# Charm physics at BESIII


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For BESIII Collaboration


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# Main goals of charm physics at BESIII

**Leptonic and semileptonic decays of charmed mesons ($D^0$, $D^+$ and $D_s^+$ ) provide an ideal window to explore weak and strong effects**

- **D leptonic and semileptonic decays**

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

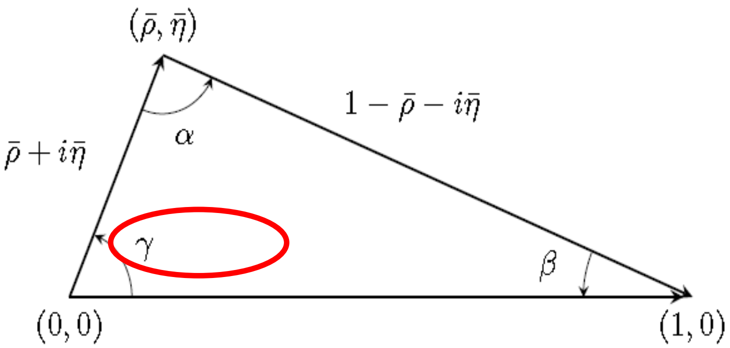
  **$|V_{cs(d)}|$: better test on CKM unitarity**

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

- **D hadronic decays**

  **$D^0\bar{D}^0$ mixing parameters and CP voilation**

  **Strong phase in $D^0$ decays: Constraint on $\gamma/\phi_3$ measurement in B decays**




- **Rare D decays → New physics**

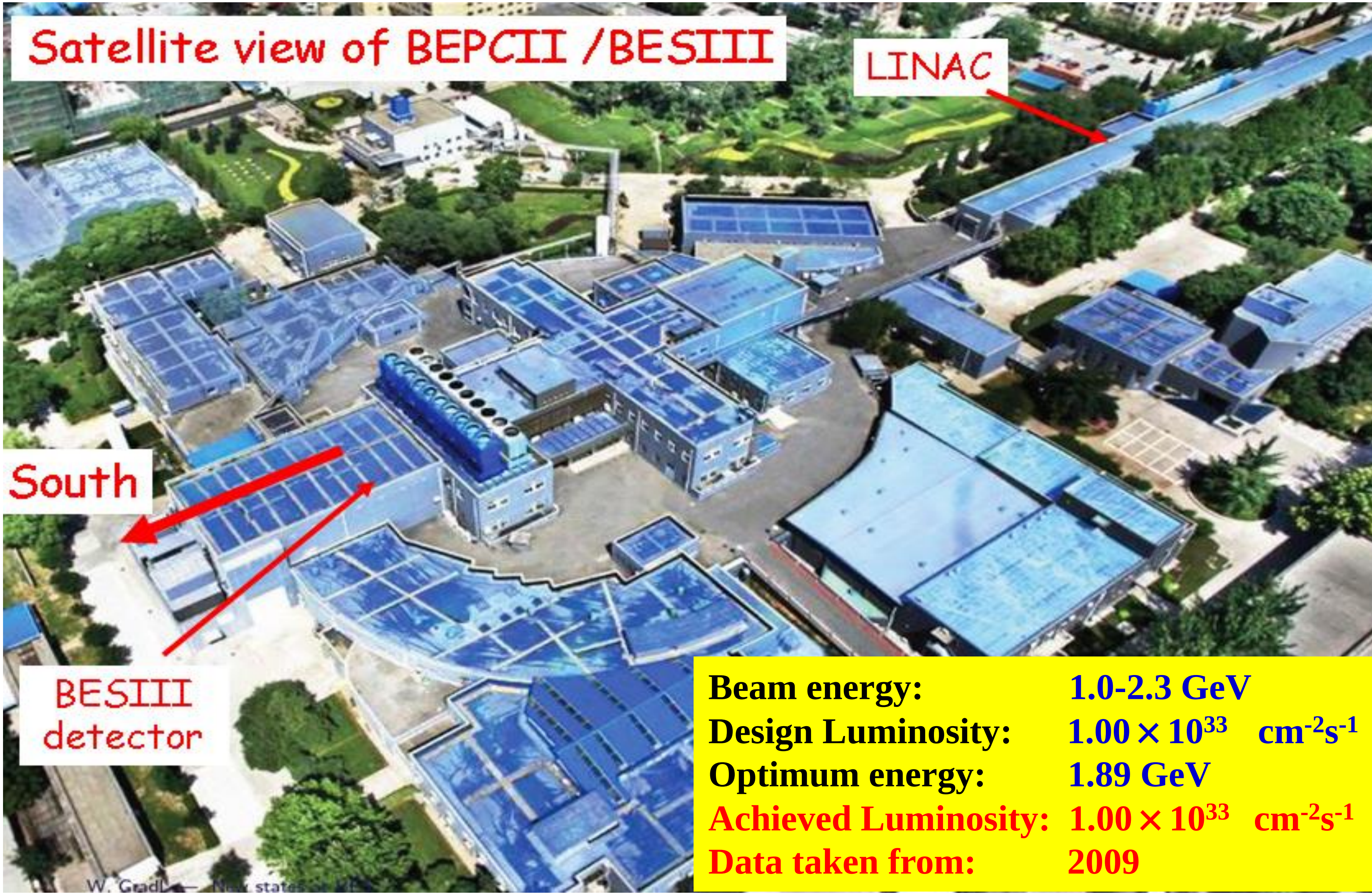
- **Absolute BFs of $\Lambda_c^+$**

  **Before BESIII, no absolute BF measurements of $\Lambda_c^+$ using near threshold data, in the past 40 years**

# Contents

- Samples of $D_{(s)}^{+}$
- $D_{(s)}^{+} \rightarrow l^{+}v$ ($l=\mu, \tau$)
- $D^{0(+)} \rightarrow Kl^{+}v$ and $\pi l^{+}v$ ($l=e, \mu$)
- Search for $D^{0(+)} \rightarrow a_0(980)^{-(0)}e^{+}v$ and $\gamma e^{+}v$
- Hadronic decays of D
- Summary

# BEPCII: high luminosity double–ring collider



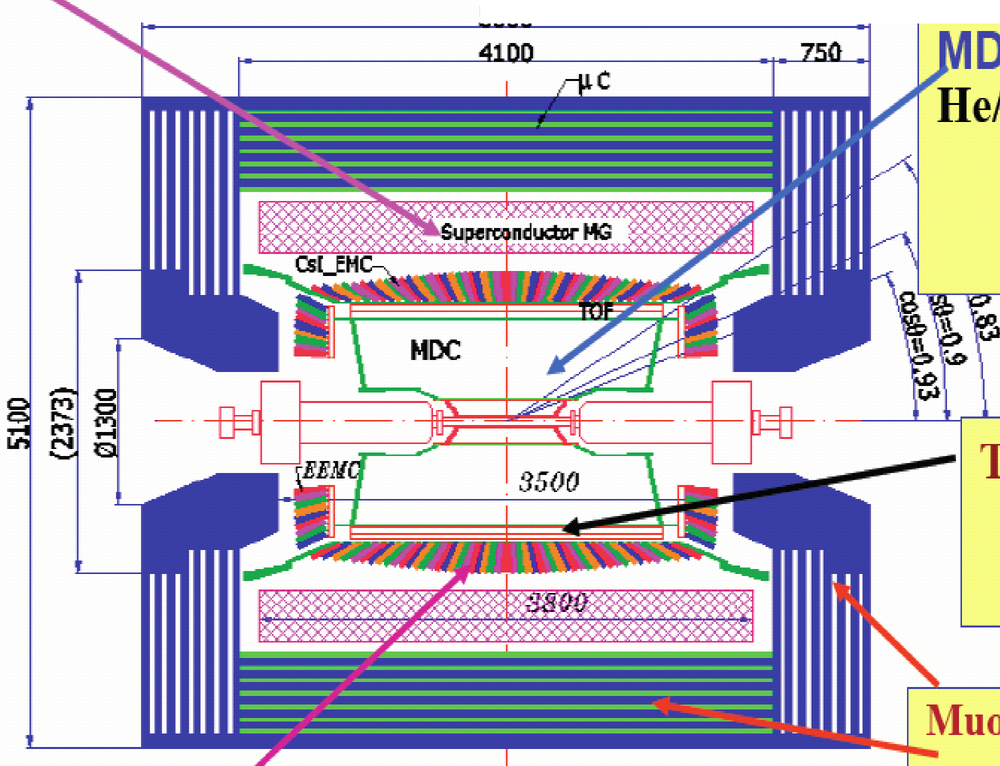

| | |
|---|---|
| Beam energy: | 1.0-2.3 GeV |
| Design Luminosity: | $1.00 \times 10^{33}$ cm$^{-2}$s$^{-1}$ |
| Optimum energy: | 1.89 GeV |
| Achieved Luminosity: | $1.00 \times 10^{33}$ cm$^{-2}$s$^{-1}$ |
| Data taken from: | 2009 |

# 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
$\sigma_{xy}$=130 μm
$\sigma_p/p$ = 0.5% @1GeV
dE/dx=6%




TOF:
$\sigma_T$ = 100 ps Barrel
110 ps Endcap

Muon ID: 9 layers RPC
8 layers for endcap

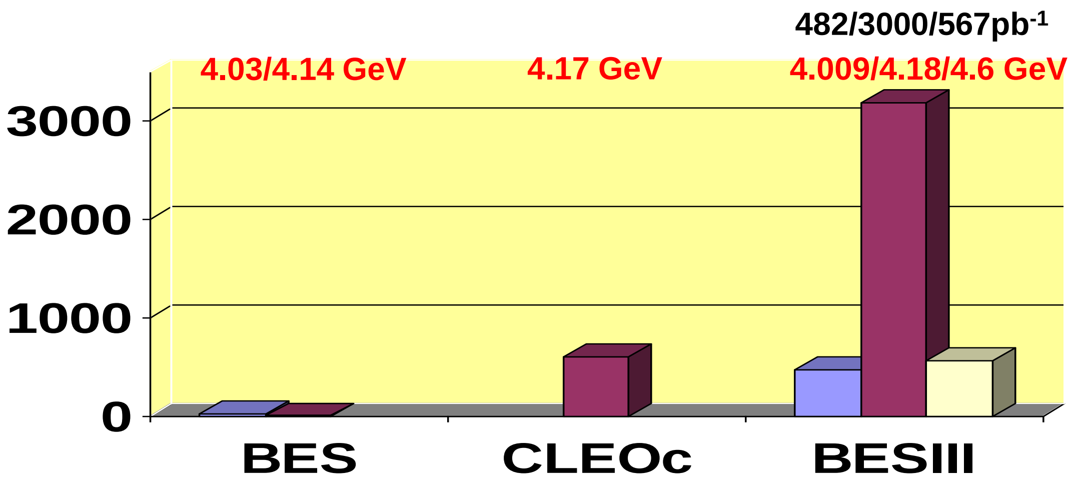
EMC: CsI crystal, 28 cm
ΔE/E = 2.5% @1 GeV
σz = 0.6 cm/√E

