Charm Physics at BESIII

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Introduction

Precision measurement of charm decays provide rich information to probe for strong and weak effects

- **Unitarity test of CKM matrix: direct access quark mixing matrix element $|V_{cs(d)}|$ or strong phase constrained γ/ϕ_3**

- **LQCD calibration: precise decay constant $f_{D(s)+}$, form factors $f_{D\to K(\pi)}(q^2)$ and others**

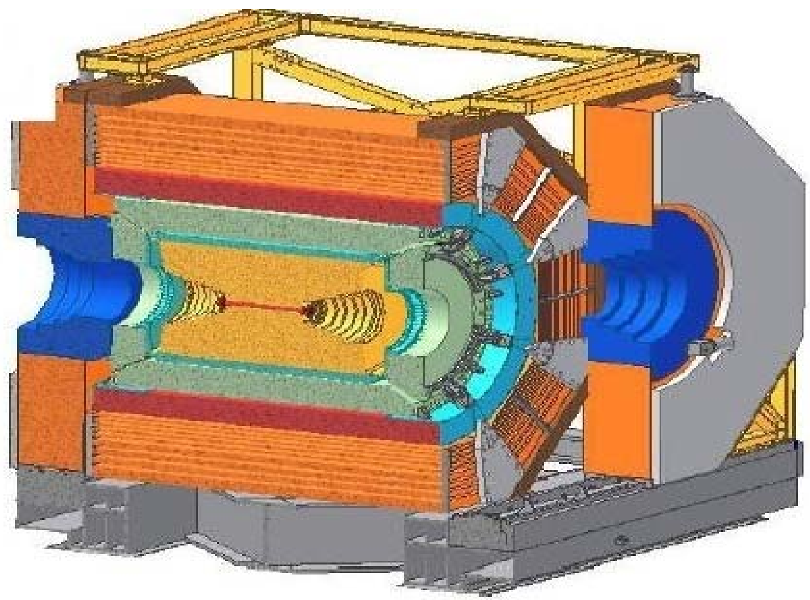
- **New physics BSM: evidence of rare decay/CP violation, or significant deviation of CKM untarity/LQCD calculation**

- **Better inputs for beauty physics: Significantly improved decay rates or dynamics**

Samples of Charm decays

Designed luminosity is 1×10^{33} cm^{-2}s^{-1} at $\psi(3770)$

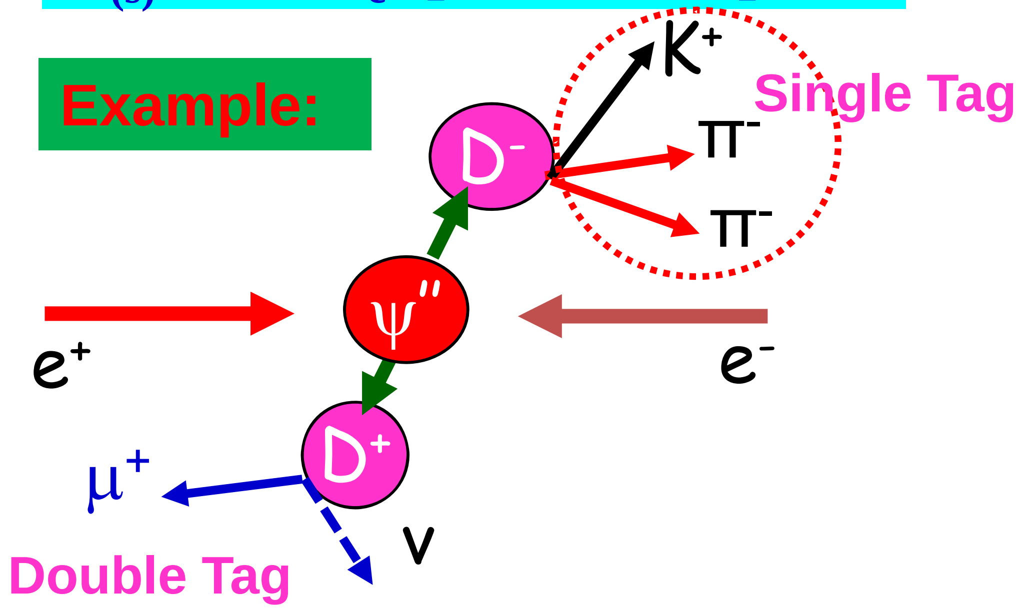
Highest luminosity reached 0.85×10^{33} cm^{-2}s^{-1} at $\psi(3770)$ in 2014



The parameters of each sub-detectors can be found in previous talks

2.92/0.48/0.57 fb^{-1} data at 3.773/4.009/4.6 GeV, where $D_{(s)}^{0(+)}$ or Λ_c^+ produce in pair

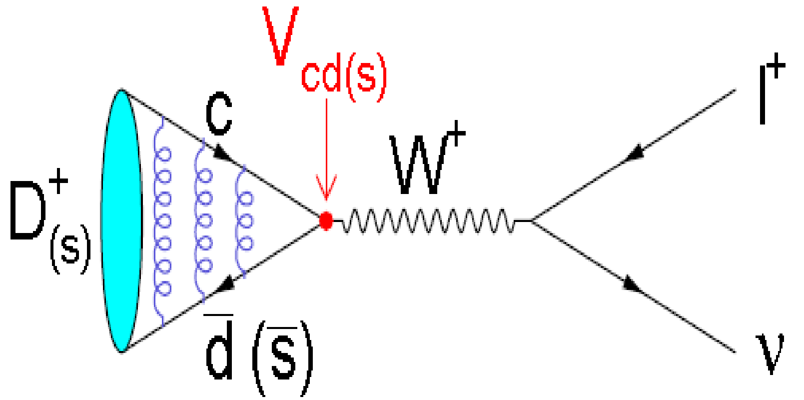
Example:

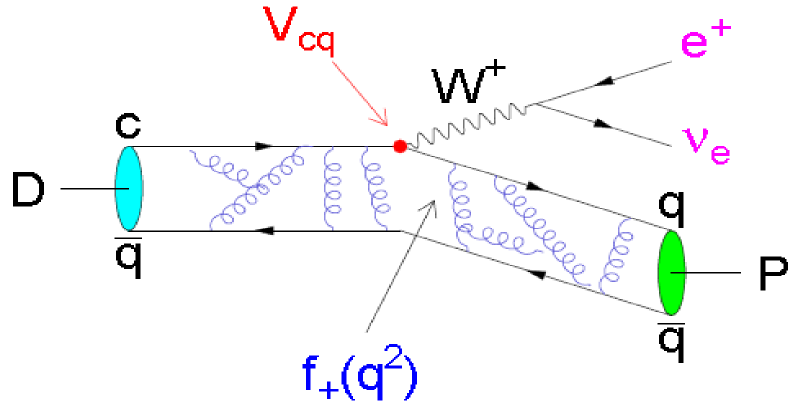


Clean sample of singly tagged charmed mesons (baryons) can be fully reconstructed by hadronic decays with large BFs and less combinatorial backgrounds. Based on which, one can access to absolute BFs and dynamics in the decays.

D leptonic and semileptonic decays

Bridge to extract $D_{(s)}^{+}$ decay constant(s), form factors and quark mixing matrix elements $|V_{cs(d)}|$





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

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

- **Improved decay constant $f_{D(s)+}$, form factor $f_{+}^{D\to K(\pi)}(q^2)$ of semi-leptonic decays of D mesons calibrate LQCD calculations at higher accuracy. Once they pass experimental test, the precise LQCD calculations of f_D/f_B, f_{Ds}/f_{Bs} and form factor ratios are helpful for measurements in B decays**

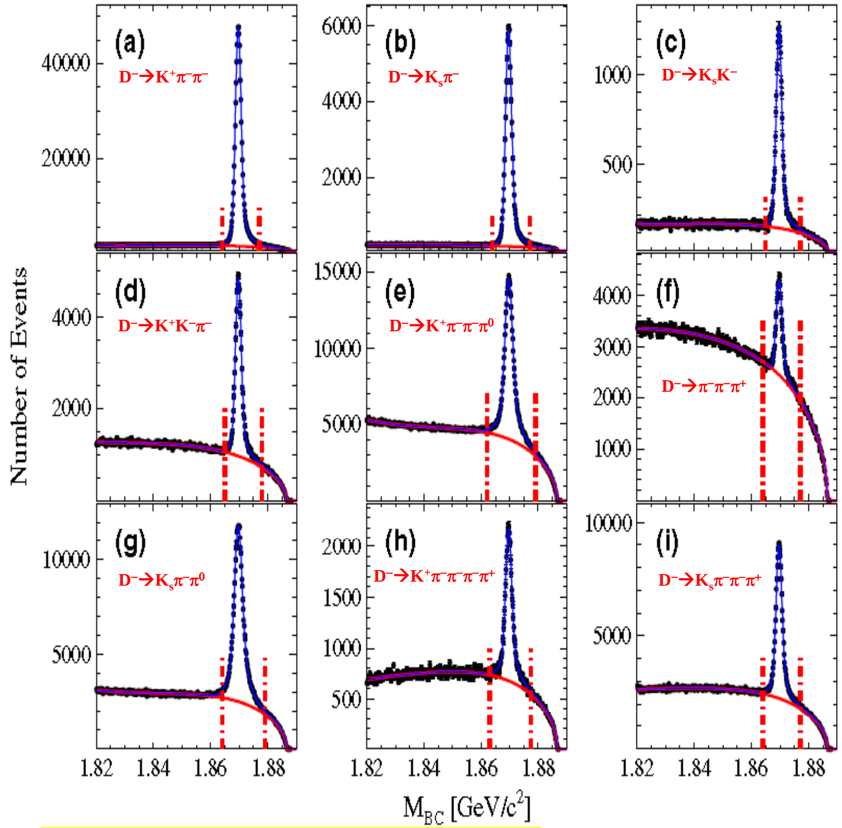
- **Recent LQCD calculations on $f_{D(s)+}$[0.5(0.5)%], $f_{+}^{D\to K(\pi)}(0)$ [1.7(4.4)%] provide good chance to precisely measure the CKM matrix element $|V_{cs(d)}|$.**

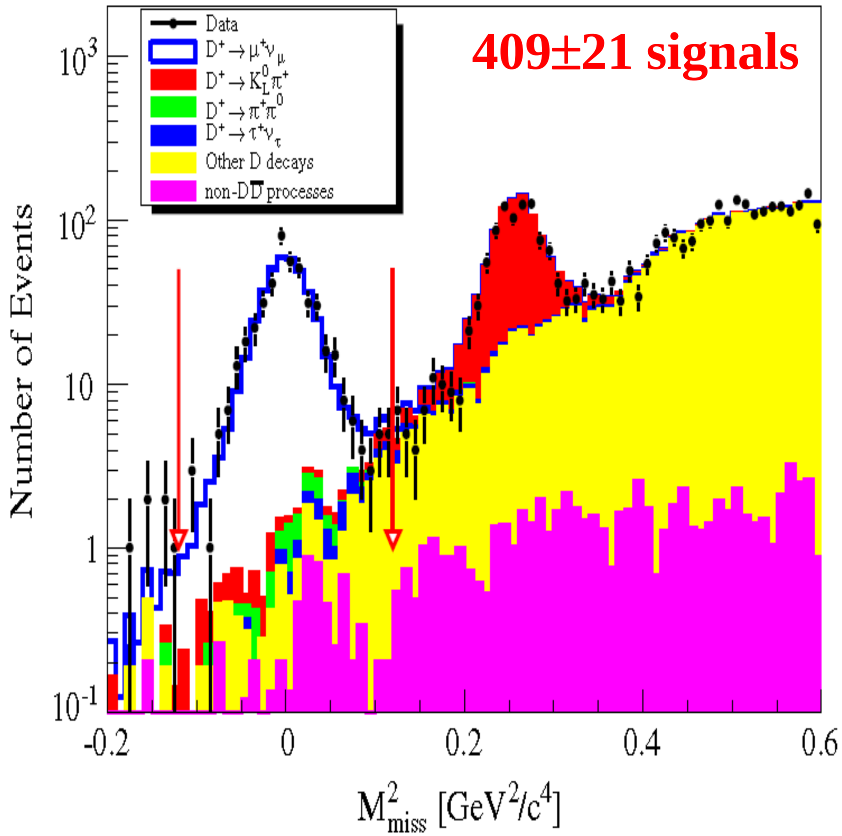
Measurement of $B[D^+ \to \mu^+ \nu]$, f_{D+} and $|V_{cd}|$

