Overview of
Charm Meson Decays at BESIII

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- Introduction
- D leptonic and semi-leptonic decays
- D hadronic decays
- D rare decays
- Summary

BESIII粲介子物理主要物理目标

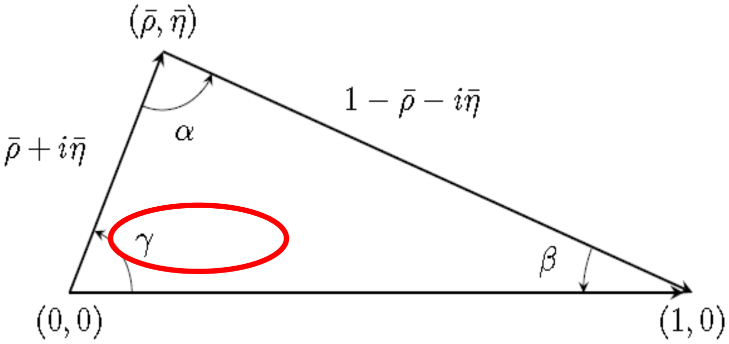
- **D介子纯、半轻衰变**
  - **$f_{D(s)+}$, $f^{K(\pi)}_{+}(0)$: 刻度LQCD计算**
  - **$|V_{cs(d)}|$: 精密检验CKM矩阵**

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

$$\begin{pmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho-i\eta) \\ -\lambda & 1-\frac{1}{2}\lambda^2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + \Theta(\lambda^4)$$

- **D介子强子衰变**
  - **$D^0\bar{D}^0$混合参数和CP破坏**
  - **D^0和$\bar{D}^0$强相差：约束γ/ϕ_3**
  - **D→PP,VP,SP：SU(3)对称性破坏**
  - **D→3/4体以上衰变：Dalitz分析**
  - **$D\to K_{S/L}X$:**

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

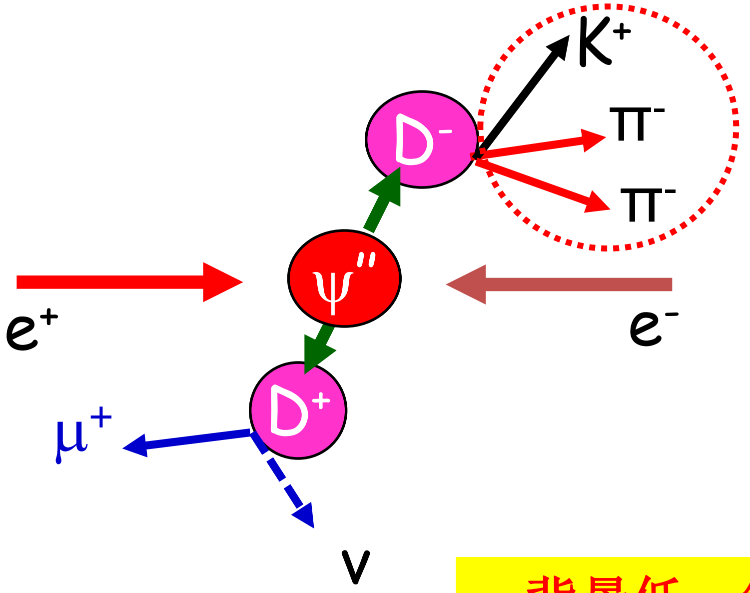


- **D介子稀有衰变：寻找超出SM新物理**

粲介子样本

- 2.93 fb^{-1} @ 3.773 GeV 3.6×CLEO-c
- 482 pb^{-1} @ 4.009 GeV 最大的近阈$D_s^+D_s^-$样本

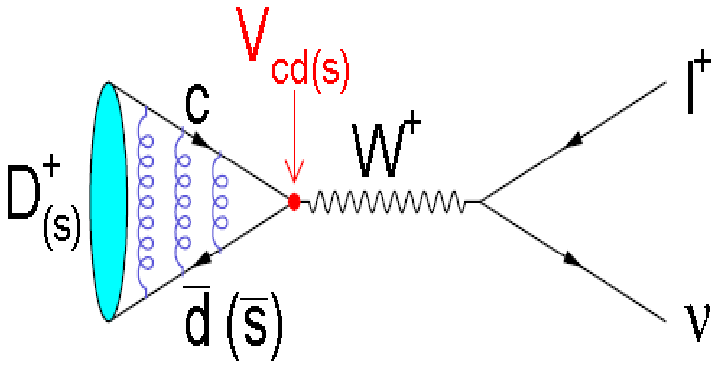
3 fb^{-1} @ 4.180 GeV 最大的近阈$D_s^{*+}D_s^-$样本, 2016

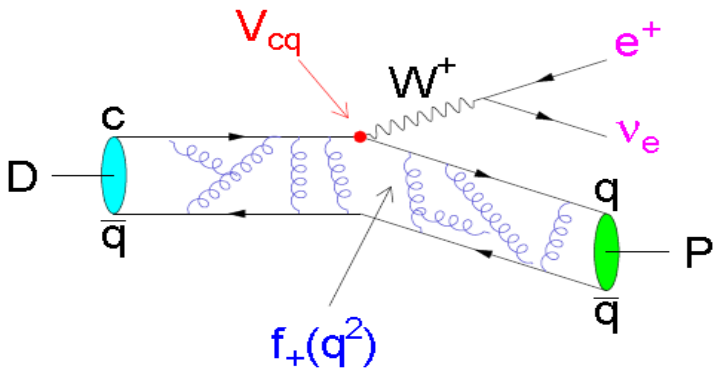


背景低、绝对分支比、系统误差小

粲介子 ($D_{(s)}^{0(+)}$) 轻子和半轻子衰变

粲介子(半)轻子衰变是精密测定CKM矩阵元$|V_{cs(d)}|$的桥梁





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

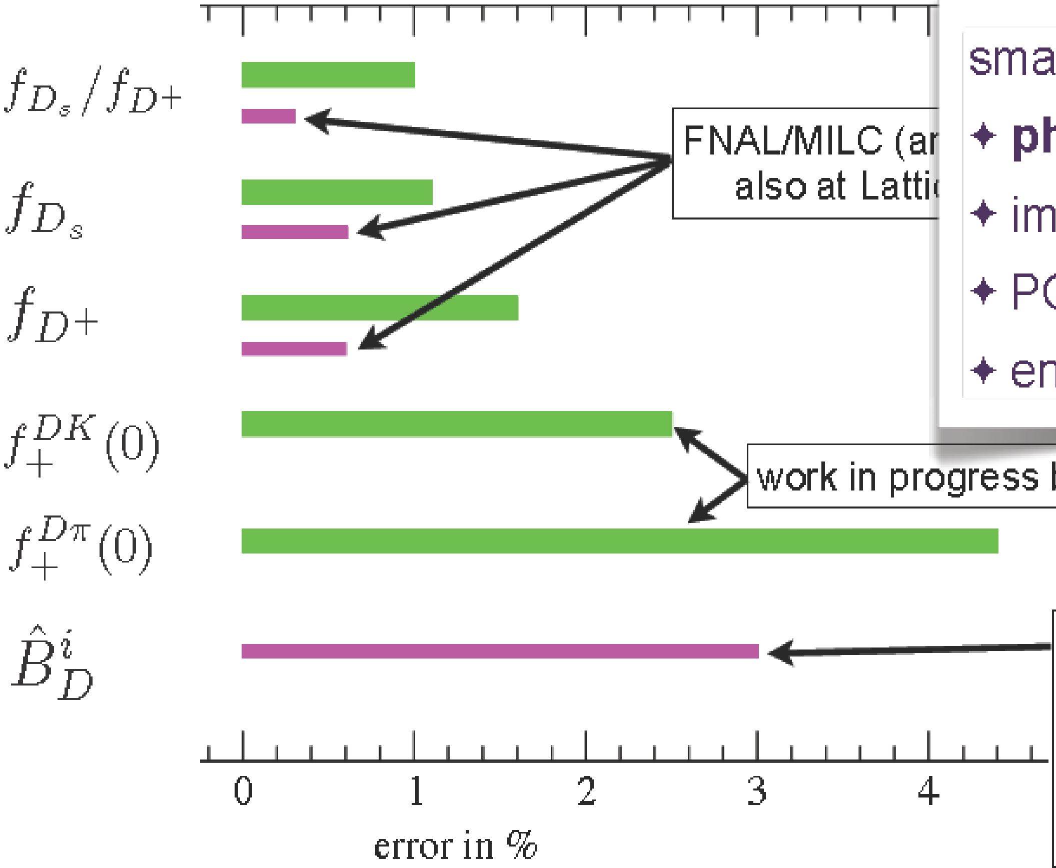
$$\frac{d\Gamma}{dq^2} = X\frac{G_F^2|V_{cd(s)}|^2}{24\pi^3}p^3|f_+(q^2)|^2$$

- 改进的$f_{D(s)+}$, $f_+^{D\to K(\pi)}(q^2)$能够在更高精度上检验格点QCD的理论计算

- 理论计算精度的提高为精密测量$|V_{cs(d)}|$提供了必要条件

Progress in LQCD Calculation

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



FNAL/MILC (ar
also at Latti

small errors due to

- ✦ **physical light quark masses**
- ✦ improved charm-quark action (HISQ)
- ✦ PCAC (no renormalization)
- ✦ ensembles with small lattice spacings

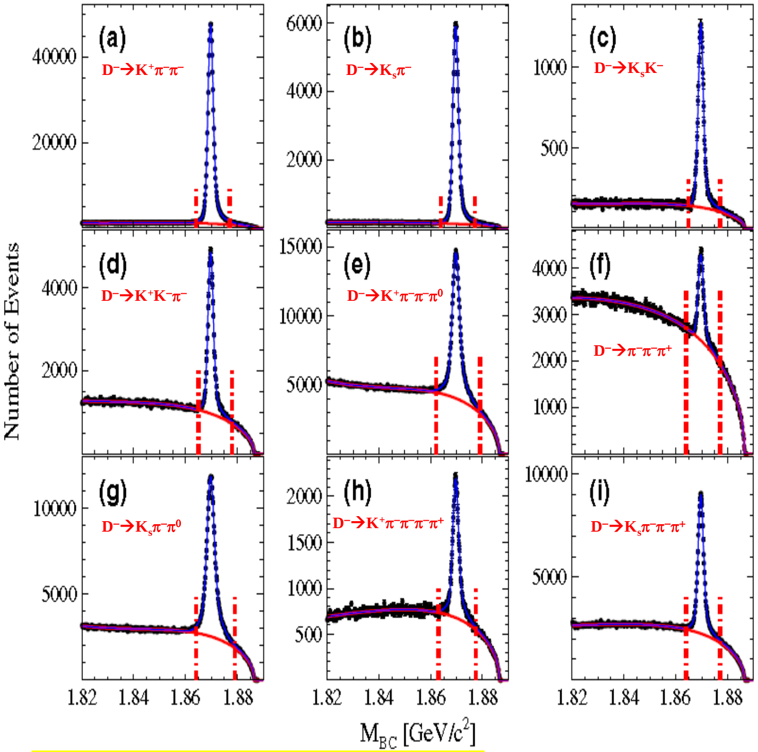
work in progress by FNAL/MILC (Lattice 2014), ETM, HPQCD, ...

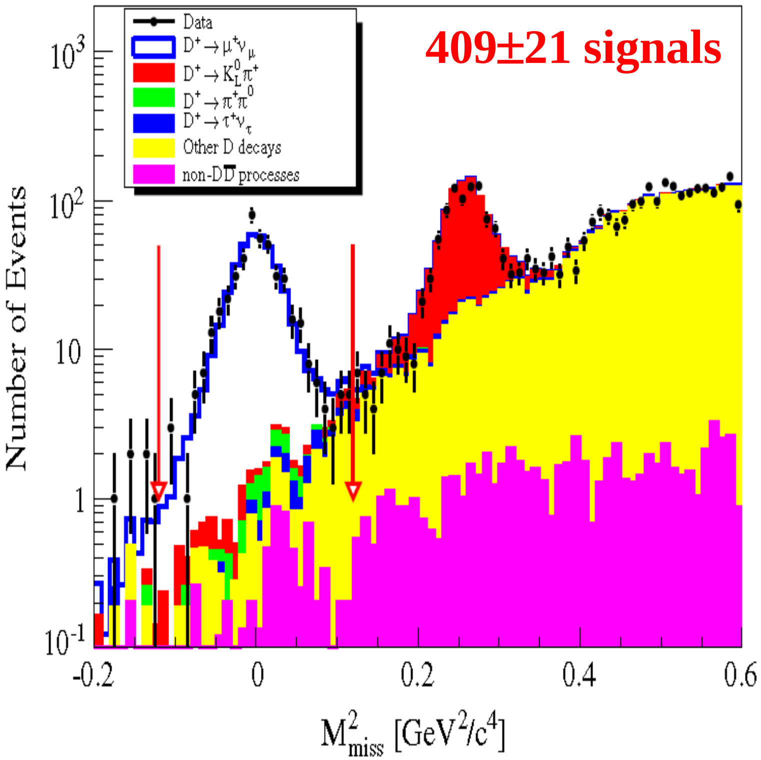
- **First results for D mixing bag parameters** (all five) with local operators only by ETM (2013, 2014) $n_f = 2$, 2+1+1
- work in progress: FNAL/MILC (Lattice 2014)

review by C. Bouchard @ Lattice 2014

$D^+ \rightarrow \mu^+ v \rightarrow f_{D+}|V_{cd}|$

PRD89(2014)051104R





409±21 signals

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

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

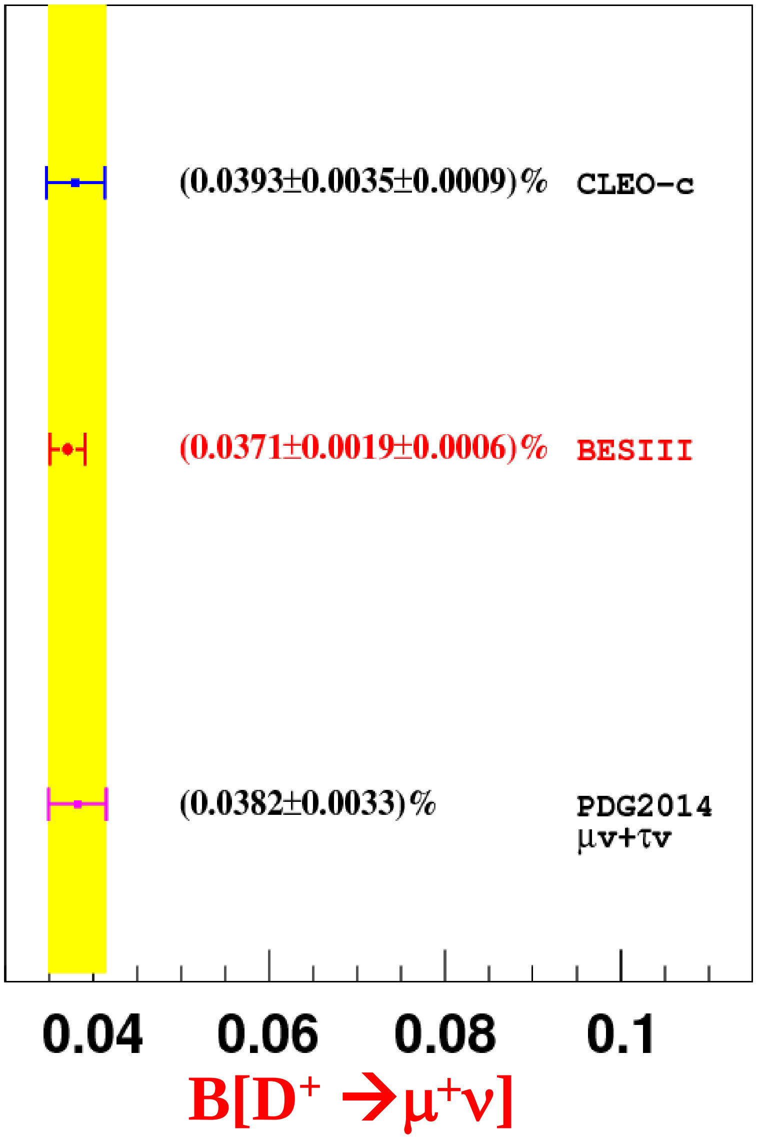
$f_{D+} = (203.2 \pm 5.3 \pm 1.8)$ MeV

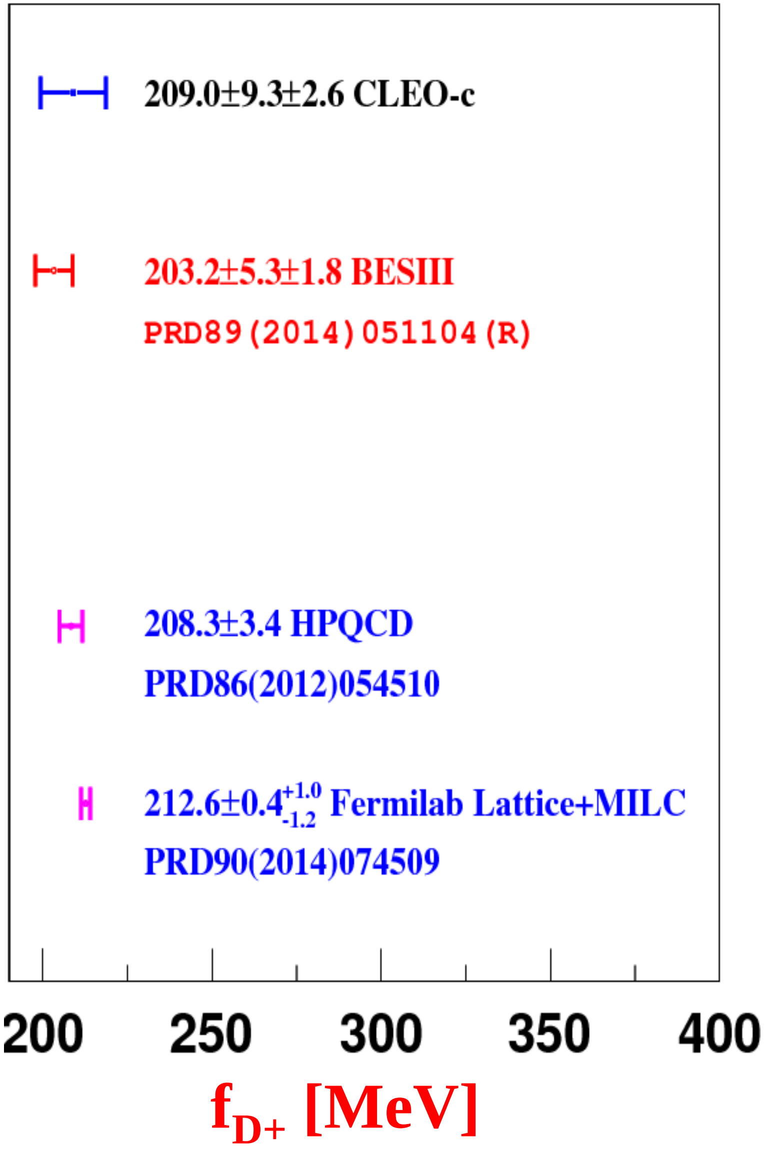
$|V_{cd}| = 0.2210 \pm 0.0058 \pm 0.0047$

