Charm Decays at Belle

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on behalf of the Belle collaboration

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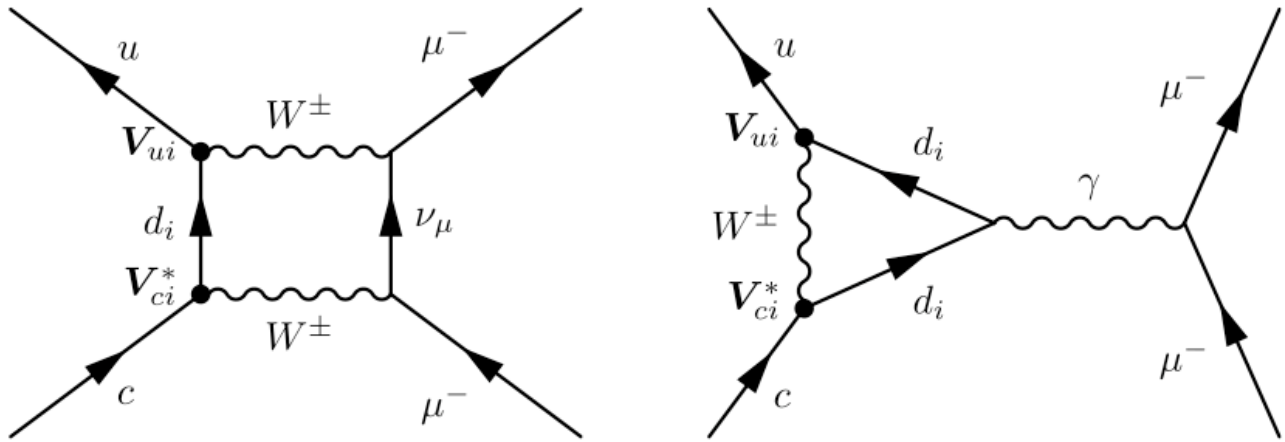
Contents

- Search for leptonic decay of D^0 (new: best limits)
- Study of $D^+_{(s)} \to K_S h^+$ (new: best measurements)
- First observation of DCSD in $D^+_s \to K^+K^+\pi^-$

Search for $D^0 \to \ell^+\ell^-$

- FCNC does not appear in SM on tree level (higher order below allowed)



- Certain new physics scenarios allows this process: new particle replacing W boson

Model	$\mathcal{B}_{D^0\to\mu^+\mu^-}$
Experiment	$\leq 4.3 \times 10^{-7}$ (CDF preliminary)
Standard Model (SD)	$\sim 10^{-18}$
Standard Model (LD)	$\sim$ several $\times 10^{-13}$
$Q = +2/3$ Vector-like Singlet	4.3×10^{-11}
$Q = -1/3$ Vector-like Singlet	$1 \times 10^{-11}\ (m_S/500\ \text{GeV})^2$
$Q = -1/3$ Fourth Family	$1 \times 10^{-11}\ (m_S/500\ \text{GeV})^2$
Z' Standard Model (LD)	$2.4 \times 10^{-12}/(M_{Z'}(\text{TeV}))^2$
Family Symmetry	0.7×10^{-18}
RPV-SUSY	$4.8 \times 10^{-9}\ (300\ \text{GeV}/m_{\tilde{d}_k})^2$

E. Golowich, J. Hewett, S. Pakvasa, A. A. Petrov
PRD79 114030 (2009)

Except Family Symmetry all NP exceed the SM prediction

Belle is most sensitive to RPV-SUSY scenario

Search for $D^0 \to \ell^+\ell^-$

Data Sample

- 659 fb-1 of Υ(4S) resonance and near data analyzed
- Normalization channel $D^0 \to \pi^+\pi^-$ (both MC and data)

