Search for Flavor Changing Neutral Currents and Lepton Flavor Violating Decays $D^0 \to l\bar{l}$ ($l = e\mu$)

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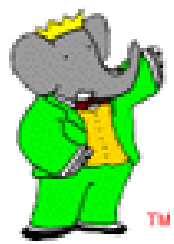


Introduction

- Flavor Changing Neutral Currents (FCNC) are forbidden at tree level in the SM for Charm decays $\Rightarrow$ small branching fraction values

  e.g. for $D^0 \to \mu^+\mu^-$ Br~ 1×10^{-13} (SM)

- Lepton Flavor Violation (LFV) is forbidden in the SM

- Charm Rare decay search: sensitive to new physics beyond the SM

- New Physics can enhance FCNC contributions by a few orders of magnitude, LFV is allowed in New Physics

{ Burdman et al. PRD 66, 014009 (2002) }

e.g. for $D^0 \to \mu^+\mu^-$ Br~ 1×10^{-6} ($\not{R}$-parity SUSY)

Introduction

Present experimental and theoretical status

Decay mode	SM	$\not{R}$-SUSY	Present Exp. limit
$D^0 \to e^+e^-$	10^{-23}	1.0×10^{-10}	6.2×10^{-6} (90% CL)
$D^0 \to \mu^+\mu^-$	3.0×10^{-13}	3.5×10^{-6}	2.0×10^{-6} (90% CL)
$D^0 \to e^+\mu^- + c.c.$	0	1.0×10^{-6}	8.1×10^{-6} (90% CL)

BaBar is not only a B-factory but also a charm factory:

Charm meson produced in fragmentation: $e^+e^- \to c\bar{c}$

Cross section is 1.3nb compared to 1.1nb for $e^+e^- \to B\bar{B}$

Goal: search for Rare charm decays:

FCNC decays: $D^0 \to e^+e^-$, $D^0 \to \mu^+\mu^-$

LFV decays: $D^0 \to e^+\mu^- +$ c.c.

Analysis Approach

Data:

Use 122 fb^{-1} $D^{*+}\to D^0\pi^+$ tagged sample with $p^*(D^0)\geq 2.4$GeV/c

$p^*(D^0)$: D^0 momentum in the e^+e^- center of mass frame

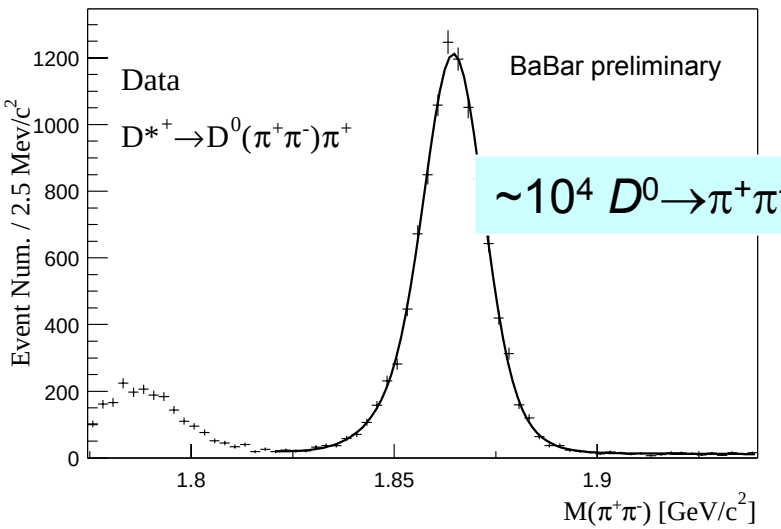
$p^*(D^0)$ requirement rejects combinatoric background from B decay

Blind analysis approach: counting experiment

The D^0 signal mass window is blinded until we determine the final event selection criteria and background estimate

