Hadronic charm decays at BESIII

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on behalf of BESIII collaboration

BESIII is at Institute of High Energy Physics(IHEP) in Beijing, China

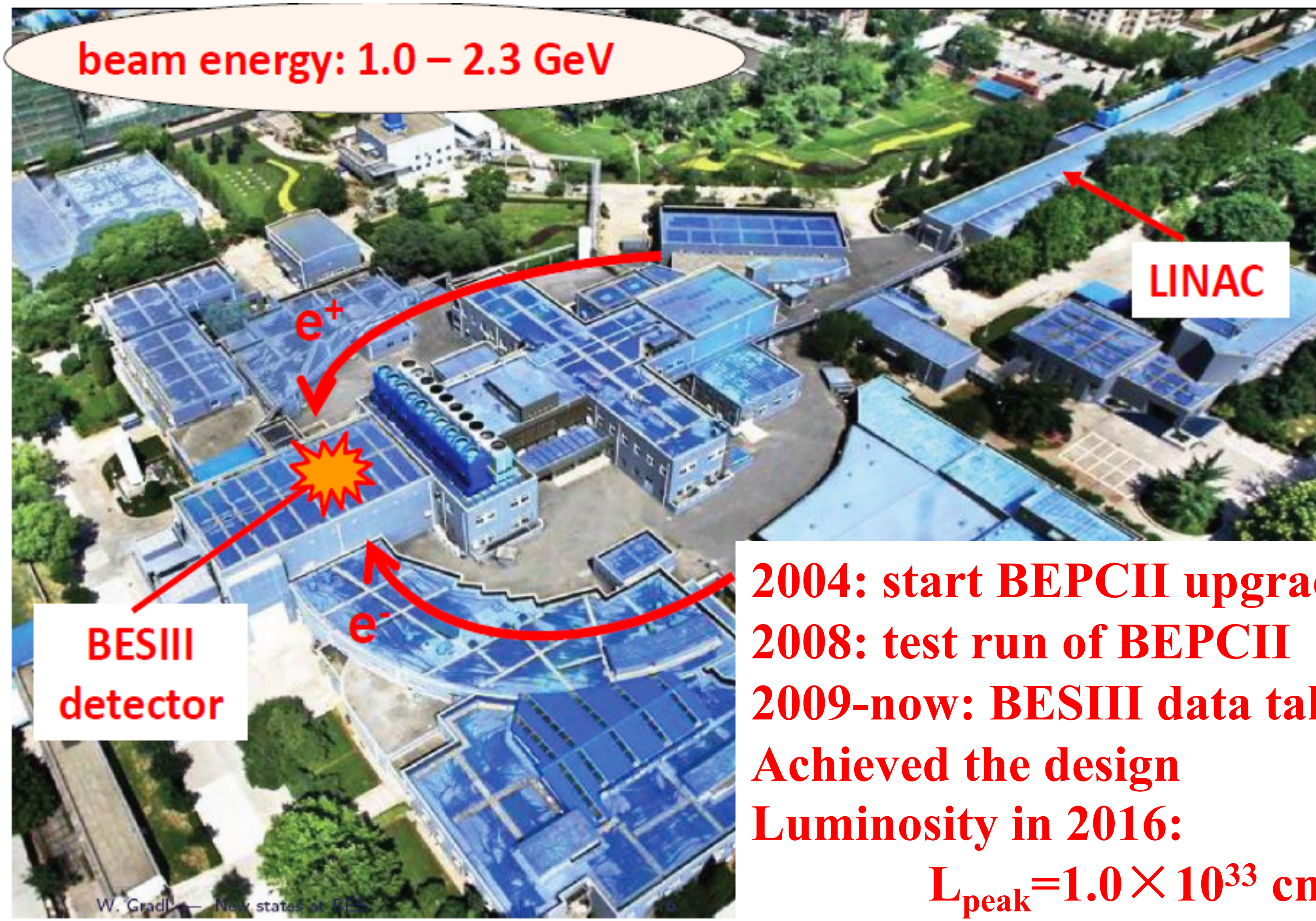
BESIII Collaboration

15 countries

72 institutions

~500 members

Beijing Electron Positron Collider (BEPCII)



2004: start BEPCII upgrade

2008: test run of BEPCII

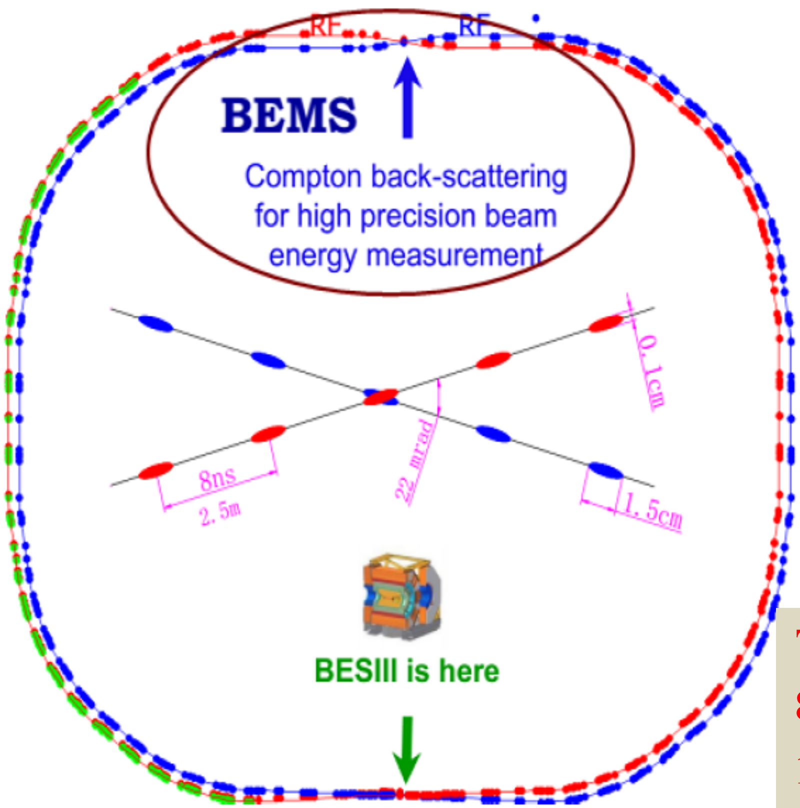
2009-now: BESIII data taking

Achieved the design Luminosity in 2016:

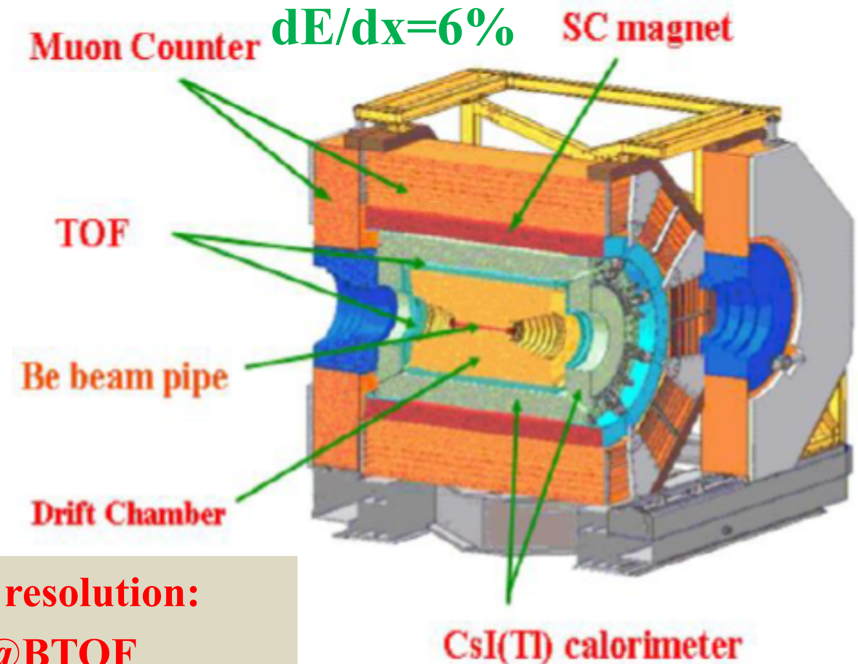
$$L_{peak}=1.0\times10^{33}\ cm^{-2}s^{-1}$$

The BESIII Detector @ BEPCII

<u>*NIM A614, 345 (2010)*</u>



Excellent tracking:
$\delta p/p=0.5\%@1GeV$
$dE/dx=6\%$



Time resolution:
80ps@BTOF
110ps@ETOF
（65ps after updtate）

Shower reconstruction:
$\delta E/E=2.5\%@1GeV$

The new BESIII detector is hermetic for neutral and charged particle with excellent resolution, PID, and large coverage.