Event Selection

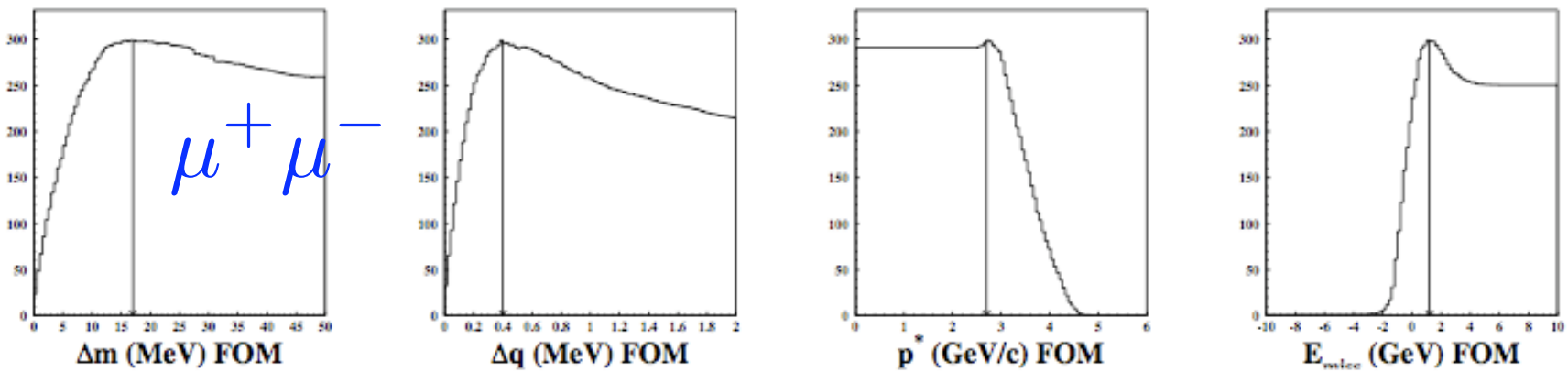
- Particle identification, soft pion tagging for D meson
- vertex fit for D(*) meson, $q \equiv m_{D^{*+}} - m_{D^0} - m_{\pi_s} < 0.02\ \mathrm{GeV}/c^2$
- D meson momentum cut: $p_{D^{*+}} > 2.5\ \mathrm{GeV}/c$

Optimization

- maximizing $\epsilon_{\ell\ell}/N_{UL}$

$\epsilon_{\ell\ell}$: efficiency N_{UL} : Poisson average of FC 90% CL upper limit