Branching fractions normalized to $D^0\to\pi^+\pi^-$ due to similar kinematics

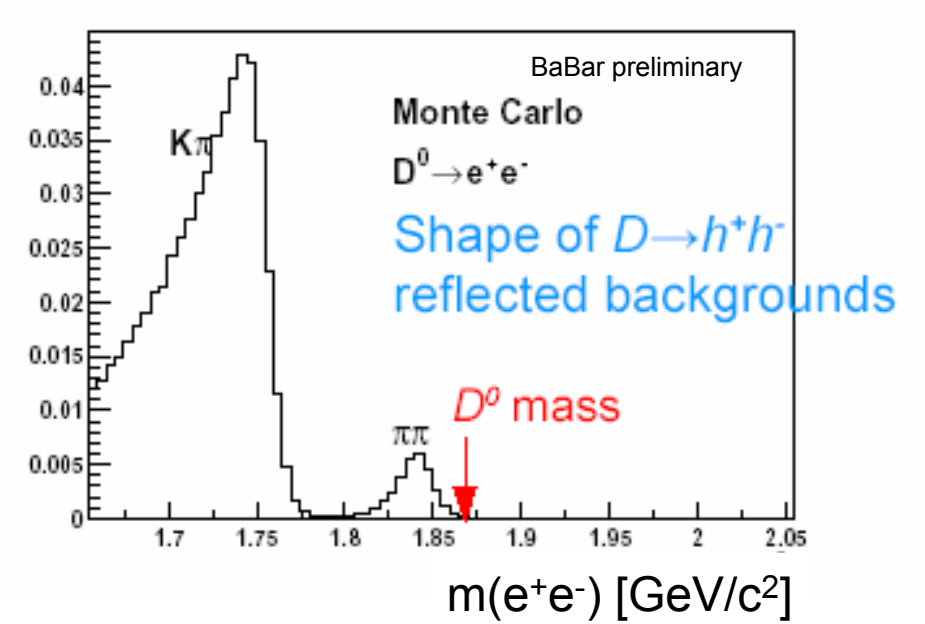
Identical selection except PID



Reflection Background

Main challenge of this analysis is to reject combinatoric background and background from hadronic D^0 decays.

Reflection background from $D^0 \to h^+h^-$ (h=K,π):
Both hadrons are mis-identified as leptons



The dominant reflection background is from $D^0 \to \pi^+\pi^-$

Background Estimate

Particle Identification:

95% efficiency per electron, 0.2% pion mis-identification rate.
60% efficiency per muon, 2% pion mis-identification rate.

Determination of the reflection background:

MC and measured particle mis-identification rate.
Use the measured number of $D^0 \to \pi^+\pi^-$ decays as normalization.
The reflection backgrounds are small for e^+e^- and $e^+\mu^-$ modes.

Combinatoric background:

Dominated by random lepton pairs.
Study shape using MC and data.
Normalize the distribution to the number of events in the dilepton mass sidebands observed in the data.

Optimization of the Selection Criteria

Optimize the selection criteria (reduce background)

Discriminating variables:

dm: Mass difference between the D^0 and D^{*+} candidate

ct: proper flight distance of the D^0 meson,

m(D^0): signal mass window for $D^0 \to ll$

Maximize the experimental sensitivity: Feldman and Cousins: PRD 57,3873 (1998)

Assume no signal, optimize ε/N_{sens}

ε: signal efficiency;

N_{sens}: mean upper limit expected for a given background

Predict the expected background as a function of cut values

$$N_{bg} = N_{SB} \times R_{mass} \times R_{dm} \times R_{ct}$$

N_{SB}: number of events in side bands (loose cuts)

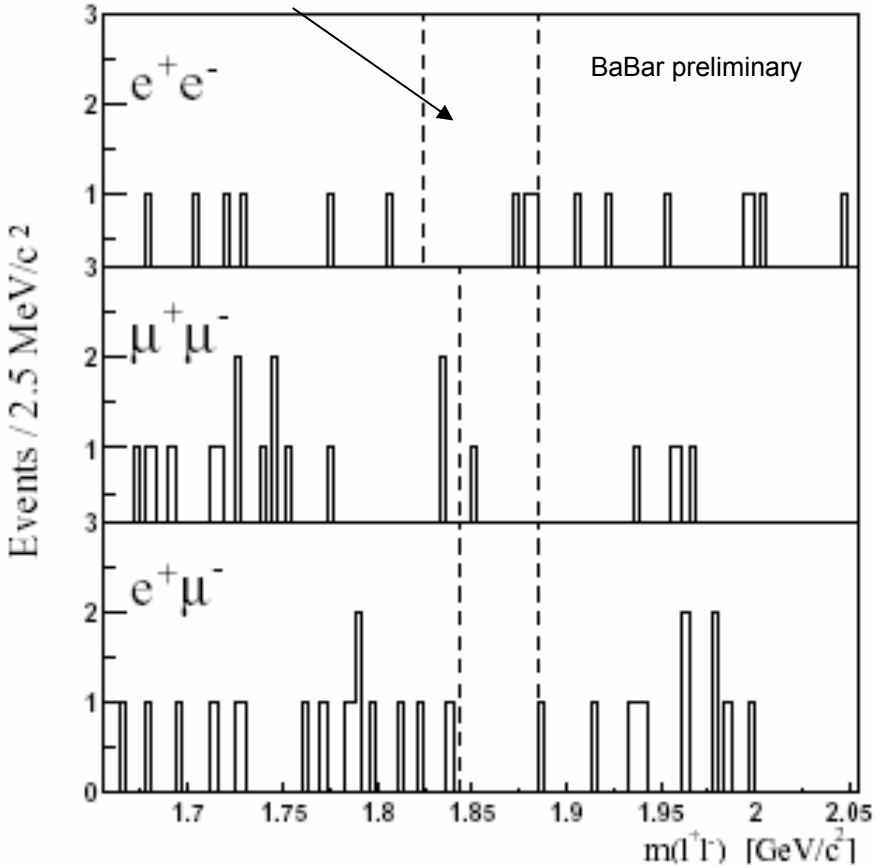
R: cut rejection factors, no correlation between mass, dm and ct

