Hadronic decays of $D_{(s)}$ at BESIII

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Outline

- BEPCII and BESIII
- BESIII Data Taken near DD^{bar} Threshold
- Analysis Technique
- $D_s^+ \to \eta' X$ and $D_s^+ \to \eta' \rho^+$
- $D^+ \to \omega\pi^+$ and $D^0 \to \omega\pi^0$
- $D^+ \to K_S K_S K^+$, $K_S K_S \pi^+$ and $D^0 \to K_S K_S (K_S)$
- $D^0 \to K^- \pi^+ \pi^+ \pi^-$ (amplitude analysis)
- $D^0 \to K_S K^+ K^-$
- $D_s^+ \to \omega\pi^+$ and $D^0 \to \omega K^+$
- $D_s \to p n^{bar}$
- Summary

Beijing Electron Positron Collider (BEPCII)

New Two-Ring Machine

2004: start BEPCII construction
2008: test run of BESPCII
2009-now: BESIII data taking
Beam energy: 1.0-2.3 GeV
Design Luminosity: 1×10^{33} $cm^{-2}s^{-1}$
Achieved Luminosity in 2016:
1.0×10^{33} $cm^{-2}s^{-1}$

BESIII Detector

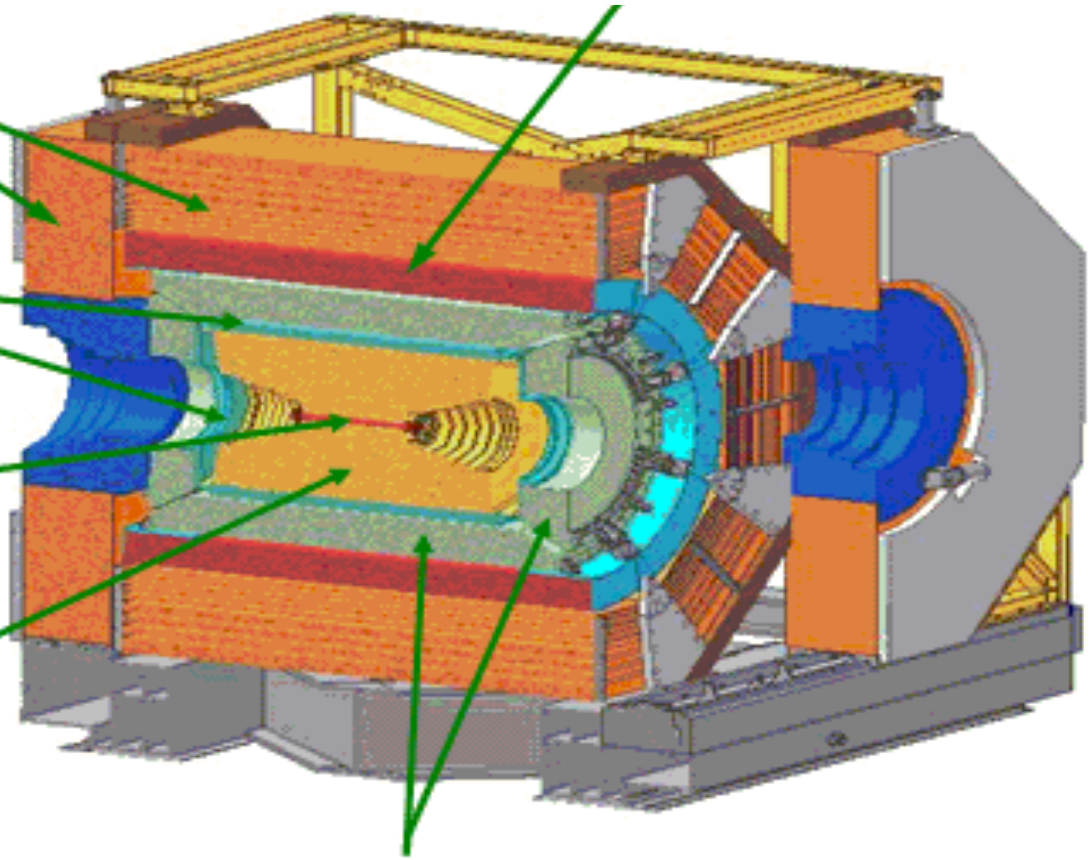
Muon Counter
8-9 layers RPC
$\Delta R\varphi$ = 1.4 cm ~ 1.7 cm

Super-conducting magnet
1.0 Tesla

Time of Flight (TOF)
σ_T: 90 ps Barrel
110 ps Endcap

Beryllium beam pipe

Drift Chamber (MDC)
σ_p/p = 0.5% (1 GeV)
$\sigma_{dE/dx}$ = 6%



EMC (CsI)
$\sigma_E/\sqrt{E}$ = 2.5% (1 GeV)
$\sigma_{Z,\varphi}$ = 0.5 - 0.7 cm/$\sqrt{E}$

BESIII Data Taken near $D\bar{D}$ Threshold

- 2.9 fb^{-1} dataset at ψ(3770) resonance

M_{D0} = 1864.84 MeV M_{D+} = 1869.62 MeV

2 M_{D0} = 3729.68 MeV 2 M_{D+} = 3739.24 MeV

- 0.48 fb^{-1} dataset at center of mass energy 4.009 GeV

M_{Ds} = 1968.47 MeV

2 M_{Ds} = 3936.94 MeV

- Advantages of $D\bar{D}$ pair production near threshold:
  - The $D\bar{D}$ events are clean; not enough energy for even one additional pion
  - Tagging reduces background from light-quark "continuum" and other charm final states
  - Double tag technique can provide access to absolute BFs
  - Many systematic uncertainties cancel with tagging technique
- New 3.19 fb^{-1} dataset at E_{cm} 4.178 GeV
  - $D_s^{\pm}$ are produced mostly via $e^+e^- \rightarrow D_s D_s^*$

Important Variables

- Beam-Constrained Mass (M_{BC})

$$M_{\mathrm{BC}} = \sqrt{E_{\mathrm{beam}}^2 - |\vec{p}_D|^2}$$

M_{BC} peaks at D mass:
momentum conservation

- Energy Difference (ΔE)

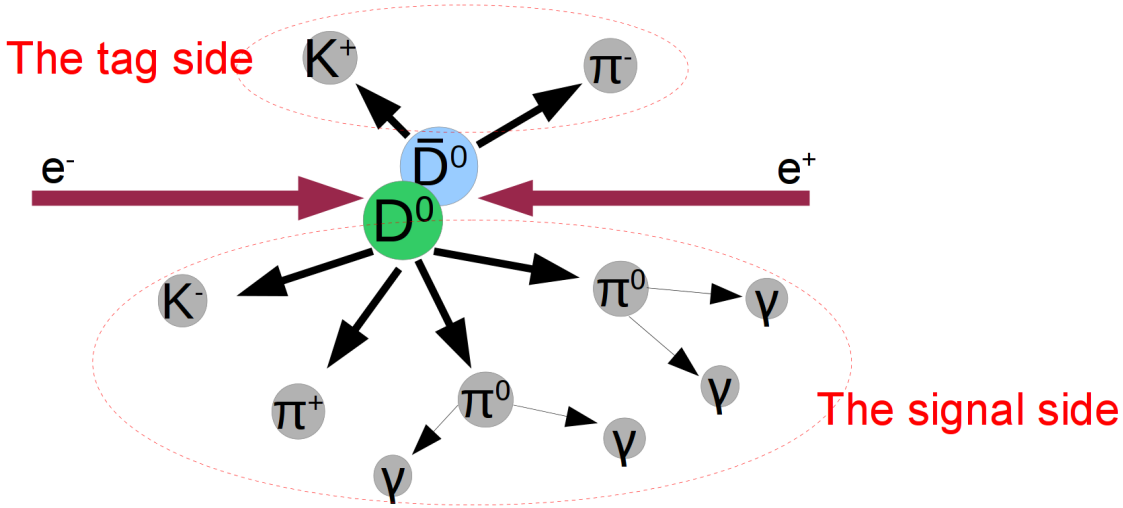
$$\Delta E = E_D - E_{\mathrm{beam}}$$

ΔE peaks at zero:
energy conservation

Typically cut on ΔE, then fit to M_{BC} obtain yield

DTag Technique

- There are two types of samples used in the DTag technique: single tag (ST) and double tag (DT).
- Single tag: only one D or $\overline{D}$ meson is reconstructed through a chosen hadronic decay.
- Double tag: both D and $\overline{D}$ are reconstructed,
- The D reconstructed through the studied hadronic decay is called “the signal side”.
- The $\overline{D}$ reconstructed through well-known and clean hadronic decay modes is called “the tag side”.
- (Charge-conjugate states are implied throughout this talk.)



