D_s多体衰变振幅分析

卢泽辉

高能物理研究所

2025.08 贵阳

Theory under Topological Diagram Approach

PhysRevD.109.073008, Phys. Rev. D 104, 073003 (2021)

Cabbibo Favored

Singly Cabbibo Suppressed

D_s^+	$\bar{K}^{*0}K^+$	$\lambda_{sd}(C_P+A_V)$	3.79 ± 0.09	3.80 ± 0.10	3.79 ± 0.09	$D_s^+\to\pi^+K^{*0}$	2.55 ± 0.35^{a}	2.06 ± 0.06	1.58 ± 0.05
	$K_S^0K^{*+}$	$\frac{1}{\sqrt{2}}[\lambda_{sd}(C_V+A_P)-\lambda_{ds}(T_P+C_V)]$	0.77 ± 0.07^{a}	0.79 ± 0.04	0.78 ± 0.03	$D_s^+\to\pi^0K^{*+}$	0.75 ± 0.25^{b}	0.71 ± 0.03	0.67 ± 0.03
	$\rho^+\pi^0$	$\frac{1}{\sqrt{2}}\lambda_{sd}(A_P-A_V)$	$\cdots$	0.012 ± 0.003	0.011 ± 0.002	$D_s^+\to K^+\rho^0$	2.17 ± 0.25	1.01 ± 0.03	1.11 ± 0.03
$D_s\to VP$	$\rho^+\eta$	$\lambda_{sd}[\frac{1}{\sqrt{2}}(A_P+A_V)\cos\phi-T_P\sin\phi]$	8.9 ± 0.8	9.25 ± 0.35	8.75 ± 0.31	$D_s^+\to K^0\rho^+$	5.46 ± 0.95^{b}	7.54 ± 0.27	7.30 ± 0.26
	$\rho^+\eta'$	$\lambda_{sd}[\frac{1}{\sqrt{2}}(A_P+A_V)\sin\phi+T_P\cos\phi]$	5.8 ± 1.5	3.24 ± 0.11	3.60 ± 0.11	$D_s^+\to\eta K^{*+}$	$\cdots$	0.37 ± 0.07	0.39 ± 0.09
	$\pi^+\rho^0$	$\frac{1}{\sqrt{2}}\lambda_{sd}(A_V-A_P)$	0.0112 ± 0.0013^{b}	0.011 ± 0.003	0.011 ± 0.002	$D_s^+\to\eta' K^{*+}$	$\cdots$	0.40 ± 0.02	0.42 ± 0.02
	$\pi^+\omega$	$\frac{1}{\sqrt{2}}\lambda_{sd}(A_V+A_P)$	0.238 ± 0.015^{c}	0.24 ± 0.01	0.24 ± 0.01	$D_s^+\to K^+\omega$	0.99 ± 0.15	1.16 ± 0.03	1.17 ± 0.03
	$\pi^+\phi$	$\lambda_{sd}T_V$	4.50 ± 0.12	4.49 ± 0.11	4.50 ± 0.11	$D_s^+\to K^+\phi$	0.18 ± 0.04	0.11 ± 0.01	0.29 ± 0.02

Doubly Cabbibo Suppressed

$D_s^+\to K^{*+}K^0$	$\lambda_{ds}(T_P+C_V)$	$\cdots$	1.47 ± 0.09	1.44 ± 0.11
$D_s^+\to K^{*0}K^+$	$\lambda_{ds}(T_V+C_P)$	0.90 ± 0.51	0.20 ± 0.02	0.11 ± 0.02

$D_s\to SP$

$D_s^+\to a_0^+\pi^0$	$\frac{1}{\sqrt{2}}\lambda_{sd}(A-A')$	$\frac{1}{\sqrt{2}}\lambda_{sd}(A-A'+\bar{T})$
$\to a_0^0\pi^+$	$\frac{1}{\sqrt{2}}\lambda_{sd}(-A+A')$	$\frac{1}{\sqrt{2}}\lambda_{sd}(-A+A'-\bar{T})$

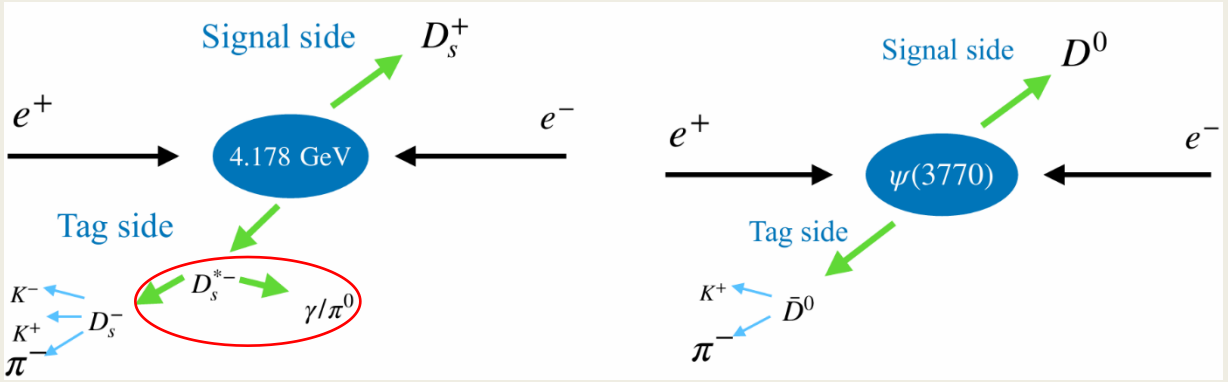
$D_s^+\to a_0(980)^+\pi^0+a_0(980)^0\pi^+\to\pi^+\pi^0\eta$	–	$(1.6\text{–}3.0)\times10^{-2\,a}$	$(1.46\pm0.27)\%^{b}$

$D_s\to VV$

$D_s^+\to\bar{K}^{*0}K^{*+}$	$\lambda_{sd}(C_h+A_h)$	$D_s^+\to\rho^+\rho^0$	0
$D_s^+\to\rho^+\omega$	$\frac{1}{\sqrt{2}}\lambda_{sd}A_h$	$D_s^+\to\rho^+\phi$	$\lambda_{sd}T_h$
$D_s^+\to\rho^+K^{*0}$	$\lambda_dT_h+\lambda_sA_h$	$D_s^+\to\rho^0K^{*+}$	$\frac{1}{\sqrt{2}}(\lambda_dC_h-\lambda_sA_h)$
$D_s^+\to K^{*+}\omega$	$\frac{1}{\sqrt{2}}(\lambda_dC_h+\lambda_sA_h)$	$D_s^+\to K^{*+}\phi$	$\lambda_s(T_h+C_h+A_h)$
$D_s^+\to K^{*+}K^{*0}$	$\lambda_{ds}(T_h+C_h)$		

$$|T_P|>|T_V|>|C_P|>|E_P|>|C_V|\gtrsim|E_V|>|A_{P,V}|$$

数据集



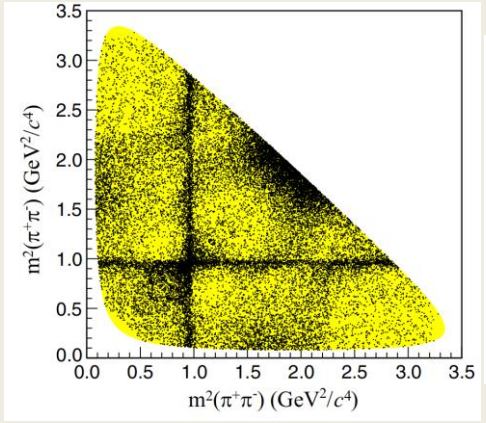
$e^+e^- \to D_s^{*\pm}D_s^{\mp}$: **7.33 fb^{-1}** @4.128-4.226 GeV

样本	年份	亮度（pb^{-1}）
4130	2019	401.5
4160	2019	408.7
4180	2016	3189.0
4190	2012, 2017	570.0
4200	2017	526.0
4210	2013, 2017	572.0
4220	2013, 2017	569.2
4230	2012, 2013	1091.8

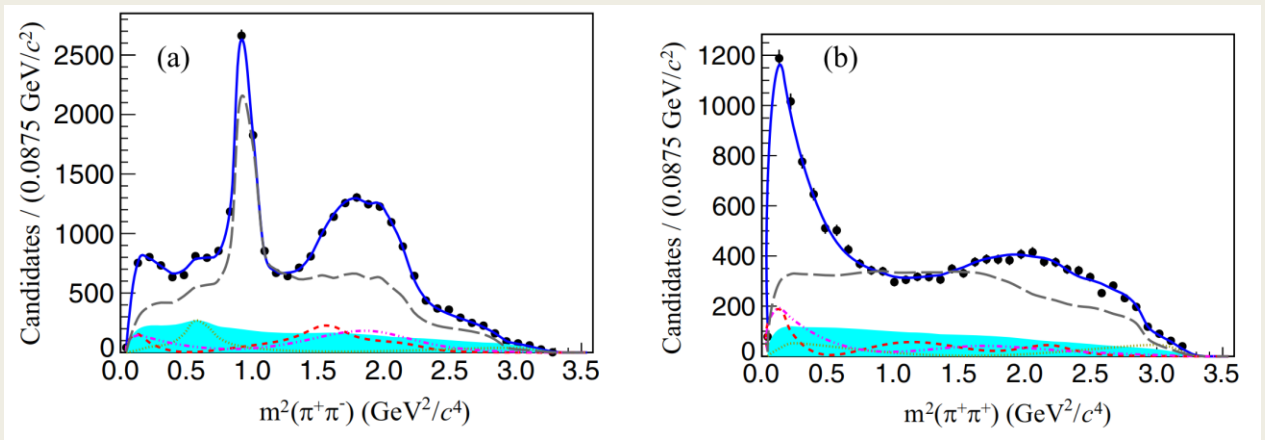
$D_s^+ \to \pi^+\pi^+\pi^-$ & $D_s^+ \to \pi^+\pi^0\pi^0$