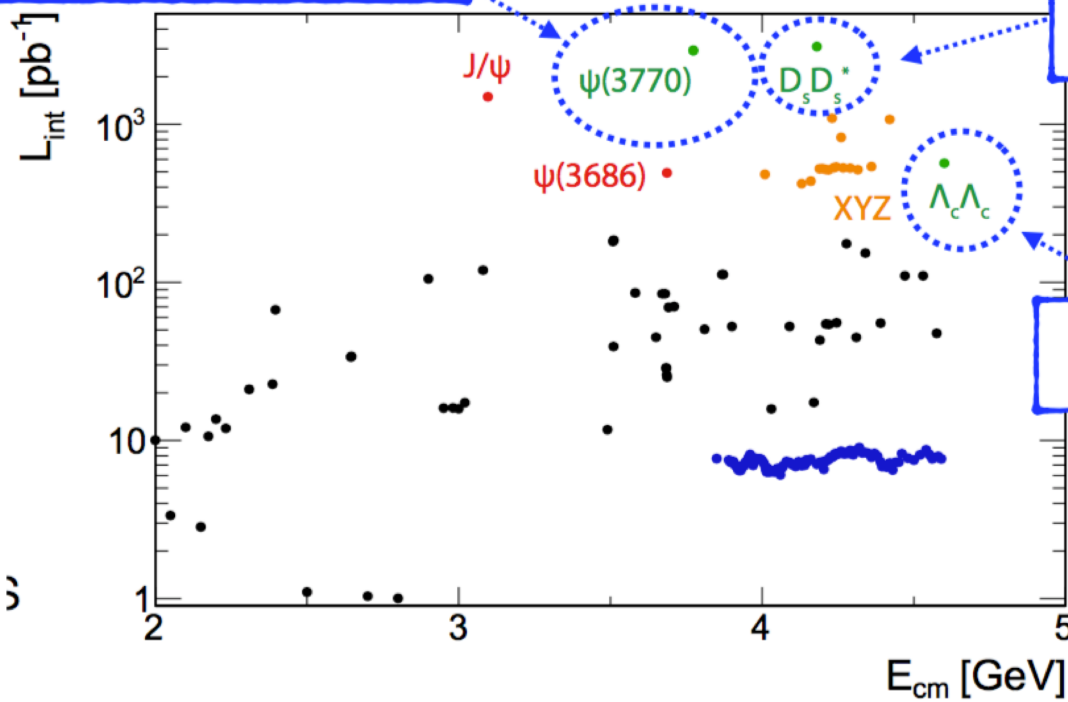
Data samples in this talk

$\sqrt{s}$ / GeV	$\mathcal{L}$ / fb^{-1}	
3.77	2.93	$D\bar{D}$
4.008	0.48	DD^*, $\psi(4040)$, $D_s^+D_s^-$
4.18	3.2	$D_sD_s^*$
4.6	0.59	$\Lambda_c^+\bar{\Lambda}_c^-$

$N_{D0D0} = (10{,}597\pm28\pm98)\times10^3$
$N_{D+D-} = (8{,}296\pm31\pm65)\times10^3$
produced

N_{Ds^*Ds} ~ 3M produced

$N_{\Lambda c\bar{\Lambda}c} = (105.9\pm4.8\pm0.5)\times10^3$
produced



The advantage of data at threshold:

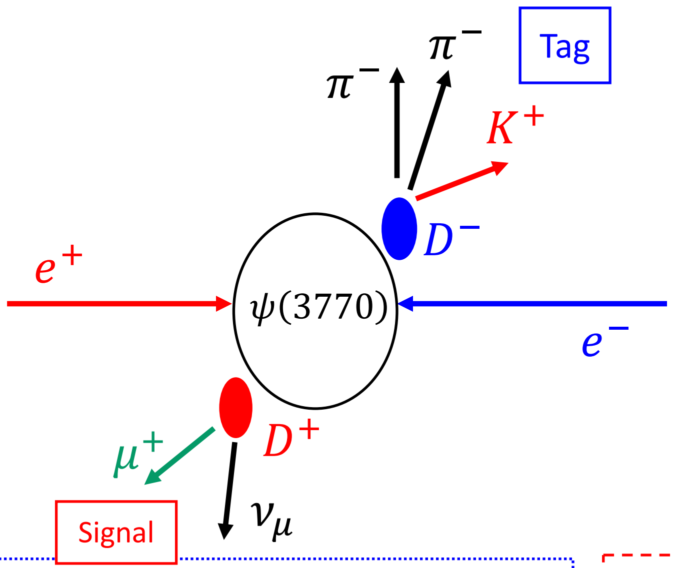
■Charmed hadrons can be fully reconstructed by hadronic decays with large Branching Fractions(BF).

■Double Tag technique make one can access to absolute BFs and dynamics in the other side decays with clean background.

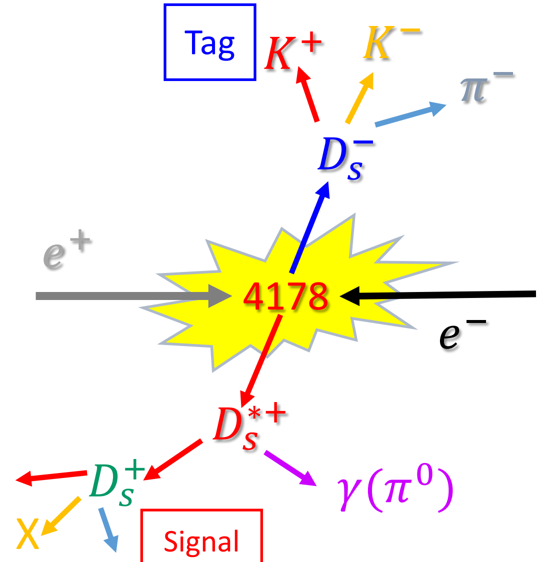
■Most systematic uncertainty in tag side are cancelled out.

Tagging method

$e^+ e^- \rightarrow \psi(3770) \rightarrow D^+ D^-$
2.93 fb^{-1} @3.773 GeV



$e^+ e^- \rightarrow D_s^{*+} D_s^-$
3.19 fb^{-1} @4.178 GeV



Charge conjugated processes are implied

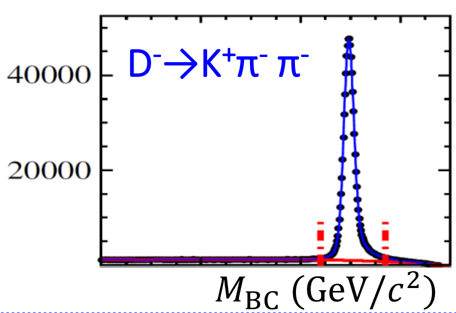
The signal branching:

$$B_{sig} = \frac{N_{sig}}{N_{D_{(s)}^{tag}} \times \epsilon}$$

For Tag side(reconstructed from $K^+\pi^-\pi^-$):

$$\Delta E = E_{D^-} - E_{\text{beam}}$$

$$M_{BC} = \sqrt{E_{\text{beam}}^2 - |\vec{p}_{D^-}|^2}$$



For Signal side(reconstruct μ^+):

$$E_{\text{miss}} = E_{\text{beam}} - E_{\mu^+}$$

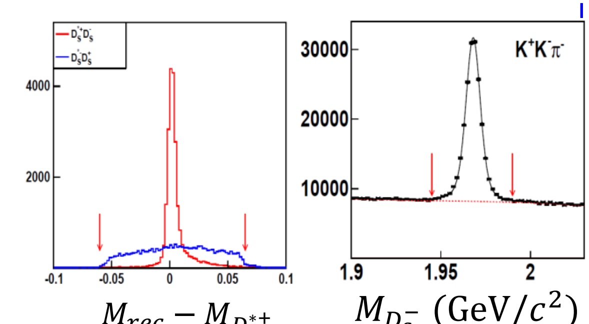
$$\vec{p}_{\text{miss}} = -\vec{p}_{D^-} - \vec{p}_{\mu^+}$$

$$M_{\text{miss}}^2 = E_{\text{miss}}^2 - |\vec{p}_{\text{miss}}|^2$$

$$U_{\text{miss}} = E_{\text{miss}} - |\vec{p}_{\text{miss}}|$$

For Tag side(reconstructed from $K^+K^-\pi^-$):

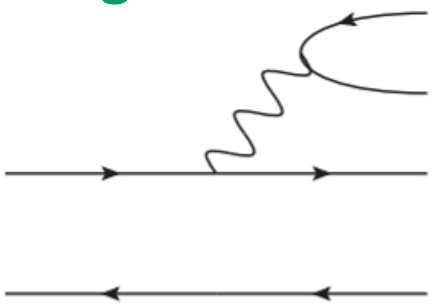
$$M_{rec} = \sqrt{\left(E_{cm} - \sqrt{|\vec{p}_{D_s^-}|^2 + m_{D_s^-}^2}\right)^2 - |-\vec{p}_{D_s^-}|^2}$$



