Hightlight of charm meson physics at BESIII

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For BESIII Collaboration

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Main goals of charm physics at BESIII

Decays of charmed mesons (D^0, D^+, D_s^+ and Λ_c^+) provide an ideal window to explore weak and strong effects

- **D (semi)leptonic decays**

  $f_{D(s)+}$, $f^{K(\pi)}_{+}(0)$: better calibrate LQCD

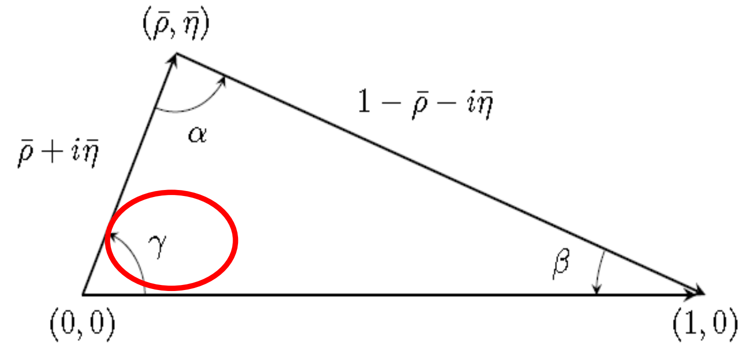
  $|V_{cs(d)}|$: better test on CKM unitarity

$$U = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & \boldsymbol{V_{cb}} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

- **D hadronic decays**

  $D^0\bar{D}^0$ mixing and CP violation

  Strong phase in D^0 decays: Constraint on γ/ϕ_3 measurement in B decays



- **Absolute BFs of Λ_c^+**

  No absolute BF measurements of Λ_c^+ ,**Before 2014**

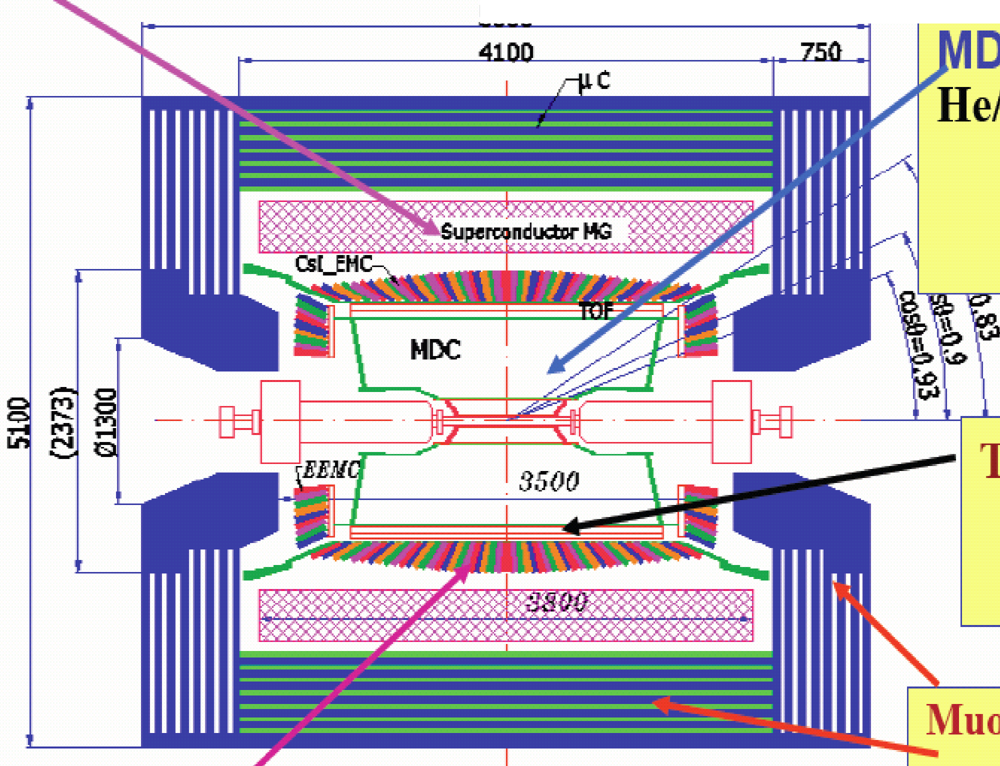
Contents

- $D_{(s)}^+ \rightarrow l^+ v$ ($l=\mu, \tau$)
- $D^{0(+)} \rightarrow K l^+ v$ and $\pi l^+ v$ ($l=e, \mu$)
- Hadronic decays of D
- Leptonic and hadronic decays of Λ_c^+
- Summary

BESIII detector

Nucl. Instr. Meth. A614, 345 (2010)

Magnet: 1 T Super conducting



MDC: small cell & Gas:
He/C_3H_8 (60/40), 43 layers
σ_{xy}=130 μm
σ_p/p = 0.5% @1GeV
dE/dx=6%

TOF:
σ_T = 100 ps Barrel
110 ps Endcap

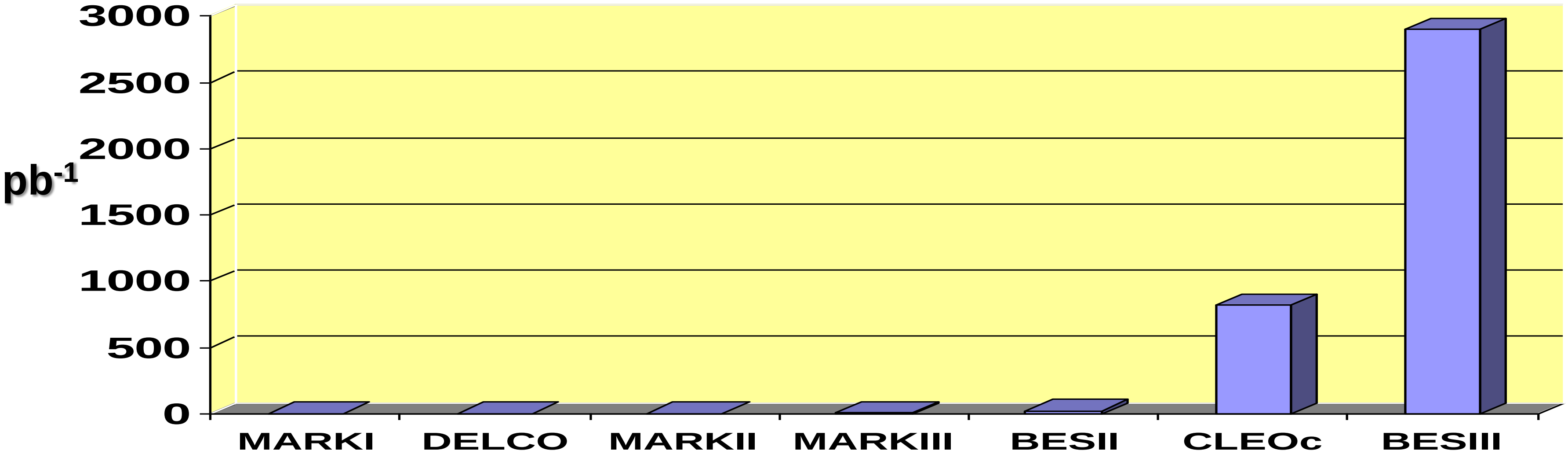
Muon ID: 9 layers RPC
8 layers for endcap

EMC: CsI crystal, 28 cm
ΔE/E = 2.5% @1 GeV
σz = 0.6 cm/√E

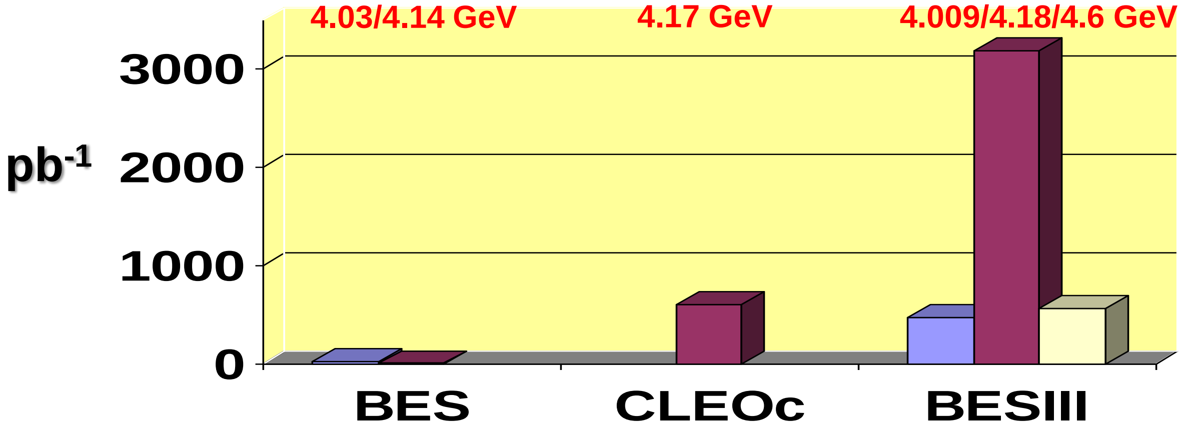
Data Acquisition:
Event rate = 4 kHz
Total data volume ~ 50 MB/s

$D^{0(+)}$, D_s^+, Λ_c^+ data set at BESIII

➢ $D^{0(+)}$ data set at 3.773 GeV



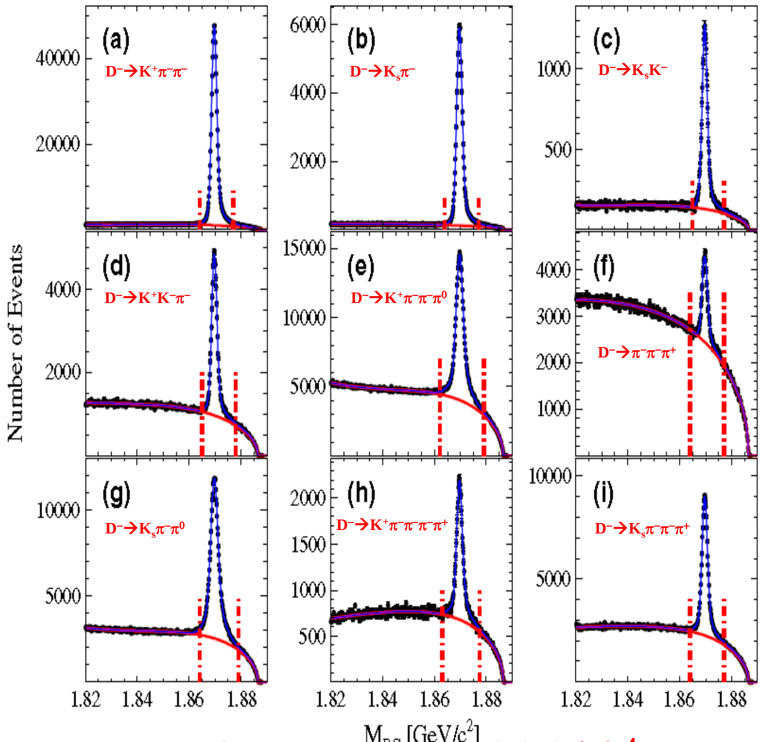
➢ D_s^+/Λ_c^+ data set at 4.009/4.18/4.6 GeV