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

2.92 fb^{-1} data@ 3.773 GeV

PRD89(2014)051104R





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

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

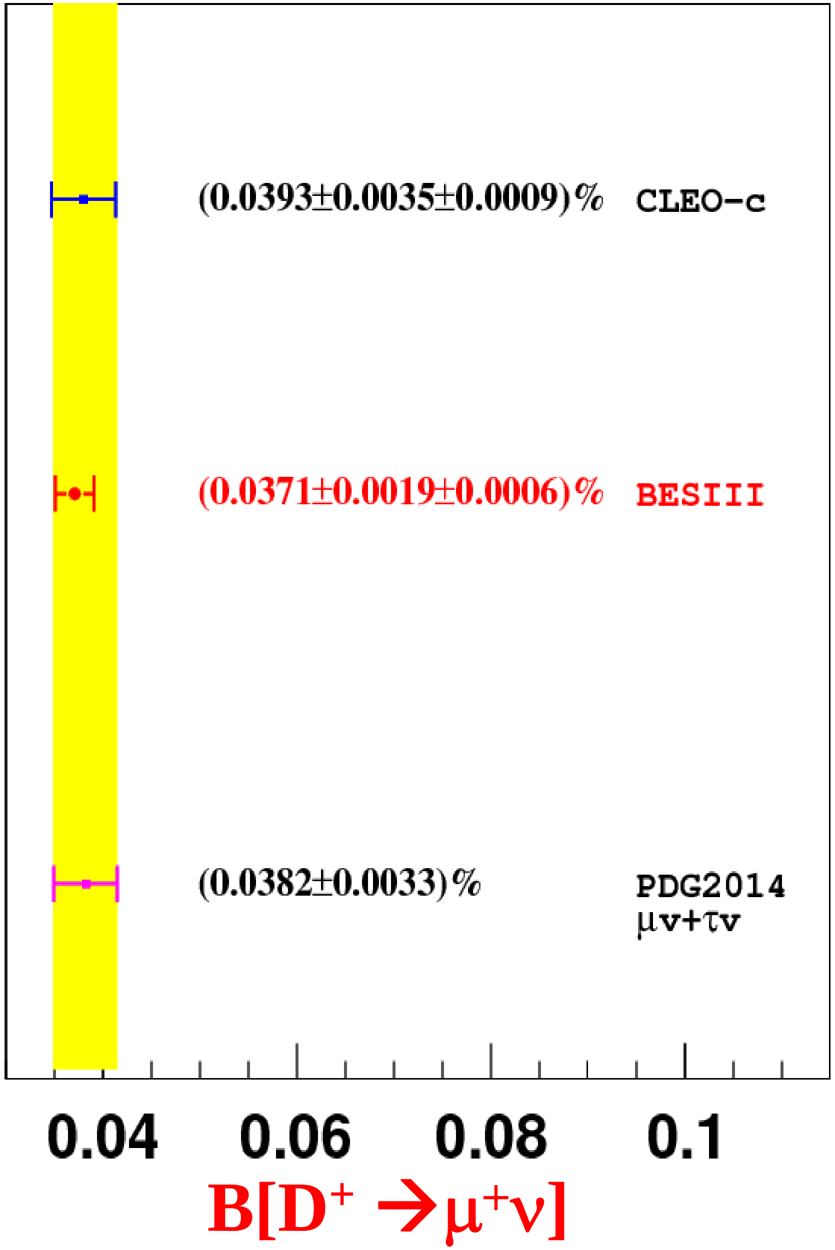
Input t_{D+}, m_{D+}, $m_{\mu+}$ on PDG and $|V_{cd}|$ of CKM-Fitter

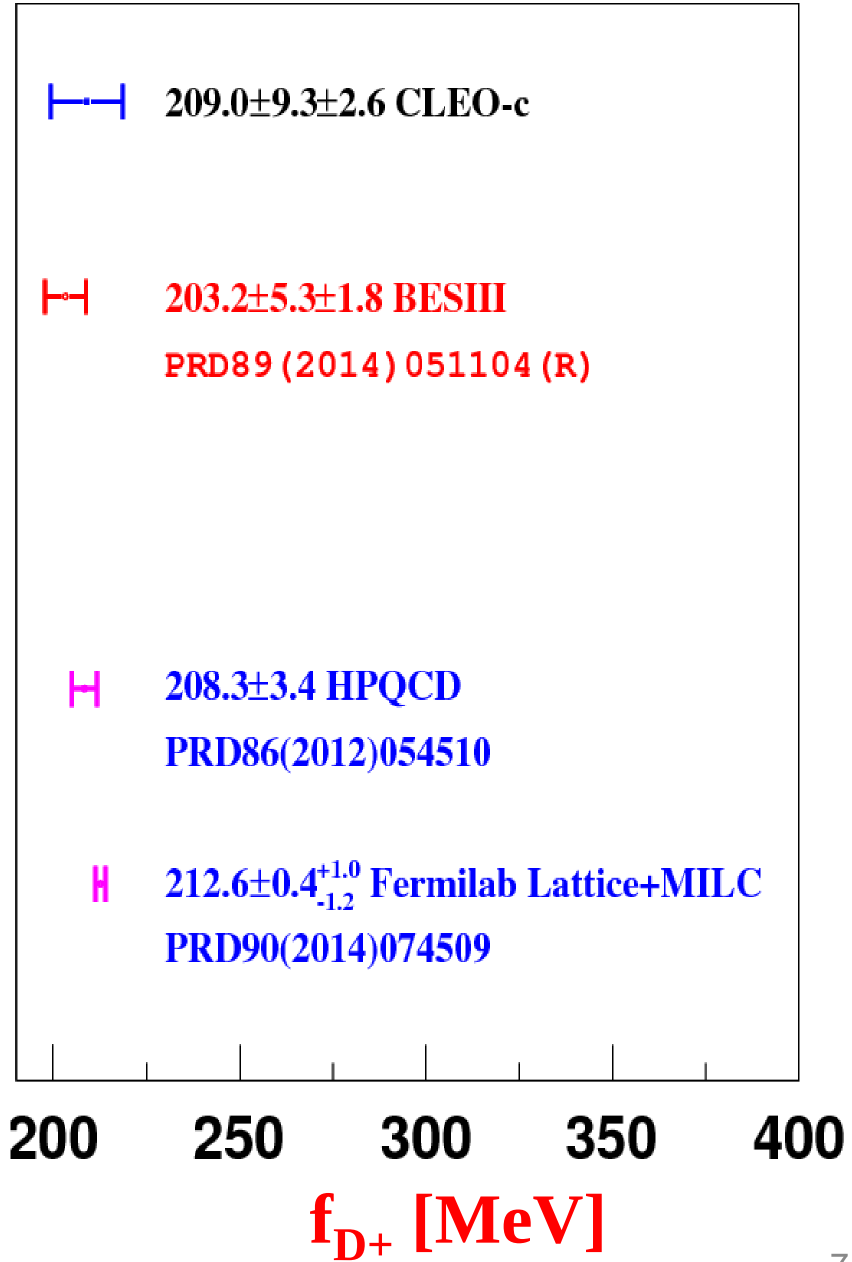
$f_{D+} = (203.2 \pm 5.3 \pm 1.8)$ MeV

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

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

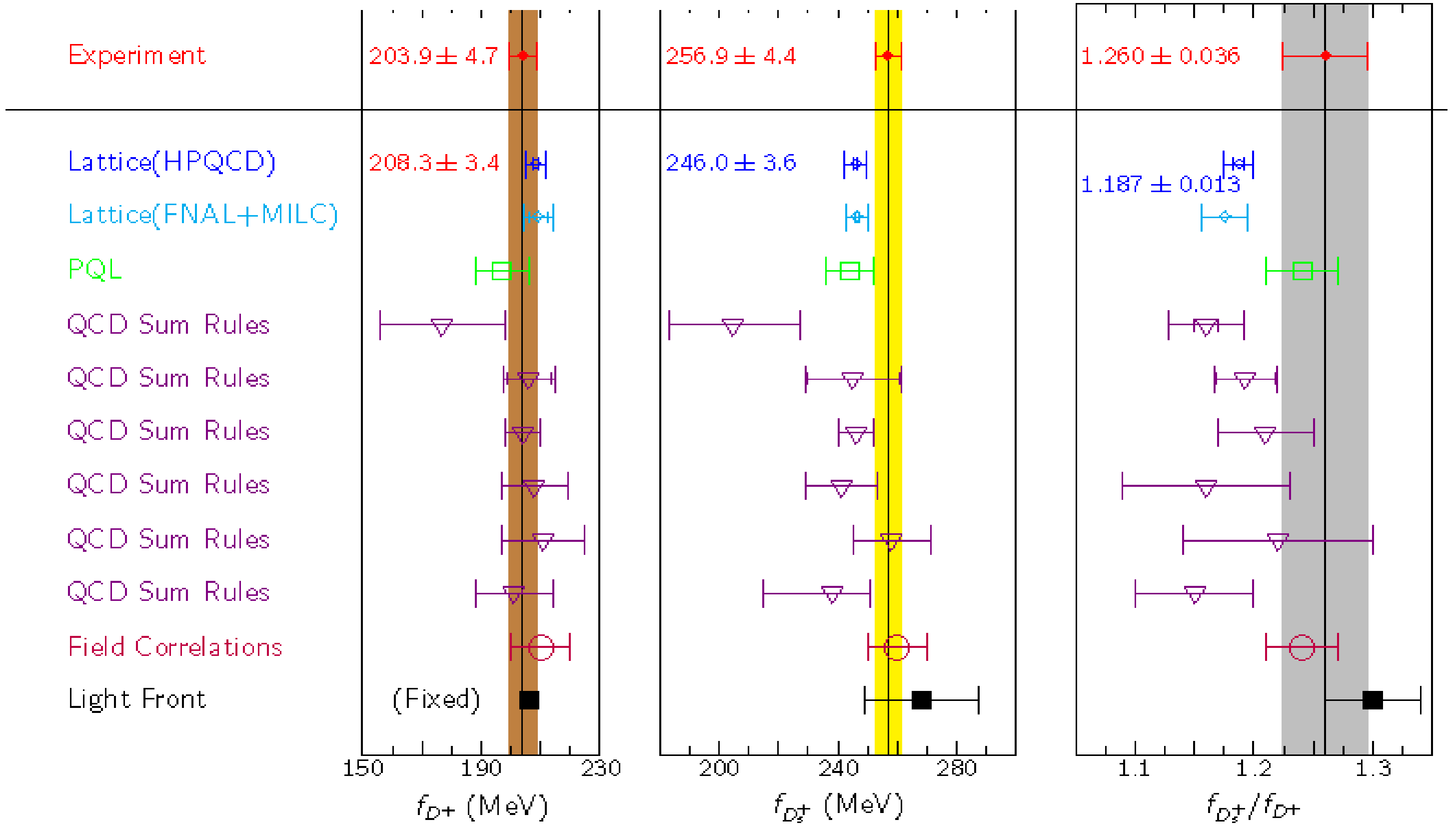
Comparisons of $B[D^+ \to \mu^+ \nu_\mu]$ and f_{D^+}





Comparisons of existing f_{D+}, f_{Ds+} and $f_{D+}:f_{Ds+}$

Taken from Gang Rong's talk at CKM2014

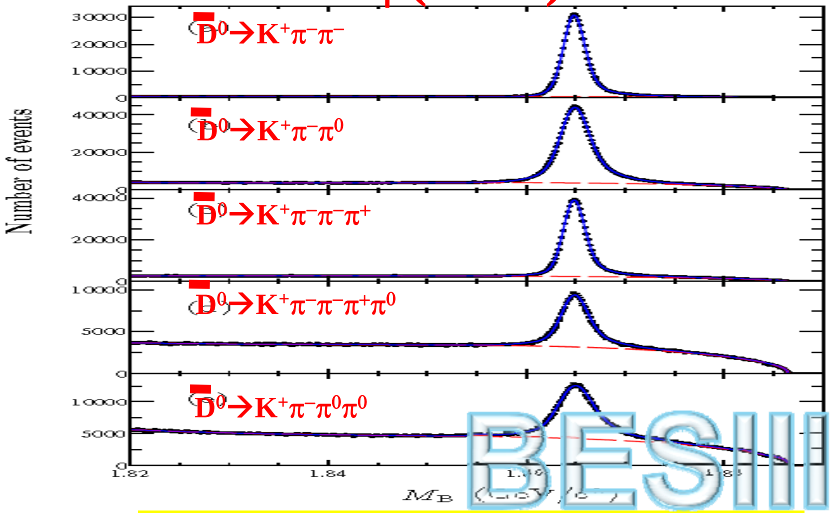


- Precisions of the LQCD calculations of f_{D+}, f_{Ds+}, $f_{D+}:f_{Ds}$ reach 0.5%, 0.5% and 0.3%, which are challenging the experiments
- Experimentally measured and theoretical expected f_{D+}, f_{Ds+}, $f_{D+}:f_{Ds+}$ differ by about 2σ
- Improving measurement at BESIII

	Experiments	Femilab Lattice+MILC (2014)		HPQCD (2012)	
	Averaged	Expected	Δ	Expected	Δ
f_{D+}(MeV)	203.9±4.7	$212.6\pm0.4^{+1.0}_{-1.2}$	1.8σ	208.3±3.4	0.8σ
f_{Ds+}(MeV)	256.9±4.4	$249.0\pm0.3^{+1.1}_{-1.5}$	1.7σ	246.0±3.6	1.4σ
$f_{D+}:f_{Ds+}$	1.260±0.036	$1.1712\pm0.0010^{+0.0029}_{-0.0032}$	2.5σ	1.187±0.013	1.9σ

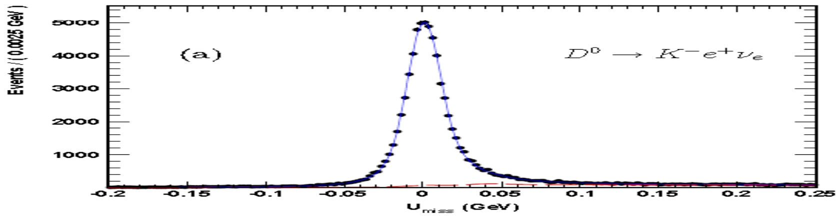
Measurement of B[$D^0 \rightarrow K(\pi)^- e^+ \nu$]

$e^+e^- \rightarrow \psi(3770) \rightarrow D^0\bar{D}^0$

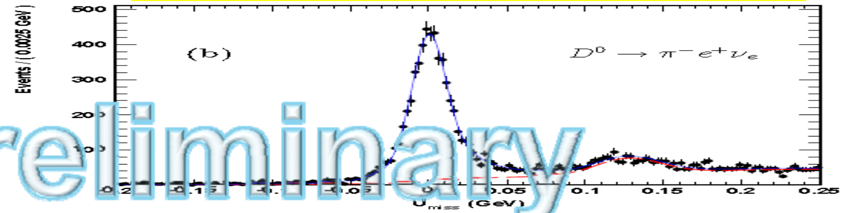


$N_{\bar{D}^0_{tag}} = (279.33 \pm 0.37) \times 10^4$

Submitted to PRD, arxiV:1508.07560 [hep]

