A Comparison Study of the Exclusive Decays $\bar{B}^0 \to D^{*+} l^- \bar{\nu}_l$ & $B^- \to D^{*0} l^- \bar{\nu}_l$ Via Partial Reconstruction

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J15, APS
April 30, 2000
Long Beach, CA

Introduction

- **CLEO II:** $\simeq 3.0 \times 10^6$ $B\bar{B}$ **at** $\Upsilon(4S)$
  $1.6\ fb^{-1}$ **taken at 60 MeV below** $\Upsilon(4S)$
- **Monte Carlo:** 18×10^6 $B\bar{B}$**.**

First Mode:

$\bar{\mathrm{B}}^0 \to \mathrm{D}^{*+} l^- \bar{\nu}_l \Longrightarrow \mathrm{D}^{*+} \to \mathrm{D}^0 \pi^+$

The lepton have a charge opposite to the slow pion (Right Sign Combination)

This signal mode will be noted as N_+

Background : uncorrelated and correlated

Second Mode:

$\mathrm{B}^- \to \mathrm{D}^{*0} l^- \bar{\nu}_l \Longrightarrow \mathrm{D}^{*0} \to \mathrm{D}^0 \pi^0$

plus

$\bar{\mathrm{B}}^0 \to \mathrm{D}^{*+} l^- \bar{\nu}_l \Longrightarrow \mathrm{D}^{*+} \to \mathrm{D}^+ \pi^0$

These signal modes will be noted as N_0

Background : fake π^0, uncorrelated and correlated

Partial Reconstruction Method

- **The** D* **is detected only through a pion daughter from the decay** D$^* \to D\pi$
- **This method will gain a factor of** $\approx\ 20$ **in statistics compared to the full reconstruction method**
- **Observable Missing Mass Squared:**

$$\boxed{\widetilde{\mathcal{M}}_{\nu}^{2} \equiv (E_{\mathrm{beam}} - \widetilde{E}_{D^*} - E_{\ell})^2 - (\widetilde{\mathbf{p}}_{D^*} + \mathbf{p}_{\ell})^2}$$

where:

$$E_{D^*} \simeq \frac{E_\pi}{E_\pi^{CM}} M_{D^*} \equiv \widetilde{E}_{D^*}$$

$$\mathbf{p}_{D^*} \simeq \hat{\mathbf{p}}_\pi \times \sqrt{\widetilde{E}_{D^*}^2 - M_{D^*}^2} \equiv \widetilde{\mathbf{p}}_{D^*}$$

- **Momentum Cuts:**

$1.8\ GeV/c \leq P_l \leq 2.5\ GeV/c$

$50\ MeV/c \leq P_{\pi^+} \leq 220\ MeV/c$

$50\ MeV/c \leq P_{\pi^0} \leq 220\ MeV/c$

Solving for $\frac{f_{+-}}{f_{00}} \frac{\tau_{B+}}{\tau_{B0}}$

- **To make model-independent comparisons of the two decay modes, we take the ratio of N_0 and N_+ with efficiency correction in each $10\ MeV/c$ pion momentum bin**

- **Assuming $\Gamma_{\bar{B}^0 \to D^{*+} l^- \bar{\nu}_l} = \Gamma_{B^- \to D^{*0} l^- \bar{\nu}_l}$ and defining $n_{eff} \equiv \frac{N_0}{N_+} \frac{\epsilon_{0+}}{\epsilon_{ave}}$ then :**

$$\boxed{\frac{f_{+-}}{f_{00}} \frac{\tau_{B+}}{\tau_{B0}} = \frac{n_{eff}\, Br(D^{*+} \to D^0 \pi^+) - Br(D^{*+} \to D^+ \pi^0)}{Br(D^{*0} \to D^0 \pi^0)}}$$

- Some definition :

