Measurement of the

$B^- \to D^{*0}\,\ell^-\,\bar{\nu}$ Branching Fraction

and

Study of V_{cb}

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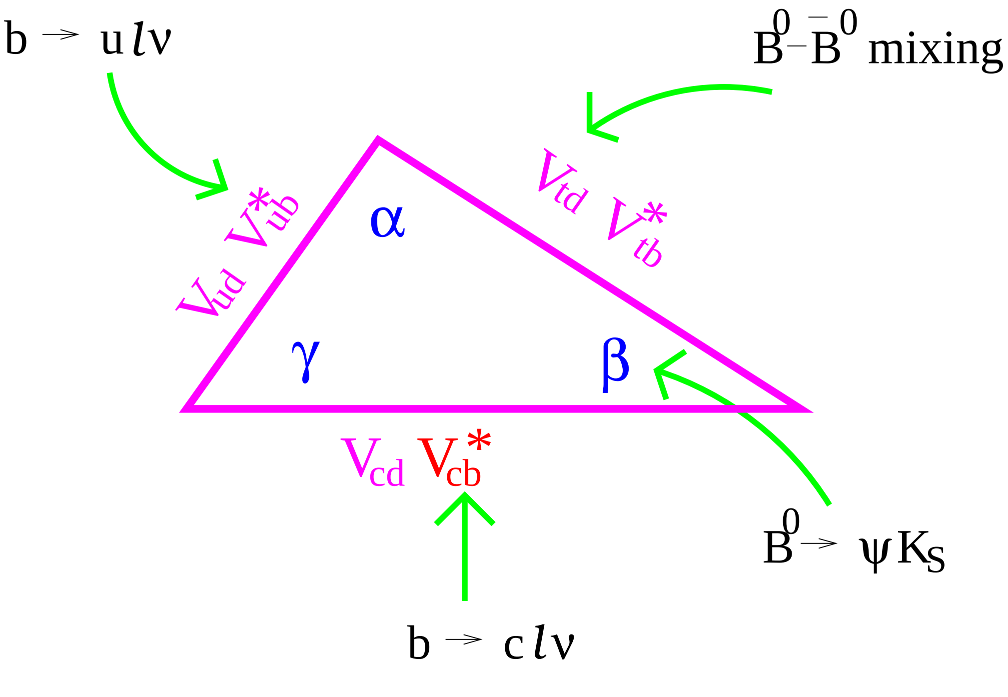
Outline:

- Theory of $B \to D^* \ell \bar{\nu}$
- Branching fraction measurement
- Progress towards V_{cb}

The CKM Matrix

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} \tag{1}$$

$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0 \tag{2}$$



Heavy Quark Effective Theory

$$w \equiv v \cdot v'$$

varies from 1 to 1.51

$$\frac{d\Gamma}{dw} = \frac{G_F^2}{48\pi^3} m_{D^*}^3 (m_B - m_{D^*})^2 |V_{cb}|^2 \sqrt{w^2 - 1}\, K(w)\, \mathcal{F}^2(w)$$

$$K(w) = 4w(w+1)\frac{1 - 2w(m_{D^*}/m_B) + (m_{D^*}/m_B)^2}{(1 - m_{D^*}/m_B)^2} + (w+1)^2$$