Estimate the cut rejection factors independently from MC and control data

Results

$$\mathcal{B}_{90\%\mathrm{CL}}(D^0 \to ll) = Br(D^0 \to \pi\pi) \times \frac{N^{\mathrm{upper}}_{90\%\mathrm{CL}}}{N(\pi\pi)} \times \frac{\epsilon(\pi\pi)}{\epsilon(ll)}$$

Signal mass window



Systematic uncertainties:
particle identification efficiency,
PID fake rate
limited statistics in the mass side band

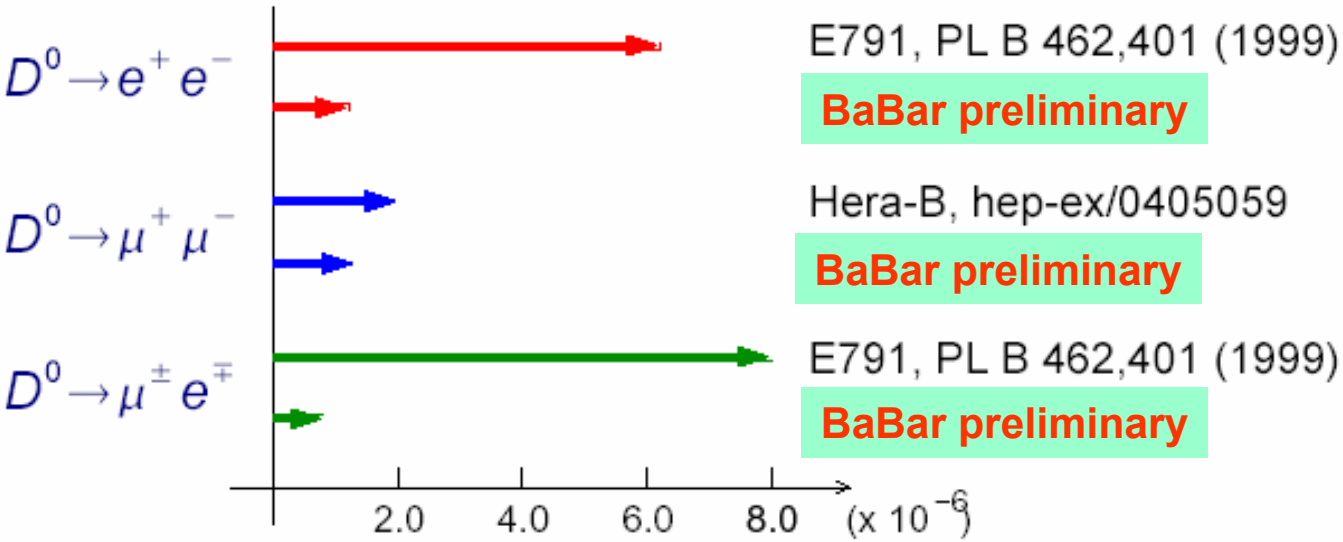
Include the systematic uncertainties in the upper limit calculation:
PRD 67, 012002 (2003)

Results

	$D^0 \to e^+e^-$	$D^0 \to \mu^+\mu^-$	$D^0 \to e^\pm\mu^\mp$
$N_{\rm bg}^{hh}$	0.02	3.34 ± 0.31	0.21
$N_{\rm bg}^{\rm comb}$	2.21 ± 0.38	1.28 ± 0.32	1.93 ± 0.36
$N_{\rm bg}$	2.23 ± 0.38	4.63 ± 0.45	2.14 ± 0.36
S $[10^{-7}]$	2.25 ± 0.12	4.53 ± 0.30	3.27 ± 0.20
$N_{\rm obs}$	3	1	0
UL obtained	1.2×10^{-6}	1.3×10^{-6}	8.1×10^{-7}

BaBar preliminary

@ 90% CL



Conclusions

- The results of a search for FCNC and LFV $D^0 \rightarrow ll$ decays have been shown.
- No signals are observed.
- New 90% CL upper limits have been obtained:
  ee mode: 1.2×10^{-6} μμ mode: 1.3×10^{-6} eμ mode: 0.81×10^{-6}
- Our results reduce the present upper limits by factors of 2-10.
- Paper: hep-ex/0408023 (submitted to PRL).