  f_{+-} **is the fraction of** $\Upsilon(4S) \to B^+ B^-$

  f_{00} **is the fraction of** $\Upsilon(4S) \to B^0 \bar{B}^0$

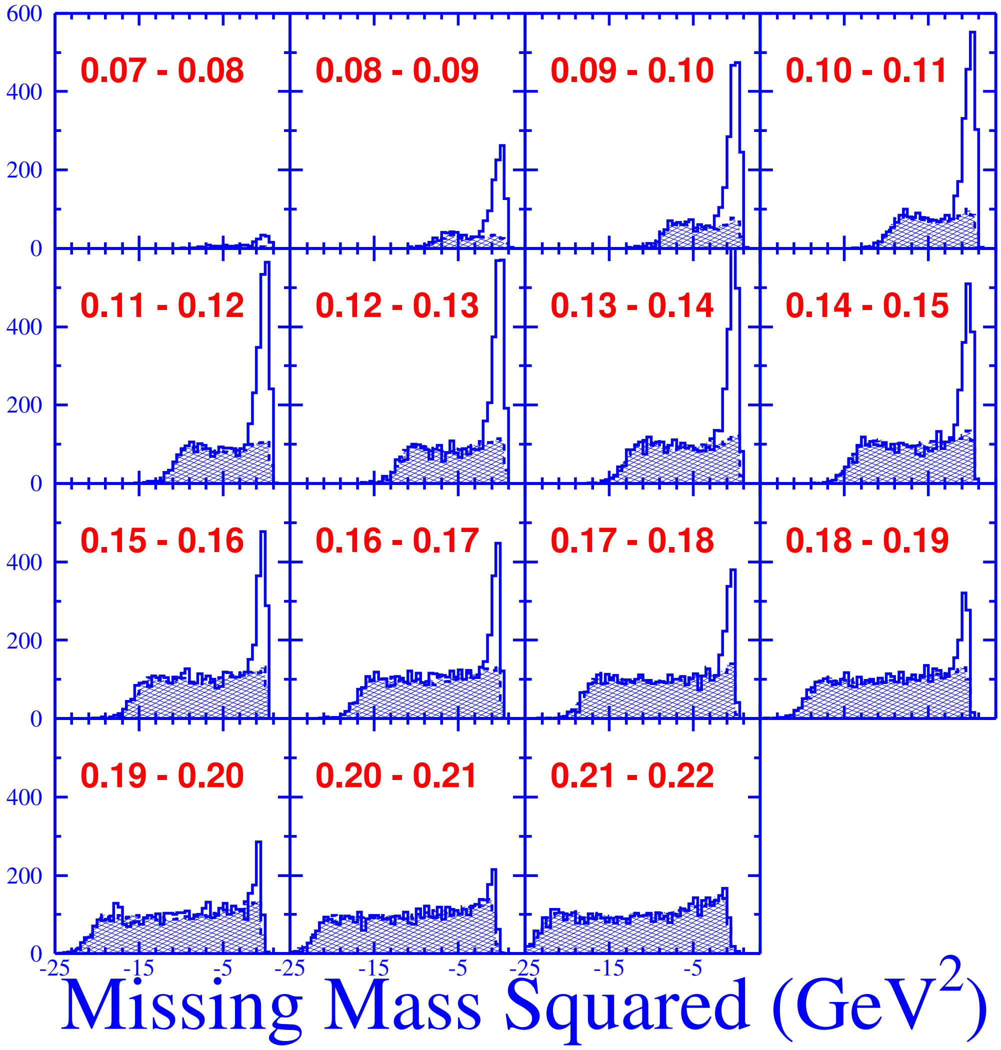
  $\bar{B}^0 \to D^{*+} l^- \bar{\nu}_l, \quad D^{*+} \to D^0 \pi^+ \Longrightarrow \epsilon_{0+}$

  $B^- \to D^{*0} l^- \bar{\nu}_l, \quad D^{*0} \to D^0 \pi^0 \Longrightarrow \epsilon_{-0}$

  $\bar{B}^0 \to D^{*+} l^- \bar{\nu}_l, \quad D^{*+} \to D^+ \pi^0 \Longrightarrow \epsilon_{00}$