世界精度最好的f_{D+}

在国际上首次使用纯轻衰变测定$|V_{cd}|$ (charm2012)

$B[D^+ \rightarrow \mu^+ \nu_\mu]$和$f_{D+}$比较



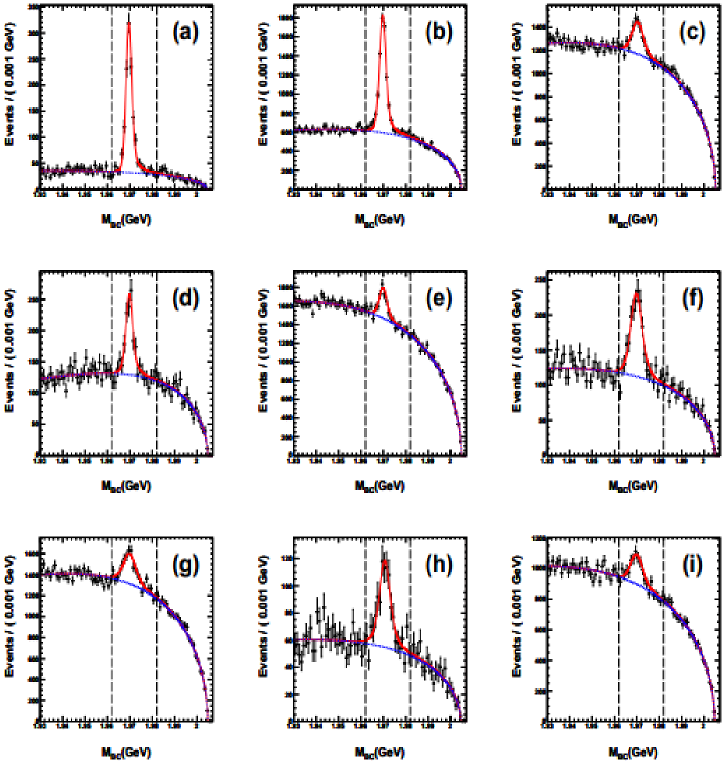


f_{D+}, f_{Ds+}和$f_{D+}:f_{Ds+}$比较

	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

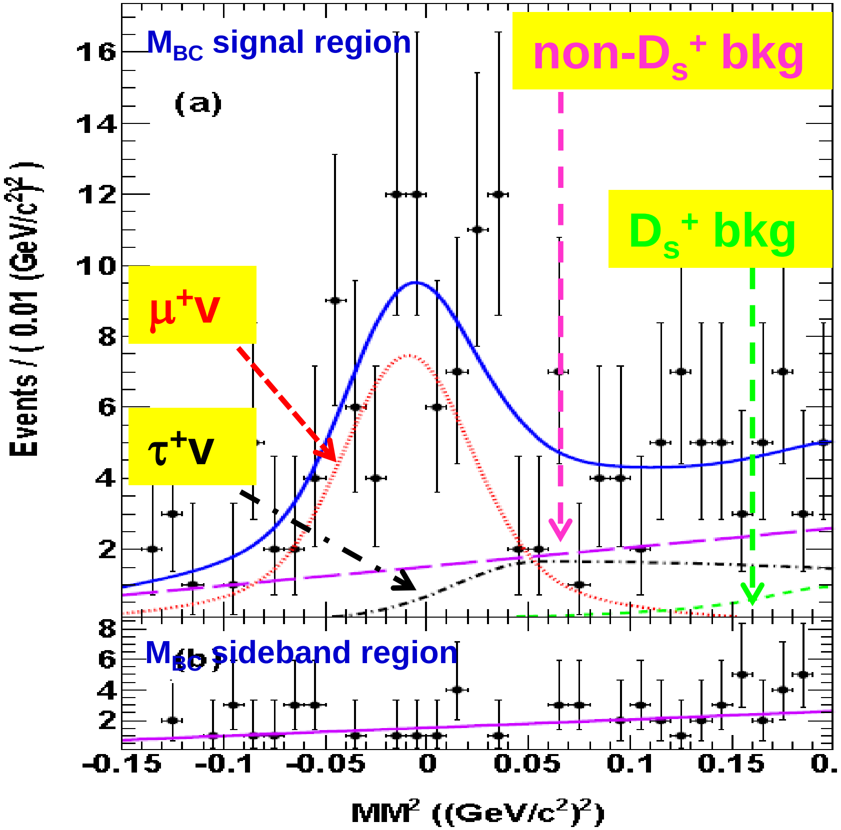
- 实验精度远小于理论精度(f_{D+}, f_{Ds+}, $f_{D+}:f_{Ds}$达0.5%,0.5%,0.3%)
- 实验与理论预期f_{D+}, f_{Ds+}, $f_{D+}:f_{Ds+}$偏离约2σ
- 期待实验上更精确的结果

f_{Ds+} at 4.009 GeV



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

PRD94(2016)072004

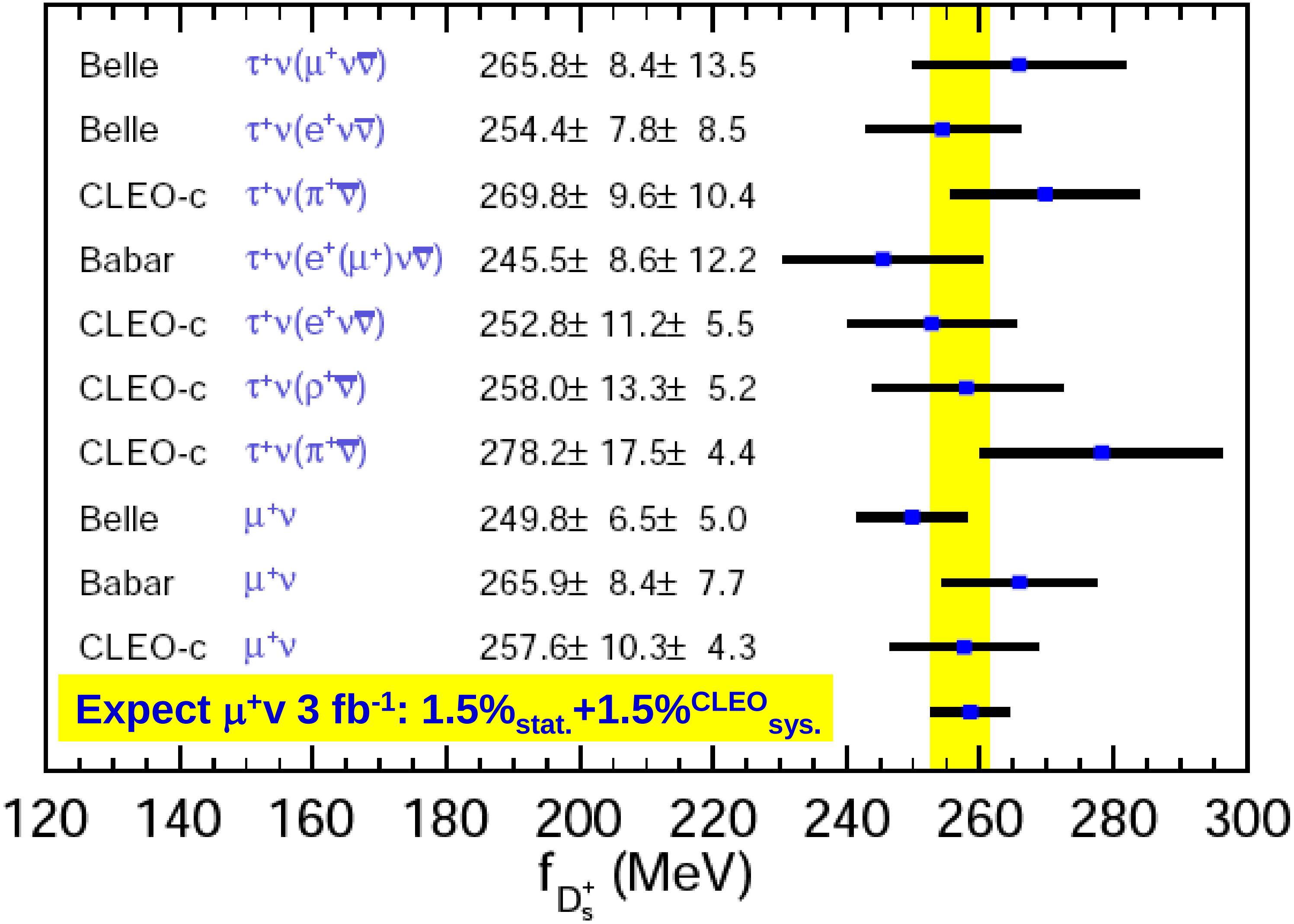


$B[D_s^+ \rightarrow \mu^+\nu] = (0.495 \pm 0.067 \pm 0.026)\%$

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

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

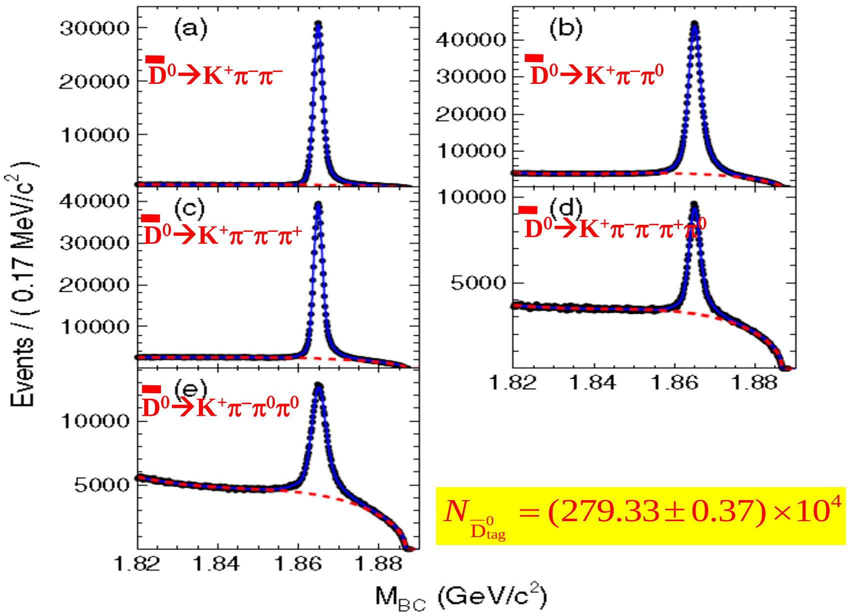
Potential of measuring f_{Ds+} at 4.18 GeV



Expect $\mu^+ v$ 3 fb^{-1}: 1.5%$_{stat.}$+1.5%$^{CLEO}_{sys.}$

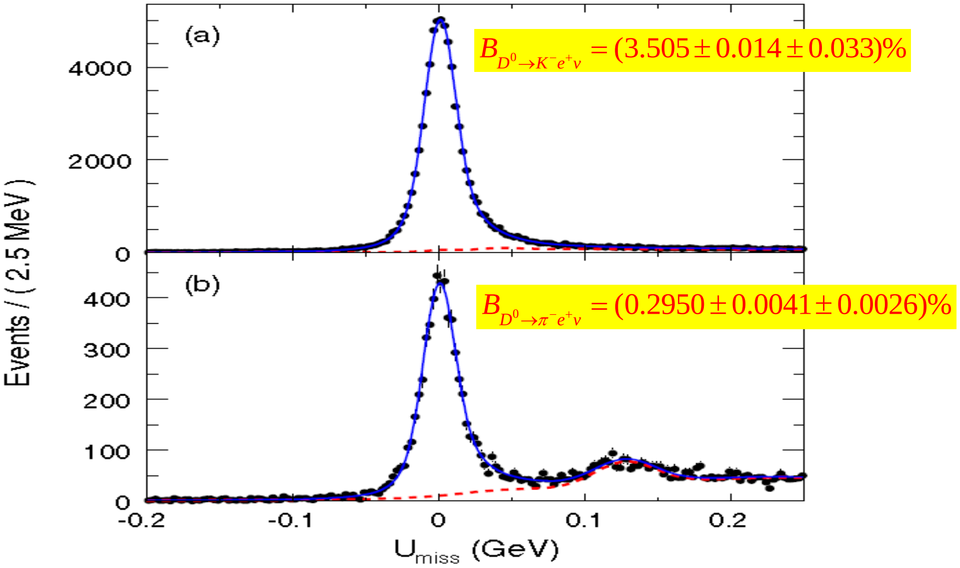
$D_s^+ \rightarrow \tau^+ v$研究可进一步改进测量精度

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



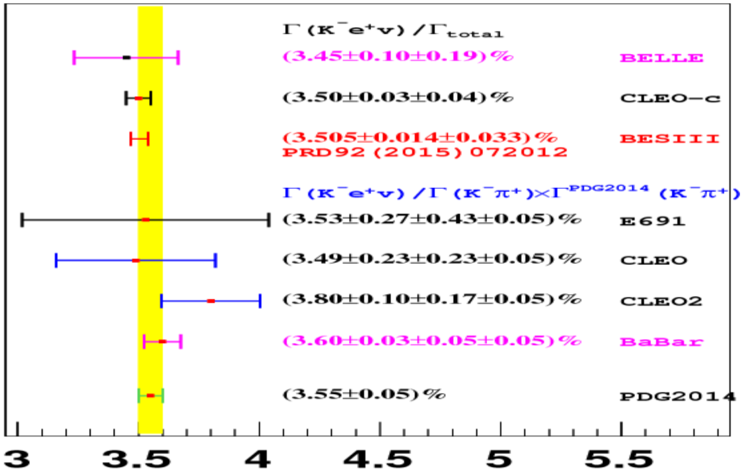
$N_{\bar{D}^0_{tag}} = (279.33 \pm 0.37) \times 10^4$