Branching Fraction and Tagging

- Single tag (ST)

$$N_{\rm tag}^{\rm ST} = 2N_{D^0\bar{D}^0}\mathcal{B}_{\rm tag}\varepsilon_{\rm tag}$$

- Double tag (DT)

$$N_{\rm tag,sig}^{\rm DT} = 2N_{D^0\bar{D}^0}\mathcal{B}_{\rm tag}\mathcal{B}_{\rm sig}\varepsilon_{\rm tag,sig}$$

$\varepsilon_{\rm tag,sig} \approx \varepsilon_{\rm tag}\varepsilon_{\rm sig}$ (factorization)

where $N_{D^0\bar{D}^0}$ is the total number of produced $D^0\bar{D}^0$ pairs, $\mathcal{B}_{\rm tag(sig)}$ is the branching fraction of the tag (signal) side, and the ε are the corresponding efficiencies.

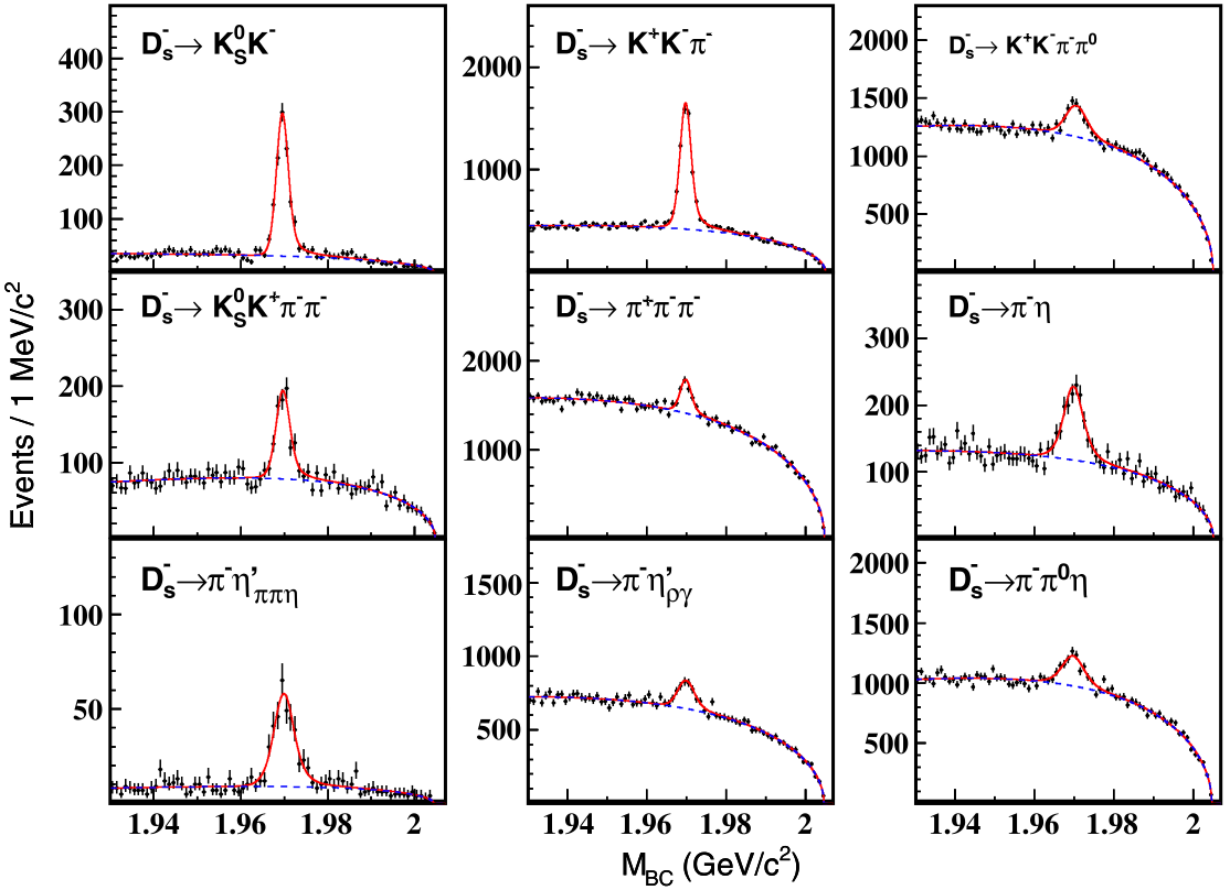
$$\mathcal{B}_{\rm sig} = \frac{N_{\rm tag,sig}^{\rm DT}}{N_{\rm tag}^{\rm ST}}\frac{\varepsilon_{\rm tag}}{\varepsilon_{\rm tag,sig}}$$

$N_{D^0\bar{D}^0}$, $\mathcal{B}_{\rm tag}$ are canceled.
$\varepsilon_{\rm tag}$ is approximately canceled due to factorization

This is the basic idea for branching fraction.
Equations used in analysis vary case by case.

Measurements of the branching fraction of $D_s^+ \to \eta' X$

Single tag nine tag modes

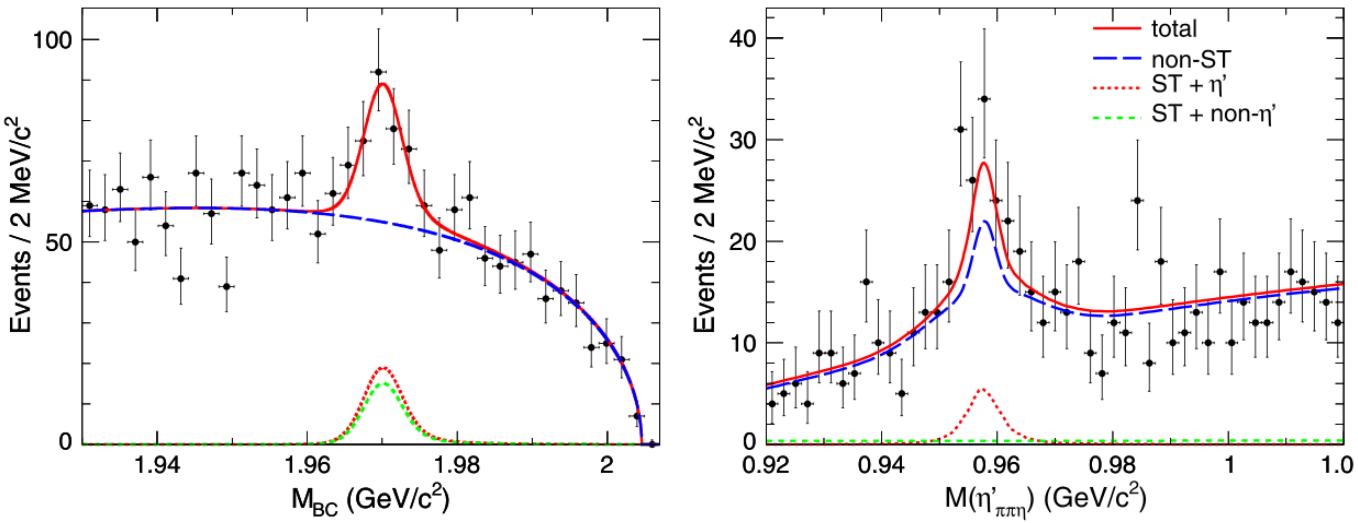


First, single tag nine tag modes. Then, reconstruct $\eta' \to \pi^+\pi^-\eta$ with $\eta \to \gamma\gamma$.

The decay mode $\eta' \to \rho^0\gamma$ is not used due to large combinatorial background.

$$\mathcal{B}(D_s^+ \to \eta' X)\mathcal{B}_{\eta'}^{\rm PDG} = \frac{\sum_\alpha y_{\rm DT}^\alpha}{\sum_\alpha y_{\rm ST}^\alpha \cdot \frac{\varepsilon_{\rm DT}^\alpha}{\varepsilon_{\rm ST}^\alpha}} = \frac{y_{\rm DT}}{\sum_\alpha y_{\rm ST}^\alpha \cdot \frac{\varepsilon_{\rm DT}^\alpha}{\varepsilon_{\rm ST}^\alpha}}$$

A two-dimensional fit to M_{BC} (tag) vs. $M(\eta'_{\pi+\pi-\eta})$ (signal) is performed to obtain the DT yields.