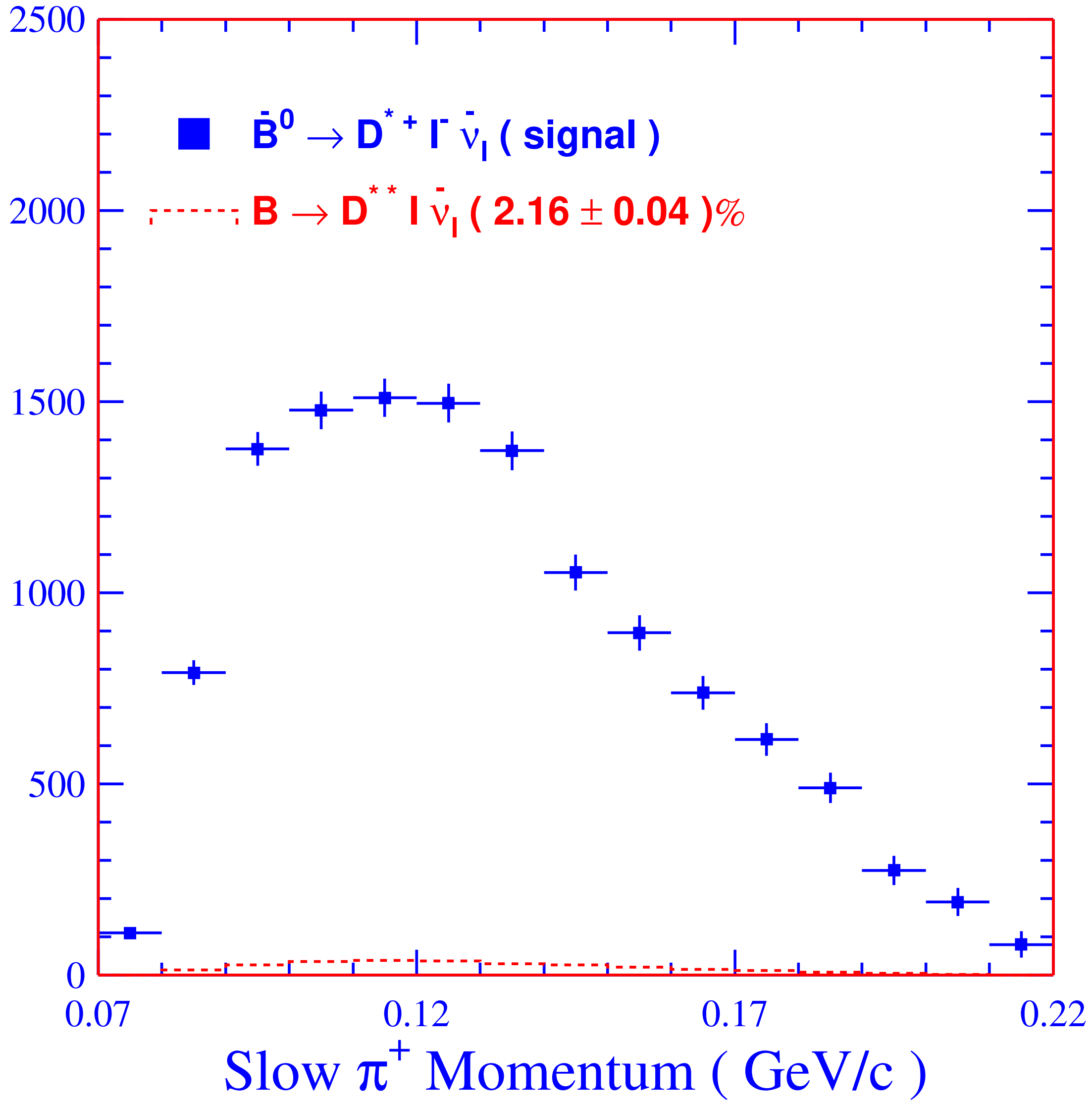
Uncorrelated Background for N_+

- **The uncorrelated background comes from a random combination of l^- with π^+**
- **Sideband :** $-25 \leq \widetilde{\mathcal{M}}_\nu^2 \leq -4 \ (GeV^2)$
- **Peak :** $-2 \leq \widetilde{\mathcal{M}}_\nu^2 \leq 3 \ (GeV^2)$