PRD92(2015)072012

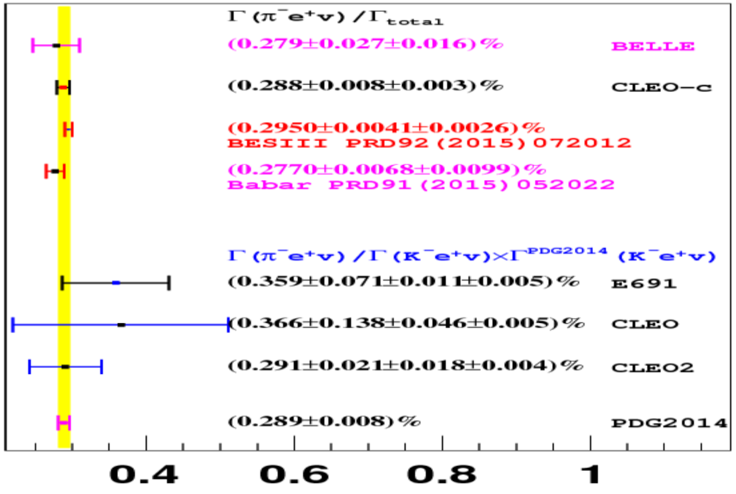


$B_{D^0\to K^- e^+ \nu} = (3.505 \pm 0.014 \pm 0.033)\%$

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



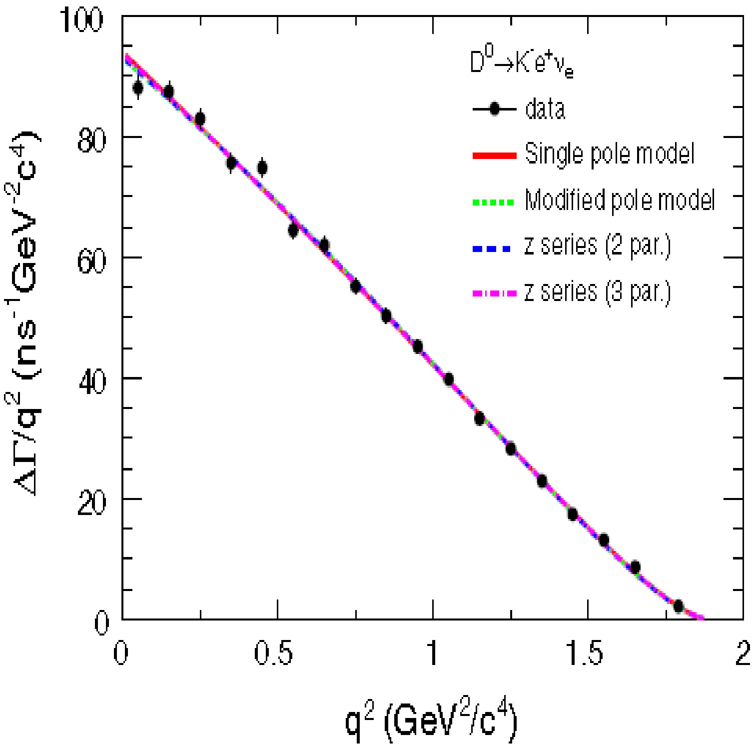
$B[D^0 \to K^- e^+ \nu]$

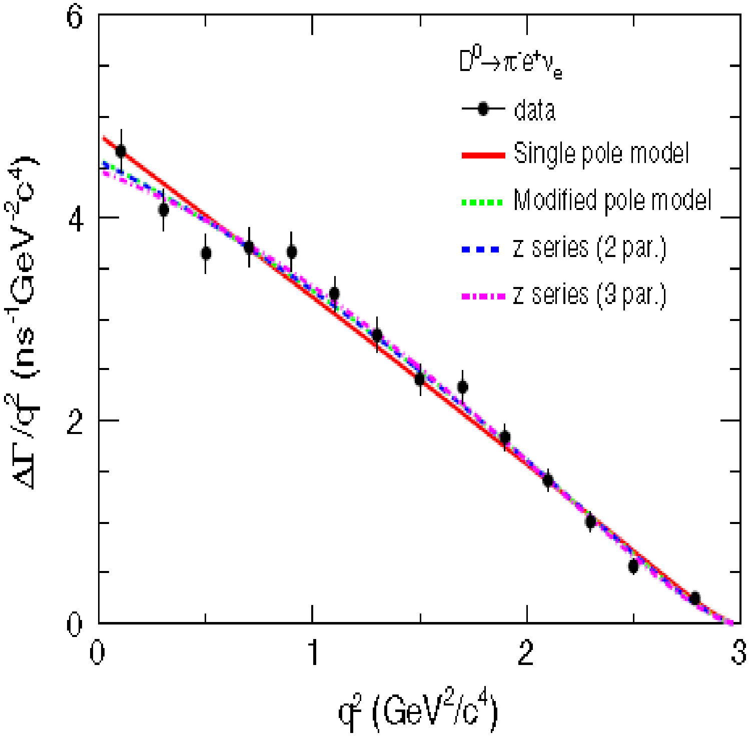


$B[D^0 \to \pi^- e^+ \nu]$

微分跃迁率拟合→$f_{+}^{D\to K(\pi)}(0)|V_{cs(d)}|$

PRD92(2015)072012





- **Single pole form**

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

- **Modified pole model**

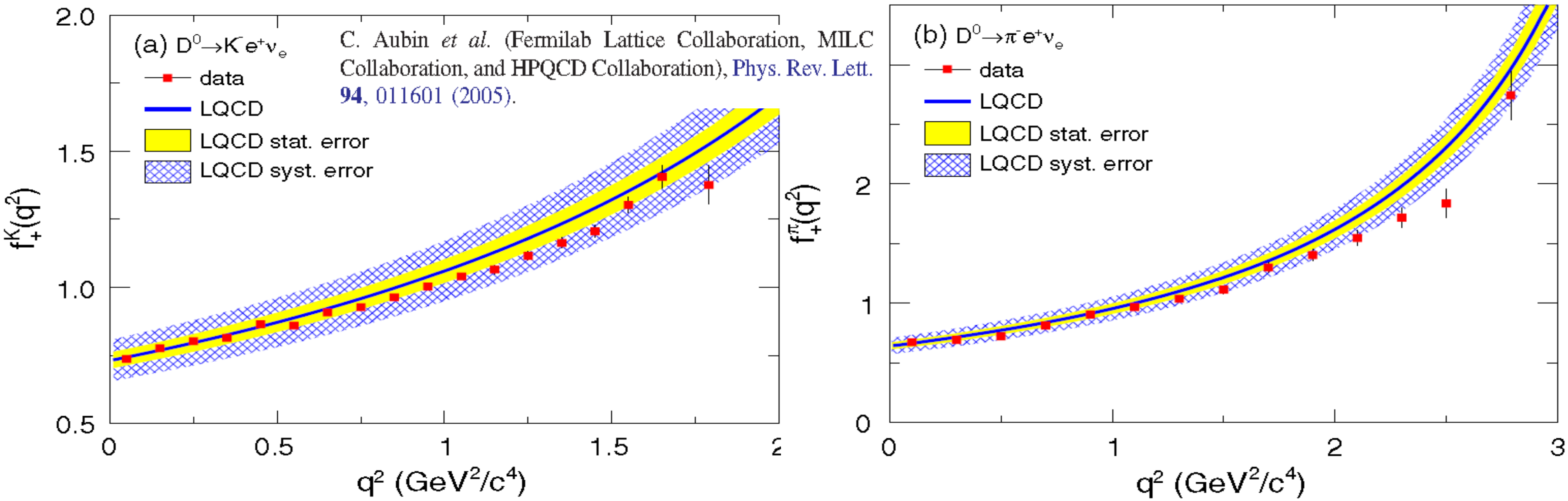
$$f_+(q^2) = \frac{f_+(0)}{(1-\frac{q^2}{M_{\rm pole}^2})(1-\alpha\frac{q^2}{M_{\rm pole}^2})}$$

- **Series expansion model**

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

刻度LQCD计算

PRD92(2015)072012

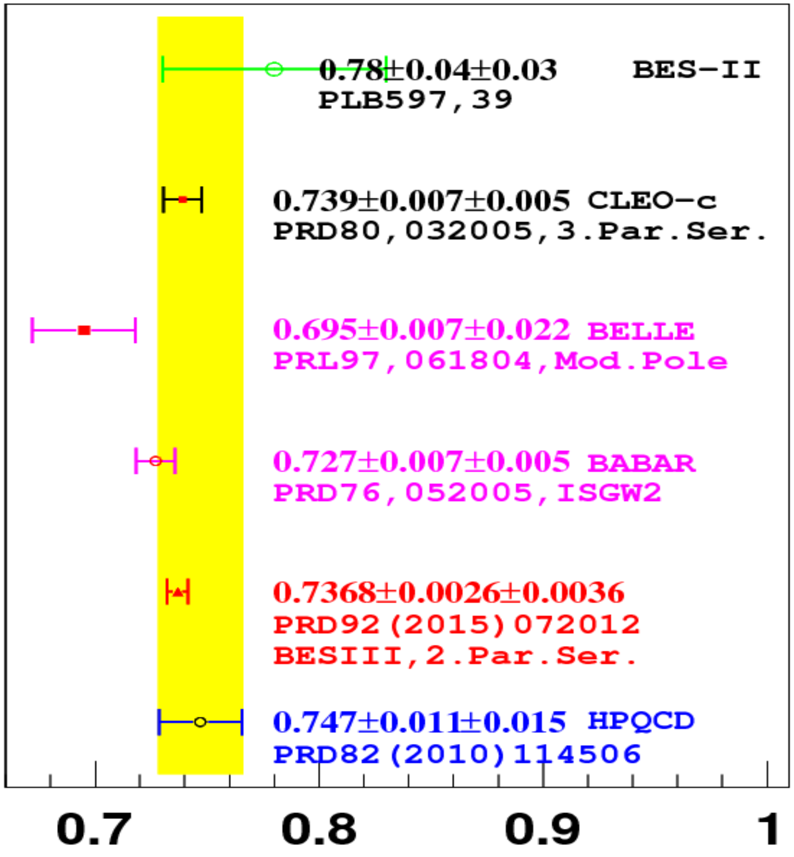


C. Aubin *et al.* (Fermilab Lattice Collaboration, MILC Collaboration, and HPQCD Collaboration), Phys. Rev. Lett. **94**, 011601 (2005).

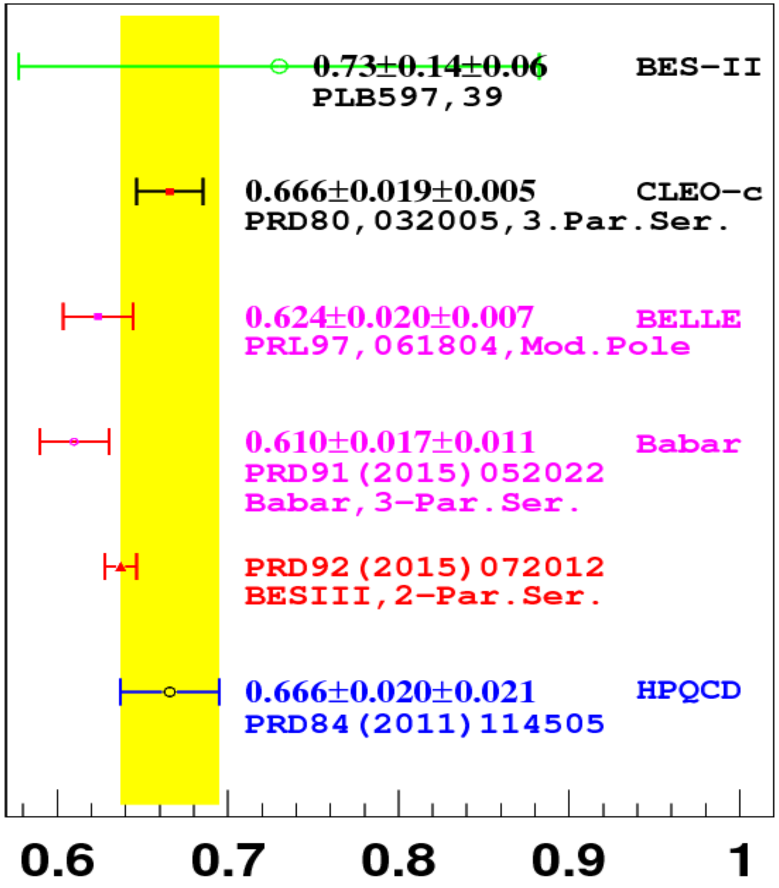
		$D^0 \to K^- e^+ \nu$		$D^0 \to \pi^- e^+ \nu$
Simple Pole	$f_K^+(0)\|V_{cs}\|$	0.7209±0.0022±0.0033	$f_\pi^+(0)\|V_{cd}\|$	0.1475±0.0014±0.0005
	M_{pole}	1.9207±0.0103±0.0069	M_{pole}	1.9114±0.0118±0.0038
Mod. Pole	$f_K^+(0)\|V_{cs}\|$	0.7163±0.0024±0.0034	$f_\pi^+(0)\|V_{cd}\|$	0.1437±0.0017±0.0008
	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

$f_+^{K(\pi)}(0)$测定

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



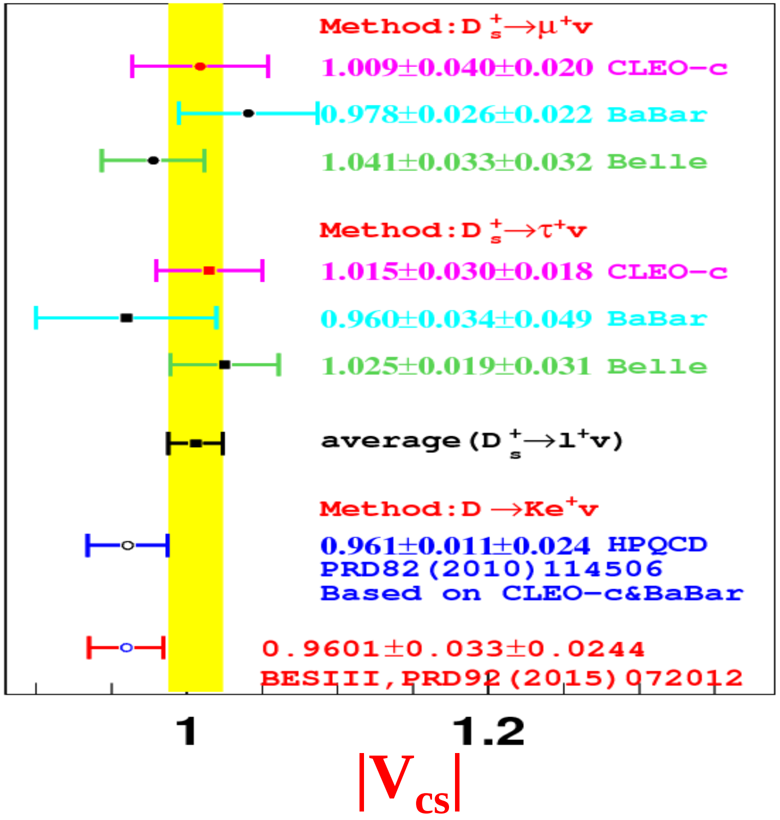
$f_+^K(0)$

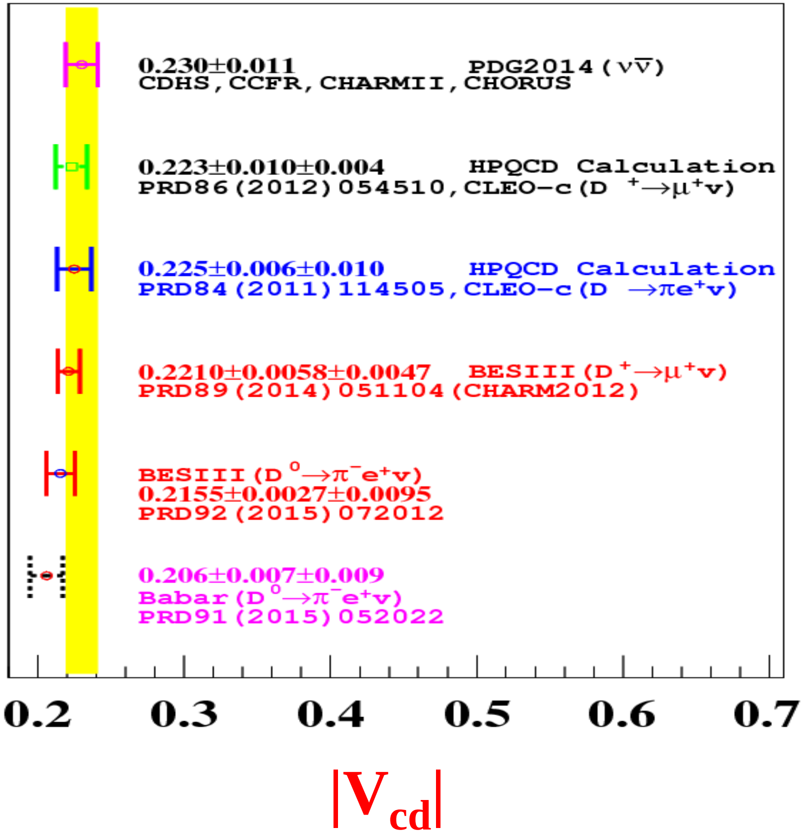


$f_+^{\pi}(0)$

$|V_{cs(d)}|$测定

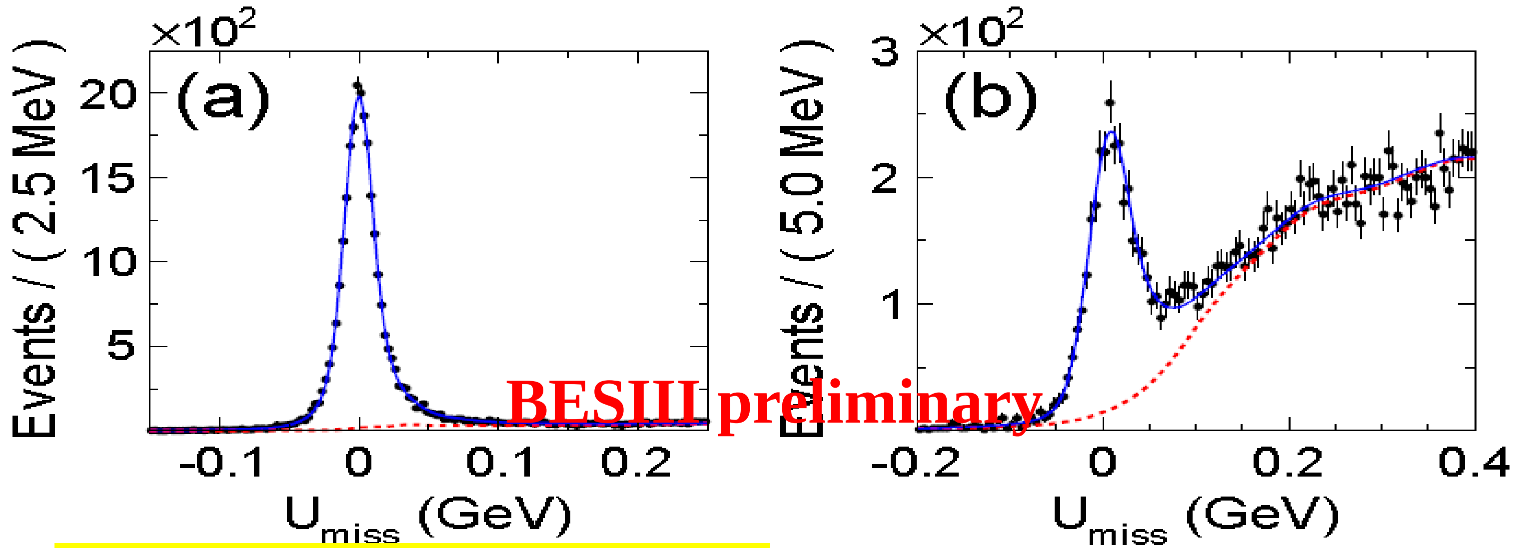
- 方法 1　$B[D_{(s)}^{+} \to l^{+}\nu]$ → $|V_{cd(s)}|$
- 方法 2　$f_{+}^{D\to K(\pi)}(0)|V_{cs(d)}|$ → $|V_{cs(d)}|$





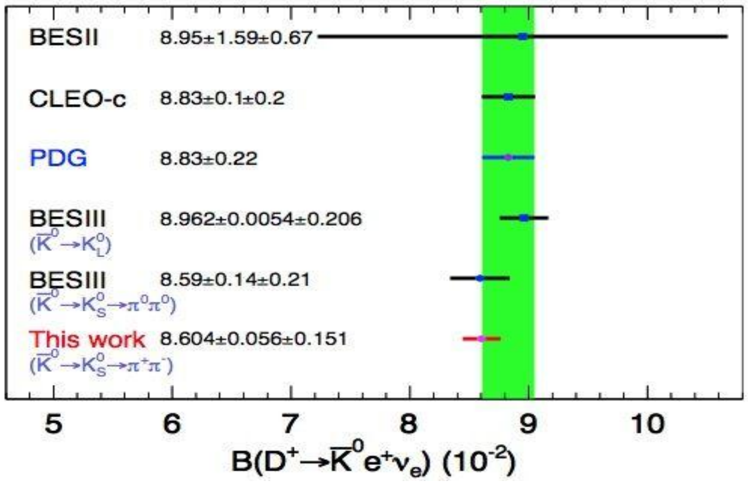
方法2受$f_{+}^{D\to K(\pi)}(0)$理论计算精度限制 [1.7(4.4)%]

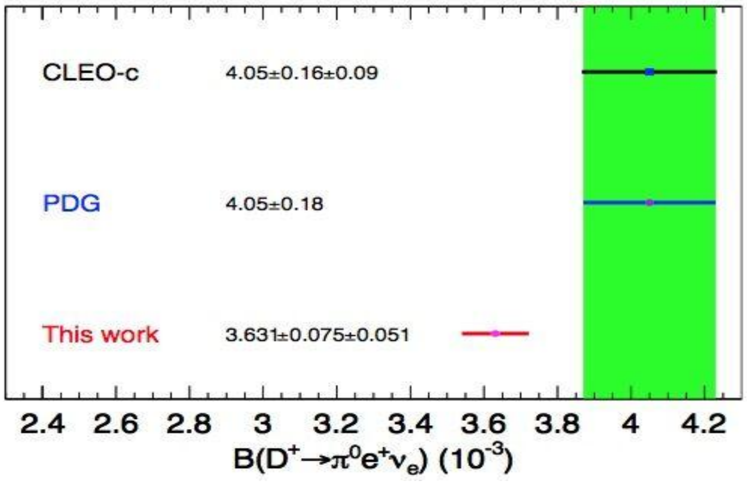
Analysis of $D^+ \rightarrow \bar{K}^0 e^+ v$ and $\pi^0 e^+ v$


