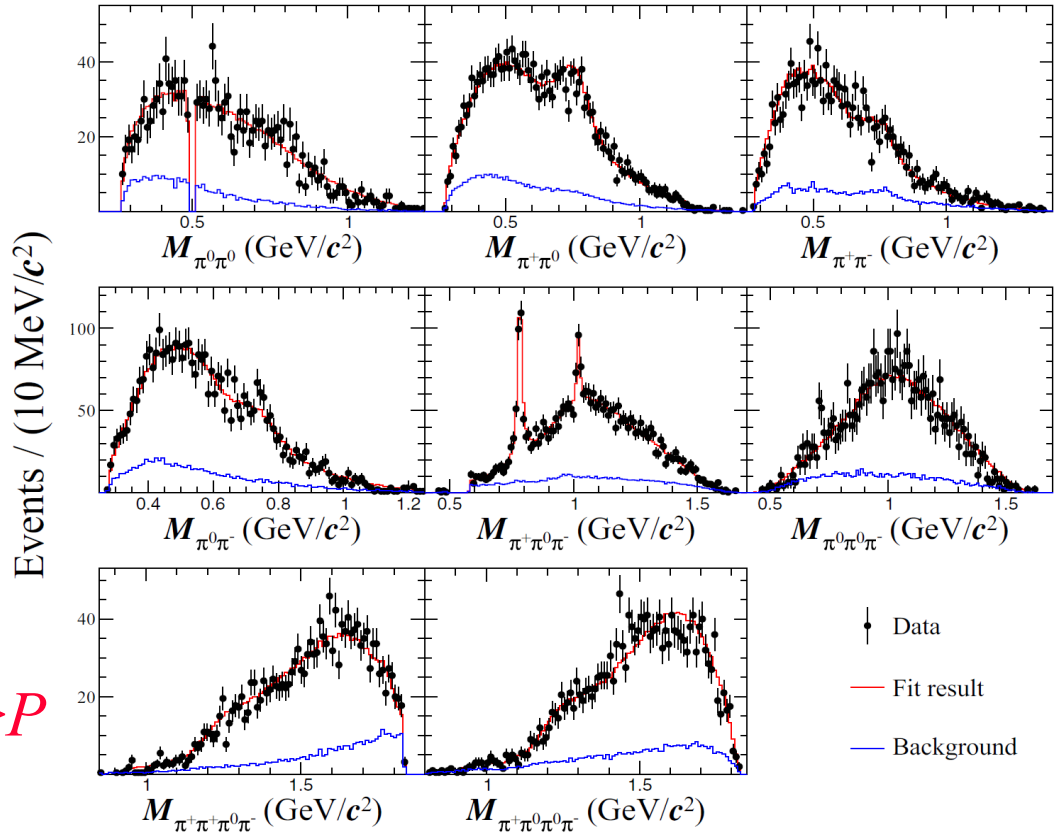
Polarization puzzle

Amplitude	BF (%)
$D_s^+ \to \rho(1450)^+\pi^0,\ \rho(1450)^+ \to \omega\pi^+$	$0.39 \pm 0.04\ ^{+0.03}_{-0.03}$
$D_s^+[S] \to a_1(1260)^0\rho^+,\ a_1(1260)^0[S] \to \rho^+\pi^-$	$0.23 \pm 0.02\ ^{+0.01}_{-0.01}$
$D_s^+[P] \to a_1(1260)^0\rho^+,\ a_1(1260)^0[S] \to \rho^+\pi^-$	$0.50 \pm 0.04\ ^{+0.02}_{-0.02}$
$D_s^+ \to a_1(1260)^0\rho^+,\ a_1(1260)^0 \to \rho^+\pi^-$	$0.50 \pm 0.04\ ^{+0.02}_{-0.02}$
$D_s^+[S] \to a_1(1260)^0\rho^+,\ a_1(1260)^0[S] \to \rho^-\pi^+$	$0.16 \pm 0.02\ ^{+0.01}_{-0.01}$
$D_s^+[P] \to a_1(1260)^0\rho^+,\ a_1(1260)^0[S] \to \rho^-\pi^+$	$0.17 \pm 0.01\ ^{+0.01}_{-0.01}$
$D_s^+ \to a_1(1260)^0\rho^+,\ a_1(1260)^0 \to \rho^-\pi^+$	$0.33 \pm 0.02\ ^{+0.02}_{-0.02}$
$D_s^+[S] \to a_1(1260)^+\rho^0,\ a_1(1260)^+[S] \to \rho^+\pi^0$	$0.41 \pm 0.05\ ^{+0.05}_{-0.05}$
$D_s^+[P] \to a_1(1260)^+\rho^0,\ a_1(1260)^+[S] \to \rho^+\pi^0$	$0.31 \pm 0.04\ ^{+0.02}_{-0.02}$
$D_s^+ \to a_1(1260)^+\rho^0,\ a_1(1260)^+ \to \rho^+\pi^0$	$0.73 \pm 0.07\ ^{+0.07}_{-0.07}$
$D_s^+ \to b_1(1235)^+\pi^0,\ b_1(1235)^+[S] \to \omega\pi^+$	$0.53 \pm 0.05\ ^{+0.03}_{-0.03}$
$D_s^+ \to b_1(1235)^0\pi^+,\ b_1(1235)^0[S] \to \omega\pi^0$	$0.72 \pm 0.06\ ^{+0.05}_{-0.05}$

Amplitude	BF (%)
$D_s^+[S] \to \omega\rho^+$	$0.30 \pm 0.07\ ^{+0.02}_{-0.03}$
$D_s^+[P] \to \omega\rho^+$	$0.25 \pm 0.04\ ^{+0.04}_{-0.04}$
$D_s^+[D] \to \omega\rho^+$	$0.52 \pm 0.07\ ^{+0.04}_{-0.07}$
$D_s^+ \to \omega\rho^+$	$0.99 \pm 0.08\ ^{+0.05}_{-0.07}$
$D_s^+[S] \to \phi\rho^+$	$3.32 \pm 0.29\ ^{+0.19}_{-0.17}$
$D_s^+[P] \to \phi\rho^+$	$0.63 \pm 0.12\ ^{+0.05}_{-0.06}$
$D_s^+ \to \phi\rho^+$	$3.98 \pm 0.33\ ^{+0.21}_{-0.19}$

$D>S>P$

$S>P>D$



$$\frac{\mathcal{B}(\phi(1020) \to \pi^+\pi^-\pi^0)}{\mathcal{B}(\phi(1020) \to K^+K^-)} = 0.222 \pm 0.019_{\text{stat}} \pm 0.016_{\text{syst}}$$

Taking from $D_s^+ \to K^+K^-\pi^+\pi^0$ BESIII, PRD 104, 032011 (2021)

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

Naive prediction: PRL 128,011803

transverse dominates than longitudinal in charm decays

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

7.33fb^{-1} @ 4.178 – 4.226GeV , PRL 136, 161902 (2025)

2310 candidates with >78% purity

Measurement of $\phi \to K_S^0 K_L^0$

$$\mathcal{B}_{D_s^+ \to K_S^0 K_L^0 \pi^+} = (1.86 \pm 0.06_{\text{stat}} \pm 0.003_{\text{syst}})\%$$

Amplitude	Phase (rad)	BF (%)
$D_s^+ \to \phi\pi^+$	0.0 (fixed)	$1.31 \pm 0.05 \pm 0.03$
$D_s^+ \to K_L^0 K^*(892)^+$	$1.10 \pm 0.20 \pm 0.20$	$0.36 \pm 0.03 \pm 0.02$
$D_s^+ \to K_S^0 K^*(892)^+$	$-1.93 \pm 0.20 \pm 0.25$	$0.27 \pm 0.02 \pm 0.02$

$$\frac{\mathcal{B}(\phi(1020) \to K_S^0 K_L^0)}{\mathcal{B}(\phi(1020) \to K^+K^-)} = (0.593 \pm 0.023_{\text{stat}} \pm 0.014_{\text{syst}} \pm 0.016_{\phi\pi})$$

Taking from PDG

$\mathcal{B}(D_s^+ \to \phi\pi^+, \phi \to K^+K^-)$

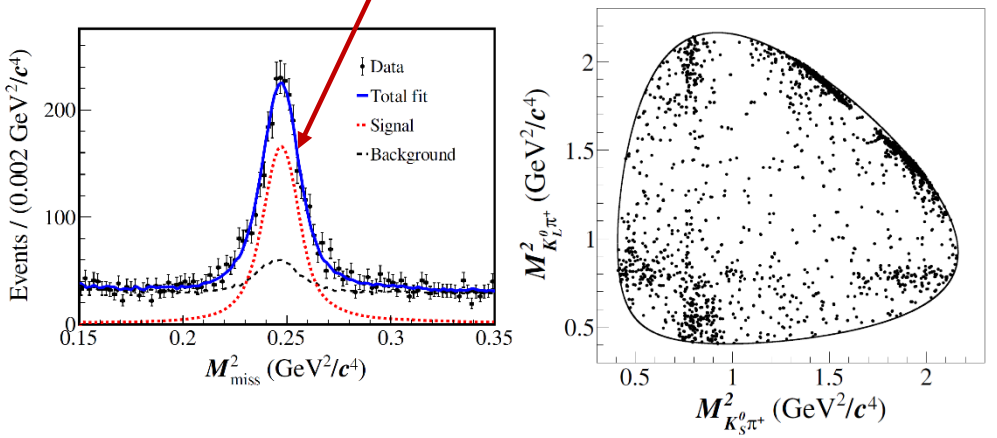
Deviates from PDG value (0.740±0.031) by >3σ

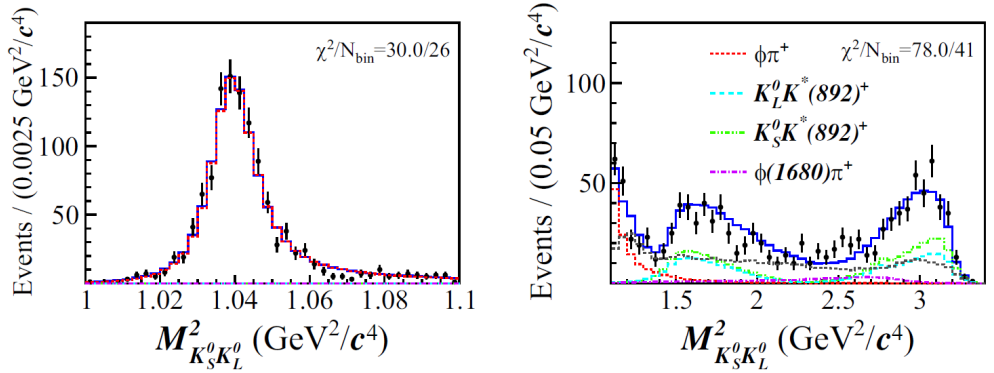
Measurement of $K_S^0 - K_L^0$ asymmetry