$D_s^+ \to \pi^+\pi^+\pi^-$ Phys. Rev. D 106, 112006 (2022)

13797 events with ~80% purity

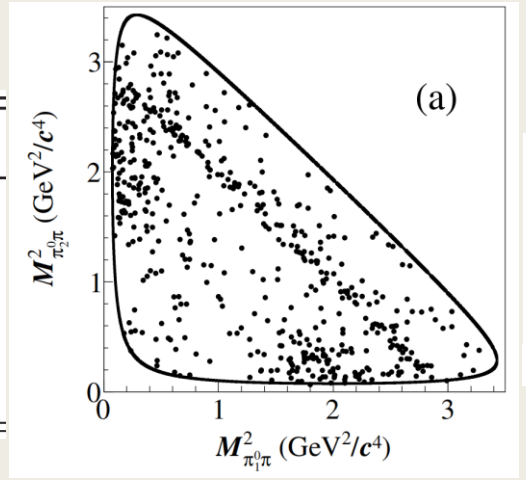


Decay mode	Fit fraction (%)
$f_2(1270)\pi^+$	$10.5 \pm 0.8 \pm 1.1$
$\rho(770)\pi^+$	$0.9 \pm 0.4 \pm 0.5$
$\rho(1450)\pi^+$	$1.3 \pm 0.4 \pm 0.5$
$\mathcal{S}$ wave	$84.2 \pm 0.8 \pm 1.2$
$\sum_i \mathcal{F}_i$	$96.8 \pm 2.4 \pm 3.3$

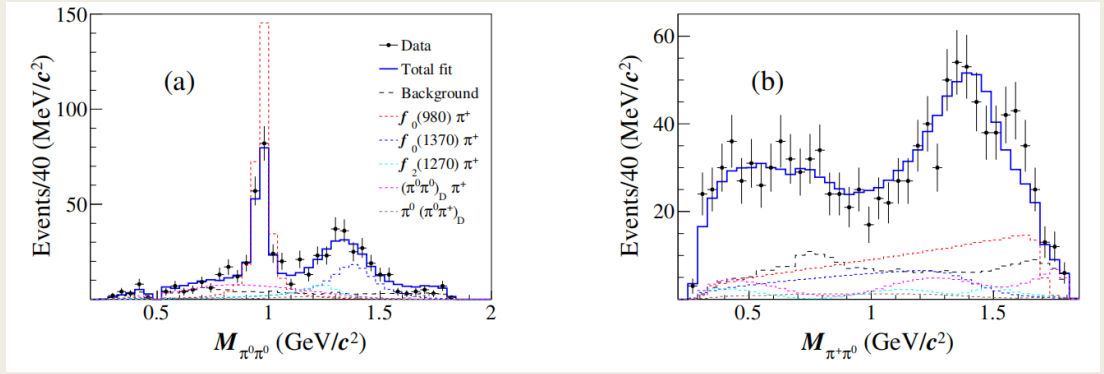


$D_s^+ \to \pi^+\pi^0\pi^0$ JHEP01(2022)052

572 events with ~78% purity



Amplitude		
$D_s^+ \to f_0(980)\pi^+$	FF (%)	$55.4 \pm 6.8 \pm 7.3$
$D_s^+ \to f_0(1370)\pi^+$	FF (%)	$25.5 \pm 5.1 \pm 9.3$
$D_s^+ \to f_2(1270)\pi^+$	FF (%)	$9.7 \pm 2.9 \pm 6.0$
$D_s^+ \to \pi^+(\pi^0\pi^0)_D$	FF (%)	$21.8 \pm 6.8 \pm 3.6$
$D_s^+ \to (\pi^+\pi^0)_D\pi^0$	FF (%)	$5.7 \pm 2.6 \pm 2.0$



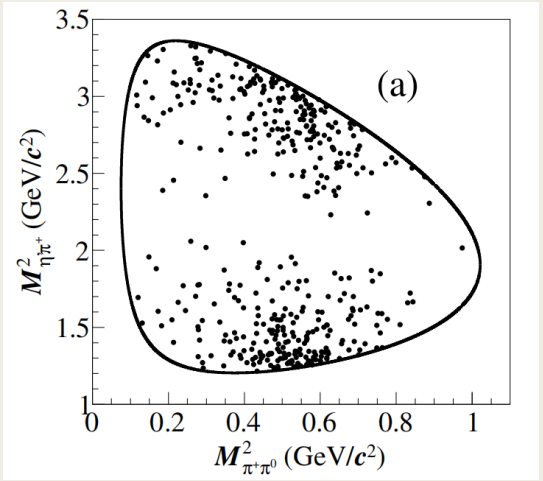
$$\frac{f_{0(2)} \to \pi^+\pi^-}{f_{0(2)} \to \pi^0\pi^0} \sim 2$$

$D_s^+ \to \pi^+\pi^0\eta'$ & $D_s^+ \to \pi^+\pi^0\eta$

$$\frac{1}{\sin\phi}\mathcal{A}(D_s^+ \to \pi^+\omega) = \frac{\cos\phi}{\sin\phi}\mathcal{A}(D_s^+ \to \rho^+\eta) + \mathcal{A}(D_s^+ \to \rho^+\eta').$$

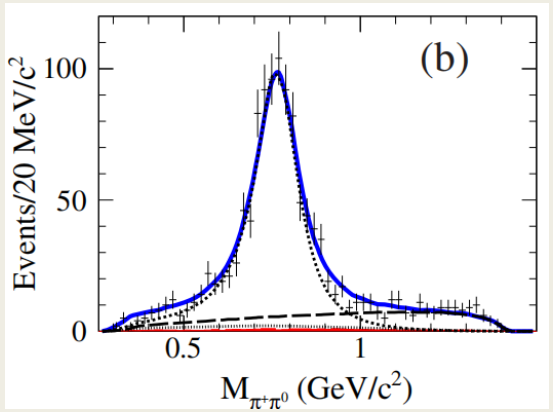
➡ $1.6\% < \mathrm{B}(D_s^+ \to \rho^+\eta') < 3.9\%$

411 events with ~96% purity

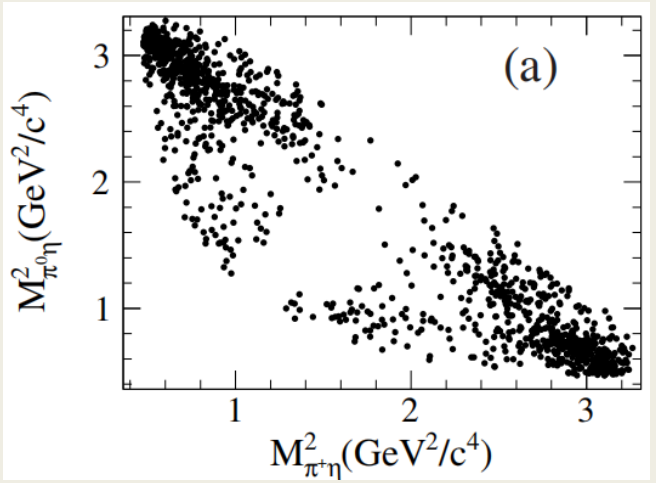


Phys. Rev. Lett. 123, 112001 (2019)