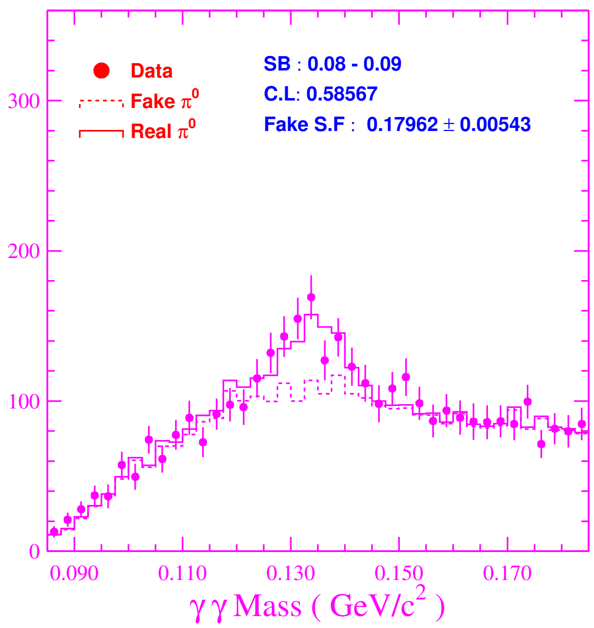
N_+ vs π^+ Momentum

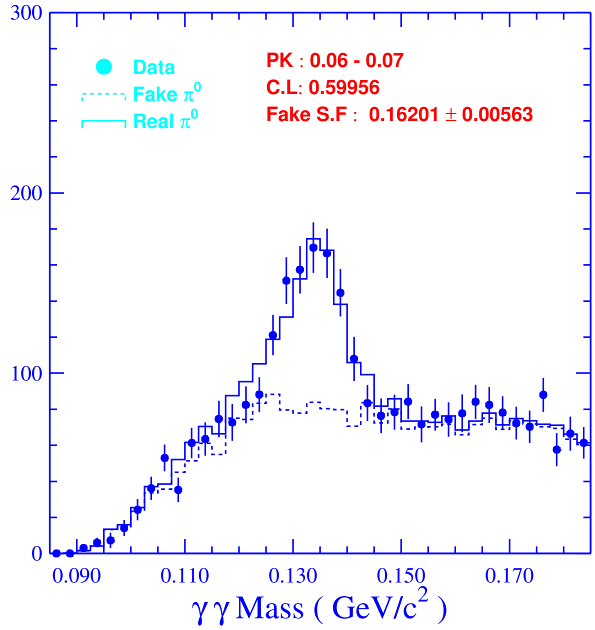
- Scaled the sum of Resonance and Non-resonance with BR($D^{**}l\bar{\nu}_l$) : $[2.26 \pm 0.29 \pm 0.33]\%$ (ALEPH)



Fake π^0 Background for N_0

- **We fit a sum of fake and real π^0 in $\widetilde{\mathcal{M}}^2_\nu$ Sideband (SB) and Peak (PK) to estimate the fake π^0 background**

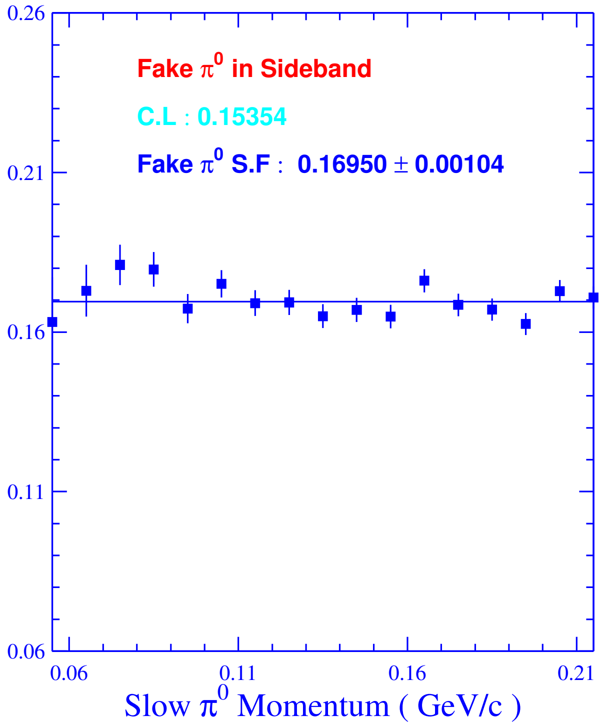


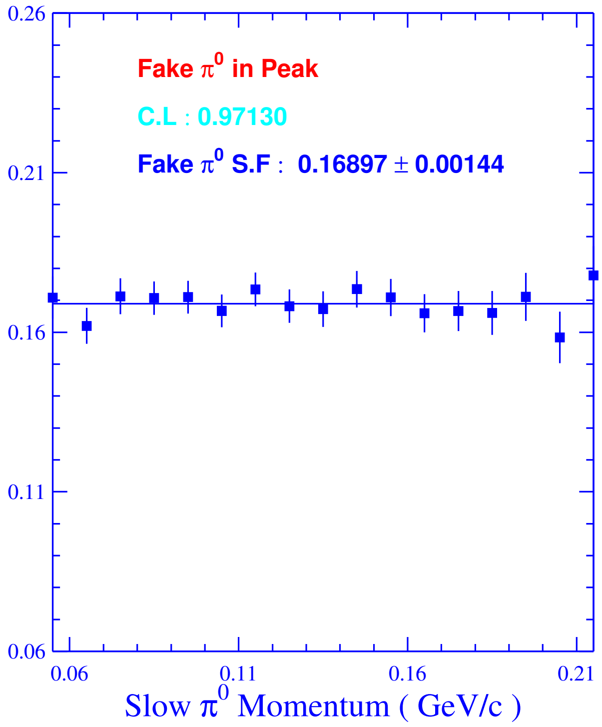


- **SB :** $-25 \leq \widetilde{\mathcal{M}}^2_\nu \leq -4 \ (GeV^2)$
- **PK :** $-2 \leq \widetilde{\mathcal{M}}^2_\nu \leq 3 \ (GeV^2)$