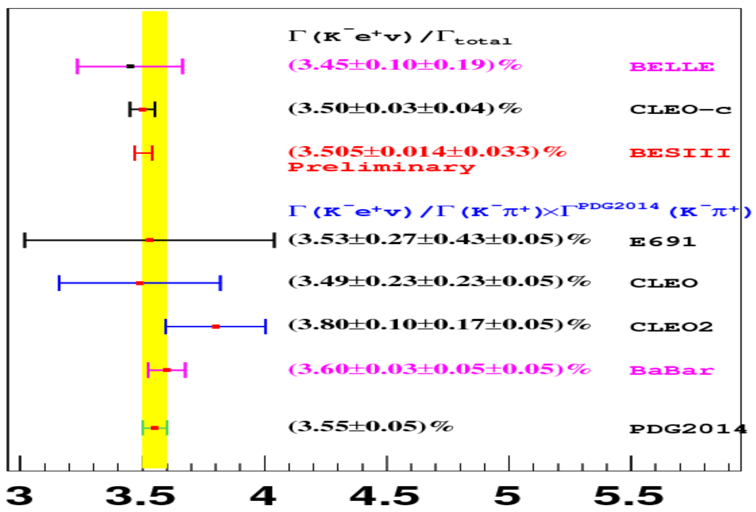


$B_{D^0 \rightarrow K^- e^+ \nu} = (3.505 \pm 0.014 \pm 0.033)\%$

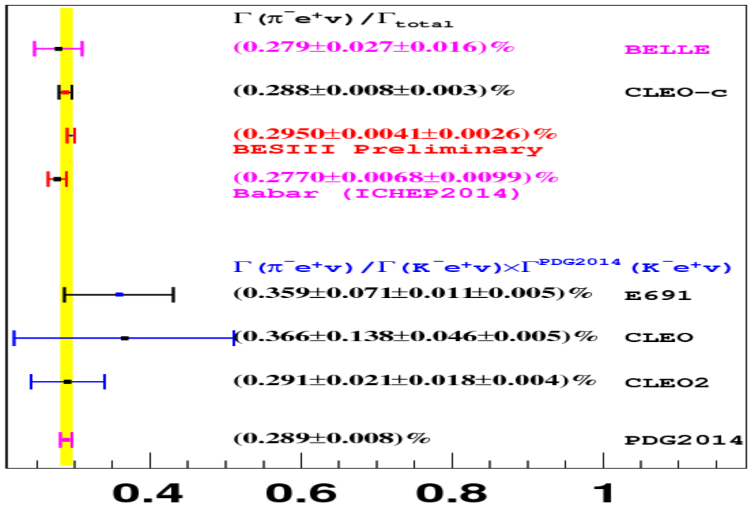


BESIII Preliminary

$B_{D^0 \rightarrow \pi^- e^+ \nu} = (0.2950 \pm 0.0041 \pm 0.0026)\%$

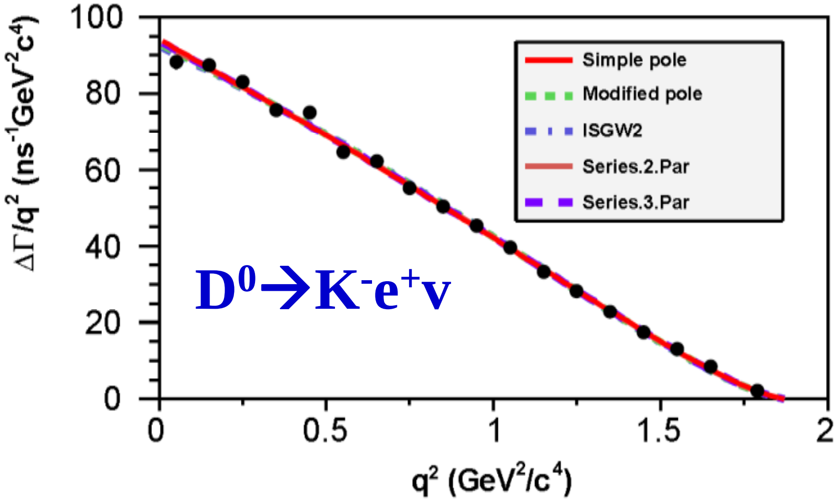


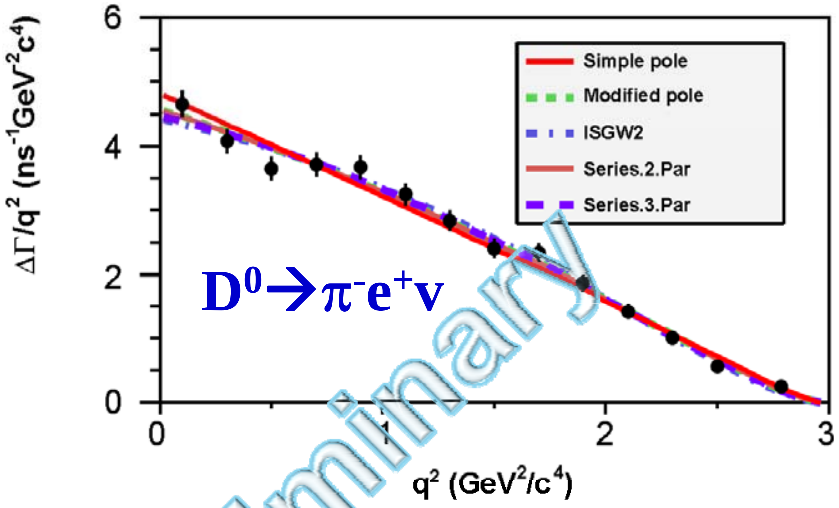
B[$D^0 \rightarrow K^- e^+ \nu$]



B[$D^0 \rightarrow \pi^- e^+ \nu$]

Extracted Parameters of Form Factors





BESIII Preliminary

– **Single pole form**

$$f_+(q^2) = \frac{f_+(0)}{1 - \frac{q^2}{M_{\rm pole}^2}}$$

– **ISGW2 model**

$$f_+(q^2) = f_+(q^2_{\rm max}) \left(1 + \frac{r^2_{\rm ISGW2}}{12}(q^2_{\rm max} - q^2)\right)^{-2}$$

– **Modified pole model**

$$f_+(q^2) = \frac{f_+(0)}{(1 - \frac{q^2}{M_{\rm pole}^2})(1 - \alpha\frac{q^2}{M_{\rm pole}^2})}$$

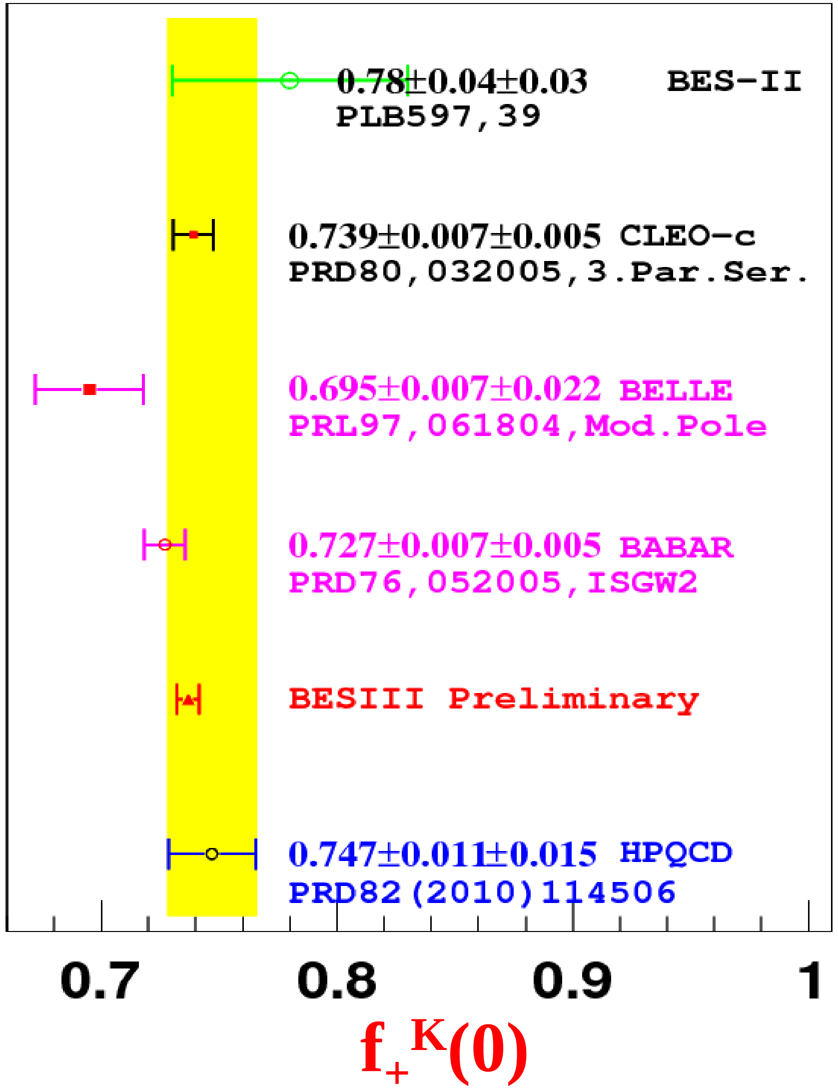
– **Series expansion model**

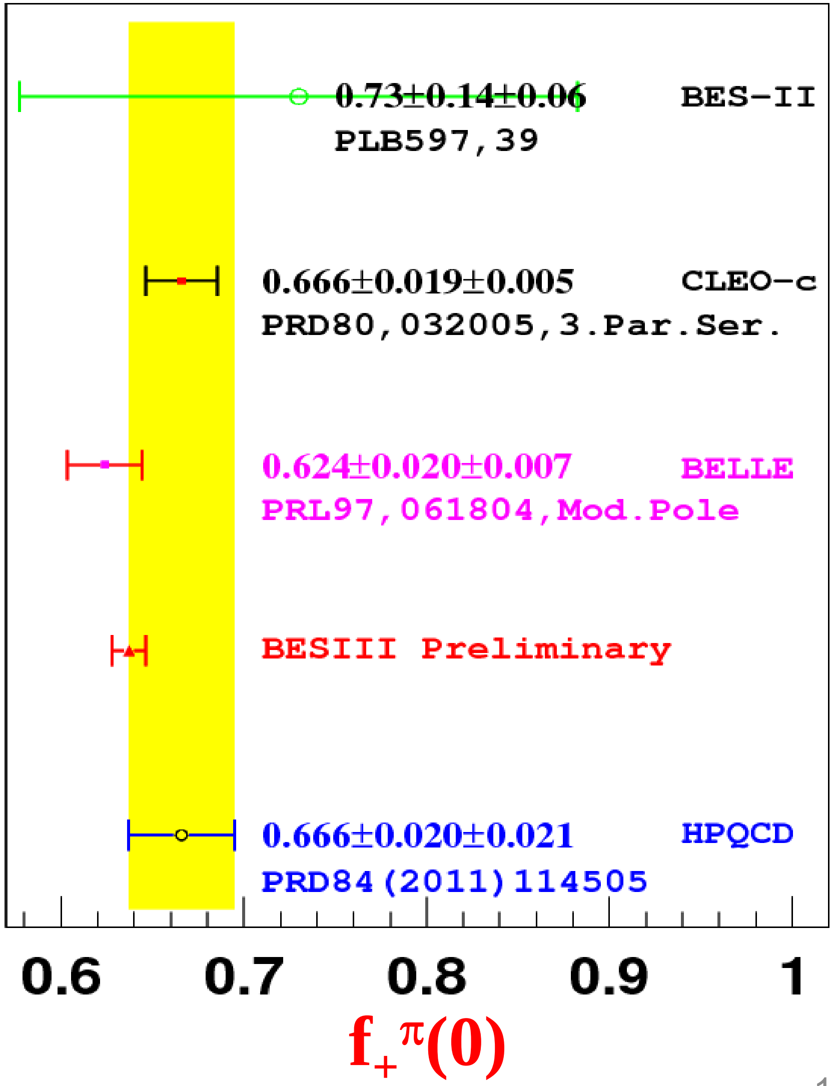
$$f_+(t) = \frac{1}{P(t)\Phi(t,t_0)} a_0(t_0) \left(1 + \sum_{k=1}^{\infty} r_k(t_0)[z(t,t_0)]^k\right)$$

		$D^0 \to K^- e^+ v$		$D^0 \to \pi^- e^+ v$
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
ISGW2	$f_K^+(0)\|V_{cs}\|$	0.7139±0.0023±0.0034	$f_\pi^+(0)\|V_{cd}\|$	0.1415±0.0016±0.0006
	r_{ISGW2}	1.6000±0.0141±0.0091	r_{ISGW2}	2.0688±0.0394±0.0124
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

