The hadronic decays of charmed mesons at BESIII

Jiajv Wang

Wuhan University

On behalf of BESIII Collaboration

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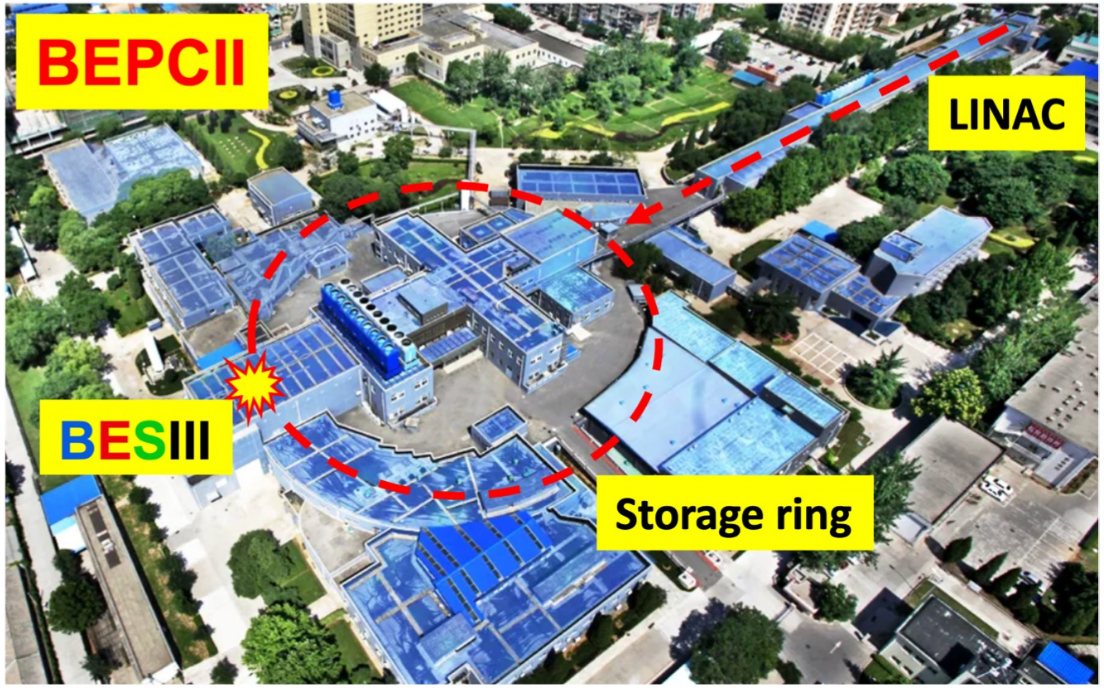
Outline

1. BEPCII and BESIII detector
2. Data sample
3. Analysis strategy
4. Amplitude analyses
5. Summary

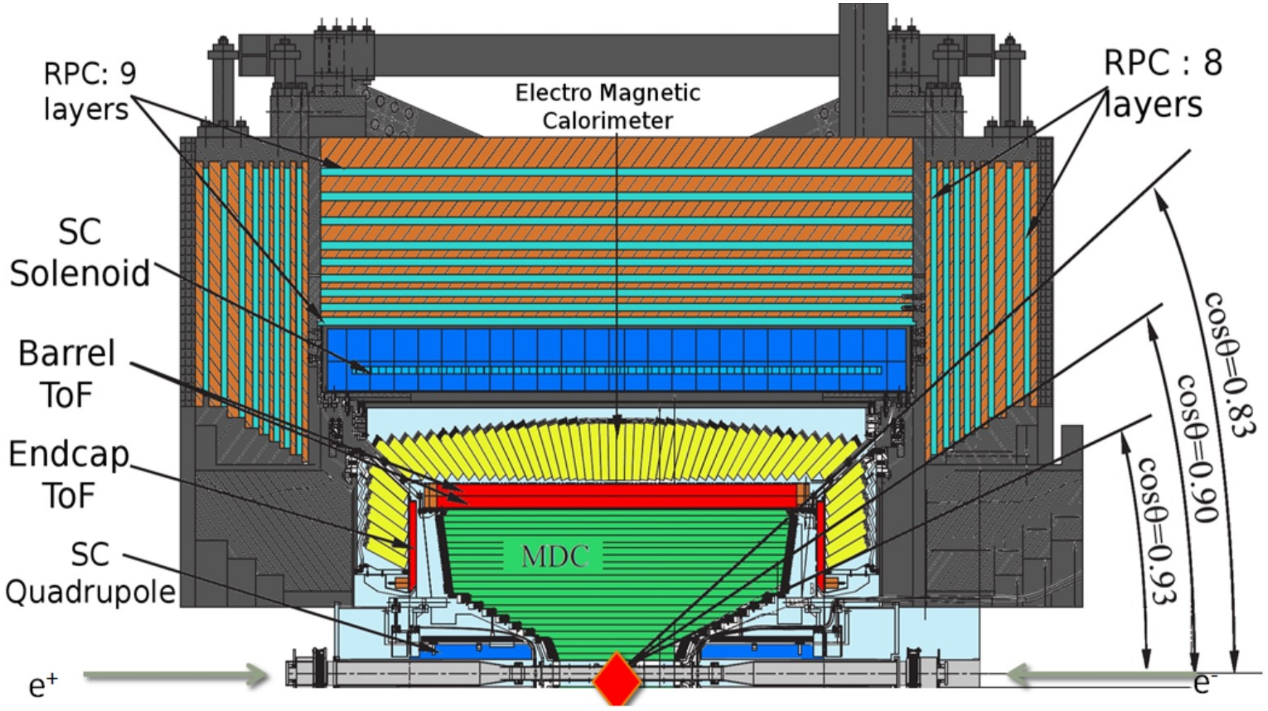
BEPCII and BESIII detector

Beijing Electron Positron Collider-II



Maximum Luminosity: $1.1\times10^{33}\mathrm{cm}^{-1}\mathrm{s}^{-1}$
Beam energy up to: 2.8 GeV

BEijing Spectrometer III

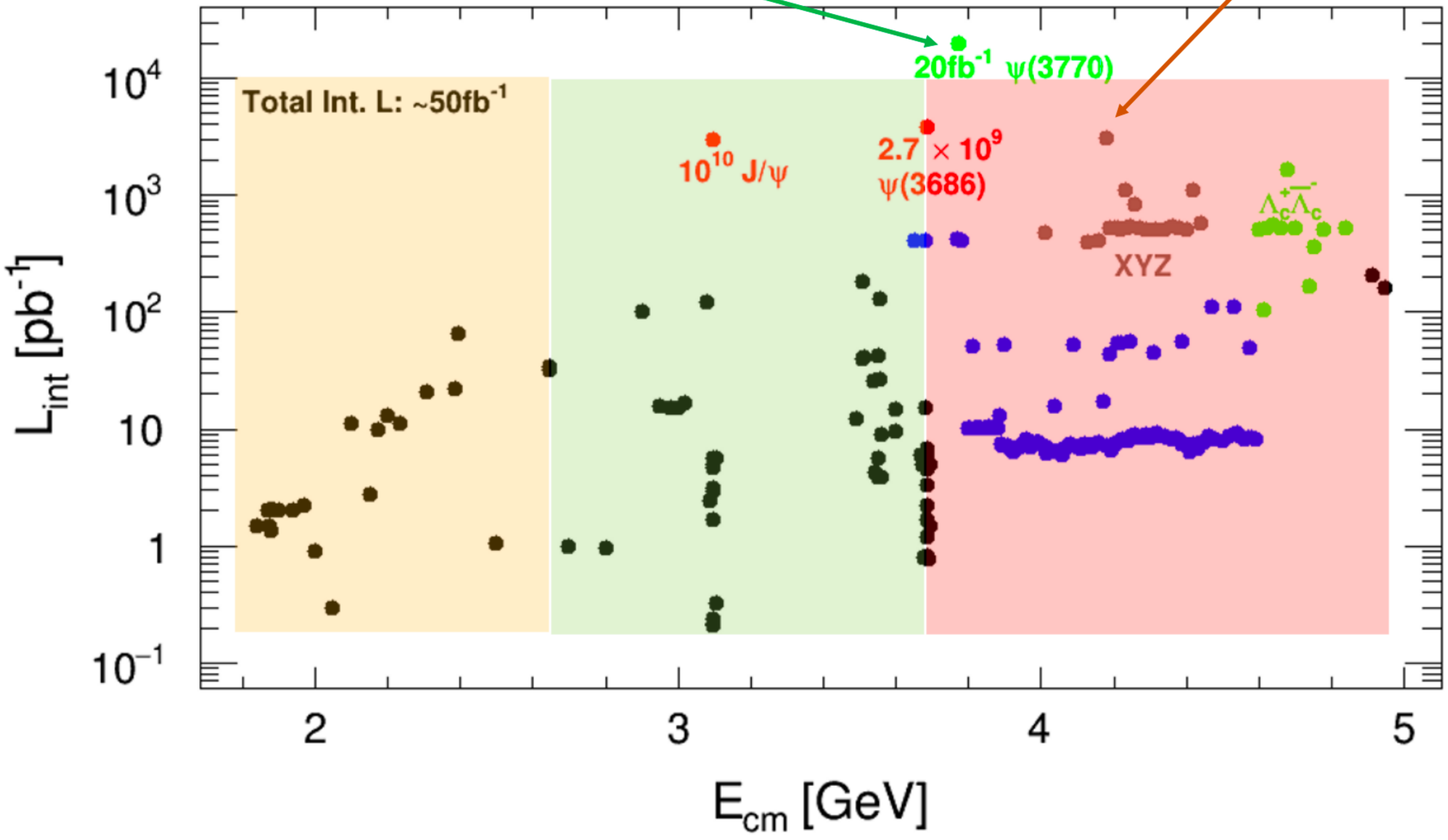


BESIII at the BEPCII accelerator is for the studies of hadron physics and τ-charm physics with the highest accuracy achieved until now