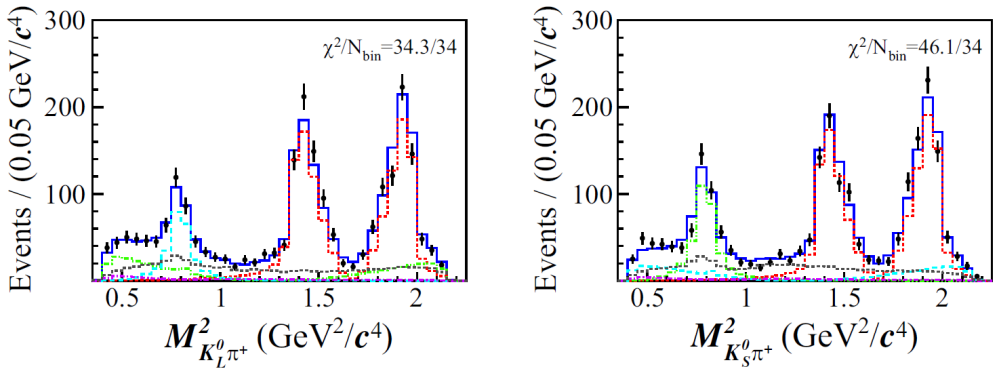
$$\frac{\mathcal{B}(D_s^+ \to K_S^0 K^*(892)^+) - \mathcal{B}(D_s^+ \to K_L^0 K^*(892)^+)}{\mathcal{B}(D_s^+ \to K_S^0 K^*(892)^+) + \mathcal{B}(D_s^+ \to K_L^0 K^*(892)^+)} = (-14.5 \pm 5.1_{\text{stat}} \pm 1.8_{\text{syst}})\%$$

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（2024）







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

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

11387 candidates with >67% purity

Measurement of $\phi \to K_S^0 K_L^0$

arXiv: 2605.11464

$$\mathcal{B}(D^+ \to K_S^0 K_L^0 \pi^+) = (5.780 \pm 0.085 \pm 0.052) \times 10^{-3}$$

Amplitude	Phase (rad)	BF (10^{-3})
$D^+ \to \phi\pi^+$	0.0(fixed)	$1.69 \pm 0.06 \pm 0.04$
$D^+ \to K_L^0 K^*(892)^+$	$2.34 \pm 0.09 \pm 0.09$	$2.33 \pm 0.06 \pm 0.03$
$D^+ \to K_S^0 K^*(892)^+$	$5.50 \pm 0.09 \pm 0.09$	$2.20 \pm 0.06 \pm 0.03$

$$\frac{\mathcal{B}(\phi(1020) \to K_S^0 K_L^0)}{\mathcal{B}(\phi(1020) \to K^+K^-)} = 0.628 \pm 0.022 \pm 0.015 \pm 0.017$$

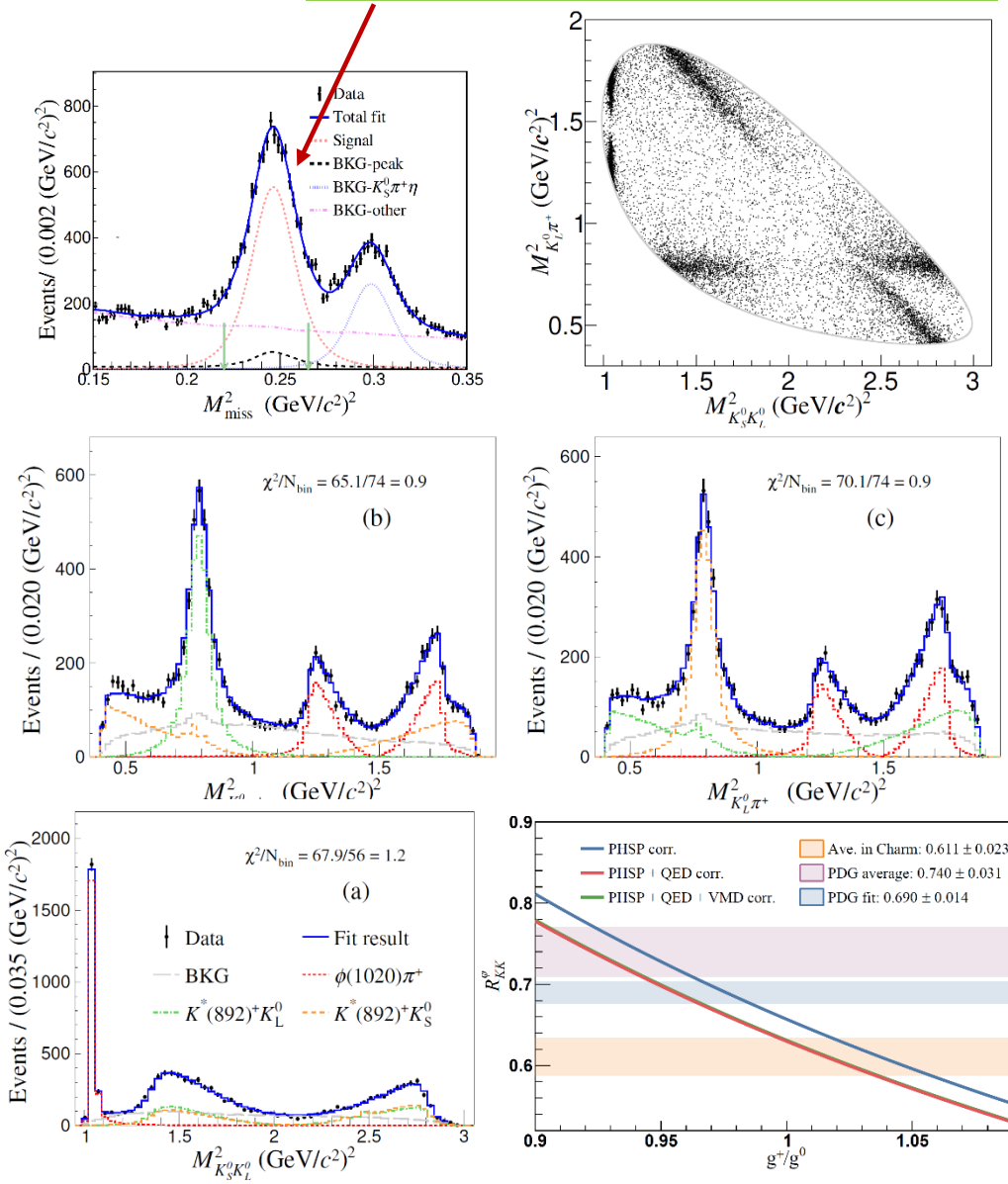
Taking from PDG

$\mathcal{B}(D^+ \to \phi\pi^+, \phi \to K^+K^-)$

Deviates from PDG value (0.740±0.031) by 2.5σ

Measurement of $K_S^0 - K_L^0$ asymmetry

$$\frac{\mathcal{B}(D^+ \to K_S^0 K^*(892)^+) - \mathcal{B}(D^+ \to K_L^0 K^*(892)^+)}{\mathcal{B}(D^+ \to K_S^0 K^*(892)^+) + \mathcal{B}(D^+ \to K_L^0 K^*(892)^+)} = (-2.9 \pm 1.6_{\text{stat.}} \pm 0.9_{\text{syst.}})\%$$



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

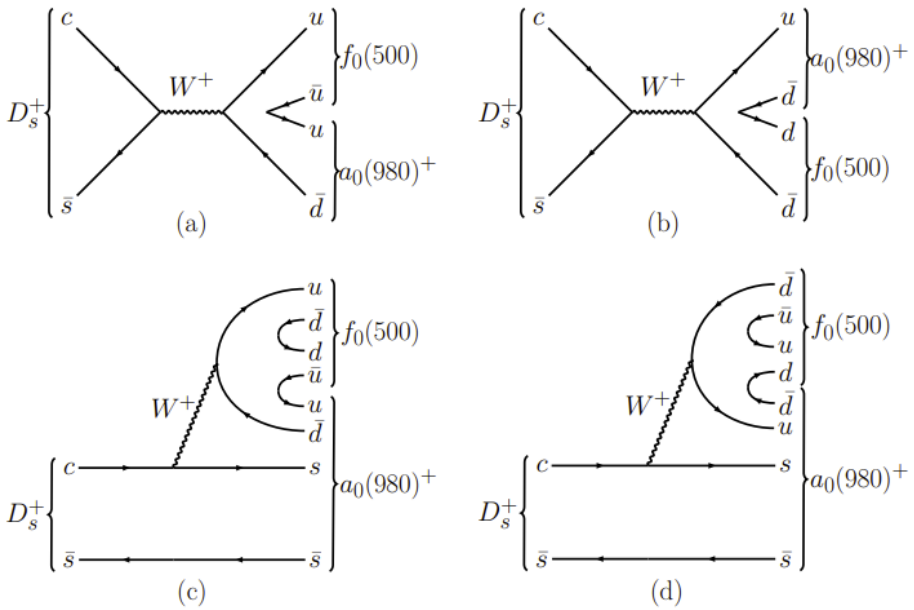
arXiv: 2603.18521

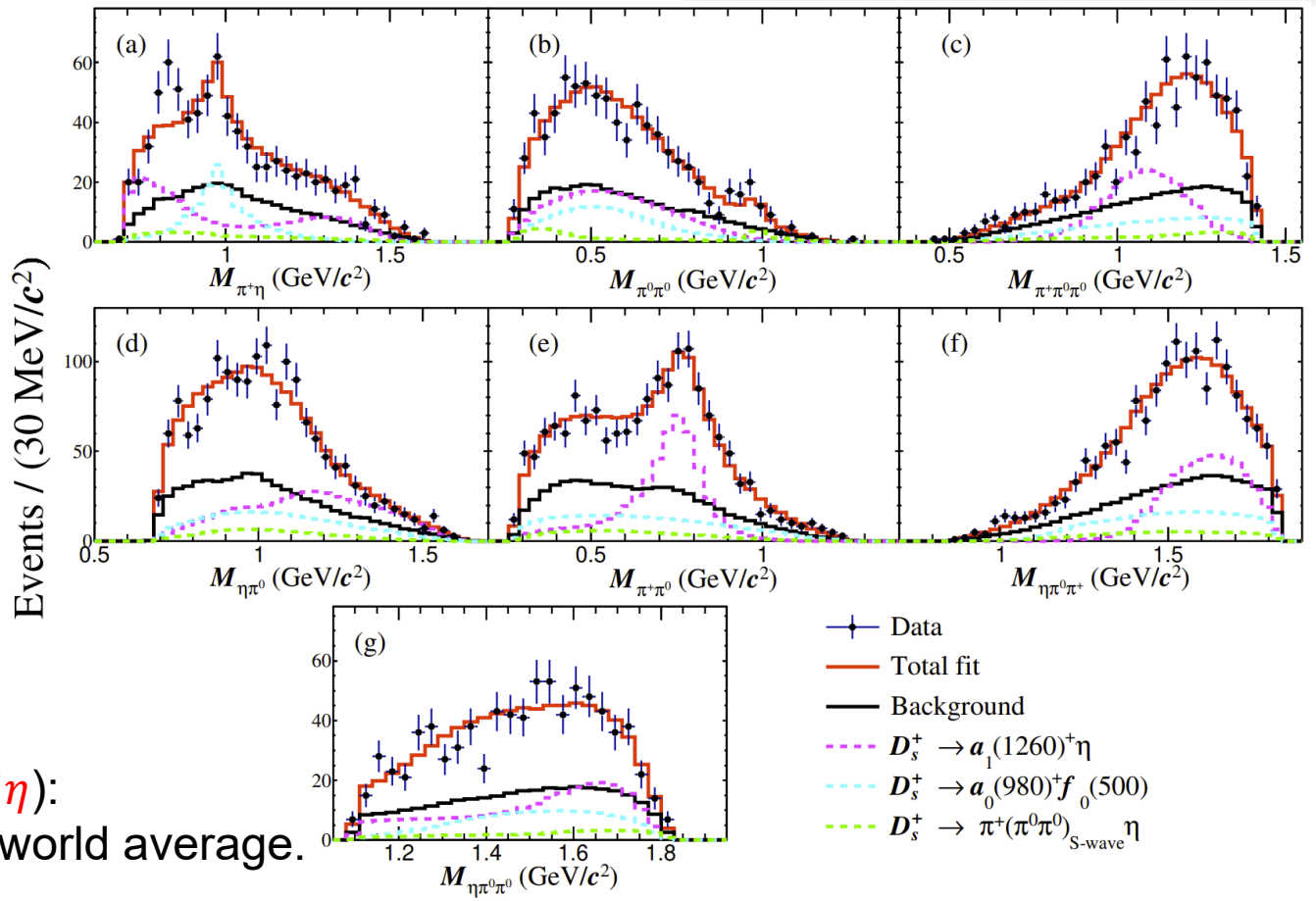
BESIII

Observation of $D_s^+ \to SS$ decay:

821 candidates with 58.3% purity

$$D_s^+ \to a_0(980)^+ f_0(500)$$





BF($D_s^+ \to a_1(1260)^+\eta$):
Consistent with the world average.