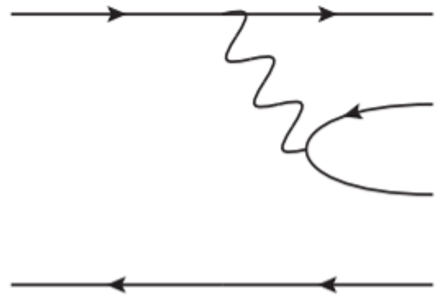
PhysRevLett.56.1655

A theory model: Diagrammatic Approach

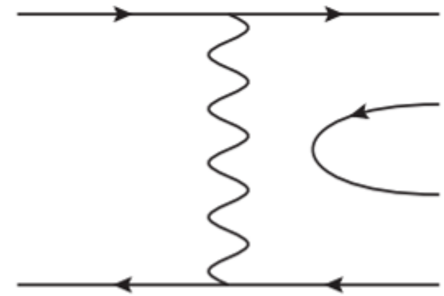
All decays can be described in terms of six different quark diagrams



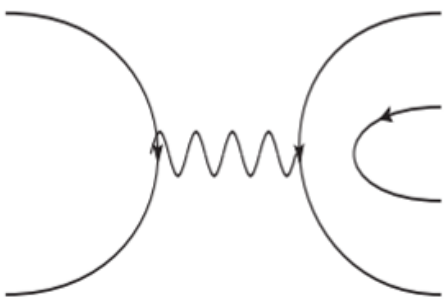
the external W emission



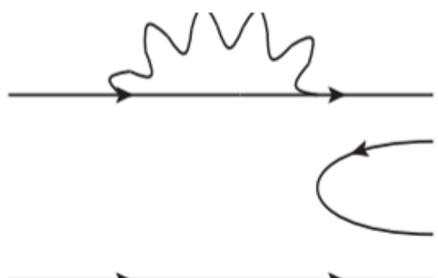
internal W emission



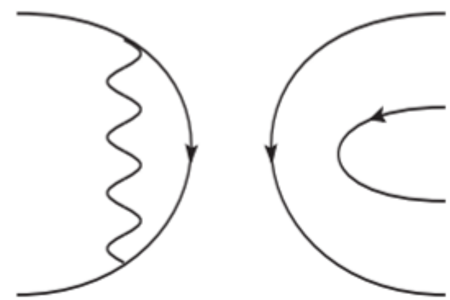
W exchange



W annihilation



horizontal W-loop diagram



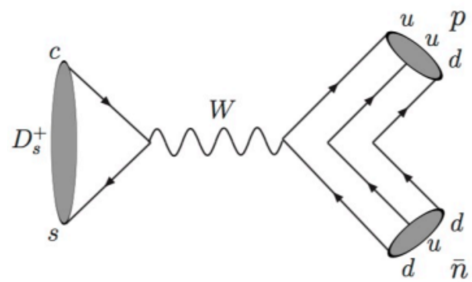
vertical W-loop diagram

Most amplitude need to be determined by experiment!

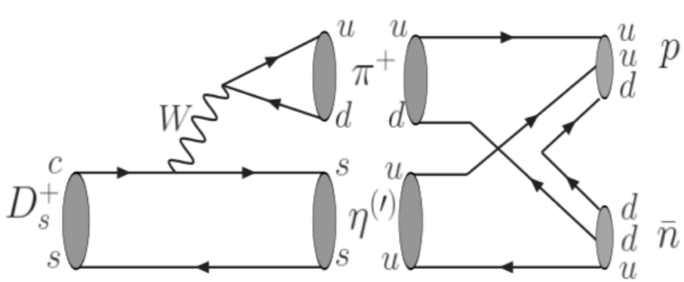
$D_s^+ \to p\bar{n}$ decay

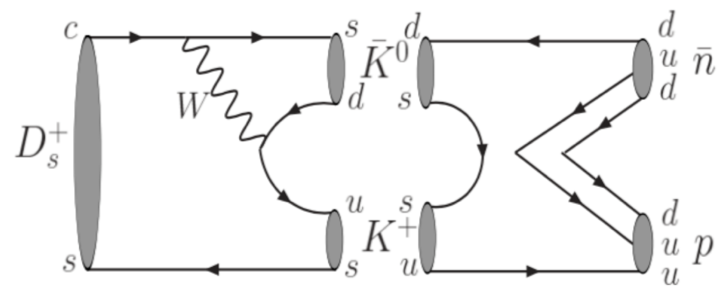
-as a "smoking gun" for W annihilation process

- The only kinematically allowed hadronic decay, involving baryons.
- Short-distance contribution(Chiral suppression) is expected to be small: BF~10^{-6}



- Long distance can enhance to ~10^{-3}(C.H.Chen,et al. PLB663,326)



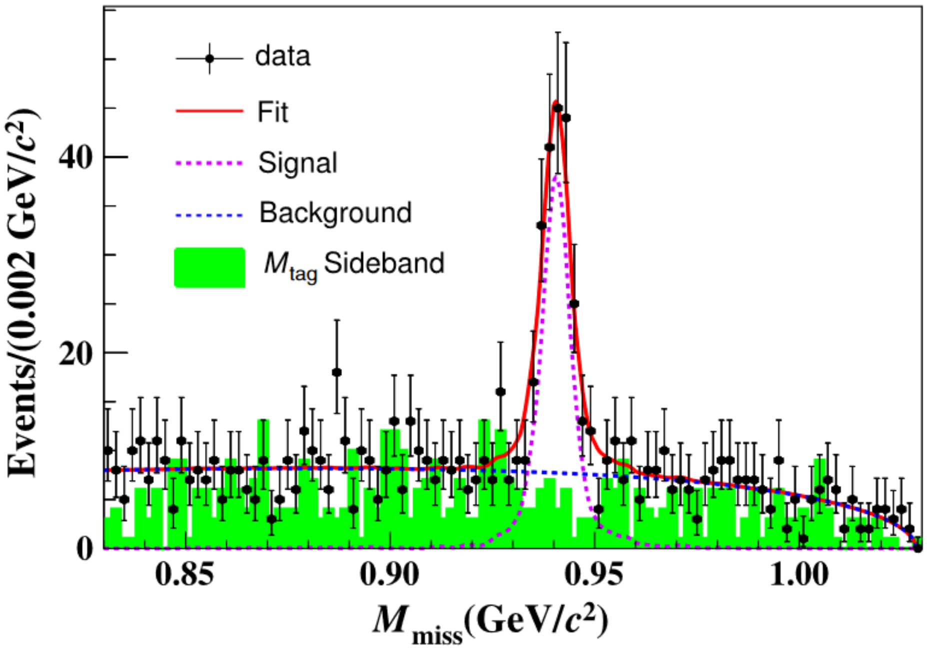


- First evidence was reported by CLEO with 13.0$\pm$3.6 events with BF=$(1.30\pm0.36^{+0.12}_{-0.16})\times10^{-3}$(PRL100,181802)

$D_s^+ \to p\bar{n}$ decay

-as a "smoking gun" for W annihilation process

Phys.Rev.D99 , 031101 (2019)



- **DT: reconstruct all final states, except missed $\bar{n}$**
- **BESIII confirm it is indeed large: BF=(1.21±0.10±0.05)×10^{-3}**

- **The short distance dynamics is not the dominated mechanism.**
- **Long distance hadronization process, driven by nonperturbative dynamic determines the underlying physics**

$D_s^+ \to \omega K^+, \omega\pi^+$

Based on the 4178 data

- ωK^+, CF : Has seen by CLEO (PRD80,051102) : BF = $(2.1 \pm 0.9 \pm 0.1) \times 10^{-3}$.
- $\omega\pi^+$, SCS: CLEO (PRD80,051102) set an UL = 2.4×10^{-3} @ 90% C.L.

- Q. Qin et al. (PRD89, 054006) predicts (factorization)
- BF(ω K) ~ 0.6×10^{-3} (with Acp ~ -0.6×10^{-3}) or it could become ~0.07×10^{-4} (with Acp ~ -2.3×10^{-3}) if ρ-ω mixing is considered.