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

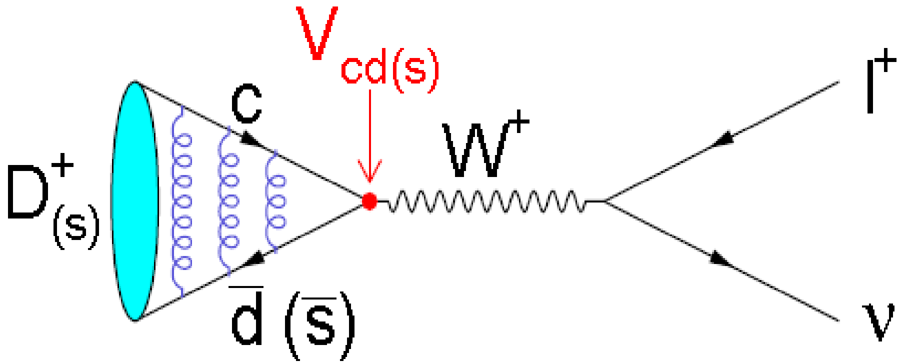
# $D^{0(+)}$, $D_s^+$ samples at BESIII (in $pb^{-1}$)

- $D^{0(+)}$ samples at 3.773 GeV


- $D_s^+/D_s^+$ samples at 4.009/4.18



# $D_{(s)}^+$ leptonic decays




**In the SM:**

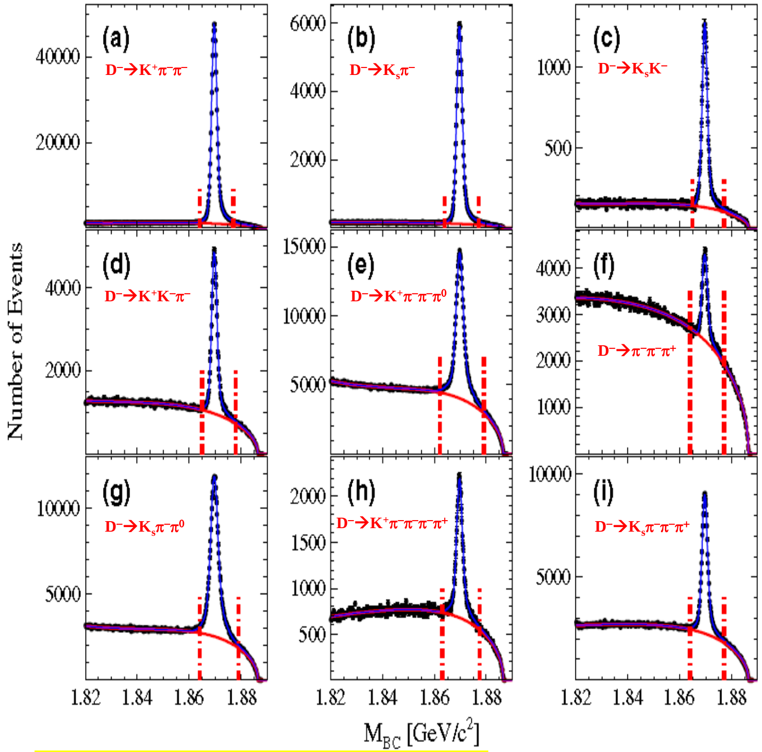
$$\Gamma(D^+_{(s)} \to \ell^+ \nu_\ell) = \frac{G_F^2 f^2_{D^+_{(s)}}}{8\pi} |V_{cd(s)}|^2 m_\ell^2 m_{D^+_{(s)}} \left(1 - \frac{m_\ell^2}{m^2_{D^+_{(s)}}}\right)^2$$

**Bridge to precisely measure**

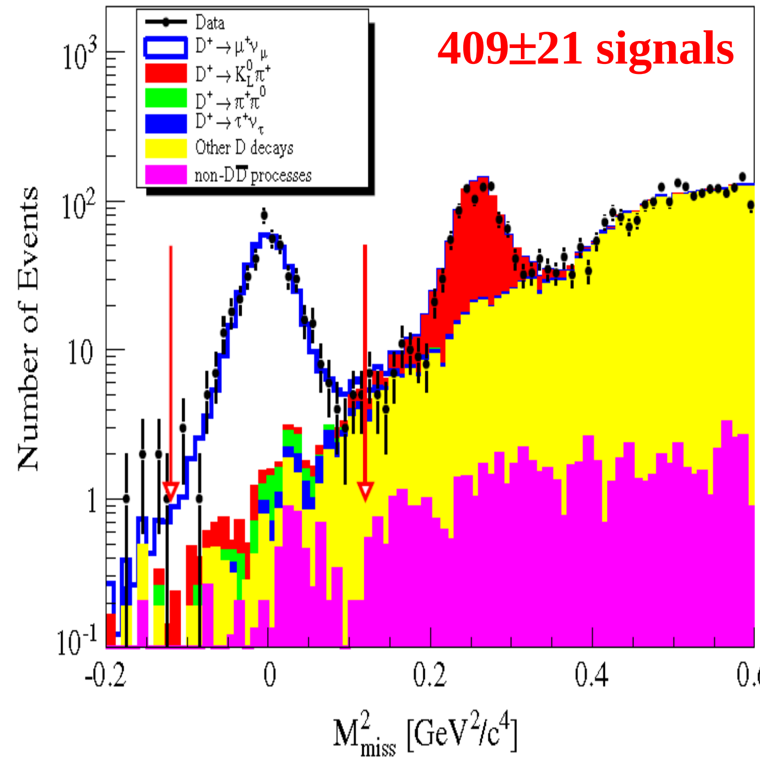
- **Decay constant $f_{D(s)+}$ with input $|V_{cd(s)}|^{CKMfitter}$**
- **CKM matrix element $|V_{cd(s)}|$ with input $f^{LQCD}_{D(s)+}$**