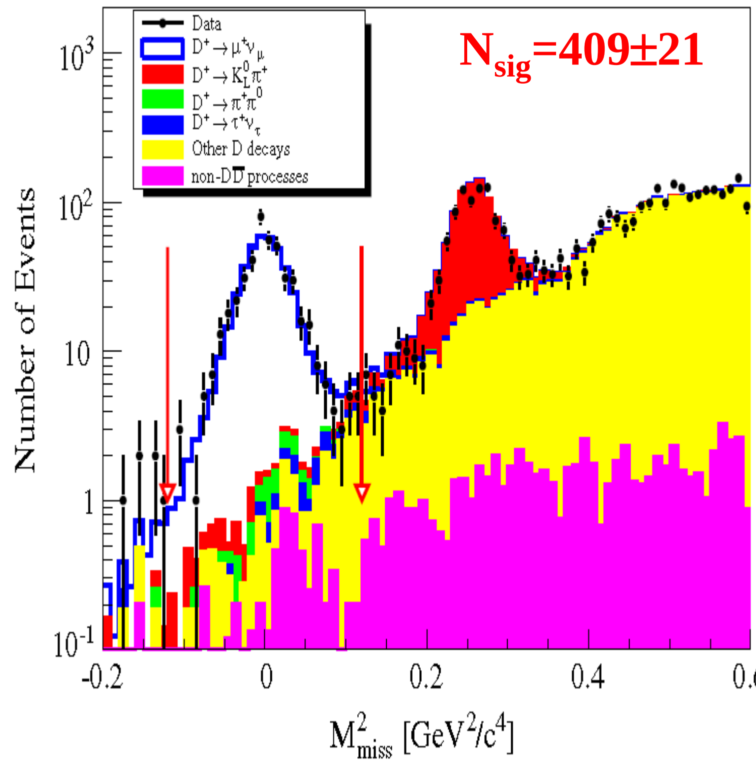


Improved $B[D^+ \rightarrow \mu^+ \nu]$, f_{D+} and $|V_{cd}|$

$e^+e^- \rightarrow \psi(3770) \rightarrow D^+D^-$

2.93 fb^{-1} data@ 3.773 GeV
PRD89(2014)051104R





$N_{tag}=(170.31\pm0.34)\times10^4$

$B[D^+ \rightarrow \mu^+\nu]=(3.71\pm0.19\pm0.06)\times10^{-4}$

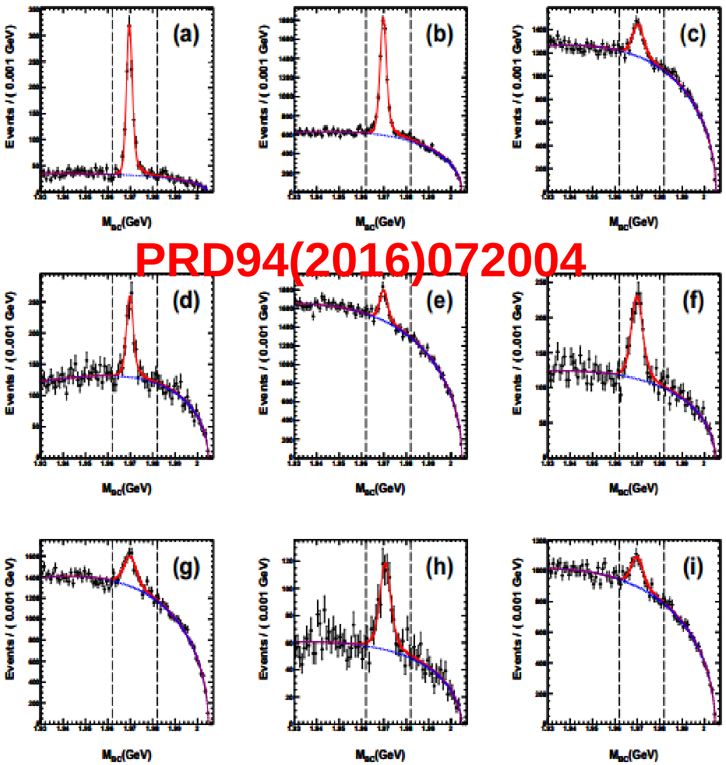
τ_{D+}, m_{D+}, $m_{\mu+}$ (PDG),
$|V_{cd}|$(CKM-Fitter)

$f_{D+}=(203.2\pm5.3\pm1.8)$ MeV

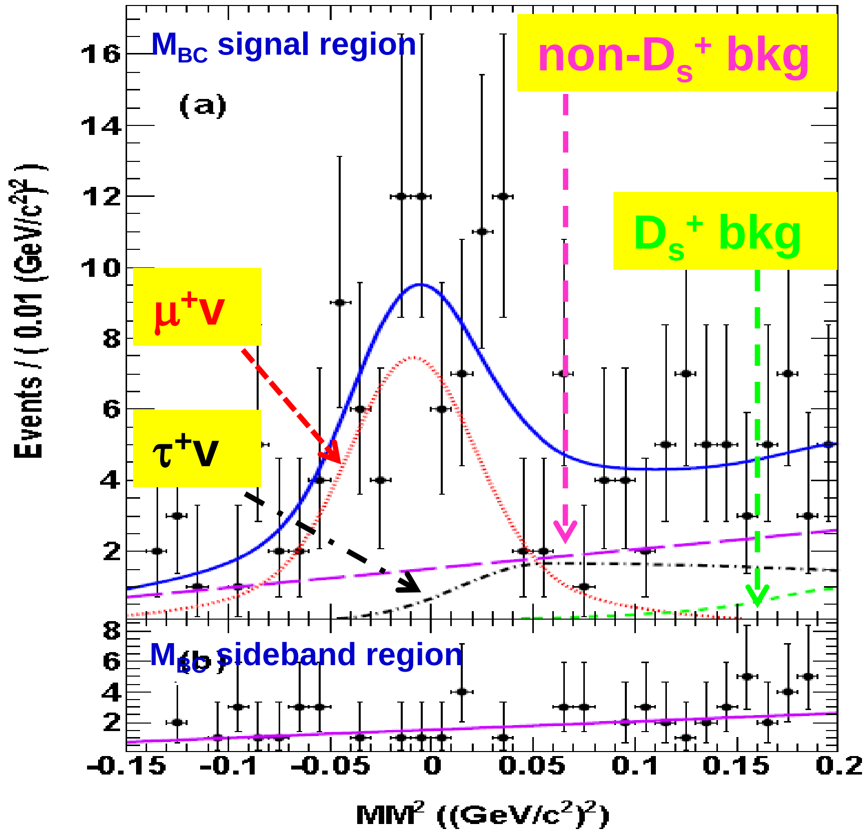
τ_{D+}, m_{D+}, $m_{\mu+}$ (PDG),
f_{D+}=207±4MeV(LQCD[PRL100 (2008)062002])

$|V_{cd}|=0.2210\pm0.0058\pm0.0047$

$f_{D_s^+}$ at 4.009 GeV



PRD94(2016)072004



N_{tag}=15127 ±312

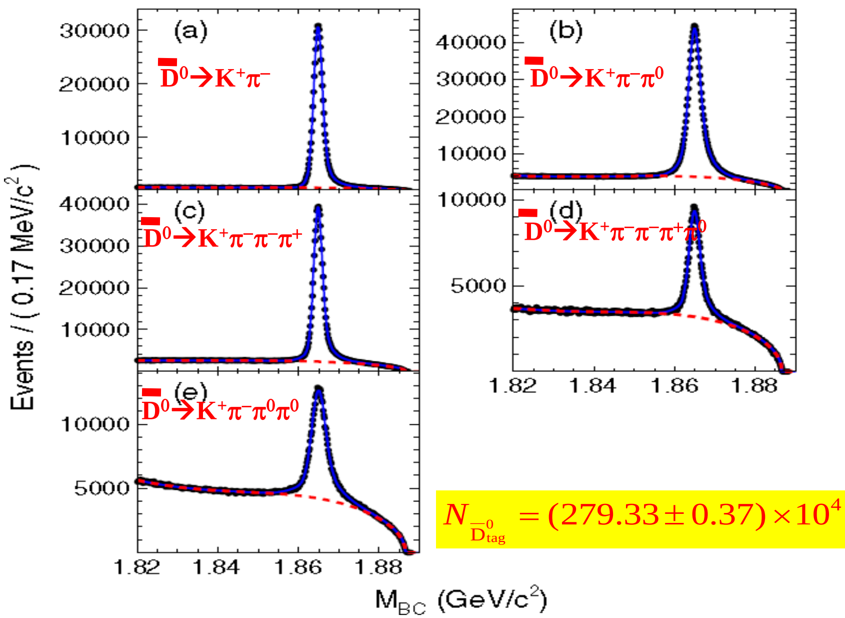
$f_{D_s^+}$=(241.0±16.3±6.6)MeV

$B[D_s^+ \rightarrow \mu^+\nu]$=(0.495±0.067±0.026)%

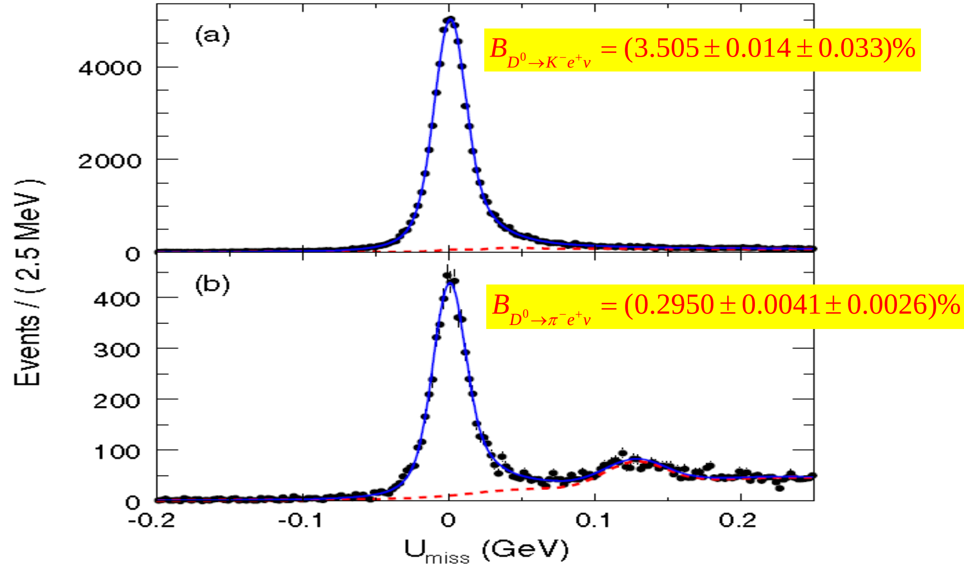
$B[D_s^+ \rightarrow \tau^+\nu]$=(4.83±0.65±0.26)%

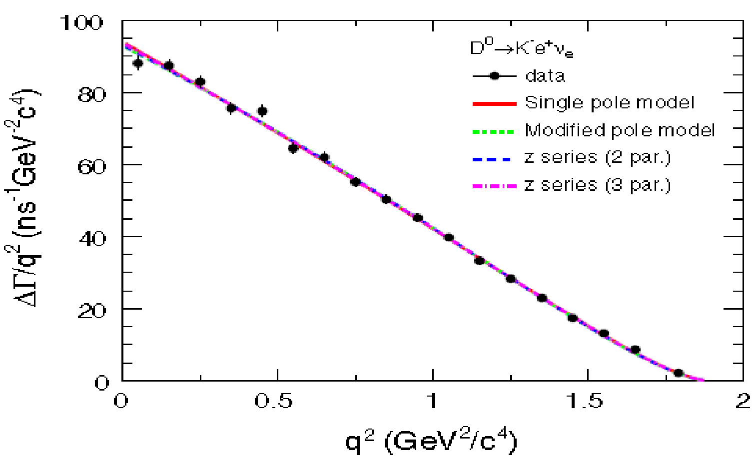
3fb^{-1} data@4.18GeV is in hand, more precise measurement will come soon!