$\mathcal{F}(w)$ describes strong interaction

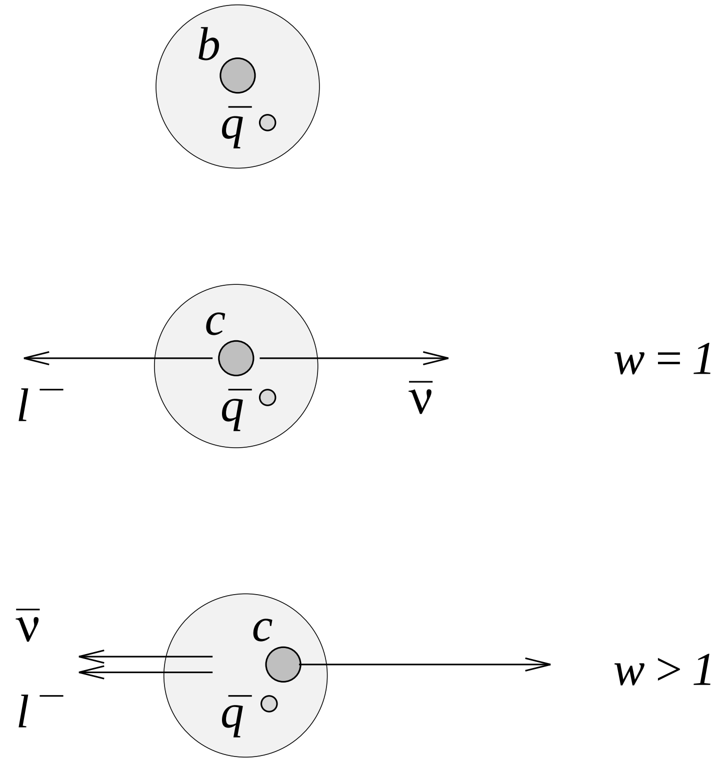
In the infinite quark-mass limit,

$$\mathcal{F}(1) = 1$$

For finite quark mass and 1 loop corrections,

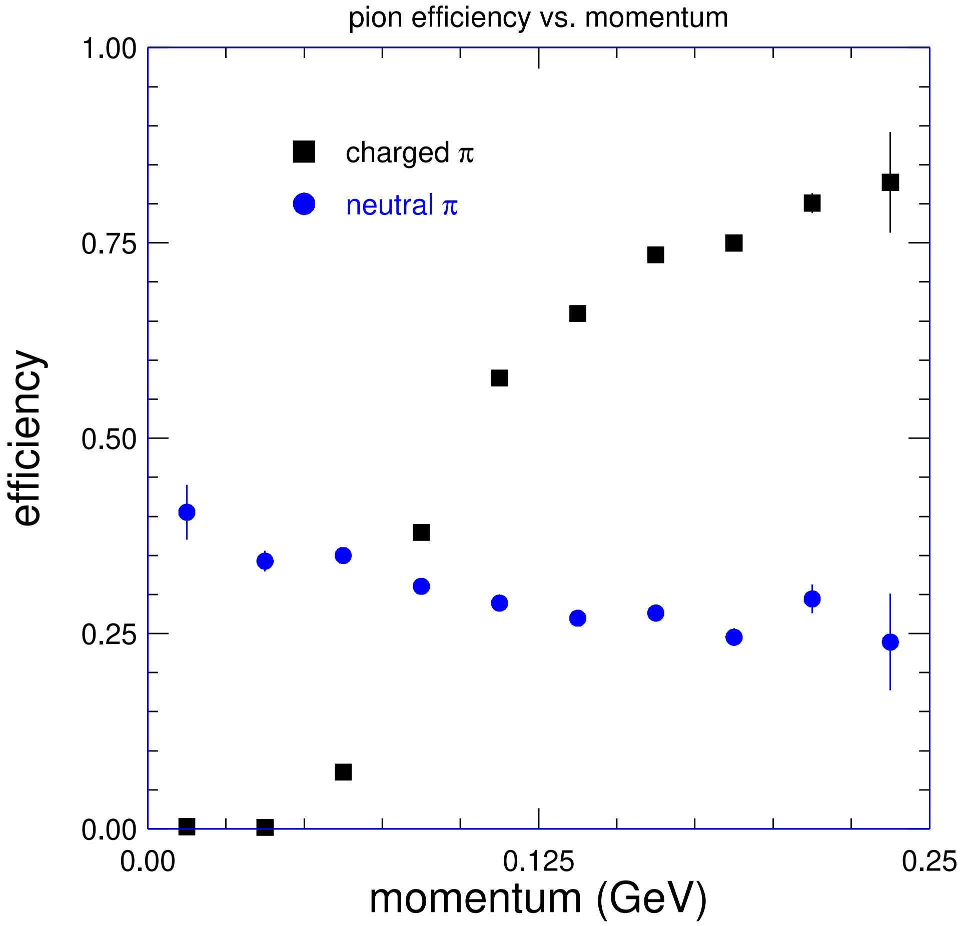
$\mathcal{F}(1) = 0.913 \pm 0.030$ (Neubert+others)

