BEACH Conference 2006

Recent Charm Physics Results from the Tevatron

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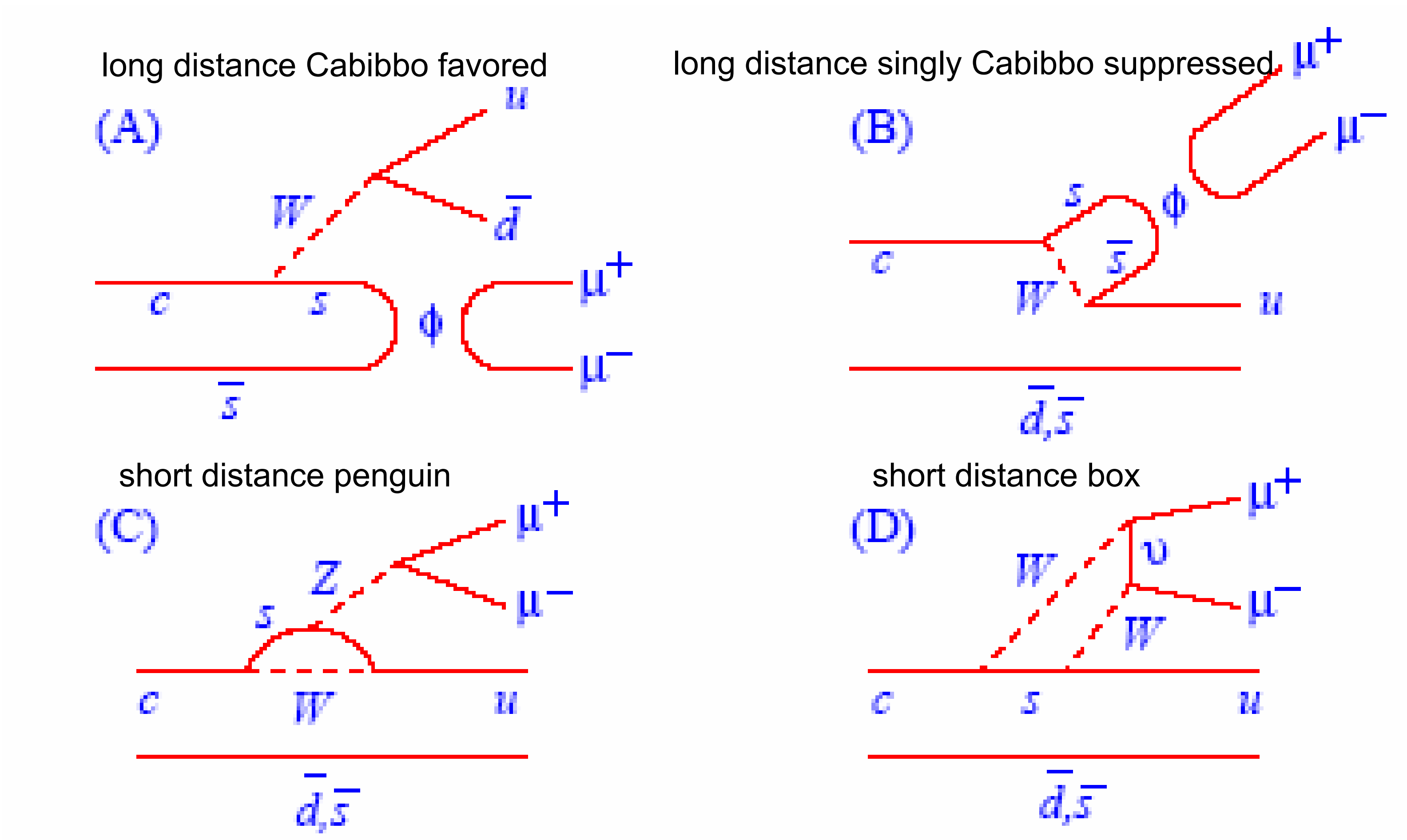
Preliminary DZero Measurement of $D^{\pm} \rightarrow \pi^{\pm} \mu^{+}\mu^{-}$ and $D_s^{\pm} \rightarrow \pi^{\pm} \mu^{+}\mu^{-}$

Preliminary CDF Measurement of X(3872) Angular Distribution and Analysis of Quantum Numbers

CDF Measurement of the Doubly Cabibbo Suppressed Charm Decay $D^0 \rightarrow K^{+}\pi^{-}$ (and c.c.)

Preliminary DZero Measurement of $D^{\pm} \rightarrow \pi^{\pm} \mu^{+}\mu^{-}$ and $D_s^{\pm} \rightarrow \pi^{\pm} \mu^{+}\mu^{-}$



$D \rightarrow \pi^{\pm} \mu^{+} \mu^{-}$
Br SM Predictions and Measurements

Decay	Prediction	Measurement
$D_s^{\pm} \rightarrow \pi^{\pm} \phi \rightarrow \pi^{\pm} \mu^{+} \mu^{-}$	$Br(D_s^{\pm} \rightarrow \pi^{\pm} \phi)$ x $Br(\phi \rightarrow \mu^{+} \mu^{-}) =$ 10.3 x 10^{-6}	<29 x 10^{-6} @ 90% C.L. FOCUS
$D_s^{\pm} \rightarrow \pi^{\pm} \mu^{+} \mu^{-}$ (non-res)	zero	same as above
$D^{\pm} \rightarrow \pi^{\pm} \phi \rightarrow \pi^{\pm} \mu^{+} \mu^{-}$	$Br(D^{\pm} \rightarrow \pi^{\pm} \phi)$ x $Br(\phi \rightarrow \mu^{+} \mu^{-}) =$ 1.77 x 10^{-6}	<8.8 x 10^{-6} @ 90% C.L. FOCUS
$D^{\pm} \rightarrow \pi^{\pm} \mu^{+} \mu^{-}$ (non-res)	9.4 x 10^{-9}	same as above