Fit π^0 Scaling Factor to a Constant

- **We fit a fake π^0 scaling factor to a constant in $\widetilde{\mathcal{M}}_\nu^2$ Sideband and Peak**

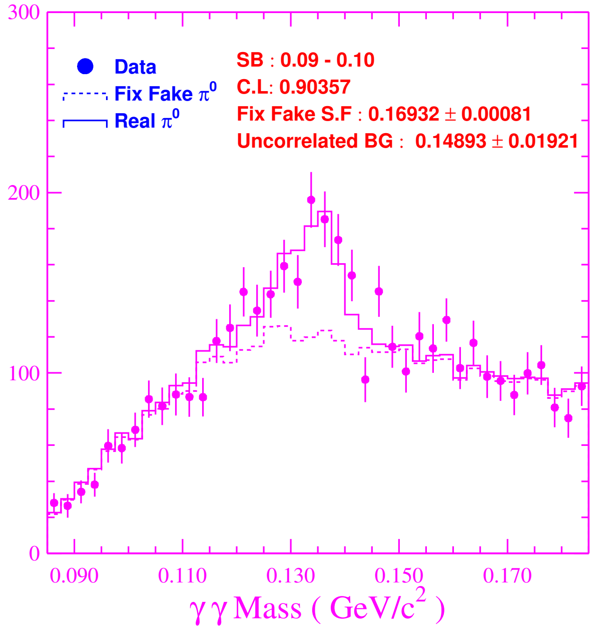


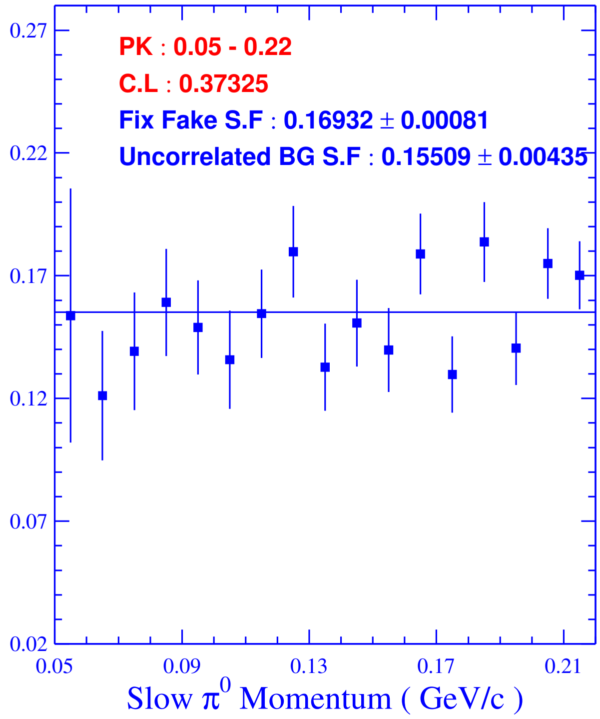


- **The combination fit of fake π^0 scaling factor in $\widetilde{\mathcal{M}}_\nu^2$ sideband and peak :** 0.16932 ± 0.00081

Uncorrelated Background for N_0

- **We fit a sum of fake and real π^0 in $\widetilde{\mathcal{M}}_\nu^2$ Sideband with the fake normalization fixed to estimate the uncorrelated background**