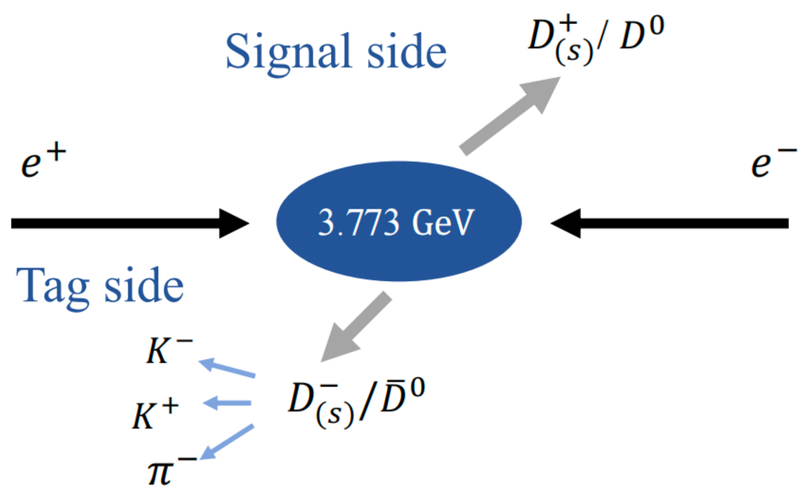
Data sample

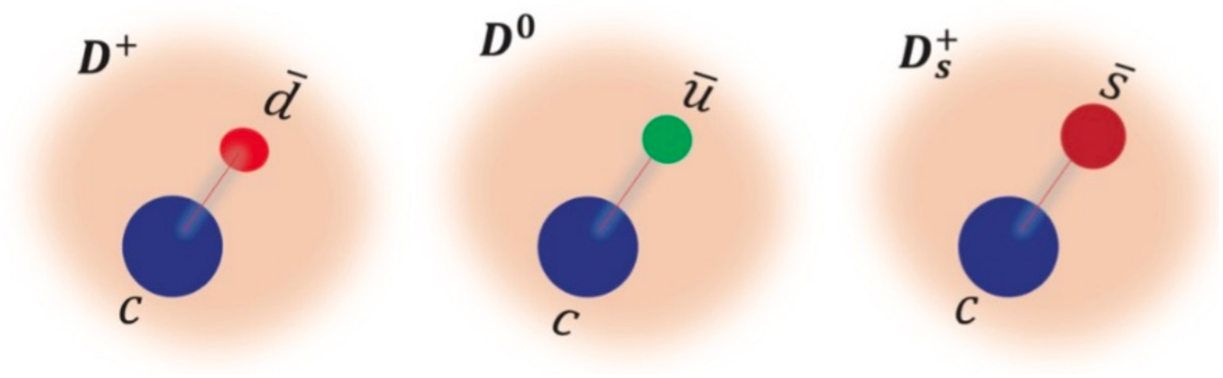
2024， 20.3 fb^{-1} data samples @ 3.773 GeV

2022， 7.33 fb^{-1} data samples @ 4.128-4.226 GeV



Analysis Strategy and Amplitude analyses



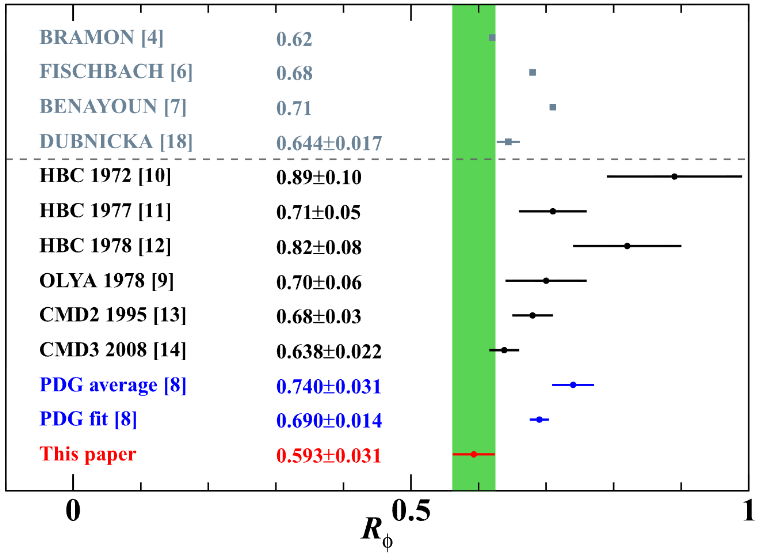


- Single Tag (ST): reconstruct only one D/D_S
  - ✓ Relative high background
  - ✓ Relative high efficiency
- Double Tag (DT): reconstruct both D/D_S
  - ✓ Relative clean background
  - ✓ Kinematic constraint on missing particles
  - ✓ Access to absolute BFs

D/D_S decays via $\boldsymbol{c \to s}$ transitions can directly decay into light quark final states, avoiding complex backgrounds. Precise amplitude analysis helps in studying the structure of intermediate resonances, e.g. $a_0(980)$ and $f_0(980)$ etc.

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

Phys. Rev. Lett. 136 (2025), 161902

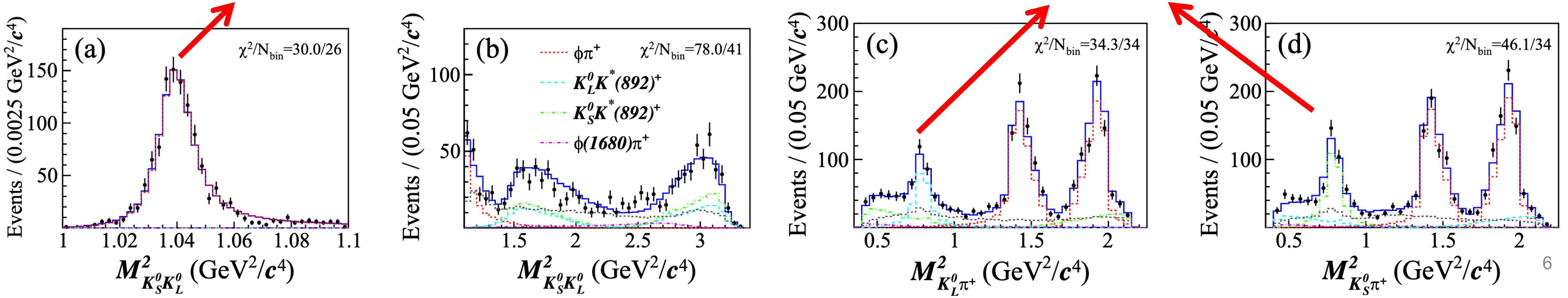


Amplitude	Phase (rad)	FF (%)	BF (%)	σ
$D_s^+ \to \phi\pi^+$	0.0(fixed)	$70.2 \pm 1.4 \pm 1.2$	$1.31 \pm 0.05 \pm 0.03$	>10
$D_s^+ \to K_L^0 K^*(892)^+$	$1.10 \pm 0.20 \pm 0.20$	$19.3 \pm 1.2 \pm 1.0$	$0.36 \pm 0.03 \pm 0.02$	>10
$D_s^+ \to K_S^0 K^*(892)^+$	$-1.93 \pm 0.20 \pm 0.25$	$14.4 \pm 1.2 \pm 1.2$	$0.27 \pm 0.02 \pm 0.02$	>10
$D_s^+ \to \phi(1680)\pi^+$	$-1.26 \pm 0.22 \pm 0.14$	$3.3 \pm 0.9 \pm 0.7$	$0.06 \pm 0.02 \pm 0.02$	4.3

- $R_\phi \equiv \frac{\mathcal{B}(\phi \to K_S^0 K_L^0)}{\mathcal{B}(\phi \to K^+ K^-)} = 0.593 \pm 0.023 \pm 0.014 \pm 0.016$, deviates from PDG by 3.2 σ
- $\frac{B(D_S^+ \to K_S^0 K^*(892)^+) - B(D_S^+ \to K_L^0 K^*(892)^+)}{B(D_S^+ \to K_S^0 K^*(892)^+) + B(D_S^+ \to K_L^0 K^*(892)^+)} = (-14.5 \pm 5.1 \pm 1.8)\ \%$

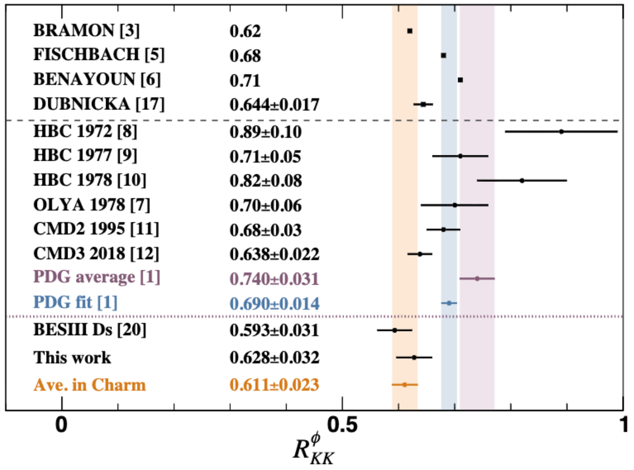
$\phi(1020)$

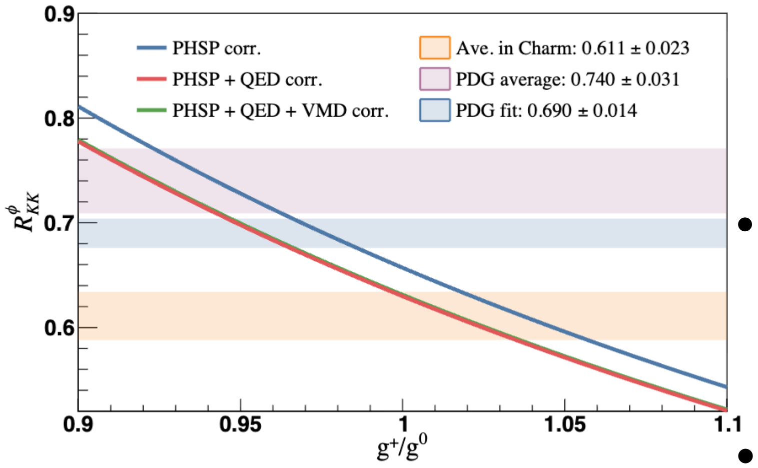
$K^*(892)^+$



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

arXiv: 2605.11464



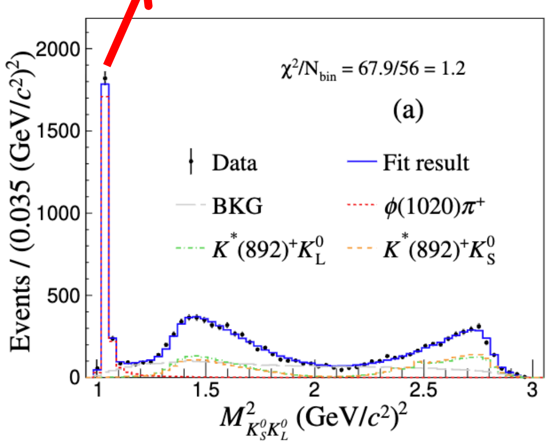


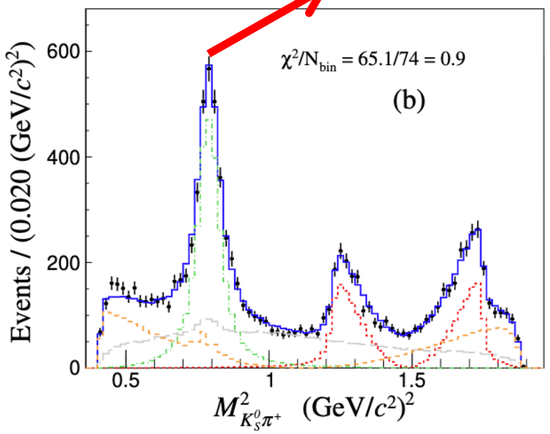
- $R_\phi \equiv \frac{\mathcal{B}(\phi \to K_S^0 K_L^0)}{\mathcal{B}(\phi \to K^+ K^-)} = 0.628 \pm 0.022 \pm 0.015 \pm 0.017$, deviates from PDG by 3.4σ
- $K_S^0 - K_L^0$ asymmetry test: phase difference is nearly π rad