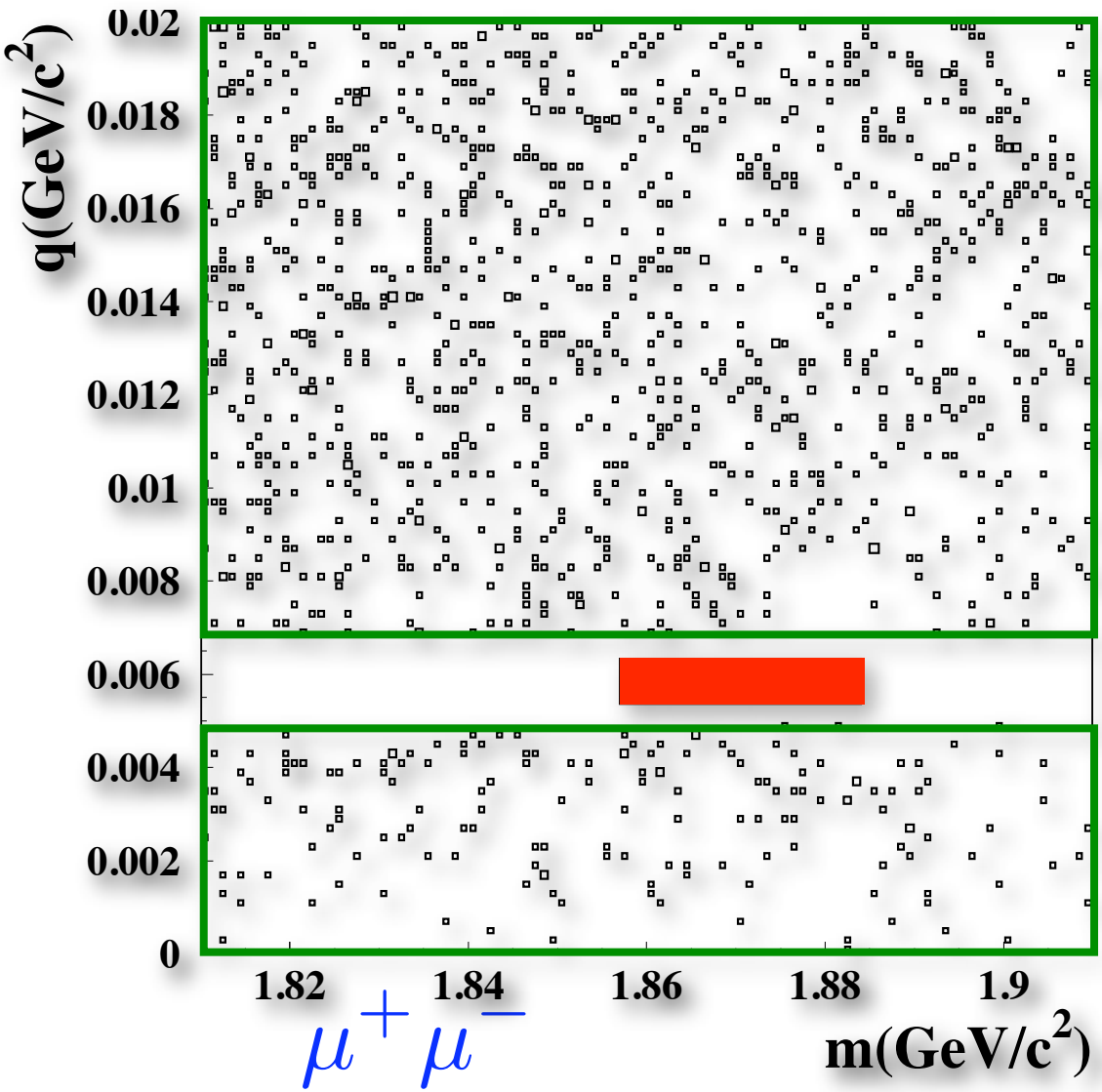
lepton ID, $\Delta m, \Delta q, E_{\mathrm{miss}}, p^*_{D^{*+}}$ are used for the optimization



Search for $D^0 \to \ell^+\ell^-$

- Estimation of background

$q \equiv m_{D^{*+}} - m_{D^0} - m_{\pi_s}$



- Combinatorial background

2 D estimation with $a(1-bm)/\sqrt{q}$

The ratio of combinatorial background in the signal to the number in the side band

channel	p[%]
$\mu^+\mu^-$	1.08
e^+e^-	1.49
$e^\pm\mu^\mp$	1.43

- Reflection background from $D^0 \to \pi^+\pi^-$

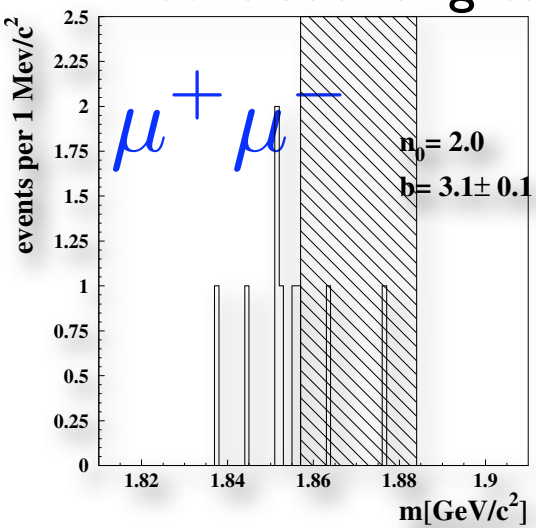
- peak shifted in m but on peak in q
- $\pi^+ \to \ell^+$ mis-id measured with $D^0 \to K^-\pi^+$