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

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




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




$N_{D^-_{tag}} = (170.31 \pm 0.34) \times 10^4$

$B[D^+ \to \mu^+\nu] = (3.71 \pm 0.19 \pm 0.06) \times 10^{-4}$

Input $t_{D+}$, $m_{D+}$, $m_{\mu+}$ on PDG and $|V_{cd}|$ of CKM-Fitter

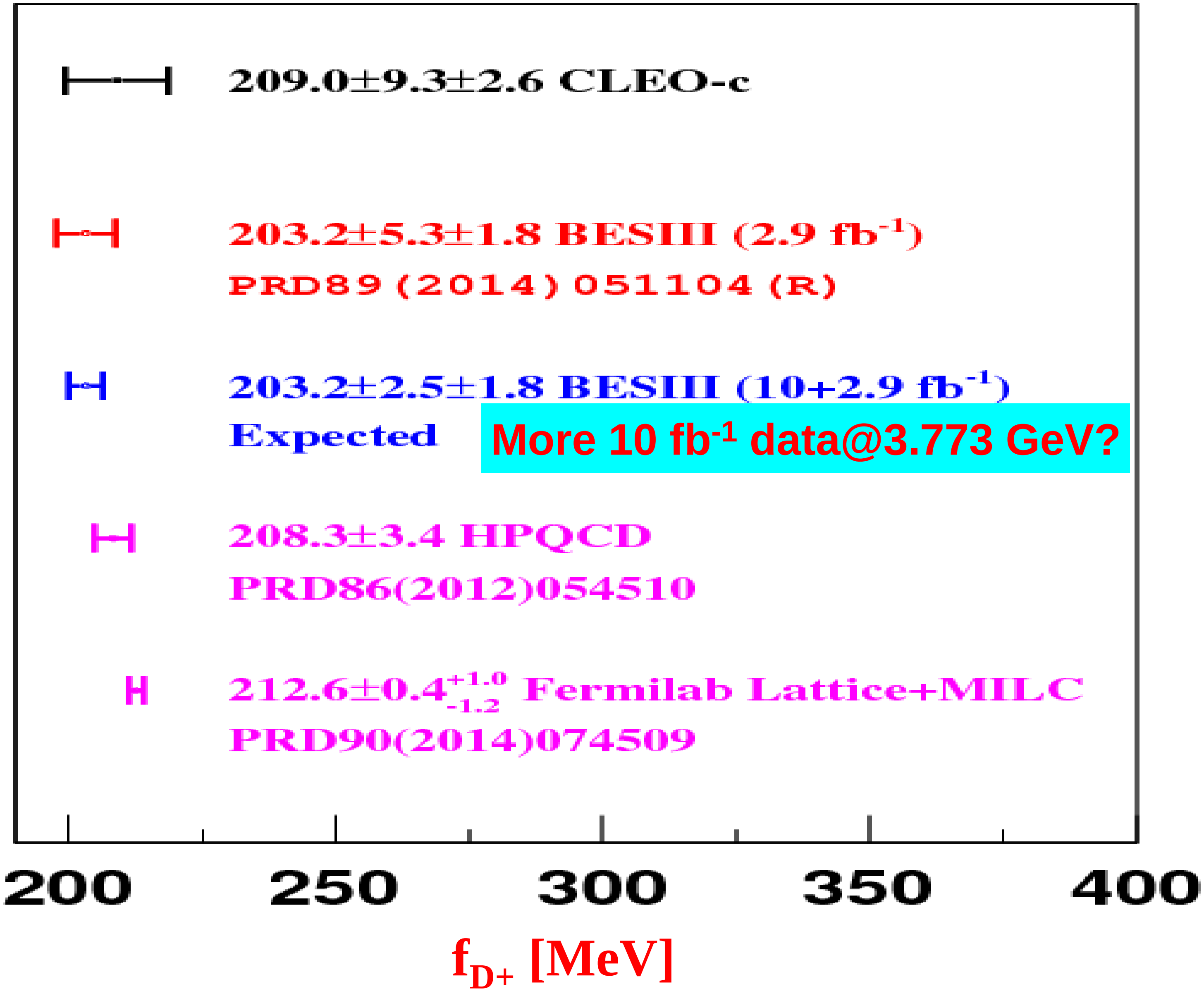
$f_{D+} = (203.2 \pm 5.3 \pm 1.8)$ MeV

BESIII

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

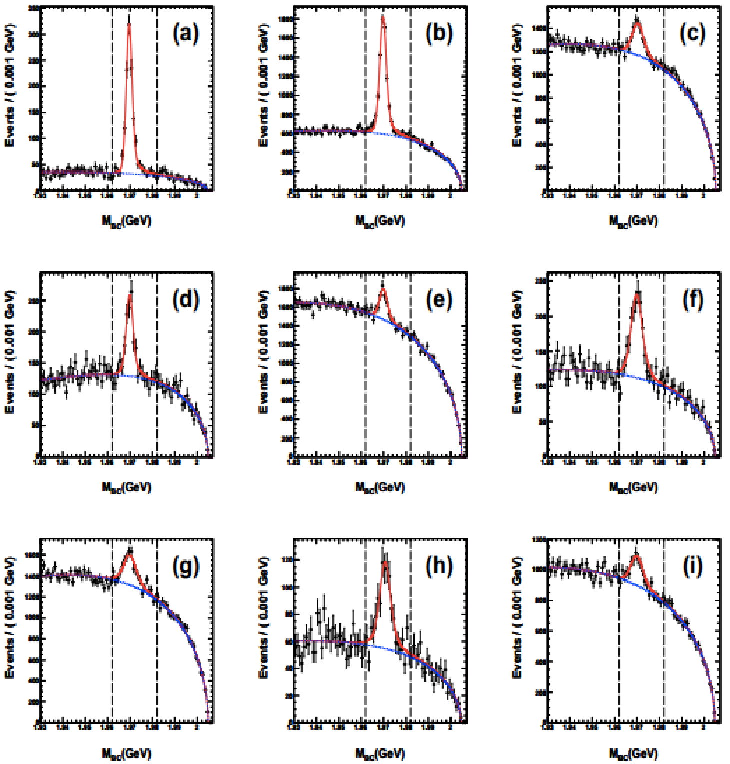
$|V_{cd}| = 0.2210 \pm 0.0058 \pm 0.0047$

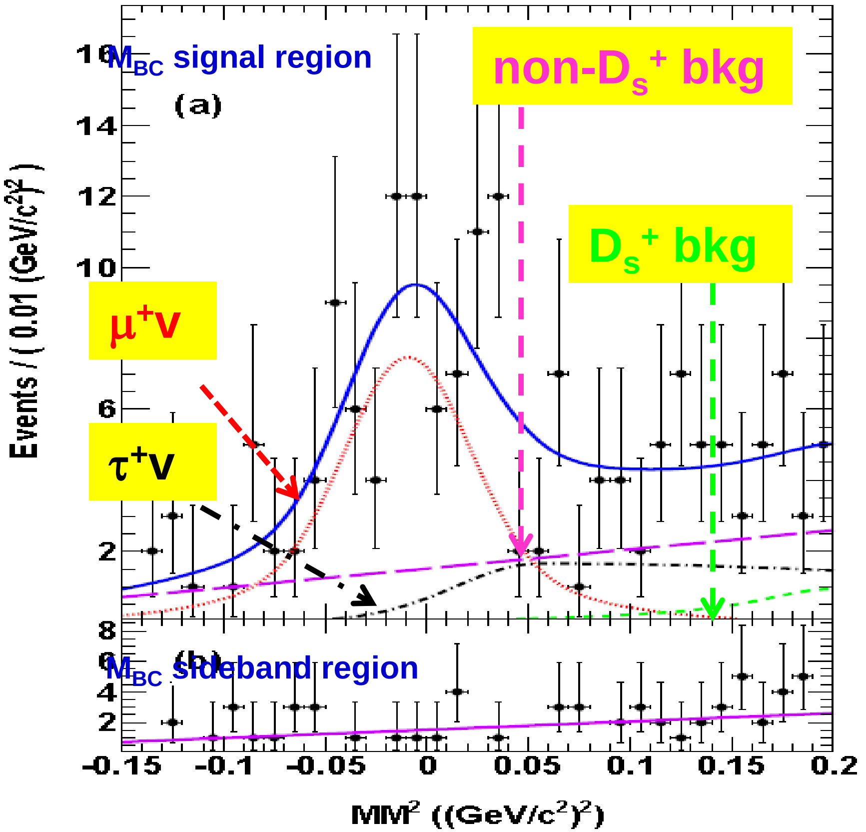
# Comparison of $f_{D^+}$ and prospect at BESIII



# $f_{D_s+}$ at 4.009 GeV

PRD94(2016)072004




$N_{D_s^- tag} = 15127 \pm 312$

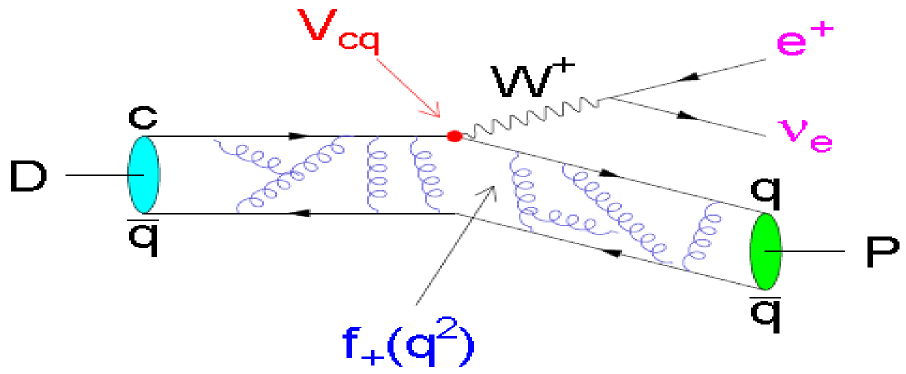
$B[D_s^+ \rightarrow \mu^+ \nu] = (0.495 \pm 0.067 \pm 0.026)\%$

$f_{D_s+} = (241.0 \pm 16.3 \pm 6.6)$ MeV

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

~3 fb$^{-1}$ data@ 4.18 GeV in hand, will further improve measurements

# Semi-leptonic decay $D^0 \to K(\pi)^- e^+ \nu$

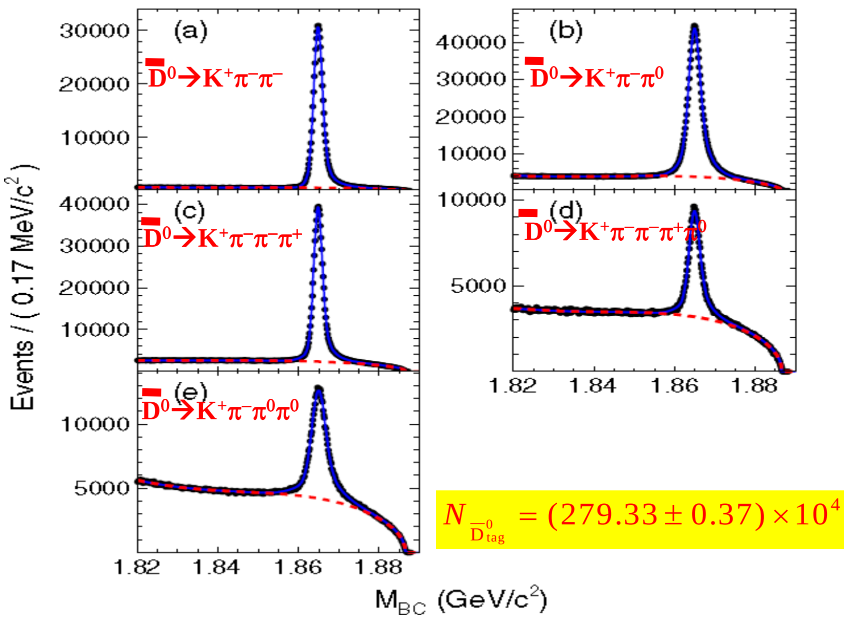



**Differential rates:** $$\frac{d\Gamma}{dq^2} = X \frac{G_F^2 |V_{cd(s)}|^2}{24\pi^3} p^3 |f_+(q^2)|^2$$

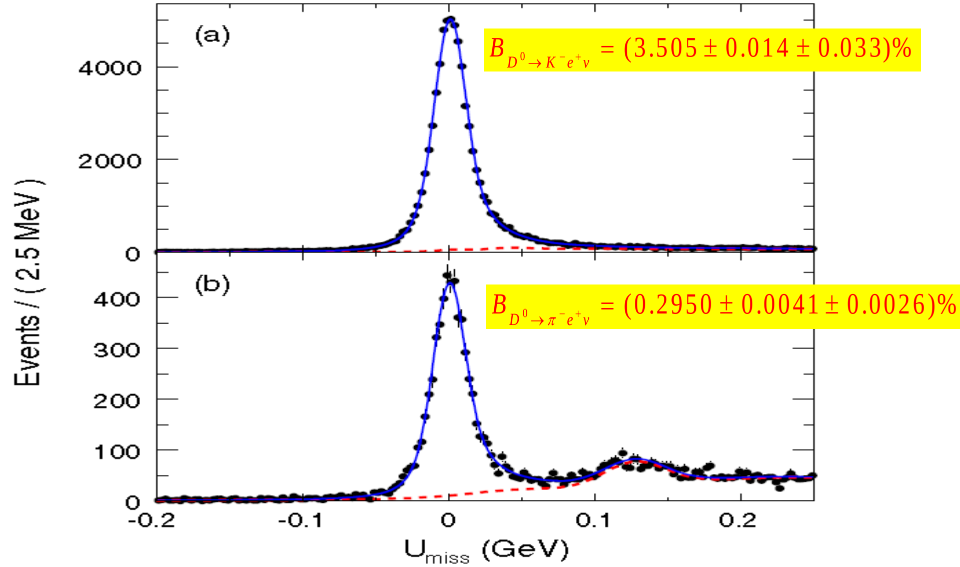
**Bridge to precisely measure:**

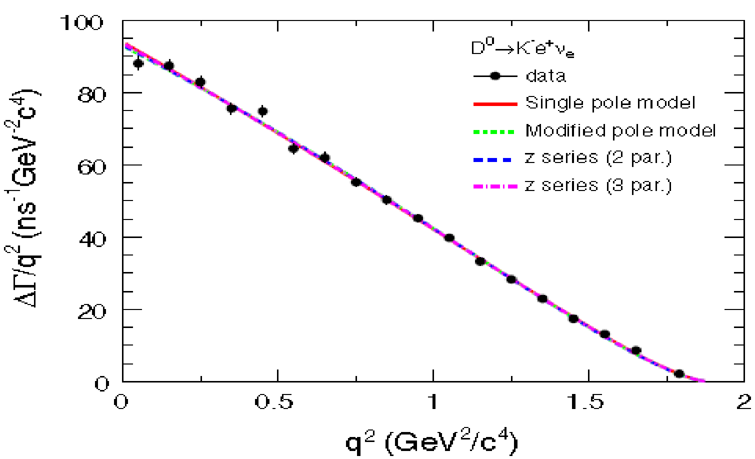
- **Form factors $f_+^{D\to K(\pi)}(0)$ with input $|V_{cd(s)}|^{\text{CKMfitter}}$**
  - **Single pole form** $$f_+(q^2) = \frac{f_+(0)}{1 - \frac{q^2}{M_{\text{pole}}^2}}$$
  - **Modified pole model** $$f_+(q^2) = \frac{f_+(0)}{(1 - \frac{q^2}{M_{\text{pole}}^2})(1 - \alpha \frac{q^2}{M_{\text{pole}}^2})}$$
  - **ISGW2 model** $$f_+(q^2) = f_+(q^2_{\text{max}}) \left(1 + \frac{r^2_{\text{ISGW2}}}{12}(q^2_{\text{max}} - q^2)\right)^{-2}$$
  - **Series expansion model** $$f_+(t) = \frac{1}{P(t)\Phi(t,t_0)} a_0(t_0) \left(1 + \sum_{k=1}^{\infty} r_k(t_0)[z(t,t_0)]^k\right)$$
- **CKM matrix element $|V_{cs(d)}|$ with input $f_+^{\text{LQCD},D\to K(\pi)}(0)$**