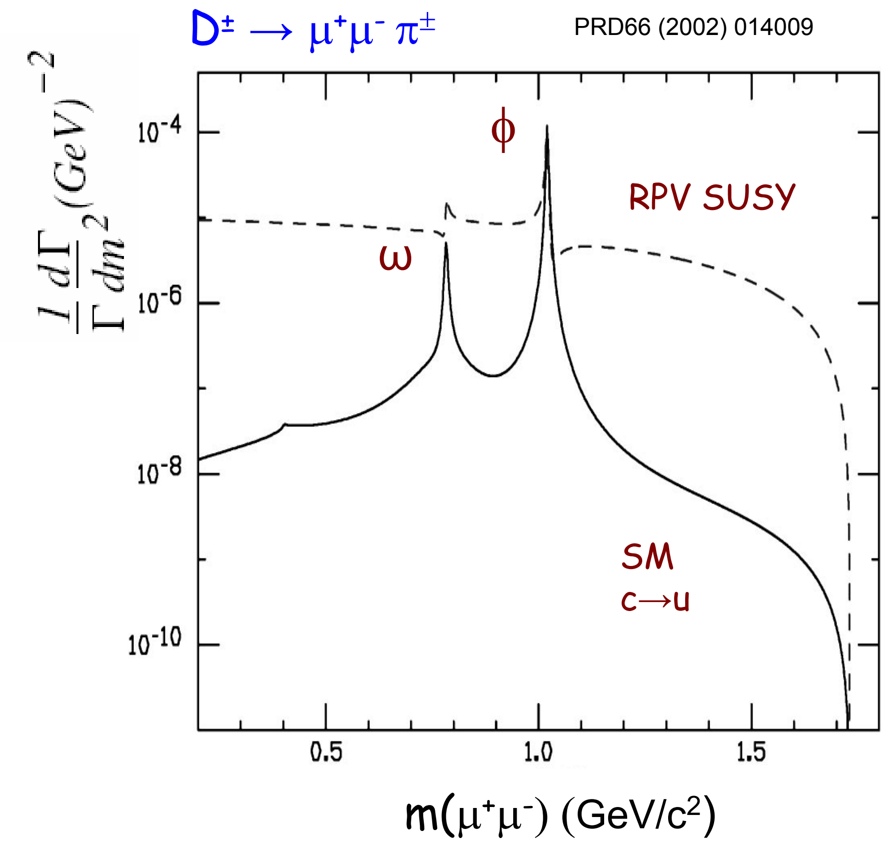
$D \rightarrow \pi^{\pm} \mu^{+} \mu^{-}$
NEW PHYSICS

FCNC processes with <u>down type quarks</u>

- $s \rightarrow d$ studied with K mesons
- $b \rightarrow s$ studied with B mesons

New physics may occur only with <u>up type quarks</u>: study with D mesons

- R-parity violating supersymmetry, Burdman *et al.*
- Little Higgs model with new up-type vector quark, Fajfer *et al*., hep-ph/0511048



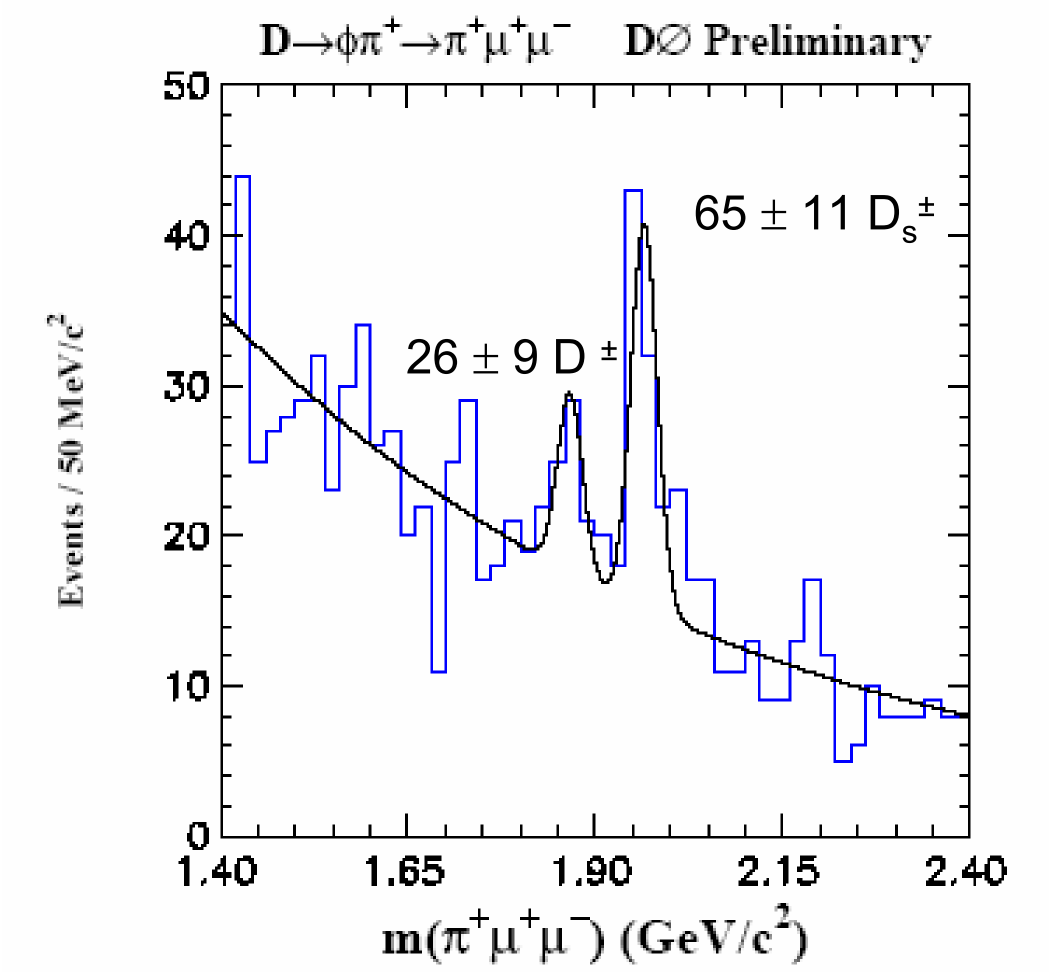
First Observation of $D_s^\pm \rightarrow \pi^\pm \phi \rightarrow \pi^\pm \mu^+\mu^-$