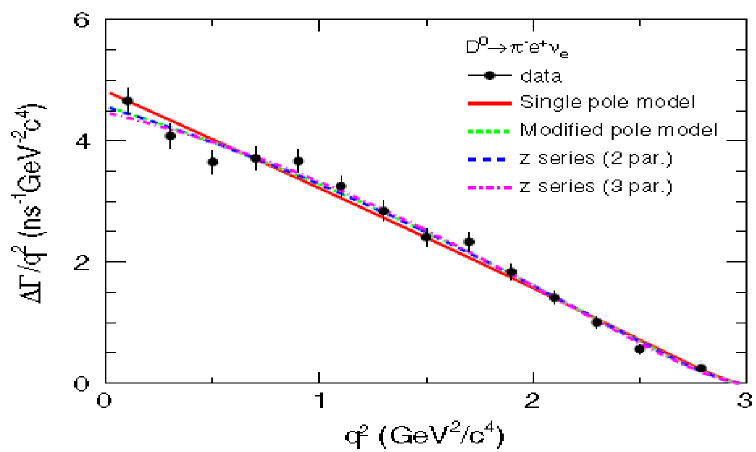
$D^0 \to K(\pi)^- e^+ \nu \ \to\ f_+^{D\to K(\pi)}(q^2)|V_{cs(d)}|$



PRD92(2015)072012

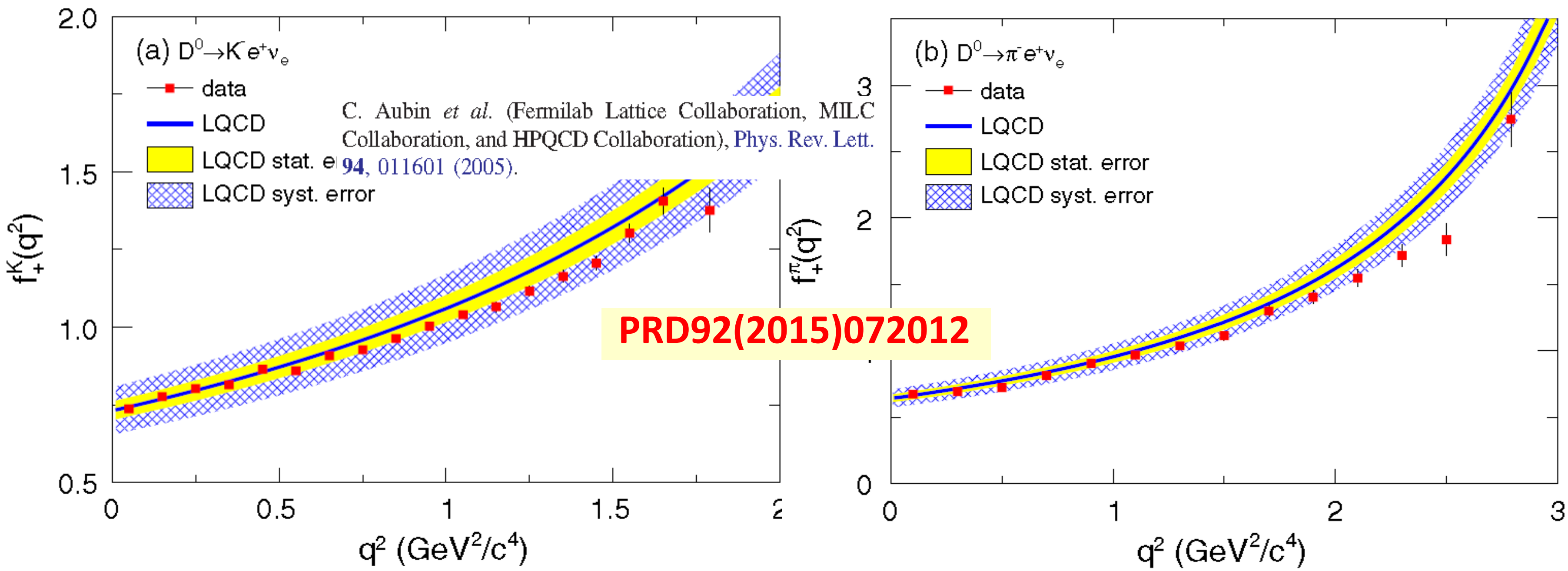






$B[D^0 \to K^- e^+ \nu]$ **$B[D^0 \to \pi^- e^+ \nu]$**

Calibration of LQCD

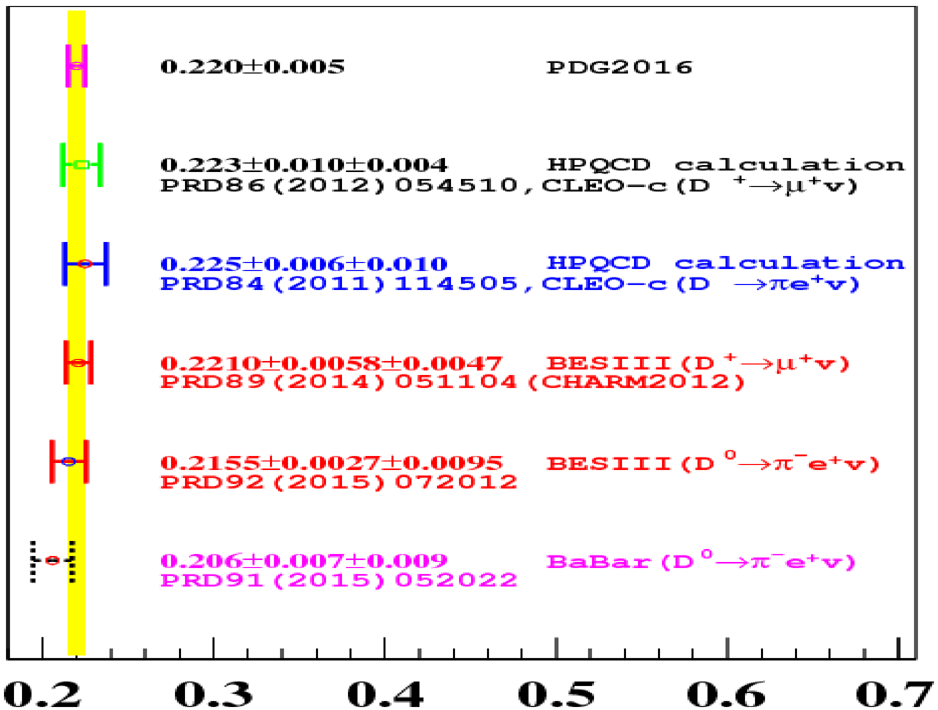


C. Aubin *et al.* (Fermilab Lattice Collaboration, MILC Collaboration, and HPQCD Collaboration), Phys. Rev. Lett. **94**, 011601 (2005).

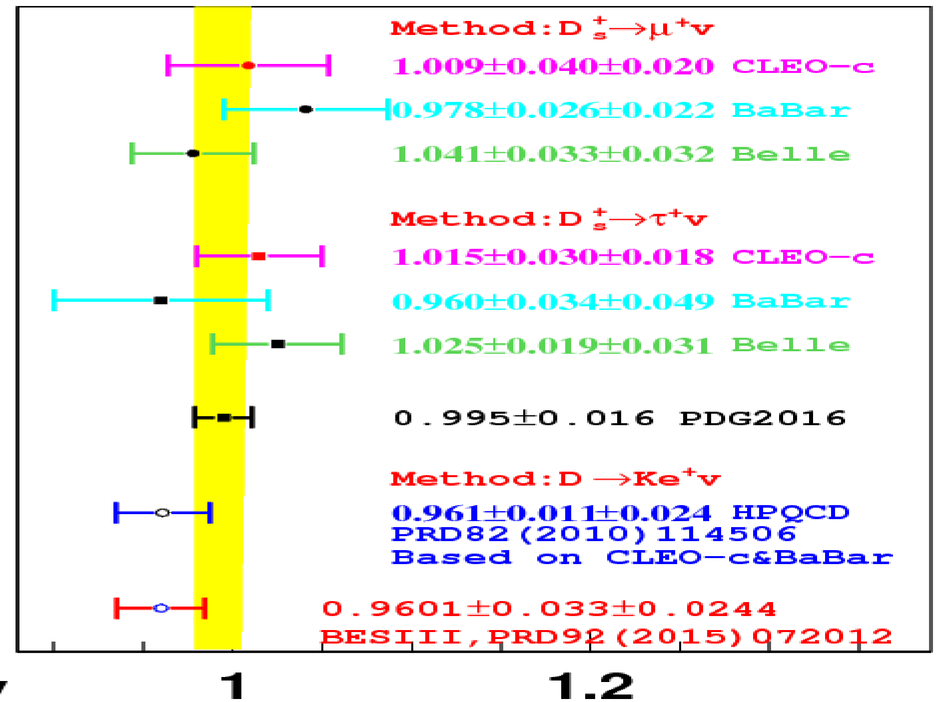
PRD92(2015)072012

		$D^0 \to K^- e^+ v$		$D^0 \to \pi^- e^+ v$
Simple Pole	$f_K^+(0)\|V_{cs}\|$	0.7209±0.0022±0.0033	$f_\pi^+(0)\|V_{cd}\|$	0.1475±0.0014±0.0005
	M_{pole}	1.9207±0.0103±0.0069	M_{pole}	1.9114±0.0118±0.0038
Mod. Pole	$f_K^+(0)\|V_{cs}\|$	0.7163±0.0024±0.0034	$f_\pi^+(0)\|V_{cd}\|$	0.1437±0.0017±0.0008
	α	0.3088±0.0195±0.0129	α	0.2794±0.0345±0.0113
Series.2.Par	$f_K^+(0)\|V_{cs}\|$	0.7172±0.0025±0.0035	$f_\pi^+(0)\|V_{cd}\|$	0.1435±0.0018±0.0009
	r_1	-2.2278±0.0864±0.0575	r_1	-2.0365±0.0807±0.0260
Series.3.Par	$f_K^+(0)\|V_{cs}\|$	0.7196±0.0035±0.0041	$f_\pi^+(0)\|V_{cd}\|$	0.1420±0.0024±0.0010
	r_1	-2.3331±0.1587±0.0804	r_1	-1.8434±0.2212±0.0690
	r_2	3.4223±3.9090±2.4092	r_2	-1.3871±1.4615±0.4677