$\mathrm{B}(D_s^+ \to \rho^+\eta) = (7.44 \pm 0.52 \pm 0.38)\%$

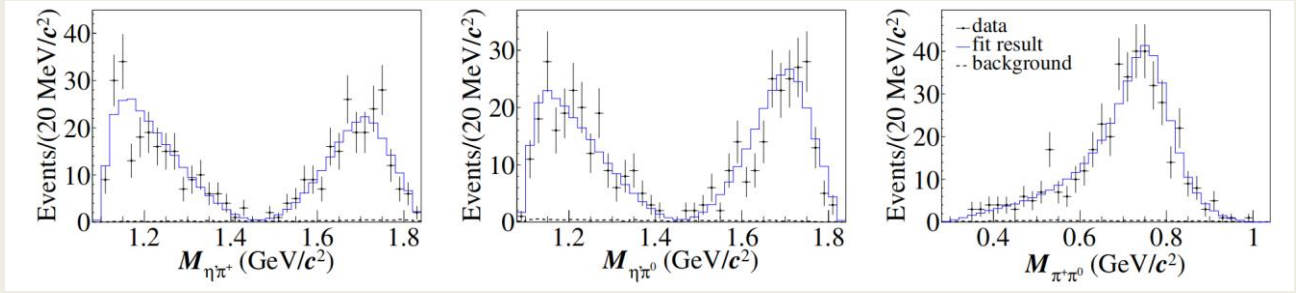


1239 events with ~98% purity



JHEP04(2022)058

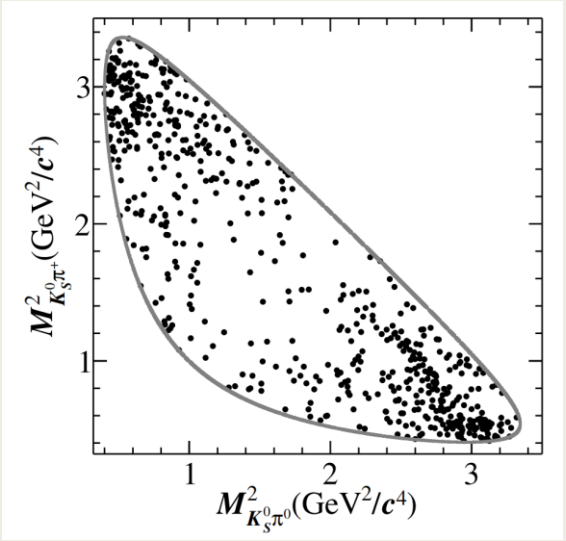
$\mathrm{B}(D_s^+ \to \rho^+\eta') = (6.15 \pm 0.25 \pm 0.18)\%$

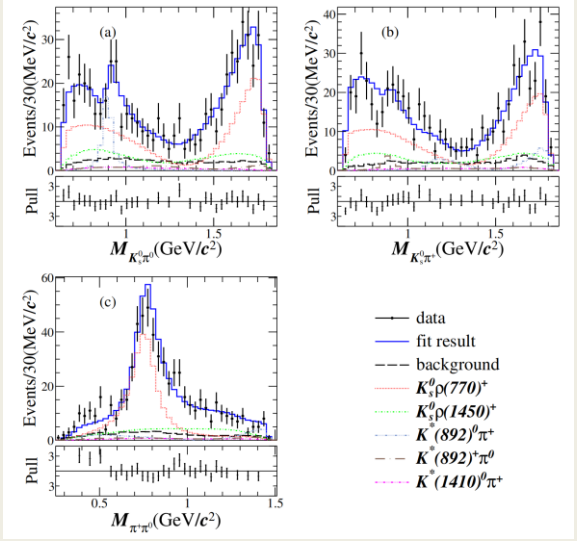


$D_s^+ \to K_S^0\pi^+\pi^0$ & $D_s^+ \to K^+\pi^+\pi^-$

609 events with ~85% purity

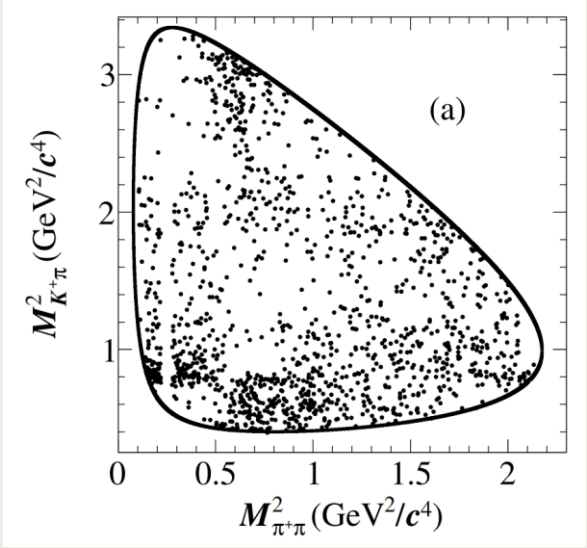
JHEP06(2021)181

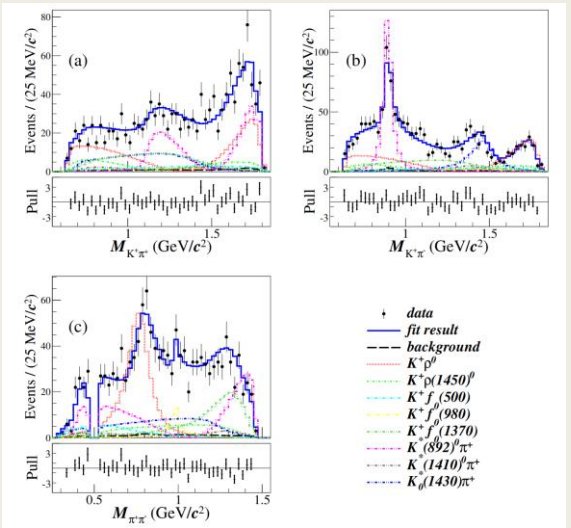




1356 events with ~95% purity

JHEP08(2022)196





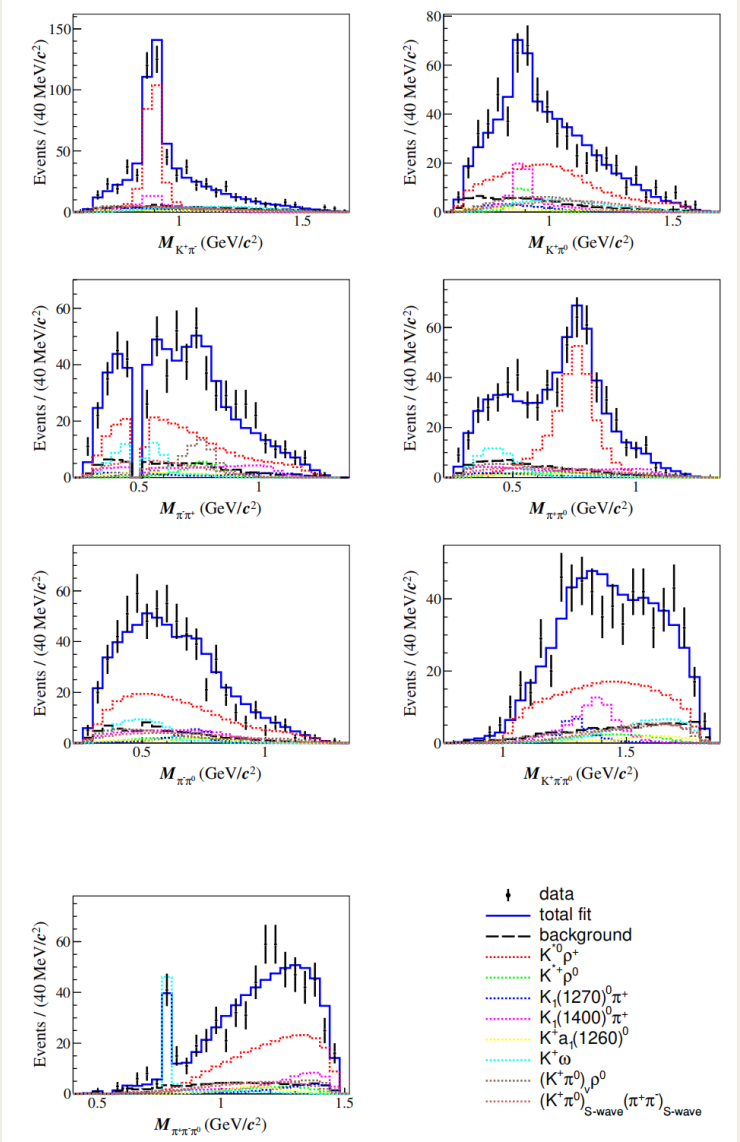
Intermediate process	BF (10^{-3})
$D_s^+ \to K_S^0\rho^+$	$2.73 \pm 0.42 \pm 0.22$
$D_s^+ \to K_S^0\rho(1450)^+$	$1.11 \pm 0.24 \pm 0.24$
$D_s^+ \to K^*(892)^0\pi^+$	$0.45 \pm 0.12 \pm 0.05$
$D_s^+ \to K^*(892)^+\pi^0$	$0.25 \pm 0.08 \pm 0.02$
$D_s^+ \to K^*(1410)^0\pi^+$	$0.18 \pm 0.09 \pm 0.03$

Intermediate process	BF(10^{-3})
$D_s^+ \to K^+\rho^0$	$1.96 \pm 0.19 \pm 0.23$
$D_s^+ \to K^+\rho(1450)^0$	$0.80 \pm 0.19 \pm 0.18$
$D_s^+ \to K^*(892)^0\pi^+$	$1.85 \pm 0.12 \pm 0.13$
$D_s^+ \to K^*(1410)^0\pi^+$	$0.27 \pm 0.13 \pm 0.15$
$D_s^+ \to K_0^*(1430)^0\pi^+$	$1.13 \pm 0.16 \pm 0.16$
$D_s^+ \to K^+f_0(500)$	$0.44 \pm 0.13 \pm 0.27$
$D_s^+ \to K^+f_0(980)$	$0.27 \pm 0.08 \pm 0.07$
$D_s^+ \to K^+f_0(1370)$	$1.22 \pm 0.18 \pm 0.57$