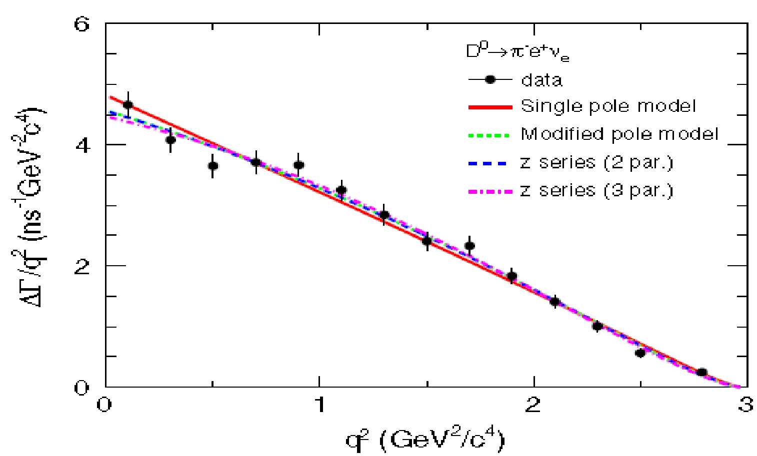
# $D^0 \to K(\pi)^- e^+ \nu \to f_+^{D\to K(\pi)}(q^2)|V_{cs(d)}|$




