Charm Results from e^+e^- machines

Alex Gilman

University of Minnesota
On behalf of the BESIII Collaboration

June 9th, 2020

FPCP 2020

Outline

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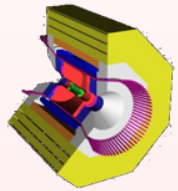
e^+e^- Charm Experiments

CLEO-c

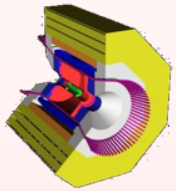


BESIII

- Symmetric e^+e^-
- $\sqrt{s}$: $2 - 4.6$ GeV
- Charm collected through pair-production near threshold

e^+e^- Charm Experiments

CLEO-c



BABAR

BESIII

Belle,BelleII

- Symmetric e^+e^-
- $\sqrt{s}$: $2 - 4.6$ GeV
- Charm collected through pair-production near threshold

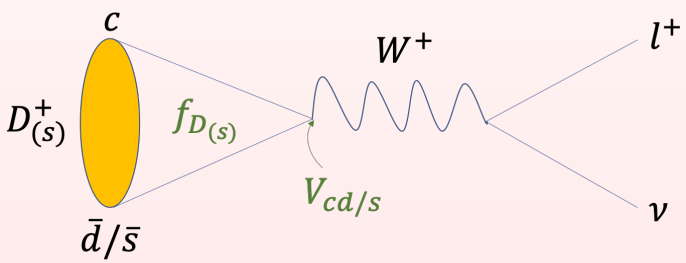
- Asymmetric e^+e^-
- $\sqrt{s}$: 10.8 GeV
- Charm collected through $b\bar{b}$ decays and $\gamma_{ISR}c\bar{c}$

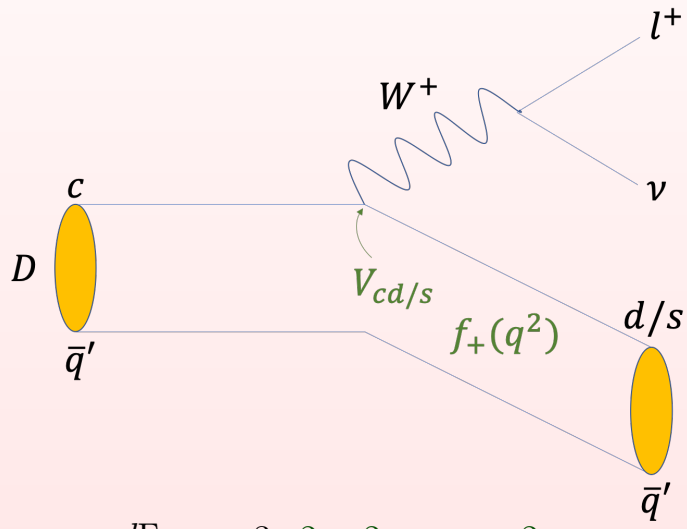
Datasets

- CLEO-c: Data collected until 2008
  - $D^{+(0)}$ 0.82 fb^{-1} @ $E_{cm} = 3.77$ GeV.
  - D_s^+ 0.57 fb^{-1} @ $E_{cm} = 4.170$ GeV.
- BESIII
  - $D^{+(0)}$ 2.93 fb^{-1} @ $E_{cm} = 3.773$ GeV. Collected in 2011
  - D_s^+ 3.19 fb^{-1} @ $E_{cm} = 4.178$ GeV. Collected in 2016
  - Λ_c^+ 0.587 fb^{-1} @ $E_{cm} = 4.600$ GeV. Collected in 2014
- BABAR: Data collected until 2008
  - 468 fb^{-1} near $\Upsilon(4S)$
- Belle: Data collected until 2010
  - 976 fb^{-1} near $\Upsilon(4S)$

Outline

Motivations





$$\Gamma\left(D^+_{(s)} \to l^+\nu\right) = \frac{G_F^2}{8\pi} f^2_{D_{(s)}} |V_{cd/s}|^2 m_l^2 m_{D_{(s)}} \left(1 - \frac{m_l^2}{m^2_{D_{(s)}}}\right)^2 \qquad \frac{d\Gamma}{dq^2} \propto p^3 f_+^2(q^2) |V_{cd/s}|^2$$

- Extract $f_{D_{(s)}}|V_{cd/s}|$ and $f_+(q^2)|V_{cd/s}|$ from measured BFs and
  - Test unitarity of CKM Matrix with $|V_{cd}|$ and $|V_{cs}|$
  - OR Test lattice predictions of $f_{D(s)}$ and $f_+(q^2)$

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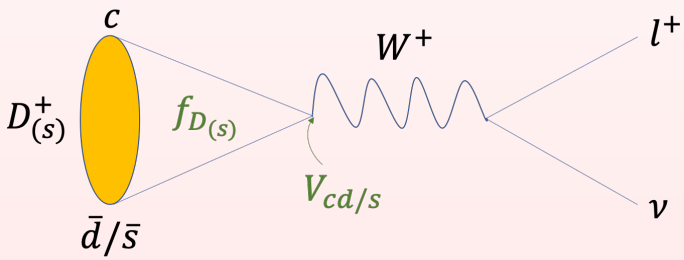

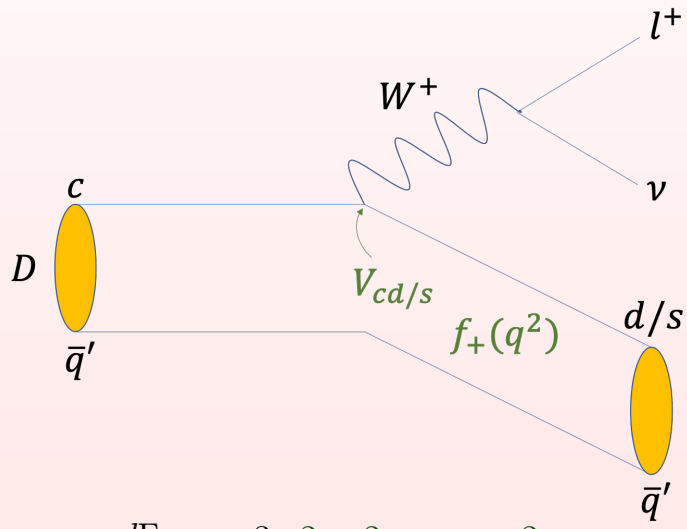

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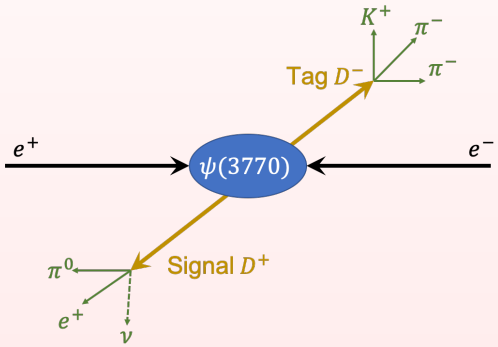
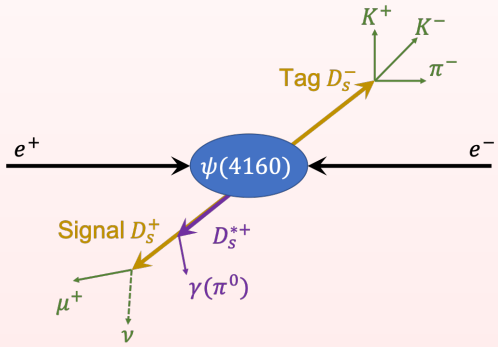
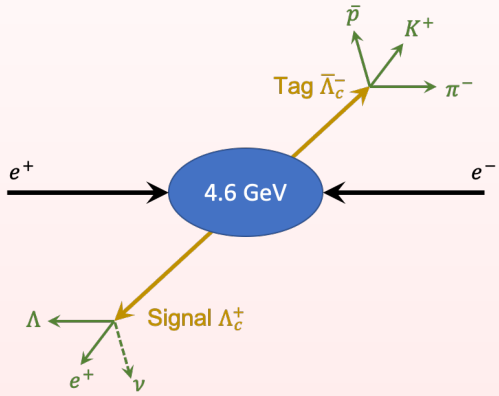
- Extract $f_{D_{(s)}}|V_{cd/s}|$ and $f_+(q^2)|V_{cd/s}|$ from measured BFs and
  - Test unitarity of CKM Matrix with $|V_{cd}|$ and $|V_{cs}|$
  - OR Test lattice predictions of $f_{D(s)}$ and $f_+(q^2)$
- Search for Lepton Flavor Universality Violation (LFUV) in the charm sector

Double Tag Method

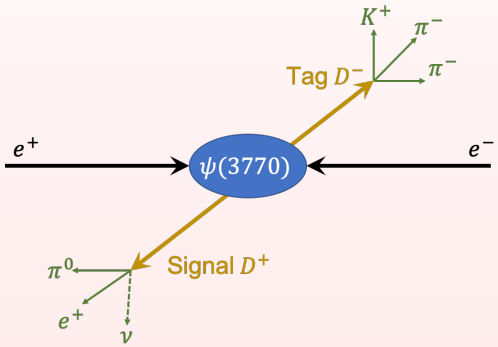


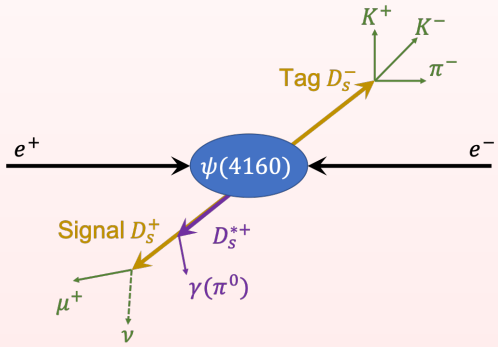


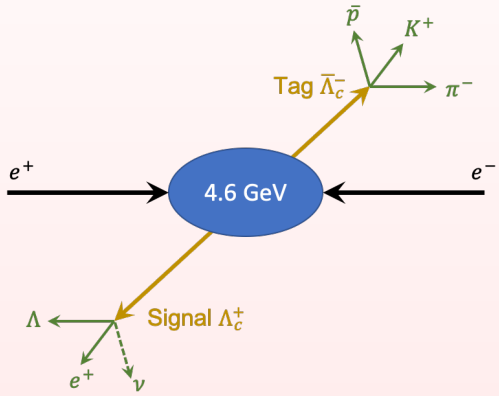


- Reconstruct charmed hadron $\overline{H}$ through clean decay mode (the tag)

Double Tag Method







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- Search for signal process of the H meson

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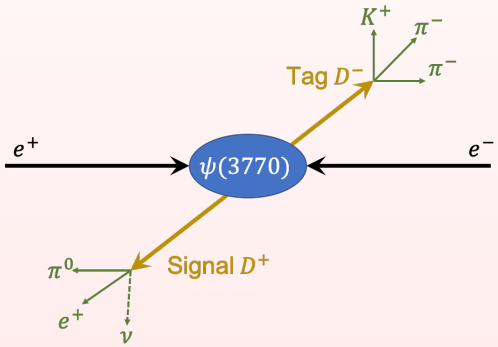

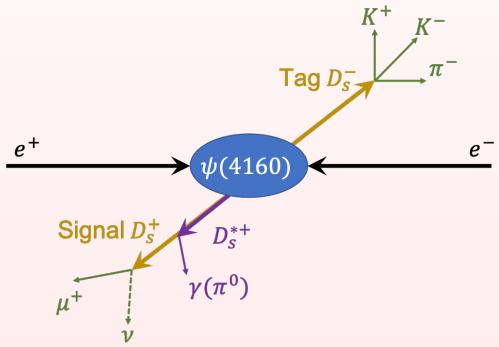

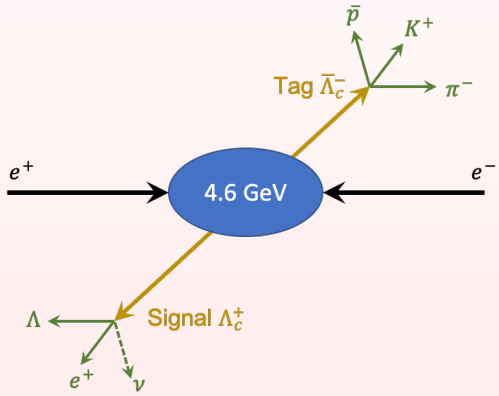

$$\mathcal{B}(H \to \text{signal}) = \frac{N_{\text{Signal}}/\epsilon_{\text{Tag \& Signal}}}{N_{\text{Tag}}/\epsilon_{\text{Tag}}}$$