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

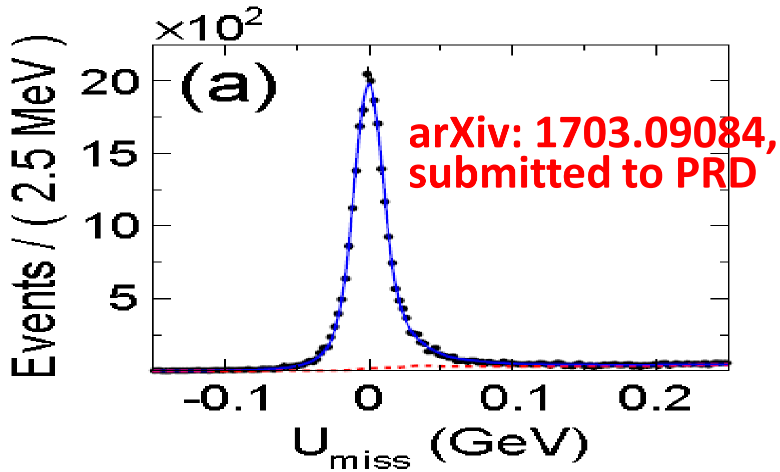


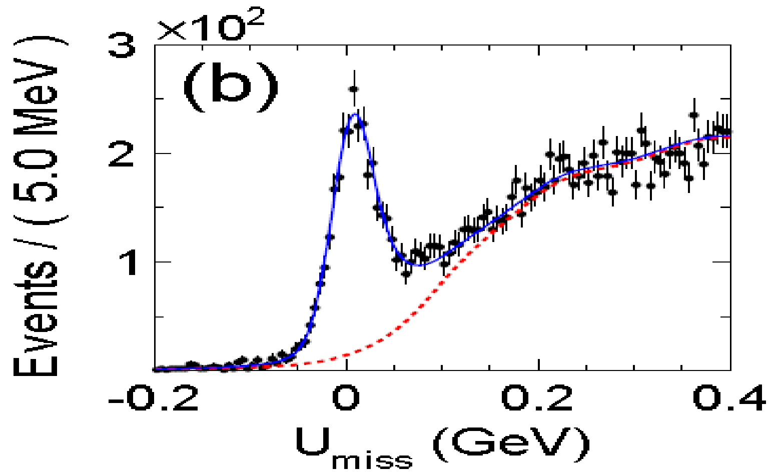
$|V_{cd}|$



$|V_{cs}|$

Analysis of $D^+ \to \bar{K}^0(\pi^0)\, e^+ \nu$



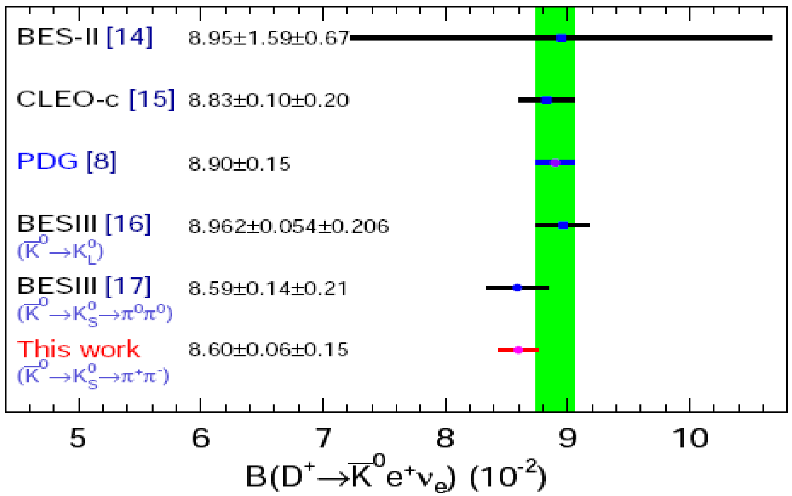


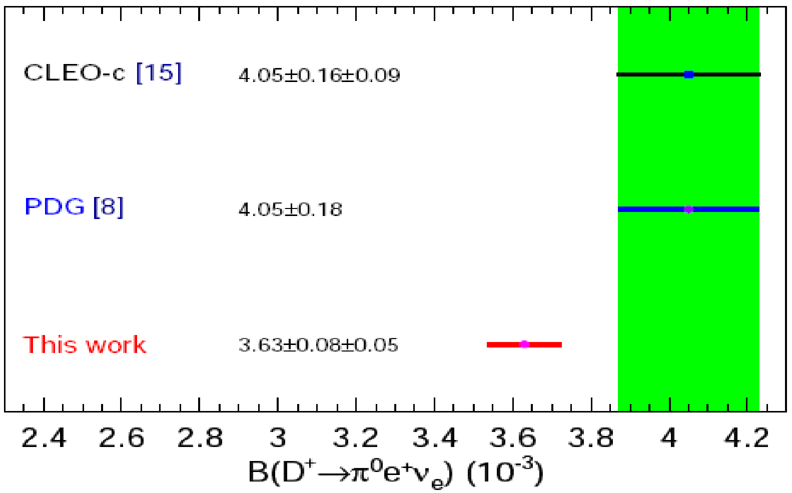
$$B[D^+ \to \overline{K}^0 e^+ \nu] = (8.604 \pm 0.056 \pm 0.151)\%$$

$$B[D^+ \to \pi^0 e^+ \nu] = (3.631 \pm 0.075 \pm 0.051) \times 10^{-3}$$

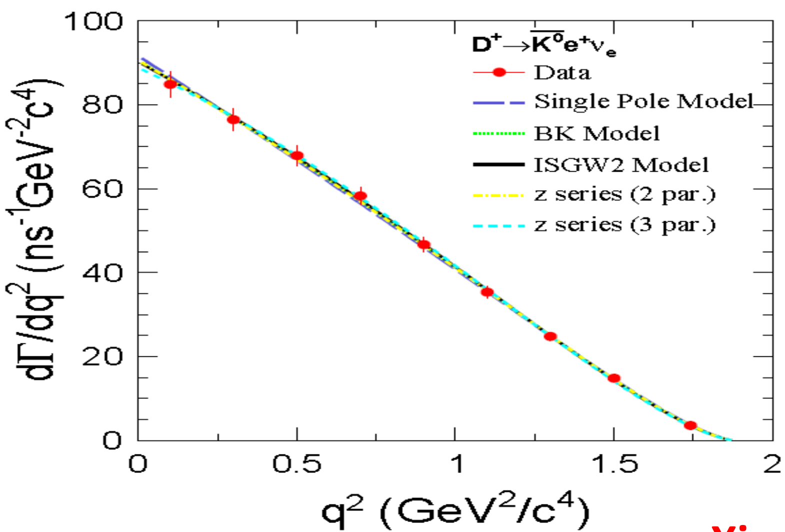
$$\frac{\Gamma[D^0 \to K^- e^+ \nu]}{\Gamma[D^+ \to \overline{K}^0 e^+ \nu]} = 1.03 \pm 0.01 \pm 0.02$$

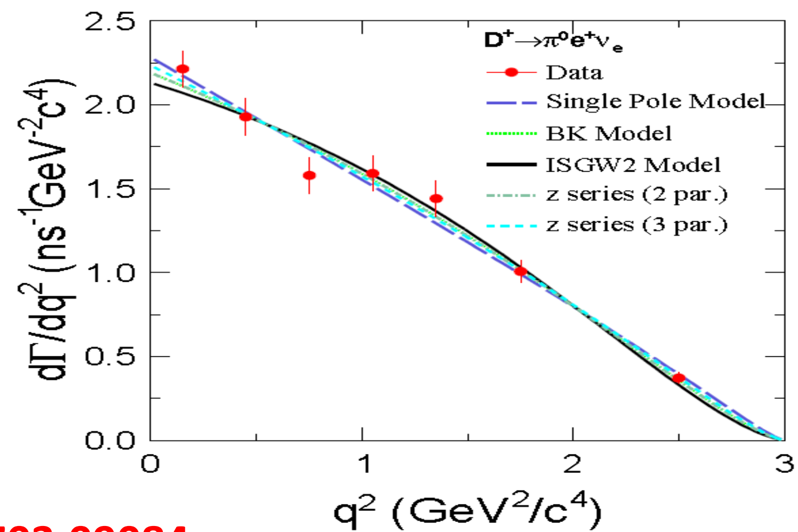
$$\frac{\Gamma[D^0 \to \pi^- e^+ \nu]}{2\Gamma[D^+ \to \pi^0 e^+ \nu]} = 1.03 \pm 0.03 \pm 0.02$$



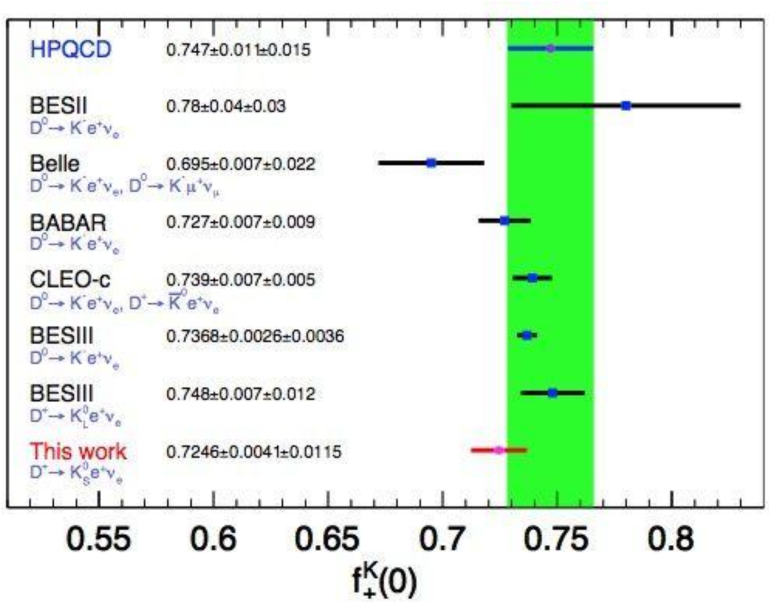


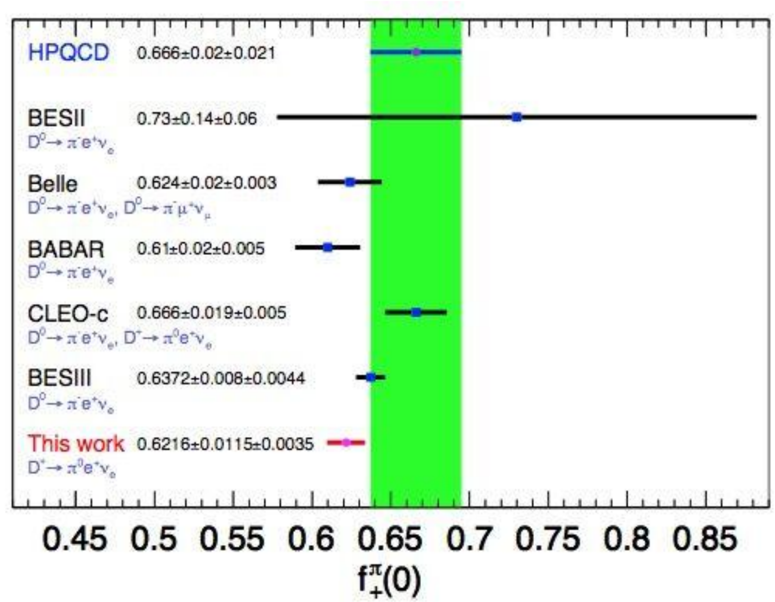
Comparisons of FFs by $D^+ \to \bar{K}^0(\pi^0)e^+\nu$