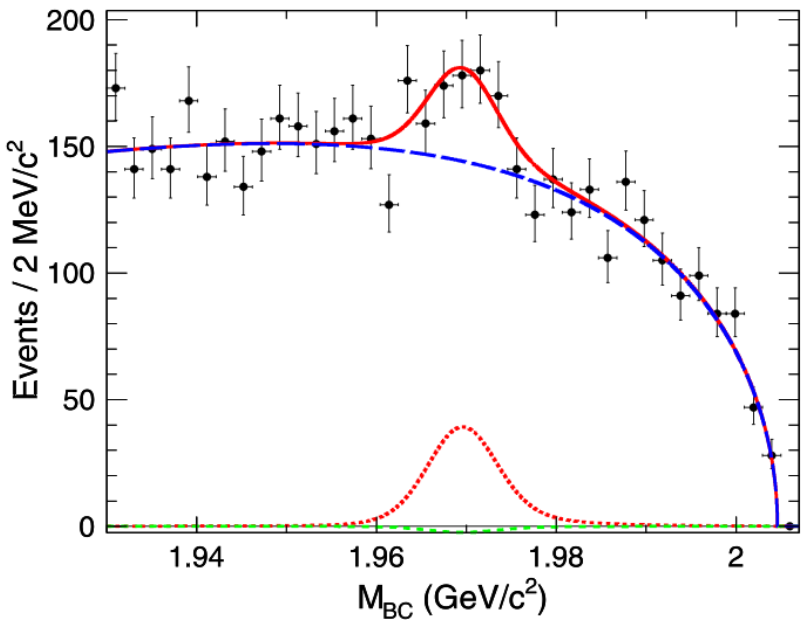
ST mode α	$\varepsilon^{\alpha}_{ST}$ (%)	y^{α}_{ST}	$\varepsilon^{\alpha}_{DT}$ (%)	y_{DT}
$K^0_S K^-$	47.89 ± 0.35	1088 ± 40	13.75 ± 0.14	
$K^+K^-\pi^-$	44.16 ± 0.18	5355 ± 118	12.46 ± 0.14	
$K^+K^-\pi^-\pi^0$	13.25 ± 0.22	1972 ± 145	4.32 ± 0.08	
$K^0_S K^+\pi^-\pi^-$	24.27 ± 0.37	595 ± 50	6.05 ± 0.09	
$\pi^+\pi^-\pi^-$	60.26 ± 0.90	1657 ± 143	17.18 ± 0.16	68 ± 14
$\pi^-\eta$	48.39 ± 0.70	843 ± 54	14.82 ± 0.16	
$\pi^-\eta'_{\pi\pi\eta}$	29.48 ± 0.52	461 ± 41	7.91 ± 0.11	
$\pi^-\eta'_{\rho\gamma}$	43.11 ± 0.88	1424 ± 147	11.96 ± 0.13	
$\pi^-\pi^0\eta$	26.02 ± 0.32	2260 ± 156	7.90 ± 0.11	

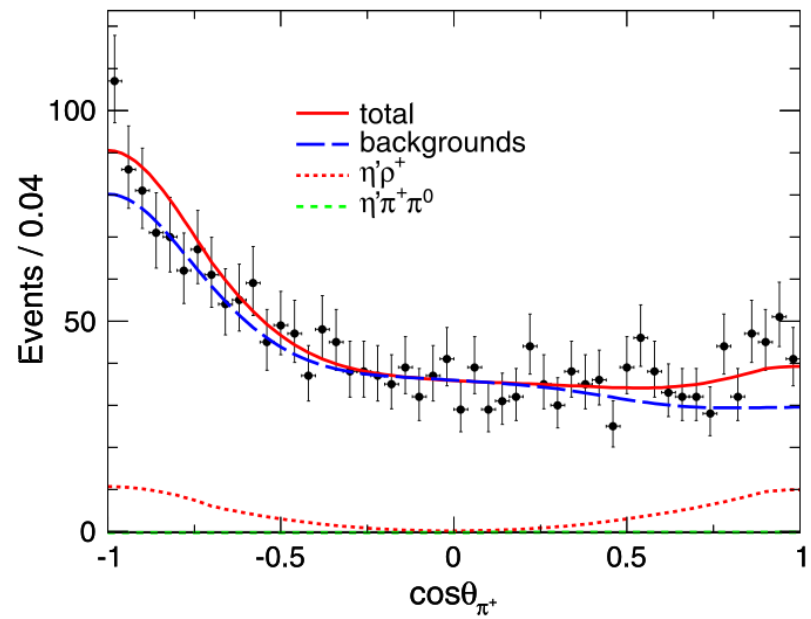
$$\mathcal{B}(D_s^+ \to \eta' X) = (8.8 \pm 1.8 \pm 0.5)\%$$

Measurements of the branching fraction of $D_s^+ \to \eta'\rho^+$

Using the DT samples from $D_s^+ \to \eta' X$ analysis, invariant mass cuts on η' and ρ^+ are applied to enrich the $D_s^+ \to \eta'\rho^+$ signal events.

A two-dimensional fit to the distribution of M_{BC} vs. $\cos\theta_{\pi+}$ to determine the signal yield.





$$\frac{\mathcal{B}(D_s^+ \to \eta'\rho^+)\mathcal{B}_{\rho^+}^{\rm PDG}\mathcal{B}_{\eta'}^{\rm PDG}}{\mathcal{B}(D_s^+ \to K^+K^-\pi^+)} = \frac{y_{\rm ST}^{\eta'\rho^+}}{y_{\rm ST}^{K^+K^-\pi^+}} \cdot \frac{\varepsilon_{\rm ST}^{K^+K^-\pi^+}}{\varepsilon_{\rm ST}^{\eta'\rho^+}}$$

$$\mathcal{B}(D_s^+ \to \eta'\rho^+) = (5.8 \pm 1.4 \pm 0.4)\%$$

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Observation of the Singly Cabibbo-Suppressed Decay $D^+ \to \omega\pi^+$ and Evidence for $D^0 \to \omega\pi^0$

Chose six (five) decay modes for $D^{+(0)}$.

In order to have a better solution for $D^{+(0)} \to \pi^+\pi^-\pi^0\pi^{+(0)}$ background, DT samples $D^{+(0)} \to \pi^+\pi^-\pi^0\pi^{+(0)}$ vs. tag modes are reconstructed first. Then fits to $\pi^+\pi^-\pi^0$ mass are performed.

Note that we are searching for $\omega \to \pi^+\pi^-\pi^0$.

$$\mathcal{B}_{\rm sig} = \frac{\sum_\alpha N_{\rm sig}^{{\rm obs},\alpha}}{\sum_\alpha N_{\rm tag}^{{\rm obs},\alpha}\epsilon_{\rm tag,sig}^\alpha/\epsilon_{\rm tag}^\alpha}$$