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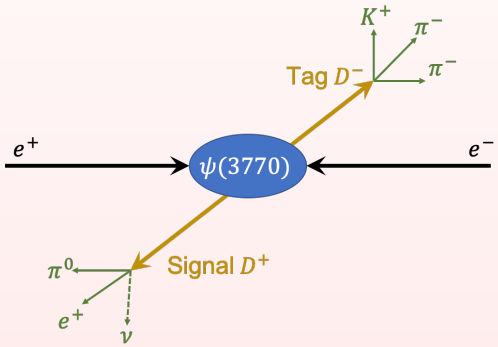

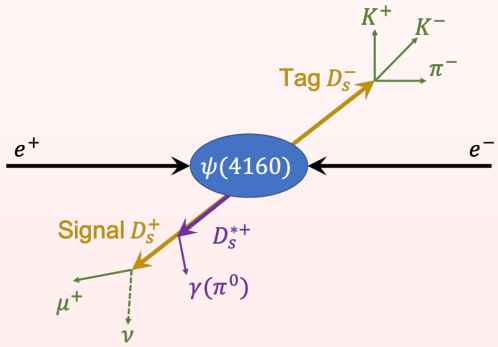

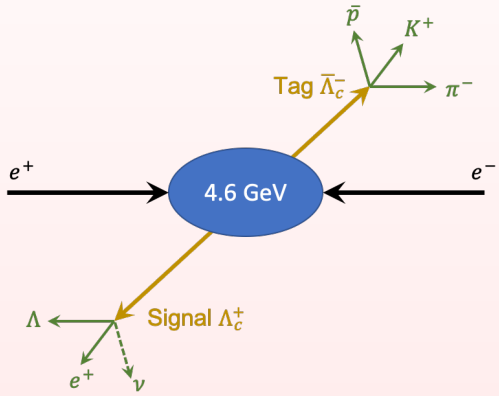

$$\mathcal{B}(H \to \text{signal}) = \frac{N_{\text{Signal}}/\epsilon_{\text{Tag \& Signal}}}{N_{\text{Tag}}/\epsilon_{\text{Tag}}}$$

- Reconstruct charmed hadron $\overline{H}$ through clean decay mode (the tag)
- Search for signal process of the H meson
- Advantages: Don't need to know $N_{H\overline{H}}$, can identify ν through missing mass, removes large component of backgrounds

$D^+_{(s)} \to \ell^+ \nu$

- $D^+ \to \tau^+ \nu$: BESIII PRL123(2019)211802

First observation, 5.1σ significance

$$\mathcal{B}\left(D^+ \to \tau^+ \nu\right) = (1.20 \pm 0.24 \pm 0.12) \times 10^{-3}$$

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- $D_s^+ \to \mu^+ \nu$: BESIII PRL122(2019)071802

  $$\mathcal{B}\left(D_s^+ \to \mu^+ \nu\right) = (5.49 \pm 0.16 \pm 0.15) \times 10^{-3}$$

  Most precise measurement of $f_{D_s^+}|V_{cs}|$ to date

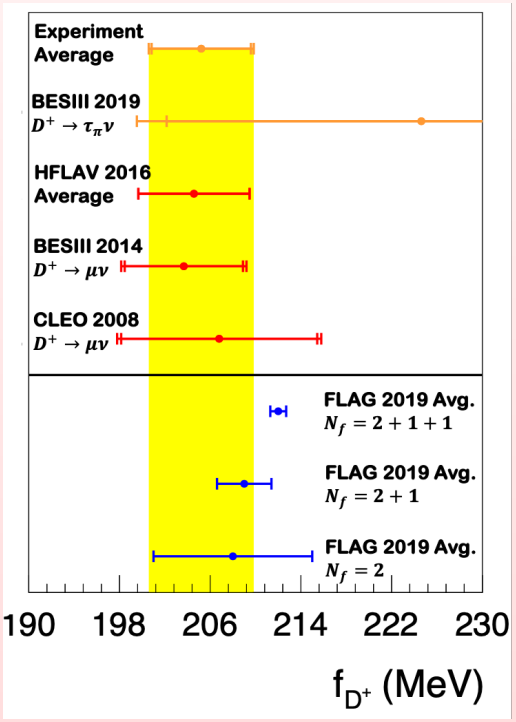
  $$f_{D_s^+}|V_{cs}| = 246.2 \pm 3.6 \pm 3.5 \text{ MeV}$$

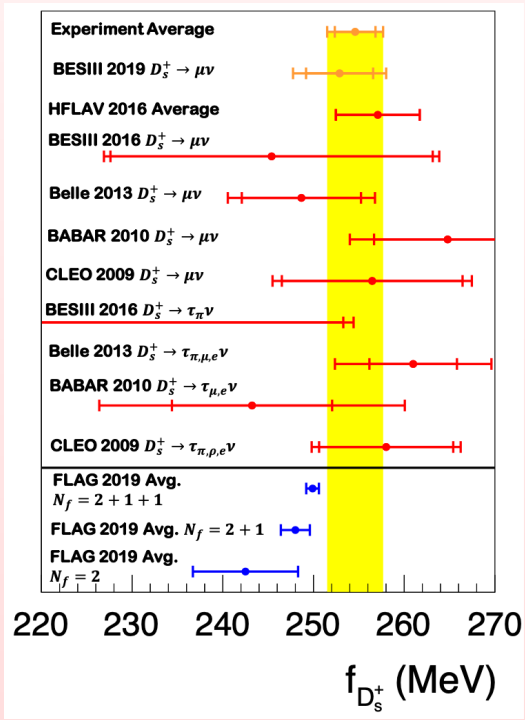
f_{D^+} and f_{D_s}

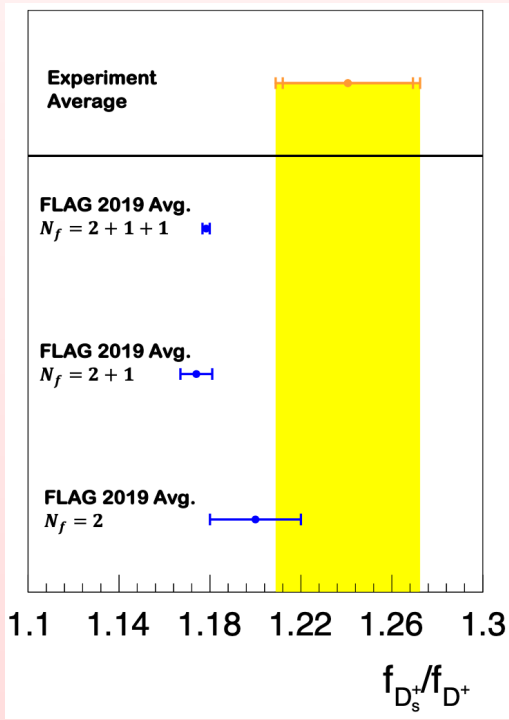
Inputs from 2018 PDG Global Fits

Inputs:
$|V_{cd}| = 0.22438 \pm 0.00044$

Inputs:
$|V_{cs}| = 0.97359^{+0.00010}_{-0.00011}$







Orange points published after HFLAV Avg.

$D \to K(\pi)\mu^+\nu$

- $D^0 \to K^-\mu^+\nu$: BESIII PRL122(2019)011804

$$\mathcal{B}\left(D^0 \to K^-\mu^+\nu\right) = (3.413 \pm 0.019 \pm 0.035)\,\%$$

$$f_+^{D\to K}(0)|V_{cs}| = 0.7148 \pm 0.0038 \pm 0.0029$$

$D \to K(\pi)\mu^+\nu$

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$$f_+^{D\to K}(0)|V_{cs}| = 0.7148 \pm 0.0038 \pm 0.0029$$

- $D \to \pi\mu^+\nu$: BESIII PRL121(2018)171803

$$\mathcal{B}\left(D^0 \to \pi^-\mu^+\nu\right) = (2.72 \pm 0.08 \pm 0.06) \times 10^{-3}$$

$$\mathcal{B}\left(D^+ \to \pi^0\mu^+\nu\right) = (3.50 \pm 0.11 \pm 0.10) \times 10^{-3}$$

$f_+^{D\to K}$ and $f_+^{D\to\pi}$

Inputs from 2018 PDG Global Fits

Inputs:

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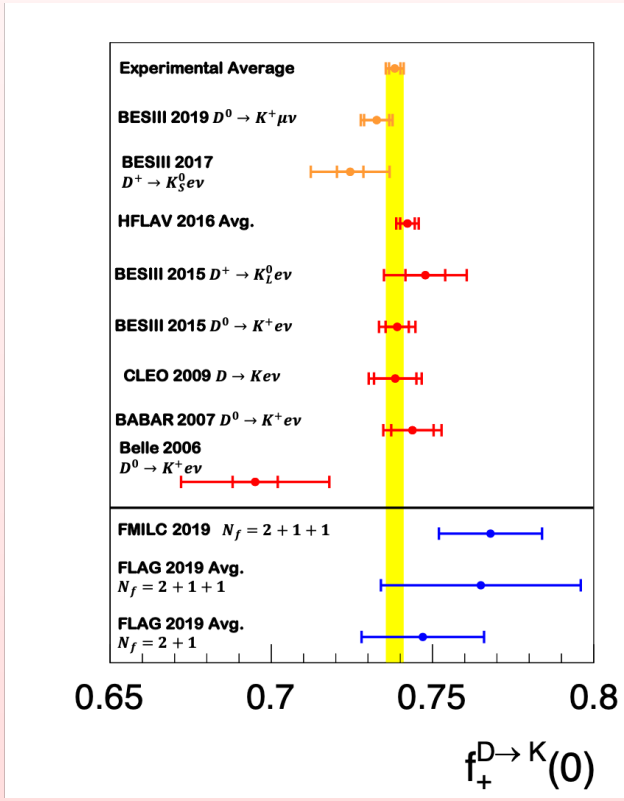

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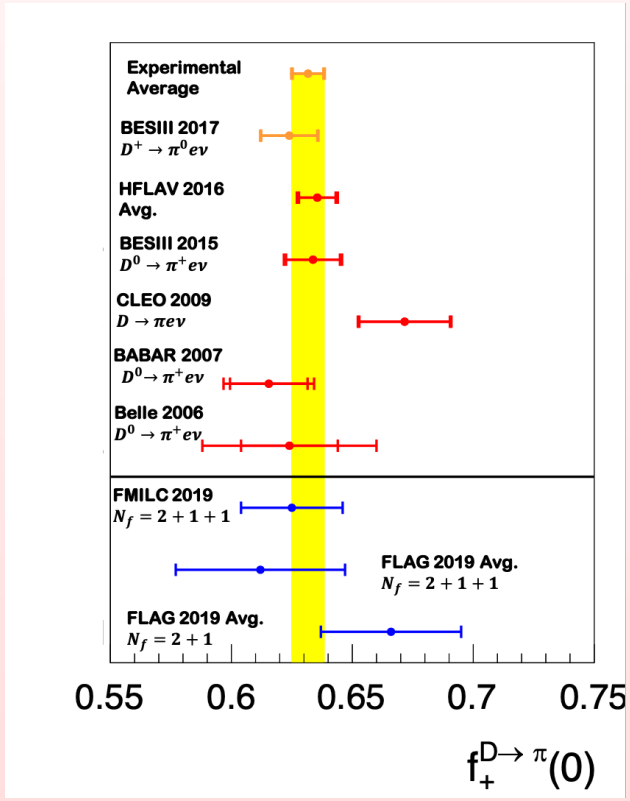