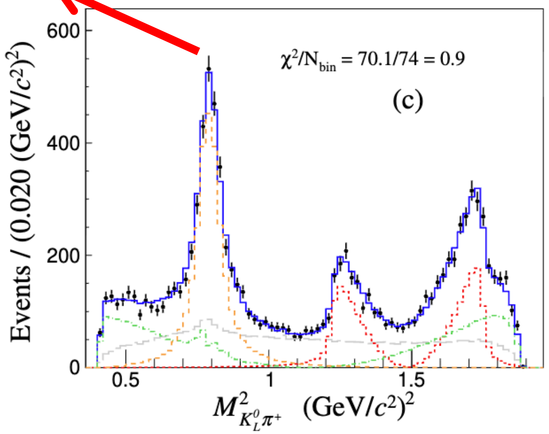
Amplitude	Phase (rad)	FF (%)	BF (10^{-3})	σ
$D^+ \to \phi\pi^+$	0.0(fixed)	$29.24 \pm 0.97 \pm 0.65$	$1.69 \pm 0.06 \pm 0.04$	>10
$D^+ \to K_L^0 K^*(892)^+$	$2.34 \pm 0.09 \pm 0.09$	$40.21 \pm 0.83 \pm 0.26$	$2.33 \pm 0.06 \pm 0.03$	>10
$D^+ \to K_S^0 K^*(892)^+$	$5.50 \pm 0.09 \pm 0.09$	$38.06 \pm 0.79 \pm 0.25$	$2.20 \pm 0.06 \pm 0.03$	>10

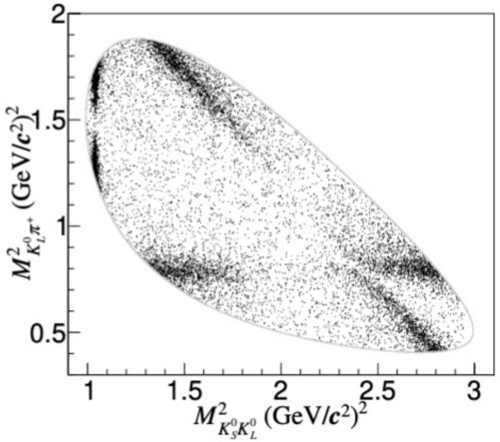
$\phi(1020)$

$K^*(892)^+$

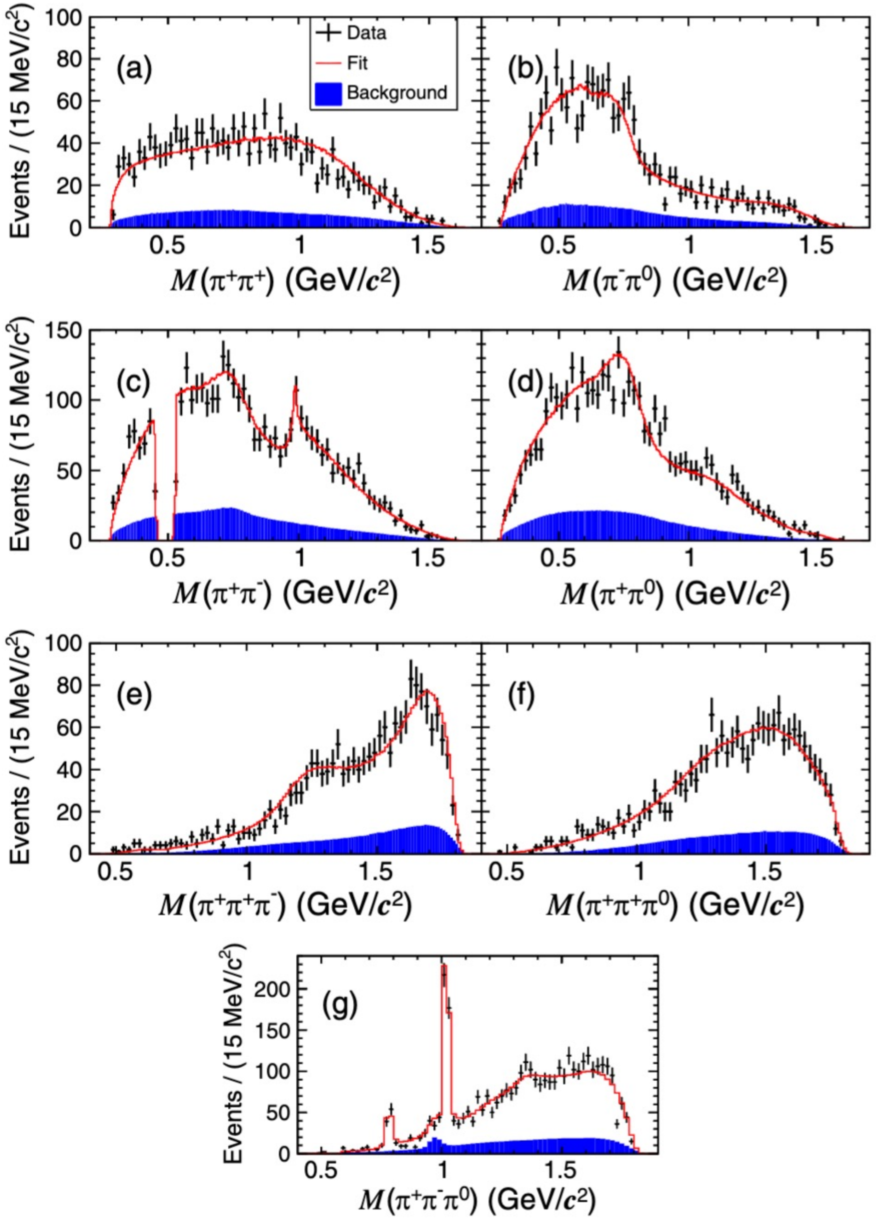








Amplitude analysis of $D_s^+ \to \pi^+\pi^+\pi^-\pi^0$



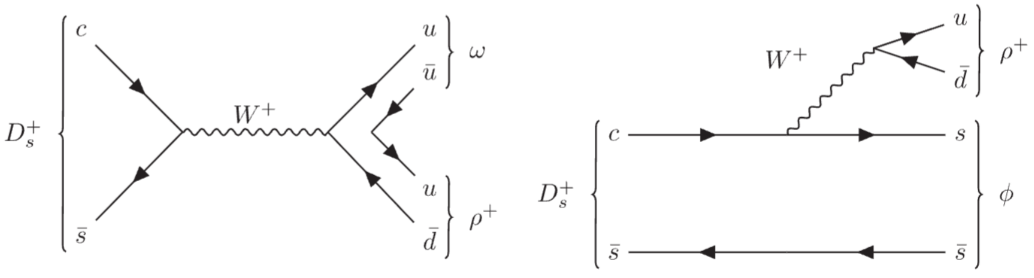
Phys. Rev. Lett. 134(2025) 1, 011904

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

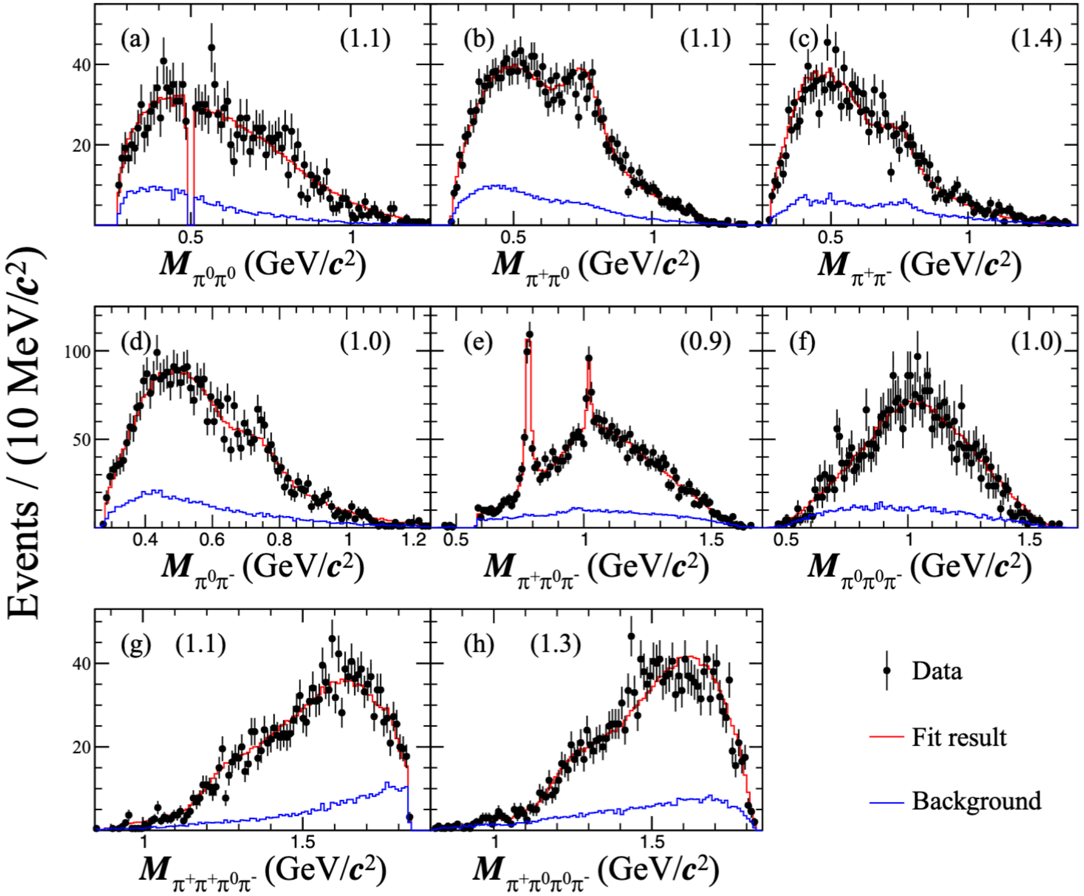
- First observation of the $D_s^+ \to f_0(980)\rho^+$
- $R_\phi = \frac{\mathcal{B}(\phi\to\pi^+\pi^-\pi^0)}{\mathcal{B}(\phi\to K^+K^-)} = 0.230 \pm 0.014 \pm 0.05$, deviating from the world average value by $> 4\sigma$
- The BF measurement of the W-annihilation decay $D_s^+ \to \omega(\to \pi^+\pi^-\pi^0)\pi^+$, a factor 2 more precise than previous measurements