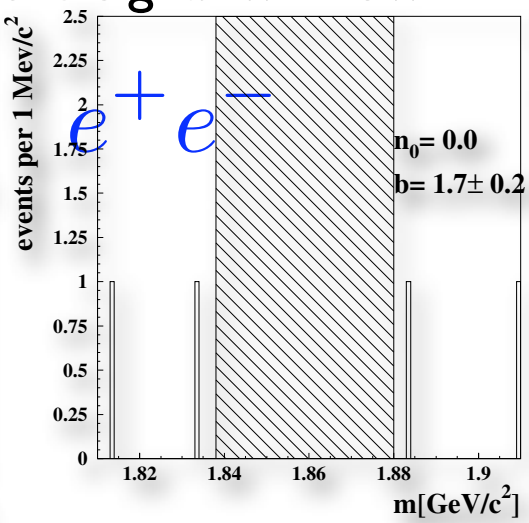
(Number of reflection in the signal window)

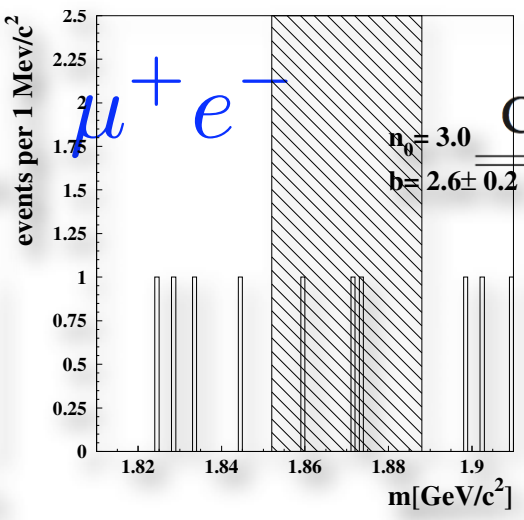
channel	N_{refl}^{DATA}
$\mu^+\mu^-$	1.81 ± 0.002
e^+e^-	0.0372 ± 0.0002
$e^\pm\mu^\mp$	0.1935 ± 0.0006