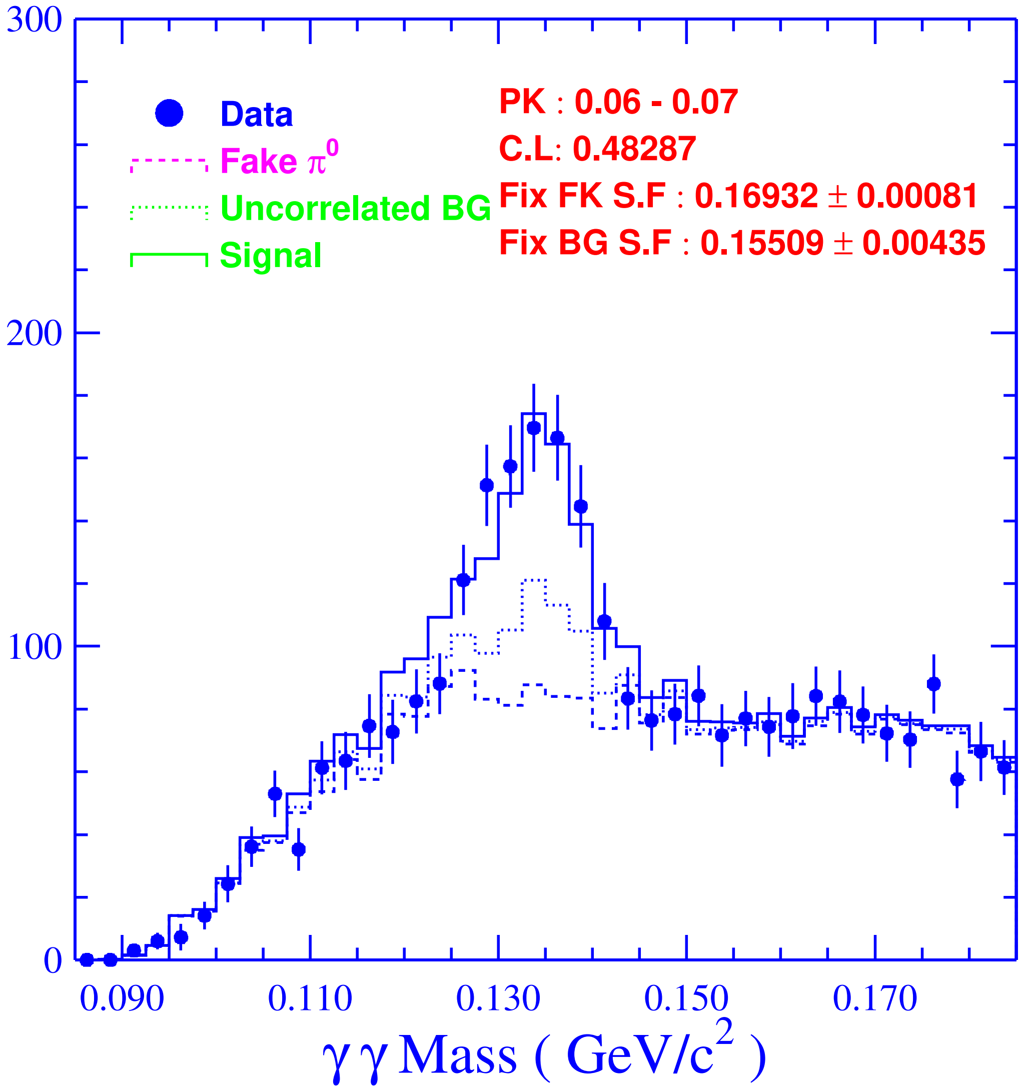




- **The $\widetilde{\mathcal{M}}_\nu^2$ Sideband consists only of uncorrelated background, we use it to estimate the uncorrelated background among $\widetilde{\mathcal{M}}_\nu^2$ Peak as well**
- **Uncorrelated BG S.F :** 0.15509 ± 0.00435