Large BF suggests a sizable tetraquark component and/or strong triangle-rescattering effects.

Amplitude	Phase (rad)	BF (%)
$D_s^+ \to a_1(1260)^+\eta, a_1(1260)^+ \to \rho(770)^+\pi^0$	0.0 (fixed)	$1.77 \pm 0.21 \pm 0.12$
$D_s^+ \to a_0(980)^+ f_0(500)$	$2.8 \pm 0.2 \pm 0.3$	$0.98 \pm 0.16 \pm 0.22$
$D_s^+ \to \pi^+(\pi^0\pi^0)_{S-\text{wave}}\eta$	$-0.8 \pm 0.2 \pm 0.3$	$0.28 \pm 0.06 \pm 0.13$

Amplitude analysis of $D^+ \to \pi^+\pi^{+(0)}\pi^{-(0)}\eta$

- Observation of $D \to SS$ decay:

arXiv: 2604.10444

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

$D^+ \to a_0(980)^+ f_0(500)$

- Observation of $D \to SV$ decays:

$D^+ \to a_0(980)^+\rho^0$ and $D^+ \to a_0(980)^0\rho^+$

$$r_{+/0} = \frac{\mathcal{B}(D^+ \to a_0^+\rho^0)}{\mathcal{B}(D^+ \to a_0^0\rho^+)} = 0.58 \pm 0.08 \pm 0.06$$

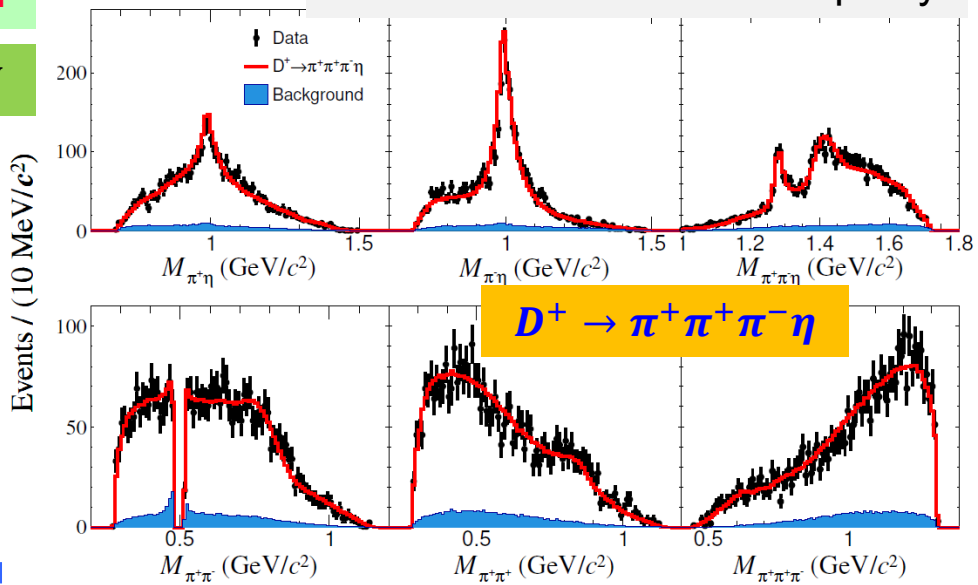
Amplitude	ϕ	BF($\times 10^{-4}$)
$D^+ \to \pi^+\pi^+\pi^-\eta$ decay:		
$D^+ \to a_0(980)^+\rho(770)^0$	0 (fixed)	$4.7 \pm 0.4 \pm 0.3$
$D^+ \to a_0(980)^+ f_0(500)$	$5.5 \pm 0.1 \pm 0.2$	$7.5 \pm 0.7 \pm 0.7$
$D^+ \to \eta(1405)\pi^+$	$2.4 \pm 0.1 \pm 0.1$	$3.6 \pm 0.5 \pm 0.5$
$D^+ \to f_1(1285)\pi^+$	$4.9 \pm 0.1 \pm 0.3$	$5.5 \pm 0.3 \pm 0.3$
$D^+ \to f_1(1420)\pi^+$	$6.2 \pm 0.1 \pm 0.1$	$5.2 \pm 0.5 \pm 0.8$
$D^+ \to [a_0(980)^\pm\pi^\mp]_{S-wave}\pi^+$	$3.5 \pm 0.1 \pm 0.3$	$11.0 \pm 0.9 \pm 1.0$
$D^+ \to \pi^+\pi^0\pi^0\eta$ decay:		
$D^+ \to a_0(980)^0\rho(770)^+$	0 (fixed)	$8.5 \pm 0.9 \pm 0.6$
$D^+ \to a_0(980)^+ f_0(500)$	$0.4 \pm 0.1 \pm 0.0$	$8.4 \pm 0.8 \pm 0.3$
$D^+ \to \eta(1405)\pi^+$	$2.6 \pm 0.3 \pm 0.2$	$1.0 \pm 0.4 \pm 0.2$
$D^+ \to f_1(1285)\pi^+$	$2.9 \pm 0.2 \pm 0.3$	$3.1 \pm 0.5 \pm 0.2$
$D^+ \to f_1(1420)\pi^+$	$5.9 \pm 0.2 \pm 0.3$	$4.3 \pm 0.8 \pm 0.4$
$D^+ \to [a_0(980)^0\pi^0]_{S-wave}\pi^+$	$4.4 \pm 0.2 \pm 0.2$	$2.7 \pm 0.6 \pm 0.2$

$\mathcal{B}(D^0 \to \pi^+\pi^+\pi^-\eta) = (3.20 \pm 0.06 \pm 0.03)\%$

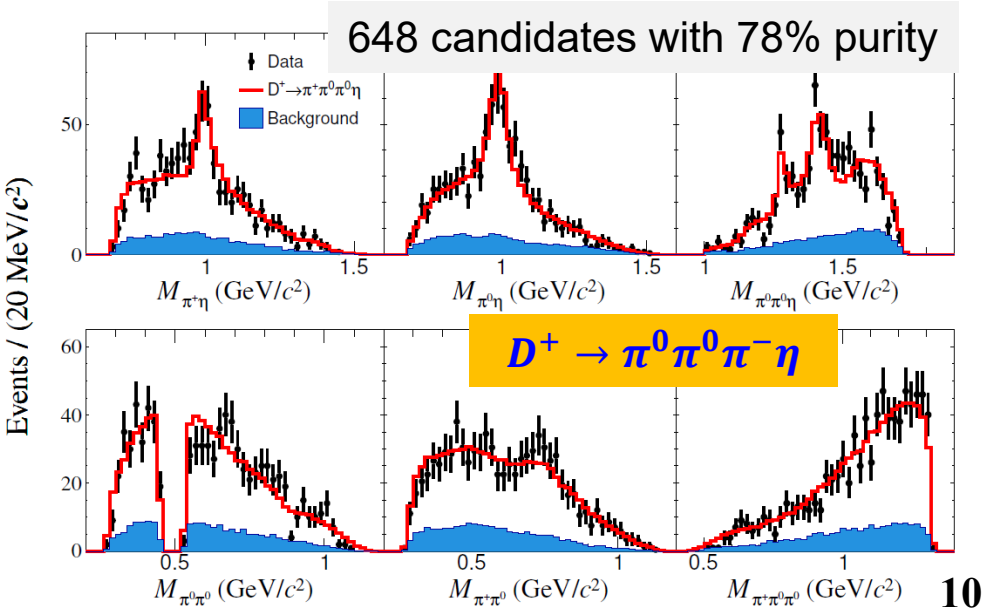
$\mathcal{B}(D^+ \to \pi^+\pi^0\pi^0\eta) = (2.43 \pm 0.11 \pm 0.04)\%$

No $a_1(1260)$ is observed

3122 candidates with 89% purity



648 candidates with 78% purity



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

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

7.9 fb^{-1}@$E_{\rm cm}$ = 3.773GeV,
PRD 110, L111102 (2024)

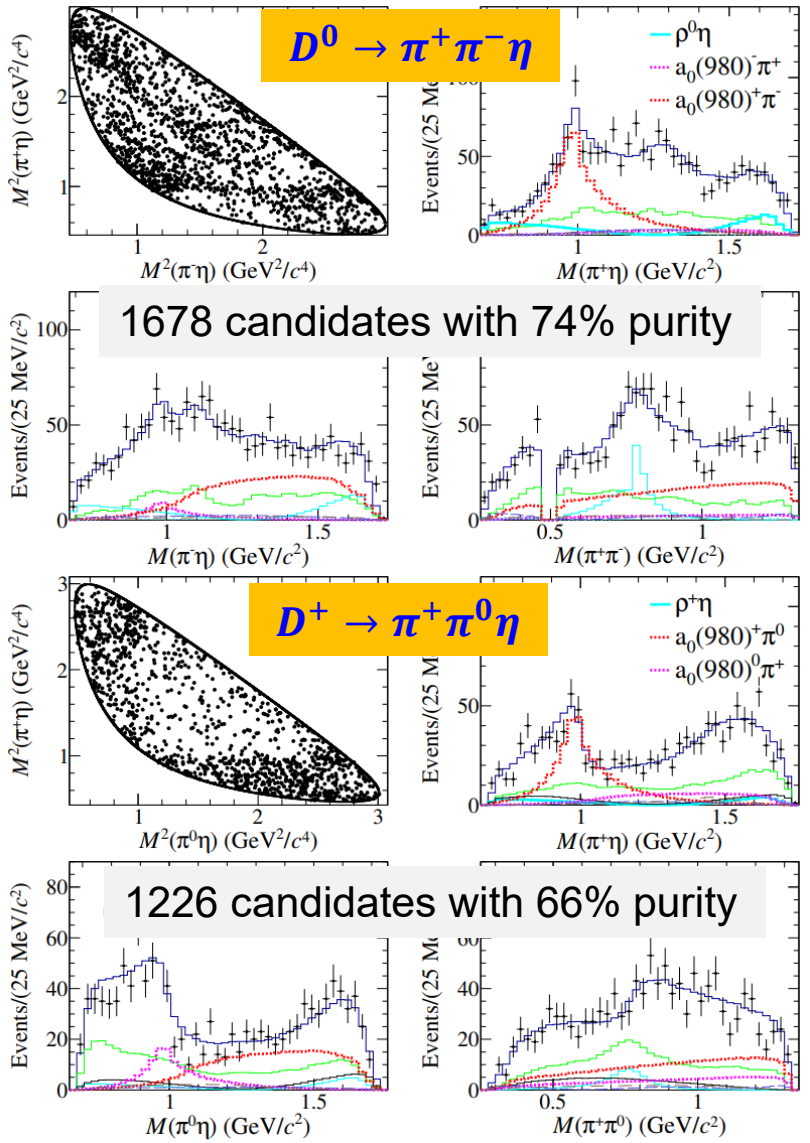
$\mathcal{B}(D^0 \to \pi^+\pi^-\eta) = (1.24 \pm 0.04 \pm 0.03)\%$