BESIII preliminary

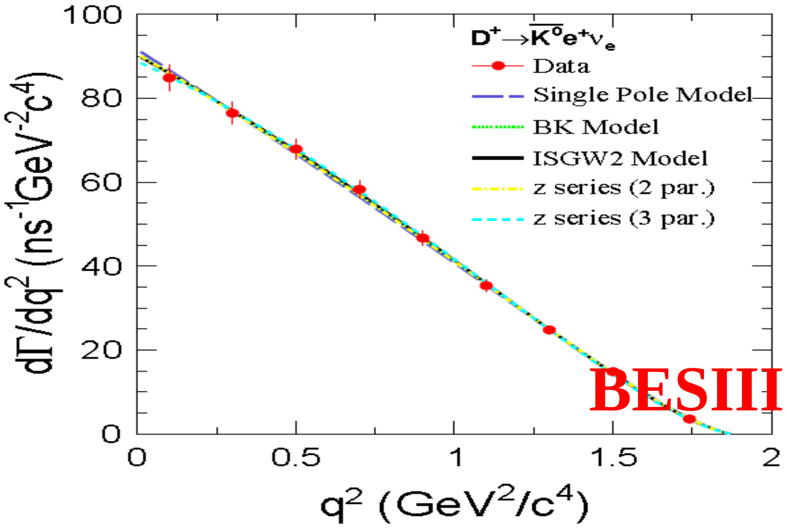
$B[D^+ \to \overline{K}^0 e^+ v] = (8.604 \pm 0.056 \pm 0.151)\%$

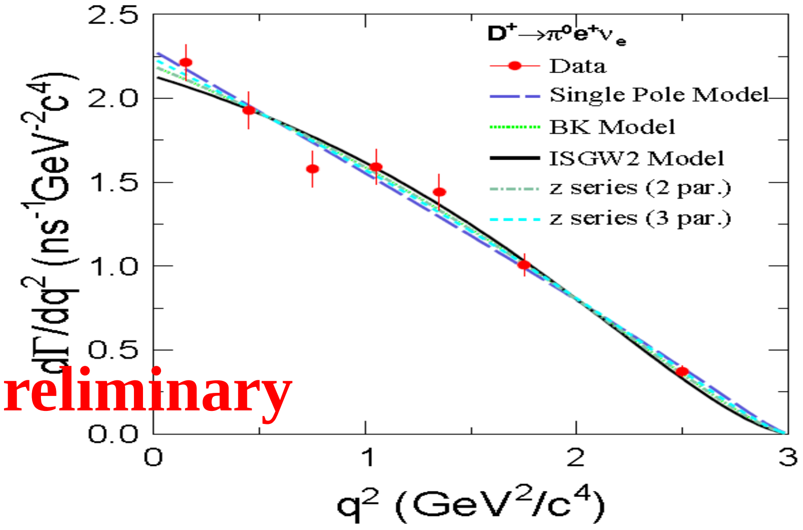
$B[D^+ \to \pi^0 e^+ v] = (3.631 \pm 0.075 \pm 0.051) \times 10^{-3}$



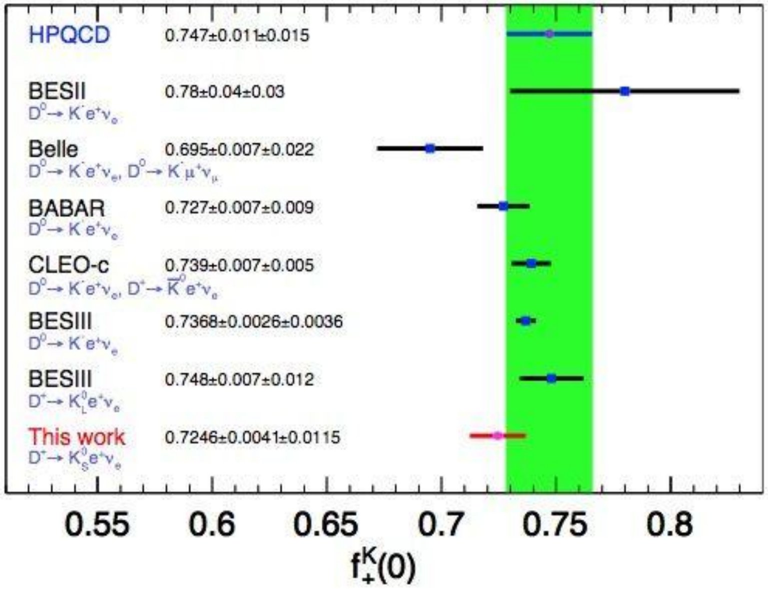


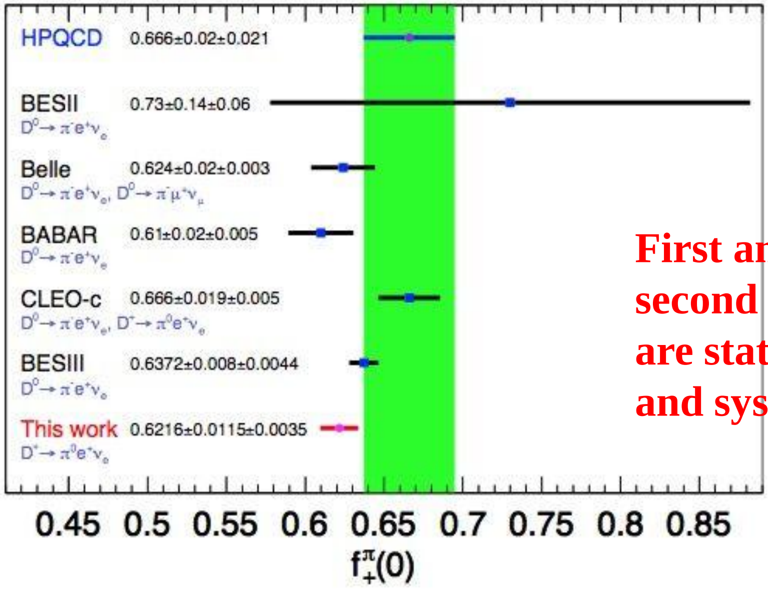
Comparisons of FFs by $D^+ \rightarrow \bar{K}^0(\pi^0)e^+v$





BESIII preliminary





First and second errors are statistical and systematic

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

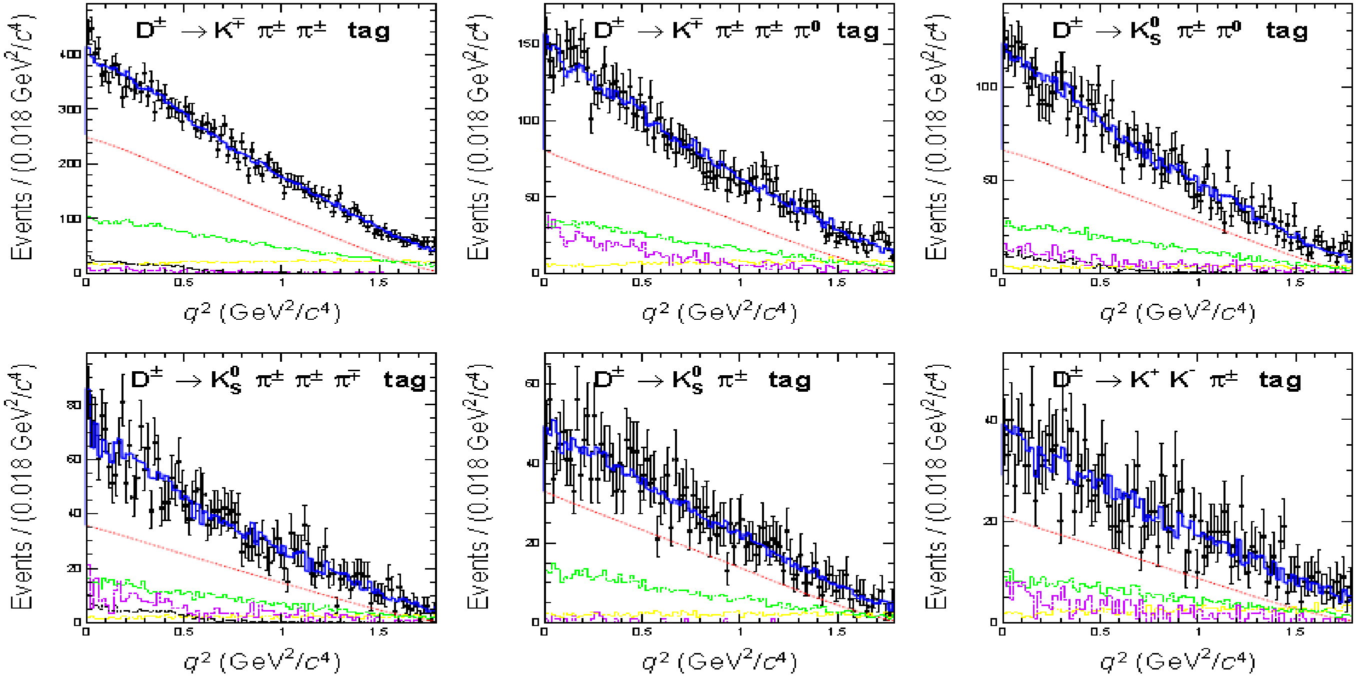
- Regardless of long flight distance, K_L interact with EMC and deposit part of energy, thus giving position information
- After reconstructing all other particles, K_L can be inferred with position information and constraint $U_{miss} \to 0$

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

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

$A_{CP}^{D^+ \to K_L e^+ v} = (-0.59 \pm 0.60 \pm 1.50)\%$

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



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

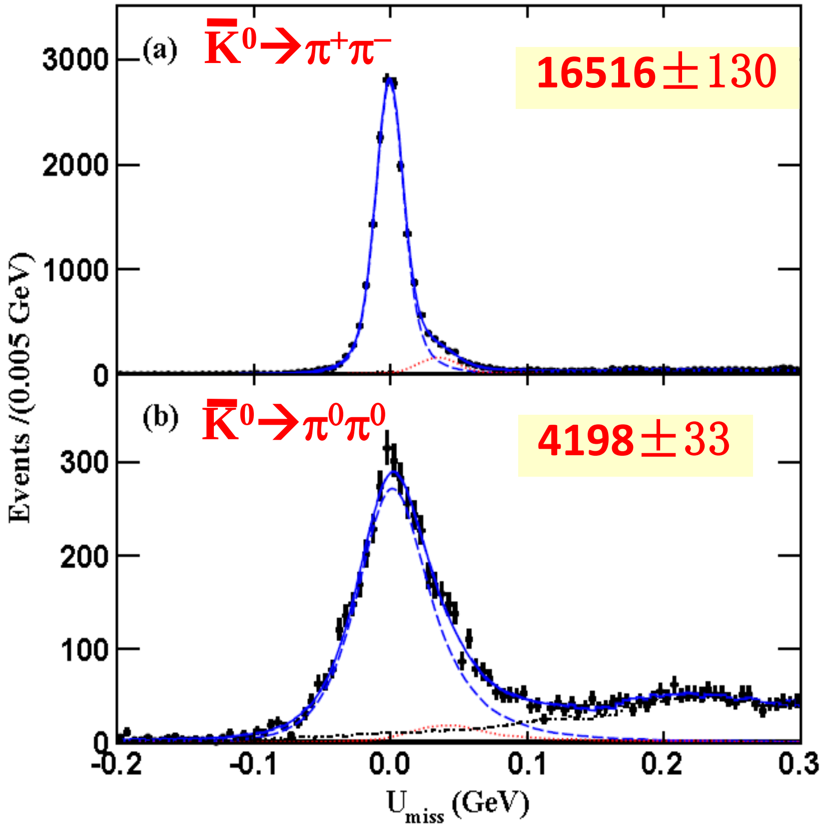
PRD92(2015)112008

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

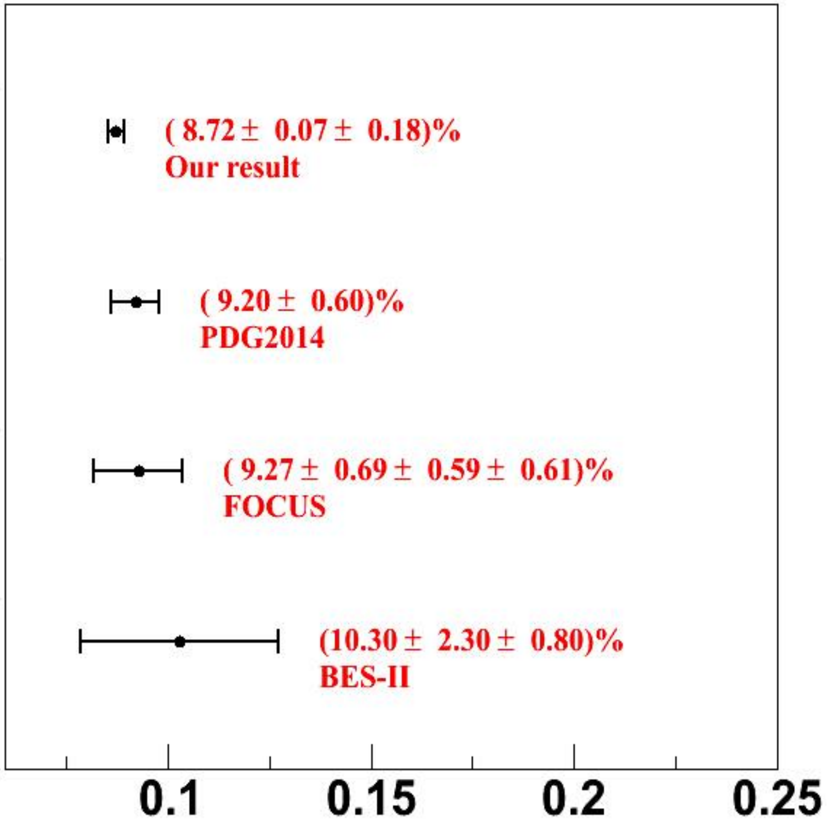
$r_1 = a_1/a_0 = -1.91 \pm 0.33 \pm 0.24$

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

Simultaneous fits



EPJC76(2016)369



Taking B[$D^0 \rightarrow K^-\mu^+\nu$] and B[$D^+ \rightarrow \bar{K}^0 e^+\nu$] from the PDG as input

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

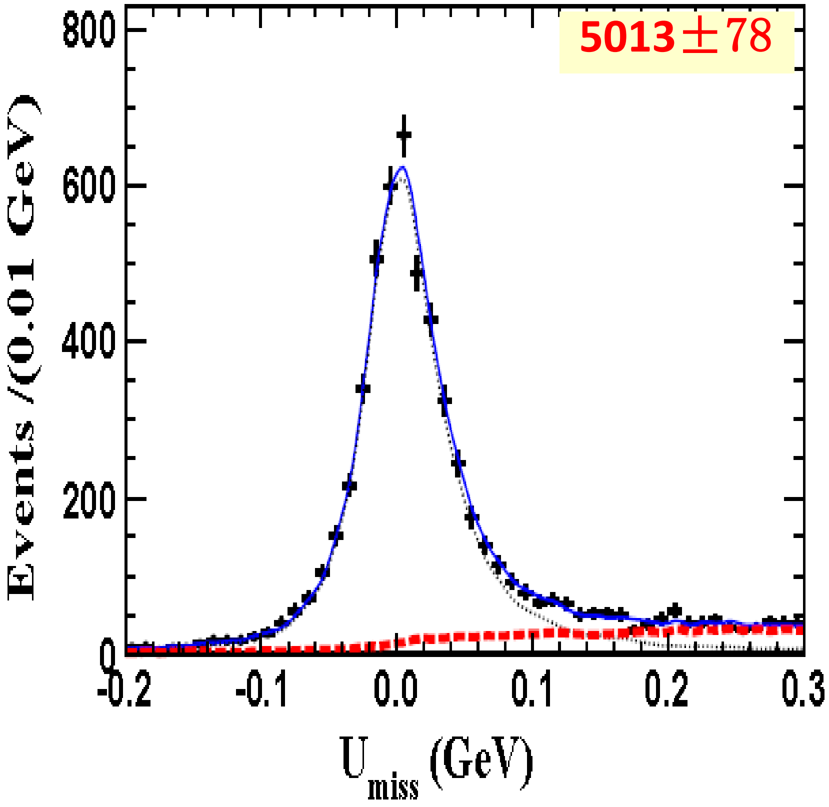
$$\frac{\Gamma[D^+ \rightarrow \bar{K}^0 \mu^+ \nu]}{\Gamma[D^+ \rightarrow \bar{K}^0 e^+ \nu]} = 0.988 \pm 0.033$$

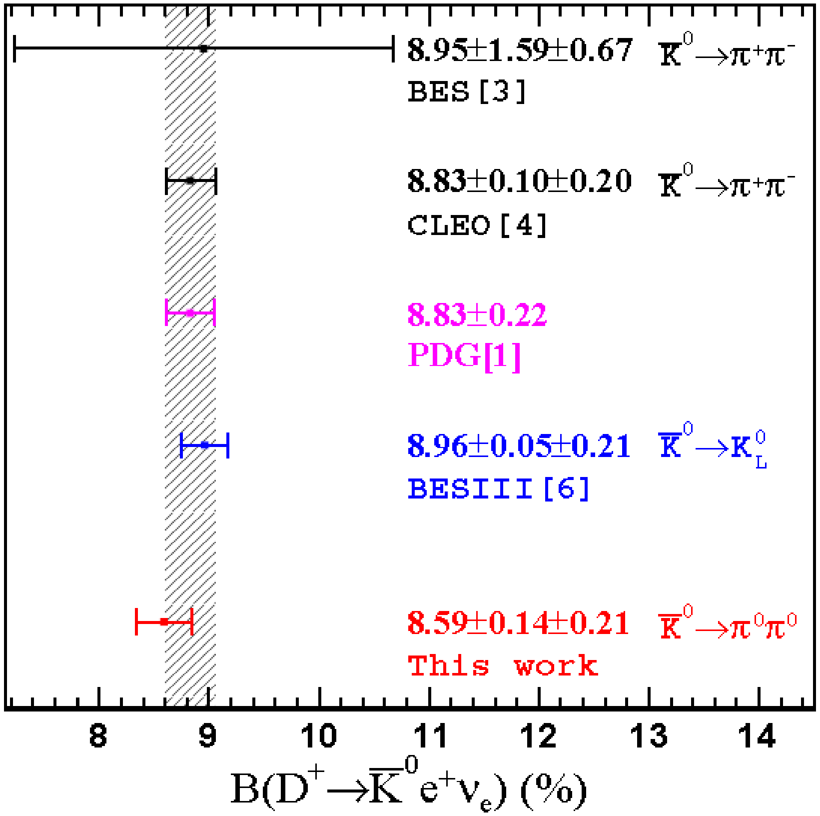
Support isospin conservation in these two decays within errors

Consistent with theory prediction 0.97 within error

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

CPC40(2016)113001





Taking τ_{D^+}, τ_{D^0}, $B[D^0 \to K^- e^+ \nu]$ and $B[D^+ \to \bar{K}^0 e^+ \nu]$ from the PDG as input

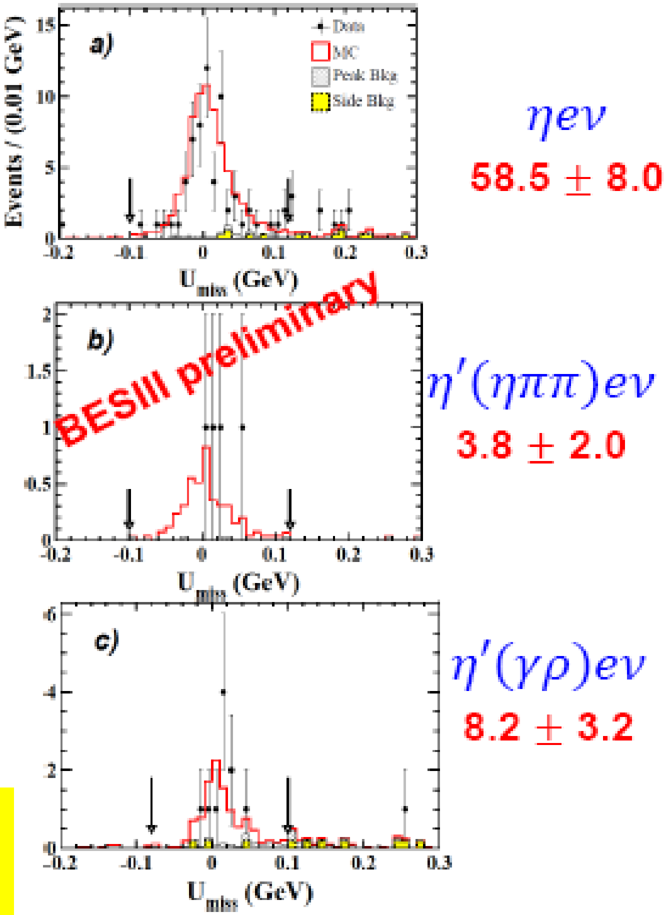
$$\frac{\Gamma[D^0 \to K^- e^+ \nu]}{\Gamma[D^+ \to \bar{K}^0 e^+ \nu]} = 0.969 \pm 0.025$$

Supporting isospin conservation in these two decays within 1.2σ

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

Submitted to PRD arXiv 1608.06484

- ISGW2 model (PRD 52, 2783 (1995))
  - Predict a difference between the *D* and D_s^+ inclusive semileptonic rates
- BRs measurements
  - Double Tag method
  - Agree to previous experimental measurements.
  - Can be used to determine the $\eta-\eta'$ mixing angle.(PLB 404, 166 (1997))
  - Improve upon the *Ds*+ semileptonic branching ratio precision.