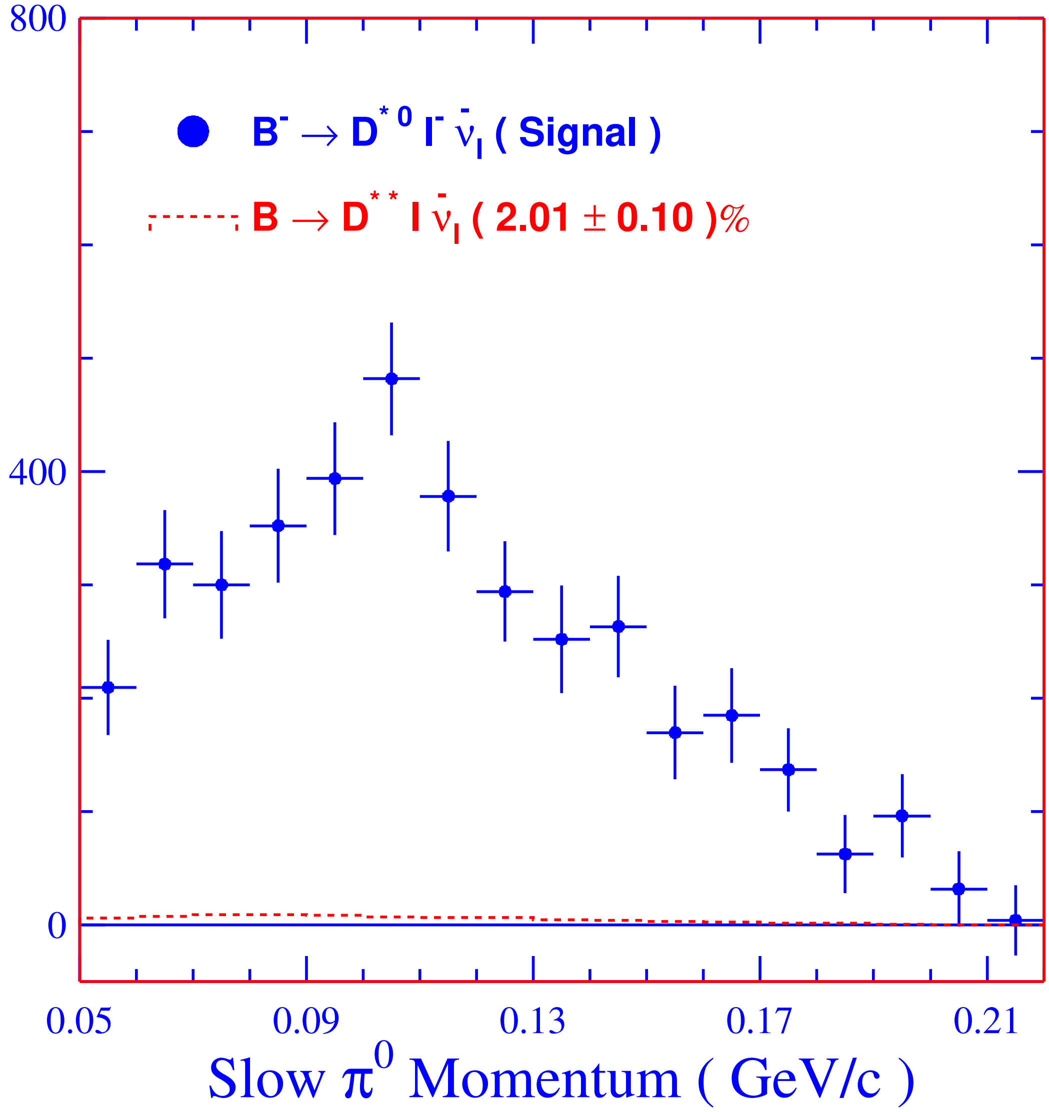
Signal Candidates in $\widetilde{\mathcal{M}}_\nu^2$ Peak

- **Fit the fake & real π^0 from uncorrelated bg both with fixed normalizations and real π^0 with floating normalization in $\widetilde{\mathcal{M}}_\nu^2$ Peak**