**PRD92(2015)072012**

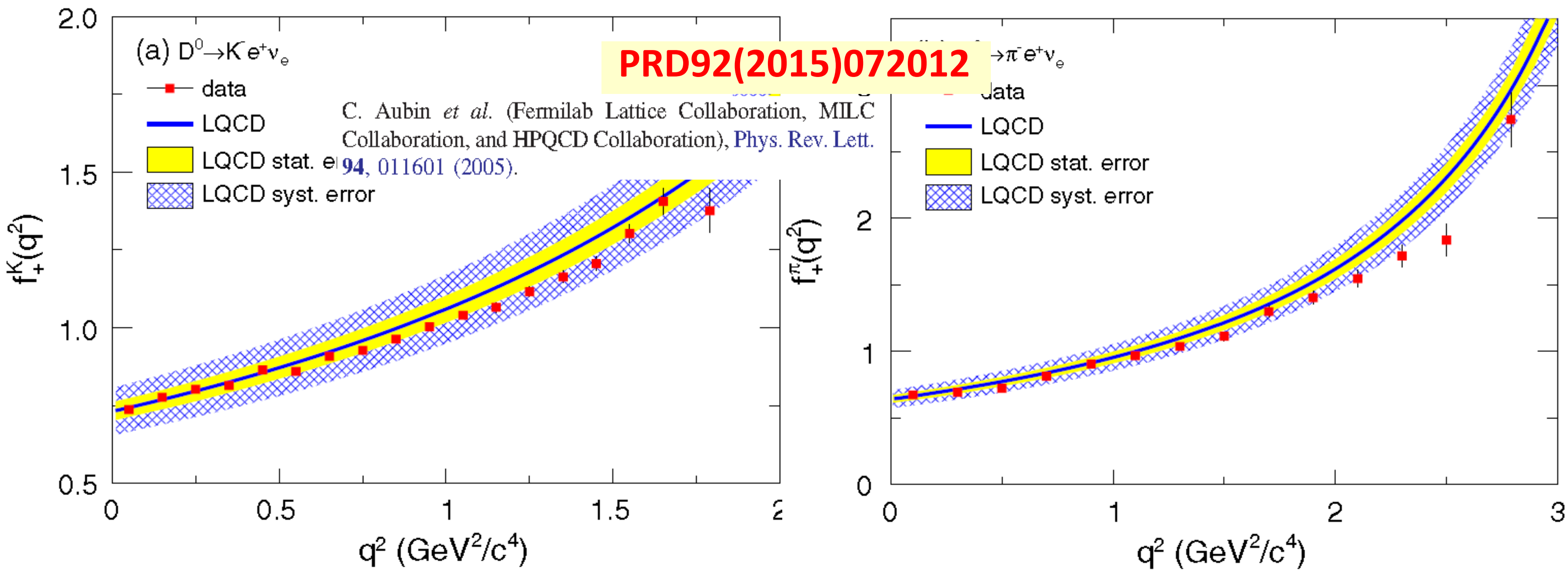



**$B[D^0 \to K^- e^+ \nu]$** **$B[D^0 \to \pi^- e^+ \nu]$**

# Calibration of LQCD

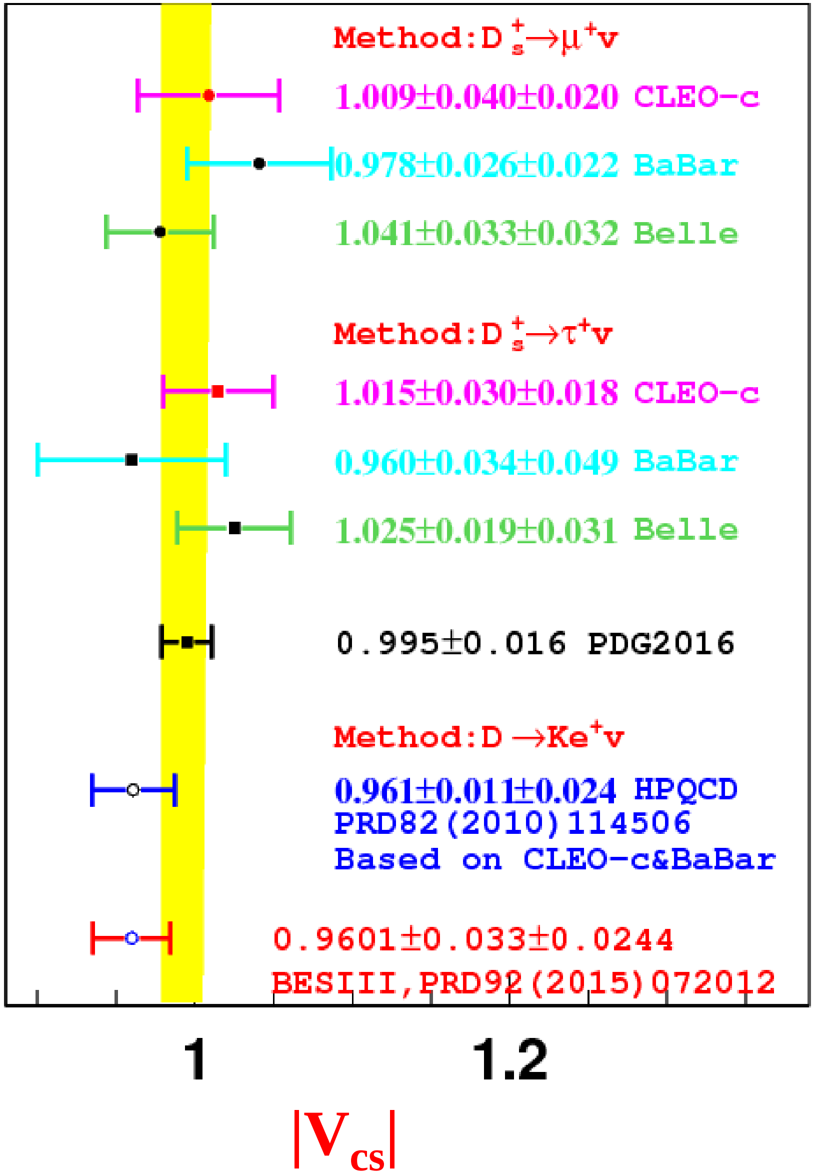


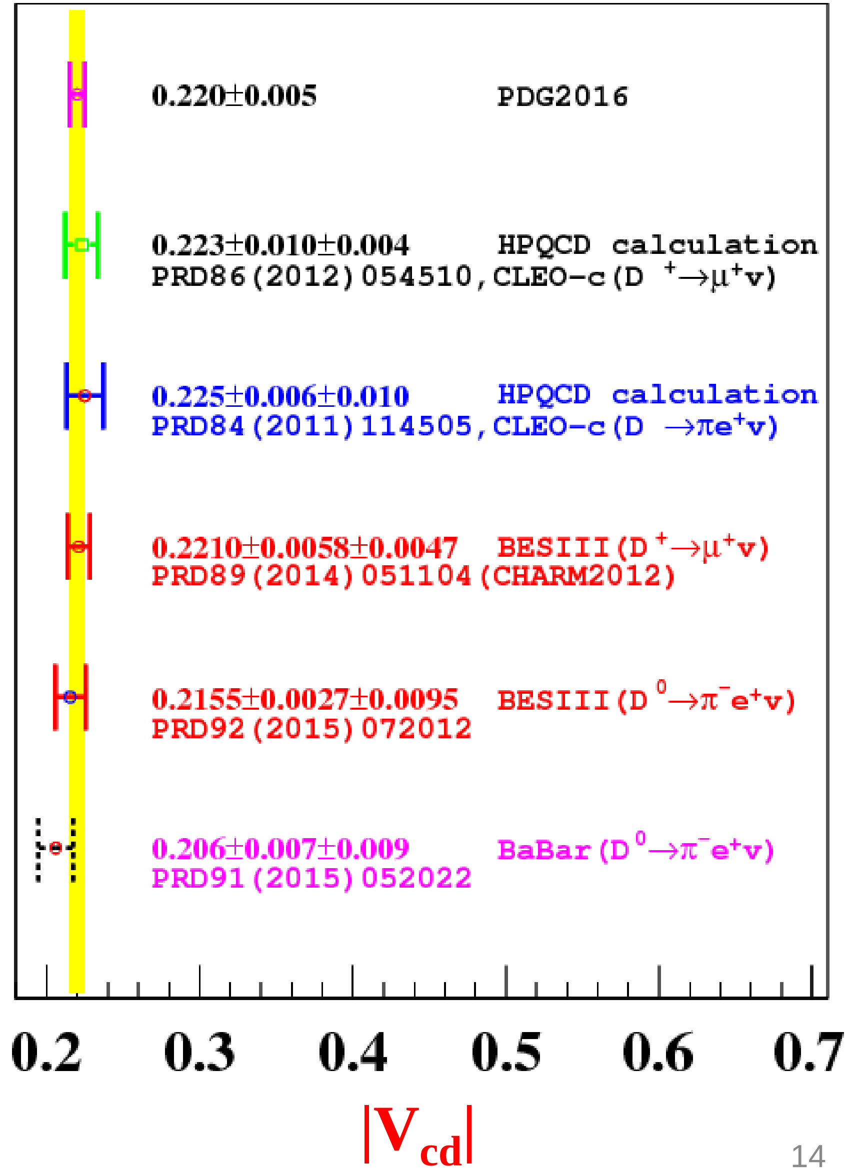

PRD92(2015)072012

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

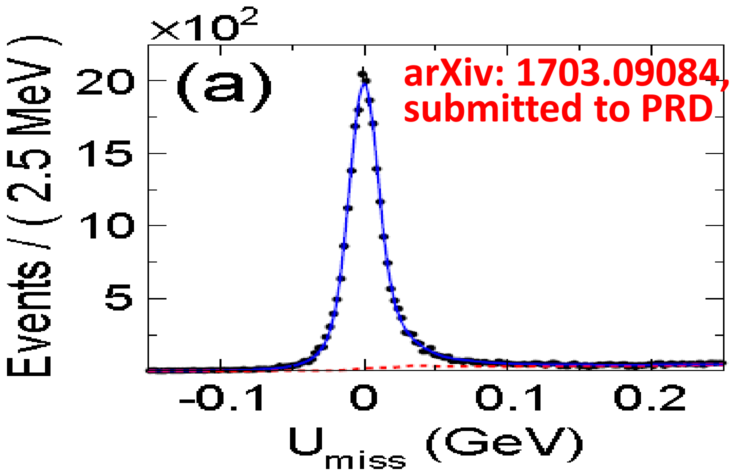
| | | $D^0 \to K^- e^+ \nu$ | | $D^0 \to \pi^- e^+ \nu$ |
|---|---|---|---|---|
| Simple Pole | $f_K^+(0)\|V_{cs}\|$ | 0.7209±0.0022±0.0033 | $f_\pi^+(0)\|V_{cd}\|$ | 0.1475±0.0014±0.0005 |
| | $M_{pole}$ | 1.9207±0.0103±0.0069 | $M_{pole}$ | 1.9114±0.0118±0.0038 |
| Mod. Pole | $f_K^+(0)\|V_{cs}\|$ | 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 |

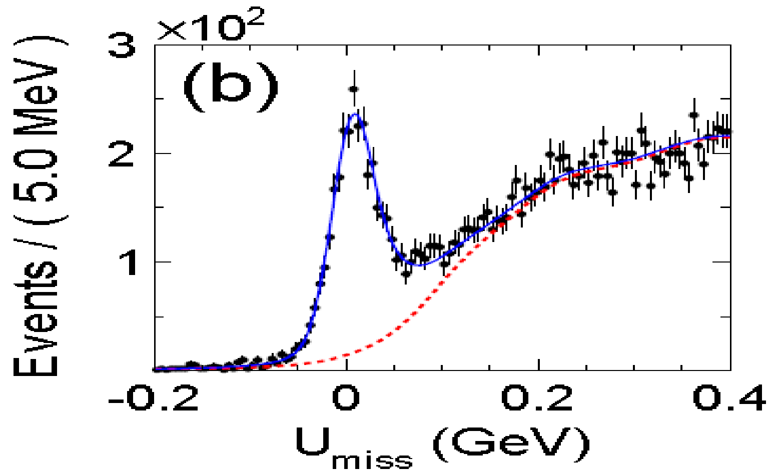
# Comparison of $|V_{cs(d)}|$



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



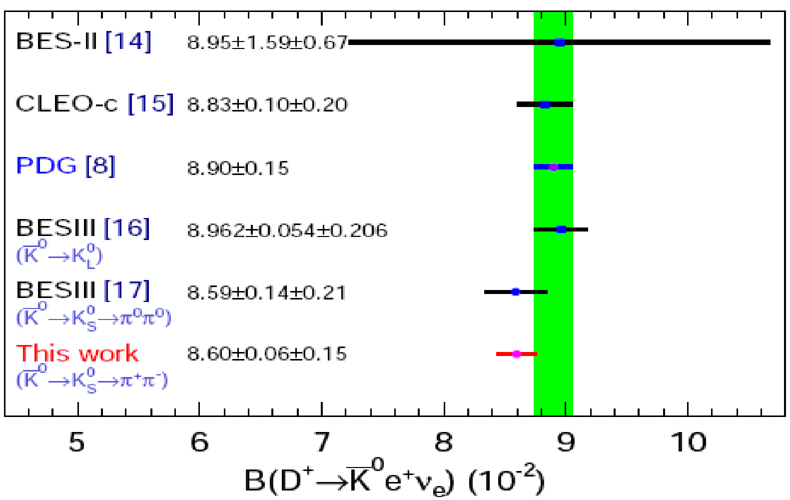



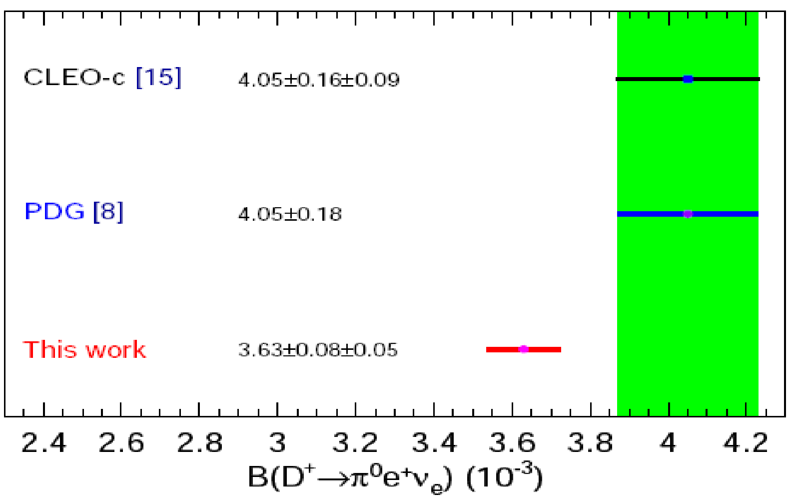

$$B[D^+ \to \overline{K}^0 e^+ \nu] = (8.604 \pm 0.056 \pm 0.151)\%$$

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

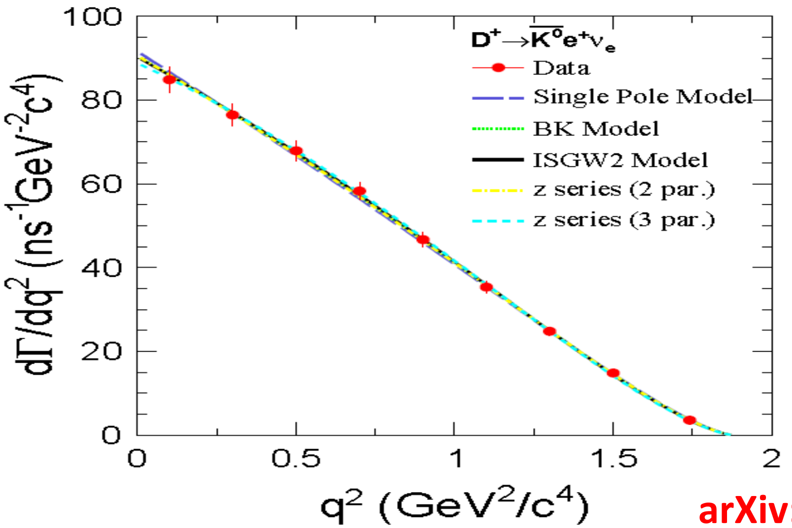
$$\frac{\Gamma[D^0 \to K^- e^+ \nu]}{\Gamma[D^+ \to \overline{K}^0 e^+ \nu]} = 1.03 \pm 0.01 \pm 0.02$$

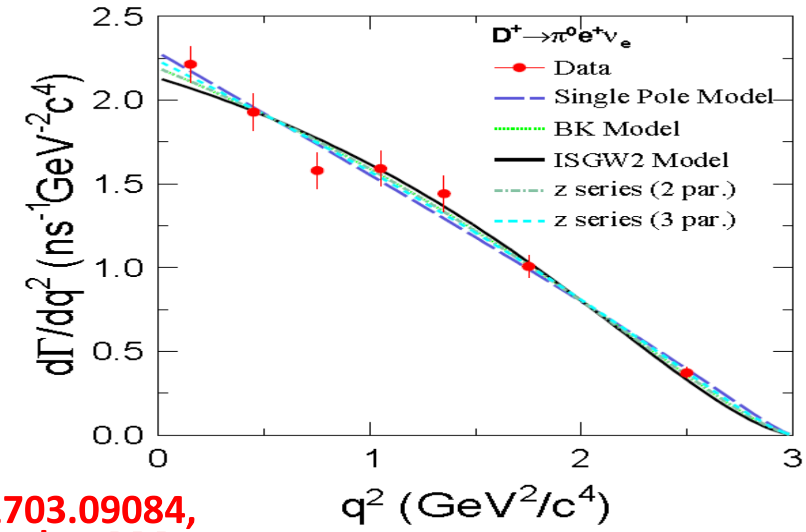
$$\frac{\Gamma[D^0 \to \pi^- e^+ \nu]}{2\Gamma[D^+ \to \pi^0 e^+ \nu]} = 1.03 \pm 0.03 \pm 0.02$$