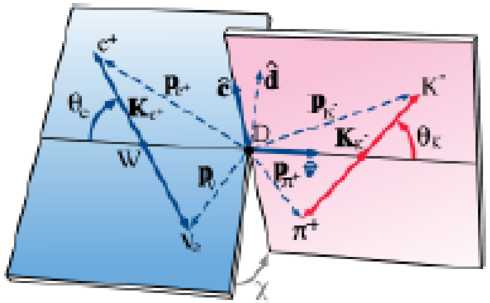
Ref. [7]: PRL 75, 3804 (1995) (CLEO II)
Ref. [8]: PRD 80, 052007 (2009) (CLEO-c)
Ref. [9]: PRD 92, 012009 (2015)

	BESIII	Ref. [7]	Ref. [8]	Ref. [9]	PDG [4]
$\mathcal{B}(D_s^+ \to \eta e^+ \nu_e)[\%]$	$2.30 \pm 0.31 \pm 0.09$	—	$2.48 \pm 0.29 \pm 0.13$	$2.28 \pm 0.14 \pm 0.20$	2.67 ± 0.29
$\mathcal{B}(D_s^+ \to \eta' e^+ \nu_e)[\%]$	$0.93 \pm 0.30 \pm 0.05$	—	$0.91 \pm 0.33 \pm 0.05$	$0.68 \pm 0.15 \pm 0.06$	0.99 ± 0.23
$\frac{\mathcal{B}(D_s^+ \to \eta' e^+ \nu_e)}{\mathcal{B}(D_s^+ \to \eta e^+ \nu_e)}$	$0.40 \pm 0.14 \pm 0.02$	$0.35 \pm 0.09 \pm 0.07$	—	—	—

BESIII preliminary using data@4.009

CLEO **CLEO** **CLEO**

Study of D→Ve^+v



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

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 $D^+ \rightarrow K^-\pi^+e^+\nu$

PRD94(2016)032001

- **Fractions with >5σ significance**

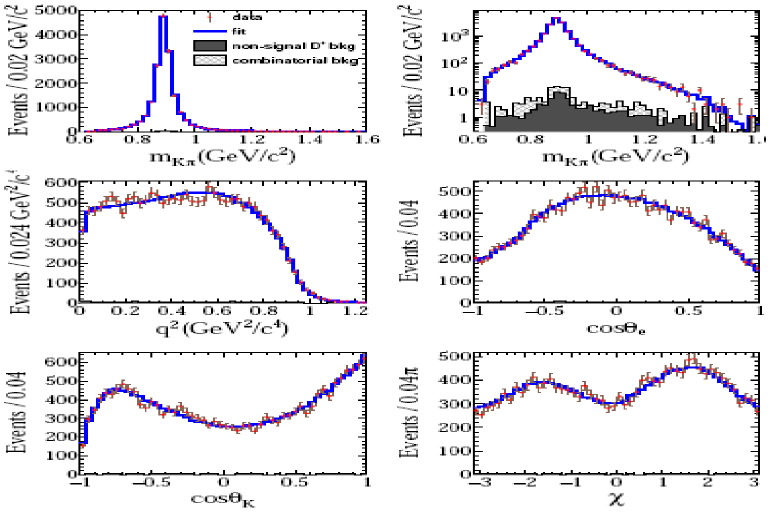
$$f(D^+ \to (K^-\pi^+)_{K^{*0}(892)}\, e^+\nu_e) = (93.93 \pm 0.22 \pm 0.18)\%$$

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

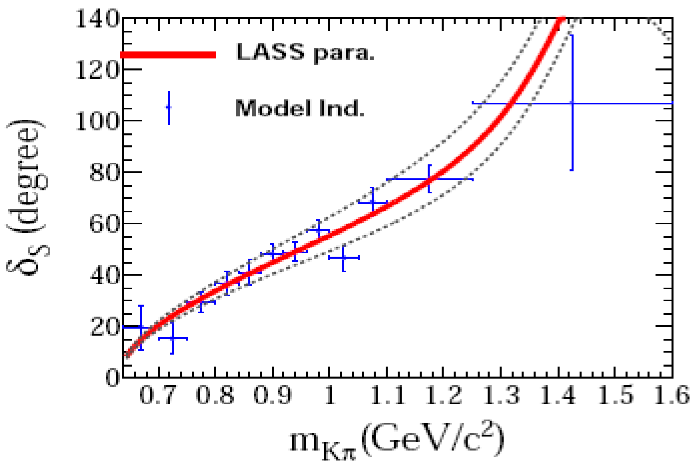
- **Properties of different Kπ (non-) resonant amplitudes**

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

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



Model independent S-wave phase measurement



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

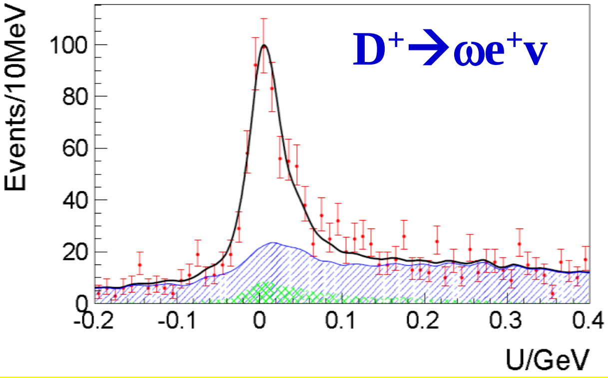
$M_{V/A}$ is expected to $M_{D^*(1-/+)}$

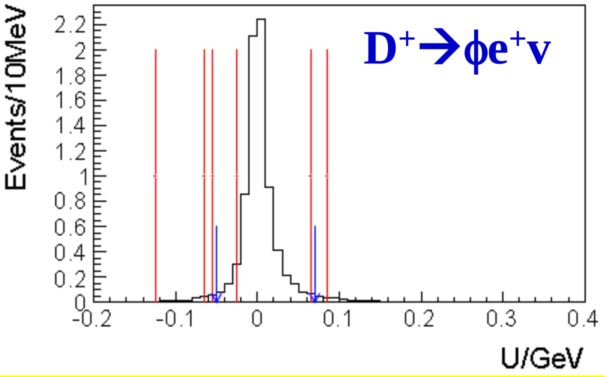
$$m_V = (1.81^{+0.25}_{-0.17} \pm 0.02)\ \mathrm{GeV}/c^2$$
$$m_A = (2.61^{+0.22}_{-0.17} \pm 0.03)\ \mathrm{GeV}/c^2$$
$$A_1(0) = 0.573 \pm 0.011 \pm 0.020$$
$$r_V = V(0)/A_1(0) = 1.411 \pm 0.058 \pm 0.007$$
$$r_2 = A_2(0)/A_1(0) = 0.788 \pm 0.042 \pm 0.008$$

Model independent form factors

Study of $D^+ \rightarrow \omega e^+ v$ and search for $D^+ \rightarrow \phi e^+ v$

PRD92(2015)071101R

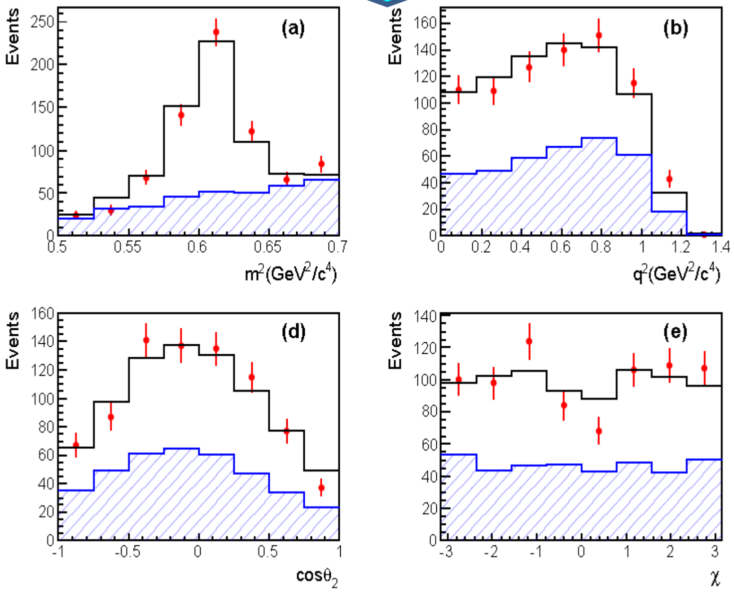




$B[D^+ \rightarrow \omega e^+ v]=(1.63\pm0.11\pm0.08)\times10^{-3}$

$B[D^+ \rightarrow \phi e^+ v]<1.3\times10^{-5}$ at 90% C.L.

Better precision or sensitivity



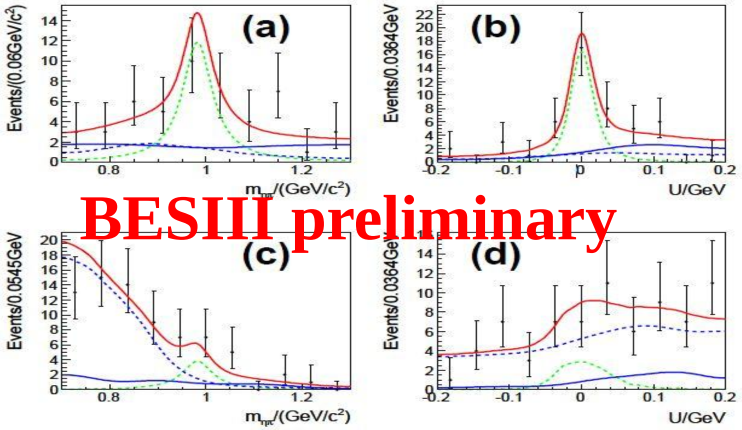
Amplitude analysis of $D^+ \rightarrow \omega e^+ v$ is performed for the first time

$r_V=V(0)/A_1(0)=1.24\pm0.09\pm0.06$

$r_2=A_2(0)/A_1(0)=1.06\pm0.15\pm0.05$

First observation/evidence of $D^{0/+} \rightarrow a^{-/0}(980)\ e^{+}\nu$

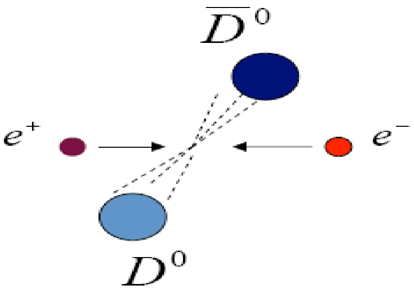
- To uncover the nontrivial internal structure of the light scalar mesons, traditional $q\bar{q}$ state, tetra quark system, or etc.
- $R \equiv \frac{B(D^+ \to f_0 l^+ \nu) + B(D^+ \to \sigma l^+ \nu)}{B(D^+ \to a_0 l^+ \nu)}$ provides a model-independent way to understand the classification of the light scalar mesons. Phys. Rev. D **82**, 034016 (2010)
  R=1(3) if those mesons are traditional qqbar (tetra quark) system.
  This analysis alone will not get us to the answer, but will provide an anchor for the further understanding of light scalar mesons.
- Semileptonic D decays provide a suitable environment
- The first measurement of the two signal channels, $D^0 \to a_0(980)^- e^+ \nu_e$ and $D^+ \to a_0(980)^0 e^+ \nu_e$. Phys. Rev. D 92, 054038 (2015)
- With the chiral unitarity approach in coupled channels, the predicted BFs are order of $5(6)\times10^{-5}$ for $D^0(D^+)$



Projection of data set, the fit results and backgrounds on (left) $M_{\eta\pi}$ and (right) U for (top) $D^0 \to a_0(980)^- e^+ \nu_e$and (bottom) $D^+ \to a_0(980)^0 e^+ \nu_e$.
[BESIII Preliminary]

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

粲介子$(D_{(s)}^{0(+)})$强子衰变



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

$$\psi(3770) : J^{PC} = 1^{--}$$

$$\hat{C}|D^0\rangle = |\bar{D}^0\rangle$$

$$\hat{C}|\bar{D}^0\rangle = |D^0\rangle$$

正反D介子处于反对称状态：

$$\psi_- = \frac{1}{\sqrt{2}}(|D^0\rangle|\bar{D}^0\rangle - |\bar{D}^0\rangle|D^0\rangle)$$

At 3.773 GeV, ψ(3770)→$D^0\bar{D}^0$衰变特有的量子关联特性

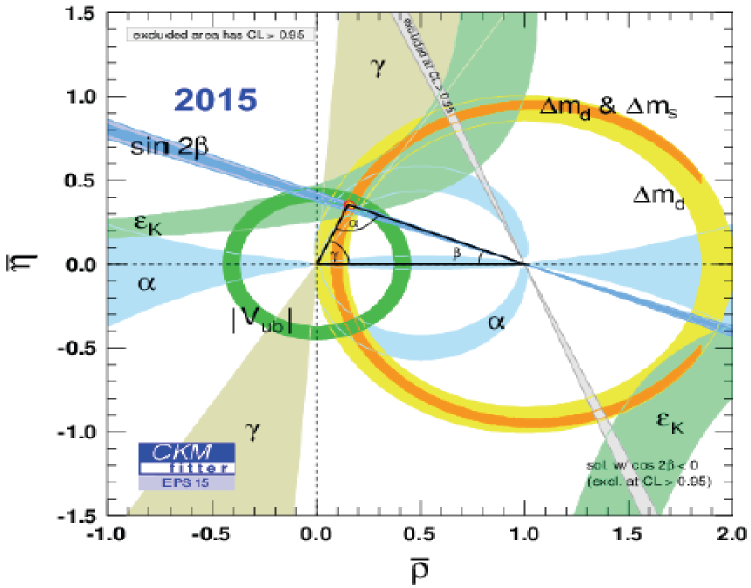
- **干涉→强相差参数c_i和s_i→约束γ/ϕ_3测量**
- **$D^0\bar{D}^0$混合参数和CP破坏**

$$\alpha/\phi_2 = (85.4^{+4.0}_{-3.9})^\circ$$

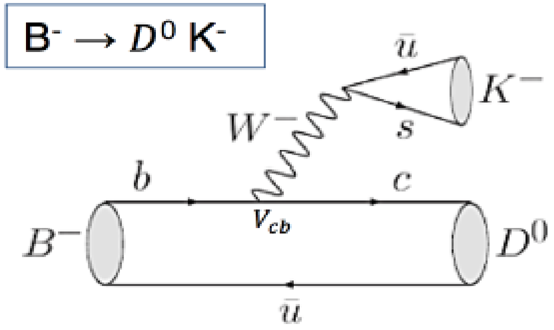
$$\beta/\phi_1 = (21.38^{+0.79}_{-0.77})^\circ$$

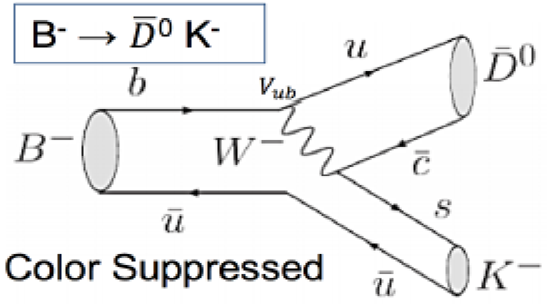
$$\boxed{\gamma/\phi_3 = (68^{+8.0}_{-8.5})^\circ}$$

目前，γ测量精度最差



γ/ϕ_3 at BELLE


$B^- \to D^0 K^-$


$B^- \to \bar{D}^0 K^-$

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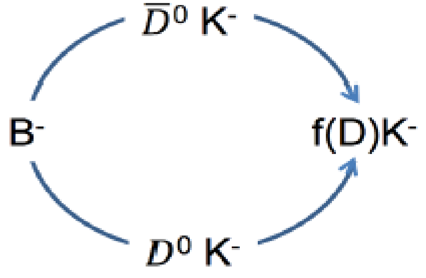


$$\frac{\langle B^- \to \overline{D^0} K^- \rangle}{\langle B^- \to D^0 K^- \rangle} = r_B e^{i(\delta_B - \phi_3)}$$

测量b→c 和b→u 的干涉

$$\boxed{\Gamma(B^- \to f(D^0)K^-) = A_B^2 A_f^2 (r_D^2 + r_B^2 + 2 r_D r_B \cos(\delta_B + \delta_D - \phi_3))}$$