Study of $D^0 \to \ell^+\ell^-$

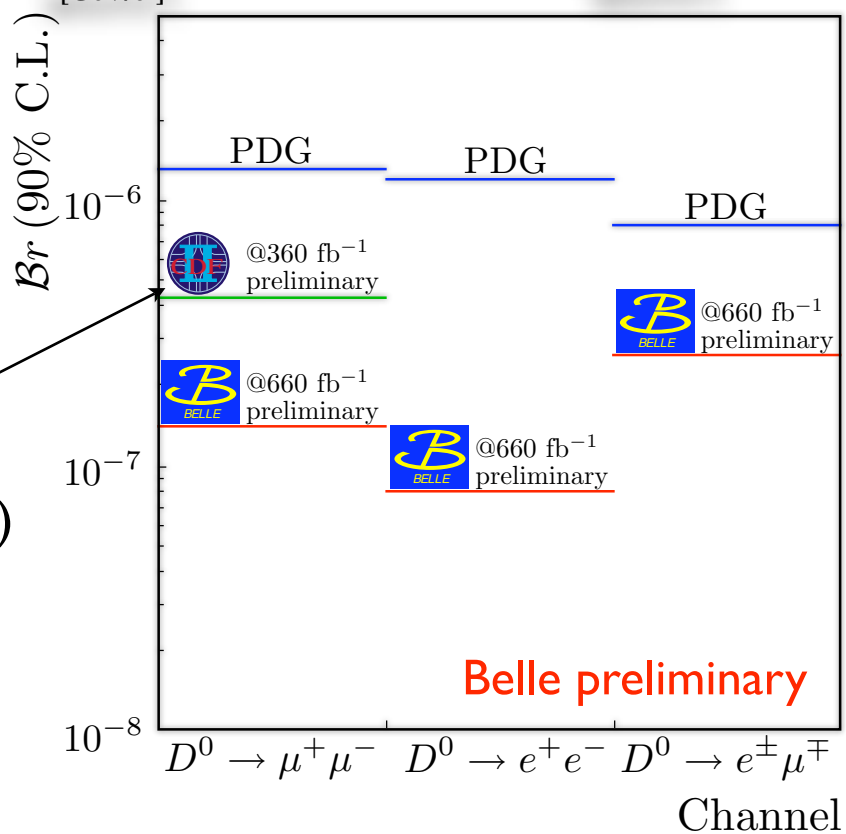
- Event counting at the signal window







Channel.	n	b
$\mu^+\mu^-$	2	3.1±0.1
e^+e^-	0	1.7±0.2
$e^\pm\mu^\mp$	3	2.6±0.2



ICHEP08 CDF
(4.3×10^{-7})

90% CL upper limit Belle preliminary

$$\mathcal{B}(D^0 \to \mu^+\mu^-) < 1.4 \times 10^{-7}$$
$$\mathcal{B}(D^0 \to e^+e^-) < 7.9 \times 10^{-8}$$
$$\mathcal{B}(D^0 \to \mu^\pm e^\mp) < 2.6 \times 10^{-7}$$

Study of $D^+_{(s)} \to K_S h^+$

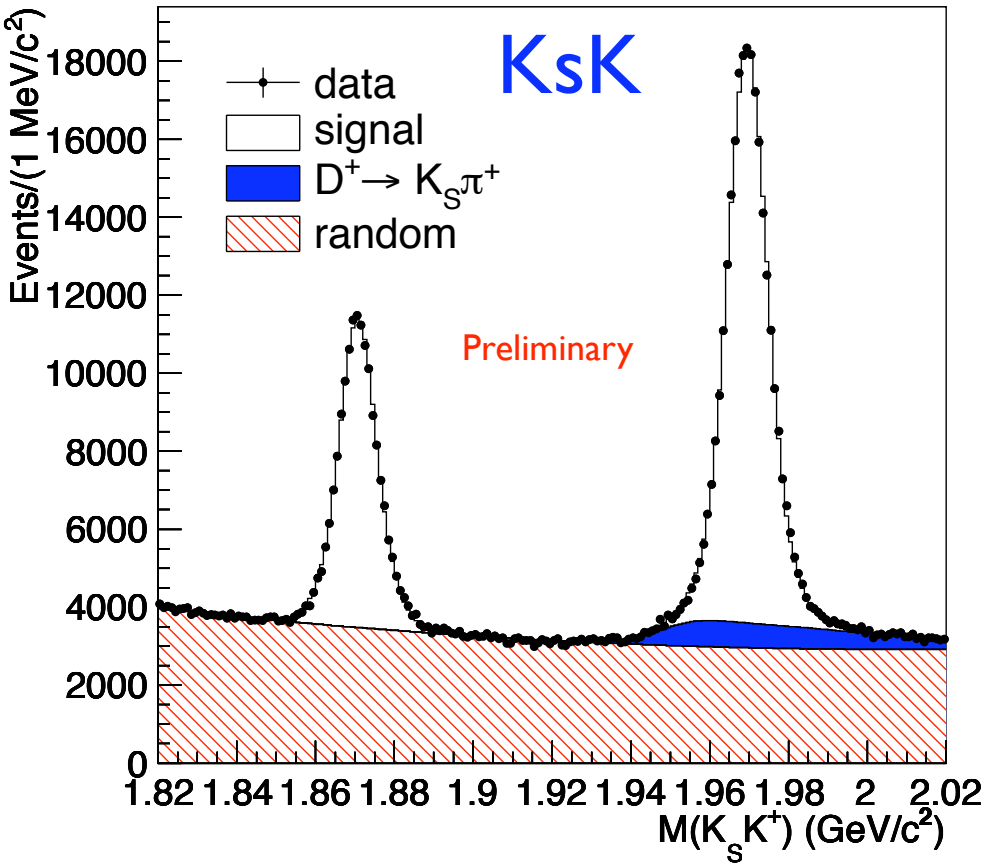
- We look for ratios of SCS to CF $D^+_{(s)}$ decays
- Present measurements are dominated by CLEO