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

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

$$\mathcal{B}(D^0 \to a_0(980)^+\pi^-)/\mathcal{B}(D^0 \to a_0(980)^-\pi^+) = 7.5^{+2.5}_{-0.8\,\rm stat.} \pm 1.7_{\rm syst.}$$
$$\mathcal{B}(D^+ \to a_0(980)^+\pi^0)/\mathcal{B}(D^+ \to a_0(980)^0\pi^+) = 2.6 \pm 0.6_{\rm stat.} \pm 0.3_{\rm syst.}$$

→ **Disagrees with theoretical predictions by orders of magnitude**



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

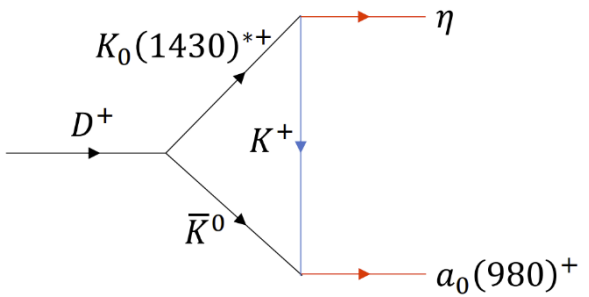
arXiv: 2505.12086 submitted to PRL
arXiv: 2606.17724 accepted by PRD

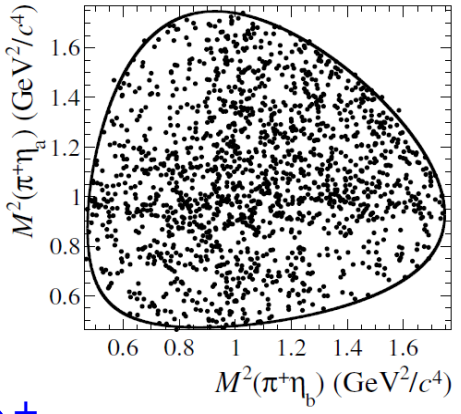
BESIII

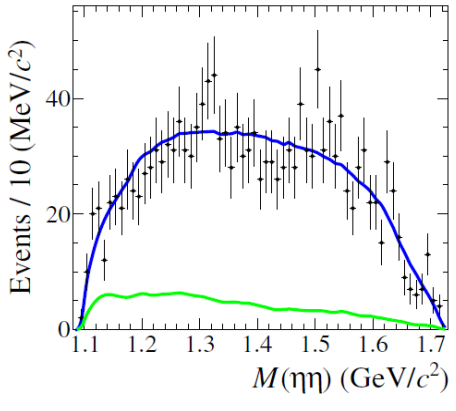
20.3fb^{-1} @3.773GeV

1624 candidates with 85% purity

- First observation of an altered $a_0(980)$ line-shape due to triangle loop rescattering







Fit1: $P_{a_0(980)}$ three-channel coupled Flatte formulae,
the fitted pole position is inconsistent with previous measurement.

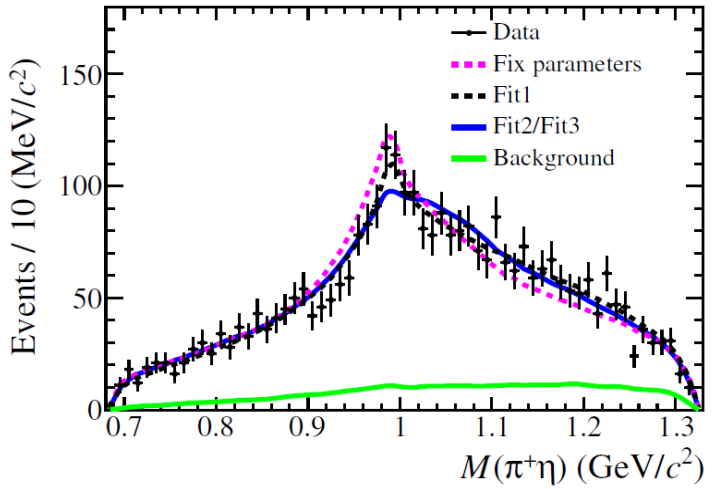
To consider the rescattering process $D^+ \to \bar{K}_0^*(1430)^0 K^+ \to a_0(980)^+\eta$

we perform Fit2 and Fit3

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

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

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



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

- **BF measurement**

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

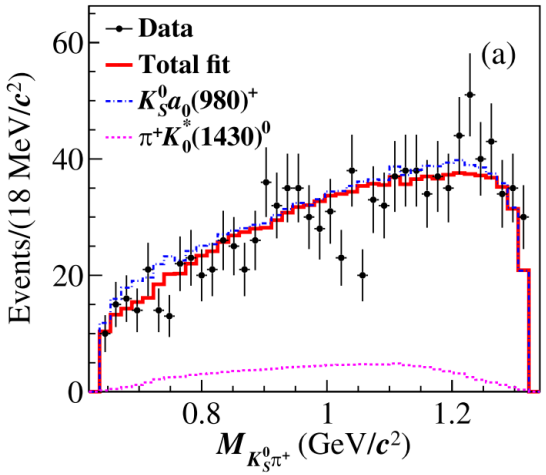
Amplitude analysis of $D^+ \to K_S^0\pi^+\eta$

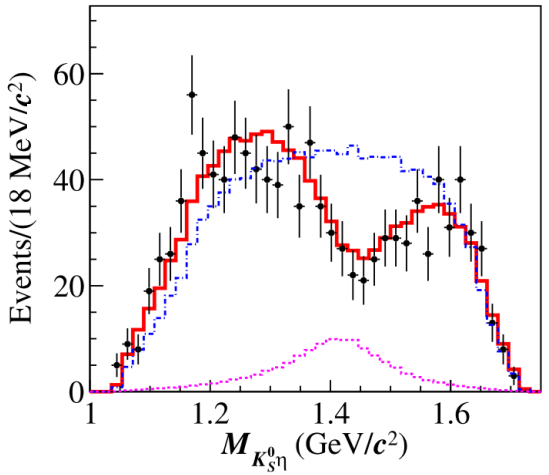
PRL 132, 131903 (2024)

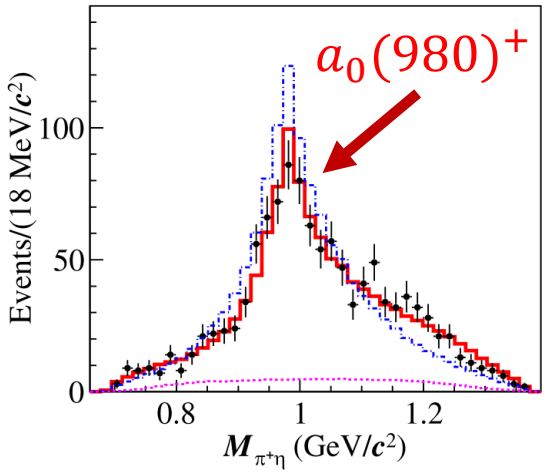
BESIII

2.93fb^{-1} @3.773GeV

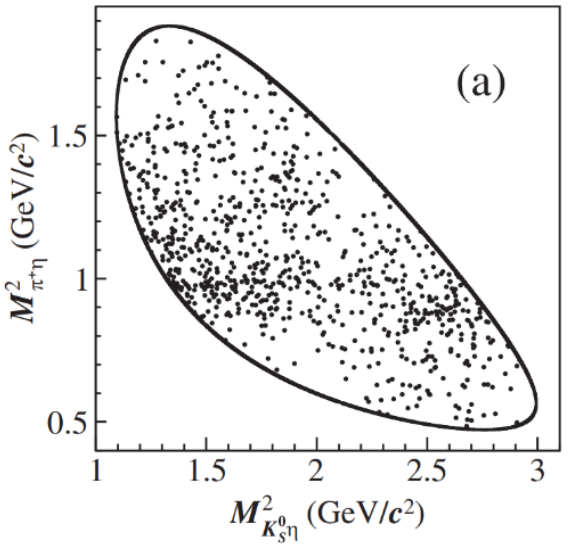
Observation of *W*-annihilation-free decay $D^+ \to K_S^0 a_0(980)^+$







1113 candidates with 98% purity

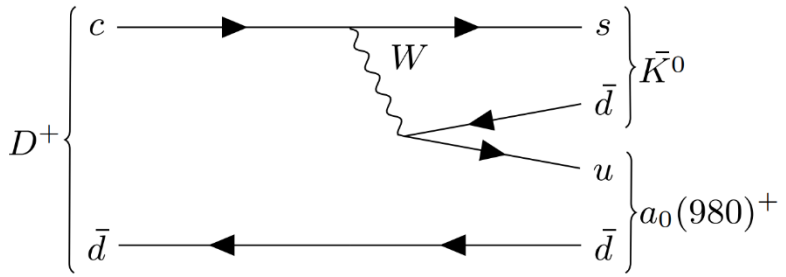


$$\mathcal{B}(D^+ \to K_S^0 a_0(980)^+, a_0(980)^+ \to \pi^+\eta) = (1.33 \pm 0.05_{\text{stat}} \pm 0.04_{\text{syst}})\%$$

$$\mathcal{B}(D^+ \to \bar{K}_0^*(1430)^0\pi^+, \bar{K}_0^*(1430)^0 \to K_S^0\eta) = (0.14 \pm 0.02_{\text{stat}} \pm 0.02_{\text{syst}})\%$$

$$\mathcal{B}(D^+ \to K_S^0\pi^+\eta) = (1.27 \pm 0.04_{\text{stat}} \pm 0.03_{\text{syst}})\%$$

Provide sensitive constraints in the extraction of contributions from internal W-emission diagrams