Form Factor



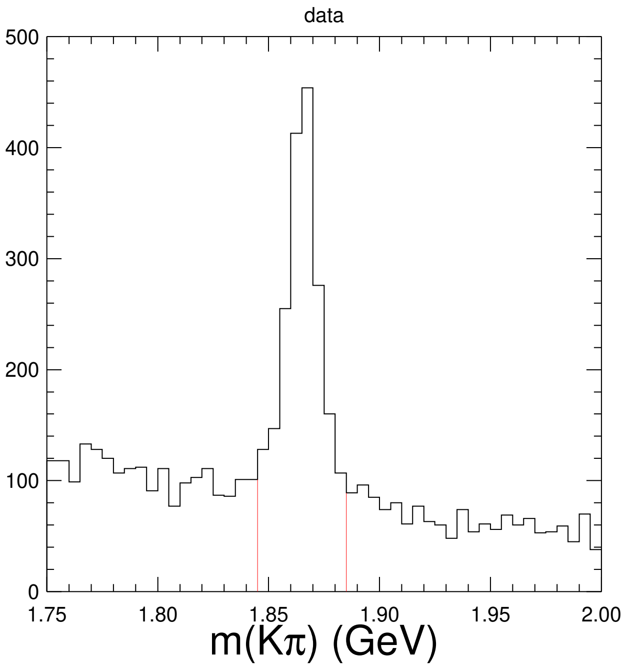
$B^- \to D^{*0}\,\ell^-\,\bar\nu$ vs. $\bar B^0 \to D^{*+}\,\ell^-\,\bar\nu$

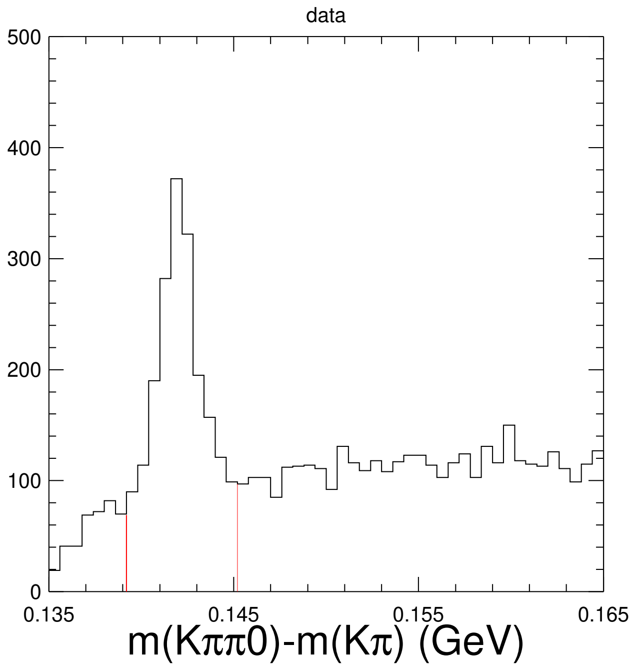
- modes:
  - $B^- \to D^{*0}\,\ell^-\,\bar\nu$ $\quad\quad$ $\bar B^0 \to D^{*+}\,\ell^-\,\bar\nu$
  - $D^{*0} \to D^0\pi^0$ $\quad\quad$ $D^{*+} \to D^0\pi^+$
  - $D^0 \to K^-\pi^+$ $\quad\quad$ $D^0 \to K^-\pi^+$



$B^- \to D^{*0}\,\ell^-\,\bar{\nu}$ Reconstruction

- modes:
  - $B^- \to D^{*0}\,\ell^-\,\bar{\nu}$
  - $D^{*0} \to D^0\pi^0$
  - $D^0 \to K^-\pi^+$
- Selection criteria:
  - using 3.0 million $B\bar{B}$ events generated from e^+e^- collisions at CESR and collected in the CLEO detector
  - $m(K\pi)$ (20 MeV)
  - $m(K\pi\pi^0) - m(K\pi)$ (3 MeV)
  - lepton momentum (0.8 to 2.4 GeV for electron, 1.4 to 2.4 GeV for muon)





Branching Fraction Fit Method

From kinematics:

$$p_\nu^2 = (p_B - p_{D^*} - p_l)^2 \tag{3}$$

Set neutrino mass to zero:

$$0 = m_B^2 + m_{D^{*0}\ell}^2 - 2(E_B E_{D^{*0}\ell} - \vec{p}_B \cdot \vec{p}_{D^{*0}\ell}) \tag{4}$$

Solve for unknown:

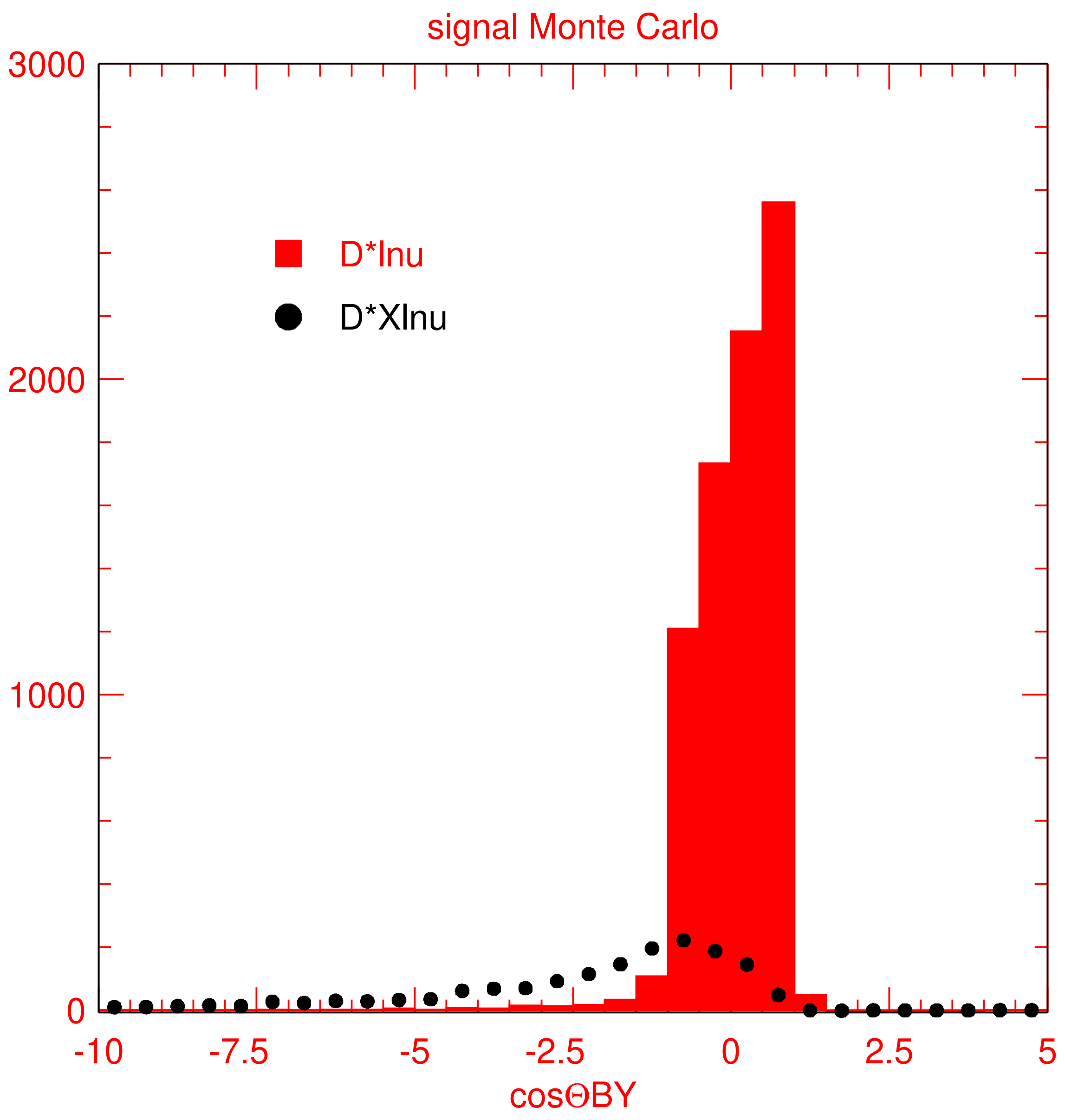
$$\cos\theta_{B-D^{*0}\ell} = \frac{2E_B E_{D^{*0}\ell} - m_B^2 - m_{D^{*0}\ell}^2}{2|\vec{p}_B||\vec{p}_{D^{*0}\ell}|} \tag{5}$$

$$Y = D^{*0}\ell$$

To determine the branching fraction:

- make $\cos\theta_{BY}$ distribution of data that pass all cuts
- make $\cos\theta_{BY}$ distribution of $B \to D^*\ell\bar{\nu}$ and $B \to D^*X\ell\bar{\nu}$ from Monte Carlo
- make $\cos\theta_{BY}$ distributions of other backgrounds
- fit data distribution with $B \to D^*\ell\bar{\nu}$ (float), $B \to D^*X\ell\bar{\nu}$ (float), and other backgrounds (fixed)