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

Phys. Rev. Lett. 134(2025) 20, 201902



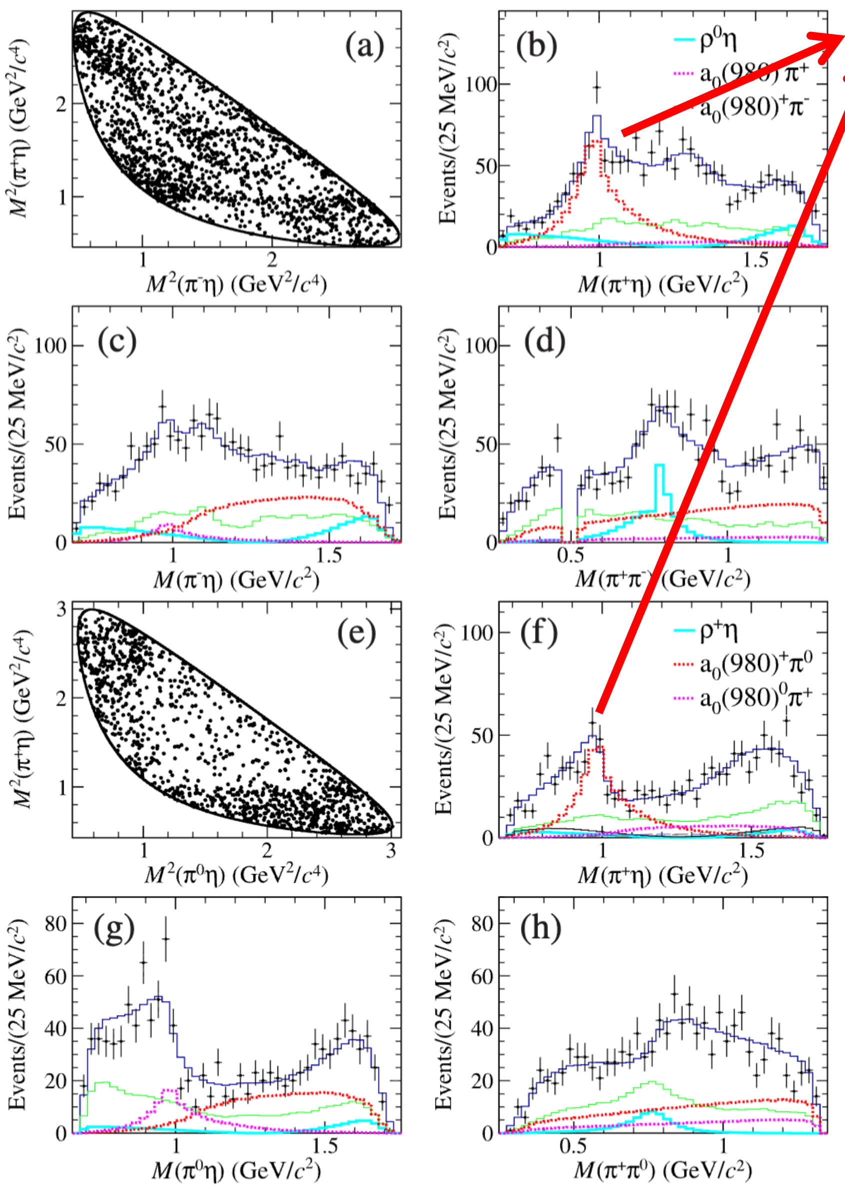
(a) (b)



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

- First observation of the pure *W*-annihilation decay $D_s^+ \to \omega\rho^+$ with the “polarization puzzle”
- $R_\phi = \frac{\mathcal{B}(\phi\to\pi^+\pi^-\pi^0)}{\mathcal{B}(\phi\to K^+K^-)} = 0.222 \pm 0.019_{stat.}{}^{+0.21}_{-0.19}{}_{syst.}$, deviates from results of e^+e^- annihilation and $K-N$ scattering experiments by more than 3σ

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



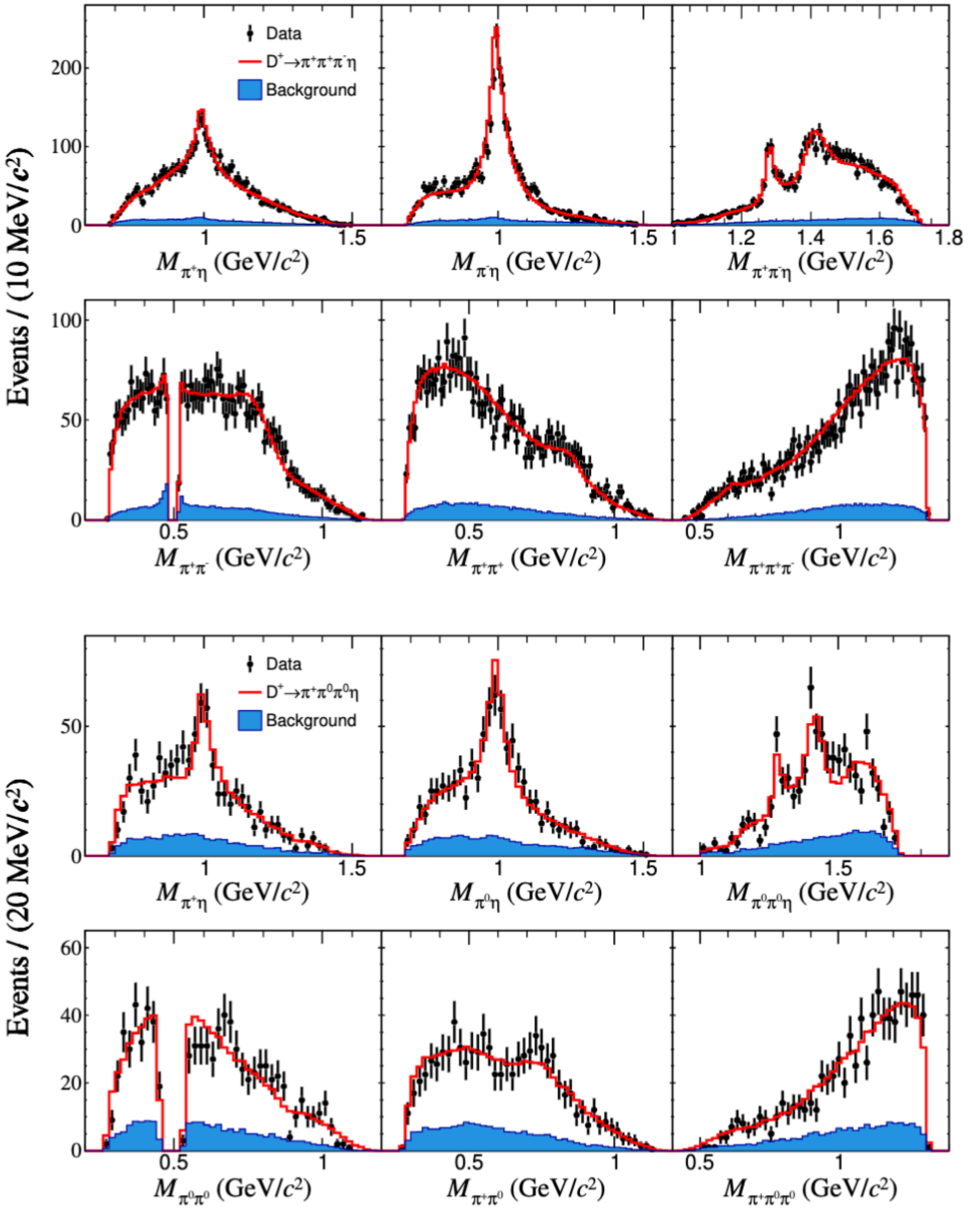
$a_0(980)^+$

Physical Review D 110, L111102 (2024)

Amplitude	Phase (in unit rad)	FF (%)	Significance (σ)	BF ($\times 10^{-3}$)
$D^0 \to \rho^0\eta$	0 (fixed)	$15.2 \pm 1.7 \pm 1.0$	>10	$0.19 \pm 0.02 \pm 0.01$
$D^0 \to a_0(980)^-\pi^+$	$0.06 \pm 0.16 \pm 0.12$	$5.9 \pm 1.3 \pm 1.0$	8.9	$0.07 \pm 0.02 \pm 0.01$
$D^0 \to a_0(980)^+\pi^-$	$-1.06 \pm 0.12 \pm 0.10$	$44.0 \pm 4.0 \pm 5.3$	>10	$0.55 \pm 0.05 \pm 0.07$
$D^0 \to a_2(1320)^+\pi^-$	$-1.16 \pm 0.25 \pm 0.23$	$2.1 \pm 0.9 \pm 0.8$	4.5	$0.03 \pm 0.01 \pm 0.01$
$D^0 \to a_2(1700)^+\pi^-$	$0.08 \pm 0.17 \pm 0.23$	$5.5 \pm 1.8 \pm 2.7$	6.1	$0.07 \pm 0.02 \pm 0.03$
$D^0 \to (\pi^+\pi^-)_{S\text{-wave}}\eta$	$-0.92 \pm 0.29 \pm 0.14$	$3.9 \pm 1.8 \pm 2.1$	5.3	$0.05 \pm 0.02 \pm 0.03$
$r_{+/-}$		$7.5^{+2.5}_{-0.8} \pm 1.7$	7.7[a]	$\cdots$
$D^+ \to \rho^+\eta$	$-4.03 \pm 0.19 \pm 0.13$	$9.3 \pm 3.0 \pm 2.1$	6.0	$0.20 \pm 0.07 \pm 0.05$
$D^+ \to (\pi^+\pi^0)_V\eta$	$-0.64 \pm 0.22 \pm 0.19$	$15.8 \pm 4.8 \pm 5.2$	4.7	$0.34 \pm 0.11 \pm 0.11$
$D^+ \to a_0(980)^+\pi^0$	0 (fixed)	$43.7 \pm 5.6 \pm 1.9$	9.1	$0.95 \pm 0.12 \pm 0.05$
$D^+ \to a_0(980)^0\pi^+$	$2.44 \pm 0.20 \pm 0.10$	$17.0 \pm 4.4 \pm 1.7$	7.9	$0.37 \pm 0.10 \pm 0.04$
$D^+ \to a_2(1700)^+\pi^0$	$0.92 \pm 0.20 \pm 0.14$	$4.2 \pm 2.1 \pm 0.7$	3.6	$0.09 \pm 0.05 \pm 0.02$
$D^+ \to a_0(1450)^+\pi^0$	$0.63 \pm 0.41 \pm 0.30$	$7.0 \pm 2.8 \pm 0.7$	4.7	$0.15 \pm 0.06 \pm 0.02$
$r_{+/0}$		$2.6 \pm 0.6 \pm 0.3$	4.0[a]	$\cdots$