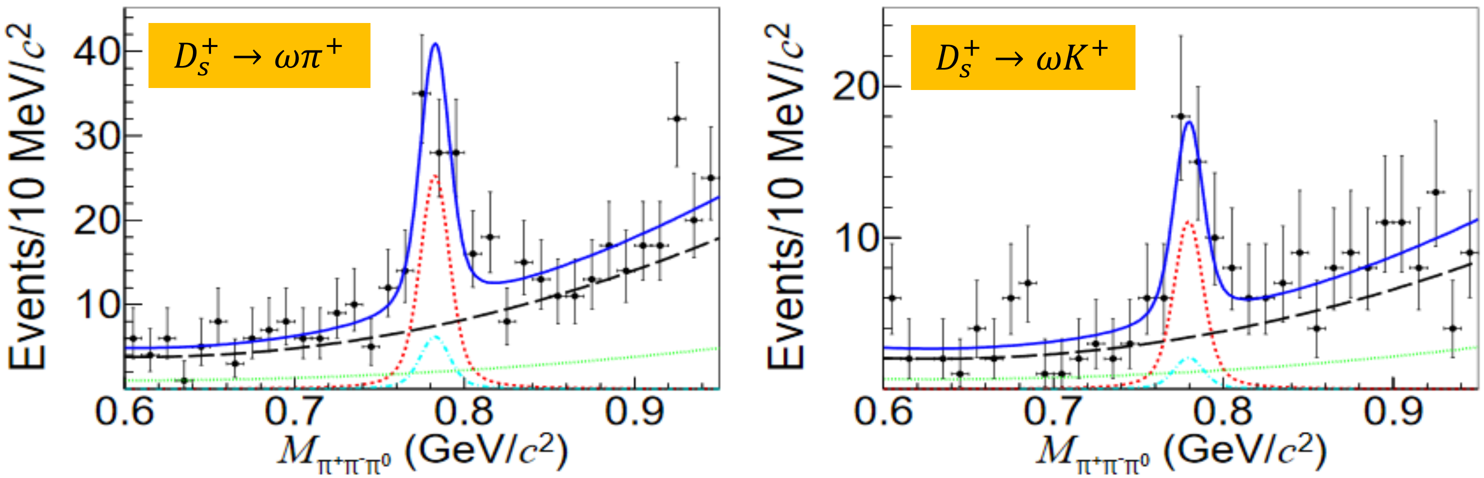
- DT method: Reconstruct the all final states.
  Cut on $\Delta M = M_{signal\text{-}side} - M_{tag\text{-}side}$ to select $D_s \to$ tag and the other Ds → ω (π/K). - Then project onto $M_{\pi\pi\pi 0}$.

$D_s^+ \to \omega K^+, \omega\pi^+$

Phys.Rev.D99 , 091101(R) (2019)

ωπ:65.0±11.6 evts (6.7σ)

ωK:28.5±7.8 evts (4.4σ)



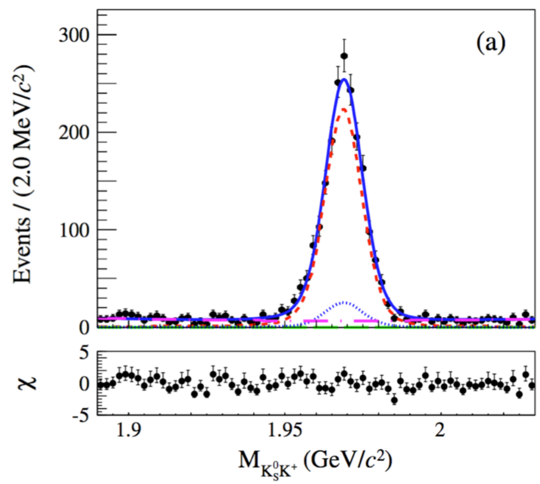
- BF(Ds → ωπ) = (1.77 ± 0.32 ± 0.13) × 10^{-3}
  - Consistent with CLEO's measurement, but more precise.
- BF(Ds → ωK) = (0.87 ± 0.24 ± 0.08) × 10^{-3}
  - First evidence!
  - According to Qin et al., this implies Acp ~ -0.6 × 10^{-3}. and negligible effect from ρ-ω mixing.

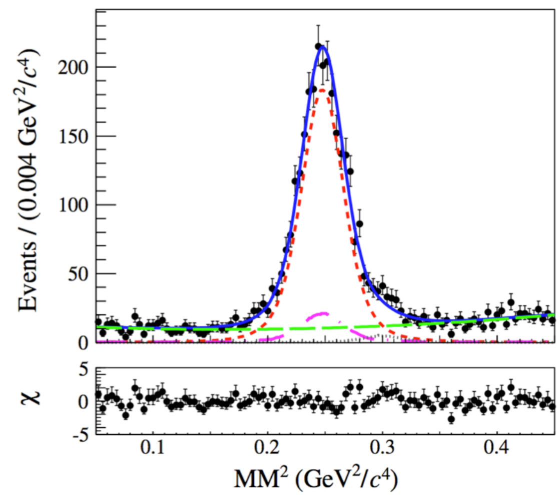
$D_s^+ \to K_S K^+$ and $K_L K^+$

Phys.Rev.D99 , 112005 (2019)

Based on the 4178 data

- **Amplitudes of CF $D_s^+ \to K^0 K^+$ and DCS $D_s^+ \to \overline{K}^0 K^+$ could interfere.**
- **Such interference effect could also lead to CPV : A_{cp}~ 10^{-3}, predicted by D. Wang et al. (PRL 119, 181802(2017)).**





- **BF($D_s^+ \to K_S K^+$)=(1.425 $\pm$ 0.038 $\pm$ 0.031)%, consistent with world average.**
- **BF($D_s^+ \to K_L K^+$)=(1.485 $\pm$ 0.039 $\pm$ 0.046)%, first measurement.**

- **Ks/K_L asymmetry,**

R=(B($D_s^+ \to K_S K^+$)- $B(D_s^+ \to K_L K^+)$)/(B($D_s^+ \to K_S K^+$)+ $B(D_s^+ \to K_L K^+)$) =(-2.1 $\pm$ 1.9 $\pm$ 1.6)%, consistent with zero

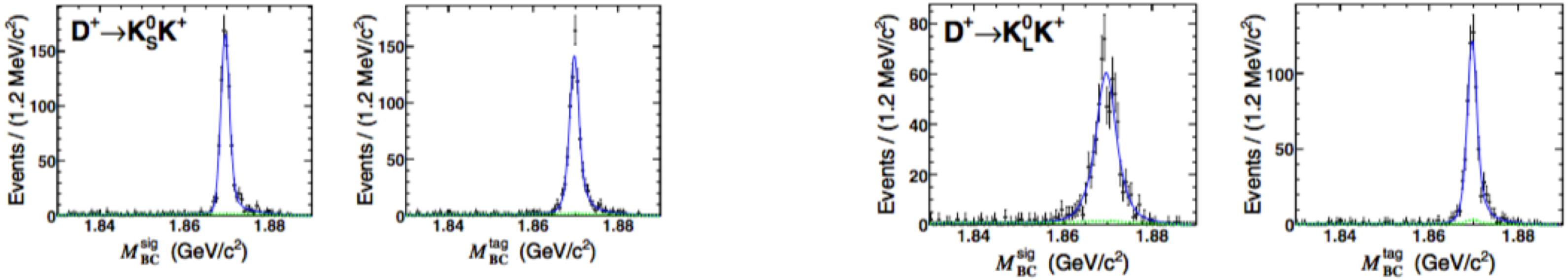
- **$A_{cp}(D_S \to K_S K)$= (0.6 $\pm$ 2.8 $\pm$ 0.6)% and $A_{cp}(D_S \to K_L K)$= (-1.1 $\pm$ 2.6 $\pm$ 0.6)%**

$D^+ \to K_S K^+(\pi^0)$ and $K_L K^+(\pi^0)$

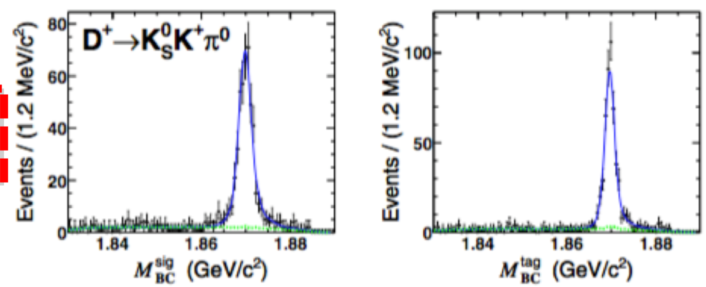
Phys.Rev.D99 , 032002 (2019)

Based on the 3773 data

- **Also looks like similar process, but in D+ decays.**
- **An additional π^0 processes are also studied.**
- **For 3-body decay, MC was tuned based on D-KKπ by CLEO:PRD78,072003(2008).**



1st measurements!