Signal Distributions



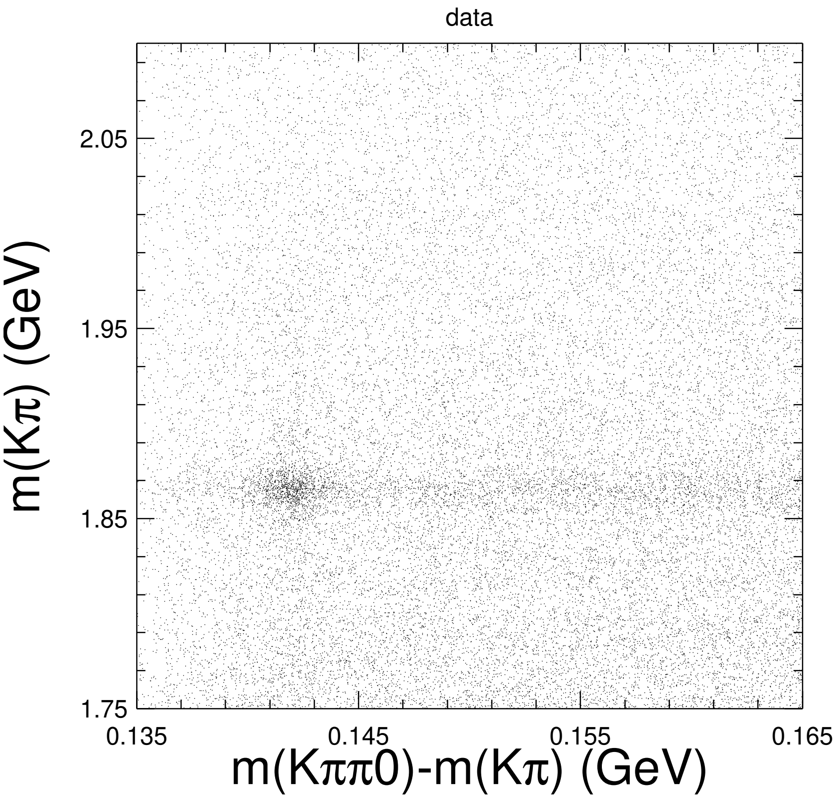
Backgrounds

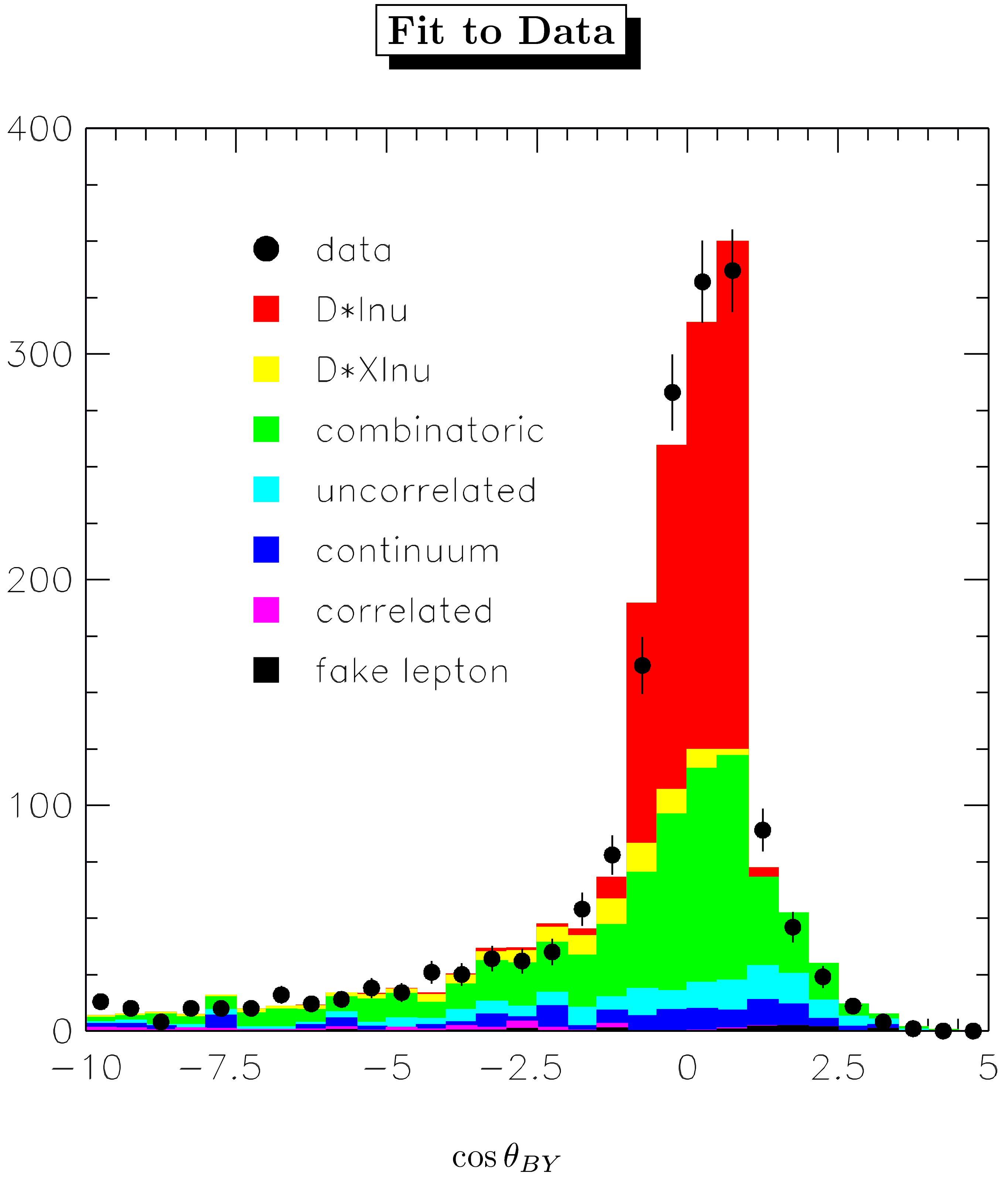
- (28%) Combinatoric: any D^{*0} candidate which is not correctly reconstructed
- (4%) Uncorrelated: D^{*0} and lepton from different B's
- (3%) Continuum: $e^+e^- \to q\bar{q}$ events with D^{*0} and lepton (q is u,d,s,c)
- (0.2%) Correlated: D^{*0} and lepton come from same B, but not from a $B \to D^* \ell \bar{\nu}$ or $B \to D^* X \ell \bar{\nu}$ event (e.g. $B^- \to D^{*0} \tau^- \bar{\nu}$)
- (0.1%) Fake Lepton: hadrons misidentified as leptons and combined with real D^{*0}'s

All backgrounds are either determined from or constrained by data.

Combinatoric

- any D^{*0} candidate which is not correctly reconstructed
- get $\cos\theta_{BY}$ shape from $m(K\pi\pi^0) - m(K\pi)$ sideband in data
- normalize using $m(K\pi)$ sideband




Fit to Data
400
300
200
100
0
−10
−7.5
−5
−2.5
0
2.5
5
data
D*lnu
D*Xlnu
combinatoric
uncorrelated
continuum
correlated
fake lepton
$\cos\theta_{BY}$

Systematic Errors

PRELIMINARY (APS '99)

Source	uncertainty (%)	updated
π^0 efficiency	7.1	2.4
$\mathcal{B}(D^{*0} \to D^0\pi^0)$	4.7	
Track reconstruction	3.0	
$B \to D^*\ell\bar{\nu}$ model	2.7	
Combinatoric background	2.4	
$\mathcal{B}(D^0 \to K^-\pi^+)$	2.3	
Beam energy	2.1	
Lepton identification	2.0	
Hadron identification	2.0	0
Number of $B\bar{B}$	1.8	
$B \to D^*X\ell\bar{\nu}$ model	1.3	
Correlated background	1.0	0.3
Uncorrelated background	1.0	0.9
Fake lepton background	0.0	
Total	10.9	