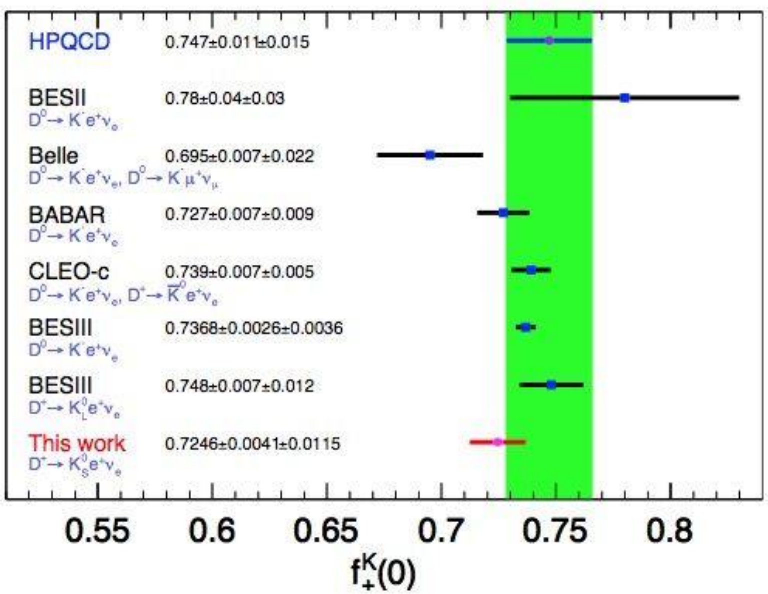



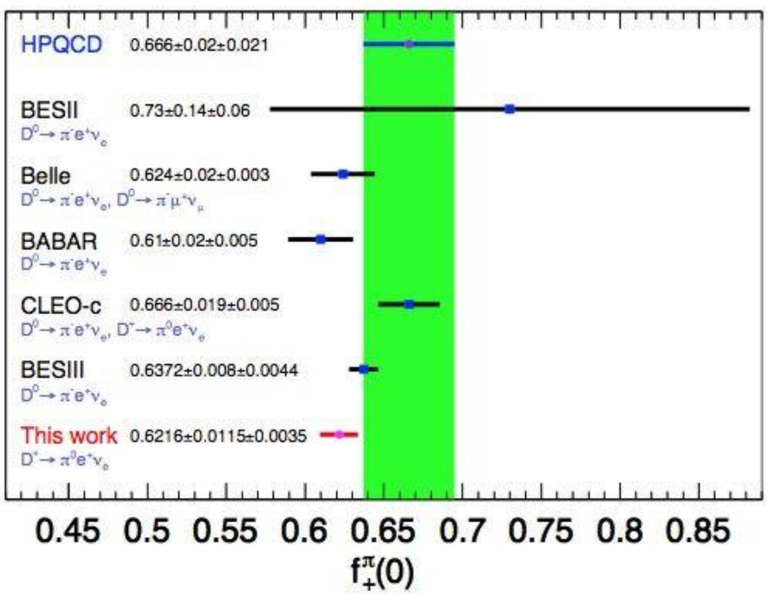
# Comparisons of FFs by $D^+ \rightarrow \bar{K}^0(\pi^0)e^+v$




arXiv: 1703.09084,
submitted to PRD



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

- **Lepton universality (LU)**

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

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

**BFs on PDG16:**

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

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

**Large error in B[$D^0 \to \pi^- \mu^+ \nu$] and no measure of B[$D^+ \to \pi^0 \mu^+ \nu$]. Precision measurements are desired**

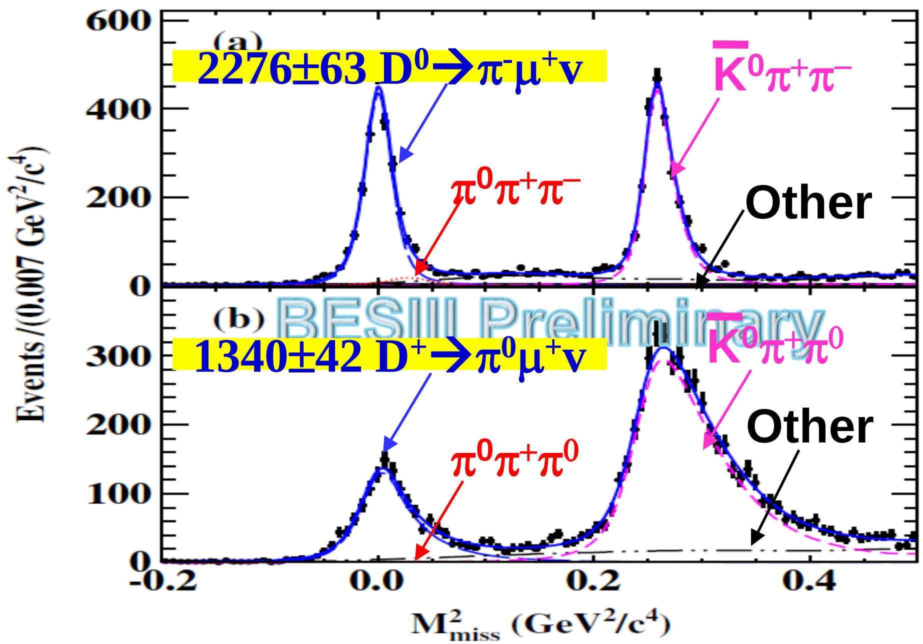
- **Isospin symmetry (IS)**

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

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

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

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




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

**agrees with PDG and with better precision**

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

**measured for the first time**

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

**agree with expectation in 1.5(1.1) σ**

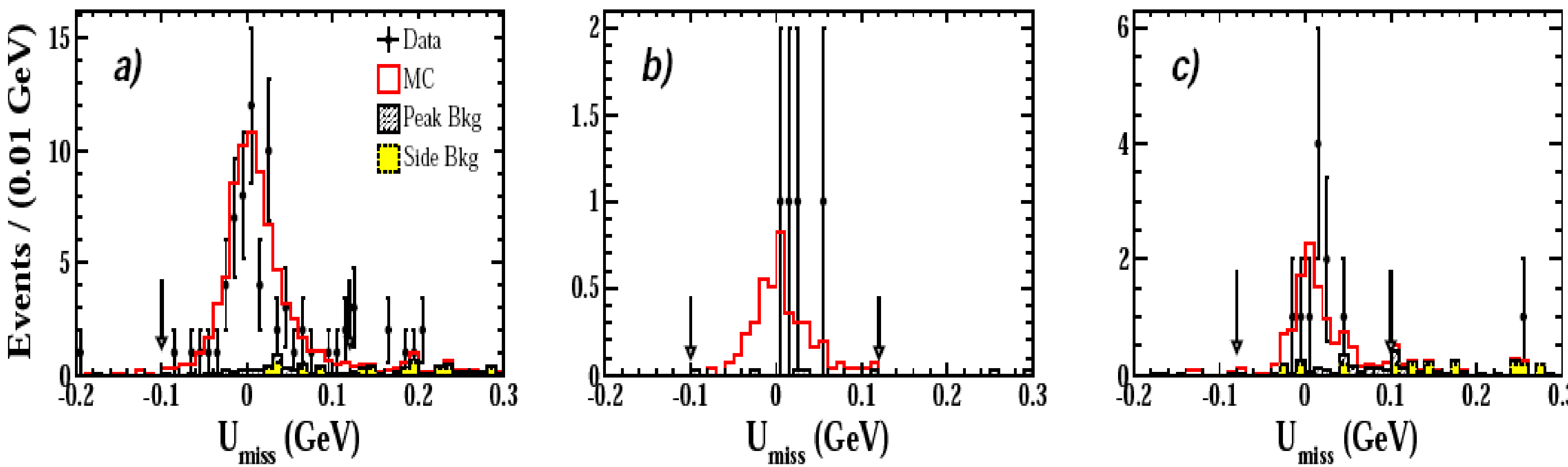
**IS:** $R_{IS}^{\mu} = 0.990 \pm 0.054$

**agree with IS prediction within uncertainty**

# Measurements of BFs of $D_s^+ \rightarrow \eta^{(')} e^+ \nu$

- **Benefit the understanding of the source of difference of inclusive decay rates of $D^{0(+)}$ and $D_s^+$**
- **Complementary information to understand $\eta-\eta'$ mixing**

**PRD94(2016)112003**




| | BESIII | CLEOII 95 | CLEOc09 | CLEOc15 | PDG [4] |
|---|---|---|---|---|---|
| $B(D_s^+ \to \eta e^+ \nu_e)[\%]$ | $2.30 \pm 0.31 \pm 0.08$ | — | $2.48 \pm 0.29 \pm 0.13$ | $2.28 \pm 0.14 \pm 0.20$ | $2.67 \pm 0.29$ |
| $B(D_s^+ \to \eta' e^+ \nu_e)[\%]$ | $0.93 \pm 0.30 \pm 0.05$ | — | $0.91 \pm 0.33 \pm 0.05$ | $0.68 \pm 0.15 \pm 0.06$ | $0.99 \pm 0.23$ |
| $\frac{B(D_s^+ \to \eta' e^+ \nu_e)}{B(D_s^+ \to \eta e^+ \nu_e)}$ | $0.40 \pm 0.14 \pm 0.02$ | $0.35 \pm 0.09 \pm 0.07$ | — | — | — |

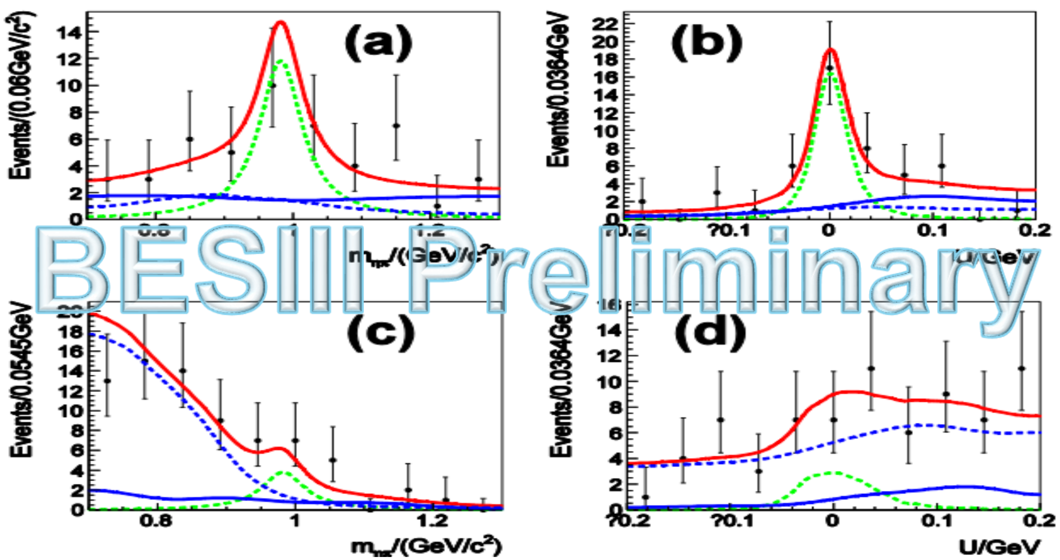
# Search for $D^{0(+)} \rightarrow a_0(980)^{-(0)} e^+ \nu$