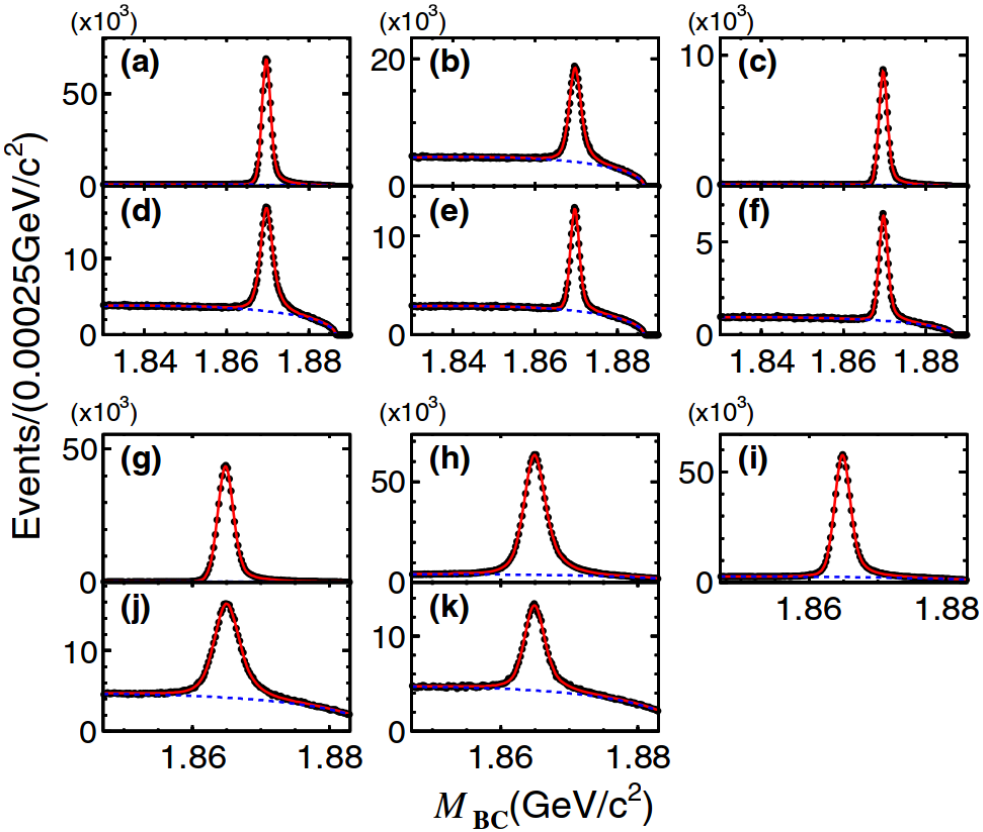


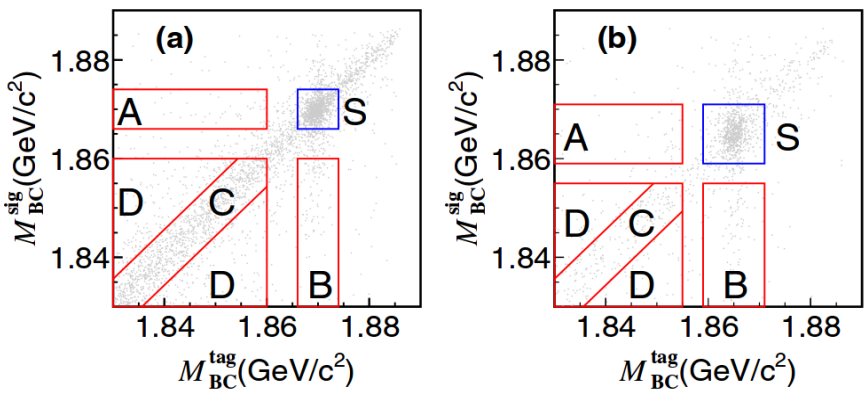
FIG. 1. $M_{\rm BC}$ distributions of ST samples for different tag modes. The first two rows show charged D decays: (a) $K^+\pi^-\pi^-$, (b) $K^+\pi^-\pi^-\pi^0$, (c) $K_S^0\pi^-$, (d) $K_S^0\pi^-\pi^0$, (e) $K_S^0\pi^+\pi^-\pi^-$, (f) $K^+K^-\pi^-$, the latter two rows show neutral D decays: (g) $K^+\pi^-$, (h) $K^+\pi^-\pi^0$, (i) $K^+\pi^-\pi^+\pi^-$, (j) $K^+\pi^-\pi^0\pi^0$, (k) $K^+\pi^-\pi^+\pi^-\pi^0$. Data are shown as points, the (red) solid lines are the total fits and the (blue) dashed lines are the background shapes. D and $\bar{D}$ candidates are combined.

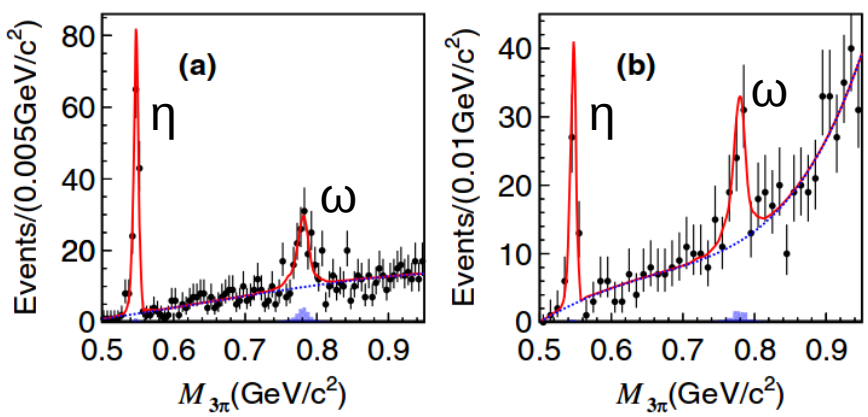
DT $D^{+(0)} \to \pi^+\pi^-\pi^0\pi^{+(0)}$ vs. tag modes

Fits to M3π distributions of signal and sideband regions to obtain the signal and peaking background yields, respectively.

Events counts in sidebands are projected into the signal region with scale factors.

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





Red line: total fit

Blue line: background

Hatched histogram: peaking background From sidebands

ModeH	$N_{\omega(\eta)}$	$N_{\omega(\eta)}^{bkg}$	N_{sig}^{obs}
$D^+ \to \omega\pi^+$	100 ± 16	21 ± 4	79 ± 16
$D^0 \to \omega\pi^0$	50 ± 12	5 ± 5	45 ± 13
$D^+ \to \eta\pi^+$	264 ± 17	6 ± 2	258 ± 18
$D^0 \to \eta\pi^0$	78 ± 10	3 ± 2	75 ± 10

Mode	This work	Previous measurements
$D^+ \to \omega\pi^+$	$(2.79 \pm 0.57 \pm 0.16) \times 10^{-4}$	$< 3.4 \times 10^{-4}$ at 90% C.L.
$D^0 \to \omega\pi^0$	$(1.17 \pm 0.34 \pm 0.07) \times 10^{-4}$	$< 2.6 \times 10^{-4}$ at 90% C.L.
$D^+ \to \eta\pi^+$	$(3.07 \pm 0.22 \pm 0.13) \times 10^{-3}$	$(3.53 \pm 0.21) \times 10^{-3}$
$D^0 \to \eta\pi^0$	$(0.65 \pm 0.09 \pm 0.04) \times 10^{-3}$	$(0.68 \pm 0.07) \times 10^{-3}$

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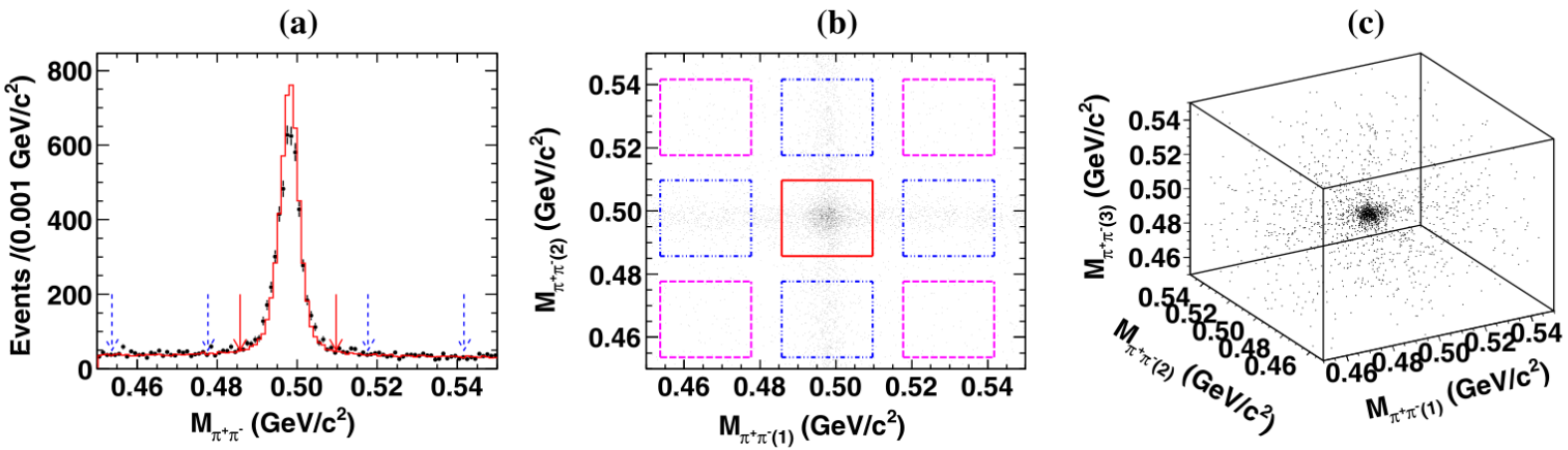
Measurements of the branching fractions for $D^+ \to K_S K_S K^+$, $K_S K_S \pi^+$ and $D^0 \to K_S K_S (K_S)$

Single tag the signal mode.
The combinatorial $\pi^+\pi^-$ pair background is the main issue.