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

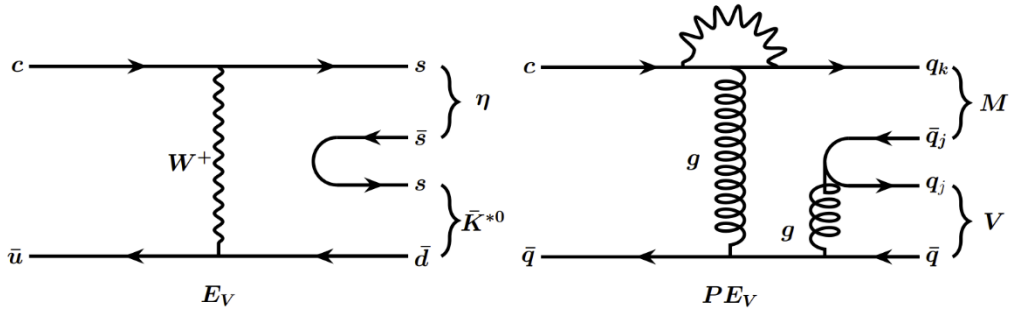
$D^0 \to \eta\bar{K}^*(892)^0$

20.3fb^{-1} @ 3.773GeV, arXiv:2512.23389

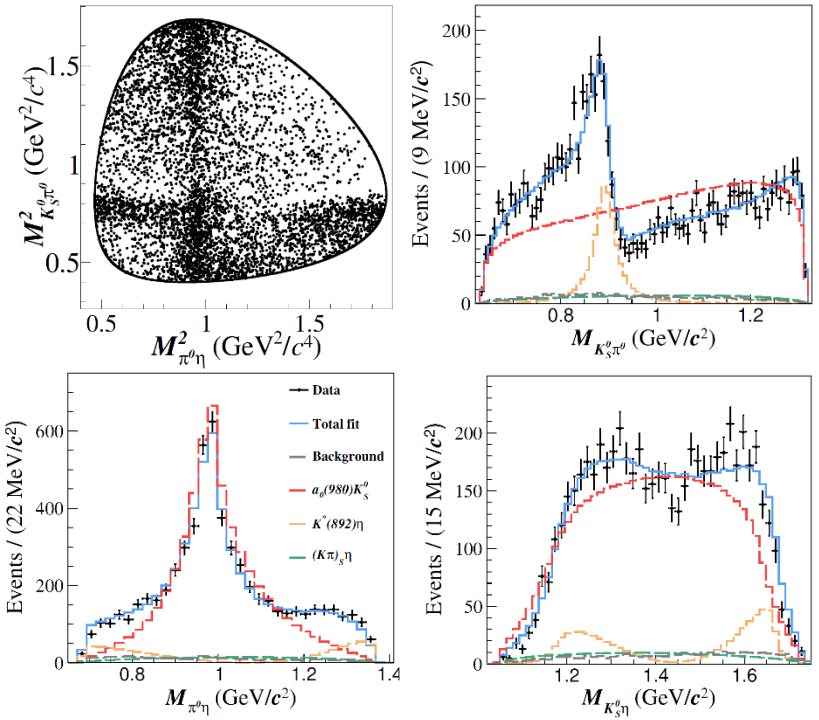
6070 candidates with 94.6% purity

Impacts predictions from the topological diagram approach,

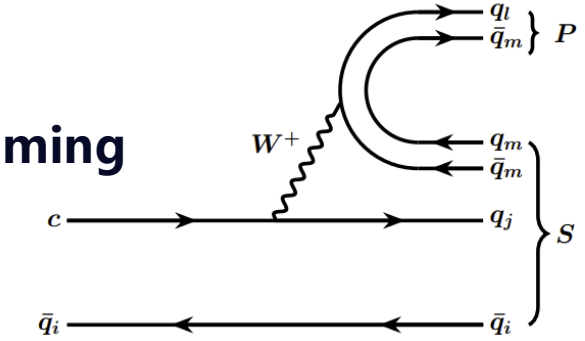
affecting CP violation and DCS branching fraction estimates.



The BF determines the magnitude of E_V → E_V determines the magnitude of the penguin diagram PE_V → PE_V affects predictions for DCS decays and CP violation calculations.



$D^0 \to K_S^0 a_0(980)^0$



- **Consistent with the prediction assuming $a_0(980)^0$ is a tetraquark state.**
- **Helps determine the $\bar{T}$-diagram contribution under the tetraquark scenario.**

$$\mathcal{B}(D^0 \to K_S^0 a_0(980)^0, a_0(980)^0 \to \pi^0\eta) = (9.88 \pm 0.37_{\text{stat.}} \pm 0.42_{\text{syst.}}) \times 10^{-3}$$

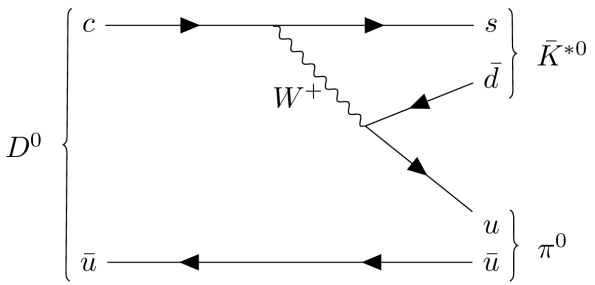
Amplitude	BF (10^{-3})
$D^0 \to K_S^0 a_0(980)^0, a_0(980)^0 \to \pi^0\eta$	$9.88 \pm 0.37 \pm 0.42$
$D^0 \to K_S^0 a_2(1320)^0, a_2(1320)^0 \to \pi^0\eta$	$0.08 \pm 0.11 \pm 0.11$
$D^0 \to \bar{K}^*(892)^0\eta, \bar{K}^*(892)^0 \to K_S^0\pi^0$	$1.22 \pm 0.09 \pm 0.11$
$D^0 \to \bar{K}^*(1410)^0\eta, \bar{K}^*(1410)^0 \to K_S^0\pi^0$	$0.56 \pm 0.14 \pm 0.16$
$D^0 \to (K_S^0\pi^0)_{S-\text{wave}}\eta$	$0.64 \pm 0.10 \pm 0.10$
$D^0 \to \bar{K}^*(1680)^0\pi^0, \bar{K}^*(1680)^0 \to K_S^0\eta$	$0.19 \pm 0.07 \pm 0.05$
$D^0 \to \bar{K}_2^*(1980)^0\pi^0, \bar{K}_2^*(1980)^0 \to K_S^0\eta$	$0.45 \pm 0.15 \pm 0.16$

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

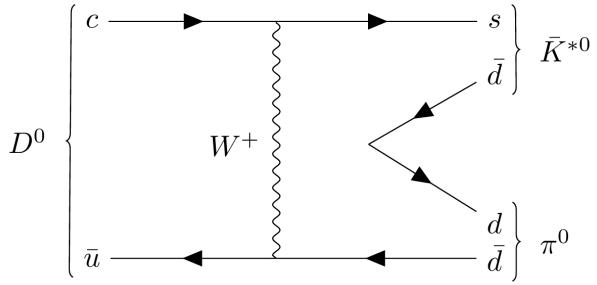
20.3fb^{-1} @ 3.773GeV, JHEP03(2026)060

19117 candidates with >93% purity

Dominant contribution: $D^0 \to \bar{K}^*(892)^0\pi^0$

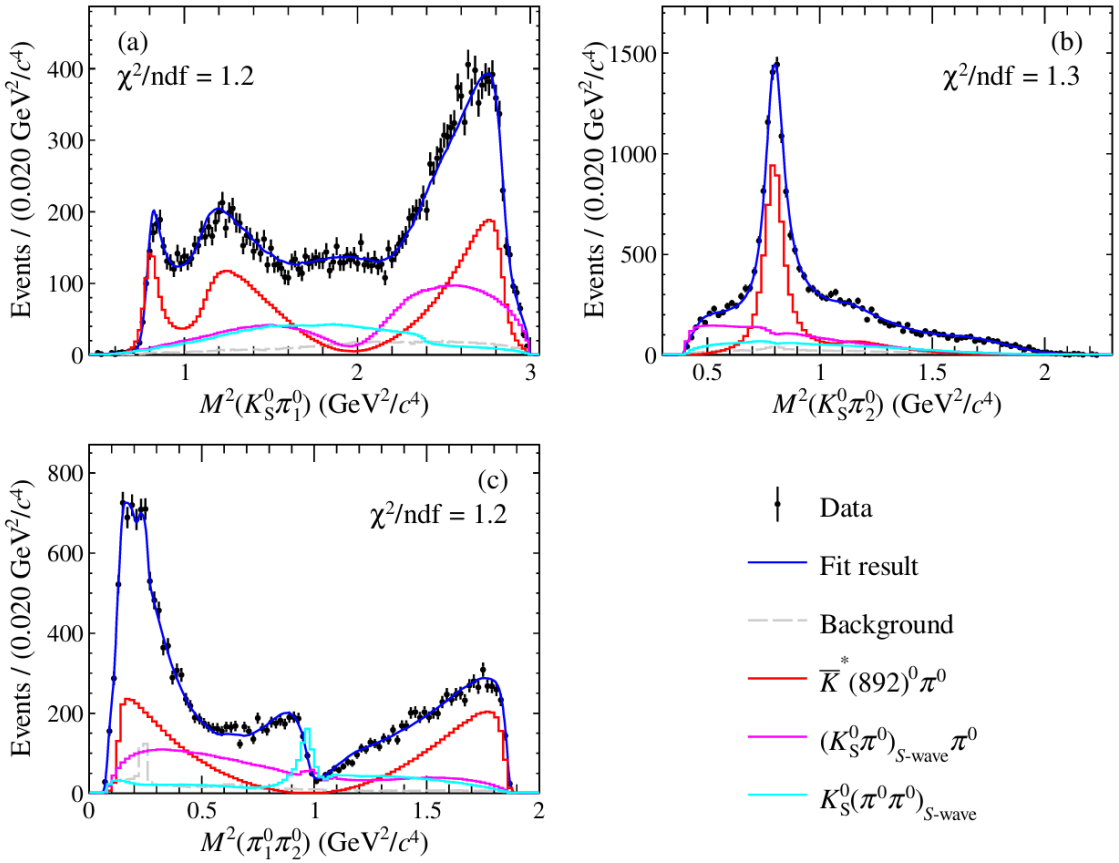


W-internal emission



W-exchange

Amplitude	$\mathcal{B}(D^0 \to \bar{K}^{*0}\pi^0)$ (%)
TDA	3.61±0.18
FAT [mix]	3.25
pole	2.9±1.0
CLEO [from $D^0 \to K^-\pi^+\pi^0$]	2.74±0.23(stat.)±0.41(syst.)
CLEO [from $D^0 \to K_S^0\pi^0\pi^0$]	4.16±0.37(stat.)±0.33(syst.)
This work	2.46 ± 0.06(stat.) ± 0.04(syst.)



Precise BF measurement of $D^0 \to K_S^0\pi^0\pi^0$

$$\mathcal{B}(D^0 \to K_S^0\pi^0\pi^0) = \left(1.026 \pm 0.008_{\text{stat.}} \pm 0.009_{\text{syst.}}\right)\%$$

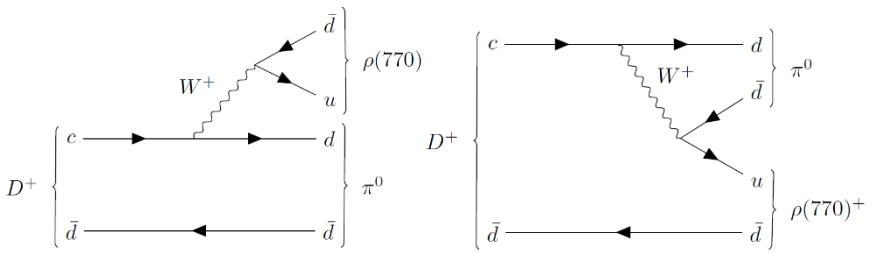
consistent with PDG value $(0.91 \pm 0.11)\%$
with precision improved by a factor of 10

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

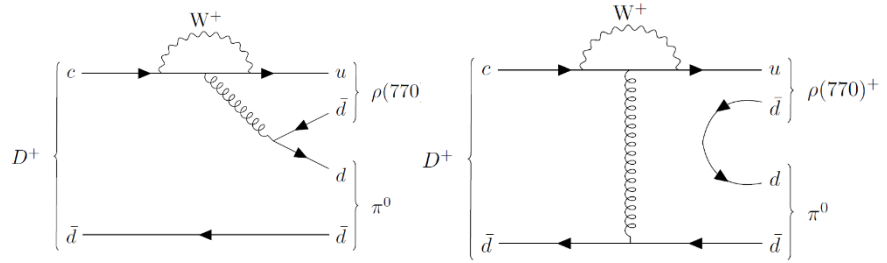
First observation of $D^+ \to \rho(770)^+\pi^0$

20.3fb^{-1} @ 3.773GeV, JHEP07(2026)029

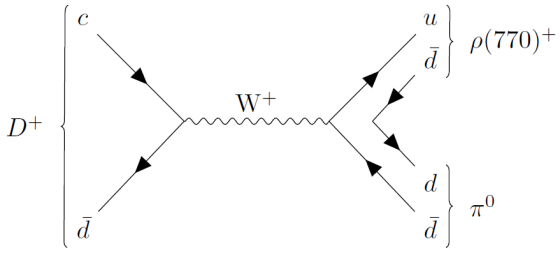
13498 candidates with >87% purity



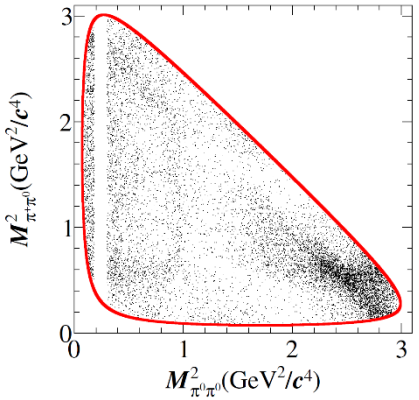
W-external emission　　W-internal emission