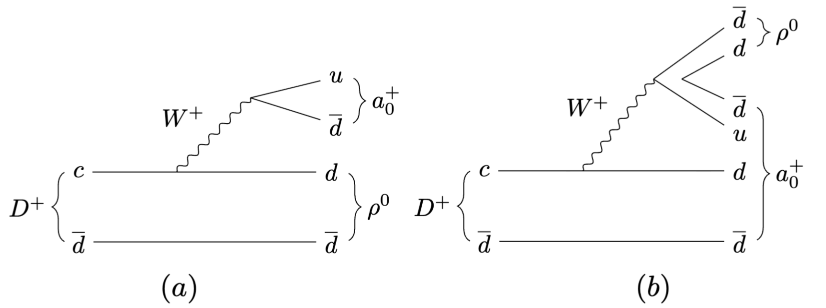
- The dominant decay mode is $D^{0(+)} \to a_0(980)^{-(+)}\pi^{+(0)}$
- $r_{+/-}$ is enhanced by FSI effect
  - ✓ $r_{+/-} = \frac{\mathcal{B}(D^0 \to a_0(980)^+\pi^-)}{\mathcal{B}(D^0 \to a_0(980)^-\pi^+)} = 7.5^{+2.5}_{-0.8} \pm 1.7$, two orders larger than the theoretical prediction of $r_{+/-} < 0.05$
  - ✓ $r_{+/0} = \frac{\mathcal{B}(D^+ \to a_0(980)^+\pi^0)}{\mathcal{B}(D^+ \to a_0(980)^0\pi^+)} = 2.6 \pm 0.6 \pm 0.3$
- The possible structure of $a_0(980)$
  - ✓ Four-quark model: additional contribution from a T-like diagram
  - ✓ Conventional diquark model: WE diagrams are enhanced

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



arXiv:2604.10444

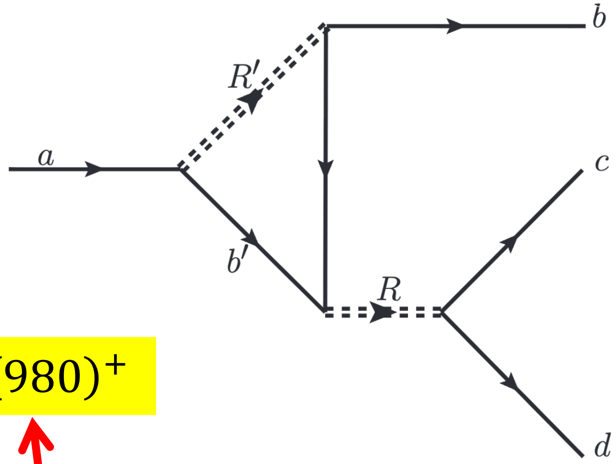
Amplitude	ϕ	FF(%)	Significance (σ)	BF($\times 10^{-4}$)
$D^+ \to \pi^+\pi^+\pi^-\eta$ decay:				
$D^+ \to a_0(980)^+\rho(770)^0$	0 (fixed)	$14.7 \pm 1.1 \pm 1.0$	> 10	$4.7 \pm 0.4 \pm 0.3$
$D^+ \to a_0(980)^+f_0(500)$	$5.5 \pm 0.1 \pm 0.2$	$23.2 \pm 2.3 \pm 2.2$	> 10	$7.5 \pm 0.7 \pm 0.7$
$D^+ \to \eta(1405)\pi^+$	$2.4 \pm 0.1 \pm 0.1$	$11.2 \pm 1.4 \pm 1.5$	> 10	$3.6 \pm 0.5 \pm 0.5$
$D^+ \to f_1(1285)\pi^+$	$4.9 \pm 0.1 \pm 0.3$	$17.3 \pm 0.9 \pm 0.8$	> 10	$5.5 \pm 0.3 \pm 0.3$
$D^+ \to f_1(1420)\pi^+$	$6.2 \pm 0.1 \pm 0.1$	$16.4 \pm 1.6 \pm 2.5$	> 10	$5.2 \pm 0.5 \pm 0.8$
$D^+ \to [a_0(980)^\pm\pi^\mp]_{S-wave}\pi^+$	$3.5 \pm 0.1 \pm 0.3$	$34.3 \pm 2.8 \pm 3.2$	> 10	$11.0 \pm 0.9 \pm 1.0$
$D^+ \to \pi^+\pi^0\pi^0\eta$ decay:				
$D^+ \to a_0(980)^0\rho(770)^+$	0 (fixed)	$35.0 \pm 3.5 \pm 2.6$	> 10	$8.5 \pm 0.9 \pm 0.6$
$D^+ \to a_0(980)^+f_0(500)$	$0.4 \pm 0.1 \pm 0.0$	$34.6 \pm 3.1 \pm 1.0$	> 10	$8.4 \pm 0.8 \pm 0.3$
$D^+ \to \eta(1405)\pi^+$	$2.6 \pm 0.3 \pm 0.2$	$4.3 \pm 1.7 \pm 0.7$	5.1	$1.0 \pm 0.4 \pm 0.2$
$D^+ \to f_1(1285)\pi^+$	$2.9 \pm 0.2 \pm 0.3$	$12.8 \pm 1.9 \pm 0.7$	> 10	$3.1 \pm 0.5 \pm 0.2$
$D^+ \to f_1(1420)\pi^+$	$5.9 \pm 0.2 \pm 0.3$	$17.8 \pm 3.0 \pm 1.6$	> 10	$4.3 \pm 0.8 \pm 0.4$
$D^+ \to [a_0(980)^0\pi^0]_{S-wave}\pi^+$	$4.4 \pm 0.2 \pm 0.2$	$11.0 \pm 2.6 \pm 0.9$	8.6	$2.7 \pm 0.6 \pm 0.2$



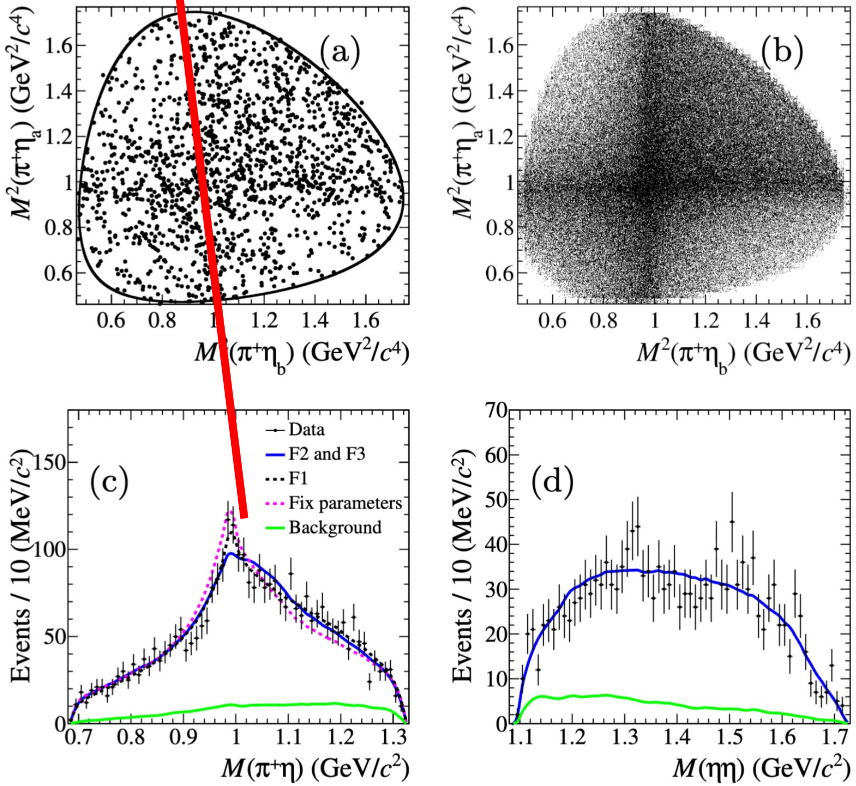
- The decay mode $D^+ \to a_0(980)^+f_0(500)$ is observed for the first time with an order of 10^{-3}
- $r_{+/0} \equiv \frac{\mathcal{B}(D^+ \to a_0(980)^+\rho(770)^0)}{\mathcal{B}(D^+ \to a_0(980)^0\rho(770)^+)} = 0.55 \pm 0.08 \pm 0.05$, implying substantial FSI effects, and provide a new perspective on the nature of the $a_0(980)$ states