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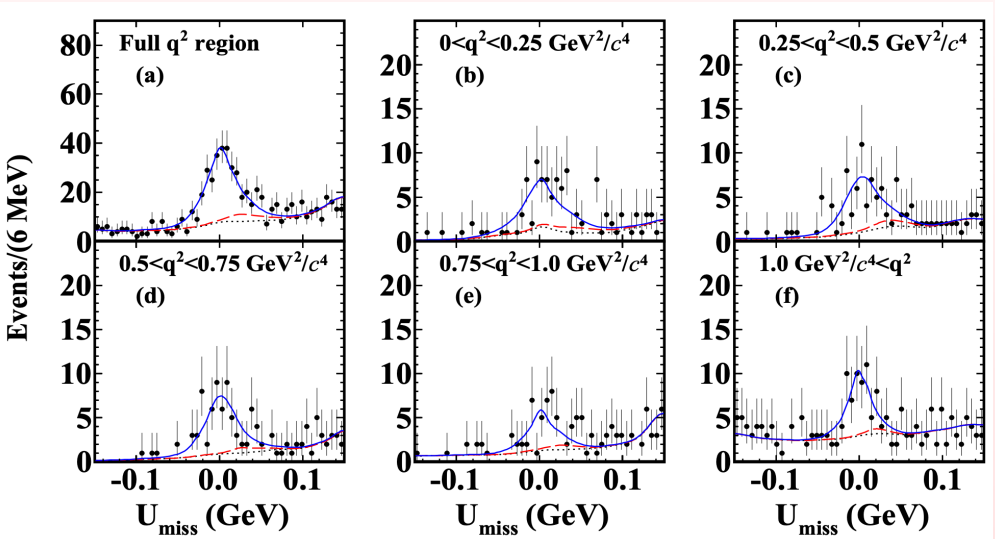
$D^+ \to \eta \mu^+ \nu$

BESIII arXiv:2003.12220
Accepted by PRL



$U_{\text{miss}} \equiv E_{\text{miss}} - p_{\text{miss}}$

$$\mathcal{B}\left(D^+ \to \eta \mu^+ \nu\right) = (10.4 \pm 1.0 \pm 0.5) \times 10^{-4}$$

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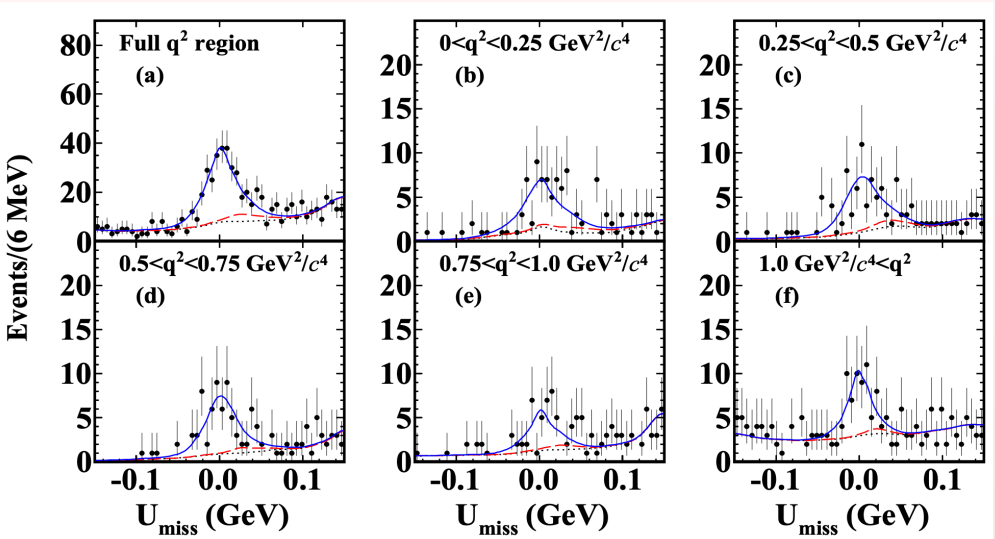

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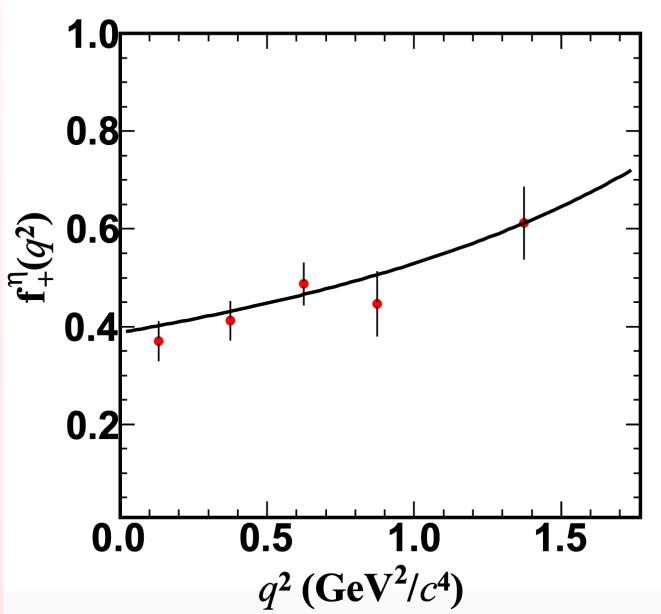


With $|V_{cd}|$ from 2018 PDG

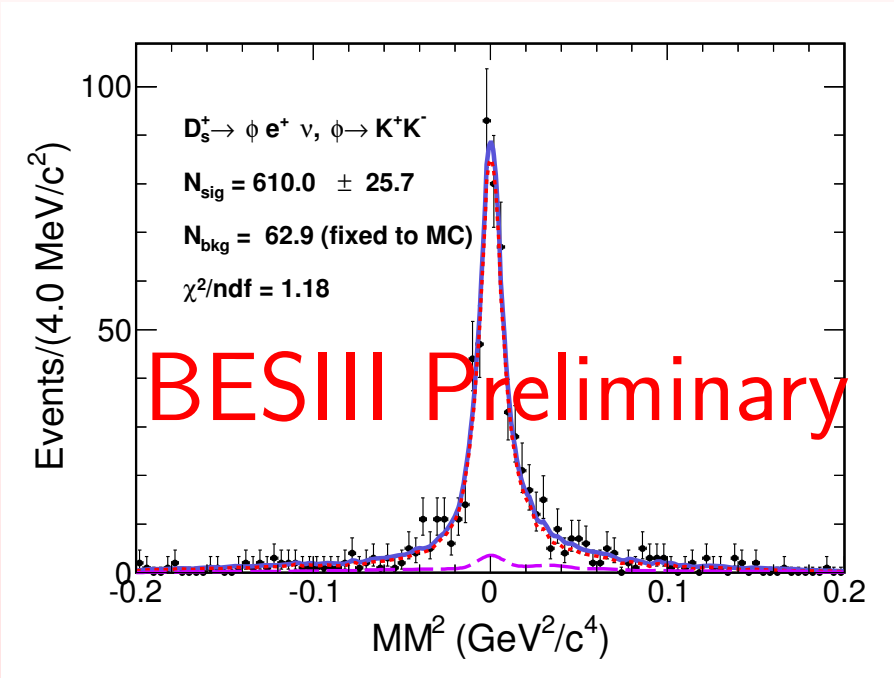
$$f_+^{D\to\eta}(0) = 0.39 \pm 0.04 \pm 0.01$$

$$\mathcal{B}\left(D^+ \to \eta\mu^+\nu\right) = (10.4 \pm 1.0 \pm 0.5) \times 10^{-4}$$

BESIII $D^+ \to \eta e^+\nu$ from PRD97(2018)092009

$$f_+^{D\to\eta}(0) = 0.35 \pm 0.03 \pm 0.01$$

$D_s^+ \to K^+K^-e^+\nu$



$$\mathcal{B}\left(D_s^+ \to \phi e^+\nu\right) = (2.35 \pm 0.10 \pm 0.10)\,\%$$

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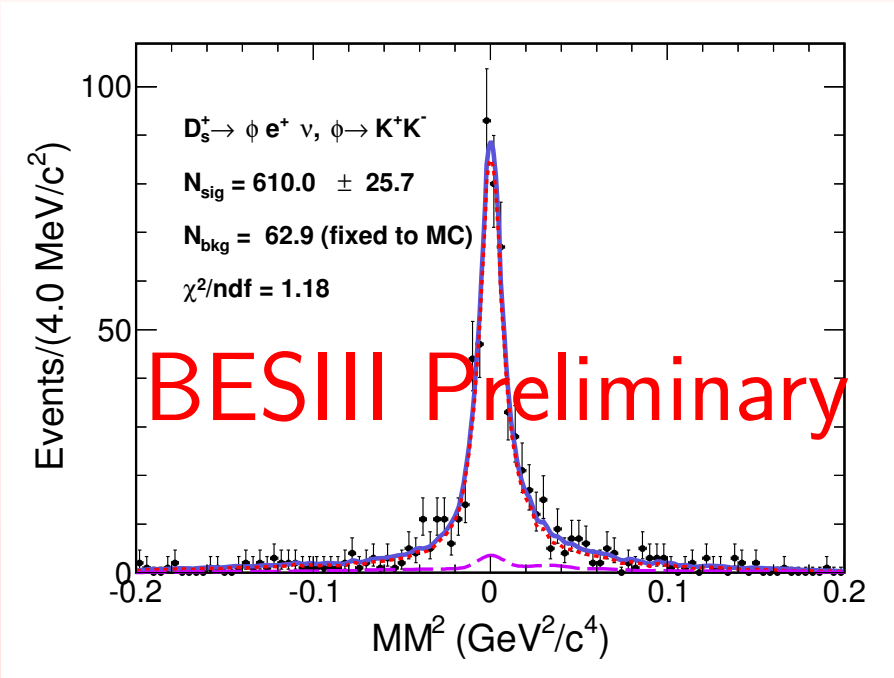

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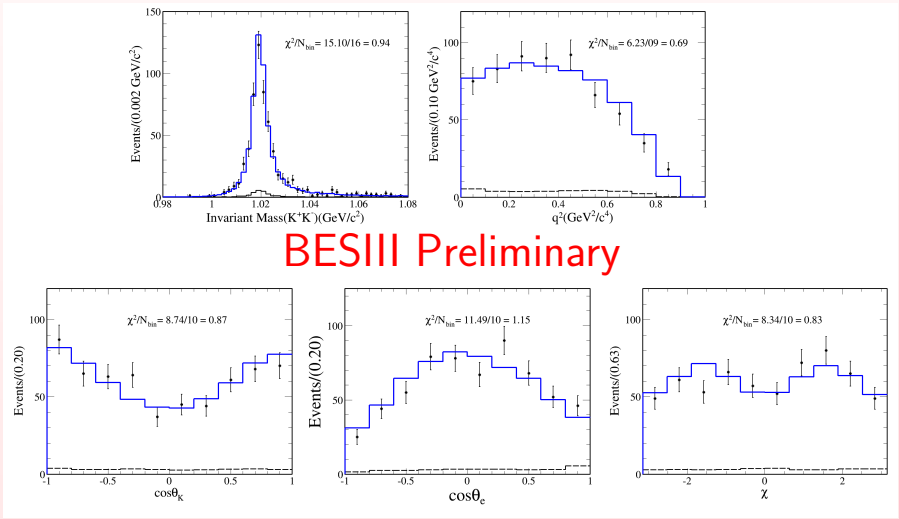
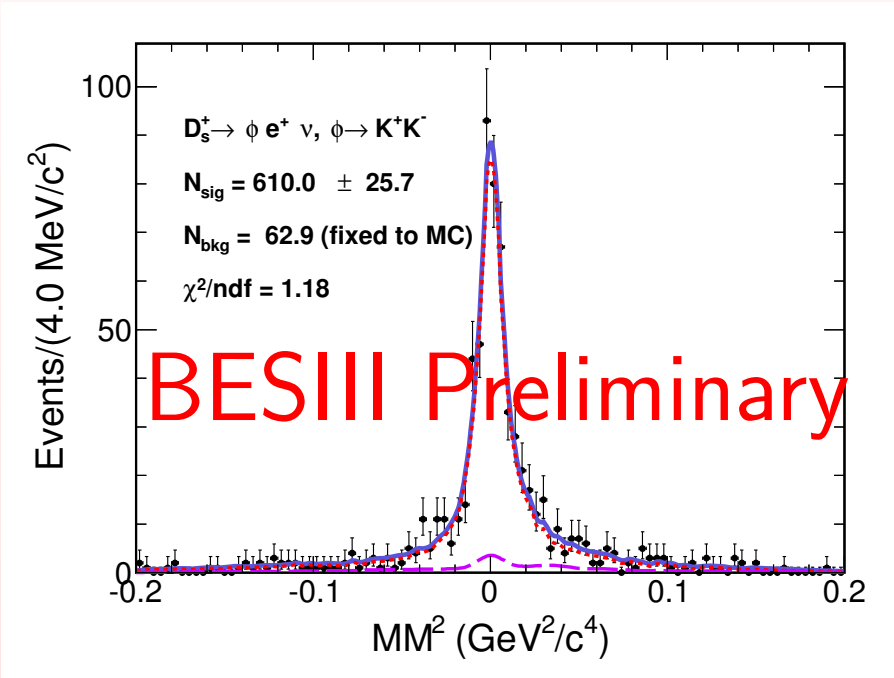