$D_s^+ \to K^+\pi^+\pi^-\pi^0$

630 events with ~85% purity

JHEP09(2022)242



Intermediate process	BF (10^{-3})
$D_s^+[S] \to K^*(892)^0\rho^+$	$1.41 \pm 0.23 \pm 0.07$
$D_s^+[P] \to K^*(892)^0\rho^+$	$2.53 \pm 0.28 \pm 0.12$
$D_s^+ \to K^*(892)^0\rho^+$	$3.95 \pm 0.35 \pm 0.17$
$D_s^+[P] \to K^*(892)^+\rho^0$	$0.42 \pm 0.16 \pm 0.06$
$D_s^+ \to K^+\omega$	$0.95 \pm 0.12 \pm 0.06$
$D_s^+ \to K_1(1270)^0\pi^+$, $K_1(1270)^0[S] \to K^+\rho^-$	$0.39 \pm 0.12 \pm 0.06$
$D_s^+ \to K_1(1400)^0\pi^+$, $K_1(1400)^0[S] \to K^*(892)^+\pi^-$	$0.55 \pm 0.09 \pm 0.03$
$D_s^+ \to K_1(1400)^0\pi^+$, $K_1(1400)^0[S] \to K^*(892)^0\pi^0$	$0.59 \pm 0.09 \pm 0.02$
$D_s^+ \to K_1(1400)^0\pi^+$, $K_1(1400)^0[S] \to K^*(892)\pi$	$1.10 \pm 0.19 \pm 0.04$
$D_s^+ \to a_1(1260)^0K^+, a_1(1260)^0[S] \to \rho^+\pi^-$	$0.19 \pm 0.07 \pm 0.09$
$D_s^+ \to a_1(1260)^0K^+, a_1(1260)^0[S] \to \rho^-\pi^+$	$0.19 \pm 0.07 \pm 0.09$
$D_s^+ \to a_1(1260)^0K^+, a_1(1260)^0[S] \to \rho\pi$	$0.32 \pm 0.12 \pm 0.15$
$D_s^+[S] \to (K^+\pi^0)_V\rho^0$	$1.01 \pm 0.20 \pm 0.06$
$D_s^+ \to (K^+\pi^0)_{\text{S-wave}}(\pi^+\pi^-)_{\text{S-wave}}$	$0.93 \pm 0.22 \pm 0.09$

$D_s^+ \to K^+\rho^0, D_s^+ \to K^+\omega \sim$ Diagram C

TDA: ~ 1

FAT: ~ 30

Experiment: ~2

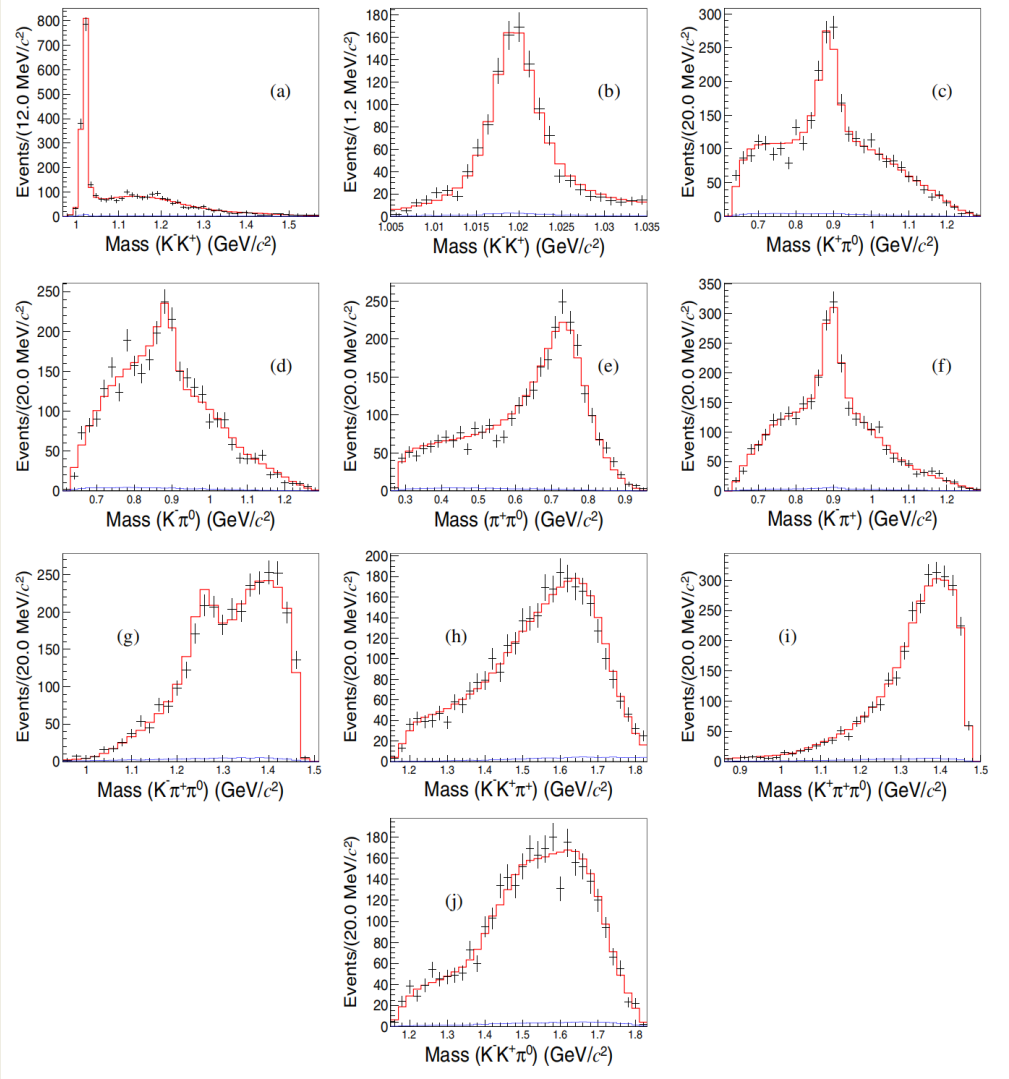
PhysRevD.109.073008

PhysRevD.89.054006

$D_s^+ \to K^+K^-\pi^+\pi^0$

3088 events with ~97% purity

Phys. Rev. D 104, 032011 (2021)



Process	BF (%)
$D_s^+[S] \to \phi\rho^+$	$2.10 \pm 0.09 \pm 0.13$
$D_s^+[P] \to \phi\rho^+$	$0.52 \pm 0.05 \pm 0.02$
$D_s^+[D] \to \phi\rho^+$	$0.18 \pm 0.04 \pm 0.02$
$D_s^+ \to \phi\rho^+$	$2.75 \pm 0.07 \pm 0.15$
$D_s^+[S] \to \bar{K}^{*0}K^{*+}$	$0.88 \pm 0.05 \pm 0.03$
$D_s^+[P] \to \bar{K}^{*0}K^{*+}$	$0.37 \pm 0.03 \pm 0.02$
$D_s^+[D] \to \bar{K}^{*0}K^{*+}$	$0.18 \pm 0.03 \pm 0.01$
$D_s^+ \to \bar{K}^{*0}K^{*+}$	$1.25 \pm 0.05 \pm 0.06$
$D_s^+ \to \bar{K}_1^0(1270)K^+$, $\bar{K}_1^0(1270) \to K^-\rho^+$	$0.57 \pm 0.05 \pm 0.04$
$D_s^+ \to \bar{K}_1^0(1270)K^+$, $\bar{K}_1^0(1270)[S] \to K^*\pi$	$0.21 \pm 0.04 \pm 0.03$
$D_s^+ \to \bar{K}_1^0(1270)K^+$, $\bar{K}_1^0(1270)[D] \to K^*\pi$	$0.07 \pm 0.02 \pm 0.01$
$D_s^+ \to \bar{K}_1^0(1270)K^+$, $\bar{K}_1^0(1270) \to K^*\pi$	$0.29 \pm 0.04 \pm 0.04$
$D_s^+ \to \bar{K}_1^0(1400)K^+$, $\bar{K}_1^0(1400) \to K^*\pi$	$0.44 \pm 0.06 \pm 0.07$
$D_s^+ \to a_0^0(980)\rho^+$	$0.19 \pm 0.03 \pm 0.03$
$D_s^+ \to f_1(1420)\pi^+$, $f_1(1420) \to K^{*\mp}K^{\pm}$	$0.13 \pm 0.02 \pm 0.01$
$D_s^+ \to f_1(1420)\pi^+$, $f_1(1420) \to a_0^0(980)\pi^0$	$0.04 \pm 0.01 \pm 0.01$
$D_s^+ \to \eta(1475)\pi^+$, $\eta(1475) \to a_0^0(980)\pi^0$	$0.07 \pm 0.02 \pm 0.02$

LHCb: J. High Energy Phys. 02 (2019) 126.
CLEO: Phys. Rev. D 85,122002 (2012).

$$R_{K_1(1270)} = \frac{B(K_1^0 \to K^*\pi)}{B(K_1^0 \to K\rho)} = 0.99 \pm 0.15 \pm 0.18$$