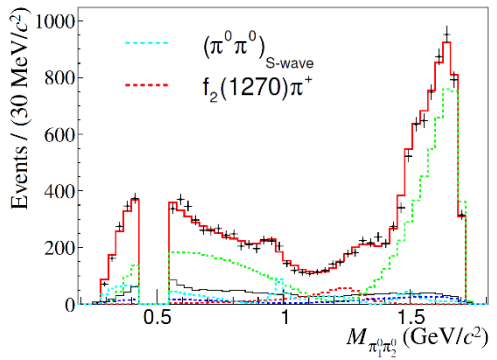


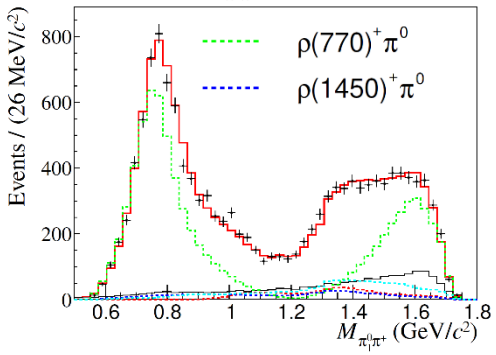
QCD penguin　　QCD penguin exchange

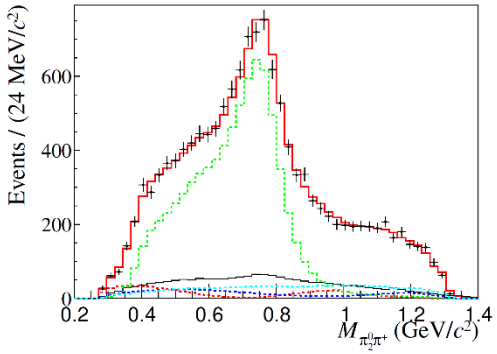


W-annihilation









$$\mathcal{B}(D^+ \to \rho(770)^+\pi^0) = \left(3.08 \pm 0.10_{\text{stat.}} \pm 0.05_{\text{syst.}}\right) \times 10^{-3}$$

$$\mathcal{B}(D^+ \to \pi^+\pi^0\pi^0) = \left(4.84 \pm 0.05_{\text{stat.}} \pm 0.05_{\text{syst.}}\right) \times 10^{-3}$$

CP asymmetry

Decay mode	D^+ FF (%)	D^- FF (%)	A_{CP}(%)
$D^{+(-)} \to \rho(770)^{+(-)}\pi^0$	$66.2 \pm 2.7 \pm 1.5$	$61.5 \pm 2.6 \pm 1.3$	$+3.7 \pm 2.9 \pm 1.5$
$D^{+(-)} \to \rho(1450)^{+(-)}\pi^0$	$4.7 \pm 0.8 \pm 0.7$	$6.7 \pm 1.0 \pm 0.9$	$-17.5 \pm 9.8 \pm 7.0$
$D^{+(-)} \to f_2(1270)\pi^{+(-)}$	$4.3 \pm 0.4 \pm 0.3$	$4.5 \pm 0.5 \pm 0.3$	$-2.2 \pm 6.6 \pm 3.6$
$D^{+(-)} \to (\pi^0\pi^0)_{S\text{-wave}}\pi^{+(-)}$	$12.8 \pm 1.3 \pm 0.8$	$10.5 \pm 1.1 \pm 0.7$	$+10.2 \pm 6.6 \pm 3.8$

$$A_{\text{CP}} = \left(-1.4 \pm 1.0_{\text{stat.}} \pm 0.6_{\text{syst.}}\right)\%$$

No evidence for CP violation is observed!

Amplitude analysis of $D^0 \to K^0_{S,L}\pi^+\pi^+$

arXiv: 2610.13101

20.3fb^{-1} @3.773GeV

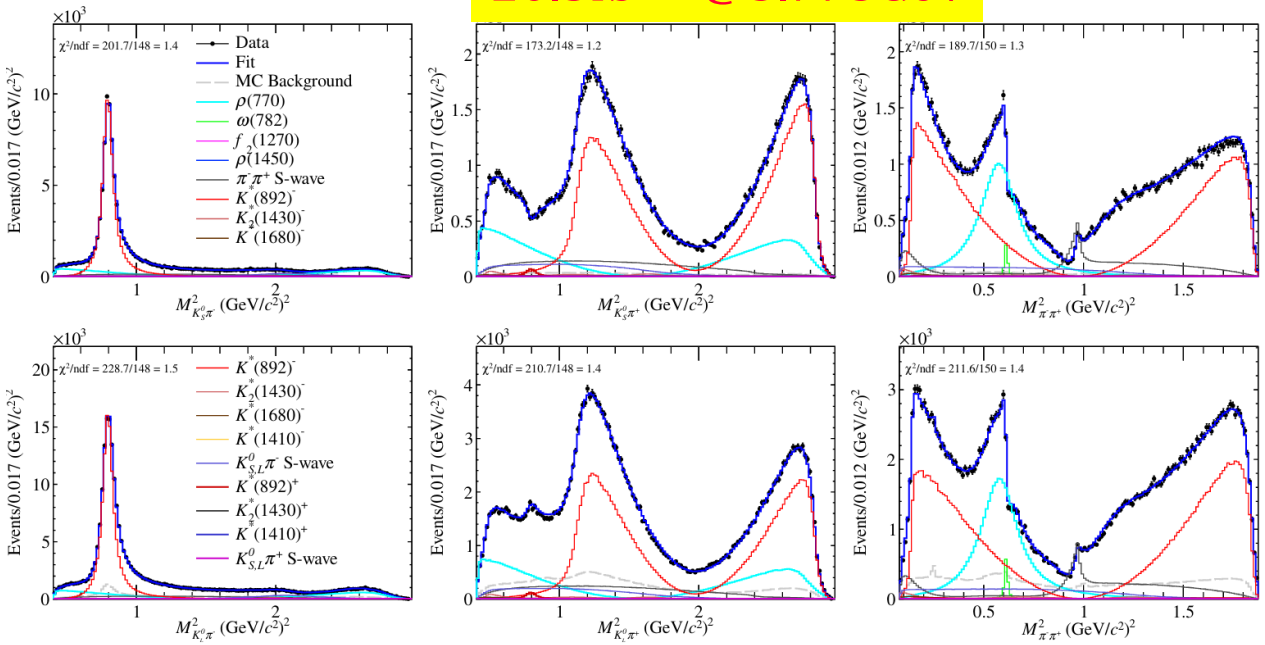
$K^0_S - K^0_L$ asymmetry ⟷ U-spin breaking parameter

$$\mathcal{R}(D,\pi\pi) = \frac{\mathcal{B}(D \to K^0_S\pi^+\pi^-) - \mathcal{B}(D \to K^0_L\pi^+\pi^-)}{\mathcal{B}(D \to K^0_S\pi^+\pi^-) + \mathcal{B}(D \to K^0_L\pi^+\pi^-)} \simeq 2\tan^2\theta_C\,\mathrm{Re}[\hat{\rho}],$$

Resonance	$\lvert\hat{\rho}\rvert$	$\arg(\hat{\rho})$ [rad]	$\lvert 1-2\hat{\rho}\tan^2\theta_C\rvert^2$
$\rho(770)$	$0.62 \pm 0.09 \pm 0.06$	$-2.73 \pm 0.16 \pm 0.27$	$1.13 \pm 0.02 \pm 0.02$
$\omega(782)$	$1.56 \pm 0.53 \pm 0.29$	$-2.78 \pm 0.25 \pm 0.16$	$1.34 \pm 0.13 \pm 0.07$
$f_2(1270)$	$3.34 \pm 0.34 \pm 0.19$	$-0.73 \pm 0.09 \pm 0.05$	$0.59 \pm 0.05 \pm 0.03$
$\rho(1450)$	$4.45 \pm 0.83 \pm 0.60$	$1.30 \pm 0.19 \pm 0.14$	$0.97 \pm 0.18 \pm 0.13$
$\pi\pi$ S-wave	$0.77 \pm 0.13 \pm 0.17$	$-1.74 \pm 0.13 \pm 0.11$	$1.04 \pm 0.02 \pm 0.02$

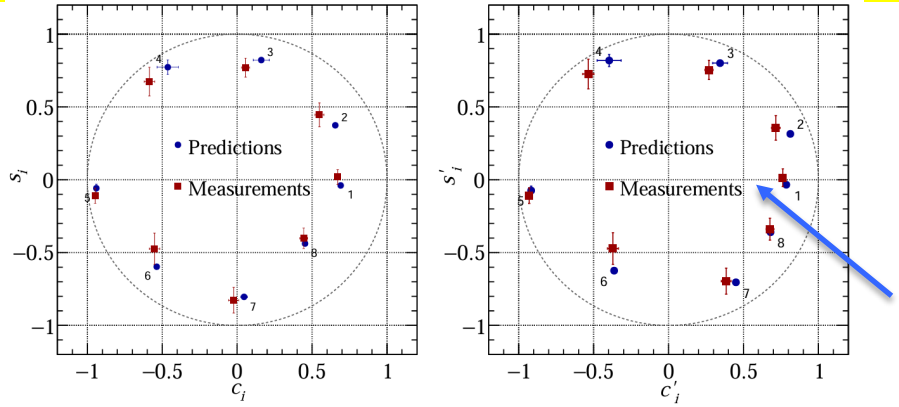
Obvious asymmetry

Resonance	Phase (rad)	$K^0_S\pi^+\pi^-$ FF (%)	$K^0_L\pi^+\pi^-$ FF (%)
$K^0_{S,L}\rho(770)$	0.0	$19.68 \pm 0.24 \pm 0.26$	$19.50 \pm 0.22 \pm 0.31$
$K^0_{S,L}\omega(782)$	$1.87 \pm 0.04 \pm 0.04$	$0.50 \pm 0.03 \pm 0.03$	$0.58 \pm 0.03 \pm 0.03$
$K^0_{S,L}f_2(1270)$	$-0.70 \pm 0.03 \pm 0.04$	$0.94 \pm 0.06 \pm 0.05$	$0.49 \pm 0.04 \pm 0.03$
$K^0_{S,L}\rho(1450)$	$1.48 \pm 0.06 \pm 0.12$	$0.24 \pm 0.05 \pm 0.04$	$0.21 \pm 0.03 \pm 0.04$
$K^0_{S,L}\pi\pi$ S-wave		$11.51 \pm 0.20 \pm 0.24$	$10.47 \pm 0.17 \pm 0.22$
β_1	$1.27 \pm 0.01 \pm 0.02$		
β_2	$0.35 \pm 0.01 \pm 0.04$		
f_{11}^{prod}	$-2.24 \pm 0.01 \pm 0.06$		
f_{12}^{prod}	$-2.57 \pm 0.03 \pm 0.07$		
$K^*(892)^-\pi^+$	$5.47 \pm 0.01 \pm 0.02$	$57.88 \pm 0.23 \pm 0.37$	$57.71 \pm 0.19 \pm 0.28$
$K_2^*(1430)^-\pi^+$	$-0.77 \pm 0.02 \pm 0.03$	$1.28 \pm 0.05 \pm 0.08$	$1.27 \pm 0.05 \pm 0.08$
$K^*(1680)^-\pi^+$	$-5.12 \pm 0.05 \pm 0.10$	$0.65 \pm 0.08 \pm 0.12$	$0.60 \pm 0.07 \pm 0.11$
$K^0_{S,L}\pi^-$ S-wave π^+	$1.65 \pm 0.01 \pm 0.04$	$6.44 \pm 0.12 \pm 0.35$	$6.35 \pm 0.11 \pm 0.35$
$K^*(892)^+\pi^-$	$-3.85 \pm 0.03 \pm 0.03$	$0.40 \pm 0.02 \pm 0.03$	$0.40 \pm 0.02 \pm 0.03$
Resonance	Phase (rad)	$K^0_S\pi^+\pi^-$ FF ($\times 10^{-4}$)	$K^0_L\pi^+\pi^-$ FF ($\times 10^{-4}$)
$K^*(1410)^-\pi^+$	$4.25 \pm 0.15 \pm 0.29$	$1.76 \pm 0.96 \pm 0.67$	$1.74 \pm 0.95 \pm 0.65$
$K_2^*(1430)^+\pi^-$	$-2.13 \pm 0.14 \pm 0.10$	$1.12 \pm 0.40 \pm 0.30$	$1.11 \pm 0.30 \pm 0.29$
$K^*(1410)^+\pi^-$	$-1.63 \pm 0.13 \pm 0.09$	$1.83 \pm 0.50 \pm 0.22$	$1.82 \pm 0.50 \pm 0.26$
$K^0_{S,L}\pi^+$ S-wave π^-	$1.92 \pm 0.07 \pm 0.08$	$4.56 \pm 0.80 \pm 0.38$	$4.50 \pm 0.80 \pm 0.49$
Total		$99.52 \pm 0.25 \pm 0.63$	$97.58 \pm 0.21 \pm 0.64$



The amplitude model can reduce model-dependent systematic effects in strong-phase measurements.