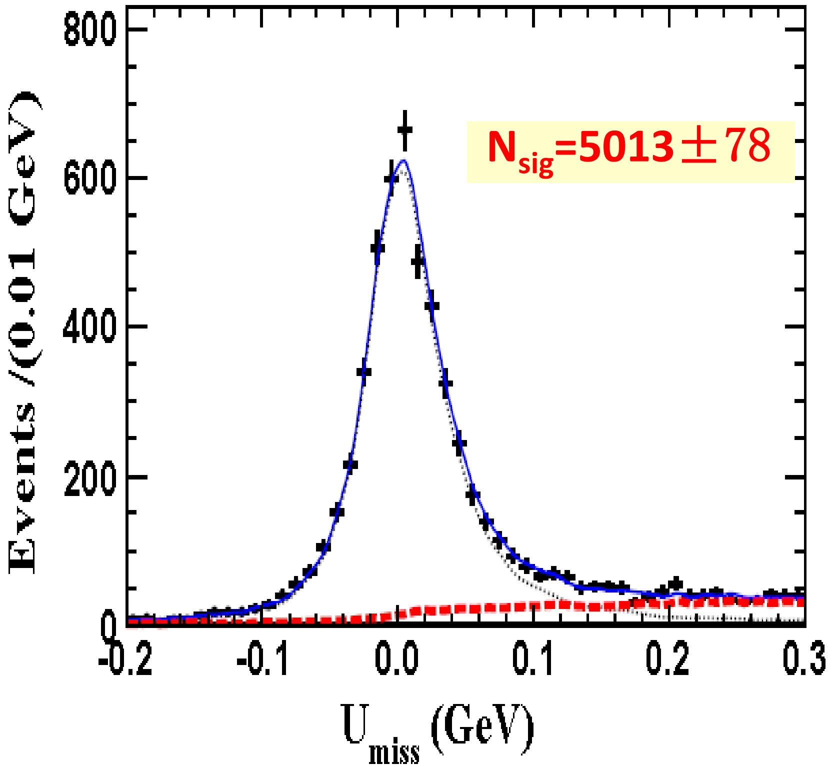
arXiv: 1703.09084, submitted to PRD



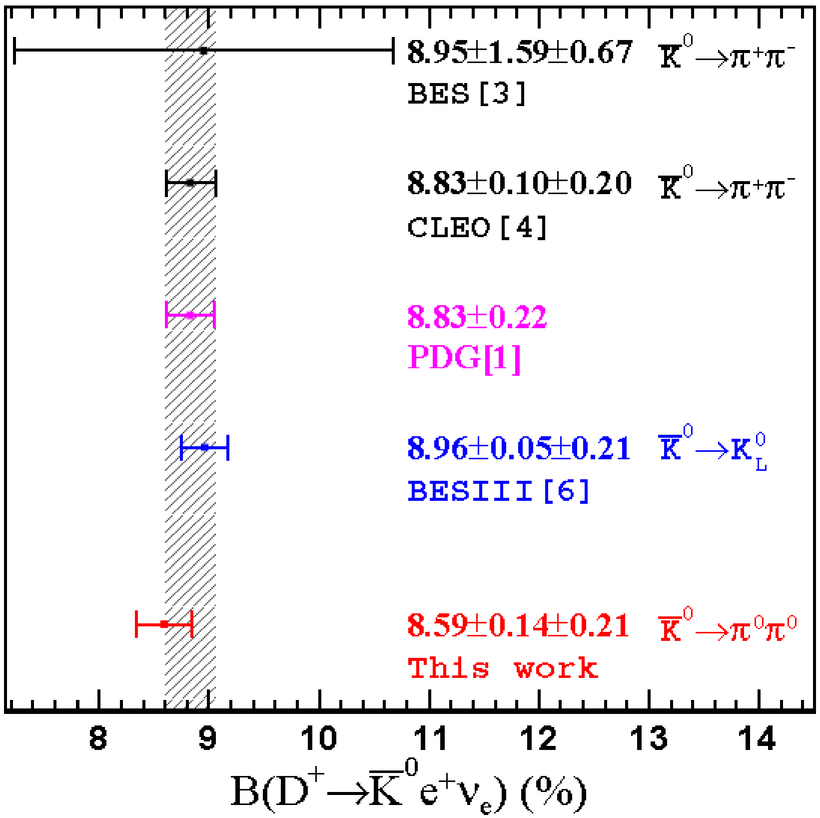


Absolute BF for $D^+ \to \bar{K}^0 e^+ \nu$ via $\bar{K}^0 \to \pi^0 \pi^0$

With 6 dominant D^- tag modes



CPC40(2016)113001



Input τ_{D+}, τ_{D0}, $B[D^0 \to K^- e^+ \nu]$ and $B[D^+ \to \bar{K}^0 e^+ \nu]$ (PDG)

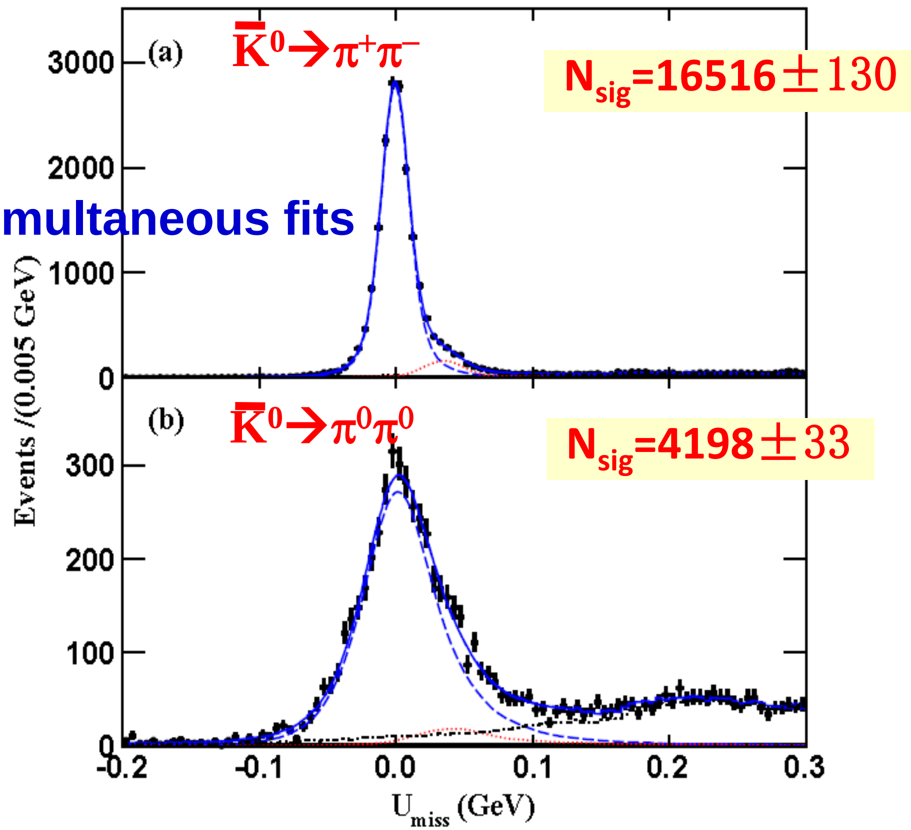
$$\frac{\Gamma[D^0 \to K^- e^+ v]}{\Gamma[D^+ \to \bar{K}^0 e^+ v]} = 0.969 \pm 0.025$$

Agrees with isospin conservation within 1.2σ

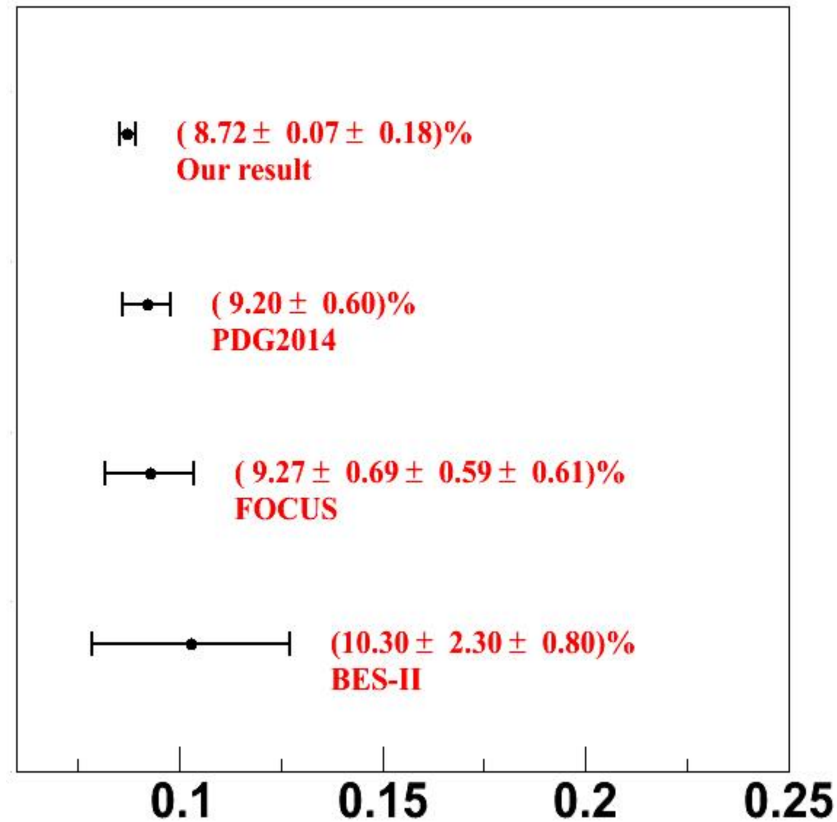
Improved BF for $D^+ \to \bar{K}^0 \mu^+ \nu$

With 6 dominant D^- tag modes

Simultaneous fits



EPJC76(2016)369



Input $B[D^0 \to K^-\mu^+\nu]$ and $B[D^+ \to \bar{K}^0 e^+\nu]$(PDG)

$$\frac{\Gamma[D^0 \to K^-\mu^+\nu]}{\Gamma[D^+ \to \bar{K}^0\mu^+\nu]} = 0.963 \pm 0.044$$

Support isospin conservation in these two decays within errors

$$\frac{\Gamma[D^+ \to \bar{K}^0\mu^+\nu]}{\Gamma[D^+ \to \bar{K}^0 e^+\nu]} = 0.988 \pm 0.033$$

Consistent with theory prediction 0.97 within error

Lepton universality in $D^{0(+)} \to \pi^{-(0)} l^+ \nu$

➢ Lepton universality (LU)

$$R_{\rm LU}^{0(+)} = \frac{B(D^{0(+)} \to \pi^{-(0)} \mu^+ \nu)}{B(D^{0(+)} \to \pi^{-(0)} e^+ \nu)} \sim 0.97$$

Expectations based on ZPC46 (1990)93, PRD69 (2004)074025, PLB633(2006)61 and PDG16

BFs on PDG16:

$$R_{\rm LU}^{0} = 0.82 \pm 0.08 \quad (\sim 2.0\sigma)$$

$B(D^0 \to \pi^- \mu^+ \nu) = (0.237 \pm 0.024)\%$

Large error in $B[D^0 \to \pi^- \mu^+ \nu]$ and lack of measurement in $B[D^+ \to \pi^0 \mu^+ \nu]$