An invariant mass cut, $M_{\pi+\pi-}$, is applied during the reconstruction of K_S, but the combinatorial $\pi^+\pi^-$ (not from K_S) pairs may also satisfy the cut. To remove this background, the 2D or 3D sideband regions are studied.



1D $M_{\pi+\pi+}$ distribution. Solid (dashed) arrows denote the KS signal (sideband) region.

2D $M_{\pi+\pi+}$ distribution.

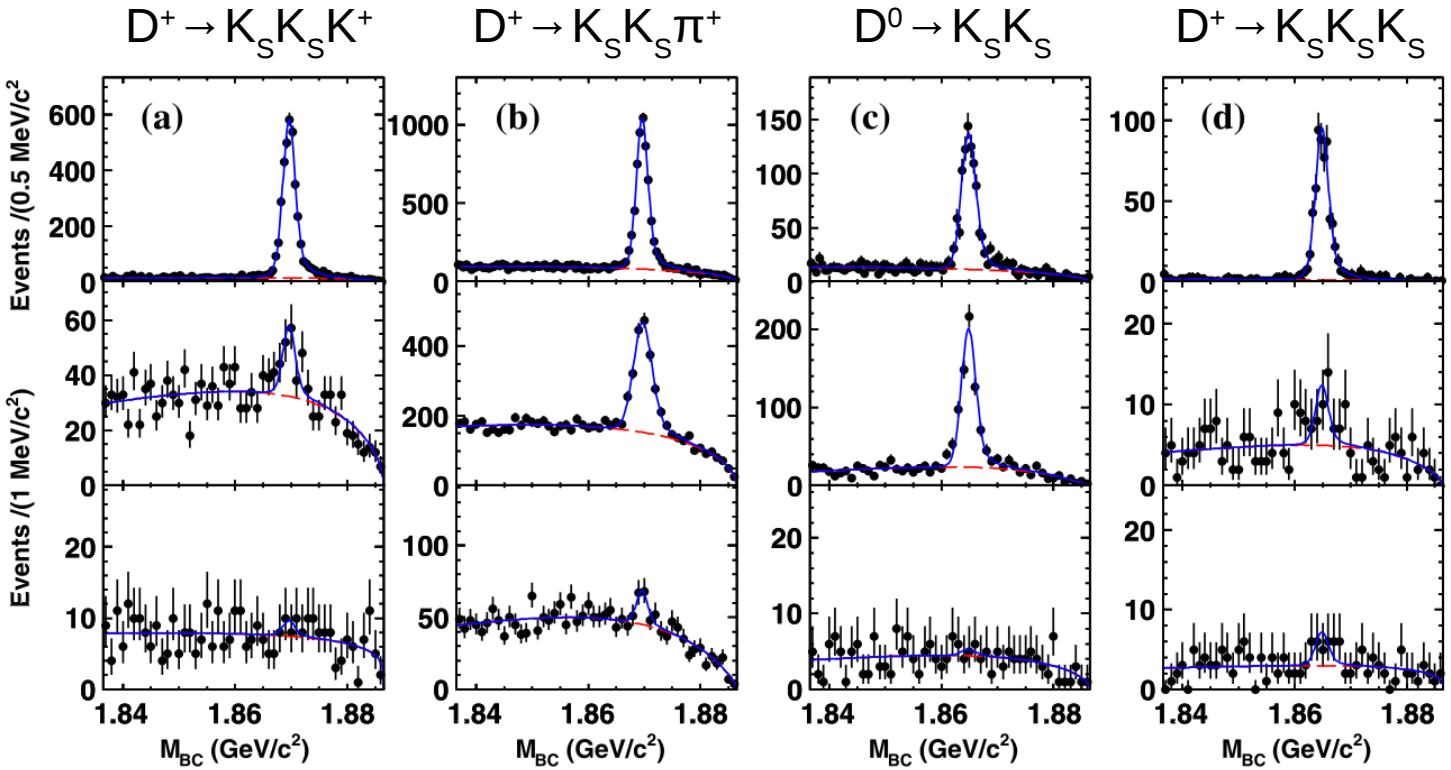
3D $M_{\pi+\pi+}$ distribution.

$$\mathcal{B}(D^{+(0)} \to f) = \frac{N_{\rm net}}{2 \cdot \sigma_{D^+D^-\,(D^0\bar{D}^0)} \cdot \mathcal{L} \cdot \epsilon}$$

Signal region

One $\pi^+\pi^-$ pair sideband region

Two $\pi^+\pi^-$ pairs sideband region



For modes with two K_S: $N_{\rm net} = N_{K^0_S{\rm sig}} - \frac{1}{2}N_{\rm sb1} + \frac{1}{4}N_{\rm sb2} - N^{\rm b}_{\rm other}$

For mode with three K_S: $N_{\rm net} = N_{K^0_S{\rm sig}} - \frac{1}{2}N_{\rm sb1} + \frac{1}{4}N_{\rm sb2} - \frac{1}{8}N_{\rm sb3} - N^{\rm b}_{\rm other}$

Decay modes	$N_{K^0_S{\rm sig}}$	$N_{\rm sb1}$	$N_{\rm sb2}$	$N_{\rm sb3}$	$N^{\rm b}_{\rm other}$	$N_{\rm net}$	ϵ (%)	$\mathcal{B}$ ($\times 10^{-4}$)
$D^+ \to K^0_S K^0_S K^+$	3616 ± 66	97 ± 19	6 ± 8	–	18 ± 2	3551 ± 67	8.27 ± 0.04	25.4 ± 0.5
$D^+ \to K^0_S K^0_S \pi^+$	5643 ± 88	1464 ± 68	69 ± 19	–	31 ± 3	4897 ± 94	10.72 ± 0.04	27.0 ± 0.5
$D^0 \to K^0_S K^0_S$	888 ± 36	626 ± 31	3 ± 6	–	0	576 ± 39	16.28 ± 0.30	1.67 ± 0.11
$D^0 \to K^0_S K^0_S K^0_S$	622 ± 27	24 ± 8	14 ± 6	0	16 ± 3	597 ± 27	3.92 ± 0.05	7.21 ± 0.33

Physics Letters B 765 (2017) 231–237

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

Double tag:
$D^0 \to K^-\pi^+\pi^+\pi^-$ vs. $D^{0bar} \to K^+\pi^-$

Using only the cleanest tag mode, since amplitude analysis requires a clean sample.

An unbinned likelihood fit is performed using the signal PDF given by

$$f_S(p_j) = \frac{\epsilon(p_j)|M(p_j)|^2 R_4(p_j)}{\int \epsilon(p_j)|M(p_j)|^2 R_4(p_j) dp_j}$$