Consistent with zero

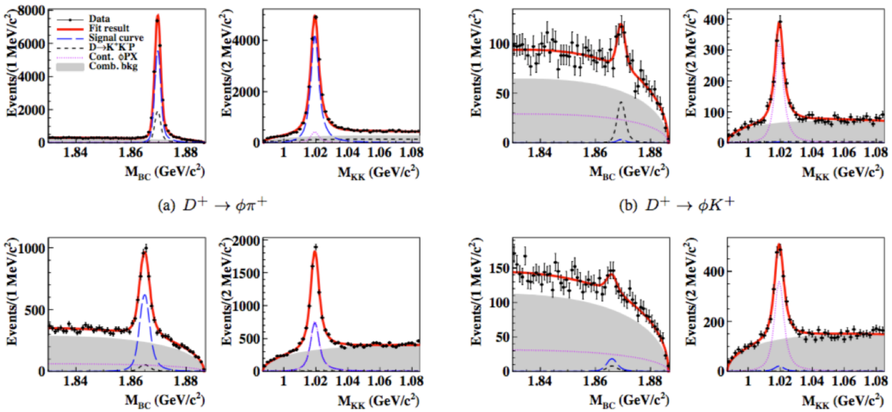
Signal mode	$\mathcal{B}(D^+)$ ($\times 10^{-3}$)	$\mathcal{B}(D^-)$ ($\times 10^{-3}$)	$\bar{\mathcal{B}}$ ($\times 10^{-3}$)	$\mathcal{B}$ (PDG) ($\times 10^{-3}$)	$\mathcal{A}_{CP}$ (%)
$K^0_S K^\pm$	$2.96 \pm 0.11 \pm 0.08$	$3.07 \pm 0.12 \pm 0.08$	$3.02 \pm 0.09 \pm 0.08$	2.95 ± 0.15	$-1.8 \pm 2.7 \pm 1.6$
$K^0_S K^\pm \pi^0$	$5.14 \pm 0.27 \pm 0.24$	$5.00 \pm 0.26 \pm 0.22$	$5.07 \pm 0.19 \pm 0.23$	$\cdots$	$1.4 \pm 3.7 \pm 2.4$
$K^0_L K^\pm$	$3.07 \pm 0.14 \pm 0.10$	$3.34 \pm 0.15 \pm 0.11$	$3.21 \pm 0.11 \pm 0.11$	$\cdots$	$-4.2 \pm 3.2 \pm 1.2$
$K^0_L K^\pm \pi^0$	$5.21 \pm 0.30 \pm 0.22$	$5.27 \pm 0.30 \pm 0.22$	$5.24 \pm 0.22 \pm 0.22$	$\cdots$	$-0.6 \pm 4.1 \pm 1.7$

$D^{+(0)} \to \phi\pi^{+(0)}$, $D^0 \to \phi\eta$, $D^+ \to \phi K^+$

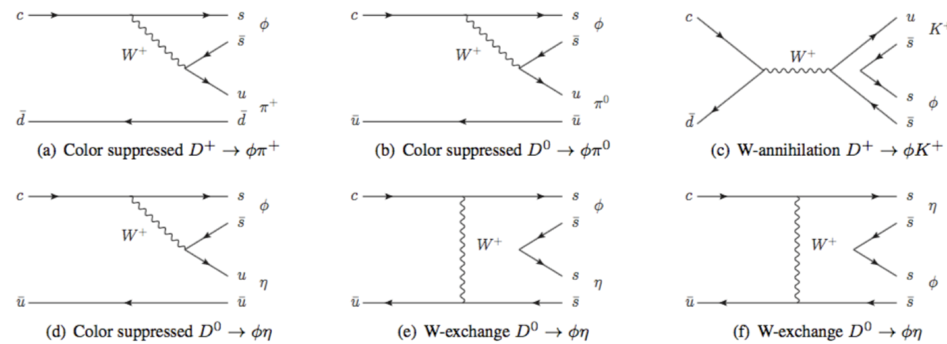
PLB submitted, arXiv:1907.11258

Based on the 3773 data

- $D \to \phi P$,(P= π,K, η) are suppressed by phase space due to ϕ meson mass.



(a) $D^+ \to \phi\pi^+$ (b) $D^+ \to \phi K^+$ (c) $D^0 \to \phi\pi^0$ (d) $D^0 \to \phi\eta$



(a) Color suppressed $D^+ \to \phi\pi^+$ (b) Color suppressed $D^0 \to \phi\pi^0$ (c) W-annihilation $D^+ \to \phi K^+$ (d) Color suppressed $D^0 \to \phi\eta$ (e) W-exchange $D^0 \to \phi\eta$ (f) W-exchange $D^0 \to \phi\eta$

Figure 1: Feynman diagrams of four $D \to \phi P$ decay modes.

- M_{BC} vs M_{KK} two dimensional fit are performed to determine the yields.

Decay mode	ΔE(GeV)	N^i_{sig}	$\varepsilon^i(\%)$	$\mathcal{B}^i(\times 10^{-4})$	$\mathcal{B}_{PDG}(\times 10^{-4})$ [4]
$D^+ \to \phi\pi^+$	$[-0.020, 0.019]$	17527 ± 152	37.7 ± 0.1	$57.0 \pm 0.5 \pm 1.3$	53.7 ± 2.3
$D^+ \to \phi K^+$	$[-0.019, 0.018]$	12^{+28}_{-12}	23.7 ± 0.1	$0.062^{+0.144}_{-0.062} \pm 0.002$ < 0.21 at 90% CL	–
$D^0 \to \phi\pi^0$	$[-0.077, 0.035]$	3333 ± 76	27.7 ± 0.1	$11.68 \pm 0.28 \pm 0.28$	13.2 ± 0.8
$D^0 \to \phi\eta$	$[-0.040, 0.038]$	102 ± 26	13.7 ± 0.1	$1.81 \pm 0.46 \pm 0.06$	1.4 ± 0.5

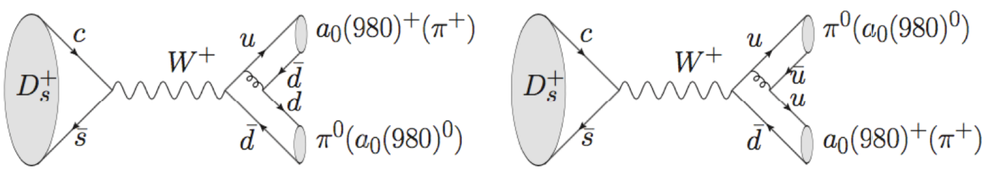
- SCS $D^{+(0)} \to \phi\pi^{+(0)}$, $D^0 \to \phi\eta$ are measured with higher precision.
- DCS $D^+ \to \phi K^+$ is studied for the first time.
- Ratio of $D^0 \to \phi\pi^0$ and $D^+ \to \phi\pi^+$ is used to test isospin symmetry.(Consistent.)

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

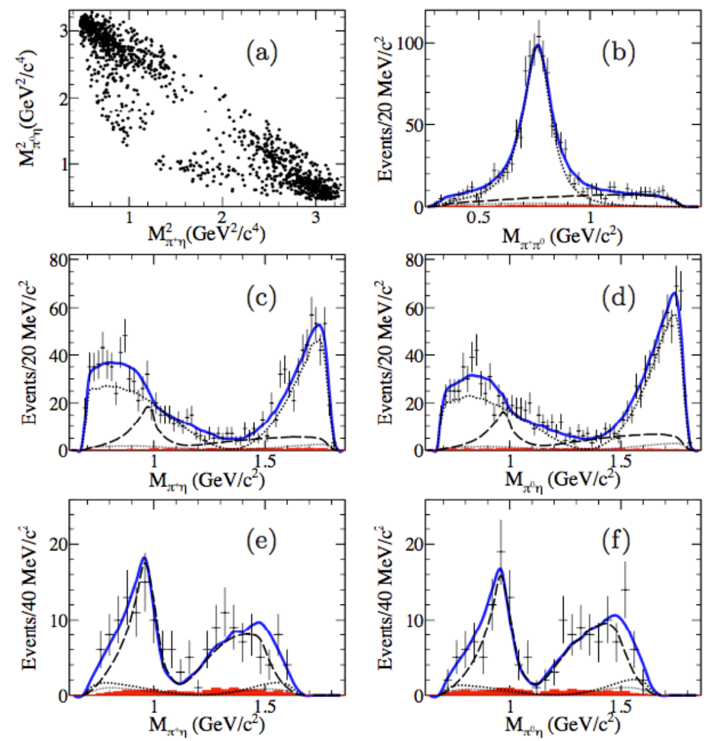
PRL Accepted (arXiv:1903.04118)

Based on the 4178 data

- **Amplitudes analysis based on DT 1239 events(purity:97.7%)**
- **W-annihilation dominant.**



Amplitude	ϕ_n (rad)	FF_n
$D_s^+ \to \rho^+\eta$	0.0 (fixed)	$0.783 \pm 0.050 \pm 0.021$
$D_s^+ \to (\pi^+\pi^0)_V\eta$	$0.612 \pm 0.172 \pm 0.342$	$0.054 \pm 0.021 \pm 0.025$
$D_s^+ \to a_0(980)\pi$	$2.794 \pm 0.087 \pm 0.044$	$0.232 \pm 0.023 \pm 0.033$