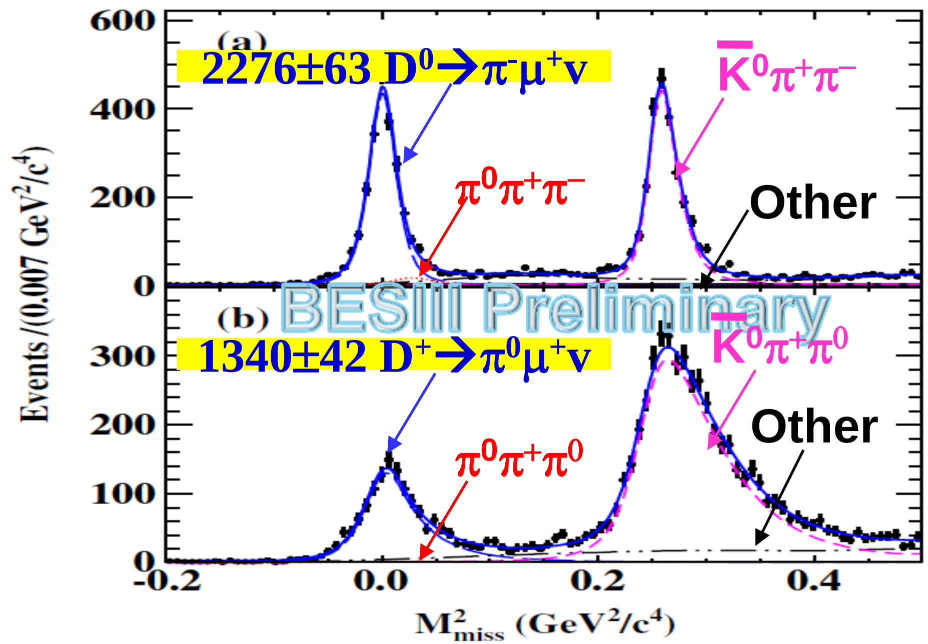
➢ Isospin symmetry (IS)

$$R_{\rm IS}^{\ell} = \frac{\Gamma(D^0 \to \pi^- \ell^+ \nu)}{2\Gamma(D^+ \to \pi^0 \ell^+ \nu)} \sim 1$$

PDG16: $R_{\rm IS}^{e} = 0.911 \pm 0.043 \quad (2.1\sigma)$

BESIII: $R_{\rm IS}^{e} = 1.03 \pm 0.03 \pm 0.02$

With 3(6) dominant $D^{0(-)}$ tag modes



Br: $B(D^0 \to \pi^- \mu^+ \nu) = (0.267 \pm 0.007 \pm 0.007)\%$

consistent with PDG in better precision

$B(D^+ \to \pi^0 \mu^+ \nu) = (0.342 \pm 0.011 \pm 0.010)\%$

First measurement

LU: $R_{\rm LU}^{0} = 0.918 \pm 0.036$ $\quad R_{\rm LU}^{+} = 0.921 \pm 0.045$

agree with expectation in 1.5(1.1) σ

IS: $R_{\rm IS}^{\mu} = 0.990 \pm 0.054$

agree with IS prediction within uncertainty

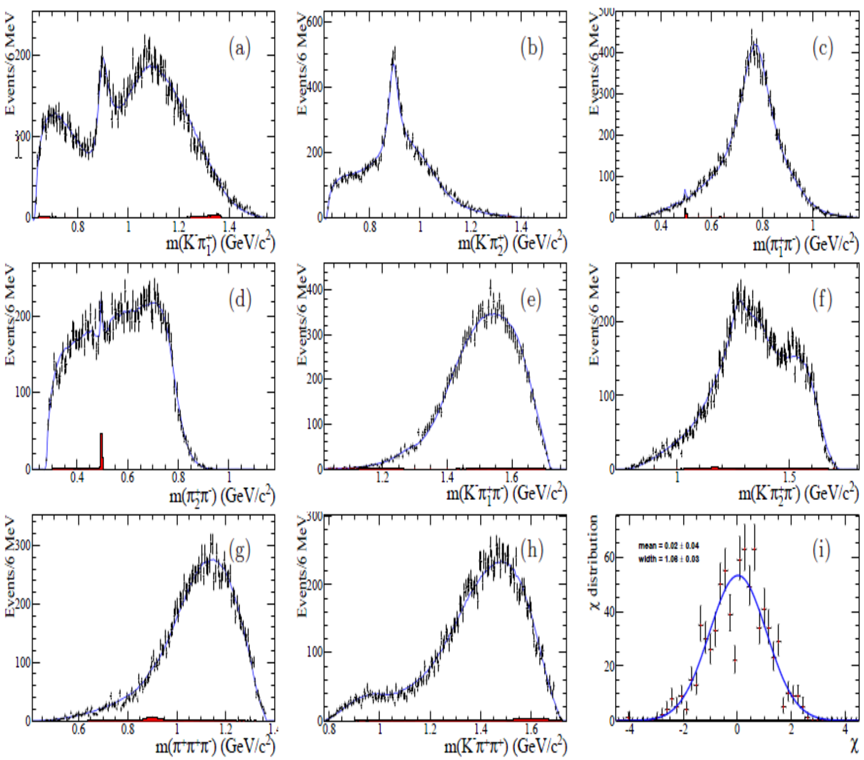
Amplitude analysis of $D^0 \to K^-\pi^+\pi^+\pi^-$

Understand strong phase, γ/ϕ_3 and CP violation

Phys.Rev.D 95, 072010(2017)

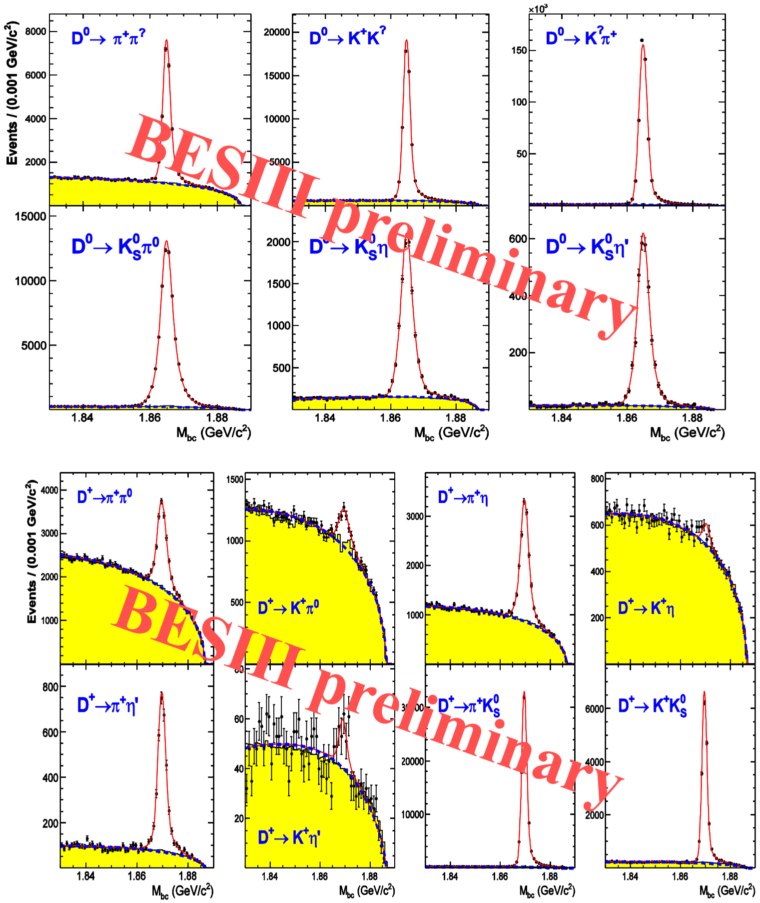
Improve the absolute BF

Other isospin conjugate decay $D \to K3\pi$ on going



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

Br measurements of some $D^{0(+)} \rightarrow PP$



Mode	N^{net}_{signal}	ε (%)	$\mathcal{B}\pm$(stat)$\pm$(sys)	$\mathcal{B}_{PDG}$
$\pi^+\pi^-$	21105 ± 249	66.03 ± 0.25	$(1.505 \pm 0.018 \pm 0.031) \times 10^{-3}$	$(1.421 \pm 0.025) \times 10^{-3}$
K^+K^-	56438 ± 273	62.82 ± 0.32	$(4.229 \pm 0.020 \pm 0.087) \times 10^{-3}$	$(4.01 \pm 0.07) \times 10^{-3}$
$K^-\pi^+$	537745 ± 767	64.98 ± 0.09	$(3.896 \pm 0.006 \pm 0.073)$ %	(3.93 ± 0.04) %
$K^0_S\pi^0$	66539 ± 302	38.06 ± 0.17	$(1.236 \pm 0.006 \pm 0.032)$ %	(1.20 ± 0.04) %
$K^0_S\eta$	9532 ± 126	31.96 ± 0.14	$(5.149 \pm 0.068 \pm 0.134) \times 10^{-3}$	$(4.85 \pm 0.30) \times 10^{-3}$
$K^0_S\eta'$	3007 ± 61	12.66 ± 0.08	$(9.562 \pm 0.197 \pm 0.379) \times 10^{-3}$	$(9.5 \pm 0.5) \times 10^{-3}$
$\pi^0\pi^+$	10108 ± 267	48.98 ± 0.34	$(1.259 \pm 0.033 \pm 0.025) \times 10^{-3}$	$(1.24 \pm 0.06) \times 10^{-3}$
π^0K^+	1834 ± 168	51.52 ± 0.42	$(2.171 \pm 0.198 \pm 0.060) \times 10^{-4}$	$(1.89 \pm 0.25) \times 10^{-4}$
$\eta\pi^+$	11636 ± 215	46.96 ± 0.25	$(3.790 \pm 0.070 \pm 0.075) \times 10^{-3}$	$(3.66 \pm 0.22) \times 10^{-3}$
ηK^+	439 ± 72	48.21 ± 0.31	$(1.393 \pm 0.228 \pm 0.124) \times 10^{-4}$	$(1.12 \pm 0.18) \times 10^{-4}$
$\eta'\pi^+$	3088 ± 83	21.49 ± 0.18	$(5.122 \pm 0.140 \pm 0.210) \times 10^{-3}$	$(4.84 \pm 0.31) \times 10^{-3}$
$\eta' K^+$	87 ± 25	22.39 ± 0.22	$(1.377 \pm 0.428 \pm 0.202) \times 10^{-4}$	$(1.83 \pm 0.23) \times 10^{-4}$
$K^0_S\pi^+$	93884 ± 352	51.38 ± 0.18	$(1.591 \pm 0.006 \pm 0.033) \times 10^{-2}$	$(1.53 \pm 0.06) \times 10^{-2}$
$K^0_S K^+$	17704 ± 151	48.45 ± 0.14	$(3.183 \pm 0.028 \pm 0.065) \times 10^{-3}$	$(2.95 \pm 0.15) \times 10^{-3}$

$$\mathcal{B} = \frac{N^{signal}_{net}}{2 \cdot N_{D^0\bar{D}^0(D^+D^-)} \cdot \varepsilon}, N_{D^0\bar{D}^0} = (10{,}621 \pm 29_{(stat)}) \times 10^3, N_{D^+D^-} = (8{,}296 \pm 31_{(stat)}) \times 10^3$$

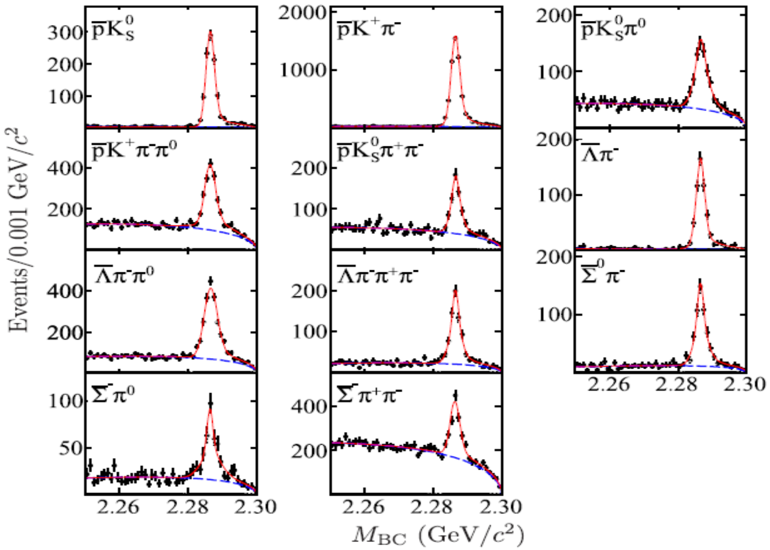
quoted from Derrick's talk given at APS2014

The $\mathcal{B}(D^0 \to K^-\pi^+)$ has been corrected by the PDG value of $\mathcal{B}(D^0 \to K^+\pi^-)$.