- Explore the nontrivial internal structure of light hadron mesons, traditional $q\bar{q}$ states, tetra quark system.
- With chiral unitarity approach in the coupled channels, BF is predicted to be order of $5(6)\times10^{-5}$ for $D^{0(+)}$ decays
- Improve understanding of classification of light scalar mesons

$$R \equiv \frac{B(D^+ \to f_0 l^+ \nu) + B(D^+ \to \sigma l^+ \nu)}{B(D^+ \to a_0 l^+ \nu)}$$

R=1(3) if traditional $q\bar{q}$ (tetra quark) system

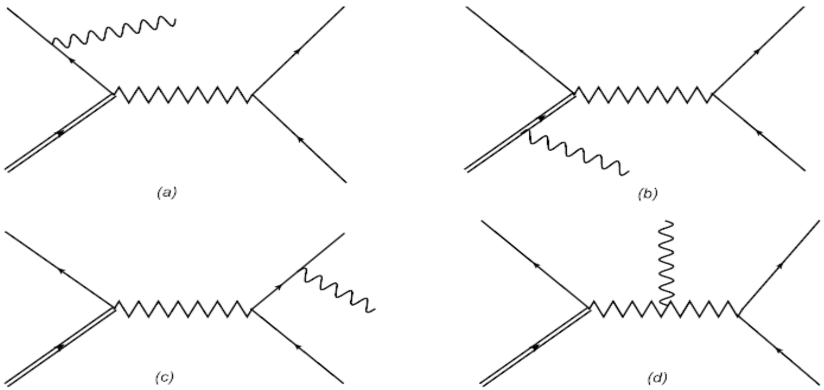
**With 3(6) dominant $D^{0(-)}$ single tag**




- $B(D^0 \to a_0(980)^- e^+ \nu_e) \times B(a_0(980)^- \to \eta\pi^-)$
  $= (1.12^{+0.31}_{-0.28}(stat) \pm 0.10(syst)) \times 10^{-4}$ $5.9\sigma$
- $B(D^+ \to a_0(980)^0 e^+ \nu_e) \times B(a_0(980)^0 \to \eta\pi^0)$
  $= (1.47^{+0.73}_{-0.59}(stat) \pm 0.14(syst)) \times 10^{-4}$ $3.0\sigma$
- $B(D^+ \to a_0(980)^0 e^+ \nu_e) \times B(a_0(980)^0 \to \eta\pi^0)$
  $< 2.7 \times 10^{-4}$ @ 90% C.L.

# Search for $D^+ \to \gamma e^+ \nu$

**J.C. Yang and M.Z. Yang, NPB889,778(2014)**




**Various theory models predict BFs in $10^{-6}$–$10^{-4}$**

Figure 1: Feynman diagrams of short-distance contribution at tree level (taken from Ref. [1]). The double line represents the heavy quark propagator. Fig.(a) and (b) are structure-dependent radiative decays, Fig.(c) is the Bremsstrahlung radiative decay. Fig.(d) is suppresssed by a factor of $1/m_W^2$.

**Tree level amplitudes**

**PRD95(2017)071102(R)**

**With 6 dominant $D^-$ single tag**

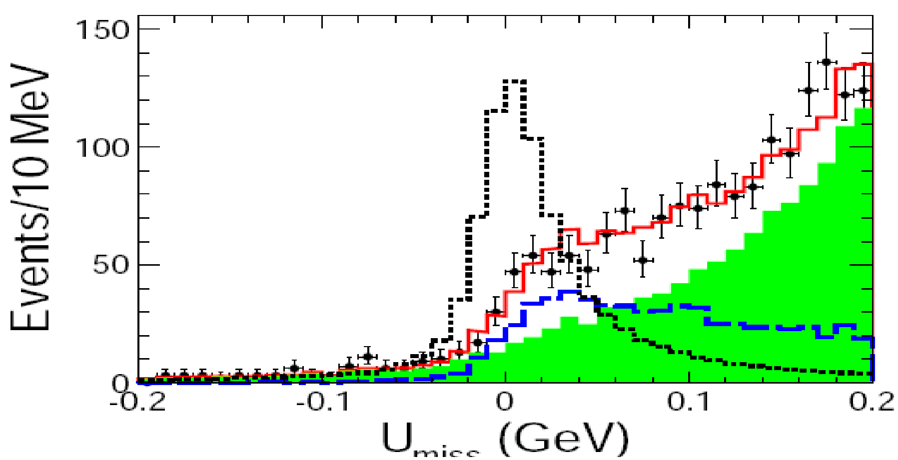
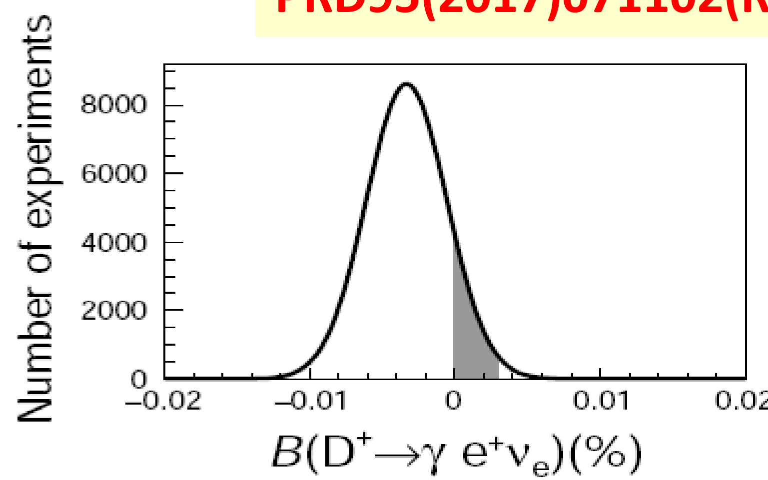



FIG. 2. (color online) The $U_{\rm miss}$ distribution. Dots with error bars are data, the red solid-line histogram shows the overall fit curve, the blue dash-line histogram shows the background $D^+ \to \pi^0 e^+ \nu_e$, and the green shaded histogram includes all other background. The black dotted line shows the signal MC simulation normalized to the branching fraction $\mathcal{B}(D^+ \to \gamma e^+ \nu_e) = 100 \times 10^{-5}$.

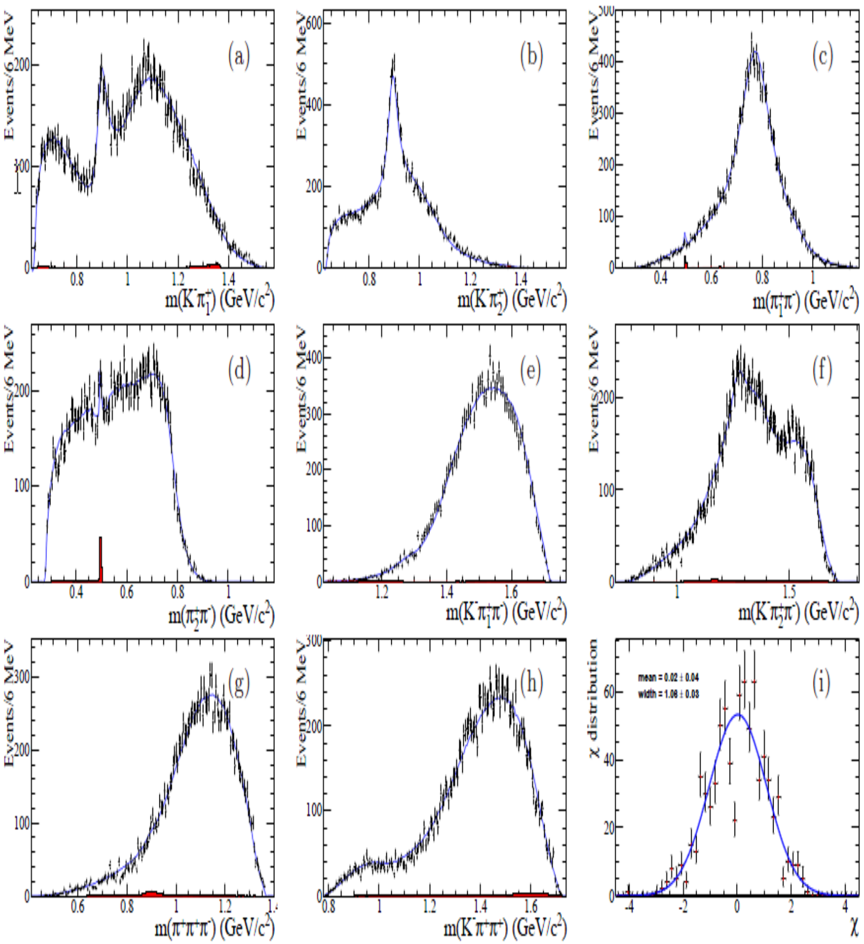



$B[D^+ \to \gamma e^+ \nu]|_{E\gamma>10\ \rm MeV} < 3.0\times10^{-4}$ @90%C.L.

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

## Help to determine the absolute BF, strong phase, benefit $\gamma/\phi_3$

**Previous analyses only from MarkIII and E691**




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

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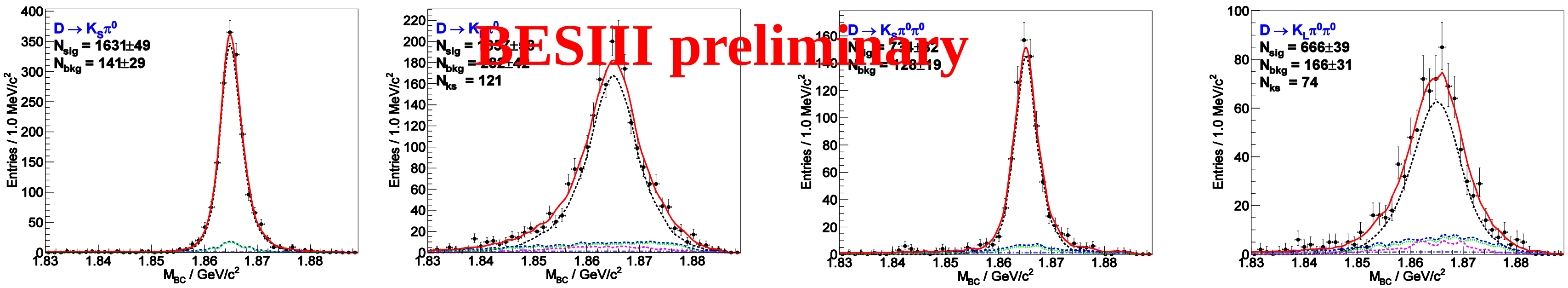
# Absolute BFs and $y_{CP}$ of $D^0 \to K_{S/L}\pi^0(\pi^0)$