- **BF($D_s^+ \to \pi^+\pi^0\eta$)=(9.50$\pm$0.28$\pm$0.41)%, improved precision.**

- **first measurement (16.2σ stat. significance)**
  BF(D_s^+->$a_0(980)^{+(0)}\pi^{0(+)}$, $a_0(980)^{+(0)}$->$\pi^{+(0)}\eta$)=(1.46$\pm$0.15$\pm$0.23)%

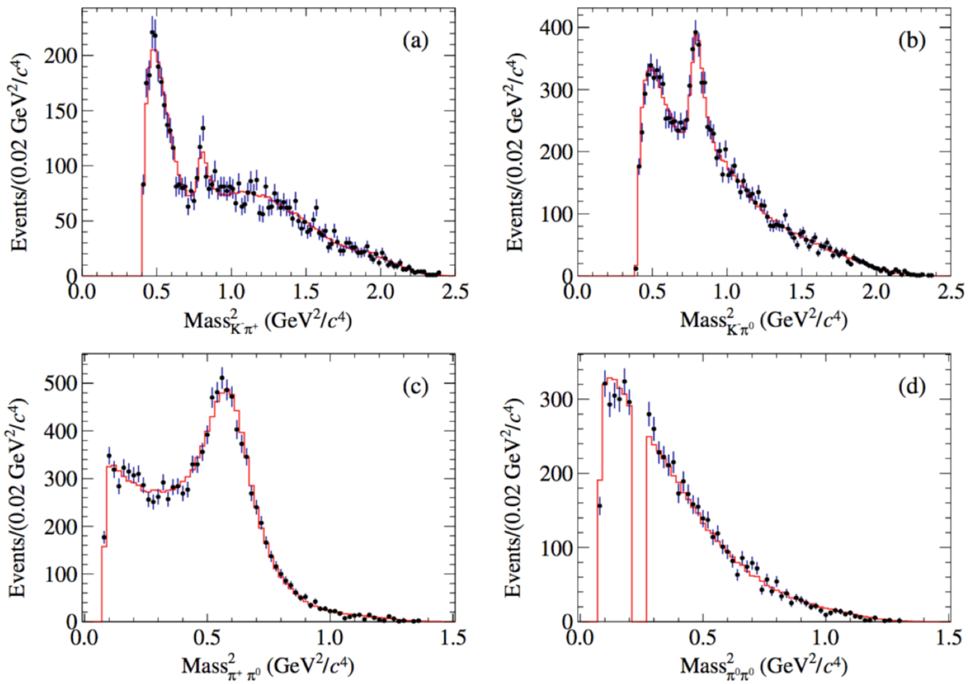
- **Large W-annihilation decay rate when compared with $p\bar{n}/\omega\pi^+$(~10^{-3} level).**

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

PRD99,092008(2019)

Based on the 3773 data

- **First Amplitudes analysis based on DT 5950 events(purity:98.9%)**
- **One of the largest BF in D^0 decays**



Amplitude mode	FF [%]	Phase [ϕ]	Significance [σ]
$D \to SS$			
$D \to (K^-\pi^+)_{S\text{-wave}}(\pi^0\pi^0)_S$	$6.92 \pm 1.44 \pm 2.86$	$-0.75 \pm 0.15 \pm 0.47$	>10
$D \to (K^-\pi^0)_{S\text{-wave}}(\pi^+\pi^0)_S$	$4.18 \pm 1.02 \pm 1.77$	$-2.90 \pm 0.19 \pm 0.47$	6.0
$D \to AP, A \to VP$			
$D \to K^-a_1(1260)^+, \rho^+\pi^0[S]$	$28.36 \pm 2.50 \pm 3.53$	0 (fixed)	>10
$D \to K^-a_1(1260)^+, \rho^+\pi^0[D]$	$0.68 \pm 0.29 \pm 0.30$	$-2.05 \pm 0.17 \pm 0.25$	6.1
$D \to K_1(1270)^-\pi^+, K^{*-}\pi^0[S]$	$0.15 \pm 0.09 \pm 0.15$	$1.84 \pm 0.34 \pm 0.43$	4.9
$D \to K_1(1270)^0\pi^0, K^{*0}\pi^0[S]$	$0.39 \pm 0.18 \pm 0.30$	$-1.55 \pm 0.20 \pm 0.26$	4.8
$D \to K_1(1270)^0\pi^0, K^{*0}\pi^0[D]$	$0.11 \pm 0.11 \pm 0.11$	$-1.35 \pm 0.43 \pm 0.48$	4.0
$D \to K_1(1270)^0\pi^0, K^-\rho^+[S]$	$2.71 \pm 0.38 \pm 0.29$	$-2.07 \pm 0.09 \pm 0.20$	>10
$D \to (K^{*-}\pi^0)_A\pi^+, K^{*-}\pi^0[S]$	$1.85 \pm 0.62 \pm 1.11$	$1.93 \pm 0.10 \pm 0.15$	7.8
$D \to (K^{*0}\pi^0)_A\pi^0, K^{*0}\pi^0[S]$	$3.13 \pm 0.45 \pm 0.58$	$0.44 \pm 0.12 \pm 0.21$	>10
$D \to (K^{*0}\pi^0)_A\pi^0, K^{*0}\pi^0[D]$	$0.46 \pm 0.17 \pm 0.29$	$-1.84 \pm 0.26 \pm 0.42$	5.9
$D \to (\rho^+K^-)_A\pi^0, K^-\rho^+[D]$	$0.75 \pm 0.40 \pm 0.60$	$0.64 \pm 0.36 \pm 0.53$	5.1
$D \to AP, A \to SP$			
$D \to ((K^-\pi^+)_{S\text{-wave}}\pi^0)_A\pi^0$	$1.99 \pm 1.08 \pm 1.55$	$-0.02 \pm 0.25 \pm 0.53$	7.0
$D \to VS$			
$D \to (K^-\pi^0)_{S\text{-wave}}\rho^+$	$14.63 \pm 1.70 \pm 2.41$	$-2.39 \pm 0.11 \pm 0.35$	>10
$D \to K^{*-}(\pi^+\pi^0)_S$	$0.80 \pm 0.38 \pm 0.26$	$1.59 \pm 0.19 \pm 0.24$	4.1
$D \to K^{*0}(\pi^0\pi^0)_S$	$0.12 \pm 0.12 \pm 0.12$	$1.45 \pm 0.48 \pm 0.51$	4.1
$D \to VP, V \to VP$			
$D \to (K^{*-}\pi^+)_V\pi^0$	$2.25 \pm 0.43 \pm 0.45$	$0.52 \pm 0.12 \pm 0.17$	>10
$D \to VV$			
$D \to K^{*-}\rho^+[S]$	$5.15 \pm 0.75 \pm 1.28$	$1.24 \pm 0.11 \pm 0.23$	>10
$D \to K^{*-}\rho^+[P]$	$3.25 \pm 0.55 \pm 0.41$	$-2.89 \pm 0.10 \pm 0.18$	>10
$D \to K^{*-}\rho^+[D]$	$10.90 \pm 1.53 \pm 2.36$	$2.41 \pm 0.08 \pm 0.16$	>10
$D \to (K^-\pi^0)_V\rho^+[P]$	$0.36 \pm 0.19 \pm 0.27$	$-0.94 \pm 0.19 \pm 0.28$	5.7
$D \to (K^-\pi^0)_V\rho^+[D]$	$2.13 \pm 0.56 \pm 0.92$	$-1.93 \pm 0.22 \pm 0.25$	>10
$D \to K^{*-}(\pi^+\pi^0)_V[D]$	$1.66 \pm 0.52 \pm 0.61$	$-1.17 \pm 0.20 \pm 0.39$	7.6
$D \to (K^-\pi^0)_V(\pi^+\pi^0)_V[S]$	$5.17 \pm 1.91 \pm 1.82$	$-1.74 \pm 0.20 \pm 0.31$	7.6
$D \to TS$			
$D \to (K^-\pi^+)_{S\text{-wave}}(\pi^0\pi^0)_T$	$0.30 \pm 0.21 \pm 0.30$	$-2.93 \pm 0.31 \pm 0.82$	5.8
$D \to (K^-\pi^0)_{S\text{-wave}}(\pi^+\pi^0)_T$	$0.14 \pm 0.12 \pm 0.10$	$2.23 \pm 0.38 \pm 0.65$	4.0
TOTAL	98.54		