Four-body phase-space: R_4

Measurement efficiency: ε

Amplitude	ϕ_i	Fit fraction (%)
$D^0[S] \to \bar{K}^*\rho^0$	$2.35 \pm 0.06 \pm 0.18$	$6.5 \pm 0.5 \pm 0.8$
$D^0[P] \to \bar{K}^*\rho^0$	$-2.25 \pm 0.08 \pm 0.15$	$2.3 \pm 0.2 \pm 0.1$
$D^0[D] \to \bar{K}^*\rho^0$	$2.49 \pm 0.06 \pm 0.11$	$7.9 \pm 0.4 \pm 0.7$
$D^0 \to K^- a_1^+(1260),\ a_1^+(1260)[S] \to \rho^0\pi^+$	0(fixed)	$53.2 \pm 2.8 \pm 4.0$
$D^0 \to K^- a_1^+(1260),\ a_1^+(1260)[D] \to \rho^0\pi^+$	$-2.11 \pm 0.15 \pm 0.21$	$0.3 \pm 0.1 \pm 0.1$
$D^0 \to K_1^-(1270)\pi^+,\ K_1^-(1270)[S] \to \bar{K}^{*0}\pi^-$	$1.48 \pm 0.21 \pm 0.24$	$0.1 \pm 0.1 \pm 0.1$
$D^0 \to K_1^-(1270)\pi^+,\ K_1^-(1270)[D] \to \bar{K}^{*0}\pi^-$	$3.00 \pm 0.09 \pm 0.15$	$0.7 \pm 0.2 \pm 0.2$
$D^0 \to K_1^-(1270)\pi^+,\ K_1^-(1270) \to K^-\rho^0$	$-2.46 \pm 0.06 \pm 0.21$	$3.4 \pm 0.3 \pm 0.5$
$D^0 \to (\rho^0 K^-)_A\pi^+,\ (\rho^0 K^-)_A[D] \to K^-\rho^0$	$-0.43 \pm 0.09 \pm 0.12$	$1.1 \pm 0.2 \pm 0.3$
$D^0 \to (K^-\rho^0)_P\pi^+$	$-0.14 \pm 0.11 \pm 0.10$	$7.4 \pm 1.6 \pm 5.7$
$D^0 \to (K^-\pi^+)_{\text{S-wave}}\rho^0$	$-2.45 \pm 0.19 \pm 0.47$	$2.0 \pm 0.7 \pm 1.9$
$D^0 \to (K^-\rho^0)_V\pi^+$	$-1.34 \pm 0.12 \pm 0.09$	$0.4 \pm 0.1 \pm 0.1$
$D^0 \to (\bar{K}^{*0}\pi^-)_P\pi^+$	$-2.09 \pm 0.12 \pm 0.22$	$2.4 \pm 0.5 \pm 0.5$
$D^0 \to \bar{K}^{*0}(\pi^+\pi^-)_S$	$-0.17 \pm 0.11 \pm 0.12$	$2.6 \pm 0.6 \pm 0.6$
$D^0 \to (\bar{K}^{*0}\pi^-)_V\pi^+$	$-2.13 \pm 0.10 \pm 0.11$	$0.8 \pm 0.1 \pm 0.1$
$D^0 \to ((K^-\pi^+)_{\text{S-wave}}\pi^-)_A\pi^+$	$-1.36 \pm 0.08 \pm 0.37$	$5.6 \pm 0.9 \pm 2.7$
$D^0 \to K^-((\pi^+\pi^-)_S\pi^+)_A$	$-2.23 \pm 0.08 \pm 0.22$	$13.1 \pm 1.9 \pm 2.2$
$D^0 \to (K^-\pi^+)_{\text{S-wave}}(\pi^+\pi^-)_S$	$-1.40 \pm 0.04 \pm 0.22$	$16.3 \pm 0.5 \pm 0.6$
$D^0[S] \to (K^-\pi^+)_V(\pi^+\pi^-)_V$	$1.59 \pm 0.13 \pm 0.41$	$5.4 \pm 1.2 \pm 1.9$
$D^0 \to (K^-\pi^+)_{\text{S-wave}}(\pi^+\pi^-)_V$	$-0.16 \pm 0.17 \pm 0.43$	$1.9 \pm 0.6 \pm 1.2$
$D^0 \to (K^-\pi^+)_V(\pi^+\pi^-)_S$	$2.58 \pm 0.08 \pm 0.25$	$2.9 \pm 0.5 \pm 1.7$
$D^0 \to (K^-\pi^+)_T(\pi^+\pi^-)_S$	$-2.92 \pm 0.14 \pm 0.12$	$0.3 \pm 0.1 \pm 0.1$
$D^0 \to (K^-\pi^+)_{\text{S-wave}}(\pi^+\pi^-)_T$	$2.45 \pm 0.12 \pm 0.37$	$0.5 \pm 0.1 \pm 0.1$

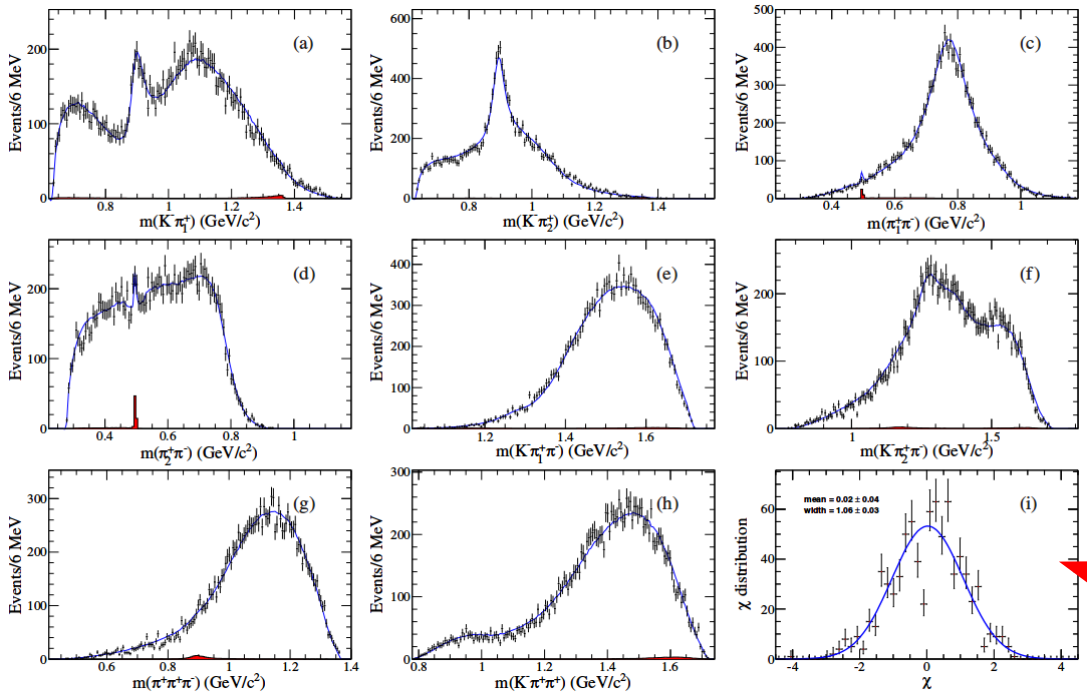
$$FF(n) = \frac{\sum_{k=1}^{N_{\text{gen}}} |\tilde{A}_{\mathbf{n}}(p_j^k)|^2}{\sum_{k=1}^{N_{\text{gen}}} |M(p_j^k)|^2}$$

Total amplitude: $M(p_j) = \sum c_n A_n(p_j)$

$$A_n(p_j) = P_n^1(m_1)P_n^2(m_2)S_n(p_j)F_n^1(p_j)F_n^2(p_j)F_n^D(p_j)$$

Propagator Spin factor Blatt-Weisskoft barrier factor

Four-body decay is in a five-dimensional phase-space.
Here are 1D projections onto two- or three-body system.



X value distribution of bins in five-dimension for goodness-of-fit

Component	Fit fraction (%)	Mark III's result	E691's result
$D^0 \to \bar{K}^{*0}\rho^0$	$12.3 \pm 0.4 \pm 0.5$	$14.2 \pm 1.6 \pm 5$	$13 \pm 2 \pm 2$
$D^0 \to K^- a_1^+(1260)(\rho^0\pi^+)$	$54.6 \pm 2.8 \pm 3.7$	$49.2 \pm 2.4 \pm 8$	$47 \pm 5 \pm 10$
$D^0 \to K_1^-(1270)(\bar{K}^{*0}\pi^-)\pi^+$	$0.8 \pm 0.2 \pm 0.2$	$6.6 \pm 1.9 \pm 3$	$\cdots$
$D^0 \to K_1^-(1270)(K^-\rho^0)\pi^+$	$3.4 \pm 0.3 \pm 0.5$		
$D^0 \to K^-\pi^+\rho^0$	$8.4 \pm 1.1 \pm 2.5$	$8.4 \pm 2.2 \pm 4$	$5 \pm 3 \pm 2$
$D^0 \to \bar{K}^{*0}\pi^+\pi^-$	$7.0 \pm 0.4 \pm 0.5$	$14.0 \pm 1.8 \pm 4$	$11 \pm 2 \pm 3$
$D^0 \to K^-\pi^+\pi^+\pi^-$	$21.9 \pm 0.6 \pm 0.6$	$24.2 \pm 2.5 \pm 6$	$23 \pm 2 \pm 3$

PHYSICAL REVIEW D **95,** 072010 (2017)