- Two dimensional fits to $M_{BC}$(tag) versus $M_{BC}$(signal)
- Projections of DT evens on the $M_{BC}$(sig) vs. $K\pi$ (for example)



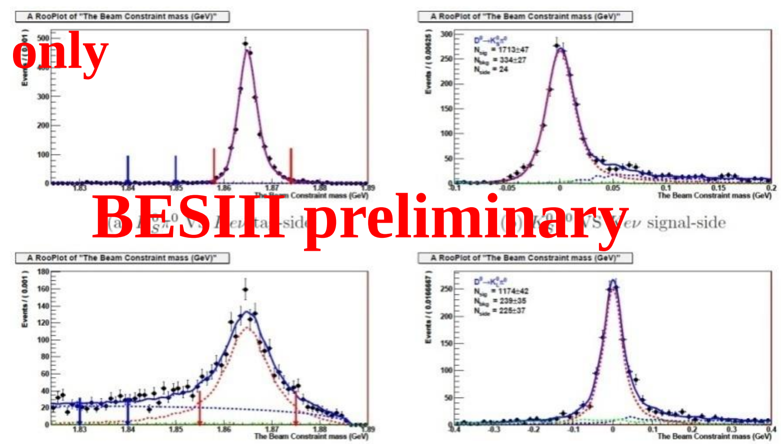

## Branching fractions and asymmetries

Statistical only

$$R(D \to K_{S,L} + \pi's) = \frac{Br(D \to K_S\pi's) - Br(D \to K_L\pi's)}{Br(D \to K_S\pi's) + Br(D \to K_L\pi's)}$$

Table 10: Decay rates and the asymmetries of $D \to K^0_{S,L}\pi^0$ and $D \to K^0_{S,L}\pi^0\pi^0$.

| | $D \to K^0_{S,L}\pi^0$ | | |
|---|---|---|---|
| | $Br_{K_S\pi^0}(\%)$ | $Br_{K_L\pi^0}(\%)$ | $R(D \to K_{S,L}\pi^0)$ |
| $K\pi$ | 1.208±0.041 | 1.061±0.038 | 0.0646±0.0245 |
| $K3\pi$ | 1.212±0.037 | 0.985±0.036 | 0.1035±0.0237 |
| $K\pi\pi^0$ | 1.251±0.028 | 0.953±0.029 | 0.1351±0.0186 |
| All | 1.230±0.020 | 0.991±0.019 | 0.1077±0.0125 |
| | $D \to K^0_{S,L}\pi^0\pi^0$ | | |
| | $Br_{K_S2\pi^0}(\%)$ | $Br_{K_L2\pi^0}(\%)$ | $R(D \to K_{S,L}2\pi^0)$ |
| $K\pi$ | 1.024±0.049 | 1.299±0.080 | -0.1183±0.0385 |
| $K3\pi$ | 0.887±0.043 | 1.097±0.073 | -0.1060±0.0409 |
| $K\pi\pi^0$ | 1.010±0.036 | 1.158±0.060 | -0.0681±0.0313 |
| All | 0.975±0.024 | 1.175±0.040 | -0.0929±0.0209 |

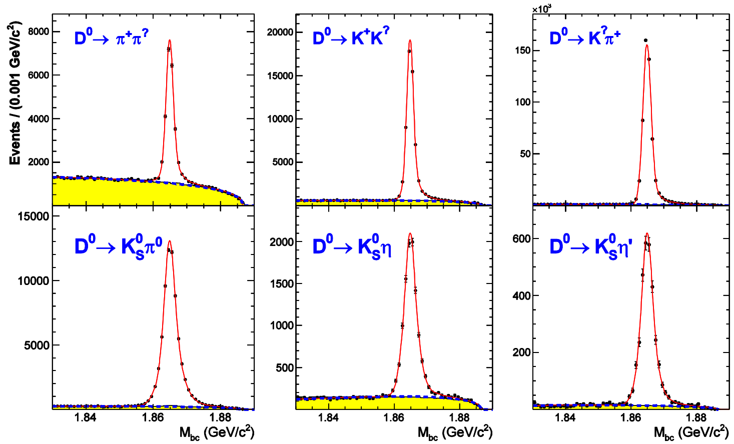


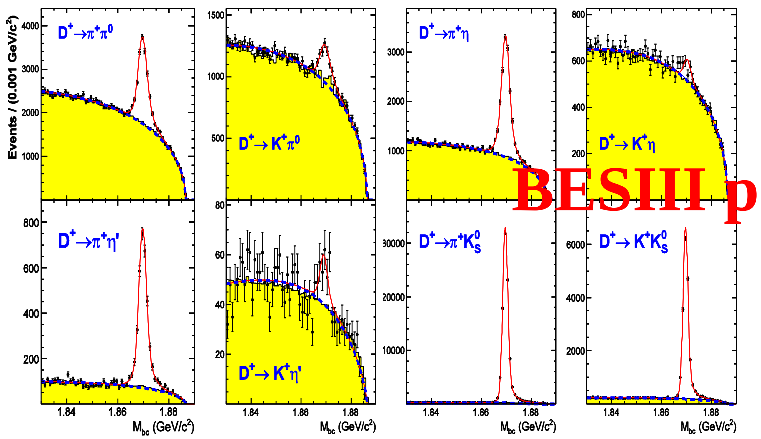

(c) $K^0_L\pi^0$ VS $Ke\nu$ tag-side

(d) $K^0_L\pi^0$ VS $Ke\nu$ signal-side

- $y_{CP}$ (($K_S\pi^0$, $K_L\pi^0$) vs. $Ke\nu$) = (0.98±2.43)%

# BF measurements of some $D^{0(+)} \to PP$




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

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 study of the hadronic decays of charmed $D$ mesons is of great significance in the study of the strong and weak interactions in $D$ decays.
- The analysis on $D \to PP$ modes will provide materials for the study of SU(3) breaking effect[1]. And the observation of CP violation in D decay is commonly believed to be indications of new physics.
- $D^0 \to K^-\pi^+$ is an important normalization mode.
- Most of the D decays have been studied by CLEO in 2010[2], other measurements come from Belle[3], BaBar[4] and CDF[5], etc.
- Some of the branching fractions (BFs) are not well established. With the 2.93 fb$^{-1}$ data taken at 3.773 GeV within BESIII, the results will help to improve these measurements.

BESIII preliminary

| Mode | $N^{net}_{signal}$ | $\varepsilon$ (%) | $\mathcal{B}\pm$(stat)$\pm$(sys) | $\mathcal{B}_{PDG}$ |
|---|---|---|---|---|
| $\pi^+\pi^-$ | $21105 \pm 249$ | $66.03 \pm 0.25$ | $(1.505 \pm 0.018 \pm 0.031) \times 10^{-3}$ | $(1.421 \pm 0.025) \times 10^{-3}$ |
| $K^+K^-$ | 5543[illegible] $\pm 273$ | $62.82 \pm 0.32$ | $(4.229 \pm 0.020 \pm 0.087) \times 10^{-3}$ | $(4.01 \pm 0.07) \times 10^{-3}$ |
| $K^-\pi^+$ | $537745 \pm 767$ | $64.98 \pm 0.09$ | $(3.896 \pm 0.006 \pm 0.073)$ % | $(3.93 \pm 0.04)$ % |
| $K^0_S\pi^0$ | $66539 \pm 302$ | $38.06 \pm 0.17$ | $(1.236 \pm 0.006 \pm 0.032)$ % | $(1.20 \pm 0.04)$ % |
| $K^0_S\eta$ | $9532 \pm 126$ | $31.96 \pm 0.14$ | $(5.149 \pm 0.068 \pm 0.134) \times 10^{-3}$ | $(4.85 \pm 0.30) \times 10^{-3}$ |
| $K^0_S\eta'$ | $3007 \pm 61$ | $12.66 \pm 0.08$ | $(9.562 \pm 0.197 \pm 0.379) \times 10^{-3}$ | $(9.5 \pm 0.5) \times 10^{-3}$ |
| $\pi^0\pi^+$ | $10108 \pm 267$ | $48.98 \pm 0.34$ | $(1.259 \pm 0.033 \pm 0.025) \times 10^{-3}$ | $(1.24 \pm 0.06) \times 10^{-3}$ |
| $\pi^0K^+$ | $1834 \pm 168$ | $51.52 \pm 0.42$ | $(2.171 \pm 0.198 \pm 0.060) \times 10^{-4}$ | $(1.89 \pm 0.25) \times 10^{-4}$ |
| $\eta\pi^+$ | $11636 \pm 215$ | $46.96 \pm 0.25$ | $(3.790 \pm 0.070 \pm 0.075) \times 10^{-3}$ | $(3.66 \pm 0.22) \times 10^{-3}$ |
| $\eta K^+$ | $439 \pm 72$ | $48.21 \pm 0.31$ | $(1.393 \pm 0.228 \pm 0.124) \times 10^{-4}$ | $(1.12 \pm 0.18) \times 10^{-4}$ |
| $\eta'\pi^+$ | $3088 \pm 83$ | $21.49 \pm 0.18$ | $(5.122 \pm 0.140 \pm 0.210) \times 10^{-3}$ | $(4.84 \pm 0.31) \times 10^{-3}$ |
| $\eta' K^+$ | $87 \pm 25$ | $22.39 \pm 0.22$ | $(1.377 \pm 0.428 \pm 0.202) \times 10^{-4}$ | $(1.83 \pm 0.23) \times 10^{-4}$ |
| $K^0_S\pi^+$ | $93884 \pm 352$ | $51.38 \pm 0.18$ | $(1.591 \pm 0.006 \pm 0.033) \times 10^{-2}$ | $(1.53 \pm 0.06) \times 10^{-2}$ |
| $K^0_S K^+$ | $17704 \pm 151$ | $48.45 \pm 0.14$ | $(3.183 \pm 0.028 \pm 0.065) \times 10^{-3}$ | $(2.95 \pm 0.15) \times 10^{-3}$ |

# Summary

- With 2.93, 0.482 $fb^{-1}$ data taken at 3.773, 4.009 GeV, BESIII have studied $D_{(s)}^{+} \to l^{+}v$ and $D^{0} \to K(\pi)^{-}l^{+}v$, searched for $D^{+(0)} \to a_{0}(980)^{0(-)}e^{+}v$ and $\gamma e^{+}v$, measurements of D haronic decays, using near threshold data

- Improved measurements of decay constant $f_{D+}$ and form factor $f_{+}^{D\to K(\pi)}(q^{2})$, which 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

- More results are expected in the near future

- More results with better precision are expected with more data

- 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 $D_{s}^{+} \to \eta^{(')}e^{+}v$… can be expected in the near future

# Thank you!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