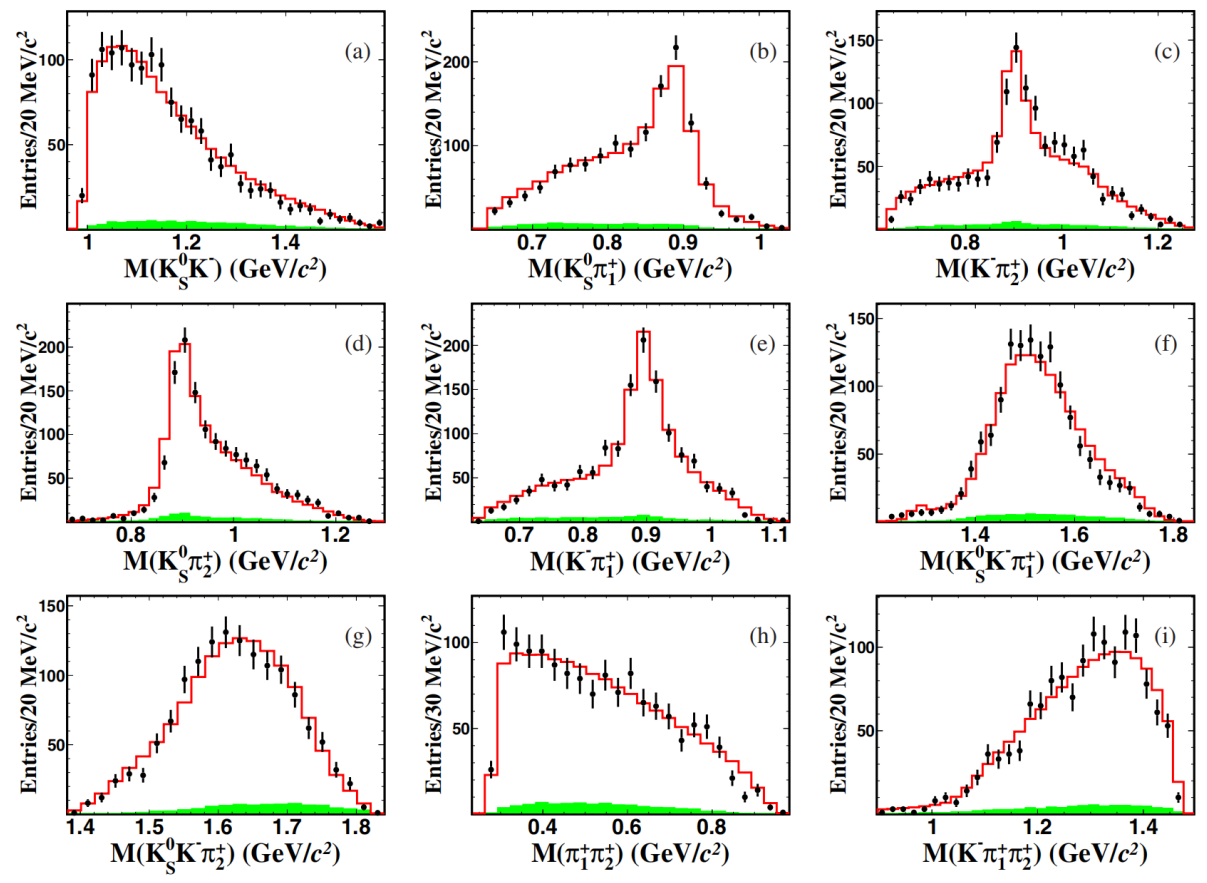
BESIII via $D^{+/0} \to K_1(1270)e^+\nu_e$: $(0.203 \pm 0.021 \pm 0.087)$

2503.02196

$D_s^+ \to K_S^0 K^- \pi^+ \pi^+$

1318 events with ~95% purity

Phys. Rev. D 103, 092006 (2021)



Process	BF(10^{-3}) This analysis	BF(10^{-3}) PDG
$D_s^+[S] \to K^*(892)^+ \bar{K}^*(892)^0$	$5.01 \pm 0.49 \pm 0.78$	
$D_s^+[P] \to K^*(892)^+ \bar{K}^*(892)^0$	$1.10 \pm 0.16 \pm 0.10$	
$D_s^+[D] \to K^*(892)^+ \bar{K}^*(892)^0$	$0.65 \pm 0.12 \pm 0.10$	
$D_s^+ \to K^*(892)^+ \bar{K}^*(892)^0$	$5.93 \pm 0.47 \pm 0.74$	7.98 ± 2.88
$D_s^+ \to K^*(892)^+ (K^-\pi^+)_{S-\text{wave}}$	$0.73 \pm 0.17 \pm 0.15$	
$D_s^+ \to \bar{K}^*(892)^0 (K_S^0\pi^+)_{S-\text{wave}}$	$1.06 \pm 0.16 \pm 0.13$	
$D_s^+ \to \eta(1475)\pi^+, \eta(1475) \to a_0(980)^-\pi^+$	$1.57 \pm 0.39 \pm 0.76$	
$D_s^+ \to \eta(1475)\pi^+, \eta(1475) \to \bar{K}^*(892)^0 K_S^0$	$0.32 \pm 0.10 \pm 0.10$	
$D_s^+ \to \eta(1475)\pi^+, \eta(1475) \to K^*(892)^+ K^-$	$0.32 \pm 0.10 \pm 0.10$	
$D_s^+ \to \eta(1475)\pi^+, \eta(1475) \to K^*(892) K$	$0.72 \pm 0.21 \pm 0.14$	
$D_s^+ \to \eta(1475)\pi^+, \eta(1475) \to (K_S^0\pi^+)_{S-\text{wave}} K^-$	$3.44 \pm 0.54 \pm 1.10$	
$D_s^+ \to f_1(1285)\pi^+, f_1(1285) \to a_0(980)^-\pi^+$	$0.33 \pm 0.08 \pm 0.10$	
$D_s^+ \to (K^*(892)^+ K^-)_P \pi^+, (K^*(892)^+ K^-)_P \to K^*(892)^+ K^-$	$1.58 \pm 0.28 \pm 0.26$	
$D_s^+ \to K_S^0 K^- \pi^+ \pi^+$	$14.60 \pm 0.46 \pm 0.48$	16.50 ± 1.00

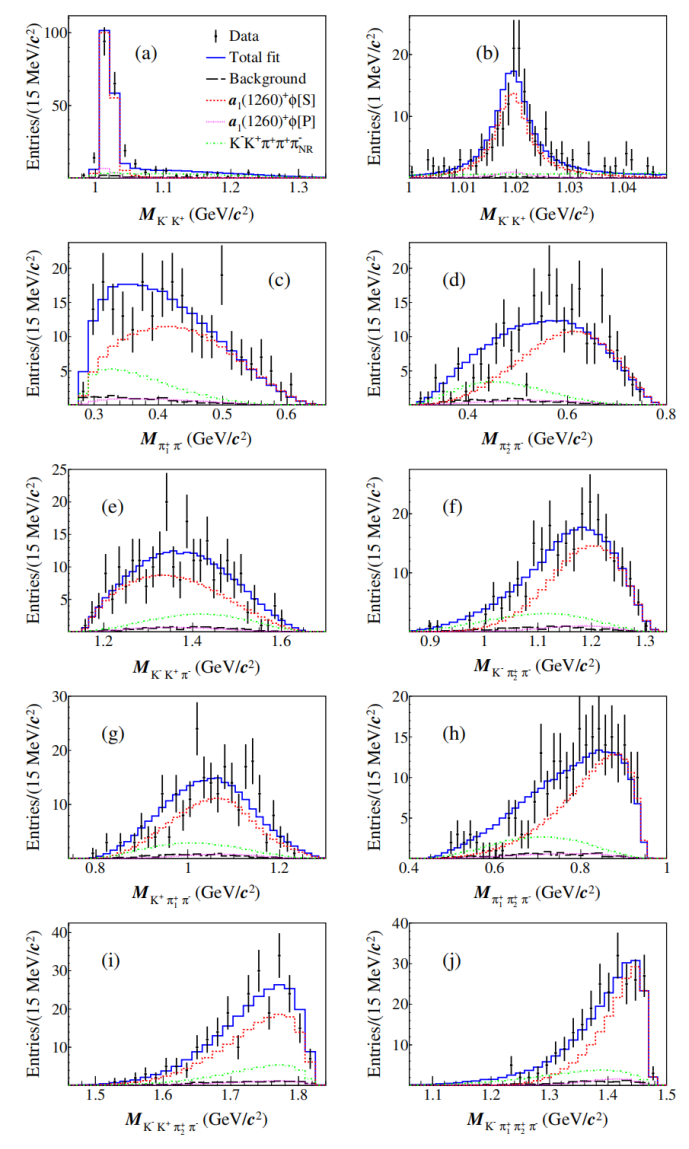
$$D_s^+ \to \bar{K}^{*0} K^{*+} = (5.64 \pm 0.23 \pm 0.27)\% \; from \; D_s^+ \to K^+ K^- \pi^+ \pi^0$$