For $D^0 \to K^0_S\eta$, $D^+ \to \pi^0\pi^+$, $D^+ \to \eta\pi^+$, $D^+ \to \eta'\pi^+$, $D^+ \to K^0_S\pi^+$ and $D^+ \to K^0_S K^+$, it shows better precision than the present values.

The statistical uncertainties are much smaller than PDG value.

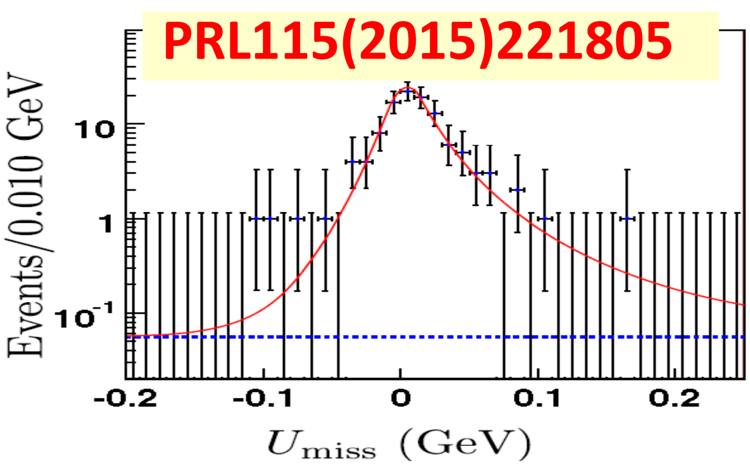
First absolute BFs of $\Lambda_c^+ \rightarrow \Lambda l^+ \nu$

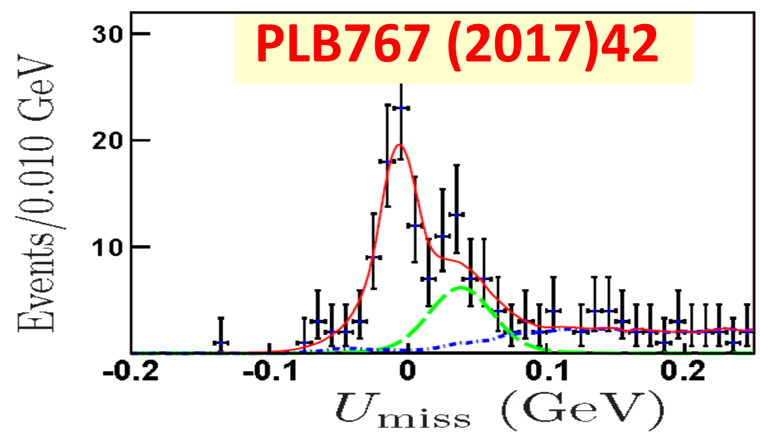


Theory: (1.4-9.2)%

Theoretical Models	predicated branching fraction for $\Lambda_c^+ \rightarrow \Lambda e^+ \nu_e$
MBM [1]	1.9%
NRQM [1]	2.6%
SU(4)-symmetry limit [2]	9.2%
RSQM [3]	4.4%
QCM [4]	5.62%
SQM [5]	1.96%
NRQM2 [6]	2.15%
NRQM3 [7]	1.42%
QCD SR1 [8]	(3.0 ± 0.9)%
QCD SR2 [9]	(2.6 ± 0.4)%
QCD SR3 [9]	(5.8 ± 1.5)%
STSR [10]	2.22% for $\Lambda_c^+ \rightarrow \Lambda l^+ \nu_l$
STNR [10]	1.58% for $\Lambda_c^+ \rightarrow \Lambda l^+ \nu_l$
HOSR [10]	4.72% for $\Lambda_c^+ \rightarrow \Lambda l^+ \nu_l$
HONR [10]	4.2% for $\Lambda_c^+ \rightarrow \Lambda l^+ \nu_l$
LCSRs [11]	(3.0 ± 0.3)% for $\Lambda_c^+ \rightarrow \Lambda l^+ \nu_l$ (CZ-type)
PDG 2014 [14]	(2.1 ± 0.6)%
BESIII	$(3.63 \pm 0.38 \pm 0.20)$%

3 fb^{-1} help to explore FF studies





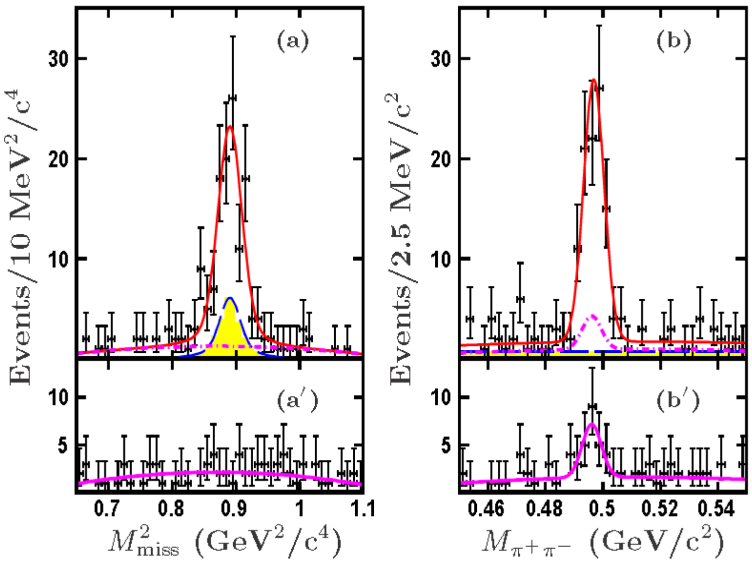
$B[\Lambda_c^+ \rightarrow \Lambda e^+ \nu] = (3.63 \pm 0.38 \pm 0.20)\%$

$B[\Lambda_c^+ \rightarrow \Lambda \mu^+ \nu_\mu] = (3.49 \pm 0.46 \pm 0.26)\%$

$\Gamma[\Lambda_c^+ \rightarrow \Lambda \mu^+ \nu_\mu] / \Gamma[\Lambda_c^+ \rightarrow \Lambda e^+ \nu_e] = 0.96 \pm 0.16 \pm 0.04$

Observation of $\Lambda_c^+ \rightarrow nK_S\pi^+$

PRL118(2017)112001



$B[\Lambda_c^+ \rightarrow nK_S\pi^+]=(1.82\pm0.23\pm0.11)\%$

$\Gamma[\Lambda_c^+ \rightarrow n\bar{K}^0\pi^+]/\Gamma[\Lambda_c^+ \rightarrow pK^-\pi^+]=0.62\pm0.09$

$\Gamma[\Lambda_c^+ \rightarrow n\bar{K}^0\pi^+]/\Gamma[\Lambda_c^+ \rightarrow p\bar{K}^0\pi^+]=0.97\pm0.16$

First measurement of BF of Λ_c^+ decay containing neutron

$$\cos\delta = -0.24 \pm 0.08$$

$$|I^{(1)}|/|I^{(0)}| \quad 1.14 \pm 0.11$$

Cai-Dian Lv et al, PRD93(2016)056008 **Understand SU(3) and isospin symmetry; determine strong phase.**

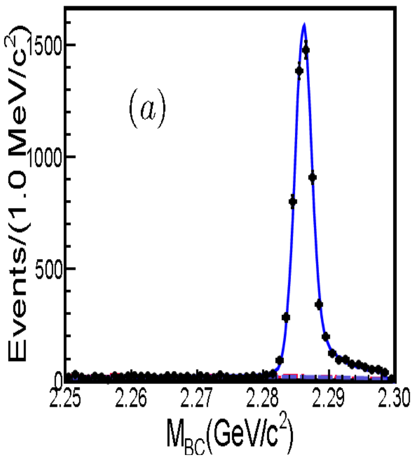
$$\cos\delta = \frac{\mathcal{B}(n\bar{K}^0\pi^+) - \mathcal{B}(pK^-\pi^+)}{2\sqrt{\mathcal{B}(p\bar{K}^0\pi^0)(\mathcal{B}(pK^-\pi^+) + \mathcal{B}(n\bar{K}^0\pi^+) - \mathcal{B}(p\bar{K}^0\pi^0))}}$$

$$R_p = \frac{\mathcal{B}(\Lambda_c \rightarrow p\bar{K}^0\pi^0)}{\mathcal{B}(\Lambda_c \rightarrow pK^-\pi^+)}, \qquad R_n = \frac{\mathcal{B}(\Lambda_c \rightarrow n\bar{K}^0\pi^+)}{\mathcal{B}(\Lambda_c \rightarrow pK^-\pi^+)}$$

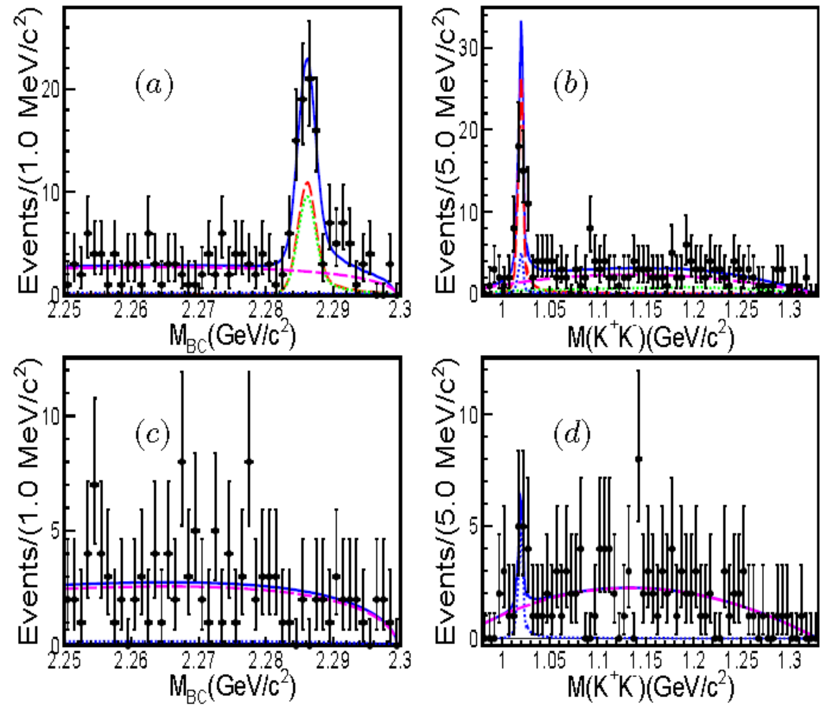
SCS decays $\Lambda_c^+ \rightarrow pK^+K^-$ and $p\pi^+\pi^-$

PRL117(2016)232002

$\Lambda_c^+ \rightarrow pK^-\pi^+$ $\Lambda_c^+ \rightarrow p\pi^-\pi^+$



$\Lambda_c^+ \rightarrow pK^-K^+$



Distinguish predictions from different theoretical models and understand contributions from factored effects.

