



Studies of the Leptonic Decay

$$D^+ \rightarrow \mu^+ \nu_\mu$$

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*representing the
CLEO collaboration*

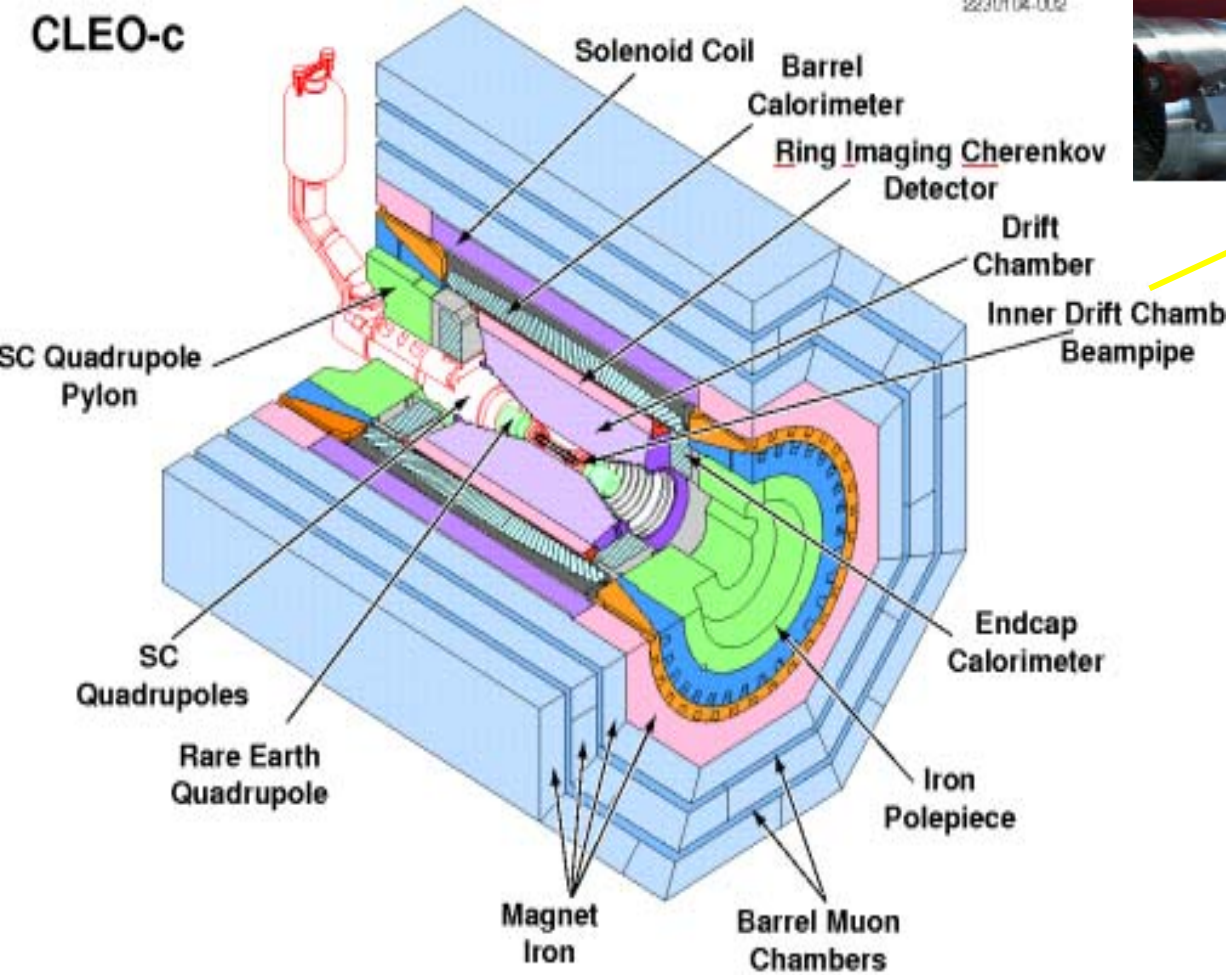


Introduction

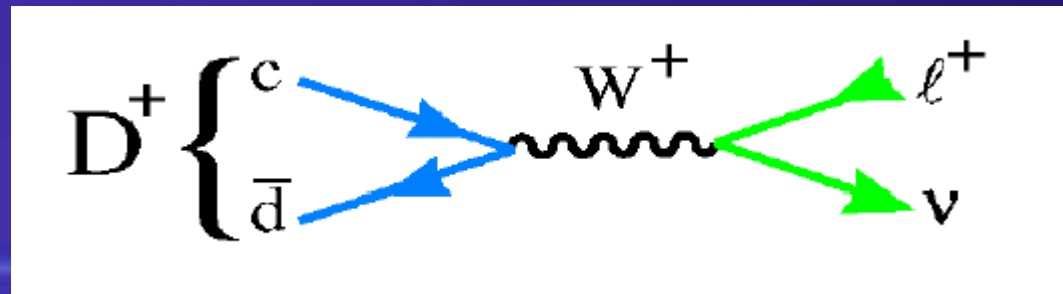
- *I will talk about the preliminary measurement of $D^+ \rightarrow \mu^+ \nu$ branching fraction and determination of f_D from CLEO-c.*
- *We make use of single "D-tagging" in which one D is fully reconstructed.*
- *We pass the information of the found D to the other \bar{D} .*



The CLEO-c detector



- ✓ Data Sample: ~60/pb collected with the CLEO-c detector at $\psi(3770)$
- ✓ New 6-layer inner drift chamber.
- ✓ 1T B field.
- ✓ Otherwise Same as CLEOIII detector.



Motivation

$$\Gamma(M \rightarrow l\nu) = \frac{1}{8\pi} G_F^2 \underbrace{f_M^2}_{\text{Decay Constant}} \underbrace{m_l^2}_{\text{Helicity}} M_M \left(1 - \frac{m_l^2}{M_M^2} \right)^2 |V_{qq'}|^2$$