Measurement of $f_+^{K(\pi)}(0)$

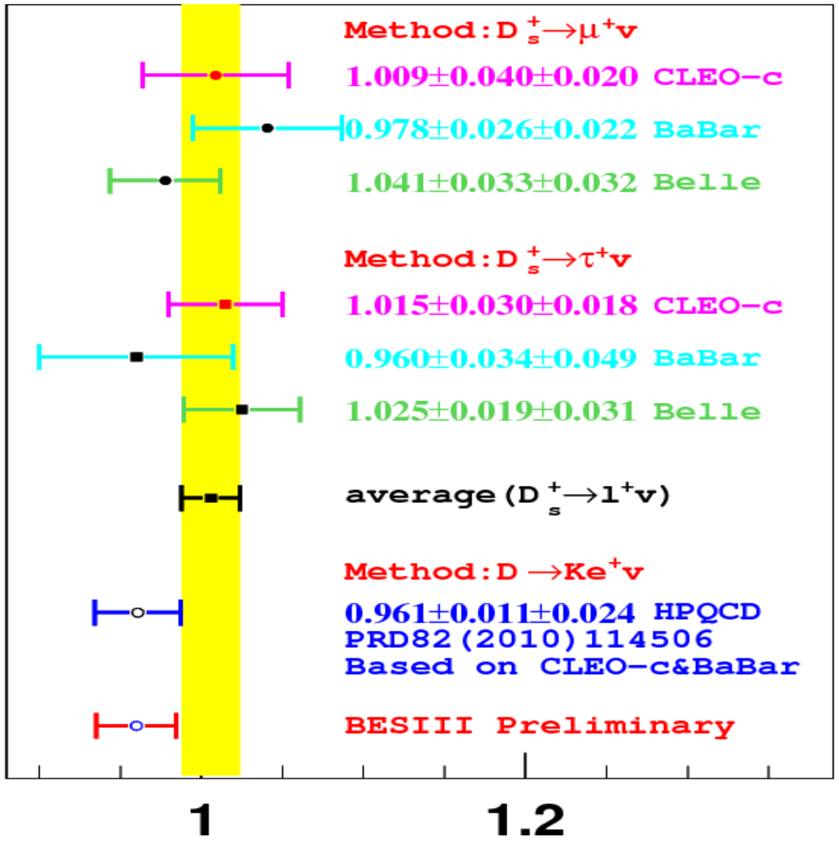
$f^{D\to K(\pi)}_+(0)|V_{cs(d)}|$ → Input $|V_{cs(d)}|$ of CKM-Fitter → $f^{D\to K(\pi)}_+(0)$

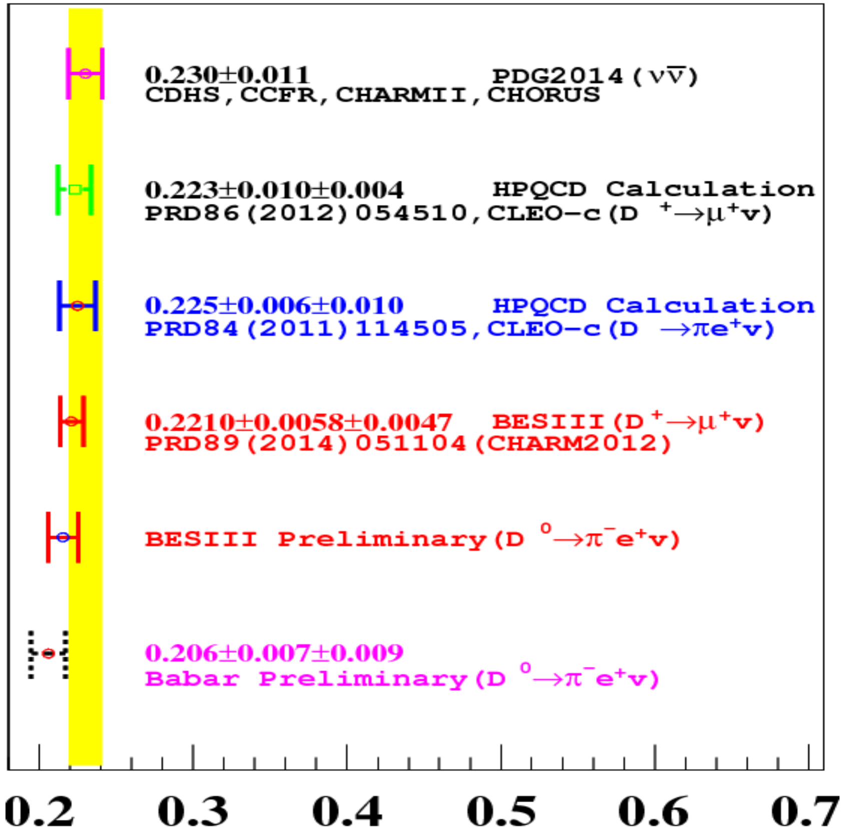




Measurement of $|V_{cs(d)}|$

- **Method 1** — $B[D_{(s)}^{+} \to l^{+}\nu]$ — Input t_{D+}, m_{D+}, $m_{\mu+}$ on PDG and LQCD calculated $f_{D(s)+}$ → $|V_{cd(s)}|$
- **Method 2** — $f^{D\to K(\pi)}_{+}(0)|V_{cs(d)}|$ — Input $f^{D\to K(\pi)}_{+}(0)$ of LQCD → $|V_{cs(d)}|$





Method 2 suffers larger theoretical uncertainty in $f_{+}^{D\to K(\pi)}(0)$ [1.7(4.4)%]

Analysis of $D^+ \rightarrow K_L e^+ v$

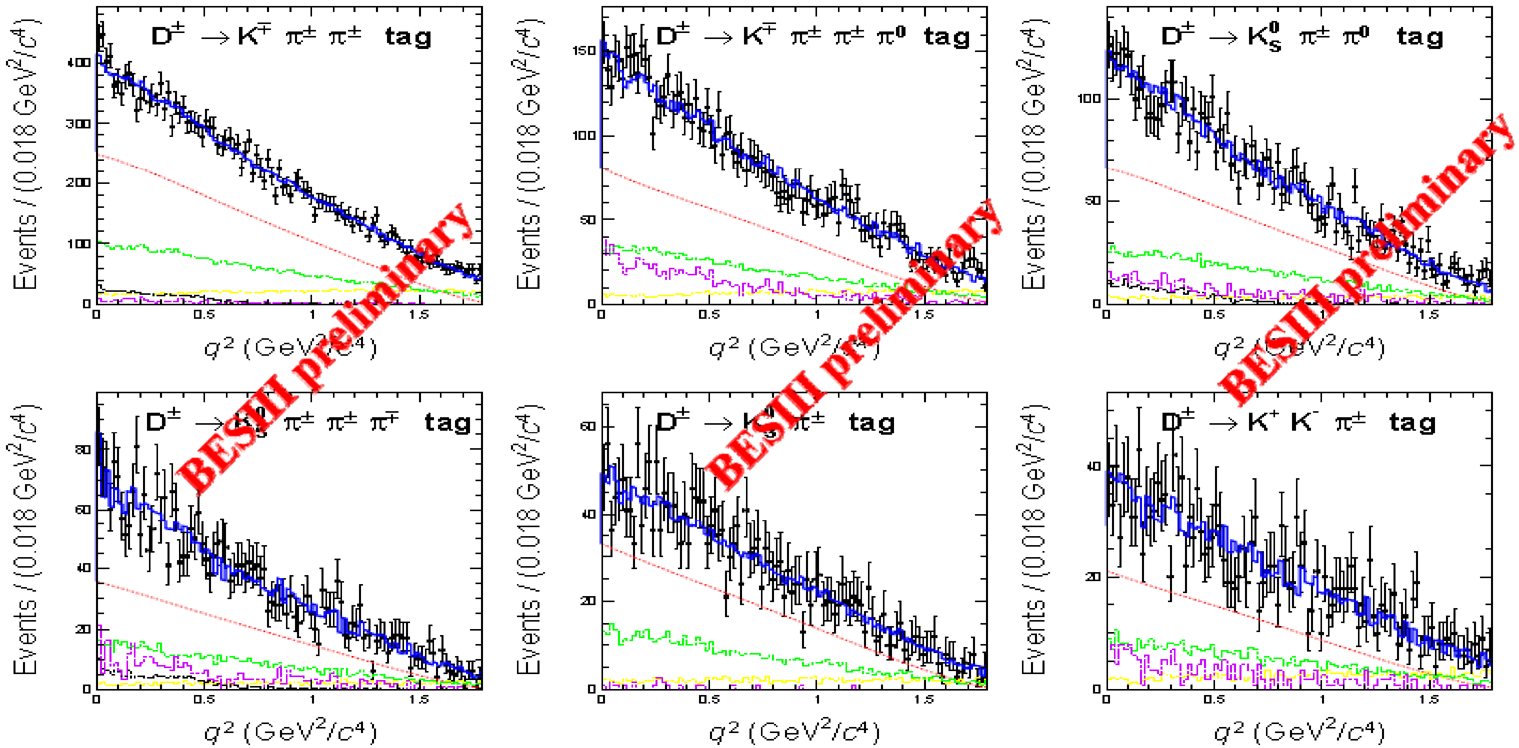
- Regardless of long flight distance, K_L interact with EMC and deposit part of energy, thus giving position information
- After reconstructing all other particles, K_L can be inferred with position information and constraint $U_{miss} \rightarrow 0$.

$\bar{B}(D^+ \rightarrow K_L e^+ v) = (4.482 \pm 0.027 \pm 0.103)\%$

$$A_{CP} \equiv \frac{\mathcal{B}(D^+ \to K_L^0 e^+ \nu_e) - \mathcal{B}(D^- \to K_L^0 e^- \bar{\nu}_e)}{\mathcal{B}(D^+ \to K_L^0 e^+ \nu_e) + \mathcal{B}(D^- \to K_L^0 e^- \bar{\nu}_e)}$$

$A_{CP}^{D+ \rightarrow KLe+v} = (-0.59 \pm 0.60 \pm 1.50)\%$

Simultaneous fit to event density $I(q^2)$ with 2-par. series Form Factor



$D^+ \rightarrow K_L e+v$ is measured for the first time

$f^K_+(0)|V_{cs}| = 0.728 \pm 0.006 \pm 0.011$

$r_1 = a_1/a_0 = -1.91 \pm 0.33 \pm 0.24$

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

- **Fractions with >5σ significance**

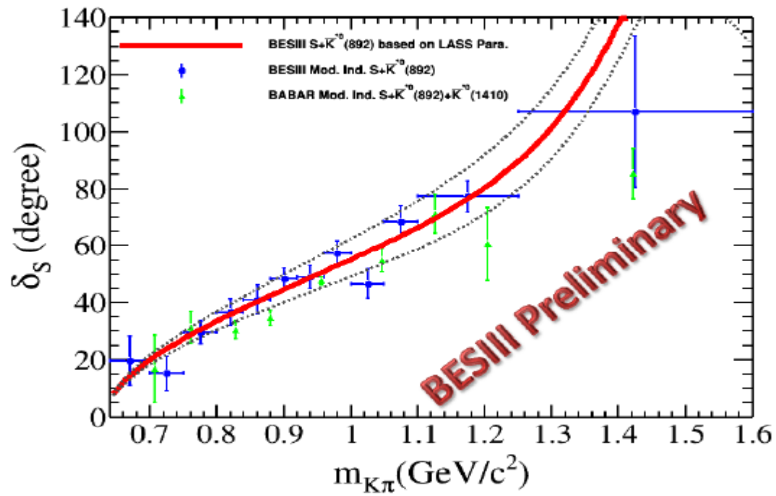
$$f(D^+ \to (K^-\pi^+)_{K^{*0}(892)}\, e^+\nu_e) = (93.93 \pm 0.22 \pm 0.18)\%$$

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

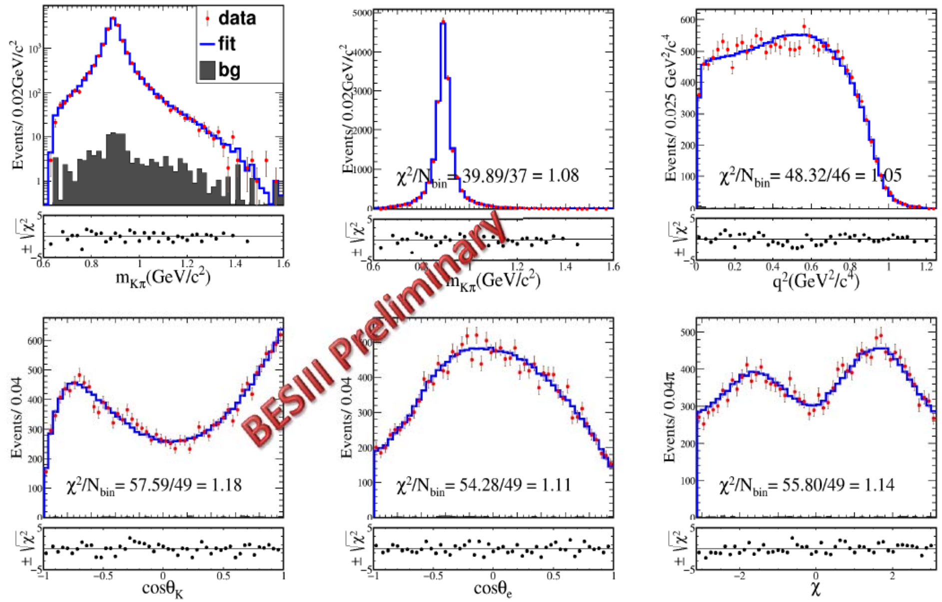
- **Properties of different Kπ (non-) resonant amplitudes**

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

Model independent S-wave phase measurement



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



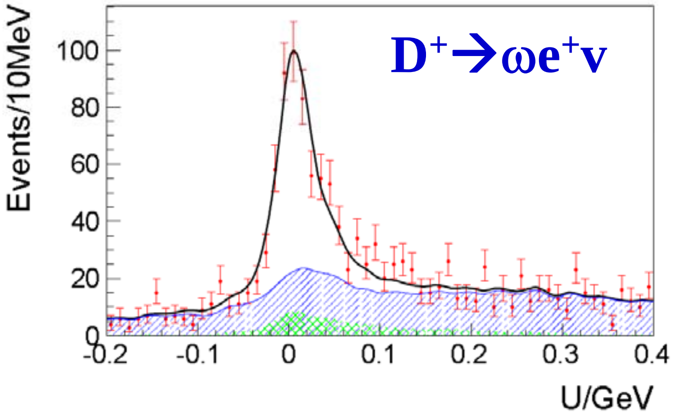
$$V(q^2) = \frac{V(0)}{1-q^2/m_V^2},\quad A_{1,2}(q^2) = \frac{A_{1,2}(0)}{1-q^2/m_A^2}$$