~1 fb-1 of data

di-muon trigger

cuts optimized for $D_s^\pm$ and
$0.96 < m(\mu^+\mu^-) < 1.06$ GeV

use $D_s^\pm \rightarrow \pi^\pm \phi \rightarrow \pi^\pm \mu^+\mu^-$ for normalization of $D^\pm$ Br



Most Precise Br for $D^{\pm} \rightarrow \pi^{\pm} \phi \rightarrow \pi^{\pm} \mu^{+}\mu^{-}$

cuts optimized for $D^{\pm}$ and
$0.96 < m(\mu^{+}\mu^{-}) < 1.06$ GeV

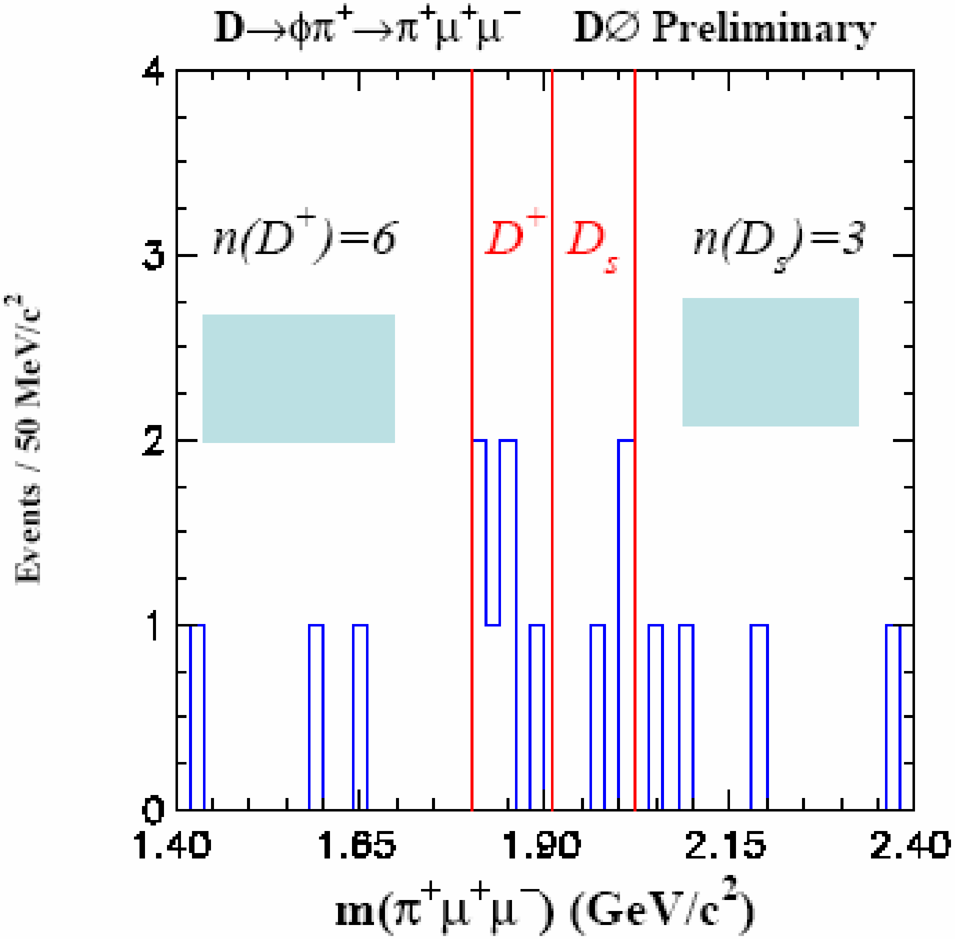
$Br(D^{\pm} \rightarrow \pi^{\pm} \phi \rightarrow \pi^{\pm} \mu^{+}\mu^{-})$