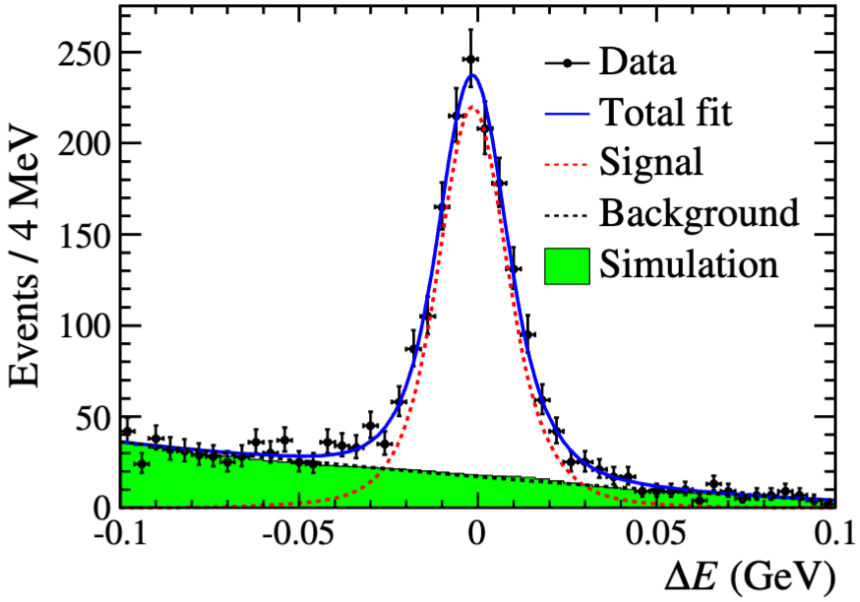
Amplitude analysis of $D^+ \to \pi^+\eta\eta$

arXiv:2505.12086



$a_0(980)^+$





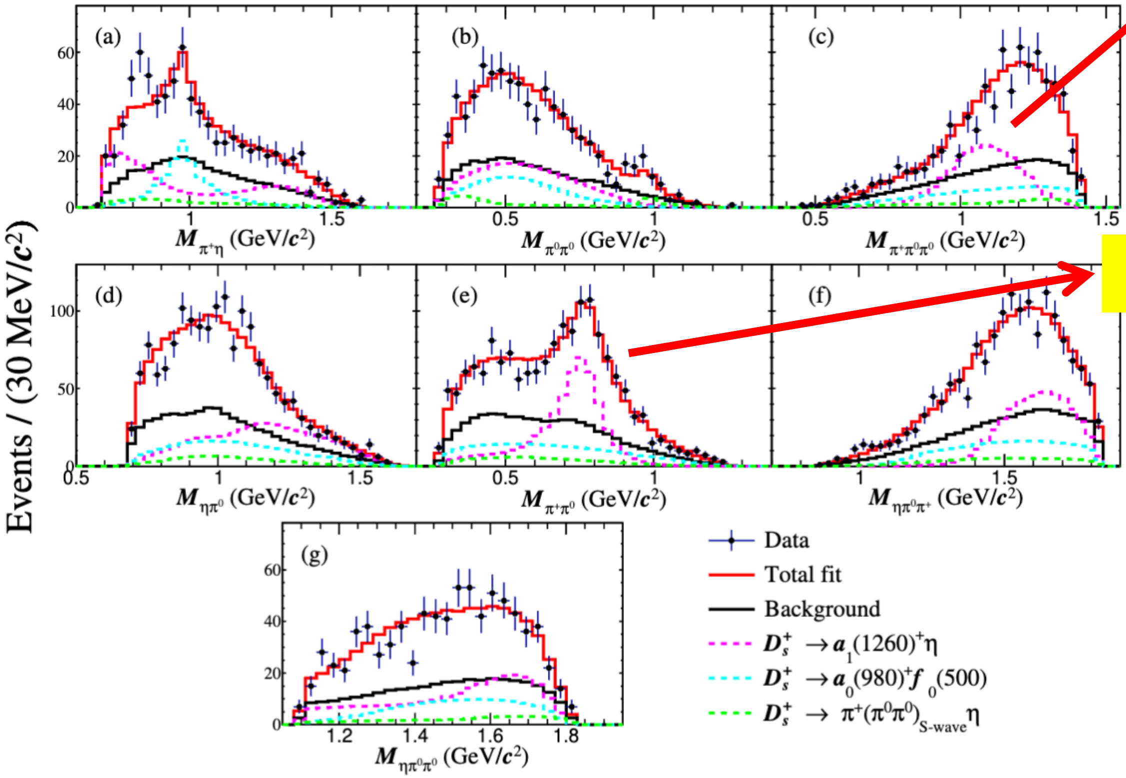
- The first observation of $\boldsymbol{D^+ \to a_0(980)^+(\to \pi^+\eta)\eta}$ with 5.8σ
- $\mathcal{B}(\boldsymbol{D^+ \to a_0(980)^+(\to \pi^+\eta)\eta}) = (3.67 \pm 0.12 \pm 0.06)\times10^{-3}$
- The line-shape of $\boldsymbol{a_0(980)}$ deviate from the shape expected from Flatté formalism
- The first experimental observation of a triangle loop rescattering effect

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

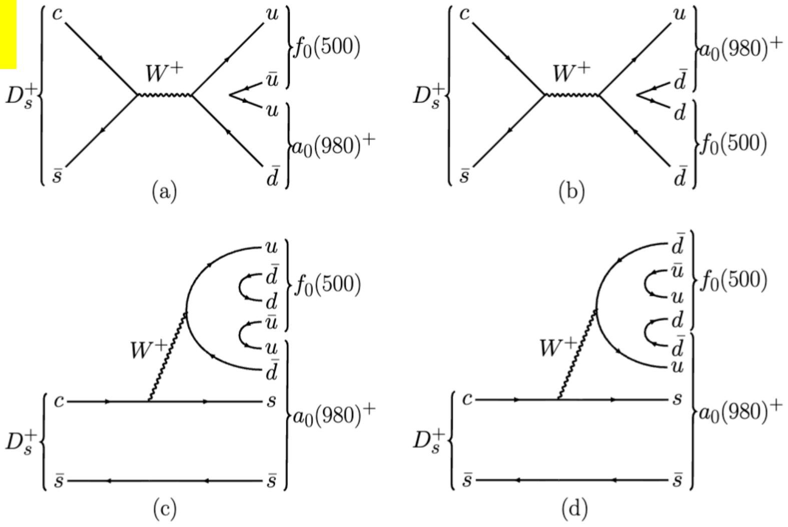
$a_1(1260)^+$

arXiv:2603.18521

$\rho(770)^+$



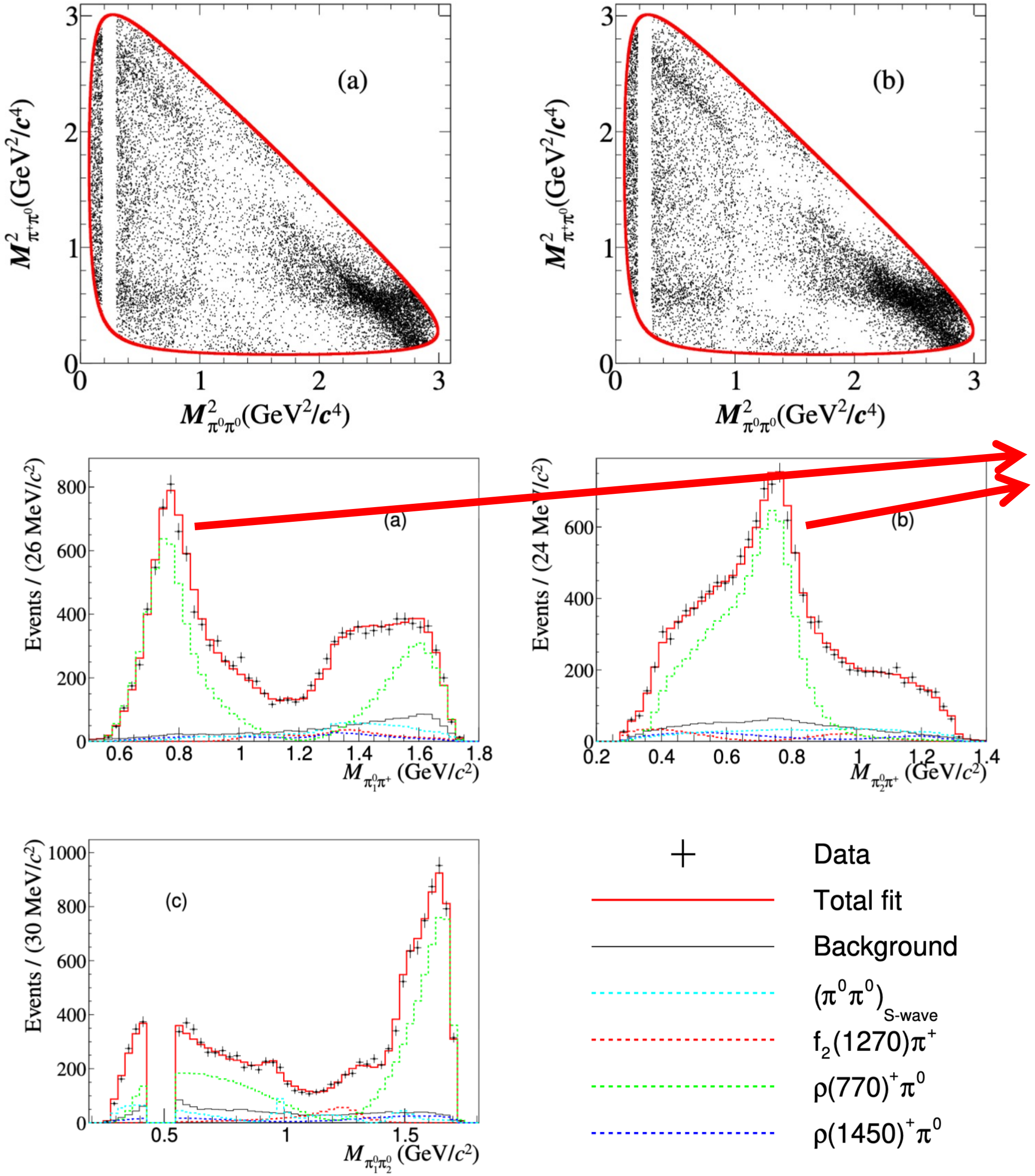
Amplitude	Phase (rad)	FF (%)	BF (%)	Significance
$D_s^+ \to a_1(1260)^+\eta, a_1(1260)^+ \to \rho(770)^+\pi^0$	0.0 (fixed)	$59.7 \pm 5.2 \pm 2.9$	$1.77 \pm 0.21 \pm 0.12$	$> 10\sigma$
$D_s^+ \to a_0(980)^+ f_0(500)$	$2.8 \pm 0.2 \pm 0.3$	$33.1 \pm 4.9 \pm 6.8$	$0.98 \pm 0.16 \pm 0.22$	$> 10\sigma$
$D_s^+ \to \pi^+(\pi^0\pi^0)_{S-\text{wave}}\eta$	$-0.8 \pm 0.2 \pm 0.3$	$9.4 \pm 1.9 \pm 4.1$	$0.28 \pm 0.06 \pm 0.13$	4.5σ



- The decay mode $D_s^+ \to \boldsymbol{a_0(980)^+ f_0(500)}$ is observed for the first time with an order of 10^{-2}
- $\mathcal{B}\left(D_s^+ \to \boldsymbol{a_0(980)^+ f_0(500)}\right) = (\mathbf{0.98 \pm 0.16 \pm 0.22})\%$, may indicate a substantial tetraquark component in the $\boldsymbol{a_0(980)}$ or significant contributions from final state interactions of triangle rescattering
- The isospin symmetry has been validated for $a_1(1260)^+ \to \rho(770)^{+(0)}\pi^{0(+)}$