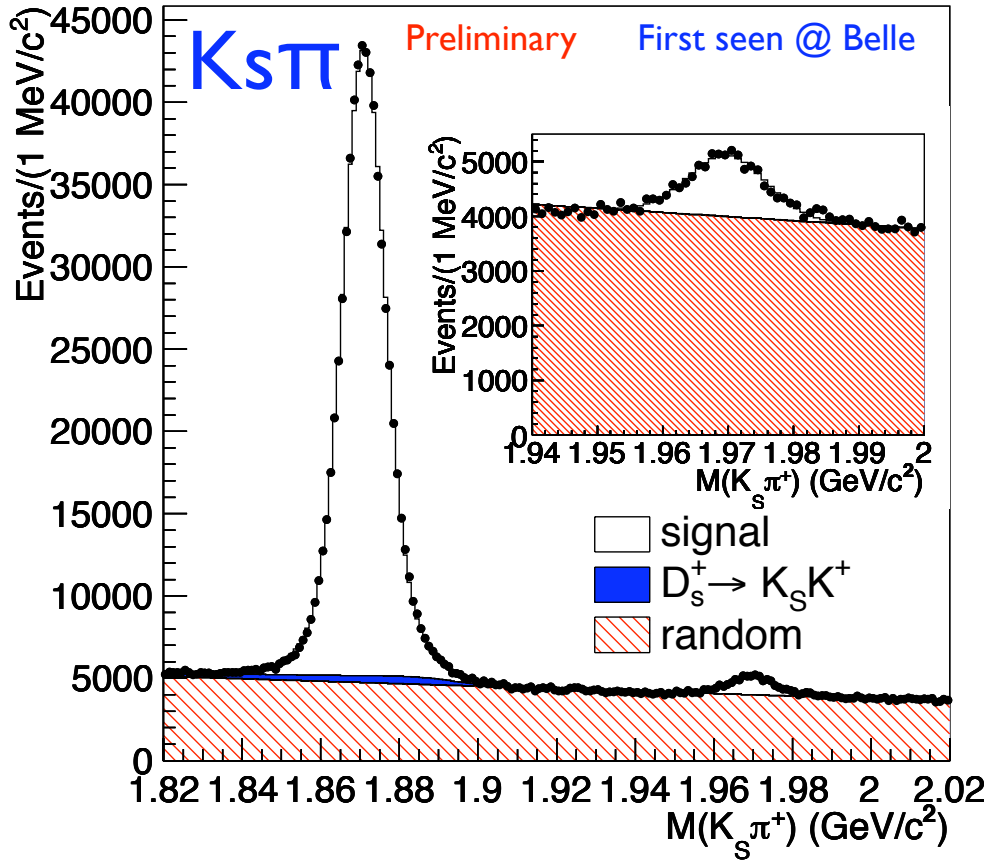
Mode	PDG2008	CLEO 2009 (*)
$\mathcal{B}(D^+ \to K_S K^+)/\mathcal{B}(D^+ \to K_S \pi^+)$	0.189±0.016±0.007	0.199±0.007
$\mathcal{B}(D_s^+ \to K_S \pi^+)/\mathcal{B}(D_s^+ \to K_S K^+)$	0.082±0.009±0.002	0.085±0.007

(*) My personal calculation from CLEO arXiv: 0906.3198v1 (including systematics)

- The goal of this study is to improve this ratio measurements
- It may give us better understanding on flavor SU(3) symmetry with other measurements

Study of $D^+_{(s)} \to K_S h^+$





Preliminary fit yields

Decay modes	Yields
$D^+ \to K_S K^+$	100855 ± 561
$D_s^+ \to K_S K^+$	204093 ± 768
$D^+ \to K_S \pi^+$	566105 ± 1159
$D_s^+ \to K_S \pi^+$	16817 ± 448