Model-predicted strong-phase parameters



JHEP **06** (2025) 086

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

arXiv: 2603.25649

791 candidates with 94.2% purity

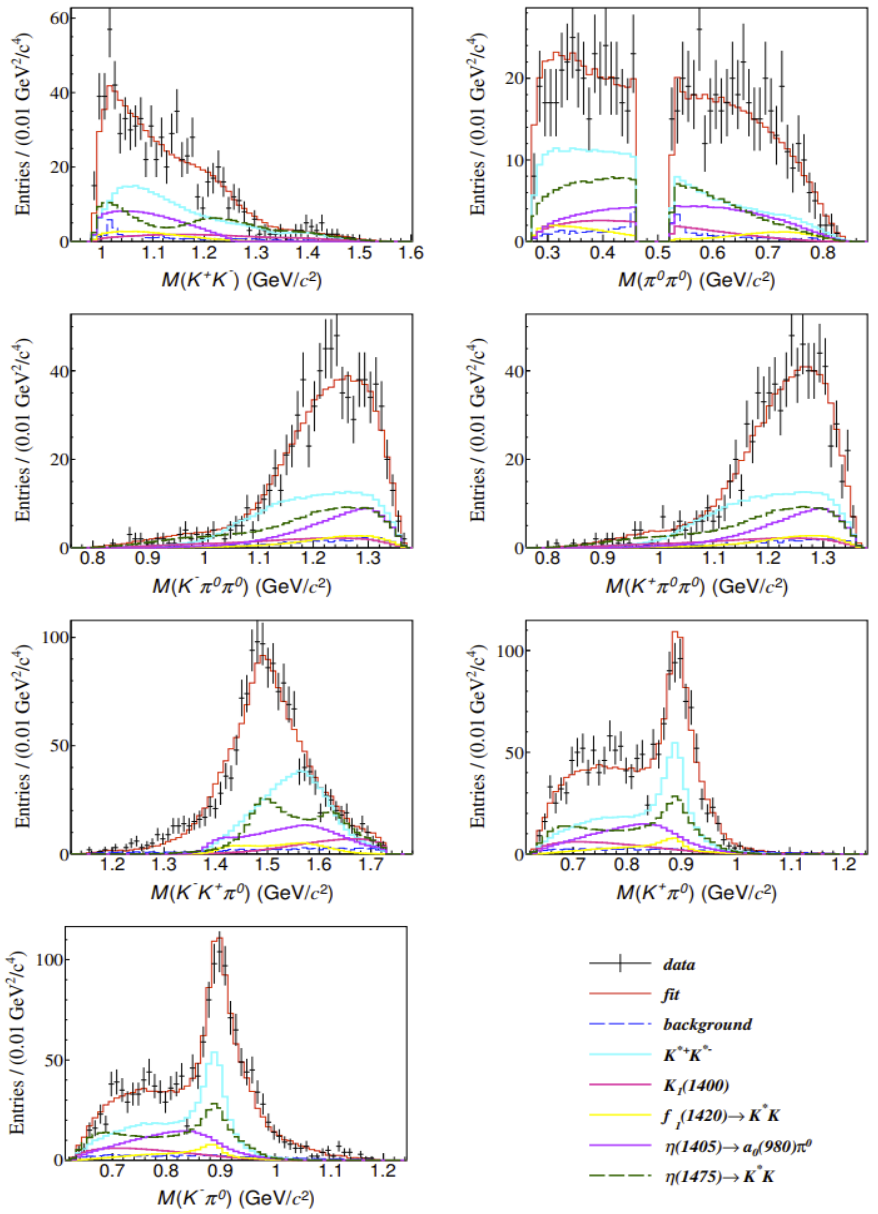
Dominant contribution:

$$\mathrm{BF}(D^+ \to K^*(892)^+K^*(892)^-) = (2.79 \pm 0.13_{\mathrm{stat.}} \pm 0.11_{\mathrm{syst.}}) \times 10^{-3}$$

Longitudinal polarization fraction:

$$F_L(D^0 \to K^*(892)^+K^*(892)^-) = 0.468 \pm 0.046_{\mathrm{stat.}} \pm 0.011_{\mathrm{syst.}}$$

Amplitude	Phase ϕ_n (rad)	FF (%)	BF ($\times 10^{-4}$)
$D^0[S] \to K^*(892)^+K^*(892)^-$	0.0 (fixed)	$26.8 \pm 3.5 \pm 1.7$	
$D^0[P] \to K^*(892)^+K^*(892)^-$	$3.00 \pm 0.16 \pm 0.11$	$8.0 \pm 1.8 \pm 0.9$	
$D^0[D] \to K^*(892)^+K^*(892)^-$	$5.33 \pm 0.20 \pm 0.13$	$4.4 \pm 1.5 \pm 0.5$	
$D^0 \to K^*(892)^+K^*(892)^-$	-	$40.2 \pm 4.2 \pm 1.5$	$2.90 \pm 0.34 \pm 0.12$
$D^0 \to K_1(1400)^+(\to K^*(892)^+\pi^0)K^-$	$1.17 \pm 0.18 \pm 0.12$	$8.3 \pm 2.0 \pm 1.5$	$0.59 \pm 0.18 \pm 0.11$
$D^0 \to f_1(1420)(\to K^*(892)^+K^-)\pi^0$	$1.38 \pm 0.17 \pm 0.24$	$3.1 \pm 0.8 \pm 0.5$	
$D^0 \to f_1(1420)(\to K^*(892)^-K^+)\pi^0$	$1.38 \pm 0.17 \pm 0.24$	$3.1 \pm 0.8 \pm 0.5$	
$D^0 \to f_1(1420)\pi^0$	-	$8.1 \pm 2.1 \pm 1.1$	$0.58 \pm 0.16 \pm 0.08$
$D^0 \to \eta(1405)(\to a_0(980)\pi^0)\pi^0$	$2.25 \pm 0.26 \pm 0.30$	$19.0 \pm 2.9 \pm 1.9$	$1.37 \pm 0.20 \pm 0.14$
$D^0 \to \eta(1475)(\to K^*(892)^-K^+)\pi^0$	$1.20 \pm 0.15 \pm 0.20$	$14.8 \pm 1.7 \pm 1.2$	
$D^0 \to \eta(1475)(\to K^*(892)^+K^-)\pi^0$	$1.20 \pm 0.15 \pm 0.20$	$14.8 \pm 1.7 \pm 1.2$	
$D^0 \to \eta(1475)\pi^0$	-	$33.7 \pm 3.9 \pm 2.4$	$2.42 \pm 0.44 \pm 0.18$



Doubly Cabibbo-suppressed Decays

SU(3) Relations between DCS and CF D decays: arXiv:hep-ph/0210166

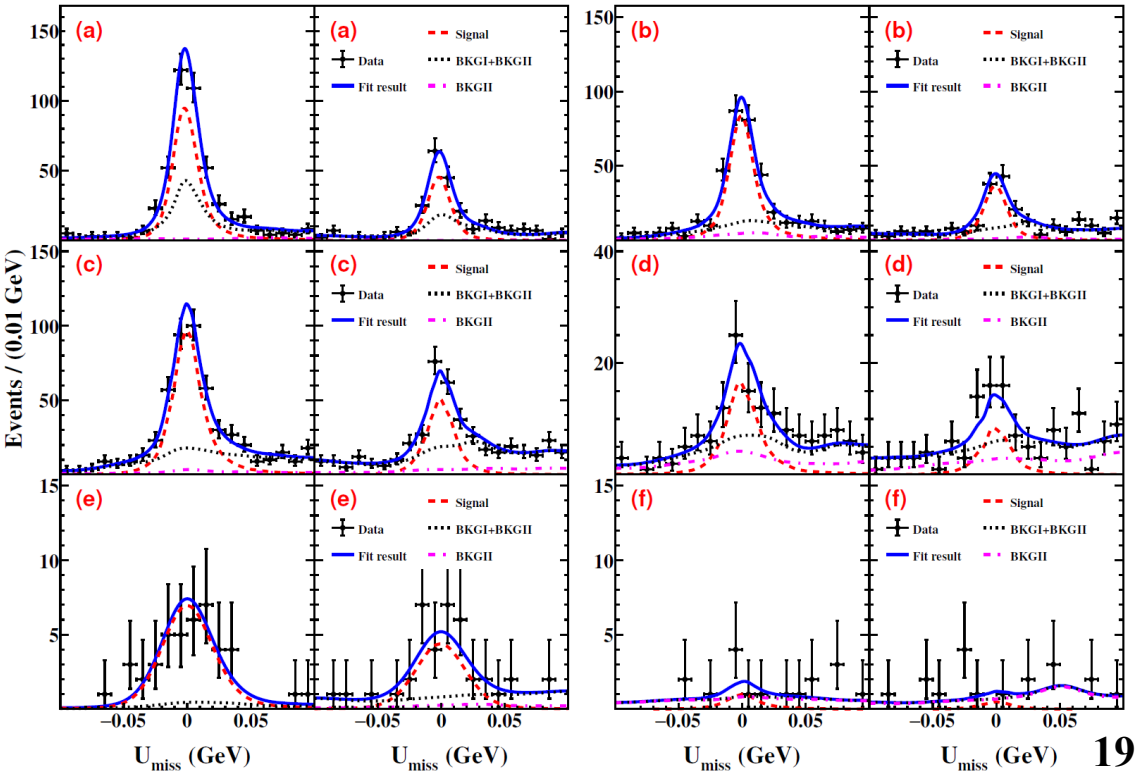
→ D^0: $tan^4\theta_c = \frac{BR(D^o \to K^+\pi^-)}{BR(D^o \to K^-\pi^+)}$

→ D^+ and D_s^+: $tan^8\theta_c = \frac{BR(D_s \to K^+K^+\pi^-)}{BR(D_s \to K^+K^-\pi^+)} \cdot \frac{BR(D^+ \to K^+\pi^+\pi^-)}{BR(D^+ \to K^-\pi^+\pi^+)}$

Measurement of BFs of DCS D decays:

JHEP06(2025)220, 20.3fb^{-1} @ 3.773GeV

Signal decay	$\mathcal{B}_{\rm DCS}^{\rm This\ work}$ $(\times10^{-4})$	$\mathcal{B}_{\rm DCS}^{\rm PDG}$ $(\times10^{-4})$	$\mathcal{B}_{\rm DCS}^{\rm This\ work}/\mathcal{B}_{\rm CF}$ (%)	$\times \tan^4\theta_C$
$D^0 \to K^+\pi^-$	$1.30 \pm 0.09 \pm 0.04$	1.50 ± 0.07	0.328 ± 0.027	1.14 ± 0.09
$D^0 \to K^+\pi^-\pi^-\pi^+$	$2.38 \pm 0.19 \pm 0.12$	2.65 ± 0.06	0.289 ± 0.028	1.00 ± 0.10
$D^0 \to K^+\pi^-\pi^0$	$3.06 \pm 0.21 \pm 0.10$	3.06 ± 0.16	0.212 ± 0.021	0.74 ± 0.07
$D^0 \to K^+\pi^-\pi^0\pi^0$	$1.40 \pm 0.27 \pm 0.09$	< 3.6	0.158 ± 0.036	0.55 ± 0.12
$D^0 \to K^+\pi^-\eta$	$1.04 \pm 0.16 \pm 0.08$	–	0.555 ± 0.092	1.93 ± 0.32
$D^0 \to K^+\pi^-\pi^0\eta$	< 0.7	–	< 1.78	< 6.19
$D^+ \to K^+\pi^+\pi^-$	$4.50 \pm 0.12 \pm 0.35$	4.91 ± 0.09	0.480 ± 0.019	1.67 ± 0.07
$D^+ \to K^+\pi^+\pi^-\eta$	$1.56 \pm 0.22 \pm 0.04$	–	–	–
$D^+ \to K^+(\pi^+\pi^-\eta)_{\rm non-}{}_{\eta'}$	$0.67 \pm 0.18 \pm 0.02$	–	5.0 ± 1.4	17.3 ± 4.8
$D^+ \to K^+K^+K^-$	$0.51 \pm 0.05 \pm 0.01$	0.614 ± 0.011	–	–
$D^+ \to K^+\eta\eta$	$0.59 \pm 0.23 \pm 0.02$	–	–	–



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

arXiv: 2610.05261

BESIII

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

1739 candidates with 86.1% purity

- First measurement of DCS $D^+ \to VV$ decays:
  - → $D^+ \to K^{*0}\rho^+, K^{*+}\rho^0$, both transversely dominated:

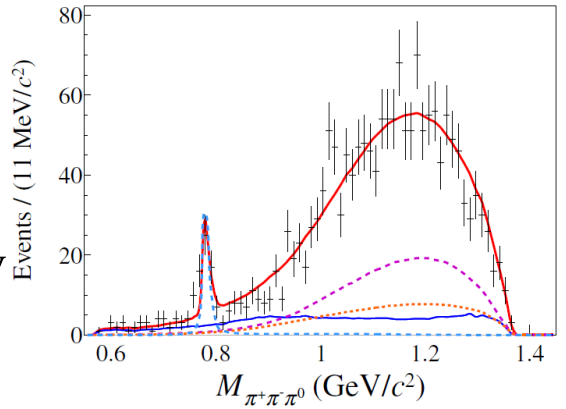
$$F_L(D^+ \to K^{*0}\rho^+) = 0.111 \pm 0.024 \pm 0.008$$
$$F_L(D^+ \to K^{*+}\rho^0) = 0.263 \pm 0.049 \pm 0.015$$

- Precision measurement of $D^+ \to K^+\omega$:

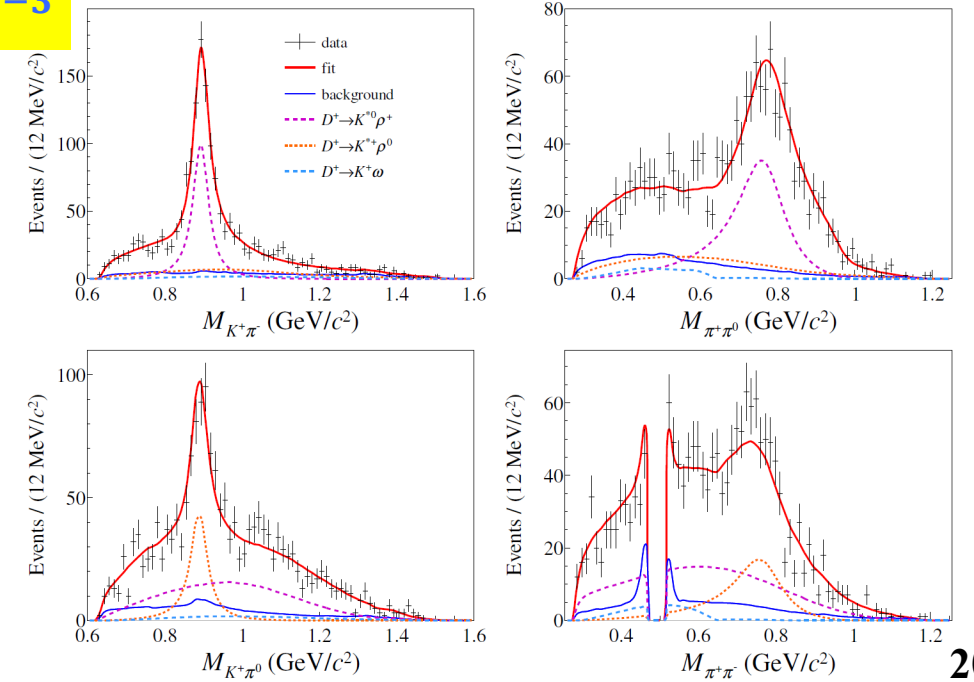
$$\mathcal{B}(D^+ \to K^+\omega) = (4.76 \pm 0.84 \pm 0.13) \times 10^{-5}$$ significantly below theory

- Distinct intermediate dynamics explain $R_{\mathrm{DCS/CF}} \neq \tan^4\theta_C$

$$\mathcal{B}(D^+ \to K^+\pi^+\pi^-\pi^0) = (1.062 \pm 0.028 \pm 0.012) \times 10^{-3}$$



Amplitude	Phase ϕ_n (rad)	BF ($\times 10^{-4}$)
$D^+[\mathcal{S}] \to K^{*0}\rho^+$	0.0(fixed)	1.58±0.25±0.09
$D^+[\mathcal{P}] \to K^{*0}\rho^+$	2.19±0.09±0.02	1.82±0.17±0.05
$D^+[\mathcal{D}] \to K^{*0}\rho^+$	3.84±0.09±0.02	0.89±0.16±0.04
$D^+ \to K^{*0}\rho^+$ total	-	3.78±0.27±0.11
$D^+[\mathcal{S}] \to K^{*+}\rho^0$	2.62±0.15±0.04	0.48±0.12±0.03
$D^+[\mathcal{P}] \to K^{*+}\rho^0$	5.24±0.12±0.05	1.01±0.12±0.10
$D^+[\mathcal{D}] \to K^{*+}\rho^0$	1.08±0.17±0.02	0.28±0.10±0.02
$D^+ \to K^{*+}\rho^0$ total	-	1.77±0.19±0.08
$D^+ \to K^+a_1(1260)^0[\mathcal{S}](\to \rho^\pm\pi^\mp)$	0.47±0.16±0.14	0.43±0.12±0.06
$D^+ \to K^+a_1(1260)^0(\to f_0(500)\,\pi^0)$	2.01±0.16±0.15	0.47±0.13±0.04
$D^+ \to K_1(1270)^+[\mathcal{S}](\to K^+\rho^0)\,\pi^0$	5.40±0.17±0.06	0.35±0.09±0.03
$D^+ \to K_1(1400)^0[\mathcal{S}](\to K^*\pi)\,\pi^+$	1.62±0.17±0.09	0.30±0.10±0.02
$D^+ \to K_1(1400)^+[\mathcal{S}](\to K^{*0}\pi^+)\,\pi^0$	4.72±0.17±0.09	0.37±0.10±0.02
$D^+ \to K^+\omega$	3.67±0.38±0.14	0.43±0.08±0.01
$D^+ \to K^{*+}f_2(1270)$	4.87±0.18±0.05	0.21±0.09±0.02



New inclusive MC samples @3.773 GeV

- Upgrade of KKMC External Packages in BOSS 7.1.2

  PHOTOS (Final-state radiation simulation) V2.03 → V2.15

  TAUOLA (τ-lepton decay simulation) V2.6 → V3.1

- Update D^0 and D^+ decay in DECAY.DEC using PDG 2026 and BESIII results.

- Add/update >29 D^0 and >29 D^+ amplitude models:

  → D^0 generators: D0To*.cc

EvtD0To2pip2pim.cc	EvtD0ToKpi0enu.cc	EvtD0ToKSKpi.cc	EvtD0ToKSpienu.cc	EvtD0Topipienu.cc
EvtD0To2pip2pimpi0.cc	EvtD0ToKpi0munu.cc	EvtD0ToKSKppimpi0.cc	EvtD0ToKSpimpip.cc	EvtD0TopipiEta.cc
EvtD0ToKKeta.cc	EvtD0ToKpieta.cc	EvtD0ToKSLKK.cc	EvtD0ToKSpimunu.cc	EvtD0Topipipi0eta.cc
EvtD0ToKKpi0pi0.cc	EvtD0ToKpiEtap.cc	EvtD0ToKSpi0eta.cc	EvtD0ToKSpipiEta.cc	EvtD0Topippim2pi0.cc
EvtD0ToKLKSKS.cc	EvtD0ToKpipi0Eta.cc	EvtD0ToKSpi0pi0.cc	EvtD0ToKSpipipi0.cc	EvtD0ToPipPimPi0.cc
EvtD0ToKLpimpip.cc	EvtD0ToKSKmpippi0.cc	EvtD0ToKSpi0pi0pi0.cc	EvtD0ToKSpipipi0pi0.cc	

  → D^+ generators: DTo*.cc

EvtDToEta2pi0pi.cc	EvtDToKmPipPipPi0.cc	EvtDToKppipi.cc	EvtDToKSKpPipPim.cc	EvtDToKSpipi0pi0.cc
EvtDToEta3pi.cc	EvtDToKpienu.cc	EvtDToKppipi_isobar.cc	EvtDToKSKSpi.cc	EvtDTopipi0Eta.cc
EvtDToKKpi.cc	EvtDToKpipi.cc	EvtDToKppipipi0.cc	EvtDToKSLKpi0.cc	EvtDTopipi0pi0.cc
EvtDToKLKmpippip.cc	EvtDToKpipilnu.cc	EvtDToKSKLpi.cc	EvtDToKSpi0lnu.cc	EvtDTopipienu.cc
EvtDToKLpieta.cc	EvtDToKppi0eta.cc	EvtDToKSKLpipi0.cc	EvtDToKSpieta.cc	EvtDTopipimunu.cc
EvtDToKmPipPipEta.cc	EvtDToKppi0pi0.cc	EvtDToKSKmpippip.cc	EvtDToKSpipi0.cc	

These inclusive MC samples will be ready before the winter collaboration meeting

Summary and Prospects

- **利用在阈值附近采集的粲强子样本，开展强子衰变研究，对**
  - 检验并刻度理论计算非微扰效应的参数化方法和唯象模型，
  - 理解粲强子弱衰变机制，
  - 检验SU(3)味对称性和提高粲强子*CP*破坏的理论预言，

  具有重要意义
- **课题组按计划开展了粲强子衰变的精密测量工作，进展顺利，已取得一系列重要成果。**
- **课题组将按研究计划，推进并完成后续各项工作。**

谢谢！