- ✓ Direct Measurement of f_D .
- ✓ Challenge to potential models and LQCD computations; their uncertainties are important in B decays.
- ✓ Charm measurements can be used to improve predictions for B decays.

For example: precise CLEO-c f_D measurement + LQCD f_B/f_D could give a $\sim 1\%$ prediction for f_B



Tagging Technology

$e^+ e^- \longrightarrow \psi (3770) \quad (1^{--})$ Vector Particle

D^+

D^-

$\mu^- \nu$
Signal Side

Tagged Side

- $K^- \pi^+ \pi^+$
- $K^- \pi^+ \pi^+ \pi^0$
- $K_S \pi^+ \pi^0$
- $K_S \pi^+$
- $K_S \pi^+ \pi^- \pi^+$

+ CC Event

D^+ Decay Mode	\mathcal{B} (%) (PDG-02)
$D^+ \rightarrow \bar{K}^0 \pi^+$	(2.77 ± 0.18)
$D^+ \rightarrow K^- \pi^+ \pi^+$	(9.1 ± 0.6)
$D^+ \rightarrow \bar{K}^0 \pi^+ \pi^0$	(9.7 ± 3.0)
$D^+ \rightarrow K^- \pi^+ \pi^+ \pi^0$	(6.4 ± 1.1)
$D^+ \rightarrow \bar{K}^0 \pi^+ \pi^+ \pi^-$	(7.0 ± 0.9)