No obs. of $f_0(980)$ or non-resonant $\left(K^+K^-\right)_S$

$$\mathcal{B}\left(D_s^+ \to \phi e^+\nu\right) = (2.35 \pm 0.10 \pm 0.10)\,\%$$

$D_s^+ \to K^+K^-e^+\nu$



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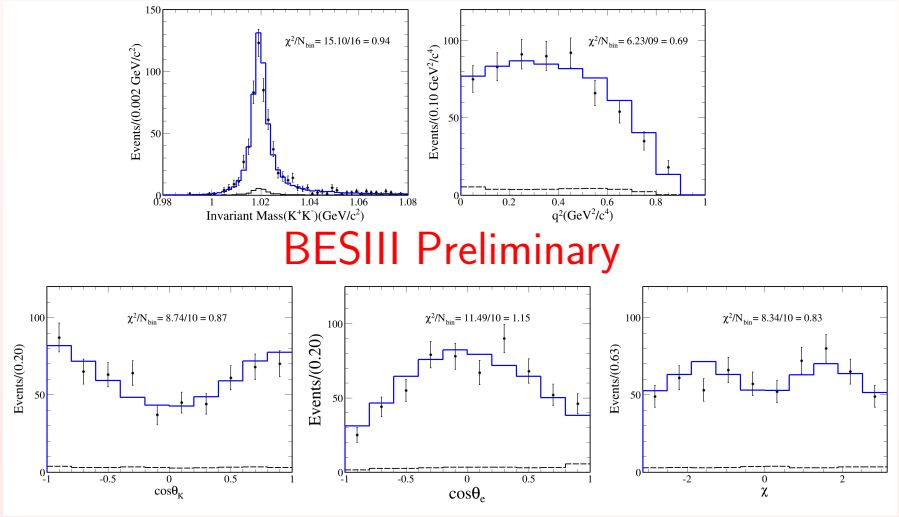

No obs. of $f_0(980)$ or non-resonant $\left(K^+K^-\right)_S$

$$\phi e^+\nu\ d\Gamma/dq^2 \propto V(q^2), A_{1,2}(q^2)$$

	$r_V = V(0)/A_1(0)$	$r_2 = A_2(0)/A_1(0)$
PDG2019	1.80±0.08	0.84±0.11
this work	1.79±0.19±0.06	0.77±0.15±0.07
BABAR [PRD78,051101(R)(2008)]	1.807±0.046±0.065	0.816±0.036±0.030
LQCD [PRD90,074506(2014)]	1.72±0.21	0.74±0.12
CLFQM [EPJC77,587(2017)]	1.42	0.86
CLFQM [PRD78,054002(2008)]	1.49	0.95
HQET [PRD72,034029(2005)]	1.80	0.52
CUA [PRD92,054038(2015)]	–	–

$$\mathcal{B}\left(D_s^+ \to \phi e^+\nu\right) = (2.35 \pm 0.10 \pm 0.10)\,\%$$

D_s Semileptonic Decays

- $D_s \to K^0 \left[K^{0*}(892)\right] e^+\nu$

  BESIII PRL122(2019)061801

- $D_s \to \eta^{(\prime)} e^+\nu$

  BESIII PRL122(2019)121801

D_s Semileptonic Decays

- $D_s \to K^0 \left[K^{0*}(892)\right] e^+\nu$

  BESIII PRL122(2019)061801

$$\mathcal{B}\left(D_s^+ \to K^0 e^+\nu\right) = 3.25(38)(16) \times 10^{-3}$$
$$\mathcal{B}\left(D_s^+ \to K^{0*} e^+\nu\right) = 2.37(26)(20) \times 10^{-3}$$

- $D_s \to \eta^{(\prime)} e^+\nu$

  BESIII PRL122(2019)121801

$$\mathcal{B}\left(D_s^+ \to \eta e^+\nu\right) = 2.323(63)(83)\%$$
$$\mathcal{B}\left(D_s^+ \to \eta' e^+\nu\right) = 0.824(73)(27)\%$$

BF Precision improved $\sim 2\times$ over PDG

D_s Semileptonic Decays

- $D_s \to K^0 \left[K^{0*}(892)\right] e^+\nu$

  BESIII PRL122(2019)061801

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- $D_s \to \eta^{(\prime)} e^+\nu$

  BESIII PRL122(2019)121801

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BF Precision improved $\sim 2\times$ over PDG

$$f_+^{D_s\to K^0}(0) = 0.720(84)(13)$$

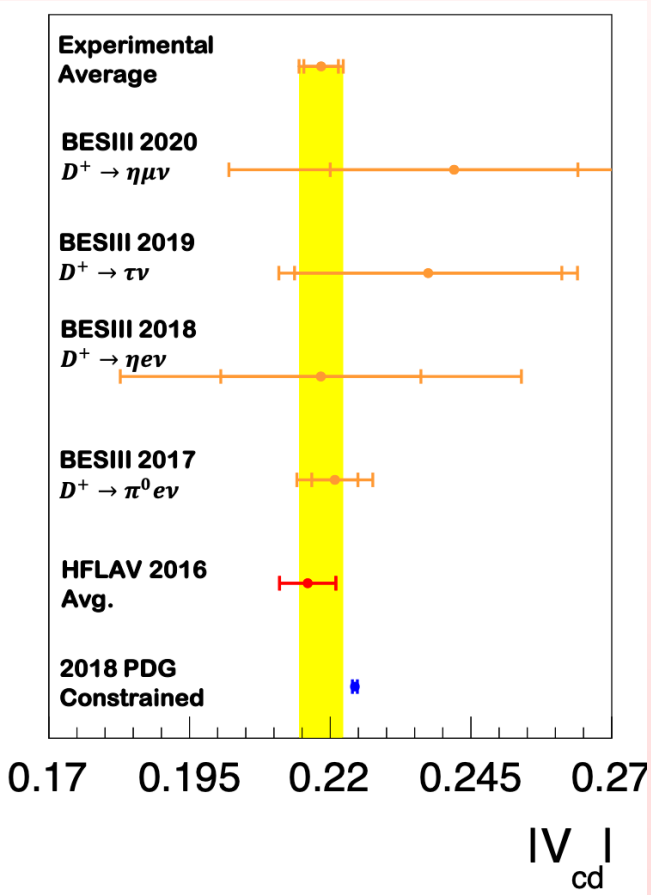
K^* $r_V = 1.67(34)(16)$ $r_2 = 0.77(28)(07)$

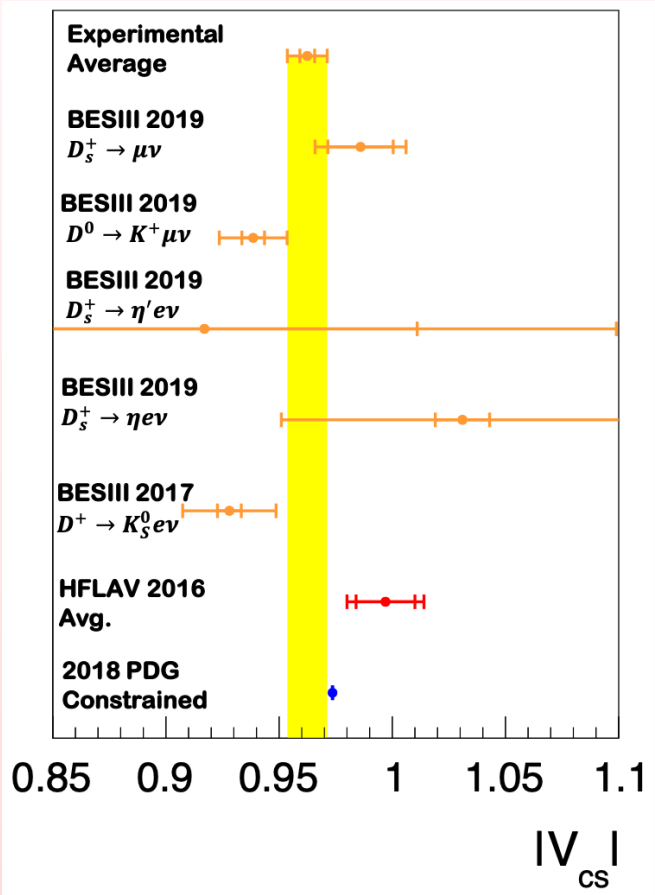
$$f_+^{D_s\to \eta}(0) = 0.4576(70)$$
$$f_+^{D_s\to \eta'}(0) = 0.490(51)$$

First measurements of $D_s \to K^*, \eta, \eta'$ FFs

$|V_{cd}|$ and $|V_{cs}|$

$f_{D_{(s)}}$ and $f_+^{D\to K(\pi)}$ averaged from FLAG 2019 Avgs. + FMILC 2019 $D \to K(\pi)e^+\nu$
$f_+^{D\to\eta}$ from . from Front. Phys. 14(2019)64401. $f_+^{D_s\to\eta^{(\prime)}}$ from PRD88(2013)034023



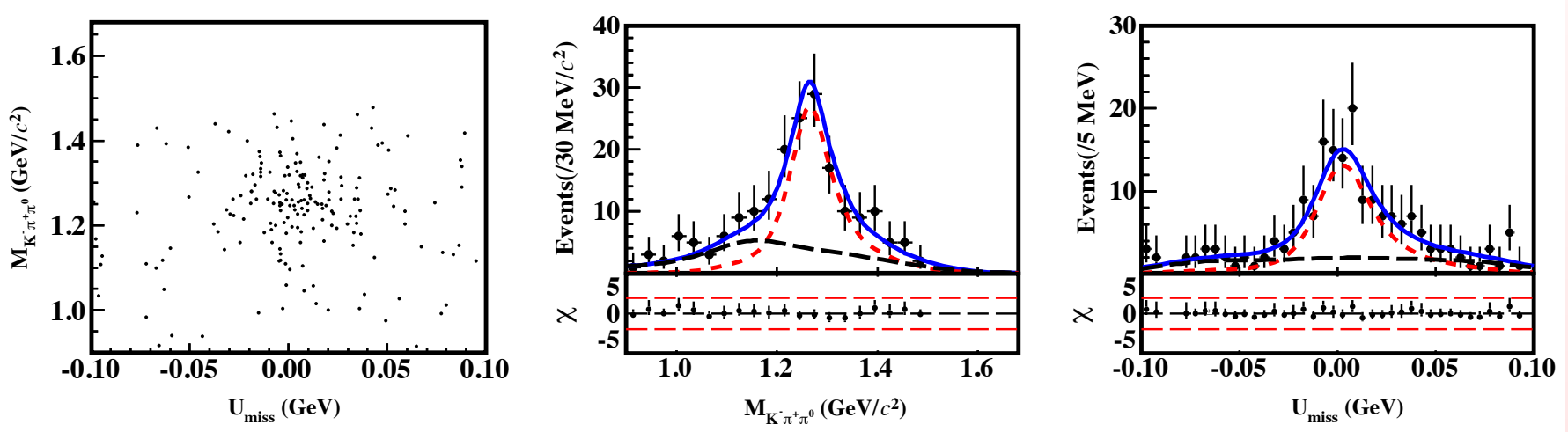


Orange points not included in HFLAV Averages

A. Gilman University of Minnesota On behalf of the BESIII Collaboration

$D^+ \to \overline{K}_1(1270)^0 e^+\nu$

BESIII PRL123(2019)231801



$$\mathcal{B}\left(D^+ \to \overline{K}_1(1270)^0 e^+\nu\right) = \left(2.30 \pm 0.26^{+0.18}_{-0.21} \pm 0.25\right) \times 10^{-3}$$