Branching-fraction measurement of $D^0 \to K_S K^+ K^-$

$$\mathcal{B}_{D^0 \to K_S^0 K^+ K^-} = \frac{N^{sig}}{\epsilon_{BF} \cdot \mathcal{B}_{K_S^0 \to \pi\pi} \cdot \mathcal{L} \cdot 2\sigma_{D^0\bar{D}^0}}$$

qq/Ddbar background peaks in m_{KS}
non-KS background peaks in m_{BC}

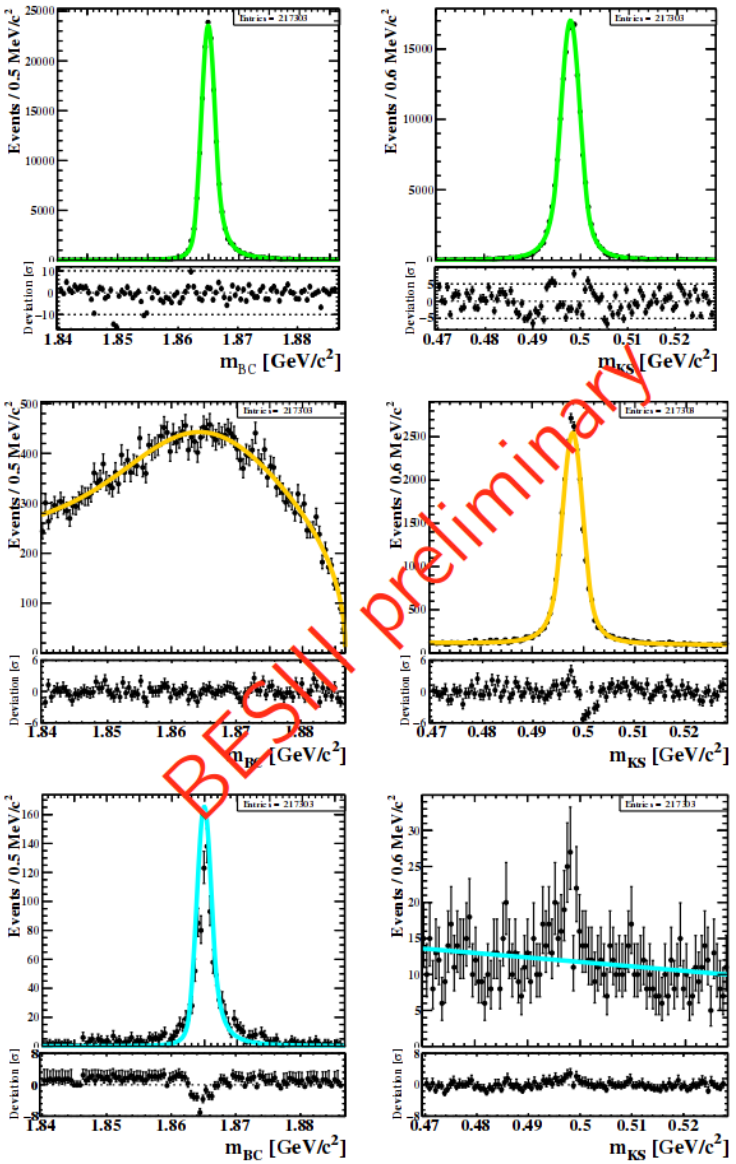
PDF models for Signal and background

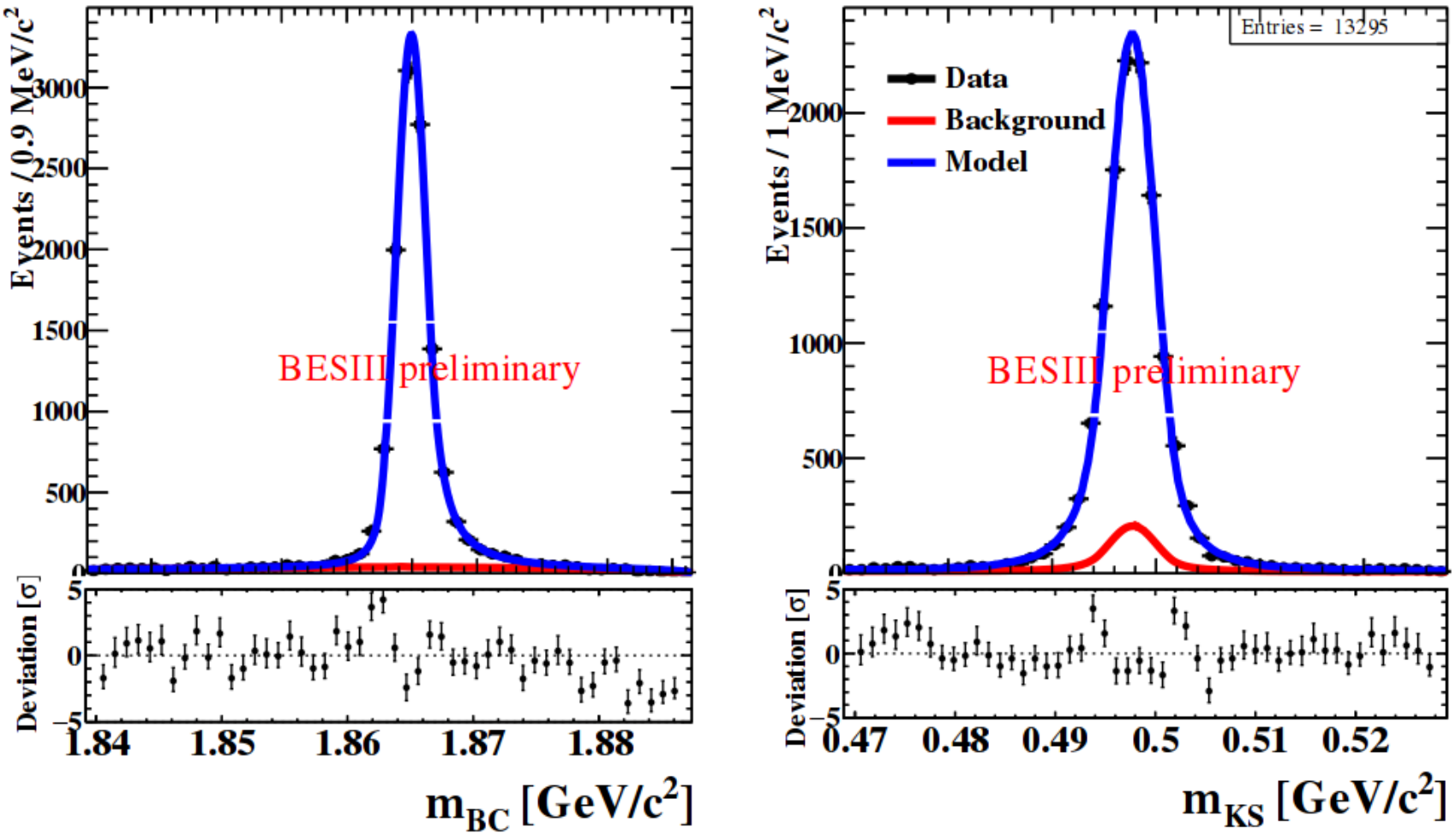
- Signal: $S(\vec{x}) = CB2(m_{BC}) \times Gauss(m_{KS})$
- qq/$D\bar{D}$: $B1(\vec{x}) = (Argus + Gauss)(m_{BC}) \times (Gauss + pol0)(m_{KS})$
- non-KS: $B2(\vec{x}) = CB2(m_{BC}) \times pol1(m_{KS})$

Simultaneous fit of common parameters

Fix shape parameters and determine yields:

$$PDF(m_{BC}, m_{KS}) = N_{sig} \times S(m_{BC}, m_{KS}) + N_{Bkg_{KS}} B_1(m_{BC}, m_{KS}) + N_{Bkg_{nonKS}} B_2(m_{BC}, m_{KS})$$





$$N_{sig} = 11743 \pm 113$$

$$BF_{data}(D^0 \to K_S^0 K^+ K^-) = (4.622 \pm 0.045\,(\text{stat.}) \pm 0.181\,(\text{sys.})) \times 10^{-3}$$