Charged D-Tag Reconstruction

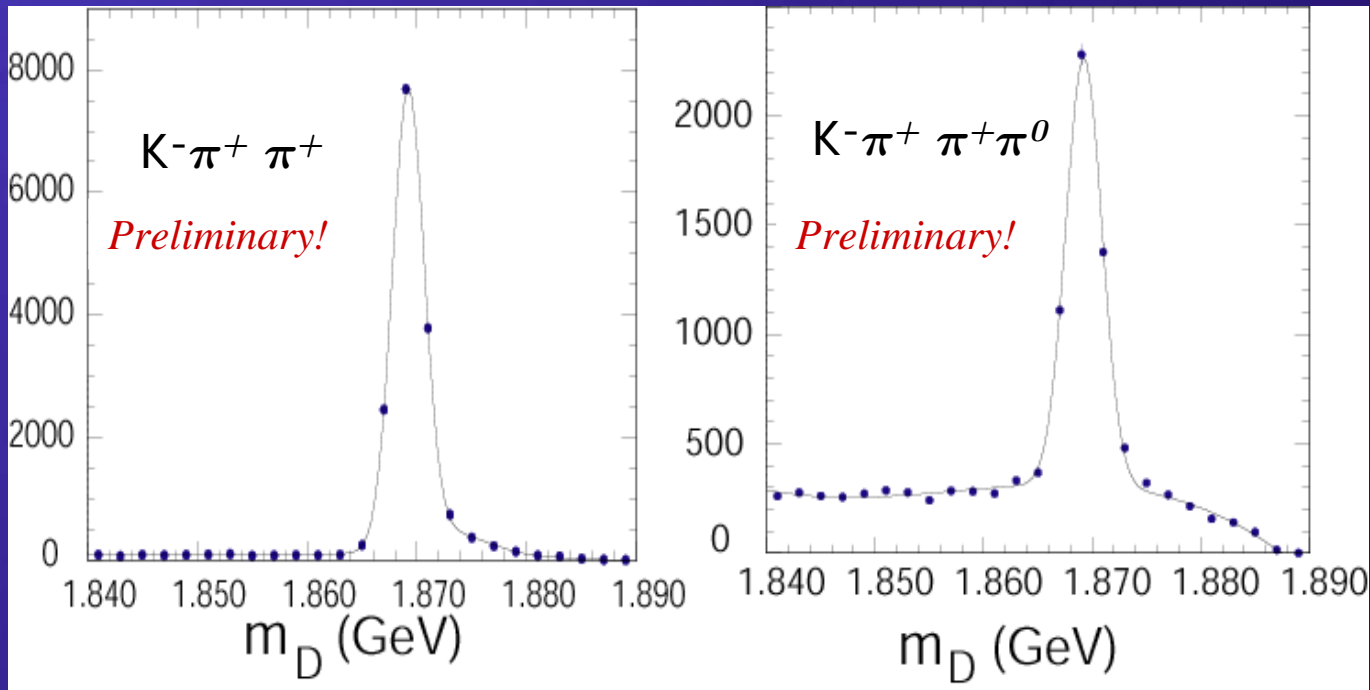
➤ Two key variables:

$$M_{bc} = \sqrt{E_{beam}^2 - P_{candidate}^2}$$

$$\Delta E = E_{beam} - E_{candidate}$$

Mode	Signal
$K^+ \pi^- \pi^-$	15188
$K^+ \pi^- \pi^- \pi^0$	4082
$K_S \pi^-$	2110
$K_S \pi^- \pi^- \pi^+$	3975
$K_S \pi^- \pi^0$	3297
Sum	28652

$|\Delta E| < 20 \text{ MeV}$



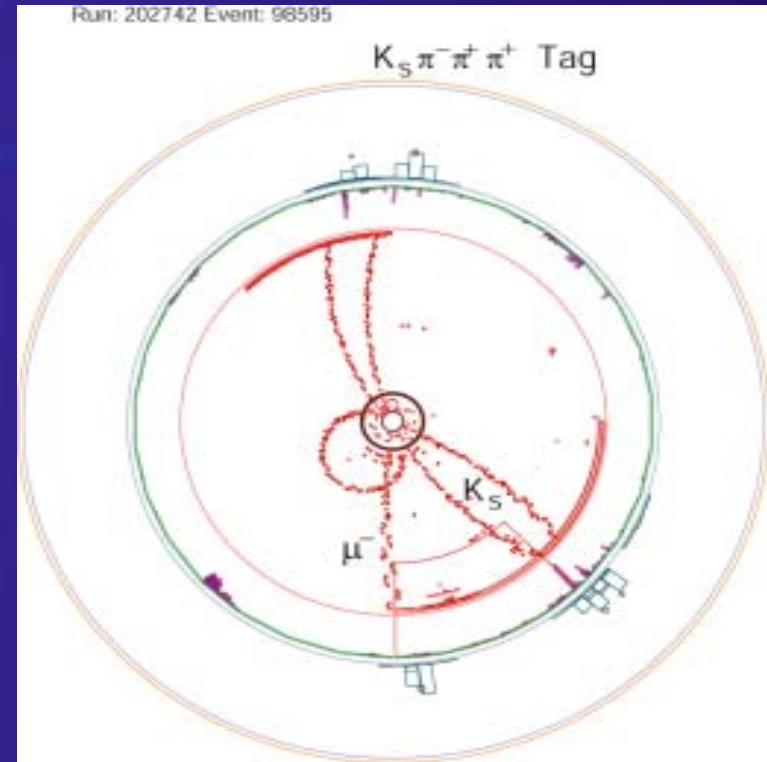


Signal Extraction

- Make use of the neutrino MM^2 observable to separate signal and background:

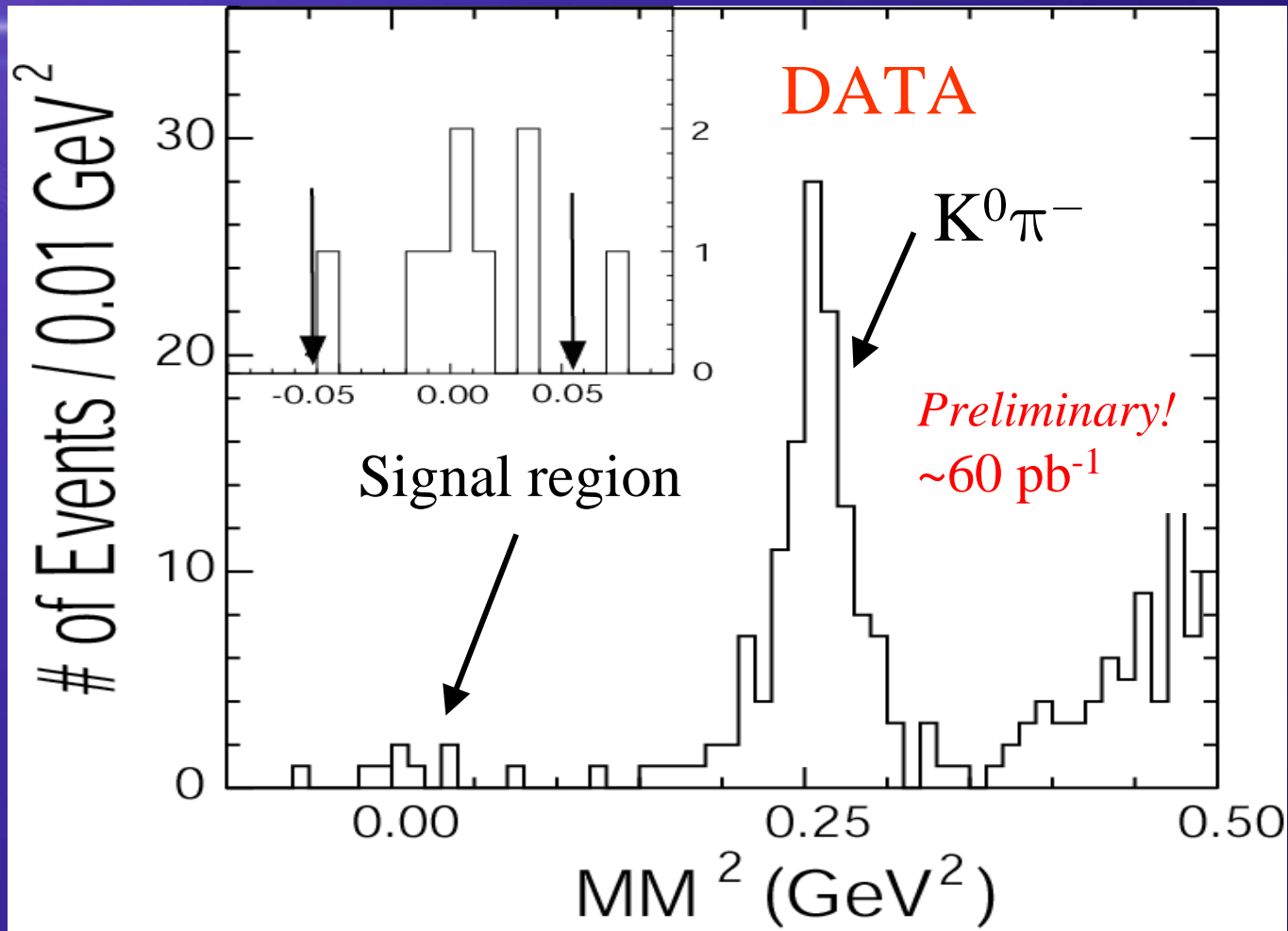
$$MM^2 = (E_{beam} - E_{\mu})^2 - (-\vec{P}_{D^+} - \vec{P}_{\mu})^2$$

- Signal peaks at $MM^2 = 0$
- Largest unmatched shower energy is less than 0.25 GeV.
- Muon candidate consistent with minimum ionizing particle, deposited energy < 300 MeV in calorimeter
- Account for the background in the signal region of MM^2 (see later).