DZero: $(1.75 \pm 0.7 \pm 0.5) \times 10^{-6}$

Pred: 1.77 x 10-6

$Br(D^{\pm} \rightarrow \pi^{\pm} \phi \rightarrow \pi^{\pm} e^{+}e^{-})$

CLEO-c: $(2.7{+3.6}{-1.8} \pm 0.5) \times 10^{-6}$



Best Limit Br for $D^{\pm} \rightarrow \pi^{\pm} \mu^{+} \mu^{-}$ (non-res)

exclude $0.96 < m(\mu^{+}\mu^{-}) < 1.06$ GeV

$Br(D^{\pm} \rightarrow \pi^{\pm} \mu^{+} \mu^{-})$

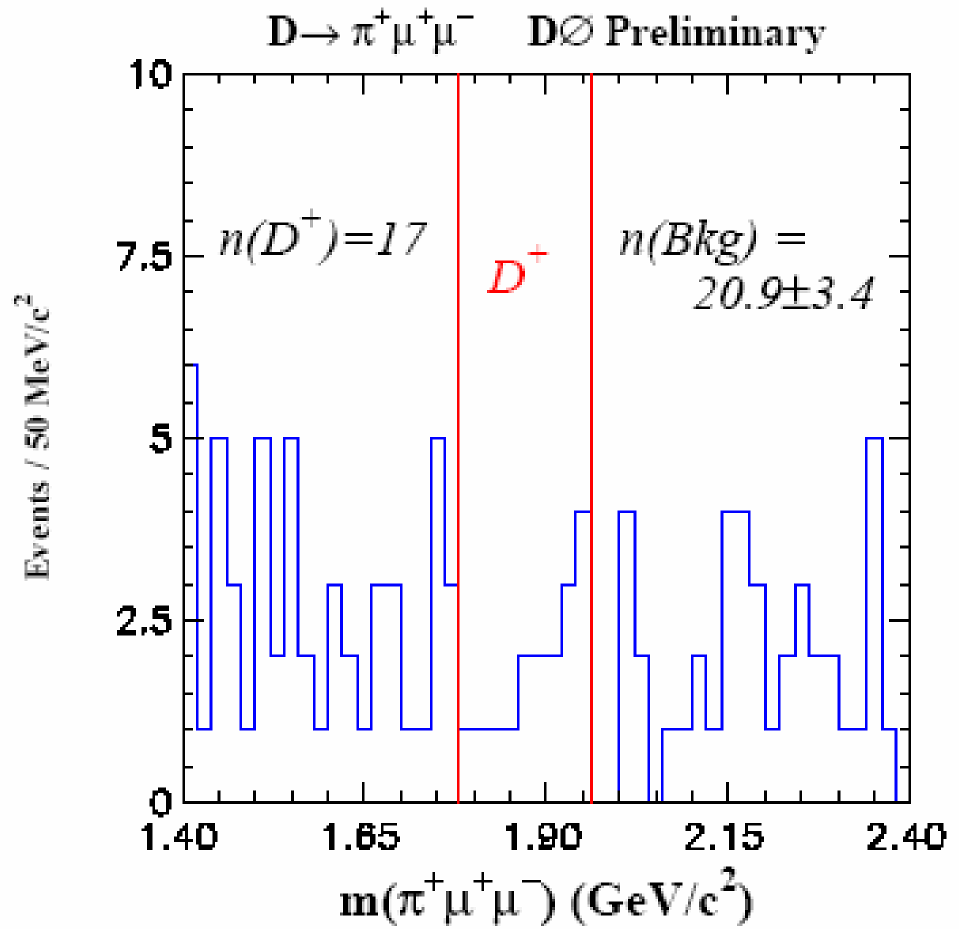
DZero: $< 4.7 \times 10^{-6}$ @ 90% C.L.

FOCUS: $<8.8 \times 10^{-6}$ @ 90% C.L.

SM Pred: 9.4×10^{-9}

Still lots of room left for new physic

New limit on 2nd generation RPV couplings: $\overline{\lambda}_{22k}\overline{\lambda}_{21k} < 0.002$



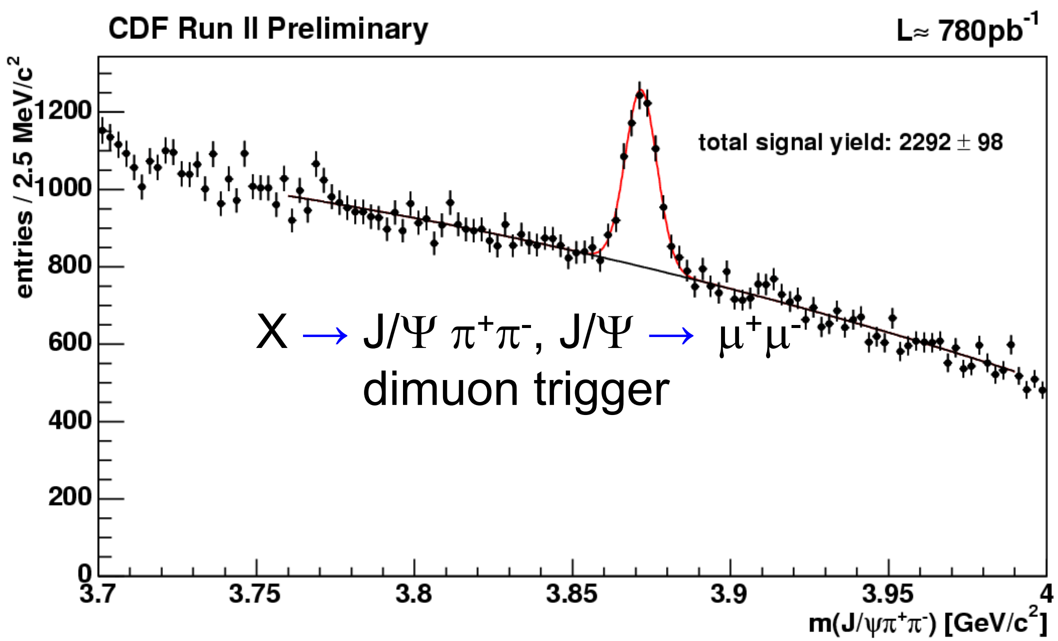
Preliminary CDF Measurement of X(3872) Angular Distribution and Analysis of Quantum Numbers

What is the X(3872)?