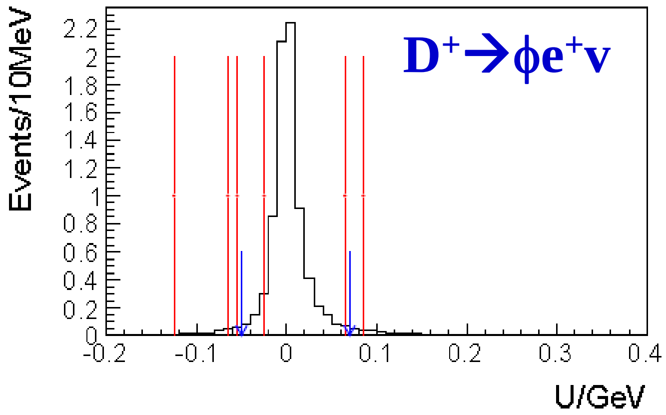
$M_{V/A}$ is expected to $M_{D^*(1-/+)}$

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

Model independent form factors

Study of $D^+ \to \omega e^+ \nu$ and search for $D^+ \to \phi e^+ \nu$

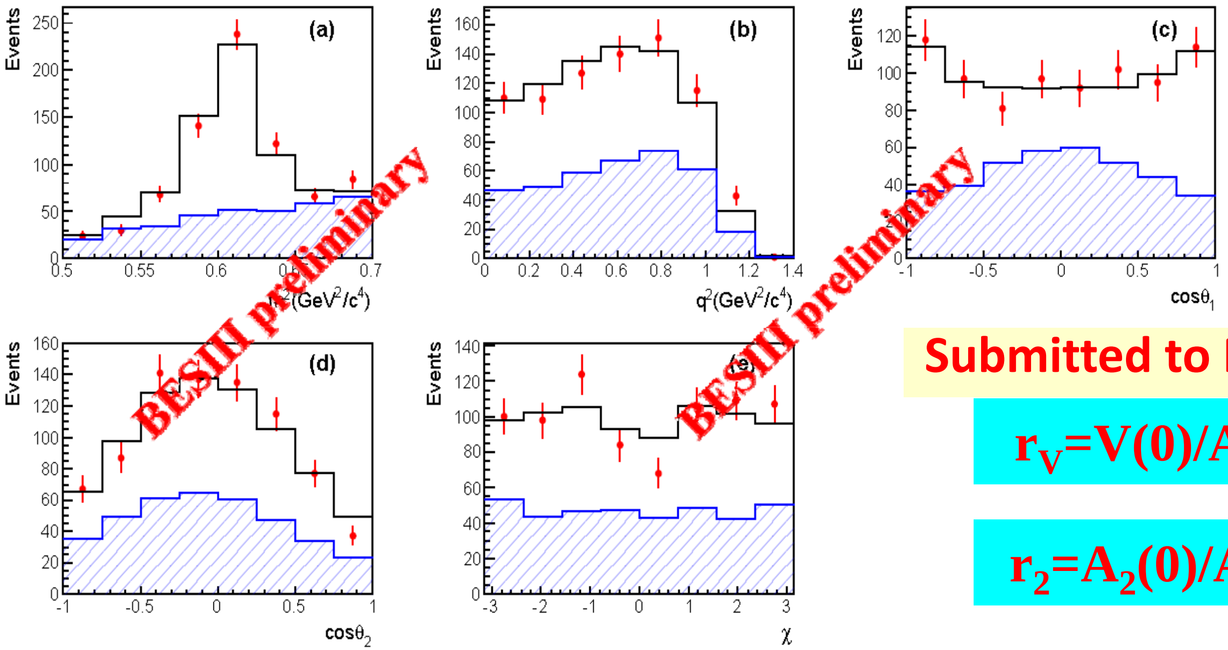




$B[D^+ \to \omega e^+ \nu] = (1.63 \pm 0.11 \pm 0.08) \times 10^{-3}$

$B[D^+ \to \phi e^+ \nu] < 1.3 \times 10^{-5}$ at 90% C.L.

Better precision or sensitivity



Amplitude analysis of $D^+ \to \omega e^+ \nu$ is performed for the first time

Submitted to PRD, arxiV:1508.00151 [hep]

$r_V = V(0)/A_1(0) = 1.24 \pm 0.09 \pm 0.06$

$r_2 = A_2(0)/A_1(0) = 1.06 \pm 0.15 \pm 0.05$

D hadronic decays

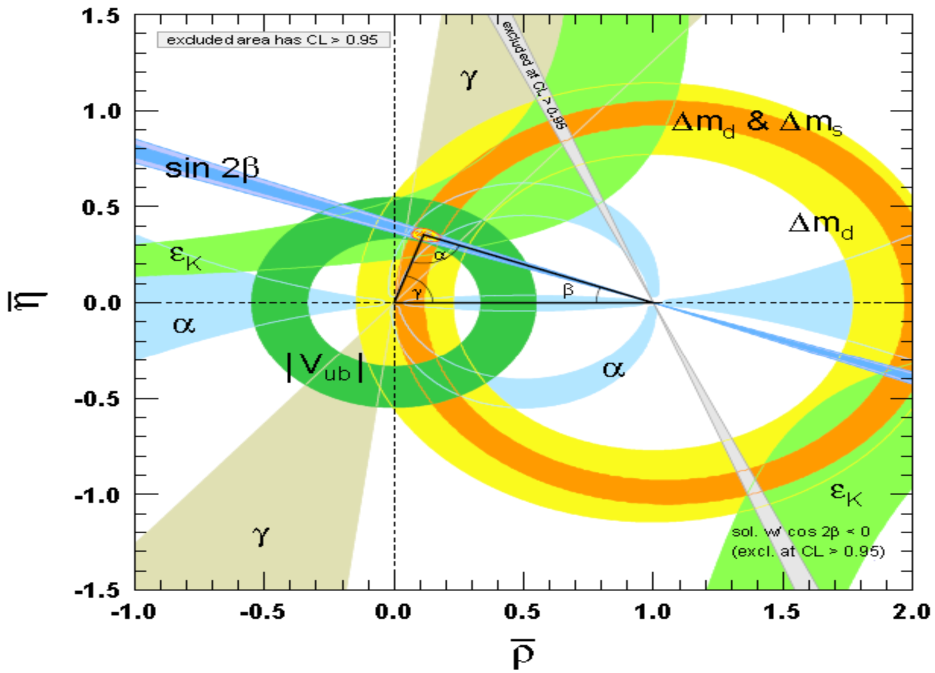
- **Provide better inputs for beauty physics**
- **Open a window into strong final-state interactions**
- **Quantum correlated D^0 decays:**
  - **CP asymmetry in mixing and decays**
  - **Interference → strong phase parameters c_i and s_i → Impact on γ/ϕ_3, which is important for CKM UT**

Direct measurement

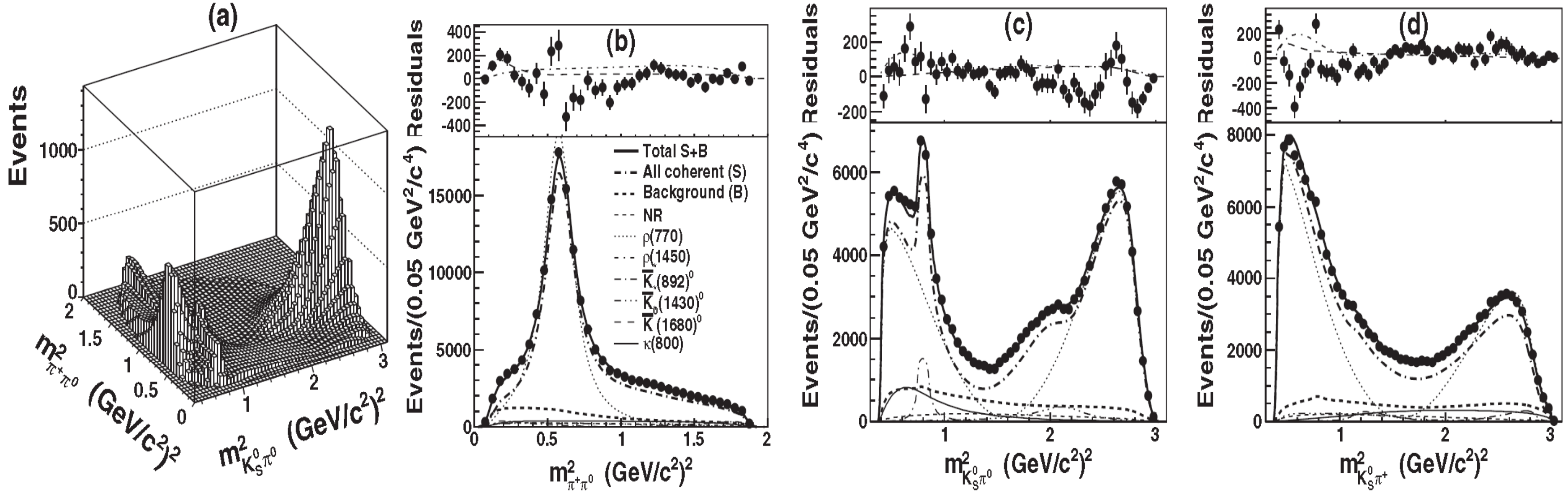
$$\alpha/\phi_2 = \left(85.4^{+4.0}_{-3.9}\right)^\circ$$
$$\beta/\phi_1 = \left(21.38^{+0.79}_{-0.77}\right)^\circ$$
$$\gamma/\phi_3 = \left(68^{+8.0}_{-8.5}\right)^\circ$$

γ is the worst measured angle, mostly due to systematic error

Significant deviation from UT implies NP beyond SM



Dalitz Plot Analysis of $D^+ \rightarrow K_s^0 \pi^+ \pi^0$



PRD89(2014)052001

TABLE IV. Partial branching fractions calculated by combining our fit fractions with the PDG's $D^+ \to K_S^0\pi^+\pi^0$ branching ratio. The errors shown are statistical, experimental systematic, and modeling systematic, respectively.

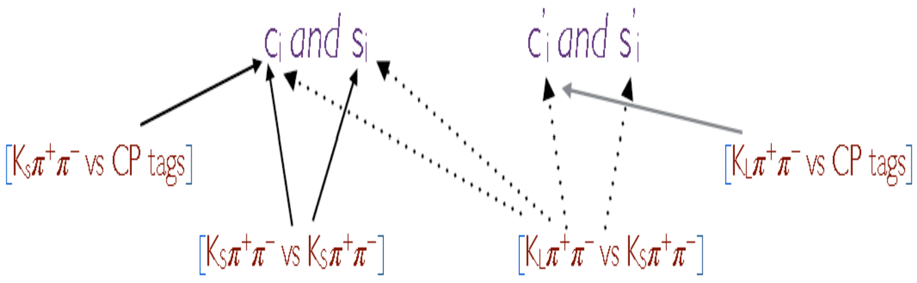
Mode	Partial branching fraction (%)
$D^+ \to K_S^0\pi^+\pi^0$ nonresonant	$0.32 \pm 0.05 \pm 0.25^{+0.28}_{-0.25}$
$D^+ \to \rho^+ K_S^0$, $\rho^+ \to \pi^+\pi^0$	$5.83 \pm 0.16 \pm 0.30^{+0.45}_{-0.15}$
$D^+ \to \rho(1450)^+ K_S^0$, $\rho(1450)^+ \to \pi^+\pi^0$	$0.15 \pm 0.02 \pm 0.09^{+0.07}_{-0.11}$
$D^+ \to \bar{K}^*(892)^0\pi^+$, $\bar{K}^*(892)^0 \to K_S^0\pi^0$	$0.250 \pm 0.012 \pm 0.015^{+0.025}_{-0.024}$
$D^+ \to \bar{K}_0^*(1430)^0\pi^+$, $\bar{K}_0^*(1430)^0 \to K_S^0\pi^0$	$0.26 \pm 0.04 \pm 0.05 \pm 0.06$
$D^+ \to \bar{K}^*(1680)^0\pi^+$, $\bar{K}^*(1680)^0 \to K_S^0\pi^0$	$0.09 \pm 0.01 \pm 0.05^{+0.04}_{-0.08}$
$D^+ \to \bar{\kappa}^0\pi^+$, $\bar{\kappa}^0 \to K_S^0\pi^0$	$0.54 \pm 0.09 \pm 0.28^{+0.36}_{-0.19}$
$NR + \bar{\kappa}^0\pi^+$	$1.30 \pm 0.12 \pm 0.12^{+0.12}_{-0.30}$
$K_S^0\pi^0$ S-wave	$1.21 \pm 0.10 \pm 0.16^{+0.19}_{-0.27}$

Dalitz Plot Analysis of charm meson decays can provide rich information about parameters of sub-resonances and strong phases

Phase difference c_i&s_i by $D^0 \to \bar{K}^0\pi^+\pi^-$

c_i, s_i can be measured using the Double Tags:

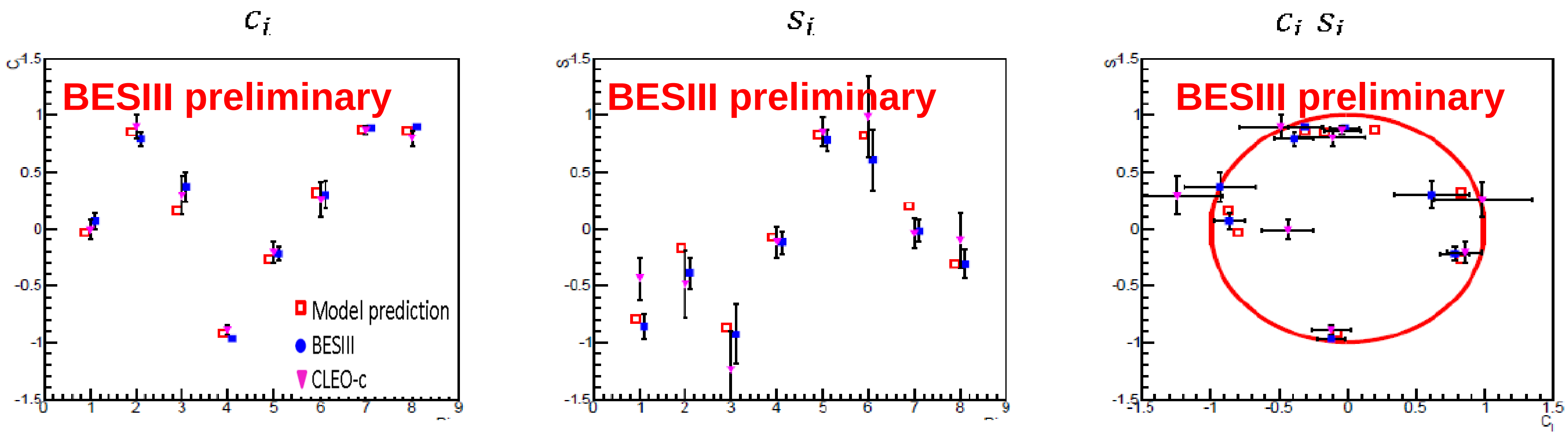
$D^0 \to K_S\pi^+\pi^-$ vs ($K_{S/L}\pi^+\pi^-$ or CP tags)



Use both (c_i,s_i) and (c_i',s_i') to further constrain the results (c_i,s_i)

Bins	c_i BES-III	c_i CLEO-c	s_i BES-III	s_i CLEO-c
1	0.066 ± 0.066	-0.009 ± 0.088	-0.843 ± 0.119	-0.438 ± 0.184
2	0.796 ± 0.061	0.900 ± 0.106	-0.357 ± 0.148	-0.490 ± 0.295
3	0.361 ± 0.125	0.292 ± 0.168	-0.962 ± 0.258	-1.243 ± 0.341
4	-0.985 ± 0.017	-0.890 ± 0.041	-0.090 ± 0.093	-0.119 ± 0.141
5	-0.278 ± 0.056	-0.208 ± 0.085	0.778 ± 0.092	0.853 ± 0.123
6	0.267 ± 0.119	0.258 ± 0.155	0.635 ± 0.293	0.984 ± 0.357
7	0.902 ± 0.017	0.869 ± 0.034	-0.018 ± 0.103	-0.041 ± 0.132
8	0.888 ± 0.036	0.798 ± 0.070	-0.301 ± 0.140	-0.107 ± 0.240

BESIII only statistical error **CLEO-c PRD82,112006**

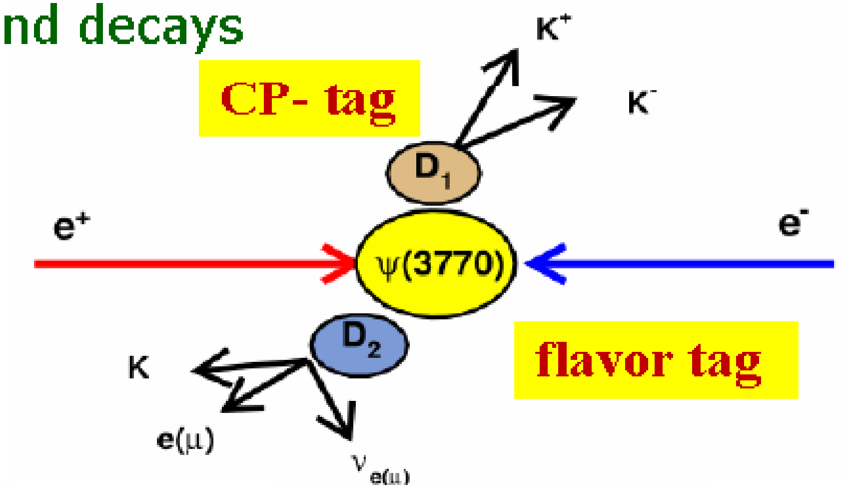


Consistent with CLEO-c with better statistical error

MC estimates these c_i&s_i contribute to γ uncertainty of $\pm 2.1^0$ with optimal binning, compared to Belle's current measurement of $\pm 4.3^0$ from CLEO-c's results

$D\bar{D}$ mixing parameter y_{CP}

We measure the y_{CP} using CP-tagged semi-leptonic D decays allow to access CP asymmetry in mixing and decays



Type	Modes
CP^+	K^+K^-, $\pi^+\pi^-$, $K_S\pi^0\pi^0$
CP^-	$K^0_S\pi^0$, $K^0_S\omega$, $K^0_S\eta$
$l^\pm$	$Ke\nu$, $K\mu\nu$

y_{CP}=(-2.1±1.3±0.7)%

PLB 744(2015)339

For D decay to CP eigenstates:

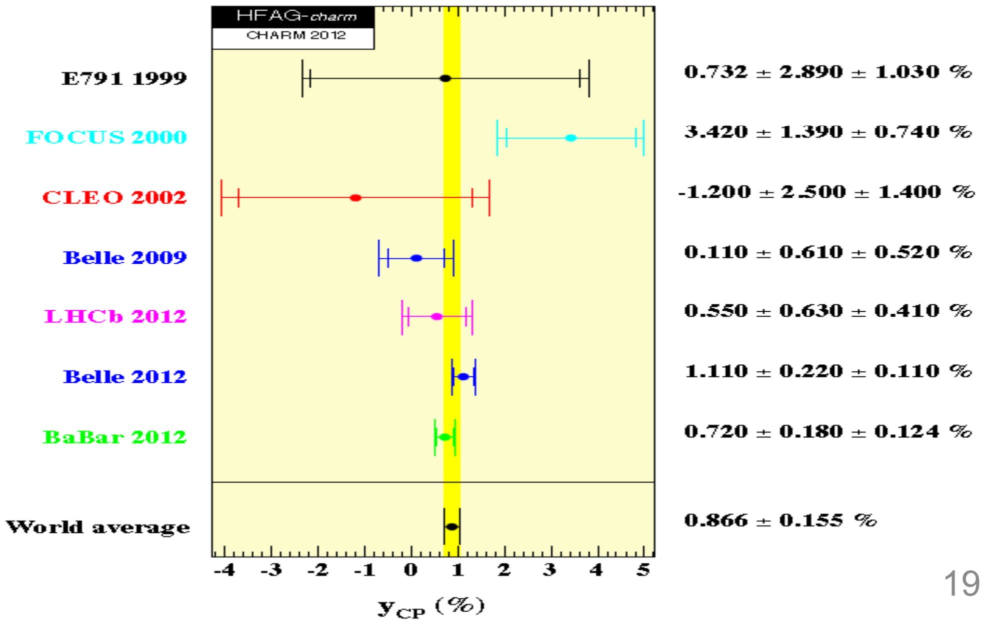
$$R_{CP\pm} \propto |A_{CP\pm}|^2(1 \mp y_{CP})$$

$$y_{CP} = \frac{1}{2}[y\cos\phi(|\frac{q}{p}| + |\frac{p}{q}|) - x\sin\phi(|\frac{q}{p}| - |\frac{p}{q}|)]$$

For CP tagged semileptonic D decays:

$$R_{l,CP\pm} \propto |A_l|^2|A_{CP\pm}|^2$$

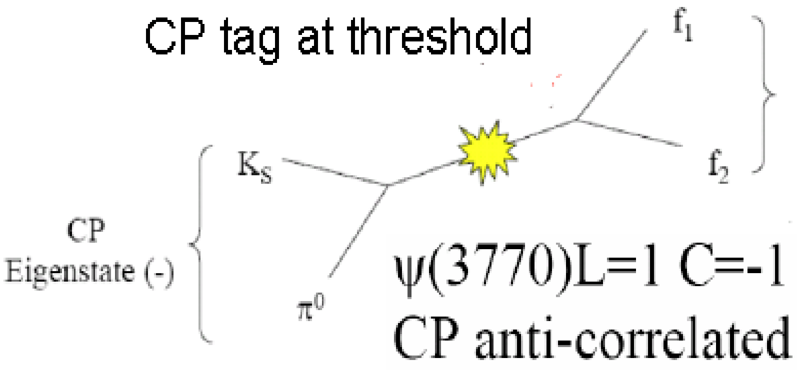
$$y_{CP} \approx \frac{1}{4}(\frac{R_{l;CP+}R_{CP-}}{R_{l;CP-}R_{CP+}} - \frac{R_{l;CP-}R_{CP+}}{R_{l;CP+}R_{CP-}})$$

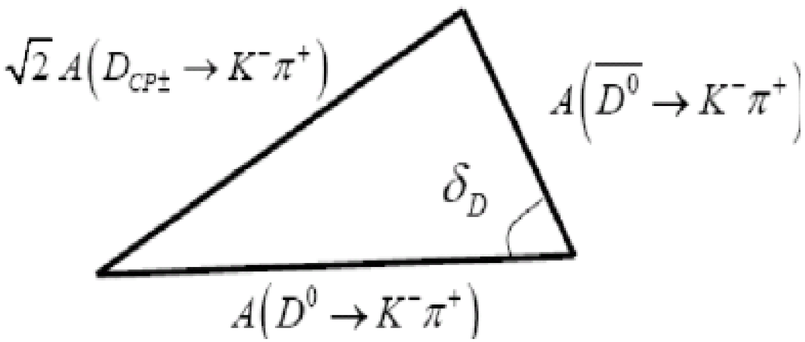


Strong phase difference $\delta_{K\pi}$

Quantum correlation → Interference → access strong phase!

If CP violation in charm is neglected: mass eigenstates = CP eigenstates





$$\mathcal{A}_{CP\to K\pi} = \frac{\mathcal{B}_{D_2\to K^-\pi^+} - \mathcal{B}_{D_1\to K^-\pi^+}}{\mathcal{B}_{D_2\to K^-\pi^+} + \mathcal{B}_{D_1\to K^-\pi^+}}.$$

$$2r\boxed{\cos\delta_{K\pi}} + y = (1 + R_{\rm WS}) \cdot \mathcal{A}_{CP\to K\pi},$$

$$|D_1\rangle \equiv \frac{|D^0\rangle + |\overline{D}^0\rangle}{\sqrt{2}} \quad |D_2\rangle \equiv \frac{|D^0\rangle - |\overline{D}^0\rangle}{\sqrt{2}}.$$

$A^{K\pi}_{CP}=(12.7\pm1.3\pm0.7)\times10^{-2}$

$\delta_{K\pi}$ is important to relate to mixing parameters x and y from x' and y'

Type	Mode
Flavored	$K^-\pi^+, K^+\pi^-$
$CP+$	$K^+K^-, \pi^+\pi^-, K^0_S\pi^0\pi^0, \pi^0\pi^0, \rho^0\pi^0$
$CP-$	$K^0_S\pi^0, K^0_S\eta, K^0_S\omega$

With external inputs of the parameters in HFAG2013 and PDG

$$R_{\rm D} = 3.47 \pm 0.06‰, \ y = 6.6 \pm 0.9‰ \quad R_{\rm WS} = 3.80 \pm 0.05‰$$

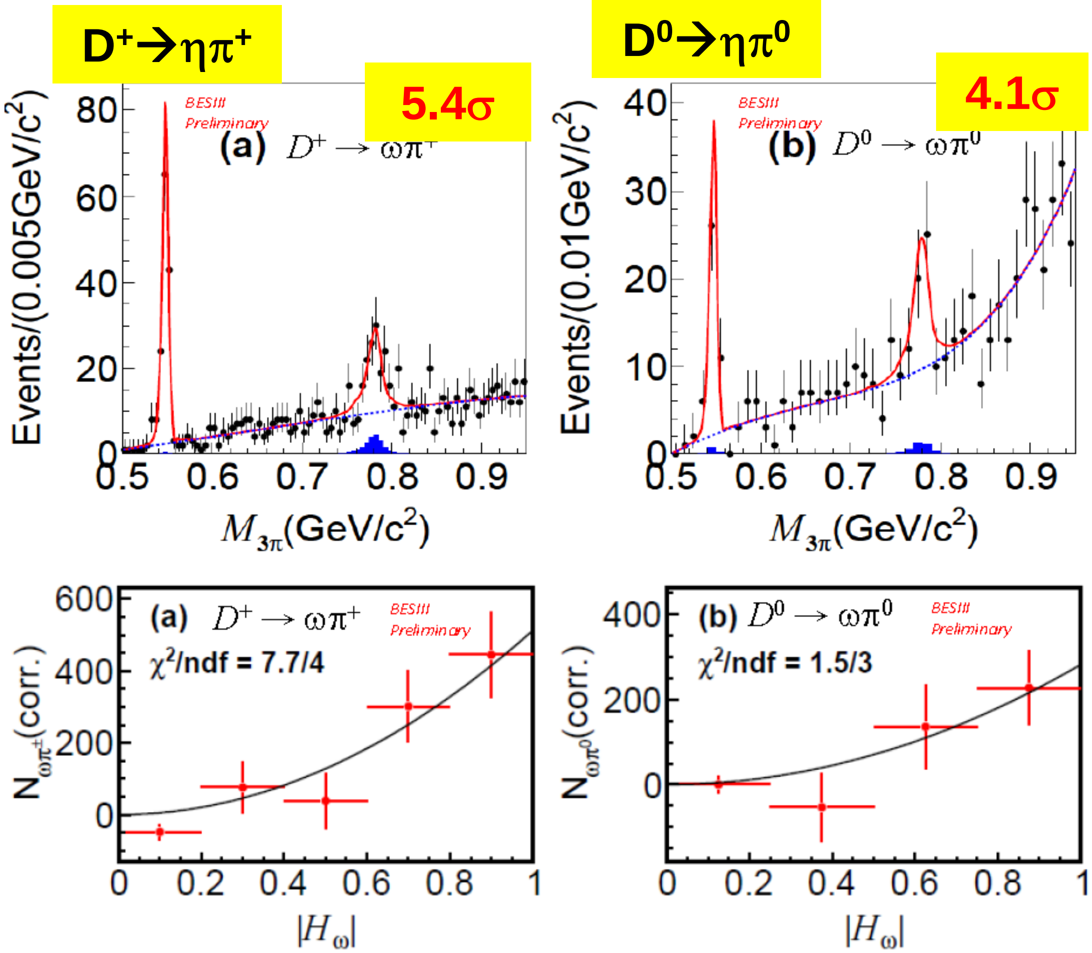
$\cos\delta_{K\pi}=1.02\pm0.11\pm0.06\pm0.01$