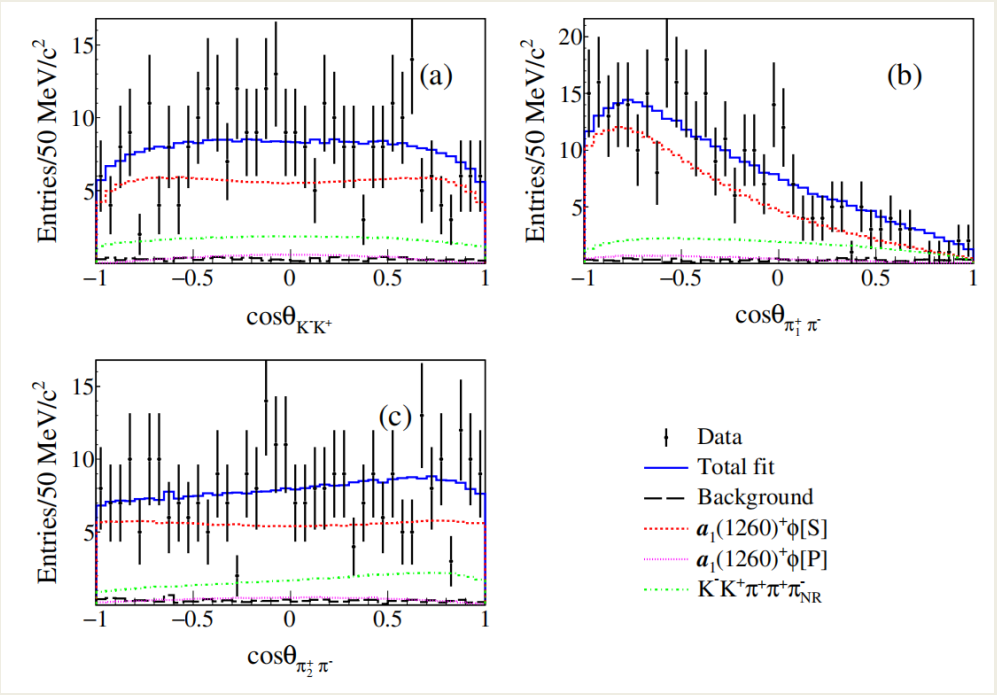
$$D_s^+ \to \bar{K}^{*0} K^{*+} = (5.34 \pm 0.39 \pm 0.64)\%$$

$D_s^+ \to K^+K^-\pi^+\pi^+\pi^-$

243 events with ~96% purity

JHEP07(2022)051



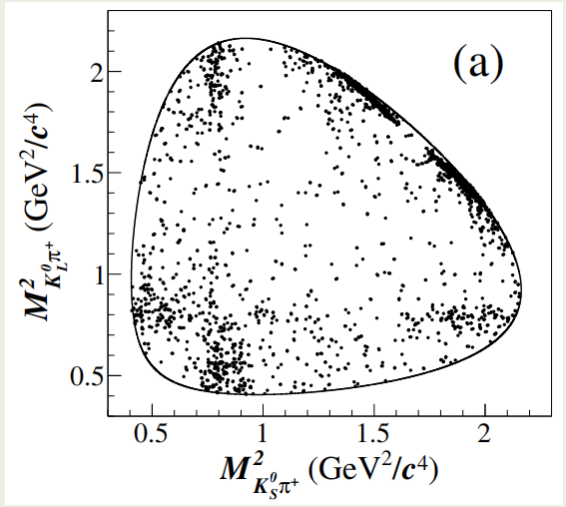


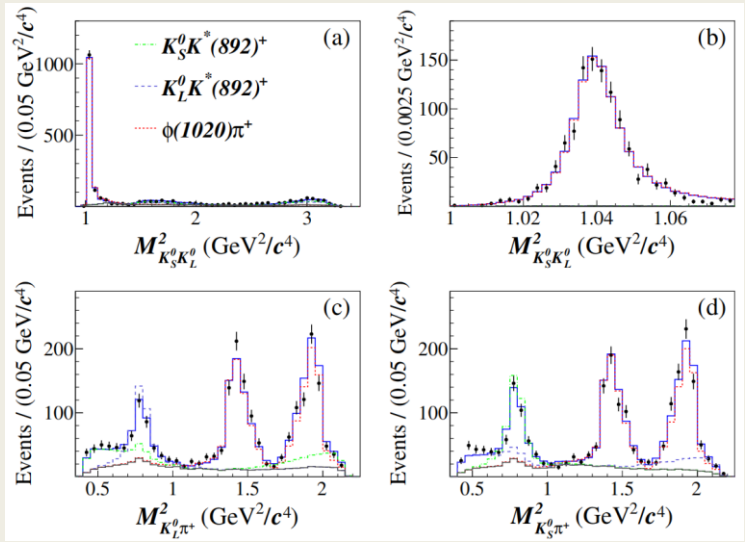
Intermediate process	BF (10^{-3})	PDG (10^{-3})
$D_s^+[S] \to a_1(1260)^+\phi, a_1(1260)^+[S] \to \rho^0\pi^+$	$4.82 \pm 0.40 \pm 0.29$	
$D_s^+[P] \to a_1(1260)^+\phi, a_1(1260)^+[S] \to \rho^0\pi^+$	$0.34 \pm 0.11 \pm 0.05$	
$D_s^+ \to a_1(1260)^+\phi$	$5.15 \pm 0.41 \pm 0.32$	7.4 ± 1.2
$D_s^+ \to (K^-K^+\pi^+\pi^+\pi^-)_{\rm NR}$	$1.44 \pm 0.22 \pm 0.10$	0.9 ± 0.7

$D_s^+ \to K_S^0 K_L^0 \pi^+$

2310 events with ~78% purity

arXiv:2503.11383



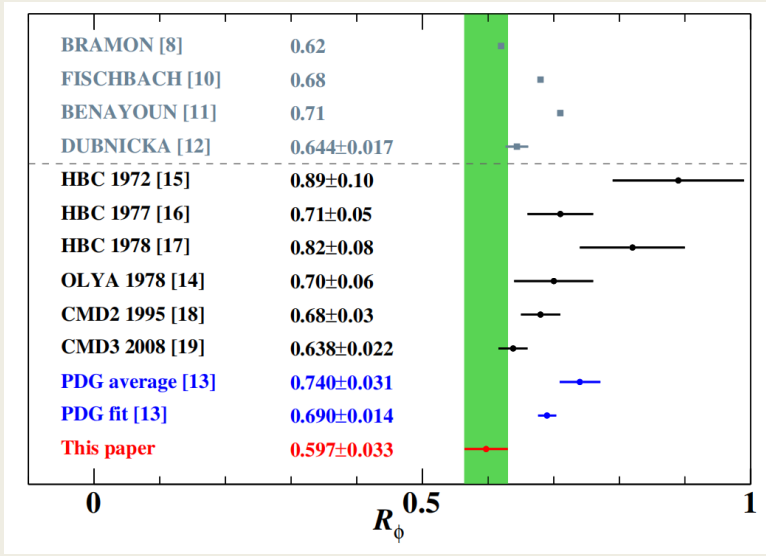


$$\frac{B(D_s^+ \to K_S^0 K^*) - B(D_s^+ \to K_L^0 K^*)}{B(D_s^+ \to K_S^0 K^*) + B(D_s^+ \to K_L^0 K^*)} = (-13.4 \pm 5.0 \pm 3.4)\%$$

TDA: -0.164 ± 0.032 / -0.159 ± 0.028

FAT: -0.066 ± 0.191

Amplitude	Phase (rad)	FF (%)	BF (%)	σ
$D_s^+ \to \phi\pi^+$	0.0(fixed)	$70.9 \pm 1.3 \pm 1.5$	$1.32 \pm 0.05 \pm 0.04$	>10
$D_s^+ \to K_L^0 K^*(892)^+$	$0.68 \pm 0.17 \pm 0.21$	$22.8 \pm 1.3 \pm 1.5$	$0.42 \pm 0.03 \pm 0.03$	>10
$D_s^+ \to K_S^0 K^*(892)^+$	$-2.40 \pm 0.18 \pm 0.31$	$17.4 \pm 1.2 \pm 0.9$	$0.31 \pm 0.02 \pm 0.02$	>10