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

arXiv:2512.12397



$\rho(770)^+$

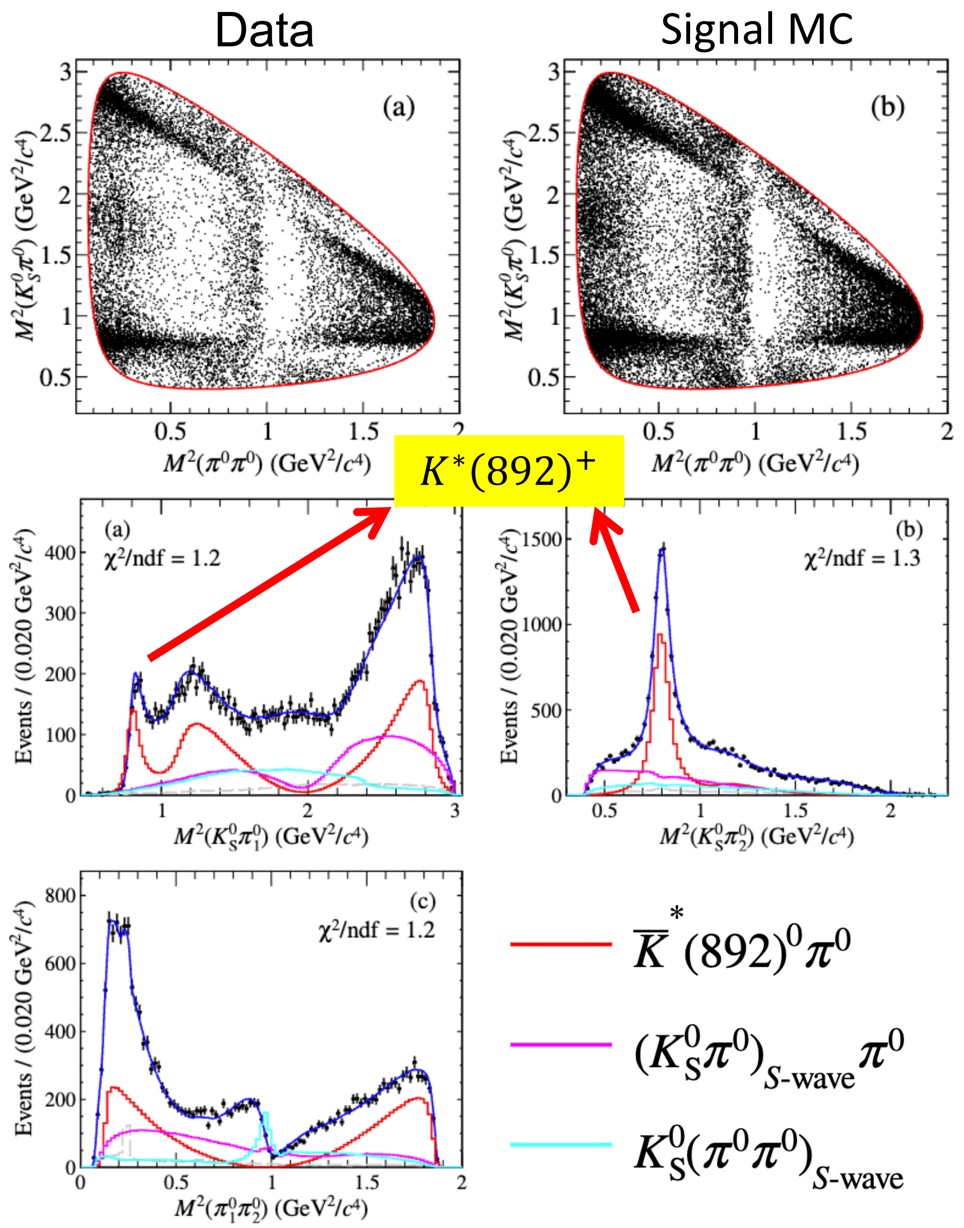
Decay mode	D^+ FF (%)	D^- FF (%)	A_{CP}(%)
$D^{+(-)} \to \rho(770)^{+(-)}\pi^0$	$66.2 \pm 2.7 \pm 1.5$	$61.5 \pm 2.6 \pm 1.3$	$+3.7 \pm 2.9 \pm 1.5$
$D^{+(-)} \to \rho(1450)^{+(-)}\pi^0$	$4.7 \pm 0.8 \pm 0.7$	$6.7 \pm 1.0 \pm 0.9$	$-17.5 \pm 9.8 \pm 7.0$
$D^{+(-)} \to f_2(1270)\pi^{+(-)}$	$4.3 \pm 0.4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

Decay mode	$\mathcal{B}$ ($\times 10^{-3}$)
$D^+ \to \rho(770)^+\pi^0$	$3.08 \pm 0.10 \pm 0.07$
$D^+ \to \rho(1450)^+\pi^0$	$0.25 \pm 0.04 \pm 0.03$
$D^+ \to f_2(1270)\pi^+$	$0.22 \pm 0.02 \pm 0.01$
$D^+ \to (\pi^0\pi^0)_{S\text{-wave}}\pi^+$	$0.56 \pm 0.04 \pm 0.02$

- $A_{CP} = (-1.4 \pm 1.0 \pm 0.6)\%$, no evidence for *CP* violation is observed
- $\mathcal{B}(D^+ \to \pi^+\pi^0\pi^0) = (4.84 \pm 0.05 \pm 0.05) \times 10^{-3}$
- The dominant decay mode is $D^+ \to \rho(770)^+\pi^0$, $\mathcal{B}(D^+ \to \rho(770)^+\pi^0) = (3.08 \pm 0.10 \pm 0.07) \times 10^{-3}$, which can be compared with the theoretical predictions

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

JHEP 03 (2026) 060



Amplitude	Magnitude	Phase (rad)	FF(%)
$D^0 \to \bar{K}^*(892)^0\pi^0$	1 (fixed)	0 (fixed)	$40.0 \pm 0.9 \pm 0.6$
$D^0 \to \bar{K}^*(1410)^0\pi^0$	0.33 ± 0.09	$3.74 \pm 0.22 \pm 0.31$	$0.5 \pm 0.3 \pm 0.4$
$D^0 \to \bar{K}_2^*(1430)^0\pi^0$	0.84 ± 0.07	$5.57 \pm 0.11 \pm 0.06$	$1.6 \pm 0.3 \pm 0.2$
$D^0 \to \bar{K}^*(1680)^0\pi^0$	1.56 ± 0.29	$1.73 \pm 0.18 \pm 0.21$	$3.7 \pm 1.5 \pm 2.5$
$D^0 \to K_S^0 f_2(1270)$	2.04 ± 0.22	$1.02 \pm 0.13 \pm 0.05$	$2.5 \pm 0.6 \pm 0.5$
$D^0 \to (K_S^0\pi^0)_{S-\text{wave}}\pi^0$	—	—	$30.4 \pm 5.4 \pm 2.2$
$\alpha_{K\pi}$	$2.86 \pm 0.24 \pm 0.12$	$8.57 \pm 0.16 \pm 0.31$	
$\alpha_{K\eta'}$	$21.15 \pm 2.27 \pm 2.43$	$-10.77 \pm 0.14 \pm 0.23$	
α_{32}	$4.10 \pm 0.53 \pm 0.90$	$3.93 \pm 0.09 \pm 0.06$	
$D^0 \to K_S^0(\pi^0\pi^0)_{S-\text{wave}}$	0.77 ± 0.04	$0.49 \pm 0.06 \pm 0.06$	$14.6 \pm 1.7 \pm 0.6$
β_1	$8.71 \pm 0.42 \pm 0.59$	$1.17 \pm 0.04 \pm 0.02$	
f_{11}^{prod}	$8.07 \pm 0.23 \pm 0.25$	$-2.13 \pm 0.03 \pm 0.03$	
Total			93.3

- Compare to previous CLEO results
  - ✓ Additional contribution from $(K_S^0\pi^0)_{S-wave}$
  - ✓ K-matrix formalism is adopted rather than isobar model
- $\mathcal{B}(D^0 \to K_S^0\pi^0\pi^0) = (1.026 \pm 0.008 \pm 0.009)\%$
- $\mathcal{B}(D^0 \to \bar{K}^*(892)^0 (\to K_S^0\pi^0)\pi^0) = (4.10 \pm 0.10 \pm 0.07) \times 10^{-3}$

BFs measurement of D_s^+ hadronic decays

Mode	$\mathcal{A}_{CP}$ (%)	PDG $\mathcal{A}_{CP}$ (%)
$D_s^\pm \to K_S^0 K^\pm$	$0.29 \pm 0.50 \pm 0.21$	0.09 ± 0.26
$D_s^\pm \to K^+ K^- \pi^\pm$	$0.48 \pm 0.26 \pm 0.24$	-0.5 ± 0.9
$D_s^\pm \to K_S^0 K^\pm \pi^0$	$-0.85 \pm 1.97 \pm 0.46$	-2 ± 6
$D_s^\pm \to K_S^0 K_S^0 \pi^\pm$	$1.14 \pm 1.58 \pm 0.44$	3 ± 5
$D_s^\pm \to K^+ K^- \pi^\pm \pi^0$	$-0.66 \pm 0.91 \pm 0.33$	0.0 ± 3.0
$D_s^\pm \to K_S^0 K^\pm \pi^+ \pi^-$	$2.00 \pm 2.37 \pm 0.70$	-6 ± 5
$D_s^\pm \to K_S^0 K^\mp \pi^\pm \pi^\pm$	$-0.24 \pm 1.05 \pm 1.07$	4.1 ± 2.8
$D_s^\pm \to \pi^\pm \pi^+ \pi^-$	$-0.88 \pm 1.17 \pm 0.38$	-0.7 ± 3.1
$D_s^\pm \to \pi^\pm \eta$	$-0.44 \pm 0.89 \pm 0.19$	0.3 ± 0.4
$D_s^\pm \to \pi^\pm \pi^0 \eta$	$1.05 \pm 1.45 \pm 0.62$	-1 ± 4
$D_s^\pm \to \pi^\pm \pi^+ \pi^- \eta$	$2.42 \pm 2.85 \pm 0.78$	-
$D_s^\pm \to \pi^\pm \eta'$	$-0.59 \pm 0.76 \pm 0.20$	-0.9 ± 0.5
$D_s^\pm \to \pi^\pm \pi^0 \eta'$	$-1.60 \pm 2.57 \pm 0.64$	0 ± 8
$D_s^\pm \to K_S^0 \pi^\pm \pi^0$	$-2.17 \pm 4.65 \pm 1.10$	3 ± 6
$D_s^\pm \to K^\pm \pi^+ \pi^-$	$1.81 \pm 2.01 \pm 0.45$	4 ± 5