MM² Distribution





Backgrounds

□ D^\pm Background:

- ✓ $D^+ \rightarrow \pi^+ \pi^0$
- ✓ $D^+ \rightarrow \bar{K}^0 \pi^+$
- ✓ $D^+ \rightarrow \tau^+ \nu, \tau^+ \rightarrow \pi^+ \nu$
- ✓ $D^+ \rightarrow \pi^0 \mu^+ \nu$

□ $D^0 \bar{D}^0$ Background:

- ✓ $D^0 \bar{D}^0$ can look like $D^+ D^-$:
ex: $D^0 \rightarrow K^- \pi^+, \bar{D}^0 \rightarrow \pi^+ \mu^- \nu$

□ Continuum Background

Mode	\mathcal{B} (%)	# of events
$\pi^+ \pi^0$	0.13 ± 0.02	0.31 ± 0.04
$\bar{K}^0 \pi^+$	2.77 ± 0.18	0.06 ± 0.05
$\tau^+ \nu$	$3.2 \times \mu^+ \nu$	0.36 ± 0.08
$\pi^0 \mu^+ \nu$	0.31 ± 0.15	negligible
$D^0 \bar{D}^0$		0.16 ± 0.16
continuum		0.17 ± 0.17
Total		1.07 ± 0.25

Estimated backgrounds
from MC



Signal

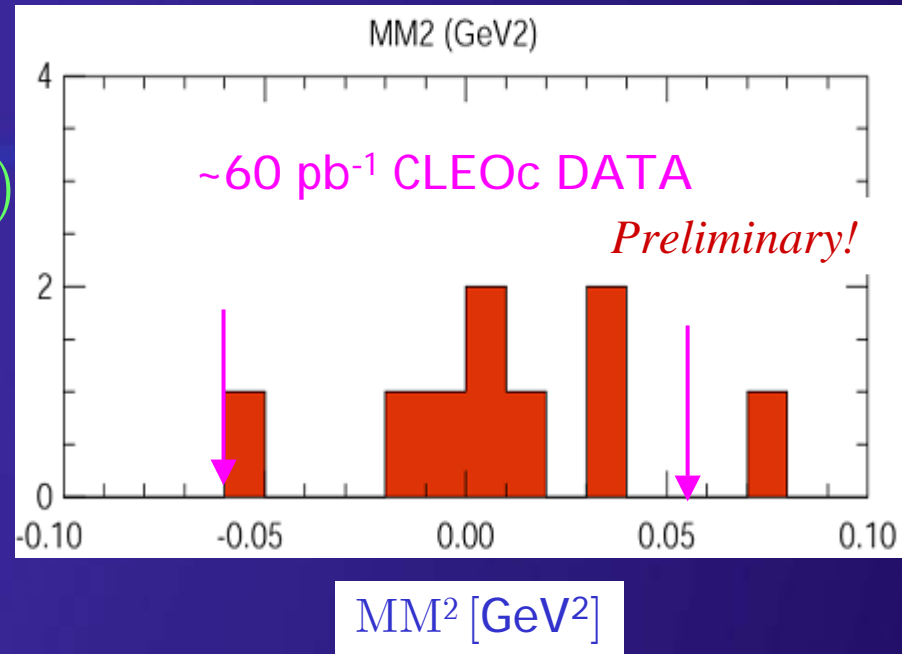
- 8 events within 2σ
($-0.056 < MM^2 < 0.056 \text{ GeV}^2$)
- 1.07 ± 1.07 estimated background events.
- Reconstruction efficiency:
69.9 %

$$B(D^+ \rightarrow \mu^+ \nu) = \frac{N_{sig}}{\epsilon * N_{tag}}$$

$$B = (3.5 \pm 1.4 \pm 0.6) 10^{-4}$$

$$f_D = (201 \pm 41 \pm 17) \text{ MeV}$$

Preliminary!