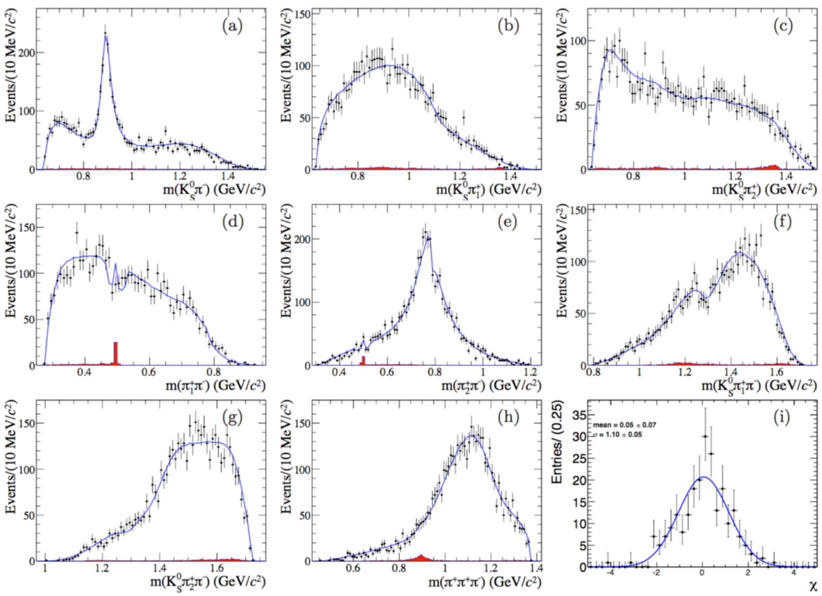
- **BF($D^0 \to K^-\pi^+\pi^0\pi^0$)=(8.86±0.13±0.19)%, dominated by $D^0 \to K^-a_1(1260)^+$**

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

PRD submitted(arXiv:1901.05936)

Based on the 3773 data

- **Amplitudes analysis based on DT 4559 events(purity:97.5%)**



Extracted BFs by the PDG BF($D^+ \to K_S\pi^+\pi^+\pi^-$)

Component	Branching fraction (%)
$D^+ \to K_S^0 a_1(1260)^+(\rho^0\pi^+)$	$1.197 \pm 0.062 \pm 0.086 \pm 0.044$
$D^+ \to K_S^0 a_1(1260)^+(f_0(500)\pi^+)$	$0.163 \pm 0.021 \pm 0.005 \pm 0.006$
$D^+ \to \bar{K}_1(1400)^0(K^{*-}\pi^+)\pi^+$	$0.642 \pm 0.036 \pm 0.033 \pm 0.024$
$D^+ \to \bar{K}_1(1270)^0(K_S^0\rho^0)\pi^+$	$0.071 \pm 0.009 \pm 0.021 \pm 0.003$
$D^+ \to \bar{K}(1460)^0(K^{*-}\pi^+)\pi^+$	$0.202 \pm 0.018 \pm 0.006 \pm 0.007$
$D^+ \to \bar{K}(1460)^0(K_S^0\rho^0)\pi^+$	$0.024 \pm 0.006 \pm 0.015 \pm 0.009$
$D^+ \to \bar{K}_1(1650)^0(K^{*-}\pi^+)\pi^+$	$0.048 \pm 0.012 \pm 0.027 \pm 0.002$
$D^+ \to K_S^0\pi^+\rho^0$	$0.190 \pm 0.021 \pm 0.089 \pm 0.007$
$D^+ \to K_S^0\pi^+\pi^+\pi^-$	$0.241 \pm 0.018 \pm 0.018 \pm 0.009$

- **Improved precisions.**
- **Consistent with previous measurements.**
- **Also $D^+ \to K_S a_1(1260)^+$ dominated. (Consistent with $D^0 \to K^-\pi^+\pi^+\pi^-$: PRD 95,072010(2017))**
- **While $D^+ \to \bar{K}_1(1400)^0\pi^+$ is found to larger, unlike what we saw in the two D^0 decays.**

$\Lambda_c^+ \to \Sigma^+\eta, \Sigma^+\eta'$

CPC43,083002(2019)

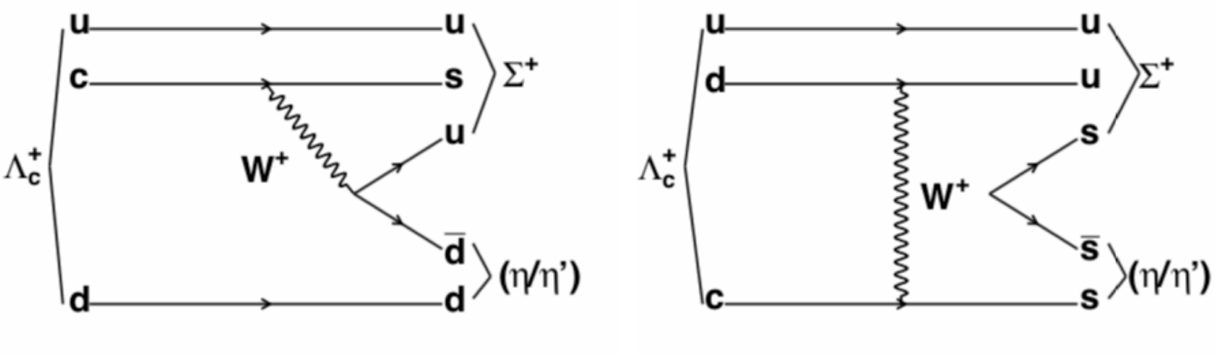
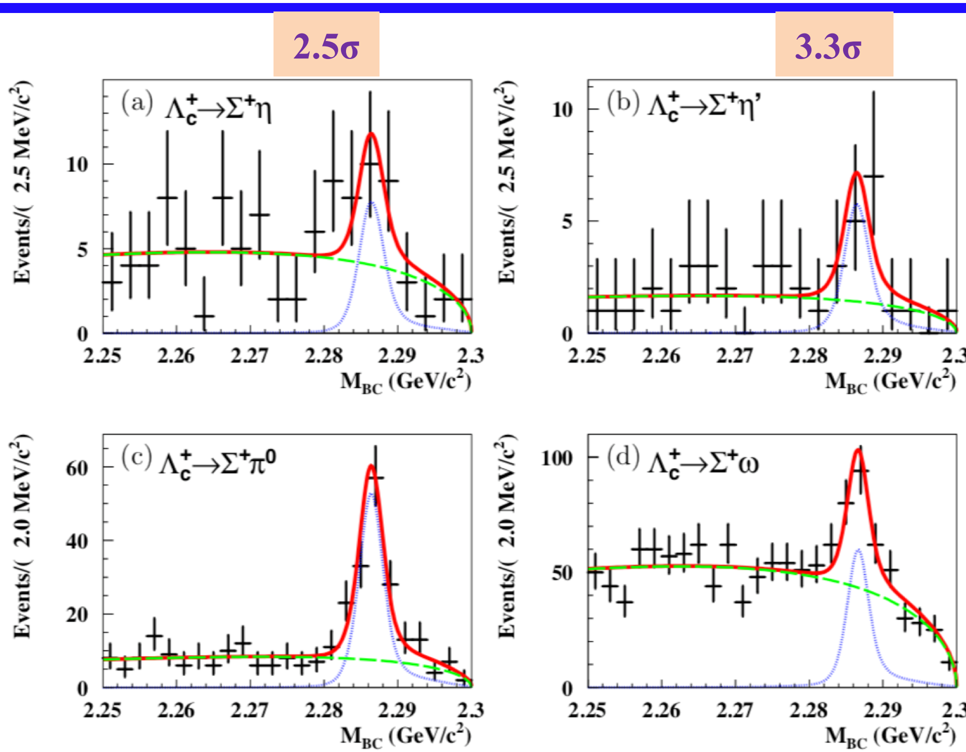


Figure 1. Representative tree level diagrams of decays of $\Lambda_c^+ \to \Sigma^+\eta$ and $\Lambda_c^+ \to \Sigma^+\eta'$.