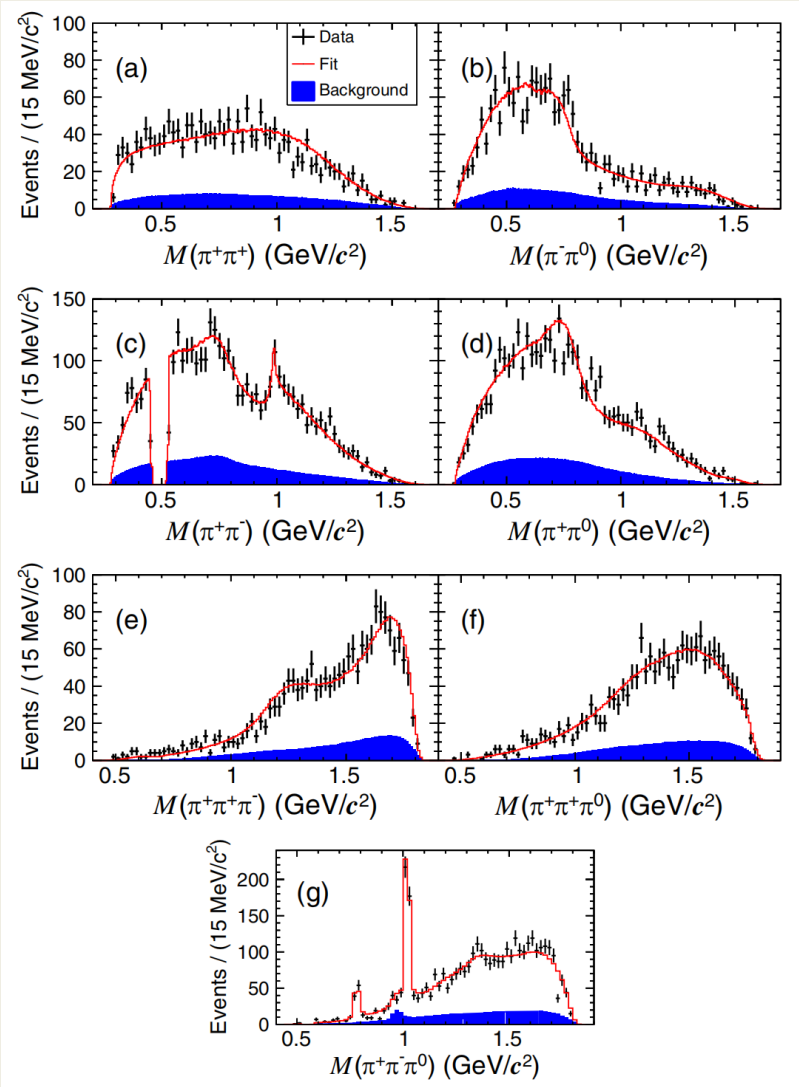


$$R_\phi = B(\phi \to K_S^0 K_L^0 / \phi \to K^+ K^-)$$

$D_s^+ \to \pi^+\pi^+\pi^-\pi^0$

1552 events with ~80% purity

Phys. Rev. Lett. 134, 011904 (2025)



Component	Phase (rad)	FF (%)	BF (10^{-3})
$f_0(1370)\rho^+$	0.0(fixed)	$24.9 \pm 3.8 \pm 2.1$	$5.08 \pm 0.80 \pm 0.43$
$f_0(980)\rho^+$	$3.99 \pm 0.13 \pm 0.07$	$12.6 \pm 2.1 \pm 1.0$	$2.57 \pm 0.44 \pm 0.20$
$f_2(1270)\rho^+$	$1.11 \pm 0.10 \pm 0.10$	$9.5 \pm 1.7 \pm 0.6$	$1.94 \pm 0.36 \pm 0.12$
$(\rho^+\rho^0)_S$	$1.10 \pm 0.18 \pm 0.10$	$3.5 \pm 1.2 \pm 0.6$	$0.71 \pm 0.25 \pm 0.12$
$[\rho(1450)^+\rho^0]_S$	$0.43 \pm 0.18 \pm 0.17$	$4.6 \pm 1.3 \pm 0.8$	$0.94 \pm 0.27 \pm 0.16$
$[\rho^+\rho(1450)^0]_P$	$4.58 \pm 0.16 \pm 0.09$	$8.6 \pm 1.3 \pm 0.4$	$1.75 \pm 0.27 \pm 0.08$
$\phi[(\rho\pi) \to \pi^+\pi^-\pi^0]\pi^+$	$2.90 \pm 0.15 \pm 0.18$	$24.9 \pm 1.2 \pm 0.4$	$5.08 \pm 0.32 \pm 0.10$
$\omega[(\rho\pi) \to \pi^+\pi^-\pi^0]\pi^+$	$3.22 \pm 0.21 \pm 0.09$	$6.9 \pm 0.8 \pm 0.3$	$1.41 \pm 0.17 \pm 0.06$
$a_1^+(\rho^0\pi^+)_S\pi^0$	$3.78 \pm 0.16 \pm 0.12$	$12.5 \pm 1.6 \pm 1.0$	$2.55 \pm 0.34 \pm 0.20$
$a_1^0[(\rho\pi)_S \to \pi^+\pi^-\pi^0]\pi^+$	$4.82 \pm 0.15 \pm 0.12$	$6.3 \pm 1.9 \pm 1.2$	$1.29 \pm 0.39 \pm 0.24$
$\pi(1300)^0[(\rho\pi)_P \to \pi^+\pi^-\pi^0]\pi^+$	$2.22 \pm 0.14 \pm 0.08$	$11.7 \pm 2.3 \pm 2.2$	$2.39 \pm 0.48 \pm 0.45$

- $R_\phi = \mathcal{B}(D_s^+ \to \phi(\to \pi^+\pi^-\pi^0)\pi^+)/\mathcal{B}(D_s^+ \to \phi(\to K^+K^-)\pi^+)$

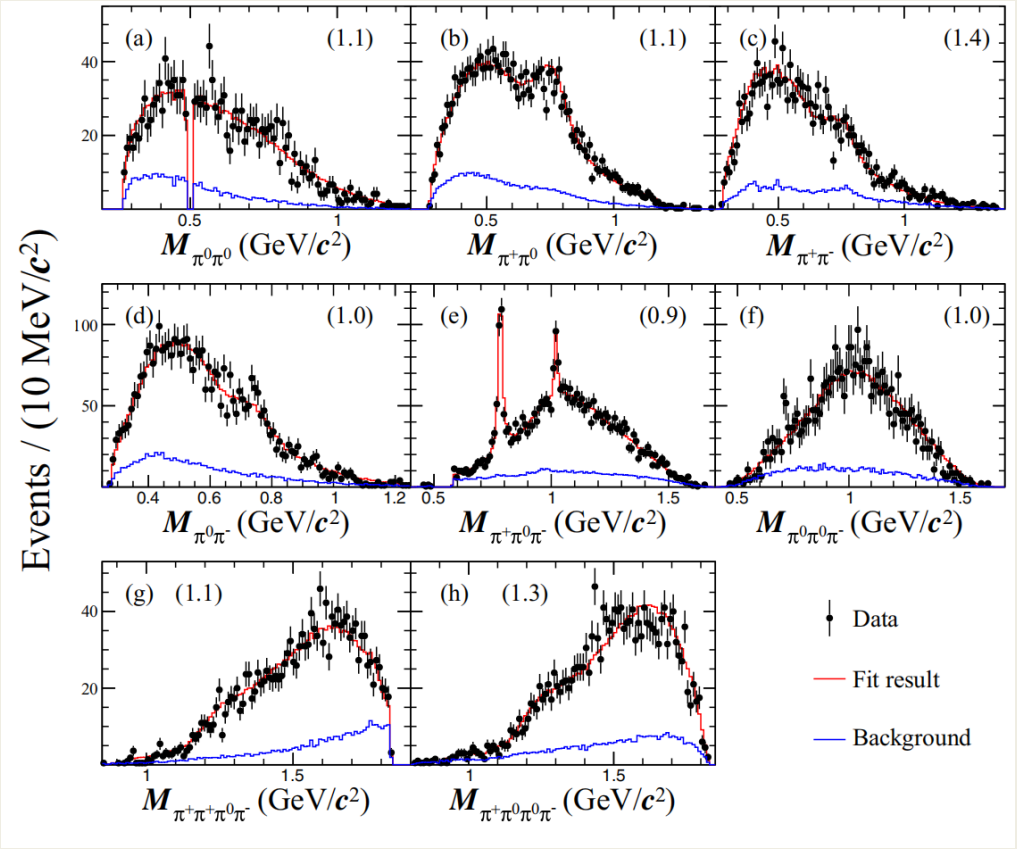
  $= \mathcal{B}(\phi \to \pi^+\pi^-\pi^0)/\mathcal{B}(\phi \to K^+K^-) = 0.230 \pm 0.014 \pm 0.010$

  $R_\phi(\mathrm{PDG}) = 0.313 \pm 0.010$ 大于4倍标准偏差
- $D_s^+ \to f_0(980)\rho^+$ --- W-外发射过程主导
- $D_s^+ \to \omega\pi^+$ --- 纯W-湮灭过程

$D_s^+ \to \pi^+\pi^+\pi^-\pi^0\pi^0$

1888 events with ~80% purity

Phys. Rev. Lett. 134, 201902 (2025)



$$R_\phi = \mathcal{B}\left(D_s^+ \to \phi\left(\to \pi^+\pi^-\pi^0\right)\rho^+\right)/\mathcal{B}(D_s^+ \to \phi(\to K^+K^-)\rho^+)$$