$c\bar{c}$ resonance?

$D^0 \bar{D}^{*0}$ molecule?

$c\bar{c}d\bar{d}$ 4-quark state?



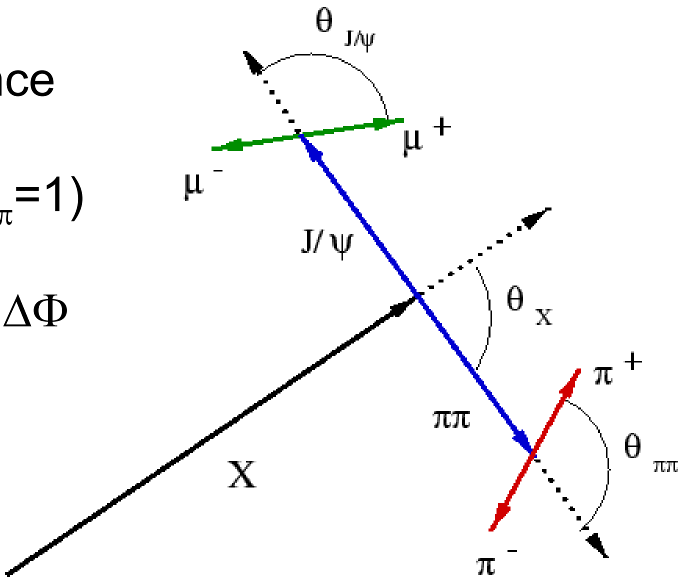
reduce number of possible interpretations by determining J^{PC} from analysis of angular distributions

X(3872) Angular Variables

model decay as X $\rightarrow$ J/Ψ + $(\pi^+\pi^-)$-resonance

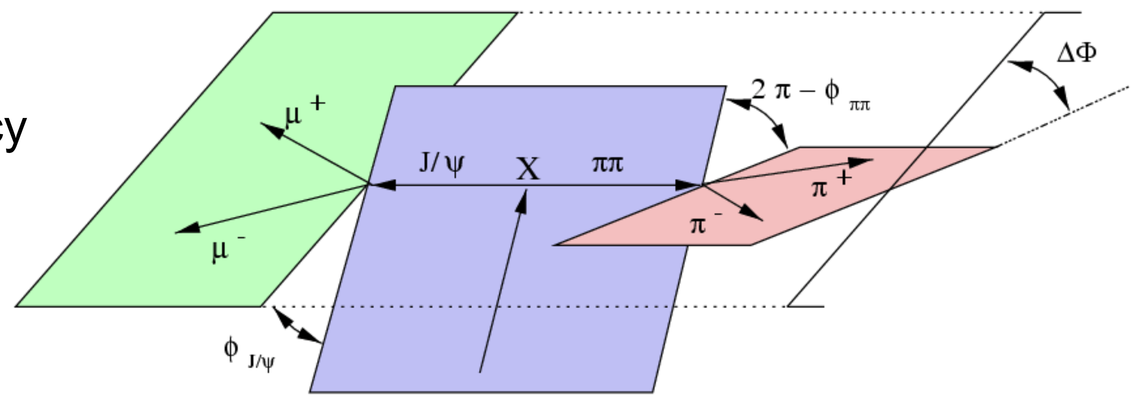
$(\pi^+\pi^-)$ in s-wave state ($L_{\pi\pi}$=0) or from ρ ($L_{\pi\pi}$=1)

J^{PC} of X affects distribution of $\theta_{J/\Psi}$, $\theta_{\pi\pi}$ and $\Delta\Phi$