- **Decay through internal W-emission and W-exchange.**
- **Both are non-factorable in theoretic calculation.**
- **Large variations in theory: $B(\Lambda_c^+ \to \Sigma^+\eta)$ =(0.11-0.94)%, $B(\Lambda_c^+ \to \Sigma^+\eta')$ =(0.1-1.28)%**
- **$\Lambda_c^+ \to \Sigma^+\eta$ is measured by CLEO with BF=(0.70±0.23)% (~33% uncertainty)**
- **$\Lambda_c^+ \to \Sigma^+\eta'$ is not observed yet.**

$\Lambda_c^+ \to \Sigma^+\eta\,,\Sigma^+\eta'$

CPC43,083002(2019)



$$R_{ac} = \frac{\mathcal{B}(a)}{\mathcal{B}(c)} = \frac{N_a\varepsilon_c\mathcal{B}(\pi^0\to\gamma\gamma)}{N_c\varepsilon_a\mathcal{B}(\eta\to\gamma\gamma)}$$

$$R_{bd} = \frac{\mathcal{B}(b)}{\mathcal{B}(d)} = \frac{N_b\varepsilon_d\mathcal{B}(\omega\to\pi^+\pi^-\pi^0)\mathcal{B}(\pi^0\to\gamma\gamma)}{N_d\varepsilon_b\mathcal{B}(\eta'\to\pi^+\pi^-\eta)\mathcal{B}(\eta\to\gamma\gamma)}$$

Decay mode	N_i	ε_i (%)
(a) $\Lambda_c^+\to\Sigma^+\eta$	14.6 ± 6.6	7.80
(b) $\Lambda_c^+\to\Sigma^+\eta'$	13.0 ± 4.8	4.61
(c) $\Lambda_c^+\to\Sigma^+\pi^0$	122.4 ± 14.5	8.98
(d) $\Lambda_c^+\to\Sigma^+\omega$	135.4 ± 20.4	7.83

$$\frac{\mathcal{B}(\Lambda_c^+\to\Sigma^+\eta)}{\mathcal{B}(\Lambda_c^+\to\Sigma^+\pi^0)} = 0.35\pm0.16\pm0.03 \qquad \frac{\mathcal{B}(\Lambda_c^+\to\Sigma^+\eta)}{\mathcal{B}(\Lambda_c^+\to\Sigma^+\pi^0)} < 0.58$$

$$\frac{\mathcal{B}(\Lambda_c^+\to\Sigma^+\eta')}{\mathcal{B}(\Lambda_c^+\to\Sigma^+\omega)} = 0.86\pm0.34\pm0.07 \qquad \frac{\mathcal{B}(\Lambda_c^+\to\Sigma^+\eta')}{\mathcal{B}(\Lambda_c^+\to\Sigma^+\omega)} < 1.2$$

$$\frac{\mathcal{B}(\Lambda_c^+\to\Sigma^+\eta')}{\mathcal{B}(\Lambda_c^+\to\Sigma^+\eta)} = 3.5\pm2.1\pm0.4$$

- **$\Lambda_c^+\to\Sigma^+\eta$ is smaller than CLEO but still compatible within uncertainty.**
- **$\Lambda_c^+\to\Sigma^+\eta'$ is measured for first time.**
- **Our measurement contradict with most theoretical calculations.**

Decay mode	Körner [5]	Sharma [3]	Zenczykowski [4]	Ivanov [6]	CLEO [12]	This work
$\Lambda_c^+\to\Sigma^+\eta$	0.16	0.57	0.94	0.11	0.70±0.23	0.41±0.20 (<0.68)
$\Lambda_c^+\to\Sigma^+\eta'$	1.28	0.10	0.12	0.12	-	1.34±0.57 (<1.9)

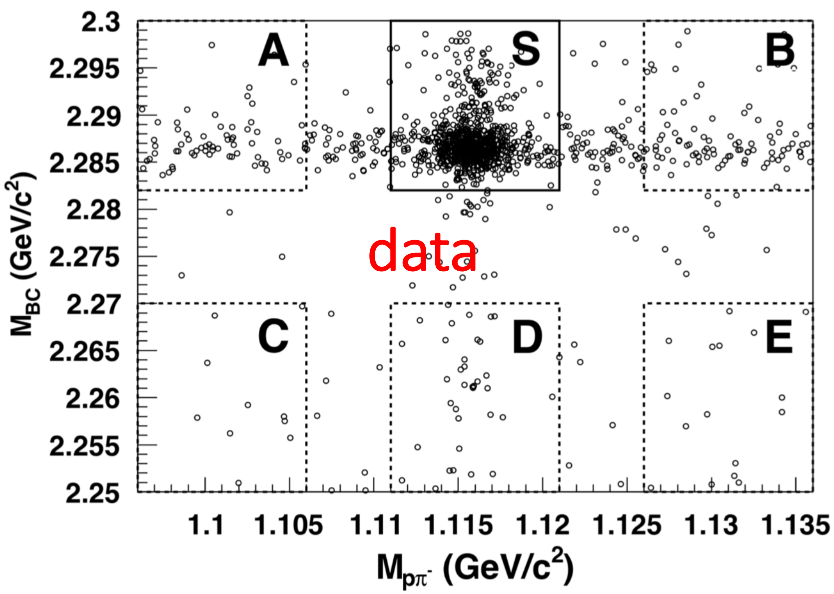
The inclusive channel $\Lambda_c^+ \to \Lambda + X$

- **The inclusive process mediated by the *c*-*s* transition.**
- **Essential input in the calculation of the Λ_c^+ life time.**
- **Useful in understanding the heavier charmed baryons, esp. the less known double- or triple-charm baryons.**
- **Current PDG: BF($\Lambda_c^+ \to \Lambda$+X)=(35±11)% with large uncertainty.**
- **The sum of know exclusive modes only accounts for (24.5±2.1)% => need better understanding of the gap between exclusive and inclusive rates.**
- **Comparison with K+X will shed light on the Λ_c^+ internal dynamics.**
- **Search for the CPV by measuring the asymmetry.**

$$\mathcal{A}_{CP} \equiv \frac{\mathcal{B}(\Lambda_c^+ \to \Lambda + X) - \mathcal{B}(\bar{\Lambda}_c^- \to \bar{\Lambda} + X)}{\mathcal{B}(\Lambda_c^+ \to \Lambda + X) + \mathcal{B}(\bar{\Lambda}_c^- \to \bar{\Lambda} + X)}$$

The inclusive channel $\Lambda_c^+ \to \Lambda + X$

PRL 121, 062003(2018)



$$N^{\rm sig} = N^{\rm S} - \frac{N^{\rm A} + N^{\rm B}}{2} - f \cdot \left(N^{\rm D} - \frac{N^{\rm C} + N^{\rm E}}{2}\right)$$

- **Comparison with K+X will shed light on the internal dynamics**

- **In the ST modes of $\Lambda_c^+ \to pK^- \pi^+$ and pK_S^0, to measure the probability of find a Λ in the final states.**
- **Extract yields from 2D distributions in bins of $p - |cos\theta|$**
- **Data-driven 2D efficiency correction using several Λ control samples.**
- $\mathcal{B}(\Lambda_C^+ \to \Lambda + X) = (38.2^{+2.8}_{-2.2} \pm 0.8)\%$

(excl. rate $(24.5 \pm 2.1)\%$ observed, indicates ~1/3 BFs are unknown)

- $A_{cp} = (2.1^{+7.0}_{-6.6} \pm 1.4)\%$ **(No CPV is observed.)**

Summary

- BESIII has collected data samples corresponding to luminosities of 2.93 fb^{-1}, 3.19 fb^{-1} and 0.567 fb^{-1} at center-of-mass energies of 3.773, 4.178, and 4.6 GeV, respectively.
- BESIII is a charm factory to study charm hadron decays and released many new results.
- Threshold features: low backgrounds and high detection efficiency
- BEPCII is ready for energy up to 4.7GeV.
- More fruitful results will come out!

Thanks

Prospect Charm Hadron data sample at BESIII

Energy	physics highlight	Current data # of events or integrated luminosity	Expected final data # of events or integrated luminosity
1.8 - 2.0 GeV	R values cross-sections	N/A	Scan: 3 energy points
2.0 - 3.1 GeV	R values cross-sections	Scan: 20 energy points	No requirement
J/ψ peak	Light Hadron & Glueball Charmonium decay	5.0 billion	10.0 billion
$\psi(3686)$ peak	Light hadron& Glueball Charmonium decay	0.5 billion	3.0 billion
$\psi(3770)$ peak	$D^0/D^\pm$ decays Form-factor/CKM decay constant	2.9 fb^{-1}	20.0 fb^{-1}
3.8 - 4.6 GeV	R value XYZ/Open charm	Scan: 105 energy points	No requirement
4.180 GeV	D_s decay XYZ/Open charm	3.1 fb^{-1}	6.0 fb^{-1}
4.0 - 4.6 GeV	XYZ/Open charm Higher charmonia cross-sections	Scan: 12.0 fb^{-1}	Scan: 30.0 fb^{-1} 10 MeV step/0.5 fb^{-1}/point 30 energy points
4.60 GeV	Λ_c/XYZ	0.56 fb^{-1}	1.0 fb^{-1}
4.64 GeV	Λ_c/XYZ	N/A	5.0 fb^{-1}
4.65 GeV	Λ_c/XYZ	N/A	0.2 fb^{-1}
4.70 GeV	Λ_c/XYZ	N/A	0.65 fb^{-1}
4.80 GeV	Λ_c/XYZ	N/A	1.0 fb^{-1}
4.90 GeV	Λ_c/XYZ	N/A	1.3 fb^{-1}
$\Sigma_c^+\bar{\Lambda}_c^-$ 4.74 GeV	Charm Baryons	N/A	1.0 fb^{-1}
$\Sigma_c\bar{\Sigma}_c$ 4.91 GeV	Charm Baryons	N/A	1.0 fb^{-1}
$\Xi_c\bar{\Xi}_c$ 4.95 GeV	Charm Baryons	N/A	1.0 fb^{-1}