Belle Model-Dependent Dalitz [Phys. Rev. D 81, 112002 (2010)]

$$78.4^{+10.8}_{-11.6}(stat) \pm 3.6(syst) \pm \boxed{8.9(Model)}$$

Belle Model-Independent Dalitz [Phys. Rev. D 85, 112014 (2012)]

$$77.3^{+15.1}_{-14.9}(stat) \pm 4.2(syst) \pm \boxed{4.3(c_i/s_i)}$$

CLEO $\overline{K}^0\pi^+\pi^-$

BelleII 和LHCb最终统计误差可以达到 1.5度左右，要求D Dalitz衰变的不确定性为1.0度。

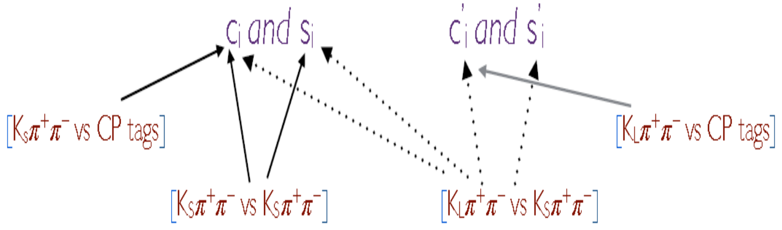
期待BESIII进一步改进(c_i,s_i), 以改进γ/ϕ_3精度

$D^0 \rightarrow \bar{K}^0\pi^+\pi^-$ DPA $\rightarrow$ (ci,si)

at 3.773 GeV

c_i,s_i can be measured using the Double Tags:

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



c_i and s_i

c'_i and s'_i

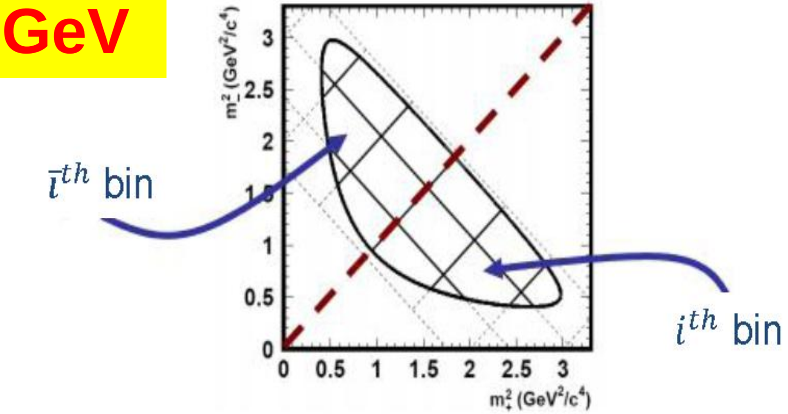
[$K_S\pi^+\pi^-$ vs CP tags]

[$K_L\pi^+\pi^-$ vs CP tags]

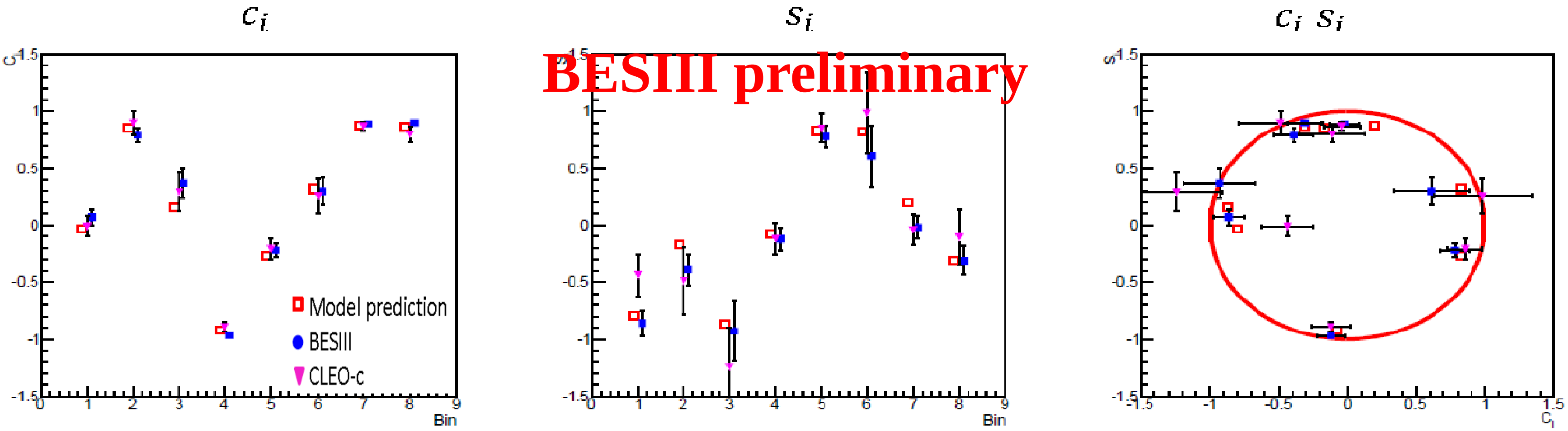
[$K_S\pi^+\pi^-$ vs $K_S\pi^+\pi^-$]

[$K_L\pi^+\pi^-$ vs $K_S\pi^+\pi^-$]

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



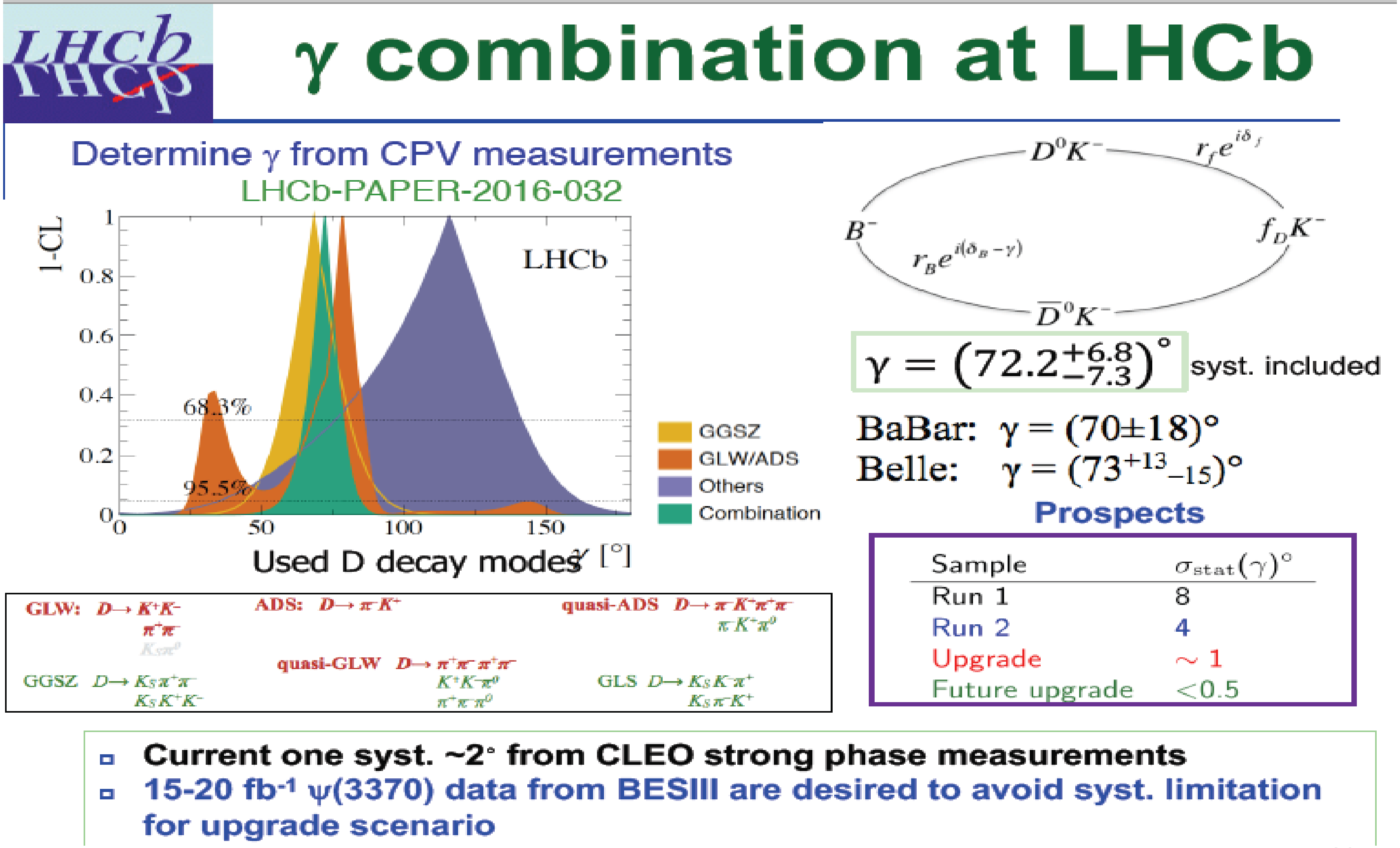
Mirrored binning over x=y makes it so $c_i = c_{\bar{i}}$ and $s_i = -s_{\bar{i}}$



此BESIII输入对γ/ϕ_3的影响: 3fb^{-1}→2.1^0

γ/ϕ_3 at LHCb

Blow slides is taken from Liming Zhang's talk



γ combination at LHCb

Determine γ from CPV measurements

LHCb-PAPER-2016-032

$$\gamma = \left(72.2^{+6.8}_{-7.3}\right)^\circ$$ syst. included

BaBar: $\gamma = (70\pm18)^\circ$

Belle: $\gamma = (73^{+13}{}_{-15})^\circ$

Used D decay modes

GLW: $D \to K^+K^-$, $\pi^+\pi^-$, $K_S\pi^0$

ADS: $D \to \pi^-K^+$

quasi-ADS $D \to \pi^-K^+\pi^+\pi^-$, $\pi^-K^+\pi^0$

quasi-GLW $D \to \pi^+\pi^-\pi^+\pi^-$, $K^+K^-\pi^0$, $\pi^+\pi^-\pi^0$

GGSZ $D \to K_S\pi^+\pi^-$, $K_SK^+K^-$

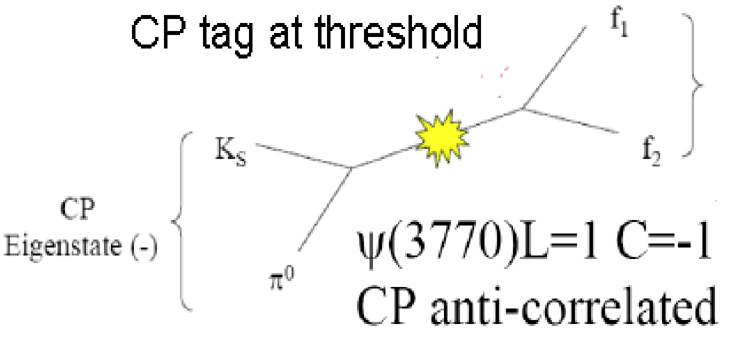
GLS $D \to K_SK^-\pi^+$, $K_S\pi^-K^+$

Prospects

Sample	$\sigma_{\text{stat}}(\gamma)^\circ$
Run 1	8
Run 2	4
Upgrade	~ 1
Future upgrade	<0.5

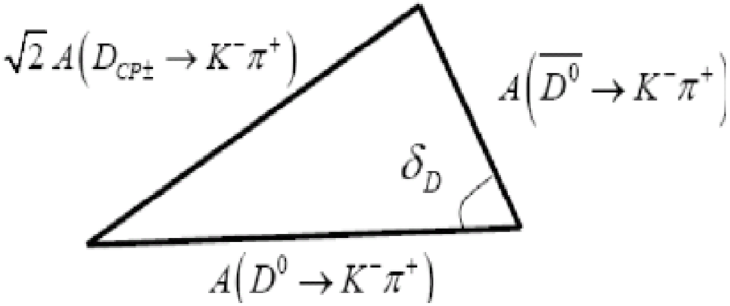
- **Current one syst. ~2° from CLEO strong phase measurements**
- **15-20 fb^{-1} $\psi(3370)$ data from BESIII are desired to avoid syst. limitation for upgrade scenario**

强相差$\delta_{K\pi}$测量



ψ(3770)L=1 C=-1

CP anti-correlated



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

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

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

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

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

目前最精确结果

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

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

PLB734(2014)227

$D^0\bar{D}^0$混合参数y_{CP}测量

For D decay to CP eigenstates:

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

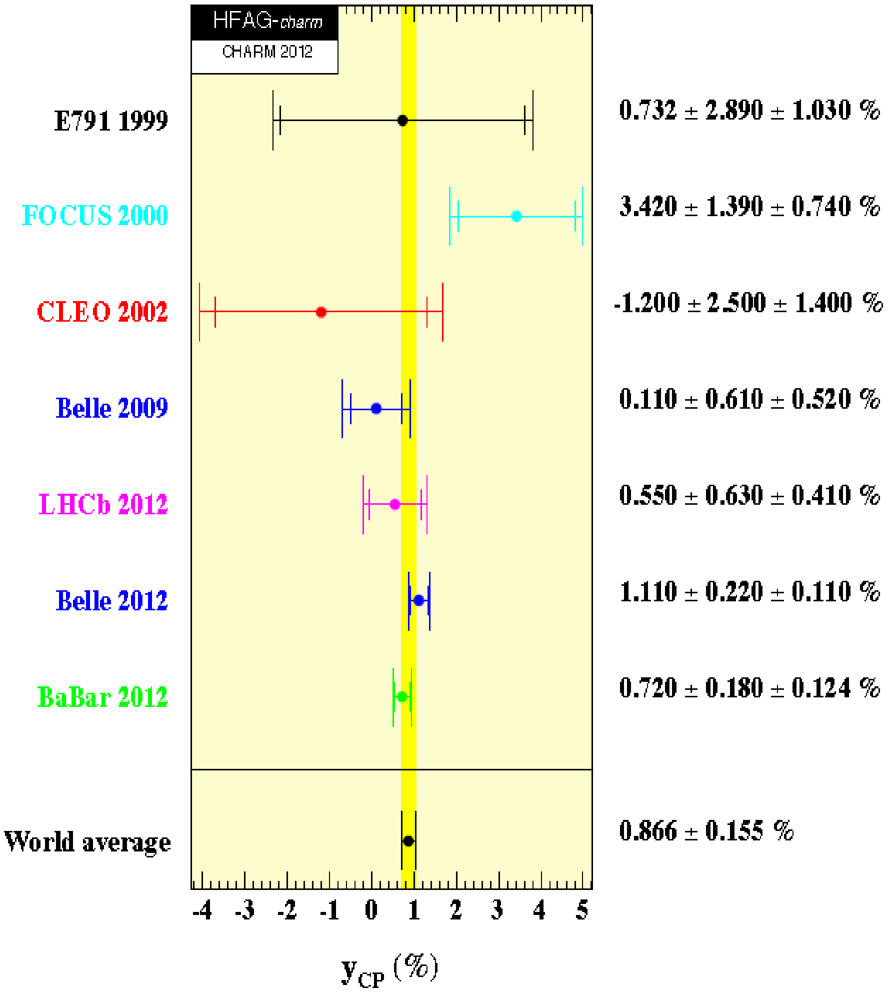
$$y_{CP} = \frac{1}{2}[y\cos\phi(|\frac{q}{p}| + |\frac{p}{q}|) - x\sin\phi(|\frac{q}{p}| - |\frac{p}{q}|)]$$

For CP tagged semileptonic D decays:

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

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

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

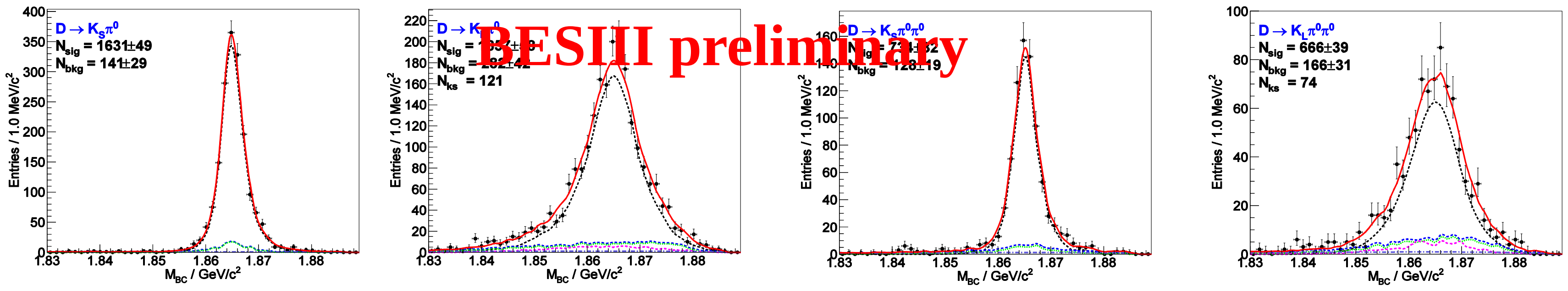


$$\boxed{y_{CP}=(-2.0\pm1.3\pm0.7)\%}$$

PLB 744(2015)339

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. Kπ (for example)



BESIII preliminary

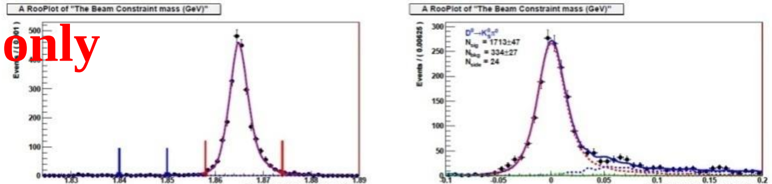
Branching fractions and asymmetries

Statistical only

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

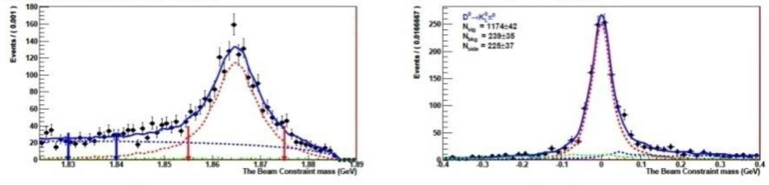
Table 10: Decay rates and the asymmetries of $D \to K^0_{S,L}\pi^0$ and $D \to K^0_{S,L}\pi^0\pi^0$.