Preliminary ratios of CS/CF

$\mathcal{B}(D^+ \to K_S K^+)/\mathcal{B}(D^+ \to K_S \pi^+)$ =0.190±0.001±0.002

$\mathcal{B}(D_s^+ \to K_S \pi^+)/\mathcal{B}(D_s^+ \to K_S K^+)$ =0.077±0.002±0.002

Observation of $D_s^+ \to K^+K^+\pi^-$

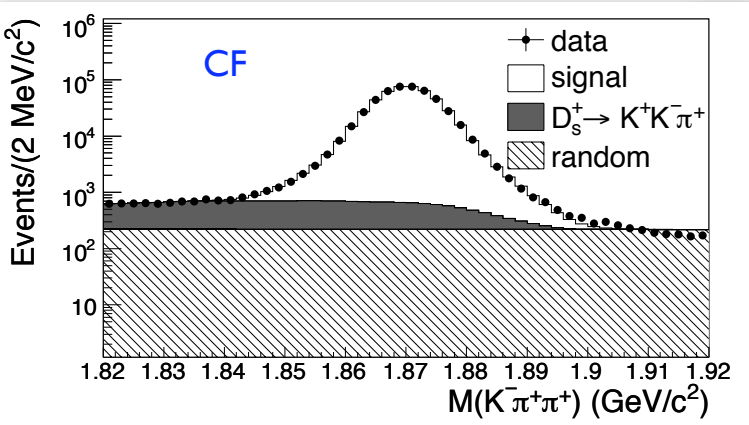
- Not observed yet
- One can look at the double ratio to test SU(3) flavor symmetry : Lipkin, NPB 115 117 (2003)

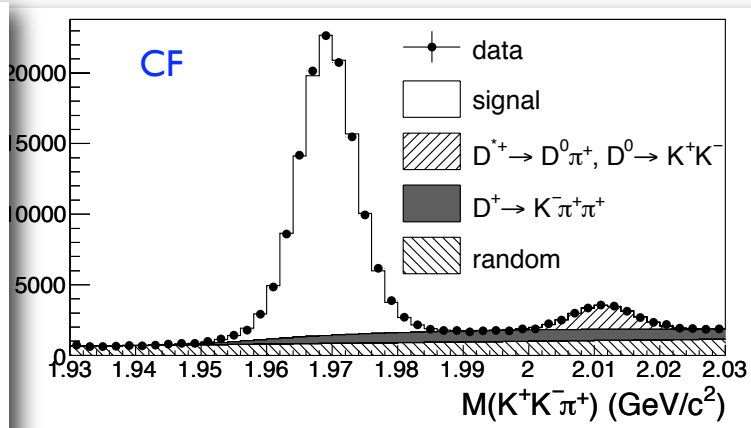
$$\frac{\mathcal{B}(D_s^+ \to K^+K^+\pi^-)}{\mathcal{B}(D_s^+ \to K^+K^-\pi^+)} \frac{\mathcal{B}(D^+ \to K^+\pi^+\pi^-)}{\mathcal{B}(D^+ \to K^-\pi^+\pi^+)} = \tan^8\theta_C$$

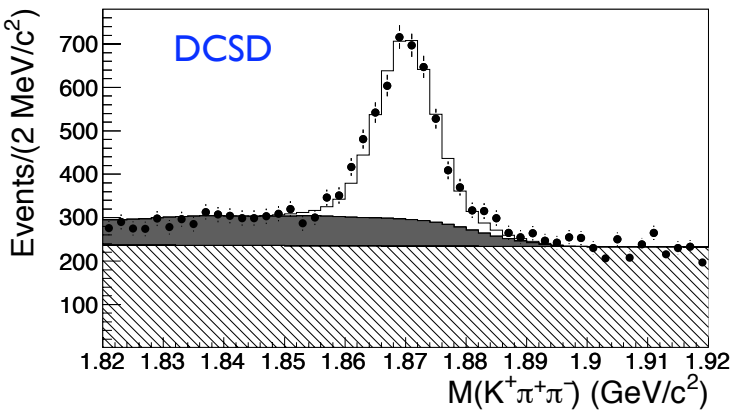
- Differences in the phase space cancel in the ratios
- SU(3) breaking effects due to resonant intermediate states in the 3-body violates the equation above