Theoretical predictions sensitive to $K_1(1270), K_1(1400)$ mixing angle θ_{K_1}
CLFQM and LCSR predictions agree when $\theta_{K_1} \approx 33^\circ$ or 57°

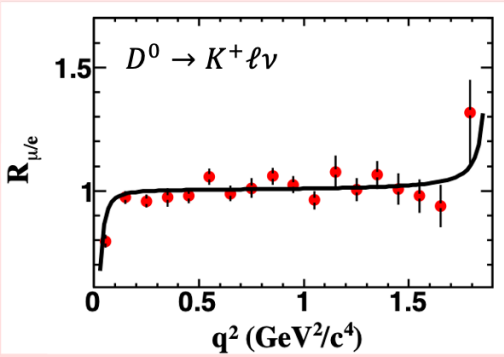
Strongly disfavors $\theta_{K_1} < 0$

Lepton Flavor Universality in Charm

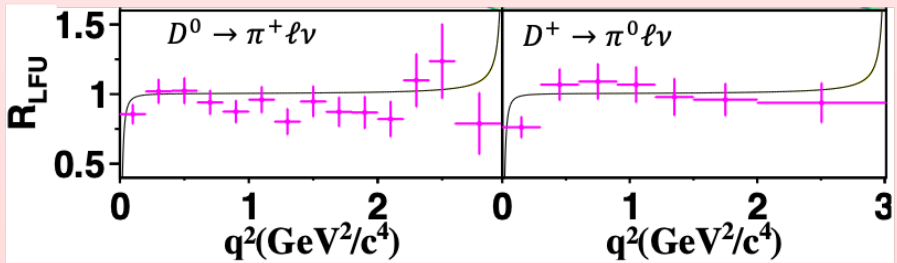
Mode	Measured $\mathcal{B}(\ell)/\mathcal{B}(\ell')$	SM Prediction
$D^+ \to \tau(\mu)\nu$	3.21 ± 0.77	2.66
$D_s^+ \to \tau(\mu)\nu$	9.98 ± 0.52	9.74
$D^+ \to \eta\mu(e)\nu$	0.91 ± 0.13	$0.97 - 1.00$
$D^+ \to \omega\mu(e)\nu$	1.05 ± 0.14	$0.93 - 0.99$
$D^+ \to \pi^0\mu(e)\nu$	0.964 ± 0.045	~ 0.985
$D^0 \to \pi^+\mu(e)\nu$	0.922 ± 0.037	~ 0.985
$D^0 \to K^+\mu(e)\nu$	0.974 ± 0.014	~ 0.970

μ/e Ratios of $\frac{d\Gamma}{dq^2}$

PRL122(2019)011804



PRL121(2018)171803



A. Gilman University of Minnesota On behalf of the BESIII Collaboration

Selected Summary of Recent $D_{(s)}$ Semileptonic Results

* BESIII PRD101(2020)072005
  $D^+ \to \omega\mu^+\nu$

$$\mathcal{B}\left(D^+ \to \omega\mu^+\nu\right) = (17.1 \pm 1.8 \pm 1.1) \times 10^{-4}$$

$$\frac{\mathcal{B}\left(D^+ \to \omega\mu^+\nu\right)}{\mathcal{B}^{\text{PDG}}\left(D^+ \to \omega e^+\nu\right)} = 1.05 \pm 0.14$$

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* BESIII PRD100(2019)112008
  Search for $D_s^+ \to p\bar{p}e^+\nu$

$$\mathcal{B}\left(D_s^+ \to p\bar{p}e^+\nu\right) < 2.0 \times 10^{-4}$$

---

* BESIII PRD99(2019)072002
  Search for $D_s^+ \to \gamma e^+\nu$

$$\mathcal{B}\left(D_s^+ \to \gamma e^+\nu\right) < 1.4 \times 10^{-4}$$

---

* BESIII PRD99(2019)011103
  $D^0 \to \overline{K}^0\pi^- e^+\nu$

$$\mathcal{B}\left(D^0 \to \overline{K}^0\pi^- e^+\nu\right) = (1.434 \pm 0.029 \pm 0.032)\,\%$$

$$\frac{\mathcal{B}\left(D^0 \to \left(\overline{K}^0\pi^-\right)_{S-\text{wave}} e^+\nu\right)}{\mathcal{B}\left(D^0 \to \overline{K}^0\pi^- e^+\nu\right)} = (5.51 \pm 0.97 \pm 0.62)\,\%$$

$$\mathcal{B}\left(D^0 \to \overline{K}^*(892)^- e^+\nu\right) = (2.033 \pm 0.046 \pm 0.047)\,\%$$

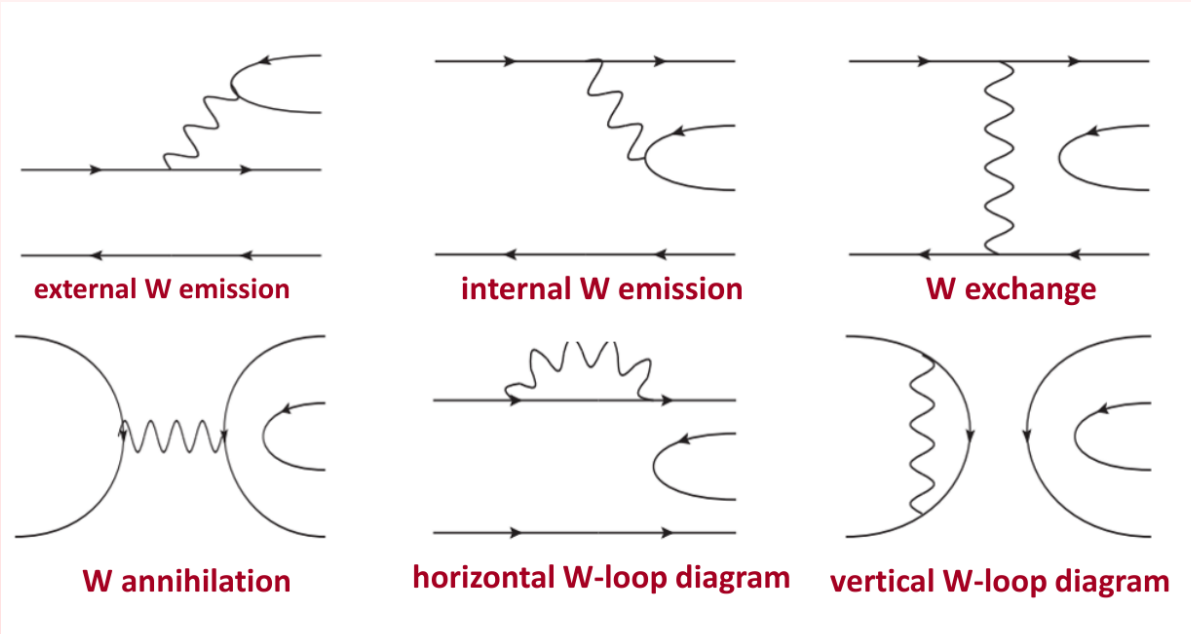
First K^{*0} FF Meas.

$$r_V = 1.46 \pm 0.07 \pm 0.02$$
$$r_2 = 0.67 \pm 0.06 \pm 0.01$$

Outline

Motivations

- Study strong-phase and charm mixing in D^0
- Study amplitudes of weak contributions to meson decays



- Search for (additional) evidence of charm-sector CP Violation

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

- Using 2.93 fb^{-1} of BESIII data @ $E_{CM} = 3.773$ GeV
- Amplitude anlysis of the
$a_0\,(980)\,, \phi\,(1020)\,, a_2\,(1320)^{\pm}$, and $a_0\,(1450)$
- Dalitz analysis flavor-tagged events
- BF determination from untagged events
- $D^0 - \overline{D}^0$ entanglement effects accounted for
- $a_0(980)$ coupling to $K\overline{K}$ $g_{K\overline{K}}$ determined

arXiv:2006.02800
Submitted to PRD

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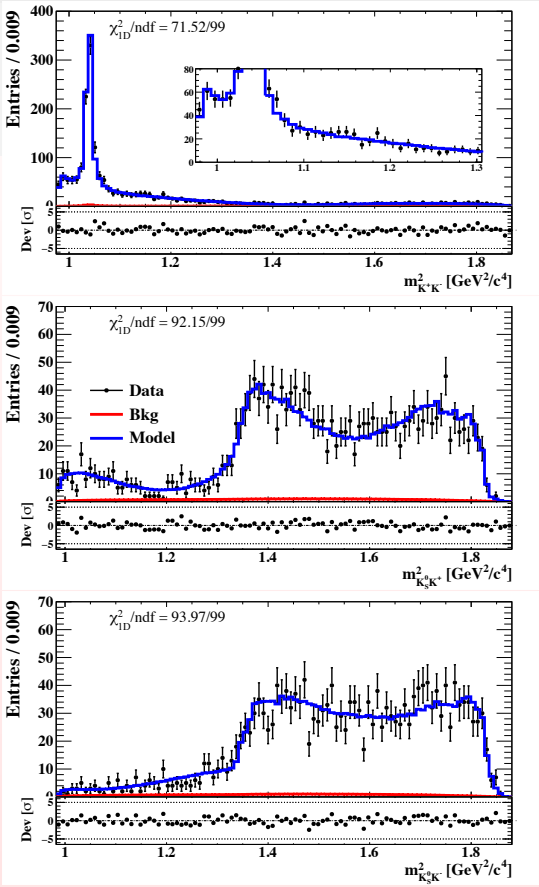

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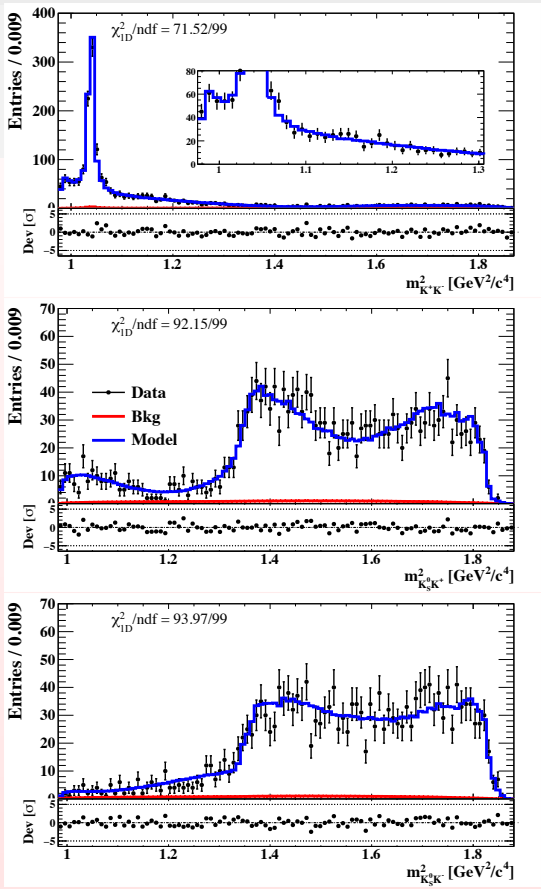

arXiv:2006.02800
Submitted to PRD

$$\mathcal{B}\left(D^0 \to K^0_S K^+ K^-\right) = (4.51 \pm 0.05 \pm 0.16) \times 10^{-3}$$