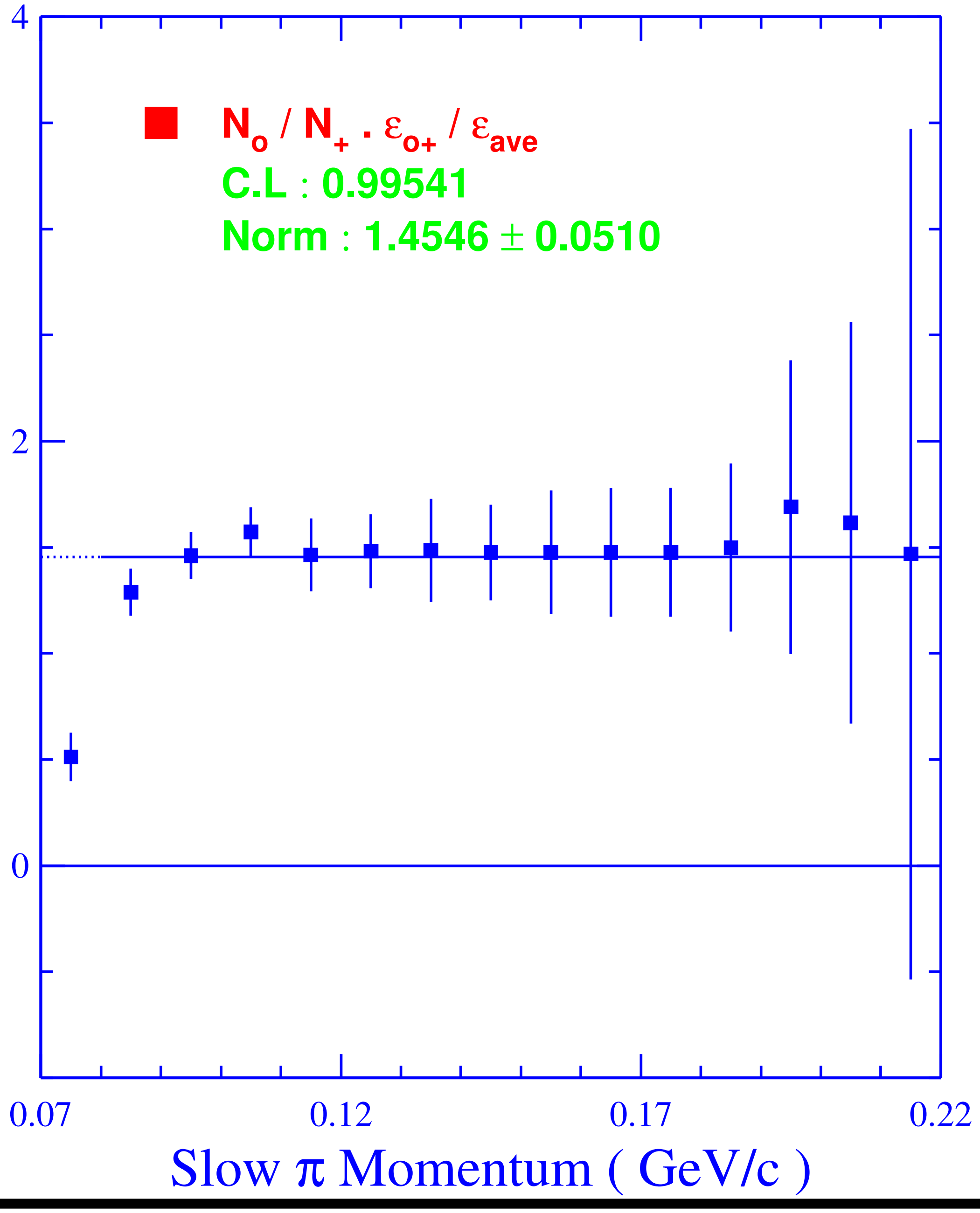
N_0 vs π^0 Momentum

- Scaled the sum of Resonance and Non-resonance with BR$(D^{**}l\bar{\nu}_l)$: $[2.26 \pm 0.29 \pm 0.33]\%$ (ALEPH)



$\frac{N_0}{N_+}$ With Efficiency Correction $\equiv n_{eff}$

- N_0 is the signal yield of $(l^\pm - \pi^0)$
- N_+ is the signal yield of $(l^\pm - \pi^\mp)$



Systematic Error

- **Systematic Error estimation :**

TYPE	$(l^{\pm} - \pi^{\mp})$	$(l^{\pm} - \pi^{0})$
Continuum subtraction	0.2%	0.2%
Fake Lepton	0.4%	0.4%
Lepton ID efficiency	2.5%	2.5%
Uncorrelated Background	1.7%	1.3%
$D^{**} l \bar{\nu}_l$ subtraction	2.0%	2.2%
Fake π^0 subtraction	—	3.0%
Slow π^+ efficiency	5.0%	—
Slow π^0 efficiency	—	7.0%
D* branching fraction	1.0%	2.6%
Total Systematic Error	6.3%	8.8%

- **The Systematic error is mainly dominated by slow pion efficiency**
- π^+ **efficiency systematic uncertainty :** 5.0%
- π^0 **efficiency systematic uncertainty :** 7.0%

Preliminary Result

- **Assuming** $\Gamma_{\bar{\mathrm{B}}^0 \to \mathrm{D}^{*+} l^- \bar{\nu}_l} = \Gamma_{\mathrm{B}^- \to \mathrm{D}^{*0} l^- \bar{\nu}_l}$ **and using** $n_{eff} \equiv \frac{N_0}{N_+} \frac{\epsilon_{0+}}{\epsilon_{ave}}$ **:**

$$\Longrightarrow \frac{f_{+-}}{f_{00}} \frac{\tau_{B^+}}{\tau_{B^0}} = [1.10 \pm 0.04 \pm 0.13]$$

- **Using the ratio of** B^+ **and** B^0 **lifetimes :**

$$\frac{\tau_{B^+}}{\tau_{B^0}} = [1.066 \pm 0.024] \text{ (F. Ukegawa '99)}$$

- **The charged to neutral** B **production ratio at** $\Upsilon(4S)$ **:**

$$\Longrightarrow \frac{f_{+-}}{f_{00}} = [1.03 \pm 0.04 \pm 0.12 \pm 0.02]$$

The 3^{rd} systematic error is due to the uncertainty on the B lifetime ratio

- **CLEO Preliminary measurement:**

$$\frac{f_{+-}}{f_{00}} \frac{\tau_{B^+}}{\tau_{B^0}} = 1.113 \pm 0.074^{+0.039}_{-0.041} \ (B \to J/\psi K^{(*)})$$

$$\frac{f_{+-}}{f_{00}} = 1.044 \pm 0.069^{+0.043}_{-0.045} (B \to J/\psi K^{(*)})$$