Branching Fraction

assuming $\mathcal{B}(\Upsilon(4s) \to B^+B^-) = 0.5$

PRELIMINARY (APS '99)

$$\mathcal{B}(B^- \to D^{*0}\,\ell^-\,\bar{\nu}) = 5.84 \pm\ 0.34 \pm\ 0.64\%$$

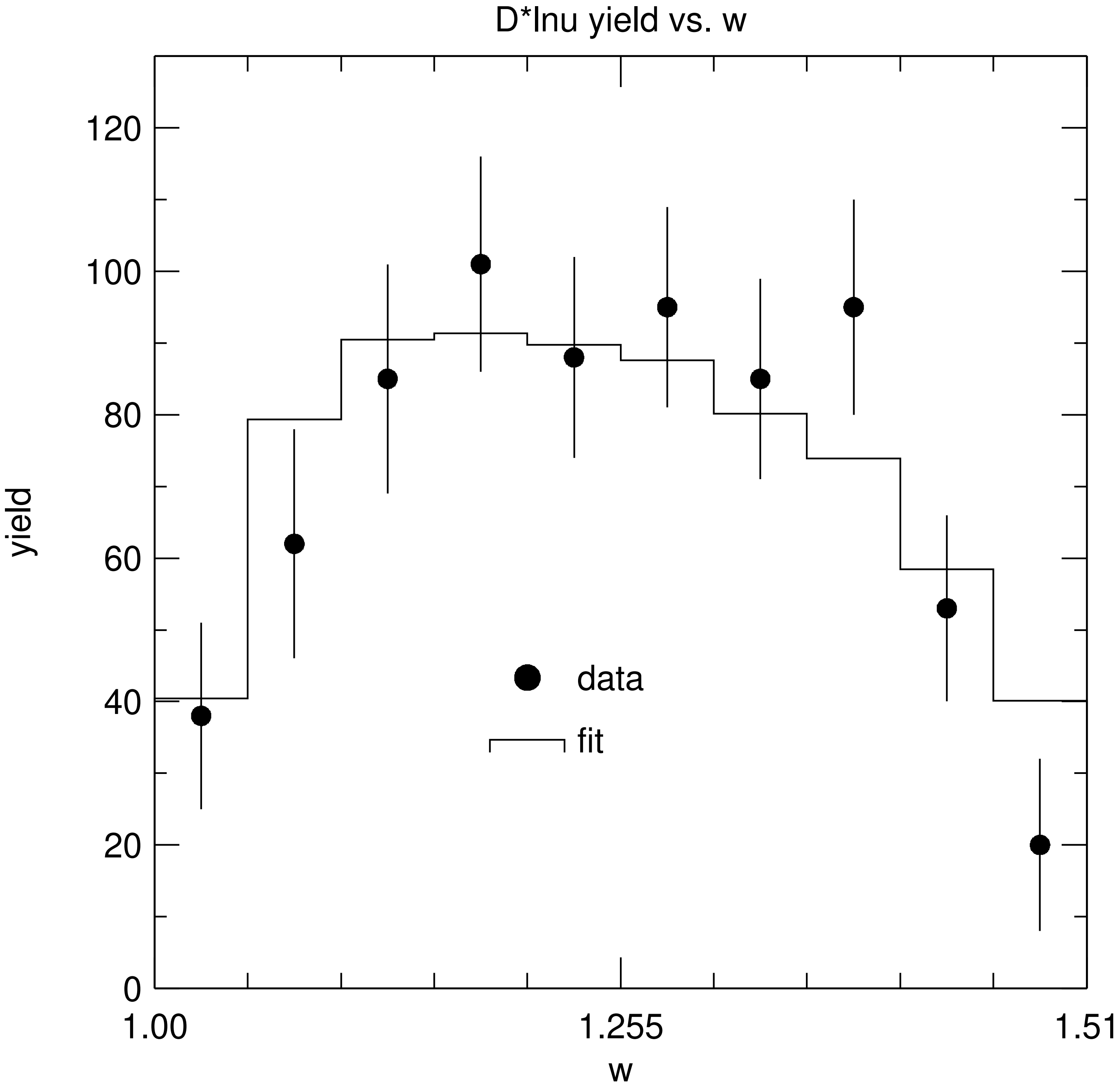
errors: statistical, systematic

Previous CLEO result:

$$\mathcal{B}(B^- \to D^{*0}\,\ell^-\,\bar{\nu}) = 5.35 \pm 0.56 \pm 0.64\%$$

World Average (PDG'98):

$$\mathcal{B}(B^- \to D^{*0}\,\ell^-\,\bar{\nu}) = 5.3 \pm 0.8\%$$


D*lnu yield vs. w
yield
w
120
100
80
60
40
20
0
1.00
1.255
1.51
data
fit