Parameter	g_{KK}	$a_0(980)^0$	$a_0(980)^+$			$\phi(1020)$			$a_2(1320)^+$			$a_2(1320)^-$			$a_0(1450)^-$		
	[GeV]	FF [%]	$\lvert c\rvert$	ϕ [rad]	FF [%]	$\lvert c\rvert$	ϕ [rad]	FF [%]	$\lvert c\rvert$	ϕ [rad]	FF [%]	$\lvert c\rvert$	ϕ [rad]	FF [%]	$\lvert c\rvert$	ϕ [rad]	FF [%]
Fit value	3.80	93	0.59	2.96	33	0.71	1.67	47	0.13	−2.97	1.5	0.10	−0.14	0.9	0.21	−0.23	4.1
Corrected value	3.77	90	0.64	2.94	34	0.74	1.67	48	0.12	−2.92	1.4	0.09	−0.06	0.8	0.16	0.12	2.2
Mean stat. uncertainty $\bar{\sigma}$	0.24	10	0.11	0.17	7	0.06	0.08	2	0.03	0.23	0.6	0.03	0.23	0.4	0.08	0.58	2.4
Sys. uncertainty	0.35	14	0.09	0.06	6	0.08	0.19	3	0.01	0.31	0.3	0.02	0.28	0.2	0.04	0.50	1.9
Total uncertainty	0.42	17	0.14	0.17	9	0.10	0.21	4	0.03	0.39	0.7	0.03	0.36	0.5	0.10	0.76	3.1

Measurement of y_{CP} in $D^0 \to K^0_S\omega$

- Using 976 fb^{-1} of Belle data @ $\Upsilon(4S)$
- Measure y_{CP} through the lifetime ratio of flavor and CP eigenstates $y_{CP} = 1 - \frac{\tau(K^-\pi^+)}{\tau(K^0_S\omega)}$
- Select D^0 from $D^{*+} \to \pi^+ D^0$ decays
- Backgrounds accounted for by sideband subtraction in M_D and $\Delta M \equiv M_{D^*} - M_D$

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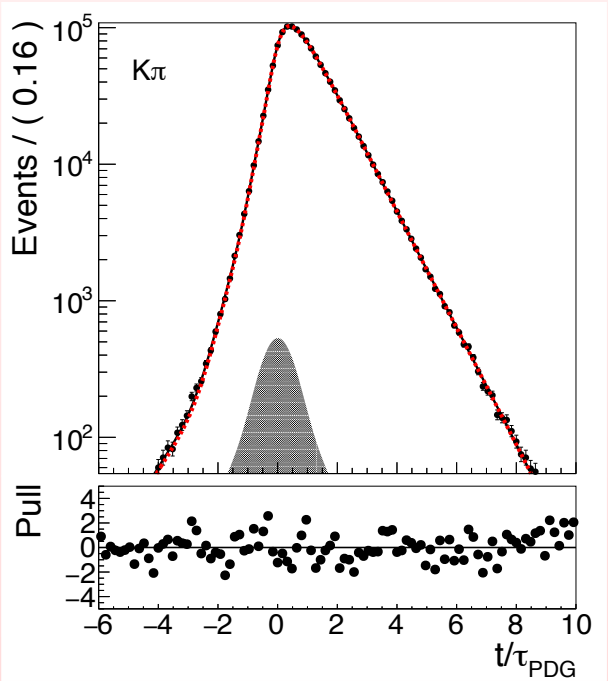
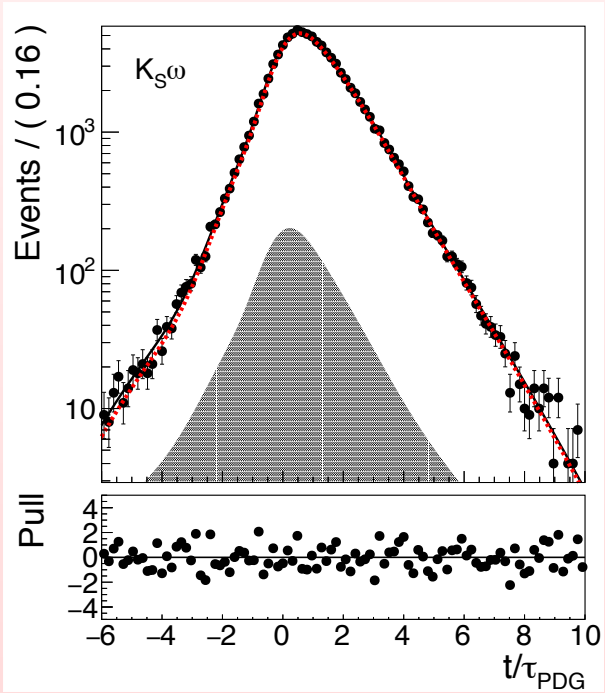


arXiv:1912.10912
Submitted to PRD



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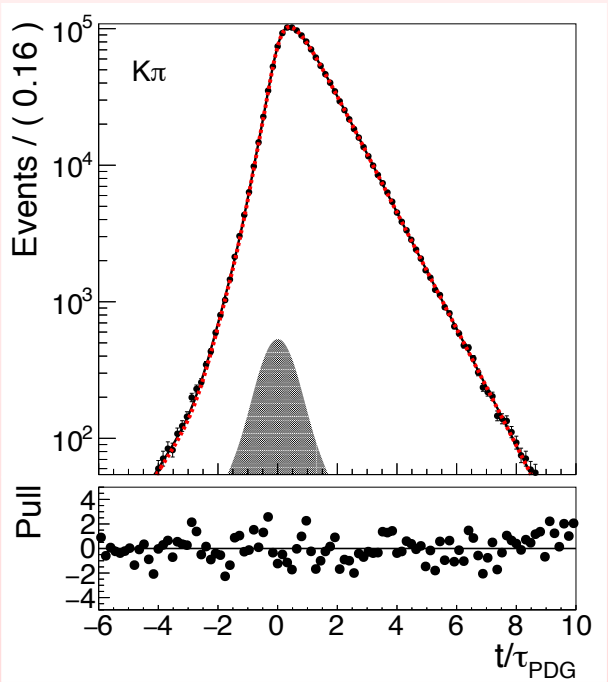
$$y_{CP} = \left(0.96 \pm 0.91 \pm 0.61^{+0.17}_{-0.00}\right)$$

HFLAV 2018 Avg:
$$y_{CP} = (0.715 \pm 0.11)$$



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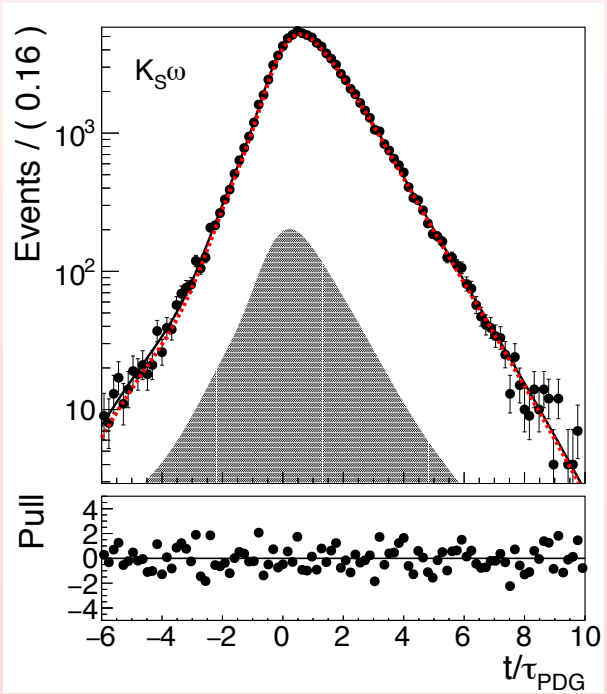
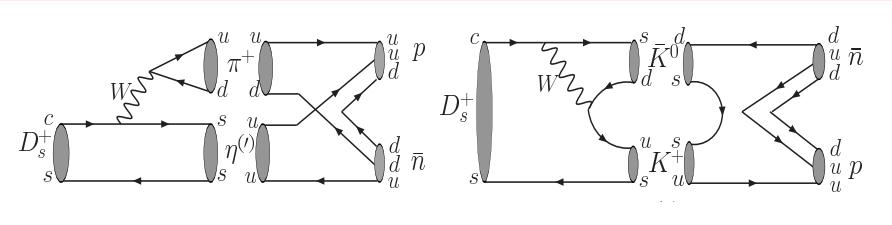


$D_s^+ \to p\overline{n}$

- Using 3.19 fb^{-1} of BESIII data @ $E_{CM} = 4.178$ GeV
- Only kinematically allowed baryonic decay of charmed mesons
- Weak annihilation chirally suppressed by $\left(\frac{m_\pi}{m_{D_s}}\right)^4 \sim 10^{-6}$
- Possible 10^{-3} enhancements from W emission
  Chen,Cheng,Hsiao PLB663(2008) 326



- First evidence from CLEO PRL100(2008)181802 with 13 ± 3.6 events:

$\mathcal{B}(D_s \to p\overline{n}) = \left(1.30 \pm 0.36^{+0.12}_{-0.16}\right) \times 10^{-3}$

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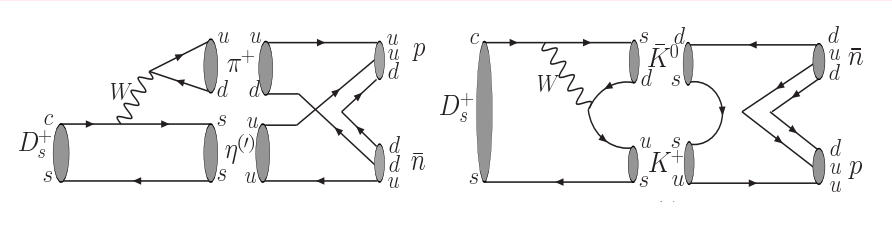

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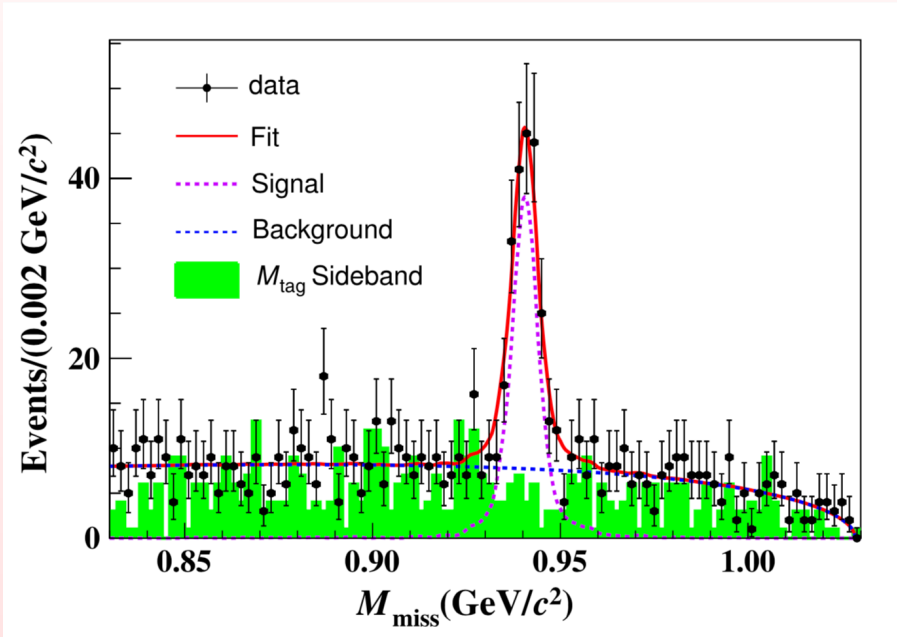
PRD99(2019) 031101(R)

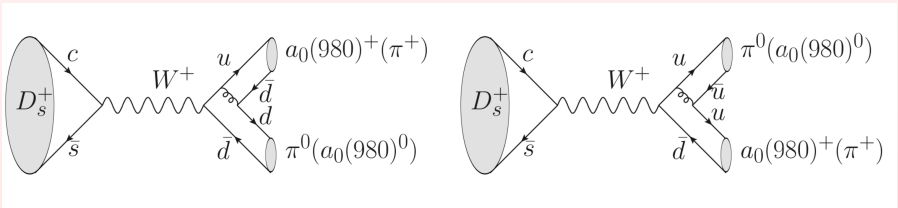


$\mathcal{B}(D_s^+ \to p\overline{n}) = (1.20 \pm 0.10 \pm 0.05) \times 10^{-3}$

Confirms enhanced contribution of long-distance effects

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

- Using 3.19 fb^{-1} of BESIII data @ $E_{CM} = 4.178$ GeV
- PWA examining $\rho\eta$,$(\pi^+\pi^0)_V\eta$, $a_0(980)\pi$ intermediate states
- Ignoring $a_0 - f_0$ mixing, $D_s \to a_0(980)\pi$ is pure WA