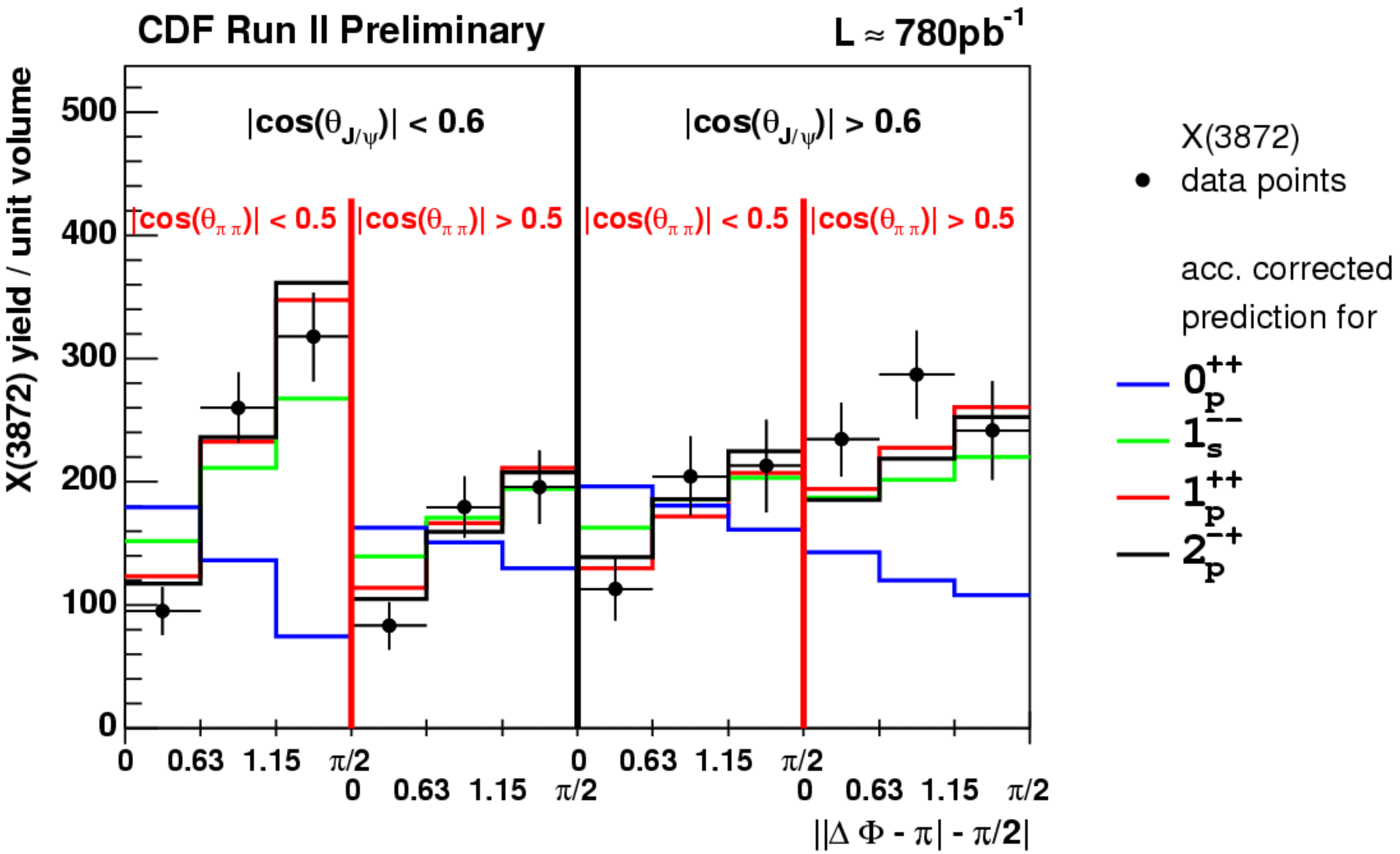
analysis method:

generate expected distributions for a given J^{PC} using
- helicity amplitudes
- parameterized detector
  - acceptance & efficiency



CDF Preliminary Result: X(3872) Angular Distributions and Fits

$\theta_{J/\Psi}$, $\theta_{\pi\pi}$ and $\Delta\Phi$ in 2 x 2 x 3 bins



CDF Preliminary Result for J^{PC} of X(3872)

hypothesis	3D χ^2 / 11 d.o.f.	χ^2 prob.
1^{++}	13.2	27.8%
2^{-+}	13.6	25.8%
1^{--}	35.1	0.02%
2^{+-}	38.9	$5.5 \cdot 10^{-5}$
1^{+-}	39.8	$3.8 \cdot 10^{-5}$
2^{--}	39.8	$3.8 \cdot 10^{-5}$
3^{+-}	39.8	$3.8 \cdot 10^{-5}$
3^{--}	41.0	$2.4 \cdot 10^{-5}$
2^{++}	43.0	$1.1 \cdot 10^{-5}$
1^{-+}	45.4	$4.1 \cdot 10^{-6}$
0^{-+}	103.6	$3.5 \cdot 10^{-17}$
0^{+-}	129.2	$\leq 1 \cdot 10^{-20}$
0^{++}	163.1	$\leq 1 \cdot 10^{-20}$

only 2 J^{PC} hypotheses survive!

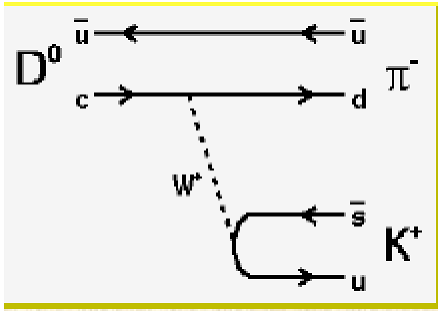
1^{++} goes with χ'_{c1}
but predicted mass is too high

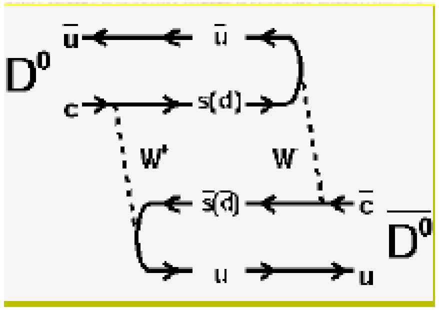
2^{-+} goes with 1^1D_2 $\bar{c}c$ state
but predicted mass off by 100 MeV
and $J/\Psi\ \rho$ decay violates isospin

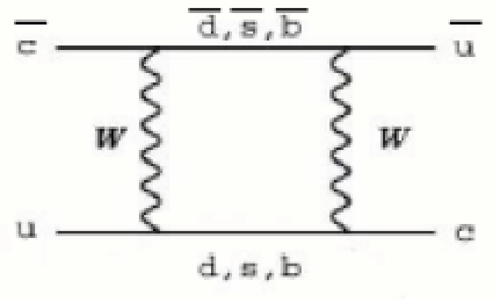
1^{++} is compatible with molecular model