The most precise to date

PLB734(2014)227

Observation/Evidence of D→ωπ

Suppress background via DT method



- **Prediction of D→ωπ: 10^{-4}, PRD81 (2010)074021**
- **Singly Cabibbo-suppressed decays D→ωπ were studied at CLEO-c with ST method, but only set BF upper limits**

Decay mode	This work	Previous meausurements
$D^+ \to \omega\pi^+$	$(2.74 \pm 0.58 \pm 0.17) \times 10^{-4}$	$< 3.4 \times 10^{-4}$ at 90% C.L.
$D^0 \to \omega\pi^0$	$(1.05 \pm 0.41 \pm 0.09) \times 10^{-4}$	$< 2.6 \times 10^{-4}$ at 90% C.L.
$D^+ \to \eta\pi^+$	$(3.13 \pm 0.22 \pm 0.19) \times 10^{-3}$	$(3.53 \pm 0.21) \times 10^{-3}$
$D^0 \to \eta\pi^0$	$(0.67 \pm 0.10 \pm 0.05) \times 10^{-3}$	$(0.68 \pm 0.07) \times 10^{-3}$

Improve understanding of U-spin and SU(3) flavor symmetry breaking effects in D decays and benefitting theoretical prediction of CP violation in D decays

Search for New physics

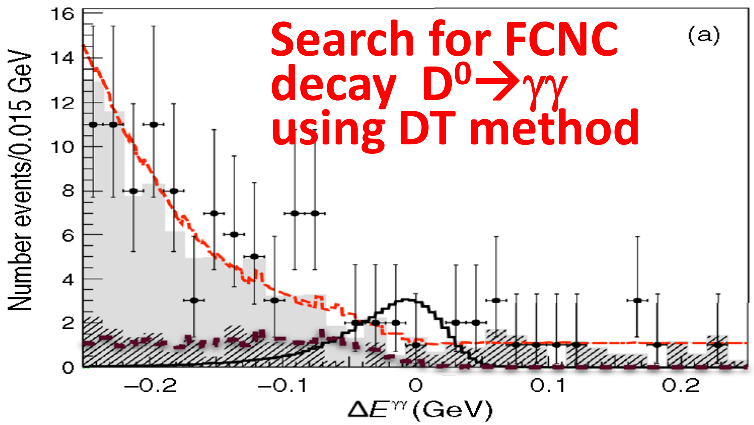
In SM, D^0D^0 mixing, CP violation and rare decay of charm are small

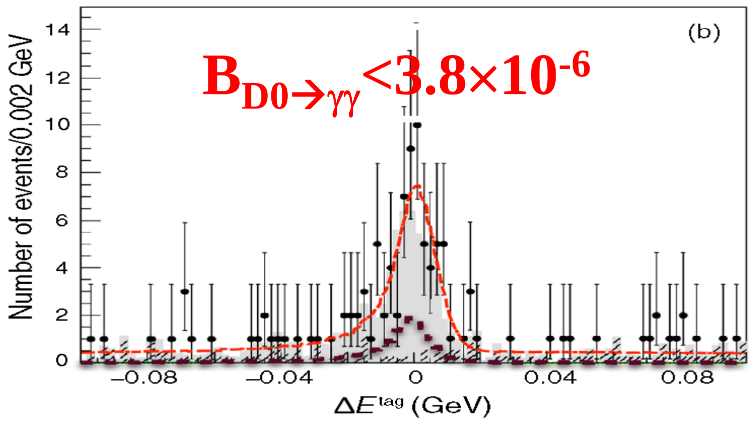
$D^0\overline{D}^0$ mixing $x \approx y \approx 10^{-3} \Rightarrow r_D = [x^2 + y^2]/2 \approx 10^{-6}$

CP violation asymmetries $\sim 10^{-3}$

Rare decays $\leq 10^{-6}$

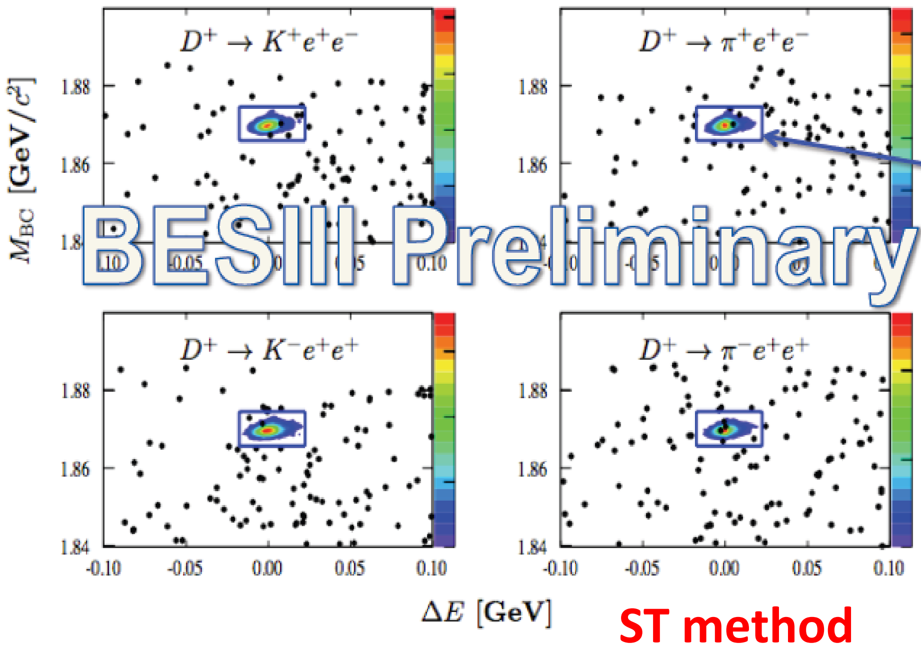
Search for rare decays probes for New Physics, which may enhance them to observable at BESIII





PRD 91(2015)112015

Consistent with Babar result



FCNC decay

Blinding signal region, optimize cuts and study backgrounds based on MC and sideband data.

LPV decay

ST method

$\mathcal{B}(D^+ \to) \setminus [\times 10^{-6}]$	$K^+e^+e^-$	$K^-e^+e^+$	$\pi^+e^+e^-$	$\pi^-e^+e^+$
CLEO	3.0	3.5	5.9	1.1
Babar	1.0	0.9	1.1	1.9
PDG	1.0	0.9	1.1	1.1
This work	1.2	0.6	0.3	1.2

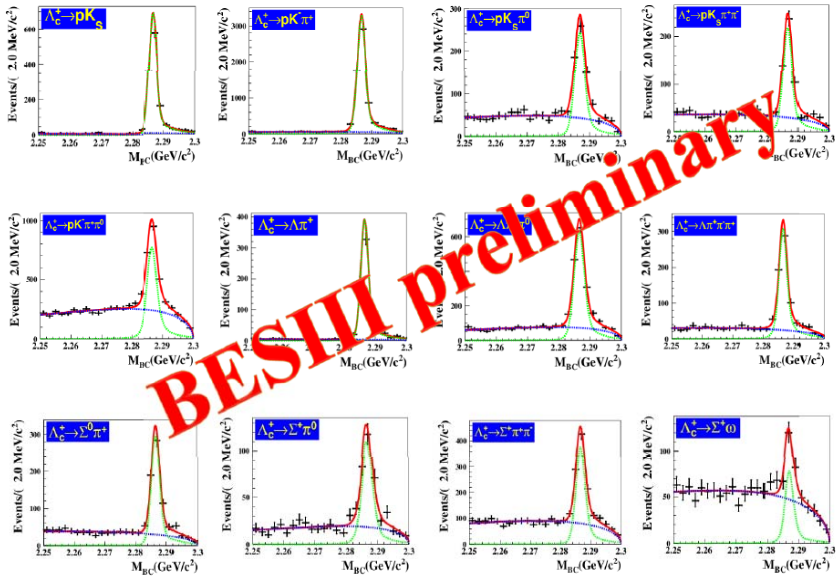
Λ_c^+ decays

- Λ_c^+ was found in 1979
- Many efforts have been performed to study Λ_c^+ decays. But, experimental knowledge of Λ_c^+ decays are still deficient
- Sum of the branching fractions for Λ_c^+ known exclusive decays is around 50%
- Most of decays are measured refered to $\Lambda_c^+ \rightarrow pK^-\pi^+$. Uncertainty of its PDG BF is about 25%. In 2014, BELLE improve it to about 5% level.

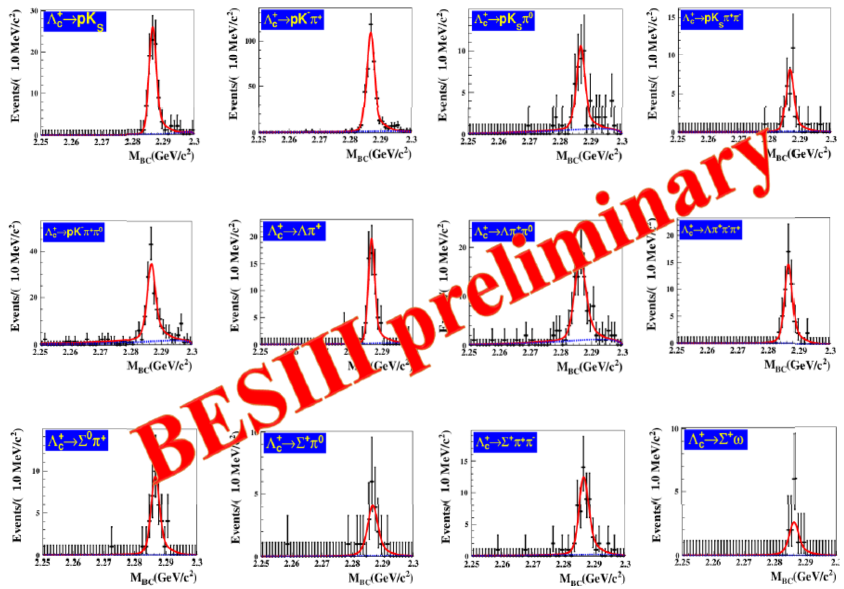
Significantly improved measurements of the absolute BFs for known decays and search for new decay modes are urgent to better understand Λ_c^+ decays

Absolute BFs for Λ_c^+ hadron decays

~15000 ST Λ_c^-



~1000 DT Λ_c^-



Decay mode	global fit $\mathcal{B}$	PDG $\mathcal{B}$ [1]	Belle $\mathcal{B}$ [4]
pK_S	$1.61 \pm 0.09 \pm 0.03$	1.15 ± 0.30	
$pK^-\pi^+$	$6.09 \pm 0.29 \pm 0.24$	5.0 ± 1.3	$6.84 \pm 0.24^{+0.21}_{-0.27}$
$pK_S\pi^0$	$1.98 \pm 0.14 \pm 0.06$	1.65 ± 0.50	
$pK_S\pi^+\pi^-$	$1.55 \pm 0.11 \pm 0.09$	1.30 ± 0.35	
$pK^-\pi^+\pi^0$	$4.69 \pm 0.26 \pm 0.32$	3.4 ± 1.0	
$\Lambda\pi^+$	$1.31 \pm 0.08 \pm 0.04$	1.07 ± 0.28	
$\Lambda\pi^+\pi^0$	$7.63 \pm 0.41 \pm 0.27$	3.6 ± 1.3	
$\Lambda\pi^+\pi^-\pi^+$	$3.56 \pm 0.25 \pm 0.19$	2.6 ± 0.7	
$\Sigma^0\pi^+$	$1.31 \pm 0.09 \pm 0.04$	1.05 ± 0.28	
$\Sigma^+\pi^0$	$1.29 \pm 0.12 \pm 0.05$	1.00 ± 0.34	
$\Sigma^+\pi^+\pi^-$	$4.09 \pm 0.26 \pm 0.21$	3.6 ± 1.0	
$\Sigma^+\omega$	$2.00 \pm 0.28 \pm 0.12$	2.7 ± 1.0	