	$D \to K^0_{S,L}\pi^0$		
	$Br_{K_S\pi^0}(\%)$	$Br_{K_L\pi^0}(\%)$	$R(D \to K_{S,L}\pi^0)$
$K\pi$	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



(a) $K^0_S\pi^0$ VS $Ke\nu$ tag-side (b) $K^0_S\pi^0$ VS $Ke\nu$ signal-side

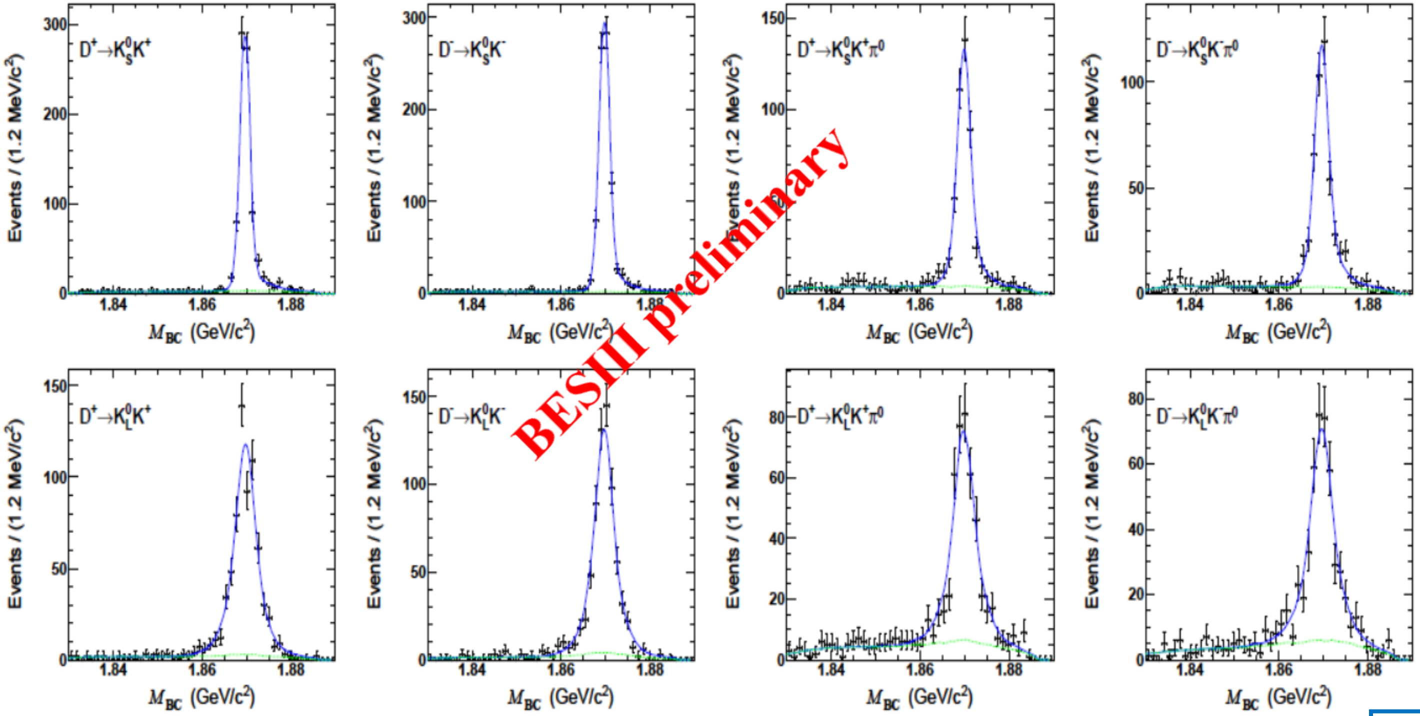
BESIII preliminary



(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)%

Absolute BFs and A_{CP} of $D^+ \rightarrow K_{S/L}K^+(\pi^0)$



The first and second uncertainties are statistical and systematic

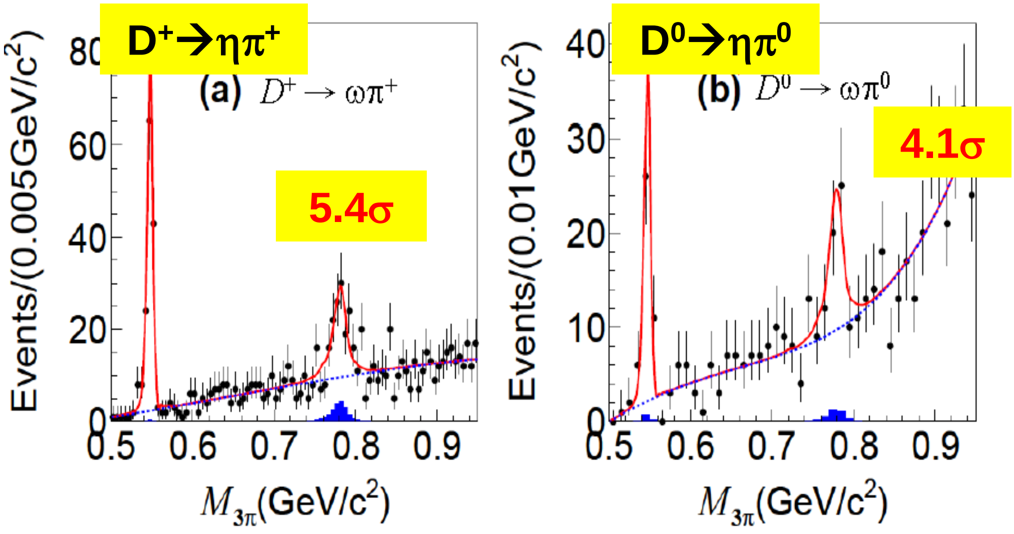
$$\mathcal{A}_{CP} = \frac{\mathcal{B}(D^+) - \mathcal{B}(D^-)}{\mathcal{B}(D^+) + \mathcal{B}(D^-)}$$

Mode	$\mathcal{B}(D^+)$ ($\times 10^{-3}$)	$\mathcal{B}(D^-)$ ($\times 10^{-3}$)	$\overline{\mathcal{B}}$ ($\times 10^{-3}$)	$\mathcal{A}_{CP}$ (%)
$K^0_S K^\pm$	$3.01 \pm 0.12 \pm 0.10$	$3.10 \pm 0.12 \pm 0.10$	$3.06 \pm 0.09 \pm 0.10$	$-1.5 \pm 2.8 \pm 1.6$
$K^0_S K^\pm \pi^0$	$5.23 \pm 0.28 \pm 0.24$	$5.09 \pm 0.29 \pm 0.22$	$5.16 \pm 0.21 \pm 0.23$	$1.4 \pm 4.0 \pm 2.4$
$K^0_L K^\pm$	$3.13 \pm 0.14 \pm 0.13$	$3.32 \pm 0.15 \pm 0.13$	$3.23 \pm 0.11 \pm 0.13$	$-3.0 \pm 3.2 \pm 1.2$
$K^0_L K^\pm \pi^0$	$5.17 \pm 0.30 \pm 0.21$	$5.26 \pm 0.30 \pm 0.20$	$5.22 \pm 0.22 \pm 0.21$	$-0.9 \pm 4.1 \pm 1.6$

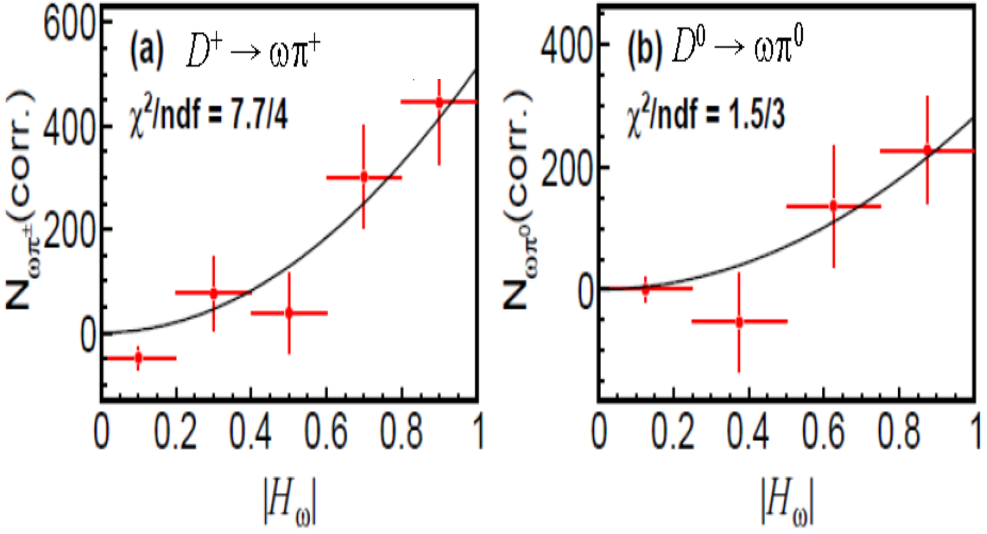
Observation/Evidence of D→ωπ

双标记方法

PRL116(2016)082001



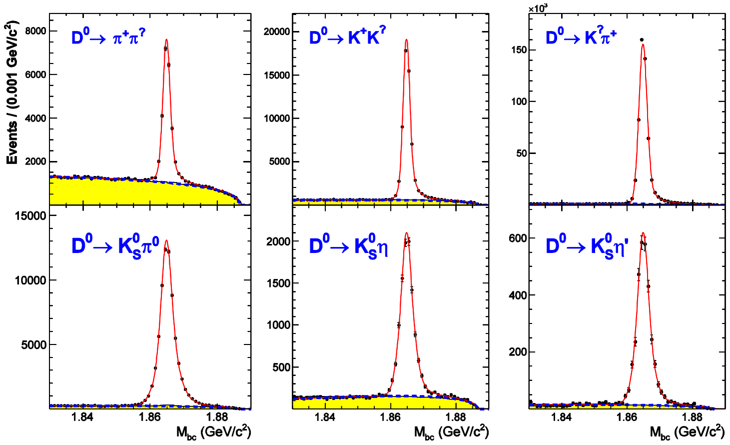
Decay mode	This work	Previous meausurements
$D^+ \to \omega\pi^+$	$(2.74 \pm 0.58 \pm 0.17) \times 10^{-4}$	$< 3.4 \times 10^{-4}$ at 90% C.L.
$D^0 \to \omega\pi^0$	$(1.05 \pm 0.41 \pm 0.09) \times 10^{-4}$	$< 2.6 \times 10^{-4}$ at 90% C.L.
$D^+ \to \eta\pi^+$	$(3.13 \pm 0.22 \pm 0.19) \times 10^{-3}$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

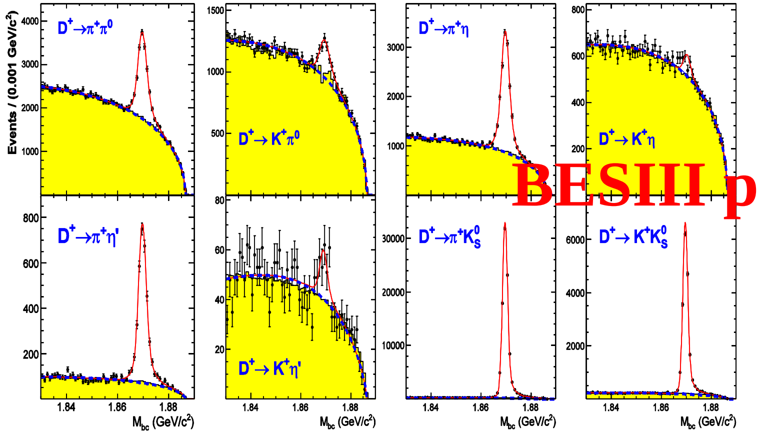


SCS衰变的研究受数据样本和方法限制

Singly-Cabibbo-Suppressed衰变的研究有助于改进人们对D介子衰变中 SU(3)对称性破坏的理解，进而改进对CP破坏的理论预期

BF measurements of some $D^{0(+)}$→PP





BESIII preliminary

- 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.

Mode	$N^{\rm net}_{\rm signal}$	ε (%)	$\mathcal{B}\pm$(stat)$\pm$(sys)	$\mathcal{B}_{\rm PDG}$
$\pi^+\pi^-$	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^-	5543[illegible] ± 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	$(1.591 \pm 0.006 \pm 0.033) \times 10^{-2}$	$(1.53 \pm 0.06) \times 10^{-2}$
$K^0_SK^+$	17704 ± 151	48.45 ± 0.14	$(3.183 \pm 0.028 \pm 0.065) \times 10^{-3}$	$(2.95 \pm 0.15) \times 10^{-3}$

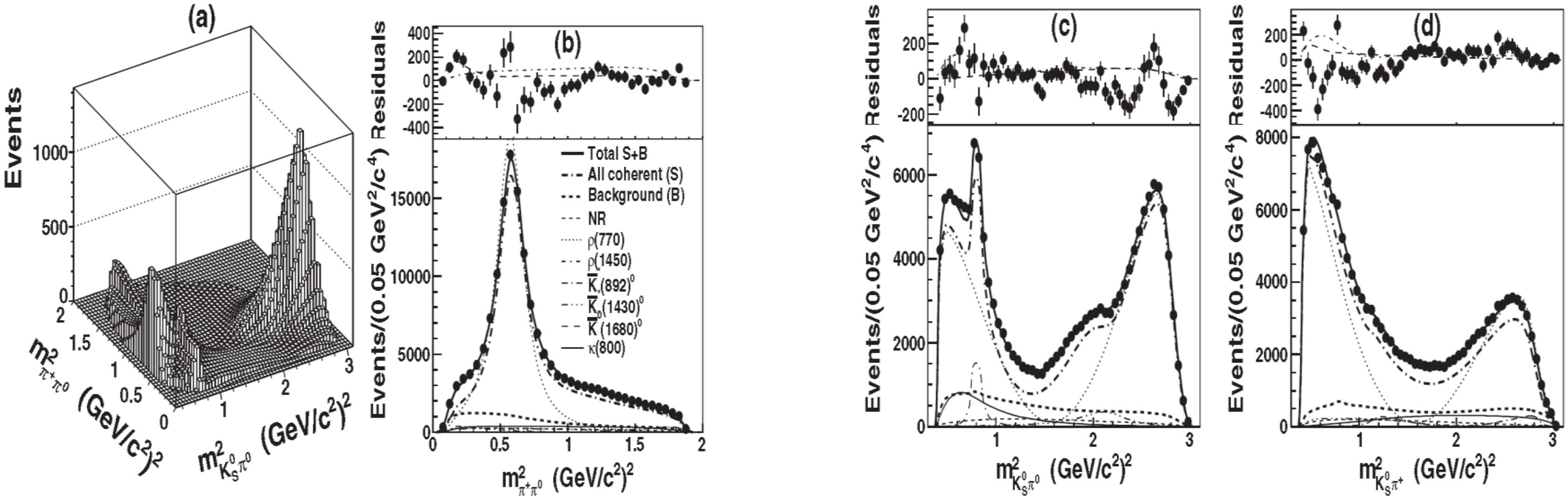
$$\mathcal{B} = \frac{N^{signal}_{net}}{2\cdot N_{D^0\bar{D}^0(D^+D^-)}\cdot\varepsilon},\ N_{D^0\bar{D}^0} = \left(10{,}621 \pm 29_{(stat)}\right) \times 10^3,\ N_{D^+D^-} = \left(8{,}296 \pm 31_{(stat)}\right) \times 10^3$$

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 $D^+ \to K^0_SK^+$, it shows better precision than the present values.

Amplitude analysis of $D^+ \rightarrow K_S^0\pi^+\pi^0$



PRD89(2014)052001

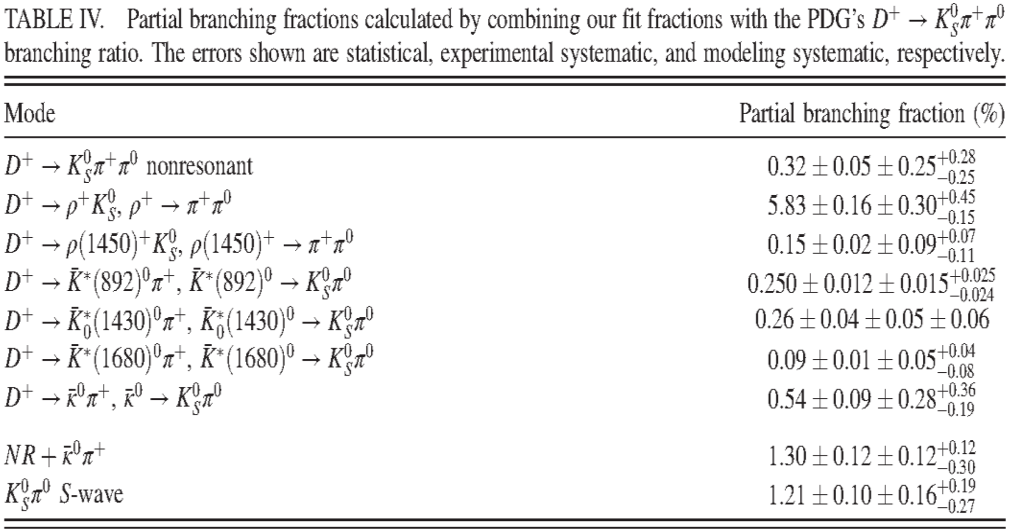


TABLE IV. Partial branching fractions calculated by combining our fit fractions with the PDG's $D^+ \rightarrow K_S^0\pi^+\pi^0$ branching ratio. The errors shown are statistical, experimental systematic, and modeling systematic, respectively.