CDF Measurement of the Doubly Cabibbo Suppressed Charm Decay $D^0 \rightarrow K^+\pi^-$

submitted to PRD-RC, hep-ex/0605027







doubly Cabibbo suppressed

dominant, depends on $SU(3)_f$ symmetry violation (FSV)

long range intermediate state

could be dominant, <u>depends on FSV</u>

box (and penguin) diagrams negligible in SM

new physics possible

Theory for $D^0 \rightarrow K^+\pi^-$

$$R_{\mathcal{B}} = \mathcal{B}(D^0 \to K^+\pi^-)/\mathcal{B}(D^0 \to K^-\pi^+) = R_D + \sqrt{R_D}y' + \frac{x'^2 + y'^2}{2}$$

R_B = ratio of branching fractions
R_D = squared modulus of ratio of DCS to CF amplitudes
x' and y' = mixing parameters

limit of $SU(3)_f$ symmetry: $R_D = \tan^4\theta_c$
θ_c = Cabibbo angle measured in kaon decays

Current world average measurements:
$R_D = (3.62 \pm 0.29) \times 10^{-3}$
$\tan^4\theta_c = (2.88 \pm 0.27) \times 10^{-3}$

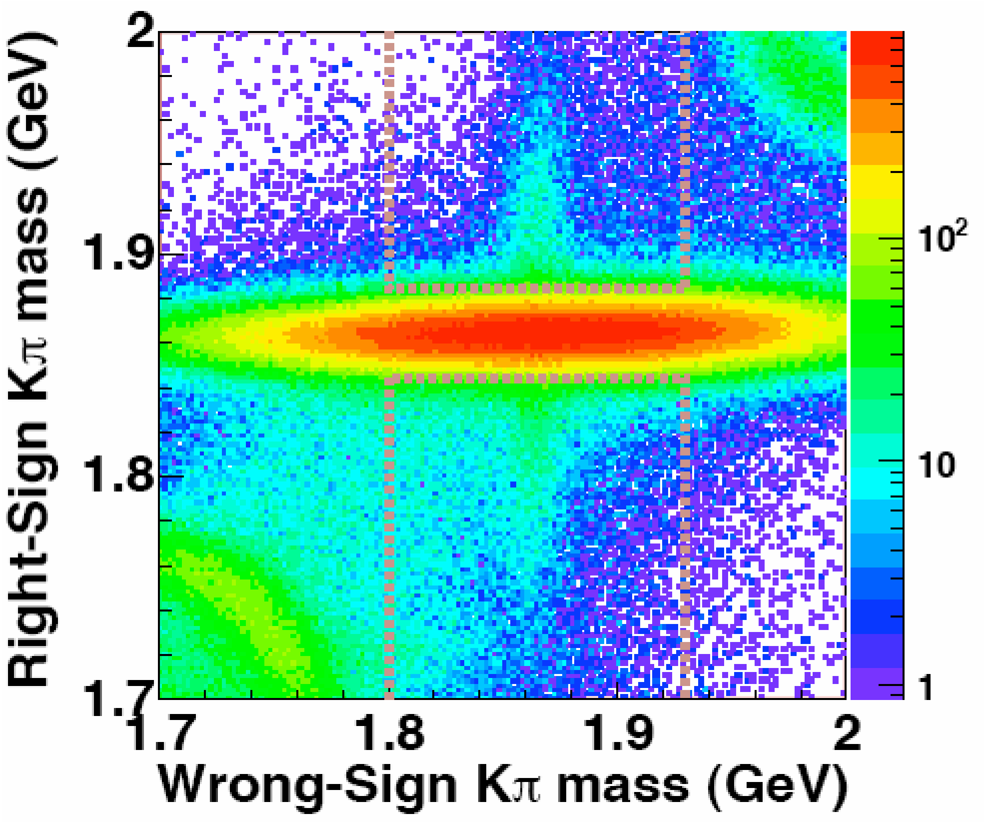
are consistent

CDF II Data for $D^0 \rightarrow K^+\pi^-$

integrated luminosity 0.35 fb^{-1}

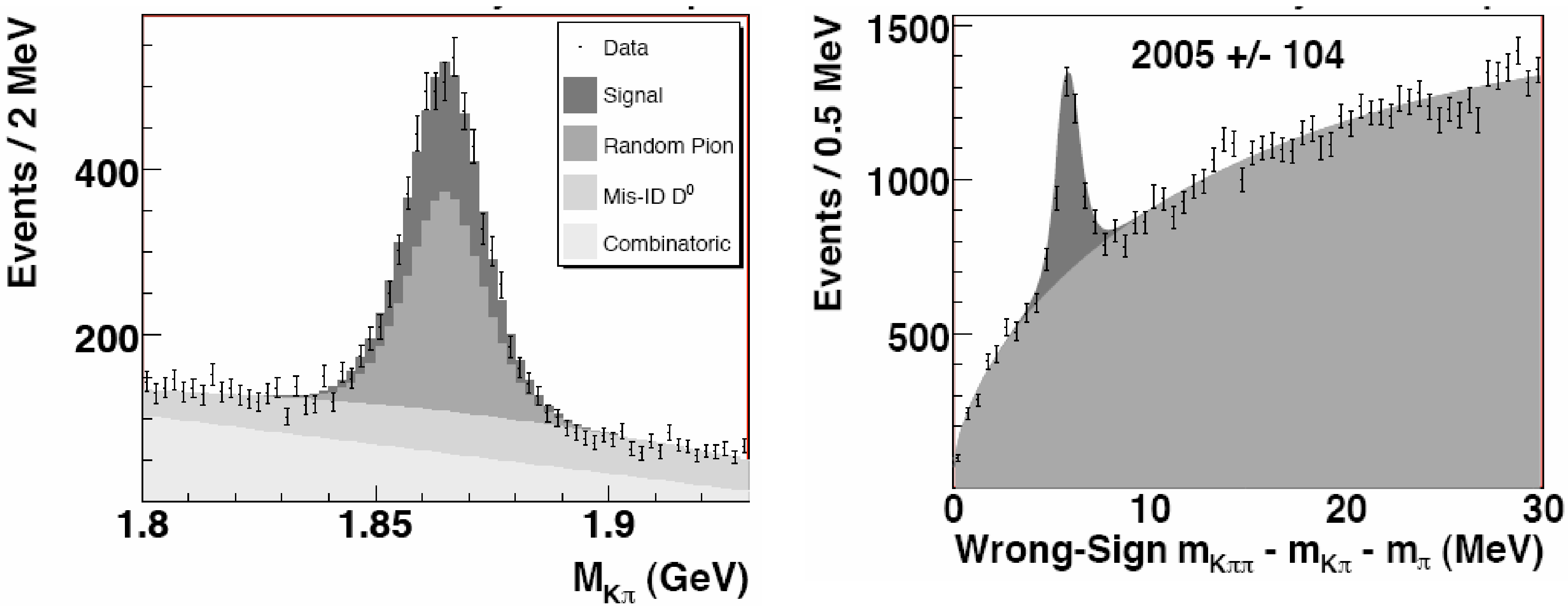
secondary vertex trigger
$L_{xy} > 200\ \mu m$