BESIII preliminary

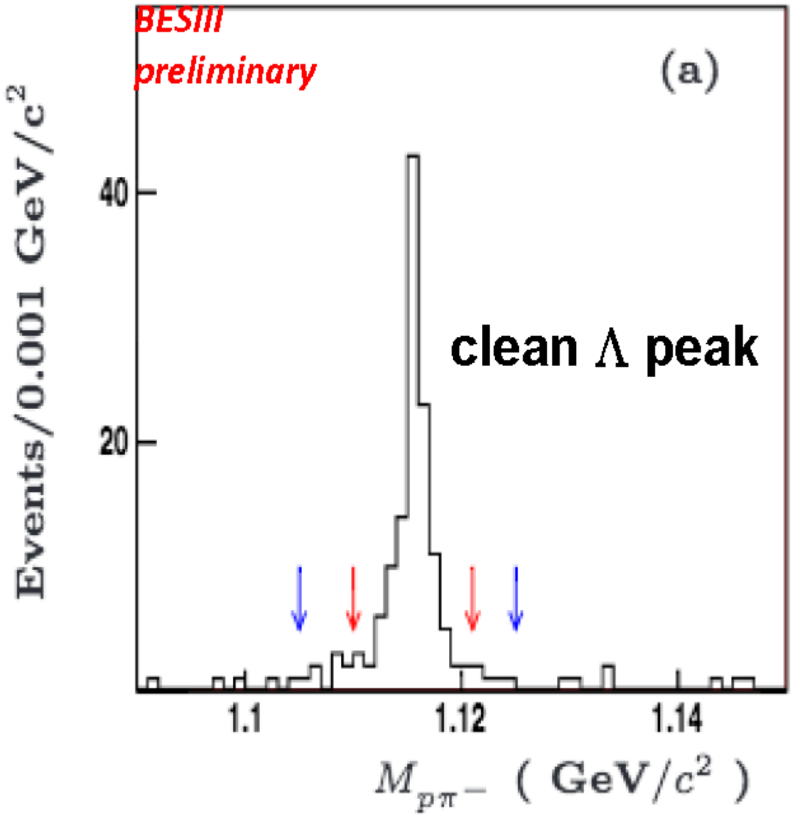
567 pb^{-1} data @4.6 GeV

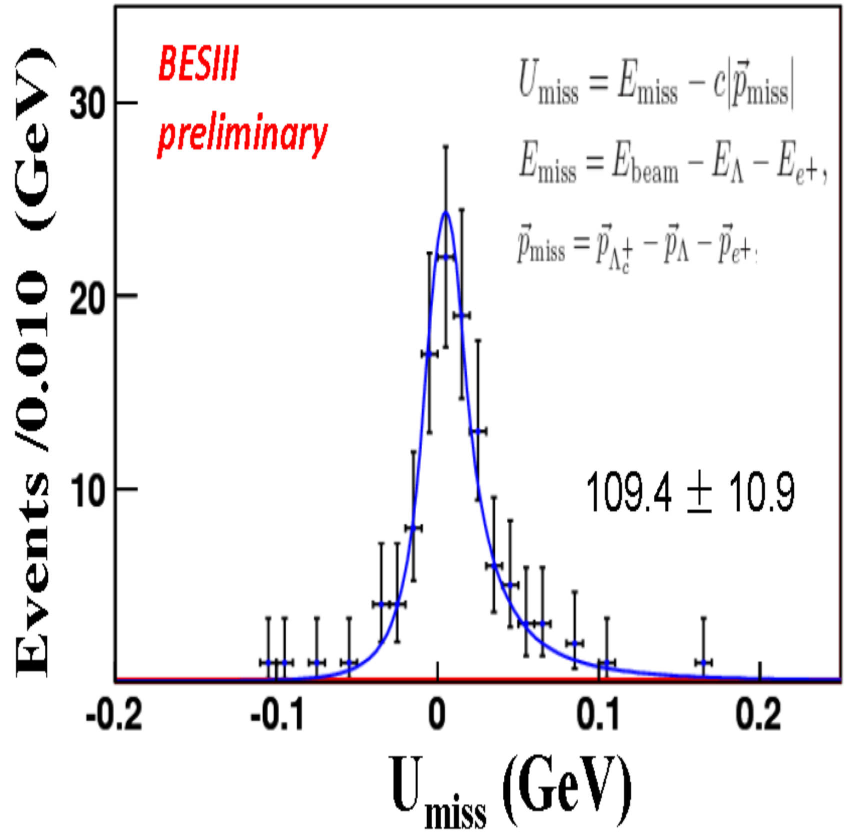
Absolute BFs are improved significantly

Improved absolute BF of $pK^-\pi^+$ together with BELLE's result is key to calibrate other decays

Absolute BF for $\Lambda_c^+ \rightarrow \Lambda e^+ \nu$

LQCD calculations on the BF ranges from 1% to 9%





$B[\Lambda_c^+ \rightarrow \Lambda e^+ \nu] = (3.76 \pm 0.35 \pm \Delta_{sys})\%$

PDG: (2.0±0.6)%

Test on LQCD calculations with significantly better precision

Summary

- With 2.92/0.48/0.57 fb^{-1} data taken at 3.773/4.009/4.6 GeV
  - Precise D^+ decay constant, form factors in $D^+ \rightarrow P/Ve^+ \nu$
  - Accurate quark mixing matrix element $|V_{cs(d)}|$, and strong phase parameters
  - Significantly improved knowledge of D/Λ_c^+ decays

important to test LQCD calculations, CKM matrix UT, search for NP BSM

- 3 fb^{-1} data at 4.18 GeV will be taken in 2016. More $D^{0(+)}$ and Λ_c^+ samples are expected. More interesting Charm results are expected.

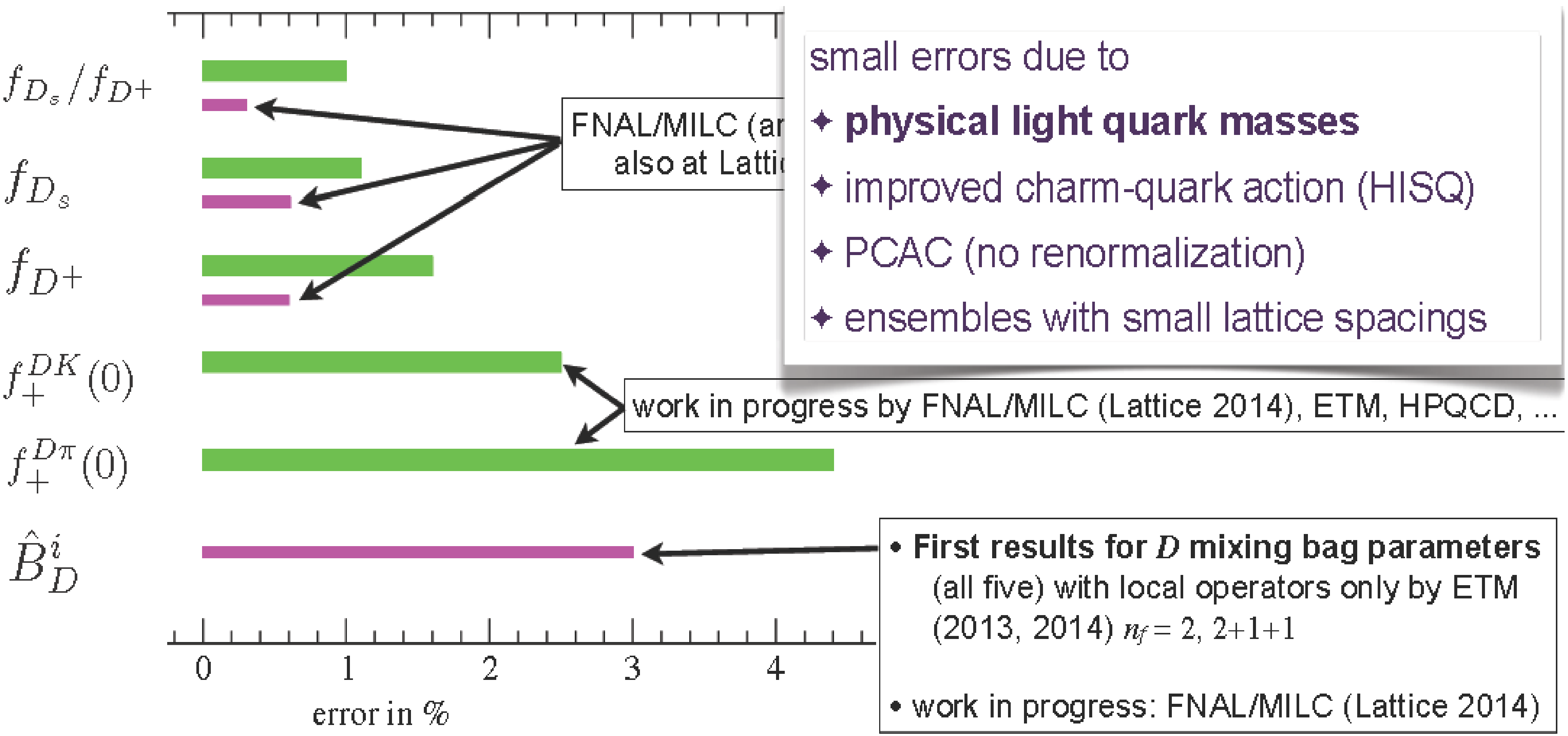
Thank you!

Back up

Progress in LQCD Calculation

Taking from Aida X. El-Khadra's talk at Beauty2014

errors (in %) comparison: **FLAG-2 averages** vs. **new results**



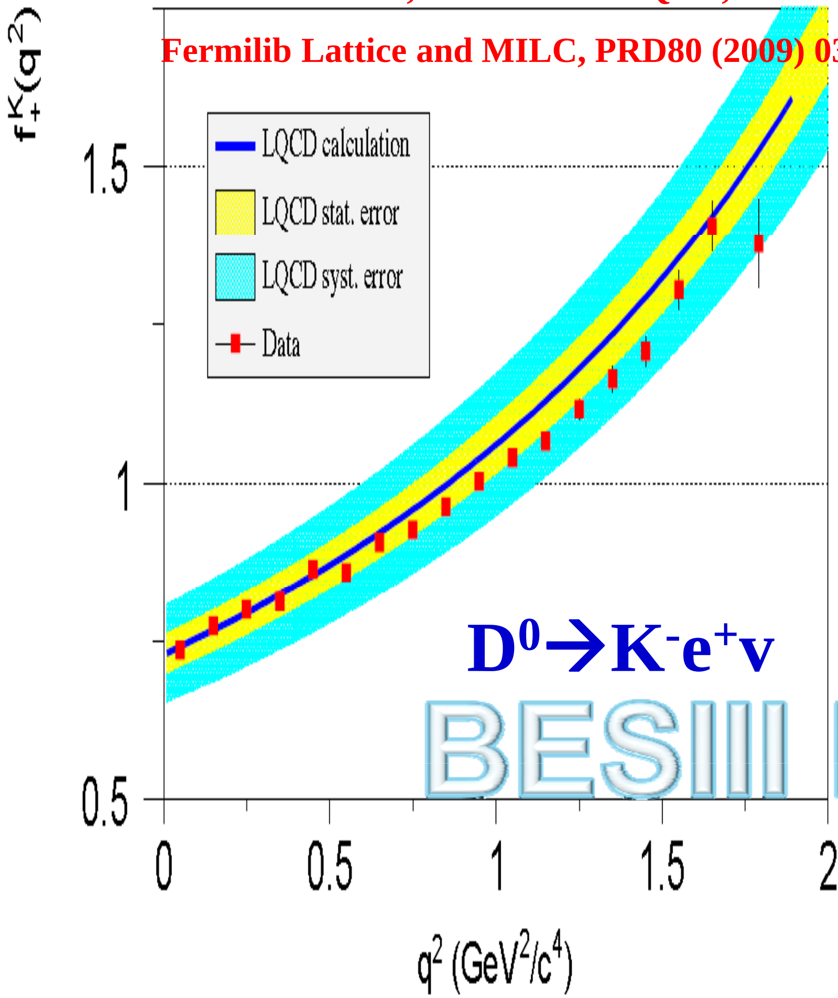
review by C. Bouchard @ Lattice 2014

Measurement of $f_+^{K(\pi)}(q^2)$

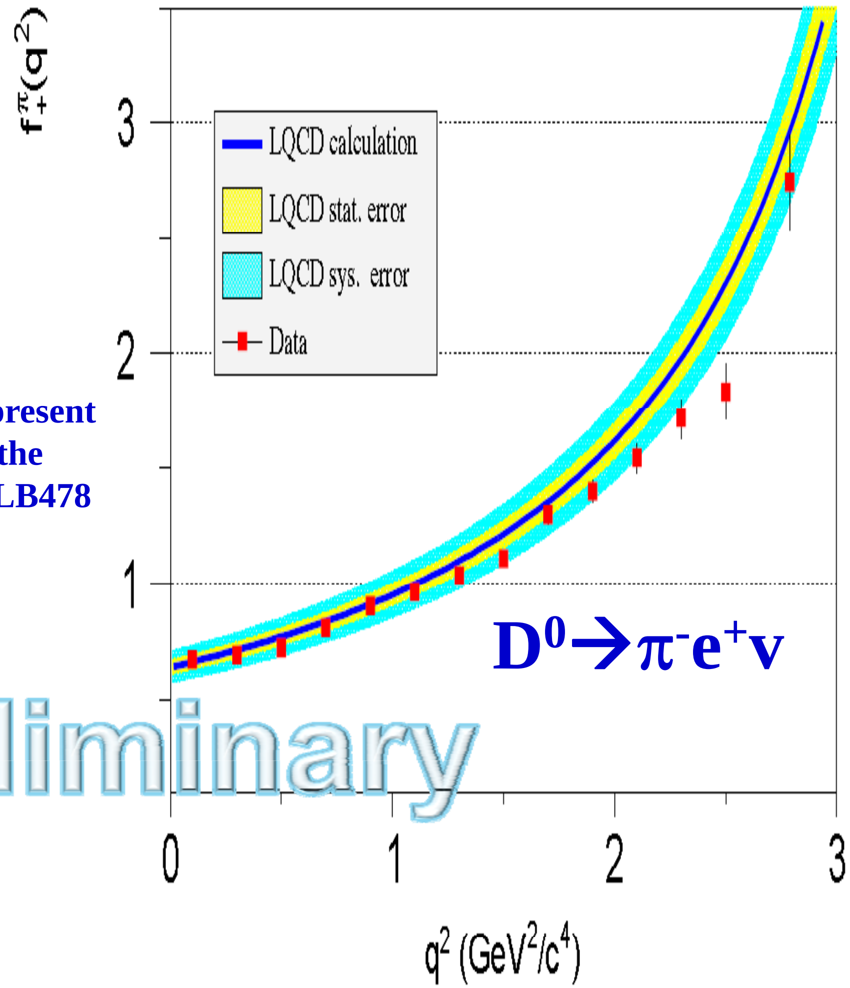
Experimental data calibrate LQCD calculation

Fermilib Lattice, MILC and HPQCD, PRL94 (2005) 011601

Fermilib Lattice and MILC, PRD80 (2009) 034026



Solid lines represent LQCD fits to the BK model, PLB478 (2000)417



BESIII Preliminary