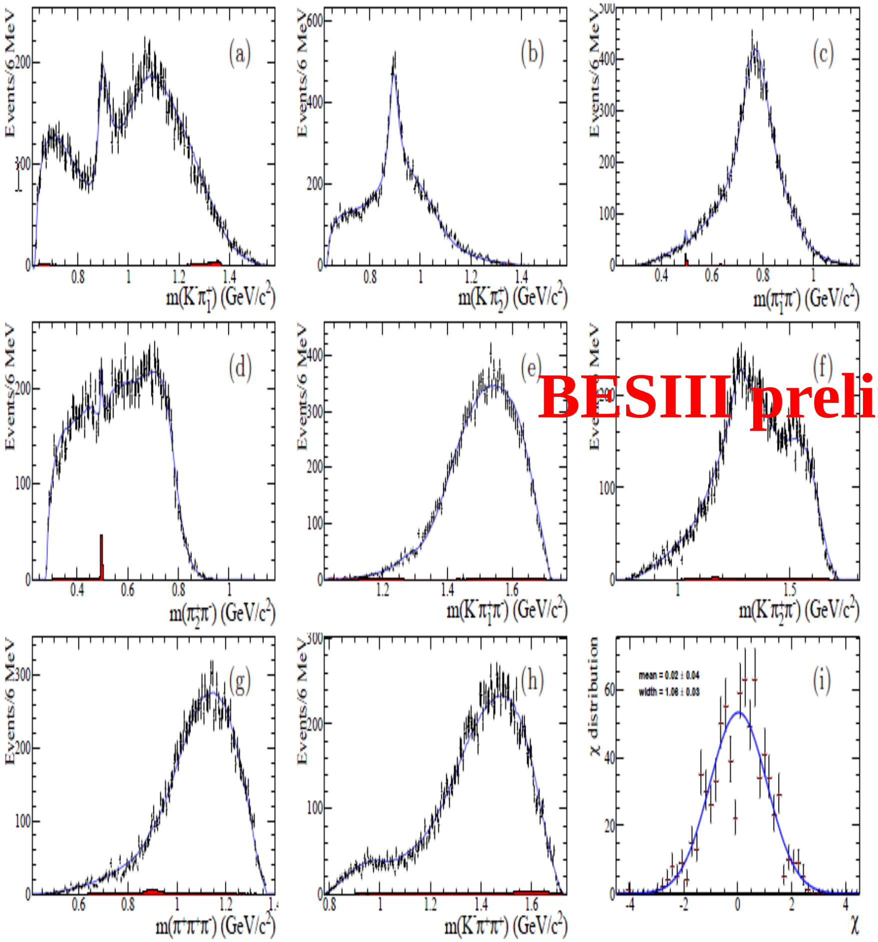
Mode	Partial branching fraction (%)
$D^+ \rightarrow K_S^0\pi^+\pi^0$ nonresonant	$0.32 \pm 0.05 \pm 0.25^{+0.28}_{-0.25}$
$D^+ \rightarrow \rho^+ K_S^0$, $\rho^+ \rightarrow \pi^+\pi^0$	$5.83 \pm 0.16 \pm 0.30^{+0.45}_{-0.15}$
$D^+ \rightarrow \rho(1450)^+ K_S^0$, $\rho(1450)^+ \rightarrow \pi^+\pi^0$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

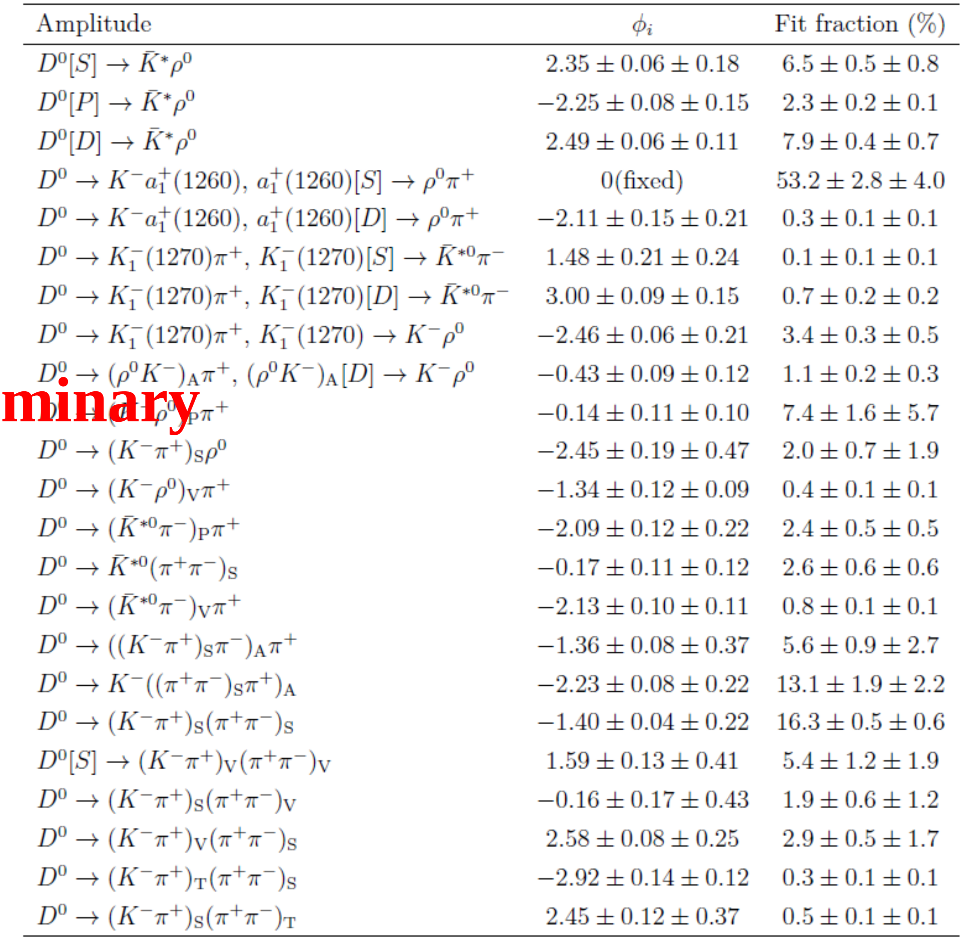
Amplitude analysis of $D^0 \rightarrow K^-\pi^+\pi^+\pi^-$

Help to determine the absolute BF, strong phase, benefit γ/ϕ_3

Previous analyses only from MarkIII and E691



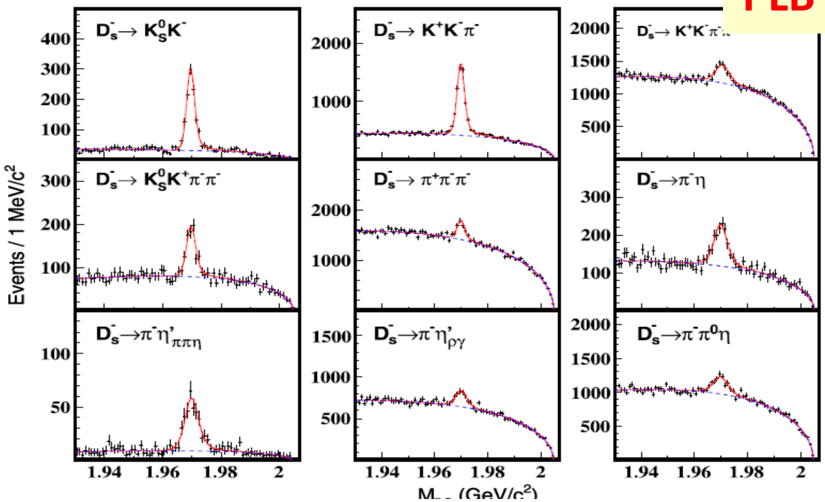
BESIII preliminary



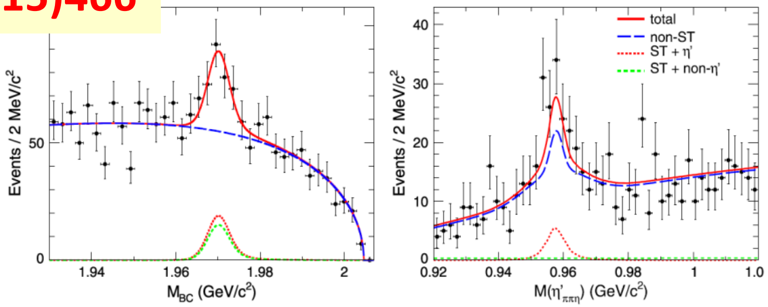
Amplitude	ϕ_i	Fit fraction (%)
$D^0[S] \to \bar{K}^*\rho^0$	$2.35 \pm 0.06 \pm 0.18$	$6.5 \pm 0.5 \pm 0.8$
$D^0[P] \to \bar{K}^*\rho^0$	$-2.25 \pm 0.08 \pm 0.15$	$2.3 \pm 0.2 \pm 0.1$
$D^0[D] \to \bar{K}^*\rho^0$	$2.49 \pm 0.06 \pm 0.11$	$7.9 \pm 0.4 \pm 0.7$
$D^0 \to K^-a_1^+(1260),\ a_1^+(1260)[S] \to \rho^0\pi^+$	0(fixed)	$53.2 \pm 2.8 \pm 4.0$
$D^0 \to K^-a_1^+(1260),\ a_1^+(1260)[D] \to \rho^0\pi^+$	$-2.11 \pm 0.15 \pm 0.21$	$0.3 \pm 0.1 \pm 0.1$
$D^0 \to K_1^-(1270)\pi^+,\ K_1^-(1270)[S] \to \bar{K}^{*0}\pi^-$	$1.48 \pm 0.21 \pm 0.24$	$0.1 \pm 0.1 \pm 0.1$
$D^0 \to K_1^-(1270)\pi^+,\ K_1^-(1270)[D] \to \bar{K}^{*0}\pi^-$	$3.00 \pm 0.09 \pm 0.15$	$0.7 \pm 0.2 \pm 0.2$
$D^0 \to K_1^-(1270)\pi^+,\ K_1^-(1270) \to K^-\rho^0$	$-2.46 \pm 0.06 \pm 0.21$	$3.4 \pm 0.3 \pm 0.5$
$D^0 \to (\rho^0K^-)_{\rm A}\pi^+,\ (\rho^0K^-)_{\rm A}[D] \to K^-\rho^0$	$-0.43 \pm 0.09 \pm 0.12$	$1.1 \pm 0.2 \pm 0.3$
$D^0 \to (K^-\rho^0)_{\rm P}\pi^+$	$-0.14 \pm 0.11 \pm 0.10$	$7.4 \pm 1.6 \pm 5.7$
$D^0 \to (K^-\pi^+)_{\rm S}\rho^0$	$-2.45 \pm 0.19 \pm 0.47$	$2.0 \pm 0.7 \pm 1.9$
$D^0 \to (K^-\rho^0)_{\rm V}\pi^+$	$-1.34 \pm 0.12 \pm 0.09$	$0.4 \pm 0.1 \pm 0.1$
$D^0 \to (\bar{K}^{*0}\pi^-)_{\rm P}\pi^+$	$-2.09 \pm 0.12 \pm 0.22$	$2.4 \pm 0.5 \pm 0.5$
$D^0 \to \bar{K}^{*0}(\pi^+\pi^-)_{\rm S}$	$-0.17 \pm 0.11 \pm 0.12$	$2.6 \pm 0.6 \pm 0.6$
$D^0 \to (\bar{K}^{*0}\pi^-)_{\rm V}\pi^+$	$-2.13 \pm 0.10 \pm 0.11$	$0.8 \pm 0.1 \pm 0.1$
$D^0 \to ((K^-\pi^+)_{\rm S}\pi^-)_{\rm A}\pi^+$	$-1.36 \pm 0.08 \pm 0.37$	$5.6 \pm 0.9 \pm 2.7$
$D^0 \to K^-((\pi^+\pi^-)_{\rm S}\pi^+)_{\rm A}$	$-2.23 \pm 0.08 \pm 0.22$	$13.1 \pm 1.9 \pm 2.2$
$D^0 \to (K^-\pi^+)_{\rm S}(\pi^+\pi^-)_{\rm S}$	$-1.40 \pm 0.04 \pm 0.22$	$16.3 \pm 0.5 \pm 0.6$
$D^0[S] \to (K^-\pi^+)_{\rm V}(\pi^+\pi^-)_{\rm V}$	$1.59 \pm 0.13 \pm 0.41$	$5.4 \pm 1.2 \pm 1.9$
$D^0 \to (K^-\pi^+)_{\rm S}(\pi^+\pi^-)_{\rm V}$	$-0.16 \pm 0.17 \pm 0.43$	$1.9 \pm 0.6 \pm 1.2$
$D^0 \to (K^-\pi^+)_{\rm V}(\pi^+\pi^-)_{\rm S}$	$2.58 \pm 0.08 \pm 0.25$	$2.9 \pm 0.5 \pm 1.7$
$D^0 \to (K^-\pi^+)_{\rm T}(\pi^+\pi^-)_{\rm S}$	$-2.92 \pm 0.14 \pm 0.12$	$0.3 \pm 0.1 \pm 0.1$
$D^0 \to (K^-\pi^+)_{\rm S}(\pi^+\pi^-)_{\rm T}$	$2.45 \pm 0.12 \pm 0.37$	$0.5 \pm 0.1 \pm 0.1$

$D_s^+ \rightarrow \eta' X$ and $\eta'\rho^+$

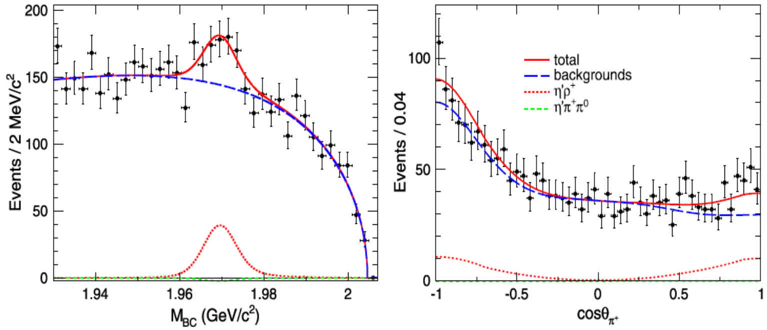
PLB 750(2015)466



~15.6 K ST



$N[D_s^+ \rightarrow \eta' X] = 68 \pm 14$



$N[D_s^+ \rightarrow \eta'\rho^+] = 210 \pm 50$

$B_{CLEO}[D_s^+ \rightarrow \eta'\rho^+] = (12.5 \pm 2.2)\%$

PRD58(1998)052002

是理论预期(3.0±0. 5)%的4倍

F.S.Yu PRD84(2011)074019

$B^{PDG14}_{SUM}[D_s^+ \rightarrow \eta' X] = (18.6 \pm 2.3)\%$

$B_{MSR}[D_s^+ \rightarrow \eta' X] = (11.7 \pm 1.8)\%$

PRD79(2009)112008

$B[D_s^+ \rightarrow \eta' X] = (8.8 \pm 1.8 \pm 0.5)\%$

$B[D_s^+ \rightarrow \eta'\rho^+] = (5.8 \pm 1.4 \pm 0.4)\%$

与CLEOPRD88(2013)032009一致

实验结果解决了实验和理论不一致的矛盾

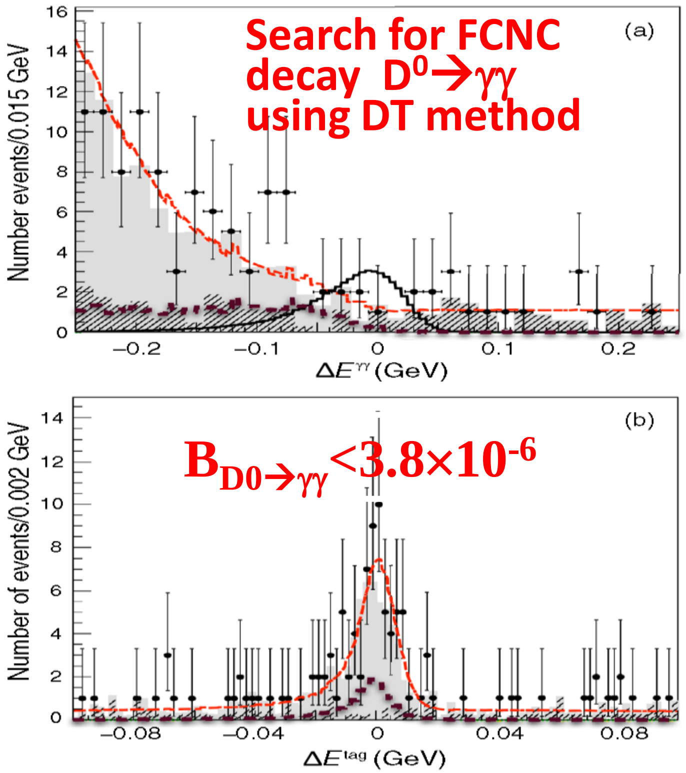
D介子稀有衰变的寻找

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

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

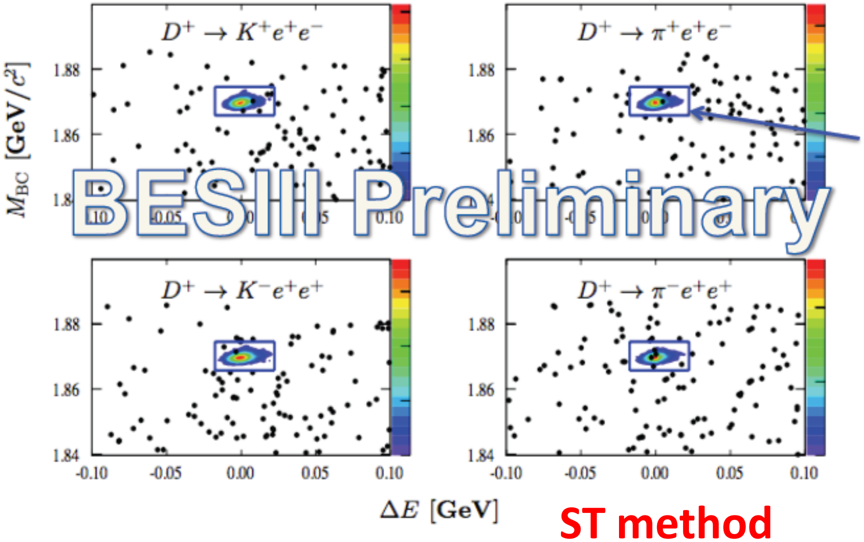
$$CP \text{ violation asymmetries } \sim 10^{-3}$$

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



Search for FCNC decay $D^0 \rightarrow \gamma\gamma$ using DT method

$B_{D0 \rightarrow \gamma\gamma} < 3.8 \times 10^{-6}$

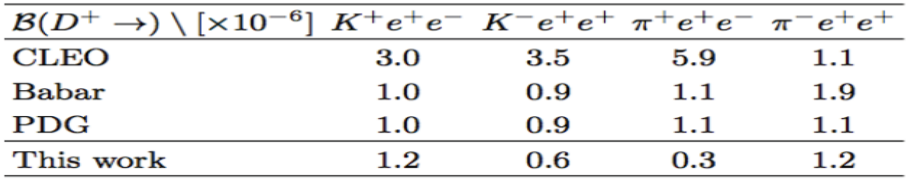


FCNC decay

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

LNV decay

ST method



$\mathcal{B}(D^+ \rightarrow) \setminus [\times 10^{-6}]$	$K^+e^+e^-$	$K^-e^+e^+$	$\pi^+e^+e^-$	$\pi^-e^+e^+$
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

PRD 91(2015)112015

Consistent with Babar result

总结

- 使用在3.773/4.009 GeV采集的2.93/0.482 fb^{-1} 的样本，取得了世界最好精度的研究结果

  --Decay constant f_{D+}

  --Form factor $f^{D\rightarrow K(\pi)}_{+}(q^2)$

  --CKM matrix element $|V_{cs(d)}|$

  →精密检验LQCD理论计算和CKM矩阵幺正性、探讨CP破坏

  --y_{CP}, $\delta_{K\pi}$

  --强相差(c_i,s_i)初步结果. More ψ(3770) data help further reduce input uncertainty of measuring γ/ϕ_3 at Belle2@LHCb

  --More results are expected in the near future

- 2016年，BESIII在4.18 GeV采集了约3 fb^{-1}数据，D_s^+物理分析正在积极开展

谢谢！