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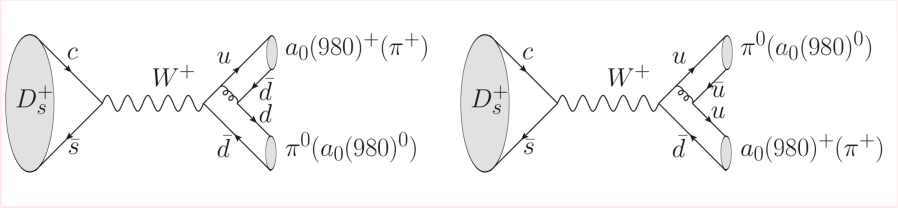
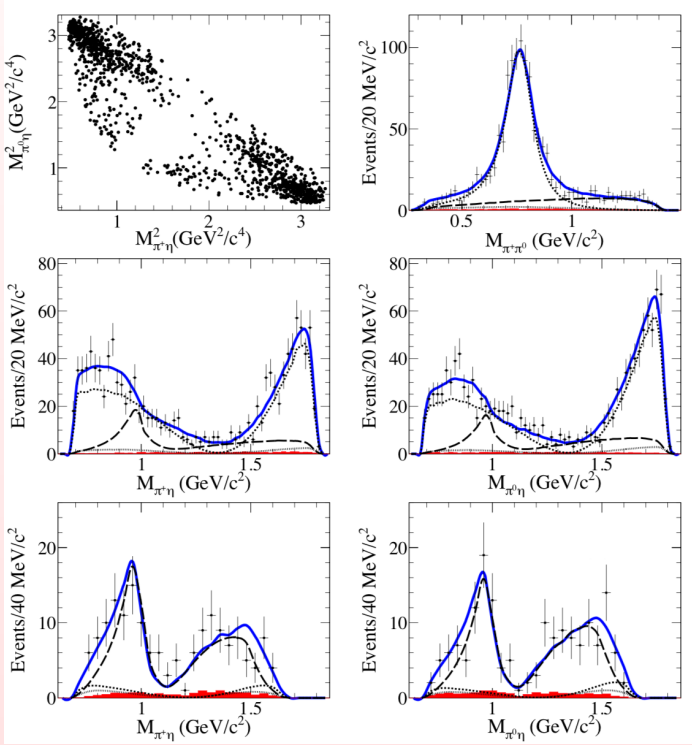


PRL123(2019)112001



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

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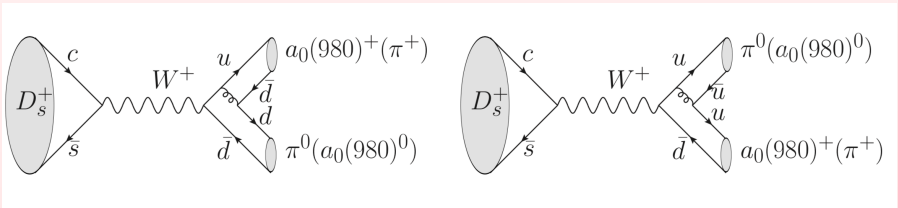
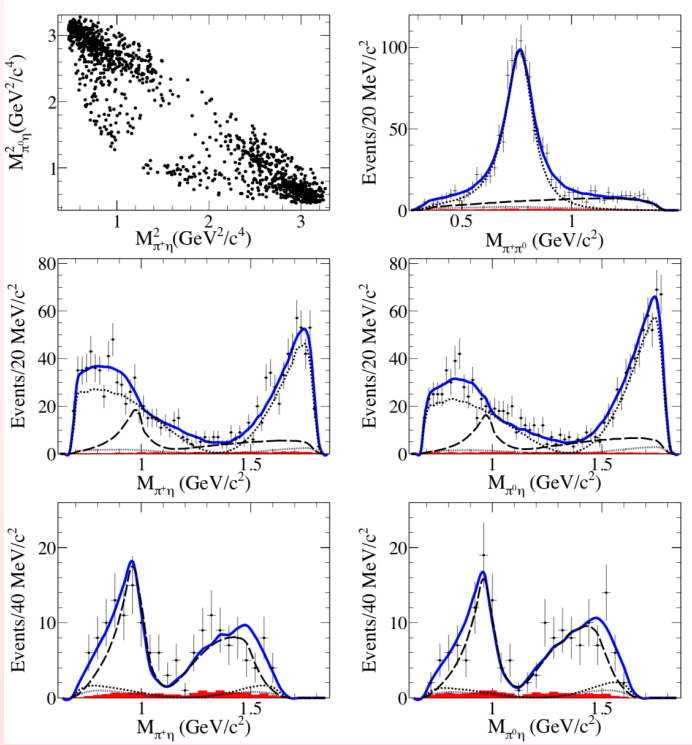


PRL123(2019)112001



$$\mathcal{B}\left(D_s^+ \to \pi^+\pi^0\eta\right) = (9.50 \pm 0.28 \pm 0.41)\,\%$$

$$\mathcal{B}\left(D_s^+ \to a_0(980)\pi\right) = (1.46 \pm 0.15 \pm 0.23)\,\%$$

Significantly larger WA effects than seen in any other D_s decays

Amplitude	ϕ_n (rad)	FF$_n$
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Selected Summary of Recent $D_{(s)}$ Hadronic Results

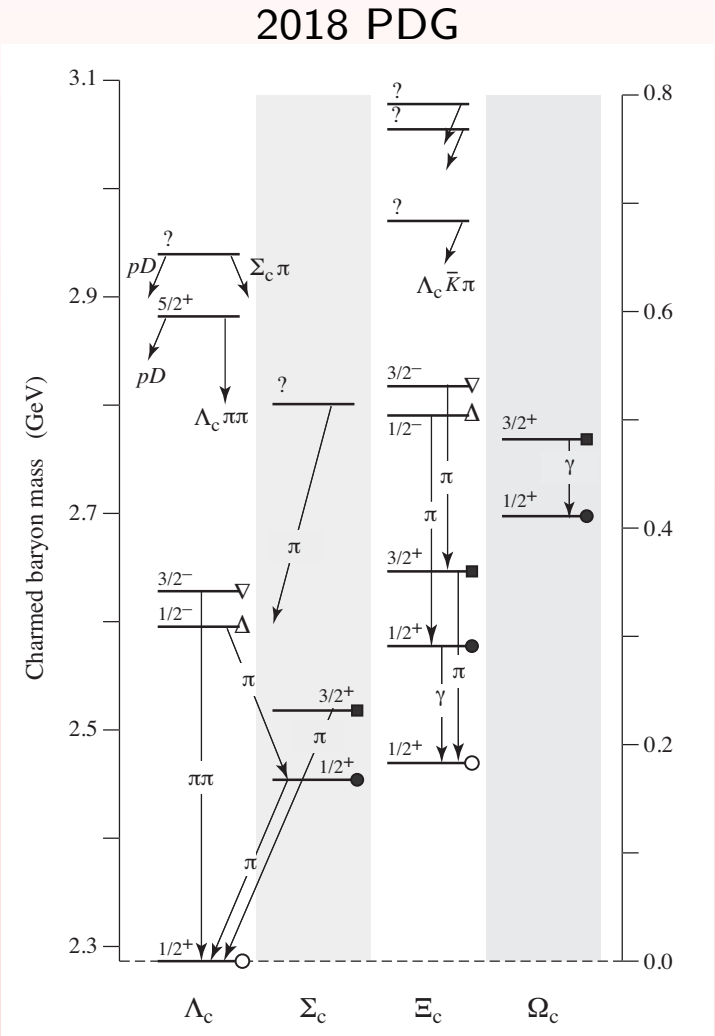
*	BESIII arXiv: 2005.05072 $D_s \to PP$	Significantly improved precision on BF's to $K^+(\pi^+)\eta, K^+(\pi^+)\eta', K^+(\pi^+)K^0_S, K^+\pi^0$ final states
*	BESIII arXiv:2004.13910 Hadronic D decays to η	Improved measurement of 14 final states containing η No evidence for CPV at 1.6% precision
*	BESIII PRD 101(2020)052009 $D \to \eta\pi\pi$, $D^+ \to \eta\eta\pi$	$\mathcal{B}\left(D^+ \to \eta\eta\pi\right) = 2.96(24)(10) \times 10^{-3}$ $\mathcal{B}\left(D^+ \to \eta\pi^+\pi^0\right) = 2.23(15)(10) \times 10^{-3}$ $\mathcal{B}\left(D^0 \to \eta\pi^+\pi^-\right) = 1.20(7)(4) \times 10^{-3}$
*	BESIII PRD 100(2019)072006 $D \to \phi X$	$\mathcal{B}\left(D^+ \to \phi X\right) = 1.135(34)(31)\%$ $\mathcal{B}\left(D^0 \to \phi X\right) = 1.091(27)(35)\%$ No evidence for CPV at 2.6% precision
*	BESIII PRD 99(2019)112005 $D^+ \to K^0_{S,L}K^+$	$\mathcal{B}\left(D^+ \to K^0_S K^+\right) = 1.425(28)(31)\%$ $\mathcal{B}\left(D^+ \to K^0_L K^+\right) = 1.485(39)(46)\%$ No evidence for CPV at 2.7% precision

See Meng Wang's Talk:
Hadronic Charm Meson Decays at BESIII
Wednesday 9:45am

Outline

Motivations

- Lightest Charmed Baryon
- Important in measuring decays of charm and bottom baryons
- $\sim 60\%$ of branching fraction has been observed
- Study weak decays



A. Gilman
University of Minnesota On behalf of the BESIII Collaboration

Weak Decay Asymmetries in $\Lambda_c \to BP$

- Using 567 pb^{-1} of BESIII data @ $E_{CM} = 4.6$ GeV
- Angular analysis of $pK^0_S, \Lambda\pi^+, \Sigma\pi$ final states
- Measure Lee-Yang weak asymmetry parameters

$\alpha_{BP} \equiv \frac{2\mathrm{Re}(s\cdot p)}{|s|^2+|p|^2}$

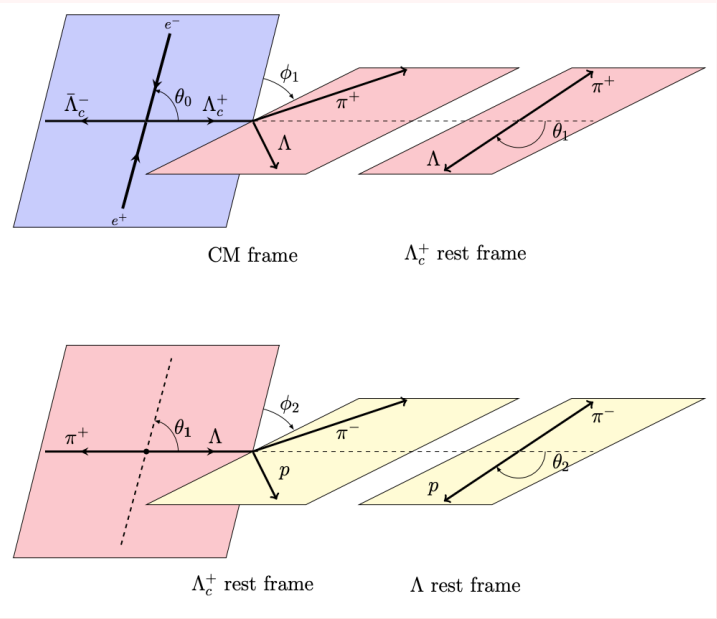
$\beta_{BP} \equiv \frac{2\mathrm{Im}(s\cdot p)}{|s|^2+|p|^2}$