$D^{*+} \rightarrow \pi^+ D^0$, $D^0 \rightarrow K^+\pi^-$

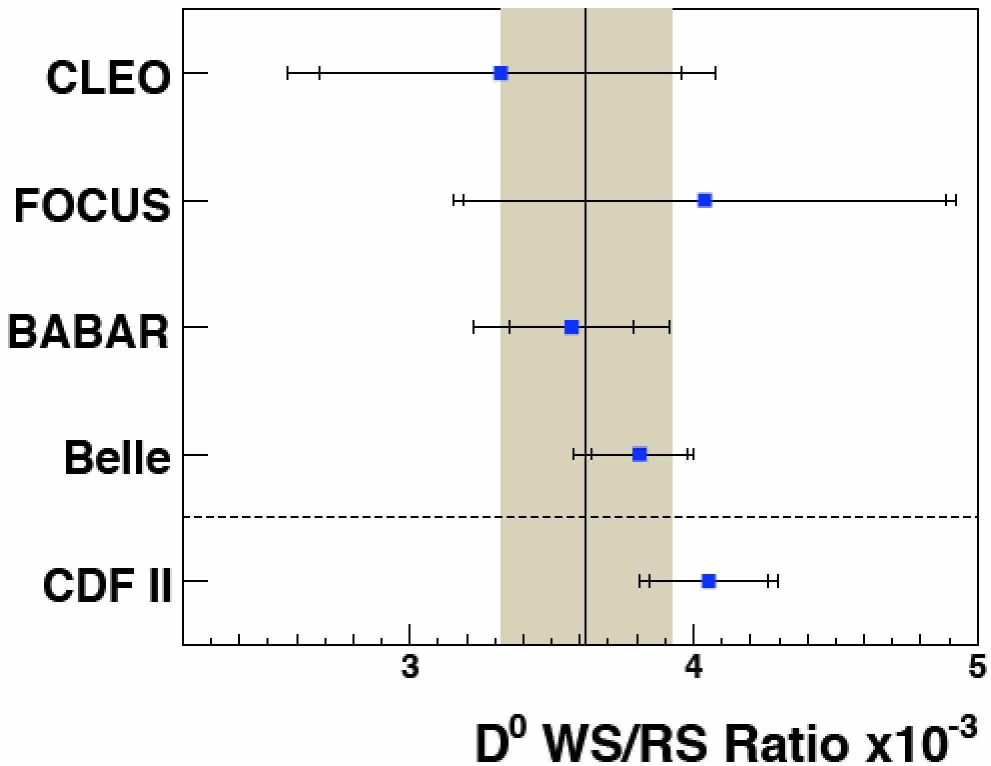


CDF II Data for $D^0 \rightarrow K^+\pi^-$

analysis technique separates signal from background due to:
- real D0 with random π from from primary vertex
- mis-identified Cabibbo favored decays
- combinations of K and π from primary vertex



Comparison of Results for $D^0 \rightarrow K^+\pi^-$



interpret CDF result using

$$R_{\mathcal{B}} = \mathcal{B}(D^0 \to K^+\pi^-)/\mathcal{B}(D^0 \to K^-\pi^+)$$
$$= R_D + \sqrt{R_D}y' + \frac{x'^2 + y'^2}{2}$$

note: latest Belle result is $3.77 \pm 0.08 \pm 0.05$

compare CDF result of $R_B = (4.05 \pm 0.21 \pm 0.11) \times 10^{-3}$
with $\tan^4\theta_c = (2.88 \pm 0.27) \times 10^{-3}$

significance of difference is $3.4\ \sigma$

possibilities: statistical fluctuation, modest $SU(3)_f$ violation, mixing

Conclusions

hadron collider experiments are making world-class contributions to charm physics

specialized triggers (di-muon, vertex) are crucial

data samples with expected 8 pb^{-1} will be 8 to 23 times larger than used for analyses presented here

Good prospects for charm physics at LHC?

supplementary slide

CDF II Simulation of D^0-D^0 Mixing

95% C.L. limits

0.35 fb^{-1}