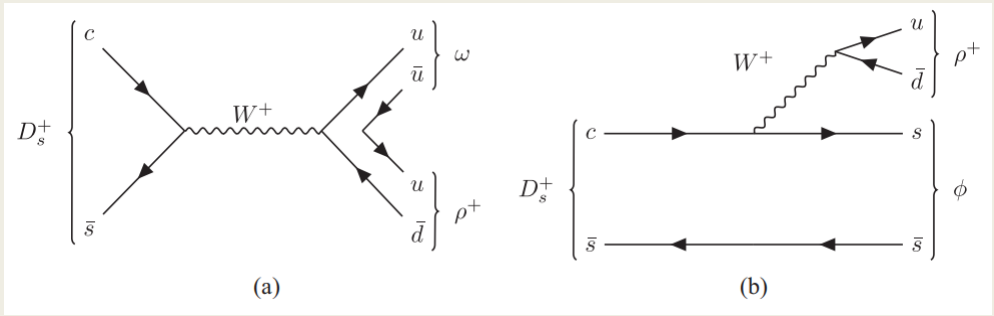
$$=\mathcal{B}\left(\phi \to \pi^+\pi^-\pi^0\right)/\mathcal{B}(\phi \to K^+K^-) = 0.222 \pm 0.019 \pm 0.016$$

$$R_\phi(\mathrm{PDG}) = 0.313 \pm 0.010$$

大于3倍标准偏差

纯W-湮灭过程

纯W-外发射过程

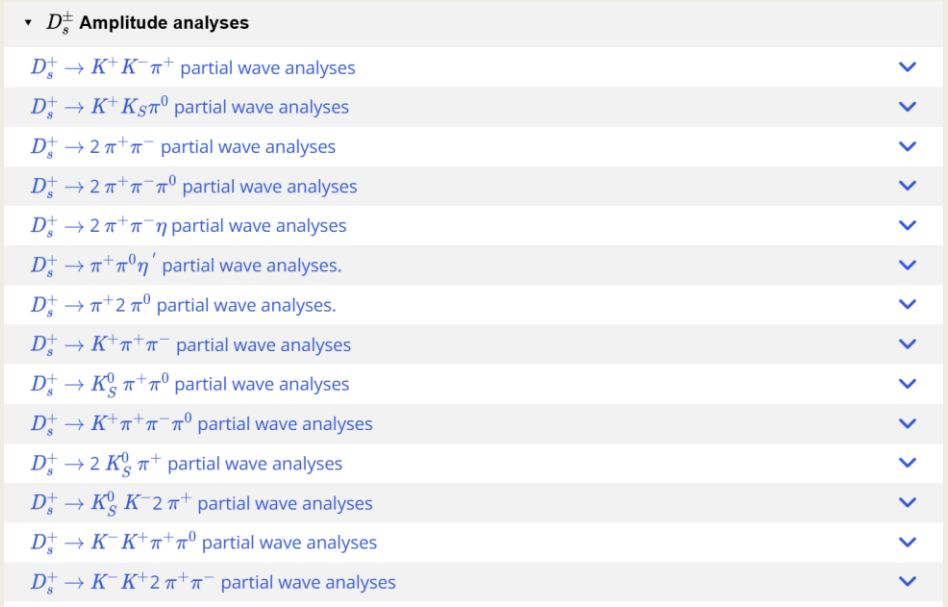


Amplitude	Phase ϕ (rad)	FF (%)	BF (%)	Significance
$D_s^+[S] \to \omega\rho^+$	0.0 (fixed)	$6.12 \pm 1.34^{+0.44}_{-0.52}$	$0.30 \pm 0.07^{+0.02}_{-0.03}$	$> 10\sigma$
$D_s^+[P] \to \omega\rho^+$	$2.92 \pm 0.13^{+0.05}_{-0.07}$	$5.05 \pm 0.86^{+0.83}_{-0.79}$	$0.25 \pm 0.04^{+0.04}_{-0.04}$	6.1σ
$D_s^+[D] \to \omega\rho^+$	$4.91 \pm 0.09^{+0.04}_{-0.09}$	$10.36 \pm 1.26^{+0.70}_{-1.45}$	$0.52 \pm 0.07^{+0.04}_{-0.07}$	$> 10\sigma$
$D_s^+ \to \omega\rho^+$	···	$19.98 \pm 1.40^{+0.92}_{-1.20}$	$0.99 \pm 0.08^{+0.05}_{-0.07}$	···
$D_s^+[S] \to \phi\rho^+$	$0.72 \pm 0.11^{+0.06}_{-0.09}$	$11.62 \pm 0.94^{+0.46}_{-0.39}$	$3.32 \pm 0.29^{+0.19}_{-0.17}$	$> 10\sigma$
$D_s^+[P] \to \phi\rho^+$	$1.34 \pm 0.15^{+0.07}_{-0.30}$	$2.22 \pm 0.42^{+0.15}_{-0.15}$	$0.63 \pm 0.12^{+0.05}_{-0.06}$	$> 10\sigma$
$D_s^+ \to \phi\rho^+$	···	$13.86 \pm 1.03^{+0.47}_{-0.35}$	$3.98 \pm 0.33^{+0.21}_{-0.19}$	···
$D_s^+ \to \rho(1450)^+\pi^0$, $\rho(1450)^+ \to \omega\pi^+$	$1.55 \pm 0.11^{+0.06}_{-0.08}$	$7.84 \pm 0.83^{+0.49}_{-0.58}$	$0.39 \pm 0.04^{+0.03}_{-0.03}$	6.3σ
$D_s^+[S] \to a_1(1260)^0\rho^+$, $a_1(1260)^0[S] \to \rho^+\pi^-$	$4.61 \pm 0.10^{+0.14}_{-0.15}$	$5.19 \pm 0.50^{+0.22}_{-0.21}$	$0.23 \pm 0.02^{+0.01}_{-0.01}$	$> 10\sigma$
$D_s^+[P] \to a_1(1260)^0\rho^+$, $a_1(1260)^0[S] \to \rho^+\pi^-$	$0.06 \pm 0.10^{+0.14}_{-0.15}$	$6.25 \pm 0.52^{+0.23}_{-0.25}$	$0.50 \pm 0.04^{+0.02}_{-0.02}$	$> 10\sigma$
$D_s^+ \to a_1(1260)^0\rho^+$, $a_1(1260)^0 \to \rho^+\pi^-$	···	$11.43 \pm 0.67^{+0.35}_{-0.35}$	$0.50 \pm 0.04^{+0.02}_{-0.02}$	···
$D_s^+[S] \to a_1(1260)^0\rho^+$, $a_1(1260)^0[S] \to \rho^-\pi^+$	$4.61 \pm 0.10^{+0.14}_{-0.15}$	$3.64 \pm 0.35^{+0.17}_{-0.17}$	$0.16 \pm 0.02^{+0.01}_{-0.01}$	$> 10\sigma$
$D_s^+[P] \to a_1(1260)^0\rho^+$, $a_1(1260)^0[S] \to \rho^-\pi^+$	$0.06 \pm 0.10^{+0.14}_{-0.15}$	$3.76 \pm 0.31^{+0.20}_{-0.20}$	$0.17 \pm 0.01^{+0.01}_{-0.01}$	$> 10\sigma$
$D_s^+ \to a_1(1260)^0\rho^+$, $a_1(1260)^0 \to \rho^-\pi^+$	···	$7.39 \pm 0.44^{+0.26}_{-0.26}$	$0.33 \pm 0.02^{+0.02}_{-0.02}$	···
$D_s^+[S] \to a_1(1260)^+\rho^0$, $a_1(1260)^+[S] \to \rho^+\pi^0$	$1.85 \pm 0.11^{+0.18}_{-0.19}$	$9.43 \pm 1.14^{+1.13}_{-1.13}$	$0.41 \pm 0.05^{+0.05}_{-0.05}$	9.2σ
$D_s^+[P] \to a_1(1260)^+\rho^0$, $a_1(1260)^+[S] \to \rho^+\pi^0$	$3.52 \pm 0.12^{+0.20}_{-0.21}$	$7.10 \pm 0.88^{+0.51}_{-0.51}$	$0.31 \pm 0.04^{+0.02}_{-0.02}$	$> 10\sigma$
$D_s^+ \to a_1(1260)^+\rho^0$, $a_1(1260)^+ \to \rho^+\pi^0$	···	$16.53 \pm 1.37^{+1.52}_{-1.52}$	$0.73 \pm 0.07^{+0.07}_{-0.07}$	···
$D_s^+ \to b_1(1235)^+\pi^0$, $b_1(1235)^+[S] \to \omega\pi^+$	$4.27 \pm 0.10^{+0.05}_{-0.06}$	$10.79 \pm 0.98^{+0.68}_{-0.68}$	$0.53 \pm 0.05^{+0.03}_{-0.03}$	9.7σ
$D_s^+ \to b_1(1235)^0\pi^+$, $b_1(1235)^0[S] \to \omega\pi^0$	$1.22 \pm 0.09^{+0.04}_{-0.06}$	$14.60 \pm 1.20^{+0.52}_{-0.49}$	$0.72 \pm 0.06^{+0.05}_{-0.05}$	$> 10\sigma$

$D > S > P!$

总结

- D_s^+介子强子末态衰变是研究W-湮灭过程的良好环境
  - $D_s^+ \to \rho^0\pi^+,\ a_0(980)\pi^+,\ \omega\rho^+\ldots$
- BESIII D_s^+强子衰变振幅分析硕果累累：已发表/在投17篇文章
  - 3 (1) PRL, 7 PRD, 6 JHEP
- 多个黄金标记道模型
  - $D_s^+ \to K^+K^-\pi^+, D_s^+ \to K^+K^-\pi^+\pi^0, D_s^+ \to \pi^+\pi^-\pi^0\ldots$
- 为轻标量介子研究提供许多重要信息
  - $a_0(980), \phi, a_0(1817)\ldots$



感谢您的垂听！