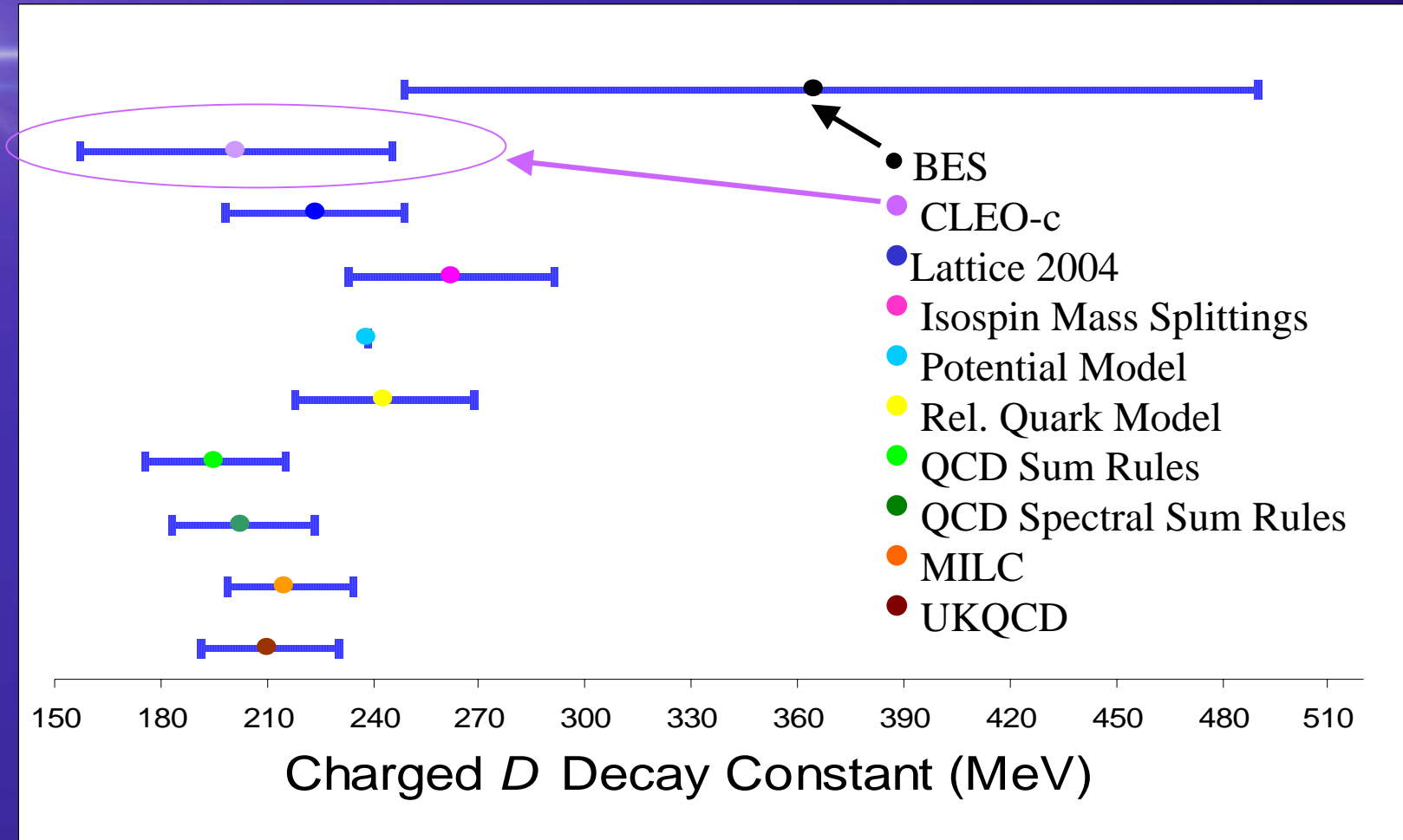


Systematic errors on B :

- a) μ detection ϵ (5%)
- b) background, taken as 100% uncertainty (15.4%)
- c) D^+ sample size (1%)



Predictions vs Measurements





Summary

- We report a preliminary measurement of $D \rightarrow \mu \nu$ branching fraction, and hence a measurement of the D meson decay constant

$$B(D^+ \rightarrow \mu \nu) = (3.5 \pm 1.4 \pm 0.4) \times 10^{-4}$$

$$f_D = (201 \pm 41 \pm 17) \text{ MeV}$$

Preliminary!

- Work in progress – data taking resumes in September.

- *More information is available on: hep-ex/0408071*