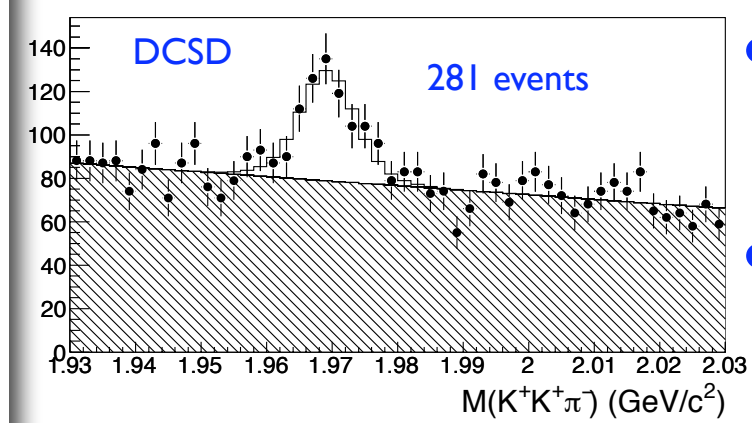
Observation of $D_s^+ \to K^+K^+\pi^-$

PRL 102 221802 (2009)









- First observation of $D_s^+ \to K^+K^+\pi^-$
- 9.1 standard deviation effect

Branching fraction	Belle	World average [3]
$\mathcal{B}(D^+ \to K^+\pi^+\pi^-)$	$(5.2 \pm 0.2 \pm 0.1) \times 10^{-4}$	$(6.2 \pm 0.7) \times 10^{-4}$
$\mathcal{B}(D_s^+ \to K^+K^+\pi^-)$	$(1.3 \pm 0.2 \pm 0.1) \times 10^{-4}$	$(2.9 \pm 1.1) \times 10^{-4}$

$$\frac{\mathcal{B}(D_s^+ \to K^+K^+\pi^-)}{\mathcal{B}(D_s^+ \to K^+K^-\pi^+)} \frac{\mathcal{B}(D^+ \to K^+\pi^+\pi^-)}{\mathcal{B}(D^+ \to K^-\pi^+\pi^+)} = (1.57 \pm 0.21) \cdot \tan^8\theta_C$$

Summary of Charm decays

- Search for leptonic decays of D^0

  - Best limits are achieved (preliminary)

90% CL upper limit

$$\mathcal{B}(D^0 \to \mu^+\mu^-) < 1.4 \times 10^{-7}$$
$$\mathcal{B}(D^0 \to e^+e^-) < 7.9 \times 10^{-8}$$
$$\mathcal{B}(D^0 \to \mu^\pm e^\mp) < 2.6 \times 10^{-7}$$

- Study of $D^+_{(s)} \to K_S h^+$

  - Most precise BRs are obtained (preliminary)

Preliminary ratios of CS/CF

$$\mathcal{B}(D^+ \to K_S K^+)/\mathcal{B}(D^+ \to K_S \pi^+) = 0.190 \pm 0.001 \pm 0.002$$
$$\mathcal{B}(D_s^+ \to K_S \pi^+)/\mathcal{B}(D_s^+ \to K_S K^+) = 0.077 \pm 0.002 \pm 0.002$$

- Observation of DCSD in $D_s^+ \to K^+K^+\pi^-$

  - Observed for the first time (final: PRL 102 221802 (2009))

Branching fraction	Belle	World average [3]
$\mathcal{B}(D^+ \to K^+\pi^+\pi^-)$	$(5.2 \pm 0.2 \pm 0.1) \times 10^{-4}$	$(6.2 \pm 0.7) \times 10^{-4}$
$\mathcal{B}(D_s^+ \to K^+K^+\pi^-)$	$(1.3 \pm 0.2 \pm 0.1) \times 10^{-4}$	$(2.9 \pm 1.1) \times 10^{-4}$