$\gamma_{BP} \equiv \frac{|s|^2-|p|^2}{|s|^2+|p|^2}$

$\Delta_1^{BP} \equiv$ phase between helicity states

in terms of helicity angles

PRD100(2019)072004



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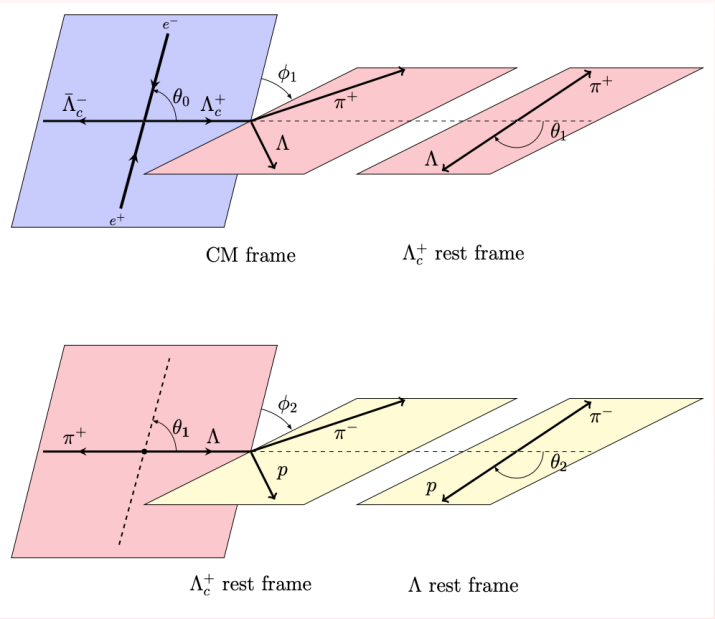
PRD100(2019)072004



$\Lambda_c^+ \to$		pK^0_S	$\Lambda\pi^+$	$\Sigma^+\pi^0$	$\Sigma^0\pi^+$
$\alpha_{BP}^{\Lambda_c^+}$	PDG		-0.91 ± 0.15	-0.45 ± 0.32	
	This work	$0.18 \pm 0.43 \pm 0.14$	$-0.80 \pm 0.11 \pm 0.02$	$-0.57 \pm 0.10 \pm 0.07$	$-0.73 \pm 0.17 \pm 0.07$
Δ_1^{BP}(rad)	This work		$3.0 \pm 2.4 \pm 1.0$	$4.1 \pm 1.1 \pm 0.6$	$0.8 \pm 1.2 \pm 0.2$
β_{BP}	This work		$0.06^{+0.58+0.05}_{-0.47-0.06}$	$-0.66^{+0.46+0.22}_{-0.25-0.02}$	$0.48^{+0.35+0.07}_{-0.57-0.13}$
γ_{BP}	This work		$-0.60^{+0.96+0.17}_{-0.05-0.03}$	$-0.48^{+0.45+0.21}_{-0.42-0.04}$	$0.49^{+0.35+0.07}_{-0.56-0.12}$

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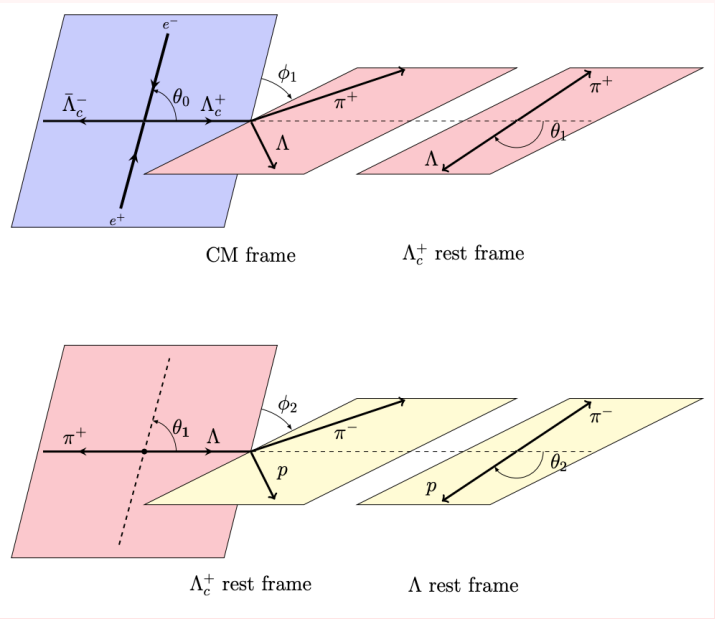
in terms of helicity angles

PRD100(2019)072004

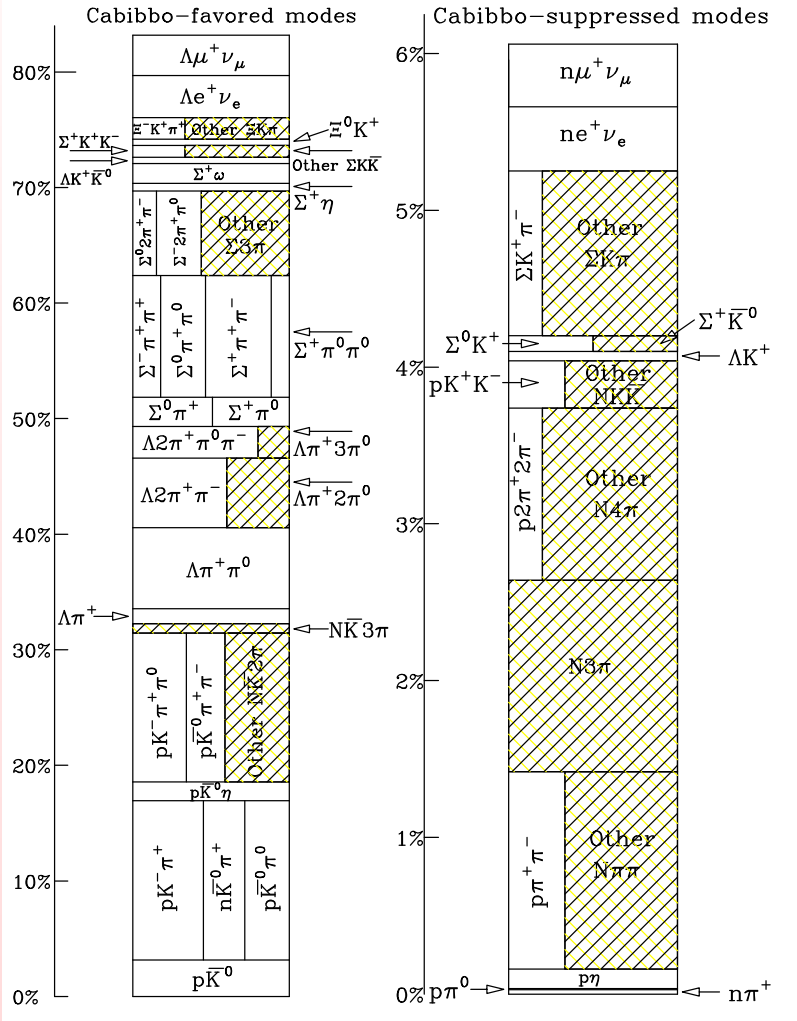


$\Lambda_c^+ \to$		pK^0_S	$\Lambda\pi^+$	$\Sigma^+\pi^0$	$\Sigma^0\pi^+$
$\alpha_{BP}^{\Lambda_c^+}$	PDG		-0.91 ± 0.15	-0.45 ± 0.32	
	This work	$0.18 \pm 0.43 \pm 0.14$	$-0.80 \pm 0.11 \pm 0.02$	$-0.57 \pm 0.10 \pm 0.07$	$-0.73 \pm 0.17 \pm 0.07$
Δ_1^{BP}(rad)	This work		$3.0 \pm 2.4 \pm 1.0$	$4.1 \pm 1.1 \pm 0.6$	$0.8 \pm 1.2 \pm 0.2$
β_{BP}	This work		$0.06^{+0.58+0.05}_{-0.47-0.06}$	$-0.66^{+0.46+0.22}_{-0.25-0.02}$	$0.48^{+0.35+0.07}_{-0.57-0.13}$
γ_{BP}	This work		$-0.60^{+0.96+0.17}_{-0.05-0.03}$	$-0.48^{+0.45+0.21}_{-0.42-0.04}$	$0.49^{+0.35+0.07}_{-0.56-0.12}$

Evidence for transverse polarization of Λ_c^+ at 2σ

Λ_c decays

- Figure from Gronau, Rosner, Wohl (PRD98(2018)073003)
- Area of white boxes correspond to measured BFs
- Shaded boxes expected by statistical isospin model (PRD97(2018)116015)
- In total, $\sim 90\% \pm 5\%$ of Λ_c decay width accounted for
- BESIII has recently collected a ~ 3 fb^{-1} data sample near $\Lambda_c^+\overline{\Lambda}_c^-$ threshold which will help understand and fill in the gap



Selected Summary of Recent Charmed Baryon Results

* Belle PRL122(2019)082001
  First measurements of Absolute Ξ_c BF's

$$\mathcal{B}\left(\Xi_c^0 \to \Xi^- \pi^+\right) = 1.80(50)(14)\%$$
$$\mathcal{B}\left(\Xi_c^0 \to \Lambda K^- \pi^+\right) = 1.17(37)(09)\%$$
$$\mathcal{B}\left(\Xi_c^0 \to p K^- K^+ \pi^+\right) = 1.80(50)(14)\%$$

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* BESIII CPC43(2019)083002
  $\Lambda_c^+ \to \Sigma^+ \eta^{(\prime)}$

$$\mathcal{B}\left(\Lambda_c^+ \to \Sigma^+ \eta\right) = (0.41 \pm 0.20)\,\%$$
$$\mathcal{B}\left(\Lambda_c^+ \to \Sigma^+ \eta'\right) = (1.34 \pm 0.57)\,\%$$

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* BESIII arXiv:2005.11211
  Submitted to EPJC
  $\Lambda_c^+ \to K_S^0 X$

$$\mathcal{B}\left(\Lambda_c^+ \to K_S^0 X\right) = (10.1 \pm 0.6 \pm 0.4)\,\%$$
Unobserved $B\left(\Lambda_c^+ \to \overline{K}^0/K^0 X\right) = (19.8 \pm 7.9)\,\%$

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* BESIII PRL121(2018)062003
  $\Lambda_c^+ \to \Lambda X$

$$\mathcal{B}\left(\Lambda_c^+ \to \Lambda X\right) = \left(38.2^{+2.8}_{-2.2} \pm 0.9\right)\,\%$$

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* BESIII PRL121(2018)251801
  $\Lambda_c^+ \to X e^+ \nu$

$$\mathcal{B}\left(\Lambda_c^+ \to X e^+ \nu\right) = (3.95 \pm 0.34 \pm 0.09)\,\%$$

Outline

Relevant Talks

Charm and Charmonium at Belle II
Roy Briere
Monday 4:45pm

Hadronic Charm Meson Decays at BESIII
Meng Wang
Wednesday 9:45am

Rare and Forbidden decays of the D^0 Meson
Gerald Eigen
Wednesday 9:30am

Measurement of hadronic inputs for gamma at BESIII
Yingrui Hou
Thursday 12:20pm

Summary

- New precision measurements of $|V_{cs}|$ and $|V_{cd}|$
  - $D^+ \to \tau^+\nu$ (First observation, 5.1σ)
  - $D \to K\mu^+\nu$
  - $D_s \to \mu^+\nu$
- Decay Constants/Form Factors:
  - 2σ consistency of f_{D_s}/f_D with LQCD
  - $f_+^{D\to P}(0)$ consistent with LQCD
  - First meas. of $D_s \to \eta(')$, $K^{0(*)}$ FFs
  - First meas. of $D^0 \to K^{(*)}$ FFs
- No evidence for LFUV in charm at 1.5% precision
- Interesting results related to weak contributions to meson decays
- New and improved measurements of parity violation in Λ_c^+ decays
- First evidence of transverse polarization of Λ_c^+ in $e^+e^- \to \Lambda_c^+\Lambda_c^-$

More results and data from BESIII and Belle II to come!