Mode	$\mathcal{B}$ (%)	PDG $\mathcal{B}$ (%)
$D_s^+ \to K_S^0 K^+$	$1.502 \pm 0.012 \pm 0.009$	1.453 ± 0.035
$D_s^+ \to K^+ K^- \pi^+$	$5.49 \pm 0.04 \pm 0.07$	5.37 ± 0.10
$D_s^+ \to K_S^0 K^+ \pi^0$	$1.47 \pm 0.02 \pm 0.02$	1.47 ± 0.07
$D_s^+ \to K_S^0 K_S^0 \pi^+$	$0.73 \pm 0.01 \pm 0.01$	0.71 ± 0.04
$D_s^+ \to K^+ K^- \pi^+ \pi^0$	$5.50 \pm 0.05 \pm 0.11$	5.50 ± 0.24
$D_s^+ \to K_S^0 K^+ \pi^+ \pi^-$	$0.93 \pm 0.02 \pm 0.01$	0.95 ± 0.08
$D_s^+ \to K_S^0 K^- \pi^+ \pi^+$	$1.56 \pm 0.02 \pm 0.02$	1.53 ± 0.08
$D_s^+ \to \pi^+ \pi^+ \pi^-$	$1.09 \pm 0.01 \pm 0.01$	1.08 ± 0.04
$D_s^+ \to \pi^+ \eta$	$1.69 \pm 0.02 \pm 0.02$	1.67 ± 0.09
$D_s^+ \to \pi^+ \pi^0 \eta$	$9.10 \pm 0.09 \pm 0.15$	9.5 ± 0.5
$D_s^+ \to \pi^+ \pi^+ \pi^- \eta$	$3.08 \pm 0.06 \pm 0.05$	3.12 ± 0.16
$D_s^+ \to \pi^+ \eta'$	$3.95 \pm 0.04 \pm 0.07$	3.94 ± 0.25
$D_s^+ \to \pi^+ \pi^0 \eta'$	$6.17 \pm 0.12 \pm 0.14$	6.08 ± 0.29
$D_s^+ \to K_S^0 \pi^+ \pi^0$	$0.51 \pm 0.02 \pm 0.01$	0.54 ± 0.03
$D_s^+ \to K^+ \pi^+ \pi^-$	$0.620 \pm 0.009 \pm 0.006$	0.620 ± 0.019

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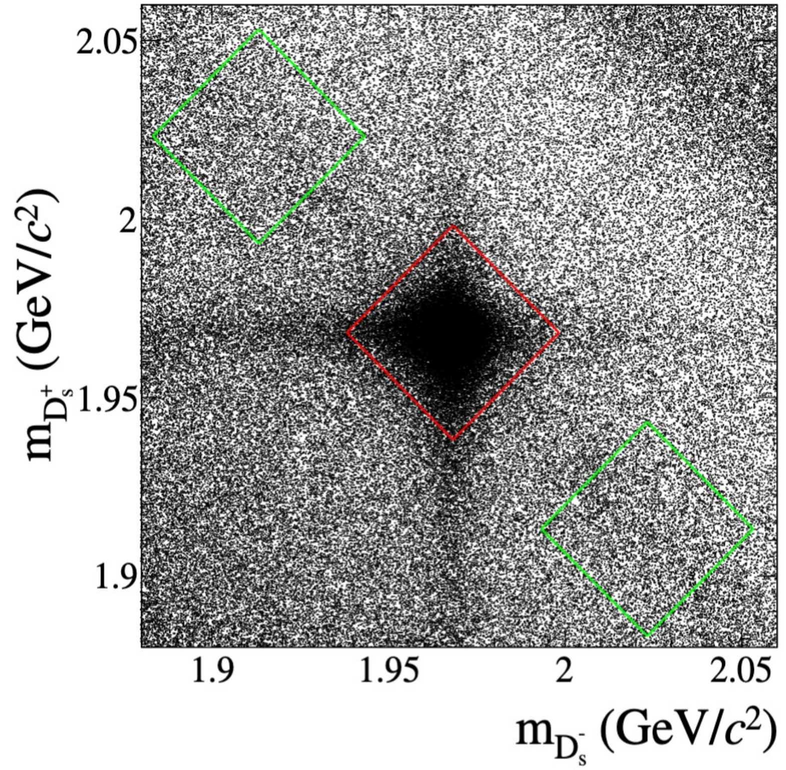
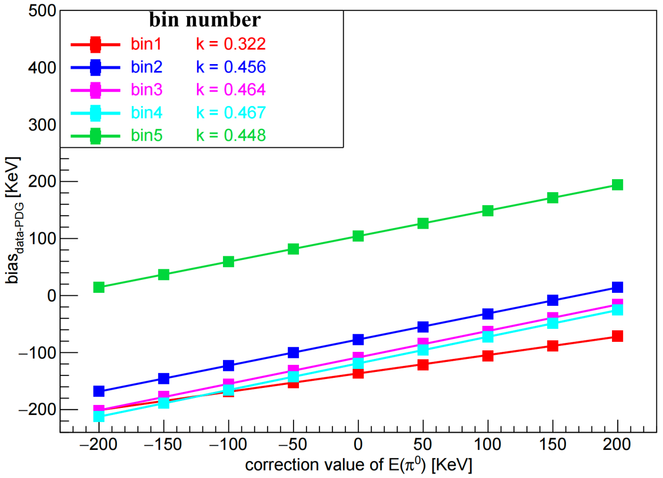


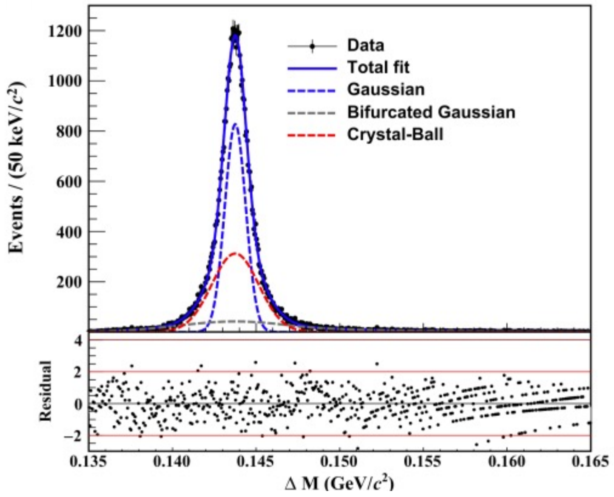
- Absolute branching fractions of 15 hadronic D_s^+ decays are measured by a global fit
- CP-violating asymmetries of the 15 hadronic $D_s^\pm$ decays are measured. No significant asymmetries are observed

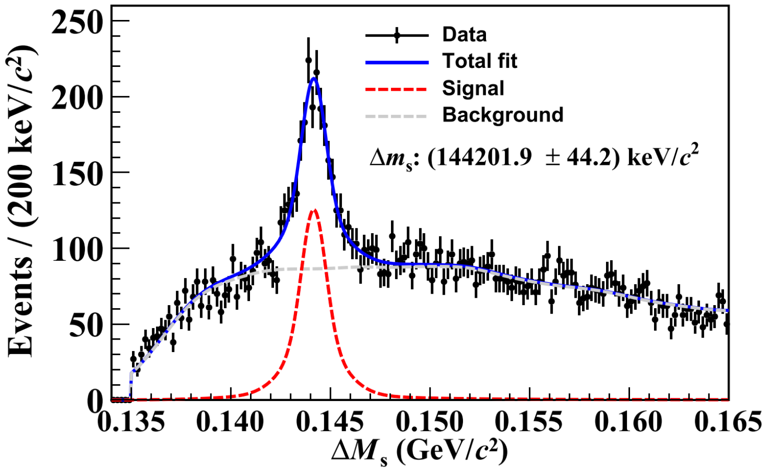
Precision measurement of $D_s^{*+} - D_s^{+}$ meson mass splitting

Science Bulletin 71 (2026) pp. 2675-2681
Poster: 2-14

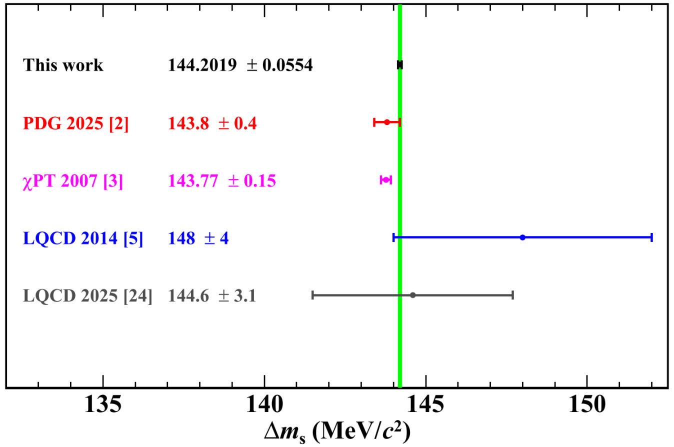
a. $D^{*+} \to D^+ (\to K^- \pi^+ \pi^+) \pi^0$ (calibrate)
b. $D^{*+} \to D^+ (\to K^+ K^- \pi^+) \pi^0$ (validate)
c. $D_s^{*+} \to D_s^+ (\to K^+ K^- \pi^+) \pi^0$ (signal)







Label	Decay Chain	no-correction [keV/c^2]	Level1 (P) correction [keV/c^2]	Level2 (cos θ) correction [keV/c^2]	PDG value [keV/c^2]
(a)	$D^{*+} \to D^+(\to K^-\pi^+\pi^+)\pi^0$	140615.9 ± 3.4	140606.9 ± 3.4	140604.0 ± 3.4	140603 ± 15
(b)	$D^{*+} \to D^+(\to K^+K^-\pi^+)\pi^0$	140601.8 ± 12.8	140592.7 ± 12.8	140589.8 ± 12.8	140603 ± 15
(c)	$D_s^{*+} \to D_s^+(\to K^+K^-\pi^+)\pi^0$	144216.1 ± 44.2	144206.2 ± 44.2	144201.9 ± 44.2	143800 ± 400



- $\Delta m \equiv M(D_s^{*+}) - M(D_s^+) = 144201.9 \pm 44.2_{stat.} \pm 29.9_{syst.} \pm 15.0_{input}$ with a precision 7 times better than the current world average
- The momentum calibration method can be applied to any measurement involving soft π^0 reconstruction, e.g., $D_{s0}^*(2317), D_{s1}(2460)\ and\ \Xi^0$

Summary

- Using threshold-produced $D_{(s)}^{*+}D^{(*)-}$ data, BESIII experiment has performed precise measurements of the hadronic decays of charmed mesons:
  - ✓ Observation of the anomalous enhancement of the branching fraction due to FSI
  - ✓ Provided further constraints on the internal structure models of $a_0(980)$ and $f_0(980)$ etc.
  - ✓ Provided further evidence for the ϕ meson decay puzzle
  - ✓ Precise measurements of hadronic parameters