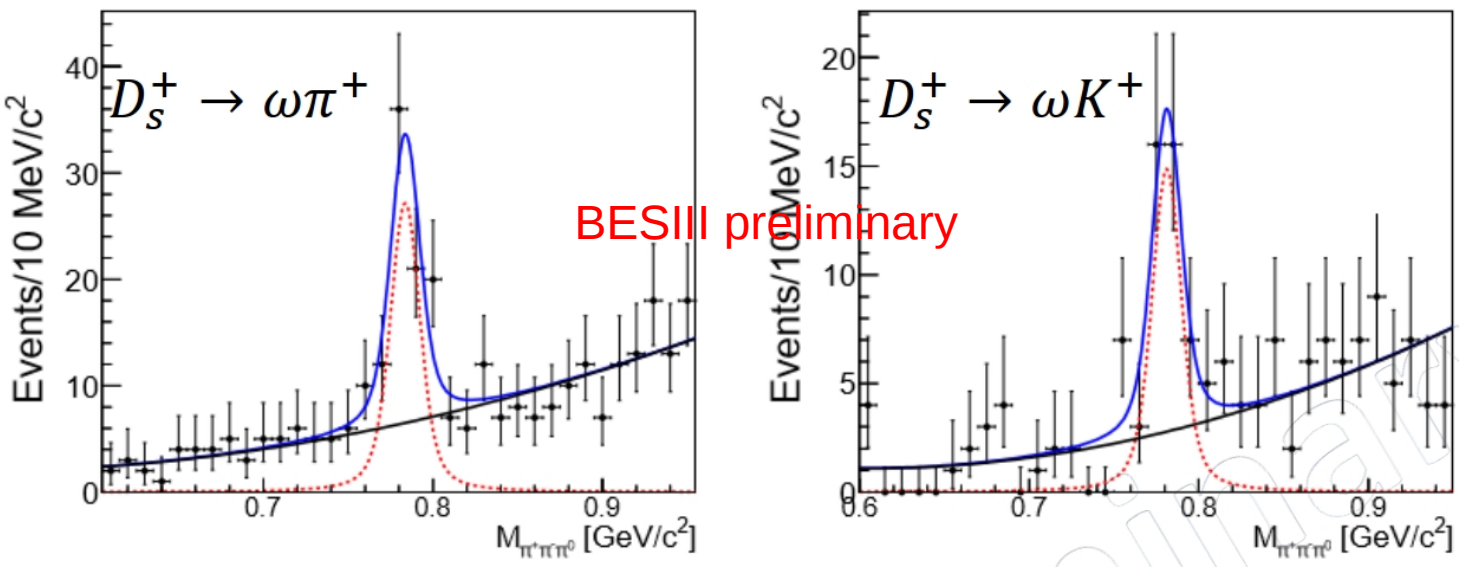
- Relative uncertainty: 4.0 %
- PDG(2014) value: $(4.47 \pm 0.34) \times 10^{-3}$ $\to$ Deviation $0.81\,\sigma$
- Ongoing Dalitz plot analysis

Preliminary results on observation of $D_s^+ \to \omega\pi^+$ and ωK^+

With 3.19 fb^{-1} data @ 4.178GeV collected by the BESIII

Double tag: One $M_{rec} > 2.1$ GeV

- Best candidate: average mass of two D_s mesons closet to PDG value.
- K_s^0 veto for $D_s^+ \to \omega K^+$ to suppress the background from $D_s^+ \to \bar{K}^{*0}K^+$:
  If $|m_{\pi\pi} - 0.4976| < 0.03$GeV, $L_{decay}/\sigma_{L_{decay}} > 2.0$, veto this event.



Signal mode	Branching fraction (10^{-3})	Statistical significance (σ)
$D_s^+ \to \omega\pi^+$	$1.85 \pm 0.30(stat.) \pm 0.19(sys.)$	7.7
$D_s^+ \to \omega K^+$	$1.13 \pm 0.24(stat.) \pm 0.14(sys.)$	6.2

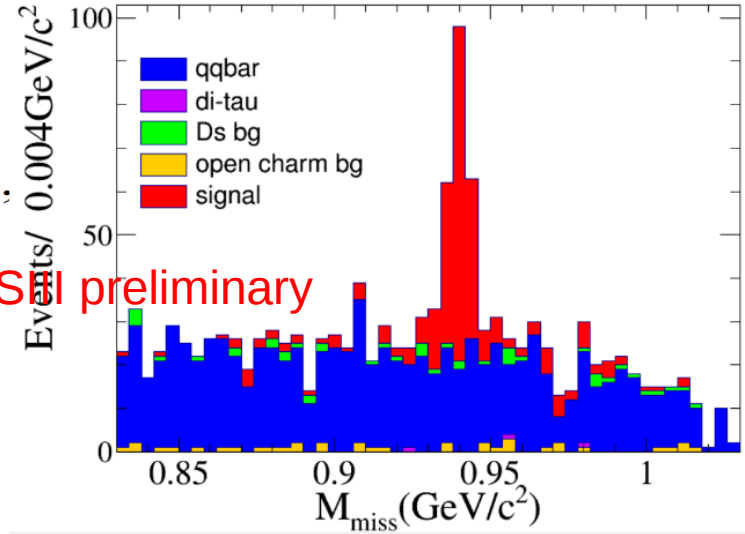
BESIII preliminary

Preliminary result for $D_s \rightarrow p\bar{n}$

With 3.19 fb^{-1} data @ 4.178GeV collected by the BESIII

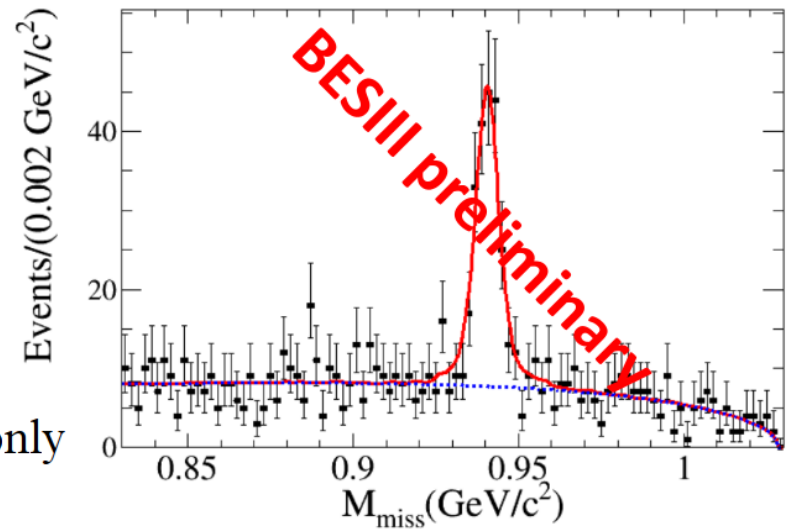
Double tag

- Kinematic fit to improve missing neutron resolution
- Constraint the 4 momenta of the total events, the two Ds and Ds* mass, set anti-neutron 4 momenta free: (7-4)C
- Set two hypotheses to select the one with smaller χ^2
  - Ds*→γDs(→tag modes)
  - Ds*→ γDs(→$p\bar{n}$)
- No peaking background
- Signal efficiency ~ 48% from inclusive MC



Preliminary result

$$\mathcal{B}_{D_s\to p\bar{n}} = \frac{1}{\mathcal{B}_{D_s^*\to\gamma D_s}}\cdot\frac{N_{DT}}{N_{ST}}\cdot\frac{\epsilon_{ST}}{\epsilon_{DT}} = \frac{1}{\mathcal{B}_{D_s^*\to\gamma D_s}}\cdot\frac{\sum N_{DT}}{\sum(N_{ST}\cdot\frac{\epsilon_{DT}}{\epsilon_{ST}})}$$



By combining the 11 tag modes together, we obtain (only statistic error here):

$$\mathcal{B}_{D_s^+\to p\bar{n}} = (1.22 \pm 0.10)\times 10^{-3}$$

BESIII preliminary

Signal: MC shape ⊗Gaussian
Background: Argus function

- Statistically limited.
- Uncertainty due to baryon ID dominates the systematic

- Confirm CLEO-c's measurement with greatly improved accuracy
- Consistent with the prediction of the enhanced BR due to long-distance effect via hadronic loop

5

Summary

- DTag and DD^{bar} therehold data allow us to perform inclusive and exclusive branching fraction measurement
- Double tag proves clean samples for amplitude analysis
- Many D^0 and D^+ studies have been published
- More D_s studies are on-going

(based on 3.19 fb^{-1} data at E_{cm} = 4.178 GeV)