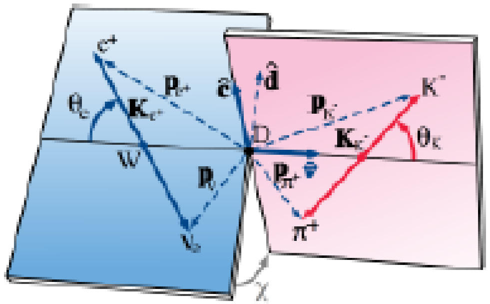
Decay modes	$\mathcal{B}_{\rm mode}/\mathcal{B}_{\rm ref.}$	$\mathcal{B}_{\rm mode}$	$\mathcal{B}$(PDG)
$\Lambda_c^+ \to p\pi^+\pi^-$	$(6.70 \pm 0.48 \pm 0.25) \times 10^{-2}$	$(3.91 \pm 0.28 \pm 0.15 \pm 0.24) \times 10^{-3}$	$(3.5 \pm 2.0) \times 10^{-3}$
$\Lambda_c^+ \to p\phi$	$(1.81 \pm 0.33 \pm 0.13) \times 10^{-2}$	$(1.06 \pm 0.19 \pm 0.08 \pm 0.06) \times 10^{-3}$	$(8.2 \pm 2.7) \times 10^{-4}$
$\Lambda_c^+ \to pK^+K^-$ (non-ϕ)	$(9.36 \pm 2.22 \pm 0.71) \times 10^{-3}$	$(5.47 \pm 1.30 \pm 0.41 \pm 0.33) \times 10^{-4}$	$(3.5 \pm 1.7) \times 10^{-4}$

Summary

- With 2.93, 0.482, 0.567 fb^{-1} data taken at 3.773, 4.009 and 4.6 GeV, BESIII have studied $D_{(s)}^+ \to l^+ v$ and $D^0 \to K(\pi)^- l^+ v$, measurements of D hadronic decays and absolute Λ_c^+ BFs using near threshold data;
- Improved measurements of decay constant f_{D+} and form factor $f_+^{D \to K(\pi)}(q^2)$ are important to test and calibrate LQCD calculations;
- Improved measurements of CKM matrix element $|V_{cs(d)}|$, which are important to test the CKM matrix unitarity;
- Better understanding of D hadronic decays is helpful in strong phase, γ/ϕ_3,CP violation.
- More results with better precision are expected in future;
- About 3 fb^{-1} data at 4.18 GeV was accumulated in 2016, the measurements of f_{Ds+} and $|V_{cs}|$ by $D_s^+ \to l^+ v$, the first FF studies of $D_s^+ \to \eta^{(')} e^+ v$, D_s hadronic decays for golden modes… can be expected in the near future.

Thank you!

Study of D→Ve⁺ν



- $m^2 = (p_{\pi^+} + p_{K^-})^2$
- $\cos(\theta_K) = \frac{\hat{\nu}\cdot \boldsymbol{K}_{K^-}}{|\boldsymbol{K}_{K^-}|}$
- $\cos(\chi) = \hat{\boldsymbol{c}} \cdot \hat{\boldsymbol{d}}$
- $q^2 = (p_{e^+} + p_{\nu_e})^2$
- $\cos(\theta_e) = -\frac{\hat{\nu}\cdot \boldsymbol{K}_{e^+}}{|\boldsymbol{K}_{e^+}|}$
- $\sin(\chi) = (\hat{\boldsymbol{c}} \times \hat{\boldsymbol{\nu}}) \cdot \hat{\boldsymbol{d}}$

Decay rate depend on 5 variables and 3 form factors

$$d^5\Gamma = \frac{G_F^2|V_{cs}|^2}{(4\pi)^6 m_D^2} X\beta\mathcal{I}(m^2, q^2, \theta_K, \theta_e, \chi)\, dm^2\, dq^2\, d\cos(\theta_K)\, d\cos(\theta_e)\, d\chi$$

- $X = p_{K\pi} m_D$, $p_{K\pi}$ is the momentum of the $K\pi$ system in the D rest frame
- $\beta = 2p^*/m$, p^* is the breakup momentum of the $K\pi$ system in its rest frame
- $\mathcal{I}$ can be expressed in terms of helicity amplitudes $H_{0,\pm}$:

  $H_0(q^2) = \frac{1}{2m_q}\left[(m_D^2 - m^2 - q^2)(m_D + m)A_1(q^2) - 4\frac{m_D^2 p_{K\pi}^2}{m_D + m}A_2(q^2)\right]$

  $H_\pm(q^2) = (m_D + m)A_1(q^2) \mp \frac{2m_D p_{K\pi}}{m_D + m}V(q^2)$

- Vector form factor: $V(q^2) = \frac{V(0)}{1 - q^2/m_V^2}$; or: FF ratio $r_V = V(0)/A_1(0)$
- Axial-vector form factor: $A_1(q^2) = \frac{A_1(0)}{1 - q^2/m_A^2}$, $A_2(q^2) = \frac{A_2(0)}{1 - q^2/m_A^2}$; or: FF ratio $r_2 = A_2(0)/A_1(0)$

PWA analysis of $D^+ \to K^-\pi^+e^+\nu$

PRD94(2016)032001

- **Fractions with >5σ significance**

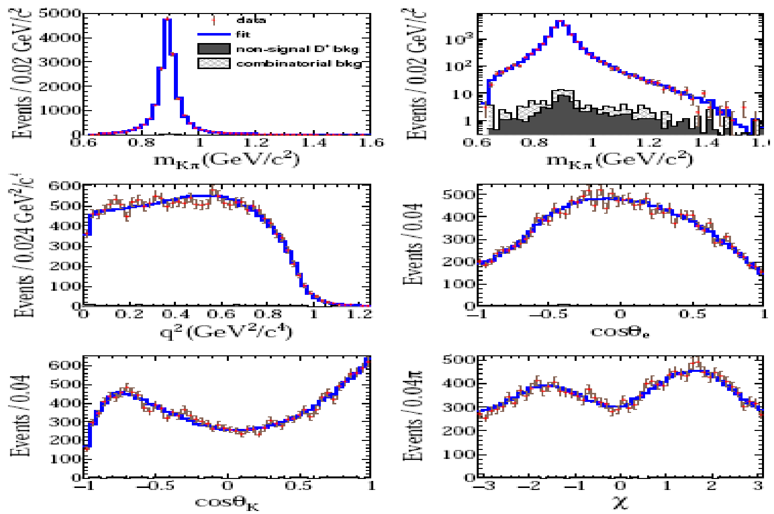
$$f(D^+ \to (K^-\pi^+)_{K^{*0}(892)}\, e^+\nu_e) = (93.93 \pm 0.22 \pm 0.18)\%$$

$$f(D^+ \to (K^-\pi^+)_{S-wave}\, e^+\nu_e) = (6.05 \pm 0.22 \pm 0.18)\%$$

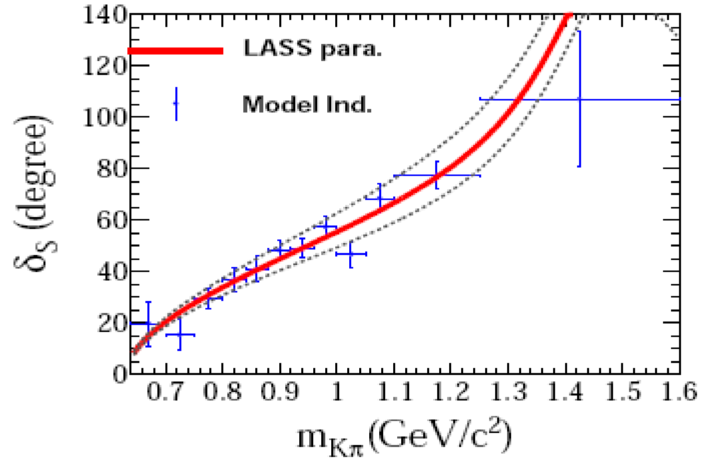
- **Properties of different Kπ (non-) resonant amplitudes**

$$m_{K^{*0}(892)} = (894.60 \pm 0.25 \pm 0.08)\ \mathrm{MeV}/c^2$$
$$\Gamma_{K^{*0}(892)} = (46.42 \pm 0.56 \pm 0.15)\ \mathrm{MeV}/c^2$$
$$r_{BW} = (3.07 \pm 0.26 \pm 0.11)\ (\mathrm{GeV}/c)^{-1}$$

- **q^2 dependent form factors in $D^+ \to \overline{K}^{*0}(892)e^+\nu$**



Model independent S-wave phase measurement



$$V(q^2) = \frac{V(0)}{1-q^2/m_V^2}, \quad A_{1,2}(q^2) = \frac{A_{1,2}(0)}{1-q^2/m_A^2}$$

$M_{V/A}$ is expected to $M_{D^*(1-/+)}$

$$m_V = (1.81^{+0.25}_{-0.17} \pm 0.02)\ \mathrm{GeV}/c^2$$
$$m_A = (2.61^{+0.22}_{-0.17} \pm 0.03)\ \mathrm{GeV}/c^2$$
$$A_1(0) = 0.573 \pm 0.011 \pm 0.020$$
$$r_V = V(0)/A_1(0) = 1.411 \pm 0.058 \pm 0.007$$
$$r_2 = A_2(0)/A_1(0) = 0.788 \pm 0.042 \pm 0.008$$

Model independent form factors

Prospects on $f_{D(s)+}$, $f^{K(\pi)}_{+}(0)$, $|V_{cs(d)}|$ and Λ_c^+

- Precision of the LQCD calculations of f_{D+}, f_{Ds+}, $f_{D+}:f_{Ds}$ is 0.5%, 0.5% and 0.3%. Measurements of $f_{D(s)+}$ and $|V_{cs(d)}|$ by $D_{(s)}^+ \to l^+ v$ are still statistics limited. More 10 fb^{-1} data near 3.773/4.18 GeV will help to improve precision to 1% level

- Measurements of $|V_{cs(d)}|$ by $D \to K(\pi)e^+v$ is restricted by precision of LQCD calcualtion 2.4(4.4)%. Improved theoretical calculation will be very helpful

- Measurement of $f^{\pi}_{+}(0)$ by $D \to \pi e^+ v$ decay is still statistics limited. More 10 fb^{-1} data at 3.773 GeV can improve precision to 1% level

- In addition, with more 3 fb^{-1} data in 4.6-4.65 GeV will help to improve $B[\Lambda_c^+ \to pK^-\pi^+]$ to about 2% level and further explore FF in $\Lambda_c^+ \to \Lambda l^+ v$ decays